Low-Q^2 tagger

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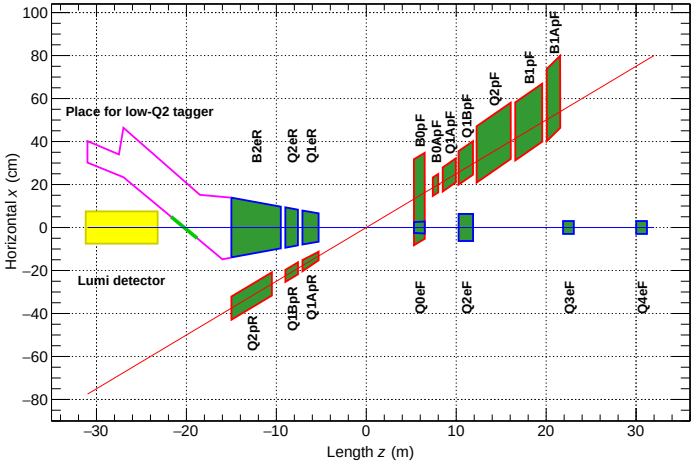
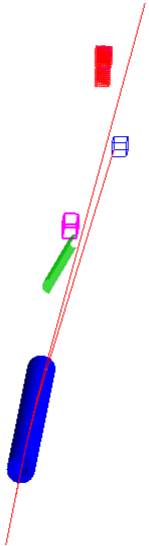
Introduction

- Studies on characteristics of low-Q^2 tagger aimed for electrons scattered at very small angles
- Geant4 model for the tagger was added to luminosity framework, along with B2eR magnet
- Acceptance in Q^2 will be shown with a custom-made generator of scattered electrons and with Pythia6



Low-Q^2 tagger in Geant4



- The tagger is represented as the box right to the luminosity system
- Beam electron and scattered electron are passing through the B2eR dipole magnet
- The scattered electron is stopped in the tagger
- The edge of the tagger is placed 10 cm away from the axis of the beam, z = 27 m
- For the acceptance studies shown here, the tagger is implemented as a box 20x20 cm, length 35 cm
- The tagger stops the track and marks the hit (no secondaries)

Model of quasi-real photoproduction

- Event generator implemented to *lgen* using one photon exchange cross section from HERA study in Conf.Proc. C790402 (1979) 1-474
- The parametrization for quasi-real photoproduction in low-Q^2 approximation (Eq. II.6 in HERA study) is

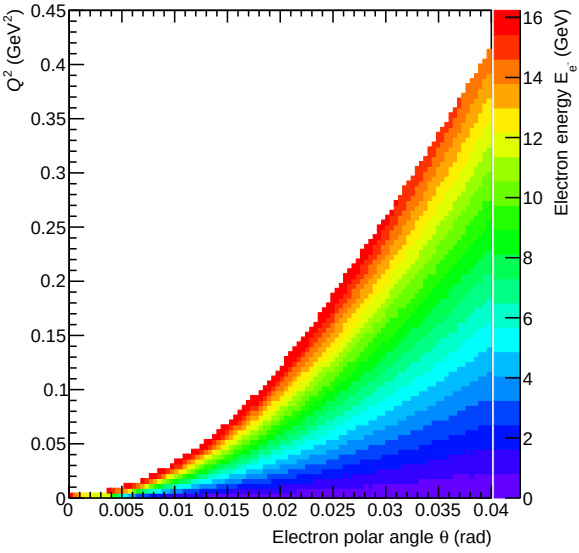
$$\frac{\mathrm{d}^2\sigma}{\mathrm{d}x\mathrm{d}y} = \frac{\alpha}{2\pi}\,\frac{1+(1-y)^2}{y}\,\sigma_{\gamma p}(ys)\,\frac{1-x}{x}\,(\mathrm{mb}) \tag{1}$$

- The total photon-proton cross section $\sigma_{\gamma p}$ is used from Regge fit in Phys.Lett. B296 (1992) 227-232:

$$\sigma_{\gamma p}(ys) = 0.0677(ys)^{0.0808} + 0.129(ys)^{-0.4525}\,(\mathrm{mb}) \tag{2}$$

- Equation 1, with input from Eq. 2, is used to generate values of Bjorken x and inelasticity y
- Kinematics is then applied to generate the electrons with output to TX or Pythia6 format
- Similar procedure was used for H1 low-Q^2 tagger in H1-04/93-287 (1993)

Scattered electrons from quasi-real photoproduction



- Relation between electron scattering angle θ and Q^2
- The colors give the electron energy E_{e^-}
- Beam energy is 18x275 GeV
- Compatible with Fig. 2.20 in pCDR, page 90
- Values of low Q^2 are reached at very small angles

