

Overview of NSTec Los Alamos Imaging/Detector Characterization

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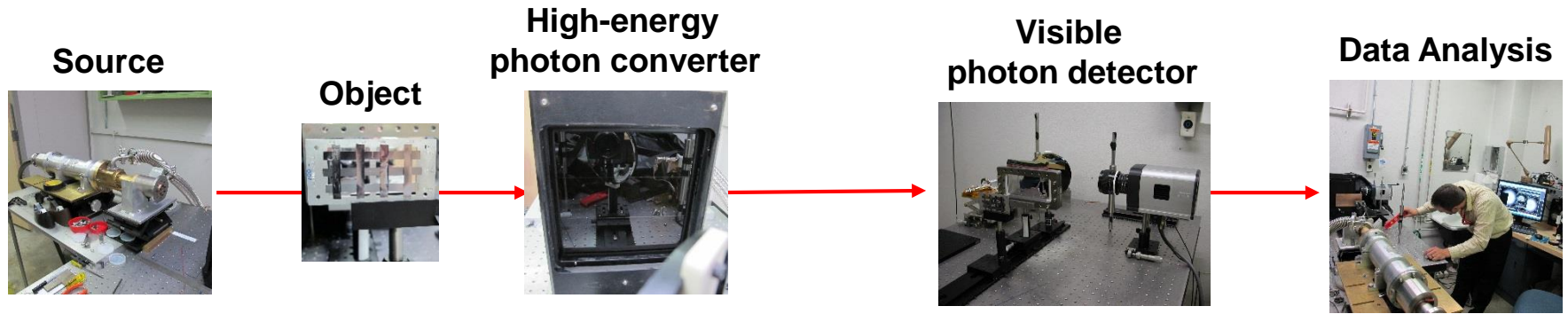


Outline

- Radiographic Support Capabilities at Los Alamos Operations
 - X-ray sources
 - Variable energy 2 MeV electron accelerator
 - Platts flash x-ray source, ~300 keV 50 ns pulse x-ray source
 - CW 225 keV confined x-ray source
 - Scintillator testing
 - Examine scintillator performance from local test
 - Test developmental scintillators
 - Camera evaluation
 - Provide systematic evaluations of camera performance
 - Radiography analysis
 - Battle-hardened analysis/processing software has been developed by the team
 - Simulation development



Radiographic Chain



- End-point Energy
 - Higher end-point energies have better resolving power of denser objects
 - Lower end-point provides high-contrast of low-density object
- Intensity
 - High intensity gives better SNR
- Multi-pulse
 - Can acquire multiple time images
- Spot Size
 - Smaller spot size provides better resolution

- Due to high-energy, high intensity beam imaging require a scintillator
- Resolution
 - Limited by source size and radiation scatter and not scintillator
- Brightness
 - Material dependent
- High density
 - Greater ability to convert high-energy photons
- Decay time
 - $T < 100$ ns for pulsed machines

- High quantum efficiency
- Large collection area
- Low readout noise

- Overworked
- Takes work home
- Finds boring images amazing

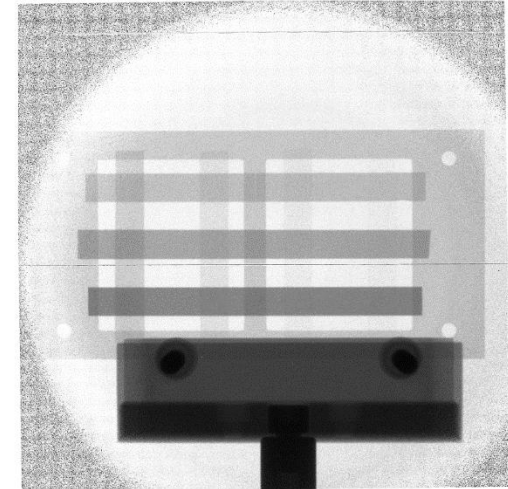


Sources: Platts Source

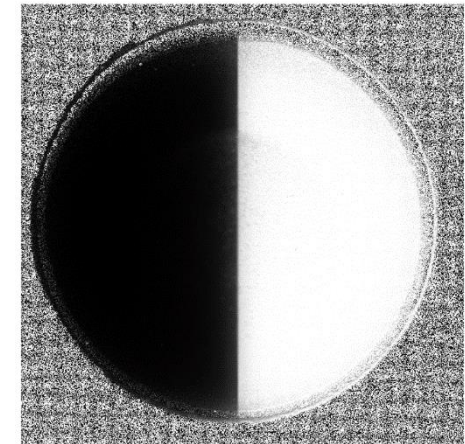
- Low end-point energy
 - ~300 keV
- 35 mR @ 1 m
- Single-pulse or multi-pulse configurations
- Spot size of ~1.5 mm
- Red Sage development work
- X-ray diffraction



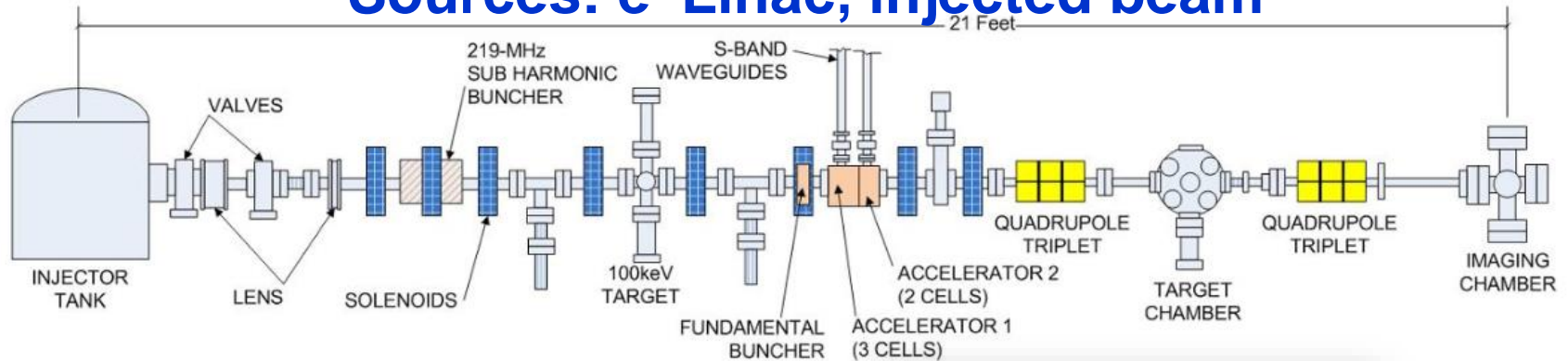
flat field corrected, rotated Basket Weave 3 mm LYSO



