Improvement of photon reconstructions in Pandora

CLICdp workshop

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Content

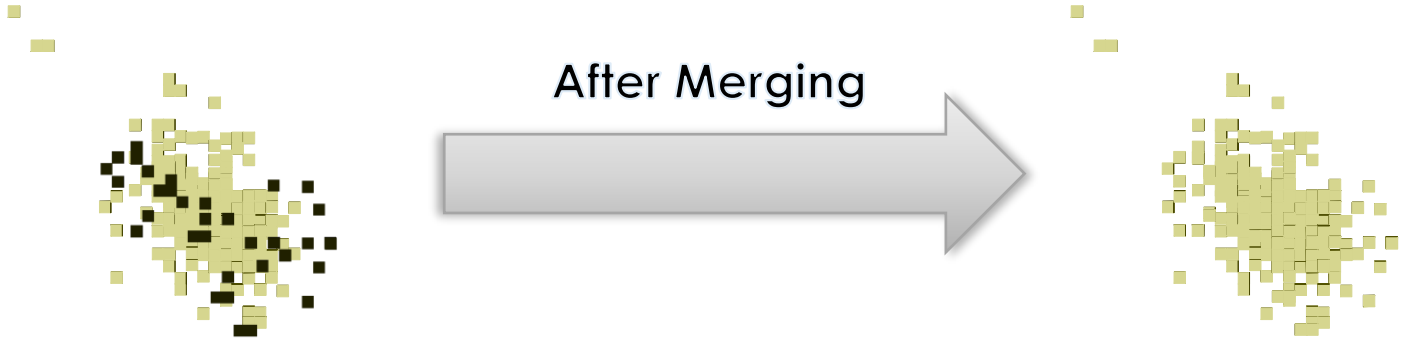
- The release and the performance of *Photon Fragment Merging Algorithm*
- The performance of *High Energy Photon Recovery Algorithm*
- The jet energy with gamma gamma to hadron overlay with different Pandora Configurations
- Current research and future plan

Photon Frag Removal: Motivations

- Want to do better physics, such as π, τ lepton reconstruction.
- These physics channels require good photon reconstructions.
- Hence want to improve the single photon reconstruction.

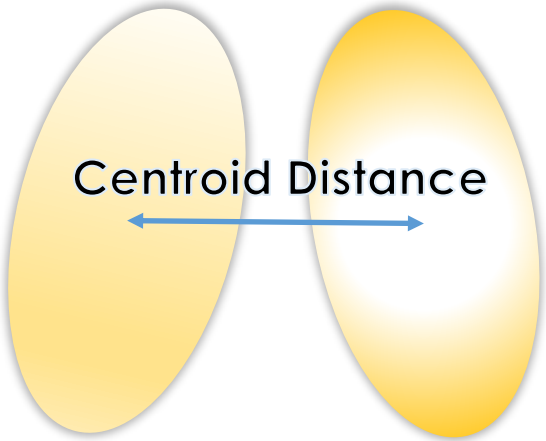
Photon Frag Removal: Motivation II

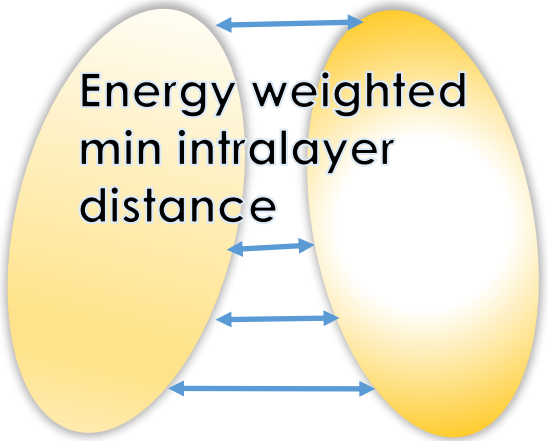
- By improving photon completeness and purity, we can get a more accurate 4 momenta of the photon.
- Pandora used to identify main photons using the core of the clusters, but produce fragments.
- Need to remove photon fragments, see blow.

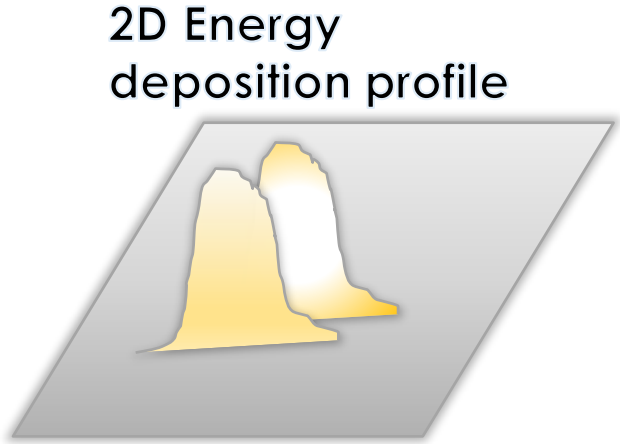


Photon Frag Removal: Selection cuts

- Merge fragments based on quantities.
- Selection cuts determined using MC information, by comparing the distribution for pairs that should be merged and pairs that should not be merged,
- Example quantities:







Photon Frag Removal: Samples

- Selection cuts were developed using samples:
  - 1) single photon of different energies, fired at random directions
  - 2) two photons of different energies, fired at random directions
  - 3) Z'->uds Jets with centre of mass from 91GeV to 500GeV
- Only consider photons without conversions, in barrel region or in end cap region, to avoid gap region.

Photon Frag Removal: Algorithm I

Pandora "Default"

Muon
- Muon Reco

Photon
- Photon Reco

Charged
- Charged Particle Reco

Pandora "DefaultNew"

