DVCS with JLab CLAS6/CLAS12 : Observables, data binning, theory questions

F.-X. Girod

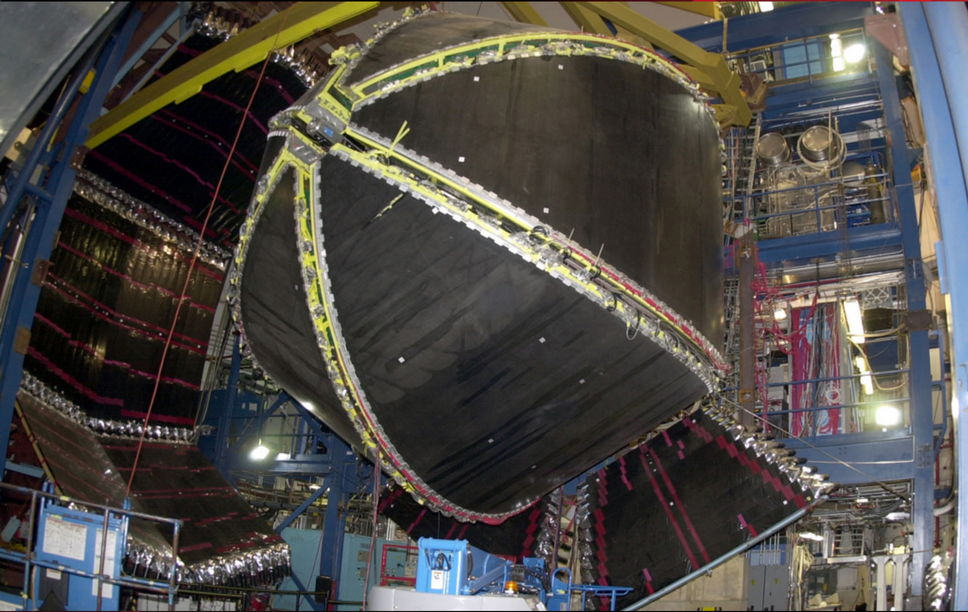
JLab Hall-B

Feb. 10^{th} 14

Outline

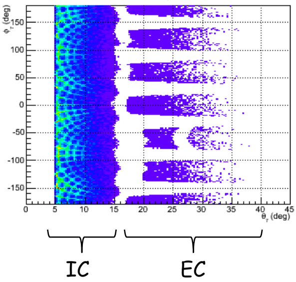
6 GeV measurements

Historical pictures

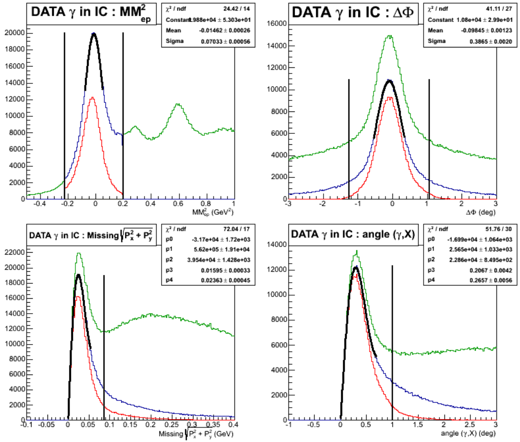


Kinematics and Exclusivity Cuts

Photon : θ vs ϕ

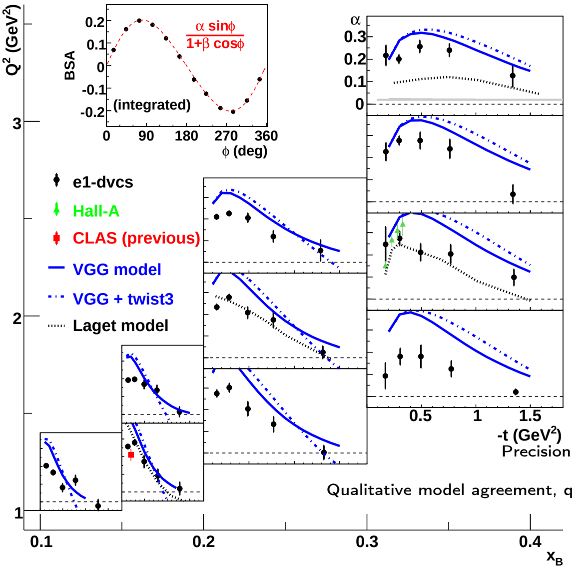


ep→epγ exclusivity cuts in the case where the photon is detected in the IC



proton DVCS BSA

$$F_1\mathcal{H} + \xi G_M \tilde{\mathcal{H}} - \frac{t}{4M^2} F_2 \mathcal{E}$$



