

DSC-FBWD high rate trackers

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The logo for the Electron-Ion Collider User Group Meeting 2023. It features the letters 'E', 'I', 'C', 'U', and 'G' in a stylized font. 'E' is orange, 'I' is dark blue, 'C' is white, 'U' is dark blue, and 'G' is white with a dark blue outline. To the right of 'G' is the year '2023' in orange. The entire logo is set against a blue rectangular background.

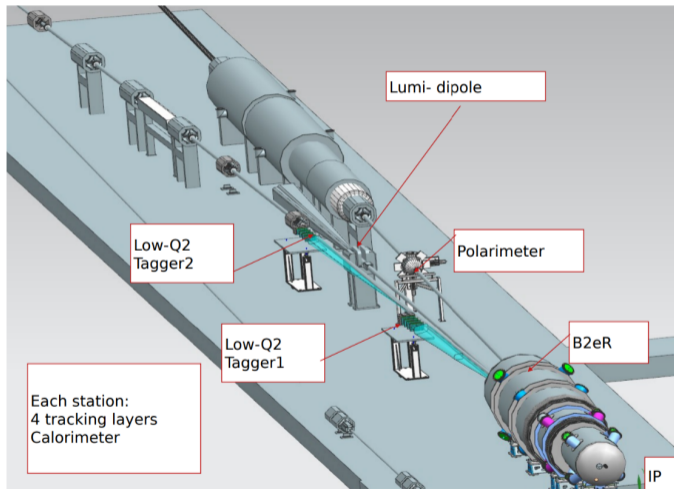
EICUG 2023

Electron-Ion Collider User Group Meeting 2023

Warsaw, July 29, 2023

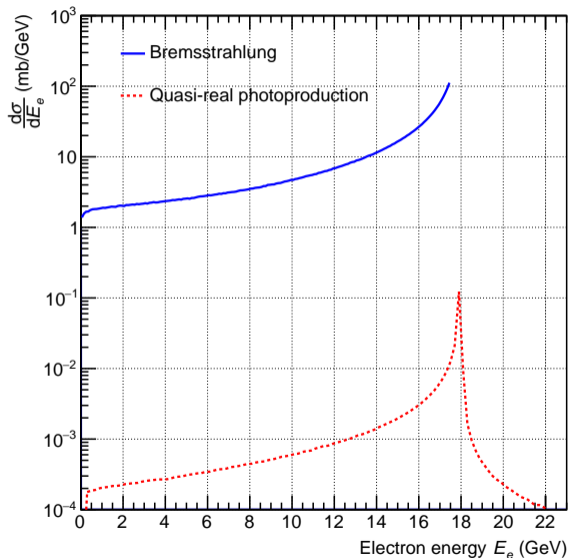
Introduction

- Jaroslav Adam (Project Lead)
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- Simon Gardner (Technical Lead)
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- Two low- Q^2 tagger detectors along outgoing electron beam pipe
- Placed at about -20 m and -36 m from IP



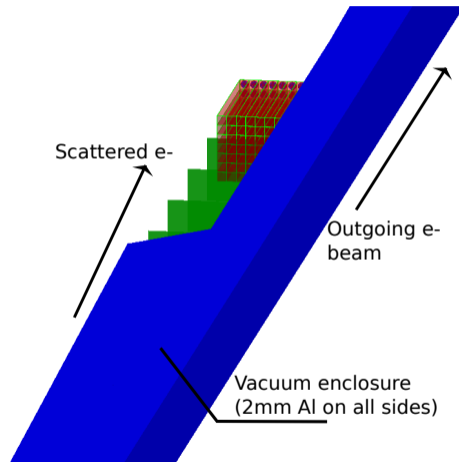
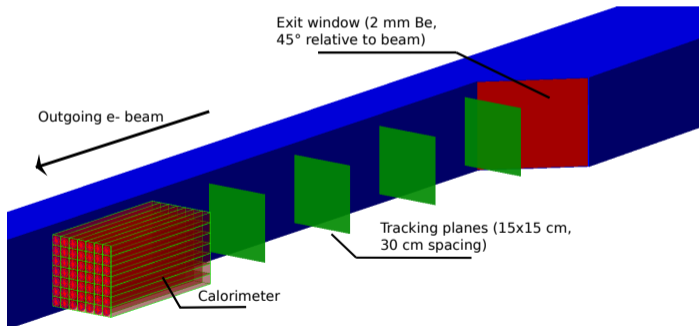
Physics for low- Q^2 taggers

- Photoproduction in $10^{-3} \lesssim Q^2 \lesssim 10^{-1} \text{ GeV}^2$
- Scattered electrons for meson spectroscopy and exclusive pair production
- Help for luminosity measurement by coincidence with pair spectrometer
- Large background and event rates due to Bethe-Heitler bremsstrahlung – illustrated by comparing to photoproduction cross section
- The background can be mitigated by good tracking and Q^2 reconstruction



