Geant4 Simulations of Space Radiation Sensors at The Aerospace Corporation

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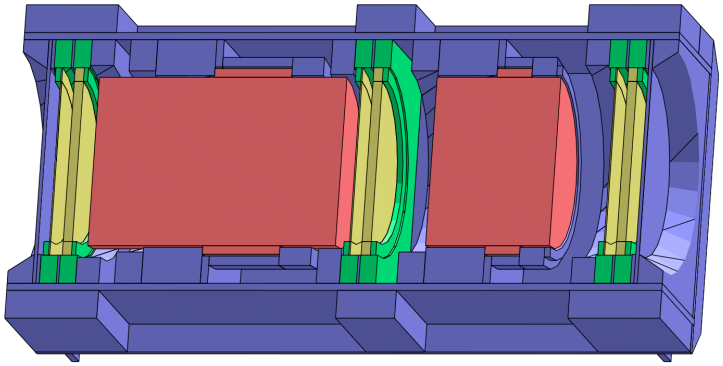
Recent Space Missions and Radiation Sensors

- Cosmic Ray Telescope for the Effects of Radiation (CRaTER)
  - *Launched June 2009 aboard Lunar Reconnaissance Orbiter (LRO)*
  - *Nominal mapping orbit is circular at 50 km altitude, polar*
  - *Purpose is to measure energy deposit spectra under shielding*
- Relativistic Proton Spectrometer (RPS)
  - *Launched August 2012 aboard Radiation Belt Storm Probes (RBSP)*
    - After launch, renamed Van Allen Probes
  - *Two S/C in near-equatorial, elliptical Earth orbits out to 5.8 Earth radii*
  - *Sensor to measure protons up to GeV in heart of Inner Van Allen Belt*
- Magnetic Electron Ion Spectrometer (MagEIS)
  - *Also aboard Van Allen Probes*
  - *Focus here on electron sensors, tens of keV to several MeV*

CRaTER Sensor Head



- Six silicon solid-state detectors
- Thick detectors measure low LET and thin detectors measure high
- Two cylinders of A-150 Tissue Equivalent Plastic in stack

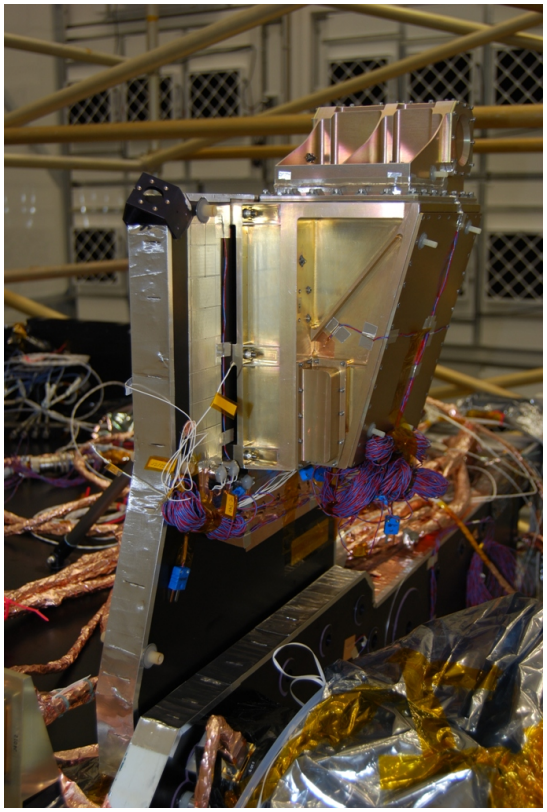
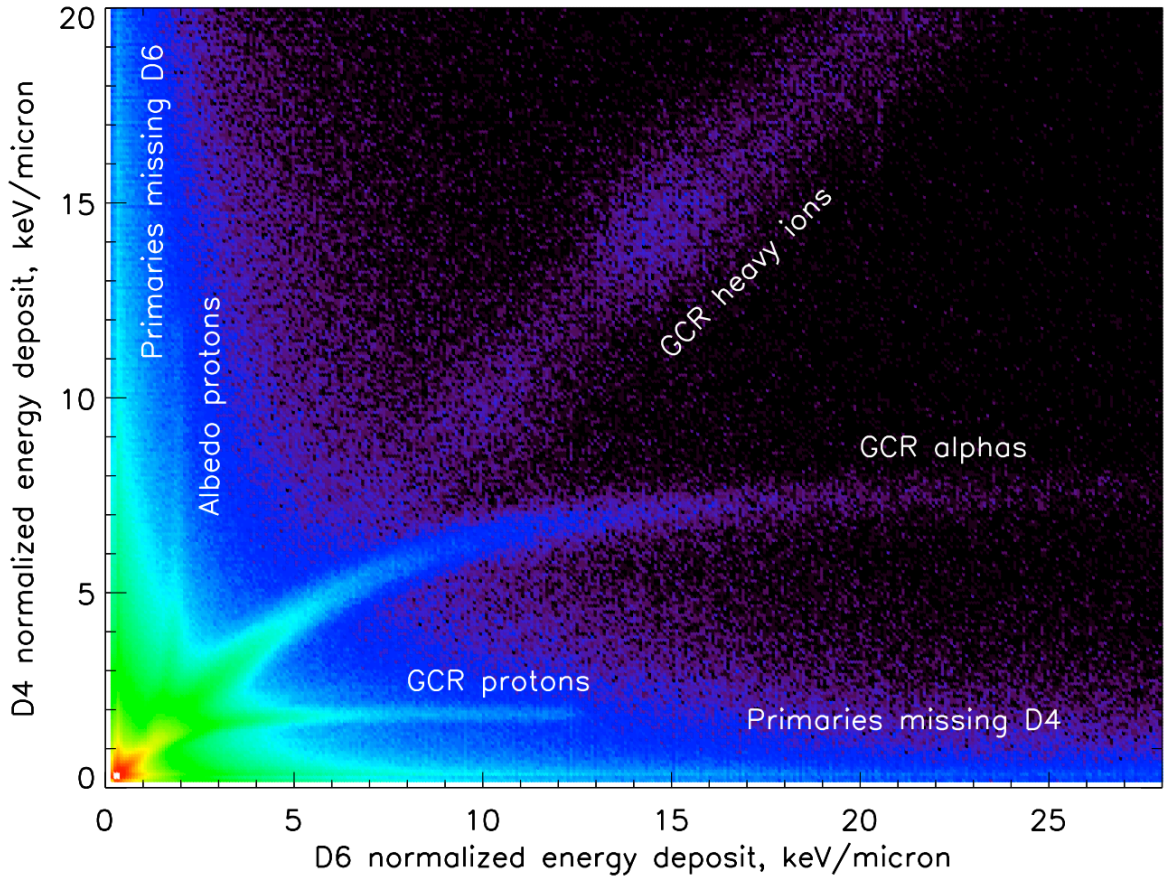
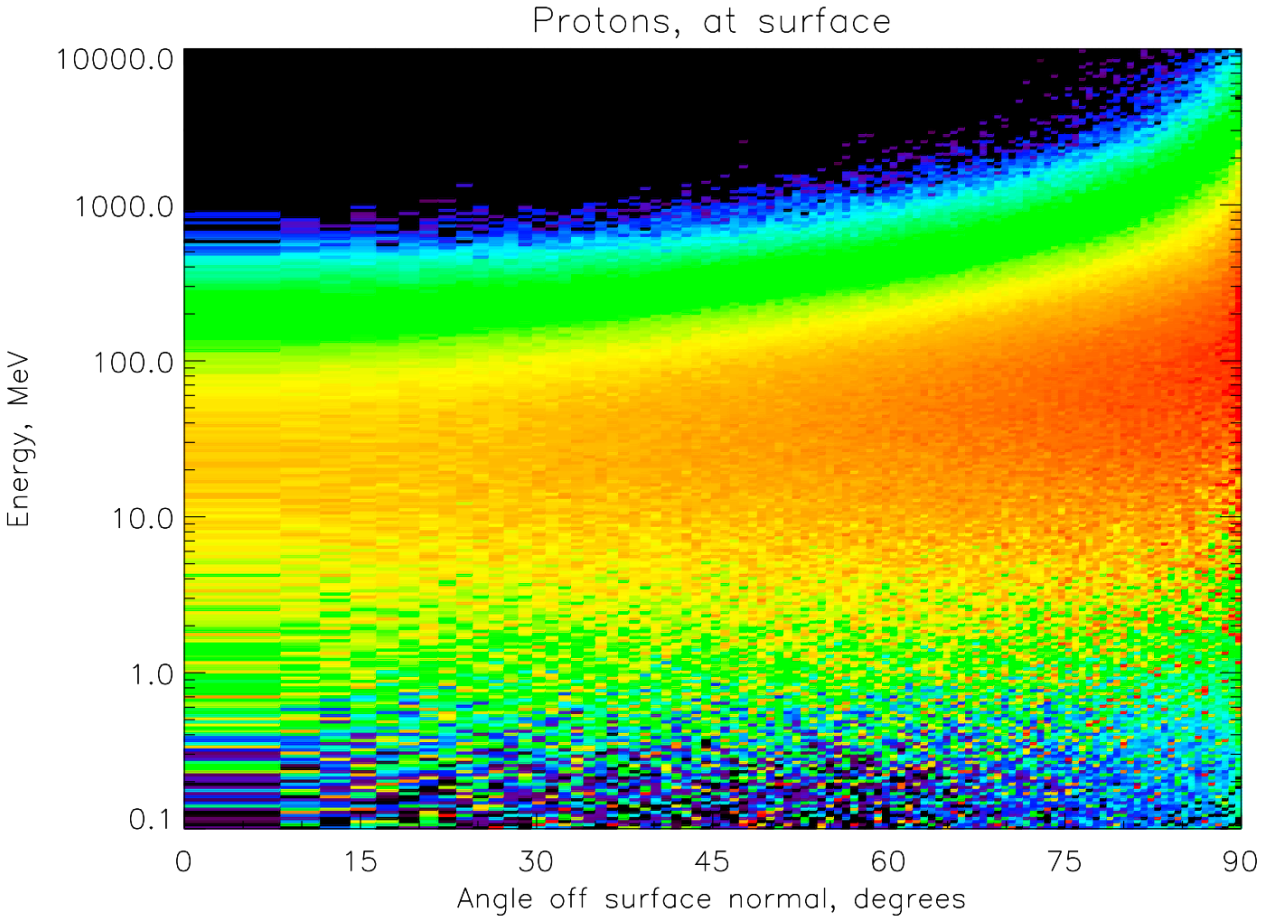