Muon
- Muon Reco

Photon
- Photon Reco
- **Reco Fragment Merging**

Charged
- Charged Particle Reco
- **Fragment Merging**

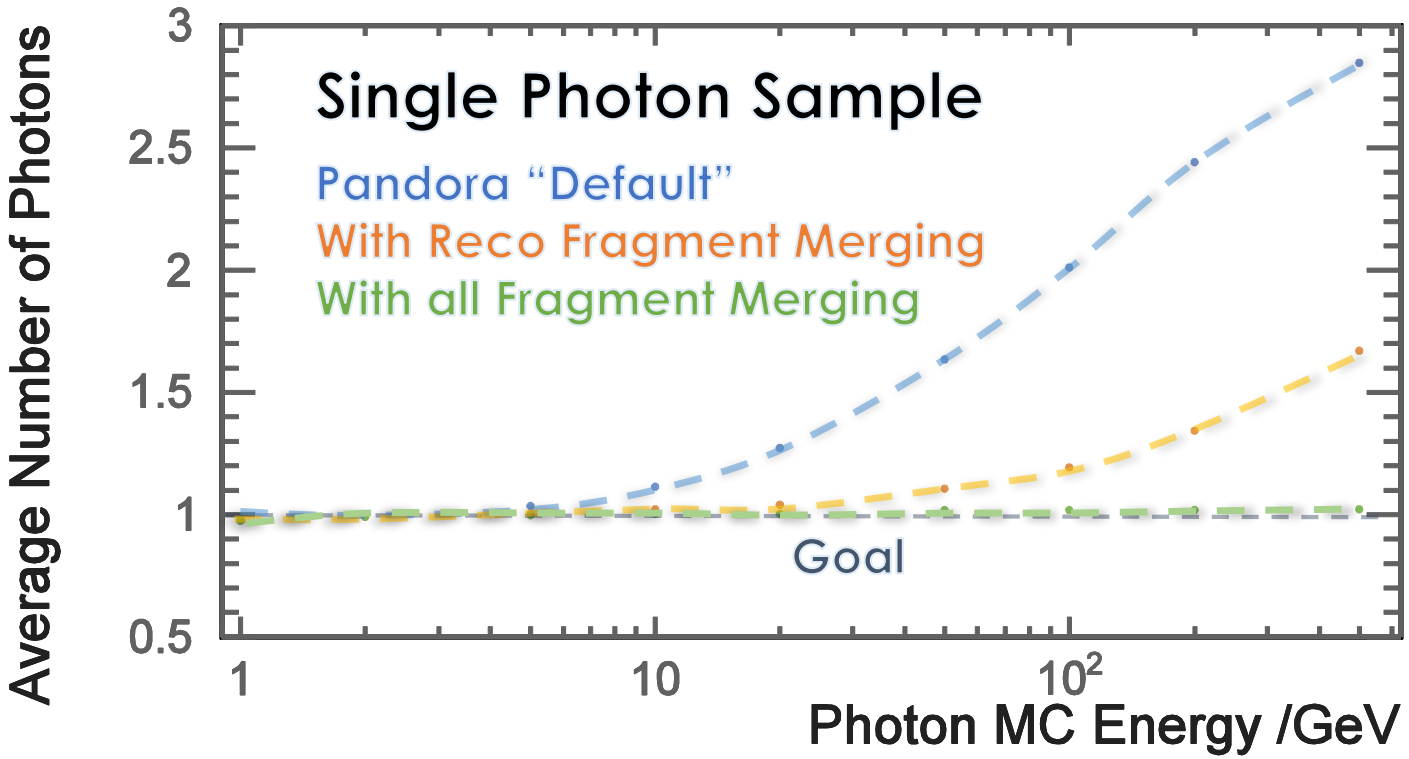
Photon Frag Removal: Algorithm II

- Two fragment merging algorithms have been added, one after the photon reconstruction (Reco Photon Fragment Merging Algorithm), one after the reconstruction of all particles (Photon Fragment Merging Algorithm)
- The reason for having two algorithms: The current photon reconstruction (stand-alone one) identifies most obvious photons, as a choice. Thus a second fragment merging algorithm is need at the end of the particle reconstruction.

Photon Frag Removal: Performance I

Pandora "DefaultNew"

- **Muon**
  - Muon Reco
- **Photon**
  - Photon Reco
  - **Reco Fragment Merging**
- **Charged**
  - Charged Particle Reco
  - **Fragment Merging**



$$N_{photon} = N_{photon,MC} + N_{photon\ fragment}$$

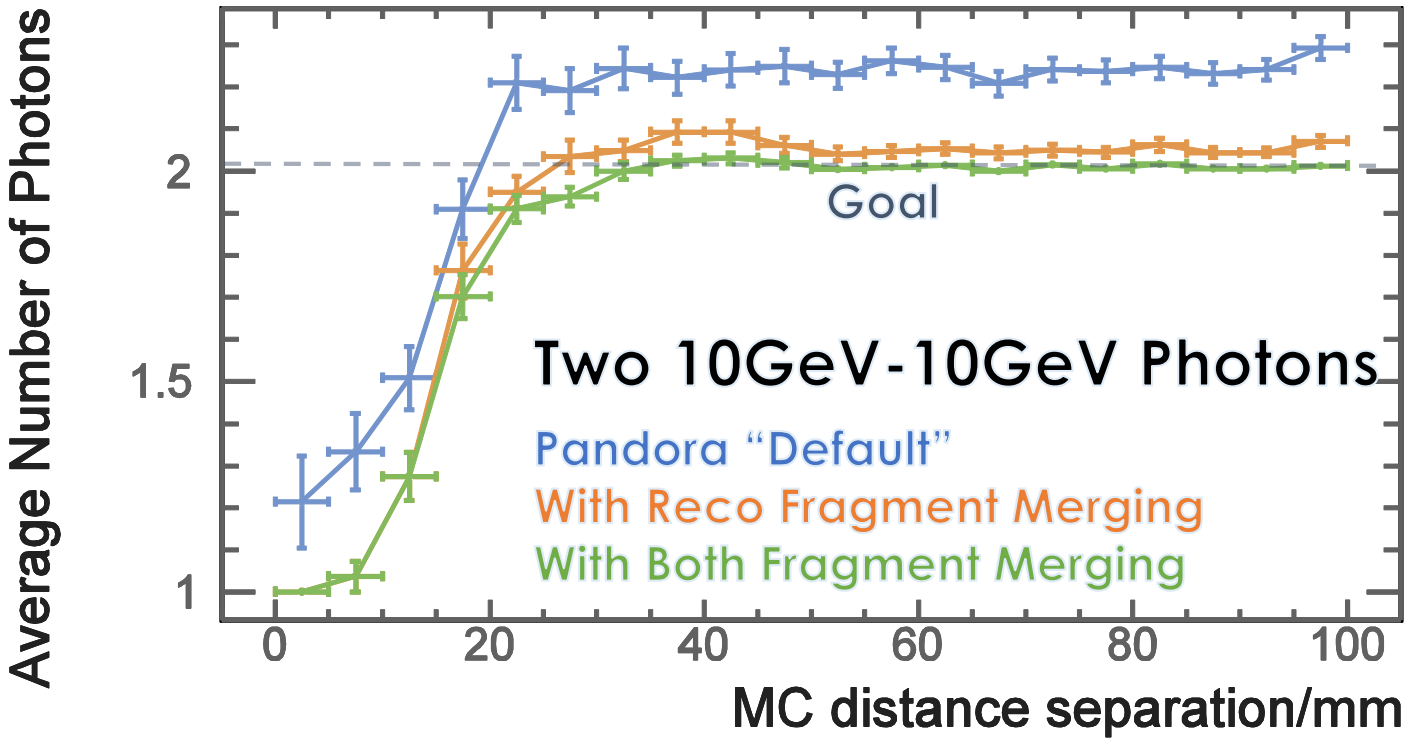
Photon Frag Removal: Performance II

Pandora "DefaultNew"

Muon
- Muon Reco

Photon
- Photon Reco
- **Reco Fragment Merging**

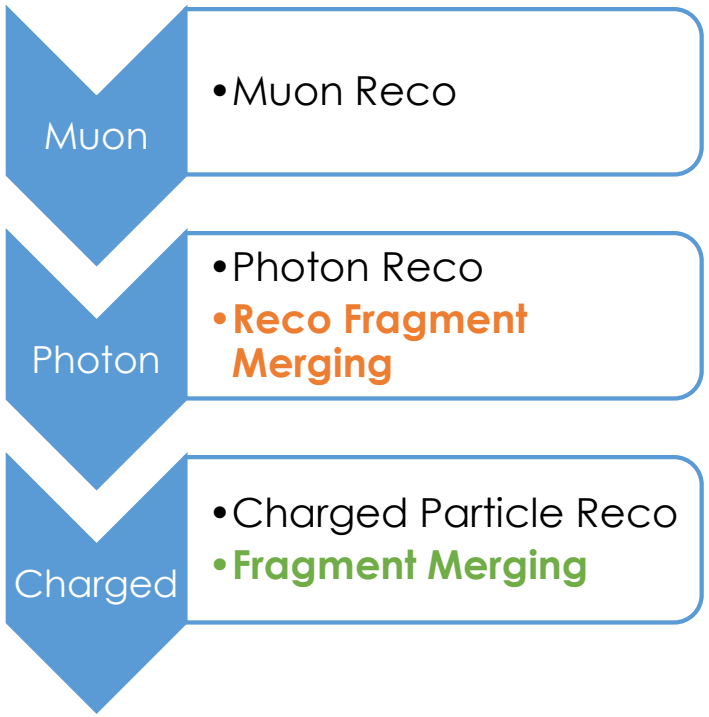
Charged
- Charged Particle Reco
- **Fragment Merging**

