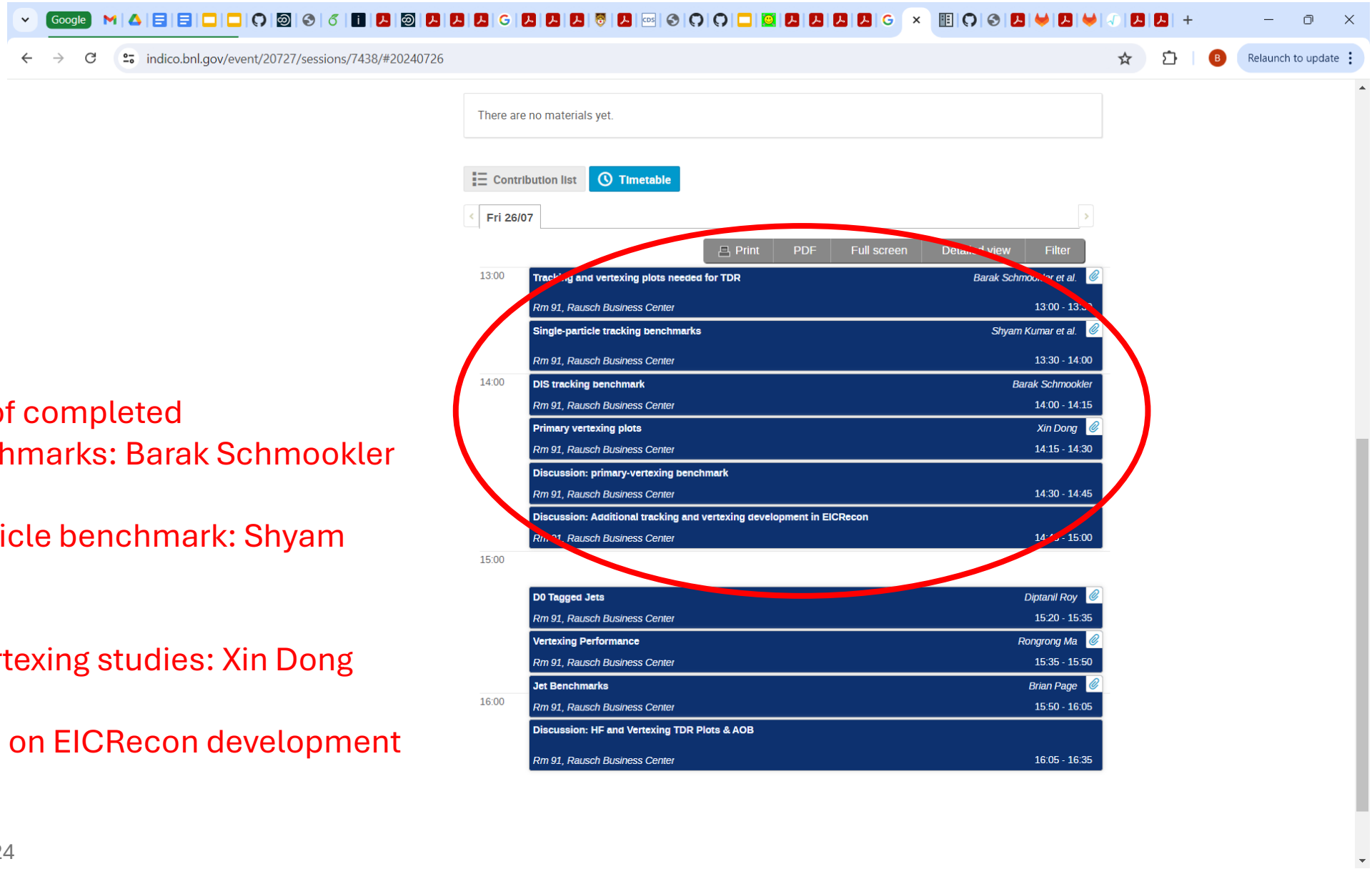
Track / vertex reconstruction +Jets/HF workfest

Xin Dong, Olga Evdokimov, Shujie Li, Brian Page,
Barak Schmookler, Ernst Sichtermann

~15 participants in-person + 5 on Zoom

Workfest Summary: Track reconstruction and primary vertexing

Session Overview



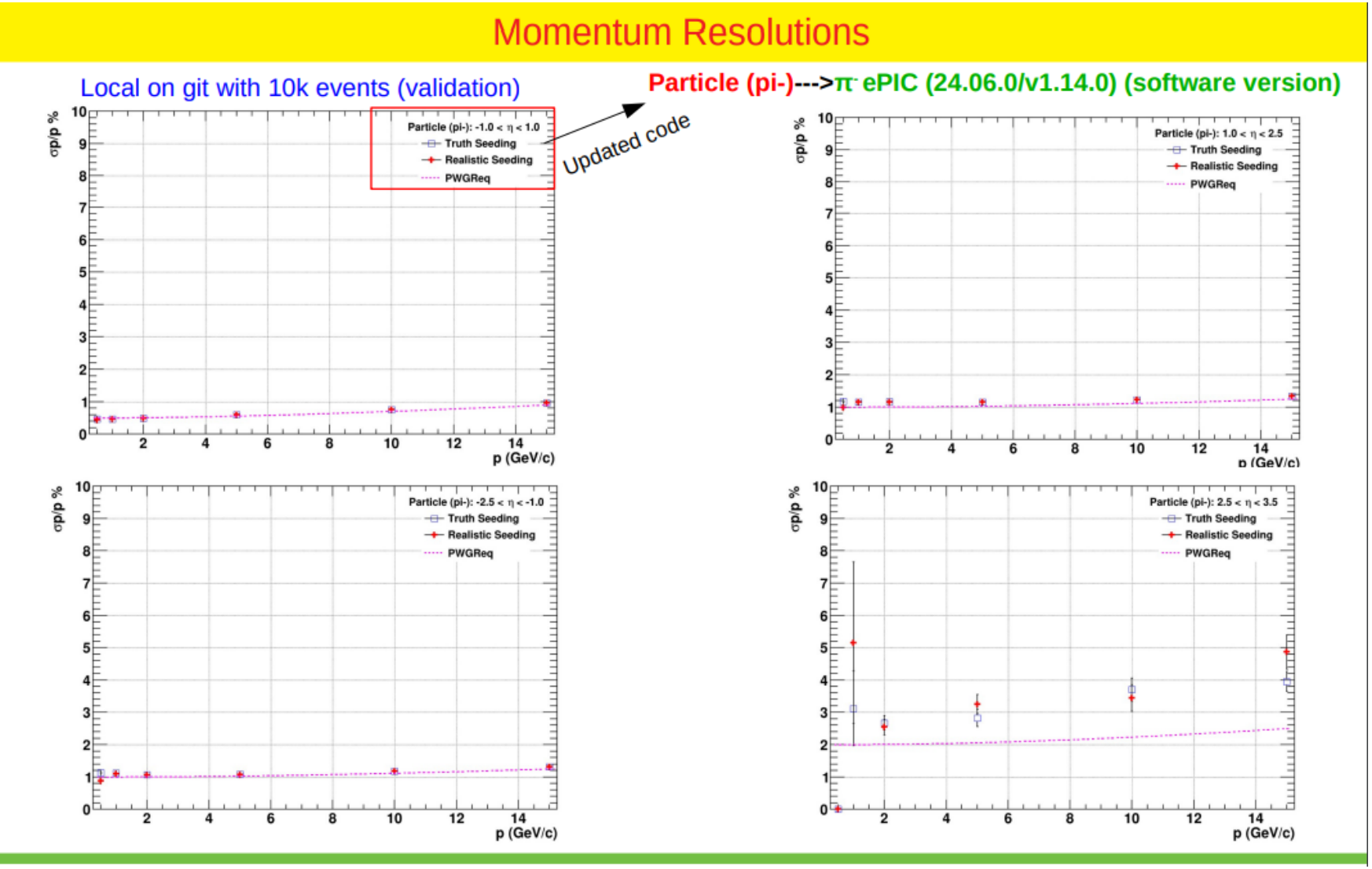
Summary of completed plots/benchmarks: Barak Schmookler

