PNNL-30365

Beta-Gamma Data Viewer v2.2.34 User's Manual

August 2020

Ryan E. Wilson
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James C. Hayes
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Mark Panisko

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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1.0 Introduction

This document provides an overview, and procedures, for operating the beta-gamma data viewer for 7 regions of interest (7 ROI) data. The Beta-Gamma 7 ROI Data Viewer is a set of software tools that allow for viewing and analysis of IMS 2.0 Pulse Height Data (PHD) / Pulse Beta Gamma (PBG) files, state of health (SoH) files, and event log files. The data viewer is designed to analyze files using the 7 ROI analysis method; refer to *MDC and Concentration Calculations* [1] for a description of 7 ROI analysis method.

2.0 Beta-Gamma 7 ROI Data Viewer

The beta-gamma viewer was developed to allow the user to have access to four primary functions. The first is to review and analyze data for radioxenon activity concentration, second is to view multiple nuclear data files, third is to view system state of health files, and the last is to view system event log files. There are five tabs at the top of the viewer (Figure 1) that access the five tools. The *Beta-Gamma Analysis (7 ROI)* tool is used primarily to analyze U.S. developed beta-gamma system data files (.pbg) to calculate the activity concentration of the sample. This tab will open the sample file, the gas background file, and the detector background file along with file information, and will automatically perform the activity concentration calculations for ^{135}Xe, ^{133}Xe, ^{133m}Xe, and ^{131m}Xe. The *Beta-Gamma Spectra Viewer* tool (the second tab) is used to view and compare multiple data files including from different systems. The *Beta-Gamma Spectra Viewer* allows viewing beta singles spectra, gamma singles spectra, beta coincidence spectra, and gamma coincidence spectra for one or multiple files. The third tab, *State of Health Viewer*, allows viewing the sensor output logged to .soh files, providing a tool to diagnose system performance. The fourth tab, *Event Viewer*, allows opening event log files and allows filtering of the entries based on category, process, client, source, and function. The fifth tab, *Advanced Analysis*, allows for more advanced data file analysis like ^{137}Cs spectrum analysis.

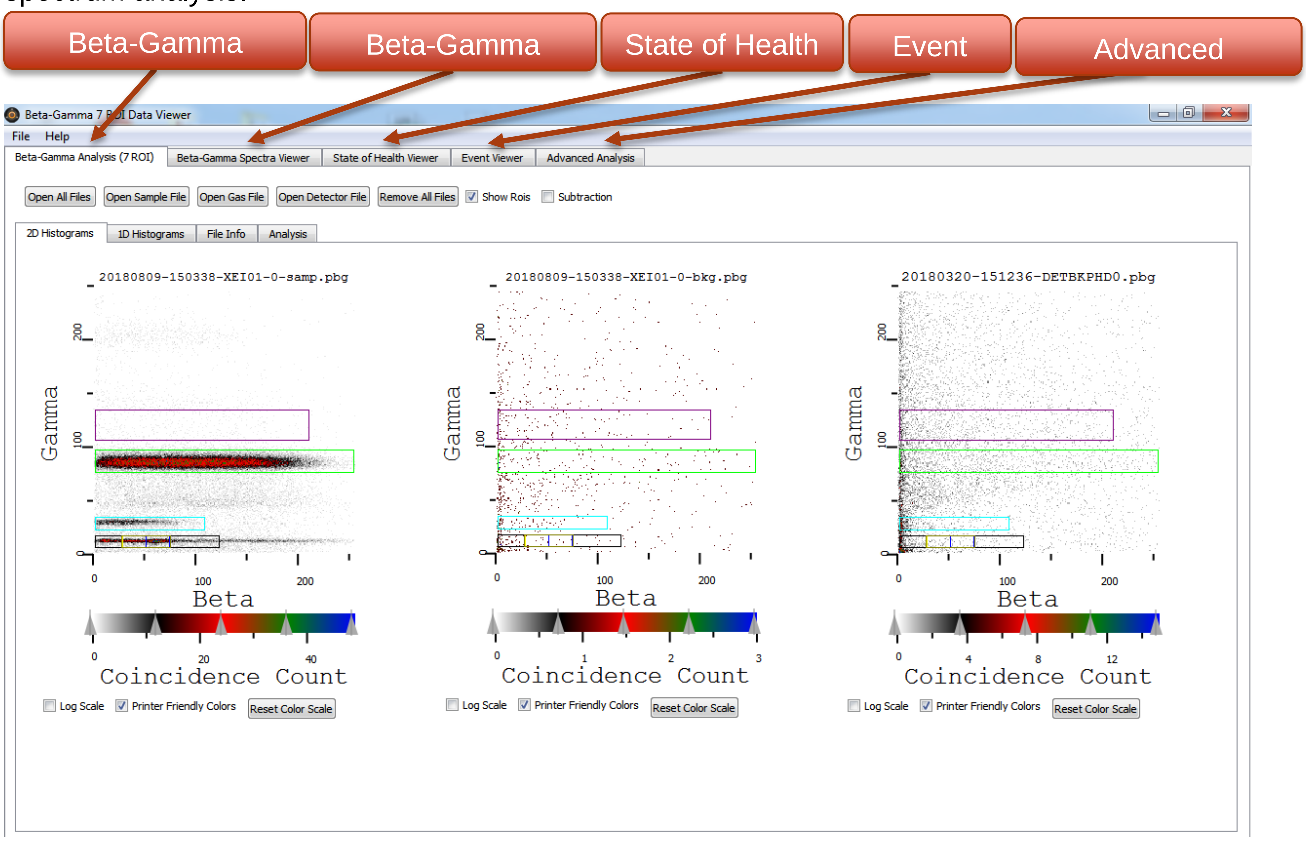


Figure 1 - First screen of the viewer displays the Beta-Gamma Analysis (7 ROI) tab and the 2D Histograms subtab, displayed with printer friendly colors selected.

2.1 Beta-Gamma Analysis (7 ROI)

The *Beta-Gamma Analysis (7 ROI)* tool is used for analyzing xenon beta-gamma coincidence spectra generated from the nuclear detectors used in the Xenon International system. The analysis technique is based on seven regions of interest (ROI) within the 2D coincidence plots. This tab allows the user to read a set of three beta-gamma spectral files (sample, gas background, and detector background), display them using 1- and 2-dimensional histograms (1D & 2D), and calculate the activity concentrations, uncertainites, and the minimum-detectable-concentrations (MDC) for each of the radioxenon isotopes present. The screen capture in Figure 2 illustrates the features available when selecting this tab.

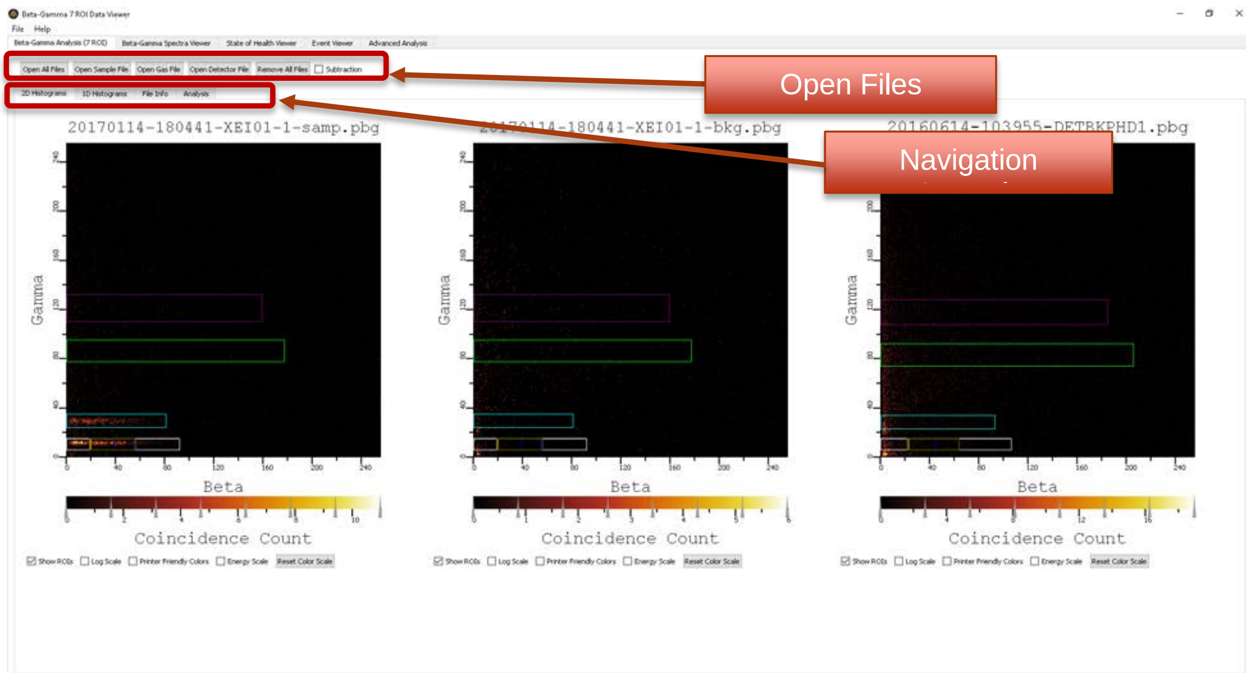


Figure 2 - A screenshot showing the 2D histograms from files loaded via the button group, displayed with printer friendly colors selected.

2.1.1 Controls

2.1.1.1 Open Files Controls

The Control buttons used for opening files are shown in Figure 3 and the navigation tabs that are used to view 2D Histograms, 1D Histograms, File Info and to perform data Analysis are shown in Figure 4. A description of each of these funcitons are described in Table 1.

Figure 3 - Beta-Gamma Analysis Open Files Control

Table 1 - Beta-Gamma Analysis (7 ROI) Open File Control Break Down

Description	Graphic
Open Full File Set: This button opens a file browser where the sample file to be open is chosen. The sample file contains sample identification for the gas and detector background files. The viewer software will automatically look for the gas background file in the same directory location as the sample file, and it will look for the detector background file in the user selected folder, configured in the setting menu. If the detector background file isn't found in the user selected folder it will look for it in the sample file location.	Open Full File Set
Open Sample File: This button opens a file browser where you can choose which sample file to open without opening the associated background files	Open Sample File
Open Gas Background File: This button opens a file browser where you can choose which gas background file to open without opening an associated detector background file or sample file.	Open Gas Background File
Open Detector Background File: This button opens a file browser where you can choose which detector background file to open without opening an associated gas background or sample file.	Open Detector Background File
Clear All Files: This button clears all previously opened files.	Clear all Files
Subtraction: This check box will display 2D and 1D histograms of the sample and gas background spectra with the detector background subtracted. When the Subtraction box is checked, the Log Scale feature is unusable and is greyed out.	Subtraction

2.1.1.2 Navigation Controls

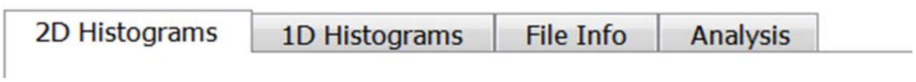


Figure 4 - Beta-Gamma Analysis Navigation

Table 2 - Beta-Gamma Analysis Navigation Break Down

Description	Graphic
2D Histograms: This tab displays the 2-dimensional histograms of the selected data files. (see section *2.1.2 Subtraction*)	2D Histograms
1D Histograms: This tab displays the 1-dimensional histograms of the selected files. (see section *2.1.3.2 1D Histograms*)	1D Histograms
File Info: This tab displays the information in the files separated into different sections. (see section *2.1.3.5 File Info*)	File Info
Analysis: This tab displays the analysis for the selected files. (see section *2.1.4 Analysis*)	Analysis

2.1.2 Subtraction

The subtraction feature subtracts the detector background spectral data from the sample and gas background spectral data. This is accomplished by normalizing the spectral data in each file to account for real time vs live time. Then the sample and gas background spectral data is normalized to the real time of the detector background and the detector background spectral data is subtracted from the sample and gas background spectral data. The resulting 2D and 1D histograms are then displayed. **Note:** The subtraction is preformed to all the 2D and 1D histograms, so the detector background file is subtracted from itself, resulting in zero valued detector background spectra. For more information see Minimum Detectable Concentration and Concentration Calculations by Cooper et al. [1].

2.1.3 2D Histograms Tab

All IMS 2.0 format beta/gamma data files contain a 2D histogram and two 1D histograms. The **2D Histogram** tab allows the user to view the 2D histograms embedded in the file. This is the default view when the user first opens the viewer. The plots are lined up left to right as sample file, gas background file, and detector background file as shown in Figure 2. Each plot has the beta channel on the *x-axis* and the gamma channel on the *y-axis*. The left most 2D histogram shows a sample file with a strong signal for Xe-133. The center 2D histogram shows the associated gas background file collected just prior to the sample file and the rightmost 2D histogram is the detector background associated with this detector. Also found on this tab are controls that adjust the scaling of the colors used.

The 2D Histogram plot is a colored heat map of the beta gamma coincidence count. A Pulse Height Detection/Pulse-height Beta Gamma (PHD/PBG) file using the IMS 2.0 format contains information including histograms that contain the counts observed by the detector. This plot provides a visual means of displaying that information. The *x-axis* is the beta channel/energy, the *y-axis* shows the gamma channel/energy, and z-axis (shown as a ranges of colors) is the histogram height for each beta/gamma channel pair.

2.1.3.1 2D Histogram Plot Functions

The charts have several embedded functions that are described in this section and allow the user to perform a number of useful functions and alter the display. Figure 5 shows the different parts of the 2D plots.

