Update on BeamCal reconstruction

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DESY Zeuthen

Andrey Sapronov, André Sailer

Overview

- BeamCal background simulation
- Shower fitting method
- Fit algorithm performance
- Summary

Background simulation methods

- **Pregenerated** - the background is constructed with random samples from bg pool. Simulate 40BX = select 40 samples and add them.
- **Gaussian** - the bg is generated according to gaussian distribution in each pad:

  `gaus(mean*Nbx, st.dev*√Nbx)`.

  The parameters are obtained from bg pool and are stored in a root file. Good for large N_{bx}.
- **Average** - very similar to **Gaussian**, but with **`mean=0`**
- **Parametrised** - bg is generated according to

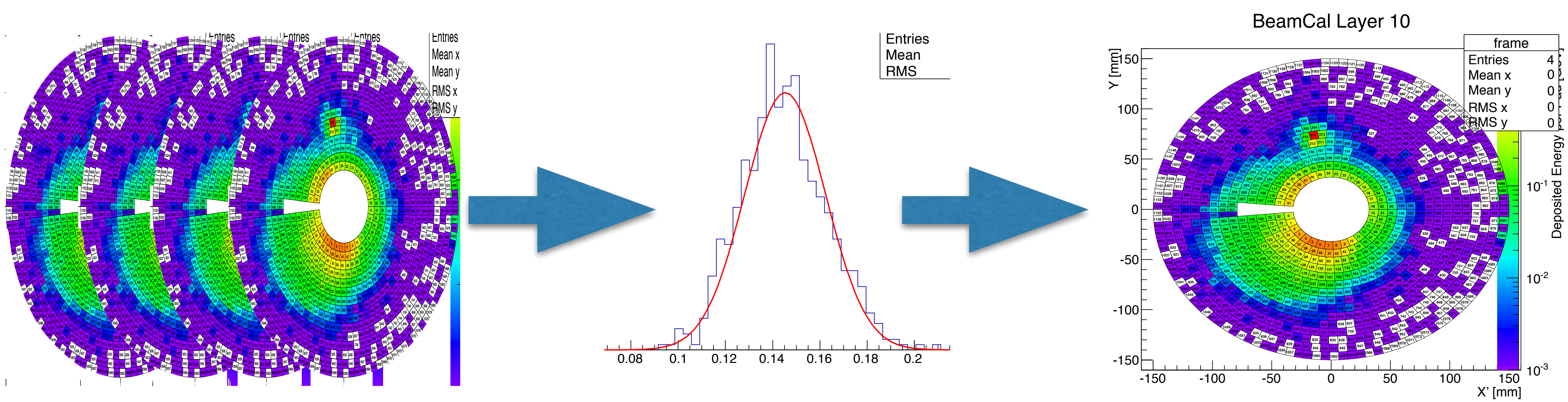
$$f(x) = \frac{[1]}{x} \exp\left[-\left(\frac{x-[2]}{[3]}\right)^2\right]$$

with parameters obtained from the pool. Good for $N_{bx} < 4$

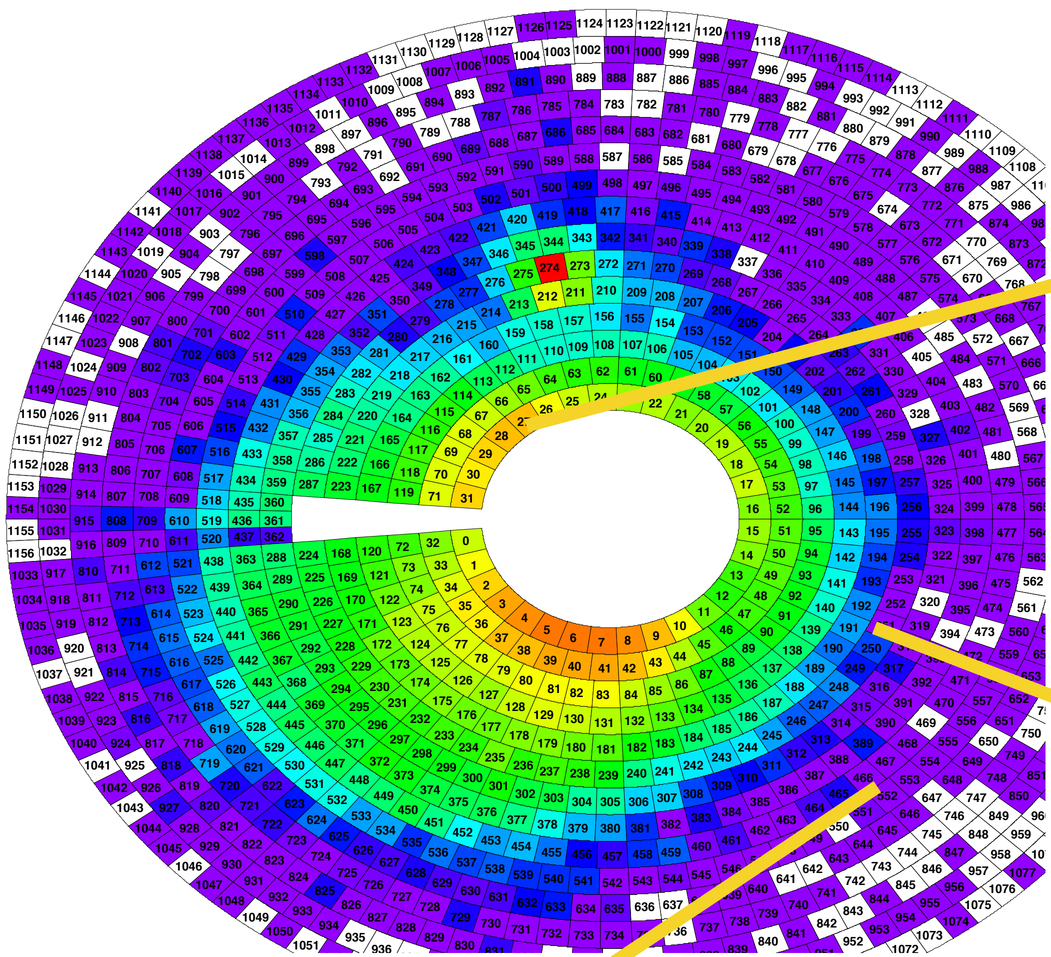
Background parametrisation

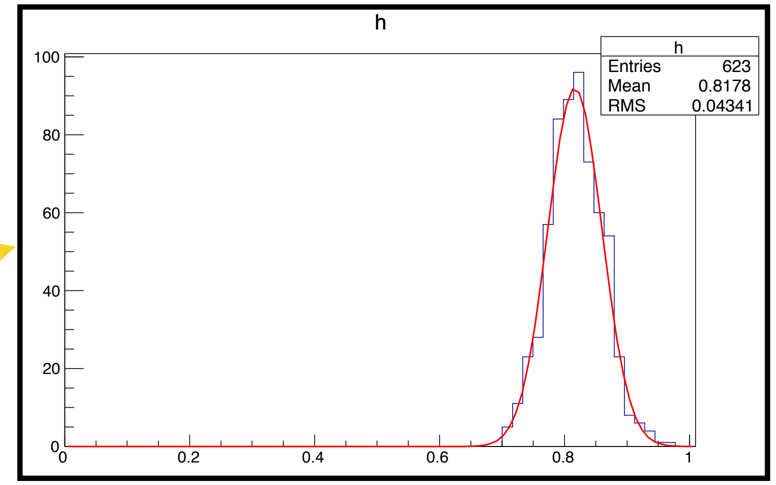
The distributions from the pool are used for background parametrisation:

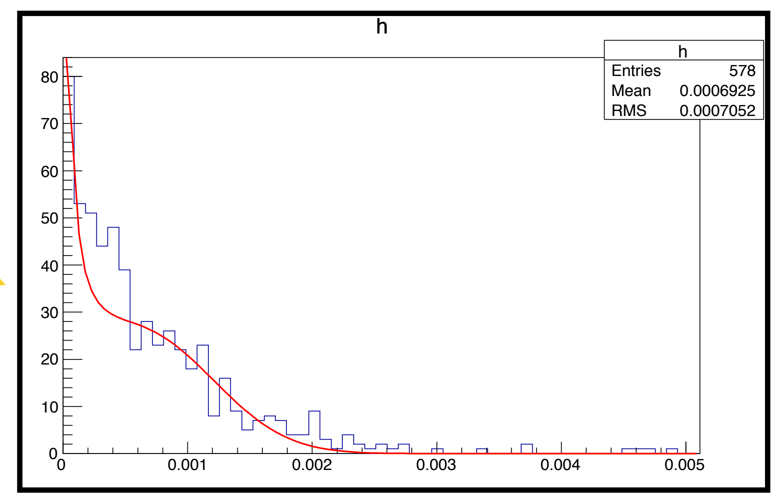
- Take energy distribution in each pad
- Fit it with gaussian or other shape
- Store the parameters in a root file for future bg generation

