Improvement of photon reconstruction in PandoraPFA

ILD analysis WG
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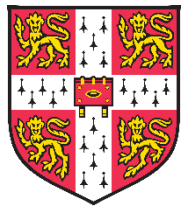
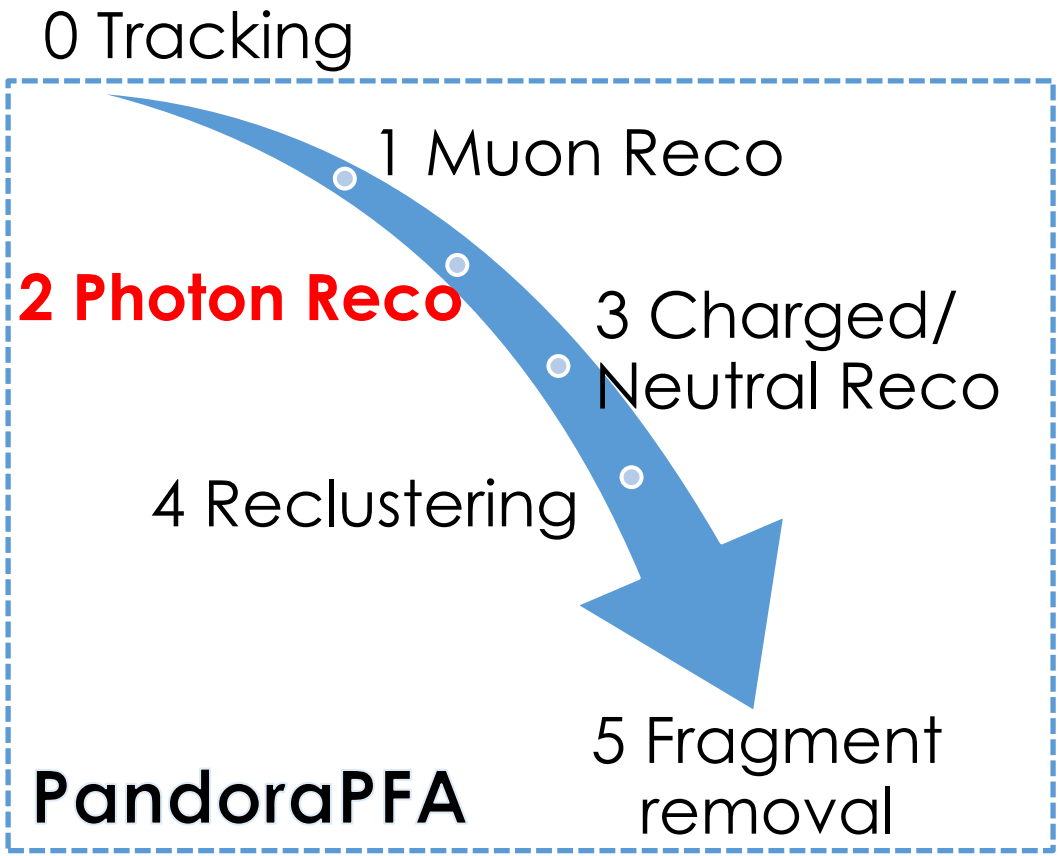


Content

- Overview of photon reconstruction
- Improvement to photon reconstruction
  - Fragment removal in ECAL and HCAL
  - New peak finding algorithm
- Figure of merits
- New algorithms are in PandoraPFA github repository

