Status report of Photon Isolation and di-muon analysis

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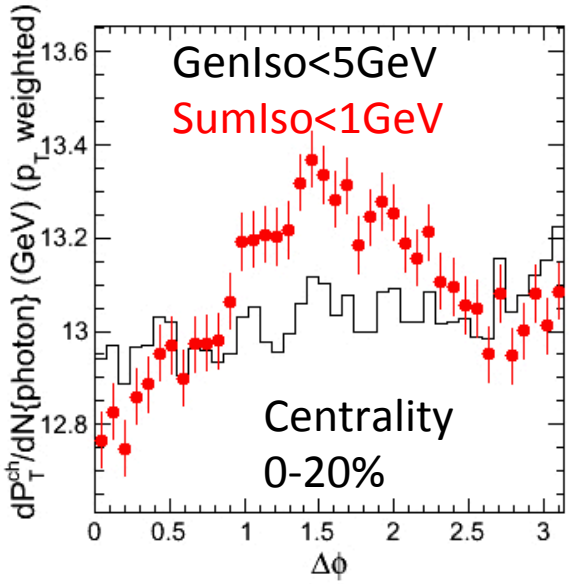
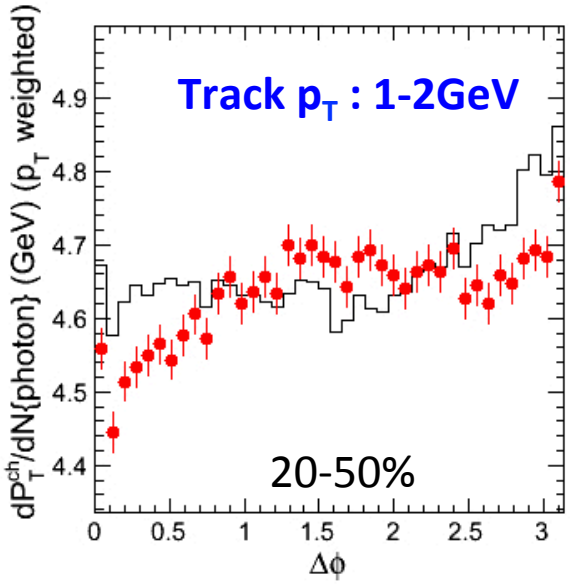
29-Aug-14

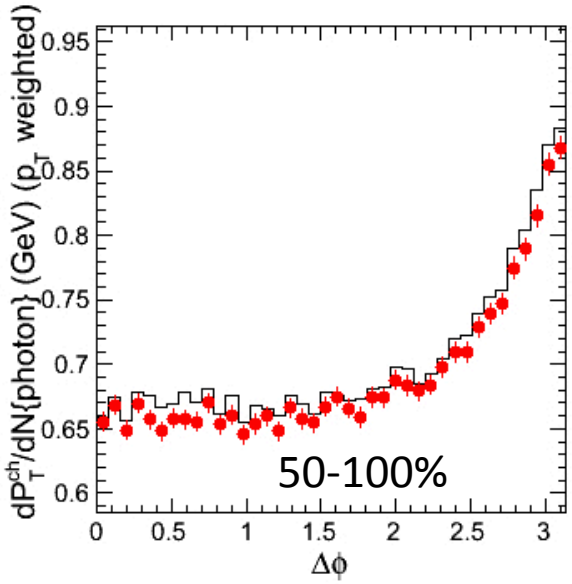
Overall status

- pPb J/psi
  - 2nd crisis of MC production in CMS HI settled
  - Update of muon cuts according to the latest muon ID developed by pp colleagues
  - New T&P studies to be followed (🡐 Yongsun is inspecting the machinery)
  - Will rewrite PAS (aimed end of September)
- B analysis
  - Rapidity asymmetry of yield turned to be a bug
  - Acceptance systematics method is (almost) fixed
  - Found problems in Tag&Probe machinery and being fixed
  - No visible showstopper at the moment
- Gamma-jet correlation
  - Agreed to move the pPb data points for paper with updated jet energy correction, and go ahead writing paper.
  - Idea is straightforward but wait until MC sample is ready (4 weeks)
- Gamma-hadron correlation
  - Progress made in photon isolation variable development
  - Aim to show the Moriond/QCD on March 2015 if everything is going well
  - Otherwise, we will push gamma-hadron analysis with 5TeV PbPb in 2016. Fast track

Angular correlation : PYTHIA+HYDJET







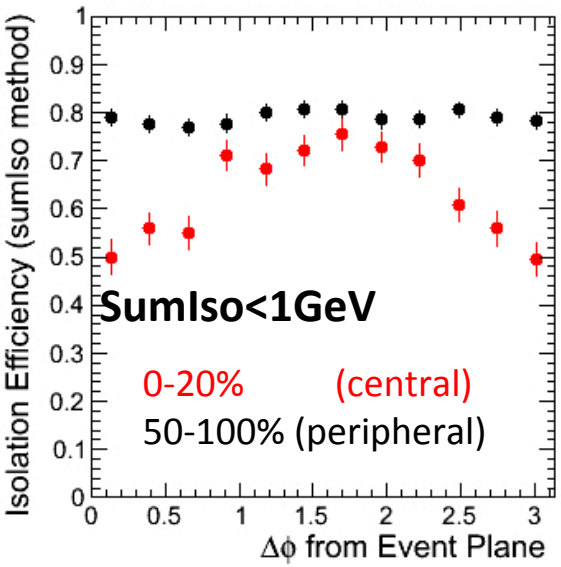
Background tracks are not subtracted yet!

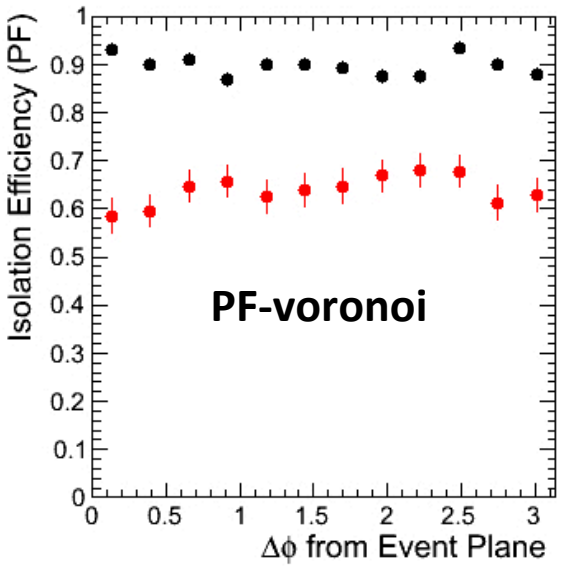
Changed the Y range to look closer.

