

Cosmic Ray Dosage and Shielding in GEO

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Outline

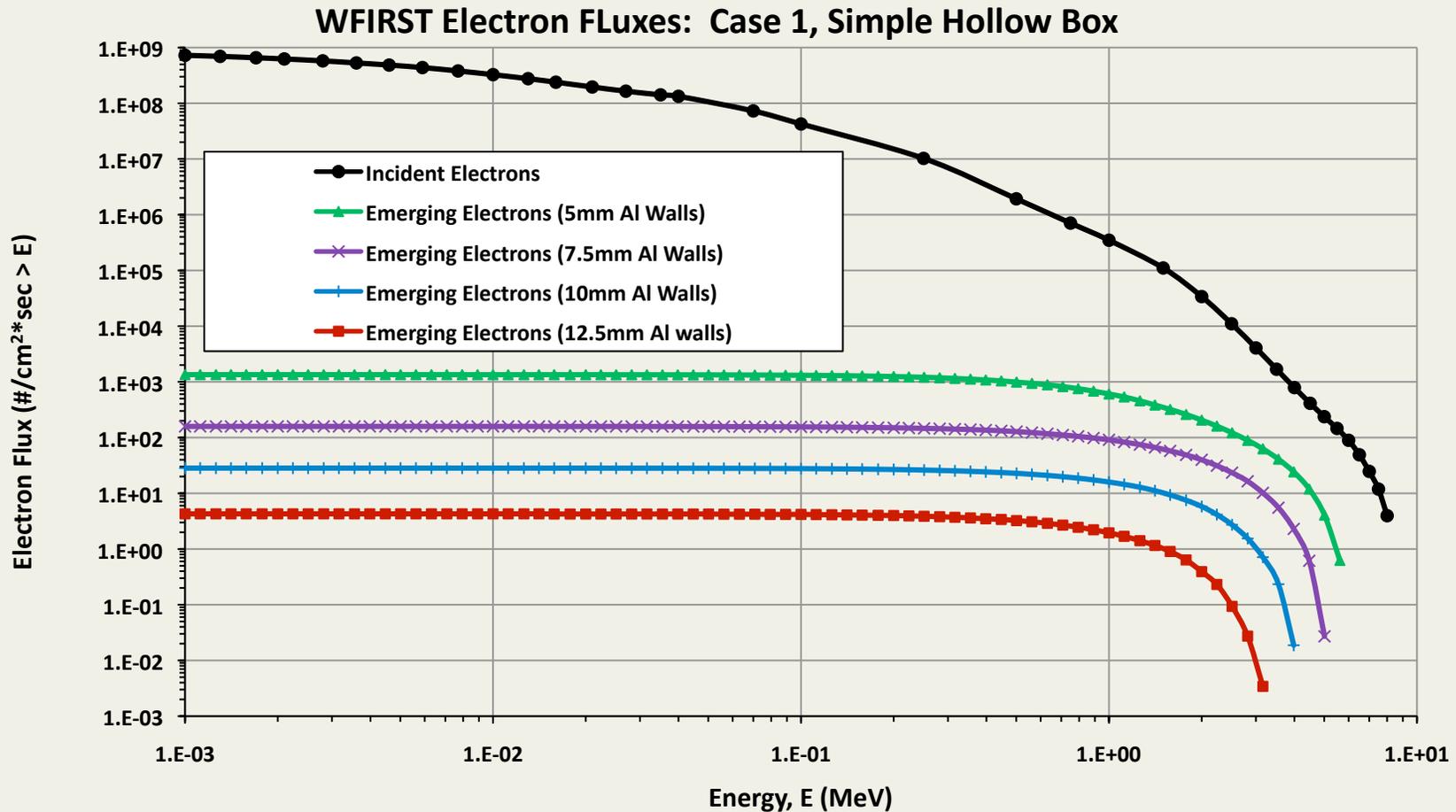
- Initial shielding study
- Interactions with HgCdTe
 - Cleaning with Sample-Up-The-Ramp
 - In-flight vs ground processing
- Time variability of radiation environment
- Future work

Initial Shielding Study

- Three cases:
 1. Simple aluminum sealed box
 2. Al/Pb sealed box
 3. Box with lid displaced
 - What gets in w/o direct line-of-sight trajectory
 - Proxy for open light path with lid = last mirror in path
- Use annual-average electron flux distribution in GEO-synch orbit

