GPD measurements at COMPASS II

DPG Dresden 2013 HK 77.6

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March 7^{th} 2013

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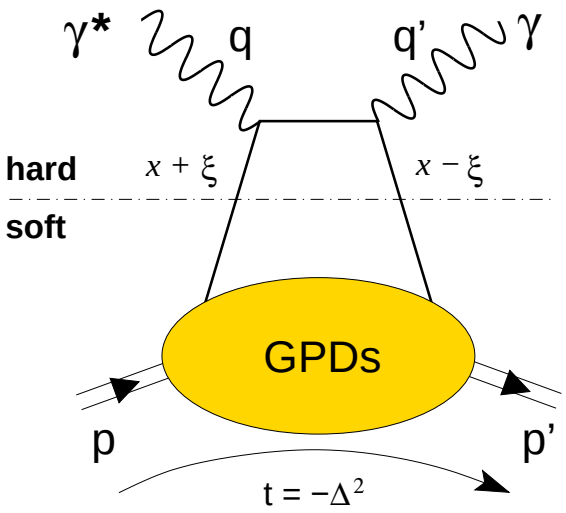
Generalised Parton Distributions



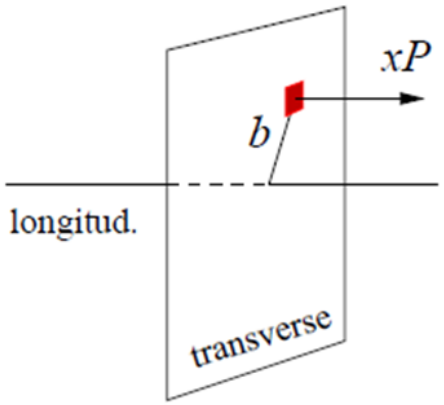
Generalised parton distribution for quarks: $H^f, E^f, \tilde{H}^f, \tilde{E}^f$

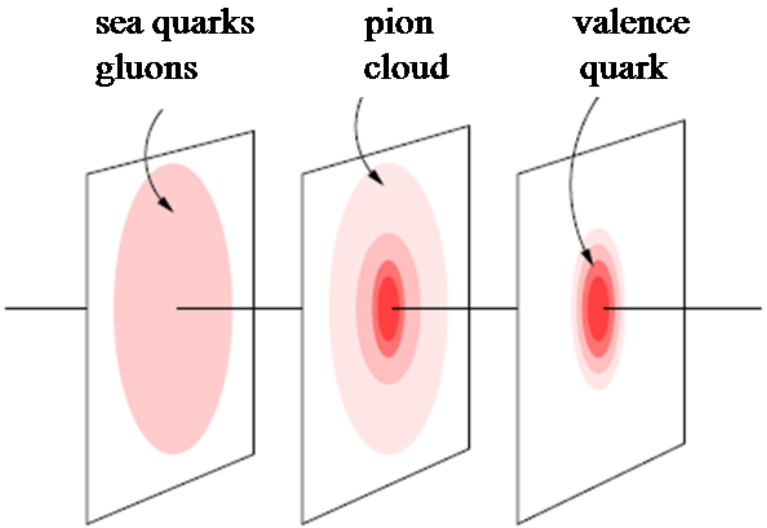
Longitudinal momentum distribution

Transverse spacial distribution

Nucleon tomography

3D picture of the nucleon



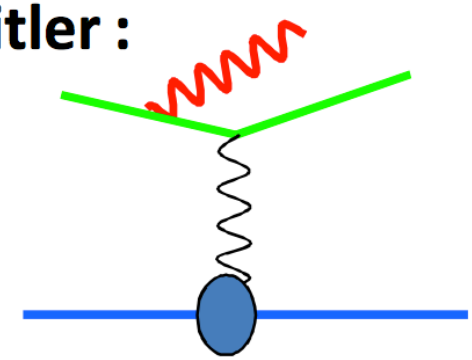


Deep Virtual Compton Scattering

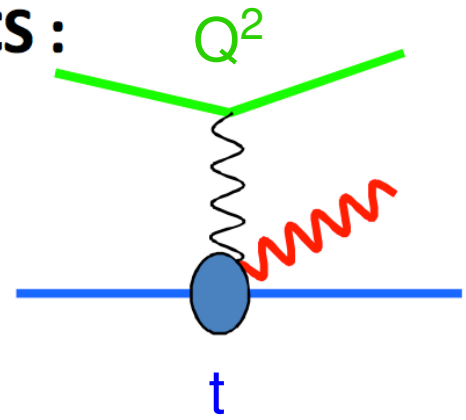
Hard exclusive photon production

$$\mu p \to \mu' p' \gamma$$

Bethe-Heitler :



