LUMI spectrometer tracking: what do we need?

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08.08.23

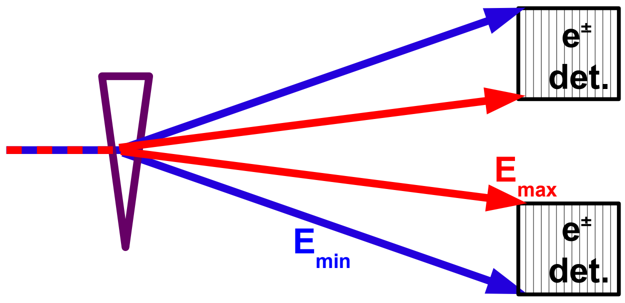
Three things we need (no particular order):
- Define calorimeter fiducial area
- Reconstruct photon position
- Calibrate calorimeter energy

More?

Each point:
- How did we do at ZEUS, without tracking?
- How can we improve with various tracking options?
  - 1st generally, what info do we need?
  - 2nd discuss implementation

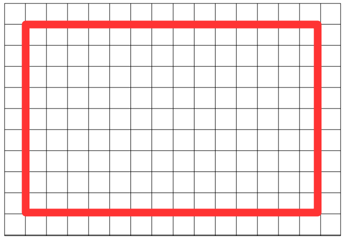
Calorimeter fiducial area

- Select calorimeter 'hits' in some way
- Inner/outer edges vertically define range
  $e^{\pm}$ energies each calorimeter;
  2 calorimeters $\Rightarrow E_{\gamma}$ range



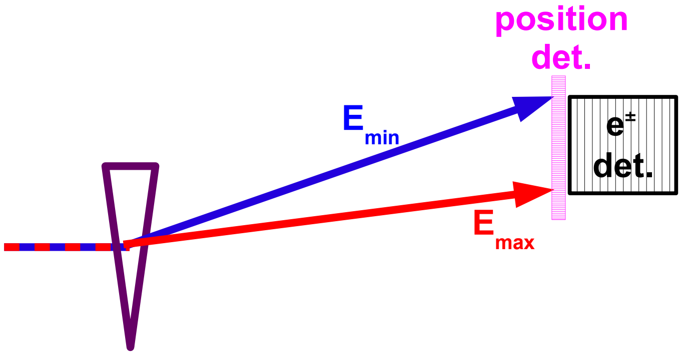
ZEUS:

- Calorimeters read out X,Y channels
- Select 'hits': max. energy channel X,Y not an edge channel
- Defines fiducial area □:
- Uncertainties: relative calibration
  of edge & adjacent channels



Improved:

- Any position detector at/near
  face of calorimeters
- Independent of calorimeter calib.
- Cover/exceed calorimeter dimensions
- Define X,Y fiducial region



Photon position

- Need distribution of photon positions: correct for loss outside aperture

ZEUS:

- calorimeter position linearly weighted:

$$X_{up} = \frac{\sum_i E_i x_i}{\sum_i E_i}$$

similarly for X_{dn}, Y_{up}, Y_{dn}

E_i, x_i strip energy, position

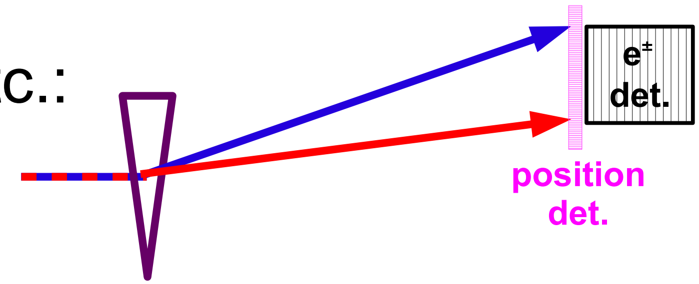
- Photon position:

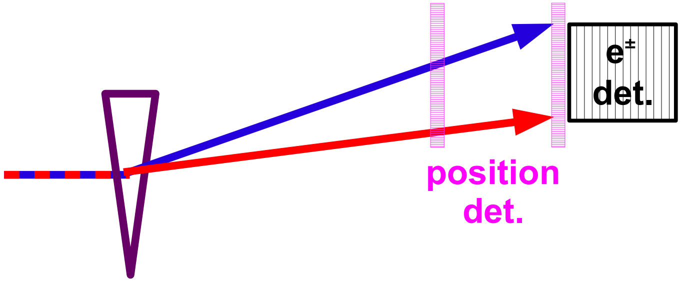
Y_γ energy weighted

$$X_\gamma = \frac{1}{2}(X_{up} + X_{dn}) \qquad Y_\gamma = \frac{E_{up}Y_{up} + E_{dn}Y_{dn}}{E_{up} + E_{dn}}$$

Improved:

- Easier: tracker at calorimeter face for X_{up} etc.:
- Harder: two or more tracking planes: measure angle, $\int$BdL $\Rightarrow E_{up}$ etc.