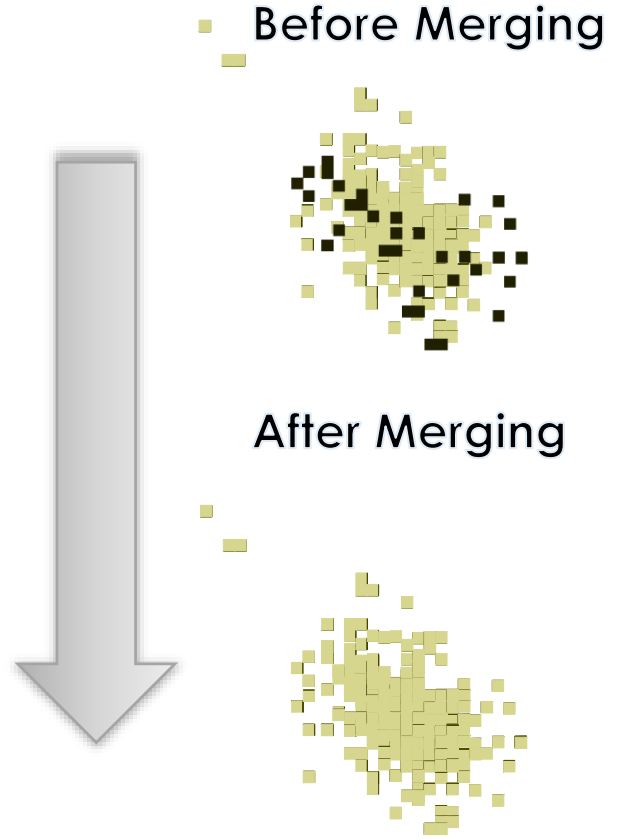
Photon reconstruction in PandoraPFA

- Standalone photon reconstruction before the charged particle reconstruction will provide a cleaner environment for particle reconstruction
  - Reduce photon confusion
- Carefully identify EM showers without making mistakes



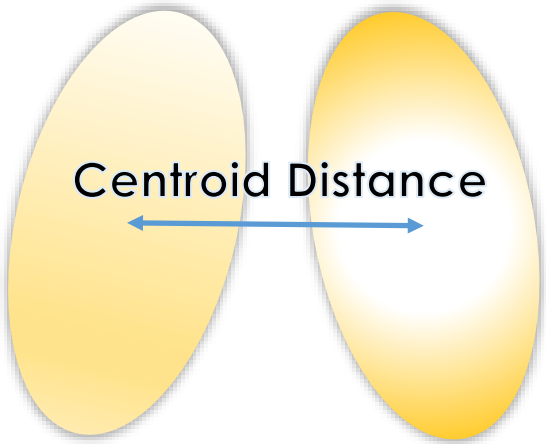
Photon Fragment Removal

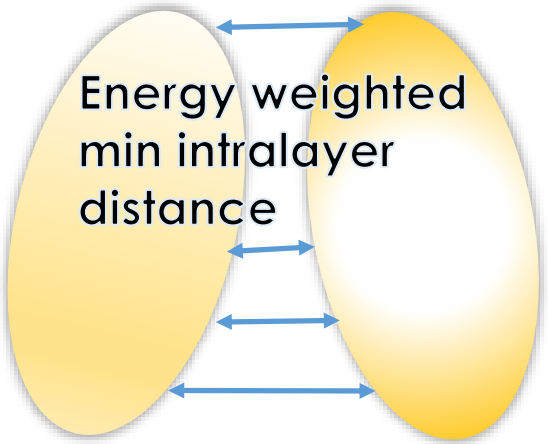
- The aggressive reconstruction identifies EM shower cores, which may leave fragments as fake photons
- Remove photon fragments in ECAL
  - Improving photon completeness and purity.
- Identifying the fragments;
- Collecting evidence;
- Make careful decisions to merge.

