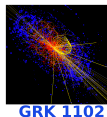


# Exclusive $\rho^0$ muoproduction on transversely polarized protons and deuterons

Katharina Schmidt

On behalf of the COMPASS Collaboration

QNP2012, Palaiseau, France

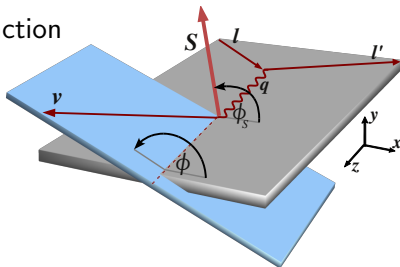


# Hard exclusive $\rho^0$ production

- ▶ Hard exclusive  $\rho^0$  production from transversely polarized target allows extraction of  $A_{UT}^{\sin(\phi-\phi_S)}$

$$A_{UT}^{\sin(\phi-\phi_S)} \sim \frac{\text{Im}(\mathcal{E}^*\mathcal{H})}{|\mathcal{H}|^2}$$

transverse target spin asymmetry

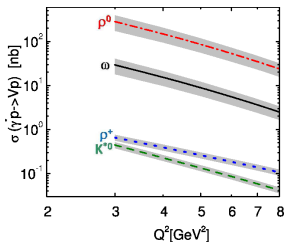
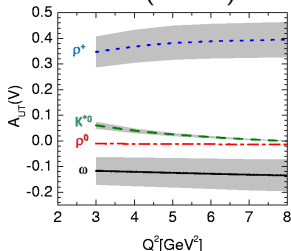


- ▶  $\mathcal{E}$  &  $\mathcal{H}$  are weighted sums of generalized parton distributions (GPDs) **E&H**

→ Constrain GPD **E**

Goloskokov & Kroll

Eur.Phys.J.C 59 (2009)



# Generalized parton distributions - basic facts

- ▶ Factorisation valid for  $\sigma_L$
- ▶ 4 GPDs  $H(x, \xi, t)$ ,  $E(x, \xi, t)$ ,  $\tilde{H}(x, \xi, t)$ ,  $\tilde{E}(x, \xi, t)$  for each quark flavor and gluons
- ▶ Hard exclusive meson production (HEMP)  
vector meson:  $\rho^0, \omega, \phi, \dots \rightarrow H \ \& \ E$   
pseudo-scalar:  $\pi, \eta, \dots \rightarrow \tilde{H} \ \& \ \tilde{E}$
- ▶ In HEMP quark and gluon GPDs enter at the same order of  $\alpha_S$
- ▶ HEMP allows for flavor separation

$$E_{\rho^0} = \frac{1}{\sqrt{2}} \left( \frac{2}{3} E^u + \frac{1}{3} E^d + \frac{3}{8} E^g \right)$$

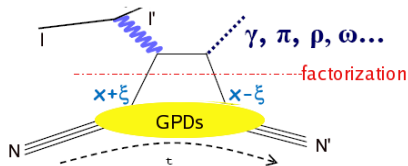
$$E_{\omega} = \frac{1}{\sqrt{2}} \left( \frac{2}{3} E^u - \frac{1}{3} E^d + \frac{1}{8} E^g \right)$$

$$E_{\phi} = -\frac{1}{3} E^s - \frac{1}{8} E^g$$

$$I + N \rightarrow I' + N' + M \text{ (HEMP)}$$

or

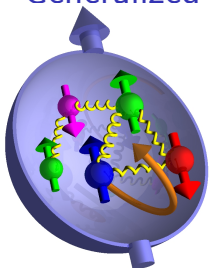
$$I + N \rightarrow I' + N' + \gamma \text{ (DVCS)}$$



$$M = \rho^0, \omega, \phi, \pi, \dots$$

$x$  = average long. momentum fraction of the parton  
 $t = \Delta^2 = (N-N')^2$   
 $2\xi$  = long. momentum fraction of  $\Delta$

# Generalized parton distributions - application



$$\frac{1}{2} = \frac{1}{2} \Delta\Sigma + \Delta G + \mathcal{L}$$

(Jaffe&Manohar Nucl.Phys.B337 (1990))

- ▶  $\frac{1}{2} \Delta\Sigma \sim 0.15$  known from DIS/SIDIS
- ▶  $|\Delta G| \sim 0.2$  first indications from DIS/pp
- ▶  $\mathcal{L}$  unknown

