Arbor in CEPCSW

International Workshop on the High Energy Circular Electron Positron Collider
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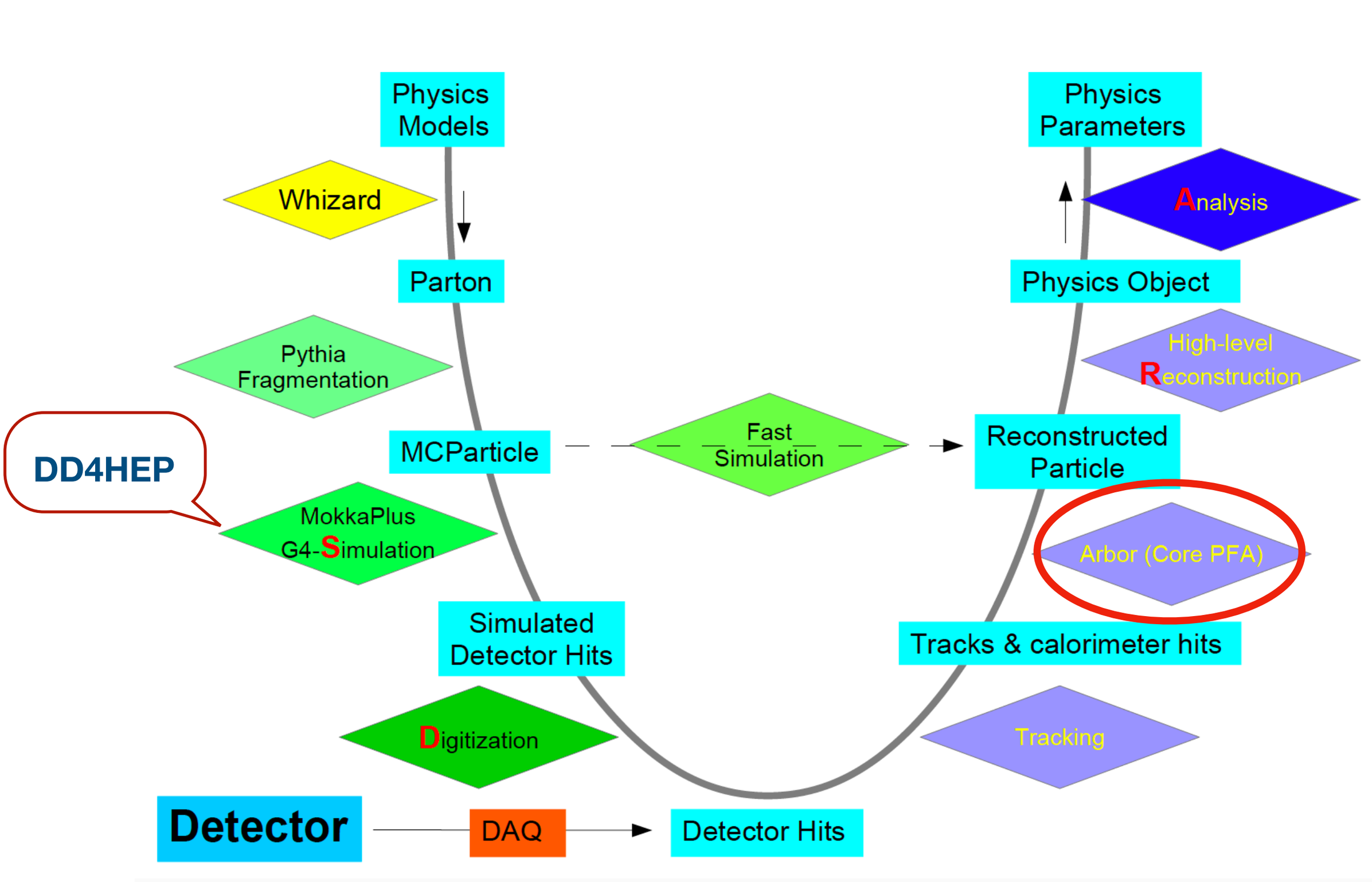
Plan

- CEPCSW Overview
- Arbor PFA: Idea & Migration
- Performance & Validation Tools

CEPCSW

- The CEPCSoft was used to produce results in CEPC-CDR
- It is developed from ILCSoft and takes ILCSoft data format & management
- In 2019, Key4HEP: Software components sharing between different experiments (CEPC, ILC, FCC, CLIC, SCTF)
- CEPCSW: based on Key4HEP and Gaudi framework, integrated with CEPC components

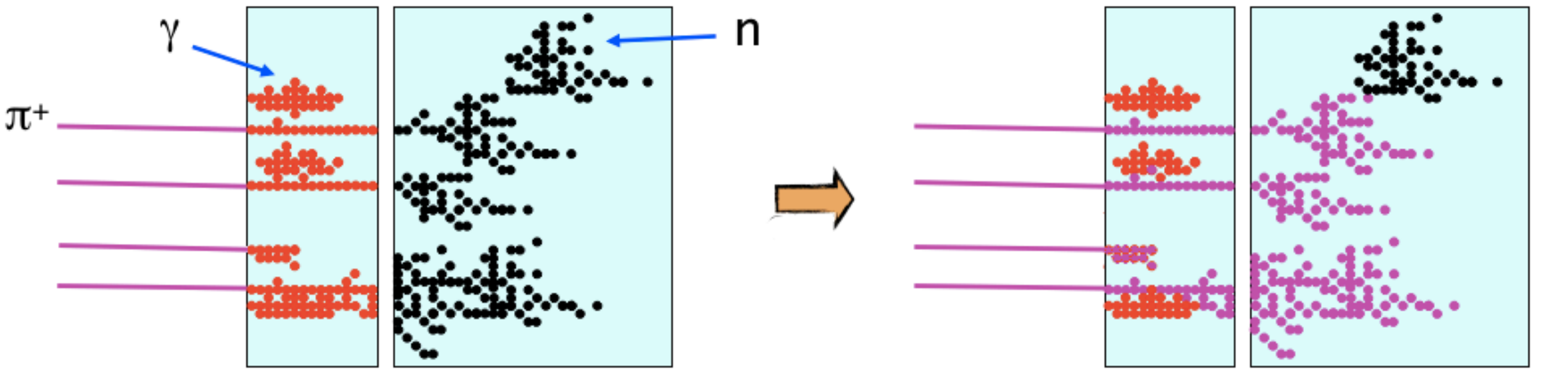
CEPCSoft


Physics Models
Whizard
Parton
Pythia Fragmentation
DD4HEP
MCParticle
MokkaPlus G4-Simulation
Fast Simulation
Simulated Detector Hits
Digitization
Detector
DAQ
Detector Hits
Physics Parameters
Analysis
Physics Object
High-level Reconstruction
Reconstructed Particle
Arbor (Core PFA)
Tracks & calorimeter hits
Tracking

