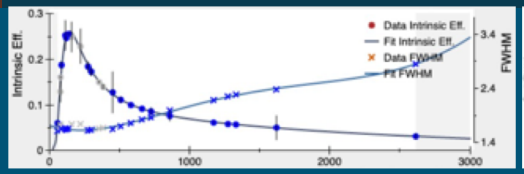
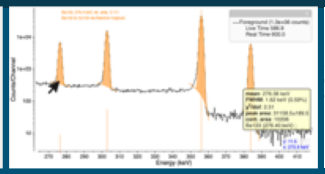
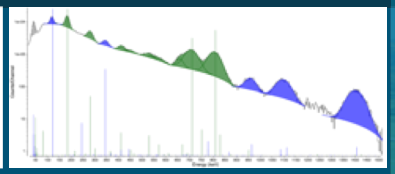
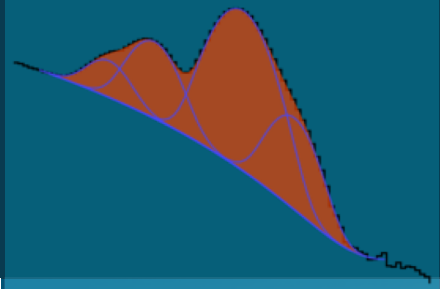
Detector Characterization in InterSpec









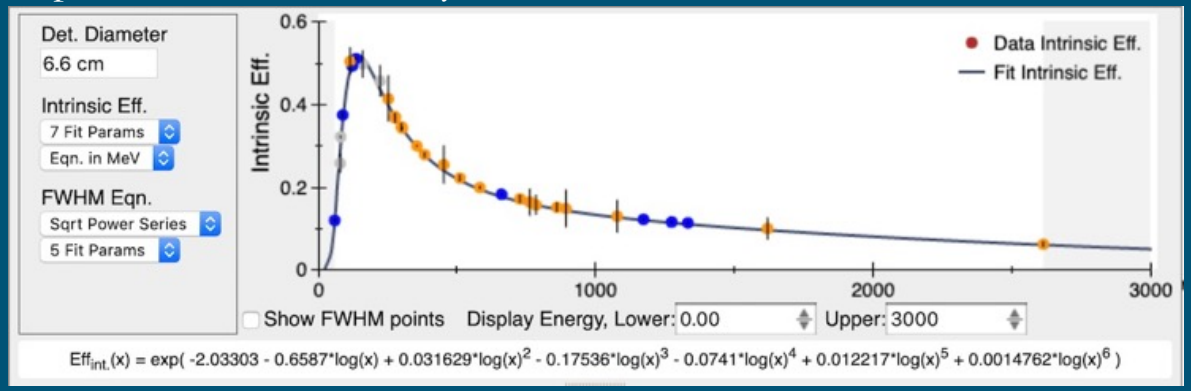
PRESENTED BY

Will Johnson 20190617

SAND2019-7262 TR

Motivation/Overview

To determine an unknown source's activity, or unknown shielding, or nuclide age you usually need to know the photo-peak detection efficiency of the detector.



To determine the detector response function (DRF), you will need some calibration data of known sources with photo-peaks that span the energy range you might later be interested in.

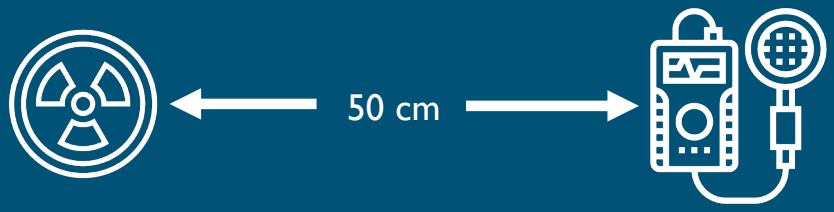
- Common choices of sources include Am-241, Cd-109, Co-57, Ba-133, Y-88, Cs-137, Co-60, Na-22, and Th-228, or Th-232, or U-232. However, InterSpec should accommodate using nearly any test-sources.

The known calibration data is used to fit the *Intrinsic Efficiency* equation. I.e., the equation that describes the efficiency of a gamma incident on the detector face to contribute to the full-energy photopeak for that gamma energy.

Characterization usually only has to be done once for a detector, and is usually valid for other detectors of the same model

How to create a DRF:

Step 1: take or acquire spectra of known sources, at known distances



Most portable or lab systems can use sources in the 10's of μCi range at 25 to 100 cm, for 5 to 30 minute dwells.

