

BIC SciFi and AstroPix clustering and response

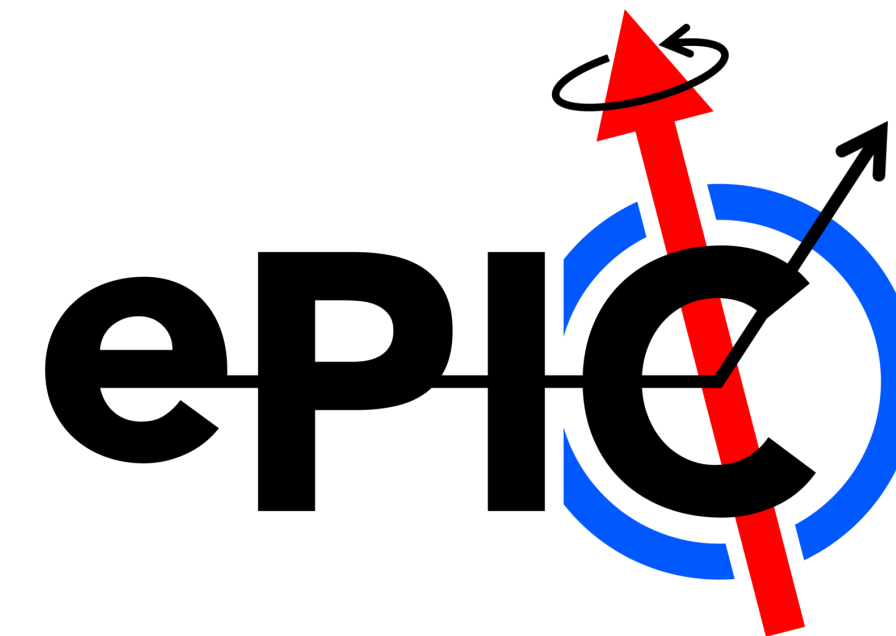
Followup on last BIC Simulations Meeting presentation, 4 August 2026

22 September 2026
BIC Simulation Meeting

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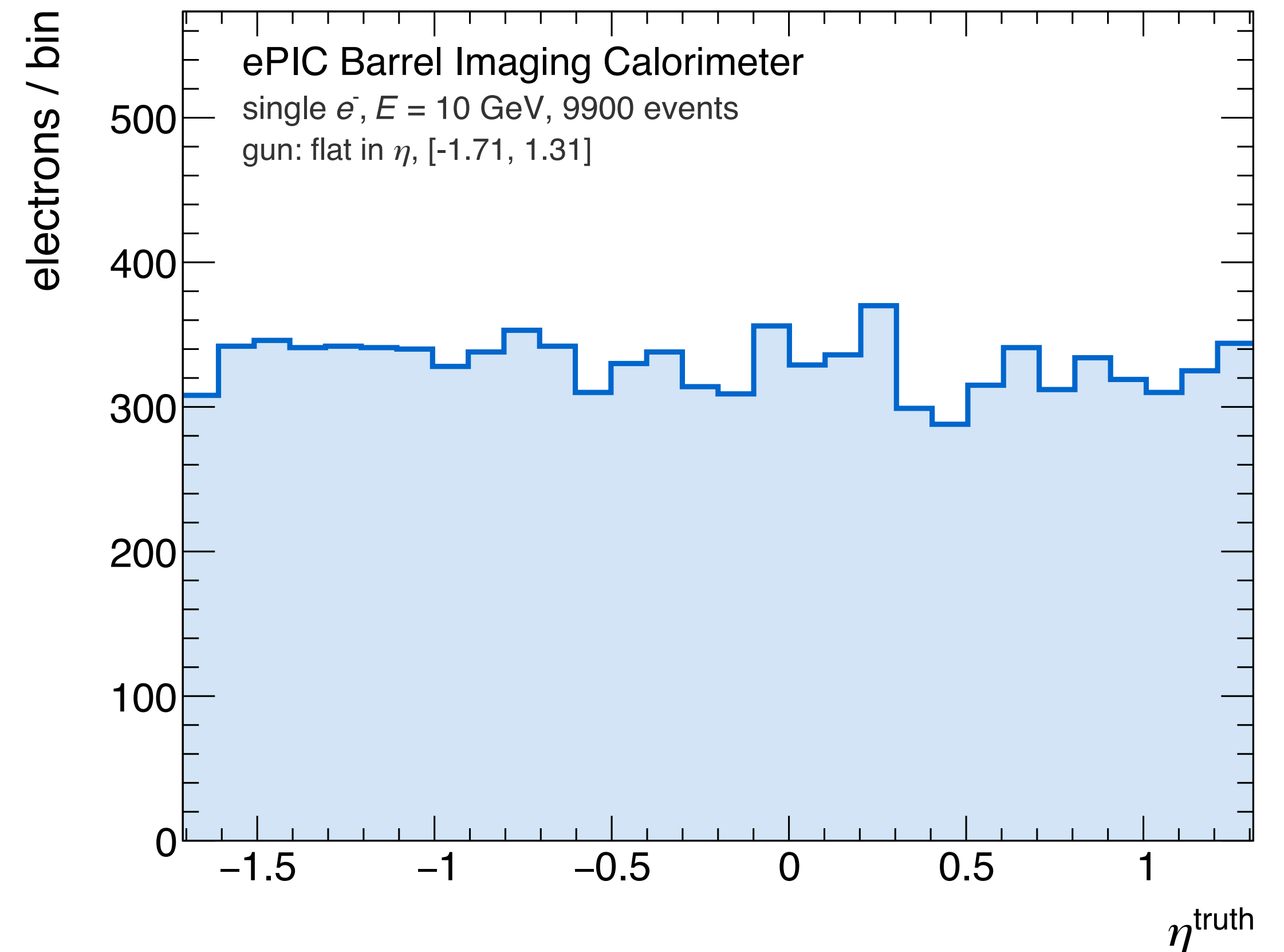


University of Colorado **Boulder**



Datasets

- Analyzing $\sim 10\text{k}$ $E = 10$ GeV single electron events, uniform in η from -1.71 to $+1.31$
 - ➔ Thanks Tommy for npsim/eicrecon code snippets!
- Note that when fired from $(0,0,0)$, particles which enter the front face of BIC have $\eta = -1.84$ to $+1.49$, and those which exit the back face have $\eta = -1.53$ to $+1.19$
 - ➔ So my range includes some partially contained showers near the edges
- Important caveat: any conclusions about the performance may well be E -dependent

