



Spacelike and Timelike Compton Scattering

Progress report

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Conclusions

H. Moutarde

Irfu/SPhN, CEA-Saclay

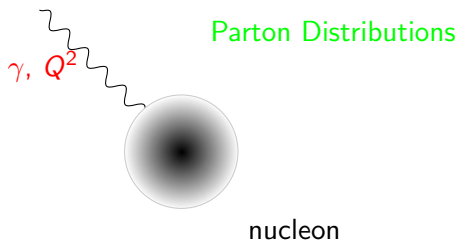
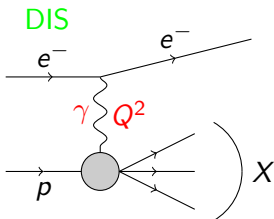
DIS 2012 - 28 / 03 / 2012

- 1 Theoretical framework
- 2 Next-to-Leading Order computation of DVCS and TCS
- 3 Computation of DVCS observables
- 4 Technical remarks

In collaboration with : S. Goloskokov, P. Kroll, B. Pire,
F. Sabatié, L. Szymanowski and J. Wagner.

Generalized Parton Distributions.

Viewing nucleon structure in 3d.



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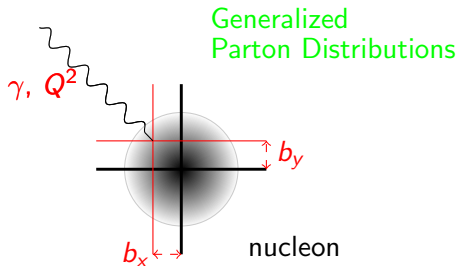
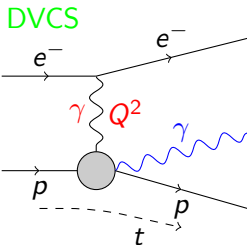
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Viewing nucleon structure in 3d.



- Correlation of the **longitudinal momentum** and the **transverse position** of the struck quark.
- **3-dimensional** description of the nucleon.
- Insights on :
 - spin structure,
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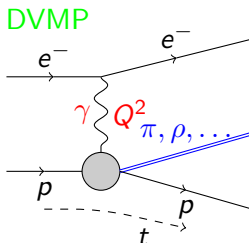
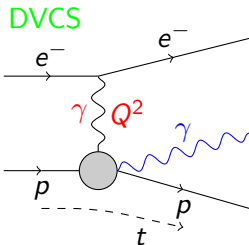
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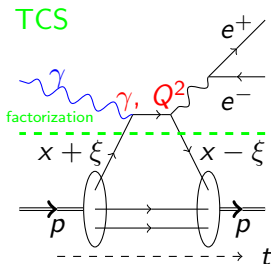
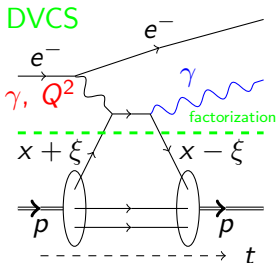
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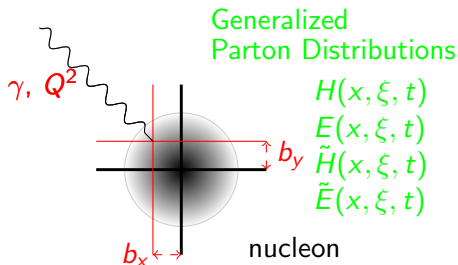
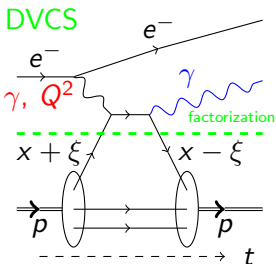
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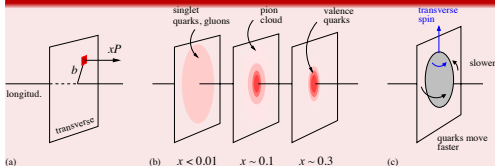
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Obtain this 3d picture from exclusive measurements ?



Weiss, AIP
Conf. Proc.
1149, 150
(2009)

The Kroll-Goloskokov GPD model.

Model of GPD H using a factorized Double Distribution Ansatz.

