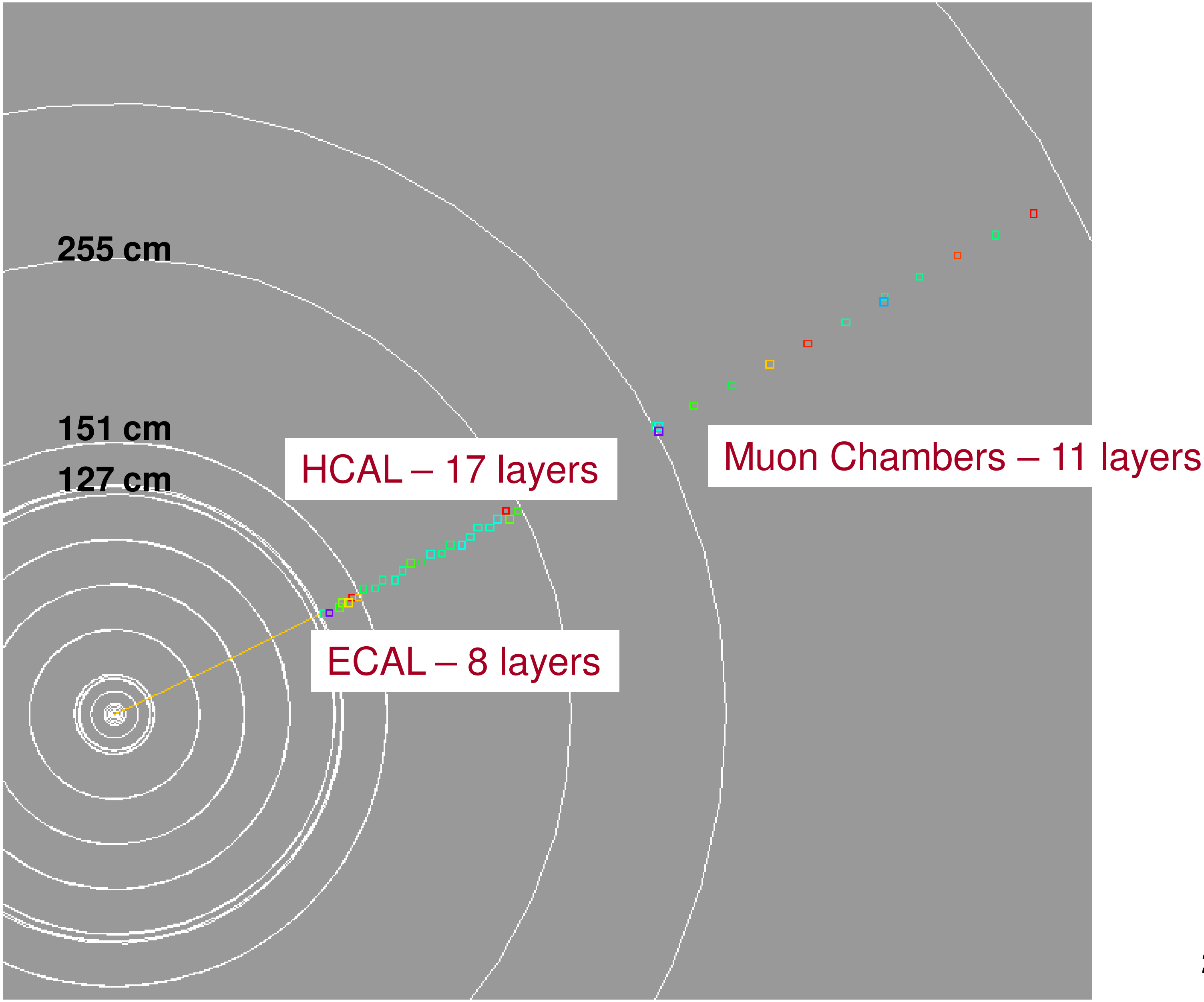
Dual Readout Clustering and Jet Finding

Dual Readout Calorimeter *[in SiD02 Shell]*

DR ECAL	DR HCAL
3 cm x 3 cm x 3 cm BGO	6 cm x 6 cm x 6 cm BGO
8 layers – 21.4 X_0 (1.1 λ_I)	17 layers – 4.6 λI
127 cm IR – 151 cm OR	151 cm IR – 253 cm OR
Scin/Ceren analog hits	Scin/Ceren analog hits