Precision in a large phase-space (x_B, Q^2, t)

Qualitative model agreement, quantitative constraints on parameters

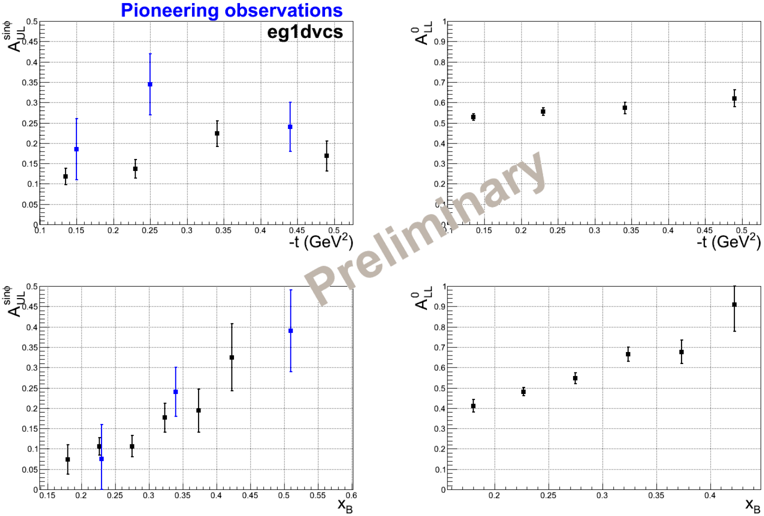
F.-X. G. *et al.*, PRL **100** (2008) 162002

proton DVCS TSA

Ten fold improvement in statistics

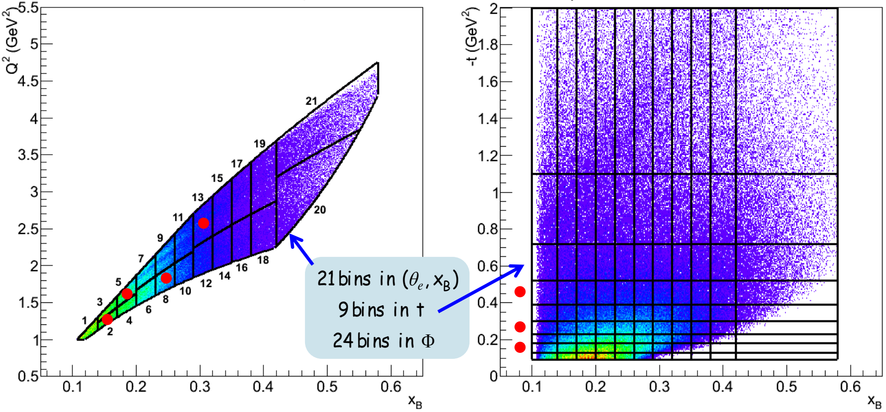
$$F_1 \tilde{\mathcal{H}} + \xi G_M \left(\mathcal{H} + \frac{\xi}{1+\xi} \mathcal{E} \right)$$

$A_{UL} \propto F_1 \, \mathcal{I}m \, \tilde{\mathcal{H}}$ $\quad$ $A_{LL} \propto F_1 \, \mathcal{R}e \, \tilde{\mathcal{H}}$

