



Update on the KLOE-NXT luminosity study

Niels Vestergaard 1/6/2026 - Muon general meeting

Motivation and background

- Measure luminosity using the KLOE detector itself by utilising Very Large Angle Bhabha events (VLAB). Serves as an important cross-check for the analysis of $\mu\mu\gamma$ events

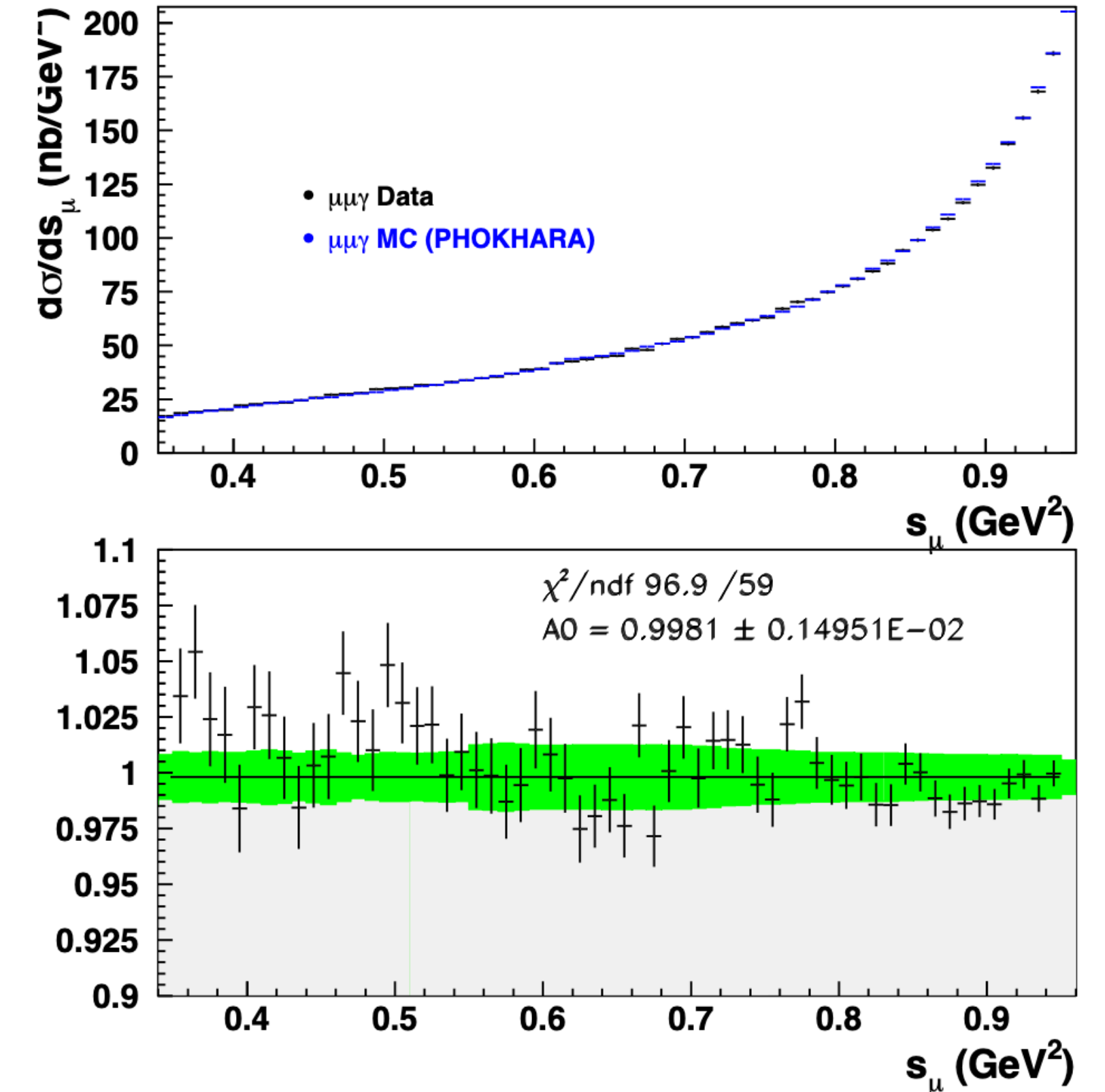
- Luminosity is given by $\int \mathcal{L} dt = \frac{N_{\text{obs}} - N_{\text{bkg}}}{\sigma_{\text{eff}}}$, where N_{obs} is the number of VLAB events, N_{bkg} is the number of background events and σ_{eff} is the cross section obtained with the Monte Carlo generator Babayaga interfaced with the detector simulation GEANFI

Motivation and background

Systematics from previous luminosity study from 2006

	correction (%)	systematic error (%)
acceptance	$\delta_{accept} = +0.25$	$\Delta_{accept} = 0.25$
tracking	–	$\Delta_{track} = 0.06$
clustering	$\delta_{split} = +0.14$	$\Delta_{cluster} = 0.11$
background	$\delta_{bkg} = -0.55$	$\Delta_{bkg} = 0.08$
cosmic veto	$\delta_{cosmic} = +0.40$	–
dependence on \sqrt{s}	$\delta_{\sqrt{s}} = +0.10$	$\Delta_{\sqrt{s}} = 0.10$
E_{clu} drifts	–	$\Delta_{E_{clu}} = 0.10$
Total experimental	$\delta_{tot} = +0.34$	$\Delta_{tot} = 0.32$

Data/MC comparison of $\mu\mu\gamma$ cross section



Event selection: LAB-selection

Initial large angle selection is done using only calorimeter information:

- 1) At least two calorimeter clusters with an energy $300 \text{ MeV} < E_{clu} < 800 \text{ MeV}$
- 2) For all pairs of clusters fulfilling the energy requirement, the polar angle acollinearity $\zeta = |\theta_{clu1} + \theta_{clu2} - 180^\circ|$ is calculated. The pair of clusters minimising ζ is chosen, and $\zeta_{\min} < 10^\circ$ is required
- 3) These two clusters must satisfy the time cut $|t_{clu1} - t_{clu2}| < 4 \text{ ns}$
- 4) Both clusters have to be located at large polar angles $45^\circ < \theta_{clu} < 135^\circ$
- 5) An additional cut on the three-dimensional angle between the two clusters is applied: $\cos(\alpha) > -0.975$, where $\cos(\alpha) = \frac{\vec{r}_{clu1} \cdot \vec{r}_{clu2}}{|\vec{r}_{clu1}| |\vec{r}_{clu2}|}$. This cut rejects $e^+e^- \rightarrow \gamma\gamma$ events, which are completely back-to-back
- 6) At least 50 hits in the DC have to be present: $N_{\text{hits}} \geq 50$

Event selection: VLAB-selection

Further selection includes information from the DC and further tightens the EmC cuts

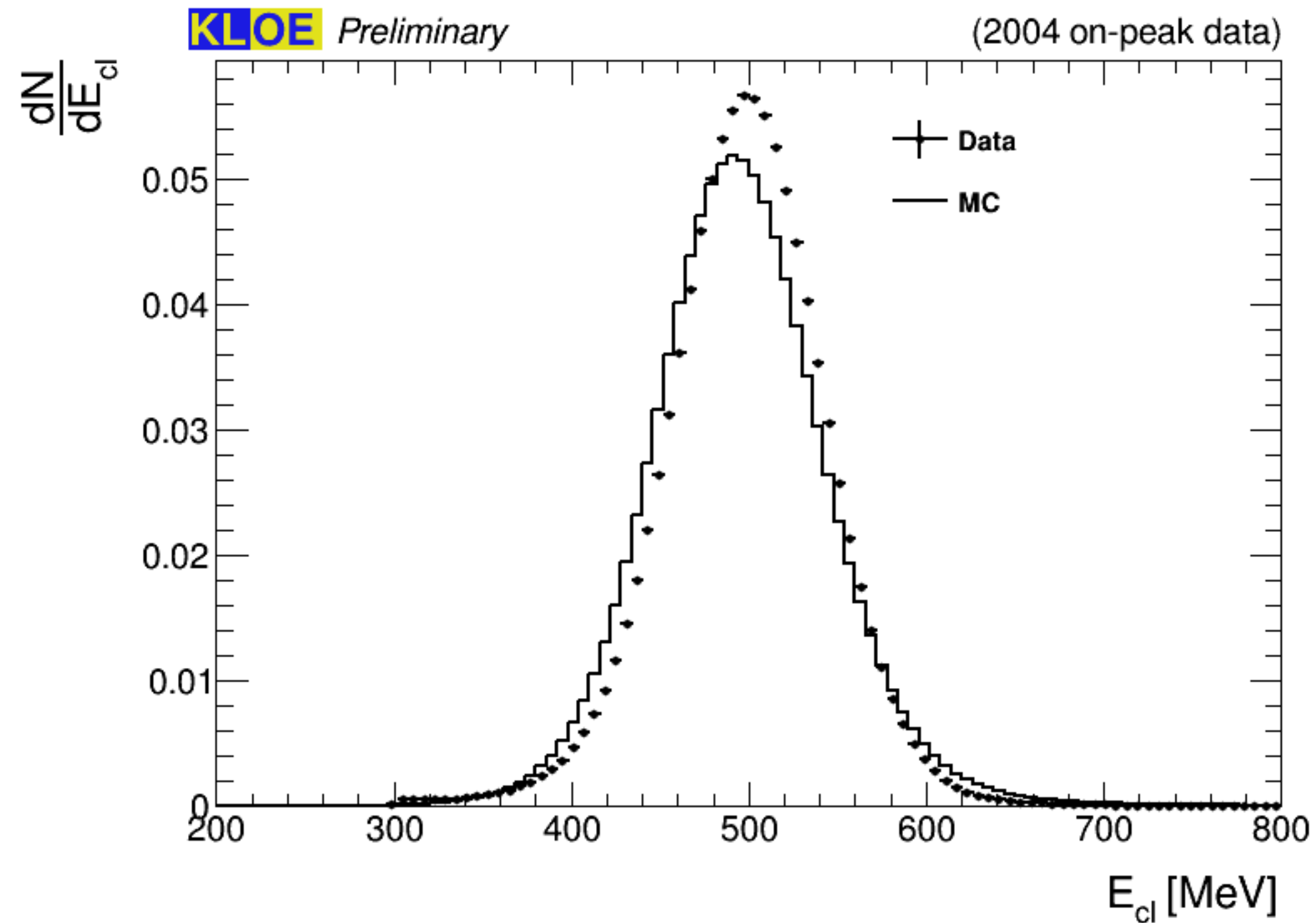
- 1) For the two tracks tr1 and tr2, with the largest number of associated hits to the tracks we require the track's point-of-closest approach to the origin (PCA) to be close to the interaction point: $\sqrt{x_{pca}^2 + y_{pca}^2} < 7.5$ cm and $|z_{pca}| < 15$ cm
- 2) If d is the spatial distance between the first hits of tr1 and tr2 we require $d > 50$ cm. This cut rejects a contamination from the process $e^+e^- \rightarrow \gamma\gamma \rightarrow \gamma e^+e^-$, where the e^+e^- pair in the final state results from photon conversion.
- 3) The two selected tracks tr1 and tr2 are required to have opposite signs of curvature.
- 4) For both tracks the momentum cut $p \equiv |p| \geq 400$ MeV is applied.
- 5) For the two clusters preselected by the LAB filter a tighter cut on the polar angle is applied: $55^\circ < \theta < 125^\circ$
- 6) Also the cut on the polar angle acollinearity for the two LAB cluster is further tightened: $\zeta < 9^\circ$