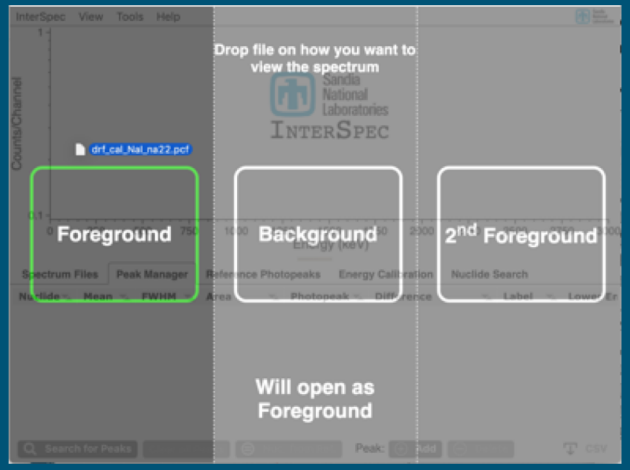
If any of the sources have photo-peaks that overlap with background peaks, or the detectors seed-source (e.x., Cs-137, Na-22), a background is also needed.

Test-source photo-peaks should have substantial statistics. I.e., a clearly visible, high statistics peak.

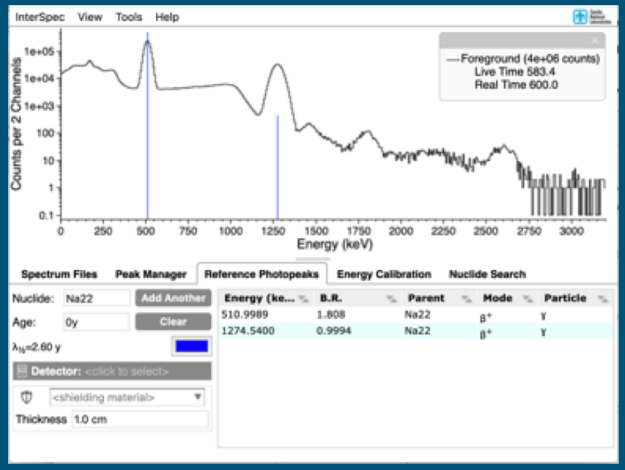
You will also need to know the detectors face surface area; InterSpec assumes a circular diameter, but if other geometry you can just convert to the equivalent surface area (ex, a 7cm by 7cm rectangular face is equivalent to a circle with diameter 3.95 cm).

How to create a DRF:

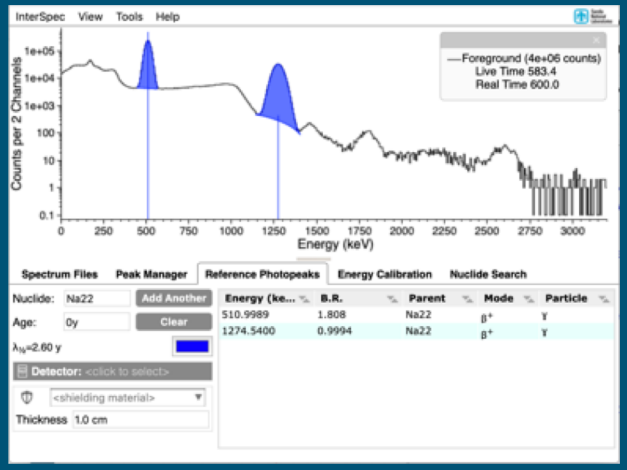
Step 2: Fit photo-peaks of test-sources



Open spectrum files by dragging them from the Explorer/Finder onto InterSpec. Or you can use "Open File…" from within InterSpec



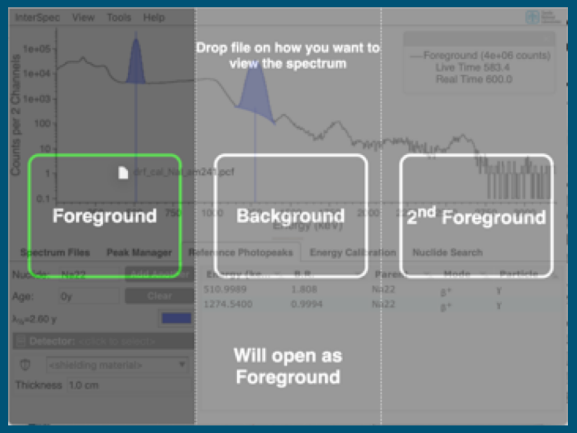
Display reference photo-peaks for your test-source.



