X-Ray / Gamma-Ray Polarimetry

Mark McConnell

Space Science Center
University of New Hampshire
Durham, NH

What is Next Priority?

- Measurements to date do not provide convincing evidence for polarization.
- First and foremost, we need some definitive measurement of polarization.
- This requires some optimized polarimeter design with high sensitivity.
- Spatially-integrated measurements are ok.

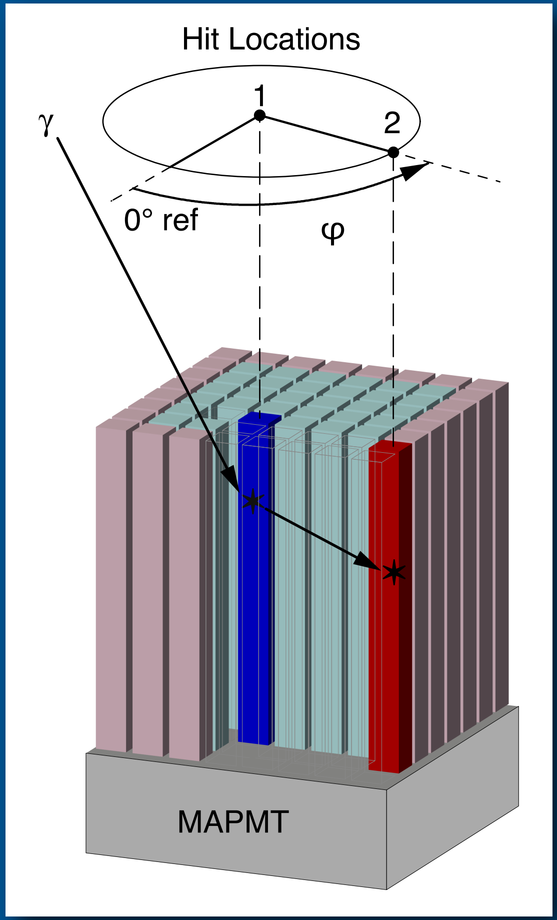
Improving Upon RHESSI

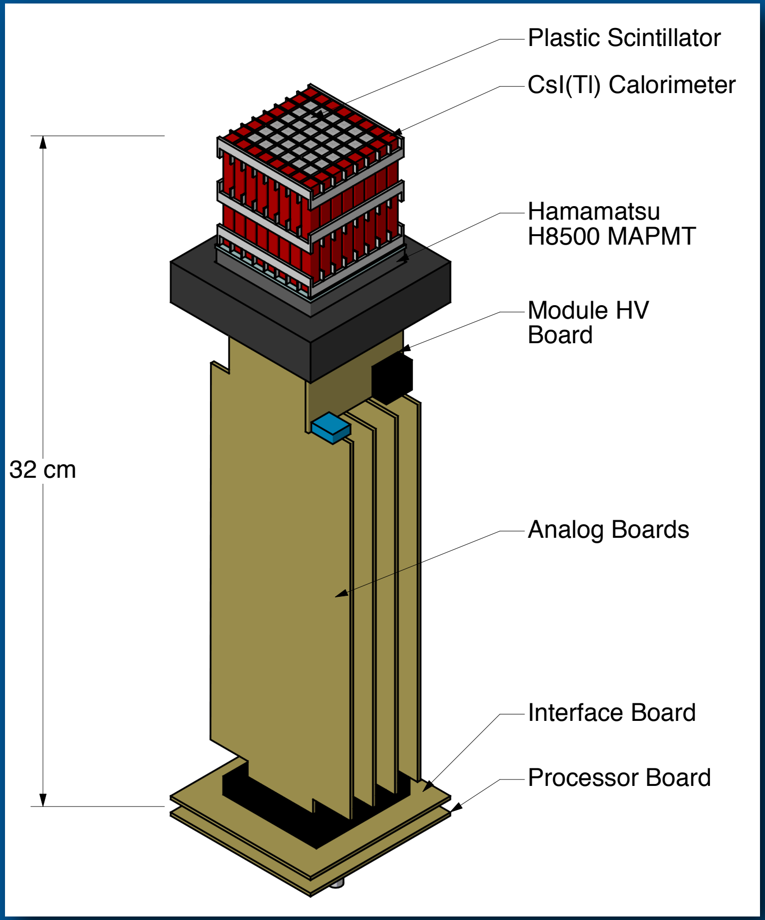
low energy (BeGe) polarimetry mode
high energy (GeGe) polarimetry mode