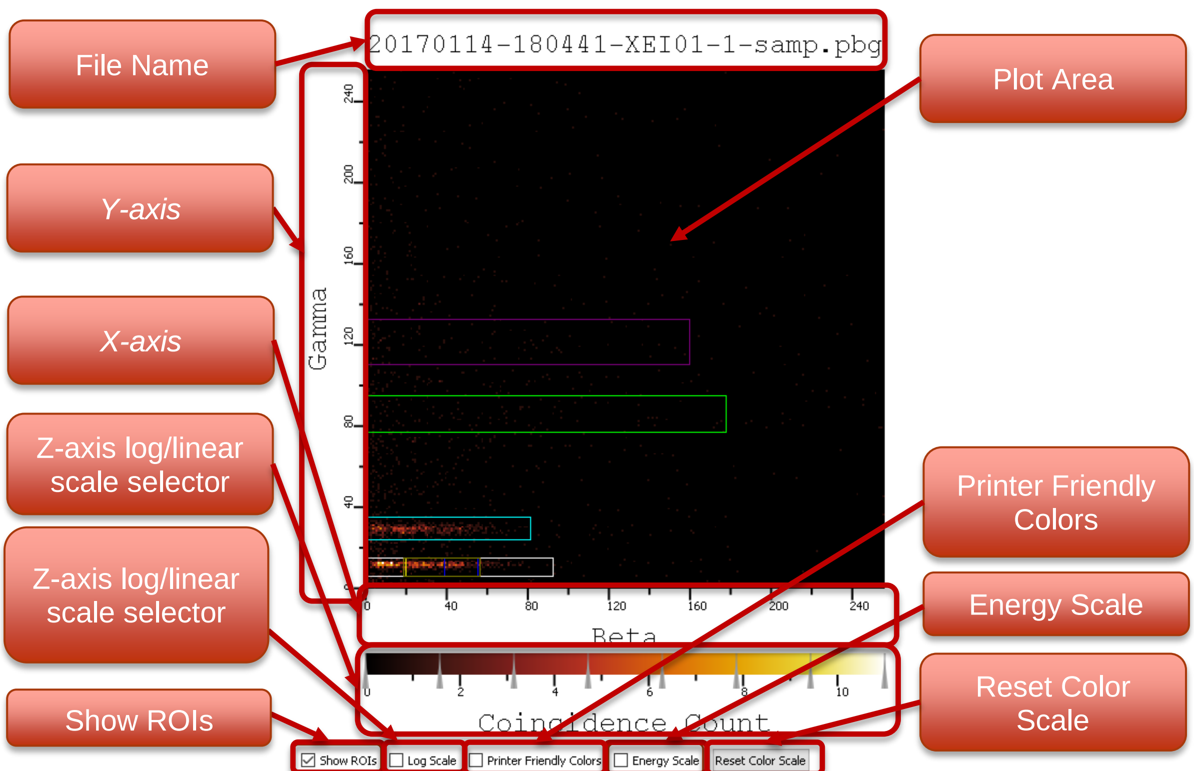
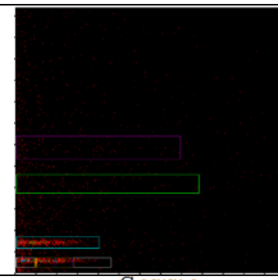
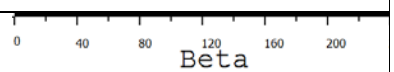
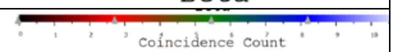
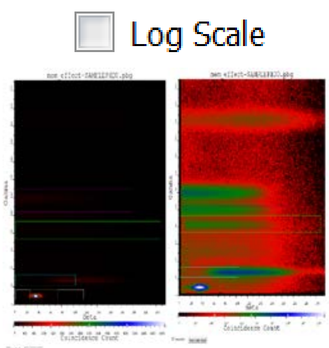
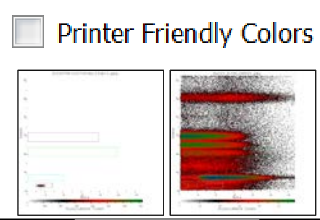
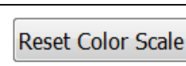


Figure 5 – Plot area of 2D histogram

Table 3 - Plot area as a 2D histogram

Description	Graphic
File Name: This is the name of the (PHD/PBG) file loaded into this plot.	
Plot Area: The plot area is a 256 x 256 element 2D array of bins which correspond to the beta and gamma energies of a coincidence decay event (an event in which a beta particle and associated gamma ray are emitted nearly simultaneously as the result of a single disintegration). For each such decay, the bin corresponding to the measured beta and gamma energies is incremented by one. Over time, patterns emerge indicative of specific isotopes of interest. Right clicking allows the user to save the 2D histogram as an image.	
***Y-axis*:** The histogram bin (or channel) number of the gamma event (proportional to gamma energy). **Note:** Rotated 90º here to save vertical space.	
***X-axis*:** The histogram bin (or channel) number of the beta event (proportional to beta energy).	
Z-axis adjustable color legend: This feature determines how individual bins in the plot area are colored. It uses an adjustable color scale that has 5 points of adjustment. Moving the far left, or far right marker will scale the others between the two. The inner markers can be adjusted by the user that makes the data more visible for them.	
Show ROIs: This button when selected puts the regions of interest on the 2D histogram. When unselected, it hides the regions of interest.	
Z-axis log/linear scale selector: The log scale will convert the coincidence count to a log base 10 scale, very useful for high dynamic range plots in which different features have total aggregate counts that vary by many orders of magnitude. You can see in the example to the right, the left and right plot are the same sample file. The left shows a concentration in the lower left of the plot. The right plot is that same data with the log scale check box enabled, you can clearly see the data was being hidden by the extremely high counts for ^{131m}Xe.	
Printer Friendly Colors: This check box applies the printer friendly colors to the 2D histogram chart. The normal order from left to right of the adjustable color legend is black, red, green, blue, and white. Checking this box shifts those to the right and moves white to the first spot making it: white, black, red, green, and blue. Images of the effect are shown using ^{131m}Xe and ^{214}Pb data.	
Energy Scale: This check box when checked will convert the X and Y axis to keV.	
Reset Color Scale: This button will reset the color scale used for the coincidence count back to default settings which evenly spaces the 5 selectors.	

2.1.3.2 1D Histograms Tab

This tab allows the user to view the 1D and 2D beta/gamma projection histograms, see Figure 6. Shown in the screen shot is the sample coincidence events for both beta and gamma (blue trace), the same for the gas background file (green trace), and the detector background file (orange trace). This view contains an Aspect Selection Tree for selecting different beta gamma aspects for each of the 7 ROI's, beta and gamma coincidences (shown in Figure 6) and the beta and gamma single histograms. To display the additional Aspect Selection Tree entries, push the small black triangle (V) which will toggle the view to display and not display the rest of the Aspect Selection Tree for each of the files loaded. To display an individual trace, click the left mouse button.

The Aspect Selection Tree allows for multiple selections using the *shift-key* (for a beginning ROI to an end ROI) and the *control-key* to select several noncontiguous ROI's. Each action is completed by clicking the left mouse button. Control buttons allow the user to interact with the chart and tree view. Common functionality for the line charts can be found in section *2.1.3.3 1D Histogram Plot/Line Chart Functions*.

Beneath the Aspect Selection Tree is a set of buttons that allow the user to control aspects of the charting functions shown in Figure 7. Each of the buttons change the data presented on the charts and each of check boxes toggles a feature of the charts, more details in Table 4.

Figure 6 - The 1D histogram tab

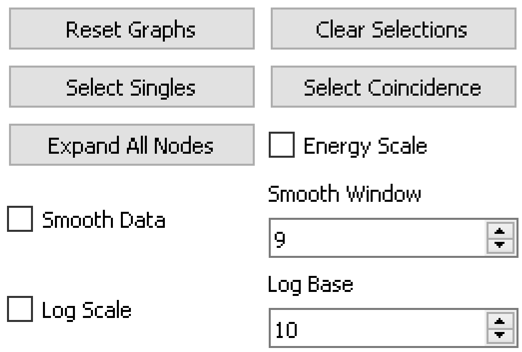


Figure 7 - 1D Plot Controls

Table 4 - 1D Plot Controls Breakdown

Description	Graphic
Reset Graphs: This button un-zooms the graphs and returns the graphs to their original *x-axis* and *y-axis* span.	Reset Graphs
Clear selections: This button will clear any selections in the tree view and refresh the chart.	Clear Selections
Select Singles: This button allows the user to select the beta singles and the gamma singles graphs from each of the spectral file.	Select Singles
Select Coincidence: This button allows the user to select the two coincidence graphs (beta and gamma) from each of the spectral files.	Select Coincidence
Expand All Nodes: This button will expand all the nodes in the tree view to show all of the traces available for plotting for each of the spectral files.	Expand All Nodes
Energy Scale: This button toggles the *x-axis* between energy(keV) and the channel display for the gamma and beta plots.	Energy Scale
Smooth Data: This button will smooth the data in each displayed graph using a Savitzky-Golay filtering method.	Smooth Data
Smooth Window: This number selector changes the window frame used by the smoothing method. The higher the number the farther out the method looks to adjust the plot to smooth the chart. The range of numbers that can be selected are all odd integers from 5 to 25. Higher numbers might over smooth the chart distorting it.	Smooth Window 9
Log Scale button: This button toggles *y-axis* of each graph between linear display and logarithmic display using base-10 log scaling.	Log Scale
Log Base: This number selector changes the base used when viewing in log scale.	Log Base 10

2.1.3.3 1D Histogram Plot/Line Chart Functions

As with the 2D plots the 1D charts have embedded functions that are available. This section describes those features enumerated in Figure 8.

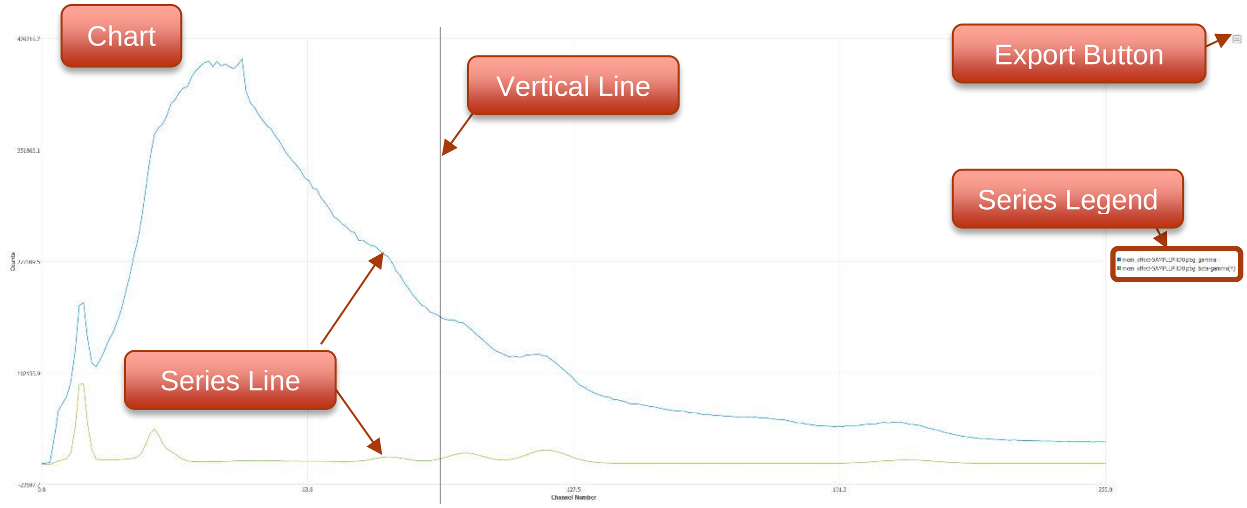
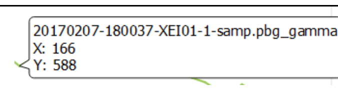
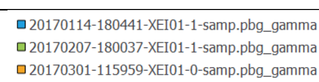


Figure 8 - A screen capture of the 1D plot with functions highlighted

Table 5 - Chart Break Down

Description	Graphic
Chart: This is a line chart used for information that is formatted as a series. To zoom in on the chart the user clicks and drags an area. The area will be shown as a highlighted rectangle. When the mouse button is released the chart will zoom in to that area.	
Export Button: Clicking the export button will open a context menu that allows the user to export the chart data as an image or text file. Different formats are available for each. The image can be exported as (png, xpm, jpg, jpeg, bmp, or ppm) by using that extension when naming the file, default is png. The text format is a set of Comma/Tab Separated Variables (CSV/TSV) that can be laid out with the series lined up vertically (long) or horizontally (wide), or as a JavaScript Object Notation (JSON) format. (see section *2.1.3.4 Example Export Format*)	
Vertical Line: When hovering the mouse over the chart a vertical line will be displayed. If this line crosses a series line it will display a bubble with information about the series closest to the mouse pointer in that position.	
Series Legend: This displays the names for the series. Hovering over one of the names will lower the visibility of the other series in the chart. Left clicking a name will hide/show that series. Right clicking a name will open a context menu that allows the user to hide all other series in the chart.	
Series Line: This is the data for that series displayed as a line.	

2.1.3.4 Example Export Format

CSV:

```
series name,,
count,xValue,yValue
1,x1,y1
2,x2,y2
etc.,etc.,etc.
```

TSV:

```
series name\t\t
count\txValue\tyValue
1\tx1\ty1
2\tx2\ty2
etc.\tetc.\tetc.
```

JSON:

```
{
   "name":"series name",
   "data":[
      [x1,y1],
      [x2,y2],
      [etc.,etc.]
   ]
}
```

2.1.3.5 File Info

This view allows the user to view the data from the files separated into tabs, each tab is a section of the file that is broken out and displayed in a table view as shown in Figure 9 and described in Table 6.

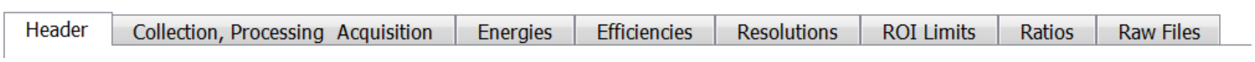


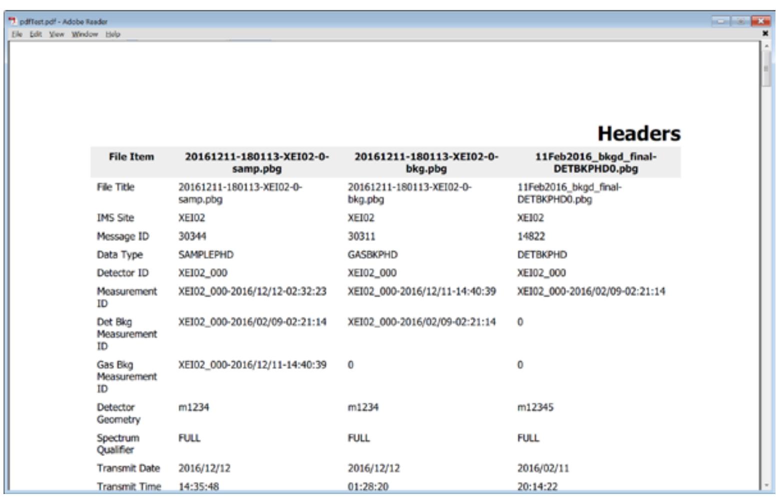
Figure 9 - File Information Navigation.

Table 6 - File Information Navigation Break Down

Description	Graphic
Header: This tab shows the header section from each of the opened files.	Header
Collection, Processing, Acquisition: This tab shows sections collection, processing, and acquisition of only the samples file. The other files types do not have information associated with this tab.	Collection, Processing Acquisition
Energies: This tab shows the energies section from each of the opened files	Energies
Efficiencies: This tab shows the efficiencies section from each of the opened files	Efficiencies
Resolutions: This tab shows the resolutions section from each of the opened files	Resolutions
ROI Limits: This tab shows the ROI Limits section from each of the opened files	ROI Limits
Ratios: This tab shows the ratios section from each of the opened files	Ratios
Raw Files: This tab has buttons to show each file in its raw form, no special formatting will be applied. **Note**: It has a scroll bar on the right-hand side to scroll through the file.	Raw Files

2.1.3.6 Create PDF

The *Create PDF* button, located in the file info tab, allows the user to save the information from the file info tabs as a pdf as shown in Figure 10. Note the raw files will not be included in this generated file.



