

# **GADRAS Update**

## **(Gamma Detector Response and Analysis Software)**

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# What Is GADRAS?

- **GADRAS is a spectral analysis application that incorporates the following capabilities:**
  - Spectrum plotting, file conversion, and file manipulation
  - Response functions for gamma-ray and neutron detectors
  - Characterization of empirical parameters for gamma and neutron detectors
  - Radiation analysis tools (six methods tailored to specific objectives)
  - 1D radiation source model creation (and associated databases)
  - Fast and accurate radiation transport calculations
  - Simulations for training and performance evaluations using injection calculations
- **The analysis package is tightly integrated, enabling rapid analysis when moving from gross isotope identification to detailed source diagnostics**



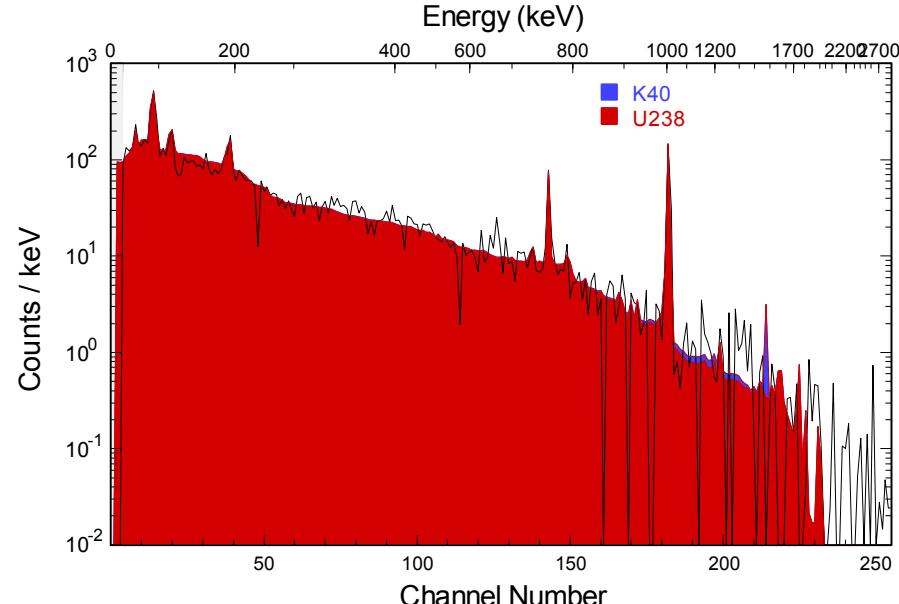
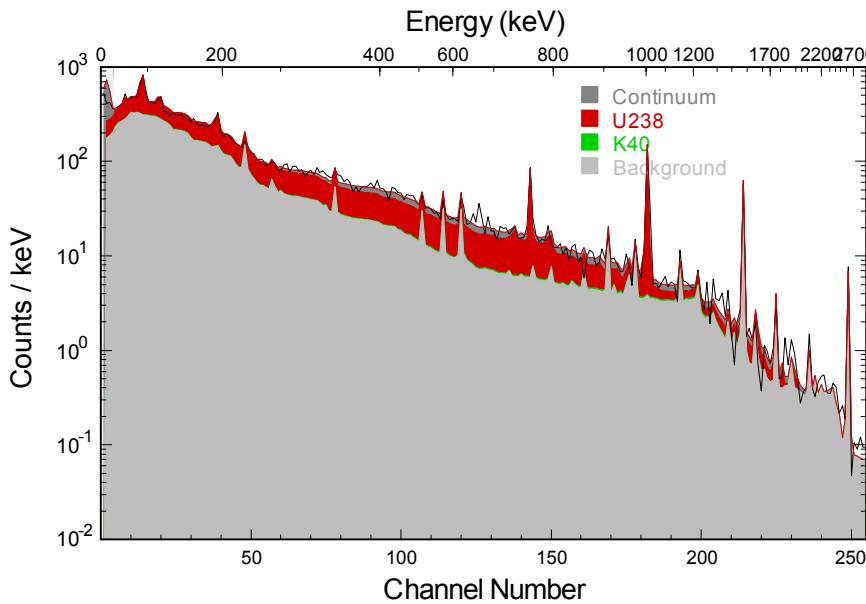
# Recent Improvements

- **Improved performance for DHSIsotopeID:**
  - Synthesizes background spectra when backgrounds are not provided
  - Greatly improved accuracy for HPGe
  - Source code can be compiled to execute on PDA
- **Shift-click on peak to display spectra for isotopes emitting gamma rays in nearby region:**
  - This is a good way to identify isotopes or capture emissions manually
- **Graphic energy calibration:**
  - Right click and drag to adjust gain, offset, or quadratic terms
- **Synthesis of background spectra and neutron rates:**
  - Specify where and when a measurement is performed. This determines the cosmic term. Works both indoors and outdoors.
  - Slider bars are used to adjust radiation from NORM



# DHSIsotopeID: Background Synthesis

- **Background spectra are synthesized from templates for  $^{40}\text{K}$ ,  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ , cosmic term, and continua to estimate the background component.**
  - Analysis can determine whether excess  $^{40}\text{K}$ ,  $^{226}\text{Ra}$ , or  $^{232}\text{Th}$  is present because shapes of these isotopes in cargo generally differ from background components.
  - The background component can be displayed as a filled region (left) or the estimated background can be stripped (right).



