# HyperLab 2014

# Gamma Spectroscopy Software

Manuals



HyperLabs Software

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#### Welcome to HyperLab 2014!

Thank you for purchasing HyperLab. We hope you will use it successfully in your everyday work.

The documentation guidelines for our gamma spectroscopy system are the following:

- To install HyperLab System quickly, start reading the **Installation Guide**.
- When you have successfully installed the software system, read either **Quick Start Guide for Main Module** or **Quick Start Guide for Spectrum File Batch Evaluator** to become familiar with its concepts and learn how to use it efficiently.
- If you are interested HyperLab's processes in detail, refer to **Reference Guide**.
- When you are interested a specific software function, use the **On-line Help** (Windows Help file, press F1 in any HyperLab application to display it).

HyperLabs Software Budapest, Hungary

HyperLab 2014 Gamma Spectroscopy Software Installation Guide



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## About this document

To install HyperLab System quickly, start reading this *Installation Guide*. For detailed instructions on using the installed components, see either the *Quick Start Guide for Main Module* or the *Quick Start Guide for Spectrum File Batch Evaluator*.

## 1. Setup Types

This Installation Guide describes two possible setup types: **HyperLab Main Module** application and **Spectrum File Batch Evaluator** utility setup.

## 1.1. Main Module overview

Main Module provides gamma spectrum evaluation and fit refinement on a rich graphical user interface, as well as system nonlinearity, detector efficiency and resolution determination.

To efficiently accomplish these tasks, it uses a relational database as a back-end, even for storing spectrum details, including counts.

This setup type is recommended for most users. For detailed installation instructions, see Chapter 2, "Installing HyperLab Main Module" on page 6.



## 1.2. Spectrum File Batch Evaluator overview

Spectrum File Batch Evaluator utility provides fully automatic evaluation of a series of spectrum files, even without using a database.

This is suggested for specific users only, who do not require Main Module's advanced visual environment during their daily work.

**Note:** Main Module has a different batch evaluation utility, which works from the database and its results are also stored in the database. With this approach, you can also use nonlinearity calibration, which results in much more exact peak positions.

For detailed installation instructions, see Chapter 3 "Installing Spectrum File Batch Evaluator" on page 15.



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## 2. Installing HyperLab Main Module

This module utilizes relational databases to store all measurement and evaluation information as well as provides several advanced features and options, thus requires more software components to be installed.

## Before installing a new HyperLab version, always make a database backup with your older HyperLab software!

See the Reference Guide for details.

#### Warning to users of previous HyperLab versions:

Altough in general more than one HyperLab installations may peacefully coexist on the same computer, please keep in mind the followings:

- HyperLab 2002 or 2005 versions require an old version of the Sentinel hardware key driver, so they will stop functioning when a newer version is installed.
- Almost all HyperLab installation will upgrade your database to a slightly improved format. This newer format sometimes may cause minor problems with the older HyperLab versions. Thus using the same database with different HyperLab versions is not recommended.
- HyperLab installers neither changes the existing database management software of the existing versions, nor its database password. For a clean installation, however, the latest version of the database management software will be installed, with a new password.

## 2.1. Database topologies for Main Module

Two arrangements are common for Main Module regarding the database management server:

- Local database exists (common case): user installs a local Microsoft database server, and uses it, among possibly other remote databases (located on another computers).
- No local database exists (for advanced users): user does not install a local Microsoft database server, because it is unnecessary; it uses only other machines' SQL server remotely, e.g. a central SQL server of the Institution. Requires a high-quality permanent network connection and an SQL Server administrator person at the central server.

In the latter case, you should manually de-select the Microsoft database component during setup, because it is unnecessary. This way the setup also becomes much simpler. See further database topologies in Reference Guide.

## 2.2. System requirements

System requirements for the Main Module of HyperLab 2014:

#### **Operating system**

Supported systems:

- Windows 7 SP1 (32-bit and 64-bit versions)
- Windows 8 or 8.1 (32-bit and 64-bit versions)

#### Hardware requirements

CPU:

- Minimum: 2 GHz Pentium 4 for very simple spectra
  - Recommended: Fast Core2 CPU for automatic analysis of
- 6 HyperLab 2014 Installation Guide

complex gamma spectra.

Minimum: 2 GB
Recommended: 4 GB

Hard disk:

•	Minimum:	800 MB free space
•	Recommended:	5 GB free space
Displa	y devices:	

•	Minimum:	1024x768 resolution, 256 colors
•	Recommended:	1280x1024 or better resolution, 16 million colors.

**Notes:** the most resource-hungry operation is the peak evaluation of complicated gamma spectra in HyperLab, so its performance will be most effectively enhanced by a faster CPU.

#### Software environment requirements

Possible conflicting software applications:

- As the Main Module installs a new version of Microsoft' SQL Server as database management software, there is a small chance that some application may conflict with it.
- Software applications which require Sentinel hardware keys to run. In this case it
  may be problematic that HyperLab requires the newest version of the Sentinel
  hardware key driver to be installed, while the other application requires an older
  driver version.
- Using of *Large font size* or a custom DPI setting may be problematic, so we recommend Windows default fonts.

#### 2.3. Preparing to the installation

HyperLab gamma spectroscopy system requires a multi-step installation procedure. Please read carefully and follow the instructions below.

#### 2.3.1. Administrator privileges

HyperLab 2014 requires that you have *Administrator security privileges* during setup. Please start Setup.exe by "Run as administrator".

#### 2.3.2. Removing existing Sentinel hardware key driver

Some other applications on your computer also may require another Sentinel hardware key to run. These keys require a Windows driver for functioning.

HyperLab sets up a recent version of these Rainbow key drivers, which will automatically replace the existing driver. However, this driver replacement is not always done automatically. Therefore it is the safest to remove the old driver manually before HyperLab installation.

#### Automatic removal

To remove a successfully installed Sentinel driver, follow the steps below:

- Start Control Panel and select Add or Remove programs.
- Select "SuperProNet Combo Installer", "Sentinel protection driver", "SafeNet hardware key driver" or similar software component which may refers to the driver of Sentinel's parallel or USB key.
- Click Remove to uninstall it from your system.

#### Manual removal

If the regular uninstall could not be successfully finished, try with manual removal:

• Run "SSDCleanUp" or the "SSDCleanUpx64" utility from the distribution media, by opening the folder AddOns\HardwareKey\RemoveOldDriver .

This will silently remove the old driver, thus it cannot interfere with the new one.

#### 2.3.3. Removing unnecessary SQL Server instances

In order to use Main Module's advanced database back-end, a reliable database management application must be used. HyperLab utilizes Microsoft's "SQL Server" for this purpose. Microsoft SQL Server is designed to be installable on a single computer multiple times (may have "multiple instances"), and each installation or "instance" must have a unique name. One server instance is capable of serving one or more concurrent applications.

HyperLab 2002 and 2005 installed an older version of SQL server, called "MSDE" (Microsoft SQL Server Desktop Engine), and used its so-called "Default Instance", which has the name "MSSQLSERVER".

If this instance exists on your machine, then the new installer assumes that it was created by a previous HyperLab installation. In this case the HyperLab setup will not initiate another, new database server installation, just simply use the existing one.

If you detected that an unnecessary installation of the old MSDE exists, which is not used by any known application, you should remove it by the usual *Control Panel / Add or Remove programs* way, because HyperLab setup may interfere with this previous installation. After modifying the MSDE installation, please restart your computer.

### 2.4. Installing HyperLab software components - overview

HyperLab 2014 Setup application (Setup.exe) will install the necessary HyperLab software components to your computer. The installation may require to restart your computer several times, and typically takes half an hour to complete.

If the setup program requires you to restart your computer after the installation of a specific software component, do so. HyperLab 2014 Setup should automatically start again when your Windows system restarts. If Setup is not starting automatically after a reboot, start it manually again by running Setup.exe. HyperLab Setup will then continue the installation process where it has been interrupted.

### 2.4.1. Starting the main setup application

Start the Setup program by right-clicking the Setup.exe program icon in the root folder of the distribution media, and select "Run as administrator".

HyperLab 2014 Welcome window appears. Click Next to proceed.



The License window appears now with the HyperLab License Agreement. Use scrollbar at the right or press PgDn key to read the License Agreement entirely. Accept the License Agreement in order to continue setup, then click Next.

HyperLab Setup	X
Accept license	
Please read following license agreement. Use PAGE DDWN key to read the remaining sections. If you do not accept its terms, setup will close.	
License Agreement for HyperLab System, version 2013.1	
In short: HyperLabs Software only warrants defective media replacement, and disclaims any other kind of warranty regarding HyperLab System 2013.	
By accepting this license agreement during setup procedure or otherwise using HyperLab System, you agree to the following terms and conditions and any additional terms and conditions in the accompanying documentation.	
If you do not agree with the terms and conditions contained herein, return the $\ensuremath{\mathbf{v}}$	
<ul> <li>I accept the terms of License Agreement above</li> <li>I do <u>N</u>OT accept the terms of License Agreement above</li> </ul>	
< <u>Back</u> <u>Next&gt;</u> Help Close	

Destination customizing window appears now. You can set folders for HyperLab program files and documents here.

#### Notes:

- Program files folder may be a readonly location, but documents folder must reside in a writable directory.
- The size of documents folder will be continuously growing, so you must always keep free space on the destination drive.

 HyperLab Setup
 Customize setup destination

 Please customize your setup destination, then click Next.

 Pestination folder for program files:

 C:\Program Files (k96)\HyperLabs Software\HyperLab2013\

 Pestination folder for documents and databases:

 C:\Users\HUUser\UDuents\HyperLab\

 User settings

 Install for gll users on this computer

 Install for the gurrent user only

 Note: installing for all users is strongly recommended.

You can set here the type of installation:

you can choose either the application to be installed in a common folder - to be used by all users on the computer, or just install it for the current user. We recommend to install HyperLab for all users.

When your settings are appropriate, click Next.



HyperLab Setup		
<mark>ş</mark> ş	Select components to install	
	Please select system components to be installed, then click Next.	
õ	Windows Installer     Sentinel Hardware key driver     Sentinel Hardware key driver     HypetLab Common Files     Common Report Files     Spectrum File Batch Evaluator     Microsoft SQL Server database engine     Component description Provides seamless installation and removal of software components.	
	< <u>B</u> ack ∐elp Close	]

Next.



The Setup type window appears. Select Full Install option here, then click Next.

The software component customization window appears. You can check here the software components you want to set up.

HyperLab Setup tries to determine the software components to be installed, and designates these components with check marks on the component list. If a check box is empty, it means that Setup detected a previous installation for that component, and its setup is not required.

After you selected the components, click

You are ready to start setup process now. Check the listed components which are selected for installation. If the list is complete, click Install. Installation starts now, and you can follow the progress of the setup steps in this window. Name of the currently installed component and elapsed time is displayed at the top, while the interpreted responses of the setup applications are displayed in the Messages area.

**Note:** Installation process of each specific component is detailed in the section 2.5 "Installing Main Module software components – details" on page 11.

When setup has finished, a message window appears. Click Close to finish setup.

erLab Setup	
Installing, please wait	
Please wait while HyperLab components are installing. Overall progress: 0% Current component: Sentinel hardware key driver Elapsed: 4.1 sec Messages:	
Setup of Sentinel hardware key driver started	*

oerLab Setup				
<u>ş</u>	Setup finish	ed		
HyperLab installa	ation finished. Click Clo	se.		
Setup of HyperL Successfully ins	ab Common Files start talled HyperLab Comm	ed on Files		*
Setup of Commo Successfully ins	n Report Files started. talled Common Report	 Files		
Setup of HyperL	ab Main Module starte	d		
Setup of Spectr	um File Batch Evaluato	or started		E
Successfully ins	talled Spectrum File Ba	atch Evaluator		
Setup of Micros Successfully ins	oft SQL Server databa talled Microsoft SQL S	se engine start erver database	ed e engine	
				-

After Setup, a dialog may appear requiring a computer reboot. Click on Yes to perform a reboot.



After reboot, SQL server database management software should start in the background in order to serve HyperLab Main Module's database requests. You should check immediately the status of the local SQL server. See details in *Appendix A*..

## 2.5. Installing Main Module software components - details

Following sub-sections will contain the detailed steps necessary to install specific HyperLab software components.

#### 2.5.1. Setting up Windows Installer component

If you selected Windows Installer component in the main setup program, it installs first. This requires minimum interaction from the user.

Result of setup process will be indicated in the Messages panel of the main setup program.



Sometimes necessary to reboot your computer after setting up Windows Installer. In this case, a warning message box appears. Press Yes to reboot your computer.



After reboot, HyperLab setup automatically restarts itself, and lets you choose continuing the installation interrupted before, or starting a new, clean install. Click on Yes to continue your previous setup procedure.

#### 2.5.2. Setting up Sentinel Hardware Key Driver component

If you selected Sentinel Hardware Key Driver component in the main setup program, its setup application will appear on the screen for a few seconds, and the status of the installation will be written into the message pane.

#### 2.5.3. Setting up HyperLab Main Module component

This software component performs core spectrum evaluation and post-processing tasks. If you selected Main Module component in the main setup program, its setup starts now, and requires no interaction from you.

#### 2.5.4. Setting up Microsoft SQL Server component

The Database Engine is a required component for HyperLab Main Module, if you are planning to use a local database, because it makes it possible to store and retrieve spectroscopic and evaluation data in a relational database.

See also "Database topologies for Main Module" on page 6.

Please wait while SQL Server 2008 R2 Setup processes the current operation.

m Windows Update and complete the installation

Cancel

SQL Server 2008 R2

An app on your PC needs the following Windows feature:

apps might not work correctly without this feature

.NET Framework 3.5 (includes .NET 2.0 and 3.0)

Download and install this feature Windows will get the files that it needs from

Skip this installation

Tell me more about this feature

📀 國 Windows Features

When the SQL Server setup application is started, a Windows Installer window appears on your screen, and displays the installation progress.

If your computer has no .NET 3.5 SP1 software component installed, a confirmation message appears, requiring to download and install it automatically. Please acknowledge the request. Wait until the component installation finishes, then close the .NET 3.5 installer window.

Setup of SQL Server starts now, and it may take 5-10 minutes. If it is successfully finished, the window disappears, and main setup continues. Sometimes a reboot is required at this point. After reboot, HyperLab Setup should start automatically. If it is not started, run Setup.exe again.

🐮 SQL Server 2008 R2 Setup		
Installation Progress		
Installation Progress	Install_sql_engine_core_inst_Cpu32_Action : Install/	itialize.
		Next > Cancel Help

### 2.5.5. Setting up HyperLab Common Files component

This component contains the software utilities necessary to run any HyperLab application, such as energy and resolution calibration, nuclide library handling, reporting and others. The installation requires no interaction from you.

#### 2.5.6. Setting up Common Report Files component

This component contains the report template files necessary to create HyperLab reports, and requires no interaction from you.

## 2.6. Hardware key installation

Please attach the accompanying hardware key to your computer now.

### 2.6.1. Installing parallel-port keys

If you have a parallel port based HyperLab key, then no additional software installation steps are necessary.

## 2.6.2. Installing USB keys



In majority of the cases, after attaching the hardware key, you should see an informational message about the driver installed.

If you have a USB-port-based HyperLab key, however, then sometimes – depending on your hardware and software configuration – the Windows system requires you the installation of additional drivers.

In this case, allow the system to install the newest driver software beside your current one. If the system prompts you about the file to be copied is older than the one found on your computer, it is strongly recommended to keep the newer files.

## 2.7. Post-installation steps

After you have successfully installed HyperLab Main Module to your computer, start reading "Quick Start Guide for Main Module" on getting HyperLab 2014 started.

## 3. Installing Spectrum File Batch Evaluator

This module provides advanced features for users, while utilizes relational databases to store all measurement and evaluation information, thus requires more software components to be installed.

#### Warning to HyperLab 2002, 2005 or 2009 users:

Altough in general more than one HyperLab installations may peacefully coexist on the same computer, please keep in mind the followings:

- HyperLab 2002 or 2005 versions require an old version of the Sentinel hardware key driver, so they will stop functioning when a newer version is installed.
- If you want to step back to your previous HyperLab 2002 or 2005 installation of Batch Evaluator, simply uninstall the new Sentinel driver and install the older one again (uninstalling the whole HyperLab package is not necessary).

## 3.1. System requirements

System requirements for the Spectrum File Batch Evaluator identical to those of the HyperLab MainModule version. Please ensure that your system meets them.

## 3.2. Preparing to the installation

HyperLab gamma spectroscopy system requires a multi-step installation procedure. Please read carefully and follow instructions below.

## 3.2.1. Administrator privileges

HyperLab 2014 requires that you have *Administrator security privileges* during setup. Please start Setup.exe by "Run as administrator".

### 3.2.2. Removing existing Sentinel hardware key driver

Some other applications on your computer also may require another Sentinel hardware key to run. These keys require a Windows driver for functioning.

HyperLab sets up a recent version of these Rainbow key drivers, which will automatically replace the existing driver. However, this driver replacement is not always done automatically. Therefore it is the safest to remove the old driver manually before HyperLab installation.

#### Automatic removal

To remove a successfully installed Sentinel driver, follow the steps below:

- Start Control Panel and select Add or Remove programs.
- Select "SuperProNet Combo Installer", "Sentinel protection driver", "SafeNet hardware key driver" or similar software component which may refers to the driver of Sentinel's parallel or USB key.
- Click Remove to uninstall it from your system.

#### Manual removal

If the regular uninstall could not be successfully finished, try with manual removal:

• Run "SSDCleanUp" or the "SSDCleanUpx64" utility from the distribution media, by opening the folder AddOns\HardwareKey\RemoveOldDriver .

This will silently remove the old driver, thus it cannot interfere with the new one.

#### 3.3. Installing software components - overview

HyperLab 2014 Setup application (Setup.exe) will install the necessary HyperLab software components to your computer. The installation may require to restart your computer several times, and typically takes several minutes complete.

If the setup program requires you to restart your computer after the installation of a specific software component, do so. HyperLab 2014 Setup should automatically start again when your Windows system restarts. If Setup is not starting automatically after a reboot, start it manually again by running Setup.exe. HyperLab Setup will then continue the installation process where it has been interrupted.

#### 3.3.1. Starting the main setup application

Start the Setup program by double-clicking the Setup.exe program icon in the root folder of the distribution media.

HyperLab Setup	
Welcome to HyperLab 2013.1!	
This Setup application will install HyperLab 2013.1 Gamma Spectroscopy Software System to your computer. It may be necessary to reboot the computer several times during the installation. NOTE: It is strongly recommended to quit any Windows application before continuing setup, otherwise setup may fail.	
< <u>Back</u> Next> Help Closs	•

At first, the HyperLab 2014 Welcome window appears. Click Next to proceed.

HyperLab Setup	
Accept license	
Please read following license agreement. Use PAGE DOWN key to read the remaining sections. If you do not accept its terms, setup will close.	
License Agreement for HyperLab System, version 2013.1	
In short: HyperLabs Software only warrants defective media replacement, and disclaims any other kind of warranty regarding HyperLab System 2013.	
By accepting this license agreement during setup procedure or otherwise using HyperLab System, you agree to the following terms and conditions and any additional terms and conditions in the accompanying documentation.	
If you do not agree with the terms and conditions contained herein, return the $\pi$	
I accept the terms of License Agreement above ○ I do <u>N</u> OT accept the terms of License Agreement above	
Close	

The License window appears now with the HyperLab License Agreement. Use scrollbar at the right or press PgDn key to read the License Agreement entirely. Accept the License Agreement in order to continue setup, then click Next. Destination customizing window appears now. You can set folders for HyperLab program files and databases here. Please note that the size of databases folder will be continuously growing, so you must always keep free space on the destination drive. **Note:** 

If you were using previous HyperLab versions on the same computer, it is advisable to use the same *database* folder as before.

You can set here the type of installation:

you can choose either the application to be installed in a common folder - to be used by all users on the computer, or just install it for the current user. We recommend to install HyperLab for all users in these cases. If you are ready, click Next.

vperLab Setur

15/5

Customize setup destination

Destination folder for documents and databases:

Install for all users on this computer

Install for the <u>c</u>urrent user only

< Back

C:\Users\HLUser4\Documents\HyperLab\

C:\Program Files (x86)\HyperLabs Software\HyperLab2013\

Destination folder for program files:

User settings

Please customize your setup destination, then click Next

Note: installing for all users is strongly recommended.

Help

Close

Next >

The Setup type window appears. Select Spectrum File Batch Evaluator option here, then click Next.



The software component customization window appears. You can check here the software components you want to set up. HyperLab Setup tries to determine the software components already installed, and adjust the check marks accordingly on the component list.

If a check box is empty, it means that Setup detected a previous installation for that component, and its setup is not recommended.

After you selected the components you require, click Next.





lyperLab Setup	×
Installing, please wait	
Please wait while HyperLab components are installing. Overall progress: 0% Current component: Sentinel hardware key driver Elapsed: 4.1 sec Messages:	
Setup of Sentinel hardware key driver started	
	Ŧ
< <u>B</u> ack Install Help Qose	

#### page 19.

HyperLab Setup				X
Se Se	etup finished			
HyperLab installation fir	nished. Click Close.			
Setup of HyperLab Co Successfully installed H Setup of Common Rep Successfully installed f Setup of Spectrum File Successfully installed S	mmon Files started HyperLab Common Files iont Files started Common Report Files Batch Evaluator started Spectrum File Batch Evaluato	я		~
	< <u>B</u> ack	<u>N</u> ext >	Help	Close

You are ready to start setup process now. Check the listed components which are selected for installation. If the list is complete, click Install.

Installation starts now, and you can follow the progress of the setup steps in this window. Name of the currently installed component and elapsed time is displayed at the top, while the interpreted responses of the setup applications are displayed in the Messages area.

Note: Installation process of each specific component is detailed in section 3.4 "Installing Batch Evaluator software components – details" on

When setup has finished, a message window appears. Click Close to finish setup.

During Setup, a dialog may appear requiring a computer reboot. Click on Yes to perform a reboot.



## 3.4. Installing Batch Evaluator software components - details

Following sub-sections will contain the detailed steps necessary to install specific HyperLab software components.

#### 3.4.1. Setting up Windows Installer component

If you selected Windows Installer component in the main setup program, it installs first. This requires minimum interaction from the user. Result of setup process will be indicated in the Messages panel of the main setup program.

Sometimes necessary to reboot your computer after setting up Windows Installer. In this case, a warning message box appears. Press Yes to reboot your computer.



After reboot, HyperLab setup automatically restarts itself, and lets you choose continuing the installation interrupted before, or starting a new, clean install. Click on Yes to continue your previous setup procedure.



### 3.4.2. Setting up Sentinel Hardware Key Driver component

If you selected Sentinel Hardware Key Driver component in the main setup program, its setup application will appear on the screen for a few seconds, and the status of the installation will be written into the message pane.

#### 3.4.3. Setting up Spectrum File Batch Evaluator component

This software component performs evaluation of spectrum files. If you selected Batch Evaluator setup type in the main setup program, the setup of this component starts, and requires no interaction from you.

### 3.4.4. Setting up HyperLab Common Files component

This component contains the software utilities necessary to run any HyperLab application, such as energy and resolution calibration, nuclide library handling, reporting and others. The installation should finish silently, requiring no interaction from you.

### 3.4.5. Setting up Common Report Files component

This component contains the files necessary to create HyperLab reports, and requires no interaction from you.

## 3.5. Hardware key installation

Please attach the accompanying hardware key to your computer now.

#### 3.5.1. Installing parallel-port keys

If you have a parallel port based HyperLab key, then no additional software installation steps are necessary.

### 3.5.2. Installing USB keys



In majority of the cases, after attaching the hardware key, you should see an informational message about the driver installed.

If you have a USB-port-based HyperLab key, however, then sometimes – depending on your hardware and software configuration – the Windows system requires you the installation of additional drivers.

In this case, allow the system to install the newest driver software beside your current one. If the system prompts you about the file to be copied is older than the one found on your computer, it is strongly recommended to keep the newer files.

### 3.6. Post-installation steps

After you have successfully installed the Batch Evaluator to your computer, start reading "Quick Start Guide for Spectrum File Batch Evaluator" on getting HyperLab 2014 started.

## Appendix A. Managing SQL Server

As HyperLab Main Module operates on one or more of your HyperLab databases, it requires Microsoft SQL Server database service to be started before using it. Generally, this software component works silently in the background, and does not need interactions from the end user.

#### Checking status and starting of SQL Server

Make sure that the MSDE database management system is running when you start HyperLab. This can be checked by the help of the SQL Server Configuration Manager utility. Start this utility by click on Start / All Programs / Microsoft SQL Server 2008 R2 / Configuration Tools shortcut.

When the configuration starts, click on the SQL Server Services item on the left.

Check at the right if the status of the "SQL Server (MSSQLHYPERLAB)" is Running. If that is the case, then the database server is running. In this case, you can immediately use HyperLab.

If a SQL Server is in stopped state, theat means the service is installed, but presently is not running (stopped). You must start database service to use HyperLab.

To achieve this, right-click over the SQL Server line, and select Start from the pop-up menu. After a few seconds, status of the server will change to Running.

You can start using HyperLab now.

#### Stopping SQL Server temporarily

If you do not want SQL Server to interfere with the installation process of some other application, you can temporarily stop it using the same row in the Configuration Manager.



Sql Server Configuration Manager       Eile     Action       Yeew     Help       Image: Participation of the second s		
SQL Server Configuration Manager (Local)             SQL Server Services             P         SQL Server Network Configuration (32bit)             SQL Server Optimized Services             SQL Server Optized Services	Name SQL Server (MSSQLHYPERLAB) SQL Server Agent (MSSQLHYPERLAB) SQL Server Browser	State Running Stopped Running

SQL Server Configuration Manager (Local)       Name       State         SQL Server Services       SQL Server (MSSQLHYPERLAB)       Stopped         SQL Server Network Configuration (32bit)       SQL Server Agent (MSSQLHYPERLAB)       Stopped         SQL Server Network Configuration (32bit)       SQL Server Browser       Running	and Server Configuration Manager File Action View Help ← ➡ 2 □ □		
	SQL Server Configuration Manager (Local)                 SQL Server Services                 SQL Server Network Configuration (32bit)                 SQL Server Network Configuration (32bit)                 SQL Server Network Configuration (32bit)	Name SQL Server (MSSQLHYPERLAB) SQL Server Agent (MSSQLHYPERLAB) SQL Server Browser	State Stopped Running

HyperLab 2014 Quick Start Guide for Main Module



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## About this document

For detailed instructions on using the installed Main Module, start reading this *Quick Start Guide*. If you did not install the Main Module yet, refer to *Installation Guide* first. If you want to get finer details about peak evaluation or other HyperLab processes, see the *Reference Guide*.

## 1. Introduction

This Quick Start Guide contains basic information on HyperLab system, including system overview, and usage instructions. It also details initial steps to fill up a sample database and to carry out most common spectroscopy tasks. We will guide you through a comprehensive tour, where a set of sample spectra will be processed by HyperLab system.

## 1.1. Purpose of HyperLab

HyperLab is a sophisticated software system, which is intended to greatly ease daily tasks of gamma spectroscopists and scientists with up-to-date techniques and algorithms. It uses novel techniques for reliable **deconvolution** of extremely complex gamma spectra taken with semiconductor detectors. Evaluation of Dual LFC (Loss Free Counting) gamma spectra is also supported for compensating the radioactive decay during measurements.

A high quality **nuclide identification** and minimum detectable activity (MDA) calculation is also available for virtually all nuclei found in common nuclear libraries. Our isotope identification method behaves exceptionally well if isotopes are present with overlapping spectrum peaks.

The software system is also capable of determining your system's various important characteristic functions from multiple measurements taken with multiple radioactive sources:

- detector resolution,
- system nonlinearity,
- absolute or relative full-energy detector efficiency,
- peak-to-total ratio.

All of the functions above are determined by numerically stable methods, while providing extremely convenient user interfaces.

## 1.2. System architecture overview

HyperLab Main Module stores *all* spectroscopic information in relational databases. The next figure illustrates basic system components.

**Main module** is the application where you will operate various evaluation utilities (peak area evaluator, detector efficiency evaluator etc.) and also the primary interface to information stored in one or more **databases**. Benefits of database systems are described in *Reference Guide*.



### 1.3. Overview of HyperLab tasks

When a gamma spectroscopist starts using HyperLab, usually the following steps are performed:

- Creating one or more databases with Main Module. The new database is "empty" at this point (indeed, it contains nuclear data).
- Defining the measurement setup, and also custom projects. Projects in the database are similar to folders of hard disks, and helps to manage vast amount of information.
- Transferring of existing spectrum files into the database.
- Peak evaluation of spectra; possibly with defining modified energy and FWHM calibration.
- Exporting peak lists for outer evaluation applications.

The resulting peak lists may also be used to perform system *nonlinearity* evaluation, detector *efficiency* or *resolution* determination within Main Module. See *Reference Guide* for details.

## 2. Getting Started with Main Module

Start HyperLab Main Module by clicking on Start/ Programs/ HyperLab 2014/ HyperLab 2014.1 menu.

A message appears, which warns you about missing databases. Press Ok.

Main Module window appears now.

## 2.1. The Main Module window

This window appears when Main Module is started. Its main parts are the following: **Database browser tree [1]** provides hierarchic listing of objects stored in HyperLab databases. The items displayed in this tree are called *nodes*.

**Detail lister [2]** shows common details for the item which is currently selected in the browser tree.

#### Tasks and Sub-items panels [3] are

refreshing their content according to the data entry you have selected in the database browser tree. *Tasks* provides you operations which may be performed on the selected database entry; whereas *Sub-items* shows special sub-components about it.

Content of the *Tasks* window also appears in a **context menu**, when user right-clicks on a database node.

Common **keyboard shortcuts** may help your work: database tree may be walked through by using the *cursor arrow* keys, while the currently selected task may be started by hitting the *Enter* key. *Tab* key switches between the browser tree and the *Tasks* window.



Server', then pick a task at the right named 'Create a

OK

Database creation will take about 5 minutes.

🛤 XPS Viewer

database'.



## 3. Creating a new HyperLab database

In most cases, the initial step of using HyperLab is to create a new local database. First check if your local MSDE database service is running: the icon with the green triangle should be displayed on your system tray.

HyperLab is able to use a remote database, that is, to transfer the evaluation data through the computer network from another user's database or from a central SQL server for safe and consolidated data storage. In this case, no local database installation is required, just a registration of the remote database. See *Reference Guide* for details.

## 3.1. Database creation



Specify the name of the new database, then click Next.

Automatic database creation process starts now, which also incorporates the copying of large amount of nuclear data to the new database.

The process may take several minutes. When the copying process ends, click Finish.

After database successfully created, it appears under *HyperLab databases* node. By double-clicking on it, you will be able access its content.

If no such entry appears under *HyperLab databases* node after a successful database creation, refer to *Database registration* section of the *Reference Guide* in order to display it.

