Software & Reconstruction: Forward Calorimeters

André Sailer

CERN-EP-LCD

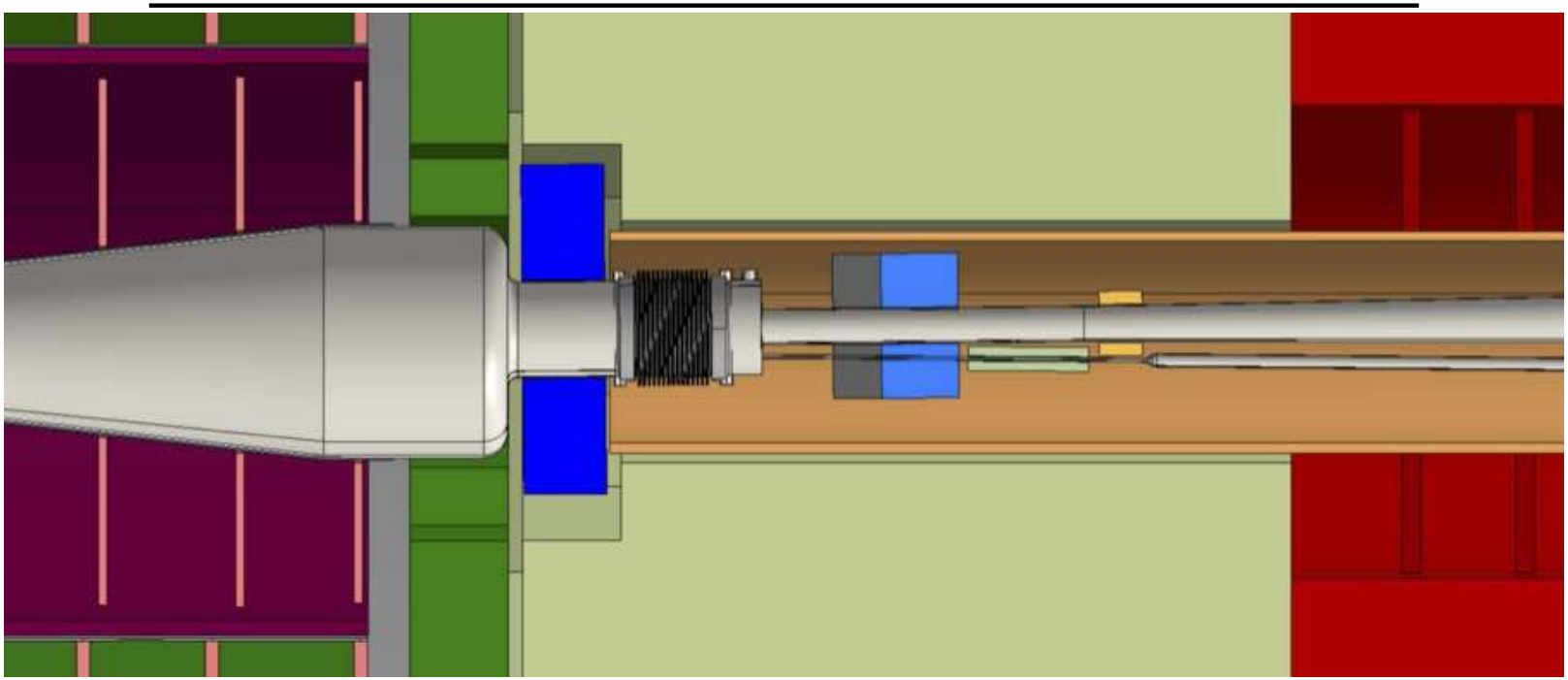
CLICdp Detector Optimisation Meeting
December 12, 2017

