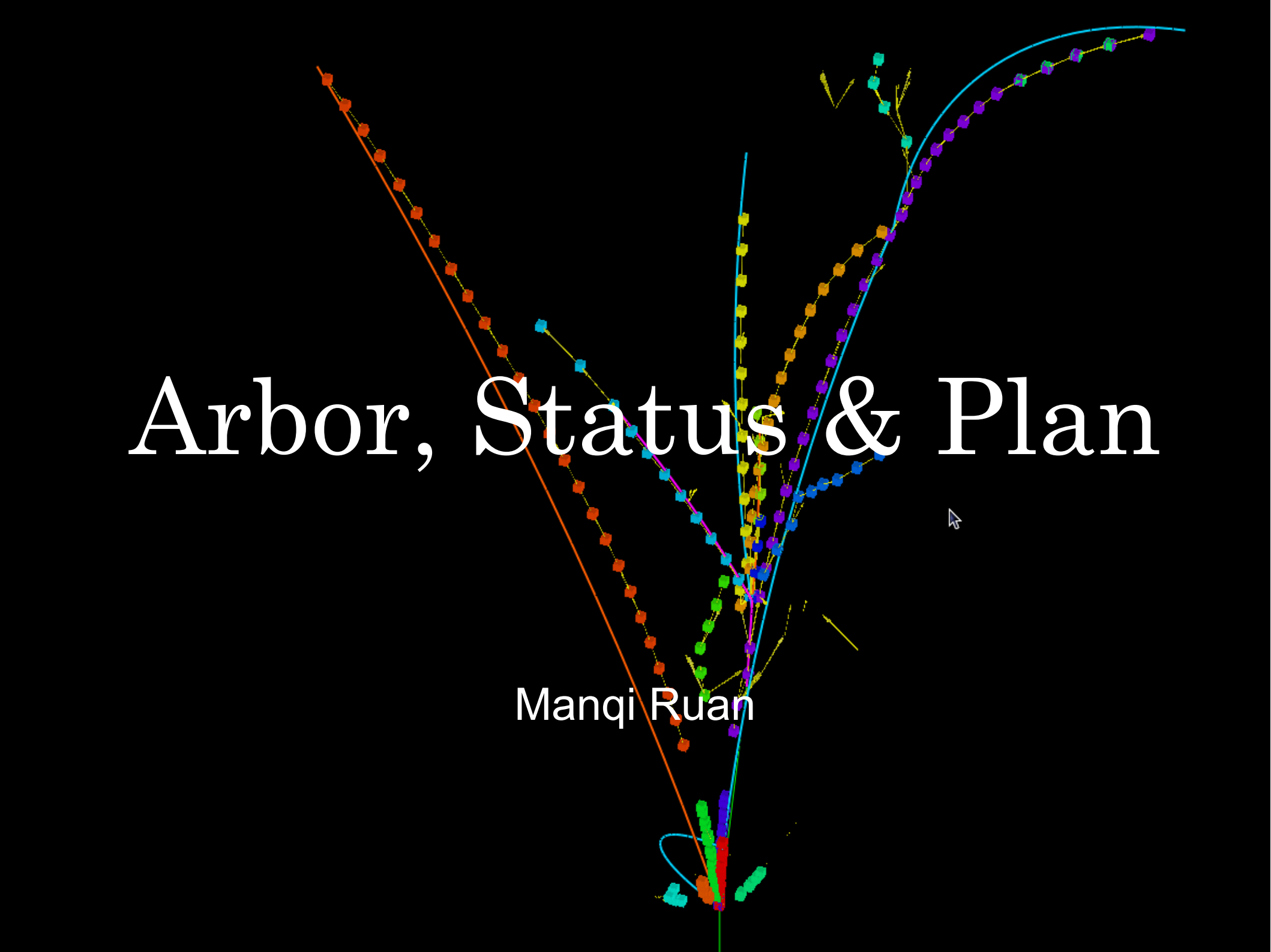
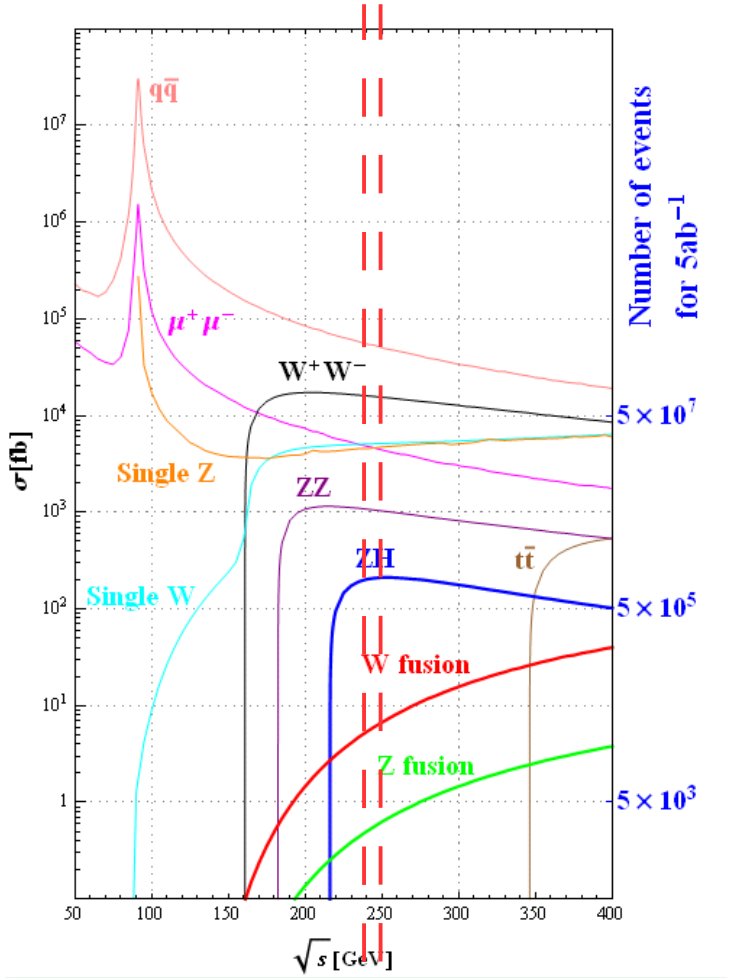
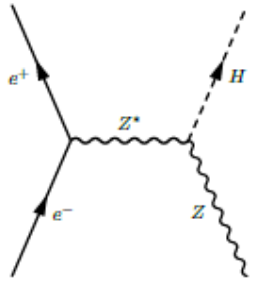
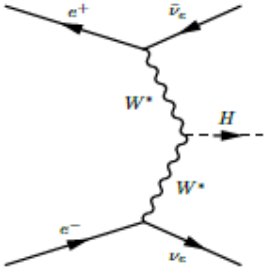
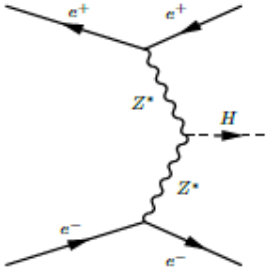

Arbor, Status & Plan
Manqi Ruan

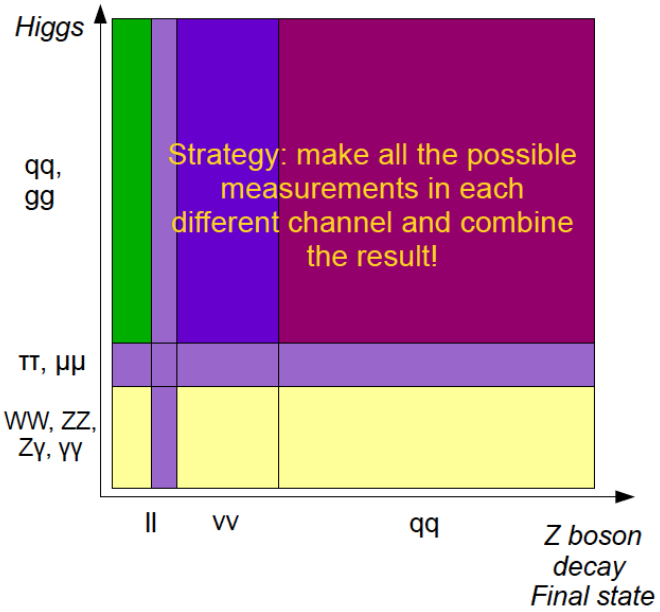
ILD based CEPC Conceptual detector

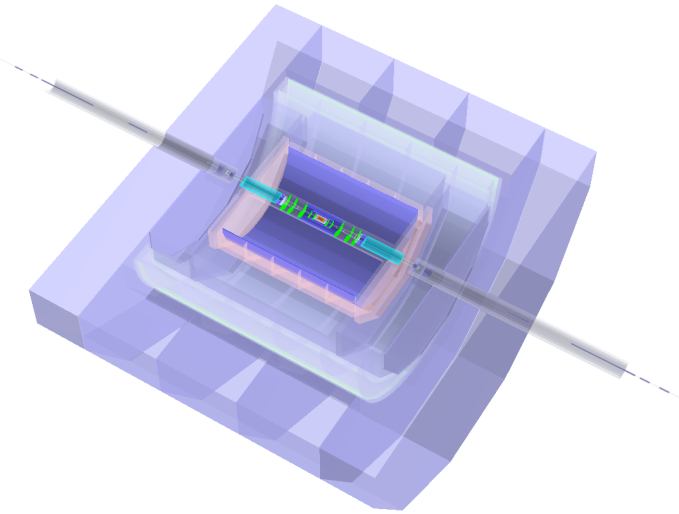




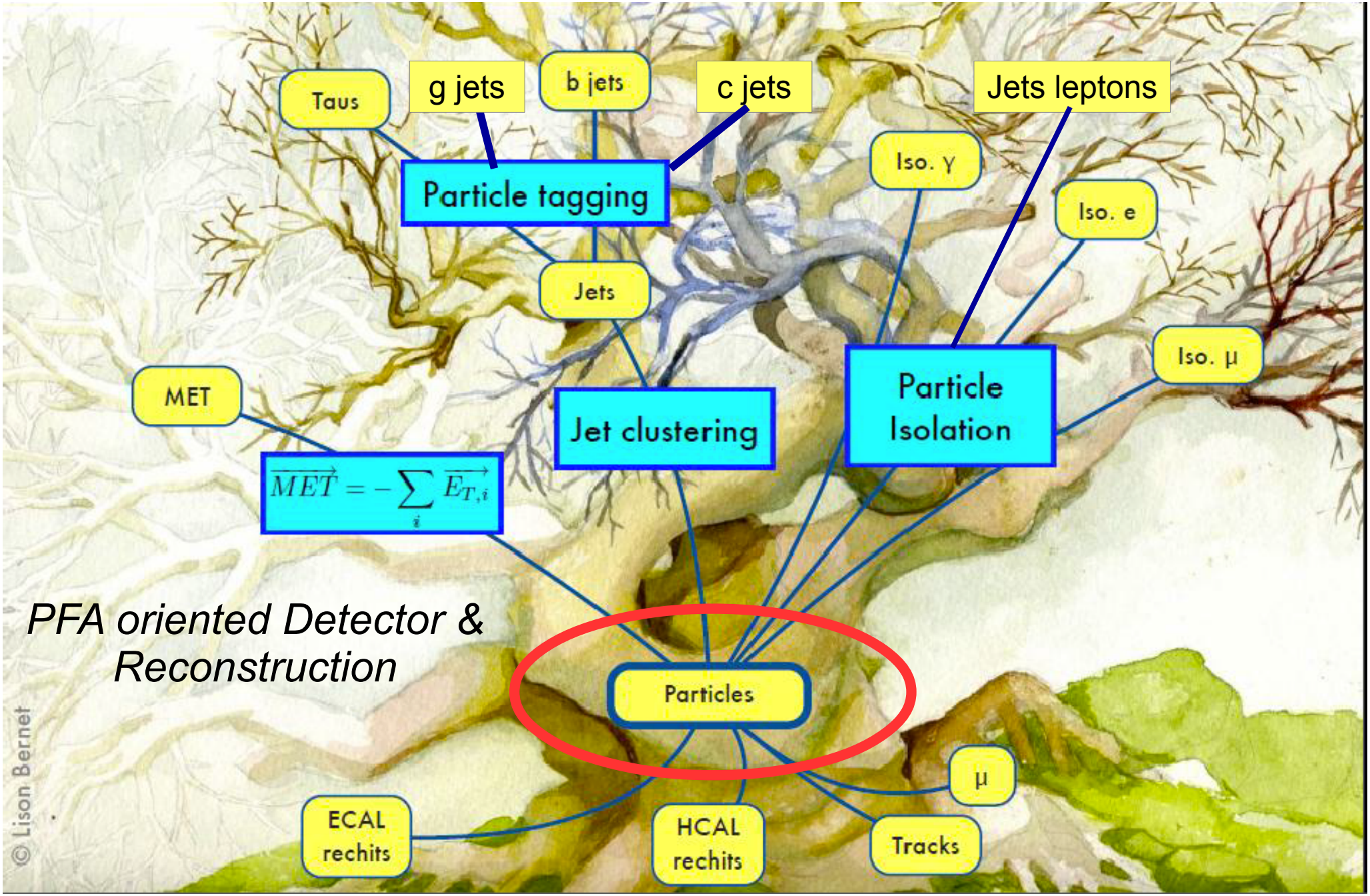




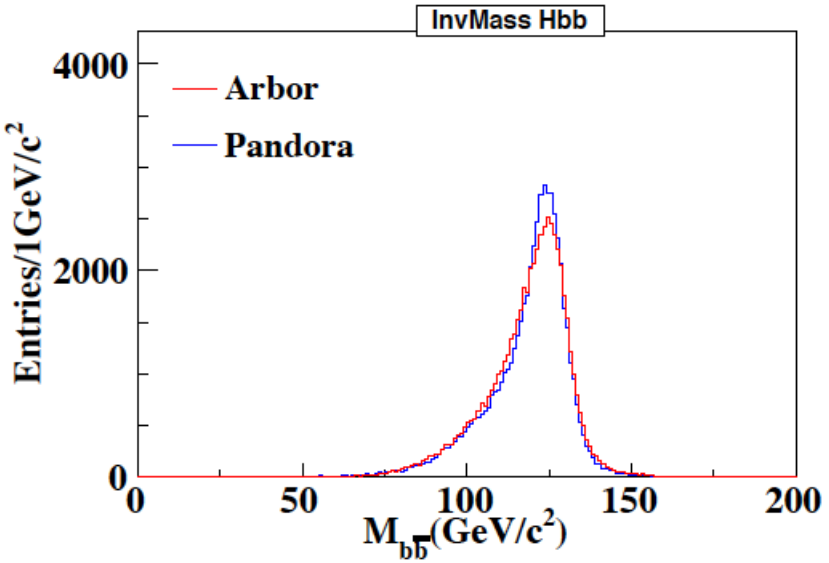


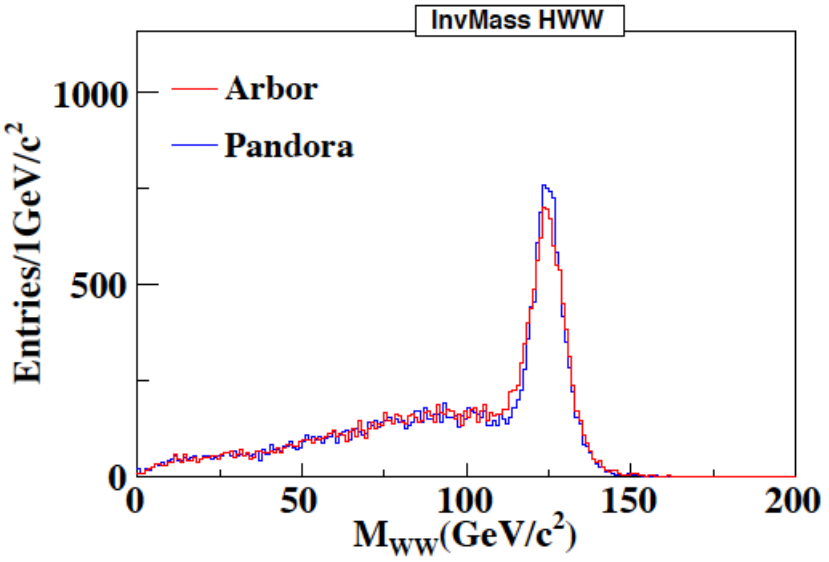


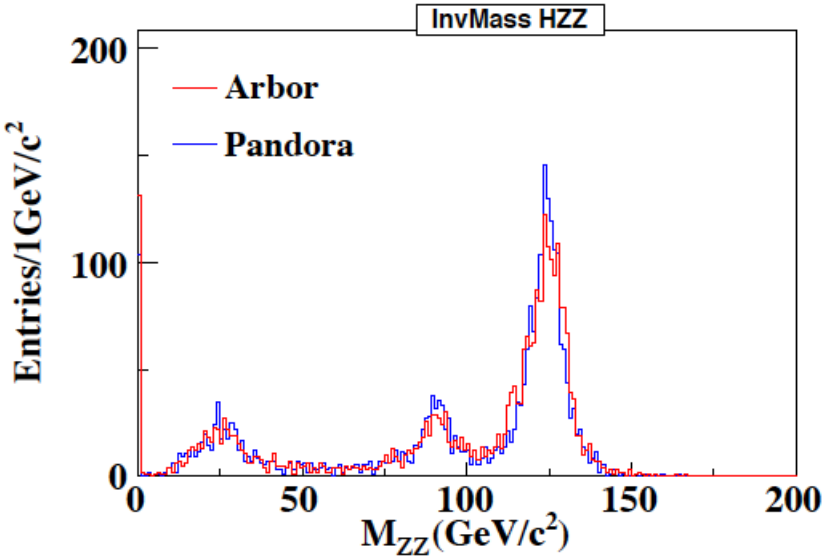
A detector reconstruct all the physics object (lepton, photon, tau, Jet, MET, ...) with high efficiency/precision