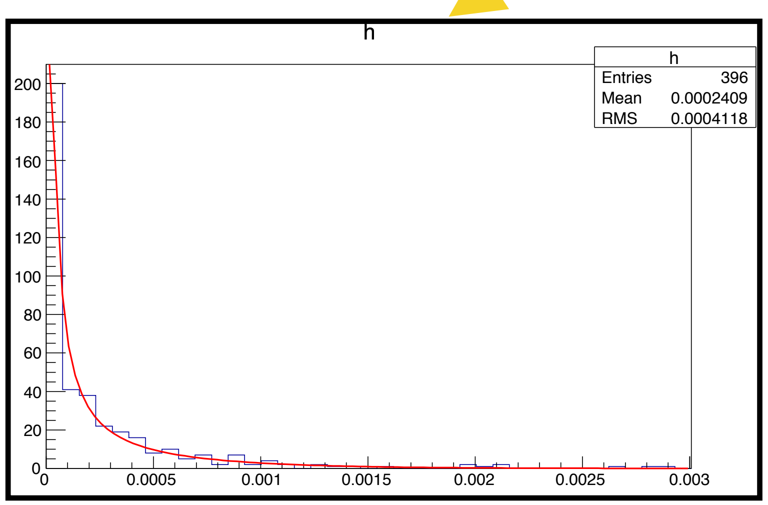


Background parametrisation: fits







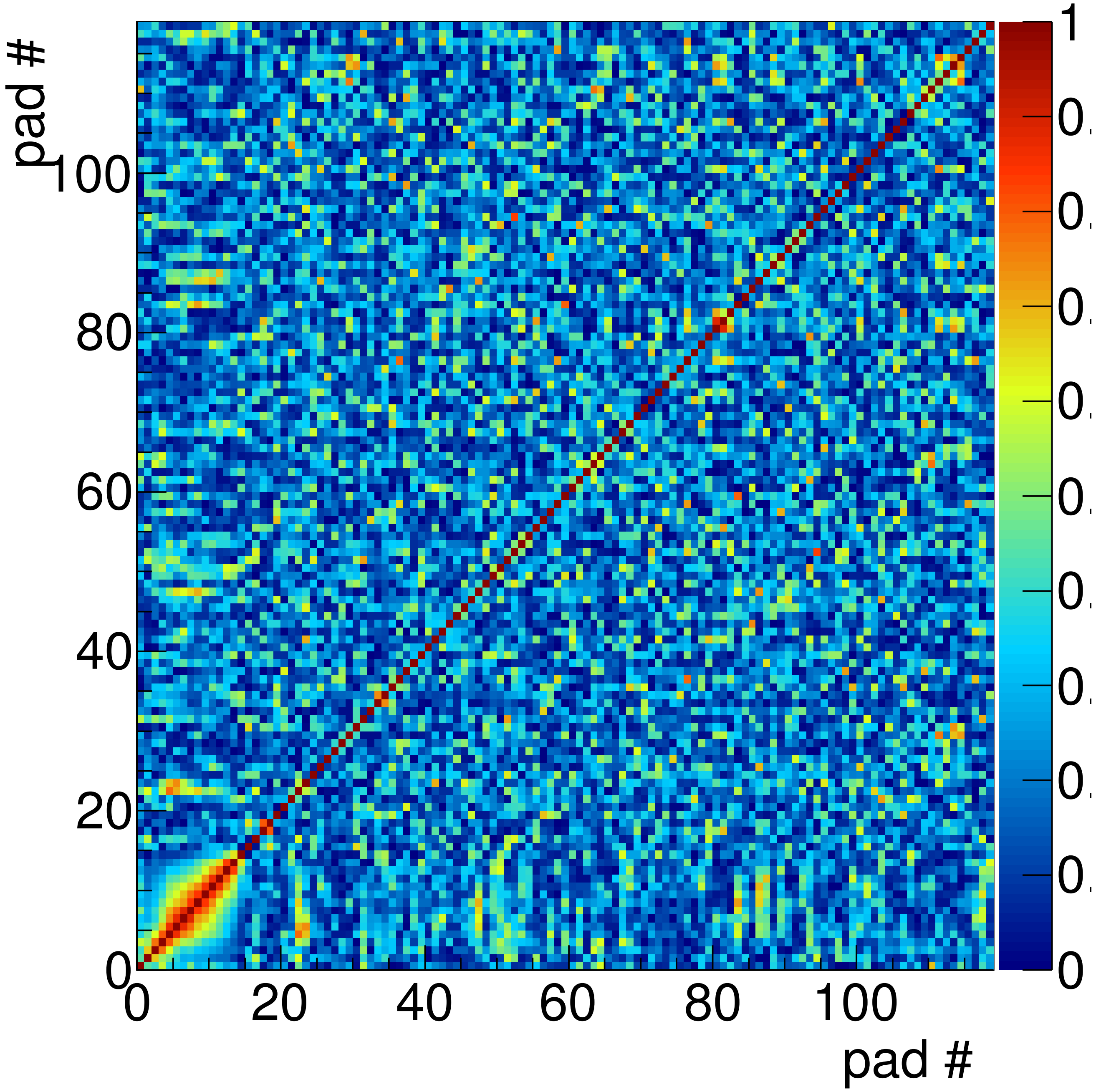


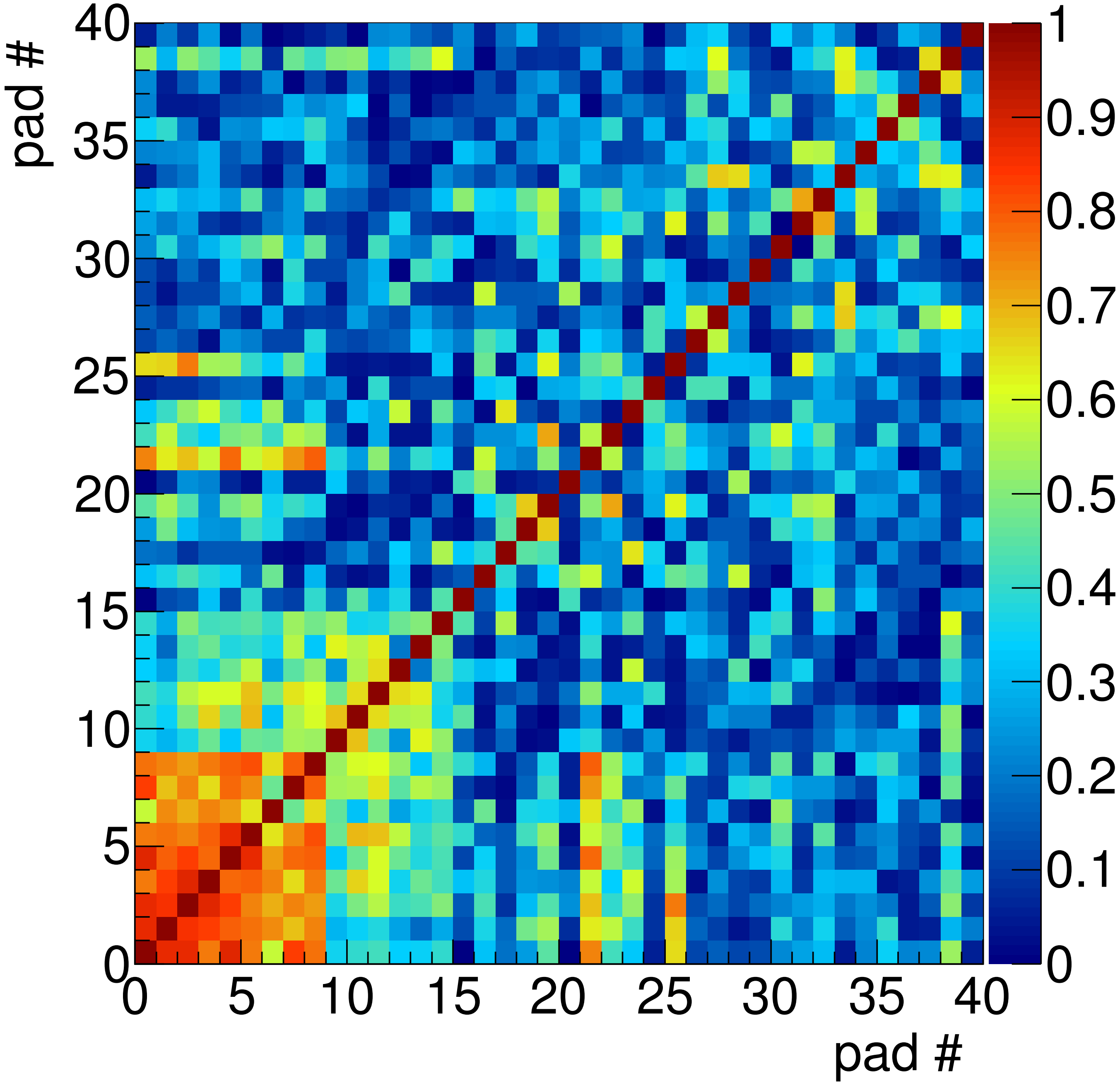
General formula:

$$f(x) = \frac{[1]}{x} \exp\left[-\left(\frac{x-[2]}{[3]}\right)^2\right]$$

Background correlations

The energy deposition correlations between pads are investigated. Important only for inner row of pads and <10 layers. Rather small for most part of the detector.





Background: create and configure

In the BeamCalReco processor the parametrised background can be created using executable in the `./bin` directory:

```
> ./BCBackgroundPar [list_of_bkg_pool.root]
```

which will produce `BeamCal_bg.root` file with fitted parameters.

In config-file the background method is selected with option:

```
BackgroundMethod = Gaussian
```

Other options are: `Pregenerated, Averaged, Parametrised`

The background input file is set with:

```
InputFileBackgrounds = [background_file(s).root]
```

Which has to be a list of bg pool files or one parametrised bg file, depending on the method option.

Shower fitting method

- The signal energy distribution is overlaid over randomly selected or generated background sample
- The energies are projected along calorimeter axis, so that each pad contains energies of all the pads behind it.
- Also a simple χ_p^2 is calculated along these towers:

$$\chi_p^2 = \sum_{\text{tower}} (E_{sig} - E_{bg})^2/\sigma_{bg}^2$$

- A central shower pad is selected:

  - by maximum of this χ_p^2 (gives highest deviation)

  - χ_p^2/ndf is higher than config parameter `TowerChi2ndfLimit`

  - energy is over 0.7*`ETCluster` (shower energy threshold)

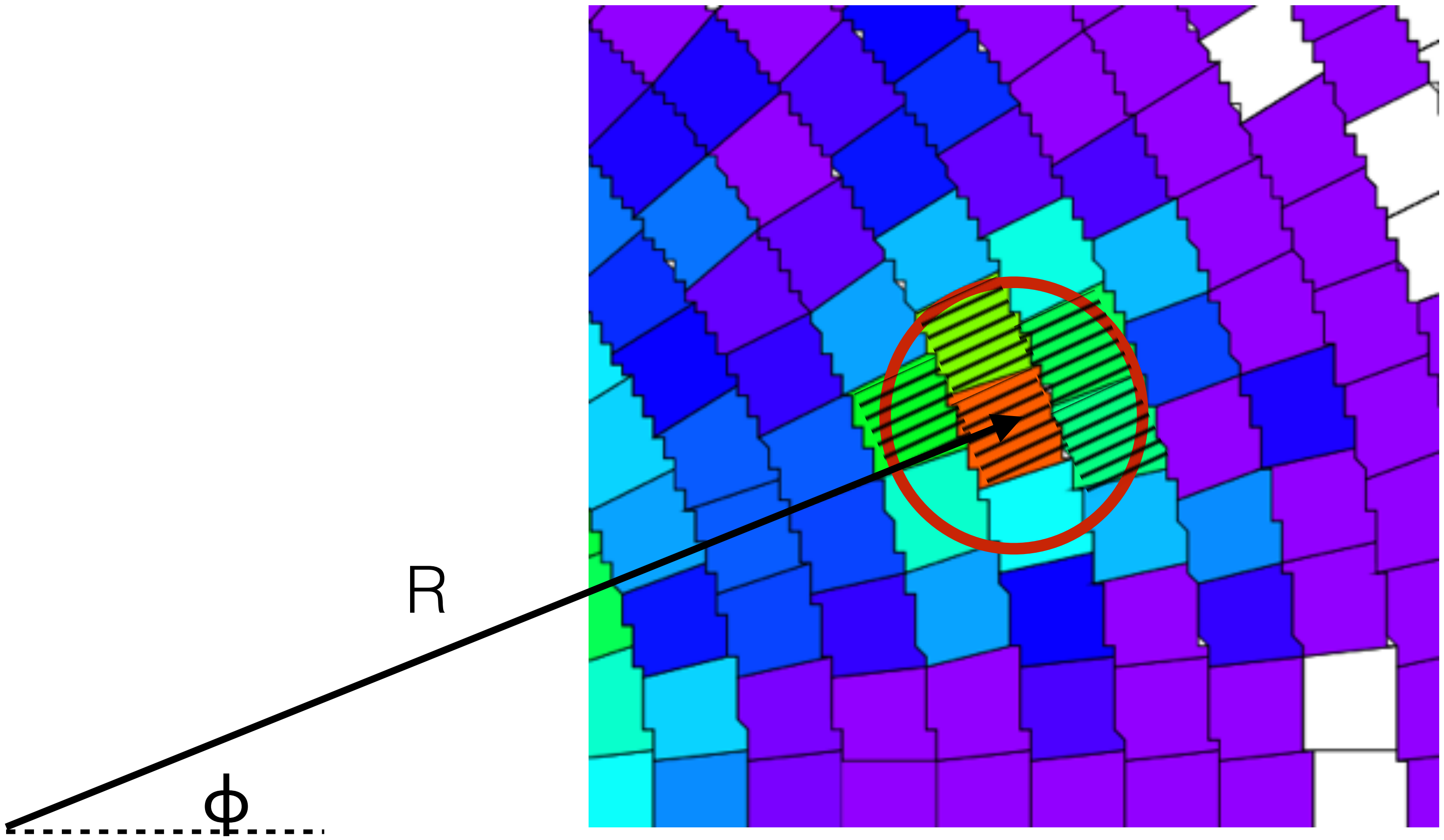
Shower fitting method (contd.)

