High Performance $PbWO_4$- Lead Glass Hybrid Calorimeter at Jefferson Lab

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Outline

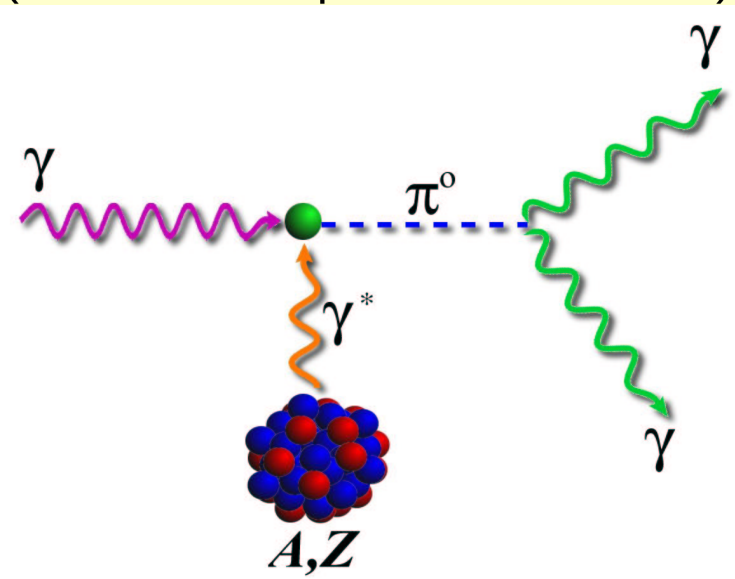
1. **Requirements for the Calorimeter**
2. **The HYCAL calorimeter design**
3. **Physics run performance**
4. **Summary.**

Requirements for the Calorimeter

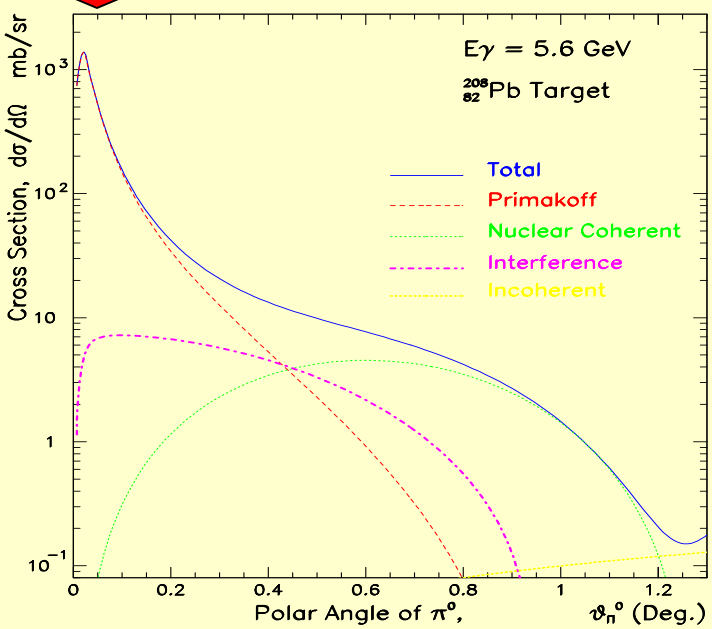
Forward electro-photoproduction of neutral mesons (π^o η η') @ 1- 10 GeV requires:

- High energy resolution;
- High position resolution;
- Good photon detection efficiency @ few GeV;
- Large geometrical acceptance.

π^o life-time measurement at JLab (the PrimEx experiment E-02-103):