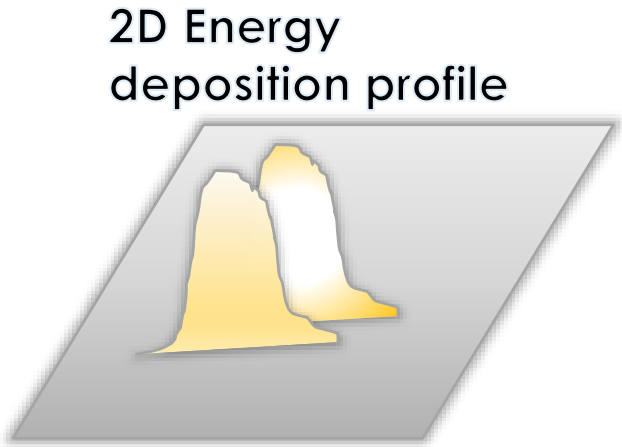


Photon Fragment Removal

- Identify the fragments using generator information
- Collecting evidences. Example quantities below
- Make decisions and apply to reconstructed fragments.

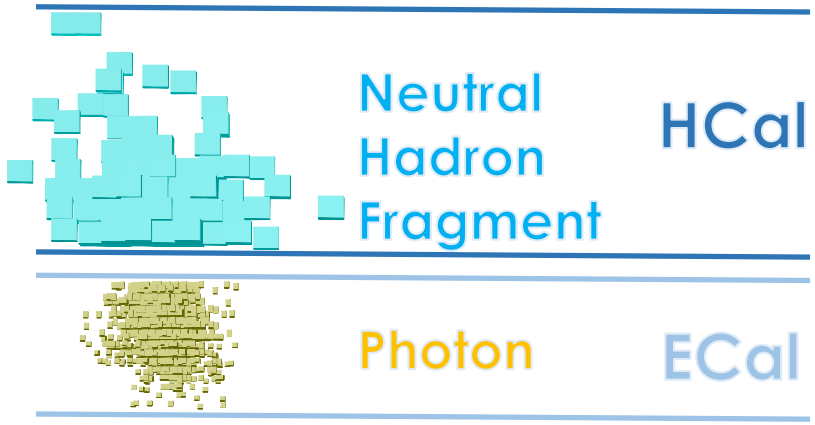






High energy photon recovery

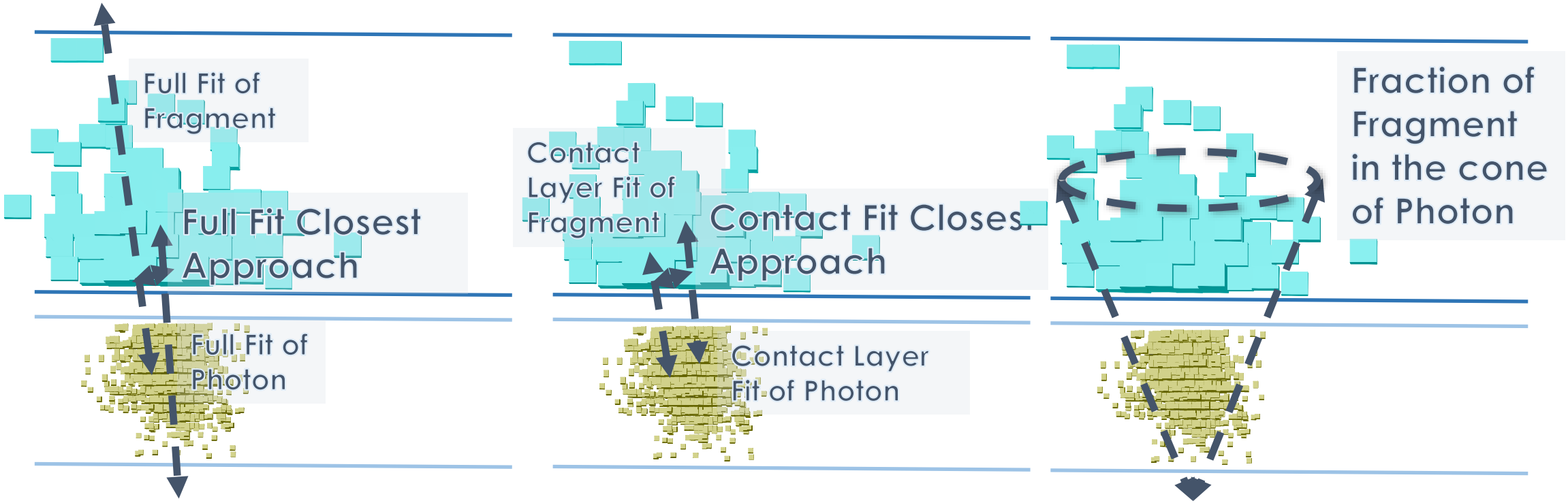
- Recover photon fragments in HCAL
- This typically happens for photon with energy > 50 GeV
  - Energy in HCAL is relatively small
- Photon reconstruction implicitly assumes photons deposit all energy in ECAL. Hence energy in HCAL would be typically reconstructed as neutral hadron.



