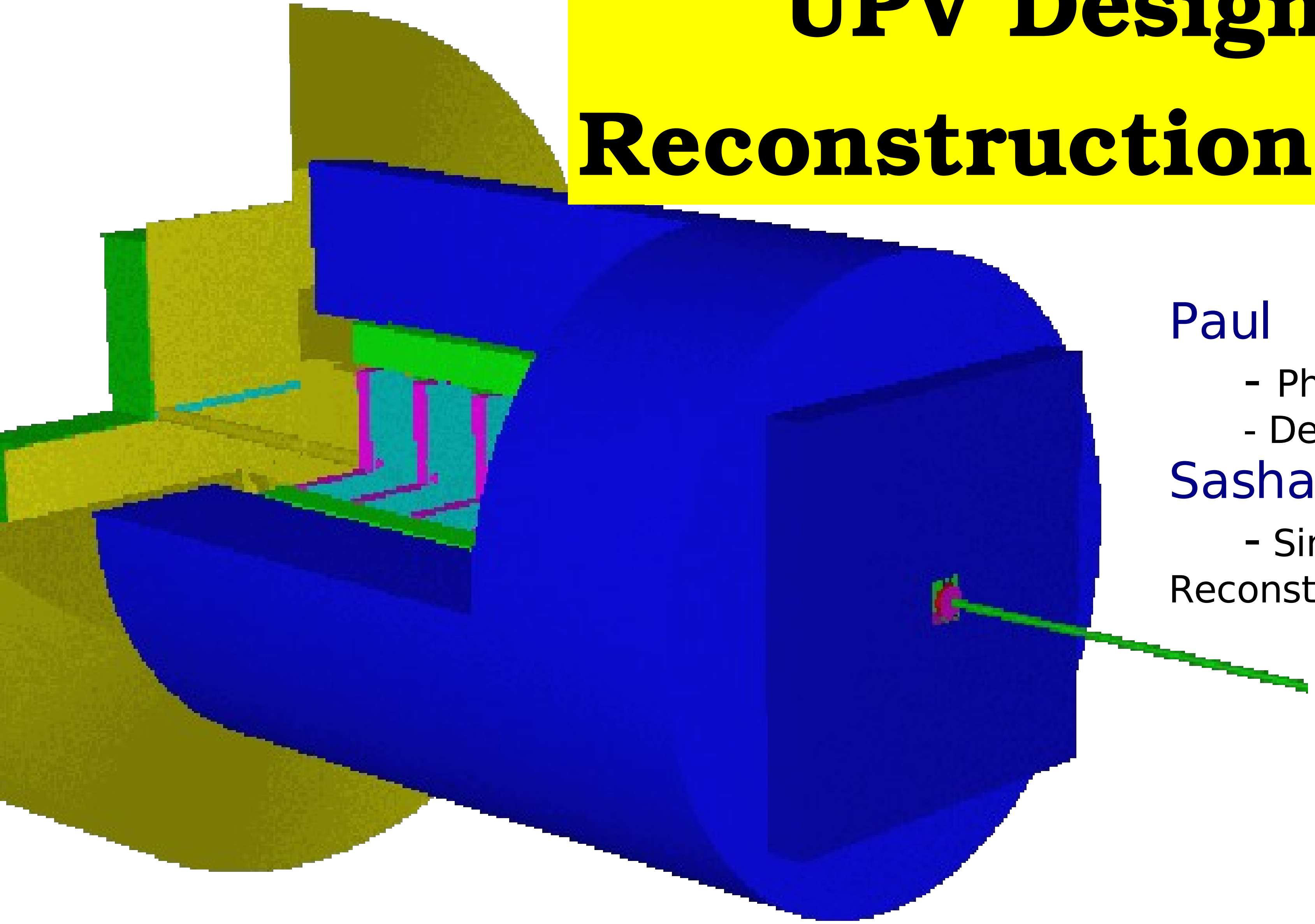
UPV Design & Reconstruction Issues



Paul

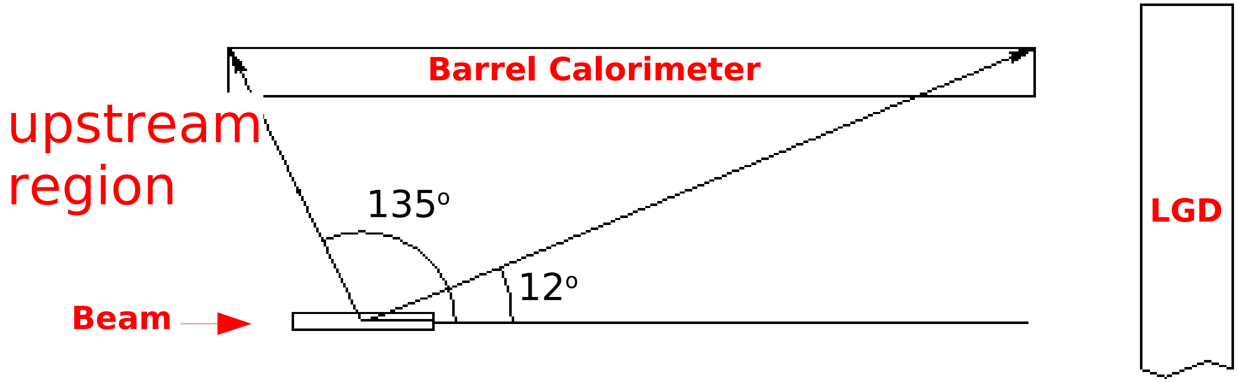
- Physics demands
- Design issues

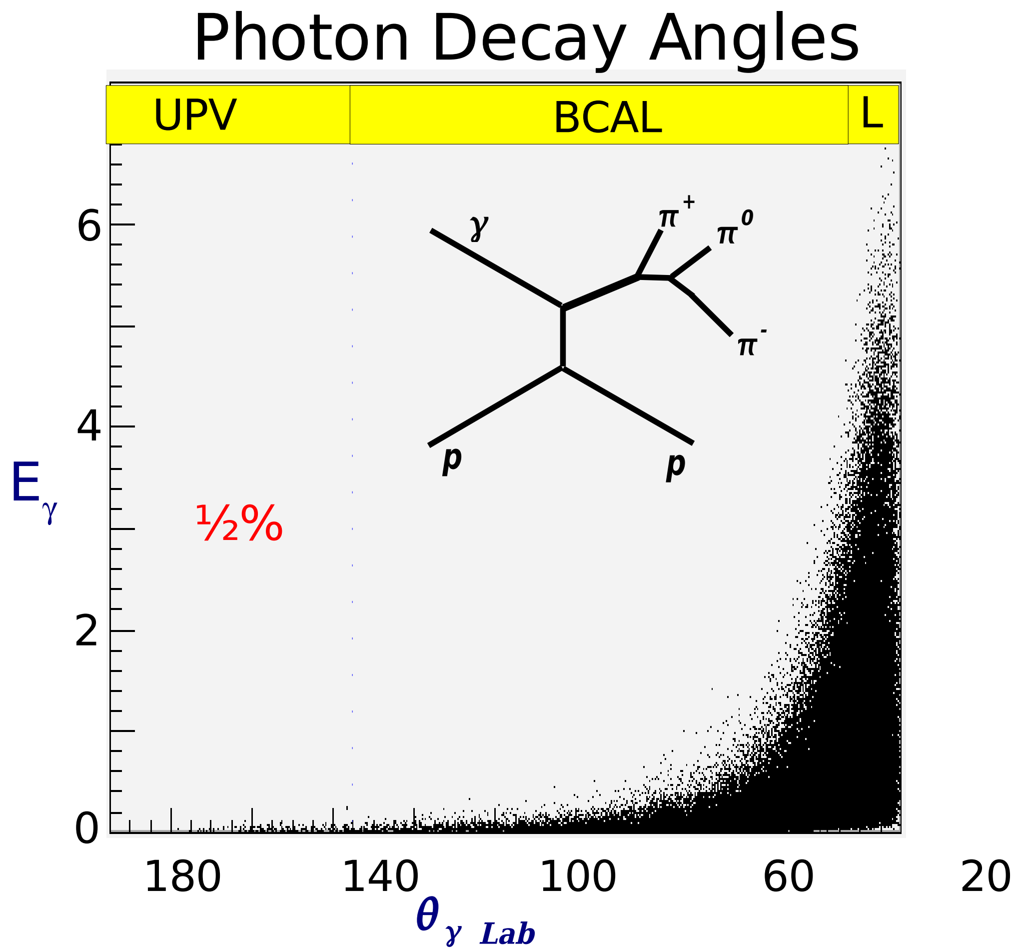
Sasha

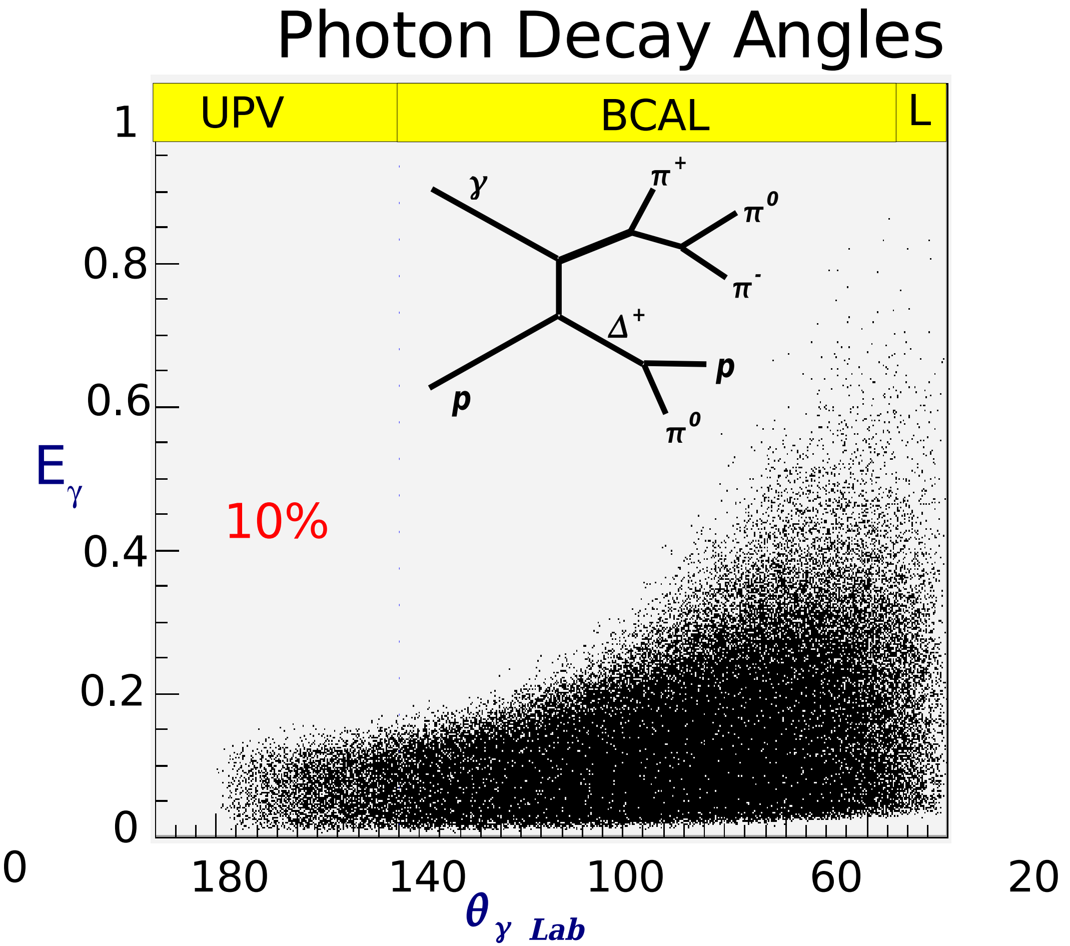
- Simulations & Reconstruction Issues

Paul Eugenio & Alexander Ostrovidov
Florida State University

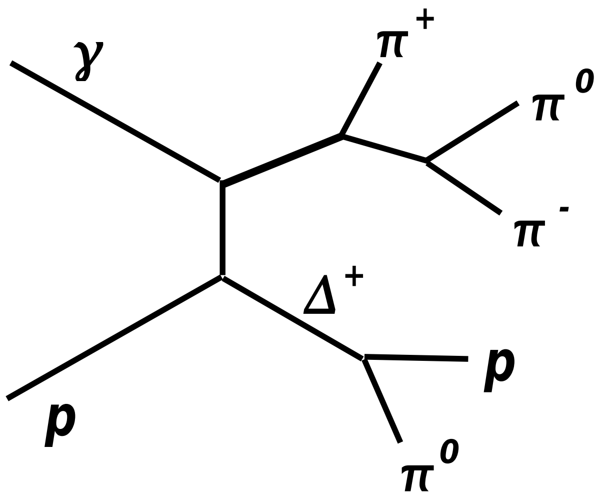
Soft Photon Backgrounds

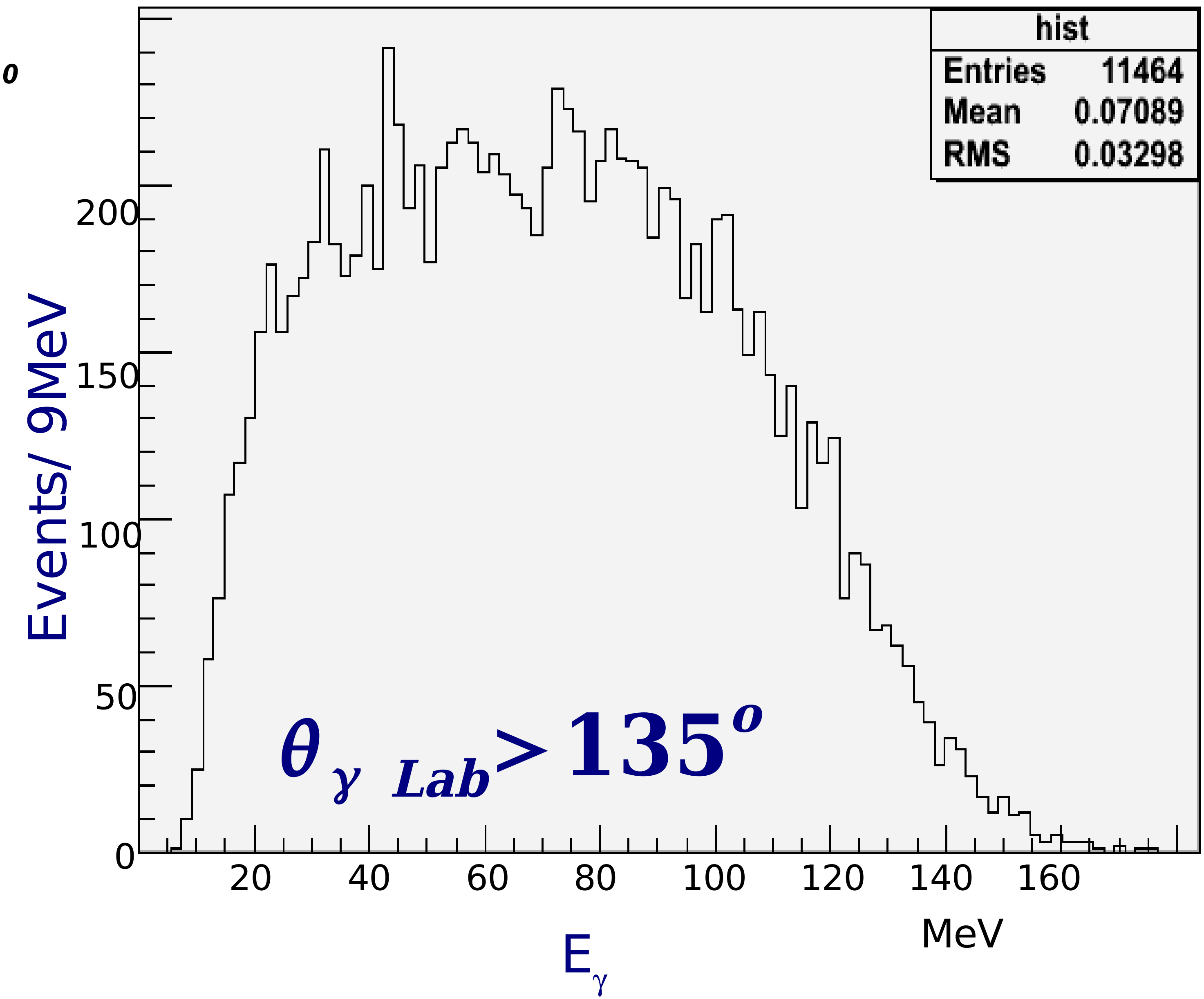




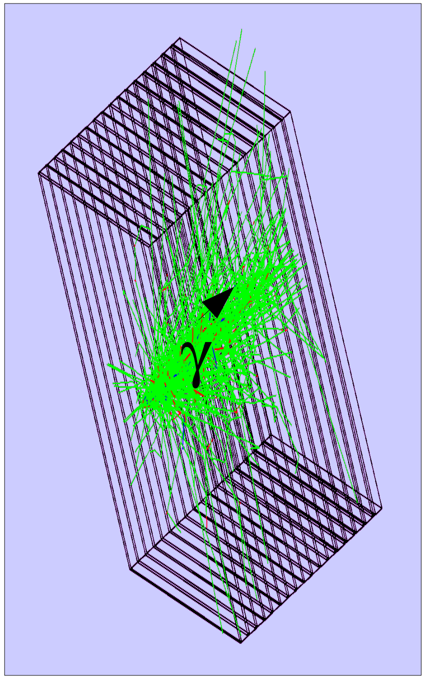


Soft Photon Energy Spectrum





UPV Design



Lead/Scintillator Sampling Calorimeter

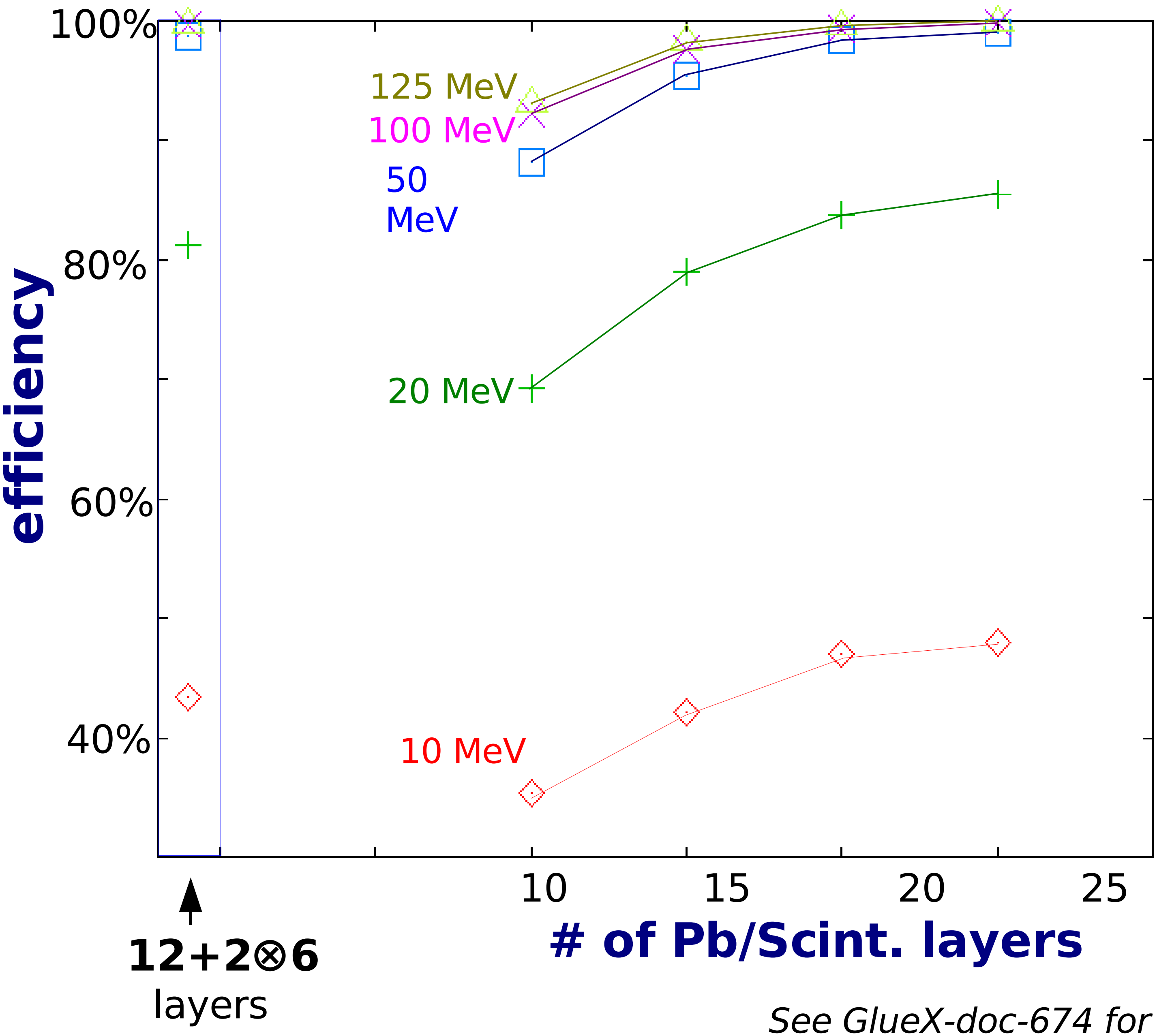
Alternating lead/scintillator layers

- 18 layers of 1cm thick scintillator
- 12 layers of 0.185 cm thick lead sheets ($0.36X_0$ each) followed by 6 layers 0.370 cm thick ($0.72X_0$ each)

material thickness: 22.4 cm or $8.91X_0$

