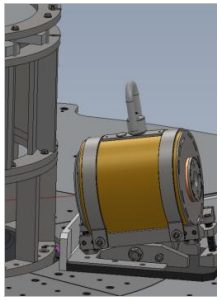
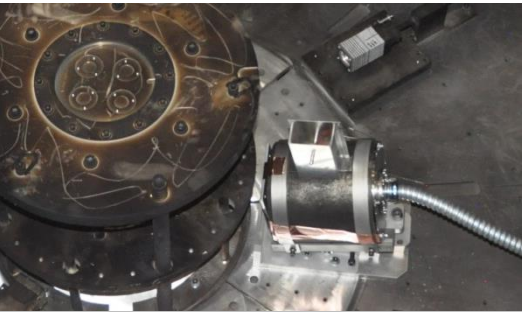
The Differential Absorption Hard X-ray (DAHX) Spectrometer for the Z Facility*

SAND2014-4704C





K.S. Blesener, C.A. Coverdale, D.J. Ampleford, L.A. McPherson, V. Harper-Slaboszewicz, B. Jones, M. Kernaghan, C. Bourdon, M.C. Jones, M.E. Cuneo, P.W. Lake, K. Austin

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Sandia National Laboratories

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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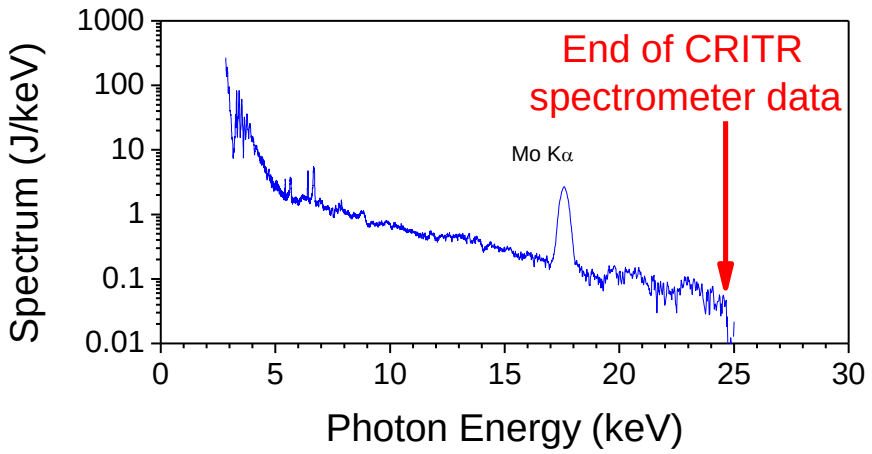
Supported in part by Sandia National Laboratories LDRD program project 173104.

Motivation

- To better understand the hard x-ray content and evolution of the spectrum emitted by various Z loads.
  - Instabilities can produce energetic electron beams
- Diagnostics Limited above 25 keV
  - Hard Filtered TLD stack
  - Time Integrated Pinhole Camera (TIPC) – newly developed
  - Hard Filtered Thick Calorimeters – coming online



Diagnostic Goals

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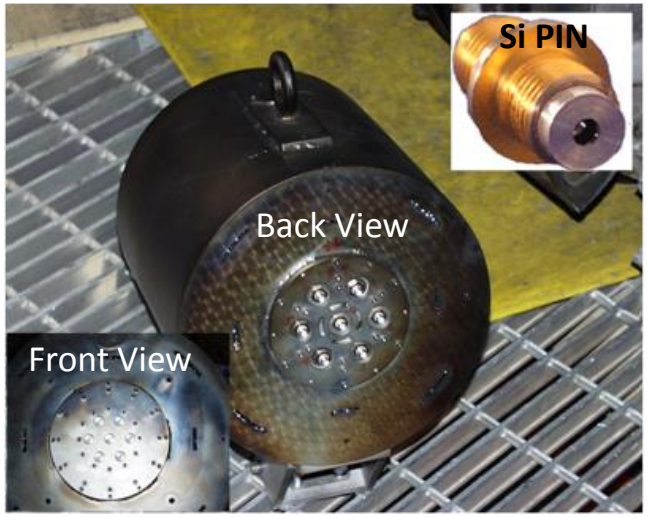
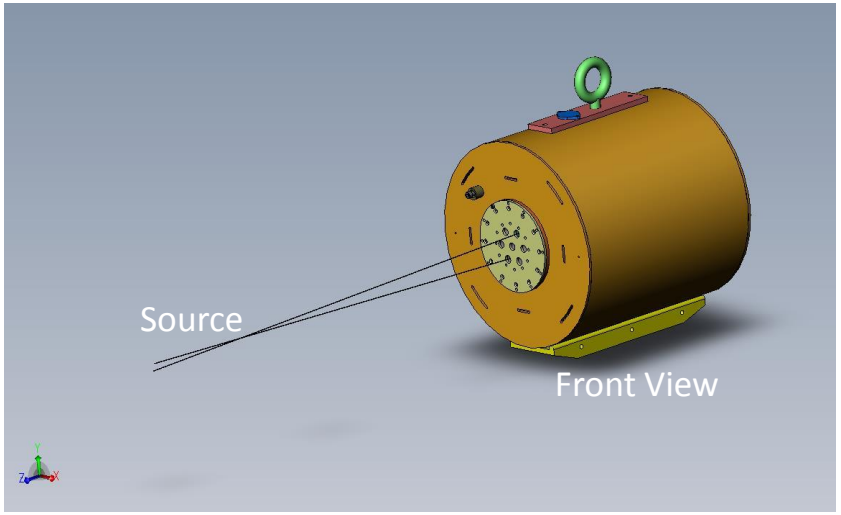
- Diagnose 20 – 100 keV x-ray
- Highly Collimated
  - Only x-rays from pinch
- High Time Resolution ≤ 1 ns
  - Diode selection
  - Data acquisition
- Coarse Spectral Resolution
  - Dictated by number of channels
  - Filter selection for each channel

History

- Hard X-Ray Spectrometer (HXRS)
- Developed by Mike Cuneo and Ken Moy (Bechtel/NSTec)
- Fielded on Z prior to refurbishment
- 3 variations of the HXRS built:
  - **1 cylindrical housing with 7 Si PIN diodes** - Prototype
  - 2 square housings each with 13 Si PIN diodes





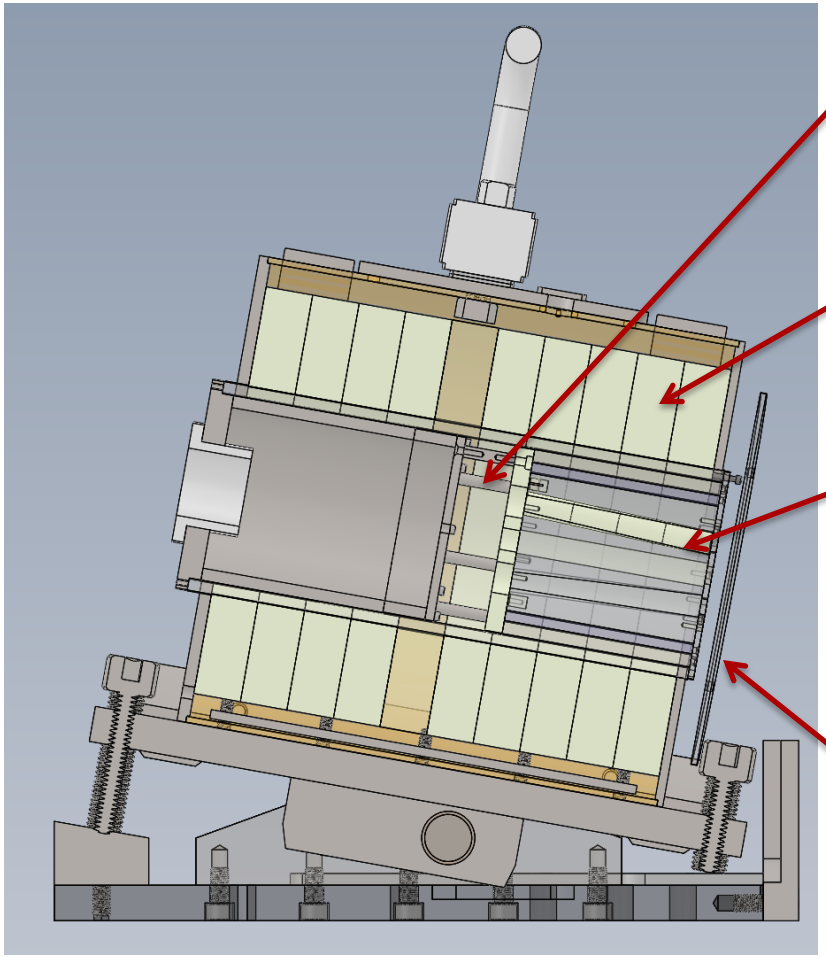
K. Moy *et al.*, Proc. SPIE Vol. 6319, 63190I, (2006).