- Around the central pad, select others to form a 'spot':
  - distance < $2R_{mol}$
  - energy above 0.1*(lower shower energy threshold)
  - energy above σ_{tow} (st.dev. of the projected background energy)
- The shower shape is approximated with $E = E_0 \exp(-r/R_M)$ with its centre in the central pad.
- Energies in the spot pads are estimated by Simpson integration -> E_{int}.
- Calculate χ_s^2 of the spot pads

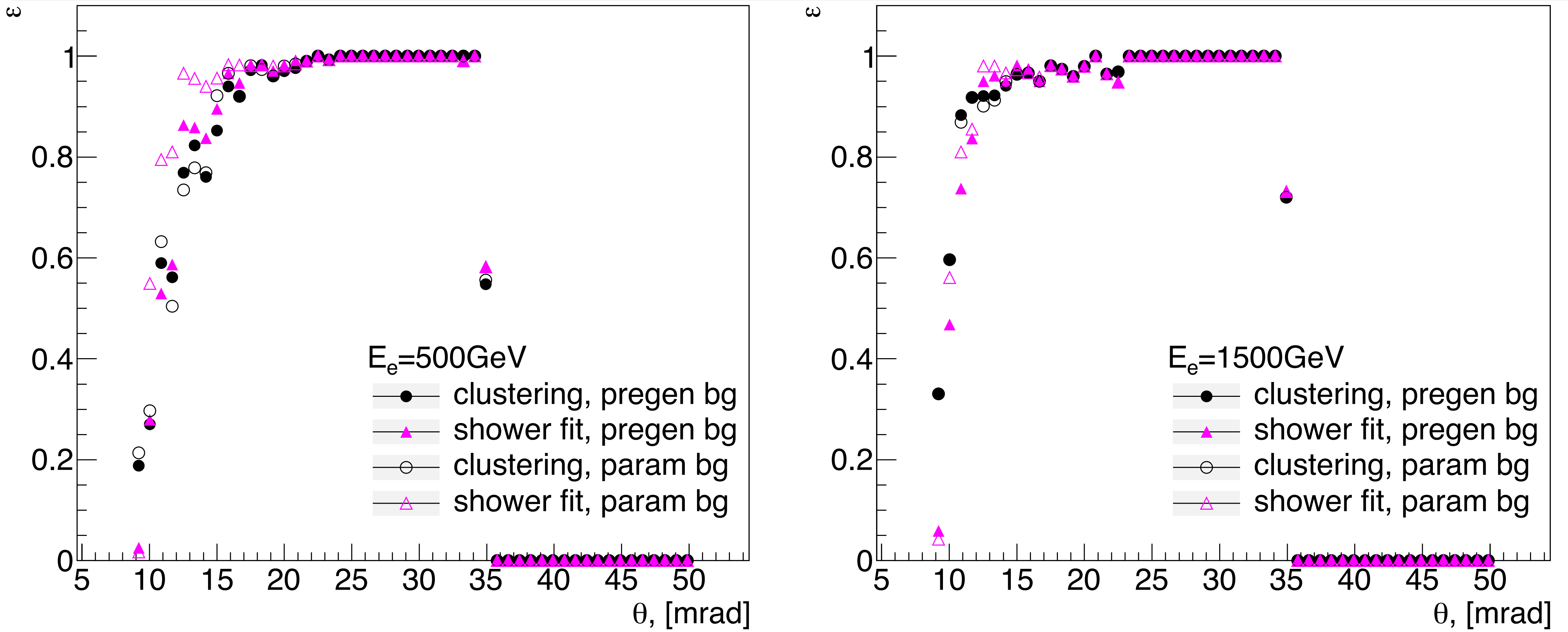
$$\chi_s^2 = \sum_{spot} (E_{int}-E_{dep})^2/\sigma_{tow}^2$$

Shower fitting method (contd.)

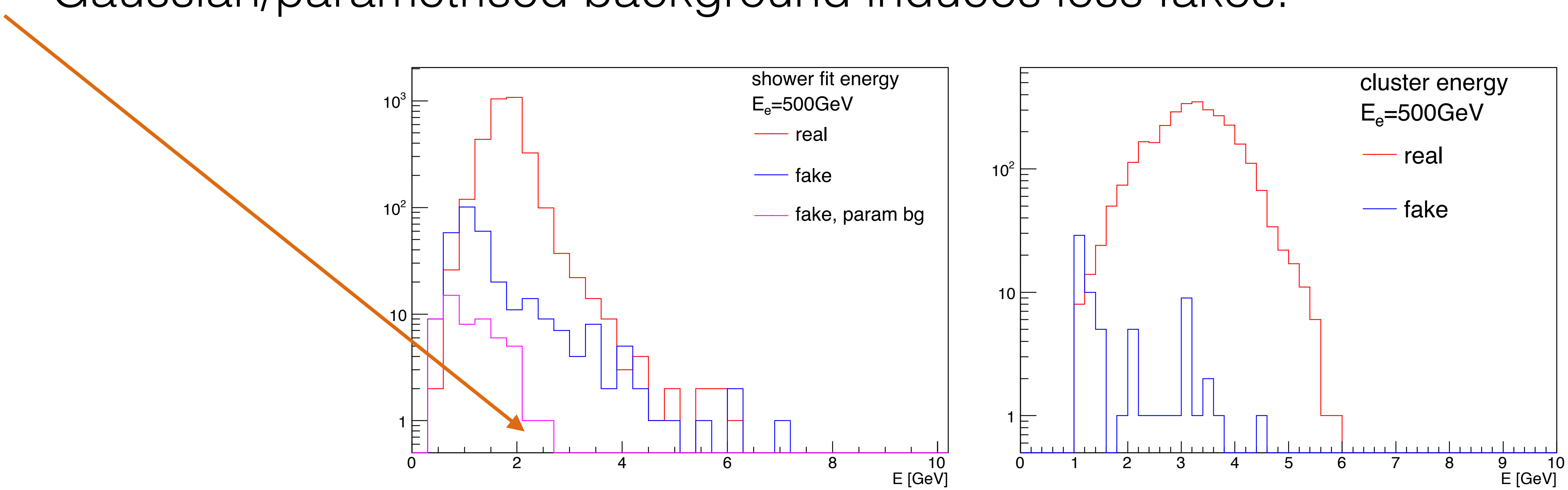
- Perform minimisation of the χ_s^2 with MINUIT over shower centre R and ϕ, and two gaussian parameters.
- If the fit is good, shower energy is high enough, select it as an electron candidate.
- Otherwise search another spot and iterate.