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- For $i = g$, sea or val :

$$H_i(x, \xi, t) = \int_{|\alpha|+|\beta|\leq 1} d\beta d\alpha \delta(\beta + \xi\alpha - x) f_i(\beta, \alpha, t)$$

$$f_i(\beta, \alpha, t) = e^{b_i t} \frac{1}{|\beta|^{\alpha' t}} h_i(\beta) \pi_{n_i}(\beta, \alpha)$$

$$\pi_{n_i}(\beta, \alpha) = \frac{\Gamma(2n_i + 2)}{2^{2n_i+1} \Gamma^2(n_i + 1)} \frac{(1 - |\beta|)^2 - \alpha^2}{(1 - |\beta|)^{2n_i+1}} \alpha^{n_i}$$

- Expressions for h_i and n_i :

$$h_g(\beta) = |\beta| g(|\beta|) \quad n_g = 2$$

$$h_{\text{sea}}^q(\beta) = q_{\text{sea}}(|\beta|) \text{sign}(\beta) \quad n_{\text{sea}} = 2$$

$$h_{\text{val}}^q(\beta) = q_{\text{val}}(\beta) \Theta(\beta) \quad n_{\text{val}} = 1$$

Goloskokov and Kroll, Eur. Phys. J. **C42**, 281 (2005)

The Kroll-Goloskokov GPD model.

Model of GPD E .

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- Choose a PDF-like parametrization for $E(x, \xi = 0, t = 0)$ and use a factorized Double Distribution Ansatz.
- Normalize E_{val} with the contribution of quarks to the proton anomalous magnetic moment κ .
- Fix t -dependence by computation of F_2 .
- Constrain E_g and E_{sea} by saturating positivity bound.
- Variants :
 - Opposite sign for E_{sea} .
 - Do not saturate positivity bound.
 - $E_{\text{sea}} = 0$.

Goloskokov and Kroll, Eur. Phys. J. **C59**, 809 (2009)

Diehl *et al.*, Eur. Phys. J. **C39**, 1 (2005)



Compton scattering and Compton Form Factors.

More on Timelike Compton Scattering in J. Wagner's talk (29/03/2012).

- A convolution of GPD enter the amplitude :

$$\mathcal{H}(\xi, t) = \int_{-1}^{+1} dx H^q(x, \xi, t) T^q(x) \\ + H^g(x, \xi, t) T^g(x)$$

Belitsky *et al* Phys. Lett. **B474**, 2000 (163)

Pire *et al*, Phys. Rev. **D83**, 2011 (034009)

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- A convolution of GPD enter the amplitude :

$$\mathcal{H}(\xi, t) = \int_{-1}^{+1} dx H^q(x, \xi, t) C_0^q + H^g(x, \xi, t) 0$$

Belitsky *et al* Phys. Lett. **B474**, 2000 (163)

Pire *et al*, Phys. Rev. **D83**, 2011 (034009)

- Integration yields **real** and **imaginary** parts to \mathcal{H} :

$$\text{Im}\mathcal{H}(\xi, t) = \left(H^q(\xi, \xi, t) - H^q(-\xi, \xi, t) \right) \pi$$

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- A convolution of GPD enter the amplitude :

$$\mathcal{H}(\xi, t) = \int_{-1}^{+1} dx H^q(x, \xi, t) \left(C_0^q + C_1^q + \frac{1}{2} \ln \frac{|Q^2|}{\mu_F^2} \right) \\ + H^g(x, \xi, t) \left(0 + C_1^g + \frac{1}{2} \ln \frac{|Q^2|}{\mu_F^2} \right)$$

Belitsky *et al* Phys. Lett. **B474**, 2000 (163)

Pire *et al*, Phys. Rev. **D83**, 2011 (034009)

- Integration yields **real** and **imaginary** parts to \mathcal{H} :

$$Im\mathcal{H}(\xi, t) = \int_{-1}^{+1} dx \mathcal{T}^q(x) \left(H^q(x, \xi, t) - H^q(-x, \xi, t) \right) \\ + \left(H^q(\xi, \xi, t) - H^q(-\xi, \xi, t) \right) \mathcal{I}(\xi) + \text{gluons}$$

Deeply Virtual Compton Scattering at NLO.

Computation on a wide kinematic range (EIC \rightarrow JLab).