Photo courtesy of NASA

Observations During Recent Solar Minimum



Geant4 Simulations of Lunar GCR Secondaries



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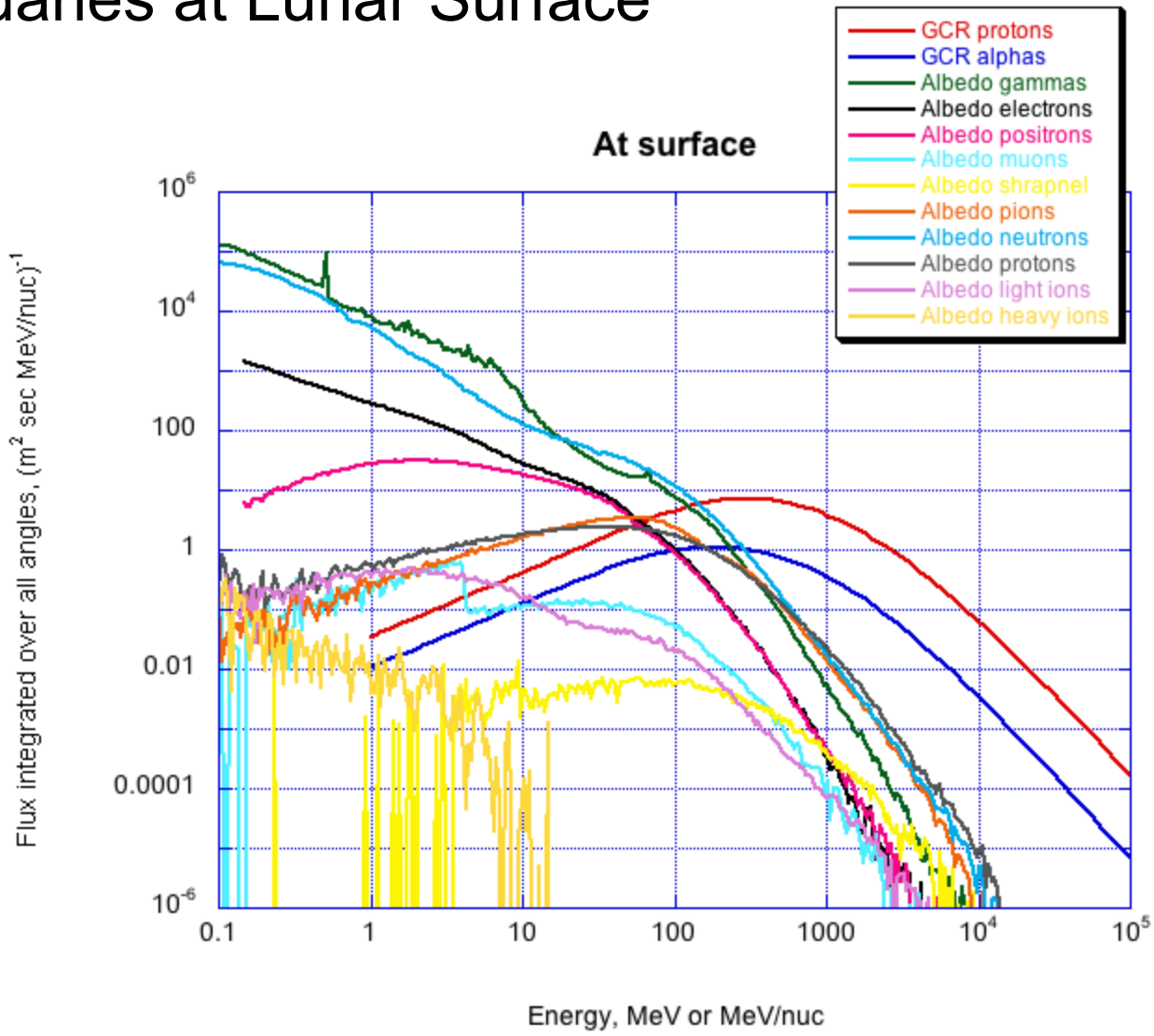
Secondaries at Lunar Surface



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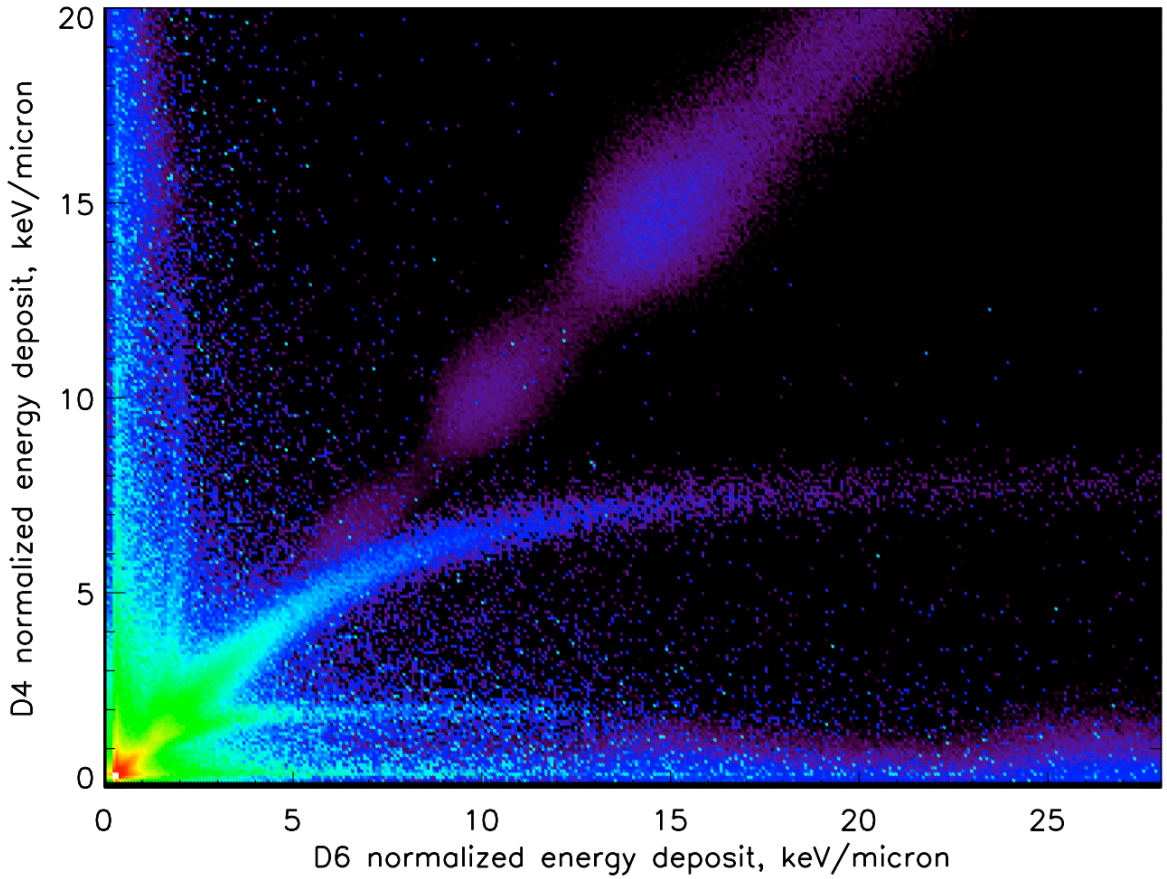
Geant4 Simulations of ~D2D4D6 Double Coincidences



