Timelike Compton Scattering Update

Exclusive Diffractive & Tagging
Physics Working Group

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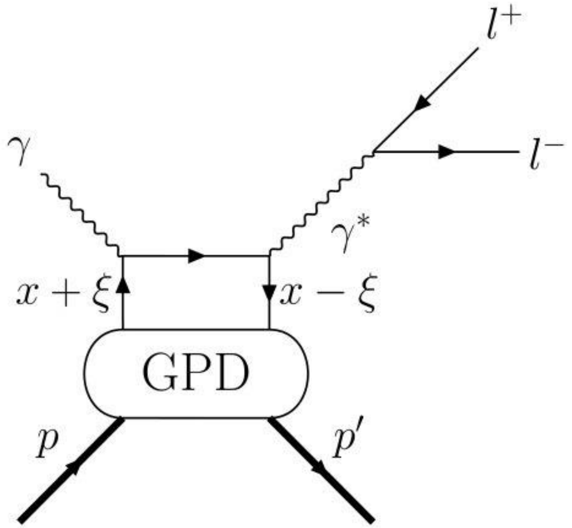
WORLD CHANGING GLASGOW

A WORLD TOP 100 UNIVERSITY

Overview



1. Simulation (Campaign) Analysis
    - Basic detector reconstruction performance
        - Single particle acceptances & resolutions
    - Exclusive final state statistical projections
    - Missing Scattered Electron Topology
    - Missing Recoil Proton Topology
2. Backgrounds
    - Physics backgrounds
    - Machine merged background campaign analysis
        - Estimate contamination of ee pair mis-ID/mis-reconstruction in central detector
    - Standalone Far Backward Bremsstrahlung analysis
        - Low-Q2 tagger timing -> match "physics event" electron to correct beam bunch O(10ns) within 2us "Timeframe"
3. Phenomenology
    - Comparison of binned asymmetries with existing published results
    - Extraction of FF/GPDs through amplitude fitting with Brufit

Green: Presented, Grey: In Progress

1. Simulation Analysis* (26.07.1)

**disclaimer: these are results from in-house simulations using 26.07.1 at Glasgow, while waiting for the July campaign to be available from sim team.*

Simulation Analysis (26.07.1)

9x130 Config, single plus helicity ebeam file

Selection Criteria

- e': All "ReconstructedParticles" with PID==11, reconstructed from tracks in the Low-Q2 tagger, via Associations.
- e-: All "ReconstructedParticles" with g4 truth PID==11, NOT from the tagger.
- e+: All "ReconstructedParticles" with g4 truth PID==-11.
  - *ToDo: analyse new selection algo for e+e- using reco charge, PID, E/p (i.e not using truth PID).*
- p': All "FarForwardRomanPotRecParticles" and B0(ReconstructedTruthSeededChargedParticles) with rec PID==2122 (default for RP anyway)

- Form all possible *combinatorials* from these reconstructed particles for a given topology,
  - e' e-e+ p' (Fully Exclusive) -> Low folded acceptance, Under study
  - e' e-e+ (Missing recoil proton) -> Reduced kinematic resolution, Under study
  - e-e+ p' (Missing scattered electron) -> Preliminary (Dec25) studies showed near zero sensitivity to polarisation observables. (Large driving point to have a Low-Q2 tagger!)

Single Particle Performance: Scattered Electron

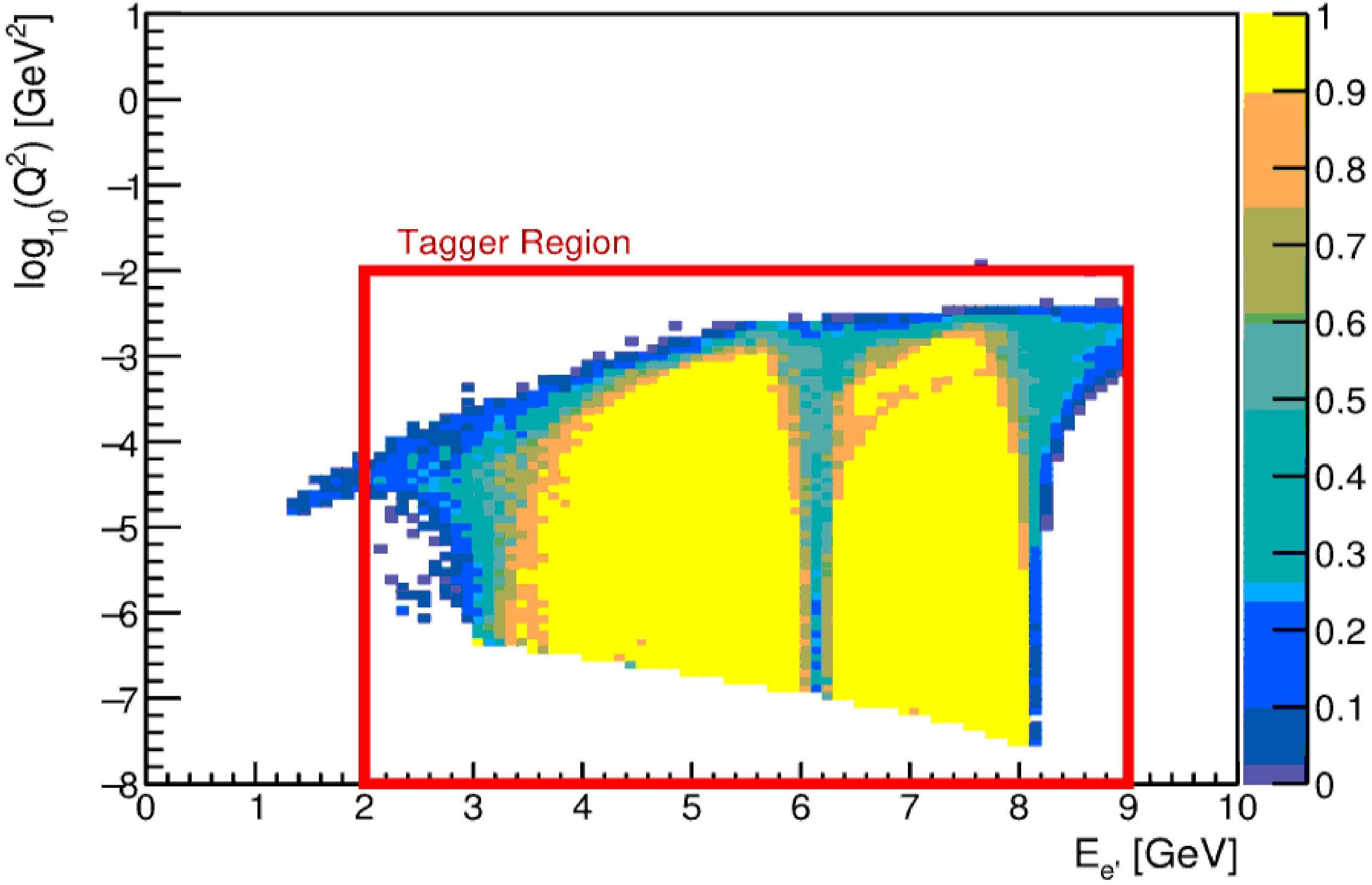


Figure 1. Acceptance of the scattered electron measured in the low-Q2 tagger, binned in E_e vs $\log(Q^2)$.

