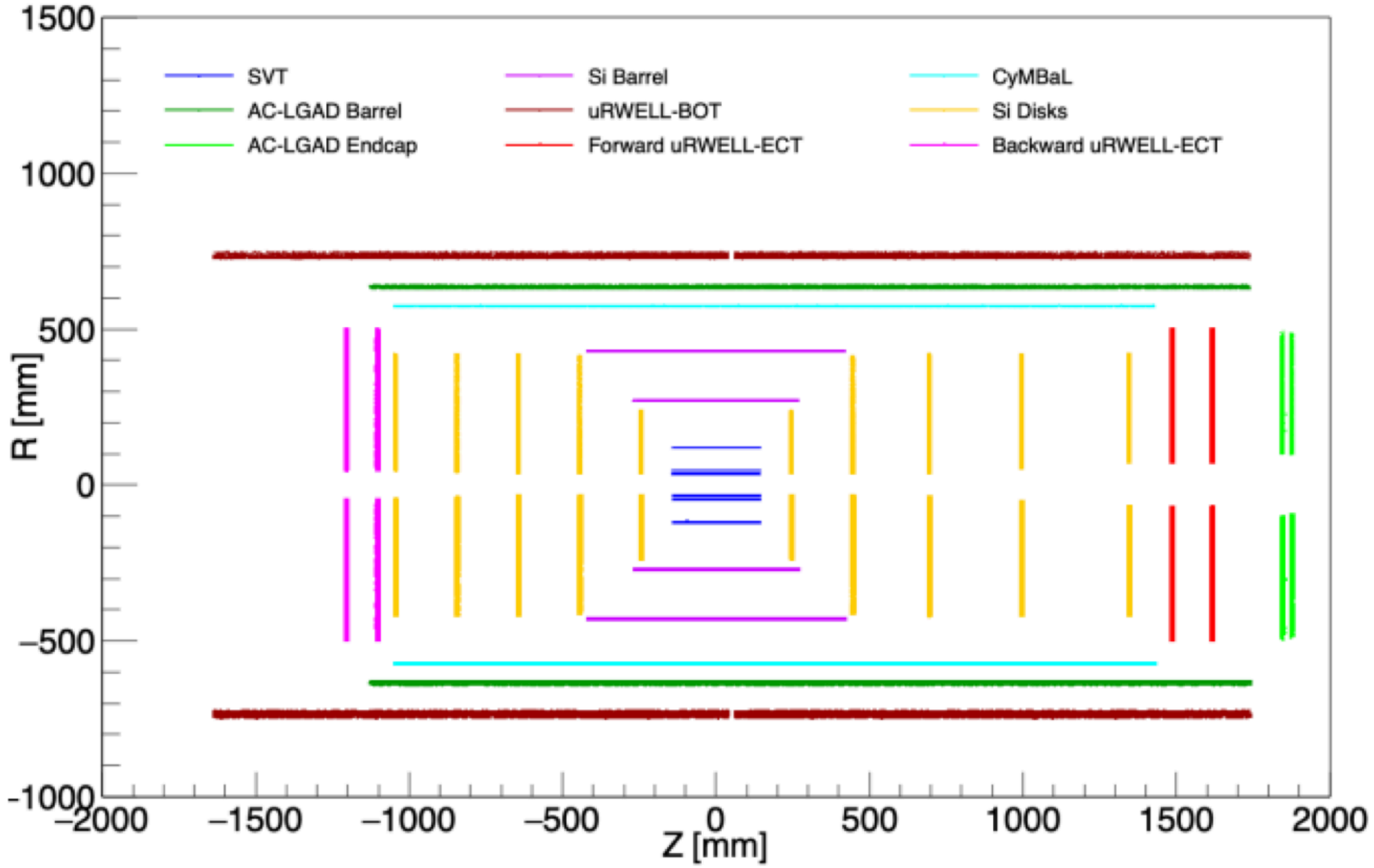
Tracking performance of the ePIC detector: Studies from Berkeley

Minjung Kim (UC Berkeley)
including nice work from: Rey, Barak, Beatrice, Ben, …

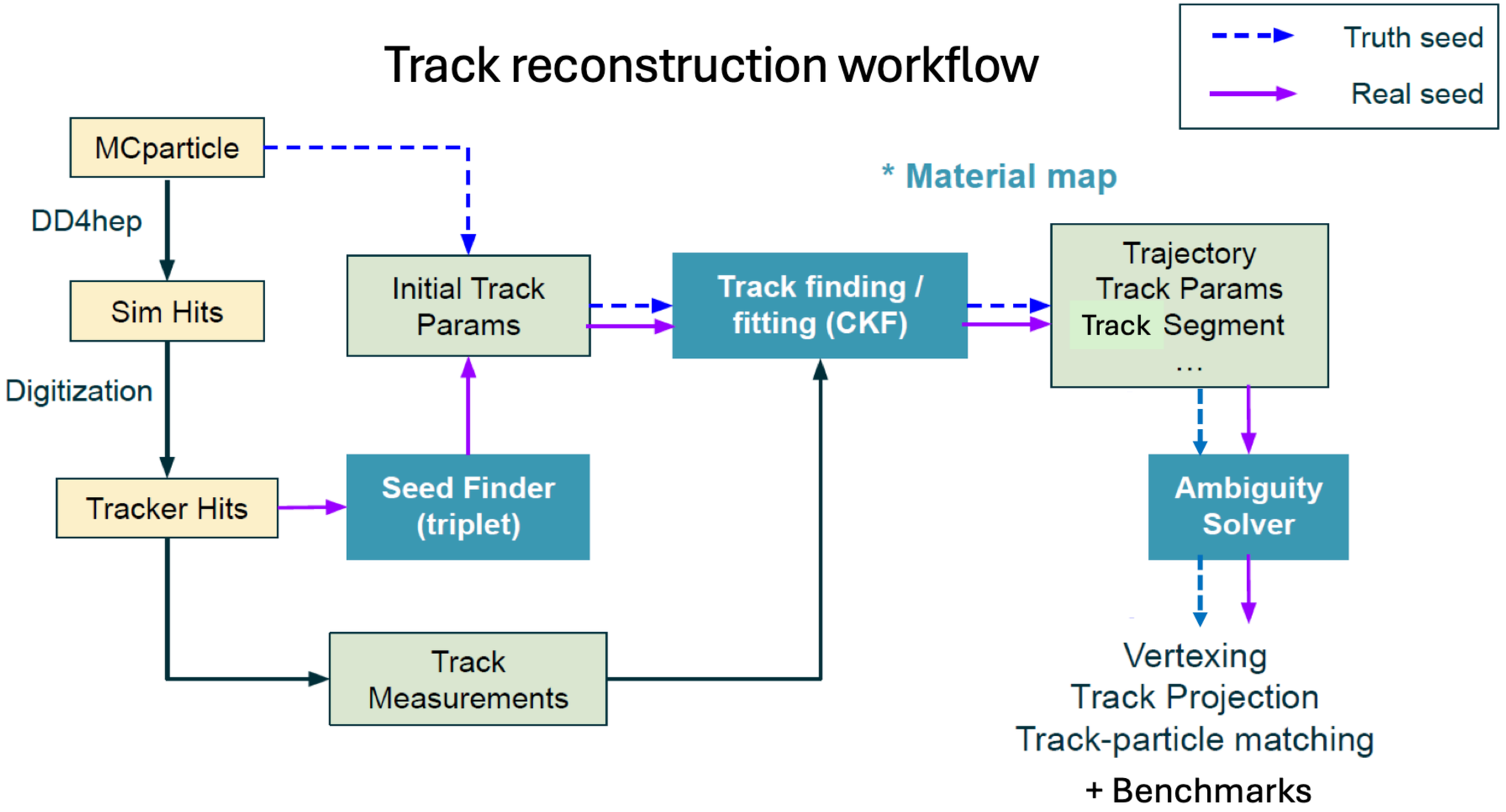
California EIC consortium meeting, Davis

