Tracking requirements DVCS

F.-X. Girod

University of Connecticut & George Washington

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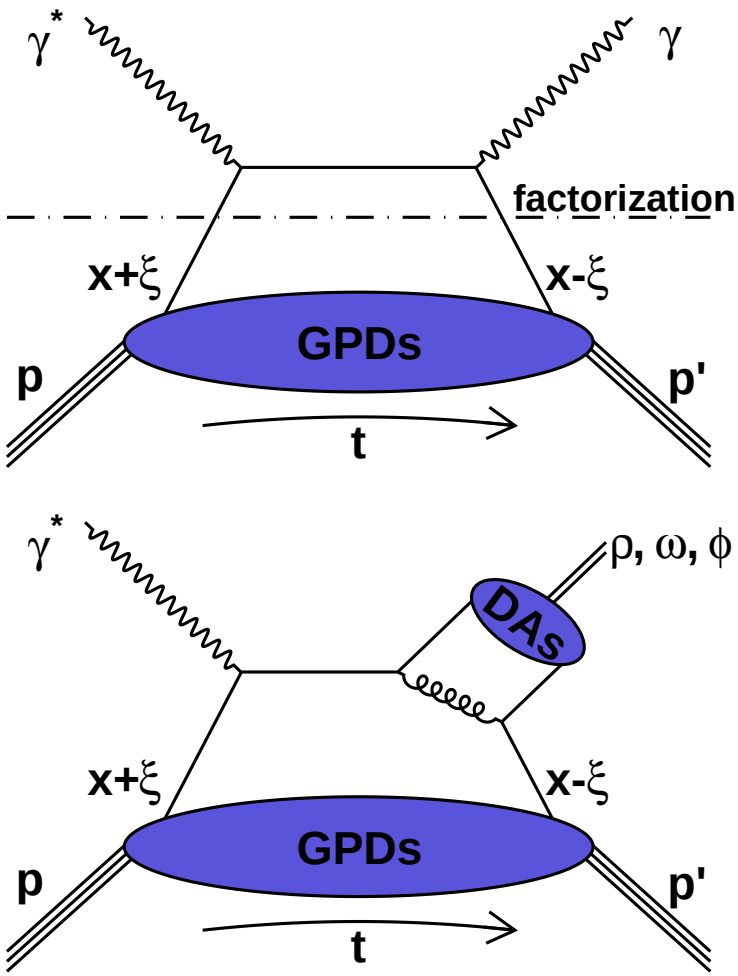
Introduction

Deep Exclusive Scattering

Generalized Parton Distributions



$$\gamma^* p \to \gamma p' \,,\ \gamma^* p \to \rho p' \,,\ \omega p' \,,\ \phi p'$$

Bjorken regime :

$$Q^2 \to \infty,\ x_B \text{ fixed}$$

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

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

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

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

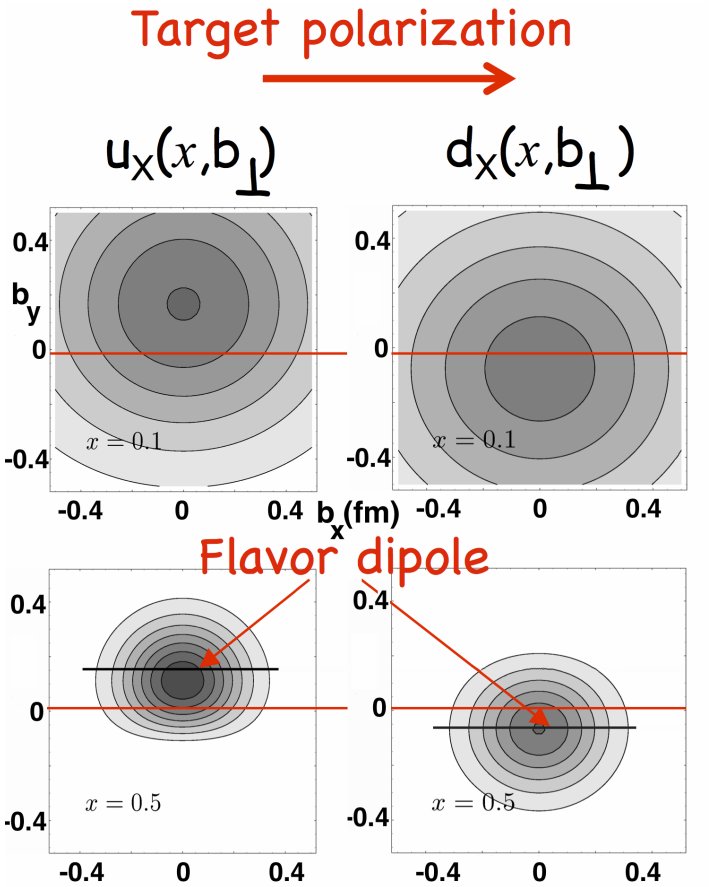
spin	N no flip	N flip
q no flip	H	E
q flip	$\tilde{H}$	$\tilde{E}$

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

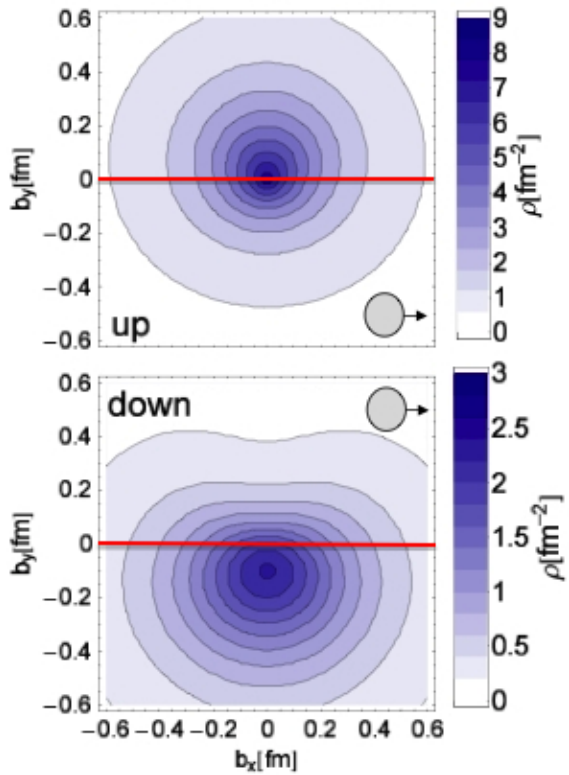
GPDs and Transverse Imaging

(x_B, t) correlations

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



Lattice calculation



GPDs and Energy Momentum Tensor

(x, ξ) correlations

Form Factors accessed *via* second x-moments :

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

Angular momentum distribution

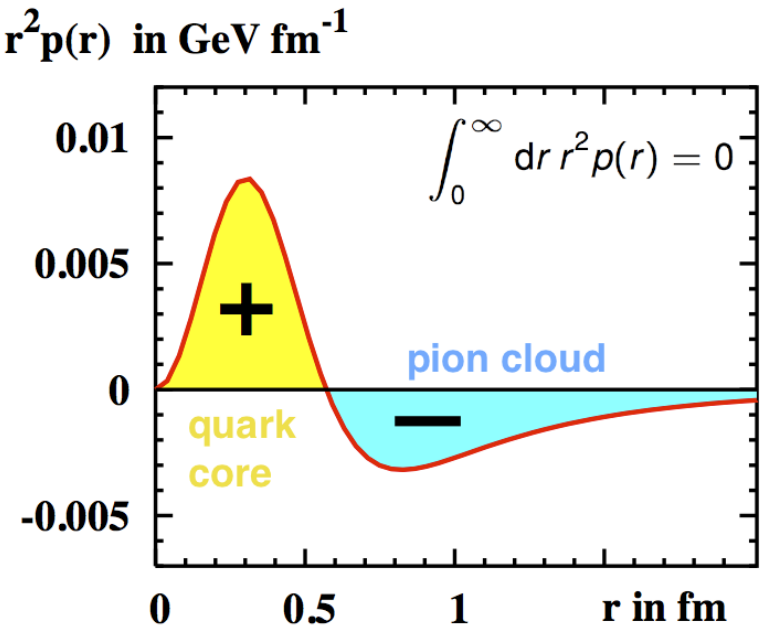
$$J^q(t) = \frac{1}{2}\int_{-1}^{1} \mathrm{d}x\, x\,[H^q(x,\xi,t) + E^q(x,\xi,t)]$$

Mass and force/pressure distributions

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

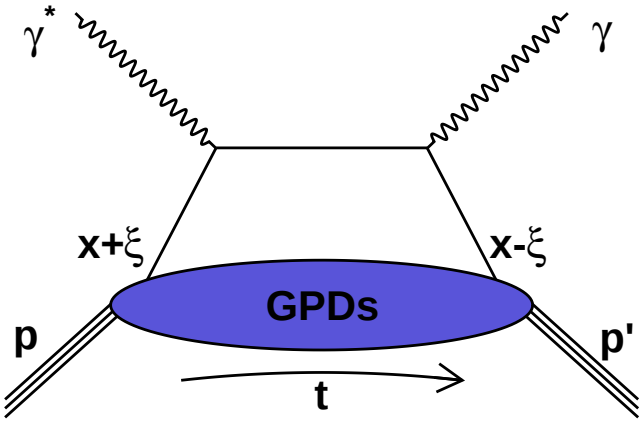
$$d_1(t) = 15M\int \mathrm{d}^3\vec{r}\,\frac{j_0(r\sqrt{-t})}{2t}\,p(r)$$

Distribution of pressure



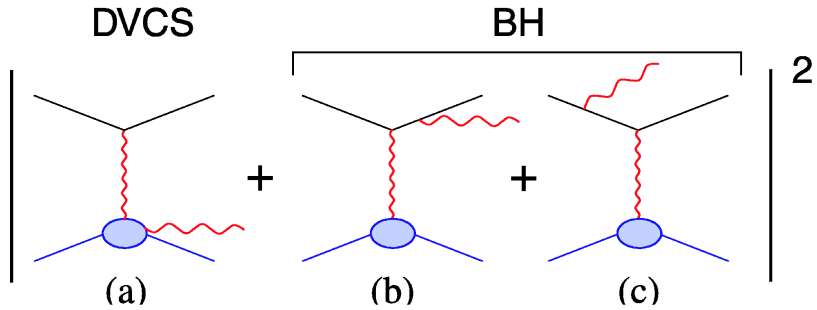
Deeply Virtual Compton Scattering

The cleanest GPD probe at low and medium energies



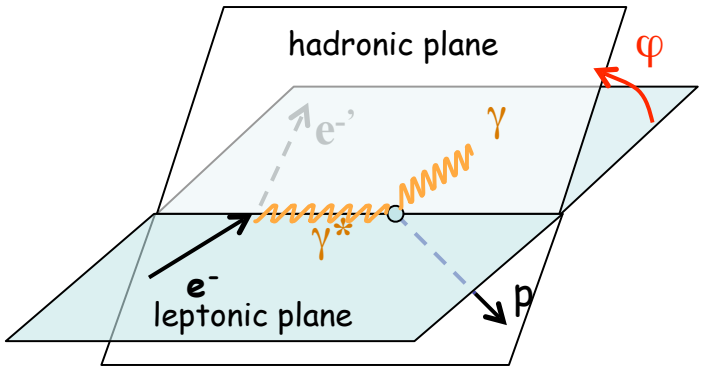
$$ep \to ep\gamma$$

$$\sigma(ep \to ep\gamma) \propto$$



Diehl, Gousset, Pire, Ralston (1997)

Belitsky, Müller, Kirchner (2002, 2010)



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

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

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

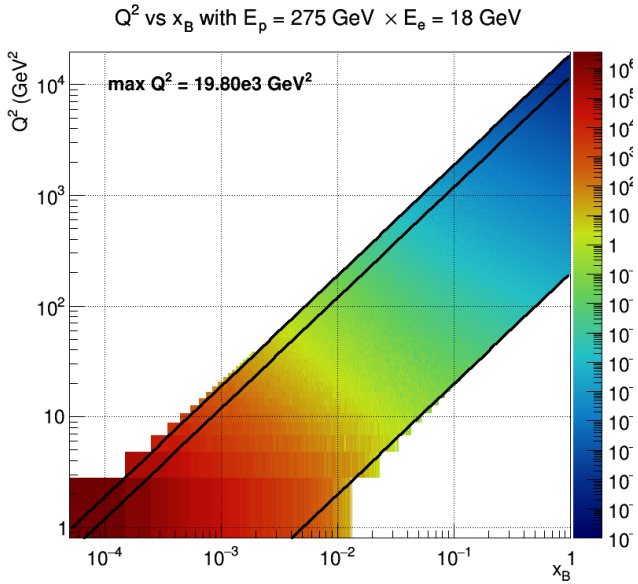
$$A_{UL} \propto \mathcal{I}\mathrm{m}\left(F_1\tilde{\mathcal{H}} + \xi G_M\mathcal{H} + G_M\frac{\xi}{1+\xi}\mathcal{E} + \cdots\right)\sin\phi$$