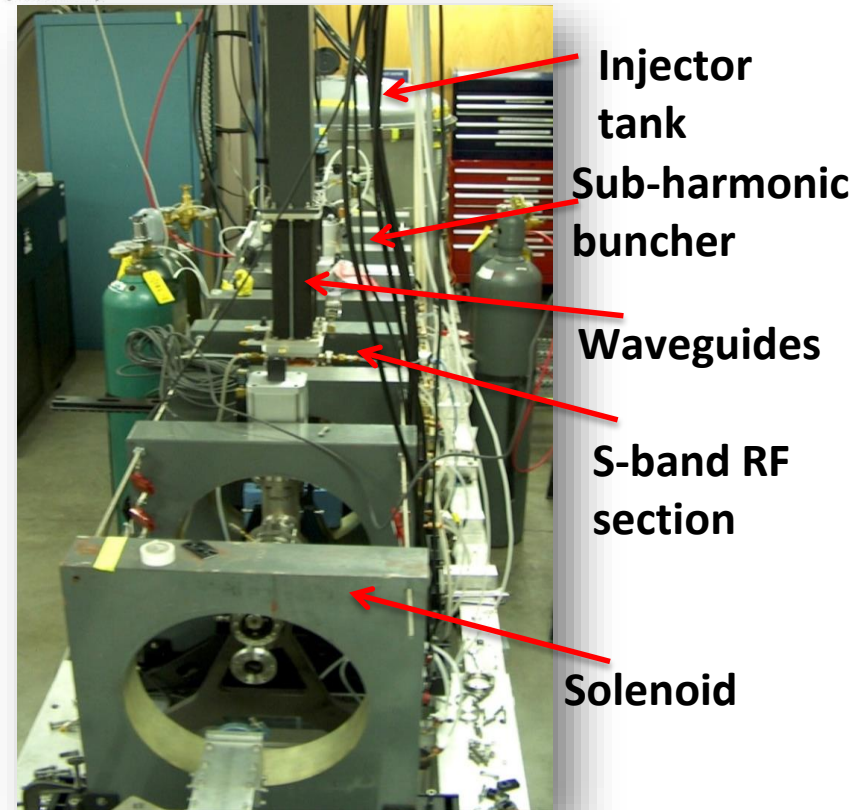
Lul Edge



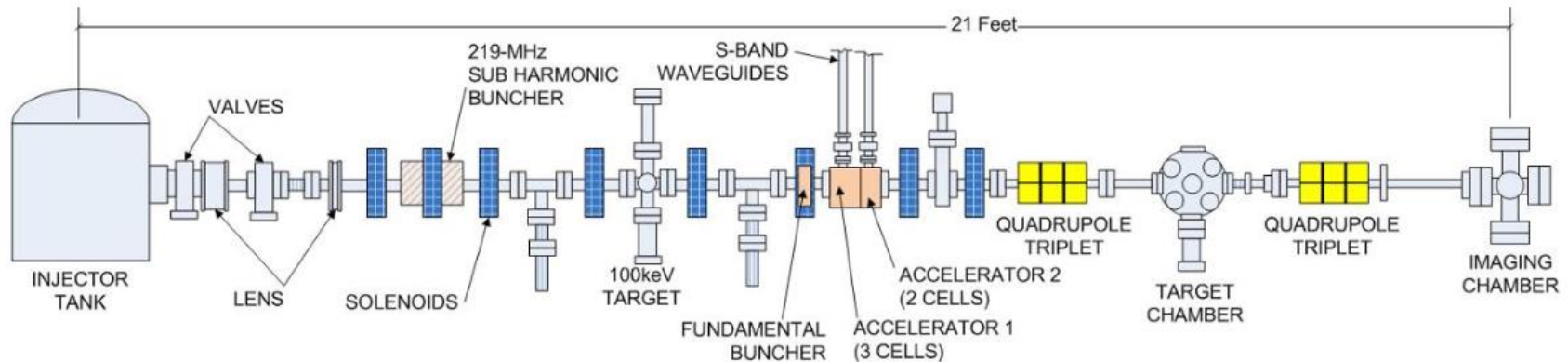
Sources: e⁻ Linac, injected beam



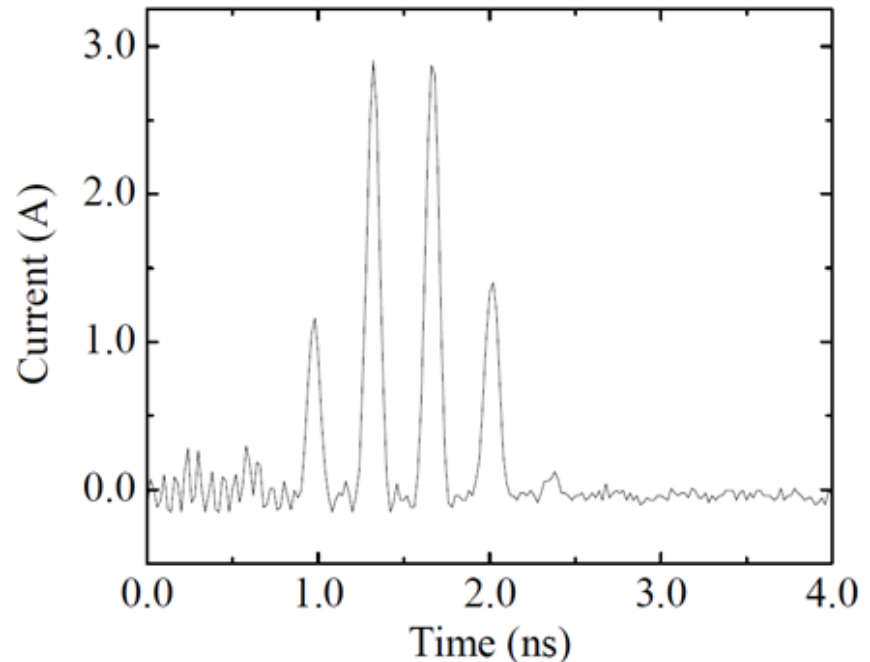
- Beam current: 6 A peak
- Energy range: 10–100 keV
- Variable pulse width, 250 ps to 4 μ s
- Rep rate single shot: 100 Hz
- Based on Santa Barbara LINAC (Idaho State)