15 Aug. 2024 (Thu.)

EPIC Tracking Geometry



Track reconstruction workflow



Greedy ambiguity resolution solver

✦ Greedy ambiguity resolution solver:

1. Iterate trajectories and find the trajectory having number of shared hits larger than certain threshold
2. Find the competetors and keep better quality trajectory only
3. Repeat till you have trajectories having shared hits below certain threshold

✦ Implementation in EPIC software (EICrecon):

- Based on ACTS: Core/include/Acts/AmbiguityResolutionGreedyAmbiguityResolution.ipp
- Officially part of EICrecon (from daily tag of 2024-06-04): Only resolved (filtered) tracks from “Greedy ambiguity resolution solver” propagate as “default” tracks used for further processes (vertaxing, PID matching,…); no modification required
- Output collections with full tracks still available with “unfiltered” tag and applied both on truth/realistic seeded tracking

➡ Positive feedback from Vertex WG as well as Physics working groups :)

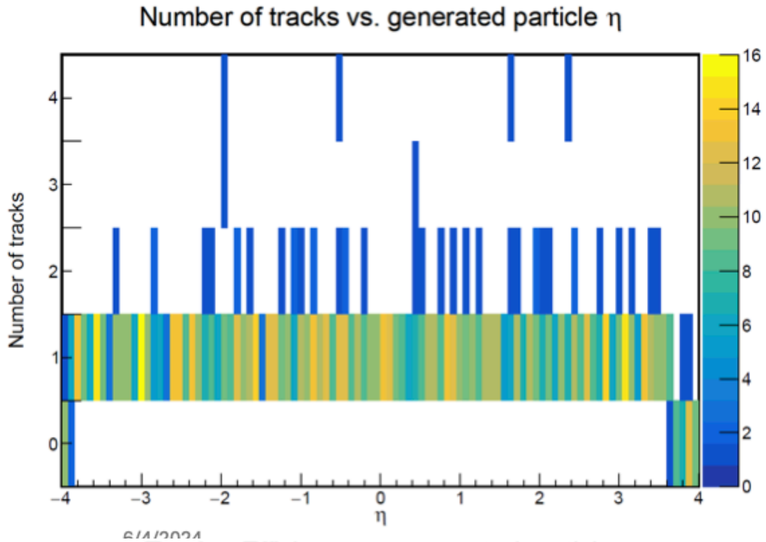
Impact of greedy ambiguity resolution solver in true-seeded tracking

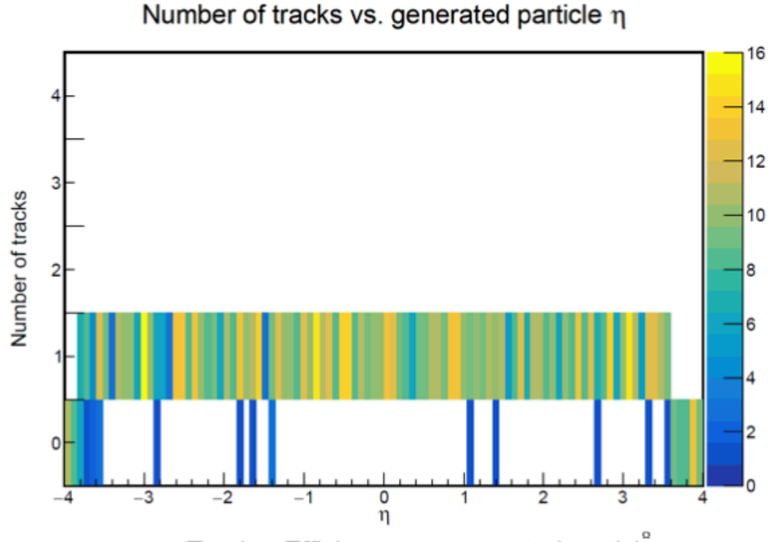
Single μ^- generated:

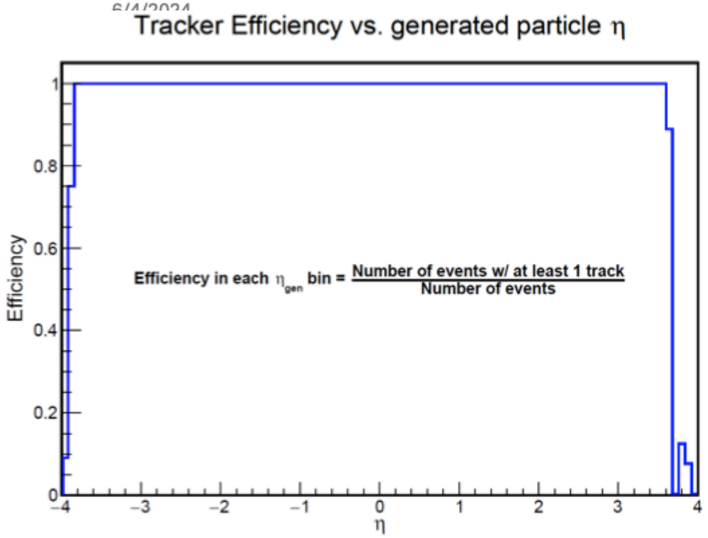
0.5 GeV/c < P < 20 GeV/c

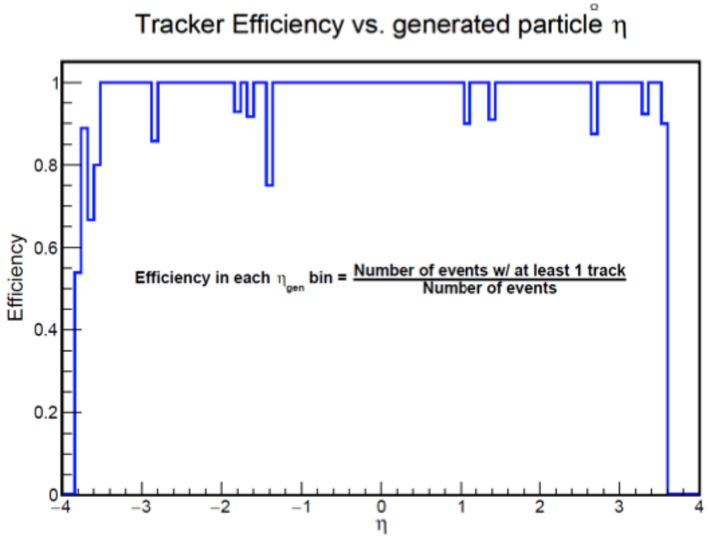
-4 < η < 4

Generated vertex: (0,0,0) mm









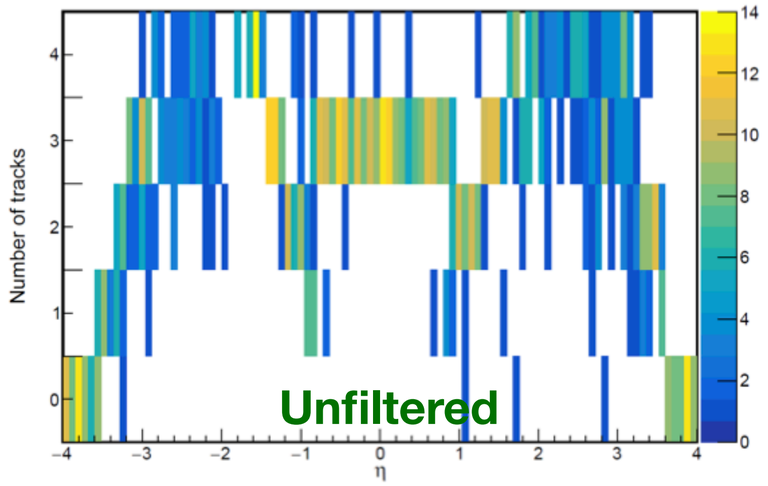
Impact of greedy ambiguity resolution solver in real-seeded tracking

