Directional Spectrometer Software

SL15-V-DirectSoftware-PD2Jc

Dean J. Mitchell, Gregory G. Thoreson, Steven M. Horne, Lee T. Harding

Objectives

Fully utilize data collected by directional sensors
- Previous objectives focused on image reconstruction rather than spectroscopic analysis
- Current capability for synthesis of back projection spectra incomplete or nonexistent
  - Some mask vs. anti-mask methods are count-rate neutral for background, so no absolute counts or uncertainties
  - Some Compton camera methods do not propagate uncertainties
  - Existing directional sensors provide software to other users for construction of back projection spectra
- Directional sensors can improve signal-to-noise for selected spatial regions
- Utilization of series of spatially-resolved back projection spectra can add spatial dimension to spectroscopic analysis

Improve sensitivity for search by using directional information
- No unqualified successes to date
- Compton crosstalk method (NSTec) shows promise

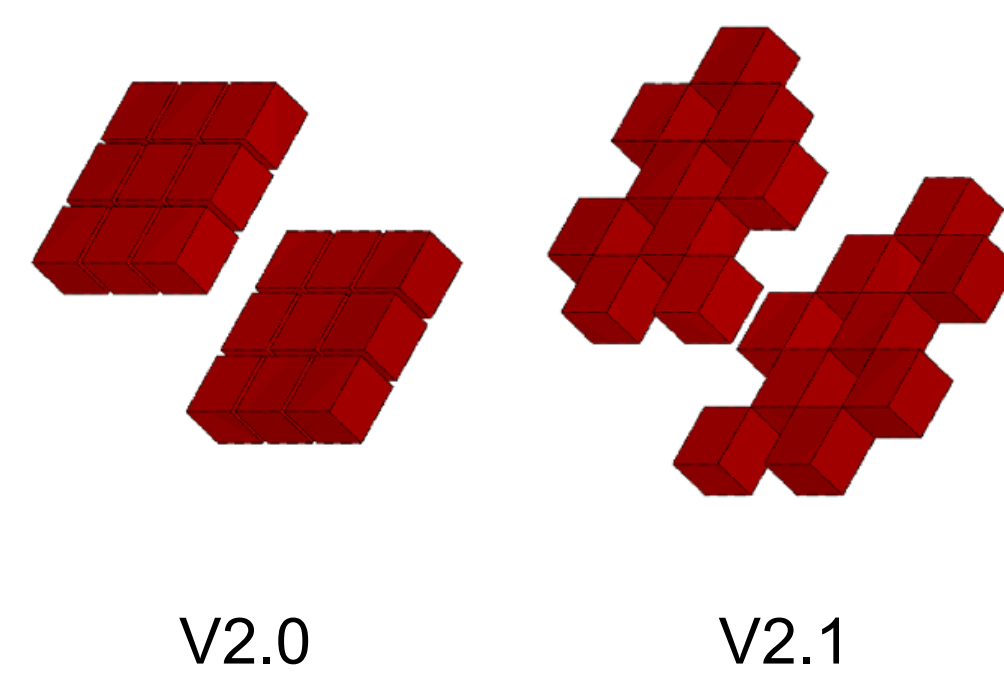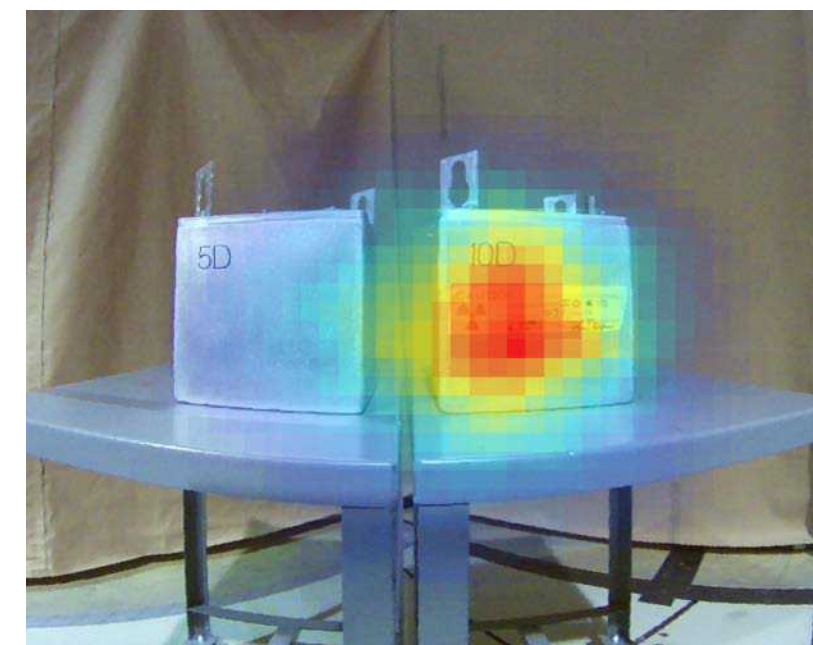**Incorporate analysis into GADRAS, provide to all users**
- Algorithms can be exported for use on sensor platforms