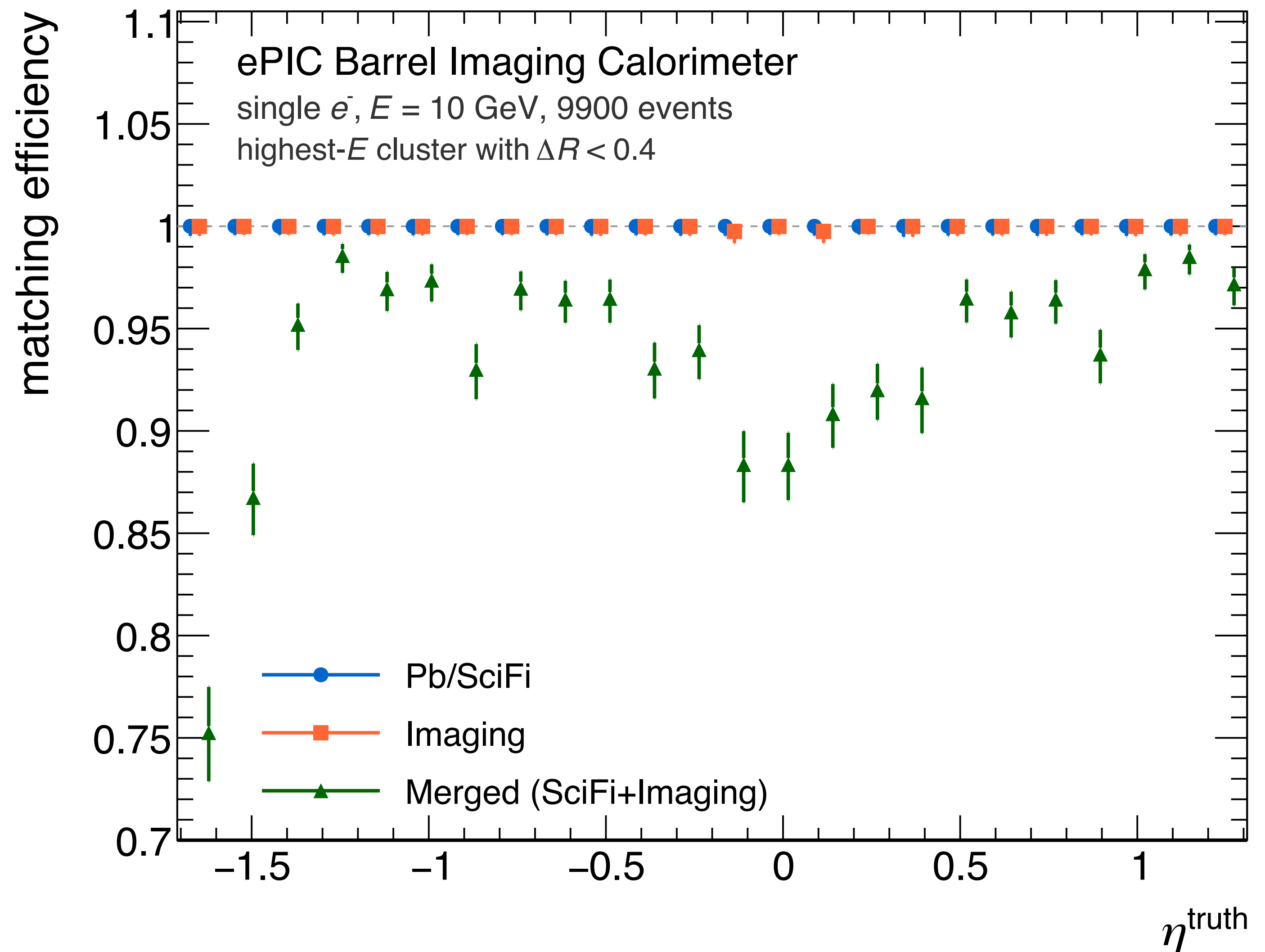


AI acknowledgement: I am using Claude Code to understand the simulation structure/ content and for plotting/analysis, with direction and vetting by human expert (me)

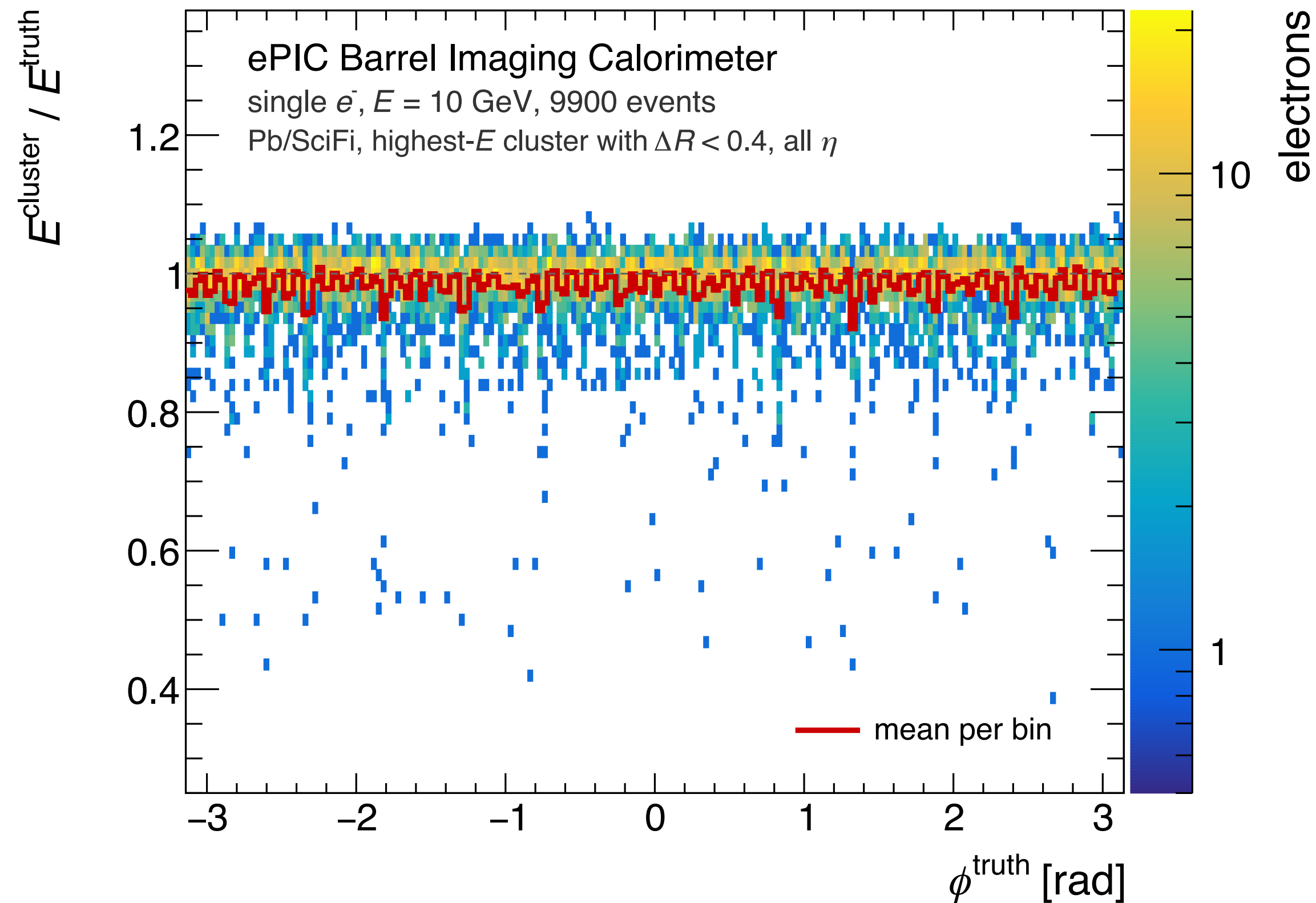
Basic matching to clusters

- ~Unity efficiency for finding a nearby SciFi and Imaging cluster
- ~5-10% (η -dependent) inefficiency for finding a Merged cluster (SciFi+Imaging)