~24% sampling fraction

GEANT Detection Efficiency

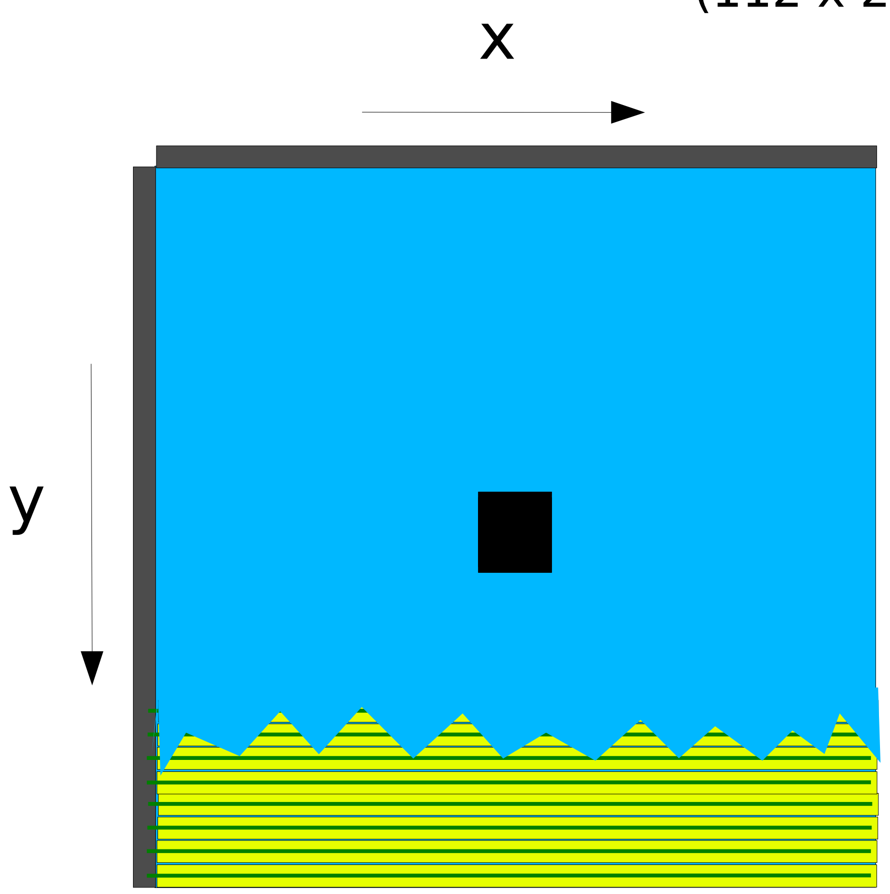


Events were accepted if the visible energy exceeded a threshold of 2.0 MeV

See GlueX-doc-674 for design optimization studies

UPV Segmentation

56 x,y by 2 *z*
segments
(112 x 2 = 224 channels)



Total UPV volume:
240cm x 240cm x 26cm

x, y segmentation

- **each scint. plane is composed of 56 4.25cm x 238cm scint. strips**
- **alternating layers of scint. are rotated forming a x-*y* stereo readout**

z segmentation

- **inner and outer segmentation in *z***

beam hole

- **central region has a 25.5cm x 25.5cm void**

Readout Options

option 1

WLS Fibers

Advantages

- good attenuation
- use fibers to bring light out
- use of extruded scint.
  - w/ groove & reflective wrap
- lower cost option
- fiber detour by beam hole

