Analysis Update: DVCS ep

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ePIC Collaboration Meeting, Villa Mondragone

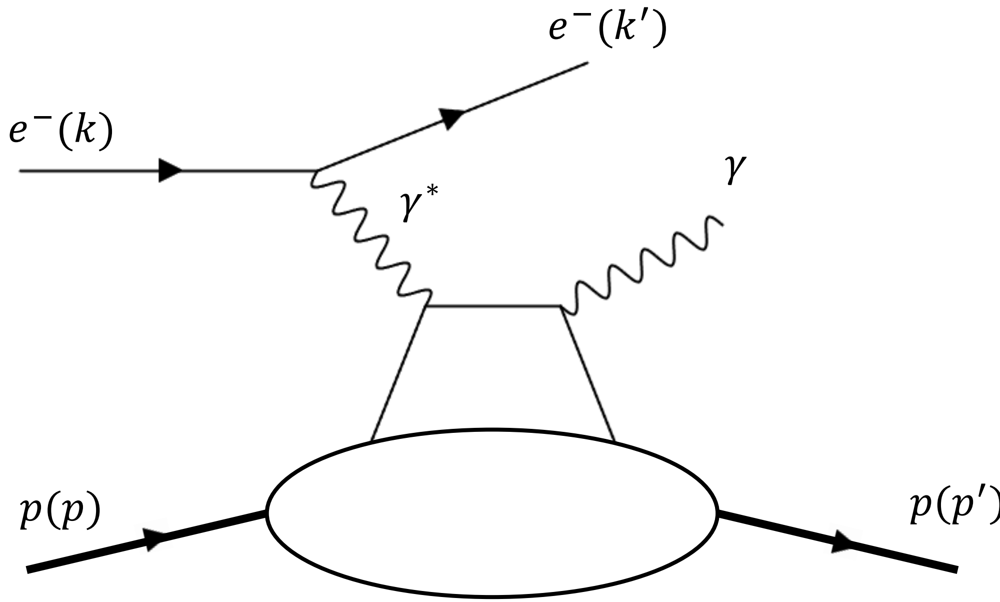
23/01/25

Introduction

DVCS in ep collisions

- **D**eeply **V**irtual **C**ompton **S**cattering

- Looking at $e(k)p(p) \rightarrow e'(k')p'(p')\gamma$ process to probe Generalized Parton Distributions (GPDs).
  - GPDs describe the internal structure of hadrons, as a function of longitudinal position and transverse momentum.
- (Some) Important variables:
  - Photon 4-momentum transfer, $Q^2 = -q^2 = -(k - k')^2$
  - $t = (p' - p)^2$
  - Parton longitudinal momentum fraction, x
  - Bjorken-x, $x_B = \frac{Q^2}{2q.p}$



Why DVCS for ePIC?

- Physics:
  - Clean process to study (only 3 final state particles; all well-identified; no worry about short lifetimes).
  - Simple channel for analysis – so should be an early port of call.

- Detector utility:
  - Good channel to test many subsystems.
  - Scattered electron and photon detected in the central barrel.
    - Can test PID and energy/momentum resolutions in the barrel and endcaps.
  - Scattered proton picked up in the far forward region.
    - B0 for 5x41 and 10x100.
    - Roman Pots for 10x100 and 18x275.

Analysis procedure

- Using EpIC generator files, passed through the ePIC detector geometry in monthly simulation campaigns.
  - No backgrounds yet included – only true DVCS events.
  - Focus is currently on 24.10.1 campaign (as defined for the TDR).

- Run through MC and reconstructed particle branches to identify candidates.
  - MC generated: MCParticles
  - Reco. (barrel): ReconstructedParticles
  - Reco. (B0): ReconstructedTruthSeededChargedParticles
  - Reco. (RP): ForwardRomanPotRecParticles

Analysis procedure (cont.)

- PID method varies.
  - MC gen. – given in branch MCParticles.PDG
  - Explicit candidate matching for e’, γ and B0 p’ (separate ParticleAssociations branch needed for p’).
  - No PID or MC associations for RP – assume all RP tracks are protons.

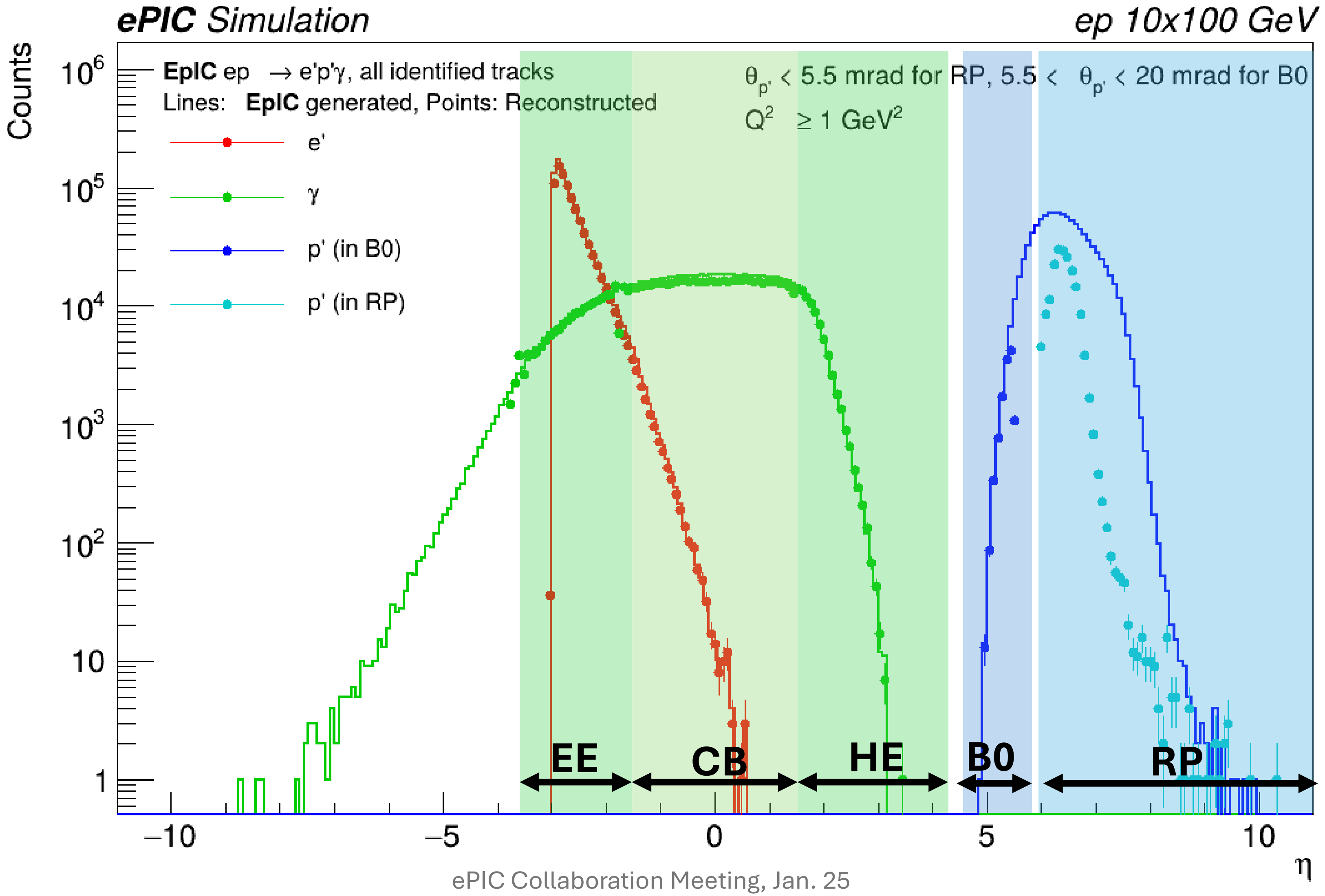
- Beams are taken as an average over all “beam particles” (MCParticles.Status==4) in the first file for the campaign.
- Afterburner needs to be undone for all particle tracks (except those from RP) – see A. Jentsch’s talk (slides 15 and 16) from PWGEDT meeting on 20th May ’24 for procedure.

Analysis procedure (cont.)

- Accepted particle candidates:
  - For e’: $Q^2 > 1$ GeV^2; only 1 ID’ed e’ in event.
  - For γ: only 1 ID’ed γ in event.
  - For p’: only 1 ID’ed p’ in event; p’ track angle within acceptance for the detector flagged[1].
- DVCS full event cuts:
  - All single species cuts.
  - $MM^2 < 1$ GeV^2.

[1] Current analysis code still assumes $0<\theta<5$ mrad for RP tracks – needs to be updated to reflect change to RP geometry.