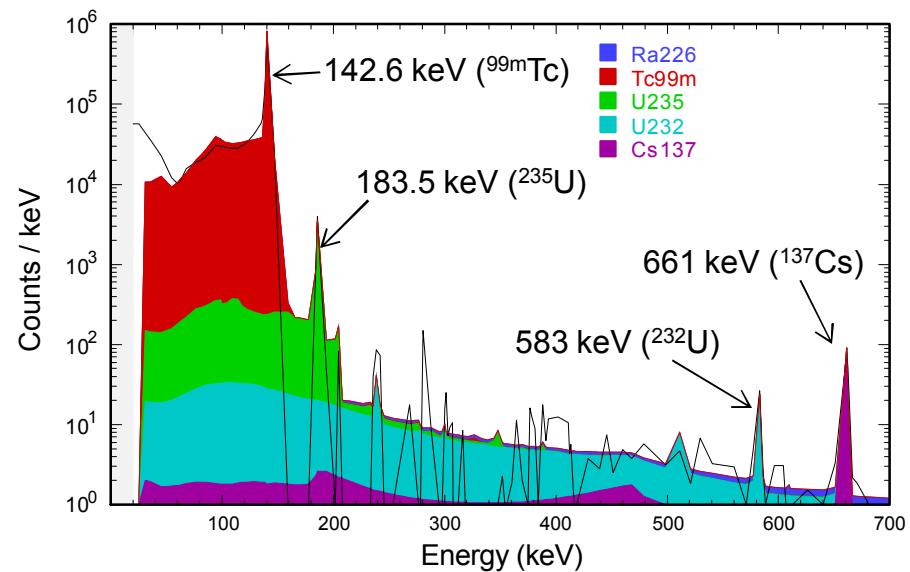
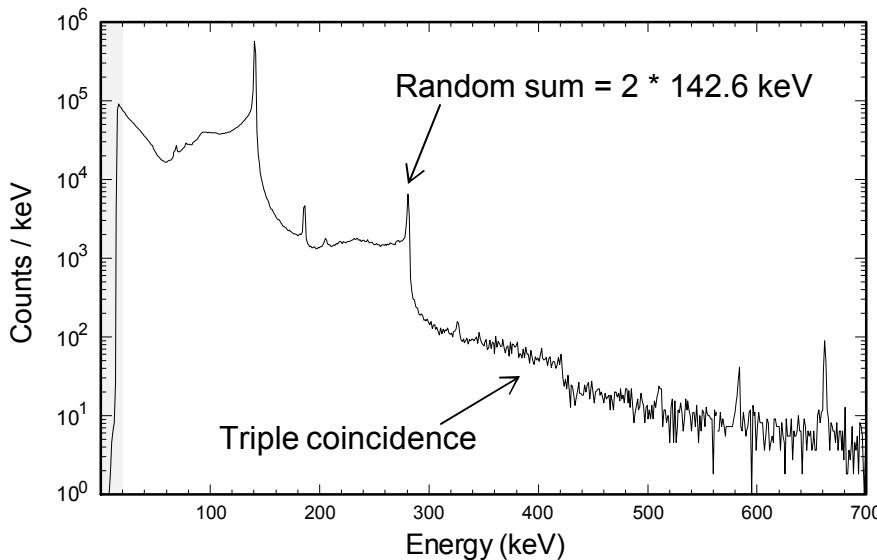
256 channels with selected group widths accelerates calculations & preserves content



# DHSIsotopelD: Pileup Compensation

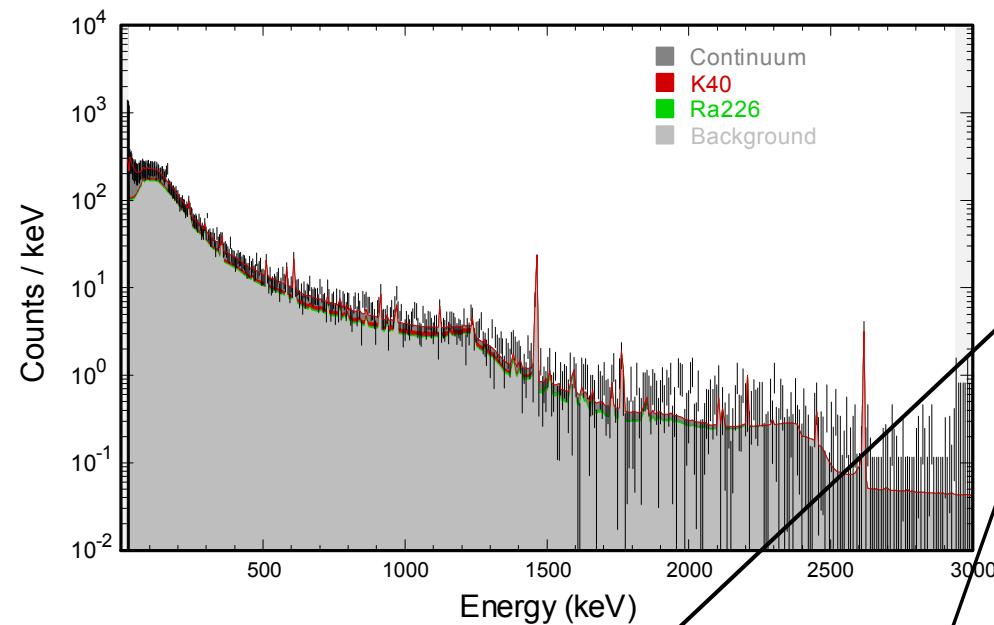
- Effects of random pileup are estimated to remove pulse pileup peaks and associated continuum

- The spectrum below left shows a 91,307 cps foreground spectrum of  $^{99m}\text{Tc}$ , HEU (with  $^{232}\text{U}$ ) and trace  $^{137}\text{Cs}$  collected with MicroDetective
- The spectrum below right gives the analysis result (after compensating for pileup effects)
- Uncertainties associated with pileup effects are added to the variance array