History

- After 2006 ZR refurbishment
  - 1 square HXRS went to NSTec
  - Others lost
- After many searches , found the prototype in MESA building

K. Moy *et al.*, Proc. SPIE Vol. 6319, 63190I, (2006).

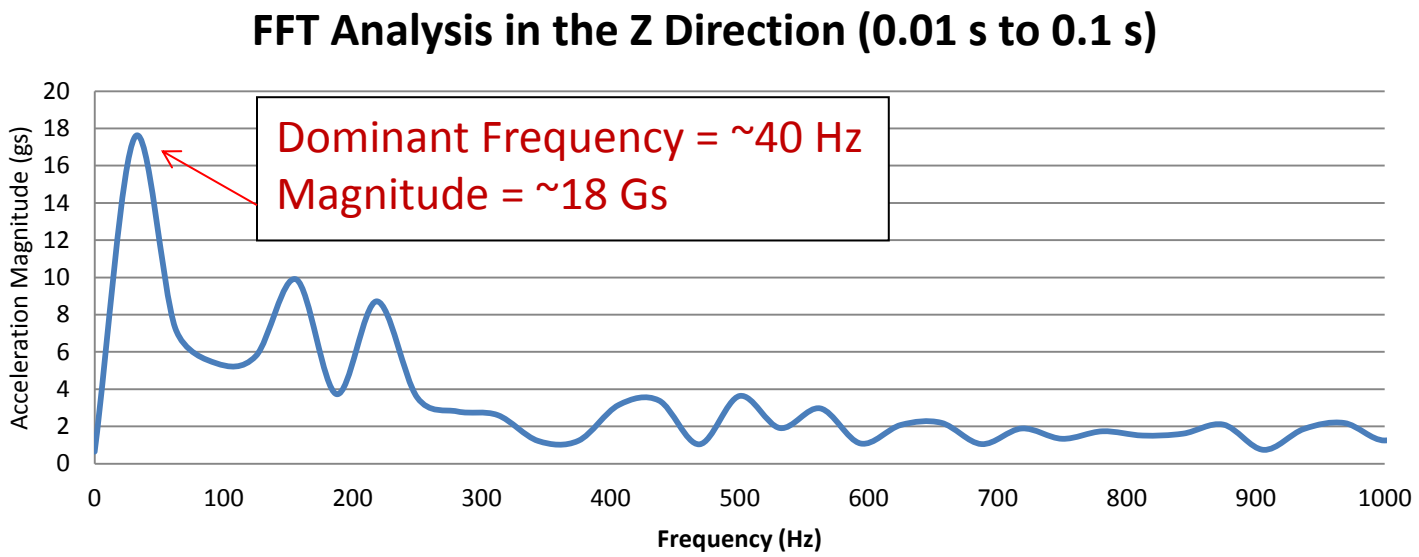
DAHX



- 7 Si PIN diodes (1 noise)
- 10 W “rings”
- 4” deep W collimator & filter holder
- Blast & debris shield

Mounting Hardware Requirements

- Support weight of DAHX ~400 lbs w/o mount
- Enable alignment
  - Focus determined by collimation
    - Set distance to load center
  - Tilt to view load center for many load heights
- Survive 18 Gs



Mounting Hardware Design

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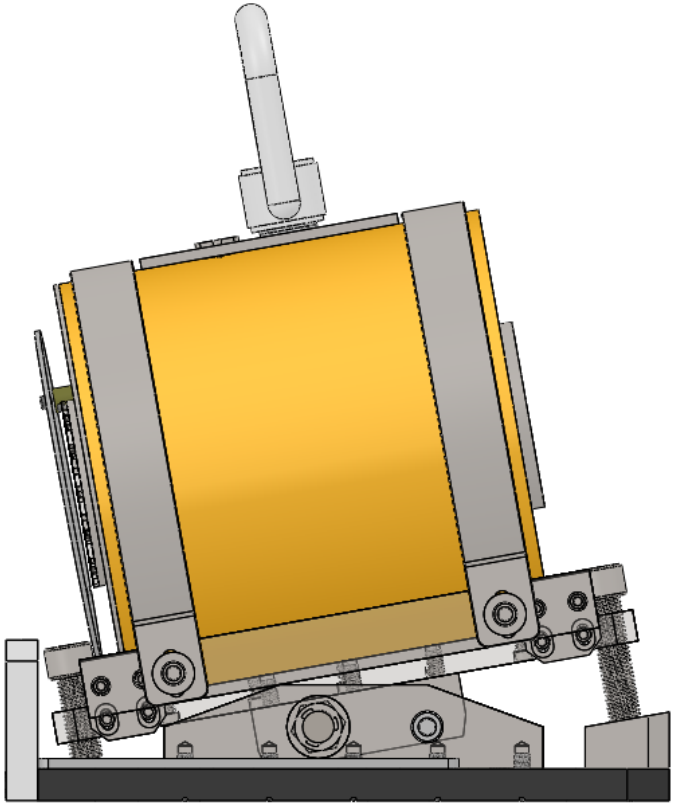
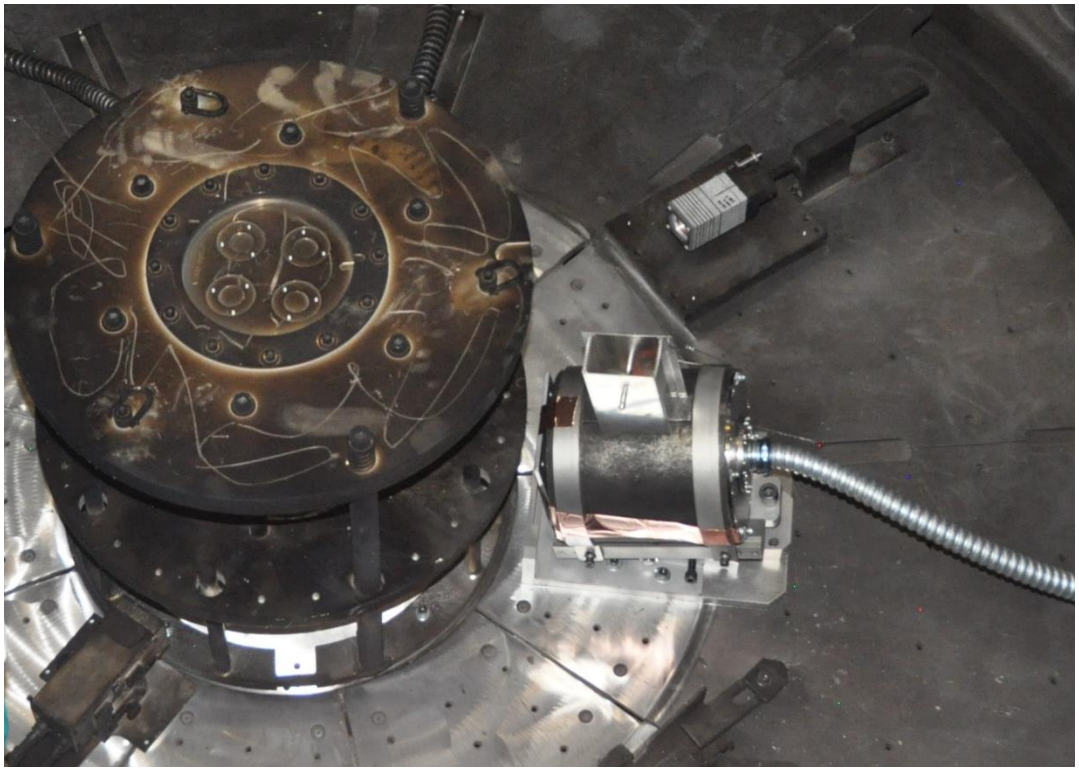
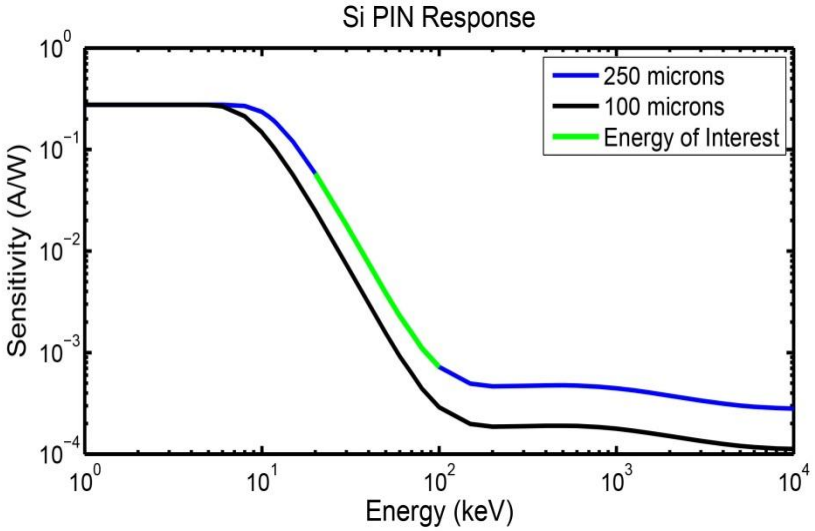
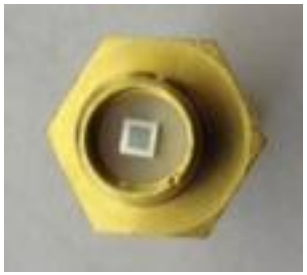




