Transverse Target Spin Asymmetry extraction from Exclusive ρ_0 production

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"On behalf of the COMPASS collaboration"
Erice School 2007

Outline :

1/ Generalized partons distributions (GPDs)

2/ COMPASS

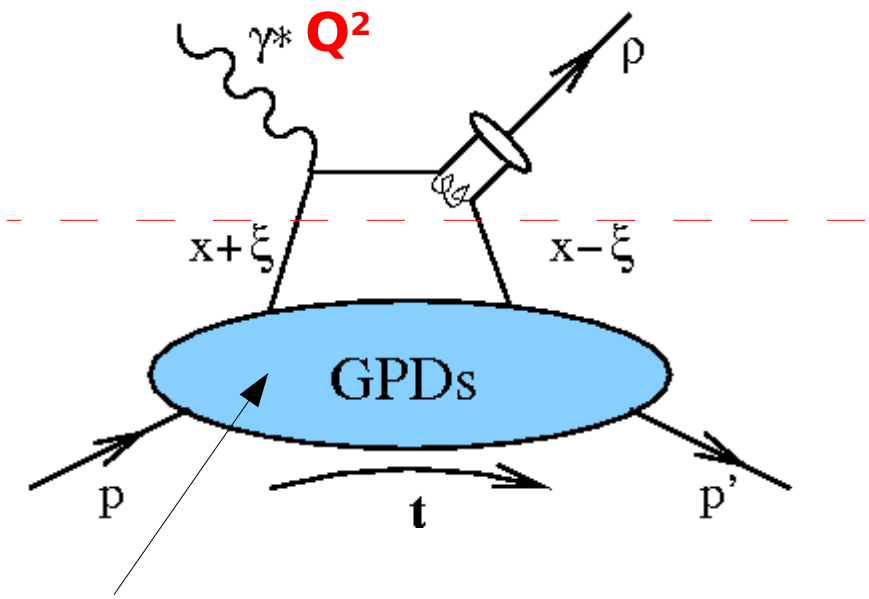
3/ Exclusive ρ_0 production

4/ Transverse Target Spin Asymmetries

5/ Future work

1/ Generalized partons distributions (GPDs)

At leading order : ρ production dominated by handbag diagram



Factorisation: Q^2 large, -t small
And γ^* longitudinal

$$4\,GPDs : H(x,\xi,t), E(x,\xi,t), \tilde{H}(x,\xi,t), \tilde{E}(x,\xi,t)$$

ρ production is only sensitive to H and E

$$\int_{-1}^{1} dx\, H(x,\xi,t) = F_1(t)$$
$$\int_{-1}^{1} dx\, E(x,\xi,t) = F_2(t)$$

GPDs contains :
- Form factors
- Partons distributions
- Angular momentum of quarks (Ji sum rule)

$$H(x,\xi=0,t=0) = q(x)$$

No equivalent continuity condition for E(x,0,0)

1/ Generalized partons distributions (GPDs)

How partons contribute to the proton spin : $\frac{1}{2} = J_q + J_g = \frac{1}{2}\Delta\Sigma + L_q + \Delta G + L_g$

quarks gluons

≈30% unknown unknown

Large values excluded
(COMPASS, RHIC, HERMES)

L_q is measurable from GPDs via the Ji sum rule

$$J_q = \frac{1}{2}\Delta\Sigma + L_q = \frac{1}{2}\int dx\, x\,(H_q(x,\xi,0) + E_q(x,\xi,0))$$

Directive line

Exclusive rho production ——— sensitive to H and E

↓

Transverse target spin asymmetries extraction ——— Related to some combination of H(x,ξ,t) and E(x,ξ,t) integrals

