DVCS at ENC:
Acceptance and background studies

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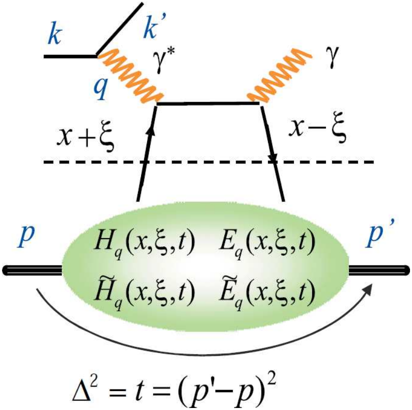
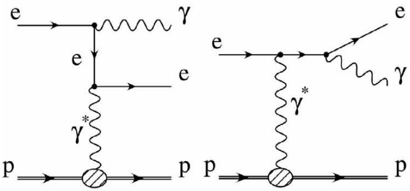
DVCS



- Use DVCS to get access to GPDs
- x: long. momentum fraction of active quark
- Δ: 4-mom. transfer to nucleon
- ξ: long. fraction of Δ
- $t \equiv (p' - p)^2$
- $Q^2 \equiv -q^2 = -(k - k')^2$
- Experimentally accessible: t, $\xi \sim x_{Bj}$, Q^2

Competing process: Bethe-Heitler



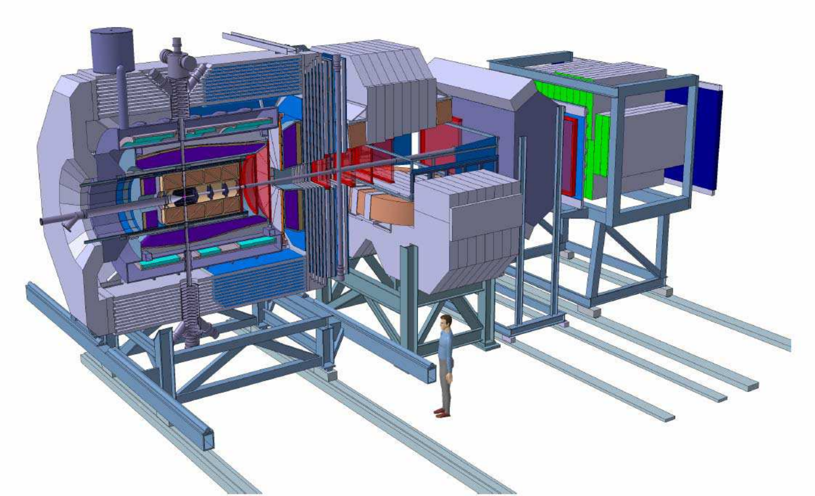
For ENC kinematics:
$\mathcal{T}_{BH} \gg \mathcal{T}_{DVCS}$

Interference between QCD and QED amplitudes creates ϕ_γ asymmetry of differential cross section
➠ access to DVCS amplitude

$$\frac{\mathrm{d}^4\sigma(ep \to ep\gamma)}{\mathrm{d}x\mathrm{d}t\mathrm{d}Q^2\mathrm{d}\cos\phi_\gamma} \propto |\mathcal{T}_{BH}|^2 + |\mathcal{T}_{DVCS}|^2 + \mathcal{T}_{DVCS}\mathcal{T}_{BH}^* + \mathcal{T}_{BH}\mathcal{T}_{DVCS}^*$$

DVCS at ENC@FAIR

Use PANDA detector:



- Target spectrometer around interaction region
- Forward dipole spectrometer

Method

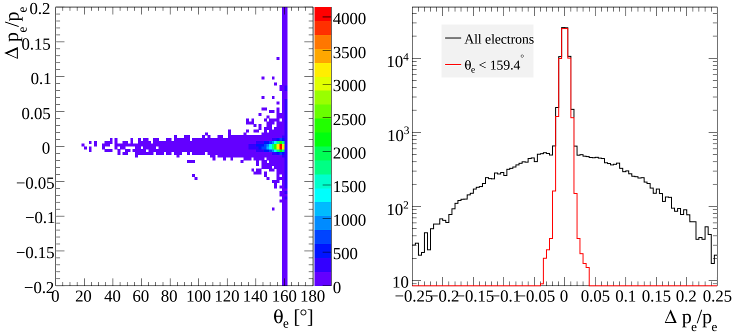
- Generate DVCS and BH with GenDVCS (F. Saull; FFS model), modified for low centre-of-mass
- $ep\pi^0$ background with PYTHIA

- Beam energies simulated: $15\mathrm{GeV}(p) \times 3\mathrm{GeV}(e)$
- For now, point-like IP at PANDA target position
- Use PANDA FastSim
  parametric smearing of tracks and clusters

- More realistic detector and efficiencies: ➡ Donghee Kang

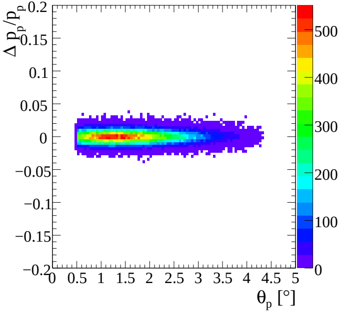
Caveat: Work in progress!

