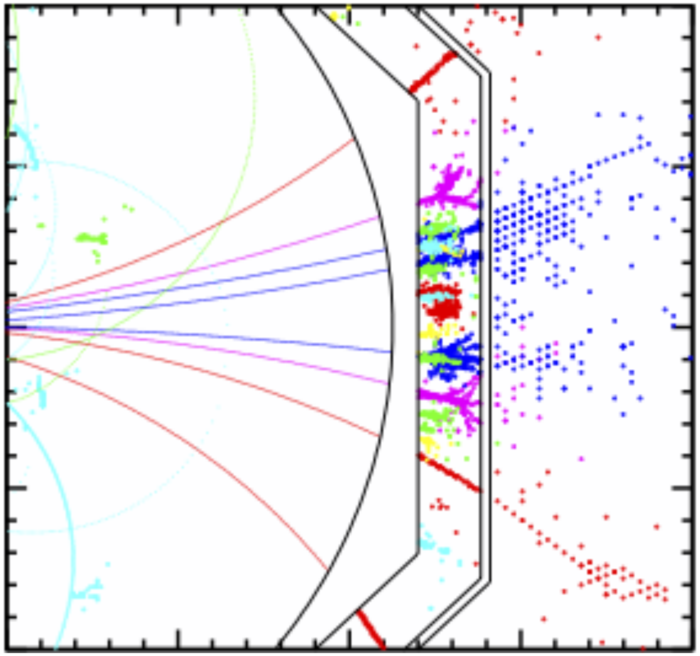
Software compensation in PandoraPFA



Huong Lan Tran

ILD Software&Optimisation Workshop

23 February 2016

HELMHOLTZ ASSOCIATION

CALICE

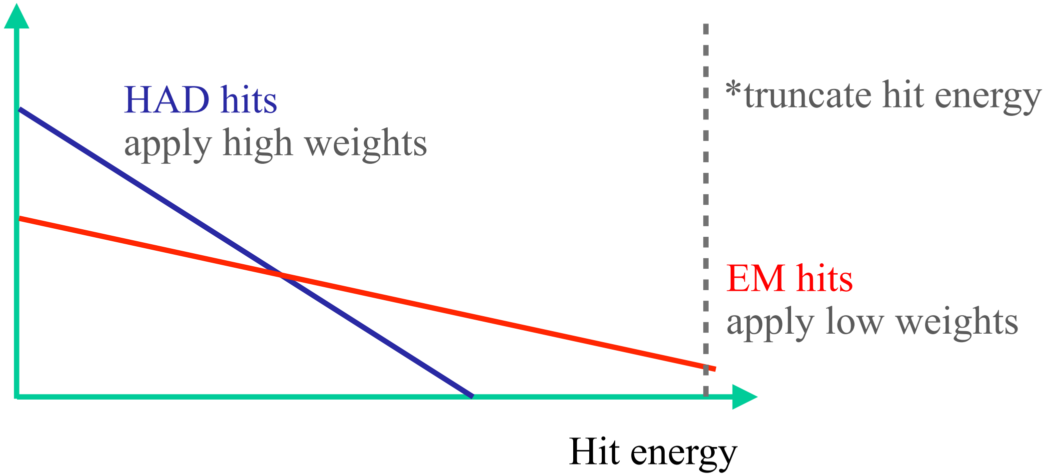
DESY

Software compensation in brief

- Reducing electromagnetic response
- Increasing hadronic response
- "Offline" compensation: **Software Compensation**
  - Inside hadronic showers energy of hits from electromagnetic ***sub-showers*** are typically higher compared to hits from hadronic ***sub-showers***

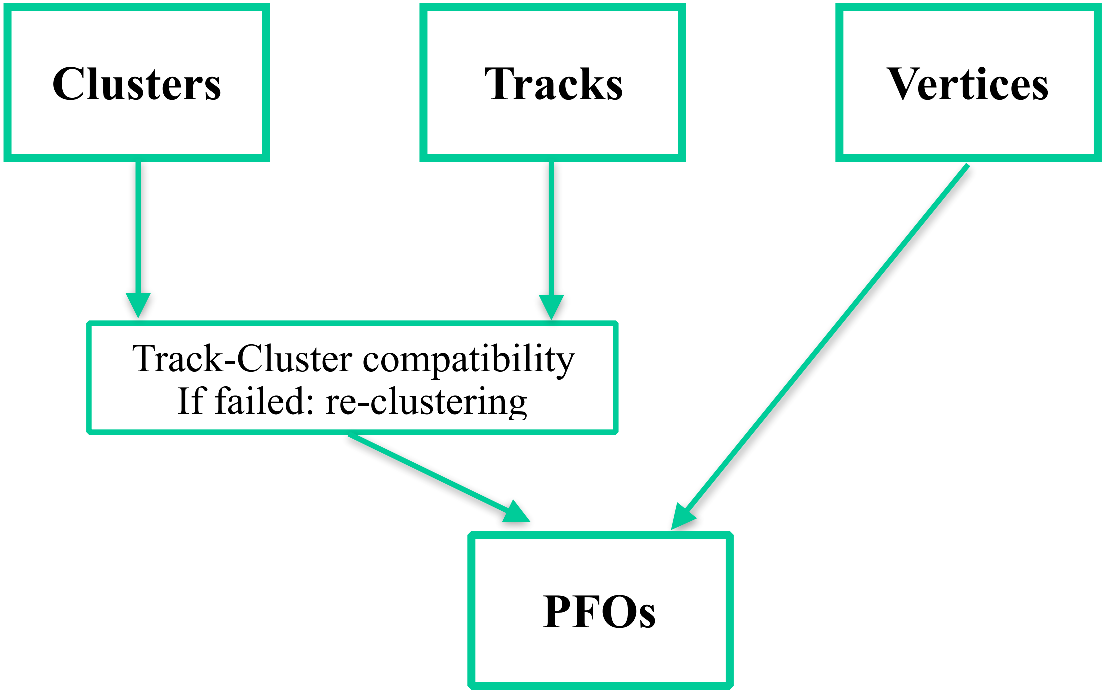
➢ Cut out high energy hits to reduce EM response *

➢ Applying different ***weights*** for hits of different energy densities



Software compensation in PandoraPFA

- PandoraPFA uses vertex, tracker and calorimeter information
- Output: Particle Flow Objects (PFO) (including vertex, tracks, clusters)