TTSA $\propto Im(\mathcal{E}\mathcal{H})$

↓

Constraint on E(x,ξ,t) GPD

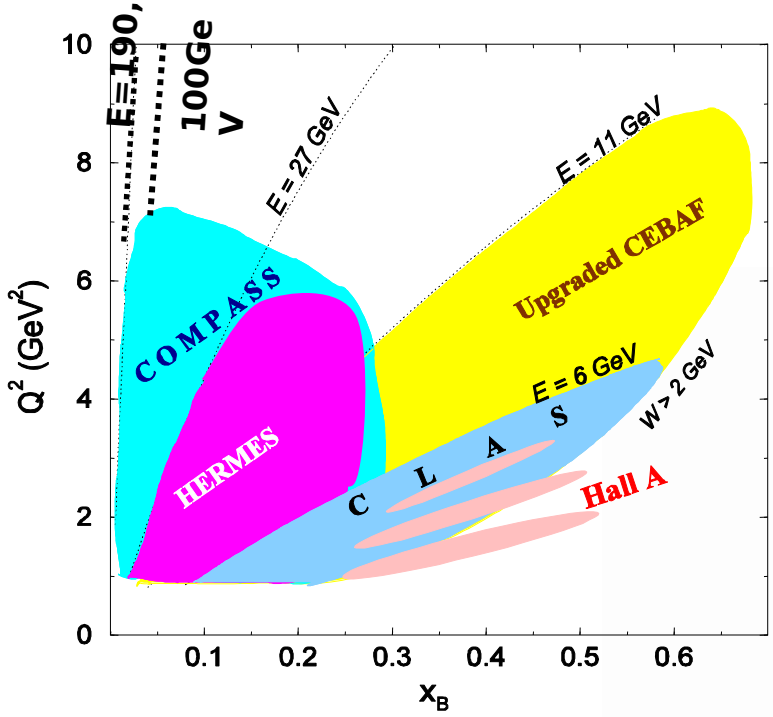
↓

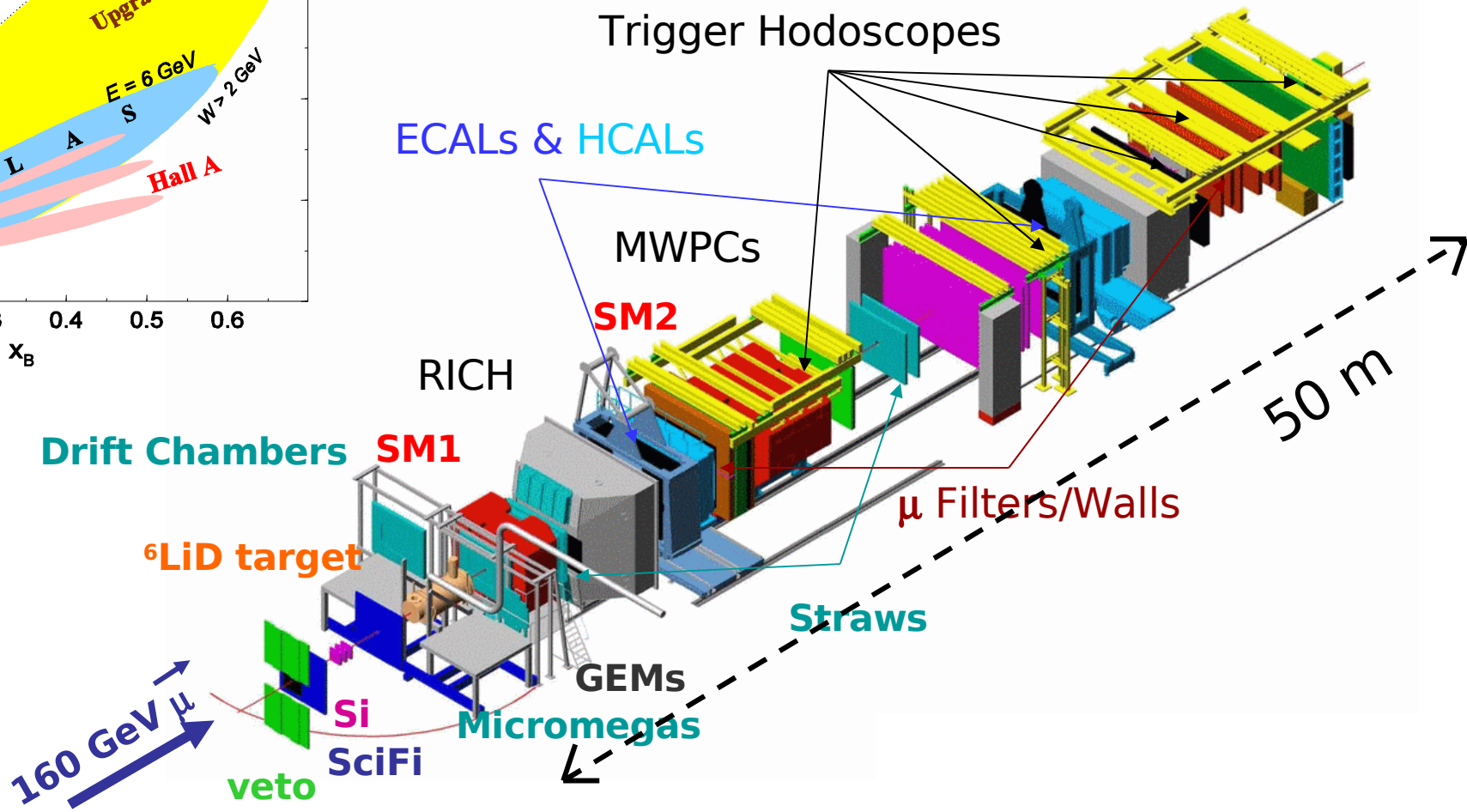
Check of models

2/ COMPASS

Longitudinally polarized muons : 160 GeV/*c*
2.10^8 μ/spill (4.8s / 16.8s)
P_{Beam} = -80%

