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Electron energy reconstruction

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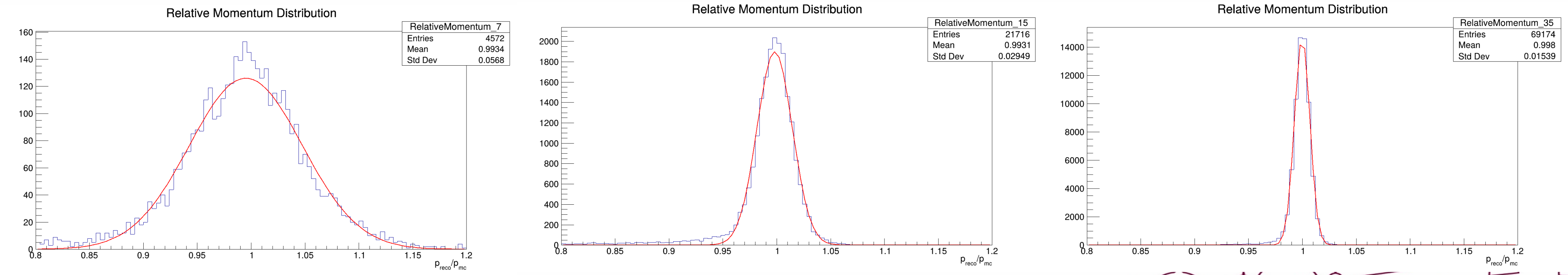
Overview

- When retrieving an energy from ReconstructedParticles/ReconstructedChargedParticles, by default we get the energy by the track momentum
- Generally the track momentum resolution is very good – but it degrades somewhat with increasing momentum, and degrades significantly with increasing dip angle (larger pseudorapidities) due to the decreasing lever arm
- For electrons we have a very good ECAL in the backwards direction – it’s been known for some time that this is what we will be using for electron energy reconstruction, but I’ve not yet seen a clear evaluation of how much improvement we would expect
- ECCE had some success when combining track and ECAL info for the scattered electron → let’s see for ePIC

Methodology

- Single electron simulations from 26.02.0 simulation campaign
  - 1, 2, 5, 10, 20 GeV
  - Can get away with single particle simulations because electrons are usually isolated
  - Newer campaign available – will update plots, but don't expect major changes

- Evaluate electron energy resolution with both tracker only and ECAL only, at fixed momenta, as a function of pseudorapidity
  - Single gaussian fit of p_{rec}/p_{true} over full range (would like to update to fit over limited range used in tracking resolution plots → 2σ?)



