Introduction to InterSpec
Part 1 of 2

PRESENTED BY

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Some general information:

This presentation uses InterSpec v1.0.7_rc1
- Windows, Linux, macOS: https://github.com/sandialabs/InterSpec/releases
  - Installation: unzip downloaded file, and place resulting directory where ever you would like (e.x., C:\Program Files\InterSpec) and manually add a shortcut to the InterSpec.exe executable to your start menu and/or desktop.
- macOS: https://apps.apple.com/us/app/interspec-radiation-analysis/id1476886954
- Currently phone and tablet version of InterSpec is at v1.0.3, but this presentation is still largely applicable. You can install InterSpec through the app store, namely:
  - iPhone/iPad: https://itunes.apple.com/us/app/interspec-radiation-analysis/id1447080767
  - Android: https://play.google.com/store/apps/details?id=gov.sandia.interspec

This presentation and all example spectrum files can be found at https://sandialabs.github.io/InterSpec/ under tutorials section, under the overview heading

The "live" version of this presentation takes about 3 hours, and there is a part 2

InterSpec is completely open-source (LGPL v2.1), and code available from:
- https://github.com/sandialabs/InterSpec
- https://github.com/sandialabs/SandiaDecay
- https://github.com/sandialabs/SpecUtils

Support, bug reports, and requests: InterSpec@sandia.gov

Topics to be covered

Part 1 (this presentation)
- InterSpec's Capabilities
- A demonstration of using InterSpec for analysis
- Using InterSpec
  - Interacting with spectra, viewing options, spectrum files, saving work, reference photopeak lines, peak-fitting, nuclide search
- Energy calibration
  - Manual adjustment, graphical adjustment, fitting from photo-peaks, multi-file, non-linear deviation pairs
- Fitting activity and shielding
  - Multiple isotopes, shielding types, limitations

Part 2
- Nuclide ID
  - Including with shielding, neutron reactions, and x-rays
- Creating detector response functions
- Advanced activity and shielding fit
  - Self-attenuating sources, isotopics, nuclide age
- Other calculations available
  - Dose, gamma flux, nuclide decay
- Example problems to work together
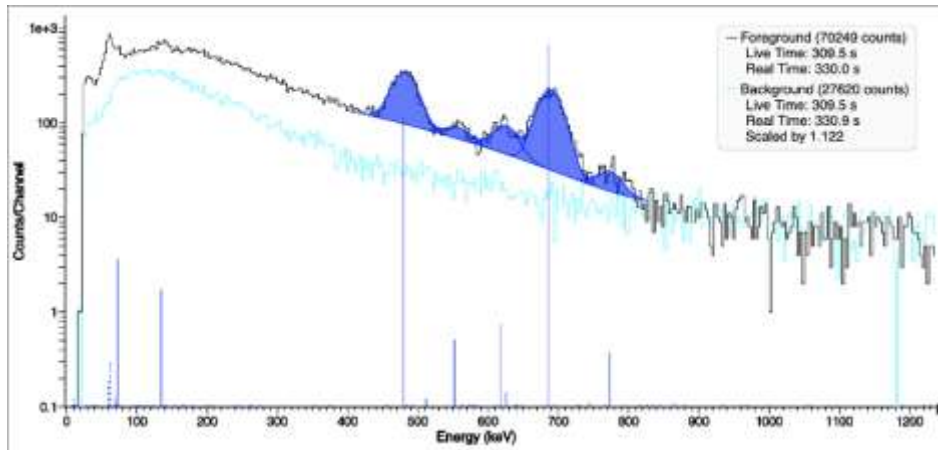
InterSpec's Capabilities

general features

Some InterSpec Capabilities
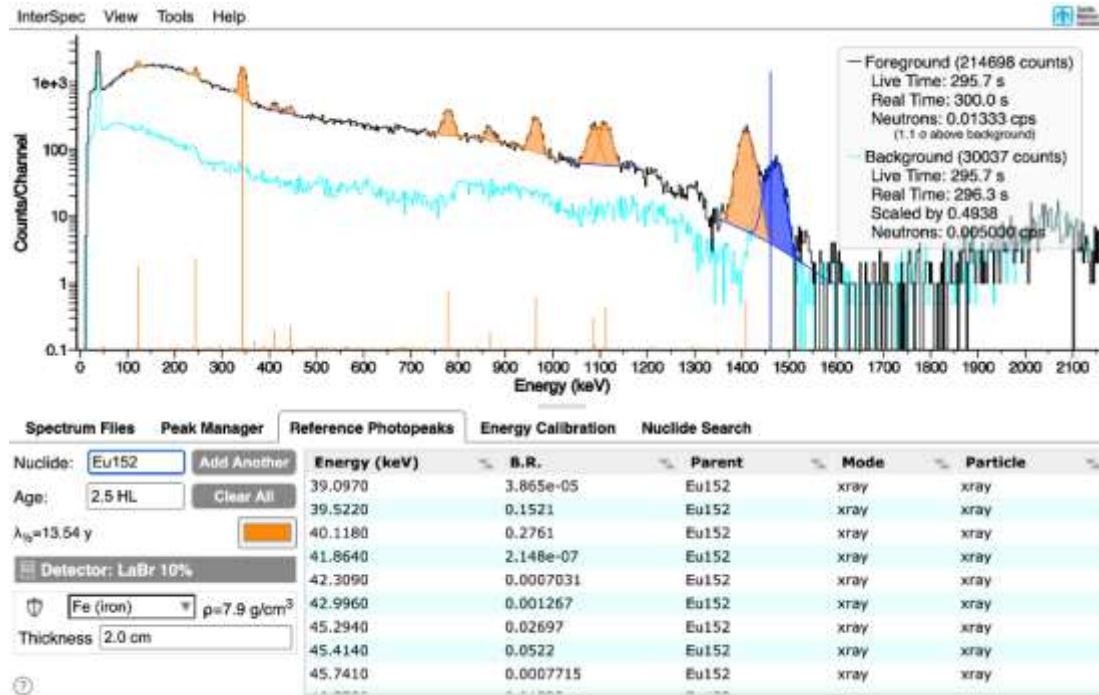
- InterSpec helps perform peak-based spectral analysis of radioactive isotope data collected with most handheld, backpack, search, portal, and laboratory based equipment
- Helps perform nuclide identification, determine source activity, shielding around source, characterize detectors, identify neutron interactions, and inspect other data features
- Reads >100 spectrum file format variants, and exports to a dozen or so useful export formats
- A comprehensive nuclide database (~4k nuclides) with all aging calculations performed on-the-fly
- Extensive shielding database (NIST + GADRAS + generic)
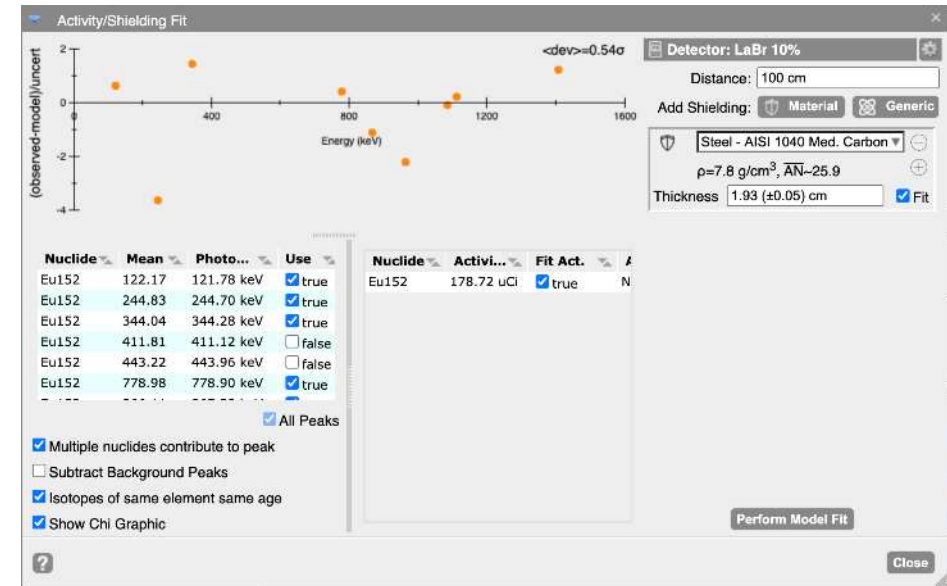- Lots of features to make analysis quick and convenient

Some InterSpec Capabilities (cont)

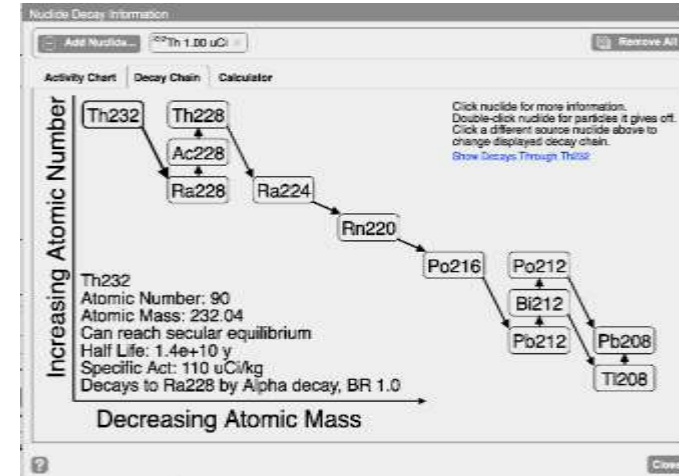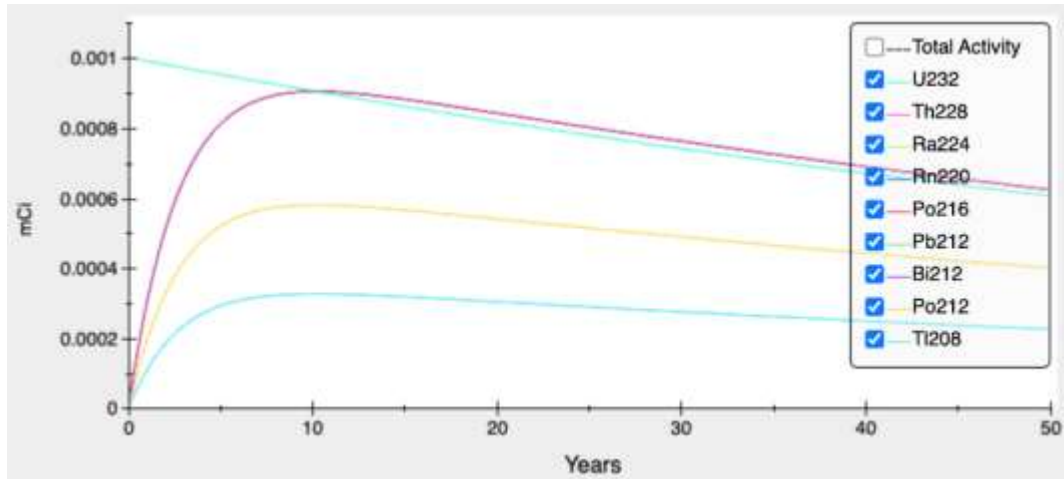A quickly and easy way to view spectrum files and fit peaks
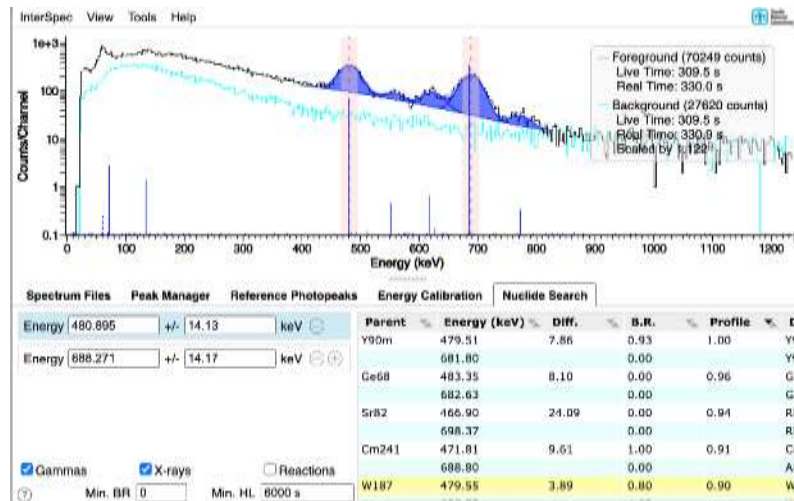
Fit for nuclide activities, shielding amounts, isotopics, and ages

Assist with nuclide ID

Some InterSpec Capabilities (cont)

Perform various nuclide decay calculations and get reference information
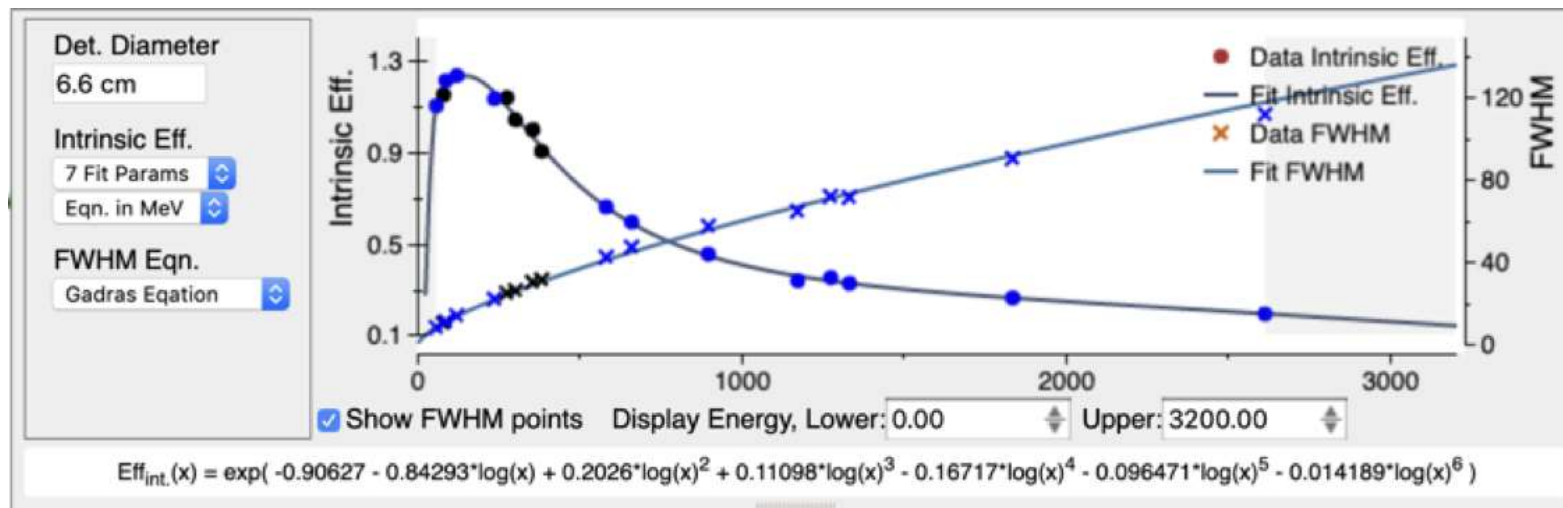
Develop detector response functions (efficiency + FWHM)

Some InterSpec Capabilities (cont)

Dose calculations, or determining activity/distance/shielding from a dose rate

Cross-section calculator

1/r² calculator

Gamma flux calculator

Some InterSpec Capabilities (cont)
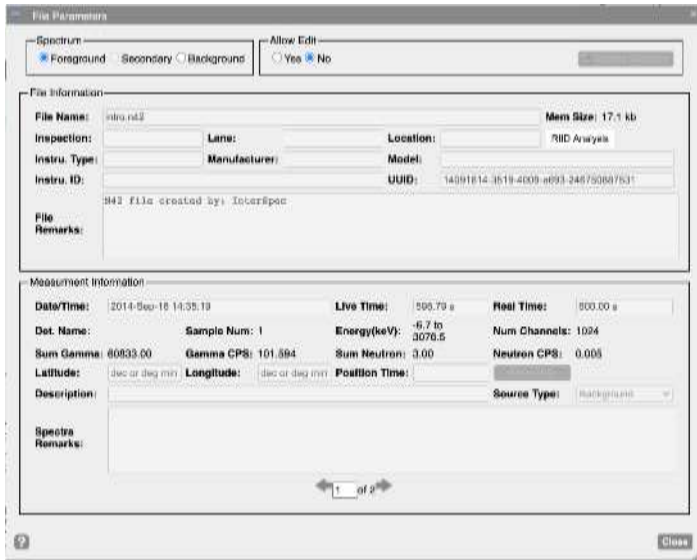
View and edit spectrum file meta-data

Plot measurement GPS points and load from selected region (may not be enabled for all releases).
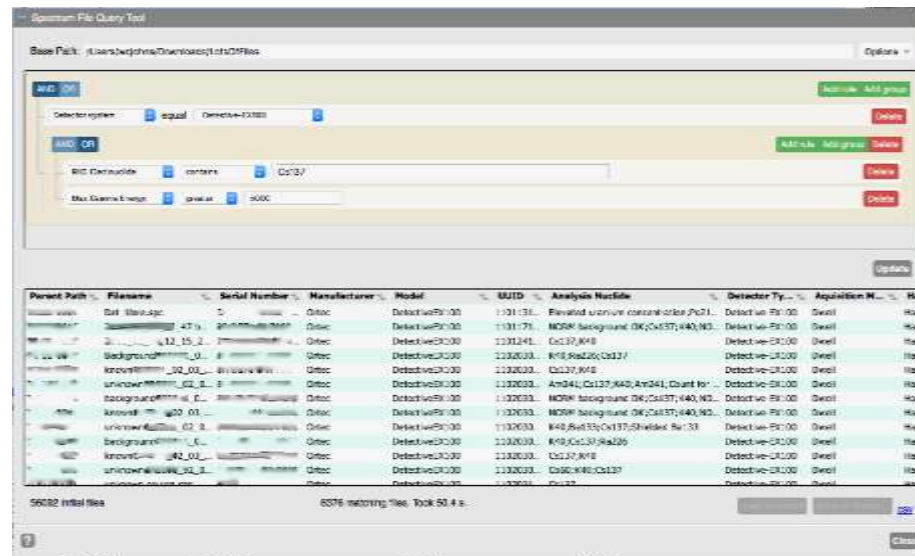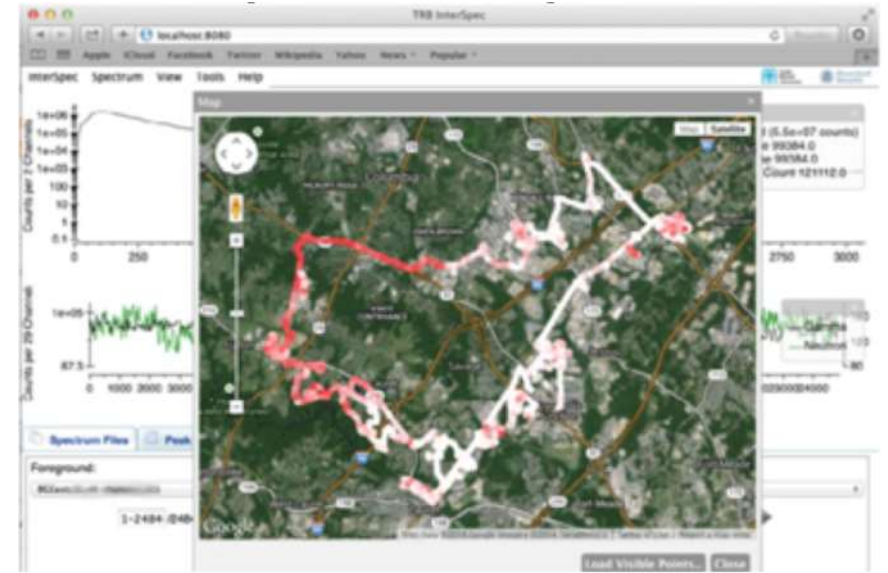
Perform data-mining on repositories of spectrum files

Some InterSpec Capabilities (cont)

Can be run pretty much anywhere

Customize colors
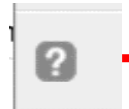
Has help pages associated with most tools
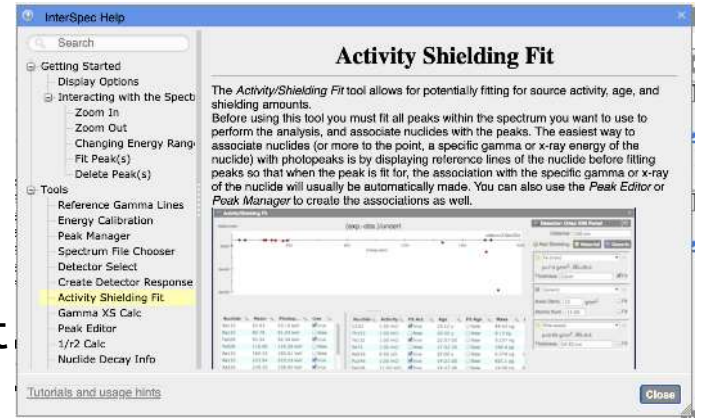
Export and import CSV files, or similar, in a bunch of places

Stores settings, previous work, and application states to internal database (everything stays on your computer – InterSpec doesn't communicate of connect to anything external to your computer)

The different platforms
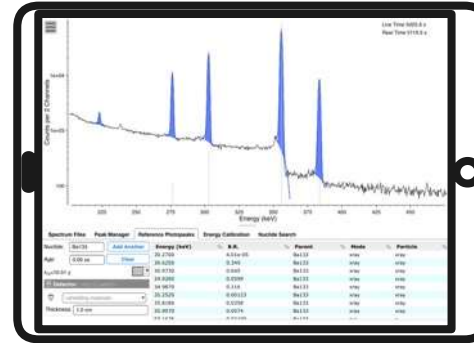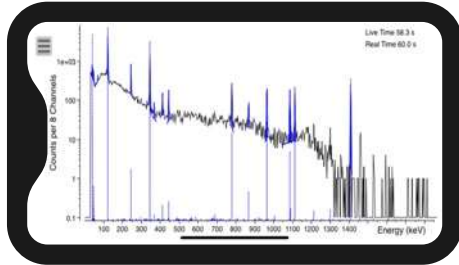
On phones, great for:
- Checking that data taken in the field is good
- Referencing nuclide half-life, decay chains, and decay products
- Calculating gamma dose or decay times
- $1/r^2$ calculations
- Quick nuclide identification or activity determination
- Nearly all features are available on phones, but involved or complex analysis is a little cumbersome

On tablets and computers:
- Everything you can do on phones
- Complex or detailed nuclide identification, activity, shielding, or age determination
- Challenging peak-fitting or nuclide identification
- Detector characterization
- File type conversion, and meta-information editing
- Searching your spectrum file archives
- …

What InterSpec isn't:

InterSpec is not a magic easy button – all features are interactive – doesn't tell you the answer automatically, but assists the user to perform analysis

Not full-spectrum analysis, i.e., not GADRAS.
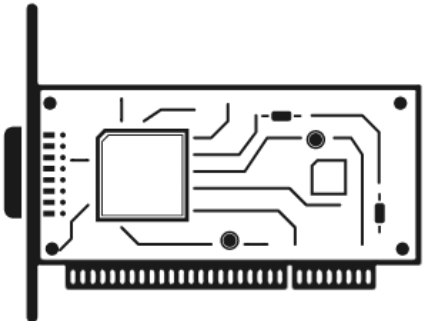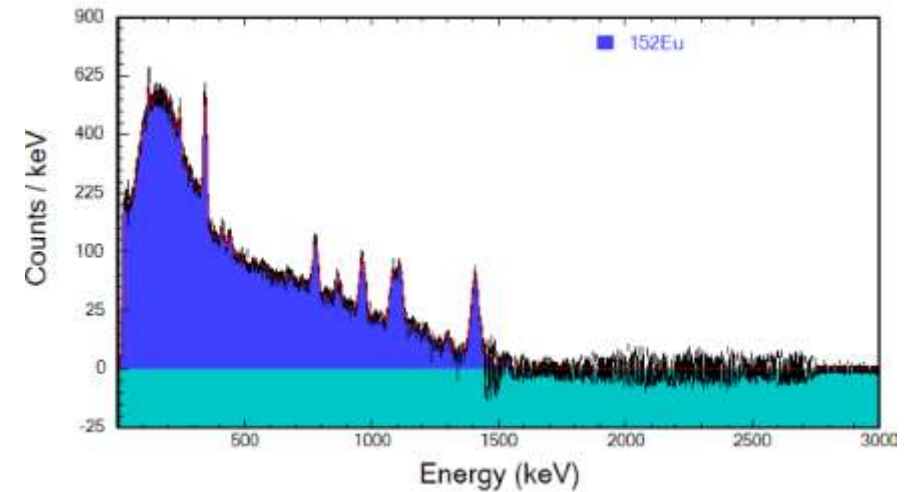
Does not do data acquisition - only accepts data already taken