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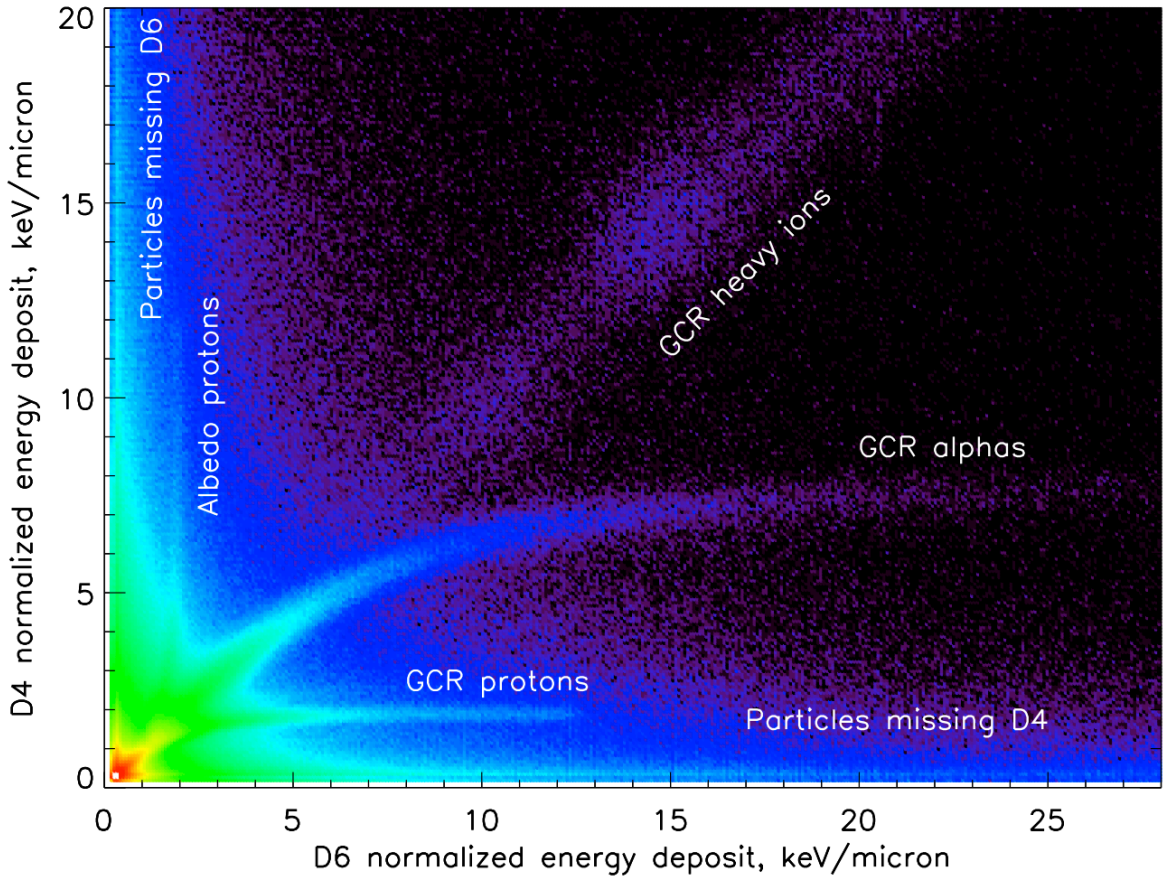
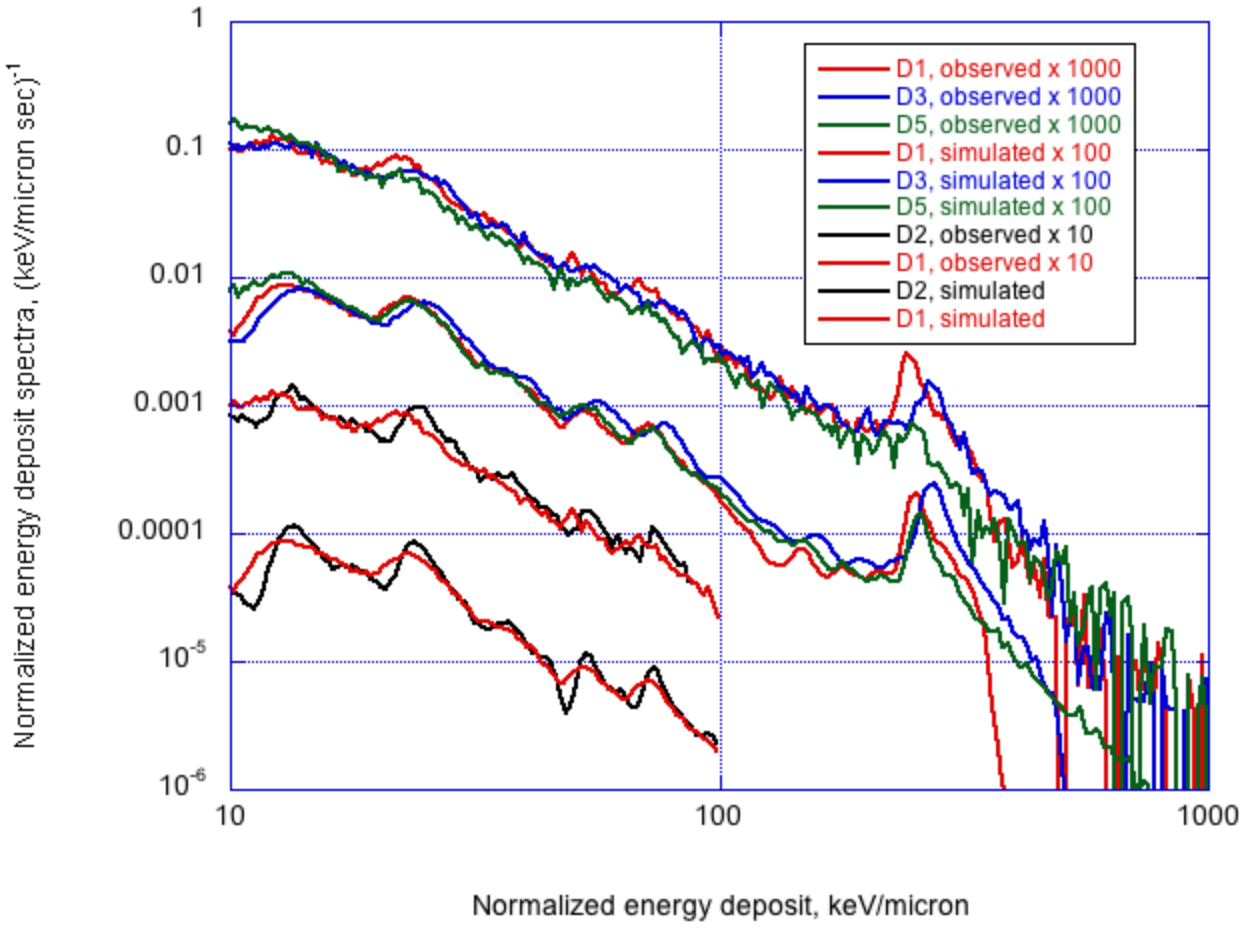
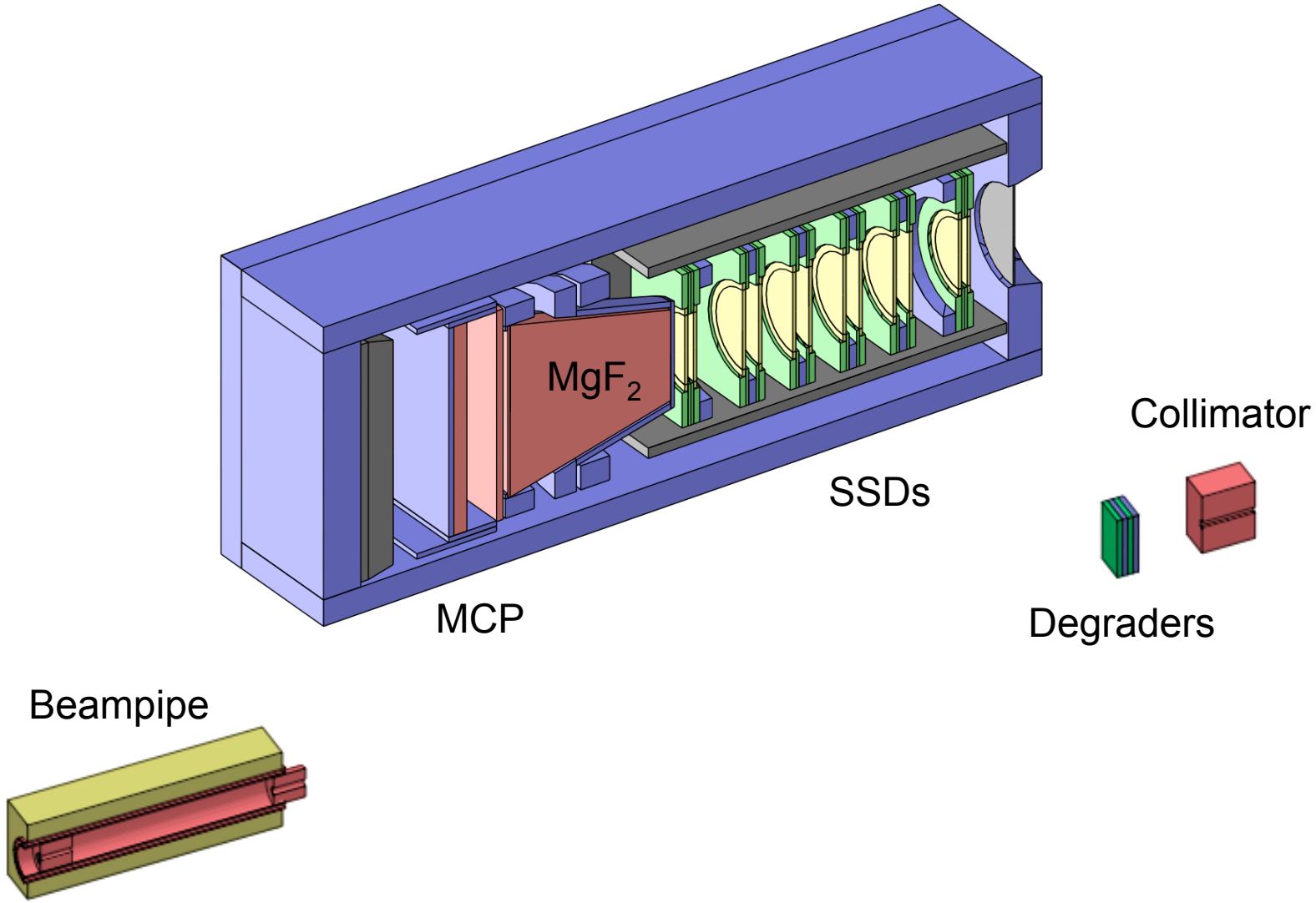
Observations During Recent Solar Minimum