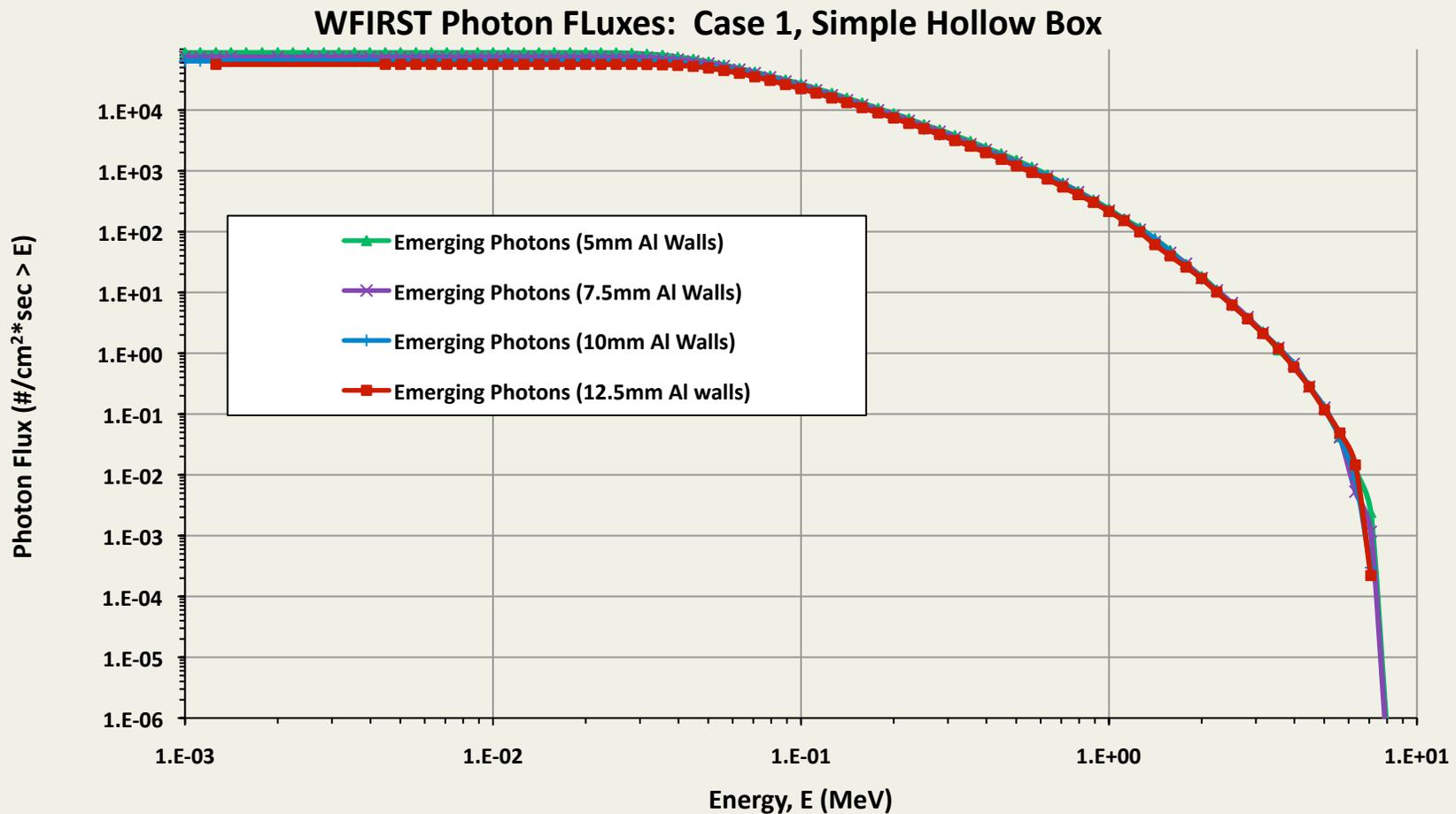
Calculations done by Mike Xapsos of GSFC radiation branch