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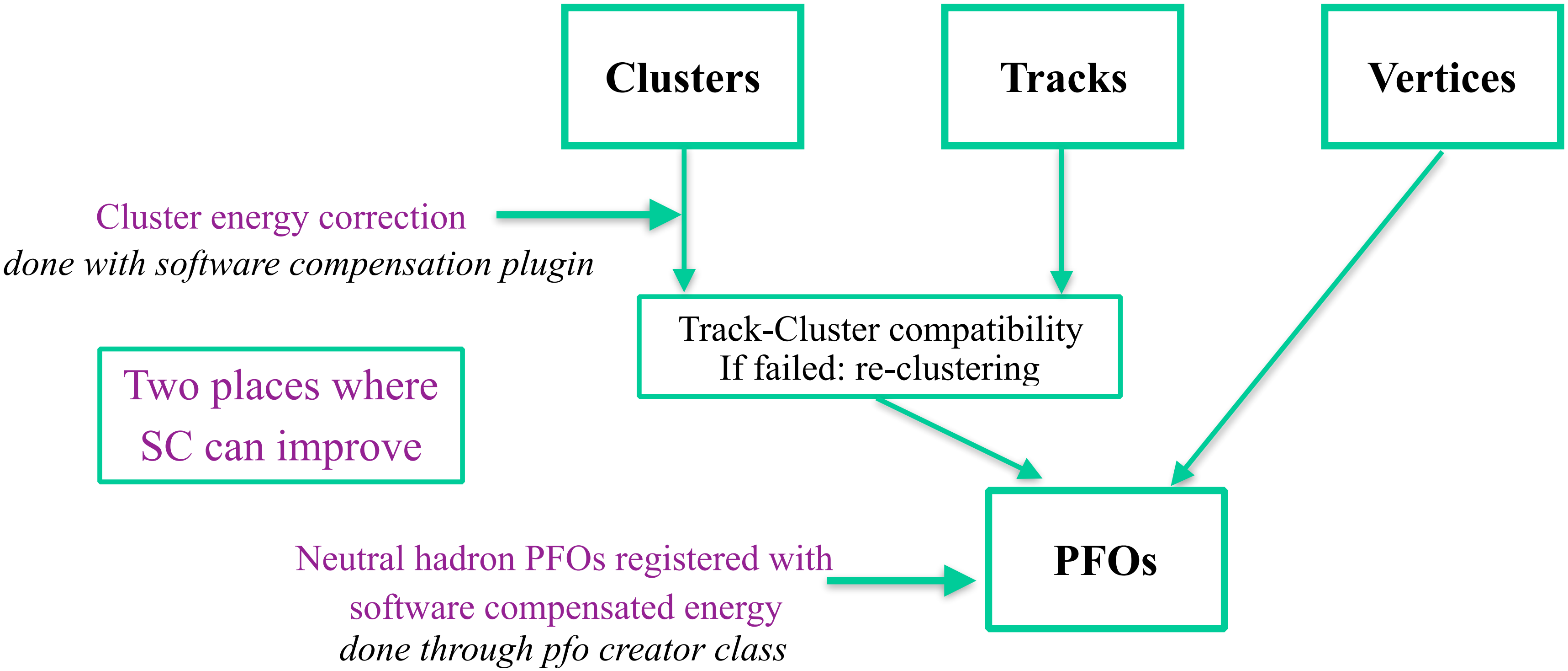
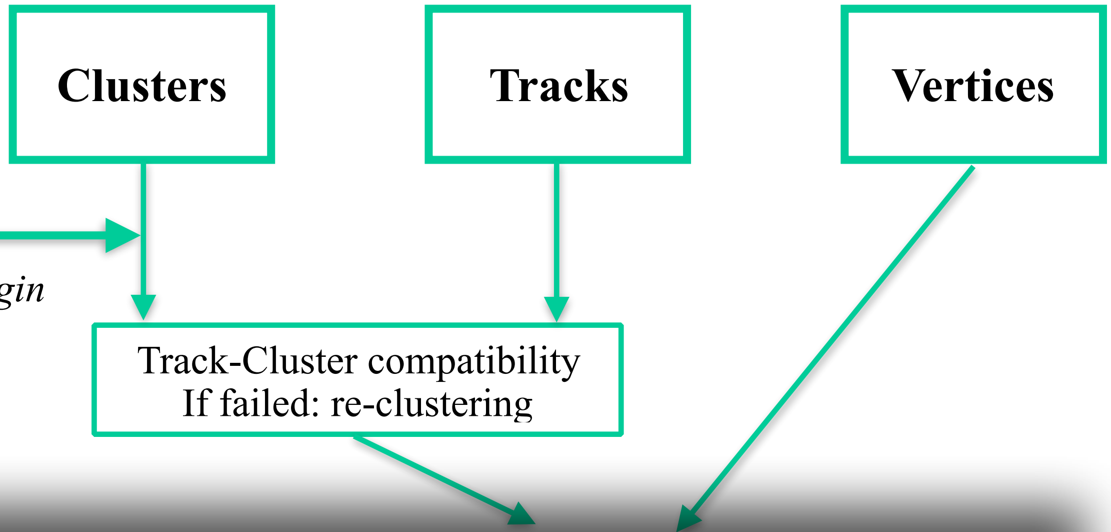


Cluster energy correction



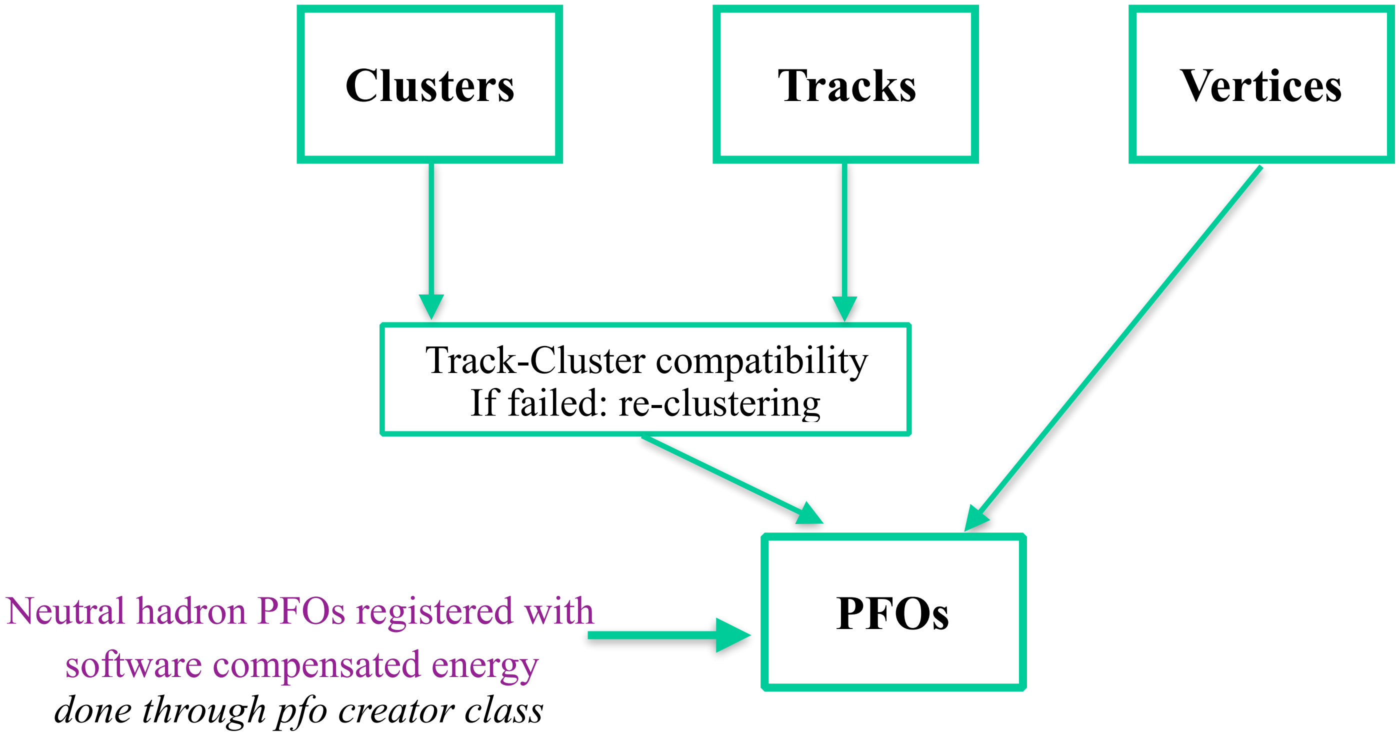
Cluster energy correction

done with software compensation plugin
Modifications in
PandoraSettingsDefault.xml

```
<HadronicEnergyCorrectionPlugins>EnergyCorrectionSC</HadronicEnergyCorrectionPlugins>
<!--HadronicEnergyCorrectionPlugins>CleanClusters ScaleHotHadrons</HadronicEnergyCorrectionPlugins-->
<EmShowerPlugin>LCEmShowerId</EmShowerPlugin>
<PhotonPlugin>LCPhotonId</PhotonPlugin>
<ElectronPlugin>LCElectronId</ElectronPlugin>
<MuonPlugin>LCMuonId</MuonPlugin>
```

```
  <!-- PLUGIN SETTINGS -->
  <EnergyCorrectionSC>
    <SCEnergyConstants> 2.08143 -0.0189623 0.000255872 -0.017591 -0.00031179 -1.14228e-06 0.425478 0.573655 -0.0594601 </SCEnergyConstants>
tral hadron files-->
    <Cheating> 0 </Cheating>
    <TrueEnergy> 0. </TrueEnergy>
  </EnergyCorrectionSC>
```