Luminosity: ~ 5. 10^{32} $cm^{-2}s^{-1}$



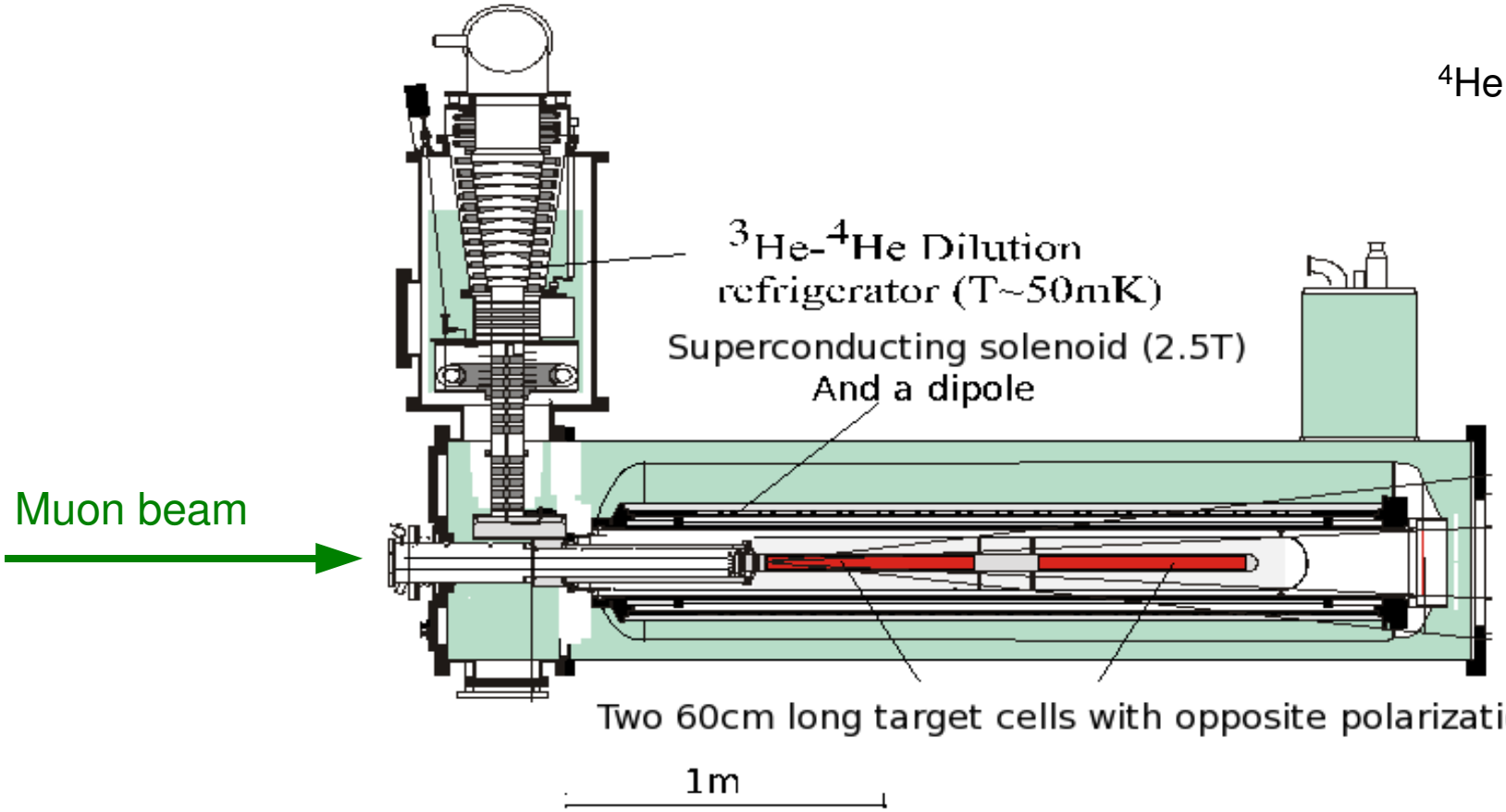


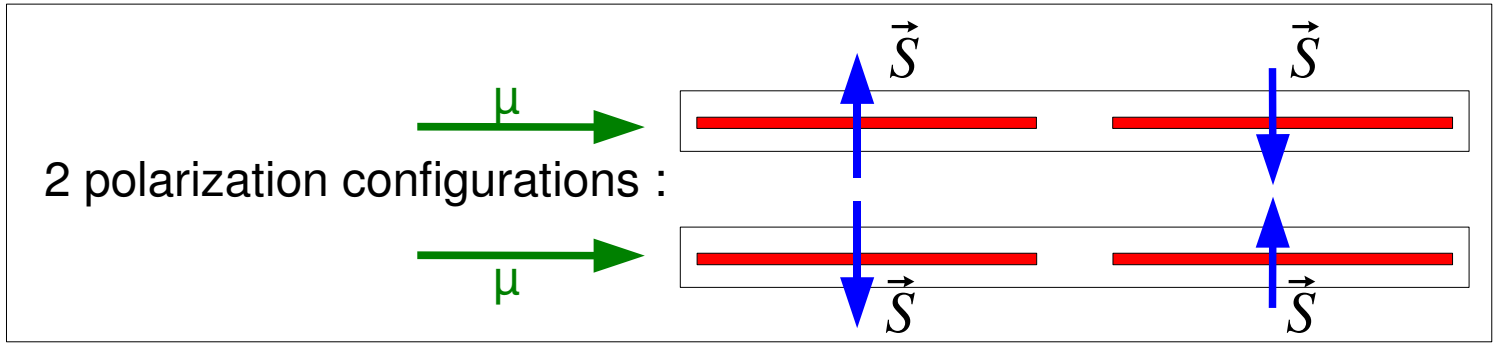
2/ COMPASS

Transversally (or longitudinally) polarized deuteron target : ^{6}LiD $P_T \sim 50\%$

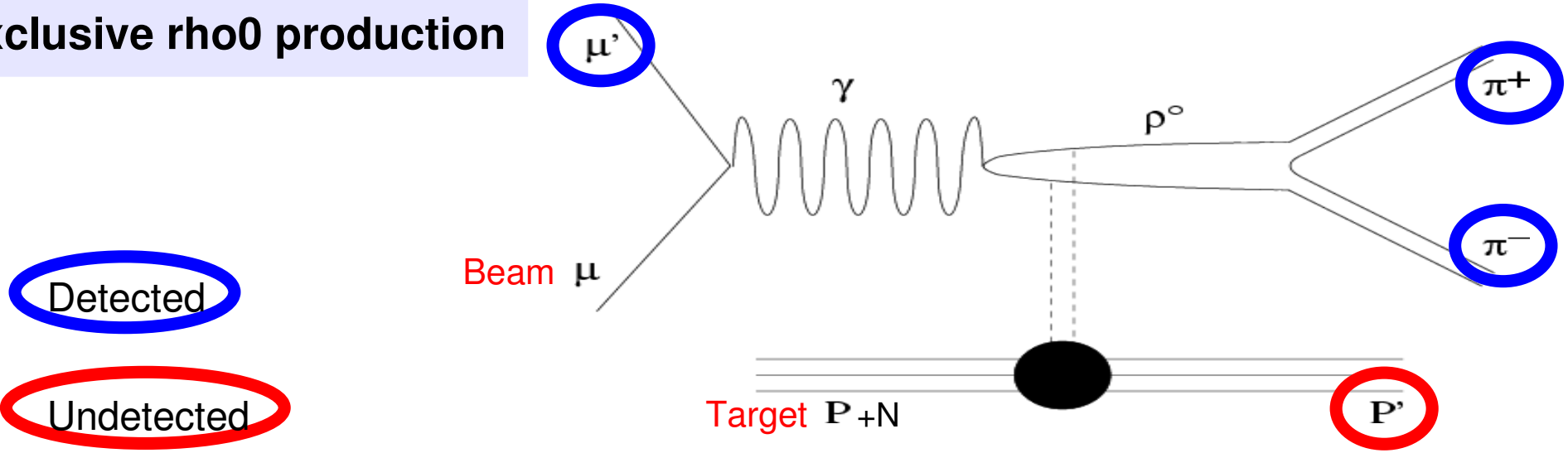
^{4}He + D + D

Polarizable





3/ Exclusive rho0 production

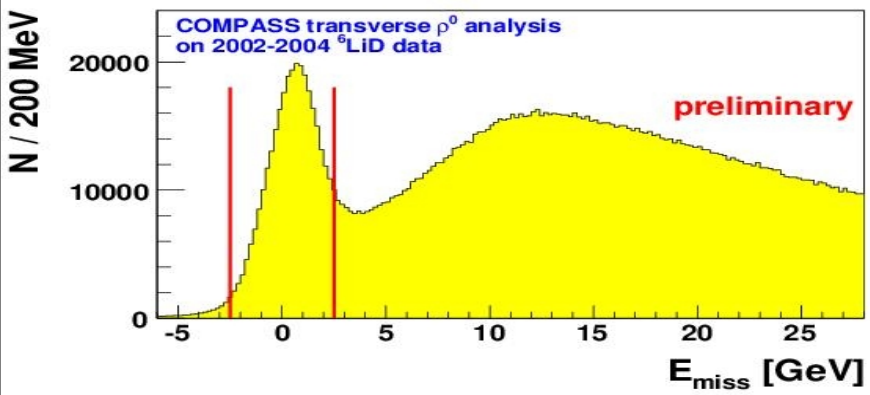


Exclusive ρ_0 Production

Recoil proton (p') is not detected,

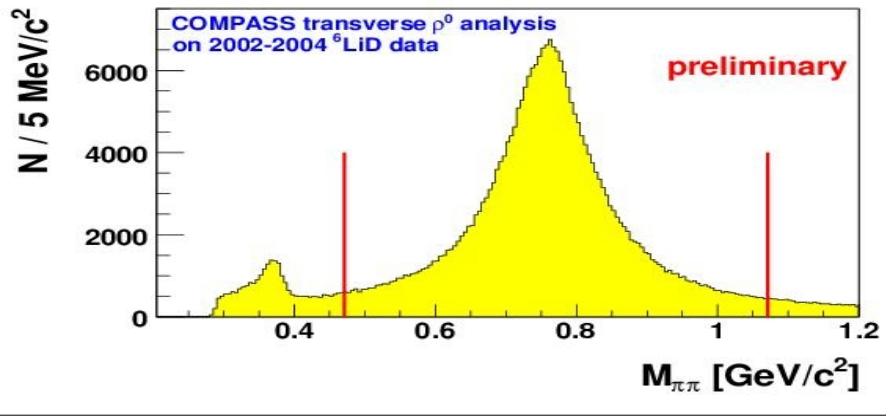
Check if the proton is intact :