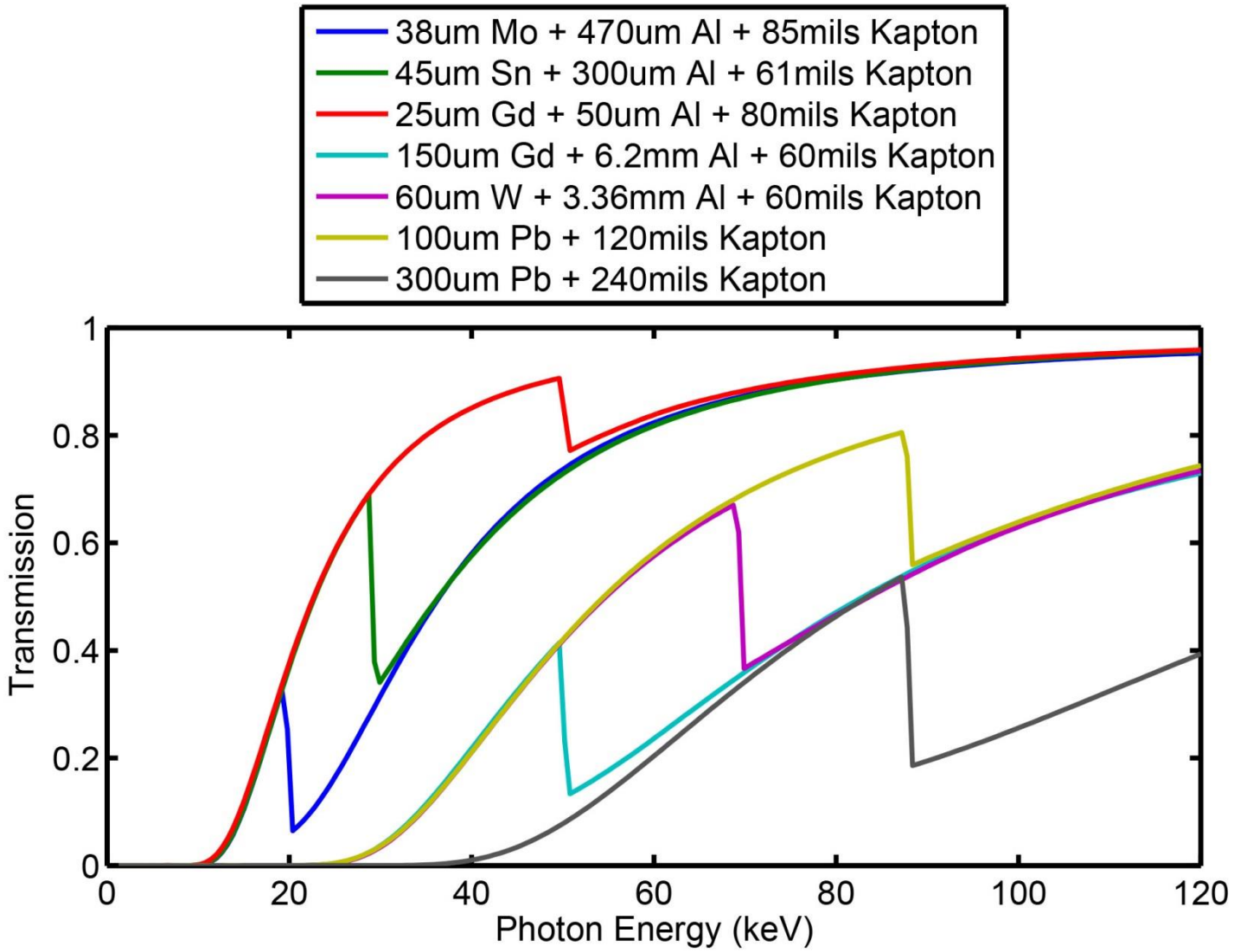
Si PIN Diodes



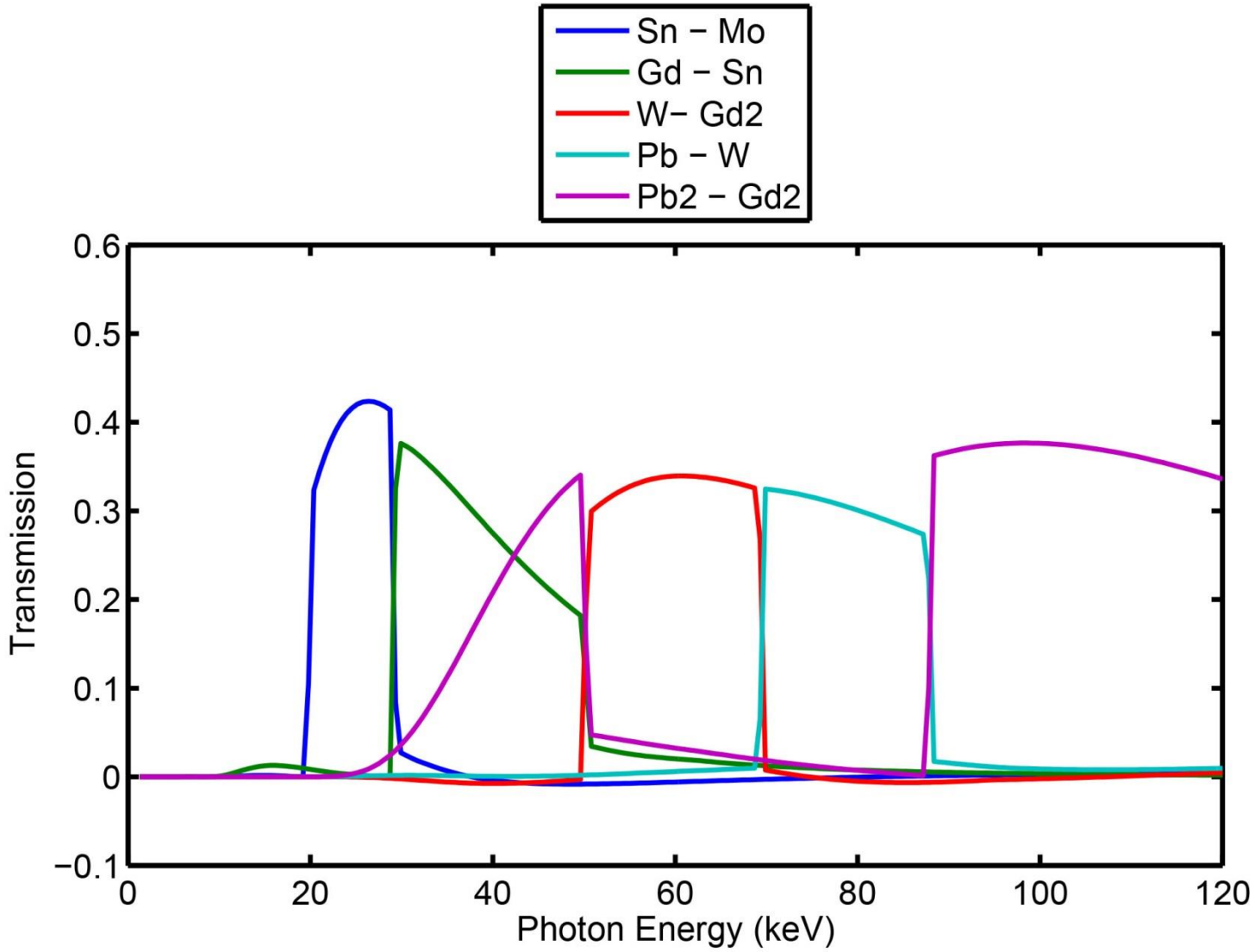


- Custom Optodiode Si PIN diode
  - 100µm Active Layer Thickness
  - 1mm^2 Active Area
- Not as thick or large as prior diodes
  - Compensating by thoughtful filter selection
- Test fielding on Z LOS 50 & LOS210 to gauge signal levels & relative response v. photon energy
  - Thanks to Robert Hohlfelder, Brent Jones, Pat Knapp, & Dave Ampleford!
- Begin with relative calibration across diodes and spectral cuts.

