IR2 Requirements for DVCS and DVπ^0P

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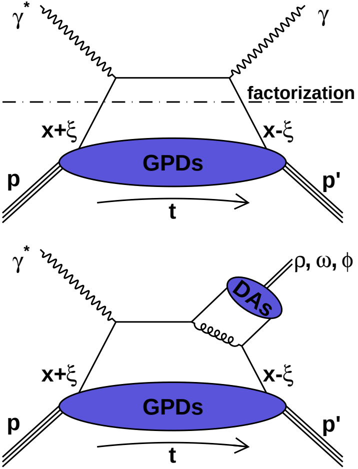
Theory Context

Deep Exclusive Scattering

Generalized Parton Distributions



$\gamma^* p \to \gamma p'$, $\gamma^* p \to \rho p'$, $\omega p'$, $\phi p'$
Bjorken regime :
$Q^2 \to \infty$, x_B fixed

t fixed $\ll Q^2$, $\xi \to \frac{x_B}{2-x_B}$

$$\frac{P^+}{2\pi}\int dy^- \, e^{ixP^+y^-} \langle p'|\bar{\psi}_q(0)\gamma^+(1+\gamma^5)\psi(y)|p\rangle$$

$$= \bar{N}(p')\left[H^q(x,\xi,t)\gamma^+ + E^q(x,\xi,t)i\sigma^{+\nu}\frac{\Delta_\nu}{2M}\right.$$

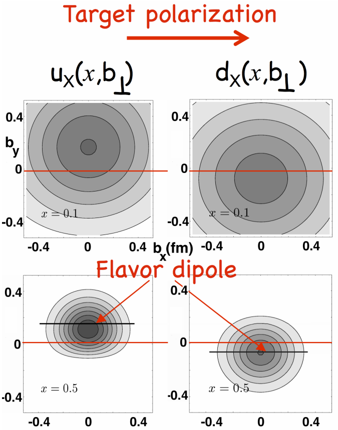
$$\left. + \tilde{H}^q(x,\xi,t)\gamma^+\gamma^5 + \tilde{E}^q(x,\xi,t)\gamma^5\frac{\Delta^+}{2M}\right] N(p)$$

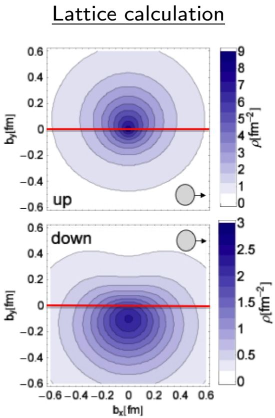
spin	N no flip	N flip
q no flip	H	E
q flip	$\tilde{H}$	$\tilde{E}$

3-D Imaging conjointly in transverse impact parameter and longitudinal momentum

GPDs and Transverse Imaging
(x_B, t) correlations

$$q_X(x, \vec{b}_\perp) = \int \frac{d^2\vec{\Delta}_\perp}{(2\pi)^2}\left[H(x,0,t) - \frac{E(x,0,t)}{2M}\frac{\partial}{\partial b_y}\right] e^{-i\vec{\Delta}_\perp\cdot\vec{b}_\perp}$$





GPDs and Energy Momentum Tensor

(x,ξ) correlations

Form Factors accessed *via* second x-moments :

$$\langle p'|\hat{T}^q_{\mu\nu}|p\rangle = \bar{N}(p')\left[\; M_2^q(t)\,\frac{P_\mu P_\nu}{M} + J^q(t)\,\frac{\imath(P_\mu\sigma_{\nu\rho}+P_\nu\sigma_{\mu\rho})\Delta^\rho}{2M} + d_1^q(t)\,\frac{\Delta_\mu\Delta_\nu - g_{\mu\nu}\Delta^2}{5M}\;\right]N(p)$$

Angular momentum distribution

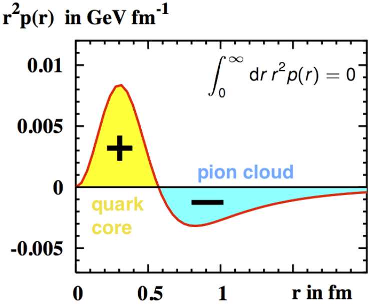
$$J^q(t) = \frac{1}{2}\int_{-1}^{1} \mathrm{d}x\, x\,[H^q(x,\xi,t) + E^q(x,\xi,t)]$$

Mass and force/pressure distributions

$$M_2^q(t) + \frac{4}{5}d_1(t)\xi^2 = \frac{1}{2}\int_{-1}^{1} \mathrm{d}x\, xH^q(x,\xi,t)$$

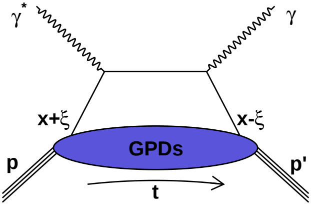
$$d_1(t) = 15M\int \mathrm{d}^3\vec{r}\,\frac{j_0(r\sqrt{-t})}{2t}\,p(r)$$

