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Advances in Imaging Fission Neutrons with a Neutron Scatter Camera

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Motivation

- Fast Neutrons are prime detectable for SNM (difficult to shield)
- Improve threat/range detection limits
- Large standoff /short dwell time requires good S/N (signal/noise)
- Imaging improves S/N
- Obtain spectral information

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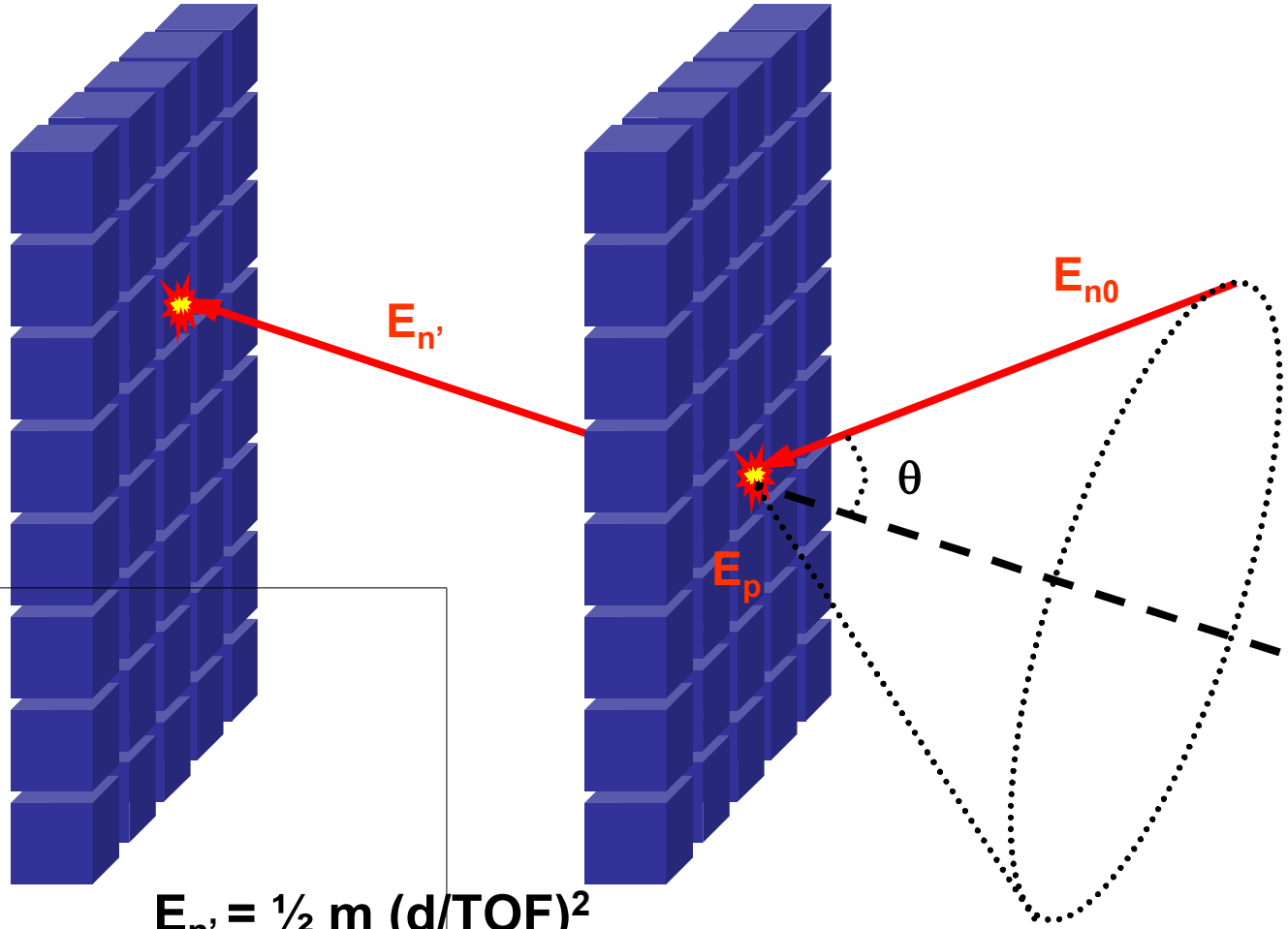
Fundamentals of a Neutron Scatter Camera