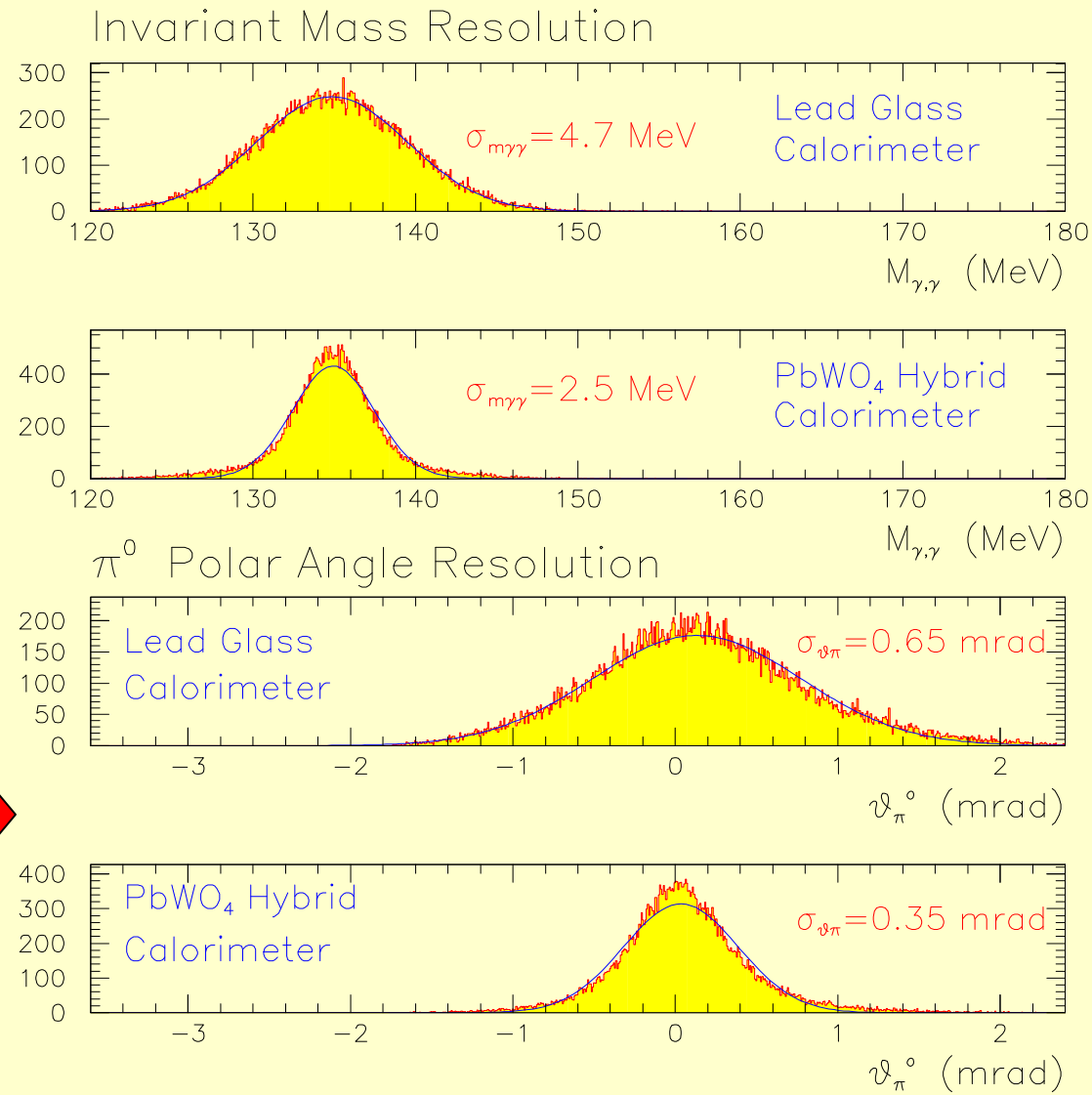
$(\vartheta_{Pr})_{peak}$~ 0.3 mrad



Design Concept and Resolutions

$\gamma\gamma$ Invariant Mass Resolution

Angular Resolution

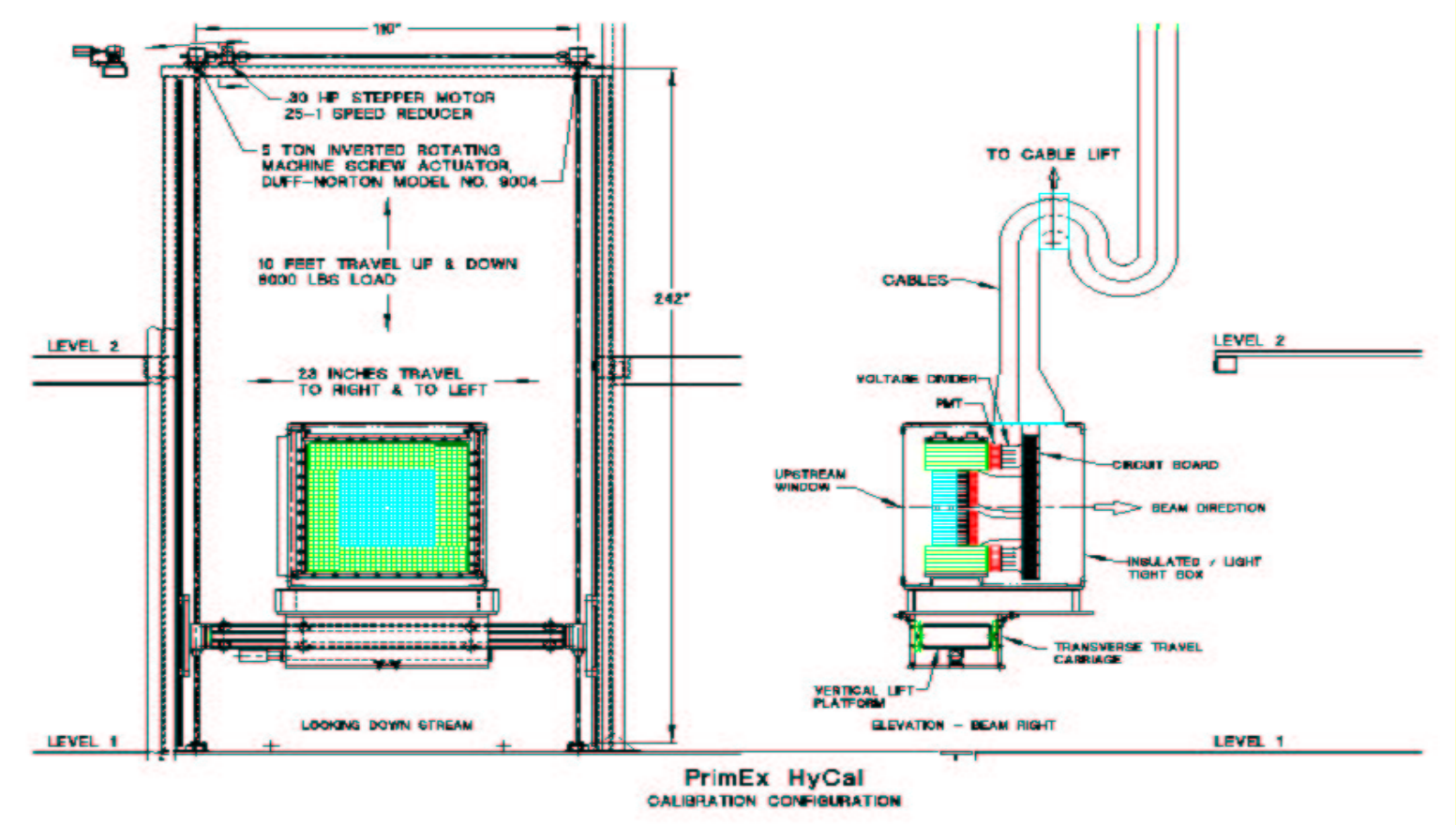


Design Concept

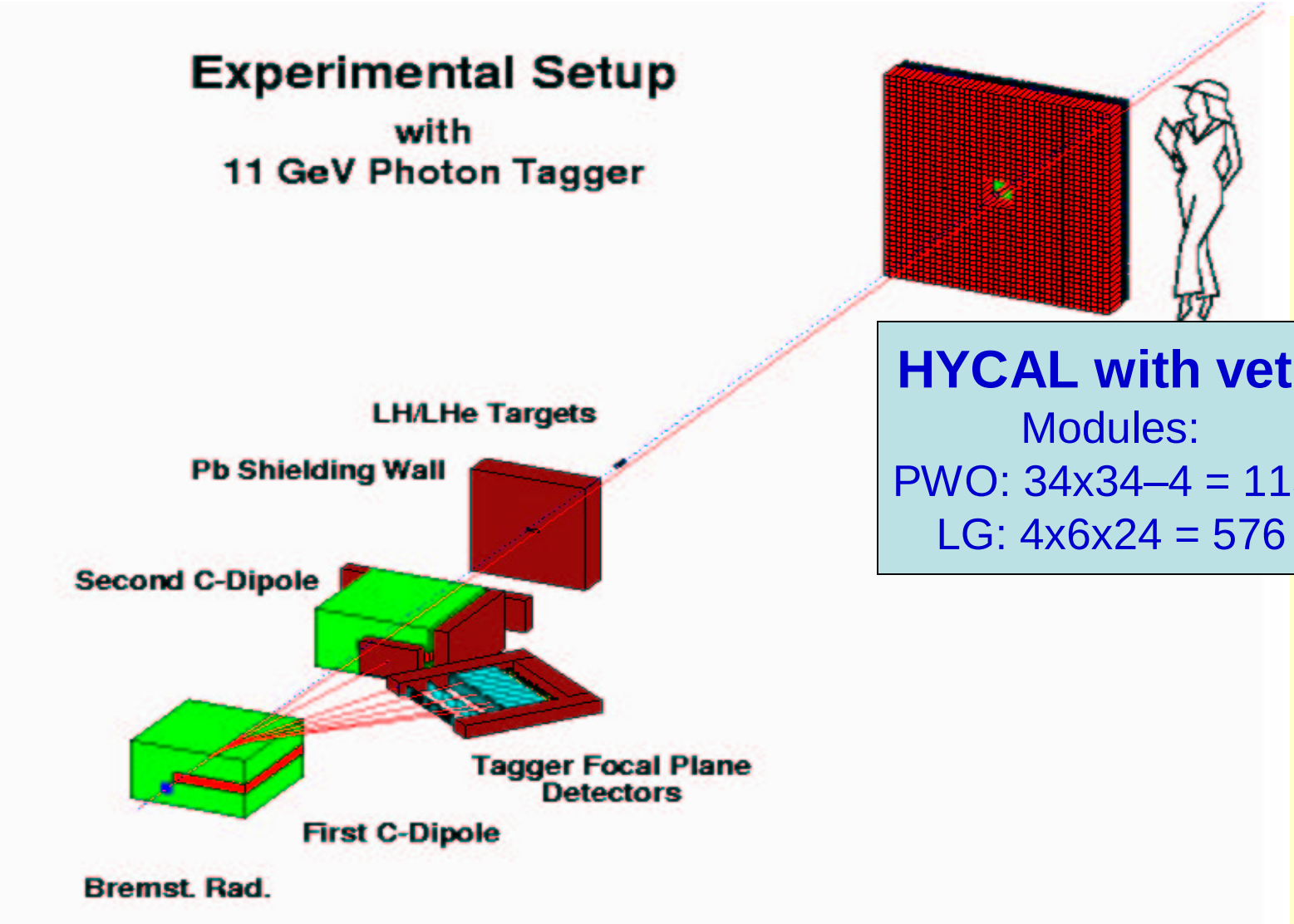
Resolution + Budget

PbWO4 crystal Detectors

Pb – glass Cherenkov detectors



Design Concept



HYCAL with veto

Modules:

PWO: 34x34–4 = 1152

LG: 4x6x24 = 576

$PbWO_4$ Crystal Dimensions

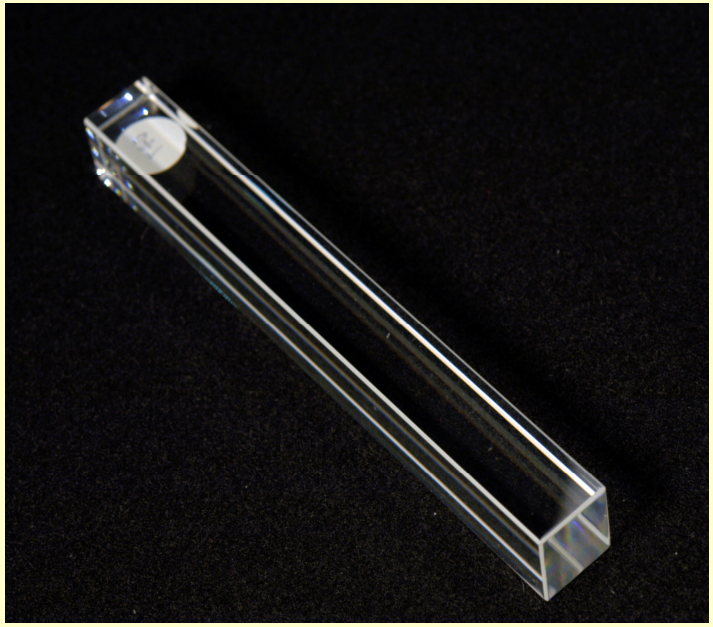
Geometrical size:

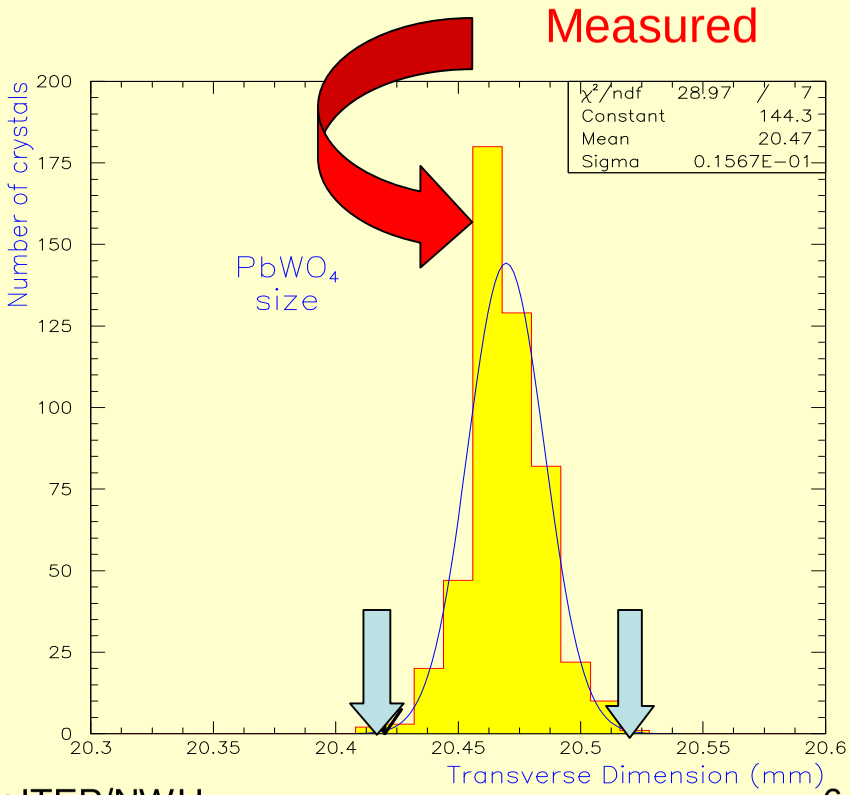
20.5 x 20.5 x 180.0 mm^3

Tolerances (mm):