A demonstration of using InterSpec for analysis

Load spectra, perform nuclide ID, fit activity

A quick example of using InterSpec to perform nuclide ID and determine activity and shielding of a spectrum.

intro_LaBr_10Percent_50cm.n42

Using InterSpec

Interacting with spectra

Loading Spectra
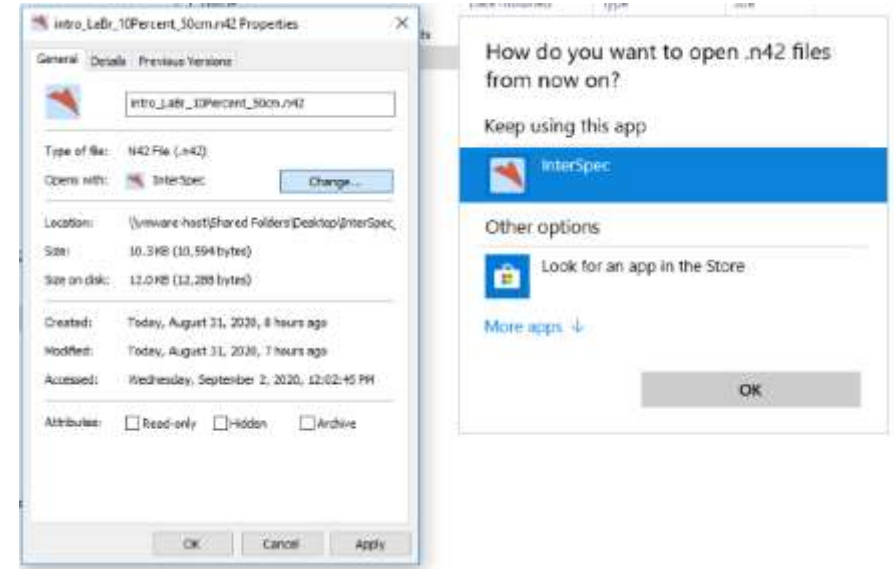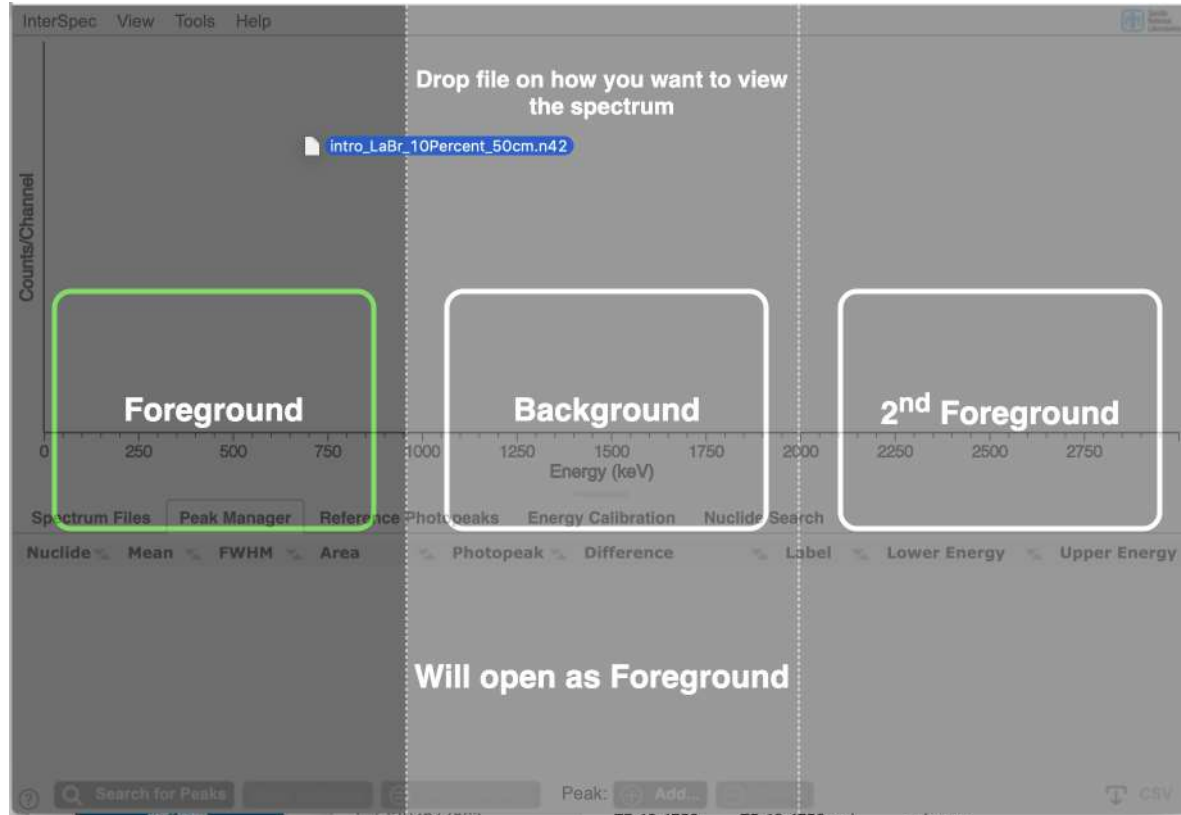
The easiest way to load a spectrum file is just to drag-n-drop files from your computer
◦ You can open the file as either foreground, background, or a secondary spectrum, depending on where you drop the file
◦ If you open as a foreground, and the file also contains a background, InterSpec will load that as well

The **InterSpec→Open File…** menu option lets you browse for file

And you can also associate file types to be automatically opened when you double-click them in the operating system, using the standard OS preferences.

On iOS, Android, and macOS the file type associations should be automatic

Interacting with spectra
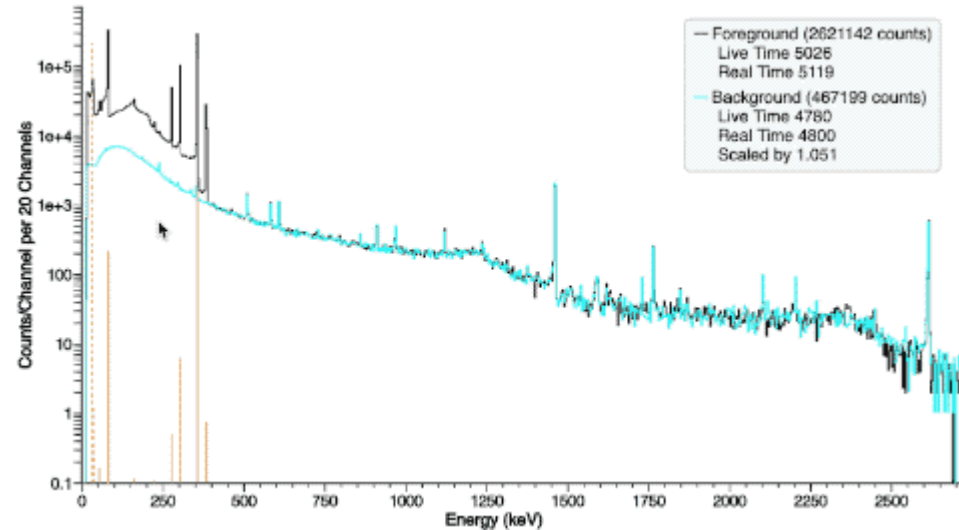
Zoom in: click and drag to the right to highlight the region you want to zoom in to. When you let go of the mouse, it will zoom in.

Zoom out: click and drag to left; zooming out will happen continuously

To pan left or right: hold control key and use mouse to drag left and right. Or click and drag labels (numbers) on the x-axis

Or you can use the up and down mouse-wheel (and trackpad equivalent) to zoom in and out, and wheel left/right to pan

Touch screens work to, and basics are reasonably intuitive

You can also zoom in on the y-axis by holding the Alt-key (mac: command-key) clicking and dragging down, and do same thing but up to zoom out. Or you can click and drag on y-axis labels (numbers), or for more control use the mouse-wheel when mouse is over y-axis area

Interacting with spectra (cont)
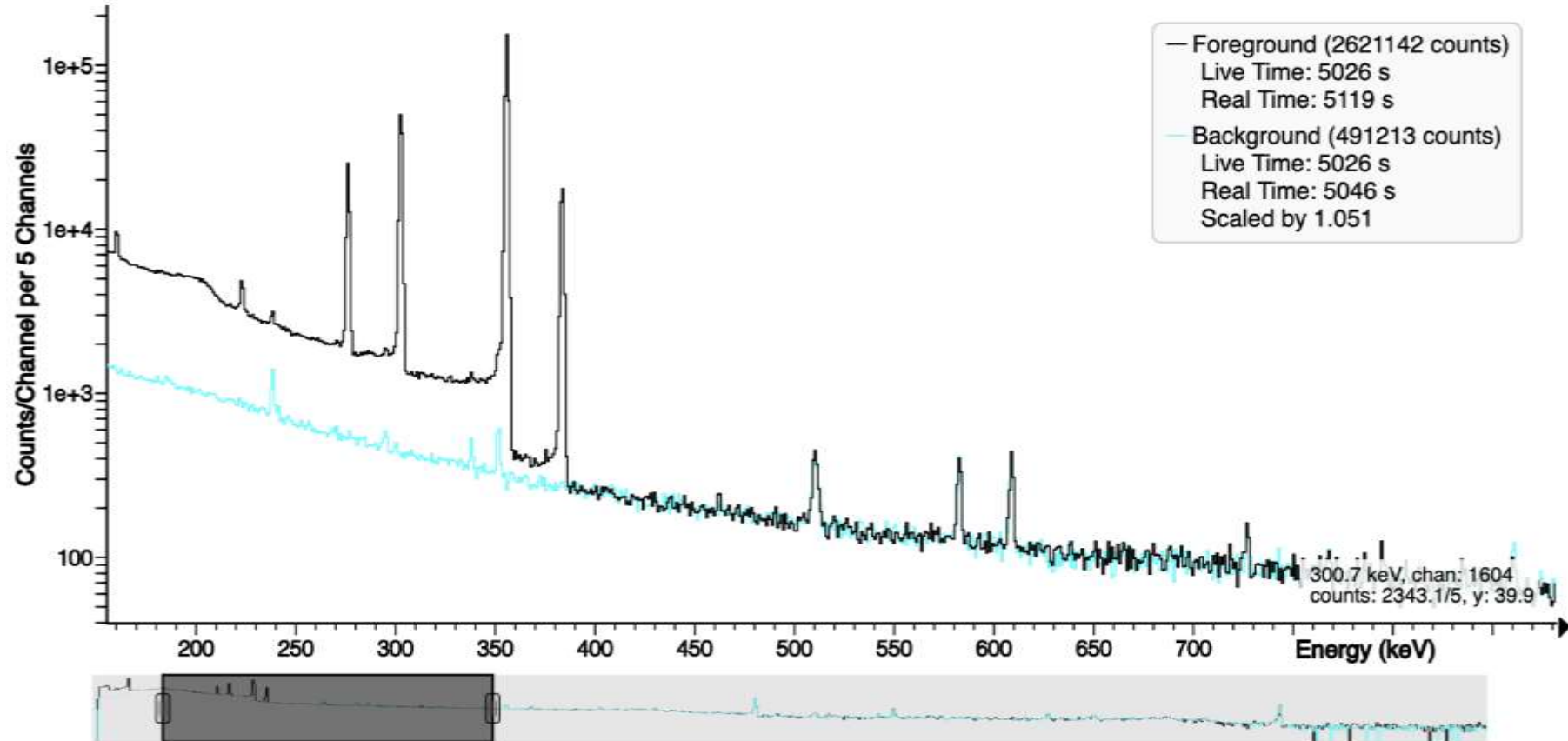
View → "Show Energy Slider" will bring up a strip chart
- Drag on edges to change displayed energy ranges, or click and drag on dark part to pan
- Especially useful for really inspecting HPGe specra

Basic peak-fitting
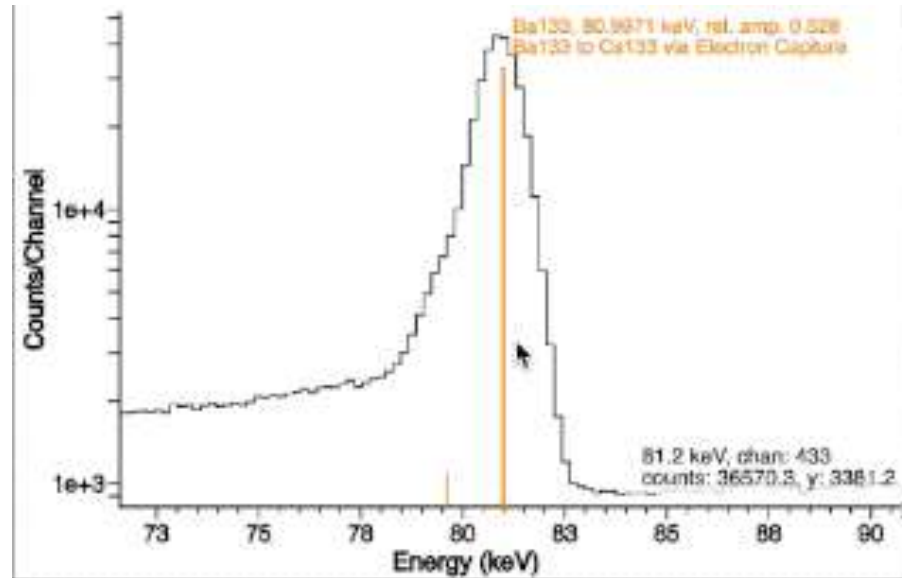
Usually to fit a peak, just double click near it.

Want to add on other nearby peak? Just double click again.

If you move your mouse to the edge of the Region Of Interest (ROI), you can adjust ROI extent.

Right-click on a peak to get a menu to add or remove a peak from a ROI

Peak Fitting (cont)
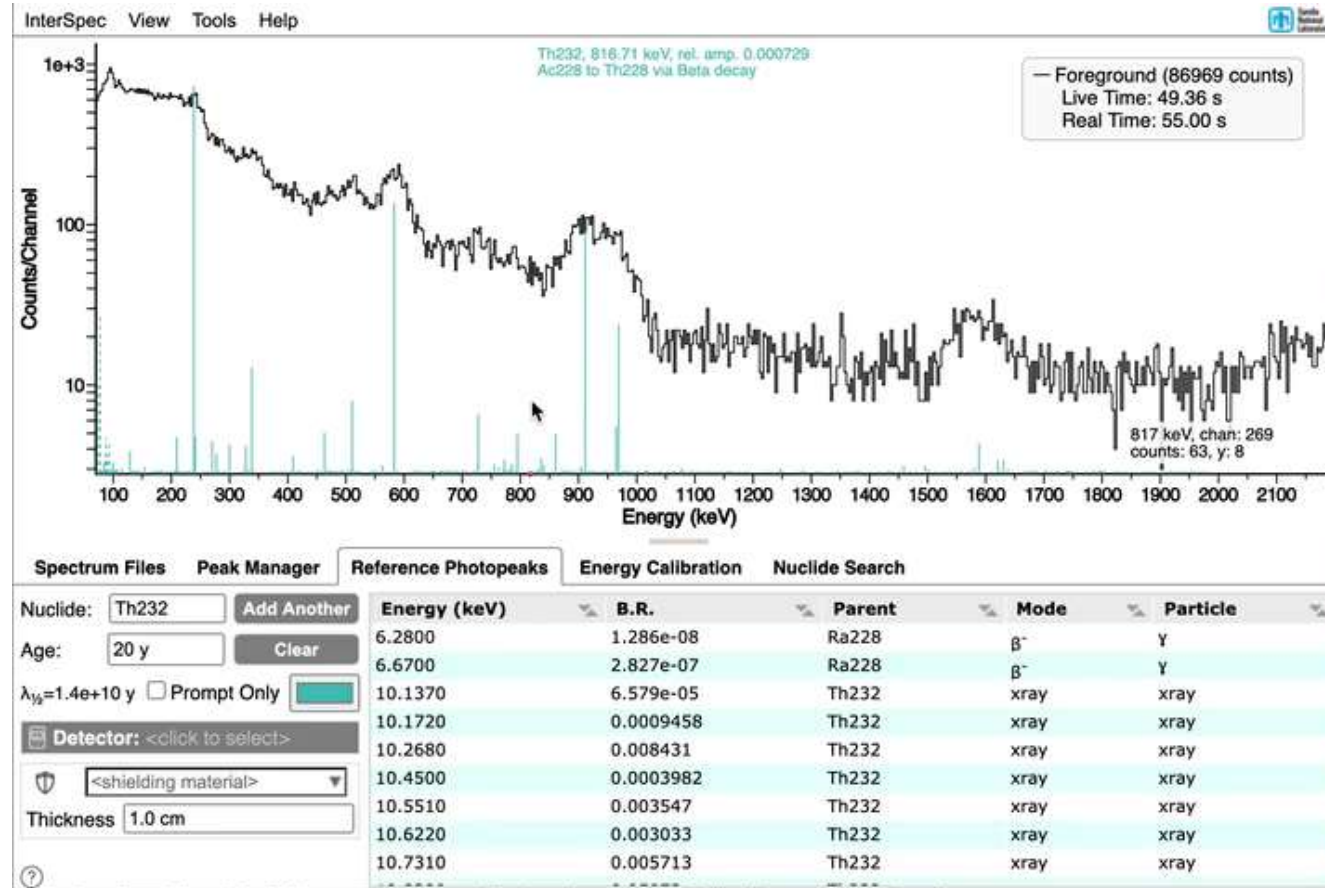
Holding control and dragging across a region lets you fit for multiple peaks in a ROI

Peak Fitting (cont)
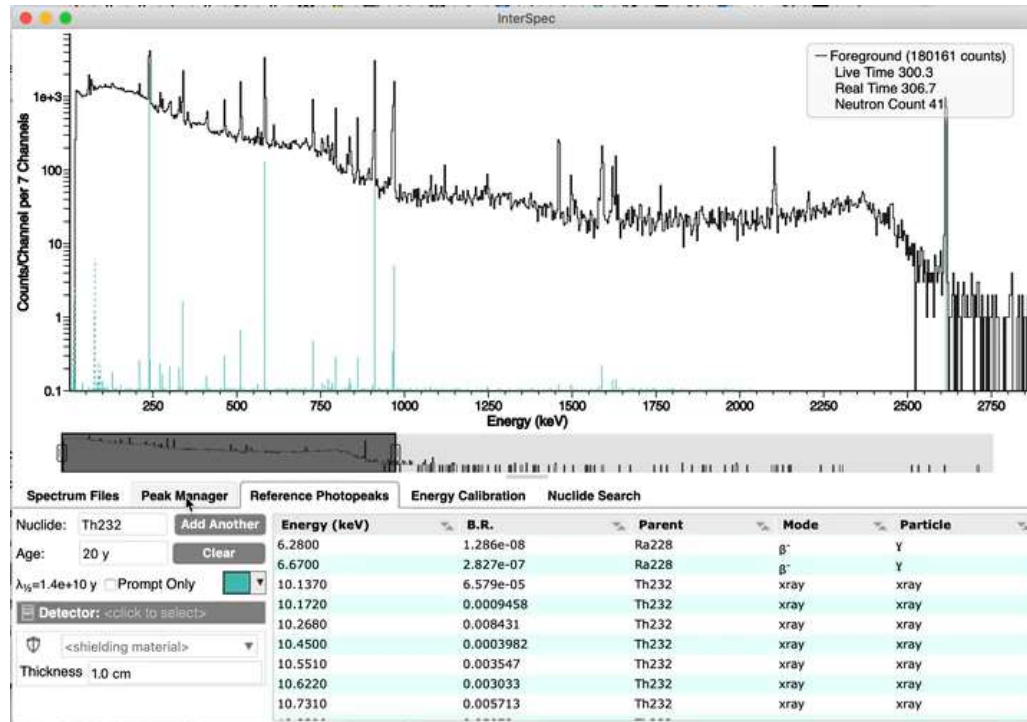
There is also an automated peak search that works pretty well
- Does not use the currently showing reference lines, or detector response function (DRF) to identify peaks
- Does let you keep peaks that only belong to nuclide(s) the reference lines are showing for
- Gets most peaks pretty well, and then you can usually go back through and quickly cleanup any issues

Peak Fitting (cont.)
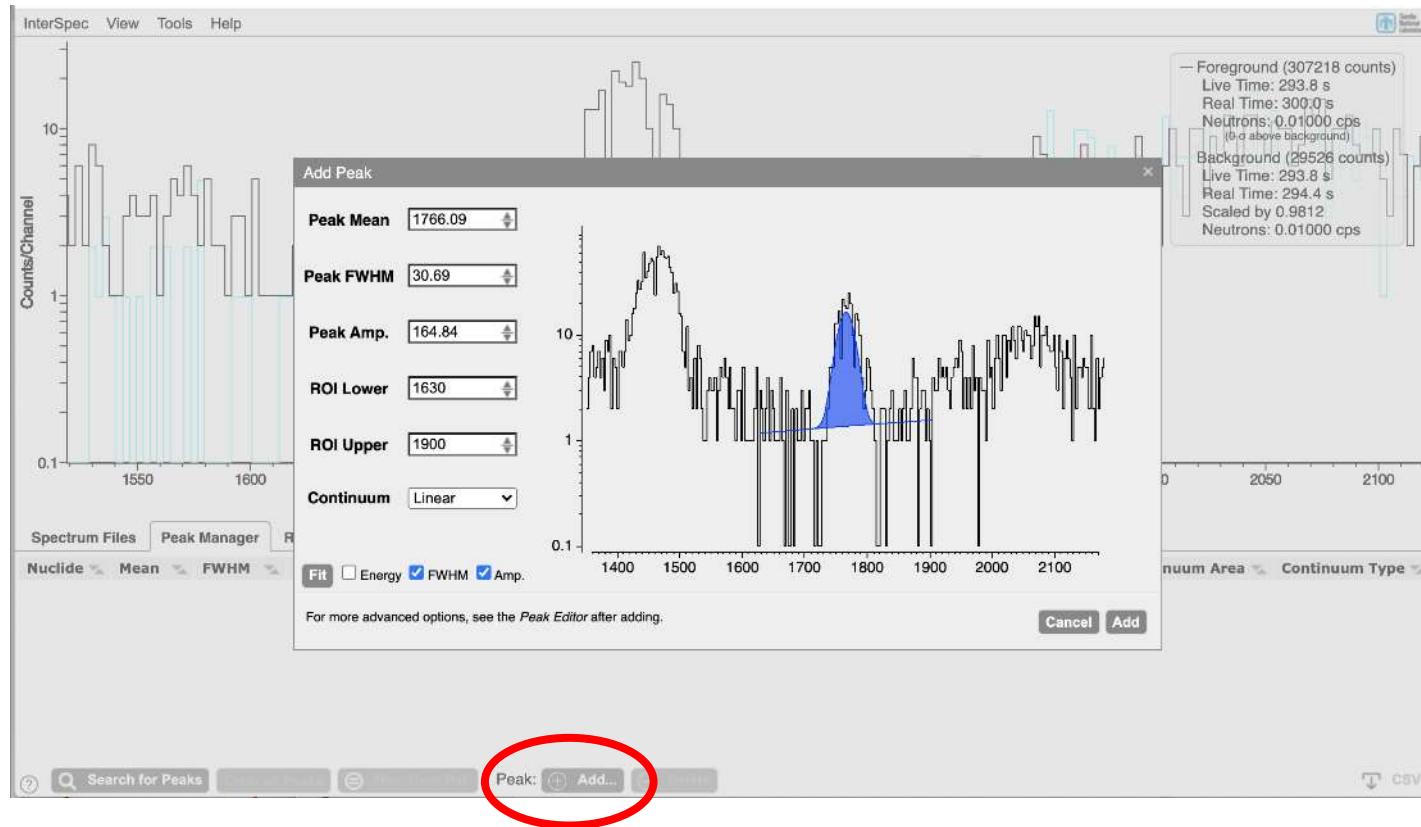
As a last resort, if InterSpec just really refuses to add a peak where you want one, on the "Peak Manager" tab, there is an "Add…" button that gives you more control over adding the peak and overrides statistical tests and such to force adding one

- This is usually only necessary for peaks of dubious statistics or shape, or when there is a small peak "on the side" of a larger peak
- After adding a peak this way you can further modify it, or you can join the new peak to the continuum of a previous peak

Peak Fitting (cont)

You can also right-click on a peak and choose "Peak Editor…" from the popup menu to have more control over fitting a peak.