Sources: e⁻ Linac, accelerated beam

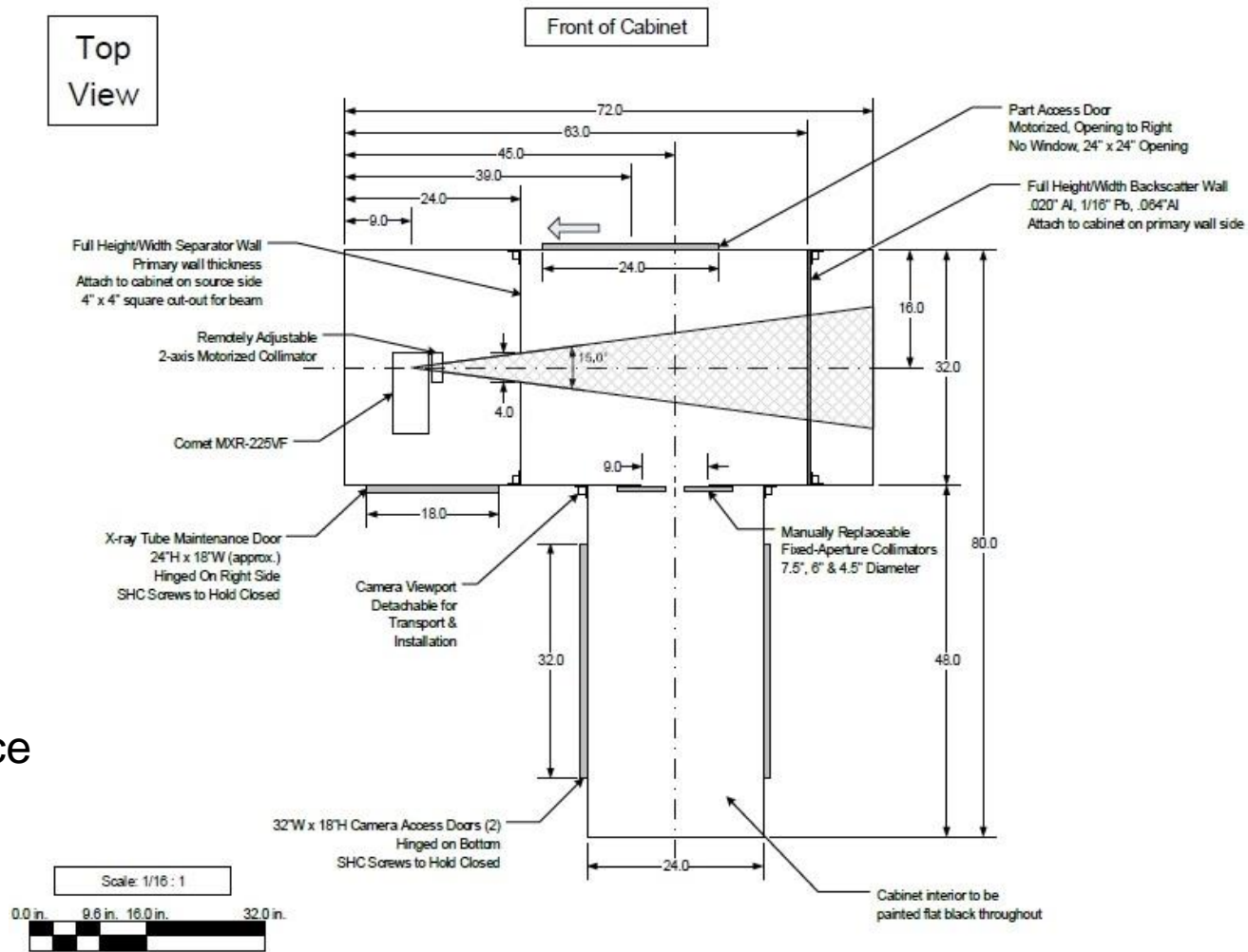


- Accelerated peak current of ~0.5 A
- S-band microstructure
 - Calculated 30 ps pulse width with 350 ps separation
- Calculated energy range from 250 keV to 2.5 MeV
- New spectrometer to be installed, beam optics to be optimized
- MHz modulation being pursued