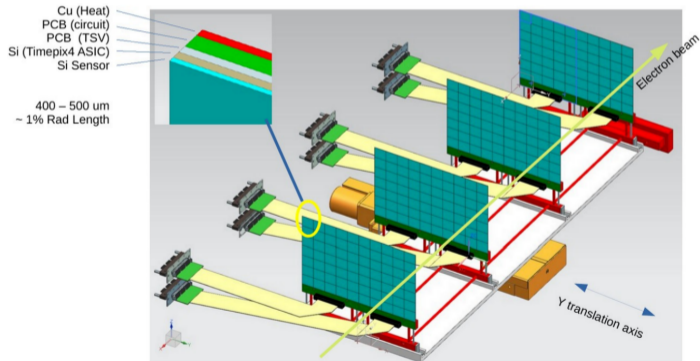
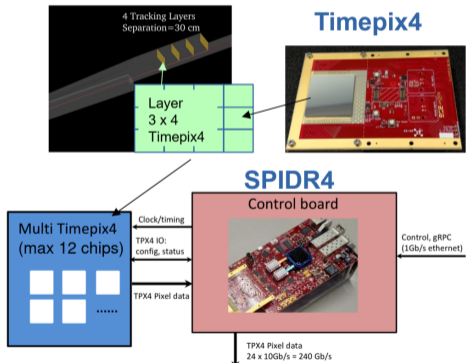
Geometry layout

- Detectors outside beam vacuum
- Several considerations for exit window (material, thin mesh followed by 90° exit window)



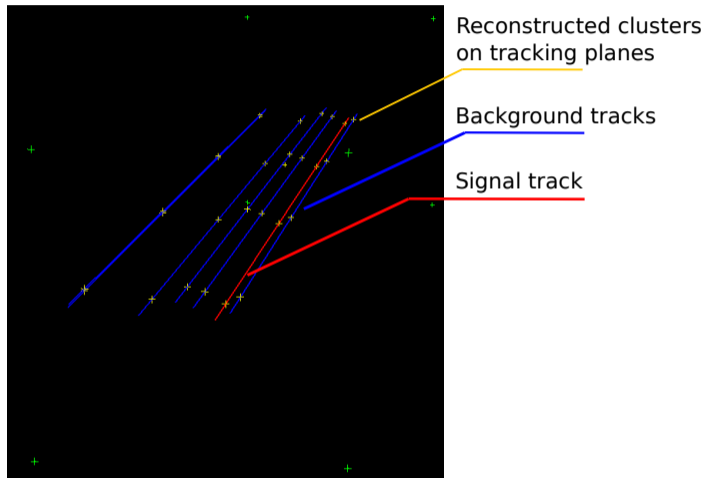
Tracker technology

- Timepix4 ASIC + silicon sensor, $\sim 50 \mu\text{m}$ thickness
- Pixels of $\sim 55 \mu\text{m}$ size
- Timing resolution of about 2 ns



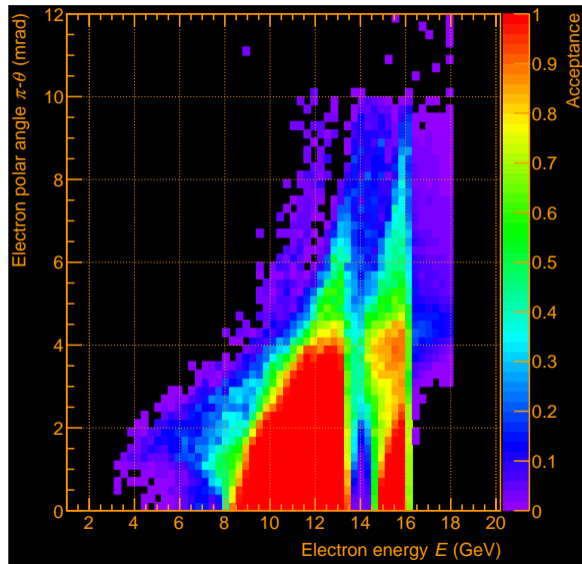
Tracking implementation

- Clustering is done in each plane
- 4-fold loop over all clusters on all 4 planes
- Every cluster combination is tested against a χ^2 limit
- No seeding is necessary, still good performance
- Event display shows mixed sample of signal and background processes
- Associations between tracks and MC particles are done after reconstruction



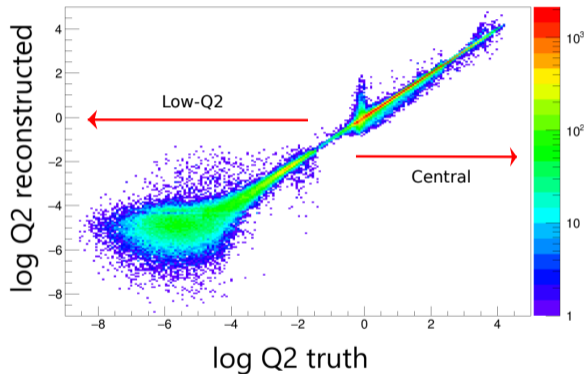
Tagger acceptance in electron energy and polar angles

- Fraction of events having track reconstructed in one of tagger detectors
- Evaluated with a sample of photoproduction events (quasi-real) approximation