Distribution of pressure

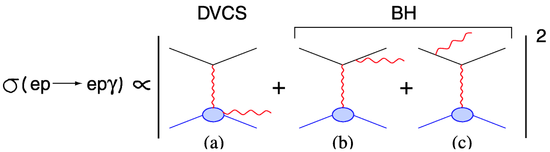


Deeply Virtual Compton Scattering

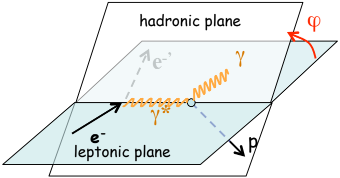
The cleanest GPD probe at low and medium energies



$$ep \to ep\gamma$$



Diehl, Gousset, Pire, Ralston (1997)
Belitsky, Müller, Kirchner (2002, 2010)



$$A_{LU} = \frac{d^4\sigma^{\rightarrow} - d^4\sigma^{\leftarrow}}{d^4\sigma^{\rightarrow} + d^4\sigma^{\leftarrow}} \overset{\text{twist-2}}{\approx} \frac{\alpha \sin\phi}{1 + \beta\cos\phi}$$

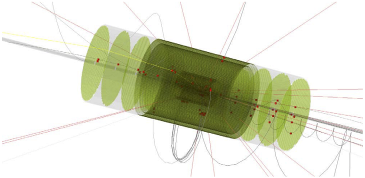
$$\alpha \propto \mathcal{I}\mathrm{m}\left(F_1\mathcal{H} + \xi G_M\tilde{\mathcal{H}} - \frac{t}{4M^2}F_2\mathcal{E}\right)$$

$$\mathcal{H}(\xi, t) = i\pi H(\xi, \xi, t) + \mathcal{P}\int_{-1}^{1} \mathrm{d}x\, \frac{H(x, \xi, t)}{x - \xi}$$

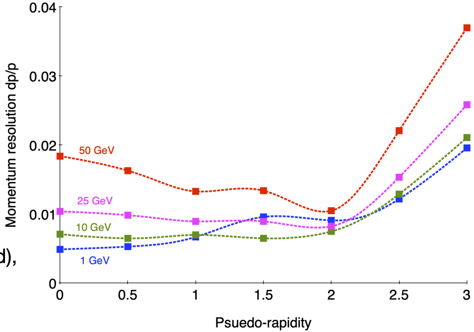
$$A_{UL} \propto \mathcal{I}\mathrm{m}\left(F_1\tilde{\mathcal{H}} + \xi G_M\mathcal{H} + G_M\frac{\xi}{1+\xi}\mathcal{E} + \cdots\right)\sin\phi$$

IR2 Studies

EIC Si Tracker Concept



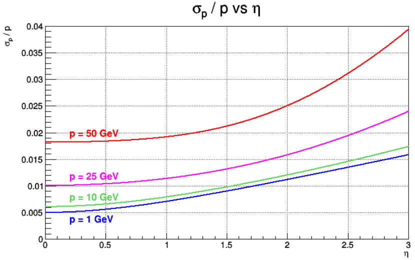
- 6 barrel layers,
- 6 tapered disks x 2 (forward, backward),
- r_{outer} ~0.45m, -1.22m < z < 1.22m,
- ~15m² area; ~10m² barrel, ~5m² disks

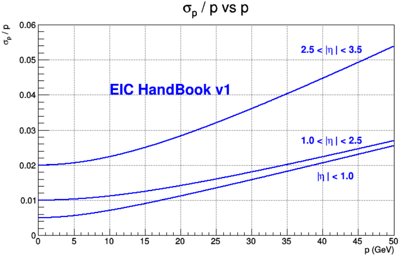


April 9, 2020 - JLab-LBNL EIC discussion

Ernst Sichtermann

Si Tracker Resolutions Parameterization



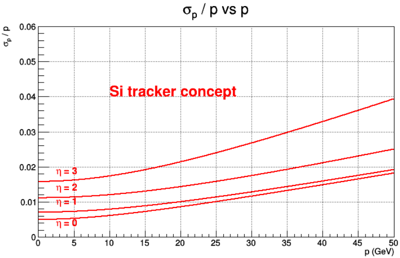


EIC Handbook Parameterizations:

$$2.5 < |\eta| < 3.5 \implies \frac{\sigma_p}{p} = 0.1\% p \oplus 2\%$$

$$1.0 < |\eta| < 2.5 \implies \frac{\sigma_p}{p} = 0.05\% p \oplus 1\%$$

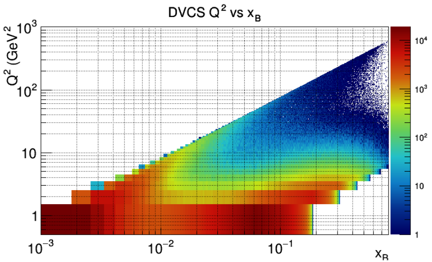
$$|\eta| < 1.0 \implies \frac{\sigma_p}{p} = 0.05\% p \oplus 0.5\%$$

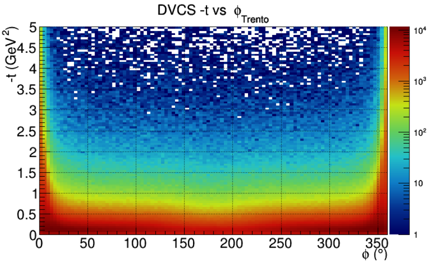


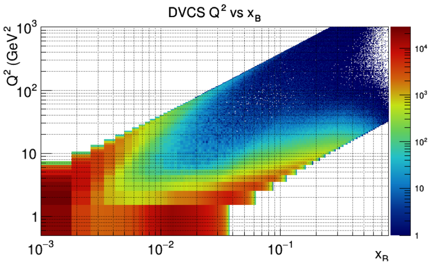
Si concept Parameterization:

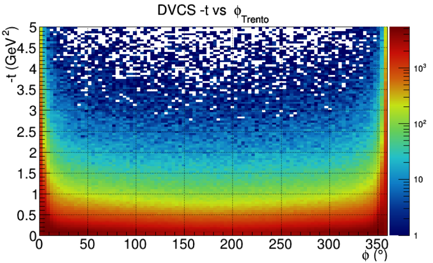
$$\frac{\sigma_p}{p} = 0.5\% \oplus 0.0035\% p \oplus 0.5\% \eta \oplus 7 \times 10^{-5} p \eta^2$$

Coverage 5×40 GeV^2 and 10×100 GeV^2

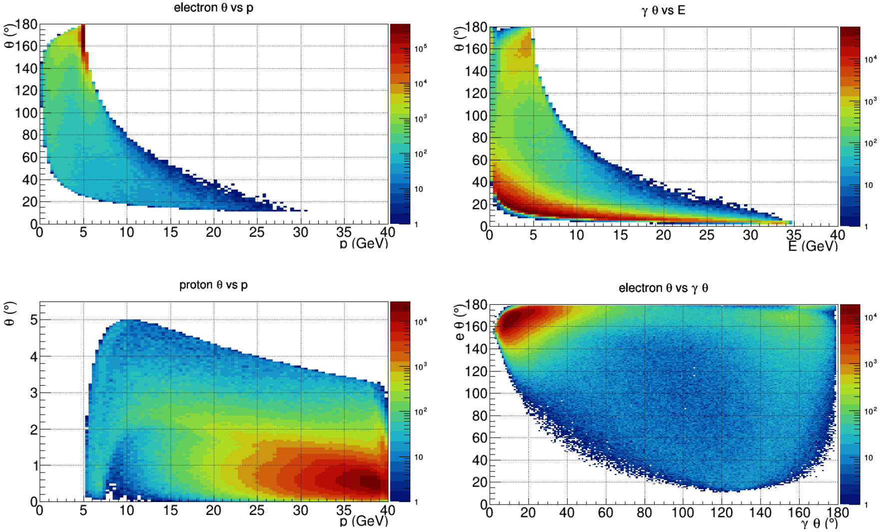




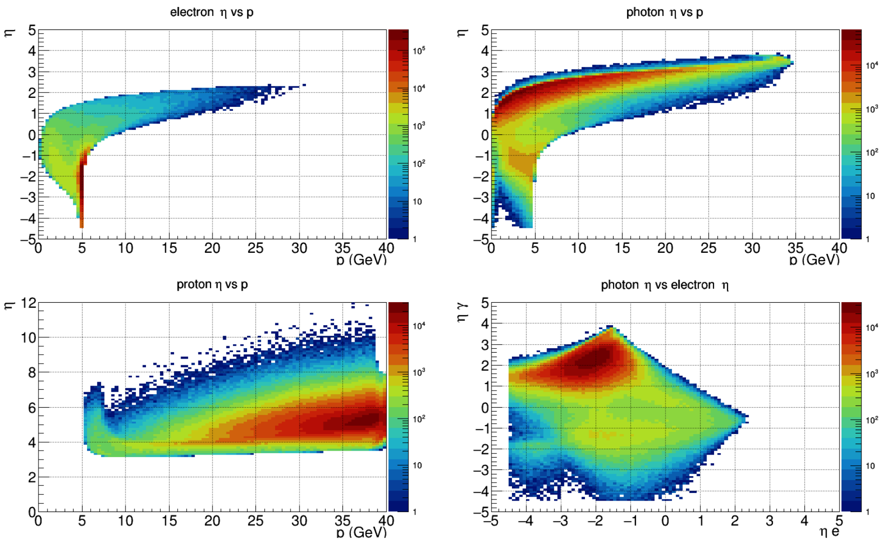




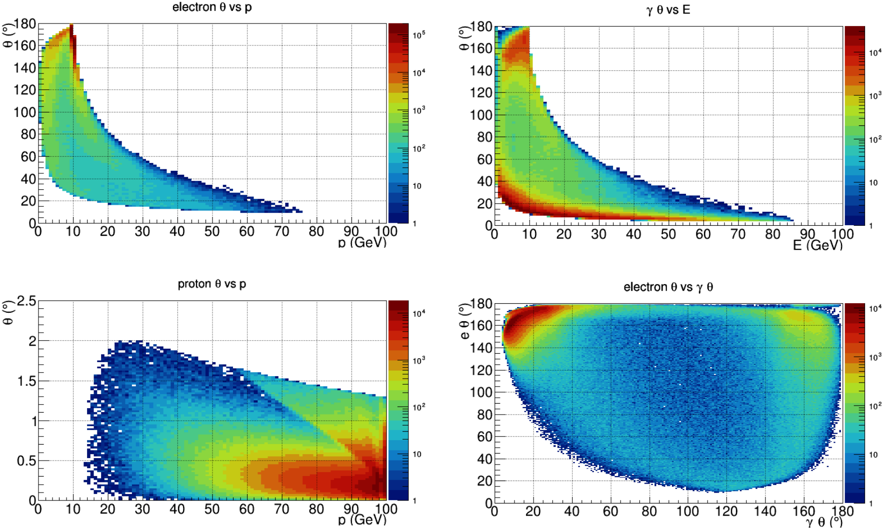
Kinematics 5×40 GeV^2