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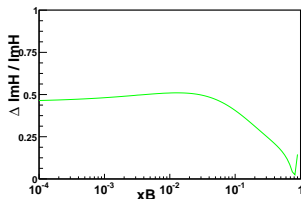
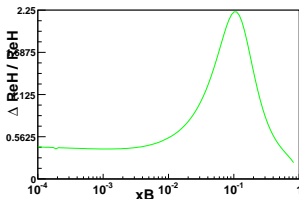
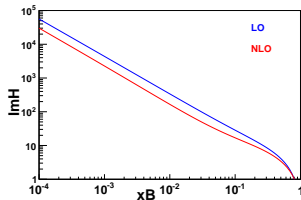
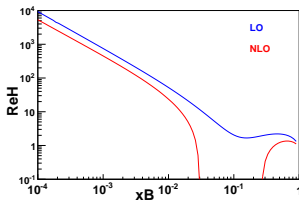
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- **Cautionary statement** : Model dependence !
- Unexpected large gluonic contribution.
- Need resummation ?



Timelike Compton Scattering at NLO.

Computation on a wide kinematic range (EIC \rightarrow JLab).

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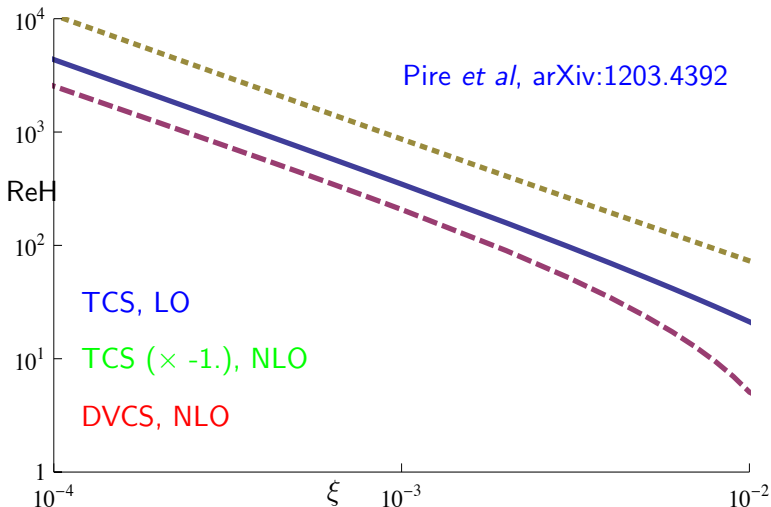
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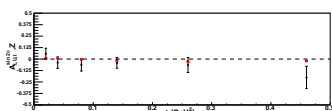
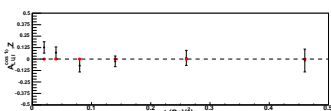
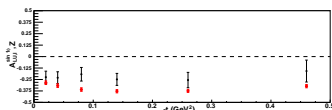
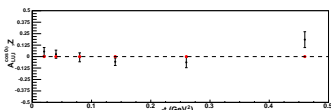
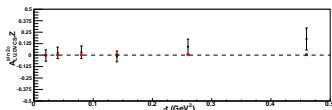
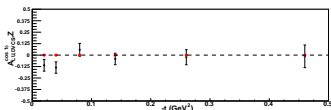
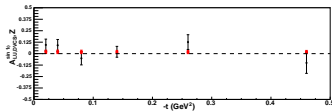
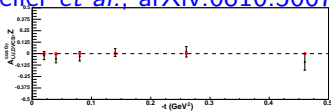


DVCS with the Kroll-Goloskokov model.

Hermes data. Computation at Leading Order.

Airapetian *et al.*, JHEP **0806**, 017 (2008)