PFA

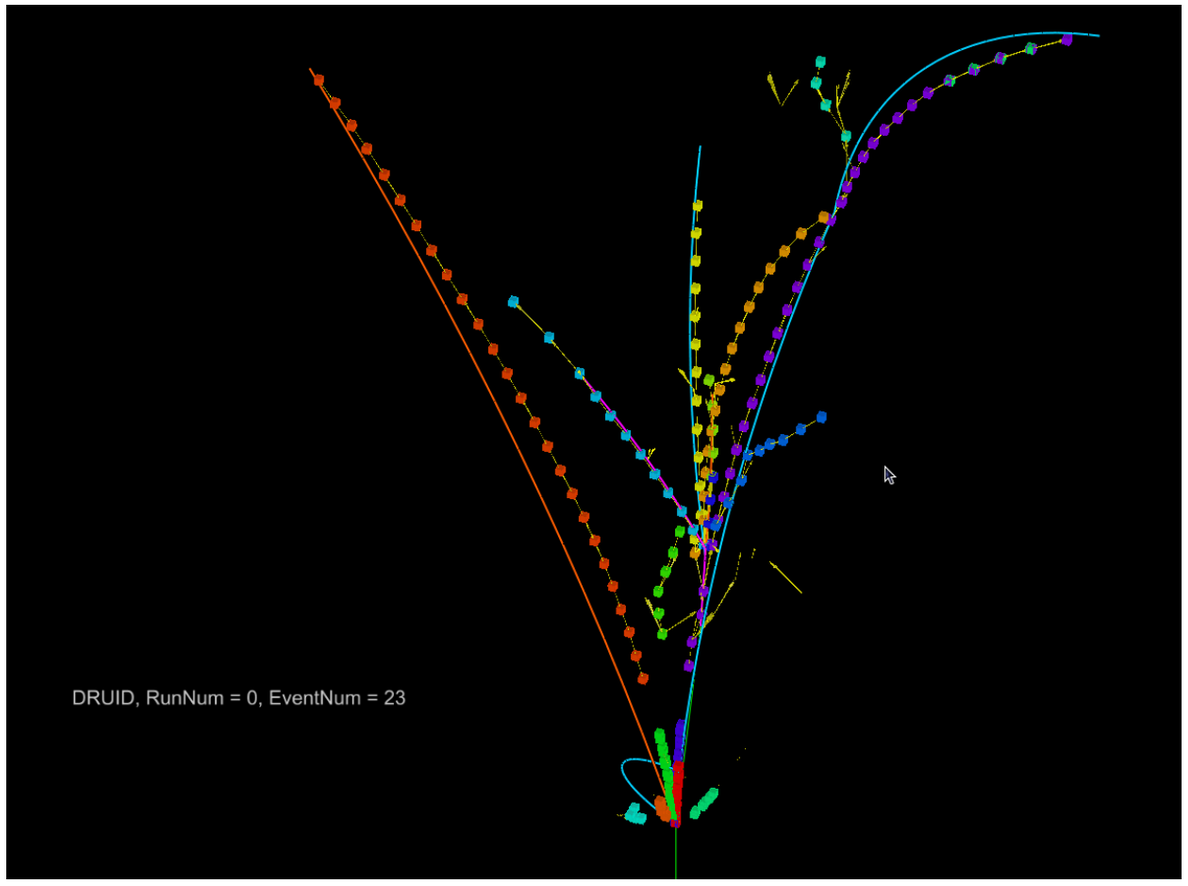
Principle: reconstructing all the final state particles - different sub-detectors suitable for different particles

- final physics objects recognized with high efficiency and purity
- jets: 63% charged + 27%photon + 10% neutral hadron



Arbor

- The spatial configuration of a particle shower follows a tree configuration
- Provides precisely reconstructed final state particles for further analysis
- All the CEPC FullSim analysis was done with Arbor till now



Baseline Performance

- Acceptance: |cos(θ)| < 099
- Tracks:
  - Pt threshold, ~ 100 MeV
  - δp/p ~ o(0.1%)
- Photons:
  - Energy threshold, ~ 100 MeV
  - δE/E: 3 – 15%/sqrt(E)
- Pi-Kaon separation: 3-sigma
- BMR: 3.7%
- Missing Energy: Consistent with BMR.