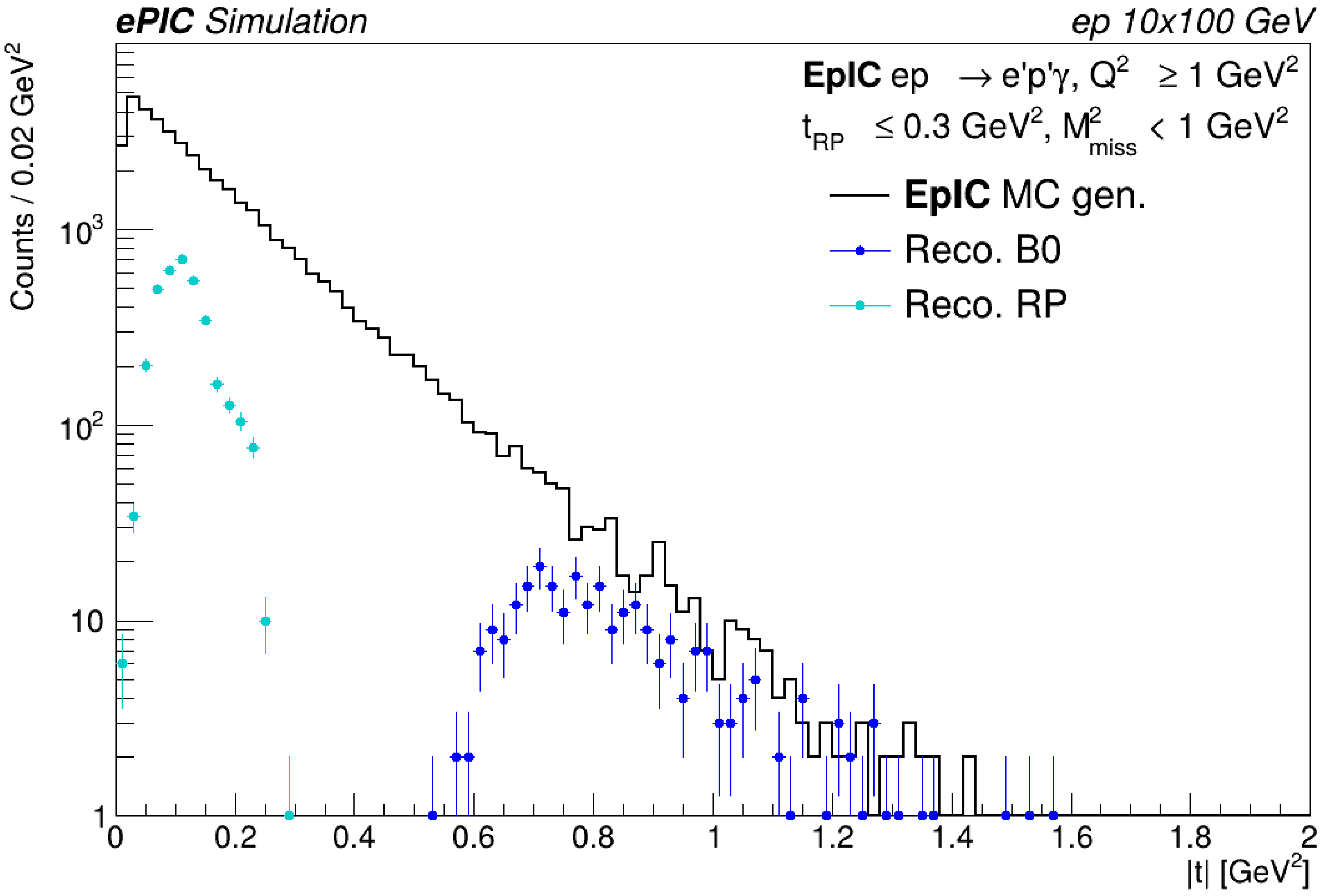
Generator coverage (10x100)



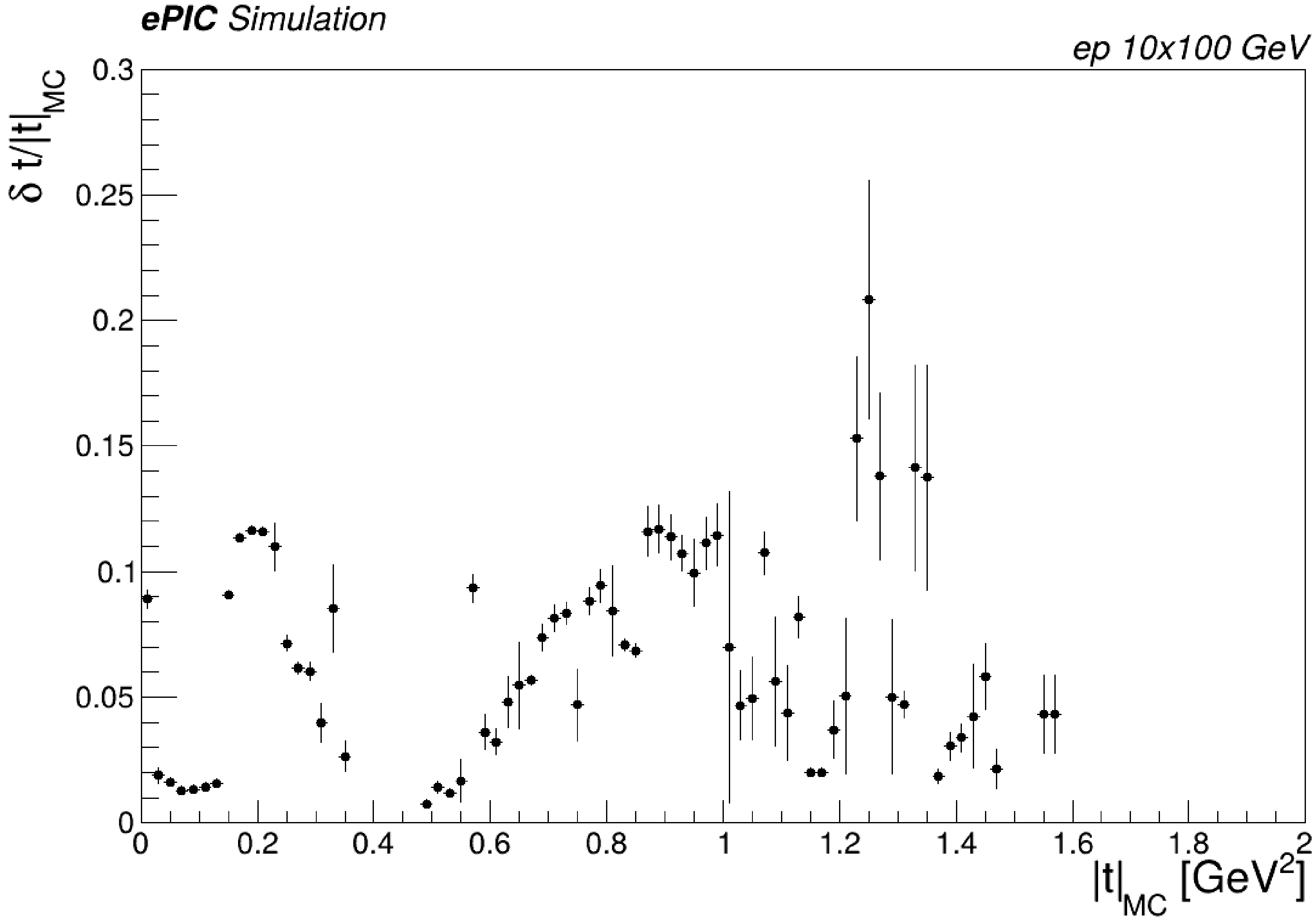
Analysis results (ep 10x100)

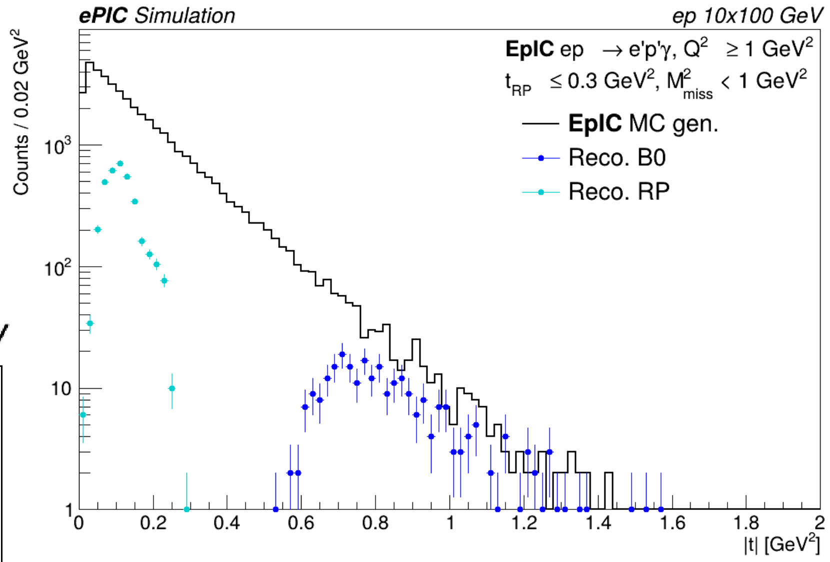
Full set of plots is still a work in progress

t distribution (full exclusivity)