Applications
- Arms control (treaty verification)
- Diagnostics (emergency response, counter-terrorism)
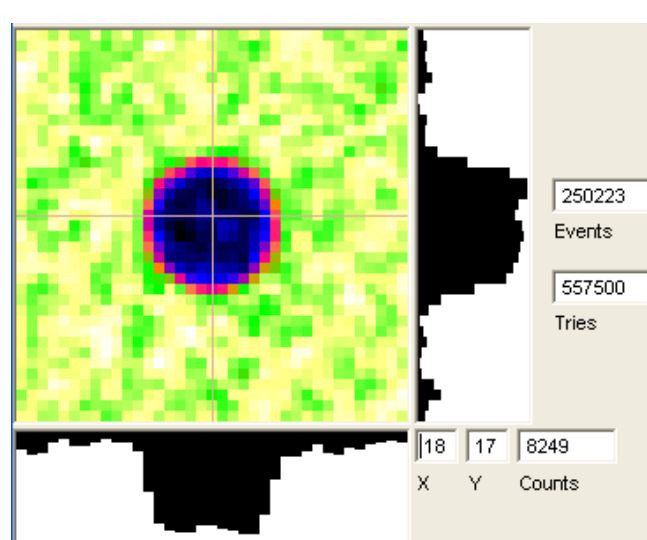- Search
- Cargo-inspection

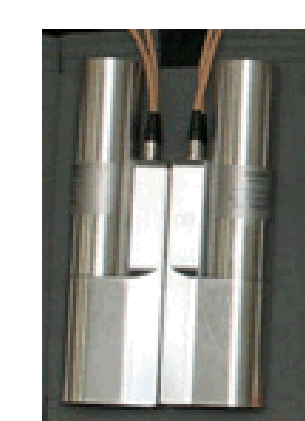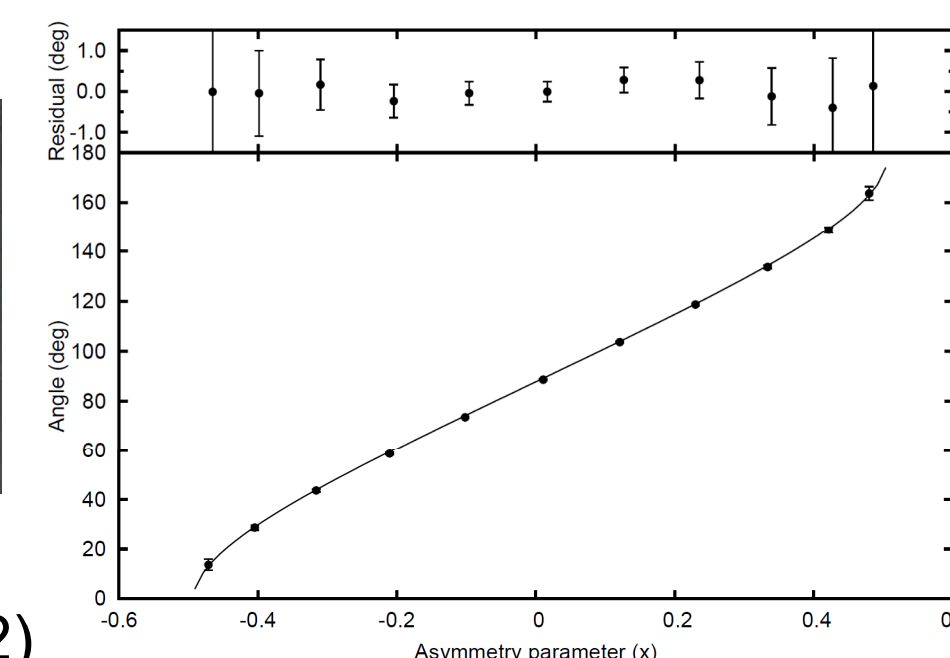## Detection Technologies