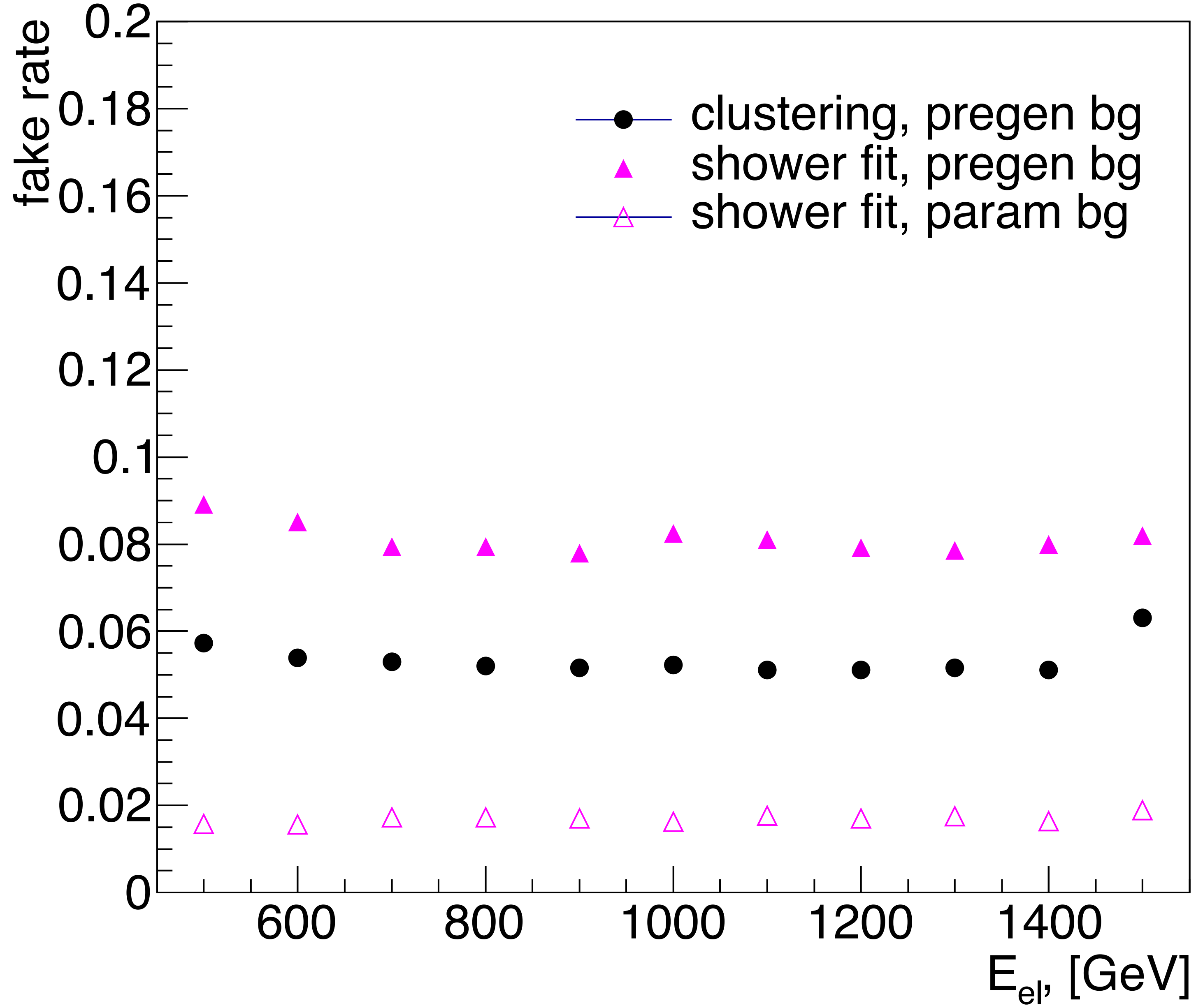
Fit performance: reco efficiency in θ



- Gaussian/parametrised background induces less fakes.