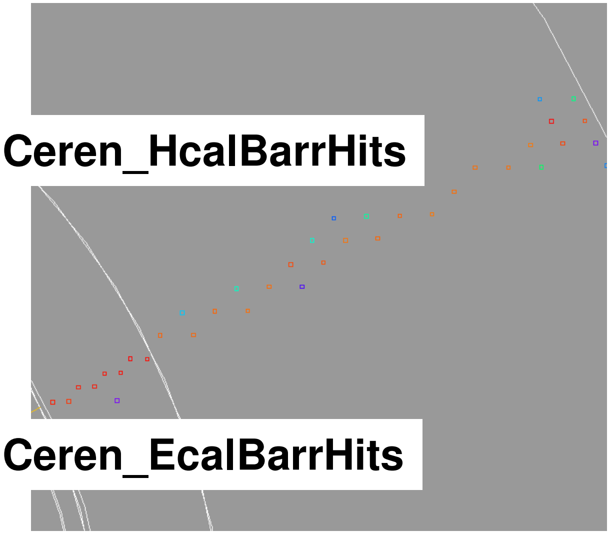
Dual Readout Detector Geometry

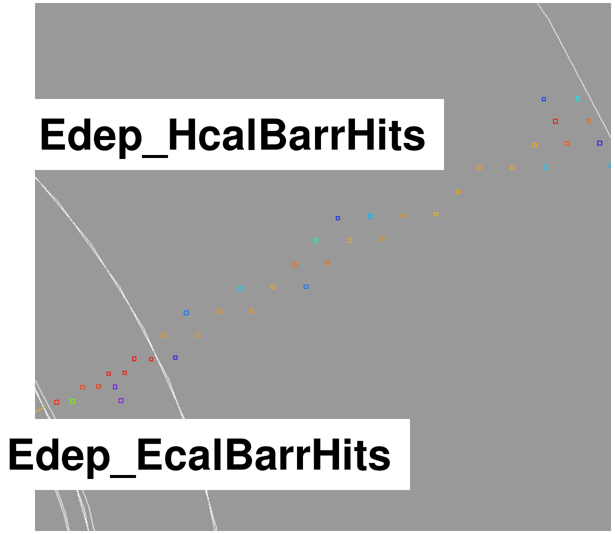


Muons

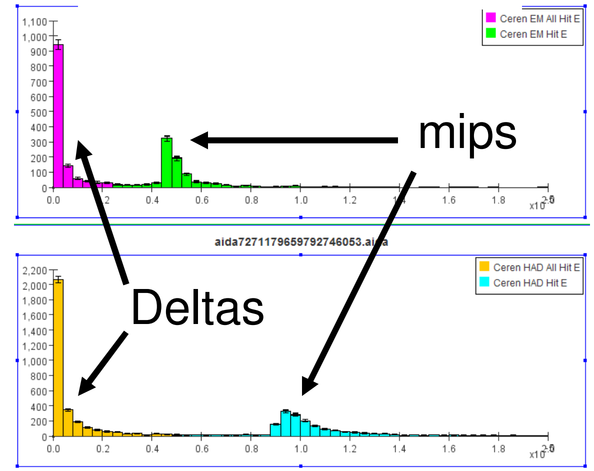
Cerenkov Collections

Scintillator Collections

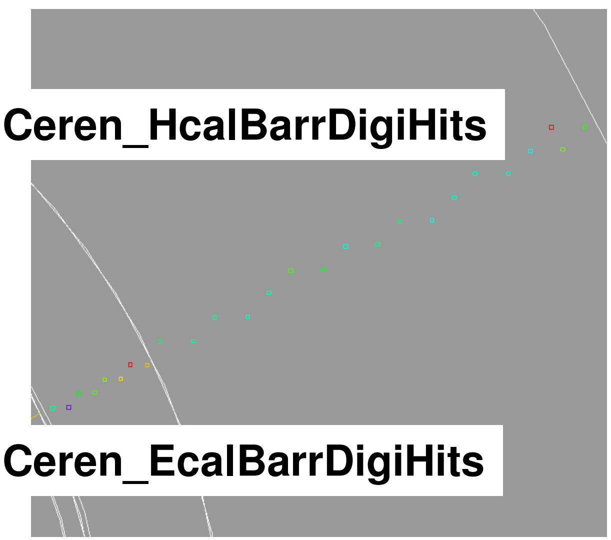


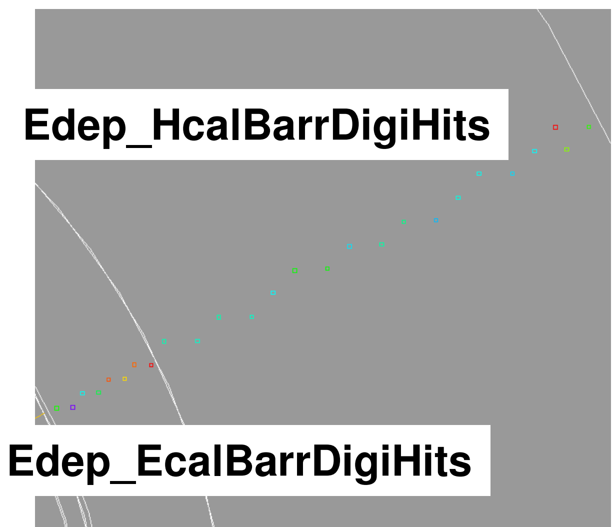


Cerenkov EM,HAD

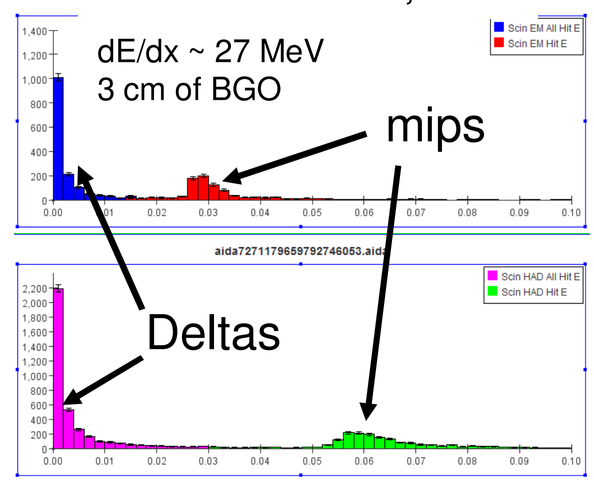


DigiSim - ½ mip threshold, 50 ns timing cut

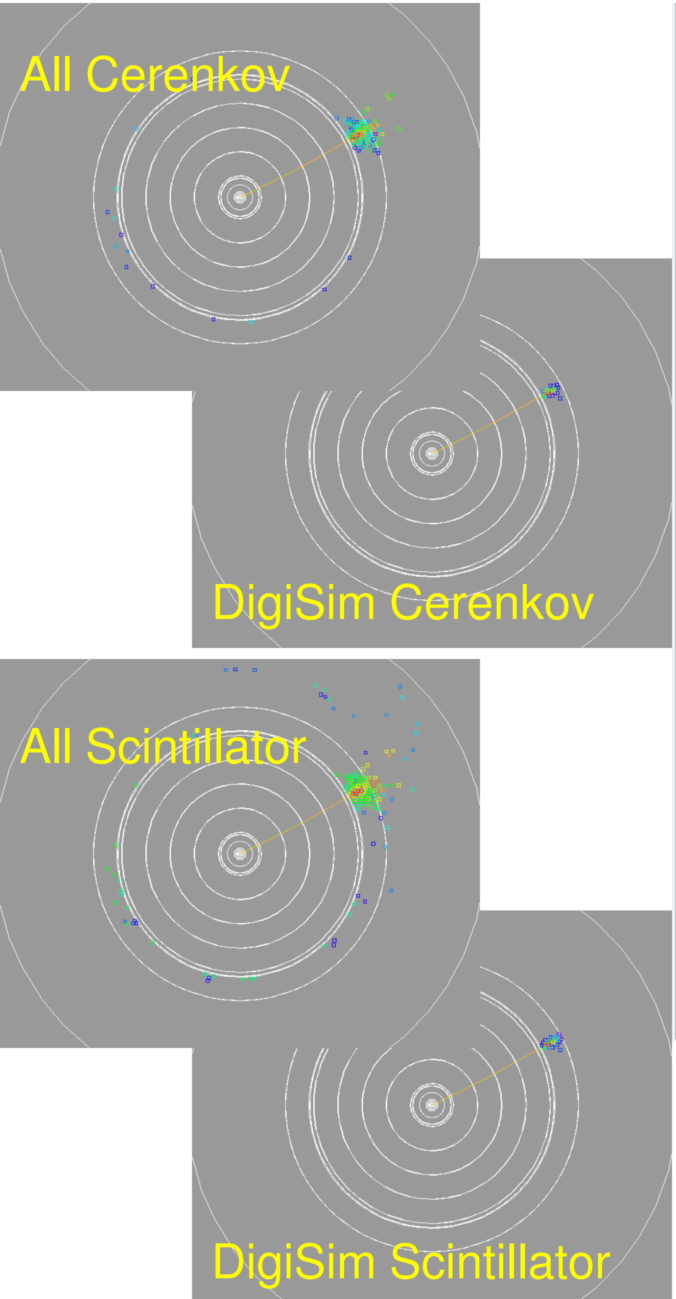


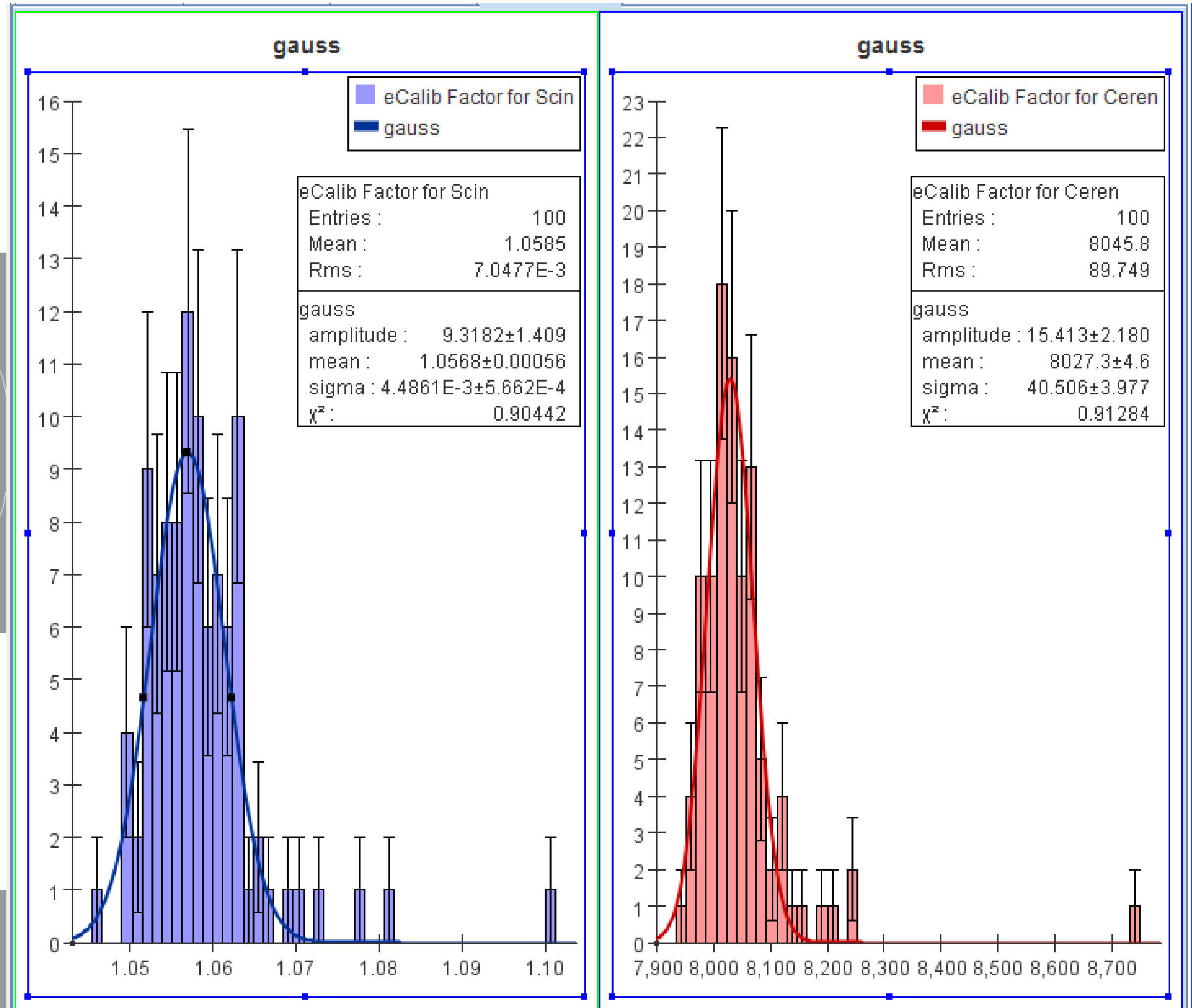


Scintillator EM,HAD



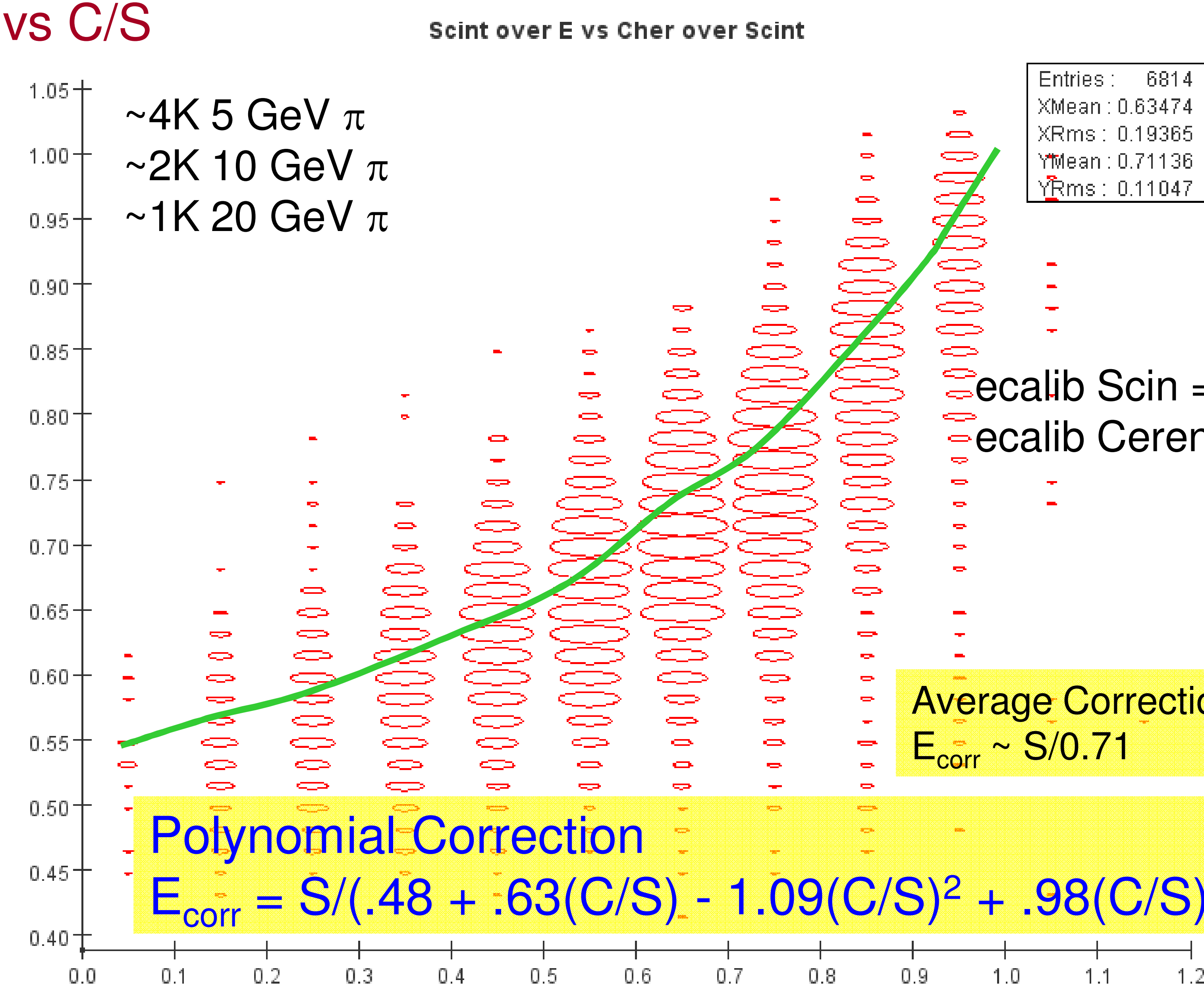
Electron Calibration for Scintillator, Cerenkov