Sources: Comet MXR-225 keV VF

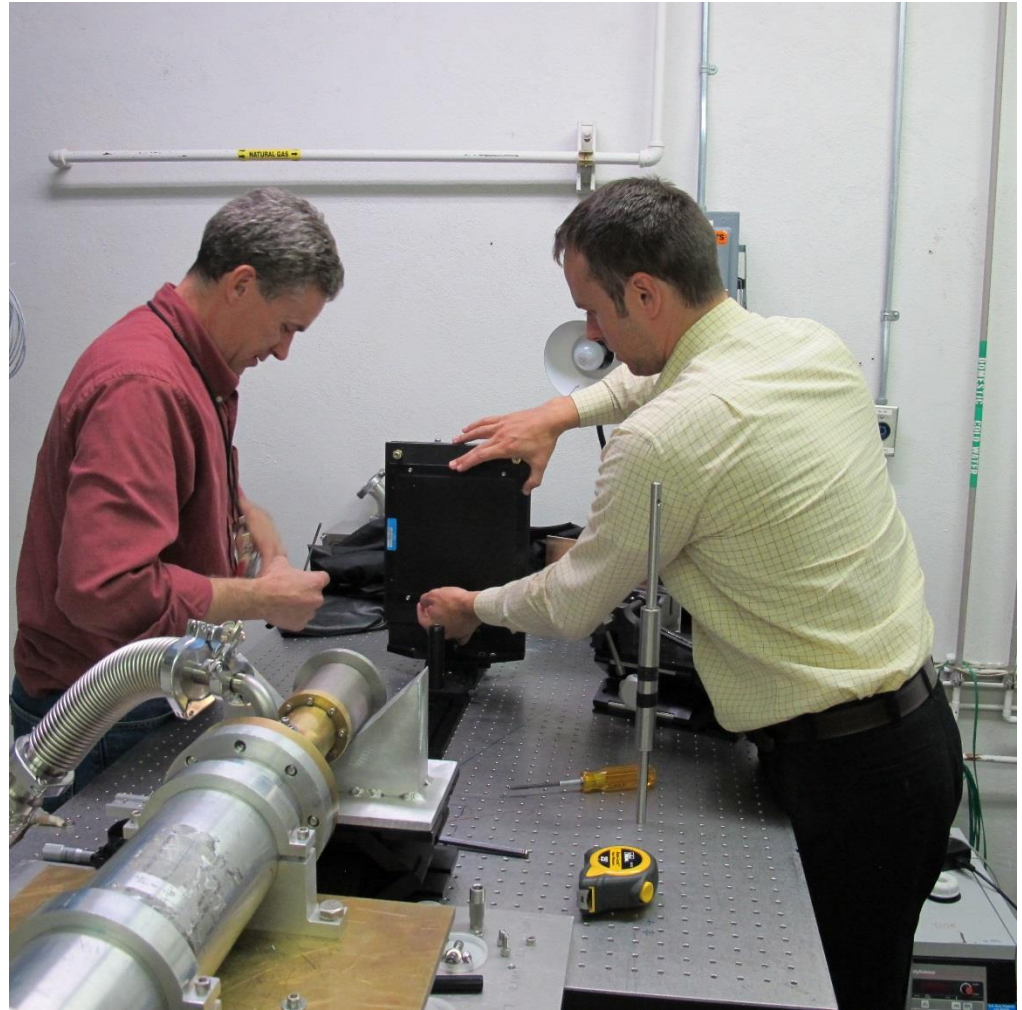
- Tunable energy up to 225 keV continuous source
- 600–1600 W power
- Small, adjustable spot size
- Easily acquired cheap precision data for evaluating basic scintillator performance



Scintillator Testing

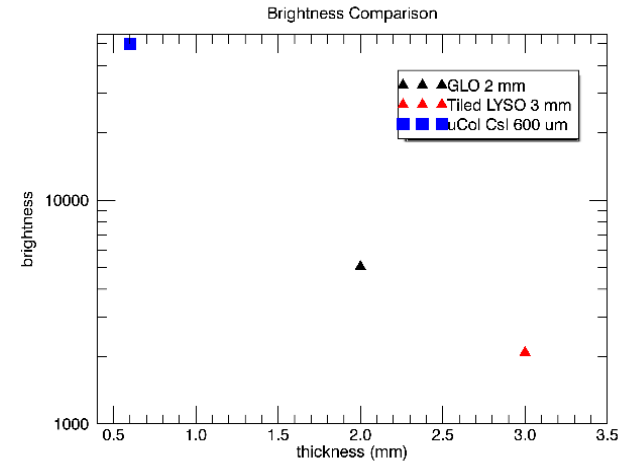
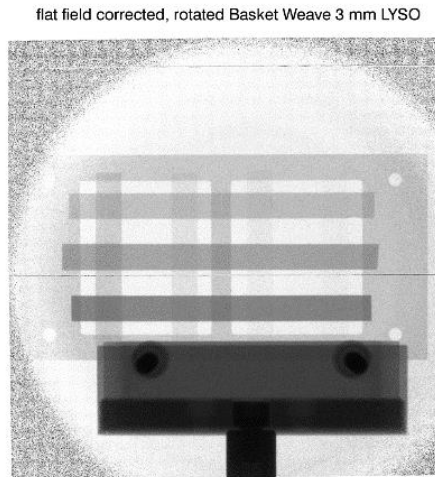
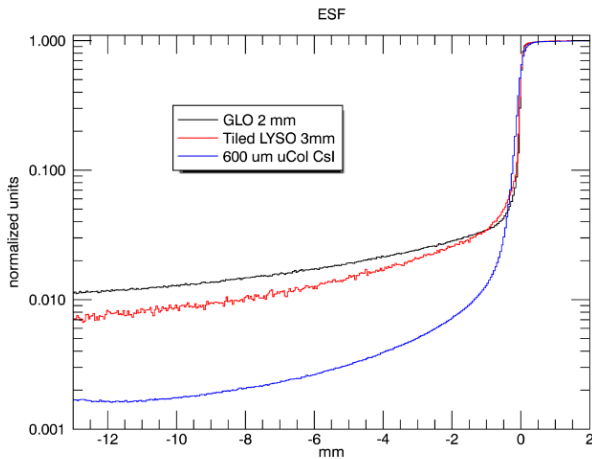