$$E_{miss} = \frac{M_X^2 - M_{proton}^2}{2\,M_{proton}} \in [-2.5, 2.5]\,GeV$$



Invariant mass selection

$$0.3 < M_{\pi\pi} - M_{\rho} < 0.3\,GeV$$

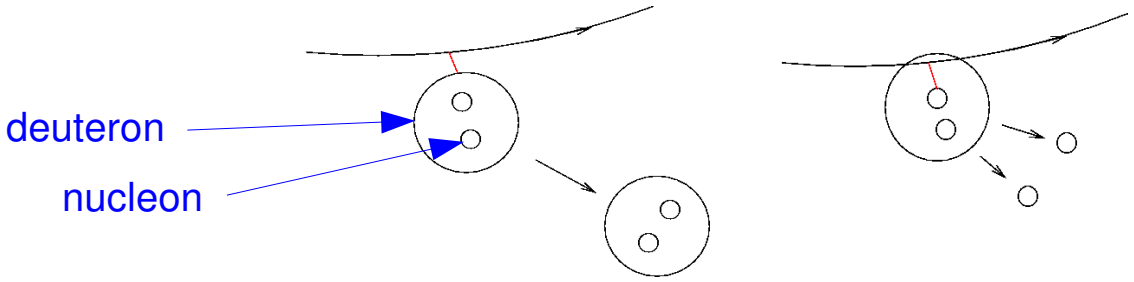


3/ Physics content of the sample

What we want :

Incoherent + **longitudinal** sample : Interpretation in the framework of the GPDs

What we have : ◆ **Coherent** + **incoherent** scattering



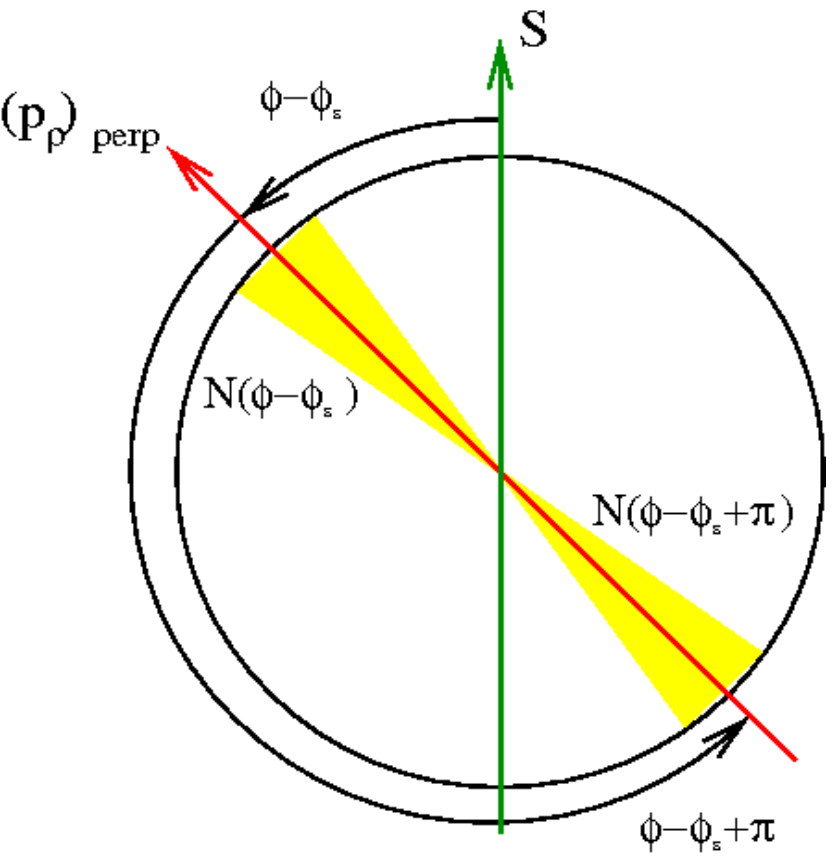
◆**Transverse** ($J_z=\pm1$) + **longitudinal** ($J_z=0$) polarization of γ^*

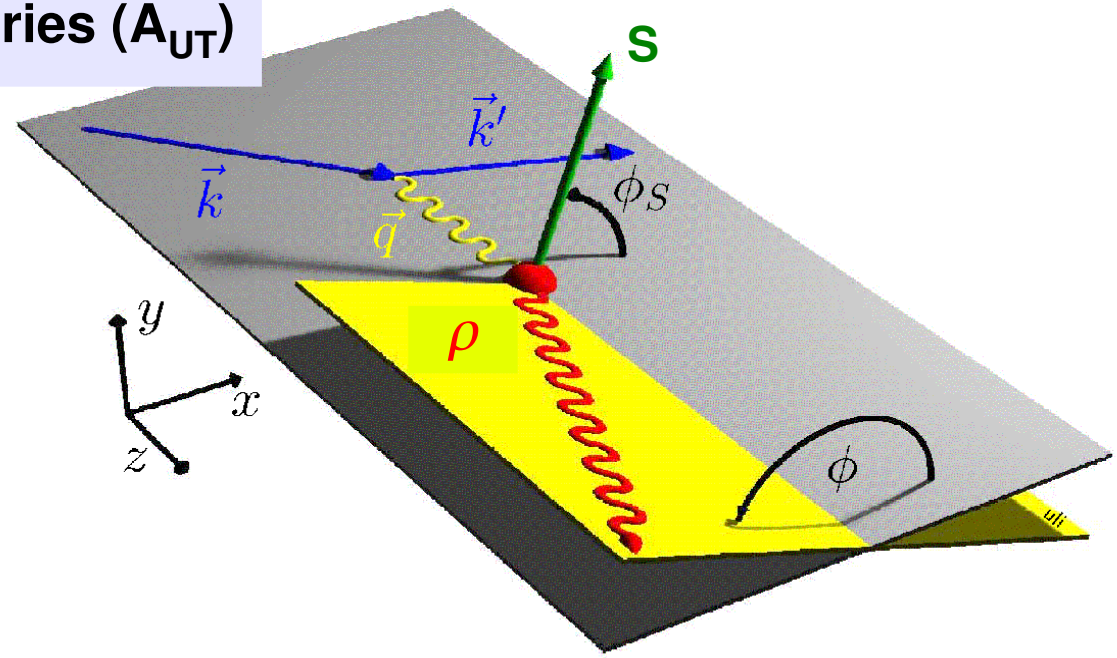
◆Scattering off **protons** and **neutrons**

What we have to do : Coherent / **incoherent** and **Transverse** / **longitudinal** separation

(last part of the presentation)

4/ Transverse Target Spin Asymmetries (A_{UT})





In GPDs framework :

$d\sigma(\phi-\phi_S) - d\sigma(\phi-\phi_S+\pi) \propto Im(\mathcal{EH}) \sin(\phi-\phi_S)$

$$A_{UT}(\phi-\phi_S) \sim \frac{\sigma(\phi-\phi_S)-\sigma(\phi-\phi_S+\pi)}{\sigma(\phi-\phi_S)+\sigma(\phi-\phi_S+\pi)}$$