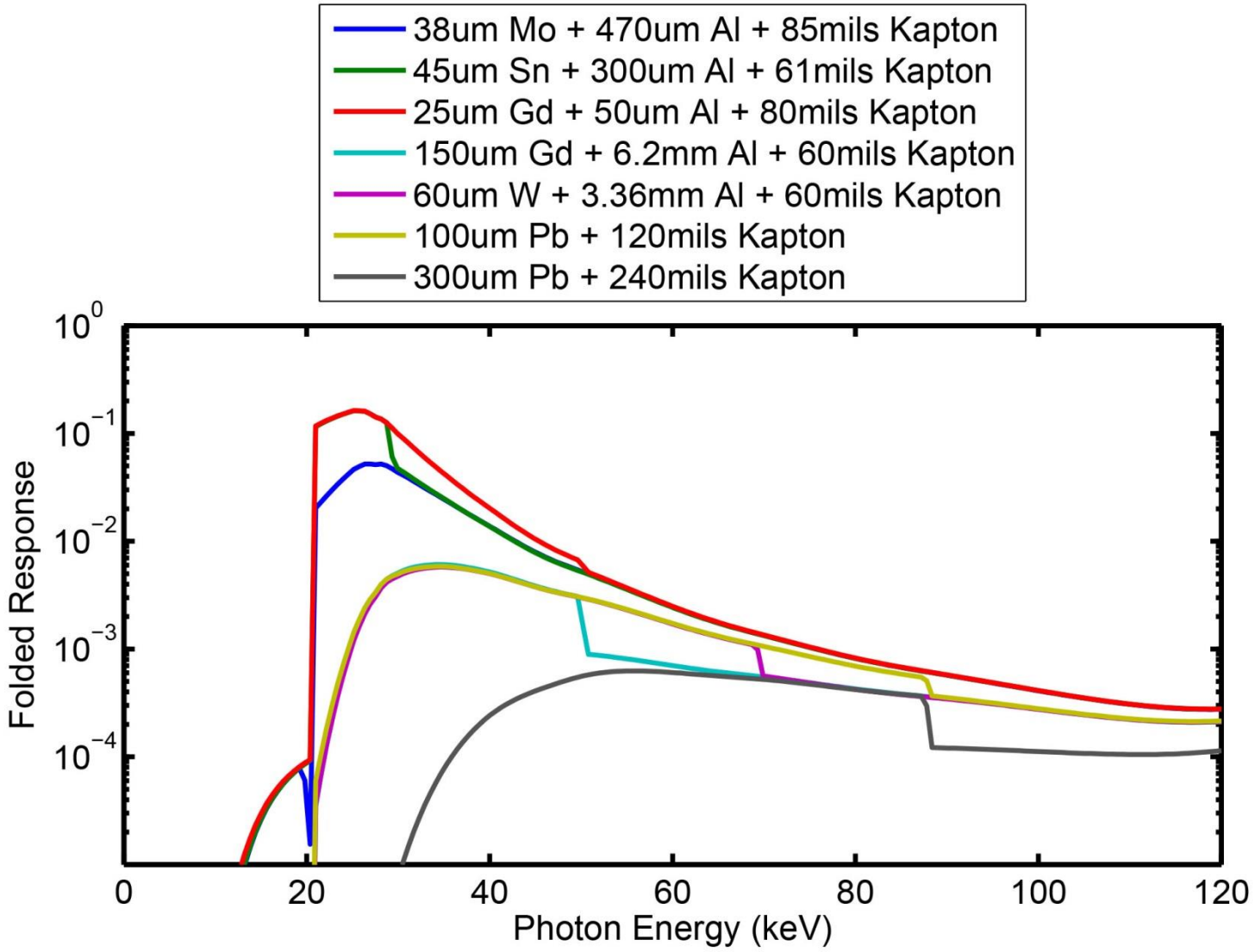
Initial Filter Selections



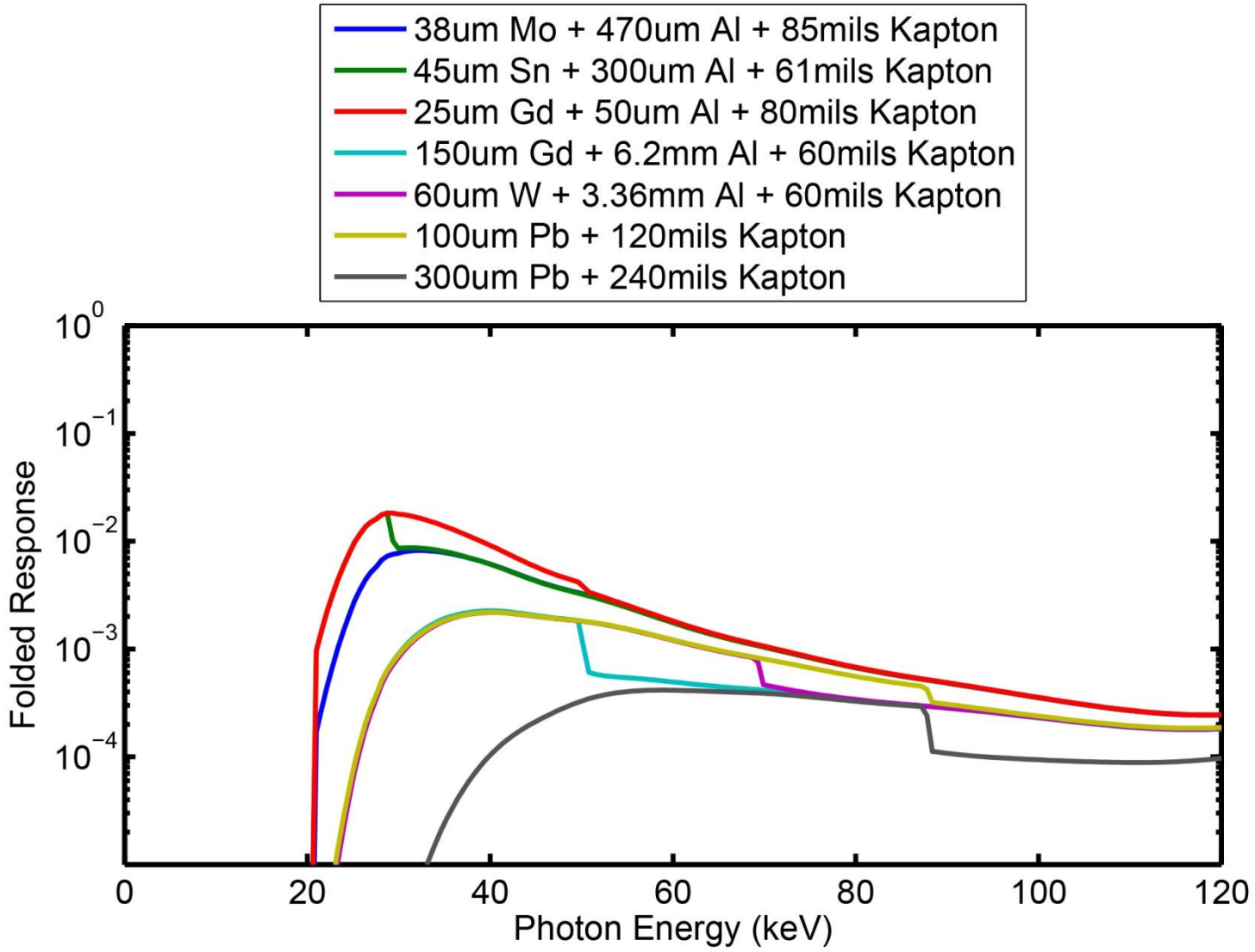
Initial Filter Selections



Response of Si Diodes w/ Filters

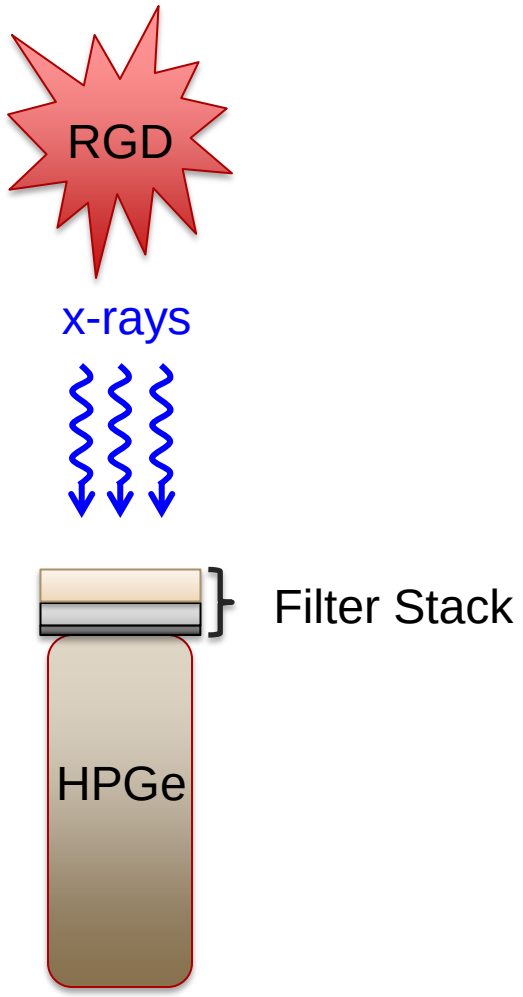


Si Diodes, Filters, ¼” Al Blast Shield



Filter Calibration

- Philips MG225 RGD
  - Steady-State Radiation
  - Variable endpoint energy
    - Up to 225keV
- HPGe detector



