Deeply Virtual Compton Scattering off ^{4}He

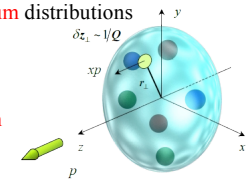
Mohammad Hattawy (hattawy@ipno.in2p3.fr), Raphaël Dupré, Michel Guidal
IPN Orsay, CNRS-IN2P3, Université Paris-Sud, 91406 Orsay, France
On behalf of the CLAS Collaboration

Physics Motivations

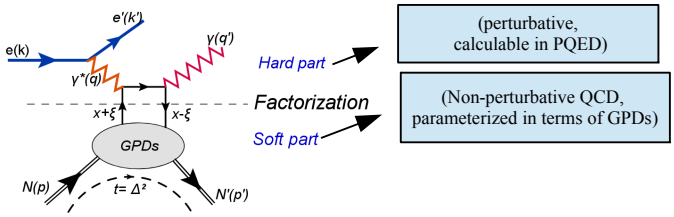
◊ **Form Factors:** → The quarks transverse spatial distributions

◊ **Parton Distribution Functions:** → The quarks longitudinal momentum distributions

◊ **Generalized Parton Distributions (GPDs):**
- **Contain information on:**
  → Partons correlation
  → Correlation between longitudinal momentum and transverse spatial position of partons
- **Accessed via exclusive processes:**
  → Deeply Virtual Compton Scattering (DVCS)
  → Deeply Virtual Meson Production (DVMP)



From the theoretical point of view, the DVCS is considered the easiest way to access the GPDs



Deeply Virtual Compton Scattering

→ DVCS amplitude can be accessed in the Beam Spin Asymmetry (BSA) because it interfers with Bethe-Heitler (BH) process, where the real photon is emitted by the incoming or the outgoing electron.

$$\rightarrow d\sigma \propto |\tau_{BH}|^2 + \underbrace{(\tau^*_{DVCS}\tau_{BH} + \tau^*_{BH}\tau_{DVCS})}_{\mathcal{I}} + |\tau_{DVCS}|^2$$

DVCS off Nuclei

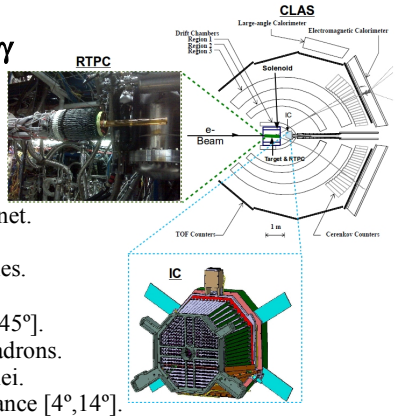
◊ **Coherent DVCS: $e^- A \rightarrow e^- A \gamma$**
→ Study the partonic structure of the nucleus.
→ 1 GPD is needed to parametrize the structure of the spinless nuclei (^{4}He, ^{12}C ...).

◊ **InCoherent DVCS: $e^- A \rightarrow e^- N X \gamma$**
→ The nucleus breaks and the DVCS takes place on a nucleon.
→ Study the partonic structure of the bound nucleons (4 GPDs are needed).
→ Study the medium modifications of the nucleons in terms of GPDs.

E08-024 experiment, Hall B, JLab (Virginia, USA), 2009

$e^- {}^4He \rightarrow e^- ({}^4He/pX)\ \gamma$

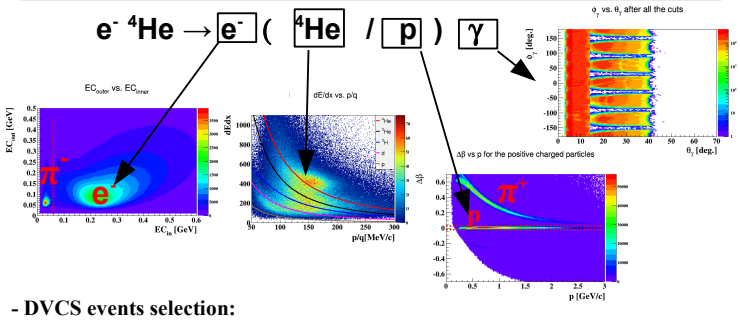
6 GeV, L. polarized



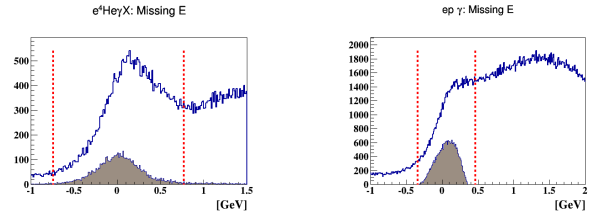
- **CLAS (4π detector):**
  → Superconducting Torus magnet.
  → 6 independent sectors:
    → DCs track charged particles.
    → CCs separate e^-/π^-.
    → ECs detect γ, e^- and n [8°,45°].
    → TOF Counters identify hadrons.
- **RTPC:** Detects low energy nuclei.
- **IC:** Improves γ detection acceptance [4°,14°].
- **Solenoid:** Shields the detectors from Moller electrons.
- **Target:** ^{4}He gas @ 6 atm, 293 K