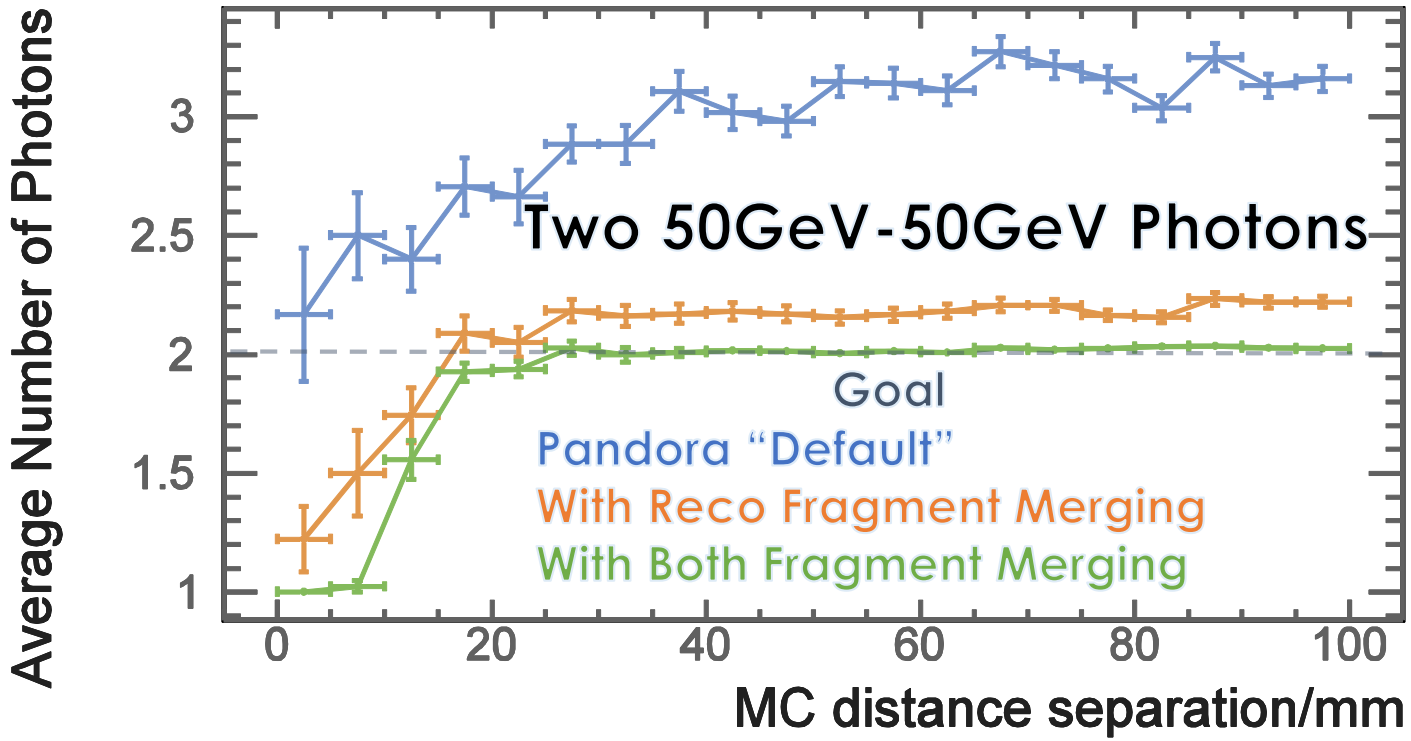


$$N_{photon} = N_{photon,MC} + N_{photon\ fragment}$$

Photon Frag Removal: Performance III

Pandora "DefaultNew"

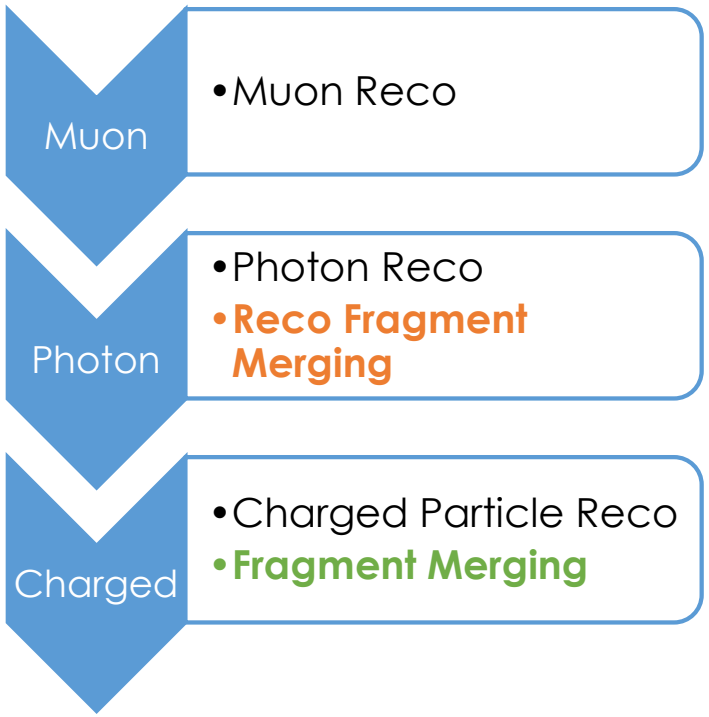


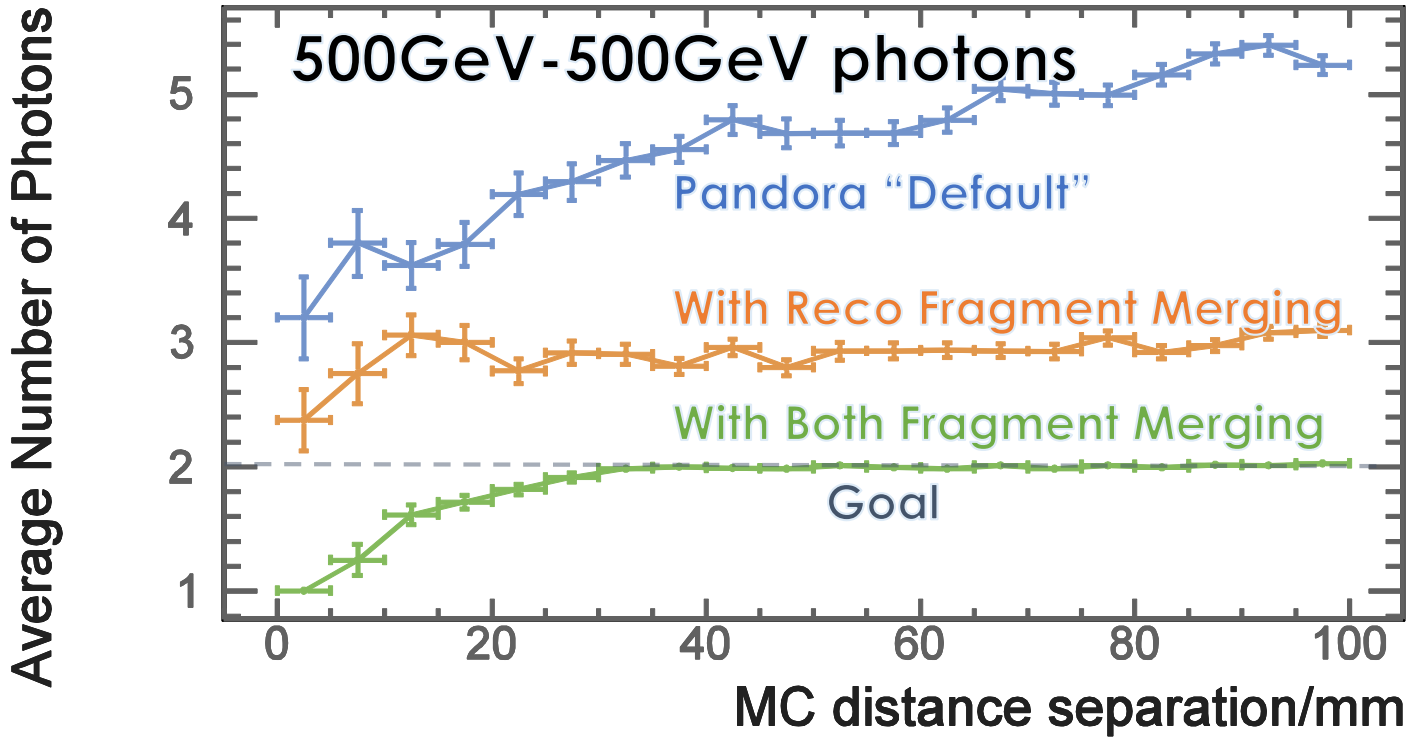


$$N_{photon} = N_{photon,MC} + N_{photon\ fragment}$$

Photon Frag Removal: Performance IV

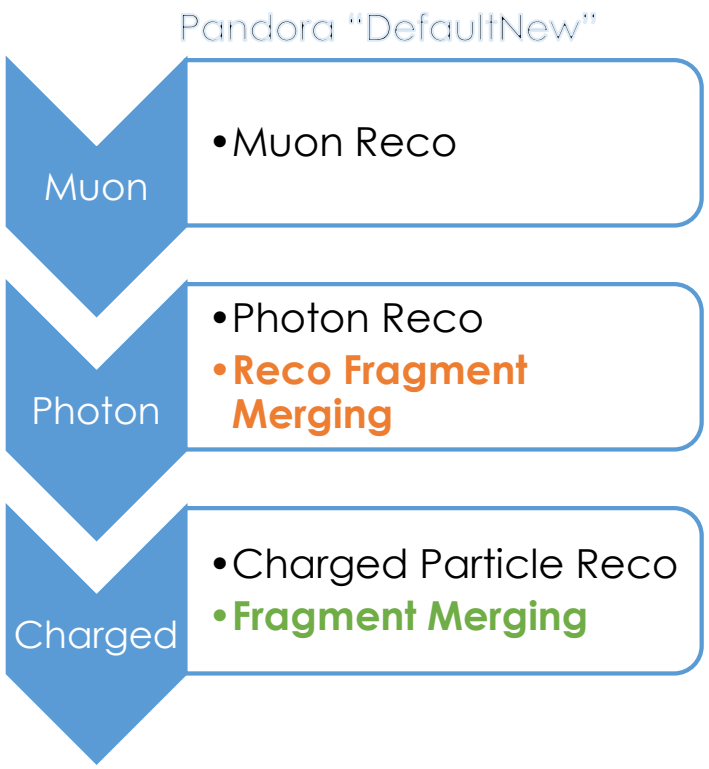
Pandora "DefaultNew"