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}		

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



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

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

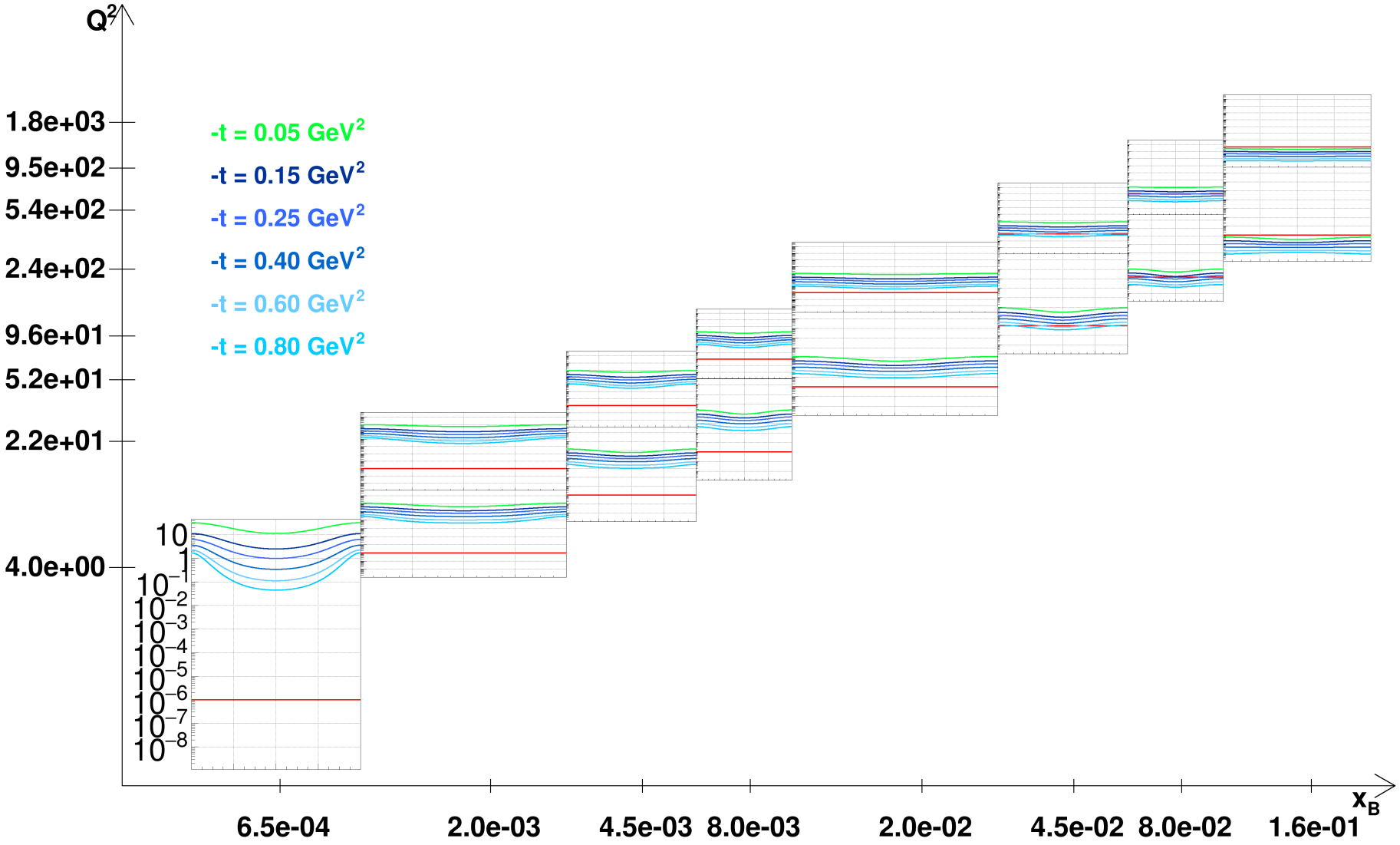
$$\Delta A_{UL} = \frac{1}{P_p}\sqrt{\frac{1-P_p^2 A_{UL}^2}{N}} \oplus 3\%_{relative} \quad P_p = 70\%$$

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

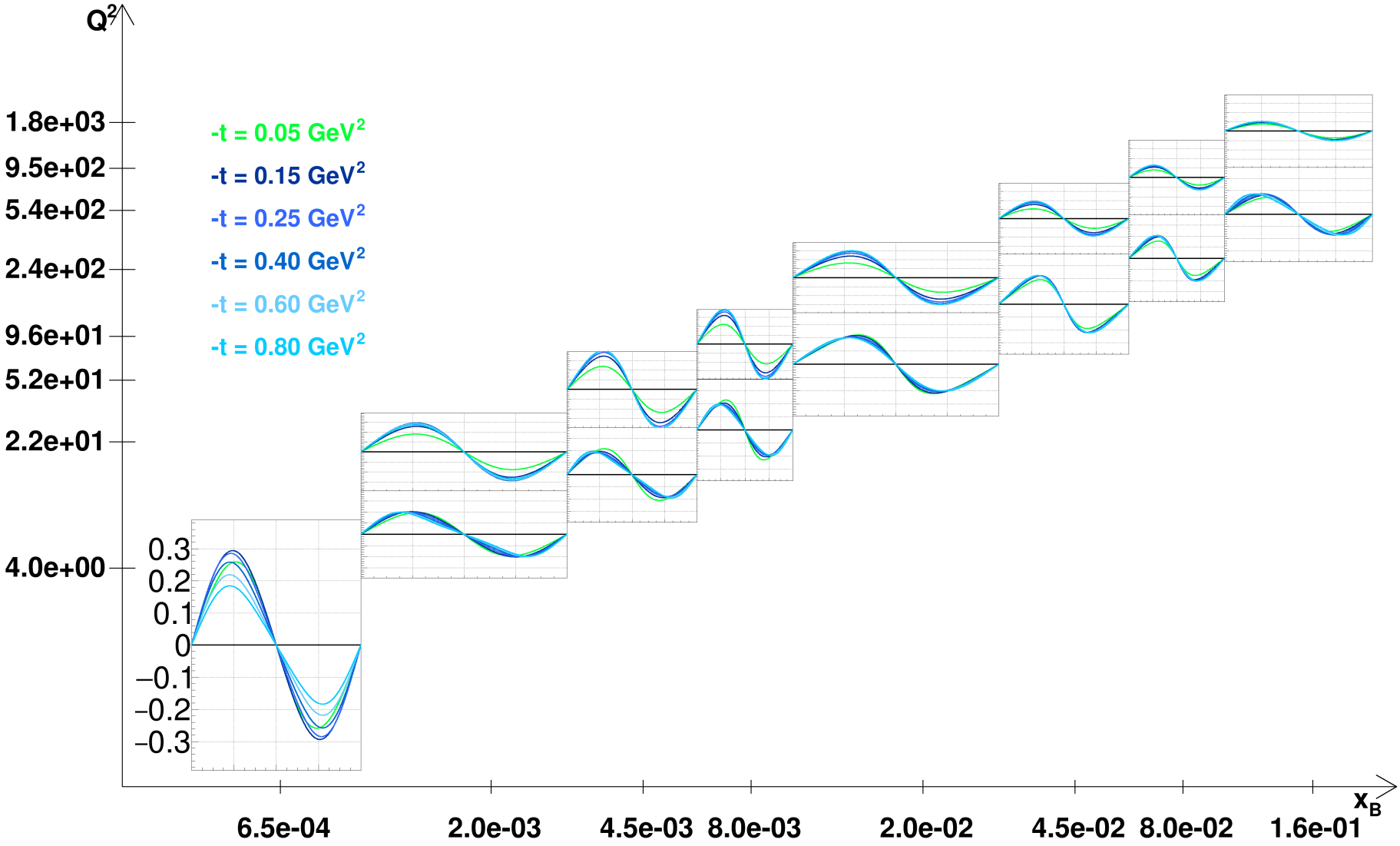
$$\Delta A_C = \sqrt{\frac{1-A_C^2}{N}} \oplus 3\%_{relative}$$