$$E_{n'} = \tfrac{1}{2}\, m\, (d/TOF)^2$$

$$E_{n0} = E_p + E_{n'}$$

$$\theta = \tan^{-1}(E_p/E_{n'})$$

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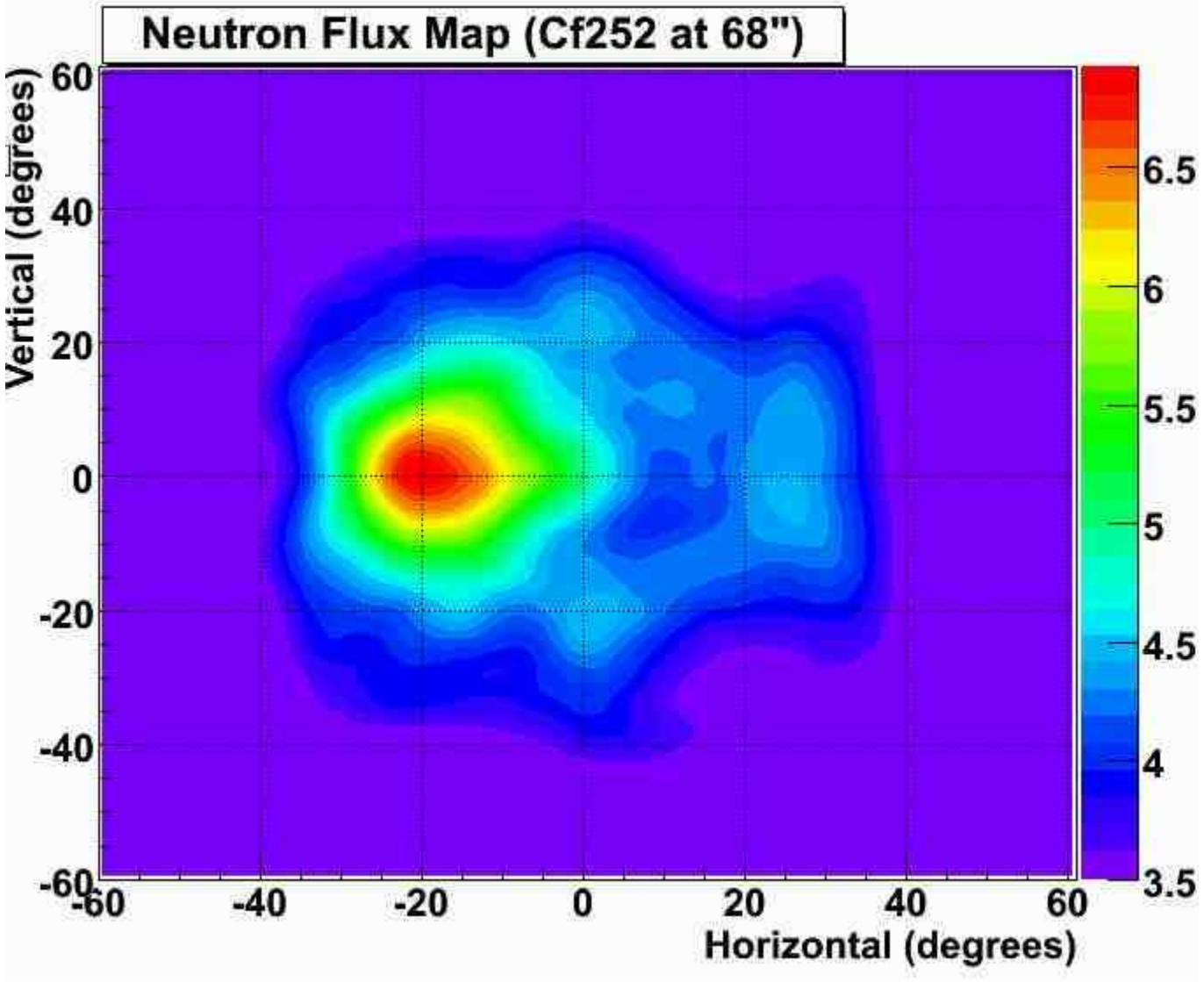
Cf252 neutron source image



