Far-backward update

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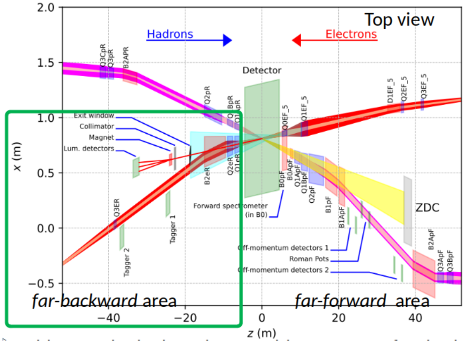
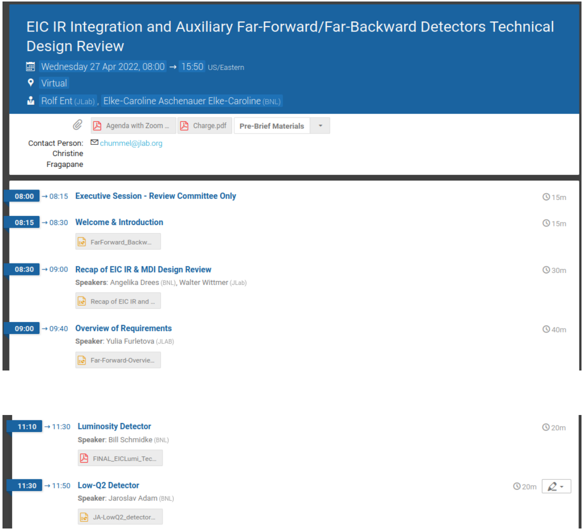
Detector 1 General Meeting

EIC IR Integration and Auxiliary Design Review

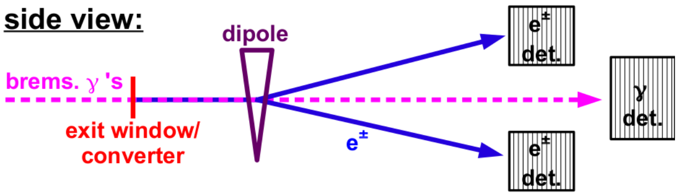
- Far-backward denotes instrumentation in electron outgoing direction
- Involves luminosity measurement
- Taggers 1 and 2 detect electrons scattered at very small angles





Luminosity detector (Bill Schmidke)

- Process of elastic bremsstrahlung, $ep \to e\gamma p$, $e\mathrm{Au} \to e\gamma\mathrm{Au}$
- Large cross section peaked for photons at small angles
- Two methods for γ detection: direct detector and $e^{\pm}$ spectrometer:



The cross section is precisely known from QED

Figure: Cross section

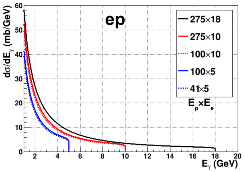
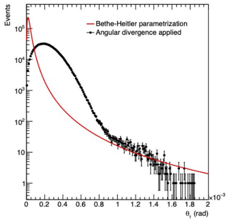
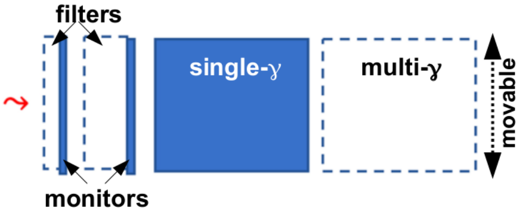


Figure: Angular distribution



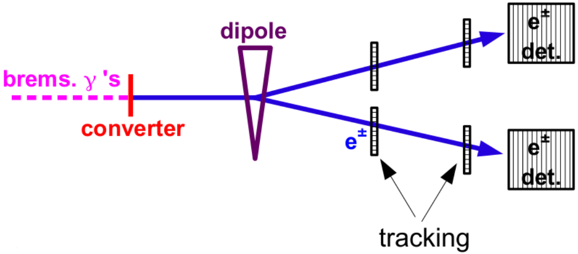
Direct photon detector and pair spectrometer (Bill Schmidke)

Figure: Direct photon detector



- Simple concept, approximate measurement
- More γ incident in every bunch crossing
- Online machine performance

Figure: Pair spectrometer

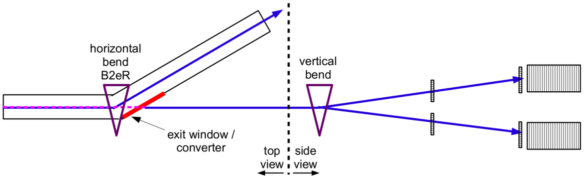


- Precise measurement for physics results
- More complex implementation
- Not sensitive to synchrotron radiation