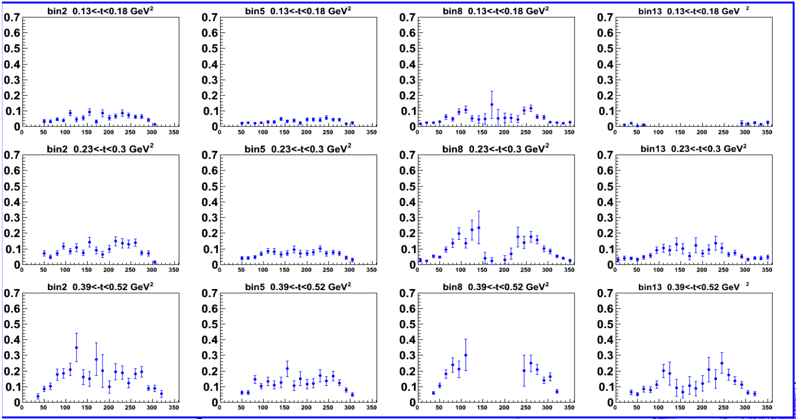


Kinematical Coverage and Binning

$Q^2 > 1,\ 0.1 < x_B < 0.58,\ 21 < \theta_e < 45,\ p_e > 0.8,\ W > 2$

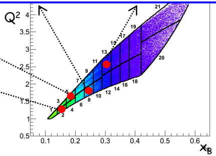


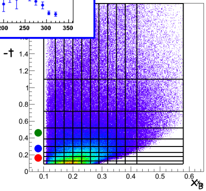
Neutral Pion Contamination



$$\frac{N_{ep\to ep\pi^0\to ep\gamma(\gamma)}}{N_{ep\to ep\gamma}}$$

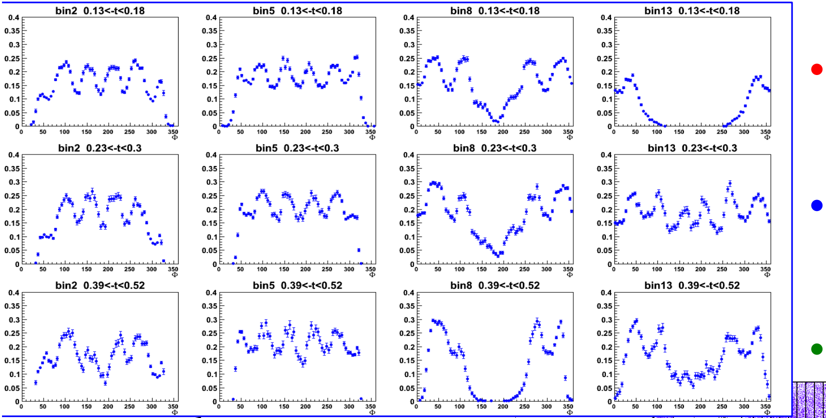
with $N_{ep\to ep\pi^0\to ep\gamma(\gamma)} = N_{\pi^0\,DATA} \times \dfrac{Acc^{1\gamma}_{\pi^0\,MC}}{Acc^{2\gamma}_{\pi^0\,MC}}$

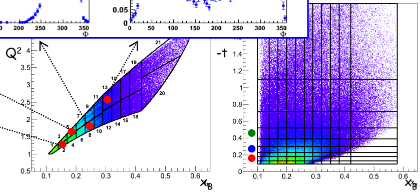




Averaged over all the bins, π^0 contamination fraction is ~12%

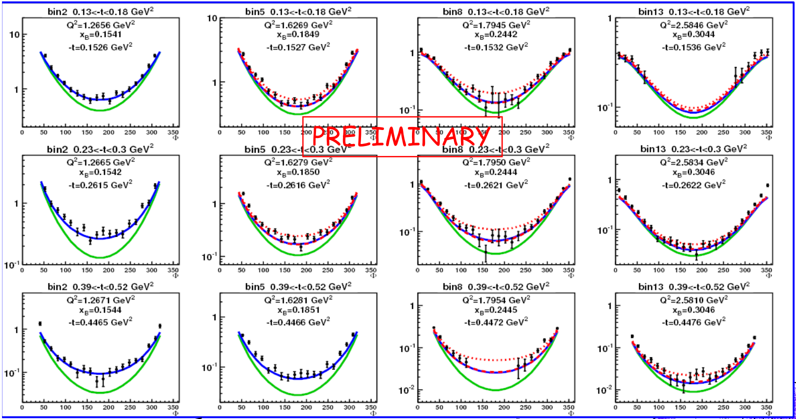
Acceptances





Averaged over all the bins, acceptance is ~14%

Unpolarized Cross-Sections

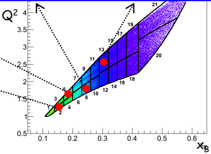


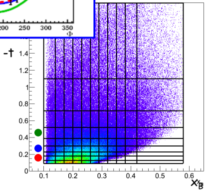
• $\frac{d^4\sigma_{ep\to ep\gamma}}{dQ^2 dx_B dt d\Phi}$ (nb/GeV^4)

BH — VGG (H only)