A typical 500GeV photon

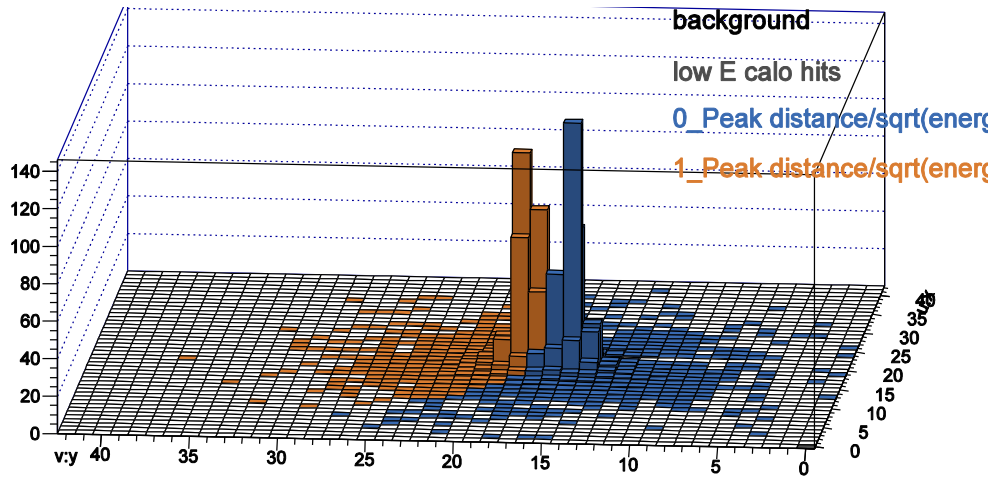
High energy photon recovery

- Collect evidences and make decisions. Example evidences



Improvement to photon reconstruction

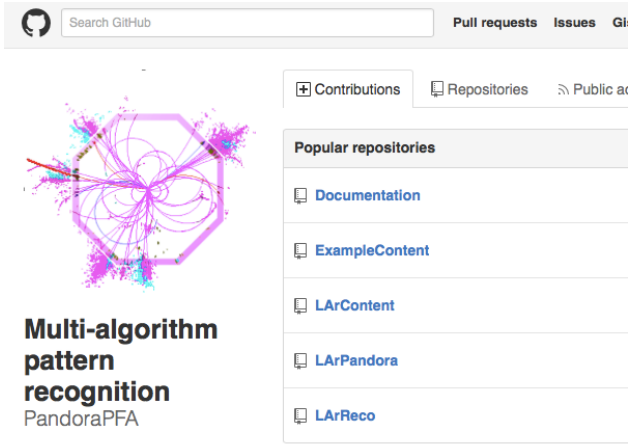
- Improve separation of photons from nearby photons and charged hadrons, without creating new fragments
- In the transverse plane of ECAL energy deposition, new peak finding algorithm provides a greater separation power.
  - Able to identify peaks if more than 1 cell apart



Example: 2 photons identified by energy deposition projection in a transverse plane to the direction of flight