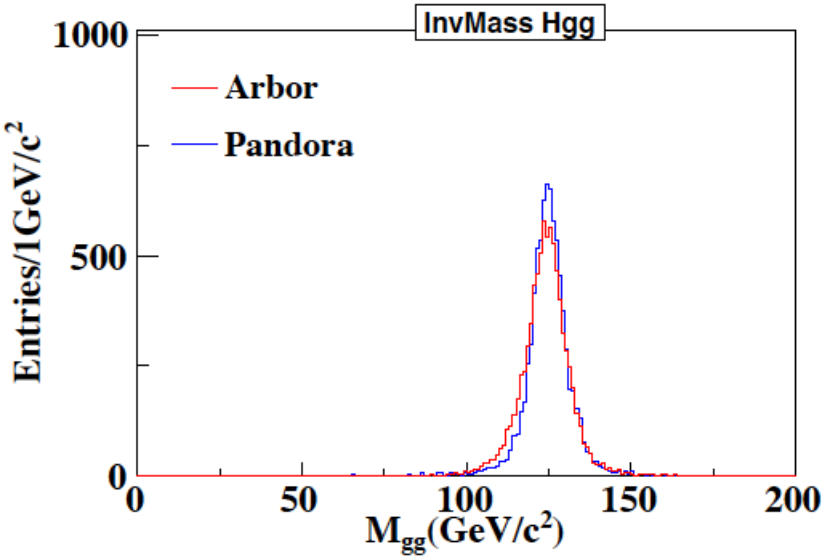

Taus
g jets
b jets
c jets
Jets leptons
Particle tagging
Iso. γ
Iso. e
Jets
Iso. μ
MET
Jet clustering
Particle Isolation
$\overrightarrow{MET} = -\sum_i \overrightarrow{E_{T,i}}$
PFA oriented Detector & Reconstruction
Particles
μ
ECAL rechits
HCAL rechits
Tracks
© Lison Bernet

JER: Invariant mass of vvH events



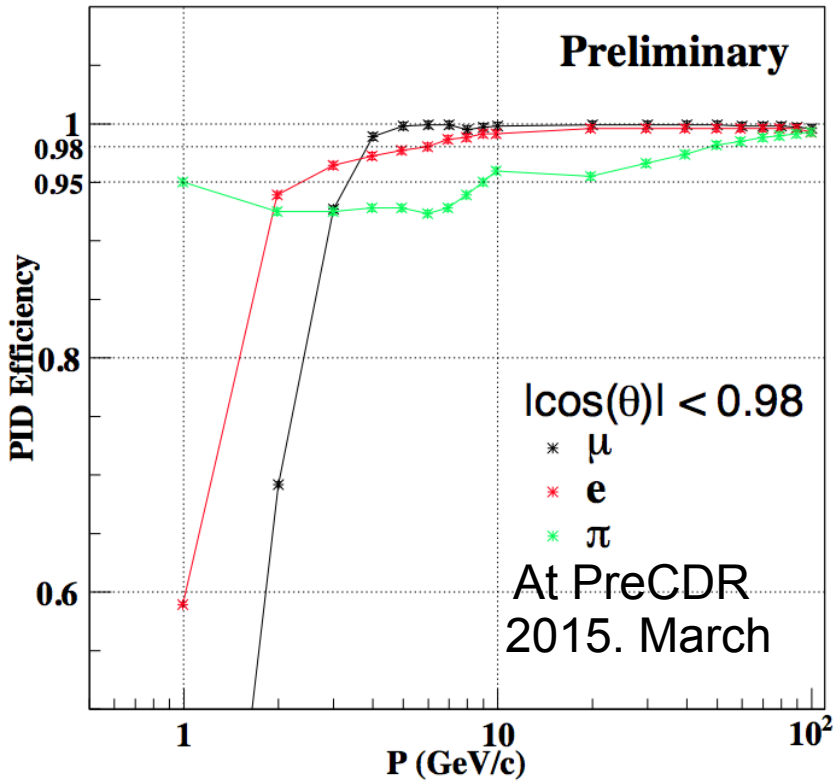


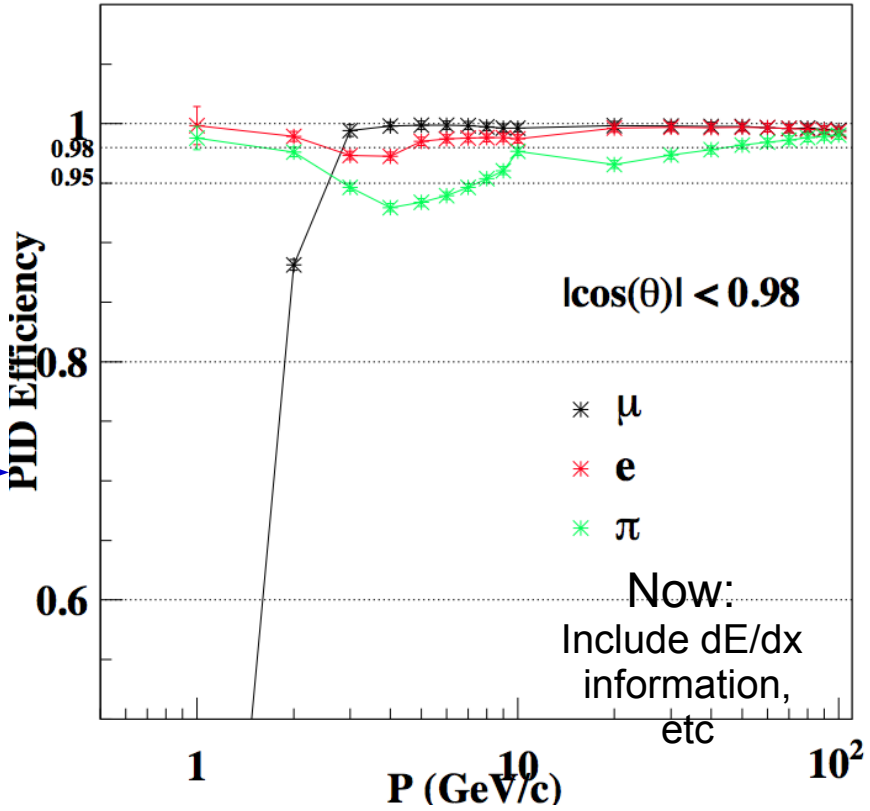




@DHCAL with simple Energy Estimator

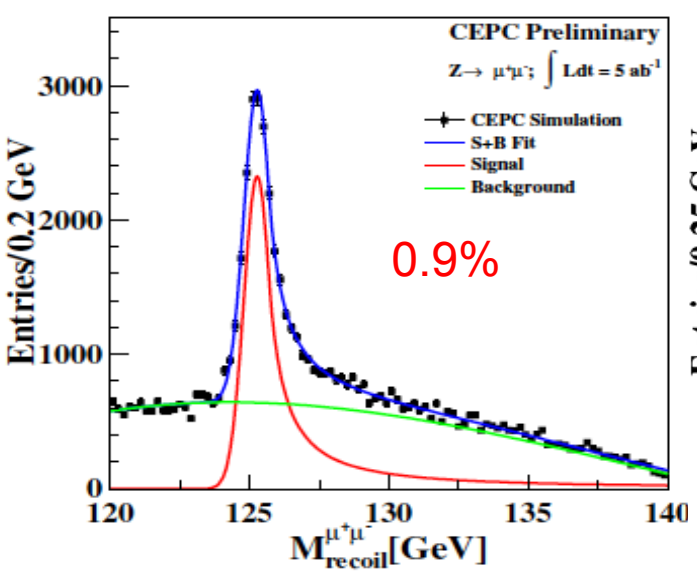
Arbor: Lepton identification

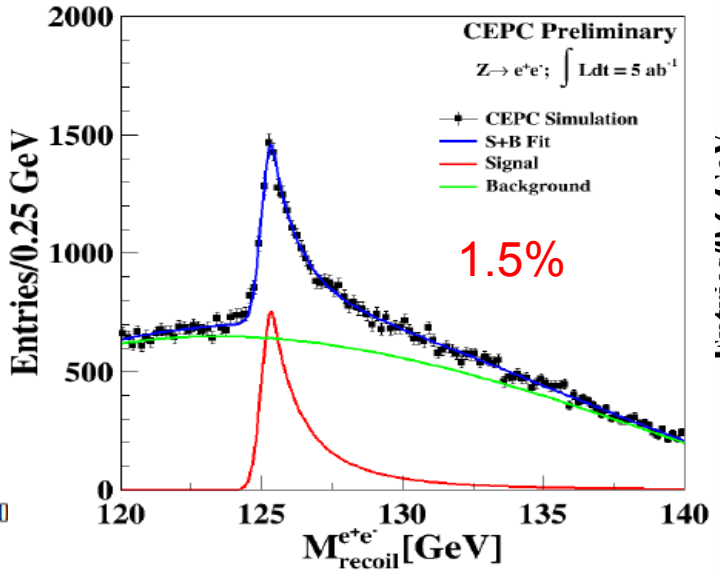




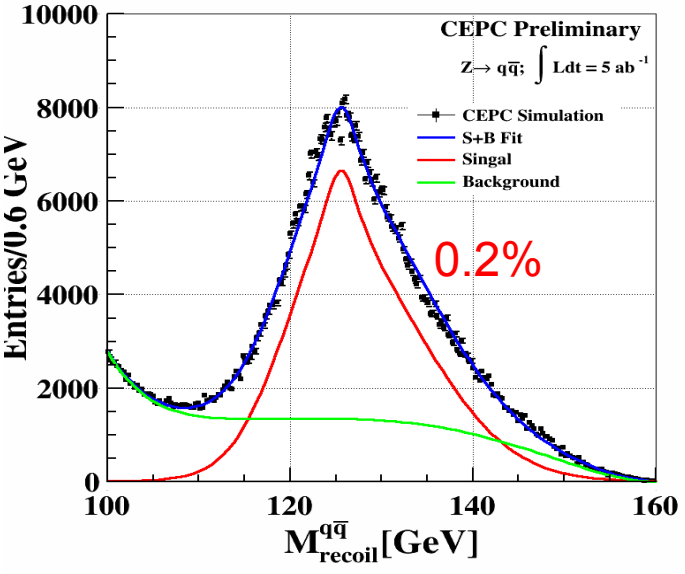
- For any charged particle: identify it as electron, muon, or else = pion

Applied to Analysis





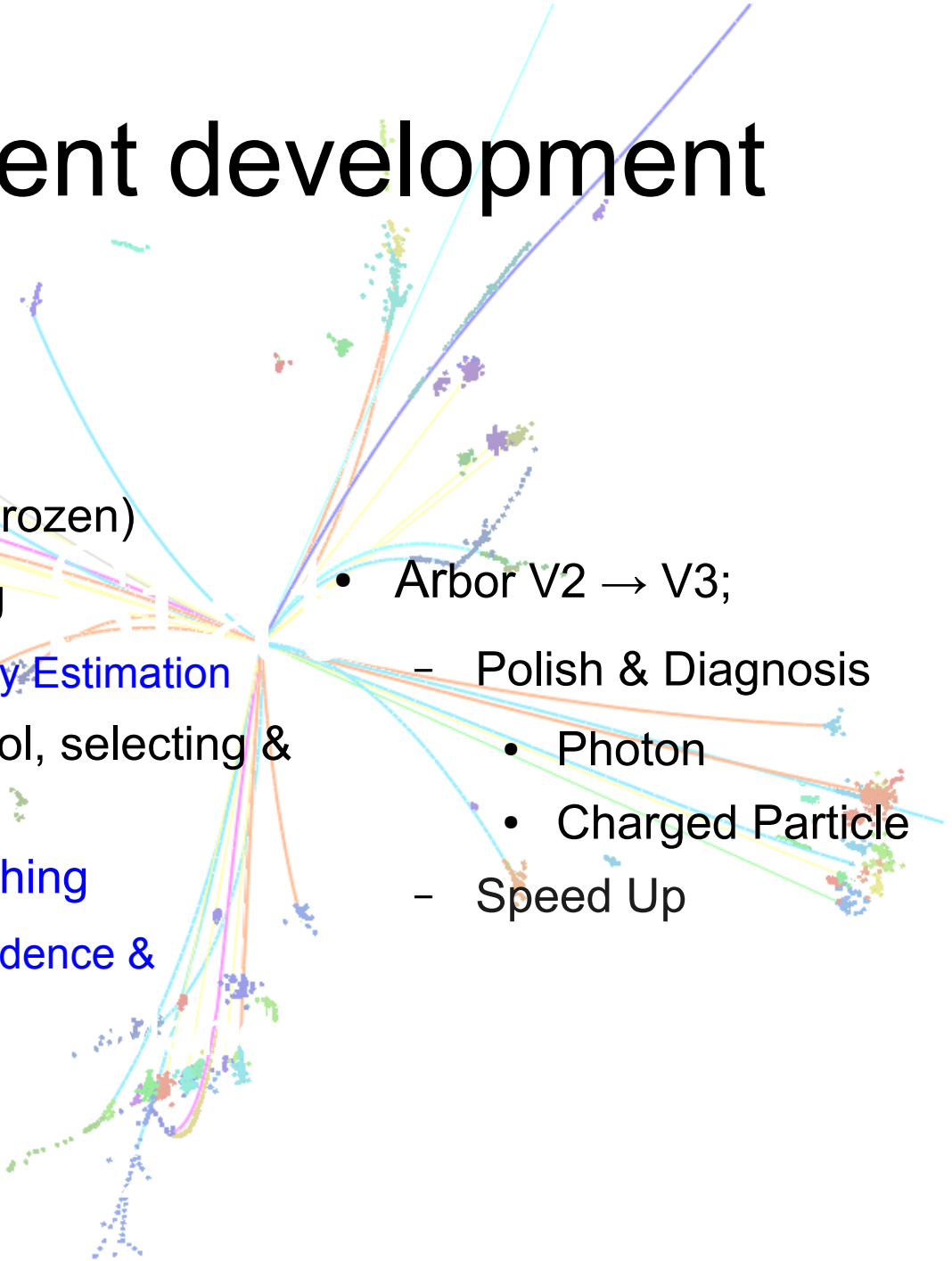
Higgs inclusive Xsection measurement
At di-lepton channels



Higgs invisible branching
Ratio limit

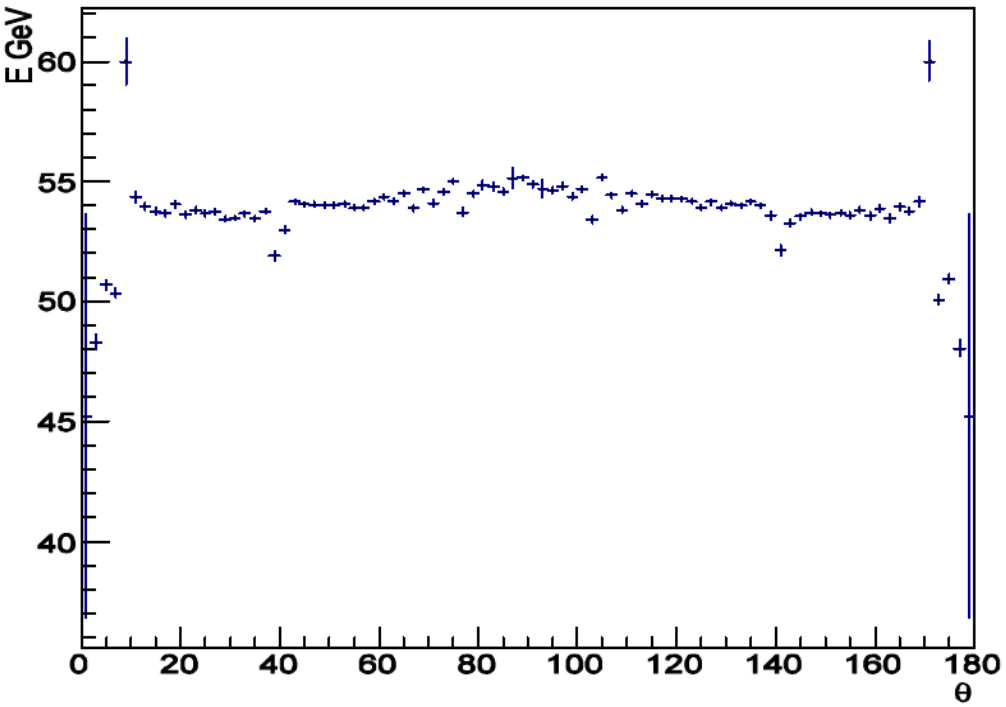
Recent development

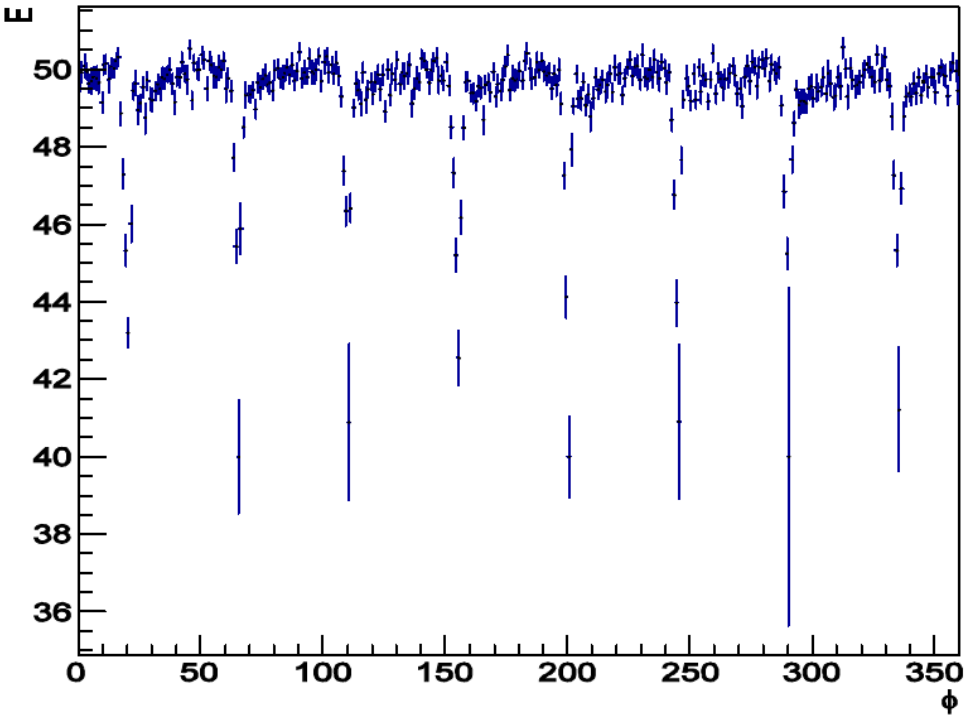
- Architecture
  - Hits Cleaning
  - Arbor Clustering (Frozen)
  - Cluster inter-linking
    - Cluster id, Energy Estimation
  - Track Quality control, selecting & sorting
  - Cluster-Track matching
    - Geometry dependence & correction
  - PFO building
  - PFO identification