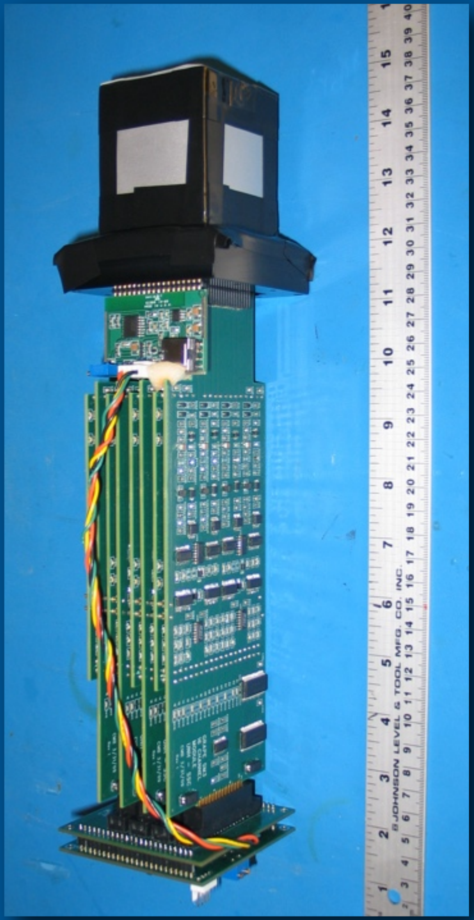
- Active scattering element would reduce background.
- Hardware coincidence would improve the identification of valid events.
- Fast coincidence timing would reduce accidental coincidences (background).
- Active shielding would reduce the background.

Gamma-Ray Polarimeter Experiment (GRAPE)

Bloser et al., NIM, 600, 424 (2009)
Legere et al.,SPIE 5898, 413 (2005)
McConnell et al., IEEE TNS 46, 890 (1999)





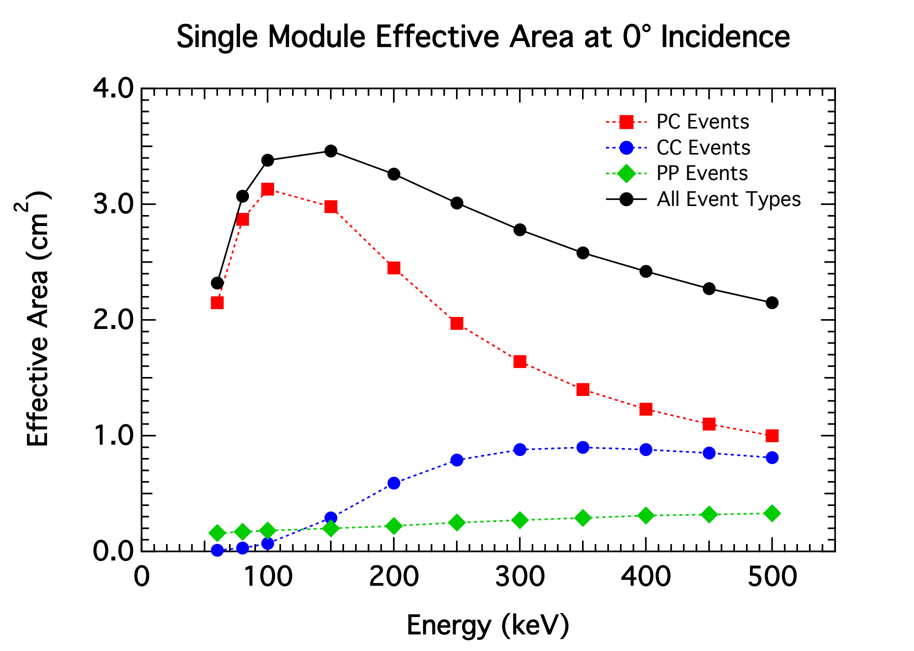


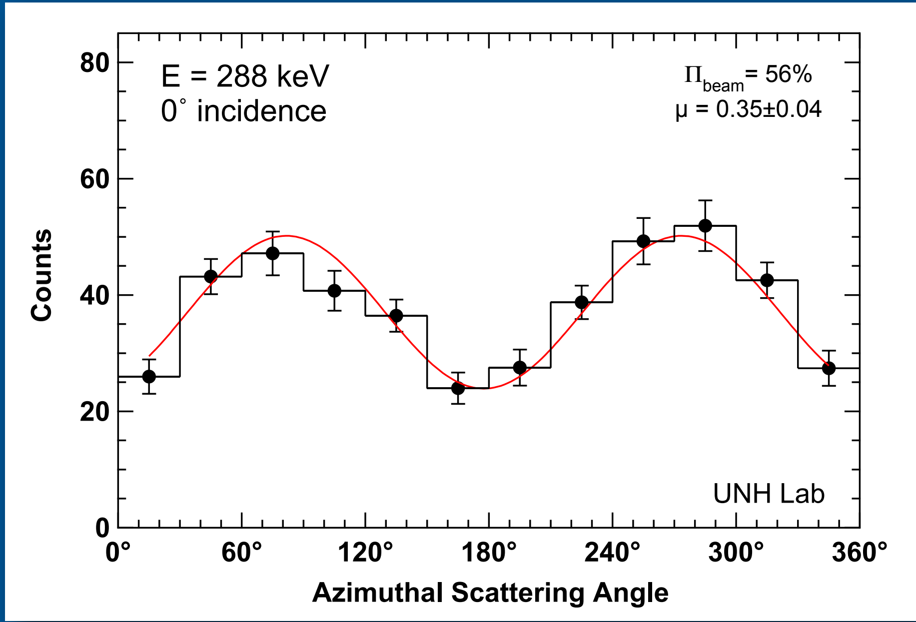
A large array of GRAPE modules could provide significant polarization sensitivity.