💋 Creating a HyperLab database			E	- • •			
Specify parameters for new database and initialization data, then click Next.							
N	Hupped ab1						
New database name: HyperLabi							
Existing databases:							
Initialization data							
Basic data file:	C:\Users\HLUser4\Documer	nts\HvperLa	b\HvperLab20	13\Data\Ir 📀			
Nuclear data file:	C:\Users\HLUser4\Documer	nts\HyperLa	b\HyperLab20	113\Data\Ir 🔗			
	< <u>B</u> ack	<u>N</u> ext :		<u>C</u> lose			
💋 Creating a HyperLab database							
Database successfi	ully created at the database serv	ver Click Fini	sh to close wiza	ard			
Messages:							
B init records inserted into table "SAMPLEGEUMHEURAHAM"     2 init records inserted into table SAMPLEGEUMHEURAHAM"     3 init records inserted into table DETECTORTYPE"     5 init records inserted into table DETECTORTYPE"     1 init records inserted into table DETECTORTYPE     1 init records inserted into table TILETYPE     1 init records inserted into table totol     1 init records inserted     1 init records inserted into table     1 init records inserted into table     1 init records inserted     1 init records inserted     1 init records inserted into table     1 init records inserted     1 init records inserted     1 init records inserted     1 init records inserted     1 init records inserted init table     1 init records inserted init table							
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💯 HyperLab Main Module - u File - Ontions - Help	ser HLUser4, instance #1 (	on WORKS	TATION				
		Selected	l item: Data	base (2 tasks, 0			
		sub-iten	<b>1)</b>				
▲		Desci Serve	iption: HyperL ir name: .\MS\$	ab1 database o SQLHYPERLAB			
▶ • <b>[]</b> HyperLab1 databa	se on local machine	Datab	ase name: Hy	vperLab1			
▷ 📄 Database Server		Statu:	s: not opened				
		Tasks	Sub-items				

## 4. Working with databases

If you start Main Module, it will display the newly created and registered databases at the left.

## 4.1. Opening a database

Select a database row at the left, and double-click it to open its content. Alternatively, you can hit the *Enter* key on the selected database node, which always starts the

selected task on the right – in this case, the database opening task.

Open database
Unregister this database

#### Working with databases

Database Login	<b>—</b> ×
Database:	HyperLab1_at_MSSQLHYPERLAB
User Name:	sa
Password:	•••••
	<u>OK</u> Cancel

Specify the database user name and password, then click OK.

### 4.2. Database upgrades



After installation, you may get a notification message about possible database upgrades.

#### 4.2.1. Database upgrade for new installations

In case of a *new installation*, that is, when the database is empty, immediately upgrade the database to the latest version. This way all the new or improved services in newer HyperLab versions will be available. For example, nuclide identification will not work if your database version is less than '2009.1'.

#### 4.2.2. Database upgrade for older HyperLab databases

If you have an older database, which is created and routinely used by an older, proven HyperLab version, there is a tiny chance that the upgrade operation fails, and this affects adversely your previous evaluation data.

As the upgrade of existing HyperLab databases can be undone only by restore the database from a backup, the upgrade decision requires caution.

#### **Before upgrading your database, always make a database backup first!** See the Reference Guide for details.

We suggest to

J

- Always make a backup before upgrade.
- After backup is ready, upgrade to the latest database version.

If you are especially cautious, you have the possibility to make a copy of your existing database, and restore it immediately under a different name.

This option may be achieved as follows (see the Reference Guide for details):

- 1. Create a backup of your old database.
- 2. Restore the backup file into a new, test database.
- 3. Start using the test database with the newest HyperLab version, and upgrade it, if prompted.
- 4. Now you can try out the new software version without any risk, as the operations do not affect your original production database in any way.
- 5. If you are satisfied with the new software version after an extended test period, you can

simply upgrade your production database, and uninstall the old HyperLab version.

#### 4.3. Basic database usage

Usually, the database browser tree is displayed at the left, with database details displayed at the top right, while the possible operations listed in the Tasks window.

Now you should create a new project for HyperLab sample spectra. Projects are the data organization units for HyperLab, like the directories for a hard disk, and able to hold measurements, peak evaluations, several different kind of analysis and so on, which are related to each other.



To create a new project for the HyperLab's default sample spectra, select *User projects*, then click on *"New project"* task at the right.

Alternatively, you can use your keyboard: the *arrow keys* can be used to quickly navigate within the database tree, and *Enter* key starts the currently selected task. The *Tab* key switches between the Tasks and the Database tree window.

Now a database entry – or *record* - editor window appears. In this case the details of a new project record may be specified.

Project propertie	25						(	- • •
Selected project - p	g 1 More projec	t entries						
PROJECT ID	1							
NAME	HyperLab sample	e spectra	1					]
START DATE	2011 Jan 23		18:06:42	×.	562	msec	3	
FINISH DATE	2011 Jan 23	-	18:06:42	×	625	msec	3	
OWNER PROJECT							-	2 😫 🛇 📗
STORED BY	Database admin	istrator						
STORED AT	2011 Jan 23, 18	:06:42						
COMMENT								
					-			
	🕜 Help		🧭 ок		🛛 🔇 Ca	ancel		🔏 Apply

Each kind of database entry has different type of editor window, but their basic building blocks are very similar. Now type a project name, say "HyperLab sample spectra", then click the OK button. Alternatively, you can hit the *Enter* key. *Tab* key will cycle through the editor fields.


A new user project node appears in the database browser tree now.

As Main Module also stores the count information in databases, you should import your spectrum files to the database before you evaluate them.

Open your project by a double click. Note that it always has a Measurements node, where its measurements will be listed.

# 5. Importing spectrum files



Click a project's *Measurements* node, and then select the *Import spectrum files* task from the right pane. A spectrum file importer window appears now.

Click on *Add file...* button to select HyperLab sample spectrum files.

Organize     New folder       Wew folder     Image: Search Sample spectra       Organize     New folder       Image: Search Sample spectra     Image: Search Sample spectra       Image: Search Sample spectra     I	tra 🔎							
Organize ▼         New folder         Image: Constraint of the state of the stat								
Favorites         Name         Date modified           Desktop         AM80320A.DAT         8/8/2006 1:23 /           Downloads         BA85211A.DAT         8/8/2006 1:23 /           Recent Places         C001043A.DAT         8/9/2006 1:23 /           Libraries         C001042A.DAT         8/8/2006 1:24 /           Documents         C005185A.DAT         8/8/2006 1:24 /           Music         C00111A.DAT         8/9/2006 1:24 /	Organize 🔻 New folder							
Desktop         AM80320A.DAT         8/8/2006 1:23 /           Downloads         BA85211A.DAT         8/8/2006 1:23 /           Recent Places         BA85211B.DAT         8/9/2006 1:23 /           Basz Double Colloque A.DAT         8/9/2006 1:23 /         8/9/2006 1:23 /           Basz Double Colloque A.DAT         8/8/2006 1:24 /         8/9/2006 1:24 /           Documents         CO01042A.DAT         8/8/2006 1:24 /           Music         CO00111A.DAT         8/9/2006 1:24 /           Music         CO00111A.DAT         8/9/2006 1:24 /	Туре							
Image: Downloads         BA85211A.DAT         8/8/2006 1:23 4           Image: Downloads         BA85211B.DAT         8/9/2006 11:28           Image: Downloads         COD0143A.DAT         8/8/2006 1:23 4           Image: Downloads         COD0142A.DAT         8/8/2006 1:24 A           Image: Downloads         COD0142A.DAT         8/8/2006 1:24 A           Image: Downloads         COD0111A.DAT         8/9/2006 1:24 A           Image: Downloads         COD0111A.DAT         8/9/2006 1:24 A	M DAT File							
Image: Second Places         BA85211B.DAT         8/9/2006 11:18           Image: Second Places         COD1043A.DAT         8/8/2006 12:3 A           Image: Second Places         COD1042A.DAT         8/8/2006 12:4 A           Image: Second Places         COD1042A.DAT         8/8/2006 12:4 A           Image: Second Places         COD1114.DAT         8/9/2006 11:4 A           Image: Second Places         COD1114.DAT         8/9/2006 11:4 A	M DAT File							
CD01043A.DAT         8/8/2006 1:23 /           Libraries         CO01042A.DAT         8/8/2006 1:24 /           Documents         CO85185A.DAT         8/8/2006 1:24 /           Music         CO0111A.DAT         8/9/2006 1:24 /           Distance         CO0111A.DAT         8/9/2006 1:24 /	PM DAT File							
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Music COD0111A.DAT 8/9/2006 11:19	M DAT File							
COD01110 DAT 0/0/2006 11 10	PM DAT File							
CODULIEDAT 8/9/2006 11:19	PM DAT File							
Videos CS96147A.DAT 8/8/2006 1:24 A	M DAT File							
EU80297A.DAT 8/8/2006 1:24 A	M DAT File							
EU80297B.DAT 8/9/2006 11:18	PM DAT File							
Local Disk (C:) MN01041A.DAT 8/8/2006 1:25 A	M DAT File							
RA37076A.DAT 8/8/2006 1:25 A	M DAT File							
Network 🔻 🕻 🔢	Þ							
File name: "AM80320A.DAT" "BA85211A.DAT ▼ AccuSpec spectra (*.	dat) 👻							
Open 🔻	Cancel							

Now a standard file selection dialog appears. Select HyperLab sample spectra from Documents \ HyperLab \ HyperLab2014 \ Sample spectra folder.

Select AccuSpec file type and all AccuSpec spectrum files where the last letter of the file name is "A", then click *Open*. These measurements were taken with 70-3300 keV energy range ("B" ending is used for 50 - 2200 keV range).

The selected files appear on the file importer's list.

As you can see, these are Dual LFC spectra with two similar halves. It is essential to correctly set the spectrum data type before loading, as HyperLab splits up dual spectra and stores their parts separately in the database.

Click on tab Main settings.



Set File content to 'Dual spectrum: LFC'.

Next the measurement setup should be selected from the list to which these measurements will be assigned. This is important, as all calibration curves will be tied to a specific setup, and the automatic selection of the calibration function can be achieved only this way.

As currently there are no measurement setups defined yet in the new database, the list is empty.

Click the *New record* icon (<sup>(=)</sup>) beside the '*Meas. Setup*' list, in order to create a new measurement setup entry.

The record editor window appears for the measurement setup.

As there are no detector, measurement position and measurement range entries in the database yet, these should also be created by clicking on their corresponding *New record* button (a) to the right of the combo boxes.

🛛 Measurement setup properti	es	- • •
Selected measurement setup - pg	1 More measurement setup entries	
MEAS. SETUP 1		
DETECTOR		📼 🖻 🖀
MEASPOSITION		💌 🗹 🔛
MEASRANGE		💌 🗹 🔛
NAME		
ADC		💌 🗹 🎦
STORED BY	Database administrator	2
0 E	lelp 🖉 OK 🔇 Cancel	🗃 Apply



Measurement setup propert	ies	
Selected measurement setup - p	More measurement setup entries	
MEAS. SETUP	1	
DETECTOR	D4	🖃 🖻 🖆
MEASPOSITION	d=25 cm	💌 🗹 🖀
MEASRANGE	70 - 3300 keV	💌 🖻 🖆
NAME	D4 setup, 70keV - 3.3MeV, d=25 cm	
ADC		💌 🖻 🛍
STORED BY	Database administrator	2
0	Help OK Scancel	ڟ Apply

Create the following entries for the HyperLab sample spectrum set: 'D4' detector, '**d=25 cm**' measurement position, and two measurement energy ranges: '**70-3300 keV**' as well as '**50-2200 keV**'. The two measurement setups are differ only in the applied energy range range, thus should be named as '**D4 Setup** 

70keV - 3.3Mev, d=25cm' and 'D4 Setup 50keV - 2.2Mev, d=25cm'.

🗾 Spectrum file im	porter	
Select spectrum files	o be loaded, adjust load settings, then press 'Load files' button.	
Spectrum files Mai	n settings Calibrations Sample Advanced	
File type		
File <u>c</u> ontent	Dual spectrum: LFC-corrected and normal spectrum halves	•
Type of 1st half	LFC corrected gamma spectrum	
Type of 2nd half	Normal HPGe gamma spectrum	
	V Determine file type automatically from spectrum, if possible	
Measurement setup		
Meas. setup	D4 setup, 70keV - 3.3MeV, d=25 cm	🖃 🗹 🗎 🗙
1		Load files Cancel

After the measurement setup has been set, check settings under other tabs as well. If you are ready to load spectrum files, click *Load files*.

💋 Spectrum file importer 📃 💼	×
Please wait until spectrum importing finishes. Progress:	
Details	
INF0: Energy cal: from spectrum file [E_keV = 0.0939999967813 + 0.409999996424 * Ch] INF0: FWHM cal: from spectrum file [Fwhm_Ch = sqrt( 6.8488 + 0.0040612 * Ch ]]	^
INFO: Loading AccuSpec spectrum file C:\Users\HLUser4\Documents\HyperLab\HyperLab2009\Sam INFO: Measurement setup determined: D4 setup, 70keV - 3.3MeV, d=25 cm ([D=1] INFO: Spectrum stored in database (MEASUREMENT_D=10, SPECTRUM_D=19-20, ECAL_ID=19-20 INFO: Title: D4 kal. 2002. okt. 1 [RA37076A.DAT] INFO: Energy cal. from spectrum file [E_keV = 0.093999999967813 + 0.409999996424 * Ch] INFO: Energy cal. from spectrum file [E_keV = 0.0939999999967813 + 0.409999996424 * Ch] INFO: Energy cal. from spectrum file [E_keV = 0.093999999967813 + 0.40999996424 * Ch]	
Loading of 10 spectrum files finished at 1/23/2011 6:52:15 PM	- -
Back Dose	

The spectrum importer now loads all available information from the spectrum file, and stores it in the new database. Click *Close* after loading finished.

After loading, the spectrum files will be displayed under *Measurements* node in the database tree.

Please import similarly the remaining sample spectrum files:

- Those with "B" as the last letter of the file name. These should be assigned to the measurement setup for the 50-2200 keV energy range.
- Spectrum '13\_53\_31.CNF', which is a Genie-2k spectrum of an irradiated complex geological material. This should be assigned to the measurement setup for the 70-3300 keV energy range. Please switch off '*Automatically determine spectrum type*' during its importing, as this spectrum is of type Dual LFC, but incorrectly states 'PHA+' as its type.

## 6. Evaluating spectra

In HyperLab system, you have three ways to evaluate your gamma spectra:

• **Spectrum peak evaluator** in Main Module, which has a rich graphical user interface, and provides all tools necessary to modify and fine-tune your fit region by region, if its one-

step automatic deconvolution is not perfect. This is the recommended evaluation method if your spectra are even slightly complicated.

- Database batch evaluator in Main Module, which is a special peak evaluation component of HyperLab Main Module. It is capable to automatically evaluate several measurement entries stored in the database, each after the other. This can reduce the human interaction needed for the evaluation, but requires proper FWHM and energy calibration for each spectrum.
- **Standalone 'batch mode' spectrum file evaluator** utility, which operates on a selected group of spectrum files, and does not require usage of databases. Please note that this file-based tool does not support neither manual fit refinement, nor nonlinear energy calibration, so its use is recommended only if you are facing with large amount of extremely simple spectrum files, where the simple evaluation is of paramount importance. For further details, see *Quick Start Guide for Spectrum file batch evaluator* section.

As a rule of thumb, we suggest you that always check the details of fitted regions graphically, as this can help to eliminate trivial problems with the spectrum fit. This can be done by using Spectrum peak evaluator or by RTF reports which may contain the fitted regions graphically. Those versatile RTF reports may also be generated by the batch evaluators.

## 6.1. HyperLab peak evaluation basics

During the automatic fit, HyperLab first takes the list of suspected peaks, and tries to optimally determine **regions** – range of consecutive channels – around them. These regions contain one or more suspected peaks, which are fitted (deconvoluted) in a nonlinear fitting procedure as a next step.

HyperLab fits several region and peak parameters for each region during the spectrum deconvolution.

#### Parameters fitted for each region:

- 2<sup>nd</sup> order polynomial for background
- background step amplitude
- skewed hill in the background under low-energy side of peaks (tail, disabled by default)
- peak skewness slope and amplitude for low-energy side of peaks (left skew)
- peak skewness slope and amplitude for high-energy side of peaks (right skew)
- common peak width (FWHM).

#### Parameters fitted individually for each peak:

- position of the peak Gaussian
- amplitude of the peak Gaussian.

HyperLab is able to reliably describe the vast majority of gamma spectra with this versatile fitting function set, commonly named as *Common peak width method*.

There is also a *Variable peak width* fitting method, when the peak width are allowed to vary independently of each other within a region – that is, not a common FWHM value used, but it is

fitted for each peak. This may lead to unexpected results for complicated multiplets, so use it only when peak widths truly differ within a region. This is the case, for example for the region around the annihilation peak. HyperLab therefore tries to fit the regions around 511 keV with the *Variable peak width* fitting method by default, thereby making it unnecessary to correct it manually every time.

Moreover, HyperLab tries to eliminate unnecessary fit function parameters after fitting regions, and to automatically remove them, if their use may be questioned. This may lead to 'disappearing' of various fitted parameters. This parameter elimination step is performed in order to increase the stability and reduce the chi-squared value of the final fit and also to reduce the uncertainties of fitted parameters.

See Reference Guide for further details of the fitting process.

# 7. Using of Spectrum peak evaluator

Spectrum peak evaluator is the recommended tool in Main Module to evaluate your spectra in most cases, as it provides you with advanced tools to fine-tune the deconvolution results.

## 7.1. Quick overview of the evaluation process

A routine gamma spectrum deconvolution in Spectrum peak evaluator module consists of several steps:

- Creating a peak evaluation entry in the database for a measurement
- Starting the evaluator
- Checking measurement's calibrations
- Performing the automatic fit
- Check the resulted regions each after the other, and fine-tuning their fit if necessary
- Saving results into database and report files, as well as exporting data for post-processing.

The following sections will describe these steps in greater detail.

## 7.2. Starting the evaluator



To start using the Peak evaluator, first select your measurement in the database browser tree, then click task *Create new peak evaluation* in the Tasks window.

Alternatively, you can hit the *Enter* key, as it starts the currently selected task.

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39.9

28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47

A new peak evaluation creation window appears now. You can leave defaults in most cases, so just click OK for now.



🍠 Spectrum peak evaluator - Geológiai minták [13\_53\_31.CNF] Eile Edit View Calibrations Fit Options Nuclide Ident. Help J 🕫 🕶 🔍 🍭 🧶 🎘 🧠 🎘 X scale: kev 🕶 Y scale: 📃

m Peak details Messages Nuclide Id

Main window of spectrum peak evaluator appears now. The center of the window is occupied by the spectrum window [1] and the residual window [2]. The residual window displays the difference between the measured counts and the fitted peak curves. A region list panel [3] is placed on the right, while a fit fine tuning toolbar [4] and a navigating toolbar [5] is at the bottom. List of fitted peaks is displayed under the Peak details tab.

Please note the **red triangles** in the spectrum:

these are the positions of the suspected peaks, and their position is determined by the current FWHM calibration. Deconvolution will use these suspected peaks as an initial estimate.

7.00

First you should try out how to modify some spectrum display settings. By default, spectrum evaluator displays the counts (black squares) and the suspected peaks.

It is also possible to display the corrected variances (gray squares) and uncorrected variances (gray diamonds). The variance correction is for taking account the distorting effect of high count rates.

For most users it is advisable to switch off the displaying of these variances via the View / Chart details menu.



## 7.3. Checking FWHM calibration



HyperLab's nonlinear spectrum deconvolution algorithm requires only a rough peak width (FWHM) calibration to start working. For exact peak positions, a valid energy calibration is also required.

Therefore it is advisable to check first the validity of the FWHM calibration.

To display current FWHM calibration, select *Calibration / FWHM* calibration menu item. Now the FWHM calibration editor window appears.

For a quick calibration check, click *Chart* tab at the top. Currently used FWHM

calibration curve displayed here together with filled green squares as FWHM calibration points. HyperLab also estimates the width of the suspected peaks, and displays these values as gray crosses. The figure shows the case when the FWHM calibration provides too low values.





If large deviation found between the current calibration line (red line), and the suspected peaks' FWHM, then a miscalibrated FWHM may be suspected.

In this case, the FWHM and/or the position values of the calibration points should be modified on the *Calibration points* page.

The figure shows the case when FWHM calibration gives higher values than expected.

In case of a proper FWHM calibration, majority of the suspected peaks' estimated FWHM value is in the neighborhood of the calibration curve.

Please note that before the fit large deviations may occur even for a valid calibration, as FWHM values of the peaks are just rough estimations and not fitted values at this time.

Much better agreement is expected after a successful fit, when peaks' FWHM values are fitted and displayed on this chart as gray triangles.

For further details about FWHM calibration editor window, see Reference Guide.

## 7.4. Checking Energy calibration

Exact energy calibration is important for sophisticated tasks, like isotope identification. However, when only a quick peak list is required for well-known isotopes, a rough energy calibration is enough before fit.

The rough energy calibration is only used during spectrum deconvolution for determining the vicinity of the 511 keV annihilation peak, because HyperLab allows to vary the width of peaks independently of each other.

Your energy calibration is proper for fitting if the annihilation peak is in the 509 – 513 keV range. Otherwise select *Calibration / Energy calibration* menu item, and edit the calibration points' position or energy values in order to correct them.

**Note:** When the fit completes, a finer energy calibration may be constructed, because exact, fitted peak centroid positions are available.

## 7.5. Performing automatic fit



Click the Autofit button or select Fit / Start automatic fitting menu item to initiate a fit for the whole spectrum. A progress window is displayed during the fit, listing the problematic regions, where the reduced Chi-squared of the fit exceeded 3.

After the automatic fit, the counts of the first fitted spectrum region is displayed, along with the fitted curves of the individual peaks (blue lines), sum curves of all fitted peaks (strong red lines), and sum curves of background components (green lines).

As HyperLab displays all fitted regions which are overlapping over a specific count range, it is common to see several regions, where the background 'wings' of the regions are overlapping. This improves the



quality of the fits, as more counts may be utilized for background determination, resulting in more stable fits and lower uncertainties in peak areas.

End points of the regions are designated by blue arrows, which point towards the center of the region. A region label also displayed at the beginning of the regions, which shows the boundaries of the region and also the chi-squared value of the fitted region.

The region list panel at the right contains several pages, from which the list of regions is displayed. Problematic regions are designated with a small, red exclamation mark.





## 7.6. Navigating fitted regions

Several methods may be used to quickly select a specific region in the Spectrum evaluator. To revise regions one after the other, click double arrow buttons on the Navigation toolbar. To quickly jump to a specific spectrum part, use scrollbar or the Position edit box at the same place. If you are interested in the problematic regions only, click the region with red exclamation mark on the right.

## 7.7. Refining fitted regions

There are several tools on the Fine tuning toolbar to modify a region's automatic deconvolution.

- Re-fits the clicked region. Rarely used, only if you suspect that a sub-optimal unstable fit found, which changes when you repeatedly fit the region.
- Re-fits the clicked region with automatic peak insertion. Used when a sub-optimal fit found with a missing peak, but the position of the missing peak is uncertain, and you want to delegate the job of peak position determination to the fitting algorithm.
- Insert a peak into the region, at the clicked position. Used when a sub-optimal fit found with a missing peak, and the position of the missing peak is suspected by the user.
- $\frac{1}{2}$  Delete a peak from the region, which is located at the clicked position.
- M Delete the clicked region with all of its peaks.
- Splits a region at the clicked position into two half regions.
- Merges two or more regions. To use this tool, click over the first region and drag the mouse cursor to the last region to be merged (do not release the mouse button).

## 7.8. Saving the results

When you are ready with the fine-tuning of the spectrum evaluation, select *File / Store* menu item to store the fitting details into the database. If required, a Sampo-90 compatible spectrum and peaklist file may also be generated by selecting the *File / Export to Sampo-90 file* menu.

Description	Template file name		
Peak list	PeakEvaluator_PeakList_ListOfPeaks.hrt		
Peak list - short	PeakEvaluator_PeakList_ListOfPeaksShortNuc		
Peak evaluation details	PeakEvaluator_PeakList_DetailsWithoutPics.hrt		
Peak evaluation details with pictures	PeakEvaluator_PeakList_DetailsWithPics.hrt		
Reak list with officiancy correction	PoplyEuplypton PoplyList ListOfEffCorrPoplyphrt		
Preak ist with enciency collection			
Report styles: Description	Style file name		
Report styles: Description Default HyperLab Report Style	Style file name		
Report styles: Description Default HyperLab Report Style Modern Report Style	Style file name 1.default.css 2.modern.css		

Select *File / Create report* menu item to create detailed fitting reports.

A report creation window appears now, where you can choose between available report templates, report styles and output file formats.

RTF format reports may contain graphical region fits, and can be loading directly into word processors.

For direct printing of reports, you should have Microsoft Word word processor installed on your computer.

### 7.9. Further readings

This Guide mentioned only a few from HyperLab's versatile functions. Please read further details in the *Reference Guide*, which deals with:

- FWHM and energy calibration,
- Nonlinearity calibration, which serves much more exact peak positions then it is expected from linear energy calibration;
- Efficiency determination, which may be used to generate efficiency-corrected peak lists;
- Database maintenance utilities for keeping your HyperLab databases in best shape,

and much more.

# 8. Using of the Database batch evaluator

Database batch evaluator is a special peak evaluation component of HyperLab Main Module. It is capable to automatically evaluate several measurement entries stored in the database, each after the other.

To use the Database Batch Evaluator, click on *Measurements* node, then select *Batch evaluation* task.



Now an evaluator window appears, listing all measurements assigned to this project. Check the list if it is really required to evaluate all spectra. If a measurement to be skipped, un-check it.

🇾 Database bat	tch evaluatio	n						• ×
Check measurem	ients to be ev	aluated, a	djust evalua	tion setting	js, then pr	ess Evalua	te button.	
<b></b>					,			
Measurements	Calibrations	Output	Advanced	Skipped				
Meas, name			Meas. s	etup	No. d	of spectra	Channels	*
🔽 D4 kal. 200	2. okt. 1 [AM8	0320A.D.	D4 Setu	p 70keV · .	2		8192+819	2
🚺 📝 D4 kal. 200	2. okt. 1 [BA8	5211A.D	. D4 Setu	p 70keV	2		8192+819	2
📝 D4 kal. 200	2. okt. 1 [CD0	1043A.D.	. D4 Setu	p 70keV	2		8192+819	2
D 4 6-L 200	2 -04 1 [000	1042A D	D.I.Calu	- 70L-17	2		0107.010	• T
				S	elect <u>a</u> ll	S	elect <u>n</u> one	
		Cou	nts of select	ed measur	ement			
10,000 -								
1,000						· · · · · · · · · · · · · · · · · · ·		
100 + 1								
1		deseting and	and the second second			1		
01								
0	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000
Counts Detail	s							
					N.c. i			



#### Change to *Calibrations* tab. If necessary, set the source of calibrations according to your measurement environment. It is possible to use either the measurement's calibration or an arbitrary one from other measurement.

🖉 Database batch evaluation
Check measurements to be evaluated, adjust evaluation settings, then press Evaluate button.
Measurements Calibrations Output Advanced Skipped
Database output
Save results into the database
Report files
Save in <u>B</u> TF format Save in plain <u>T</u> ext format
Content te <u>m</u> plate: Peak list
Formatting style: Default HyperLab Report Style 🔹
Post-processing reports
Save in Samo-90 PTE & SPE format
Output file settings
Output folder: C:\Users\HLUser4\Documents\HyperLab\HyperLab2009\Batch 😕
Evaluate Close



Specify evaluation output options under the *Output* tab.

You can save results into database, generate textual reports or Sampo files for post-processing.

Do not forget to set the folder where your report files will be saved.

You may also specify some other settings under Advanced tab.

Click Evaluate button to initiate the batch evaluation.

A new page appears now, displaying the overall progress of the batch as well as detailed messages for the last few measurement evaluation.

When evaluation finishes, press Close button.

Both the batch evaluation and the regular one-by-one spectrum deconvolution creates a new *Peak evaluation* entry into the database, which contains the fitted peaks and all of their parameters. To re-open a previous peak fit – for inspection or manual correction – open the measurement node at the left, select the proper peak evaluation entry, then doubleclick it (or simply hit Enter key).

These peak lists can be easily opened by outer applications, e.g. Microsoft Excel for further data processing.

gg HyperLab Main Module - User HLUser4, Instance #1 or	) W/C	
<u>F</u> ile <u>O</u> ptions <u>H</u> elp		
€		selecceu iceni: reak evaluation entry (7 tasks, 0
atabases sse HyperLab1 on .\MSSQLHYPERLAB ser projects Test HyperLab sample spectra - A Measurements - A D4 kal. 2002. okt. 1 [AM80320A.DAT] D - A Spectra D4 kal. 2002. okt. 1 [BA85211A.DAT] D - A Lab 2002. okt. 1 [BA85211A.DAT] D - A Lab 2002. okt. 1 [CD01043A.DAT] D - A Lab 2002. okt. 1 [CD01011A.DAT] D - A Lab 2002. okt. 1 [CD0111A.DAT] D - A D4 kal. 2002. okt. 1 [CD011A.DAT] D - A D4 kal. 2002. okt. 1 [CD0111A.DAT] D - A D4 kal. 2002. okt. 1 [CD0111A.DAT] D - A D4 kal. 2002. okt. 1 [KLM01041A.DAT] D - A D4 kal. 2002. okt. 1 [KLM01041A.DAT]		Id: 2 Name: Peak eval. of D4 kal Last modified at: 1/25/2011 Last modified by: Database a Number of regions: 6 Max RXSQ of regions: 10.80 Number of peaks: 14 Max peak area: 67931 Tasks Sub-items Depen with peak evaluator Create new peak evaluator Peak evaluation properties Peak evaluation properties Peak evaluation properties Deak evaluation Create report of fitting de Make a clone Create report

HyperLab 2014 Quick Start Guide for Spectrum File Batch Evaluator



HyperLabs Software

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# About this document

For detailed instructions on using the installed *Spectrum file batch evaluator*, start reading this Guide. If you did not install yet this utility, refer to *Installation Guide* first.

# 1. Using of Spectrum file batch evaluator

Spectrum file batch evaluator is a standalone utility of the HyperLab System. It is capable to automatically evaluate more than one spectrum files, each after the other.

This utility does not require usage of HyperLab databases, as it operates on simple spectrum files, and its results are also saved into disk files.

For batch evaluation of measurements stored in a HyperLab database please consider using Database Batch Evaluator instead. See the Reference Guide for details.

Start the utility by selecting

Start menu / Programs / HyperLab 2014 / Batch Evaluator 2014.1

The evaluator dialog appears now.



Click on *Add...* button under Spectrum files tab.

A file open dialog appears now.

Select your spectrum files to be loaded, which will listed at the left side of the utility.

💋 HyperLab - Batch spectr	rum evaluator - [Batch 1] 📃 💷 💌
<u> 6</u> ile <u>W</u> indow <u>H</u> elp	_ <i>B</i> ×
Add spectrum files, set	evaluation parameters accordingly, then press Evaluate.
Spectrum files Eval setting:	s Calibrations Reporting Misc
CD01043A.DAT	Counts of selected spectrum file
- 10 CO01042A.DAT - 10 CO85185A.DAT - 10 COD0111A.DAT	
<ul> <li>✓ Ш ▶</li> <li>✓ <u>A</u>dd</li> </ul>	0 2,000 4,000 6,000 8,000 Counts Details
	Help     Evaluate     Close

#### Using of Spectrum file batch evaluator



Change settings under Eval settings tab.

Most important is to correctly set the type of spectra: select '*Common gamma spectrum files*' or '*Dual LFC spectrum files*', according to your measurement setup.

HyperLab - Batch spectrum evaluator - [Batch 1] - - -<u> F</u>ile <u>W</u>indow <u>H</u>elp - 8 × Add spectrum files, set evaluation parameters accordingly, then press Evaluate. Spectrum files Eval settings Calibrations Reporting Misc Energy calibration If set, use each spectrum file's own calibration values Use common calibration from file Calibration file: <built-in default> 🤌 🗎 Current En.cal.: HyperLab's default energy calibration 2 🛃 -FWHM calibration 🔽 If set, use each spectrum file's o<u>w</u>n calibration values Use common calibration from file Calibration file: <built-in default> ۵ 🎓 Current EWHM cal.: HyperLab's default FWHM calibration -2 🛃 Evaluate 🔇 Close 🕜 Help

You can also set calibrations on Calibrations tab, if it is missing from the spectrum files.