Outline

Forward Calorimeter Parameter

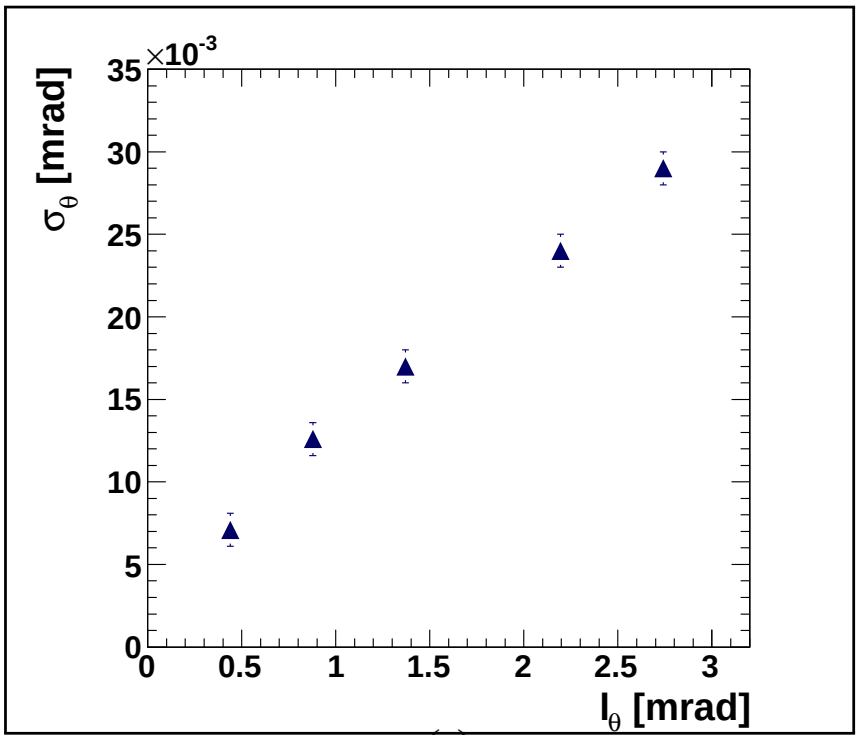
- LumiCal and BeamCal: sampling electromagnetic calorimeters in the very forward region

	Z[mm]	R[mm]	θ[mrad]	$\Delta\theta$[mrad]
BeamCal	3181–3441	32–150	10–46	2.4
LumiCal	2539–2710	100–340	39–134	1.48



LumiCal Parameters, expected Performance

- Given a cell size of about 1.5 mrad in polar direction at 1.5 TeV a polar angle resolution of about 17 μrad was estimated
  - Based on simulation sample of Bhabha electrons, average of



From LCD-Note-2009-002, 1.5 TeV electrons, optimised log constant

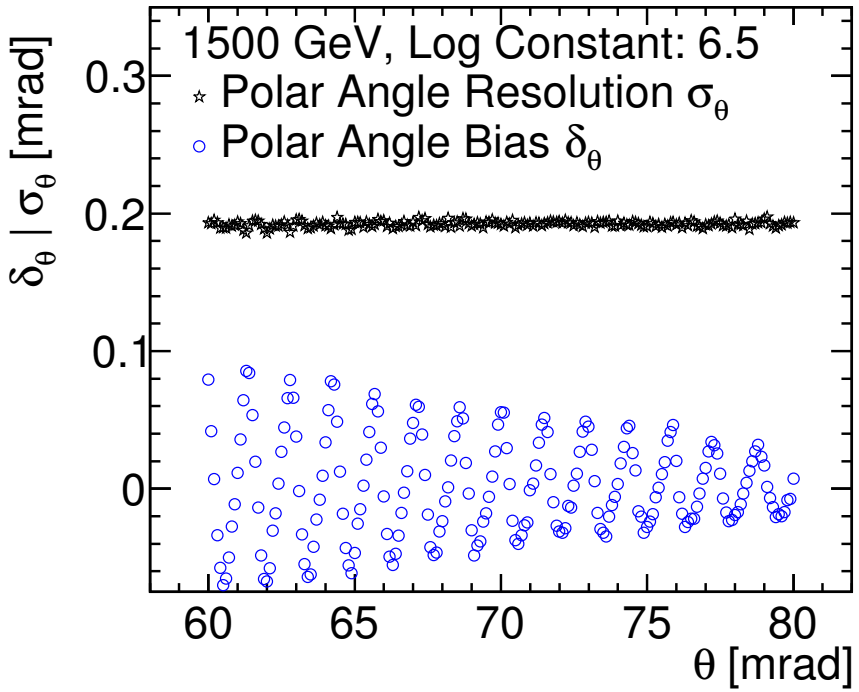
LumiCal Resolution

- Polar angle resolution 10 times worse than previously estimated
- Theta calculated from x/y/z average.

$$\bar{x}_i = \frac{\sum_{\text{Hits}} w_{\text{Hit}} x_{\text{Hit}}}{\sum_{\text{Hits}} w_{\text{Hit}}}$$

Energy weighted by

$$w_{\text{Hit}} = \max\left(0.0, \log\left(C + \frac{E_{\text{Hit}}}{E_{\text{Cluster}}}\right)\right)$$