DVCS :



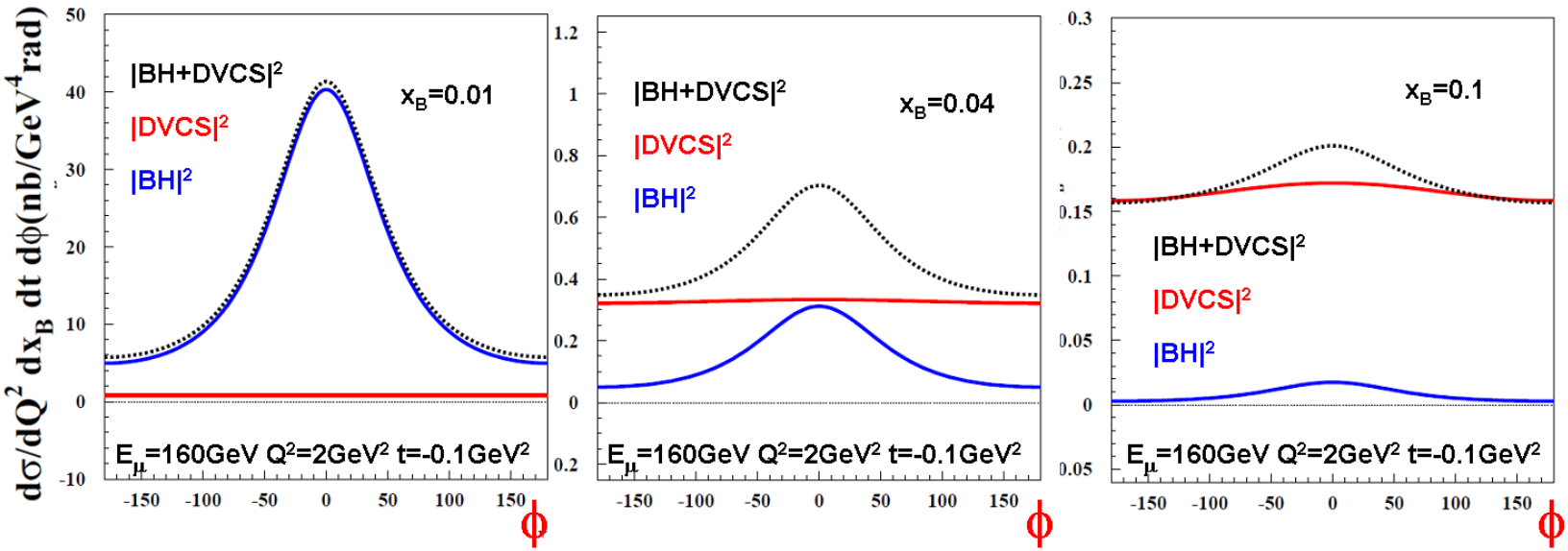
$$\sigma = \sigma_{\mathrm{BH}} + \sigma_{\mathrm{DVCS}} + \text{interference term}$$

BH	calculable
DVCS	$d\sigma^{\mathrm{DVCS}}/d\lvert t\rvert$
Interference	$Re\,A^{\mathrm{DVCS}}$ and $Im\,A^{\mathrm{DVCS}}$