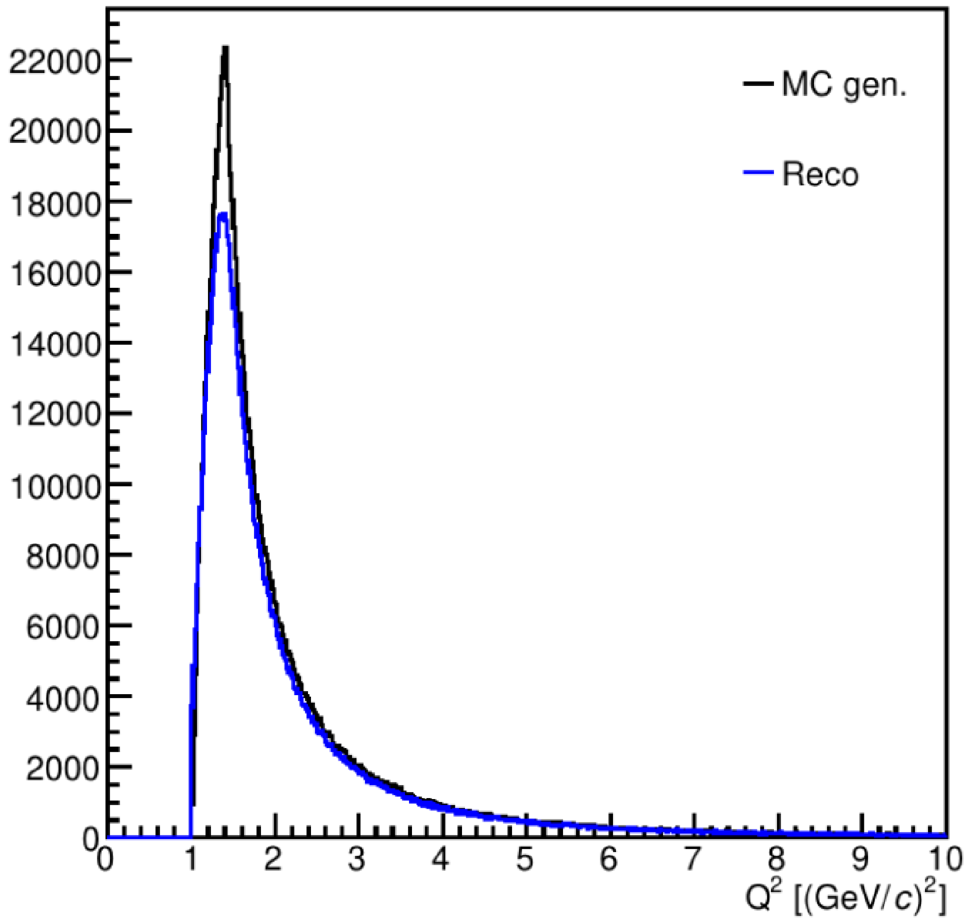
Resolution on t

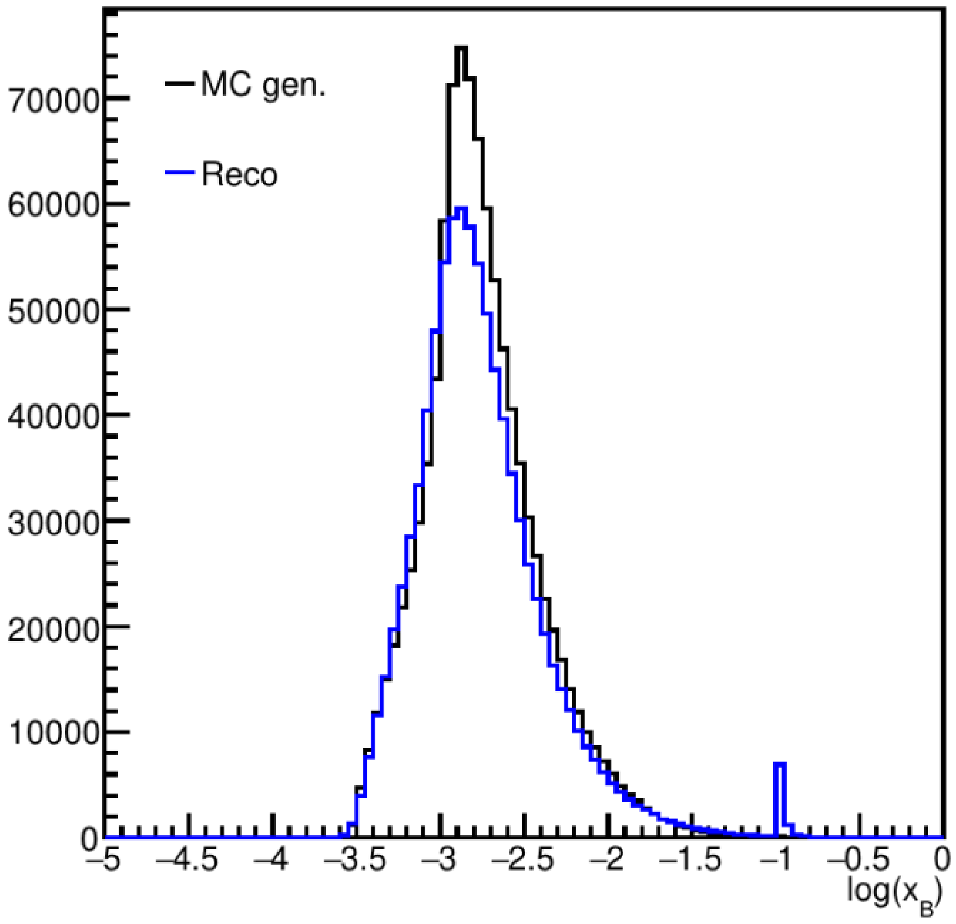




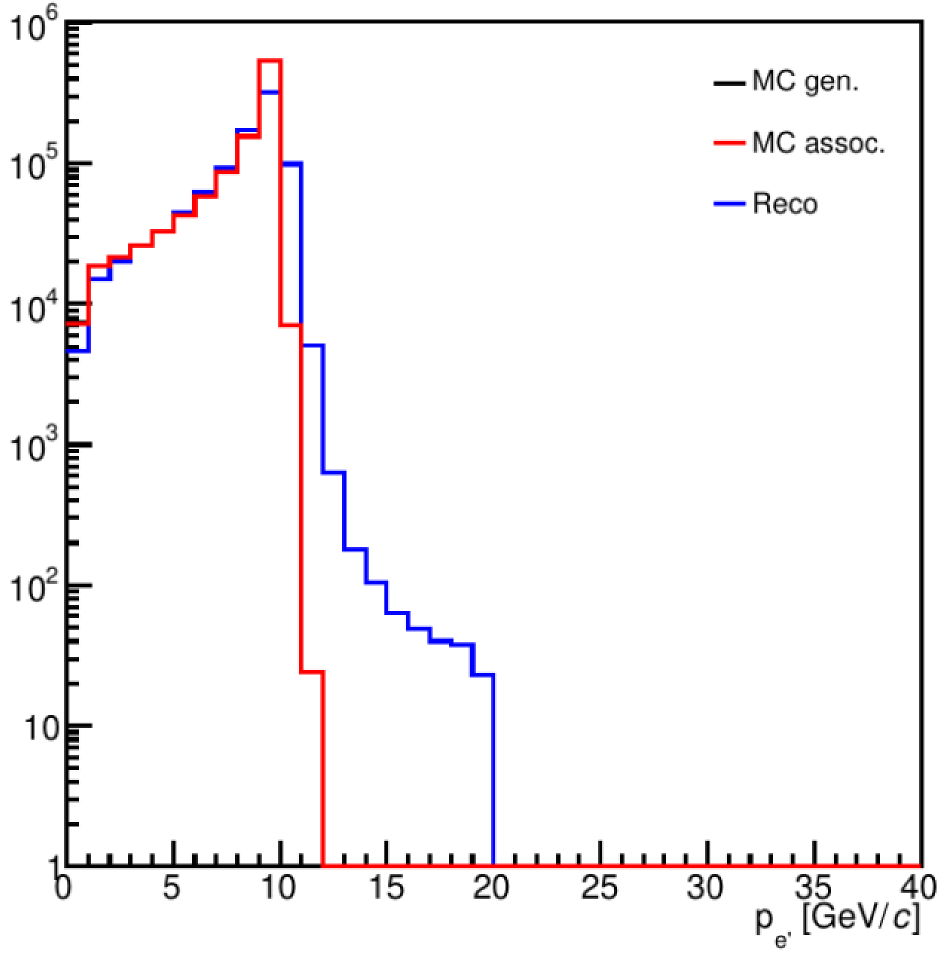
$$\delta t = t(\text{Reco.}) - t(\text{Gen.})$$