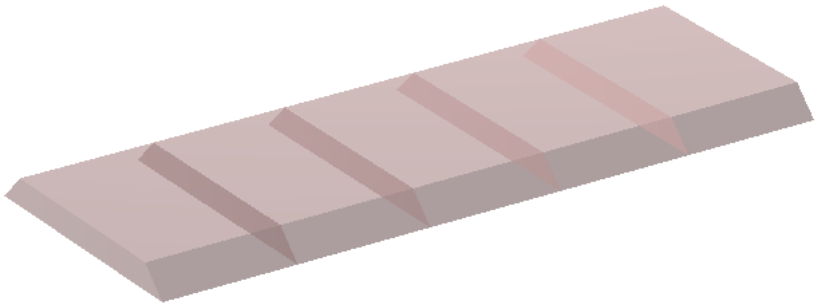


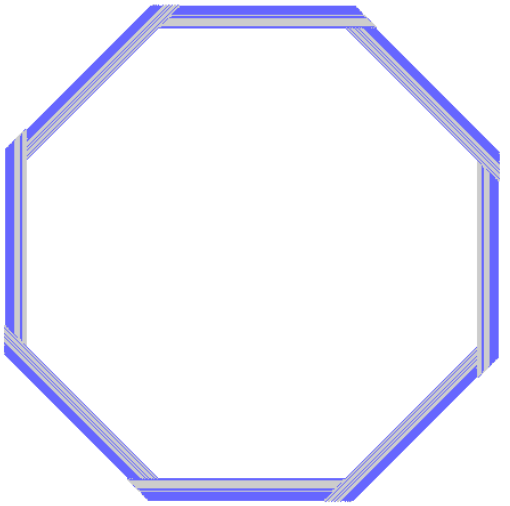
- Arbor V2 → V3;
  - Polish & Diagnosis
    - Photon
    - Charged Particle
  - Speed Up

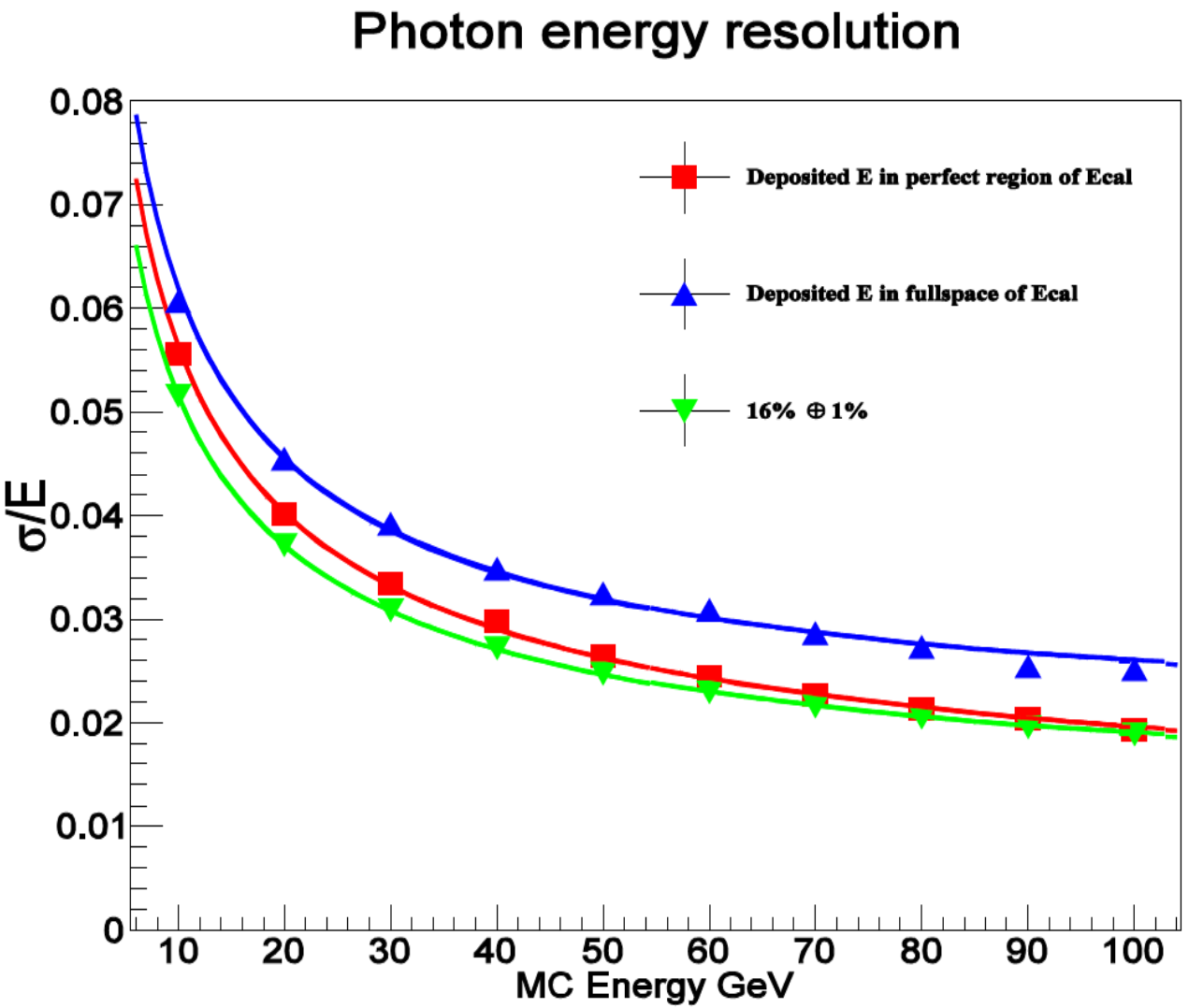
Photon reconstruction

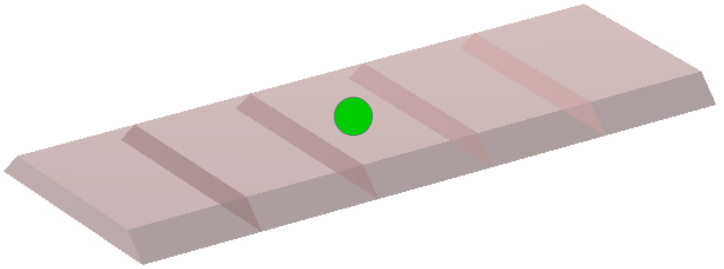








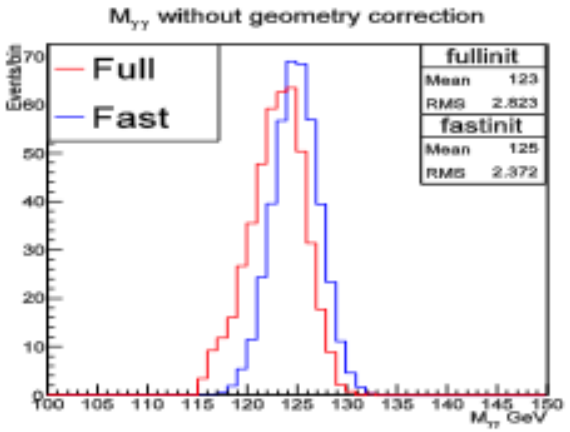


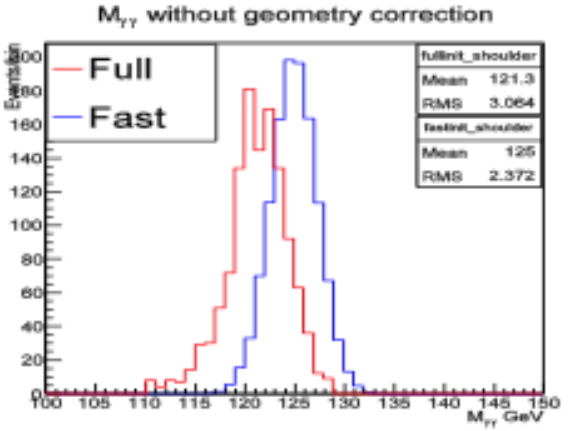


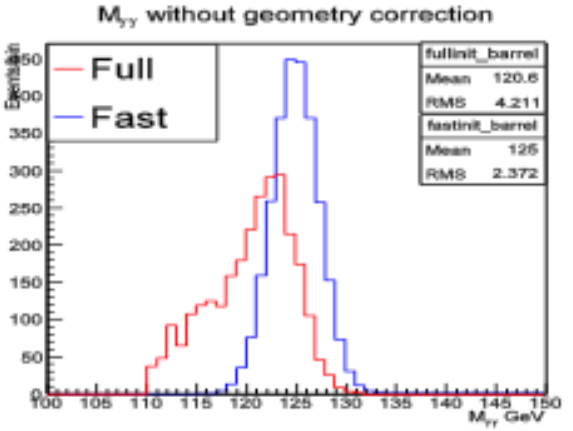
Perfect Region:
17.6%/sqrt(E) ⊕ 0.84%:

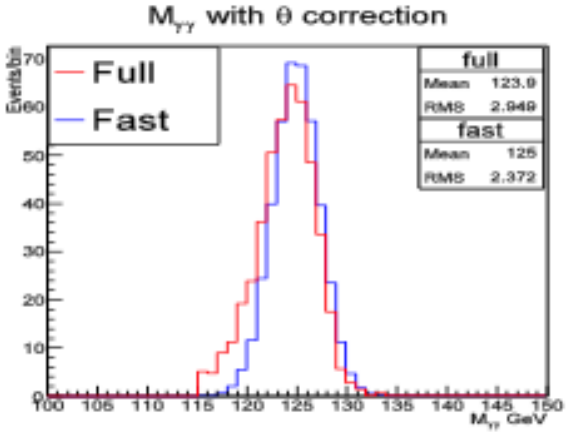
Full Region (flat theta distribution):
Before correction

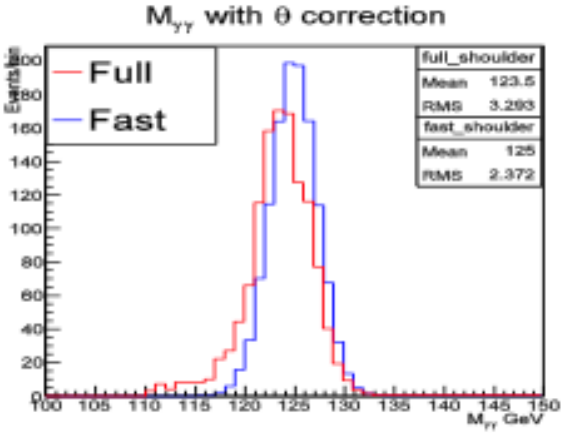
19.7%/sqrt(E) ⊕ 1.72%:

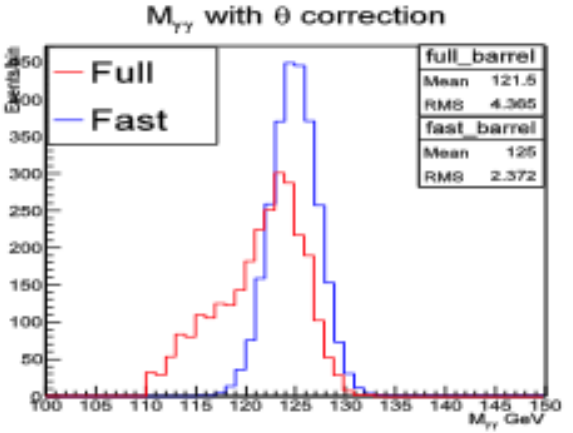

$M_{\gamma\gamma}$ without geometry correction
Full
Fast
fullinit
Mean 123
RMS 2.823
fastinit
Mean 125
RMS 2.372
Events/bin
$M_{\gamma\gamma}$ GeV

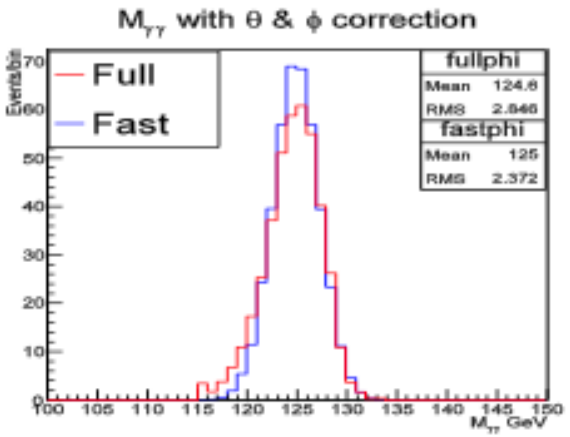

$M_{\gamma\gamma}$ without geometry correction
Full
Fast
fullinit_shoulder
Mean 121.3
RMS 3.064
fastinit_shoulder
Mean 125
RMS 2.372
Events/bin
$M_{\gamma\gamma}$ GeV

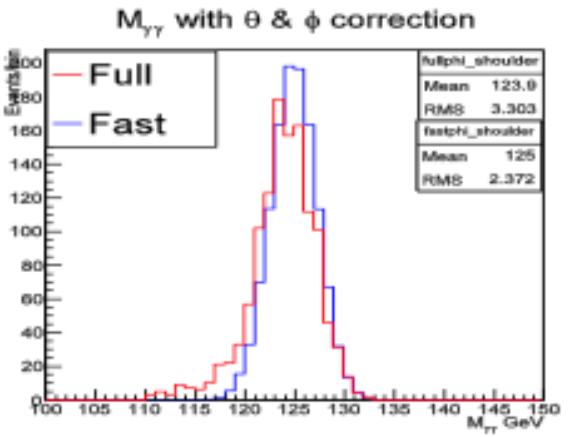

$M_{\gamma\gamma}$ without geometry correction
Full
Fast
fullinit_barrel
Mean 120.6
RMS 4.211
fastinit_barrel
Mean 125
RMS 2.372
Events/bin
$M_{\gamma\gamma}$ GeV

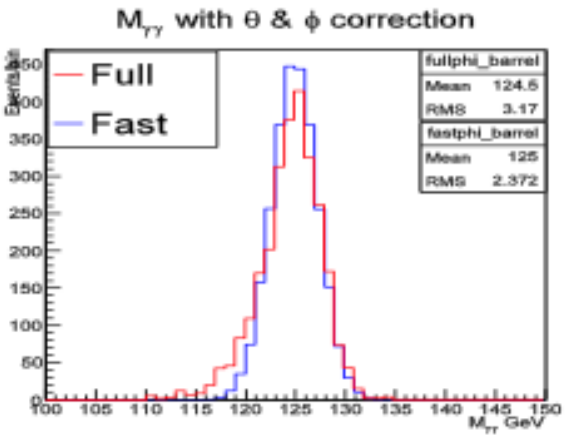

$M_{\gamma\gamma}$ with θ correction
Full
Fast
full
Mean 123.9
RMS 2.949
fast
Mean 125
RMS 2.372
Events/bin
$M_{\gamma\gamma}$ GeV

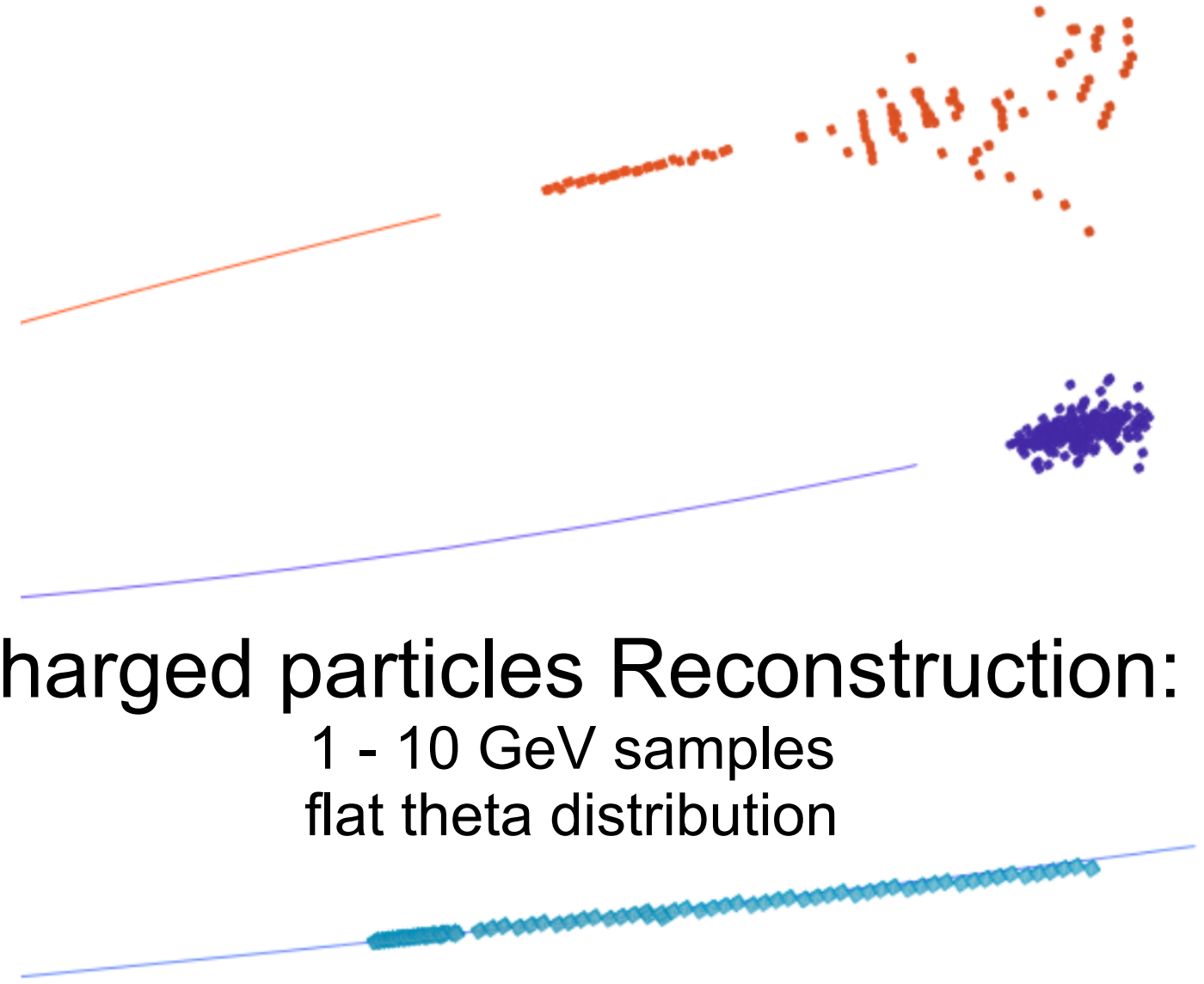

$M_{\gamma\gamma}$ with θ correction
Full
Fast
full_shoulder
Mean 123.5
RMS 3.293
fast_shoulder
Mean 125
RMS 2.372
Events/bin
$M_{\gamma\gamma}$ GeV