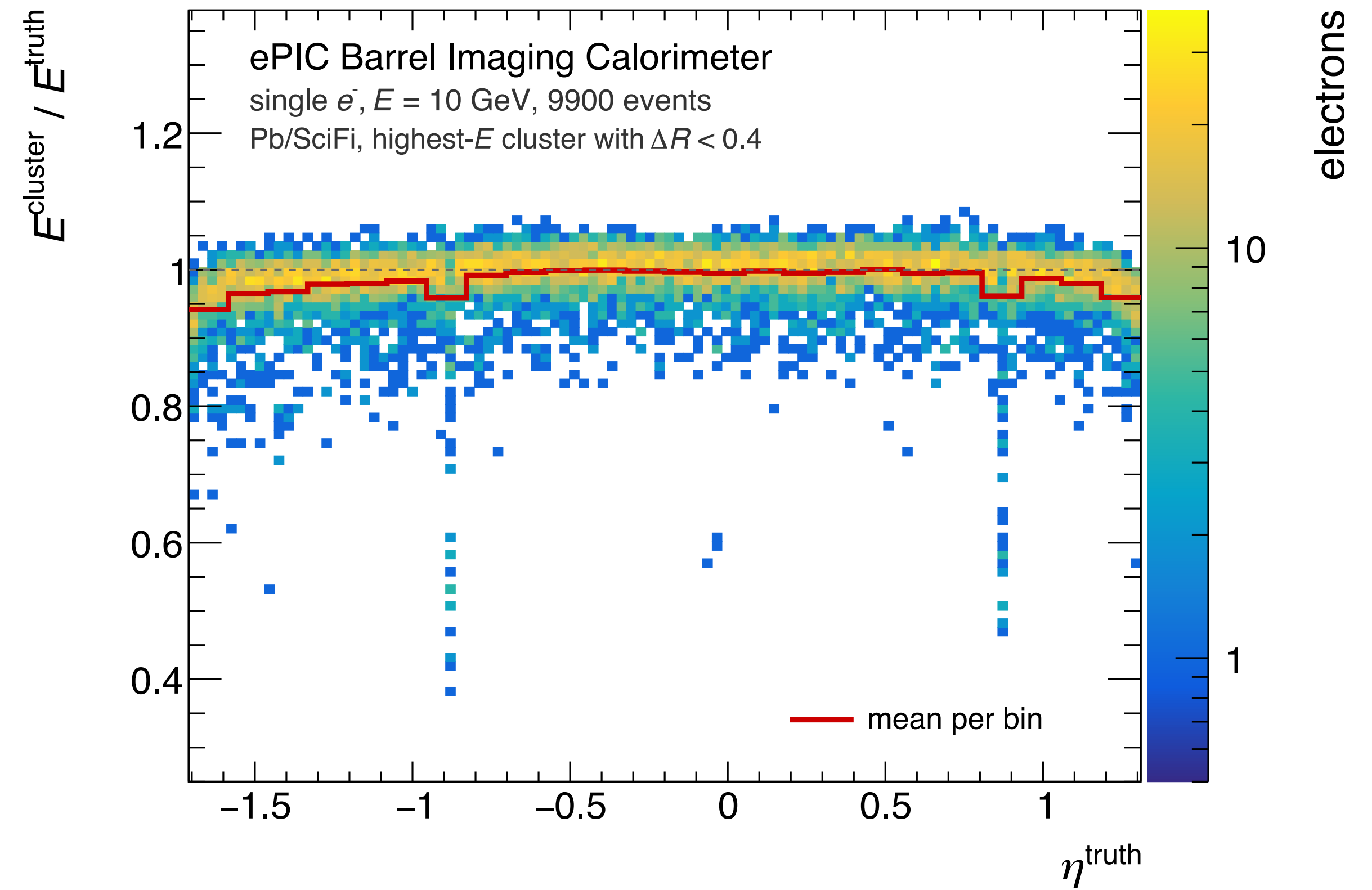
➡ more on this later



SciFi response

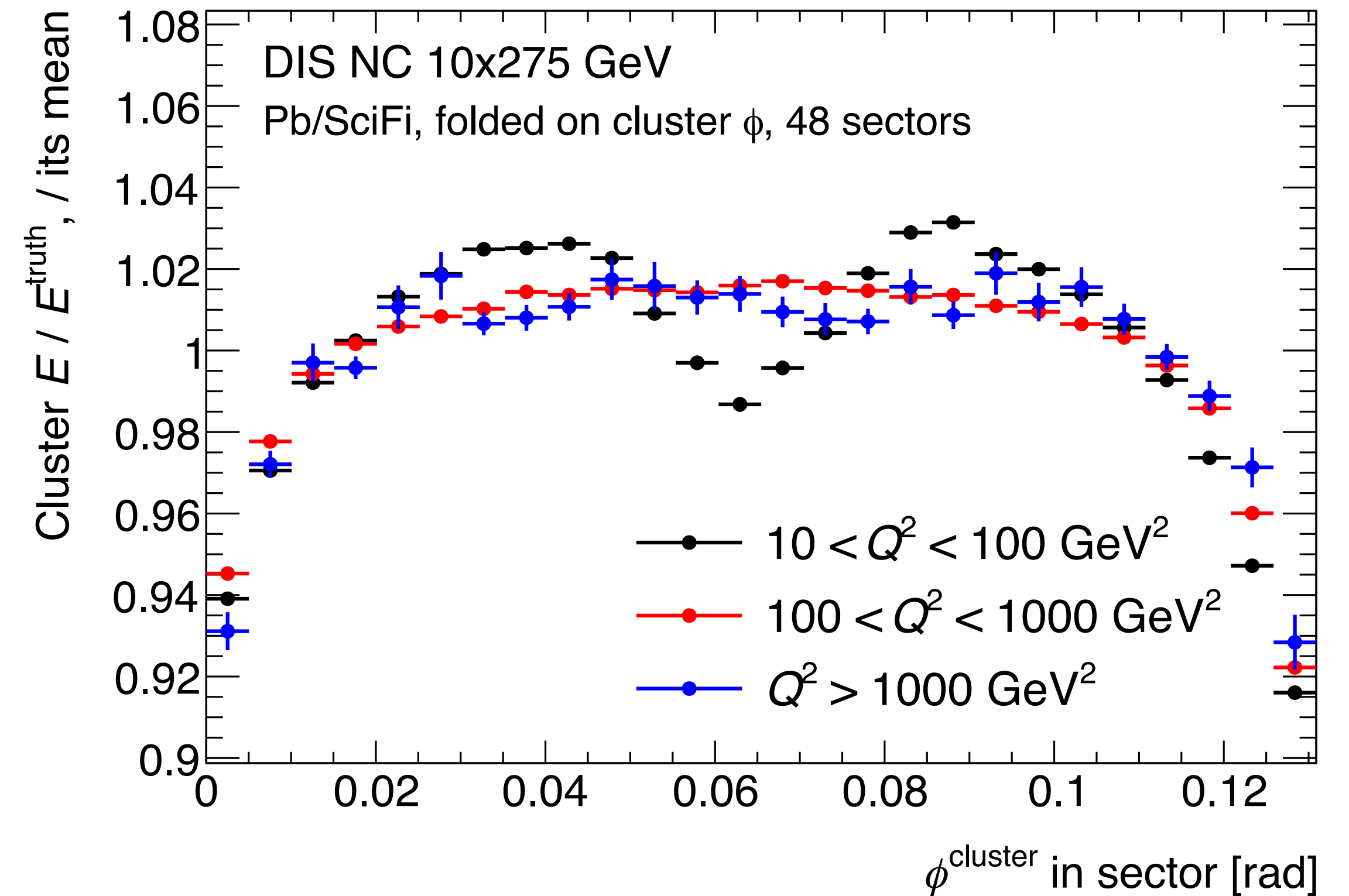
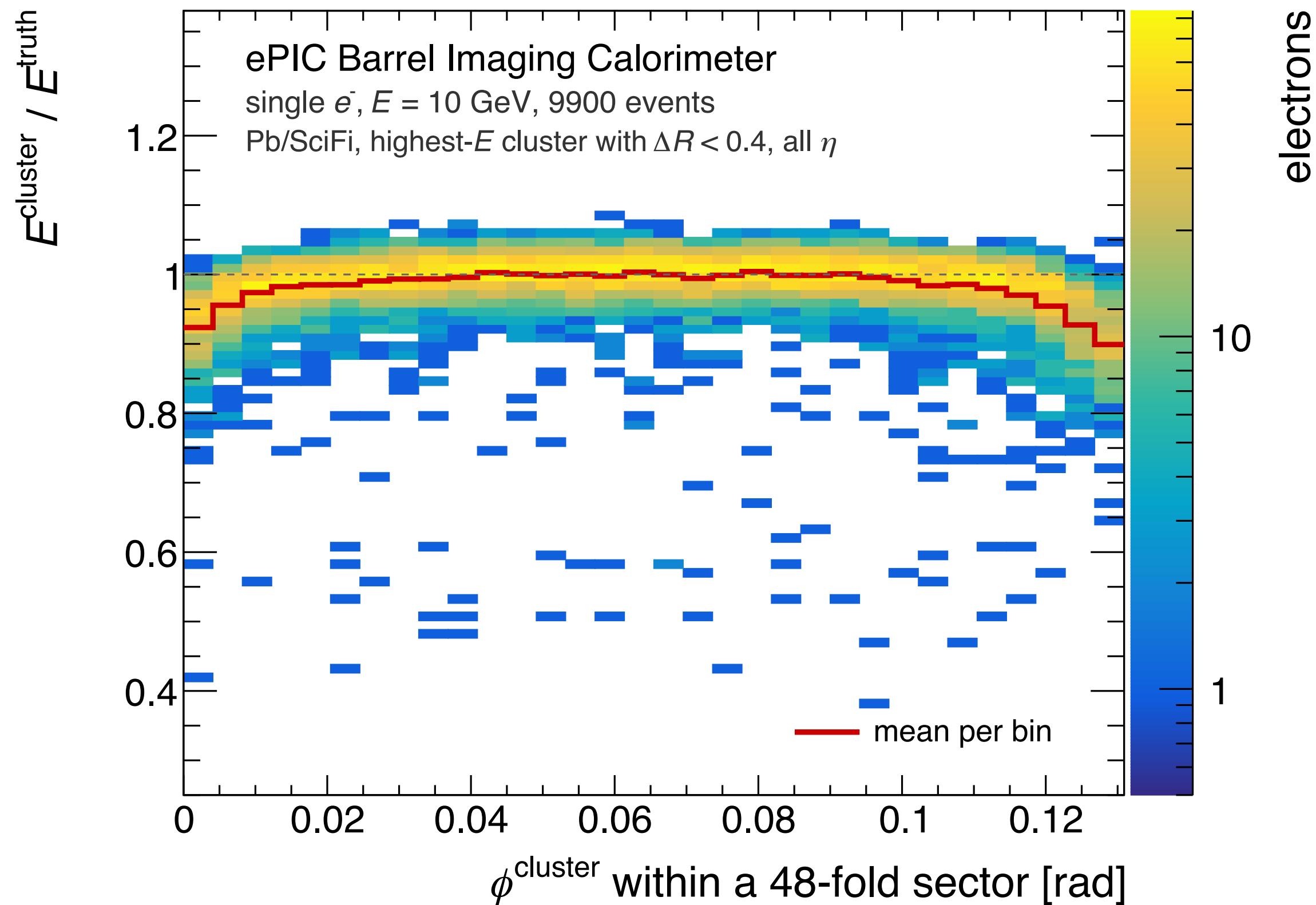


Regular regions of low response at sector boundaries — confirmed this is **not** from cluster splitting but rather from inactive material



Localized low-response tails at fixed η from material — same conclusion, I do not focus on this in these slides