File Item	20161211-180113-XEI02-0-samp.pbg	20161211-180113-XEI02-0-bkg.pbg	11Feb2016_bkgd_final-DETBKPHD0.pbg
File Title	20161211-180113-XEI02-0-samp.pbg	20161211-180113-XEI02-0-bkg.pbg	11Feb2016_bkgd_final-DETBKPHD0.pbg
IMS Site	XEI02	XEI02	XEI02
Message ID	30344	30311	14822
Data Type	SAMPLEPHD	GASBKPHD	DETBKPHD
Detector ID	XEI02_000	XEI02_000	XEI02_000
Measurement ID	XEI02_000-2016/12/12-02:32:23	XEI02_000-2016/12/11-14:40:39	XEI02_000-2016/02/09-02:21:14
Det Bkg Measurement ID	XEI02_000-2016/02/09-02:21:14	XEI02_000-2016/02/09-02:21:14	0
Gas Bkg Measurement ID	XEI02_000-2016/12/11-14:40:39	0	0
Detector Geometry	m1234	m1234	m12345
Spectrum Qualifier	FULL	FULL	FULL
Transmit Date	2016/12/12	2016/12/12	2016/02/11
Transmit Time	14:35:48	01:28:20	20:14:22

Figure 10 - Screen capture showing the PDF output generated by the Create PDF button.

2.1.4 Analysis

The user can perform an isotopic analysis of the sample file and view the results (Figure 11 and Figure 12). This analysis is performed using a 7 ROI analysis algorithm.

To perform an analysis make sure the files are loaded, select wheather to use the ^{214}Pb removal calculation, then select the Analyze Opened Detector Files button. More details about the functionallity can be found in Table 7.

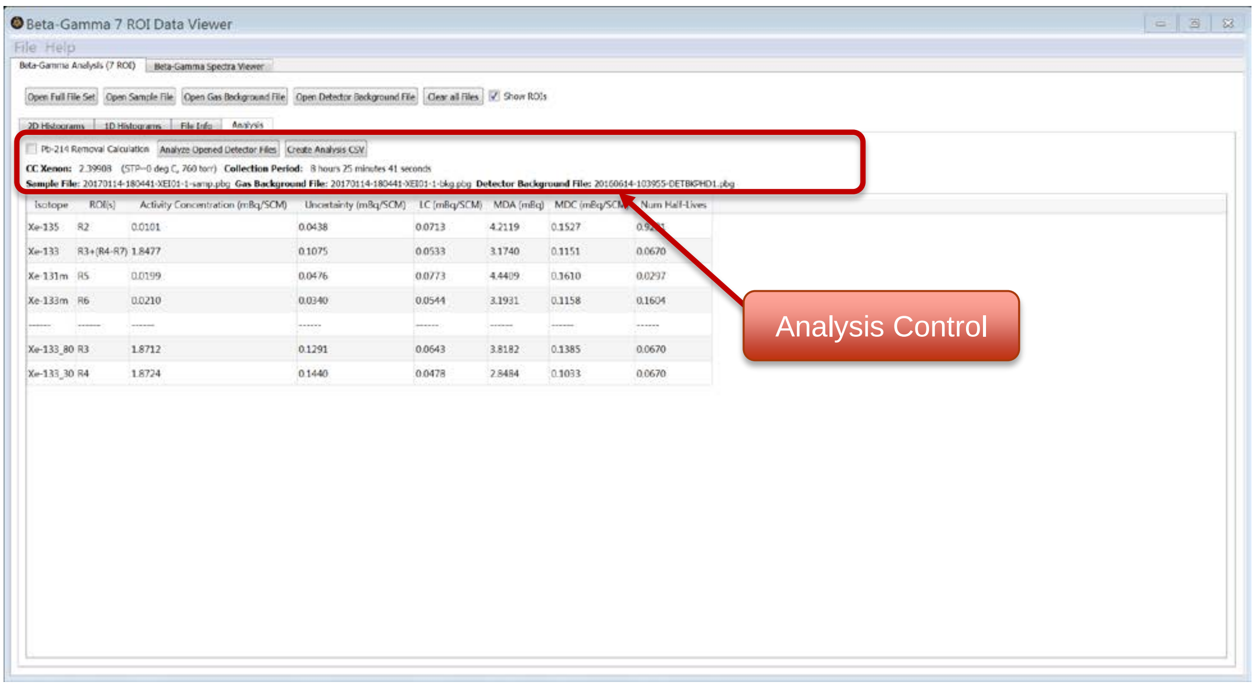


Figure 11 - Screen capture of the analysis results showing the concentrations, uncertainties and minimum-detectable-concentrations calculated from the uploaded spectral files.

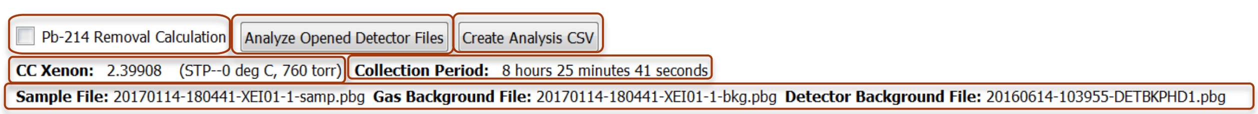


Figure 12 - Analysis Controls

Table 7 - Analysis Controls Break Down

Description	Graphic
Pb-214 Removal Calculation: When checked the analysis includes the ^{214}Pb removal calculation.	☐ Pb-214 Removal Calculation
Analyze Opened Detector Files: *This* button will perform the calculations and display the results in the panel below.	Analyze Opened Detector Files
Create Analysis CSV: This button allows the user to create a comma separated variables files with the results of the analysis. When clicking the button, a *file browser* will allow the user to choose a directory and a name for the output file.	Create Analysis CSV
CC Xenon: Displays the total volume of stable xenon gas that was analyzed for this sample and the standard temperature and pressure.	**CC Xenon:** 2.39908 (STP--0 deg C, 760 torr)
Collection Period: This is the time period from collection start to acquisition start for the sample file.	**Collection Period:** 8 hours 25 minutes 41 seconds
File Names: This is a display of the files that are currently loaded for the analysis.	**Sample File:** **Gas Background File:** **Detector Background File:**

2.2 Beta-Gamma Spectra Viewer

The *Beta-Gamma Spectra Viewer* tab is used to view multiple Beta-Gamma files regardless if they are a sample, gas background, detector background, calibration, or QA/QC files. The functions accessible to the user are shown in Figure 13 and described in Table 8.

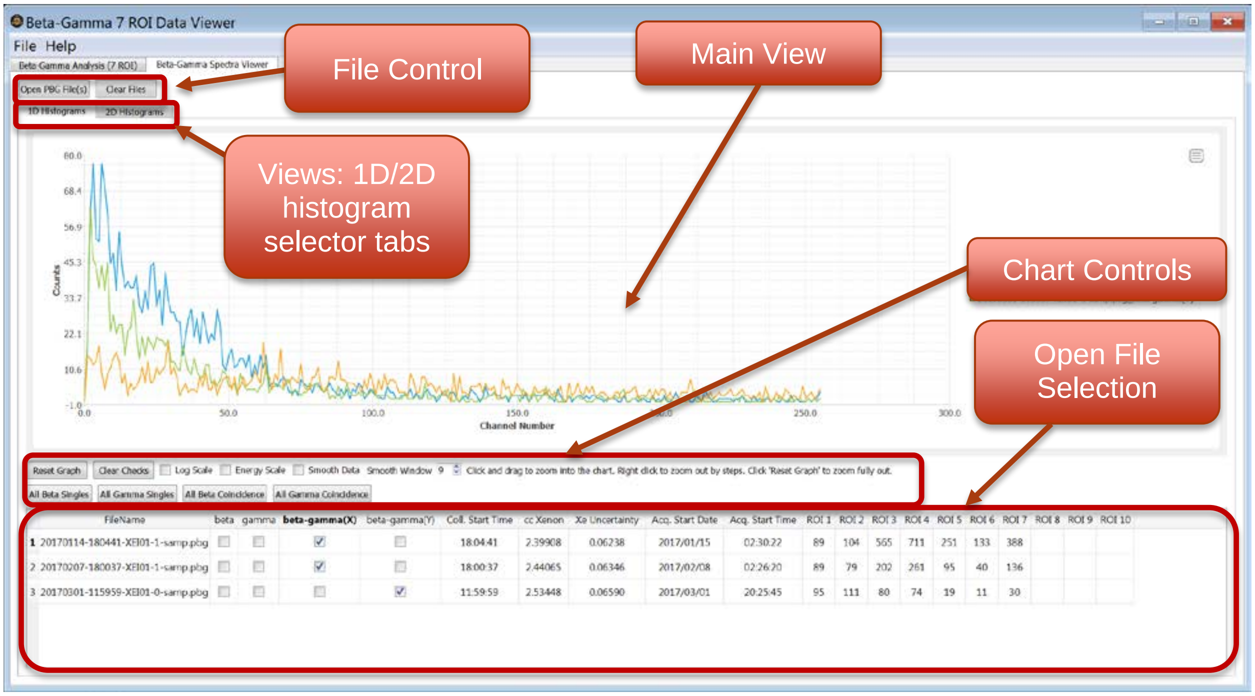
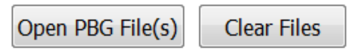
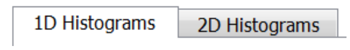


Figure 13 - Screen capture of the *Beta-Gamma Spectra Viewer* with highlighted region showing the ability of this tab to load multiple spectral files.

Table 8 - A breakdown of the *Beta-Gamma Spectra Viewer* functions

Description	Graphic
File Control: This allows the user to open multiple beta/gamma data files in the view or clear all files that are opened. Multiple files can be loaded with windows standard multiple selection method using shift/control while selecting the files.	
Views: 1D/2D histogram selector tabs: These tabs allow the user to switch between a 1D Histograms chart (see page 9) or a 2D histogram Plot (see page 5). The 1D tab allows the user to display multiple spectra in a single plot. The 2D display allows the user to click through the 2D spectra one at a time. This view will also show the total number of counts in the 2D spectra.	
Main View: The main view is where either the line chart or the 2D histogram Plot are displayed. Each of the loaded files will have 2D Histogram Plot loaded in separate tabs with the file name as the tab title.	
Chart Controls: These controls allow the user to perform operations to the chart. Detail can be found in Table 7.	
Open File Selection Table: This table displays all of the files that have been uploaded with the scroll bar on the right used to scroll through multiple files. The check boxes allow the user to choose which of the 1D spectral graphs to plot. And the buttons above the table will plot globally all the beta, gamma, gamma-gated beta coincidence, and beta-gated gamma coincidence spectra.	

2.2.1 Chart Controls

The chart controls allow the user to interact with the spectra line chart. The Chart Controls functions are shown in Figure 14 and described in Table 9.

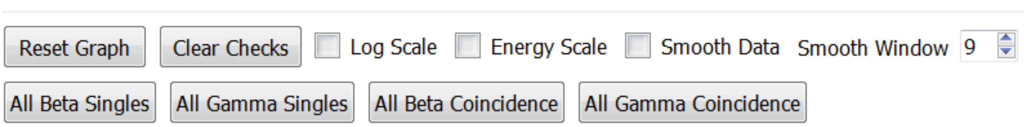


Figure 14 - Chart Controls.

Table 9 - Chart Controls Break Down

Description	Graphic
Reset Graphs: This button un-zooms the graphs and returns the graphs to their original *x-axis* and *y-axis* span.	Reset Graph
Clear Checks: This button will clear any selections in the tree view and refresh the chart.	Clear Checks
Log Scale: This check box toggles *y-axis* of each graph between linear display and logarithmic display using base-10 log scaling.	Log Scale
Energy Scale: This check box toggles the *x-axis* between energy and the channel display for the gamma and beta plots.	Energy Scale
Smooth Data: This check box will smooth the data in each displayed graph using a Savitzky-Golay filtering method.	Smooth Data
Smooth Window: This number selector changes the window frame used by the smoothing method. The higher the number the farther out the method looks to adjust the plot to smooth the chart. The range of numbers that can be selected are all odd integers from 5 to 25. Higher numbers might over smooth the chart distorting it.	Smooth Window 9
All Beta Singles: This button will check all the beta single check boxes for each file loaded in the Opened File Selection Table.	All Beta Singles
All Gamma Singles: This button will check all the gamma single check boxes for each file loaded in the Opened File Selection Table.	All Gamma Singles
All Beta Coincidence: This button will check all the beta coincidence check boxes for each file loaded in the Opened File Selection Table.	All Beta Coincidence
All Gamma Coincidence: This button will check all the gamma coincidence check boxes for each file loaded in the Opened File Selection Table.	All Gamma Coincidence

2.3 State of Health Viewer

The state of health viewer tool is used for viewing state of health (SoH) files generated from the PNNL developed systems. The state of health for a system is composed of multiple sensors (i.e., pressure sensors, thermocouples, detector count rates, valve states, etc.) which are logged to a .soh file. The logged data is used to verify system performance and, in the case of a failure, diagnose what has failed. The remainder of this section will describe the State of Health Viewer operation but will not discuss state of health analysis.

2.3.1 Controls

The State of Health Viewer tab is the third tab of the *Tool Selection* and has several buttons located just below the tab selection, as marked in Figure 15. These buttons (see *File Management Controls* marked in Figure 15) allow .soh file management such as open, close, and plotting features. The button functions are described in Table 10.