Tracking only, 10GeV

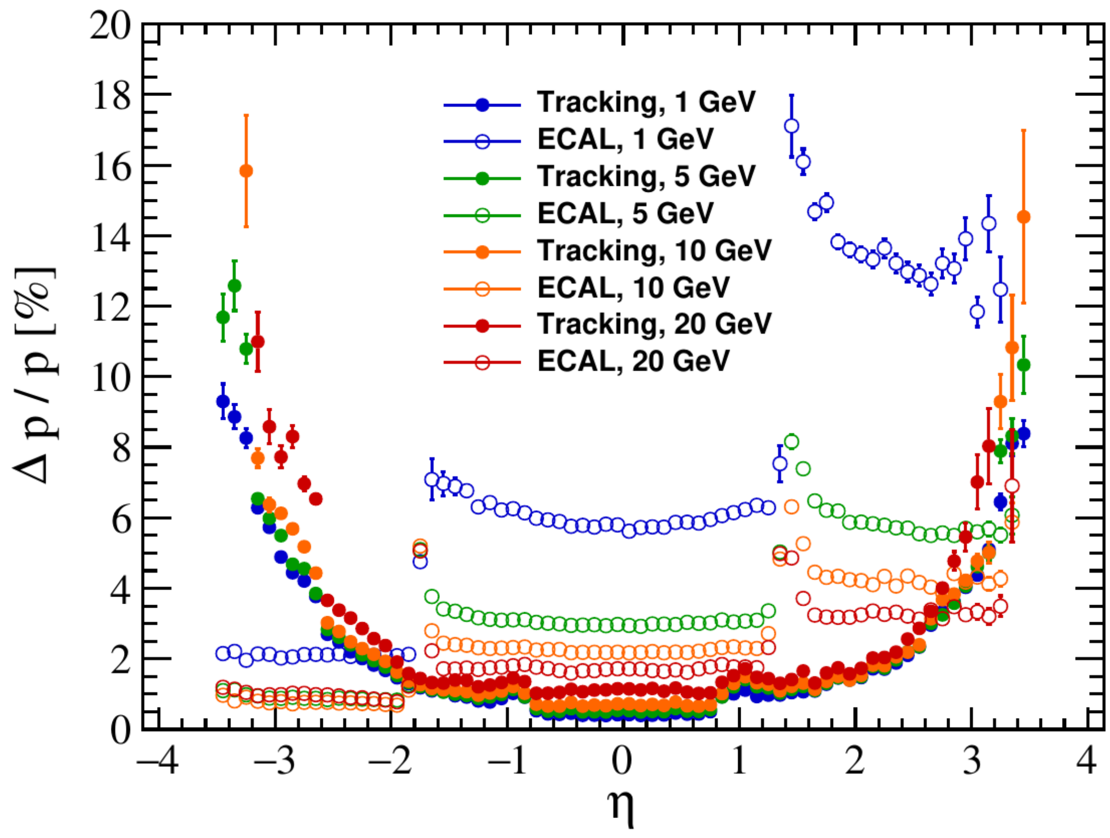
Methodology

- Write out resolutions as tables
- C++ header written with class that:
  - Reads each table
  - When given electron candidate's ECAL energy, track momentum, and track pseudorapidity, linearly interpolates to estimate of track and ECAL resolution at that η
    - Measured ECAL energy used to estimate ECAL resolution, measured track momentum used to estimate track momentum resolution
  - Returns inverse variance weighted average of the two energies → "combined" energy estimate

$$E_{combined} = \frac{E_{\rm trk}/\sigma^2_{\rm trk} + E_{\rm ECAL}/\sigma^2_{\rm ECAL}}{1/\sigma^2_{\rm trk} + 1/\sigma^2_{\rm ECAL}}$$

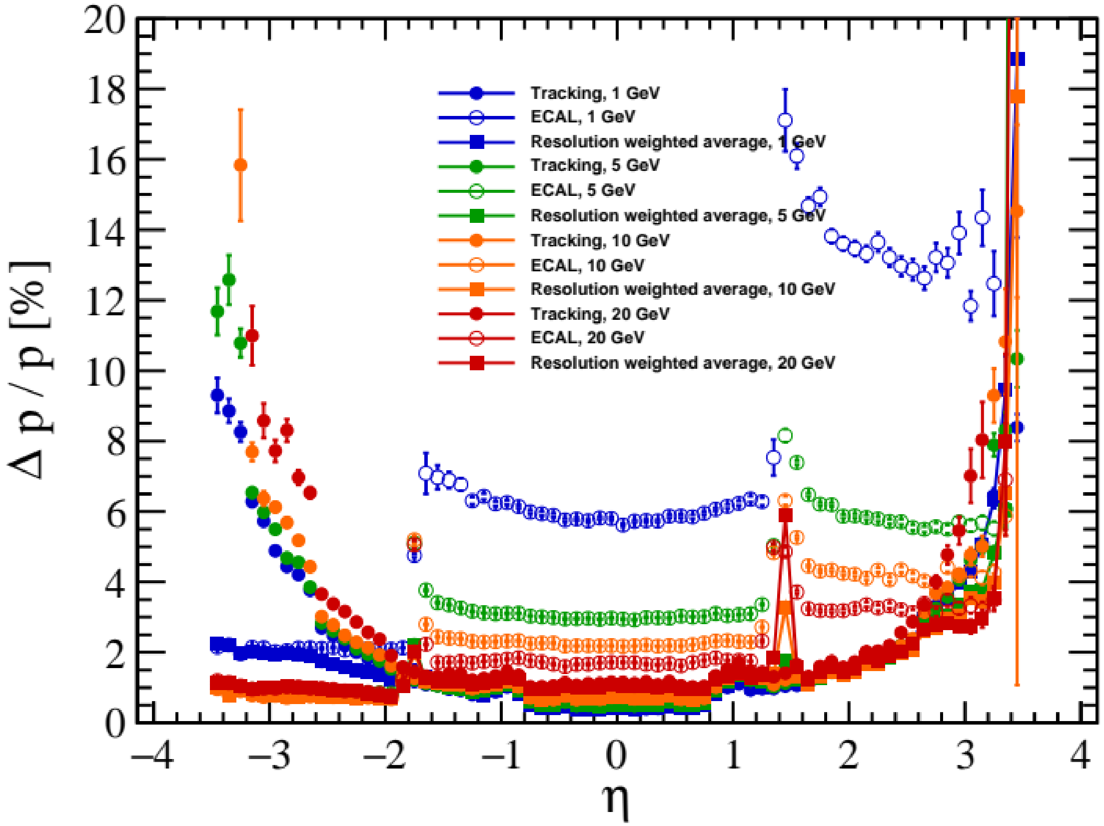
- … then analyse the electron energy resolution using same method as before
  - **<u>Not</u>** just estimating the uncertainty on the combined quantity as $\sigma_{E_{combined}} = \left(\frac{1}{\sigma^2_{\rm trk}} + \frac{1}{\sigma^2_{\rm ECAL}}\right)^{-1/2}$.

