Roman Pot approach for tagger detectors

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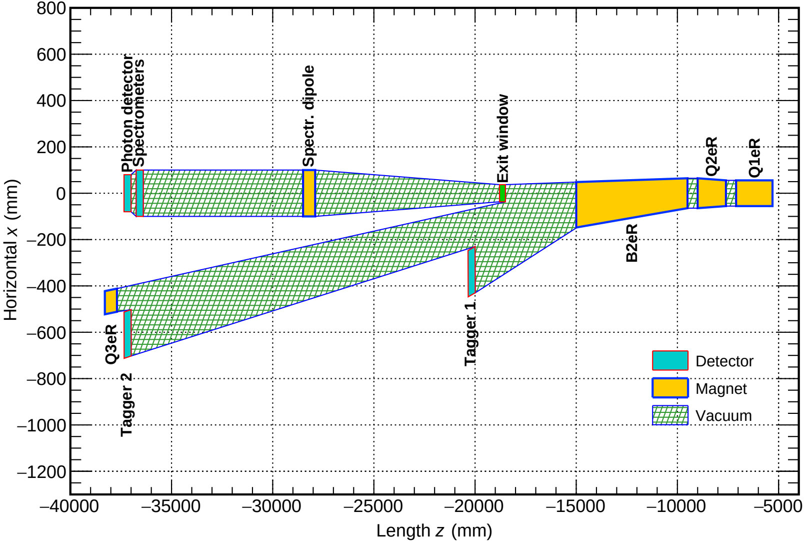
Far-backward meeting

Taggers in the proposal version

- Two detectors at a line connecting B2eR and Q3eR inner radii



Observed event rate per unit area

- Event rate R_A in mm^{-2}s^{-1} observed on surface area A in mm^2 is

$$R_A = \left(1 - e^{-\frac{N_h}{N_i}\lambda}\right) \times \frac{1}{T_b} \times \frac{1}{A}$$

- N_i is number of simulated individual *ep* interactions (bremsstrahlung or quasi-real)
- N_h is number of observed hits on surface area A out of the N_i simulated interactions
- T_b is bunch spacing in seconds
- $\lambda = \sigma \times \mathcal{L}_b$ is mean number of interactions per bunch crossing
- σ is interaction cross section in mb (bremsstrahlung or quasi-real) used for N_i simulated events
- $\mathcal{L}_b = 10^{-27} \times L_i \times T_b$ is luminosity per bunch crossing in mb^{-1}
- L_i is instantaneous luminosity in cm$^{-2}s^{-1}$ from CDR Table 3.3
- The bunch spacing $T_b = \frac{l}{\beta \times c \times n_b}$ where l = 3834 m is collider circumference, βc is speed of the beam in ms^{-1} and n_b is number of bunches from CDR Table 3.3

Event rates on tagger 1, 18x275 GeV

Figure: Bremsstrahlung, tagger 1

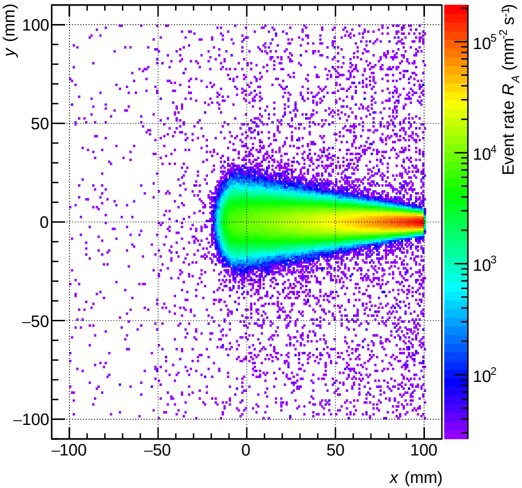
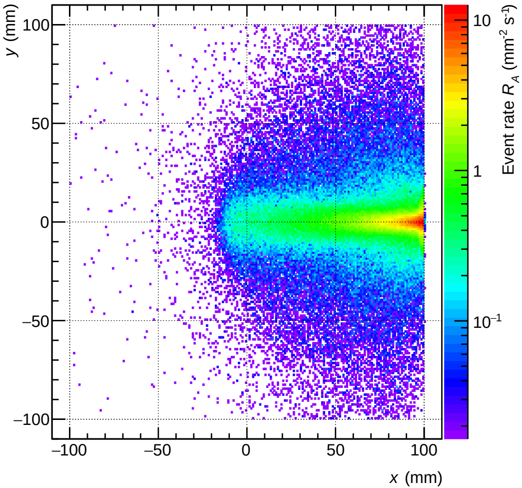