Disadvantages

- much less light
- increase complexity
- grooving of cast scint.
- aging fiber optical glue

option 2

WLS Bar

Advantages

- more light
  - reach lower threshold
- simplicity of design
- long term stability

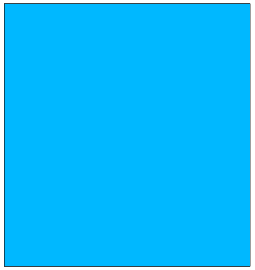
Disadvantages

- greater cost
  - need more PMTs
- increase channels
  - split beam hole coverage
- S.E.R.O. end effects

Wavelength Shifting Fibers

2- 2mm fiber/scint.

use 6mm x 6mm readout cell



9 scint. per x,y stack

5 scint. inner depth (10 fibers)

4 scint. outer depth (8 fibers)

SensL 12mm SiPM array

- 1 SensL array per readout channel
- 224 SensL arrays

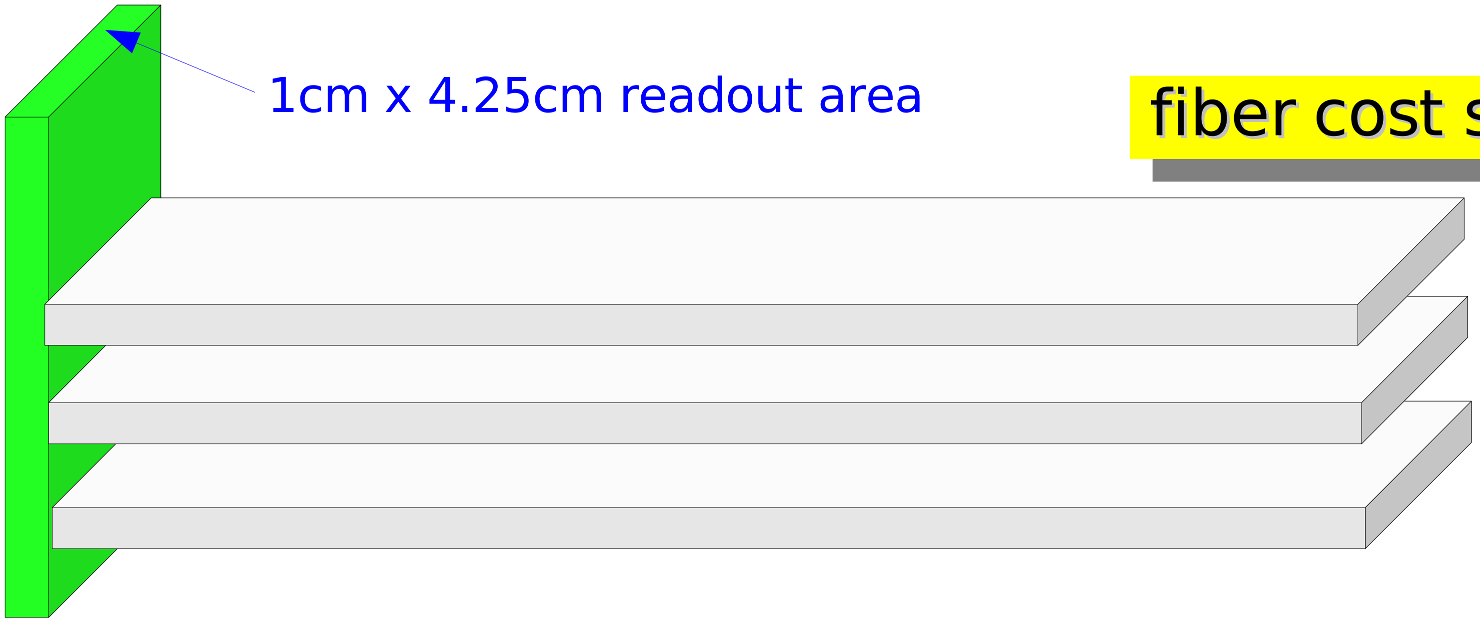
cost: 90 k$

Planacon (8 x 8) array

- 64 6mm x 6mm cells
- 224 channels = 4 tubes

cost: ~16 k$

Wavelength Shifting Bar



fiber cost savings: 51 k$

SensL 12mm SiPM array

- full coverage (100%)
  - 3 SensL array/channel
- Winston cone reduction
  - 68% area, 2 SensL arrays/chan.
  - 33% area, 1 SensL array/chan.

cost: 275 – 185 - 95 k$

Planacon (2 x 2) 25mm array

- full coverage (100%)
- 224+12 channels = 59 tubes

Planacon (4 x 4) 12.5mm array

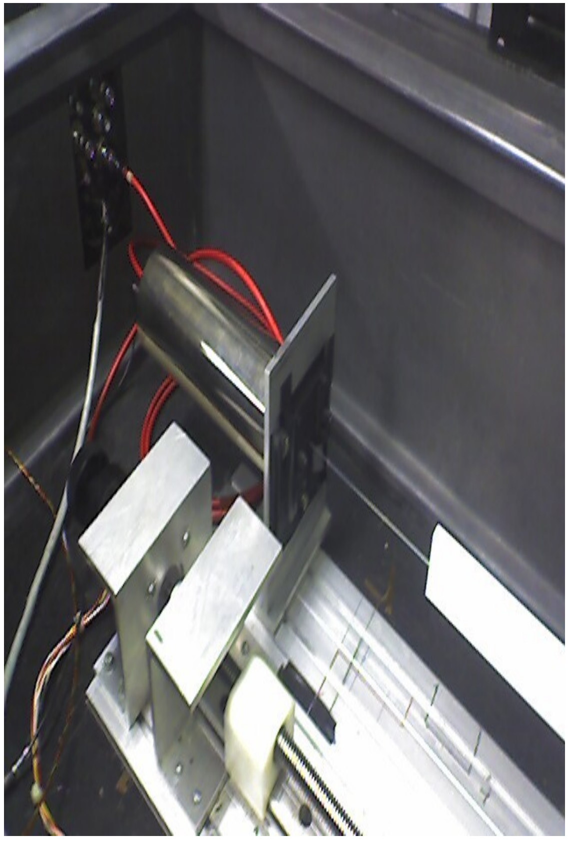
- Winston cone reduction
- 68% area, 2 cells/chan. = 29 tubes
- 33% area*2 sides, 1 cell/chan = 29 tubes

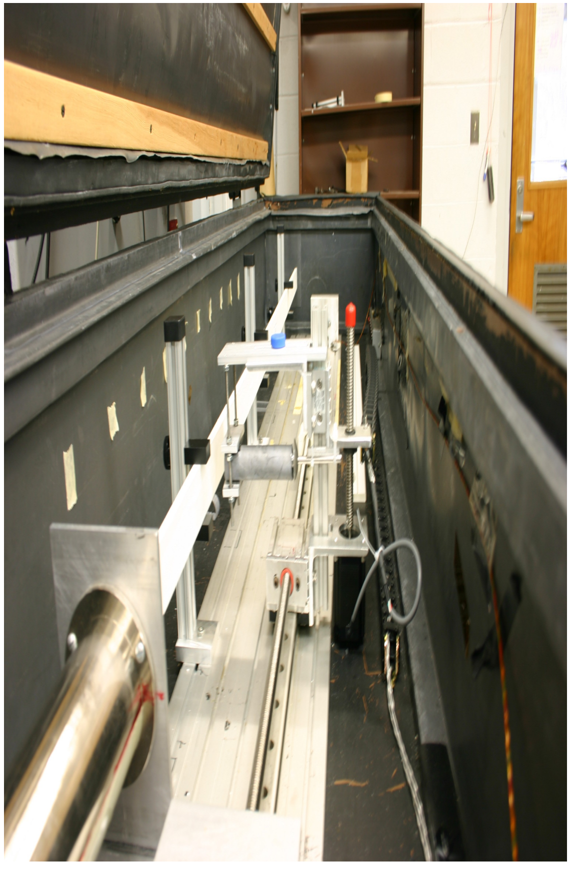
cost: 70 - 125 k$

R&D on WLS Fiber Readout

GlueX-doc-846

Light-tight test box: lower left image show the PMT/fiber interface, lower right image shows the controlling system for the radioactive source with mounted scintillator.

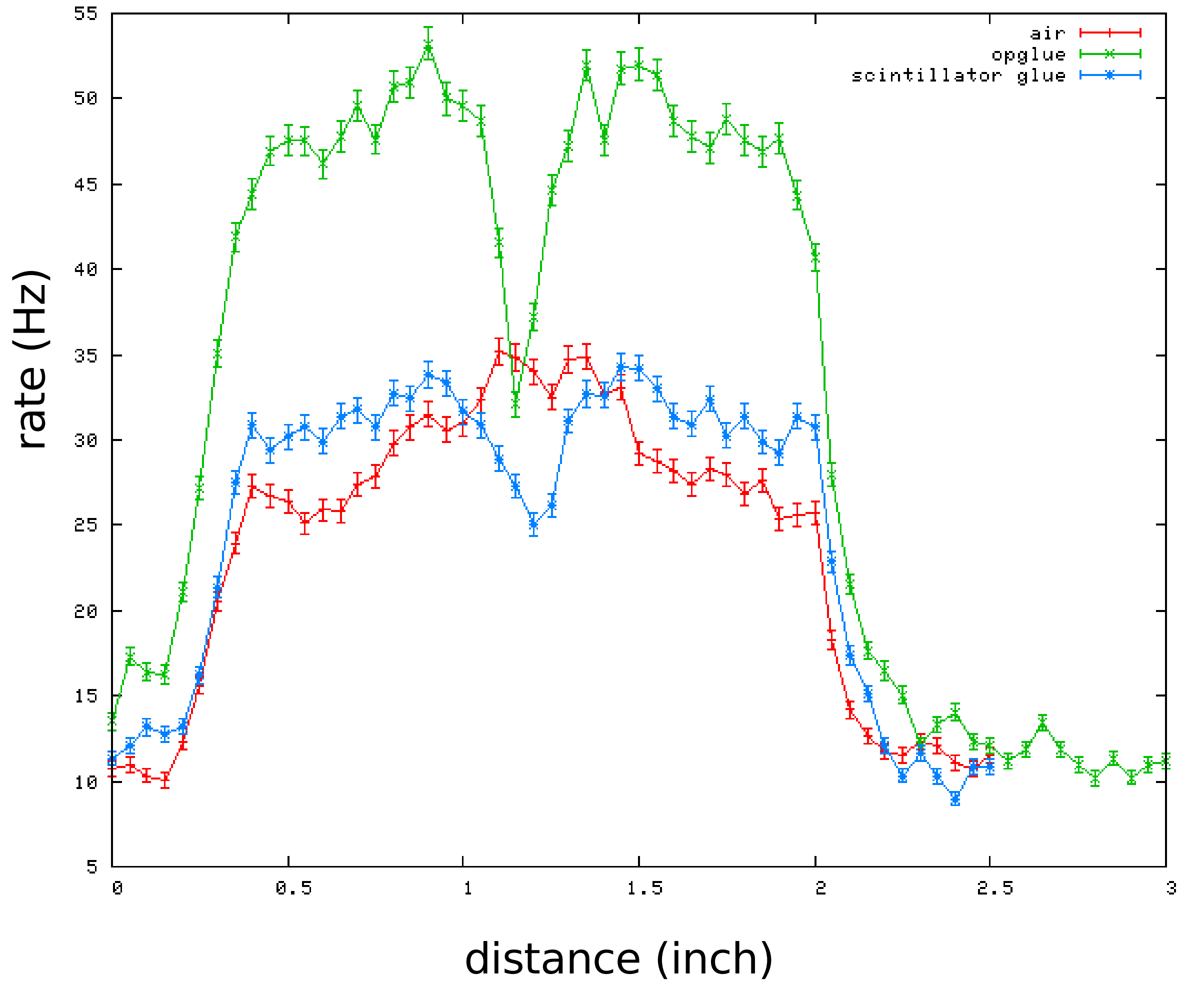




The fibers were milled flat using a specially designed fiber clamp.