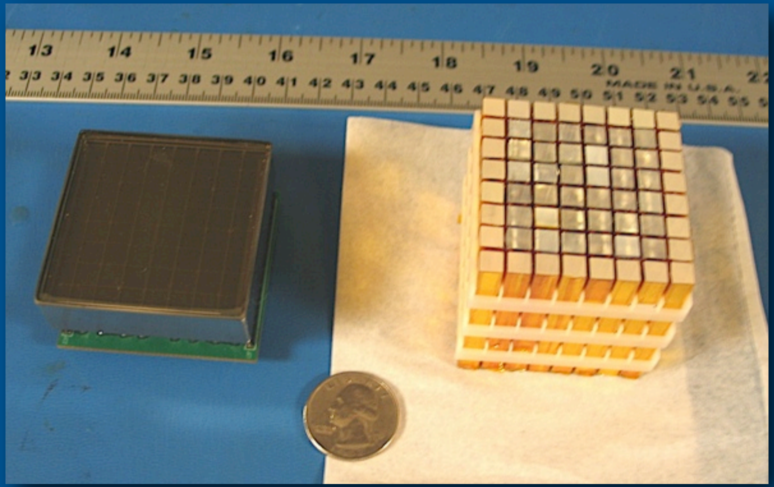
GRAPE Module Characteristics

A single module provides polarization response up to at least 500 keV.

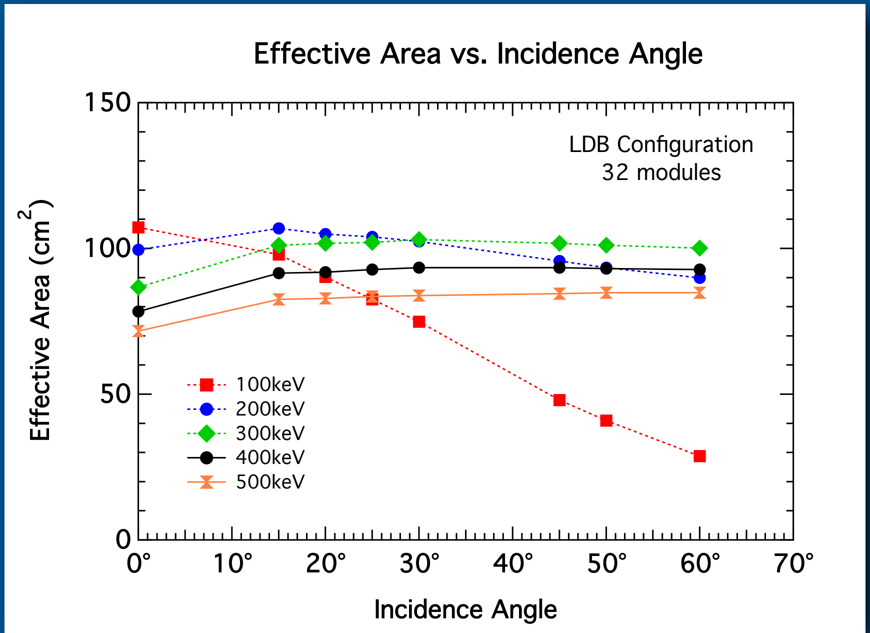
Low-Z / high-Z nature of the design yields good response down to 50 keV.