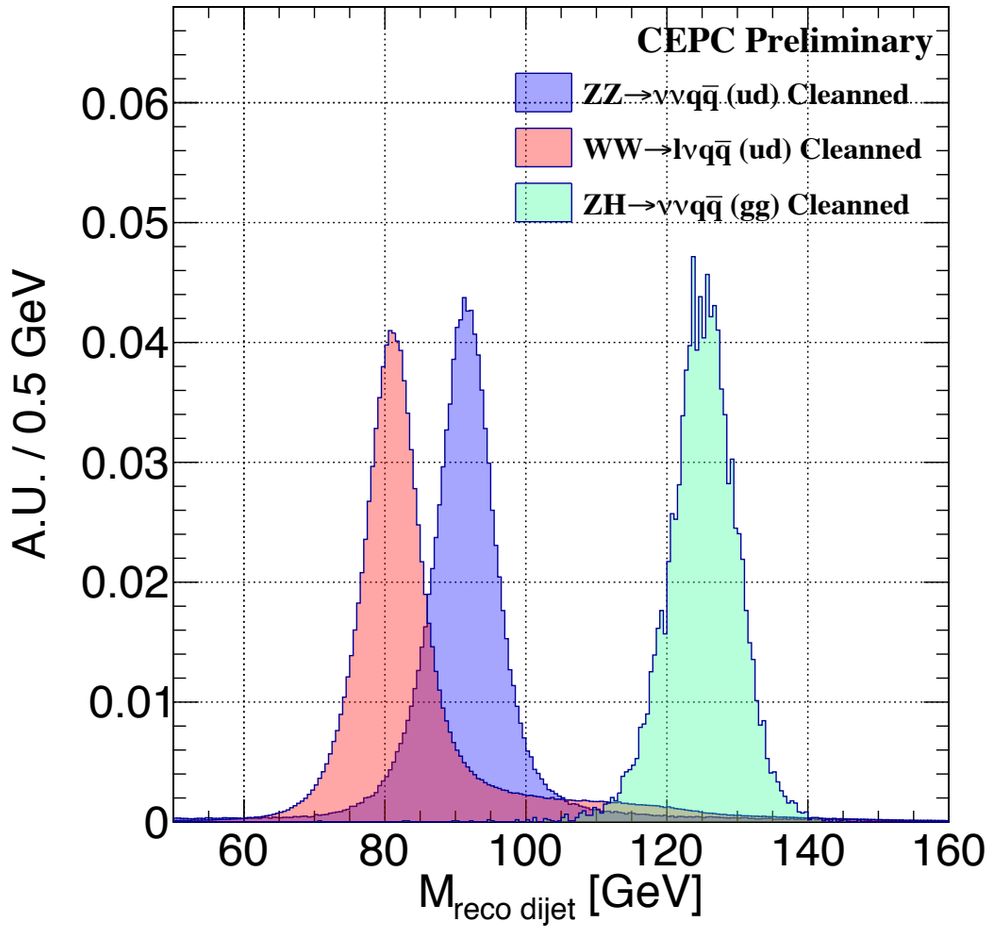
- Lepton inside jets: eff*purity @ Z→qq ~ 90% (energy > 3 GeV)
- Tau: eff*purity @ WW→tauvqq: 70%, mis id from jet fragments ~ o(1%)
- Pi-0: rec. eff*purity @ Z→qq > 60% @ 5GeV
- Reconstruction of simple combinations: Ks/Lambda/D with all tracks @ Z→qq: 60/75 – 80/85%
- B-tagging: eff*purity @ Z→qq: 70%
- C-tagging: eff*purity @ Z→qq: 40%
- Jet charge: eff*(1-2ω)2 ~ 15%/30% @ Z→bb/cc

***Detector PFA Standalone package High level objects**

BMR

Higgs Boson Mass Resolution in nnHgg channel, shows the separation power of bosons

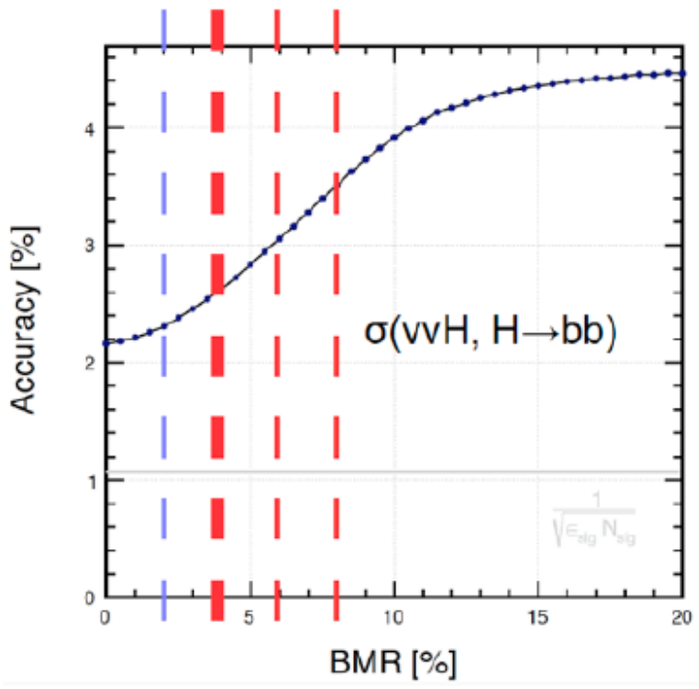
- Physics requirement: <4%
- To quantify the detector/PFA performance
- standard expression of overall performance in CEPC
  - including effects of clustering, tracking, energy scale, etc…