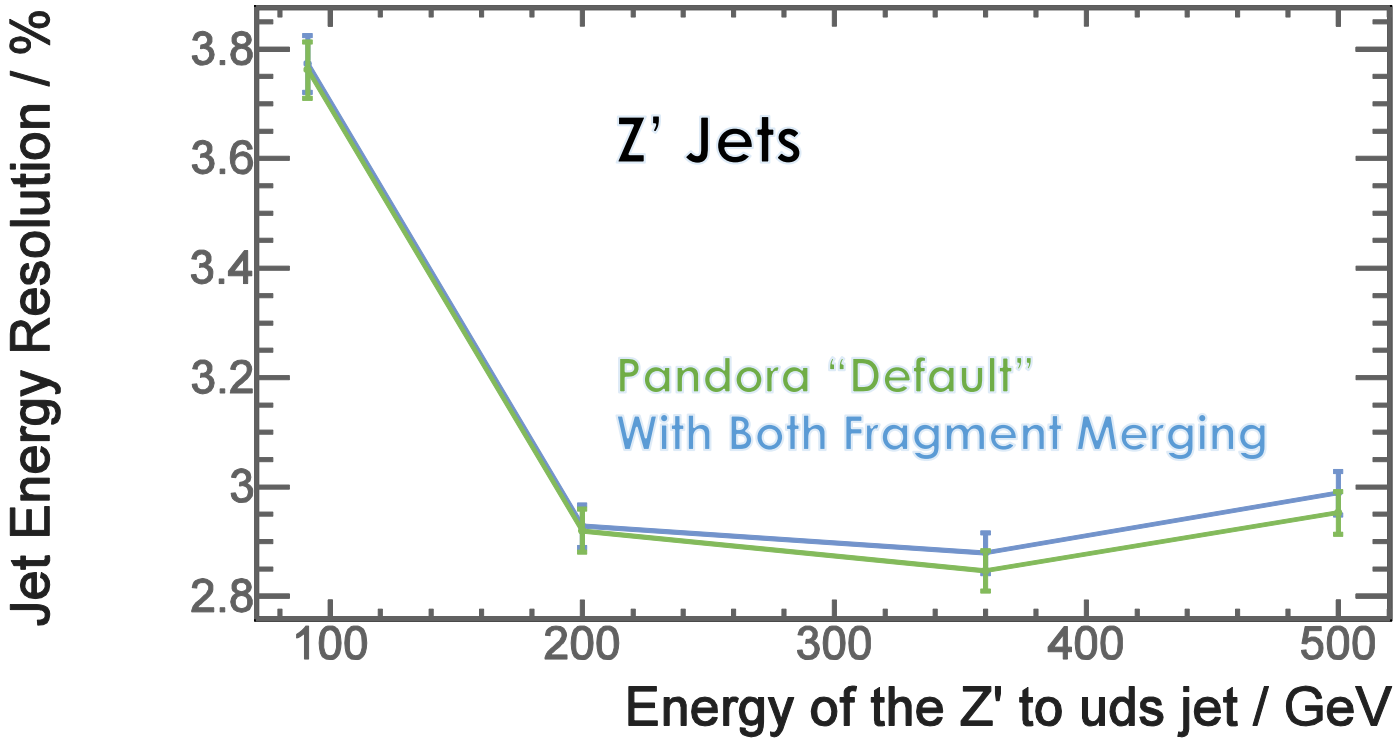




$$N_{photon} = N_{photon,MC} + N_{photon\ fragment}$$

Photon Frag Removal: Performance V





Photon Frag Removal: Conclusion

- Average number of photon reconstructed:

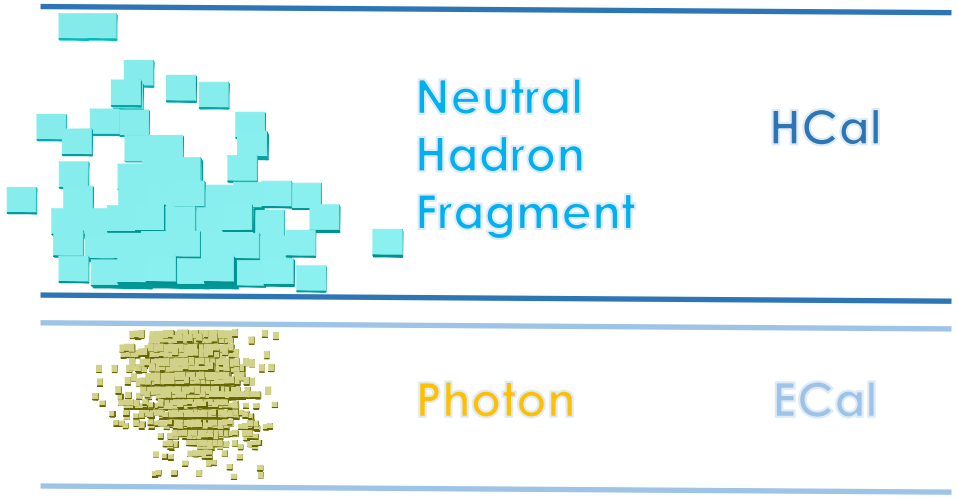
Single Photon [1 to 500GeV]	<1.02
Two photons [1 to 500GeV]	<2.05

- Two photons are well reconstructed when the centroid are separated more 40mm
- The jet energy resolutions did not change much
- The tags are **PandoraPFANew v01-02-00**, **MarlinPandora v01-00-0**
- Pandora settings file: **PandoraSettingsDefaultNew.xml**

HiE Photon Recovery I

- We have managed to remove most of the **photon fragments** in the ECal.
- However, high energy photons deposit energy in the HCal, which become **neutral hadron fragments**

A typical 500GeV photon



High Energy Photon Recovery II

- We want to remove those neutral hadron fragments.
- Again, we used the same samples as before (Single photon, Two photons, Z' Jets) and developed a series of cuts, using MC information.
- Cuts includes adjacent in layers, shower width, distance separation, and fraction in the cone

HiE Photon Recovery Algorithm I

Pandora "DefaultNew"