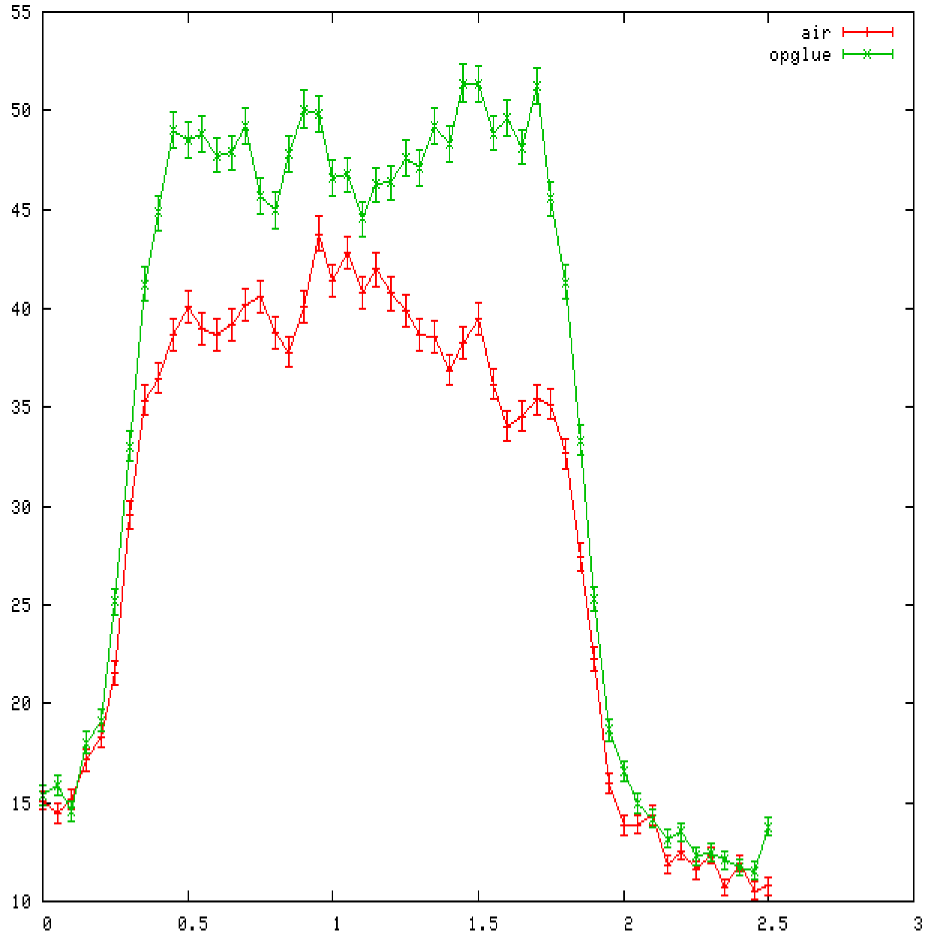
Uniformity & Yield Scans

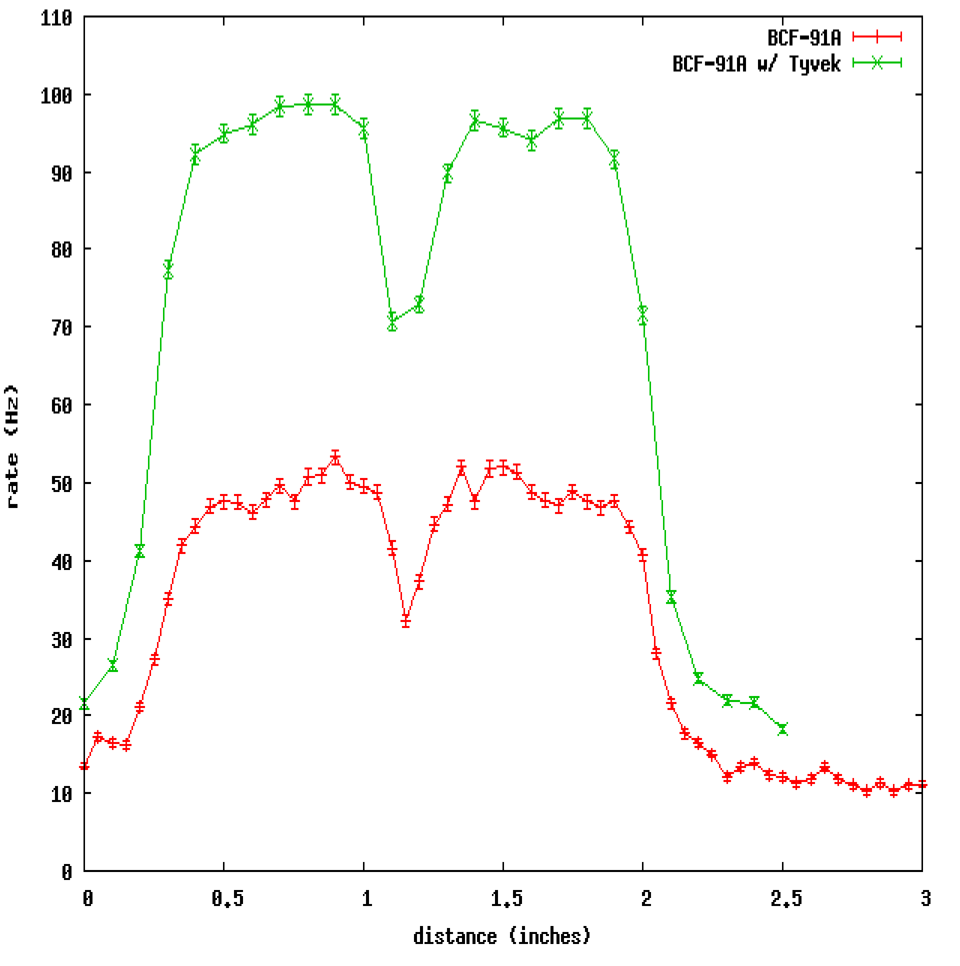
Rate (Hz) as a function of position (inches) across the scintillator surface: comparing air-gap, optical cement, and scintillator resin optical-coupling methods. The optical cement overall out performs the other methods except for the large variation in the groove region.



Extruded & Cast Scintillators

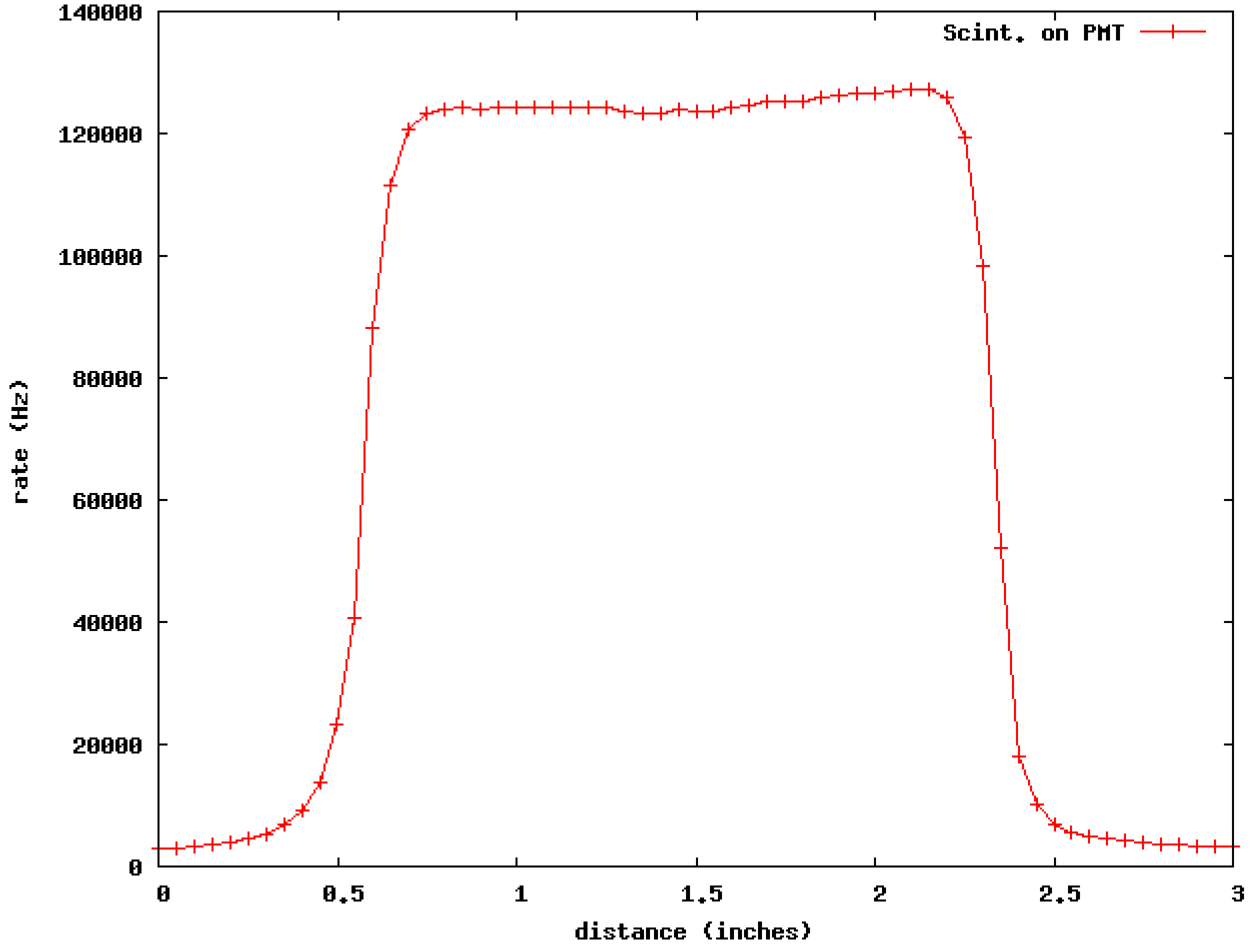
Rate (Hz) as a function of position (inches) across the scintillator surface: Extruded polystyrene-based scintillator from the Fermilab-NICADD extrusion line. The measurements are for a fiber air-gap coupling and an optical cement coupling.



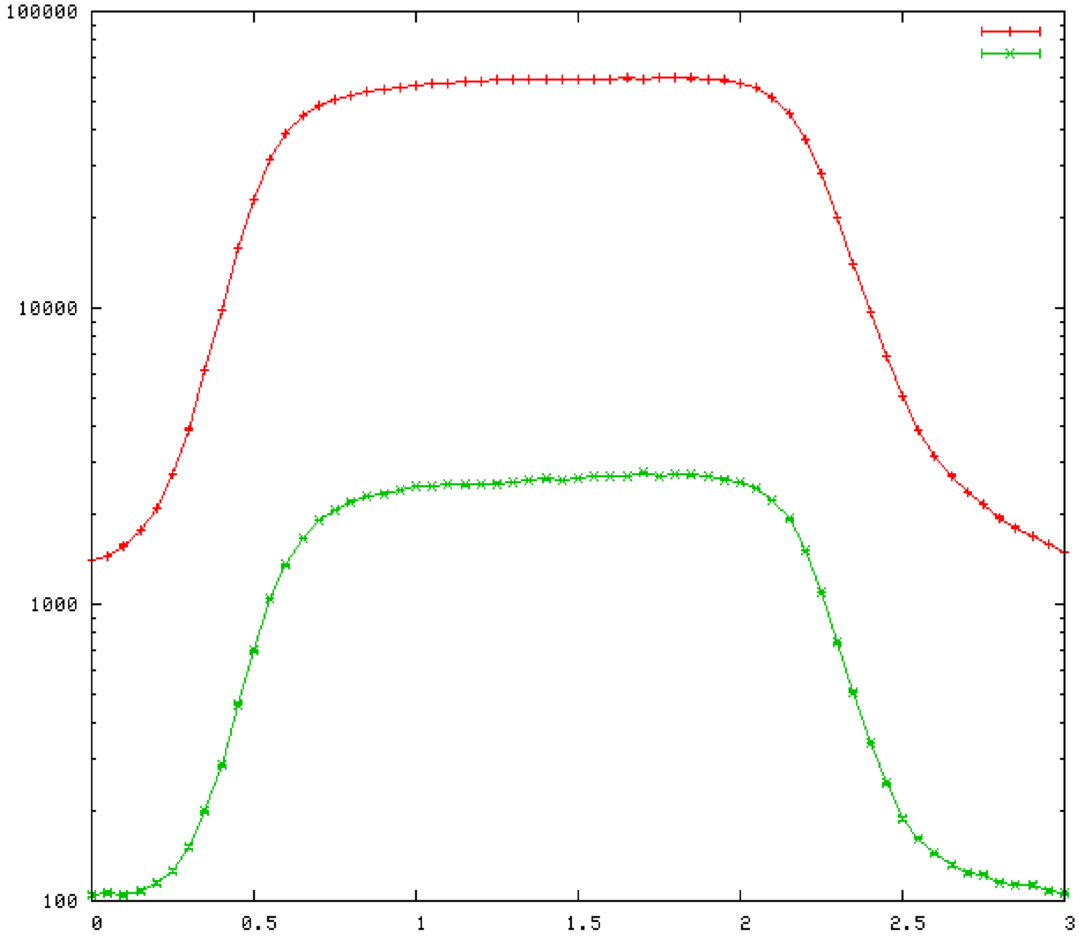


Rate (Hz) as a function of position (inches) across the scintillator surface: measurements with and without Tyvek wrapping on scintillator.