20.5 + 0.0 - 0.1
180.0 + 0.3 -0.0

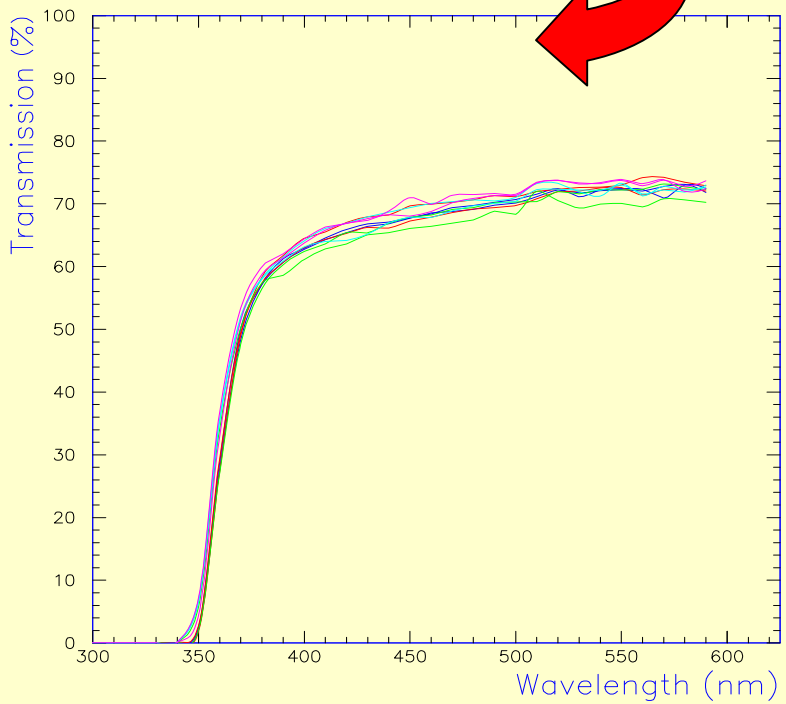
Specified

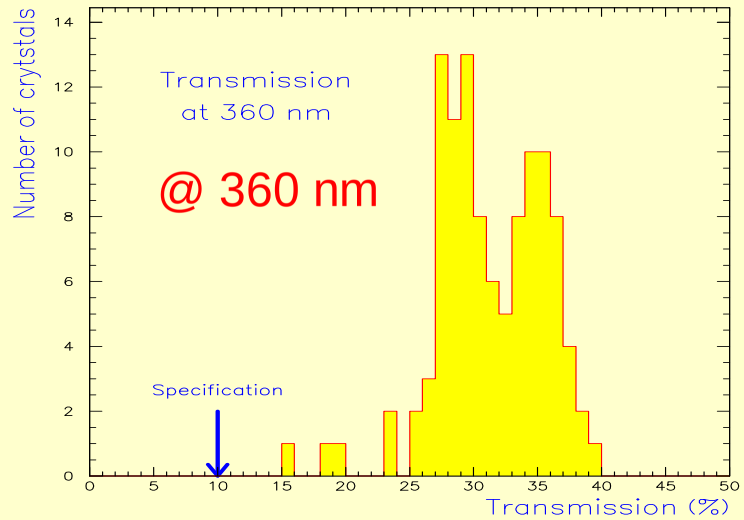


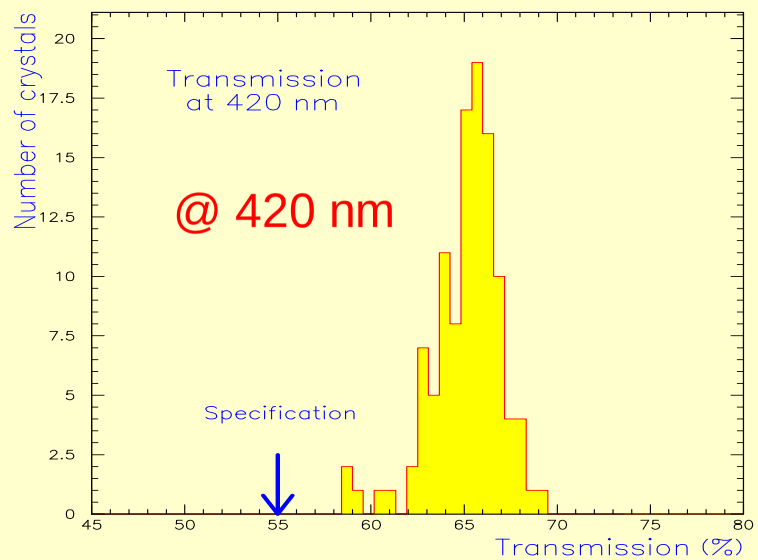


$PbWO_4$ Crystal Optical Properties

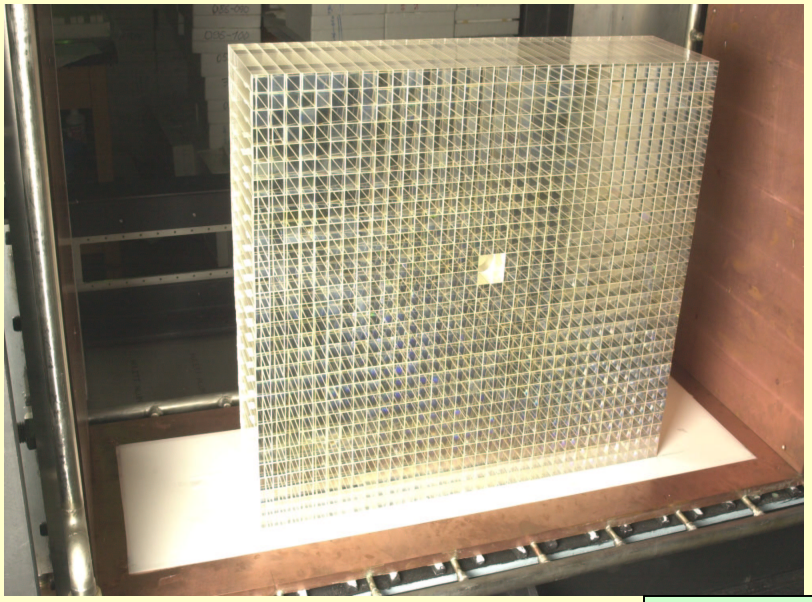
Optical Transparency

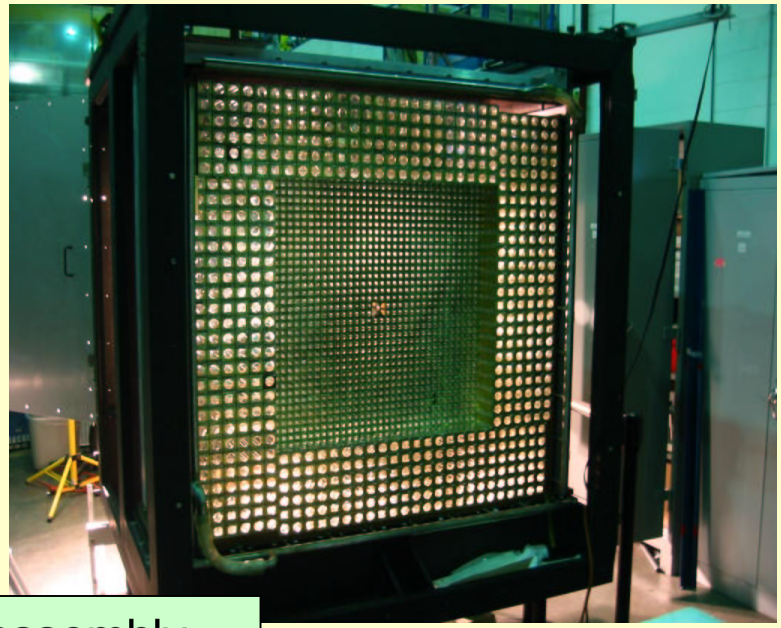




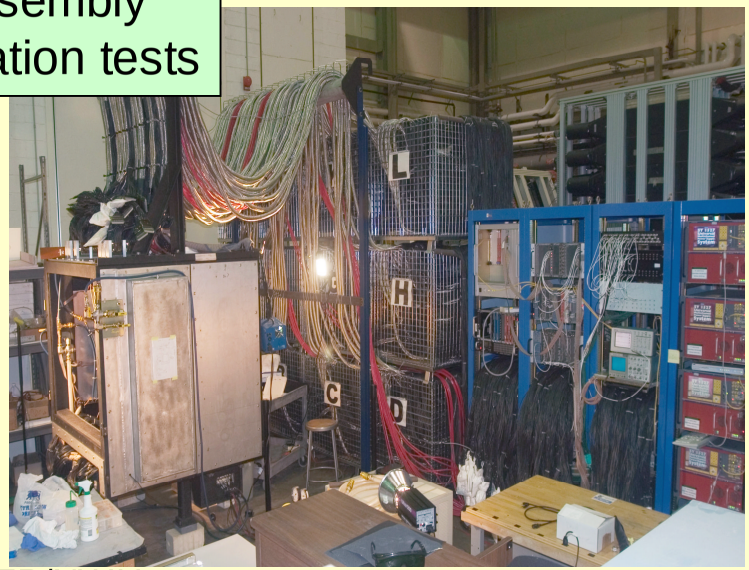


HYCAL – The Hybrid Calorimeter