You can fix some of the peak quantities, and fit for other ones, manually adjust some of the parameters, select a continuum type, and more

Peak Fitting (cont)
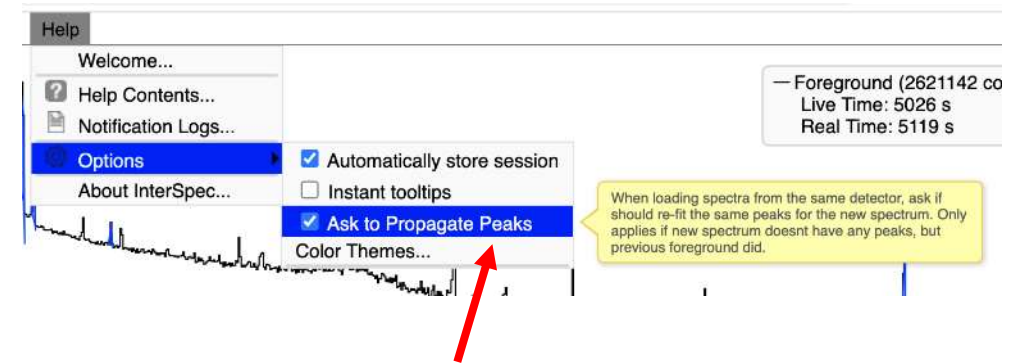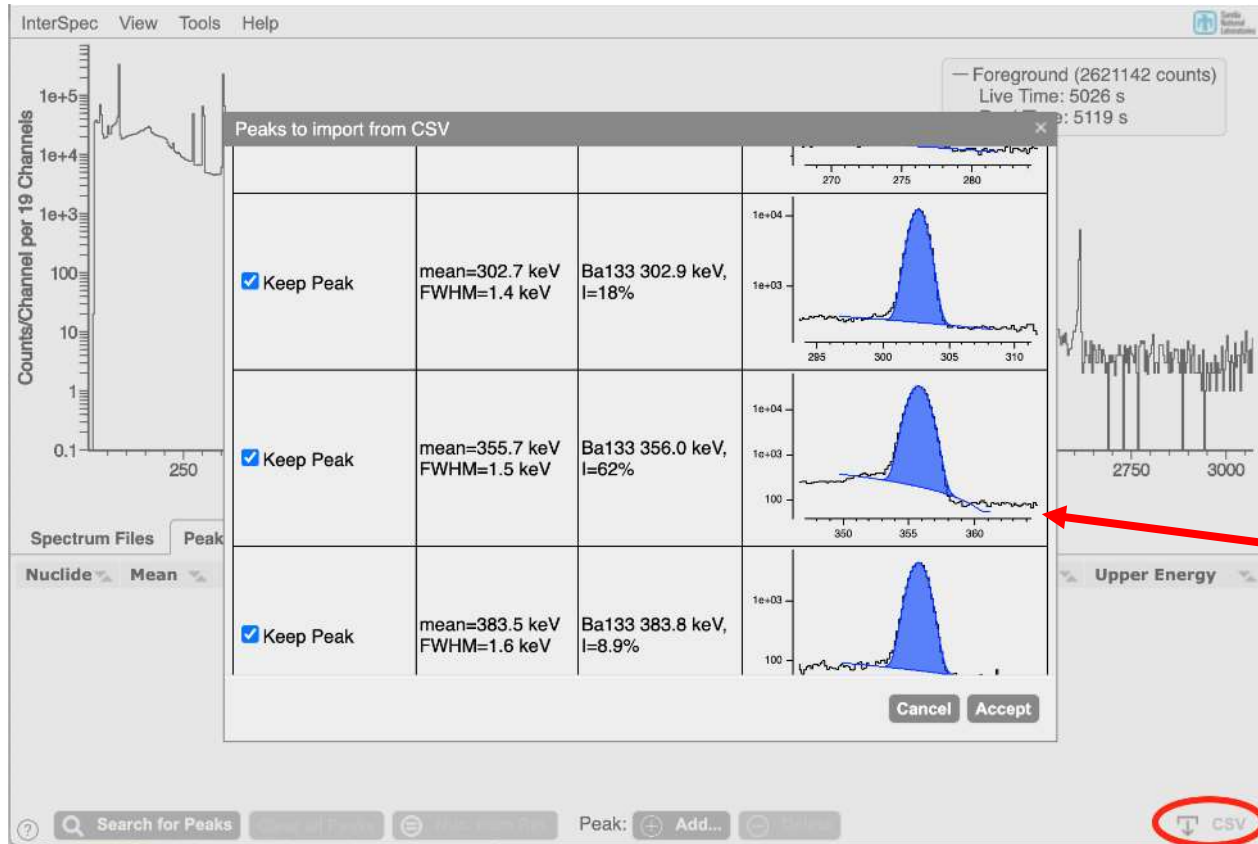
There is also an option to propagate peaks from your previous spectrum to newly opened spectra

If you drag-n-drop that CSV back onto InterSpec after opening a different spectrum file, it will try to fit for the same energy peaks – useful if you work with the same isotope a lot

You can download a CSV of your peaks from the "Peak Manager" tab
◦ This CSV is compatible with some other programs that use CSV for peak information
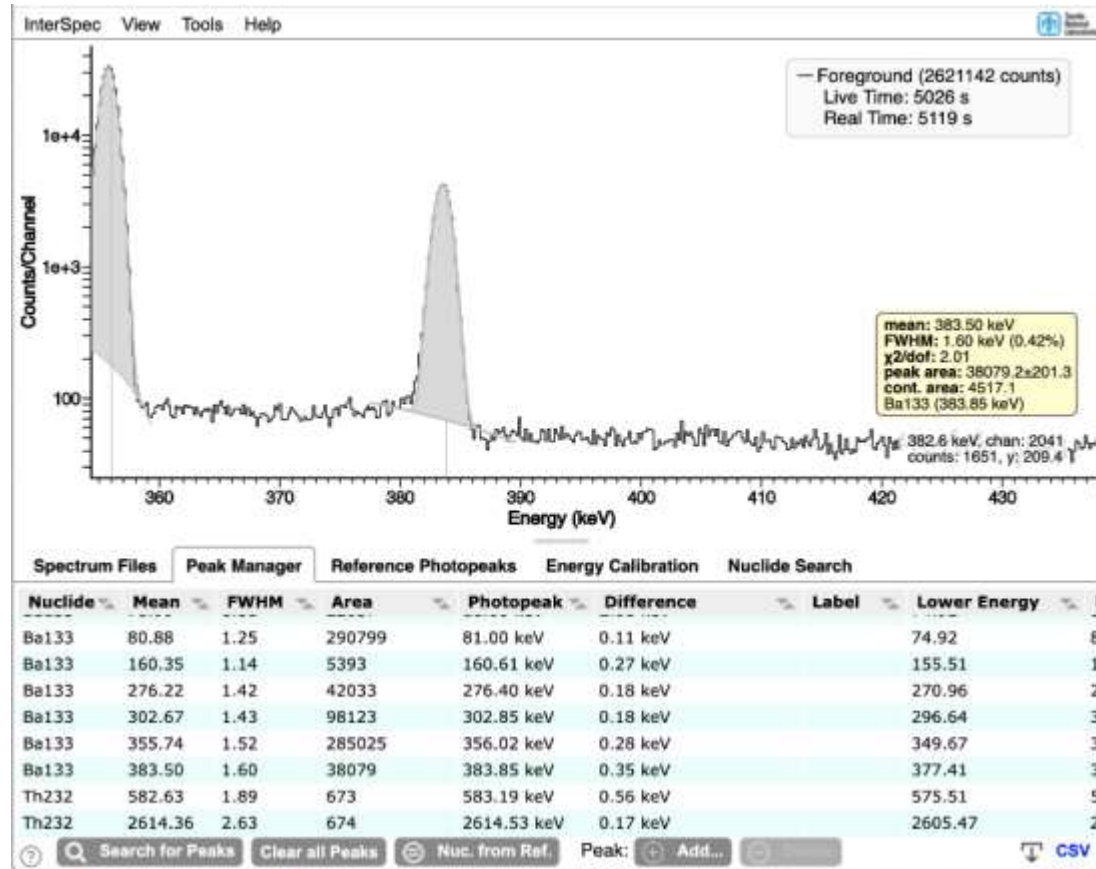
Peaks

A key aspect of peaks in InterSpec is that you can associate them with a nuclide, x-ray, or reaction
- The peak is actually associated with a specific gamma-line of the nuclide/x-ray/reaction

Doing this lets you
- Keep track of nuclide ID
- Fit for energy calibration, nuclide activity, isotope age, shielding, detector response function, calculate fluxes, …

Peaks (cont.)
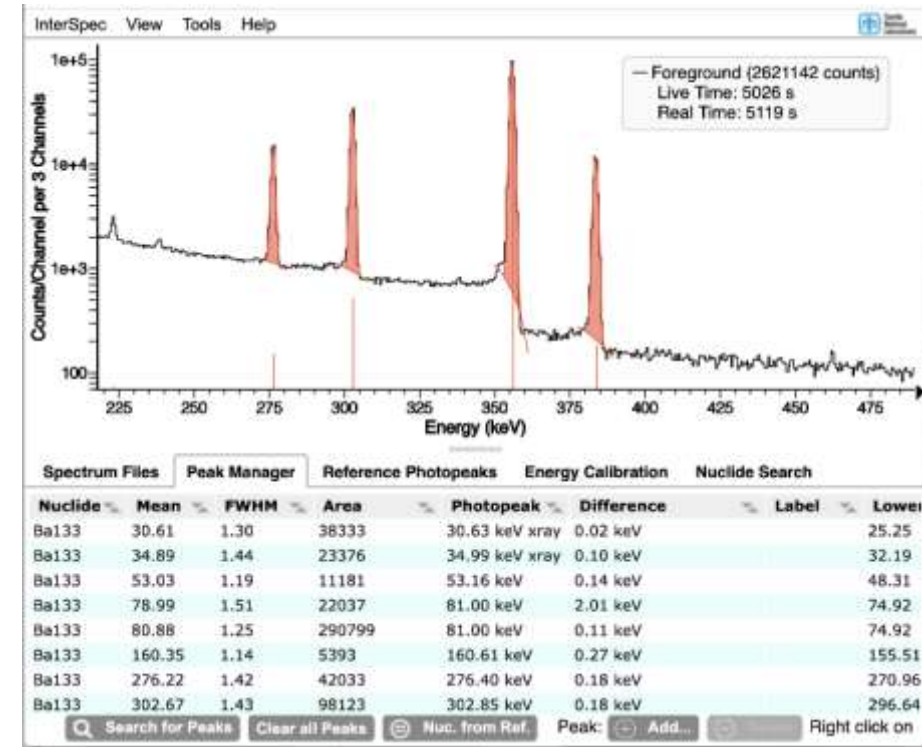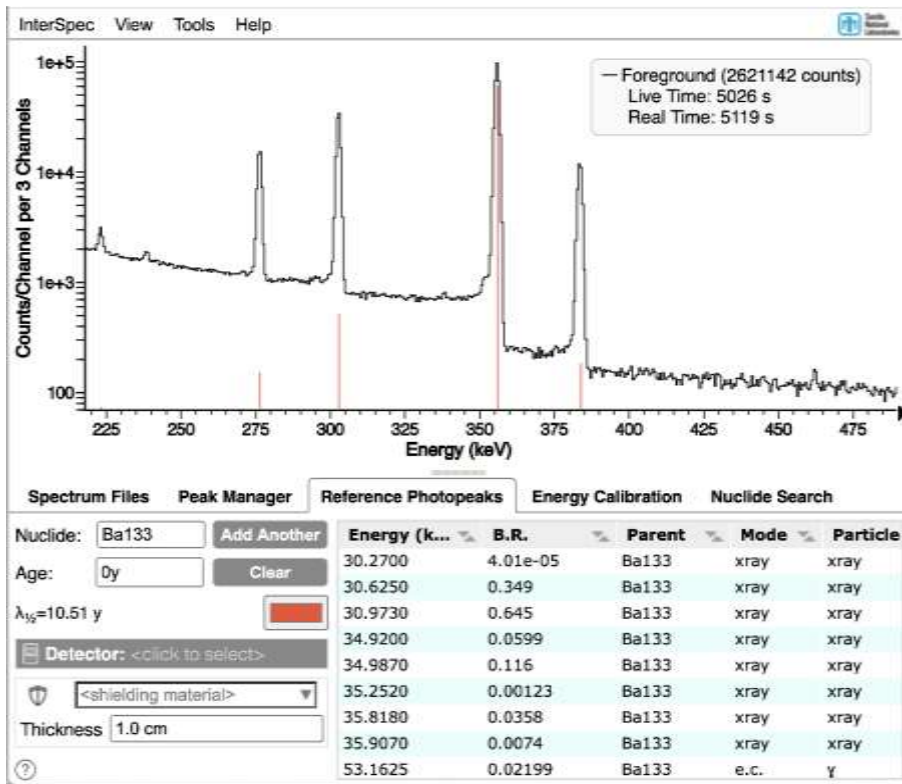
The easiest way to associate a peak with a given gamma-line, is to show reference photopeaks **before** fitting for the peak
- When you fit for the peak it will pick-up the association if the reference line is reasonably close to the fit peak
- If there are multiple gamma lines near, or within, the peak, the correct one will almost always be chosen
  - While fitting for activity/shielding InterSpec will compensate for the other gamma-lines that may contribute to the peak, or if multiple isotopes contribute
- By default the peak color will be the same as the reference lines

Peaks (cont.)
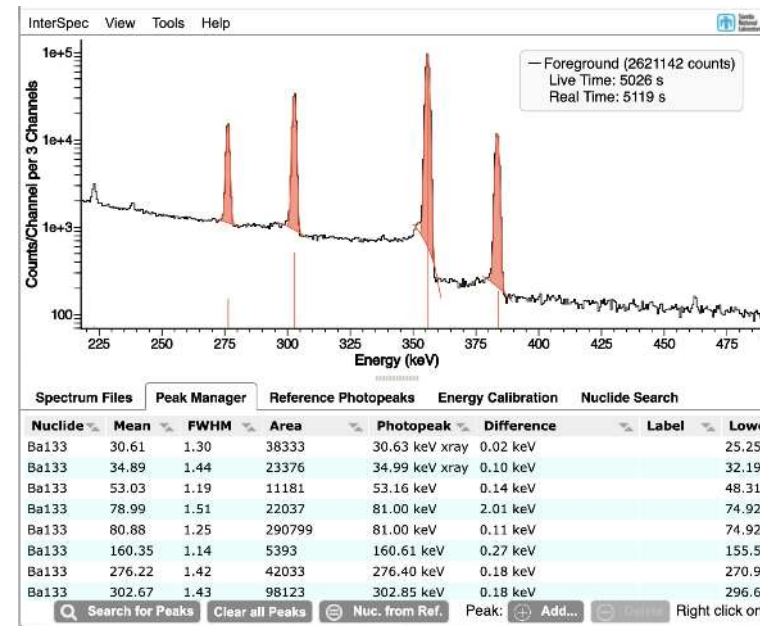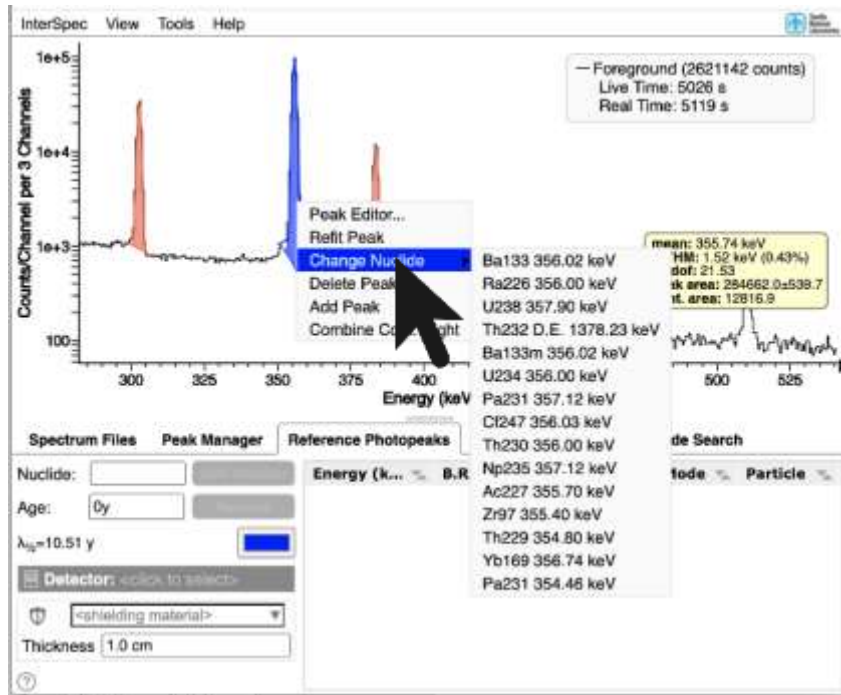
You can click on any of the peak tables to edit the nuclide and photopeak.

◦ On "Peak Manager" tab there is also a "Nuc. From Ref." as well

Right-clicking a peak and going to "Change Nuclide" item will bring up a decent selection of suggested nuclides

◦ Suggestions based on energy, other peaks in spectrum, currently showing reference lines, and a general suggestion algorithm

The peak-editor also lets you select the nuclide and energy
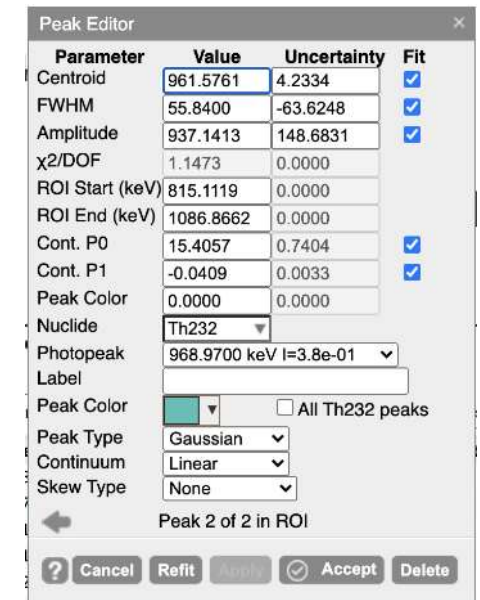
Peaks (cont.)
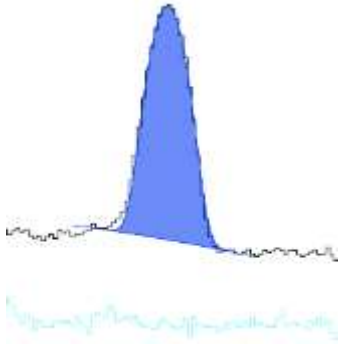
Peaks default to being Gaussians sitting on top of a polynomial continuum
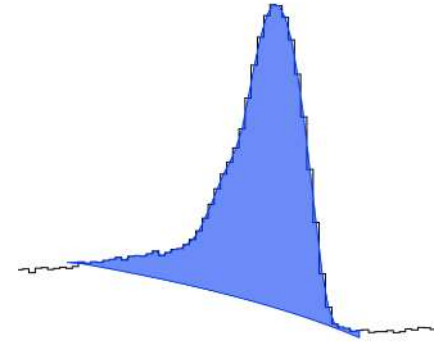
Peaks can also be "data defined" meaning their amplitude is the area between the continuum observed counts
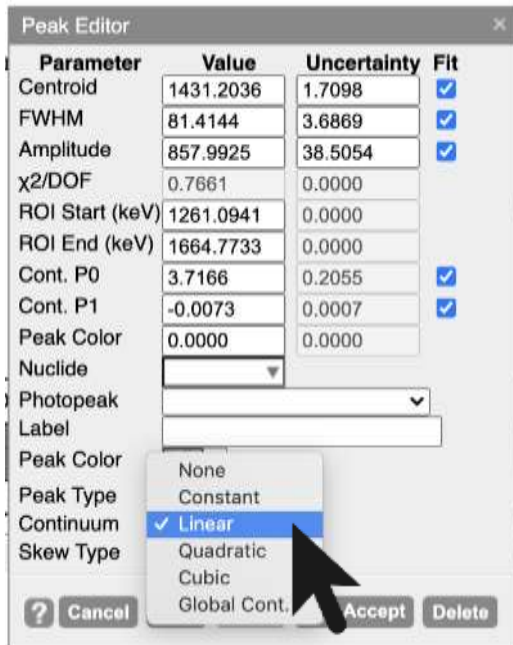
You can choose the order polynomial to fit as the continuum, or you can use a "global cont."
- The global continuum is calculated for the entire spectrum using a relaxation method
- There is a "Skew Type" option, that will likely be much improved in the next version of InterSpec

Recommend sticking with Gaussian + Polynomial unless it really isn't working
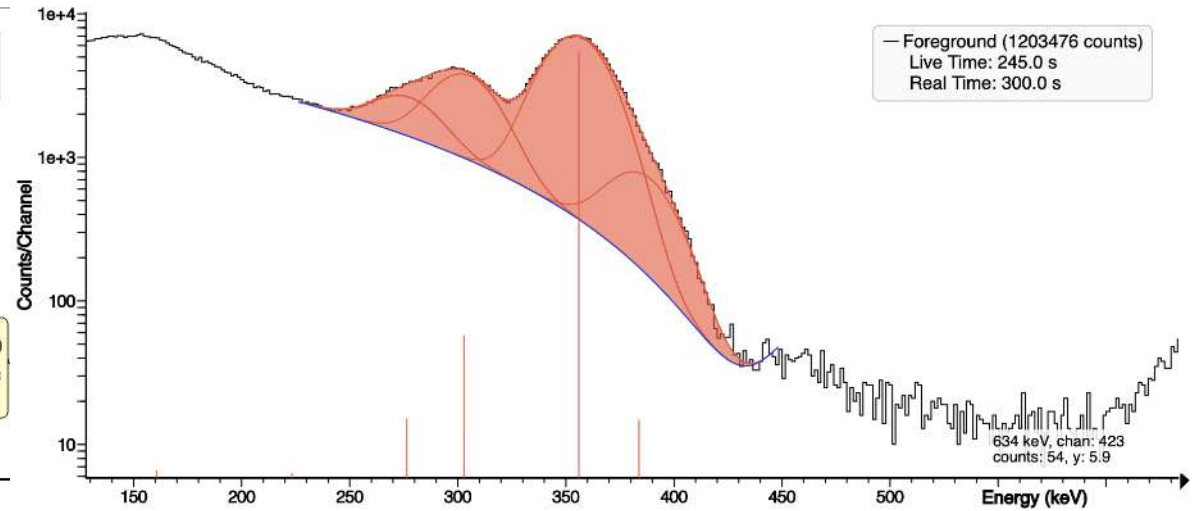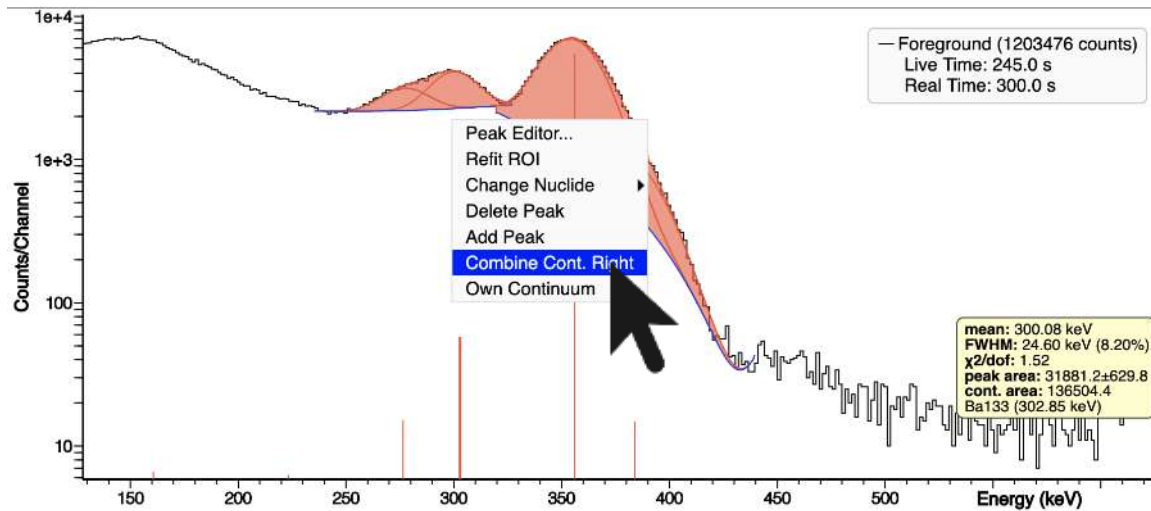
Peaks (cont.)

Peaks can share a continuum

◦ Usually InterSpec will do a decent job of having peaks share a continuum when its useful, but you can always right-click on a peak (on touch, hold down on the peak for a second) and choose to "Combine Cont. Right/Left" or "Own Continuum".