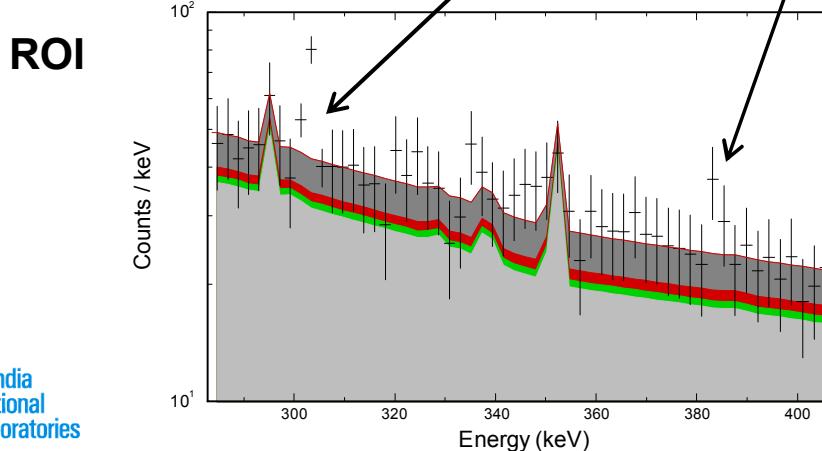




# <Shift-Click> Peak to Explore Possibilities

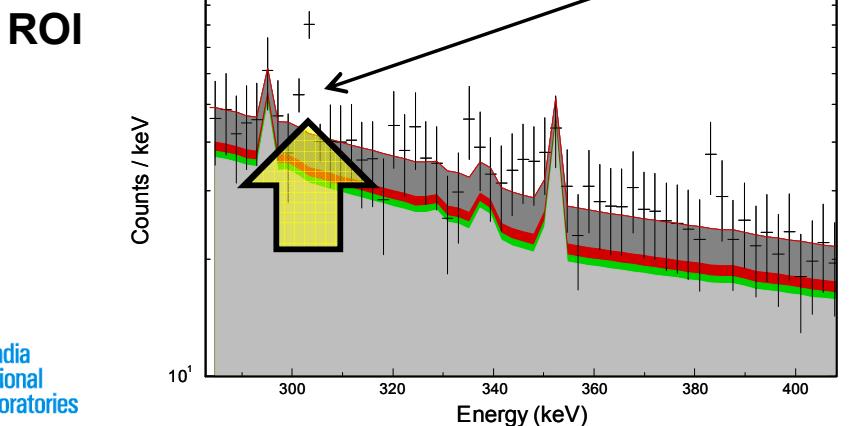
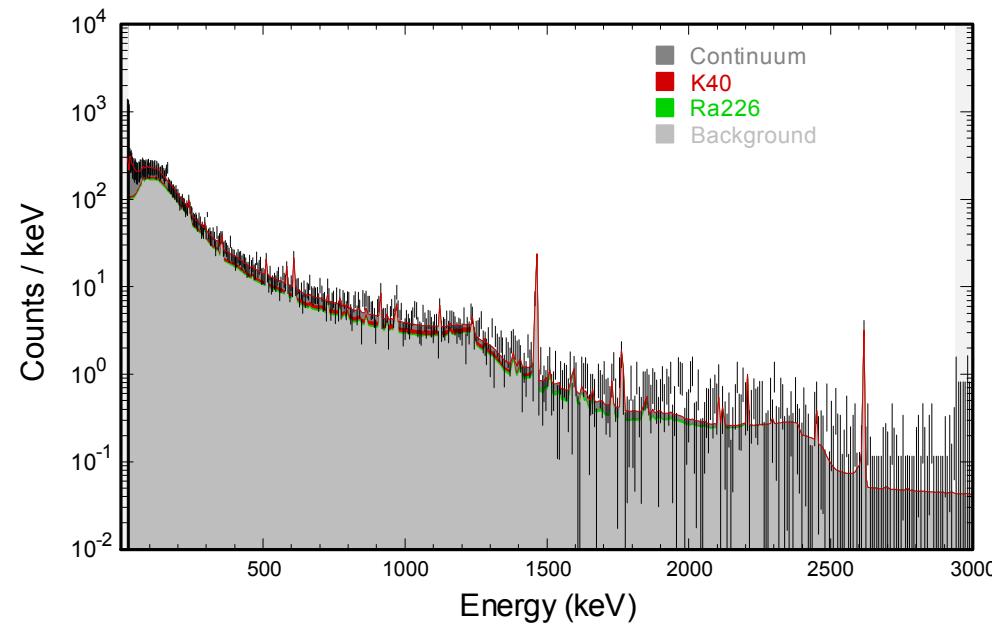


No radiation sources are obvious in full energy region, but minor photopeaks that are not reproduced in the computed spectrum are observed in the Region of Interest (ROI) graph



- <Shift-Click> displays spectral overlay to explore possibilities
- The operation can be performed either in the main graph form or the ROI form
- The overlay spectrum is displayed in the main graph and the ROI window if open

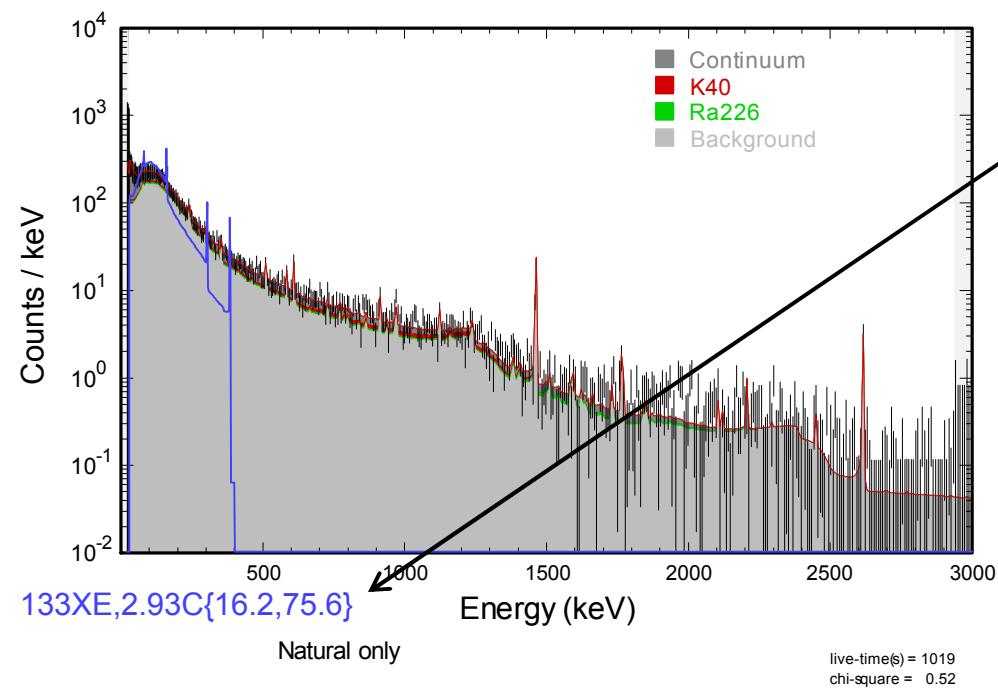
# <Shift-Click> Peak to Explore Possibilities



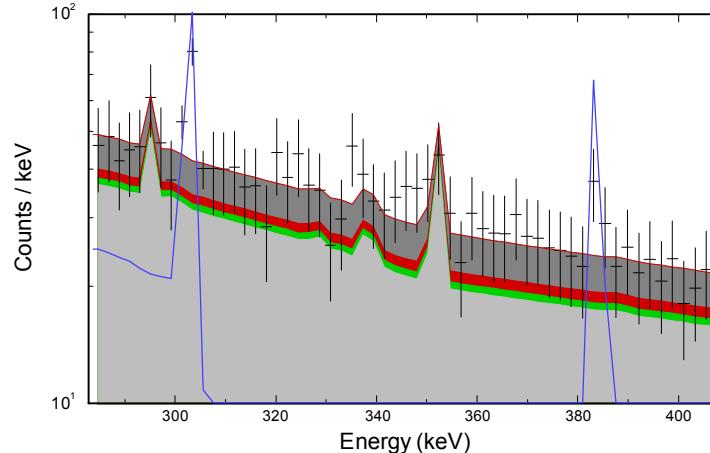
**<Shift-Click> here to search the database to:**

- Find the nearest gamma ray
- Perform single nonlinear regression to get the best shielding configuration
  - The variance array is adjusted to focus on the selected energy region
- Present a spectral overlay

# <Shift-Click> Peak to Explore Possibilities



ROI



Best fit corresponds to shielded  $^{133}\text{Xe}$  (the source is  $^{133}\text{Xe}$  in 3 cm of steel)