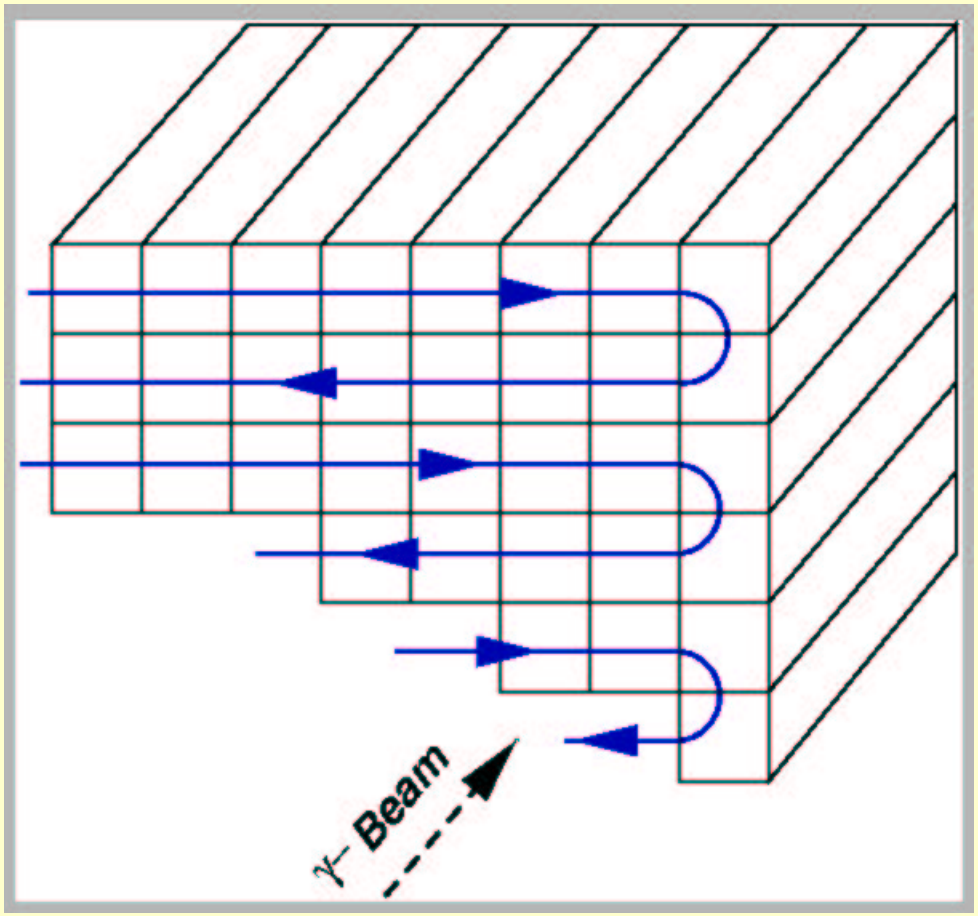




Detector assembly
and preparation tests

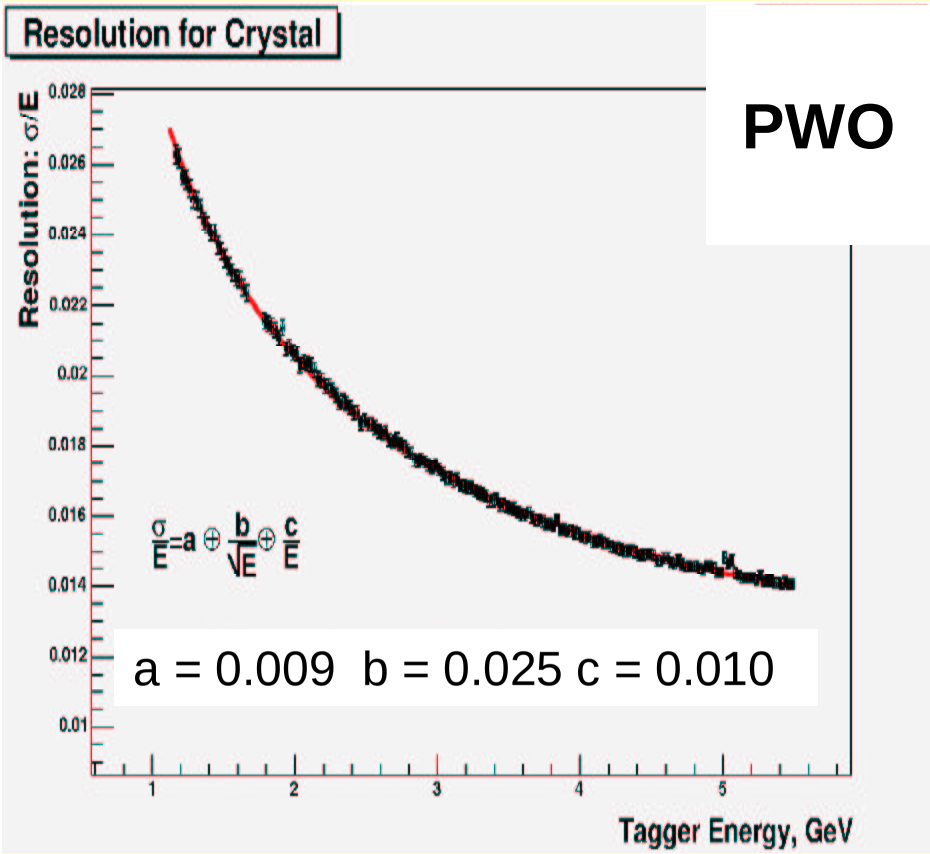


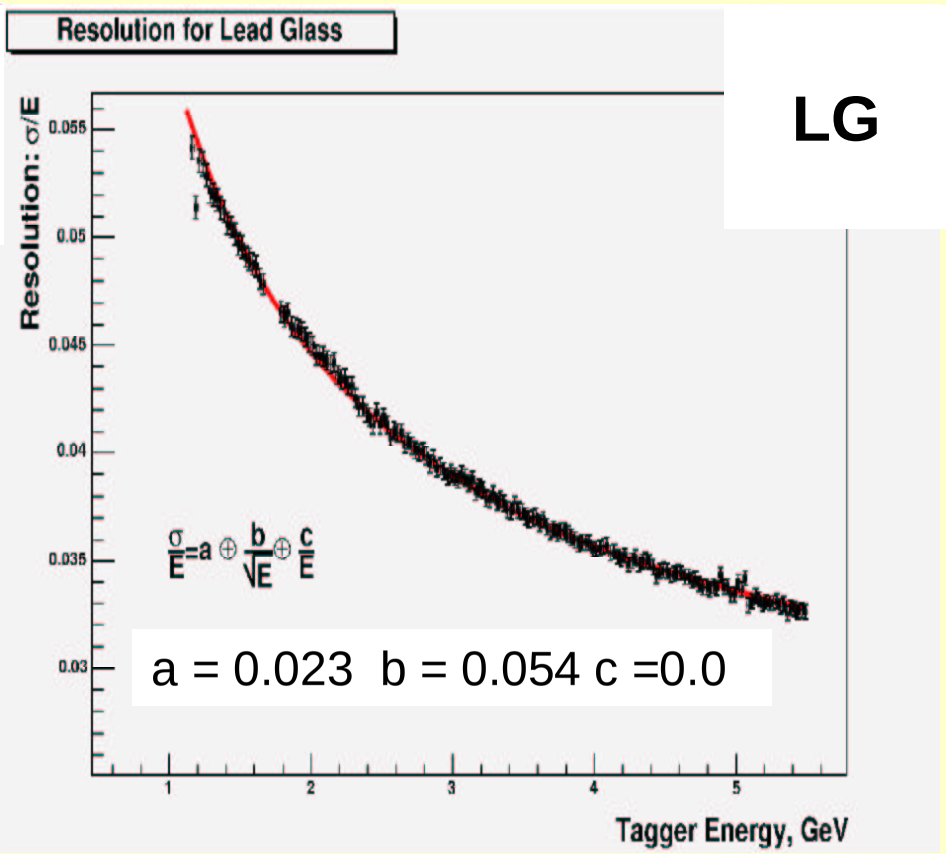
HYCAL Calibration



Scheme of calorimeter irradiation with tagged photon beam during calibration

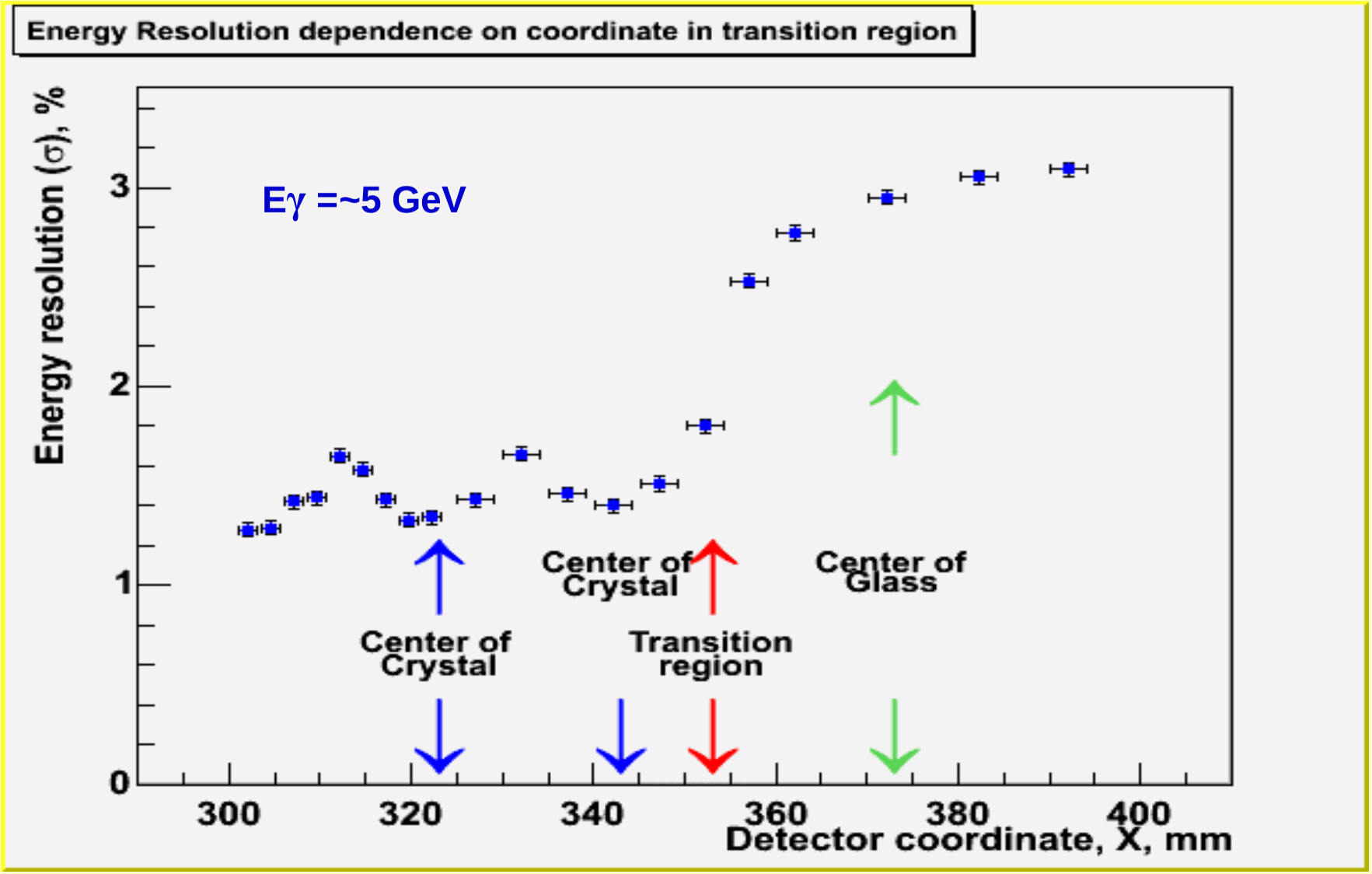
HYCAL Energy Resolution



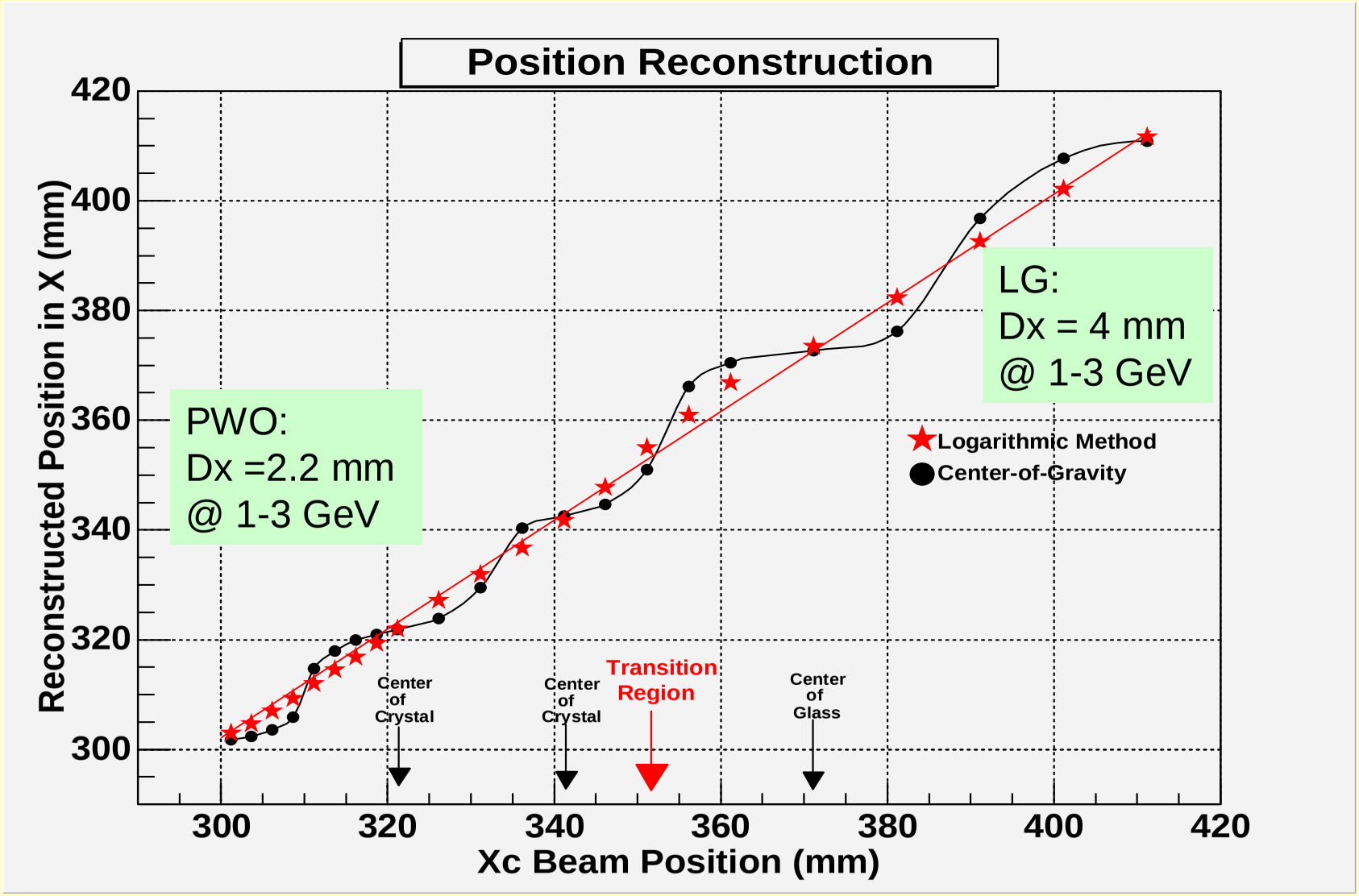