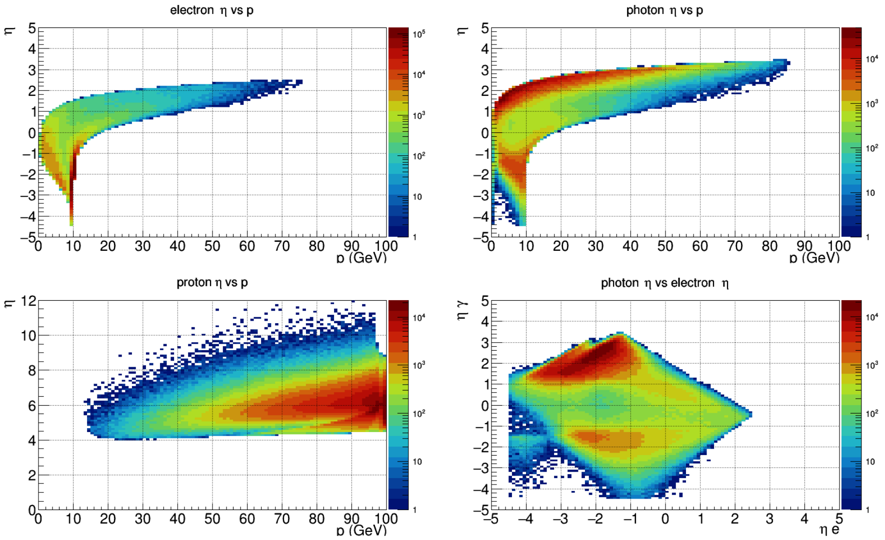
Kinematics 5×40 GeV^2



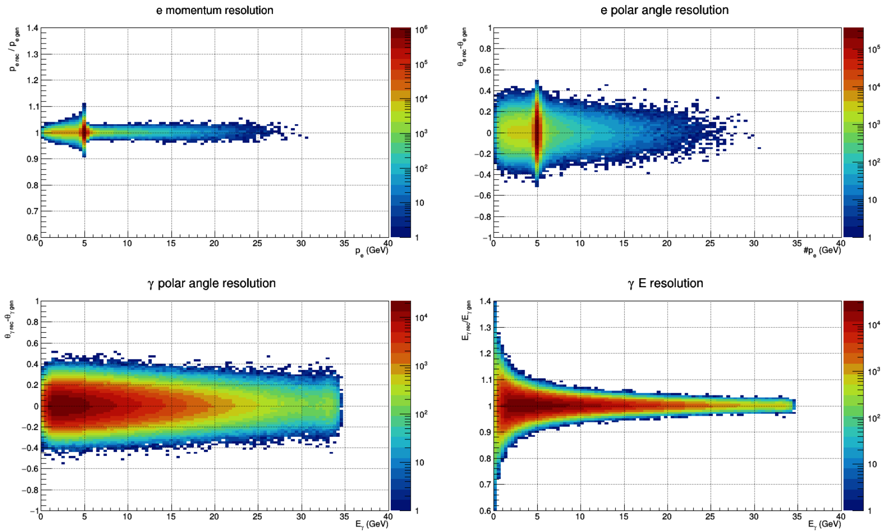
Kinematics 10×100 GeV^2



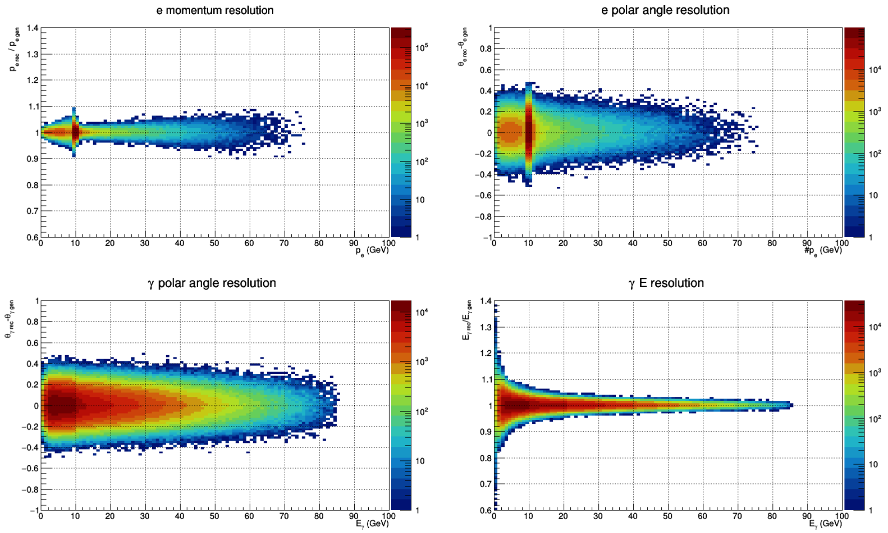
Kinematics 10×100 GeV^2



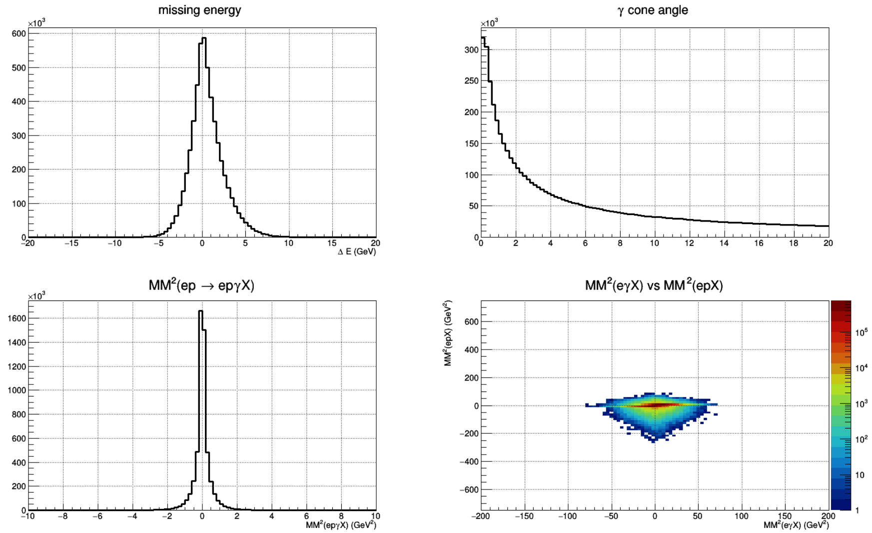
Input Resolutions 5×40 GeV^2



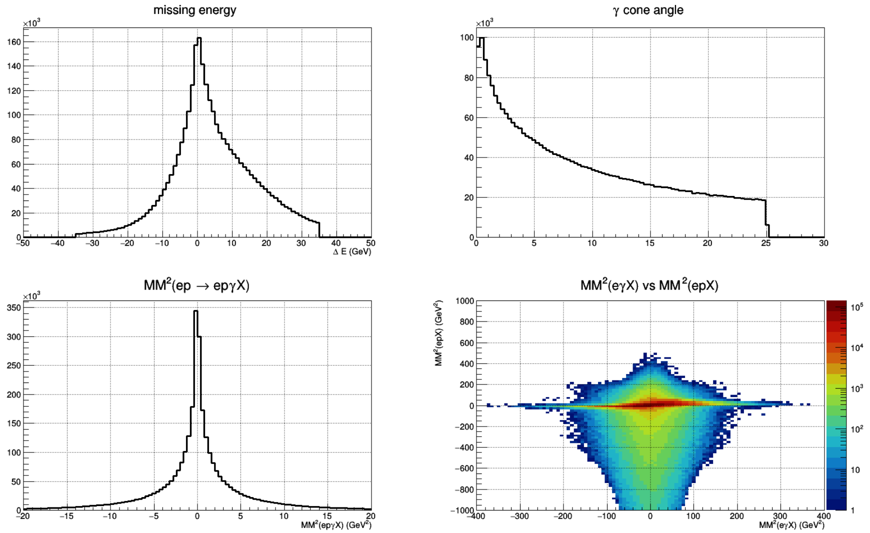
Input Resolutions 10×100 GeV^2