Resolution vs η – no combination



- Electron resolution from tracking detector degrades with increasing pseudorapidity (as expected)
  - … but gives better resolution over much of the central region
- EEEMCAL gives significantly better resolution for η<~-2.5

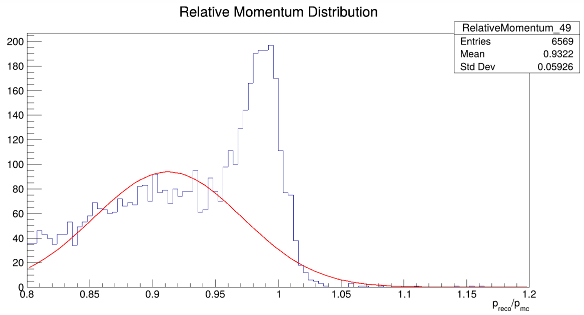
Resolution vs η – with combination



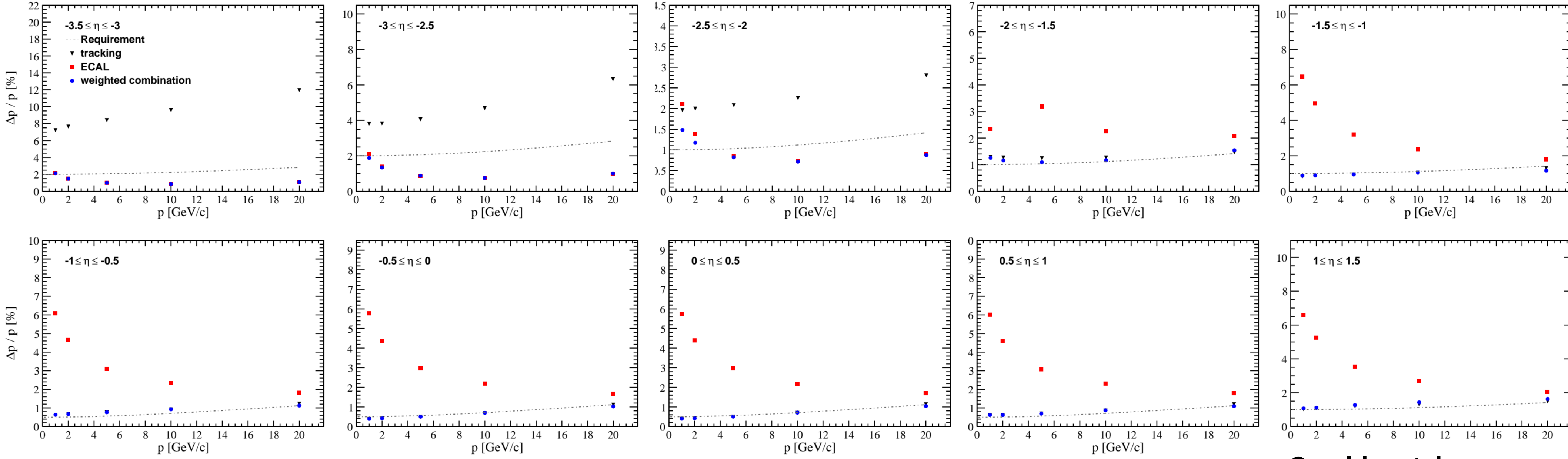
- Resolution weighted average typically follows resolution of best performing subdetector
- If the resolution of the two subdetectors are comparable, then can improve by up to factor of ~1/√2