Energy resolution for PWO crystal central part and lead glass periphery for tagged photons during calibration run

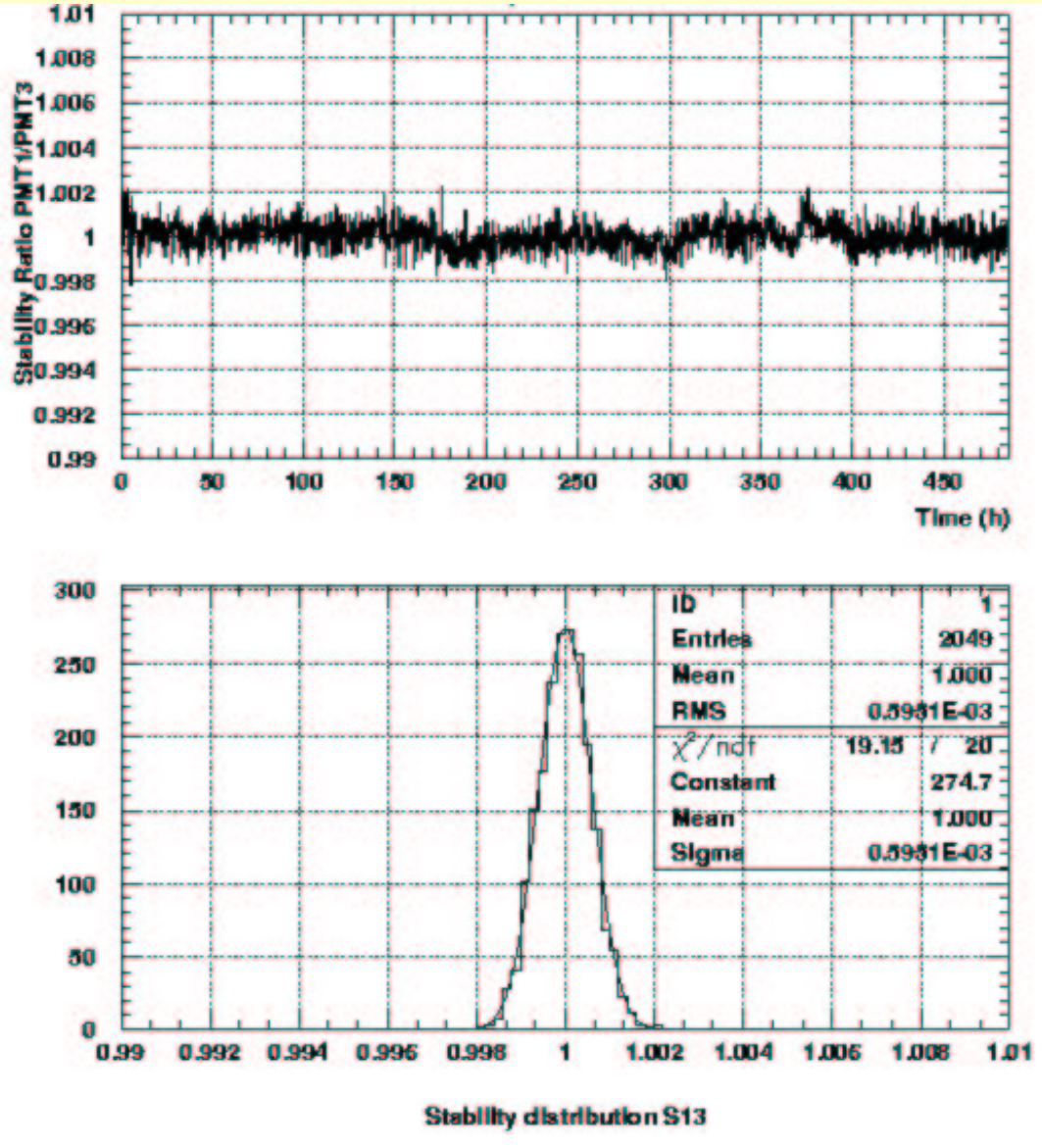
HYCAL Energy Resolution



HYCAL Position Resolution

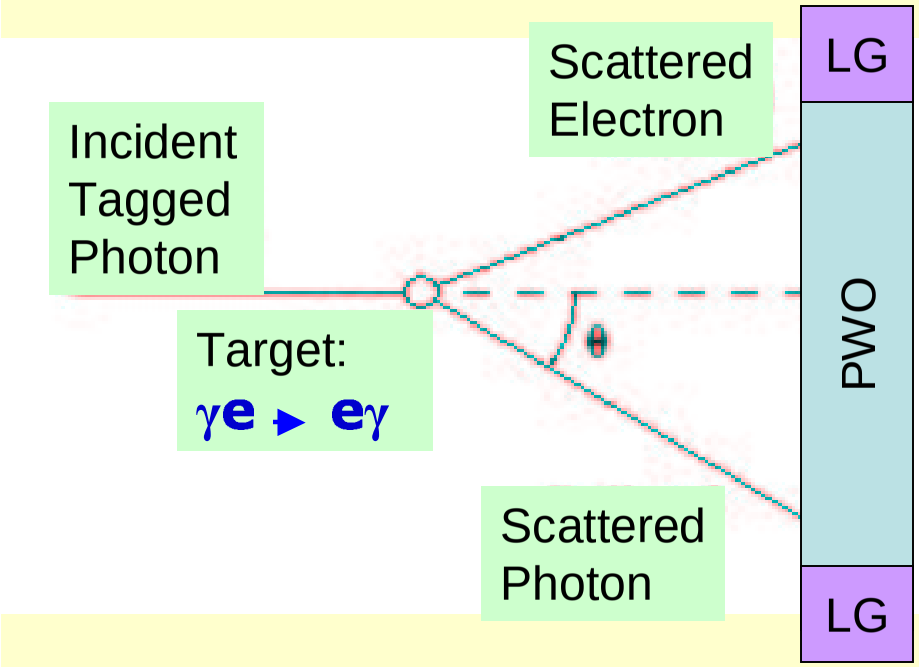


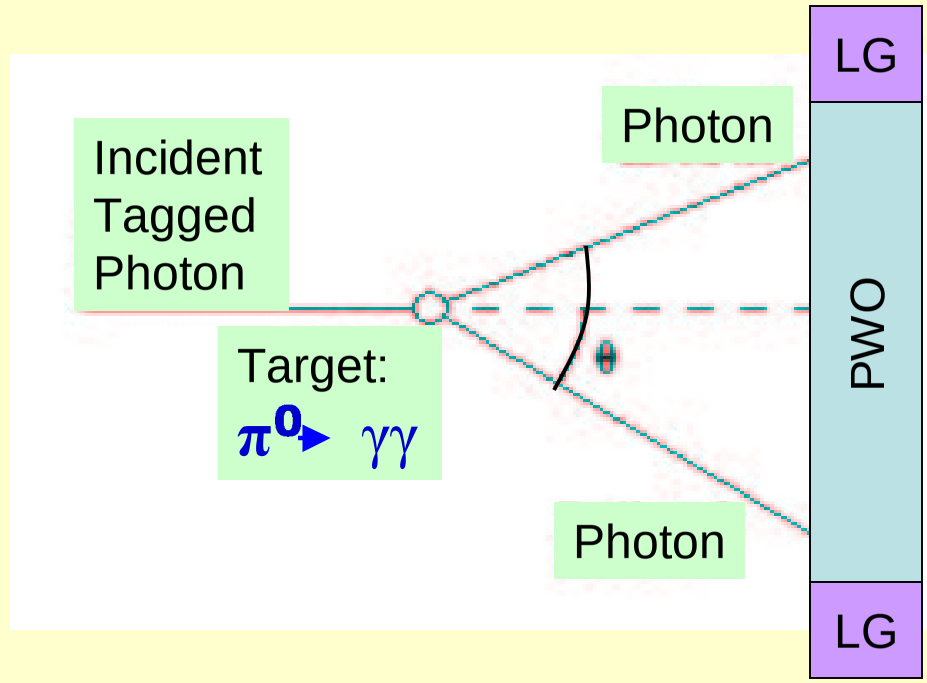
HYCAL Light Monitoring



Light monitoring system with blue LED: stability over period of 500 hours

HYCAL Performance for Physics Processes:





Compton scattering at small angles mostly (only PWO):

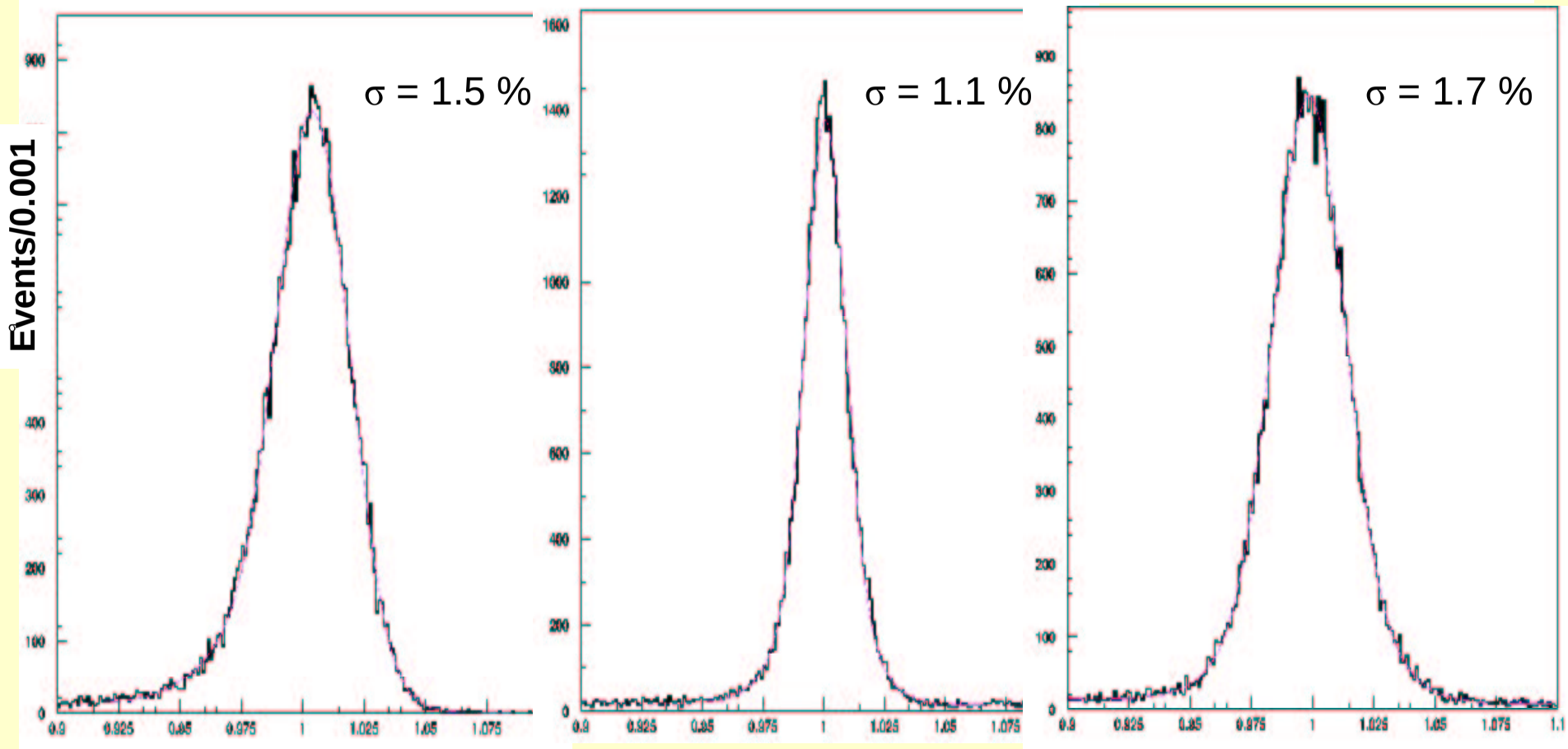
- **Pt = 0 constraint**
- **angular correlations as additional check of resolution**

π^0 production and decay to two photons at all angles (PWO and LG):

- **constraint on mass of π^0**
- **comparison of regions of the HYCAL: PWO, LG, PWO-LG border**

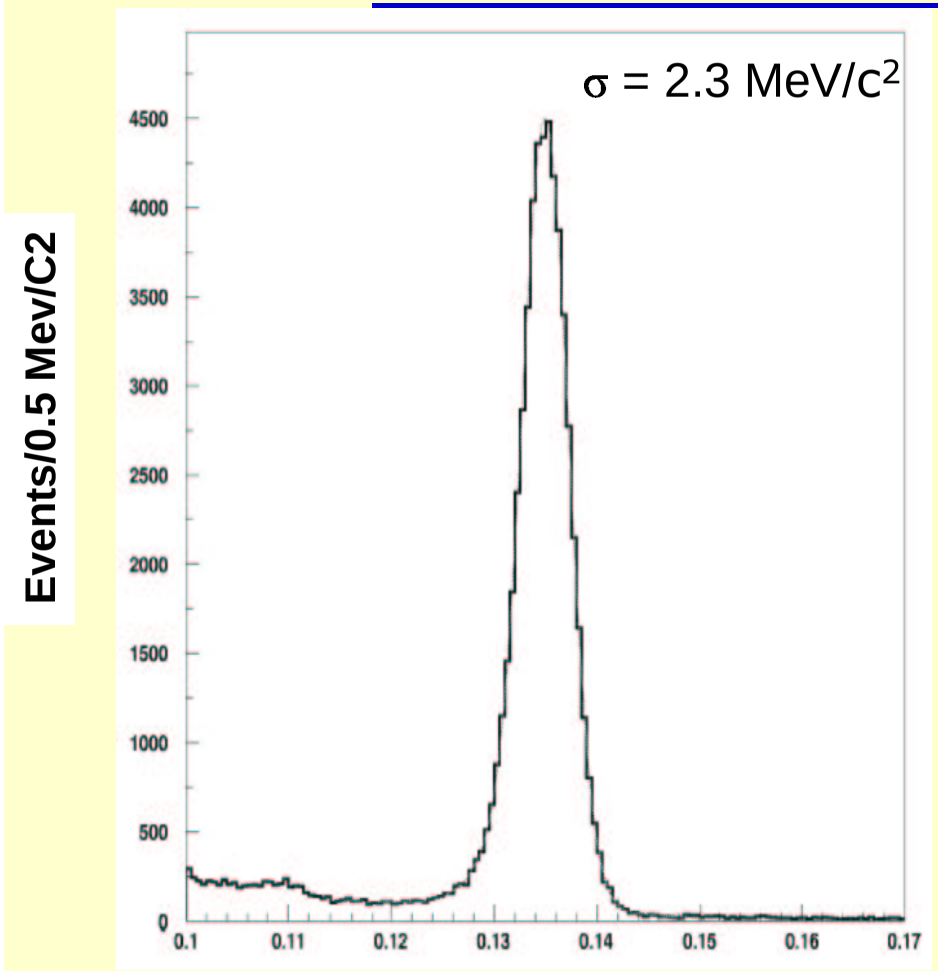
HYCAL Resolution for Compton Events:

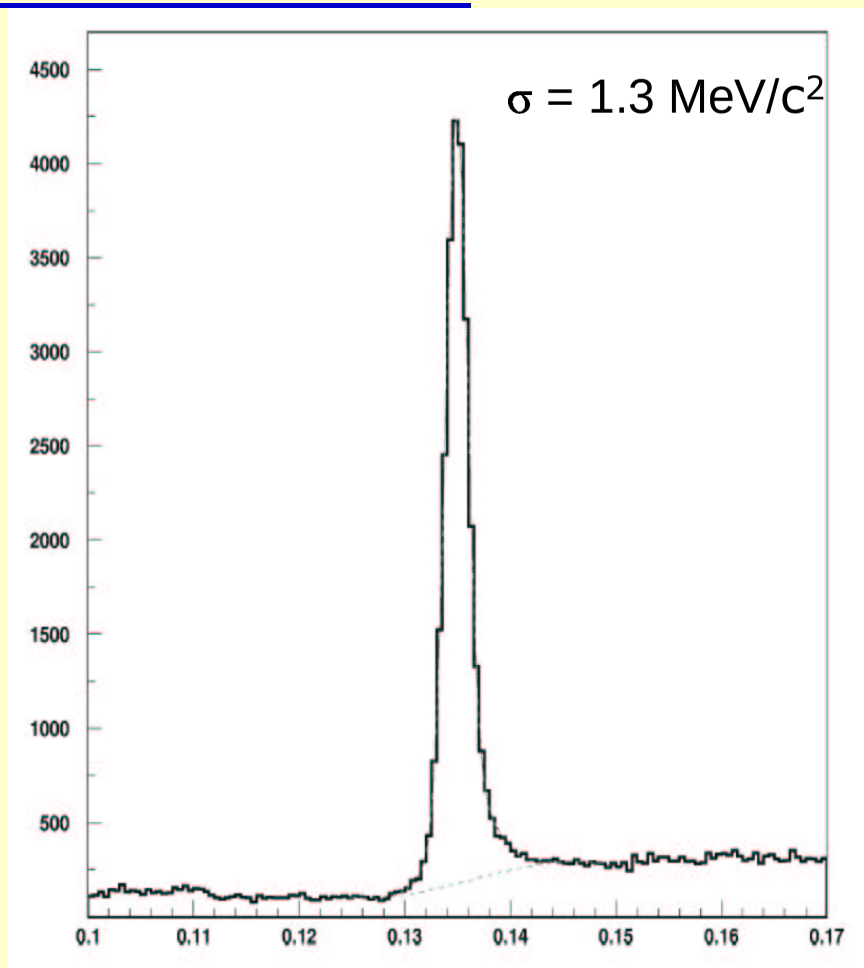
Ratio of sum of electron and photon energies measured in the calorimeter and tagged γ energy at ~5.2 GeV