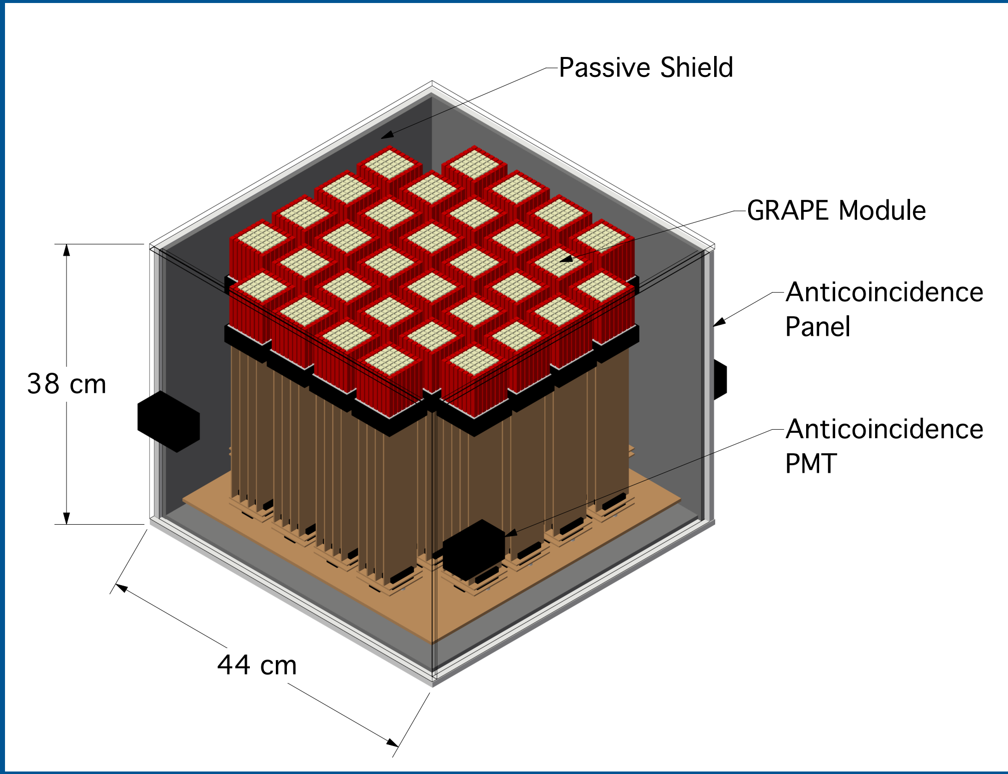


GRAPE Detector Array

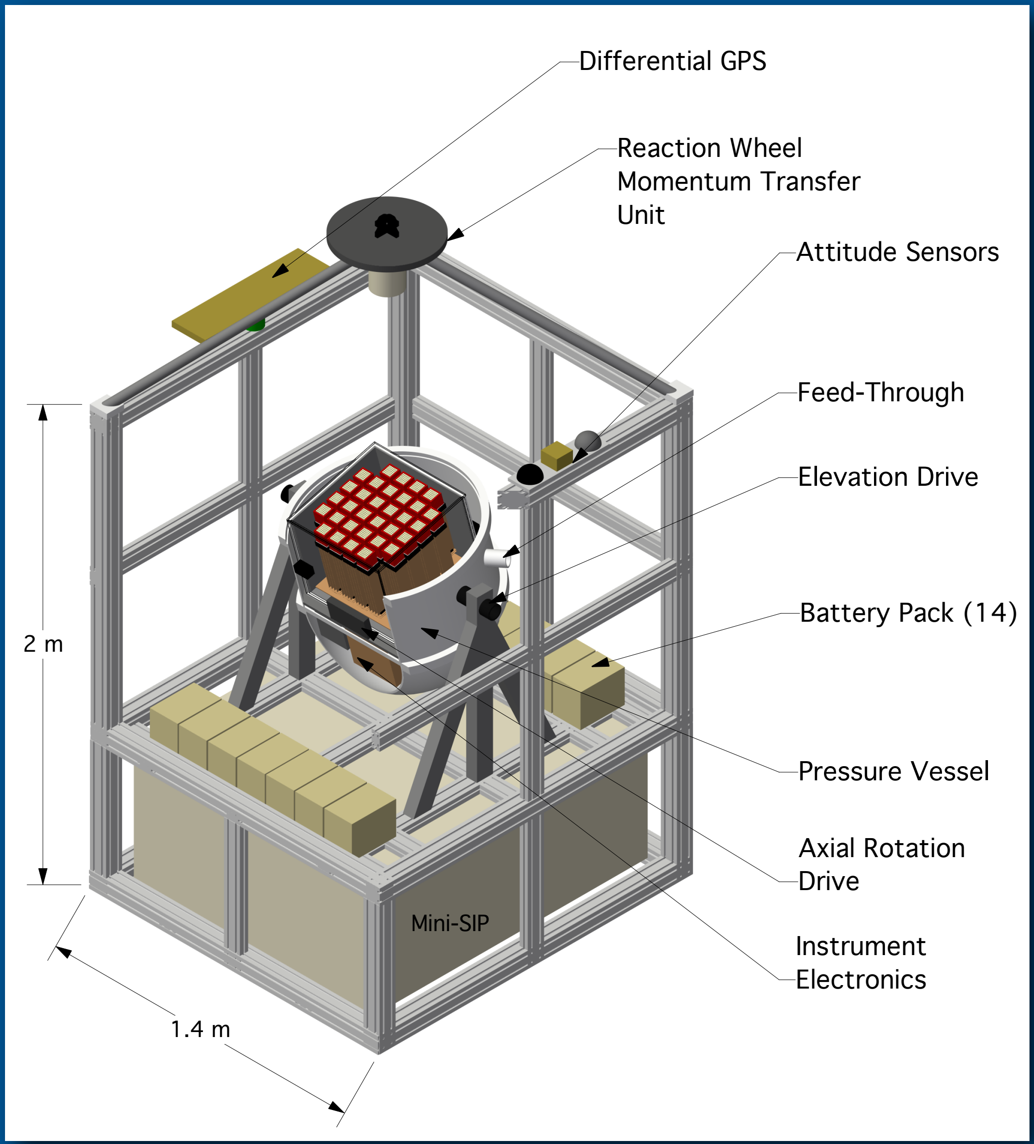


~100x the effective area of RHESSI at 100 keV

MDP for Solar Flares (50-500 keV) (PC events only)			
X4.8	**X1**	**M5**	**M1**
1.9%	2.3%	6.0%	13.2%



GRAPE Balloon Payload

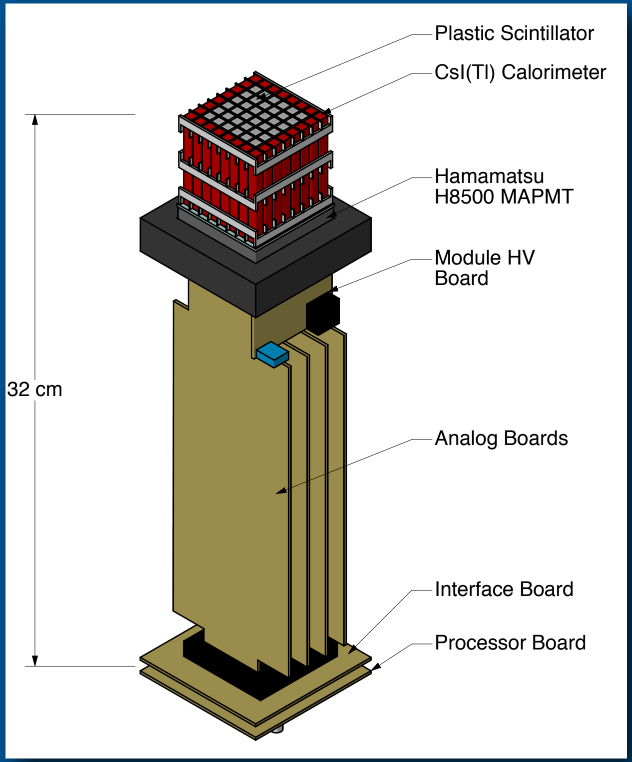