Detailed Comparisons of Heavy-Ion Energy Deposits



RPS Sensor Head and TRIUMF 500 MeV Beamline



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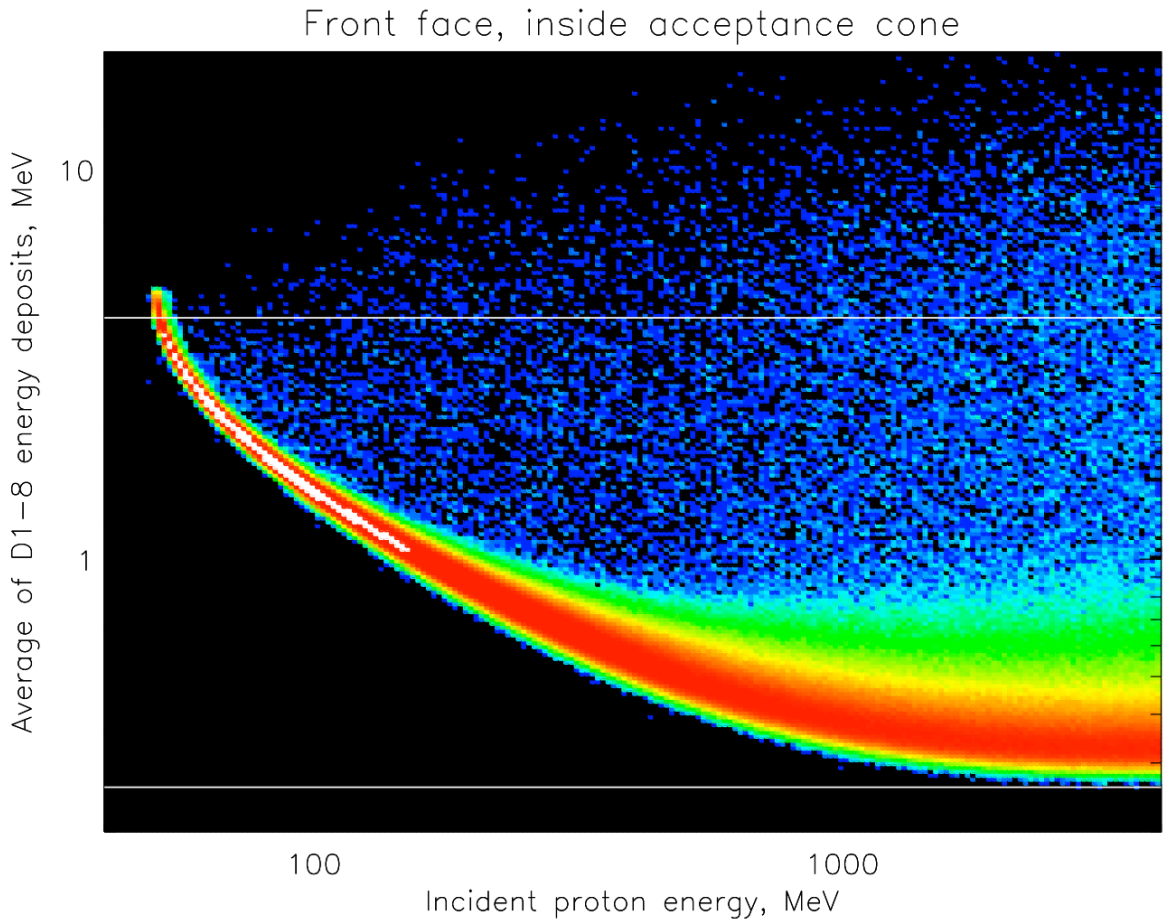
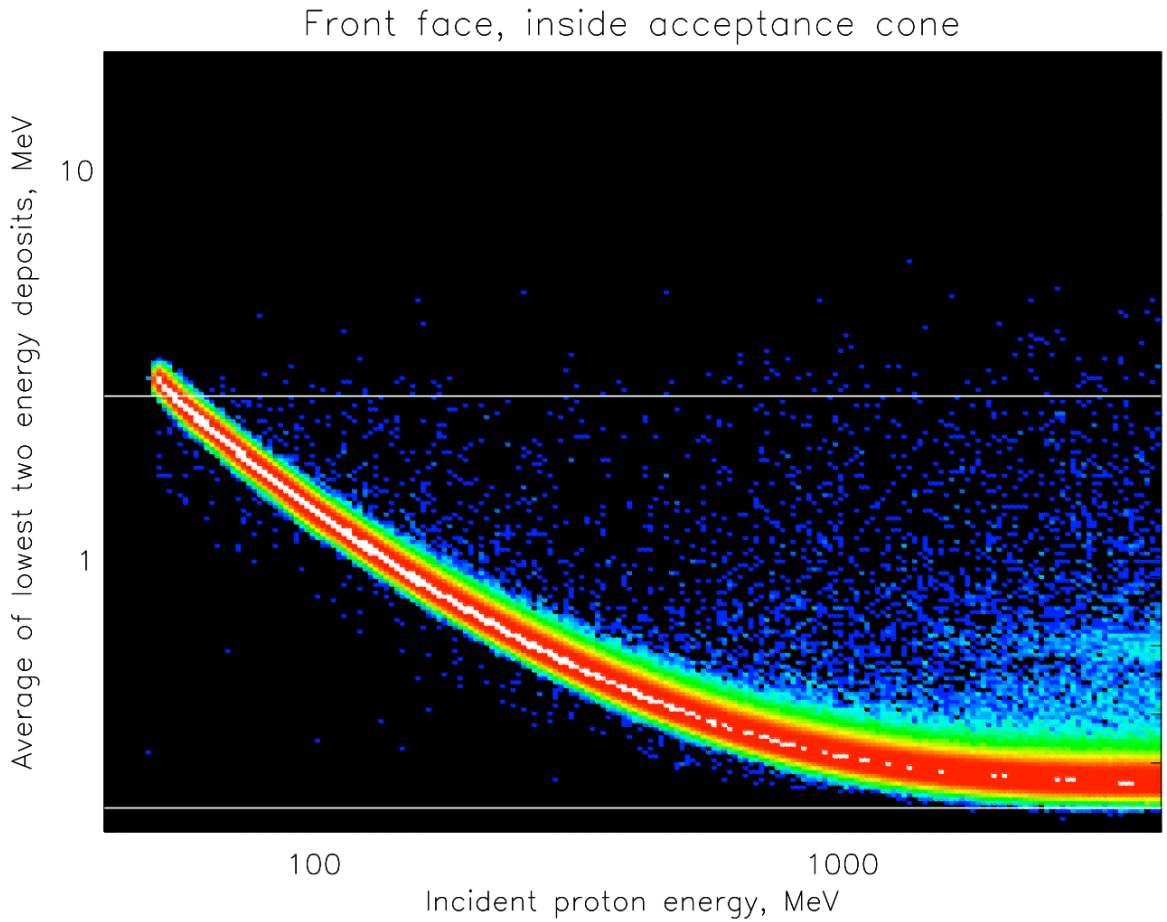
Simulation of Silicon Detector Response In-Aperture