Generated electron scattering phase space:
0 < y < 1
0 < xbj < 1
0 < Q2 < 10GeV2

Naturally, many events will generate outside the fiducial region of the tagger.

Total acceptance: 28.4%

Approximate tagger acceptance: 76.9%

Full 3D (E, theta, phi) acceptance map required next.

Tagger timing analysis/cuts discussed in next section.

Single Particle Performance: Scattered Electron

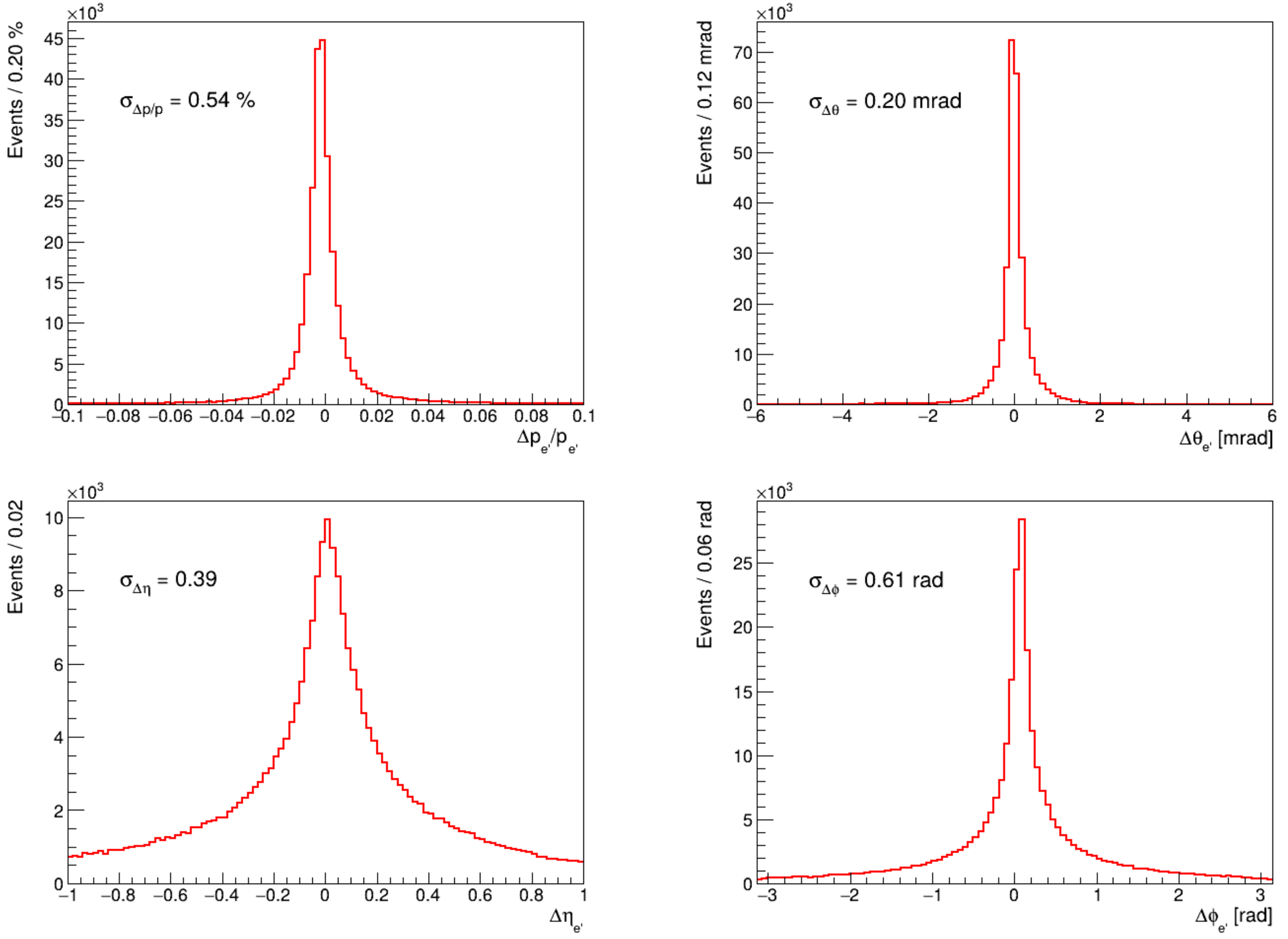


Figure 2. **p**, **θ**, **η**, **ϕ r**esolutions for scattered electrons measured in the low-Q2 tagger.