Zeiler *et al.*, arXiv:0810.5007



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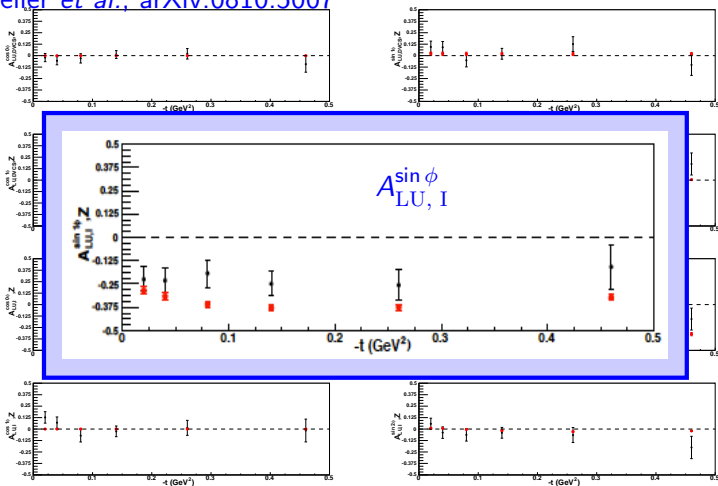
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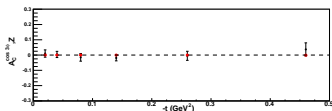
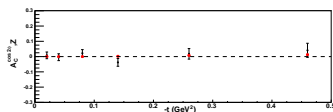
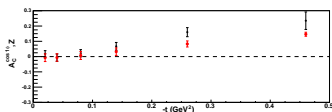
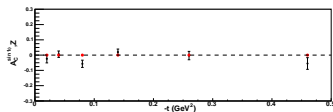
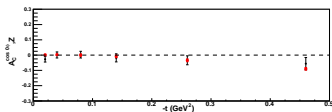
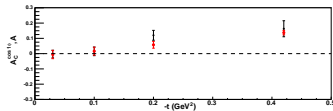
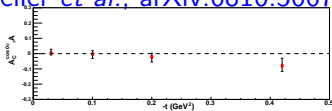
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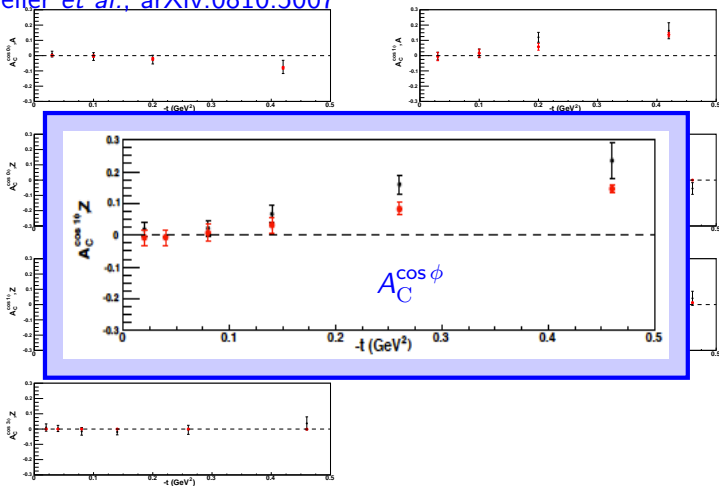


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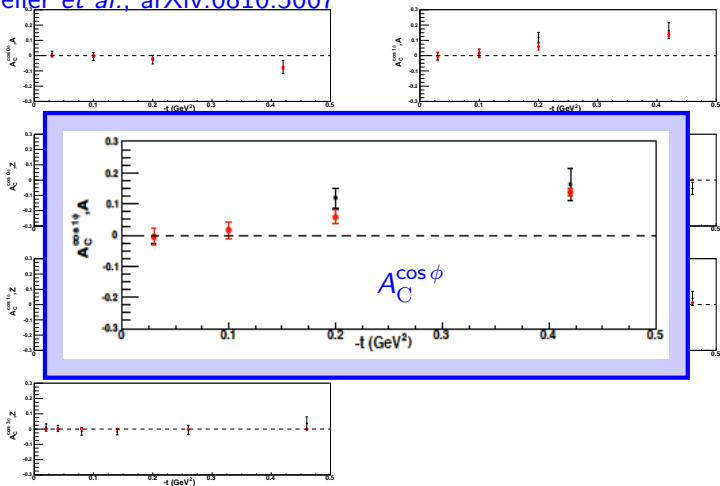
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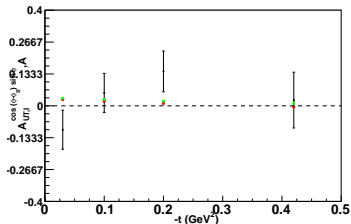
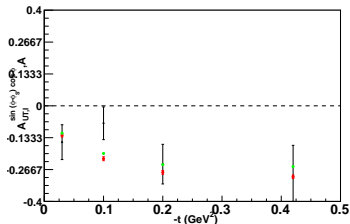
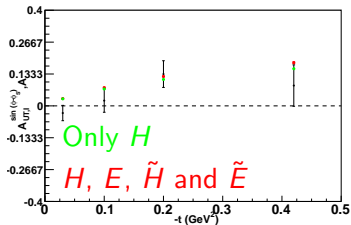
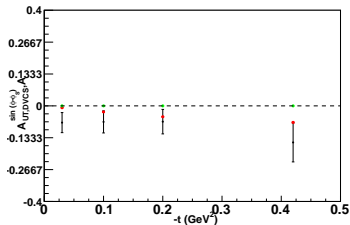
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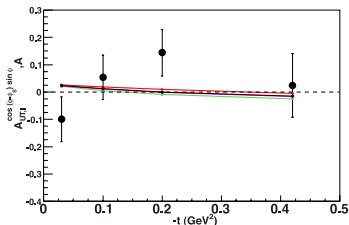
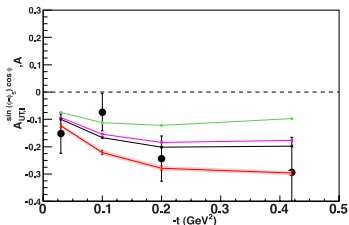
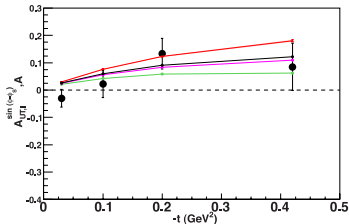
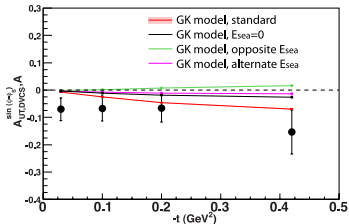


