DVCS on ep Analysis Update

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Exclusive, Diffractive and Tagging PWG meeting

10/11/25

This presentation

- DVCS at ePIC
- Updates since last presentation (27th October)
  - Initial results from October campaign
  - Best t-calculation?

Deeply Virtual Compton Scattering

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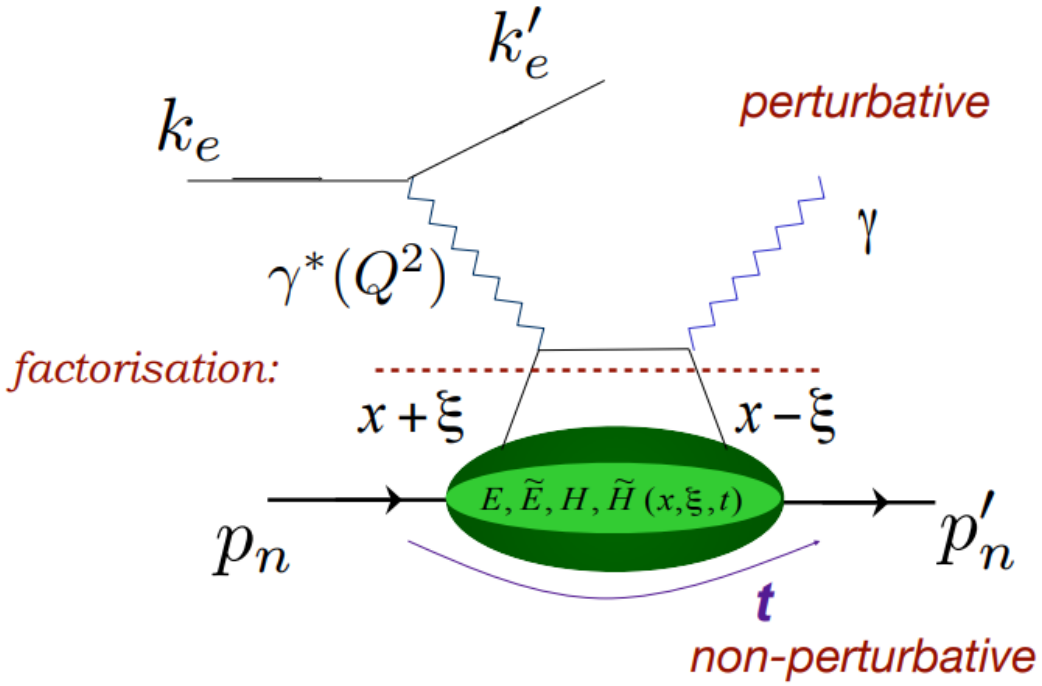
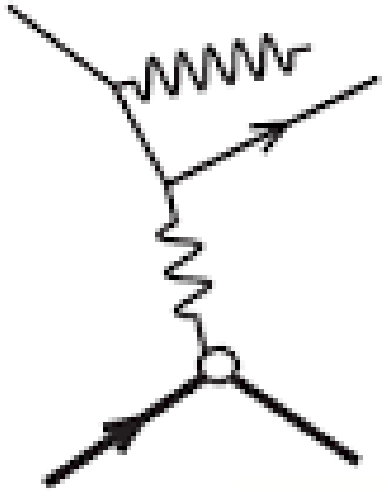




- DVCS: electroproduction of a photon off a hadron target
- QM interference: Bethe-Heitler (e^- radiates final state photon.