Having multiple files open
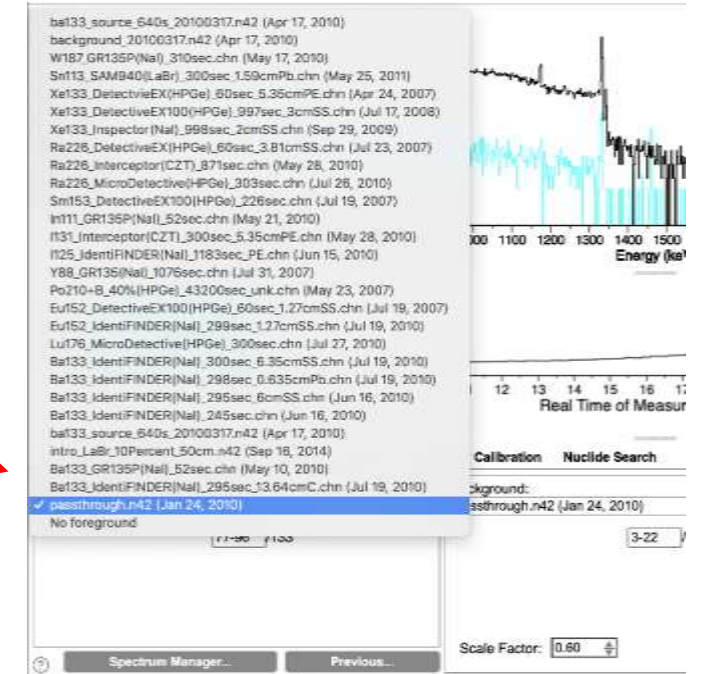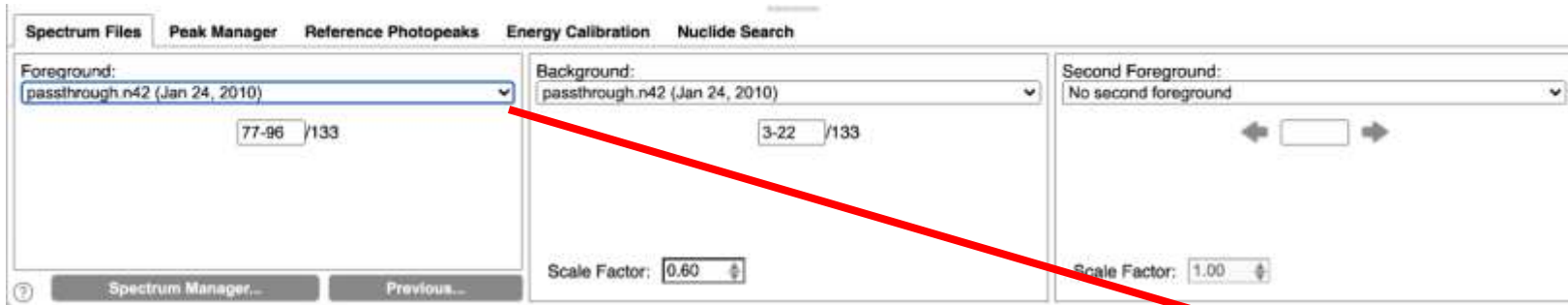
When you open a new spectrum file, all your previous files get kept in memory and any work done on previous spectra is not lost

You can go back to any of the previous spectra easily

Files with multiple samples
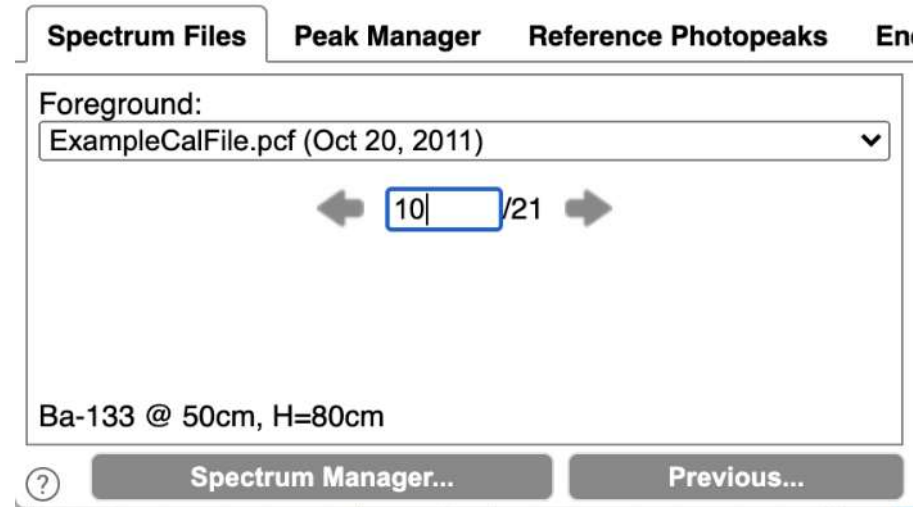
If a file has multiple measurements inside of it, you can also select which samples you want to display
- If you want to use multiple samples summed, you can enter text like:
  - "1-10" to sum samples 1 through 10
  - "2,3,5-7" to sum samples two, three, and five through seven
- If you need to sum samples across files, see the "Spectrum Manager…" to create new files with all the samples you want

Saving your work
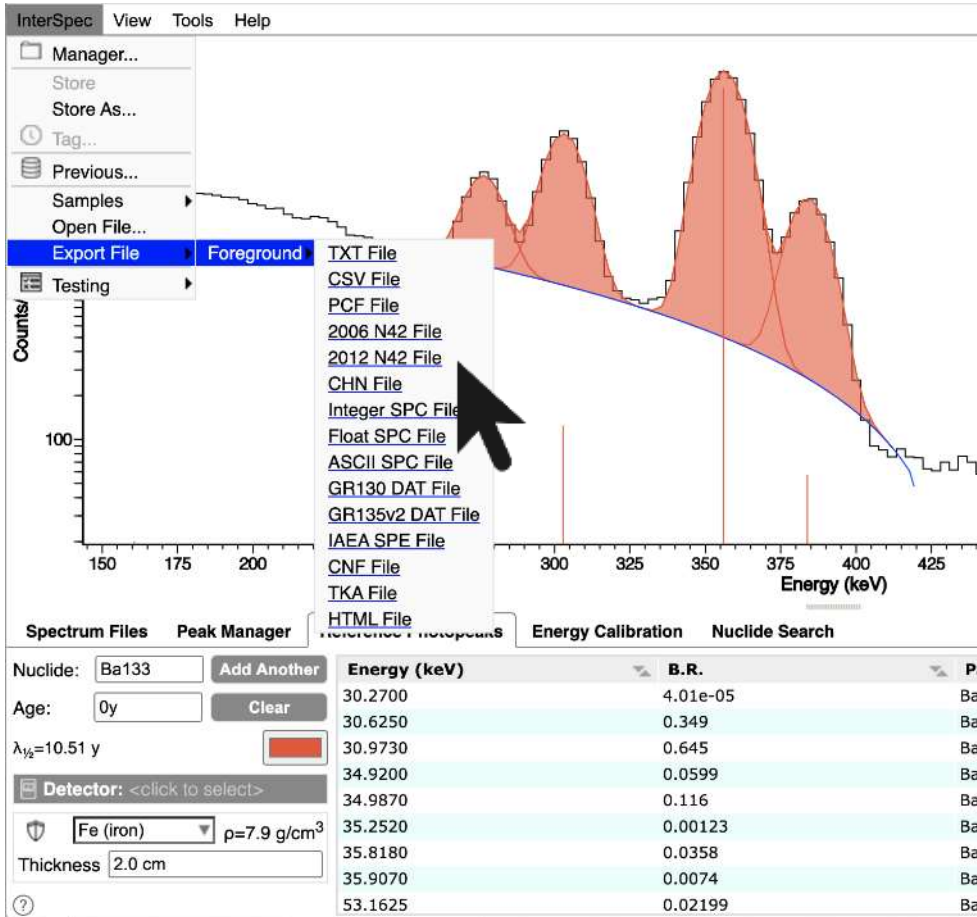
If you export to a N42-2012 file, then all of your peaks, DRF, and fit activities/shielding will be saved inside the file and restored when you load back into InterSpec
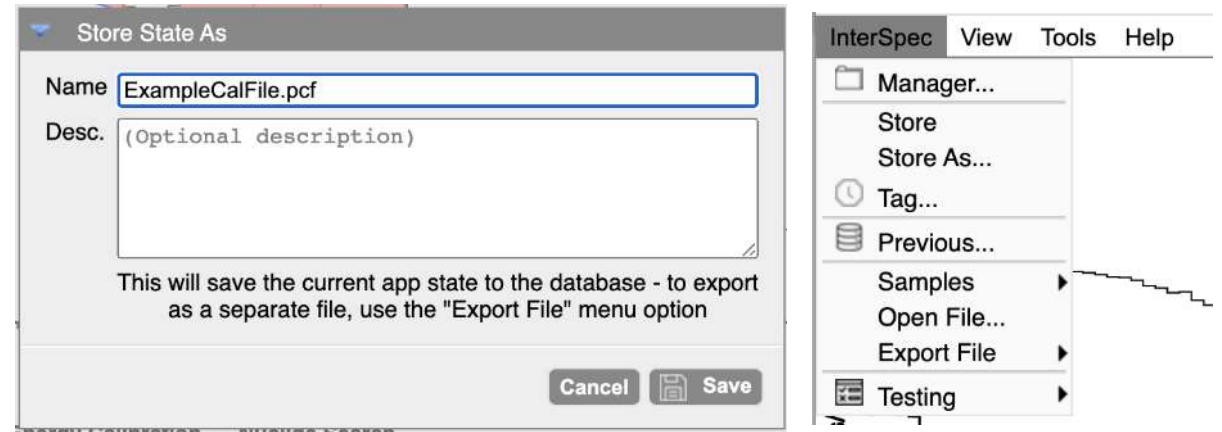
Or you can store everything in InterSpecs internal database.
- If you do this you can "Tag" snapshots of your work, or if you load the original spectrum some time later, you will be let known you can pickup where you left off before
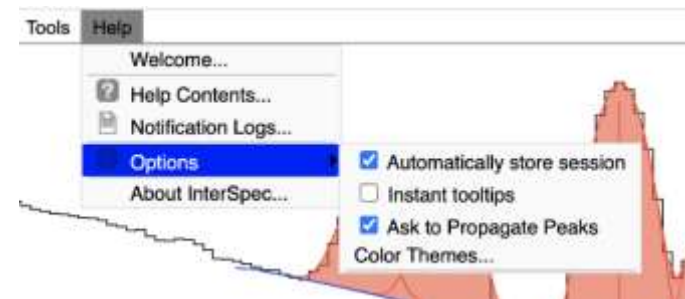
There is also an option to store your session when you quit InterSpec, or switch spectrum files
- You cant currently access these auto-saved spectra via the GUI, but if you load the same spectrum file later, a dialog will come up asking if you want to pick up where you left off

In-app help:
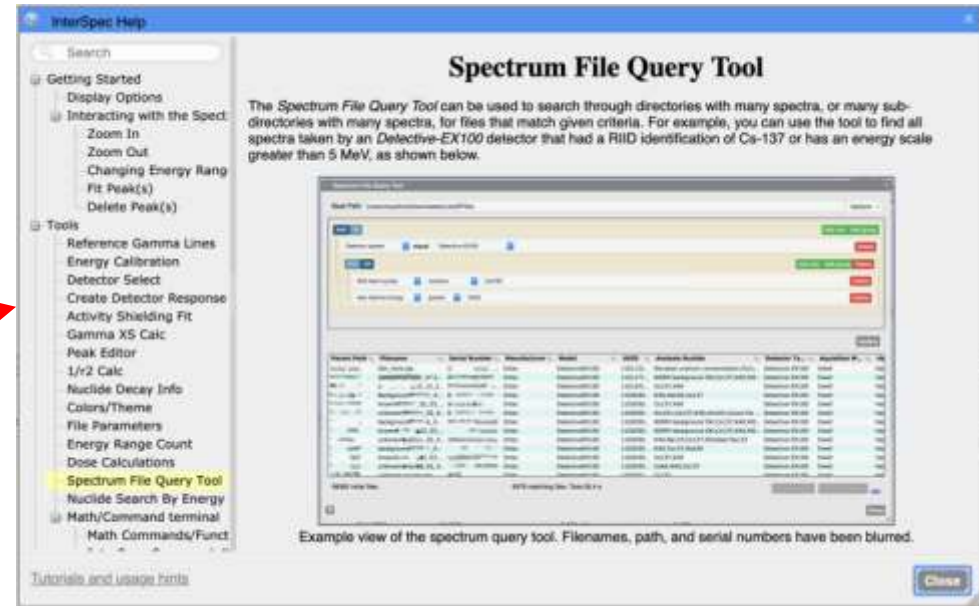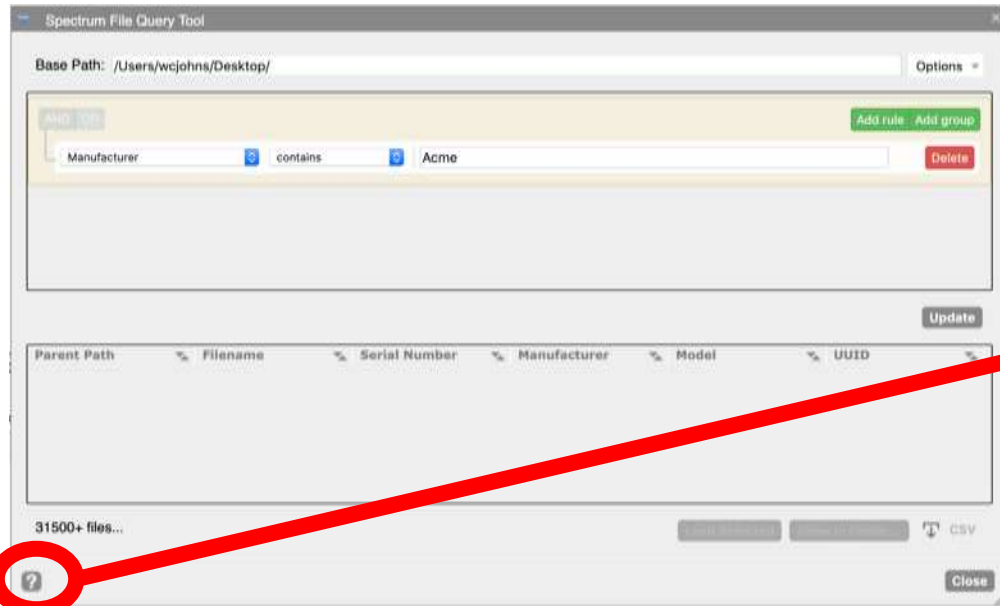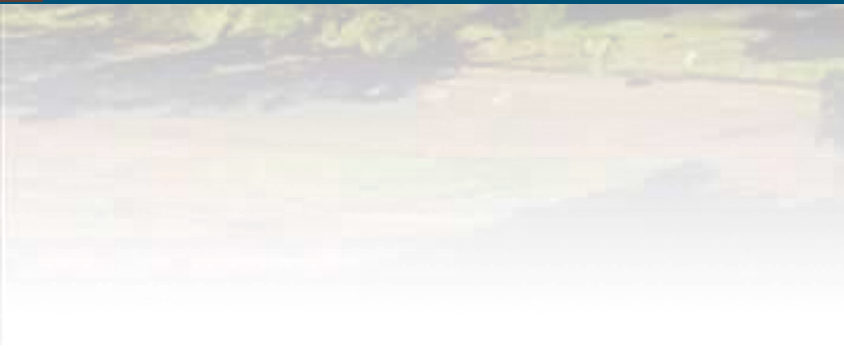
Most tools have a help button that will bring up detailed information about that tool.
   ◦ As always, the help is a work in progress…

Energy Calibration

Energy Calibration – a primer

Almost all spectrum files use one of:

- Polynomial:
  - The energy of channel i is: $E_i = c_0 + c_1 \times i + c_2 \times i^2 + c_3 \times i^3 + \ldots$
  - Spectrum file gives the coefficients c_j, usually 2 or 3 of them, but sometimes up to ~5.
  - c_0 is often times called offset, c_1 is gain, c_2 quadratic
  - The most common energy calibration form
- Full Range Fraction (FRF):
  - The energy of channel i is: $let\ x_i = \frac{i}{\#channels}$ then $E_i = c_0 + c_1 x_i + c_2 x_i^2 + c_3 x_i^3 + \frac{c_4}{1+60x_i}$
  - Primarily used in PCF files (GADRAS and related), but also in some N42-2006 files.
- Lower Channel Energies:
  - The lower energy of each channel is given.
  - Sometimes the upper energy of last channel is also given
  - Common in CSV or simple ASCII files, but can also be in N42 and PCF files

A detectors calibration may not always be great, so sometimes adjustments to the coefficients of polynomial or FRF coefficients may be necessary before analyzing data – there are a few ways to do this in InterSpec

Energy Calibration (cont.)
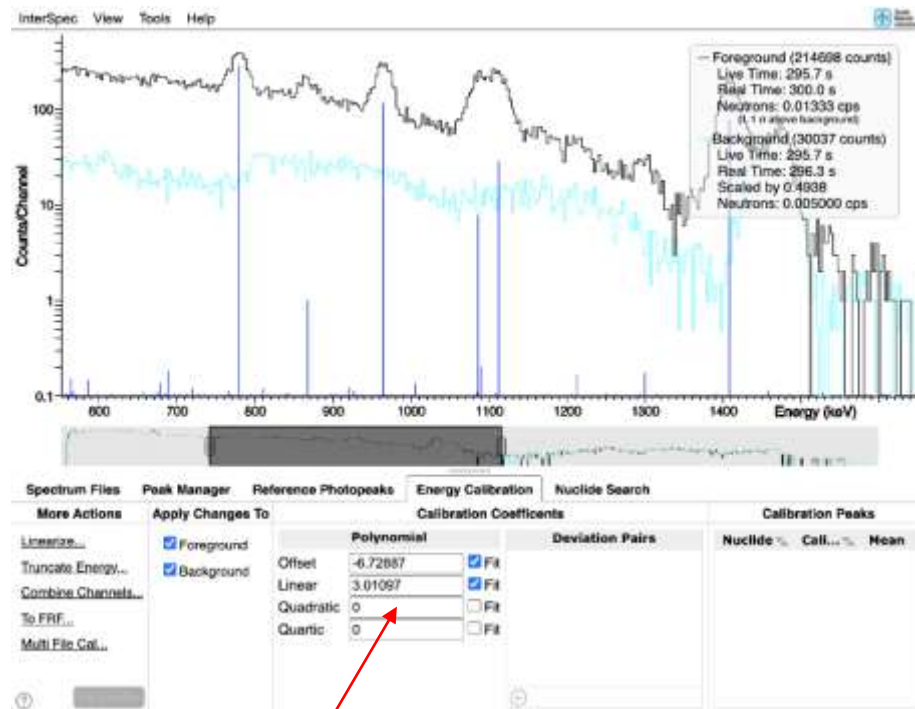
You can manually adjust parameter until the photopeak's line up with where they "should" be

Energy Calibration (cont.)

You can fit for peaks associated with nuclides, and use those to "fit" for the best coefficients
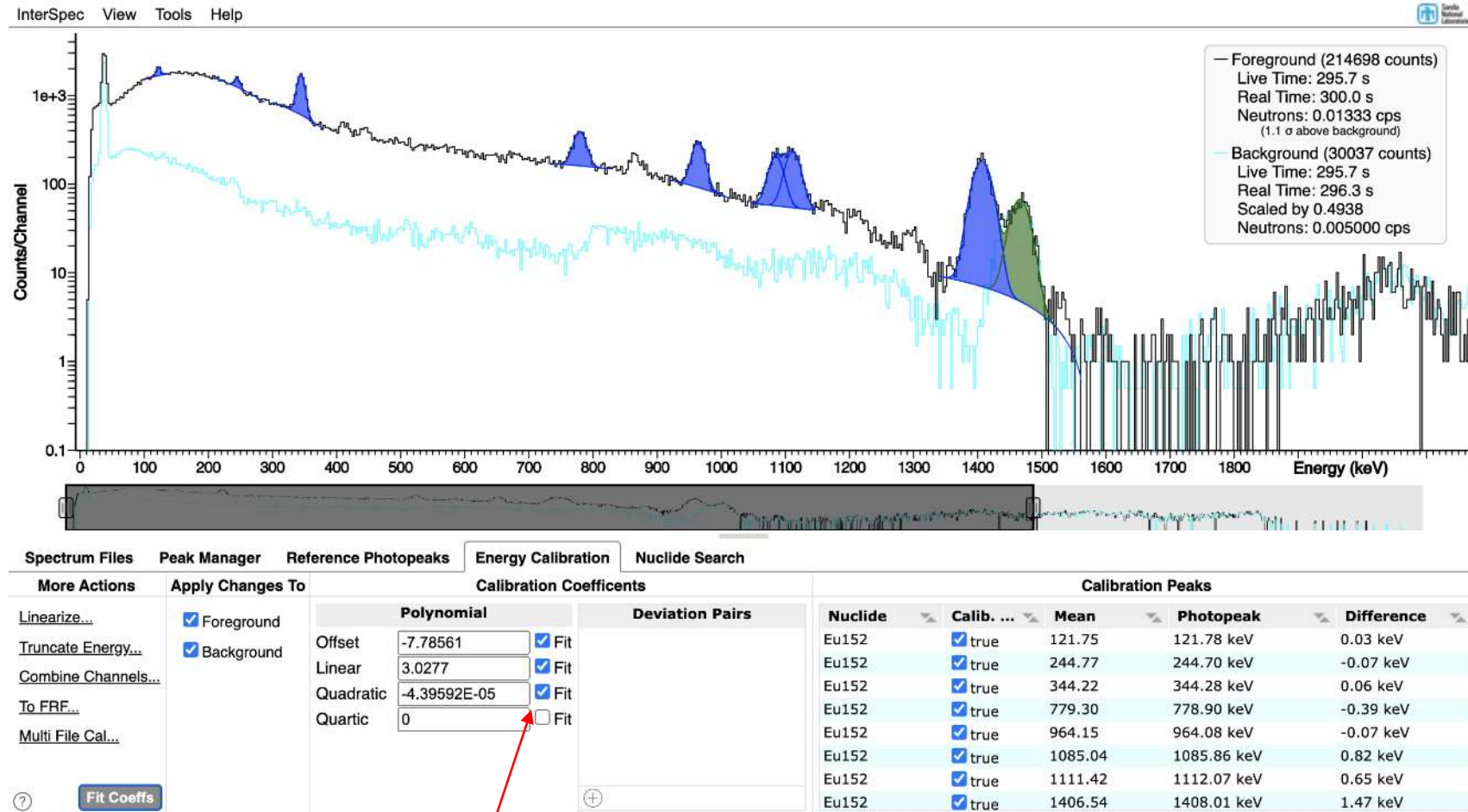
3) Push "Fit Coeffs"

2) Select which order coefficients you want to fit for

1) Select the peaks you want to use for the fit

Energy Calibration (cont.)
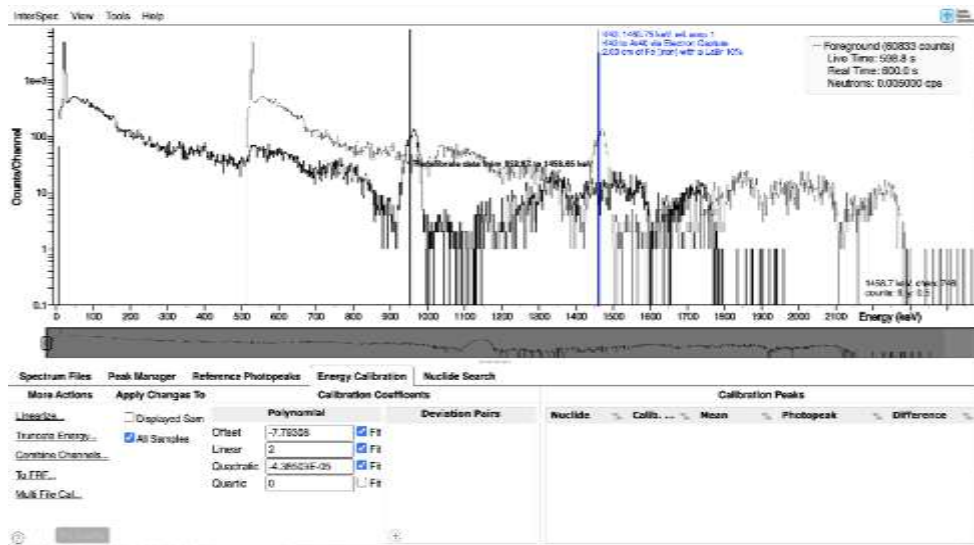
You can graphically recalibrate by holding Ctrl+Alt and dragging the spectrum to where you want
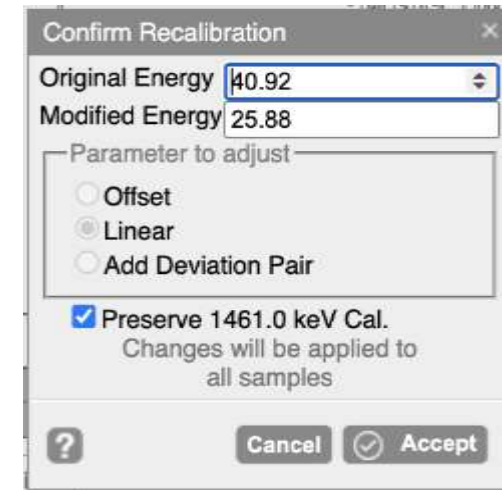
If Ctrl+Alt+drag again within 2 minutes, one of the options will be to preserve your last calibration
◦ This is useful to adjust both the gain and offset using a low and high energy peak; when you do the second calibration this option will keep your previous peak at the same location you drug it to