$S = 1.06 \times s_{raw}$ $C = 8046 \times c_{raw}$

S/E vs C/S



S/E

~4K 5 GeV π
~2K 10 GeV π
~1K 20 GeV π

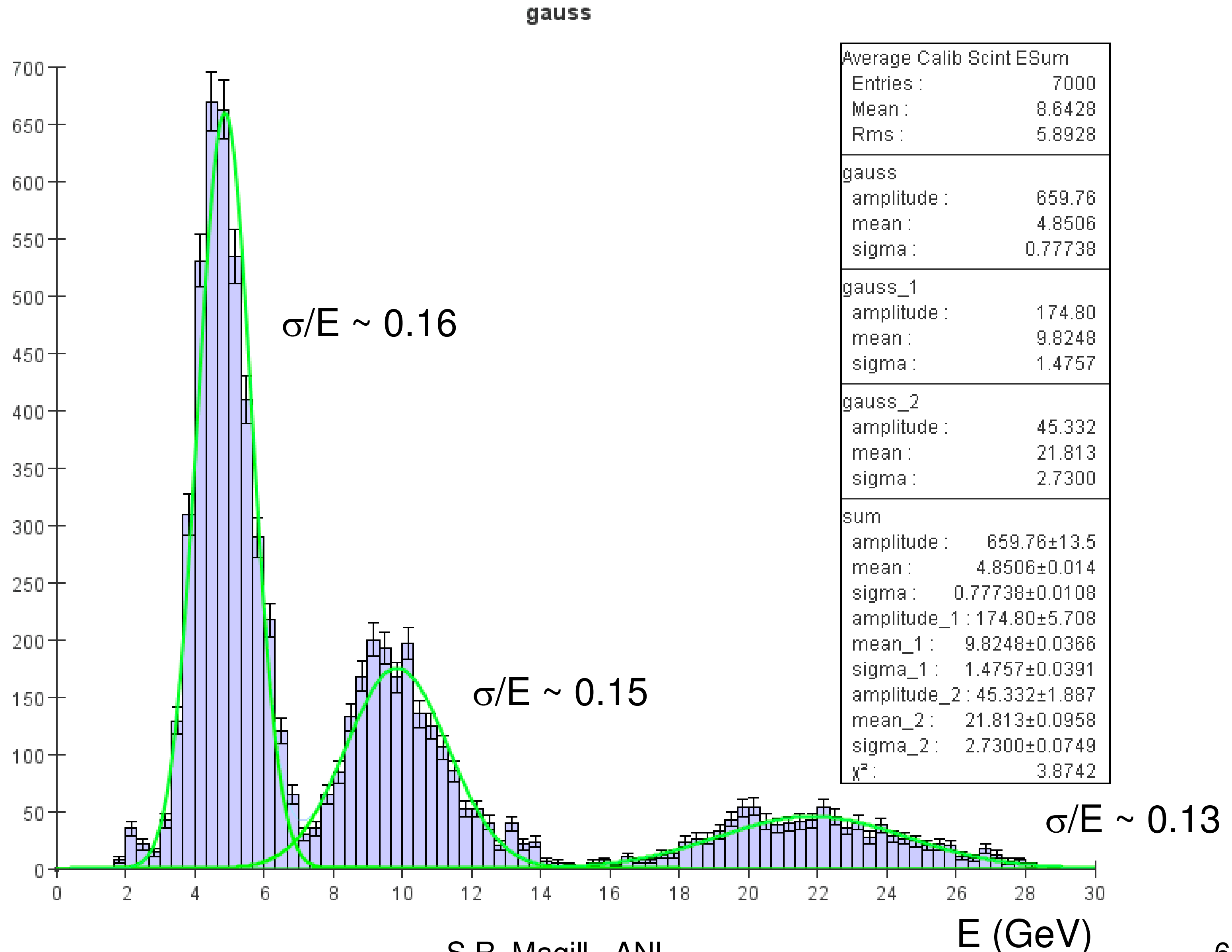
ecalib Scin = 1.05
ecalib Ceren = 7900

Average Correction
$E_{corr} \sim S/0.71$

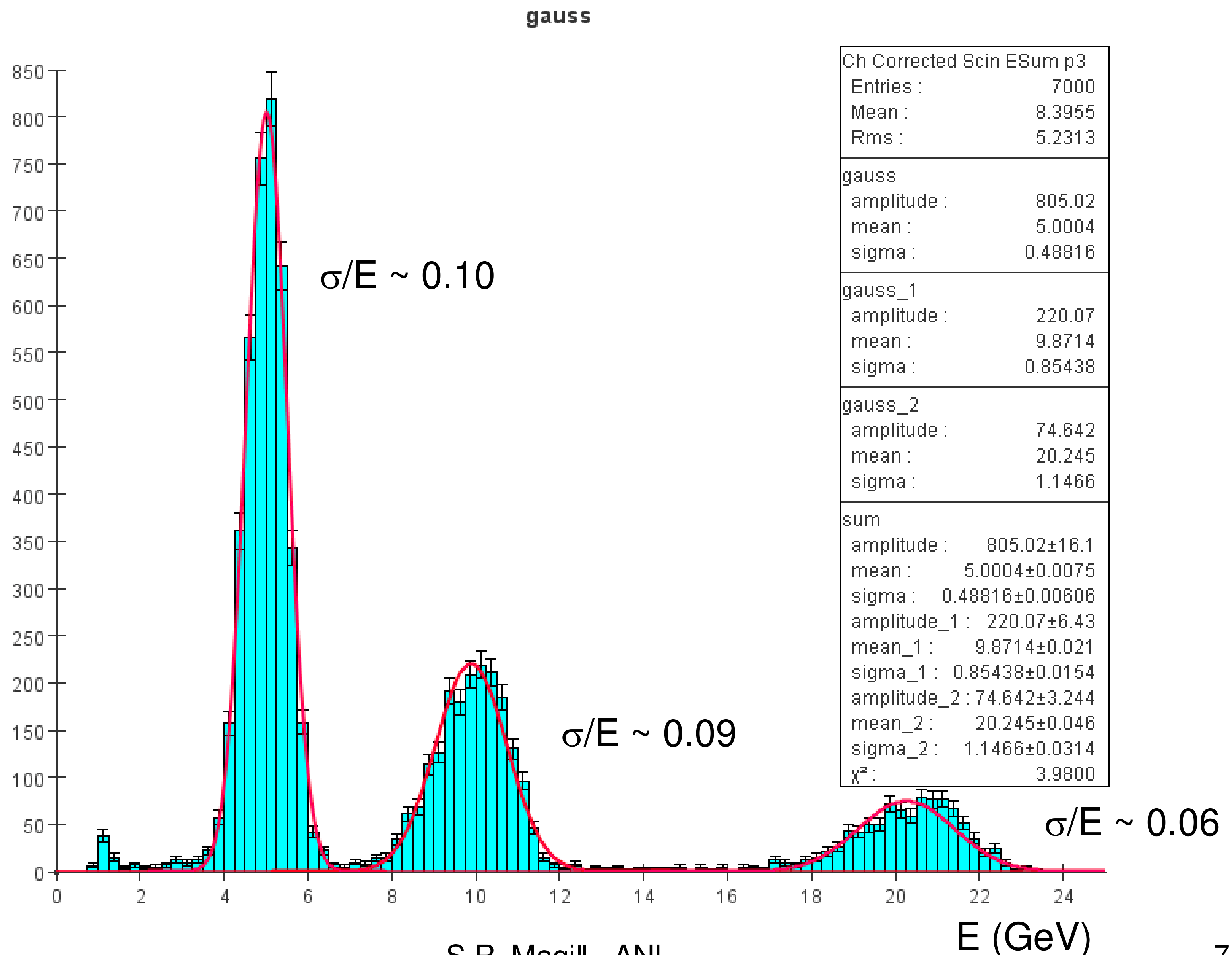
Polynomial Correction
$E_{corr} = S/(.48 + .63(C/S) - 1.09(C/S)^2 + .98(C/S)^3)$