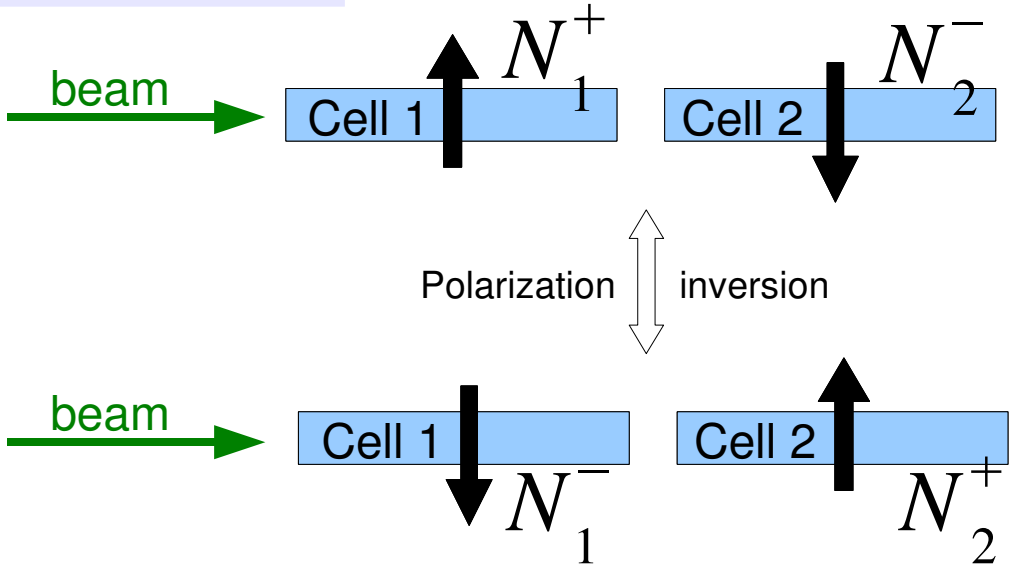
A_{UT} measurable by one target and one polarization

With only one target with one polarization, A_{UT} is dominated by acceptance effects

➔ **Asymmetry extraction from double ratio method with 2 targets with 2 polarizations**

4/ Transverse Target Spin Asymmetries (A_{UT})

Double ratio method



$$N^{\pm}_{1,2}(\phi-\phi_S)=F^{\pm}_{1,2}\,a^{\pm}_{1,2}(\phi-\phi_S)\,\sigma_0\,(1\pm f\langle P_T\rangle A_{UT}\sin(\phi-\phi_S))$$

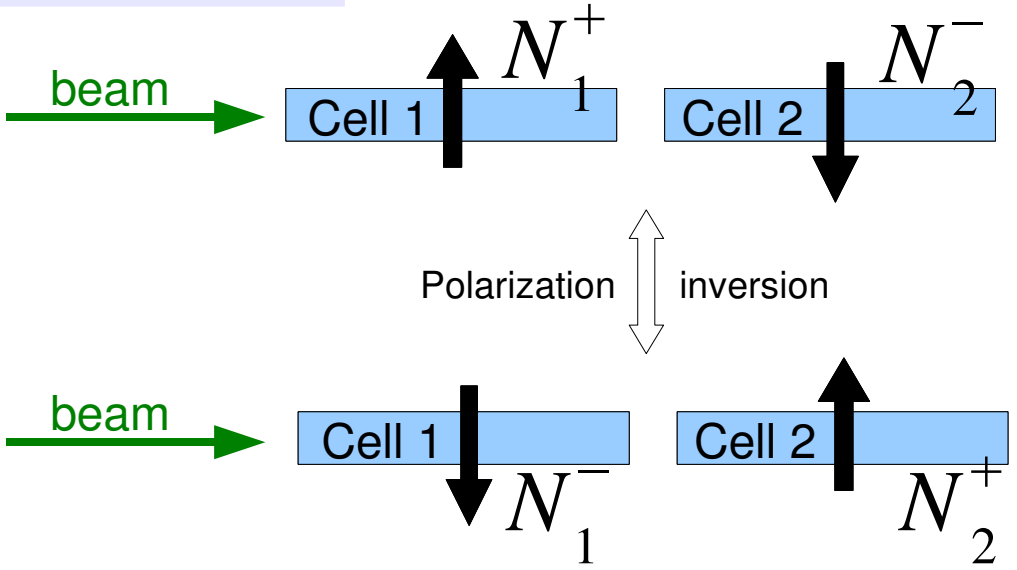
Flux — Acceptance — Dilution factor — Mean target polarization

$$\frac{N_1^+(\phi-\phi_S)N_2^+(\phi-\phi_S)}{N_1^-(\phi-\phi_S+\pi)N_2^-(\phi-\phi_S+\pi)}=\frac{F_1^+F_2^+}{F_1^-F_2^-}\,\frac{a_1^+(\phi-\phi_S)a_2^+(\phi-\phi_S)}{a_1^-(\phi-\phi_S+\pi)a_2^-(\phi-\phi_S+\pi)}\,\frac{(1+f\langle P_T\rangle A_{UT}\sin(\phi-\phi_S))^2}{(1-f\langle P_T\rangle A_{UT}\sin(\phi-\phi_S))^2}$$

$$\frac{N_1^+(\phi-\phi_S)N_2^+(\phi-\phi_S)}{N_1^-(\phi-\phi_S+\pi)N_2^-(\phi-\phi_S+\pi)}\approx C[1+4f\langle|P_T|\rangle A_{UT}\sin(\phi-\phi_S)]$$

4/ Transverse Target Spin Asymmetries (A_{UT})

Double ratio method



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Flux — Acceptance — Dilution factor — Mean target polarization

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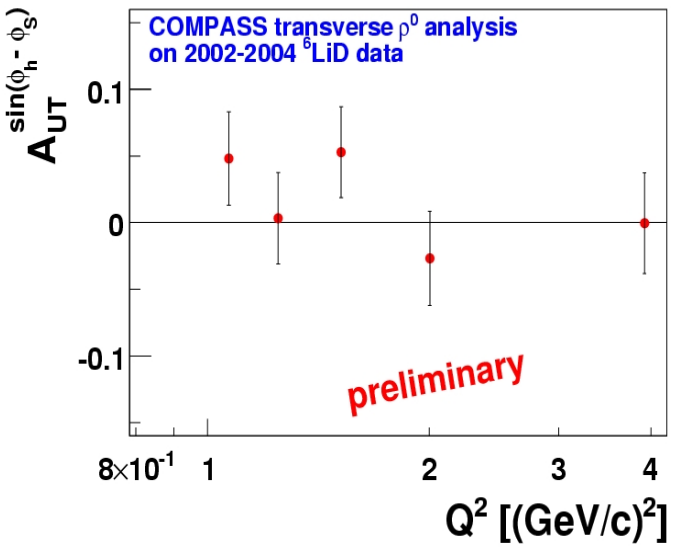
$$\frac{N_1^+(\phi-\phi_S)N_2^+(\phi-\phi_S)}{N_1^-(\phi-\phi_S+\pi)N_2^-(\phi-\phi_S+\pi)}\approx C[1+4f\langle|P_T|\rangle A_{UT}\sin(\phi-\phi_S)]$$