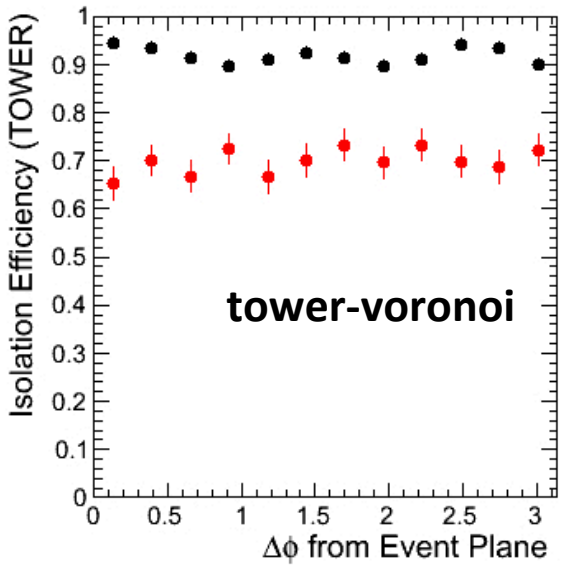
GenIso and **SumIso** methods give totally different results.
In 0-20% events, I found a Mach cone from PYTHIA+HYDJET !??!?
Where does this strange shape come from?

Let's look at the GenParticle distribution

Isolation efficiency VS Event plane







Event plane bias reduced

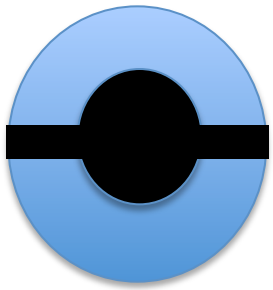
Muon Tag and Probe

Photon veto cone in E/G POG

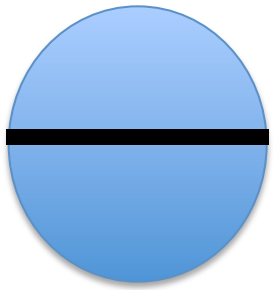
Standard photon vetoes

The vetoes should be applied whether or not the photon is identified by PFlow as a PF photon:

	charged hadrons	neutral hadrons	photons
Barrel	ΔR>0.02	none	Δη>0.015
Endcaps	ΔR>0.02	none	ΔR>0.00864*fabs(sinh(phoSCEta))*4



dEta width =0.04



dEta width =0.015

- Very narrow veto strip.
  - because pfElectrons are not counted? (Chia-Ming?)

Isolation cuts for Run 1 (to be updated)

Cuts optimized for non-triggering photons

The cone size for all isolation sums is 0.3

BARREL	Loose (90%)	Medium (80%)	Tight (70%)
Conversion safe electron veto	Yes	Yes	Yes
Single tower H/E	0.05	0.05	0.05
$\sigma_{i\eta i\eta}$	0.012	0.011	0.011
Rho corrected PF charged hadron isolation	2.6	1.5	0.7
Rho corrected PF neutral hadron isolation	3.5 + 0.04*pho_Pt	1.0 + 0.04*pho_Pt	0.4 + 0.04*pho_Pt
Rho corrected PF photon isolation	1.3 + 0.005*pho_Pt	0.7 + 0.005*pho_Pt	0.5 + 0.005*pho_Pt

ENDCAPS	Loose (85%)	Medium (75%)	Tight (65%)
Conversion safe electron veto	Yes	Yes	Yes
Single tower H/E	0.05	0.05	0.05
$\sigma_{i\eta i\eta}$	0.034	0.033	0.031
Rho corrected PF charged hadron isolation	2.3	1.2	0.5
Rho corrected PF neutral hadron isolation	2.9 + 0.04*pho_Pt	1.5 + 0.04*pho_Pt	1.5 + 0.04*pho_Pt
Rho corrected PF photon isolation	-	1.0 + 0.005*pho_Pt	1.0 + 0.005*pho_Pt

- (Rho is the pedestal density by pileup in pp collisions)

More PF Isolation variables

- New variables based on PF id added
  - X : cone size. E.g. X=1 means R = 0.1
  - pfpIsoX : photon
  - pfnIsoX : neutral hadrons
  - pfcIsoX : charged hadrons
  - pfsumIsoX : charged hadrons
  - pfpVsIsoX, pfnIsoX, pfcIsoX, pfsumIsoX are voronoi background subtracted ones
- The veto area was modified according to pp Run1 case
- **git branch : Isolation_development**
  - started from forest_CMSSW_5_3_20

```
[jazzitup@gate plugins]$ git checkout -b Isolation_development
M       HeavyIonsAnalysis/PhotonAnalysis/BuildFile.xml
M       HeavyIonsAnalysis/PhotonAnalysis/plugins/BuildFile.xml
M       HeavyIonsAnalysis/PhotonAnalysis/plugins/MultiPhotonAnalyzerTree.cc
M       HeavyIonsAnalysis/PhotonAnalysis/plugins/SinglePhotonAnalyzerTree.cc
M       HeavyIonsAnalysis/PhotonAnalysis/plugins/SinglePhotonAnalyzerTree.h
M       HeavyIonsAnalysis/PhotonAnalysis/python/SinglePhotonAnalyzer_cfi.py
```

TAG MUON condition

- Acceptance
  - '((abs(eta) <= 1.3 && pt > 3.3) || (1.3 < abs(eta) <= 2.2 && p > 2.9) || (2.2 < abs(eta) <= 2.4 && pt > 0.8))'
- Selection
  - Collection : patMuonsWithTrigger
  - TMOneStationTight && isTrackerMuon && TrackerMuonArbitrated
- Quality Cut
  - abs(dB) < 3 && abs(track.dz) < 30
  - hitPattern.pixelLayersWithMeasurement > 1
  - normalizedChi2 < 1.8
  - hitPattern.trackerLayersWithMeasurement > 5
  - Trigger matching : HLT_PAMu3 || HLT_PAMu7 || HLT_PAMu12

- RED was missing in GM's configuration
- BLUE was missing in KS's configuration
- GREEN was missing in both

Probe 1. Tracking

- Tracking : Start from patMuonsWithTriggerSta collection which is Same to patMuonsWithTrigger collection but the momentum is obtained from standard muon
  - All Probe : Non-null && in Accpetnance Range
  - Passing Probe : qualityCut && IsTrackerMuon

- This is already consistent

- RED was missing in GM's configuration
- BLUE was missing in KS's configuration
- GREEN was missing in both

Probe 2. Muon Id

- MuonID : Starts from patMuonsWithTrigger collection
  - All Probe : quality Cut && isTrackerMuon && in Accpetnance Range
  - Passing Probe: muonID('TrackerMuonArbitrated') && muonID('TMOneStationTight')

- RED was missing in GM's configuration
- BLUE was missing in KS's configuration
- GREEN was missing in both

Probe3 Trigger efficiency

- Trigger: Starts from patMuonsWithTrigger (Same as MuId)
  - All Probes : quality cut && muonId && isTrackerMuon && acceptance cut
  - Passing Probe : HLT trigger Matching