C/S

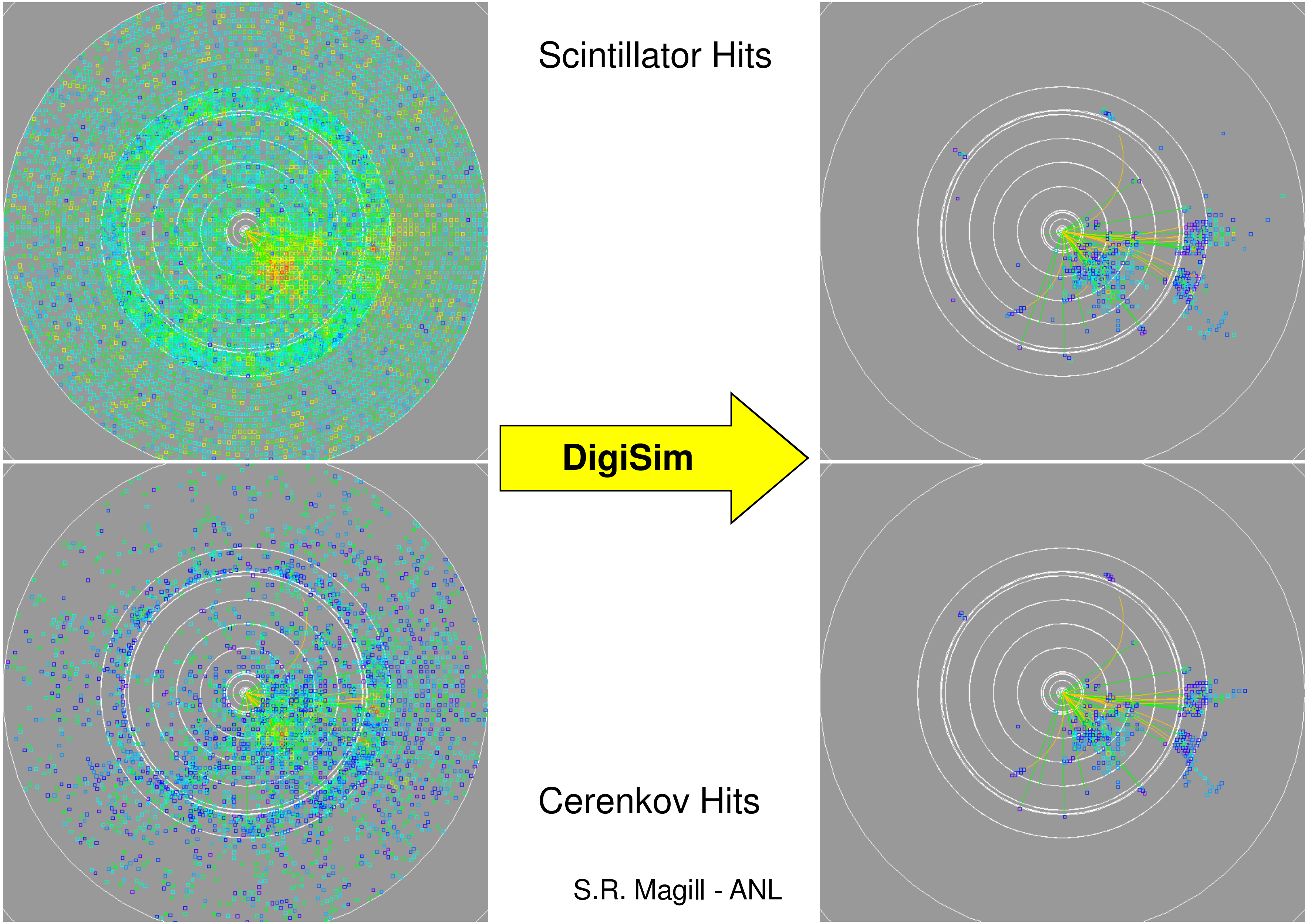
Corrected Scintillator signal for pions using average



Corrected Scintillator signal for pions using P3 Polynomial

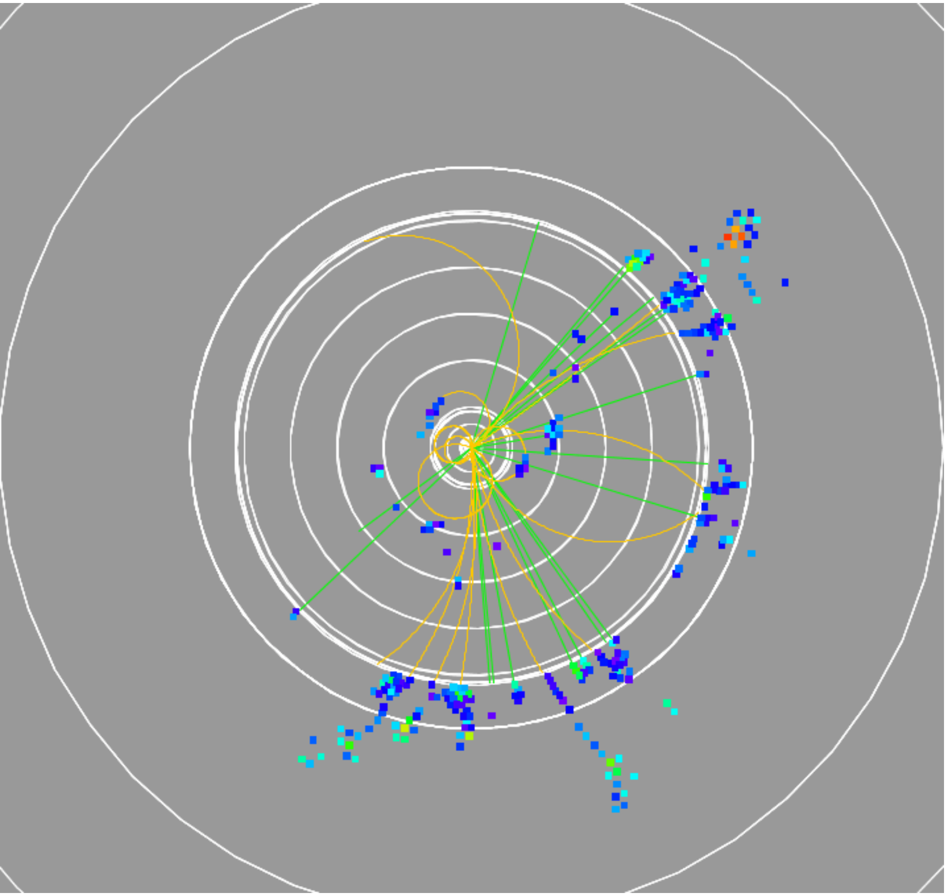


e+e- -> ZZ -> ννqq @ 500 GeV

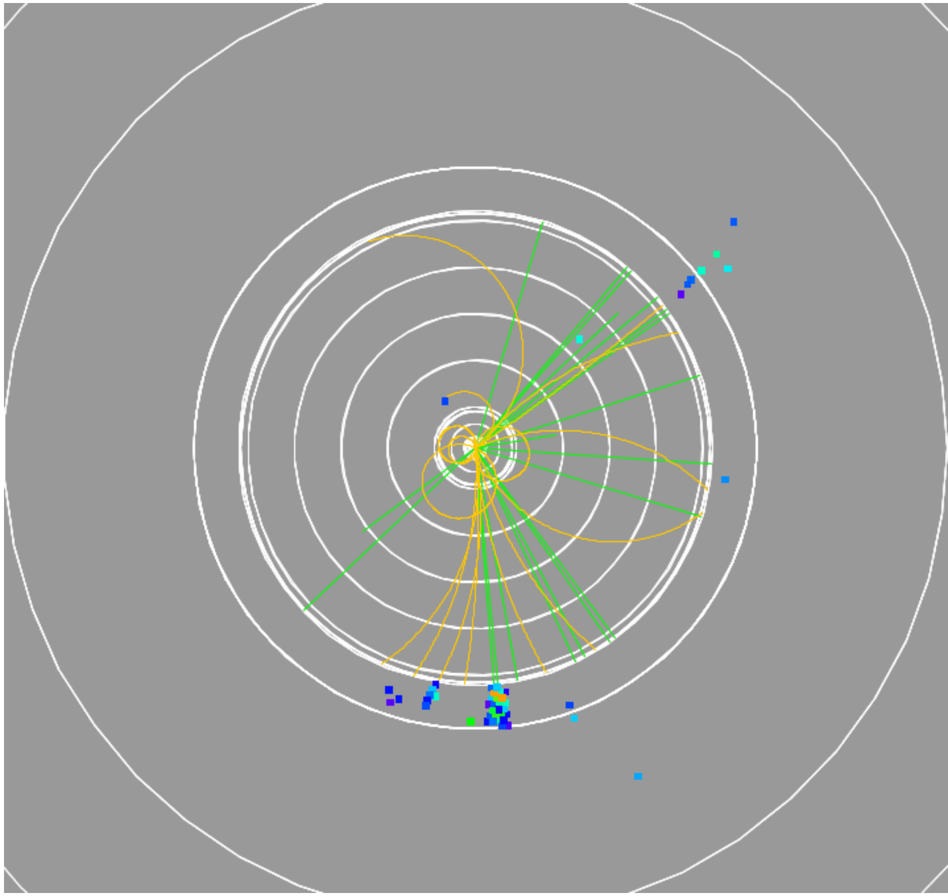


MC Particle Contribution to Cal Cells

Scintillator Hit Collections



Single Particle



Multiple Particles

Mip-finding in DR Cal

Cerenkov and Scintillator response to charged particles – Cerenkov signal << Scintillator signal