Resolution smearing of cluster variables

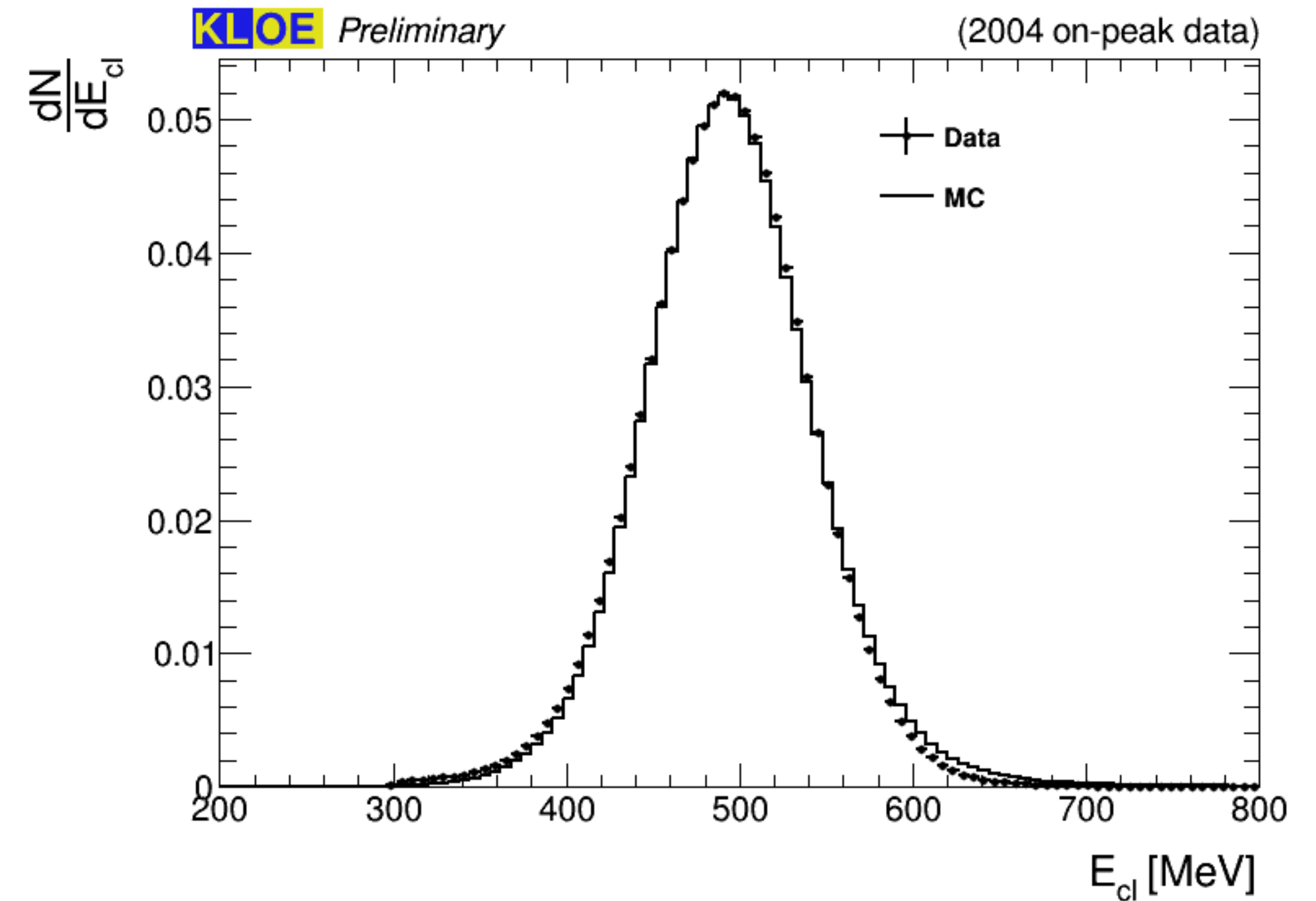
- Differences were found between data and MC in cluster variables.
- For energy a simple single Gaussian smearing is applied to data, obtained directly from a fit of both data and MC
- For angular resolution, the quantity $\theta_{\text{rec}} - \theta_{\text{ext}}$ is constructed, where θ_{rec} is the polar angle of the Bhabha cluster, and θ_{ext} is the polar angle of the Bhabha cluster using the extrapolated position of the associated track. Correction is then applied to the z -position of the cluster based on the fit parameters