after calibration **after Pt = 0 correction** **only coordinate information**

HYCAL π^0 Resolution: PWO



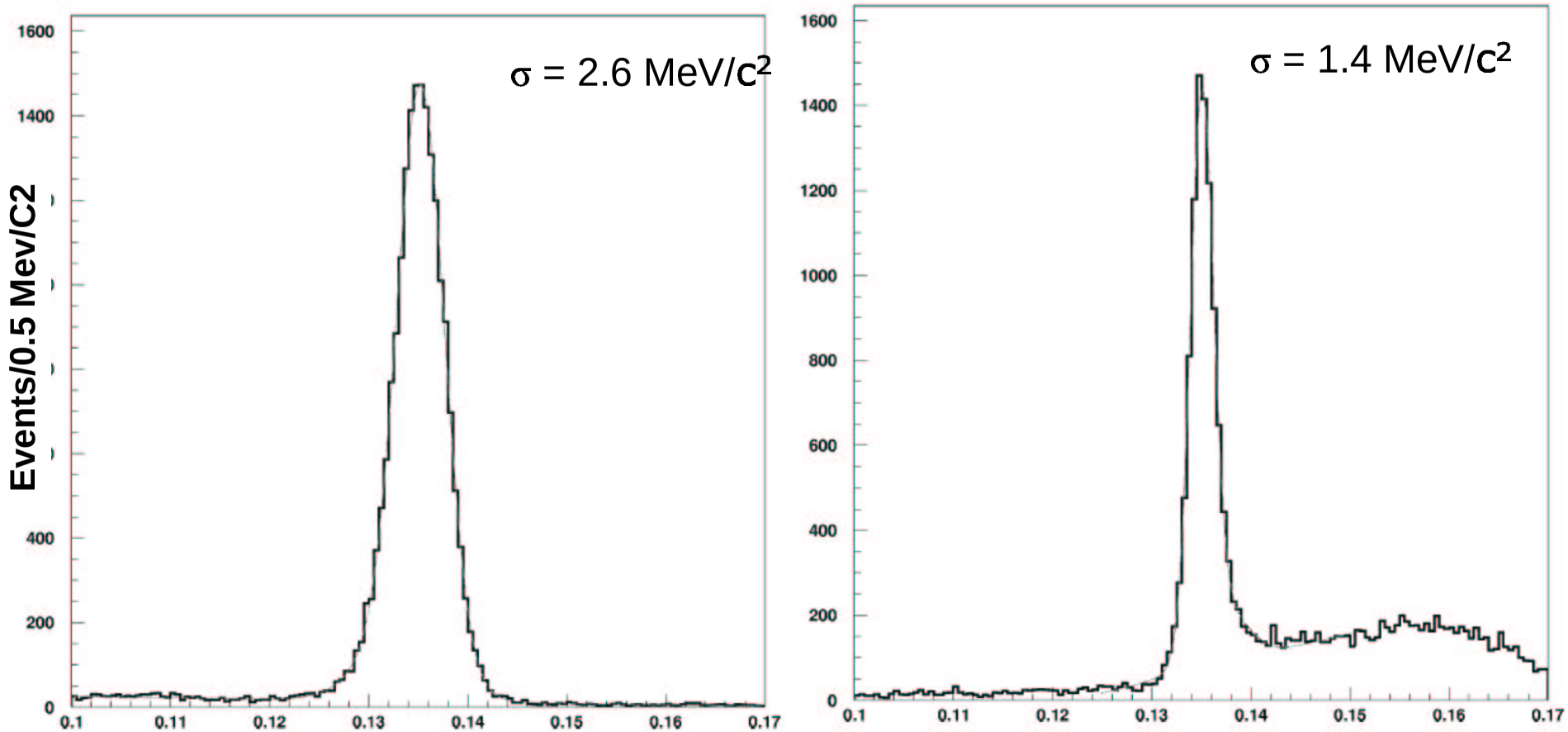


Mγγ, GeV/c2

after calibration

after correction on tagged photon energy: smearing due to coordinate resolution

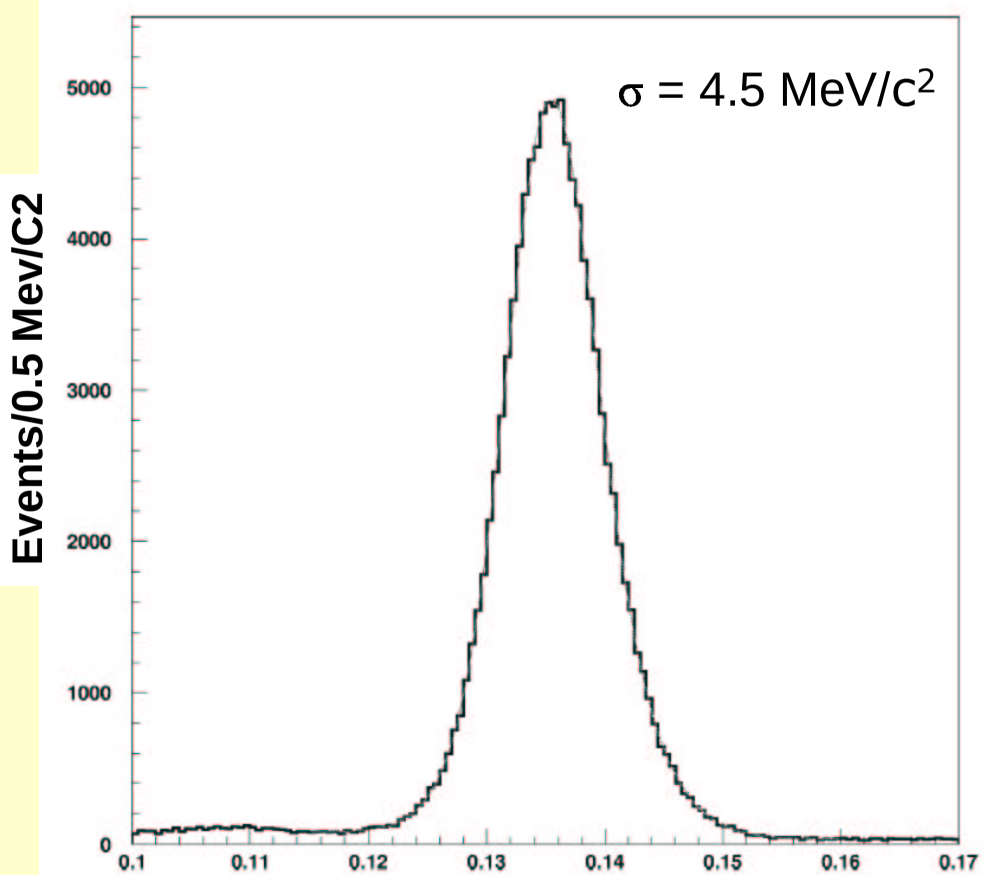
HYCAL π^0 Resolution: PWO-LG Border

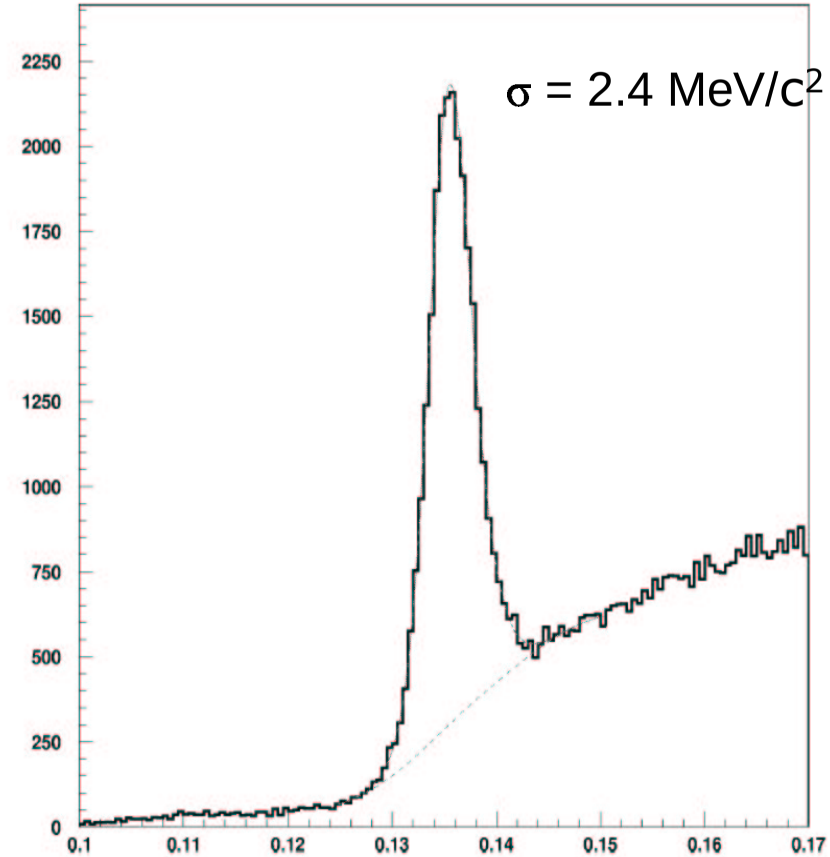


π^0 mass resolution after calibration: one photon in PWO another at the border

after correction on tagged photon energy: smearing due to coordinate resolution

HYCAL π^0 Resolution: PWO + LG



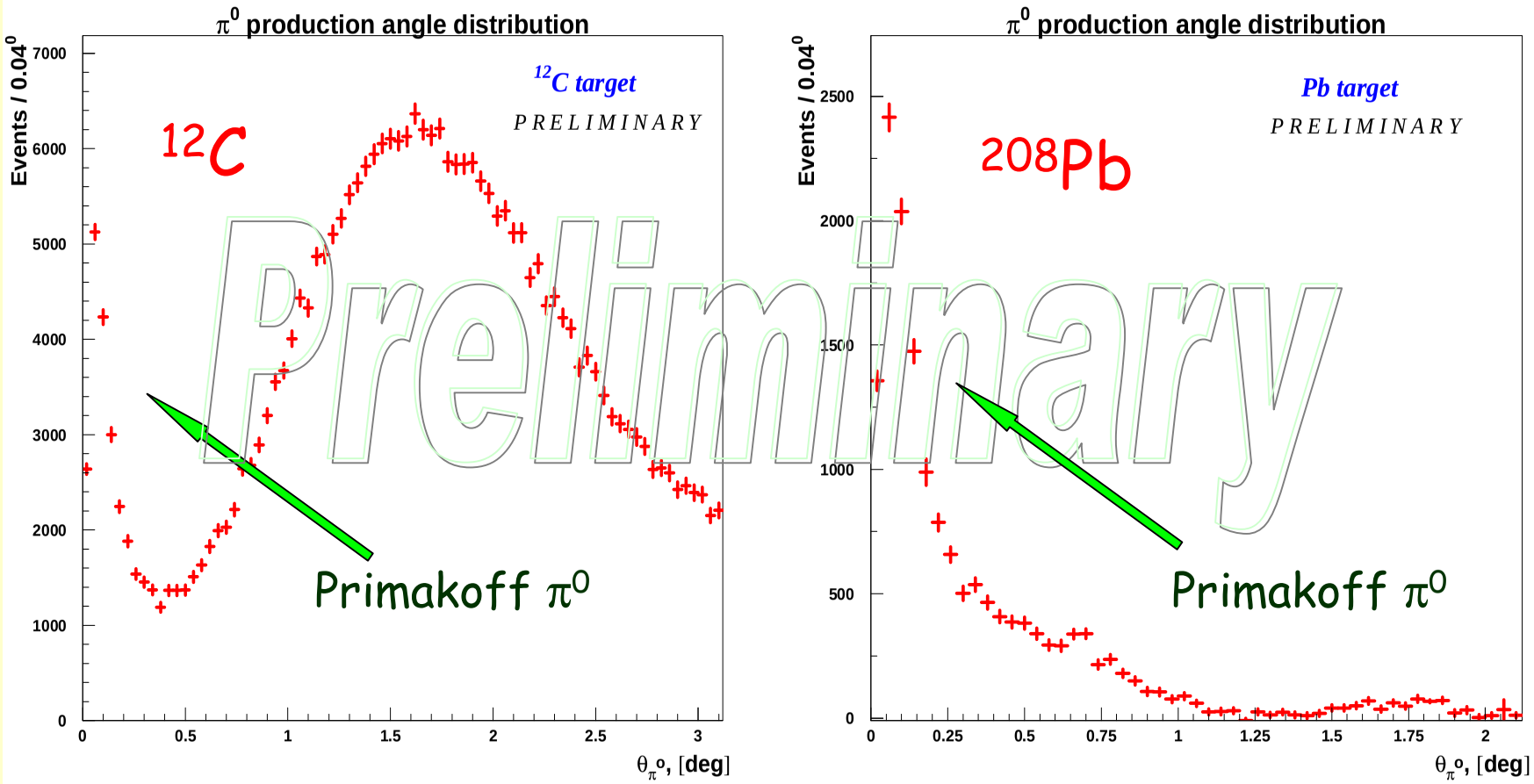


π^0 mass resolution after calibration: one photon in PWO another in LG

$M_{\gamma\gamma}$, GeV/c²

after correction on tagged photon energy: smearing due to coordinate resolution

π^0 Angular Distribution
(experiment, preliminary)



Summary

- A high performance hybrid $PbWO_4$ calorimeter(~2000 channels) has been developed constructed and run in PrimEx experiment at JLab.