a) Threshold for production in media
b) Directional dependence

Disadvantage of using Scintillator signal

1) Shower covers interaction point due to backscattered particles

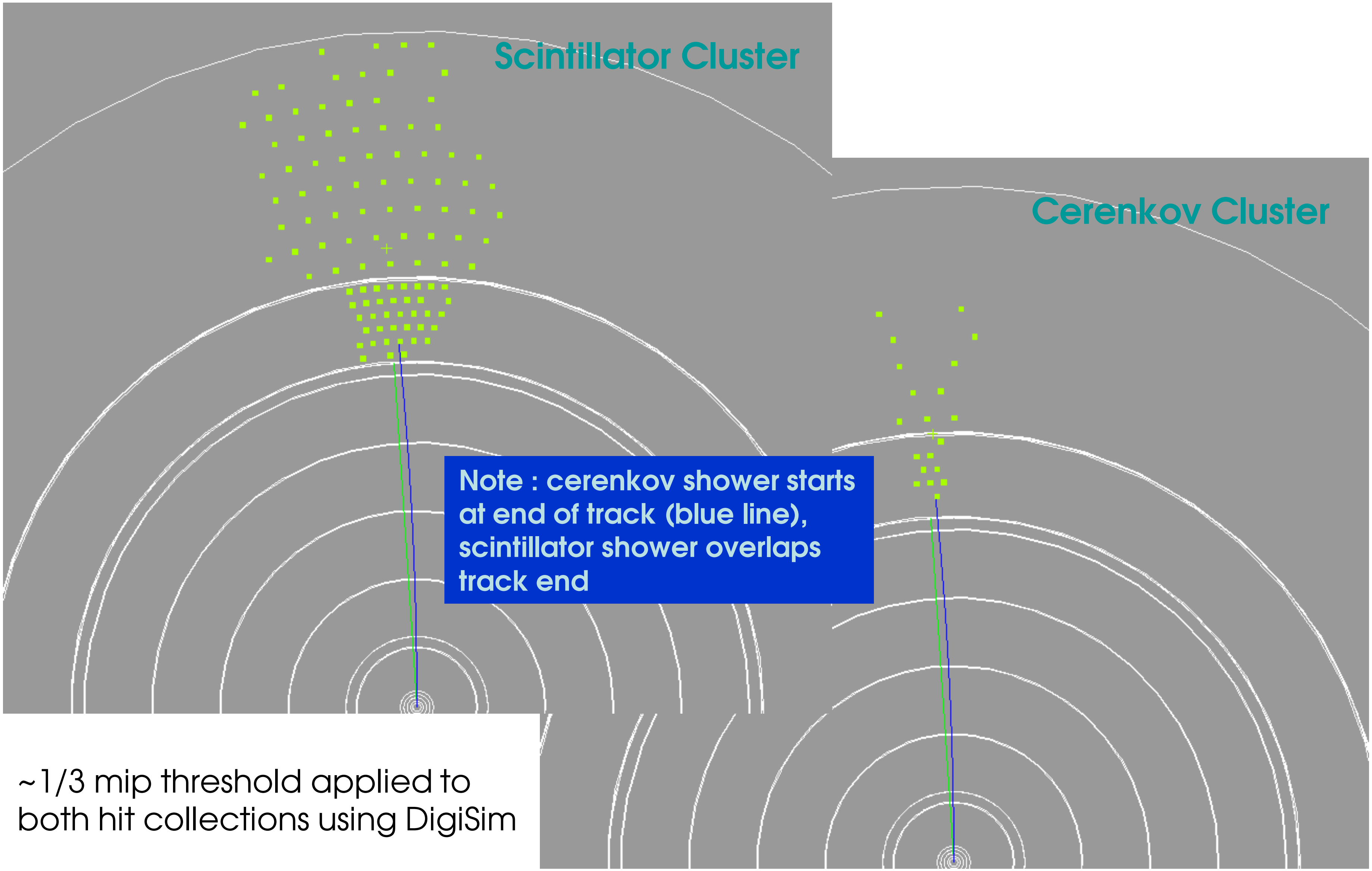
Disadvantages of using Cerenkov signal

1) Low Cerenkov light yield
2) Signal sensitive to readout SiPM position on cell

Advantages of using Cerenkov signal

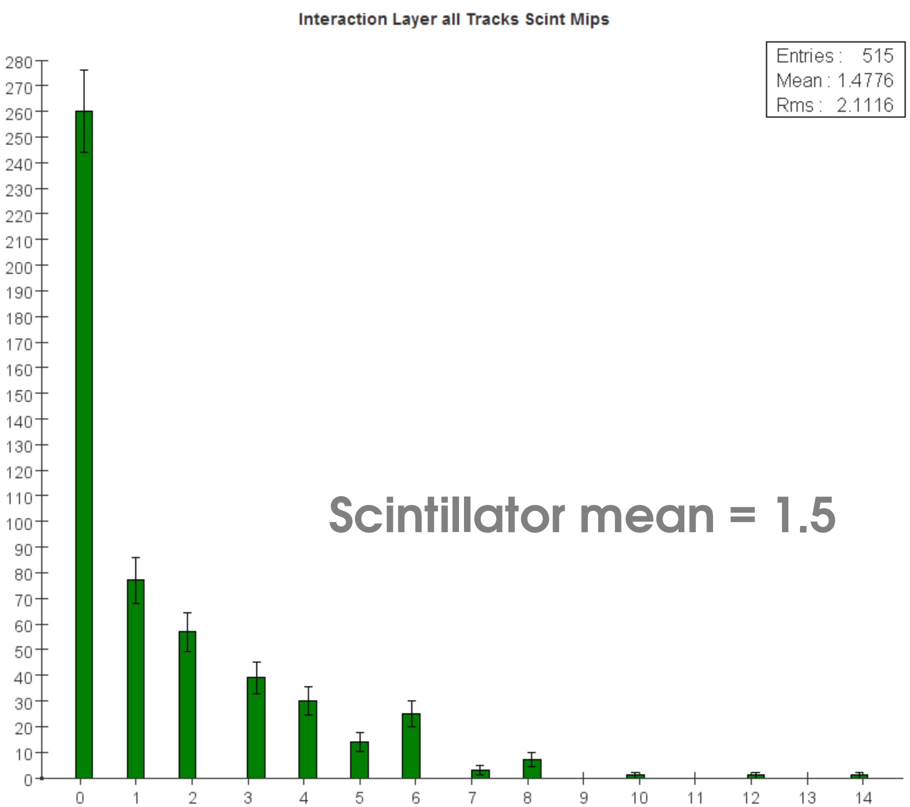
1) Less sensitive to (soft) EM interactions
2) Less sensitive to (also soft) backscattered particles?
3) Directional dependence useful for finding interaction point inside scintillator shower?

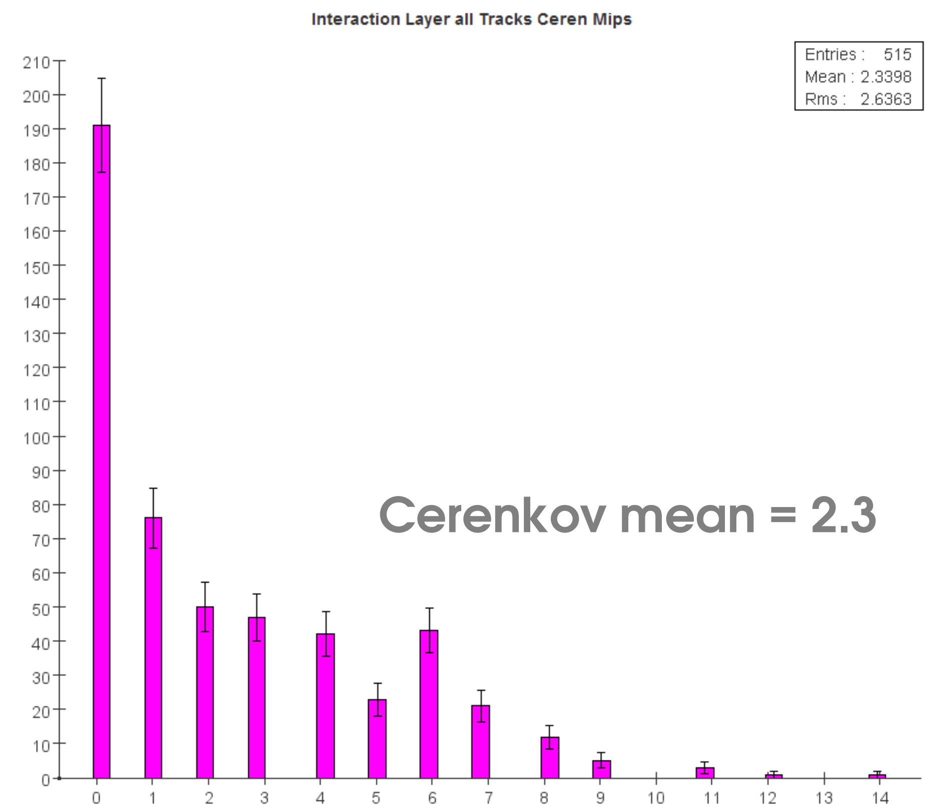
20 GeV pion shower in Dual Readout Calorimeter