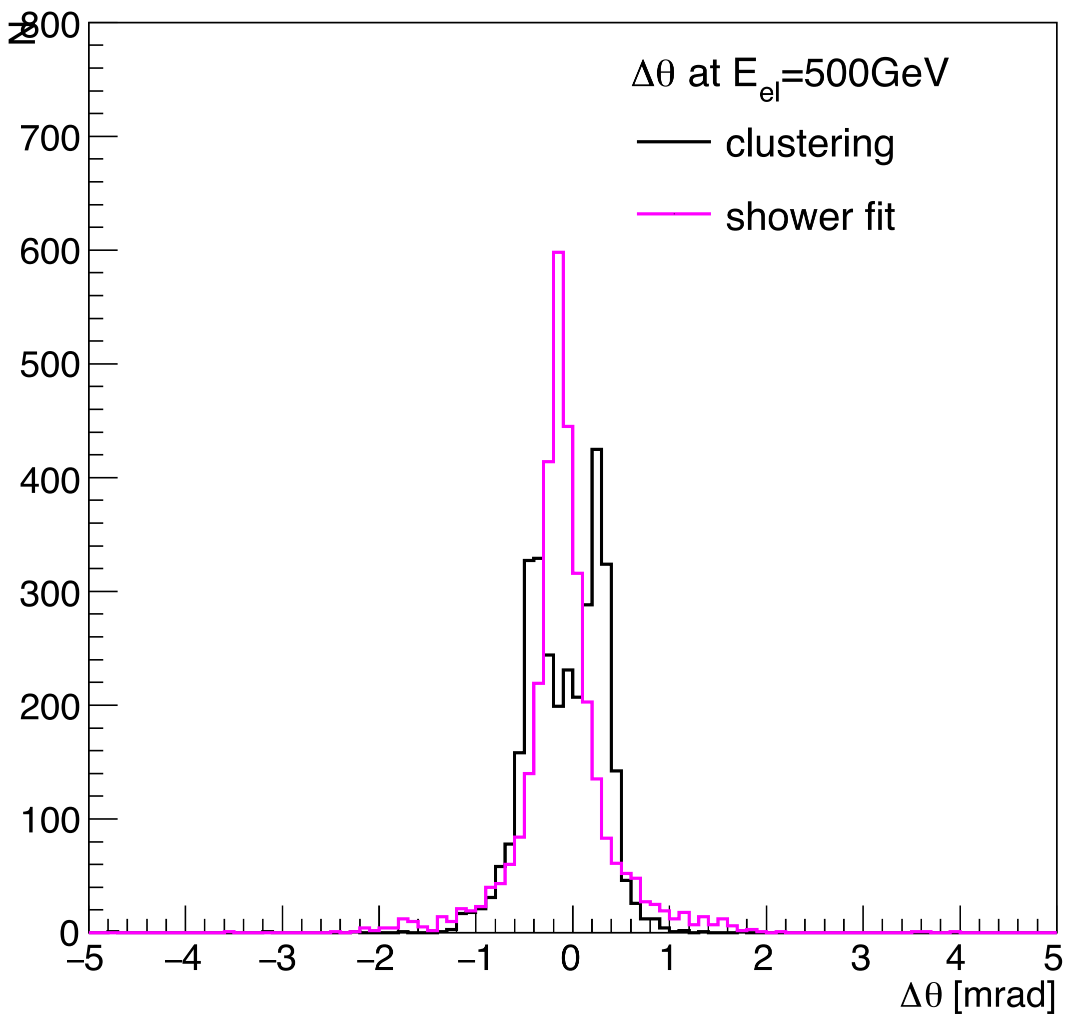


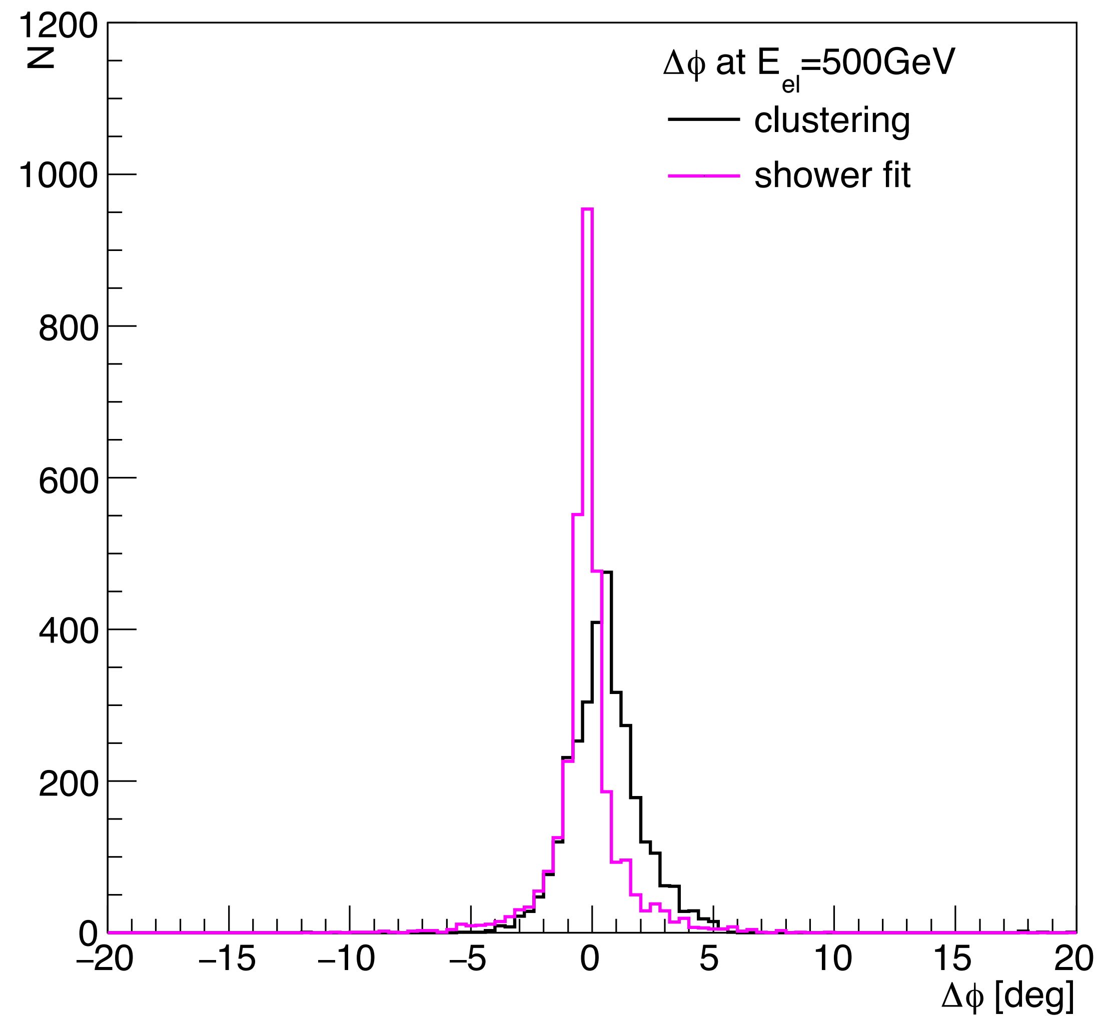
Fake rate vs E_{el}



- Doesn't vary with energy
- Overall good, but has strange features

Resolution comparison