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

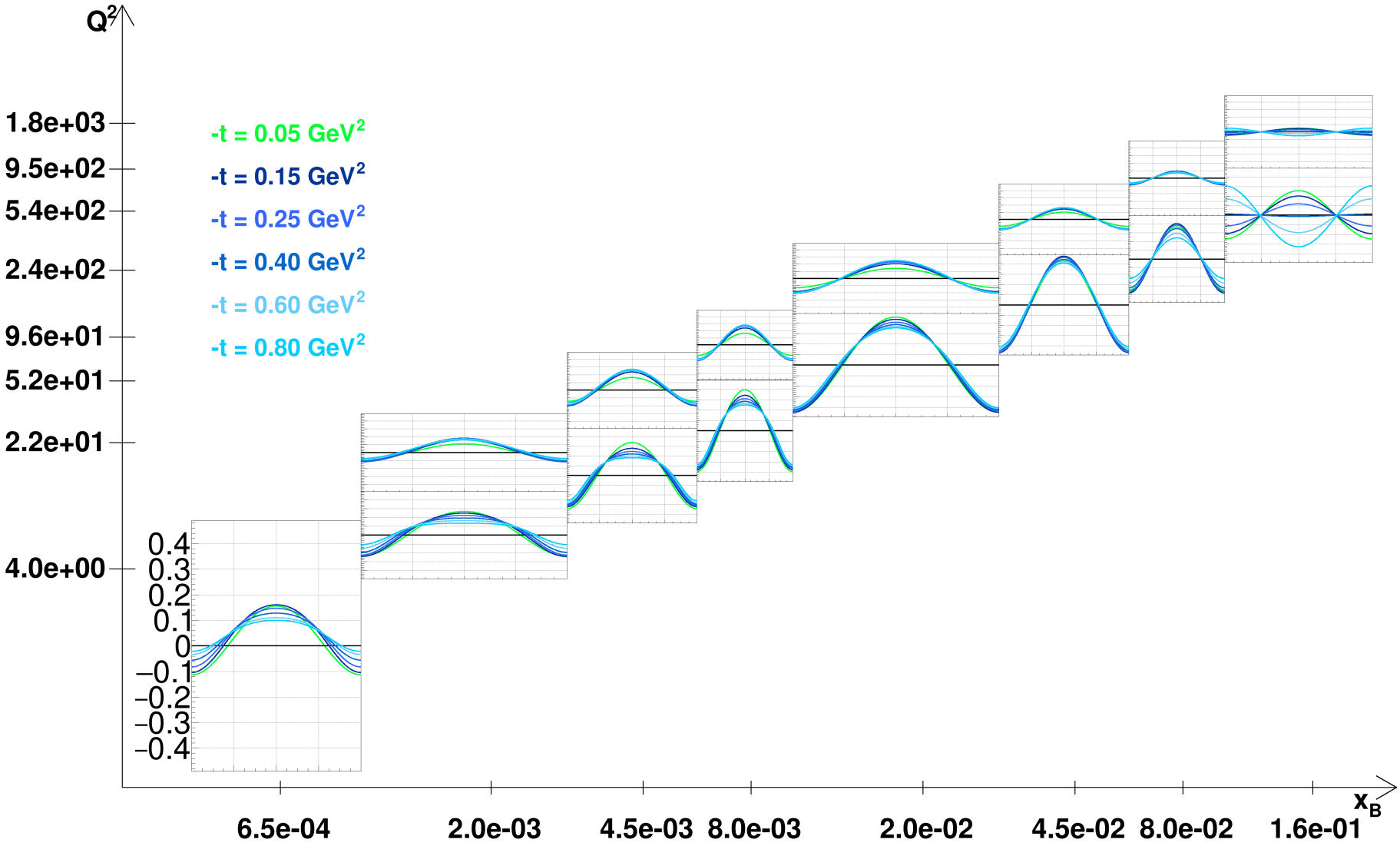
275 GeV × 18 GeV σ

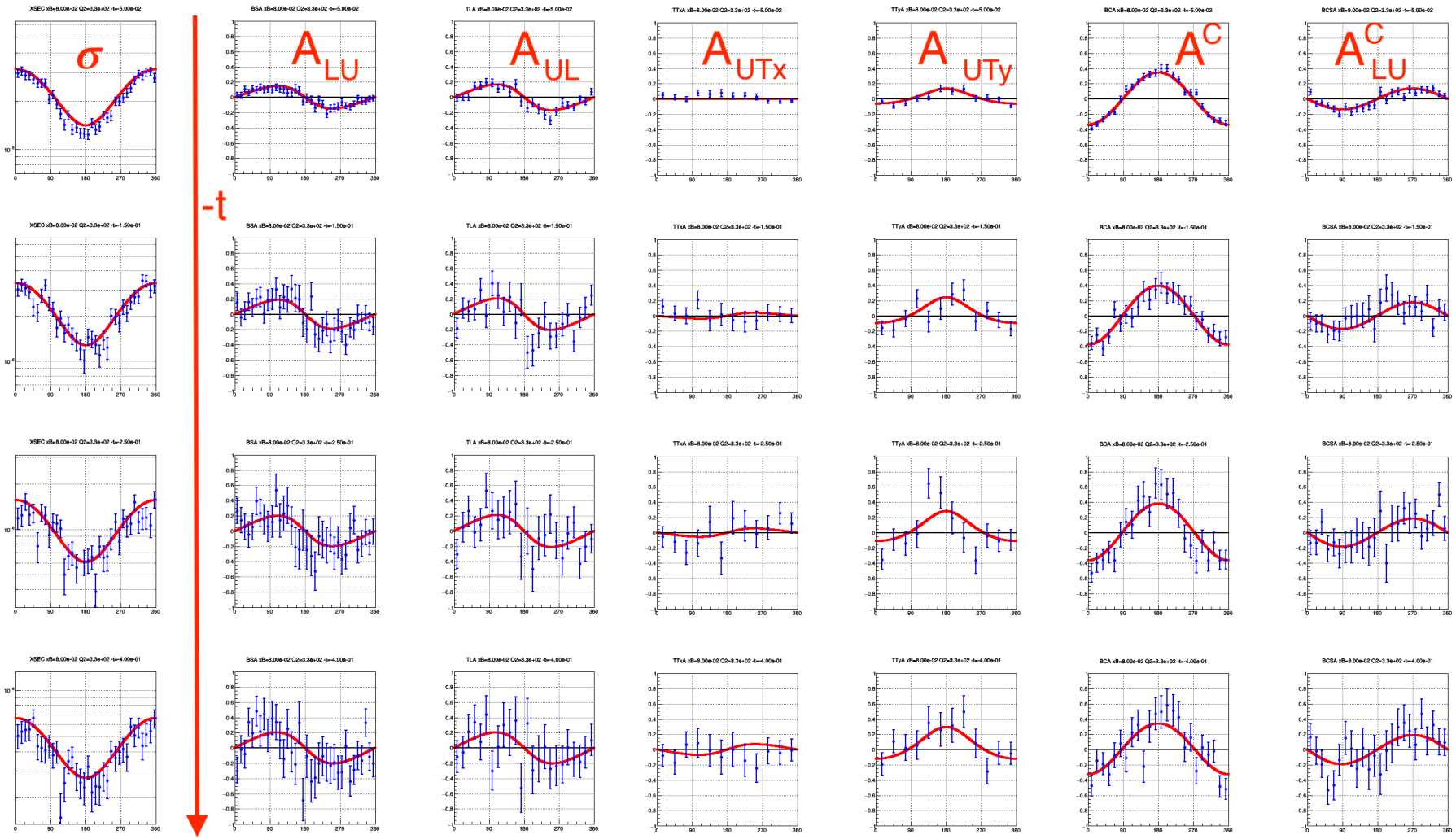


275 GeV × 18 GeV A_{LU}

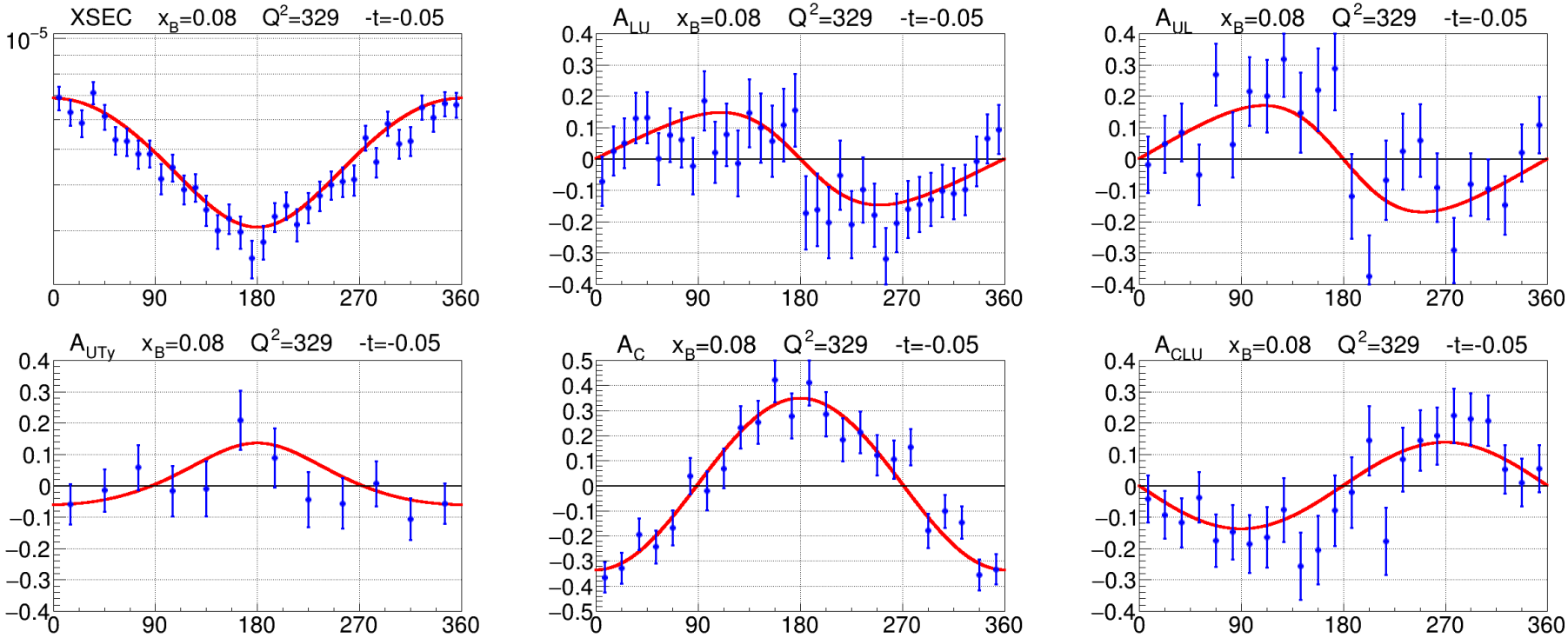


275 GeV × 18 GeV A^C



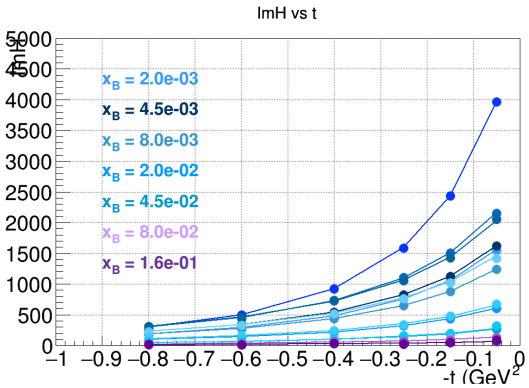


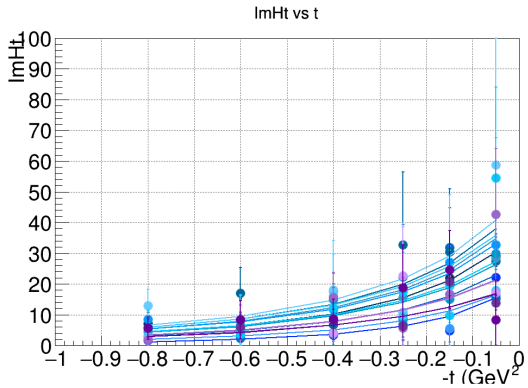
Not shown here: A_{LL} A_{LTx} A_{LTy} are small

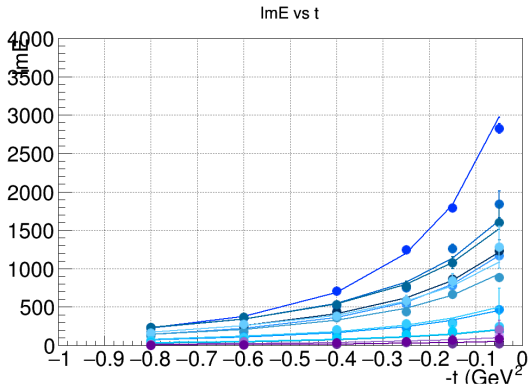


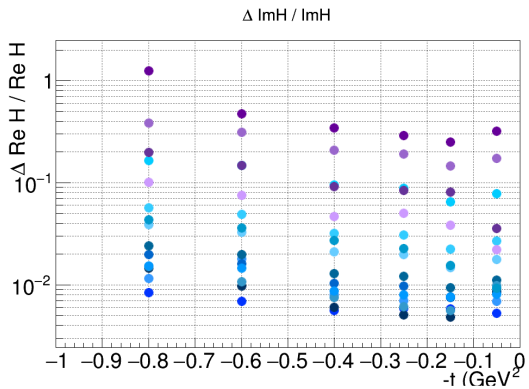
Smearing both statistics and systematics
Fit CFF wth/without to estimate systematics

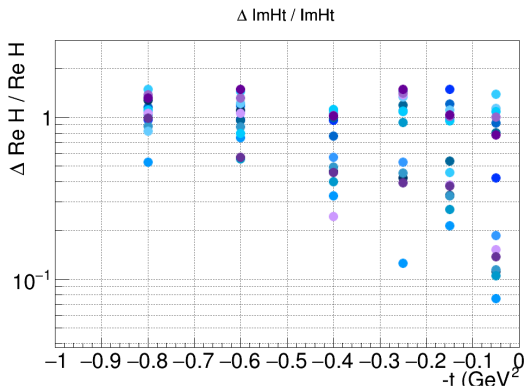
Locally extracted Im CFF

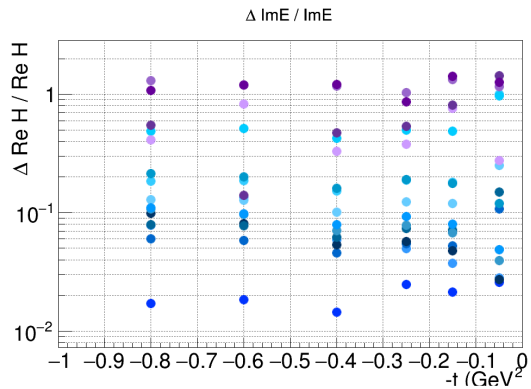




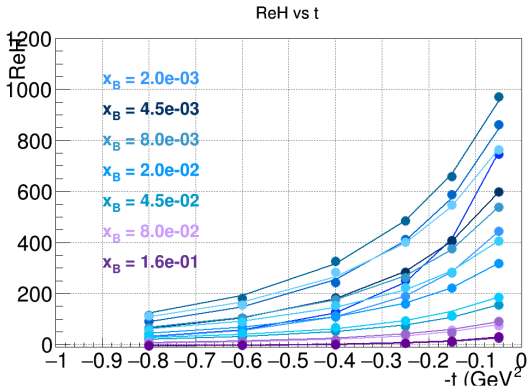


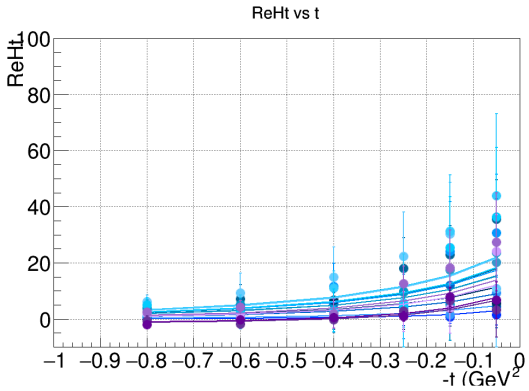


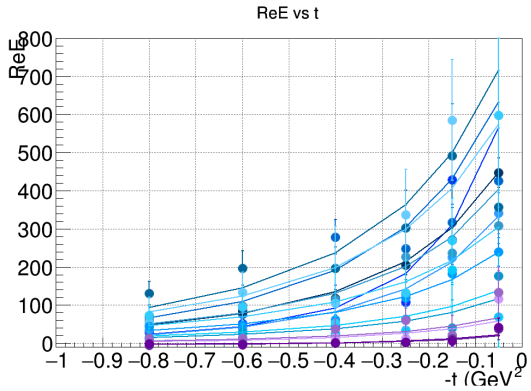


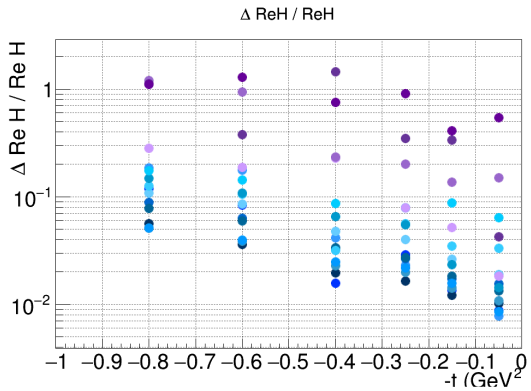


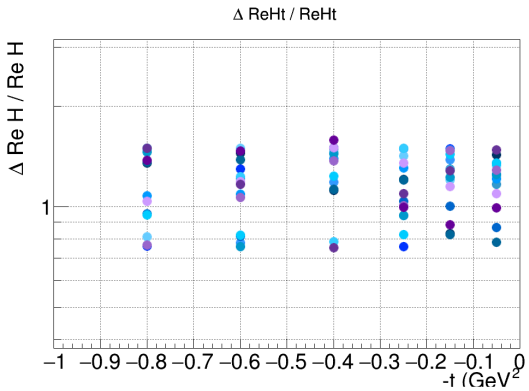
Locally extracted Re CFF

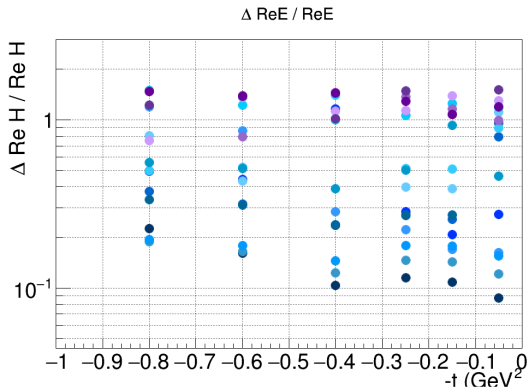






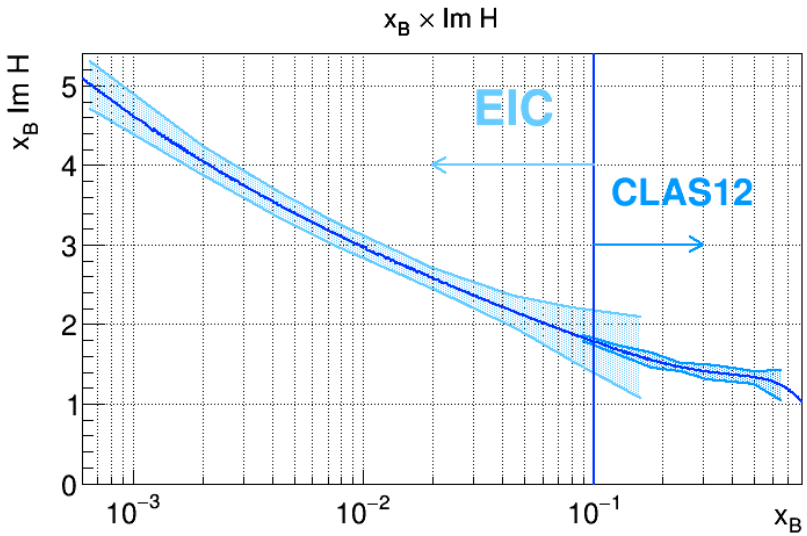


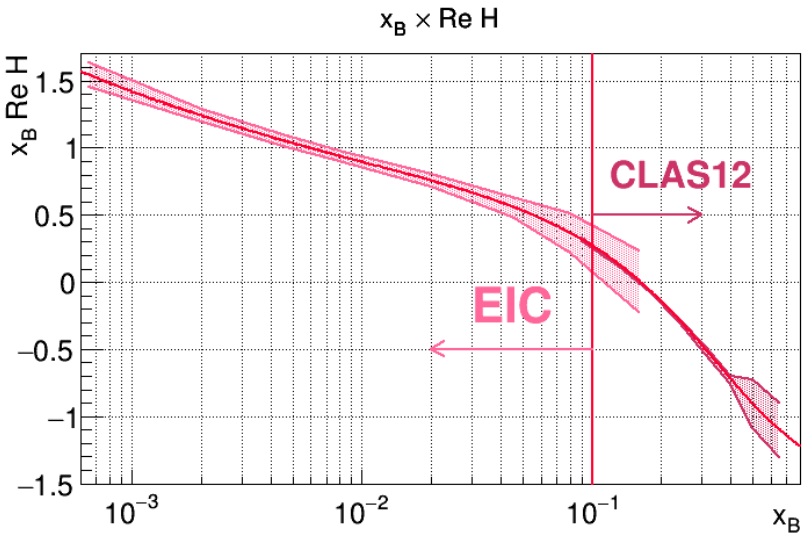




From JLab to EIC: Complementarity

Local extraction results:





Entering the GPD extraction Precision Era!