- HYCAL took physics data in November 2004:
  - Energy and position calibration with tagged photons of 1 – 5.5 GeV
  - π^0 mass resolution σ_{π^0} = 2.3 MeV (PWO),

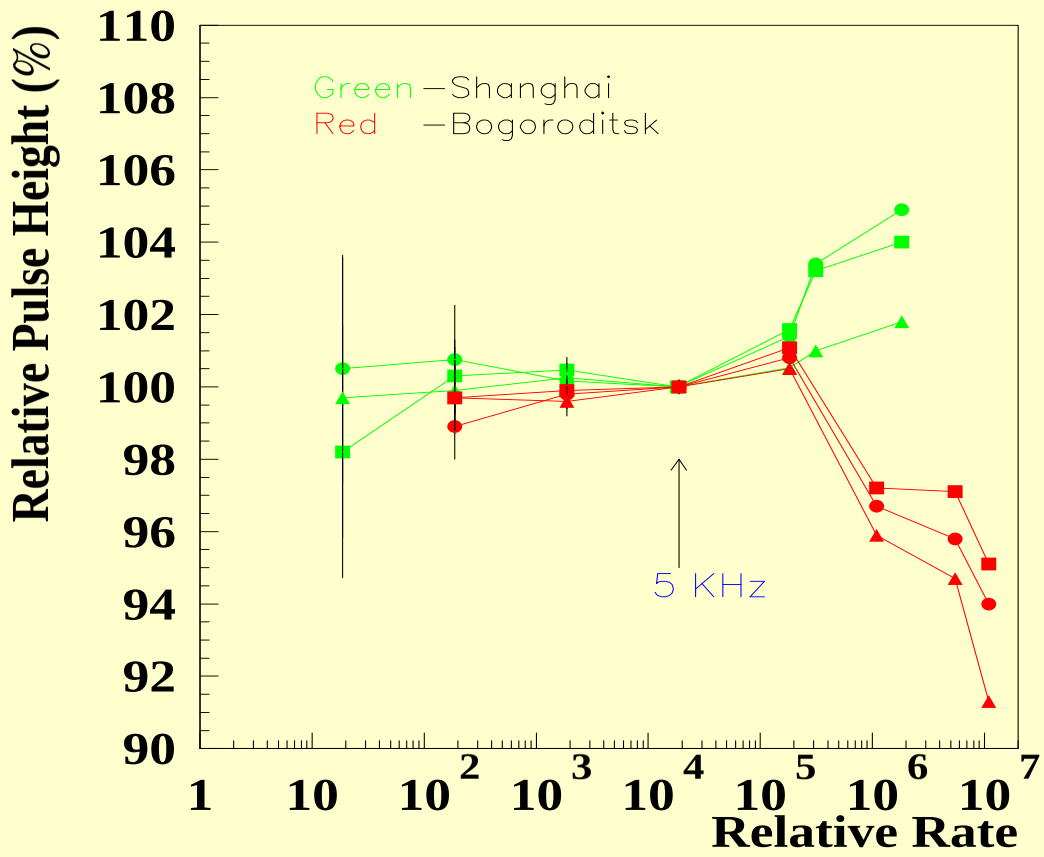
    (with energy constraint on the tagger 1.3 MeV)
  - Rich high quality data sets have been collected to extract π^0 life time
- We expect first physics results this summer:

  http://www.jlab.org/primex/

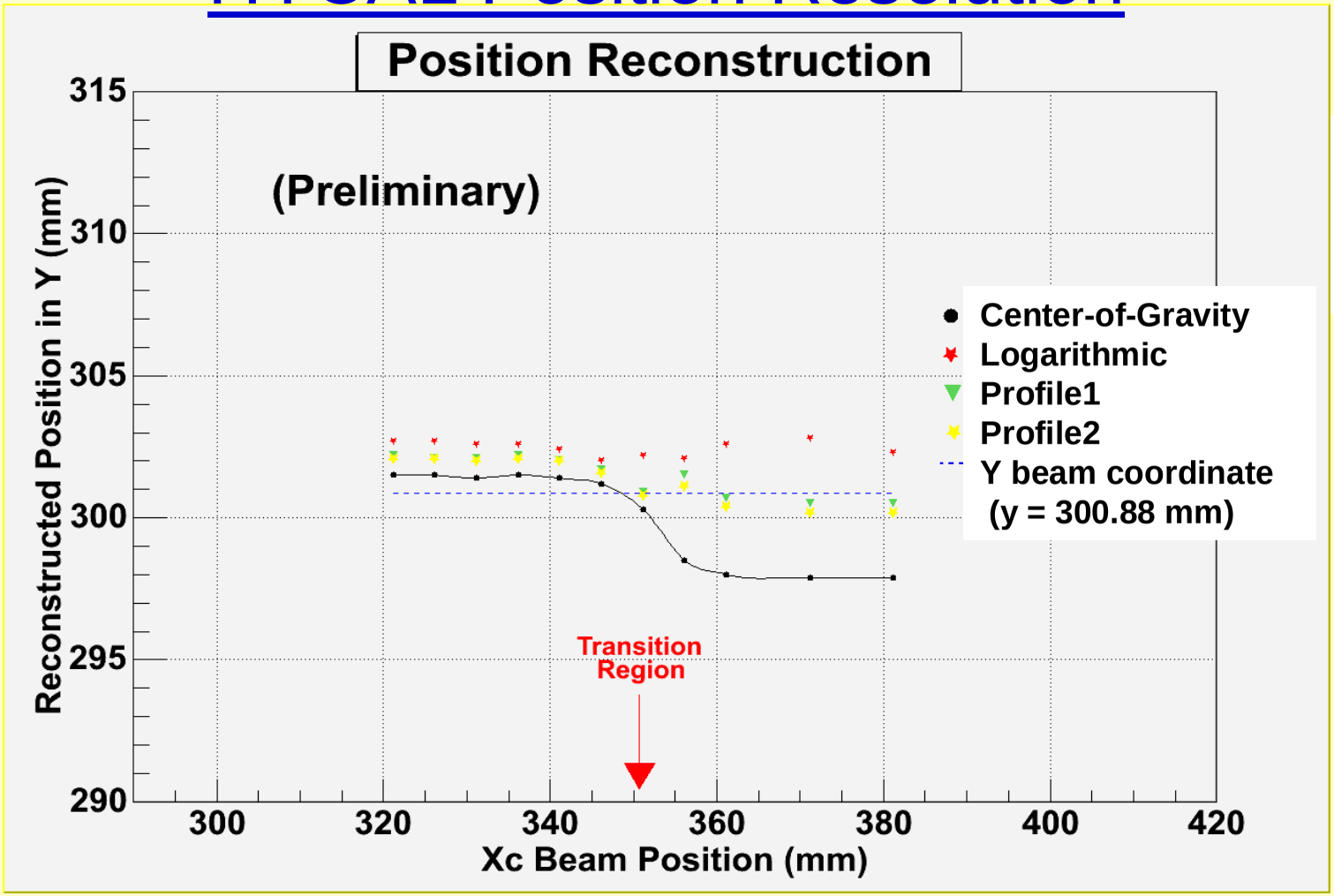
- This project is supported by the US NSF MRI grant (PHY-0079840)
- This project is supported by the RFBR Grant 04-02-17466

Spare slides

$PbWO_4$ Detector Response vs. Dose Rate



HYCAL Position Resolution



Reconstruction of photon positions in the transition region between PWO crystal central part and lead glass periphery

HYCAL Position Resolution

Coordinate of the cluster:

$X_c = \Sigma(x_i w_i)/\Sigma w_i$

Center-of-Gravity:

$W_i = E_i$

Logarithmic:

$W_i = 4.2 + \ln(E_i/E_9)$