- RED was missing in GM's configuration
- BLUE was missing in KS's configuration
- GREEN was missing in both

Outline

- Had a very close look on T&P package configuration made by Dongho and Kisoo and compared with Bfinder verion T&P macro
  - Dongho's ver. : Official package -> Dongho -> Kisoo's modification
  - Gian's ver. : based on Bfinder. See last week's slides for detail

- Keeping in close touch with Dongho for advice
  - He was busy for starting up as a new position in Korea

TAG : Gian's configuration

The definition of the tag is the same for tracking, trigger and muonID studies:
A tagged muon:

- passes the standard acceptance selection:
  abs(eta)<1.3&&pt>3.3)||(abs(eta)>1.3&&abs(eta)<2.2&&p>2.9)||(abs(eta)>2.2&&abs(eta)<2.4&&pt>0.8

- selection:
  muon::isGoodMuon(*mu_it,muon::TMOneStationTight) **AND**
  muon::isGoodMuon(*mu_it,muon::TrackerMuonArbitrated)

- quality cuts:

```
if(abs(MuonInfo_dxyPV[mu1])>=3. || abs(MuonInfo_dzPV[mu1])>=30.) isSelected=false;
if(MuonInfo_i_nPixelLayer[mu1]<1.) isSelected=false;
if(MuonInfo_normchi2[mu1]>1.8) isSelected=false;
if((MuonInfo_i_nStripLayer[mu1]+MuonInfo_i_nPixelLayer[mu1])<6.) isSelected=false;
```

TAG : Dongho/Kisoo's

- Acceptance
  - '((abs(eta) <= 1.3 && pt > 3.3) || (1.3 < abs(eta) <= 2.2 && p > 2.9) || (2.2 < abs(eta) <= 2.4 && pt > 0.8))'
- Selection
  - Collection : patMuonsWithTrigger
  - TMOneStationTight && isTrackerMuon && TrackerMuonArbitrated
- Quality Cut
  - abs(dB) < 3 && abs(track.dz) < 30
  - hitPattern.pixelLayersWithMeasurement > 1
  - normalizedChi2 < 1.8
  - hitPattern.trackerLayersWithMeasurement > 5
  - Trigger matching : HLT_PAMu3 || HLT_PAMu7 || HLT_PAMu12

Diff!!?

- Acceptance
  - '((abs(eta) <= 1.3 && pt > 3.3) || (1.3 < abs(eta) <= 2.2 && p > 2.9) || (2.2 < abs(eta) <= 2.4 && pt > 0.8))'
- Selection
  - Collection : patMuonsWithTrigger
  - TMOneStationTight && isTrackerMuon && TrackerMuonArbitrated
- Quality Cut
  - abs(dB) < 3 && abs(track.dz) < 30
  - hitPattern.pixelLayersWithMeasurement > 1
  - normalizedChi2 < 1.8
  - hitPattern.trackerLayersWithMeasurement > 5
  - Trigger matching : HLT_PAMu3 || HLT_PAMu7 || HLT_PAMu12

Probe : Gian's slide

TRACKING:

All probe:

- mu_it->outerTrack().isNonnull();

Passing probe:

- probe + quality cut **AND** mu_it->isTrackerMuon()

MuonID:

All probe:

- qualitycut **AND** mu_it->isCaloMuon()

????

Passing probe:

- probe + muoninacceptance **AND** mu_it->isTrackerMuon()

TRIGGER:

All probe:

- muon::isGoodMuon(*mu_it,muon::TMOneStationTight) **AND** muon::isGoodMuon(*mu_it,muon::TrackerMuonArbitrated) **AND** qualitycut **AND** mu_it->isTrackerMuon() **AND** isinacceptance

Passing probe:

- probe + matched with a HLT triggered muon

Probe : Dongho/Kisoo's

- Tracking : Start from patMuonsWithTriggerSta collection which is Same to patMuonsWithTrigger collection but the momentum is obtained from standard muon

  - All Probe : Non-null
  - Passing Probe : qualityCut && IsTrackerMuon

- No difference from Gians' one except the momentum measurement

TRACKING:

All probe:

- mu_it->outerTrack().isNonnull();

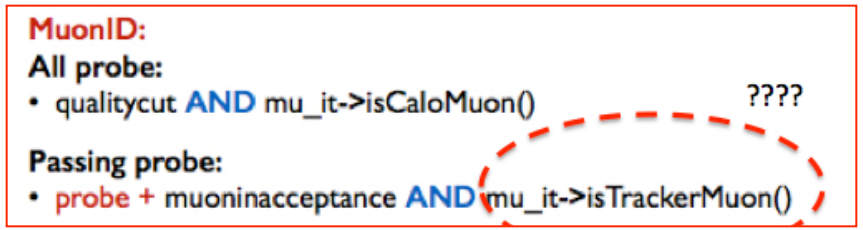
Passing probe:

- probe + quality cut AND mu_it->isTrackerMuon()

Probe : Dongho/Kisoo's

- MuonID : Starts from patMuonsWithTrigger collection
  - All Probe : quality Cut && isCaloMuon
  - Passing Probe: qualityCut && isTrackerMuon && muonID('TrackerMuonArbitrated') && muonID('TMOneStationTight')

- Diff from Gian's code
  - 1. The acceptance criteria is missing in passing probe
  - 2. muonID cut was added in passing probe



Probe : Dongho/Kisoo's

- Trigger: Starts from patMuonsWithTrigger (Same as MuId)
  - All Probes : quality cut && muonId && acceptance cut
  - Passing Probe : HLT trigger Matching

- Difference from Gian's setup
  - Gian's selection for "all probe" is tigher. It has isTrackMuon()

TRIGGER:

All probe:

- muon::isGoodMuon(*mu_it,muon::TMOneStationTight) AND muon::isGoodMuon(*mu_it,muon::TrackerMuonArbitrated) AND qualitycut AND mu_it->isTrackerMuon() AND isinacceptance

Passing probe:

- probe + matched with a HLT triggered muon

Plan

- Make the consistent configuration with Gian and rerun T&P package
- Current T&P code is very messy with bunch of repetition and overwriting of variable setup. Needs a cleanup to avoid further bugs
- Waiting for Lamia's input for the comparison with the T&P packaged used by pp colleagues
- Add Generated B meson matching in the code