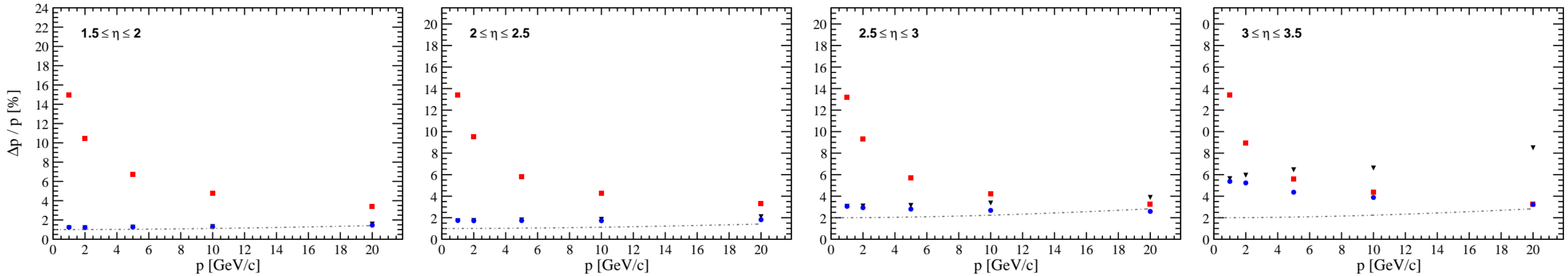
$$\sigma_{E_{combined}} = \left(\frac{1}{\sigma^2_{\mathrm{trk}}} + \frac{1}{\sigma^2_{\mathrm{ECAL}}}\right)^{-1/2}.$$

- Spike at η from fit not matching distribution due to calorimeter transition → strict E/p requirement may help necessary here (E/p>0.9)



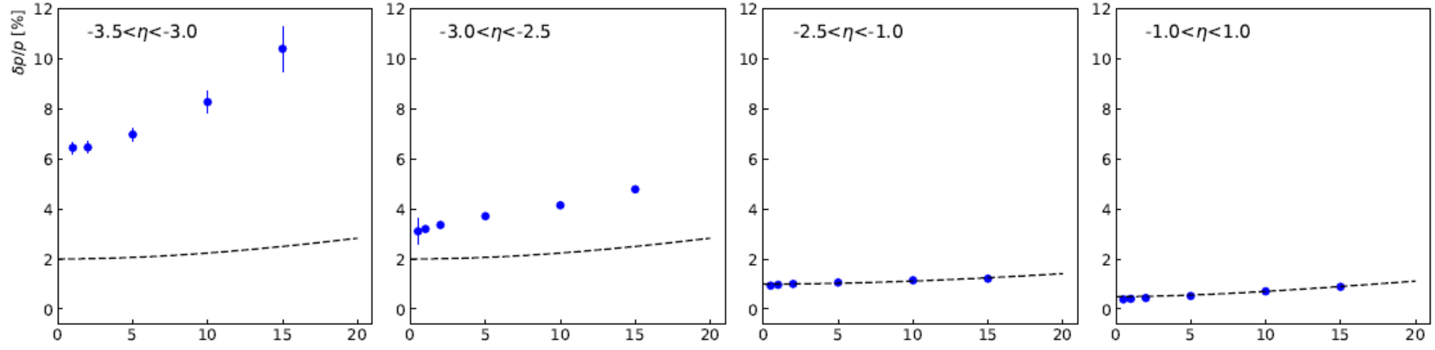
Resolution vs p in coarser η bins (compared to tracking req.)



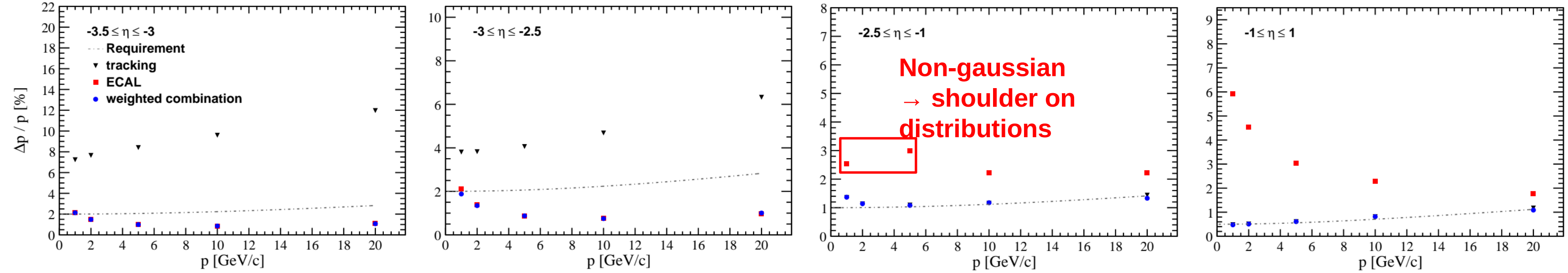


- Combi matches or beats single subsystems
- Consistent with or better than req. for -3.5<η<2 (small excesses at low p)
- Not as good beyond this → but very few electrons expected

