GPD measurements at COMPASS II
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HK 77.6

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Generalised Parton Distributions

Generalised parton distribution for quarks: $H^f, E^f, H^f, E^f$
Longitudinal momentum distribution
Transverse spatial distribution
Nucleon tomography
3D picture of the nucleon
Deep Virtual Compton Scattering

Hard exclusive photon production

\( \mu p \rightarrow \mu' p' \gamma \)

\[ \sigma = \sigma_{BH} + \sigma_{DVCS} + \text{interference term} \]

Bethe-Heitler : 

DVCS :

BH calculable
DVCS \( d\sigma_{DVCS} / d|t| \)
Interference \( \text{Re} A_{DVCS} \) and \( \text{Im} A_{DVCS} \)

N. du Fresne  GPD at COMPASS II
BH vs. DVCS

- $Q^2 = 2 \text{GeV}^2$, $t = 0.1 \text{GeV}^2$ and 160 GeV $\mu$ beam energy

Azimuthal distribution of the photon

Different contributions for different $X_B$ regions
Measuring BH, Interference term and DVCS
Observables

DVCS experiment to constrain GPD $H$

$$\mu^{+\downarrow}(P = -0.8), \mu^{\uparrow\downarrow}(P = 0.8), \text{unpol. proton target } (\ell \text{ H}_2)$$

- Beam charge & Spin Sum: $S_{CS, U} \equiv d\sigma^{+\downarrow} + d\sigma^{-\uparrow}$
  $$\Rightarrow \text{Im } A^{DVCS, \sigma^{BH}, \sigma^{DVCS}}$$

- Beam charge & Spin Difference: $D_{CS, U} \equiv d\sigma^{+\downarrow} - d\sigma^{-\uparrow}$
  $$\Rightarrow \text{Re } A^{DVCS, \sigma^{DVCS}}$$
Visualization output from TGEANT:

Spill structure: 10s
160 GeV muon $^+\! -\! -$ beam
2012 DVCS Run

6 weeks DVCS run → Measuring t-dependence
Long run in 2015/2016 for more statistics

- New 2.5 m long IH$_2$ target
- New recoil proton detector (CAMERA)
- Good acceptance for photons (Upgrades and ECAL0)
- Extension of trigger acceptance towards higher $Q^2$ and $x_{Bj}$
- Well known acceptance
- High precision luminosity determination
- $\frac{1}{3} \mu^+$ and $\frac{2}{3} \mu^-$ data taking
Exclusivity via recoil proton detection
Used for triggering and proton PID

- 2.5 m long IH$_2$ target
- 40 mm diameter
- TOF detector with two layers of scintillator
- good time resolution
- $\frac{dE}{dx}$ measurement
- Readout with board with GHz-Sampler
ECAL 0: Enlarging Photon Acceptance

- Detection of large angle photons
- Sandwich calorimeter
- Lead-scintillator with MAPD readout
Large Angle Spectrometer Trigger

Access large $Q^2$ and large $x_{Bj}$
Scintillator trigger hodoscopes consisting of 2 planes (LAST)
Principle of target pointing with coincidence matrix
H1 and H2

H1: 230 cm × 190 cm, 64 channels and 1 cm thick
H2: 500 cm × 420 cm, 128 channels and 2 cm thick
Cross section and Luminosity

\[ d^4\sigma \over dQ^2 \, dx \, d\xi \, dt = N \int L \, dt \cdot A \cdot \delta Q^2 \delta x \delta \xi \delta t \cdot \text{corrections} \]

For cross section \( \Rightarrow \) precise luminosity determination

Fixed target experiment: \( L [cm^{-2} s^{-1}] = \text{target density} \times \text{flux} \)

\( \rightarrow \) Random Trigger Method

- Radioactive Source \((^{22}\text{Na})\)
- Coincidence rate \( \approx 3\text{kHz} \) in 2009
- 500 m away from experiment
Random Trigger Method

\[
\text{Flux} = \frac{\text{number of reconstructed beam tracks}}{\text{number of random trigger} \times \text{time gate } \Delta t}
\]

- 2009 DVCS test run (2 weeks)
- Small \( \ell H_2 \) target with 40 cm length
- \( 2.5 \cdot 10^7 \) muons per second per spill (\( \mu^+ \))
- Same data quality checks as for physics events

![Graph of Tracks/ns vs Time [ns]](image1)

![Graph of Flux [1/s] vs Spill number](image2)
Systematic Uncertainties

- The statistical errors are small: 2% per spill (12000 spills)
- Systematic uncertainties estimated to 5% for 2009
  - Time gate cut $\Delta t$
  - Target density fluctuations
  - Momentum reconstruction efficiency
  - Veto dead time determination

- Integrated luminosity $3.74 \text{ pb}^{-1}$
- Goal: 1-2% for 2012
Summary and Outlook

- GPDs are accessible via hard exclusive photon production
- COMPASS has great potential to study GPDs via DVCS
- Experimental challenges
  - Recoil proton detection
  - Electro-magnetic calorimetry
  - Large Angle Spectrometer Trigger
  - High precision luminosity determination (Random Trigger)
- First measurement of $d\sigma/dt$ in 2012
- Main physics run in 2015/2016

Thanks for the attention