- Examine currently used LYSO scintillators
- Determine performance of new materials



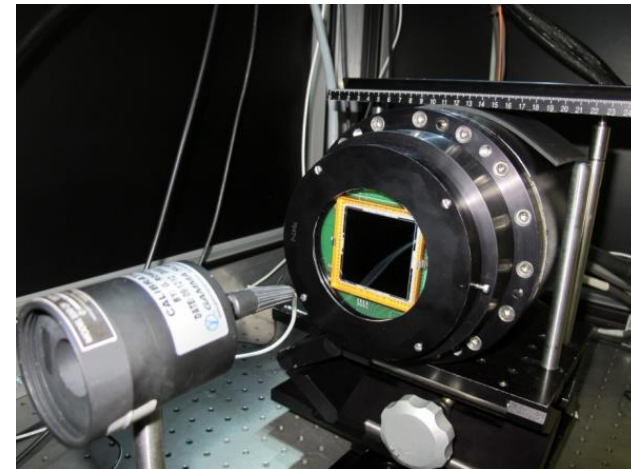
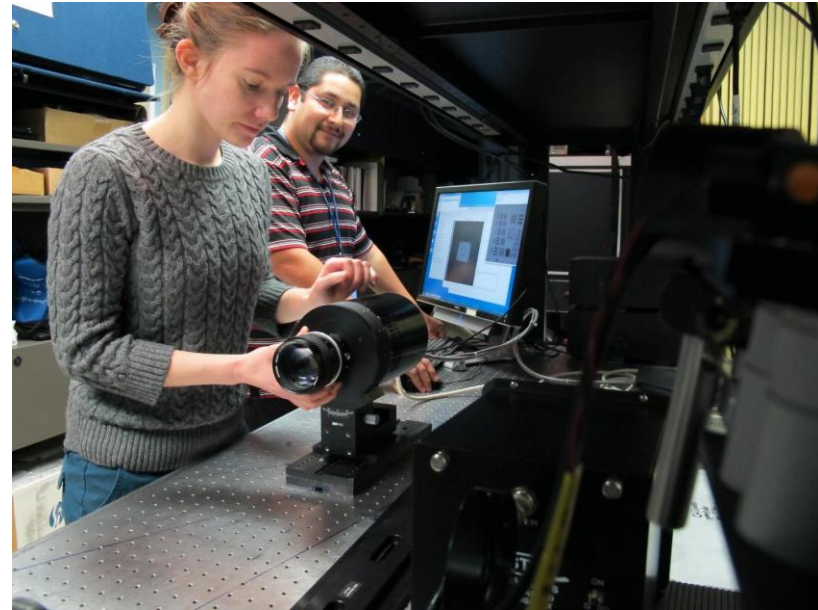
Scintillator Testing

Scintillator	$\rho(\frac{g}{cm^3})$	$\tau (ns)$	$\frac{photons}{MeV}$	Peak emission (nm)	Size (mm)	Max Thickness (on hand)
GLO	9.1	~ms	55,000	610	165 × 165	2 mm
Lul	5.6	~40	100,000	550	45 mm diameter	200 μ m
LYSO	7.1	42	32,000	420	200 × 66	10 mm
Csl	4.5	980	65,000	550	200 × 200	600 μ m



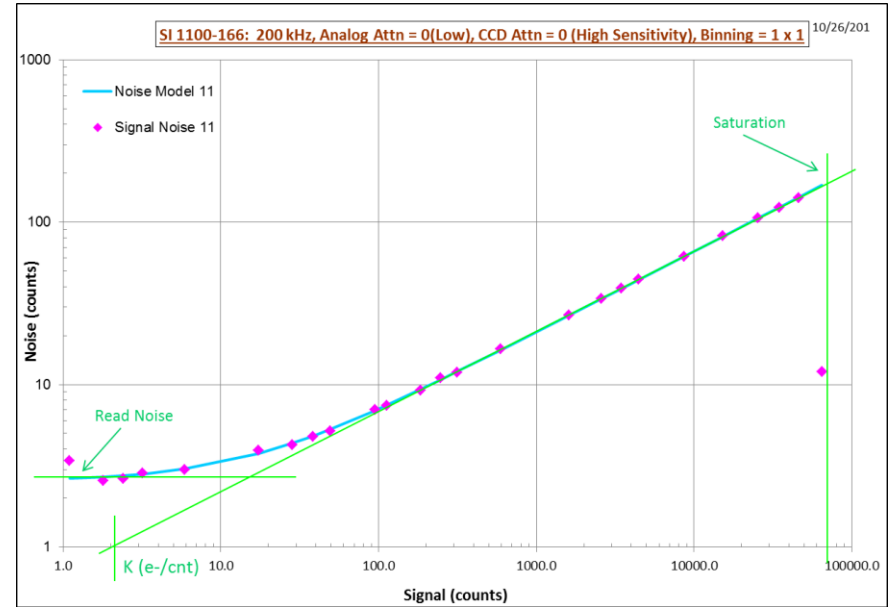
Camera Development/Evaluation

- Provide systematic evaluation of camera performance
- Light-tight camera evaluation box
- Development of digital framing camera
- Radiometric measurements of sensor performance