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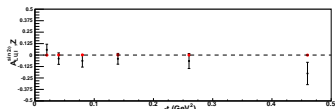
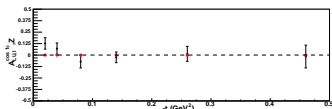
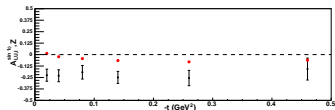
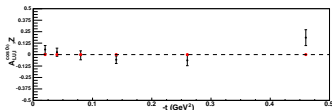
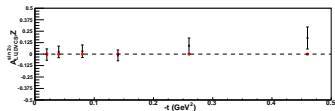
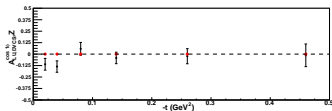
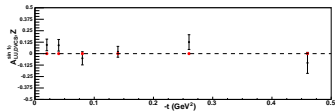
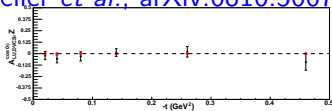
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DVCS with the Kroll-Goloskokov model.

Hermes data. **Preliminary** computation at Next to Leading Order.

Airapetian *et al.*, JHEP **0806**, 017 (2008)

Zeiler *et al.*, arXiv:0810.5007



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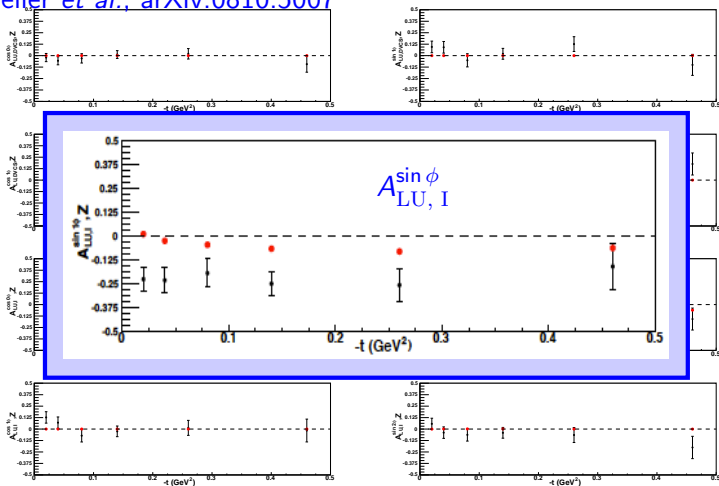
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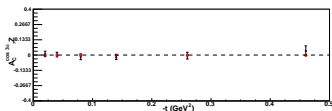
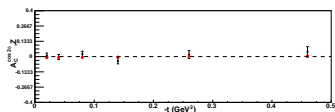
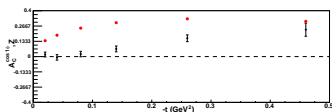
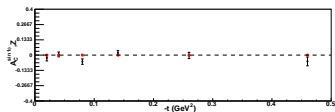
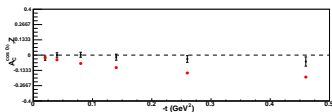
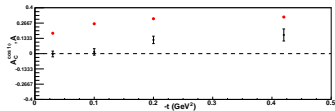
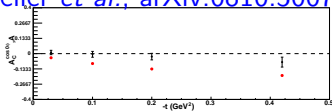
Zeiler *et al.*, arXiv:0810.5007