$M_{\gamma\gamma}$ with θ correction
Full
Fast
full_barrel
Mean 121.5
RMS 4.365
fast_barrel
Mean 125
RMS 2.372
Events/bin
$M_{\gamma\gamma}$ GeV


$M_{\gamma\gamma}$ with θ & ϕ correction
Full
Fast
fullphi
Mean 124.6
RMS 2.846
fastphi
Mean 125
RMS 2.372
Events/bin
$M_{\gamma\gamma}$ GeV


$M_{\gamma\gamma}$ with θ & ϕ correction
Full
Fast
fullphi_shoulder
Mean 123.9
RMS 3.303
fastphi_shoulder
Mean 125
RMS 2.372
Events/bin
$M_{\gamma\gamma}$ GeV


$M_{\gamma\gamma}$ with θ & ϕ correction
Full
Fast
fullphi_barrel
Mean 124.5
RMS 3.17
fastphi_barrel
Mean 125
RMS 2.372
Events/bin
$M_{\gamma\gamma}$ GeV

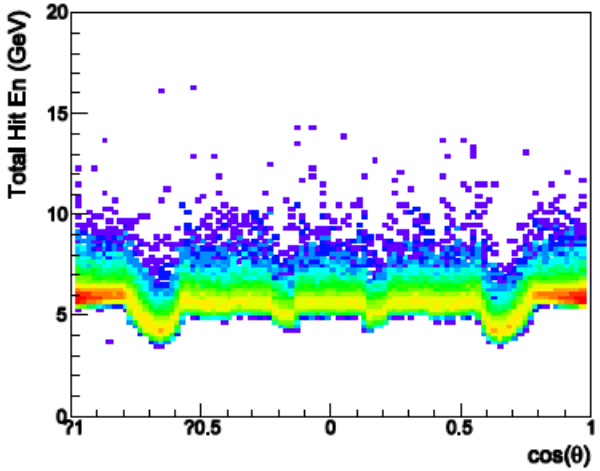


Charged particles Reconstruction:

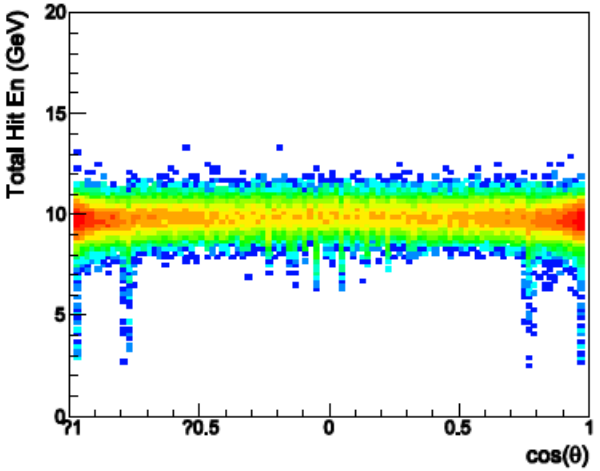
1 - 10 GeV samples

flat theta distribution

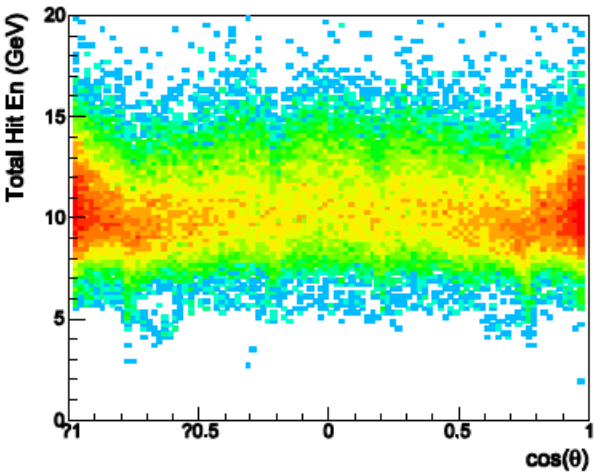
Total Hit Energy for Muon



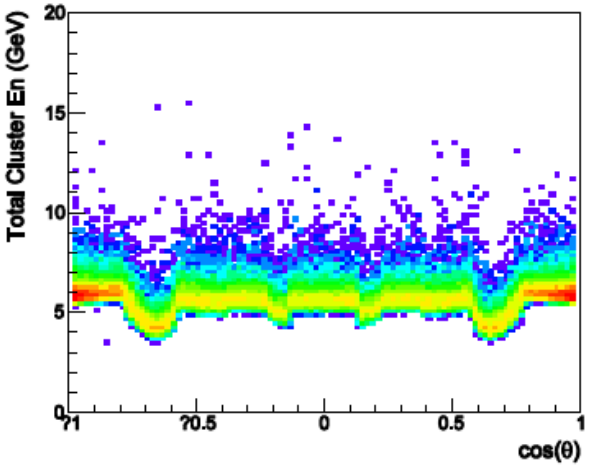
Total Hit Energy for Electron



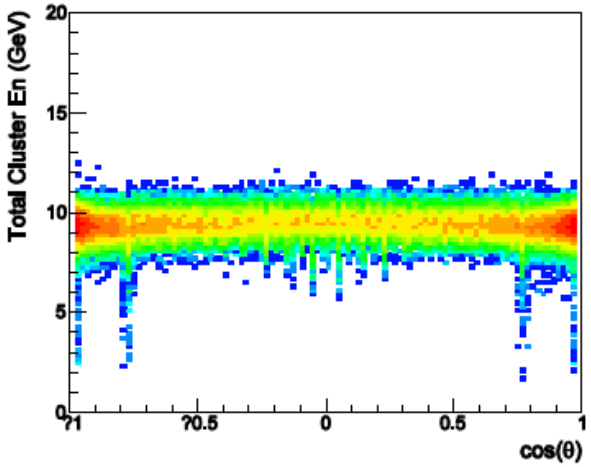
Total Hit Energy for Pion



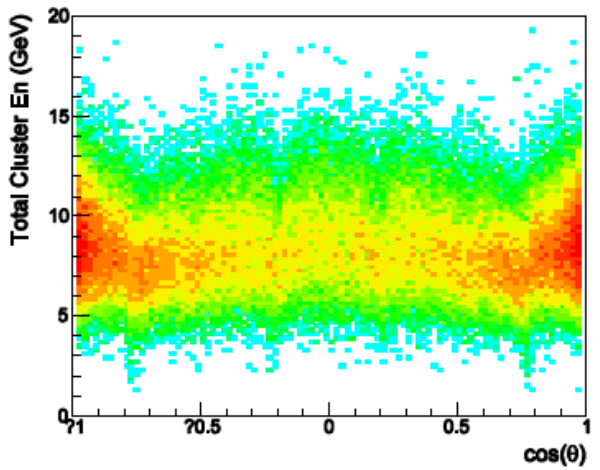
Total Cluster Energy for Muon



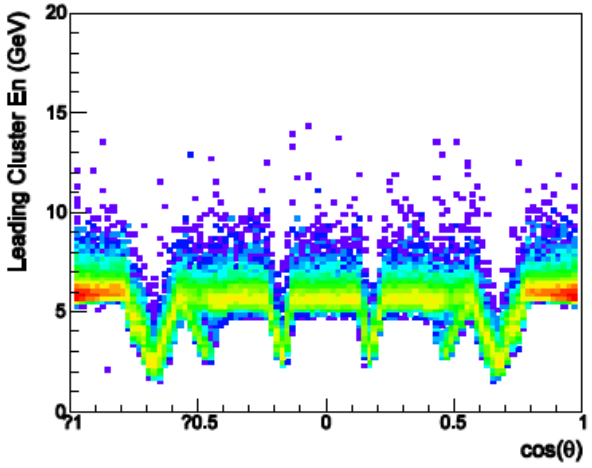
Total Cluster Energy for Electron



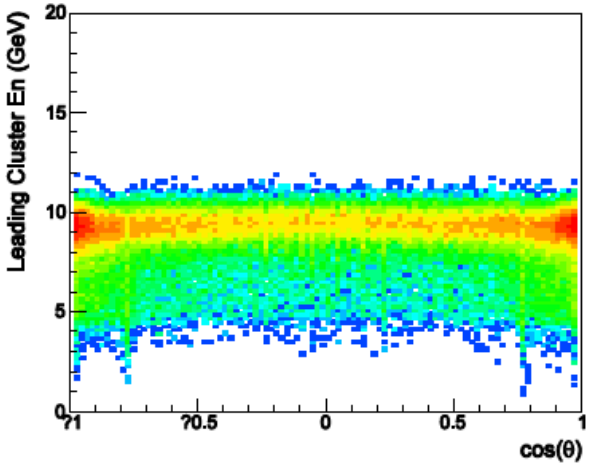
Total Cluster Energy for Pion



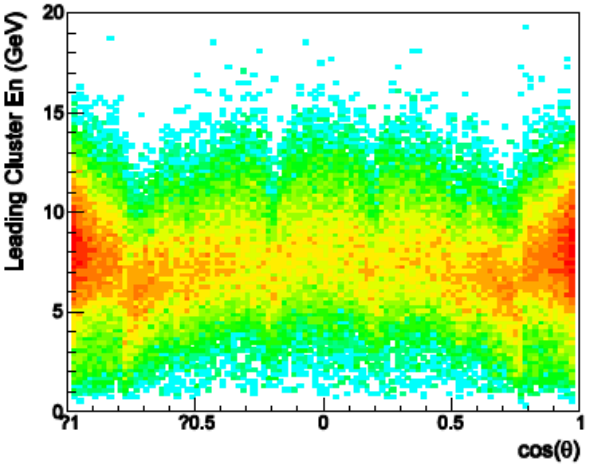
Leading Cluster Energy for Muon



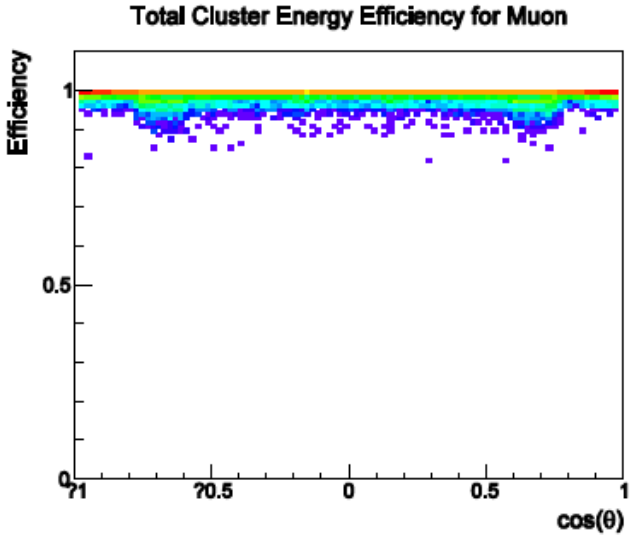
Leading Cluster Energy for Electron

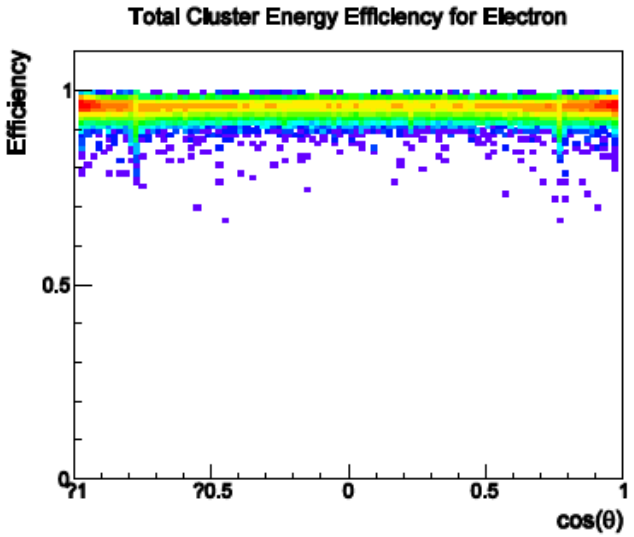


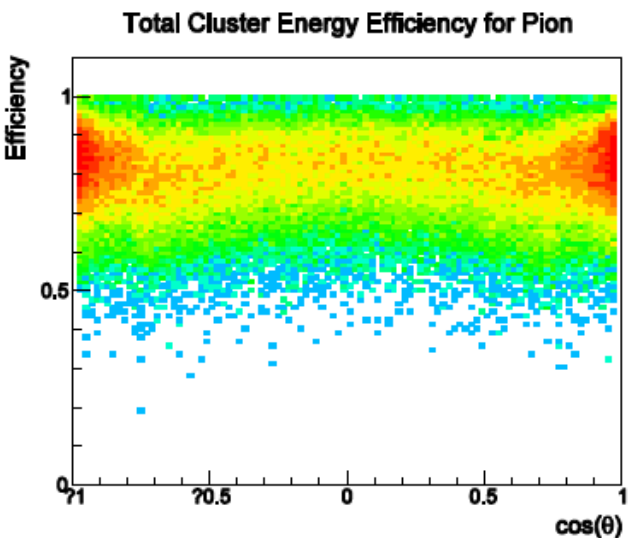
Leading Cluster Energy for Pion

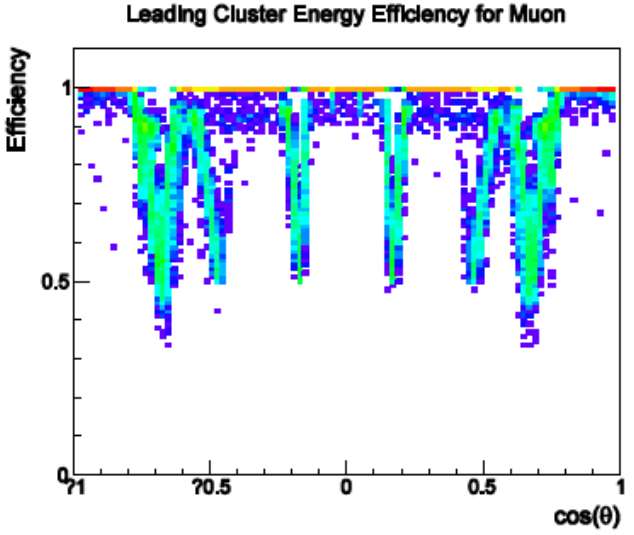


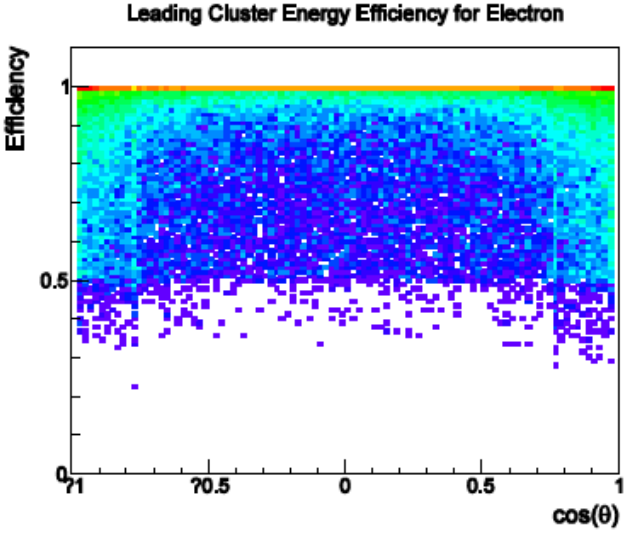
Efficiencies: hit collection & Leading Cluster