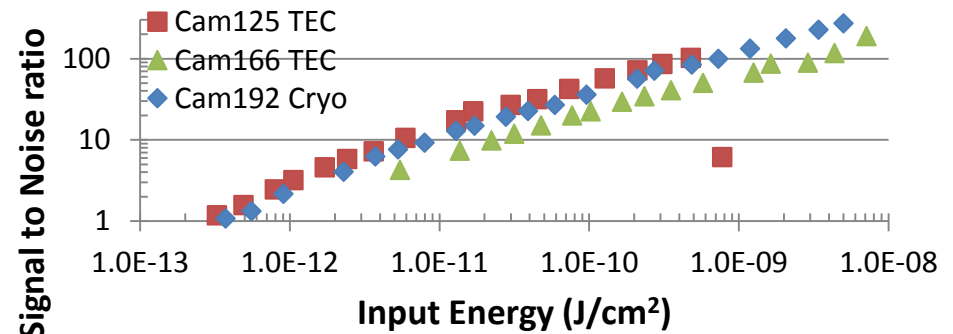


Camera Development/Evaluation

- Produce easily repeatable, low uncertainty transfer curves
- Determine signal-to-noise ratio of camera system with high precision
- Provide sensor dynamic range
- Provide baseline performance for single- or multi-frame cameras

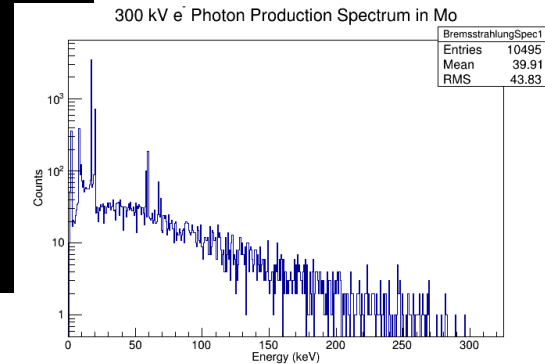
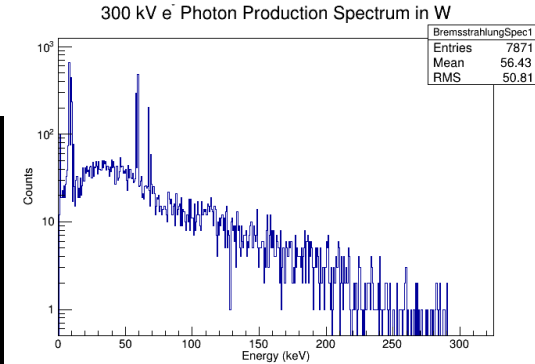
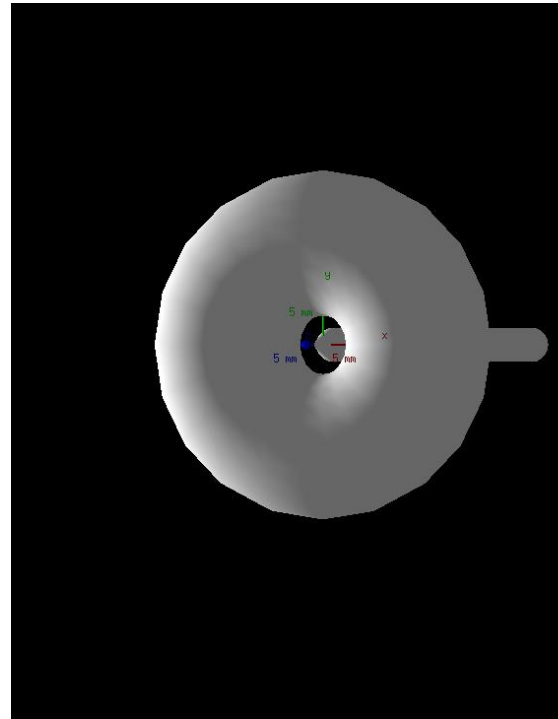


Camera Signal to Noise ratio

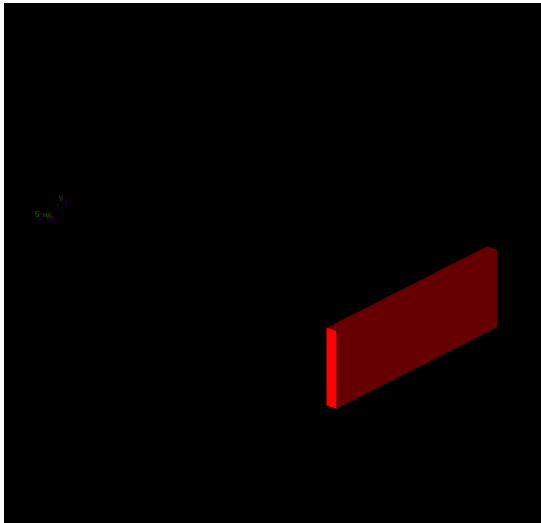


Data Analysis: Source Simulations

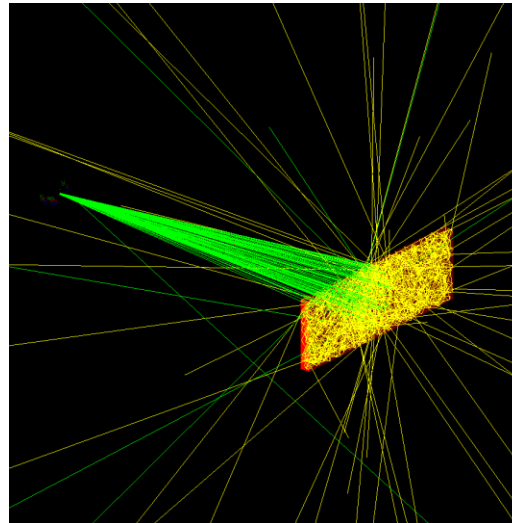
- Lacked current monitors on the Platts x-ray head
- Had to take a guess at spectrum
 - Assumed the end-point was 300 keV in a steady state voltage
- Modeled cathode and anode with GEANT4
 - Lacks electric field, currently shows cathode interaction that is not really there
- Propagate spectrum through experimental configuration



