PFlow and Machine Learning

Progress

PF in ATLAS (Quick Overview)

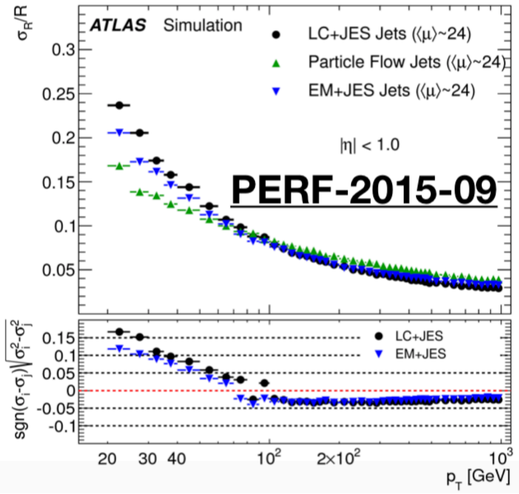
- PF in ATLAS is not an absolute necessity as it is for CMS, how less important is it?
  (Gains are smaller, but it is used in a more or less developed form in all high level objects: isolation, jets, MET and taus)

- We have a PF in ATLAS, which works very well, slowly moving towards being the baseline.

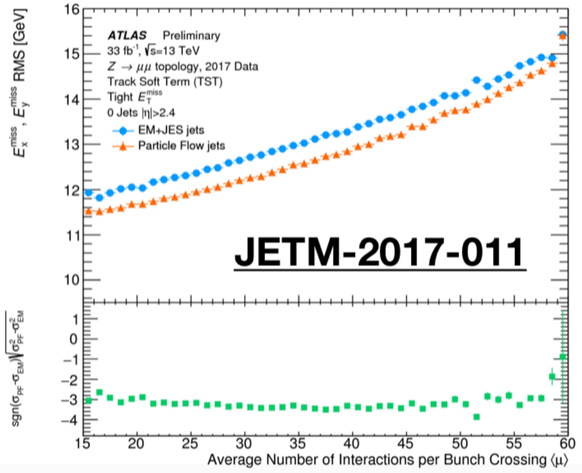
- Small but significant performance gains from ATLAS PF are clear.