~1/3 mip threshold applied to both hit collections using DigiSim

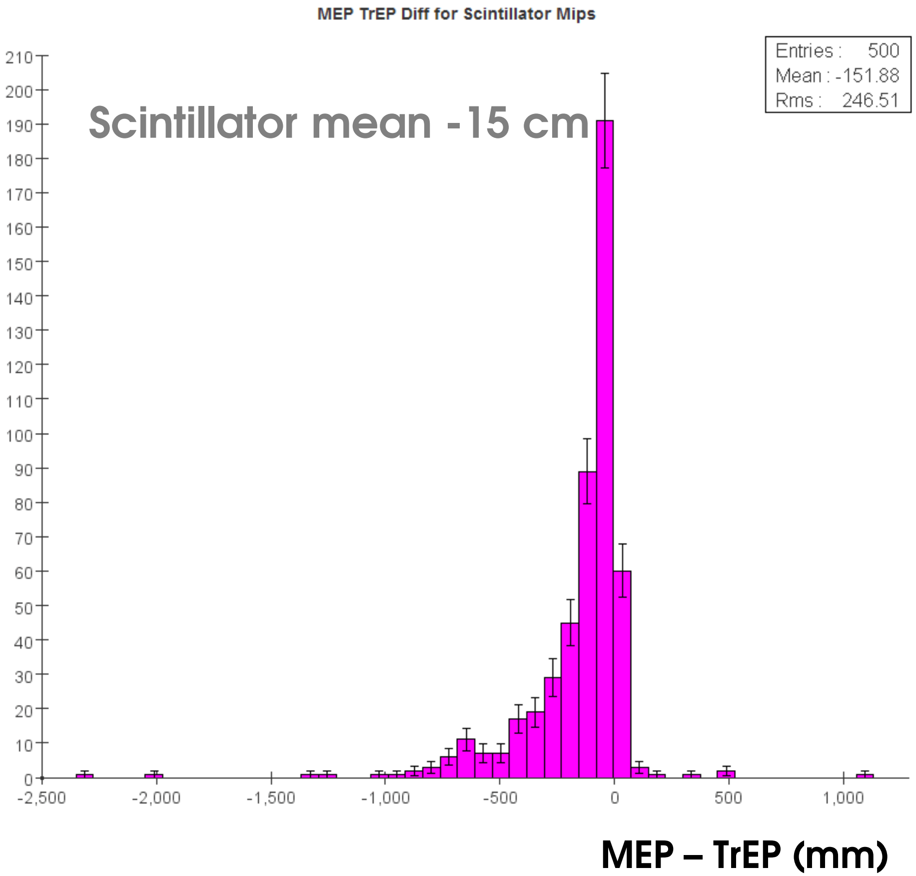
Interaction Layer Comparison

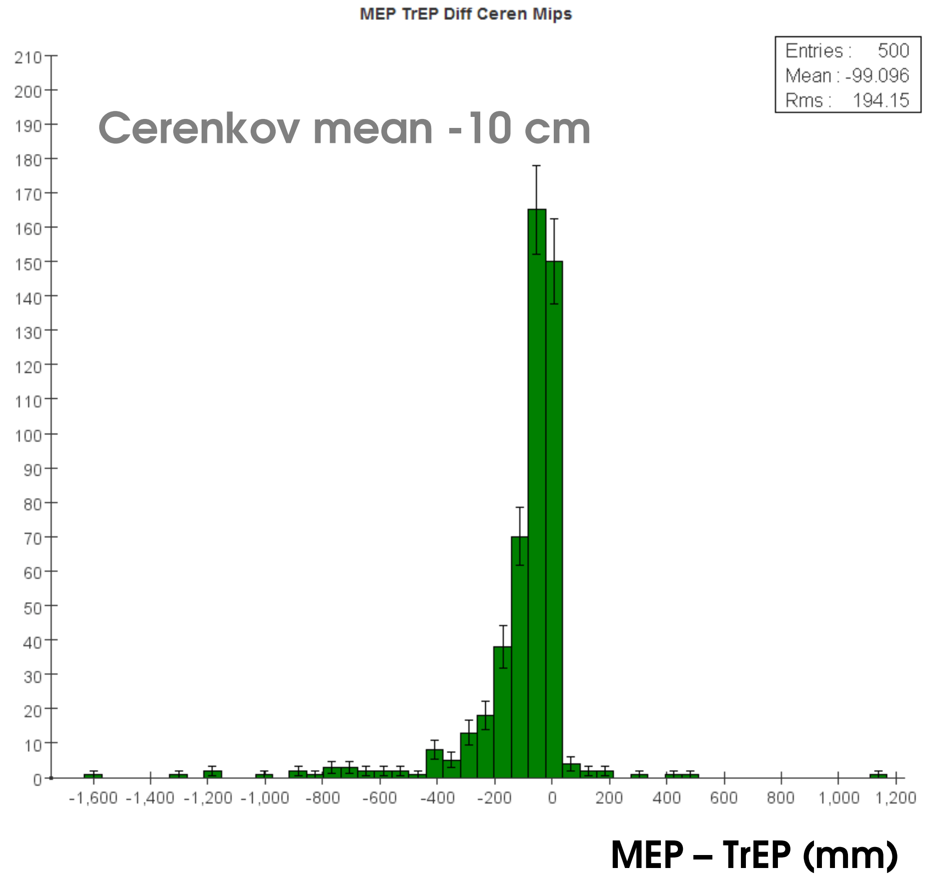




Interaction layer determined by either 0 or multiple hits in layer in a window defined by the position of extrapolated track
~ 1 layer deeper using Cerenkov hits

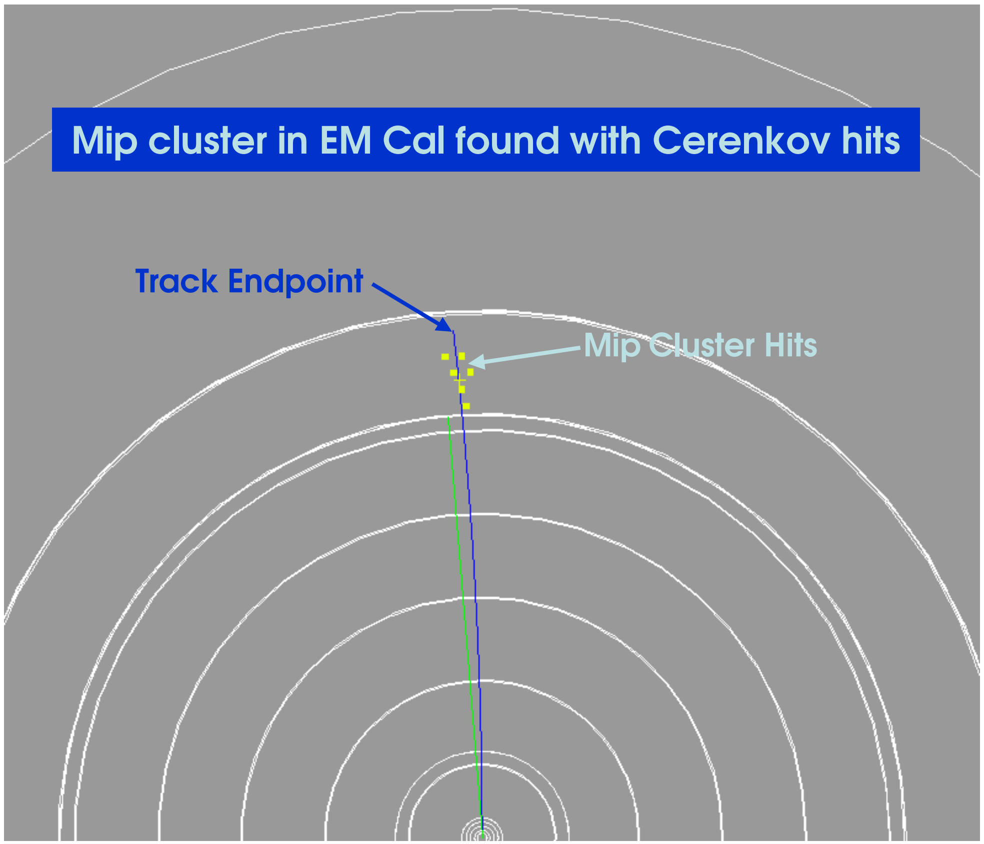
Difference between Mip and Track Endpoints

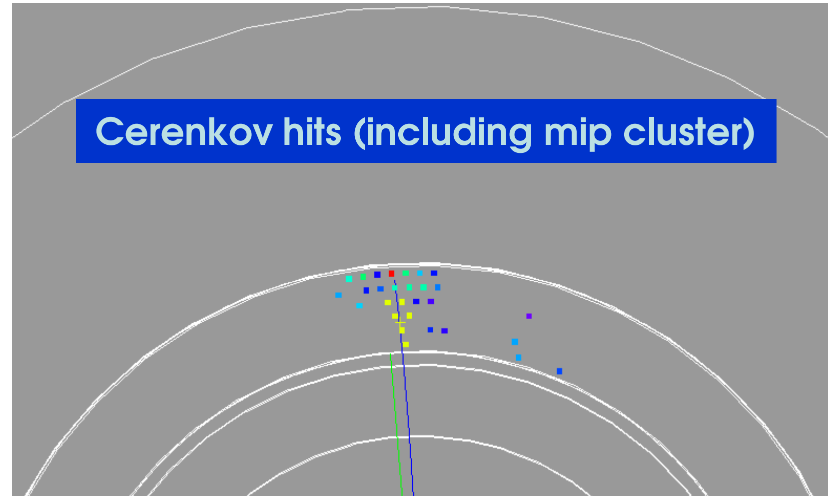


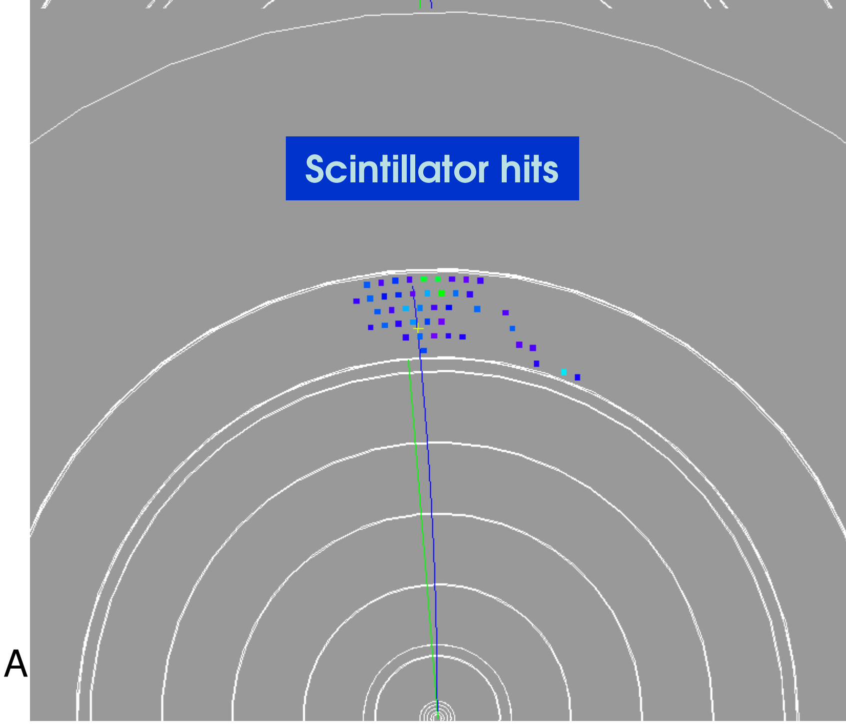


Both Mip EPs shallower than track EP, but average Cerenkov Mip EP closer to track endpoint, again by 5 cm which is 1 layer in the ECAL