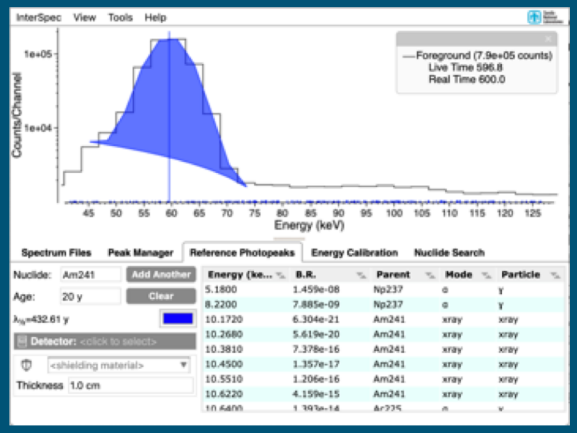
Fit peaks by double-clicking in their area on the chart. Since reference lines are showing, the test-source nuclide will be associated with the peak. You can also use the Peak Manager, or Peak Editor to associate nuclides with peaks

How to create a DRF:

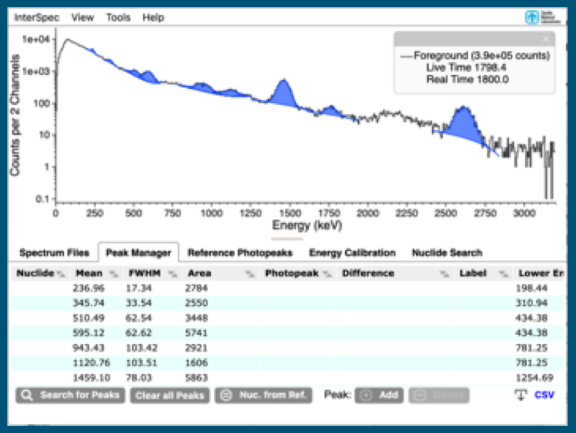
Step 2 (continued):



Open the next test-source spectrum in the same instance of InterSpec.



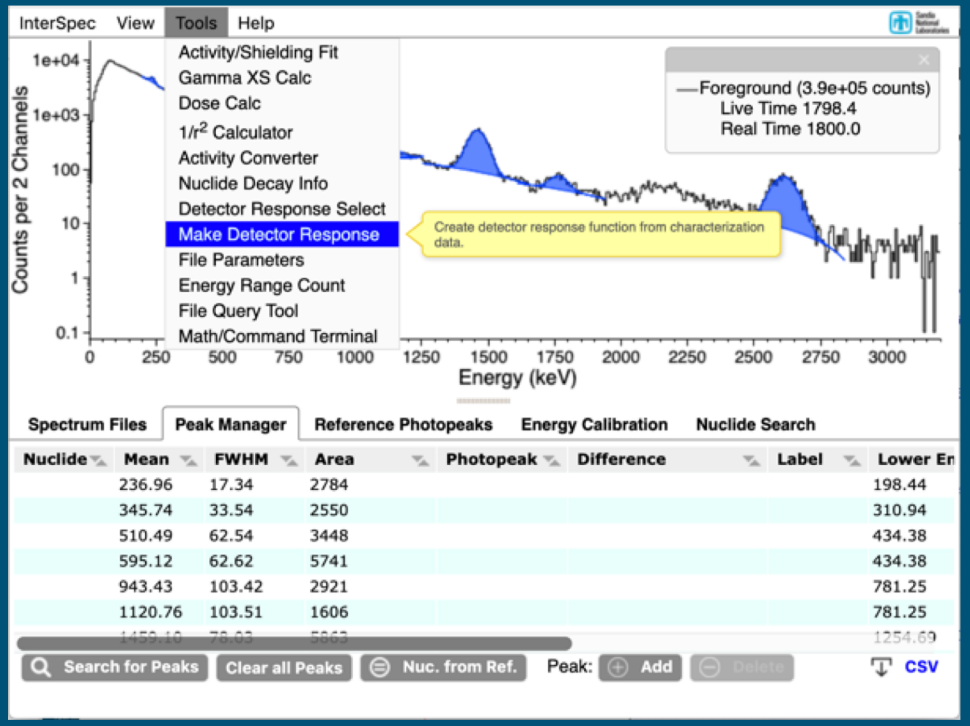
And repeat peak-fitting.
Do this for all test source measurements.



