Exclusive ρ^0 production
with transversely polarized protons
at COMPASS

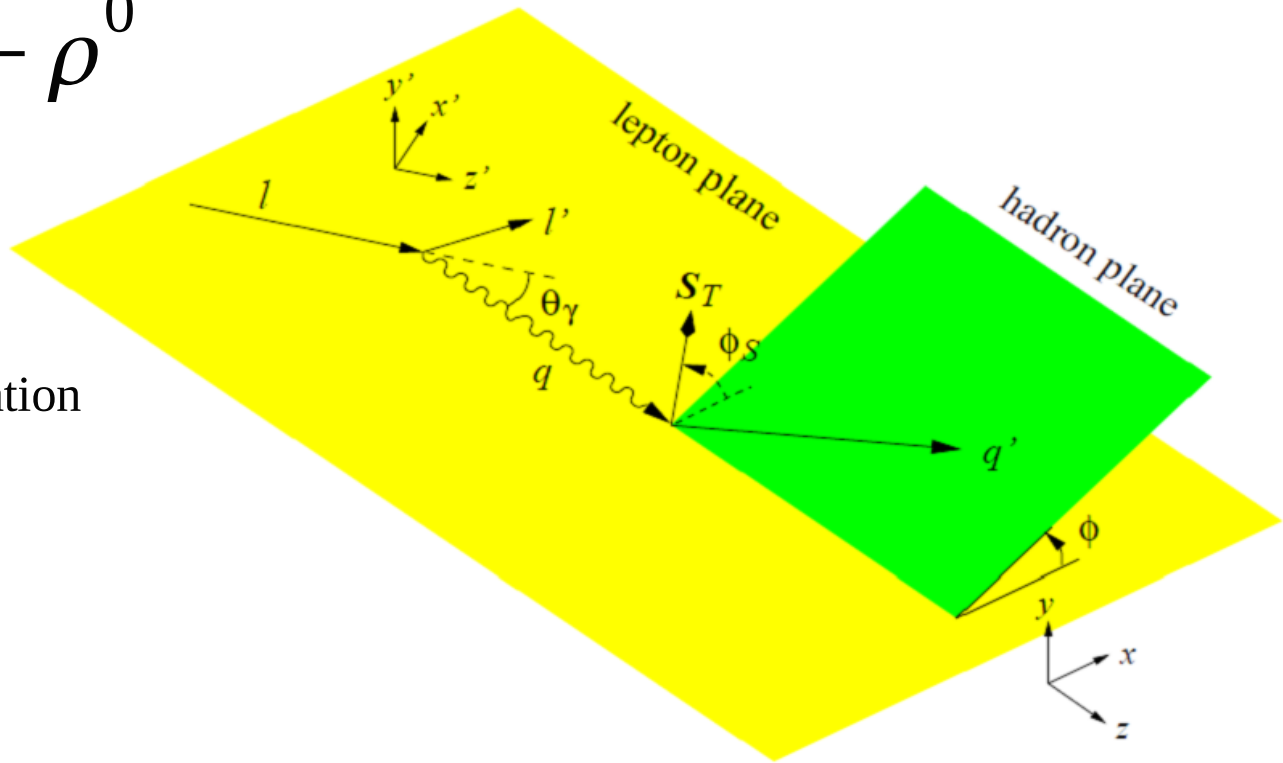$$\mu + P^{\uparrow} \rightarrow \mu' + P' + \rho^0$$

Guillaume Jegou, CEA Saclay
On behalf of the COMPASS collaboration
DIS09, Madrid

- Nucleon structure, Generalized parton distributions (GPDs)
- The COMPASS experiment
- Exclusive ρ^0 production
- Transverse Target Spin Asymmetries
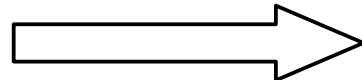
$$\mu + P^{\uparrow} \rightarrow \mu' + P' + \rho^0$$