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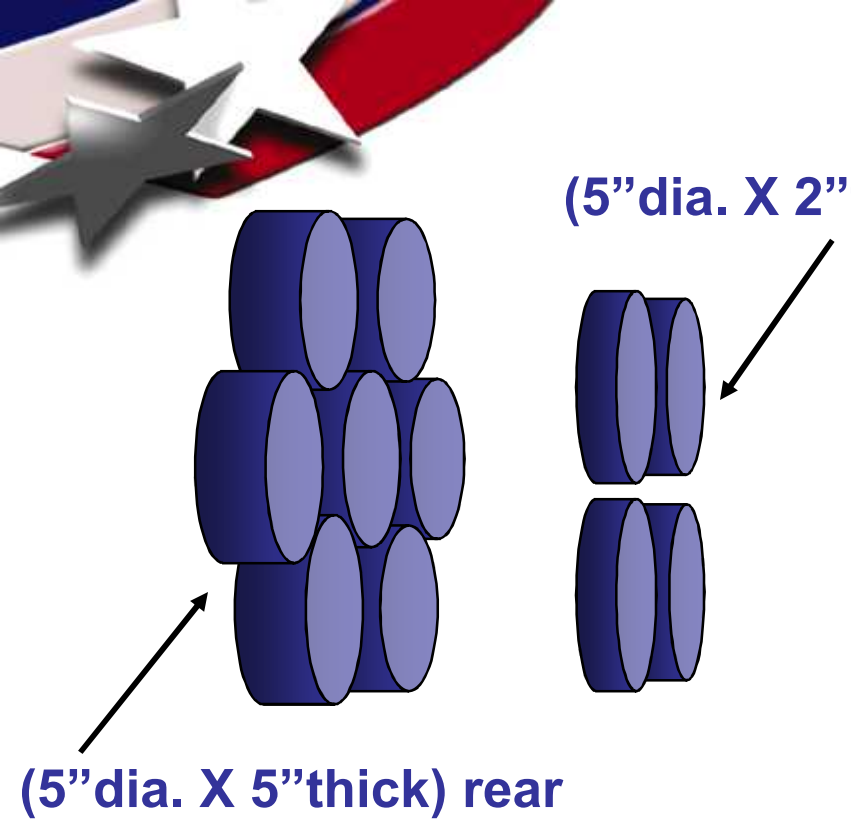
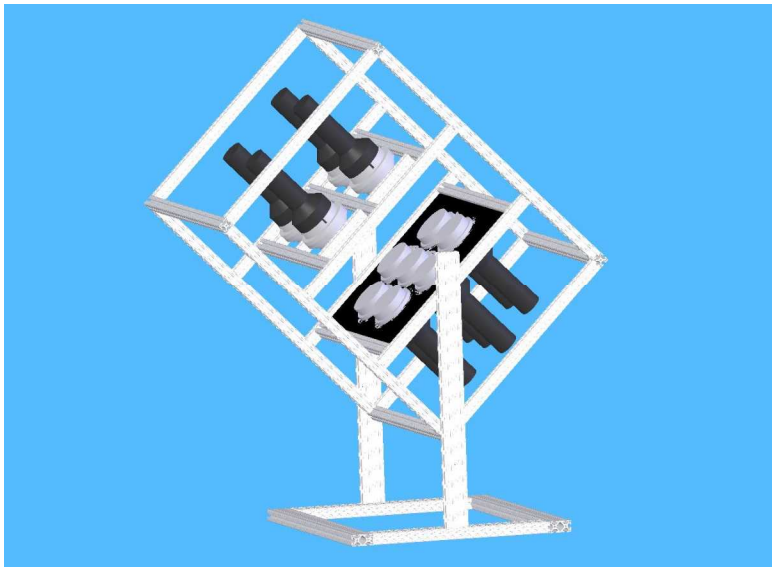
Design





- Liquid Scintillator for pulse shape discrimination (PSD) for gamma background rejection
- Fast 5” PMT’s with ~1ns timing for time of flight (TOF)
- Proton energy resolution ~20% @ 1MeVee
- Modular design, highly scalable, VME multi-channel data acquisition and electronics