SciFi response - ϕ dependence

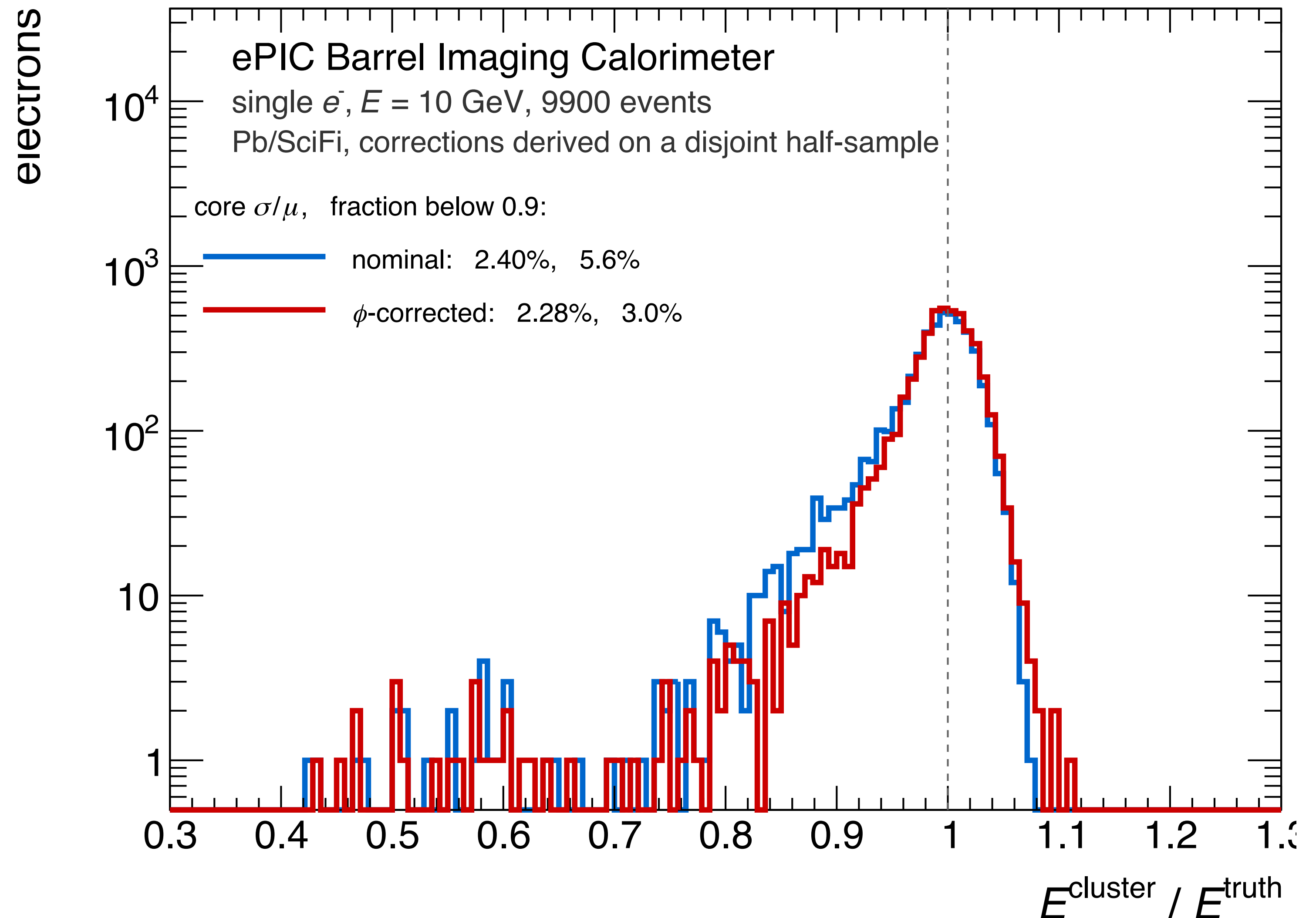


Response via vs. $\phi^{\text{reco}} \bmod (2\pi/48)$
- up to $\sim 10\%$ response difference
depending on where in the sector
the electron hits!

Similar conclusion from a related
study I did for different DIS
samples (details not shown)

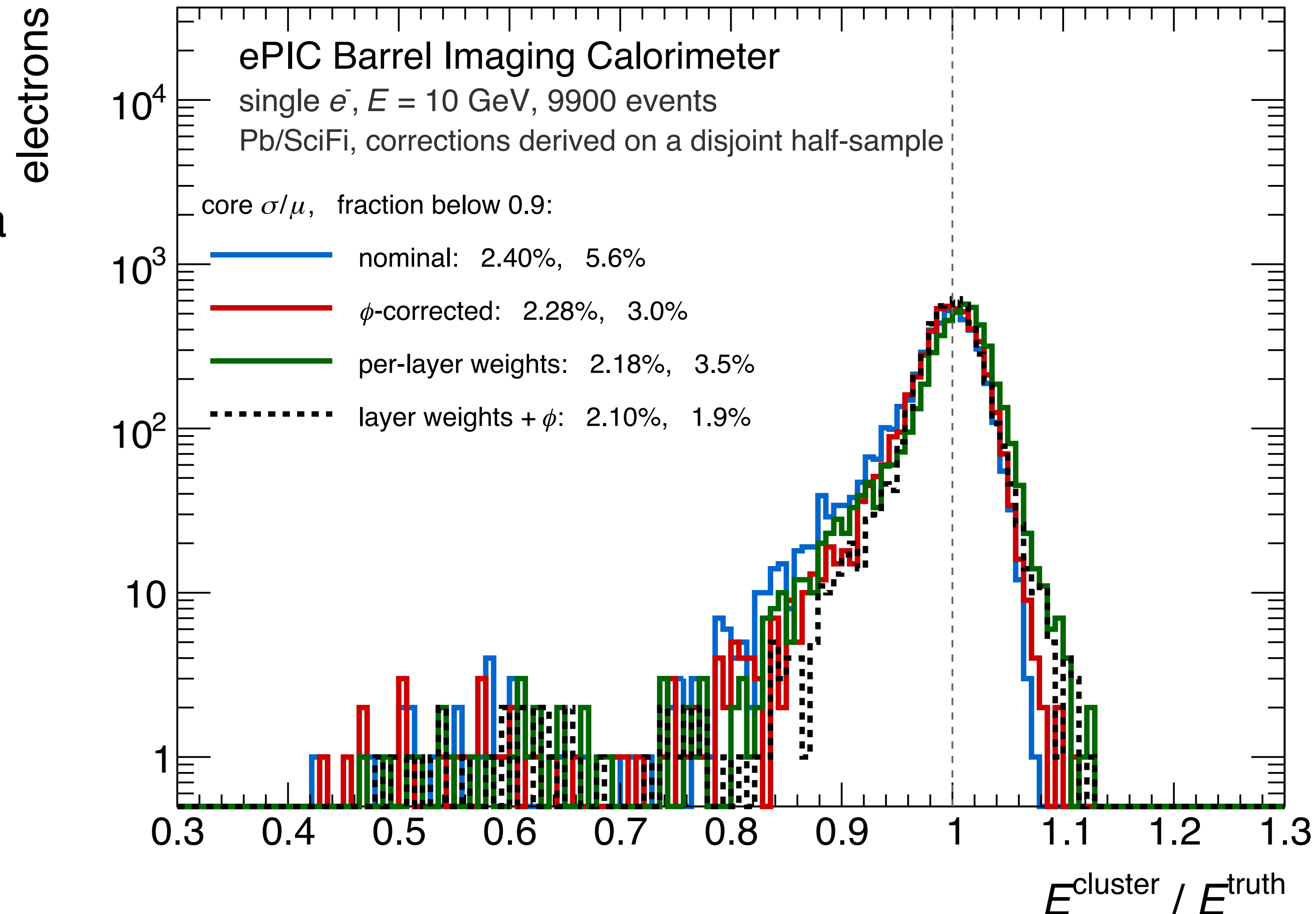
Correcting the ϕ -dependence

- One can derive a correction based purely on ϕ^{reco} in the sector (i.e. something one could apply to data)
- This correction reduces the low-side tail by half and modestly improves the energy resolution
 - ➡ Seems like an “easy win”