Input Resolutions 5×40 GeV^2

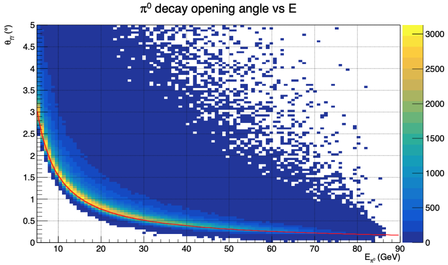


Input Resolutions 10×100 GeV^2

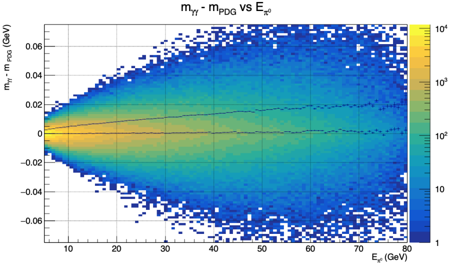


ECal granularity DVCS / π^0 separation

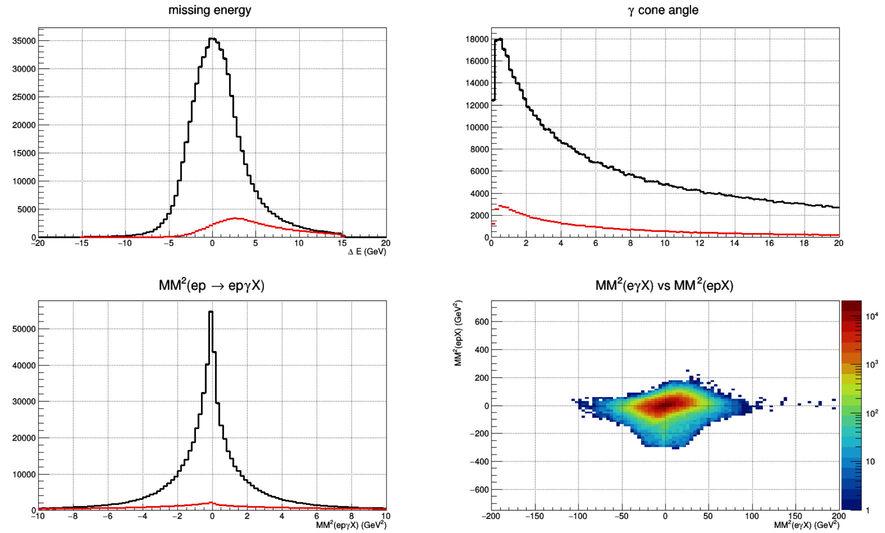
Photon angular resolution is essential to discriminate clusters at high energies
Both θ and ϕ have $\sigma \sim 0.05^\circ < 1$ mrad