Case 1: sealed Al box – e- flux



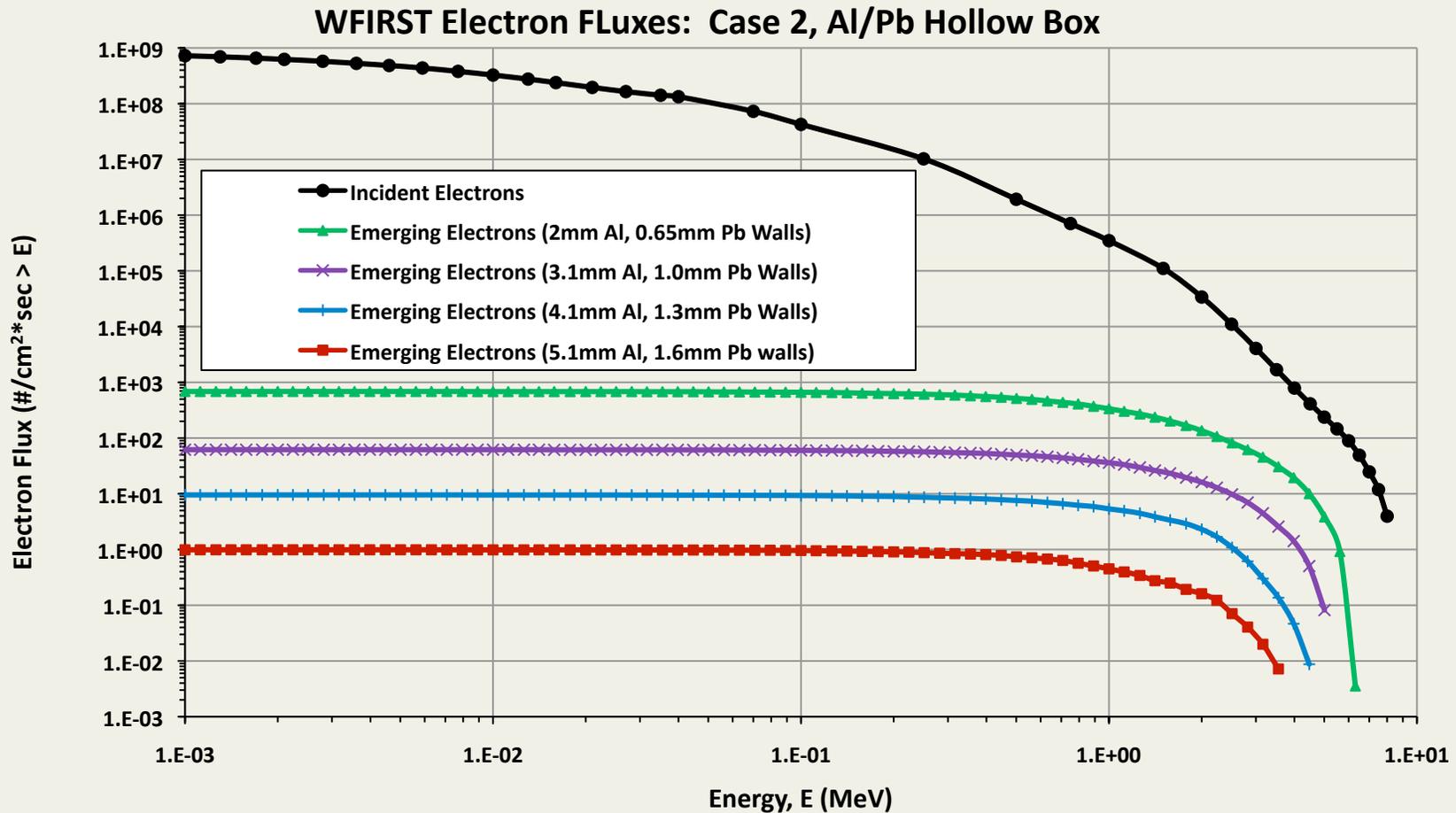
For reference: proton rate at L2 is $\sim 5/\text{cm}^2/\text{s}$ – about the red line above

Case 1: sealed Al box – γ flux



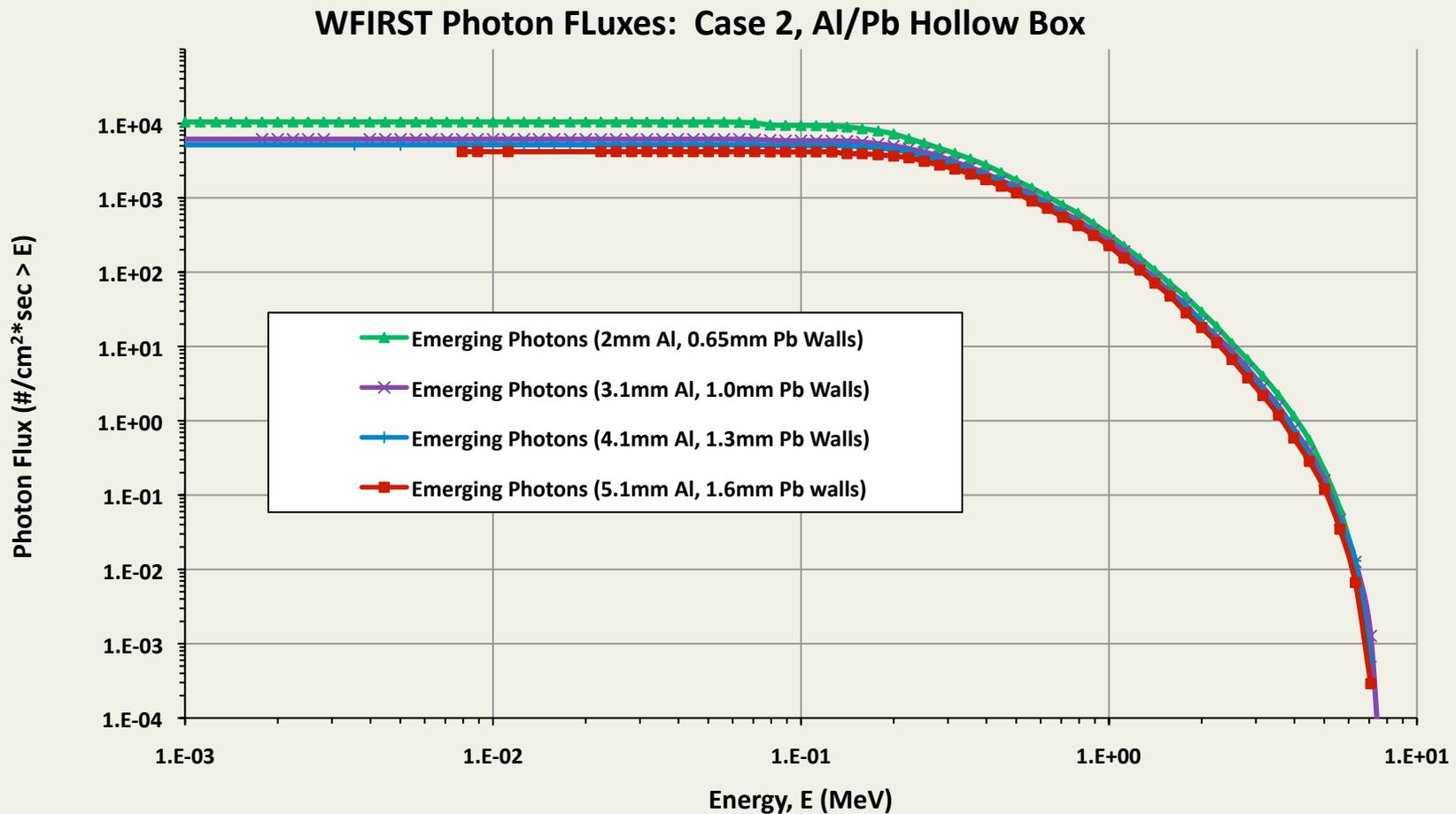
Photons produced by high-energy tail of e^- distribution; few produced after first few mm of e^- path length.