Simulation of Silicon Detector Response In-Aperture



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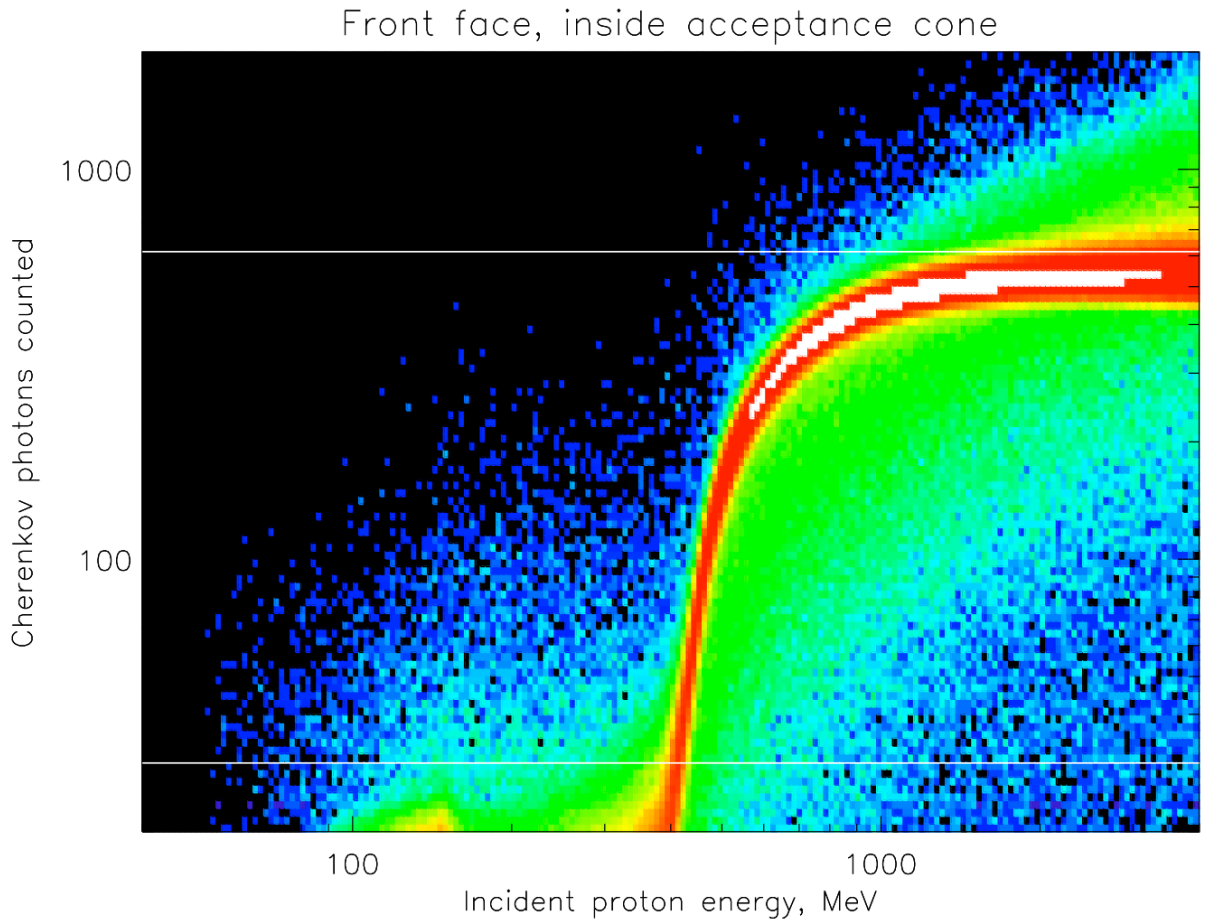
Simulation of Cherenkov Response In-Aperture