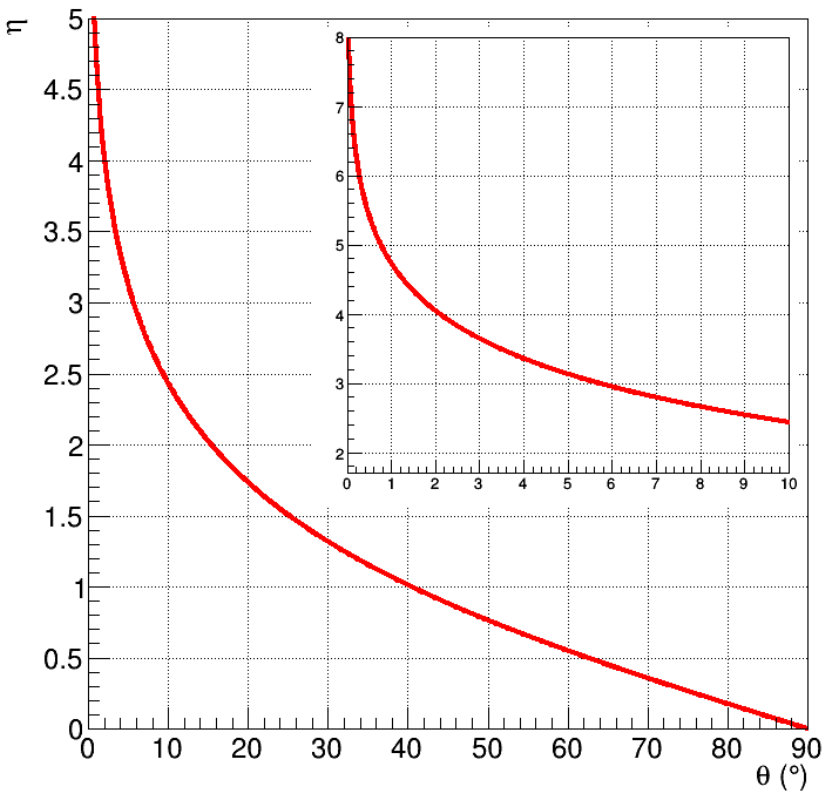
Si Tracker Study

Pseudorapidity η (apologies to experts)

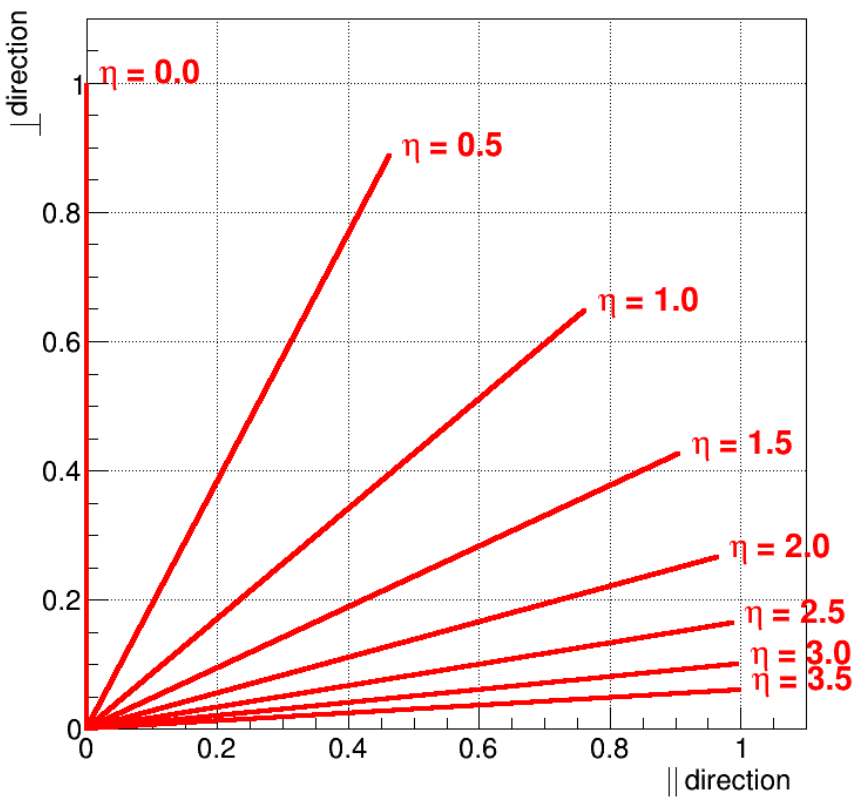
Pseudorapidity commonly replaces polar angle in collider kinematics

$$\eta = -\ln\left(\tan\frac{\theta}{2}\right) = \operatorname{arctanh}\left(\frac{p_{\parallel}}{p}\right)$$

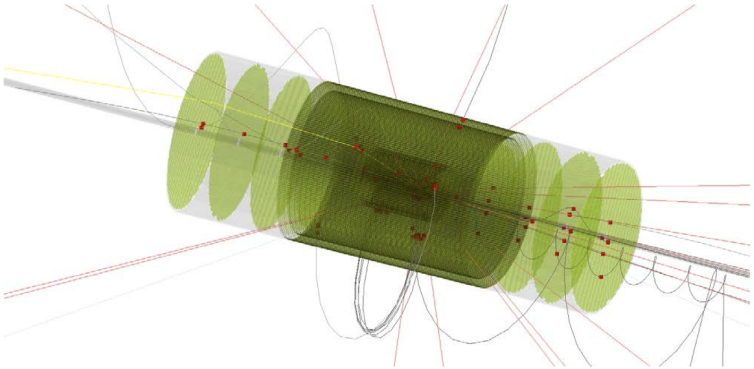
Pseudorapidity η vs polar angle θ



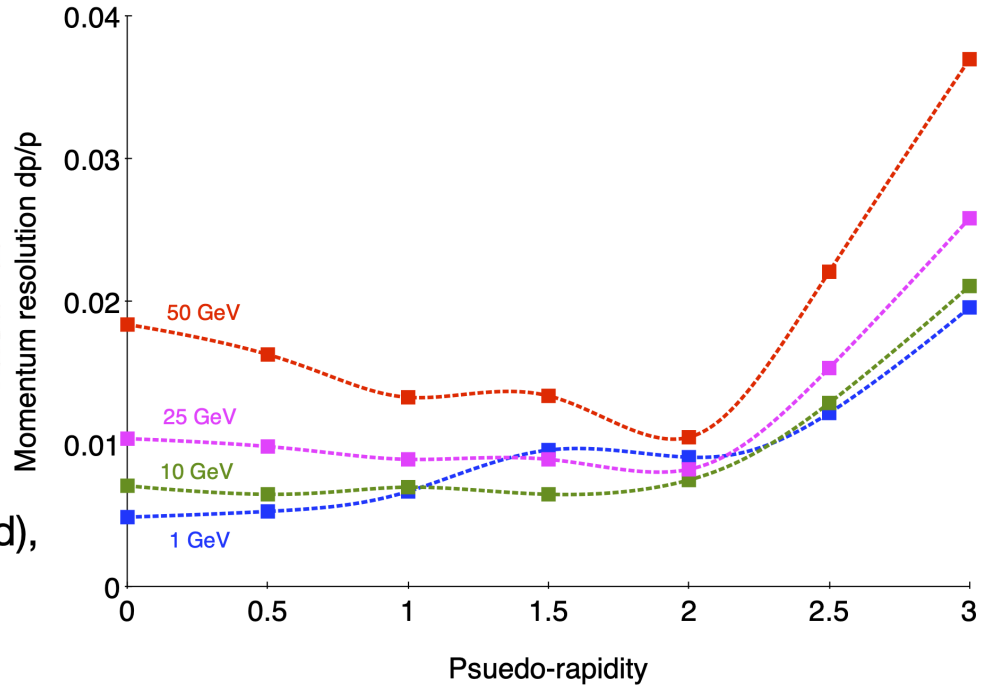
constant pseudorapidity η directions



EIC Si Tracker Concept



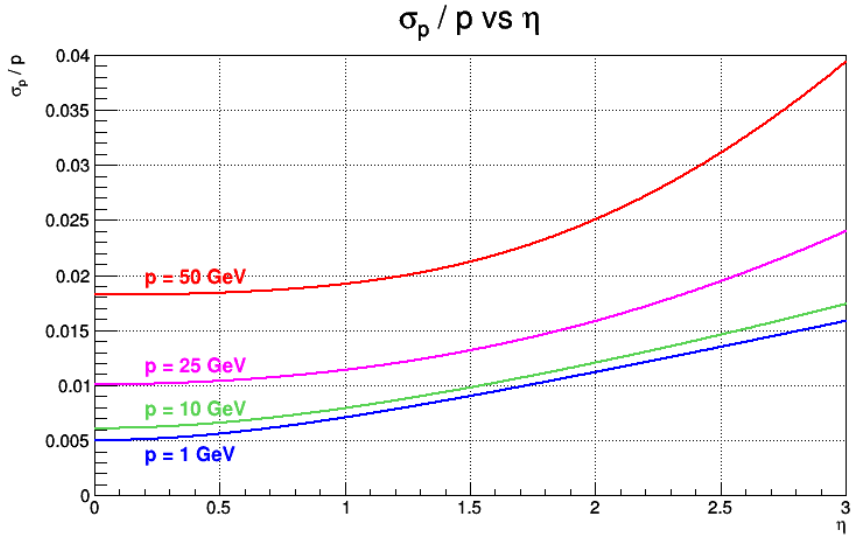
- 6 barrel layers,
- 6 tapered disks x 2 (forward, backward),
- r_{outer} ~0.45m, -1.22m < z < 1.22m,
- ~15m^2 area; ~10m^2 barrel, ~5m^2 disks

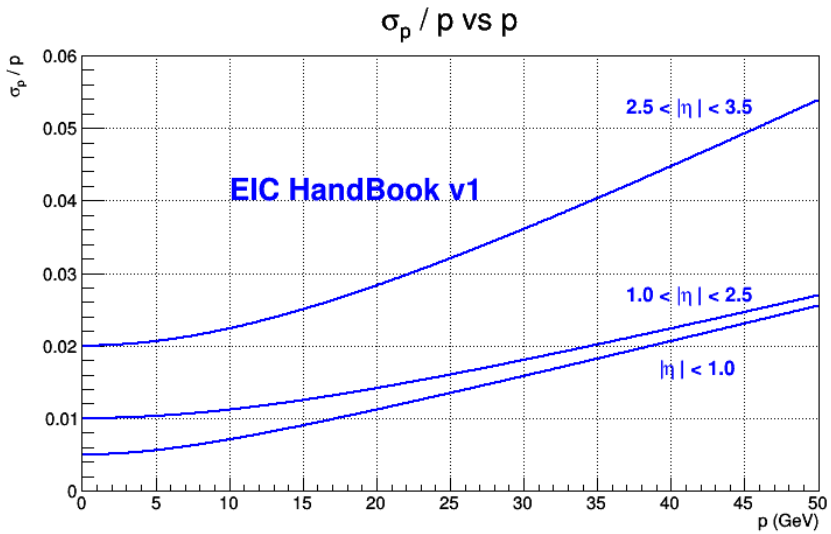


April 9, 2020 - JLab-LBNL EIC discussion

Ernst Sichtermann

Si Tracker Resolutions Parameterization





EIC Handbook Parameterizations:

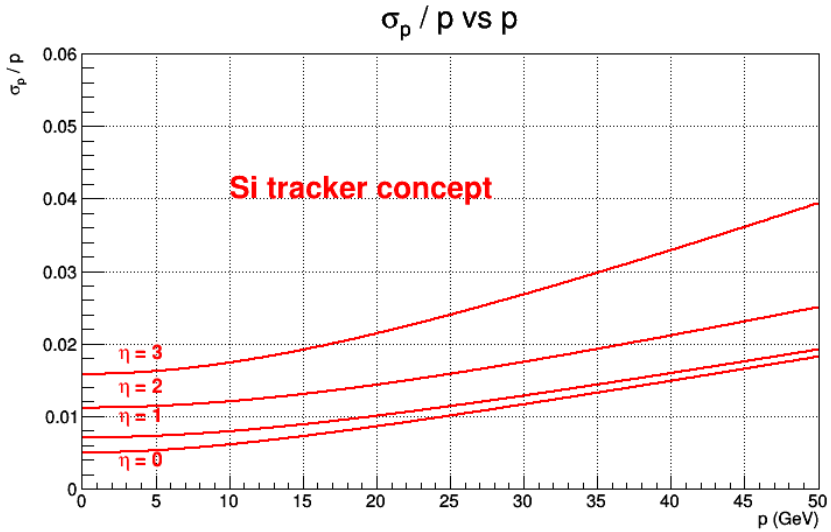
$$2.5 < |\eta| < 3.5 \implies \frac{\sigma_p}{p} = 0.1\%p \oplus 2\%$$