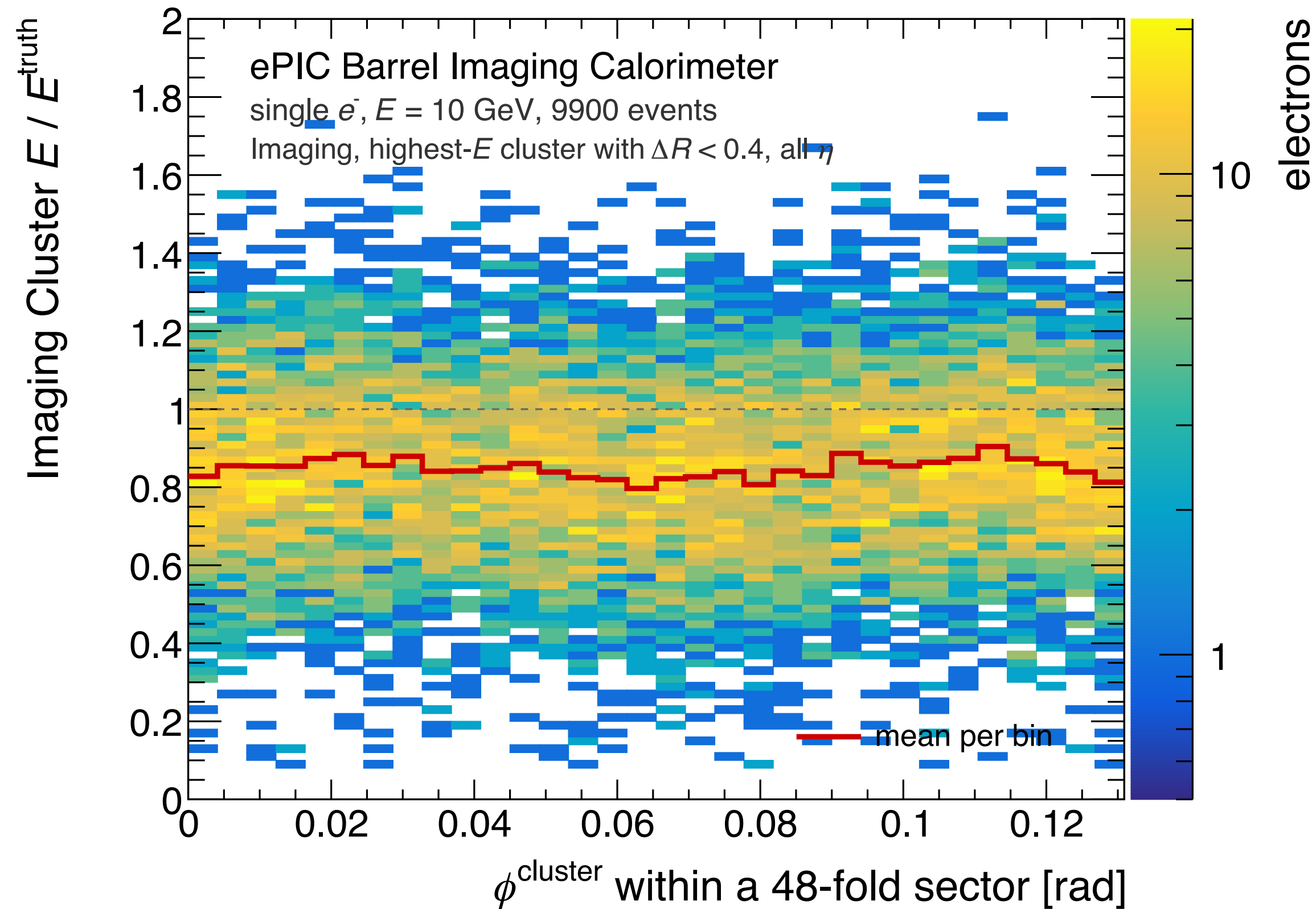


Other improvements to (SciFi) energy measurement

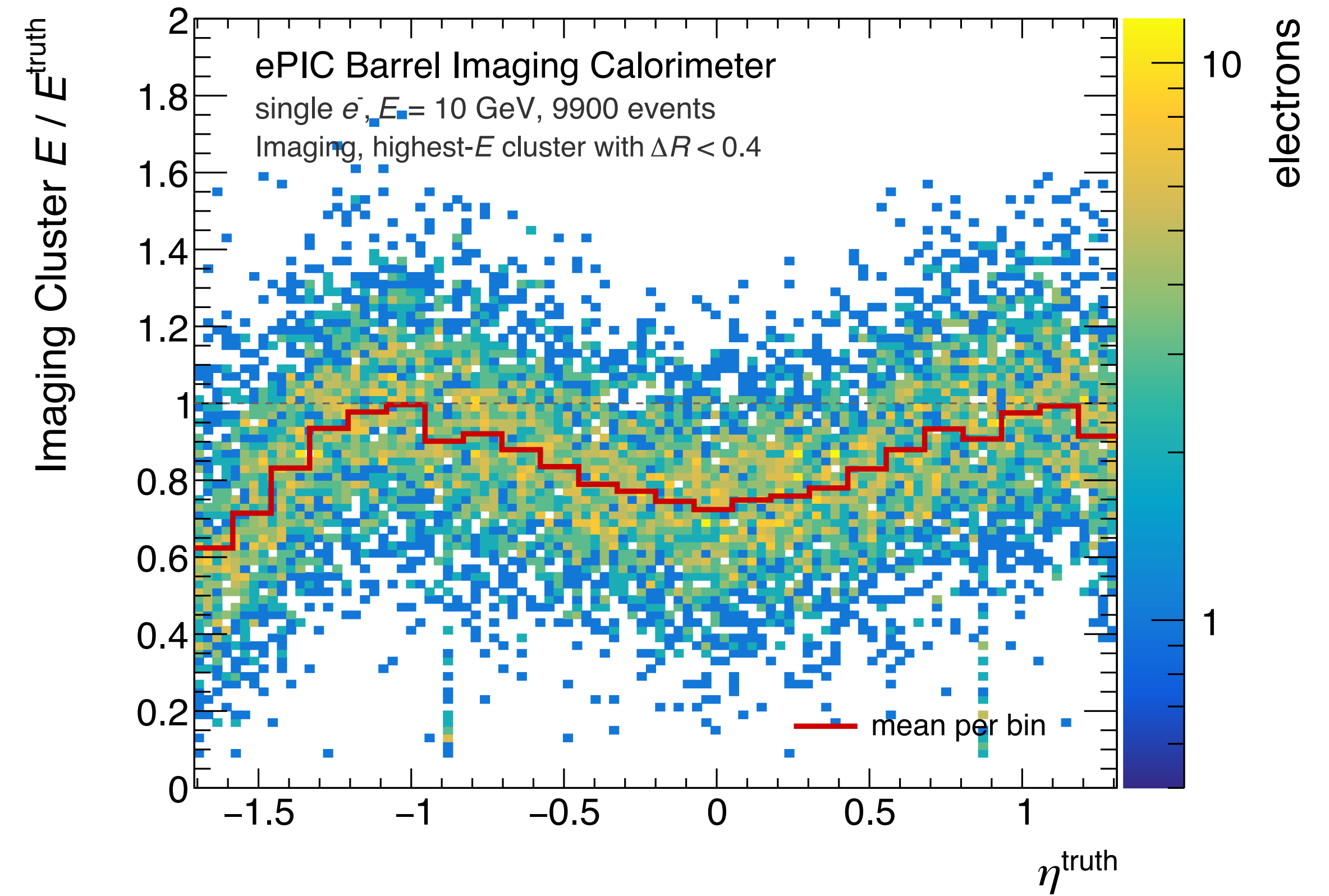
- One could construct the energy as a weighted-sum over the layers
 - ➔ This would account for showers that start particularly early/late and have a response different from average
- Using some quick-and-dirty weights determined by  Claude, there is a moderate improvement
 - ➔ Per-layer weights + ϕ -dependent correction: $\sigma_E/E = 2.4\% \rightarrow 2.1\%$ at 10 GeV, and big decrease in low-response tail
 - ➔ BIC spec is $5\%/\sqrt{E} \oplus 1\% \sim 1.7\%$
- Not sure how difficult this is in the code base...