It is also possible to abandon spectrum files' calibration values, and import common energy and FWHM calibration values from text files.

🗊 HyperLab - Batch spectrum evaluator - [Batch 1]
💋 Eile Window Help 🔤 🖉
Add spectrum files, set evaluation parameters accordingly, then press Evaluate.
Spectrum files Eval settings Calibrations Reporting Misc
Generic reporting settings
Output folder: C:\Users\HLUser4\Documents
Note: specify an absolute path. If you leave the box empty, report will be saved beside the spectrum files.
Browseable reports
Save in <u>RTF</u> format
✓ Save in <u>I</u> XT format
Content template: Peak list
Formatting style: Default HyperLab Report Style 🗸
Post-processing reports
Save in Sampo-90 PTF & SPE format
🕜 Help 🚺 Evaluate 🔇 Close

Set reporting options under Reporting tab. HyperLab is able to create reports in the following format:

- Sampo-90 \*.ptf and \*.spe files
- Plain text files (\*.txt), using HyperLab's report templates.
- Formatted Rich Text report files (\*.rtf), using HyperLab's report templates.

Do not forget to set output folder of your reports, otherwise the report files will be created into the folder of the spectrum files.

HyperLab's report templates are contained in separate files, and can be edited, created, deleted by the user. Rich Text Files also may contain pictures about the fitted regions, revealing the fine details even for a batch evaluation. Please select appropriate report template if you want to check your fits also with region pictures.

You can set miscellaneous options under Misc tab. You can set the folder of log files here, which is used by HyperLab when creating log files about the batch evaluation.

Press *Evaluate* button to start the batch. HyperLab now evaluates all of the selected spectrum files, and creates report files as well as log files about them.

During evaluation, you can minimize the utility and work with other programs.

After the end of the batch, click *Close* to finish the evaluation.







HyperLab 2014 Reference Guide



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# About this document

Start reading this *Reference Guide* for detailed description of HyperLab processes. For a short overview, refer *Quick Start Guides*, or read the *Installation Guide* if you are to install the system onto your computer.

# 1. System architecture overview

Databases are a well-developed technique in the business world, and HyperLabs Software strongly believes that it is the time to bring its power to the field of gamma spectroscopy. Therefore HyperLab Main Module stores *all* spectroscopic information in relational databases. The next figure illustrates basic system components.

**Main module** is the application where you will operate various evaluation utilities (peak area evaluator, detector efficiency evaluator etc.) and also the primary interface to information stored in one or more **database**s.

This Installation Guide describes two possible setup types: one is necessary to setup **HyperLab Main Module** application, the other is to install **Spectrum File Batch Evaluator** utility onto your computer. Batch Evaluator Utility does not require any database component to be installed, but therefore lacks features compared to the Main Module.



Report files

## 1.1. Benefits of database usage

Databases provide significant benefits compared to the conventional gamma spectroscopy, where a multitude of files are in use even if your system is of medium size.

### Structured information storage

All of your data, including spectra, calibrations, peak evaluations, efficiency evaluation, etc. are stored in central locations grouped into user projects. Thus a highly integrated and structured set of information can be utilized. If you regularly backup *one single* database file, no measurement or evaluation data may be lost anymore.

#### No duplicated data

If you are using independent spectrum files, it is tempting to save all relevant spectroscopic information – e.g. detector efficiency data - into each spectrum file, to ensure that this information is not lost. If spectroscopic data is stored in databases, only a reference is required, which points from multiple spectra to a single detector efficiency curve.

#### **Better integrity**

Databases utilize strict integrity rules in order to prevent accidental data deletion. If a user wants to delete a measurement, it is possible only if no peak evaluation points to that data entry.

#### Easier post processing

Databases provide the users with excellent resources and standard tool for post-processing: extraction of evaluation data is straightforward into e.g. spreadsheet applications.

## 1.2. Database topologies for Main Module

As HyperLab Main Module accesses data stored in HyperLab databases, and these databases may reside either on the local machine or on a remote computer, virtually unlimited number of database topologies may exist. The most common cases are detailed below.

### 1.2.1. Local database

The most common case is "Local database" topology, because only one computer is required in this arrangement.



All HyperLab components must be installed on this sole machine, which will contain a local database management server software, as well as one or more local databases. Spectrum files have to be imported into the database, then the measurement entries are evaluated by the Peak Evaluator. The resulting peak entries are also stored back in the database. In this local database scenario, database access is performed at maximum speed, because network communication overhead is omitted.

#### Installation instructions

- Install all HyperLab components on the computer, including the Main Module and the Microsoft SQL database server.
- Create a local database from the Main Module: click on "Local Database Server" node, then select task "Create database" from the right and follow the instructions.
- Register the newly created local database in Main Module: click on "HyperLab databases" node, then select task "Register a local database" from the right and follow the instructions.
- Start using your newly registered local database.

### 1.2.2. Local and remote databases

It is always possible to use additional remote HyperLab databases on other computers in your local network – provided the remote database server allows incoming connections and you have the proper password assigned to those databases.



#### Advantages of remote databases

- Remote databases may be shared between working group members
- Database files and the SQL database server itself may be hosted on a powerful server computer, where regular backup is performed, so the chance for data loss is minimized.

#### Drawbacks of remote databases

- HyperLab disallows specific operations (e.g. database creation) on remote databases. In order to create a HyperLab database, you should run database creation utility on the destination machine.
- The networked database connection may be slower than accessing local databases.

#### Installation on the remote computer

- Install all HyperLab components, including the Main Module and the SQL database server.
- Create a new database from the Main Module: click on "Local Database Server" node, then select task "Create database" from the right and follow the instructions.
- Make sure if the database server accepts incoming connections: click on "HyperLab databases" node, then select task "Manage database server" from the right. The management window appears now. Make sure that "TCP/IP" protocol is enabled. See "Configuring remote access" for further details.

#### Installation on the local computer

- Install all HyperLab components, including the Main Module and the SQL database server.
- Create a local database from the Main Module: click on "Local Database Server" node, then select task "Create database" from the right.

- Register the new local database in Main Module: click on "HyperLab databases" node, then select task "Register a local database" from the right.
- Register the remote database on the remote computer: click on "HyperLab databases" node, then select task "Register a remote database" from the right and follow the instructions. Specify the remote computer name as the database server host name.
- Start using your newly registered local and remote databases. Please note that the user name and password is tied to the database server thus it is possible that you should specify different passwords for the local and the remote databases.

### 1.2.3. Remote database

This "remote database only" scenario is for advanced users.



It requires at least two computers on the local network: one contains the database server, while other processing workstation(s) only contains HyperLab Main Module, which accesses the remote databases through local computer network. This setup is ideal for working groups, where the database is installed on a central server, and a regular backup preserves the common database. The setup steps required for the two computer case are detailed below.

#### Installation on the remote computer

- Install all HyperLab components, including the Main Module and the SQL database server.
- Create a new database from the Main Module: click on "Local Database Server" node, then select task "Create database" from the right and follow the instructions.
- Make sure if the database server accepts incoming connections: click on "HyperLab databases" node, then select task "Manage database server" from the right. The management window appears now. Make sure that "TCP/IP" protocol is enabled. See "Configuring remote access" for further details.

#### Installation on the local computer

- Install HyperLab components without the SQL database server.
- Register the remote database(s) previously created on remote computer(s): click on "HyperLab databases" node, then select task "Register a remote database" from the right and follow the instructions. Specify the remote computer name as the database server host name.

• Start using your newly registered remote databases. Please note that the user name and password is tied to the database server – thus it is possible that you should specify different passwords for different remote databases.

# 2. HyperLab Main Module

Core of the HyperLab Gamma Spectroscopy System's visually rich evaluation environment is the Main Module. This provides simultaneous connections to multiple HyperLab databases, and makes it possible to interact with HyperLab objects which are stored in these databases. You can start the Main Module by clicking on your HyperLab 2014.1 icon on the Desktop, or in your Start menu.

# 2.1. Main Module window

The most important parts of the Main Module's working window are the following:

**Database browser tree [1]** provides hierarchic listing of objects stored in HyperLab databases. The items displayed in this tree are called *nodes*.

**Detail lister [2]** shows common details for the item which is currently selected in the browser tree.

**Tasks and Sub-items panels [3]** also refresh their content according to the data entry you have selected in the database browser tree. *Tasks* provides you operations which may be performed on the



selected database entry; whereas Sub-items shows special sub-components about it.

Content of the *Tasks* window also appears in a **context menu**, when the user right-clicks on a database node. Common **keyboard shortcuts** may help your work: the database tree may be walked through by using the *cursor arrow* keys, while the currently selected task may be started by hitting the *Enter* key. *Tab* key switches between the browser tree and the *Tasks* window.

## 2.2. Record editor pages

Record editors make it possible to enter details of a new database record, or modify the value of an existing entry. These data editing pages may be accessible if you select a data node in the database browser tree, and click on its property editing task.

### Main features

Record editors support the following common operations:

- Field editing controls are grouped into pages under tabs.
- Non-editable fields are displayed as static (grayed) text.
- Field data may be entered into text boxes or are selectable from combo boxes.
- Mandatory fields are marked with colored background under their label.
- Changes may be abandoned or acknowledged with the OK, Cancel and Apply buttons.

#### Usage of record editors

At the top of the editor page, several tabs may be used to display a specific editor sheet which contains several data controls. These controls make it possible to display or edit the values of the data fields. A sample record editor page is shown for a specific Measurement entry. This property page helps to illustrate all important controls used on editor pages.

Measurement properties								×
Selected measurement - pg 1	5elected measurement - po	2 Spectra	More meas	urement entrie	s			_
MEASUREMENT ID	11							
MEAS. METHOD	Decay-gamma measurem	ent				-	<b>&gt;</b>	
MEAS. SETUP	D4 Setup 70keV - 3.3Mev	∕, d=25cm				-	1	
PROJECT	Test					-	1	
NAME	Geológiai minták [13_53_3	31.CNF]						
MEASURED BY	Database administrator	Database administrator					1	
MEAS, OBJ, TYPE	tadioactive source					•	-	
SOURCE	Test source					•	🖸 🖀 🔇	9
STARTDATE	2006 May 15 🛛 🗐 💌	13:05:00	 	800	msec	3		
ENDDATE	2006 May 15 🛛 🔲 🔻	14:05:00	*	800	msec	3		
EXPORT FILE NAME	13_53_31							
	Help	🥝 ОК		😢 Cancel		ଟ	Apply	

Several buttons are located at the bottom of the window. *OK* and the *Apply* button acknowledge changes, and store back the changed values to the database. The *OK* button also closes the window after a successful save. *Cancel* abandons the changes and closes the editor window. The mandatory data fields are designated by different background colors under their labels. The roles of quick buttons beside the data fields are detailed below.

#### **Quick buttons**

On the right side of the edit boxes, various quick function buttons are placed.

- The *record editor* buttons to edit the properties of the currently selected dependent item. These are used extensively throughout the application, also on our Measurement record editor example. One such button is beside the field MEASURED BY. If you click this button, a new record editor form appears, containing details for the currently selected user: Database administrator.
- The *new record creator* buttons are also used on most editor forms, and create a new dependent record. If you click this button beside the field MEASURED BY, a new record editor form appears, with a newly created Employee record.
- S The *reference remover* button removes a reference to a dependent item. It is displayed only for optional fields. For example, if you click on this button beside the field SOURCE, it clears the measurement's reference to any source, thus changing this field to empty value. The previously linked source record itself will not be modified.
- Of The current date and time setter button sets the value of the belonging date/time field to the current time.

#### Tab for additional records

The last tab of property editor pages lists additional records.

You can initiate the editing of any record, if you select it on the record list, and press the Select button.

🛃 Measurement pro	perties					
Selected measuremen	t - pg 1   Selected measurement - pg 2   Sp	pectra More measurement entries				
MEASUREMENT_ID	NAME	MEASMETHOD_ID PROJECT_ID MEA				
7	D4 kal. 2002. okt. 1 [CS96147A.DAT]	1 1				
8	D4 kal. 2002. okt. 1 [EU80297A.DAT]	1 1				
9	D4 kal. 2002. okt. 1 [MN01041A.DAT]	1 1				
10	D4 kal. 2002. okt. 1 [RA37076A.DAT]	1 1 🗏				
• 11	Geológiai minták [13_53_31.CNF]	1 2 🔫				
•		4				
H		• I				
Eilter						
🕜 Help	🖉 ок 🛛 😣 с	ancel Apply				

## 2.3. Special property editors

This section describe the property pages which may require some special usage instructions compared to the generic property pages.

### 2.3.1. Source properties editor window

The source properties editor page may be used to enter details for a newly created source record. Entries of radioactive sources keep together source and isotope information to use it effectively throughout HyperLab. Our example will discuss entering details for a new source entry, which belongs to a sample measurement, as detailed in section "Importing sample spectra".

Properties of selected isome

🕜 Help

After you initiated the creation of a new source entry, the source editor window appears.

Specify a descriptive name for the source in the *Name* field, then click *Isomers* tab to define the contained isotopes.

In HyperLab terminology, the source requires only the identification of isomers – and not the decays starting from that isomer level –, because it is always guaranteed that a source provides gamma radiations from all possible decays which are originated from an isomer state.

To add a new isomer entry to this source, click *Add isomer* button.

The isomer selector window appears now.



📀 ок

🔕 Cancel

2 Apply

#### HyperLab Main Module

Select one or more isomers					
Available isomers:					
▷         ●         § 88Co_m (9.04 h)           ↓         ✓         60Co (5.27 y)           ↓         ●         60Co (5.27 y)           ↓         1332.4920 keV, Int: 99.98260           ↓         1173.2280 keV, Int: 99.98260           ↓         2826 1000 keV, Int: 0.00760           ↓         826 1000 keV, Int: 0.00750           ↓         2158.5700 keV, Int: 0.00120           ↓         2505.6920 keV, Int: 0.00000           ↓         2505.6920 keV, Int: 0.00000           ↓         €           ♦         60Co_m (10.47 m)           ↓         €					
Details of selected item					
Isomer Id	10270600				
Symbol	60Co				
Halflife	5.271 y				
Halflife unc.	0.001 y				
📀 ок	🔇 Cancel				

For our sample source, select *60Co* isomer with 5.27 year half-life. To speed up the selection process, quickly type in the first few letters of the isomer, and the list will scroll to the specified position.

You can also browse the decays and the associated gamma radiations for the isomers.

When you are ready, click OK.

Source propert	ies							
Selected source - p	pg 1 Isome	rs More source	entries					
Isomers assigned	to this radio	active source						
Isomer Ca	alibrated?	Activity [kBq]	Activity un	nc. [%]	CalibrDa	ate	Calibrator	
▶ 60Co Ye	es	434.6000	0	0.7 19	985-Oct-01-1	2:00:00	OMH	
Properties of sele	Properties of selected isomer  Activity is calibrated							
Activity	434.6		kBq +- 0.7		%	(1 sigma	uncertainty)	
Calibrated at	1985-Oct -0	11 💷 🗸	12:00:00		×			
Calibrator	OMH							
		🥝 ок		😢 Cance		ସା	Apply	

The source editor's Isomer page appears again, and the list of assigned isomers contains the selected item. Now place a check "Activity is calibrated", and type in the certified calibration values.

For the "Co-60 OMH 85-185" source of the sample spectra set, specify 434.60 kBq activity and 0.7 % activity uncertainty, then 1 Oct 1985 12:00 as the calibration date.

Notes:

- Activity uncertainty has a unit changer button: this way you can specify it either in kBq (absolute uncertainty value), or in % (relative uncertainty value).
- Make sure that the entered uncertainty value corresponds to  $1\sigma$  confidence limit, as the calibrator authority sometimes specifies it with  $2\sigma$ . In this case you should enter half of the standard deviation value.

## 3. FWHM calibration

Before HyperLab performs peak evaluation of spectrum counts, at least a rough FWHM (Full Width at Half Maximum) calibration is necessary. Although HyperLab fits the width of peak, it requires a real estimation of the peak width, and it will allow to vary the fitted width from this initial value by a preset ratio.

FWHM calibration entries are created by the spectrum importer, when a proper calibration is loaded from the imported spectrum file. New calibration entries may be created by the user in the peak evaluator module.

## 3.1. FWHM calibration concept in HyperLab

In pre-2009 versions of HyperLab, the FWHM (Full Width at Half Maximum) was described with the following formula:

$$FWHM = \sqrt{A + B \cdot Ch}$$

and the resulting FWHM value was in channels. This expression depicts a linear dependence between the peaks' channel position (or energy) and their squared width.

This is proper for usual energy ranges (up to about 2MeV) and usual number of channels, but if you are utilizing broader energy ranges and/or many more channels, then significant differences start to emerge between the measured and predicted peak widths. Thus a more powerful FWHM function was introduced:

$$FWHM = \sqrt{polynomial(Ch)}$$

The meaning of this finer FWHM function remained the same: describes the FWHM in channels for any given channel value.

To create an FWHM calibration, users first specify several calibration points (channel values with belonging peak widths), and direct HyperLab to perform a least-squares fit to these data points, and determine the offset and slope parameters of the linear function, or the further polynomial parameters in case of the polynomial FWHM function. The linear function requires at least 2 calibration points, while the polynomial version requires n+1 points (n is the degree of the requested polynomial).

The FWHM calibration points as well as the fitted parameters are stored in HyperLab databases for each measurement entry. More than one FWHM calibrations may exist in the database for the same measurement, but only the last non-tentative one is treated as the current, valid FWHM calibration, and this will be automatically loaded by the peak evaluator.

The FWHM calibration editor is used to modify the values of the data points, to add or remove points, or to replace the current calibration with another from the database.

# 4. FWHM calibration editor

This window may be used to edit the calibration points of the FWHM calibration. For details about HyperLab's FWHM calibration concepts, see section "FWHM calibration". FWHM calibration window may initiated basically from two places:

- from the Spectrum peak evaluator. In this case, the primary purpose of the dialog is the editing of the calibration and especially adding new calibration points;
- from other places, e.g. from the spectrum importer, when the primary purpose of the window is to display a previous calibration in read-only mode.

This window contains multiple tabs with various data displaying or editing controls.

# 4.1. Basic FWHM editing operations

The first tab shows the input data for the calibration, as well as basic information about it.



These comprise the current status (modified or unmodified), and the calibration point list as well. The point list contains two or more editable calibration points, to which a fit is performed, thus determining a FWHM calibration curve, which basically has a square-root shape, and serves FWHM in channel units.

If the fitting function is linear, then a *line* will be fit to square of the input FWHM values. If only two input points are used, the line must go through both points. If more than two input points are specified, a least–square fit is performed, in order to

determine the optimum calibration line between scattering points.

If the fitting function is a polynomial, then a *polynomial curve* is fitted to the data points. This requires n+1 input data points, where n is the degree of the polynomial, and is advised only if you have experienced significant deviation from a simple square-root FWHM curve.





HyperLab makes it possible to quickly add a new calibration point via a convenient method. If you click *Add new* button under the list of calibration points, HyperLab displays the spectrum evaluation window, where you can click above a spectrum peak to get its FWHM value.

You can use this feature both for unfitted counts (raw channel content, as seen on this

figure) and above fitted peaks. After clicking, the position and width of the peak will be used for a new FWHM calibration point. This way the addition of a new calibration point may be accomplished rather quickly.

### **Deleting points**

To delete a specific FWHM calibration point, select it by clicking on it with the mouse, or make it active by pressing the up or down cursor arrow keys, and click *Delete* button.

#### FWHM chart for visual overview

A very useful, quick, graphical overview of the current calibration may be found on the *Chart* tab.

The FWHM calibration curve is displayed as a red line. The solid red line shows the FWHM function between the first and last calibration points, while the dashed one shows extrapolated regions. The green lines above and below the red curve shows the  $\pm 1\sigma$  uncertainties.

The calibration points which are actually used for the fitting of the FWHM curve are displayed as filled green squares.

The available peaks are displayed as gray



cross (+), if not fitted yet in the spectrum, or with gray triangle ( $\Delta$ ), if the peak is already fitted. The chart also shows a blue star symbol for orienting the user: this is theoretically the 'best' achievable resolution: 1.7 keV at 1332 keV energy. Peak labels are provided by the [P] button.

## 4.2. Example: correcting an improper FWHM calibration

This section details the correction of a FWHM calibration, which was slightly off from the real value.

When a measurement is loaded into the peak evaluator, it is always advantageous to perform a quick check on the FWHM calibration before the spectrum deconvolution.

In order to get a visual overview of the current calibration, select *Calibrations / FWHM calibration* menu.

The FWHM Calibration Editor window appears now.

Click on the Chart tab.





By the help of the chart, one can immediately characterize the situation:

- numerous non-fitted (suspected) peak is available in the spectrum (gray + signs)
- the non-fitted peaks spreads nicely along a square-root-shaped curve, so the construction of the FWHM curve is expected to be an easy task
- no significant fitted peak is available at this moment (no gray Δ signs visible)
- the current calibration curve (continuous red line) is determined from two data points (green squares)

Also immediately can be seen that the current calibration curve is sub-optimal:

- the fitted FWHM curve differs significantly from the FWHM of the peaks (the red curve is above the gray crosses, especially in the low energy region): a slight mis-calibration is suspected,
- the energy range of all the peaks are not well covered by the FWHM curve; in other words, in wide regions only extrapolation is provided,
- only two calibration points have been utilized.

The solution for this problem should be the refinement of the current calibration points, and/or adding several ones in order to get a more relevant FWHM model.

### Adding new points from list of available peaks

On the bottom of the Chart tab you can find the list of available peaks, which can be added to the FWHM calibration. This list contains the significant non-fitted and fitted peaks.



The list is filtered, so only the most relevant peaks (with the lowest area uncertainty) will be listed here. For nonfitted peaks the values will be estimated, and estimated peak areas displayed as negative values

First we increased the filter significance: entered 30 as sigma, in order to dismiss the uncertain, small peaks on the graph. Then we click over a proper candidate peak, and finally on the *Add* button. The selected peak will be added to the FWHM points, and the fit will be immediately performed. After adding 4 FWHM points, the fitted curve does not really follow the new points, but keeps following the old ones. In order to find out the reason for this, switch on the error bars by clicking on the

error bar button at the top.

This immediately shows the root of the problem: the old calibration points – which

are originating from the spectrum file – have too low FWHM uncertainties, thus their fitting weights are unreasonably high.

4.5

3.5

2.5

1.5

500

1000

2000

Position [ch]

2500

3000

3500

1500

whm value [ch]

As those points seems to be rather inaccurate in all respects, we will delete them.

To delete a point from a chart, simply click on its green square. After the click, the first tab will be active, and the clicked point's corresponding row will be selected. Now click the *Delete* button, thus remove the point from the fit.

After deleting the two original calibration points, the fitted FWHM curve reasonably

well describes the measured points, so you can acknowledge it by clicking on the *OK* button, and perform the whole-spectrum deconvolution.

Please note that HyperLab's spectrum fitter requires only a *rough, approximate* FWHM calibration, as it allows the peak width to vary by 30% from the FWHM calibration during the nonlinear fit. Nevertheless, a quick overview of the FWHM calibration is always advisable before fitting.

# 4.3. Advanced FWHM editing

### Entering new points manually

If you do not want to use HyperLab's visual calibration point adding facility, just want to enter predefined calibration points, press the  $\downarrow$  (cursor down) key repeatedly, while you leave the last point's row, and a new, empty row automatically created. Type in the proper values, then press  $\uparrow$  (cursor up) key to leave the edited calibration point row. If you want to enter a completely new calibration, first remove all calibration points, then the add them one by one.

### Modifying channel positions

To modify the channel position of a specific calibration point, you have two options: manual editing or borrowing.

To edit the value by hand, just click on the channel number value, and type the new number. To borrow, you should use the borrow button of the FWHM field.

-Points for	the FWHM	calibration
-------------	----------	-------------

	Pt. No.	Pos (ch)	Pos unc (ch)	Fwhm (ch)	F
I	1	111.25	0.5	1.94	
	2	3560.76	0.5	4 44	


#### Modifying FWHM value of an existing calibration point

FWHM values may also be modified by either manual editing, or by getting the exact fitted FWHM values from the active HyperLab spectrum. This may be required if you modified the fit of a peak, which is used for FWHM calibration. Manual editing may be initiated by simply clicking on an FWHM value and typing its new value in channels.

F	Poi	ints for t	he FWHM calibr	ation		
		Pt. No.	Pos (ch)	Pos unc (ch)	Fwhm (ch)	F
	I	1	111.25	0.5	1.94 😶	
		2	3560.76	0.5	4.44	
		3	2454-41	05	3.88	



If you want to borrow a fitted peak width value from the current spectrum, click on the FWHM value, then on the ellipsis [...] button appearing beside the number.

The spectrum fitting window appears now. Click with the position getting tool on a peak. The FWHM calibration editor will appear again, and the clicked peak's exact fitted peak width will be used as the FWHM value of the calibration point.

Should you want to cancel the borrowing process, press *Esc* key.

Please note that, after borrowing, the channel position of the FWHM point is also updated to the position of the fitted peak. This behavior is intentionally different from what you experience in the case of the energy calibration editor.

# 5. Energy calibration

After HyperLab's spectrum peak evaluator determined the position and the area of the peaks, it creates a peak list, where the peak centroids are shown both in channel and in energy (keV) unit. The energy values are calculated from the fitted channel values by utilizing the energy calibration function, which performs this transformation.

HyperLab's energy calibration function is different from most competitors' solution: it uses a simple linear channel – energy function with an optional additive nonlinearity function.

When nonlinearity is not used, energy values in keV are computed from the channel values with the following formula:

$$E = A + B \cdot Ch$$

When nonlinearity correction is in effect, that function will always provide the higher order terms for the channel vs. energy function:

$$E = A + B \cdot (Ch + NonlinShift)$$

This second formula contains the NonlinShift parameter, which is computed from the system's nonlinearity curve, and is a polynomial of the channel value.

## 5.1. Linear and nonlinear calibration

In most cases, a simple linear channel – energy function is not acceptable for post-processing, as this would lead to two adverse effects:

- **Inexact energy positions**. This is due the inherent nonlinearity of the measurement systems, and finally would cause improper nuclide identification in post-processing of the peak lists. If nonlinearity correction is not applied that is, solely the linear calibration function is used peak positions of the fitted peak positions may differ as much as 1-3 channels from their expected value.
- **Improper uncertainties**. If only the linear calibration function is used, the reported uncertainties on peak positions are smaller than the real values, thus would make the isotope identification unreliable for activity calculation and calibration purposes.

This picture shows the case when only a linear energy calibration is used for a typical measurement system. This is a measurement of a 152Eu source, in the 121 keV – 1408 keV range.

The green squares depict the difference (the residual) of the calibration points' position from the linear calibration (red line).



Despite multiple calibration points, a clear tendency shows that the system has a significant nonlinear response, which reaches several tenths keV at in the vicinity of 1408 keV.

If these discrepancies are not acceptable, the purely linear energy calibration is not enough: a correction is needed to eliminate the nonlinearity of the measurement system.

# 5.2. The energy calibration concept in HyperLab

A basic assumption of HyperLab is that every measurement system has an inherent and characteristic nonlinearity, which is rarely and slowly varying in time. We also assume that this is very different from the daily shift of the linear calibration values, and may be separated from it. Thus the nonlinearity function should only be determined occasionally, e.g. with a multi-isotope, multi-measurement calibration set, providing a high precision nonlinearity curve. This nonlinearity curve can be used in the daily work for a longer period – e.g. for a half year or a whole year –, and only the linear part of the calibration should be adjusted daily.

This way a convenient and high-precision energy calibration is achieved by minimum amount of work.

This figure shows the effect of applying a real nonlinearity curve in addition to the same linear calibration as seen on the figure in section "Linear and nonlinear calibration".

Please note that the nonlinearity virtually disappeared throughout the whole energy range, and one magnitude smaller



unwanted shifts may be observed in peak positions (hundredths of keV).

As you can see the abrupt change of the blue  $\pm 1\sigma$  error curve after the last calibration point, HyperLab does not allow nonlinearity curves to be used for extrapolation. When a nonlinearity value is requested for an energy, which is outside the energy range of the nonlinearity calibration, the nonlinearity value of the first or last point will be used instead.

#### **Further benefits**

By utilizing a separated nonlinearity curve for the system, it also provides further benefits:

- the uncertainty calculation contains the incremental effect of the system nonlinearity, and
- it is possible to apply the precise nonlinearity even when the spectrum has a small number of calibration peaks.

As the nonlinearity calibration takes only a few minutes to create, and provides peak positions with much higher precision, our advice is to *always* use the nonlinearity part of energy calibration.

In fact, this process is almost fully automatic: during loading a spectrum file, HyperLab is able to assign the actual nonlinearity curve to the measurement's energy calibration. After this step, all computations involving this energy calibration will automatically utilize the compensation.

# 5.3. Energy calibration editor

This window may be used to edit the calibration points of the linear energy calibration part, and also to select an additive nonlinear energy calibration curve to the calibration. For details about HyperLab's energy calibration concepts, see section "Energy calibration".

The energy calibration window may be initiated basically from two places:

- from the Spectrum peak evaluator. In this case, the primary purpose of the dialog is the editing of the calibration and especially adding new calibration points;
- from other places, e.g. from the spectrum importer, when the primary purpose of the window is to display a previous calibration in read-only mode.

This window contains multiple tabs with various data displaying or editing controls.

### 5.3.1. Linear and nonlinear data tab

This tab contains all the data necessary for quick overview of the calibration's most important numeric data. These comprise the current status (modified or unmodified), the calibration point list as well as the optional additive nonlinearity applied.

🖁 Energy ca	Energy calibration editor					
Linear & nonl	inear data 🛛 Cali	bration chart F	eplace Advanc	ed		
Status						
Calibration is	modified by use	er.				
E kev = -0.1	99003 + 0.409	542 × Ch				
-	- line or energy	alibration				
Points for the	e linear energy	calibration:				
Pt. #	Pos (ch)	Pos.unc.(ch)	Energy (keV)	En.unc.(keV)	Description	*
▶ 1	297.89	0.00	121.78	0.000	152EU EC DECAY	=
2	597.93	0.01	244.7	0.001	152EU EC DECAY	-
3	722.97	0.05	295.94	0.002	152EU EC DECAY	
4	841	0.00	344.28	0.001	152EU B- DECAY	
5	1004.11	0.02	411.12	0.001	152EU B- DECAY	Ŧ
•	• • • • • • • • • • • • • • • • • • •					
			<u>1 N</u> ew	×	<u>D</u> elete	
A 1-D2	E					
Additive non	ilinearity Diana ann Canadai					
Ose apprive upulitieatità critae						
D4 Nonlinearity analysis - 1/25/2011 10:24:54 PM						
	🖤 <u>H</u> elp 🛛 🛇 OK 🛛 🔇 Cancel					

The point list contains two or more editable calibration points, to which a linear fit is performed, thus determining a channel – keV calibration line. If only two points are used, the line will necessarily go through the points. If more than two points are specified, a least–square fit is performed, in order to determine the optimum calibration line between scattering points.

The nonlinearity curve provides a fine tuning, to compensate system nonlinearity. See further details in section "System nonlinearity analysis".

#### **Deleting points**

To delete a specific calibration point, select it by clicking on it with the mouse, or make it active by pressing the up or down cursor arrow keys, and click *Delete* button.

#### Entering new points manually

If you do not want to use HyperLab's visual calibration point adding facility, just want to enter predefined calibration points, press the  $\downarrow$  (cursor down) key repeatedly, while you leave the last point's row, and a new, empty row automatically created. Type in the proper values, then press  $\uparrow$  (cursor up) key to leave the edited calibration point row. If you want to enter a completely new calibration, first remove all calibration points, and add them one by one.