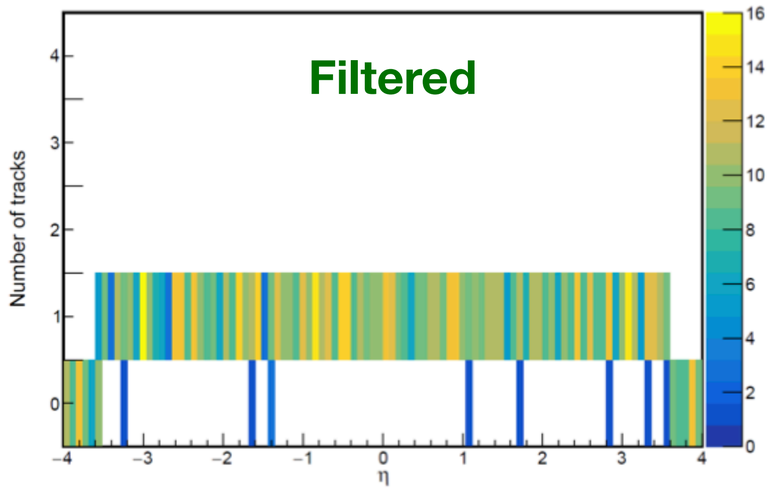
Single μ^- generated:

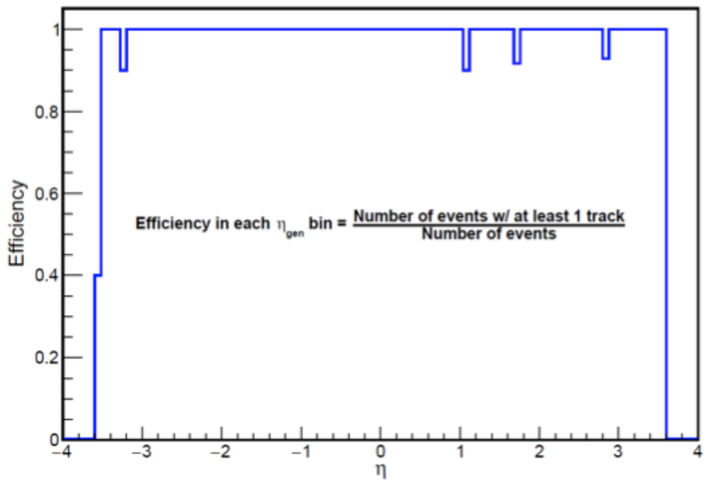
0.5 GeV/c < P < 20 GeV/c

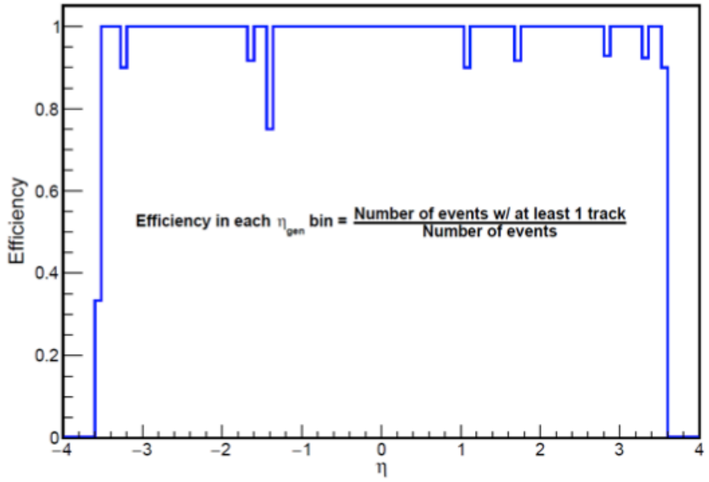
-4 < η < 4

Generated vertex: (0,0,0) mm



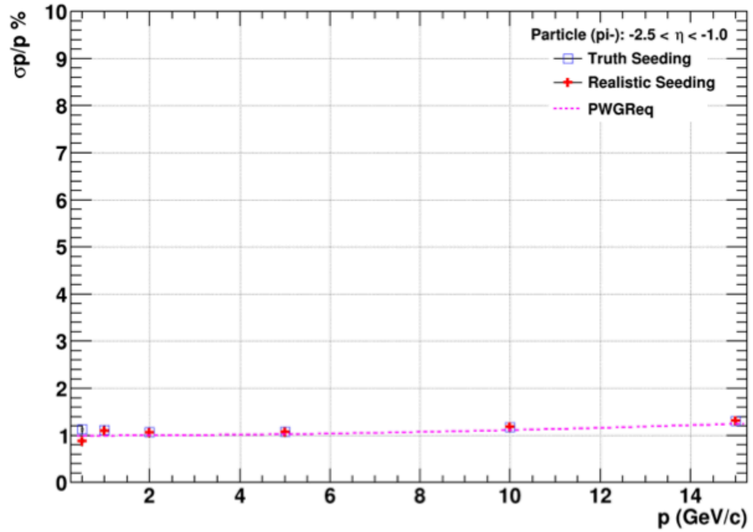


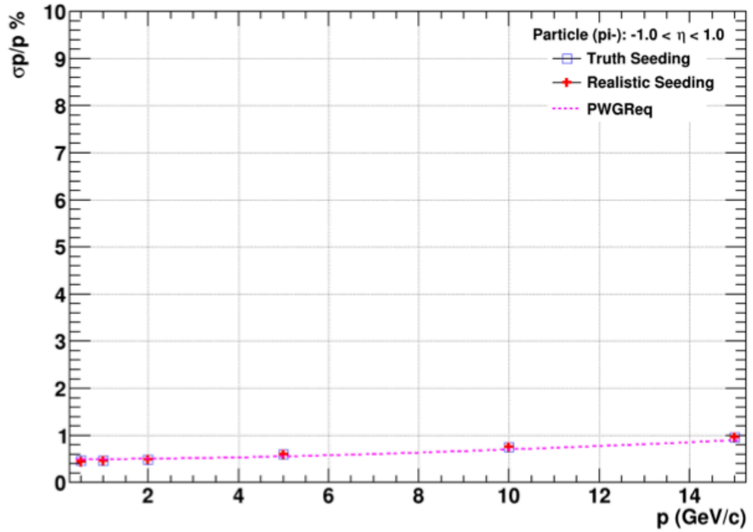


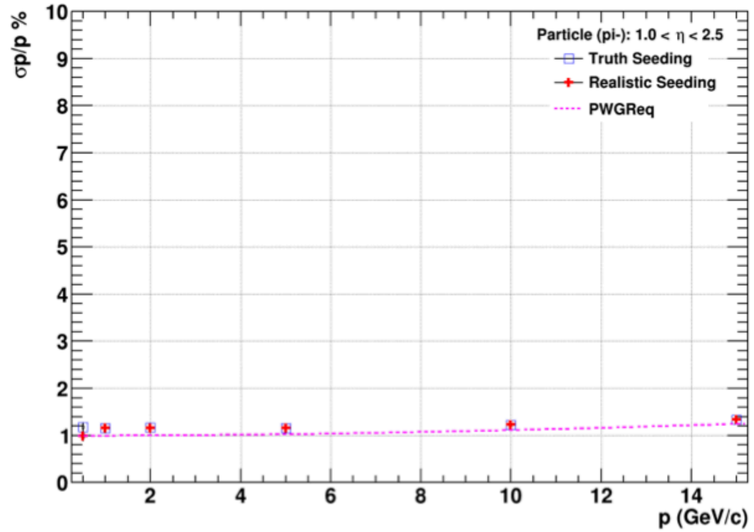


Updated track momentum resolution

Work by Shyam Kumar







- ✦ Momentum resolution plots are now part of monthly benchmark campaign
- ✦ Additional performance plots (efficiency and purity…) will be added, running automatically for quality checks - accessible in online web browser