Reconstruction in PandoraPFA

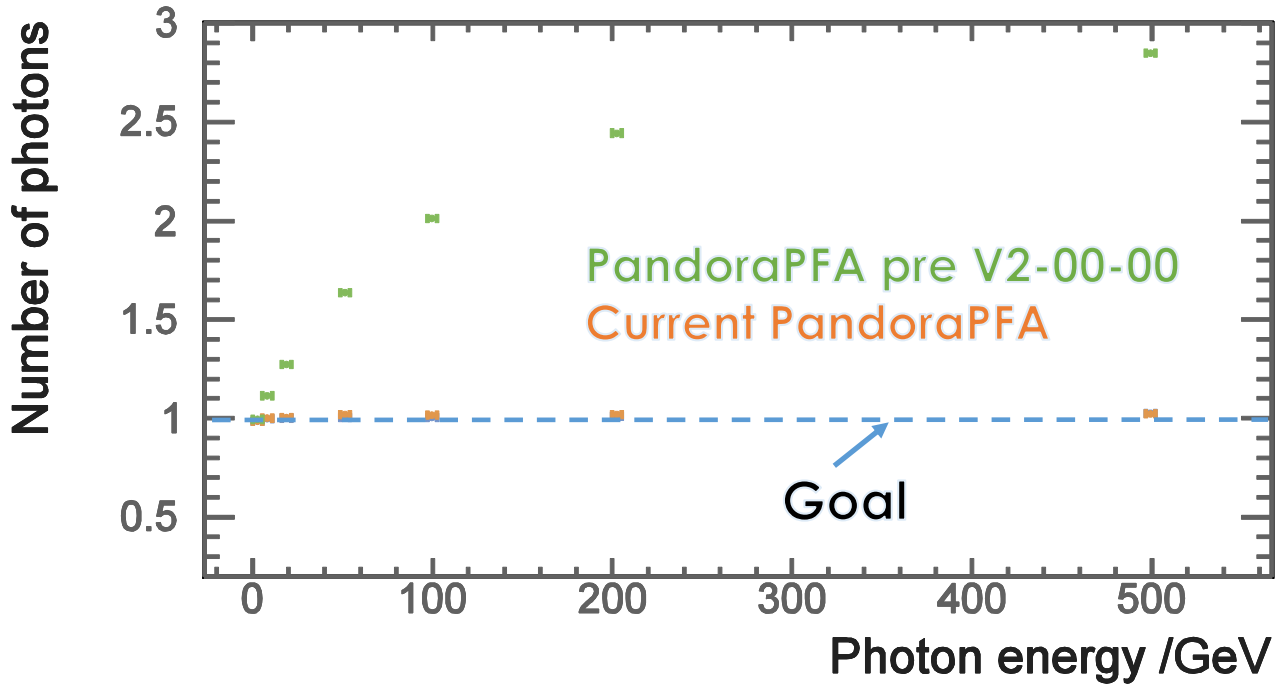
- New algorithms are in PandoraPFA github repository
  - Pandora steering files have been updated
  - Testing / comment / feedback is welcome
- FAQ: photon direction is calculated with energy weighted direction by default at current PandoraPFA,