4/ Transverse Target Spin Asymmetries (A_{UT})

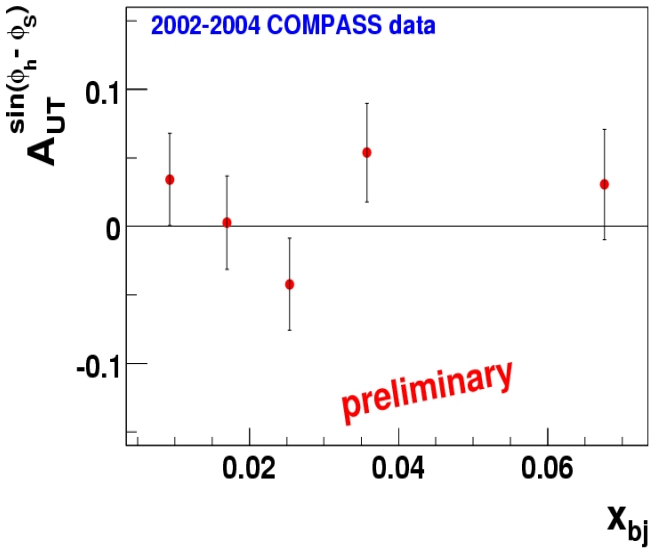
COMPASS results on a DEUTERON target

without coherent/incoherent and transverse/longitudinal separation

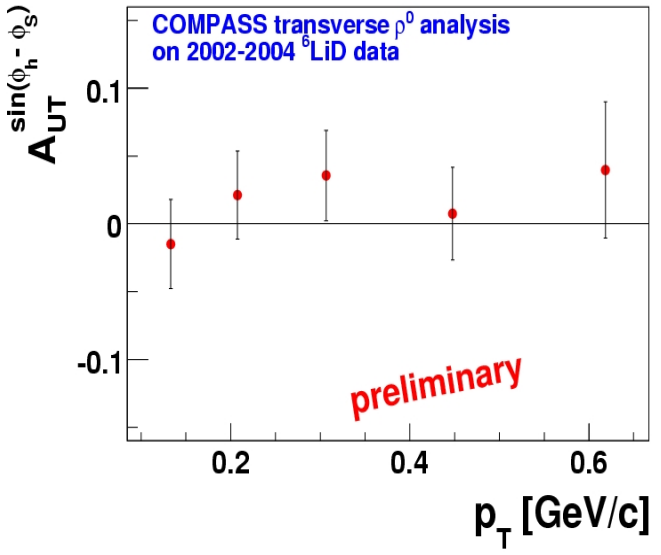
$\langle Q^2 \rangle \simeq 2.0\, GeV^2$



$\langle x \rangle \simeq 0.03$



$\langle p_T \rangle \simeq 0.30\, GeV$



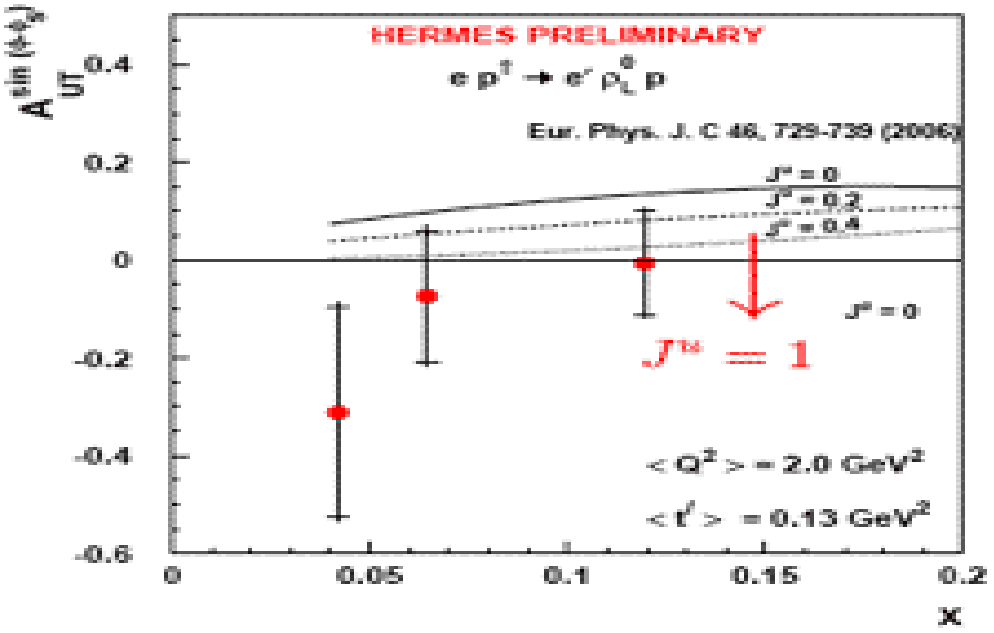
A_{UT} results on deuteron target, compatible with 0

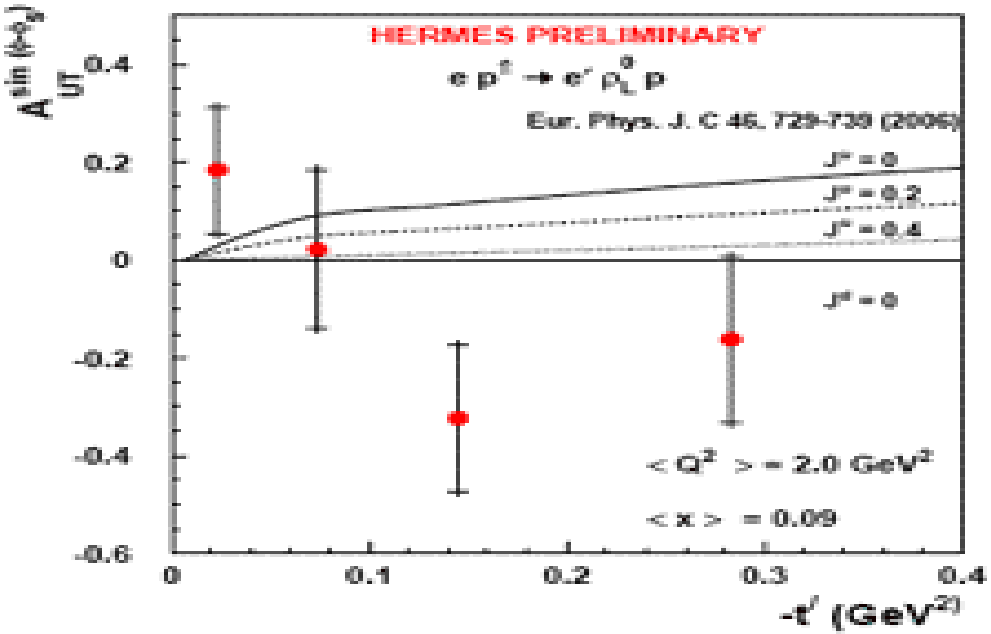
both protons and neutrons contribute and might cancel asymmetry