Tracking performance: To realistic environments

✦ **Single particle event: good and clean validation environment, but not sufficient!**

✦ **Track density: evolution from single particle to high Q2 events**

✦ **Take into account background:**

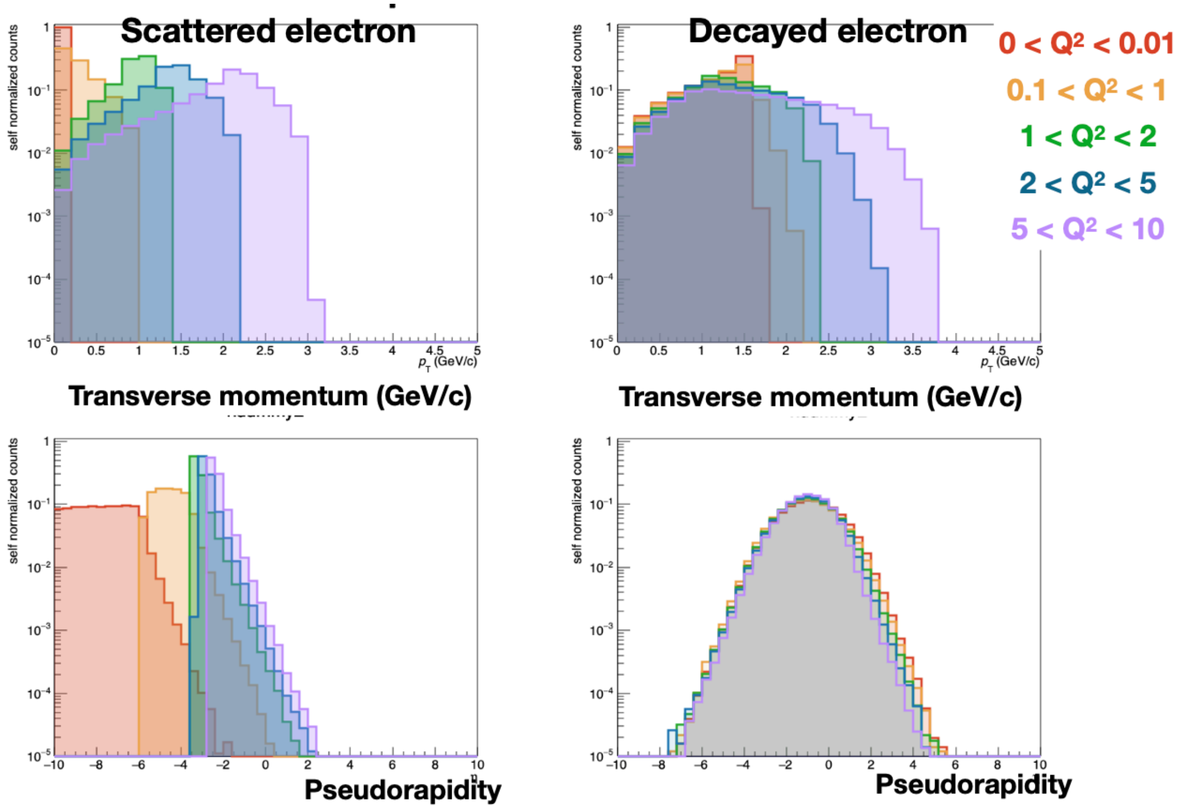
- External physics source: background from beam-gas interactions, synchrotron radiation, …
- Hardware source: noise, multiple scattering, conversion electrons, …

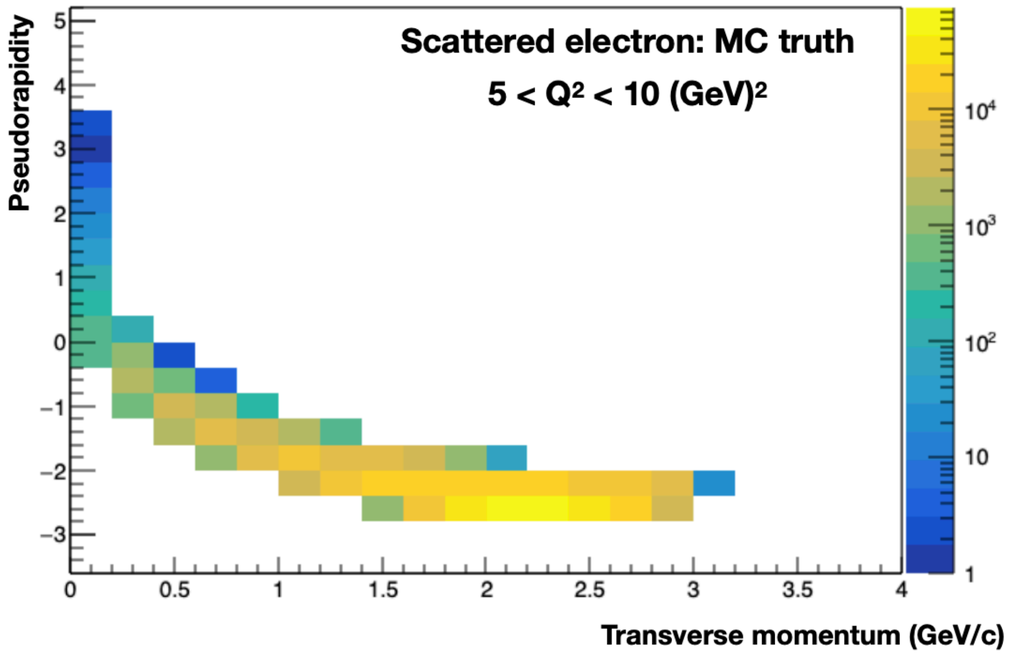
✦ **More realistic geometry and tracker spec into simulation**

➡ **Mito and Joe's talk!**

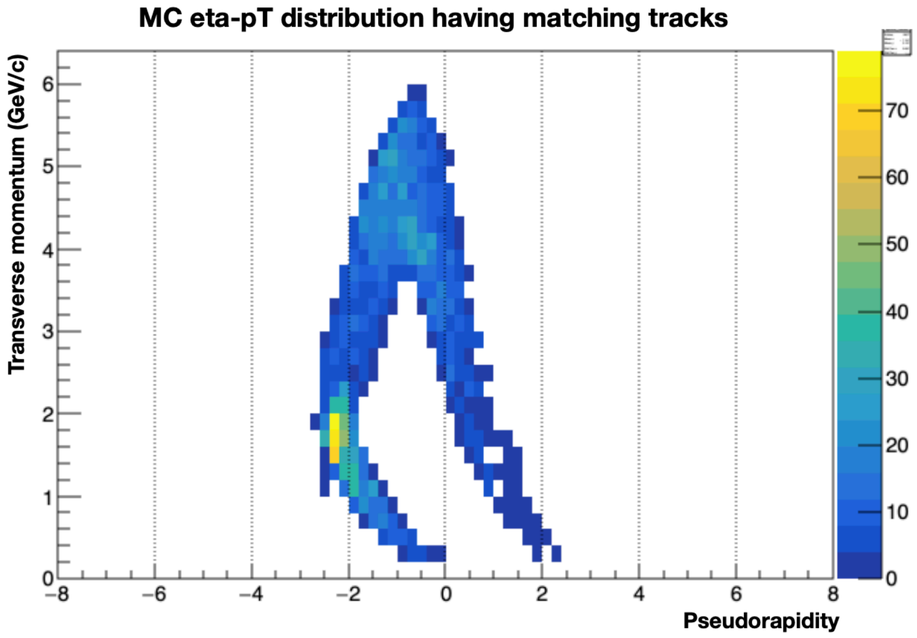
Simple physics case: Exclusive J/ψ photoproduction