Energy correction in DATA using single Gaussian

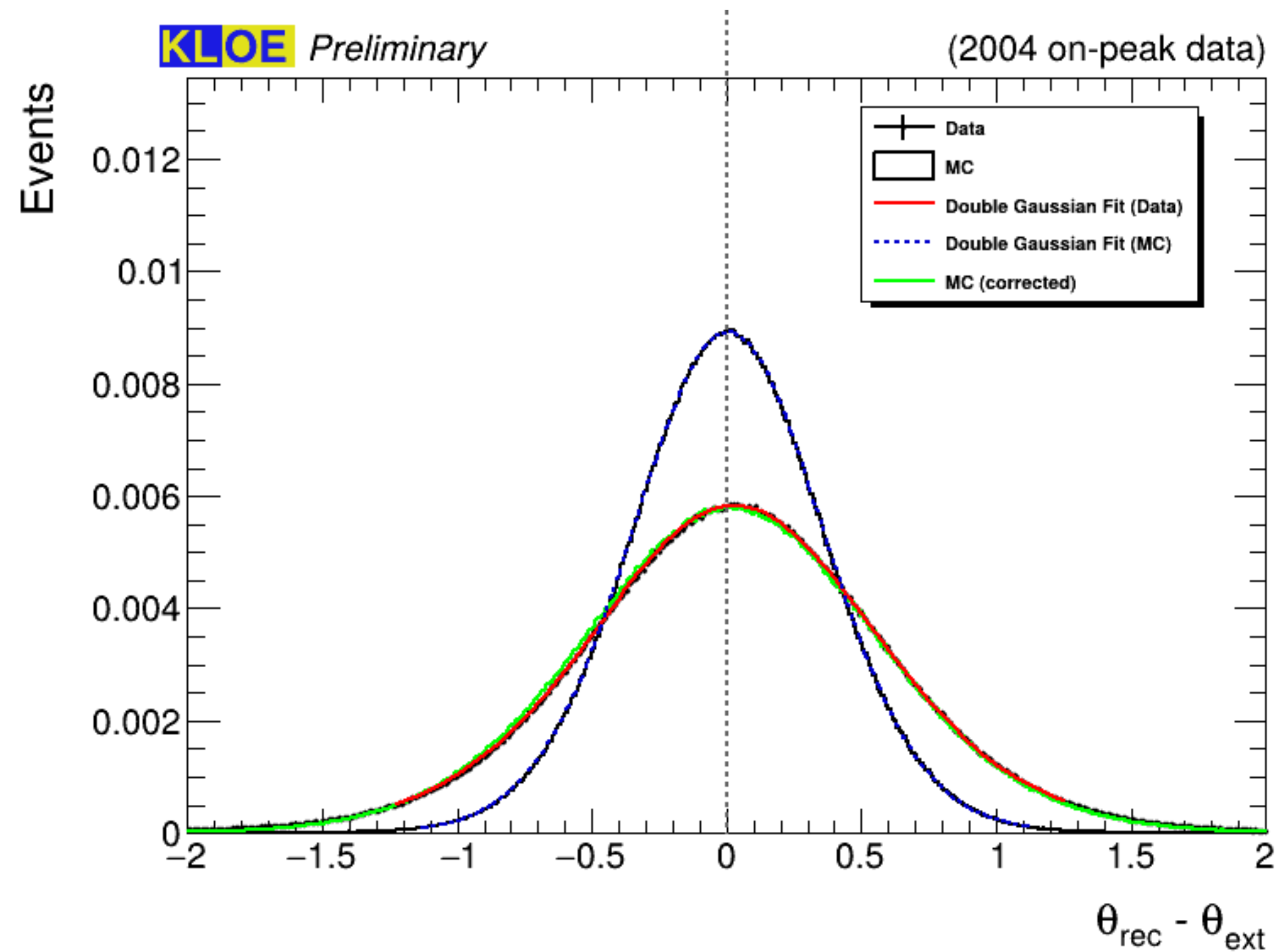
Before correction



After correction



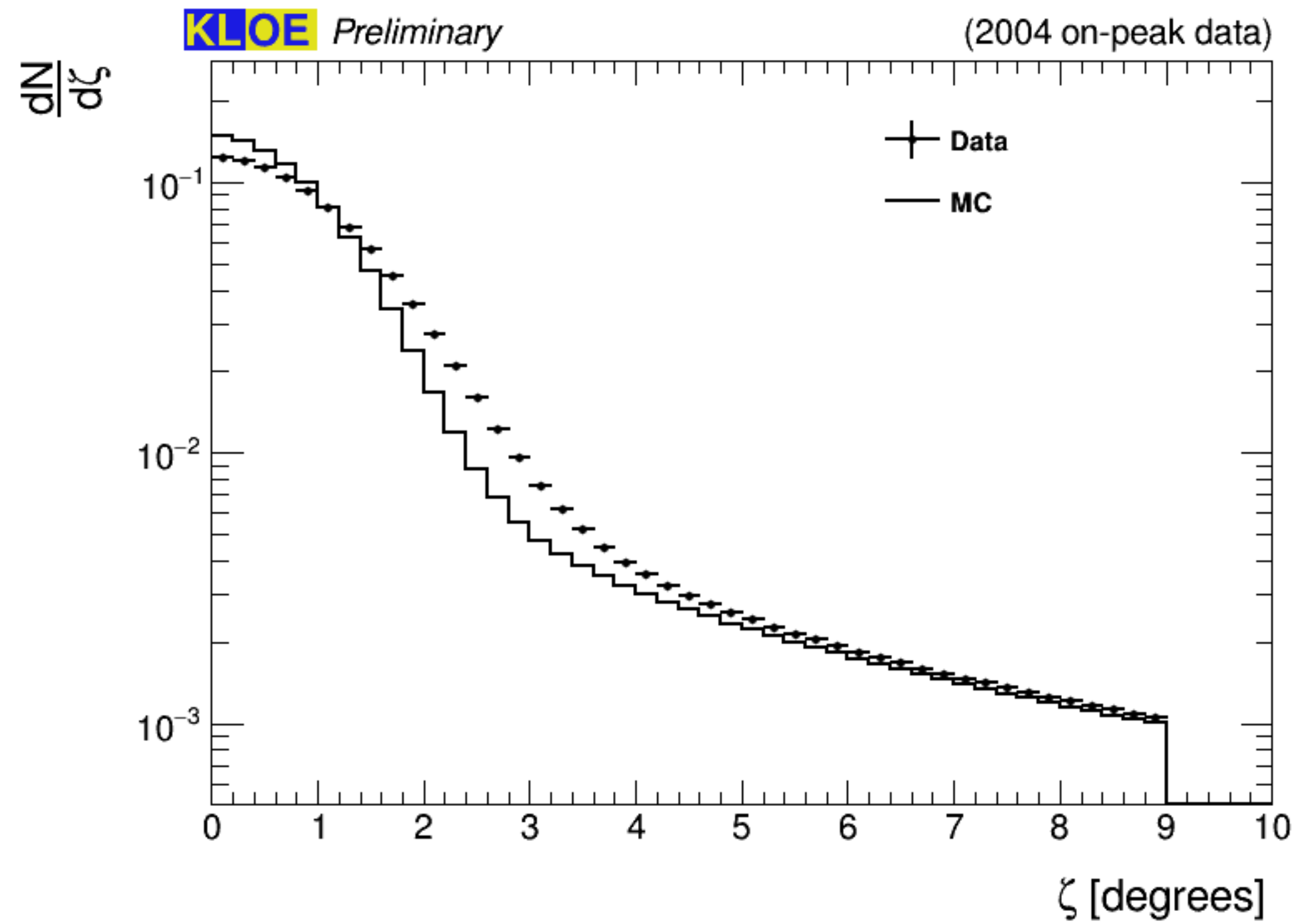
Resolution smearing of cluster variables



