First data on Deeply Virtual Compton Scattering with CLAS12 at 10.6 GeV Electron Beam

Guillaume Christiaens, Francesco Bossù
for the CLAS collaboration

CEA-Saclay Irfu/DPhN

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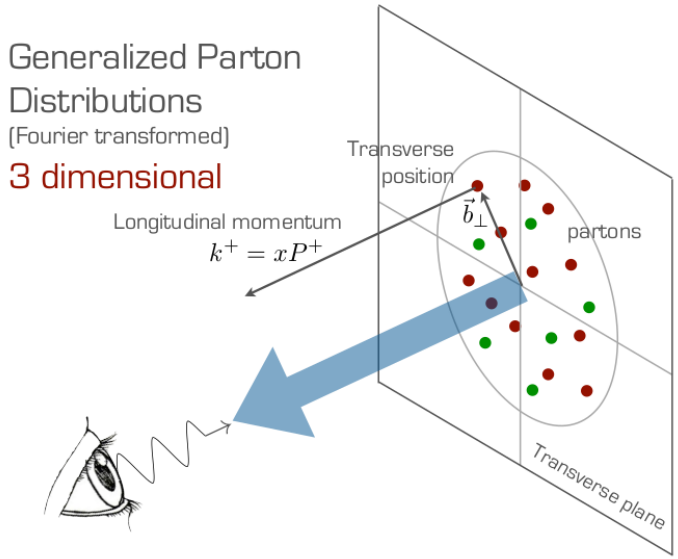
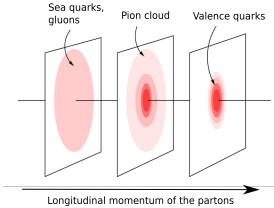

Generalized Parton Distributions
(Fourier transformed)
3 dimensional
Transverse position
$\vec{b}_\perp$
Longitudinal momentum
$k^+ = xP^+$
partons
Transverse plane

A. Bacchetta

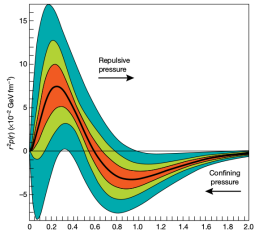
$$\rho(x, \vec{r_\perp}) = \int \frac{d^2\Delta_\perp}{(2\pi)^2} e^{(-i\vec{\Delta_\perp}\cdot\vec{r_\perp})} H(x, \xi = 0, t = -\Delta_\perp^2) \qquad \text{Burkard 2003}$$

- $t = \Delta^2$: momentum transfer to the target
- Skewness: $\xi = -\Delta^+/(2P+)$
- Fourier transformation gives us the distribution in $\vec{r_\perp}$ and x



GPDs give access to parton total angular momentum
Ji's sum rule:
$J^q = \frac{1}{2}\int_{-1}^{+1} \mathrm{d}x\ x\ (H^q(x,\xi,0) + E^q(x,\xi,0))$

Also: mechanical properties and gravitational form factors



Nature 557, 396 (2018)

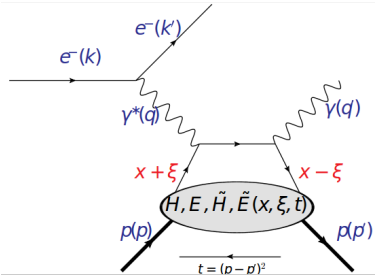
Deeply Virtual Compton Scattering

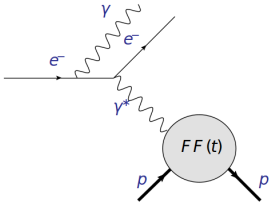
- DVCS amplitude gives access to GPDs through Compton Form Factors