BACKUP

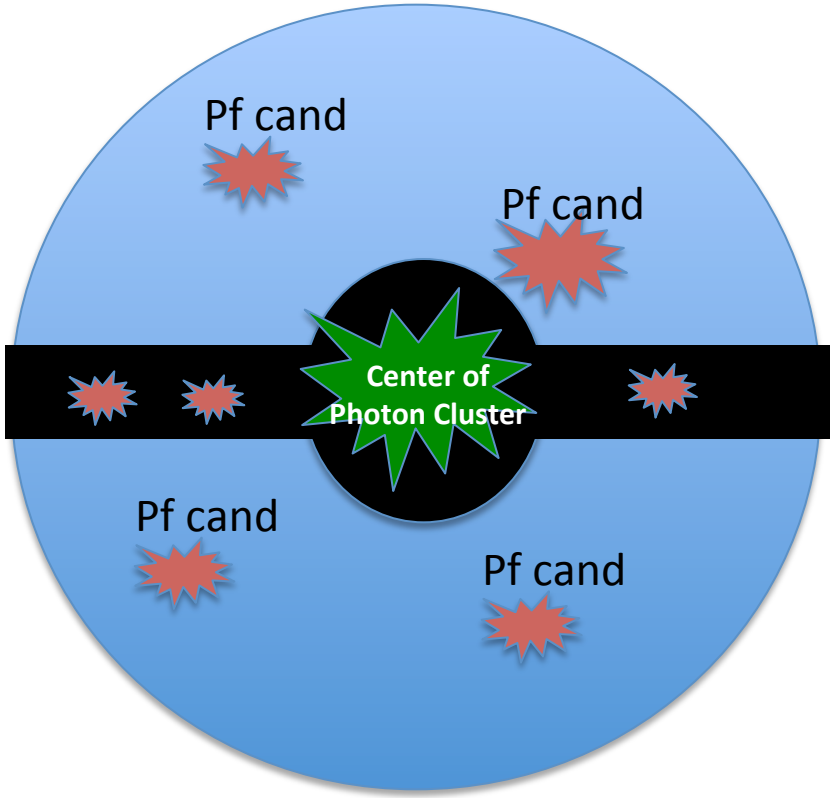
Action Voronoi Isolation variables

- New variables are added in multiPhotonAnalyzer/photon tree
  - PF based isolation variables
    - pfIso1 – pfIso5 : Sum of E_T in the cone of R = 0.1 – 0.5
    - pfIsoSubVs1 – pfIsoSubVs5 : Voronoi subt'd isolation (before equalization)
    - pfIsoVs1 – pfIsoVs5 : Voronoi subt'd isolation (after equalization)
  - Calo Tower based isolation variables
    - towerIso1 – towerIso5
    - towerIsoSubVs1 – towerIsoSubVs5
    - towerIsoVs1 – towerIsoVs5
- Algorithm is saved
  - HeavyIonAnalysis/PhotonAnalysis/src/
    - pfIsoCalculator.h, pfIsoCalculator.cc
    - towerIsoCalculator.h, towerIsoCalculator.cc
  - To be moved to RecoHI
- Validation study has been done with
  - 40k PYTHIA+HYDJET events (private embedded samples)
  - Gen-level isolated photons with pT > 40GeV are used for today's report

Cone size and veto cone

- Jurassic isolation cone : Developed to veto the electron showers bent by solenoid
  - Inner cone : 0.06
  - Strip width : 0.04

  (In eta x phi plane)

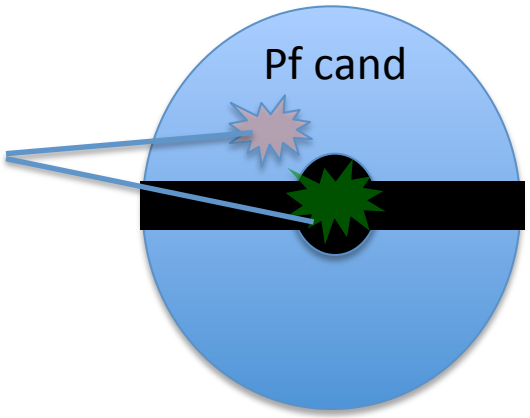


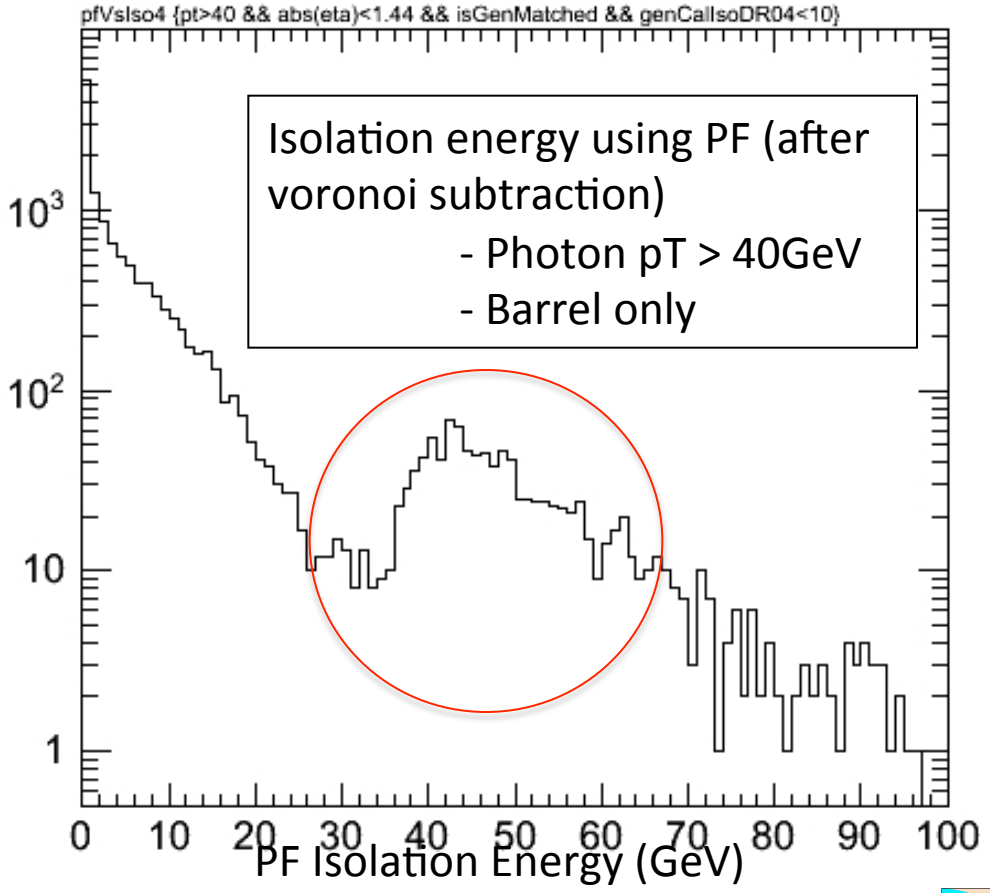
Cone size and veto cone

- However, veto is not working properly for particle flow candidates.
- The energy of photon itself is counted in isolation cone for 8% of population.