Deeply Virtual Compton Scattering: kinematics

- Default kinematics:
  - $e(k) + p(p) \rightarrow e'(k') + p'(p') + \gamma$

- Inclusive kinematics: scattered electron only ("Electron method" in EICrecon)

$$Q^2 = -q^2 = -(k - k')^2 \qquad y = \frac{q.p}{k.p} \qquad x = \frac{Q^2}{2q.p} \qquad \xi = \frac{x}{2 - x} \approx \frac{x}{2}$$

- Mandelstam *t*: beam and scattered proton (BABE method in *tRECO* convention)

$$t = (p - p')^2$$

25.10.2 simulation campaign

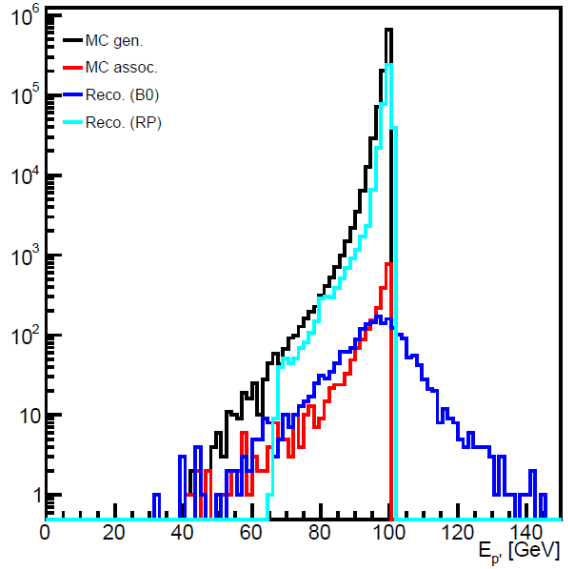
Photon reconstruction issue

- Working with Alex to look at initial results from October simulation campaign.

- 25.10.2 campaign required for correct Roman Pot reconstruction algorithm.

Initial observations: RP protons

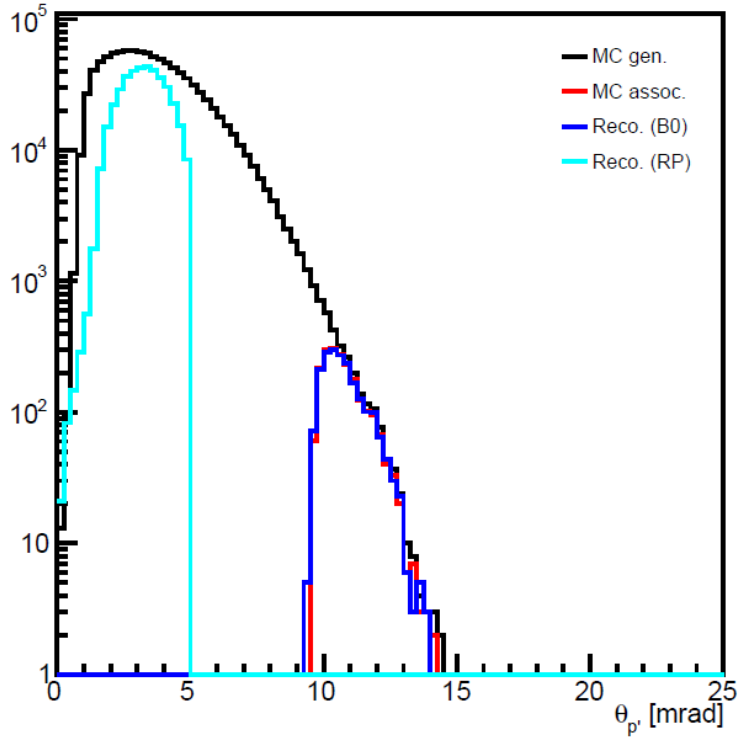
- New RP algorithm doesn't completely fix unphysical tracks.
  - Need to keep $\theta_{p'}$ cut in place.
- Fewer RP tracks getting reconstructed (~4% drop w.r.t June).
- $E_{p'}$ distribution better follows generated.
- Seems a hard cut at $E_{p'}$ ~70 GeV.
  - Not present in June campaign.



Issue: B0 protons

- Initial observation: number of B0 protons has dropped by ~80%!
  - W.r.t June 10x100 campaign (10874 for June; 2070 for October)

- Seems like drop is related to track θ.
  - For October, B0 distribution starts at ~10 mrad.
  - For June, it starts at ~8 mrad.
  - This loses a lot of protons!