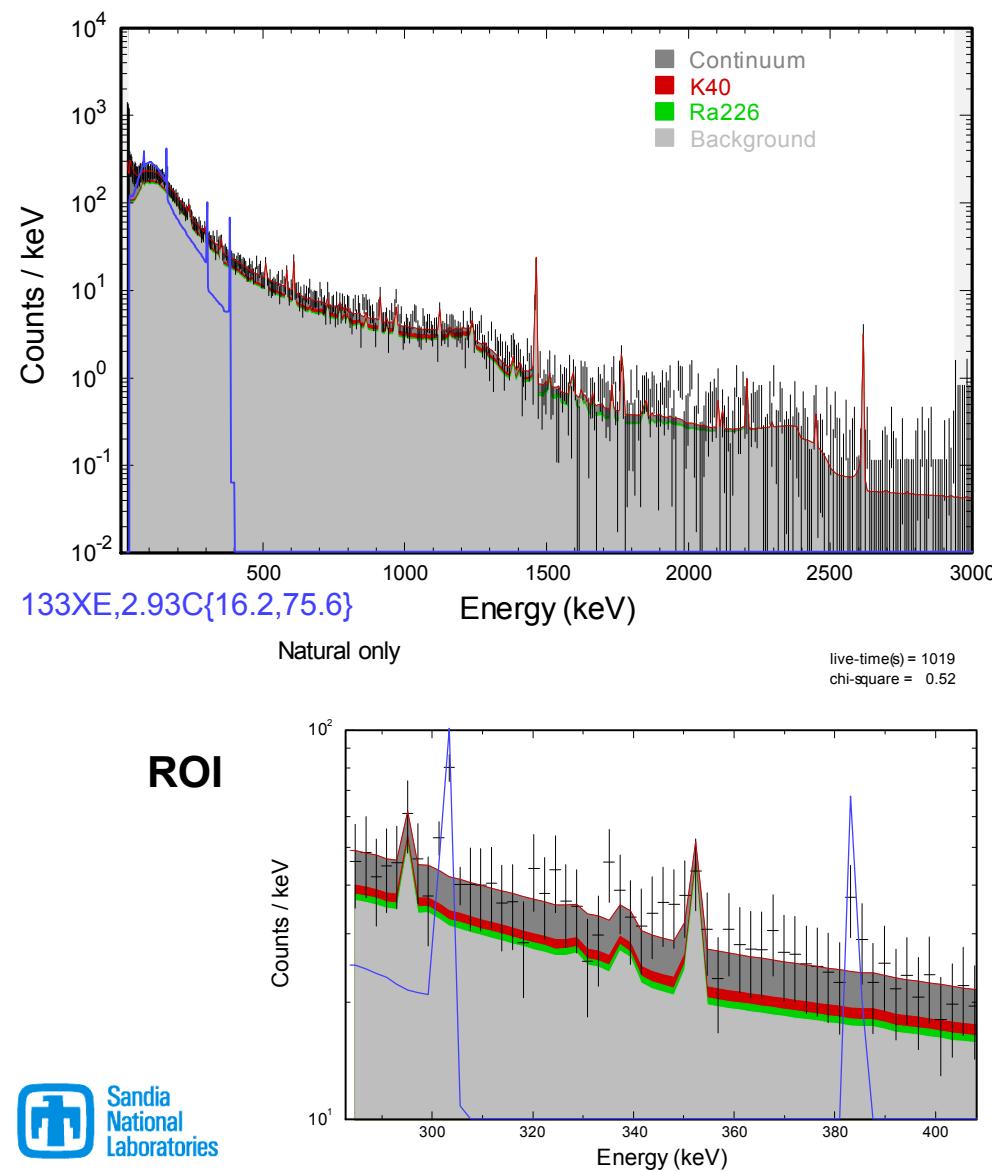
**List of photopeaks**

Minimum relative importance (%) to show: 0.001

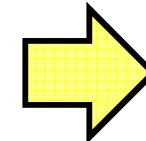
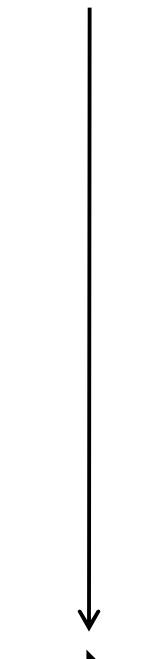
Overlay spectrum      Overlay color: blue

Energy (keV)	Source	Yield (%)
300.09	228Th	3.280
300.10	231Pa	2.300
300.22	67Ga	16.800
300.22	67Cu	0.797
300.34	233Pa	6.620
300.34	237Np	6.620
300.64	207At	12.600
300.70	166Ho	3.750
300.75	194Ir	0.350
301.00	Ta n-gamma	13.473
302.70	231Pa	2.300
302.85	<b><math>^{133}\text{Xe}</math></b>	<b>4.8E-03</b>
302.85	$^{133}\text{Ba}$	18.330
302.87	239Pu	5.1E-06
302.98	244Cm	1.7E-05
303.10	187W	2.0E-03
303.92	75Se	1.316
304.20	226Ra	0.040
304.20	214Bi	0.040
304.83	140Ba	4.370
304.87	85Krm	14.000

# <Shift-Click> Peak to Explore Possibilities



Click here to see how well  
 $^{133}\text{Ba}$  matches the spectrum



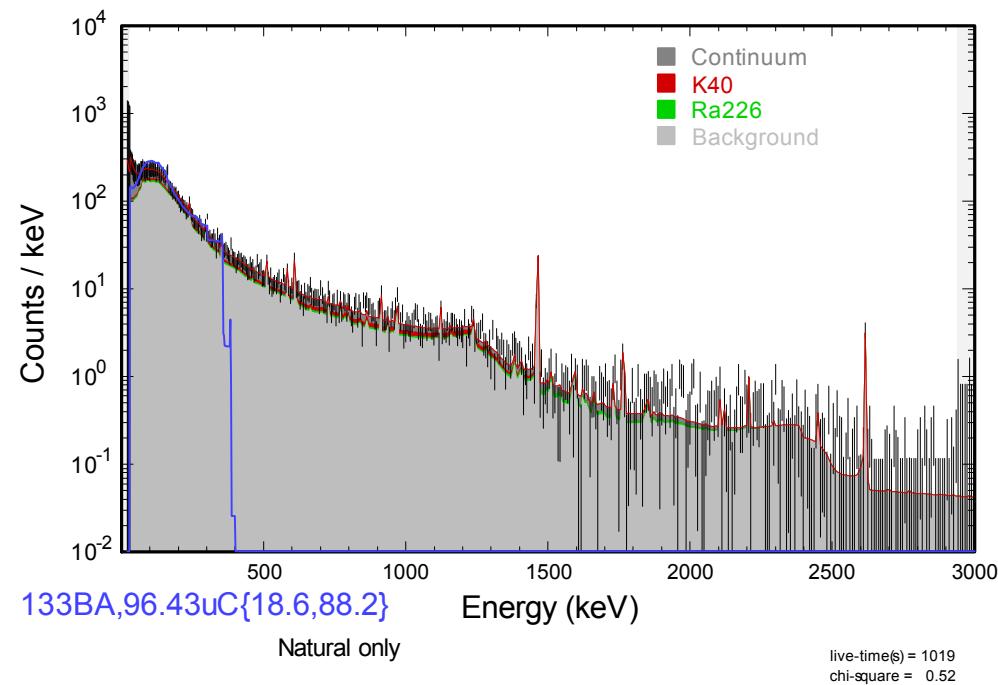
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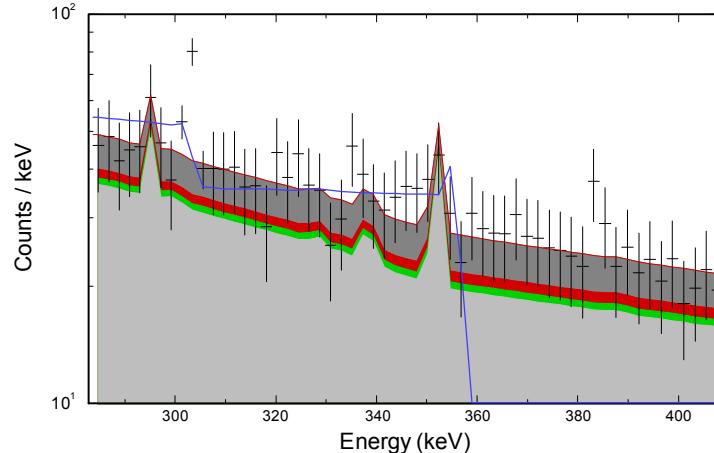
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# <Shift-Click> Peak to Explore Possibilities