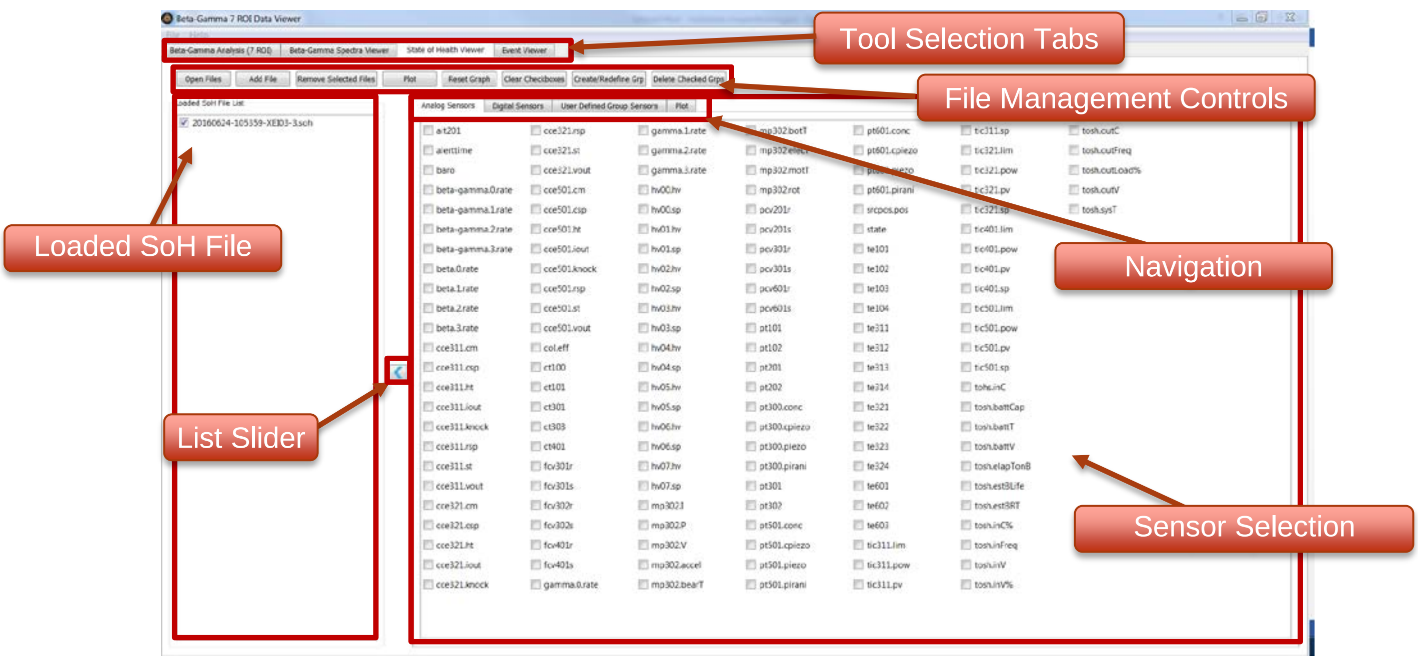


Figure 15 - The Beta-Gamma 7 ROI Data Viewer State of Health Viewer tab with an example .soh file opened.

Table 10 - A description of State of Health Viewer File Management Controls

Description	Graphic
Open Files: This button opens a file browser where you can choose state of health (.soh) files that will be added to the loaded soh file list. Multiple files can be selected for opening.	Open Files
Add File: This button opens a file browser where you can choose state of health (.soh) files that will be added to the loaded soh file list.	Add File
Remove Selected Files: This button will remove any selected files in the loaded soh file list.	Remove Selected Files
Plot: This button selects the Plot tab and plots the selected sensors to the chart.	Plot
Reset Graph: This button resets the graph to its original size.	Reset Graph
Clear Checkboxes: This button will uncheck all sensors.	Clear Checkboxes
Create/Redefine Grp: This button will open a dialog where you can create a custom group. See custom groups.	Create/Redefine Grp
Delete Checked Grps: This button deletes selected groups from the User Defined Group Sensors tab.	Delete Checked Grps

2.3.2 Loaded SoH File List

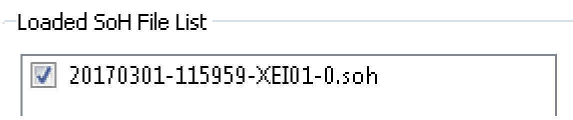


Figure 16 - Loaded SoH file list.

The list of loaded .soh files is displayed in this section. The list allows selecting files to display sensor data on the plot. Files from different systems may be loaded and the sensor list in the *Sensor Selection Interface* will contain the cumulative sensors from all loaded .soh files.

2.3.2.1 List Slider ( )

This button shows/hides the *Loaded SoH File List*.

2.3.3 Navigation

Once a .soh file is opened, there are several tabs allowing selection of different types of sensors to be plotted. The sensors are divided into analog, digital, and user defined groups.

Table 11 - Description of the navigation tabs in the SoH Viewer.

Description	Graphic
Navigation tabs	Analog Sensors | Digital Sensors | User Defined Group Sensors | Plot
Analog Sensors: This tab displays a list of analog sensors that can be selected and displayed in the plot.	Analog Sensors
Digital Sensors: This tab displays a list of digital sensors that can be selected and displayed in the plot.	Digital Sensors
User Defined Group Sensors: This tab displays a list of user defined custom groups. See section *2.3.3.2 User Defined Group Sensors*.	User Defined Group Sensors
Plot: This tab displays a graph that plots the selected sensors.	Plot

2.3.3.1 Analog and Digital Sensors

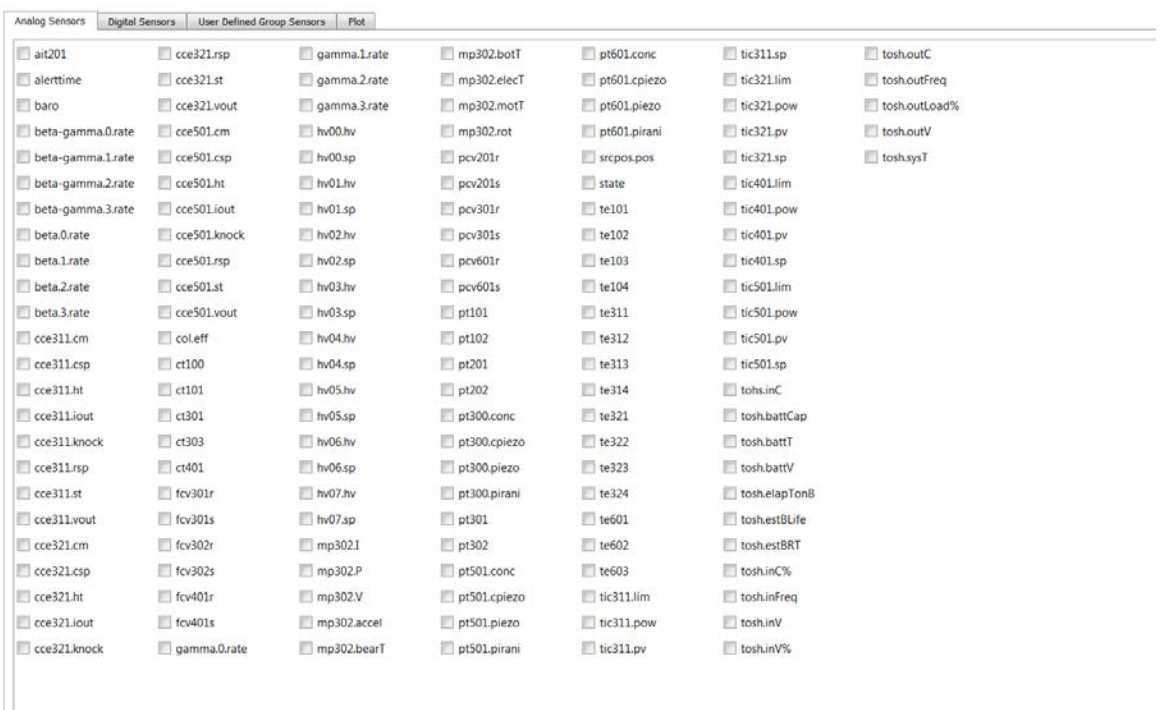


Figure 17 - This is an example of the Analog Sensors tab with example sensors.

The next section describes the parts of the viewer that allow selection of the different sensors to generate user *defined group sensors* (see Section *2.3.3.2 User Defined Group Sensors*) or to plot sensor data (see Section *2.3.3.3 Plot*).

2.3.3.2 User Defined Group Sensors

The Create/Redefine Group function allows sensors to be selected and saved as a custom group to allow the user to plot the same sensors repeatedly.

To create a group, select the sensors you want from the Analog and Digital Sensors tabs then click the Create/Redefine Grp button. A dialog box will open with a list of the sensors and a text field to enter the name for the group. The defined group is saved in a configuration file that will be loaded each time the viewer is opened, providing access to the user's predefined groups.

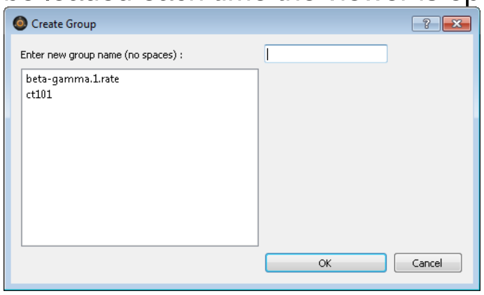


Figure 18 - The *Create Group* dialogue window.

2.3.3.3 Plot

Figure 19 - SoH viewer plotting several example sensors.

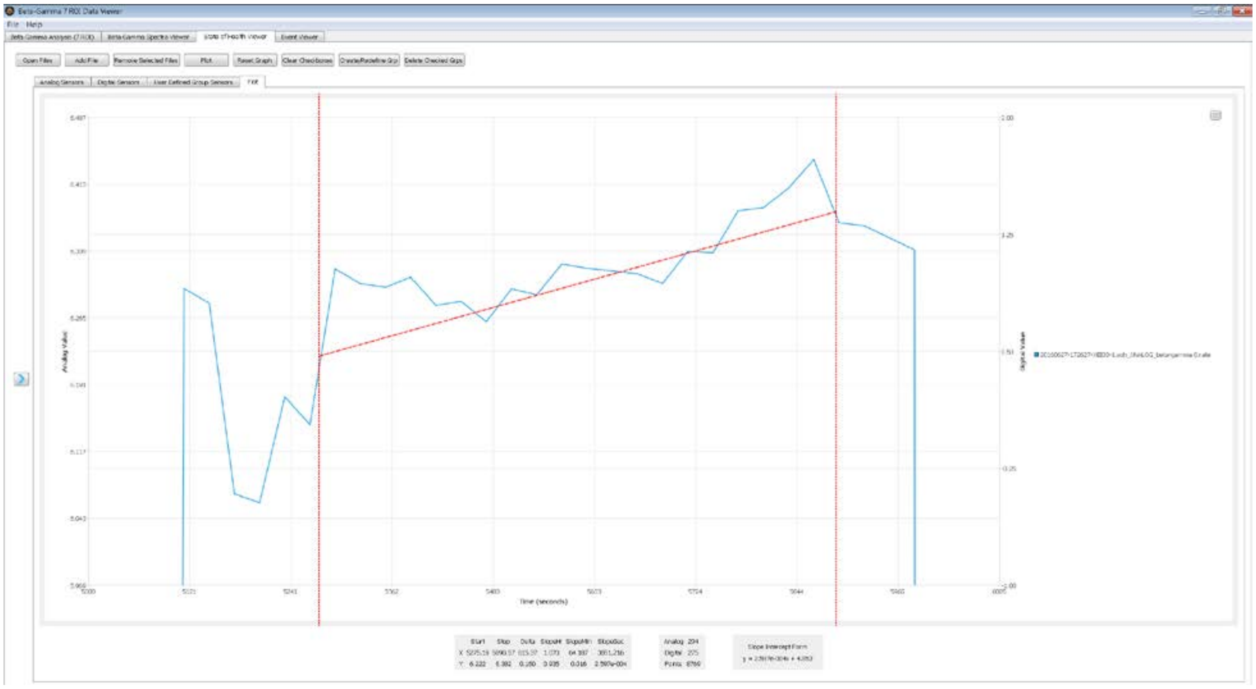


Figure 20 - SoH viewer showing a plot using the linear measurement tool.

The graph has all the same functionality as other graphs (see Section 2.1.3.3 for features such as zoom and export) but includes a linear measurement tool. The tool is used by holding ctrl on the keyboard while clicking and holding the mouse to drag the selection box over the area to be measured. The measurement tool will create a line from the starting click to where the mouse button is released. Once the mouse button is released, the information about the resulting line will displayed beneath the graph (see Figure 20).

2.4 Event Viewer

The event viewer tool (see Figure 21) is used for viewing event log files generated from U.S. developed systems. Event log files are tables where each row is a single timestamped event that is processed by the loggerServer. A summary of the event types is given in the upper center portion of the Event Viewer tab. The Event Viewer allows filtering of the event records based on five data types: Category, Process, Client, Source, and Function. The asterisk (*) is a wildcard; when selected, it does not filter the results. Selecting a filter will display logged event records containing all of the filter conditions. Multiple filters can be used to screen event records to display events of interest.

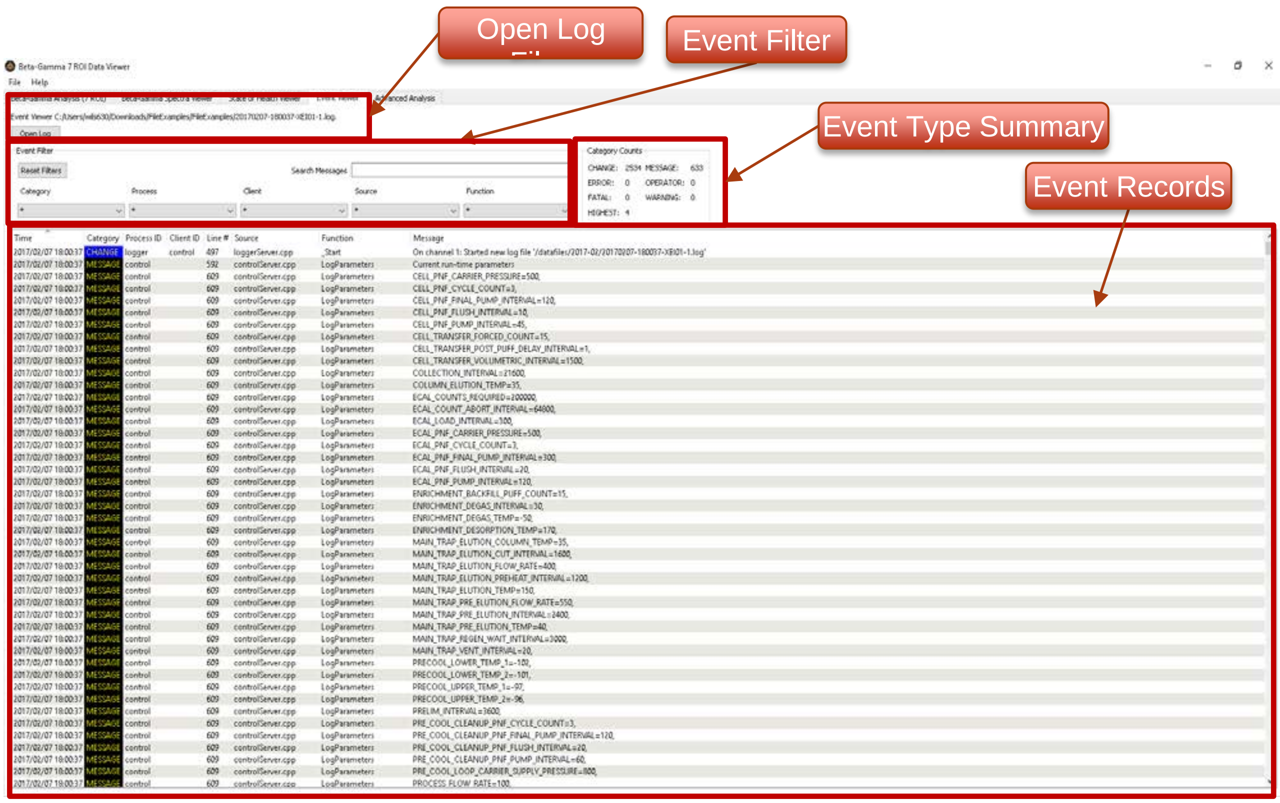


Figure 21 - The Beta-Gamma 7 ROI Data Viewer State of Health Viewer tab with an example .soh file opened.