For the background there is no need to associate nuclides with the peaks

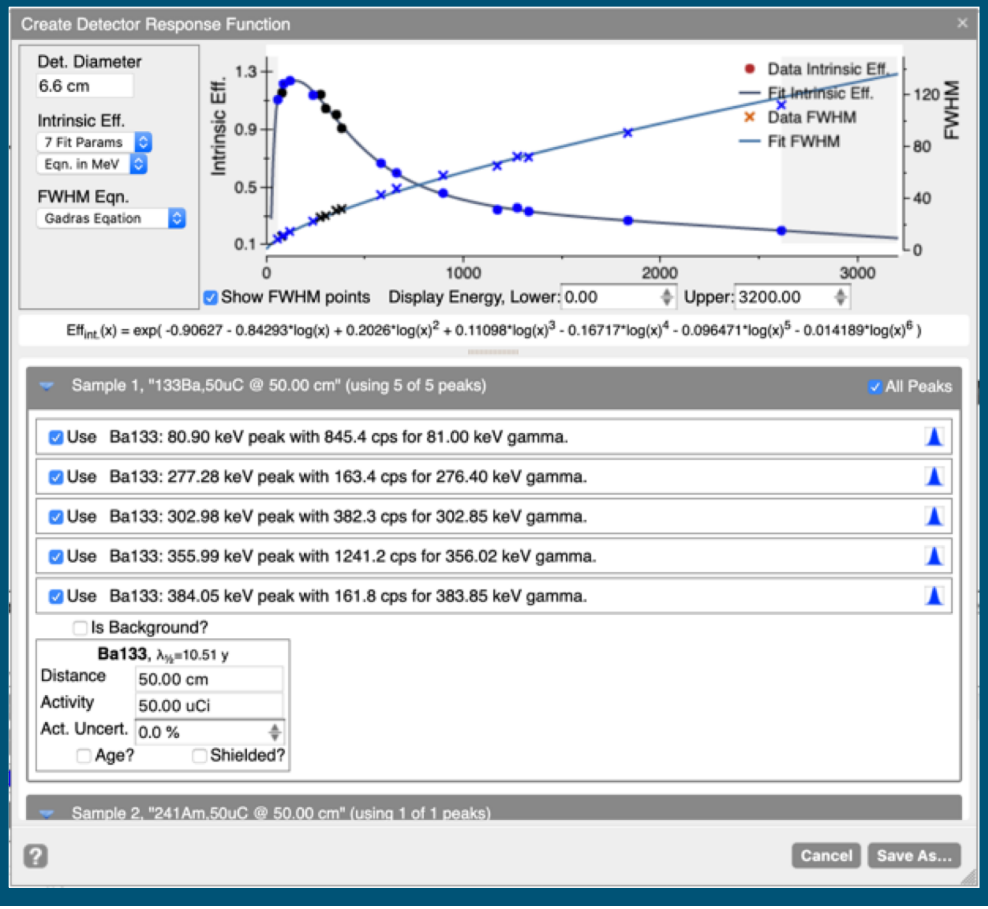
How to create a DRF:

Step 3: Open the "Make Detector Response" tool.



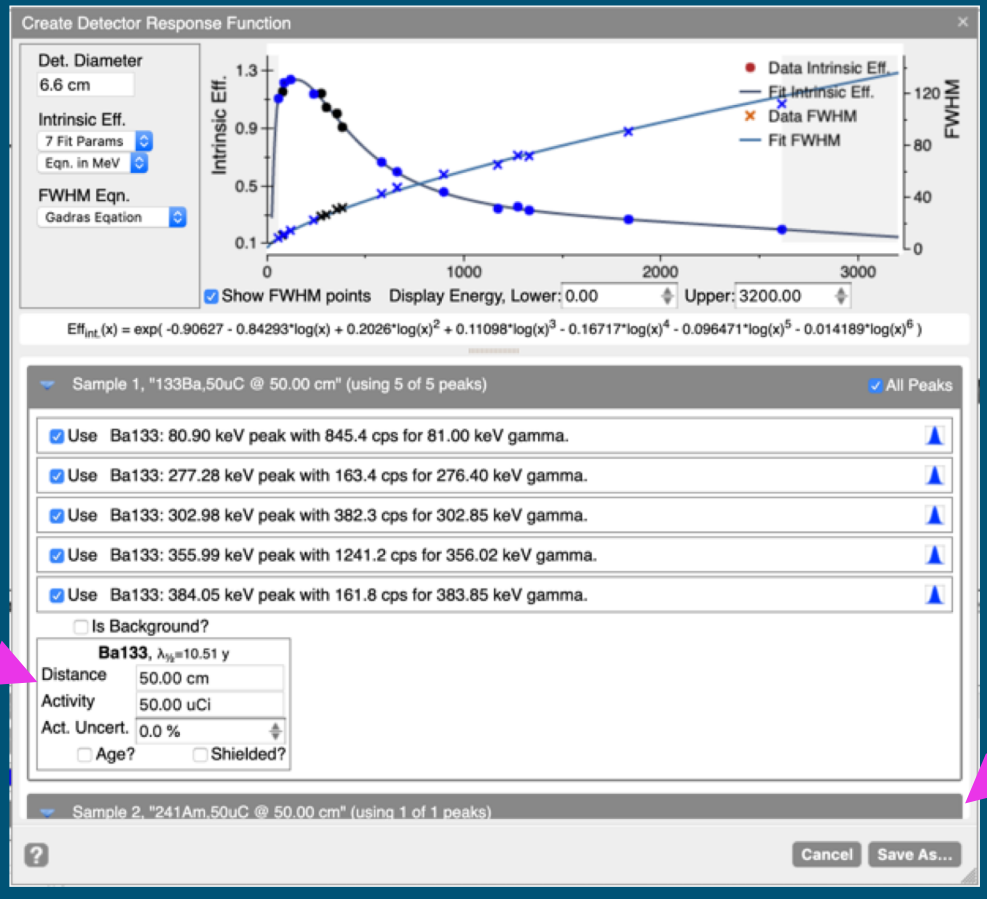
How to create a DRF:

Step 4: Enter detector diameter.



How to create a DRF:

Step 5: Select Peaks to use, and enter source information

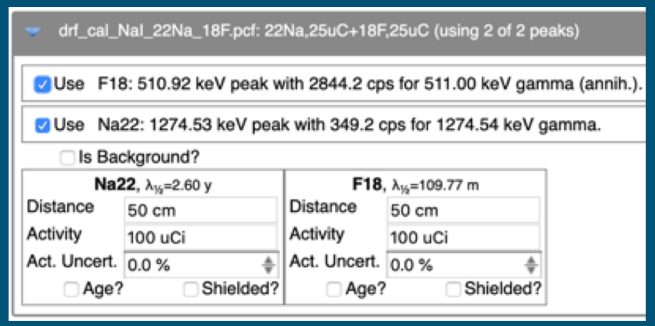


When you select a peak, an area will appear for you to enter source information

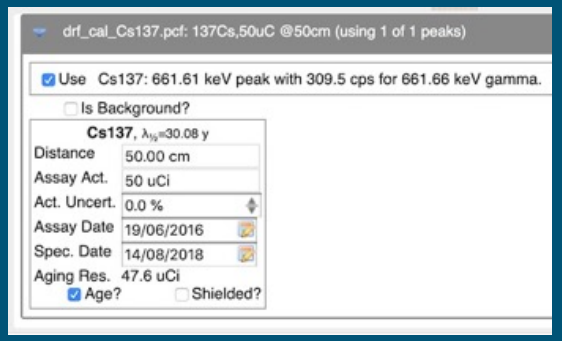
You can choose peaks from all of the spectrum files you've used in your current session by scrolling down.

How to create a DRF:

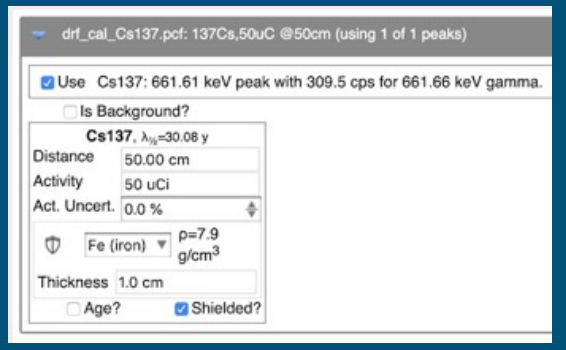
Step 5 (continued): Entering source information



You can have multiple sources for a single spectrum (especially for high-resolution detectors). Interferences between sources will be accounted for.
Distances also must be entered for each source.



Selecting the "Age?" checkbox will allow you to age the source to calculate the activity at measurement time.
If the sources spectrum changes significantly with age, you will also be prompted for age at the original assay date so the correct branching ratios can be calculated for the time of measurement.