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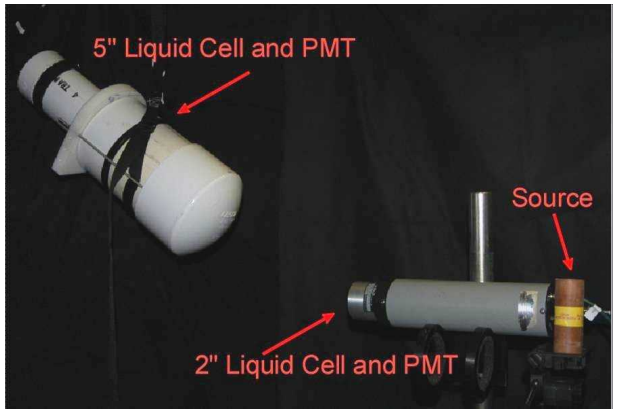
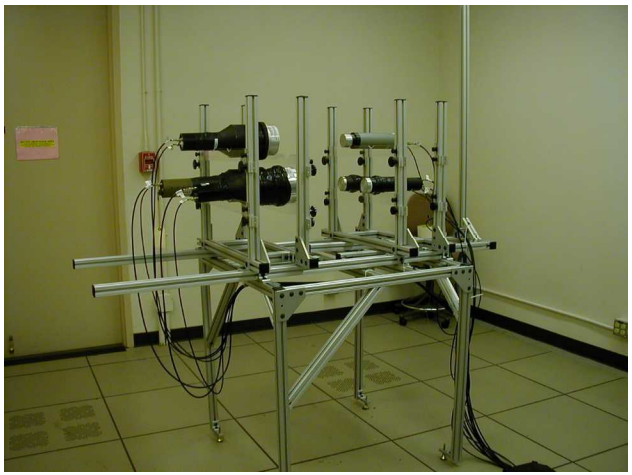
Camera evolution