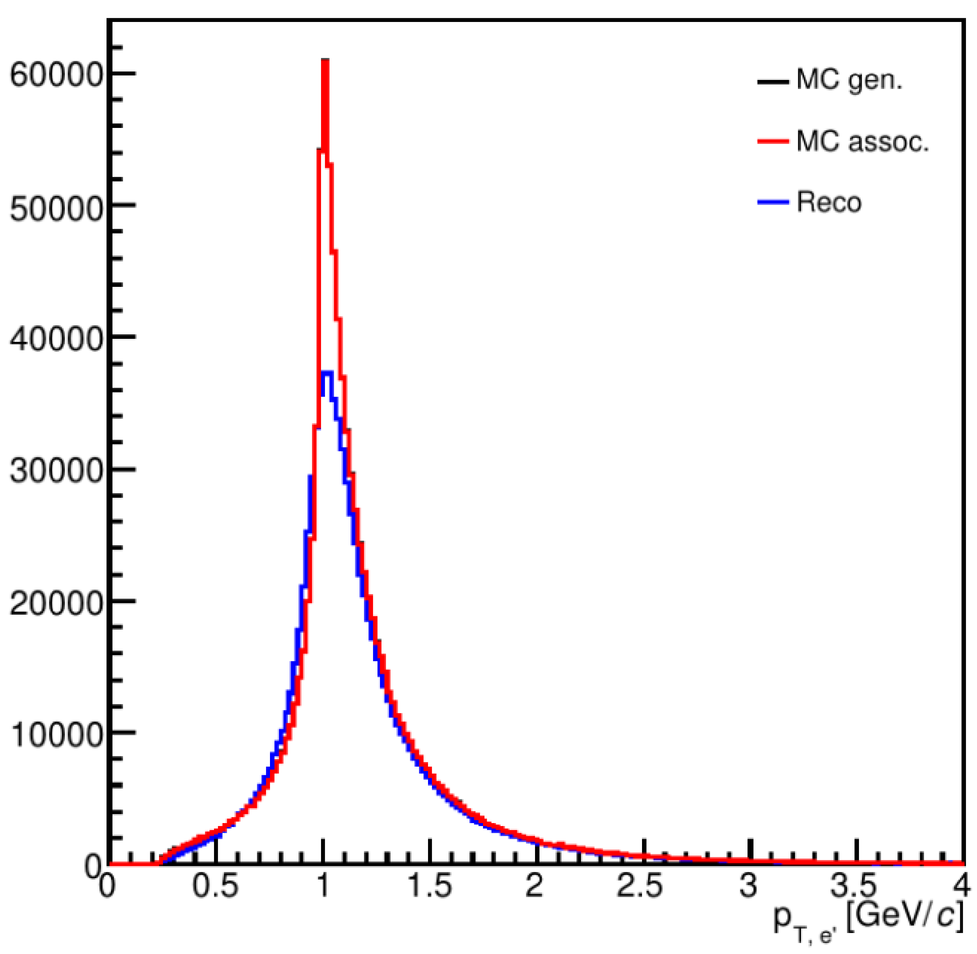
Q^2 and Bjorken-x



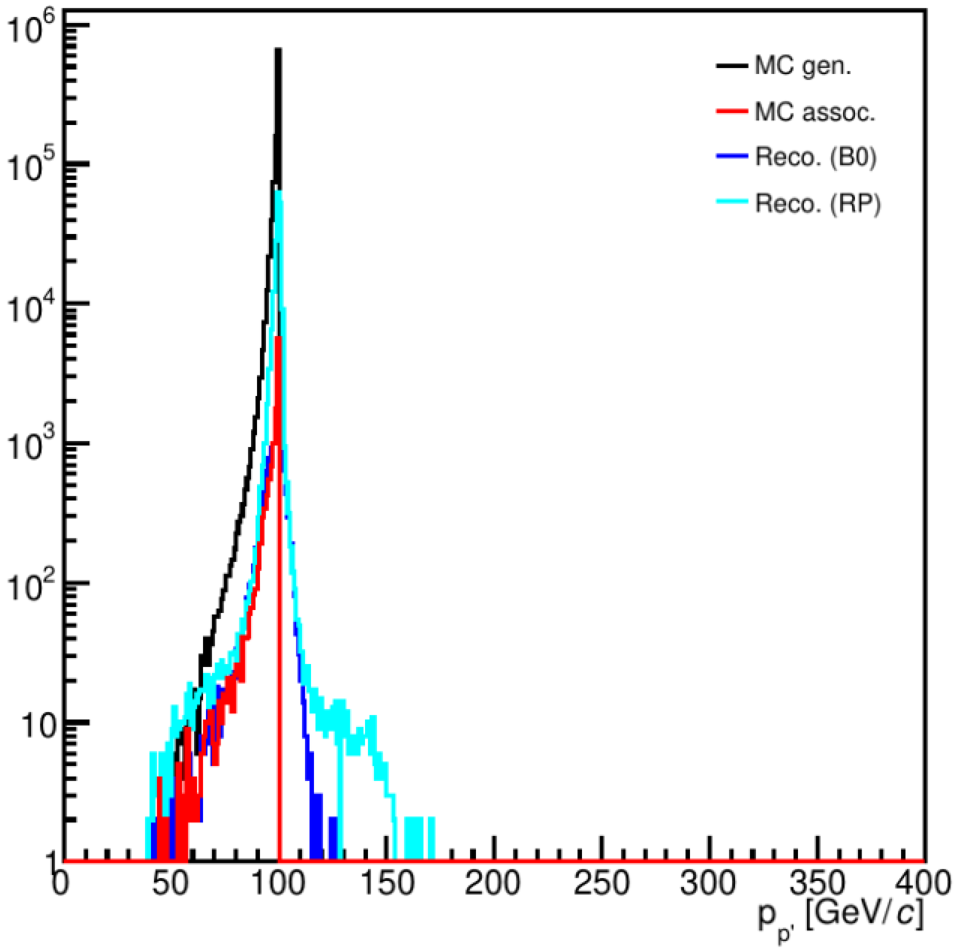


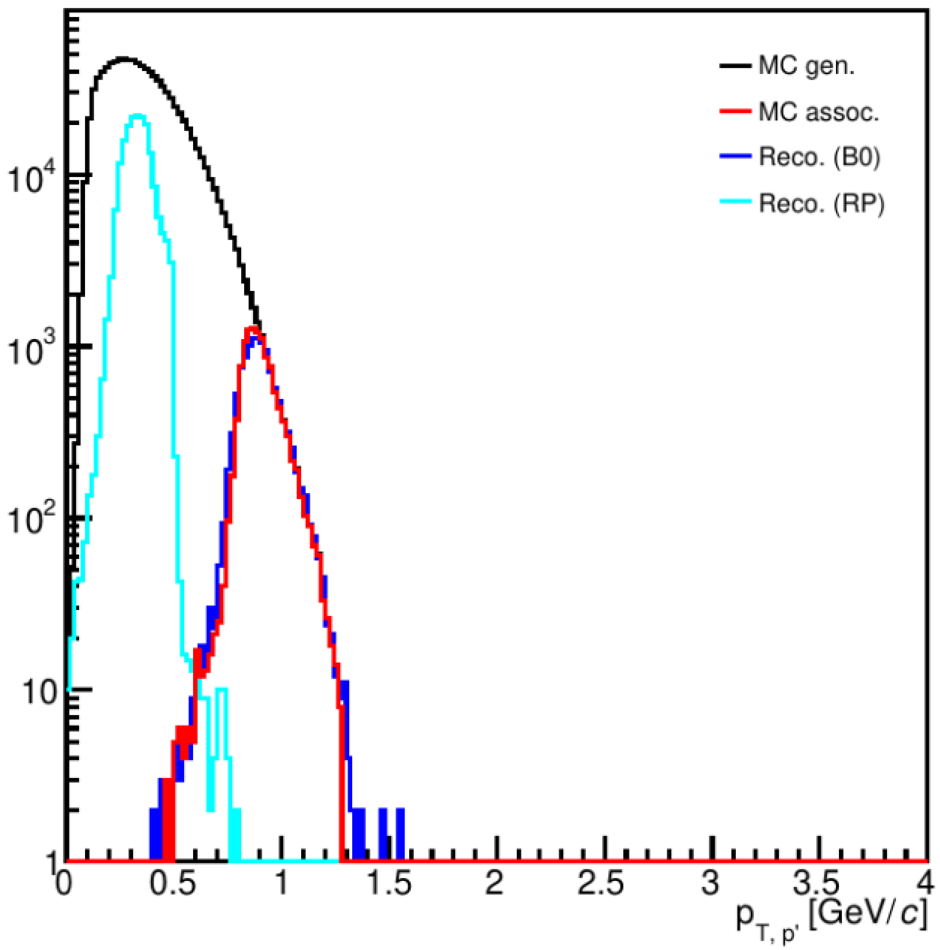
Single-particle (e’)



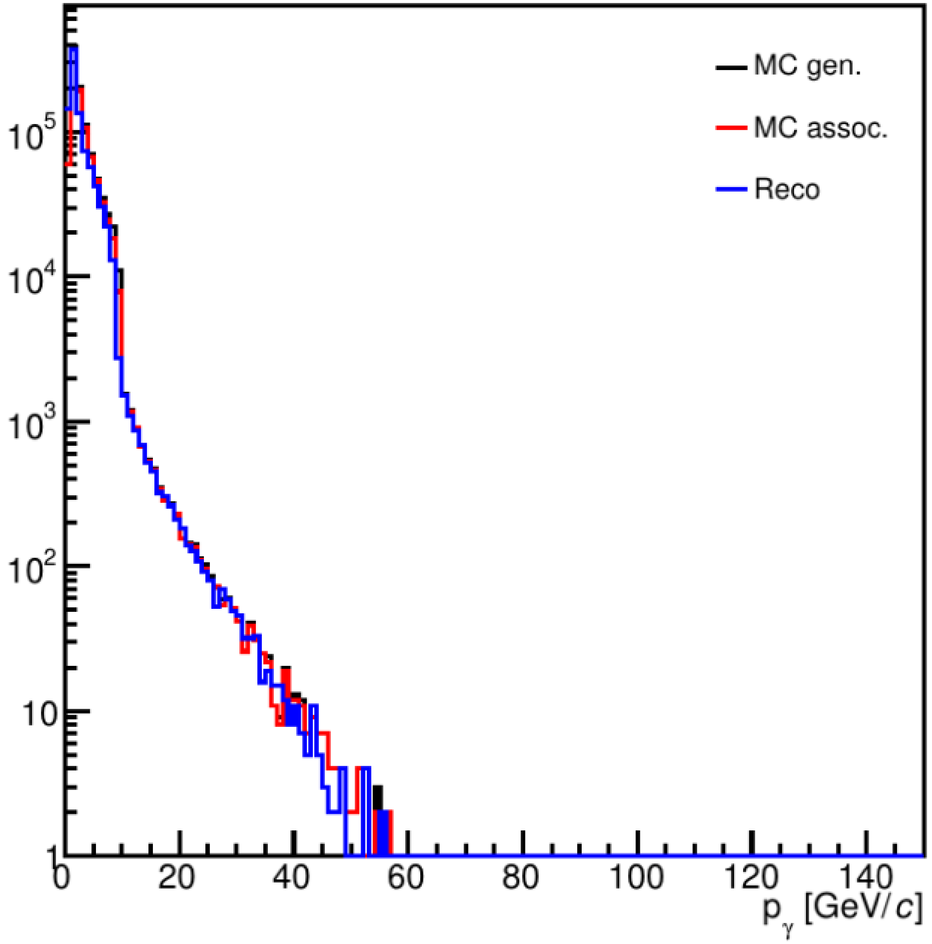


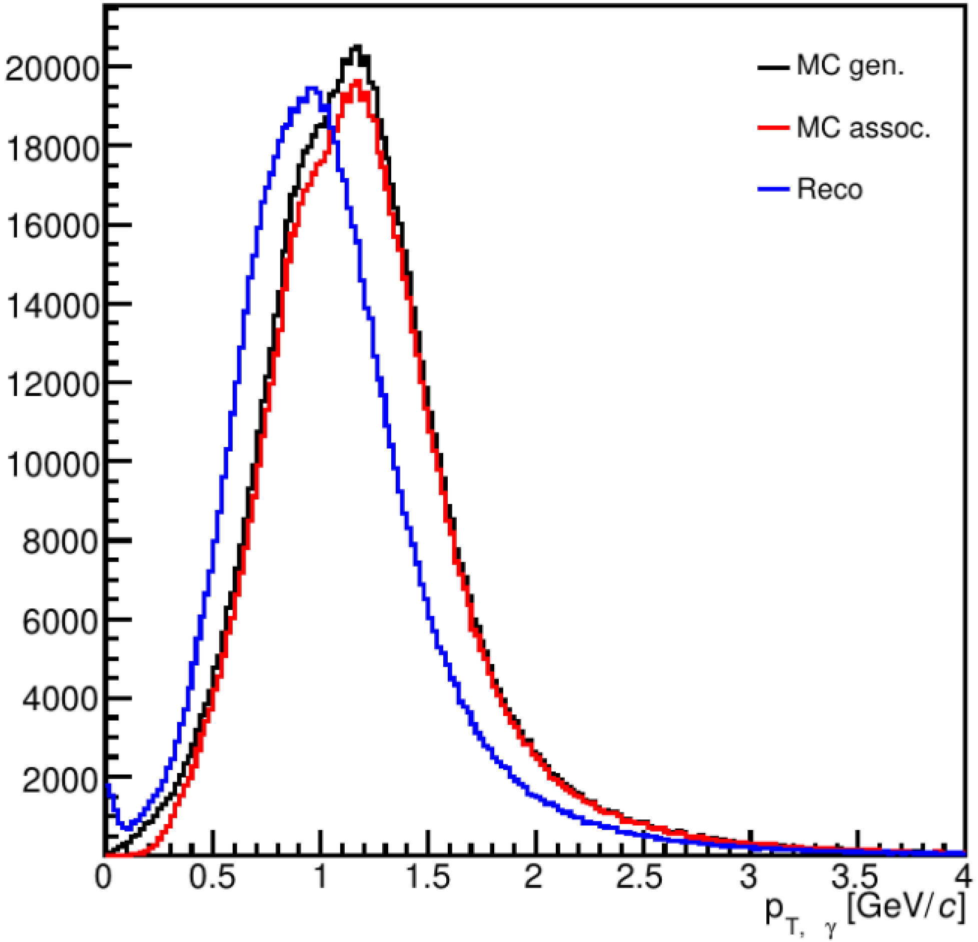
Single-particle (p’)