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

- Experimentally, one measures exclusive lepto-production of a photon.
- Two competing processes:
  - DVCS
  - Bethe-Heitler (BH)

$$\sigma(e+p \to e+p+\gamma) = |DVCS|^2 + |BH|^2 + Interference$$





DVCS: beam spin asymmetry

- Extraction of GPDs from DVCS with polarized lepton beam and unpolarized target
- Beam spin asymmetry:

$$A_{LU} = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-}$$

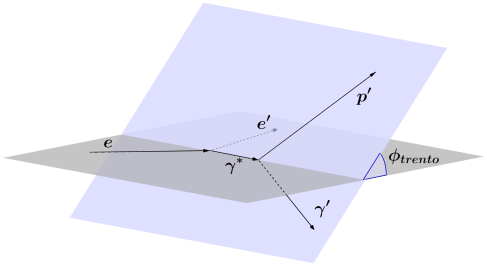
- At leading order:

$$A_{LU} \simeq \frac{A\ sin(\phi_{Trento})}{1 + B\ cos(\phi_{Trento})}$$

where:

$$A = \frac{s_1^I}{kc_0^{BH} + c_0^I}, \quad B = \frac{kc_1^{BH} + c_1^I}{kc_0^{BH} + c_0^I}$$

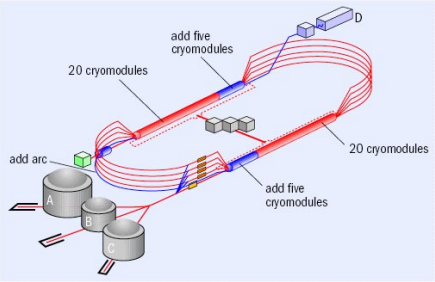
and s_1^I, c_0^I, c_1^I are combinations of Compton Form Factors
ϕ_{Trento}: angle between lepton and proton-γ planes



CLAS12 at Jefferson LAB

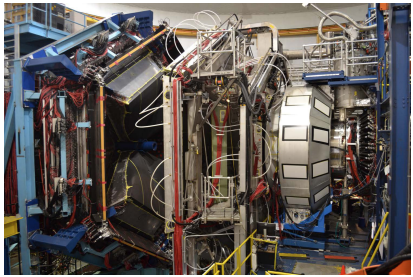
CEBAF at Jefferson Lab.

- Upgraded to 12GeV electron beam energy
- High longitudinal polarization, $> 80\%$
- High currents



New large acceptance spectrometer in Hall B: **CLAS12**

- Data taking started in 2018
- Electron energy: 10.6 GeV
- Target: unpolarized LH2 (2018) and LD2 (2019)



CLAS12 at Jefferson LAB

- CLAS12 is a package of two complementary spectrometers
- The central detectors in a solenoid field up to 5 Tesla
- The forward detectors around a toroidal field up to 3.6 Tesla

Forward Detector (FD):

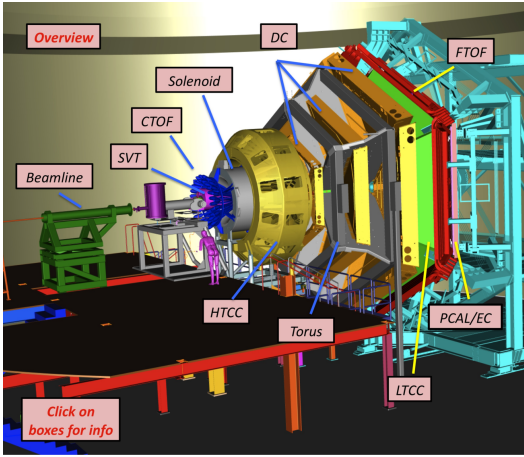
- TORUS magnet
- Drift chamber system
- HT Cherenkov Counter
- LT Cherenkov Counter
- Forward ToF System
- Preshower calorimeter
- E.M. calorimeter
- RICH detector