Energy Calibration (cont)
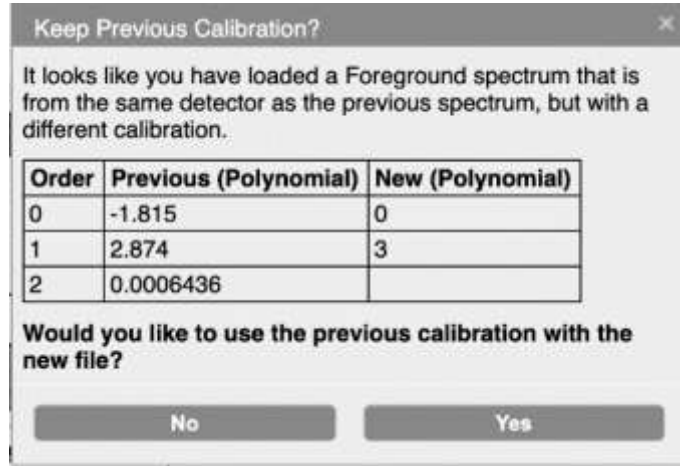
When you load a new spectrum, and its from the same detector as your previous spectrum, and the energy calibrations are different, you will be asked if you want to keep the previous calibration
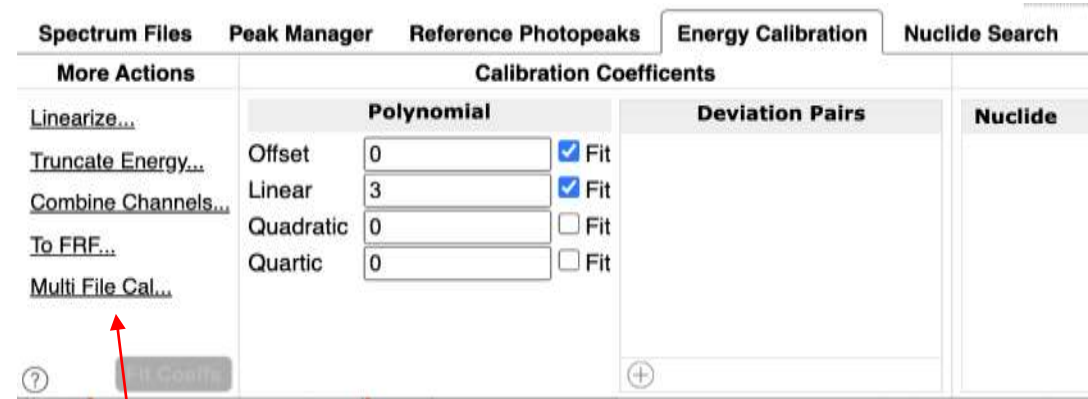
Further options having to do with energy calibrations will appear in the Energy Calibration tab depending on context

Energy Calibration - complications
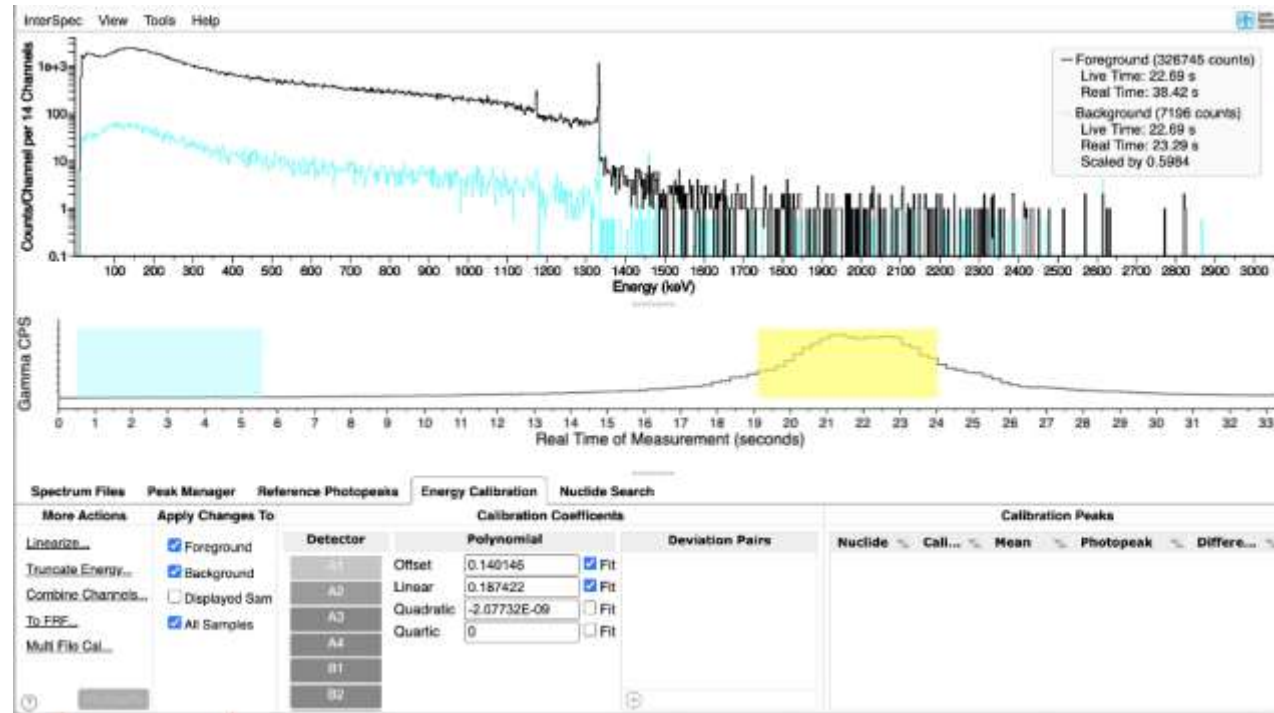
Some detection systems have multiple physical detectors, and/or may provide many different measurements all within the same file

- Each detector may have a different energy calibration
- The energy for a given detector may change for each sample

In these cases you will have to select how you want the changes applied

Energy Calibration – complications (cont.)
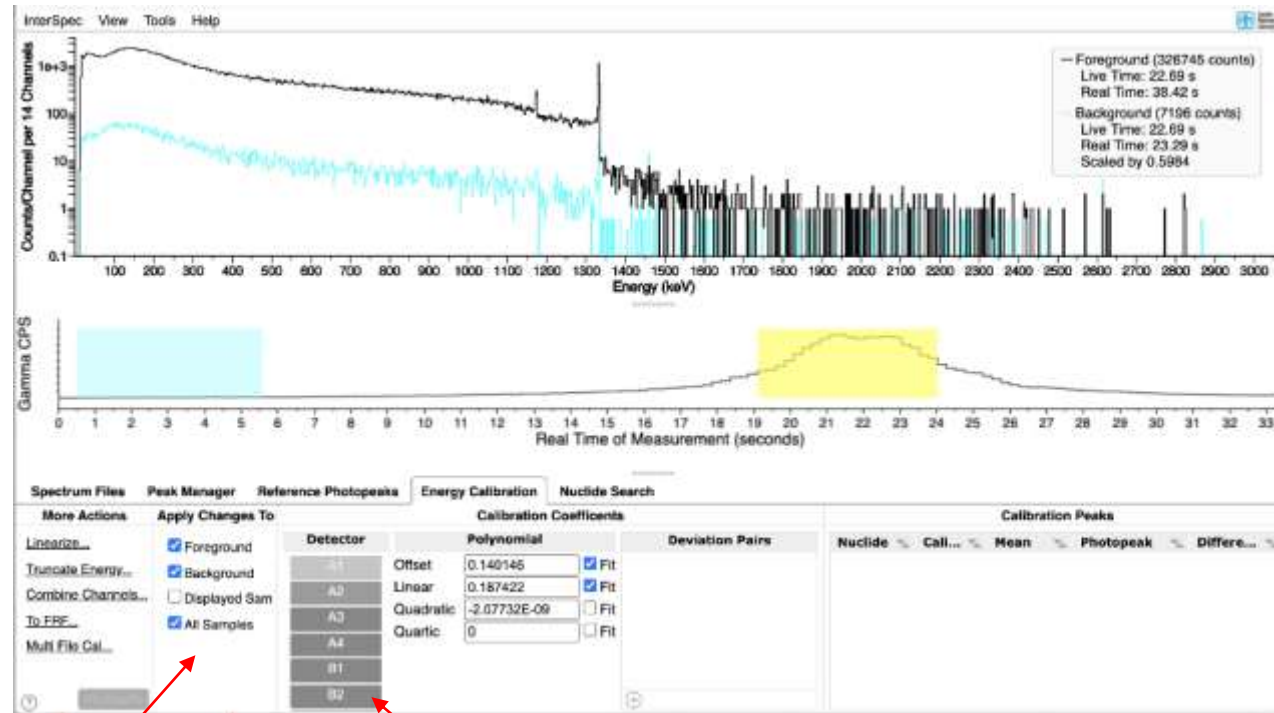
You can select which detectors, samples, and files to apply the changes to here

You can see the calibrations for each detector using this menu, which will appear when you load a spectrum with multiple detectors

Energy Calibration – complications (cont.)

For multiple detector systems, or where calibration changes throughout file:

- If you manually change a coefficient, the effect of that change is applied to all the other calibrations in the file
  - E.g., the peaks for all detectors will move the same amount
  - This isn't as straight forward as changing the coefficients of each calibration by the same amount, but InterSpec takes care of the math
- If you want to adjust the calibration of just on detector, use the "View" → "Detectors" menu to change which detectors are being shown
- Options also appear on the GUI to let you apply changes to just the visible samples, or all the samples, or just the foreground/background/secondary spectrum
  - Changes are not applied to other files you may have open, but aren't being displayed; use the "Multi File Cal…" option for that, or after an adjustment, change back to the other file you want, and you should be prompted if you would like to use the new calibration

Energy Calibration – nonlinear deviation pairs

Calibration Coefficents

Detector	Polynomial			Deviation Pairs		
A1	Offset	0.140146	☑ Fit	0	0	⊖
A2	Linear	0.187422	☑ Fit	1460	10	⊖
A3	Quadratic	0	☐ Fit	2614	0	⊖
A4	Quartic	0	☐ Fit			
B1						
B2						⊕

Non-Linear deviation pairs are typically used to account for intrinsic non-linearities not captured by a lower-order polynomial
- Non-linear deviation pairs are typically static over time and temperatures and wont need to be adjusted after initial characterization

The deviation pairs are actually the nodes of a cubic spline that specifies a change to add on-top of the polynomial or FRF calibration

An example use is:
- Use the 239 keV and 2614 keV peak to determine offset and gain
- Then if the 1460 keV K-40 peak is at 1450 keV, you would a deviation pair with energy of 1460 and offset of 10
- You would also add a deviation pair with offset 0 at 0 keV, and one with offset of 0 at 2614 keV

Practically, if you are trying to use a quartic or above calibration, you should consider non-linear deviation pairs

Fitting activity and shielding

Peak-Based Differential Attenuation Analysis

Goal: Take gamma spectrum of radioactive source, and from the spectrum potentially determine:

1. The amount of shielding
2. The effective atomic number of shielding
3. The source activity
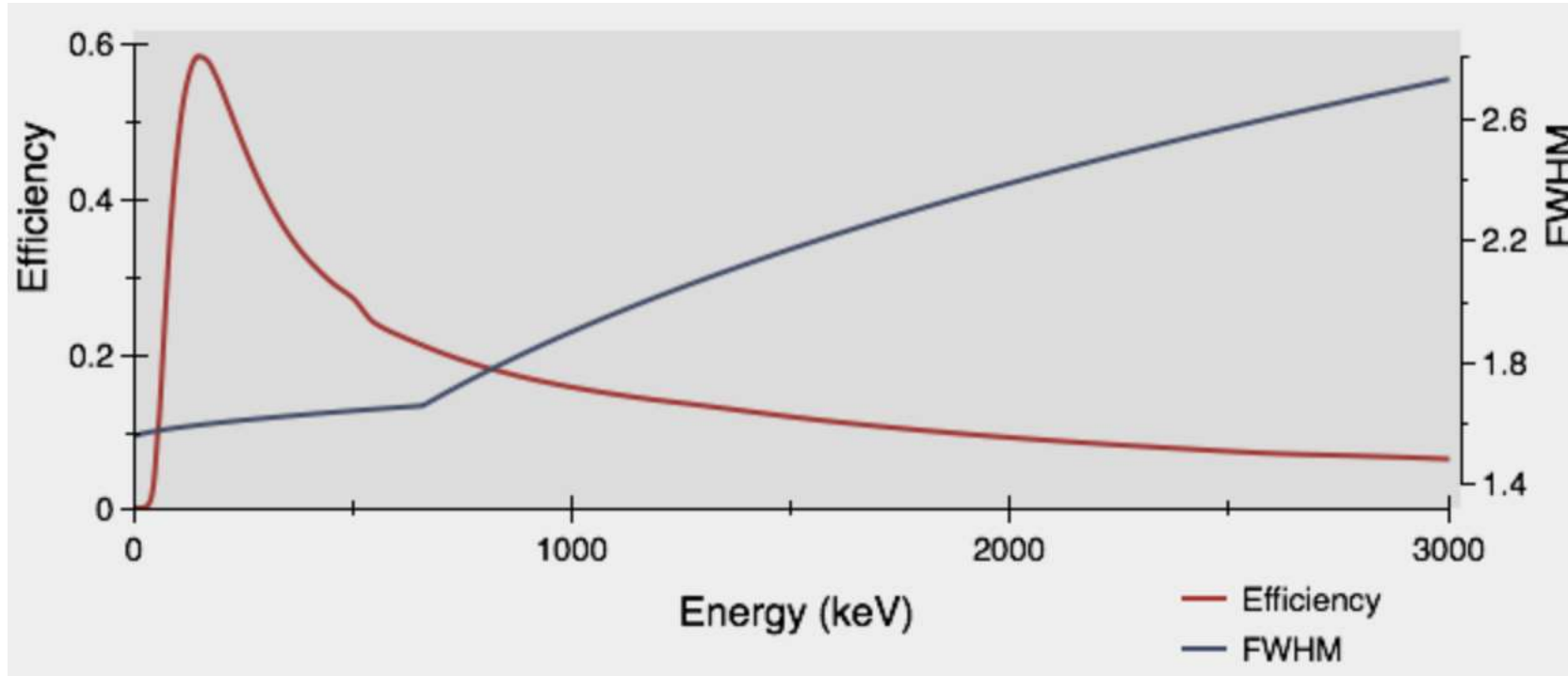4. Isotopics of material
5. The source Age

Differential Attenuation – Pretty Basic Stuff

The photon cross-section with matter varies by both photon energy and material atomic number

Gammas Making it through 1.54 g/cm2 (think 2 mm steel)
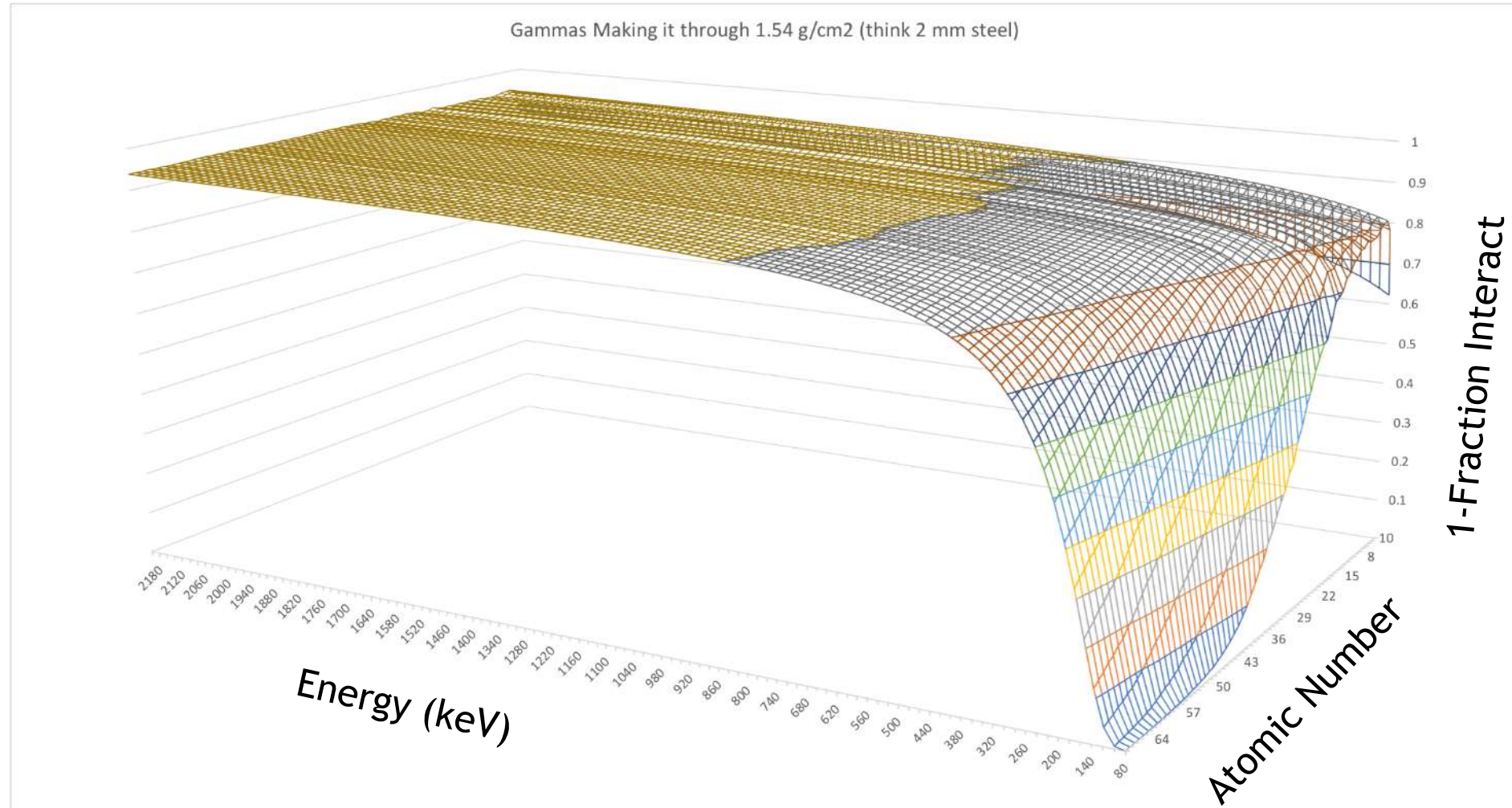
Detector Response Function

For peak-based spectroscopy, we care about the efficiency of detecting the full-energy of incoming gammas – i.e., efficiency to see peaks in the spectrum.

The efficiency is commonly given as either:
- Intrinsic: A function describing the fraction of gammas striking the detector face, who's full energy will be absorbed
- Absolute: The fraction of full-energy absorptions , for a source at a given distance

Usually given in a form like: exp(-343.63 + 269.10*log(x) -83.80*log(x)^2 + 13.0*log(x)^3 -1.01*log(x)^4 + 0.03*log(x)^5)

Source Gamma Intensities:
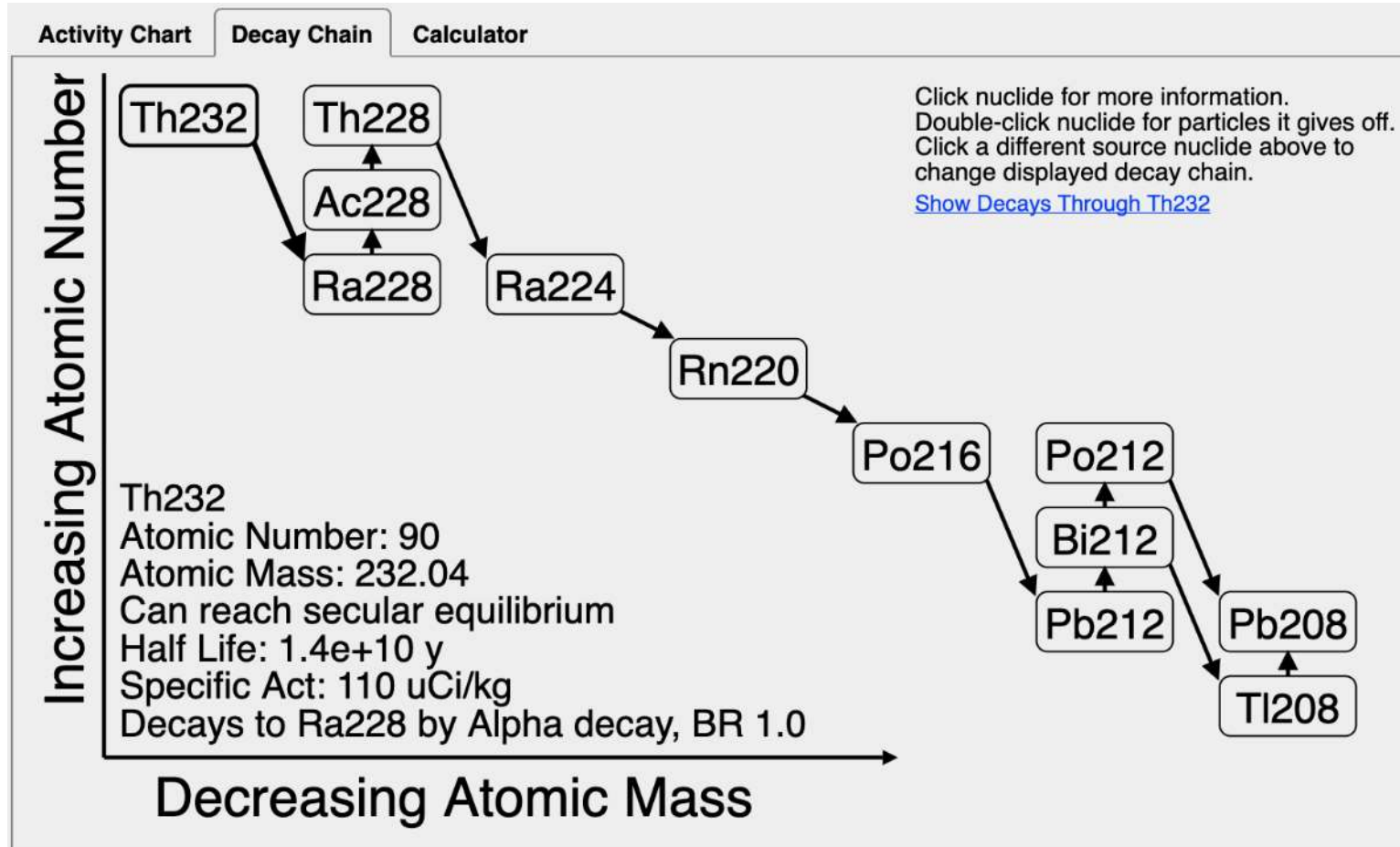
ENSDF gives us the energy and intensity of gammas for each nuclide

The Bateman equations let us determine these probabilities for decay chains as a function of time

Putting it together:

We know a nuclides output gamma spectrum (as a function of age)

We know the gamma attenuation (as a function of energy and atomic number)

We know the efficiency for a gamma to end up in a photopeak (as a function of energy, source to detector distance, and detector face size/shape)

We can fit photopeak's in spectra to determine their area

  Its now just χ^2 or -log(likelihood) fit to figure out the the unknowns

Comparison of Peak-Based analysis to Full Spectrum analysis

Advantages of peak-based:
- No background is needed (unless you want to use source peaks that overlap with background peaks)
- Does not depend on scattering of your environment.
  - For full spectrum you need to characterize the DRF to your environment, ex. concrete floor, 1m high, how big the room is, etc.
- Detector characterization much simpler (either do by measuring a couple check sources, or a simple GEANT/MCNP calc can be good enough)
- Gamma transport through material is trivial; doesn't really depend on geometry
- Peaks and spectral features from nuisance sources only effect you if they also have a gamma line overlapping a peak you want to use of the isotope of interest

Disadvantages of peak-based:
- You need at least as many peaks in your spectrum as quantities you want to fit
  - The broader energy range, the better (see next slide)
  - E.x. To fit for activity and shielding thickness, you need at least two peaks (three or more is better) – full spectrum analysis can fit for atomic number, areal density, and activity of single-peak sources like Cs-137
- You are not using spectral information outside of the peaks
- You aren't extracting information about scattering environment
- Full-spectrum analysis uses more information, so can give better results, but can also give worse results if scattering environment is not well characterized