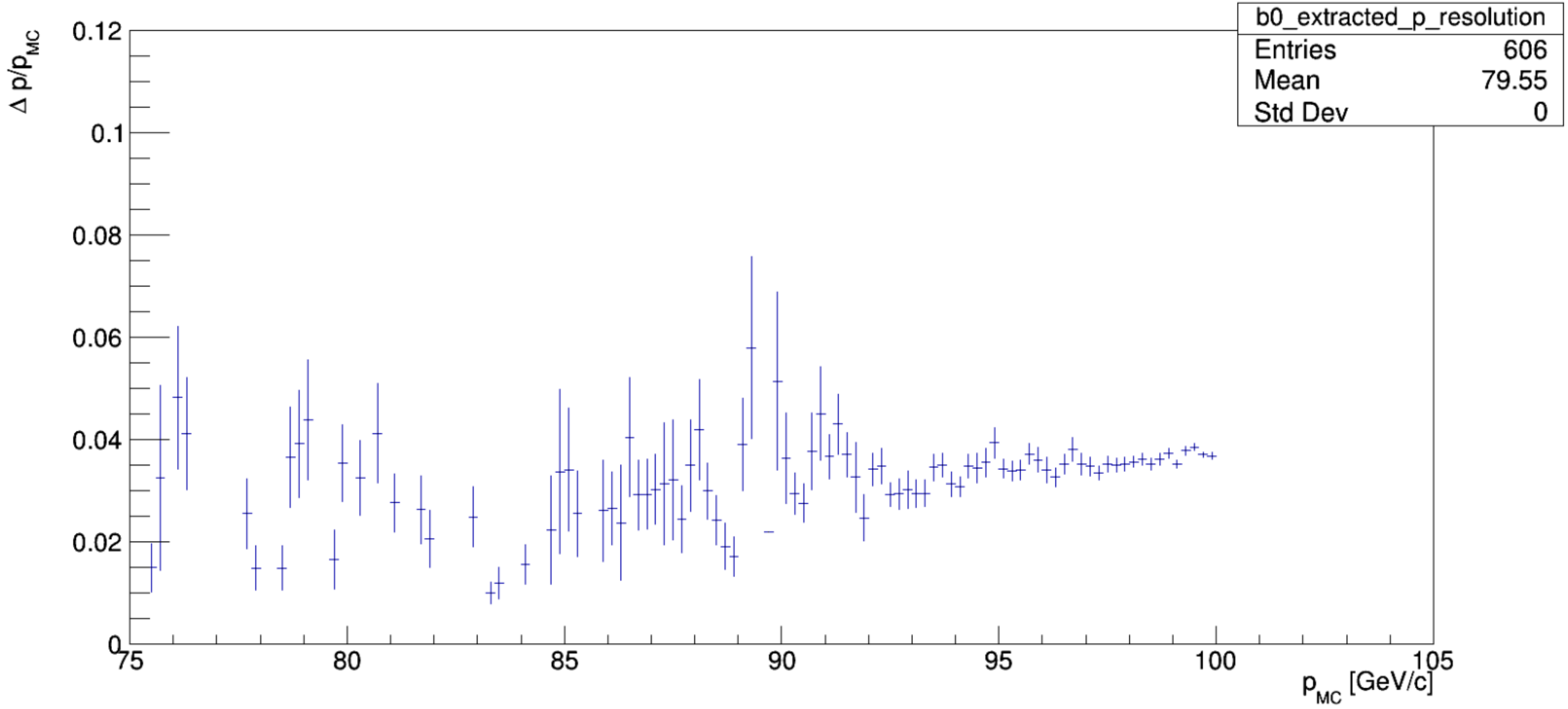


Single-particle (γ)