Case 2: Al/Pb sealed box – e- flux



Order of Al/Pb doesn't matter for electrons

Case 2: Al/Pb sealed box – γ flux

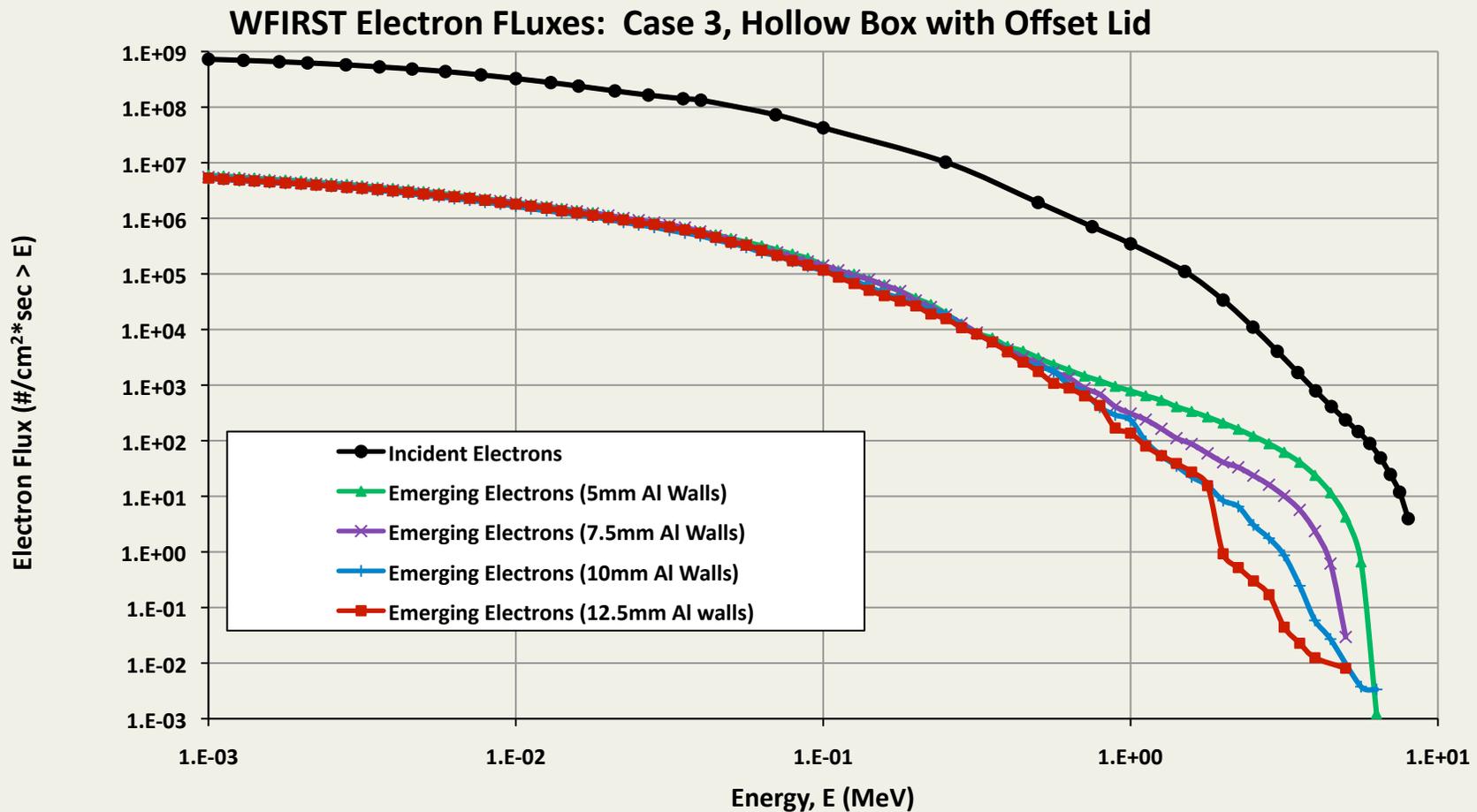


Putting Pb on outside increases photon flux by 10X

Υ flux - continued

- Convolve the photon spectrum with weighted mean of Hg,Cd,Te photo-electron and scattering cross-sections:
 - ~ 5.2 events/cm²/s
- Roughly comparable to proton flux at L2
- W/in striking distance of enough shielding
 - 5.1mmAl+1.6mmPb gives net e-/ Υ event rates 2X proton rate at L2, or 3X L2 for total rate

Case 3: displaced lid – e- flux



Need multiple labyrinth seal or window in light path

CR removal by “Sample up the Ramp”

- Read detector continuously throughout exposure.