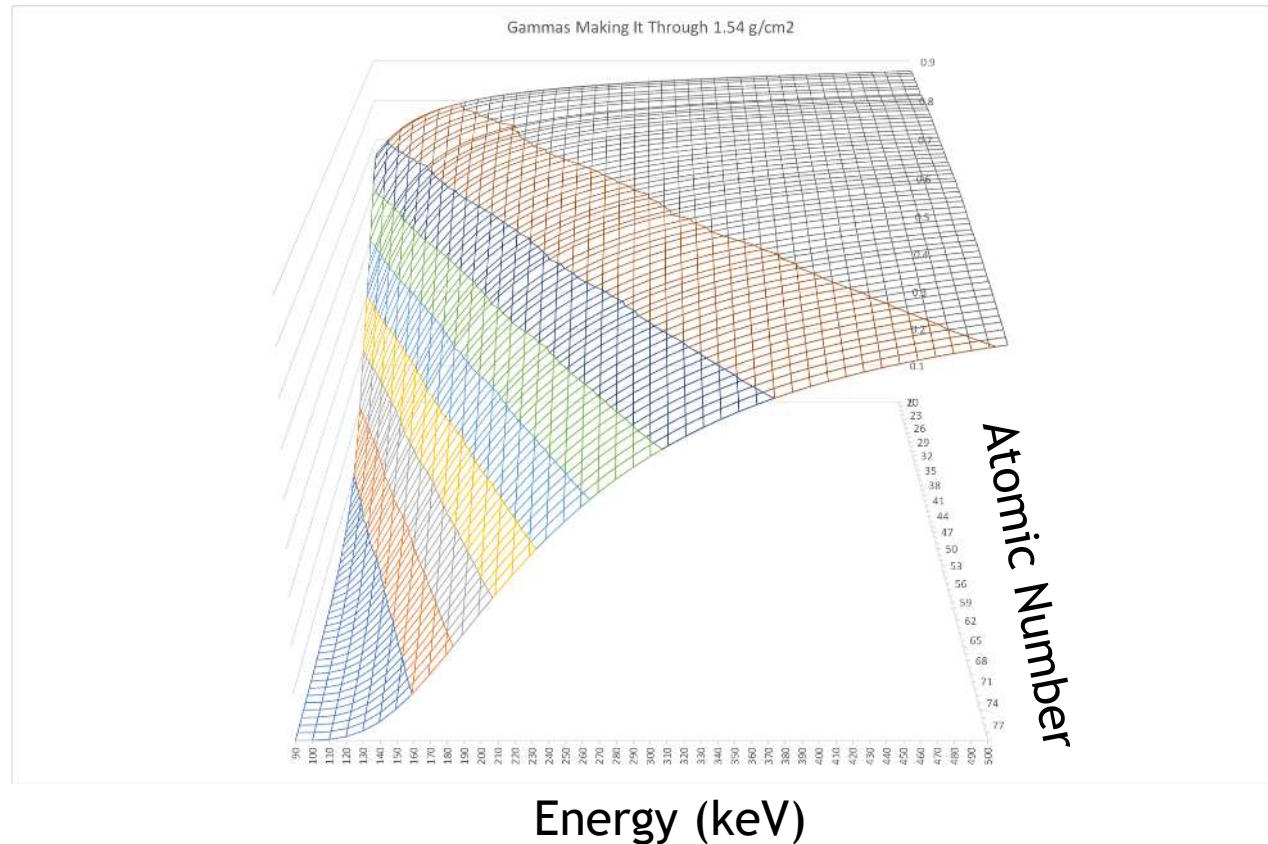# Finding shielding atomic number:

For energies ⪆ 300 keV fitting for both atomic number, and amount of shielding becomes degenerate – so you really want at least one peak bellow 300 keV (preferably a few)


Gammas Making it Through 1.54 G/cm2
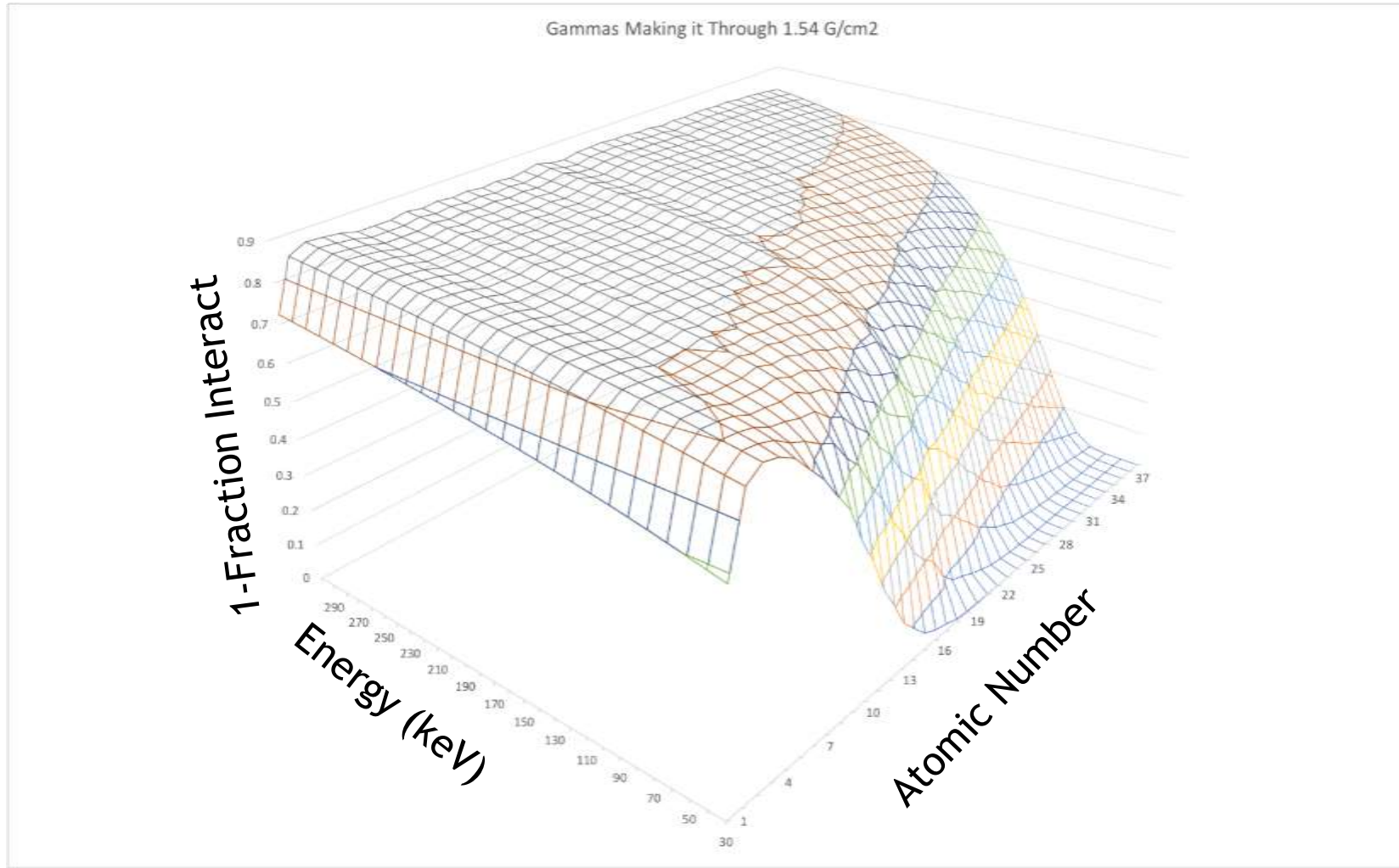
Finding shielding atomic number (cont):

Atomic Numbers > 20
80 to 400 keV

Gammas Making It Through 1.54 g/cm2

Energy (keV)

Atomic Number

Bottom line: if you want to determine the both effective atomic number, and amount of shielding, using a peak-based approach, you want at least one peak below 300 keV, and preferable a few

Fitting activity, shielding, and age in InterSpec
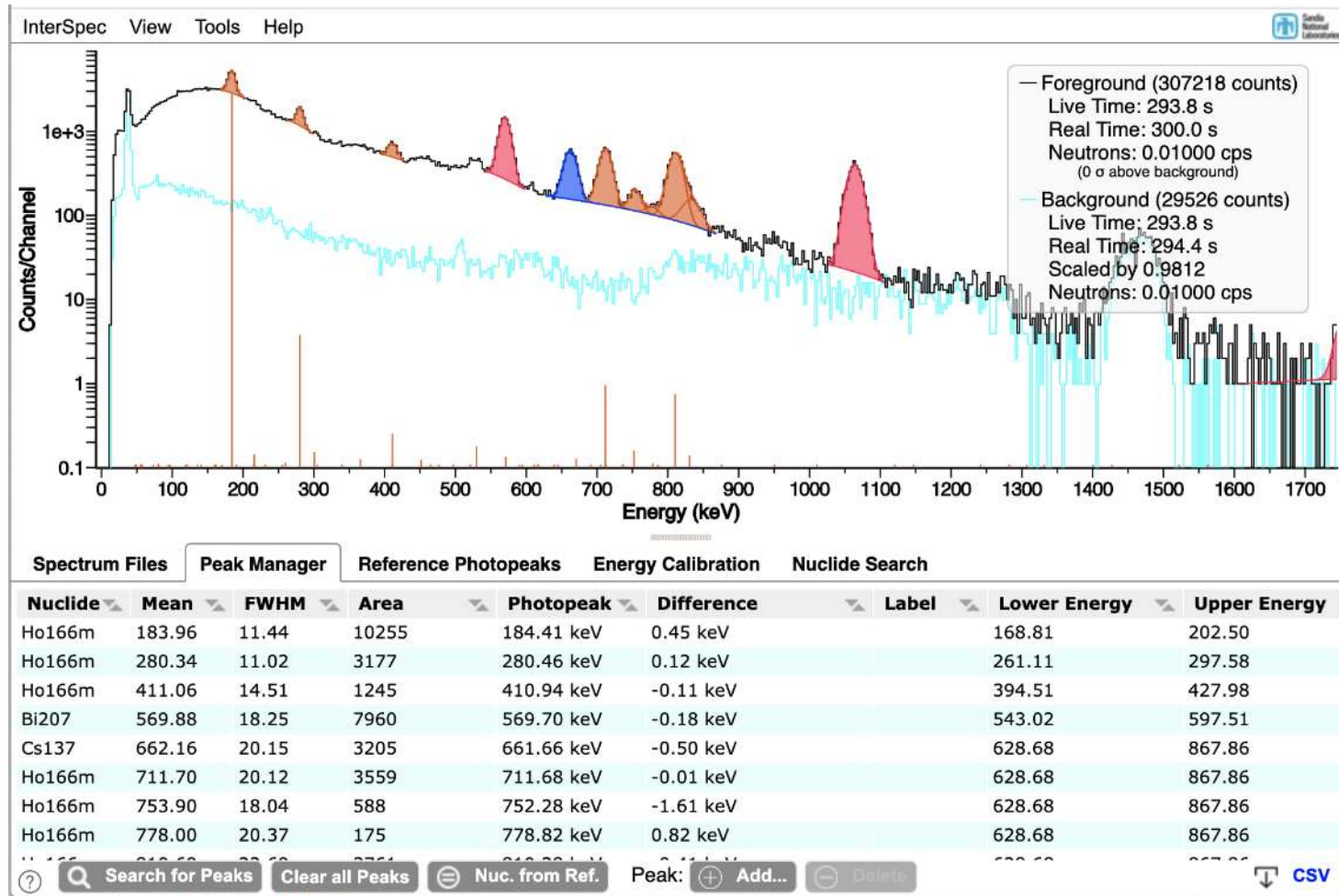

First: fit peaks, associating them with nuclides
- Peaks that are in both the background and foreground do not need to be fit. Or if a peak is for a nuclide you don't care about you can skip it
- If you have lots of peaks for a nuclide, like a HPGe spectrum of Ra-226, you can maybe fit for just the larger ones

Fitting activity, shielding, and age in InterSpec (cont.)
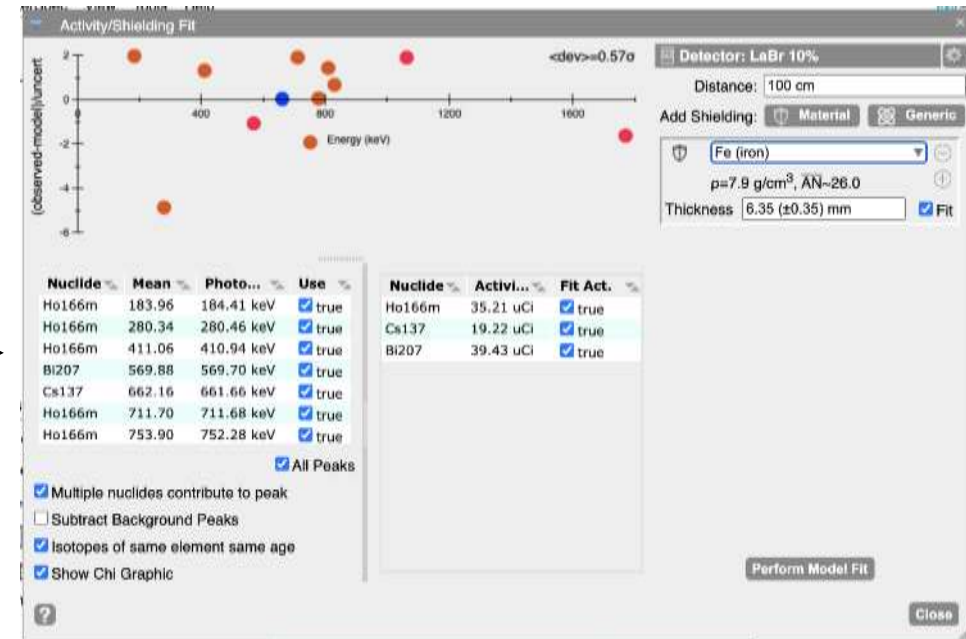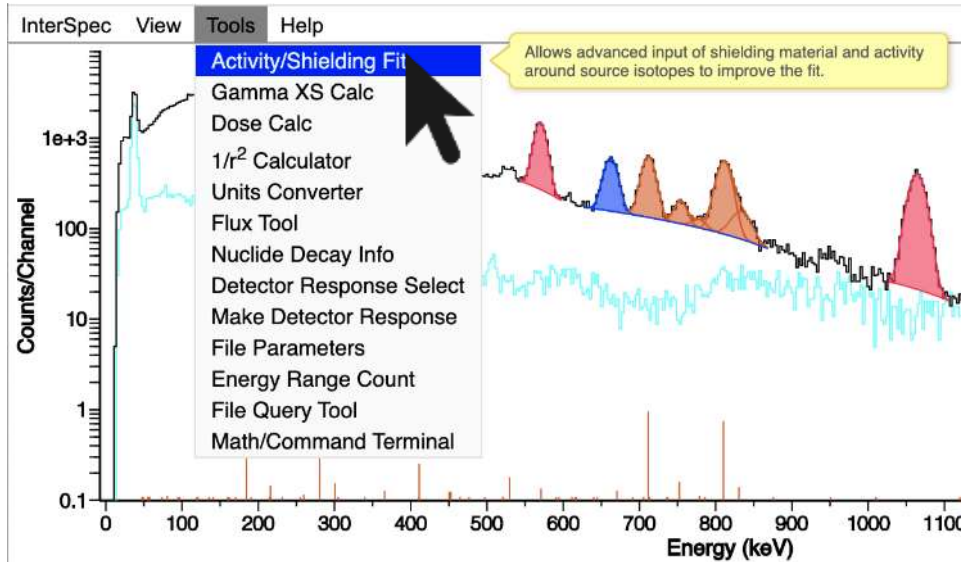
From the "Tools" menu, select "Activity/Shielding Fit"

Activity/Shielding Fit Tool
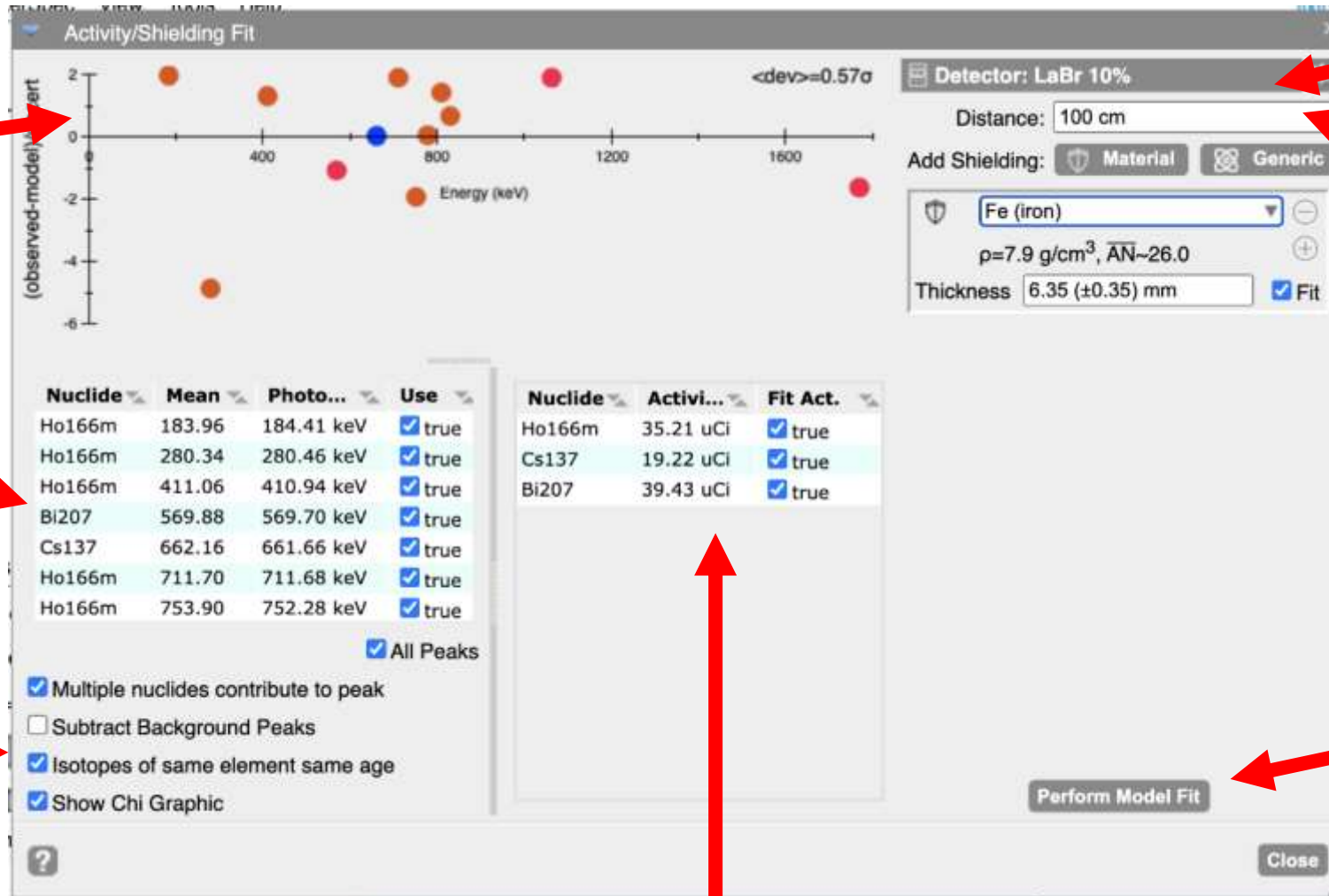
Get an idea of how good the fit is

Select DRF

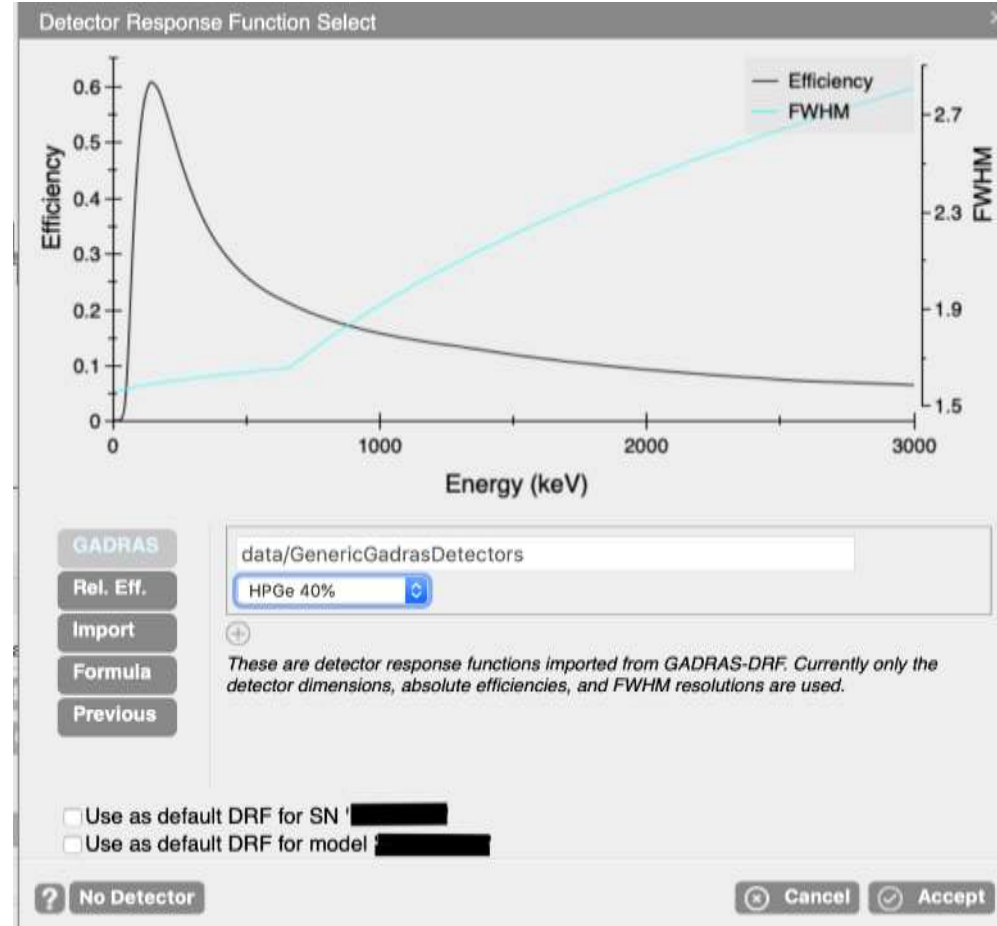Enter distance

Select shielding(s)

You can select peaks to use in the fit

Some options

Fit for the quantities you want

Decide if you want activity and/or age fixed for each nuclide

Activity/Shielding Fit Tool (DRF)

If you click/tap on the detector area, it will bring up this dialog
- ◦ We'll cover DRFs later, but this dialog lets you choose from some generic DRFs that come with InterSpec, enter your own DRF equation, upload a DRF, or select from previous DRFs

Activity/Shielding Fit Tool (peaks to use)

All of the peaks you have fit for the foreground will appear in this list.