Imaging response



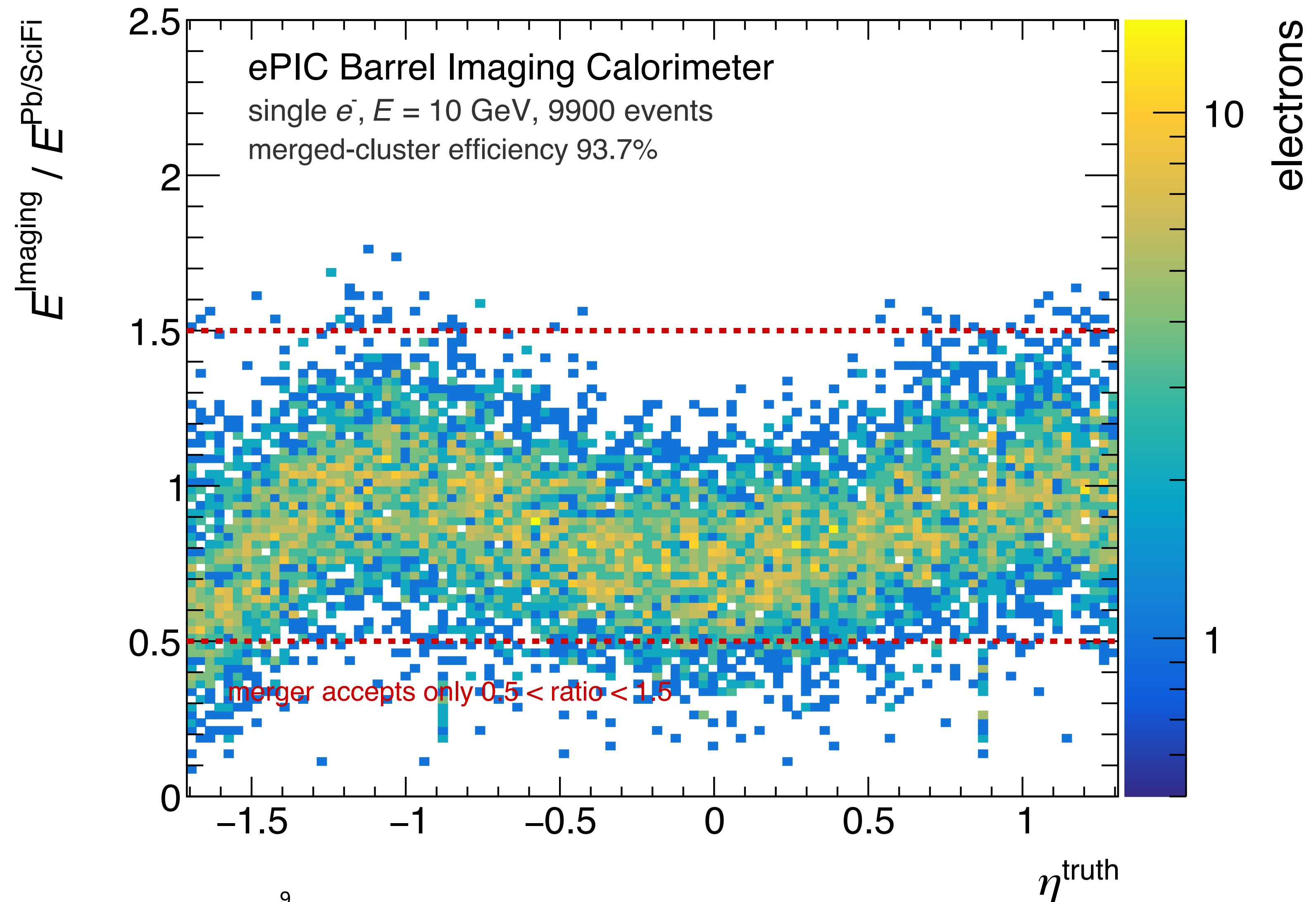
No significant ϕ -dependence within sector (at least not compared to large resolution overall)



Significant η -dependence here, with average response ranging from 0.8 to 1, investigated more in the following slides...

Merged cluster efficiency

- The merged SciFi+Imaging cluster requires $E^{\text{Imaging}} / E^{\text{SciFi}}$ between 0.5 and 1.5
 - ➔ The overall low response of the E^{Imaging} plus large resolution lead to the η -**dependent inefficiency** (seen on slide 3)
 - ➔ My thought: I understand the measurement in the Imaging layers is not what drives the electron E measurement, but it **is** used to decide when to build the merged cluster, so it deserves some attention...



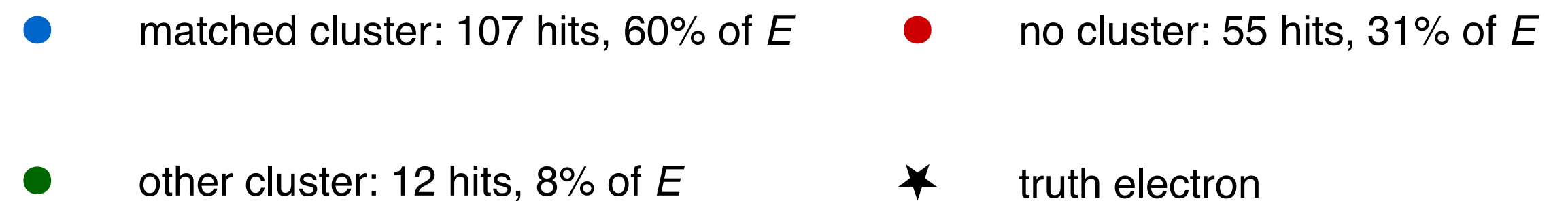
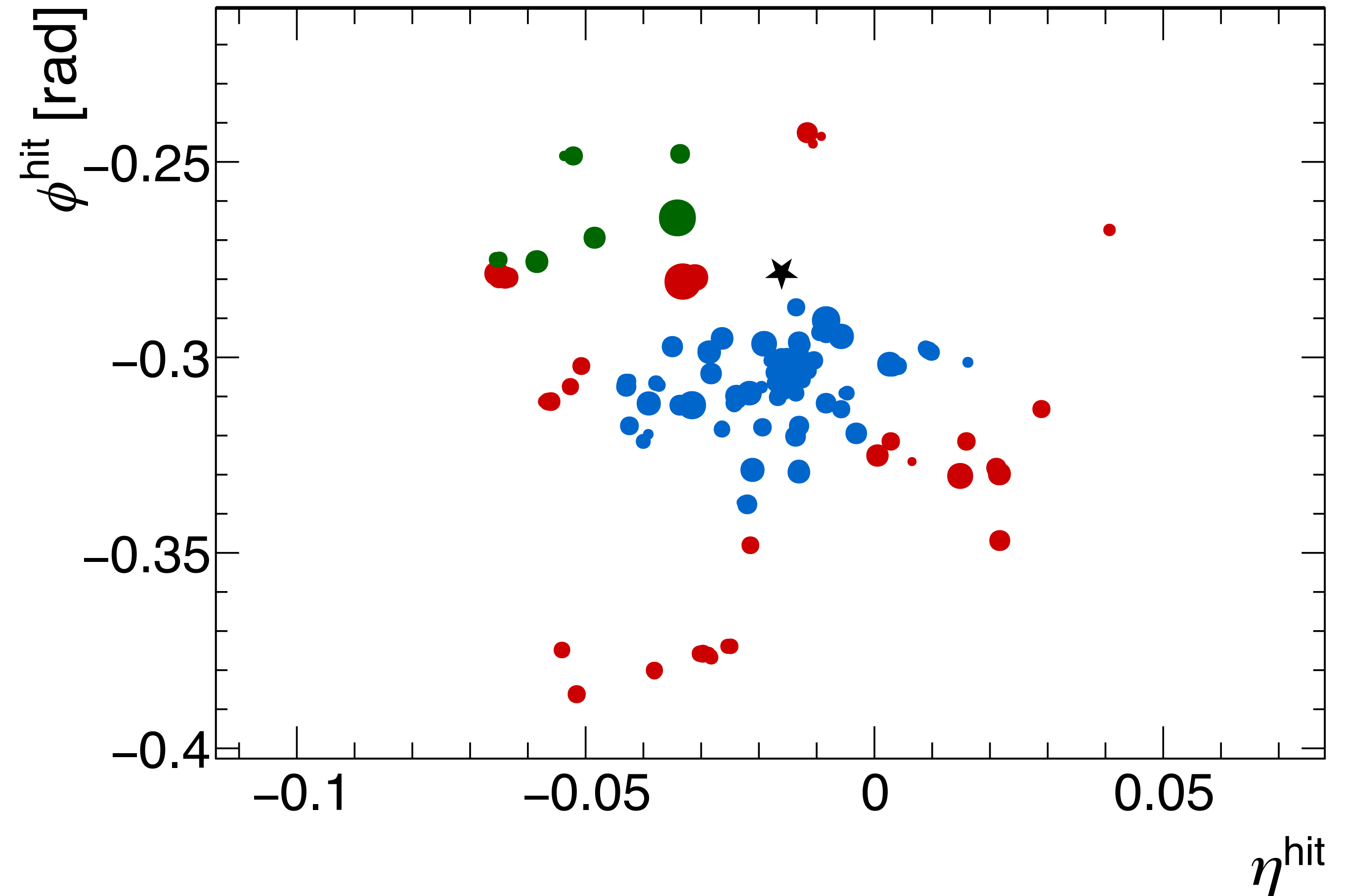
Imaging cluster construction

- The leading reconstructed cluster often only captures the “core” (or pieces) of the shower
- ➡ other hits from the electron shower form nearby clusters, or don't make it into any clusters at all