- In principle, CRs can be removed by dropping individual detector readouts.
- Even minimum-ionizing charged particles leave large signal: easily detected and flagged
- Potential complication:
 - Small amounts of charge deposited in pixels adjacent to main track
 - Photon conversions that deposit only a little charge in a pixel

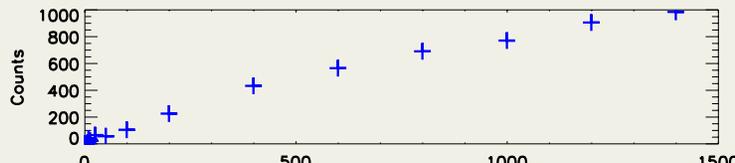
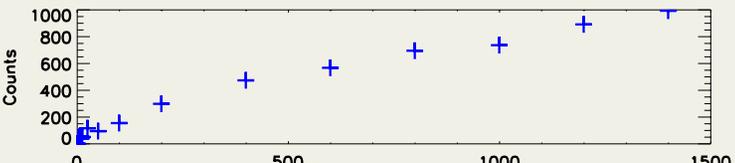
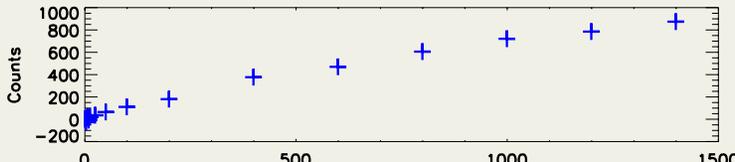
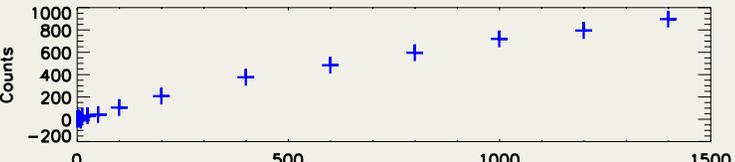
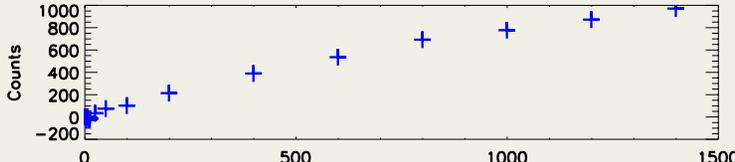
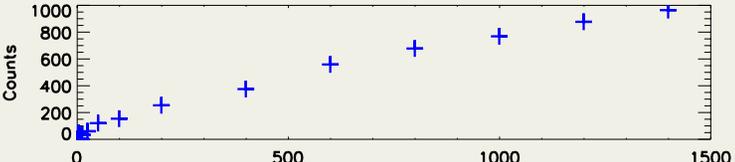
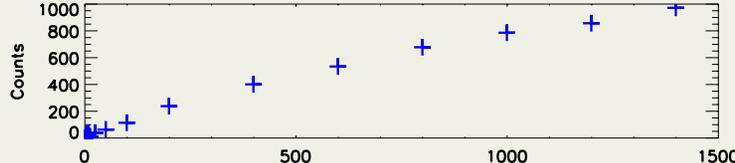
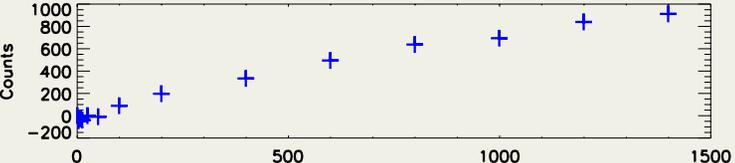
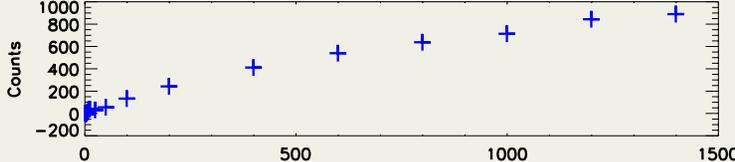
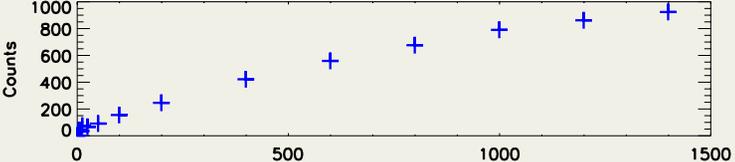
CR removal continued