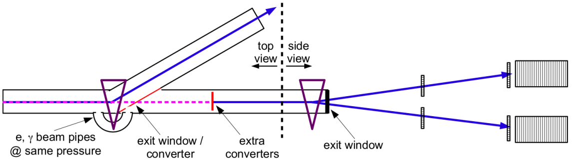
Vacuum system (Bill Schmidke)

- Conversion layer is part of beam layout
- Need for precise knowledge of conversion probability
- Heat load from synchrotron radiation is incident on the layer
- Several considerations for the design:

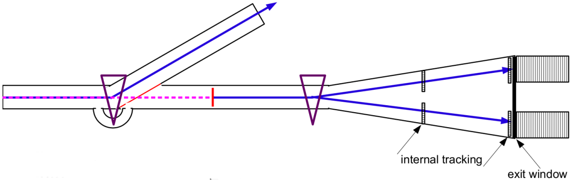
I: baseline design, converter holds the vacuum



II: thin converter in vacuum



III: vacuum up to detectors



Low Q^2 detector (JA)

- Two detectors along the outgoing electron beam
- Same Q^2 is reached at different energies and angles:

Figure: Q^2 vs. energy and scattering angle

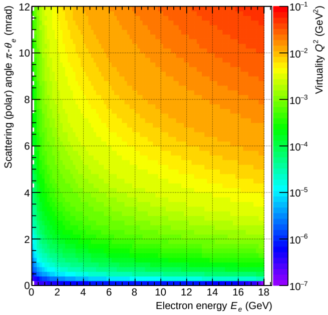


Figure: Towards central detector

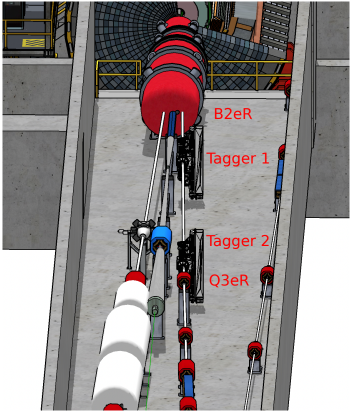
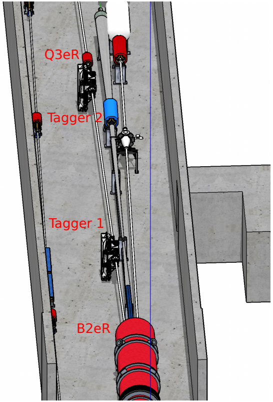


Figure: Towards the tunnel



Performance of low Q^2 detector (JA)

- Production rates are dominated by large bremsstrahlung cross section
- The rates give normalization to spectrum of reconstructed Q^2
- Clean photoproduction signal can be taken over a limited region in Q^2
- Bremsstrahlung electron are important to calibrate the luminosity measurement

Figure: Cross section

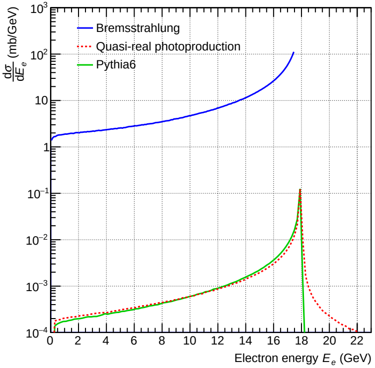
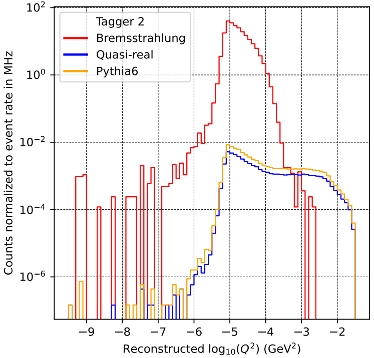
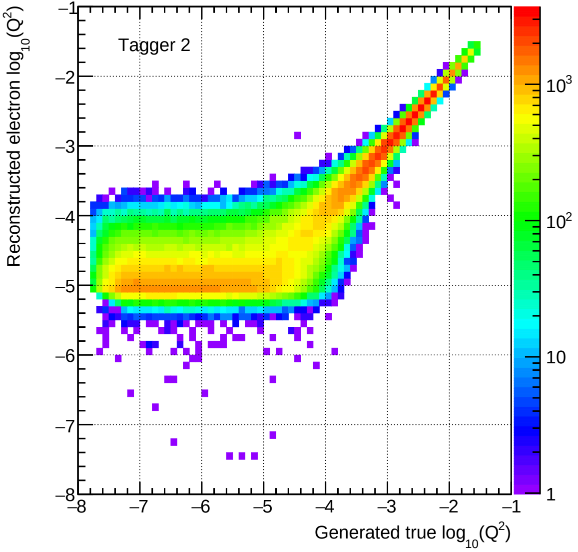