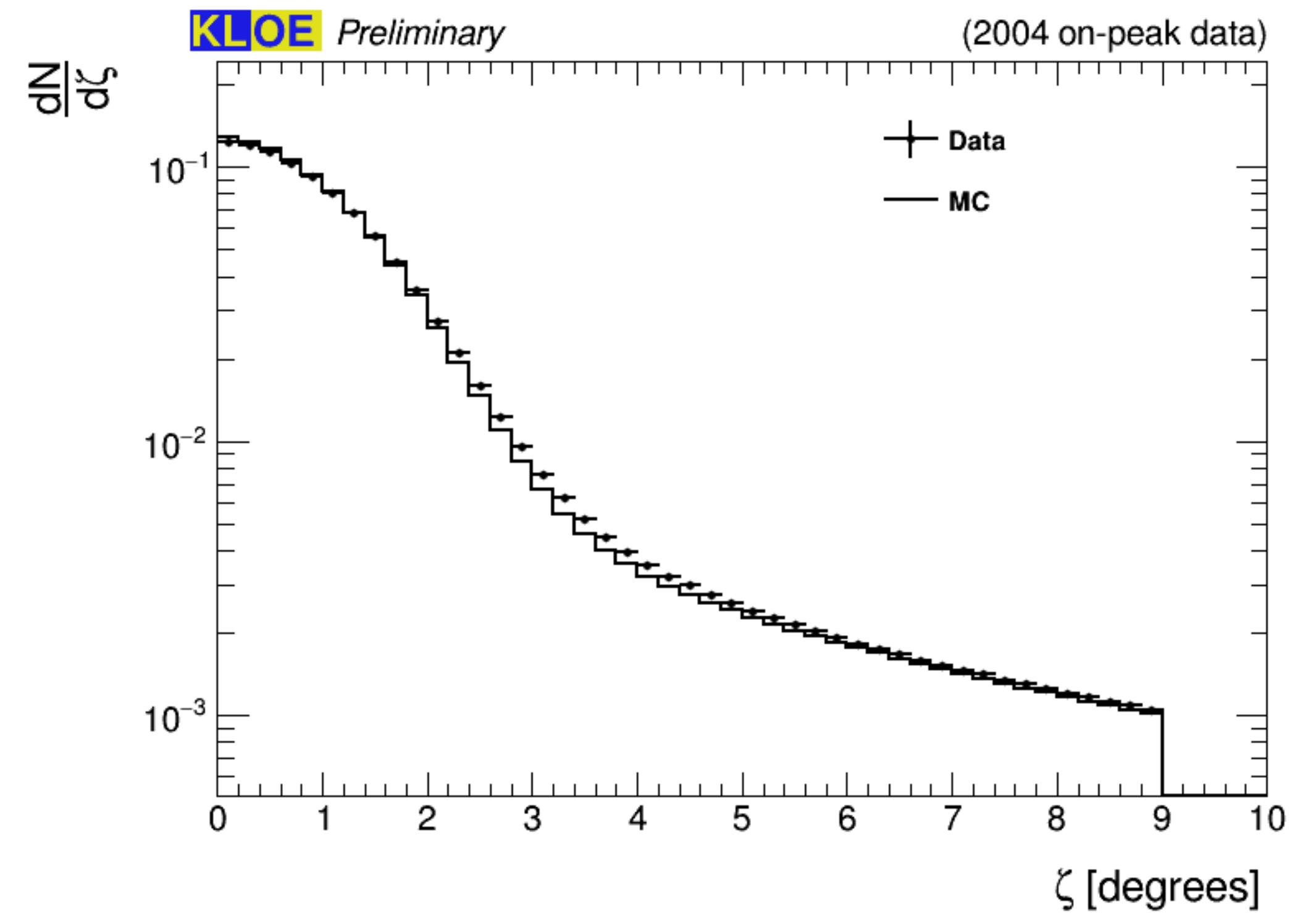
Plot of $\theta_{\text{rec}} - \theta_{\text{ext}}$ for Data and MC, along with double Gaussian fits for each and corrected MC.