2.4.1 Open Log Files

The Open Log button is in the upper left corner of the Event Viewer tab and allows the user to open a .log file.

2.4.2 Event Filter

The Event Filter provides search message bar and five optional filters to screen event records (see Figure 22). The filters default to no filtering. Each filter has a drop-down menu to select a filter condition (see Table 12). Event log files contain a significant amount of records (several thousand entries) and therefore need to be filtered to reduce the amount of information to something useable. The event filters are used to narrow the event records down to those containing the information of interest. The search message bar uses a fuzzy search to find text in the message's column that loosely matches, searching "file" would show messages that contain "file" as well as messages that contain "profile".

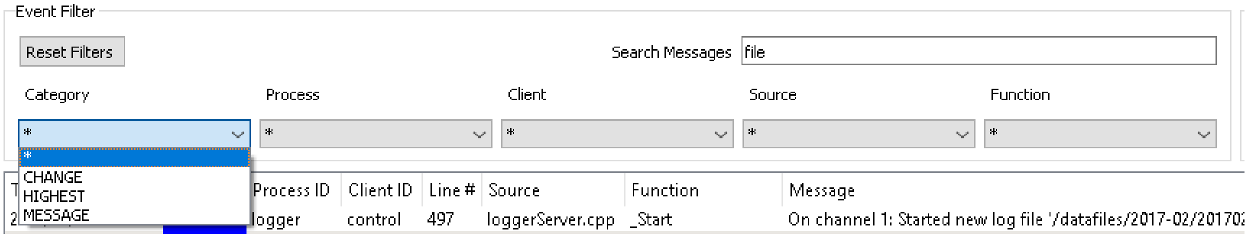


Figure 22 - An example of the drop-down menu used to select an event record filter type.

Table 12 - List of event filter types and the corresponding filters.

Event Filter Type	**Filter**
Category	Change, Error, Highest, Message, warning, * (wildcard; all)
Process	WebGUI, anadig, control, controlMenu, ezzone, f23, logger, mail, mdrive, nucdata, param, pbg, ricor, ricorMenu, soh, source, turbo, * (wildcard).
Client	<BLANK>, control, source, * (wildcard).
Source	loggerServer.cpp, sohServer.cpp, optoServer.cpp, ricorServer.cpp, pfeifferTurboServer.cpp, paramServer.cpp, ezzoneServer.cpp, pbgServer.cpp, nucDataServer.cpp, sourceServer.cpp, mdriveServer.cpp, controlServer.cpp, f23Server.cpp, mailServer.cpp, * (wildcard).
Function	_Start, _Stop, _WritePBG, DataUpdateThread, Enable, InsertSourceAtPosition, LogParameters, MakeSymlink, MoveToPosition, NSO_ElutionCutExit, NSO_QCWaitExit, NSO_StableGasQuantExit, RemoveSource, SendMail, SetAnalog, SetDigital, SetMode, SetParameter, SetRoughingMode, SetSetpoint, Start, StateChanged, StepStateMachine, Stop, TurboPower, * (wildcard).

2.4.3 Event Type Summary

The event type summary gives the number of each event type in the opened .log file. An example is shown in

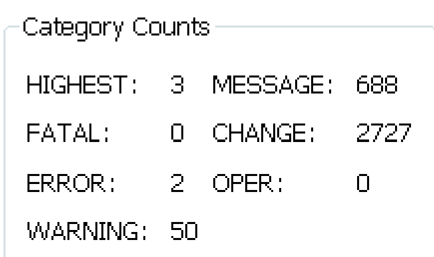


Figure 23 - A summary of the number of each event type from an example .log file

2.4.4 Event Records

The final section of the Event Viewer tab is the event records. This is where the actual event records are viewed. The top line contains the labels for each column (from left to right): Time, Category, Process ID, Client ID, Line #, Source, Function, and Message. A left mouse click on a column label will cause the event records to be sorted by that column; a second left mouse click on the same column label will reverse the sort order. A left mouse click on a particular record will bring up a dialogue box with the Message entry provided. Scroll bars on the right and bottom portion of this section may be present dependent on the number of record entries and the available width of the records.

Time	Category	Process ID	Client ID	Line #	Source	Function	Message
2017/01/14 18:04:41	MESSAGE	control		592	controlServer.cpp	LogParameters	Current run-time parameters
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	CELL_PNF_CARRIER_PRESSURE=500,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	CELL_PNF_CYCLE_COUNT=3,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	CELL_PNF_FINAL_PUMP_INTERVAL=120,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	CELL_PNF_FLUSH_INTERVAL=10,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	CELL_PNF_PUMP_INTERVAL=45,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	CELL_TRANSFER_FORCED_COUNT=15,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	CELL_TRANSFER_POST_PUFF_DELAY_INTERVAL=1,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	CELL_TRANSFER_VOLUMETRIC_INTERVAL=1500,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	COLLECTION_INTERVAL=21600,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	COLUMN_ELUTION_TEMP=35,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	ECAL_COUNTS_REQUIRED=200000,
2017/01/14 18:04:41	MESSAGE	control		609	controlServer.cpp	LogParameters	ECAL_COUNT_ABORT_INTERVAL=64800,

Figure 24 - Event records from an example .log file

2.5 Advanced Tools

The *Advanced Tools* tab features the QC (Quality Control) analysis tool and the Calibration tool.

The QC analysis tool allows users to analyze the energy gains of the quality control (QC) files and to compare a QC file with the first QC file taken during the detector calibration - the "golden" QC file. A user can load IMS 2.0 ^{137}Cs QC files and view the beta-gamma coincidence and gamma spectra. The tool determines the centroid location of the ^{137}Cs 662-keV gamma-energy peak and the extrapolated Compton scatter beta-intercept location. These values are displayed for each open file in a graph to be used for trend analysis to observe gain changes.

The Calibration tool allows users to perform an energy calibration, calculate efficiencies, and interference ratios using the absolute calibration method [2], [3]. The tool will output a configuration file to be used for beta-gamma detector systems. Multiple IMS 2.0 files in the CALIBPHD or SAMPLEPHD format are loaded to perform the calibration of a detector cell. The complete calibration analysis in this tool can be saved as a single file for review or updating using a ".bgc" file extension.

2.5.1 QC Analysis

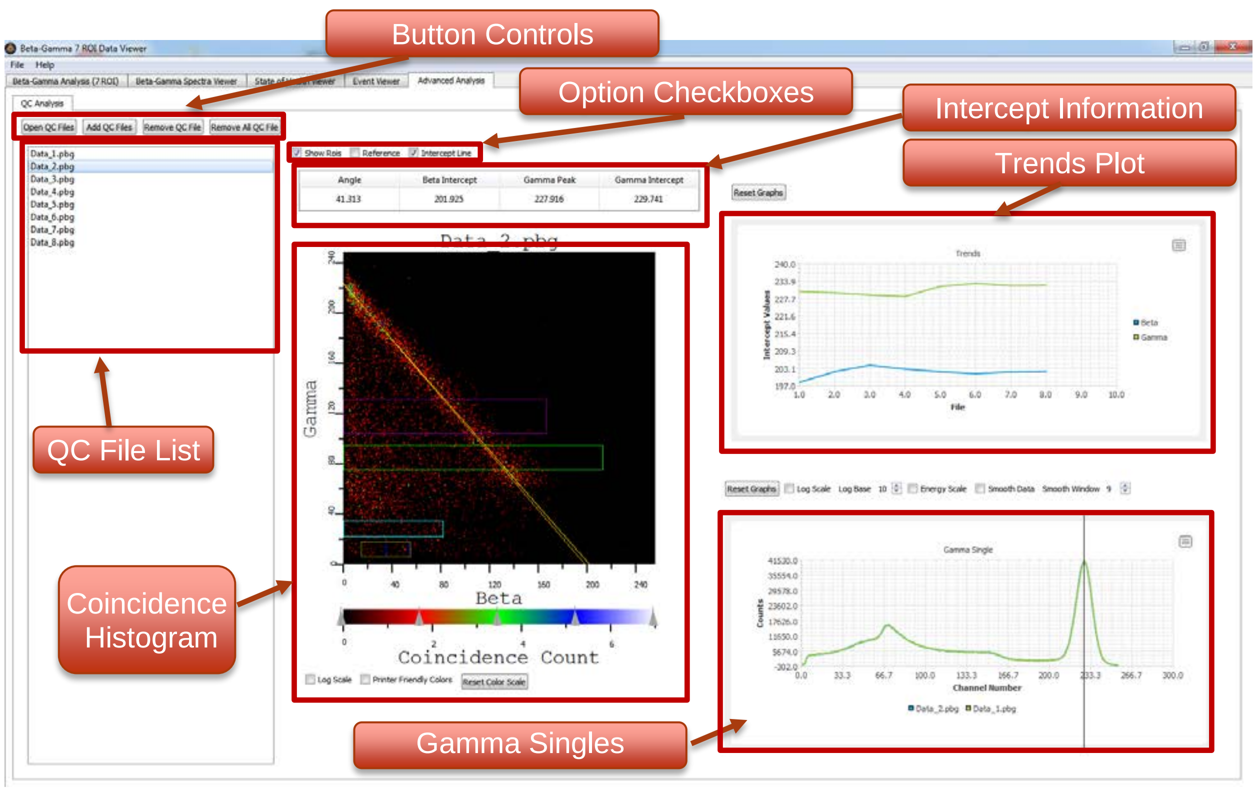
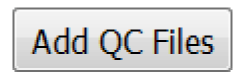
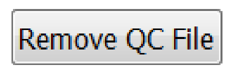
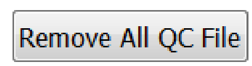


Figure 25 - QC Analysis in the Advanced Analysis tab

2.5.1.1 Button Controls

A QC file is loaded by selecting the “Open QC Files” or “Add QC Files” button. After the button is pressed, a file dialog window will open allowing the user to navigate to and select file(s) to open. Each loaded QC file will populate the trends chart in the upper right of the QC Analysis tab plotting the gamma and beta intercept between the files. The selected file names will display in the QC File List (see Figure 25).

Table 13 - A description of QC Analysis Button Controls

Description	Graphic
Open QC Files: This button opens a file dialog window where you can select QC files to open. Multiple files can be selected by using standard windows multi select options (i.e., shift + click, ctrl + click). All previously loaded files are removed before loading the new files.	
Add QC Files: This button opens a file browser where you can choose QC files to open. Multiple files can be selected by using standard windows multi select options (i.e., shift + click, ctrl + click). This will append the new files to the file list.	
Remove QC File: This button will remove the currently selected QC file from the list.	
Remove All QC Files: This button will remove all the QC files from the list.	

2.5.1.2 QC File List

The file list shows the currently loaded files and allows the user to select the file to be viewed. Clicking on the file name will load that file, also the user can use the arrow keys to select the file.

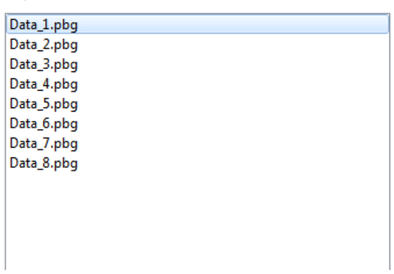


Figure 26 - QC file list

2.5.1.3 Options Checkbox

The options checkbox can be used after a QC file is selected and opened. The checkboxes allow two options to be turned off or on. The first option, *Reference*, lock the current selected file from the QC file list as a comparative reference file. This file can be any file located in the QC file list. The reference file is used to compare the intercept line on the coincidence histogram and the gamma-singles histogram. The second option, *Intercept Line*, will add or remove a yellow intercept line on the 2D coincidence histogram. The line is between the beta and gamma intercept and acts as a visual representation of the fit to the Compton scatter. If

Reference and Intercept Line are both selected, a secondary orange line will appear on the coincidence histogram to represent the intercept line of the reference file.

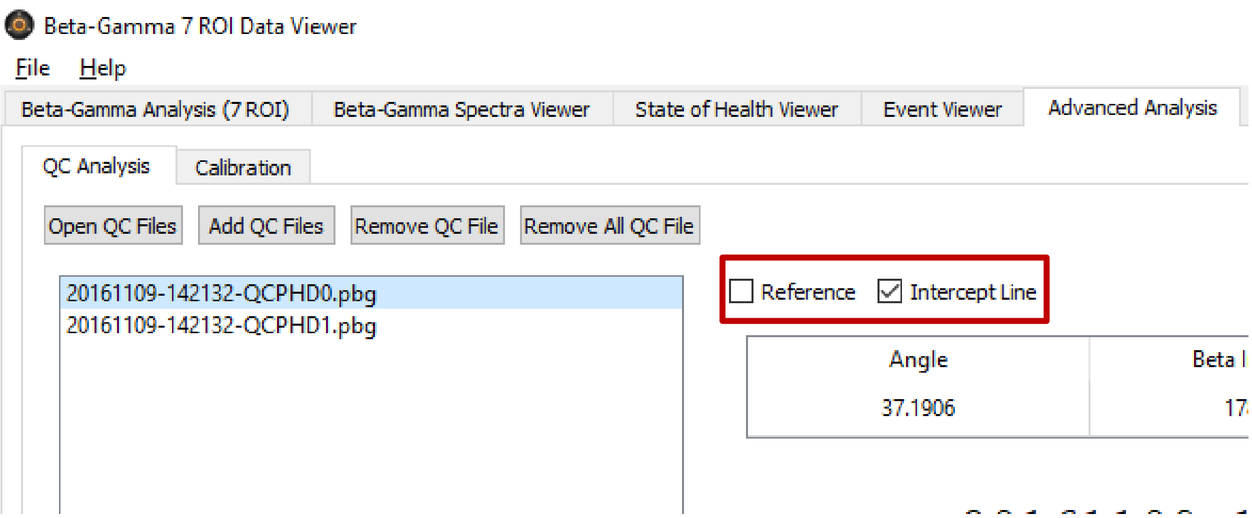


Figure 27 - The options checkbox (outlined in red) showing options checked and unchecked

2.5.1.4 Intercept Information

The intercept information of the current file selected is displayed above the 2D coincidence histogram. The beta and gamma intercepts determined using the rotated frame of reference method. This method determines the points where the Compton scattering line would intercept the beta- and gamma-axis. The angle used to determine the rotation and the intercepts are displayed. A line connecting the two intercepts can be added to the 2D coincidence histogram as described in Section 2.5.1.3. The Gamma Peak information is also displayed is the 662-keV gamma peak centroid. The 662-keV centroid (Gamma Peak) is found using a peak finding algorithm on the gamma single data.