Single-particle benchmark: Shyam Kumar

Primary vertexing studies: Xin Dong

Discussion on EICRecon development

Single-particle track reconstruction benchmark



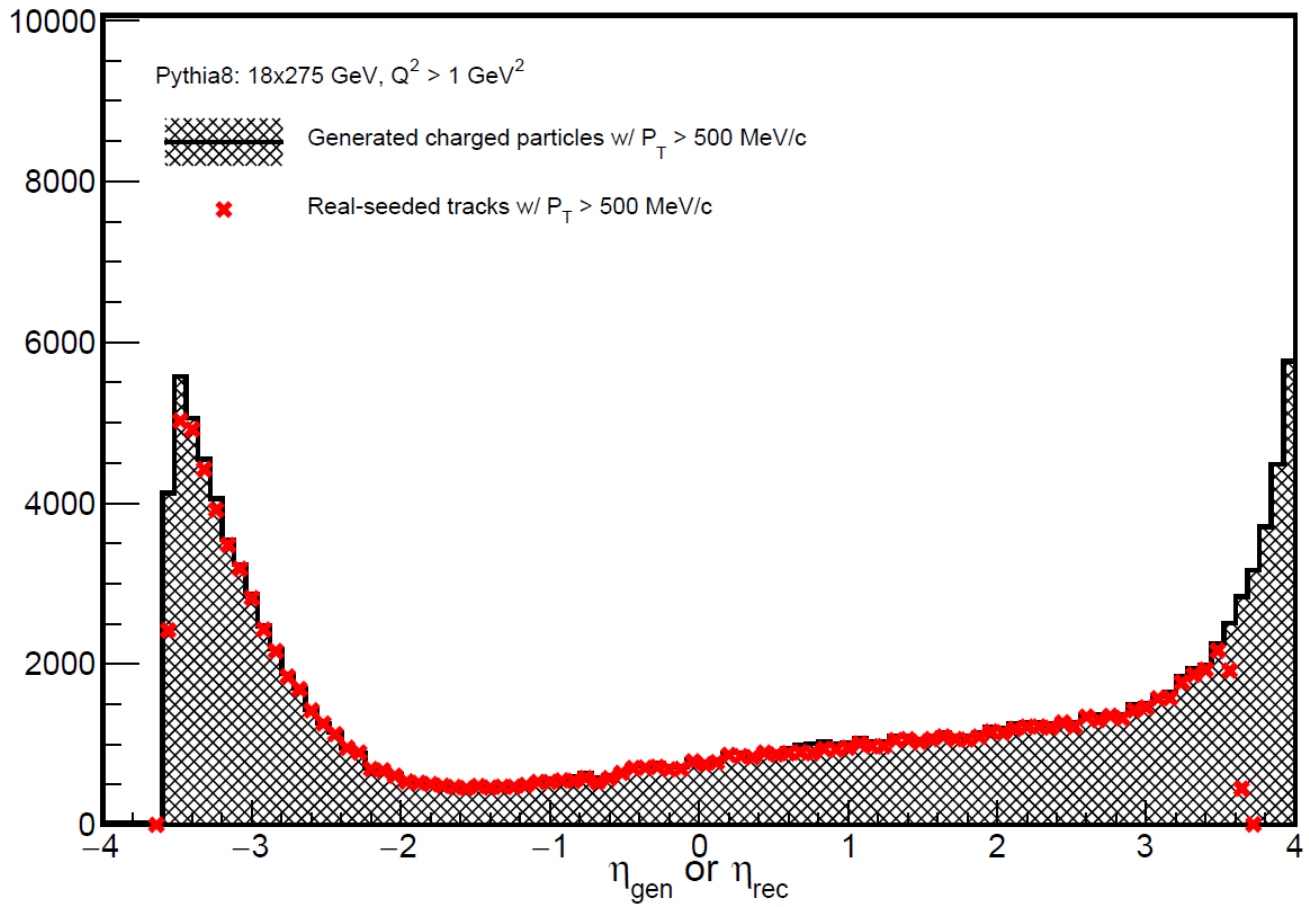
- Tracking benchmark runs on EICweb and produces tracking performance results.
- Benchmark produces single-particle momentum and pointing resolution plots.
- Now that all the machinery exists, the benchmark will be extended to include additional analysis codes for efficiency, angular resolutions, etc...
- Similar set of analysis codes will be run on monthly single-particle simulation campaigns.

Work by Shyam Kumar

DIS tracking benchmark

Benchmark under development

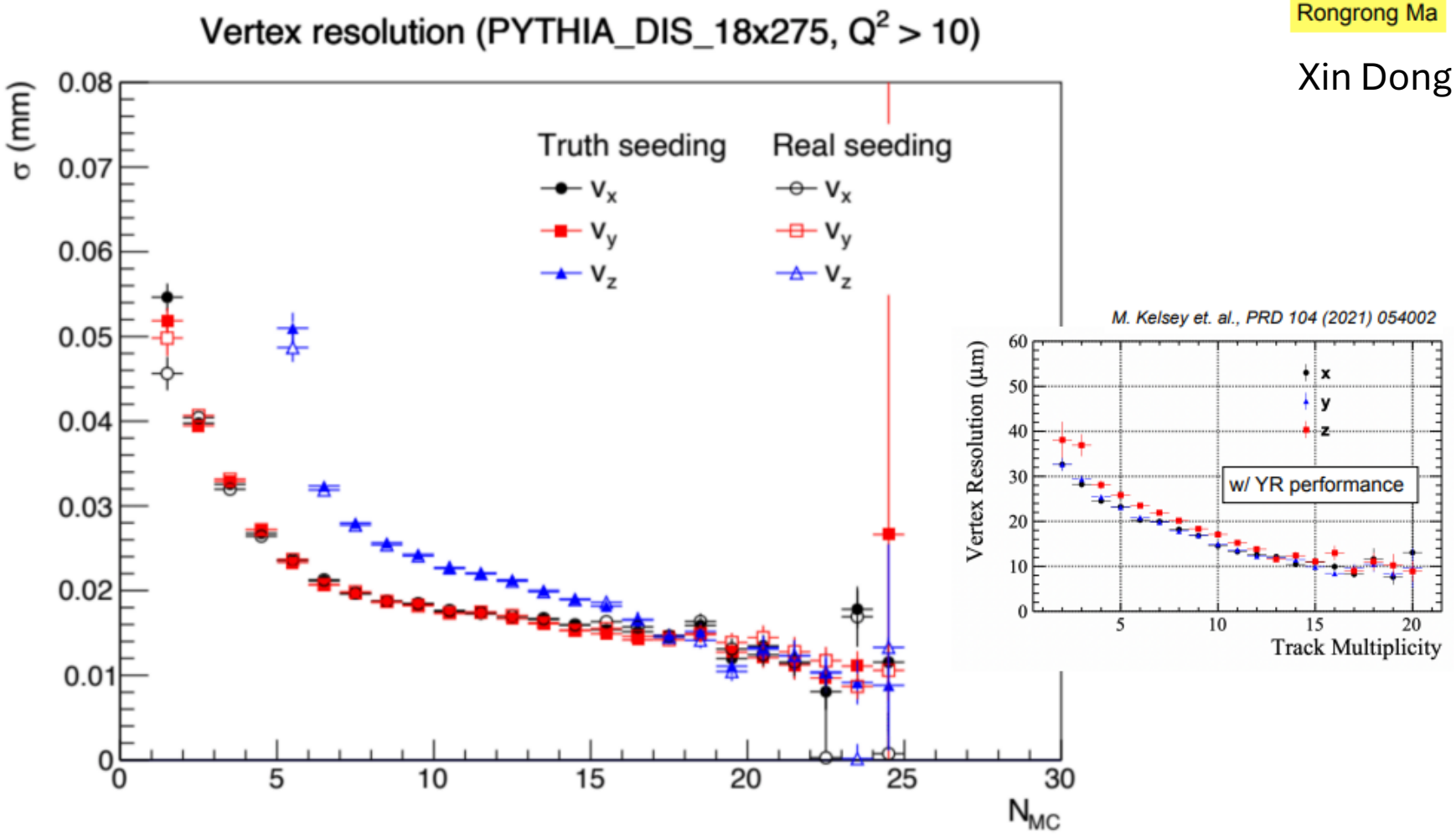
- Simulation of 50k *Pythia8* events with $Q^2 > 1$ GeV^2 at the 18x275 GeV beam energy setting.
- **Black curve**: true pseudo-rapidity distribution of all generated, final-state charged particles with true transverse momentum >500 MeV/c.
- **Red points**: reconstructed pseudo-rapidity distribution of all real-seeded tracks with reconstructed transverse momentum >500 MeV/c.