Comparison to existing tracking performance plots



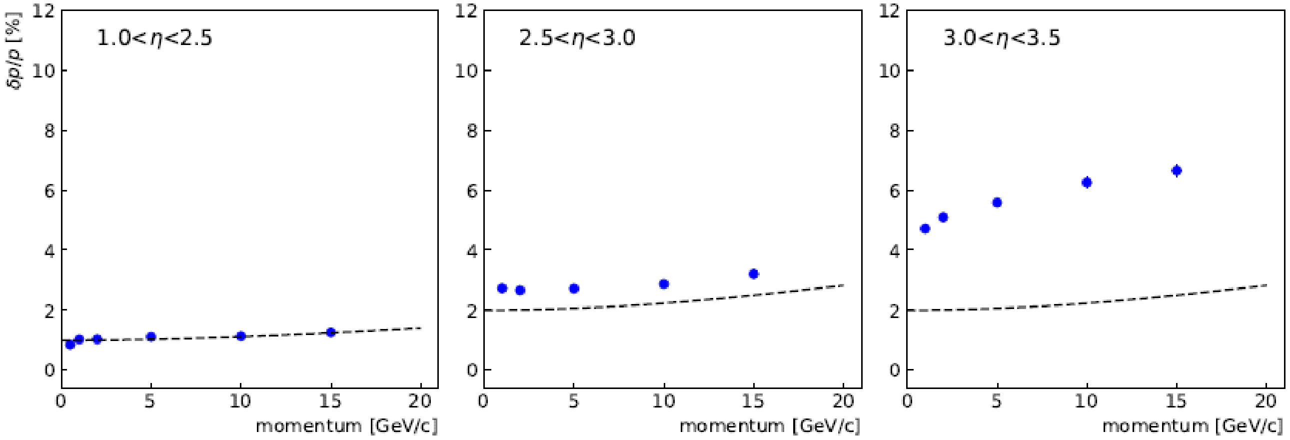
Jan SVT preliminary design review



Tracking resolutions largely match

I get slightly worse tracking resolutions at larger η →tails often more prominent here, double check with range fit (2σ?)

Comparison to existing tracking performance plots



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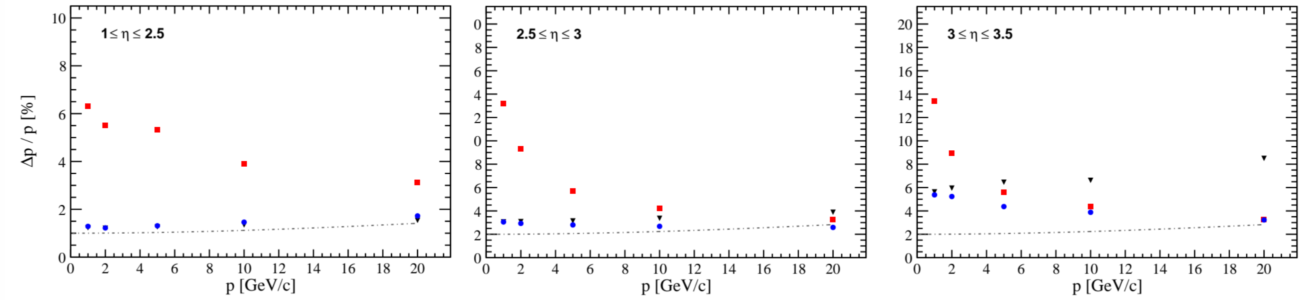

Similar story → similar tracking performance centrally, I get slightly larger at high |η|

The overall point is that, across the range -3.5<η<2.5, we achieve a performance compatible with or better than the requirement, if we combine tracking and ECAL info for e⁻

… 2.5<η<3.5 still a challenge, but I'd assume that requirement isn't set by electrons..

Summary

- We’ve largely been using the tracking detector for reconstructing electrons to this point as, by default, we use the tracker for charged particles
- Tracking becomes challenging at small angles from the beamline → ECAL can provide better performance here
- If we use the tracking and calorimeter information simultaneously, we can match or improve the performance of the best subsystem
- This makes the challenging tracking requirements for the electron endcap region achievable

Future work

- Update to recent campaign, use restricted range fit to evaluate resolutions
- Study impact on kinematic resolutions