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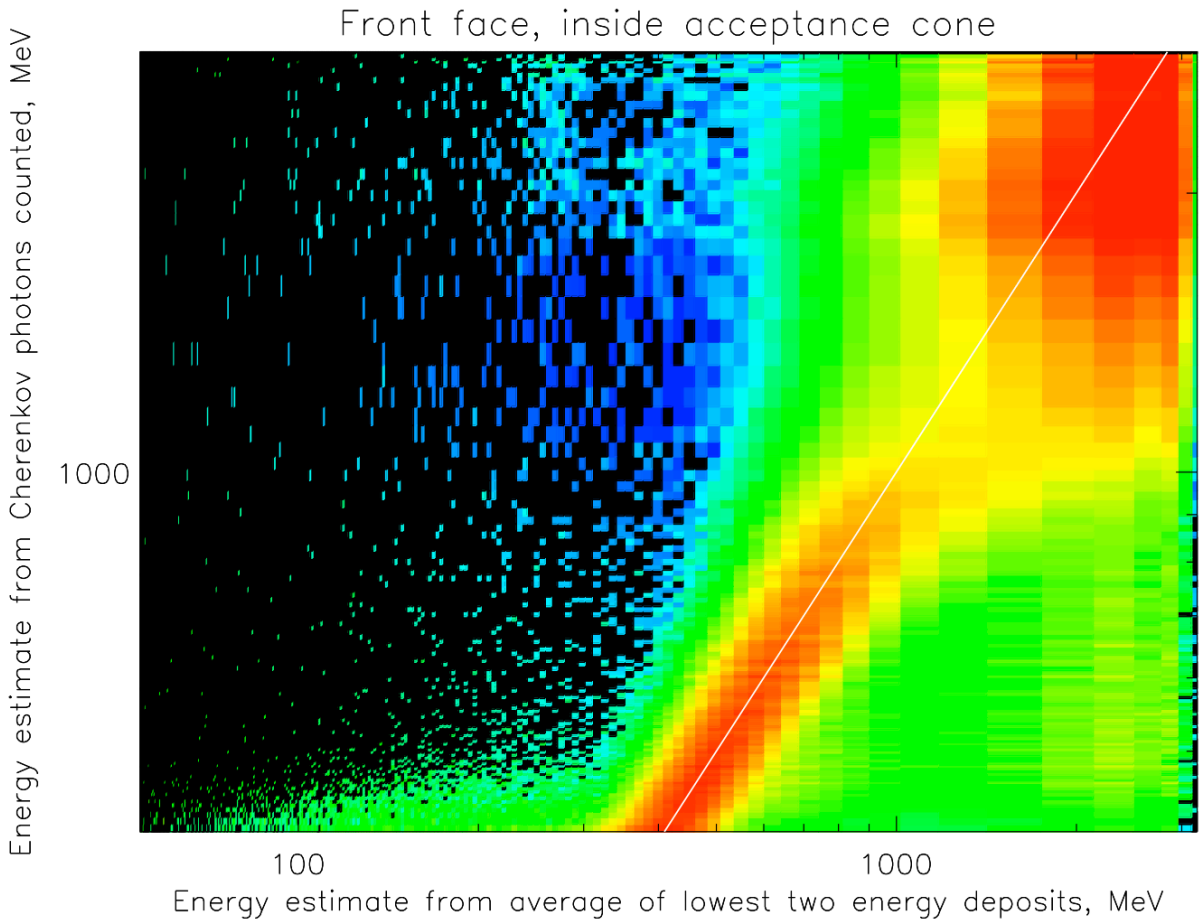
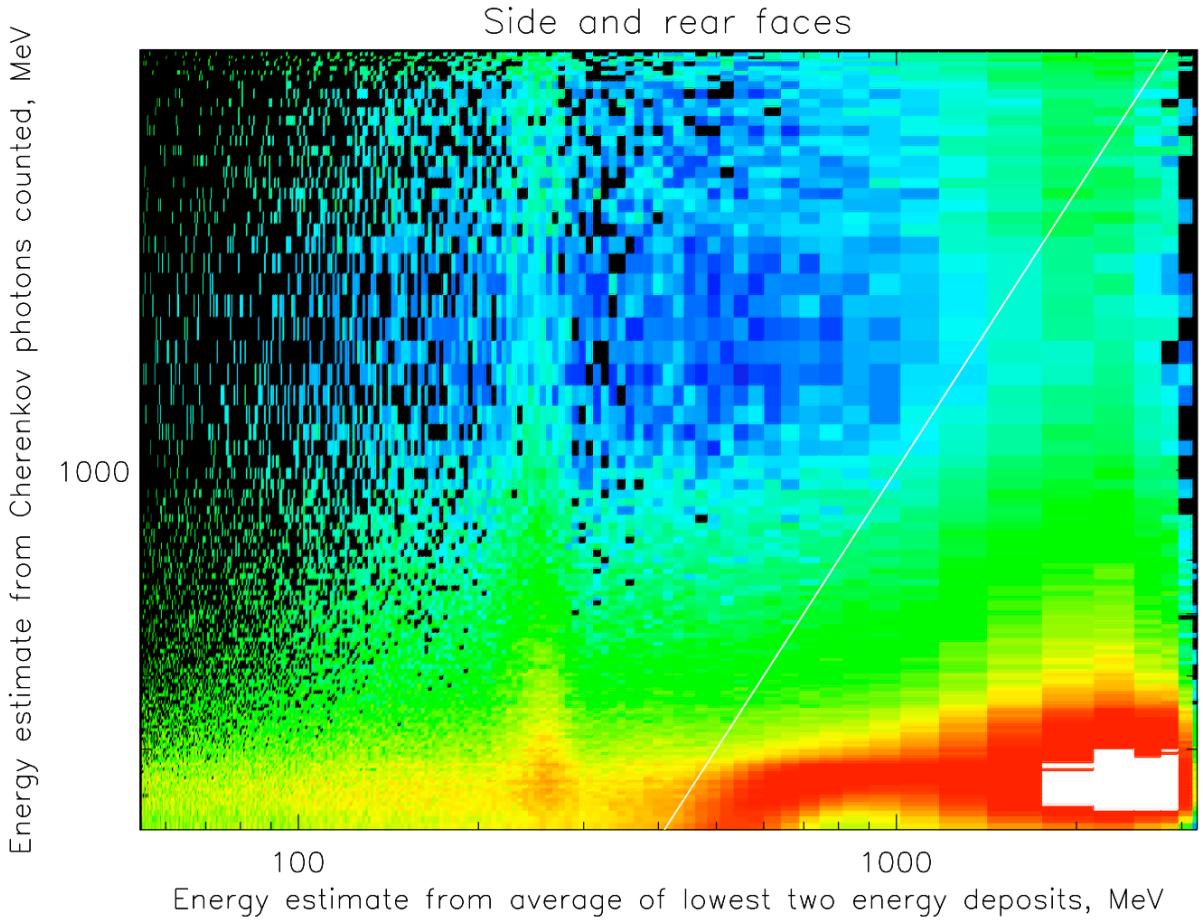
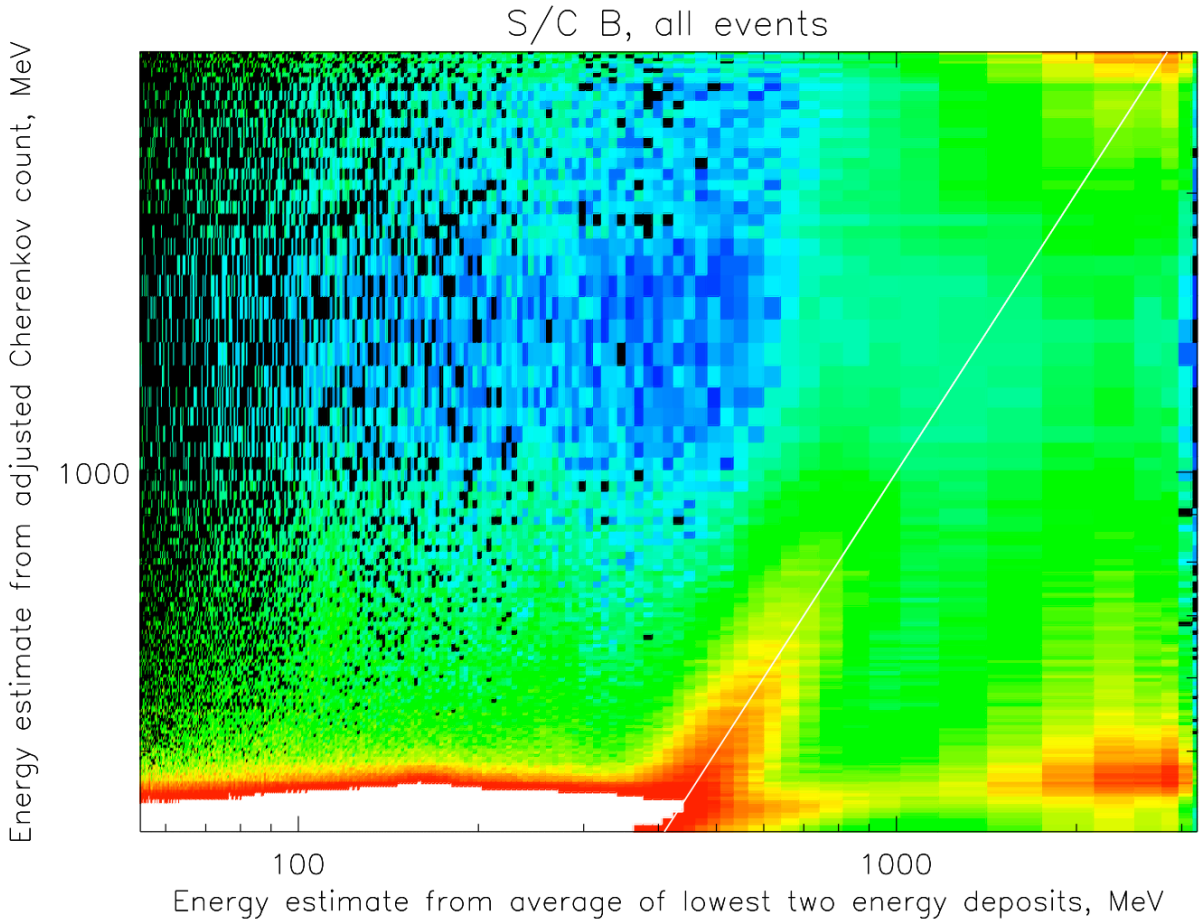
Geant4 Simulation of Response In-Aperture