Primary vertex resolutions

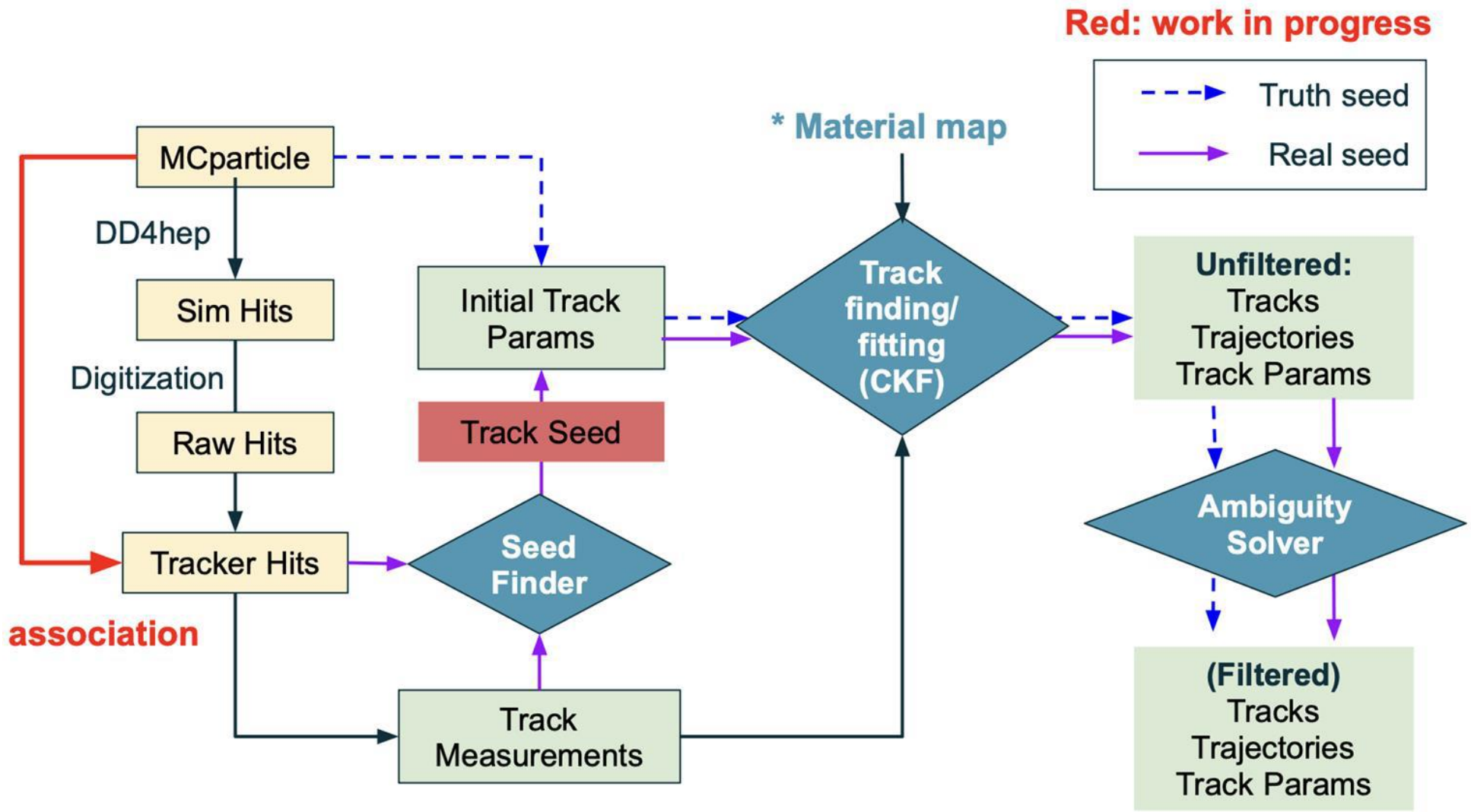
Rongrong Ma

Xin Dong



Vertex resolution reaches to < 20 μm with N_{MC} > 10

Track reconstruction / vertexing – status

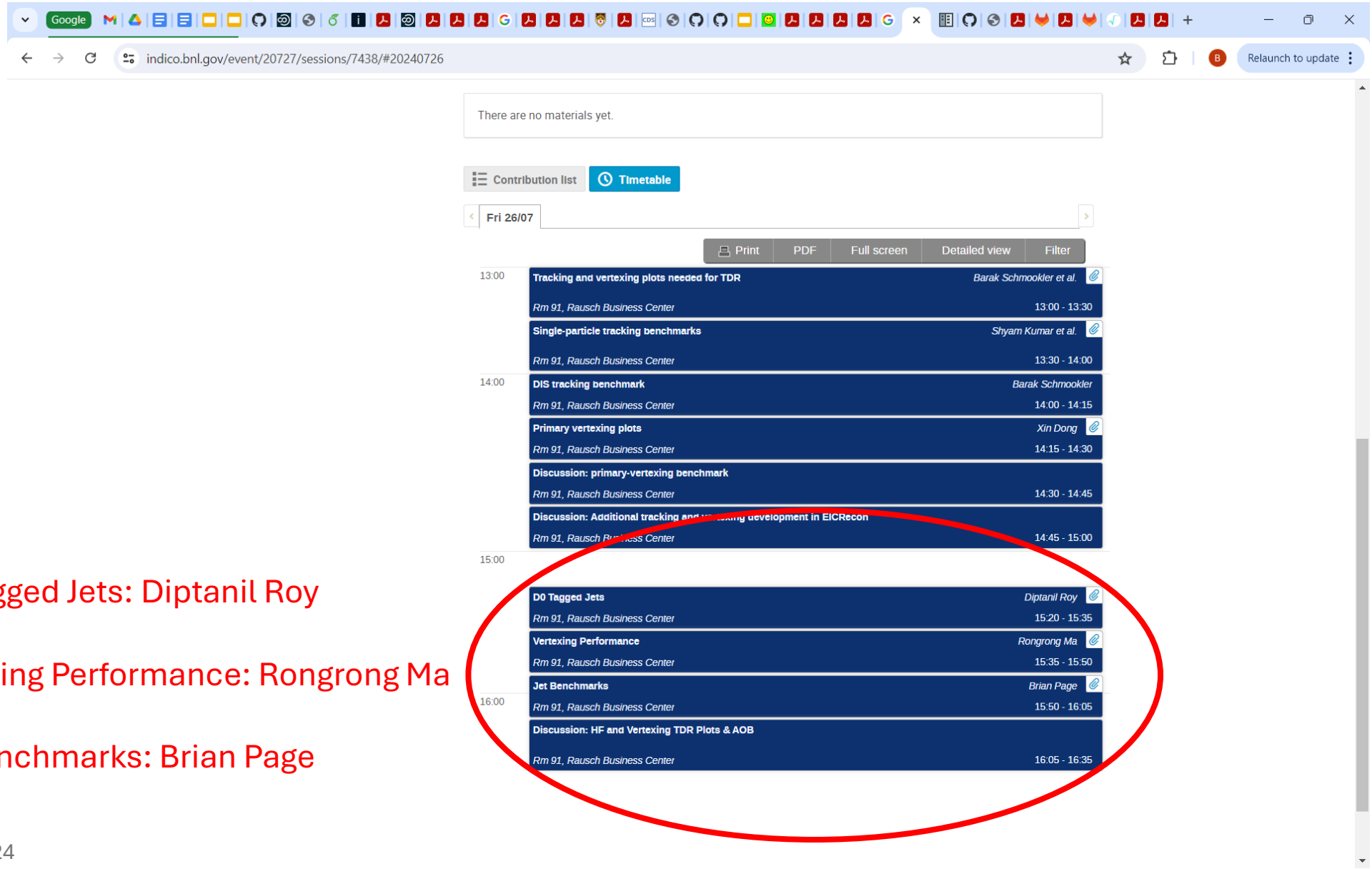


EICRecon – work in progress

- Fixes to the seed finder to address observed inefficiencies for |z|>50mm.
- Implementation of hit-based track to MC particle matching.
- Inclusion of option for noise hits and dead pixels in the SVT detector (also sensor unit with inactive area).
- Updates to vertex finder / fitter.
- Calculation of track distances w.r.t measured primary vertex.