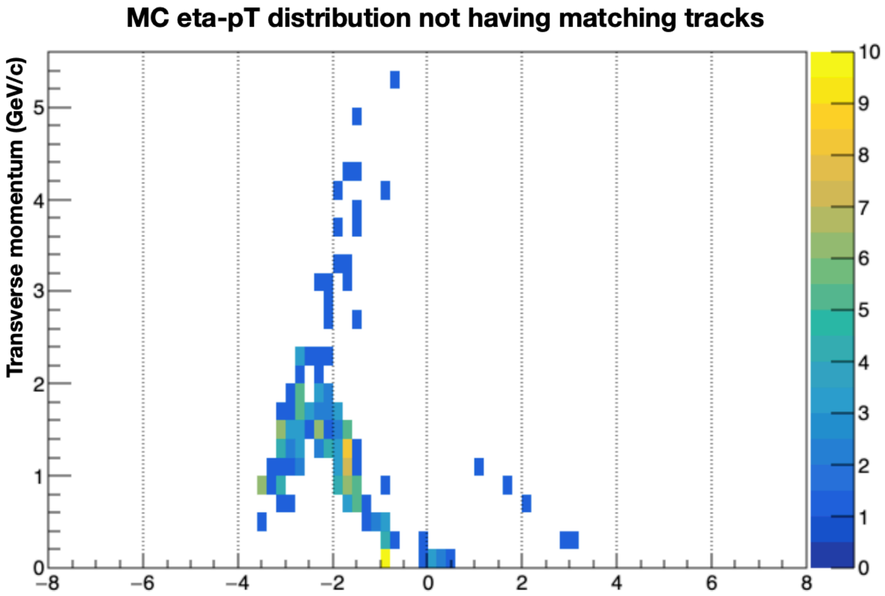
- Coherent production of eA→eA'J/ψ→e(e+e-)A' with eSTARLight
- Final state particle kinematics are well constrained; most of cases 3 electrons