Compton Camera
Polaris (H3D / UM)

V2.0   V2.1

Coded Aperture
HPGe Double-sided Strip Detector (ORNL)

Compton Cross-talk
Eagle Ray (NSTec)

NaI Crystals (2)

Approach

Develop Detector Response Function (DRF) for Compton cameras and coded aperture imagers in GADRAS
- SNL develops prototype DRF (7/30/15)
- Polaris and HPGe DSSD chosen because of sensor maturity

Define standard interface to request imaged spectra
- Directional software developers provide DLL or application
- Prototypes delivered by H3D and ORNL (8/1/15)
- Finalize software interface document (9/30/15)
- Integrate software into GADRAS (9/30/15)
- Refine software and GUI interface (FY16-17)

Evaluate enhancement provided by Compton crosstalk method
- NSTec completes benchmark test of Eagle Ray platform (10/30/15)
- SNL and NSTec complete report quantifying enhancement of Compton crosstalk versus gross spectral identification algorithm for search (3/30/16)

Extend analysis tools to utilize data from directional sensors
- Several milestones, complete integrations and documentation (9/30/17)
- Compton crosstalk method (NSTec) shows promise
  - First step is performing objective evaluate versus non-directional search algorithm

Capability Improvement

Time for a general user to complete following tasks

	Commercial Gamma-Ray Spectrometer[a]	Directional Spectrometers[b]	
		Current	Objective
Obtain spectra in usable form	seconds	months	seconds
Compute spectra for unshielded radionuclides	seconds	months	seconds
Compute spectra for 3-D models	minutes	months[c]	minutes
Analyze spectra for isotope ID	seconds	months	seconds
Inverse modeling with full utilization of directional spectra	minutes to hours	years	minutes to hours

a. Gross spectra contain no spatial information except for collimated detectors
b. Back projection spectra can be constructed for multiple, arbitrary spatial locations
c. No benchmark data available to evaluate accuracy

Progress

Contracting H3D/UM slow start (02/2015)
- Procuring R&D support for national laboratories not an efficient process