#### Modifying channel positions

To modify the channel position of a specific point, manual editing or borrowing may be used.

To edit the value by hand, just click on the channel number value, and type the new number. To borrow the exact peak position value from a fitted spectrum peak, click the ellipsis [...] button beside the channel value.

The spectrum fitting window appears now. Click with the position retrieval tool on a peak. The energy calibration editor appears again, and the clicked peak's fitted position will be used as the channel value of the calibration point. To cancel the borrowing process, press Esc.

#### Modifying energy values

Similarly to channels, energy values may also be modified by either manual editing, or by getting the exact values from HyperLab's nuclear data database. Manual editing may be initiated by simply clicking on an energy value and typing its new energy position in keV.

If you want to use a value from the nuclear database, click on the energy value, then on the ellipsis [...] button beside the energy value.

The calibration line selector window appears now. It contains decays and radiations from the database.

When this window firs appears, you can type in the first letters of the element, when the decay lister will select the appropriate element. After the element is selected, open it by clicking on the [+] at the left to show up its decays. Now click on one decay and its radiations will be listed on the right.

1 01	nits for a	ne intear energy	calibration.		
	Pt. #	Pos (ch)	Pos.unc.(ch)	Energy (keV)	E
I	1	297.89	0.00	121.7817	•
	2	597 93	0.01	244	7

Points for the linear energy cali



	Pt. #	Pos (ch)	Pos.unc.(ch)	Energy (keV)
I	1	297.89 💼	0.00	121.78
	2	597 93	0.01	244 7

Points for the linear energy calibration:



To select a radiation, click its line in the *Available radiations* table, then click *OK*. Alternatively, you can simply double-click on the radiation's data row.

The radiation list can be sorted by the *Intensity* and the *Energy* radio buttons at the top of the list as required. When you selected an energy row, the energy calibration editor window appears again, displaying the modified energy value.

#### Adding new points by visual selection

HyperLab also makes it possible to add a new calibration point via a more convenient method. If you click *New* button under the table of calibration points, HyperLab first displays the spectrum evaluation window, where you can select a fitted peak for position, then instantly shows the *calibration line selector window*, in order to select a calibration line from the nuclear database. This way addition of a new calibration point may be accomplished rather quickly.

#### The problem of missing gamma lines

It may be disturbing that some of your well-known calibration peaks are not provided in the calibration line selector window. This may be due to its missing *radiation usage flag*. HyperLab uses a gamma line for energy calibration purposes only if that radiation is equipped with "Use for energy calibration" flag. See further details in section Nuclear data library management.

## 5.3.2. Calibration chart tab

The energy calibration chart allows you to overview the quality of the calibration.



This sheet contains the chart itself at the top, a residual at middle, and a list of candidate fitted peaks at the bottom. The chart shows the *calibration line* with red, the *standard uncertainty* of the calculated energy values in blue; the calibration points' *difference* from the energy calibration line as filled green rectangles.

The peak list may be used to add new points quickly to the calibration. The peak list is filtered to display the significant peaks only: only the peaks with less than 1% peak area uncertainty will be displayed – however, this value can be edited under the list. If you find too few peaks in the list,

change this value to, say, 5%, and all the peaks below this limit will be listed immediately. To quickly *add a peak* to the calibration as a new point, click on its row, and click the *Add* button beside the list.

On the chart, gray triangles depict the positions of the fitted candidate peaks, which are listed in the peak list table. When you click on a gray triangle, its point will be shown with bolder line, and the corresponding data row will be selected. The fitted peaks are always displayed with zero difference from the calibration curve, as their library energy is not yet known. When Add button clicked, user should select a library peak, then a real difference may be computed. **Notes:** 

- The gray triangles may help you to notify if you are using dangerous extrapolation: if the last fitted peak that is, the last gray triangle is too far from the last green calibration point, its computed energy value may be rather uncertain. In this case, it is advisable to add also an other, closer peak as an additional calibration point.
- If you see a strong non-random tendency among the linear calibration points, and the difference exceeds, say, 0.1keV, this may indicate significant nonlinearity of your measurement system. In this case, it is advisable to create a nonlinearity calibration, and use it together with the two-point linear energy calibration as a nonlinearity compensation. See details in section "System nonlinearity analysis".

### 5.3.3. Advanced tab of energy calibration window

On the advanced tab, you can revise the equations of the current energy calibration. If the additive nonlinearity correction is not used for a given calibration, then a simple

$$E = A + B \cdot Ch$$

formula is used. In case of nonlinearity correction, the

$$E = A + B \cdot (Ch + NonlinShift)$$

formula will be applied, where *NonlinShift* is computed from the polynomial of nonlinearity curve for a given channel value.

This should result in much better agreement of the measured peak positions throughout the whole measurement range. The calibration chart will also significantly change: calibration points will scatter randomly around the calibration line, and the differences between the points and the line become much smaller, thus resulting in much more precise peak position determination.

This tab displays the energy calibration function in two forms.

The upper part contains the exact and



numerically stable representation, which utilizes orthogonal polynomials. This solution, however, may seem uncommon.

The lower part displays the very same function as a regular polynomial, whose computation is more straightforward. It may be used in external applications, where the simplicity has higher priority than numerical stability.

This page also makes it possible the computation of any energy value and its uncertainty from arbitrary channel values: just enter the position in channels into *Position* edit box, and possibly

its absolute  $1\sigma$  uncertainty. Upon clicking Calculate button, the corresponding energy value will be displayed, together with its absolute uncertainty value.

# 6. System nonlinearity analysis

As described in section "Energy calibration", HyperLab proposes an energy calibration model, where the slowly varying nonlinear and frequently changing linear parts are separated.

#### Nonlinearity curve

The nonlinearity of a measurement system at a specific point of time is characterized by a so called *nonlinearity curve*. This describes the system's *deviation* from the linear calibration line, as shown in the picture below.

The figure shows the nonlinearity curve of HyperLab's Nonlinearity module for several calibration measurements.

The curve itself is depicted by a red line, its  $\pm 1\sigma$  limit with blue lines, while the data points are from the centroid shift of the fitted peaks.

The green triangles (at 600ch and 2800ch) show the points where the curve crosses the zero nonlinearity value.



In HyperLab, the system nonlinearity curve always uses the channel-channel scale, as with these units the nonlinearity characteristics are supposed to be slowly varying with the time.

The calculated nonlinearity may be used for several purposes:

- The curve provides the "fine tuning" part of the energy calibration, because it transforms the system's response to nearly linear. Thus, when applied together with a linear channel-position calibration line, it serves more exact energy values. See section "Energy calibration editor" for more details about applying a previously created nonlinearity calibration to an existing linear energy calibration.
- Helps to compare the absolute nonlinearity of different measurement systems. As HyperLab also calculates an absolute percentage nonlinearity value, a simple comparison of two numbers may reveal the differences between them.
- Helps to characterize the aging or other changes in a specific measurement system for quality assurance purposes. With consecutive nonlinearity evaluations, the percentage nonlinearity values may be used to monitor the changes in characteristics of the measurement system.

## 6.1. Algorithm of nonlinearity determination

Nonlinearity determination is easy with HyperLab's Nonlinearity module. Only a few measurements are required, and a calibration curve may be constructed within a few minutes. The algorithm of the nonlinearity determination is the following:

- 1. Determination of the matching gamma lines in the measurements. Because 2 parameters will be determined during a least-squares fit for each measurement, this step drops measurements with less than 3 matching data points.
- 2. One-step fit performed on all points of all measurements with one common orthonormalized polynomial, and with more adjusting lines, one for each measurement. The shape of the polynomial describes the common nonlinearity in the system, while the

lines normalize together the individual measurements so that the common chi-squared is at the minimum.

3. As the nonlinearity of the system is described practically only by the curvature, a final common shifting line is added, which may be arbitrarily chosen by the user.

### 6.1.1. Nonlinearity intersection points

The additive line – the zeroth and first order member of the nonlinearity – is to shift or "shear" the curve such that it intersects the X axis at two specific points (where zero nonlinearity is reached, as shown by the green triangles).



The user can select from *Optimum*, *Linear fit* or *User defined* intersection (or *baseline*) determination modes. The figure shows the same nonlinearity analysis as in section "Nonlinearity curve", but with *Optimum* baseline instead of *Linear fit*. HyperLab uses the *Optimum* mode by default, because in this case the maximum absolute deviance from zero nonlinearity is minimized in the whole energy range.

The *Linear fit* option will use no additive line (or, equivalently it uses the first measurements' line – as it is selected as zero slope and offset).

In *User defined* mode the user is able to set her own intersection points (thus defining the additional line).

#### Notes:

- If you want to compare percentage nonlinearity values of different measurement systems, or the overall goodness of the same system at two different times, use *Optimum* method, because this provides the smallest possible percentage value.
- If you want to compare the shape of nonlinearity of two systems, apply *User defined* mode, and set intersection to the same values. This way the same shifting is applied to the curves, and their differences in shape will be immediately visible.
- If you want to check whether a linear energy calibration gives the same deviations from the calibration curve as the points on the nonlinearity curve, use *Linear fit* method with one single measurement.
- For energy calibration purposes, in essence there is no big difference between the methods, as the line of the linear energy calibration is able to compensate any setting of baseline. We suggest using the *Optimum* or *Linear fit* method in this case.

**Bug note:** a rarely occurring bug exists in HyperLab's minimax intersection determination algorithm. If you have a measurement system which has a nearly linear response almost in the whole range, the minimax fit sometimes results in the same intersection values for both intersection points. This is indicated by the nonlinearity display: only one green intersection triangle is visible instead of two, because they are at the same position. In this rare case please use the *Linear fit* or the *User defined* method.

## 6.2. Measurements required for nonlinearity determination

For nonlinearity determination, you need one or more multi-line measurements. The measurements should have the following properties:

- taken with the same measurement setup (same detector, ADC, energy range),
- taken roughly in the same time period (preferably within the same day, or within 1 week),
- their gamma lines of isotopes have exact energy values in HyperLab's database,
- the lines of the isotopes spread across your entire, regularly used energy range,
- every measurement has at least 3 proper gamma lines,
- every measurement has at least 2-3 identified peaks which *overlaps* with another measurements' identified peaks. Please be aware that if no overlapping is between the measurements, no proper nonlinearity curve may be constructed.

These are not stringent requirements, so the majority of usual calibration measurements – or even measurements acquired for material analysis – will be usable also for nonlinearity determination. You can also use isotopes with a few problematic lines, as you will be able to individually remove the disturbing or overlapping lines from the nonlinearity curve.

## 6.3. Steps of nonlinearity determination

In order to determine the nonlinearity curve of a measurement system, first take some measurements with calibration sources, and import them into your HyperLab database. Our example will work with HyperLab's sample spectra belonging a measurement setup with 70 keV - 3300 keV range.

Please load the spectrum files into the database and also set their corresponding source values, as specified in section "Importing sample spectra".

Perform a batch or individual evaluation on all measurements, and open a multi-line spectrum with the Peak evaluator. Check the FWHM calibration, and adjust the region fits, if necessary. Finally save the peak list, which will be input for the nonlinearity evaluation.

When all measurement are properly fitted, similar statistics will be displayed about them at the right side of the Main Module window as you can see in this picture.



#### System nonlinearity analysis

<u>File Options H</u> elp		then slick on Noulinearity and and
HyperLab databases     Database HyperLab1 on \MSSQLHYPERLAB     Database HyperLab1 on \MSSQLHYPERLAB     Database HyperLab sample spectra     Percent HyperLab sample spe	(1 task, 0 sub-item) Tasks Sub-items	then click on <i>Nonlinearity analyses</i> and select Create a new nonlinearity analysis task. A new window appears now, where basis parameters of nonlinearity fit algorithm may be specified.
Creating new nonlinearity analysis		You can specify a descriptive name of the
	ny anayon, mononen en.	for the identification of peaks
NAME Nonlinearity analysis - 1/25/20 PEAK IDENT. LIMIT 3 Ch RADIATION INT. LIMIT 0.005	11 11:59:29 PM	The <i>Peak identification limit</i> is used when peaklist peaks and nuclear library peaks
✓ Start nonlinearity analysis means of the start of t	odule when I press Ok	are matched. If the difference between
The threshold is used when assigning fitted peaks to nuc position value in channels. Set to about 3 channels to id measurement setup.	slear library peaks, using their centroid entify peaks for a moderately nonlinear	peak centroids is below this value, the peaks will be considered as matching. Its
Radiations' intensity threshold is used when adding new	radiations to the nonlinearity analysis.	usual value is 3 channels, which is
		appropriate for measurement setups with

The *Radiation intensity limit* is used when radiations are loaded for a selected decay from the database. The 0.005 default value load the radiations where the intensity is greater than 0.5% of the decay's strongest line. When you are ready, press *OK*.

🖉 System nonlinearity evaluator	
<u>File E</u> dit <u>Search View D</u> ata F <u>i</u> t <u>O</u> ptions <u>H</u> elp	
Input data Fit Messages	
	Measurements
	Add measurement
	Click 'Add measurement' to add one or more measurements to the resolution analysis.
	No fit performec

The *Nonlinearity evaluator* appears now with the empty *Input data* sheet. Click *Add measurement* button at the right. The *Measurement selector* window appears now.

#### System nonlinearity analysis

Select the 56Co sample measurement from the project, named *COD0111A.DAT*, and 152Eu measurement called EU80297A.DAT.

When you click *OK* in the measurement selector window, HyperLab performs the steps as follows.

- Loads the peaks from the most recent peak evaluation of the measurement.
- Checks if a source is specified for the measurement. If found, loads the source isomers, their decays and radiations. Otherwise prompt the user for the isotopes.
- Limits the radiations to those whose intensity is above the preset intensity limit and which have a radiation usage flag stating that the radiation is usable for nonlinearity evaluations.
- Matches the loaded radiations and peaks, by applying the preset matching limit.
- If at least 3 matching peak-radiation pairs are found within a peak list, the measurement will be used for nonlinearity evaluation, otherwise skipped.
- Checks if enough input data points exist for a polynomial fit. The number of all data points must exceed the number of fitted parameters, which added from the degree of fitting polynomial and the two linear shifting parameters for each measurement.

If you did not specify the radioactive source for the 56Co measurement, a selector windows will pop up now.

Select *Decay* option and click OK, as you are specifying a decay gamma source.

Next window let you select one or more decays for the given measurement. The gamma lines belonging to the decay is also listed, in order to help the selection.

Select 56Co EC Decay entry, and lick OK.

If you did not specify the radioactive source for the 152Eu measurement, repeat the process accordingly, and select both the EC and the  $\beta$ - decays of 152Eu.

<u> </u> Select one or mo	re measurements 📃 😐	×
Available measuremen	nts:	
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Measurement Id	8	
Name	D4 kal. 2002. okt. 1 [EU80297A.DAT]	
Started at	10/2/2002 1:17:00 PM	
Finished at	10/2/2002 2:17:00 PM	
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▷ 🚳 59Fe (44.50 d)	
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Details of selected item	
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Name	56C0 EC
Branching	100 %
Branching unc.	
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#### System nonlinearity analysis



If enough data points are supplied, the fit is performed and the tab Fit becomes active, displaying the fitted nonlinearity curve. Now you can add your other measurements to the fit one-by-one, or remove one, drop outlier gamma lines and so on.

Eventually, a multi-isotope nonlinearity curve may be constructed with almost no manual interaction.

**Note:** after you are using a specific peak evaluation for nonlinearity analysis, you had better *not modify* the peak evaluation afterwards – e.g. by adding or removing peaks from it. When you open such a peak evaluation with the spectrum evaluator module, it will warn you about this, suggesting opening the evaluation only in read-only mode.

If you want to use a measurement for multiple purposes, e.g. for nonlinearity as well as efficiency analysis or quantitative evaluation, it is advisable to create a separate peak evaluation for each purpose, e.g. by cloning the original peak evaluation.

## 6.4. Designating a proper nonlinearity curve as a default

After a successfully construction of a nonlinearity curve, you should take one last administrative step: HyperLab should know that this curve is to be used as a default one. This can be done by assigning the nonlinearity analysis to the measurement setup where it belongs. After this step, the spectrum files, which loaded next time, may get this nonlinearity correction automatically, so your energy calibrations will be more precise right after the importing.



A data entry window appears now.

Open *Measuring environment* node in your database browser tree, then *Setups and their assignments*, finally the measurement setup where your nonlinearity curve is created. In our example, the masurement setup 'D4 Setup 70keV - 3.3Mev, d=25cm' was opened. After that entry, click System nonlinearity calibrations assigned to this setup, and then select the task at the right named 'New Meas. Setup – nonlinearity assignment'. Now you should select the nonlinearity analysis you have created.

Another important field is the Valid from entry, where you can define the starting date when your nonlinearity analysis should be used as a default.

Set it to the **date of the measurements** which have been used for the analysis.

In our example, we set this date to January 1<sup>st</sup>, 2002, to make sure that it will be automatically used for all measurements taken from the very first day of that year.

You should always register a successfully created analysis as default. This way a chain of nonlinearity analyzes will be created, each representing a time range of your measurement system, when that calibration was valid.

On this picture we depict a situation, when 4 nonlinearity analysis, NL1, ... NL4 is

determined for a measurement setup. After the first assignment (NL1), there is always a valid nonlinearity in the system. For example, if a spectrum file is imported, where the acquisition time is between the 2<sup>nd</sup> and the 3<sup>rd</sup> nonlinearity analysis, then the NL2 nonlinearity will be assigned to the energy calibration of that measurement during the importing.

# 6.5. Common problems during nonlinearity determination

Although nonlinearity determination is almost a trivial task with HyperLab, there may be common problems for the users.

### Problem No.1: improper linear energy calibration of measurements

Perhaps the most important thing is to create a proper linear energy calibration for the measurements which will be used as input for the nonlinearity analysis.

The difference between the reported peak positions and the position of the library peaks at the end must not be larger than 3 channels (the actual nonlinearity peak search limit), otherwise nonlinearity module will not be able to find them.

In case of an improper linear energy calibration, as it is shown in this picture, the user forgot to use the high-energy lines of 152Eu for the linear calibration. These lines possibly will not be found by

the nonlinearity analyzer, thus 'drawing off' the nonlinearity curve.









incorporate them onto the nonlinearity curve.

This figure shows a much better linear energy calibration for the same situation. You can see that the calibration line placed such way that no any library lines is located too far away from the actual peaks. This way the nonlinearity analyzer will probably be able to find those peaks and

### Problem No.2: non-overlapping regions covered by measurements

For nonlinearity fitting, the input measurements should contain as much well-defined singlet peaks as possible, as this makes it possible to describe well the shape of the nonlinearity curve. Please keep in mind that another important constraint for the analysis is that the final curve must be constructed from measurements where the peaks are overlapping each other.



freedom to rotate the curve part freely, in order to get a joint with minimum overall nonlinearity.

Please take a look at this faulty multiisotope nonlinearity curve constructed from the two overlapping 152Eu and 56Co measurements.

We took that curve, and just for the sake of the demonstration, manually removed the

56Co lines which overlapped the 152Eu ones, this way created two measurements with disjoint regions of peaks. These two measurements cannot be used for a nonlinearity analysis. In order to reduce the overall nonlinearity, the fitting algorithm applied a 'rotation' to the 56Co measurement, and flattened out the whole curve significantly, giving an improper result. You should always avoid such situations, by adding another measurement or missing peaks to the nonlinearity analysis.

A possible solution would be to use a third measurement, which covers the middle region, while overlaps a bit with the first and the second measurements.

### Problem No.3: Radiations not found

If nonlinearity analyzer is not able to find a particular peak, it is also possible that the matching library line has no the proper *radiation usage flag*. HyperLab uses a gamma line for nonlinearity purposes only if the "Use for nonlinearity" flag is assigned to it. See further details in section Nuclear data library management.

# 7. Detector efficiency analysis

HyperLab is able to automatically construct absolute or relative full-energy detector efficiency functions (curves) from multiple measurements taken with multiple radioactive sources. The applied state-of-the-art techniques result in a single detector efficiency polynomial, and also its exactly computed uncertainty values throughout the used energy range. This provides significant advantage over HyperLab's competitors.

#### Efficiency curve

The semiconductor detectors' efficiency means a ratio between the number of photons arriving into the detector and the number of detected events resulting at the end of the measurement chain. As the probability of gamma photon detection changes rapidly with the energy of the photons, it is common to describe the logarithmic of the efficiency as a function of the

logarithmic of the photon energy. HyperLab also uses this log(Eff) vs. log(E) fitting and displaying method in its *Detector efficiency analysis* module, as you can see in this figure.

The curve itself is depicted by a red line, its  $\pm 1\sigma$  limit with blue lines, while the measured intensity points are either *not* normalized (if an absolute calibrated radioactive source is used) or normalized (in case of home-made sources).



The calculated detector efficiency may be used for generating special peak list reports, which contains peak areas and uncertainties with efficiency correction. Later versions of HyperLab will also contain nuclide identification based on the efficiency curve.

# 7.1. Algorithm of efficiency determination

Detector efficiency determination is easy with HyperLab's Efficiency module. Only several measurements and proper radioactive source entries are required, and a calibration curve may be constructed within a few minutes.

The algorithm of the efficiency determination is the following:

- 1. Determination of the matching gamma lines in the measurements. The list of gamma lines is generated from the matching radioactive sources' isomers or from manual assignment.
- 2. In case of absolutely calibrated sources, the belonging measurements will be used even if only one matching line is found in it. In case of relative measurements, at least two assigned lines are required. This is because a Y-shifting transformation will be applied to these points in order to match the points from other measurements and at least two points can only provide additional information about the shape of the curve.
- 3. One-step fit is performed on all identified points of all measurements with one common ortho-normalized polynomial, and optionally with several shifting parameters (one shifting parameter for each relative measurement). The shape of the polynomial

describes the efficiency of the measurement system, while the shifting parameters normalize together the relative measurements together or to the absolute measurements, so that the common chi-squared is at the minimum.

## 7.2. Measurements required for the efficiency analysis

For nonlinearity determination, you need one or more multi-line measurements. The measurements should have the following properties:

- taken with the same measurement setup (same detector, ADC, energy range),
- taken roughly in the same time period (preferably within the same day, or within 1 week),
- their gamma lines of isotopes have exact energy values in HyperLab's database,
- the lines of the isotopes spread across your entire, regularly used *energy range*,
- the used decay gamma cascade does not show significant *true-coincidence summing* effect (either due to the structure of the nuclear transitions, or due to the appropriately large detector-source distance),
- every relative measurement has at least 2 proper gamma lines, and every absolute calibrated measurement has at least one proper gamma line.

These are not stringent requirements, so the majority of usual calibration measurements – or even measurements acquired for material analysis – will be usable for efficiency determination. You can also use isotopes with a few problematic lines, as you will be able to individually remove the disturbing or overlapping lines from the efficiency curve.

## 7.3. Steps of efficiency determination

In order to determine the efficiency curve of a measurement system, first take some measurements with calibration sources (possibly with absolutely calibrated ones), and import them into your HyperLab database.

Our example will work with HyperLab's sample spectra belonging to a measurement setup with 70 keV - 3300 keV range. Please load the spectrum files into the database and also set their corresponding source values, as specified in section "Importing sample spectra".

Perform a batch or individual evaluation on all measurements, and open a multi-line spectrum with the Peak evaluator. Check the FWHM calibration, and adjust the region fits, if necessary. Finally save the peak list, which will be input for the efficiency evaluation.



When all measurements are properly fitted, similar statistics will be displayed about them at the right side of the Main Module window as you can see in this picture.

To ease the work of the spectroscopist, the same peak evaluations may be utilized for nonlinearity determination and for efficiency analysis. Open *Analyses* node under your project, then click on *Efficiency analyses* and select *Create new efficiency analysis* task. A new window appears now, where basic parameters of efficiency fitting algorithm may be specified.

Here you can specify a descriptive name of the new efficiency analysis, and thresholds for the identification of peaks.

The *Peak identification limit* is used when peaklist peaks and nuclear library peaks are matched. If the difference between peak centroid and radiation's energy is below this Chi value (using the combined energy uncertainty value of the peak and gamma line), the peaks will be considered as matching.

File Options Help	
HyperLab databases     HyperLab databases     Database HyperLab1 on \MSSQLHYPERLAB     HyperLab sample spectra     HyperLab sample spectr	(2 tasks, 0 sub-item) Tasks Sub-items Create new efficiency analysis Create new manual efficiency
<ul> <li></li></ul>	

💋 Creating new efficiency	/ analysis			
Please set pa	Please set parameters for the new efficiency analysis, then click Ok.			
NAME	Efficiency analysis for D4	det, 3.3MeV		
PEAK IDENT. LIMIT RADIATION INT. LIMIT	100 0.005	sigma (difference/uncertainty)		
	Start efficiency analysis	s module when I press Ok		
The threshold is used when assigning fitted peaks to nuclear library peaks, using their centroid position value in channels. Set to about 3 channels to identify peaks for a moderately efficiency measurement setup.				
Radiations' intensity threshold is used when adding new radiations to the efficiency analysis.				
🕑 OK 🔇 Cancel				

Its usual value is 100 Chi, which is appropriate even for cases when nonlinearity correction is not applied in the energy calibration, therefore huge differences may occur for peak positions. If you are using nonlinearity correction for all of your measurements used for the efficiency analysis, enter a value of 5.0 Chi here.

The *Radiation intensity limit* is used when radiations are loaded for a selected decay from the database. The 0.005 default value load the radiations where the intensity is greater than 0.5% of the decay's strongest line. When you are ready, press *OK*.

The *Detector efficiency evaluator* window appears now with the empty *Input data* sheet.

Click *Add measurement* button at the right. The *Measurement selector* window appears now.



#### Detector efficiency analysis



Select all of HyperLab's example measurements from the project.

When you click *OK* in the measurement selector window, HyperLab performs the steps as follows.

- Loads the peaks from the most recent peak evaluation of the measurement (this should be the *nonlinearity corrected* peaklist).
- Checks if a radioactive source is specified for the measurement. If found, loads its isomers and their radiations, as well as source activity details. Otherwise

prompts the user for selecting the isotopes.

- Limits the radiations to those whose intensity is over the preset intensity limit and which have a radiation usage flag, enabling the radiation for detector efficiency evaluation purposes.
- Matches the loaded radiations and their closest fitted peaks, by applying the preset matching limit.
- If at least one matching peak-radiation pair is found within a peak list (or 2 matching pairs for measurements taken with a home-made source), then the measurement may be used for efficiency evaluation.
- Checks if enough input data points exist for a polynomial fit. The number of data points must exceed the number of fitted parameters, i.e. the degree of the fitting polynomial plus one activity shifting parameter for each non-absolutely calibrated measurement.



If enough data points are identified, the fit will succeed and the tab Fit becomes active, displaying the fitted efficiency curve. It will be an absolute efficiency curve if any of the matching measurements has an absolutely calibrated source, and it will be relative efficiency if no measurement has such source.

Now you can add other measurements to the fit one-by-one, or more at a time. Eventually, a multi-measurement, multiisotope efficiency curve may be easily constructed.

#### Improvement of the fit

If you check the resulting reduced Chi-squared (RXSQ=101) or the residual of the fit, it is immediately obvious that there is a problem with the fit.

Please be aware of the outlying 152Eu data points on the previous figure, which are far off from the efficiency curve. This is the 443keV line of 152Eu, and it is improper for calibration purposes because the level scheme contains two overlapping 443keV peaks. The similar problem exists with the 1112keV line of 152Eu EC decay and the 1109keV line of 152Eu  $\beta$ -decay.

It is unavoidable to remove all of these disturbing lines. Select the first 443keV line by clicking on it (on the fit chart, or on the residual, or in the list of matching radiations), and then click *Remove* button, and repeat this for the other problematic line at 443keV. You can use the View/ Sorting of radiations menu to display energy-sorted lines. Also repeat with 1112keV and 1109keV lines of 152Eu, and the notoriously weakly fitted 79keV line of 133Ba.

With those modifications, the RXSQ value goes down to around 3, which should also be improved.

It is better to check the residuals now, to see which line exactly causes this problematic RXSQ:. Click on the outlier point at 59keV. It is immediately displayed on the right that it belongs to 241Am.



In order to see the spectrum's details, save the efficiency fit, and open the 241Am peak evaluation.

If you have a warning about that this peak evaluation is already used in an analysis, therefore cannot be modified, then select No here.

Now select the *Make a clone* task while the peak evaluation is selected, thus creating a new peak evaluation, which contains the same details as its original one, but editable. After cloning, a second peak evalution appears on the left, at the database tree. For the sake of clearer further explanations, we changed its name to '2<sup>nd</sup> Peak evaluation'. Open this new evaluation, and check the problematic 59keV region.

The problem may be evident at once: the automatic fit incorrectly included part of the background in the peak.

Move the left side of the region to right, by dragging the blue arrow to the base of the peak.









# 7.4. Designating a proper efficiency curve as a default

After a successfully construction of an efficiency curve, you should take one last administrative step: HyperLab should know that this curve is to be used as a default one. This can be done by assigning the efficiency analysis to the measurement setup where it belongs.

After this step, the efficiency of a measurement can be automatically determined, purely by its acquisition date and the measurement setup set up for the spectrum.

This is currently used by HyperLab for two purposes:

- nuclide identification is more convenient, as automatic loading of the matching efficiency curve is performed during spectrum deconvolution, and
- it is possible to generate an efficiency-corrected peak list (however, this is rarely used).

In order to assign an efficiency analysis to the measurement setup, please follow the instructions below.

Open Measuring environment node in your database browser tree, then Setups and their assignments, finally the measurement setup where your efficiency curve is created. In our example, the measurement setup 'D4 *Setup 70keV - 3.3Mev, d=25cm*' was opened. After that entry, click *Efficiency calibrations* assigned to this setup, and then select the task at the right named 'New Meas. Setup efficiency assignment'.

A data entry window appears now.

Now you should select the efficiency analysis you have created.

Another important field is the Valid from entry, where you can define the starting date when your efficiency analysis should be used as a default.

Set it to the date of the measurements which have been used for the analysis.



🖌 Measurement setup - efficiency analysis assignment properties					
Selected meas. setup - eff. assig	Selected meas, setup - eff, assignment - pg 1 More meas, setup - eff, assignments				
EFF. ANALYSIS Efficiency analysis for D4 det, 3.3MeV					
MEAS. SETUP	D4 Setup 70keV - 3.3Mev, d=25cm				
VALID FROM	2002 Jan 01 🔲 🔻 00:00:00 🚔 🥝				
STORED BY	Database administrator				
STORED AT	2011 Jan 31, 22:07:54				
COMMENT					
😧 Help 💙 OK 🔇 Cancel 🏹 Apply					

In our example, we set this date to January 1<sup>st</sup>, 2002, to make sure that it will be automatically used for all measurements taken from the very first day of the year.

You should always register a successfully created analysis as default. This way a chain of efficiency curves will be created, each representing a time range of your measurement system, when that calibration was valid.



On this picture we depict a situation, when 4 efficiency analysis, Eff1 – Eff4 is assigned to the same measurement setup.

After the first assignment (Eff1), a default efficiency curve is existing in the system. For example, when a measurement is loaded into peak evaluator, where the acquisition time is between the 2<sup>nd</sup> and the 3<sup>rd</sup> efficiency analysis (between Eff3 and Eff3), the efficiency curve Eff2 is automatically loaded, and the isotope identification will use it automatically.

# 7.5. Common problems during efficiency determination

Although efficiency determination is almost a trivial task with HyperLab, there may be common problems for the users. One such problem may arise with peak matching.