BH vs. DVCS

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

Azimuthal distribution of the photon



Different contributions for different X_B regions

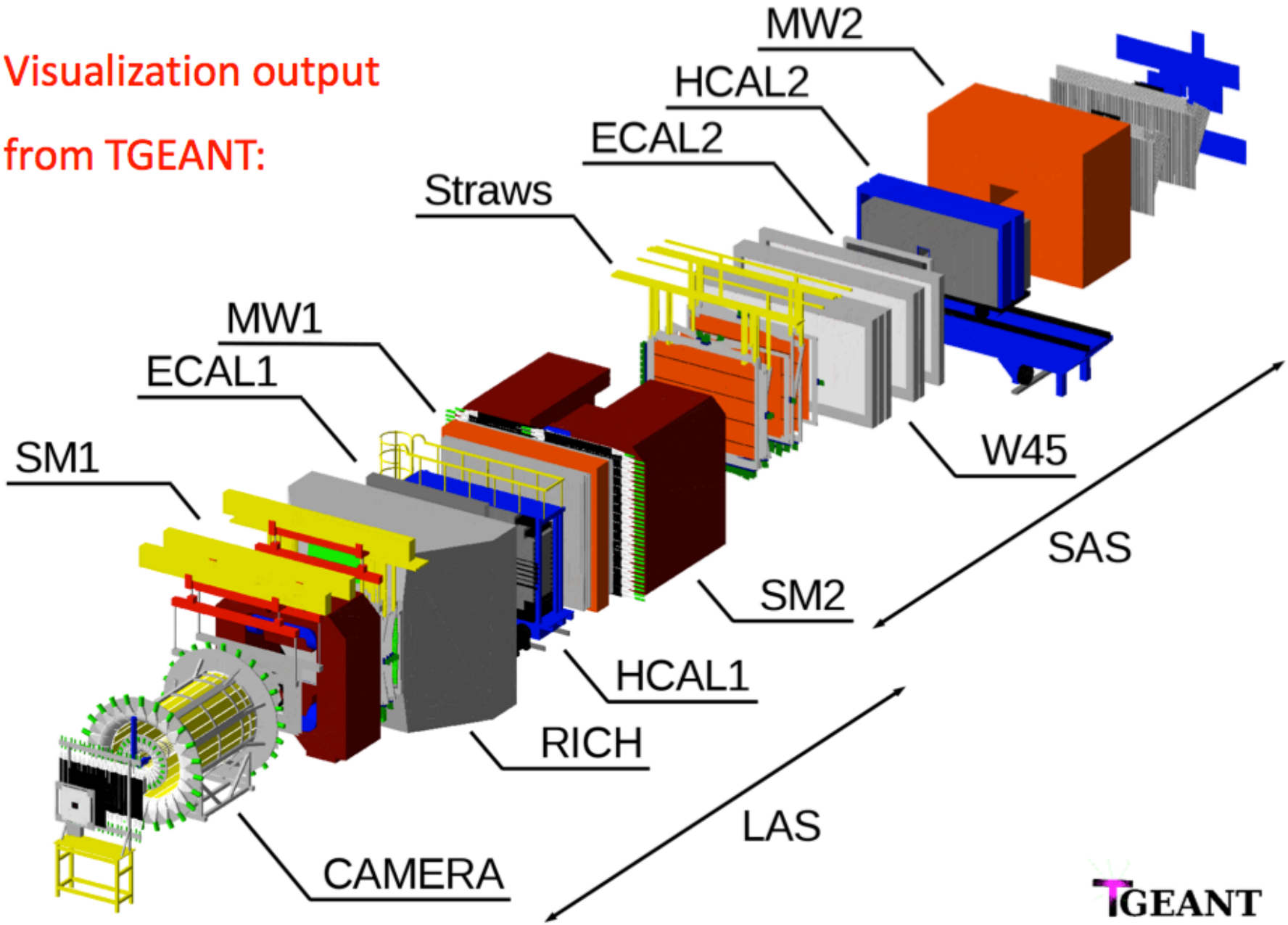
Measuring BH, Interference term and DVCS

Observables

DVCS experiment to constrain GPD *H*

$$\mu^{+\downarrow}(P=-0.8),\ \mu^{-\uparrow}(P=0.8), \text{unpol. proton target } (\ell\ \mathrm{H_2})$$

- Beam charge & Spin Sum: $\mathcal{S}_{CS,U} \equiv d\sigma^{+\downarrow} + d\sigma^{-\uparrow}$
  $\Rightarrow$ *Im* $A^{DVCS}, \sigma^{\mathrm{BH}}, \sigma^{\mathrm{DVCS}}$
- Beam charge & Spin Difference: $\mathcal{D}_{CS,U} \equiv d\sigma^{+\downarrow} - d\sigma^{-\uparrow}$
  $\Rightarrow$ *Re* $A^{DVCS}, \sigma^{\mathrm{DVCS}}$