Workfest Summary: HF

Session Overview



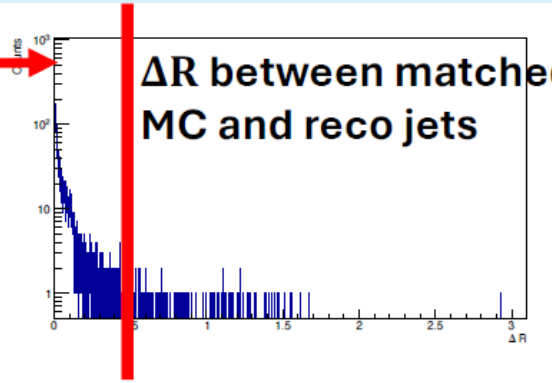
D0 Tagged Jets: Diptanil Roy

Vertexing Performance: Rongrong Ma

Jet Benchmarks: Brian Page

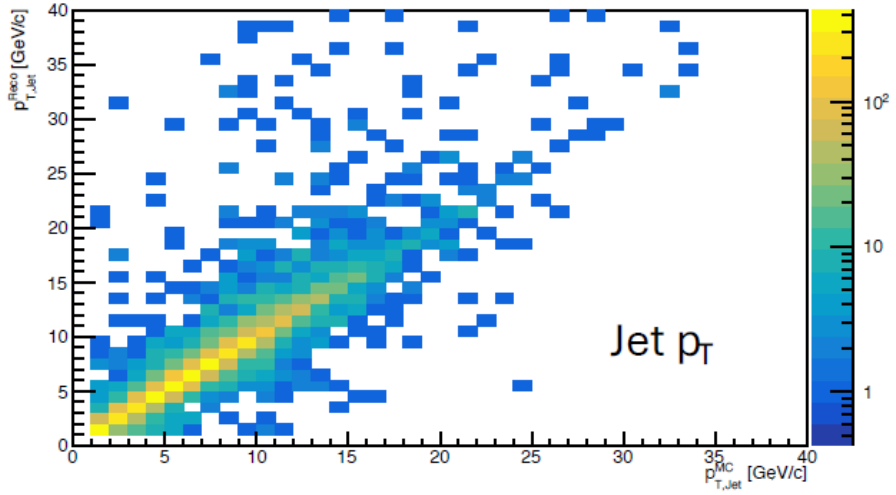
Resolution From Matched Jets in MC and Reco for matched D^0

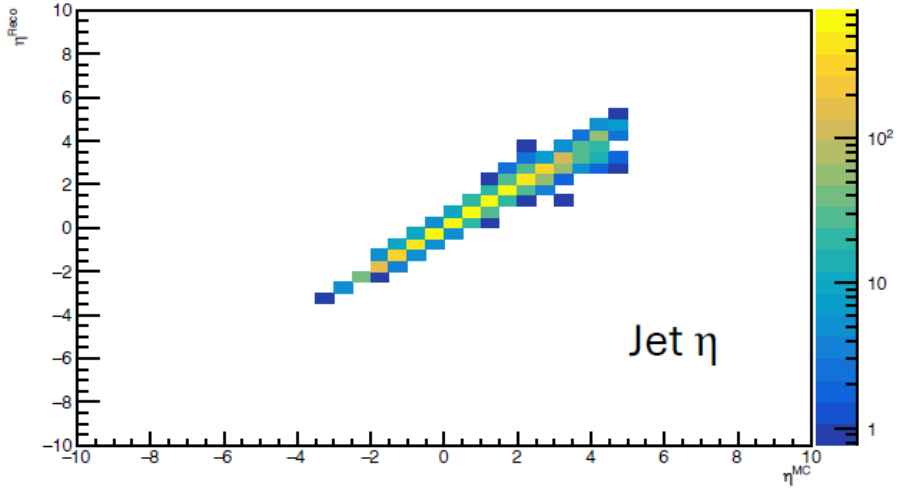
No separate matching condition on jets in MC-Reco due to D^0 being used as a tag

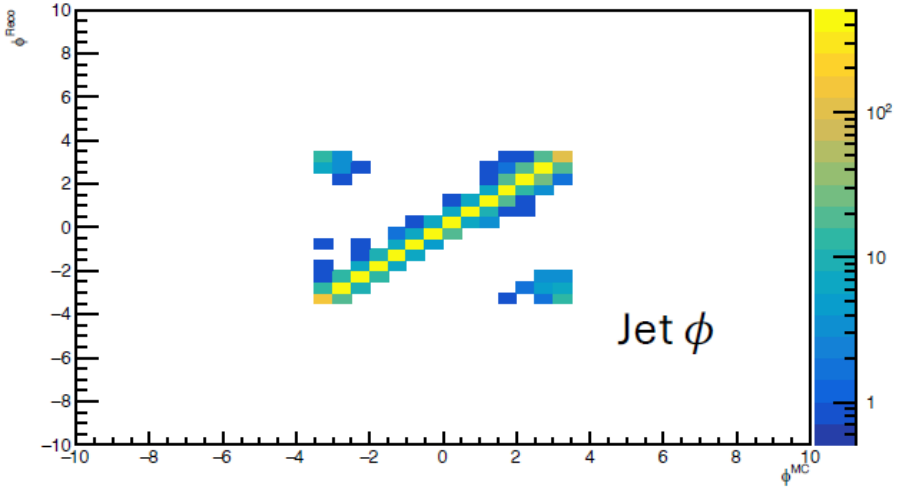


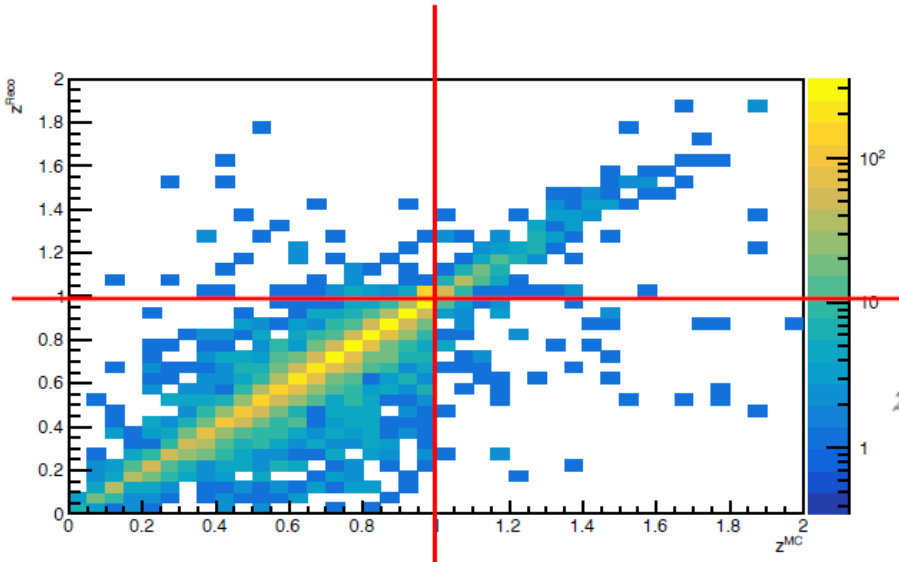
$\Delta R < 0.5$ between most truth and reco jets

Reconstructed Level









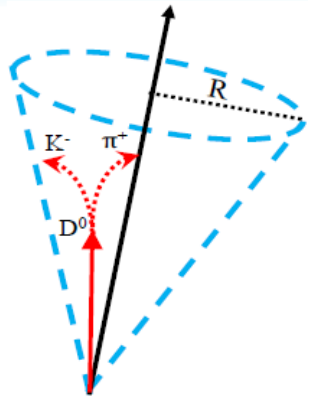
Truth Level

See D0s with more pT than their surrounding jet – need to investigate

$$z = \frac{\vec{p}_{T,D^0} \cdot \vec{p}_{T,Jet}}{|\vec{p}_{T,Jet}|^2}$$

${}_s\mathcal{P}lot$

- Native class in RooStats, and widely used in HEP
- Unbinned maximum likelihood fit to invariant mass integrated over all kinematics
- $p_{T,jet}$ and related distributions with all D^0-tagged jet candidates using sWeights
- Easy to include reconstruction efficiencies versus D^0 kinematics



$$ {}_s\mathcal{P}_n(m_{K\pi,i}) = \frac{\sum_{j=1}^{N_T} V_{nj} f_j(m_{K\pi,i})}{\sum_{k=1}^{N_T} N_k f_k(m_{K\pi,i})} $$