Clear Improvements

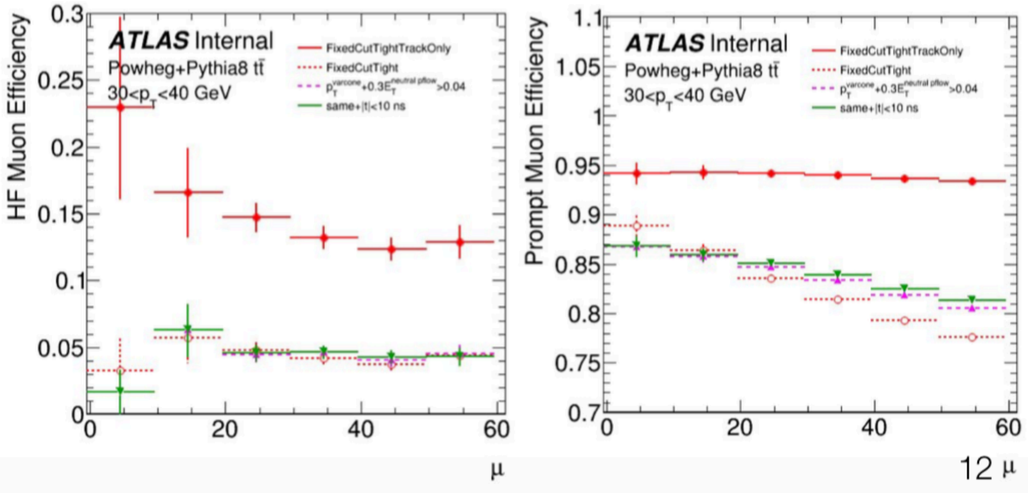
Jet resolution



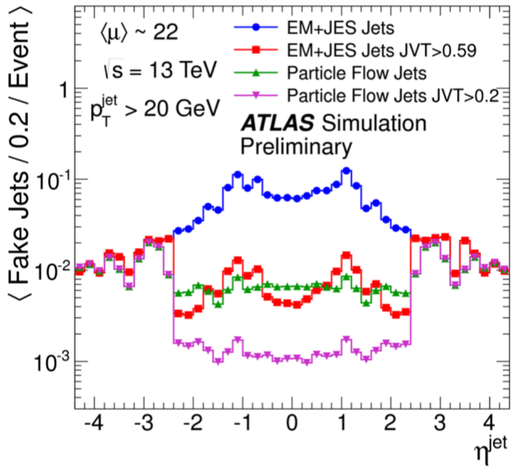
MET resolution



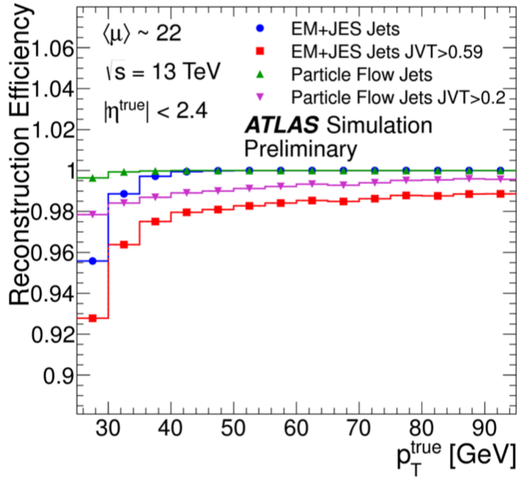
Isolation in PU environnement



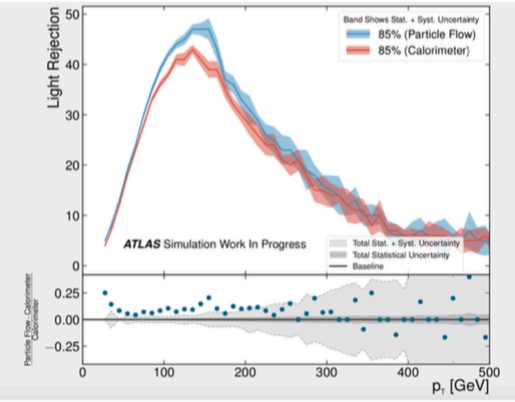
Fake Rejection



Corresponding Efficiency



Light rejection in B-Tagging



GPF *à la* CMS

- Ideally PF objects should be an intermediate reconstruction level list of particles (the CMS approach), from which all objects are reconstructed (not fully the case in CMS).

- In CMS PF objects are four vectors of electrons, photons, muons, charged hadrons and neutral hadrons.

- Objects such as taus can still be refined from more information as for instance to count pi0’s.

- CMS has now as baseline PUPPI constituent PU subtraction which was developed in large part with the PF.

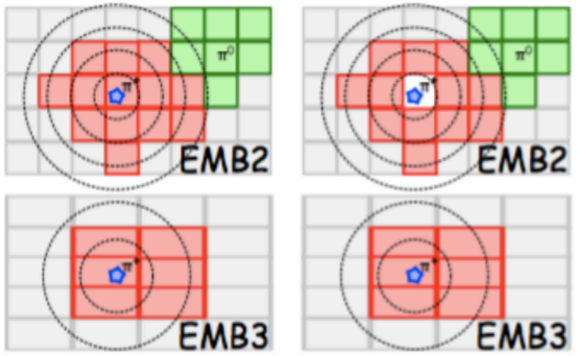
Motivation(s) (I)

- Enable analysers to work with objects at lower level than calibrated higher level reconstructed objects (isolated tight leptons (including leptons), jets, b-jets, and MET):
  - Allow for more precise/powerful/insightful analyses (instead of « one size fits all » higher level objects), with possibilities of « on the fly » reconstruction.
  - Give a framework where any improvement in one area will be ported to all objects automatically.
  - Can be used to refine calibration (e.g. Jets as a function of components).
- Simplify and harmonise: with close-to-calibrated objects, many intricacies in the reconstruction which require various passes (e.g. HF calibration, electron veto in taus, etc…) can be simplified, overlap removal, etc…
- Coherent framework: improve the object separation (overlap removal).
- Trigger: improve turn-ons (jet resolution not necessarily obvious impact on analyses but visible on trigger turn-ons).