Spill structure: 10s

160 GeV muon $^{+-}$ beam

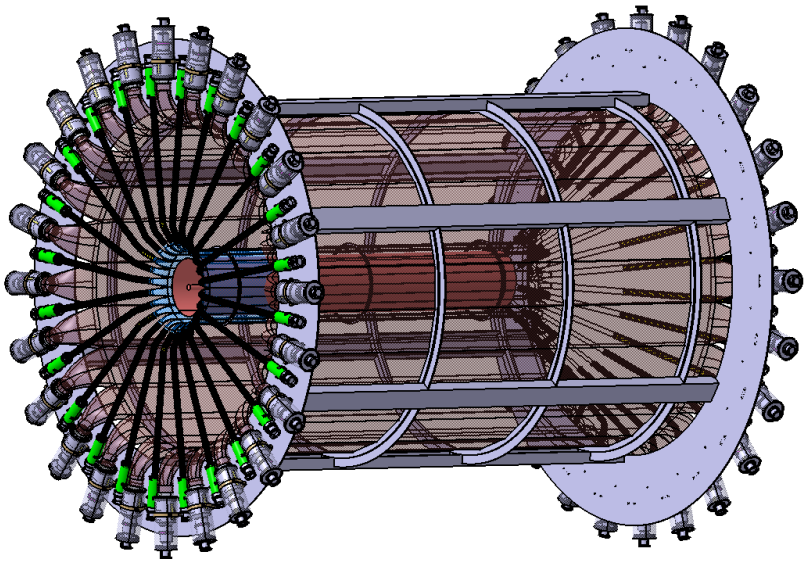
2012 DVCS Run

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

- New 2.5 m long lH_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

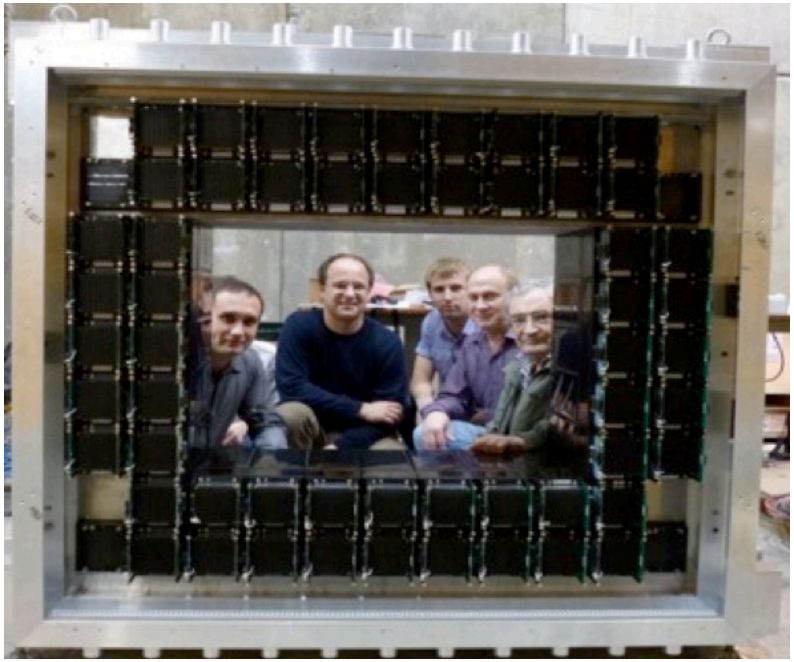
CAMERA: a Recoil Proton Detector

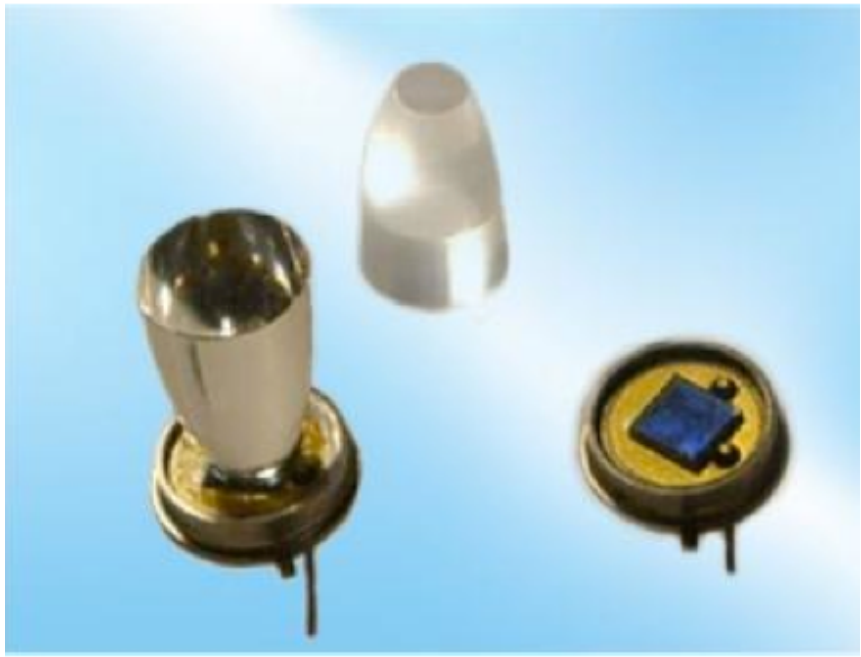
Exclusivity via recoil proton detection