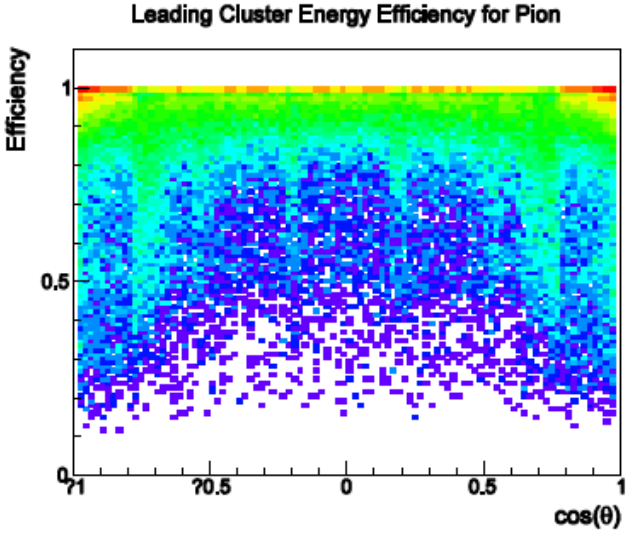




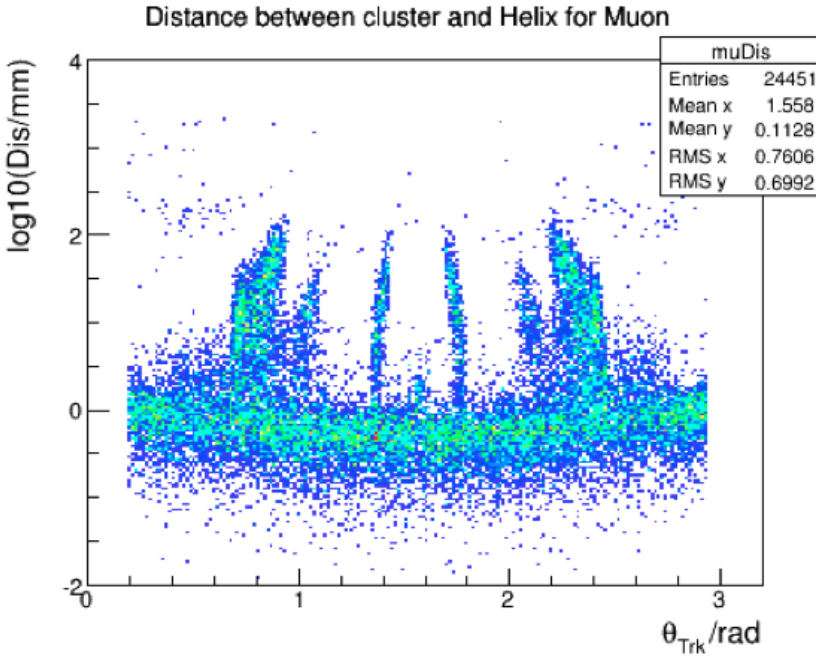


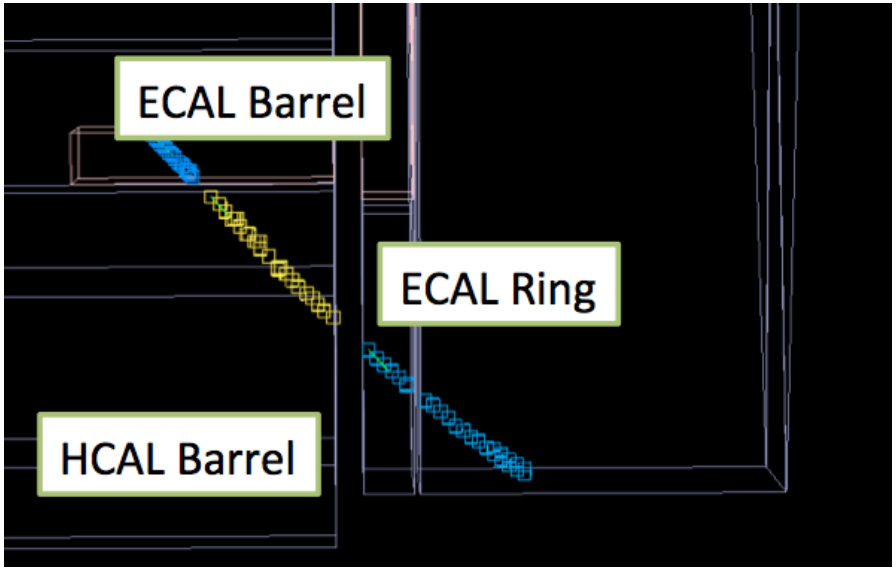


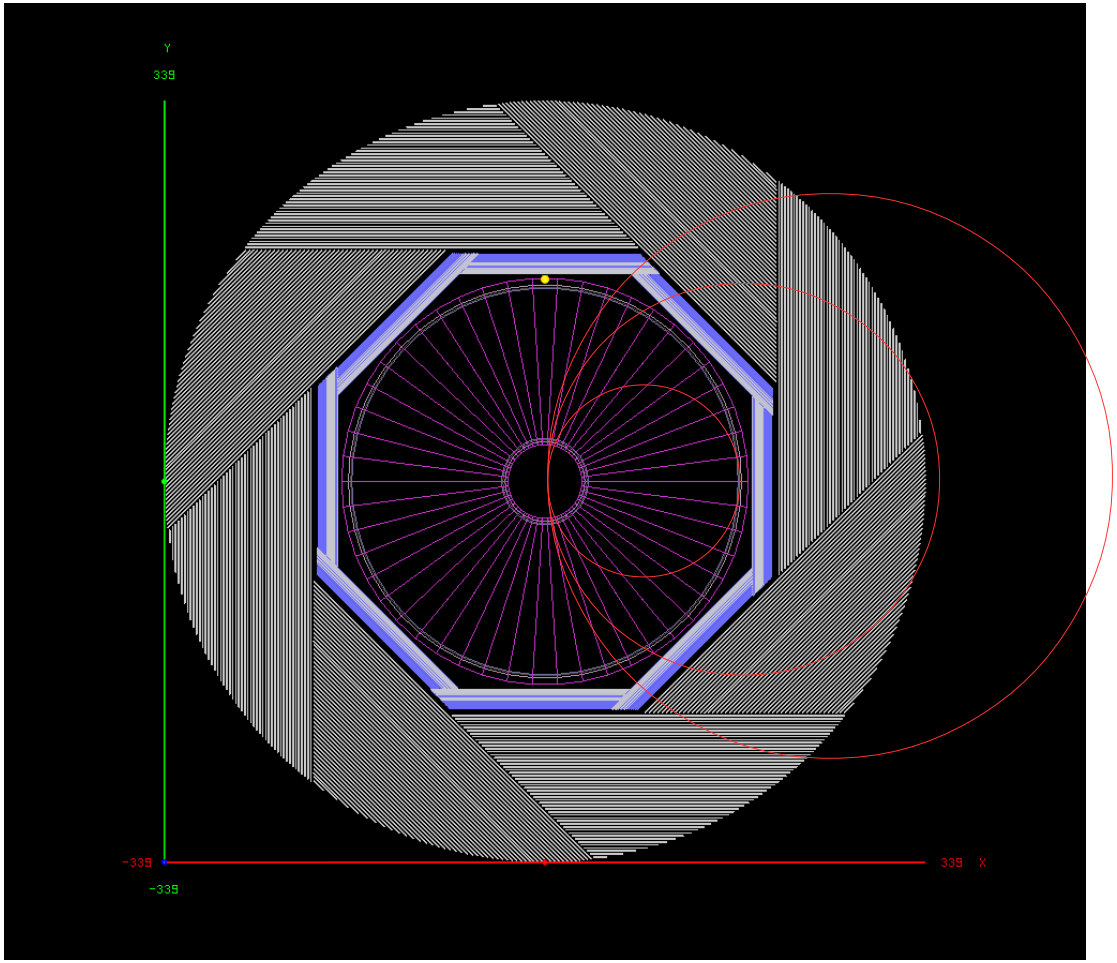




Muon: comb teeth

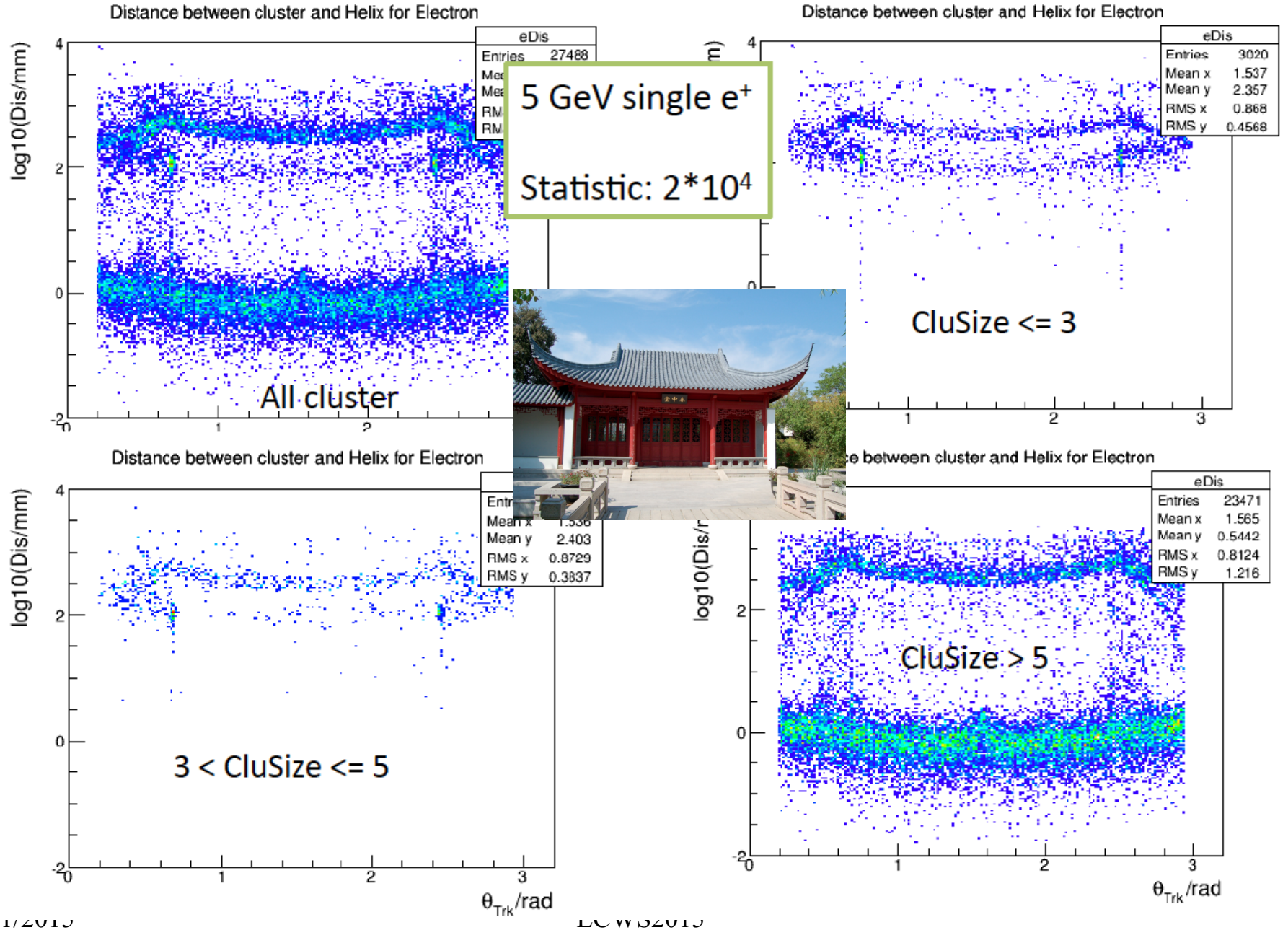




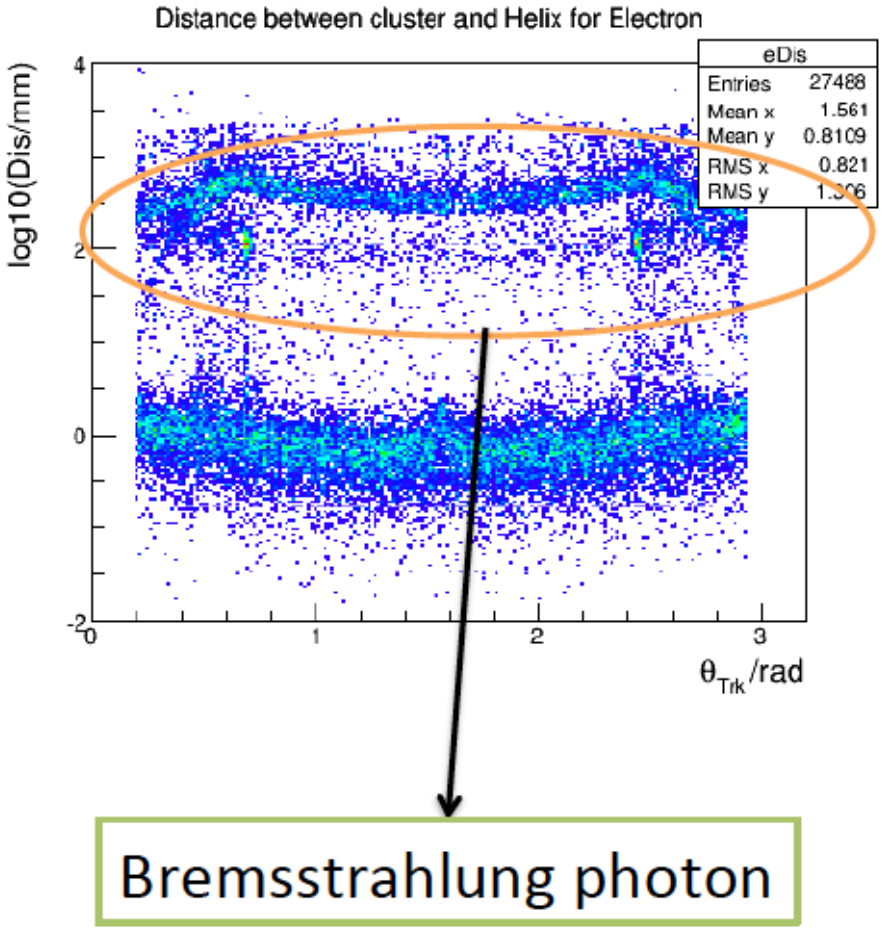


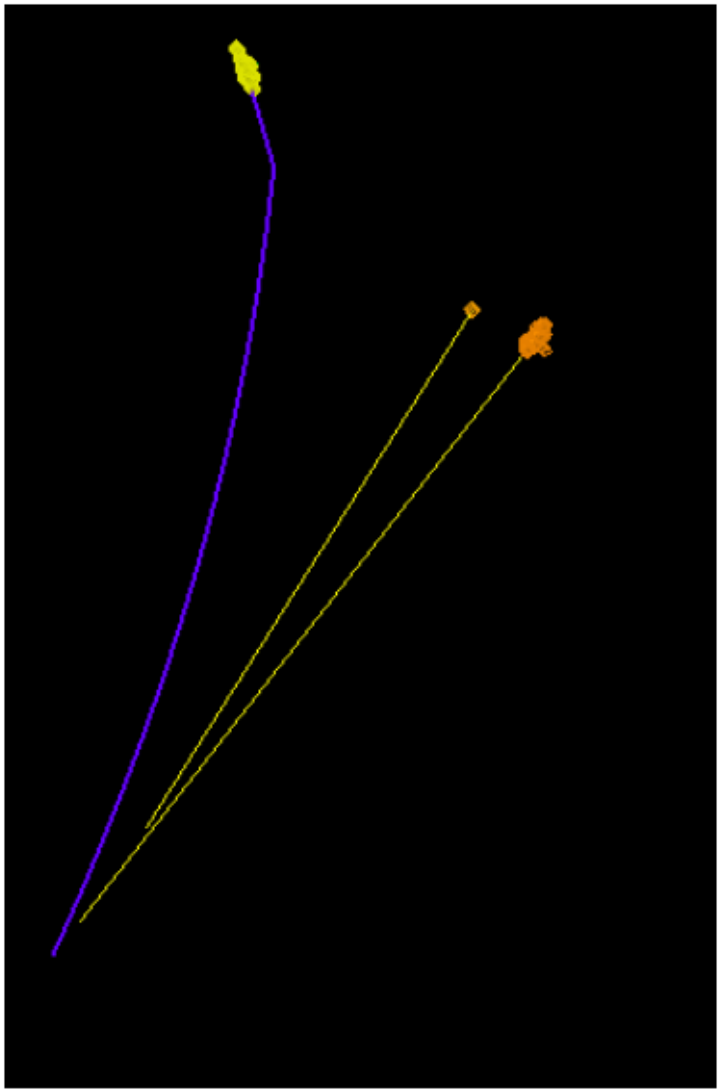
Low energy muon (1 – 3 GeV): create dis-connect Configuration in the calorimeter