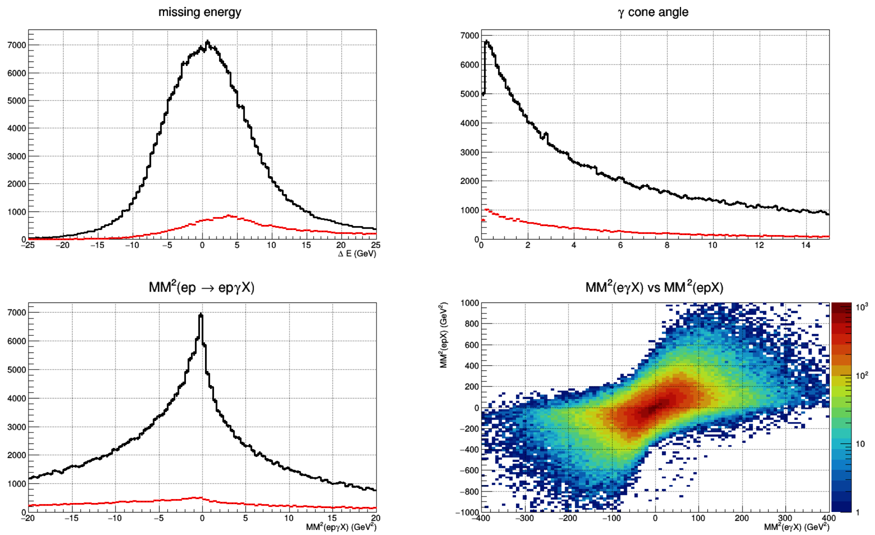
Corresponding invariant mass resolution $\sim$ 5 to 20 MeV



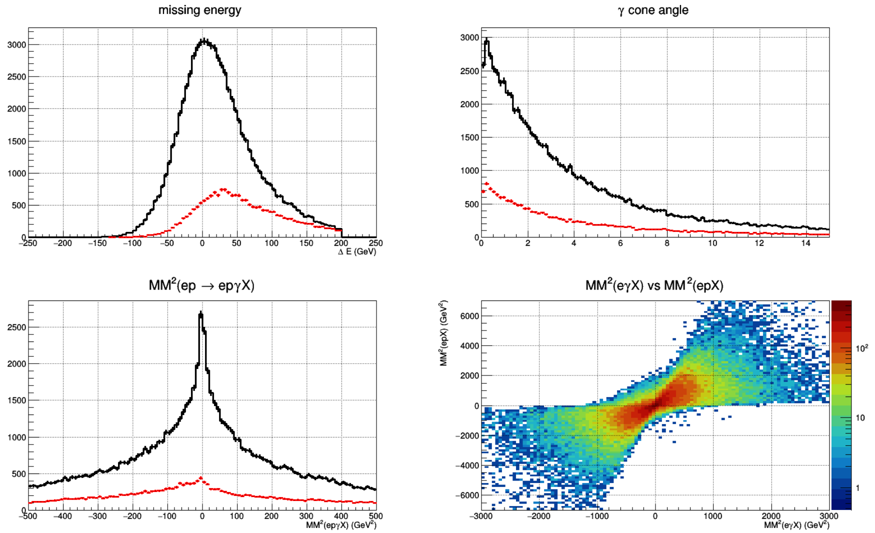
DVCS π^0 separation 5 GeV $\times$ 40 GeV



DVCS π^0 separation 10 GeV $\times$ 100 GeV



DVCS π^0 separation 18 GeV $\times$ 275 GeV

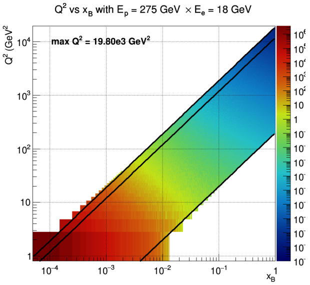


EIC CFF Extraction Study

EIC proton DVCS Observables

	$\int \mathcal{L}$	Observables	$A_{e,p}$		
unpolarized	200 fb^{-1}	σ	A_{LU}		
L polarized	100 fb^{-1}	A_{UL}	A_{LL}		
T polarized	100 fb^{-1}	A_{UTx}	A_{UTy}	A_{LTx}	A_{LTy}
e^+	100 fb^{-1}	A^C	A^C_{LU}		

$$N_{events} = \int \mathcal{L} \times \sigma \times KPS$$
$$KPS = \Delta x_B \Delta Q^2 \Delta t \Delta \phi$$



$$\frac{\Delta\sigma}{\sigma} = \frac{1}{\sqrt{N_{events}}} \oplus 5\%$$

$$\Delta A_{LU} = \frac{1}{P_e}\sqrt{\frac{1-P_e^2 A_{LU}^2}{N}} \oplus 3\%_{relative} \qquad P_e = 70\%$$

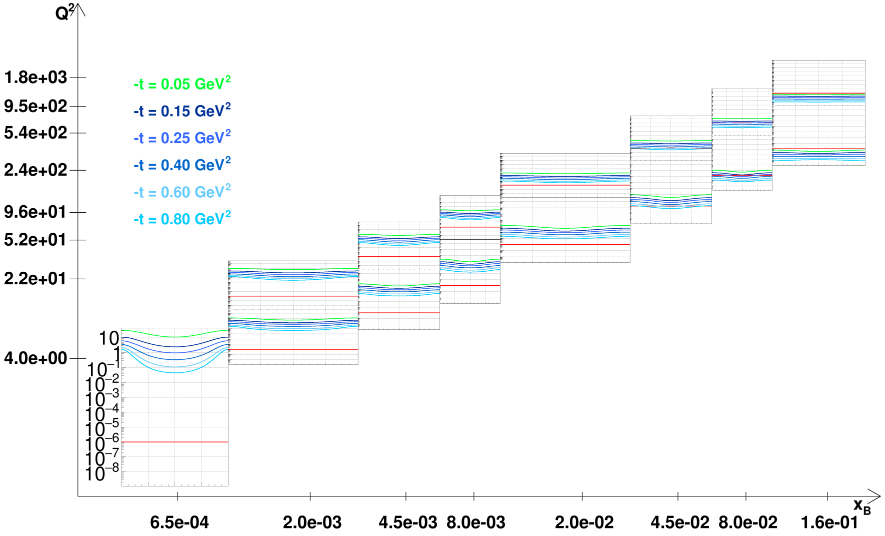
$$\Delta A_{UL} = \frac{1}{P_p}\sqrt{\frac{1-P_p^2 A_{UL}^2}{N}} \oplus 3\%_{relative} \qquad P_p = 70\%$$