Used for triggering and proton PID



- 2.5 m long lH_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

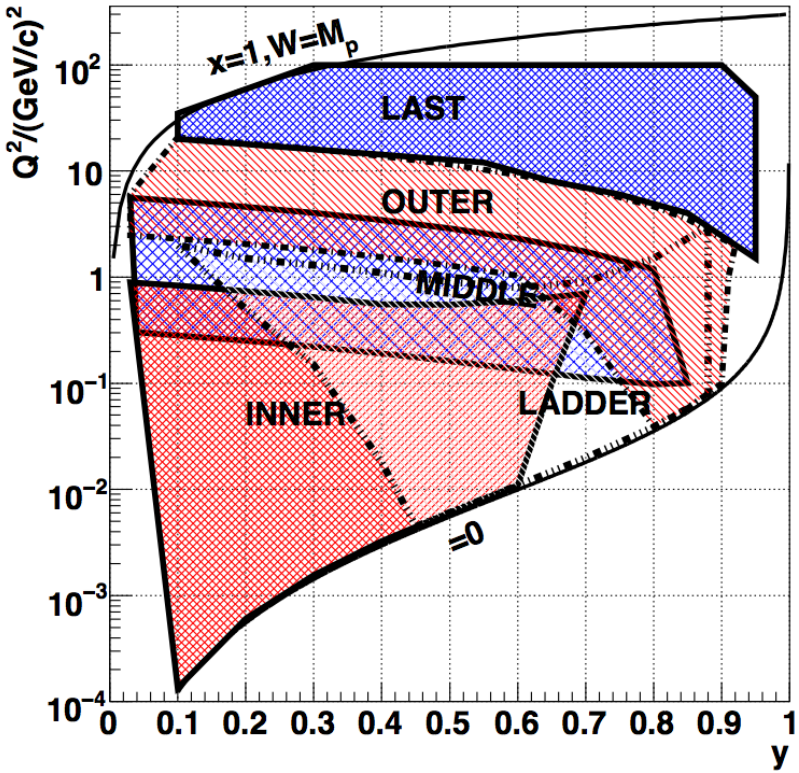




- Detection of large angle photons
- Sandwich calorimeter
- Lead-scintillator with MAPD readout

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 $\times$ 190 cm, 64 channels and 1 cm thick
H2: 500 cm $\times$ 420 cm, 128 channels and 2 cm thick