**ORNL provided preliminary application to construct imaged spectra from archived list-mode data**

H3D provided example back projection spectra for Polaris

Planning commenced for NSTec/SNL evaluation of Compton crosstalk

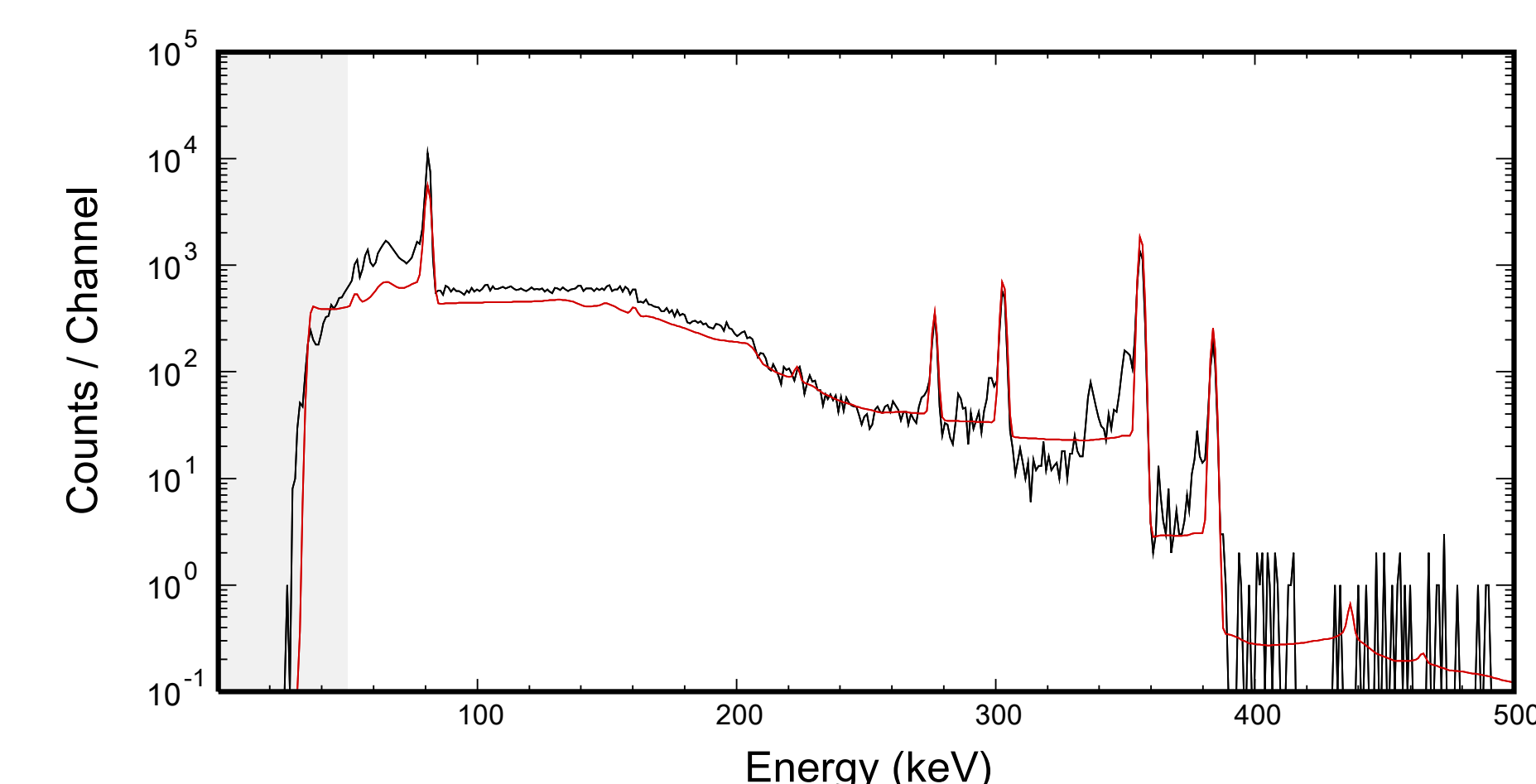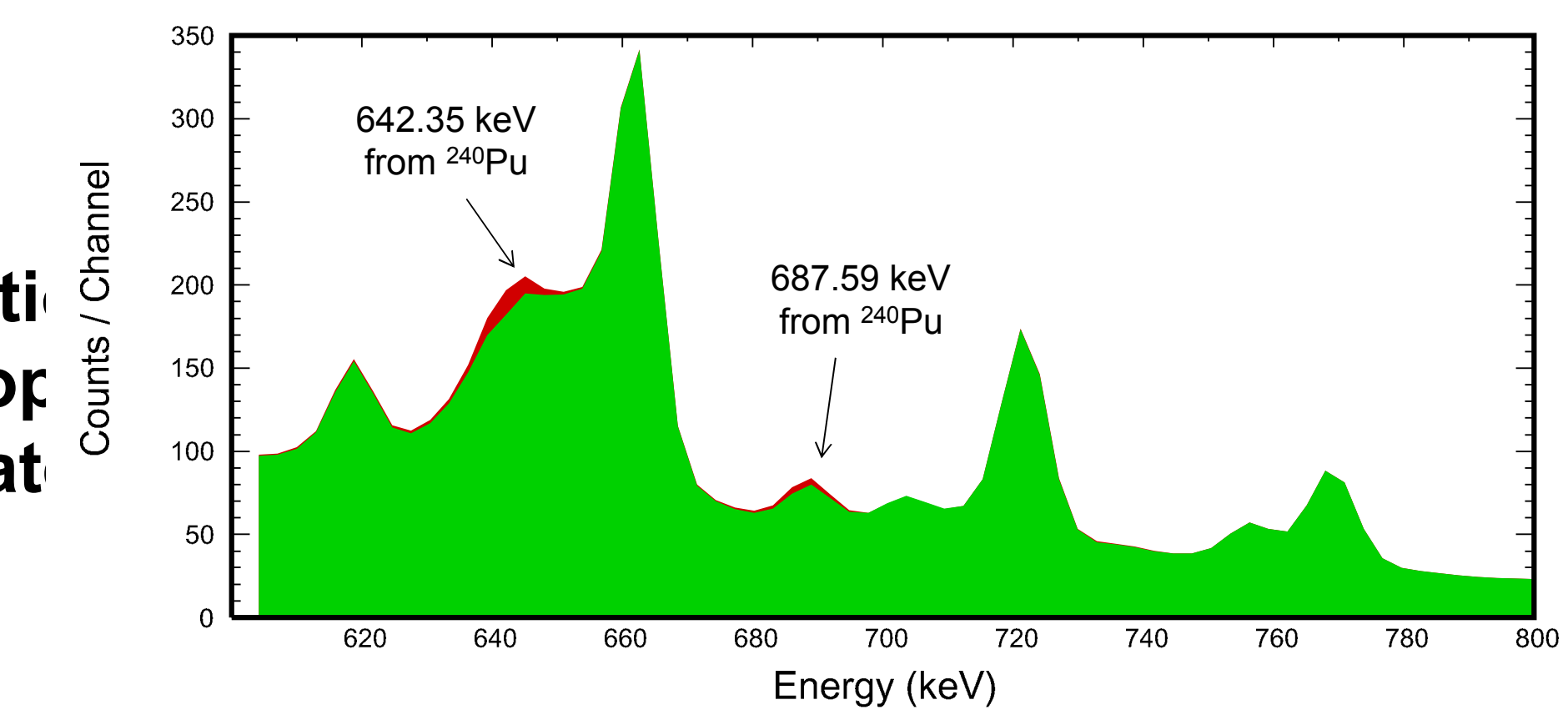**Need for common interface to directional sensors identified and preliminary development started**