**Ji's sum rule** connects the Generalized Parton Distributions (GPDs)  $H(x, \xi, t)$  and  $E(x, \xi, t)$  with the total angular momentum  $J^{q,g}$

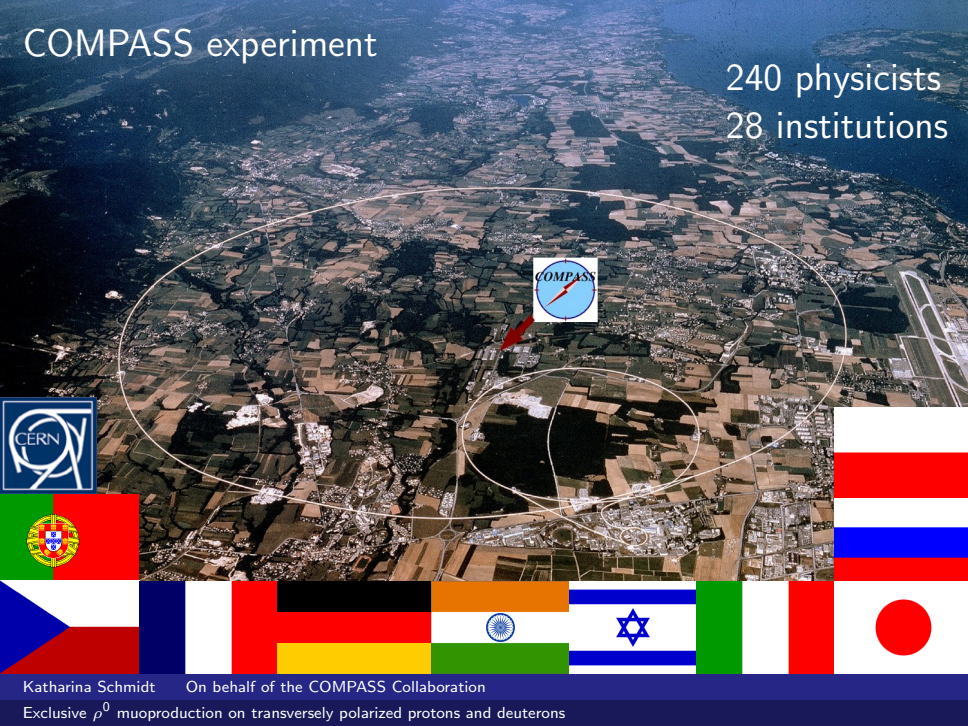
$$J^q = \frac{1}{2} \lim_{t \rightarrow 0} \int_{-1}^{+1} x [H^q(x, \xi, t) + E^q(x, \xi, t)] dx$$

(Phys.Rev.Lett.78 (1997))

$x$  = average long. momentum fraction of the parton  
 $t = \Delta^2 = (N-N')^2$   
 $2\xi$  = long. momentum fraction of  $\Delta$