The balloon payload incorporates a design that provides for back-and-forth rotation of the detector array within the pressure vessel.

First flight in Fall, 2011 will look at Crab. Subsequent LDB flights from Antarctica for GRBs and solar flares.

Imaging Polarimetry

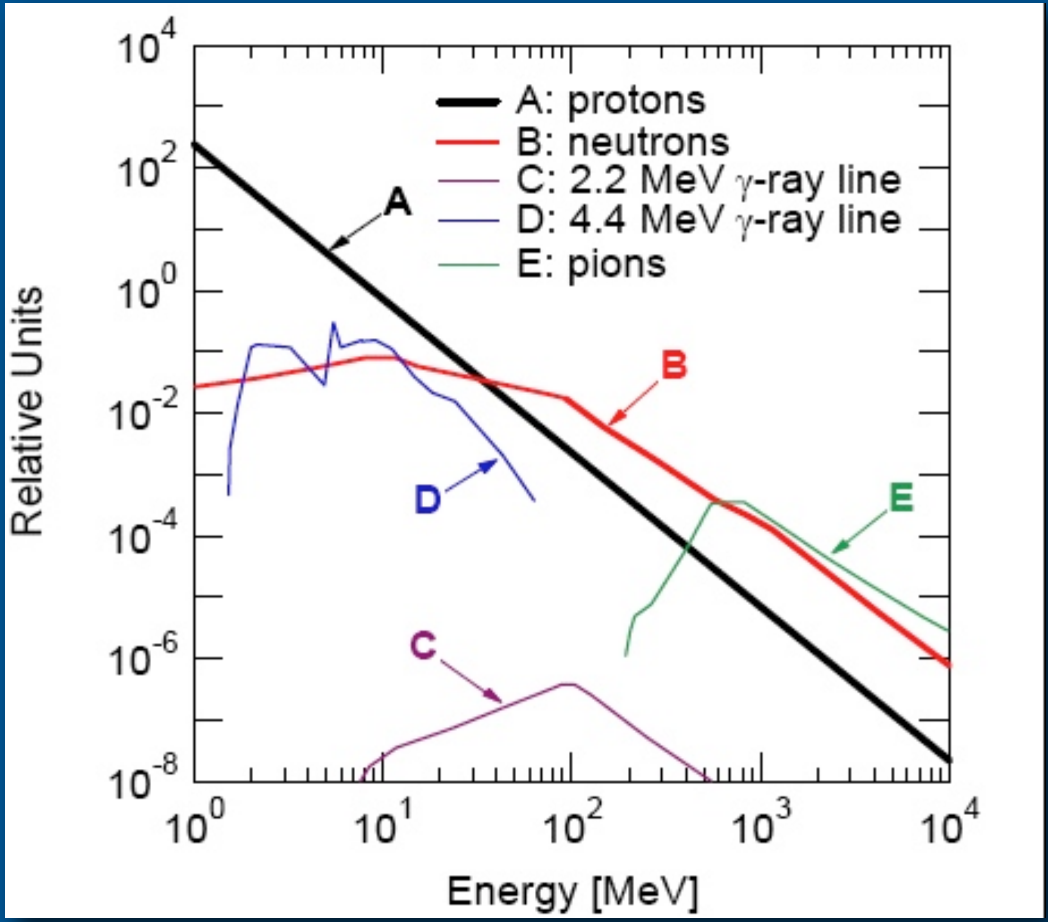
- Spatially-resolved polarimetry measurements
- Angular resolution of 1-2 arcsec would permit resolution of footpoints.