Scintillator coupled directly to PMT



Scintillator coupled directly to PMT

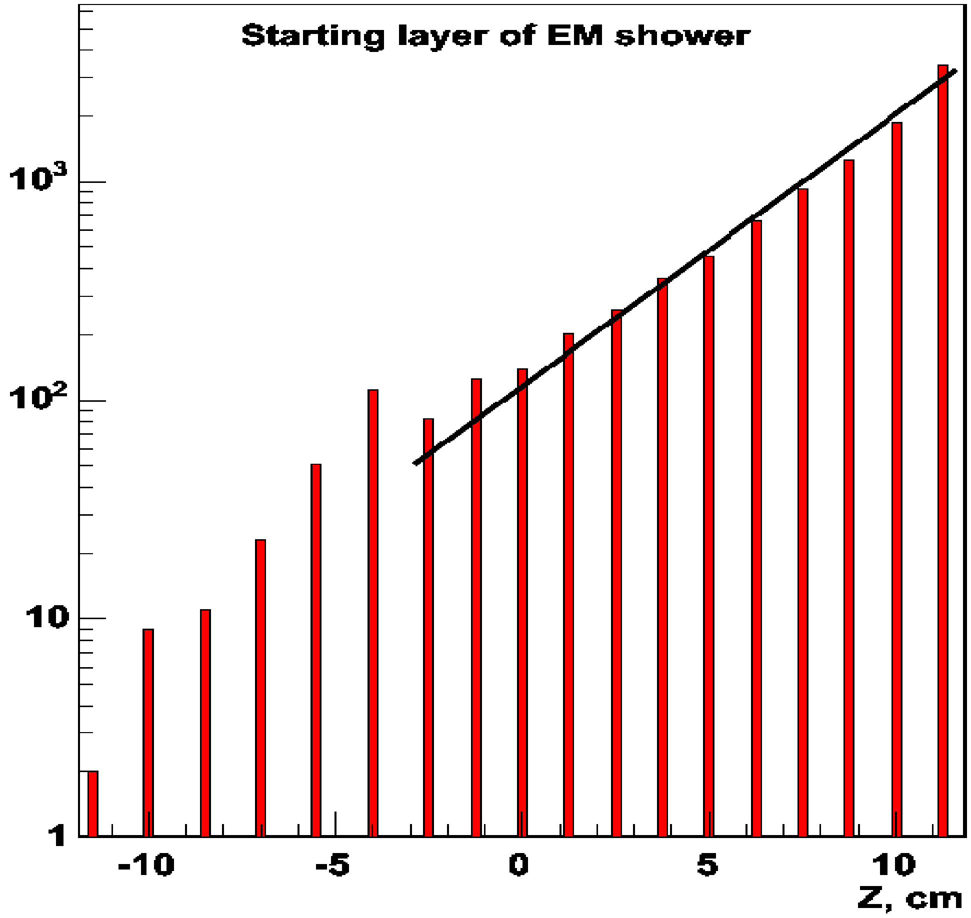


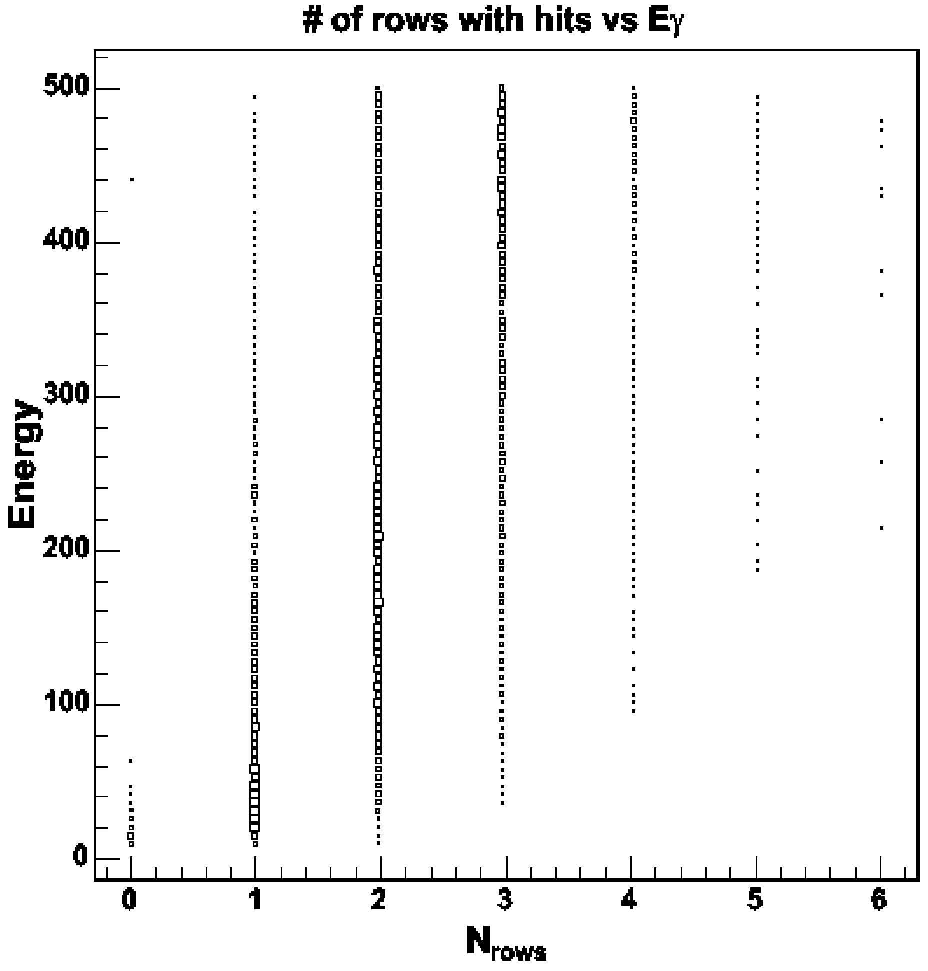
Sasha's slides

UPV reconstruction issues

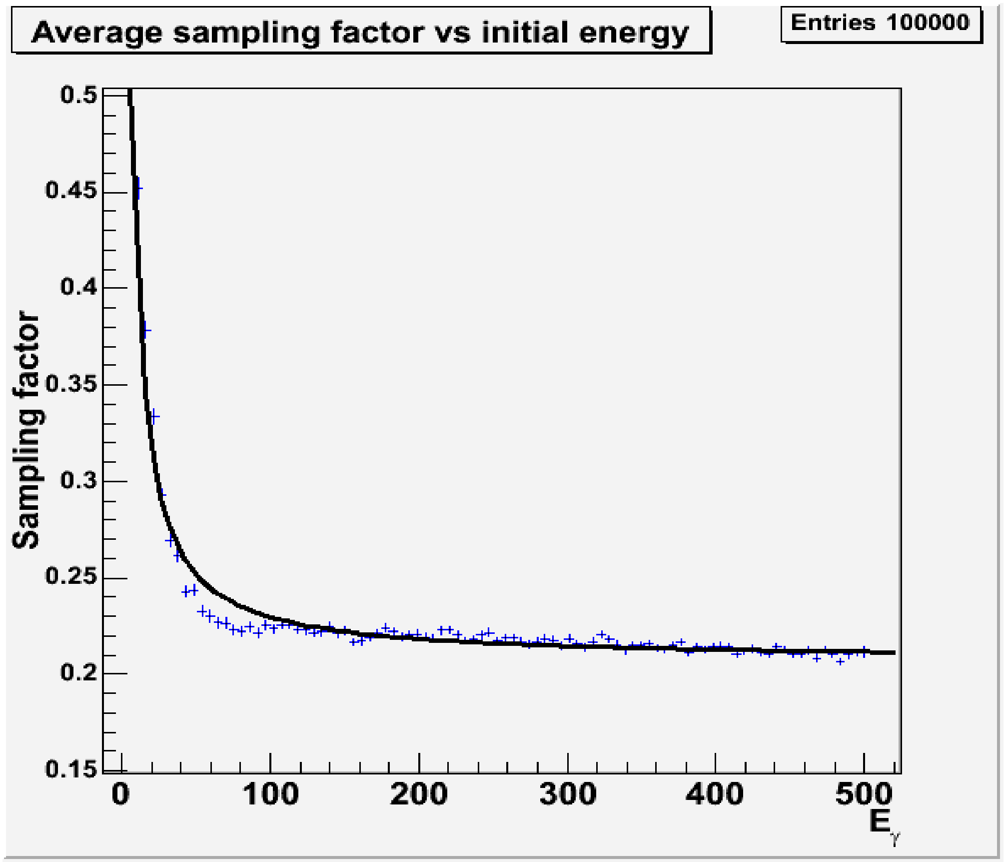
- **Code for 2 different UPV layouts:**
  - Old Design I: *1D layout with readout on both ends*
  - New Design II: *2D layout with readout on one end*
- **Single-photon Monte Carlo results:**
  - Average sampling factor
  - Energy resolution
  - Longitudinal positional resolution
    - *Time-based*
    - *Amplitude-based*
  - Transverse positional resolution
- **Current UPV reconstruction projects:**
  - Ambiguities in multi-photon events
  - Confidence level