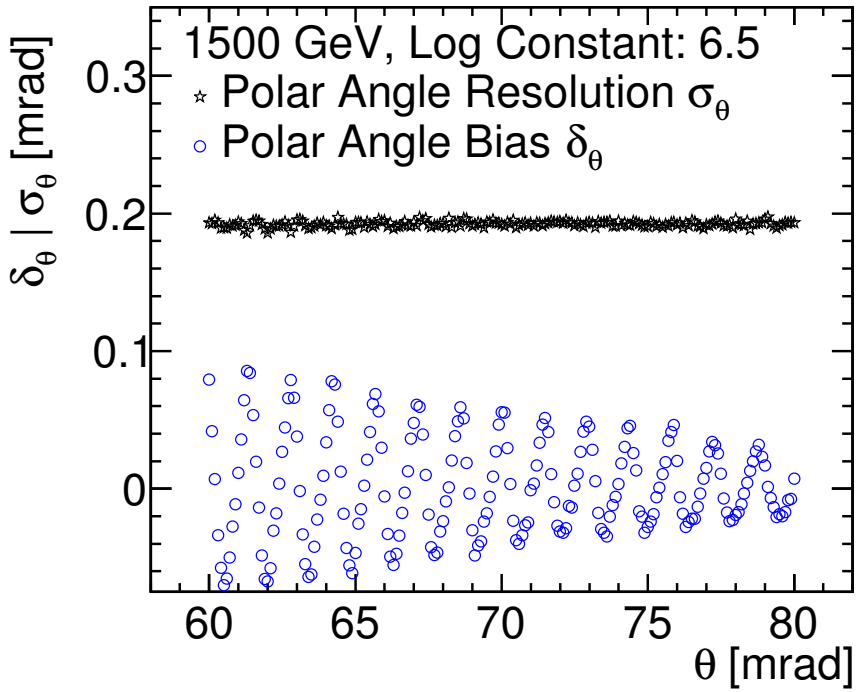


Bugs and Fixes

- Multiple places where cluster positions was calculated
  - Once for clusters for LCIO output: not averaging polar angle
  - Once for root trees written by processor: averaging polar angle, at least for *Theta* `branch`
- Re-calculating cluster position from clusters resulted in better resolutions
  - Discovered by Yorgos: wrong Z position calculated from cellID: wrong unit when reading layer thickness. Off-by-one error: starting layers at 0
    - ⋆ Impact on reconstruction performance, not just resolutions
    - ⋆ Affected output for root tree
  - Segmentation offset off by half radial cell width

Resolution Improvements

- Previously



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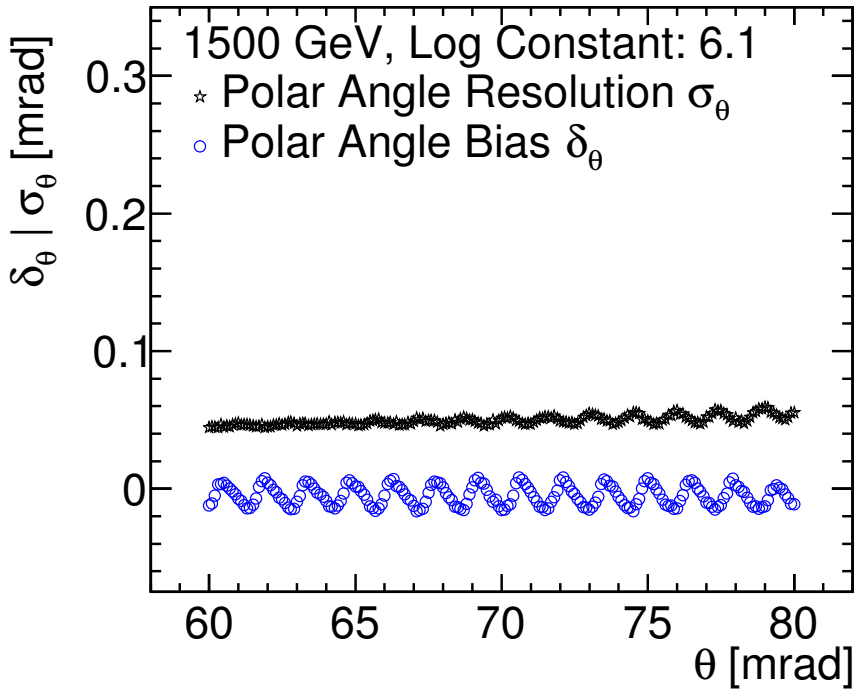
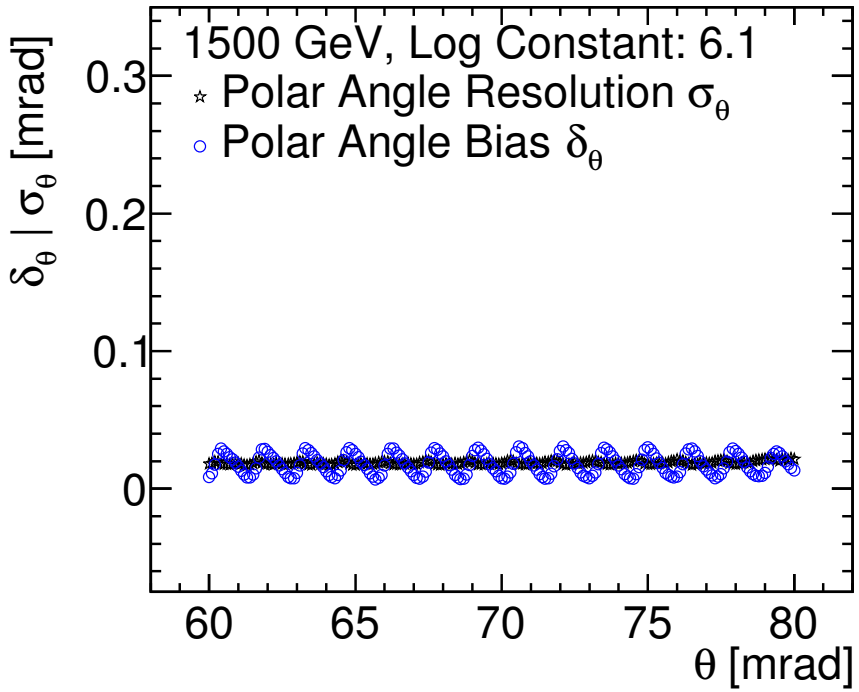
- Previously
- Fix Z-position of layers, fix layer starting with 0, place hit in middle of sensitive