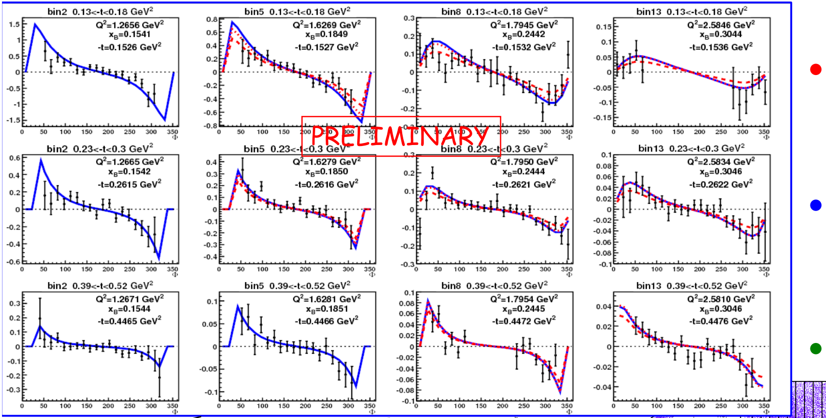
KM10 KM10a

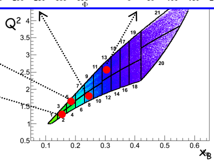
VGG : Vanderhaeghen, Guichon, Guidal *KM : Kumericki, Mueller*

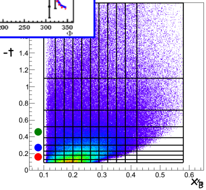




Polarized Cross-Sections







- $\frac{1}{2}\left(\frac{d^4\vec{\sigma}_{ep\to ep\gamma}}{dQ^2dx_Bdtd\Phi} - \frac{d^4\overleftarrow{\sigma}_{ep\to ep\gamma}}{dQ^2dx_Bdtd\Phi}\right)$ (nb/GeV ^{4})

—— VGG (H only) ········ KM10 - - - KM10a

VGG : Vanderhaeghen, Guichon, Guidal *KM : Kumericki, Mueller*

Analysis details

Radiative Corrections : first order

$$\left.\frac{d\sigma}{d\Omega}\right|_{\text{exp, LO}} = \left.\frac{d\sigma}{d\Omega}\right|_{\text{Virtual }\gamma} + \left.\frac{d\sigma}{d\Omega}\right|_{\text{Real }\gamma}$$
$$= \left.\frac{d\sigma}{d\Omega}\right|_{\text{Born}} \left[1 + \delta_{\text{Vertex}} + \delta_{\text{Vacuum}} + \delta_{\text{Real}}(\Delta E)\right]$$

$$\delta_{\text{Vacuum}} = \frac{2\alpha}{3\pi}\left[\ln\left(\frac{Q^2}{m_e^2}\right) - \frac{5}{3}\right] + \infty$$
$$\delta_{\text{Vertex}} = \frac{\alpha}{\pi}\left[\frac{3}{2}\ln\left(\frac{Q^2}{m_e^2}\right) - 2 - \frac{1}{2}\ln^2\left(\frac{Q^2}{m_e^2}\right) + \frac{\pi^2}{6}\right] + \infty$$

$$\delta_{\text{Real}}(\Delta E) = \frac{\alpha}{\pi}\left\{2\ln\left(\frac{\Delta E}{\sqrt{EE'}}\right)\left[\ln\left(\frac{Q^2}{m_e^2}\right) - 1\right] - \frac{1}{2}\ln^2\frac{E}{E'} + \frac{1}{2}\ln^2\left(\frac{Q^2}{m_e^2}\right) - \frac{\pi^2}{3} + \text{Sp}\left(\cos^2\frac{\theta_e}{2}\right)\right\} + \infty$$

$$\lim_{\Delta E \to 0} \left.\frac{d\sigma}{d\Omega}\right|_{\text{exp, LO}} = -\infty$$

Radiative Corrections : resummation

$$\left.\frac{d\sigma}{d\Omega}\right|_{\text{exp, LO}} = \left.\frac{d\sigma}{d\Omega}\right|_{\text{Born}} \left[1 + \delta_{\text{Vertex}} + \delta_{\text{Vacuum}} + \delta_{\text{Real}}(\Delta E)\right]$$

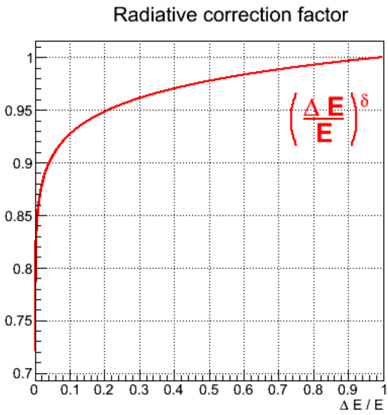
$$\left.\frac{d\sigma}{d\Omega}\right|_{\text{exp}} = \left.\frac{d\sigma}{d\Omega}\right|_{\text{Born}} \frac{e^{\delta_{\textbf{Vertex}} + \delta^{\mathbf{0}}_{\textbf{Real}}}}{(1 - \delta_{\text{Vacuum}}/2)^2} \left(\frac{\Delta E}{\sqrt{EE'}}\right)^{\delta_{\boldsymbol{S}}}$$

$$\delta_S = \frac{2\alpha}{\pi}\left[\ln\left(\frac{Q^2}{m_e^2}\right) - 1\right]$$

The term containing δ_S defines the radiative lineshape

Q: Is this justifiable beyond the peaking approximation ?