Single Particle Performance: Lepton Pair

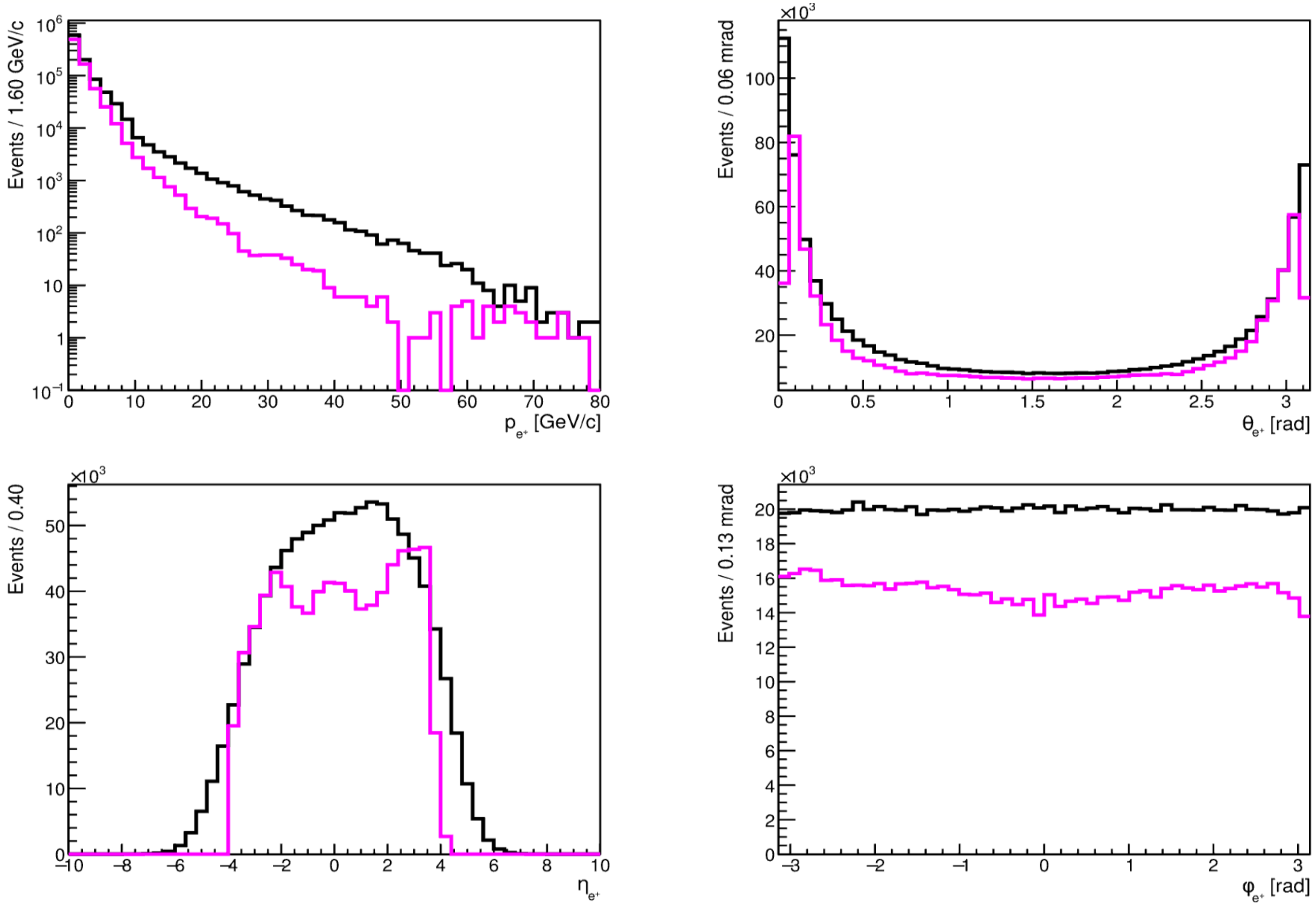


Figure 3. Truth (black) and Reco (magenta) **p**, **θ**, **η**, **ϕ** for decay electron (similar to decay positron, see full pdf supplementary material)

The angular distributions of the decay electron is related to the helicity/decay angles.

*We generate in the full allowed angular phase space. Events with |**η**| > 3.5 will leave the central detector undetected.*

Total acceptance e-: 75%, e+: 76%

Regions of worse reconstruction with acceptance > 1.0 can define fiducial cuts

p <= 65.0 GeV/c
|**η**| <= 3.5

Also, remains to be seen final effect of swapping to full ePIC PID.

Single Particle Performance: Lepton Pair -> Virtual Photon

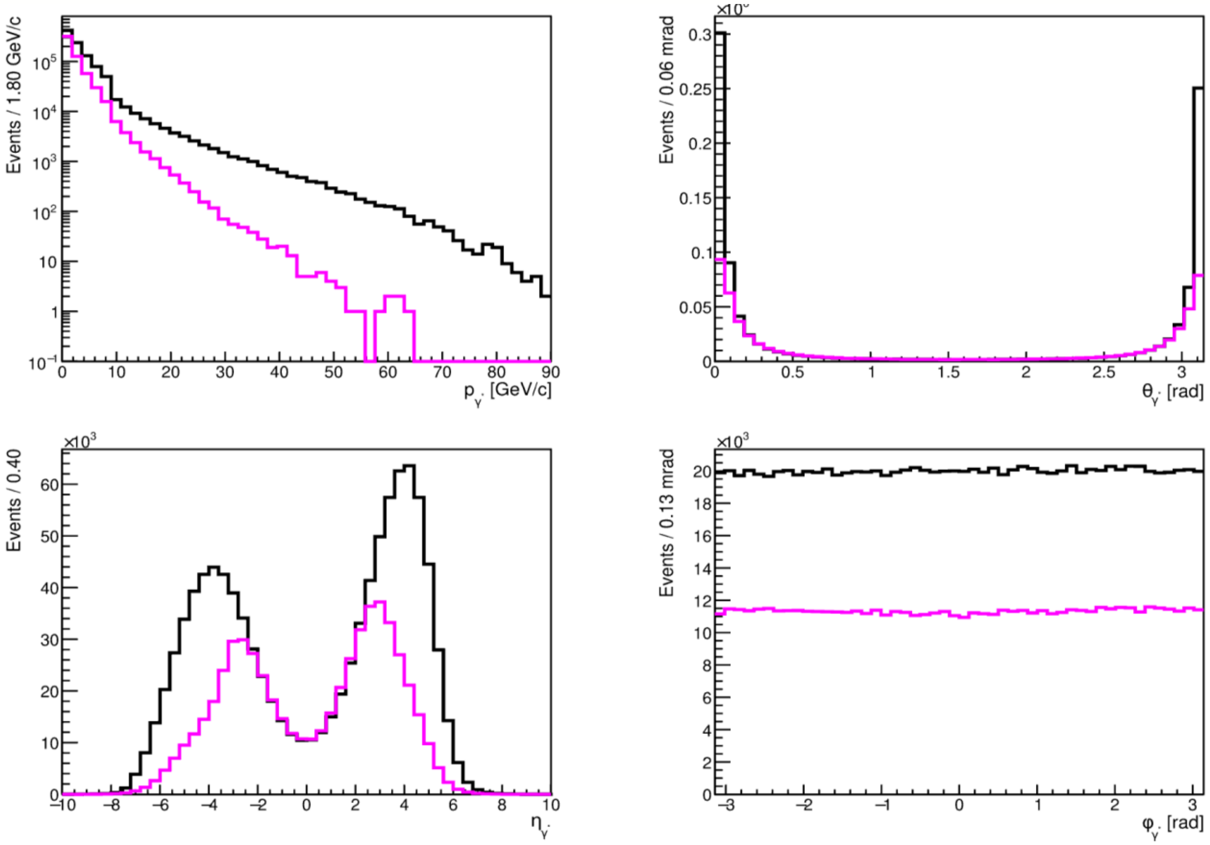


Figure 4. Truth (black) and Reco (magenta) **p**, **θ**, **η**, **ϕ** of TCS virtual photon, with fiducial cuts on detected electron and positron.

