Coherent deeply virtual Compton scattering off helium (CLAS)

Yohann Perrin
LPSC Grenoble, France

On behalf the CLAS collaboration
**Generalized Parton Distribution (GPD)**

\( p \) and \( p' \) are the momenta of the incoming and outgoing partons, respectively. \( t \) represents the transferred 4-momentum.

- \( x \) is the fraction of longitudinal momentum of the parton.
- \( \xi \) is the difference between the longitudinal momenta of the incoming and the outgoing partons.

A spin-0 object can be described at leading order by one chirally conserving GPD, \( H_A \).

### Link with form factor and parton distribution function:

\[
H_A^q(x, 0, 0) = q_A(x) = \sum_q e_q \int_{-1}^{1} dx \ H_A^q(x, \xi, t) = F_A(t)
\]

### Access to the spatial distribution of nuclear forces:

\[
\int_{-1}^{1} dx \ x \ H_A^q(x, \xi, t) = M_{2q/A}^q(t) + \frac{4}{5} \xi^2 d_{A}^q(t)
\]
Deeply Virtual Compton Scattering (DVCS) is deeply virtual electroproduction of a real photon \((Q^2 \gg M^2 \text{ and } t \ll Q^2)\).
It is the easiest way to extract GPDs.

DVCS accesses GPDs via the Compton form factors:

\[
T_{DVCS} \propto \mathcal{H}_A = \sum_q e_q^2 \mathcal{P} \left\{ \int_{-1}^{+1} dx \left( \frac{1}{x - \xi} \pm \frac{1}{x + \xi} \right) H_A^q(x, \xi, t) \right\}
- i\pi \sum_q e_q^2 \left[ H_A^q(\xi, \xi, t) \pm H_A^q(-\xi, \xi, t) \right]
\]
Electroproduction of the real photon

Interference between DVCS and Bethe Heitler

Cross section on an unpolarized target:
\[
\frac{d^5\sigma^\lambda}{dx_A dQ^2 dt d\phi_e d\phi} \propto |T_{BH}|^2 + |T_{DVCS}|^2 + \mathcal{I}^\lambda
\]

\(\phi\)-dependence of the beam spin asymmetry:
\[
A_{LU}(\phi) = \frac{d\sigma^\uparrow - d\sigma^\downarrow}{d\sigma^\uparrow + d\sigma^\downarrow}
\]
Deeply Virtual Compton Scattering off 4He

Coherent channel asymmetry at twist-2:

\[ A_{LU}(\phi) = \frac{\alpha_0(\phi) \Im(\mathcal{H}_A)}{\alpha_1(\phi) + \alpha_2(\phi) \Re(\mathcal{H}_A) + \alpha_3(\phi) (\Re(\mathcal{H}_A)^2 + \Im(\mathcal{H}_A)^2)} \]

The \( \phi \)-dependence of the beam spin asymmetry allows to extract real and imaginary parts of Compton form factor.

In the region of the minimum of the helium form factor, a non-zero asymmetry would probe twist-3 contributions.
EG6 data acquisition occurred during fall 2009, at Thomas Jefferson National Accelerator Facility (Newport News, VA). These data concern two experiments:

- **Experiment 07-009**: Meson spectroscopy in the Coherent Production on 4He with CLAS
- **Experiment 08-024**: Deeply Virtual Compton Scattering off 4He

\[ E = 6\text{GeV} \]
\[ \lambda = 85\% \]
Electron identification

Electrons are detected with CLAS. Typical phase space shaped by the 6 CLAS sectors

Pions are rejected with the Electromagnetic Calorimeter and the Cerenkov
Photon identification

Photons are detected with the Electromagnetic Calorimeter (large angles) and the Inner Calorimeter (small angles)

Inner Calorimeter

Photon phase space

Invariant mass of $\gamma\gamma$ events
Helium identification

The RTPC detects helium nuclei and provides its momentum, angles, and the vertex position.

The calibration is being improved.

Correlation between the vertex position given by CLAS and the RTPC

In red is the vertex cut applied

Elastic events at 1.2 GeV

Courtesy R. Paremuzyan
Current status of analysis

CLAS cuts
- basic RTPC cut
- z-vertex RTPC cuts
- enhanced RTPC cuts

Missing mass of the electron + photon with different cuts

Squared missing mass of the electron + photon versus t

Cuts largely reduce the high missing mass part of the spectrum

Two body breakup to proton + triton:
\[
e + {}^4\text{He} \rightarrow e + \gamma + p + {}^3\text{H}
\]
1% of the available 6GeV data are processed

More statistics must be processed to investigate DVCS signal

\[ S_h = \int_0^{\pi} (N^+ - N^-)d\phi - \int_{\pi}^{2\pi} (N^+ - N^-)d\phi \]

High statistical fluctuations.
Conclusions

Eg6 data were taken during fall 2009 with 6GeV CEBAF polarized beam.

CLAS, the Inner Calorimeter, and a Radial TPC are used to detect the electron, the photon, and the helium nucleus.

The study of the coherent DVCS will allow to access the twist-2 Compton form factor of helium.

- RTPC calibration is still being improved
- More statistics is being processed