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

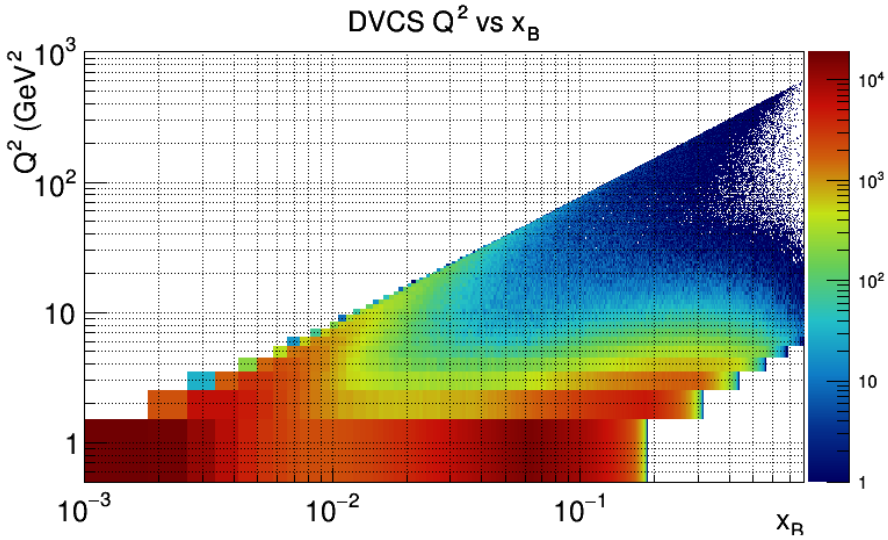
$$|\eta| < 1.0 \implies \frac{\sigma_p}{p} = 0.05\%p \oplus 0.5\%$$

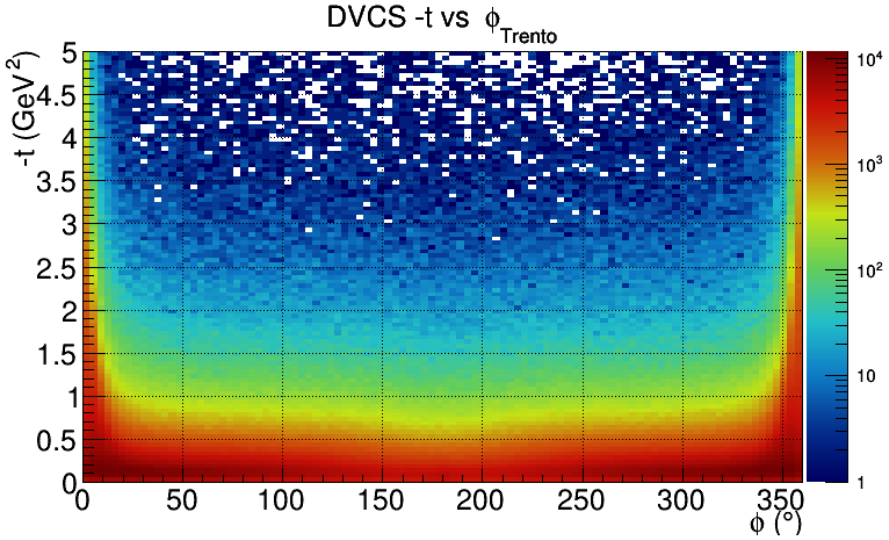
Si concept Parameterization:

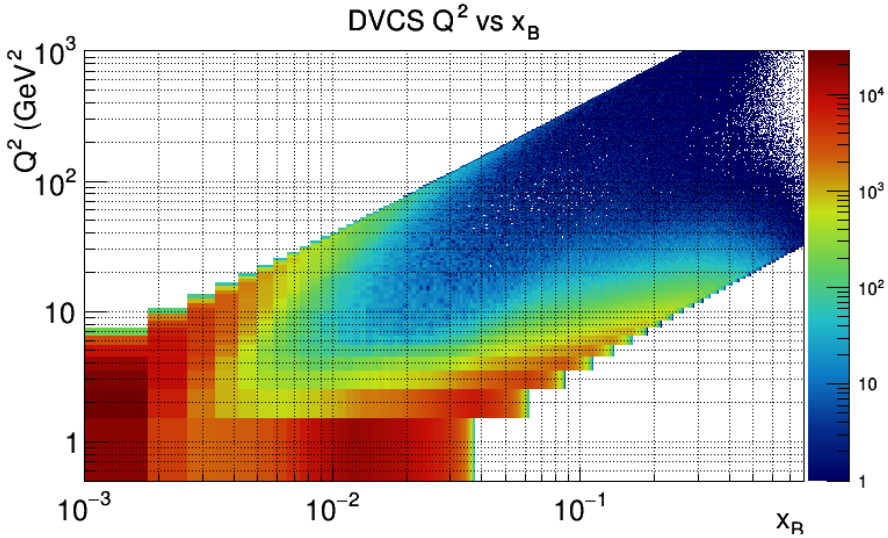
$$\frac{\sigma_p}{p} = 0.5\% \oplus 0.0035\%p \oplus 0.5\%\eta \oplus 7 \times 10^{-5} p\eta^2$$