Figure: Observed spectrum



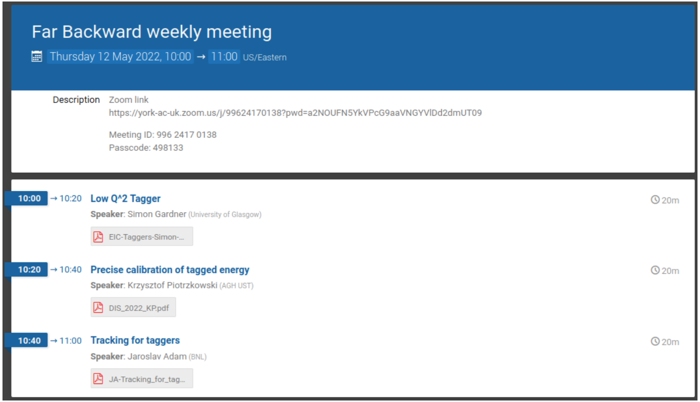
Reconstruction in low Q^2 detector (JA)

- Reconstructed virtuality Q^2 is compared to generated true event Q^2
- Machine learning connects detected track with original scattered electron
- The Q^2 is given by electron energy and scattering angle
- Beam effects (vertex spread, angular divergence) are included in the simulation
- Beam angular divergence limits the resolution at $Q^2 < 10^{-3}$ GeV^2

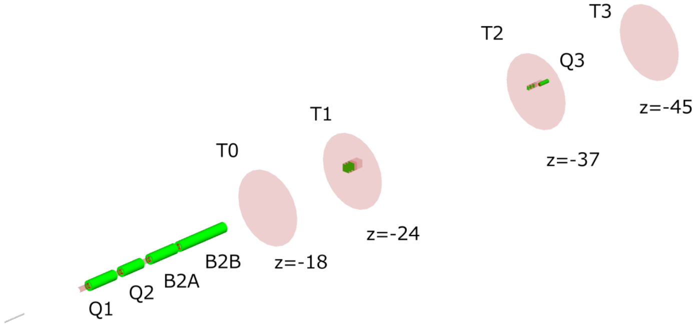


Group update

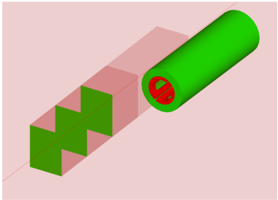
- Session on low Q^2 at the last group meeting
- indico.bnl.gov/event/15744/



DD4hep implementation (Simon Gardner)



- Counting layers T0-3 for acceptance in electrons and meson spectroscopy
- Pixel layers for reconstruction (right plot)



Reconstruction with TMVA (Simon Gardner)

- Machine learning approach using simple ROOT TMVA (DNN) neural network

Figure: Energy reconstruction

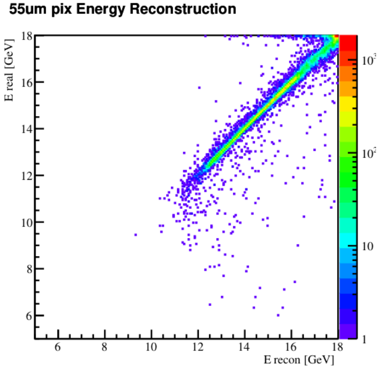


Figure: Q^2 reconstruction

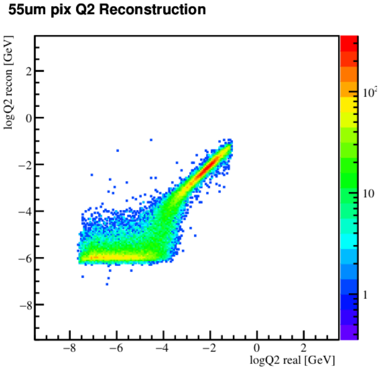
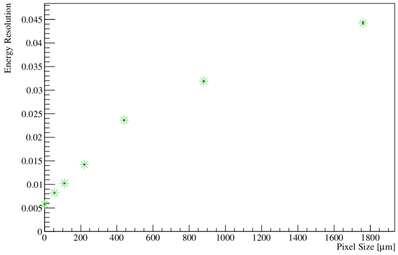
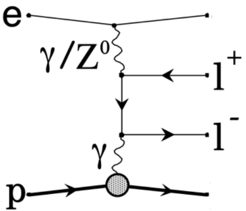


Figure: Energy resolution



Exclusive lepton pairs (Krzysztof Piotrzkowski)