Particles identification and events selection

$e^- {}^4He \rightarrow e^- ({}^4He / p) \gamma$



- **DVCS events selection:**
  → The good final state particles are identified: epγ or $e^4He\gamma$
  → Reaction occured at the parton level ($Q^2 > 1GeV^2$)
  → Avoid the baryon resonances ($W > 2$ GeV/c^2)
  → High energetic real photon ($E\gamma > 2$ GeV)
  → Impose the conservation laws (3σ exlcusivity cuts)
    - In BLUE, events before all the exclusivity cuts.
    - In shaded BROWN, DVCS events which pass all the other exclusivity cuts except the ONE on the quantity itself.

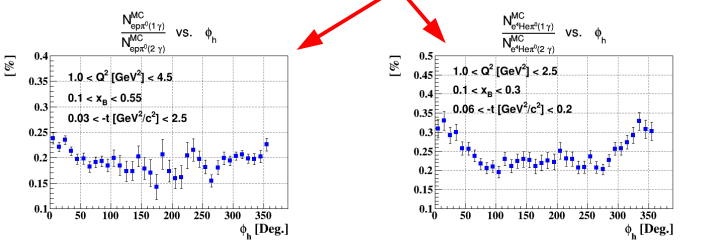


Background subtraction and beam-spin asymmetry

◊ The main background comes from the exclusive π^0 channel ($e(^4He/p)\pi^0$) in which one photon from π^0 decay is detected and passed the DVCS exclusivity cuts.

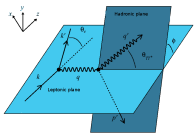
◊ We use Monte Carlo simulation to compute the contamination of π^0.

$$N_{DVCS/BH} = N^{Exp.}_{eHe\,\gamma} - N^{Exp.}_{eHe\,\pi^0(1\gamma)} = N^{Exp.}_{eHe\,\gamma} - \left(\frac{N^{MC}_{eHe\,\pi^0(1\gamma)}}{N^{MC}_{eHe\pi^0(2\gamma)}}\right) * N^{Exp.}_{eHe\,\pi^0(2\gamma)}$$



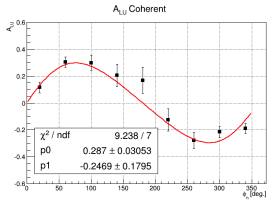
◊ Beam-spin asymmetry (A_{LU}) :

$$A_{LU} = \frac{1}{P_B}\frac{N^+ - N^-}{N^+ + N^-}$$



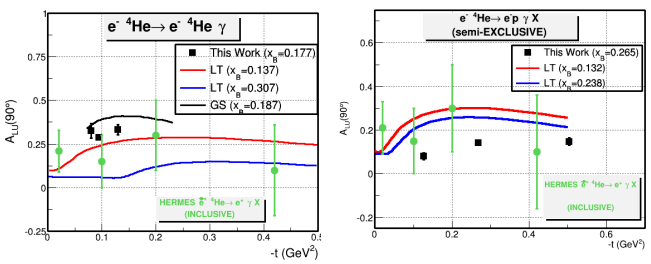
Beam polarization (P_B) = 83%
N^+/N^-: Number of events with +/- beam helicity.

- Due to statistical constraints, we constructed 2D bins -t or x_B or Q^2 versus φ
- Fit A_{LU} signals: $p_0 * \sin(\varphi)/(1 + p_1 * \cos(\varphi))$
- Statistical errors ONLY are shown



Results, conclusions and perspectives

◊ The exclusive DVCS off ^{4}He was measured for the first time with our experiment
◊ Preliminary asymmetries were extracted and compared with theoretical predictions
◊ With our available statistics, the bound proton has shown a different trend compared to the free one
◊ Perspectives:
→ Final results soon
→ Proposing a new ^{4}He DVCS experiment with JLab upgrade.



[1] LT: S. Liuti and S. K. Taneja.Phys. Rev., C72:032201, 2005.
[2] GS: V. Guzey and M. Strikman. Phys. Rev., C68:015204, 2003.
[3] HERMES: F. Ellinghaus, R. Shanidze, and J. Volmer. AIP Conf. Proc.,675:303–307, 2003.