Total acceptance e-: 75%, e+: 76%
Resultant photon acceptance: 63.2%
After cuts: 56.6%

Residual tails in Qp2 distribution after cuts – further investigation on what impacts this reconstruction efficiency.

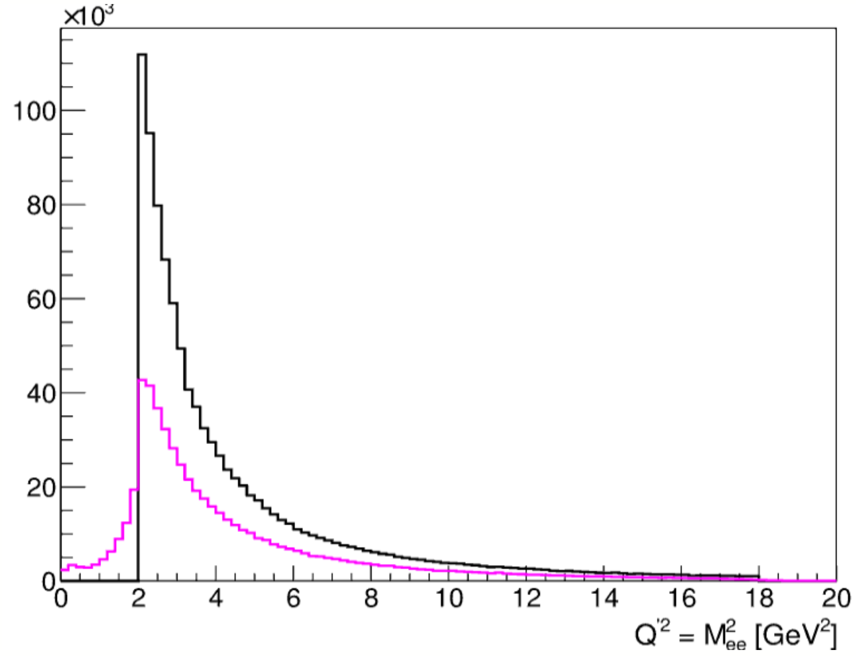


Figure 5. Truth (black) and Reco (magenta) Invariant mass squared of virtual photon after lepton pair fiducial cuts.

Single Particle Performance: Recoil Proton

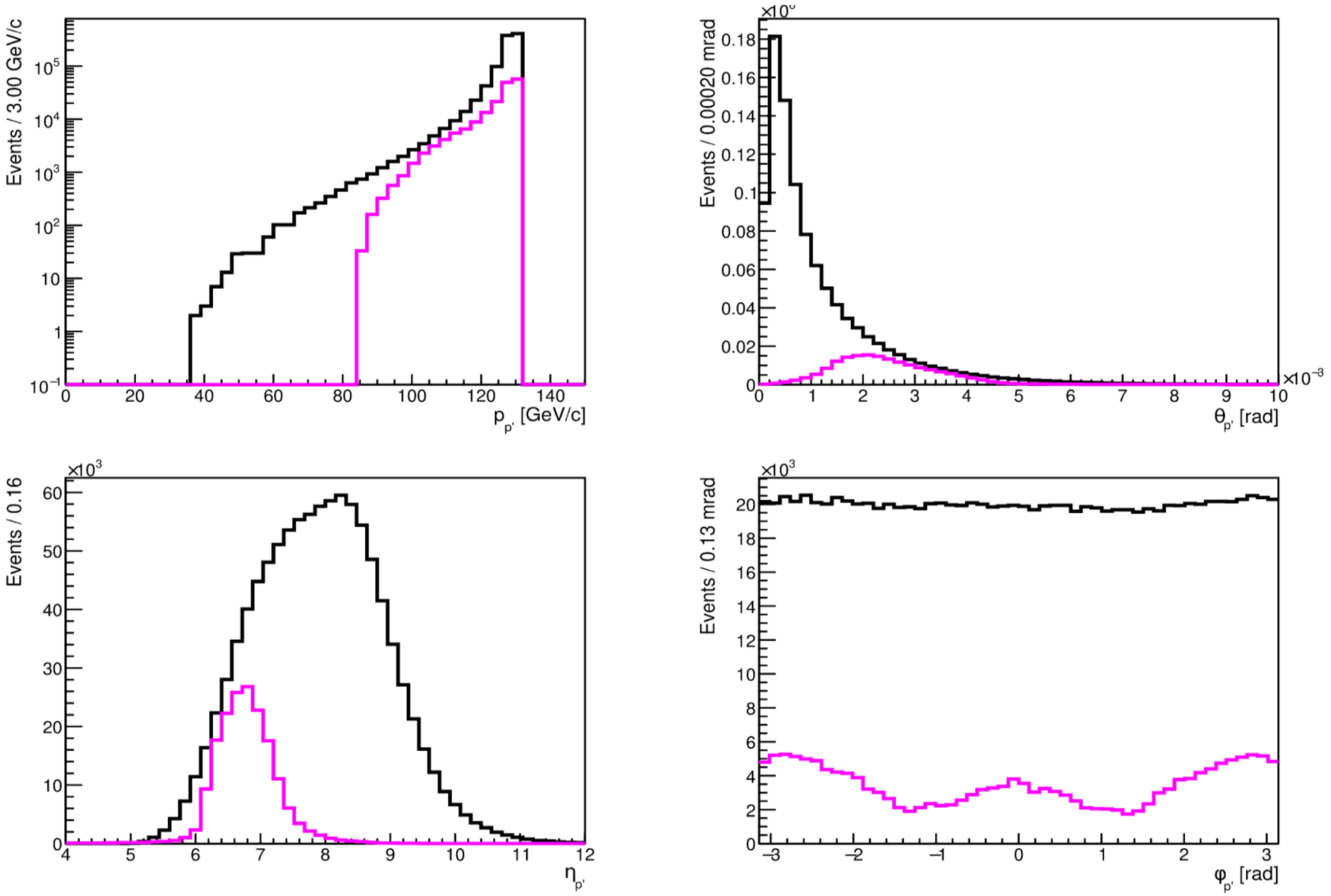


Figure 6. Truth (black) and Reco (magenta) **p**, **θ**, **η**, **ϕ** of recoil proton measured in (predominantly) the forward roman pots.