- You can choose if a peak should participate in the fitting process.
- We'll cover strategies for deciding if a peak should be included during exercises
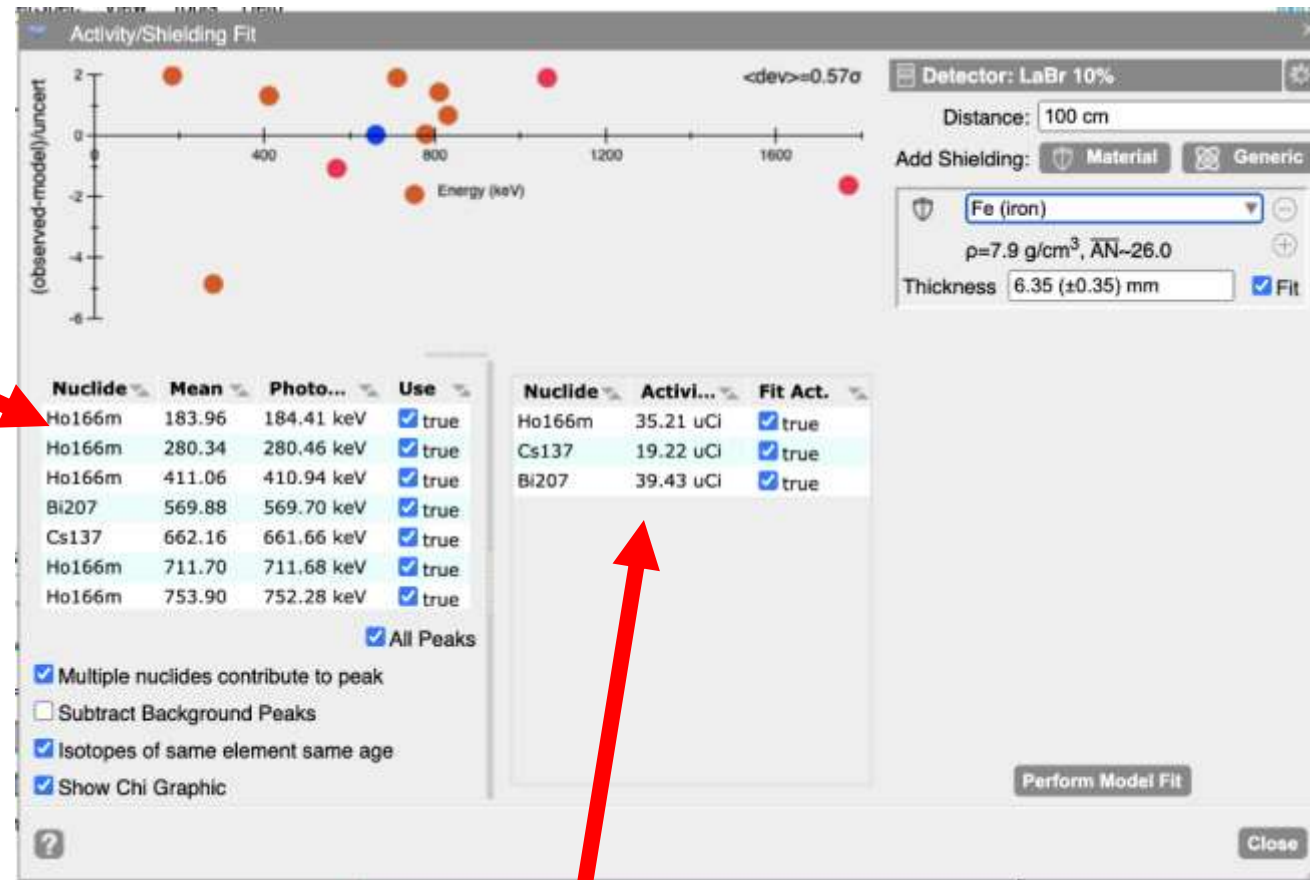
Any nuclides associated with the peaks you have selected, will appear here

- You can manually edit an activity, and choose not to fit it, if you happen to know it, but not the shielding
- Not shown above, but age of nuclides is also editable, or fittable for applicable nuclides

Activity/Shielding Fit Tool (shielding)

Clicking on these icons will toggle between shielding types

◦ The shielding can be either a specific type of material from InterSpecs database, or it can be a generic material where you specify the atomic number (AN) and areal density (AD), or you can enter a chemical formula and density.

◦ You can choose to fit for, or fix, thickness, AN, and AD

◦ You can have multiple shielding's, but of course this can get degenerate to fit for multiple of them, especially if they have similar effective atomic numbers

Activity/Shielding Fit Tool (shielding cont.)
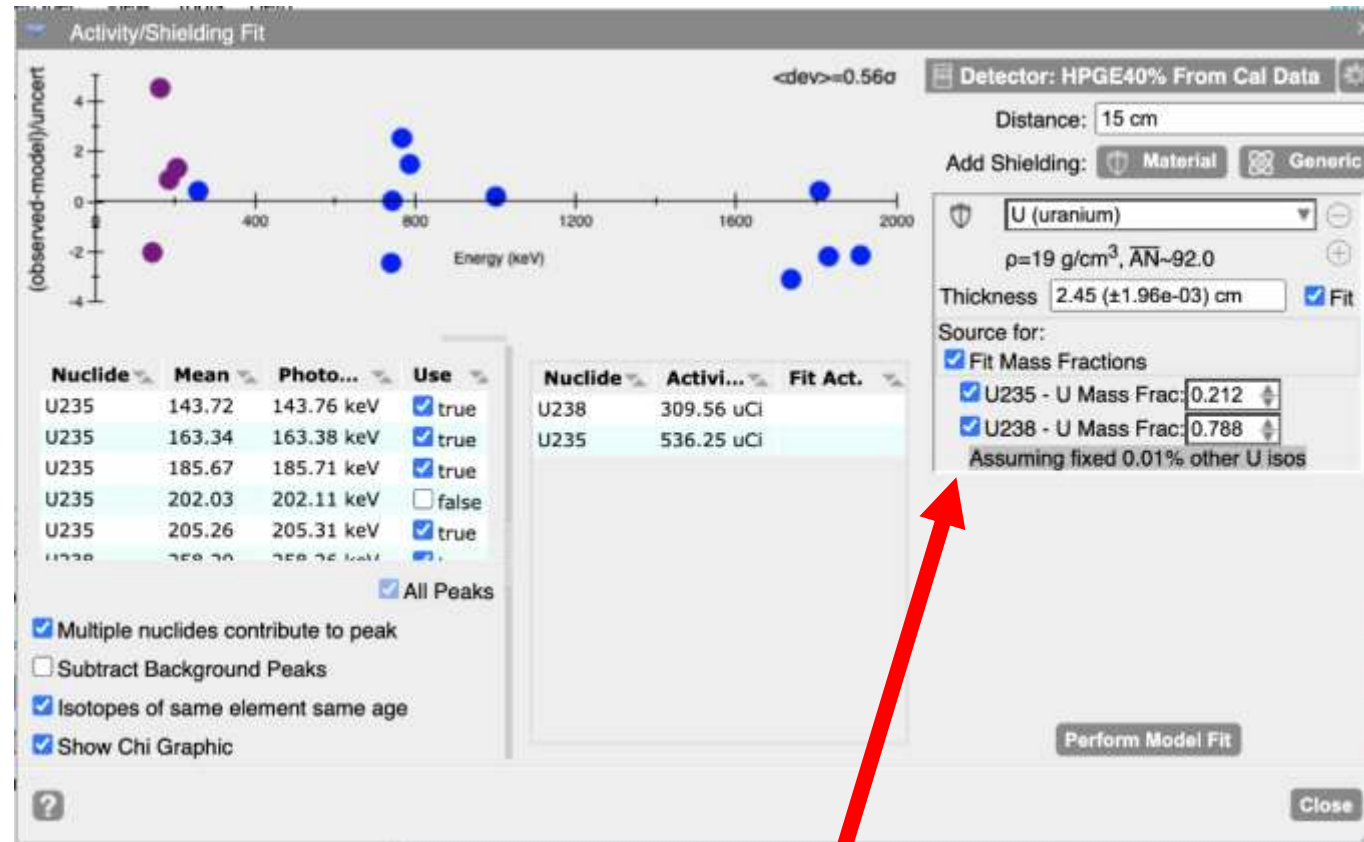
If your shielding contains the same element as one or more of the nuclides you are fitting for, you will be given the option to have the shielding become the source term

- In this case self-attenuation is taken into account; especially useful in high-Z materials (W, Th, U, Pu, etc)
  - InterSpec uses an adaptive quadrature based ray-tracing algorithm to account for self-attenuation and geometric effects
- If there are multiple nuclides composing the shielding you can fit for the isotopics as well

Activity/Shielding Fit Tool (shielding cont.)

Inner shell

2.22 cm solid sphere of Thorium metal

A 1 cm gap outside the Thorium

Outer shell

A 1.06 cm shell of wood

InterSpec uses a spherical geometry when self-attenuating sources are used

Nuclides that aren't part of shielding's are point-sources at the center of all shieldings

Activity/Shielding Fit Tool (distance)
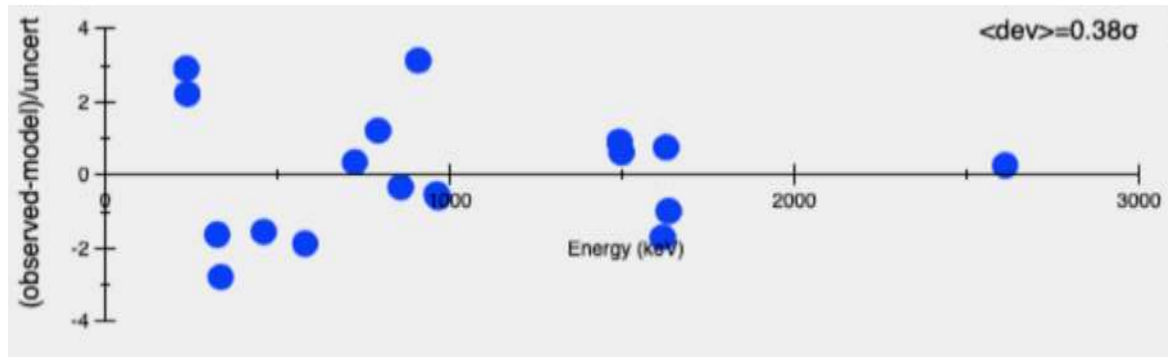

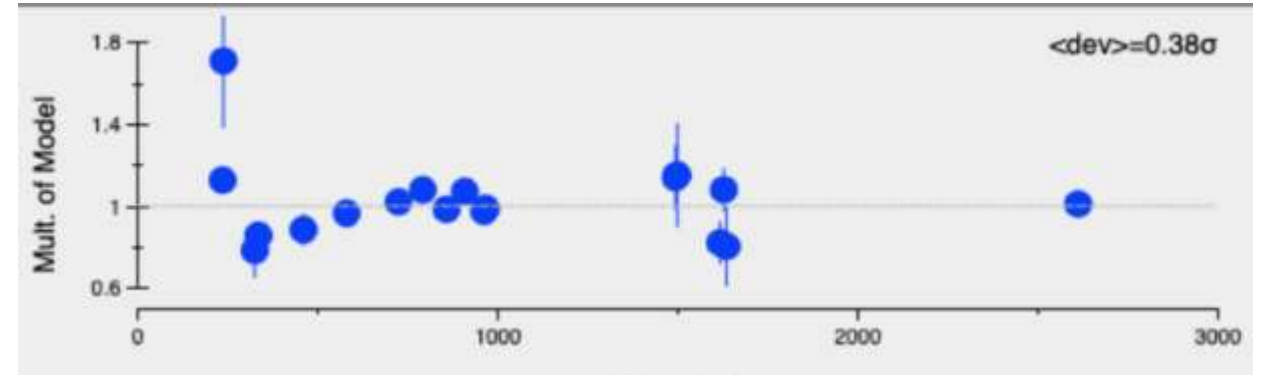The distance is from the detector face, to the center of shielding

Distance, like times, can be entered in fairly flexible formats; the following are all valid distances:

"1.2cm", "1ft", "1 ft 13 in", "1' 13''", "3 m", "3 meters", "3.6E-2 m", etc

Activity/Shielding Fit Tool (Chi graphic)

The graphic in this tool is to help provide you an idea of how well the data lines up to the model

- Left: chart shows you how many statistical deviations each peak is away from the model
- Right: chart shows you the multiple of how far away from the model each peak-area is. The error bars are 1-sigma statistical uncertainties.
  - E.x., if the dot corresponding to a peak is at 2.0, that indicates that peak would give double the activity that is currently showing

Generally, if after doing a "Perform Model Fit," a peak is greater than maybe 5-or-so-sigma away from the nominal value, you should consider removing that peak from the fit, or checking that its associated with the correct gamma line, or that there isn't an interfering nuclide that you aren't currently fitting for

Activity/Shielding Fit Tool (options)

- **Multiple nuclides contribute to peak**: if two or more nuclides being fit for contribute to a peak, allow all of the to contribute to calculating the expected peak area, not just the nuclide assigned to the peak

- **Subtract Background Peaks**: useful if background peaks contribute to your isotope of interest. To enable this option you must have a background spectrum loaded, and you must have the background peaks fit in it
  - To fit the peaks in a background spectrum, first load it as a foreground spectrum, fit the peaks, then load your foreground of interest file, and from the "File Manager" tab select the first file as background
  - Background peaks do not need nuclides associated with them; matching of which peaks to subtract from which is based on energy

- **Isotopes of same element same age**: If you are fitting for the age of a material, like Th, U, Pu, etc, and you want to constrain all isotopes for an element to be the same age, select this option

- **Show Chi Graphic**: Selects between the two different style graphics

Activity/Shielding Fit Tool (more…)
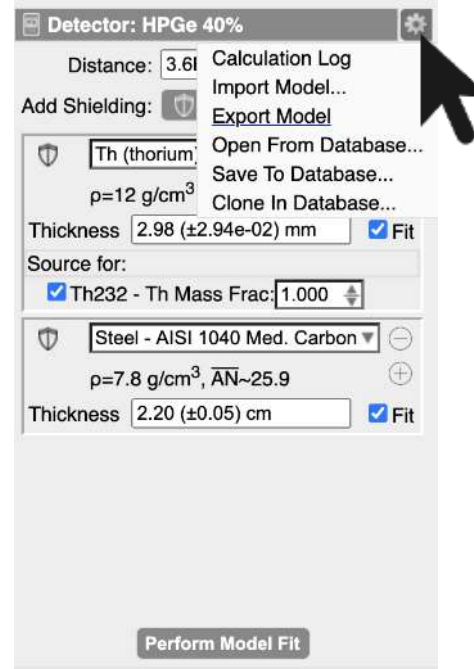
Clicking on the gear icon brings up a menu that lets you:

- See a log of calculations, which has a whole bunch of details about what exactly went into the calculations
- You can save, export, import, or load a previous model. Useful if your model is complex.

Activity/Shielding Fit Tool (general notes)

This tool requires use of *your* critical thinking and spectroscopy knowledge – you can do things that don't make sense

- E.x., if you try to fit for atomic number of shielding using two close-together peaks, or two high-energy peaks, you will get a nonsense answer (but you should also get a large error as well). Or if you fit for the age of a nuclide that has already reached equilibrium, you might get a really large age (but also hopefully large uncertainty)
- InterSpec doesn't currently do a great job of detecting and notifying you of degeneracies being fit for
  - Large uncertainties are a "smell" of these

You can only fit for as many quantities as you have peaks for

If you are fitting for the effective atomic number of your shielding, having one or more peaks below 300 keV is usually necessary.

Always ask yourself if the results make sense.

Uncertainties given are only statistical. Uncertainties about your DRF, peak-skew, distance, material composition, or other factors may dwarf the statistical uncertainties

Lets work an example problem together:

A metal container was located that was giving off increased radiation

A 5 minute spectrum was taken from 1 m away, along with a 5 minute representative background; both using the same 3x3 NaI detector†
You would like to determine:

What nuclides are present inside the box?
The nuclide(s) activity?
How much shielding is present?

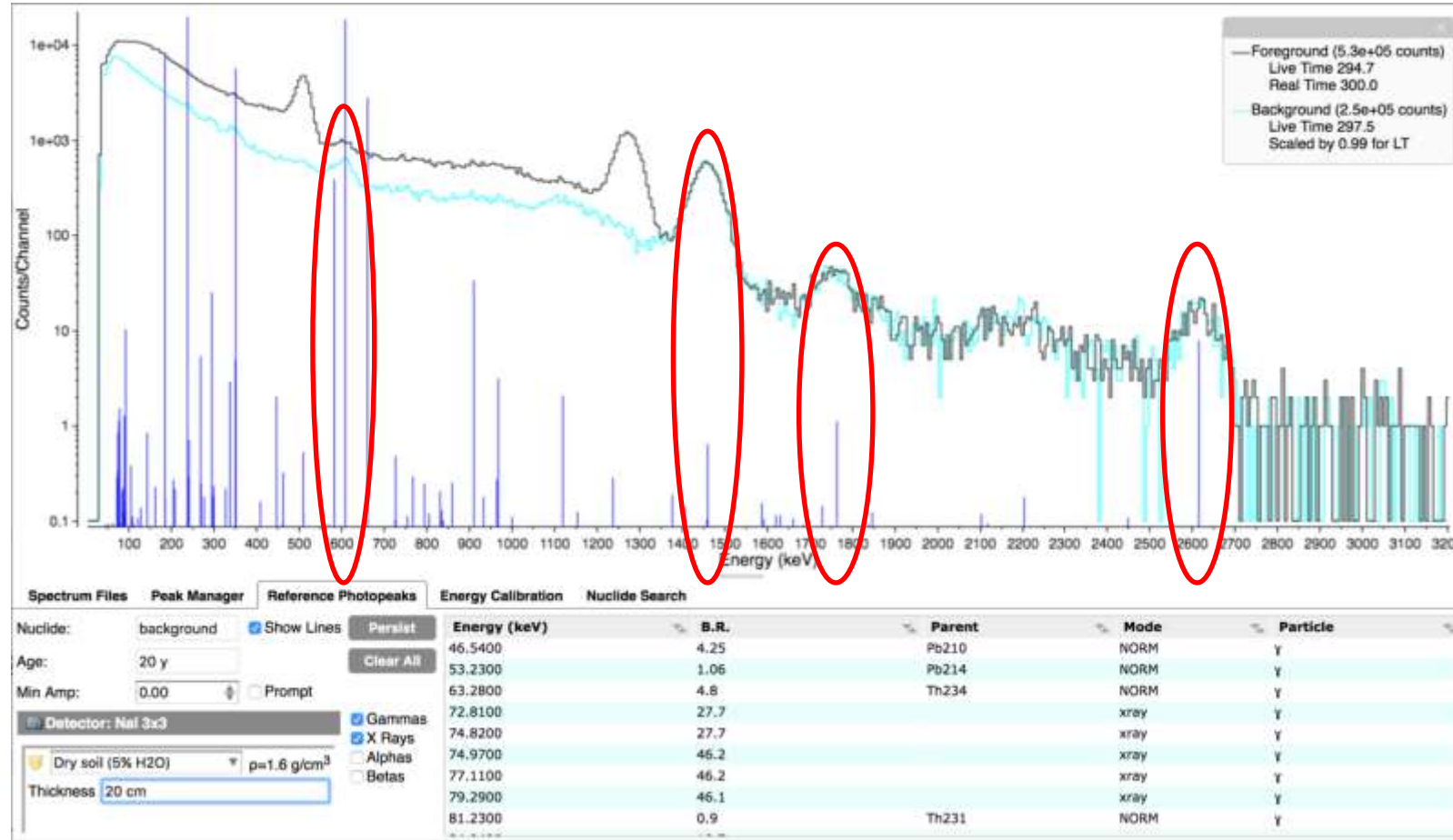Detector ←——— 1 m ———→
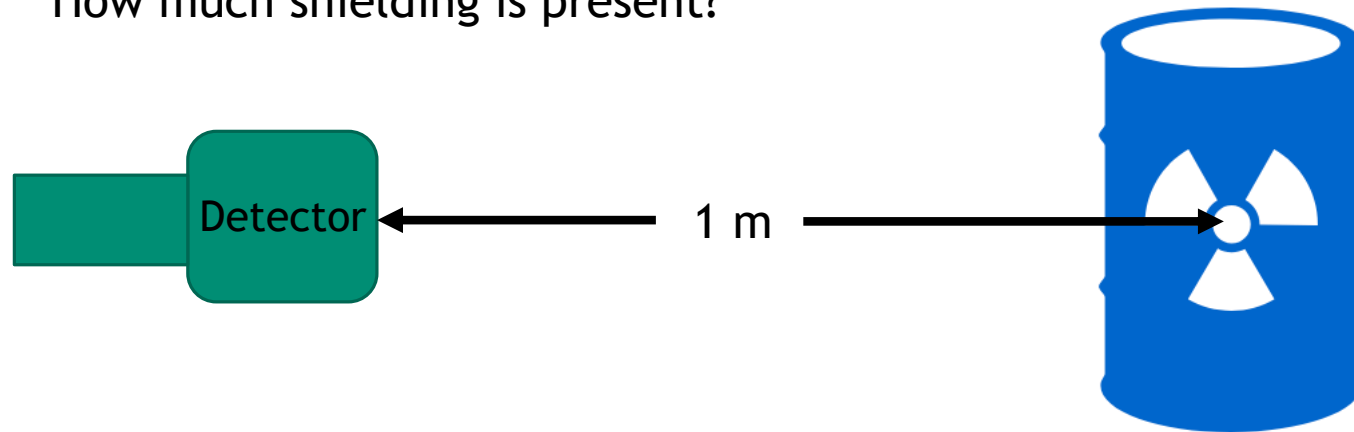
Please load **Example1.pcf** as foreground, and
Example1_background.pcf as the background

(The next bunch of slides is for later reference – we'll work it live)

† 7.62 cm diameter by 7.62 cm long NaI crystal – will produce the conceptually same spectroscopic data as an identiFINDER or RadSeeker

Example 1 (cont):

The background peaks at 1460 keV (K40), 609 keV (Ra226), and 2614 keV (Th232) look to be at the expected energies
◦ The energy calibration is acceptable, and it looks like we got the correct files off the detector

Example 1 (cont):
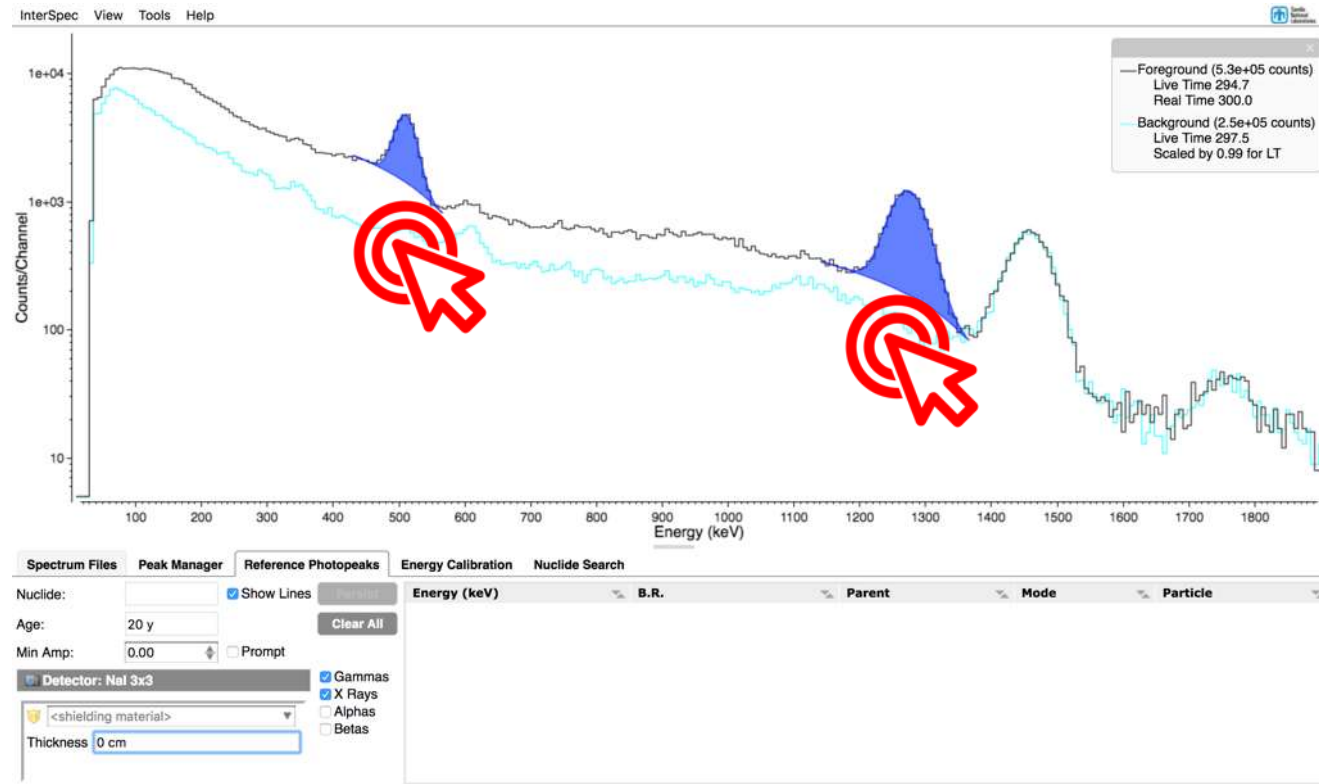
There are two obvious photo-peaks in your item of interest spectrum that are not in the background spectrum.