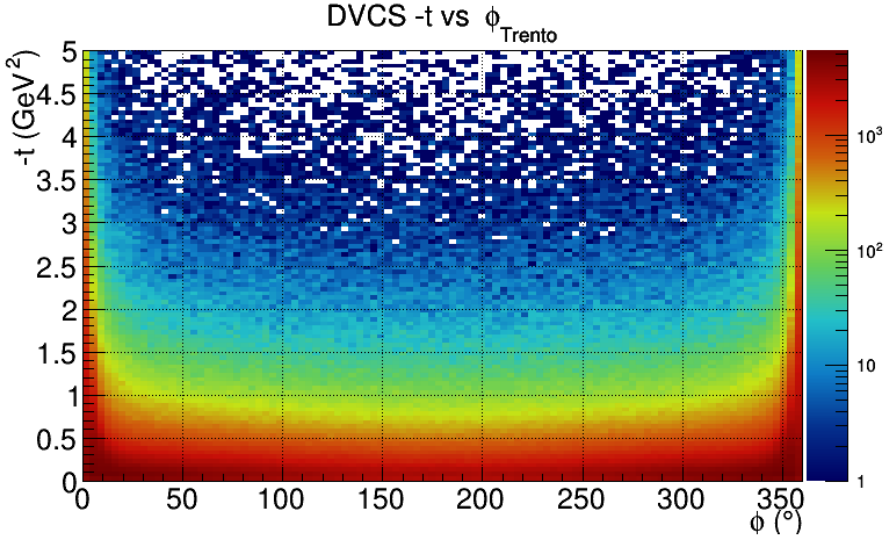


Coverage 5×40 GeV^2 and 10×100 GeV^2

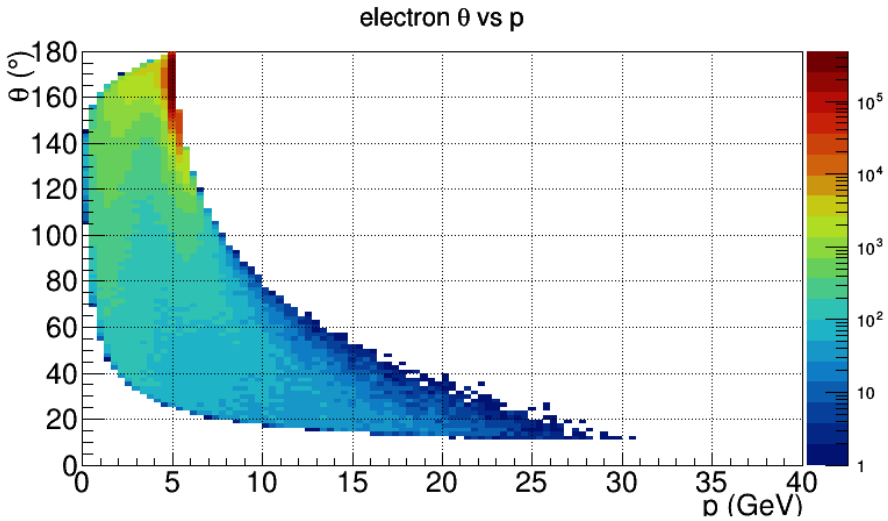


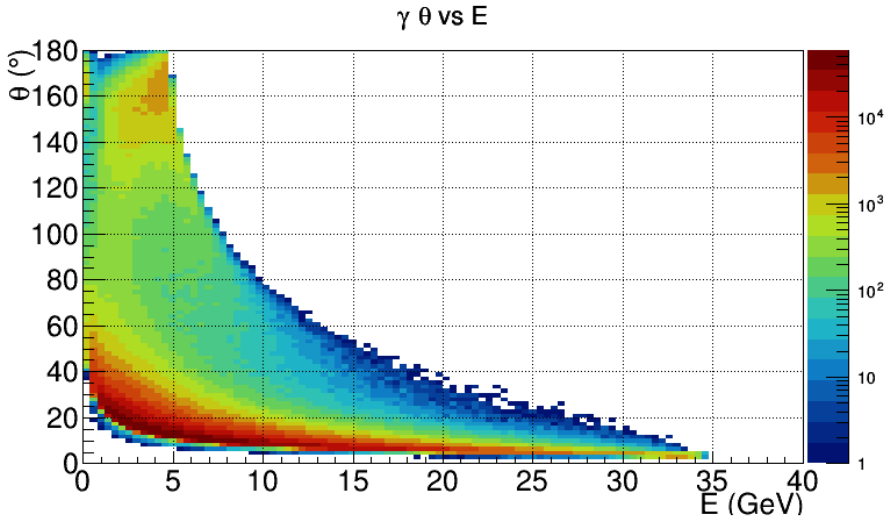


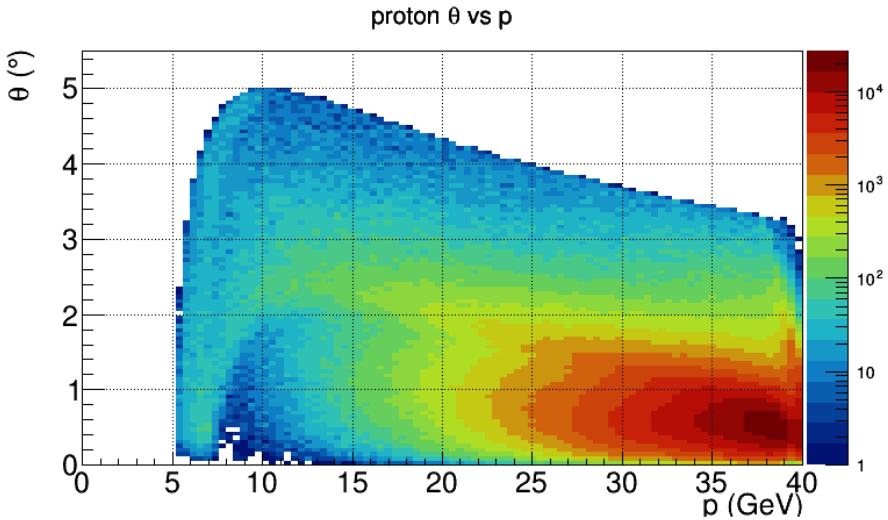


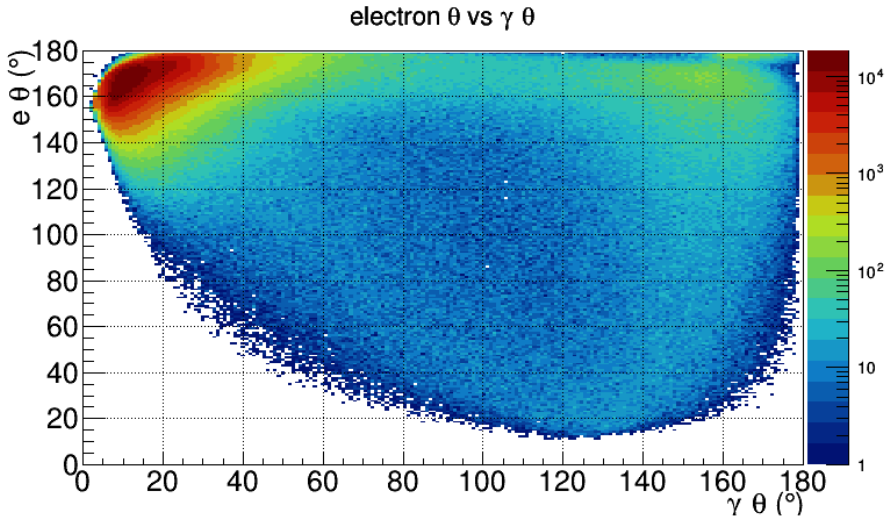


Kinematics 5×40 GeV^2

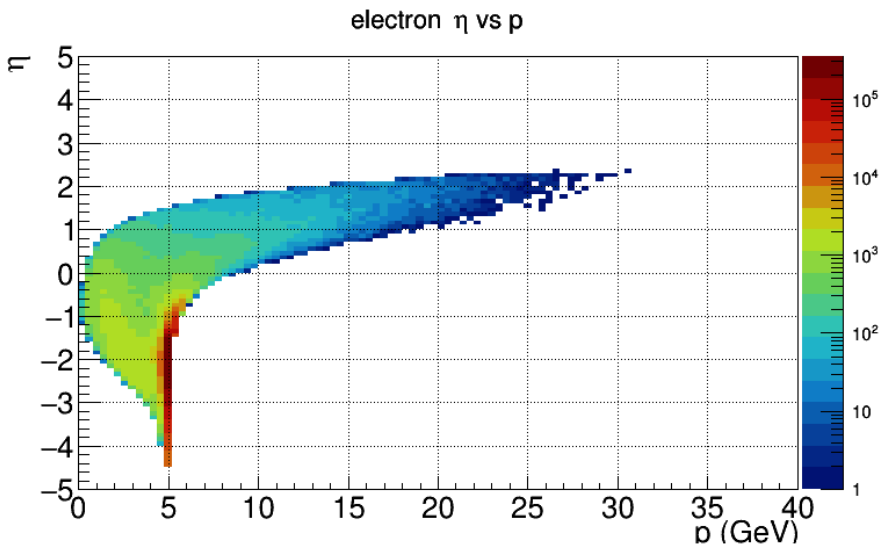


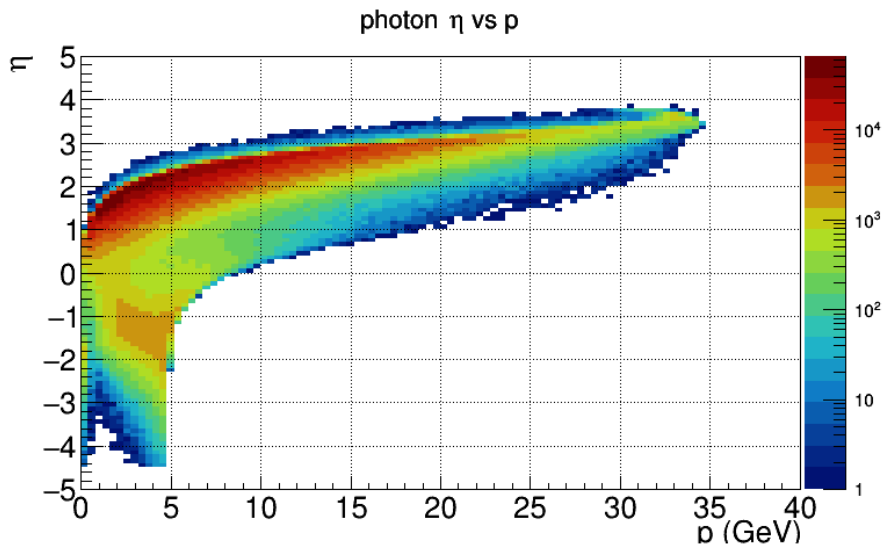


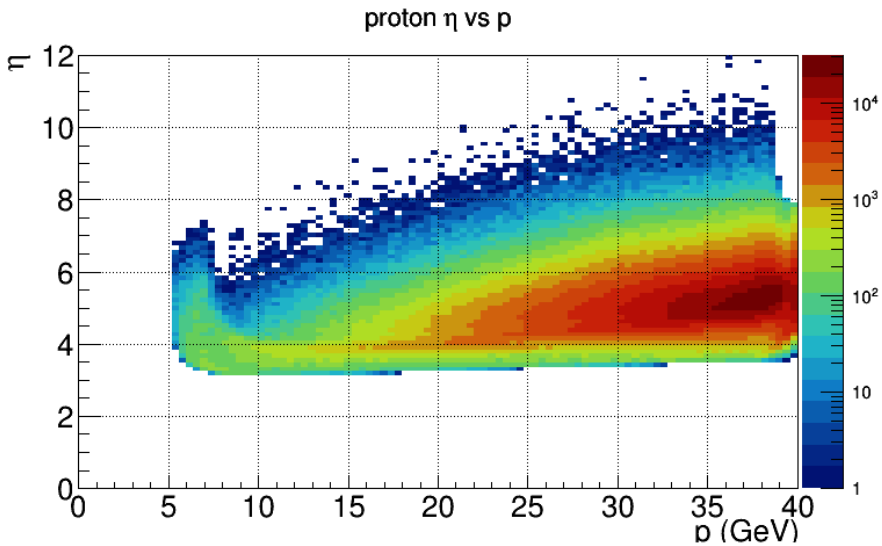


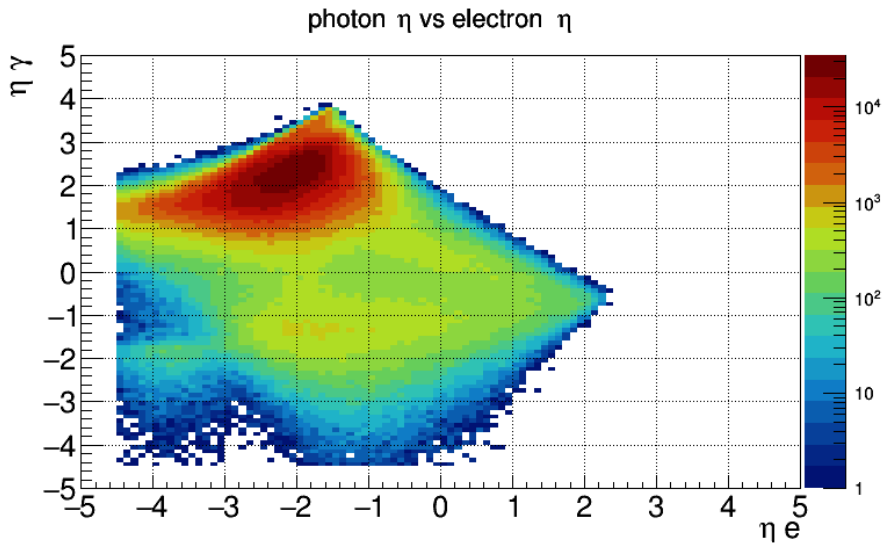


Kinematics 5×40 GeV^2

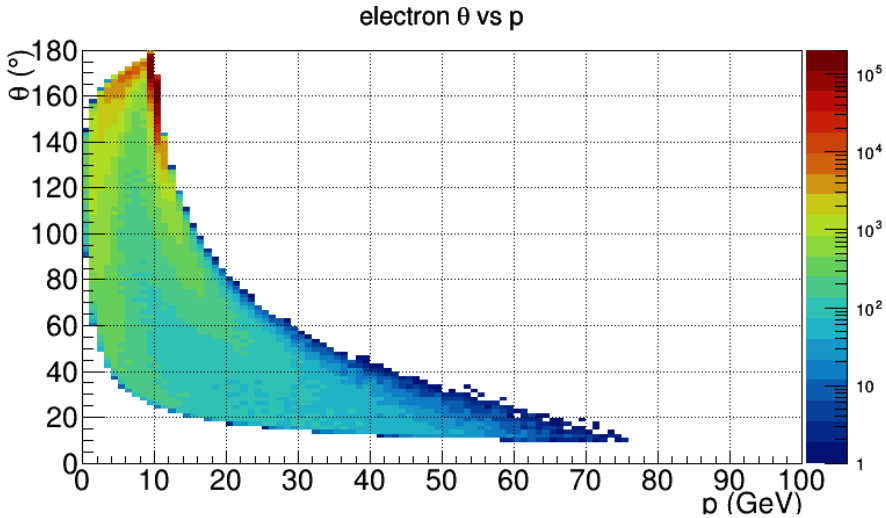


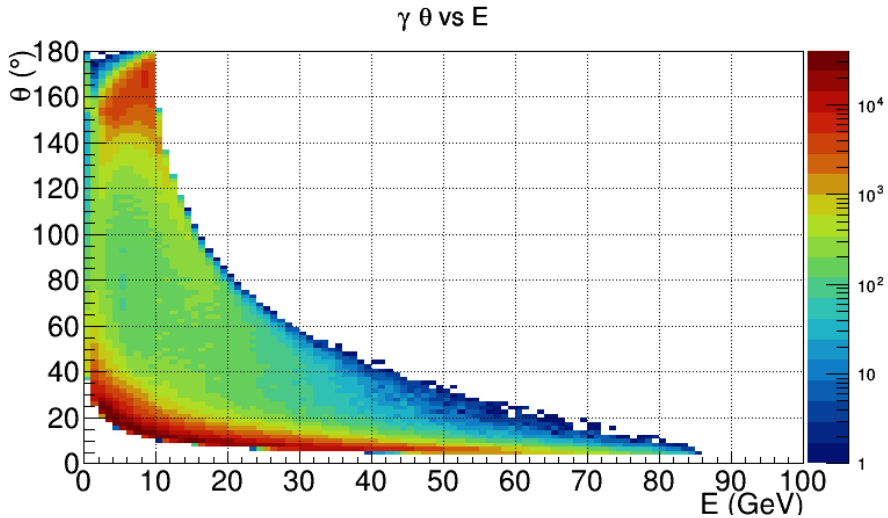


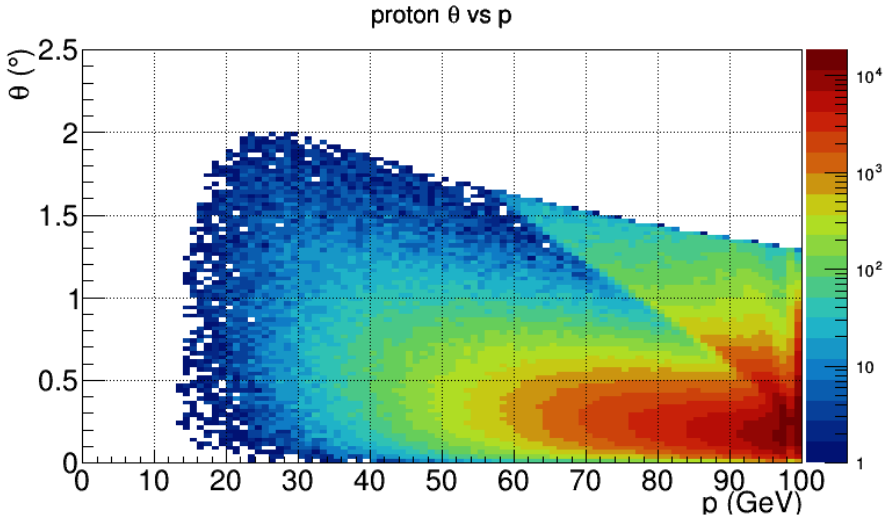


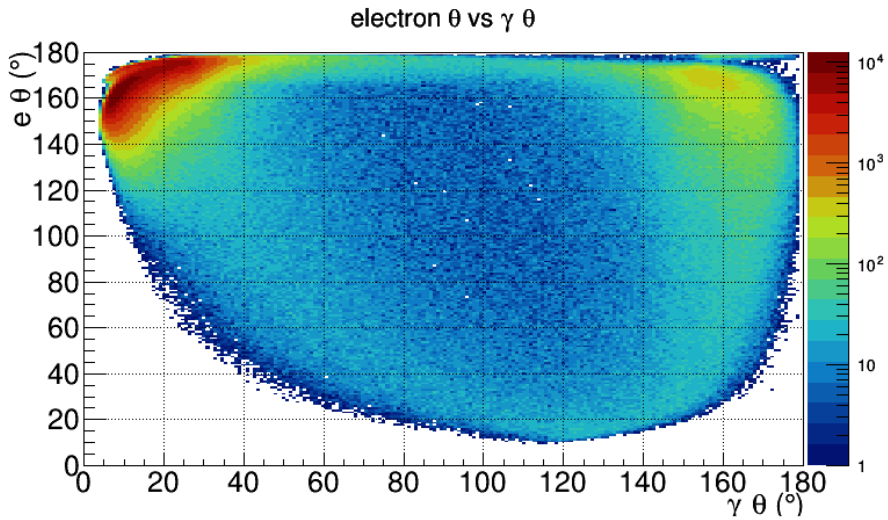