# COMPASS experiment

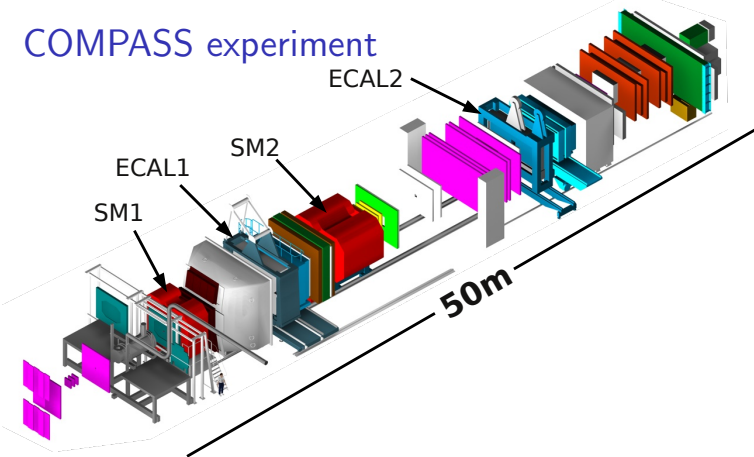
240 physicists  
28 institutions



Katharina Schmidt On behalf of the COMPASS Collaboration

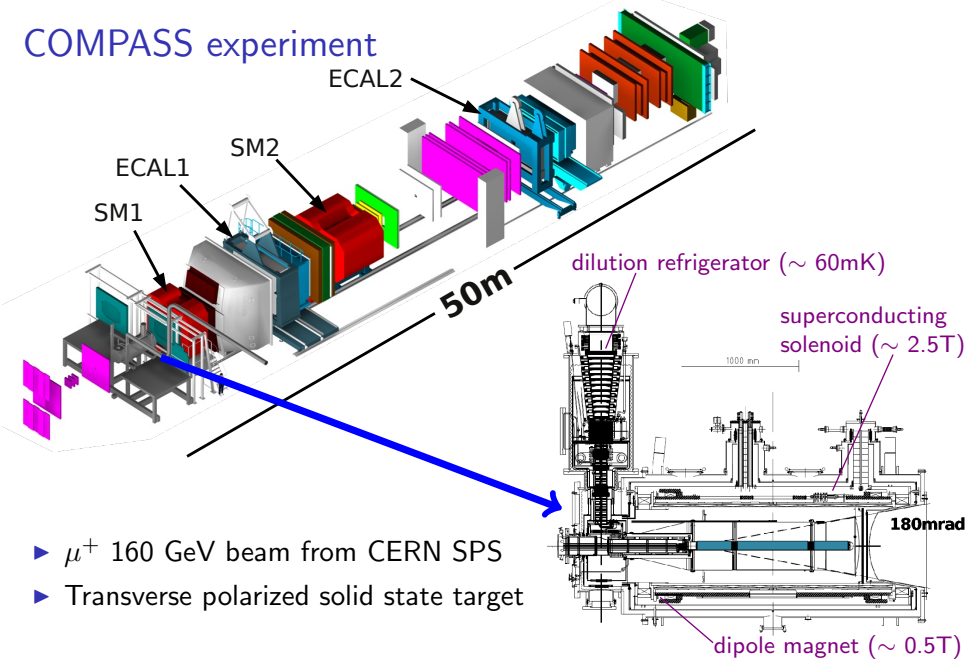
Exclusive  $\rho^0$  muoproduction on transversely polarized protons and deuterons

# COMPASS experiment



- ▶  $\mu^+$  160 GeV beam from CERN SPS
- ▶ Transverse polarized solid state target

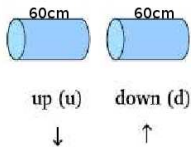
# COMPASS experiment



# Exclusive $\rho^0$ production at COMPASS

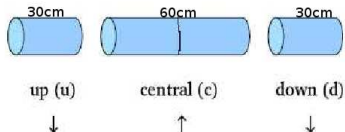
## ${}^6\text{LiD}$ target (polarized deuterons) 2003&2004

- Dilution factor  $\langle f \rangle \sim 0.45$
- Polarization  $\langle P_T \rangle \sim 50\%$



## $\text{NH}_3$ target (polarized protons) 2007&2010

- Dilution factor  $\langle f \rangle \sim 0.25$
- Polarization  $\langle P_T \rangle \sim 80\%$



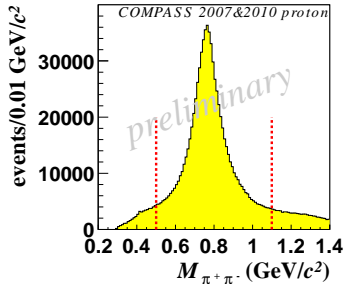
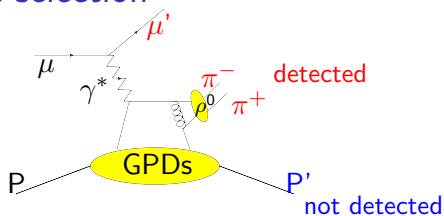
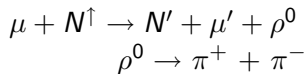
$$N^{\uparrow\downarrow}(\phi - \phi_S) \propto (1 \pm fP_T A_{UT} \sin(\phi - \phi_S))$$

$N^{\uparrow\downarrow}$  = number of events for up ↑, down ↓

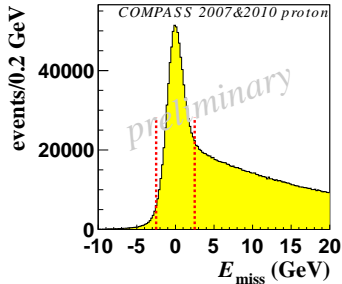
change of polarization  
~ weekly



# Exclusive $\rho^0$ production - event selection



- ▶ Peak at  $\rho^0$  pole mass  
 $\sim 0.775 \text{ GeV}/c^2$



- ▶ Signature for exclusivity  
 $E_{\text{Miss}} \sim 0$

# Semi-inclusive background estimation

- ▶ LEPTO MC (COMPASS tuning)
- ▶ Two step process:

## 1. Parameterization of MC:

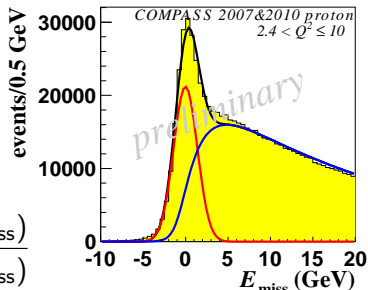
- ▶ MC weighted with the like-sign sample

$$w = \frac{N_{\text{data}}^{h^+h^+}(E_{\text{miss}}) + N_{\text{data}}^{h^-h^-}(E_{\text{miss}})}{N_{\text{MC}}^{h^+h^+}(E_{\text{miss}}) + N_{\text{MC}}^{h^-h^-}(E_{\text{miss}})}$$

- ▶ Parameterize the  $E_{\text{miss}}$  shape of weighted MC
- ▶ Used binning appropriate for asymmetry extraction

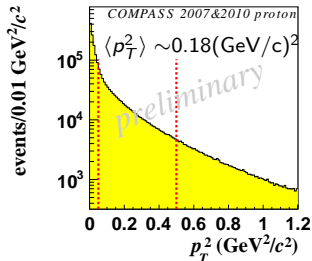
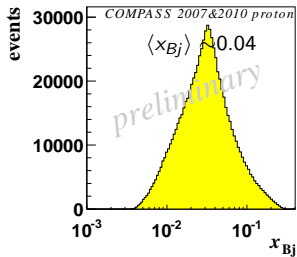
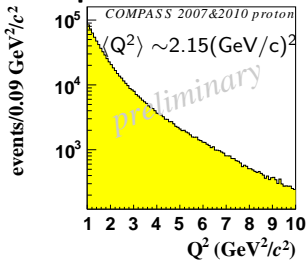
## 2. Fit to data:

- ▶ Normalize MC  $E_{\text{miss}}$  shape to data by performing a two component signal (gauss) + background fit
- ▶ Estimate the number of background events in every bin before extracting the asymmetries

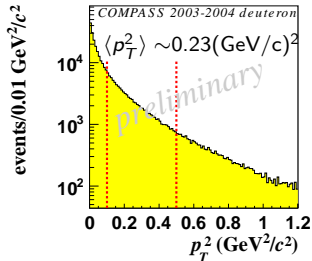
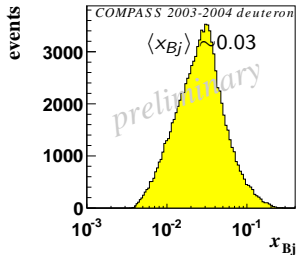
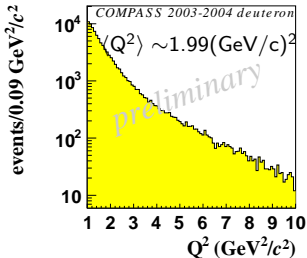