Data Unfold

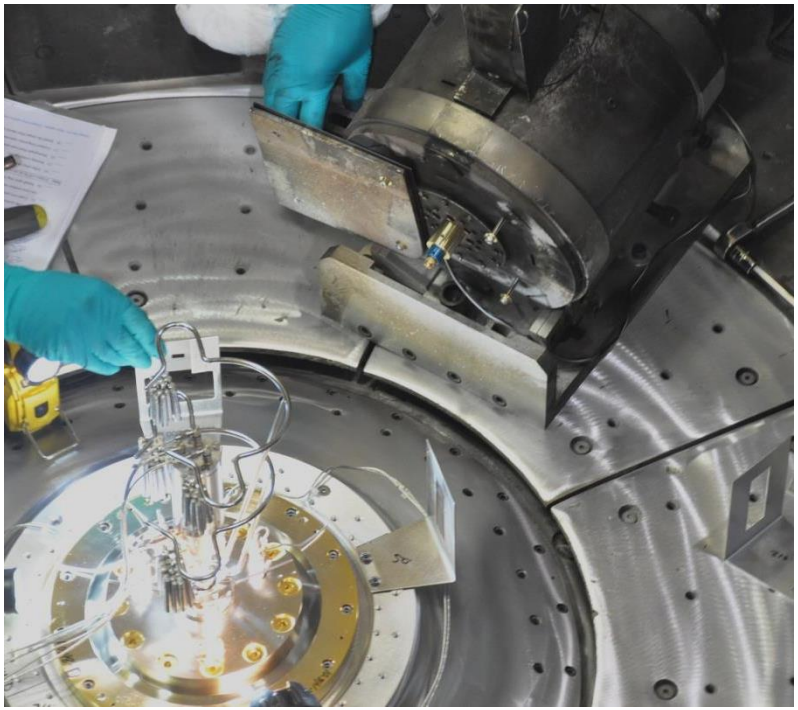
- Developing a Levenburg-Marquardt based unfold program solving for the source spectrum S(t,E).

$$M_i(t) = \int dE\ S(t,E) D_i\,(E)\ F_i(E) \qquad i = 1,2,\dots,7$$

  - $M_i(t)$ is the recorded data, i corresponds to the data channel
  - $D_i\,(E)$is the Si PIN diode response
    - Initially Calculated
    - Later Calibrated at Brookhaven
  - $F_i(E)$ is the filter and blast shield transmission
    - Initially Calculated
    - Calibrated in-house
- Problem is underdetermined, but can be aided by thoughtful filter selections.
  - First need confidence that filters passing desired photon energies

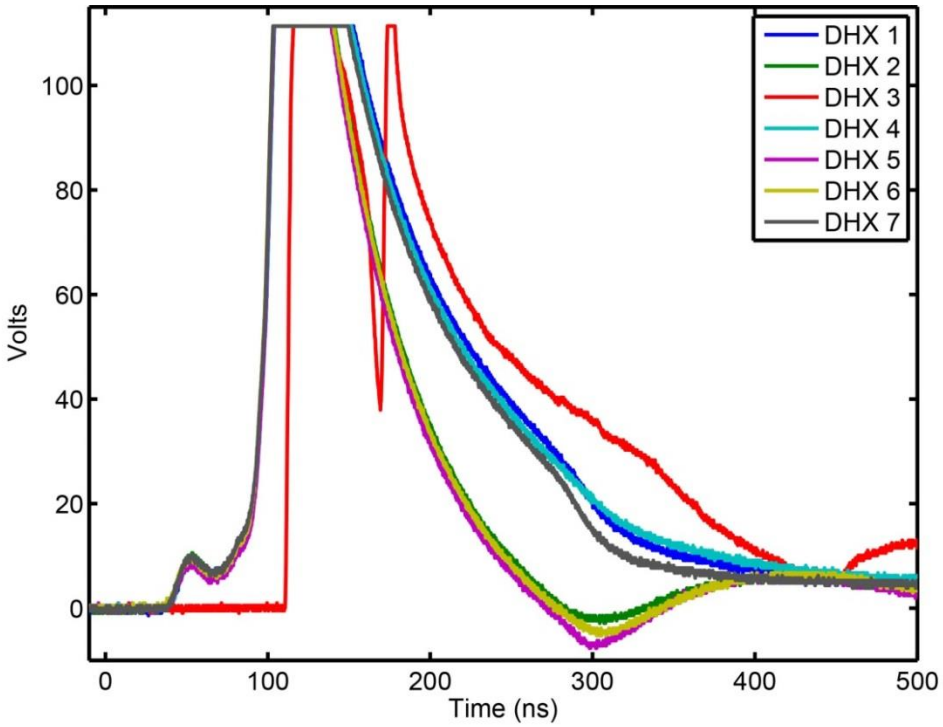
Installation & Alignment

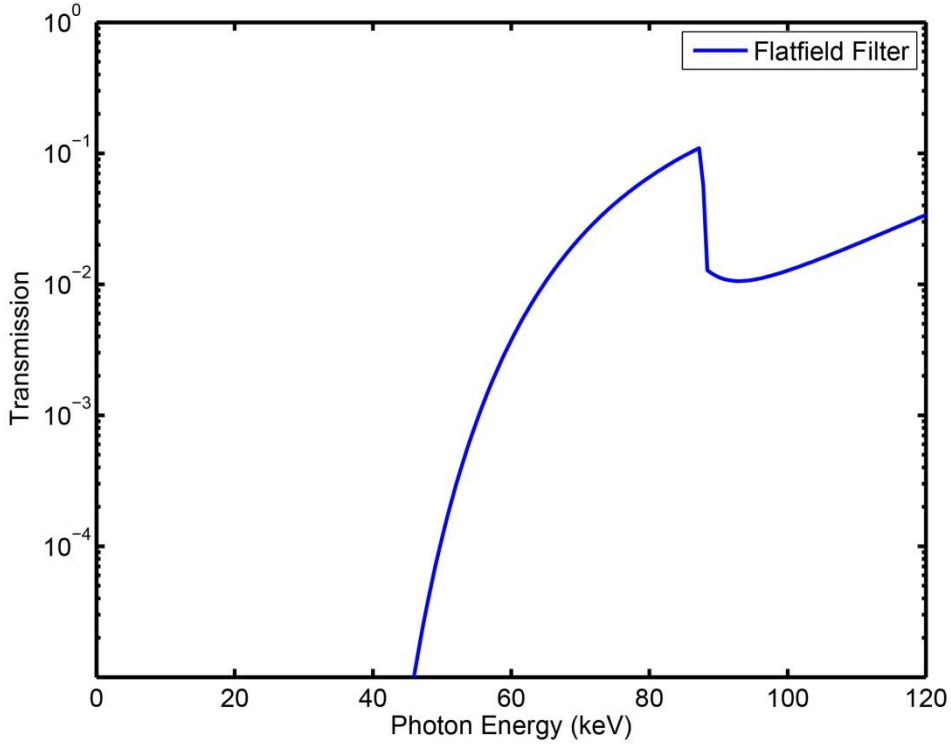
- Crane in
- F/# ~ 10, therefore in focus with bolting to MITL deck
- Laser assembly to aim at pinch