Modular design and spatial resolution of the GRAPE design could be exploited for imaging polarimetry (e.g., RMC imaging).

Neutron Spectroscopy

Importance of Neutrons



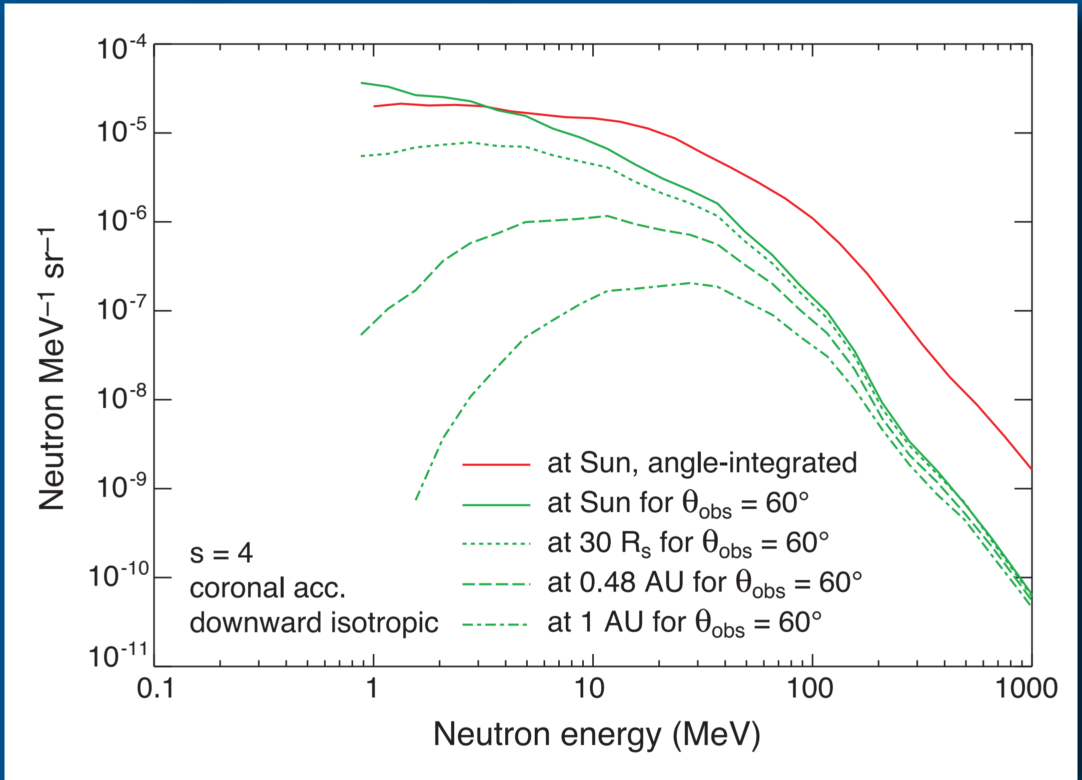
Determining the accelerated ion spectrum is a fundamental goal.

Gamma-rays provide a partial probe.

Neutrons offer a way to more fully probe the ion spectrum and search for high energy cutoffs.