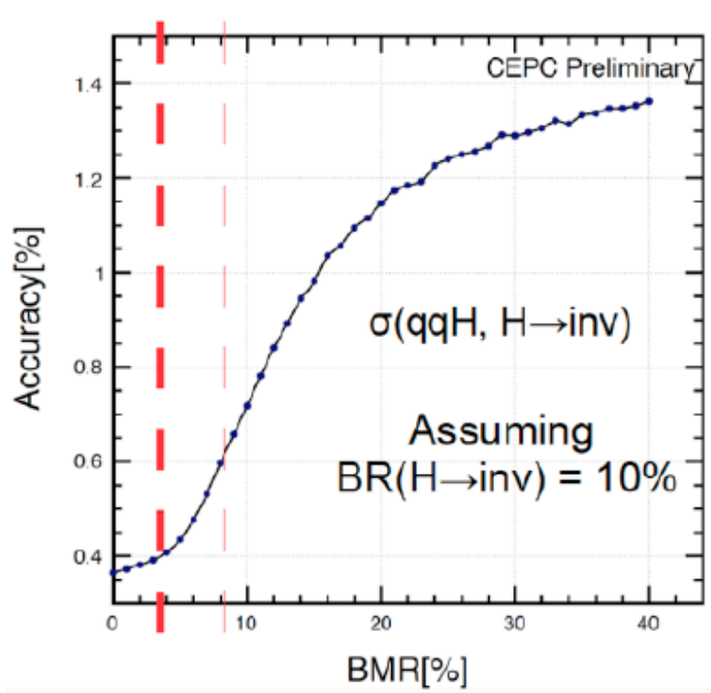


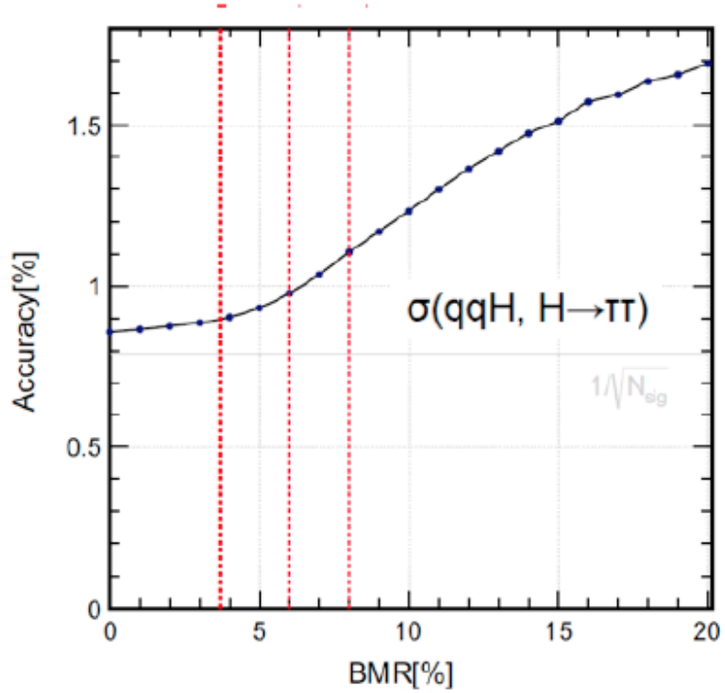
*Without events with ISR photons / neutrinos from Higgs / jets shooting to the endcaps

BMR requirement

- To reduce Z boson backgrounds (with similar FSP as signal):
  - current: 3.7%
  - requirement: 4%





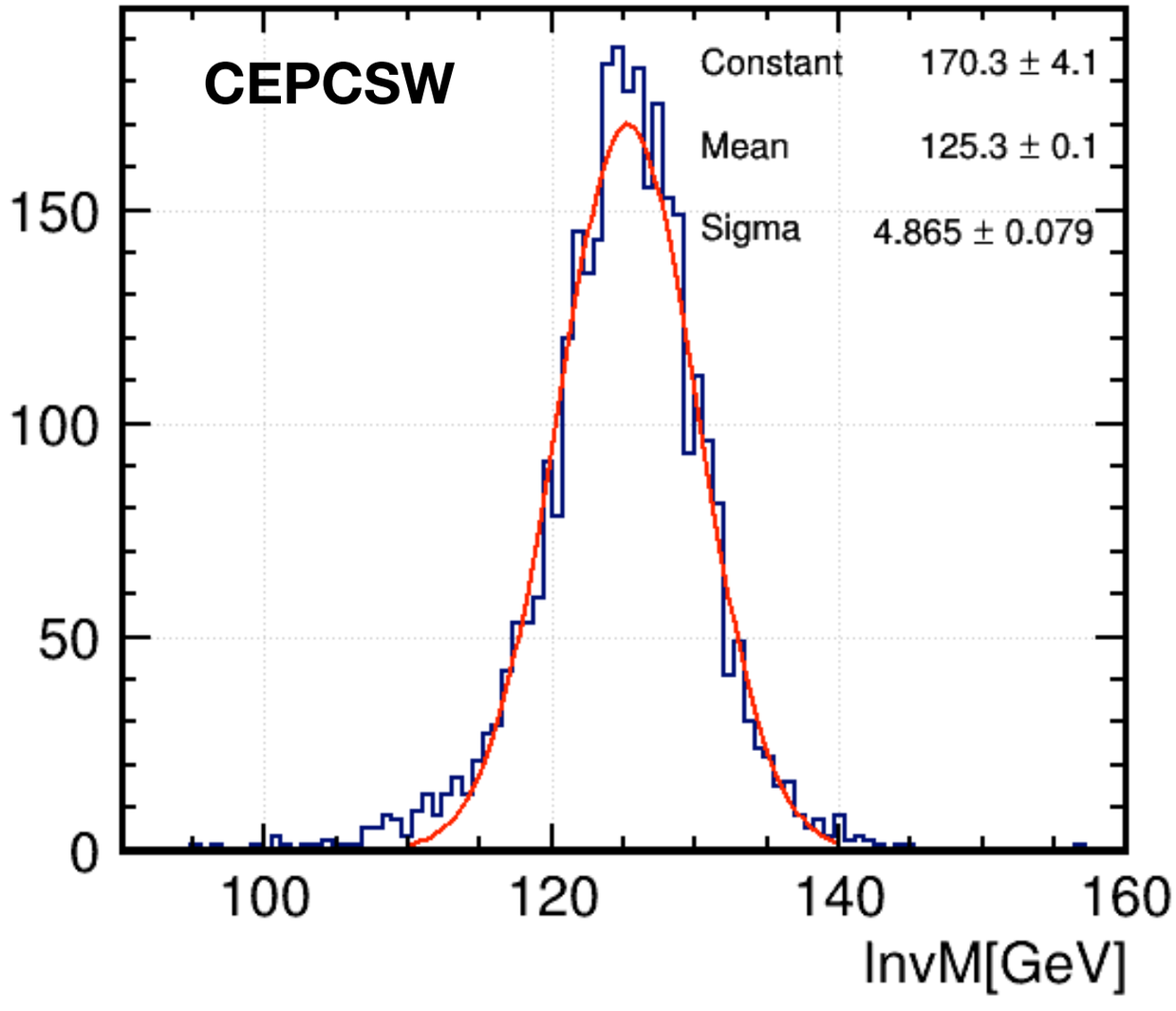


Migration to CEPCSW

- The ArborPFA is migrated to CEPCSW as a module
- https://github.com/cepc/CEPCSW/tree/master/Reconstruction/PFA/Arbor
- The new detector designs optimization needs Arbor
  - Input: Tracks & Digitized CaloHits
  - Parameters: Thresholds