Most events occur at very small (forward) angle for the recoil proton

Total acceptance : 17.5%,

Proton fairly well reconstructed within fiducial region of forward roman pots.

Few protons measured in B0 at this kinematic setting.

Acceptance here is the largest effect on total exclusive statistics. Prompts the consideration of measuring missing proton topology.

Missing Electron Topology

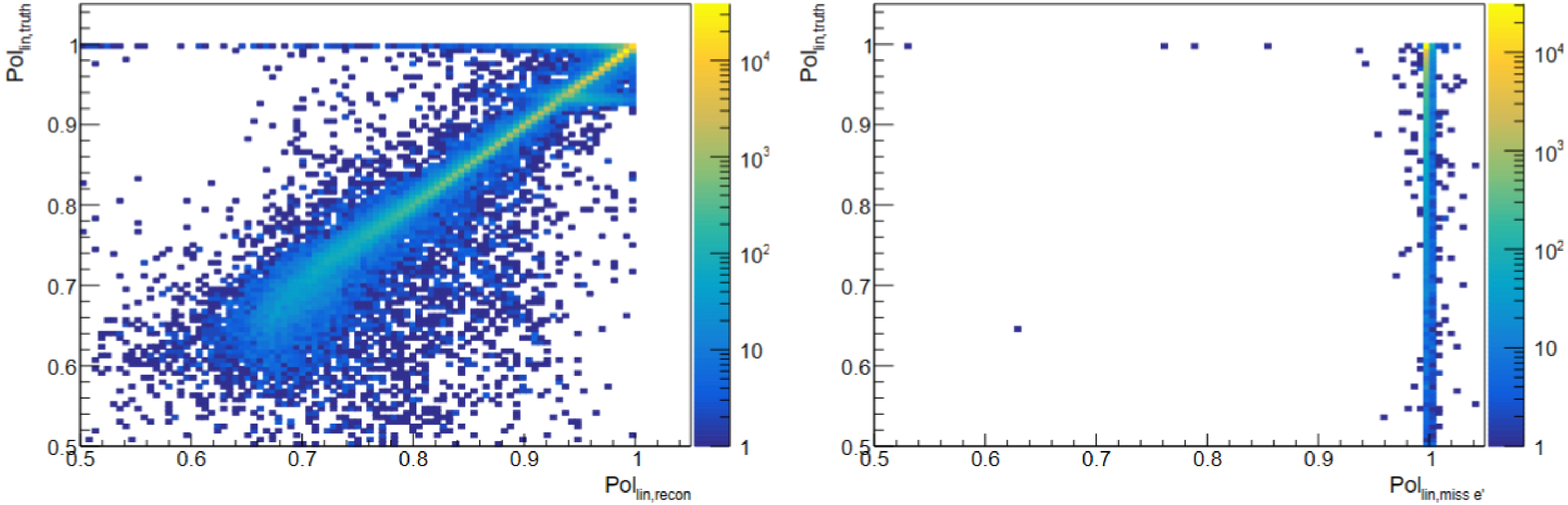


Figure 7. Correlations of truth and reconstructed linear polarisation of the quas-real photon. (Left) Truth against tagged from Low-Q2 tagger and (Right) truth against reconstructed from measured photon and recoil proton.

When we don't measure the scattered electron in the tagger, we completely lose sensitivity to the linear polarisation of the transferred photon in the reaction, limiting ability to access the GPDs entering the INT term i.e. through BSA's.