Muon
- Muon Reco

Photon
- Photon Reco
- Reco Fragment Merging

Charged
- Charged Particle Reco
- Fragment Merging

With HiE Photon Recovery

Muon
- Muon Reco

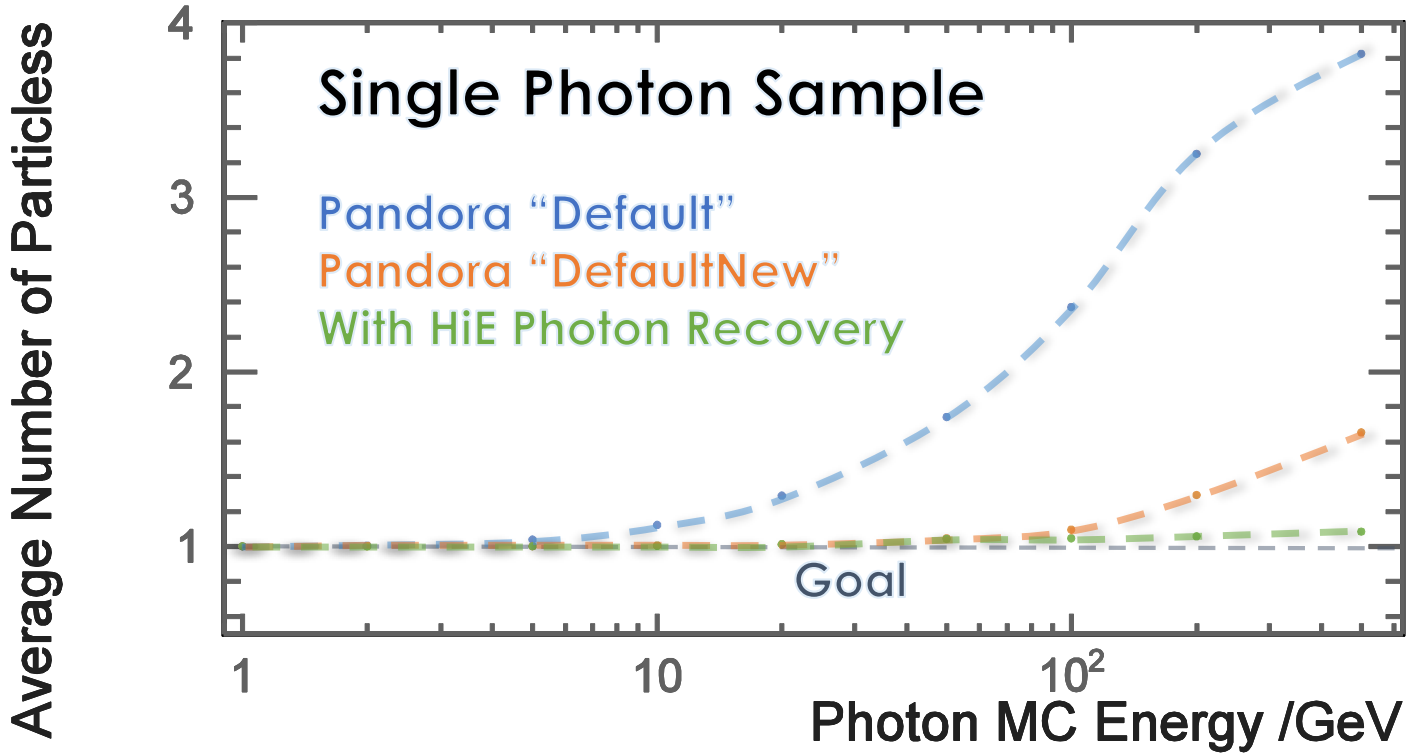
Photon
- Photon Reco
- Reco Fragment Merging

Charged
- HiE Photon Recovery
- Charged Particle Reco
- Fragment Merging

HiE Photon Recovery Performance I

With HiE Photon Recovery

- **Muon**
  - Muon Reco
- **Photon**
  - Photon Reco
  - Reco Fragment Merging
- **Charged**
  - HiE Photon Recovery
  - Charged Particle Reco
  - Fragment Merging

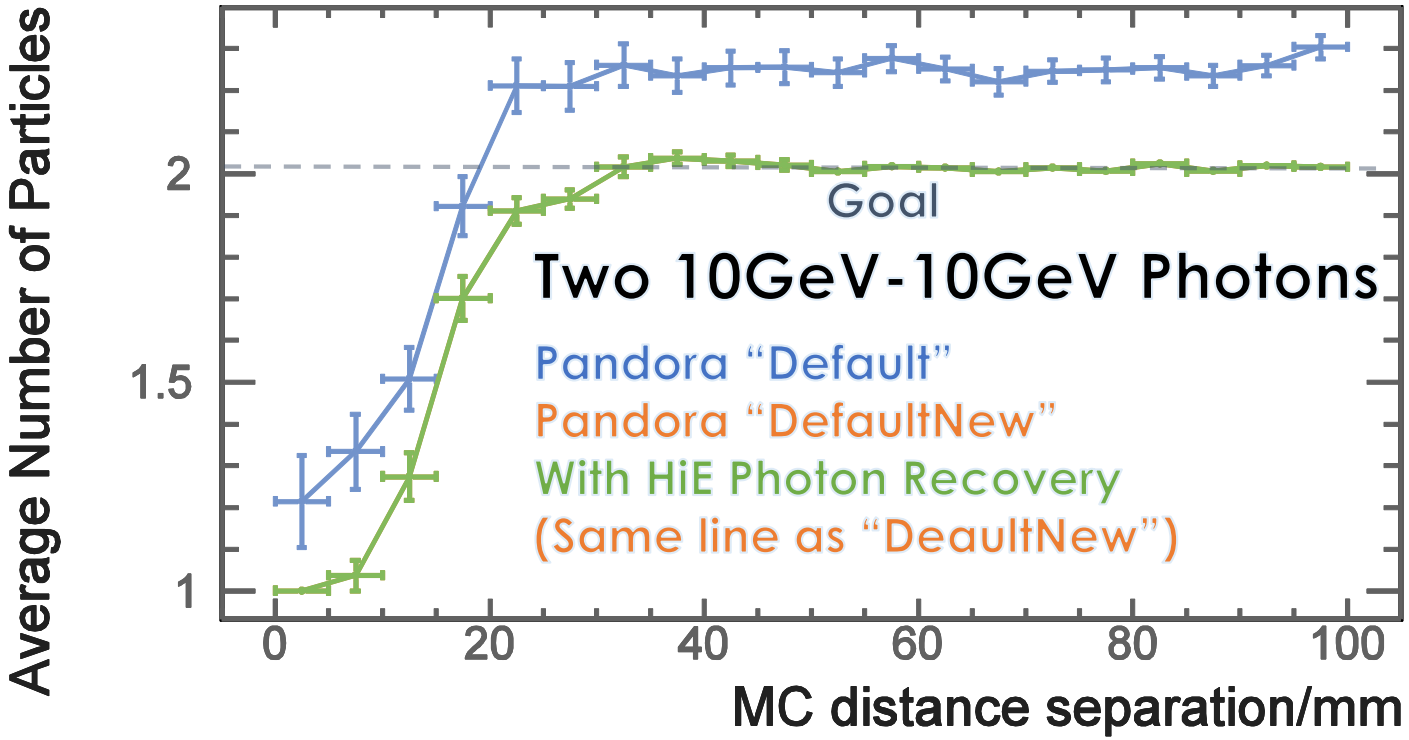


$$N_{particle} = N_{photon,MC} + N_{photon\ fragment} + N_{neutral\ fragment}$$

HiE Photon Recovery Performance II

With HiE Photon Recovery

- **Muon**
  - Muon Reco
- **Photon**
  - Photon Reco
  - Reco Fragment Merging
- **Charged**
  - HiE Photon Recovery
  - Charged Particle Reco
  - Fragment Merging