ζ -correction

Before correction

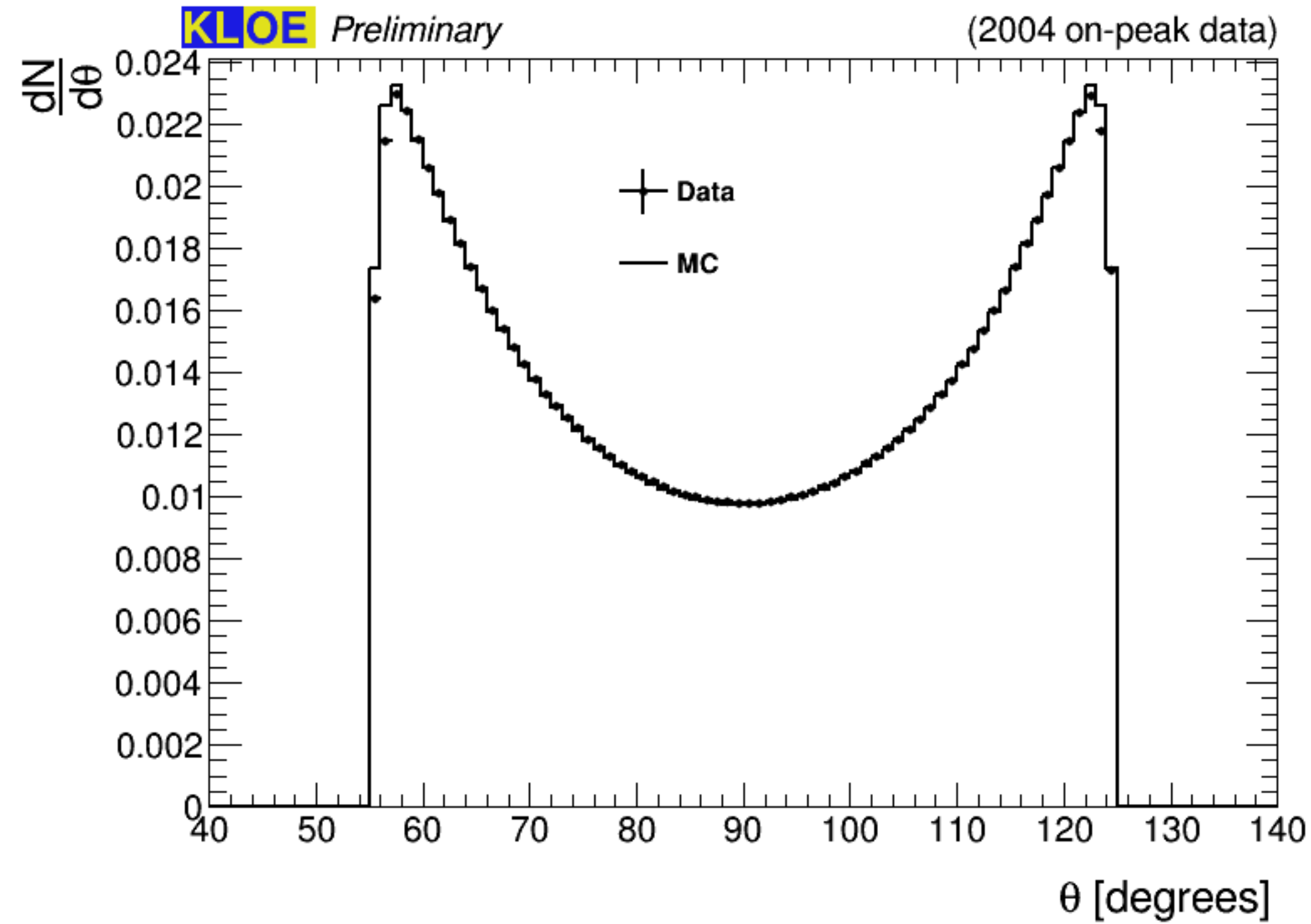


After correction

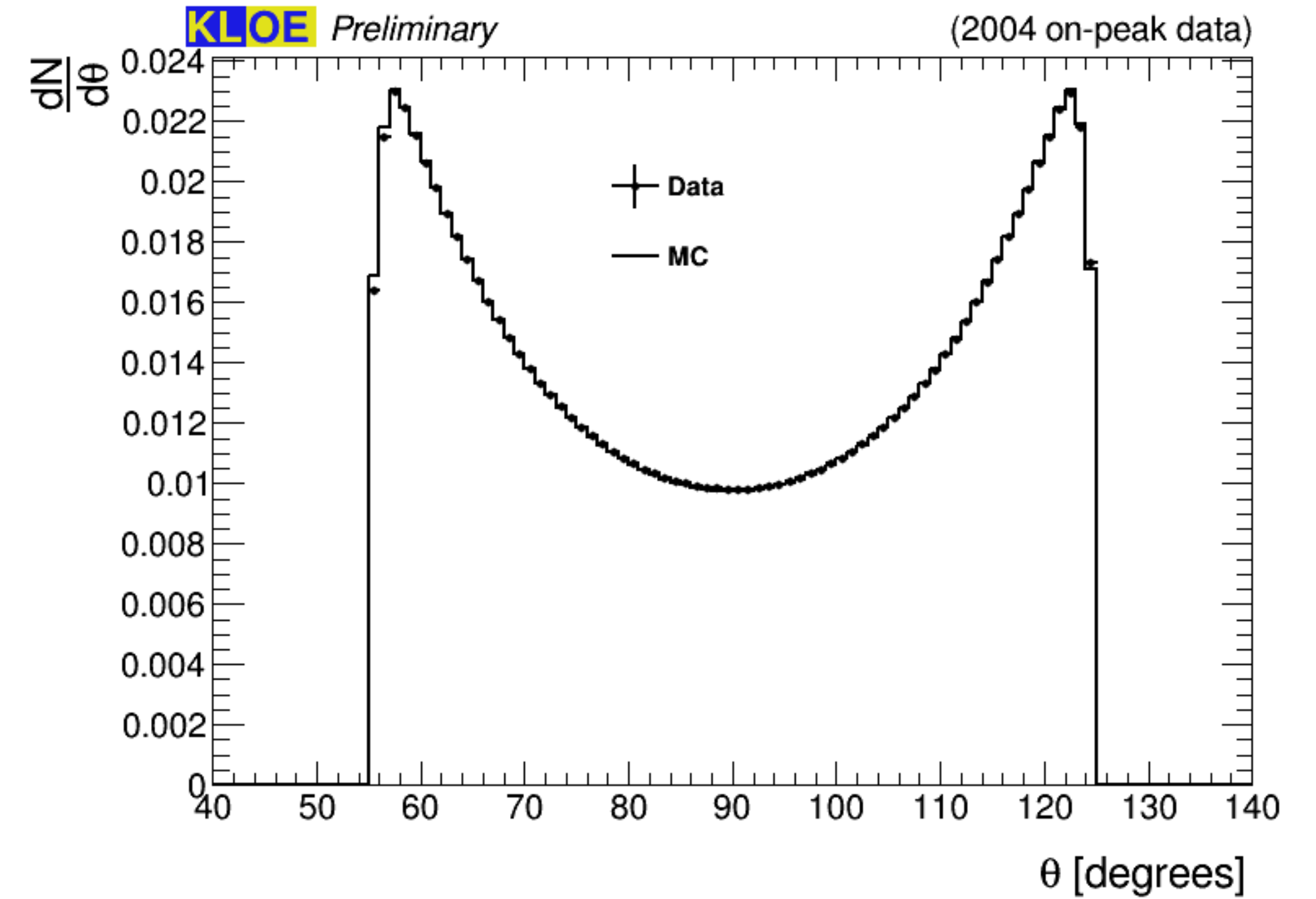


θ -correction

Before correction



After correction



Data quality using Bhabha events

- Current data quality takes into things such as beam parameters, small runs etc.
- Important to filter out bad runs where running conditions of the drift chamber were poor
- Sensible to use Bhabha events due to simple nature of the process and clean event topology
- Use the method from the tracking efficiency of previous KLOE luminosity note, to calculate both single track efficiency as well as the two track inefficiency, run by run

Single track efficiency

LAB-events are selected according to the standard procedure. Of the LAB events, a subsample is chosen:

1. $\cos(\alpha) > -0.9$, where α is the 3-dimensional angle between LAB-clusters
2. One track is required to have $p_{\text{tag}} > 400$ MeV and associated to one of the two lab clusters
3. This track must fulfill quality cut of $|z_{\text{pca}}| < 15$ cm and $\sqrt{x_{\text{pca}}^2 + y_{\text{pca}}^2} < 7.5$ cm