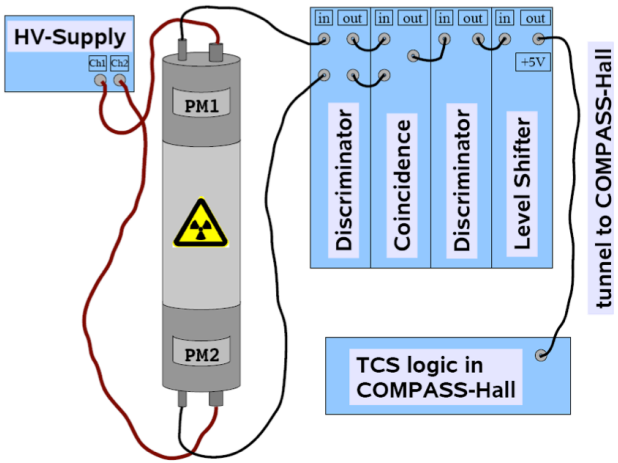
Cross section and Luminosity

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

For cross section $\Rightarrow$ precise luminosity determination

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

$\rightarrow$Random Trigger Method

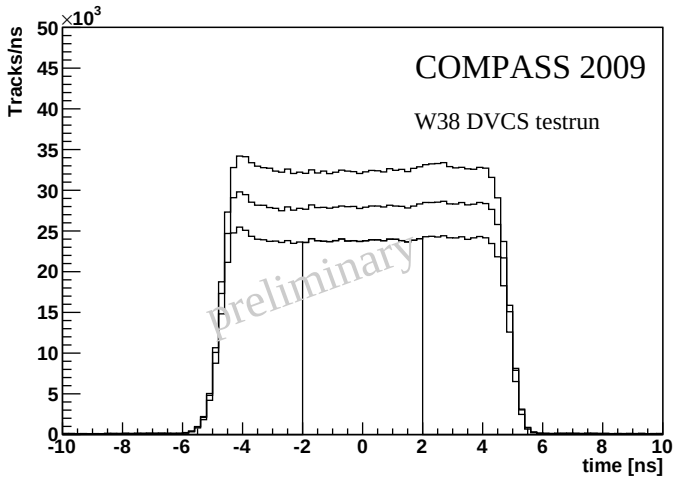


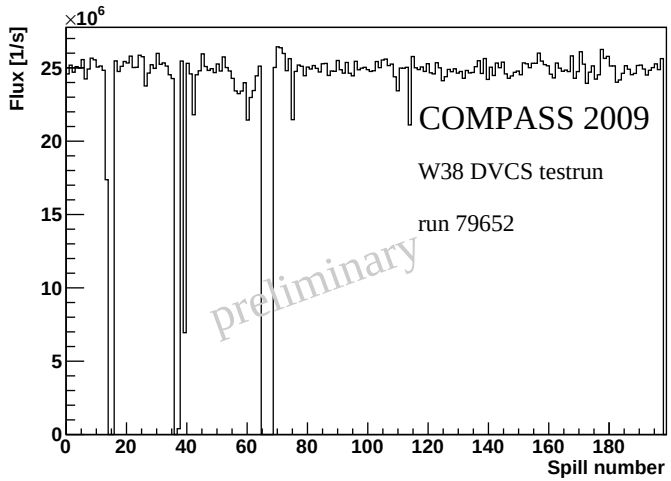
- Radioactive Source (^{22}Na)
- Coincidence rate $\approx$ 3kHz in 2009
- 500 m away from experiment

Random Trigger Method

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

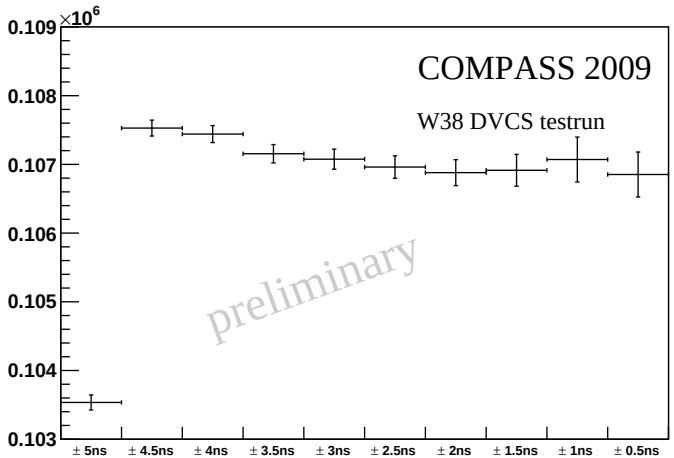
- 2009 DVCS test run (2 weeks)
- Small ℓH_2 target with 40 cm length
- $2.5 \cdot 10^7$ muons per second per spill (μ^+)
- Same data quality checks as for physics events





Systematic Uncertainties

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



- Integrated luminosity 3.74 pb^{-1}
- Goal: 1-2 % for 2012

Summary and Outlook

- GPDs are accessable 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