Angle	Beta Intercept	Gamma Peak	Gamma Intercept
55.5993	151.378	221.722	221.076

Figure 28 - Calculated intercept information

2.5.1.5 Coincidence histogram

The coincidence histogram shows the 2D spectrum from the selected QC file in the file list. If the Show ROIs and Intercept Line in Options Checkbox are selected, the visuals would appear on the histogram. See 2D Histogram Plot Functions for more information regarding controls of the histogram.

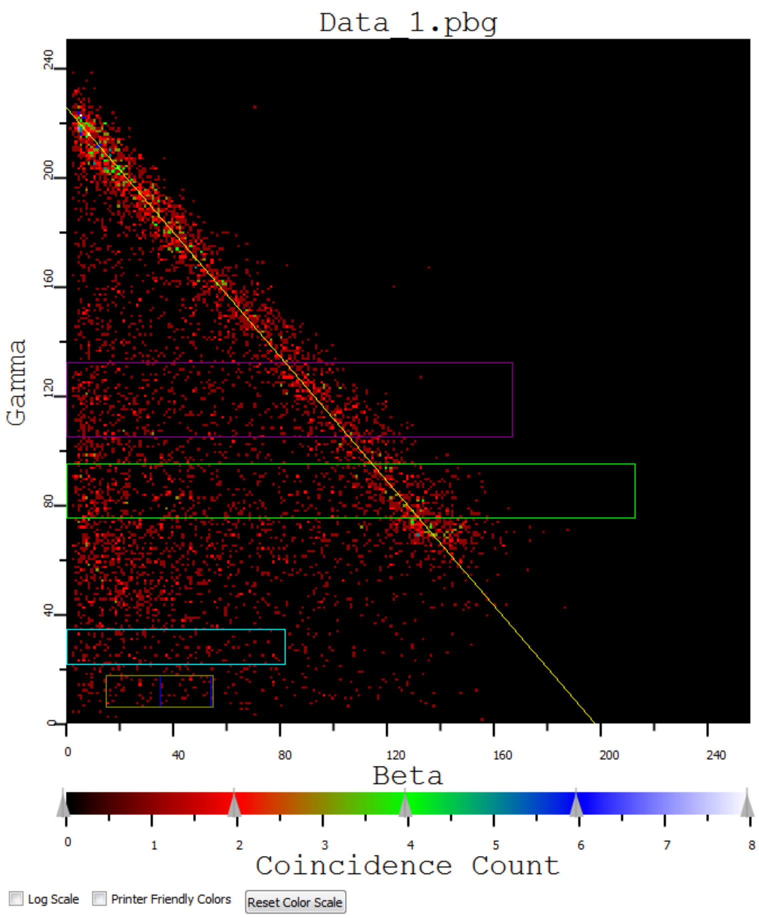


Figure 29 - Beta-gamma coincidence histogram with ROIs and intercept line displayed

2.5.1.6 Trends plot

The trends plot displays the beta and gamma intercept from every loaded file. The blue line is the beta intercept trend and the green line is the gamma intercept trend. The files are sorted by file numbering order – first to last.

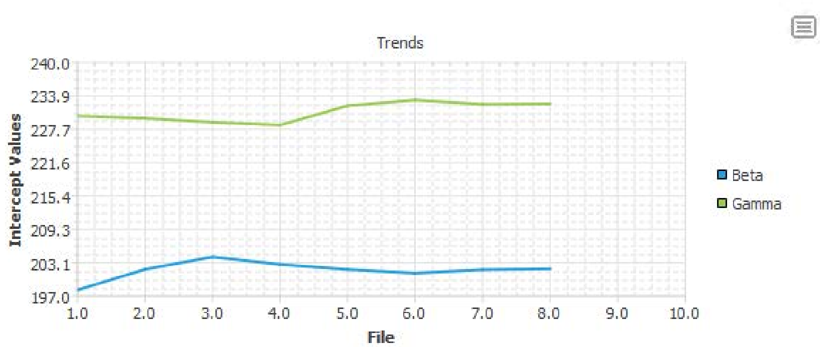


Figure 30 - Trends plots showing the beta (blue) and gamma (green) trends across several files.

2.5.1.7 Gamma single plot

The gamma singles plot displays the gamma single data from the file and places a vertical line where the at the centroid of the 662-keV peak from the ^{137}Cs. If a reference QC file is selected, then a secondary line will be displayed showing the position of the reference's ^{137}Cs 662-keV centroid.

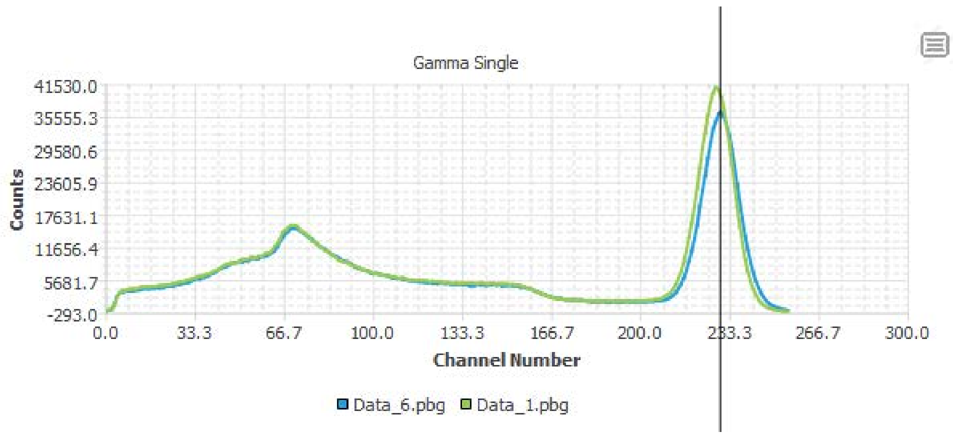


Figure 31 - Gamma singles histogram plot with reference line for the 662-keV centroid. Two histograms are displayed since a reference file is chosen.

2.5.2 Calibration

The initial view when opening the Calibration tool is the summary. When the files are loaded, the user will be shown information relevant to the calibration in the dashboard. A calibration can be loaded by either loading individual CALIBPHD and a background file, by loading a data set with the proper naming format, or a previous saved calibration file (bgc file). When loading files individually, a background file must be loaded.

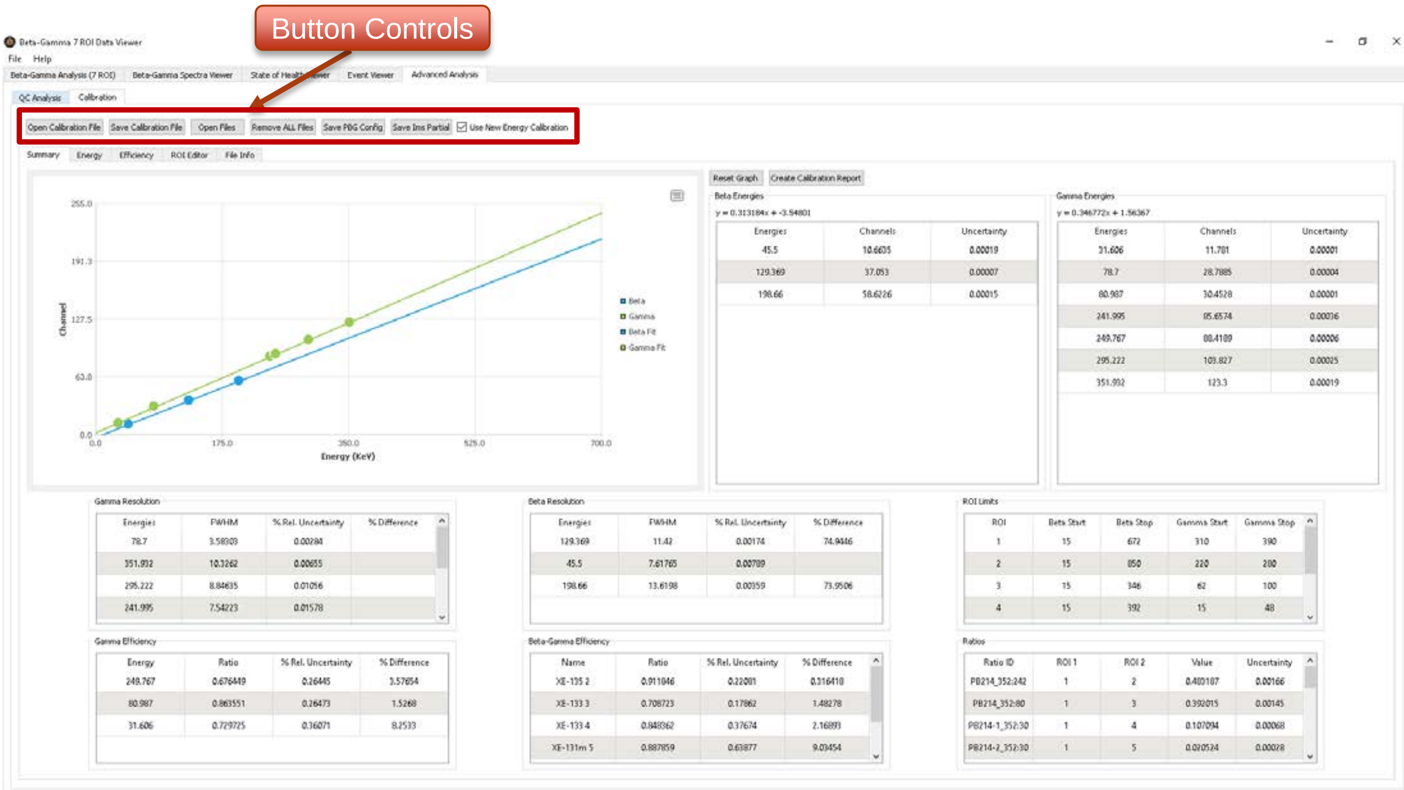


Figure 32 - Calibration Summary Tab

2.5.2.1 Button Control

Figure 33 - Calibration button controls

The buttons in Figure 33 are the principal open file and save file options for the calibration tab.

Table 14 - A Description of the Calibration Button Controls

Description	Graphic
Open Calibration File: This button opens a file dialog window where you can select a Calibration(.bgc) file to open. This is a special file this program creates to make it easy to load/save the current state of the calibration being performed. It contains all the information from the six files, all the peak information, and ROI settings.	Open Calibration File
Save Calibration File: This button opens a file browser where you can choose path to save a Calibration(.bgc) file. This is a special file this program creates to make it easy to load/save the current state of the calibration being performed. It contains all the information from the six files, all the peak information, and ROI settings. All files must be loaded in order to save this file.	Save Calibration File
Open Files: This button opens a dialog to select files to open. See Open Files Dialog	Open Files
Remove All Files: This button removes all the loaded files.	Remove ALL Files
Save PBG Config: This button opens a file dialog window where you can select a path where to save the pbg#.cfg file. This file is used in multiple systems to get the calibration information when creating other IMS 2.0 format files. i.e. SAMPLEPHD	Save PBG Config
Save IMS Partial: This button opens a file dialog window where you can select a path to save an IMS 2.0 partially formatted file this files includes the Calibration, g_Energy, b_Energy, g_Resolution, b_Resolution, g_Efficiency, b-gEfficiency, ROI_Limits, and Ratios blocks .	Save Ims Partial
Use New Energy Calibration: This checkbox allows the viewing of the results with/without the calculated energy calibrations.	☑ Use New Energy Calibration

There are multiple ways to save the calculated calibration information briefly described above. The Calibration bgc file is used to save all relevant work associated with a calibration. The PBG Config file (*.cfg) is a file used for systems that contains relevant detector and calibration information to create IMS 2.0 files on the system. An IMS Partial file is a text file that contains several blocks of detector information and calibration information (listed above) already in the IMS 2.0 format. It is not a complete pbg or phd file.

2.5.2.2 Open Files Dialog

The Open Files Dialog allows for selecting the paths for the different files that are required for a calibration. When clicking the “Browse” button a file dialog box will open allowing you to select the file path for the appropriate file. The “Open All From File Name” is special and when selecting the specially named file it will fill in all the paths, see table below for file name format.

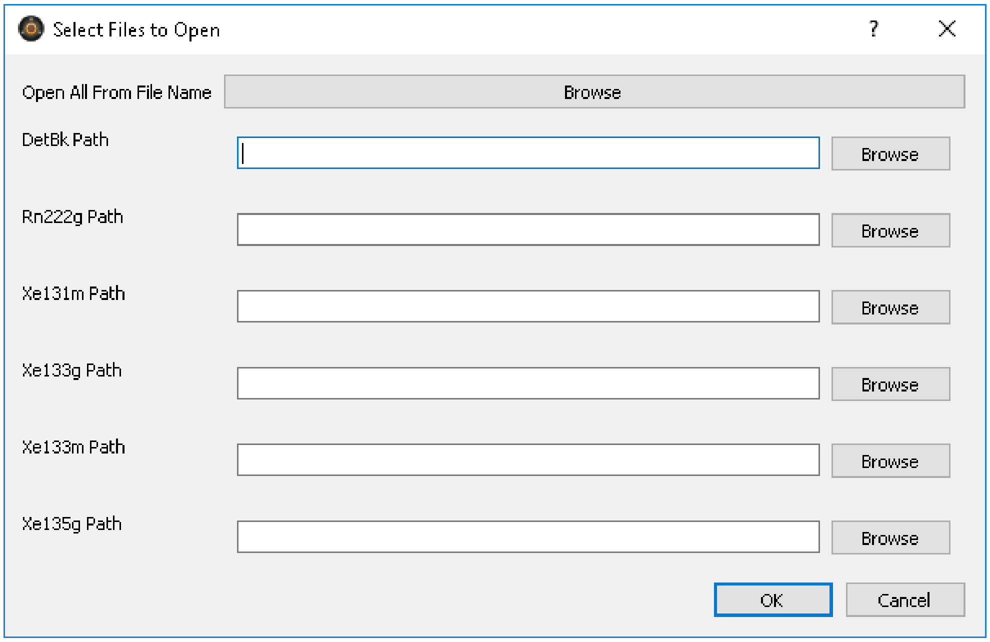


Figure 34 - Open Files Dialog.

Table 15 - A description of the Open Files dialog

Description	Graphic
Open All From File Name: This button opens a file dialog window where you can select a specially named IMS 2.0 format file that will then open all the required files that also follow the format. The format required is *[system short name]_YYYYMMDD_[#####]_[isotope]_CALIBPHD.pbg* for the isotope spiked files, and *[system short name]_YYYYMMDD_[#####]_DETBKPHD.pbg*, for the detector background. [#####] is n number of alphanumeric characters. *i.e. XIX81_20190812_W8C13_Rn222g_CALIBPHD.pbg*. The *[system short name]_YYYYMMDD_[#####]* has to match for all files you open.	
Detbk Path: This button opens a file dialog window where you can select an IMS 2.0 format detector background file.	
Rn222g Path: This button opens a file dialog window where you can select an IMS 2.0 format Rn222g file.	
Xe131m Path: This button opens a file dialog window where you can select an IMS 2.0 format Xe131m file.	
Xe133g Path: This button opens a file dialog window where you can select an IMS 2.0 format Xe133g file.	
Xe133m Path: This button opens a file dialog window where you can select an IMS 2.0 format Xe133m file.	
Xe135g Path: This button opens a file dialog window where you can select an IMS 2.0 format Xe135g file.	