#### Problem No.1: Using the same measurements for nonlinearity and efficiency

If you want to determine the nonlinearity and the efficiency from the same measurement set, it is advisable to evaluate the measurements twice:

evaluate the measurement with a purely linear energy calibration;



- create the nonlinearity calibration, and save it;
- load measurements into the peak evaluator again one by one, and assign the new nonlinearity to the energy calibration, then save a new peak list;
- load these new peak evaluations (which have now better energy calibrated peaks) into the efficiency evaluator.

#### Problem No.2: Decays not set

If you have selected a measurement, where the sample is not set to a radioactive source, HyperLab is not able to automatically assign decays and their radiations to the measurement. In this case the user should manually assign decays to the measurement.



To add decays, select *Input data* tab, then click on the *Searched decay lines* node under the measurement in question.

If you open this node and no decay has been set, click *Add decay* on the right.

Select proper decay and click *OK*. HyperLab now loads the decay and its radiations, and performs a fit with the currently identified matching radiationpeak pairs.

#### Problem No.3: Radiations not found

When only a simple linear energy calibration is applied to a spectrum, large discrepancies may exists between the expected and observed peak energies. If this difference is greater than the identification threshold (100 chi by default), radiations will not be identified. Therefore it is very important to apply the precise energy calibration (together with nonlinearity) in the Peak evaluator for the calibration measurements.

To get detailed information about the peak matching, see radiations under the *Input data* tab, or select *File / General info* menu item. A detailed listing is provided here about the matching of all searched radiations.

Another reason for missing peak matching is the missing *radiation usage flag*. HyperLab uses a gamma line for efficiency determination purposes only if that radiation is equipped with "Use for efficiency" flag. See further details in section Nuclear data library management.

## 7.6. Using efficiency curve in third party applications

When an efficiency curve is constructed in HyperLab's detector efficiency analysis module, the fitted orthogonal polynomial is available from the File / Generic info menu item or in efficiency reports. A reported polynomial may be the following:

The corresponding high-precision calculation function in C language:

The formula above is also reported to the user as a regular polynomial, which is the more usual description of the log Eff vs. log Energy dependency. See the formula at the *File / General info* menu.

A possible transcription in C:

```
double Eff_regular( double E_keV )
{
    double LogE = log(E_keV), LogE2=LogE*LogE, LogE4=LogE2*LogE2;
    double LogEff =
        30.6835240174 -46.5504384031*LogE +21.9649579373*LogE2
        -5.14575805865*LogE2*LogE +0.640226601624*LogE4
        -0.0406273018462*LogE4*LogE +0.00103266687194*LogE4*LogE2;
    return exp( LogEff );
}
```

Please note that due to the inherent numerical instability of regular polynomials, you must preserve as many significant figures in the coefficients as you can, otherwise imprecise values will be computed. At least 10-12 digits are strongly recommended.

An equivalent, and a bit numerically more stable calculation method is the following:

```
double Eff_regular_stable( double E_keV )
{
    double LogE = log(E_keV);
    double LogEff =
        30.6835240174
        +LogE*(-46.5504384031
        +LogE*(+21.9649579373
        +LogE*(-5.14575805865
        +LogE*(+0.640226601624
        +LogE*(+0.0406273018462
        +LogE*(+0.00103266687194)))))));
    return exp( LogEff );
}
```

# 8. Spectrum peak evaluator

Spectrum peak evaluator plays a key role in HyperLab, as this module makes it possible to evaluate your spectra in a visually rich graphical user interface. After you performed a fully automatic spectrum deconvolution, you can quickly revise the fits visually, and adjust the problematic regions to your needs with our convenient spectrum manipulation tools.

### Peak fitting algorithm

Predecessor of HyperLab's state-of-the-art algorithm was HYPERMET, which was developed for mainframes by the Naval Research Laboratory in the 1970's (see article in NRL Memorandum Report 3198, January 1976; G.W. Phillips and K.W. Marlow: Program HYPERMET for Automatic Analysis of Gamma-Ray Spectra from Germanium Detectors). A later variant was Hypermet-PC, which was a DOS-based clone for PCs.

HyperLab's automatic deconvolution is completely rewritten from scratch, retaining the original concepts and eliminating many constraints, limitations and faulty algorithms.

## 8.1. Control flow of the deconvolution

The new deconvolution algorithm comprises several fine-tuned steps:

- A list of suspected peaks created, based on the FWHM calibration. This is done by applying a simple, rectangular, convolution-type peak search function.
- Determination of region bounds follows. Regions are consecutive channel ranges, with one or more peaks, where the measured background may be described by the sum of HyperLab's various background functions. Regions are determined to be wide enough for the safe background function determination, but close enough to the peak to prevent unnecessary overlapping of background with peaks.
- A spectrum deconvolution is performed for the region. Various parameters are fitted in this step, in order to find the best match between the model function and the measured counts. The measure of the matching utilizes variances of counts and possibly the Westphal-corrected variances in case of Dual LFC measurements. This way the fitted areas are corrected properly for count losses.
- If the fit is not satisfactory, an iterative refinement process is started, when new peaks may be added, removed, or the region bounds extended or collapsed. This flexible automatic self-adjustment makes HyperLab an outstanding deconvolution tool.
- After a best matching deconvolution is found, the final steps follow: elimination of unnecessary fitted parameters and calculation of peak areas together with their uncertainties.
- When a region deconvolution is finished, the next region is taken until the end of the spectrum.

After spectrum fitting, a peak list is presented to the user, together with graphical representation of the fitted regions.

# 8.2. Model functions of peak fitting

HyperLab's several model functions together describe the measured counts in gamma spectra taken with semiconductor detectors. These model functions are originated from their simplified HYPERMET variants, but re-implemented with up-to-date techniques.

Model functions may be either peak type functions – Gaussian, Left Skew and Right Skew –, or background type functions: Polynomial, Step and Tail. Peak functions are summed up, resulting in the peak areas, which are reported to the spectroscopist. The basic idea behind the deconvolution is a nonlinear fitting algorithm, which adjust free parameters between well-defined limits, thus achieving a good agreement between the measured counts and the sum of all background and all peak functions.

The following sections will describe the individual peak function in greater detail.

### 8.2.1. Gaussian peak function

The Gaussian component contains the majority of peak counts. This component arises from the statistical noise which broadens the sharp line response of an ideal detector.

The fitted parameters for Gaussians are the Position, the Amplitude and the Width. Its counts may be calculated by the following formula at channel *x*:

$$Gaussian = Ampl \cdot \exp\left(-\frac{(x - Pos)^2}{Width^2}\right)$$

where

*Ampl:* Amplitude of peak

*Pos:* Position of the centroid

*Width:* Peak width parameter, so that  $FWHM = 2 \cdot Width \cdot \sqrt{\log(2)}$  or Width = FWHM/1.66

The picture shows a Gaussian with *Position=0, Width=*3 and *Amplitude=*100. In this case *FWHM* is  $6*\sqrt{log(2)}$ .

The X axis depicts channel positions in a spectrum region (zero selected for the peak centroid just for convenient display), while the Y axis shows count values.



#### Peak width determination variants

Users in HyperLab may choose from two different approaches when determining the width of the Gaussians in a region.

The first is the *Common peak width method*, which is based on gamma spectroscopy heuristics, as it fits one common peak width for each peak within a region. This model is able to describe the majority of the spectrum regions.

There are cases, however, when the *Variable peak width method* is required: this fits peak width for each Gaussian individually. A typical example for this case is the extremely broadening 511keV



annihilation peak, where valuable peaks of various radioisotopes should be separated automatically from the annihilation peak. See "Peak evaluation algorithm settings window" for further details.

## 8.2.2. Left skew peak function

Left skew is a peak function, that is, its integral over the region will be summed to the peak area. It is introduced because an electron energy shifting occurs regularly towards the lower energies, due to the incomplete charge collection in the detector crystal.



Because it is originated from a convolution of a Gaussian and an exponential, which is allowed to increase until the Gaussian's centroid, it is an asymmetric function. Therefore when the left skew is added to a Gaussian peak, it causes slight increase at the low energy side of the peak. The fitted parameters for Left skew are the Left Skew Amplitude (relative to the Gaussian's amplitude), and the Left Skew Slope. The width of the left skew is not

fitted, but assumed to be always equal to the width of the Gaussian. The picture shows a left skew with Slope=1 and relative Amplitude=0.25. Please note that skew may take part significantly in the total peak area.

Left skew's counts may be calculated by the following formula at channel *x*:

$$LeftSkew = Ampl \cdot \frac{\sqrt{\pi}}{2} \cdot Width \cdot LSAmpl \cdot \exp\left(\left[\frac{Width}{2 \cdot LSSlope}\right]^2 + \frac{x - Pos}{LSSlope}\right) \cdot erfc\left(\frac{Width}{2 \cdot LSSlope} + \frac{x - Pos}{Width}\right)$$

where

LSAmpl:Left Skew Amplitude relative to that of Gaussian (may vary from 0.0 to 0.75)LSSlope:Left Skew Slope (0.3 - 2.0)Ampl:Amplitude of GaussianPos:Position of the Gaussian centroidWidth:Gaussian width (Width = FWHM/1.66)

and erfc is the standard complementary error function.

## 8.2.3. Right skew peak function

Right skew is the third peak function, and its integral will also be summed up to the peak area. Right skew is not included by HyperLab's predecessors, but it is present in HyperLab to allow better deconvolution. It may be of great importance, because skewness on the high energy side of the peak quite frequently occurs in practice (e.g. in short time activation analysis) due to pileup effects. Right skew is very similar to Left skew which is at the low-energy side of a Gaussian, but it is mirrored to that (its flat part is on the high-energy side). Because it is originated from a convolution of a Gaussian and an exponential, which decreases starting from the Gaussian's centroid, it is an asymmetric function. Therefore when the right skew is added to a Gaussian peak, it causes slight increase at the high energy side of the peak. The fitted parameters for Right skew are the Right Skew Amplitude (relative to the Gaussian's amplitude), and the Right Skew Slope. The width of the right skew is not fitted, but assumed to be always equal to the



width of the Gaussian. The picture shows a right skew with Slope=1 and relative Amplitude=0.25.

Right skew's counts may be calculated by the following formula at channel *x*:

$$RightSkew = Ampl \cdot \frac{\sqrt{\pi}}{2} \cdot Width \cdot RSAmpl \cdot \exp\left(\left[\frac{Width}{2 \cdot RSSlope}\right]^2 - \frac{x - Pos}{RSSlope}\right) \cdot erfc\left(\frac{Width}{2 \cdot RSSlope} - \frac{x - Pos}{Width}\right)$$

where

Right Skew Amplitude relative to that of Gaussian (may vary from 0.0 to 0.75)
Right Skew Slope (0.3 – 2.0)
Amplitude of Gaussian
Position of the Gaussian centroid
Gaussian width ( <i>Width = FWHM</i> /1.66),

and *erfc* is the standard complementary error function.

## 8.2.4. Polynomial background function

Polynomial background component is able to characterize the continuous, slowly changing background under peaks.

It is implemented as a second order polynomial in the region, so constant, slanting or curved (parabolic) background may be modeled with it, freely combining its counterparts. As a background function, its area will *not* be summed up to the peak area. It may have at most three fitted parameters: Level, Slope and Curvature. The picture shows a sample polynomial background with Level=10, Slope=0.5, Curve=-0.03 parameters.



Counts from the polynomial background may be calculated by the following formula at channel *RegionPos*:

 $PolyBkg = Level + Slope \cdot RegionPos + Curve \cdot RegionPos^{2}$ 

Where

RegionPos:	Channel position within the fitted region (first channel of the region is 0)
Level:	Constant background level
Slope:	Background slope (may be positive or negative)
Curve:	Background curvature (may be positive or negative)

### 8.2.5. Step background function

HyperLab also fits regions with sharp background steps under the peaks.



This stepped background accounts for a Compton edge. Steps are fitted by one characteristic parameter, the Step Amplitude, which is relative to the amplitude of the Gaussian. The picture shows a step with relative Amplitude=0.10.

Step's counts may be calculated by the following formula at channel *x*:

$$Step = Ampl \cdot \frac{\sqrt{\pi}}{2} \cdot Width \cdot STAmpl \cdot erfc\left(\frac{x}{Width}\right)$$

where

STAmpl:Step Amplitude relative to that of GaussianAmpl:Amplitude of GaussianWidth:Gaussian width (Width = FWHM/1.66),

and *erfc* is the standard complementary error function.

## 8.2.6. Tail background function

According to the original HYPERMET concept, a slowly decreasing exponential background tailing component may also be used under the low energy side of the peaks, in order to compensate detector surface effects.



is a part of the peak.

Nowadays, however, this phenomenon seems to be less significant with the most common detectors, therefore when you perform a peak evaluation with "Default settings for moderate count rate, regular peaks" configuration, tail will be *disabled*. As tail also descends from a convolution of an exponential and a Gaussian, it is very similar to Left skew, but has much less intensity and greater slope. Important difference, however is that the tail is component of the background, while skew Therefore counts under the skew is added to the peak area, while the area under the tail only contributes to the sum of background and peak functions, which helps the nonlinear fitter to match the measured counts. The picture shows the case of Tail Amplitude=0.01 and Tail Slope=2.5 parameters.

Tail counts may be calculated by the following formula at channel *x*:

$$Tail = Ampl \cdot \frac{\sqrt{\pi}}{2} \cdot Width \cdot TLAmpl \cdot \exp\left(\left[\frac{Width}{2 \cdot TLSlope}\right]^2 + \frac{x - Pos}{TLSlope}\right) \cdot erfc\left(\frac{Width}{2 \cdot TLSlope} + \frac{x - Pos}{Width}\right)$$

where

TLAmpl:	Tail Amplitude relative to that of Gaussian (may vary from 0 to 0.01)
TLSlope:	Tail Slope (2.5 – 50)
Ampl:	Amplitude of Gaussian
Pos:	Position of the Gaussian centroid
Width:	Gaussian width ( <i>Width = FWHM/1.66</i> ),

and *erfc* is the standard complementary error function.

**Note:** If you observe significant scattering of Chi values in the peak fitting residual under the majority of the singlet peaks, and this may not be resolved by adding new peaks, it is possible that the background tail component should be enabled. This may be done either by manually enabling the component in the *Peak evaluation algorithm settings window*, or selecting another algorithm setting, where tail has been enabled previously. This is, however, may designate that your measurement set-up is improperly set or became noisy.

### 8.3. Starting the spectrum peak evaluator

A short evaluation introduction is provided in the *Quick Start Guide for Main Module* for the novice users. The following sections will detail the process of the peak evaluation. The spectrum peak evaluator may be started in two ways:

- Creating a new peak evaluation entry in the database, which does not contain any fitted peaks. In this case only the measured counts appear in the peak evaluator window.
- Loading and possibly modifying a previously created peak evaluation entry, with all of its fitted and stored region and peak parameters. All previously fitted peaks are immediately displayed in this case.

## 8.3.1. Creating a new evaluation





To create a new peak evaluation entry and start the Peak evaluator, select your measurement in the database browser tree, then click task *Create new peak evaluation* in the Tasks window.

Alternatively, you can hit the *Enter* key, after you selected the measurement node, as Enter key will always start the currently selected task.

A window appears now, which lets you create a new peak evaluation entry in the database.

The *Peak evaluation method* list should not be modified, as this is set according to the type of spectrum entries belonging to the measurement.

The *Peak evaluation settings* comprises finetuning options for the peak evaluator's algorithm. You can leave defaults in most cases, but if you regularly perform the evaluation with non-default parameters

(e.g. with enabled Tail peak component), you may select different options here.

See more details in sections "Peak evaluation algorithm settings window" and "Model functions of peak fitting".

#### 8.3.2. Loading a previously created peak evaluation

HyperLab stores peak evaluation details in its databases, together with the spectrum entries.



To load and possibly modify a previously created peak evaluation entry, open the node of the proper measurement by clicking on the [+] sign, and select the proper peak evaluation node beneath it.

Now the peak evaluator window appears. It will contain spectrum counts, as well as all previously fitted regions and peaks.

## 8.3.3. Automatically loaded entries

After creating a new evaluation, or selecting an existing one, the spectrum peak evaluator window appears. HyperLab now loads all necessary entries of the peak evaluation from the database:

- the measurement entry;
- its spectrum entries (e.g. a *Normal* and an *LFC-corrected* spectrum part in case of Dual LFC measurements);
- latest FWHM calibration for the spectrum entries;
- latest energy calibration for the spectrum entries, together with nonlinearity calibration, if that is selected by the user on the Energy calibration editor window;
- detector efficiency curve for the measurement setup, if existing. This may be used for efficiency-corrected peak area calculations in the output reports.

### Usage of latest FWHM and energy calibrations

Although you can save several independent peak evaluations for a specific measurement, when you re-load them later, the latest FWHM and energy calibration will be loaded. If you have modified these calibrations in the meantime, saving of the peak list may result in slightly different peak positions or peak fits. This way the exact reproduction of previous fitting results also requires the restoring of previous calibrations.

### Ensuring automatic loading of the efficiency curve

HyperLab is able to automatically determine which detector efficiency curve belongs to a particular measurement. If such an efficiency curve is found, it will be automatically loaded by the peak evaluator, and efficiency corrected peak list reports may be generated. To check if the efficiency analysis is successfully loaded, change to the *Messages* panel after you started the peak evaluator, and search for a message about the status of the efficiency loading. In order to ensure the automatic determination of the efficiency curve belonging to a specific measurement, you must perform the following two steps before starting the peak evaluator.

- Create a quality efficiency curve, where the relative uncertainty of the full-energy absolute detector efficiency is around the precision of your calibrated radioactive sources. For example, if you have taken measurements of absolutely calibrated radioactive sources with 1-2% activity uncertainty, then the efficiency value calculated from the efficiency curve is also expected to have 1-2% uncertainty. Store this efficiency analysis into your database.
- Assign the efficiency analysis to the measurement setup entry where the measurements were taken. Do not forget to set the validity start date. HyperLab will automatically use this efficiency calibration for all the measurements, which were taken after this validity date (and before the validity start date of the next assigned efficiency curve). When multiple efficiency curves are assigned to the same measurement setup, their validity start dates will determine the one to be applied for a specific acquisition.

#### Creating reports with efficiency corrected peak areas

Saving of efficiency-corrected peak areas may be achieved in several ways:

• Select the File / Create report menu item, and select a report template where the description of the report shows "efficiency correction".

• Select *File / Export to CSV file* menu item, and you will get a report which can be immediately loaded into a spreadsheet application.

The reports will contain the efficiency value at the energy of the peak centroid, relative uncertainty of the efficiency, as well as the efficiency corrected peak area together with its uncertainty (combined from the uncertainty of the peak area and the uncertainty of the efficiency curve at the centroid).

## 8.4. Basic parts of the evaluator window

The peak evaluator window is comprised of several re-sizable parts.



The center of the window is occupied by the **spectrum window [1]** and the **residual window [2]**. The residual window displays the difference between the measured counts and the fitted peak curves.

A **fit detail panel [3]** is placed on the right, while a fit **fine tuning toolbar [4]** and a **navigating toolbar [5]** is at the bottom. A **main toolbar [6]** is at the top of the window.

List of fitted peaks is displayed under

the *Peak details* tab.

## 8.4.1. Elements of the spectrum window

Spectrum window displays spectrum and peak evaluation information graphically.



This section describes *static* display elements as well as *dynamic* display elements, which also provide controls for quick fit manipulation. Spectrum window is basically an X-Y chart, which depicts spectrum details on

a counts versus energy scale.

### Horizontal axis of spectrum chart

Unit of horizontal axis of the spectrum chart may be either *channel* or *keV*, while its scale is always linear. Toggling between these units may be accomplished in several ways:

- Clicking on the *"keV"* or *"ch"* label on the navigating toolbar.
- Selecting the proper unit from the main toolbar's "X unit" drop-down list.
- Selecting *View / Energy scale for positions* menu.
- Pressing *Ctrl-N* keys simultaneously.

#### Vertical axis of spectrum chart

The unit of the vertical axis of the spectrum chart is always *count*, but its scale may be either *linear* or *logarithmic*. Toggling between these scaling modes may be initiated in several ways:

- Selecting the proper scaling from the main toolbar's "Y scale" drop-down list.
- Selecting *View / Logarithmic scale for counts* menu.
- Pressing *Ctrl-L* keys simultaneously.

Other axis settings (grids, tick marks etc.) temporarily may be set by selecting Edit / Edit fit chart menu, and selecting *Chart* / *Axis* tabs, then *Left Axis* item from the list. This may be helpful e.g. when special screen capture is needed.

#### Spectrum counts

At most three kinds of counts may be displayed in the spectrum window:

- *Counts to be fitted* as black squares. These are either uncorrected counts (in case of regular gamma spectra), or loss-corrected counts (in case of some Loss Free Counting method), created by some kind of compensation electronics.
- *Uncorrected variances* as gray diamonds, as found in the original spectrum file. These values hold information about uncertainties for each channel of the measured counts. For regular gamma spectra, the values are almost identical with the counts to be fitted (only a small correction is applied for very low counts). In case of Loss Free Counting methods, these are from the Dual LFC spectra's uncorrected half (e.g. for Canbera's spectra), or from a special compensated spectrum half (e.g. "ERR" spectrum half for Ortec's ERR-ZDT spectra).
- *Count variances* as gray squares. These values are computed by HyperLab, possibly by applying Westphal-correction on original variance values. This is required in some cases because the loss-corrected counts have greater statistical variance than the non-corrected ones. As HyperLab fits the corrected counts by its peak functions, proper uncertainties are required during the fit.

For everyday purposes, it is necessary only to display the counts to be fitted, and the other counts are just for checking the details when you are interested in finer details. To switch off displaying the count variances, select *View / Chart Details* menu, then remove check marks beside *Count variances* and *Uncorrected count variances* menu items.

#### Suspected peaks

Please note the red triangles in the spectrum window: these are the **suspected peaks**, whose position is determined by the help of the current FWHM calibration before the deconvolution. The peak search is performed by a zero-area square wave convolution. The final spectrum deconvolution will use these suspected peaks as an initial estimation of peak positions, when the fit model is determined.



The list of suspected peaks is always re-generated when you change the FWHM calibration. The suspected peaks are replaced by the fitted peaks after a spectrum deconvolution. Sometimes the suspected peaks remain in the spectrum window, even after a whole-spectrum automatic fit. This is because sometimes the peak search algorithm finds spurious peaks, which are not replaced with real fitted peaks by the peak deconvolution algorithm.

#### Left and right fitting threshold markers

When a spectrum is loaded into the spectrum peak evaluator, a left and a right channel threshold value is detected automatically.



the blue sign and drag it to its new position.

#### Plot of deconvoluted regions

After spectrum deconvolution is performed, fitted regions will be displayed.



The sum of background functions (2<sup>nd</sup> order polynomial background, step, tail) is drawn by green, while the sum of peak functions (Gaussian, left and right skew) and the background will be plotted by red color. The peak functions of the individual peaks are plotted by blue lines, in order to depict finer details within closely joined multiplets. *Peak labels* are displayed under the peaks with their serial

numbers, while *region labels* contain basic region information (region bounds and the reduced Chi-squared) at the beginning of the regions. These displayed items may also be configured through *View / Chart details* menu.

If you want to quickly adjust the plot to a specific fitted region, just *left-click* over it, and the spectrum chart will be immediately updated, zooming to the clicked region.

#### Left and right region bound marker arrows

At the beginning and the end of the plot of regions two *blue arrows* are displayed, which point towards the center of the region. If a region bound adjustment is needed, simply click and drag

The limits are designated by a framed blue 'X' pointing rightwards and leftwards.

The peak search algorithm will locate suspected peaks only between these outer values. In most cases, this automatic threshold determination works well, but a manual adjustment may be necessary in some very special cases.

If adjustment is needed, just click on

the proper arrow to its new place. After releasing the mouse button, an automatic fit takes place with the new bounds, and the new fit will be displayed.

#### Context-sensitive menu for fitted regions

When you right-click over a fitted region by the mouse, a context menu appears.

Its *Region info* menu item provides you a quick access to the details of the region fit. The other menu items allow a one-click fitting model manipulation, as the background and the peak skew fitting function components may be eliminated with them. This tool may lead to a trial-anderror refinement method, but it can be surprisingly effective on typical misfit situations.



If the region fit becomes significantly worse after dropping a component, just press *Undo* button on the main toolbar, and the previous fitting model will be immediately restored.

#### 8.4.2. Elements of the residual window

The residual window displays the difference between the measured counts and the deconvoluted peak curves. It is placed beneath the spectrum window, and its X axis is always adjusted according to that.

The chart shows the difference between the measured and the fitted value for each measured value with *filled green squares*, in standard deviation units. If this value is positive, then the measured count value is greater than its matching fitted count.

Due to the statistical nature of the measured counts, we never expect a perfect matching between measured and fitted counts. *Chi* value is the ideal measure of the difference, because it takes into consideration the statistical variance of each measured count value, thus shows the significance of the difference, instead



of its absolute value. On the chart, the Chi=1 limit is designated by a green dashed line, while a red dashed line shows the Chi=3 limit.

As a rule of thumb, if the absolute value of the difference is less than 1, it is considered not significant (no further improvement is required). On the other hand, if it is greater than 3, it is highly improbable that the difference is purely from the statistical scattering of counts, and closer inspection is needed in the vicinity of that channel.

The normalized sum of squared Chi values gives the *Normalized Chi-Squared* value (RXSQ, Reduced Chi-squared,  $\chi^2$ ), which describes the quality of the fit for a whole region, and
displayed in the region label at the first channel of the region. If RXSQ is significantly higher than 1.0, a manual refinement of the region fit is advisable.

### 8.4.3. Elements of the fit detail panel

The fit detail panel contains multiple tabs, which may be used to display or edit details of regions, peaks, fitted parameters or the fit history.

### **Region list tab**

The region list tab contains all the fitted regions of the loaded measurement.

ced Chi-Squared value.

	0		
۸A	Δ 🐴 🍋		The list contain
2	5.4-33.8 keV, RXSQ=2.3	*	ced Chi-Squar
34	4.6-44.3 keV, RXSQ=1.7 👘 🗍		eeu en oquu
4	2.4-49.4 keV, RXSQ=3.6		If this value is
4	7.8-72.1 keV, RXSQ=1.8		.11
70	0.2-79.7 keV, RXSQ=1.7		the region, the
79	9.7-91.3 keV, RXSQ=1.1		surromont If w
8	9.4-108.0 keV, RXSQ=2.1		surement. If y
10	04.8-119.1 keV, RXSQ=1.2		be displayed in
1.	16.4-127.2 keV, RXSQ=0.9	-	
L		·	be performed.

### Peak list tab

The region list tab contains the fitted peaks which found in the spectrum.

<u>۸۸</u>		Δ 🐴 💐	3		
#		Pos (keV)	Area		*
	1	367.590	1056		
	1	398.080	1041		
	1	410.760	2625		
	2	415.469	1325		
	1	443.503	2913		
	1	481.787	16458		
	1	511.192	1248		
	2	513.447	1473		
	1	RC2 010	1007		*
•				P	

The row contains basic information about fitted peaks (position or energy, area and its relative uncertainty). As the peaks belong to different consecutive regions, it is advantageous to group them by their regions by utilizing alternating background coloring of the rows. Active region's peaks are displayed with another different background color. If you click on a peak on this list, the selected peak's region will be displayed in the spectrum window, and a manual refinement may be performed.

The list contains the boundaries of the regions, as well as their Redu-

If this value is greater than 3, a red exclamation mark is placed beside

surement. If you click on a region in this list, the selected region will be displayed in the spectrum window, and a manual refinement may

the region, thereby designating problematic areas in the mea-

### Fit refiner tab

For advanced users, sometimes the versatile refinement tools – provided on the fine tuning toolbar – are not enough, and unconditional access is needed to the region parameters.

0	
Common FWH	4
Determination	Fitted
Fwhm	4.723
Peak #1	
Position determ.	Fitted
Position	2084.638
Ampl. determ.	Fitted
Amplitude	377.210
Fwhm determ.	Disabled
Fwhm	4.608
Peak #2	
D 12 10	mo i

The fit refiner tab may serve this purpose, as it allows enabling and disabling, as well as direct editing of fitted parameters. When you modified a parameter value, and move the cursor to

another field, the new model will be immediately drawn in the spectrum window with different colors.

If you want to reset the parameters to their initial value, just click on the original region in the spectrum window: all parameters will be restored.

The Set button will keep the edited values, so these manually edited parameters will be stored and used during reporting. The Set & fit button uses the hand-modified parameters only as an initial estimation, and performs a fit from that initial model.

The *Min/max* check box toggles the visibility of parameters' minimum and maximum boundary values. This may be very useful in case of misfits to decide if the problem is because parameters are at their boundary (e.g. when a faulty FWHM calibration may not even result a proper peak width). The *Unc.* (uncertainty) check box displays the read-only uncertainty fields for each parameter, therefore makes it possible to quickly check whether a parameter is meaningful or not.

### Fit history tab

The fit history tab is for advanced users only: it contains all estimated and fitted models for all regions. This is mainly for error tracking purposes, as it may provide information on how the fitting algorithm successively approximated the optimum solution.

### 8.4.4. Elements of the peak list panel

The peak list panel contains most important details about the suspected and fitted peaks.

The list contains Gaussian centroid position, its absolute uncertainty, its energy value together with uncertainty, peak area with absolute and relative uncertainty, fitted FWHM value and its uncertainty.

Spectrum	Peak details	Messages	Nuclide Id					
Pos (ch)	Pos unc. (ch)	) E (keV)	E unc. (keV)	Area (cnt)	Area unc (cnt)	Area unc. %	FWHM (ch)	-
111.854	0.811	30.2292	0.7006	549	274	50.0%	3.9	
147.979	0.284	39.9837	0.6554	13789	402	2.9%	3.4	
154.202	0.571	41.6639	0.6665	890	231	26.0%	3.4	
167.699	0.055	45.3083	0.6431	8700	409	4.7%	3.5	
172.018	0.157	46.4746	0.6426	3215	286	8.9%	3.5	
184.037	0.136	49.7199	0.6375	4093	328	8.0%	2.7	
187.703	0.110	50.7099	0.6357	9864	560	5.7%	2.7	
194.259	0.190	52.4802	0.6344	2436	247	10.1%	2.7	
200.149	0.157	54 0704	0.6314	3372	328	9.7%	27	Ψ.
•							4	

If efficiency calibration could be loaded automatically, then additional columns detail the efficiency value at the energy of the peak centroid, and relative uncertainty of the efficiency, as well as the efficiency corrected peak area together with its uncertainty (combined from the uncertainty of the peak area and the uncertainty of the efficiency curve at the centroid). By clicking the *Show selected peak* button, the spectrum window appears, locating the spectrum region of the selected peak.

### 8.4.5. Elements of the fit fine tuning toolbar

There are several tools on the Fine tuning toolbar to modify a region's automatic deconvolution.

- Re-fits the clicked region. Rarely used, only if you suspect that a sub-optimal (unstable) fit is found, where the optimum solution changes when you repeatedly fit the region.
- Re-fits the clicked region with automatic peak insertion. Used when a suboptimal fit is found with a missing peak, but the position of the missing peak is uncertain, and you want to delegate the job of peak position determination to the fitting algorithm.
- Inserts a peak into the region, at the clicked position. Used when a sub-optimal fit is found with a missing peak, and the position of the missing peak is suspected by the user.
  - Deletes a peak from the region, which is located at the clicked position.
- $\frac{1}{10}$  Deletes the clicked region with all of its peaks.
- Splits a region at the clicked position into two half regions.



Merges two or more regions. To use this tool, click over the first region and drag the mouse cursor to the last region to be merged (do not release the mouse button).

If you have pressed a toolbutton, but it turns out that the fine-tuning is not necessary, just press Esc key to leave the selected working mode.