Figure: Quasi-real photoproduction, tagger 1



Event rates on tagger 2, 18x275 GeV

Figure: Bremsstrahlung, tagger 2

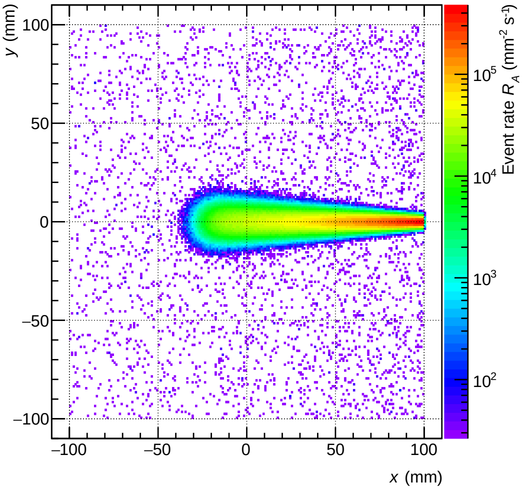
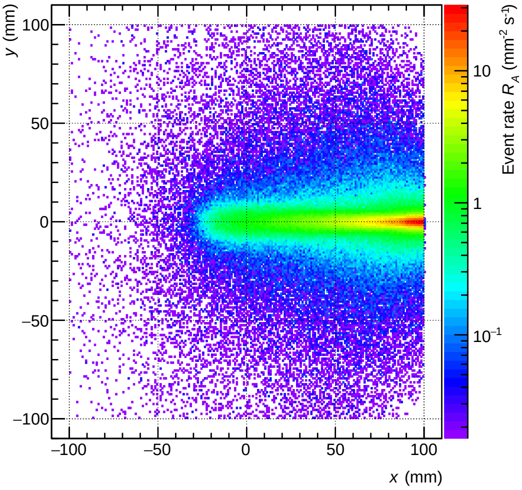


Figure: Quasi-real photoproduction, tagger 2



Roman Pots for low-Q^2 taggers

- Each tagger consists of 3 tracking layers (labeled A, B and C), 15x15 cm^2, placed 30 cm after each other
- The layers are placed with 5 cm between its closest edge and beam axis
- Layers for tagger 1 are at -20 m from IP, tagger 2 is -36.5 m
- Track is accepted in the tagger by coincidence in all 3 layers
- The layers are implemented as counting planes to show feasibility of electron reconstruction
- Beam σ in x is 2.3 mm at -20 meters (tagger 1) and 1.6 mm at -36.5 meters (tagger 2)