# Exclusive $\rho^0$ production - kinematical distributions

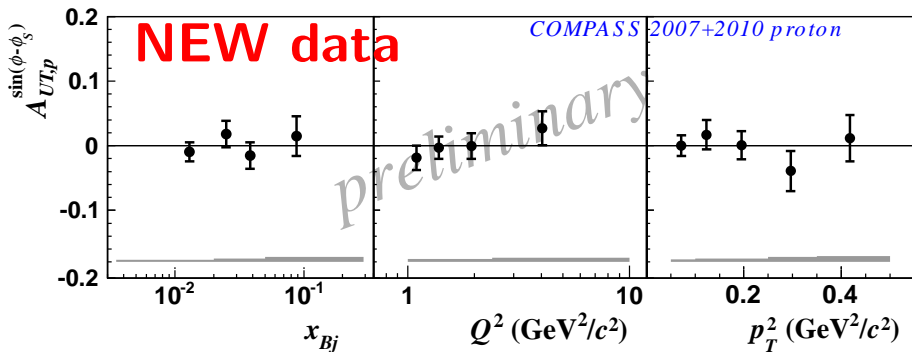
## protons



## deuterons

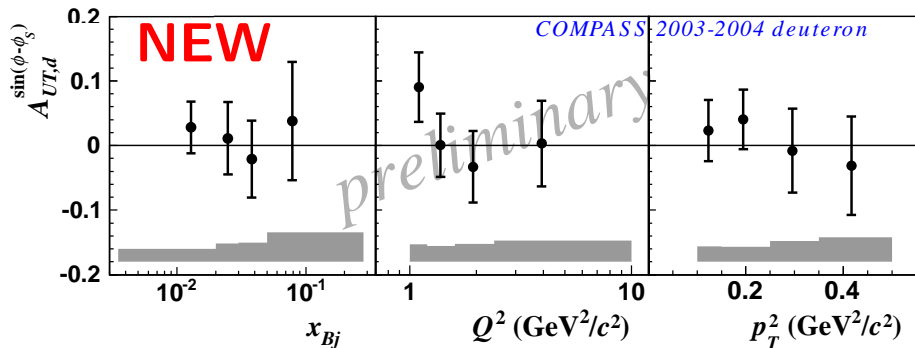


# Asymmetry $A_{UT,p}^{\sin(\phi-\phi_S)}$ - $\text{NH}_3$ target (2007&2010)



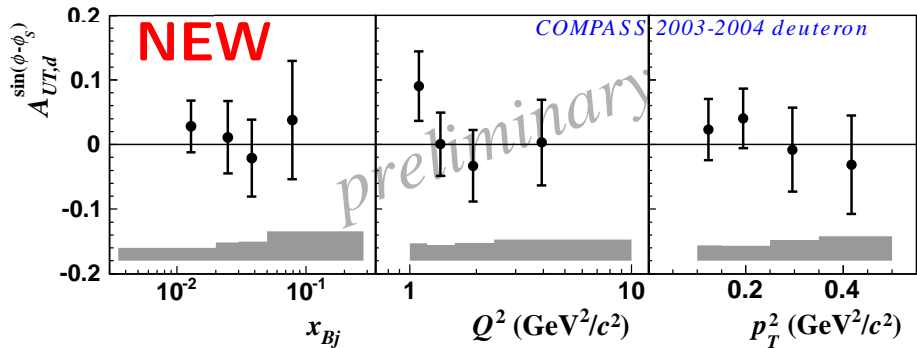
**NEW analysis:** 2010 data  
semi-inclusive background correction

# Asymmetry $A_{UT,d}^{\sin(\phi-\phi_S)}$ - ${}^6\text{LiD}$ target (2003&2004)



**NEW analysis:** semi-inclusive background correction

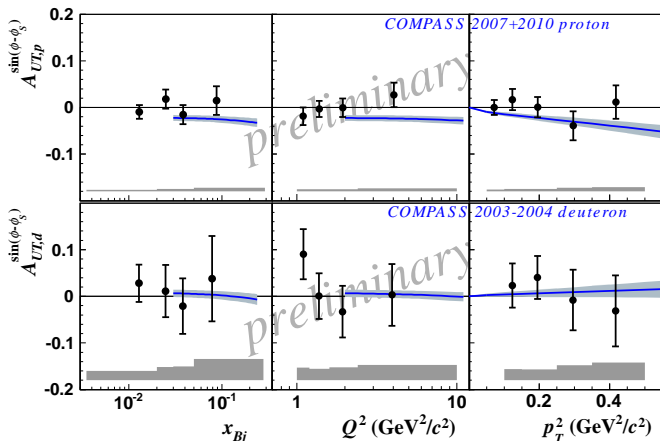
# Asymmetry $A_{UT,d}^{\sin(\phi-\phi_S)}$ - ${}^6\text{LiD}$ target (2003&2004)



- ▶ Both asymmetries  $A_{UT,p}^{\sin(\phi-\phi_S)}$  and  $A_{UT,d}^{\sin(\phi-\phi_S)}$  are small
- Publication in preparation