### 8.4.6. Elements of the navigating toolbar

Several methods may be used to quickly select a specific region in the Spectrum evaluator. The fastest region and spectrum navigation may be achieved by the Navigation toolbar, which is located at the bottom of the spectrum peak evaluator.

	<<	Previous region button: jumps to previous fitted region.
	>>>	<i>Next region button:</i> jumps to next fitted region. To revise fitted regions one after the other, click this button repeatedly. Alternatively, you can hit the + key on your keyboard.
•	4	Scroll bar: scrolls to any spectrum region.
Jump to:	555	<i>Position edit box, Jump button, X axis unit changer</i> : quick location of a specific spectrum portion is achievable by using these positioning tools. Click the unit changer (labeled with "keV" or "ch") in order to toggle the unit of positioning between channel and energy, then enter the new position, and hit Enter key or click the green jump button to display the spectrum part around the entered position.

If you hit the *Home* key, the beginning of the spectrum will be displayed, while pressing the *End* key shows the last valuable channels.

### 8.5. Performing spectrum deconvolution

HyperLab's spectrum deconvolution processes the measured single pulse-height gamma spectrum, or two spectrum halves in case of Dual LFC corrected measurement, and produces a peak list for further evaluation. See further details in section "Model functions of peak fitting".

### 8.5.1. Performing automatic peak fit

The first step of the deconvolution is to locate the non-background regions of the spectrum, where peaks may occur. This is done by a peak search algorithm, which requires at least a rough *FWHM calibration* (Full Width at Half Maximum) for its convolution function to work.

At least an approximate *energy calibration* is also necessary, because HyperLab switches to Variable peak width method in the vicinity of the 511keV annihilation peak – and naturally for calculating exact peak positions in energy units.

Therefore it is always advisable to check the validity of the calibrations before the deconvolution process.

### Checking the FWHM calibration

To display current FWHM calibration, select the *Calibration / FWHM* calibration menu item. Now the FWHM calibration editor window appears.

For a quick calibration check, click *Chart* tab at the top.

The currently used FWHM calibration curve is displayed here together with filled green squares as FWHM calibration points. HyperLab also estimates the width of the suspected peaks, and displays these values as gray crosses.

The figure shows a case when the FWHM is totally mis-calibrated: it is too high at

low energy values, and too low at high energies. You can easily add proper calibration points by clicking on a gray cross, and then on the *Add* button. The unnecessary point also may be deleted under the tab *Calibration points and function*.

For detailed description of the FWHM editor window, see section "FWHM calibration editor".

In case of proper FWHM calibration the majority of the suspected peaks' estimated FWHM value is in the neighborhood of the calibration curve.

Please note that large deviations may occur before the deconvolution, even for valid calibration, as peaks' FWHM values are

just rough estimations and not fitted values at this time.

Much better agreement is expected after a successful fit, when FWHM values of the fitted peaks are displayed with gray triangles.

### **Checking Energy calibration**

Exact energy calibration is important for sophisticated tasks, like isotope identification. However, when only a quick peak list is required for well-known isotopes, a rough energy calibration is enough before fit.

Your energy calibration is proper for fitting if the annihilation peak is in the 509 – 513 keV range. Otherwise select *Calibration / Energy calibration* menu item, and edit the calibration points' position or energy values in order to correct them.

See further details in section "Energy calibration editor".

Please note that a finer energy calibration may only be constructed when the fit is completed, because exact, fitted peak centroid positions will be then only available.

#### Starting the automatic peak fit

Click the Autofit button or select *Fit / Start automatic fitting* menu item to initiate a fit for the whole spectrum. A progress window is displayed during the fit, listing the problematic regions, where the Reduced Chi-squared of the fit exceeds the value of 3.0.

After the automatic fit is completed, the counts of the first fitted spectrum region is displayed, along with the fitted curves. The list of the regions is also refreshed on the right, with red exclamation marks beside the problematic regions.





It is advisable to always revise all of the regions at least once, because sometimes unphysical fits provide you a region fit with satisfactory Chi-squared, but the fit may be improved further by a trained spectroscopist. To revise the regions, use the double-arrow button on the navigation toolbar repeatedly, in order to walk through all of the fitted regions.

## 8.5.2. Manual fit refinements

Although HyperLab has an outstanding quality automatic deconvolution algorithm, it sometimes results in sub-optimal region fits.

This may be due to several reasons:

- it may signal a problem with the quality of the measurement system (noisy amplifiers, improper pole-zero settings etc);
- miscalibration of the FWHM values;
- lack of a well-defined background (this may be the case when extremely complicated multiplets fitted, and no relevant background information is available);
- and naturally minor imperfections in HyperLab's complex fitting algorithm.

The following sections deal with the most frequently occurring bugs and their suggested correction methods.

### 8.5.3. Refinement: merging of improperly split regions

Sometimes HyperLab fails at the difficult task of region bound determination.



This may result in improperly split regions, especially when a multitude of peaks are involved in the fit, which are packed together very closely. In this case the fitter algorithm tries to choose a proper cutting point, and it determines it between two close peaks.

The best tool to eliminate this faulty behavior is the region merge tool.

The figure shows two such regions at channel 230.



To perform the region merge:

- 1. Click on the *Region merge* tool on the fit refinement toolbar;
- 2. click over the first region, and keep the left mouse button pressed;
- 3. drag the mouse cursor over the second region;
- 4. release the mouse button.



HyperLab joins the two split regions now, refits them and displays the result.

As you can see, the low-energy side of the region also has been moved, in order to find a more stable region background.

The reduced Chi-squared indicates another serious problem, so the peaks rightwards requires a closer inspection.

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### 8.5.4. Refinement: splitting of improperly merged regions

Sometimes HyperLab tries to join peaks into one common region, when the background characteristics are not the same under the peaks.

In this case it is advisable to split the region into two or more distinct regions.

The figure shows a region, where a split is suggested at channel 138, because the type of the background drastically changes at this point.

The best tool to eliminate this faulty behavior is the region splitter tool.



To perform the region splitting:

- 1. Click on the *Region merge* tool on the fit refinement toolbar;
- 2. click over the first region, and keep the left mouse button pressed;
- 3. drag the mouse cursor over the second region;
- 4. release the mouse button.

HyperLab splits the region now into two halves, refits them and displays the result.

The figure shows the new region bounds around channel 138. Please note that a curved background chosen in the first region, while a stepped one in the second region, therefore the overall Chi-squared became better, and the residual changed to a smoother one.



Please take a closer look at the splitting position (use the *Zoom in* tool at the main toolbar). You can see that HyperLab has automatically created *overlapping* region bounds, thus the fit stability has been greatly increased.



### 8.5.5. Refinement: Missing peaks

When automatic deconvolution determines that the quality of a region fit is not satisfactory, it tries to insert several new peaks into the region, one after the other. This automatic peak where insertion process is stopped when the quality of the fit may not be further improved.



The basis of the peak insertion is the residual, the fitting algorithm seeks for typical shapes of peaks and double peaks.

Sometimes this automatic peak insertion is not successful because in complex multiplets the insertion of a new peak does not always reduce immediately the fit's Chi-squared value.

In these cases a significant difference is shown in the residual window, requiring manual inserting of peaks.

You can choose from two peak inserting tools in this case.

- "Refit with auto peak insertion" tool performs a re-fit of the clicked region with a newly added peak, whose position is determined automatically by HyperLab. It is possible that this tool does not result is inserting a new peak, if the fit became worse than before. In this case only manually forced peak insertion may help.
- "Manual peak insertion" tool requires you to click at a specific channel where the new peak should be inserted. HyperLab always tries to keep your new peak, even if the fit became worse than before. There is one case, however, when even manual peak addition is canceled: if the peak proves to be non-significant after the re-fit, that is, its amplitude is too small in absolute value; too small compared to the background or to the amplitude uncertainty; or the peak slips too close to another peak.



After clicking at channel 277 with the manual peak insertion tool, a new peak is inserted there and a refit is performed. The manually specified peak position is not hold fixed, but fitted by HyperLab's nonlinear minimizer in the usual way. Please note that the residual has become significantly smoother, and the peaks have disappeared from it – but a closer look may reveal that possibly another peak may be added at channel 291.

Several peaks also may be inserted in one-step: hold down the Ctrl key, when you click over the channel where the first peak must be added; repeat this Ctrl-click wherever the insertion of peaks may be required, then finish the multiple selection over the last peak *without* the Ctrl key. After the last click, all the selected peaks will be added to the model, and it is re-fitted.

### 8.5.6. Refinement: adjusting improper region bounds

There may be several cases, when HyperLab's default region bound determination is considered sub-optimal by the spectroscopist.

The figure depicts a well-fitted peak, but HyperLab did not notice the change in background type after channel 305. The residual and the high Chi-squared value (3.1) designates the possible problem with the fit.

If you take a closer look at the background, you can observe the sharp changing at the right side. The modification of the background boundary is suggested in this case, so let us try to move the right region boundary leftwards.

Click on the blue arrow at the right boundary of the fitted region, and drag it to its new position, e.g. to channel 305.

When you release the mouse button, HyperLab modifies the fit model, performs a refit and displays the new region.

Chi-squared value shows the better fit. If you look at the left side of the region, you will notice that the same problem of changing background may occur there, so it is worth a try moving the left region limit to channel 288. After that change, the Chi-squared may be even lower, and non-random tendencies will mostly disappear from the residual.

The region's right bound has changed, and also a

different background function is used. The improved

If you are not satisfied with the results, just click the *Undo* button, and your previous fit will be restored.

### 8.5.7. Refinement: dropping unnecessary peak parameters

After HyperLab found an optimum model for the fitting problem, it eliminates unnecessary (insignificant) fitting parameters. Basis of the elimination may be too small value, too small value compared to its uncertainty etc.







#### Spectrum peak evaluator



Sometimes this logic does not drop parameters which are unnecessary for a good fit, and user intervention will be required – or simply two models fit well to a specific region, and the spectroscopist would choose a model which was not preferred by the automatic fitter. The figure shows a region where the algorithm chooses a significant step for the background, but one can suspect that another model without a step would also fit well to the measured counts. To eliminate the step parameter from the region's fitted model, right-click the region. A popup

menu appears now, providing the parameters that may be eliminated. Choose *Drop Background Step* menu item.



HyperLab now eliminates the step, refits the region and displays the new fit. The Chi-squared value increased (from 1.1 to 1.3), showing why the automatic fitter inserted the step previously.

### 8.5.8. Refinement: manual modifying of the fit model

This example shows manual modifying of the fit model by utilizing the fit refiner tab.



This alumina spectrum has a region where HyperLab fitted a background curve (2<sup>nd</sup> order member of the background polynomial), and completely eliminated the slope (1<sup>st</sup> order member). If you are curious if the fitted curve is necessary, or it may be replaced by a slope, follow the steps below:

- switch to the fit refiner tab,
- change *Bkg curvature* to "disabled";
- change *Bkg slope* to "enabled";
- click Set & fit button.

When you manually modify a parameter of the fitted region (and change to another editor field), HyperLab automatically displays the new model with a different color scheme. This way you can immediately check the new model. This is, however, only a visual representation, and the entered data is not used elsewhere until you click one of the *Set* or *Set & fit* buttons.

As a new fit is required now, the *Set & fit* button should be clicked, therefore the manually set values are used only as an initial estimate for the fit.

After the fit, the new model is displayed with a background slope instead of a curve. Chi-squared changed from 1.8 to 4.3, so in this case the experiment showed that the slope is a worse parameter to fit the background than the curve.

Click Undo button to restore the previous fit now.





## 8.6. Peak evaluation algorithm settings window

This form contains all settings required to tailor the peak evaluation algorithm to your needs. It is available either from the database record editor of the peak evaluation algorithm setting records, or from the peak evaluation module. Use the tabs at the top of the form to switch to a specific settings category. About peak fitting functions, see "Model functions of peak fitting".

### 8.6.1. Generic tab

ieneric	Background	Peak width	Peak skewness	Advanced	
Peak s	earch threshold	s			
	For spect	trum peaks:	3	sigma	
	For resi	dual peaks:	3	sigma	
Region	bound determin	nation			
	Max No. of in	nitial peaks:	10		
F	legion extending	g for peaks:	3.5	x FWHM	
Regio	n bound extend	ing for bkg:	1.25	x FWHM	
Automa	atic peak insertio	on			
			🛽 Enable automati	peak insertion during refit	
	Max peak ins	ertion trials:	5		
	Minimum peak	amplitude:	5	counts	
	Peak insertion	R×SQ limit:	0.5		
Automa	atic curve, tail, s	tep disabling			
		5	🖊 Disable curve, ta	il and step for 'small peak-only' regions	
	Small peak am	plitude limit:	500	counts	
Evalua	tion cut-off				
	Start eval	uation from:	0	keV	
		N	lote: this is a globa	setting (applies to each algorithm settings entry).	

The generic tab contains most commonly changed generic evaluation algorithm settings.

### Peak search thresholds

For spectrum peaks

Peak search sensitivity within the spectrum. Default value is 3.0.

#### For residual peaks

Peak search sensitivity within the residual. Default value is 3.0.

### **Region bound determination**

Max No. of initial peaks

Contains the upper limit for the number of peaks used to set up an initial region for the fit. Default value is 10.

### Region extending for peaks

Region bound limits where peaks merged into an initial region. Expressed as a multiplier for current FWHM. Default is 10.

### Region bound extending for kg

Left and right wing for region, used for background determination. Expressed as a multiplier for current FWHM. Default value is 1.25.

### Automatic peak insertion

Enable automatic peak insertion during refit

Determines if peak evaluator will try to improve the fit automatically by inserting new peaks to the region's most probable locations and run a refit. Default value is Enabled.

Max peak insertion trials

Maximum number of peak insertion trials. Default value is 10.

Minimum peak amplitude

No fitted peak amplitude is allowed to be less than this value (in counts). Default value is 5.0 counts.

Peak insertion RXSQ limit

Lowest reduced Chi-squared value for the fit when refit takes place. Default value is 0.5.

#### Automatic curve, tail, step disabling

Disable curve, tail and step for 'small peak-only' regions

Disables unnecessary peak parameters in case of regions where only small peaks may be found. Default value is Enabled (that is, disabling is in effect).

Small peak amplitude limit

Maximum peak amplitude where a peak is considered to be 'small'. Default value is 500 counts.

#### Evaluation cut-off

#### Start evaluation from

Minimum peak evaluation energy value in keV, where the automatic evaluation starts. Helps to get rid of disturbed low-energy regions for routine evaluations.

### 8.6.2. Background tab

The background tab contains settings for background components under regions.

	evaluation arg	orithm settings			
Generic	Background	Peak width Pea	k skewness 🛛 Advanced		
Polynom	nial background	components			
<b>V</b>	Background le	vel enabled			
<b>V</b>	Background sl	ope enabled			
<b>V</b>	Background cu	urvature enabled			
Backgro	ound step				
1	Background st	ep enabled			
Backgro	und tail funder	low-energy side of	(nasko)		
Dackgio	Deckground to	il on shlad	poaksj		
	I all amplitude	(rel. to peak ampli	tudej		
	Minimum:	1E-10	Maximum: 0.01		
	Tail slope (acl	tual value)			
	Minimum:	2.5	Maximum: 50	Ir	nit. value: 2.75
			🕜 <u>H</u> elp	I 💙 01	K 🛛 🔀 Cancel

It affects the polynomial background, the step under peak centroid as well as the long background tail on the low-energy side of the peaks.

#### Polynomial background components

Background level enabled

Zeroth order component of polynomial background function. Almost always fitted. Default value is Enabled.

Background slope enabled

First order component of polynomial background function. Default value is Enabled.

#### Background curvature enabled

Second order component of polynomial background function. Default value is Enabled.

#### Background step

Background step enabled

Step function which jumps under the peak centroid. Default value is Enabled.

#### **Background tail**

#### Background tail enabled

If enabled, peak evaluator tries to fit a long, skewed background function under the low energy side of the peak, which also contributes to the fit also far away from the peak centroid. As this phenomenon is observable mainly for older detectors only, it is disabled by default. The bigger is the tail, the less is the area of the peaks in the region. Default value is Disabled.

#### Tail amplitude minimum

Lower limit of tail amplitude, relative to peak amplitude. Default value is 1e-10; should not be less than this value.

#### Tail amplitude maximum

Upper limit of tail amplitude, relative to peak amplitude. Default value is 0.015; should not be higher than this value.

Tail slope minimum

Lower limit of tail slope. Default value is 2.5; should not be less than this value.

Tail slope maximum

Upper limit of tail slope. Default value is 50.

Tail slope initial value

Value of tail slope used initially when starting a region fit. Must be between Minimum and Maximum values. Default value is 2.75.

### 8.6.3. Peak width tab

The peak width tab contains settings regarding the fitted FWHM of the peaks.

tings				
Peak skewness Ad	lvanced			
od				
bd				
0.7	× initial FWHM			
1.3	x initial FWHM			
0.7	x initial FWHM			
Maximum: 4 x initial FWHM				
🔽 Enable variable pea	k width around 511 keV			
5	keV			
0	Нер 📀 ОК	😣 Cancel		
	ttings h Peak skewness Ac od od 07 1.3 0.7 4 V Enable variable peal 5 V	tings         h       Peak skewness         od         od         0.7       x         1.3       x         0.7       x         1.3       x         0.7       x         0.7       x         0.7       x         0.7       x         x       initial FWHM         0.7       x         x       initial FWHM         V       initial FWHM         V       Enable variable peak width around 511 keV         5       keV		

#### FWHM fitting method

#### Common peak width method

Fits one common FWHM value for each peak within a region. This is a proper setting for most regions, where FWHM does not change significantly. The common FWHM setting significantly speeds up fitting, and results in very stable fits.

### Variable peak width method

Fits FWHM individually for each peak within a region. This is rarely selected, when users experience problems due to broadening peaks. Variable FWHM setting significantly slows down fitting, and may result in erroneous fits, because peak width may vary from extremely narrow to extremely wide. However, this is required when one region contains peaks with very different FWHM values, e.g. annihilation peaks with regular ones. The Common peak width method is the default.

### Common peak width limits

### Minimum

Low limit for FWHM for 'Common peak width method'. Relative value to that of calculated from current FWHM calibration.

Default value is 0.7 (FWHM is allowed to variate -30% below the current FWHM value).

### Maximum

High limit for FWHM for 'Common peak width method'. Relative value to that of calculated from current FWHM calibration.

Default value is 1.3 (FWHM is allowed to variate +30% above the current FWHM value).

### Variable peak width limits

#### Minimum

Low limit for FWHM for 'Variable peak width method'. Relative value to that of calculated from current FWHM calibration. Default value is 0.7 (FWHM is allowed to variate -30% below the current FWHM value).

#### Maximum

High limit for FWHM for 'Variable peak width method'. Relative value to that of calculated from current FWHM calibration. Default value is 4.0 (FWHM is allowed to reach 4 times the current FWHM value - for extremely broadened peaks).

### Automatic annihilation peak fitting

#### Enable variable peak width around 511 keV

Automatically switches to 'Variable peak width method' around the 511.0 keV annihilation peak. Default value is Enabled.

#### Peak energy tolerance

Specifies the energy tolerance relative to 511.0 keV, where automatic switch should take place. Default value is  $\pm$  5.0 keV.

### 8.6.4. Peak skewness tab

The peak skewness tab contains settings for fits that control skewness of the peaks.

🖉 Peak evaluation algo	orithm settings				
Generic Background	Peak width Peak s	kewness Adv	anced		
Left skew (on low-energ	gy side of peaks)				
📝 Left skew enab	led				
Left skew amp	litude (rel. to peak a	mplitude)			
Minimum:	1E-10	Maximum:	0.5		
Left skew slop	e (actual value) —				
Minimum:	0.3	Maximum:	2	Init. value:	0.5
Right skew ena	abled	amplitude)			
hight skew an	ipiltude (rei, to peak	amplitudej		_	
Minimum:	1E-10	Maximum:	0.5		
Right skew slo	pe (actual value) —				
Minimum:	0.3	Maximum:	2	Init, value:	0.5
l					
		0			<b>A a b</b>

It contains two panels: one for skew on the low-energy side of the peak (left skew), and one for the high-energy side of the peak (right skew).

### Left skew (on low-energy side of peaks)

#### Left skew enabled

If enabled, the peak evaluator tries to incorporate a relatively sharp peak function into the low energy side of the peaks, which decreases rapidly close to the peak centroid. This peak function is able to describe the slight broadening of the Gaussians' left bottom. The area of the left skew is also added to the reported peak area. Default value is Enabled.

#### Left skew amplitude minimum

Lower limit of Left skew amplitude, relative to peak amplitude. Default value is 1e-10; should not be less than this value.

#### Left skew amplitude maximum

Upper limit of Left skew amplitude, relative to peak amplitude. Default value is 0.75.

Left skew slope minimum

Lower limit of Left skew slope. Default value is 0.3.

Left skew slope maximum

Upper limit of Left skew slope. Default value is 2.0; should not be less than this value. Left skew slope initial value

Value of Left skew slope used initially when starting a region fit. Must be between Minimum and Maximum values. Default value is 0.5 .

### Right skew (on high-energy side of peaks)

#### Right skew enabled

If enabled, the peak evaluator tries to incorporate a relatively sharp peak function into the high energy side of the peaks, which decreases rapidly close to the peak centroid. This peak function is able to describe the slight broadening of the Gaussians' right bottom. The area of the Right skew is also added to the reported peak area. Default value is Enabled.

#### Right skew amplitude minimum

Lower limit of Right skew amplitude, relative to peak amplitude. Default value is 1e-10; should not be less than this value.

Right skew amplitude maximum

Upper limit of Right skew amplitude, relative to peak amplitude. Default value is 0.75 <u>Right skew slope minimum</u>

Lower limit of Right skew slope. Default value is 0.3.

Right skew slope maximum

Upper limit of Right skew slope. Default value is 2.0; should not be less than this value. <u>Right skew slope initial value</u>

Value of Right skew slope used initially when starting a region fit. Must be between Minimum and Maximum values. Default value is 0.5.

### 8.6.5. Advanced tab

The advanced tab contains settings to fine tune the nonlinear fitting algorithm.

Peak evaluation algorithm settings			- • ×
Generic Background Peak width Pea	ik skewness Advanced		
Iteration stopping criteria for fitting			
Max iteration count:	150		
Minimum RXSQ value:	0.05		
Minimum gradient change:	1E-6		
Min. line search derivative change:	1E-6		
Min. line search RXSQ change:	1E-6		
	🕜 <u>H</u> elp	🛛 📀 ок	🔇 Cancel
			-

Change the defaults with caution, as improper values may lead to sub-optimal deconvolution process.

### Iteration stopping criteria for fitting

Max iteration count

Upper limit for number of iterations for nonlinear fitter. Default value is 300. Less than this value may cause non-optimal fit results.

#### Minimum RXSQ value

Lower limit for reduced Chi-squared, when nonlinear fitter should quit unconditionally. Default value is 0.05 (this is almost never reached).

#### Minimum gradient change

Lower limit for gradient value change. If the gradient of fitted parameters changes to less than this value between iterations, then iteration will be stopped. Default value is 1e-9 (should not be greater than 1e-6).

Minimum line search derivative change

Lower limit for derivative value change. If the derivative of fitted parameters changes to less than this value between line search iterations, then iteration will be stopped. Default value is 1e-5.

### Minimum line search RXSQ change

Lower limit for reduced Chi-squared value change. If the reduced Chi-squared changes to less than this value between line search iterations, then iteration will be stopped. Default value is 1e-6.

### 8.7. Peak area and area uncertainty calculation

From HyperLab version 2005, a fine-tuned peak area uncertainty calculation method is applied, which is described in this section.

### **Objective function for fitting**

During the spectrum fitting, we try to fit a sum of peak, skew and background functions to the measured counts. The standard Chi-Squared used as a merit function for the goodness of fit:

$$F = \sum_{j=1}^{n} \frac{(Count_j - Y_j)^2}{\operatorname{var}(Count_j)}$$

where

Count <sub>j</sub>	Measured count in the j'th channel of the region
var(Count <sub>j</sub> )	Variance of the measured count at j
$Y_j$	Sum of peak and background functions at j
п	Number of channels in the region

### Calculation of the peak area

If the fit reaches a minimum, peak area is calculated from the actual values of the fitted and/or fixed parameters:

 $\overline{Area} = GAmpl \cdot GWidth \cdot \sqrt{\pi} \cdot (1 + LSAmpl \cdot LSSlope \cdot GWidth + RSAmpl \cdot RSSlope \cdot GWidth)$ 

where

GAmpl	Gaussian Amplitude
GWidth	Gaussian width (FWHM / 1.6651)
LSAmpl	Left Skew Amplitude
LSSlope	Left Skew Slope
RSAmpl	Right Skew Amplitude
RSSlope	Right Skew Slope

### 8.7.1. Uncertainty of fitted parameters

After the fit, also M, the inverse of the covariance matrix of the fitted parameters is computed:

$$M_{kl} = \sum_{j=1}^{n} \left( \frac{1}{\operatorname{var}\left(Count_{j}\right)} \cdot \frac{\partial F}{\partial p_{k}} \cdot \frac{\partial F}{\partial p_{l}} \right)$$

Inverse of M (the covariance matrix) contains the variances and covariances of the fitted parameters:

$$\operatorname{cov}(p_{k}, p_{l}) = (M^{-1})_{kl}$$
  
 $\operatorname{var}(p_{k}) = (M^{-1})_{kk}$ 

where

M <sup>-1</sup>	covariance matrix (inverse of M)
$cov(p_{k'}p_l)$	covariance between parameters $p_{\text{k}}$ and $p_{\text{l}}$
var( p <sub>k</sub> )	variance of parameter p <sub>k</sub>

### 8.7.2. Uncertainty of Peak Area

Variance of the area is computed by a standard error propagation method. This method is well known, and provides the overall uncertainty of arithmetic expressions, which in turn depend on other uncertain values themselves.

The calculation incorporates

- the uncertainty of the fitted parameters, and
- the dependence of the peak area on the individual uncertain parameters

$$\operatorname{var}(Area) = \sum_{k,l} \frac{\partial Area}{\partial p_k} \cdot \operatorname{cov}(p_k, p_l) \cdot \frac{\partial Area}{\partial p_l}$$

where

var(Area)variance of peak area $\frac{\partial Area}{\partial p_k}$ partial derivative of the peak area by fitted parameter  $p_k$ 

According to our Monte-Carlo simulations, this approximates the real peak area uncertainties very well.

You are able to check this calculation using

- the covariance matrix of the fitted parameters, which may be displayed in HyperLab for each region by the "File / General info" menu in HyperLab's Peak evaluator module,
- and calculating the partial derivatives of the Peak Area using the following expressions:

Fitted parameter	<u>∂ Area</u>
(p <sub>k</sub> )	$\partial p_k$
GAmpl	$GSig \cdot (1 + GSig \cdot (LSAmpl \cdot LSSlope + RSAmpl \cdot RSSlope)) \cdot \sqrt{\pi}$
GWidth	$GAmpl \cdot (1 + 2 \cdot GSig \cdot (LSAmpl \cdot LSSlope + RSAmpl \cdot RSSlope)) \cdot \sqrt{\pi}$
LSAmpl	$GAmpl \cdot GSig^2 \cdot LSSlope \cdot \sqrt{\pi}$
LSSlope	$GAmpl \cdot GSig^2 \cdot LSAmpl \cdot \sqrt{\pi}$
RSAmpl	$GAmpl \cdot GSig^2 \cdot RSSlope \cdot \sqrt{\pi}$
RSSlope	$GAmpl \cdot GSig^2 \cdot RSAmpl \cdot \sqrt{\pi}$

### 8.7.3. Comparison with conventional Peak Area calculation method

In most cases, other gamma spectrometry applications calculates the uncertainty of the peak are based on the following model:

$$\sigma_s = \sqrt{G + \left(\frac{N}{2n}\right)^2 (B_1 + B_2)}$$

The model assumes a singlet peak, where a linear background region lies beside the peak, both on the left and the right sides, with

 $\sigma_s$  uncertainty in peak area

- *G* gross counts under the peak (background + peak counts)
- *N* number of channels under the peak
- *n* number of channels both on the left and right sides
- $B_{1}$ ,  $B_{2}$  background counts on the left and right side

This approach is more or less valid, however if too narrow background region is used, the uncertainty estimations will be unnecessarily high, as this is the case of most evaluation software.

HyperLab is superior to this simple method due to the followings:

- intelligently extends the region as far as possible, thus minimizing the uncertainty
- its uniform calculation expression may be applied to every region, even for multiplets (in spite of different expressions used for singlet and multiplet cases, as can be seen in other applications)
- may take into consideration a complex (curved and/or stepped) background
- takes into consideration of the reliability of the fit (due to the partial derivatives of the fitted parameters at the minimum).

Although HyperLab applies a very different (but otherwise standard) method for peak uncertainty calculations, the calculated values agree very well with other applications, if comparable fitting situations regarded.

#### Calculation example

A typical fit of a small peak can be seen on the figure below, which contains a singlet-peak fit.



The reference uncertainty equation and HyperLab's uncertainty calculation method approximately serves the same 44% area uncertainty value. This shows that the two formulas results in nearly identical results under the same conditions.

HyperLab could reproduce this fit only after manual interventions, as it uses much wider background region during the automatic fit:



In comparison, HyperLab's automatic fit results in 27% area uncertainty for peak No. 3 (the same peak as in the previous example). This lower value can be explained by the followings:

- a much wider the background region utilized,
- thus the nonlinear fitter founds a minimum with greater confidence,
- therefore the uncertainty of the fitted parameters will be smaller,
- so the uncertainty value of the peak area will also be significantly lower.

# 9. Visual Nuclide Identification

HyperLab has a powerful quantitative isotope identification module, which is reliably identifies a large set of nuclei found in its nuclear database, determining activities of isotopes with overlapping peaks, while presenting the results in an exceptionally enjoyable visual manner. This utility is also able to perform the identification on virtually any kind of gamma-spectrum producing phenomenon, e.g. prompt-gamma activation reactions, if the gamma intensity ratios are constant within a component to be identified.

### Nuclide identification results

In HyperLab, the result of the nuclide identification is a list of activity concentrations or intensities for each component determined.

**Components** in HyperLab terminology may mean any kind of material, which provides a gamma line set with fixed relative intensities. The most common component is the radioactive decay. Other example would be any kind of gamma-producing reaction, e.g. the prompt-gamma capture, where the intensity ratios of the individual gamma lines are also constant within a capture reaction.

HyperLab's important concept is to **fit the activity of all components together** for a spectrum, and not activities at the individual components or spectrum peaks. Thus you will not see averaged activities calculated individually for each spectrum peak, just one common activity value, which is fitted to all of the peaks of all component at once.

Beside the activity concentrations, **MDA values** are also computed for gamma lines and for each component.

### Requirements for nuclide identification

- Well-calibrated measurement. In HyperLab's present version, only one measurement can be used for nuclide identification at a time. That measurement should have a relatively precise energy calibration, thus creating and using a nonlinearity curve is strongly recommended.
- **Efficiency curve.** An absolutely calibrated efficiency curve is a requirement, if you want to get absolute component activity values in kBq (this is the case almost every time). If you have only relative efficiency curves, the nuclide identification can be performed, too, but the resulting values will be only dimensionless intensities.
- **Nuclear data.** In case of decays, its is already in the database upon initializing. For prompt-gamma (or other, reaction-based) identification, you should import the reactions to your database. We are providing a default PGNAA library in the form of textual representation of reaction data, which can be installed by the user. These serve also an example for user-creatable reaction libraries.

## 9.1. Performing nuclide identification

We are demonstrating the capabilities of the nuclide identification module on the sample spectrum of the 226Ra source, named RA37076A.