Unbinned max. likelihood fit

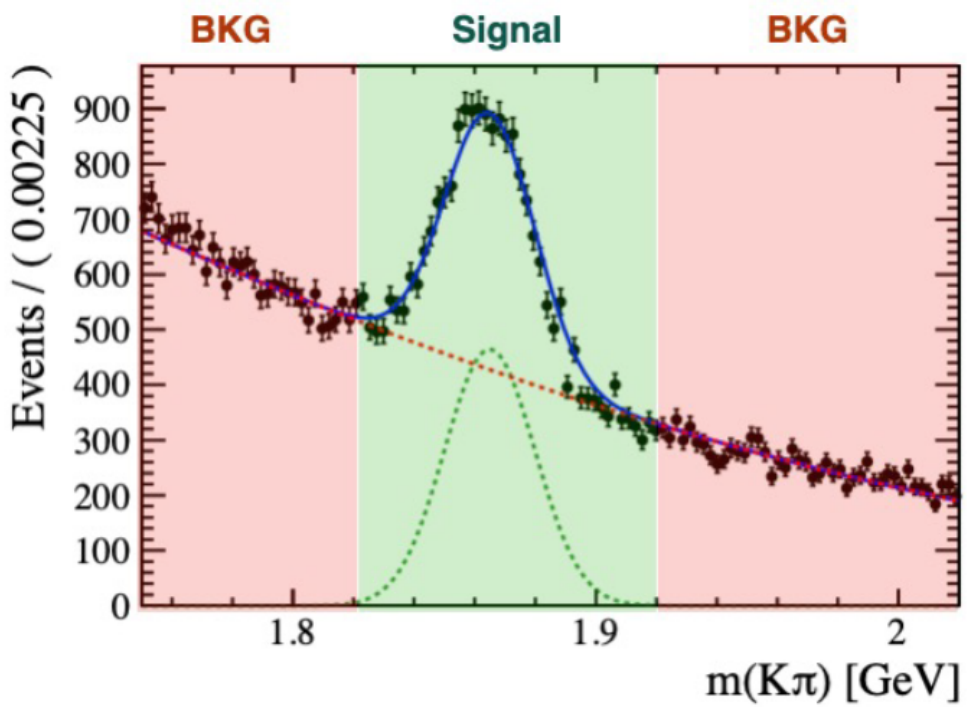
n = n-th fit component(sig/bkg)

N_k = k-th yield (T=2)

$f_k(m_{K\pi,i})$ = per-event PDF value with k^{th} hypothesis

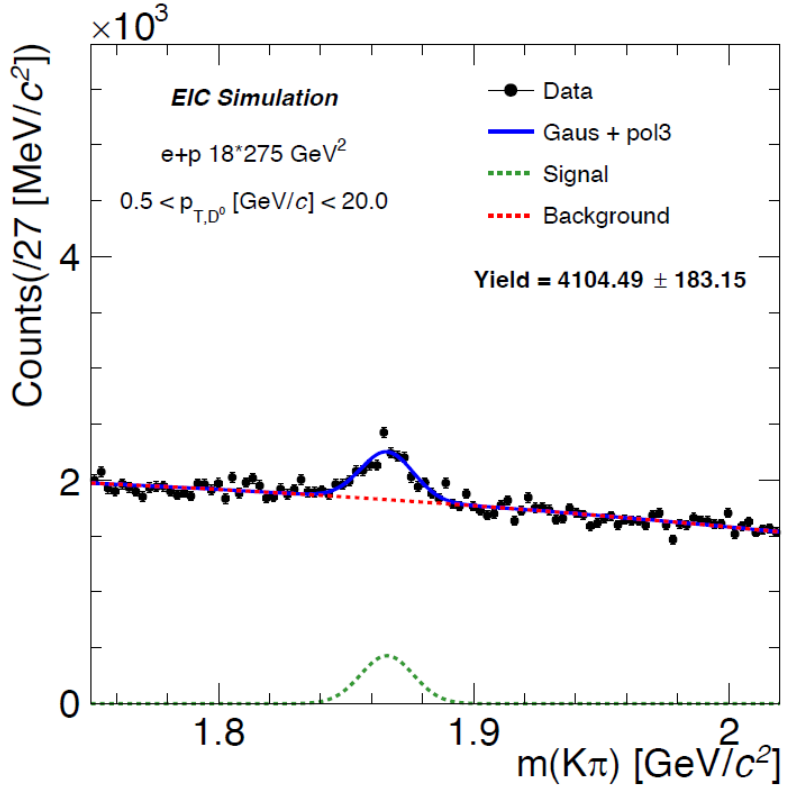
V = cov. matrix

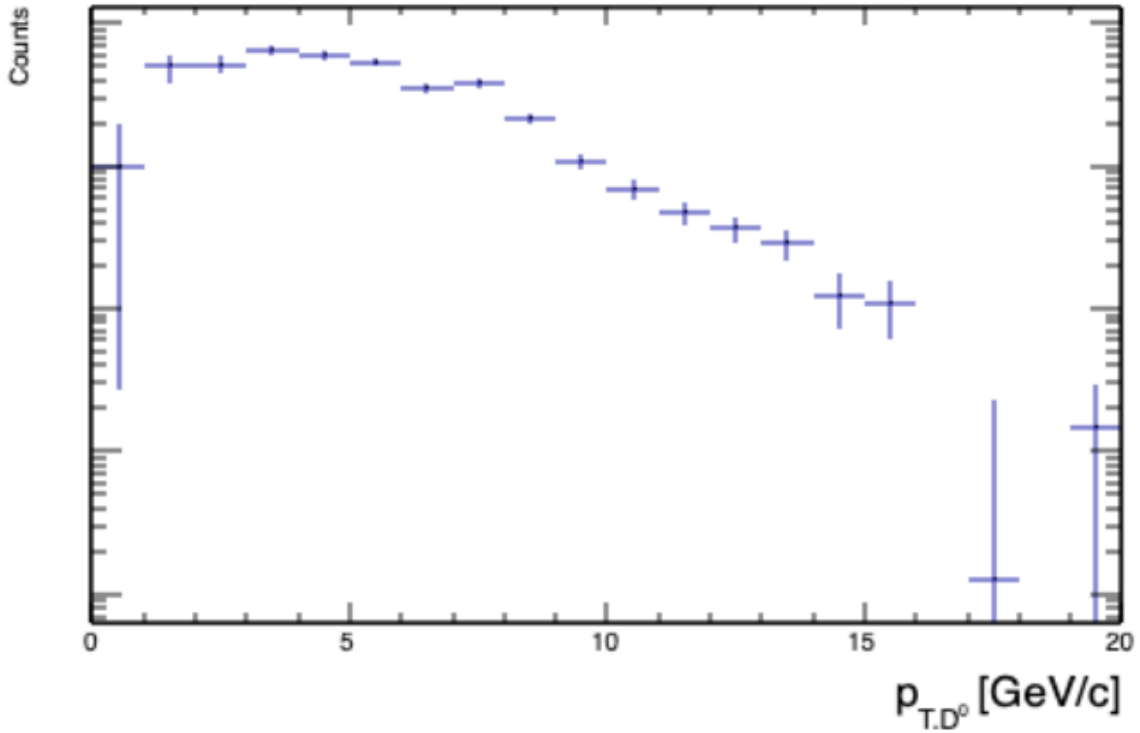
Efficiency Correction → $$ {}_s\mathcal{P}_n(m_{K\pi,i}) \rightarrow \frac{{}_s\mathcal{P}_n(m_{K\pi,i})}{\varepsilon(m_{K\pi,i})} $$