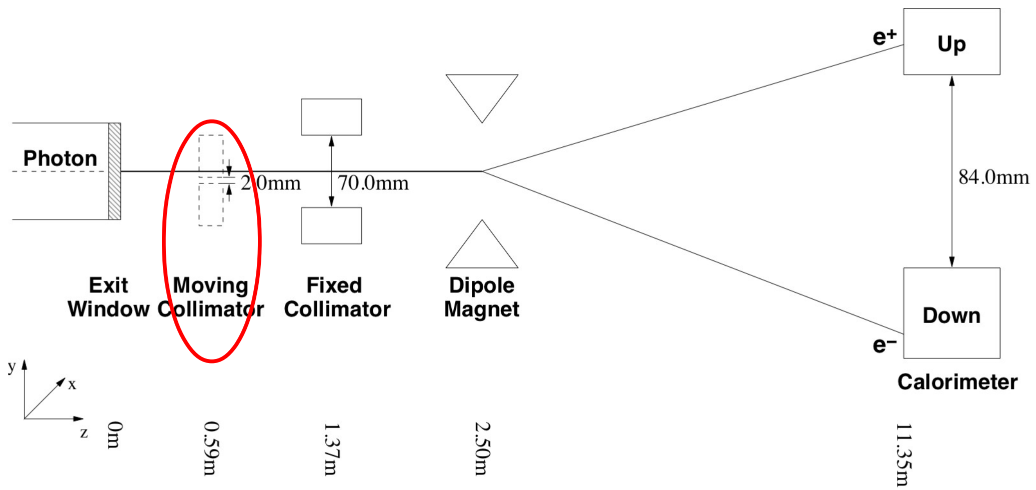


Calorimeter calibration

- Hit definition: maintain separation threshold↔signal
- Reconstruct E_γ, X_γ, Y_γ: compare to MC

<u>ZEUS:</u>

- Narrow horizontal slit collimator before analyzer magnet:

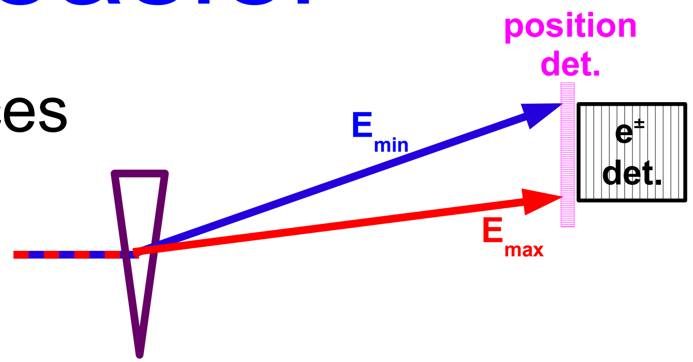


- Define initial $e^{\pm}$ Y position
- Measure Y_{up} in calorimeter: angle, $\int$ BdL $\Rightarrow E_{up}$
- Inserted end HERA fills, ~1 min. data
- Y_{up} depends on calibration; iterate, converges quickly