My guess is that
The position of the particle flow candidate, corresponding to the high pT photon itself, was measured outside of the veto cone. Don't know why…

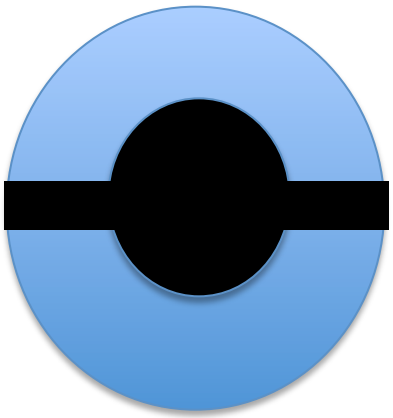
Wrong positioning of PF photon?

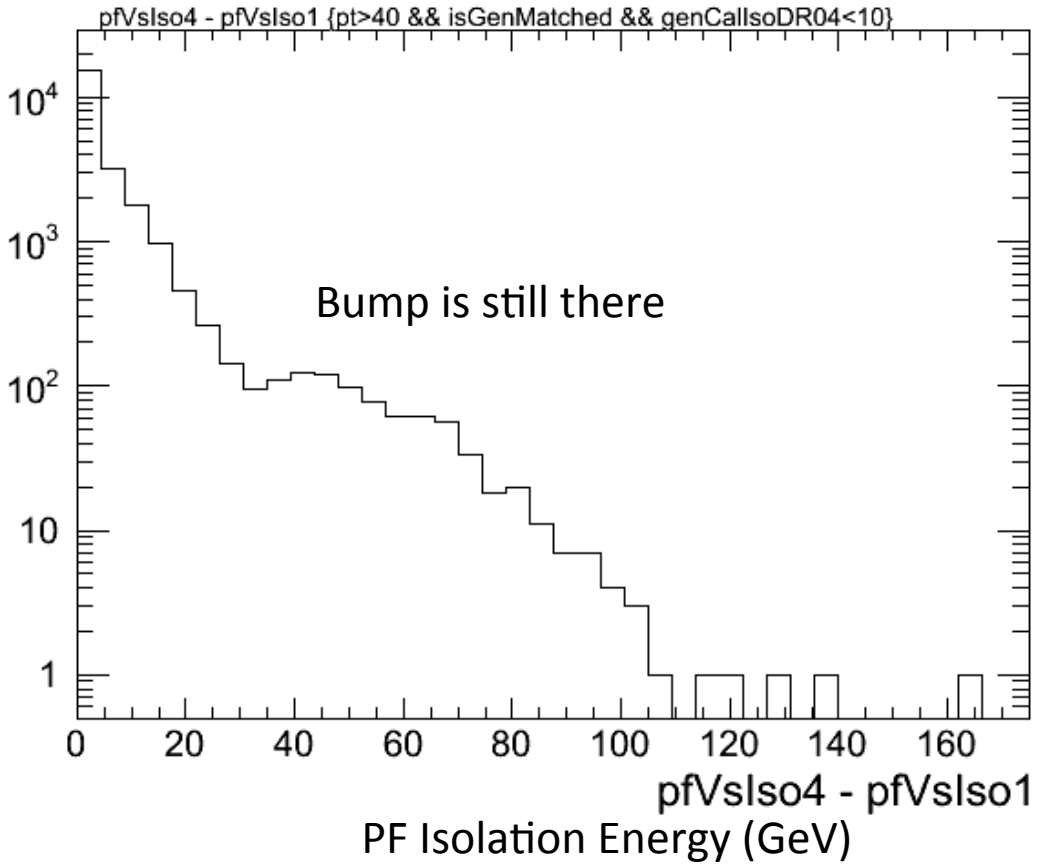




Cone size and veto cone

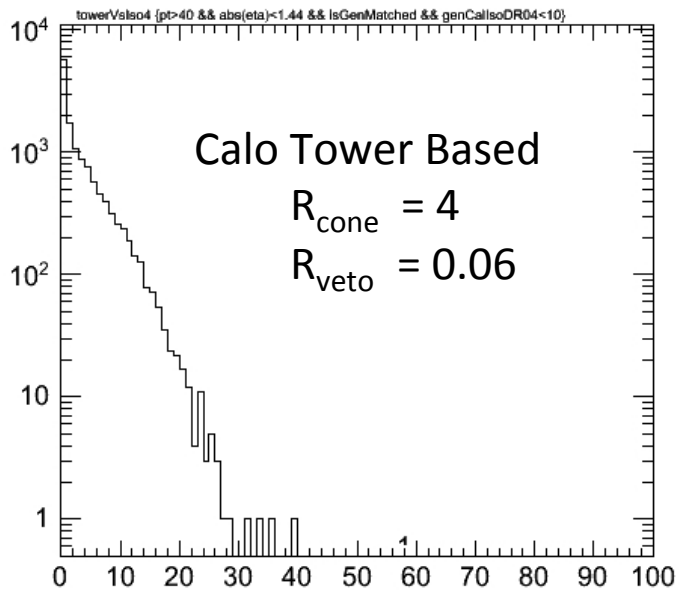
- Enlarged the size of inner veto cone 0.06 -> 0.1
  - Yet, peak remains (2% of population
- The bump becomes invisible veto cone radius > 0.2