sPlot : https://doi.org/10.1016/j.nima.2005.08.106

sWeight Extraction of D0





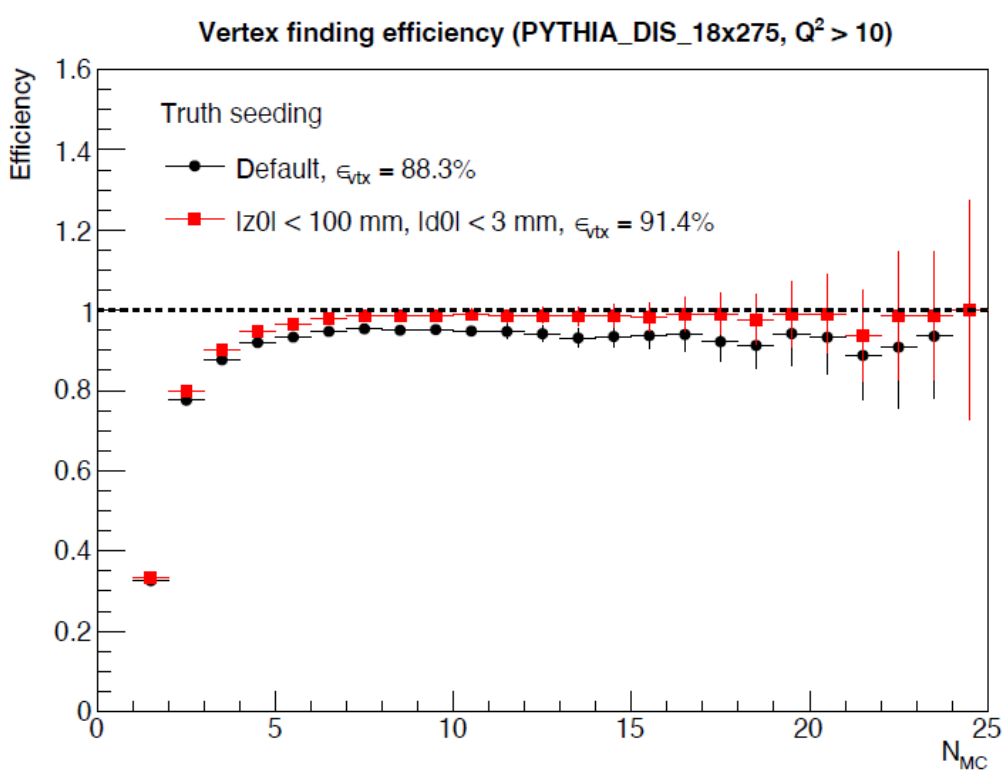
- sWeight method demonstrated to recover D0 peak from enhanced MC sample -> Integrate into a benchmark?
- Apply weights to other distributions to construct, for example, D0 pT spectrum

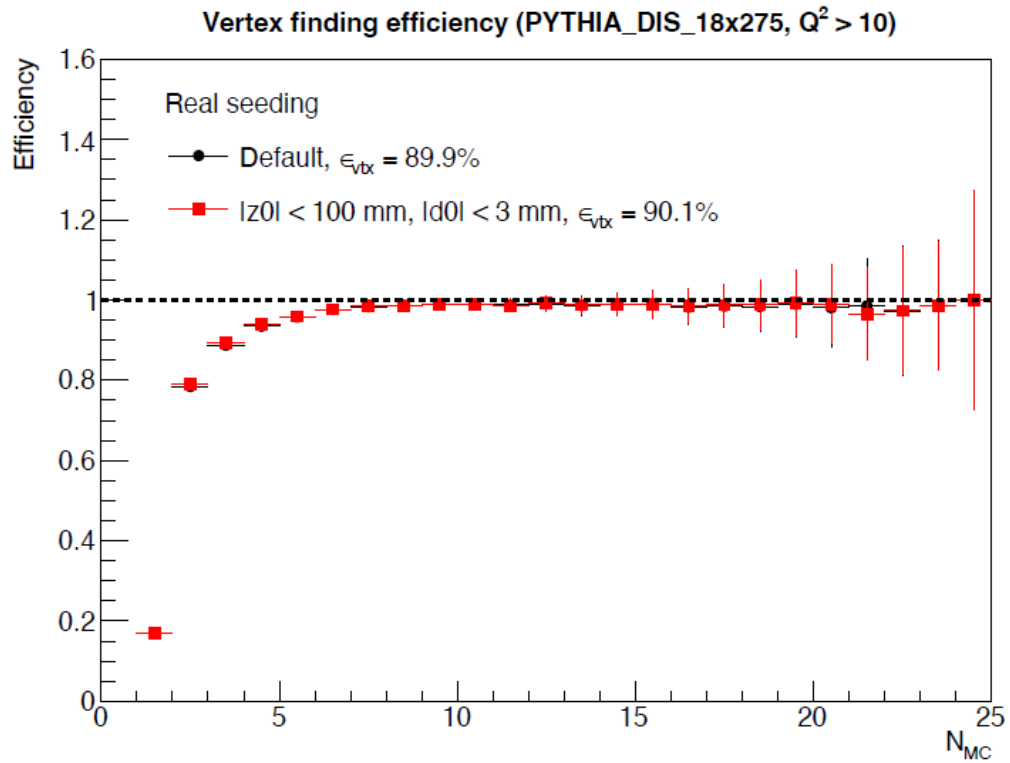
Vertex finding efficiency vs. N_{MC}

Truth seeding

$\Delta r < 1$ mm

Real seeding





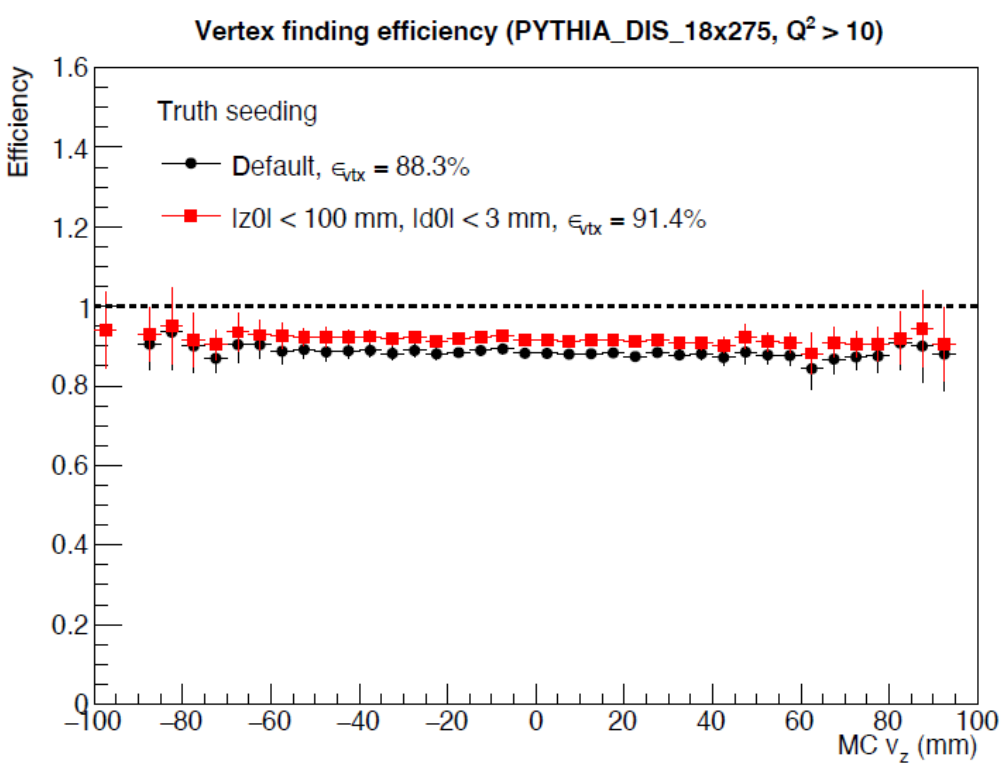
- Truth seeding: ~3% better efficiency than default with tuned track selection cuts
- Real seeding: little difference between default and tuned track cuts