Kinematics 10×100 GeV^2

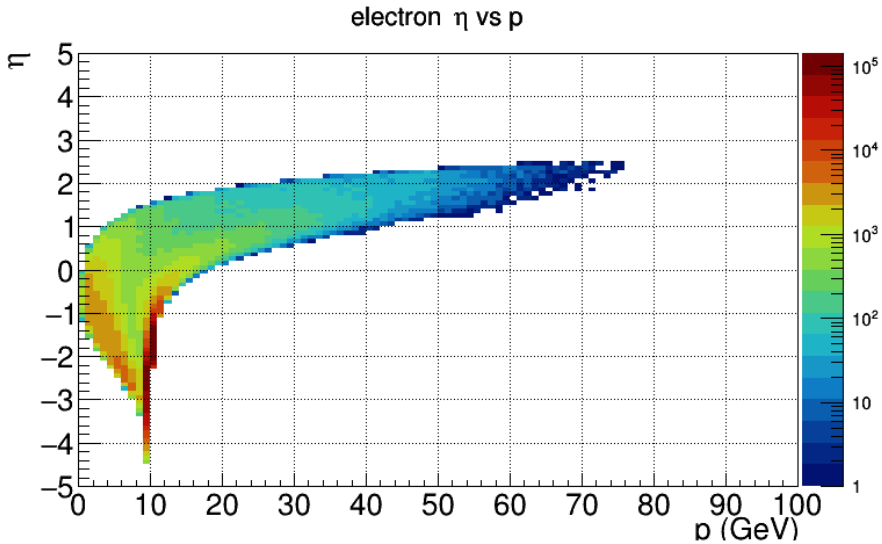


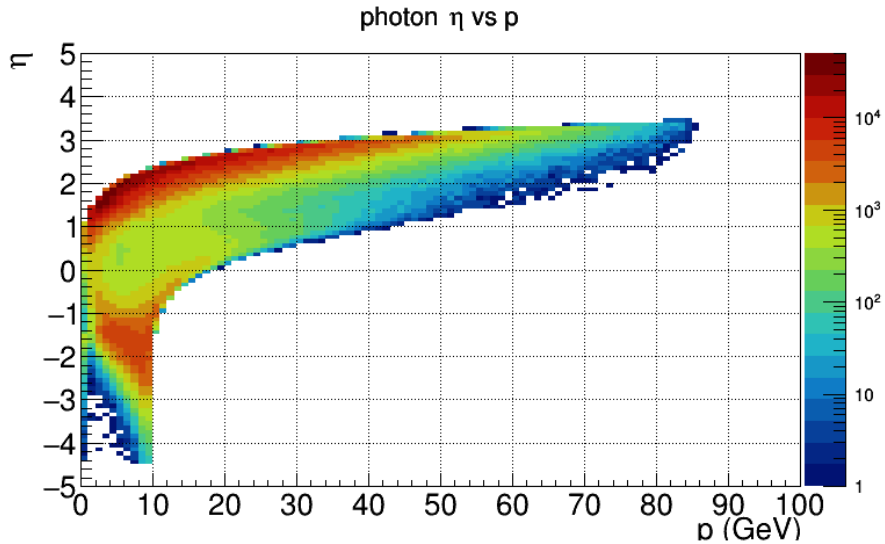


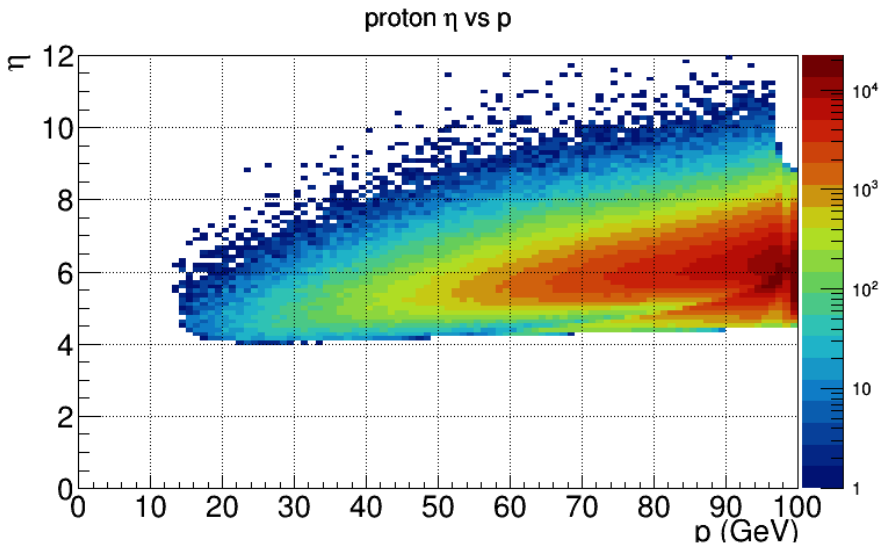


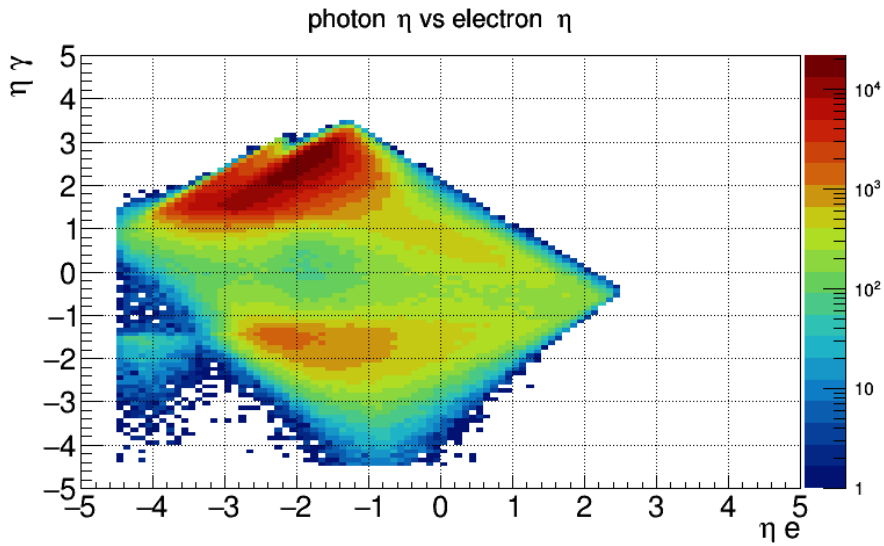


Kinematics 10×100 GeV^2

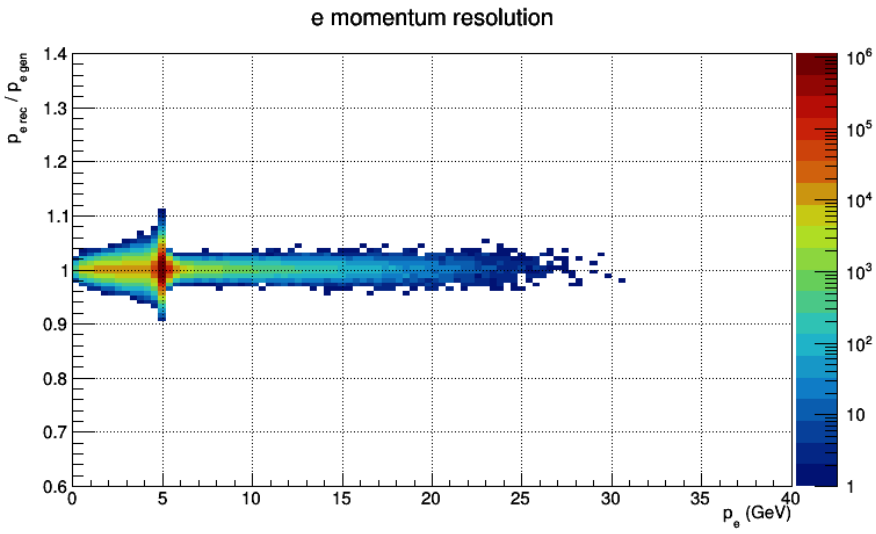


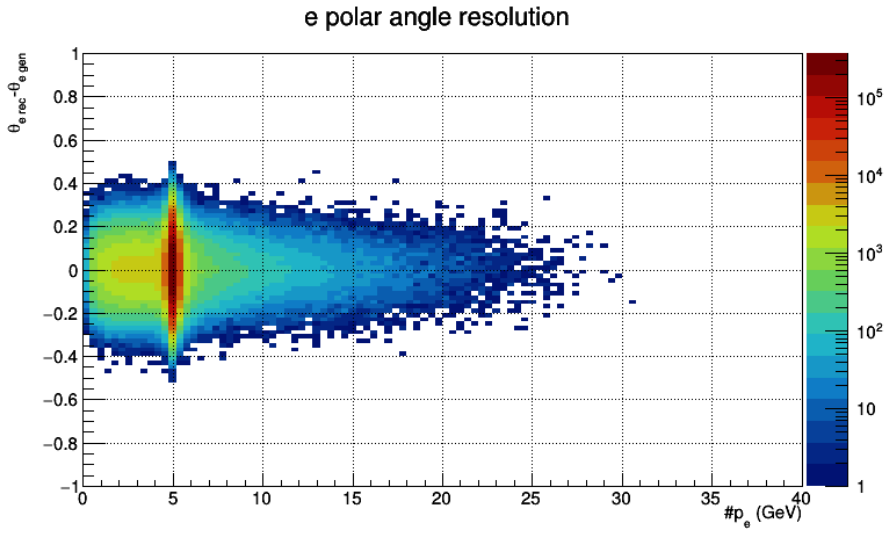


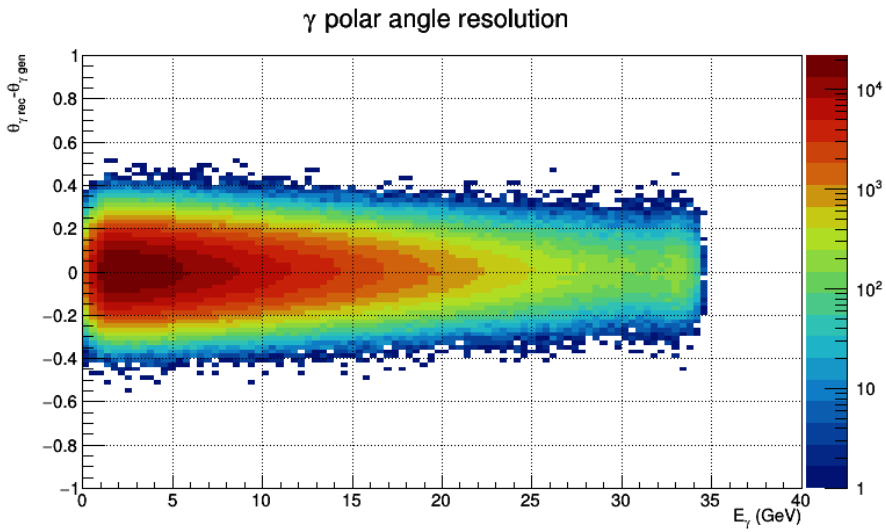


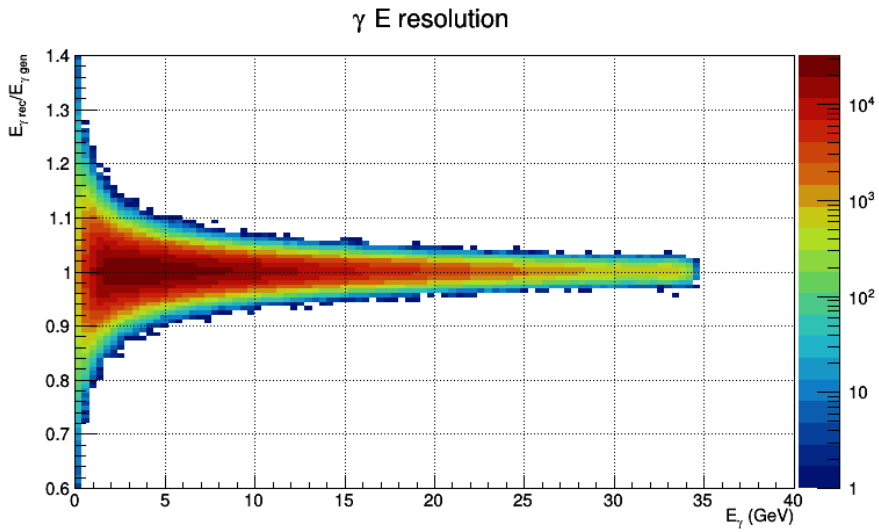


Input Resolutions 5×40 GeV^2

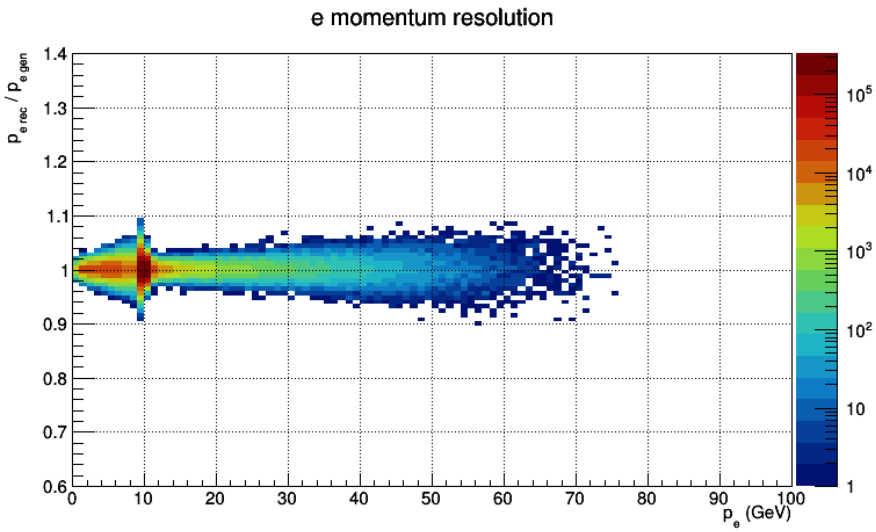


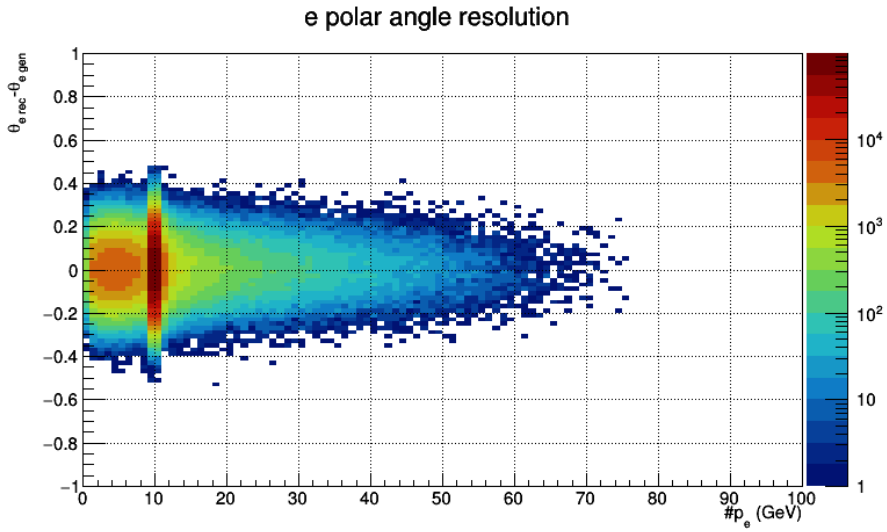


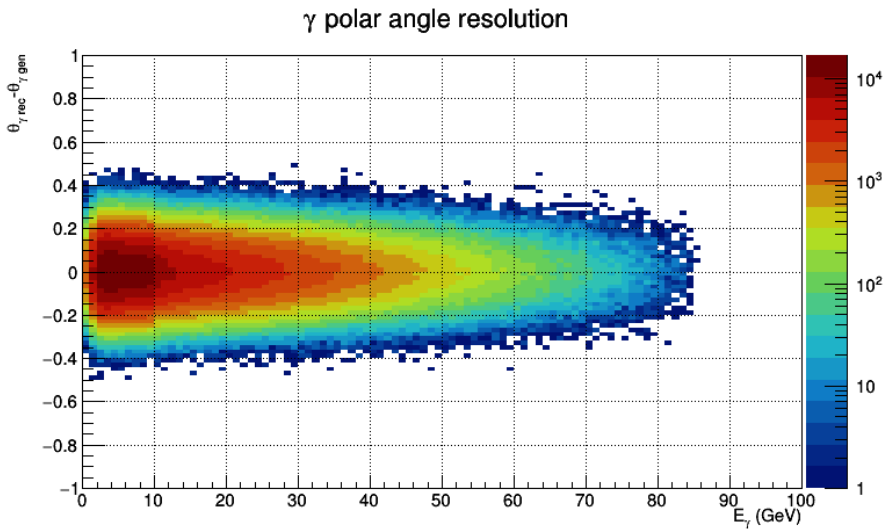


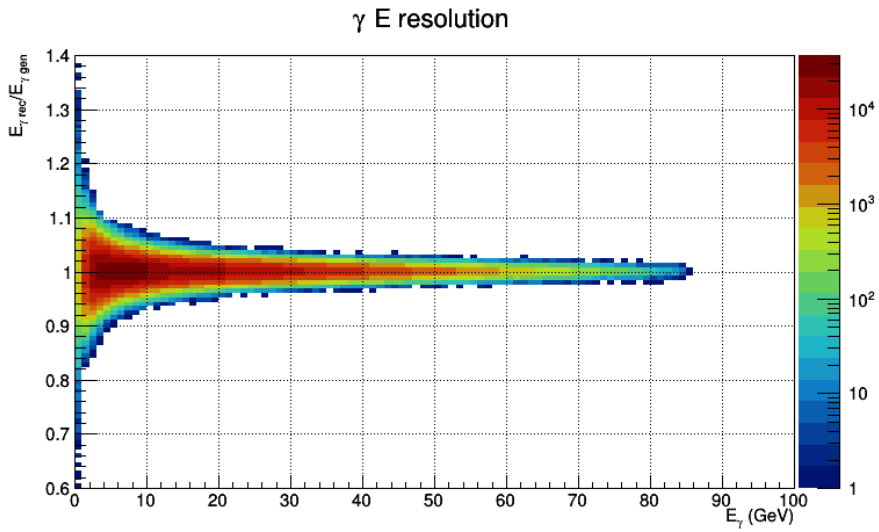


Input Resolutions 10×100 GeV^2