Initial Experiments

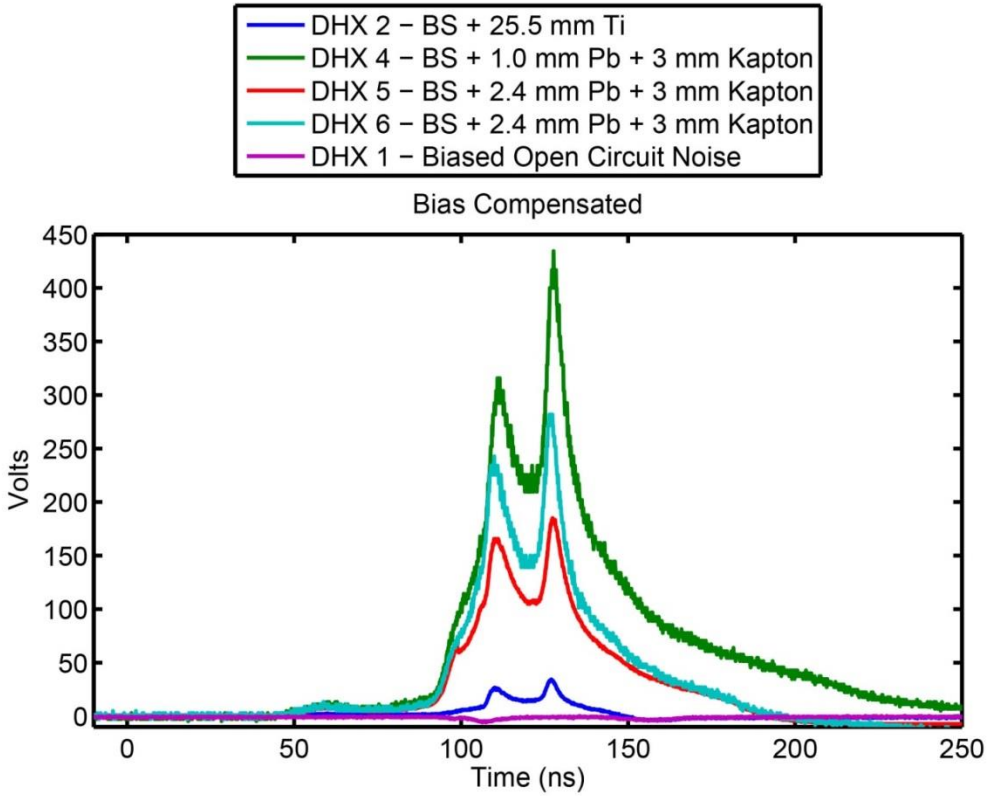
- Flatfield of detectors - Redo in 2 Weeks!
- 6.35 mm Al + 1.5 mm Kapton + 1.0mm Pb + 1.5 mm Kapton

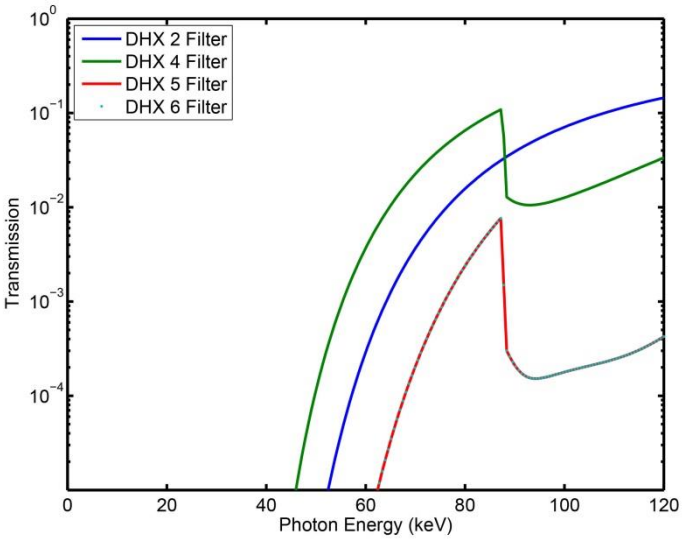


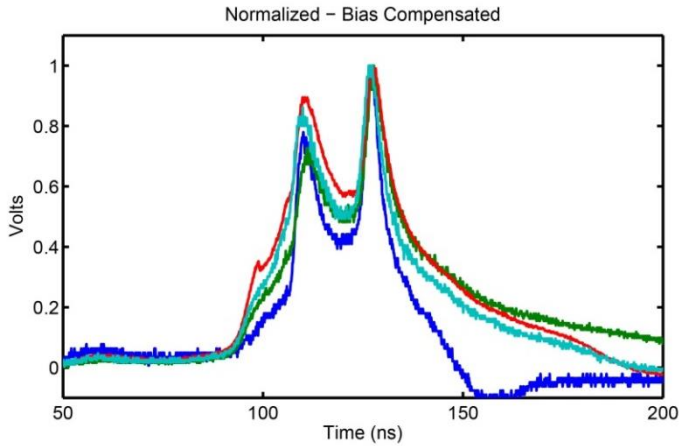


Initial Experiments

- Data collected with Mo & Ag non-thermal source – Shot 2657
- Filter Geometry Matters!
  - DHX 2: Tight Fitting Cylinder
  - DHX 4-6: Looser Disks Cut From Sheet

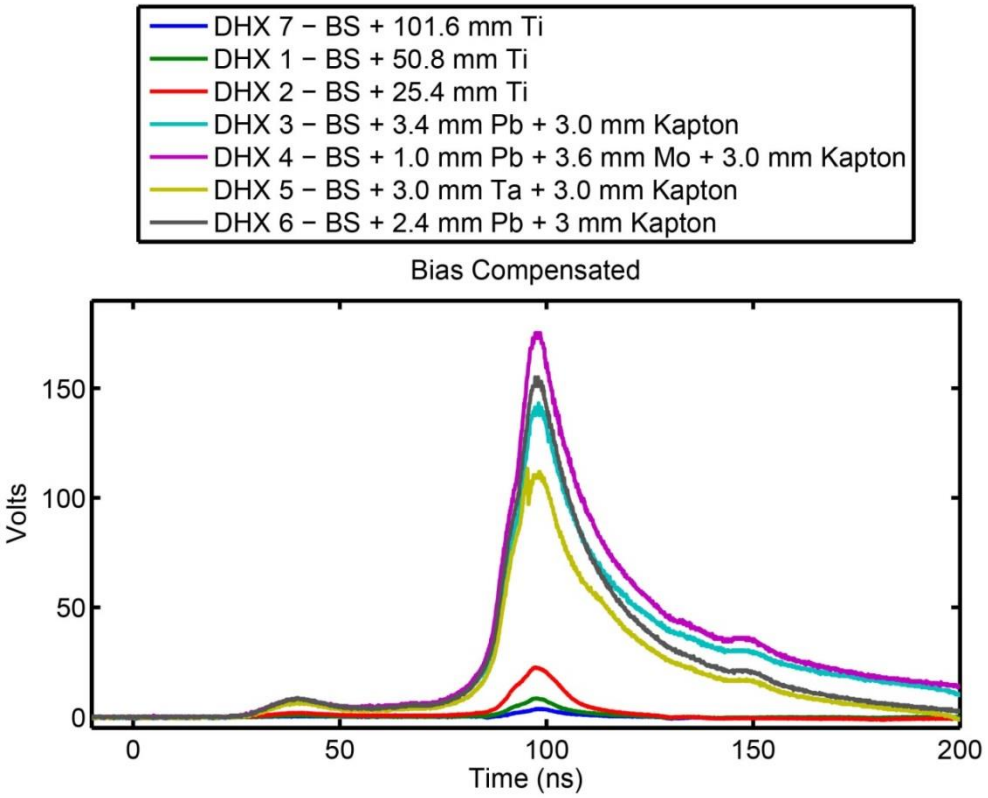


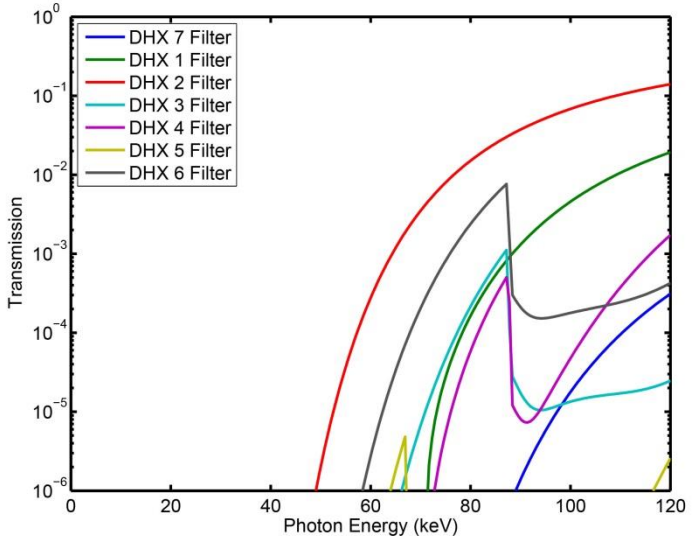


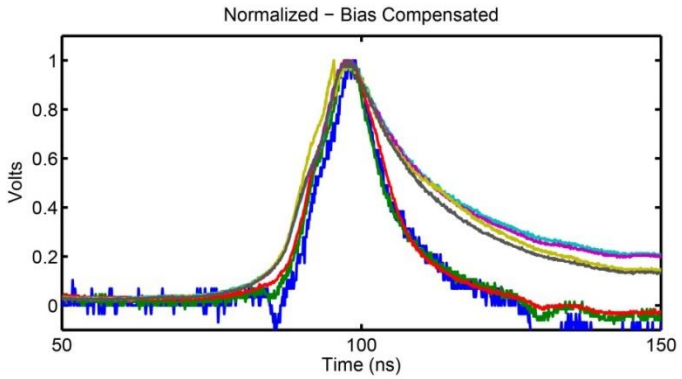


Initial Experiments

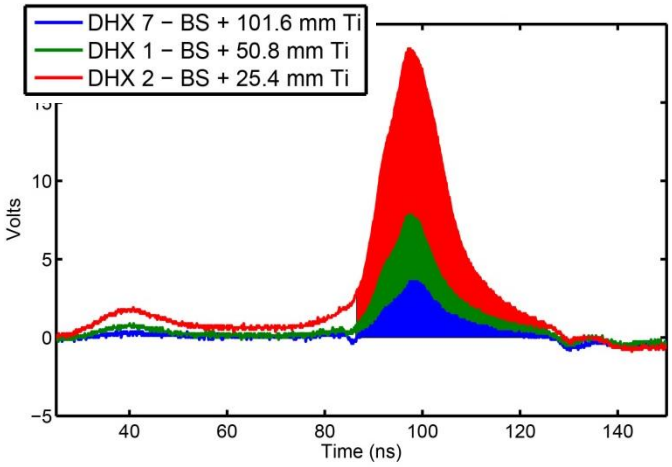
- Data collected with Mo & Ag non-thermal source – Shot 2658
- Filter Geometry Matters!
  - DHX 7,1,2: Tight Fitting Cylinders
  - DHX 3-6: Looser Disks Cut From Sheet