Issue: B0 protons

- Been looking at this on-and-off with Alex.
- Cause is unclear.
  - Angular acceptance drop also seen in other energy settings (not just a problem for 10x100).

- Going back – this has been a problem since July!
  - Didn't notice it earlier because of photon issue.
  - Only been working with June's campaign.
- GitHub issue raised.

Reconstructing Mandelstam t

Different methods being considered.

Reconstructing Mandelstam t (repeat from last week)

- Discussion from the PRW: want to find a way to reconstruct t for
  - Missing scattered p.
  - Poor t-resolution.

- Need some method to reconstruct t *without* the detection of the scattered proton.
  - Using tRECO convention note, 2 methods exist: eX / eXBE.
  - ‘e’ – Scattered/DIS electron
  - ‘X’ – Rest of final state *without the scattered baryon* (i.e. DVCS γ)
  - ‘BE’ – “Beam” hadron

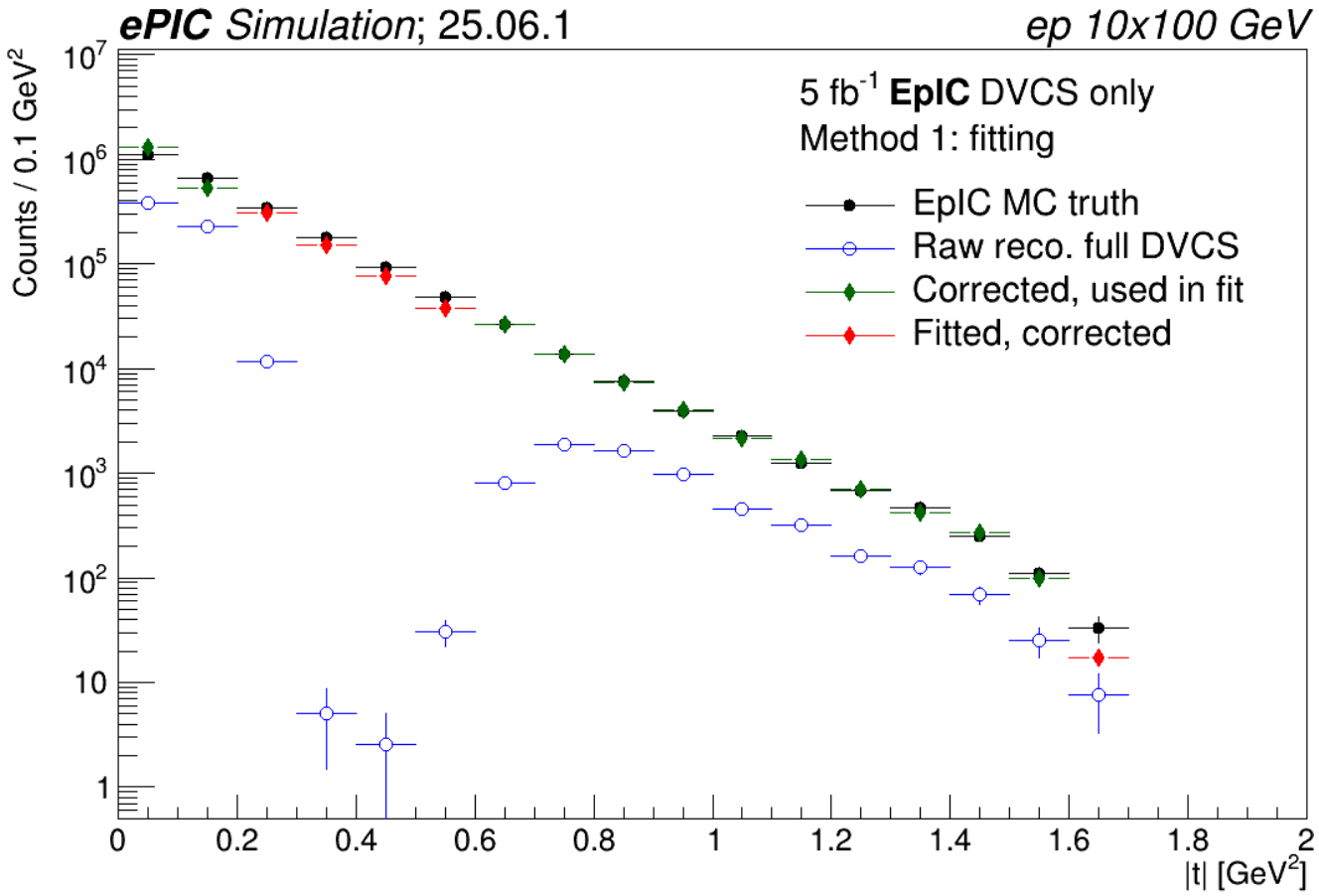
Methods used

- 3 methods under consideration:
  1. Fitting – Fit corrected BABE distributions from full DVCS events, and use the fit in the gap
  2. Bin-by-bin (proton agnostic) – Reconstruct t using multiple methods based on final state particles, then choose the best for a given t-bin.
  3. Bin-by-bin combined – combine t from events with missing protons with those where proton is reconstructed.

Method 1

- Just using data from full DVCS events, corrected for detector acceptance.
  - $Q^2 > 1\ GeV^2$; $M_{miss}^2 < 1\ GeV^2$
- Only use points in fit if purity of t-reconstruction method is >50%.
- Final distribution is sum of data used in fit, plus fit result where data not used/available.