**NEW analysis:** semi-inclusive background correction

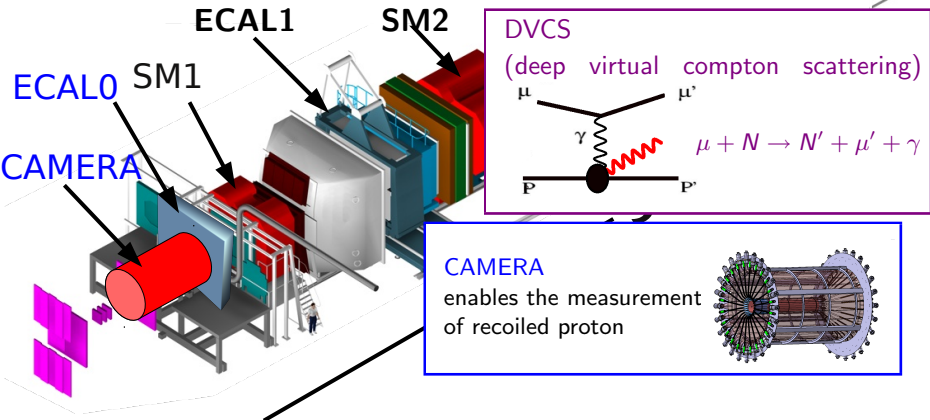
# Comparison with theory



- **Blue line:** prediction for COMPASS kinematic  
 $W = 8.1 \text{ GeV}/c^2$ ,  $p_T^2 = 0.2 (\text{GeV}/c)^2$ ,  $Q^2 = 2.2 (\text{GeV}/c)^2$   
from Goloskokov&Kroll

# COMPASS future - GPDs

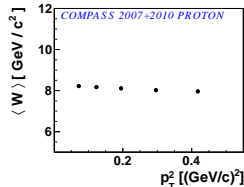
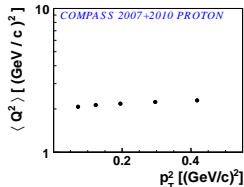
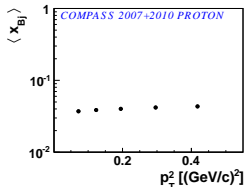
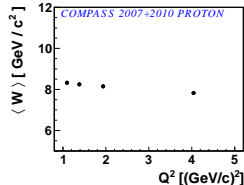
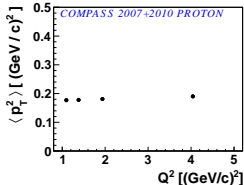
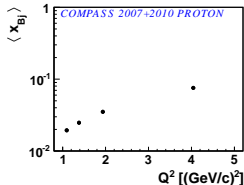
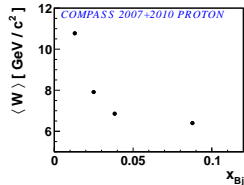
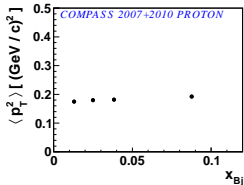
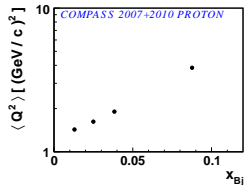
- ▶ 2012: pilot run, 2,5m LH2 target and CAMERA detector
- ▶ 2015: measurement foreseen including a third ECAL  
→ increase domain in  $x_{Bj}$



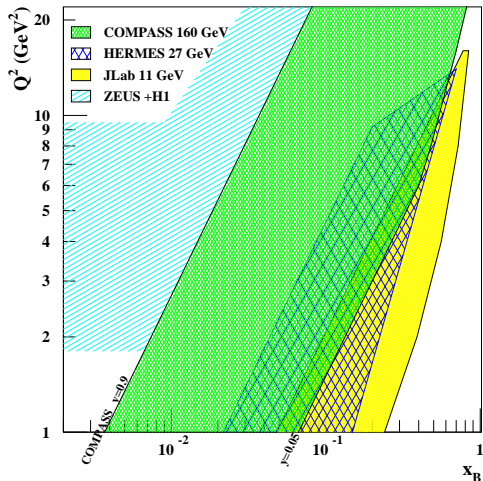


# Backup

# Mean values for 2007&2010 proton data



# DVCS at COMPASS-II



- ▶  $\mu^+$  and  $\mu^-$  beams
- ▶ Momentum: 100 – 190 GeV/c
- ▶ Polarization: 80 %  
opposite for  $\mu^+$  and  $\mu^-$
- ▶ Coverage of intermediate  $x_{Bj}$
- ▶ Unexplored region between  
ZEUS+H1 and HERMES+JLab