SNL began development of DRF for Compton cameras and coded aperture imagers

GADRAS DRF is accurate for Polaris in gross acquisition mode

Eu152_180deg Unit 1 @ 1 m, H=1 m
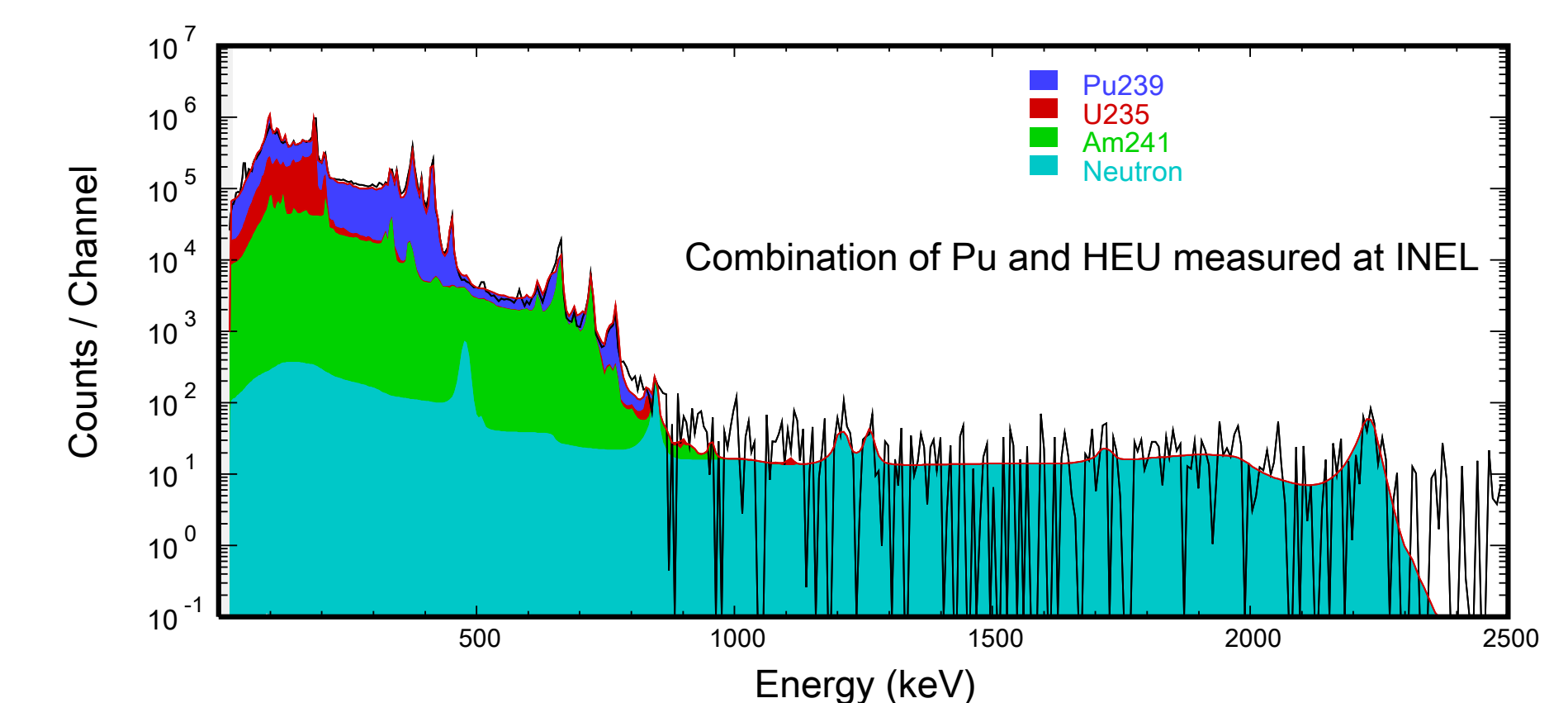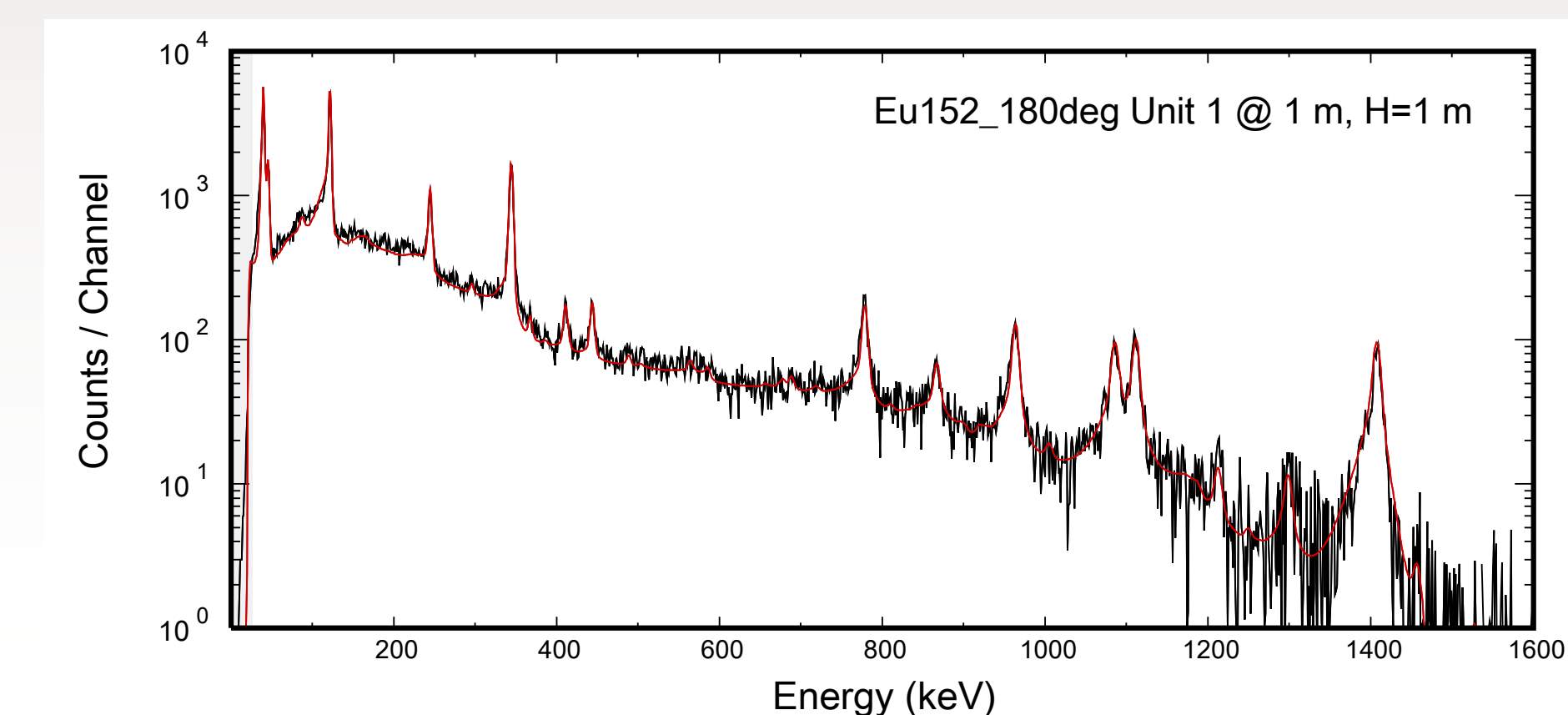
Analysis algorithms applied to Polaris gross spectra functioning well

Combination of Pu and HEU measured at INEL

Pu239 U235 Am241 Neutron

CZT may have resolution sufficient for Pu isotopic analysis with accurate DRF

642.35 keV from ^{240}Pu

687.59 keV from ^{240}Pu

Preliminary DRF for coded aperture imagers