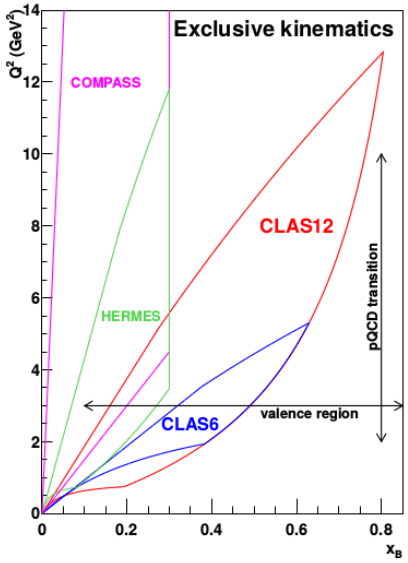
Central Detector (CD):

- SOLENOID magnet
- Barrel Silicon Tracker
- Micromegas tracker
- Central Time-of-Flight
- Central Neutron detector

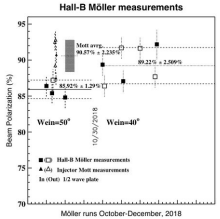
Forward Tagger (FT):

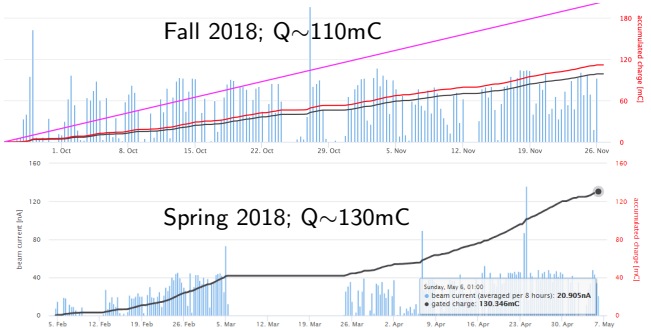
- Calorimeter at very small angles ($< 5^o$)



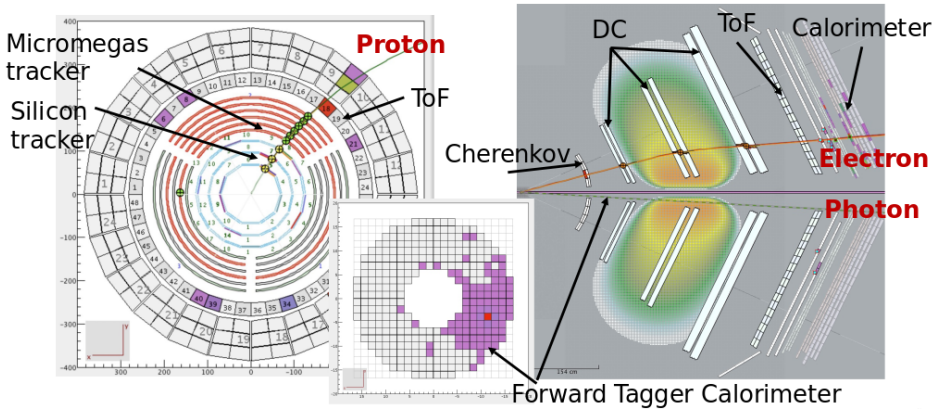


- CLAS12 extends kinematic coverage at high-x high Q^2
- Focus here on unpolarized proton target data with $E_e = 10.6$GeV
- Electron polarization higher than 85%



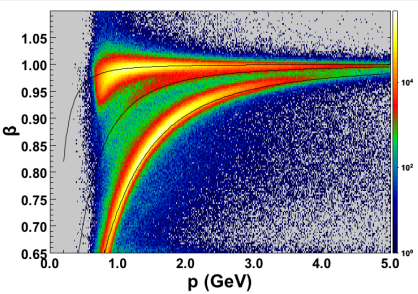


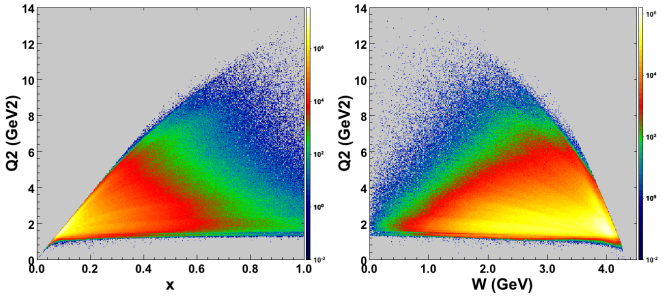
- Electron: measured in the Forward Detector or in the Forward Calorimeter
- Photon: in the FT (or FD) calorimeter
- Proton: most often in the Central Detector