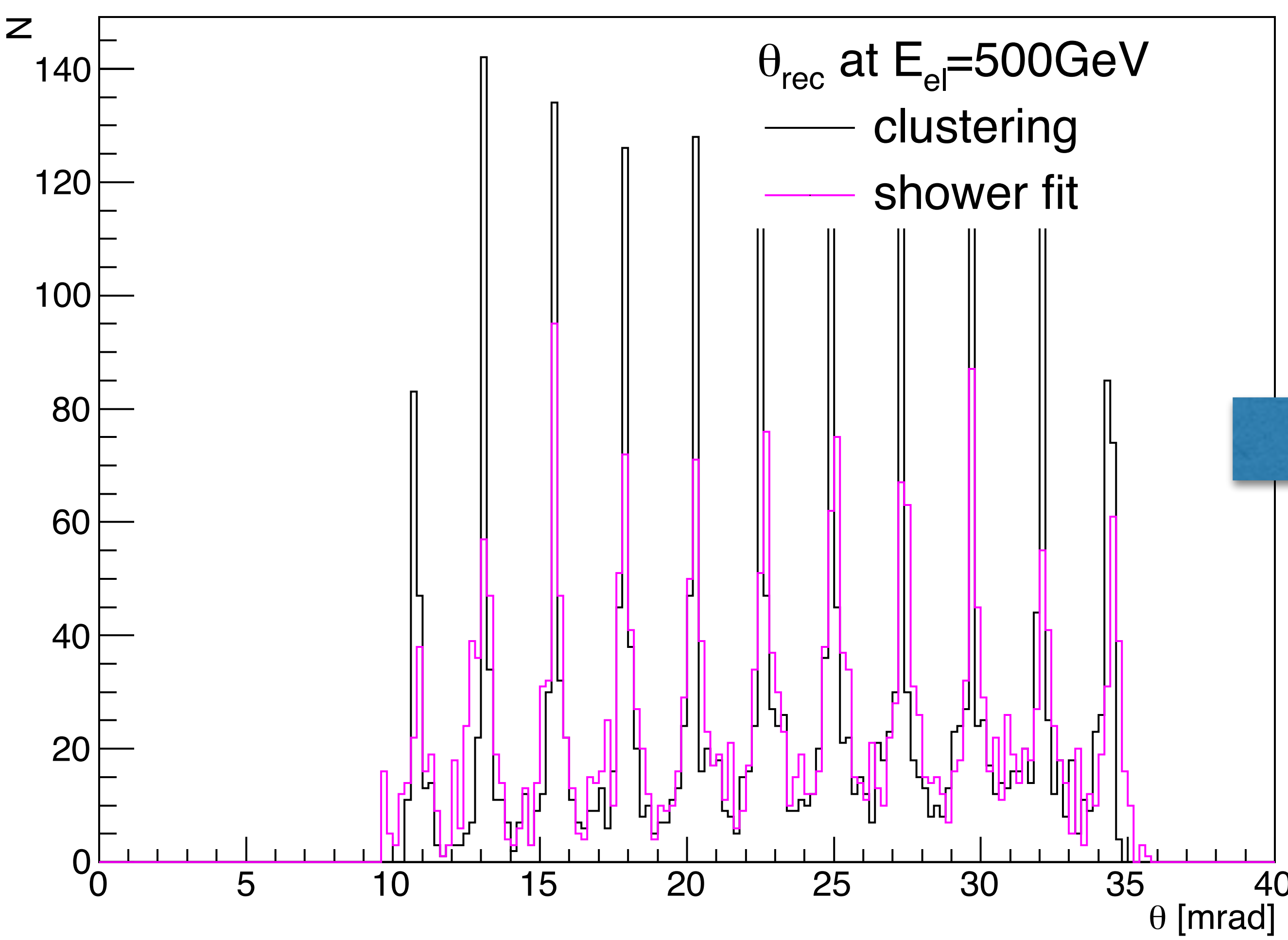


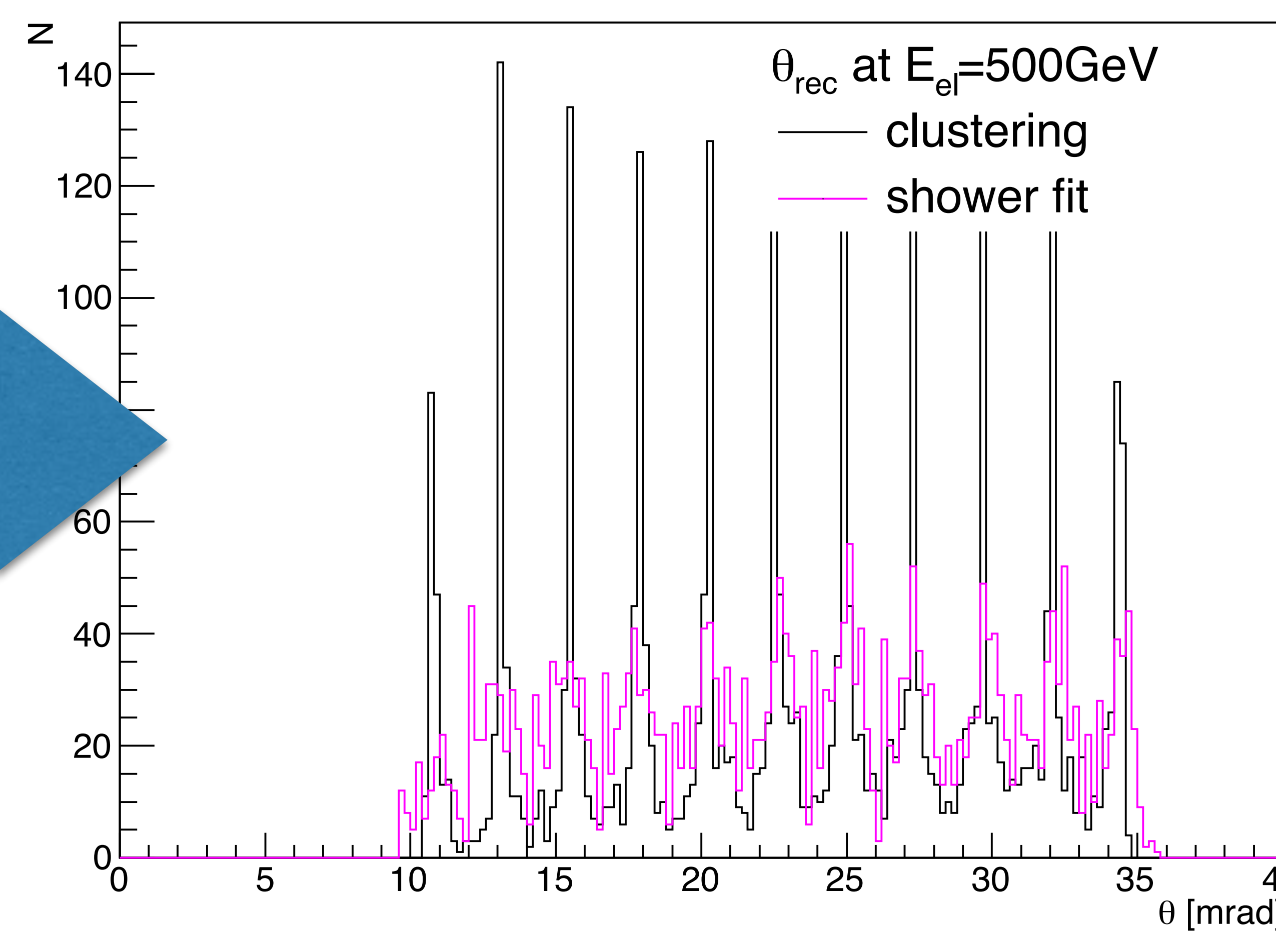


- Granularity induced systematic offsets in clustering method
- The effect is absent in ϕ direction due to relatively shifted pads