Geant4 Simulation of Response From Sides & Back



Observations of GCRs and Trapped Radiation



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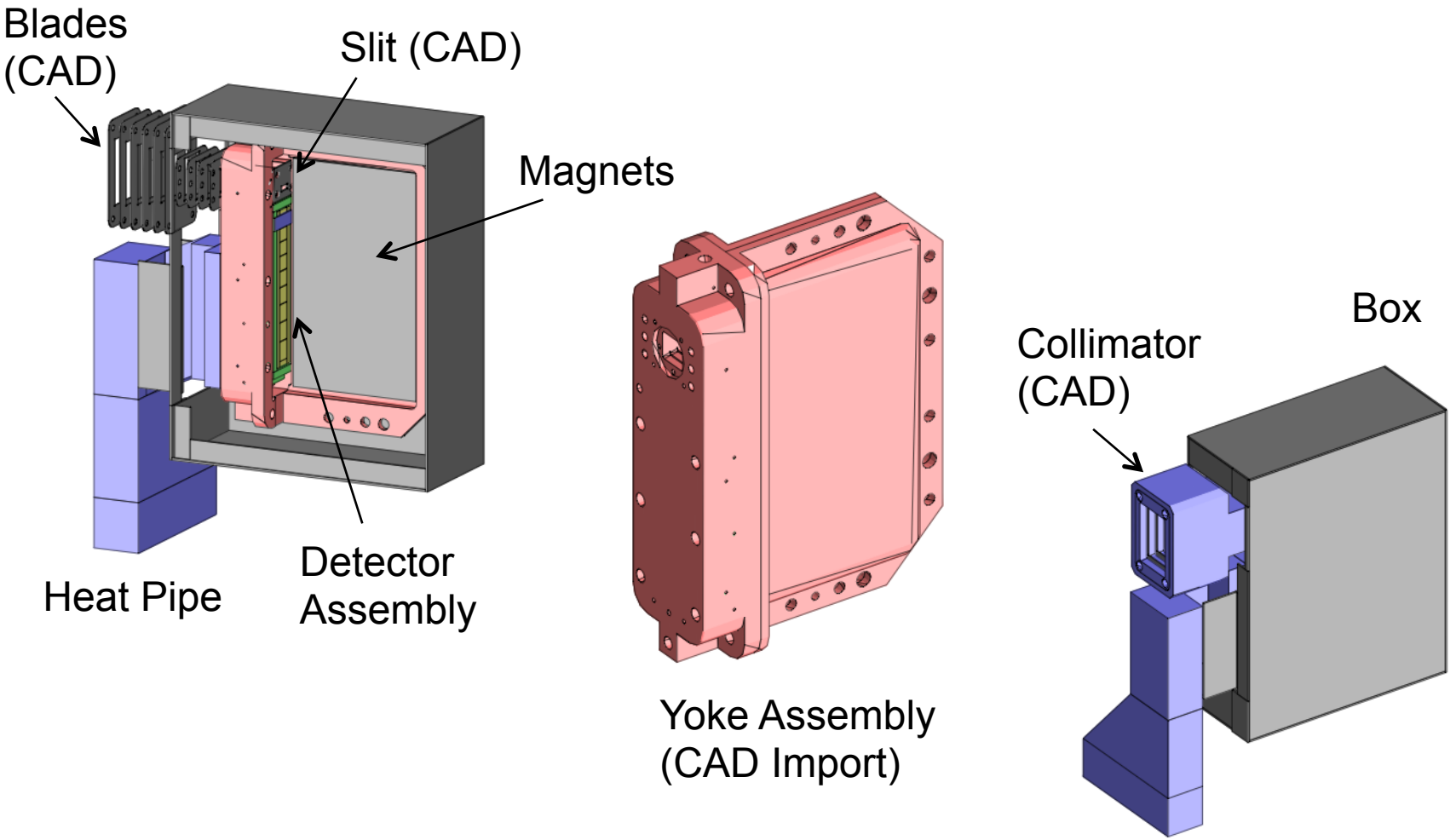
MagEIS/LE Sensor Head



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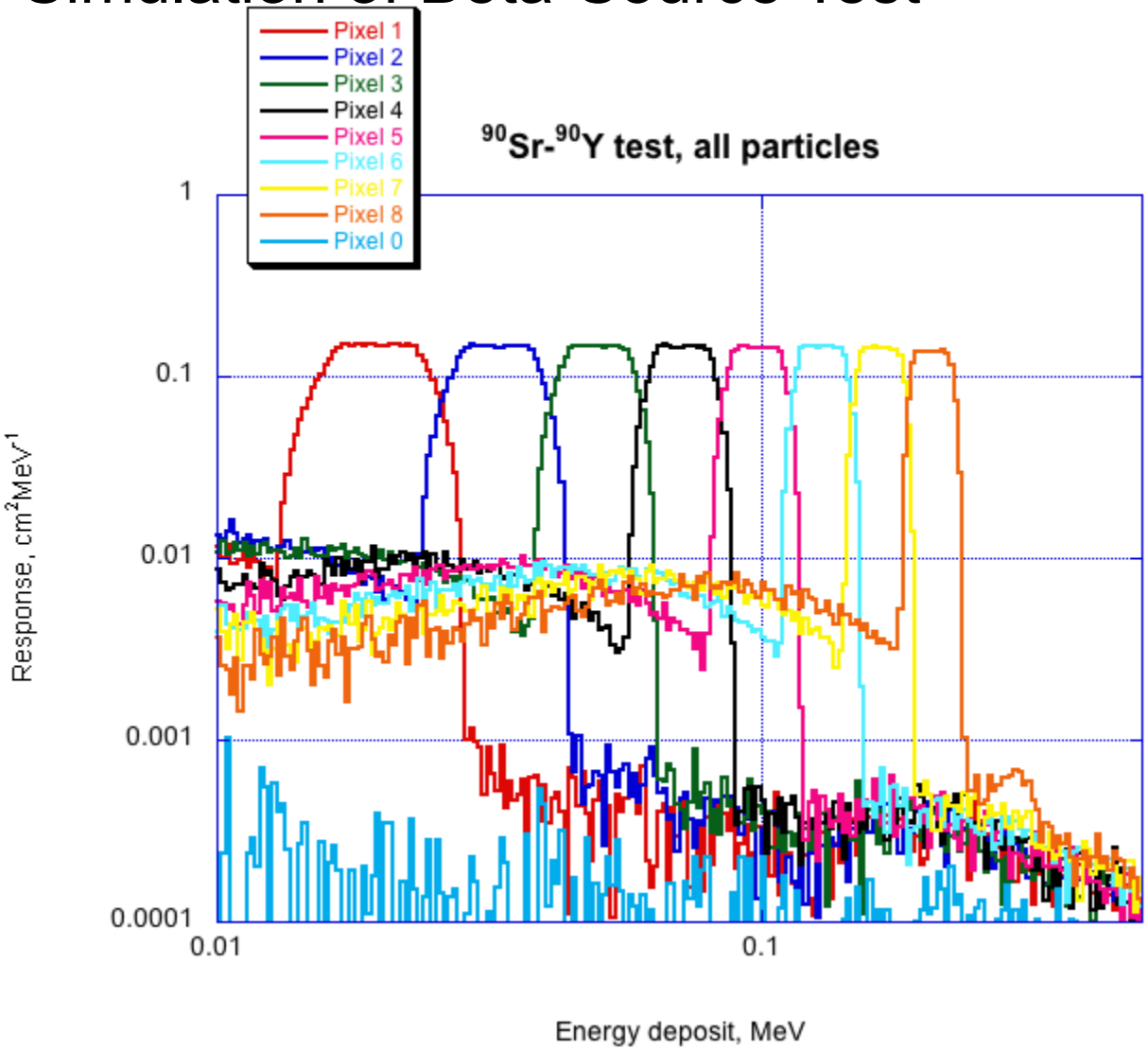
Geant4 Simulation of Beta-Source Test