- Processing individual pixel readouts on-board is demanding but straightforward in principle
 - Some risk if detection algorithm is not robust
 - Cleaning adjacent pixels requires much more processing power
- If a large subset of samples are downlinked, then pixels adjacent to clearly detected events can be pruned on the ground.
 - Easier to adapt to idiosyncracies of data

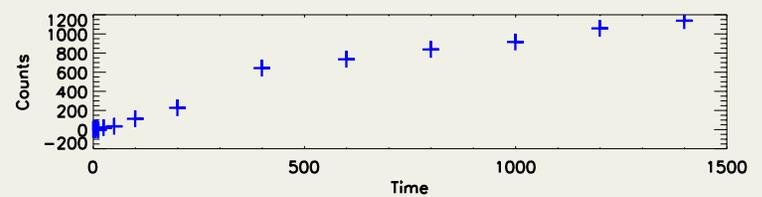
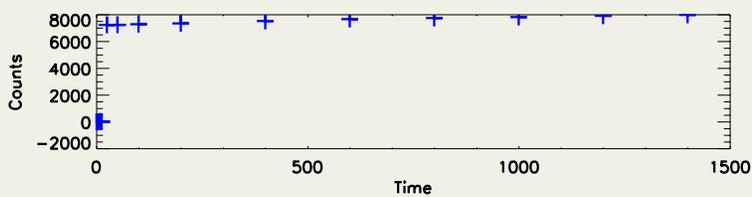
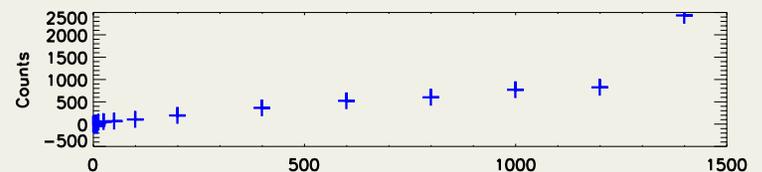
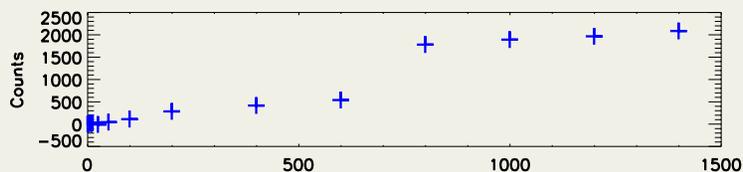
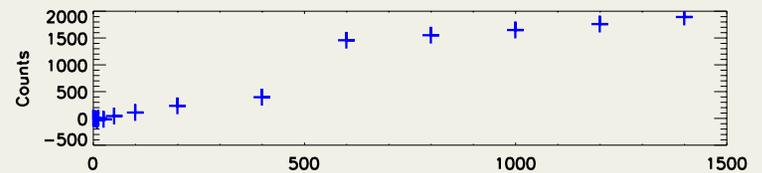
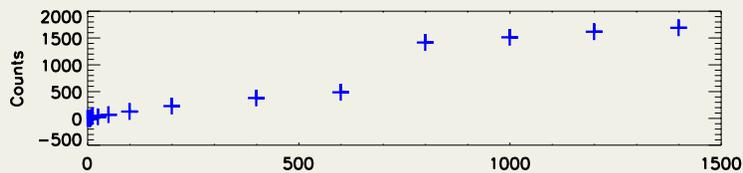
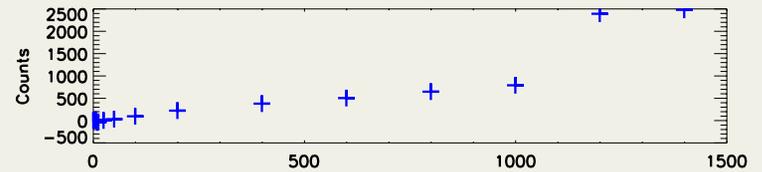
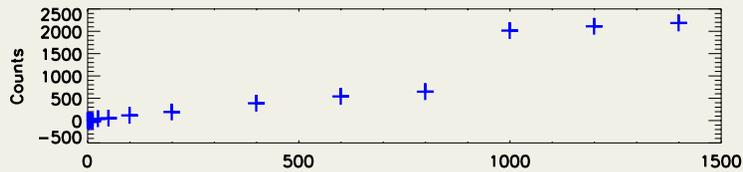
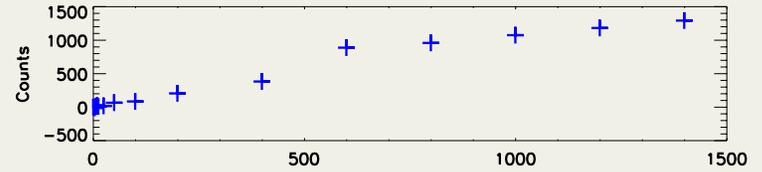
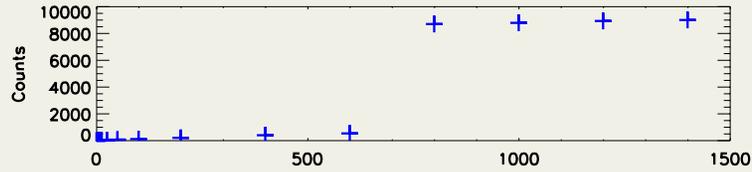
Examine CANDELS data