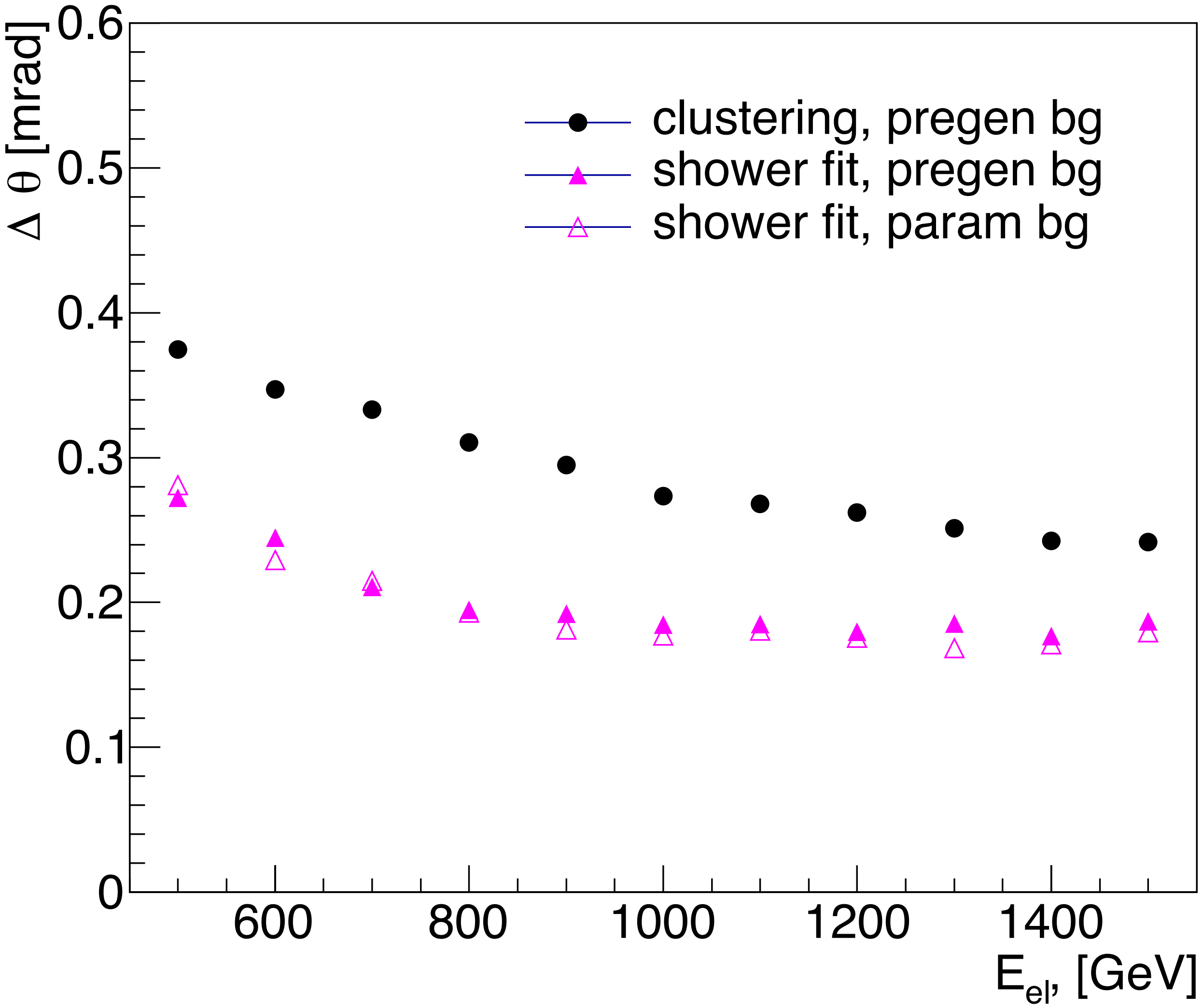
θ reconstructed values

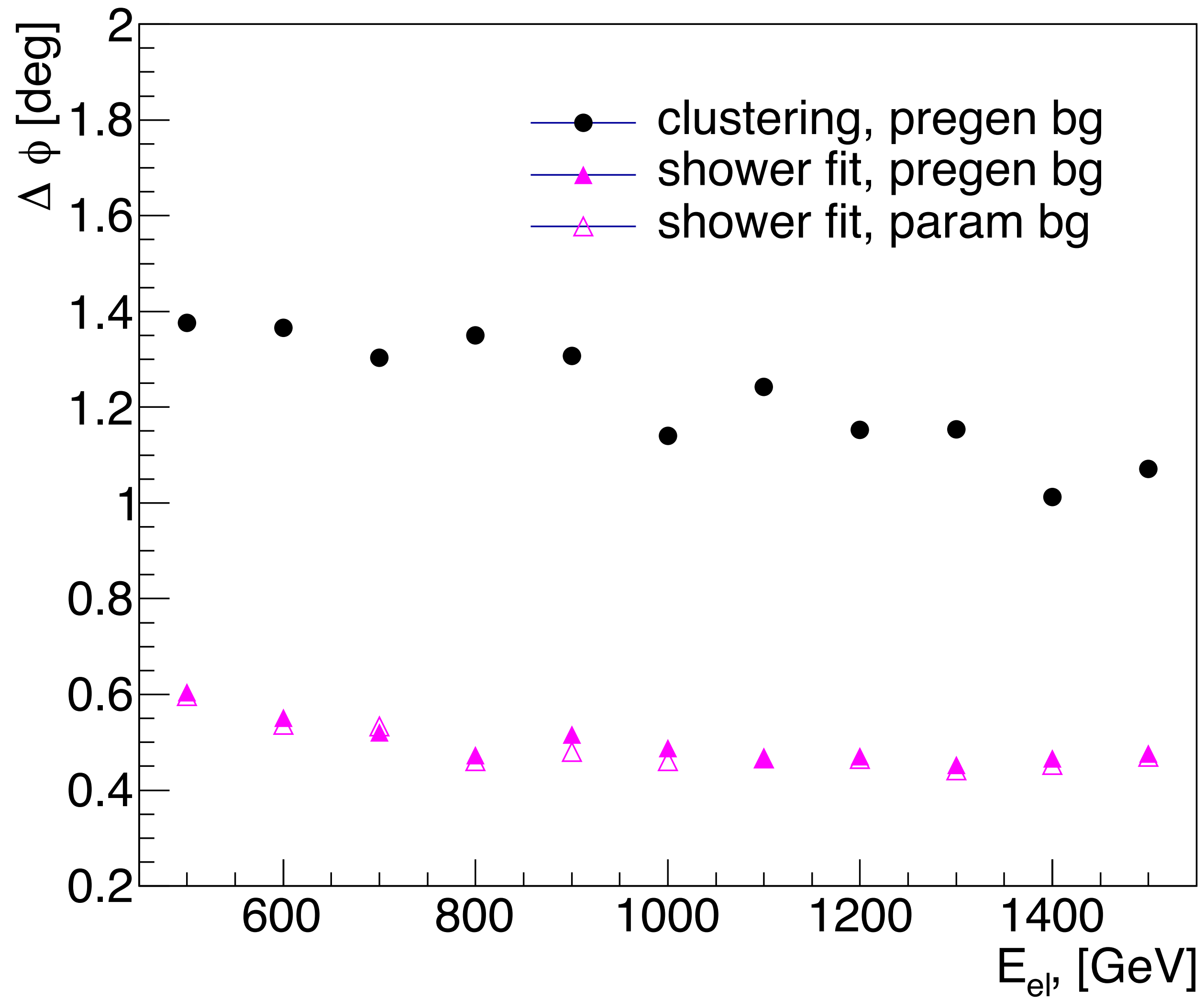
- The reconstructed θ value has better shape after adjustments of the fit, with less pronounced spikes at the pad centres.





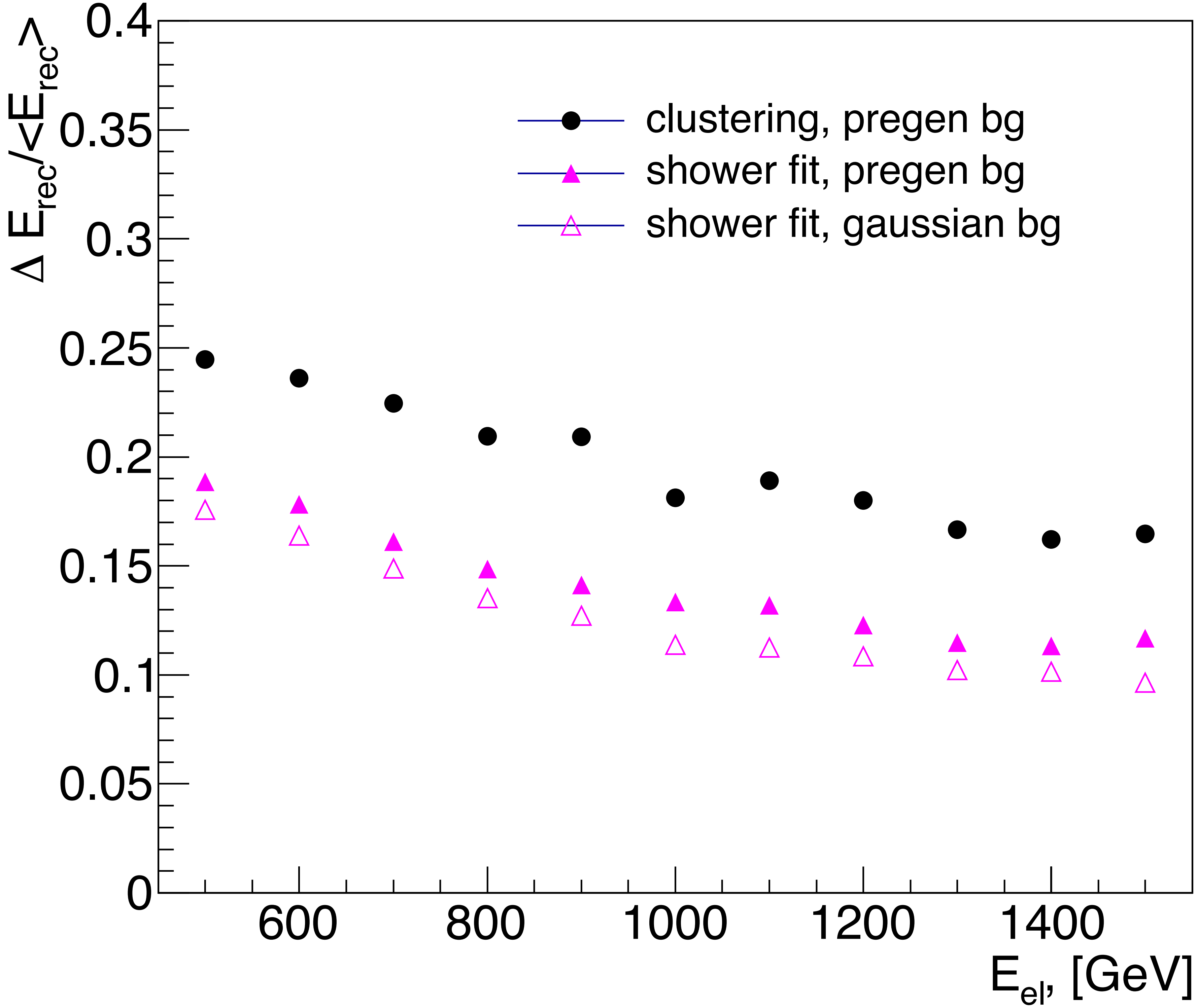
Angular resolution





- The parametrised and pregenerated background methods don't make noticeable difference for shower fitting approach

Energy resolution



Some difference in energy resolution between background methods.

Summary

- A shower fitting algorithm is implemented in BeamCal reconstruction.
- After adjustments It gives sensible improvement in angular and energy reconstruction precision.
- The code allows to use different background simulation approaches, with parameterised one being favourable for shower fitting due to higher statistics.
- It is available as part of the ILCsoft.
- A preparation of CLICdp note for BeamCal reconstruction with method and configuration description is ongoing