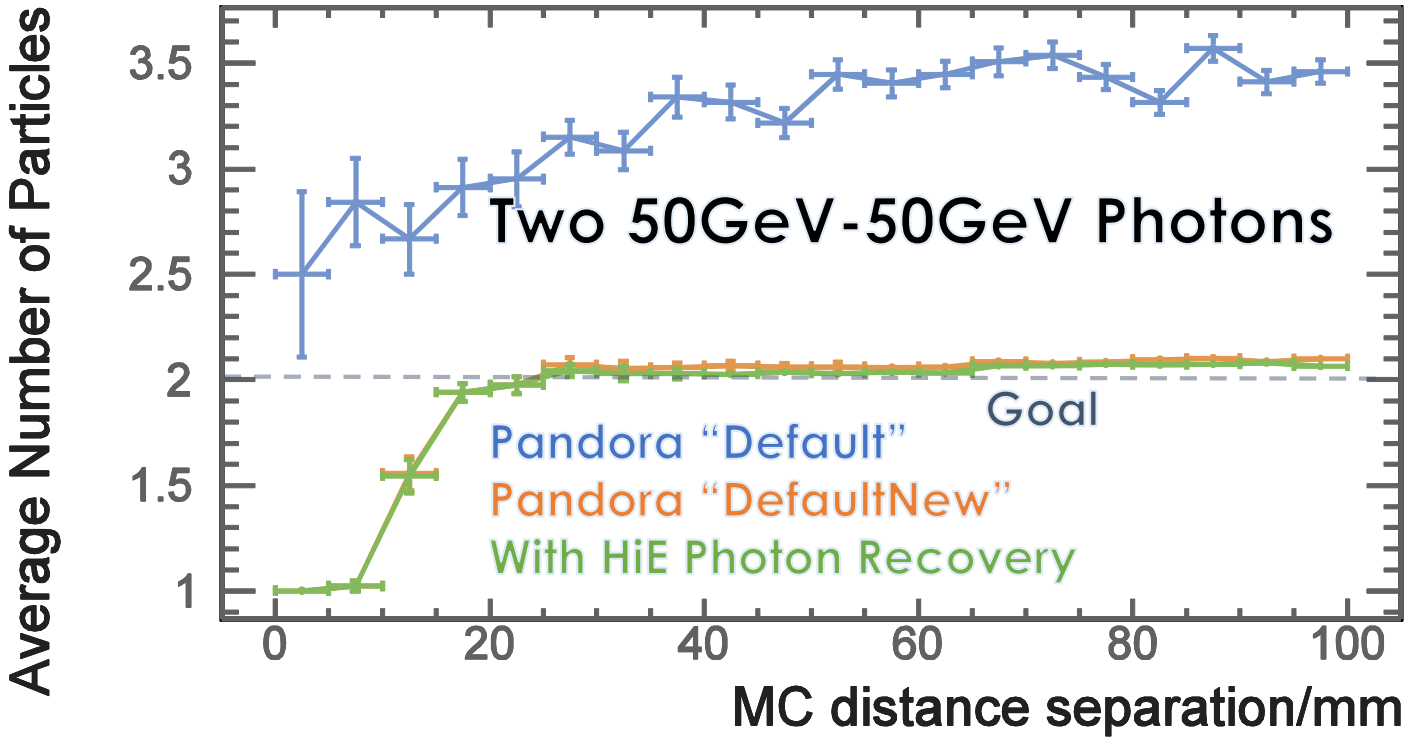


$$N_{particle} = N_{photon,MC} + N_{photon\ fragment} + N_{neutral\ fragment}$$

HiE Photon Recovery Performance III

With HiE Photon Recovery

- **Muon**
  - Muon Reco
- **Photon**
  - Photon Reco
  - Reco Fragment Merging
- **Charged**
  - HiE Photon Recovery
  - Charged Particle Reco
  - Fragment Merging



$$N_{particle} = N_{photon,MC} + N_{photon\ fragment} + N_{neutral\ fragment}$$

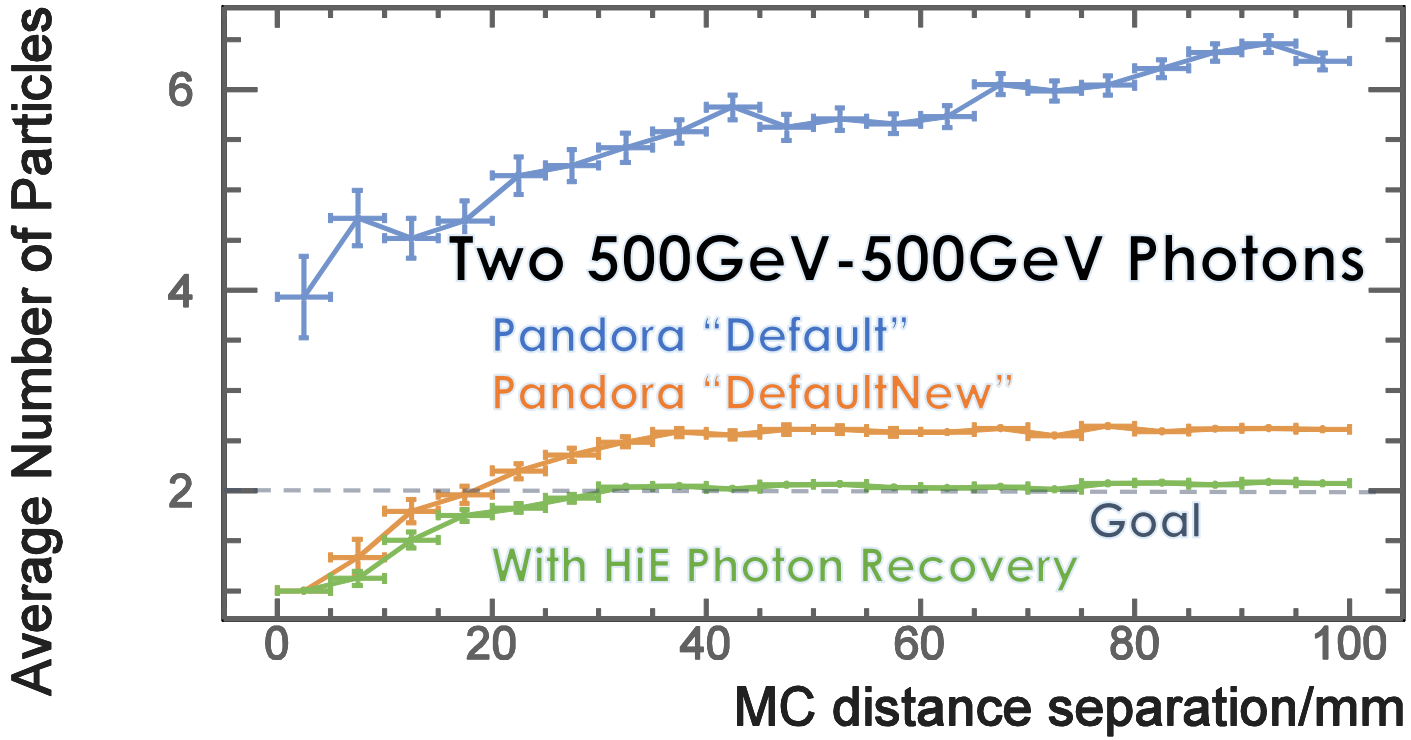
HiE Photon Recovery Performance IV

With HiE Photon Recovery

Muon
- Muon Reco

Photon
- Photon Reco
- Reco Fragment Merging

Charged
- HiE Photon Recovery
- Charged Particle Reco
- Fragment Merging



$$N_{particle} = N_{photon,MC} + N_{photon\ fragment} + N_{neutral\ fragment}$$

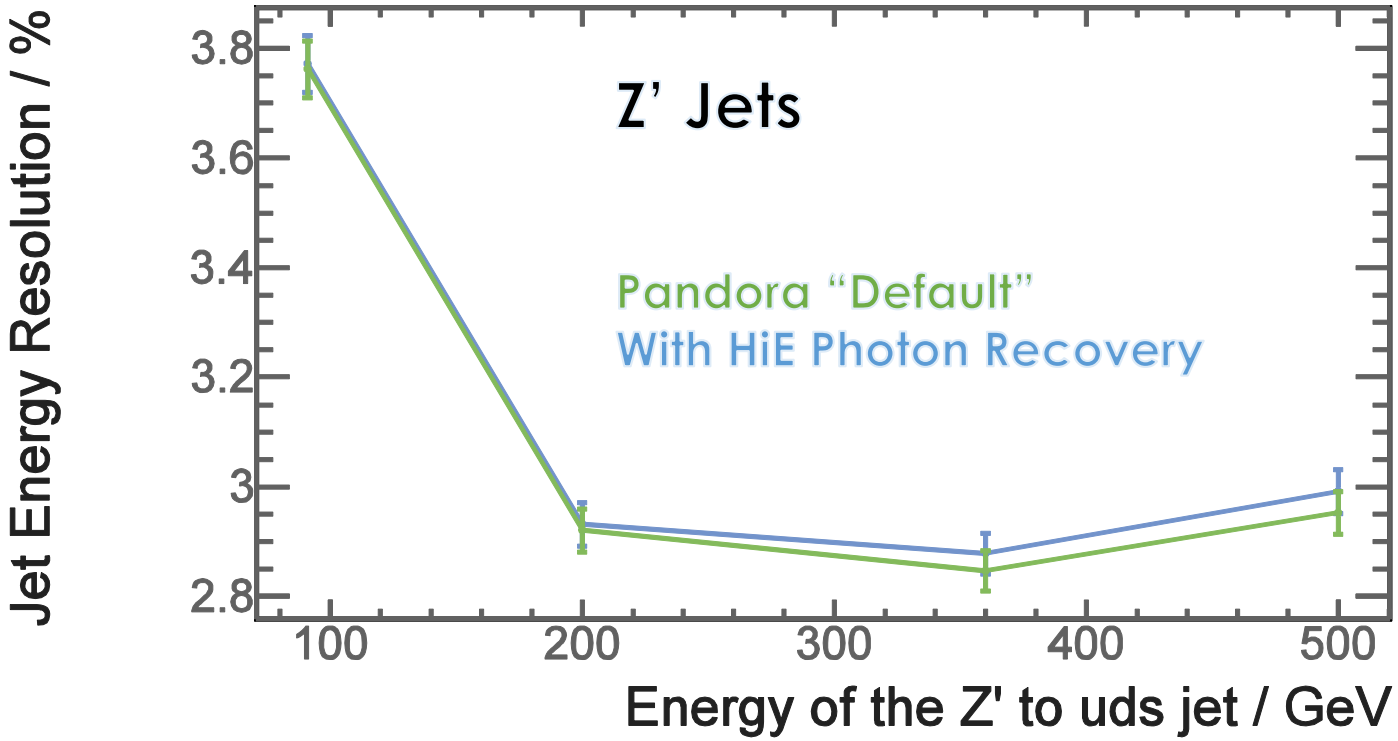
HiE Photon Recovery Performance V

With HiE Photon Recovery

Muon
- Muon Reco

Photon
- Photon Reco
- Reco Fragment Merging

Charged
- HiE Photon Recovery
- Charged Particle Reco
- Fragment Merging



HiE Photon Recovery Conclusion

- Average number of particle reconstructed:

Single Photon [1 to 500GeV]	<1.05
Two photons [1 to 500GeV]	<2.1

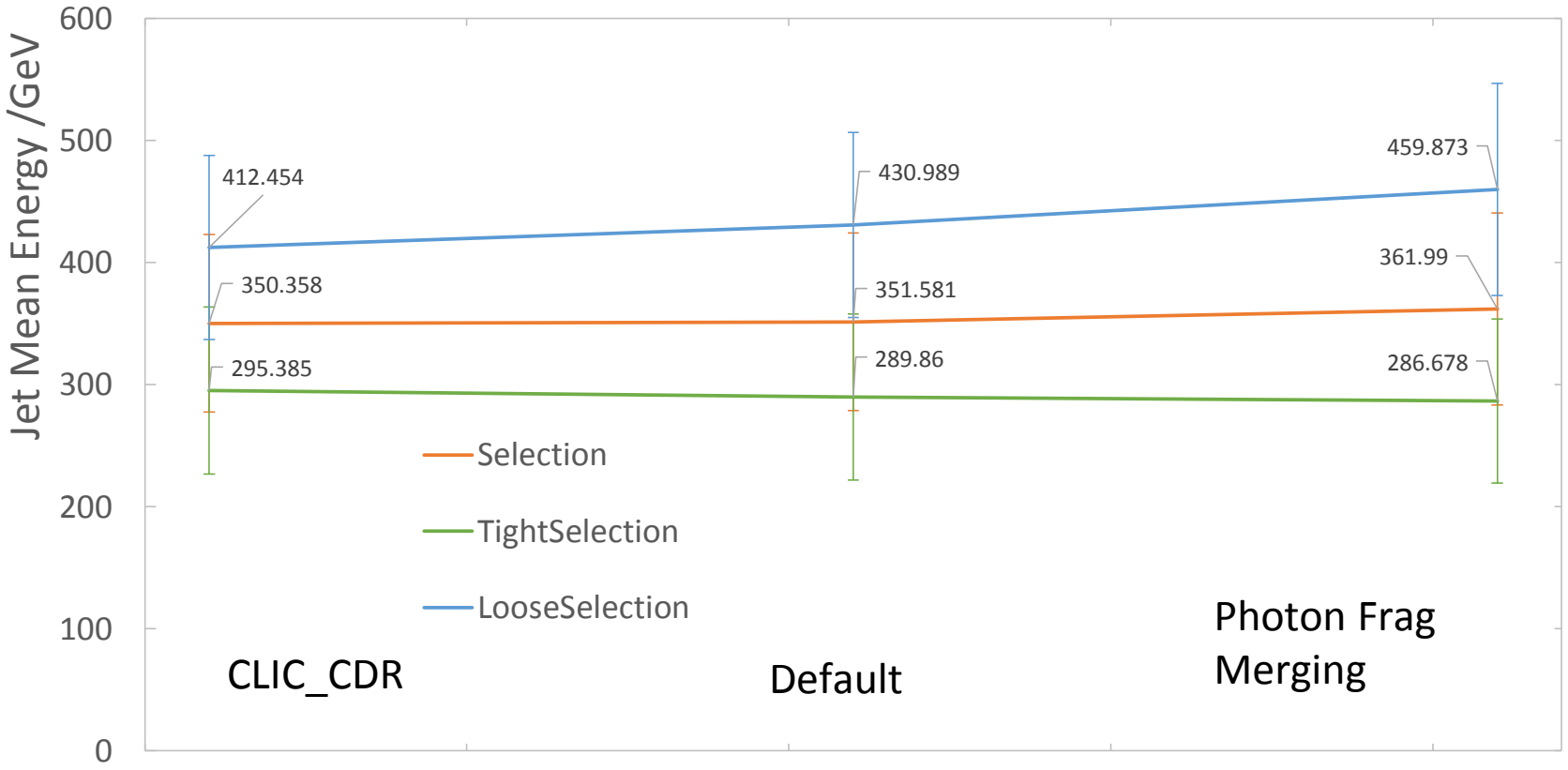
- Two photons are well reconstructed when the centroid are separated more 40mm
- The jet energy resolutions did not change much
- The High Energy Photon Recovery Algorithm is ready for releasing.

Gamma Gamma to Hadron Overlay

- Test the effect of overlaying gamma gamma to hadron background on jet events.
- Simulating Gamma gamma to hadron in 3TeV CLIC settings, but using ILD_o1_v5 model in order to use latest iLCSoft and Pandora.
- Effectively, it is a CLIC beam in a ILD detector.