Resolution Improvements

- Previously
- Fix Z-position of layers, fix layer starting with 0, place hit in middle of sensitive
- Average over polar angle instead of Cartesian coordinates
  - Regain previously estimated polar angle resolutions for 1.5 TeV



Weighting Cells by cell Area

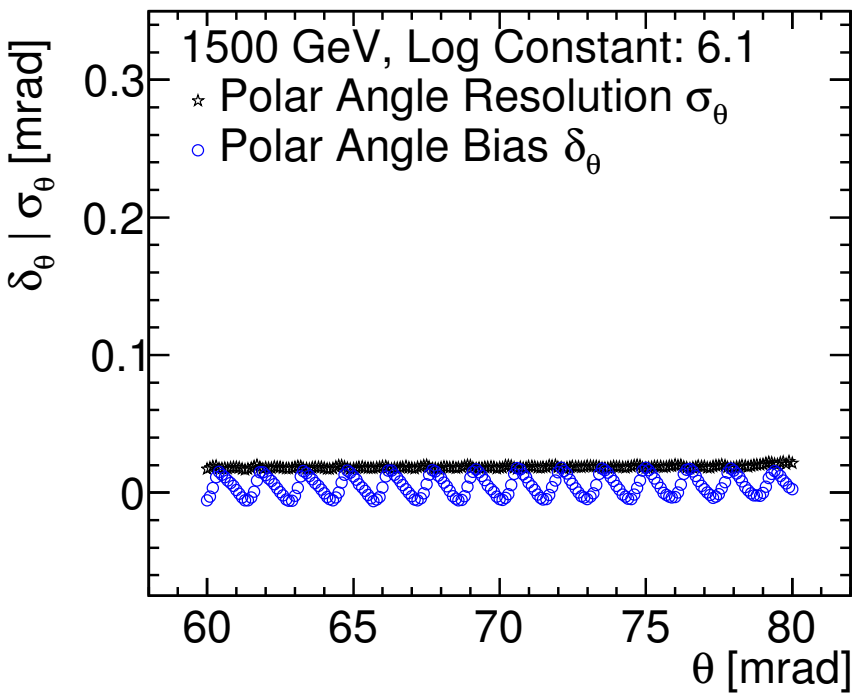
- Cell area grows by radius, larger cells receive larger energy deposit

$$A = R_{\text{cell}} \Delta\phi \Delta R \qquad (1)$$

  ΔR and $\Delta\phi$ are constant, area only scales by R.