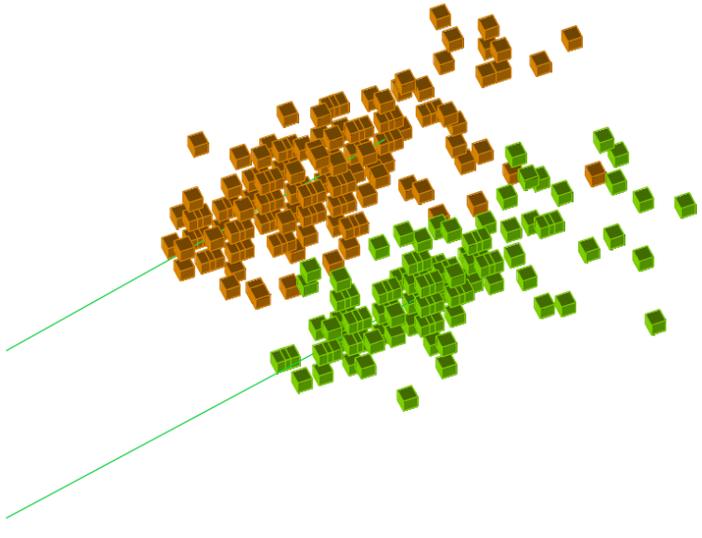
Performance in CEPCSW

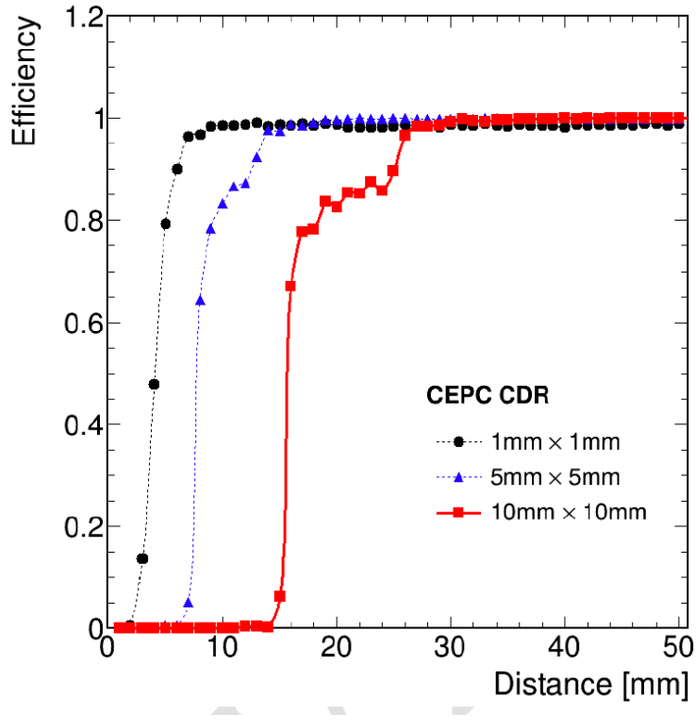
- A whole software chain test of CEPCSW, Sim+Rec
- The BMR in CEPCSW is 3.8%
- Lower level & high level validation still needed



Other Performance: Photon Separation

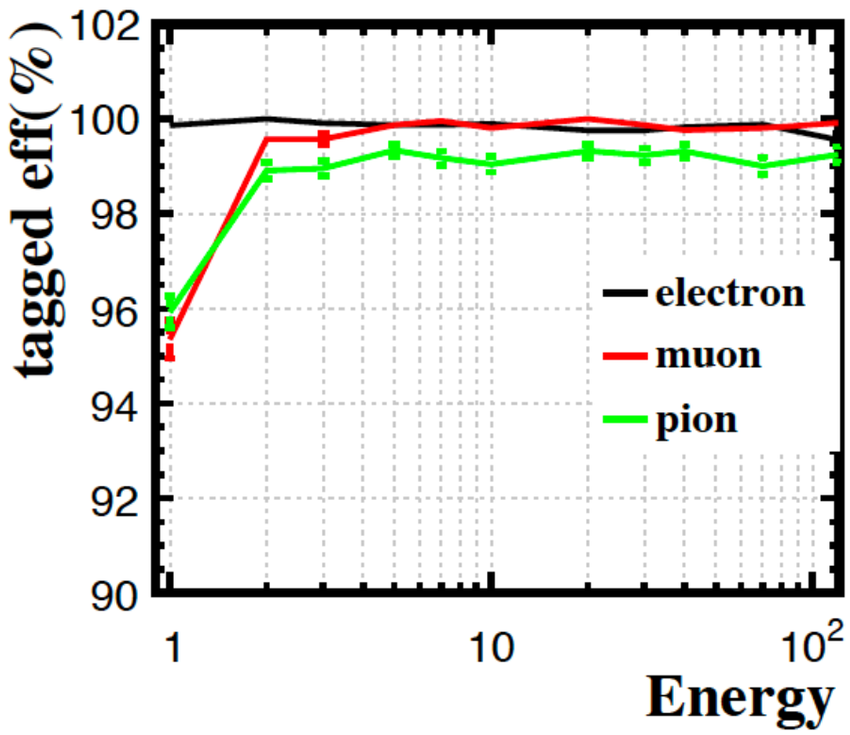
- Separation power: the efficiency to correctly reconstruct the two photons
  - ECAL design
  - PFA effects
    - energy reconstruction
    - merging
    - spitting
- Challenging for pi0 reconstruction