Motivation(s) (II)

- Bring in new ideas (e.g. Nuclear Interactions)! Not focussing only on the bulk of the distributions but also taking a closer look at the tails!

- Ideal framework for ML further developments (e.g. image recognition)!



- Give new handles for constituent PU subtraction (e.g. PUPPI in CMS). Though of course higher PU makes PFlow inherently more difficult.

- Fast simulation: new (more refined) handles to commission (true in general), check or even base FS on.

Goal and Methodology

« Minimal » has been a critical aspect of the work done. Discuss the necessary steps in order to obtain a simple to implement scheme (i.e. with the least disruption of the current reconstruction).

Gathered a very focused group with EGamma, MuonCP, software, reconstruction and Particle Flow conveners to produce a first design of an implementable scheme (Chris Young, Peter Loch, Christos Anastopoulos, Ed Moyse, JB de Vivie, Jochen Meyer, Jovan Mitrevski, William Leigh). Now contacted also Sven Menke.

The goal is an implementation in Rel. 22.

Discussed and clarified consensual boundary conditions of a GPF:

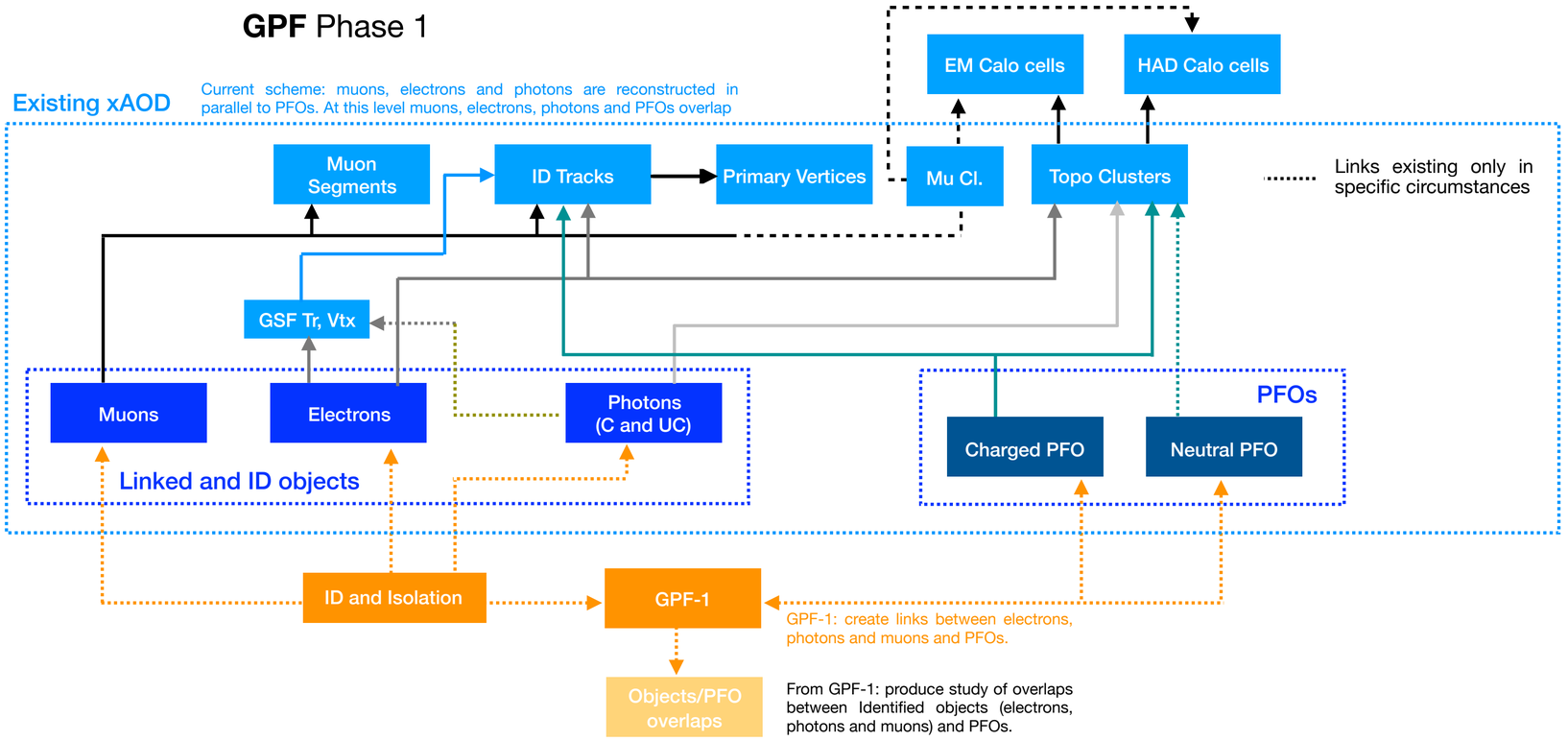
- Preserve a clear definition of the event's energy flow (meaning an unambiguous definition of objects without overlap in energy). This is not the case for the current Particle Flow.