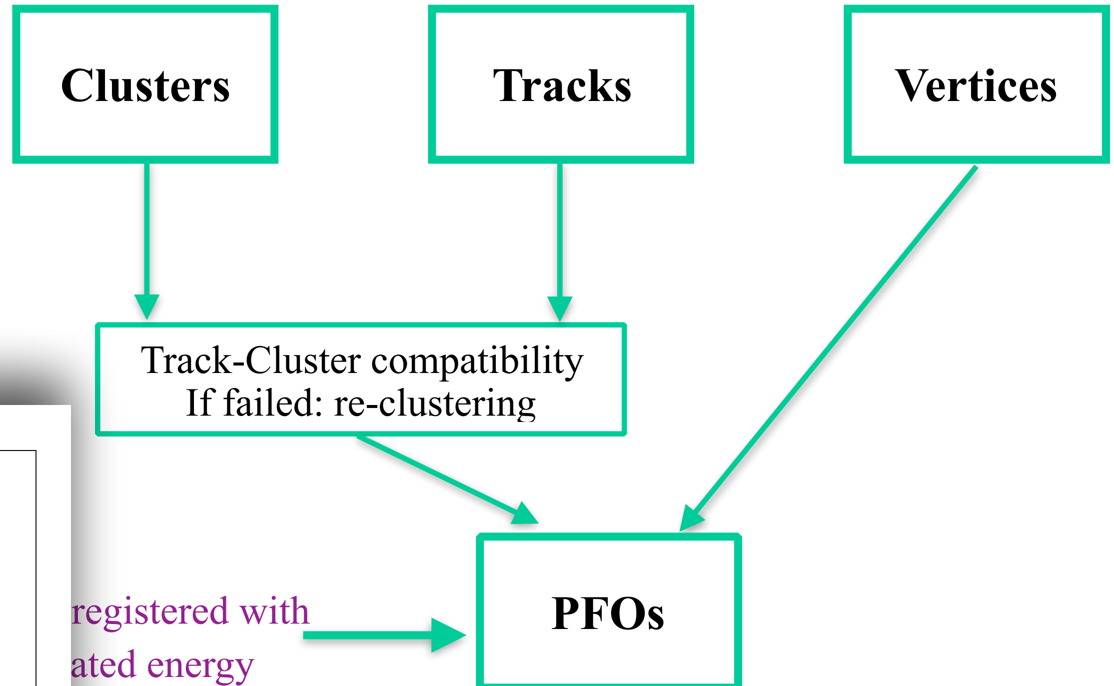
PFO energy correction



➢ Flag in ***standard steering file*** to apply software compensation:

```
  <parameter name="ApplySoftwareCompensation" type="bool"> false </parameter>
  <parameter name="SoftwareCompensationParameters" type="FloatVec"> 2.54231 -0.0470912 ...
</processor>
```

PFO energy correction



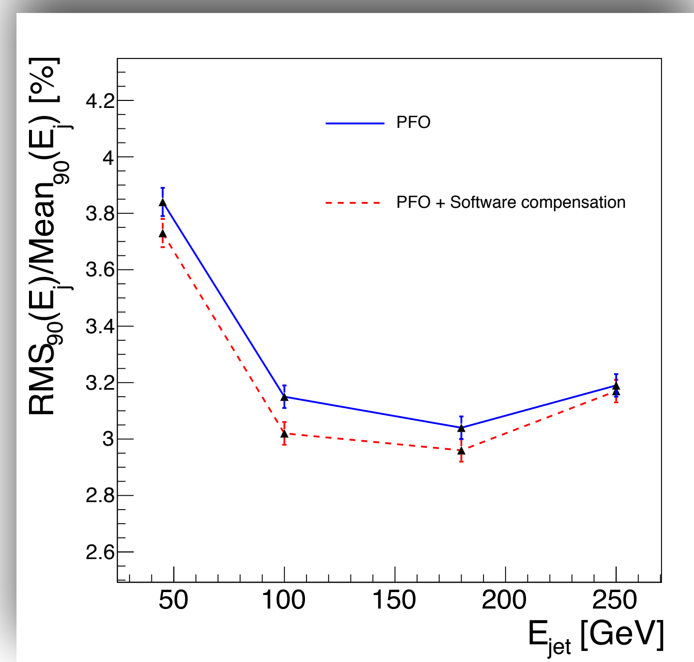
registered with

ated energy

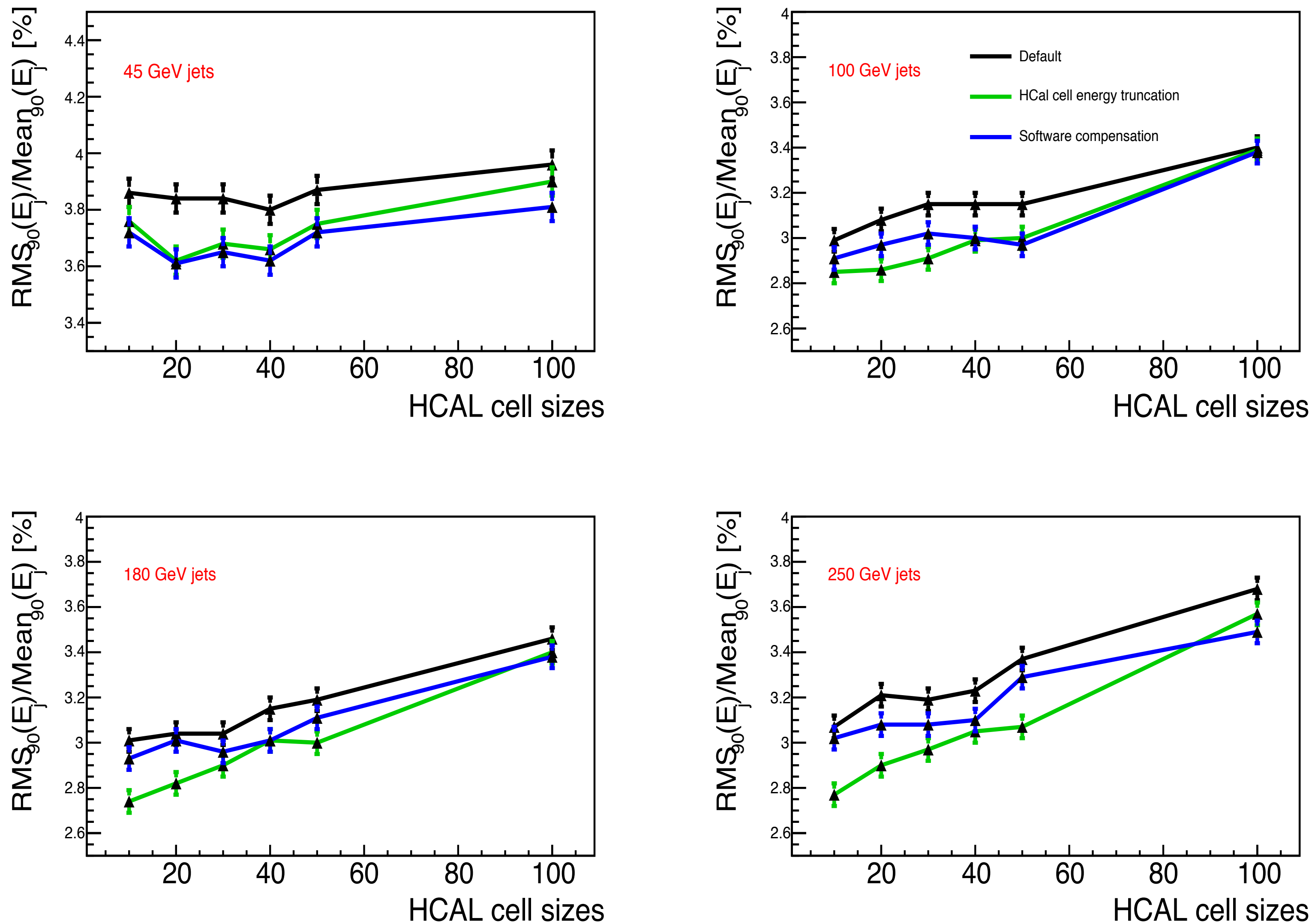
reator class

software compensation:

```
mpensation" type="bool"> false </parameter>
ationParameters" type="FloatVec"> 2.54231 -0.0470912 ...
```