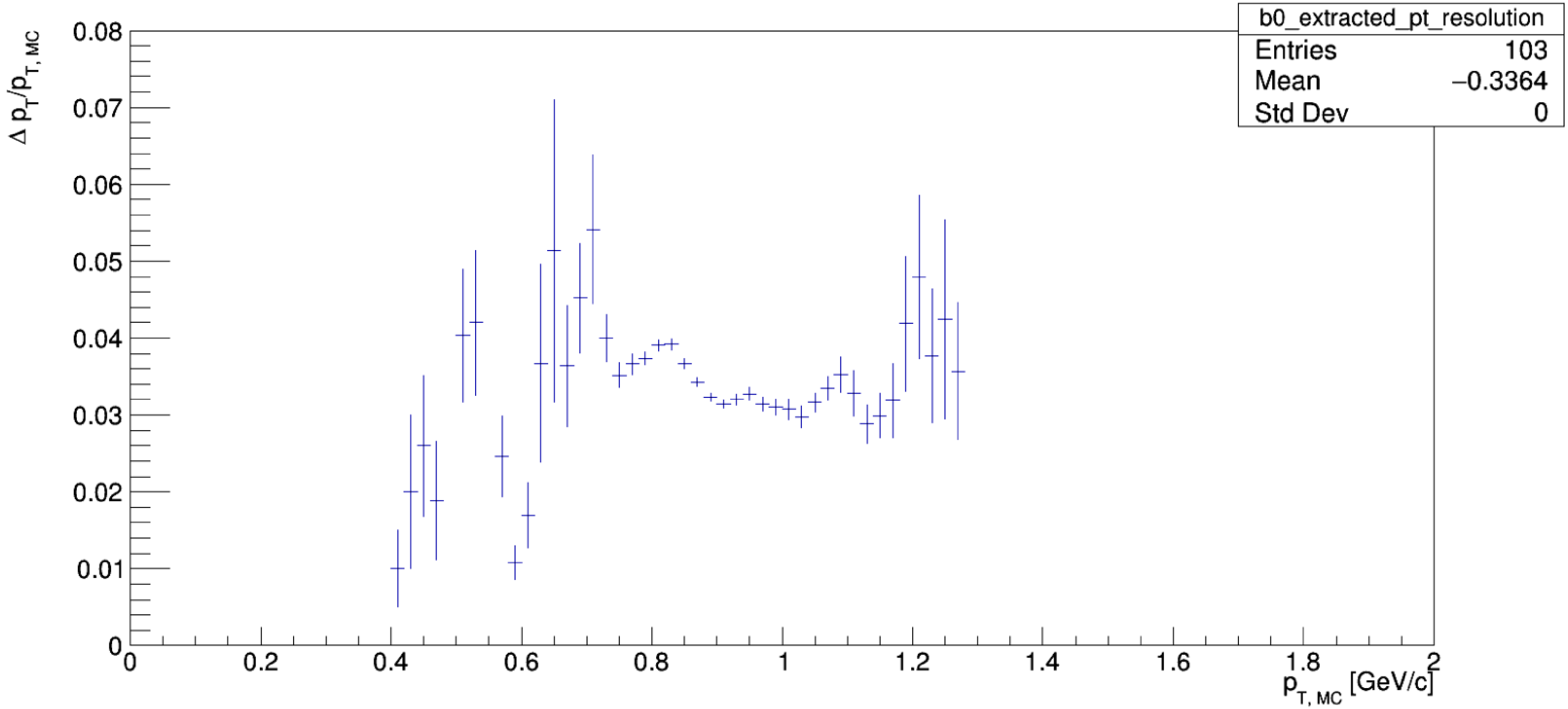




B0 p resolution

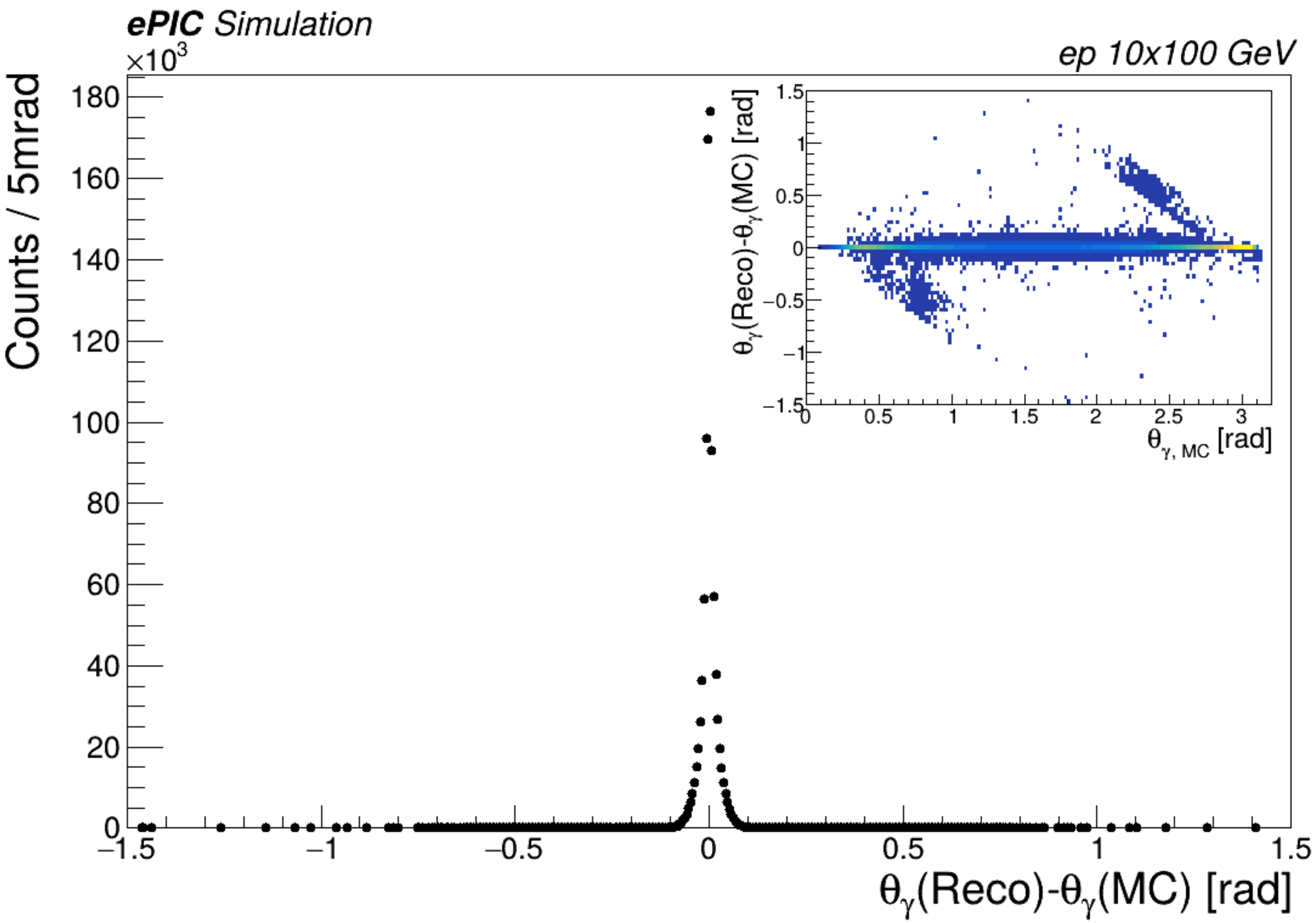


B0 p_T resolution

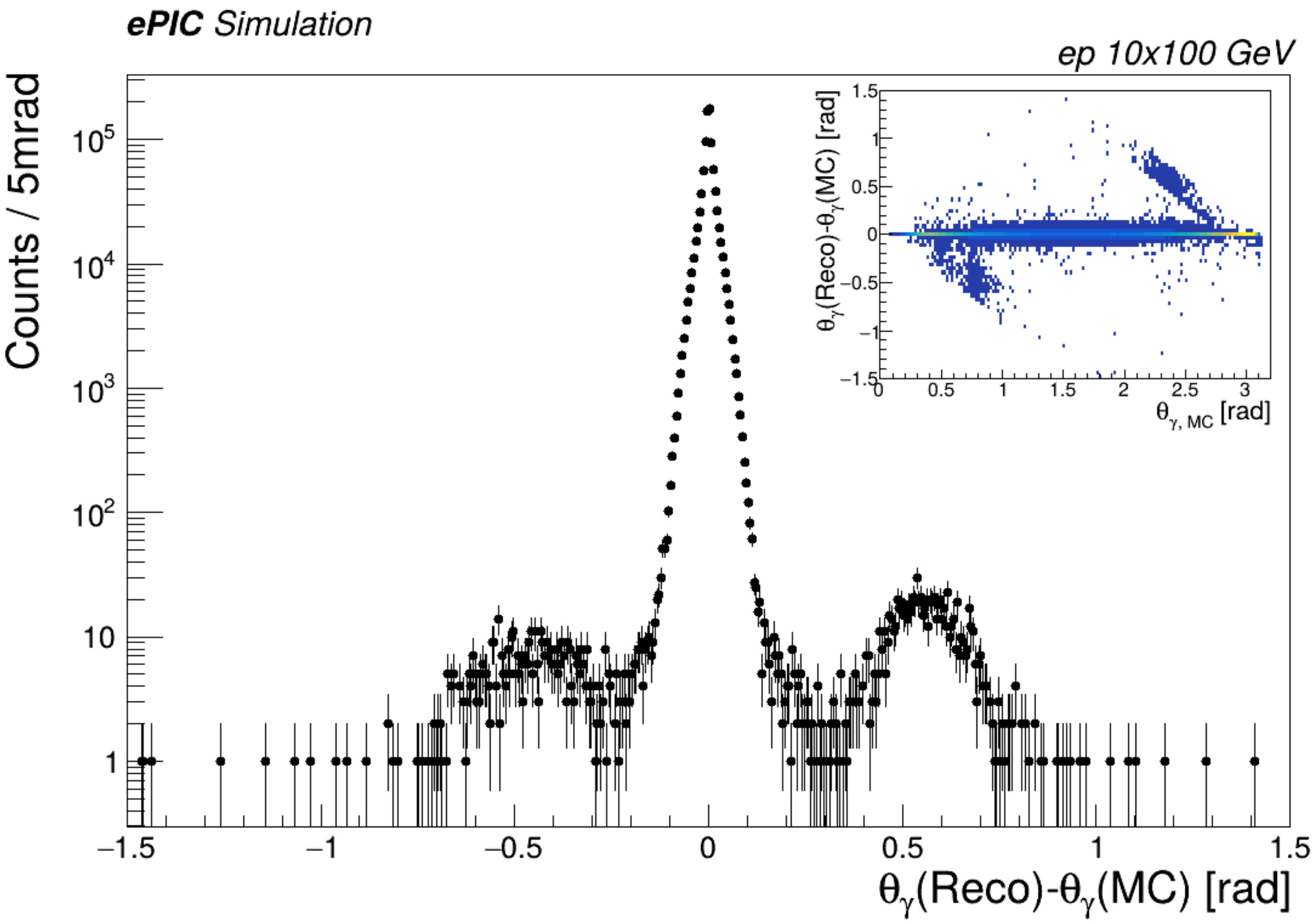


Concerns

Photon reconstruction resolution



Photon reconstruction resolution



Undoing the afterburner and ϕ_h

- [Why?] Cross-sections and asymmetries plotted as function of ϕ_h (the angle between the leptonic and hadronic planes).

- [Why?] Most formulae for ϕ_h are given in the target rest frame (most DVCS comes from fixed-target experiments).

- Trying to boost into the target rest frame sometimes fails (vectors read as zeroes).
  - Why?

Undoing the afterburner and ϕ_h

- Looking at frame boost calculation.
- Suggests that mass of beam proton after removal of afterburner effects can read negative.
  - This causes the boosts to fail.
  - Something to be looked at.

```
[DEBUG] EICRECON BEAM PROTON: (-2.48651,0.0149287,99.9879,100.023)
[DEBUG] POSTBURNED BEAM PROTON: (-1.32211e-08,0,99.9606,99.9294)
[DEBUG] Boost vector = (1.32305e-10,-0,-1.00031)
[DEBUG] beam p mass = 0
   Pre-boost      Post-boost
e:  (1.32211e-08, 0, -10.0071, 10.0071) (0, 0, 0, 0)
p:  (-1.32211e-08, 0, 99.9606, 99.9294) (0, 0, 0, 0)
e': (0.103184, 1.20078, -9.58902, 9.66446)      (0, 0, 0, 0)
p': (-0.371498, 0.0456261, 98.836, 98.8411)     (0, 0, 0, 0)
g:  (0.281855, -1.23203, 0.67114, 1.431)        (0, 0, 0, 0)
q:  (-0.103184, -1.20078, -0.418031, 0.342589)  (0, 0, 0, 0)
```

Beam p_z = 99.96 GeV
Beam E = 99.29 GeV

$E < p_z$

Wrap-up

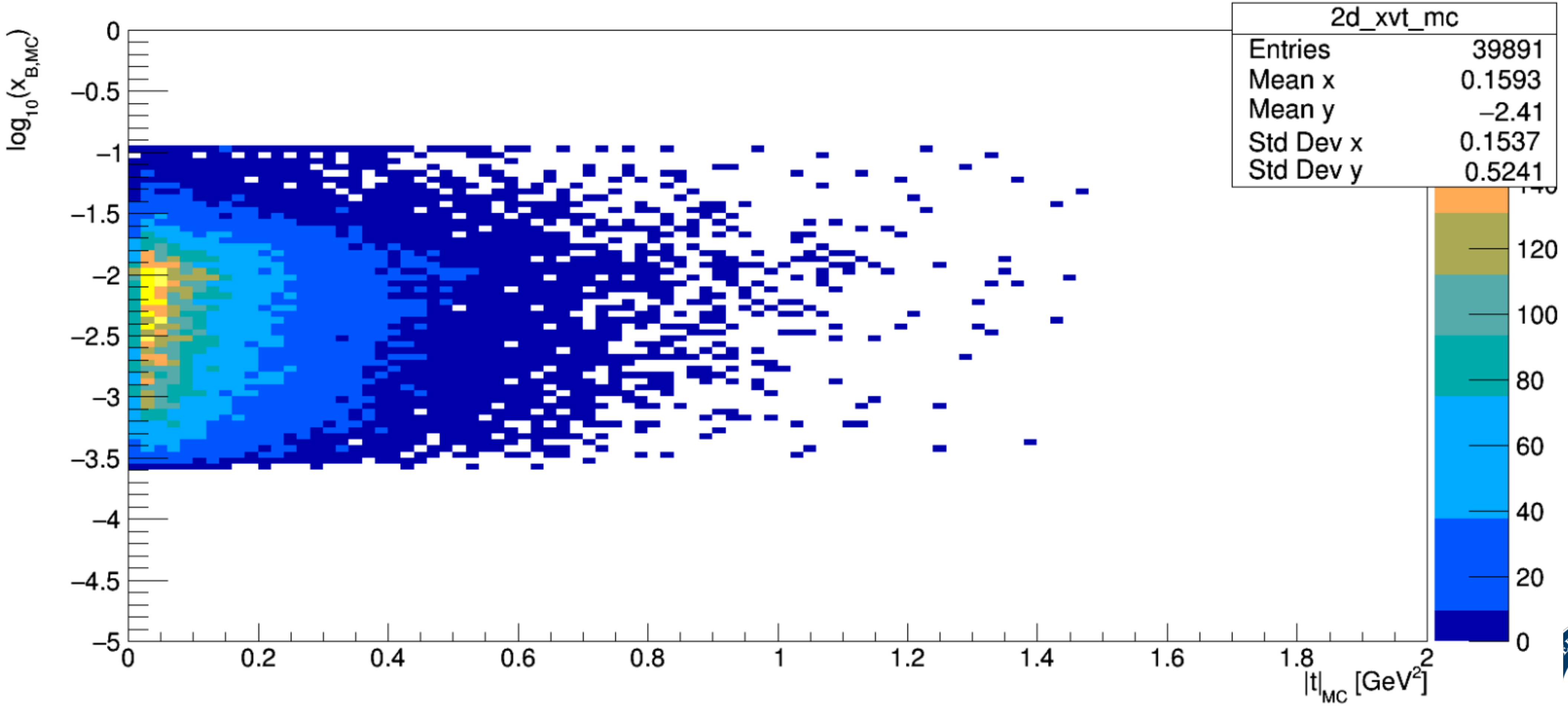
- DVCS is a very clean interaction to study within ePIC, and it is useful to probe most of the detector subsystems simultaneously.
- Current simulation efforts show:
  - The far forward region behaves well for proton measurements (~4% or smaller p resolution).
  - Some interesting structures show up for photon reconstruction.
    - Not concerning, but warrants further study.
- Expected updates to the RP reconstruction algorithm will benefit this channel greatly.

