Hard exclusive ρ^0 production to constrain generalized parton distributions

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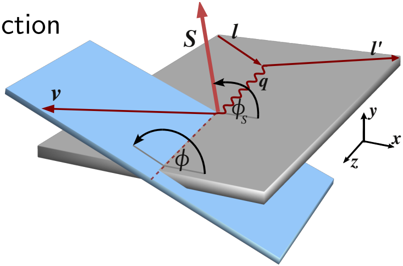
Hard exclusive ρ^0 production

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

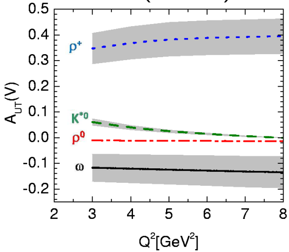


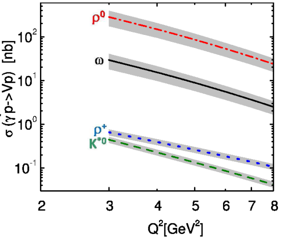
$$A_{UT}^{sin(\phi-\phi_S)} \sim \frac{Im(\mathcal{E}^\star\mathcal{H})}{|\mathcal{H}|^2}$$

transverse target single 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

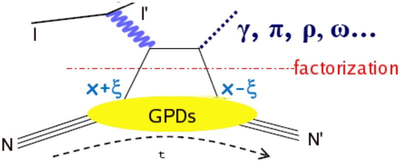
- Factorisation valid for σ_L
- 4 GPDs $H(x,\xi,t)$, $E(x,\xi,t)$, $\tilde{H}(x,\xi,t)$, $\tilde{E}(x,\xi,t)$ for each quark flavor and gluons
- Hard exclusive meson production (HEMP)
  vector meson: ρ^0, ω, ϕ, ... $\rightarrow H$ & E
  pseudo-scalar: π, η, ... $\rightarrow \tilde{H}$ & $\tilde{E}$
- In HEMP quark and gluon GPDs enter at the same order of α_S
- HEMP allows for flavor separation

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

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

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

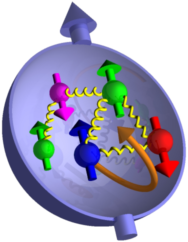
l + N $\rightarrow$ l' + N' + M (HEMP)
or
l + N $\rightarrow$ l' + N' + γ (DVCS)



M = ρ^0,ω,ϕ,π, ...

x = average long. momentum fraction of the parton
t = Δ^2 = (N-N')^2
ξ = long. momentum fraction of Δ

Generalized parton distributions - application



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

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

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

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

x = average long. momentum fraction of the parton
t = Δ^2 = (N-N')^2
ξ = long. momentum fraction of Δ

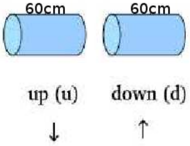
Exclusive ρ^0 production at COMPASS

All measurements done with μ^+ 160 GeV beam at CERN SPS

^{6}LiD target (polarized deuterons) 2003&2004

→ Dilution factor $\langle f \rangle \sim 0.45$

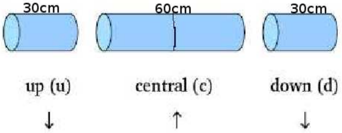
→ Polarization $\langle P_T \rangle \sim 50\%$



NH_3 target (polarized protons) 2007&2010

→ Dilution factor $\langle f \rangle \sim 0.25$

→ Polarization $\langle P_T \rangle \sim 80\%$

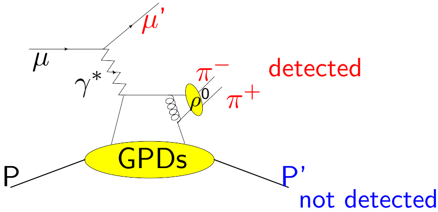


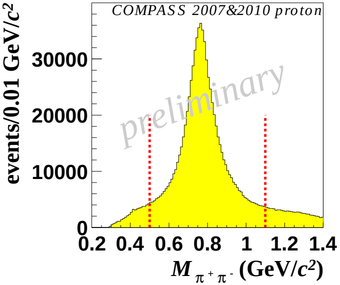
$N^{\uparrow\downarrow}(\phi - \phi_S) \propto (1 \pm f P_T A_{UT} sin(\phi - \phi_S))$
$N^{\uparrow\downarrow}$ = number of events for up ↑, down ↓