PFO energy correction vs HCAL cell truncation

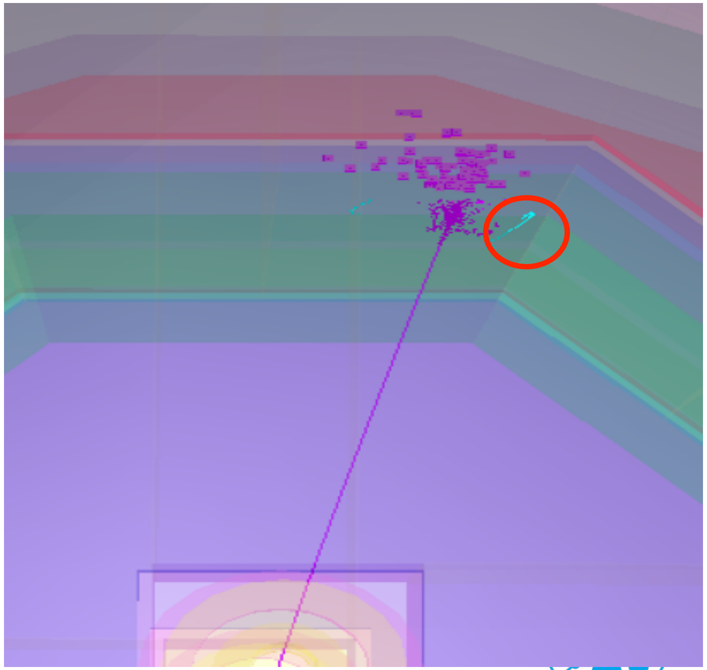


Full implementation of software compensation

- *Cluster energy correction* called after cluster-track association algorithm; *PFO energy correction* called at the very end (particle level)
- *Cluster energy correction* change cluster energy which can lead to re-clustering to improve cluster-track compatibility. But:
  - Change also "neutral" clusters (with no associated track)
    ➢ fragmentations are also weighted as "particles": wrong
  - Should only apply for "charged" clusters
- *PFO energy correction* applied for neutral hadrons

➢ Two corrections should be applied together but at different stages

➢ currently under investigation

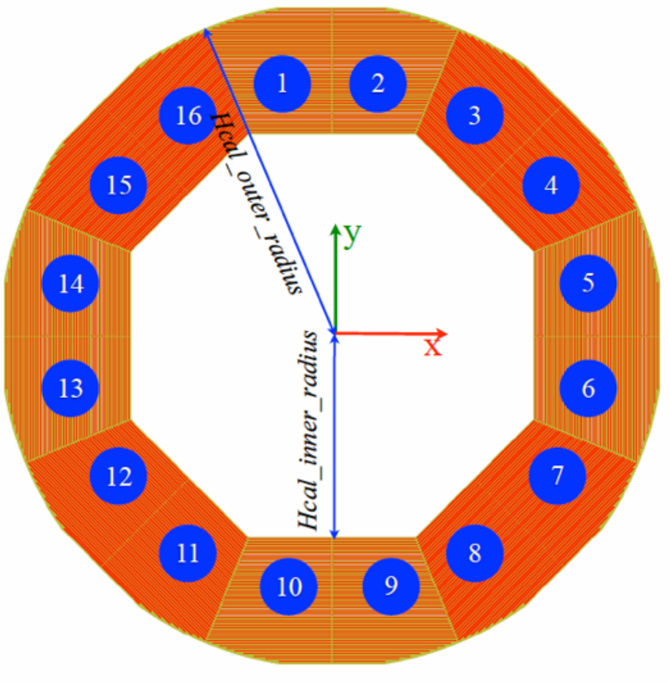


Summary for Software compensation

- Progress in understanding effect of software compensation in pattern recognition
  - Problems identified
- Software compensation at PFO level improves significantly JER, at re-clustering level degrades JER:
  - Should apply both with careful condition
  - Under investigation

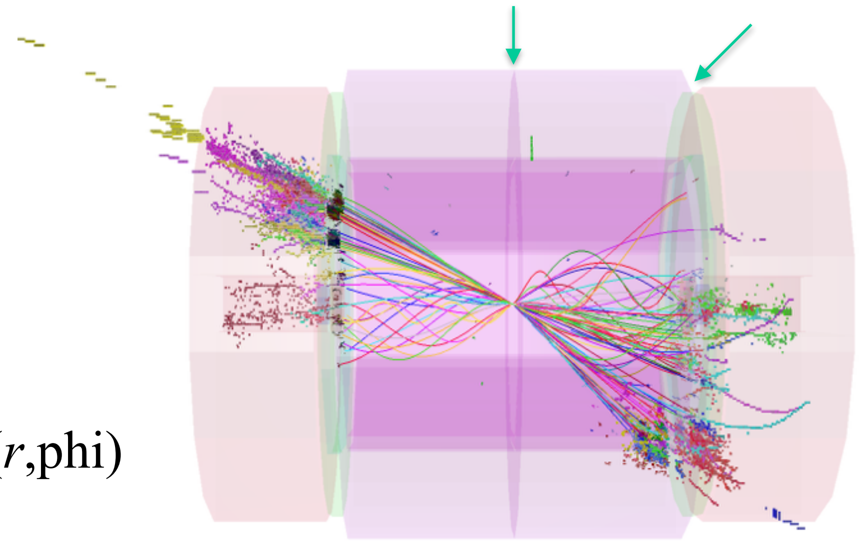
Effect of supporting structure in energy reconstruction

ILD-AHCAL view (*r*,phi)



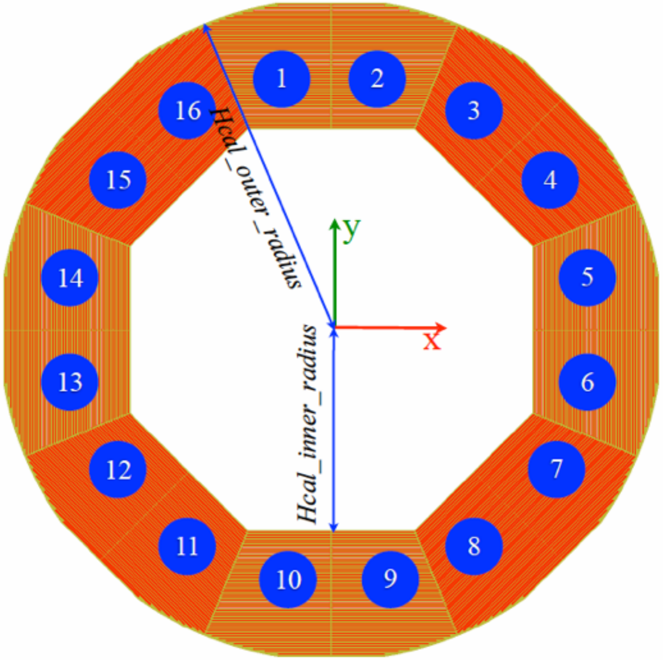
- AHCAL highly symmetric structure:
  - in (*r*,phi): 16 sectors of identified shape, but pointing cracks (filled with steel)
  - in (*r*,theta): 2 sectors with middle plate
- Pointing cracks can be made non-pointing, but less simple construction

➢ How big is the effect?