Distance between cluster and helix for Electron

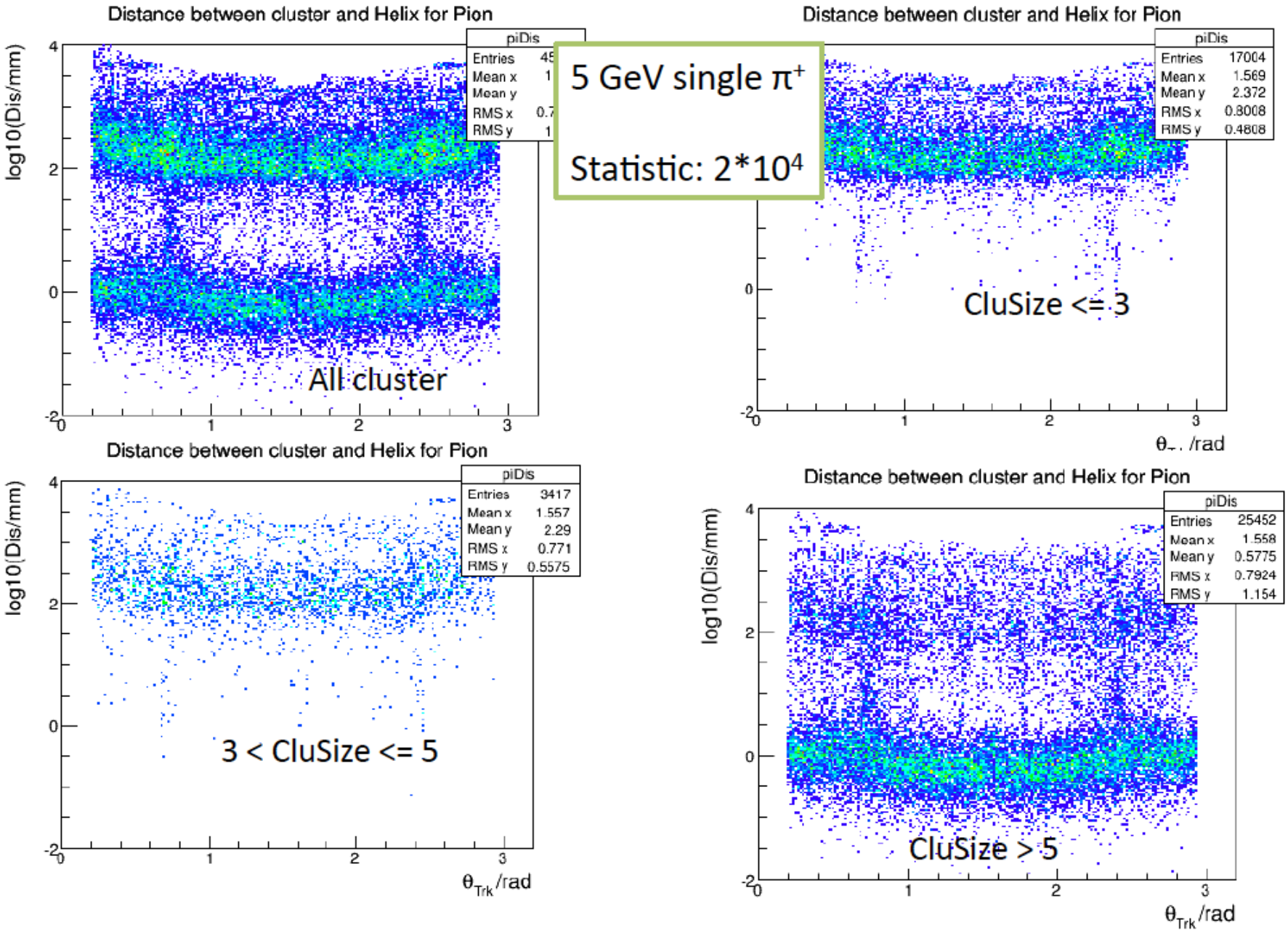


Electrons: Bremsstrahlung photon

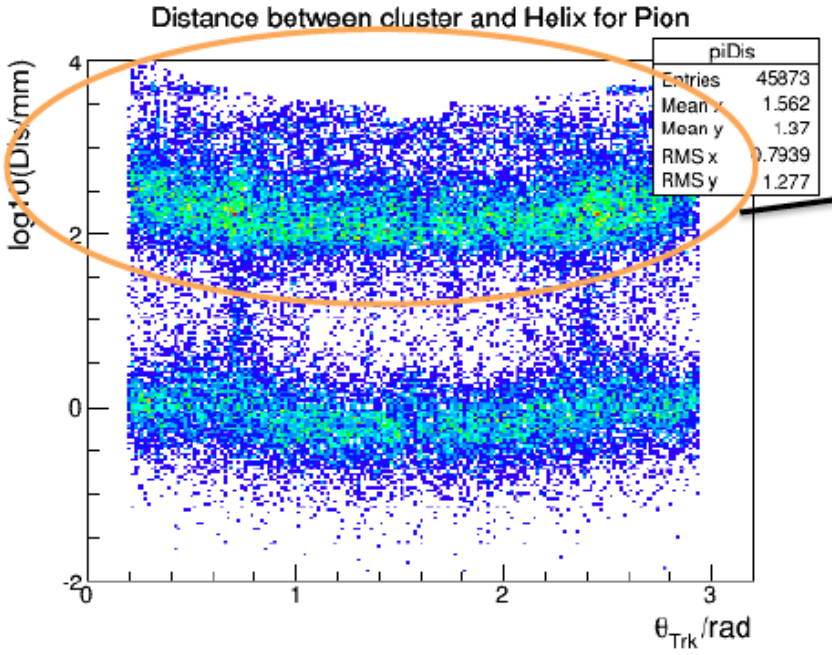




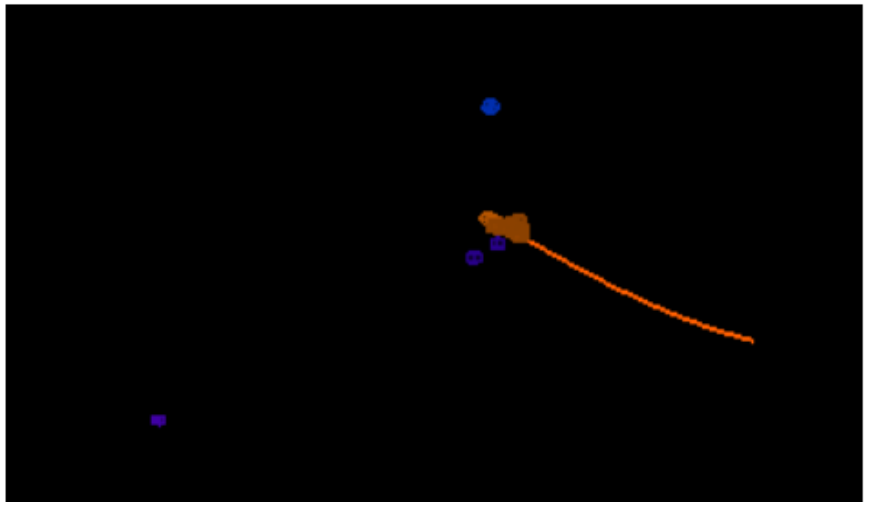
Distance between cluster and helix for Pion



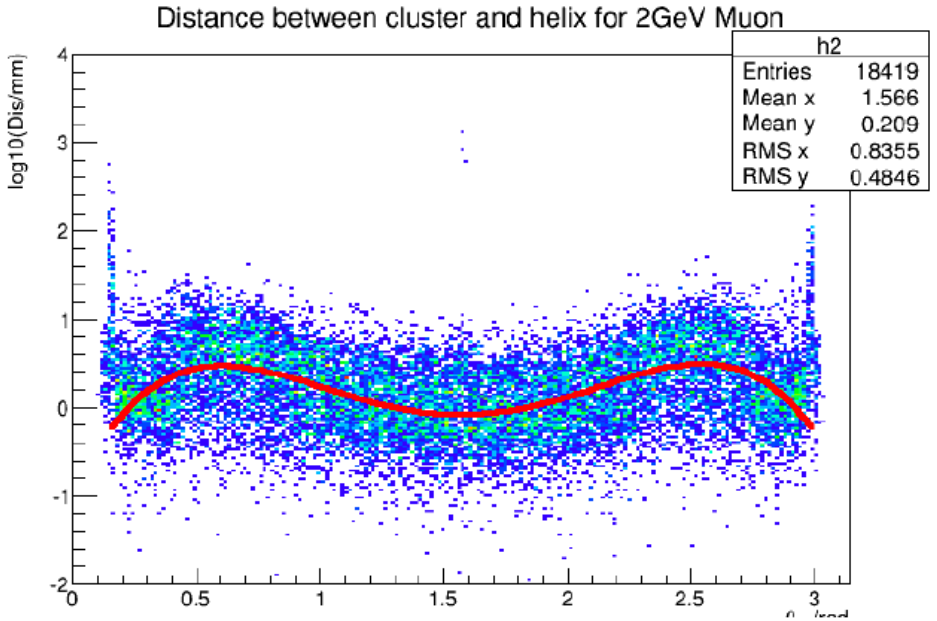
Pion: tiny fragments, backscattering & pre-interactions

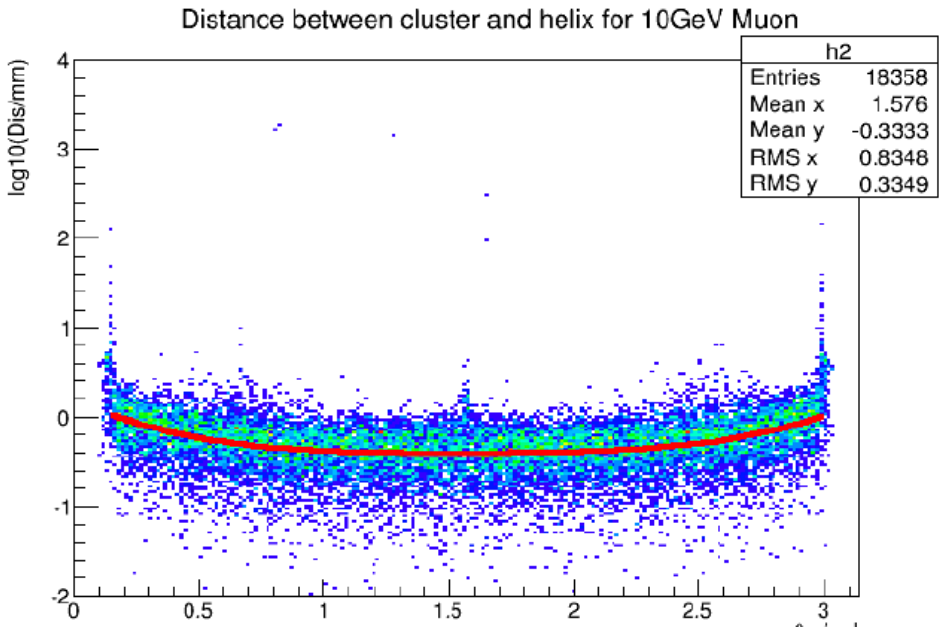


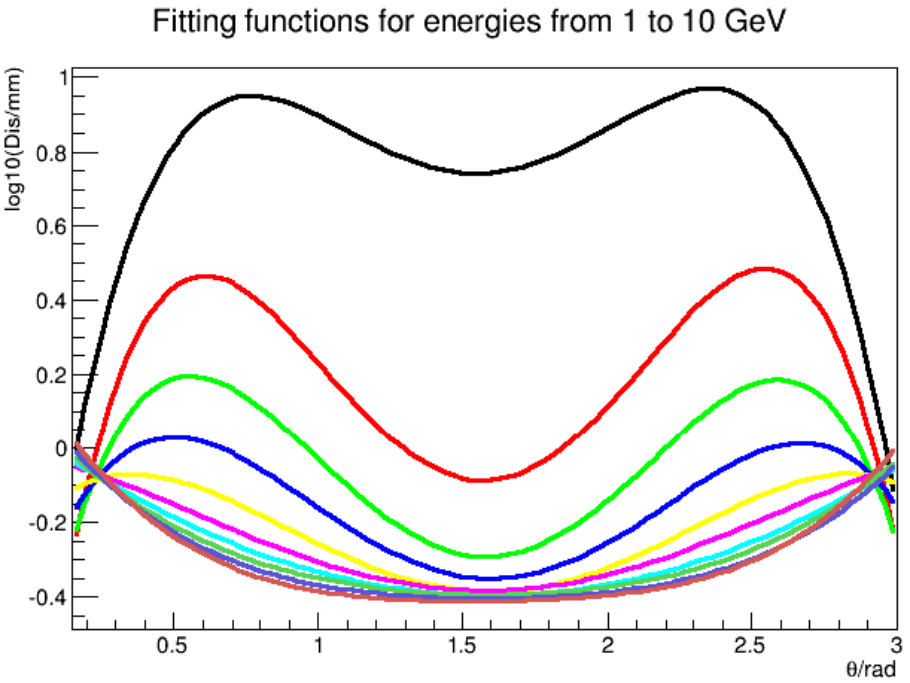
Pre interaction and low energy fragment



The nearest cluster: muon



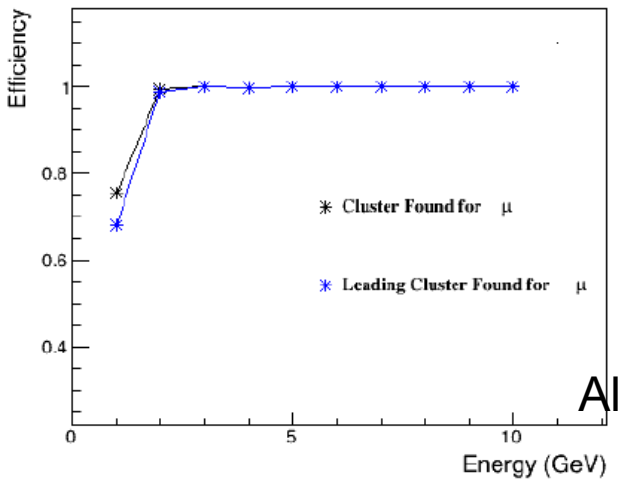


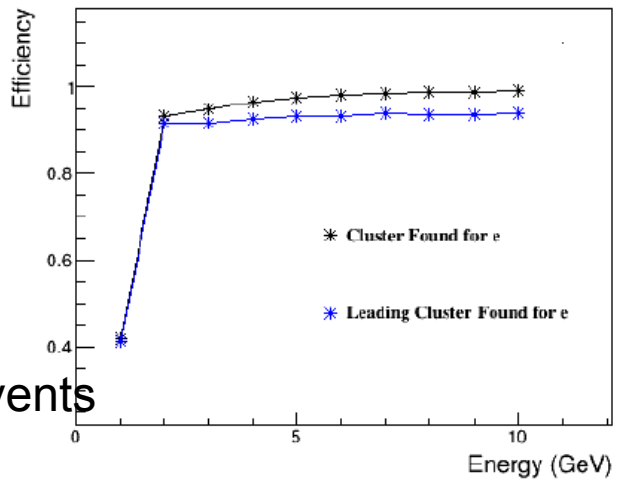


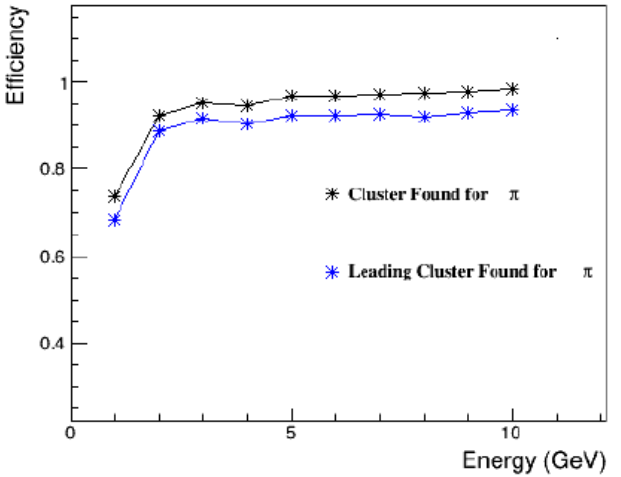
Use a pol4 function to fit the mean and sigma value to determine the cut.