<u>Improved:</u> same options as previous slide

Two options: easier

- Single tracking plane near calorimeter faces



<u>Provides:</u>

- position measurement @ calorimeters

<u>Lacks:</u>

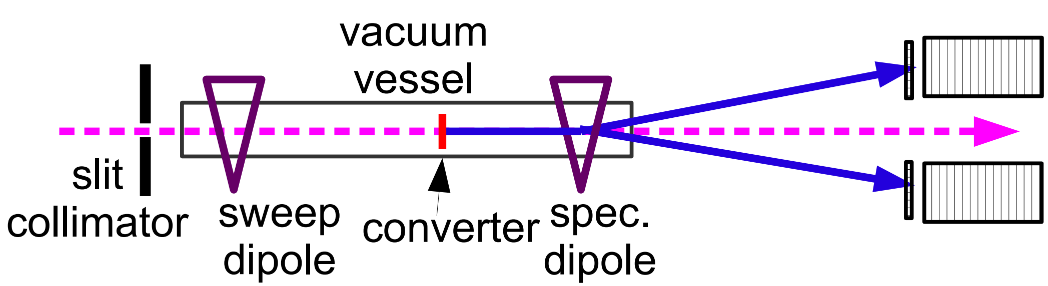
- electron energy measurement

<u>Solutions:</u>

- calorimeter energy $E_{up,dn}$, position detector $X_{up,dn}$, $Y_{up,dn}$

  $\Rightarrow$ photon reconstruction

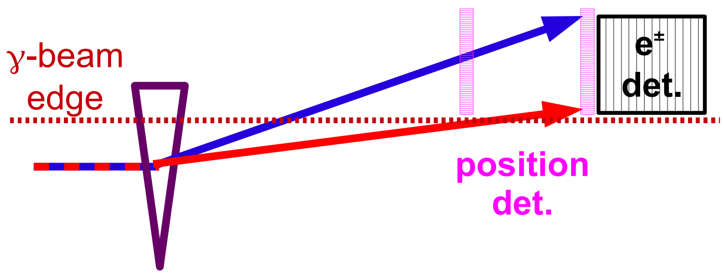
- calibration:
  - would still need slit collimator, define upstream point
  - probably upstream of sweeper/vacuum vessel



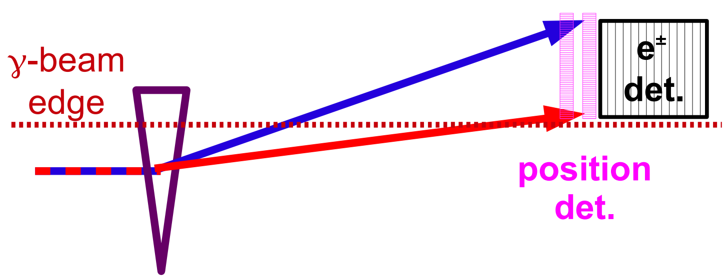
Two options: harder

- Multiple tracking planes, provide position and angle ⇒ energy
- Tradeoff: tracker spacing, resolution ⇒ angular resolution

- Tracker planes farther apart (lever arm), need moderate tracker resolution
- Problem: higher energy electrons do not leave primary γ-beam before 1st plane



- Tracker planes close to calorimeter face, all electrons leave primary γ-beam before 1st plane
- Problem: need high position resolution for sufficient angle, energy resolution



- This is where we start to require very expensive tracking

Path forward

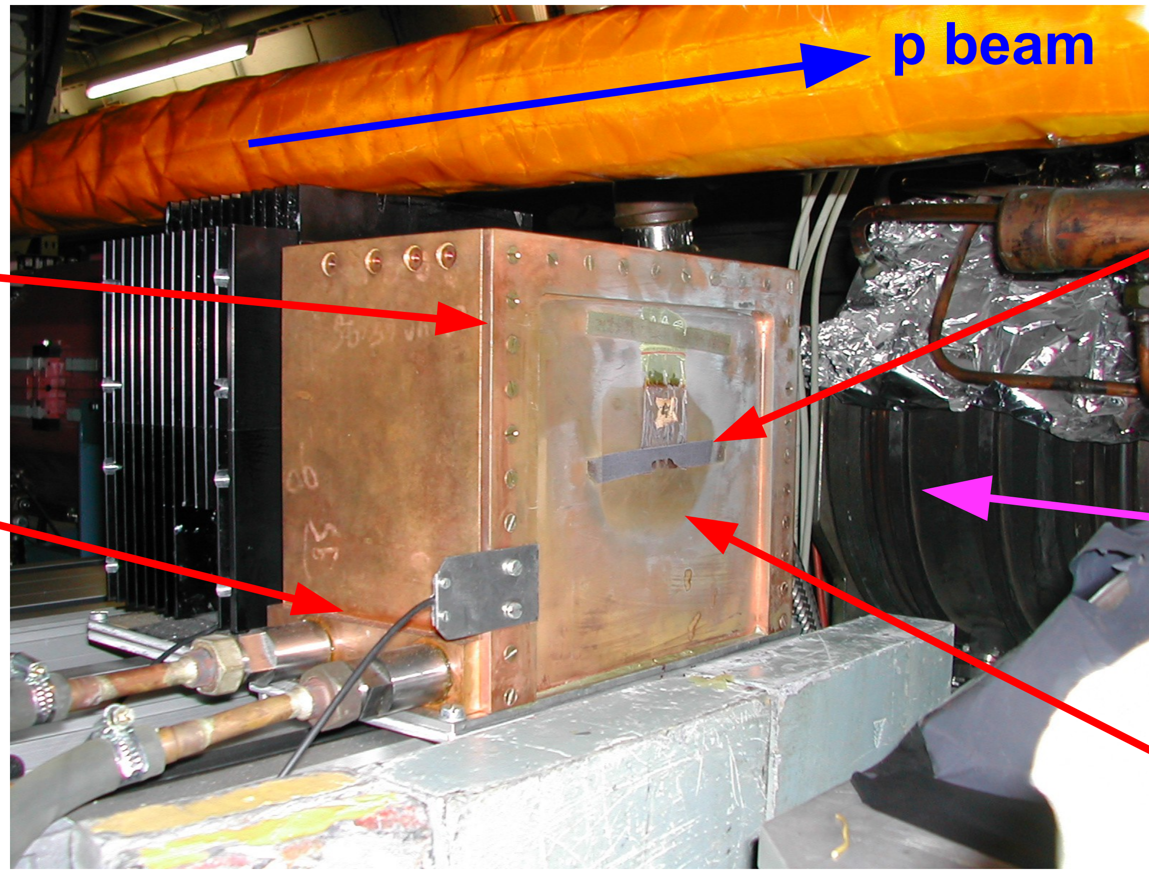
Practical considerations seem to point to 'easier' option:
- Single tracking planes at calorimeter faces, moderate resolution
- Calibration requires moveable upstream slit collimator