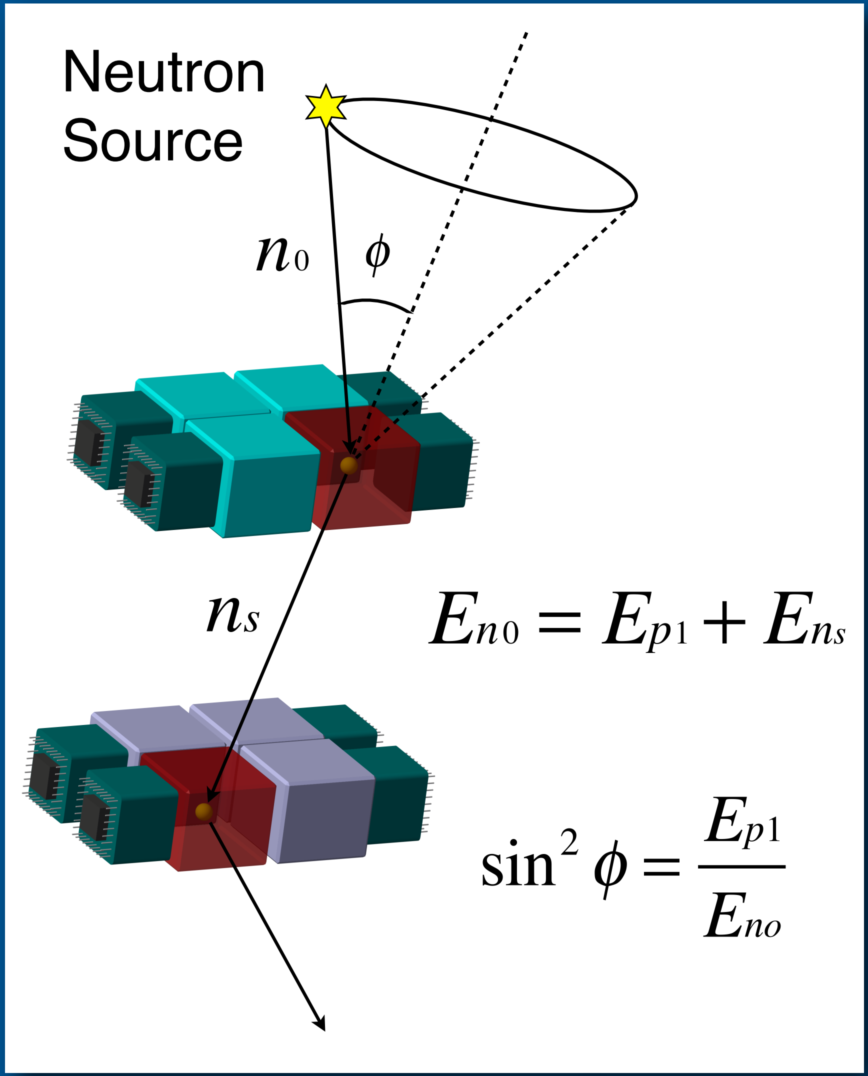
Neutron Spectra

Due to neutron beta decay, the spectrum we see at Earth will be significantly modified at low energies.



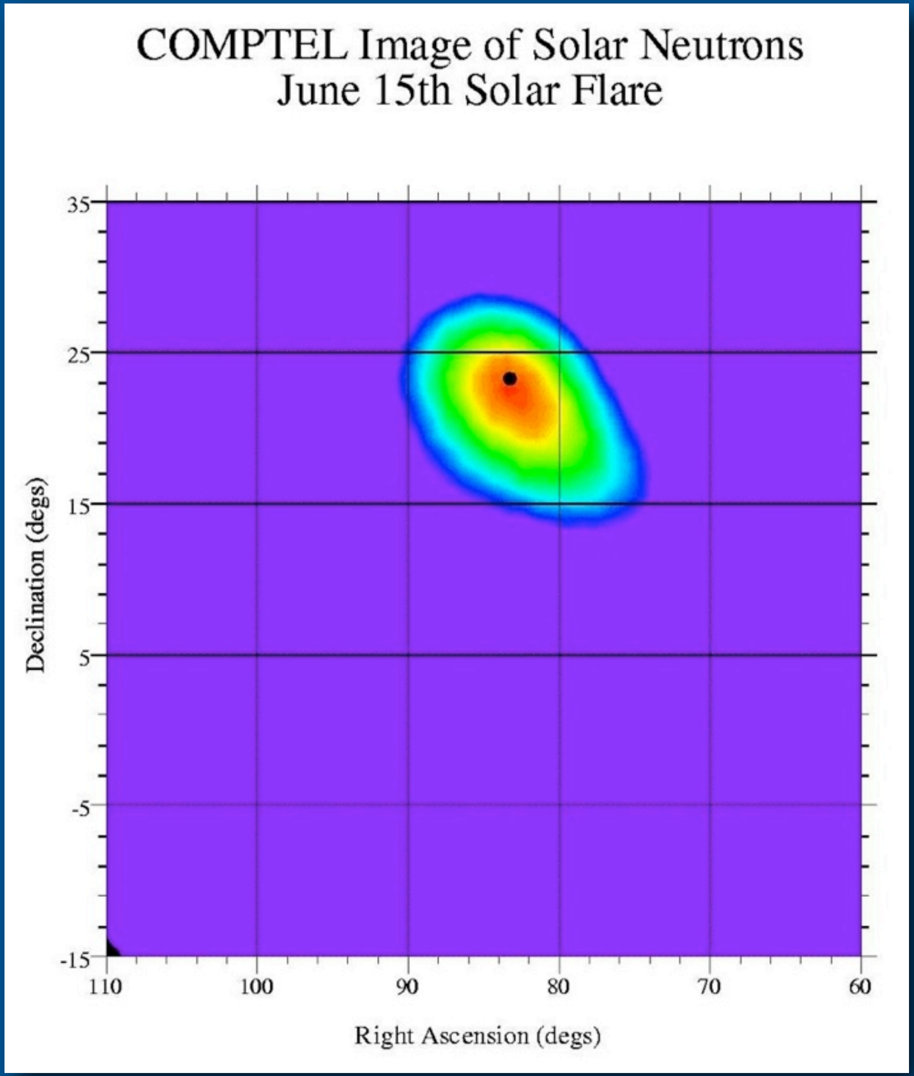
At 1 AU, 20-200 MeV event-by-event spectroscopy (with 15% energy resolution) should be the goal.