- Scale cell weights with $R_{\text{min}}/R_{\text{cell}}$

$$w_{\text{Hit}} = \max\left(0.0, \log\left(C + \frac{E_{\text{Hit}}}{E_{\text{Cluster}}}\right)\frac{R_{\text{min}}}{R_{\text{cell}}}\right)$$



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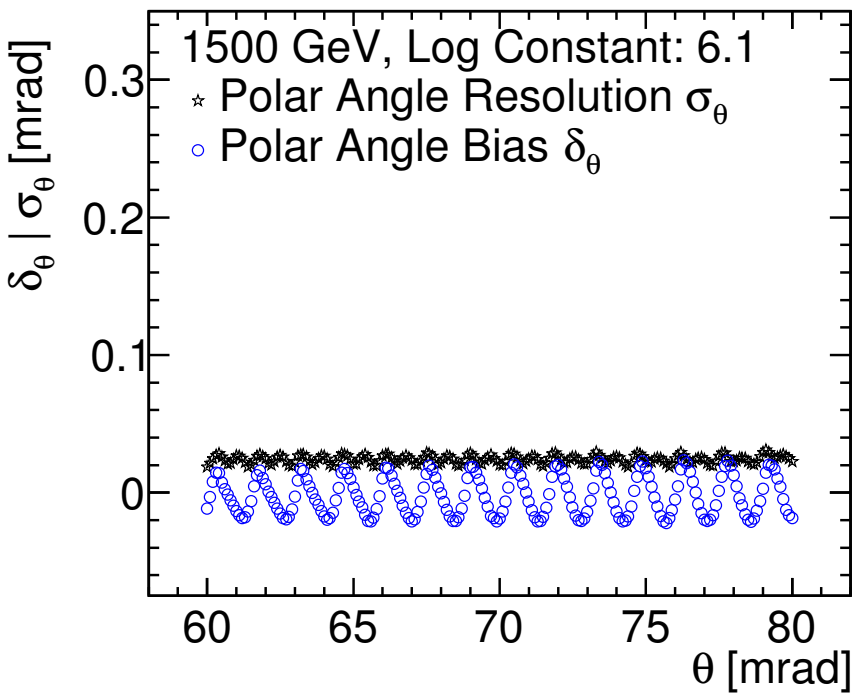

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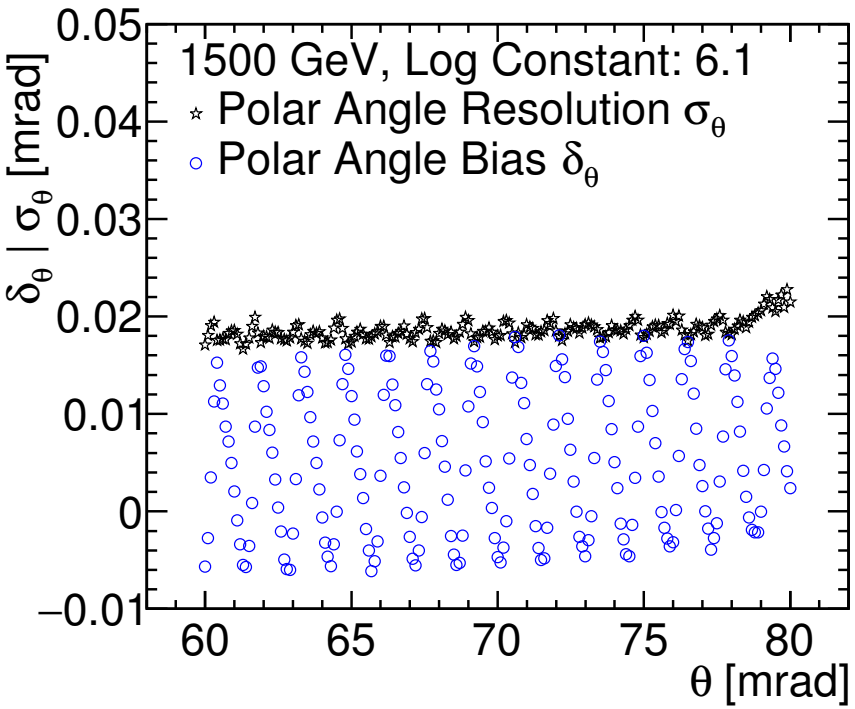