In this subsample, an event is considered efficient if at least one second candidate track satisfies:

1. The track must be one of the two with the largest number of associated hits
2. This track must also fulfill quality cut of $|z_{\text{pca}}| < 15$ cm and $\sqrt{x_{\text{pca}}^2 + y_{\text{pca}}^2} < 7.5$ cm
3. The track must have opposite charge with respect to tagging track
4. The track must have momentum $p_{\text{cand}} > 400$ MeV
5. The distance between first hits between this track and the candidate track $d > 50$ cm

Correlated inefficiency

For the correlated inefficiency, stricter cuts are placed on the clusters compared to the standard LAB selection and we are instead looking for *inefficient* events. The subsample is instead based only on the clusters, with the changes:

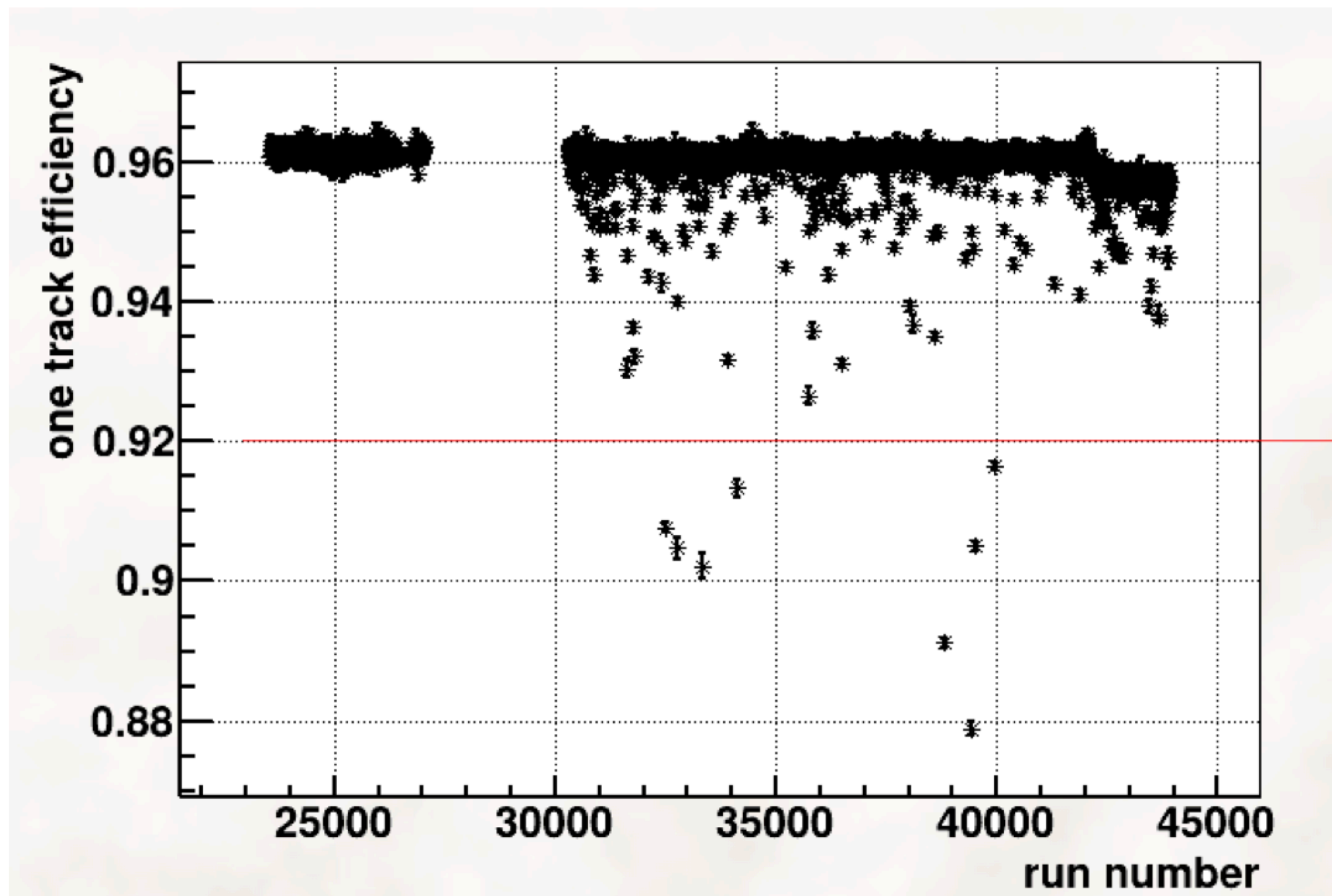
1. Two LAB clusters must have energy $800 \text{ MeV} > E_{\text{clu}} > 350 \text{ MeV}$
2. $-0.6 > \cos(\alpha) > -0.9$, where α is the 3-dimensional angle between LAB-clusters