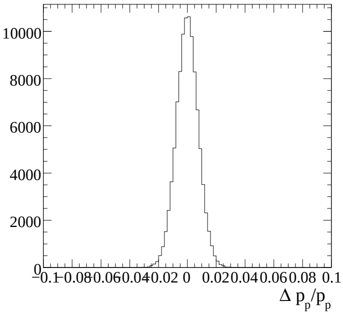
Momentum resolution: electron

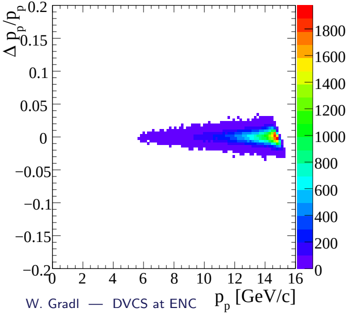


- Central tracker used in simulation: TPC
- No coverage above $\theta = 159.44°$
- Average momentum resolution for good tracks: $\Delta p/p \sim 1.2\%$ FWHM

Momentum resolution: proton

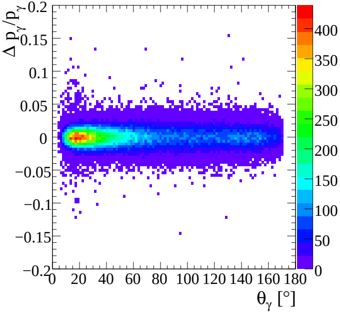


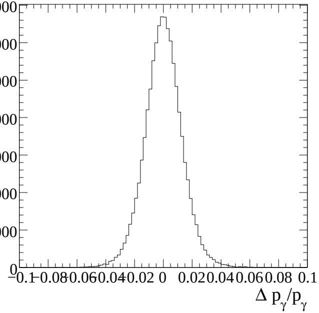


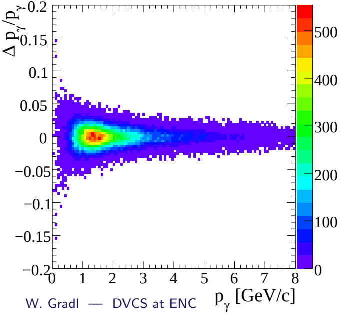


- No large variation with θ_p
- Significant broadening of $\Delta p/p$ with increasing p
- Average FWHM 1.9%

Momentum resolution: photon





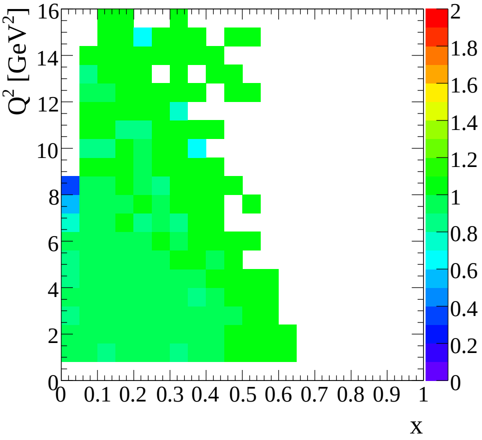


- $\sigma_\theta \sim 4\,\text{mrad}$ at low p_γ

Geometrical acceptance for DVCS

- All 3 particles visible in detector
- $\theta_e < 159.4^\circ$

- Note: fixed bug in computing x ...
- Good acceptance at moderate x and large Q^2
- Average geometrical acceptance $\approx 92\%$ for $Q^2 > 0.9\,\mathrm{GeV}^2$ and $\theta_e < 159.4^\circ$