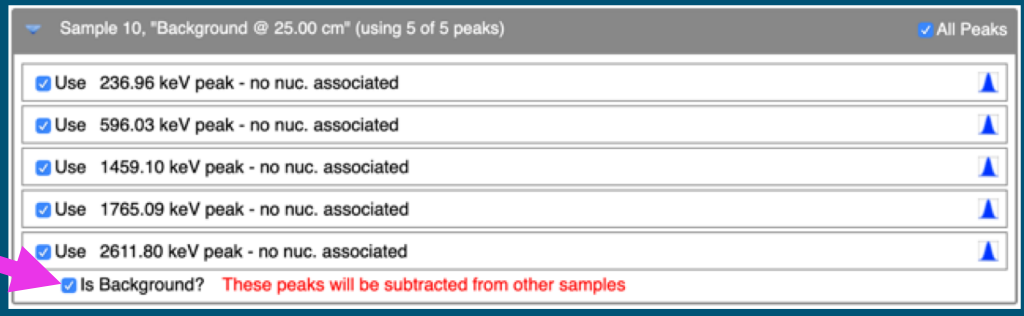


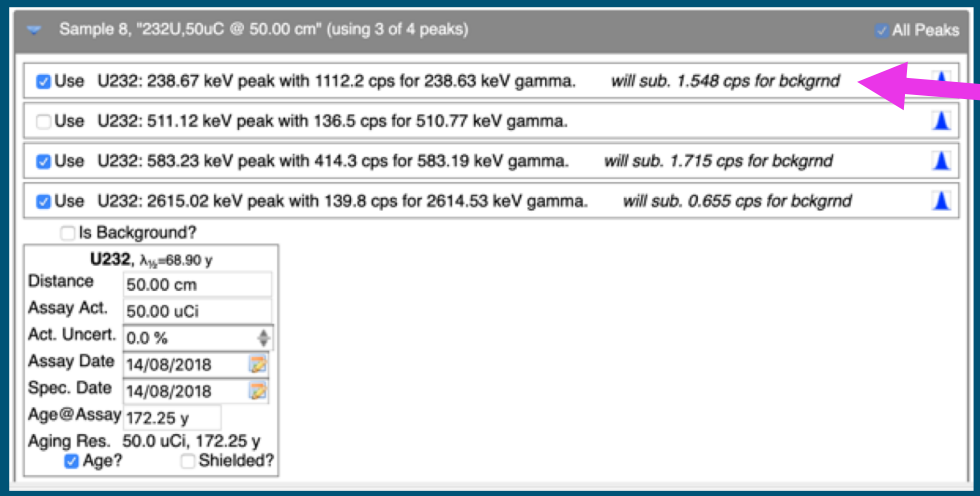
You can also opt to correct for shielding around the source. However, shielding should be avoided or minimized for characterization measurements.

How to create a DRF:

Step 5 (continued): Background

When you select to use a spectrum as background, all peaks in that spectrum that you choose to use will be considered background



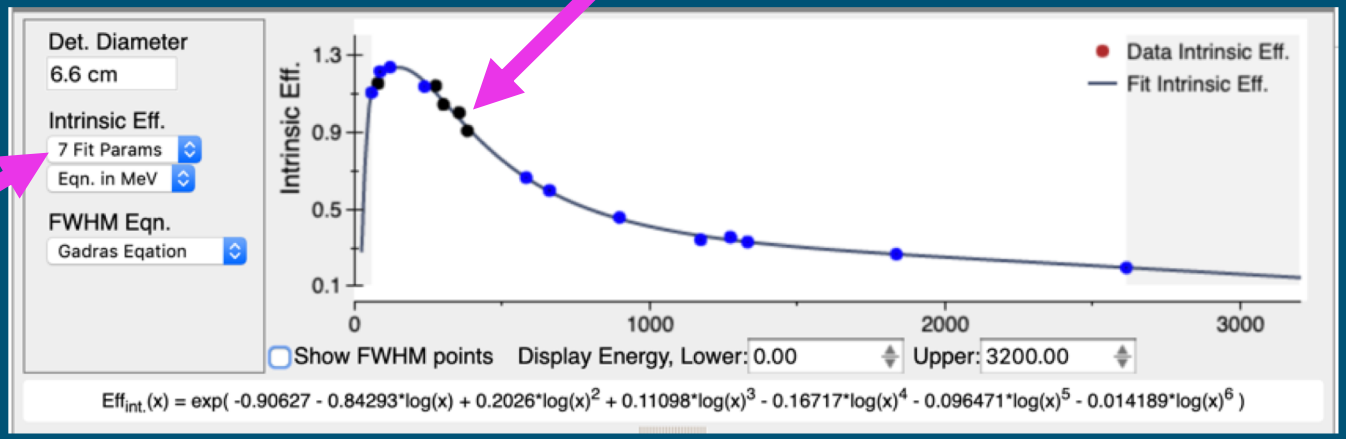


When background subtraction occurs from test-sources, it will be indicated next to the normal text

How to create a DRF:

Step 6: Refine

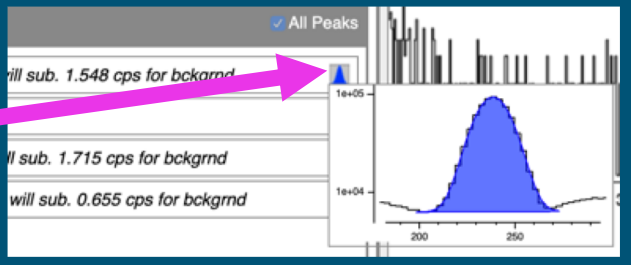
Your points should look continuous – you shouldn't have any significantly off of the fit line; if you do, check that source's activity, distance, or that the correct gamma energy is associated with that peak