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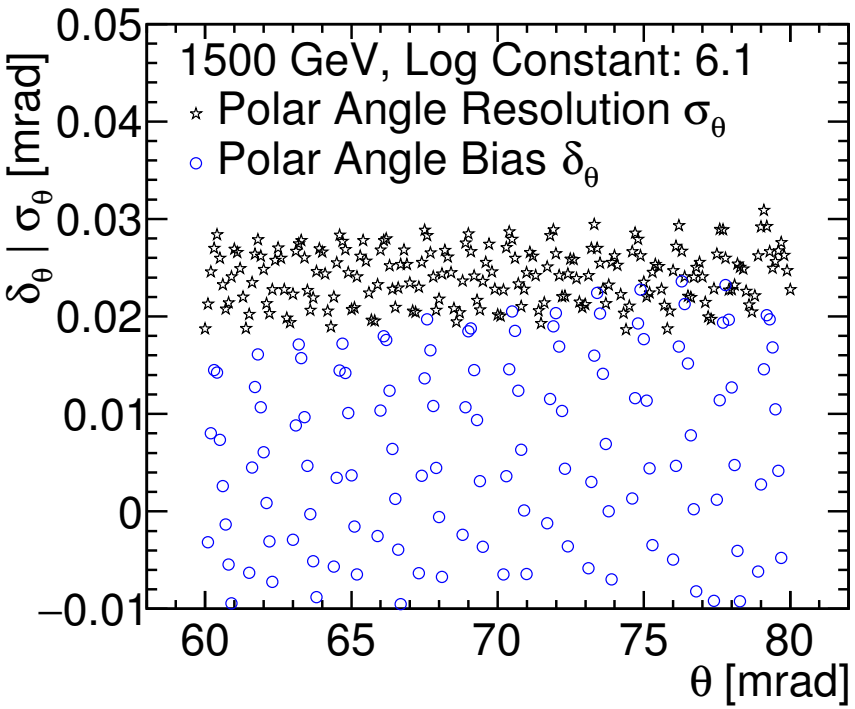

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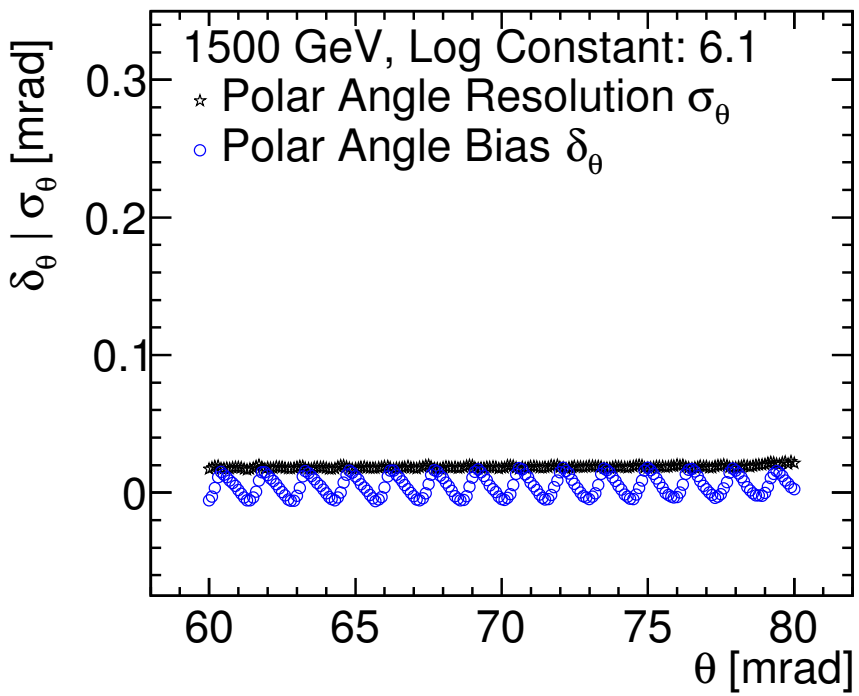
- Scaling of $\log(E)$ is implemented in the LumiCal reconstruction