<u>Position detector technologies</u>
- We've been discussing various solid state options
- Reminder: in Athena proposal position detector proposal was scintiilator or quartz hodoscope array

  should reconsider, may be viable option

Moveable slit collimator

- Don't have picture of ZEUS collimator, but identical structure: $0.7\ X_0$ Cu+C absorber in front of 0° γ calorimeter:



- Similar design w/ water cooling (sync. rad.) may be adequate only in beam few minutes, not as severe as γ exit window/converter
- Should include in planning soon

Extras

LUMI System Energy Calibration

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<u>Calibration procedures</u>

- LUMI pair spectrometer calibration
  - movable collimator
  - benefits from E calibration for LU MI measurement
- *e* tagger calibration
  - LUMI pair spectrometer $\gamma \rightarrow$ tagger *e*
- 0° γ calorimeter calibration
  - tagger *e* $\rightarrow$ calorimeter γ

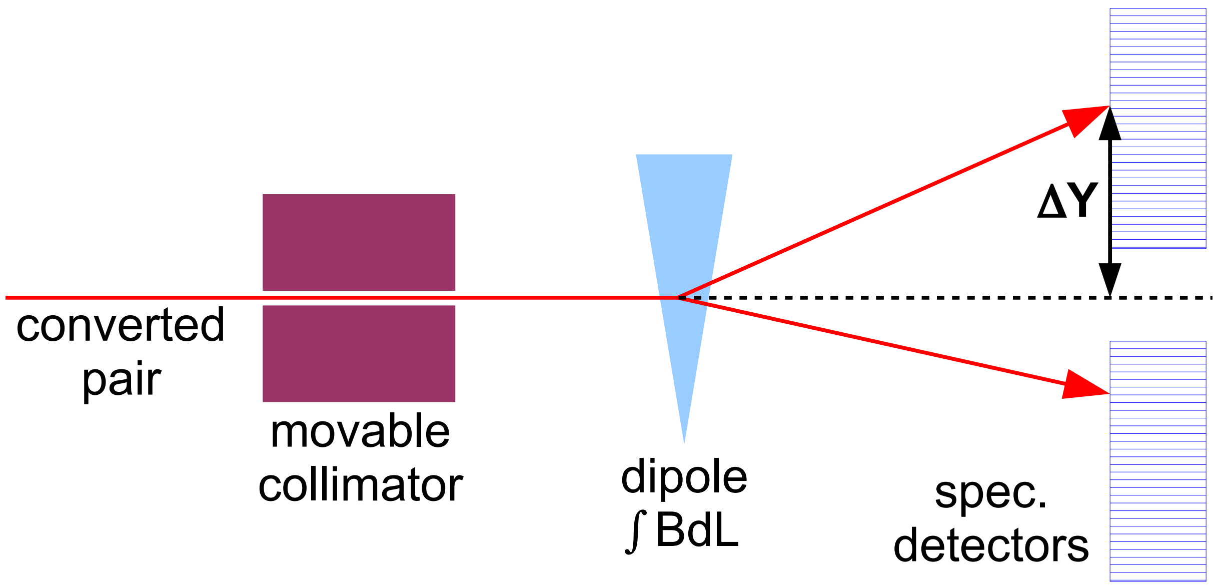
<u>Required hardware</u>

- movable collimator
  challenge: sync. rad. heating

Follows implementation by ZEUS @ HERA

LUMI pair spectrometer calibration