May 2006

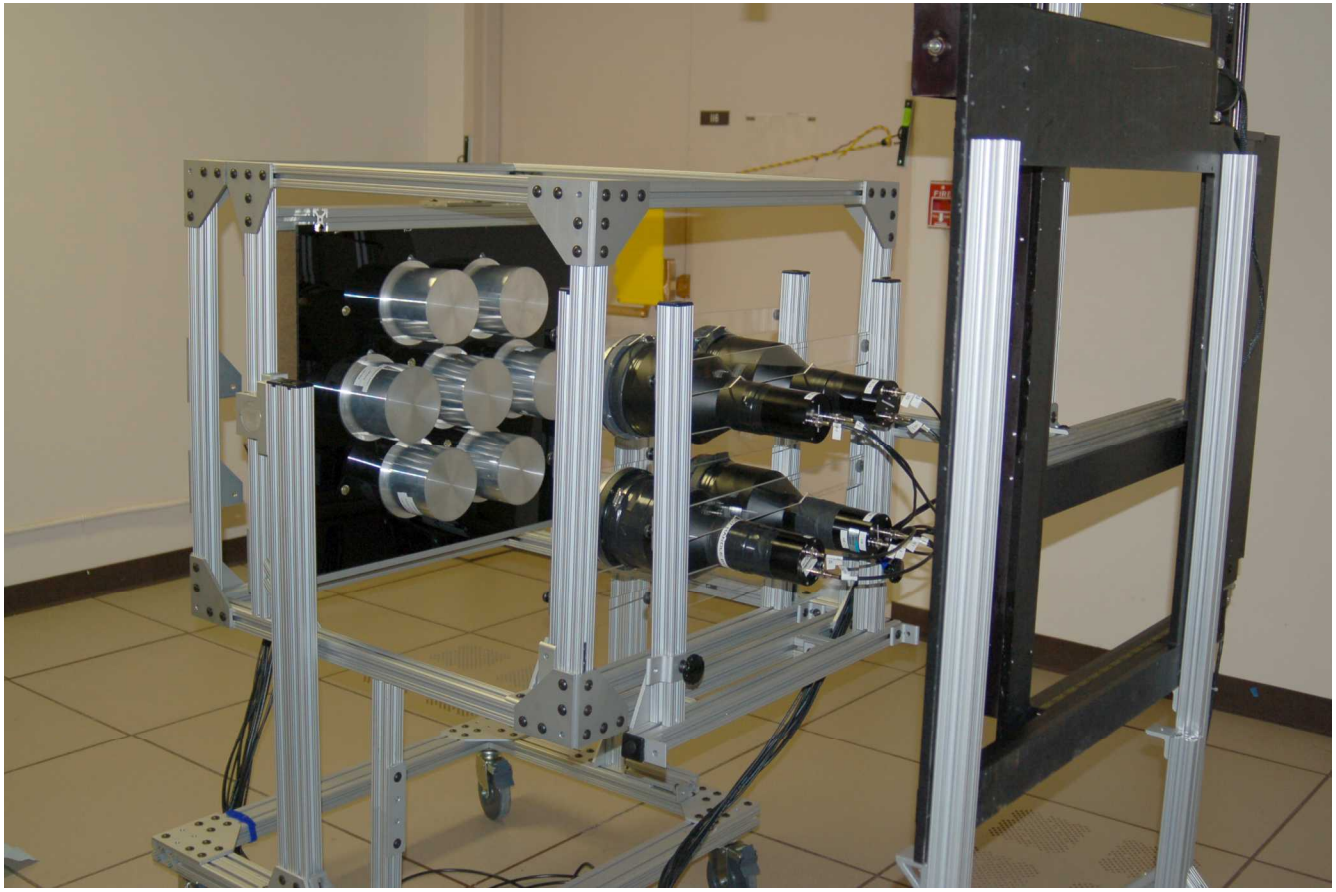


Sep 2006

Dec 2006

Feb 2007

Neutron Scatter Camera



4 - (5”dia. X 2”thick) front
7 - (5”dia. X 5”thick) rear

•0.2 MeV- 8 MeV neutrons

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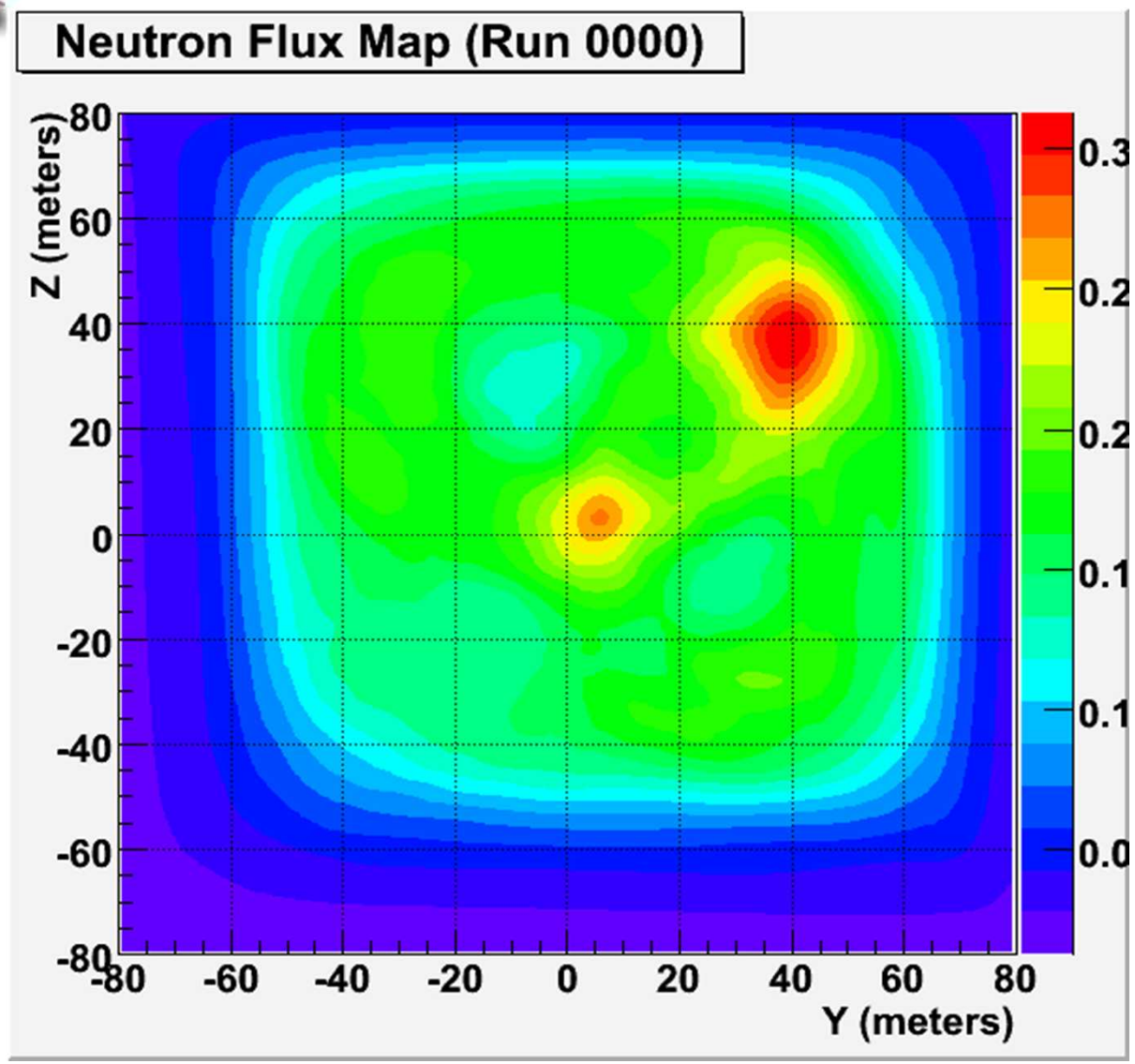

