Photon Position Resolution

• Short Review
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Short Review

- Today's goal:
  With the plots today we want to come closer to parameterize the photon resolution in the Calorimeter.

- Produced a sample of 130,000 single photon events with:
  1. Release 12.4.0g
  2. Moose (out of the box)
  3. Origin: x = 0, y = 0.0 cm, z = 0 (OLD: y = 0.37cm)
  4. E uniform between 0 and 6 GeV + 30,000 < 1GeV
  5. -0.79 < cos θ < 0.975
  6. September 2001 background file
  7. This time candxtheta and candxphi were included
  8. New variable containing number of crystals after the log-method included.

- Analysis cuts:
  1. EmcCluster originates from a true photon
  2. -0.74 < cos θ < 0.93 && theta-Gen > 0.3
• So far:
  – We have found a strong dependence of the resolution in phi and theta on the energy of the photon.
  – The theta resolution is also dependent on $\cos(\theta)$.
  – There is also a dependence on the resolution on the position on the Xtal face in xphi and xtheta.

• Puzzles:
  – Resolution vs energy was approx. 1 mrad worse than in NIM paper.
  – There was a minor shift in the mean of the phi resolution vs. Energy.
Before we get Started

• **NIM paper disagr.**
  One word to the NIM puzzle.

**WEIGHTFUNCTION:**
Ensures more photons in forward direction.

**UNFORTUNATELY**
the resolution improves only slightly (~0.1mrad)

Picture looks the same as previous graph.

Even if more dramatic, what about phi direction?
Possible Answer

• NIM paper no information about phi and theta.
• Only know angle $\alpha$ between the two measured photons
• So we believe the resolution in the NIM paper is not in phi or theta but a new angle $\alpha$ that is not comparable.

\[
p^2_\pi = p^2_\gamma + p^2_\gamma + 2p_\gamma \cdot p_\gamma
\]

\[
m^2_\pi = 2E^2_\gamma [1 - \cos(\alpha)]
\]
NOW THE NEW STUFF

Last time: Suggested to parameterize the energy dependence with a function.

It looked very good BUT:

A closer look, more statistics and a new average function showed the following:

GO TO NEXT SLIDE!
• **Theta resolution:**

**BLUE:** \( \cos(\theta) \) bins

**RED:** \( x\theta \) bins

Clear discrepancy at high energies.

At low energies \( x\theta \) bins do not have the same resolution.

NORMALIZED TO 1GeV SAMPLE!

\[
\sigma = C_1 \oplus \frac{C_2}{E^{\text{Power}}}
\]
• Closer look at low energies:

Here we see the very low energies in a particular xtheta bin. The distribution of the theta residual clearly non Gaussian:

For now, we narrowed down range to improve results. (-0.0125 – 0.0125)
HOW SHOULD WE PROCEED

• PHI DIRECTION:
  Phi is simpler:
  
  Energy function for 4 regions:
  1. End cap
  2. Forward
  3. Middle
  4. Backward

  Notice the power of the fit function: (~.43)
  This value changes only slightly in the Calorimeter.
  Except End cap (~.67).

GOAL: \( \sigma_\phi = f_{ij}(E) \) with cos \( \theta \) bins \( i = 1,...,4 \) and \( |x_\phi| \) bins \( j = 1,...,5 \)
Simplify more:

PHI resolution is symmetric in XPHI

Work with twice as much statistics.

PARAMETERIZATION IN PHI:

1. Energy function in a few cos(θ) regions.
2. Take only half as many xphi bins for symmetry reasons.
COMPLICATIONS IN THETA

- Theta has three variables, Energy, \(\cos(\theta)\), and \(x_{\theta}\).
- New dependence: Resolution jumps from forward to backward direction.

Resolution good when \(\cos(\theta)\times x_{\theta} > 0\)
Resolution bad when \(\cos(\theta)\times x_{\theta} < 0\)

Legend:
- GREEN: \(-1 < x_{\theta} < 0\)
- BLUE: \(0 < x_{\theta} < 1\)
- RED: \(-2.5 < x_{\theta} < -1\)
- PINK: \(1 < x_{\theta} < 2.5\)
Can we use symmetry again?

Here we made sure that $\cos(\theta) \times \text{xtheta} > 0$.

Not as symmetric as phi but not horribly antisymmetric.

All other regions and the case where $\cos(\theta) \times \text{xtheta} < 0$ show same accuracy.

What to do?
How to Proceed in theta Direction?

1. Energy function for several cos(θ) and \( x_\theta \) bins.
2. Halve the # of \( x_\theta \) bins due to symmetry?
3. Use same approach as for phi resolution but use more cos(θ) and \( x_\theta \) bins.

CONCLUSION:
Parameterization in theta direction is more complex

All sugestions are welcome.