You can choose the number of parameters to fit. You can fit the equation in energy units of MeV, or keV

The fit equation is continuously updated whenever you select/deselect peaks, or change source info, or other options

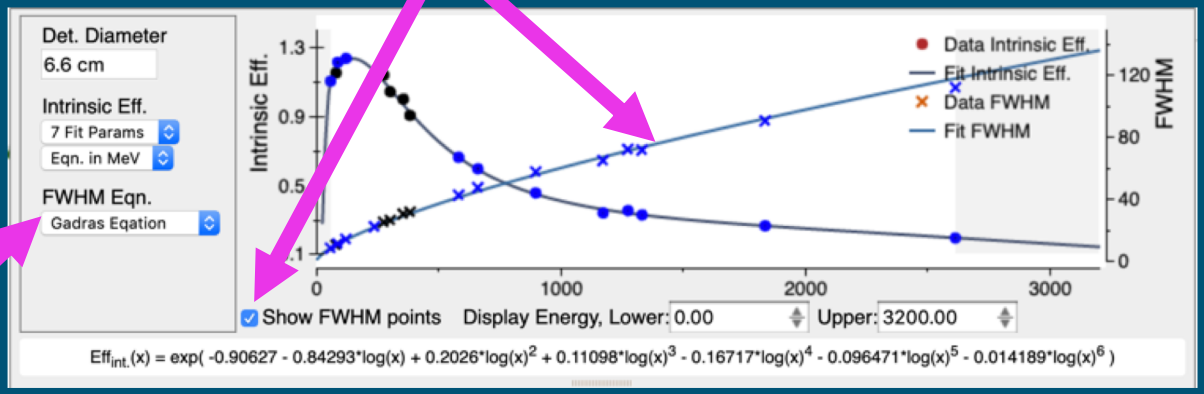
Clicking/tapping on the peak icon to the right on each row will let you preview the peak fit as a sanity check the fit is good



How to create a DRF:

Step 6: Refine (cont)

The peak resolution (Full Width Half Maximum, FWHM) as a function of energy is also fit for.



$$FWHM(energy) = sqrt(A_0 + A_1*energy + A_2*energy^2 + A_3*energy^3 + ...) \text{ [energy in MeV]}$$

```
def getFWHM( energy ):
    //P6---> resolution @ E=0 (energy in keV)
    //P7---> % FWHM @ 661 keV
    //P8---> resolution power
    if energy ≥ 661 or P6=0
        return 6.61xP7x(energy/661)^P8
    if P6 < 0.0
        var p = P8^1.0/log(1.0-P6)
        return 6.61xP7x(energy/661)^p

    if P6 > 6.61xP7
        return P6;

    var p = sqrt((6.61xP7)^2-P6^2)/6.61;
    return sqrt(P6^2+(6.61xpx(energy/661)^P8)^2)
```

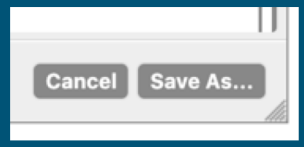
You can choose to fit FWHM to either a power series equation, or the GADRAS-DRF resolution function.

InterSpec doesn't really use the FWHM information, so this information isn't emphasized in the user interface.

How to create a DRF:

Step 7: Save

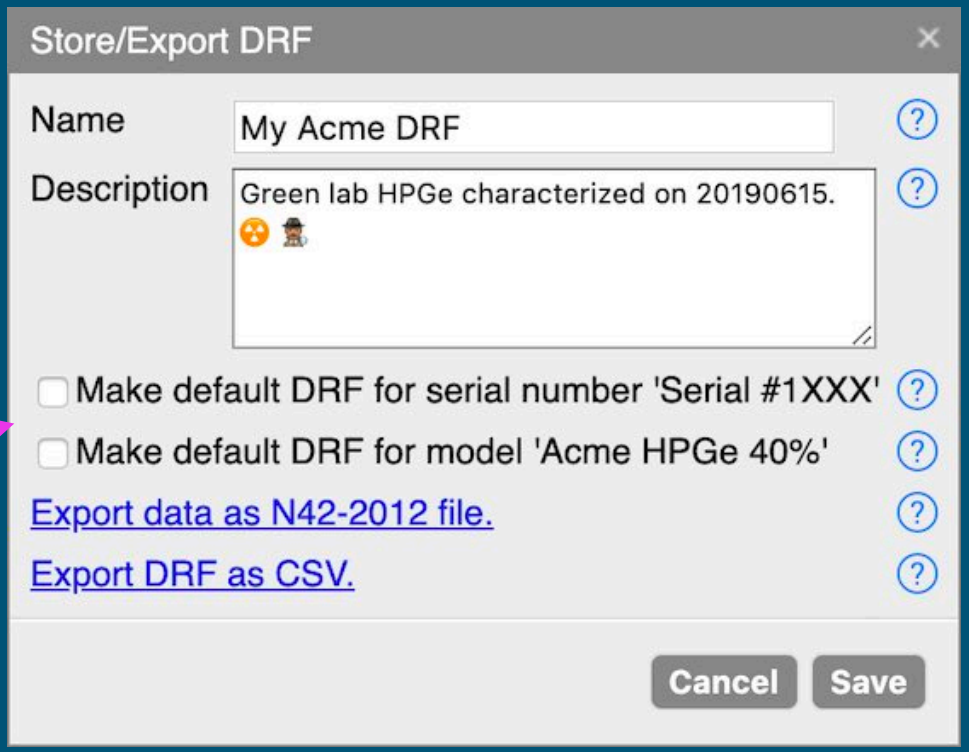
To store the DRF into InterSpecs internal database, or export it, click the ”Save As…” button



Enter a useful name and description. Symbols such as slashes, backslashes, quotes, commas, semicolons, and question marks are not allowed in the name.

You can also choose to have InterSpec load this DRF automatically when you load spectra from either this specific detector, or this model of detector.

You can also load this DRF from the “Previous” tab of the “Detector Response Select” tool.

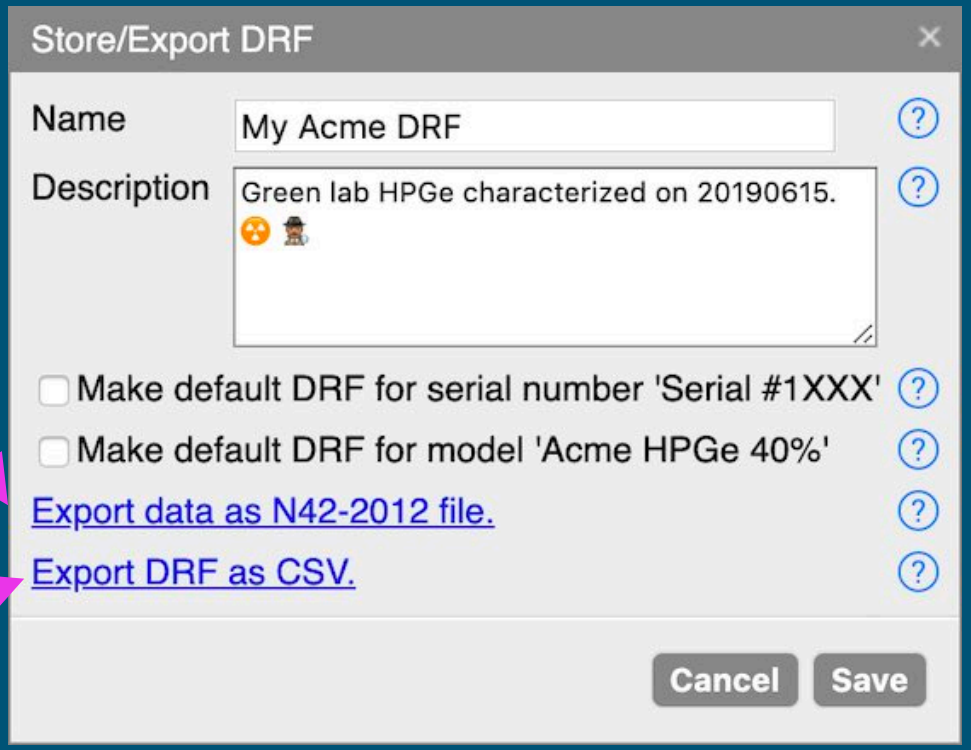


How to create a DRF:

Step 7: Save (cont)

Clicking/tapping on the export data option will create and save a single N42 file with all the data used to create the DRF.
The N42 file can be opened in other applications, but if opened in InterSpec, all of your fit peaks, source information, and the actual DRF will be included as well.

Exporting the DRF as a CSV is a nice way to use the DRF with other applications. It also includes the efficiency data points, the equation as an absolute efficiency, as well as some further information



More Info

For further information, click on the help icon in the lower-left of the tool.