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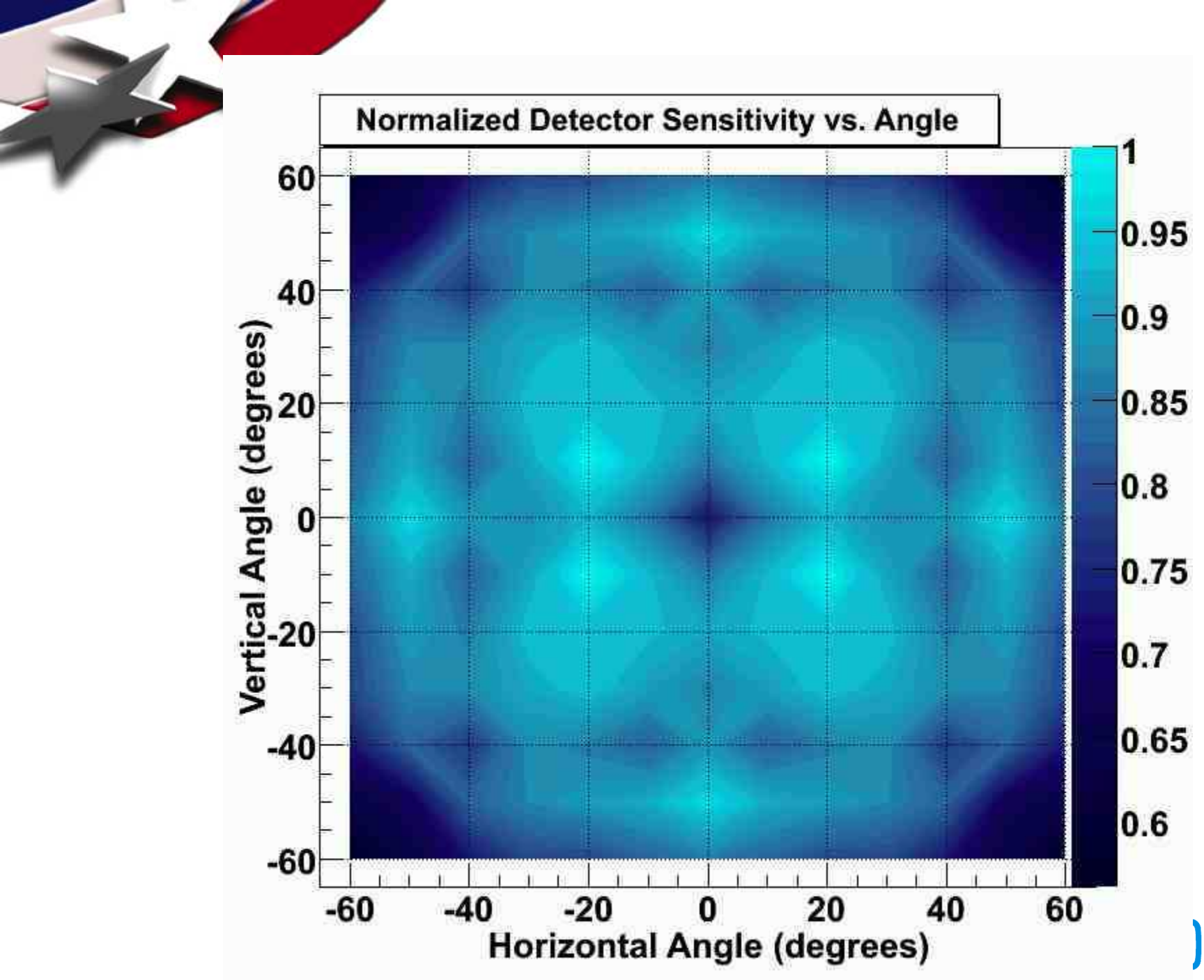