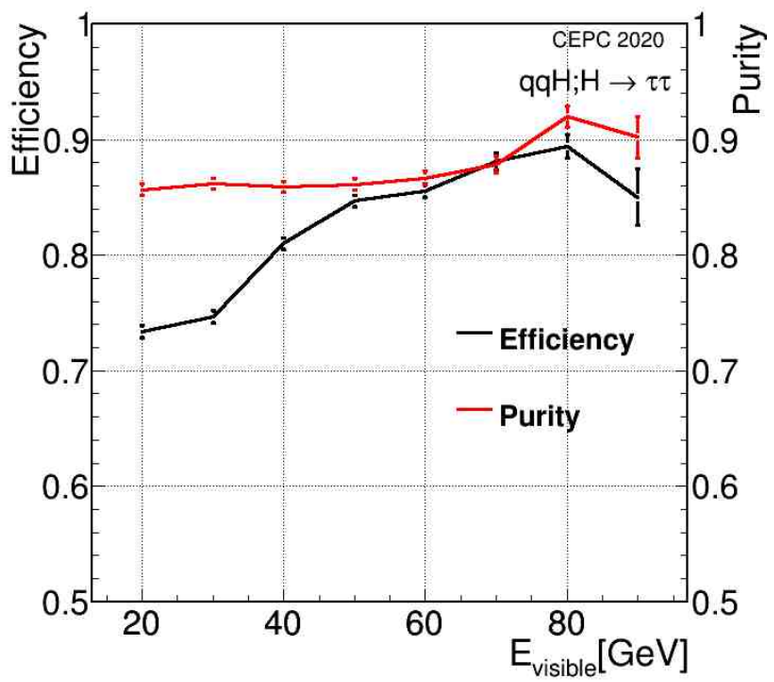
Other Performance: Lepton Identification

- Input: charged particle from Arbor (both track & cluster)
- Depends on:
  - Cluster shape & energy
  - dE/dx resolution
- Important for flavor



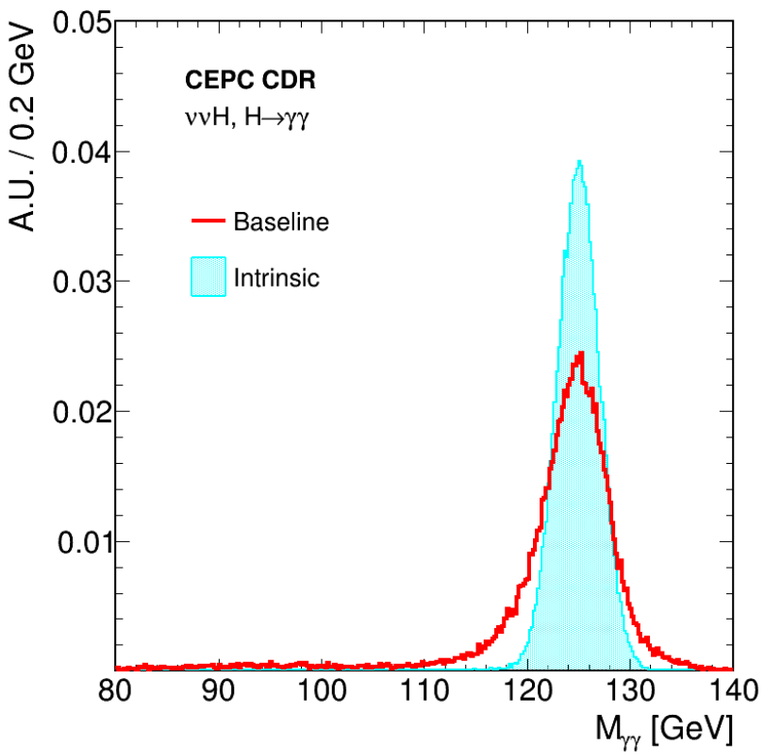
Other Performance: Tau reconstruction

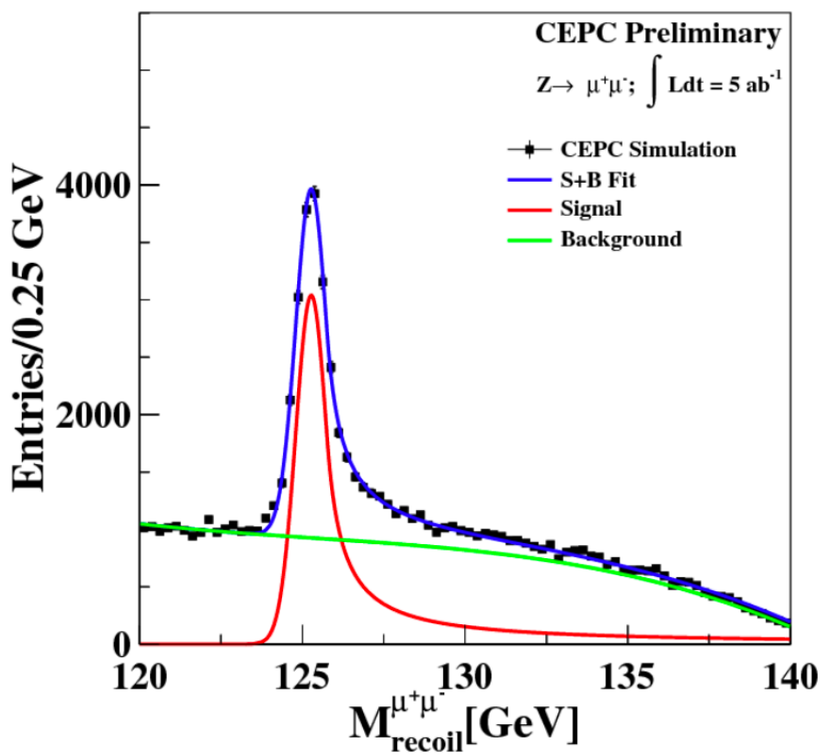
- Double cone base algorithm
- Depends on:
  - Separation
  - Energy measurements
- H->tautau analysis



Other Performance: Benchmarks

- Specific channels for different physics objects
- Input for global fitting





To do list

- Before BMR:
  - Cluster separation
  - Tracking performance
  - Photon reconstruction
  - K/pi separation
- After BMR:
  - Lepton Identification & Validation
  - Tau Reconstruction & Validation
  - Jet Clustering
  - Flavor Tag