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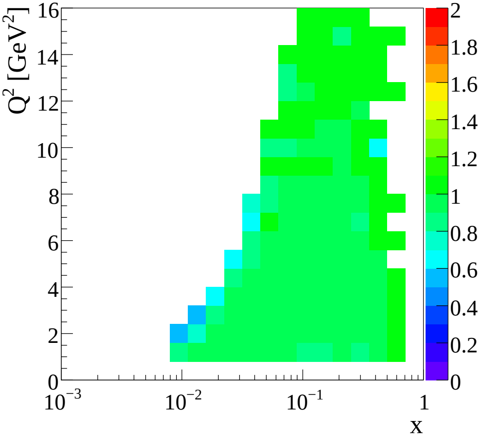
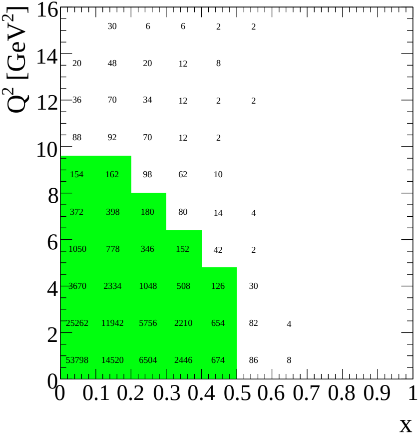


One year of ENC running

Assumptions:

- DVCS only (FFS model)
- $\mathcal{L} = 2 \times 10^{32}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- One year $= 10^7\,$s
- Reco. efficiency 50 %
- Require $>$ 100 events to perform angular fit
  ?? to be studied

- 2 years . . .



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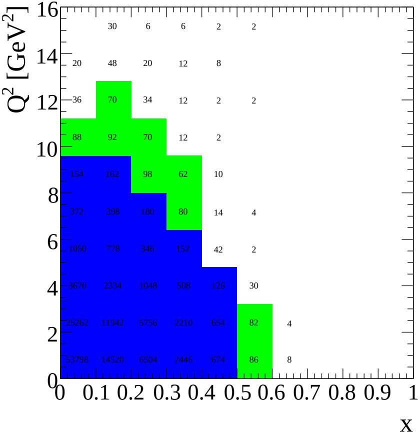
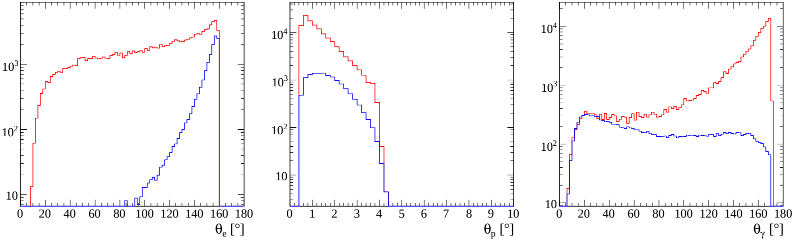


BH vs DVCS

- Cross section ratio

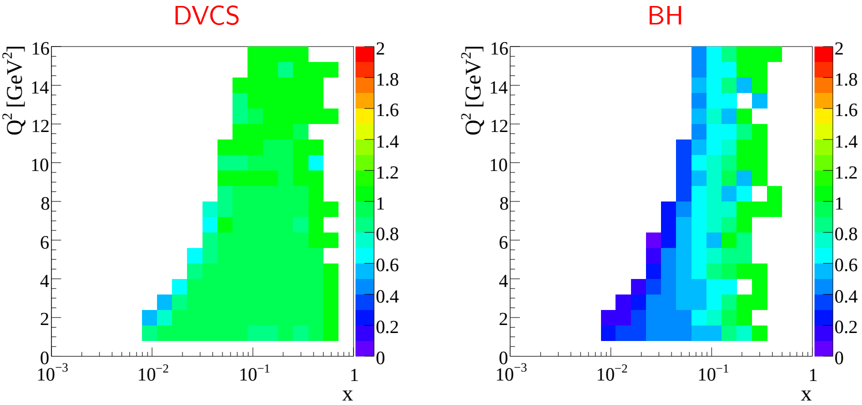
$$\frac{\sigma_{BH+DVCS}}{\sigma_{DVCS}} \sim 20$$

- Compare θ distribution for accepted events from DVCS and BH+DVCS



➡ Can cut on θ_e and θ_γ to remove large part of BH without loss of signal efficiency

Geometrical acceptance for Bethe-Heitler



$ep \longrightarrow ep\pi^0$

- Dangerous background:
  Looks like DVCS if one γ from $\pi^0 \to \gamma\gamma$ gets lost
- Cross section of exclusive π^0 production in DIS, $Q^2 \geq 0.9\mathrm{GeV}^2$ (Pythia 6.4)

$$\sigma_{\text{vis}}(ep\pi^0) \approx 1.8\,\mathrm{nb}$$

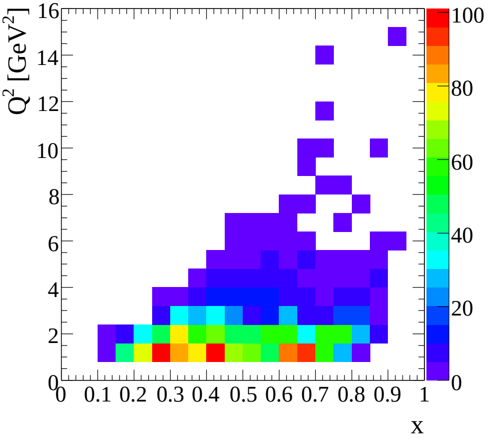
- Compare with BH+DVCS:

BH + DVCS + INT	$4.4\,\mathrm{nb}$
BH	$4.2\,\mathrm{nb}$
DVCS	$0.2\,\mathrm{nb}$

$ep\pi^0$ in Q^2–x plane

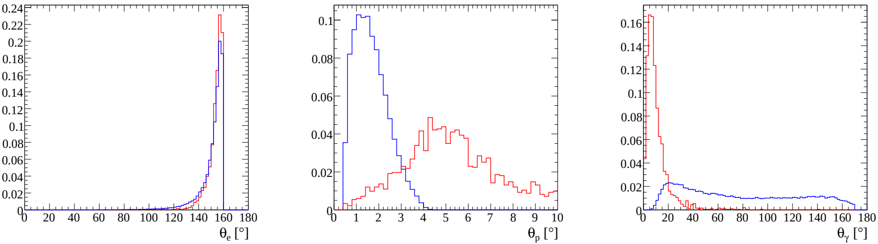
Use most energetic γ as ‘DVCS’ photon

- Arbitrary normalisation
- Concentrated at small Q^2 and medium-large x
- High-x region gets cleaned by cuts on θ_γ and θ_p



$ep\pi^0$ angular distributions

Compare DVCS signal with $ep\pi^0$ background
Normalise to same area



- Cutting on $\theta_p < 5^\circ$ and $\theta_\gamma > 20^\circ$:

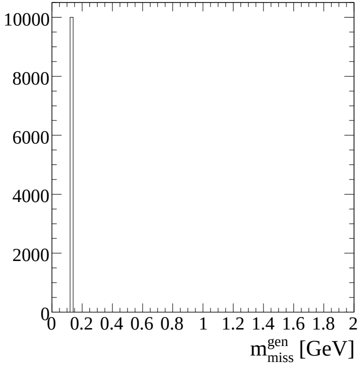
$$\varepsilon_{DVCS} = 91.3\%$$
$$\varepsilon_{ep\pi^0} = 6.8\%$$

- $\sigma_{DVCS}/\sigma_{ep\pi^0} \approx 9$

➡ $S/B_{ep\pi^0} = \mathcal{O}(1)$

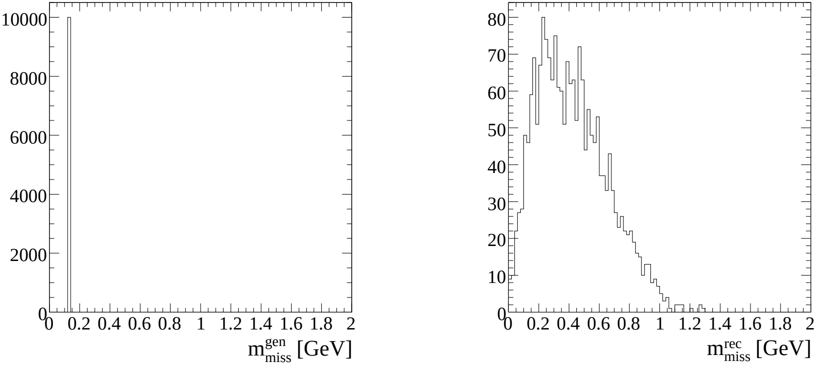
Missing mass?

$$m^2_{\text{miss}} = (p + e - (p' + e'))^2$$



Missing mass?

$$m_{\text{miss}}^2 = (p + e - (p' + e'))^2$$



- Very large resolution for $m_{\text{miss}}^{\text{rec}}$
- Not good to discriminate against $m_{\text{miss}} = 0$
- Further studies needed

Summary and outlook

- PANDA suited for DVCS physics
- Large acceptance and good momentum and angular resolutions

- Bethe-Heitler background suppression possible via kinematic cuts
- $ep\pi^0$ background looks manageable
  - Cuts on event kinematics look promising
  - m_{miss} resolution not good enough to discriminate between missing γ and π^0

Next steps

- Quantify expected number of signal and background events
- m_{miss} ? Kinematic fit?