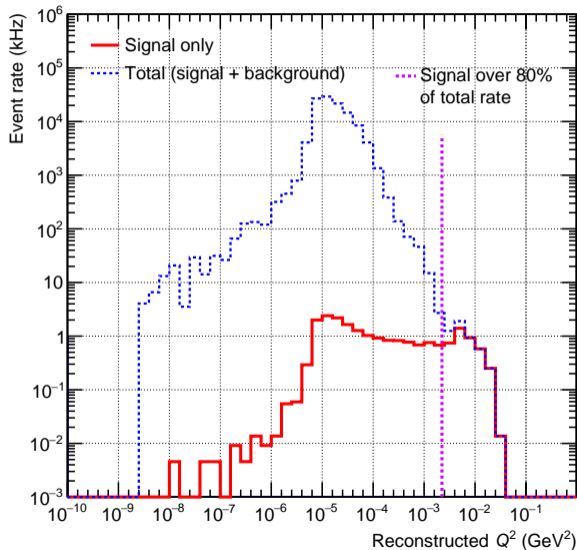
Q^2 reconstruction

- Two different ML algorithms giving compatible results
- The algorithms connect reconstructed tracks to kinematics of original scattered electrons (energy and polar and azimuthal angle)
- Q^2 is obtained from electron energy and polar angle
- Plot shows combined reconstruction in low- Q^2 taggers and central detector



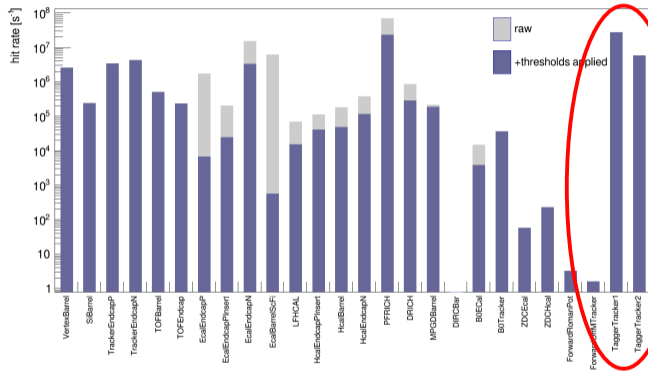
Event rate

- Mixed hepmc of signal (quasi-real photoproduction) and background (Bethe-Heitler) events
- Event rates are obtained as a function of reconstructed Q^2
- Background tracks reconstruct dominantly to very low Q^2



Beam-gas background

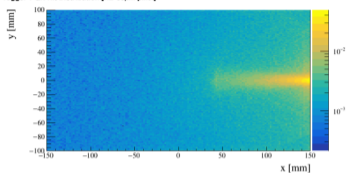
- Interaction of electron beam on residual gas
- May come not in time with expected bunch crossing
- Rates are comparable to those from the signal
- Beam-gas events originating in B2eR dipole to be included



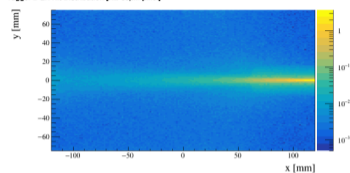
Hit rates at the level of single pixels

- Signal from quasi-real (QR) photoproduction
- Comparison to two background sources:
- Bethe-Heitler bremsstrahlung
- Electron beam-gas

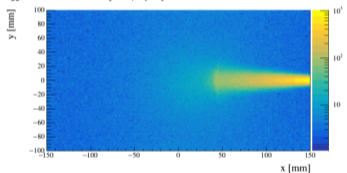
Tagger 1 QR Hit Distribution [Hz/ 55 μ m pixel]



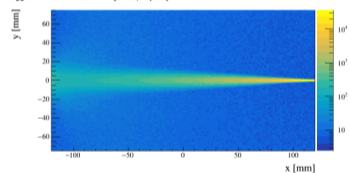
Tagger 2 QR Hit Distribution [Hz/ 55 μ m pixel]



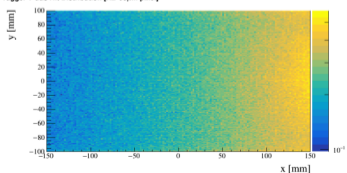
Tagger 1 Brem Hit Distribution [Hz/ 55 μ m pixel]



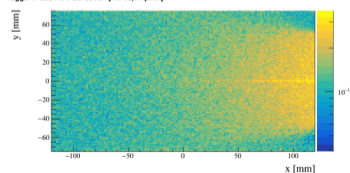
Tagger 2 Brem Hit Distribution [Hz/ 55 μ m pixel]



Tagger 1 Gas Hit Distribution [Hz/ 55 μ m pixel]



Tagger 2 Gas Hit Distribution [Hz/ 55 μ m pixel]



Summary and loose ends

- Basic MC for reconstruction, works to separate signal from background in mixed events
- Currently work in progress:
 - ▶ Implementation in dd4hep
 - ▶ Full sample of beam-gas events (including events inside the B2eR)
 - ▶ Detector optimization, signal extraction in tagger 2 (further from IP)
- Still to be done:
 - ▶ Synchrotron radiation
 - ▶ Exit window complying with impedance
 - ▶ Detector tests, estimates for services