Radiative Corrections : illustration



experimental cross-section up to resolution Δ E

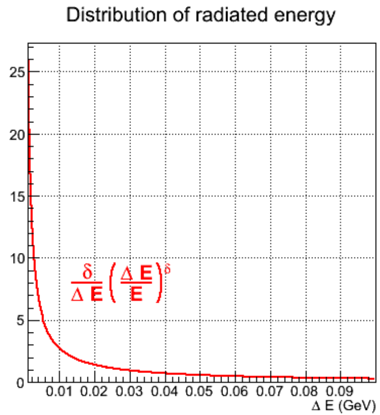
$$\frac{d\sigma}{d\Omega}_{exp} = \frac{d\sigma}{d\Omega}_{Born}(1+\delta_{virt})\left(\frac{\Delta E}{E}\right)^{\delta}$$

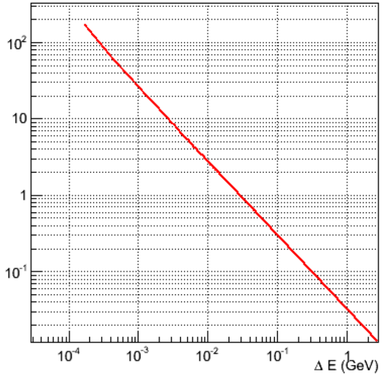
distribution w.r.t. Δ E

=

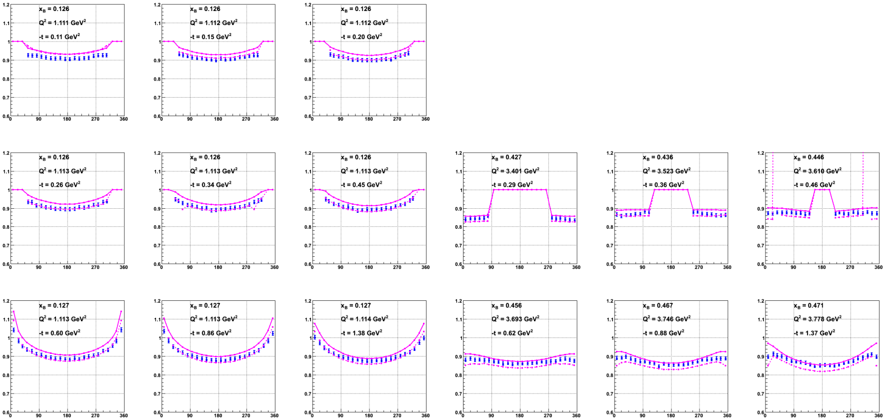
derivative of integral above

Radiative Corrections : illustration

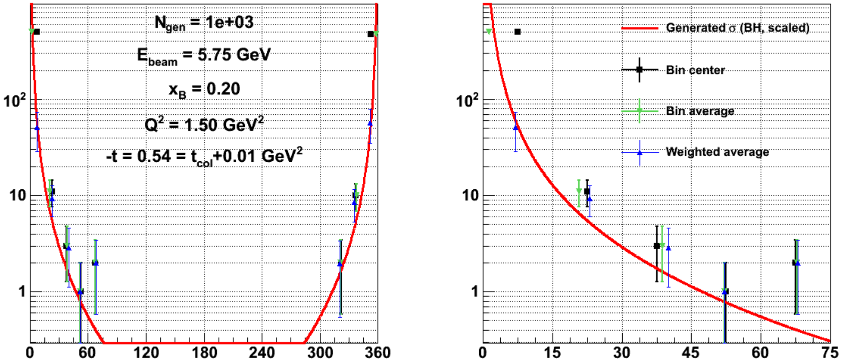




Radiative Corrections : results and comparison



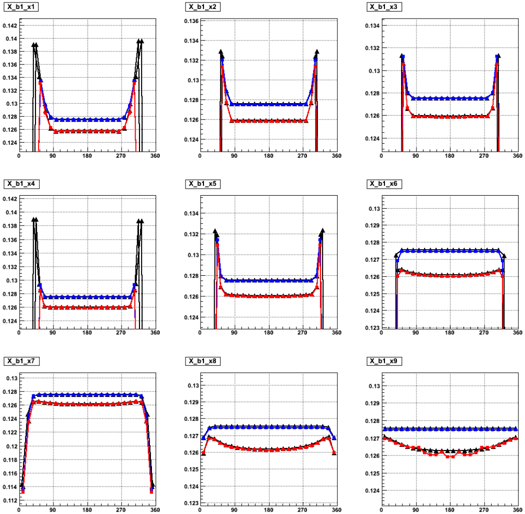
Finite Bin Size



$$\phi_w = \frac{\sum_{i=1}^{N} w(\phi_i) \times \phi_i}{\sum_{i=1}^{N} w(\phi_i)}, \quad N_w = \frac{\sum_{i=1}^{N} w(\phi_i)}{w(\phi_w)}$$

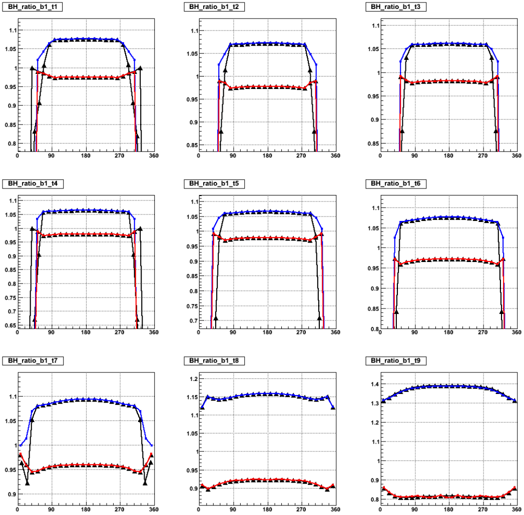
Finite Bin Size

Dependence of x_B (center of bin and average) as a function of ϕ



Finite Bin Size

Ratio of integrated cross-section to cross-section at kinematical choice (center and average)



Future strategies