- Please make sure that you have created a proper nonlinearity curve (for precise energy values) and a proper efficiency curve from the sample measurements.
- Also make sure that you have designated the your efficiency curve as a default for the measurement setup where it was taken. See details in section "Designating a proper efficiency curve as a default".



it, which can be freely modified.





To start nuclide identification, open the measurement node of RA37076A, select the peak evaluation under it.

When you double-click on it, the peak evaluator tries to open it. However, it was already used in nonlinearity as well as efficiency analysis, and that made it read-only. This is why a warning message window appears now.

As we possibly want to refine the deconvolution results by the help of the nuclide identification, it is advantageous to skip the loading of that read-only peak evaluation, and create a clone of

To clone the peak evaluation, select it on the left, and click on the task *Make a clone* on the right pane. After a few seconds, a second peak evaluation appears under the measurement. As the peak evaluations ordered from the newest to the oldest by default, select the upper one for processing (if you are in doubt, check the date of the last modification on the upper right pane).

Open it with the peak evaluator by a double-click.

After the peak evaluation loaded, please immediately go to the Messages panel, and check that if the efficiency analysis is loaded automatically for the measurement. This is indicated in the last a message line. If this is not the case, please close the peak evaluator, and follow the steps of the section "Designating a proper efficiency curve as a default" to create such an assignment. Select *Option / Nuclide identification* menu now, to check current settings.

Under *Radiation libraries* tab, you can select which radiation libraries should be involved in the nuclide search. At the bottom, it is possible to select one from the user defined nuclide exception lists.

For a regular decay measurement, it is not needed to modify these default settings.

🗾 Nuclide identification options 📃 🗖 💌				
Radiation libraries Efficiency Activity & MDA Advanced				
Use the radiations in these librarires for identification				
Default INAA quantitative gamma library     Default INAA calibration gamma library     Default PGNAA quantitative gamma library     Default PGNAA calibration gamma library     Default INAA background gamma library     Default PGNAA background gamma library     Supplement for INAA gamma library     Supplement for PGNAA gamma library				
Nuclide exception list				
<no exception="" list="" nuclide="" used=""></no>				
🗸 DK 🔀 Cancel				

Under the second tab, Efficiency, click on the 'Automatic efficiency selection from meas. setup' item.

If you properly set up your efficiency curve – measurement setup assignment earlier, then the efficiency curve will be immediately displayed at the bottom, which is belonging to the loaded measurement.

### Now click OK.

This efficiency setting will be retained for next sessions, so the nuclide identification will be even more convenient next time.

Now the nuclide identification module loads the nuclear data necessary for the evaluation.

Please wait until the message disappears, then select *Nuclide Ident. / Start identification* menu.

Now the nuclide identification starts, which may last just a few seconds on a reasonable fast computer.

After the identification, the computed spectrum of the fitted nuclei will be displayed graphically.

As you walk through the fitted regions of the spectrum, you can see the result of the simulated spectrum.



📶 Processin	ig, please wait
Progress:	
Status:	Loading 1252 decay radiations for 'Default INAA calibration gamma library'
	Stop
<u> 7</u> Processin	ig, please wait
Progress:	

Stop

The following display elements will be used:

- The deconvoluted peak curves are remained in red, the virtual peaks computed from the nuclide identification displayed in magenta color.
- The deconvoluted background is green, while the background from nuclide id is displayed in lime color.
- Individual peaks in a multiplet are blue, but the same peaks from nuclide id is displayed in grayish-green.
- The difference values in the residual window are green rectangles for the spectrum fit, and lime for the nuclide identification fit.



This region contains 214Bi and 214Pb lines, and two lines were in a properly separated multiplet.

In this region, you can immediately observe the followings:

- The energy calibration is well defined. This is imminent as peaks from the nuclide identification always placed at the location of the library energies, while the spectrum peaks are drawn at the fitted channel content, and there is a very good agreement in the peak centroid positions.
- The efficiency calibration seems to be OK, as the intensities (amplitudes) of the nuclide id and the deconvoluted peaks are practically the same.
- HyperLab's nuclide id is easily able to resolve multiplets originating from the same or from different nuclei.

### Creating a nuclide identification report

Creating a report with all of the nuclide identification results requires no different action then in case of regular peak reporting: just select File / Create report menu, and the regular peak list report will also contain the results of the nuclide identification

## 9.2. Refining nuclide identification results

As identification of components is not an easy task, fully automatic analysis is not always achievable, thus manual intervention is regularly necessary to improve the results.

### **Checking Nuclide identification details**

To see the details of the nuclide identification, click to tab Nuclide Id.

On the left, the components listed which has been included in the final activity fit. On the right, there is the list of all possible components (those where at least some of the gamma lines are found in the spectrum).

At the left side, there are two main groups under the *Determinables* (components which has meaningful lines): the *Single components*, where the activity of a decay could be determined



could be determined on its own; and the *Component groups* at the bottom of the list, where the tightly coupled, highly correlated components can be found.

Node of each component can be opened by a double click on its name, and all the searched radiations are listed under it. If a library gamma found in the spectrum, it is designated by a colorful gamma photon sign. If no spectrum peak was found at its place, a pale icon is drawn, and the "Bkg" prefix is used. In this latter case, the amount of missing counts is also displayed which would be required at the point of the missing peak, but not found.

Regardless of the status of the radiation node, double-clicking it opens the *Spectrum* tab, and jumps to the position of the clicked line.

### Removing an unnecessary nuclide

HyperLab provides two methods for removing a component (decay) from the analysis:

- Select the component on the leftside list on Nuclide Id page, the click on the arrow button, which points from left to right.
- If you are noticing the presence of an unnecessary nuclide on the Spectrum pane, right-click over its



superfluous peak, and select the 'Remove isomer from Nuclide Id' menu, and pick the component to be removed.

This latter method can be demonstrated on the region which is shown on the picture: the isomer 71Zn is unnecessary, but automatically could not be removed, as it overlaps with 511keV annihilation peak, and the 389keV peak of 214Bi.

Right-click over it and remove from the nuclide identification fit.

#### Adding back an improperly removed component

If a necessary component has been removed from the Nuclide Id fit some way, and appears on the list of the *All possible components*, just select it, and click the arrow button pointing to the left. Thus the abandoned component will be included in the nuclide list again, and a nuclide identification re-fit occurs.

#### Energy calibration shift



rarely the case.

### Non-fitted spectrum peak found by Nuclide Id



When a slight difference can be observed in the position of the virtual peaks (displayed by the nuclide identification module) and the measured peaks, probably there is a small energy calibration problem. Update your calibration, by adding this peak to the energy calibration points, and check if the nonlinearity part of the calibration is in effect. There is a small chance, too, that the nuclear data is not perfect, but this is

Due to statistical nature of the measured counts, the spectrum peak deconvolution algorithm sometimes misses a peak. In several cases, those peaks are pointed out by the nuclide identification algorithm, as it utilizes the information from all peaks of the nuclide.

The picture shows the case when a small 214Bi peak is missed by spectrum analysis, but the nuclide identification found it.

Insert the missing peak manually to the region, and re-run nuclide identification.

### Problem with the nuclear data



In some very rare cases, the nuclear libraries are not perfect: may contains errors for the energy positions or the intensities of library peaks. One such example can be seen on this figure. As we see that while intensities and the positions of other 214Bi peaks are properly matching the measured peaks, there is a true outlier at 1416keV. This is probably comes from an intensity problem in the original nuclear data.

## 9.3. Common problems during nuclide identification

Although nuclide identification is very straightforward with HyperLab, there are a few typical issues which can be easily addressed by the following tips.

### Improper energy calibration

If you experience a poor quality nuclide identification, please always check if

- the linear energy calibration is properly done, and
- you are applying a nonlinearity calibration beside the linear one.

### Improper efficiency curve selected

In case of the peak intensities of the nuclear library shows large deviations from the fitted peaks, always check that you are using the proper efficiency calibration curve, that is, which is prepared for the same measurement setup, and it is created more or less at the time when your measurement was taken.

## 9.4. Algorithm of the nuclide identification

The following sections describe the individual steps taken by the nuclide identification algorithm.

### Loading of basic data

In this phase we are collecting all the information necessary for the actual nuclide identification. These include

- Peak list, which contains the spectrum peaks to be identified. Every peak has energy, energy uncertainty, area and area uncertainty values.
- List of searched components.
- Radiations belonging to the component. Every radiation must have energy, energy uncertainty, intensity, intensity uncertainty values.
- Detector efficiency curve.

### Preliminary search and filtering of peaks and components

The process of matching of peaks and library lines is the following:

Searching for all radiations, which may belong to a spectrum peak. This is done by searching of radiations, where the uncertainty region around the radiation energy, E<sub>rad</sub> overlaps the uncertainty region around the peak energy, E<sub>peak</sub>. The uncertainty region is ESigMult \*PeakEUnc for the peak, and ESigMult \*RadEUnc for the radiation. The EsigMult is an uncertainty multiplier, its value is 4 by default.

This search process gives a very broad list of matching radiations, purely by the energies.

• Calculating the 'spectroscopic strength' value, which is a normalized sum of the PeakInt \* Efficiency values. This gives a rough descriptive number about the presence about the important library lines for each component. If the spectroscopic strength is below a threshold value (10% by default), the component will be skipped from the further analysis.

- Peak merging: the algorithm now merges together the peaks whose distance is less than MaxFwhmContract \* FWHM channels (default MaxFwhmContract=1.5). This is because the identification is much more robust, if the unnecessarily splitted doublets are joined again, and their summed areas will be splitted by the nuclide identification algorithm.
- Determination of component clusters. If no overlapping peaks exist between two components, then their activities may be determined independently, thereby reducing the computation time and increasing stability. Similarly, overlapping detection introduced for component clusters (a set of components), not just single components, which can be identified quantitatively in an independent way.

### Fitting intensities of components

- If a peak is not found in the spectrum at the position of a library line, a virtual peak created. Its area assumed to be zero, while its area uncertainty is computed from the efficiency curve, the FWHM and the actual background under the missing peak. This way a missing peak is also takes part in the activity fit of the component.
- Together with the activity fitting, the correlation is also determined between the components of the cluster. If two component shares at least one spectrum peak, then they are correlated. If the correlation is very high, exceeding MaxCompCorr value (it is 0.99 by default), then we treat the two or more components non-distinguishable. An example would be two nuclei, both having only one significant gamma line at nearly the same energy. In this case, no independent activities may be calculated purely from the spectrum, by any means. In this case, we collect these highly-correlated components into component groups, and determine them together.
- Another fitting performed on the linear equation system, which tries to describe the measured spectrum peaks and also accounts for the background under the missing peaks.
- Checking if all of the spectrum peaks is well-described by the sum of the counts originating from the components' gamma lines. If there is significant difference between the peak area and the sum of library line intensities for a peak (significance threshold is 4 by default), then we re-fit the problem by allowing large discrepancy at that peak.

### Final nuclide identification steps

- Checking the fitted activities of the components. In case unphysical values (zero or negative activities), dropping the component in question, and performing the fitting again.
- Filtering the final component list by the activity uncertainties: if that is higher than a threshold value (35% by default), then the components dropped, and a re-fit is performed. The components then sorted by the uncertainties of their activity values.

# 10. Batch spectrum evaluation

HyperLab provides more automatic spectrum evaluation tools, which are able to silently evaluate several measurements each after the other, with minimum user intervention. This makes it possible to perform the routine spectrum evaluation in a semi-automated way, and may speed up the work of the gamma spectroscopist.

## 10.1. Database batch evaluator

The database batch evaluator is a special peak evaluation tool of HyperLab Main Module. It is able to automatically evaluate several measurement entries stored in the database, each after the other.

### 10.1.1. Using of Database batch evaluator

To use the Database Batch Evaluator, open the project in Main Module where your spectra are stored.

Click on *Measurements* node under the project, then select *Batch evaluation* task.



Now an evaluator window appears, listing all measurements assigned to this project. Check the list if it is really required to evaluate all spectra. If a measurement is to be skipped, un-check it.

Measurements Calibrations Output Ad-	vanced Skipped	
Meas, name	Meas. setup	Channels ^
D4 kal. 2002. okt. 1 [CS96147A.DAT]	D4 Setup 70keV - 3.3Mev, d=25cm	8192+8192
D4 kal. 2002. okt. 1 [EU80297A.DAT]	D4 Setup 70keV - 3.3Mev, d=25cm	8192+8192
📝 D4 kal. 2002. okt. 1 [MN01041A.DAT]	D4 Setup 70keV - 3.3Mev, d=25cm	8192+8192 👻
•	III	P -
	Select <u>a</u> ll	Select <u>n</u> one
Counts o	f selected measurement	
0 1,000 2,000 3,0	00 4,000 5,000 6,000	7,000 8,000

#### Batch spectrum evaluation



Change to *Calibrations* tab. Set the source of calibrations according to your measurement environment. It is possible to use either the measurement's calibration or an arbitrary one from another measurement.



18% - D4 kal. 2002. okt. 1 [CD01043A.DAT]
 Please wait until spectrum evaluation finishes.
 Progress: Region 167 - 202 refining: RXSQ = 7.13
 Details
 INFD: Comment:
 INFD: Energy calibration's title: Energy cal from CD01043A.DAT
 INFD: Energy calibration's title: Energy cal from CD01043A.DAT
 INFD: Energy calibration's title: Energy cal from CD01043A.DAT
 INFD: Function Static: Every HM calibration's title: Every HM calibration's title: FVHM calibration's title: FVHMM calibration's title: FVHM calibration's title: FVHM calibra

😢 Stop

Specify evaluation output options under *Output* tab.

You can save results into the database; as well as generate textual reports or Sampo files for post-processing.

Do not forget to set the folder where your report files will be saved.

You may also specify some other settings under the *Advanced* tab.

Click the *Evaluate* button to initiate batch evaluations.

A new page appears now, displaying the overall progress of the batch as well as detailed messages for the last few measurement evaluation.

When evaluation finishes, press *Close*.

## 10.2. Spectrum file batch evaluator

The spectrum file batch evaluator is a standalone utility of the HyperLab System. It is capable of automatically evaluating more than one spectrum *files*, each after the other.

This utility does not require usage of HyperLab databases, as it operates on simple spectrum files, and its results are also saved into disk files. If you want to use batch evaluation for measurements stored in a HyperLab database, or you want to refine the fits manually, consider using Database batch evaluator instead.

## 10.2.1. Using of Spectrum file batch evaluator

Start the utility by selecting *HyperLab* 2014 / *Batch Evaluator* 2014.1 from your Start menu. The evaluator dialog appears now.

HyperLab - Batch spectrum	evaluator - [Batch 1]			
<u> Ile W</u> indow <u>H</u> elp _ ₽ ×				
Add spectrum files, set evaluation parameters accordingly, then press Evaluate.				
Spectrum files Eval settings	Calibrations Reporting Misc			
	Counts of selected spectrum file			
	0			
Counts Details				
Help     Evaluate     Science				
Select a spectrum file for evaluation				

Click on *Add...* button under Spectrum files tab.

A file open dialog appears now.

Select your spectrum files to be loaded, which will be listed at the left side of the utility.

👸 HyperLab - Batch spectrur	n evaluator - [Batch 1]		
<u> [ile W</u> indow <u>H</u> elp	_ & ×		
Add spectrum files, set evaluation parameters accordingly, then press Evaluate.			
Spectrum files Eval settings	Calibrations Reporting Misc		
BA85211B.DAT COD0111B.DAT EU80297B.DAT	Counts of selected spectrum file		
	0 2,000 4,000 6,000 8,000 Counts Details		
Close			
Select a spectrum file for evaluation			

#### Batch spectrum evaluation

<u>File</u> <u>Window</u>	Help _ B
Add spectrum hi	es, set evaluation parameters accordingly, then press Evaluate.
Spectrum files Eva	settings Calibrations Reporting Misc
- Loss Free Counting	J (LFC) settings
Spectrum type:	Dual LFC spectrum files 🔹
⊻ariance corr.:	Westphal's corrector
	Determine file type automatically from spectrum, if possible
Peak evaluation alg	jorithm
<u>S</u> etting file:	109\Measurement System Settings\PeakEvalSettings_Default.hlab 🛛 🤌 🍟
<u>C</u> urrent settings:	Default settings for moderate count rate, regular peaks 🔹 🗸 🚽



Change settings under Eval settings tab.

Most important is to correctly set the type of spectra: '*Common gamma spectrum files*' or '*Dual LFC spectrum files*'.

You can also set calibrations on Calibrations tab, if it is missing from the spectrum files. It is also possible to abandon spectrum files' calibration values, and import common energy and FWHM calibration values from text files.

👸 HyperLab - Batch spe	ctrum evaluato	or - [Batch I	L]	
👩 File Window He	lp		-	_ & ×
Add spectrum files set evaluation parameters accordingly, then press Evaluate				
	, or and a down			
Spectrum files Eval settings Calibrations Reporting Misc				
Generic reporting settings	:			
<u>O</u> utput folder:	C:\Users\HLUs	ser4\Docume	ents	<b>&gt;</b>
Note: specify an absolute	path. If you leav	ve the box er files.	npty, report will be saved	d beside the spectrum
Browseable reports				
Save in <u>R</u> TF format				
Save in <u>T</u> XT format	Save in <u>T</u> XT format			
Content template:	Peak list			•
Formatting style:	Default HyperL	ab Report SI	yle	•
Post-processing reports				
🔽 Save in <u>S</u> ampo-90 P	'TF & SPE forma	at		
Report charts				
<u>F</u> it chart size:	800 x	400	pixels	
<u>R</u> esid. chart size:	800 x	150	pixels	
Help     Evaluate     Close				

Set reporting options under Reporting tab. HyperLab is able to create reports in the following format:

- Sampo-90 \*.ptf and \*.spe files
- Plain text files (\*.txt), using HyperLab's report templates.
- Formatted Rich Text report files (\*.rtf), using HyperLab's report templates.

Do not forget to set the output folder of your reports, otherwise the report files will be created into the folder of the spectrum files.

HyperLab's report templates are contained in separate files, and can be edited, created, deleted by the user. Rich Text Files also may

contain pictures of the fitted regions, revealing the fine details even for a batch evaluation. Please select an appropriate report template if you want to check your fits also with region pictures. You can set miscellaneous options under Misc tab. You can set the folder of log files here, which is used by HyperLab when creating log files for the batch evaluation.

🗊 HyperLab - Batch spectrum evaluator - [Batch 1]				
💋 <u>F</u> ile <u>W</u> indow <u>H</u> elp _ 🛛 🗙				
Add spectrum files, set evaluation parameters accordingly, then press Evaluate.				
Spectrum files Eval settings Calibrations Reporting Misc				
Logging				
✓ Save batch log				
Log file folder: C:\Users\HLUser4\Documents\HyperLab\HyperLab2009\Lo				
☑ Delete log files older than 60 days				
Progress info				
Show charts during fitting (slow)				
Velp				
Start batch evaluation of selected spectra				

Press *Evaluate* button to start the batch. HyperLab now evaluates all of the selected spectrum files, and creates report files as well as log files about them.

During evaluation, you can minimize the utility and work with other programs.

After the end of the batch, click *Close* to finish the evaluation.

🗊 HyperLab - Batch spectrum evaluator - [COD0111B.DAT]	- • •
💋 <u>F</u> ile <u>W</u> indow <u>H</u> elp	_ 8 ×
Please wait until spectrum evaluation finishes.	
Batch progress:	
Spectrum progress: 📻 Region 5783 - 5879 refining: RXSQ= 0.97	
Details	
2011-01-30T19:51:43 INFO: Measurement ID: -1	*
INFO: Measurement name: D4 kalibr. hagyomanyos rendszerrel 2002. okt. 8 [COD0111B.DAT]	
INFO: Short format name: AccuSpec INFO: Comment:	
INFO: Energy calibration's title: Energy cal. from COD0111B.DAT INFO: Energy calibration: F, key = Ch * 0.27 + .0.138	
INFO: EWHM calibration's title: FWHM cal. from COD0111B.DAT	
INFO: Acquisition start: 2002 Oct 07, 16:17:00.000	
INFU: Acquisition end: 2002 Uct 08, 05:17:00.000 INFO: Livetime: 46800.000 sec	E
INFO: Truetime: 46800.000 sec	
INFU: Spectrum part inro: 2 parts INFO: Type of part#1: 2 (LFC corrected gamma spectrum)	
INFO: Type of part#2: 1 (Normal HPGe gamma spectrum)	
INFU: Min cnt: 0, max cnt: 739114, sum cnt: 62906134 INFD: Variance corrector applied: Westphal's corrector + HyperLab zero-	
count variance adjustment	- 😣 <u>S</u> top
Start batch evaluation of selected spectra	
Start Datch evaluation of selected specifia	.11

# 11. Advanced database manipulation

Although HyperLab utilizes relational databases as primary data storage method, there is no need to interact with its raw data in the course of your daily work. There are cases, however, when an advanced user requires direct access to the data contained in HyperLab databases. As the following sections will contain several database diagrams, we provide a quick overview of database terminology and the database diagrams used within HyperLab documentation.

## 11.1. Database structure basics

Relational databases use a strict, well-defined hierarchy for data storage and retrieval.

### Databases

The database is at the top level: it is a standalone entity encompassing all data that may be in connection to each other by any means.

Databases contain several data tables (e.g. Nuclide, Spectrum and Peaklist tables).



### Data tables

Database tables consist of a header and *data rows*, and each row has exactly identical inner structure. Data rows are also called *records* in database terminology.

NUCLIDE_ID	Α	Z	Symbol
51124	124	51	124Sb
51125	125	51	125Sb
52126	126	52	126Te

This figure contains a small part of the Nuclide table. Several data records are contained, and each row describes a unique Nuclide entity. Records may be queried, updated, inserted or deleted in a data table.

### Data fields

A record comprises of several *fields*. All records in a table must have fields of identical name and data type. For example, a Nuclide record contains the following data fields:

Field name	Field value	Type of field value
NUCLIDE_ID	51124	integer
А	124	integer
Z	51	integer
Symbol	124Sb	string

The values of the data fields may be queried or updated individually in a record, if the record is identified by its primary key (see below), and the field is identified by its name.

### Primary keys

*Database management systems* are required to retrieve, insert and delete records efficiently. To accomplish this task, each record must be unique, that is, must be identified unequivocally within a table. For identification purposes, one or more field values are used together, thus forming an identifier, or *primary key*.

For example, unique identifier of the nuclide table is a special field named NUCLIDE\_ID. As it is declared unique, the database management system guarantees that duplicated NUCLIDE ID will never be kept in the Nuclide table.

Please note that the A, Z field combination also would have been used as a primary key, but a single primary key was chosen because of its simpler usage.

## 11.2. Database diagrams

Database diagrams provide information on database tables, fields, and logical relationships between tables.

The rectangular objects with heading depict *database tables*, where the heading **NUCLIDE NUCLIDE NUCLIDE NUCLIDE**."NUCLIDE").

The rows under the heading list the *data fields* in a specific table (e.g. "A" or "Z" means mass number and proton number for a specific nuclide.



The graphical symbol before the field name shows additional information about a field.

- Regular data field.
- Primary key data field; all primary keys together will uniquely identify the record.
- Foreign key data field; references to a record of another table.
- ✓ One-to-many relationship; depicts that many records of the second table may have reference to the same record of the first table.

In our example this means that more nuclear level entries may refer to the same nuclide.

## 11.3. Nuclear data structure in HyperLab databases

HyperLab databases contain nuclide, nuclear level, isomer, decay and radiation information.



For diagram legend, see section Database diagrams.

HyperLab's nuclear data tables are the following:

Contains basic information about a nuclide (isotope). Its primary key
is the NUCLIDE_ID, which is composed from the mass number and
proton number.
E.g. nuclide with NUCLIDE_ID=51124 is 124Sb.
Describes one nuclear level of a given nuclide. Contains level energy
and lifetime information, and refers to its belonging nuclide.
E.g. level with NUCLEVEL_ID=511240002 is the E=10.86 keV level of
124Sb with HALFLIFE=93 sec.
Describes one specific isomer level (a nuclear level with practically
significant life time). Contains a symbol for that isomer (e.g.
"124Sb_m1"). Refers to the nuclear level which it belongs to. At most
one isomer level may belong to a specific nuclide level.
E.g. ISOMER_ID=511241 refers to the isomer level of 93 sec
mentioned before.
Describes one decay which starts from an isomer level. Also contains
a descriptive name for that decay, e.g. "124SB IT DECAY (93 S)".
Zero, one or more decay may belong to a specific isomer.
E.g. DECAY_ID=5112410 is the isomer transition, and
DECAY_ID=5112411 is the $\beta$ - decay, both originating from the same
93 sec isomer of 124Sbm1.
Describes one radiation for a decay (or for another nuclear event).
Contains energy and intensity information, and refers to its parent
decay.

	E.g. RADIATION_ID="D05112411000001" is the 602.72 keV radiation
	of the 124Sbm1 isomer's β- decay.
RadUsage	This table contains radiation usage flags. One RadUsage record
	designates if a specific radiation may be used for a given task in
	HyperLab.
	Usage types include "Energy calibration", "Efficiency evaluation" etc.
	About their manipulation, see more details in Nuclear data library
	management.

## 11.4. Nuclear data library management

HyperLab inserts significant amount of nuclear data into each HyperLab database during the installation. This section describes the most important database editing tools regarding nuclear data. See also detailed information in section Nuclear data structure in HyperLab databases.

### 11.4.1. Editing radiation usage flags

HyperLab makes it possible for you to decide if a radiation may be used for a particular purpose, e.g. for energy calibration, efficiency determination and so on. This is achieved through the radiation usage flags, which can be conveniently edited on the given radiation's property page.

In our example we show a method that is applicable to permanently disable the 443keV lines of 152Eu isotope for efficiency calibration purpose (these lines are improper for efficiency determination purposes because the level scheme results in two overlapping 443keV peaks).

### Locating the given radiation

Open your database in Main Module.

Double-click on *Nuclear and component data* node, then select *Nuclei, decays & radiations*. The list of nuclei is displayed now.

To quickly locate a given nuclide, click a nuclide node, e.g. "1H", then quickly start typing the symbol of the searched isotope. In our case, type "152". The data browser now locates the first nuclide with the typed mass number.


HyperLab Main Module - user HLUser4, instance #1 on WORK           Eile         Options         Help           Image: Select state stat	KSTATIO   Ected item: Radiation (4 iks, 0 sub-item) Id: D0631520000039 Energy: 443.9650 keV +0.003 Intensity: 2.83 +0.81 %  asks Sub-items Radiation properties New Radiation Delete Radiation entry Create report	Double-click on <i>152Eu</i> node, the open its 13.5-year <i>152Eu</i> isomer and its <i>152Eu EC decay</i> . If you check the list of radiations, you can observe the two 443-keV gamma lines of this EC decay. Click the first 443-keV radiation in the list, and select <i>Radiation properties</i> task at the right. The radiation's property editor window
		appears now.

#### **Editing radiation**

You can see the various usage types at the bottom of the radiation property editor window.

Selected radiation - pg 1 Select	ted radiation - pg 2	More radiation entries				
RADIATION ID	D06315200000039					
RADIATION TYPE	G					
ENERGY	443.965	1	œV +-	0.003	ke∀	
INTENSITY	2.829994		+-	0.02299718		
DECAY	152EU EC DECAY (1	3.537 Y)			-	11
REACTION					-	11
TRANSFORM. CHAIN					-	11
TRANSITION					-	1
RADIATION USAGE	▼ Energy calibration         ▼ Fwhm calibration         ▼ System nonlinear         ▼ Detector efficient         ▼ Detector resolut         ▼ Quantitative ant         ▼ Background calibration	on nrity calibration ncy calibration ion determination alysis oration				
	🕜 Help	🥝 ок		🔇 Cancel	Sil Ap	ply

If a check mark can be seen beside a specific usage type, then this radiation will be used for that selected purpose. Remove the check mark beside "Detector efficiency calibration".

When you click this check box, the change will be immediately stored in the database, and next time the efficiency analysis module will not use this radiation.

Click OK, and repeat this editing for the other 443-keV line.

### 11.5. Importing data into external applications

HyperLab databases contain all the data resulting from peak evaluations and various measurement system analyses. This section contains an example of the retrieval of such information. First create an ODBC data link for your database, if it is not created yet. See "Creating an ODBC data source" for further details.

#### 11.5.1. Importing peak lists

This example shows the importing of a specific peak evaluation into Microsoft Excel.

- 1. First vou have to know the PEAKEVAL ID number of the peak evaluation for which you want to query the evaluated peaks. You can find it as "Id" in the Detail lister window of the Main Module, when you click on the peak evaluation data node at the left. In this case the Peak Evaluation Id is 3717.
- 2. Start Microsoft Excel and select its *Data / Get external* data / New database query menu.

Select the ODBC alias you have created previously. Make sure that the *Query Wizard* check box is checked at the bottom, and click OK.

- Excel Files\* MS Access Database\* Browse. Mu HuperLab databas Options. 2 Se the Query Wizard to create/edit queries Connecting to data source. SQL Server Login х Data Source: ΟK My HyperLab database Use Trusted Connection Cancel Login ID: sa Help
- 3. Microsoft Excel tries to connect to the database, and displays an SQL Server login dialog box. For default HyperLab installations, un-

check the Trusted connection check box, and type your user name "sa" as well as the password. Default password for HyperLab 2014 product line is "Hlpwd2014" (in case of an upgrade, try

hlpwd2002, hlpwd2005, hlpwd2008, hlpwd2009 or Hlpwd2013). Click OK when you are ready.

Password:

Options >>





#### Advanced database manipulation

Query Wizard - Choose Columns 🛛 🔀
What columns of data do you want to include in your query?
Available tables and columns: <u>C</u> olumns in your query:
■ FEAK
PEAKEVALCALPARAMLIST
Preview of data in selected column:
Preview Now     Options     < Back     Next >     Cancel
Query wizaro - Hiter Data
Filter the data to specify which rows to include in your query.
Column to filter: Only include rows where:
PEAKEVAL_ID equals 3717
POSUNC   And  Or
E EUNC
AREA C And C Or
GAUSSFWHM GAUSSFWHMUNC V
2 <back next=""> Cancel</back>

- 4. The Query Wizard appears now, where you can select the data table from which the data to be imported. Select PEAK table from the list of tables at the right, then click on the arrow button (">") pointing to the right, in order to add all fields of PEAK table to the list of queried fields. When you are ready, click *Next*.
- 5. Now the very important filter window appears. Here you can select a small subset of the records from the huge amount of peaks stored previously in the database. Filtering is performed via specifying a filter condition on the field values of the peak record. Only those peak records will be selected where this condition is met. In our case the condition requires that the peak evaluation of the peaks equals to

3717. To specify this condition, select *PEAKEVAL\_ID* field on the left, "*equals*" operator at the middle, and type in "*3717*" to the value field. When you are ready, click Next.

Query Wizard - Sort Order 🛛 🗙	
Specify how you want your data sorted. If you don't want to sort the data, click Next.	
Sort by       E <ul> <li>Ascending</li> <li>Descending</li> <li>Then by</li> <li>C Ascending</li> <li>Descending</li> <li>Tester diagonal</li> <li>Then by</li> <li>Then by</li></ul>	
<u>Back Next</u> Cancel	

6. At the next step you can specify the sorting criteria. In our case it is advisable to select the energy field "E", which sorts the peaks of a specific peak evaluation by their peak centroid. When you are ready, click *Next*.

Query Wizard - Finish		×
What would you like to do next?		
Beturn Data to Microsoft Excel	<u>S</u> ave	Query
○ View data or edit query in Microsoft Query		
C Create an OLAP Cube from this query		
	< <u>B</u> ack Finish	Cancel

7. At the last step of the Query Wizard, simply click Finish button in order to return the queried data to Microsoft Excel.