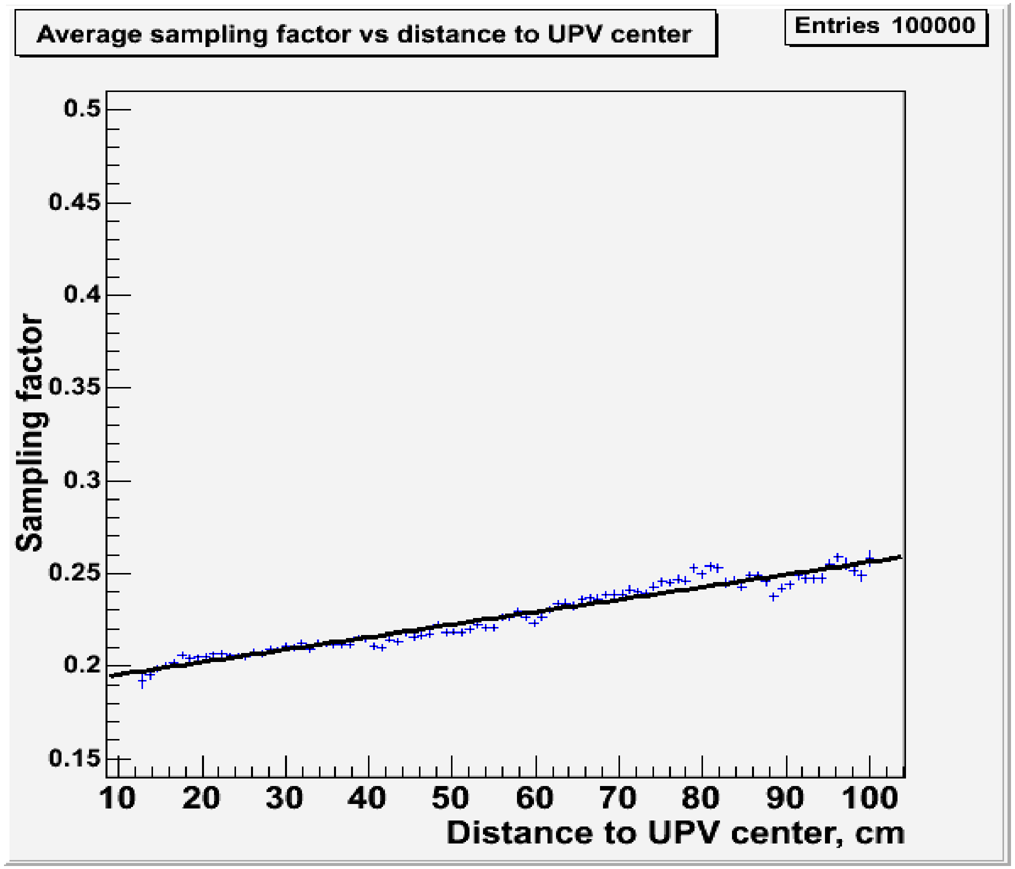
EM shower depth and width





Average sampling factor

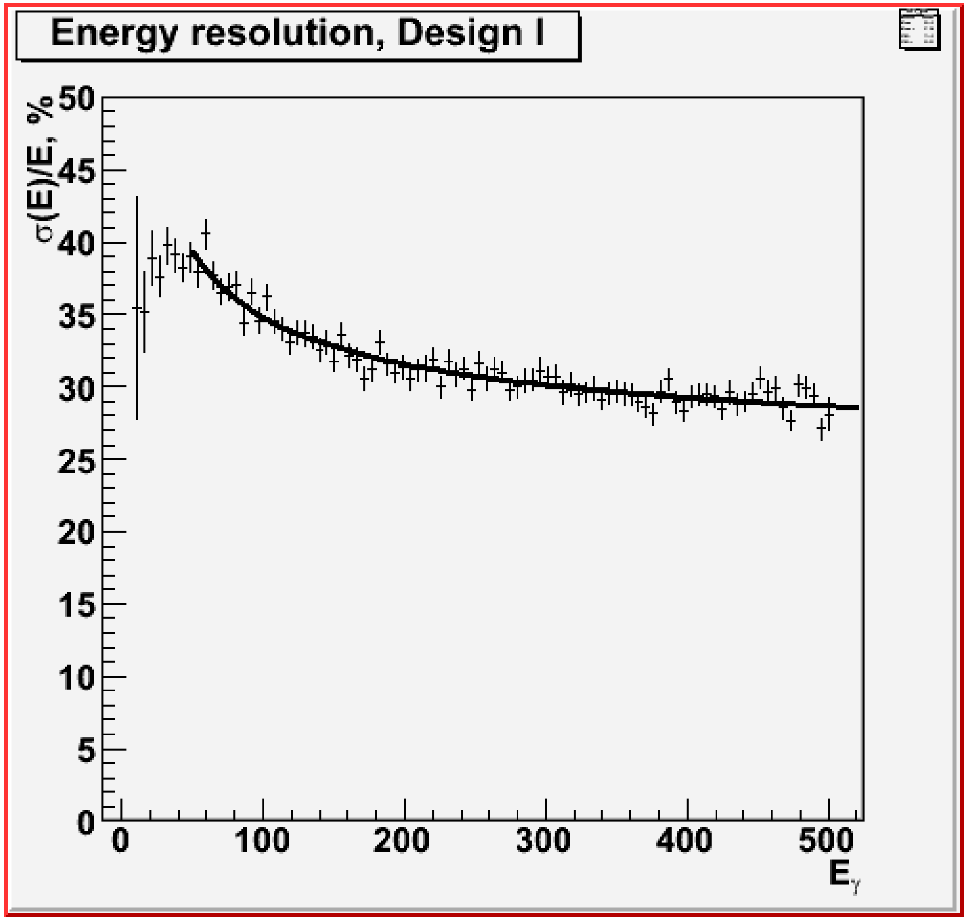


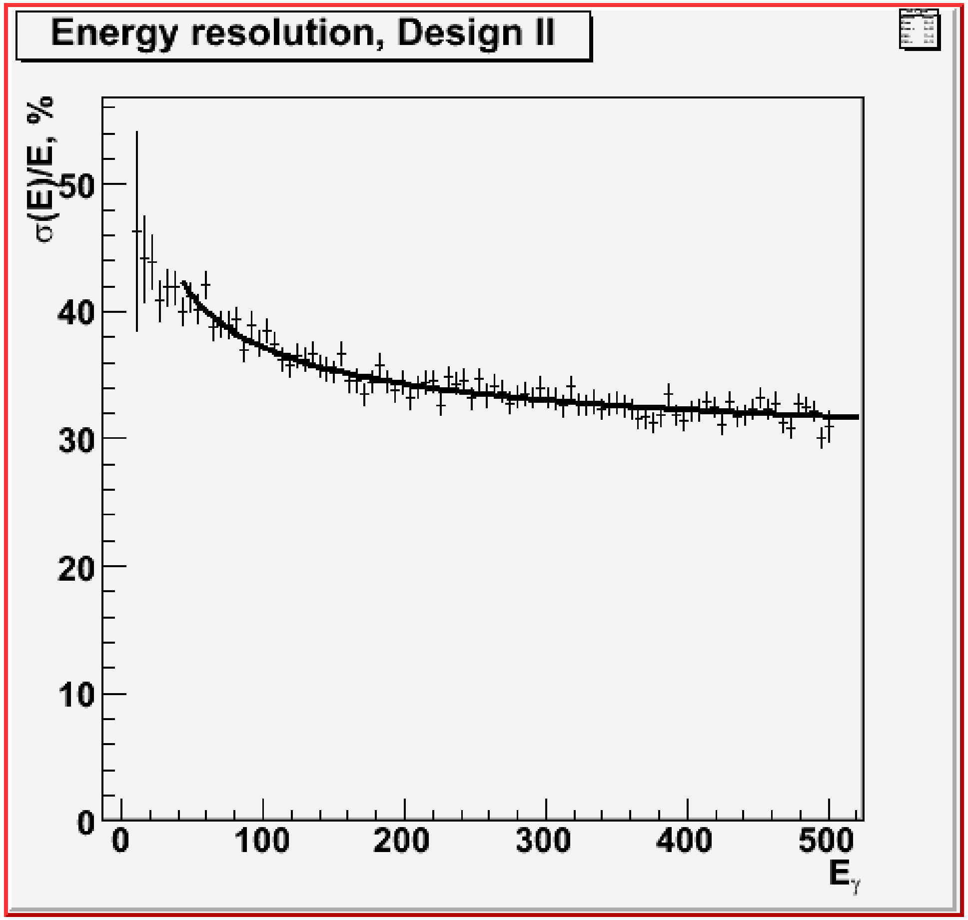


$$\frac{E_{seen}}{E_\gamma} \sim a + \frac{b}{E_\gamma}$$

$$\frac{E_{seen}}{E_\gamma} \sim c + d \cdot R$$

Energy resolution



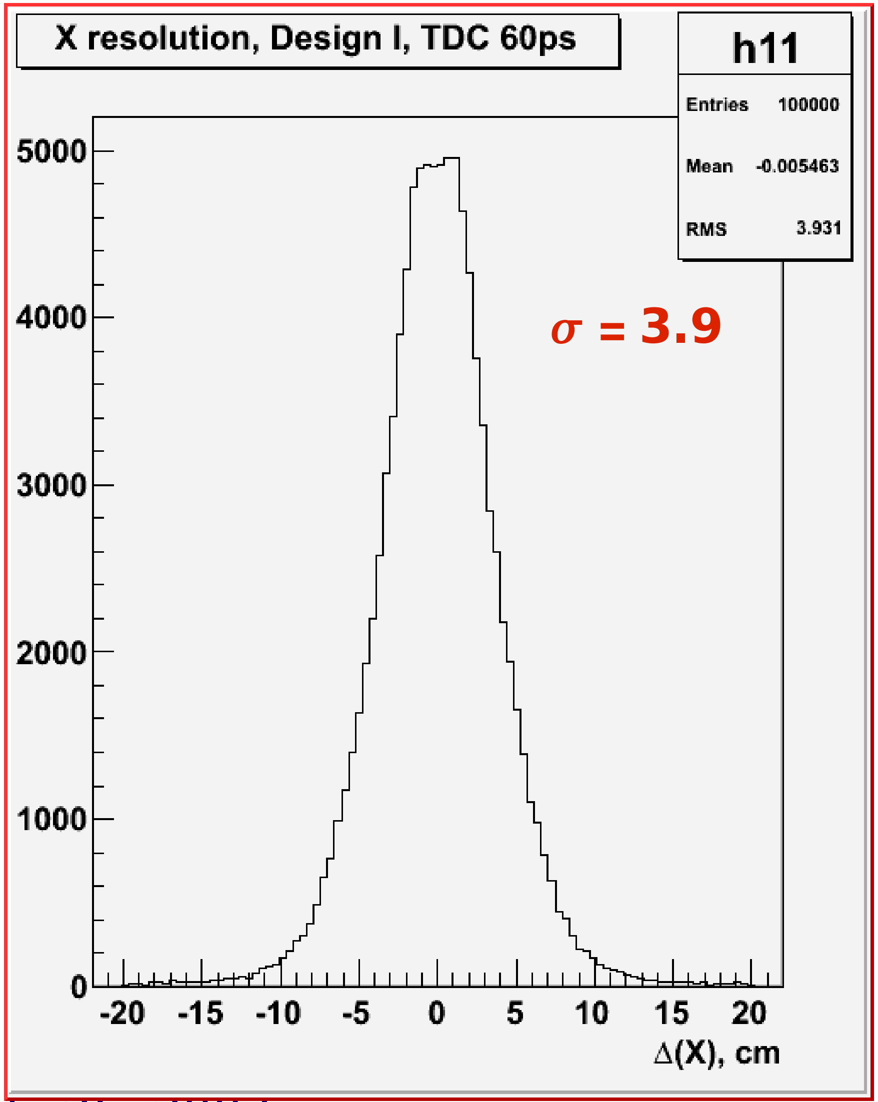


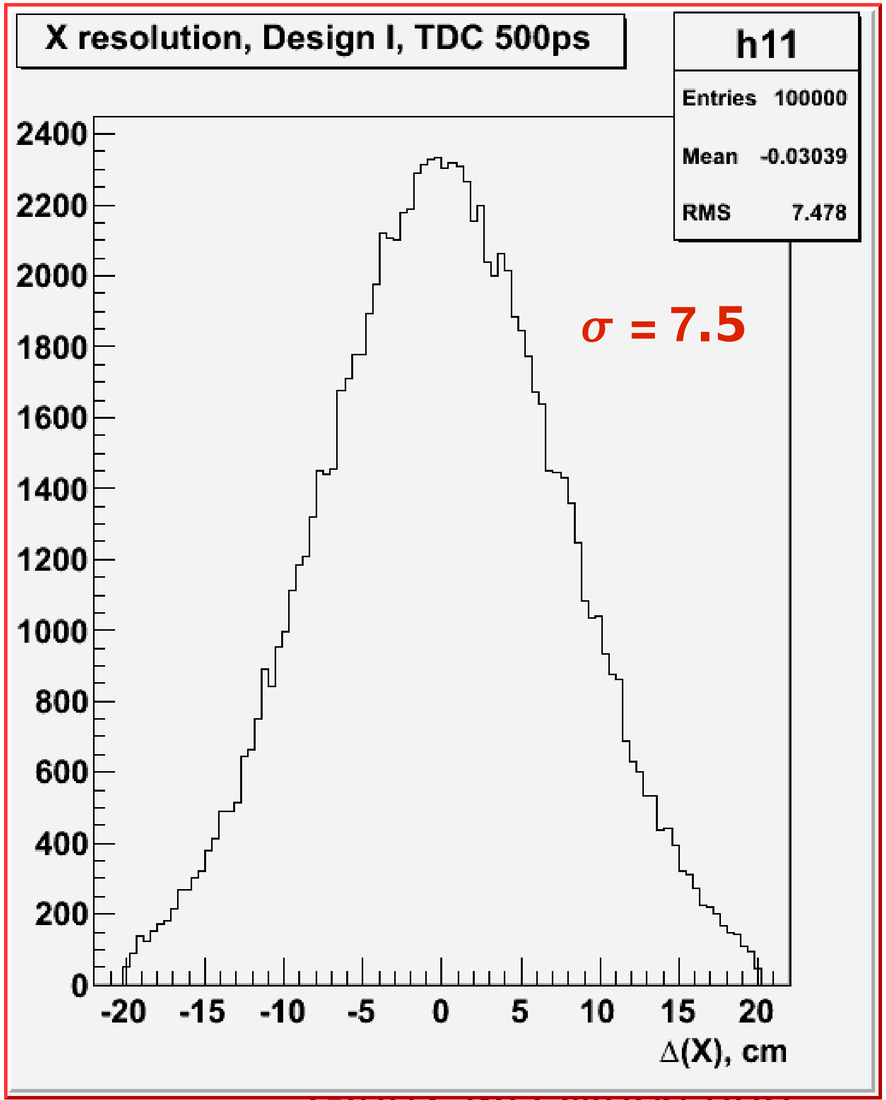
$$\frac{\sigma(E)}{E} \sim 23\,\% + \frac{3.4\,\%}{\sqrt{E}}$$

$$\frac{\sigma(E)}{E} \sim 27\,\% + \frac{3.2\,\%}{\sqrt{E}}$$

Longitudinal resolution (Design I)