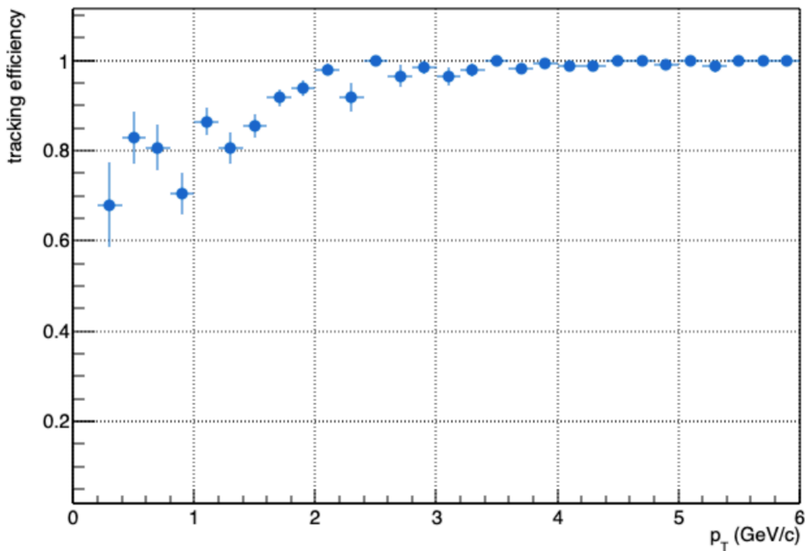


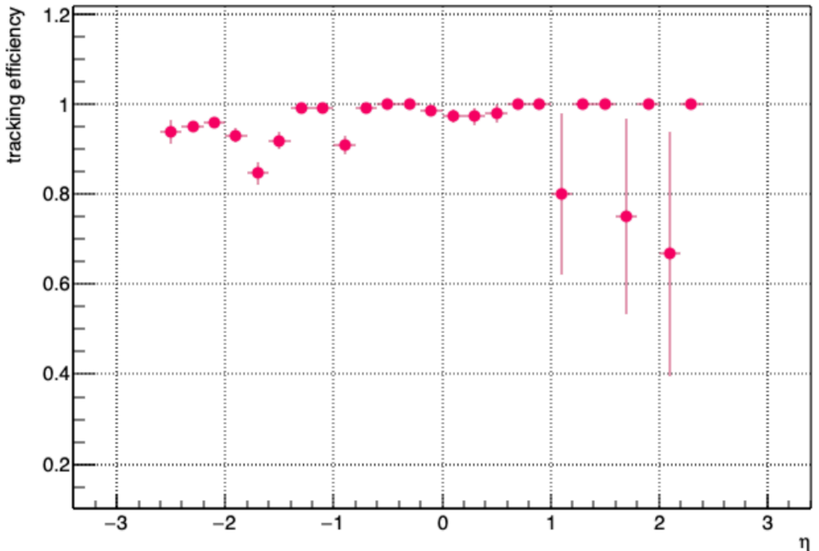


Simple physics case: Exclusive J/ψ photoproduction

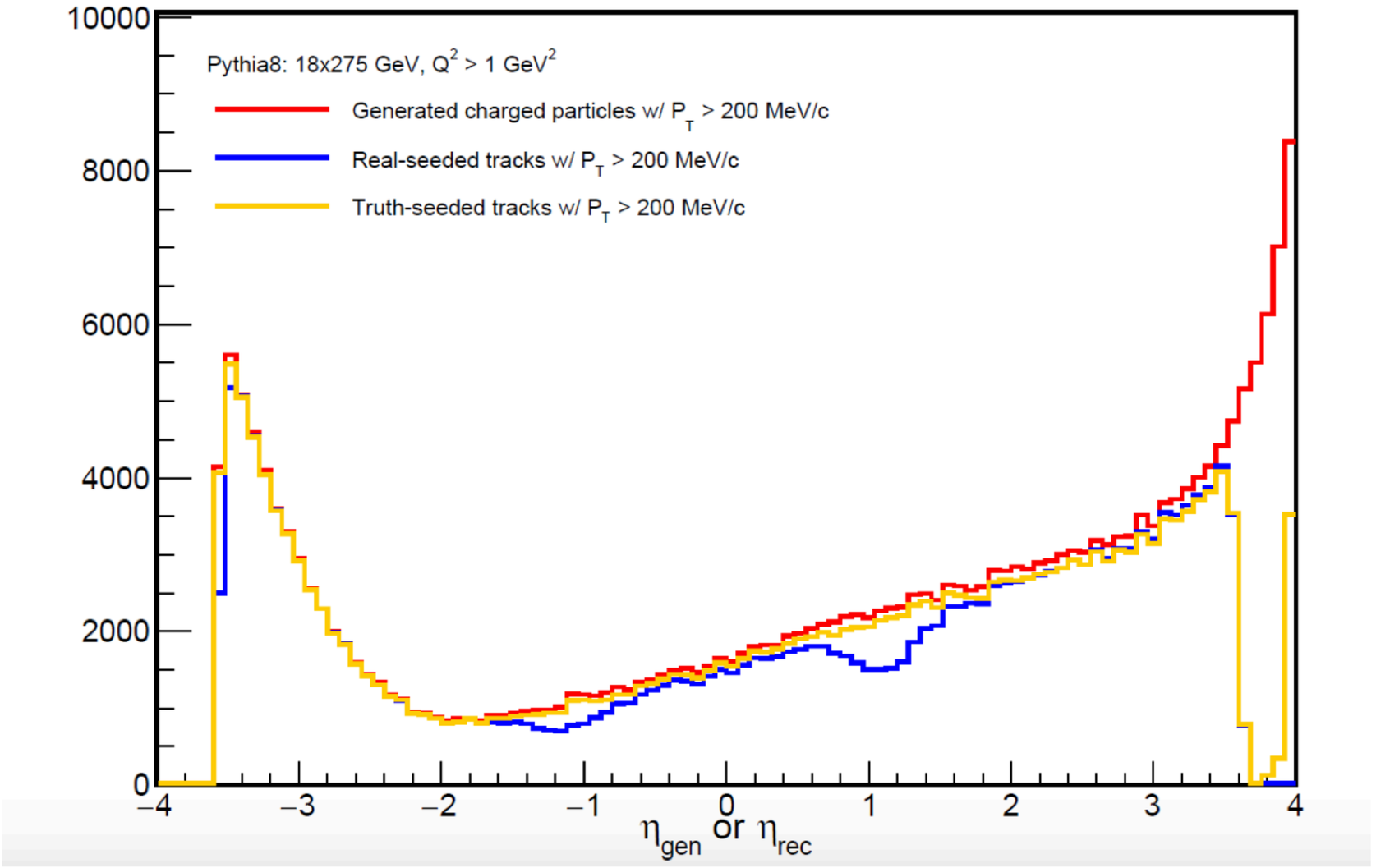




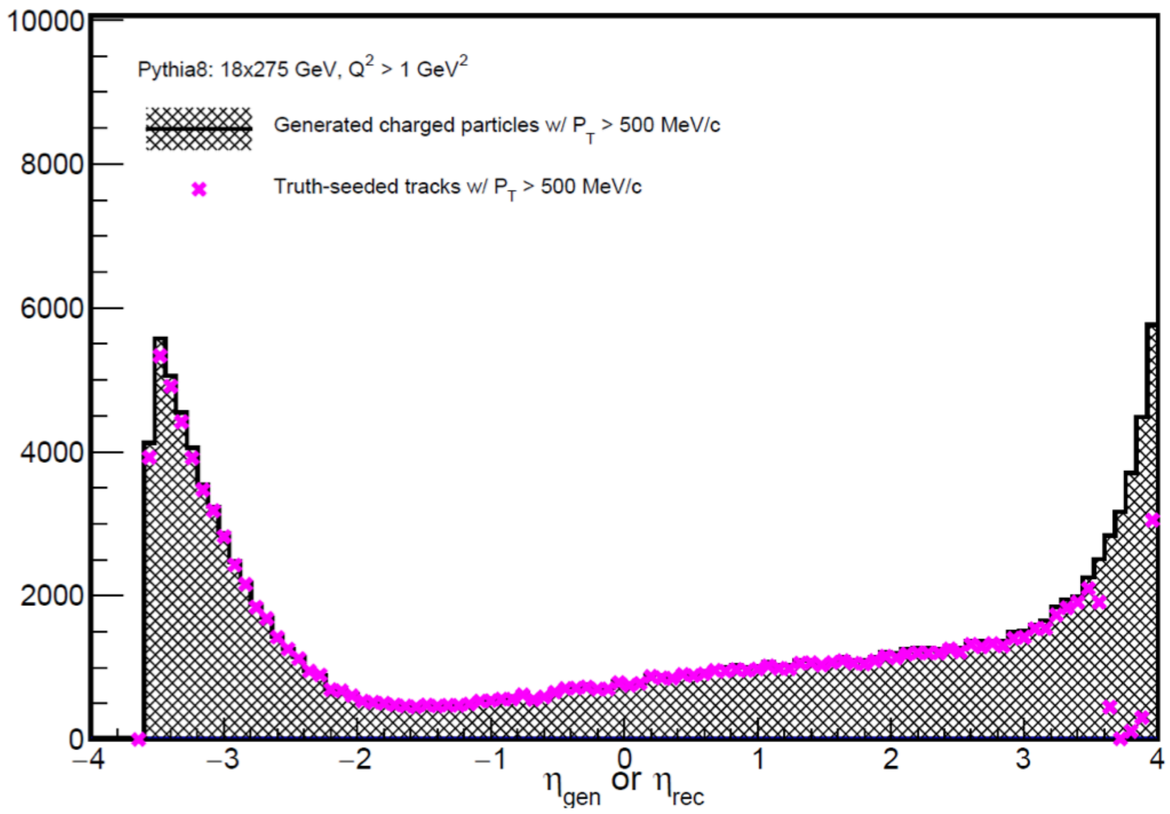


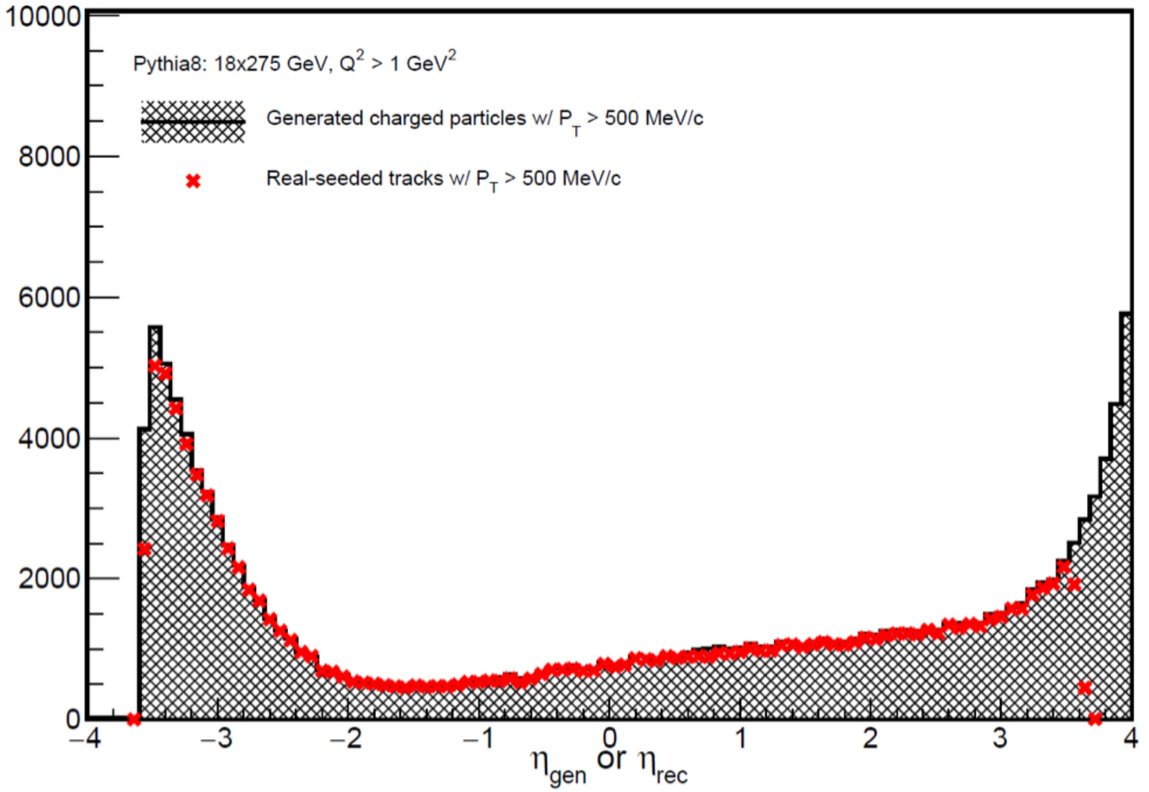


DIS event: Pythia with $Q^2 > 1$ GeV at the 18x275 GeV