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8. Excel's worksheet displayed again, requiring you to specify a destination for the queried data. Specify the target location, and click *OK*.

Microsoft Excel - Book1							
Bile Edit View Insert Format Tools Data Window Help							
□ ■ 目 昼 国 ジ X 階 電 ダ ロ・ロ・ 優 Σ fx							$\Sigma f_{\pi}$
	A1		-	=			
		A	В	С	D	E	F
1	[						
2		Detu	ning Eutowa	al Data to I	dieve ee ft Eu	col	2 1
3		Retur	ning extern	iai Data tu i	MICROSOIC EX	LEI	كن
4		When	e do you wan	it to put the c	lata?	ОК	
5		Θı	Existing works	sheet:			
6		, in the second se				T Cano	el
7	7 =\$A\$1						
8	8 C New worksheet Properties						ies
9		0	PivotTable rep	port		Paramet	erc
10						Faramet	ci sini
11							

9. Finally, the retrieved data is displayed in Excel, where further processing may be performed on it.

Microsoft Excel - Book1						
	<u>File E</u> dit <u>V</u>	jew <u>I</u> nsert F <u>o</u> rma	at <u>T</u> ools <u>D</u> ata	<u>W</u> indow <u>H</u> elp		
	🛩 🖬 é	🗿 🖪 🖤 👗	🗈 🛍 💅 🕨	n • 🖂 • 📢	Σ <i>f</i> ∗ 2↓	👬 🛍 🚯 10
	L32	▼ =				
	A	В	С	E	G	Н
1	PEAK_ID	PEAKEVAL_ID	POS	E	AREA	AREAUNC
2	247619	3717	82.69	33.63	1910	202.9
3	247620	3717	85.82	34.91	20119	374.0
4	247621	3717	87.95	35.78	5685	259.4
5	247622	3717	110.13	44.87	2014	831.3
6	247623	3717	120.87	49.26	870	227.6
7	247624	3717	123.57	50.37	1322	317.0
8	247625	3717	125.89	51.32	1919	466.8
9	247626	3717	130.49	53.20	28015	1478.9
10	247627	3717	154.22	62.92	1227	432.3
11	247628	3717	171.16	69.86	4468	471.3
12	247629	3717	190.44	77.75	94235	14076.8
13	247630	3717	194.95	79.60	46462	1406.6
14	247631	3717	198.41	81.01	720000	4049.0
4 -	0.17000		000 74	100.01	15100	005.7

## 12. Database maintenance

The following sections describe the common tasks regarding HyperLab databases.

#### **Generic information**

HyperLab installs the Microsoft SQL Server database management software component by default.

HyperLab databases are kept in disk files, containing all measurement and evaluation information used by the spectroscopist. These database files are installed in your "My documents \ HyperLab \ Databases" folder by default.

These are the data files which contain your data, and you need a continuously running server application, which provides these data in a structured manner to every application that requires them. This is the Express Edition of Microsoft's SQL Server, which is installed as a service application for Windows 2000 systems and above. These service applications are started automatically by Windows upon the boot process, even if no user is logged in to the computer. This way a properly installed and configured SQL Server application is ready to serve remote requests when the computer is switched on, so no special actions are needed on computers which are used as a central HyperLab database server.

### 12.1. Database creation

It is necessary to create new HyperLab databases when

- you start using HyperLab, or
- it is advisable to separate measurement and evaluation information into two or more independent databases. This latter scenario is used e.g. when two spectroscopists work independently of each other, and keep their work separately; or when an institute working on two unrelated research fields.

To create a new HyperLab database, follow the instructions below.

en click Next.

Click *Local database server* node, then on the task *Create a database*. Database creating wizard appears now. Enter login name **sa** and password for the database administrator.

Note: Default database server password is Hlpwd2014 for the HyperLab 2014 product line (after an upgrade, you may also try hlpwd2002, hlpwd2005, hlpwd2008, hlpwd2009 or Hlpwd2013).

When you are ready, click Next.

Specify the name of the new database, then click *Next*.

An automatic database creation process is started, which also incorporates the copying of large amount of nuclear data to the new database. The process may take several minutes. When the copying

🔐 Creating a HyperLab database	_ 🗆 ×
Canadia and a second second statement and initial distance and in the state of the state of the state	
Specily parameters for new database and initialization data, then click next.	
New database name: HyperLab1	
Location of new database: C:\Documents and Settings\HLUser3\My Documents\HyperLab\ 😥	
Existing databases:	
Initialization data	
Basic data file:  C:\Documents and Settings\HLUser3\My Documents\HyperLab\ 📂	
Nuclear data file: 🖾 Documents and Settings\HLUser3\My Documents\HyperLab\ 💋	
< Back Next > Close	
Creating a HyperLab database	_ 🗆 ×
Database successfully created at the local database server. Click Finish to close wizard	
Messages:	
Documents\HyperLab\Databases\HyperLab1.mdf' created successfully	
xxxx Database 'HyperLab1' successfully opened xxxx Creating database tables	
*** Tables successfully created *** Basic data file successfully opened	
*** Inserting basic data records	
*** Opening nuclear data initialization file	
*** Inserting nuclear data records 532 nuclides and 531 decays will be stored	
*** Nuclear data for 532 nuclei successfully stored	
*** Nuclear data records successfully inserted	

<u>F</u>inish

### 12.2. Database registration

process ends, click Finish.

When you create a new HyperLab database, SQL database server will be its owner. However, sometimes HyperLab will not be aware of this new database without *registering* it. During registration, an entry is created in the file *My Documents* \ *HyperLab* \ *HyperLab2014* \ *RegisteredDatabases.xml*, which will direct HyperLab to display the database in the Main Module's database browser tree, under *HyperLab databases* node. In order to register a newly created local database, follow the steps detailed below.

< <u>B</u>ack

• Click on the *HyperLab databases* root node in the database browser tree of the Main Module, then click *Register a local database* task from the Tasks window.

\$	Selected item: Databases (2 tasks_0 sub-item)
Elocal Database Server	
	Taska Cut iteral
	📖 Register a local database
	😣 Register a remote database

#### Database maintenance

🊜 Registering a local HyperLab database	_ 🗆 ×
Specify login name and password for the local database server, the Next.	n click
MSSQL login name: sa MSSQL password:	
< <u>B</u> ack <u>N</u> ext > <u>C</u> l	ose

🖁 Registering a local HyperLab database	
Specify database name, then click Next.	
Database name: HyperLab1	
< <u>B</u> ack <u>Next&gt;</u>	<u>C</u> lose

• The local database registering wizard appears now. Enter a valid database user name and password, then click *Next*.

• Select a local database that is not currently registered, then click *Next*.

🐕 Registering a local HyperLab database 📃 🗖 🗙
Local database successfully connected. Please change its description, if needed, then click Finish to register it.
Description: HyperLab1 database on local machine
Additional info:
Database name: HyperLab1 Database server: WORKSTATION3 Database server version: 8.00.760 Database server level: SP3 Database server edition: Desktop Engine Database server collation: SQL_Latin1_General_CP1_CI_AS
< Back Next > Einish

- If the selected database is accessible on the local database server, you can specify a description for the database. This description will be displayed in Main Module's database browser tree, under *HyperLab databases* node. Also some attributes of the local database server are displayed.
- When you are ready, click Finish.

📶 HyperLab Main Module - user HLUser4, instance #1 on WORKSTATION... 👝 💿 💌

### 12.3. Database backup

Regular backup of your working environment is essential if you want to avoid a dreaded data loss accident. Fortunately, as HyperLab stores every important piece of information in a database, this is reduced to just two simple steps:

back up the database,

ļ

move the single backup file to a safe location. This must not be on the same computer!

<u>File Options H</u>elp

To initiate a backup, select Database Server item on the left, the click the task Backup a database on the Tasks pane.



Do not forget to copy your database backup file to a safe place (e.g. to a DVD) ! Do it immediately after you performed a backup, otherwise it is pointless.

### 12.4. Restoring a database from backup

Database backup files has essentially two usage in case of HyperLab:

- Protect your precious measurement and evaluation data against being destroyed,
- Provide a simple mean to transfer your complete work from one workplace to another.

The process of taking a previously created HyperLab backup file, and turn it back to a usable database called *Restore*.



*Database Server* item on the left, the click the task *Restore a backup* on the Tasks pane.

To initiate a database restore, select

🖉 Restoring a HyperLab database from	backup 🗖 🗖 💌
Specify login name and pass	word for the database server, then click Next.
SQL Server name:	.\MSSQLHYPERLAB
MSSQL login name:	sa
MSSQL password:	•••••
	< Back Next > Close

Specify database user name and password, and click *Next*.

<u> @</u> Restoring a HyperLab d	atabase from backup		
Select database backup file and specify name of new database to be created from backup file, then click Next.			
Backup file name:	rLab\Database Backups\HyperLab	o1_2011-01-30-22h04m19.hlbup 😥	
New database name:	HyperLab1Restored	]	
Folder for new database:	C:\Users\HLUser4\Documents\Hy	vperLab\Databases\ 🔗	
Existing databases:	HyperLab1	Note: specify a name for the new database which is not currently exists.	
	< <u>B</u> ack	<u>N</u> ext > <u>C</u> lose	



Select the backup file by clicking on the folder icon at the right.

The *New database name* contains the name of the database that will be created from that backup file. You are not allowed to specify an existing database, otherwise it would be overwritten.

If you are satisfied with the restore parameters, click *Next*.

After acknowledging an information window, restore process starts. Finally a dialog appears, showing the status of the restore operation. Click Finish to close the window. After you registered the new database in your HyperLab application, you can start using it.

### 12.5. Configuring remote access

Please note that a newly installed SQL database server will not be accessible from the network unless you enable TCP/IP networking protocol for the SQL Server application. This is due to security reasons: virtually every remotely accessible service may lead to a system compromise. **Note:** If you are using a database only from the same computer – in other words, you are using 'Local database' topology – you *should not* enable remote connections.

#### Enabling TCP/IP networking protocol for the SQL Server

If you want to enable remote HyperLab Main Module instances to connect to you database server, enable its TCP/IP networking protocol by performing the following steps:

Please start SQL Server Configuration Manager manually from the start menu to configure network protocols. Start this utility by click on Start / All Programs / Microsoft SQL Server 2008 R2 / Configuration Tools shortcut. This requires Administrator privileges.

When the configuration utility starts, open the SQL Server Network Configuration node on the left, then click on Protocols for MSSQLHYPERLAB item.

Check at the right if the status of the *TCP/IP* is *Enabled*. If this is the case, then the database server is accessible from other computers via TCP/IP networking, so you can skip the further steps.

If the status is Disabled, then right-click on it, and select Enable. A message will pop up, notifying you about that an SQL Server restart is required to the changes coming into effect.

To restart SQL Server, click SQL Server Services at the left, then right-click over SQL 

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 HyperLab
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 Maintenance
 Computer

 Microsoft SQL Server 2008
 Computer

 Import and Export Data (32-bit)
 Configuration Tools

 SQL Server Configuration Manac
 Devices and Printers

 SQL Server Installation Center
 Default Programs



a Sql Server Configuration Manager		
<u>F</u> ile <u>A</u> ction <u>V</u> iew <u>H</u> elp		
SQL Server Configuration Manager (Local)         SQL Server Services         J. SQL Server Network Configuration (32bit)         ■ Protocols for MSSQLHYPERLAB         ● E. SQL Native Client 10.0 Configuration (32bit)	Name SQL Server (MSSQLHYPERLAB) SQL Server Agent (MSSQLHYPERLAB) SQL Server Browser	State Running Stopped Running ►

Server (MSSQLHYPERLAB) on the right. Choose Restart from the popup menu, and wait until it completes.

You can access your HyperLab databases from other computers now.

#### Enabling communication through firewalls

As a networked SQL Server accepts TCP/IP requests through the network, it requires appropriate network ports opened on your firewall. For default installations, the **TCP port 1433** should be enabled.

**Note:** Opening a port on your firewall poses severe threat to your computer system. Open the port only for the computers on your LAN, and only if remote access is really required.

See http://support.microsoft.com/kb/841252 for details.

### 12.6. Database upgrade

The inner structure of the HyperLab databases is rarely changing with newer versions of HyperLab, and these minor changes are transparent for different HyperLab versions – that is, the HyperLab 2002, 2005, 2008 and 2009 branches are able to use the same databases.

However, from HyperLab 2009, advanced database functions are introduced – for example the P/T (peak-to-total) analysis. These new functions of HyperLab require at least the 2009.1 version database.

Several bug fixes and serious *speed enhancements* (e.g. significantly shorter saving times in peak evaluation module) are also incorporated in the 2005 or 2008 version of databases, so it is always advisable to upgrade at least to this format.

You are not required to create a new database in order to utilize these new functions, as HyperLab Main Module provides you with a Database Upgrade tool, which is capable of performing these changes in-place.

To upgrade your database to a newer version, please follow the steps below:

1. Always create a backup of your database before the upgrade. This way you will not suffer any data loss should the backup operation fail.



🏭 Upgrading a HyperLab database	
Please wait until database version number updated, then cli	ck Finish.
Version updade log:	
Performing database version update Database succeesfully updated to version 2005.2	×
< Back Next >	Einish

- 1. Start HyperLab 2014, and open the database you want to upgrade. Please note that the version of the database is displayed at the right panel.
- 2. Select *Upgrade database* task. A wizard page appears now. The upgrade information panel contains the possible upgrade steps. Click *Next*.
- 3. Please wait while the database upgrade is in progress, then click Next, and Finish on next page. When you open your database next time, it will correctly indicate the new version number.

### 12.7. Moving databases between computers

HyperLab makes it possible to transfer all your data in your databases from one computer to another. There are plans to implement an export – import utility, which will be able to transfer standalone data items between databases, but it is not implemented yet: only complete databases may be transferred.

There are basically two methods for transferring databases between computers:

- **Backup** the database and restore it on another computer. This way one single backup file is created, which can be easily transferred to another computer where it is restored as a new database. This is the preferred method.
- **Detach** and attach database files from the local database server. This method makes it possible to make a copy of the \*.MDF (data) and \*.LDF (log) files of the database and transfer it to another SQL Server. Use this method only if backup fails.

### 12.8. Detaching and attaching databases

When a database is used by SQL database server, it is locked: you are not able to even view into it, nor make a copy of it. This is due to data protection reasons. Detach operation will break the link between the database server and data files, while attach will rebuild this link again.

#### Detaching database files

You can detach a database from the database server, and this way it will stop using it. Now you can make an exact copy of the database, or delete the database files, if these become unnecessary.

- 1. To detach a database from the server, click Local Database Server icon at the left, then select *Detach a database file* task from the right.
- 2. A detach wizard appears. Enter 'sa' database administrator name and your password to local database server, then click *Next*.

Note: Default database server password is Hlpwd2014 for the HyperLab 2014 product line (after an upgrade, you may also try hlpwd2002, hlpwd2005, hlpwd2008, hlpwd2009 or Hlpwd2013).

💯 Detaching a HyperLab database		
Specify login name and password for the database server, then click Next.		
SQL Server name:	.\MSSQLHYPERLAB	
MSSQL jogin name:	sa	
MSSQL password:	•••••	
< <u>B</u> ack	Next > Close	

#### Database maintenance

💋 Detaching a HyperLab database	- • •
Select database to be detached from server, then o	click Next.
Database to detach: HyperLab1	
< <u>Back</u> Next>	Close

3. A database selection page appears now. Select the database you want to detach, then click *Next*.

 Detaching a HyperLab database

 Database file successfully detached from database server.

 Click Finish to close wizard.

 < Back</td>
 Next >

4. Click Finish to close the wizard.

#### Attaching database files

If you have a previously saved data file – log file pair, you can attach them to your local database server. After attaching, the server always search them at the specified location. Therefore, it is not advisable to attach files residing on removable media, e.g. on a USB key or a network drive.

🎒 Attaching a HyperLab databas	e	- • •
Specify login name and p	assword for the local database	e server, then click Next.
SQL Server name:	.\MSSQLHYPERLAB	
MSSQL login name:	sa	
MSSQL password:	•••••	
	< <u>B</u> ack	<u>N</u> ext > <u>C</u> lose

To attach a database to the SQL database server, click Local Database Server icon at the left, then select 'Attach a database file' task from the right.

A detach wizard appears. Enter 'sa' database administrator name and your password to local database server.

**Note:** Default database server password is 'Hlpwd2014' for HyperLab 2014 product line (in case of an upgrade, you may also try hlpwd2002,

hlpwd2005, hlpwd2008, hlpwd2009 or Hlpwd2013). If you are ready, click Next.

A database file selection page appears now. When you successfully selected the MDF file, the wizard will automatically fill up the LOG file name field as well as the descriptive database name. Change the LOG file name if it does not match your real file name. You can also modify the descriptive database name. When you are ready, click Next. Now the attach process starts.

If an error message pops up about that the SQL Server has no right to access to the specified directory, then you should add Full access right to the predefined *NETWORK SERVICE* user over the folder and its content. Click Finish to close the wizard.

🎒 Attaching a HyperLab database 💦 💼 💷 💌
Local database file successfully attached to database server. Click Finish to close wizard.
< Back Next > Finish

### 12.9. Creating an ODBC data source

ODBC data sources or data links are a set of parameters stored in Windows. Various applications use these parameter sets to connect to a specific database.

As opposed to HyperLab 2002 product line, later HyperLab versions do *not* require the creation of an ODBC data source for a HyperLab database in order to use it with Main Module. However, when an external application requires connecting to a HyperLab database, in most cases the simplest way to perform the data transfer is via a newly created ODBC link. This section contains the detailed steps necessary to create an ODBC data source for a specific HyperLab database.

In your Control Panel, go to *System and Security / Administrative Tools*, then double-click *Data Sources (ODBC)* icon.

The *ODBC Data Source Administrator* window appears now. Click on its *System DSN* tab, and then on the *Add* button.

ser DSN	ata Source Administrator System DSN   File DSN   Drivers   Tracing   Connection Poolir	l ng About
<u>J</u> ser Dal	ta Sources:	
Name	Driver	Add
		<u>R</u> emove
		onfigure
		oningare
	An ODBC User data source stores information about how to con the indicated data provider. A User data source is only visible to and can only be used on the current machine.	nect to o you,

A database driver selection window appears now. Select the *SQL Server* item, then click Finish.

Create New Data Source			×
	Select a driver for which you wa	nt to set up a data so Version	ource. Com
	SQL Server SQL Server Native Client 10.0	6.01.7600.16385 2009.100.1600.01	Micn Micn
	4 111		4
	< <u>B</u> ack	Finish Ca	incel

#### Database maintenance

Create a New Data Sourc	e to SQL Server	
	This wizard will help you create an ODBC data source that you can use to connect to SQL Server.	
	What name do you want to use to refer to the data source?	
	Name: ODBC link to HyperLab1	
	How do you want to describe the data source?	
	Description:	
	Which SQL Server do you want to connect to?	
	Server: WORKSTATION4\MSSQLHYPERLAB	
Finish <u>N</u> ext > Cancel Help		



Specify the basic parameters of the new database: type in a name for it and specify the SQL server. If you are still using MSDE database server version (from HyperLab 2002 or 2005), you have to specify only the computer name. In case you are using SQL Server, a name required in the format *Computer*  $\ MSSQLHYPERLAB$ . then just type a dot (".") into the Server box. Description field may be omitted. Click *Next* if you are ready.

A client configuration window appears now. Select the *SQL Server authentication* method, and type "**sa**" as user name to log in into the server, as well as the database password. Default password is "**H1pwd2014**" (in case of an upgrade, you may also try h1pwd2002, h1pwd2005, h1pwd2008, h1pwd2009 or H1pwd2013).

Finally click *Client configuration* button for detailed connection parameters.

Server <u>a</u> lias:	WORKSTATION4\MSS	QLHYPE
Network libraries	Connection parameters	
Named Pipes	Server name:	WOBKSTATION4\MSSQLHYPEE
ICP/IP	<u>J</u> ervername.	
Multiprotocol	Dynamically determine	port
○ NW/Link IP <u>X</u> /SPX	Port number:	1433
🔿 AppleTal <u>k</u>		
Banyan <u>V</u> INES		
⊙ V <u>I</u> A		
─ <u>0</u> ther		

The *Client configuration* window appears now. Select TCP/IP network library. Please note that in order to make TCP/IP connection work TCP/IP network library must be enabled. See details in section "Configuring remote access" on enabling this.

Click OK when you are ready.

The Client configuration window appears again. Click Next.

Create a New Data Sour	rce to SQL Server 🗾
	Change the default database to:
	HyperLab1 -
	Attach database filename:
	$\fbox$ Greate temporary stored procedures for prepared SQL statements and drop the stored procedures:
	Only when you disconnect. When you disconnect and as appropriate while you are connected
	✓ Use ANSI quoted identifiers.
	Use ANSI nulls, paddings and warnings.
	Use the <u>failover</u> SQL Server if the primary SQL Server is not available.
	< <u>B</u> ack <u>N</u> ext > Cancel Help

Place a tick mark beside check box "Change the default database to", and select your SQL Server database from the drop-down list, then click *Next*.

Another database connection option window appears now. Change values if required, then click *Finish*.

A summary page appears now, informing you about the ODBC alias created.

As it provides a testing facility, click *Test Data Source* button to initiate the testing of the newly created ODBC link.

Create a New Data Sour	ce to SQL Server
	Change the language of SQL Server system messages to: English Use strong encryption for data Perform translation for character data Use regional settings when outputting currency, numbers, dates and times. Save long running queries to the log file: C:\Users\HLUser4\AppData\Loca\Temp\QUERY. Browse Long query time (milliseconds): 30000
	C:\Users\HUIser4\AppData\Local\Temp\STATS1  Rrowse
	< Back

ODBC Microsoft SQL Server Setup	x
A new ODBC data source will be created with the following configuration:	
Microsoft SQL Server ODBC Driver Version 06.01.7600	•
Data Source Name: ODBC link to HyperLab1 Data Source Description: Server: WORKSTATION4/MSSQLHYPERLAB Database: HyperLab1 Language: (Default) Translate Character Data: Yes Log Driver Statistics: No Use Regional Settings: No Prepared Statements Option: Drop temporary procedures on disconnect Use Asil Quoted Identifiers; Yes Use ANSI Quoted Identifiers; Yes Use ANSI Null, Paddings and Warnings: Yes Data Encryption: No	
	-
Iest Data Source OK Cancel	

Microsoft SQL Serv	ver ODBC Driver Version 06.01.7600	
Running connectiv	ity tests	
Attempting connect Connection establis Verifying option sett Disconnecting from	tion shed tings a server	
TESTS COMPLET	ED SUCCESSFULLY!	
		-

A message box appears now, and provides basic information on the ODBC link status. If the "Test completed successfully" message appears here, your ODBC data source is ready to use by an external application.

Click OK to close this window, and click OK again to close the summary page.

#### Database maintenance



The *ODBC Data Source Administrator* window appears again, but now its System Data Sources list contains the new ODBC data link entry. Click *OK* to close this window.

Now ordinary third party applications are able to access your HyperLab database. This way e.g. complex evaluations, say, a Microsoft Excel-based activity calculation

application can be developed.

# 13. Importing sample spectra

In order to perform a sample nonlinearity, efficiency and resolution analysis, HyperLab provides some sample spectra. These should be imported to HyperLab database before performing any of these analyses.

HyperLab arrives with sample sets for two measurement systems. These are assembled from the same devices, but using different energy ranges. Our description will only deal with HyperLab's sample spectra set for the system of 70 keV - 3300 keV range.

### 13.1. Importing steps

First create a project node in Main Module, which will contain all the sample measurements and their evaluations.

Then initiate the import of the sample spectra by right-clicking the *Measurements* node under the project and the select *Import spectrum files* from the pop-up menu.



Spectrum file importer window appears now.

Click *Add files* button, and select 10 sample Accuspec spectra with "A" ending in their file name, as can be seen in the picture.

Do not forget to check the settings under the *Main settings* tab.

#### Importing sample spectra

🎒 Spectrum file im	porter		
Select spectrum files t	to be loaded, adjust load settings, then pre	ess 'Load files' button.	
Spectrum files Main	n settings Calibrations Sample Adva	nced	
File type			
File <u>c</u> ontent	Dual spectrum: LFC-corrected and norm	nal spectrum halves	•
Type of 1st half	LFC corrected gamma spectrum		
Type of 2nd half	Normal HPGe gamma spectrum		
	Determine file type automatically from	n spectrum, if possible	
Measurement setup			
Meas. setup	D4 Setup 70keV - 3.3Mev, d=25cm		🖃 🗹 🎽 🕽
	Determine meas, setup automatically	from spectrum, if possible	
	Rules for auto determination		
	Text in spectrum file	Assigned measureme	nt setup
			P New
			- Delete
Other measurement	details		
Meas. method	Decay-gamma measurement		<b>• •</b>
Measured by	Database administrator		
L		_	
			Load files 🛛 😵 Cancel

Here you should specify the *Dual LFC* spectrum evaluation mode first, as these measurements are created using an LFC module, allowing compensation for count losses due to varying or high count rate situations.

At the *Measurement setup* combo box, you should select HyperLab's sample measurement setup. This is an important setting, because all calibration analyses, e.g. the nonlinearity will belong to a specific setup, thus the calibration assignment can be automatic.

If the sample setup can not be found in the

list, create it by clicking on the *New entry* button beside the combo box.

🛃 Measurement setup propert	ies	- • •
Selected measurement setup - p	More measurement setup entries	
MEAS. SETUP	1	
DETECTOR	D4	🖃 📝 揝
MEASPOSITION	d=25 cm	💌 🖬 🐪
MEASRANGE	70 - 3300 keV	💌 🖬 🖆
NAME	D4 setup, 70keV - 3.3MeV, d=25 cm	
ADC		🖃 💽 🗎
STORED BY	Database administrator	
0	Help 🛛 📀 ОК 😵 Cancel	冠 Apply

If creating of a new measurement setup is necessary, this entry editor will pop up. The editing can be done on the regular way, as described in the *Importing spectrum files* section of the *Main Module Quick Start Guide*.

When you are ready, click *OK*. The spectrum import form will appear again.

You should check the *Calibrations* tab now, where the source of FWHM and energy calibrations should be set to Spectrum files' own calibration values.

Click Load files button in order to initiate the spectrum loading.

Please wait until spectrum	importing finishes			
Progress:				
Details				
INFO: Energy cal.: fro INFO: FWHM cal.: fro	m spectrum file [E_keV = m spectrum file [Fwhm =	= 0.0939999967813 Ch = sartí 6.8488 + 0.	+ 0.409999996424 .0040612 * Ch 11	* Ch] 🔺
INFO: Loading AccuS INFO: Measurement s INFO: Spectrum store INFO: Title: D4 kal. 2 INFO: Energy cal.: fro INFO: FWHM cal.: fro	ipec spectrum file C:\Us etup determined: D4 set d in database (MEASUF 002. okt. 1 (RA37076A.C m spectrum file (E_keV m spectrum file (Fwhm_1	ers\HLUser4\Docurr tup, 70keV - 3.3MeV, 1EMENT_ID=10, SP( DAT) = 0.0939999967813 Ch = sqrt( 6.8488 + 0.	ents\HyperLab\Hyp , d=25 cm (ID=1) ECTRUM_ID=19-20 + 0.409999996424 .0040612 * Ch )]	perLab2009\Sam ), ECAL_ID=19-21 * Ch]
Loading of 10 spectru	m files finished at 1/23/	2011 6:52:15 PM		E
4				

All selected spectrum files will be loaded now, and the importer will provide basic information on the loading process.

Click *Close* to finish loading.

The database browser now displays the imported spectra. Now we will complete their missing *sample* settings. The sample is important presently only for calibration measurements, serving as input for later nonlinearity, efficiency and resolution analyses. These analyses will identify gamma lines by using isotope information, which is in turn supplied by the user, during the sample definition.

<u>F</u> ile <u>O</u> ptions <u>H</u> elp	
۵	Selected item: Measurement entry (7 tasks, 0 sub-item)
HyperLab databases ■ Database HyperLab1 on .\MSSQLHYPERLAB ■ User projects ■	Name: D4 kal. 2002. okt. 1 [ Started at: 2002 Oct 01, 14:5. Finished at: 2002 Oct 02, 03. Number of peak evaluations: ( Create new peak evaluation Measurement properties New Measurement Delete Measurement entry Create report Remove all peak evaluations Export into spectrum file

#### Radioactive source details

Spectrum file	Source name	Activity	Act. unc.	Ref. date
AM80320A.DAT	Am-241 OMH 80-320	221.50 kBq	1.0 %	1 Oct 1980
BA85211A.DAT	Ba-133 OMH 85-211	456.40 kBq	1.5 %	1 Oct 1985
CD01043A.DAT	Cd-109 OMH 2001-043	100.44 kBq	0.5 %	1 May 2001
CO01042A.DAT	Co-57 OMH-01-042	32.63 kBq	0.5 %	1 May 2001
CO85185A.DAT	Co-60 OMH 85-185	434.60 kBq	0.7 %	1 Oct 1985, 12:00
COD0111A.DAT	Co-56 (Ref.:2001/11/1)	-	-	-
CS96147A.DAT	Cs-137 OMH 96-147	20.75 kBq	1.5 %	1 Dec 1996, 12:00
EU80297A.DAT	Eu-152 OMH 80-297	250.30 kBq	2.0 %	1 Dec 1980
MN01041A.DAT	Mn-54 OMH 2001-041	18.98 kBq	0.5 %	1 May 2001
RA37076A.DAT	Ra-226 PTB 370-76	112.00 kBq	0.667 %	1 Jan 1978

HyperLab's sample spectra are taken with the following radioactive sources:

The corresponding radioactive sources must be created and assigned to the proper imported measurement. When no activity data is indicated, no absolute activity value is known. However, as only detector efficiency analysis uses intensity values of radiations, this may be disadvantageous only in that case.

To define a source, click the measurement and select its "Measurement properties" task. The measurement's property editor window appears now.

Please check if its *Source* field is set. If there is no reference to an existing source, or the *Measurement object type* field does not set to Source, then changes have to be made.



#### Importing sample spectra

Selected measurement - pg 1	Selected measurem	ent - pç	g 2 Spectra	More meas	urement ent	ries			
MEASUREMENT ID	1								
MEAS. METHOD	Decay-gamma me	asurem	ent				-		
MEAS. SETUP	D4 Setup 70keV -	3.3Mev	∕, d=25cm				-		1
PROJECT	HyperLab sample :	HyperLab sample spectra						1	
NAME	D4 kal. 2002. okt.	04 kal. 2002. okt. 1 [AM80320A.DAT]							
MEASURED BY	Database administ	Database administrator						1	
MEAS. OBJ. TYPE	Radioactive source	Radioactive source							
SOURCE	Am-241 OMH 80-3	20					-		1
STARTDATE	2002 Oct 10		12:24:00		001	msec	3		
ENDDATE	2002 Oct 10		12:34:00		000	msec	3		
EXPORT FILE NAME	AM80320A								
0	Help		ок		Cancel		<b>S1</b> Ar	nlv	

Set the *Measurement object type* field to *Radioactive source*, and check in the list of *Source* field's combo if the searched source is already defined. If it is already in the list, then select it, and click *OK* to finish editing of measurement entry.

If the source list does not contain the searched source, click the *Create new source entry* button beside the combo box. A source record editor page appears now. For further details on source entry editing, see section

"Source properties editor window".

**Note:** Alternatively, instead of batch file importing, we could have loaded the spectra one by one, while supplying the sample information under the *Sample* tab for each spectrum file.

When all source data is properly set for each sample measurement, the loading of sample spectrum set is finished.

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