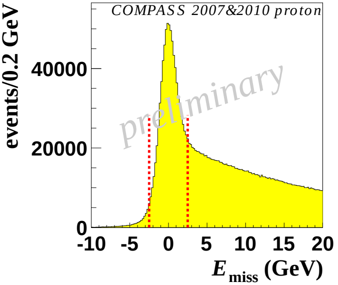
change of polarization $\sim$ weekly

Exclusive ρ^0 production - event selection

$$\mu + N^{\uparrow} \rightarrow N' + \mu' + \rho^0$$
$$\rho^0 \rightarrow \pi^+ + \pi^-$$



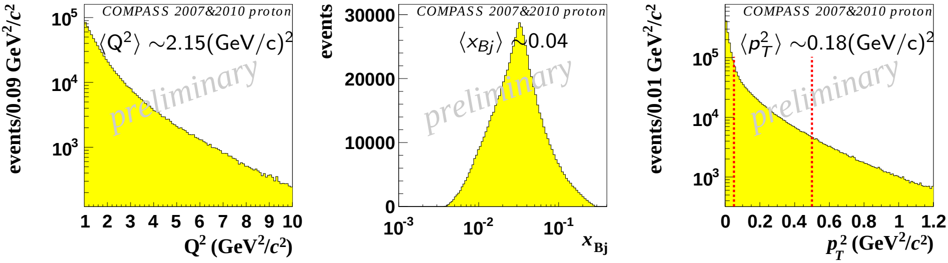




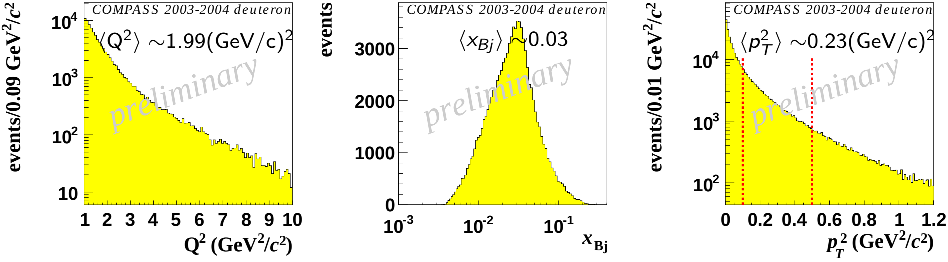
- Peak at ρ^0 pole mass ~ 0.75 GeV/c^2
- signature for exclusivity $E_{Miss} \sim 0$

Exclusive ρ^0 production - kinematical distributions

protons



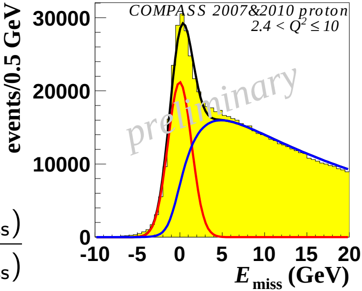
deuterons



Semi-inclusive background estimation

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

1. Parameterization of MC:
    - MC weigthed with the like sign sample

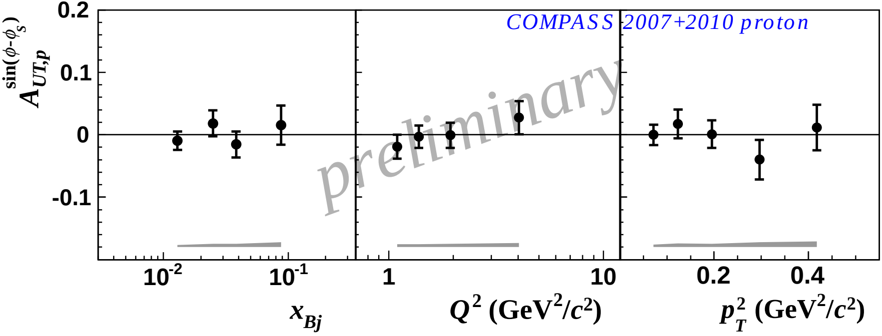


$$w = \frac{N_{\text{MC}}^{h^+h^+}(E_{\text{miss}}) + N_{\text{MC}}^{h^-h^-}(E_{\text{miss}})}{N_{\text{data}}^{h^+h^+}(E_{\text{miss}}) + N_{\text{data}}^{h^-h^-}(E_{\text{miss}})}$$