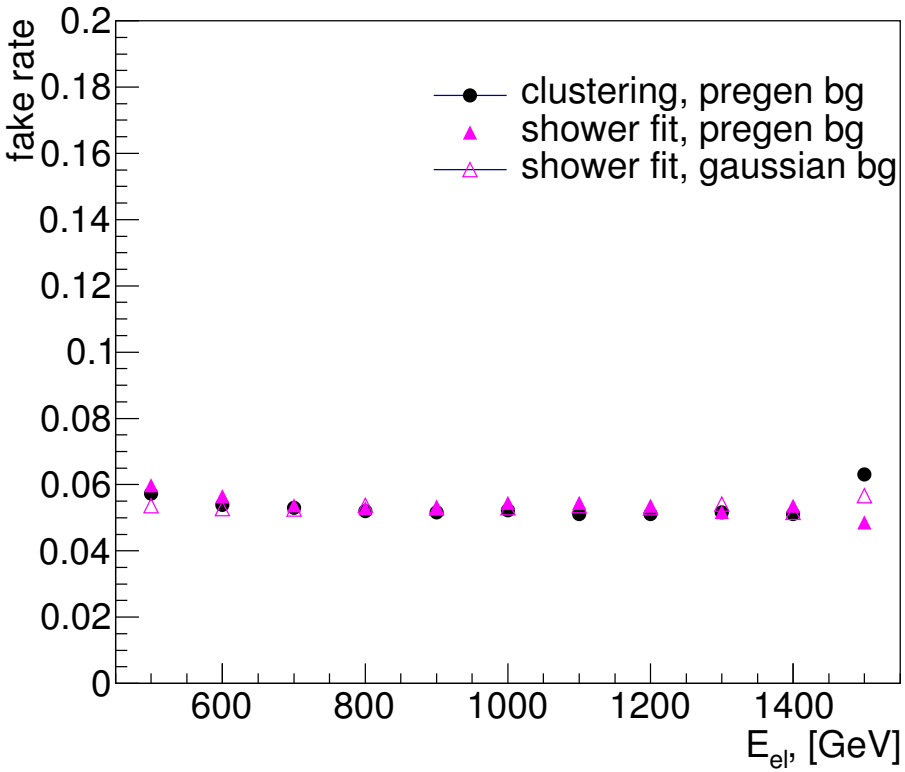


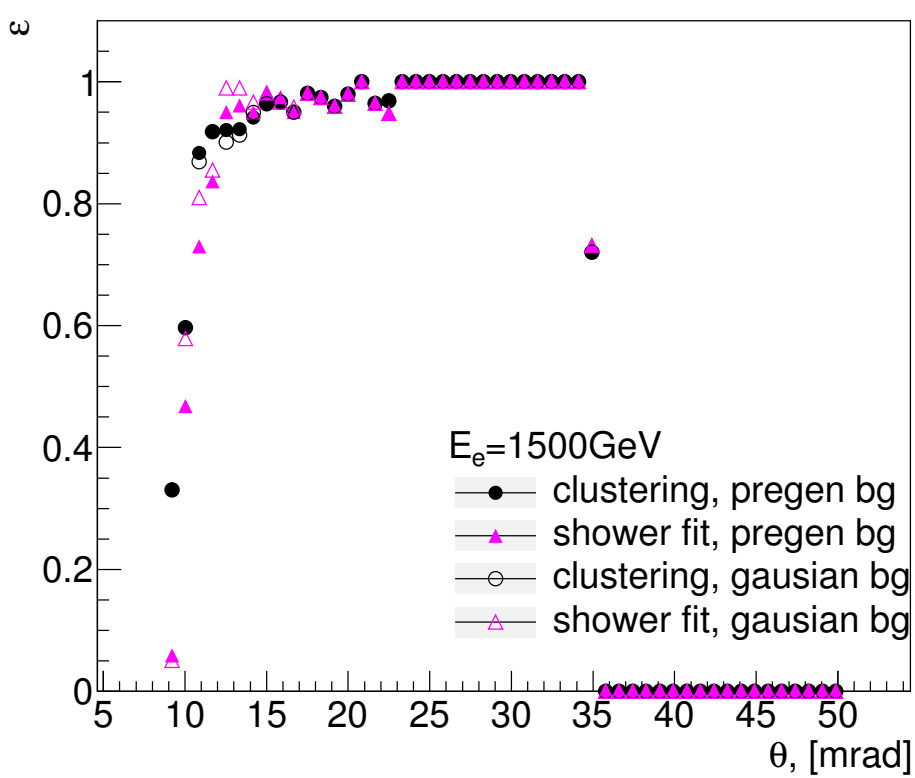
LumiCal Reconstruction Outlook

- Validated reconstruction with $\gamma\gamma \rightarrow$ hadron background overlay
- Optimise logarithmic weighting for different energies: 350 GeV, 1.4 TeV
  - Maybe parameterise optimal logarithmic weighting constant for cluster energy