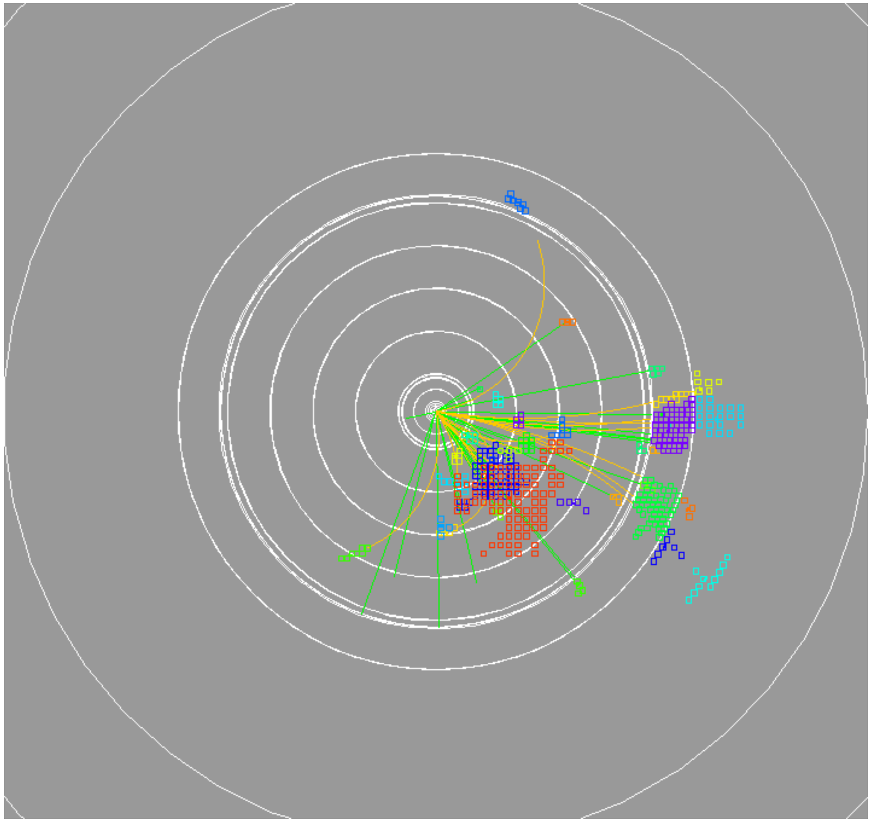
Mip Cluster compared to Hit Collections



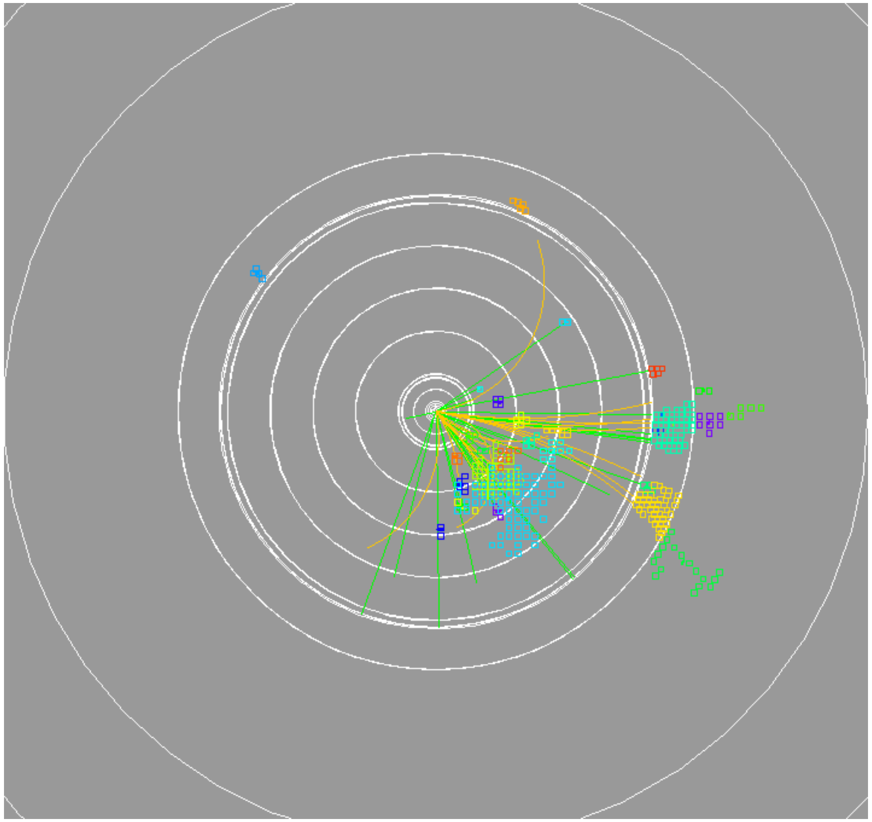




Nearest Neighbor Clustering

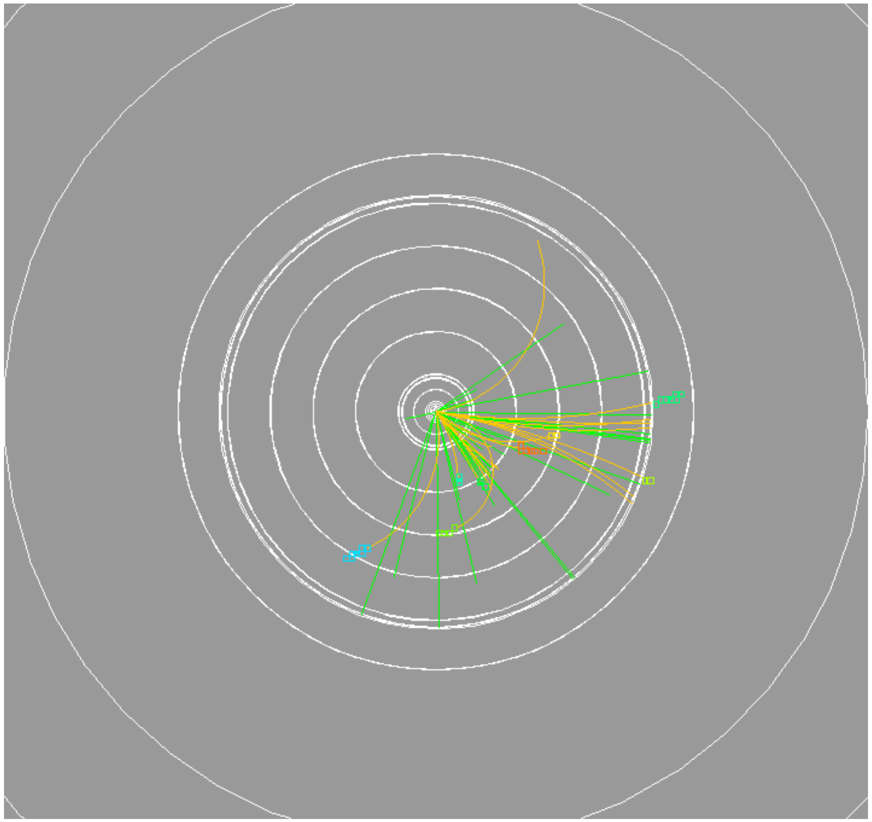


Scintillator Clusters

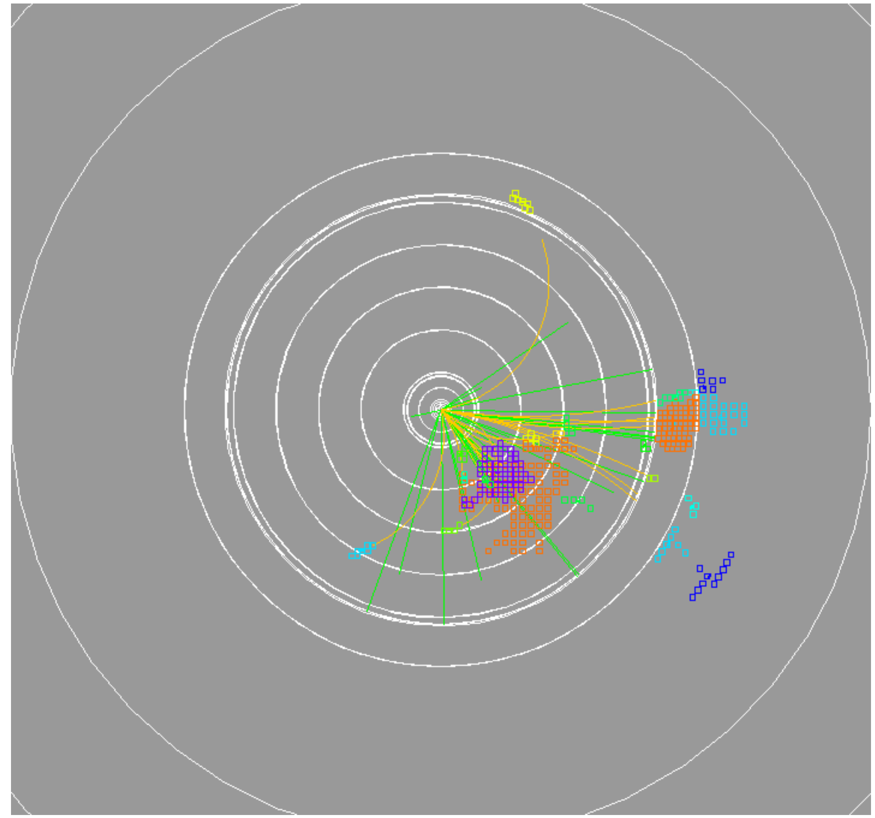


Cerenkov Clusters

Clusters Associated with Charged Particles (Tracks)