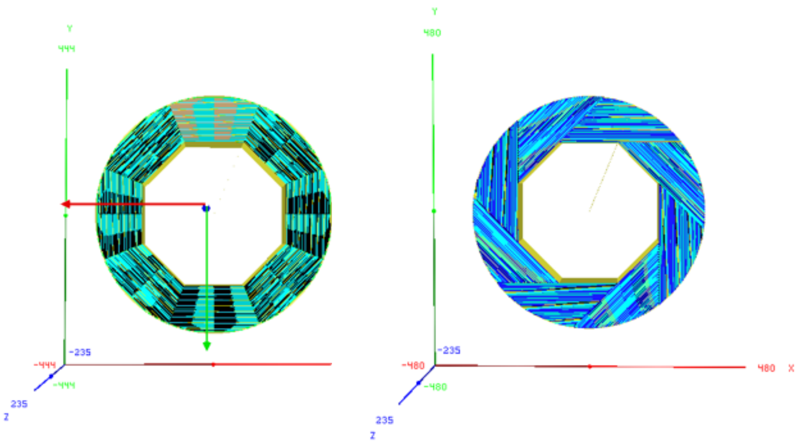


ILD-AHCAL view (*r*,phi)

Study effect of iron structure on energy reconstruction in (*r*,phi)

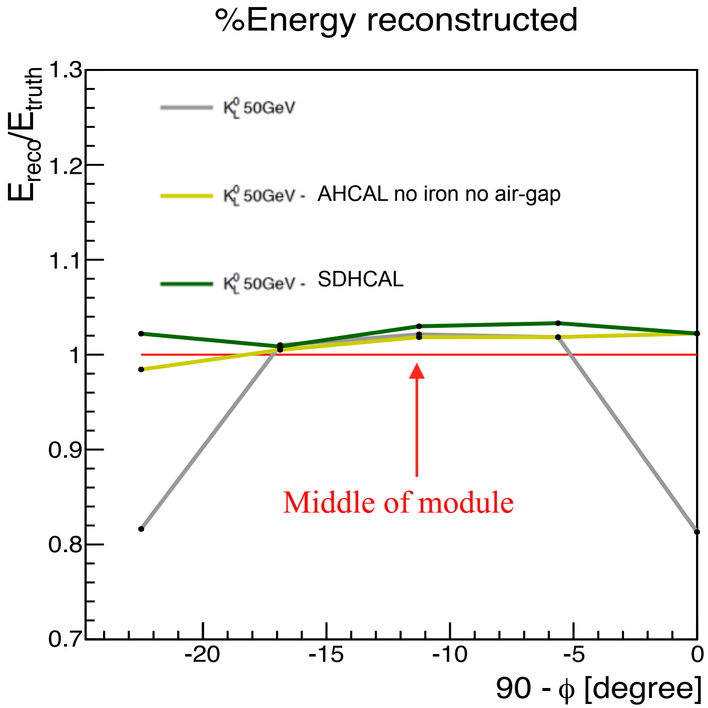


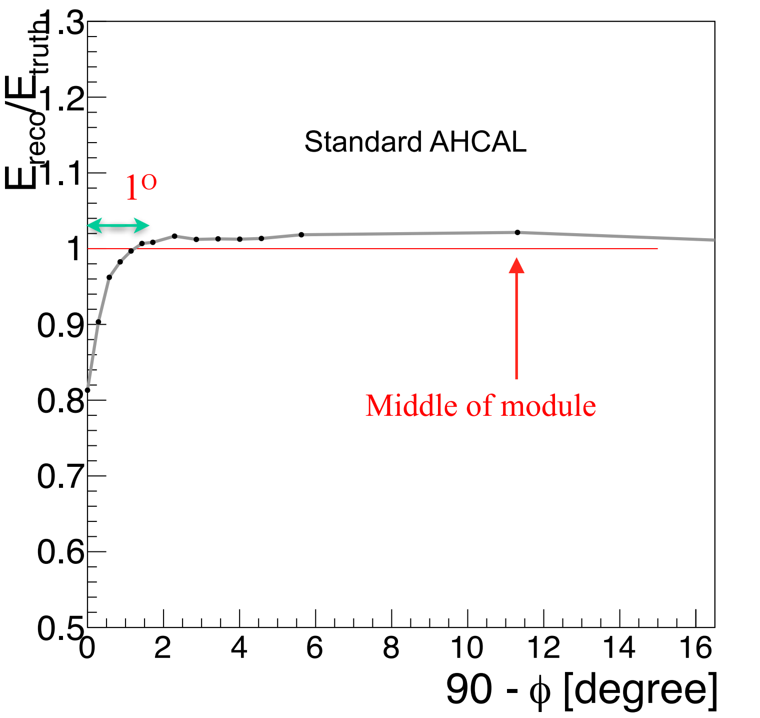
Energy reconstruction for AHCAL and SDHCAL geometries



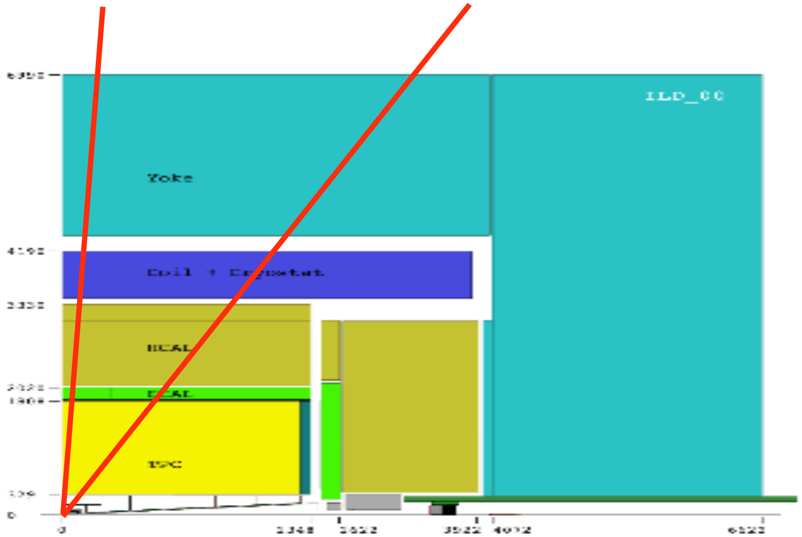
- Reconstructed energy comparison of 3 geometries:
  - AHCAL geometry
  - Ideal AHCAL geometry w/o iron and air gap in Phi
  - SDHCAL geometry

➢ Clear loss of energy response and resolution due to iron crack for AHCAL geometry