https://github.com/PandoraPFA

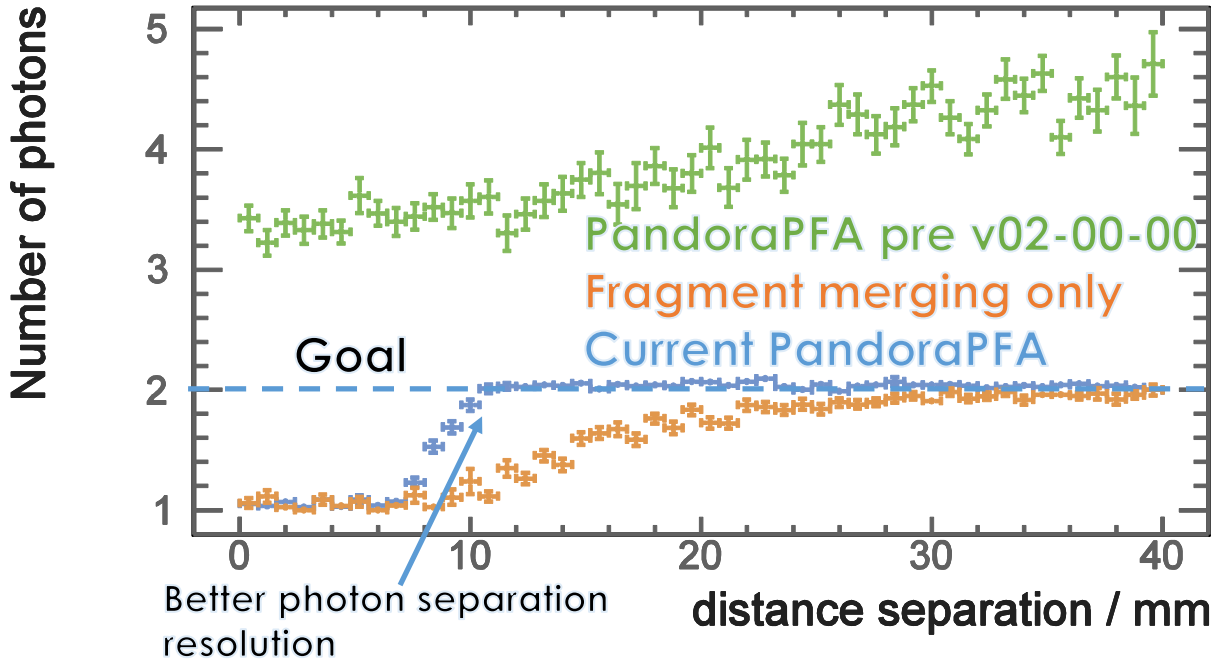
Figures of merits

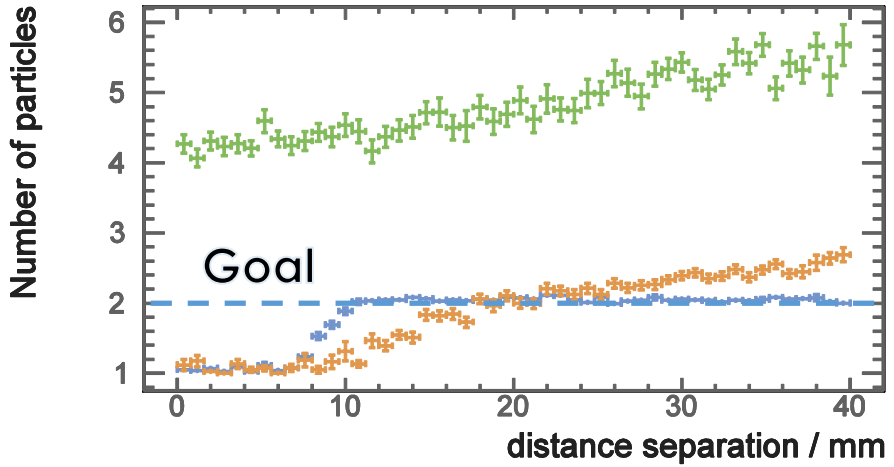
- Testing sample: single photon of energy ranged from 0.1 to 500GeV, fired at random directions with ILD detector model; No early conversion
  - Average number of reconstructed photon as a function of photon energy at generator level in barrel and endcap only