- There should always be a way to recover the necessary information to recompute the disambiguation.

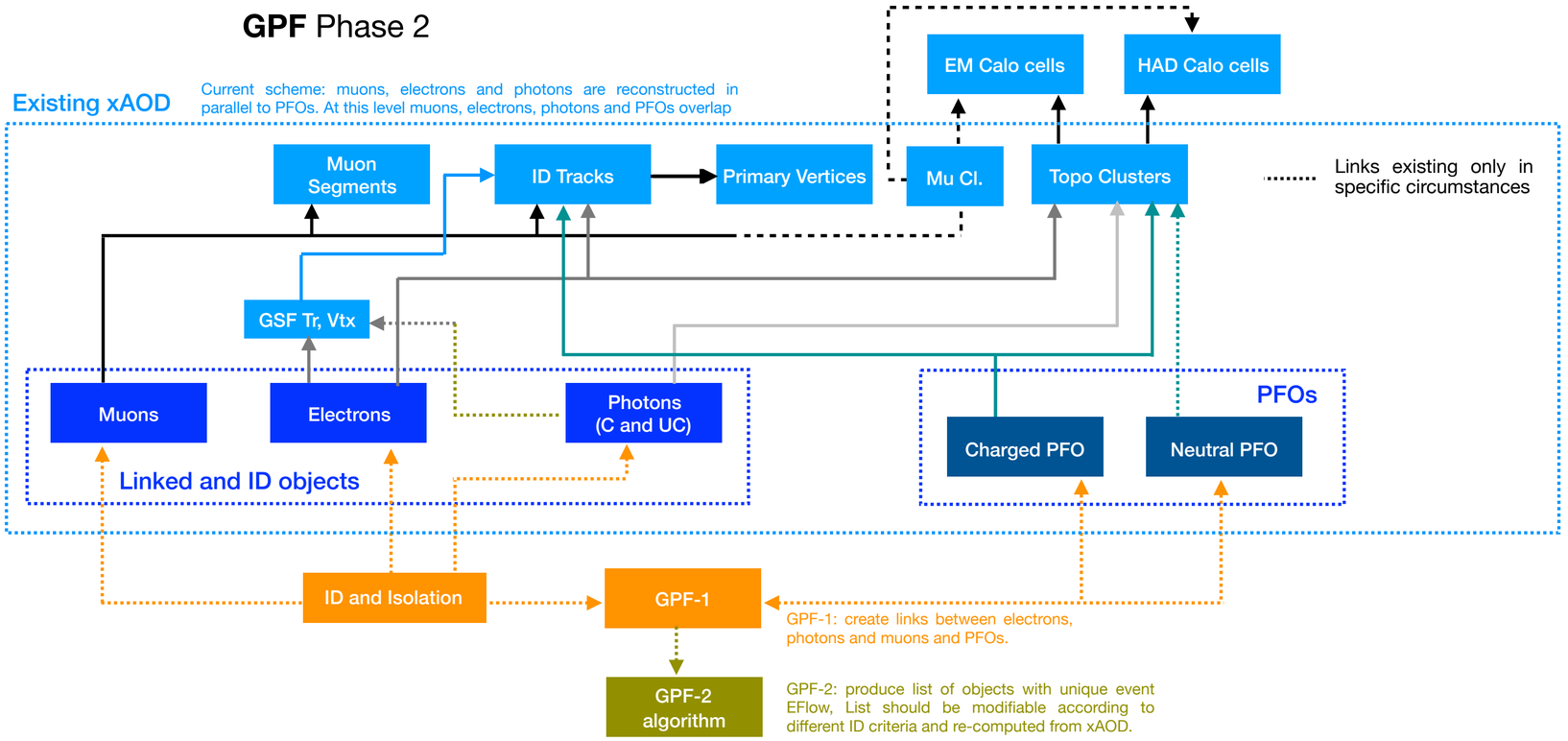
- The algorithm should be fully manageable at xAOD level and GPF definition should be modifiable in derivations.