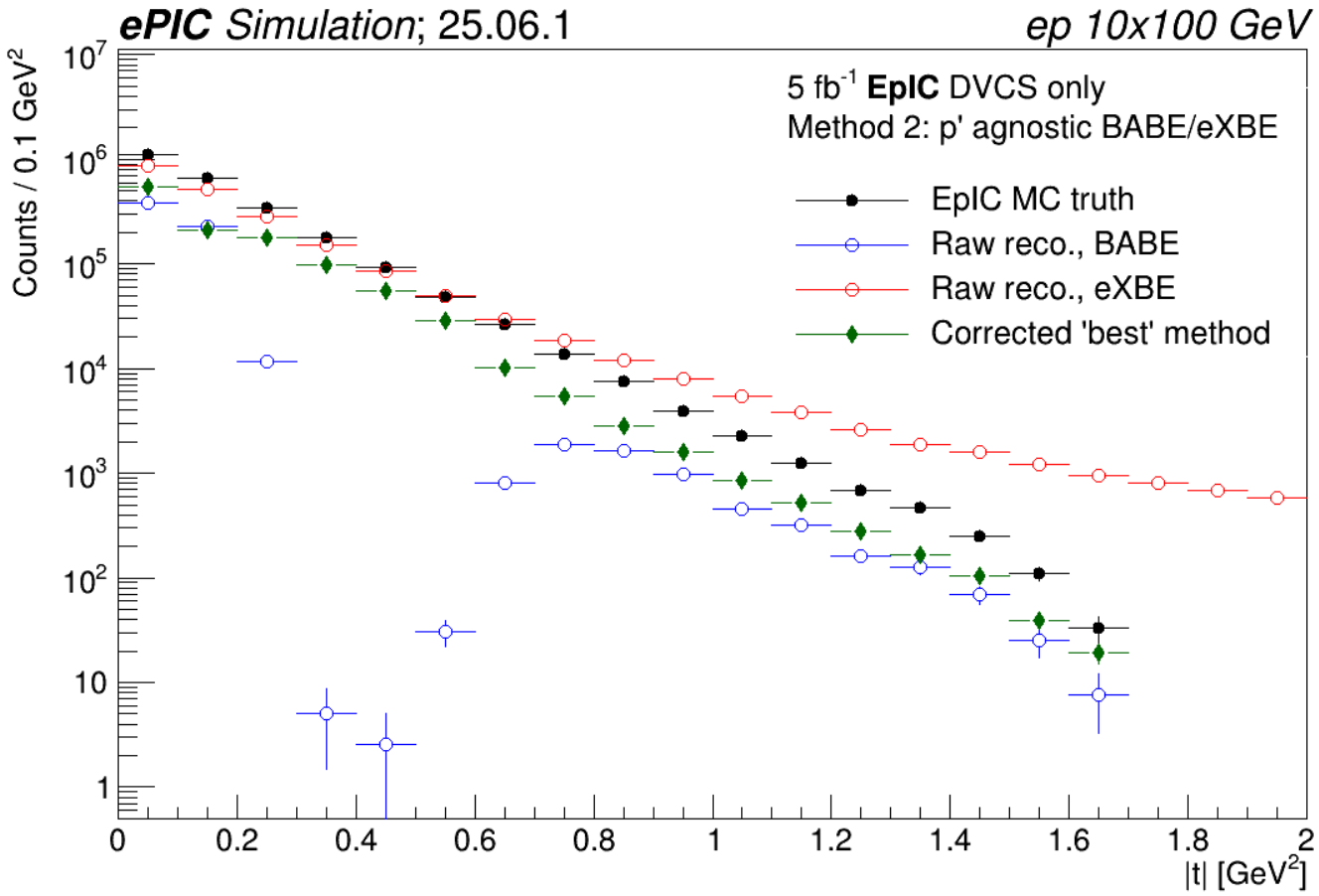
Method 1


ePIC Simulation; 25.06.1
ep 10x100 GeV
5 fb^{-1} EpIC DVCS only
Method 1: fitting
EpIC MC truth
Raw reco. full DVCS
Corrected, used in fit
Fitted, corrected
Counts / 0.1 GeV^2
|t| [GeV^2]

Method 2

- Using both the eXBE and BABE formulae for all events (if event not viable, set t outside range of histogram).
  - BABE: full DVCS event cuts (as prior)
  - eXBE: e'γ reconstructed, $Q^2 > 1\ GeV^2$, $|p_{miss} - p_{beam\ h}| < 5\%\ p_{beam\ h}$
- Look at 3 different t-distributions bin-by-bin (B0 BABE, RP BABE, eXBE).
  - Use value of detector corrected distribution for method with best purity in each bin.