ROI



**$^{133}\text{Ba}$  emits gamma rays at similar energies, but no shielding configuration matches the spectrum**

**List of photopeaks**

Minimum relative importance (%) to show: 0.001

Overlay spectrum      Overlay color: blue

Energy (keV)	Source	Yield (%)
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300.10	231Pa	2.300
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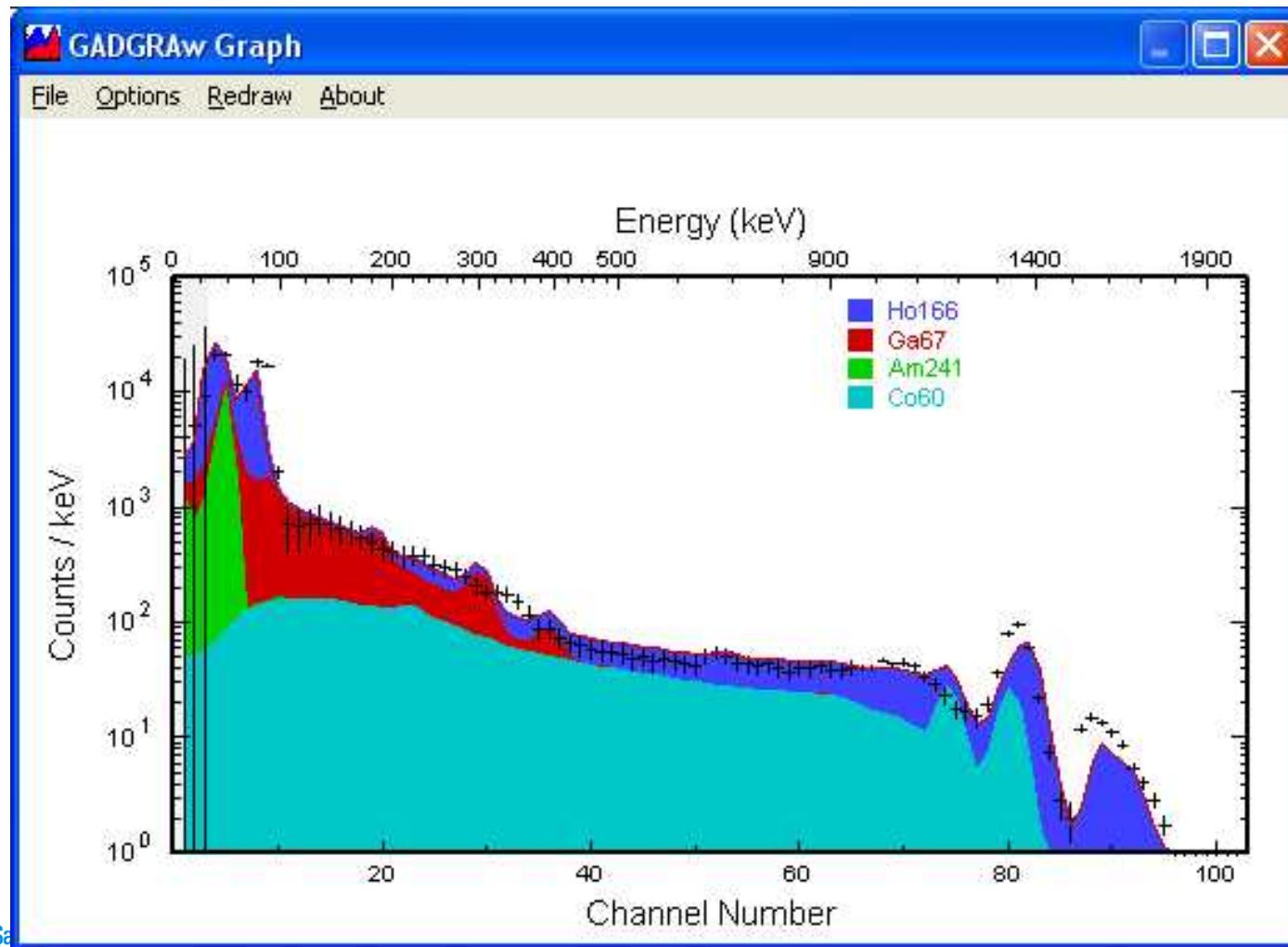
# Energy Calibration

- **Energy calibration can be performed in several ways:**
  - Perform a peak search on one or more spectra and select peaks that can be used as a basis for determining polynomial coefficients
  - Adjust energy calibration parameters by nonlinear regression as part of the response function characterization
  - **New:** Adjust gain, offset, and quadratic parameters by right-clicking on a plot and dragging the cursor to the proper location of the peak
- **GADRAS supports the definition of deviation pairs, which provides finer adjustments than can be achieved using polynomial functions:**
  - Users define energy mesh points and deviations in keV at each mesh point