- The algorithm should comply with CPU constraints and the transition to Multi Threading in Rel. 22.

ATLAS Proposal



ATLAS Proposal



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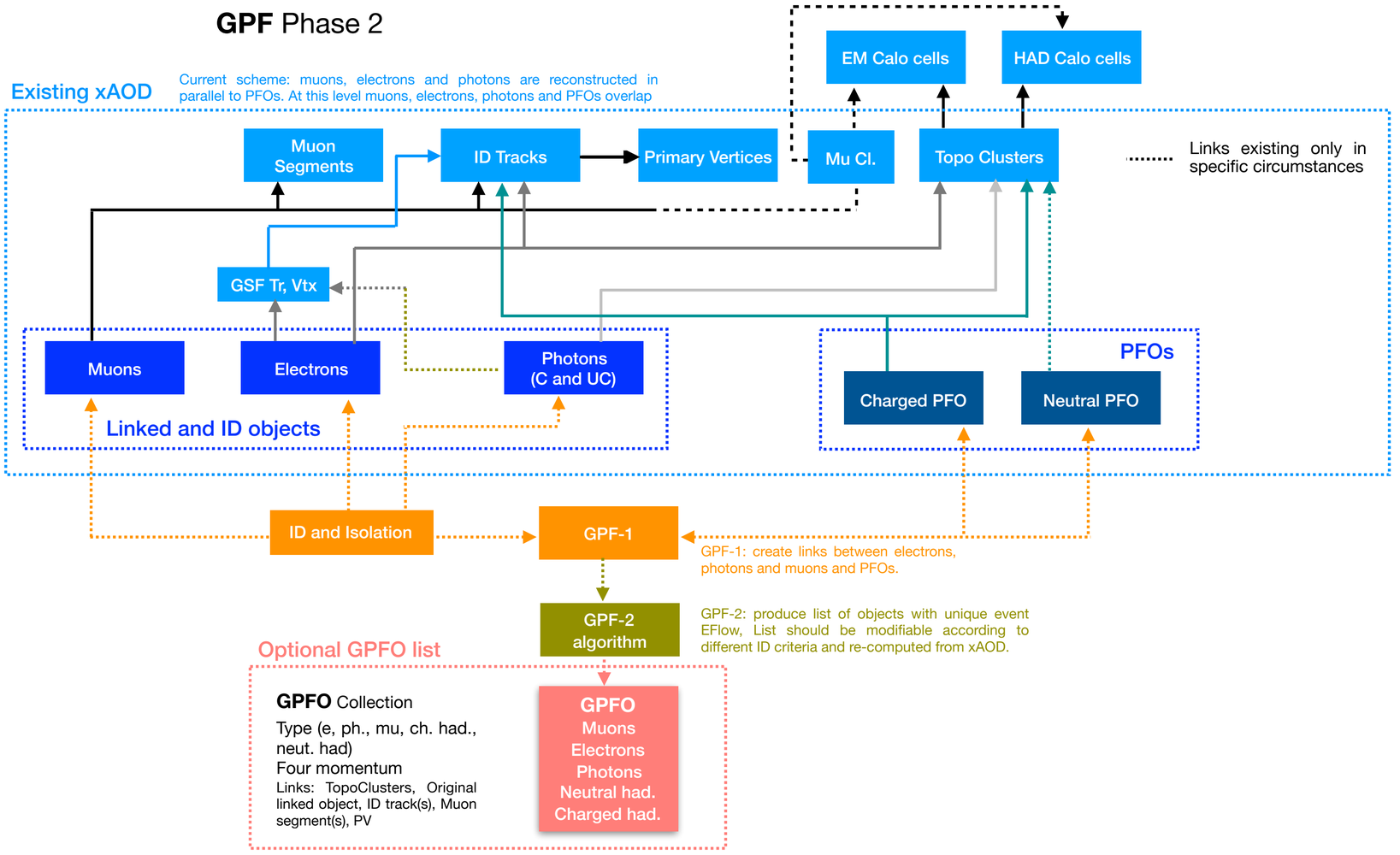