DVCS in CLAS12: kinematics and particle selection

- Well identified final states
- Electron: $E_e > 2\text{GeV}$
- High energy photon: $E_\gamma > 3\text{GeV}$
- Kinematic cuts:
  - Virtuality: $Q^2 > 1\text{GeV}^2$
  - Inv. mass of hadronic final state: $W^2 > 4\text{GeV}^2$





DVCS in CLAS12: exclusivity

Exclusivity cuts chosen:

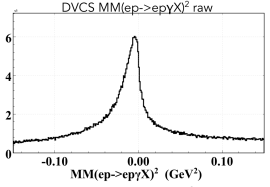
- **Missing mass** $ep \to ep\gamma X$

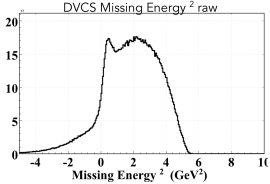
  $-0.06 < MM^2 < 0.04\text{GeV}^2$

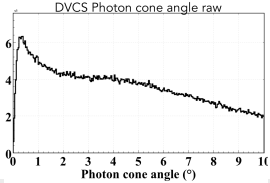
- **Missing energy**: $[-1, 2]\text{GeV}^2$

- **Cone angle**: angle between the photon and the photon direction expected from the electron and proton

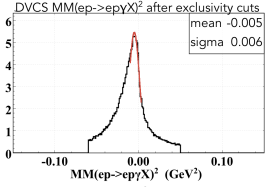
Before exclusivity cuts

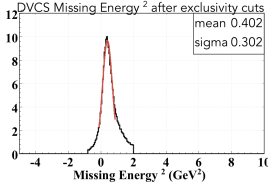


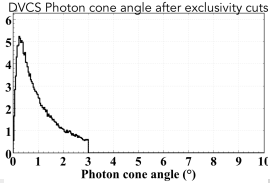




After exclusivity cuts





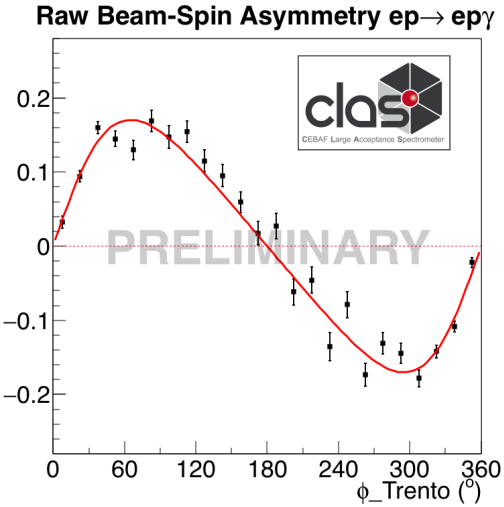


Beam spin asymmetry

$$A_{LU} = \frac{1}{P}\frac{N^+(\phi_{Trento}) - N^-(\phi_{Trento})}{N^+(\phi_{Trento}) + N^-(\phi_{Trento})}$$

- P: electron polarization
- $N^{+(-)}$: number of photon electroproduction candidates with beam helicity +(-)

- Analysis based on 2% of approved beam time
- Residual background not subtracted (main source $ep \to ep\pi^0$)
- Only statistical uncertainty showed
- Integrated over the full kinematic domain



Outlook

- First running with unpolarized proton target is completed
- CLAS12 collected about 40% of the total approved beam current
- Preliminary first look at DVCS beam-spin asymmetry
- Preliminary based on 2% of approved beam time
- Analysis ongoing, optimize π^0 subtraction and systematics evaluation
- Outlook: extraction of Compton Form Factors with global fits