$$\Delta A_{LL} = \frac{1}{P_e P_p}\sqrt{\frac{1-P_e^2 P_p^2 A_{LL}^2}{N}} \oplus 3\%_{relative} \oplus 3\%_{relative}$$

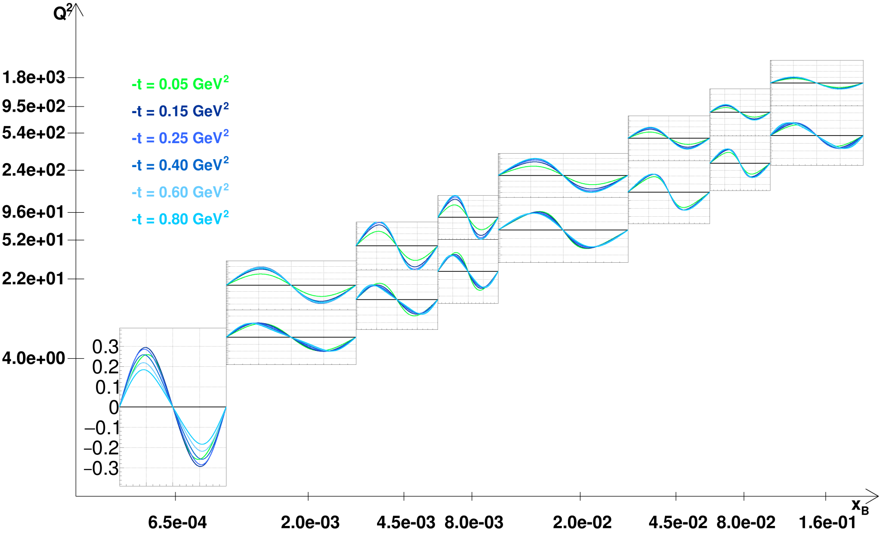
$$\Delta A_C = \sqrt{\frac{1-A_C^2}{N}} \oplus 3\%_{relative}$$

$$\Delta A_{LC} = \frac{1}{P_{e^+}}\sqrt{\frac{1-P_{e^+}^2 A_{LC}^2}{N}} \oplus 3\%_{relative} \qquad P_{e^+} = 70\%$$