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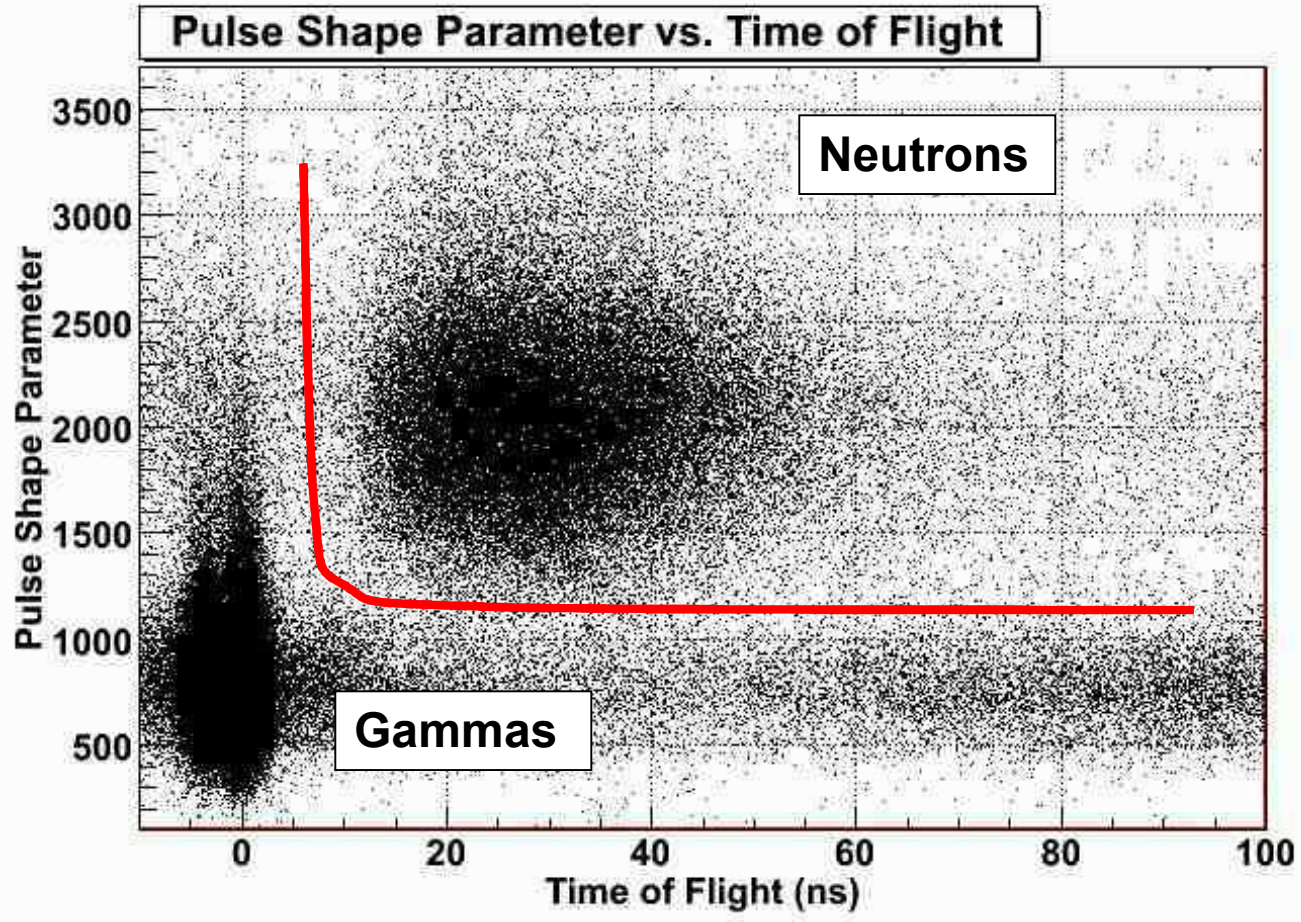
Pulse shape discrimination with liquid cells + custom PSD module + TOF