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

2. Fit to data:
    - Normalize MC E_{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

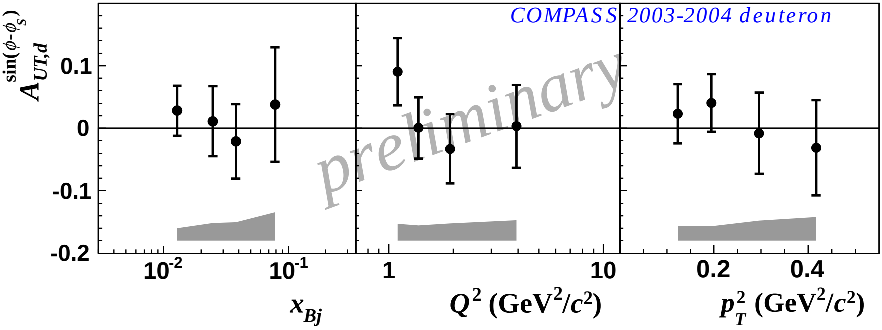
Asymmetry $A_{UT,p}^{sin(\phi-\phi_S)}$ - NH_3 target (2007&2010)



NEW analysis: 2010 data

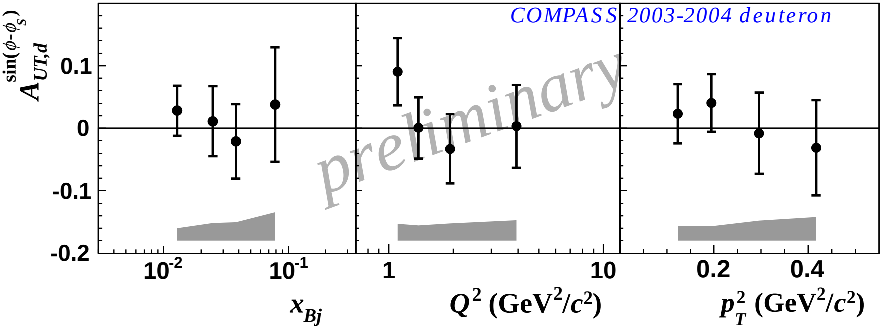
semi-inclusive background correction

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



NEW analysis: semi-inclusive background correction

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



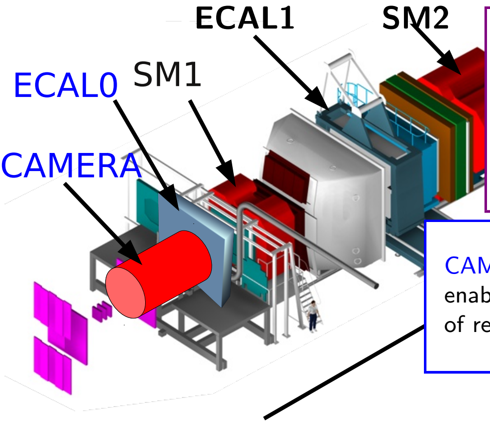
- Both asymmetries $A_{UT,p}^{sin(\phi-\phi_S)}$ and $A_{UT,d}^{sin(\phi-\phi_S)}$ are small
- In agreement with theoretical predictions

$\longrightarrow$ Publication in preparation

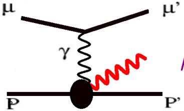
NEW analysis: semi-inclusive background correction

COMPASS future - measuring DVCS

- 2012: test measurement 2,5m LH2 target and CAMERA detector
- 2015: measurement foreseen including a third ECAL
  $\longrightarrow$ increase domain in x_{Bj}

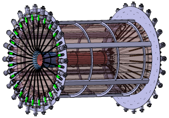


DVCS
(deep virtual compton scattering)



$\mu + N \rightarrow N' + \mu' + \gamma$

CAMERA
enables the measurement
of recoiled proton



CAMERA readout with GANDALF framework: see HK 24.5, HK 35.6, HK 53.8