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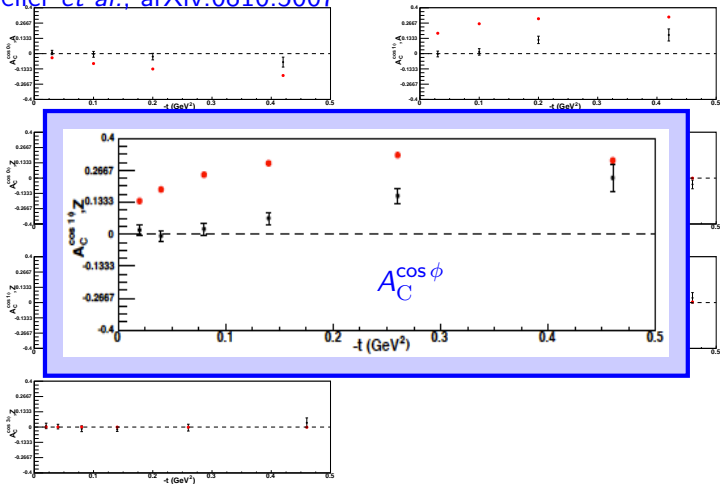
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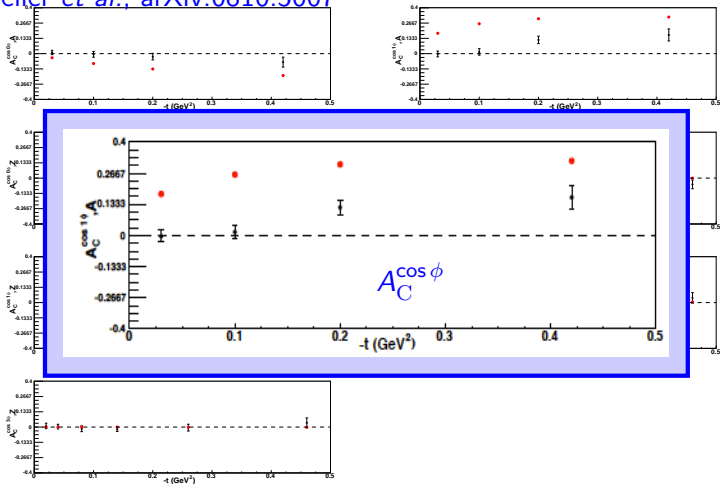


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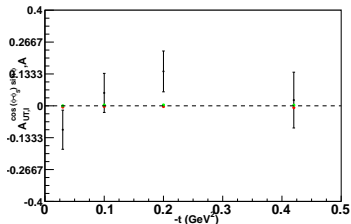
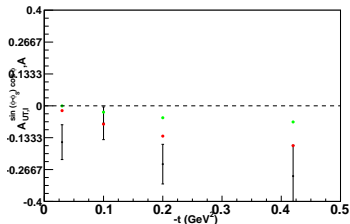
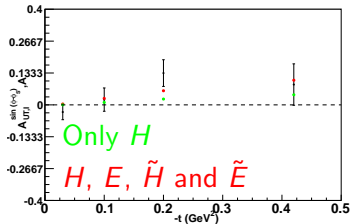
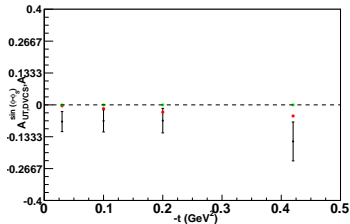
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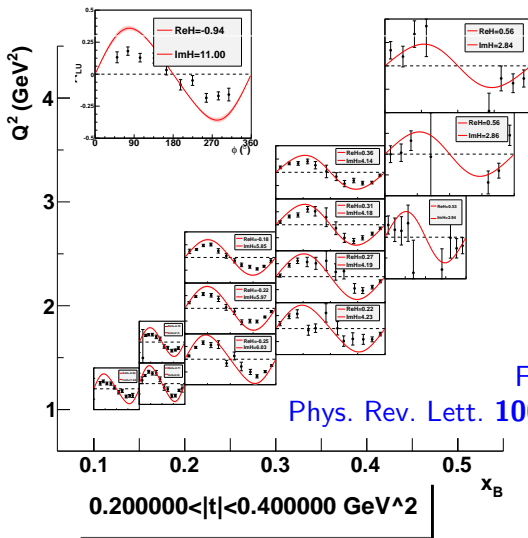
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F.-X. Girod *et al.*
 Phys. Rev. Lett. **100**, 162002 (2008)