Cut: log10(Dis) – Mean < 3Sigma

Matching efficiency at |cos(theta)| < 0.98

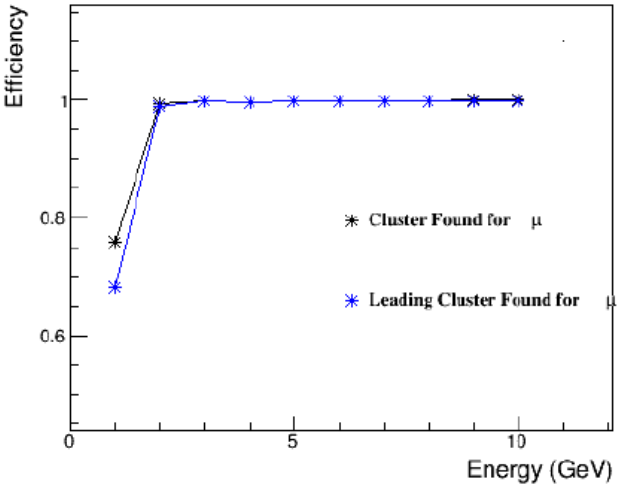


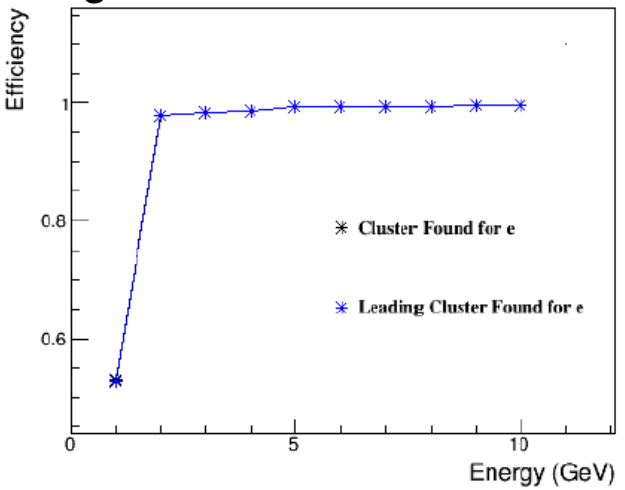


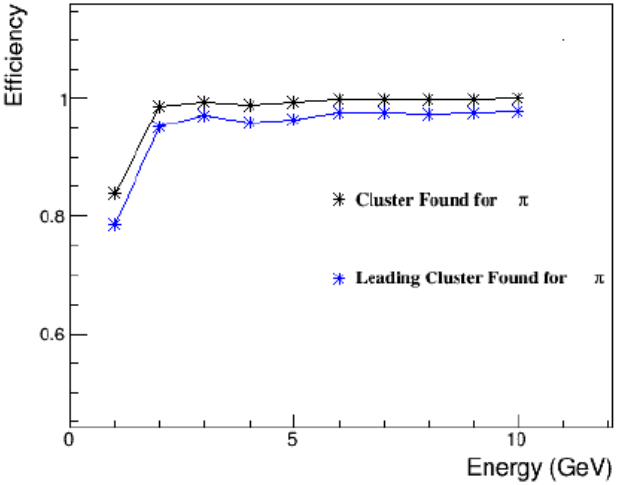


All events

Non-pre interacting events

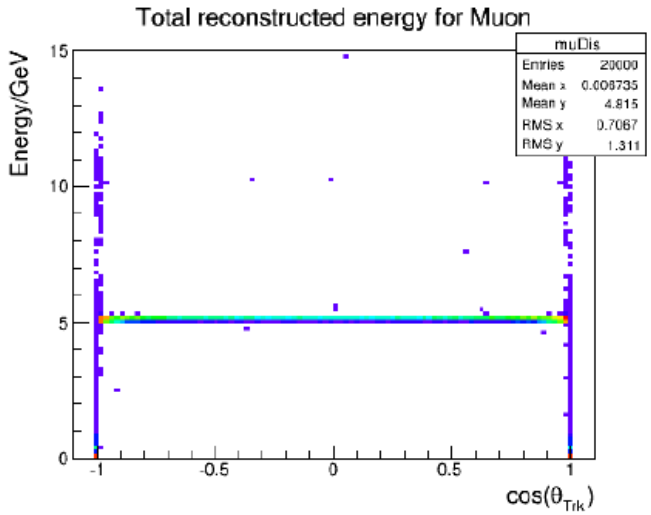


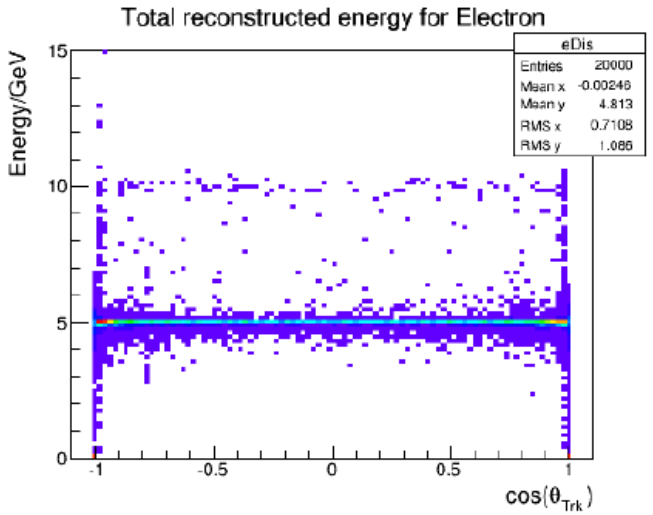


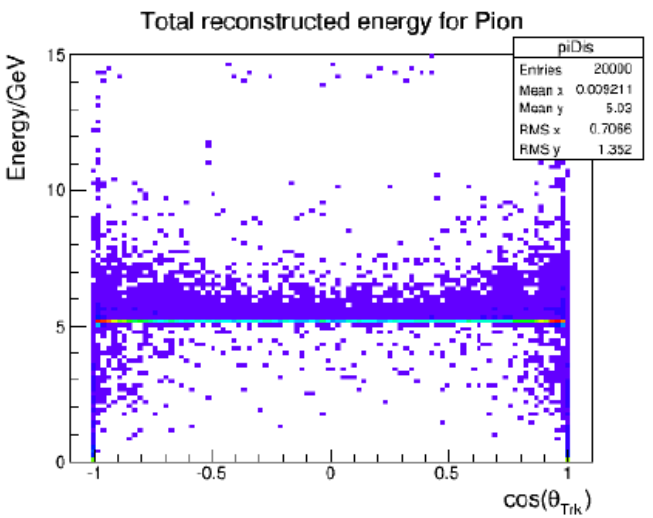


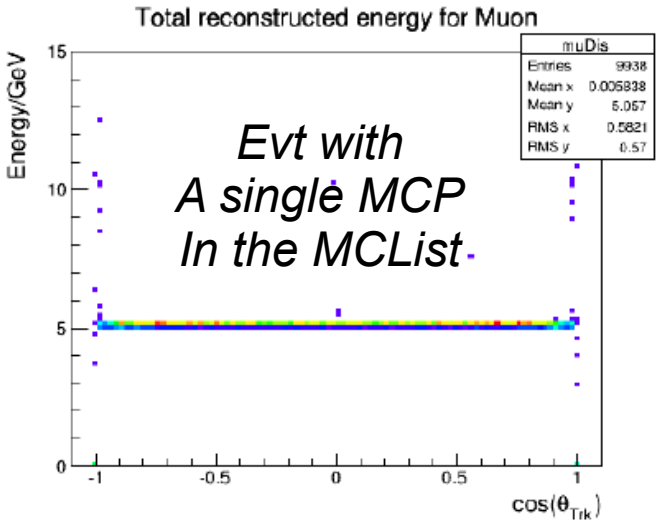
Black: #Event(Track Matched to at least one cluster)/#Evt(Track);
Blue: #Evt(Track matched to LC)/#Evt(Track)

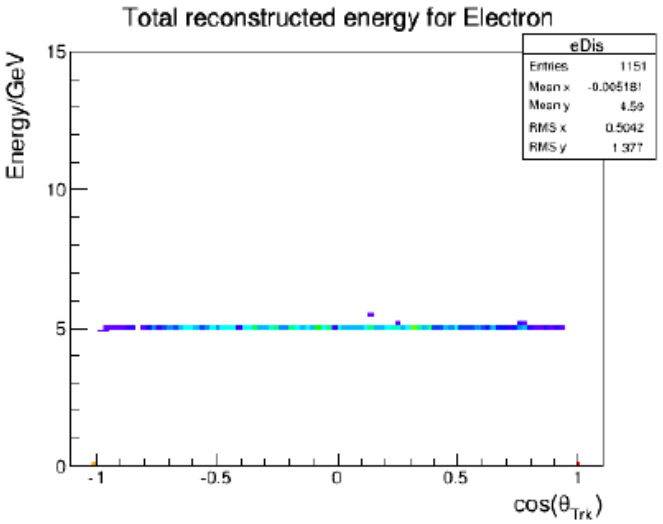
Total reconstructed energy

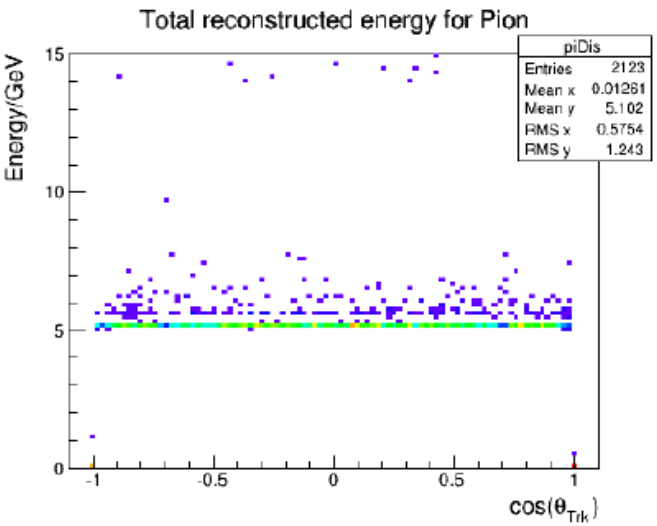




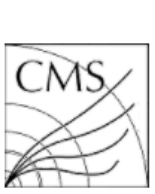




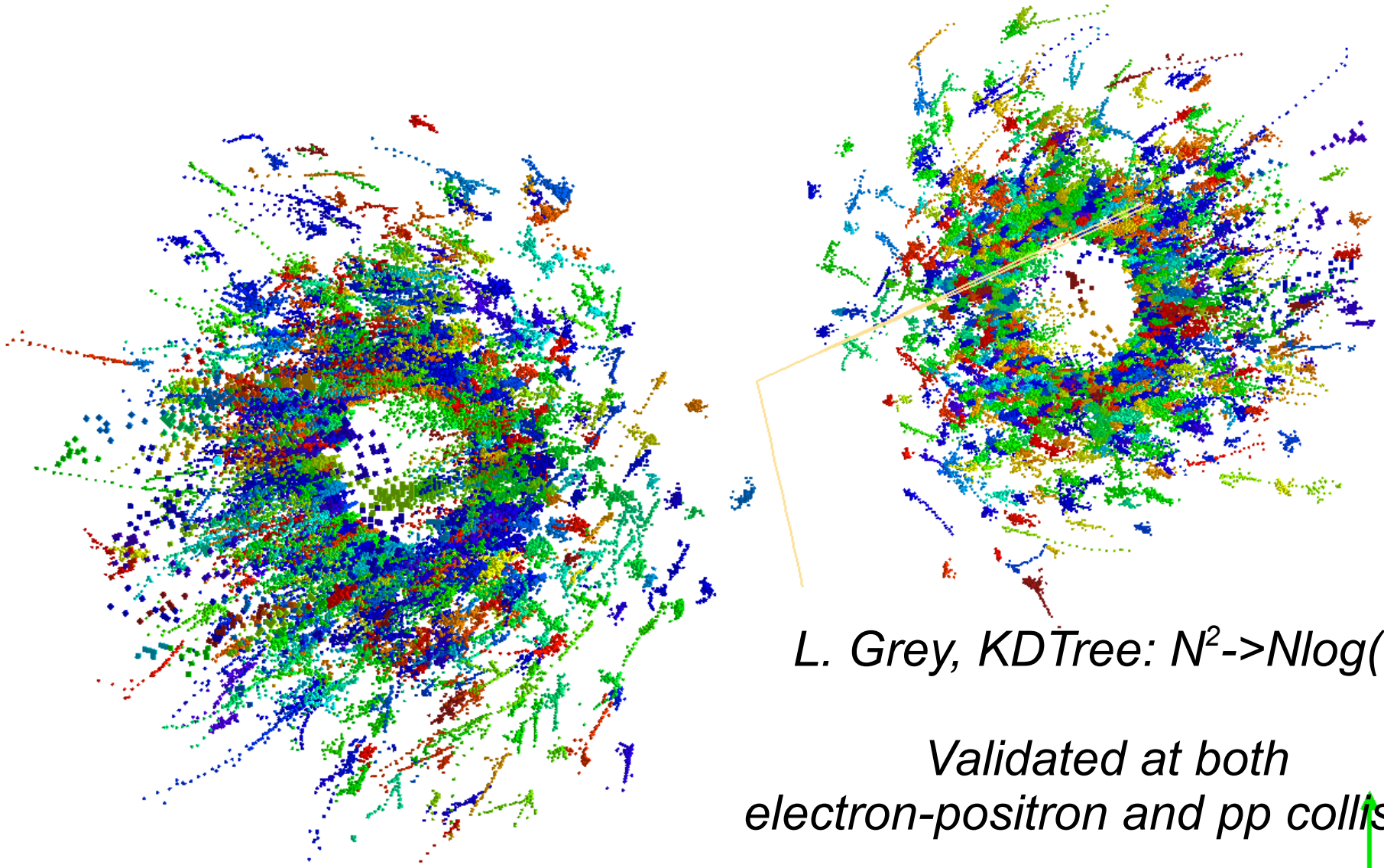




Pre-interactions: need to be carefully treated with dedicated algorithms...



CMS Experiment at LHC, CERN
Data recorded: Thu Jan 1 01:00:00 1970 CEST
Run/Event: 1 / 1201
Lumi section: 13



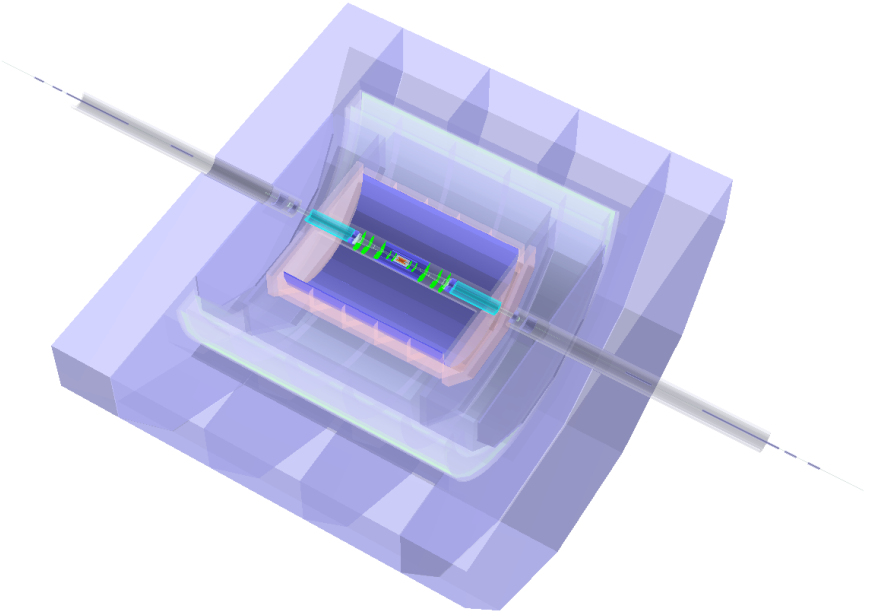
L. Grey, KDTree: N^2->Nlog(N)

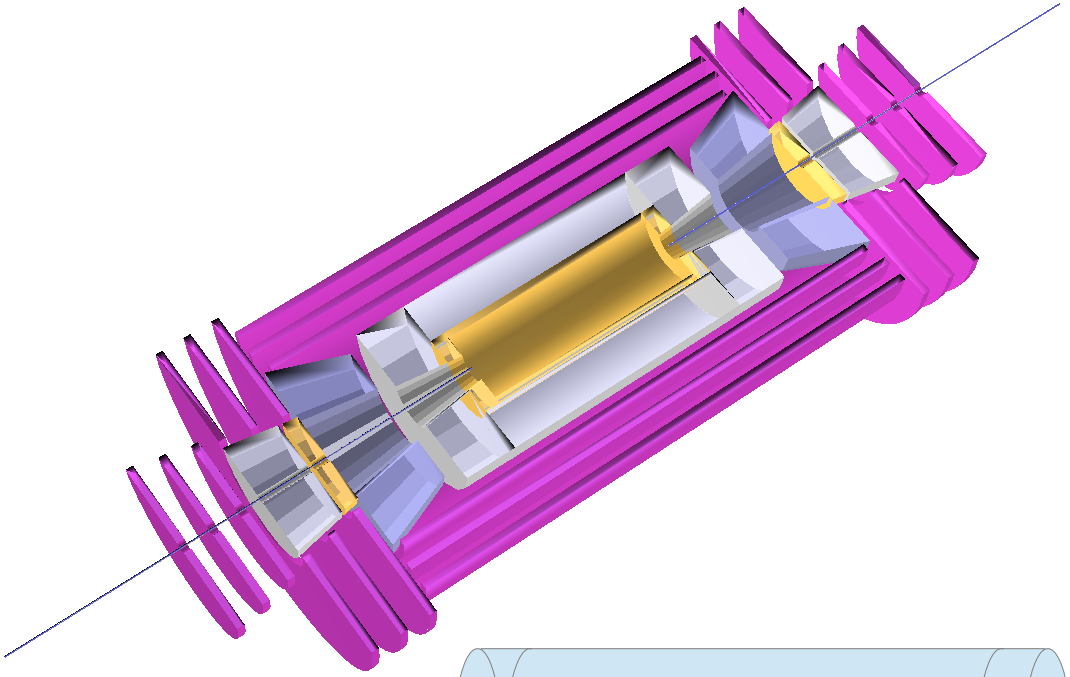
Validated at both electron-positron and pp collisions