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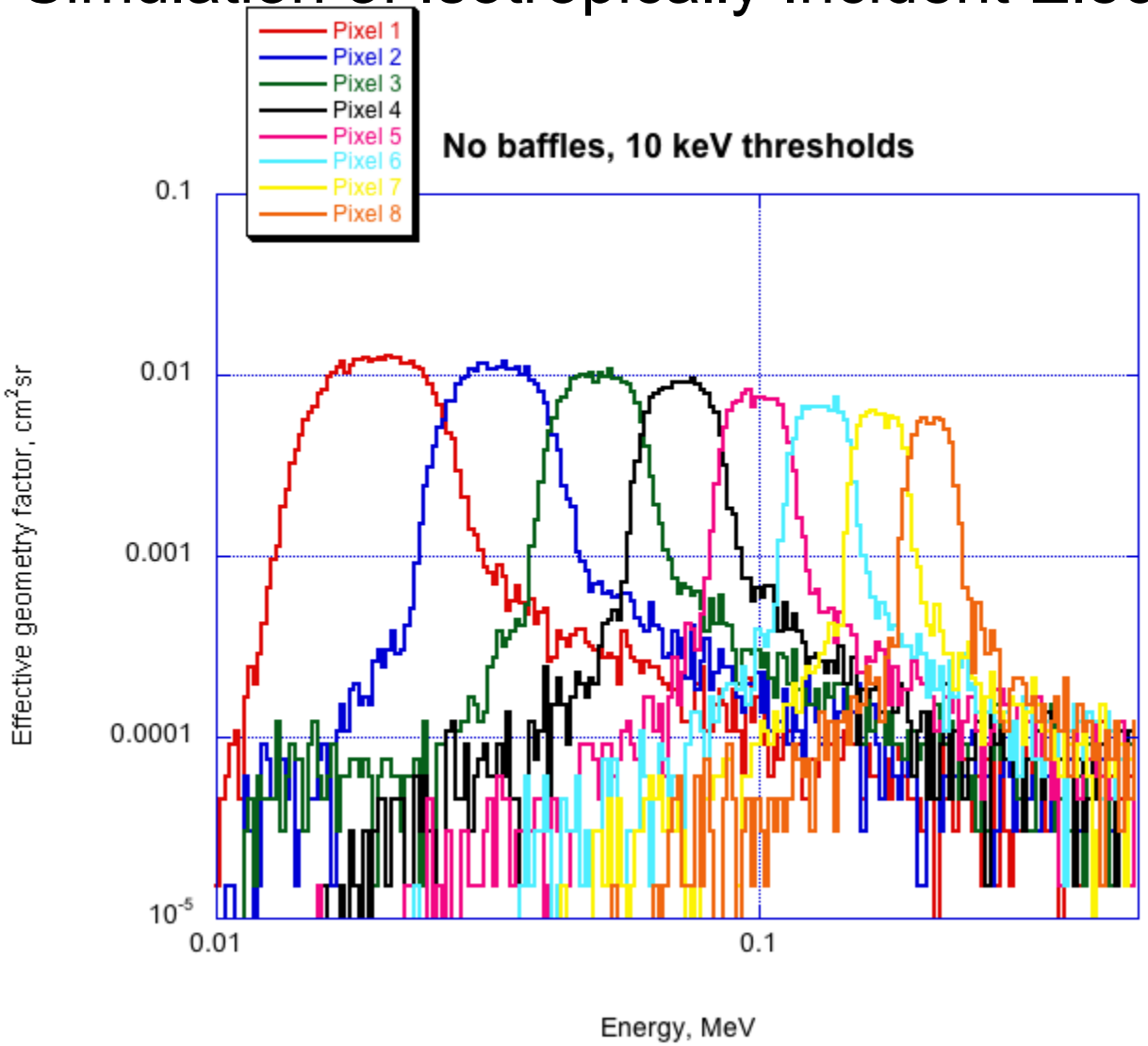
Geant4 Simulation of Isotropically Incident Electrons



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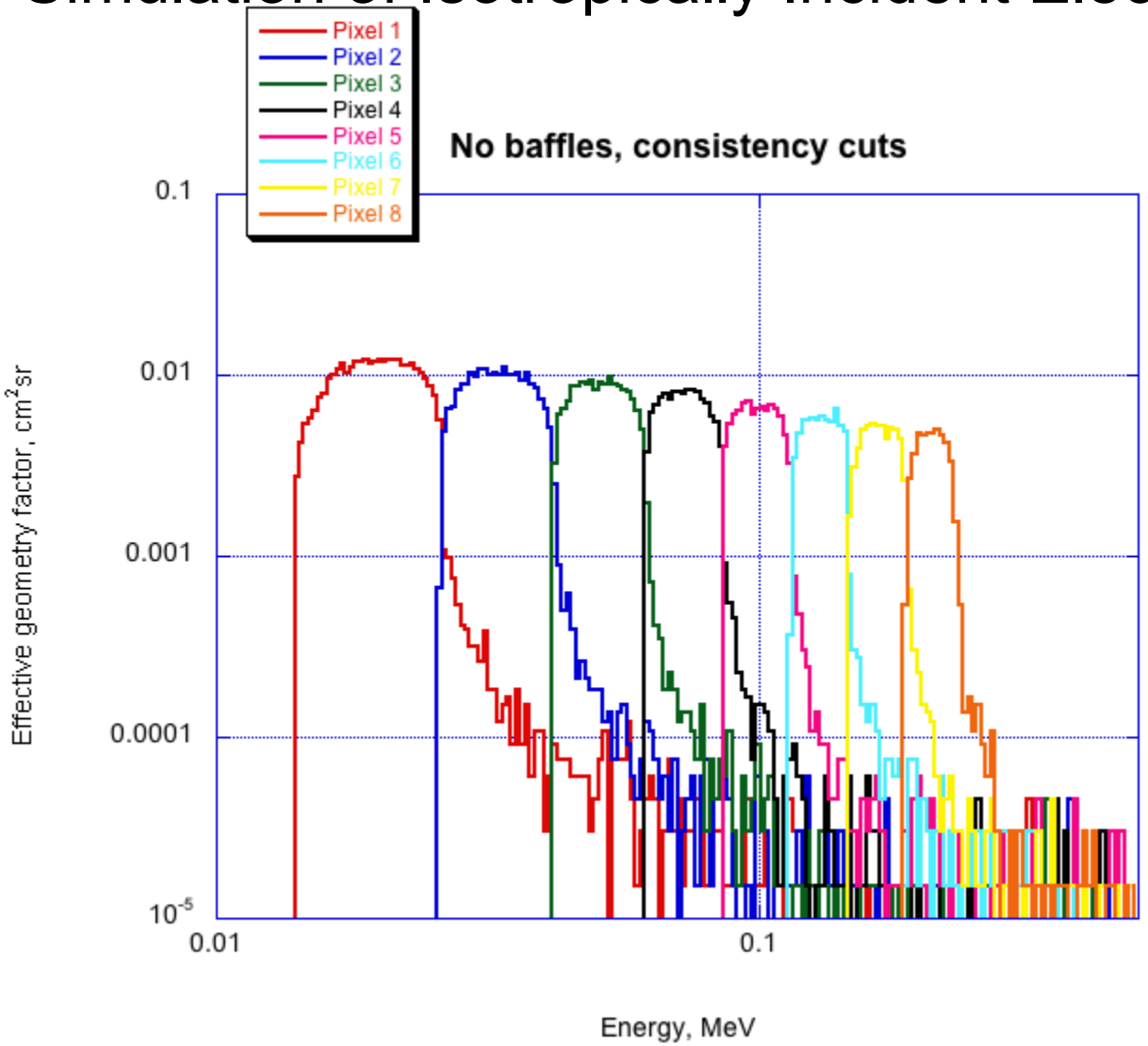

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Comments on Geant4 Components, esp. Physics Lists

- For simple dose or energy-deposit calculations, just about any physics list with a low-energy electromagnetic option works fine
  - *I default to Radioprotection and/or Microbeam example lists because models, cuts, limits can be set via macro commands*
- For more complex sensors, special care must be taken to simulate specific kinds of particle generation and transport correctly (knock-on electrons for CRaTER, optical photons for RPS, …)
- My next big learning task is to understand how best to simulate nuclear interactions of heavy-ion projectiles with heavy targets
  - *I am also very interested in microdosimetry, for other projects*
- Wish list: “the right” ion-ion physics list(s), more robust CAD import