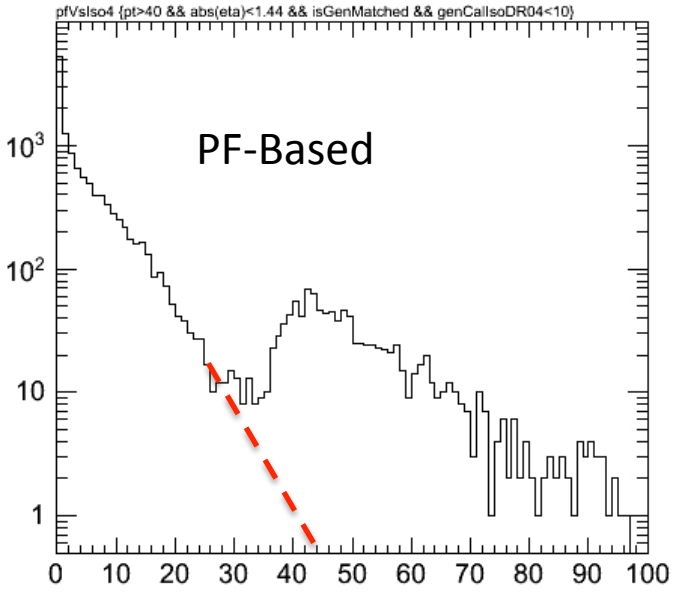




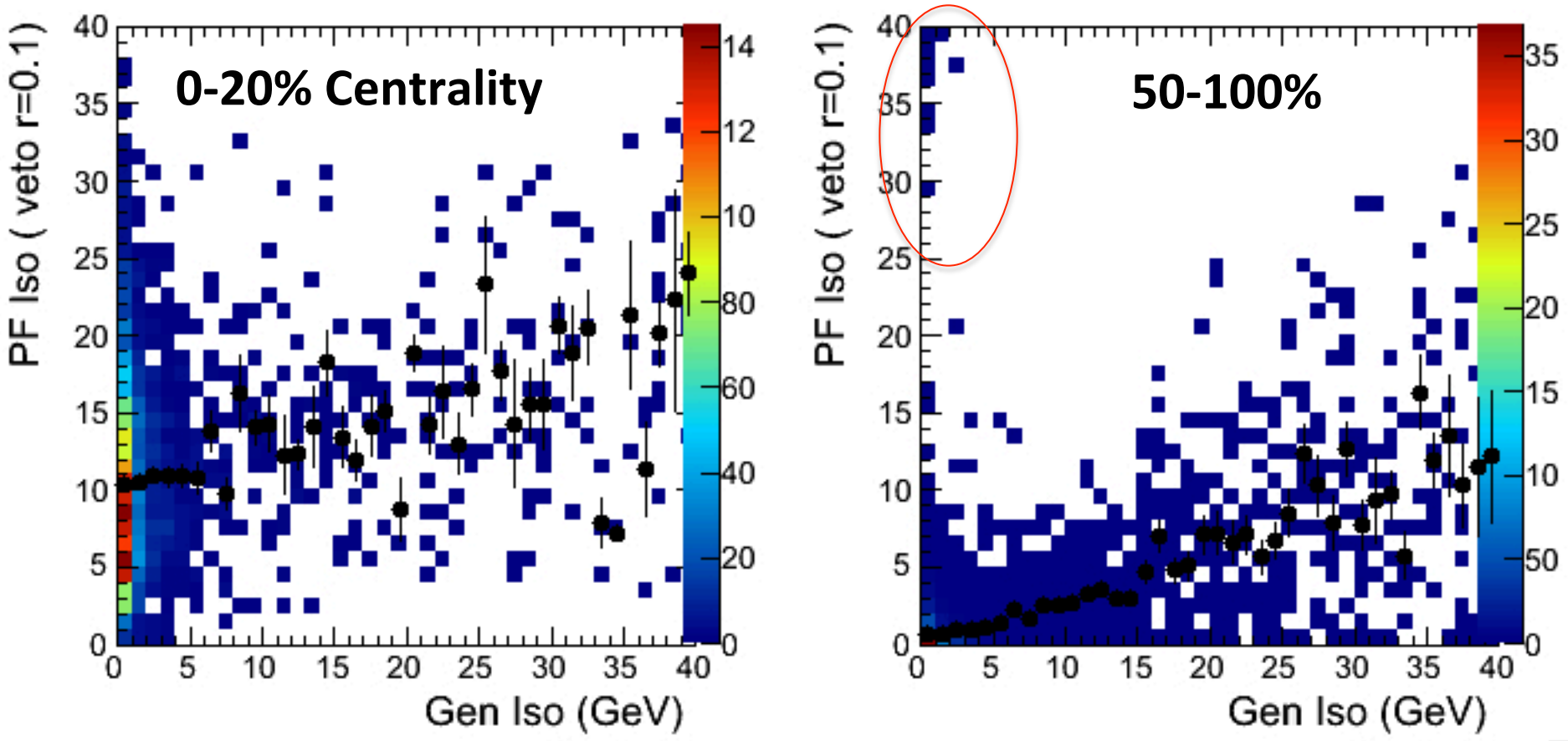
No Energy leak in Tower-based Isolation

- No problem happens for the tower-base isolation energy.
- The position of the high pT photon particleflow candidate needs to be investigated