Distribution of Q^2 for quasi-real photoproduction and Pythia6

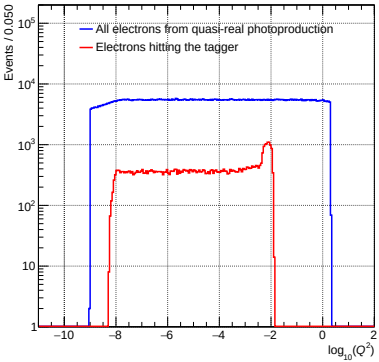


Figure: Quasi-real photoproduction

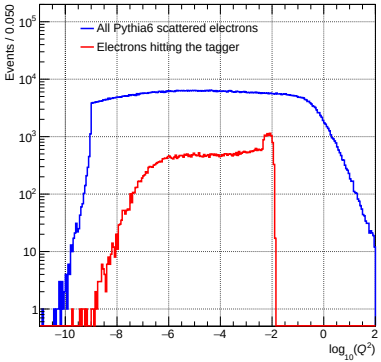
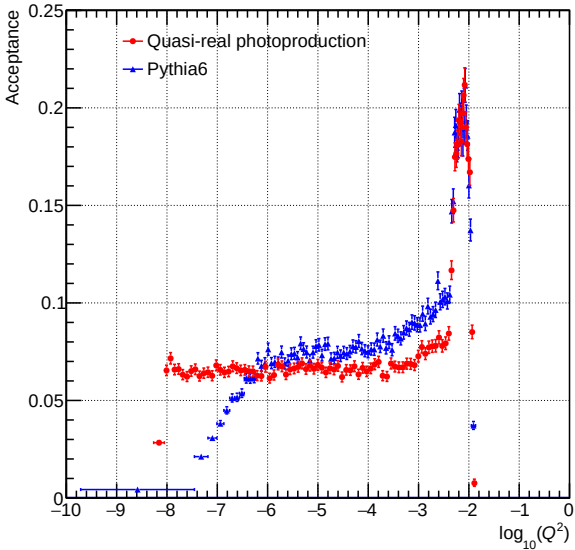


Figure: Q^2 of Pythia6 events

- Geant4 simulation of 1M events in each case
- Scattered electrons pass through the B2eR magnet
- The tagger counts the electrons which hit its volume
- The sample of electrons hitting the tagger also has a requirement for scattering angle θ to pass the B2eR aperture

- Quasi-real photproduction has range in x as $[10^{-12}, 1]$, range in y is $[1.6 \times 10^{-4}, 1]$ and range in Q^2 is $[10^{-9}, 2]$
- Approximately same intervals in x and y hold for Pythia6 sample, lower limit in Q^2 is also $\sim 10^{-9}$

Acceptance in Q^2



- Determined as a ratio of events hitting the tagger to all generated events
- Both models provide consistent results
- The acceptance has onset at $Q^2 \sim 10^{-2}$ GeV^2 (with decreasing Q^2)
- Lower limit of the acceptance is $Q^2 \lesssim 10^{-7}$ GeV^2

Kinematics of electrons hitting the tagger

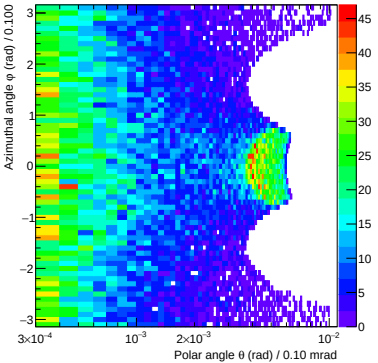


Figure: Electrons scattering angle θ and azimuthal angle φ for electrons hitting the tagger

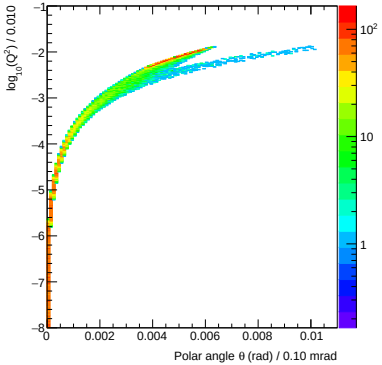


Figure: Q^2 and θ for electrons hitting the tagger

- Azimuthal angles φ are generated as uniform
- Electrons can reach the tagger from any ϕ
- Values of Q^2 and scattering angle θ for electrons which hit the tagger are strongly correlated

Hit positions on the front face of the tagger

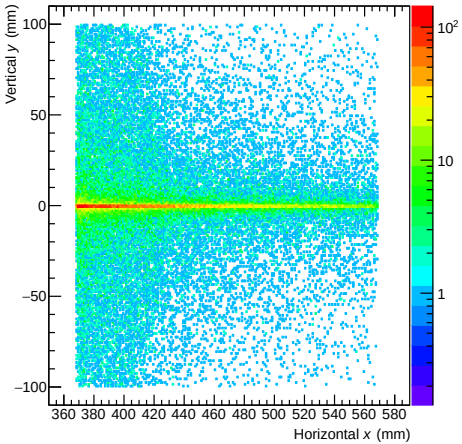


Figure: Hits on the tagger for scattered electrons from quasi-real photoproduction

- Coordinate position of electrons hitting the tagger on the front face of the tagger
- Most of the electrons are confined in horizontal plane
- Most hits take place in positions closer to the beam

Summary

- Upper range of tagger acceptance is $Q^2 \sim 10^{-2}$ GeV^2
- Confirmed by the model of quasi-real photoproduction and by Pythia6
- The upper limit is a result of B2eR (and the entire beamline) aperture, very unlikely to change
- Lower limit is $Q^2 \lesssim 10^{-7}$ GeV^2, depends on the actual physics process
- Achieved with the tagger placed 10 cm away from the axis of the beam
- Working now on a realistic model of the tagger detector and incorporation of beam effects
- Codes for Geant4 simulations are here: https://github.com/adamjaro/lmon
- Codes for event generators are here: https://github.com/adamjaro/eic-lgen