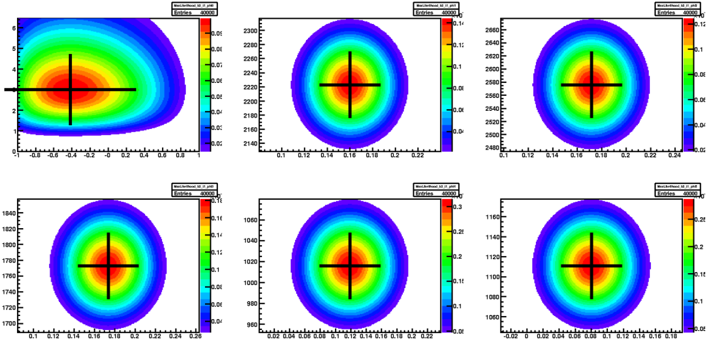
Maximum Likelihood

Probability of observing N events when we expect μ given by Poisson : $\frac{e^{-\mu}\mu^{N}}{N!}$

Relation between asymmetry and expected number of events : $\mu^{\pm} = \mu\frac{1 \pm AP}{2}$

Likelihood constructed event by event :

$$L = \frac{e^{-\mu}\mu^{N^{+}+N^{-}}}{N^{+}!N^{-}!}\left(\frac{1+AP}{2}\right)^{N^{+}}\left(\frac{1-AP}{2}\right)^{N^{-}}$$



Questions

$$
\begin{aligned}
L &= \frac{e^{-\mu}\mu^{N^+ + N^-}}{N^+! N^-!}\left(\frac{1+AP}{2}\right)^{N^+}\left(\frac{1-AP}{2}\right)^{N^-} \\
\mu &= \mathcal{L}\epsilon\sigma(\mathcal{H},\tilde{\mathcal{H}},\cdots) \\
A &= \frac{\sigma^+(\mathcal{H},\tilde{\mathcal{H}},\cdots) - \sigma^-(\mathcal{H},\tilde{\mathcal{H}},\cdots)}{\sigma(\mathcal{H},\tilde{\mathcal{H}},\cdots)}
\end{aligned}
$$

- Model ansatz for missing CFFs/GPDs
- Parameterization for CFFs/GPDs
- Higher twist/Higher order in cross-section
- Relation with radiative corrections