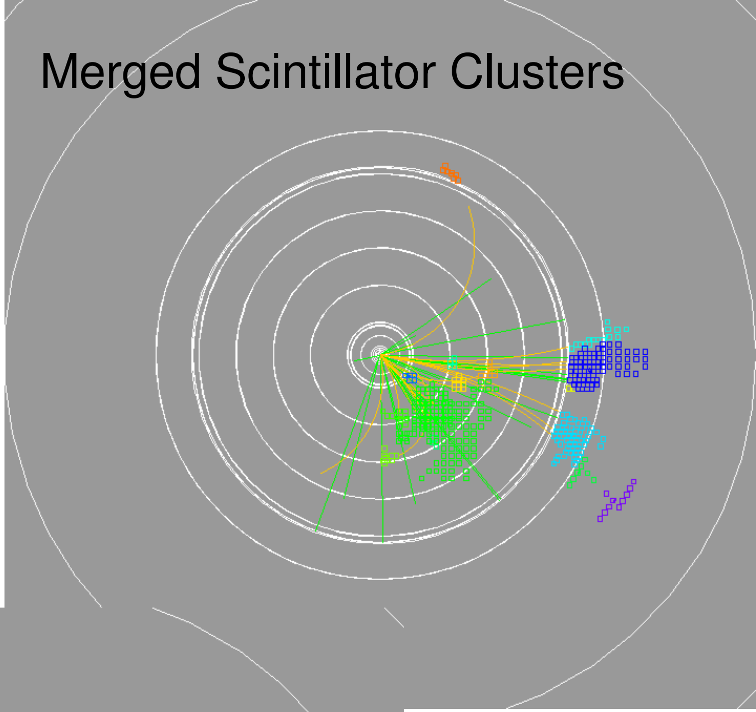
Mip clusters

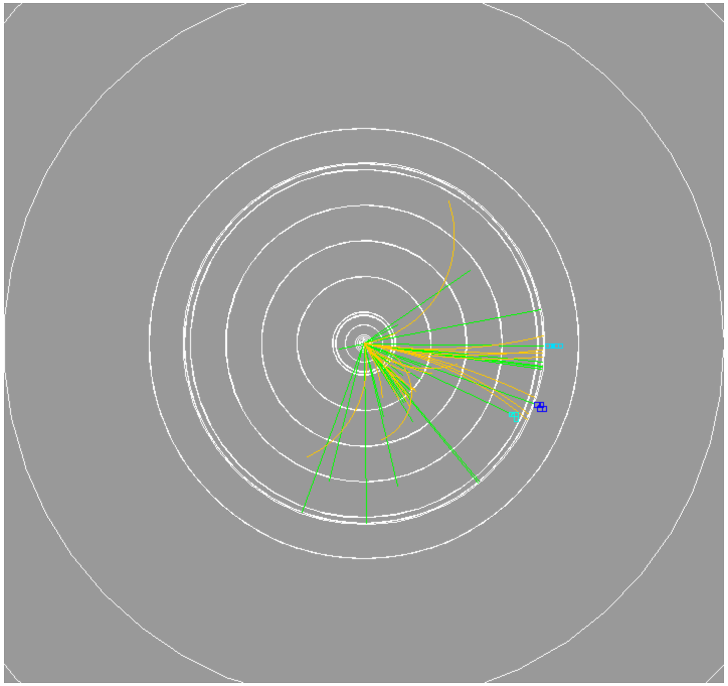


Track-associated clusters

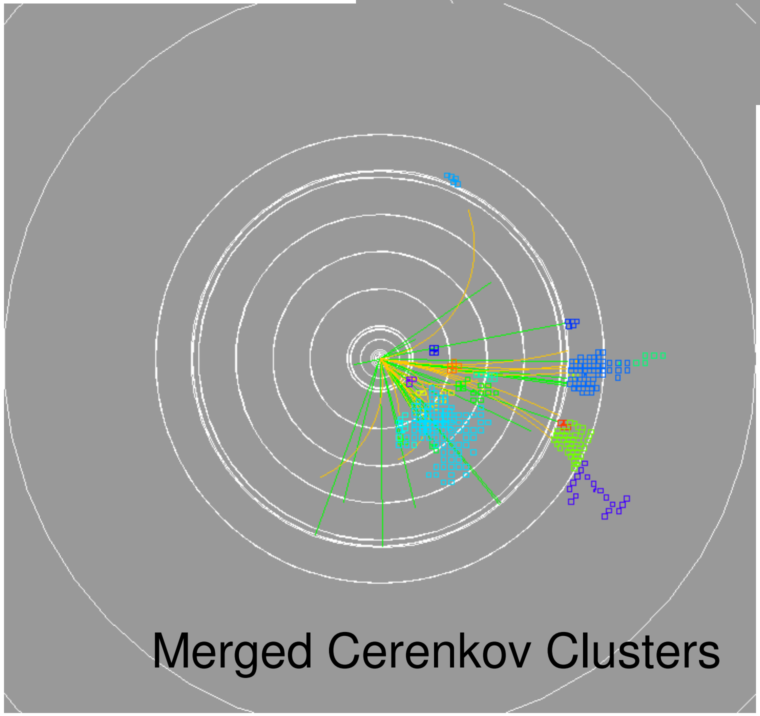
Uses : Core Cluster Algorithm, Cluster-Pointing Algorithm, E/P, etc.

Photon Clusters and Merged Clusters





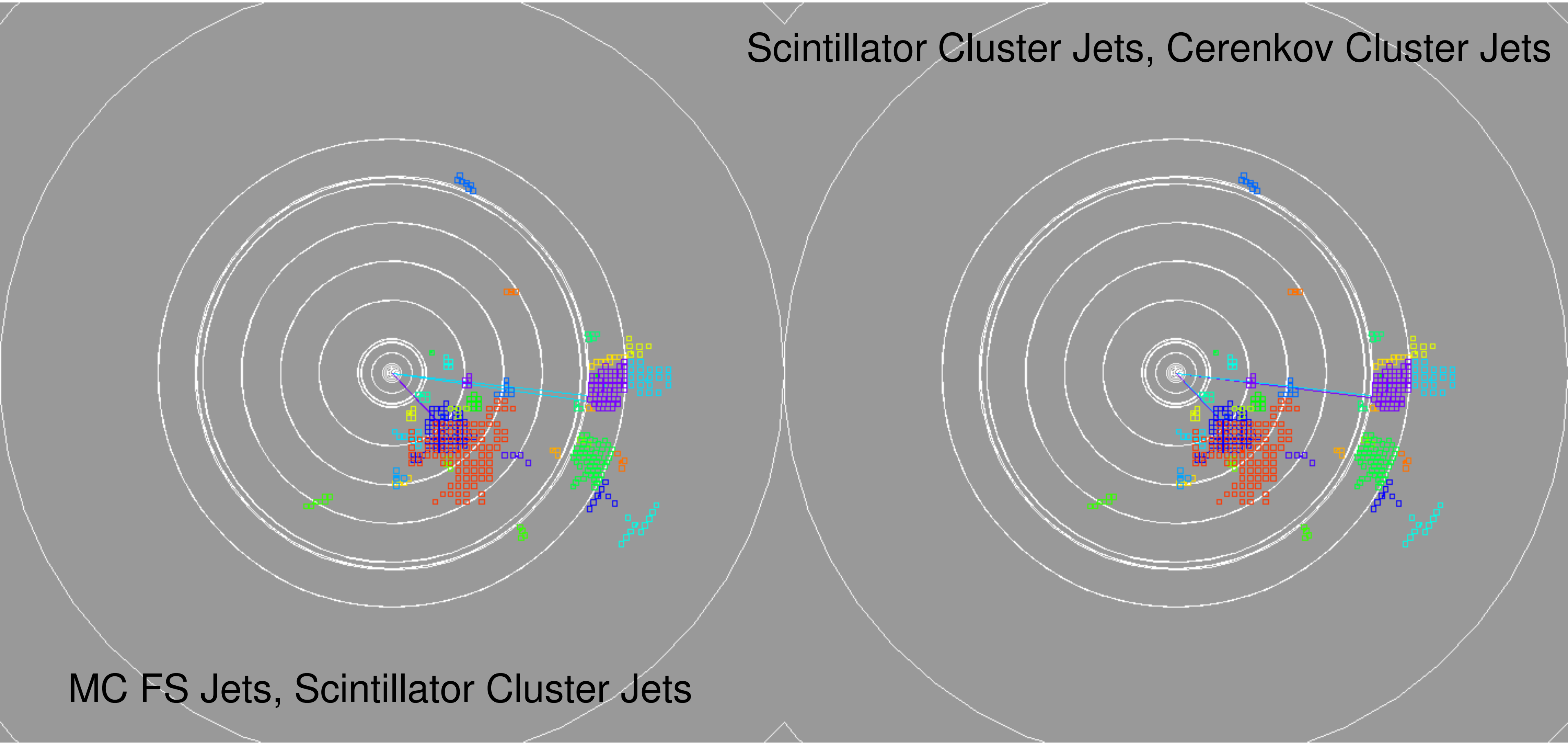
Photon Clusters



Cluster correction – use merged cerenkov clusters linked with merged scintillator clusters to apply polynomial correction

Jets

Jet finding with kT algorithm – 2 jet mode



Jet correction – use cerenkov jets linked to scintillator jets to apply polynomial correction – compare to result with cluster correction

Applying PFA algorithms to Dual Readout Calorimeter

So far – can use mip-finding, cluster pointing, core clustering, photon-finding algorithms developed in one detector (SiD) on a different detector (DR).

With no Particle Flow :
Can correct objects in events - jets, clusters, etc., using C/S ratio

With Particle Flow :
Use tracks when track/cluster associations are made