You can fit peaks by double-clicking near them.
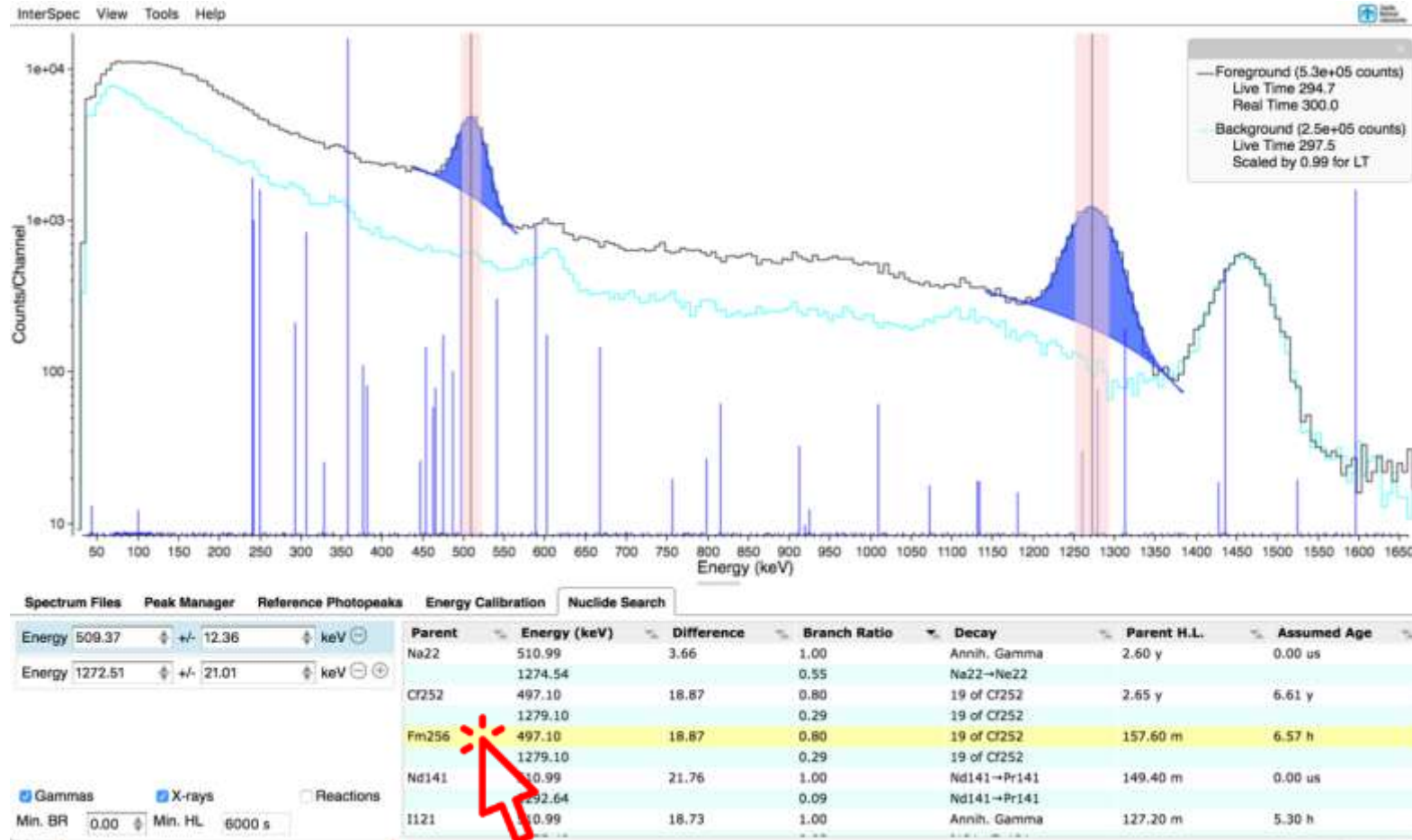
Example 1 (cont):

Lets figure out what nuclide causes these photopeaks by using the "Nuclide Search" tab

When on the "Nuclide Search" tab if you click on a place in the spectrum – that energy is filled in to search on
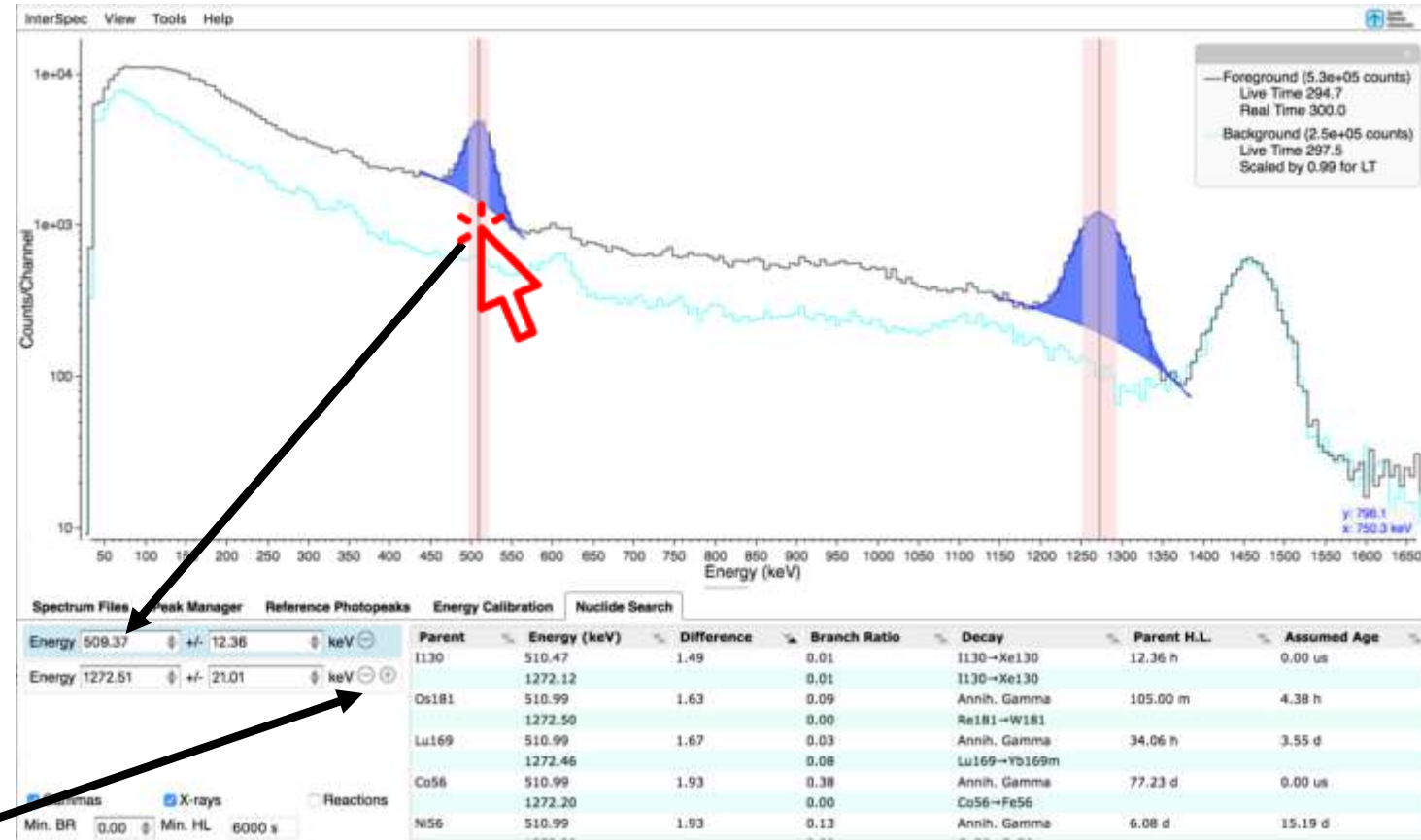
The number of energies can be changed by using the + and - icons

Example 1 (cont):

Clicking on a nuclide will cause the reference photopeak lines for that nuclide to be shown
- Here Fm256 is clearly not right because we would see many other peaks

Example 1 (cont):
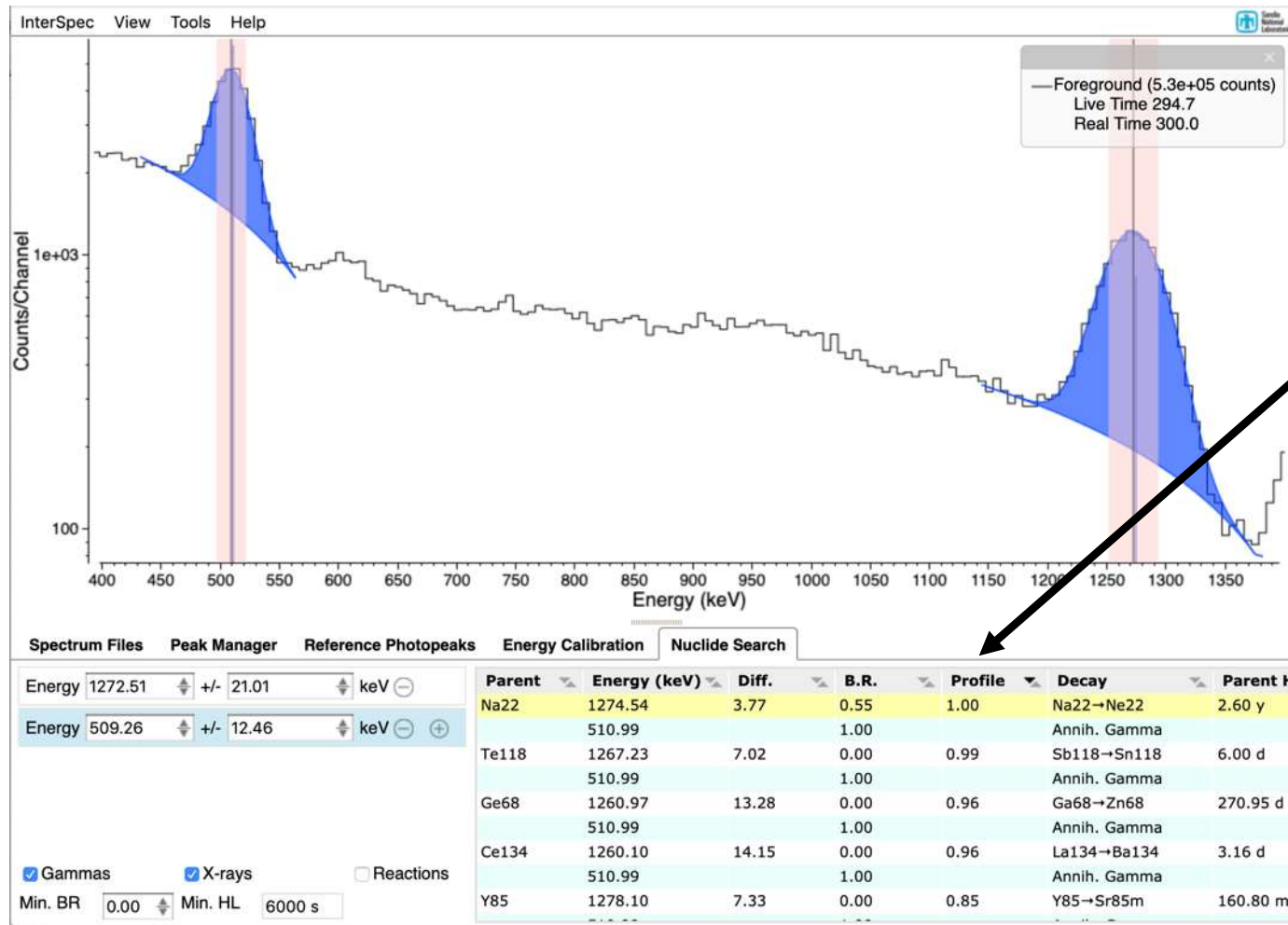
Its usually best to sort this table by the "Profile" column (default), but other ordering can be changed by clicking on the headers for other columns

It's a little hard to see, but the reference lines for Na22 line up exactly with the observed peaks – and we aren't missing any peaks we would expect for Na22 – so this is our nuclide

Example 1 (cont):

Now we need to assign nuclides to these peaks because reference lines were not showing before we fit the peaks:
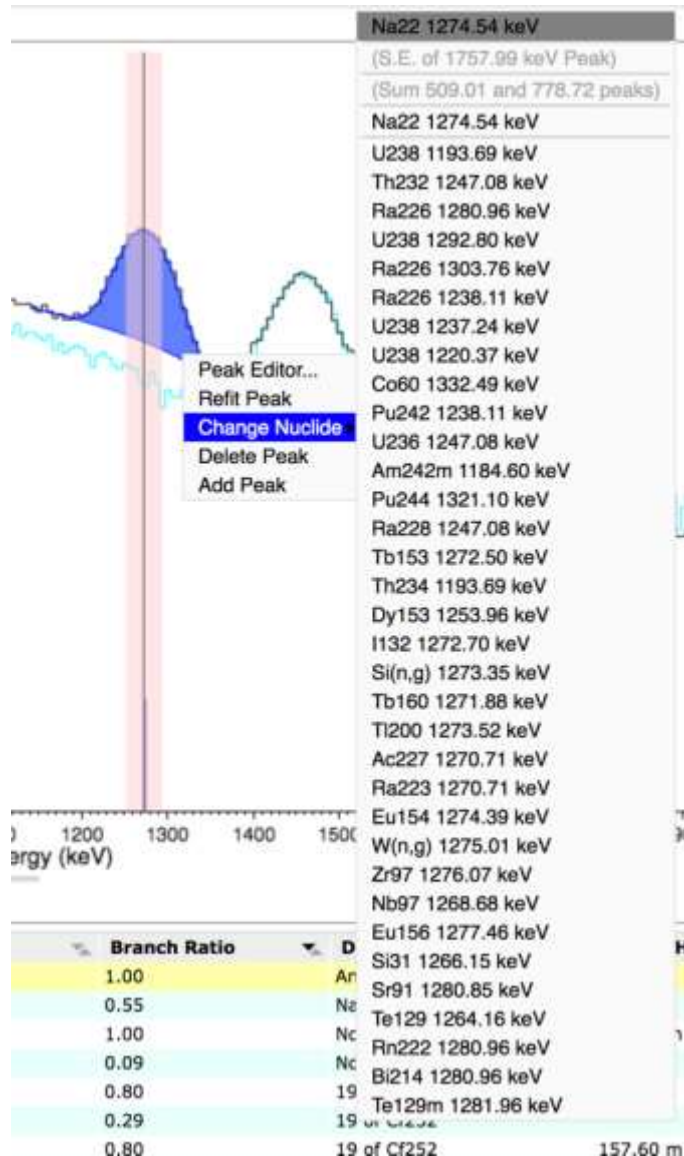
If you right-click on the peak, and go to the "Change Nuclide" menu-item, you can select Na22, or there are a number of other possible isotopes that it could be from

Example 1 (cont):

You can also assign nuclides to peaks, in a number of other ways:

By typing the nuclide name
into the "Peak Manager" tab

Spectrum Files	Peak Manager	Refer
Nuclide	**Mean**	**FWHM**
Na22	509.26	35.61
Na22	1272.51	60.02

The "Peak Editor" tool (opened
by right clicking on peak and
selecting "Peak Editor…")

Peak Editor			
Parameter	**Value**	**Uncertainty**	**Fit**
Centroid	509.2592	0.1805	☑
FWHM	35.6116	0.4598	☑
Amplitude	20699.3008	217.3821	☑
χ2/DOF	4.7400	0.0000	
ROI Start (keV)	433.1371	0.0000	
ROI End (keV)	563.4930	0.0000	
Cont. P0	365.2334	3.0797	☑
Cont. P1	-1.7892	0.0340	☑
Nuclide	Na22 ▾		
Photopeak	510.9989 keV I=1.0e+C		
Label			
Peak Type	Gaussian		
Continuum	Linear		
Skew Type	None		

Cancel Refit Accept Delete

Spectrum Files	Peak Manager	Reference Photopeaks	
Nuclide:	Na22	☑ Show Lines	Persist
			Ene
Age:	0.00 u	λ=2.60 y	Clear All
			510.9
Min Amp:	0.00		1274

Detector: NaI 3x.

☑ Gammas
☑ X Rays
☐ Alphas
☐ Betas

<shielding material ▾

Thickness 1.0 cm

Or if you are showing reference
photo-peak lines when you fit for
a peak, the peak will automatically
be associated with that nuclide

mean: 1272.51 keV
FWHM: 60.02 keV (4.72%)
x^2/dof: 1.13
peak area: 10629.6±130.4
cont. area: 7792.7
Na22 (1274.54 keV)

y: 107.6
x: 1235.8 keV

0 1150 1200 1250 1300 1350 1400 1450 1500 1550
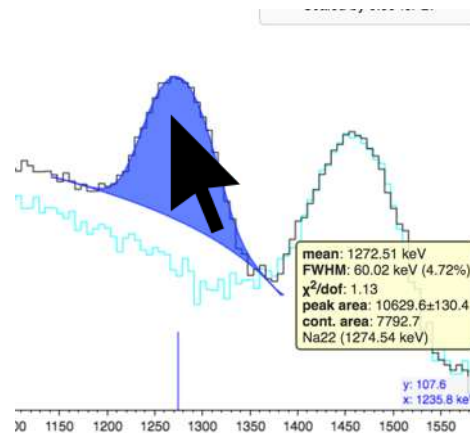
Mousing over a peak causes a
pop-up that shows info about
the peak, including nuclide

Example 1 (cont):

Fit for the source activity using the "Activity/Shielding Fit" tool

Example 1 (cont):

Select the detector response function you want to use by clicking here

Example 1 (cont)

Enter distance of measurement

Example 1 (cont):

Select which peaks you would like to use

Example 1 (cont):

Add a shielding

Here we added a single iron shielding

Make sure you are fitting for activity, and shielding thickness
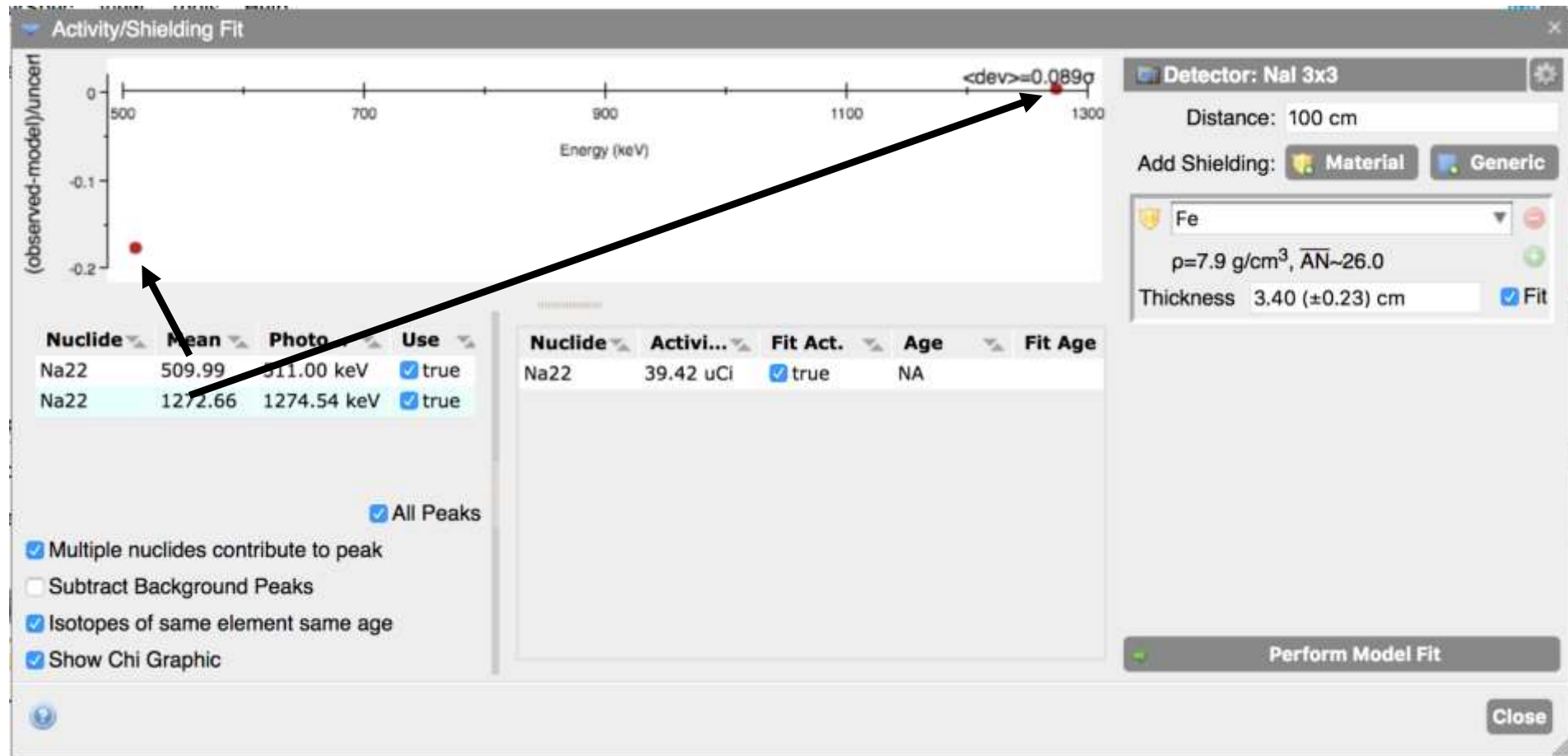
Example 1 (cont)

Click here to fit for desired quantities

Example 1 (cont)
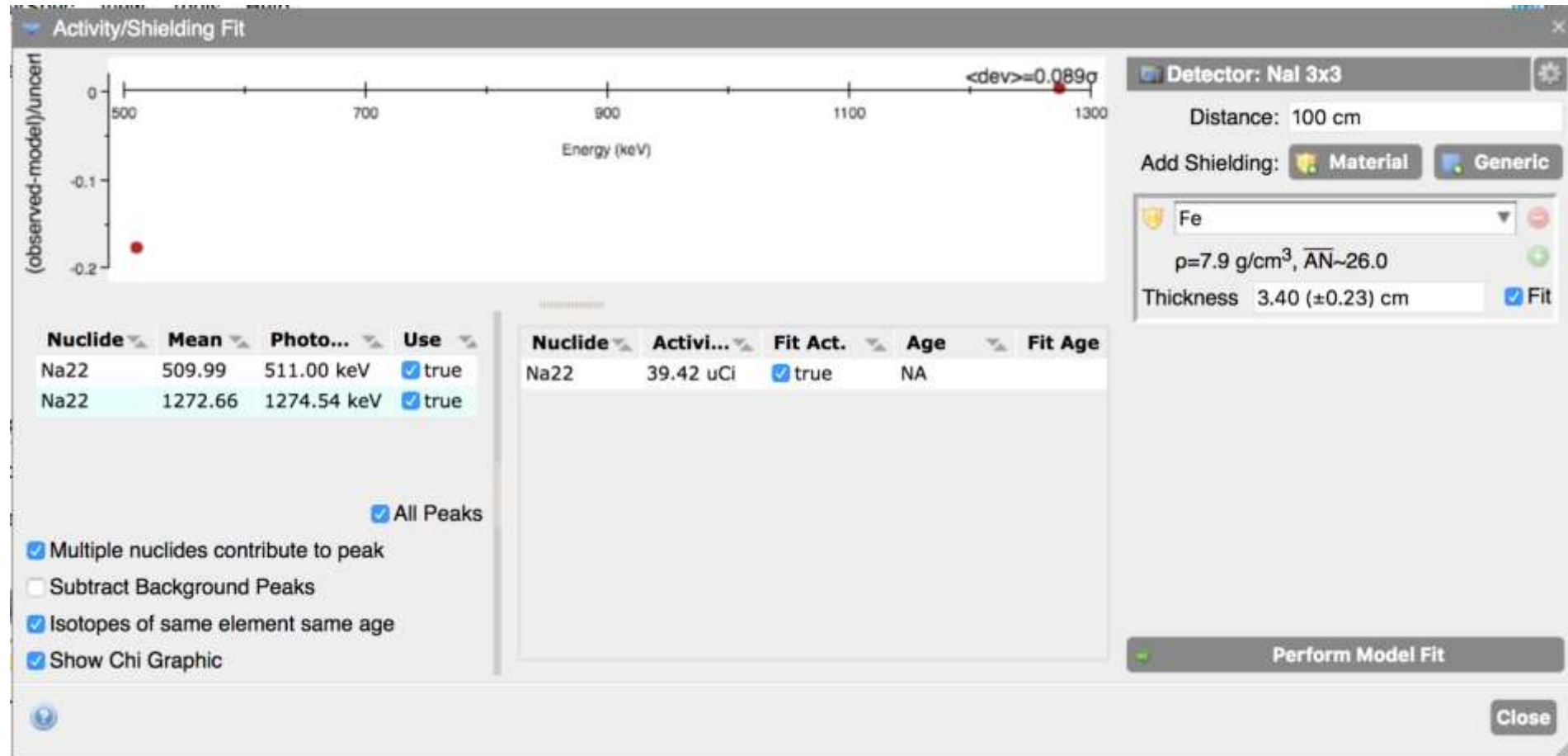
We fit for 40 uCi of Na22, with 3.4 cm of Iron Shielding
◦ Truth level: 50 uCi at 3.48 cm Fe - not bad!

Example 1 (cont)

True answer: 50 uCi, 3.48 cm Fe

This "Chi2" graphic shows you how many statistical sigmas the fit peak areas are off from what is predicted for the fit activity and shielding

- Here we fit for two quantities (activity and shielding thickness), using two peaks, so both peak areas should be at essentially zero sigmas. If we had more peaks we would expect a distribution ranging between about ±5 sigmas (or maybe a little more)

Example 2

See: uranium_problem_one_question.pdf

End of day one