# Analysis of GR-135 Spectrum for $^{166}\text{Ho}$

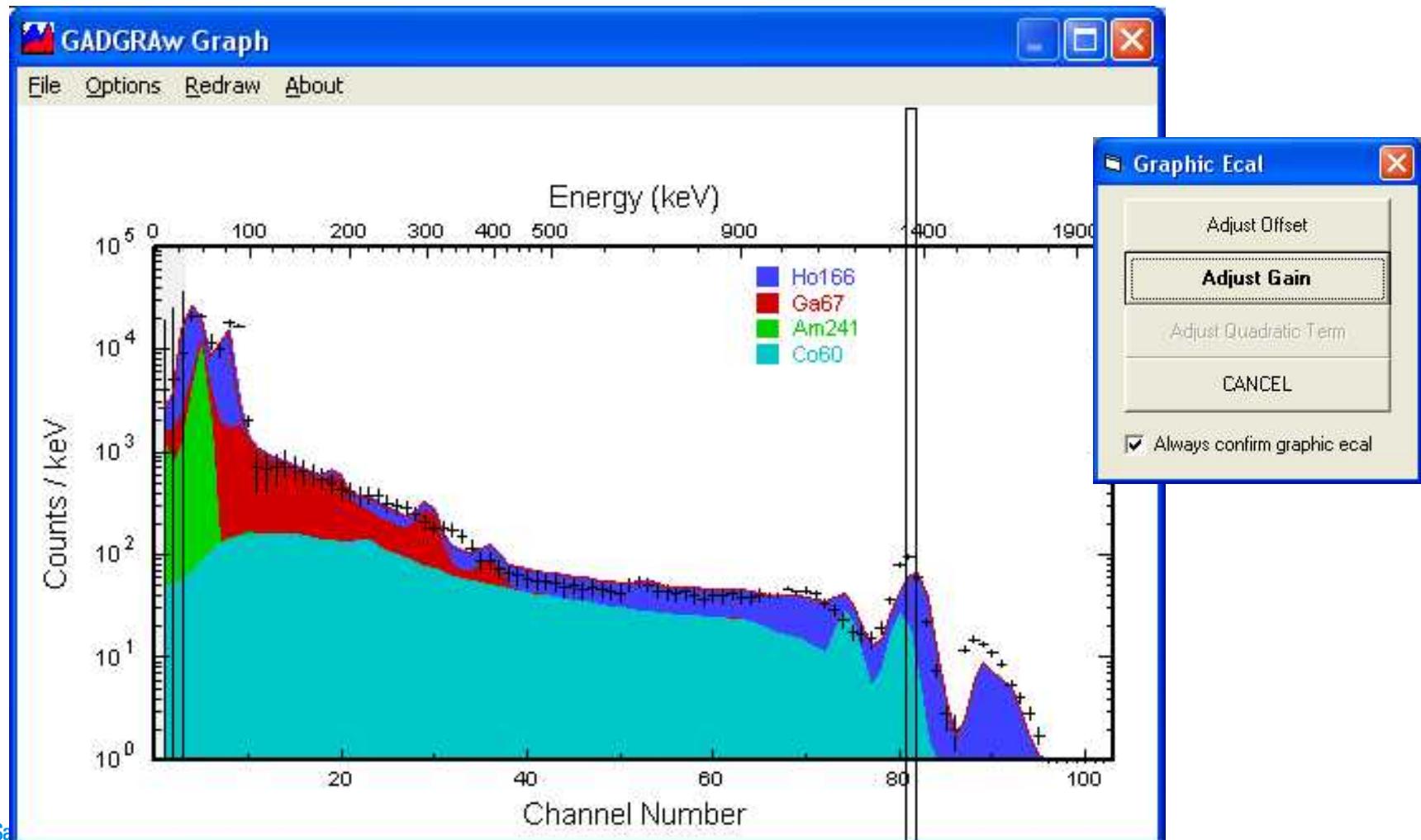
$^{166}\text{Ho}$  has exhibits many of the observed features, but the gain and offset are wrong





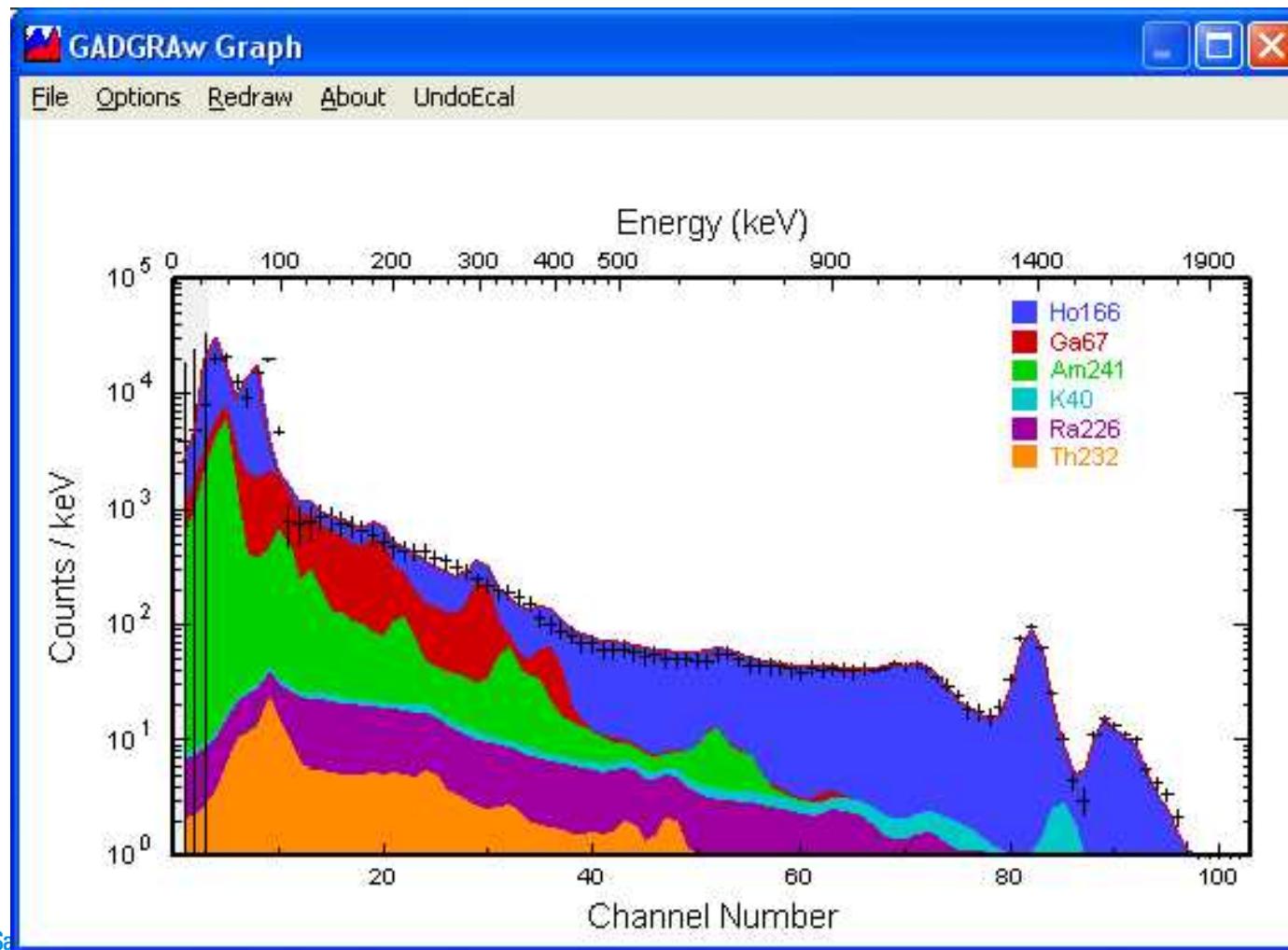
# Analysis of GR-135 Spectrum for $^{166}\text{Ho}$