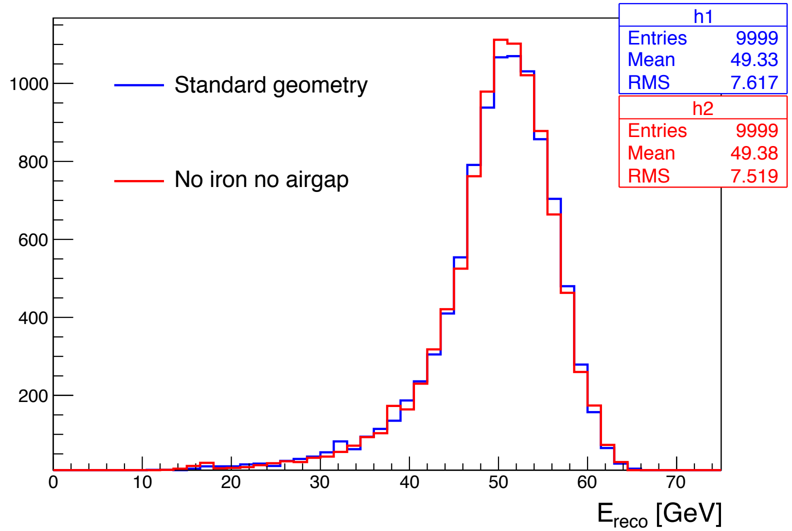


Average effect of supporting structure (*r*,phi) plane



- Cut on Theta to avoid iron support at z = 0 and barrel-endcap gap
- Look at energy distribution ***integrated over all phi***:
  - Standard geometry
  - Standard geometry w/o iron and air gap in Phi

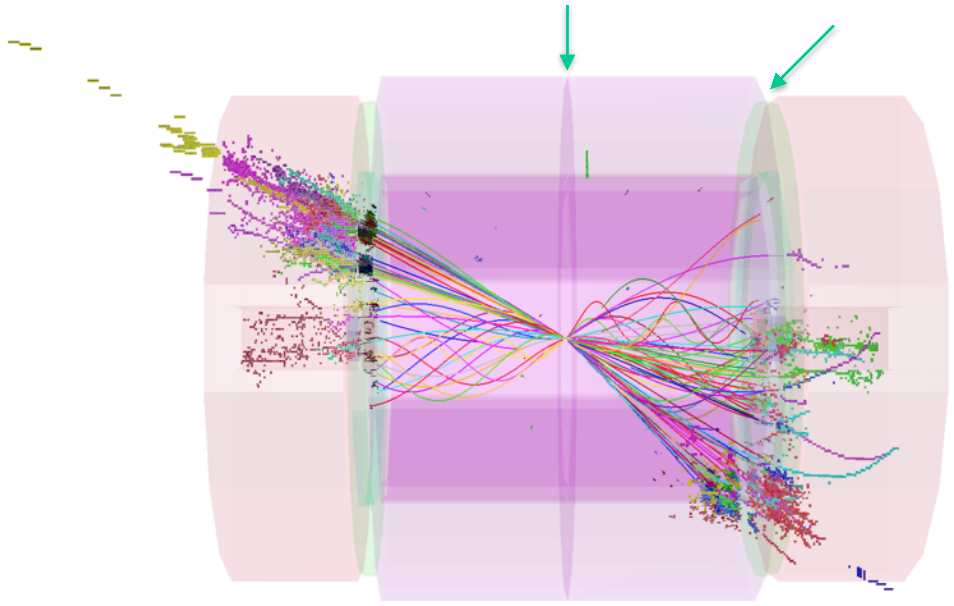
For single particle



➢ Effect of iron support on energy reconstruction is very small when integrating over all phi

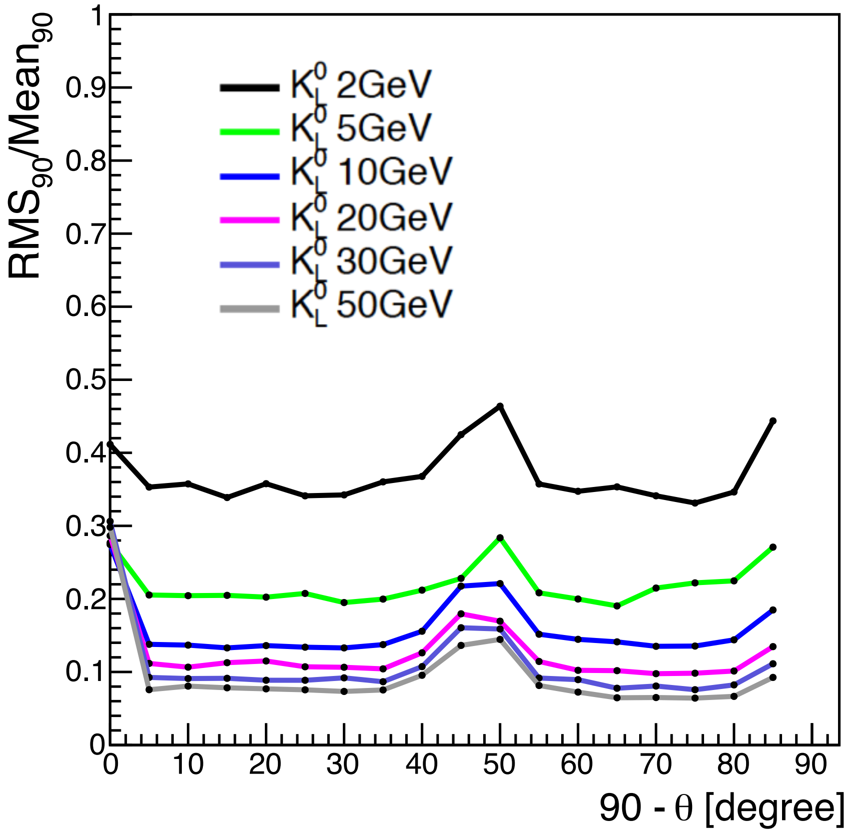
- Can be further mitigated by dead material correction
- Probably not sufficient to motivate a design modification

Study effect of iron structure on energy reconstruction in (*r*,theta)