Tagger geometry

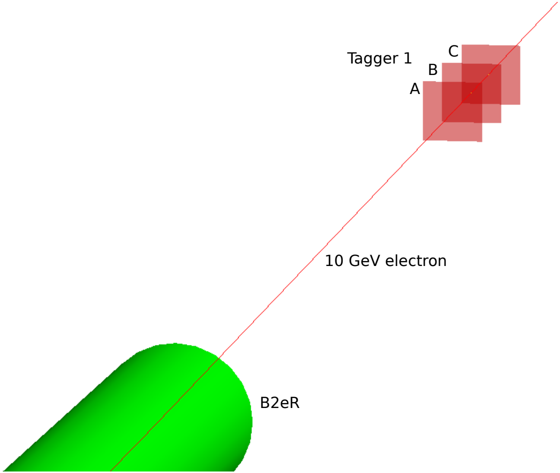


Figure: Tagger 1

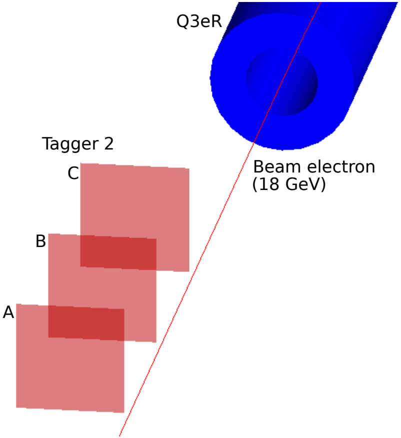


Figure: Tagger 2

Reconstruction in Roman Pots taggers

- Each tagger (its 3 layers) measures track position on its plane, x and y and track angles in the respective directions, θ_x and θ_y
- Machine learning algorithm was developed to relate measured quantities x, y, θ_x and θ_y with electron energy, polar angle and azimuthal angle, E_e, θ_e and ϕ_e
- The algorithm was trained using sample with uniform energy and angular distribution
- During reconstruction the algorithm provides electron E_e, θ_e and ϕ_e for a set of measured x, y, θ_x and θ_y as obtained for a given track in tagger
- The reconstruction was applied to quasi-real photoproduction and Pythia 6
- Performance will be shown next for reconstructed E_e, θ_e and ϕ_e from quasi-real events (is similar to Pythia 6) and for Q^2 for both generators
- Comparison will be made to the yield of reconstructed Q^2 for bremsstrahlung

Energy reconstruction in RP taggers, quasi-real photoproduction

- Reconstructed energy is compared to generated true electron energy

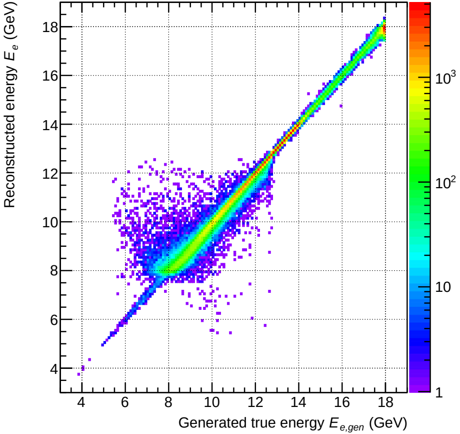


Figure: Tagger 1

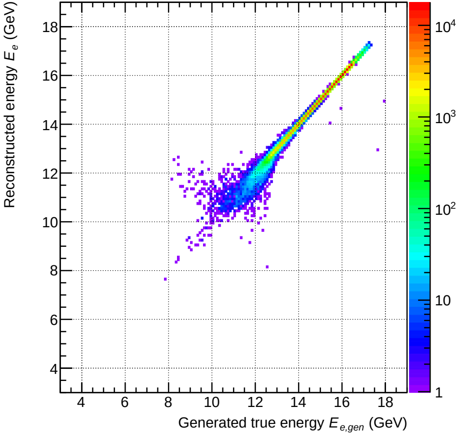


Figure: Tagger 2

Polar angle reconstruction in RP taggers, quasi-real photoproduction

- Reconstructed θ_e is compared to generated true electron θ_e

Figure: Tagger 1

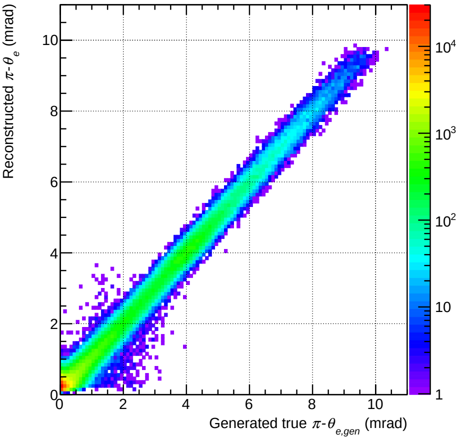
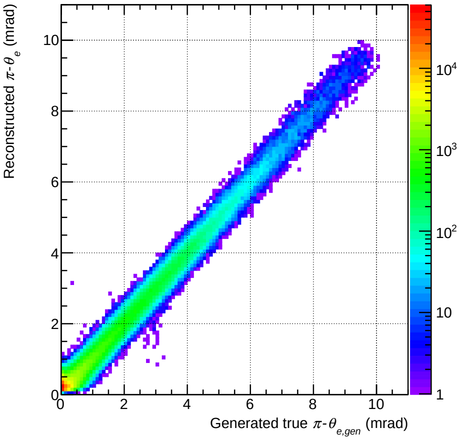