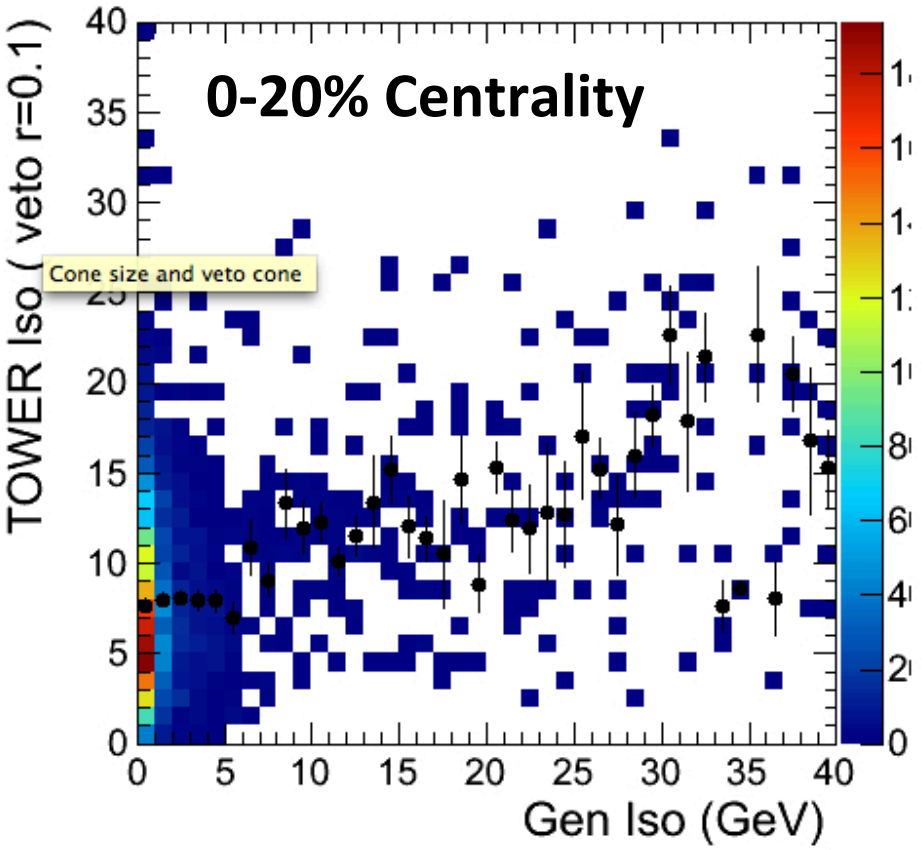


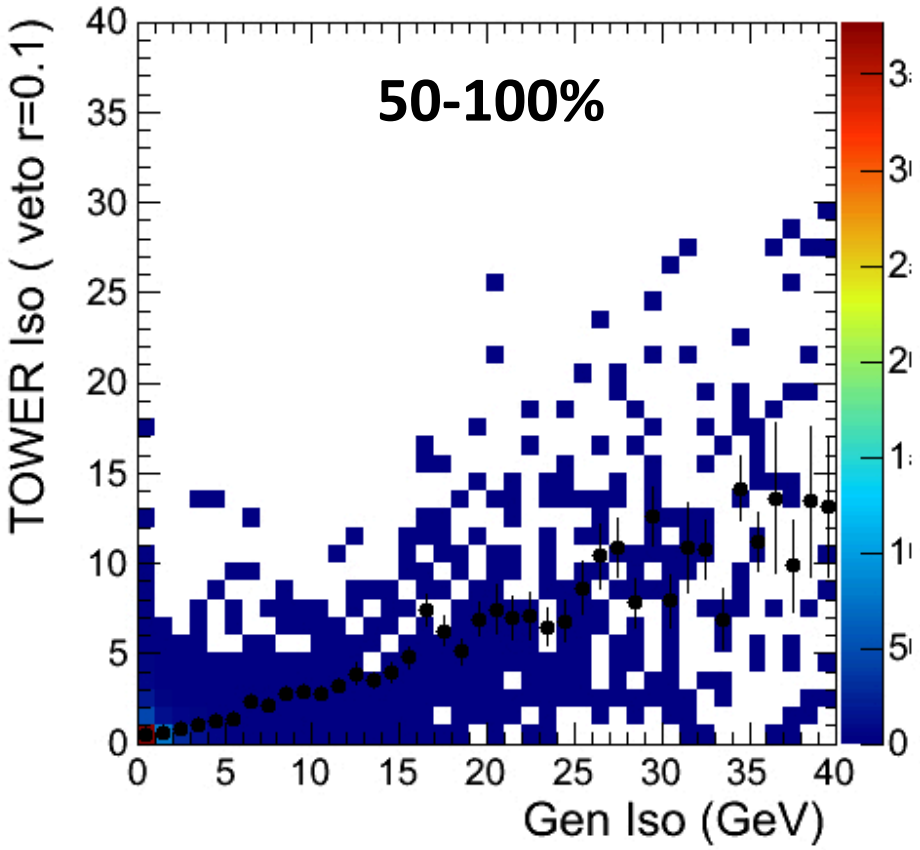
Reco to Gen ISO correlation (PF-based)



- Reconstructed Isolation is highly correlated to Gen level Isolation energy for peripheral events.
- In 0-20% central events, correlation is dimmed, and ~10GeV pedestal energy appears (positive bias?)

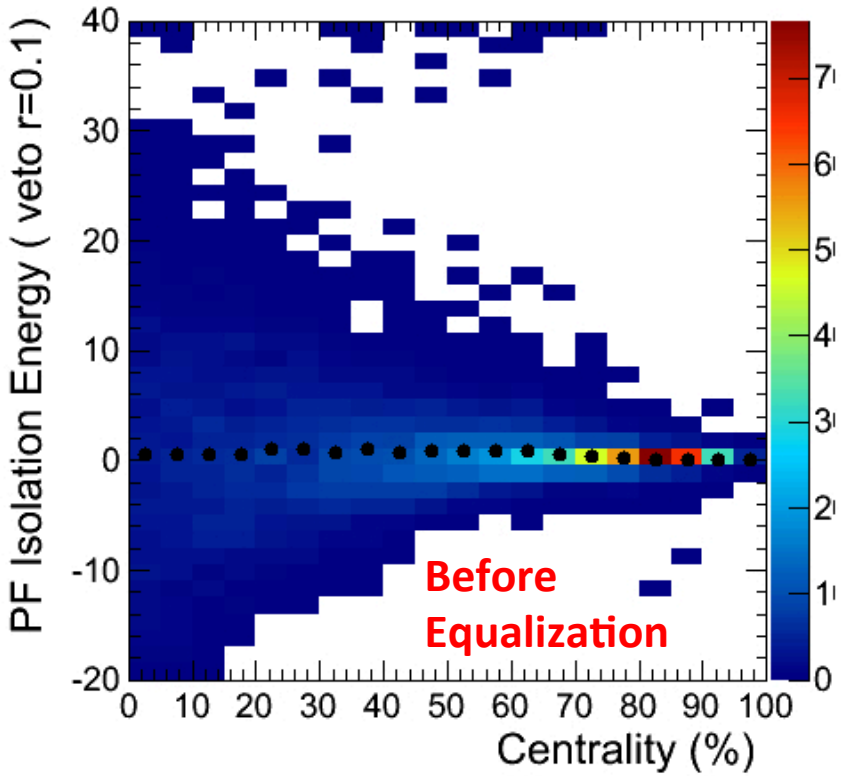
Reco to Gen ISO correlation (Tower-based)

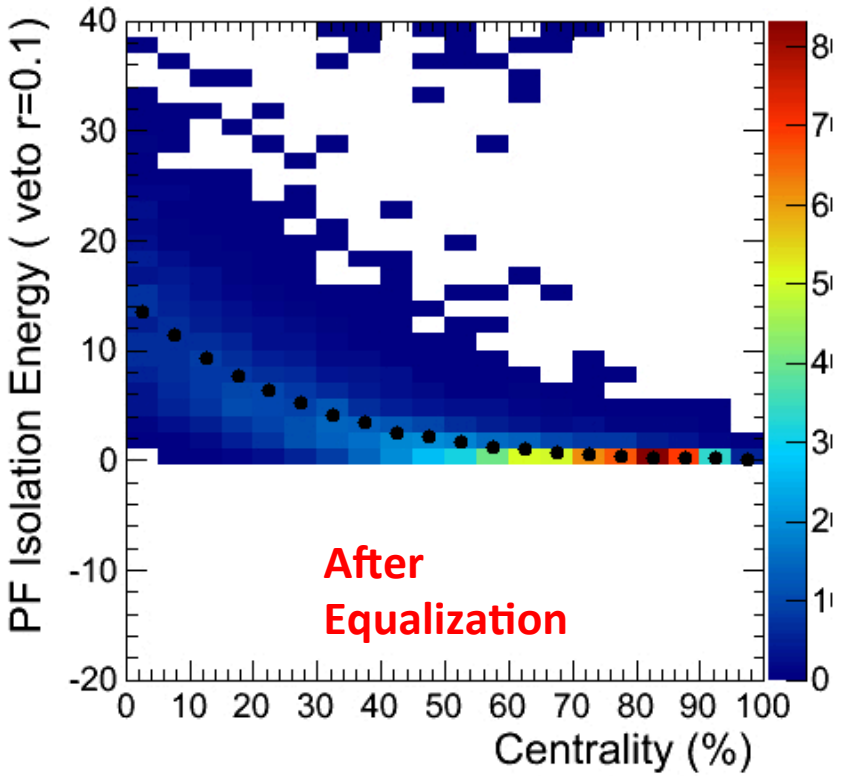




- Similar behavior with PF-based isolation
  - It doesn't necessarily mean that they have same sig/bkg resolution. (effcienvy VS S/B) study will be followed.
  - Usually the tracker isolation has the highest background suppression power.