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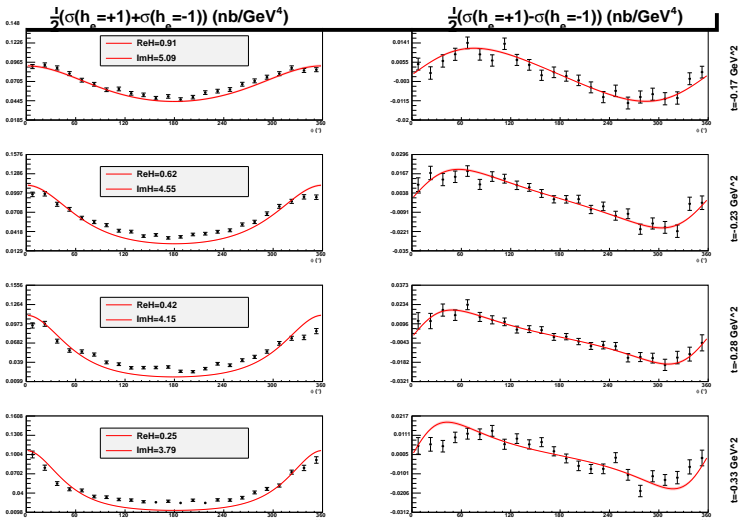
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C. Muñoz Camacho *et al.*, Phys. Rev. Lett. **97**, 262002 (2006)



A software platform for GPD phenomenology.

The path between models and data.

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- 1 Comprehensive **database of experimental results**.
- 2 Comprehensive **database of theoretical predictions**.
- 3 **Fitting engine**.
- 4 **Propagation** of statistic and systematic **uncertainties**.
- 5 **Visualizing software** to compare experimental results and model expectations.
- 6 Connection to **experimental set-up descriptions** to design new experiments.
- 7 **Interactive website** providing free access to model and experimental values.

Towards an era of high precision measurements.

Example : Dealing with 1 % statistical accuracy with JLab's 12 GeV upgrade.

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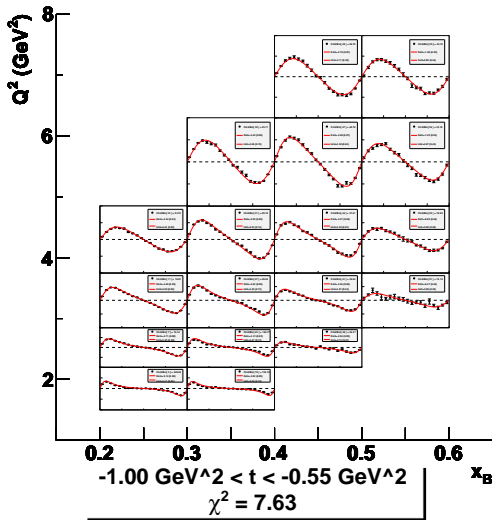
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- Projection : CLAS12 mock data.
- Tentative fit.
- Preliminary !





Conclusions.

Getting ready for multi-channel analysis.

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Conclusions

- Extension of existing tools (models, theoretical frameworks) to other processes or kinematic domains :
 - DVCS \rightarrow TCS.
 - DVMP \rightarrow DVCS.
- Treatment of NLO contributions :
 - Model-dependent statement (?) : surprisingly large gluon contribution in the HERMES / COMPASS kinematics?
 - Resummation needed ?
- Design of software components in view of expected accuracy of future data.



Acknowledgments.

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- F.-X. Girod
- P. Guichon
- M. Guidal
- C. Muñoz Camacho
- S. Procureur