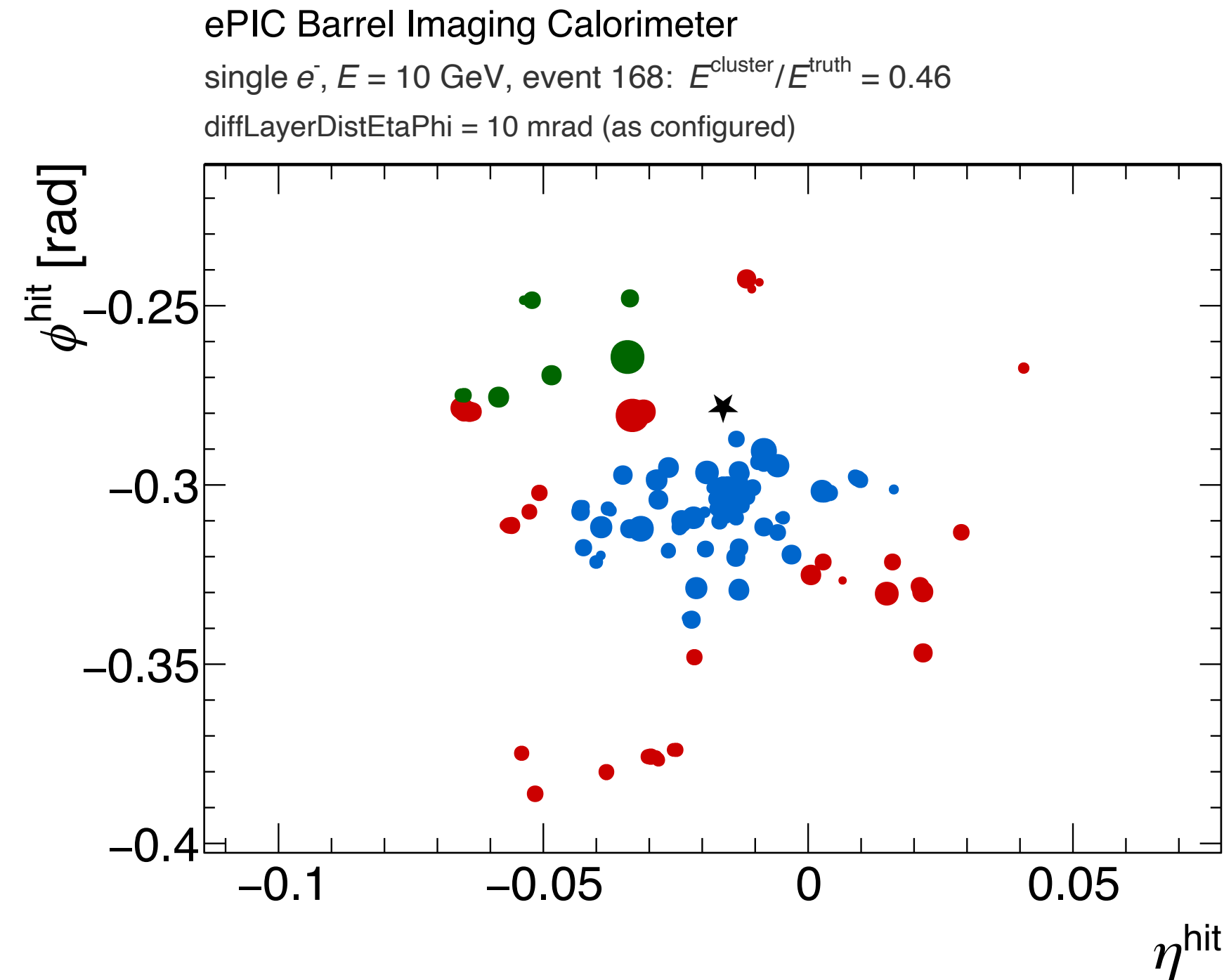
ePIC Barrel Imaging Calorimeter

single e^- , $E = 10$ GeV, event 168: $E^{\text{cluster}}/E^{\text{truth}} = 0.46$

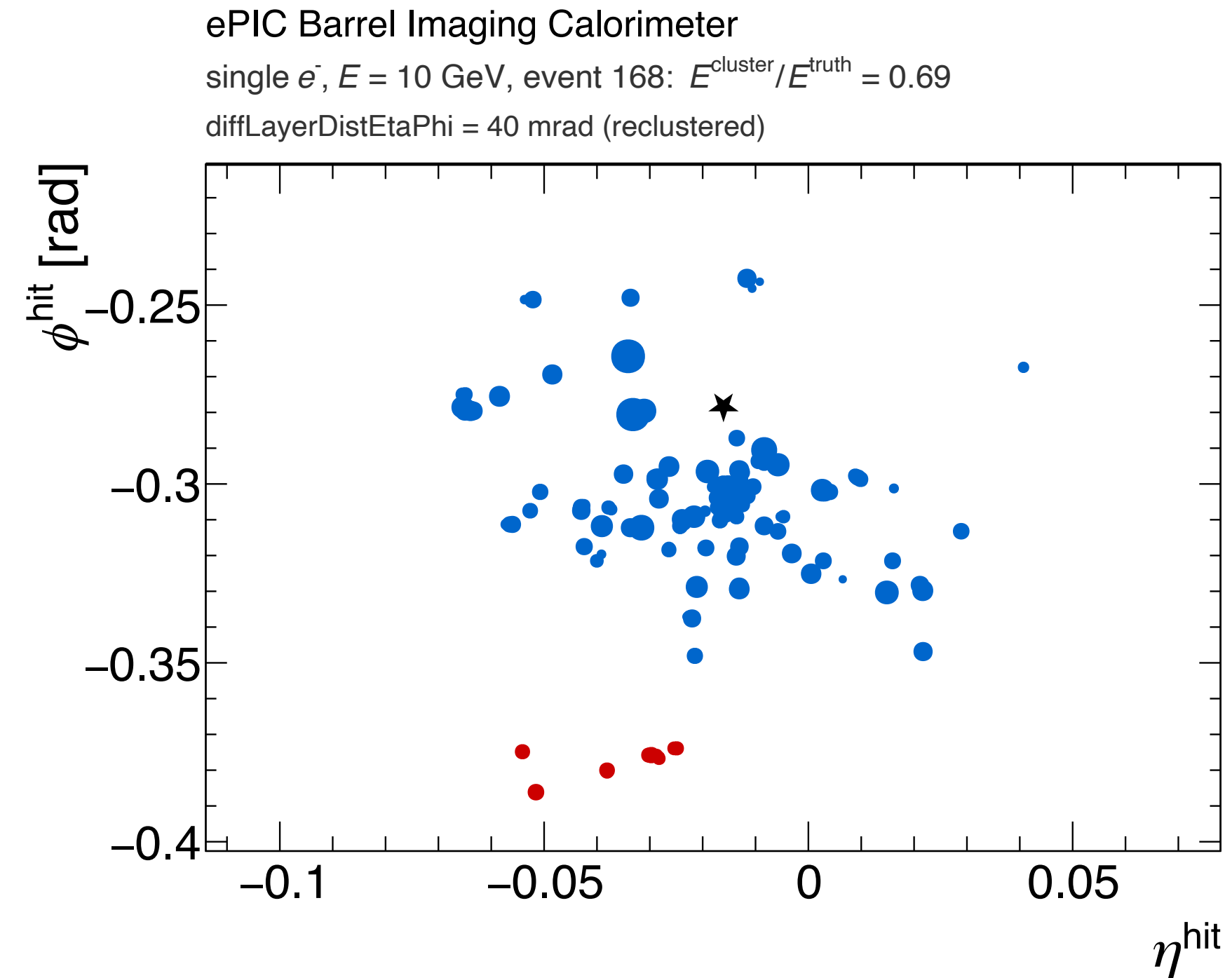
diffLayerDistEtaPhi = 10 mrad (as configured)



Imaging cluster reco configurations



● matched cluster: 107 hits, 60% of E ● no cluster: 55 hits, 31% of E
● other cluster: 12 hits, 8% of E ★ truth electron