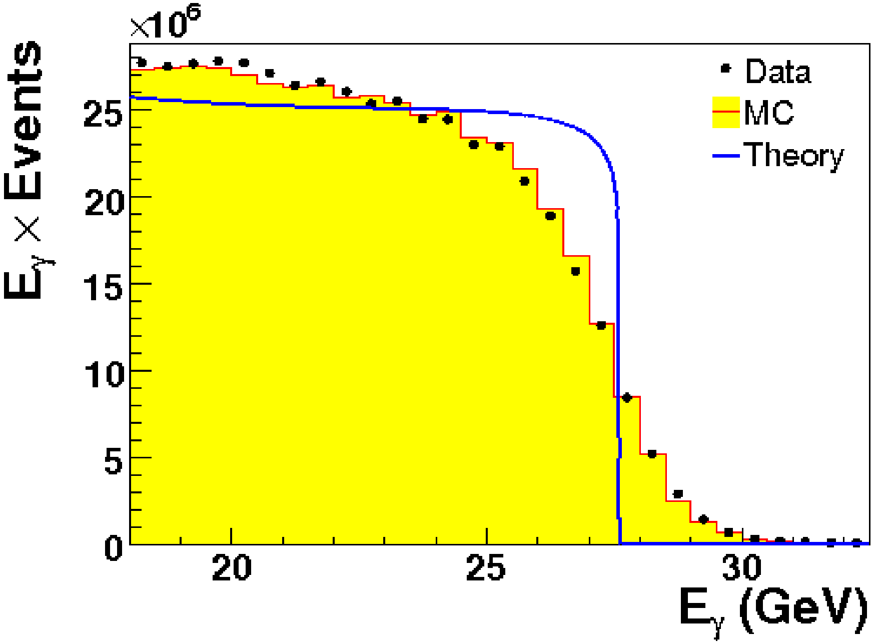
- Movable collimator: out of γ beam during physics running
  inserted in γ beam for special calib. runs
  (@ ZEUS: few min. end of HERA fills)



- Collimator defines $e^{\pm}$ position, direction before dipole
- Spec. detector measures $e^{\pm}$ position after dipole
  $\Rightarrow$ true magnetic spectrometer
- With dipole $\int BdL \Rightarrow e^{\pm}$ energy
- Calibrate spec. calorimeter channels

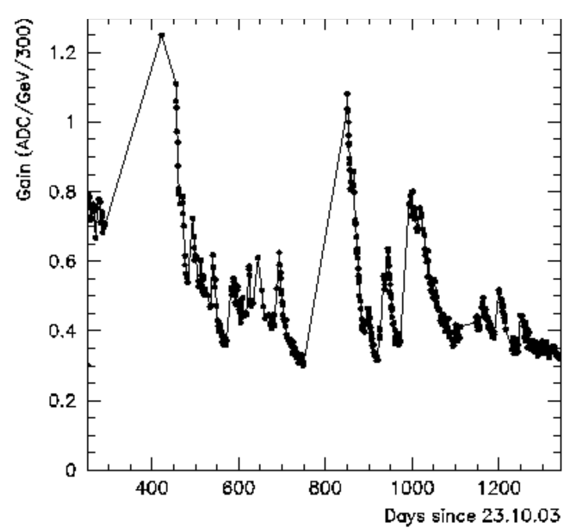
LUMI pair spectrometer calibration

- Spectrometer LUMI measurement does not need energy measurement *per se*
  - spec. acceptance (i.e. sensitive brems. cross section) defined by spec. geometry



- Simulation is need for precise acceptance determination
  - energy measurements data↔simulation verify MC
  - e.g. ZEUS spec. brems. endpoint w/ higher dipole B: ~1% agreement

- Also need some E calibration for sensible triggering, event selections
  - e.g. ZEUS spec. sync. rad. damage gain worst channel last 3 years HERA:



e tagger, 0° γ calorimeter calibration

- Need special low luminosity runs:
  ensure <<1 brems. γ per bunch ×ing,
  tagged *e* and γ from same event