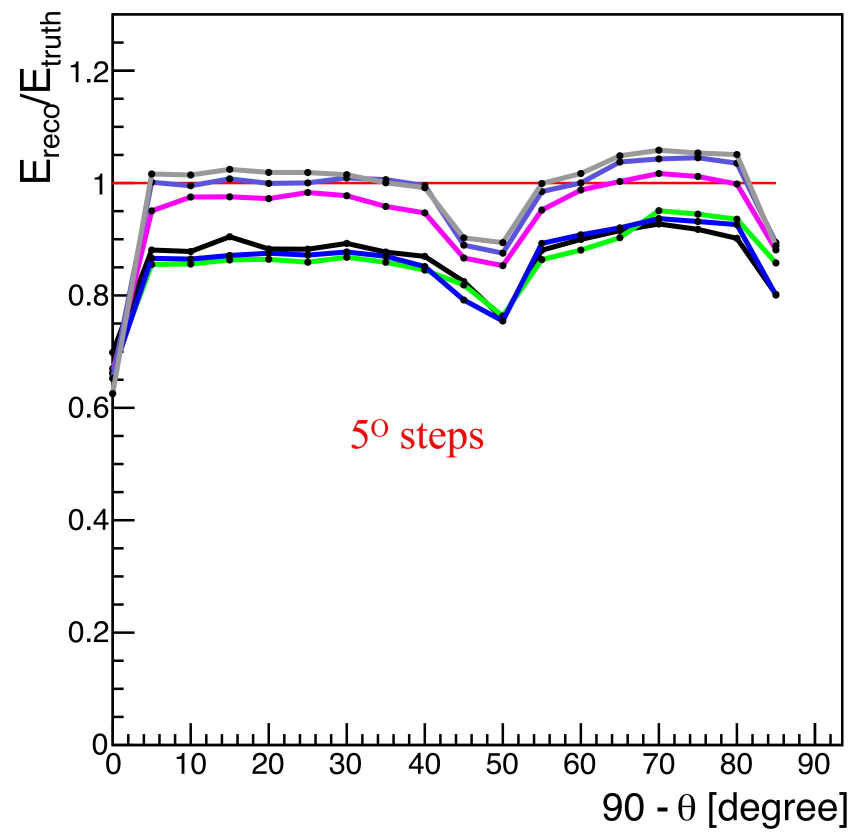


Effect of supporting structure (*r*,theta) plane

Resolution



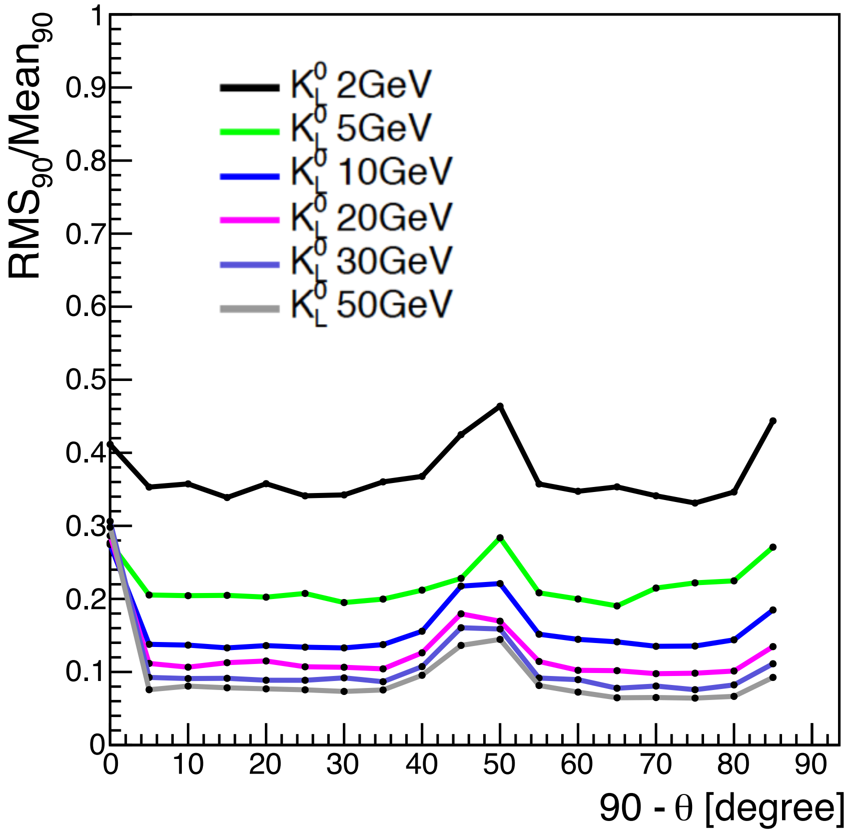
%Energy reconstructed



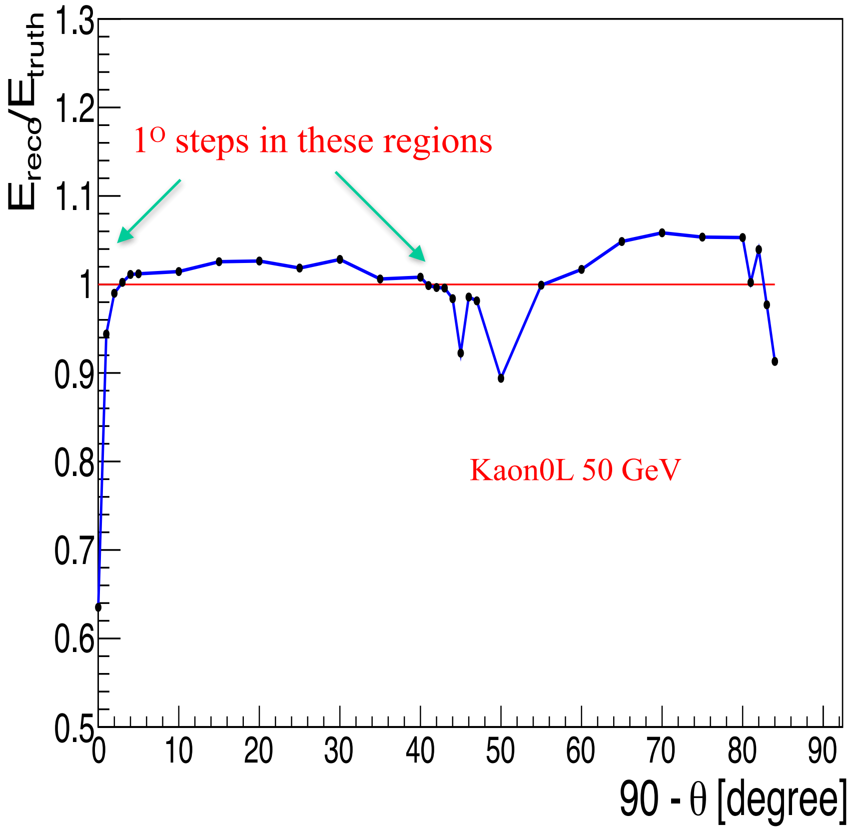
- ➢ Clear loss of energy response and resolution at central iron plate and in transition region between barrel and endcap

Effect of supporting structure - Theta dependence

Resolution

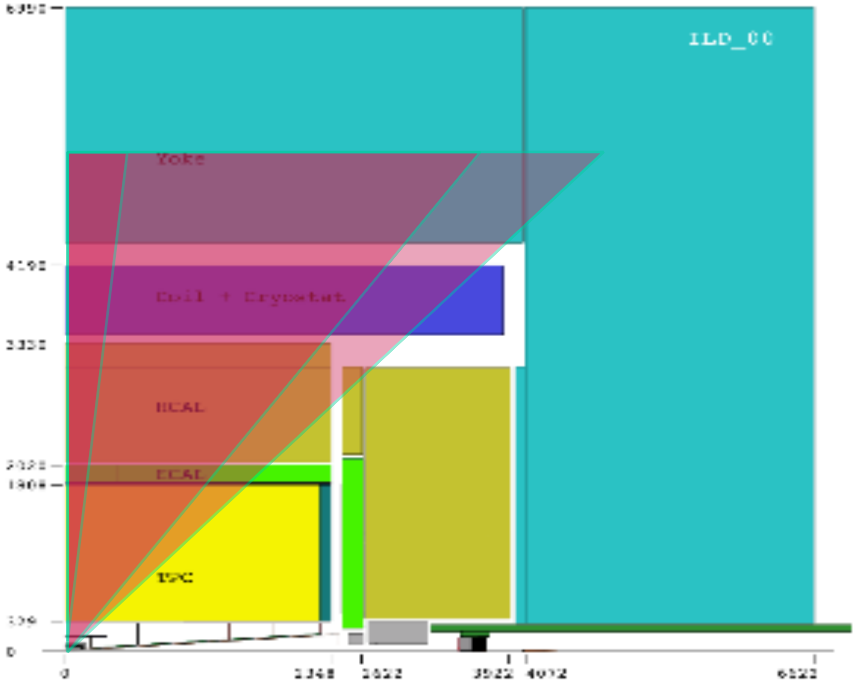


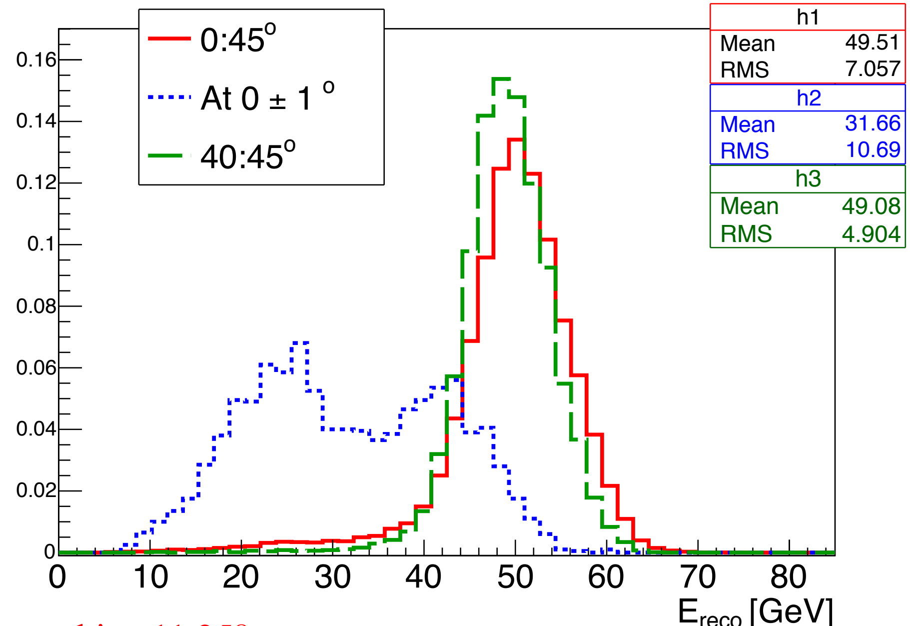
%Energy reconstructed



➢ Clear loss of energy response and resolution at central iron plate and in transition region between barrel and endcap