Fully Exclusive Topology

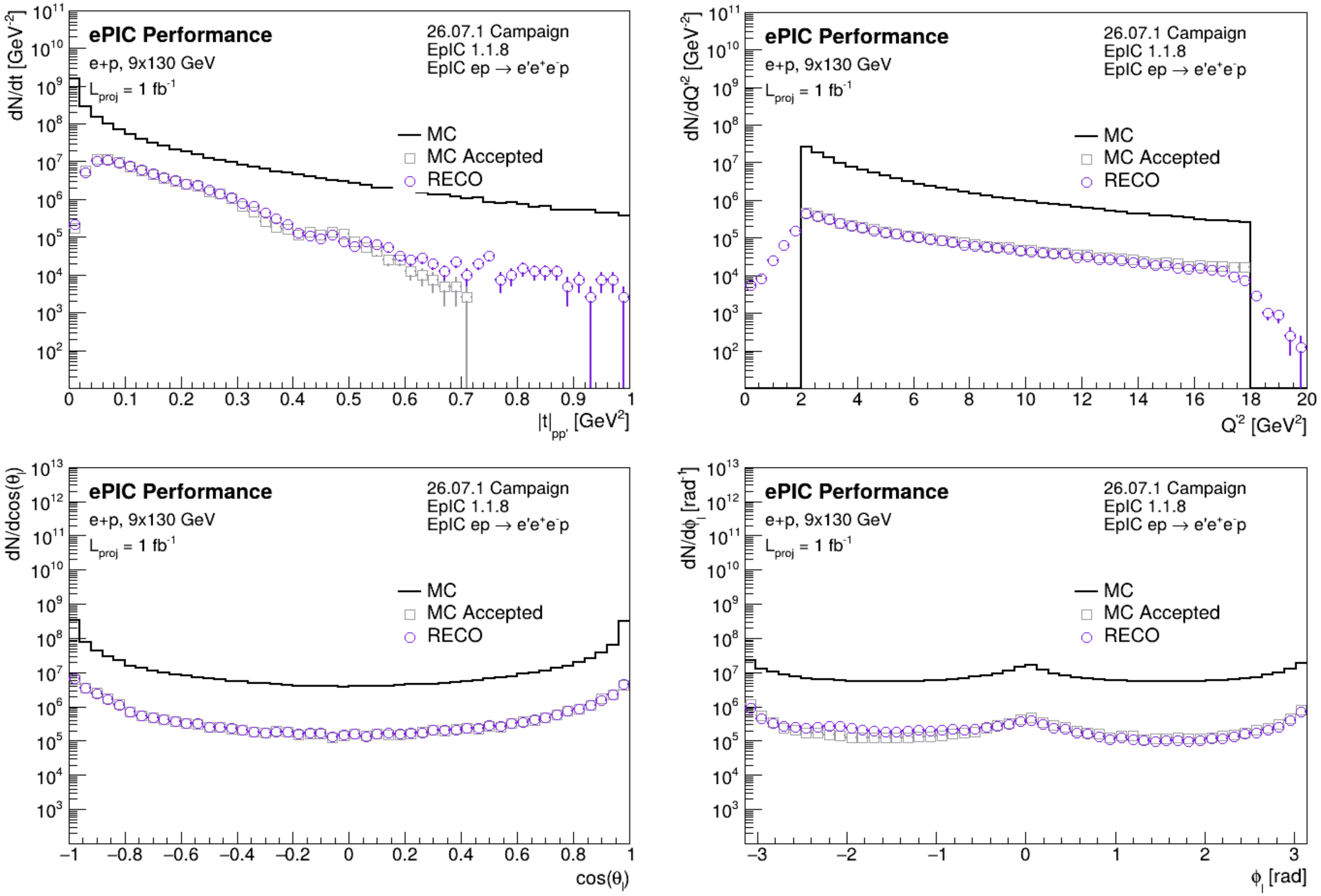


Figure 8. Differential rates for Qp2, |t| costh and phi, which enter the 4-fold TCS cross section

Final folded acceptance out of 1M generated events is 3.0%

Generator cross section: 5nb

Projected Integrated Lumi: 1fb^{-1}

Projected total stats: 150k

Event selection fairly clean due to lack of combinatorial backgrounds

2. Backgrounds

Tagger Bremsstrahlung Background (9x130)

Workflow:

1. Simulate 100k TCS signal events & 200M Bremsstrahlung background events

2. Using Eic/TimeFrameMerger: merge Bremsstrahlung BG events into TCS signal at an approx ratio of 2000:1 i.e. ~10 brem every 10ns, for 2us Timeframe.

3. Result – 100k events containing a physics signal and large (close to physical) tagger background separated in time by bunch crossings!

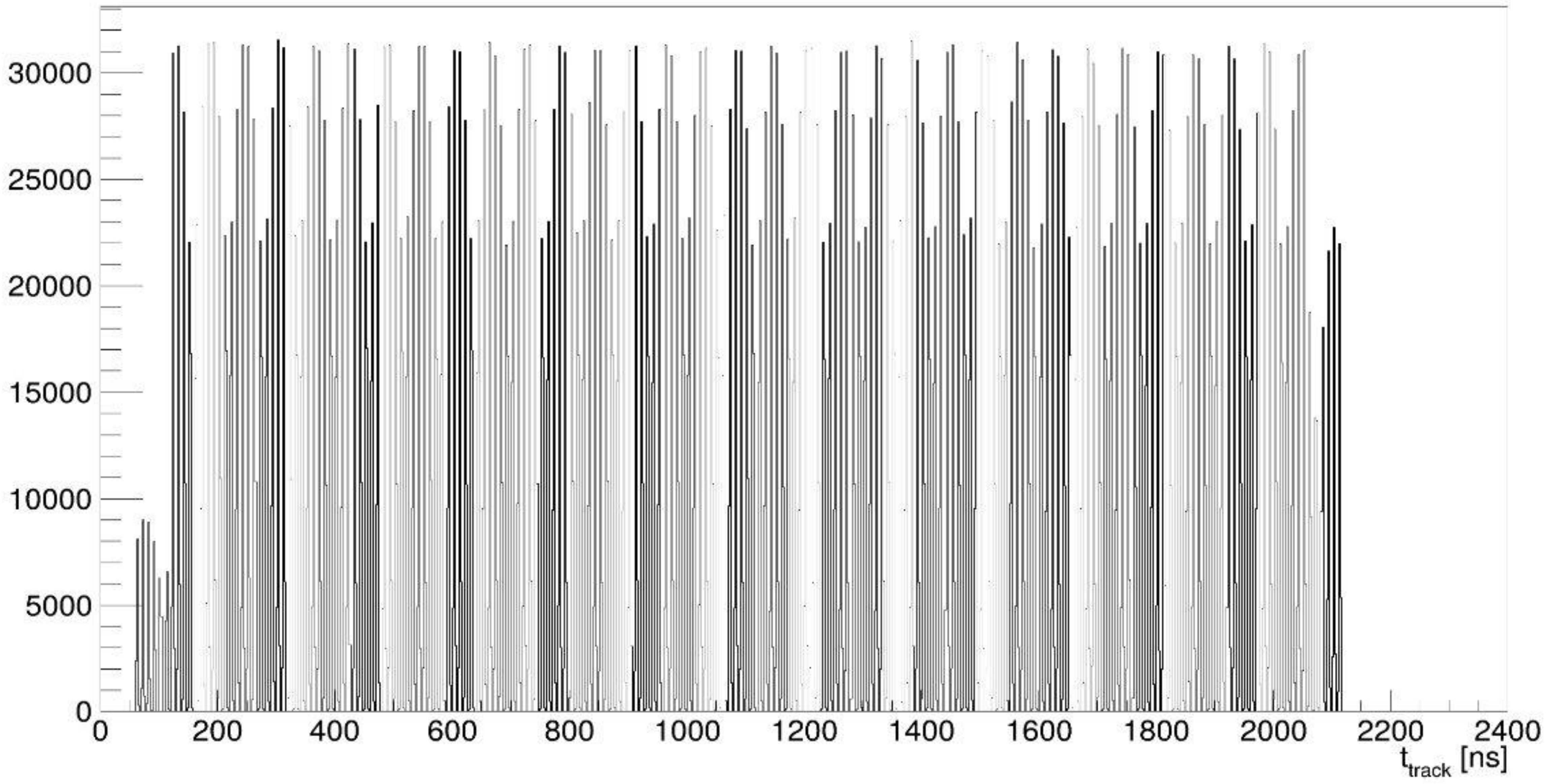
Additional Work Required:

1. Fixed tagger track containers in eicrecon to propagate track information to the reconstructed particle level and build the associations -> access track time of particle in analysis!!