Thank you for listening!

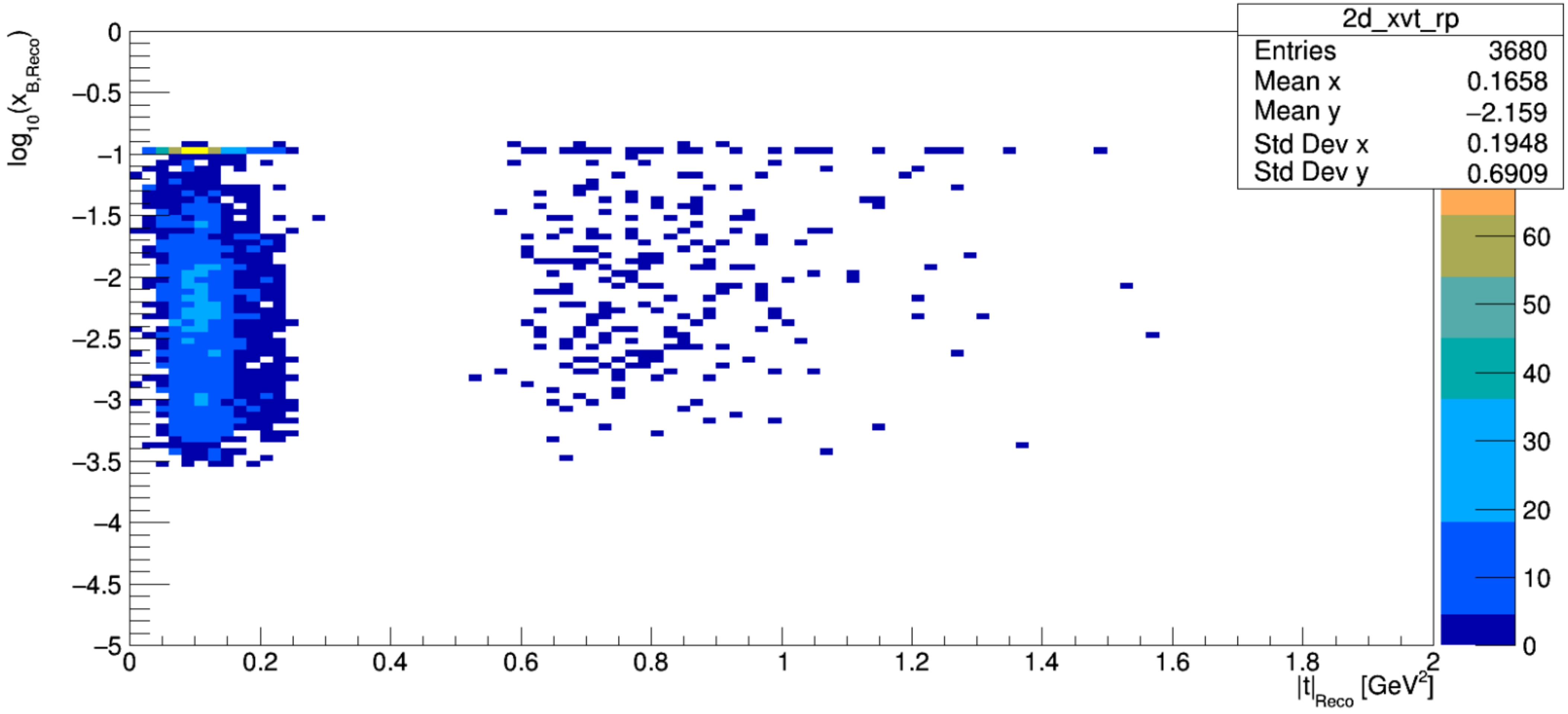
Time for questions.

Backup slides

2D distribution – x_B vs t (MC)



2D distribution – x_B vs t (Reco.)

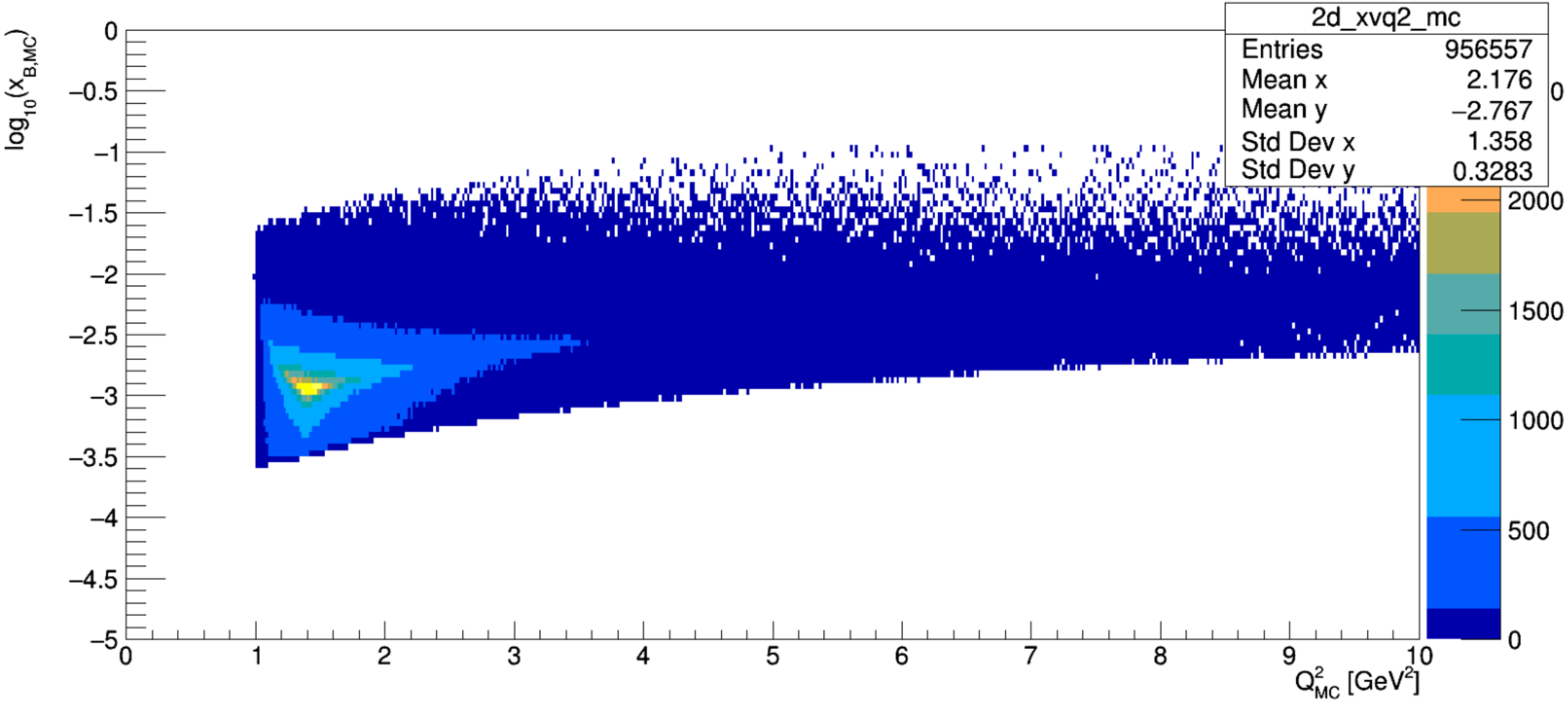


2D distribution – x_B vs t (Reco.)