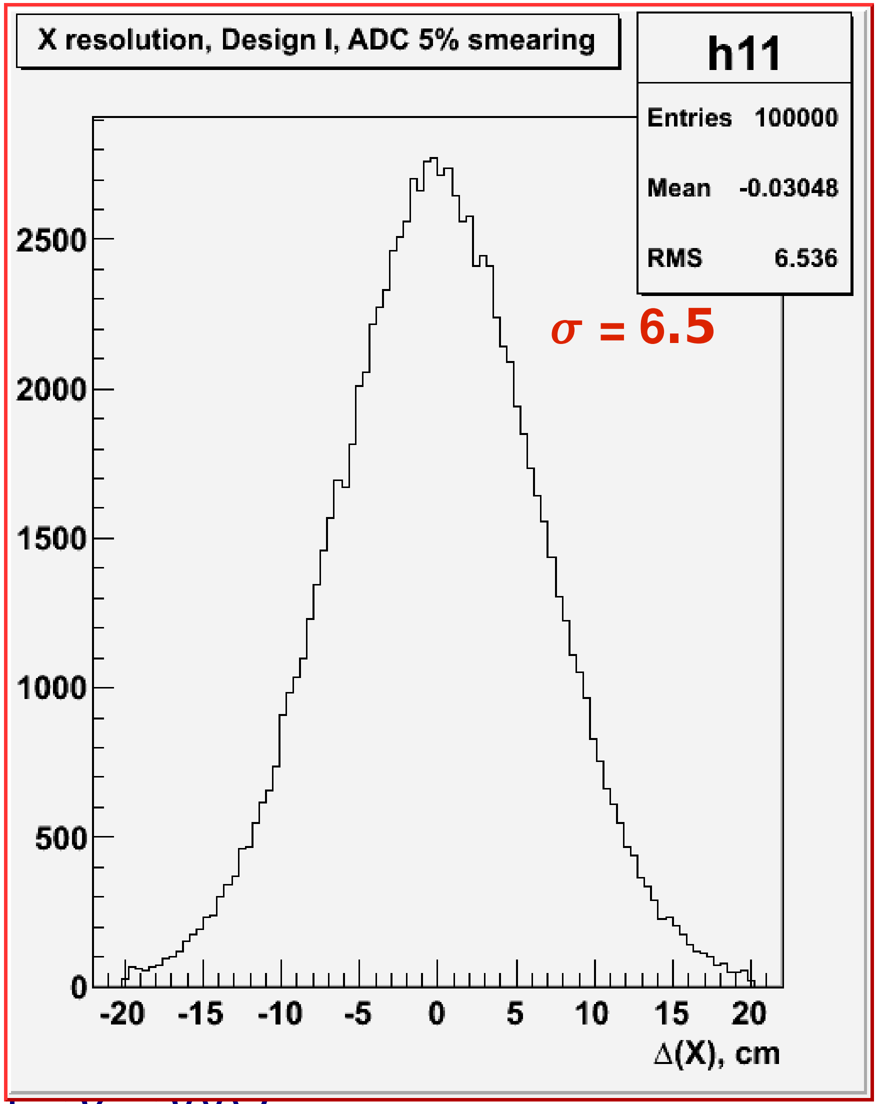
$$Using\ \ timing: \quad X_{rec} = c_{eff} * (t_1 - t_2) / 2$$

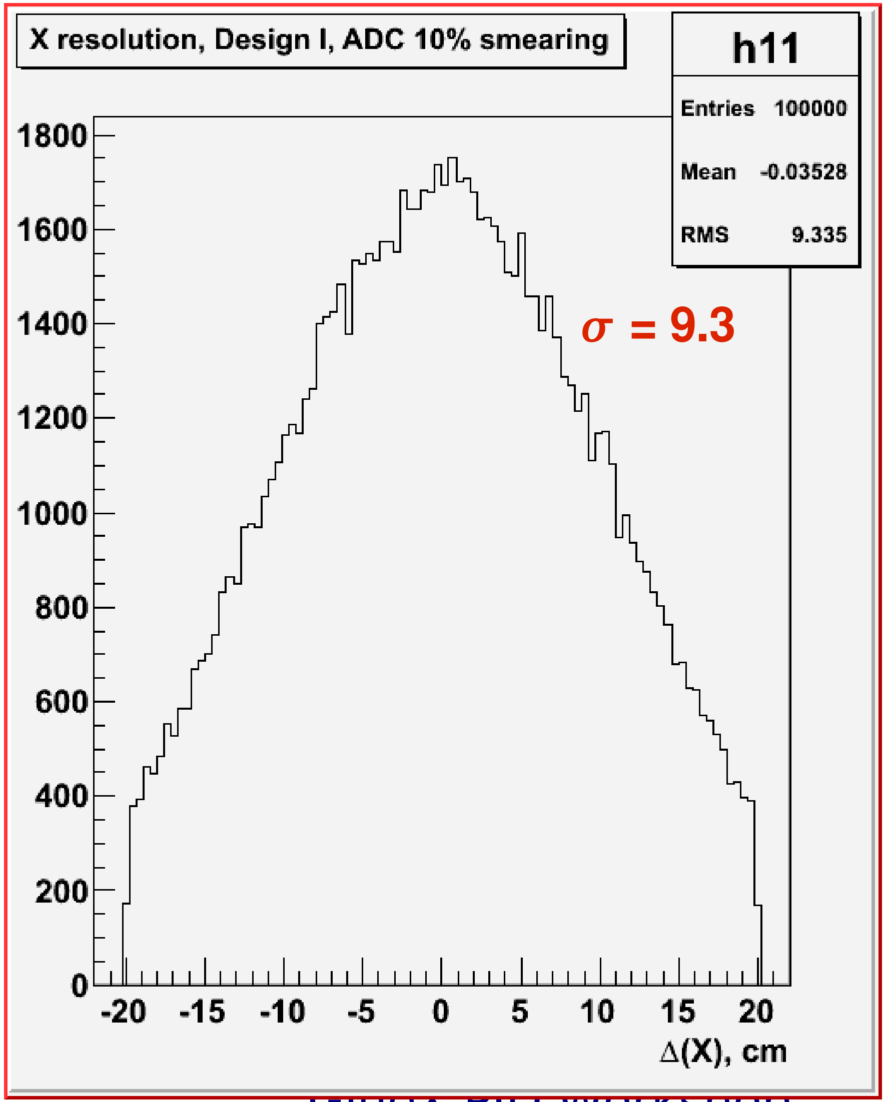




Longitudinal resolution (Design I)

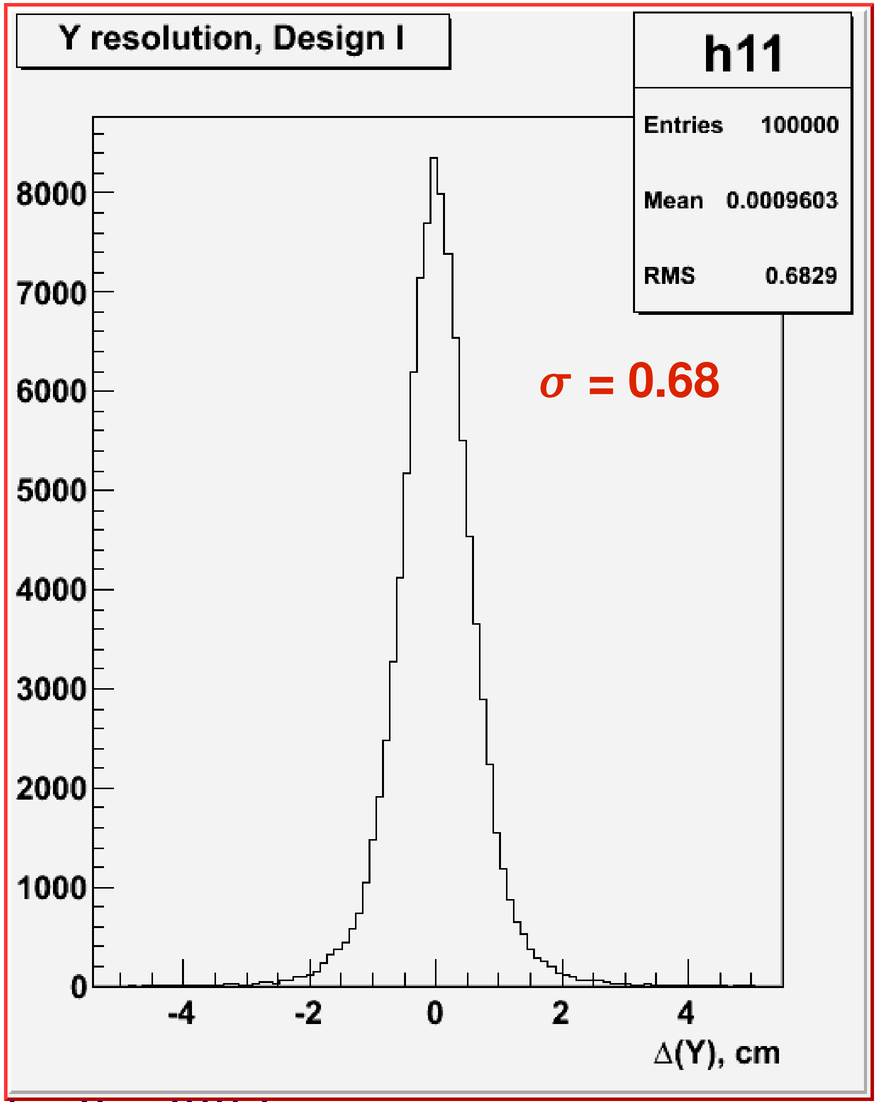
$$Using\ \ amplitude: \quad X_{rec} = 0.5\lambda_{atten} * (\log E_1 - \log E_2)$$

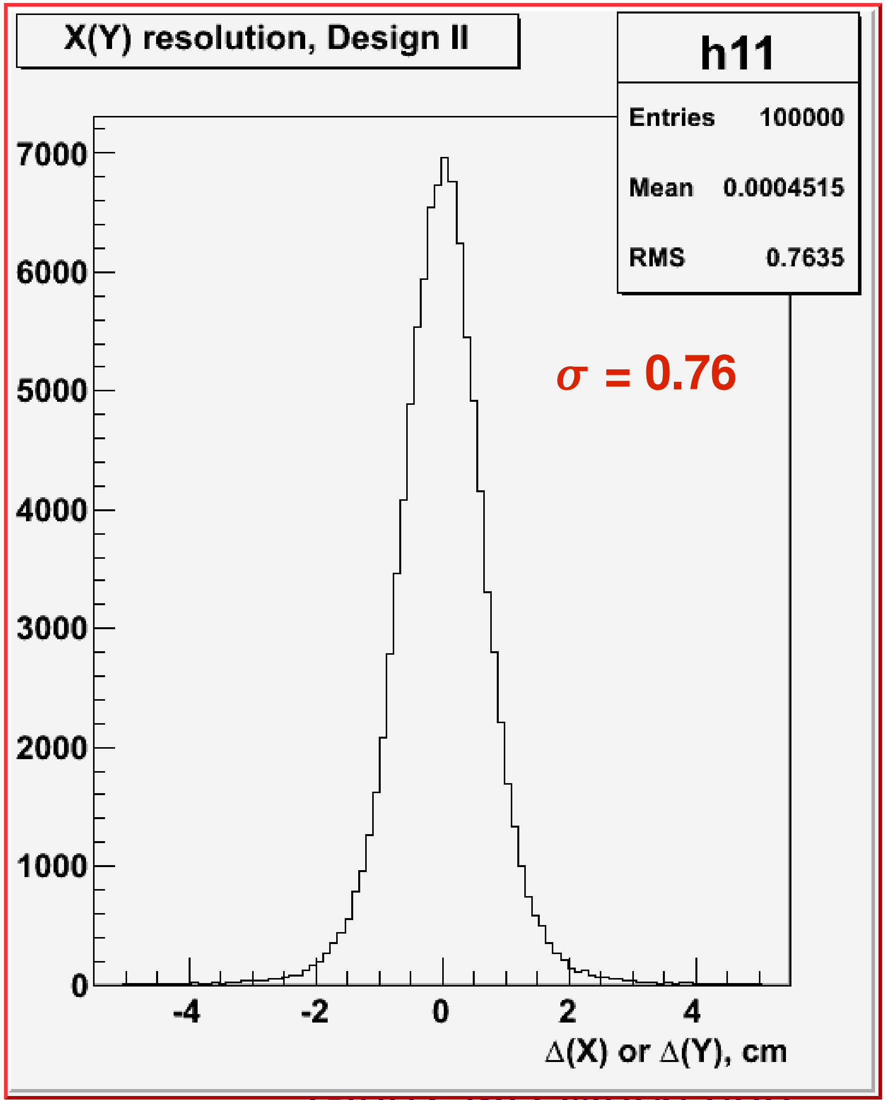




Transverse resolution

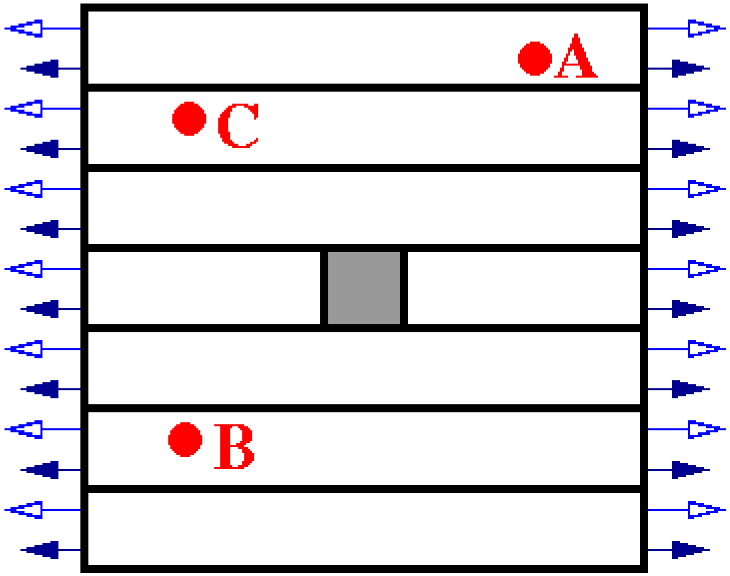
$$X_{rec} = \sum E_i x_i^c \ / \sum E_i$$