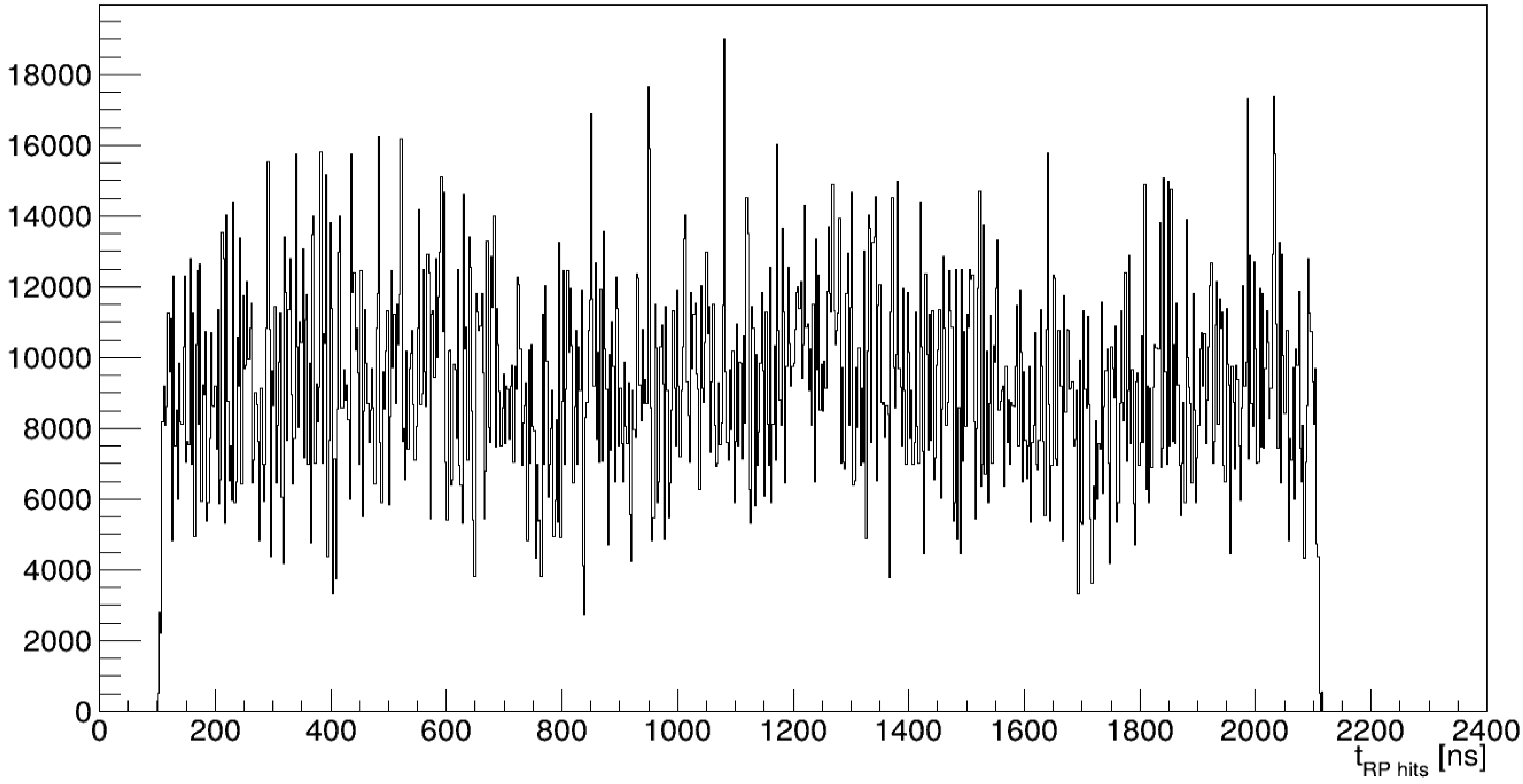
2. Construct a time from romanpots hits in event which contained a roman pot reconstructed particle and assume that the hit times are correct for that track.

3. Construct coincidence time in offline analysis for all combinatorial events.
4. Propagate all of these extra pieces of machinery through RAD analysis framework

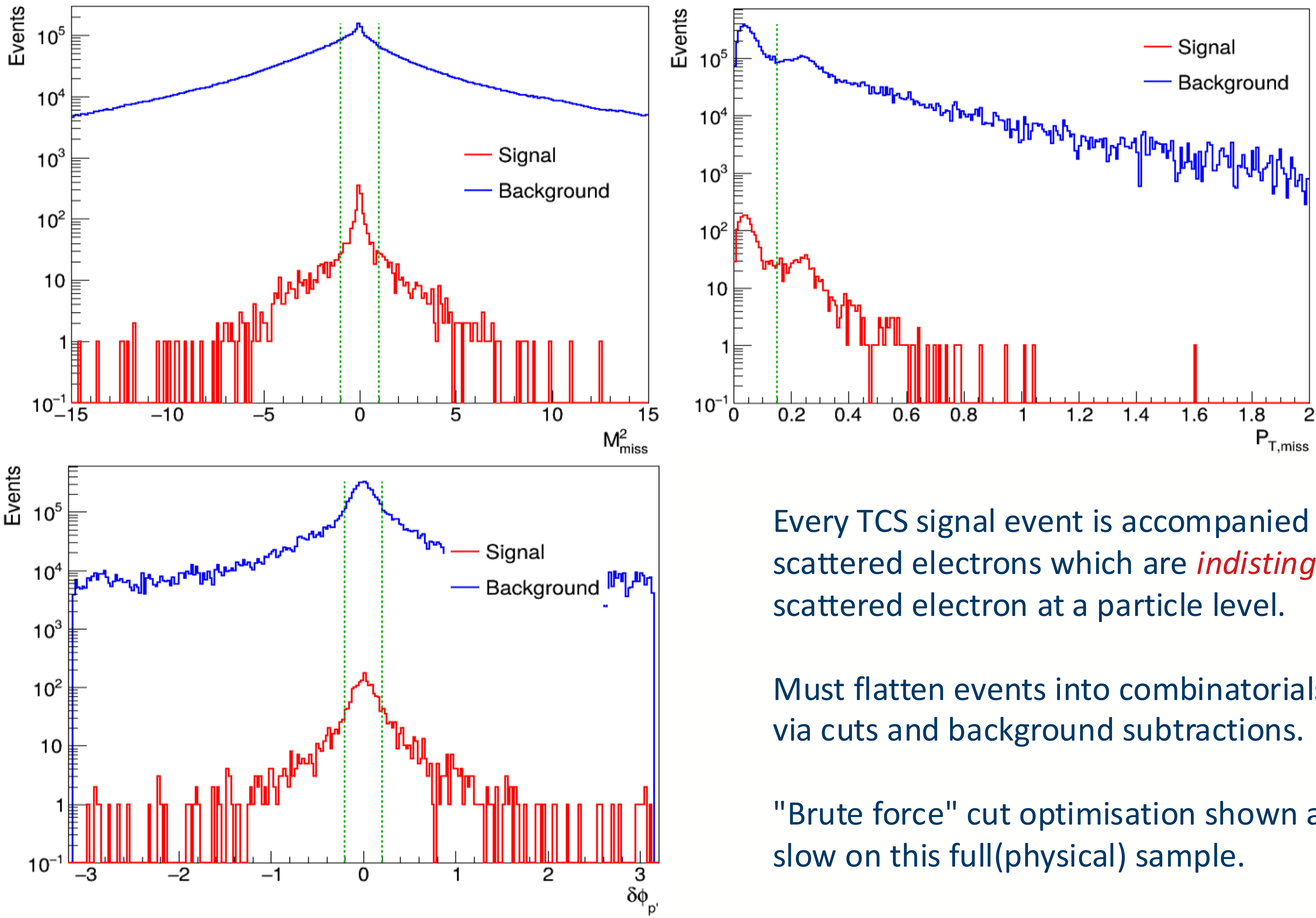
Tagger Time (Scattered Electron)