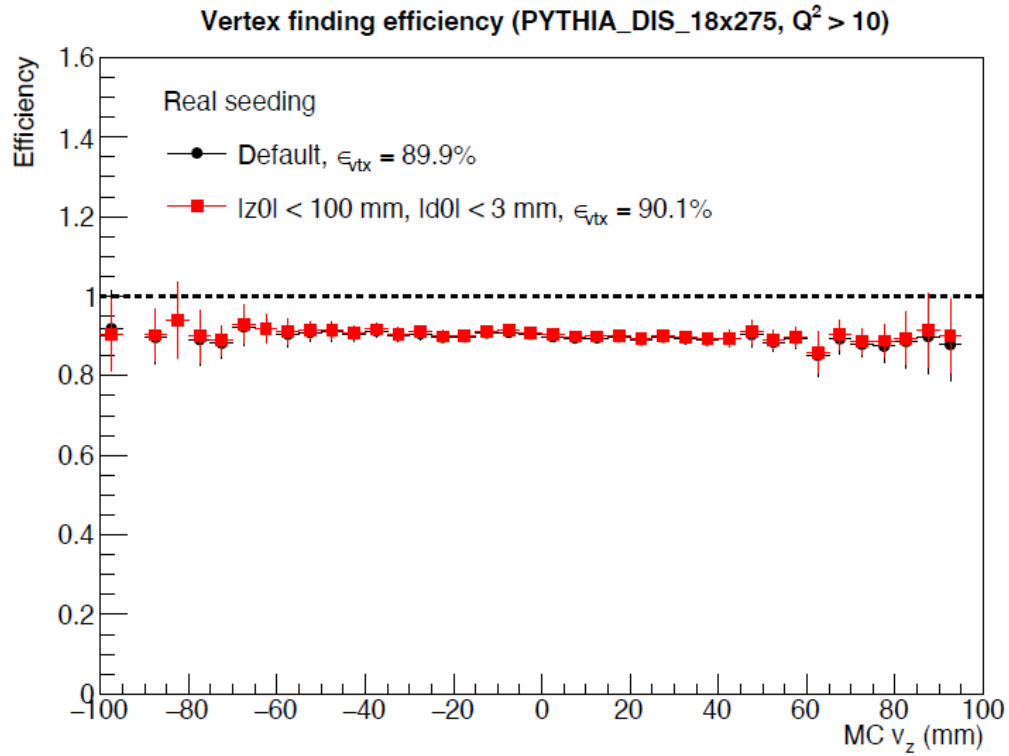
Vertex finding efficiency vs. v_z

Truth seeding

$\Delta r < 1$ mm

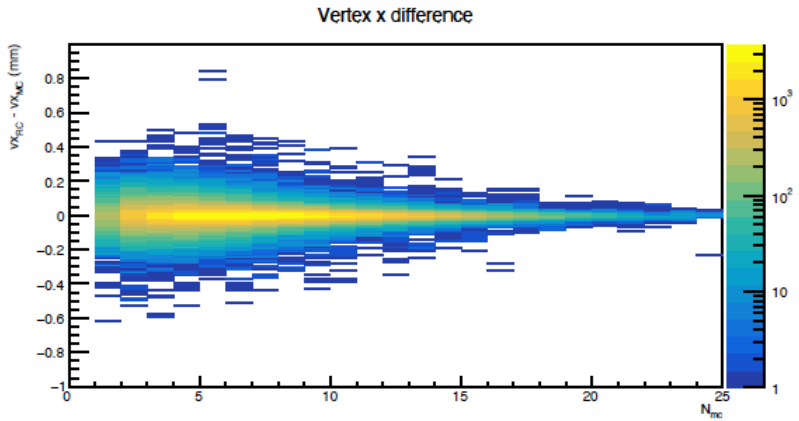
Real seeding

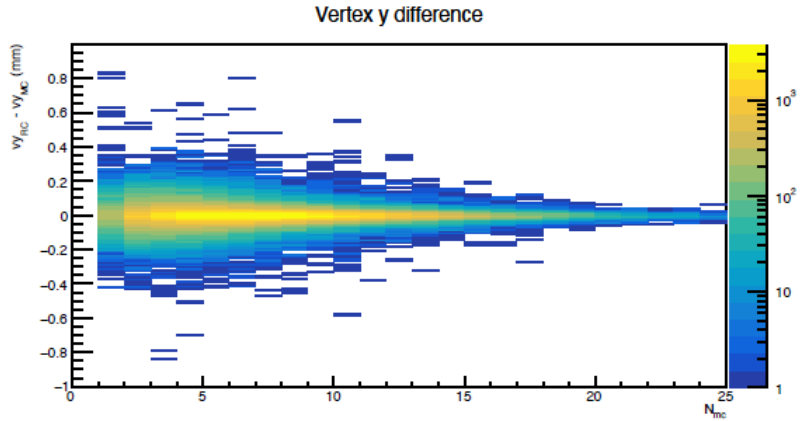


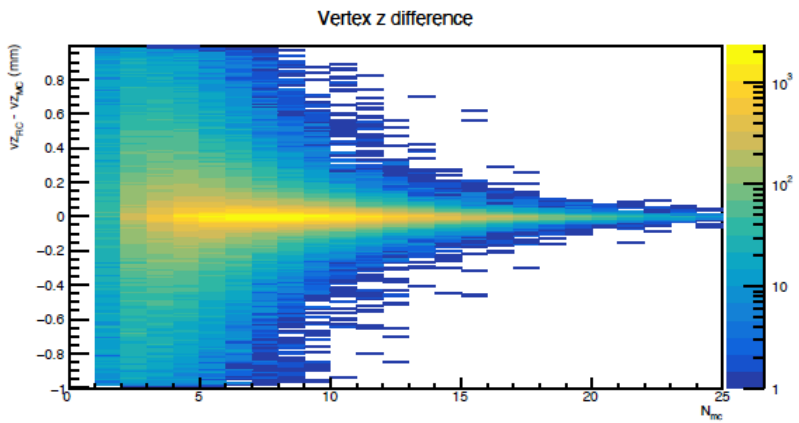


- No strong v_z dependence
- ~1% lower efficiency with real seeding compared to truth seeding for tuned track cuts