Effect of supporting structure (*r*,theta) plane





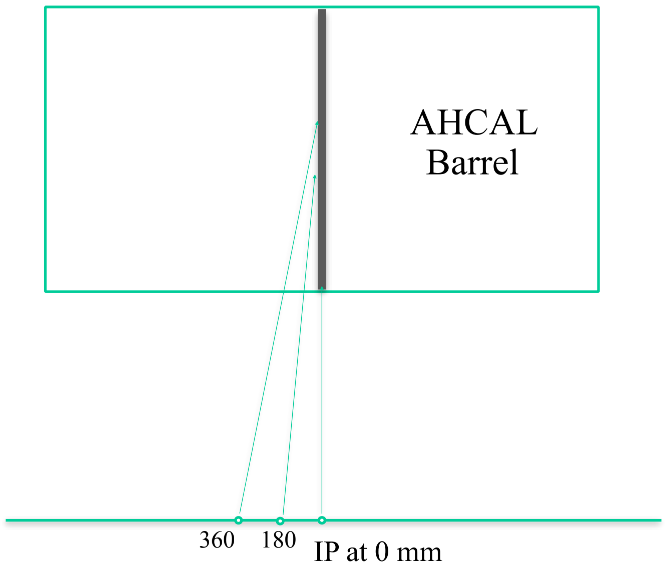
phi at 11.25°

➢Middle stave iron support seems to have stronger effect on energy reconstruction. Possible improvements:

- Cluster’s energy correction as a function of theta
- Or: Asymmetric design: middle stave iron support is not anymore “middle”

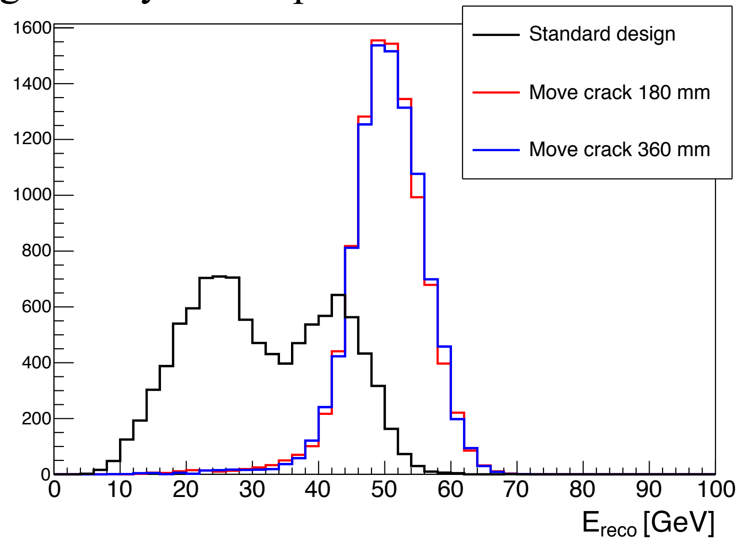
What happens if the middle stave is not anymore "middle"?

- In principle barrel structure could be made asymmetric to avoid pointing crack
- In simulation, easier to move interaction point (IP) instead
- Move IP by 180 and 360 mm (corresponding to half and one HBU in current design of AHCAL)

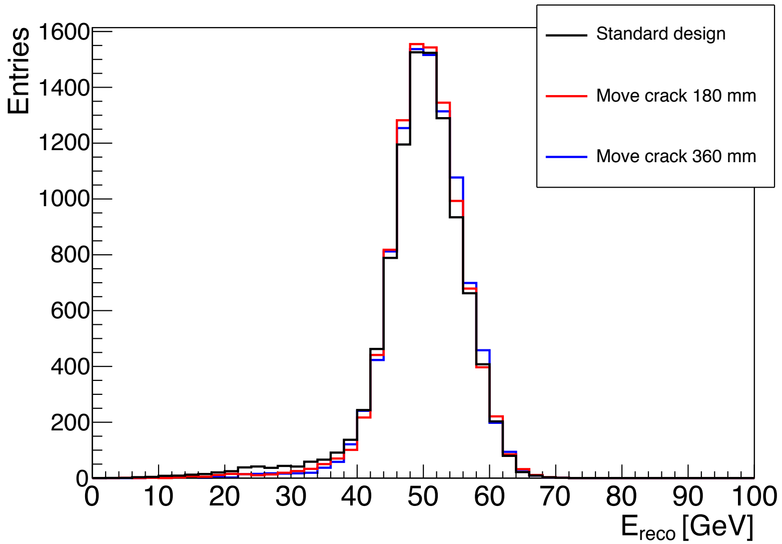


What happens if the middle stave is not anymore “middle”?

Shooting directly at iron plate



Integrate over 45 degree



- Moving the crack away from z = 0 improves significantly energy reconstruction when particle shot towards crack
- Over all effect larger than for phi crack but still small
- Can be mitigated with dead material correction
- Discontinuity at z = 0 in TPC too

➢ Need overall ILD approach

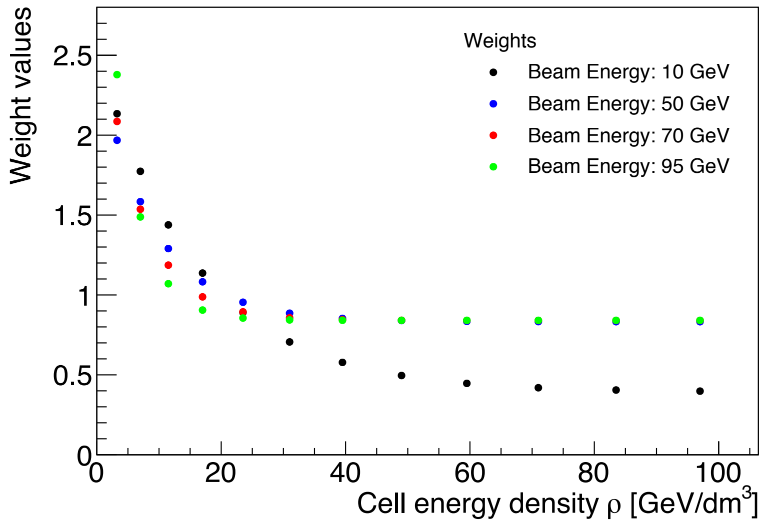
Summary for gap correction

- Global impacts in both (*r*,phi) and (*r*,theta) plane are not significant
- *Local impact of boundary regions in absorber structure*:
  - Effects of crack regions in (*r*,phi) in single particle reconstruction are small
  - Larger effect of crack at theta = 90 degree (middle plate thicker)

➢ Dead material correction to be developed

Back-up slides

Software compensation weights



$$\omega(\rho) = p_1.exp(p_2.\rho) + p_3$$