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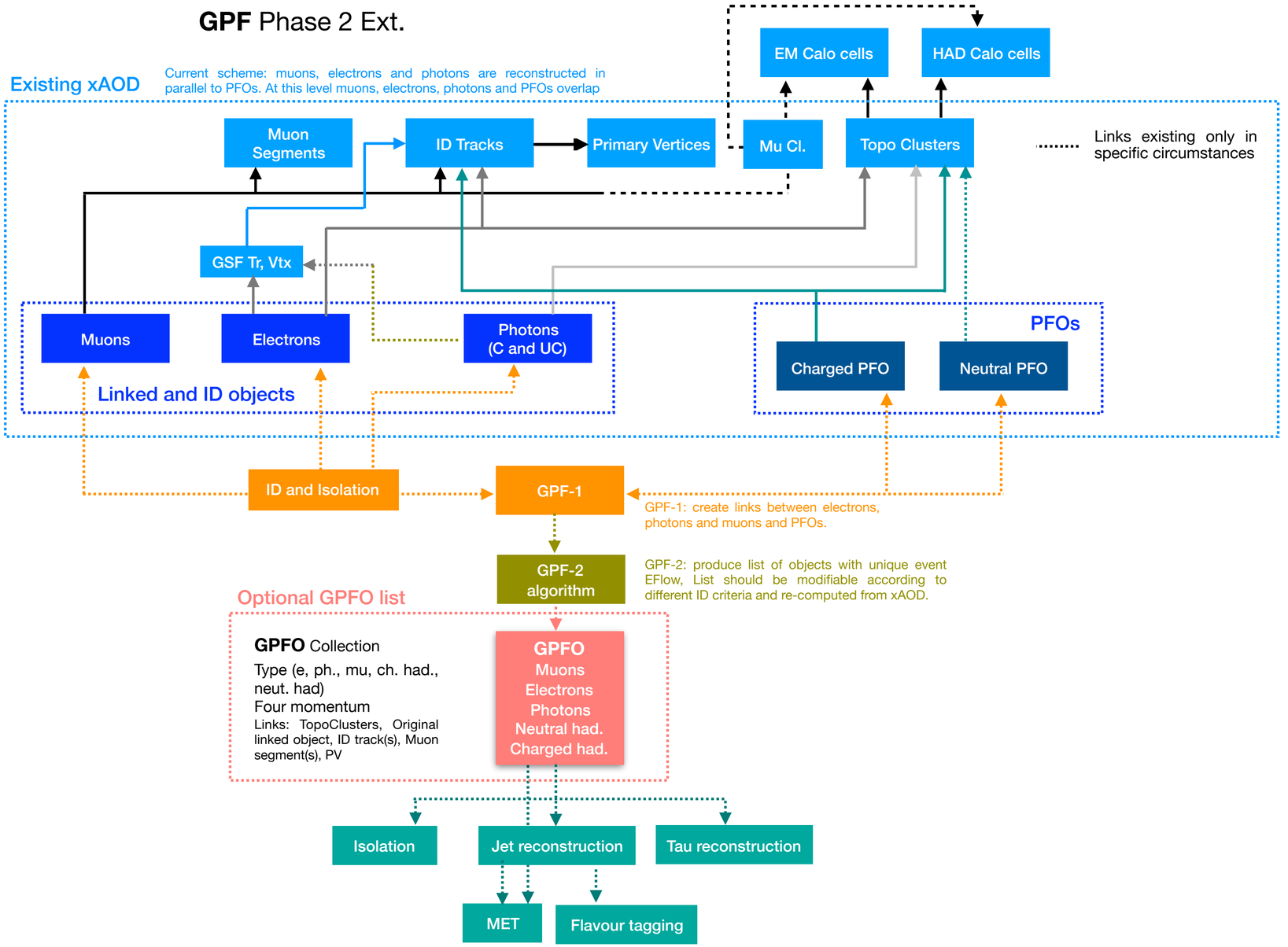
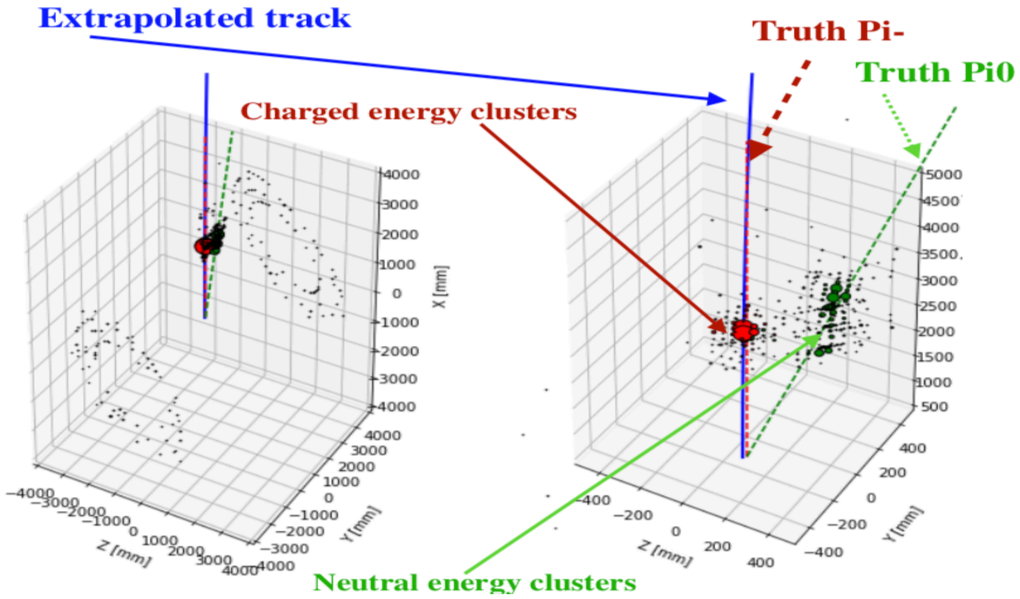
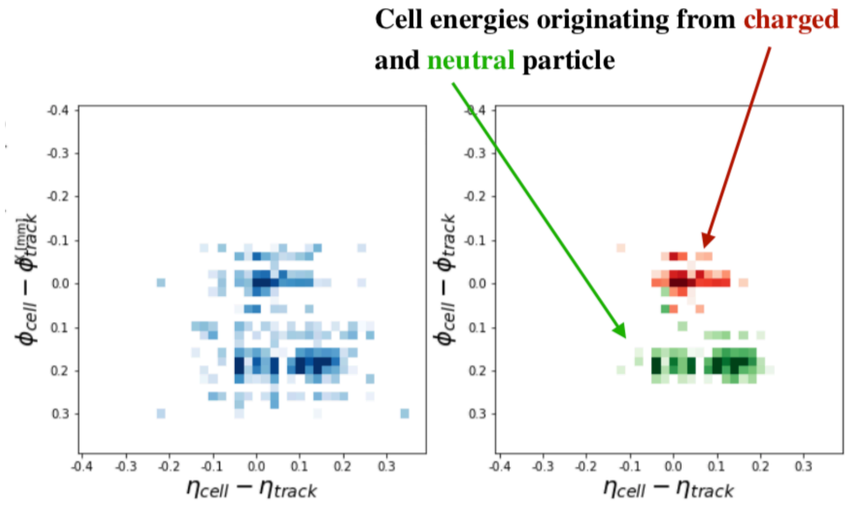


New Collaboration

- Collaboration with Weizmann team (Prof. Gross) and his Postdoc (S. Ganguly) and student (J. Shlomit): outstanding experts in ML and in particular in vision recognition algorithms.

- Results will be presented on Wednesday this week at ML workshop at CERN by Sanmay (see his presentation at https://indico.cern.ch/event/735932).





Cell energy distribution in eta-phi plane
(centered around track-eta, track-phi)