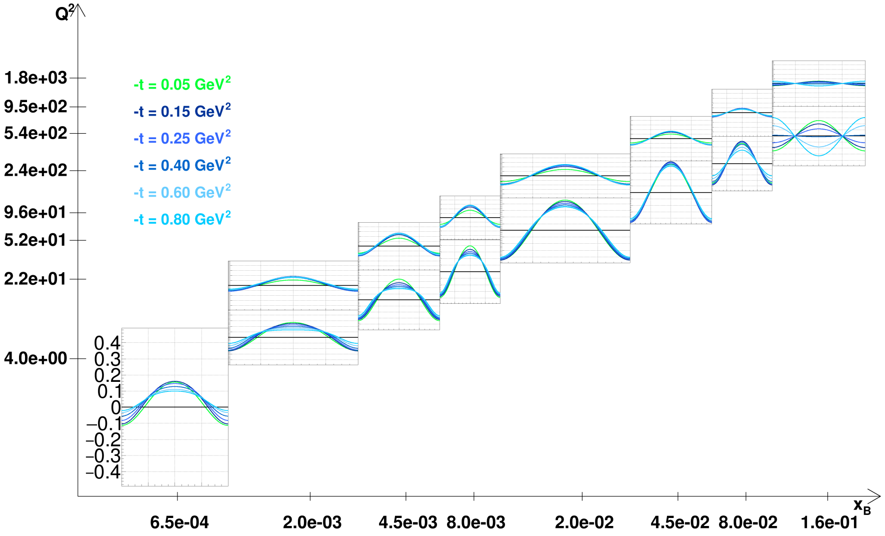
275 GeV × 18 GeV σ



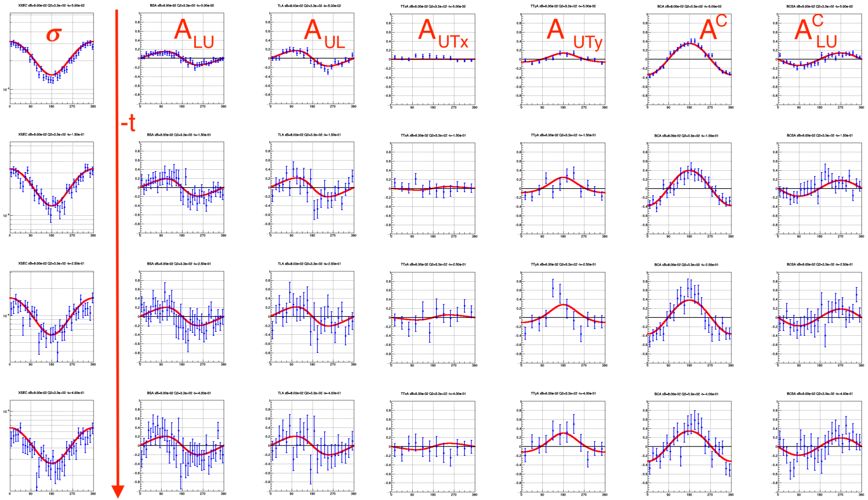
275 GeV × 18 GeV A_{LU}



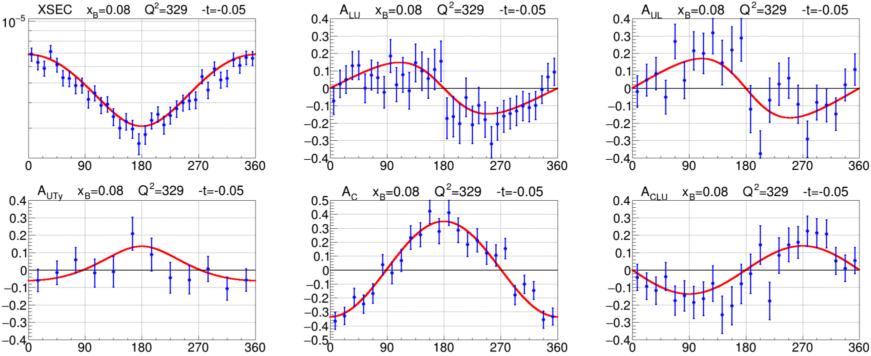
275 GeV × 18 GeV A^C



275 **GeV** $\times$ 18 **GeV** $\quad x_B = 0.08 \pm 0.02 \quad Q^2 = 329 \pm 175$ **GeV**^{2}

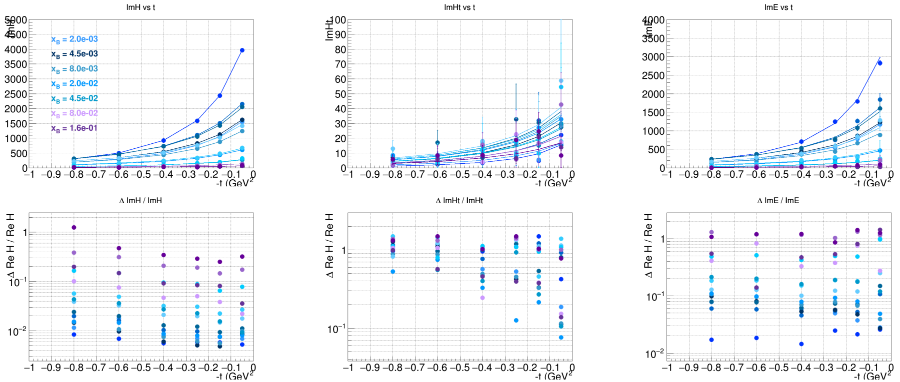


Not shown here: A_{LL} A_{LTx} A_{LTy} are small

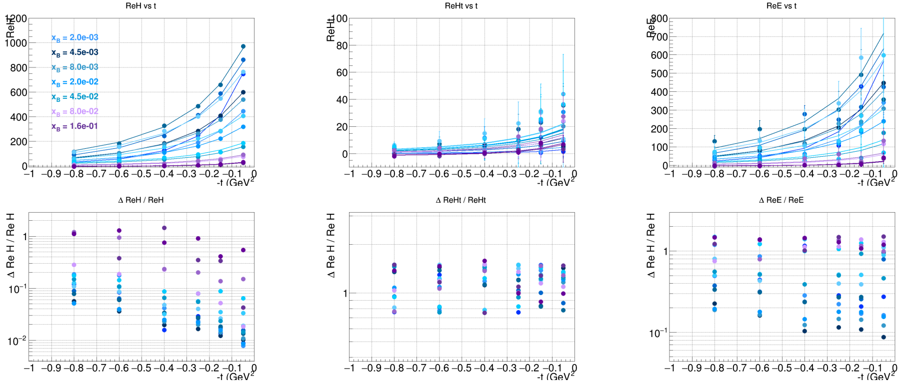


Smearing both statistics and systematics
Fit CFF wth/without to estimate systematics

Locally extracted Im CFF 275×18 GeV^2

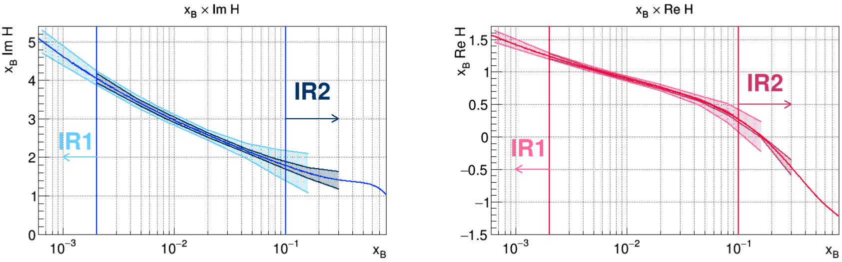


Locally extracted Re CFF 275×18 GeV^2



Complementarity of IR1 and IR2

Local extraction results:



Entering the GPD extraction Precision Era!

Summary, Outlook

Summary, Outlook

- Complementarity between IR1 and IR2
- Conceptual Design for IR2
- Resolutions similar to Handbook v1
- Next Step: implement dispersion relation (global) fit