DIS event: Pythia with $Q^2 > 1$ GeV at the 18x275 GeV

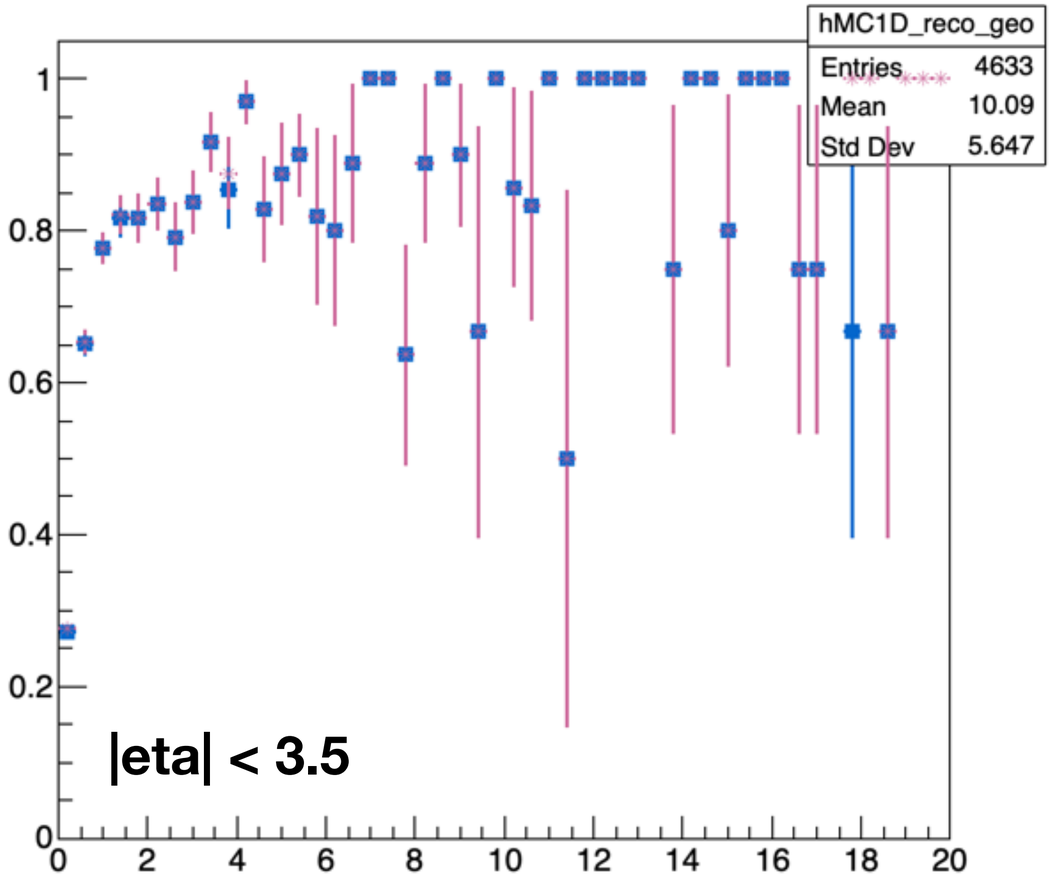


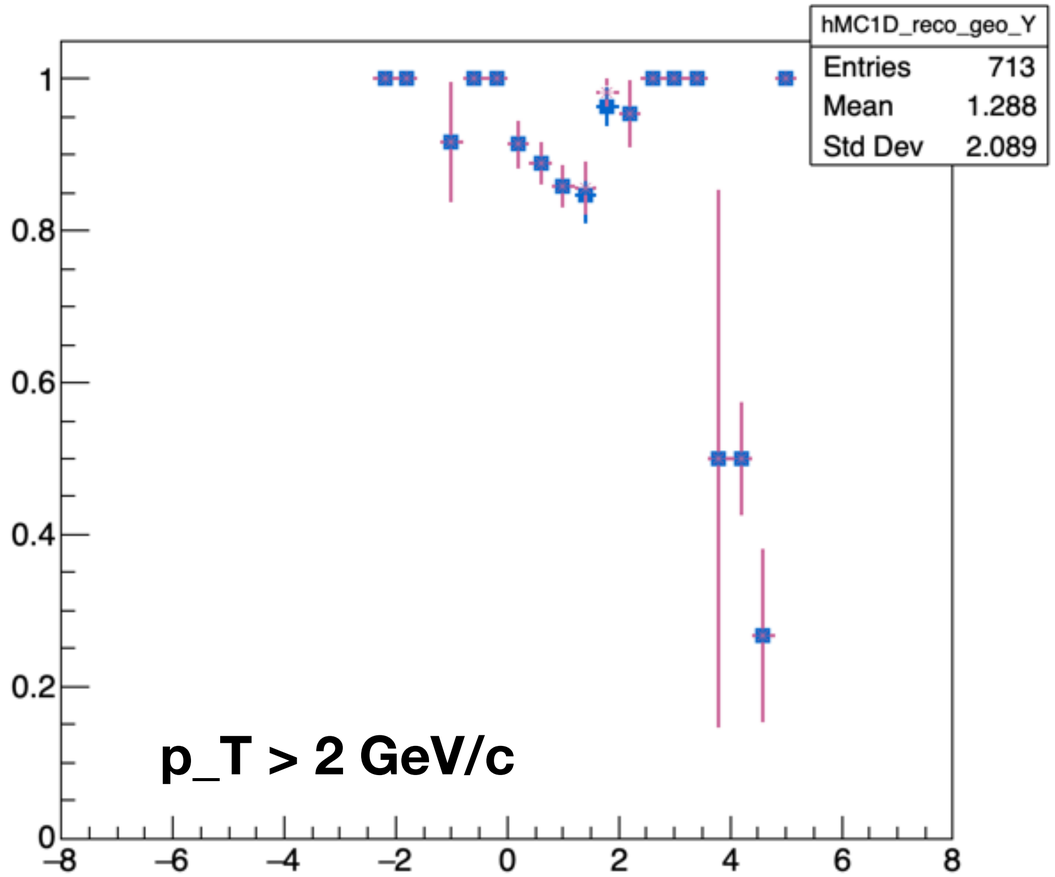


✦ Tracking efficiency above pT > 500 MeV shows no strong eta dependence and reach up to ~ 100%

DIS event: Pythia with $Q^2 > 1000$ GeV at the 18x275 GeV

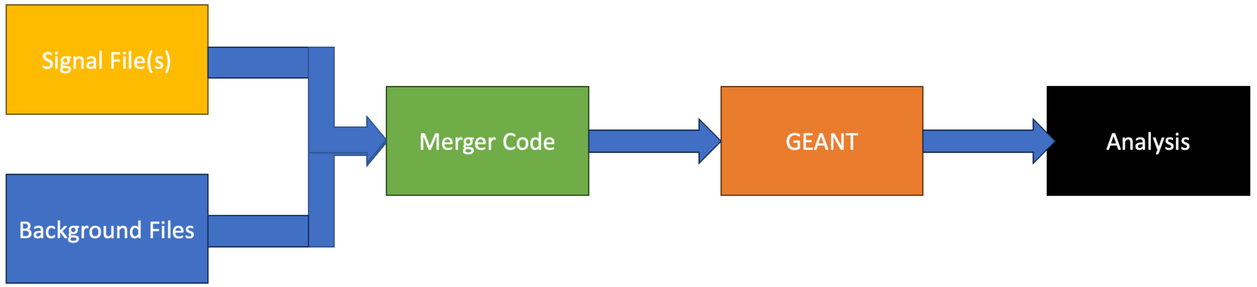
Work-in-progress!!