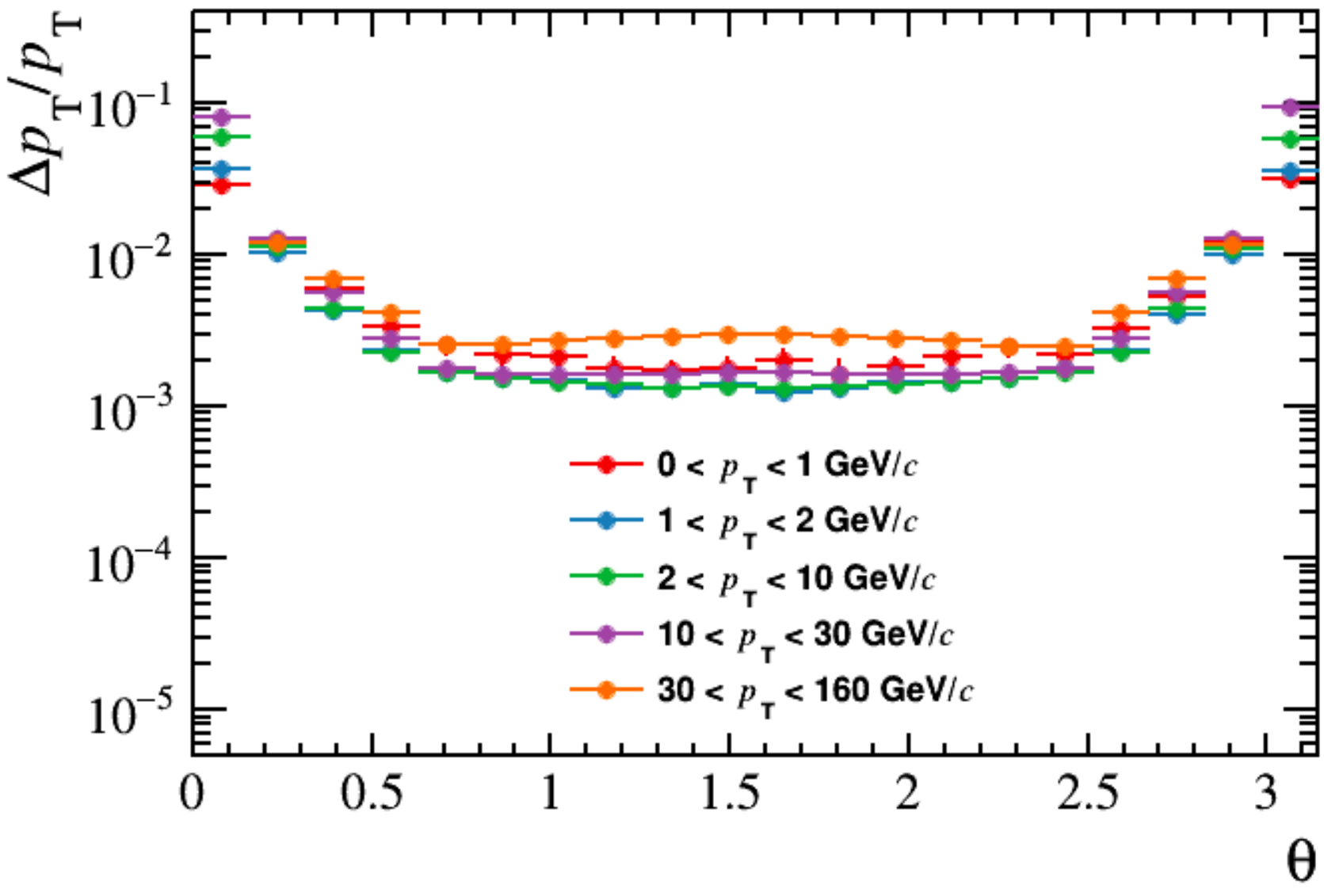
Summary & Prospect

- The Arbor PFA has been migrated to CEPCSW, the full simulation softwares are ready
  - Validation of BMR ~ 3.8% in CEPCSW, same as in CEPC CDR
  - Can be used in the 4th Det optimization
- More packages is to be integrated
  - Lepton/Tau ID
  - Jet Clustering & Flavor Tag
- Before the analyzers to use it
  - A number of validation tools should be prepared -> time & manpower