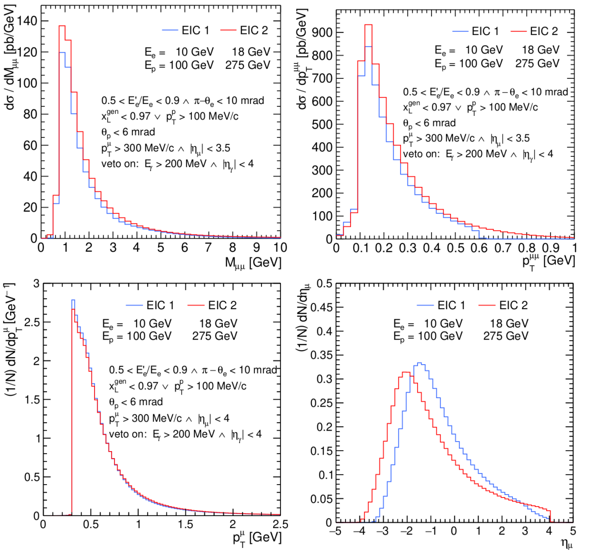


- GRAPE generator, arXiv:hep-ph/0012029
- All lepton pairs, $e^{\pm}$, $\mu^{\pm}$ and $\tau^{\pm}$ will be feasible
- Scattered proton is detected in far forward, $\theta_p < 6$ mrad
- Far backward taggers detect scattered electron, $\pi - \theta_e <$ 10 mrad

- Sensitivity to proton charge radius with $\mu^{\pm}$ pairs
- Opportunity for data-driven calibrations with two-photon exclusive process

Pairs of $\mu^{\pm}$ (Krzysztof Piotrzkowski)

- The $\mu^{\pm}$ are detected in central detector
- All constraints for scattered proton and electron are applied
- Cross section at the top energy is $\mathcal{O}(100)$ pb



Tracking for low Q^2 taggers (JA)

- Realistic clustering and tracking algorithm
- Flag for tracks by primary electrons
- Track as a straight line:

$$x = x_0 + z \times \tan\theta_x$$
$$y = y_0 + z \times \tan\theta_y$$

- Fit is performed by a set of analytic formula

Figure: Detector track frame

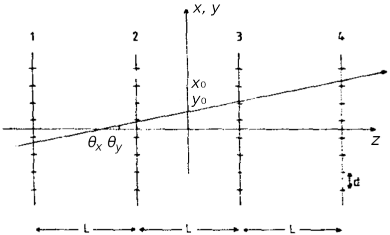
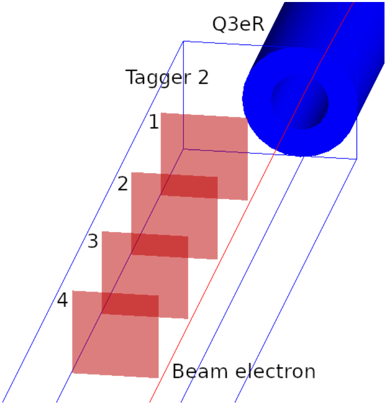
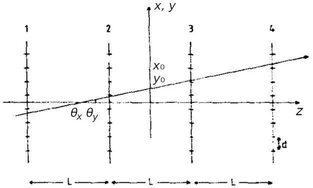


Figure: Si pixel planes



Tracking performance (JA)



- Track parameters are shown for tagger 1
- More narrow angles for tracks by primary electrons

Figure: Fit quality

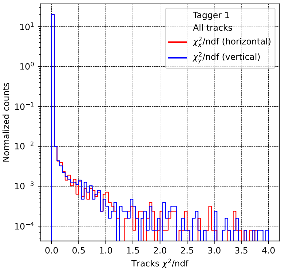


Figure: Track position

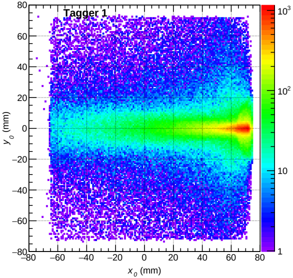


Figure: Horizontal angle

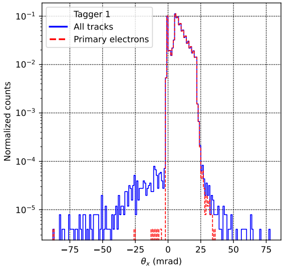
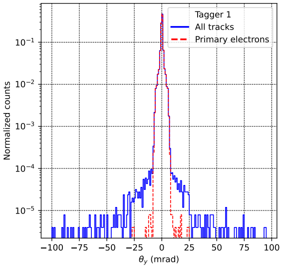


Figure: Vertical angle



Summary

- Talks at the IR review were well accepted, no concerns were raised
- Ongoing effort on comparing luminosity implementation from ECCE and ATHENA perspective
- Exit window as a conversion layer is a common project with the machine group
- Tracking in tagger detectors is to be coupled to the two machine learning tools for electron reconstruction
- Simulation of a real bunch crossing will include pileup from bremsstrahlung along with photoproduction electron
- More constrains by beam layout are likely to arrive for size of tagger detectors