- *e* tagger calibration
  - coincidence γ in spectrometer & *e* in tagger
  - know E_γ from calibrated spectrometer
  - tagger $E_e = E_{beam} - E_\gamma$

  ⇒ calibrate *e* tagger

- 0° γ calorimeter calibration
  - *e* in tagger & γ in 0° calorimeter
  - know E_e from calibrated tagger
  - calorimeter $E_\gamma = E_{beam} - E_e$

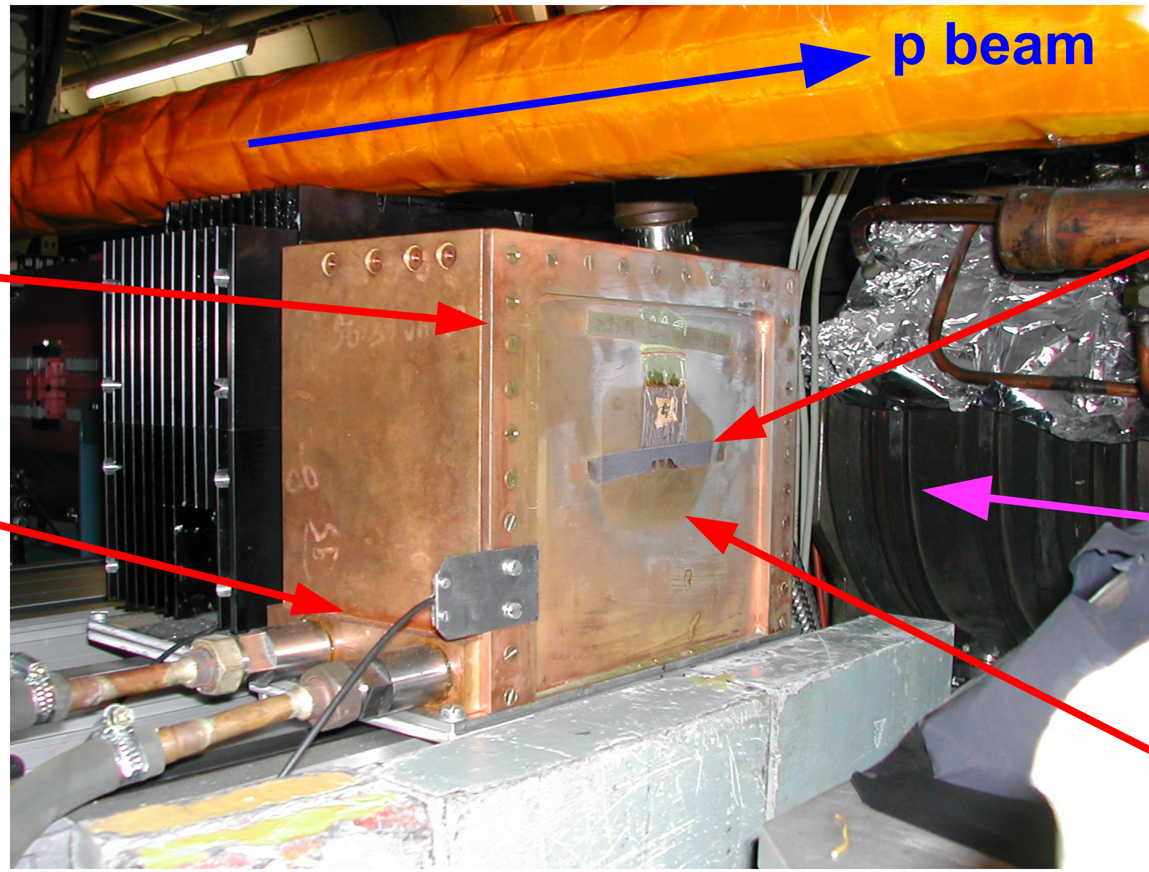
  ⇒ calibrate 0° γ calorimeter

Required hardware

- Need a movable collimator
- Don't have picture of ZEUS collimator, but identical structure:
  0.7 X_0 Cu+C absorber in front of 0° γ calorimeter:

~30w × 20h cm on horizontal moving table

water cooled Cu jacket



need ~2mm high slit in Cu block here

photon direction

photon aperture burned into face

- Similar design w/ water cooling (sync. rad.) may be adequate only in beam few minutes, not as severe as γ exit window/converter
- Should include in planning soon