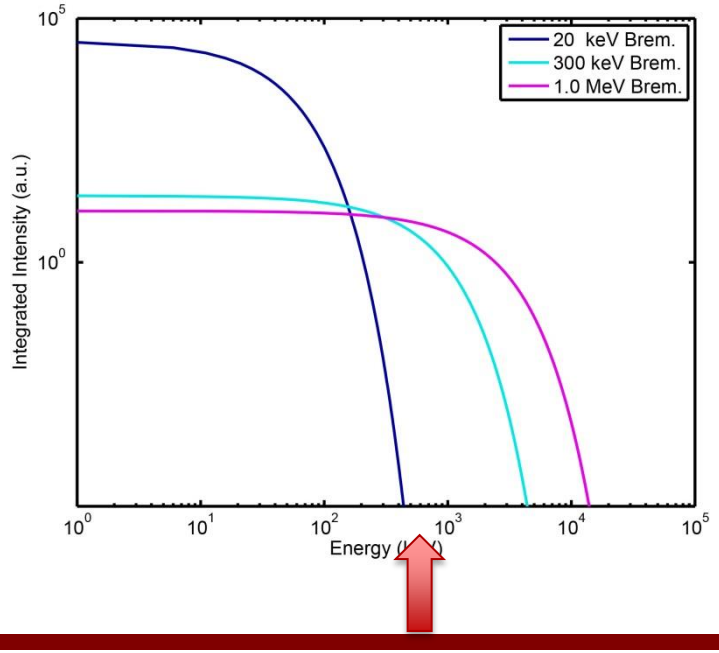


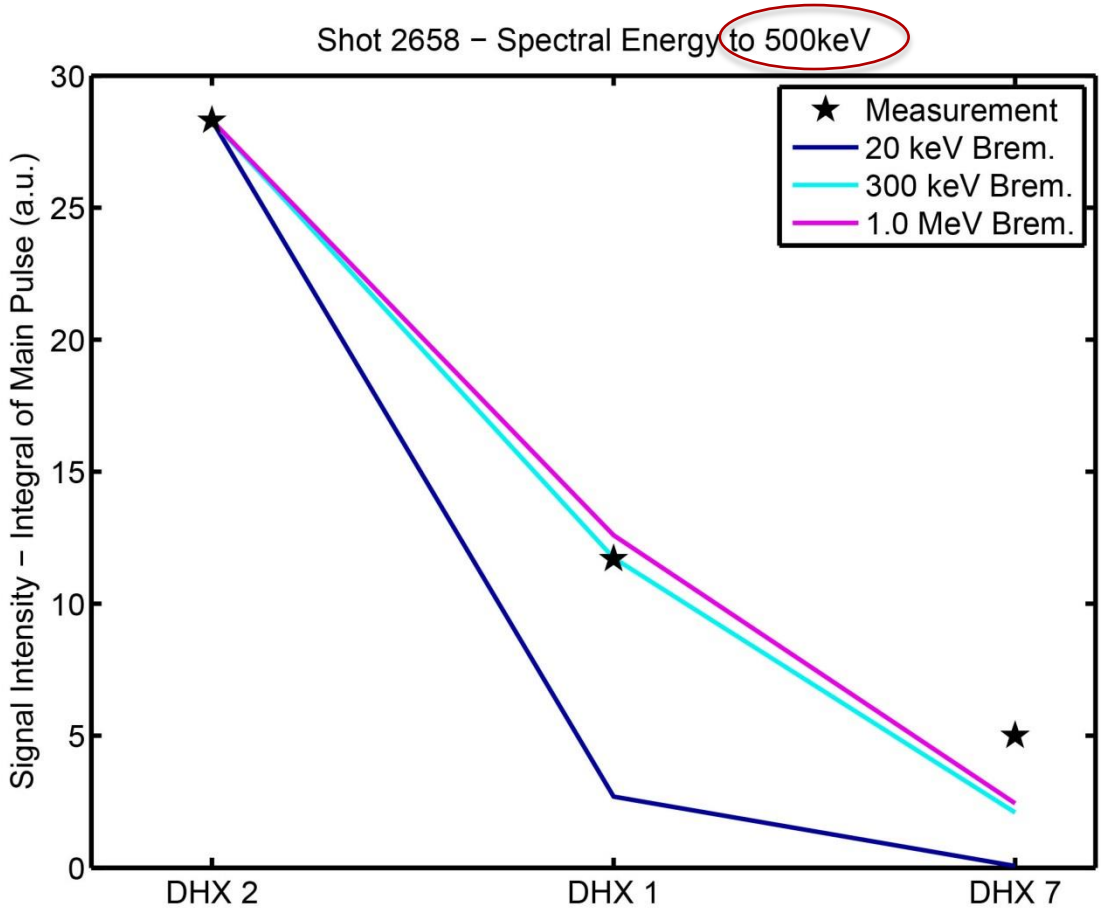




Preliminary Analysis of Shot 2658







Preliminary Analysis of Shot 2658

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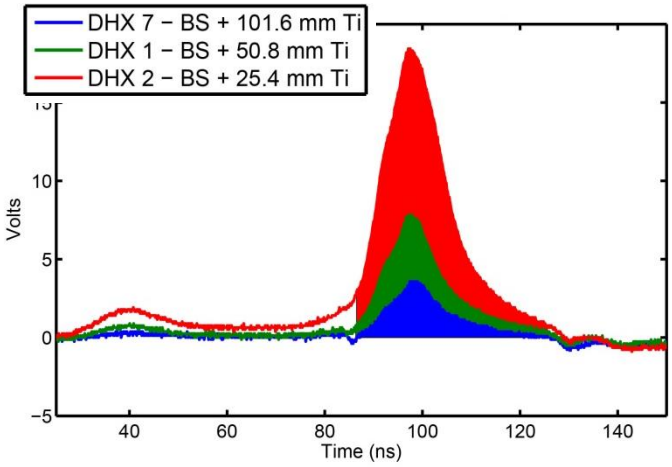