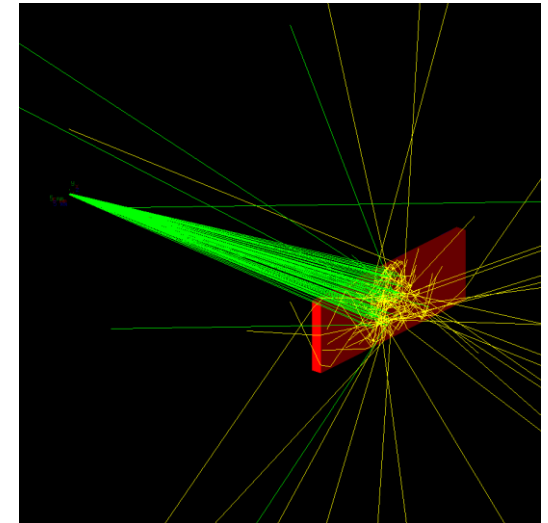
Data Analysis: Scintillator Modeling



- LYSO easily modeled in GEANT4
- Pictured is a single tile in the configuration of the experiment



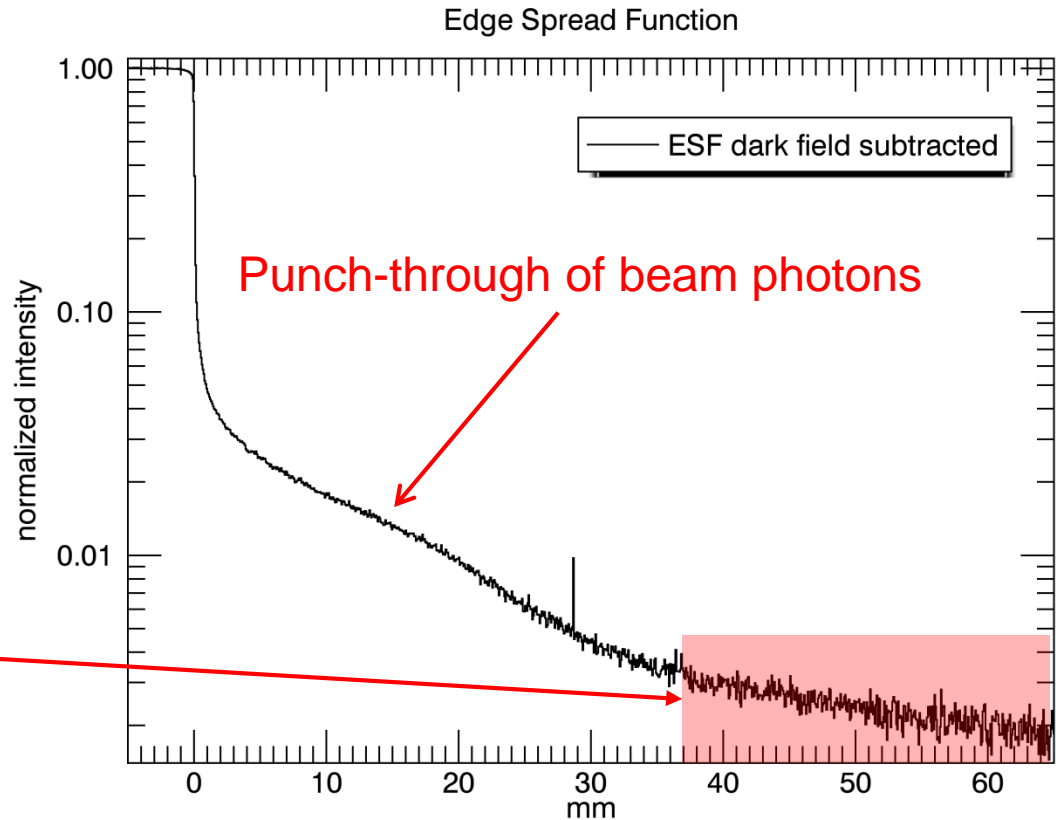
- Propagate modeled Platts energy spectrum through air
- Add scintillation light from scintillator
- Assume a perfectly polished surface



- Add surface effects
- Upstream side has black paint
- Made assumptions about reflection/absorption properties