Roman Pots Hit(s) Time (Recoil Proton)



Combinatorial Background on Exclusive Reconstruction



Every TCS signal event is accompanied by multiple Brem BG scattered electrons which are *indistinguishable* from the true scattered electron at a particle level.

Must flatten events into combinatorials and deal with background via cuts and background subtractions.

"Brute force" cut optimisation shown a few weeks ago is fairly slow on this full(physical) sample.

Combinatorial Timing Coincidence

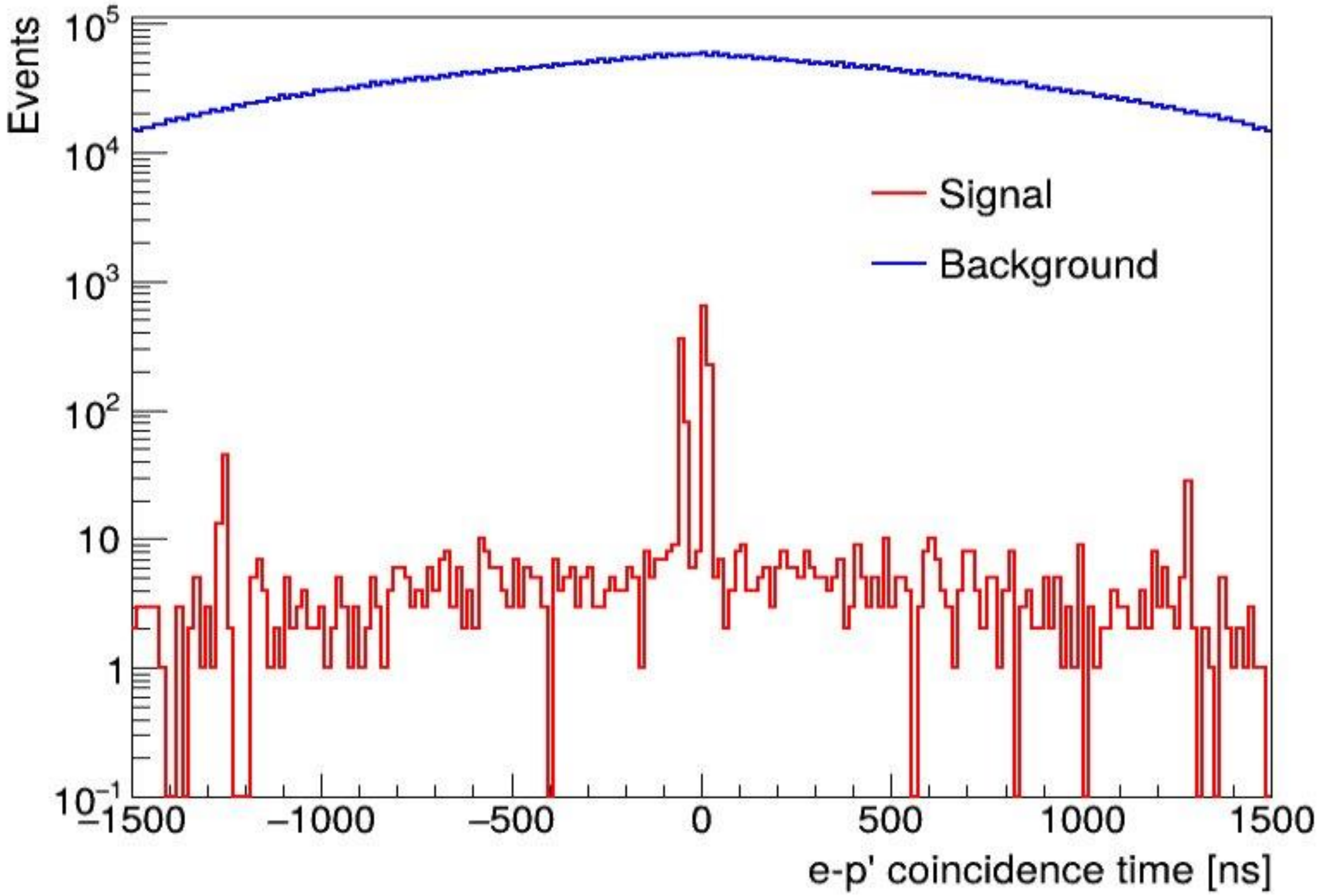


Figure 8. Coincidence time between tagger scattered electron and hits from roman pot in events with a roman pot track.

Signal to background ratio before cuts:

2201 / 7817259 = 0.00028

After:

757 / 464616 = 0.0016

~Factor 5 reduction in S/B

Next: optimisation of cuts and resolving signal peaks in full data.

Thank You!

Missing Proton Topology

Coming Soon

Machine Backgrounds (18x275)

Currently only produced for 26.02 campaign @ 18x275 energy configuration, but we can analyse and get a rough benchmark

Coming Soon

Pythia Physics Backgrounds

Coming Soon

3. Phenomenology

Binned Asymmetries vs Existing Results

Coming Soon

Brufit Analysis

Coming Soon