Right-click and drag data toward the location of the computed peak to adjust gain



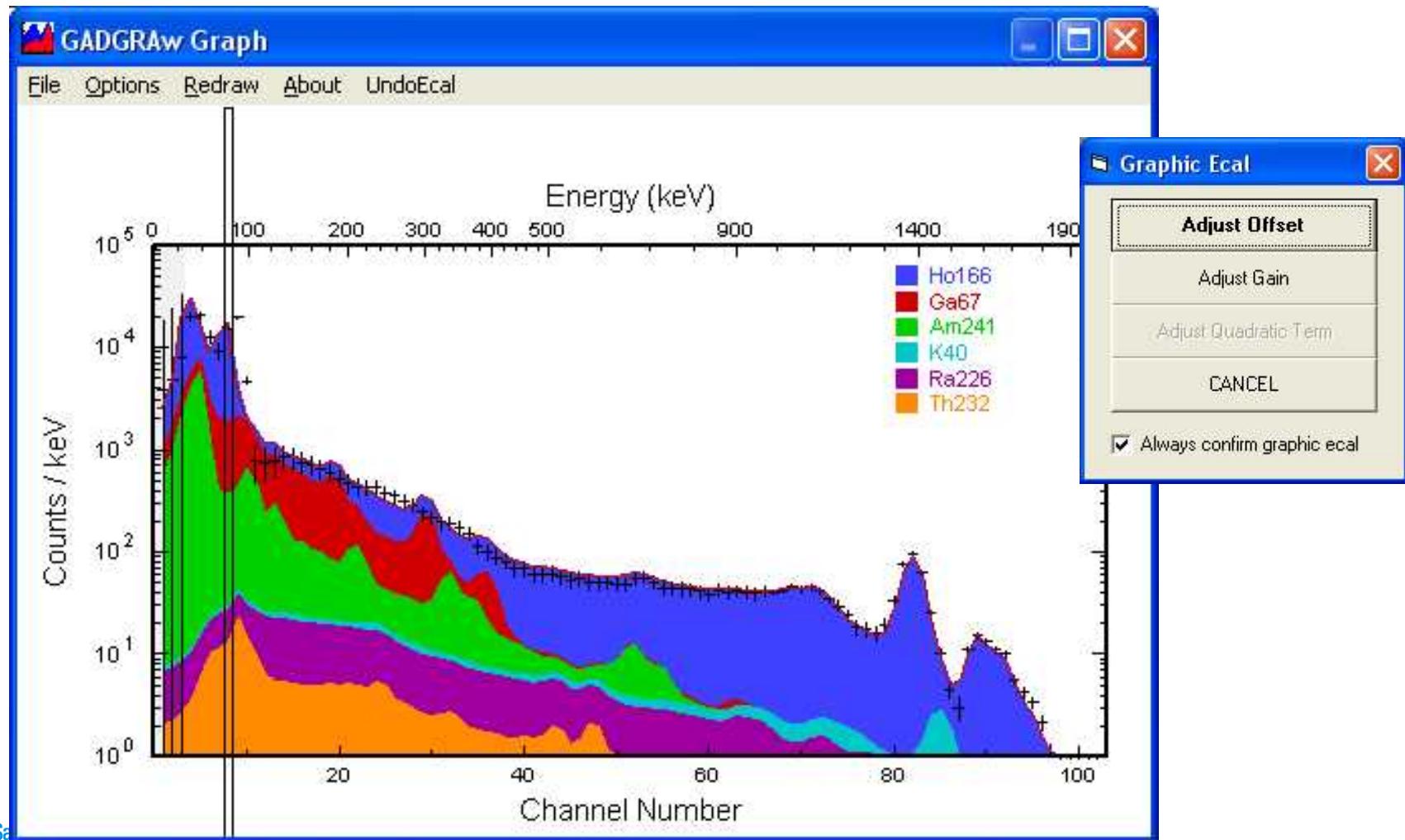
# Analysis of GR-135 Spectrum for $^{166}\text{Ho}$

Gain looks good, but the offset is a bit off (if  $^{166}\text{Ho}$  is the correct source)



# Analysis of GR-135 Spectrum for $^{166}\text{Ho}$

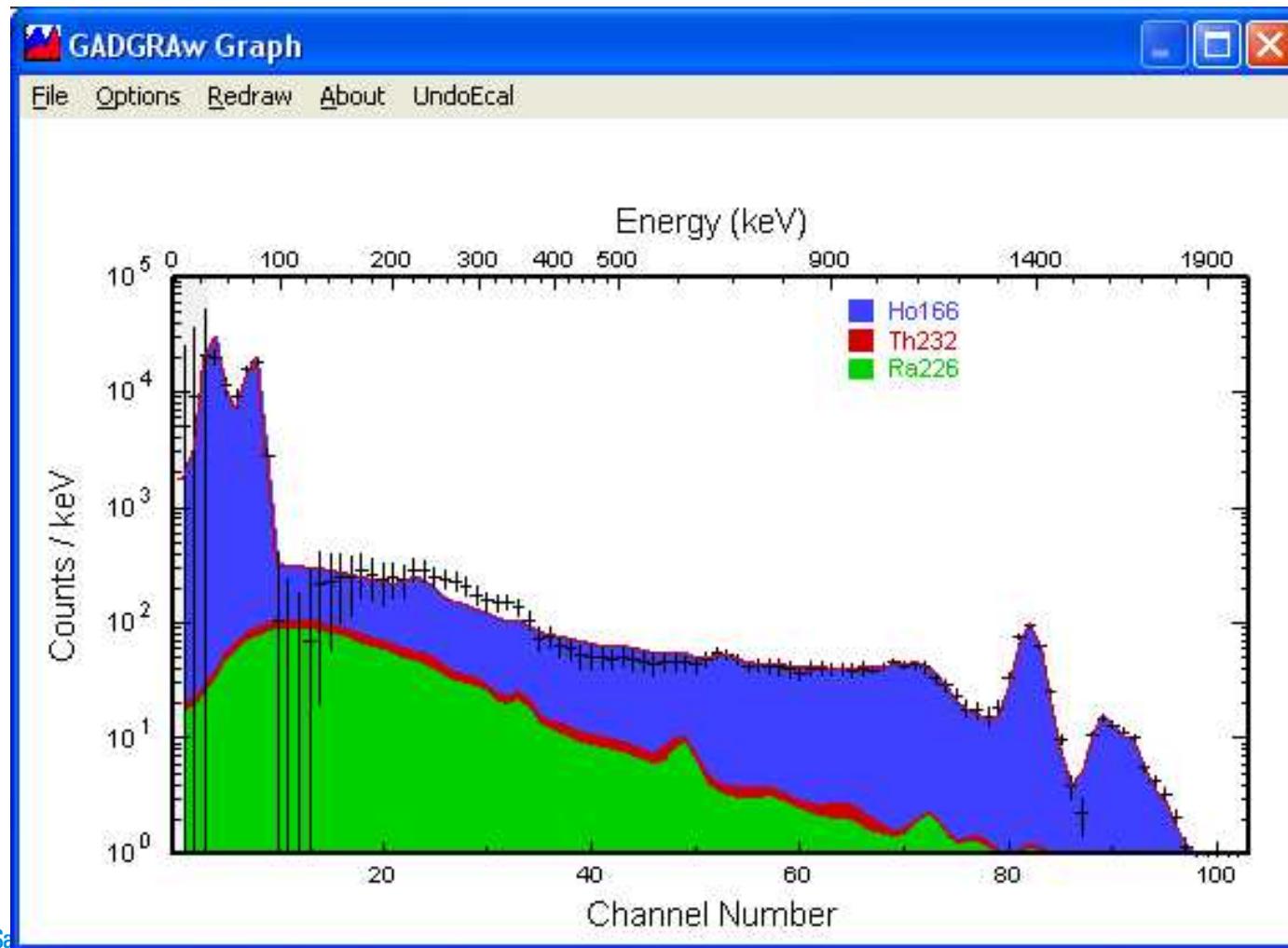
Right-click and drag near the low-energy peak to adjust the offset