Figure: Tagger 2



Azimuthal angle in RP taggers, quasi-real photoproduction

- Reconstructed ϕ_e is compared to generated true electron ϕ_e

Figure: Tagger 1

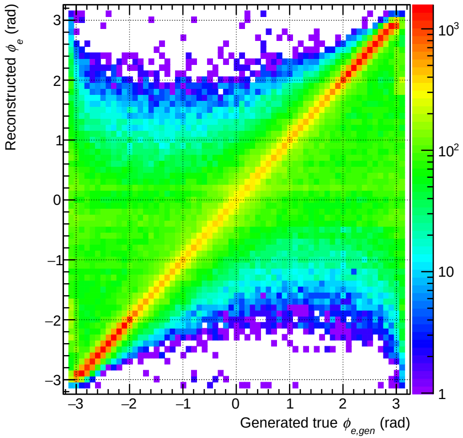
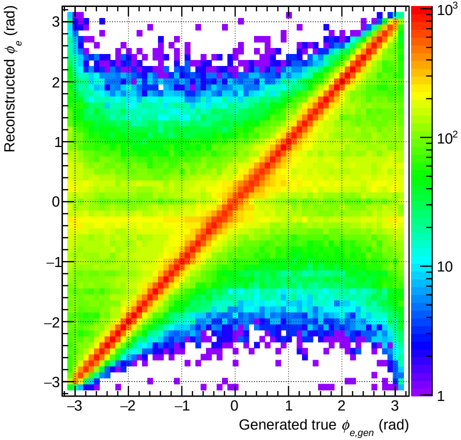


Figure: Tagger 2



Azimuthal angle in RP taggers with lower limit on polar angle

- Limit of 1 mrad is imposed on reconstructed polar angle

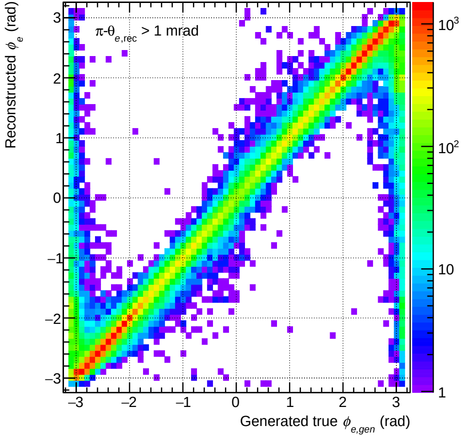


Figure: Tagger 1

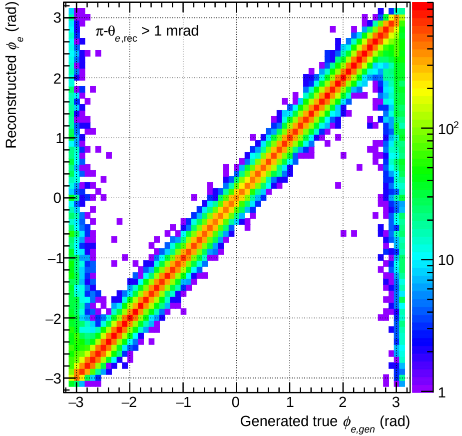


Figure: Tagger 2

Q^2 reconstruction in RP taggers for quasi-real photoproduction

- Reconstructed Q^2 is compared to generated true Q^2 from quasi-real photoproduction