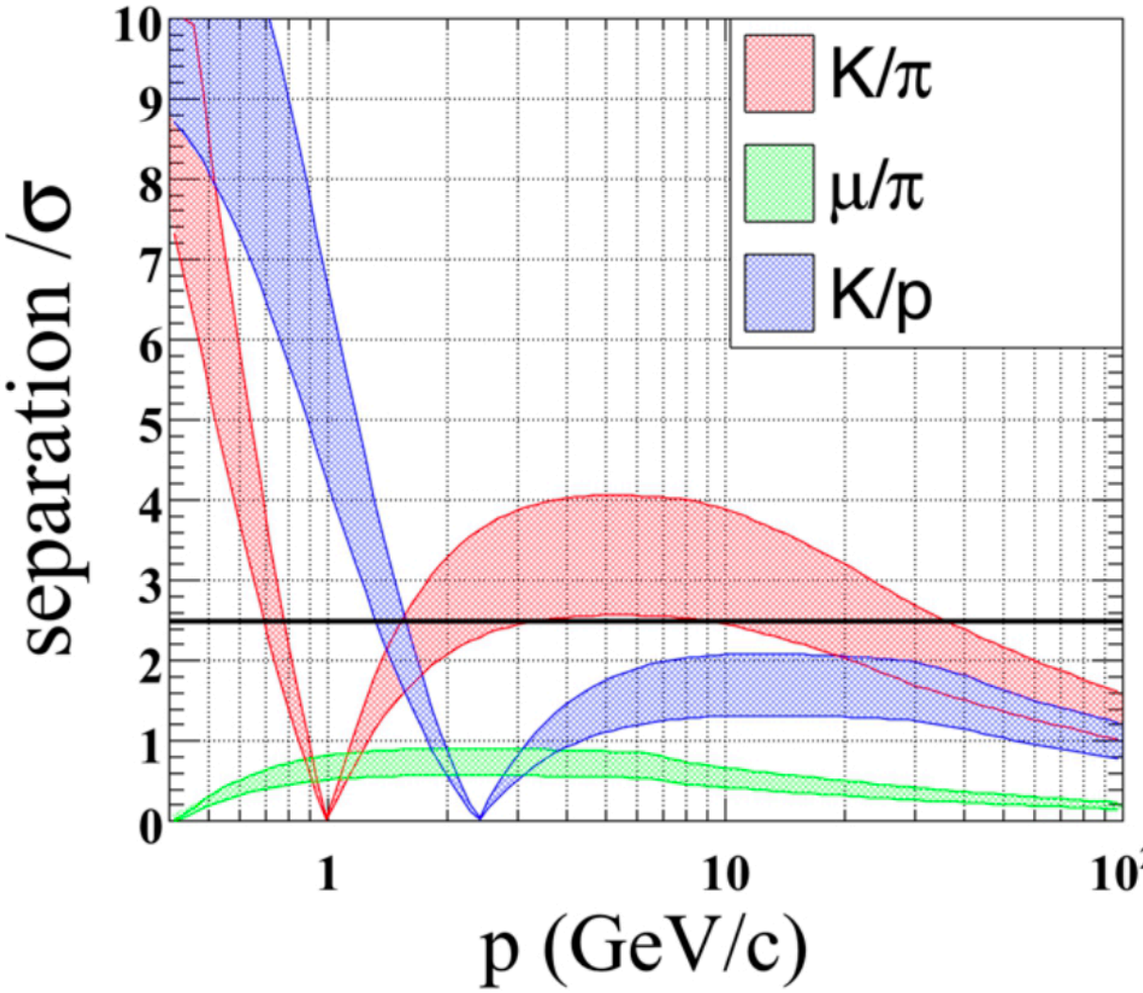
Thank you!

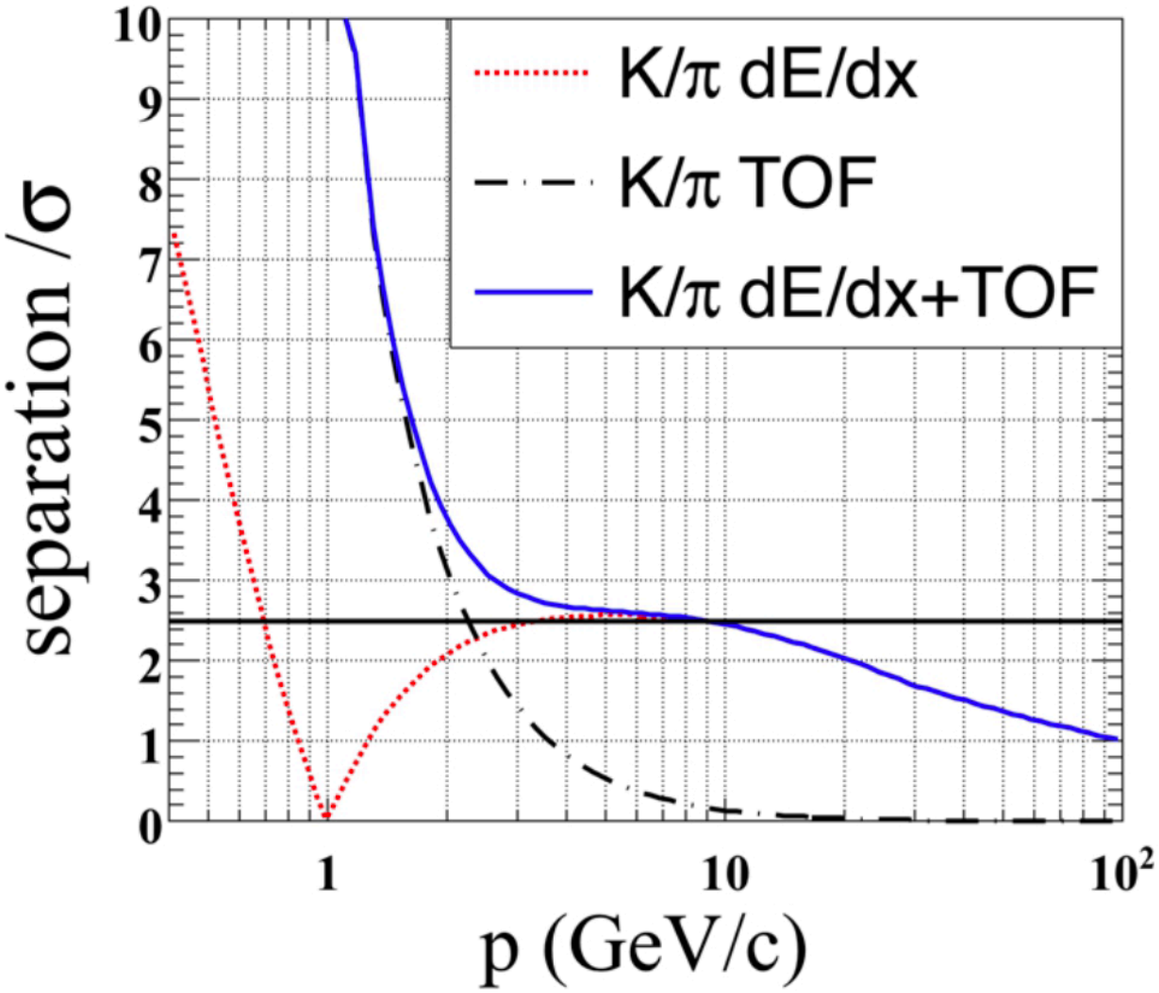
Back up

Tracking Performance



K-pi Separation





Flavor Tagging