4/ Transverse Target Spin Asymmetries (A_{UT})

HERMES results on a PROTON target
with and transverse/longitudinal separation

(see Armine Rostomyan's presentation, DIS2007)





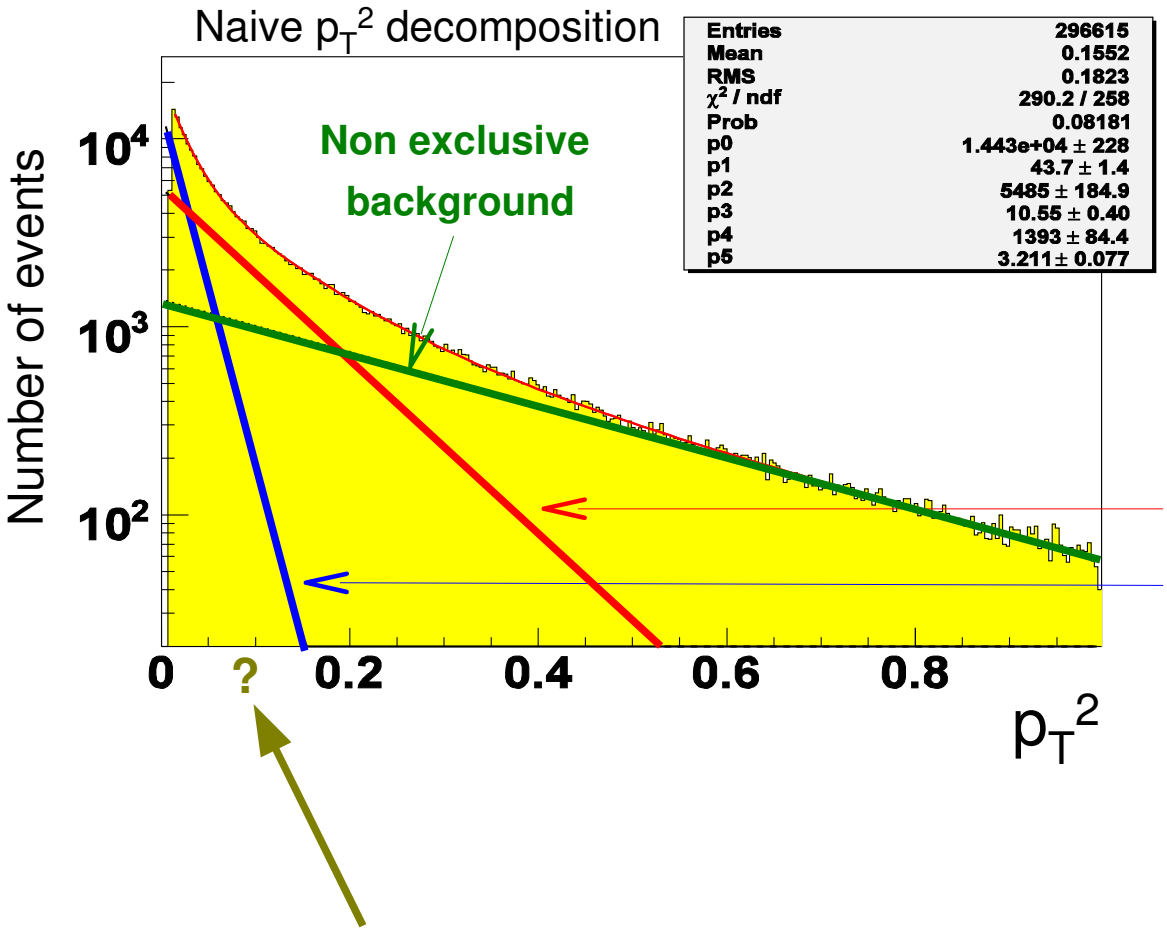
A_{UT} results on proton target is also compatible with 0

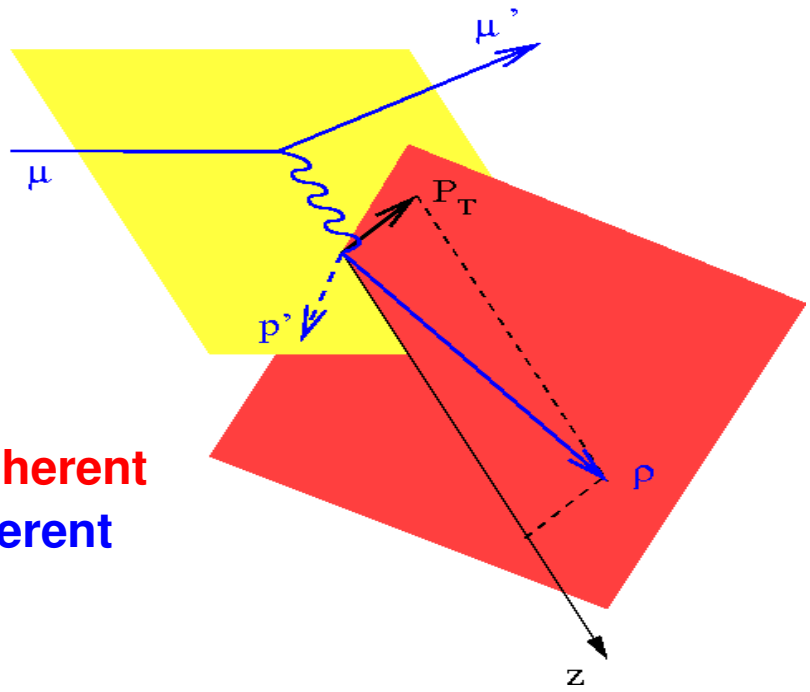
seems to favor large values of J_u (at fixed J_d=0) in the model VGG+Vinikov (ref EPJ C46)

Hermes error bars seems bigger : **transverse contribution have been removed**

5/ Coherent-Incoherent separation

Coherent / incoherent separation is in progress (Andrej Sandacz, Warsaw Univ.)