Method 2

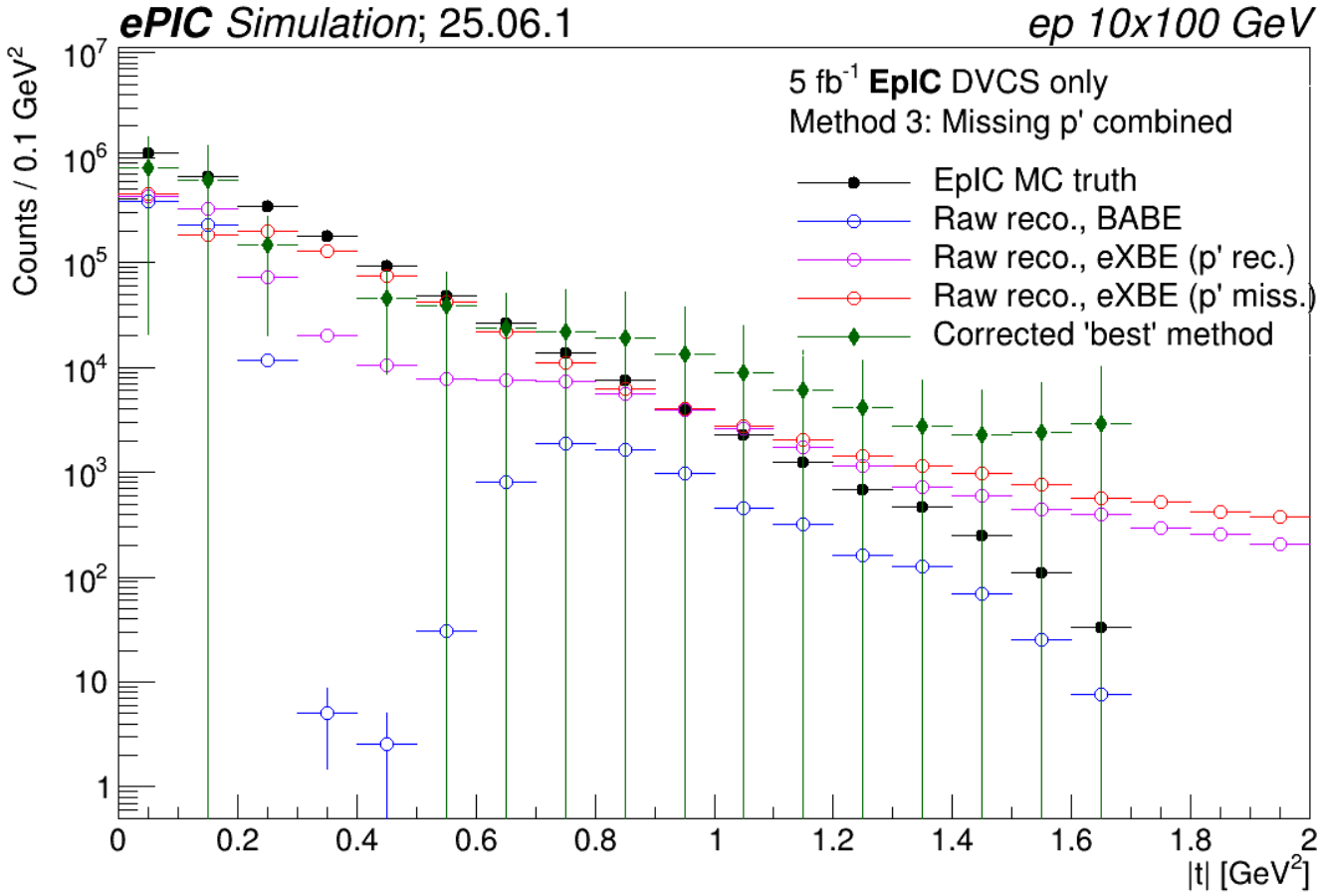

ePIC Simulation; 25.06.1
ep 10x100 GeV
5 fb^{-1} EpIC DVCS only
Method 2: p' agnostic BABE/eXBE
EpIC MC truth
Raw reco., BABE
Raw reco., eXBE
Corrected 'best' method
Counts / 0.1 GeV^2
|t| [GeV^2]

Method 3

- Similar to method 2.
- Separate out events with missing protons from those where proton is reconstructed.
- Combine “missing proton” (a) distribution with “reconstructed proton” distribution from best method (b) as decided for method 2.
  - Reco. – sum of (a) and (b)
  - Acceptance – average of (a) and (b)

- Correct for detector acceptance at end of calculation

Method 3


ePIC Simulation; 25.06.1
ep 10x100 GeV
5 fb-1 EpIC DVCS only
Method 3: Missing p' combined
EpIC MC truth
Raw reco., BABE
Raw reco., eXBE (p' rec.)
Raw reco., eXBE (p' miss.)
Corrected 'best' method
Counts / 0.1 GeV2
|t| [GeV2]

Which to use?

- These plots are at a *very* early stage.
  - Hence errors for method 3 (needs fixing).

- Which method is the most ‘correct’?
  - Which do we want to present (pre-TDR/early science paper)?
  - Once decided, more study can be devoted to that method.

Concluding remarks

Summary of this update

- 25.10.2 campaign out and available.
- New RP reconstruction algorithm behaving well.
- Problem seems to arise for B0 reconstruction.

- Different methods for t-reconstruction being looked at.
  - Need to decide what we want to use for the pre-TDR sooner rather than later.

Thank you for listening!

Any questions?

Offline questions? Ping me an email!

Backup

25.10.2 reco. proton energy