Figures of merits

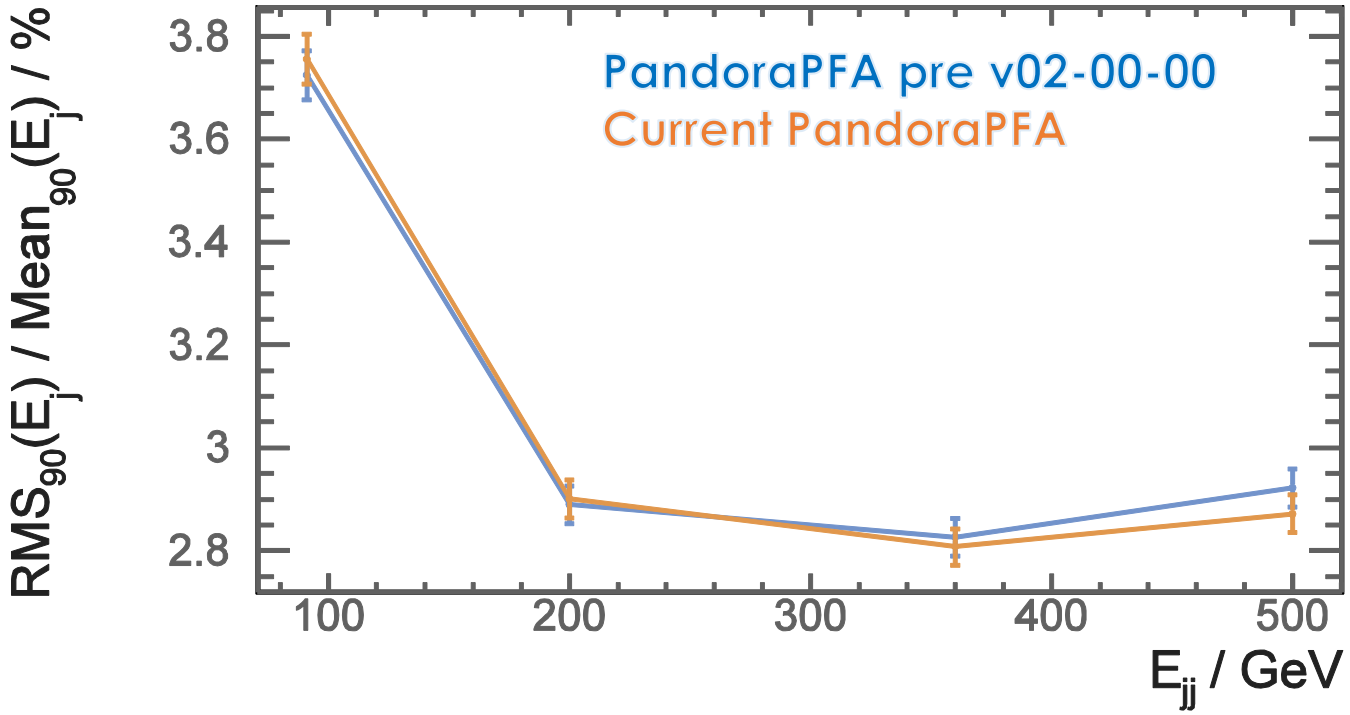
- Testing sample: two photons of energy 500GeV each, fired at random directions; No early conversion
  - Average number of reconstructed photon/particle as a function of separation, in barrel and end cap only Particle number = photons + others





Figures of merits

- Jet energy is almost the same
- Slight improvement at high energy
  - Z'->u/d/s sample, barrel only.



Jet Energy Resolution / %	91GeV	200GeV	360GeV	500GeV
Pandora in iLCSoft v01-17-07	3.727±0.049	2.889±0.037	2.824±0.036	2.924±0.037
Current PandoraPFA	3.754±0.048	2.895±0.037	2.793±0.036	2.870±0.037

Figures of merits - more to come

- Understand purity and completeness of photon reconstructed
- Demonstrate the improvement of photon reconstructions with tau lepton final states separation study
  - Direct test of photon reconstruction.
  - π^0->$\gamma\gamma$, challenging at high energy due to boost

Conclusion

- A series of new algorithms to improve the photon reconstruction
  - Fewer photon fragments in ECAL and HCAL
  - Better separation of photon next to charged particles and photons
- In https://github.com/PandoraPFA, please use the PandoraSettingsDefault.xml for new algorithms
- Testing / comment / feedback is welcome!