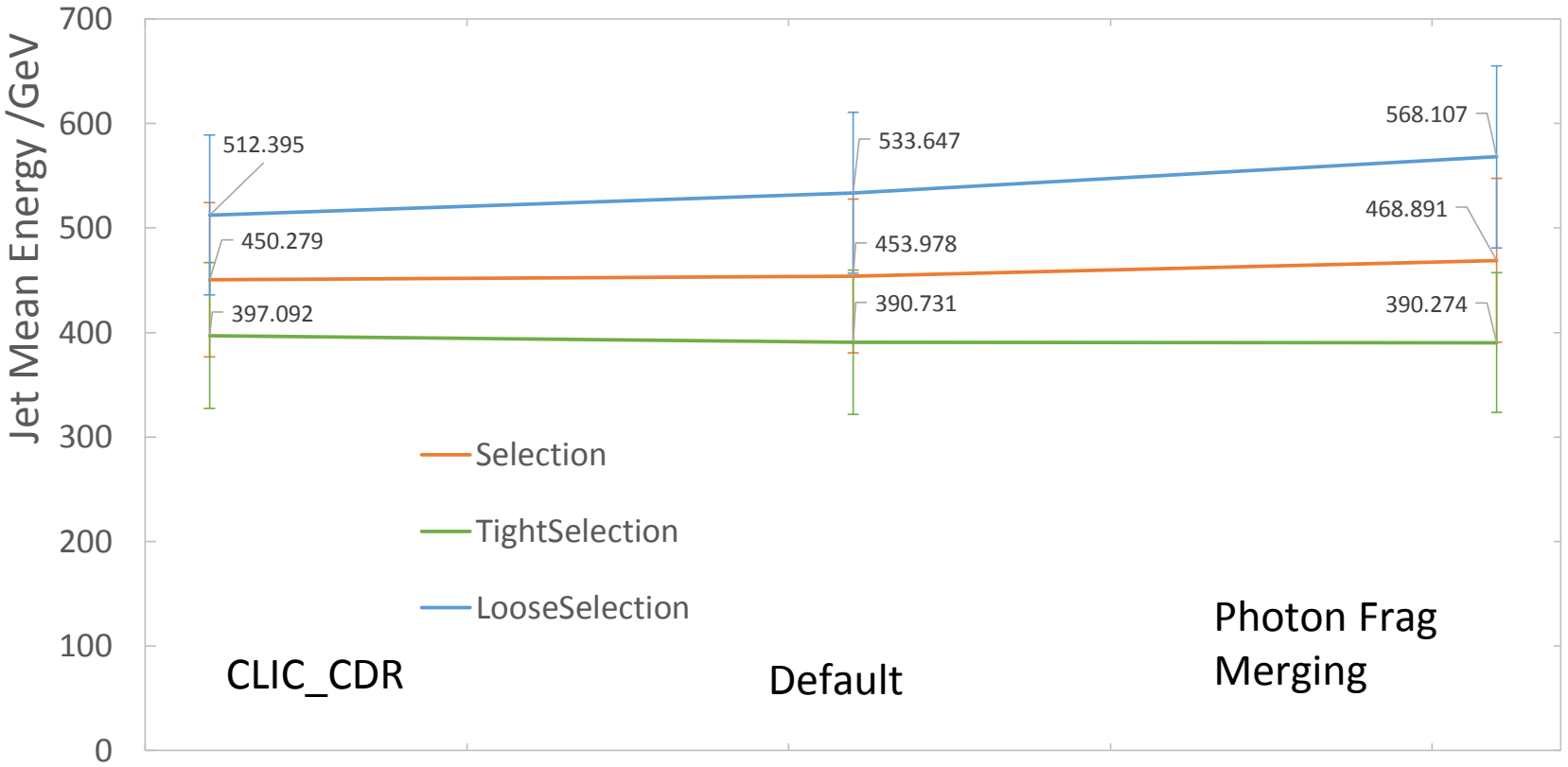
Gamma Gamma to Hadron Overlay II

- Z' -> uds jets, 91GeV



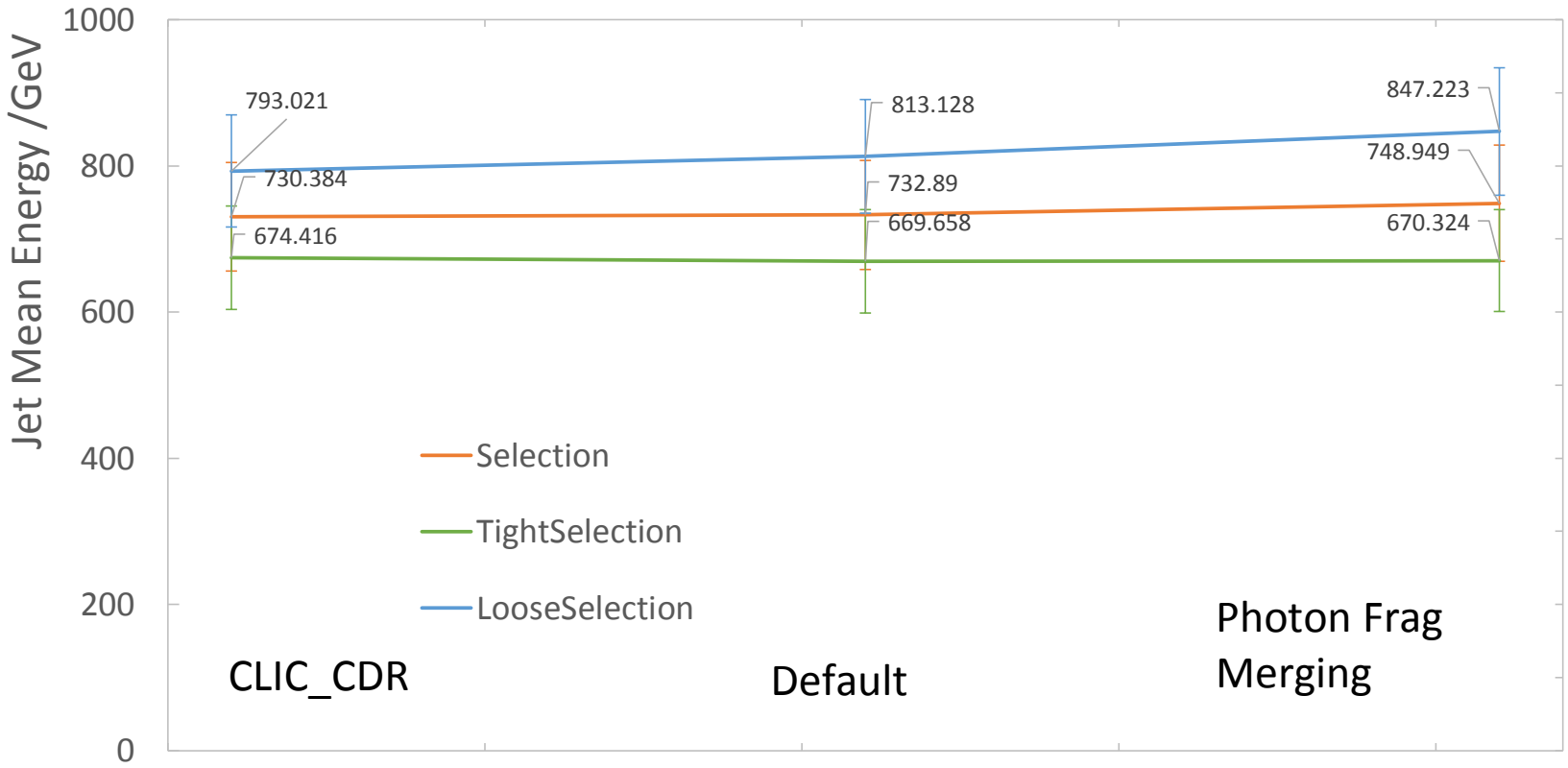
Gamma Gamma to Hadron Overlay III

- Z' -> uds jets, 200GeV



Gamma Gamma to Hadron Overlay IV

- Z' -> uds jets, 500GeV



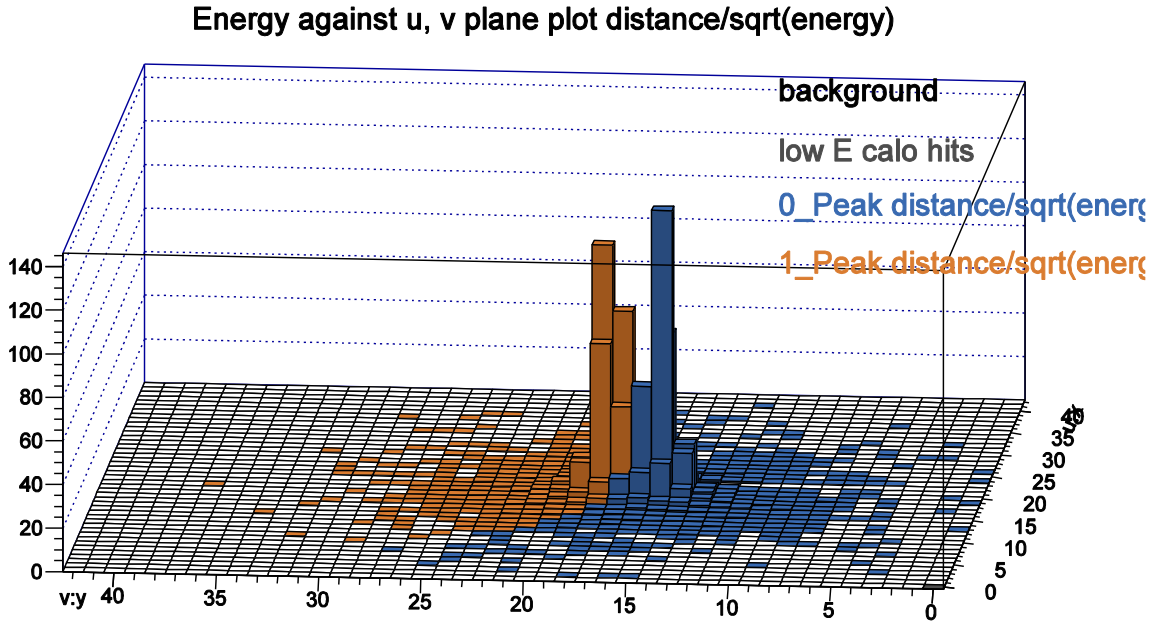
Gamma Gamma to Hadron Overlay V

- Conclusion:
- From CLIC_CDR (Pandora Muon), to Default and with Photon Fragment Merging, jet energy of loose selection increases steady, jet energy of tight selection decreases slightly.

Current research

- Improve reconstruction for 2 photons < 40mm apart
- Rewriting photon reconstruction algorithm, in particular, the peak finding for energy deposition

A typical 2D energy depositions for 2 photons:
Two peaks just about to separate



Future Plan

- Hope to improve photon reconstruction when photon separation<40mm, and possibly improving jet energy resolution
- Test these algorithms with physics channels, i.e. π, τ lepton reconstruction.

Thank you!

- Any testing and comment are welcome.
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