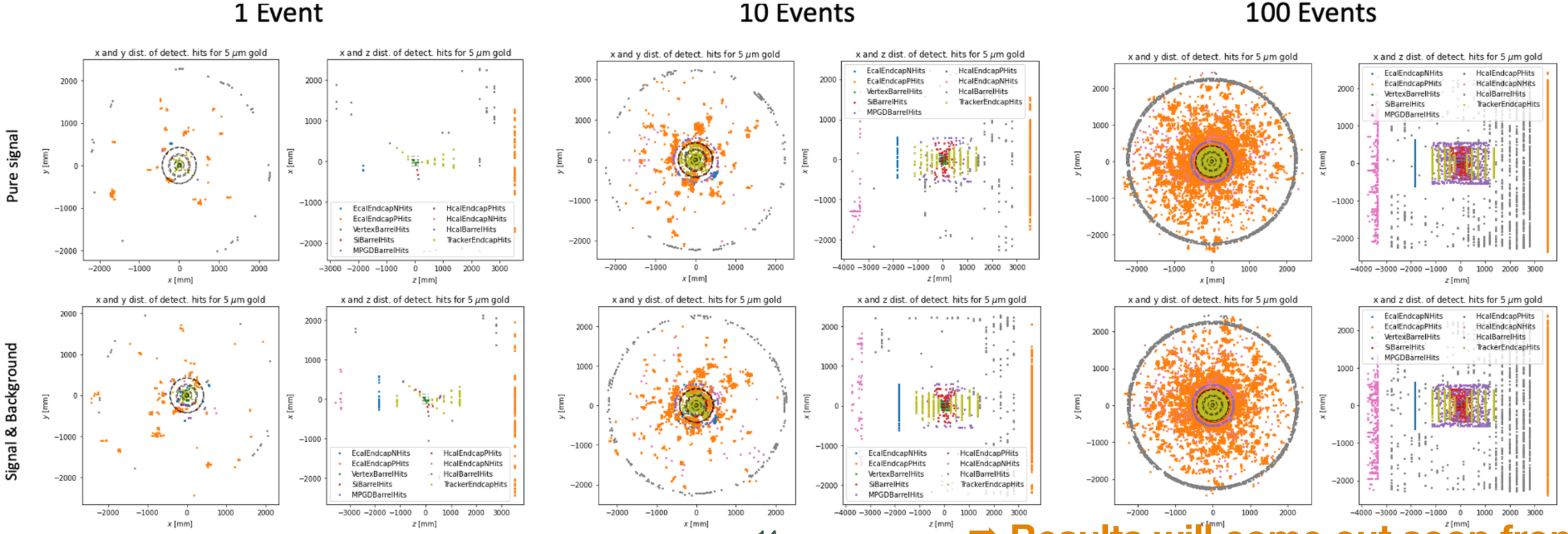


✦ Eta dependent inefficiency stays in high pT: further investigation is needed

DIS with physics background

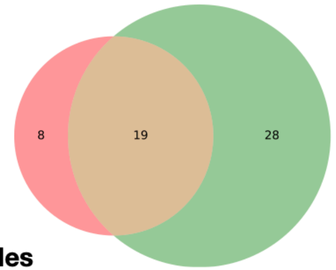


- ✦ **Signal: DIS Q2 > 1 GeV, 10x100 GeV**
- ✦ **Background:**
  - Synchrotron Radiation
  - Hadron Gas: 31347 Frequency in Nanoseconds
  - Electron Gas: 333 Frequency in Nanoseconds



➡ **Results will come out soon from Ben**

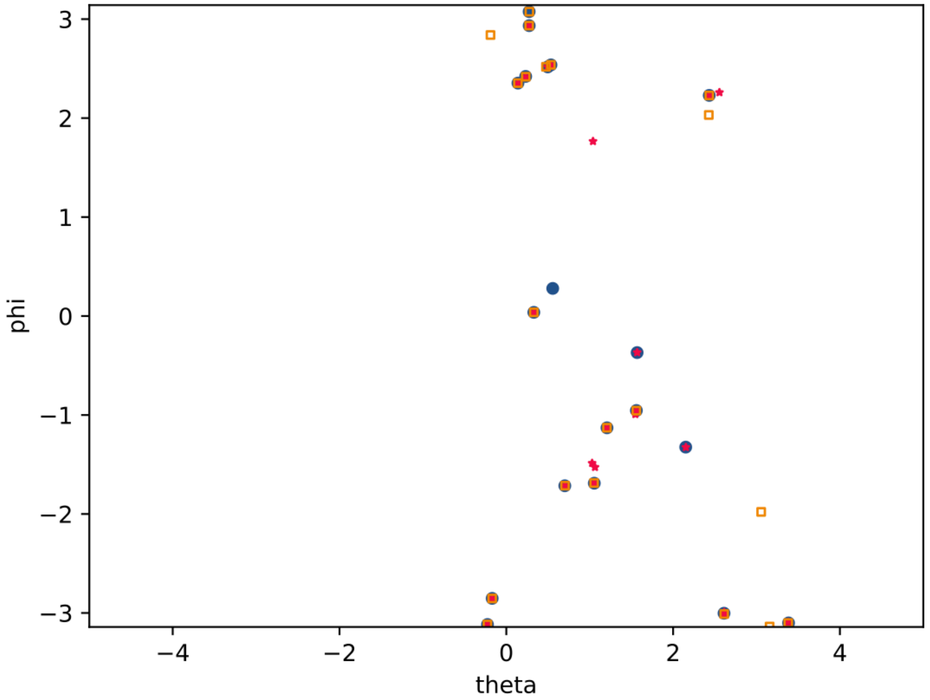
Tracking algorithm: room for improvements!

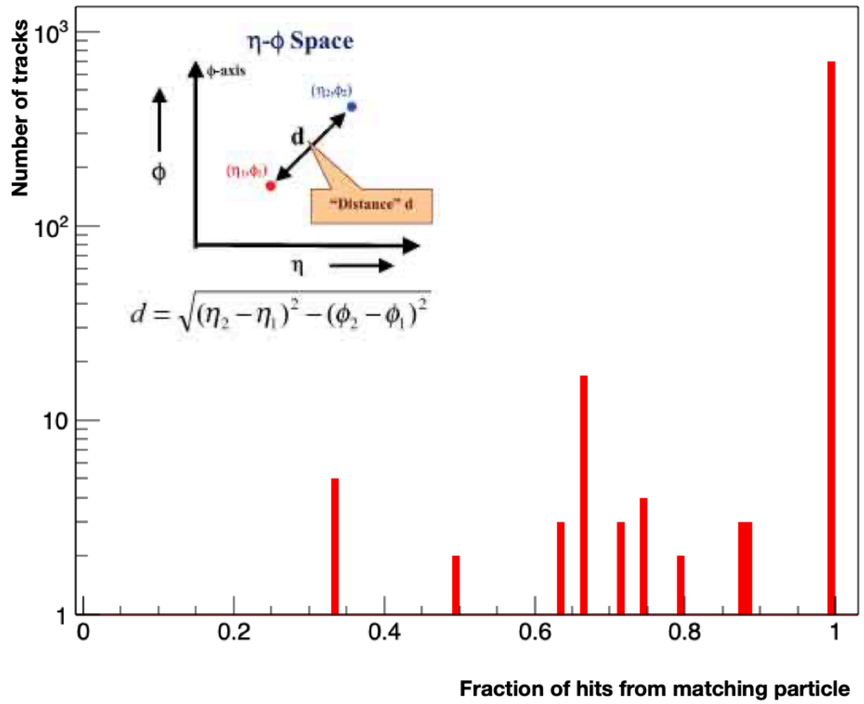


MC particles generating at least 3 hits on trackers

Final stable particles created by PYTHIA

MC particles
(PYTHIA generated stable particles with min. 3 hits)
Truth seeding
(Some kinematic cuts but covers most of final stable particles created by PYTHIA)
Realistic seeding
(Possibly reconstructed secondary particles)





✦ **Number of tracks are different in truth/realistic seeding:**

- Truth seeding takes the all charged particles generated (physics level generator) particle with loose pT and eta cut
- Truth seeding: even the particles leaving less than 3 hits on tracker are in there/secondary particles produced in material cannot be considered

✦ **Matching between MC particle and reco. tracks:**

- Matching based on angular distance/Tricky in large multiplicity events with background tracks

Summary and outlook

- ✦ Greedy Ambiguity Resolution Solver (from ACTS) is now part of EICrecon
- ✦ Further reco. algorithms (Vertexing, PID matching,..) as well as Physics performance studies can realize without additional modification in their code showing good performance!
- ✦ QA on DIS sample looks reasonable; several features should be double-checked!
- ✦ Extending towards detailed tracking performance studies
- ✦ As well as improvement on the machineries