Find the p_T^2 selection to : Reject coherent sample

Reject Non exclusive background

Keep incoherent sample

5/ Transverse-Longitudinal virtual photon contribution

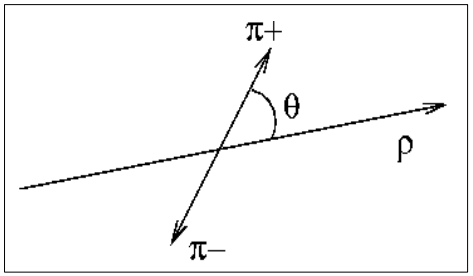
We want to estimate the asymmetry in the scattering of longitudinal photons

DIEHL SAPETA

i,j : proton helicity; m,n : γ^* helicity

$$\frac{d\sigma^{ij}_{mn}(\gamma^* p \to \pi^+ \pi^- p)}{d\cos\theta} = \frac{3\cos^2\theta}{2}\sigma^{ij}_{mn}(\gamma^* p \to \rho_L p) + \frac{3\sin^2\theta}{4}\sigma^{ij}_{mn}(\gamma^* p \to \rho_T p)$$

longitudinal / transverse separation of ρ polarization



If SCHC :

ρ polarization → γ^* polarization

→ longitudinal / transverse separation of γ polarization

Conclusions

1) Li_6D COMPASS (2002-3-4): A_{UT} close to zero with a deuteron target

Work in progress : Coherent / incoherent separation (by p_T^2 separation)

Transverse / longitudinal γ^* separation (by angular distribution)

→ back to GPD framework

Future work : Proton data analysis (NH3 COMPASS 2007)

MC to extract total cross section

2) A similar work achieved at HERMES with a proton target (see Armine Rostomyan's presentation, DIS2007)

A complete analysis have been performed to extract only longitudinal contribution.

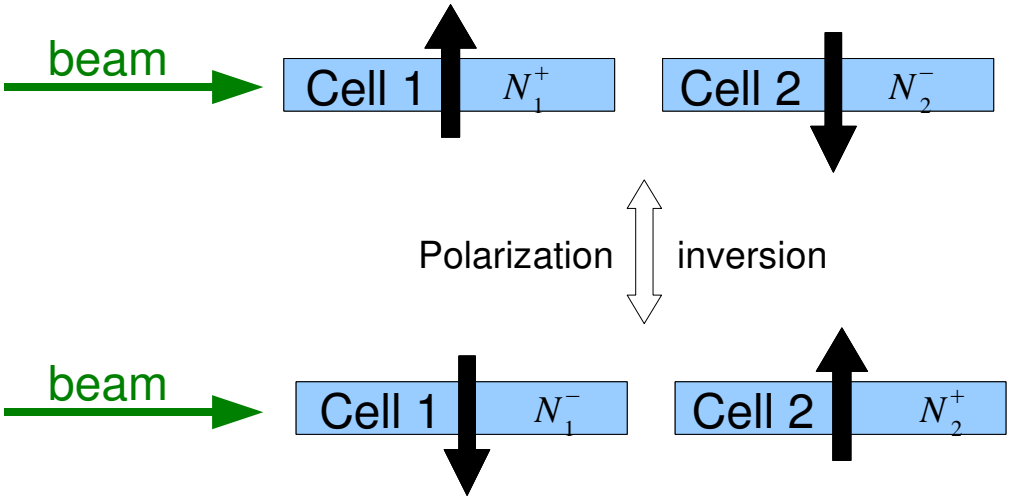
Preliminary results : A_{UT} also close to zero.

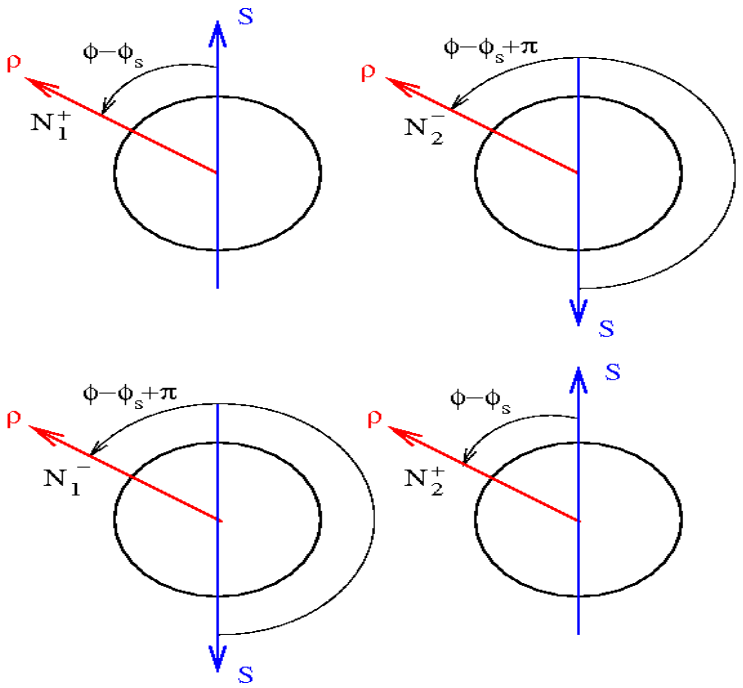
3) Goloskokov and Kroll (hep-ph/0708.3569) proposed a model for vector meson production using GPDs at $x_{BJ}<0.2$. They predict a very small value for A_{UT} of the proton.

→Both experimental and theoretical activities

Backup

4/ Transverse Target Spin Asymmetries (A_{UT})





Double ratio method

$$N^{\pm}_{1,2}(\phi-\phi_S)=F^{\pm}_{1,2}\,a^{\pm}_{1,2}(\phi-\phi_S)\,\sigma_0\,(1\pm f\langle P_T\rangle A_{UT}\sin(\phi-\phi_S))$$

Flux · Acceptance · Dilution factor · Mean target polarization

$$\frac{N_1^+(\phi-\phi_S)N_2^+(\phi-\phi_S)}{N_1^-(\phi-\phi_S+\pi)N_2^-(\phi-\phi_S+\pi)}=\frac{F_1^+F_2^+}{F_1^-F_2^-}\,\frac{a_1^+(\phi-\phi_S)a_2^+(\phi-\phi_S)}{a_1^-(\phi-\phi_S+\pi)a_2^-(\phi-\phi_S+\pi)}\,\frac{(1+f\langle P_T\rangle A_{UT}\sin(\phi-\phi_S))^2}{(1-f\langle P_T\rangle A_{UT}\sin(\phi-\phi_S))^2}$$

Flux cancellation $F_1^+=F_2^-$, $F_1^-=F_2^+$

Acceptance cancellation $\dfrac{a_1^+(\phi-\phi_S)}{a_2^-(\phi-\phi_S+\pi)}\simeq\dfrac{a_1^-(\phi-\phi_S+\pi)}{a_2^+(\phi-\phi_S)}$

$f=0.36$

P_T = target polarization

$$\frac{N_1^+(\phi-\phi_S)N_2^+(\phi-\phi_S)}{N_1^-(\phi-\phi_S+\pi)N_2^-(\phi-\phi_S+\pi)}\approx C[1+4f\langle|P_T|\rangle A_{UT}\sin(\phi-\phi_S)]$$