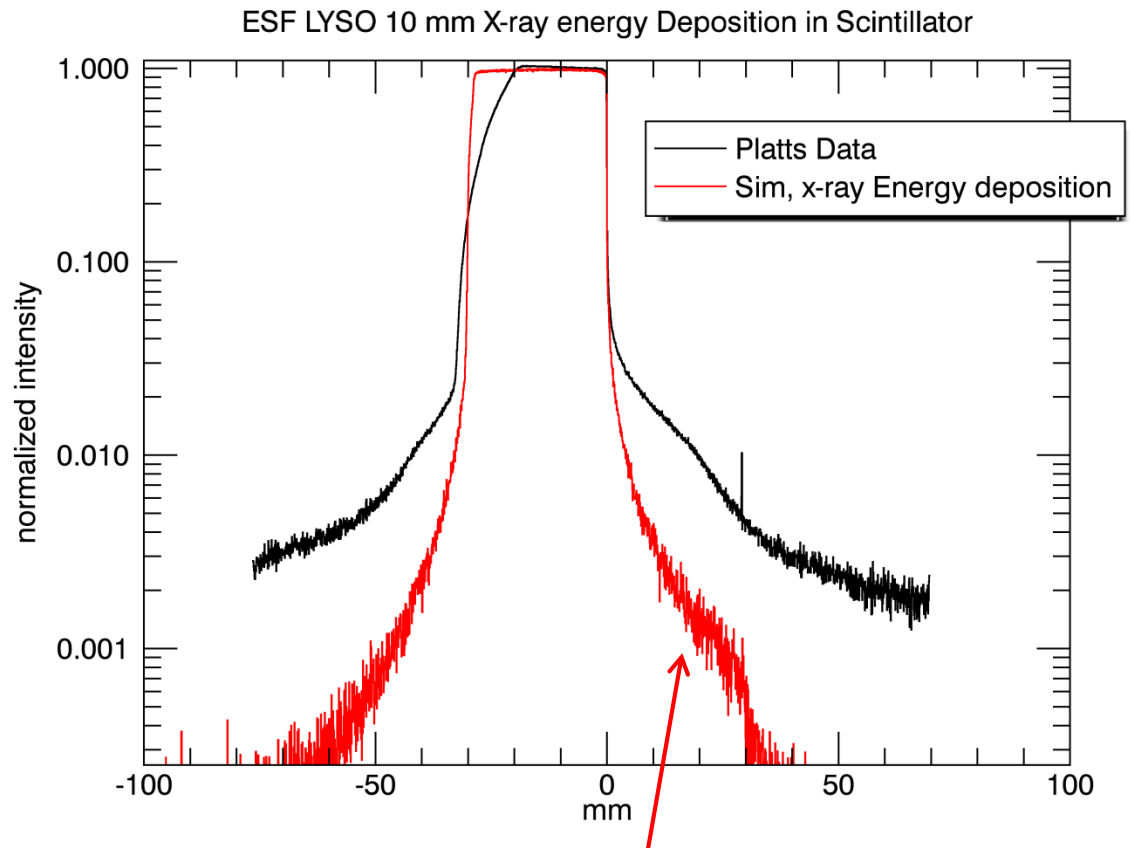
Data Analysis: Scintillator Evaluation

- Edge spread function of dark field subtracted region doesn't go to zero even at long range
- Beam punch-through of CuW observed
- Beyond beam signal still not in the noise
 - Long-range blur



Data Analysis: Scintillator Evaluation

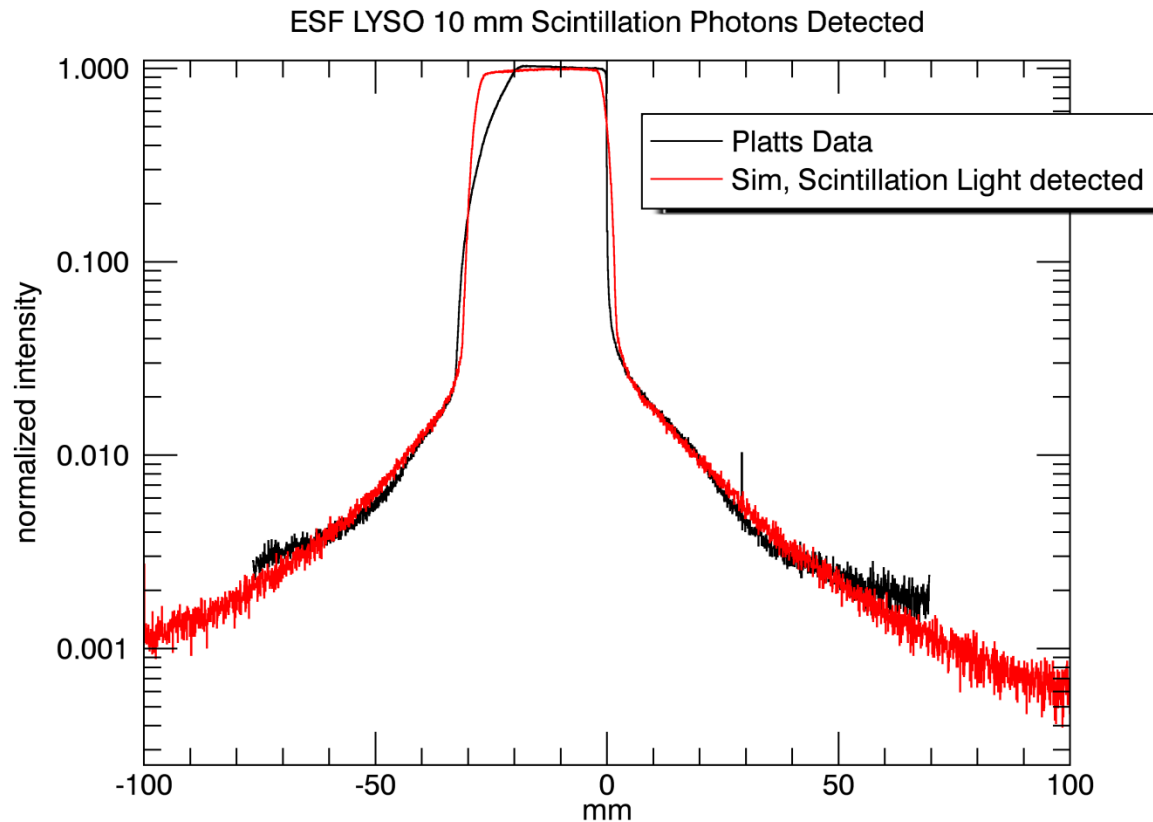
- GEANT4 simulations of the experimental setup made (red)
- X-ray energy deposition in the scintillator shows the range of x-rays
 - Shows punch-through observed in data
- Doesn't account for long-range observation



Punch-through of beam photons

Data Analysis: Scintillator Evaluation

- GEANT4 simulations of the experimental setup made (red)
- Scintillation photons are transported
 - Includes LYSO emission spectrum, polished front and sides, and painted back; assumes single tile
 - Absorbs 91%, 20% specular reflection, 20% backscatter, 60% diffuse reflection
- Qualitative agreement seen



Surface effects can account for long range blur

Data Analysis: Radiography Processing Software, RadPro

- Easy processing of data
 - Designed for minimal user input
- Currently used with Cygnus
- Provides quick-time look of data on site
- Saves option parameters for day-to-day use