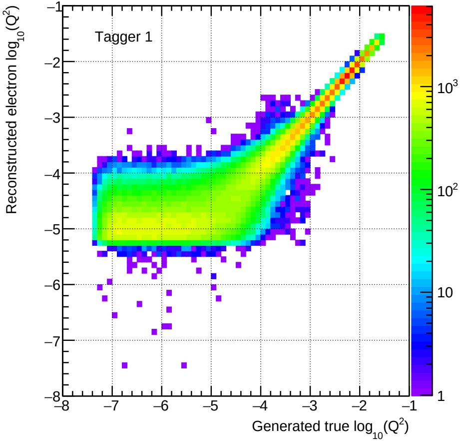


Figure: Tagger 1, quasi-real

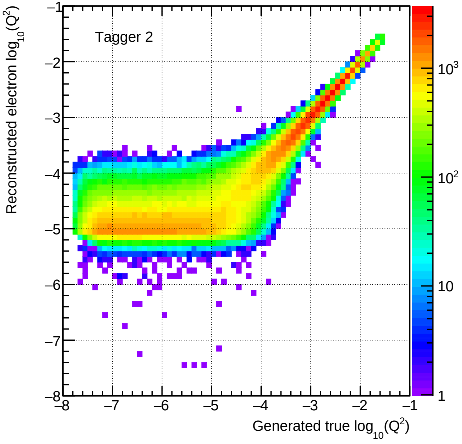


Figure: Tagger 2, quasi-real

Q^2 reconstruction in RP taggers for Pythia 6

- Reconstructed Q^2 is compared to generated true Q^2 from Pythia 6

Figure: Tagger 1, Pythia 6

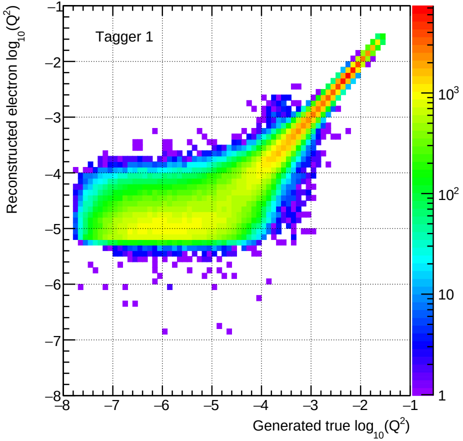
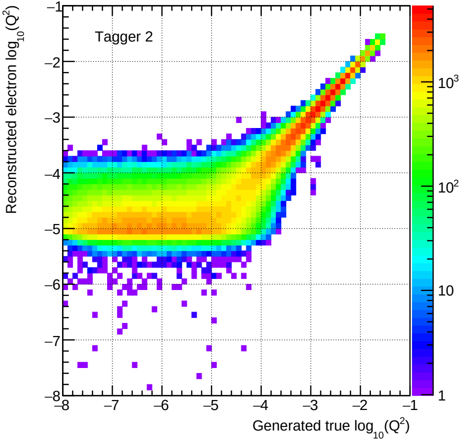


Figure: Tagger 2, Pythia 6



Spectrum of reconstructed Q^2

- Reconstructed Q^2 is shown for bremsstrahlung, quasi-real photoproduction and Pythia 6
- Generated true Q^2 for bremsstrahlung in consistent with zero
- Distributions are normalized to integrated rate for each process
- Bremsstrahlung electrons reconstruct to the lowest values
- Opportunity to extract clean photoproduction over a limited interval in Q^2

Figure: Tagger 1

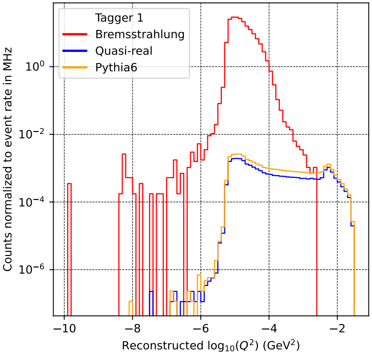
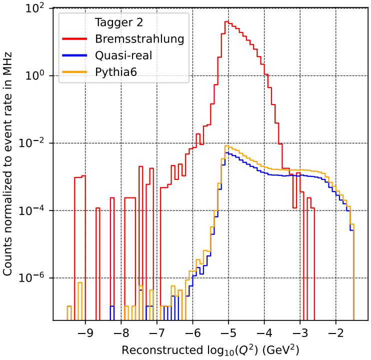


Figure: Tagger 2



Summary

- Step in reconstruction from tagger tracks to electron E_e, θ_e, ϕ_e and Q^2 works up to limit by beam divergence
- Help from Geant truth was used to find electron tracks as hits from a primary track
- The hits were transformed to a frame where they are aligned along z and centered at $xy = 0$
- Measured quantities x, y, θ_x and θ_y were found by geometry relations
- Once the electron tracks are properly identified by the tracking layers, full electron reconstruction is feasible
- Region around $Q^2 = 0.01$ GeV^2 is free of bremsstrahlung, despite its larger rate
- Machine learning implementation is here:
  github.com/adamjaro/lmon/blob/master/src/EThetaPhiReco.cxx
  github.com/adamjaro/lmon/blob/master/include/EThetaPhiReco.h