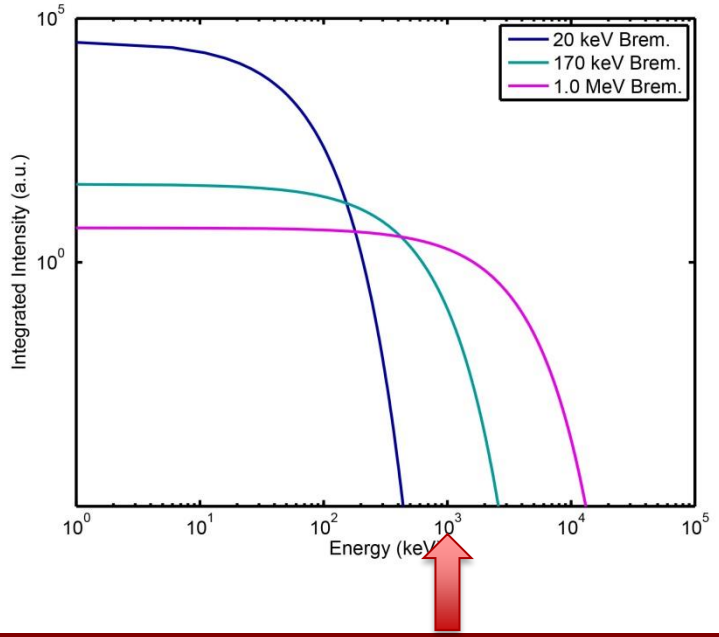

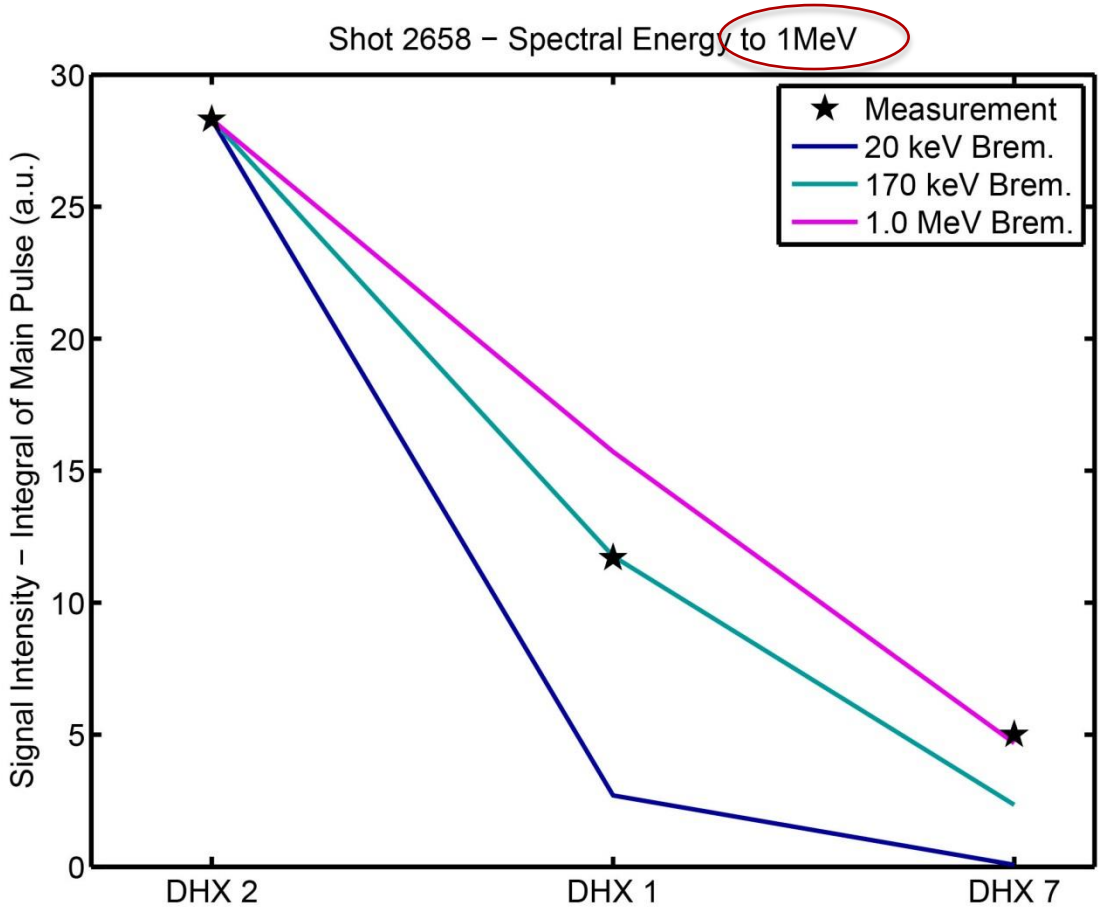

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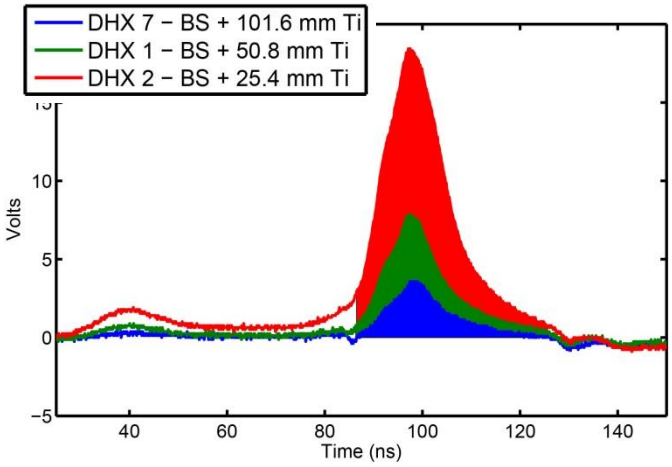

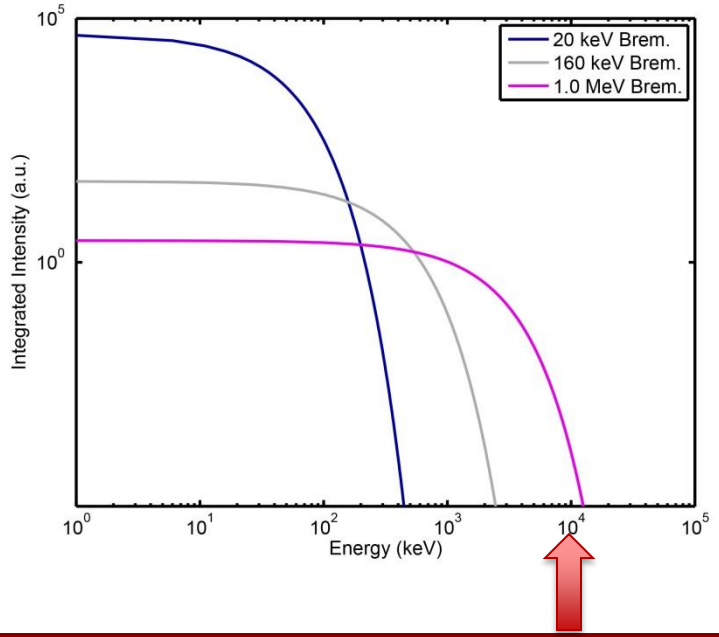

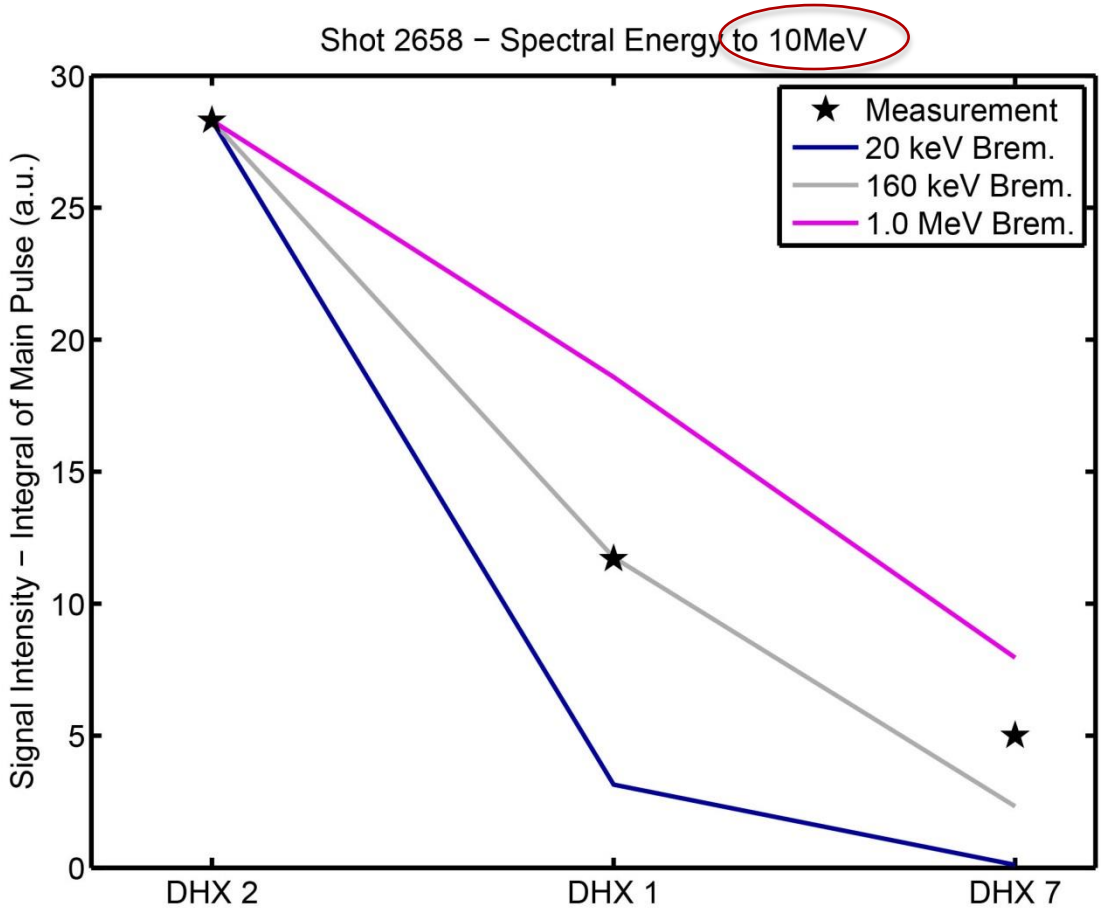

DAHX 2.0

- Begin working on more compact version with higher number of diodes.
- Design will be guided by initial fielding of DAHX
  - Finalized by September 2014
  - Ordering parts October 2014