# Analysis of GR-135 Spectrum for $^{166}\text{Ho}$

After adjusting the gain and offset slightly,  $^{166}\text{Ho}$  matches the spectrum well



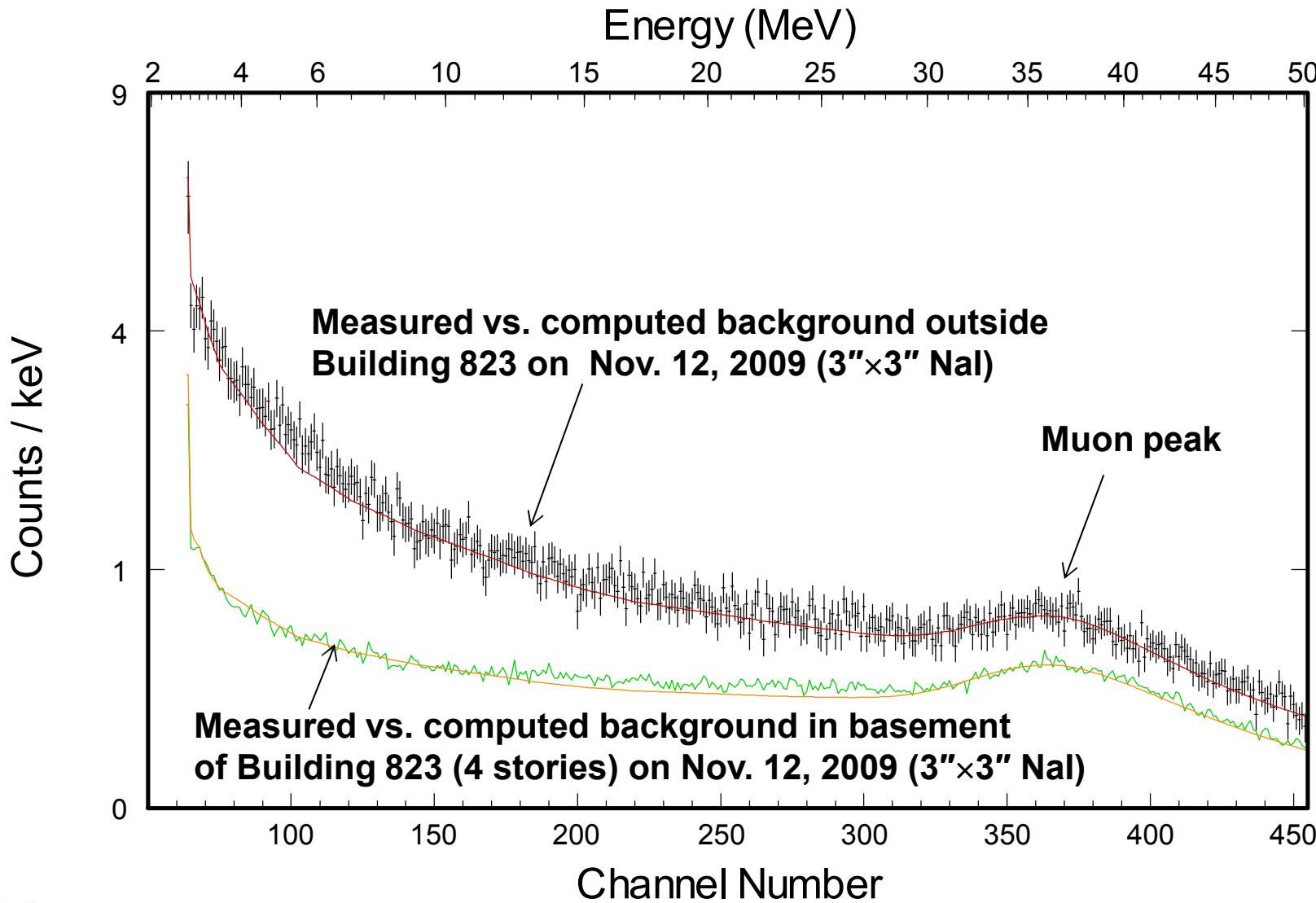


# Background Synthesis

- **Background simulation of radiation measurements is important for training and for sensor evaluation**
- **Concentrations of NORM isotopes vary with location and are difficult to predict. The inject tool uses slider bars for convenient adjustment**
- **The cosmic background reflects the following:**
  - Elevation
    - Atmospheric pressure also varies slightly with weather systems
  - Latitude and longitude
  - Overburden (floors above sensor for indoor measurements)
  - Date (determines the period of the solar cycle)
- **New: Indoor measurements were performed to validate calculations of gammas, neutrons, and muons**



# Indoor Radiation Backgrounds





# Summary

- Numerous changes have been made to make GADRAS easier to use
- The analysis subroutines have been modified to improve the analysis accuracy
- Regression testing is performed routinely to provide:
  - a quality control measure before software releases
  - a software development tool to ensure that changes provide global improvements rather than just addressing the analysis of a limited data set
- Capabilities for preparation of inject data have been improved
- The detector response function has been modified to improve accuracy for gamma-ray and neutron detectors