BeamCal Reconstruction Efficiency

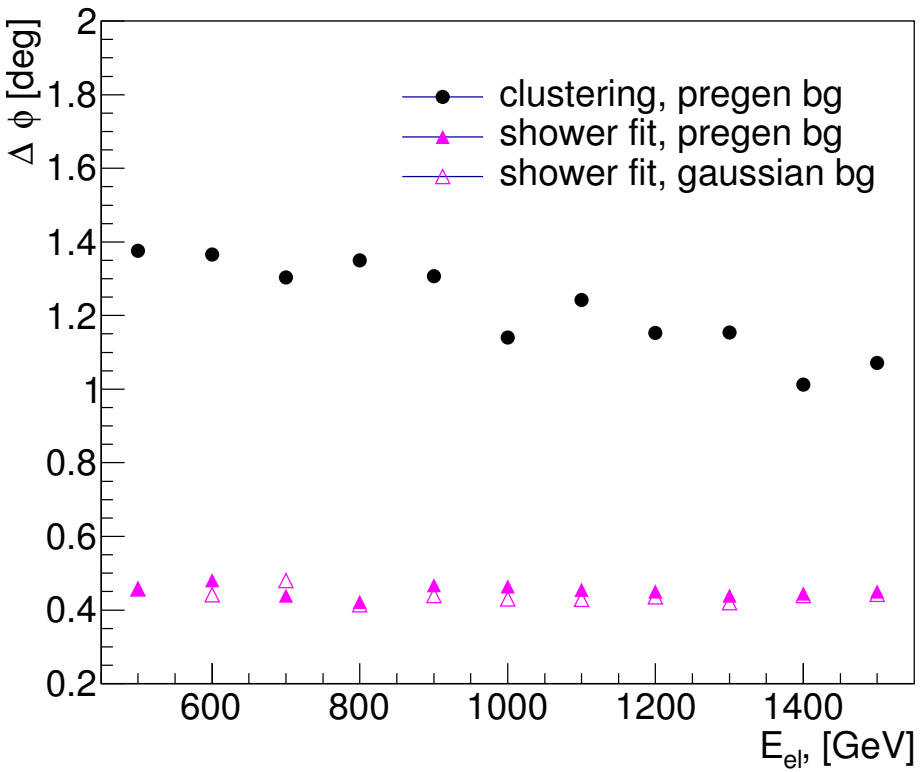
- Fake rate and reconstruction efficiency of 1.5 TeV electrons with 40 BX of CLIC 3 TeV incoherent pair background
- Reconstruction can be tuned to reduce fake rate or increase efficiency

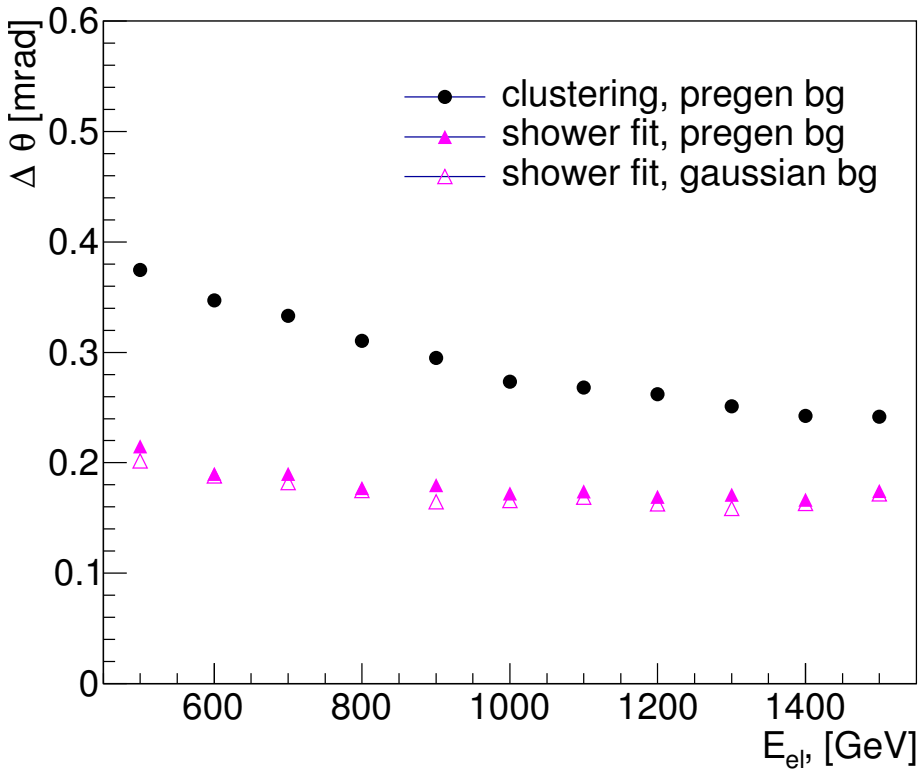




BeamCal Angular Resolutions

- Angular resolutions generally better with shower fitting reconstruction





BeamCal for Lower Energies

- Added 380 GeV incoherent pairs background file
  - Based in $L^{\star} = 6$ m beam optics simulated by D. Arominski
- No tuned reconstruction parameters for 350 GeV or 1.4 TeV
  - Use 1σ threshold for background subtraction

Summary

LumiCal Reconstruction

- Fixed bugs in the LumiCal reconstruction and recovered previously estimated polar angle resolutions
- Need to validate with background overlaid

BeamCal Reconstruction

- Added incoherent pair background file and processor to run at 380 GeV to `CLICPerformance` package