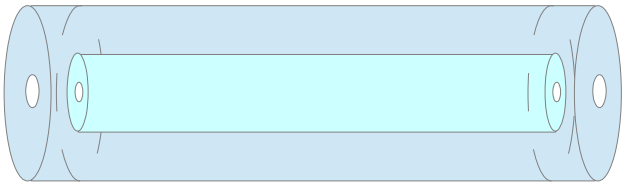
140 PU event reconstructed at 2 min/evt

Geometry tools preparation

C. Fu: **Simplified** Calorimeter geometry, applied to both CEPC & SPPC Detector design







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/Mokka/init/globalModelParameter SiCalLayerStructure Si:0.3;(Cu:0.5,W:0,Cu:0.5,PCB:1.2,Si:0.3,Air:0.5)*240
/Mokka/init/globalModelParameter SiCalWThick 10,10,10,10,10,10,10,10,10,10,10,10,10,10,10,10,...,10
/Mokka/init/globalModelParameter SiCalInnerRadius  3000 #1845
/Mokka/init/globalModelParameter SiCalBarrelHalfZ  8000 #2450
/Mokka/init/globalModelParameter SiCalEndcapEta1   4
/Mokka/init/globalModelParameter SiCalEndcapEta2   4
/Mokka/init/globalModelParameter SiCalBuildBarrel   1
/Mokka/init/globalModelParameter SiCalXCellSize    2.5
/Mokka/init/globalModelParameter SiCalYCellSize    2.5
/Mokka/init/globalModelParameter SiCalEndcapOuterR  6120
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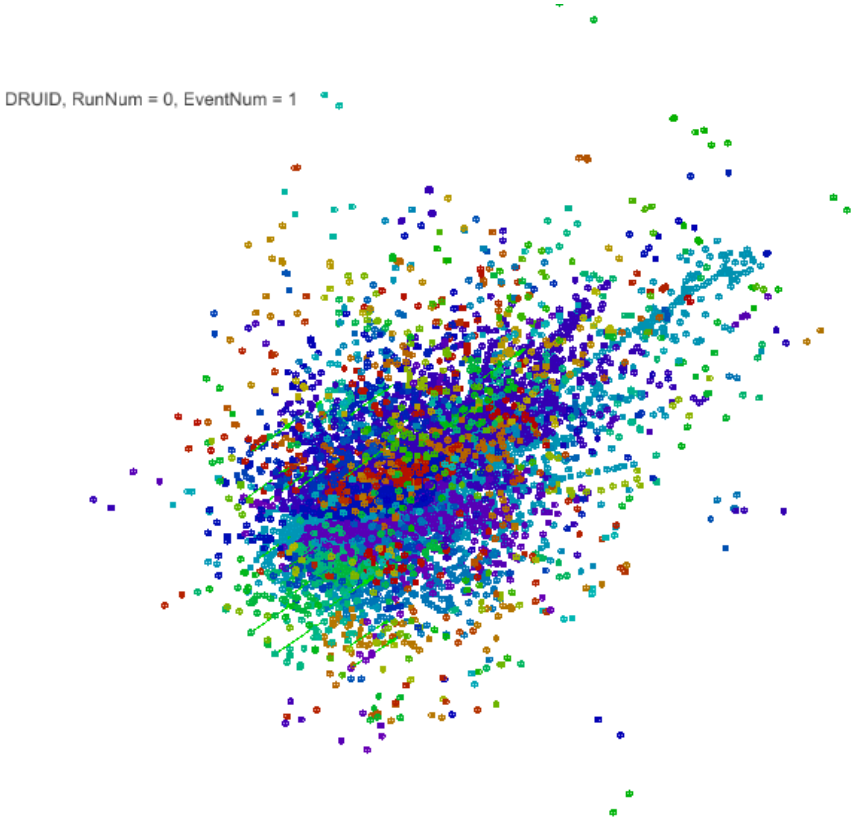
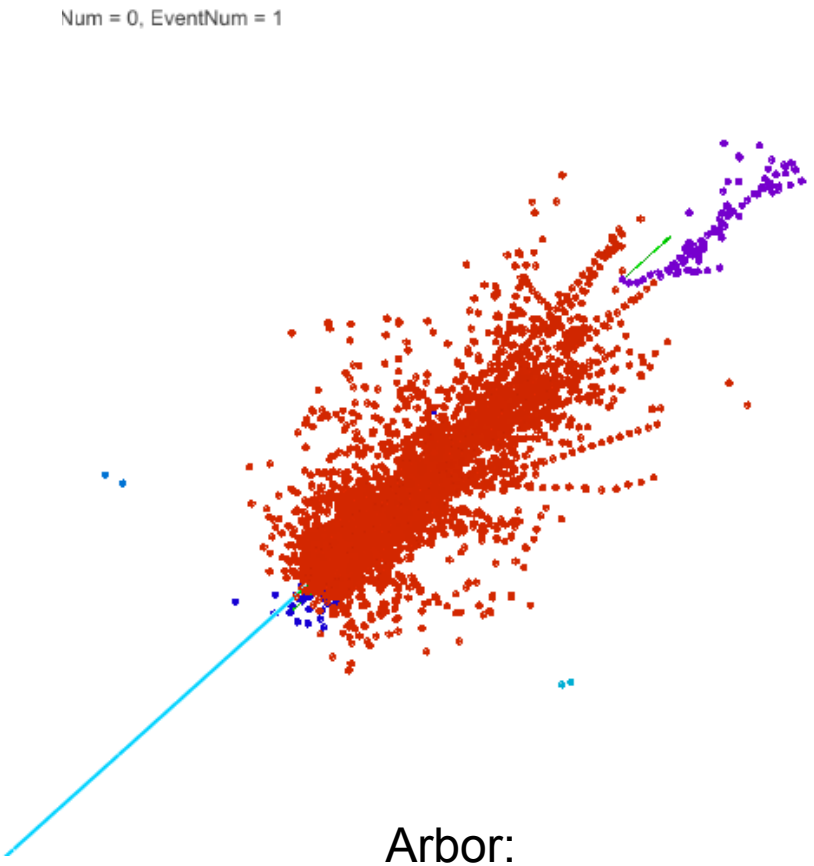
Will PFA oriented detector adequate to 100 TeV pp collision?

Defect free, deep ECAL style

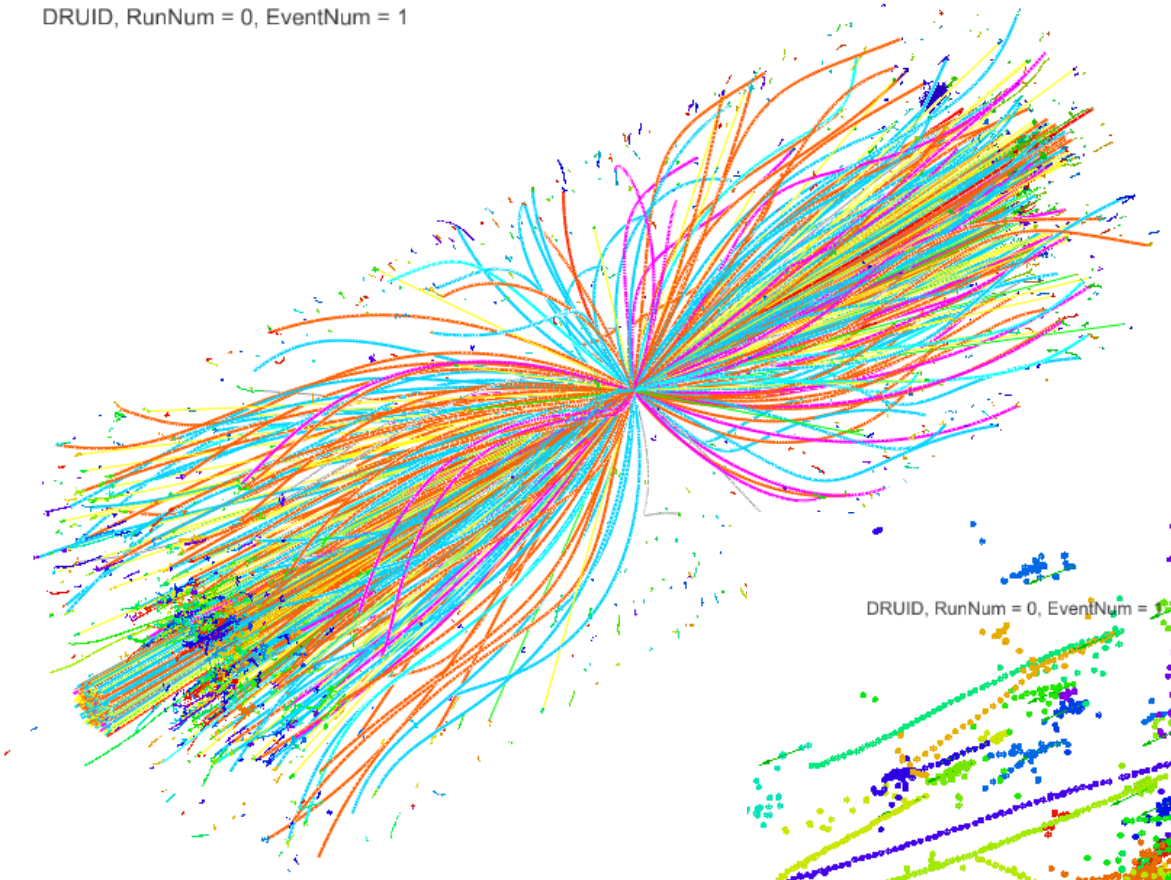
1 TeV pion reconstruction

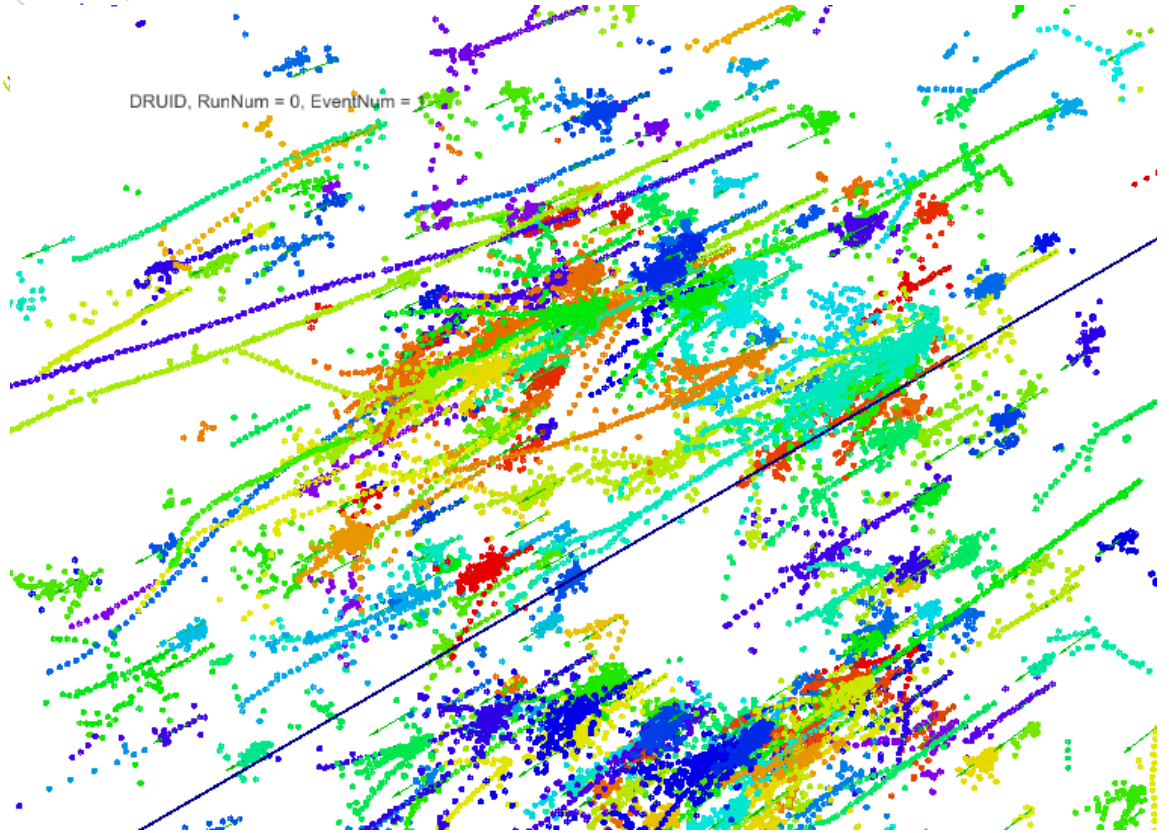


Arbor:
Original Version



Arbor:
With cleaning (Hit time, energy)
+ cluster merging

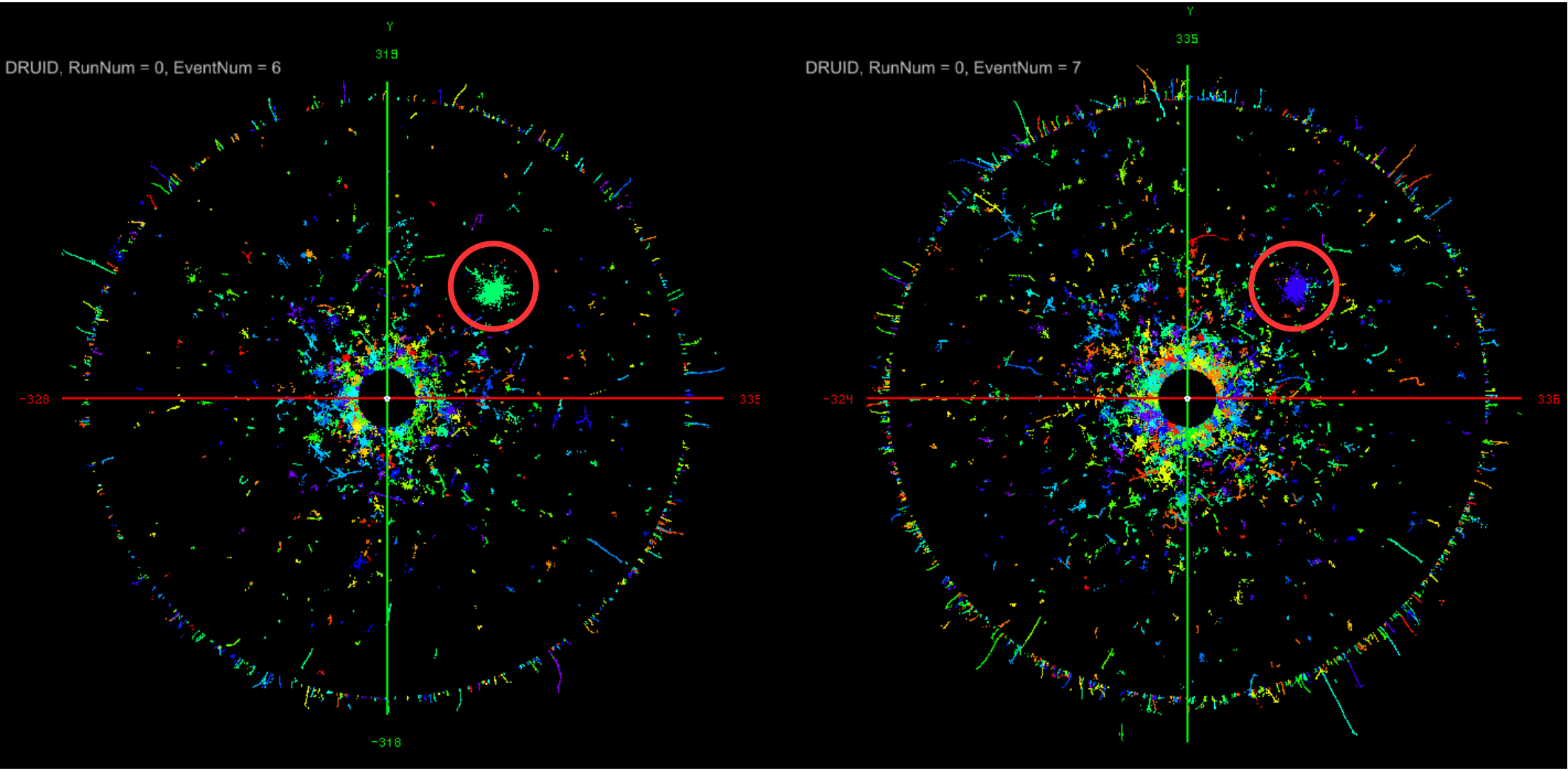




Messy
Environments

Overlap 20
Min-bias events

Reconstructed with Arbor



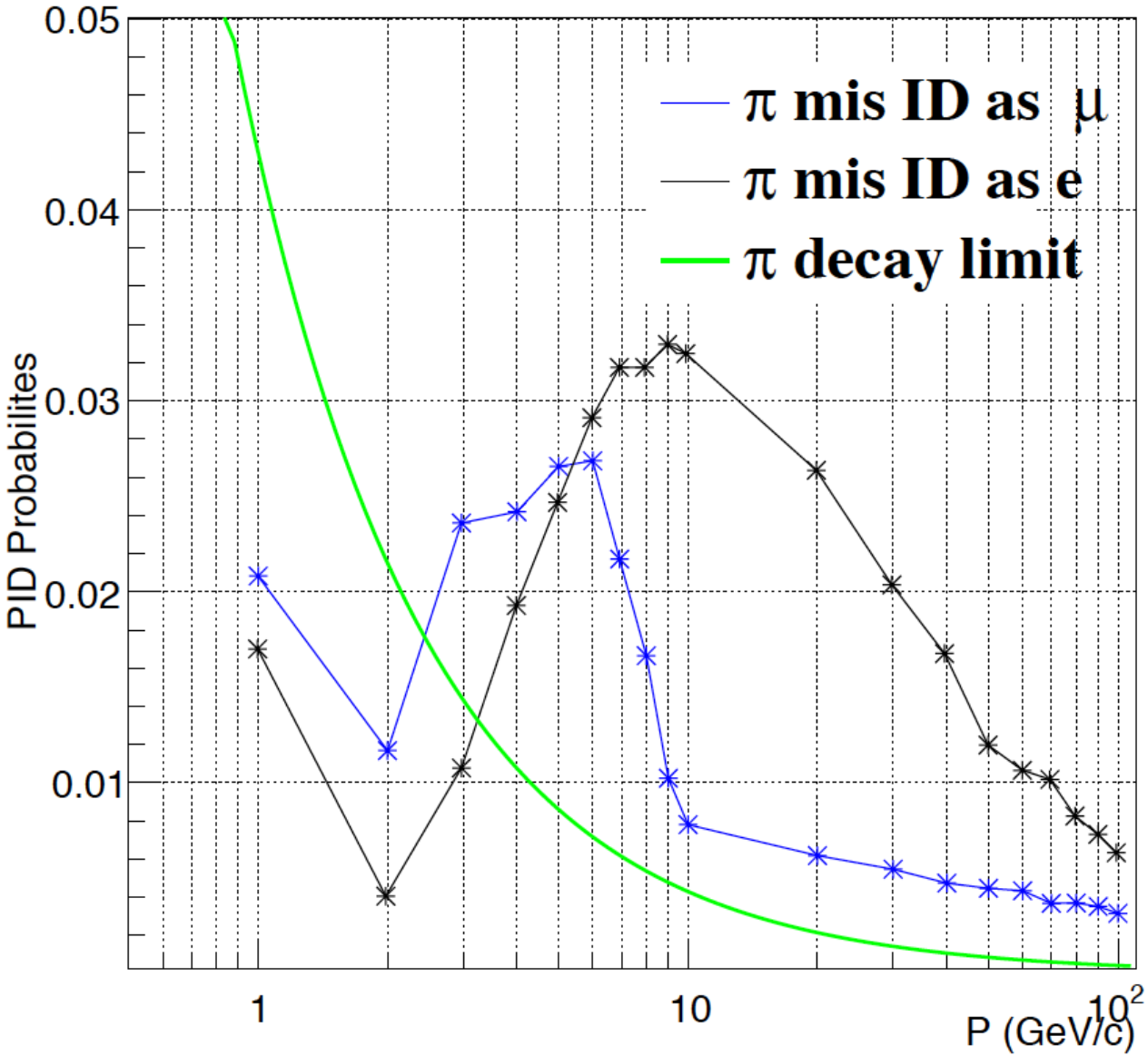
Chasing:
E, δE(E, PID, #PU, η)

1 TeV hadronic shower at 20 PU:
Perturbation from PU ~ 0.1% level

Summary

- Arbor:
  - Reasonable performance at JER, object finding & identification
  - Proof of principle at proton collisions
- Current focus:
  - Evaluation of geometry dependence:
    - Tracker material
    - Calorimeter dead zone
  - Analysis/Diagnosis versus confusions
    - Splitting: Pre-interactions induced
  - Cluster: identification & Energy Estimation

Backup



Pi mis-id in Arbor V3