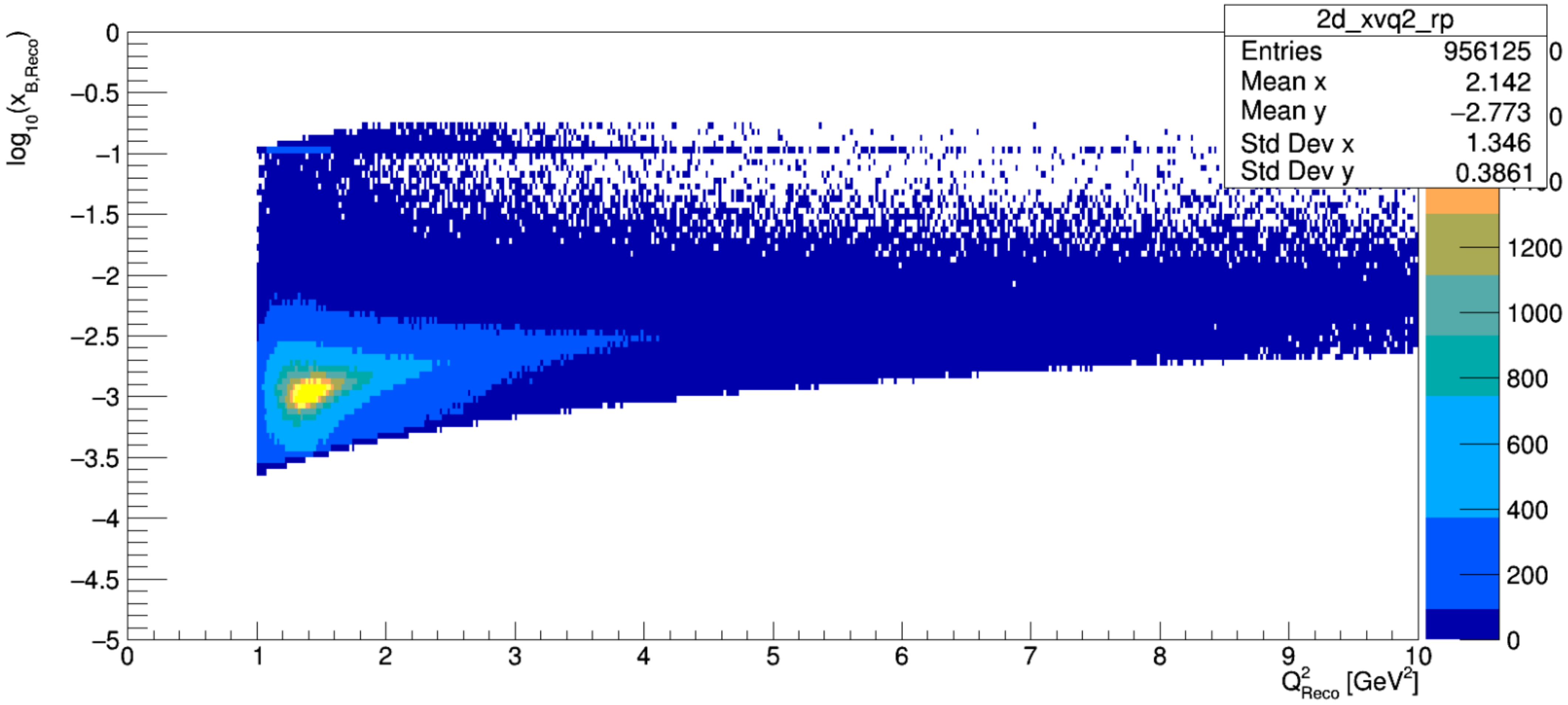
Lose a lot of events

Smearing dominates remaining events

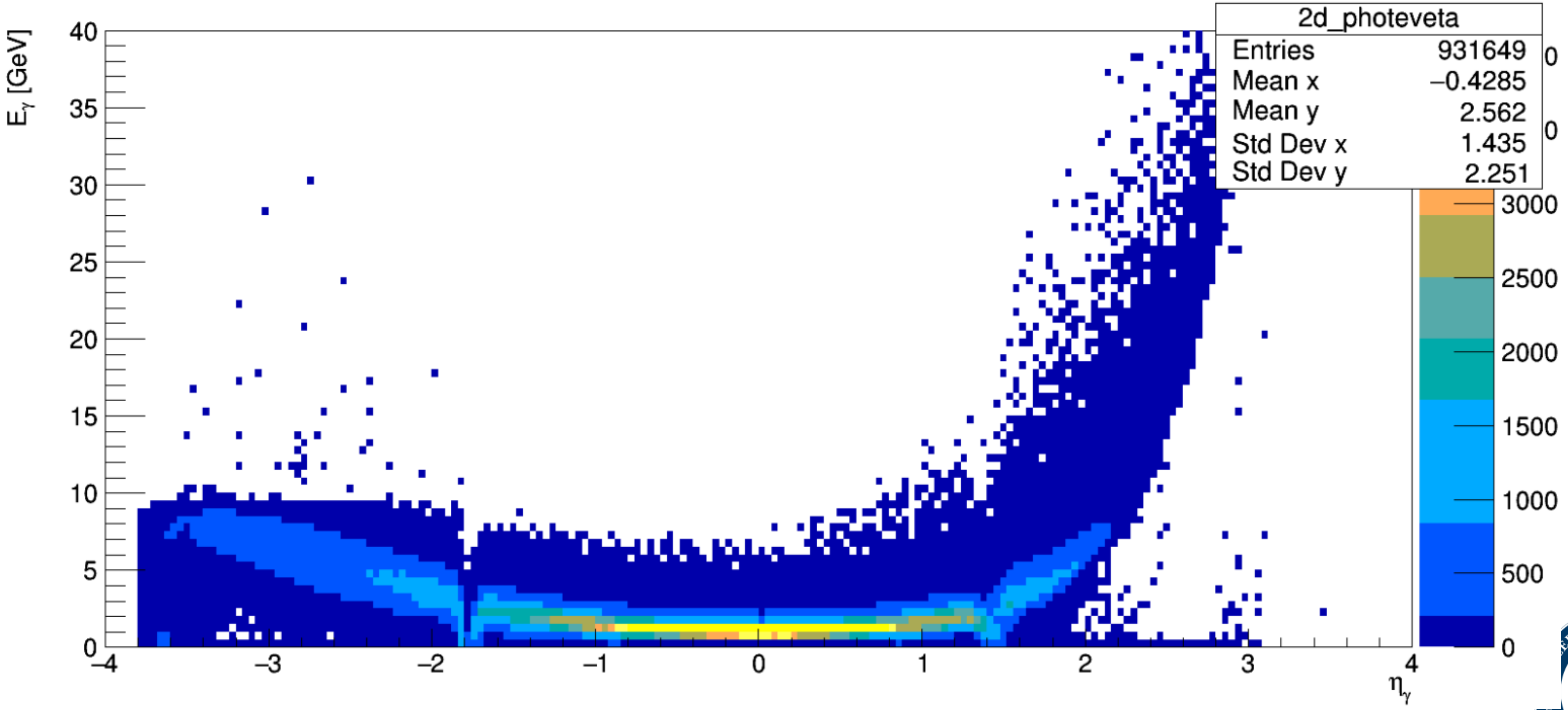
2D distributions – Q^2 vs x_B (MC)



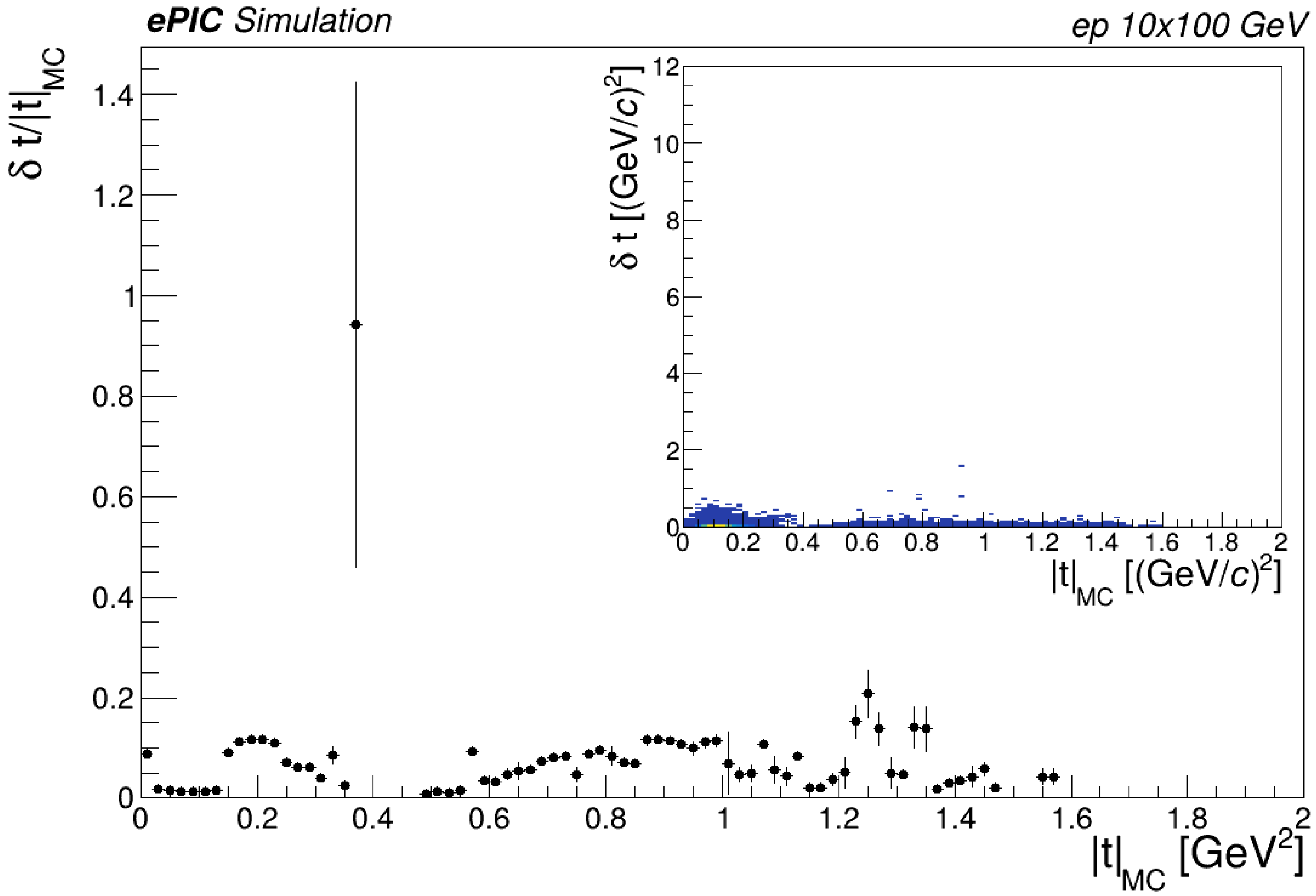
2D distributions – Q^2 vs x_B (Reco.)

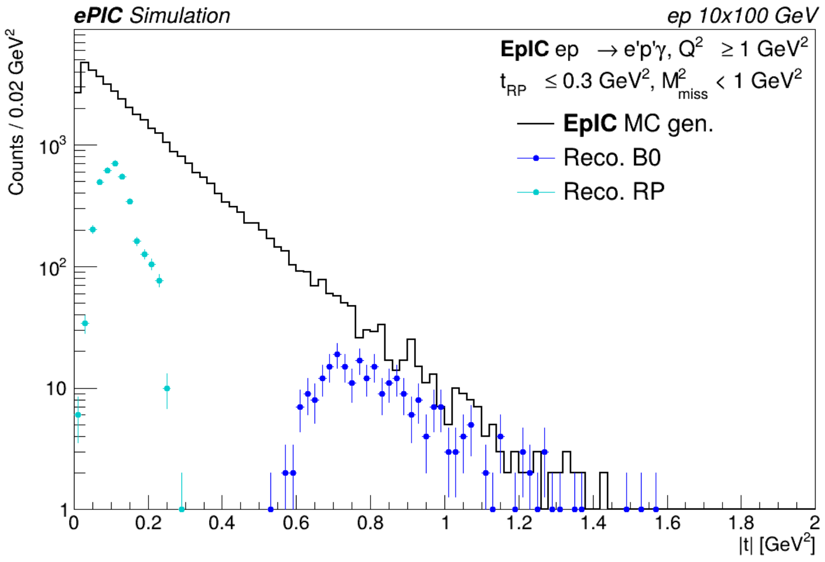


Coverage – photons (Reco. E vs η)



Resolution on t (wide)





$\delta t = t(\text{Reco.}) - t(\text{Gen.})$