Study of the photon angular resolution of the BaBar EMC

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Outline

1. Short Review
2. Analysis Method
3. Pull plots
1. Short Review

• **Dependencies** of $\sigma_\theta/\sigma_\phi$:
  - **Energy Strong.** Factor of 4
  - $\cos(\theta)$ moderate only in $\theta$. Factor of 1.7
  - $x_\theta/x_\phi$ dep strong. Factor of 2.

• **Bias Correction:**
  - Improved resolution by
    - 6.4% for $1\text{GeV}<\text{Energy}<2\text{GeV}$
    - 19% for $5\text{GeV}<\text{Energy}<5\text{GeV}$

• **Parametrization**:
  - Pull plots: Error 3-4%
    (except endcap)
**Res. $\sigma_\theta$, before and after correction**

$\sigma_\theta$ as a function of energy

Significant improvement at high energies

<table>
<thead>
<tr>
<th>Energy Range</th>
<th>BEFORE $\sigma_\theta$</th>
<th>AFTER $\sigma_\theta$</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 GeV &lt; $E$ &lt; 6 GeV</td>
<td>2.708 mrad</td>
<td>2.191 mrad</td>
<td>~18.5%</td>
</tr>
<tr>
<td>1 GeV &lt; $E$ &lt; 2 GeV</td>
<td>3.875 mrad</td>
<td>3.626 mrad</td>
<td>~6.4%</td>
</tr>
</tbody>
</table>

$\sigma_\theta(E) = C_1 + \frac{C_2}{E^p}$

Resolution before and after the mean correction:
- Resolution before mean correction
- Resolution after mean correction

Energy in [GeV]
Res. $\sigma_\phi$, before and after correction

$\sigma_\phi$ as a function of energy

No significant improvement

Resolution before and after the mean correction:
- Blue line: Resolution before mean correction
- Red line: Resolution after mean correction

$\sigma_\phi(E) = C_1 + \frac{C_2}{E^p}$

Energy in [GeV]
2. Analysis Method

> The 2 Choices:

- **Tails in residuals** → Novosibirsk
  a) 50% tails to the left
  b) 50% tails to the right
  c) Product: symmetric tails

  Need to separate pos. And neg. Xtheta bins.

- Edge, low energy **residuals horrendous**
  → Fit center of distribution to describe most photons
  Shorten Fit range for low E & edge residuals.

> Now study pull plots:

- Only positive \( x_\theta \) values (similar results for \( x_\theta < 0 \))
- **Shortened fit range** for low energies and edges.
2. Analysis Method

Gaussian vs. Novosibirsk fit function
Pull plots in diff. bins of energy average over all $\cos(\theta)$ and pos. xtal face bins.

Only positive $X_\theta$ bins
Pull plots in diff. bins of $\cos(\theta)$ averaged over all energies and pos. xtal face bins:
Pull plots in different bins of $x_\theta$ averaged over all $\cos(\theta)$ and energy bins:

Only positive $X_\theta$ bins
<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entries</td>
<td>1391892</td>
</tr>
<tr>
<td>Mean</td>
<td>-0.2203</td>
</tr>
<tr>
<td>RMS</td>
<td>1.063</td>
</tr>
<tr>
<td>Underflow</td>
<td>1.538e+04</td>
</tr>
<tr>
<td>Overflow</td>
<td>9860</td>
</tr>
<tr>
<td>Integral</td>
<td>1.367e+06</td>
</tr>
<tr>
<td>$\chi^2$/ndf</td>
<td>1.214e+04 / 30</td>
</tr>
<tr>
<td>Prob</td>
<td>0</td>
</tr>
<tr>
<td>const</td>
<td>1.086e+05 ± 126</td>
</tr>
<tr>
<td>mean</td>
<td>-0.0478 ± 0.0015</td>
</tr>
<tr>
<td>sigma</td>
<td>0.9943 ± 0.0008</td>
</tr>
<tr>
<td>tau</td>
<td>-0.1236 ± 0.0011</td>
</tr>
</tbody>
</table>

Only positive $X_\theta$ bins

Histogram of pull plot + theta for all photons + theta.
3. Pull plots

Pull plot Summary:

1. Parametrization works with an error of 3-4%.
2. Exceptions are the last two bins in the endcap.
   a) Here horrendous residuals
   b) Symmetric tails
   c) Wrong bias correction.