- CRs are primarily protons, but WFC3 IR detector is otherwise representative
- Wrote custom SUTR algorithm to process archival WFC3 IMA files.
 - First flag samples with 4.5 sigma jumps in rate
 - Also flag same sample in adjacent pixels
 - Refit count rates, excluding flagged samples
 - Histogram residuals to fits

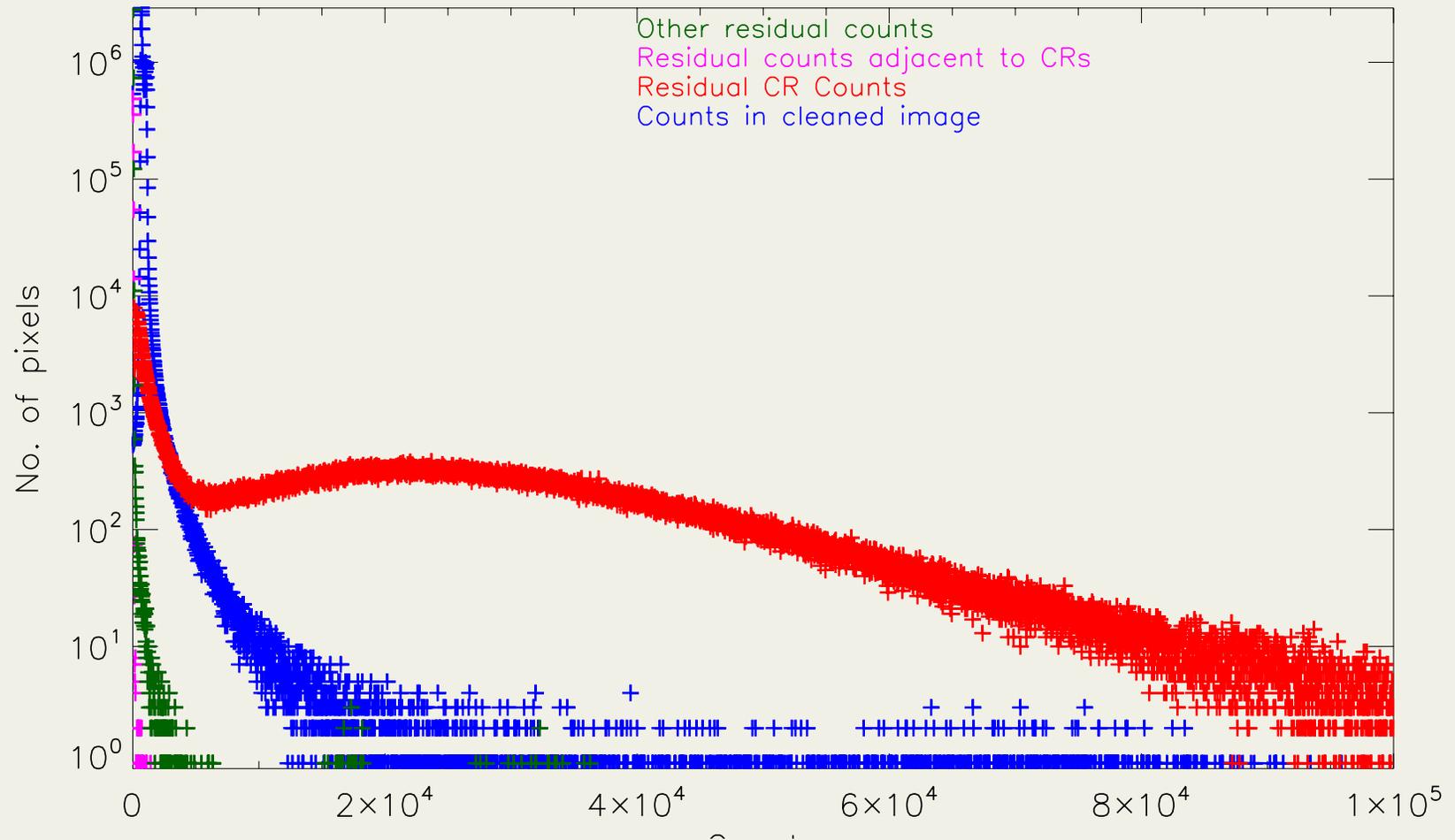
CANDELS non-CR examples



CANDELS CR examples

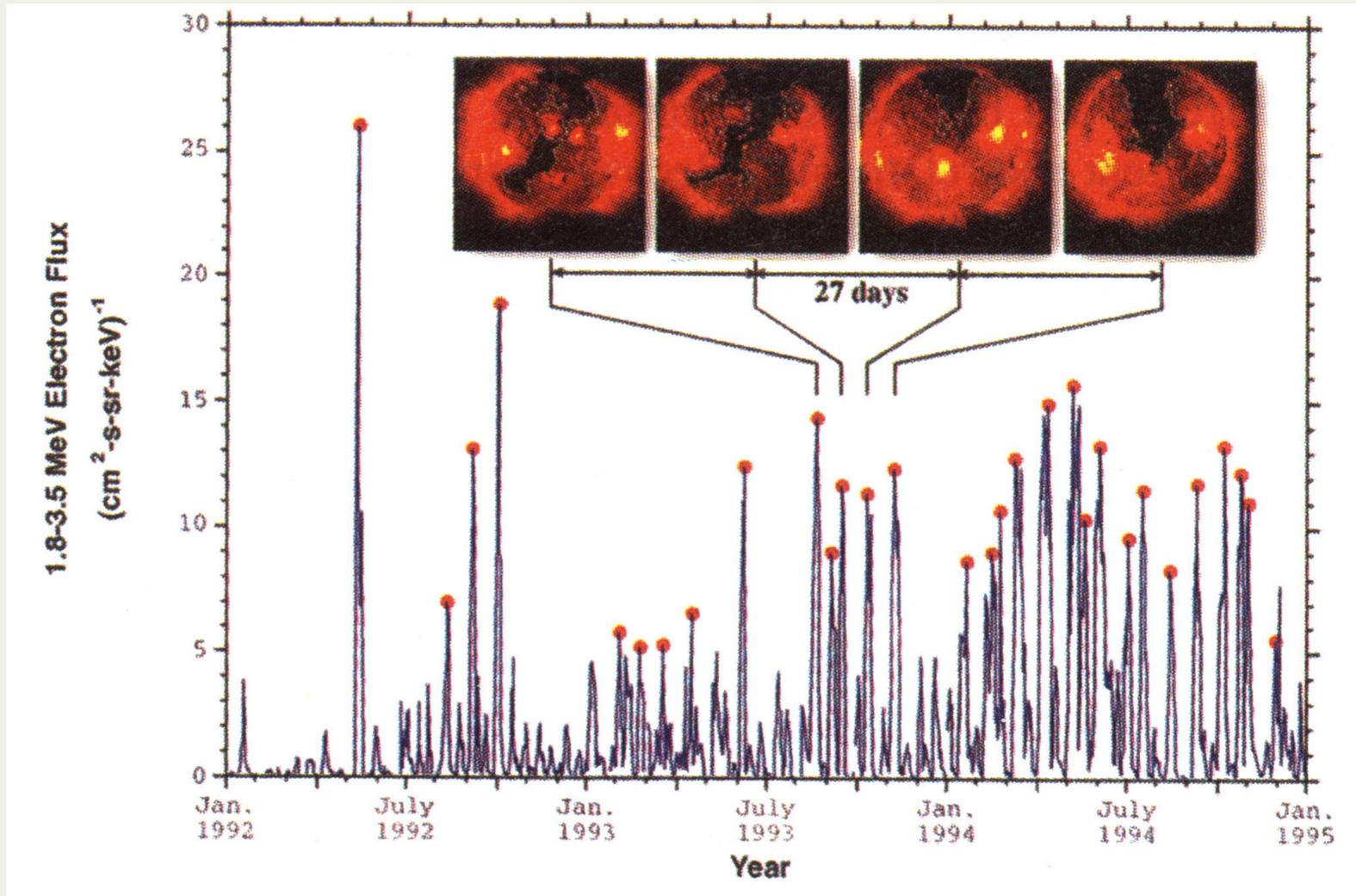


Results for residuals to SUTR fit



For protons, no significant sub-threshold charge deposited in adjacent pixels

Time Variability



Future work

- Calculate shielding properties of composite material
 - Lower Z than Al, so less bremsstrahlung
- Calculate shielding of suitable optical materials
- Evaluate more realistic enclosure geometries
- Set up more detailed model of detector, propagate electrons properly to assess track characteristics
- Obtain more information on time variability.