Neutron Detection Principle



$$E_{n0} = E_{p1} + E_{ns}$$

$$\sin^2 \phi = \frac{E_{p1}}{E_{no}}$$

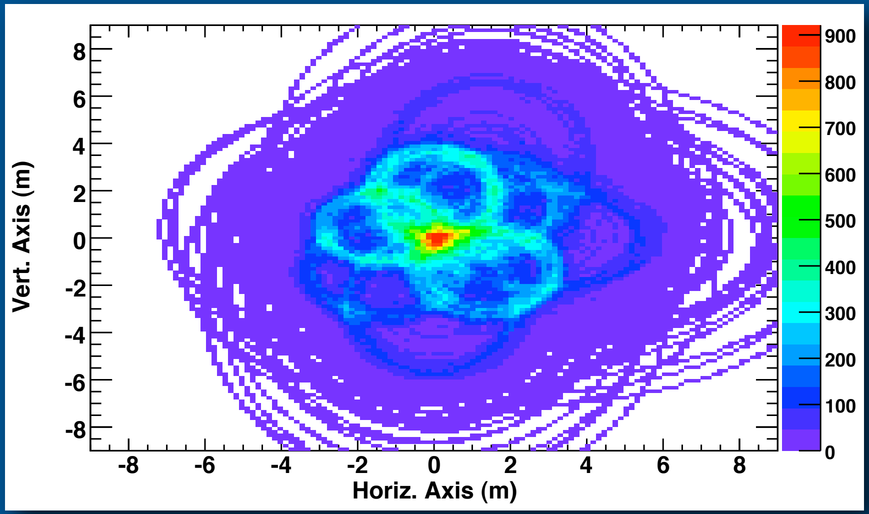


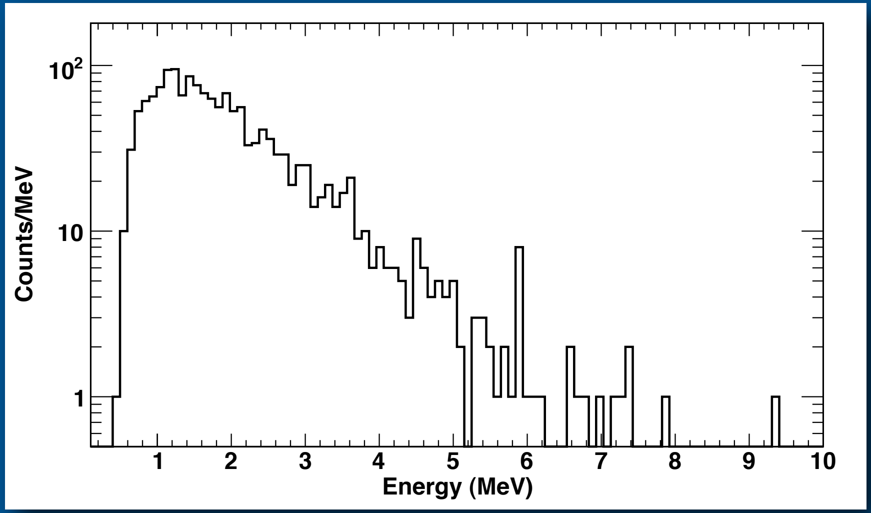
n-p scattering

PSD, ToF used to identify neutron interactions

Neutron Detection Principle

One configuration, developed at UNH for homeland security applications, uses liquid scintillator elements.





imaging / spectroscopy of Cf-252 source