In this subsample, an event is inefficient if not a single track is found that satisfies:

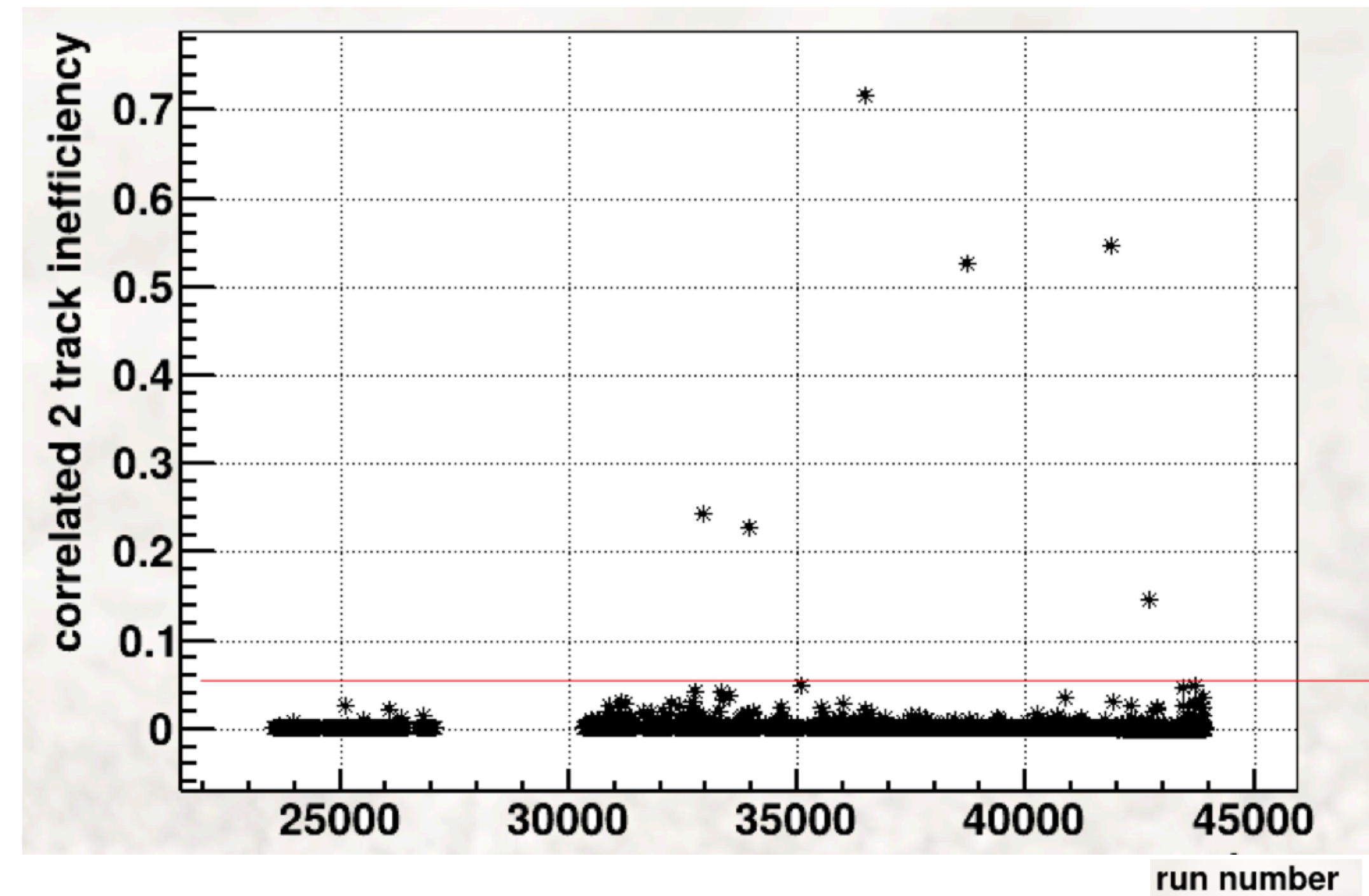
1. The track must be one of the two with the largest number of associated hits
2. Quality cut of $|z_{\text{pca}}| < 15 \text{ cm}$ and $\sqrt{x_{\text{pca}}^2 + y_{\text{pca}}^2} < 7.5 \text{ cm}$
3. The track must have momentum $p_{\text{cand}} > 350 \text{ MeV}$

Track efficiencies

Single track efficiency



2 track inefficiency



Plots thanks to Fedor!

Next steps:

- Calculate integrated luminosity for all datasets (2002, 2004 and 2005)
- Calculate all relevant associated systematics
- Analysis of $e^+e^- \rightarrow \gamma\gamma$ events and as cross check