Before & After Voronoi equalization

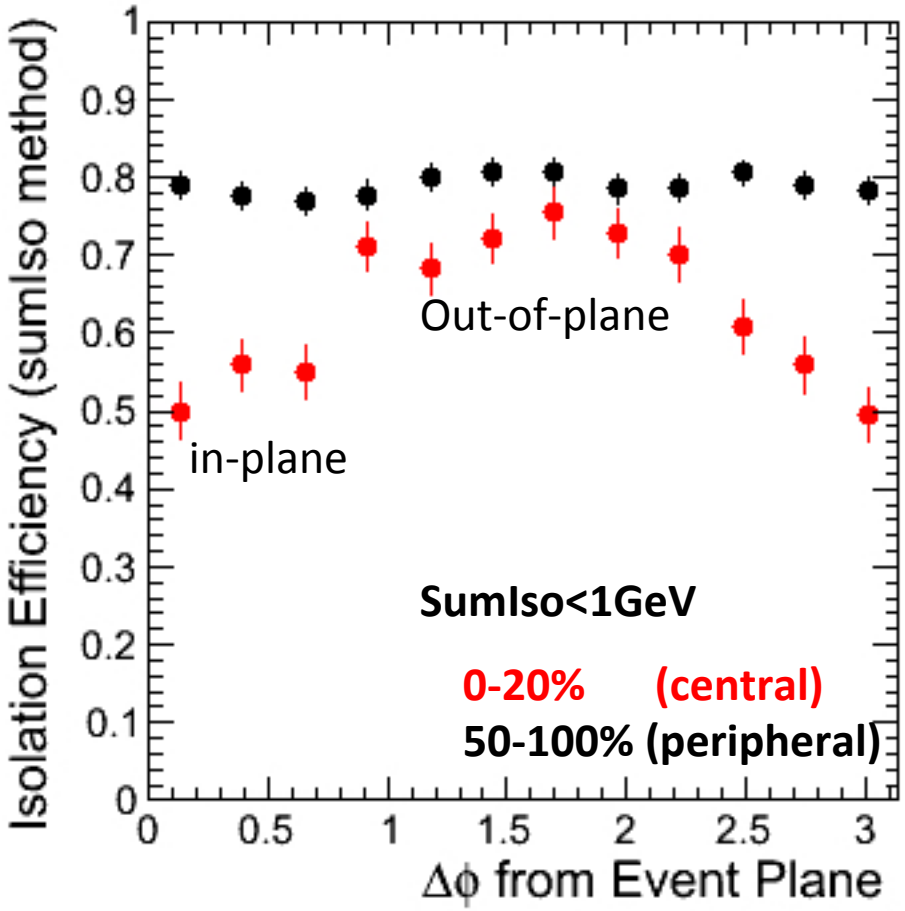




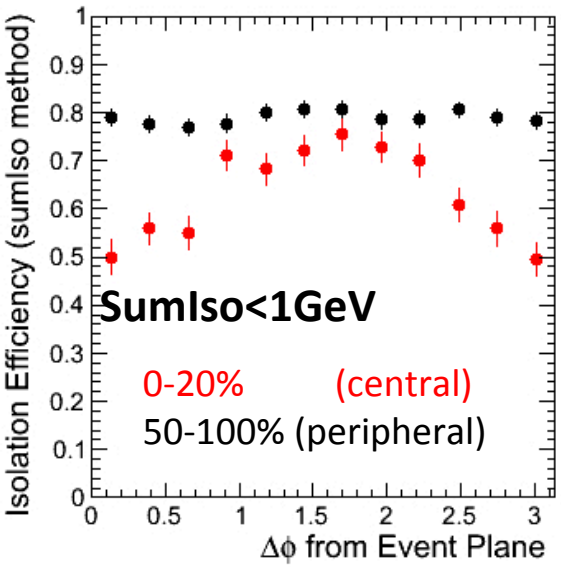
- Equalization process give positive energy bias to the isolation energy
- If Equalization process does not dramatically improve the resolution of the total energy in the cone, we can skip this step to avoid the bias

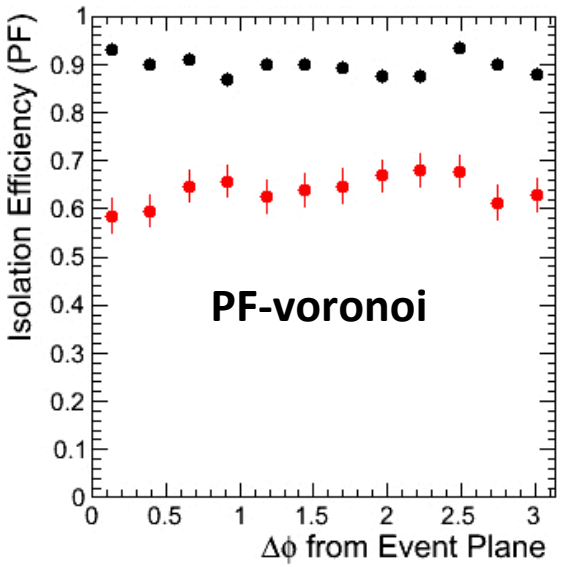
Isolation efficiency VS Event plane

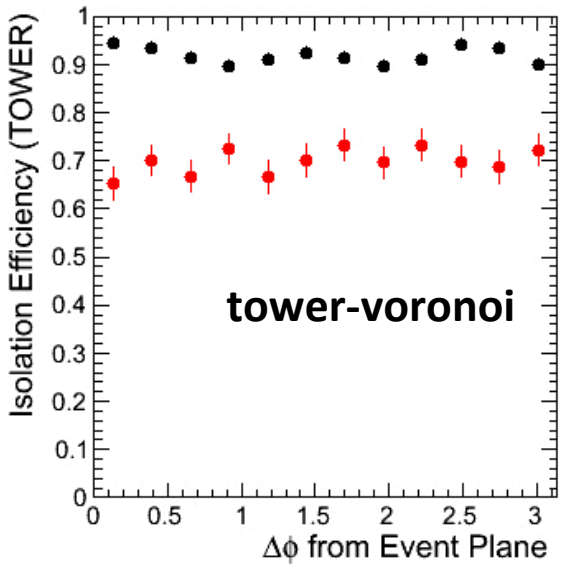
- Traditional isolation:
  - sumIso < 1GeV
  - 20% difference of isolation efficiency between in-plane and out-of-plane
- Average efficiency is 65% for 0-20% central events
- PF-based Isolation threshold was set Iso < 5GeV, which gives similar efficiency (64%)



Isolation efficiency VS Event plane







Event plane bias reduced

Summary/plan

- Tower-Based and PF-based isolation have similar correlation with gen level isolation energy for signal photons.
- Event plane bias is reduced by HF/voronoi subtraction algorithm
- Voronoi equalization introduced centrality-dependent positive energy bias
  - We want to use the non-equalization energy for photon isolation
- Plan :
  - Generation of private Em-enriched jet samples (embedded in HYDJET)
  - Efficiency VS S/B ratio - **ROC curve**
  - Investigation of the positions of high-pt PF flow photon candidate