Vertex difference vs. N_{MC}



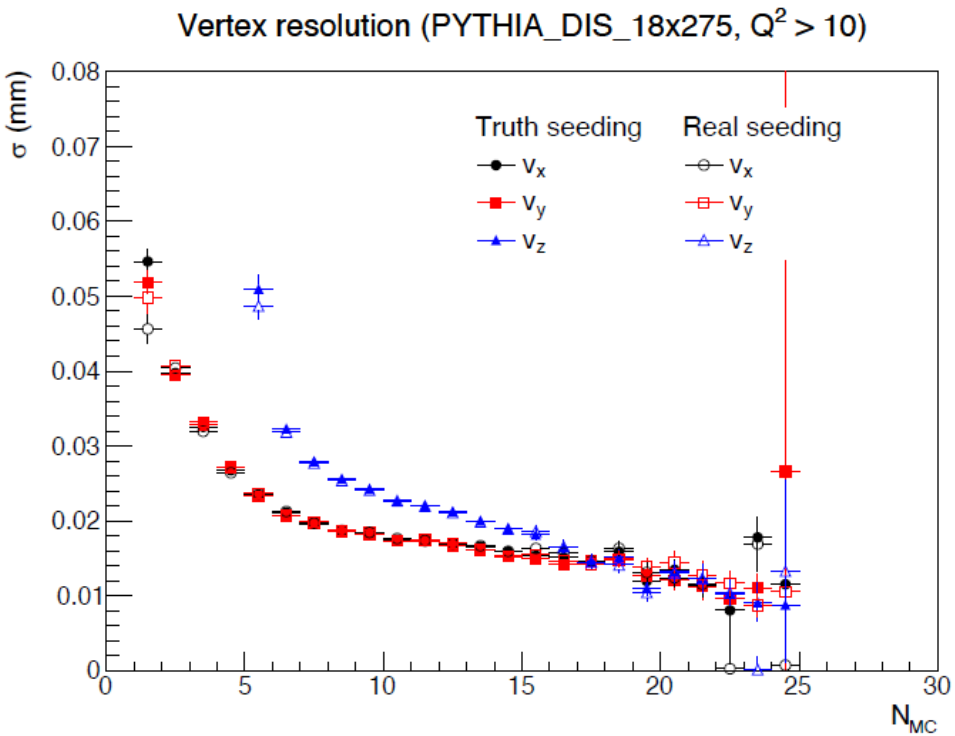




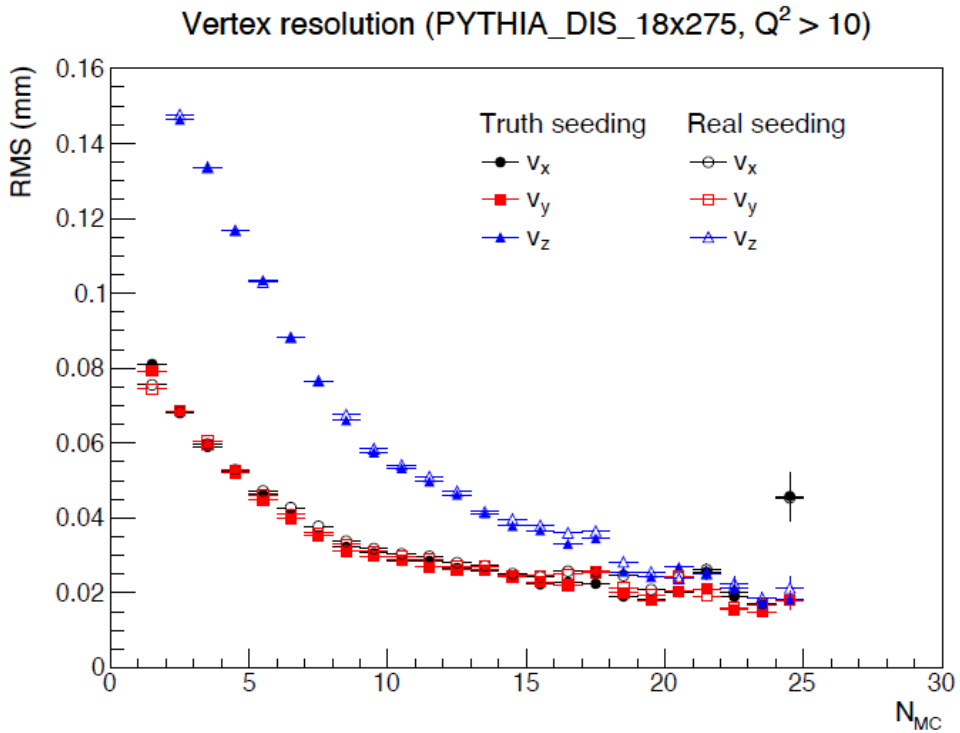
Truth seeding: default

Truth vs. real seeding

σ vs. N_{MC}



RMS vs. N_{MC}

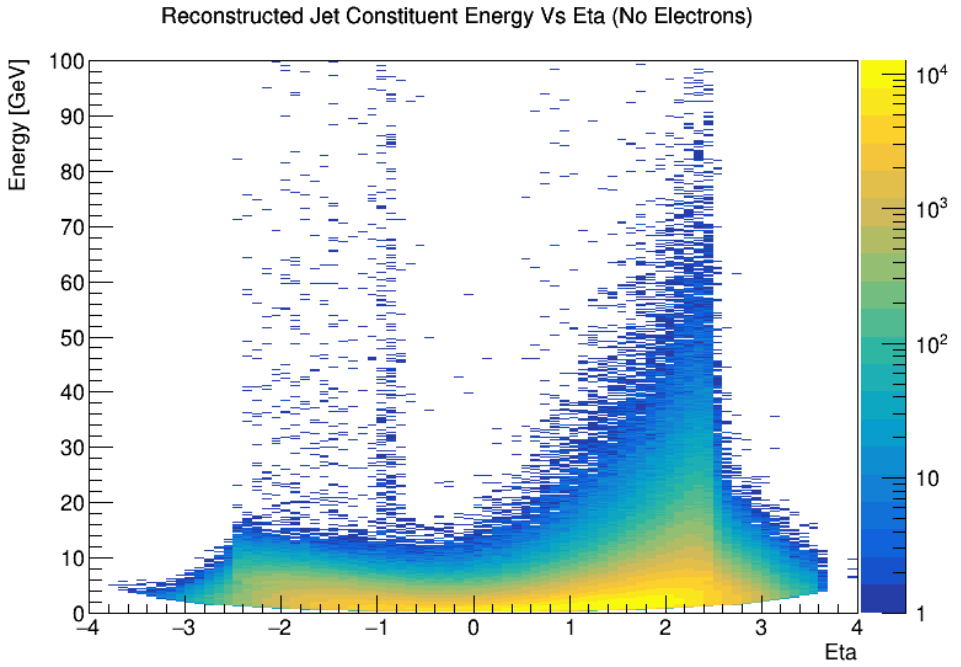


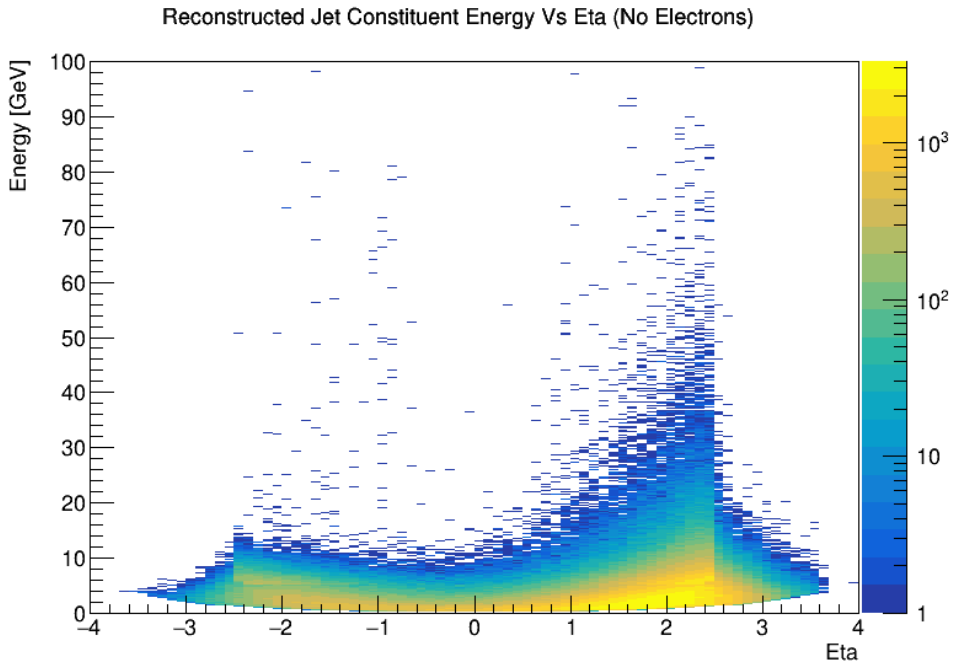
Automated Jet Benchmarks

- A set of jet benchmark plots is now being generated with each monthly production and can be accessed via a web interface: https://eic.jlab.org/epic/image_browser.html# (navigate to Physics -> Jets and Heavy Flavor)
- Results obtained from the ReconstructedChargedJets (truth seeded tracks) and GeneratedChargedJets branches
- Plots from productions 24.02 – 24.06 currently available
- Can select on energy (shown is 10x100) and minQ2 (shown is Q2 > 1)
- As an example use case, compare jet and jet constituent quantities from productions 24.05 and 24.06 (before and after ambiguity solver introduced)

Q2 Dependence

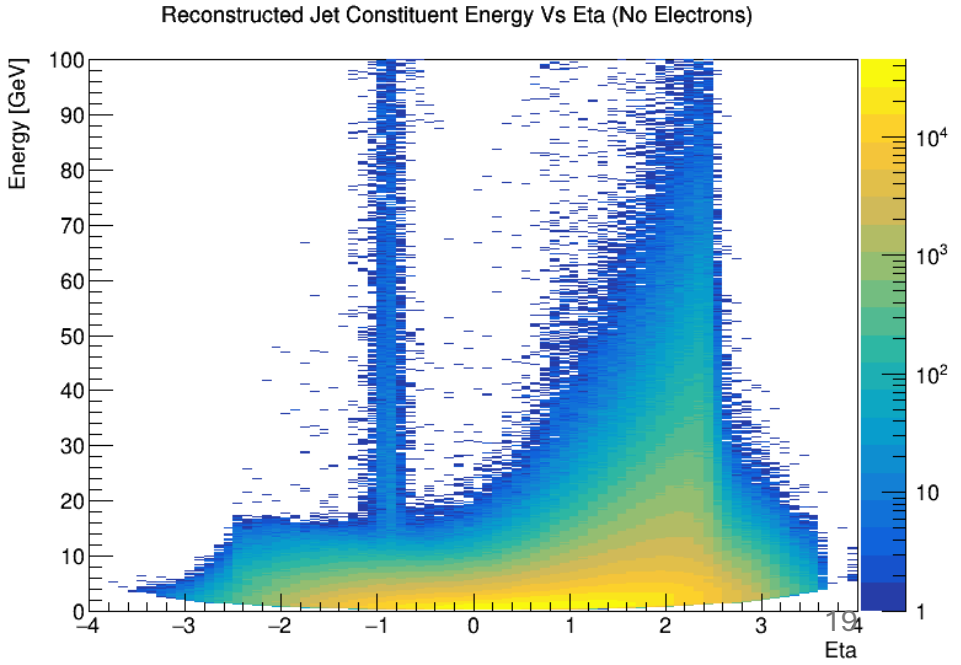
minQ2 = 10





minQ2 = 1

minQ2 = 100



HF Summary

- ❑ Presentations on D0 reconstruction, primary vertexing performance, and benchmarks
- ❑ A lot of good discussion across various points
  - ❑ Switch from Truth to Real seeding for TDR
    - ❑ Timing of switch
    - ❑ Coordination with downstream reconstruction
    - ❑ Still need to understand quirks in the Truth tracking behavior
  - ❑ What additional benchmarks are needed – both for “per pull request” and “per campaign”
  - ❑ How do we integrate vertex position for T0 determination
  - ❑ How do we move to having true DCAs with respect to the reconstructed vertex
- ❑ Useful dialogue between physics, tracking, and software groups – what the workfests are for!