2.5.3 Summary View

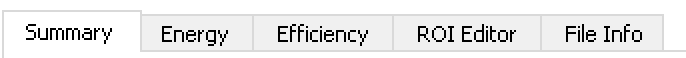


Figure 35 - Summary tab selection.

This is the main view for the calibration providing on overview of all the calculations. An overview of all the information acquired from the calibration can be found on this view. No adjustments to the data can be performed with the exception of using the new energy calibration. A summary calibration report can be saved as a pdf-formatted document.

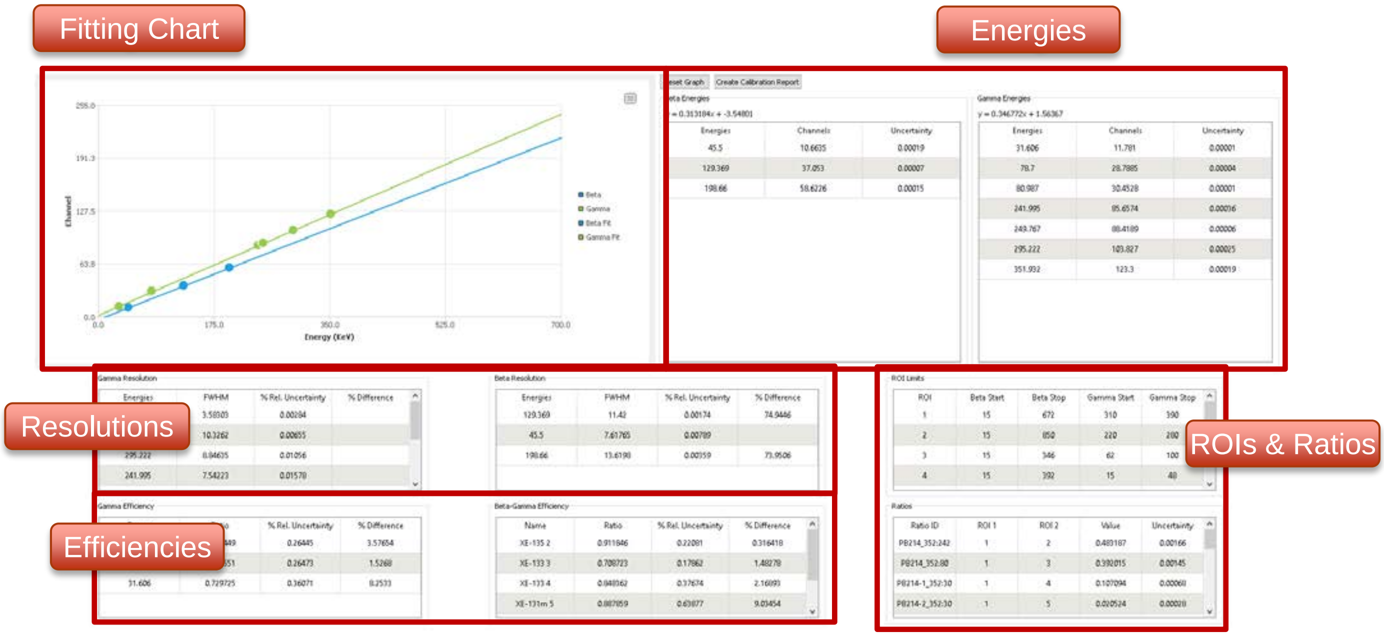


Figure 36 - Summary View Breakdown.

Fitting Chart
The fitting chart plots the relationship from channel to energy as a scatterplot. A plot using the linear least squares is used to overlay a line finding the best fit. See results view. The reset plot button can be pressed to reset the view of the plot.

Energies
Energies is a table of the calculated beta and gamma energy conversion points. See energy view.

Resolution
Resolution is a table of the beta and gamma resolution. See Resolution view.

Efficiencies
Efficiencies is a table of the beta and gamma efficiencies. See Efficiencies view.

ROIs & Ratios
ROIs & Ratios is a table of the Region of Interest (ROI) limits and ratios. ROIs are a set of bounds in keV we expect to find high concentrations of activity. The bounds produce a rectangle in the 2D Histograms. See ROI Editor. The ratios are the counts in one ROI over the counts in another ROI.

2.5.4 Energy View

Figure 37 - Energy tab selection

The Energy tab selection view allows the user to see spectra and fitting information of the loaded files. Here you can adjust the fits to that determine the beta and gamma energy to channel relationship. By editing the cells in white, fits can be provided a guess to the range of where a peak is located. Each isotope in a calibration spike CALIBPHD IMS 2.0 file will have associated peaks at an energy (keV). The detector reports these counts in the peak in channels (0 – 255). We use a Gaussian with a linear background to fit the centroid of the peak in channels. This is performed for several main peaks used in the calibration. We use this set of values to figure out the linear equation for the calibration. See Peak Edit Table.

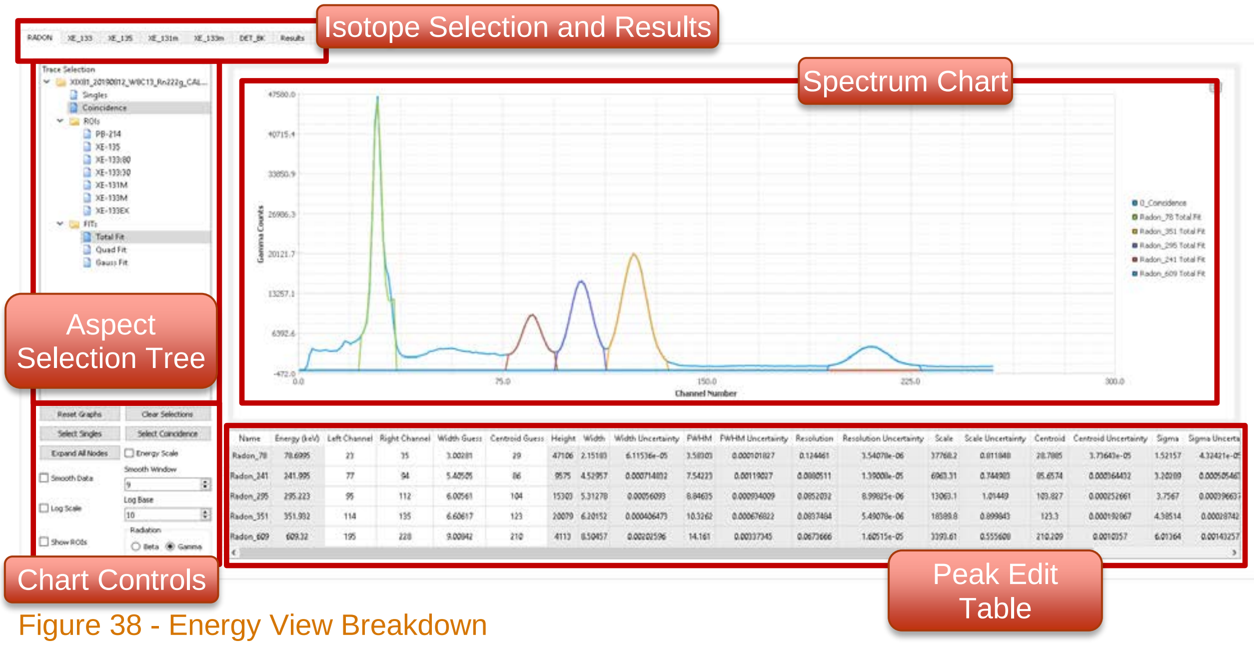


Figure 38 - Energy View Breakdown

2.5.4.1 Isotope Selection

Each tab shows the spectra associated with the calibration file selected. The default spectrum shown is the one used for fitting, but all 1D data can be viewed.

Aspect Selection Tree

This is how the user selects the different histograms to plot. The FITs selection is special and can show the total fit, the Gaussian, or the linear subtraction. The Quad fit, just the linear subtraction plot. The Gauss fit, just the Gaussian plot. This widget it capable of multiple selections by using shift + click to select a range or ctrl + click to select/deselect individual traces.

Chart Controls

This region allows for more control of the displayed spectra or fits.

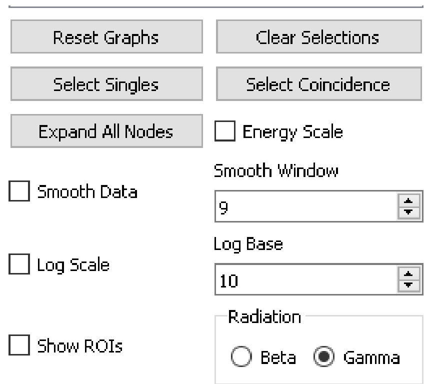
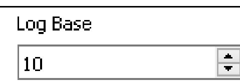


Figure 39 - Chart controls view

Table 16 - A description of the Chart controls

Description	Graphic
Reset Graphs: This button resets the graph to default zoom.	
Clear Selections: This button clears all selected traces.	
Select Singles: This button will select the singles traces.	
Select Coincidence: This button will select the coincidence traces.	
Expand All Nodes: This button will expand any collapsed sub trees in the trace selection view.	
Energy Scale: This checkbox will plot the histograms with the x axis in energy scale (keV) or channel.	
Smooth Data: This checkbox will plot the histograms with a Savitzky-Golay smoothing algorithm.	
Smooth Window: This spin box selects the size of the window used for the Savitzky-Golay smoothing algorithm.	
Log Scale: This checkbox will plot the histograms with y axis in logarithmic scale.	
Log Base: This spin box selects the base used for the log scale.	
Show ROIs: This checkbox will plot the ROIs on the chart.	
Radiation Beta/Gamma: These radio buttons switch the graph between the beta and gamma histograms for the selected traces, this doesn't change the FITs or change how the calculations are performed.	

Spectrum Chart

This is a chart that shows the spectral information of the isotope selected. The default view is the spectrum that needs to be fitted for the energy calibration.

Peak Edit Table

Name	Energy (keV)	Left Channel	Right Channel	Width Guess	Centroid Guess	Height	Width	Width Uncertainty	FWHM	FWHM Uncertainty	Resolution	Resolution Uncertainty	Scale	Scale Uncertainty	Centroid	Centroid Uncertainty	Sigma	Sigma Uncerta
Radon_78	78.6095	23	35	3.00281	29	47106	2.15183	6.11536e-05	3.58303	0.000101827	0.124461	3.54078e-06	37768.2	0.811848	28.7885	3.73643e-05	1.52157	4.32421e-05
Radon_241	241.995	77	94	5.40505	86	9575	4.52957	0.000714832	7.54223	0.00119027	0.0880511	1.39008e-05	6963.31	0.744983	85.6574	0.000364432	3.20289	0.00050546
Radon_295	295.223	95	112	6.00561	104	15303	5.31278	0.00056093	8.84635	0.000934009	0.0852032	8.99825e-06	13063.1	1.01449	103.827	0.000252661	3.7567	0.00039663
Radon_351	351.932	114	135	6.60617	123	20079	6.20152	0.000406473	10.3262	0.000676022	0.0837484	5.49070e-06	18389.8	0.899043	123.3	0.000192067	4.38514	0.00028742
Radon_609	609.32	195	228	9.00842	210	4113	8.50457	0.00202596	14.161	0.00337345	0.0673666	1.60515e-05	3393.61	0.555608	210.209	0.0010357	6.01364	0.00143257

Figure 40 - Peak Edit table with editable text in red box

This table shows the information for the different peaks and their fits that we expect to find for the current isotope spiked IMS 2.0 file. The cells in the red box are editable. Left and Right channel are the limits in which the fitting is performed for the gaussian and linear fits. Width Guess is the guess of the width of the gaussian, note this related to but not the FWHM. Centroid Guess is the best guess for the center of the gaussian; note this is not the calculated centroid. These values give the gaussian fit algorithm a starting point, sometimes changing these values will not change the results of the algorithm. The Centroid Guess should be located between the Left Channel and Right Channel. The Width Guess should be smaller than the difference between the Left Channel and Right Channel.

2.5.4.2 Results

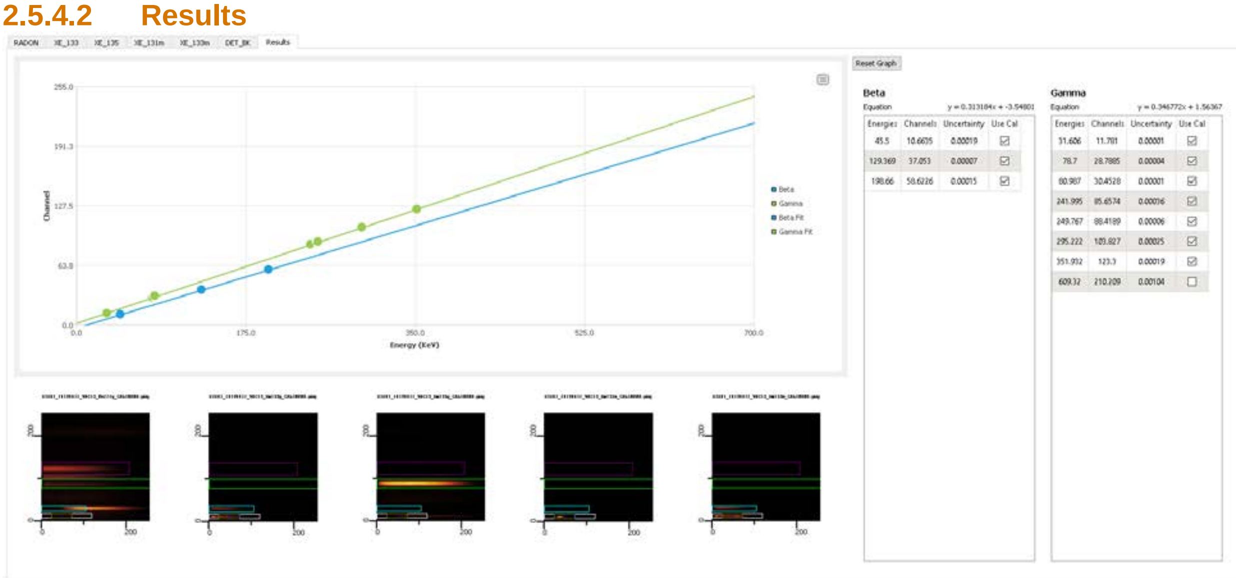


Figure 41 - Results View

This view is like the Fittings and Energies sections in the summary view except you can choose which beta and gamma energy peak is used for the calibration. There could be instances where a value for a peak is not obtainable or the detector is non-linear at higher energies. By clicking the checkbox in the table, you can select and deselect the peak. The 2D histograms at the bottom of the page give a quick visual of the changes across all calibration files.