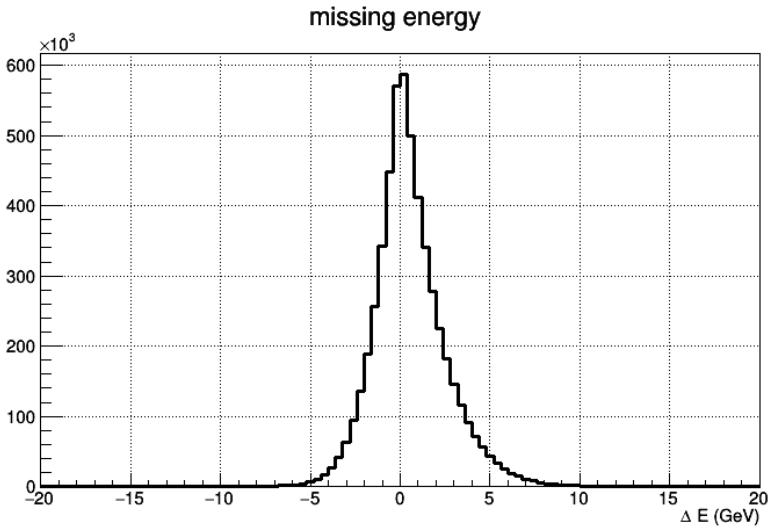


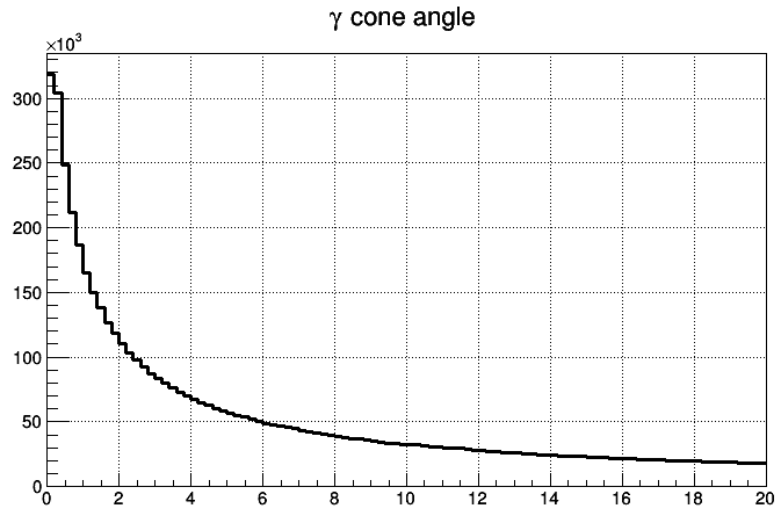


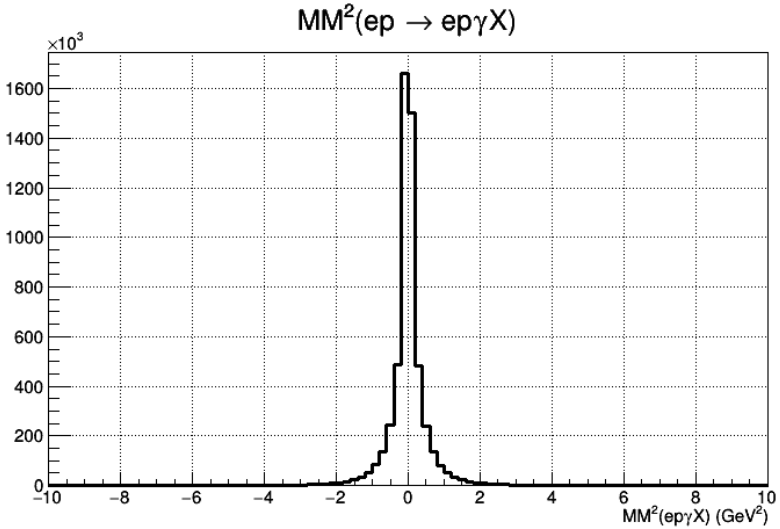


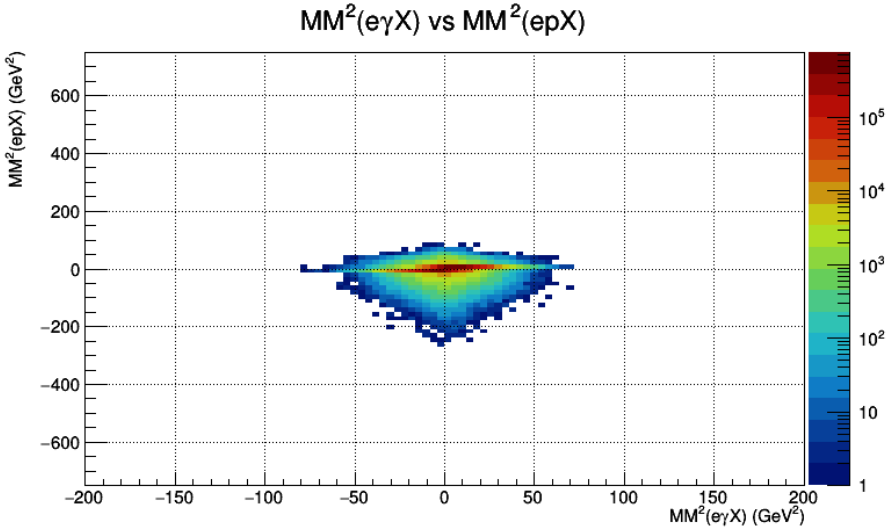


Input Resolutions 5×40 GeV^2

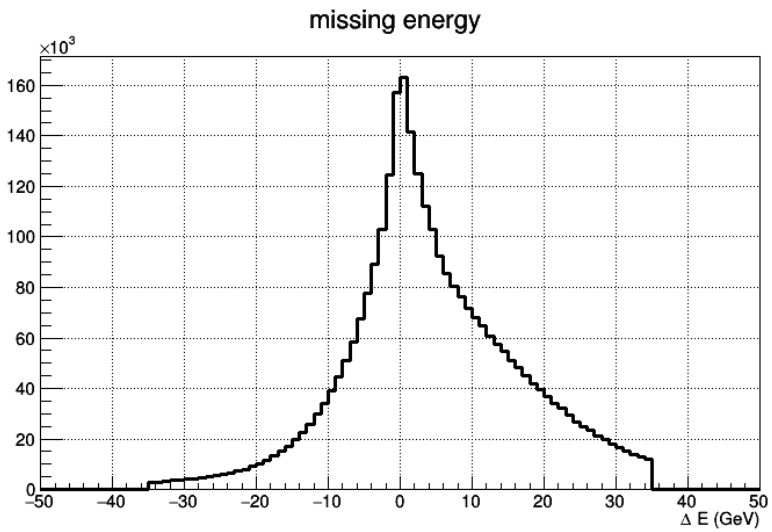


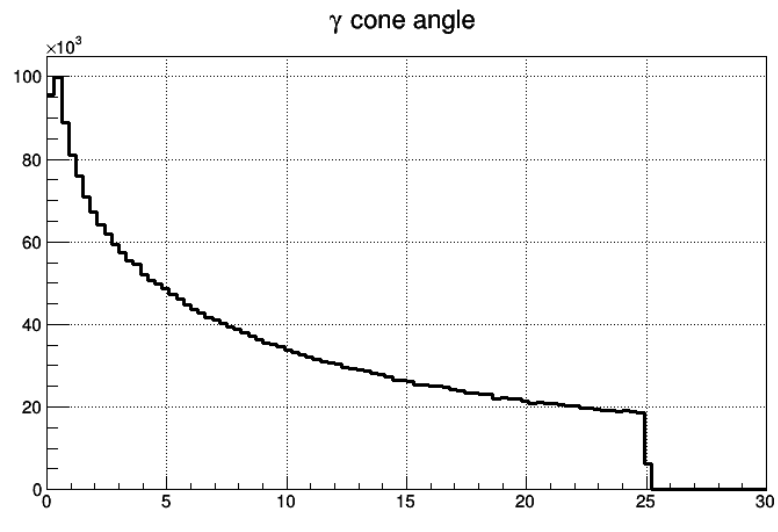


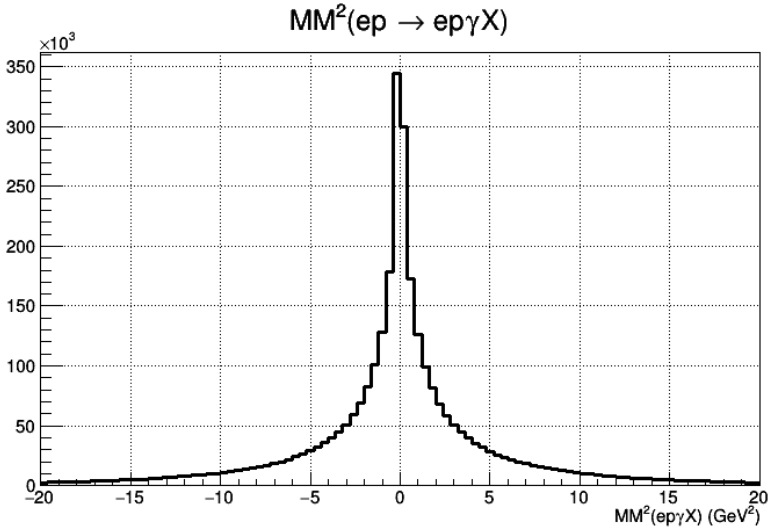


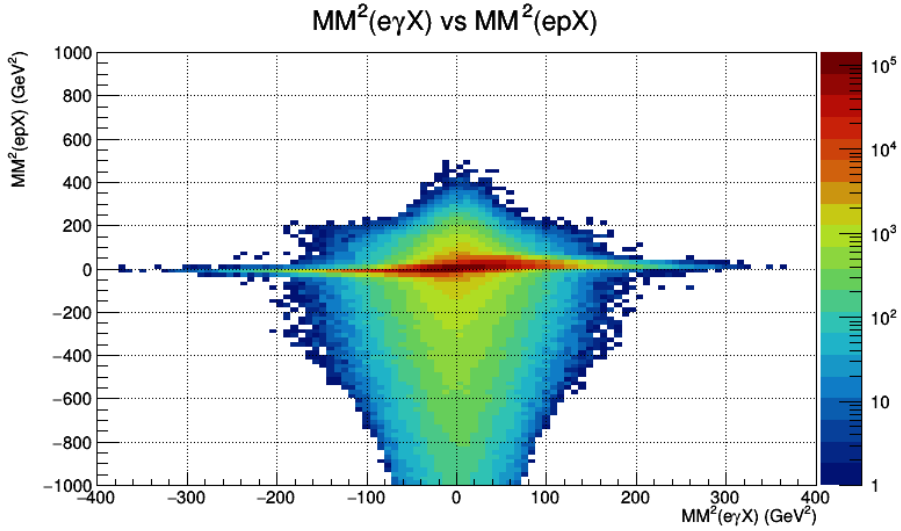


Input Resolutions 10×100 GeV^2









Summary, Outlook

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- GPD extraction now in the Precision Era
- Complementarity between JLab and EIC
- Si Tracker Concept for EIC
- Resolutions similar to Handbook v1