Gamma contamination

PSD only ~ 4 x 10^{-4}

TOF only ~ 2 x 10^{-1}

Both ~ 0.4 x 10^{-4}

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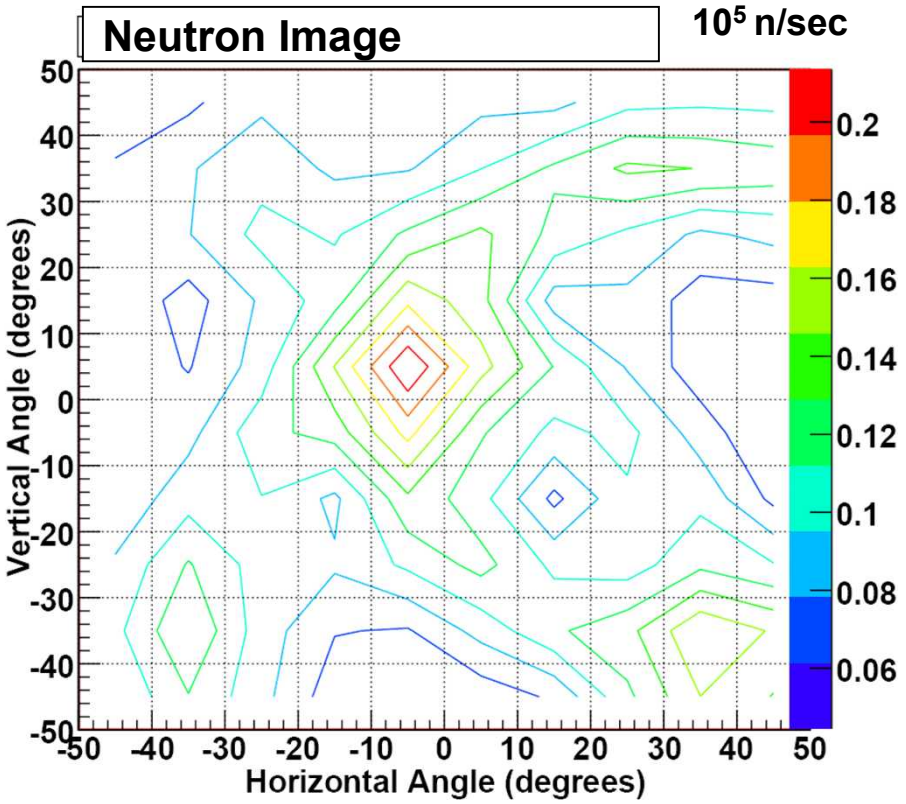
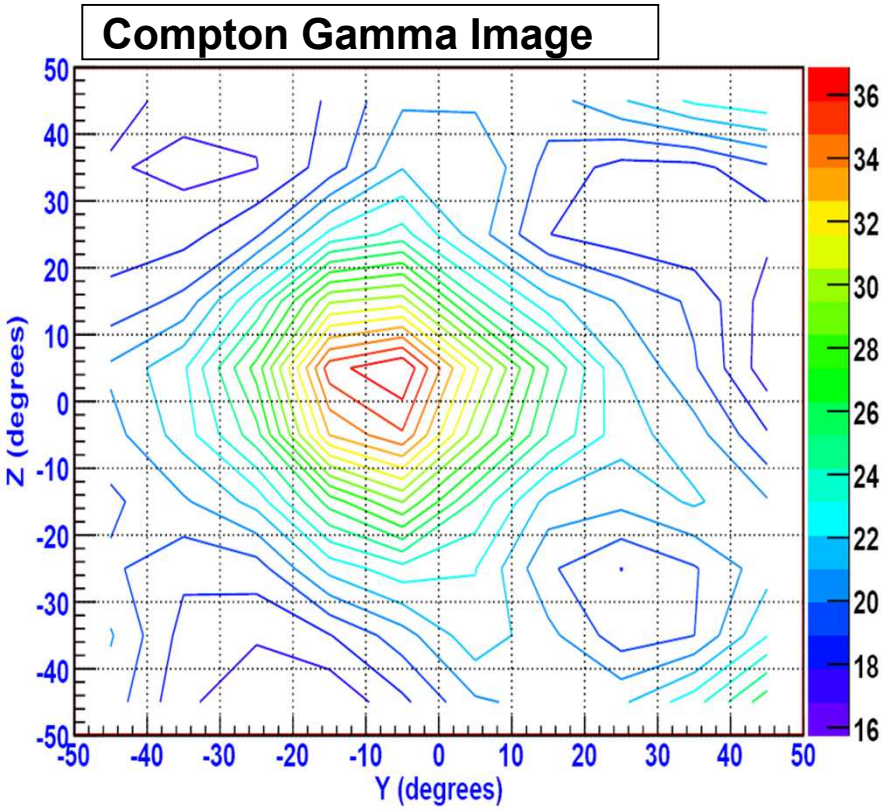
Gamma-ray imaging in “Compton Mode”





Total Significance of Detection: 58σ
(29σ/sqrt(hr))

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Summary

- We have successfully built and calibrated a scalable segmented Neutron Scatter Camera.
- Increased sensitivity for fission neutrons by a factor of 30.
- Shown PSD is essential for good gamma rejection
- Demonstrated imaging and spectroscopic capabilities.
- Measured cosmic neutron background flux angular distribution
  (see N38-6: (Thursday 11:45am))
- Plans to scale up camera to increase sensitivity, 9+9 elements in near future (already at 140 ft 3σ)

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