Energies	Channels	Uncertainty	Use Cal
45.01	10.6635	0.000194984	☑
129.369	37.053	6.58883e-05	☑

Figure 42 - Peak selection for use in energy calibration

2.5.5 Efficiency View

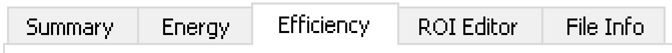


Figure 43 - Efficiency tab selection

This view shows tables of the interference terms and efficiency values calculated using the energy calibration and ROIs from the other tabs. There are two tabs which will either show just the interference terms or the efficiency terms. For each interference term and efficiency, the calculated, original, and percent difference between them are displayed. The original values are obtained from the detector background file. An analysis report can be generated which will output a text file with information relevant to the calculation of the efficiencies and interference terms.

Figure 44 - Save Analysis Report Button

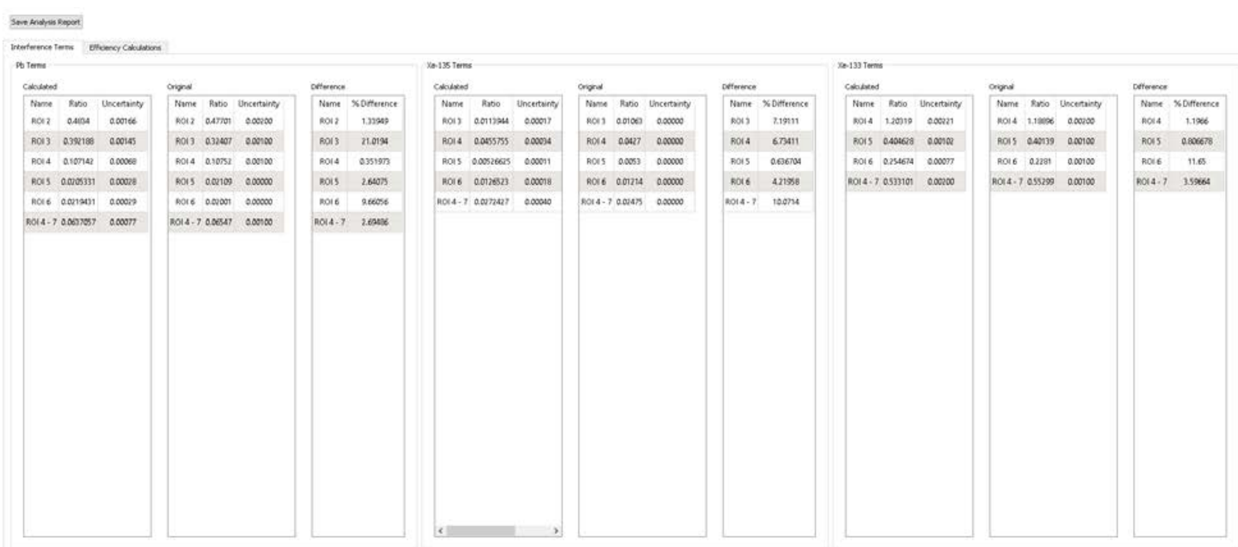


Figure 45 - Interference View

2.5.6 ROI Editor

Figure 46 - ROI Editor selection

This view allows the ROI limits to be viewed and edited. When a ROI value is edited, the calibration will be updated using the new ROI values. The user can navigate all isotopes used in the calibration to ensure the isotope signature is covered by the ROI. All values of ROI limits are expressed in the energy unit of keV.

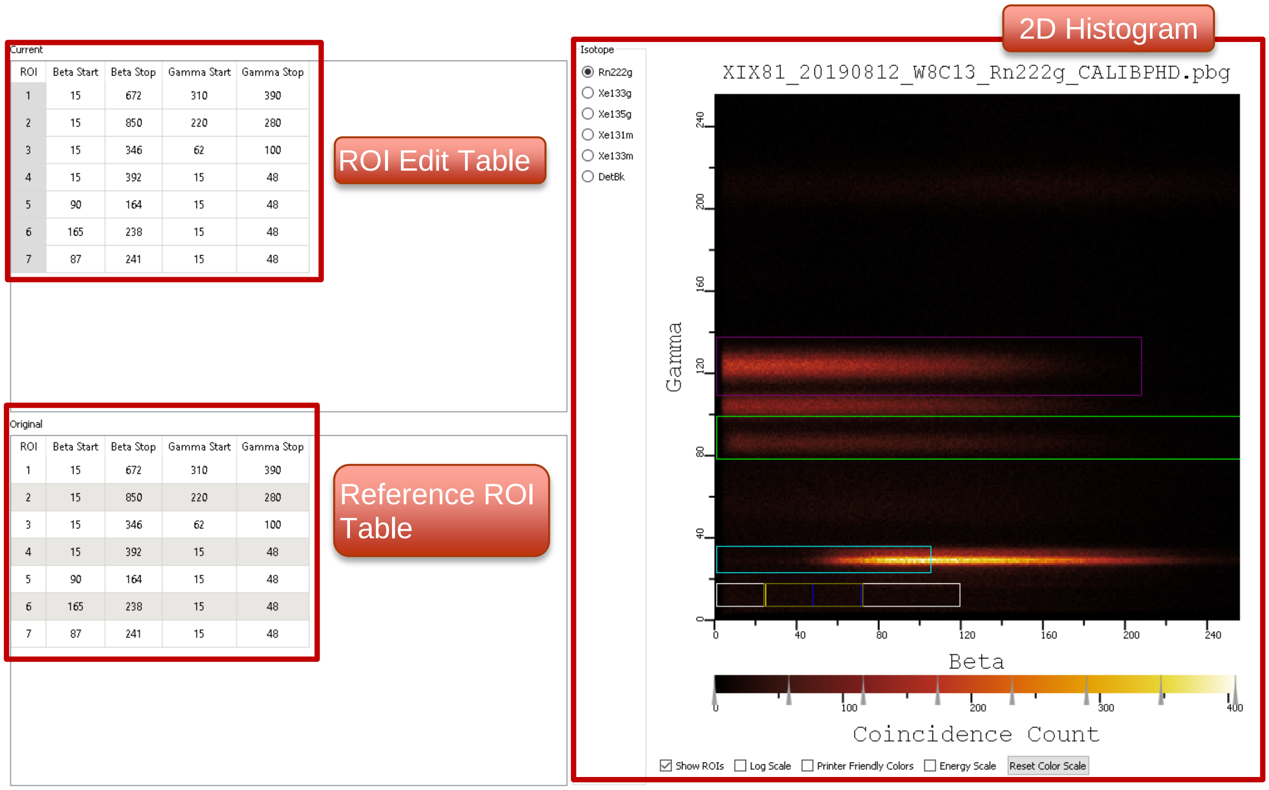


Figure 47 – The ROI Editor with ^{222}Rn displayed on the 2D Histogram.

ROI Edit Table

The ROI Edit Table allows you to edit the limits for the ROIs. The initial default values are obtained from the detector background file.

Reference ROI

An uneditable table which displays the values of the ROIs in the detector background.

2D Histogram

This is 2D coincidence histogram of the isotope selected. This histogram allows for a visual of the ROIs and any changes made to the ROIs. The radio buttons switch between different calibration files used in the calibration. See 2D Histogram Plot Functions for more information.

2.5.7 File Info

Figure 48 - File Info tab selection

This view does the same as file info located in the BG analysis, it just has the files loaded for a calibration. See File Info in Beta-Gamma Analysis for more information.

2.6 Menu bar

The menu bar allows quick access to setting for the detector background folder, universal properties for the application, and information about the application.

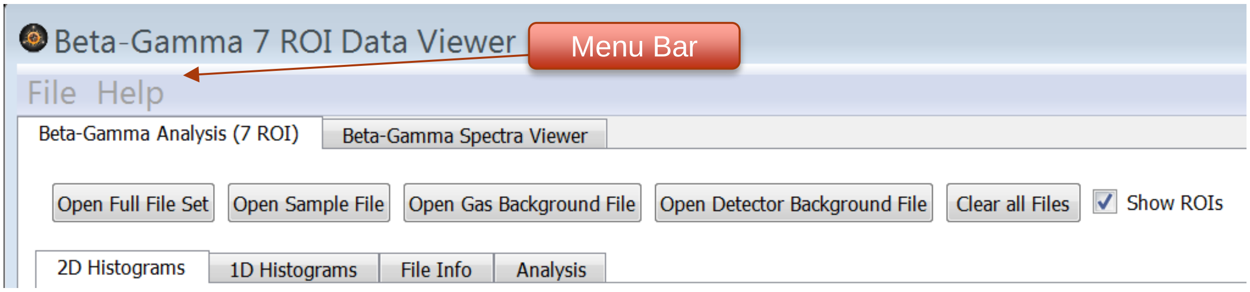


Figure 49 - A Screen Capture Showing the Menu Bar.

2.6.1 File

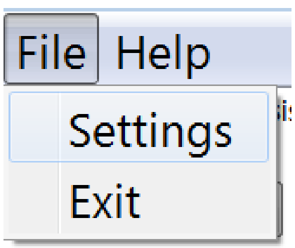


Figure 50 - Screen Capture of *File* dropdown menu.

Select *File* to open a dropdown menu that allows the user to access the *Settings* option and the *Exit* function.

2.6.1.1 Settings

The settings dialog box allows users to set the path of the detector background file. This function is necessary if the detector background files are not located in the same folder as the data files. The “Background Files Folder” is the directory that *Beta-Gamma Analysis* will search for the detector background file when choosing the “*Open Full File Set*” button. If the file can’t be found in that directory the location where the chosen sample file is will be used. A warning message will be displayed if the file can’t be found. The second feature in the settings dialogue is the 2-D histogram color palette. The user may add (*Add Color)* or remove a color (*Remove Selected Color*) and change the color order (*Move Selection Up* or *Move Selection Down*). The color order progresses from fewest counts at the top to the maximum number of counts for the lowest color. The color palette may be saved (*Save Color Schema*) and loaded (*Load Color Schema*) at a later time. Additionally, the color palette may be reset to the default (black, red, green, blue, and white) by clicking the *Default Colors* button with the left mouse button. There are additional color patterns that are available and a color palette for the color blind (*Color Blind Safe Colors*). To enable a color palette the *Apply* or *OK* button must be pressed. To cancel the action, press the *Cancel* button.

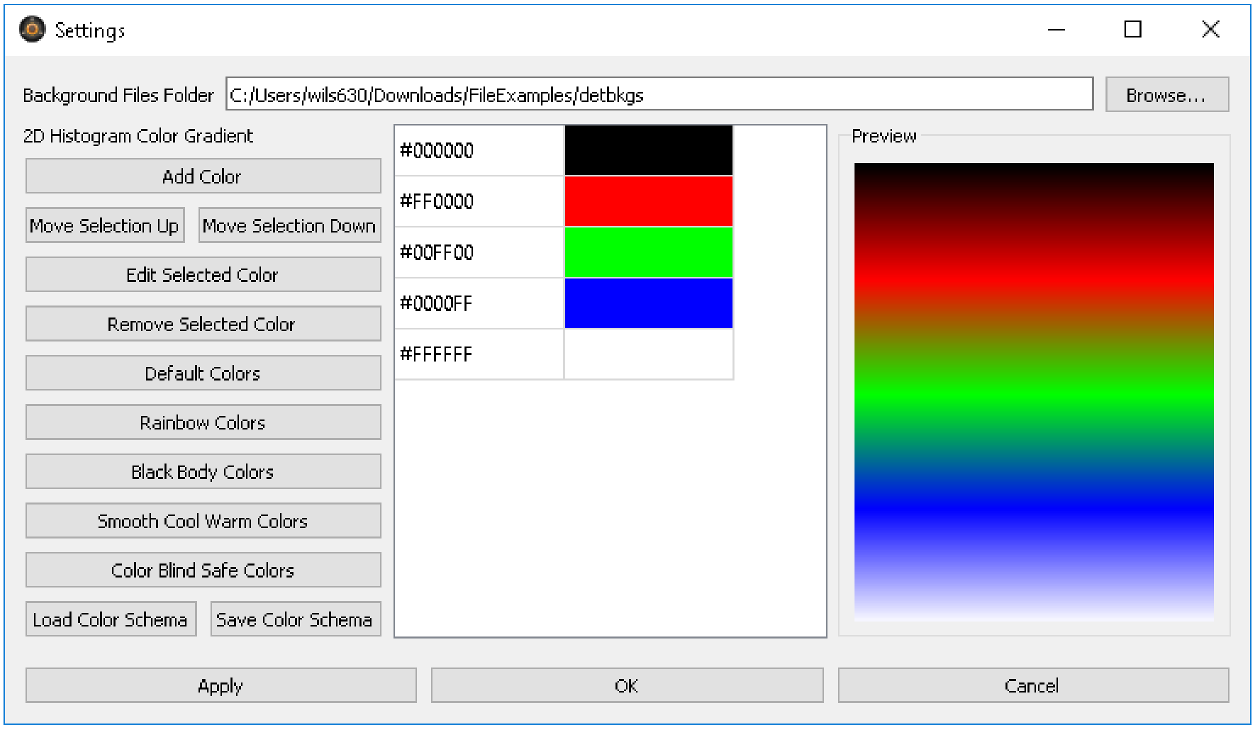


Figure 51 - Screen capture Showing Settings Dialog.

2.6.1.2 Exit

Exit will close the application.

2.6.2 Help

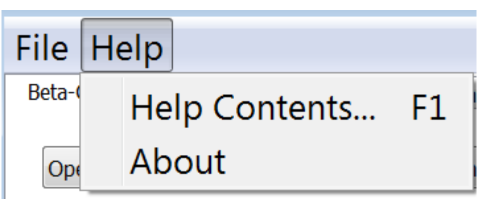


Figure 52 - Screen capture showing Help menu.

2.6.2.1 Help Contents

Select *Help Contents* or press the *F1* key to open a dialog box that contains a digital form of this documentation.

2.6.2.2 *About*

Select *About* to open a dialog box that show information about this application including name, software viewer version, algorithm (Thoth version), and disclaimer.

***NOTE*:** Thoth is the name of the algorithm used for version control for the 7 region of interest *beta-gamma analysis* software.

3.0 References

[1] M. W. Cooper, J. C. Hayes, B. T. Schrom, J. H. Ely, and J. I. McIntyre, “Minimum Detectable Concentration and Concentration Calculations,” Richland, WA, PNNL-25418, May 2016.

[2] M. W. Cooper, J. H. Ely, J. C. Hayes, M. F. Mayer, J. I. McIntyre, and J. L. Slack, “β - γ Absolute Calibration,” Richland, WA, PNNL-27572 Rev. 1, Jan. 2019.

[3] M. W. Cooper *et al.*, “Absolute Efficiency Calibration of a Beta-Gamma Detector,” *IEEE Trans. Nucl. Sci.*, vol. 60, no. 2, pp. 676–680, Apr. 2013.

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