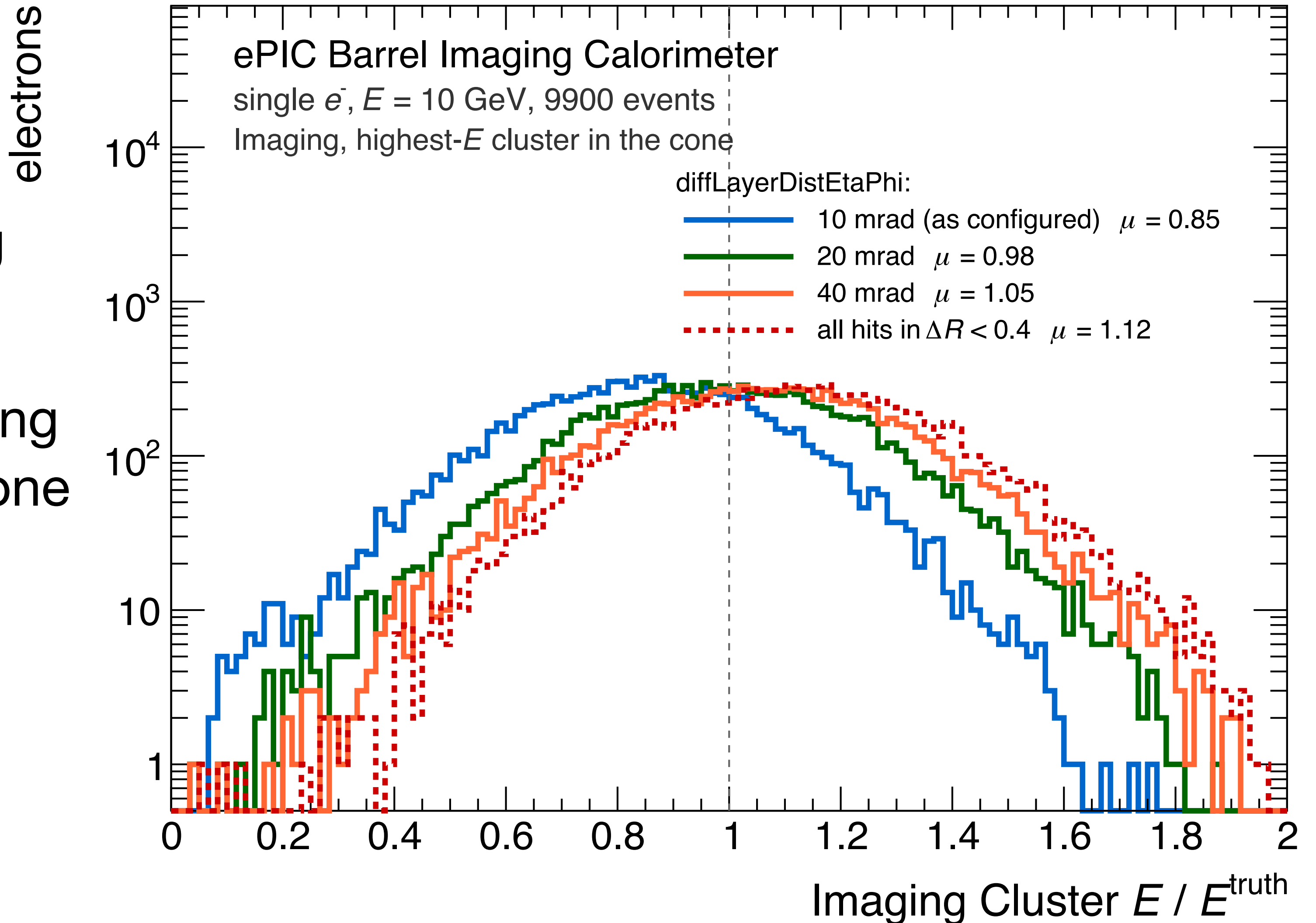


● matched cluster: 149 hits, 90% of E ● no cluster: 25 hits, 10% of E
★ truth electron

- Claude 🌟 suggests that **diffLayerDistEtaPhi** has the biggest effect here
➡ For this example event, raising it from 10 mrad to 40 mrad (for example) nicely recovers (most of) the cluster

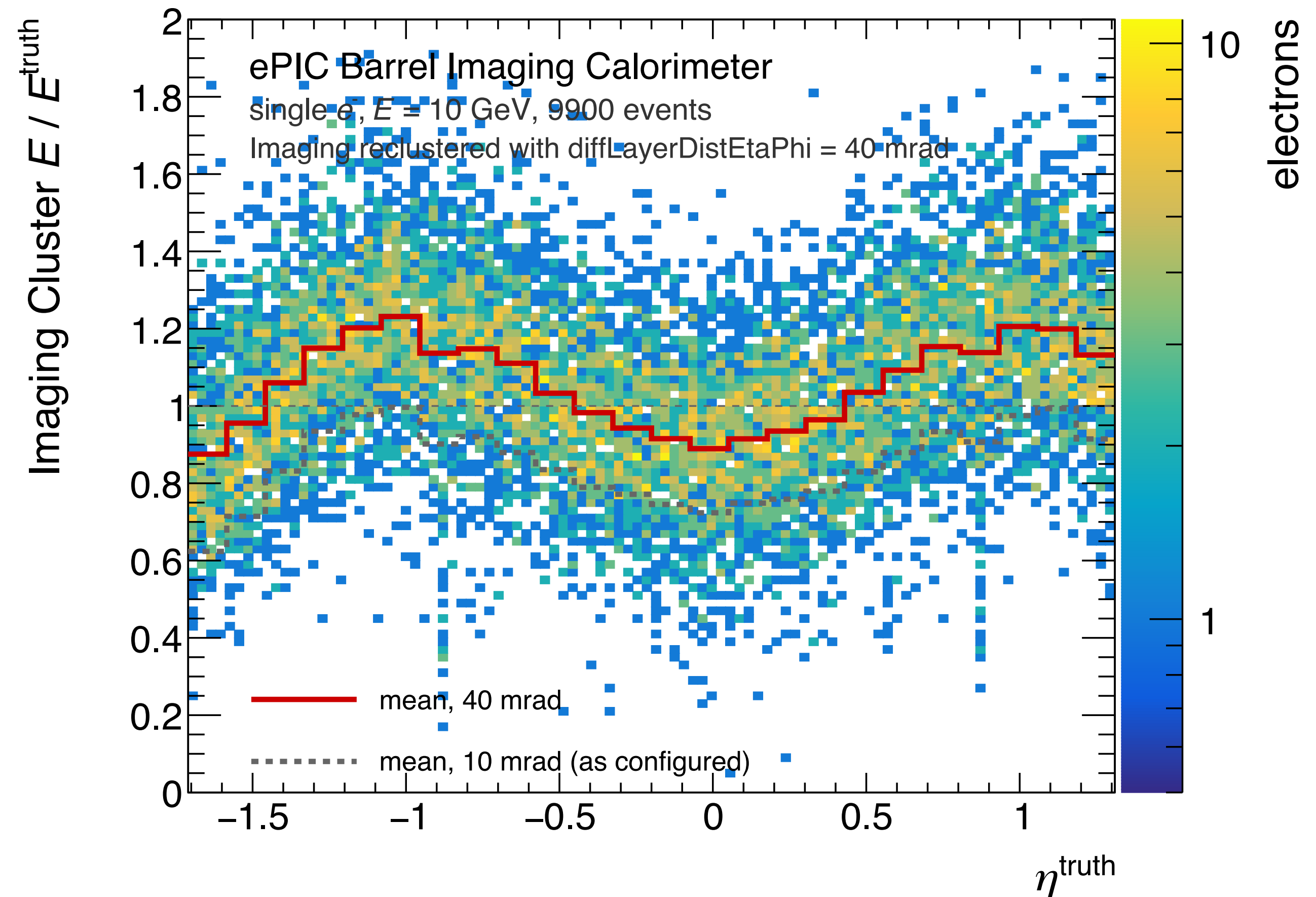
Testing diffLayerDistEtaPhi options

- Plot the distribution of cluster response under different diffLayerDistEtaPhi choices
- Big difference already in moving from 10 mrad $\rightarrow$ 20 mrad
- 40 mrad comes close to capturing all of the hits within $\Delta R < 0.4$ cone
- **Raising diffLayerDistEtaPhi to 40 mrad seems like an “easy win”,** but we should consider whether that will result in over-merging for other energy deposits?



Imaging response with $\text{diffLayerDistEtaPhi} = 40$

- The overall response is higher, but still not uniform!
- The Imaging layers are **NOT** like a sampling calorimeter
 - ➔ In a sampling calorimeter, the path-length through the active and passive layers varies with $1/\sin\theta$, so the ratio does not change with θ
 - ➔ For the Imaging layers, as θ changes, you are sampling the shower at (different) fixed points
- Near the edges (e.g. $\eta < -1.3$), there is only partial containment so the response drops



Potential improvement in Imaging cluster reconstruction

- In the current reconstruction, the Imaging hits have a “sampling fraction” (note this is really a misnomer) which is constant in eta
 - ➡ BEMC.cc: `.sampFrac = “0.00429453”;`
- One could implement an η -dependent sampling fraction for the Imaging in particular (likely not needed to first order for SciFi)
 - ➡ I don’t (yet) have enough knowledge of the reconstruction flow to gauge how easy/difficult such a change would be ...

Conclusions

- Potential improvements in cluster reconstruction for DIS scattered electron measurements:
 - ➡ Small ϕ^{reco} -dependent correction to SciFi cluster energy (in principle, this could be an analysis-level correction, not in the reconstruction...)
 - ➡ Layer-weighted energy calibration for SciFi - equalize the response between early- and late-starting showers to improve the resolution
 - ➡ Update Imaging clustering configuration (ex. `diffLayerDistEtaPhi` = 40 mrad)
 - ➡ Implement η -dependent Imaging cluster “sampling fraction”
- Other suggestions or studies welcome...