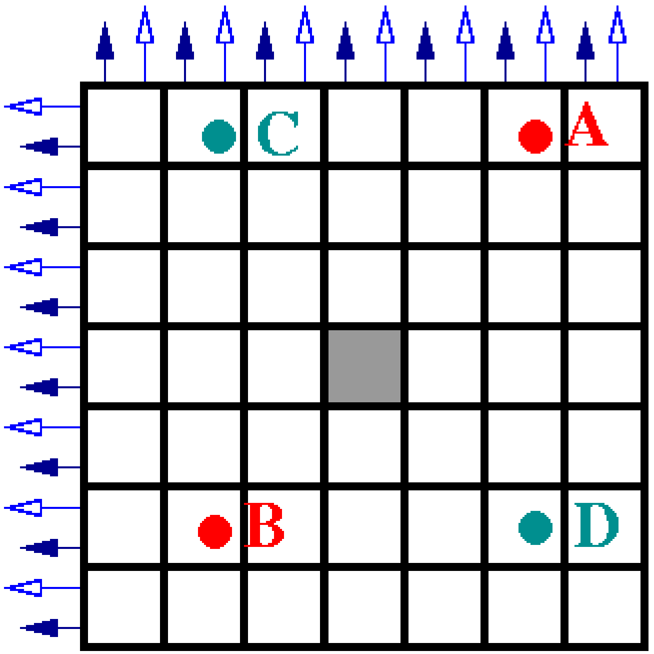


Multiple-hit ambiguities

Design I



Design II

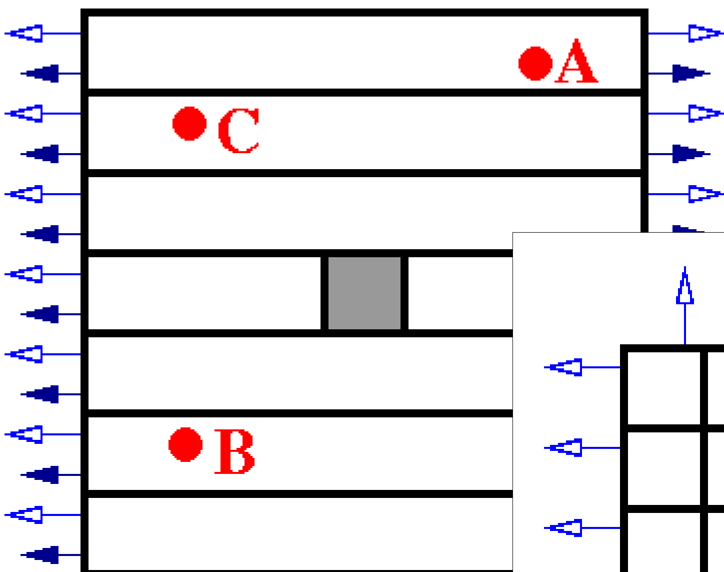


A and B: unambiguous
A and C: ? shape of ADC signal ?

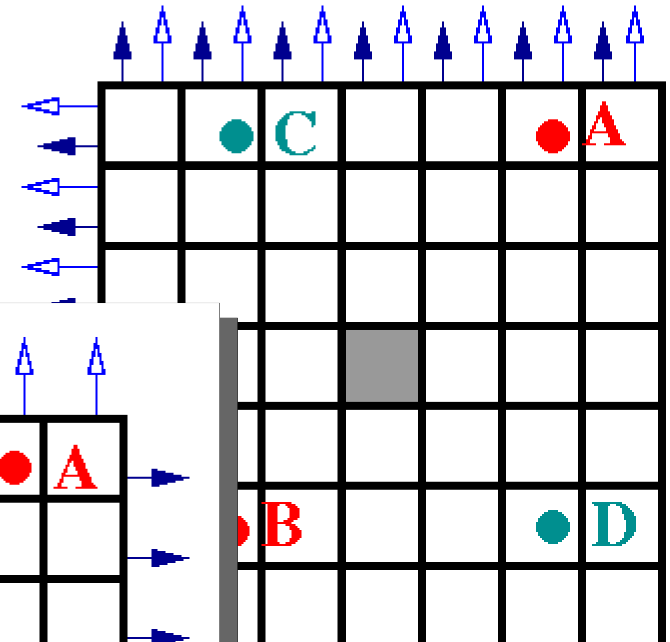
A and B: ambiguous with C and D
- Sorting by energy doesn't work
- Sorting by time doesn't work
- ? optimal confidence level ?
- ? improved Design III ?

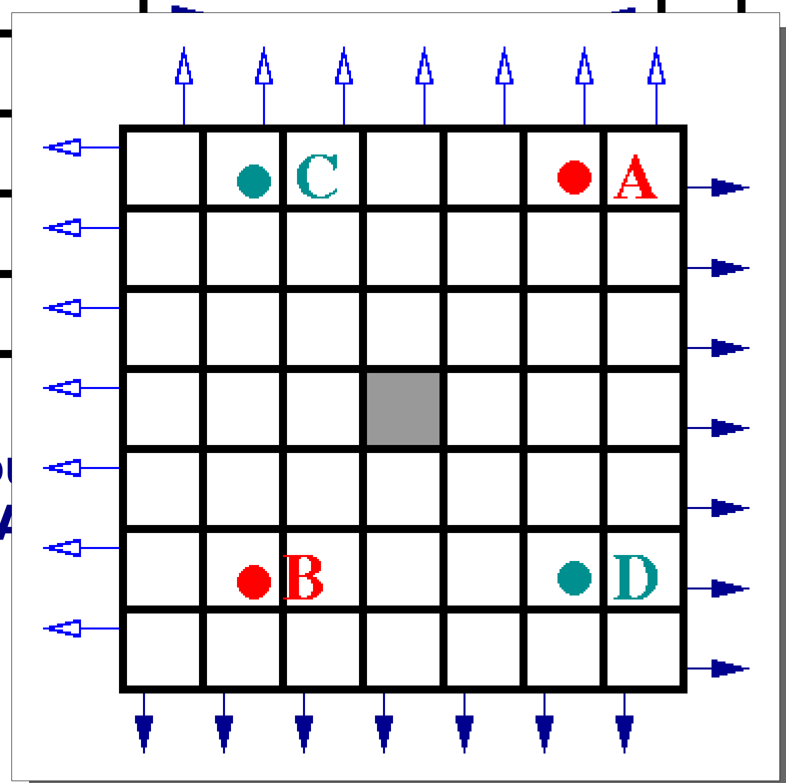
Multiple-hit ambiguities

Design I



Design II





A and B: unambiguou
A and C: ? shape of A

mbiguous with C and D
by energy doesn't work
by time doesn't work
confidence level ?
ed Design III ?

Confidence level

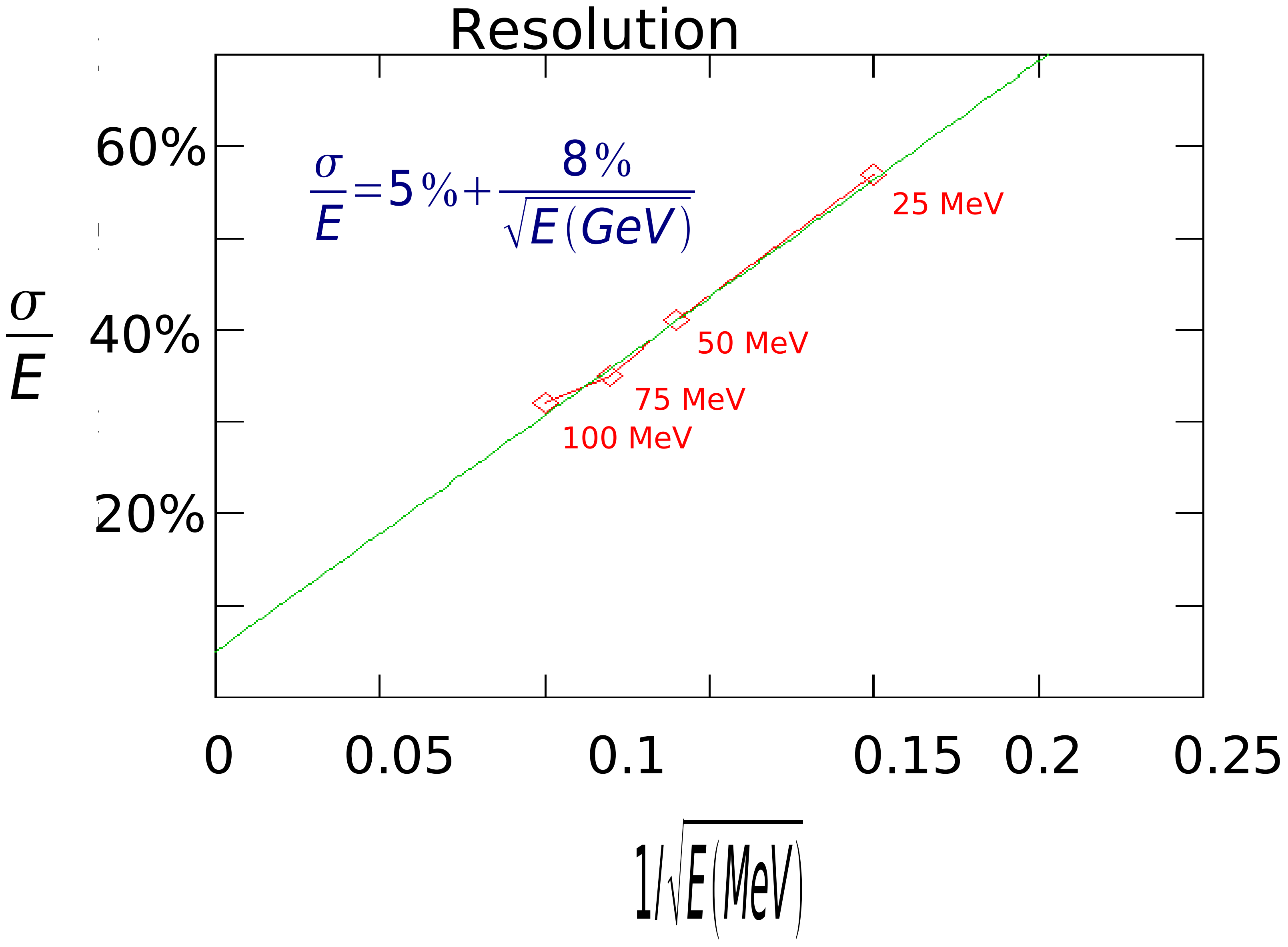
Probability of a hit to be an electromagnetic shower

Components of the error matrix:

- **Number of rows (width) as a function of energy**
- $\sigma(E_x - E_y)$
- $\sigma(E_{inner} - E_{outer})$
- **probably,** $\sigma(t_1 - t_2)$ **or** $\sigma(t_1 + t_2)$

backup slides

GEANT Resolution



Beamline Related Backgrounds

Geant simulation of beamline and shielding including photo-hadronic interactions and muon pair production.

Conclusion:
negligible background

~25 kHz whole region