S_T : Target polarization

$$\sigma(x_B, Q^2, t, \phi, \phi_S) \sim \sigma(x_B, Q^2, t)(W_U(\phi) + S_T W_T(\phi, \phi_S) + ...)$$

$$W_T(\phi, \phi_S) = \sin(\phi - \phi_S) A_{UT}^{\sin(\phi - \phi_S)} + ...$$

If the virtual photon is longitudinally polarized
If factorization holds (High Q^2, small t)
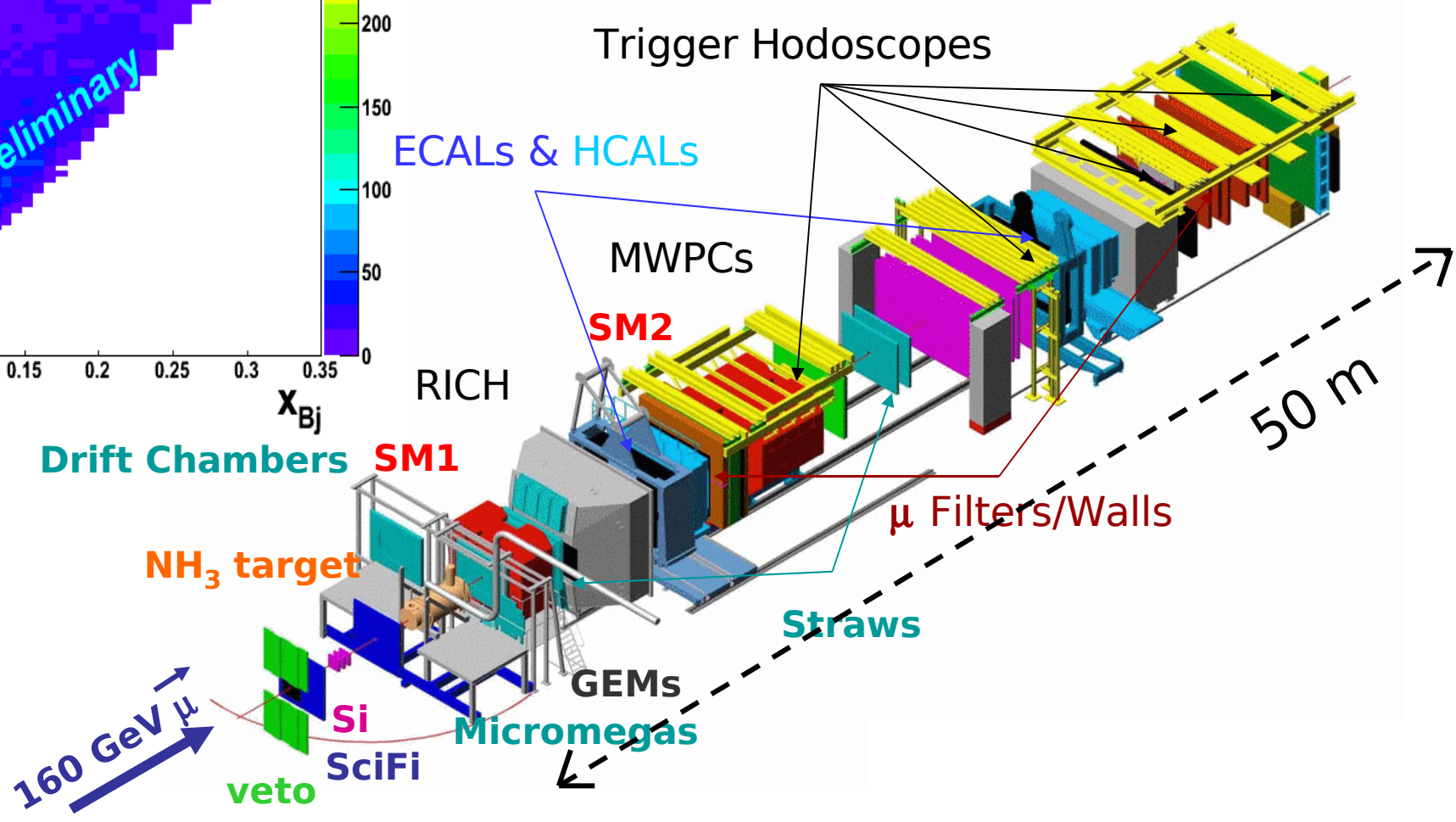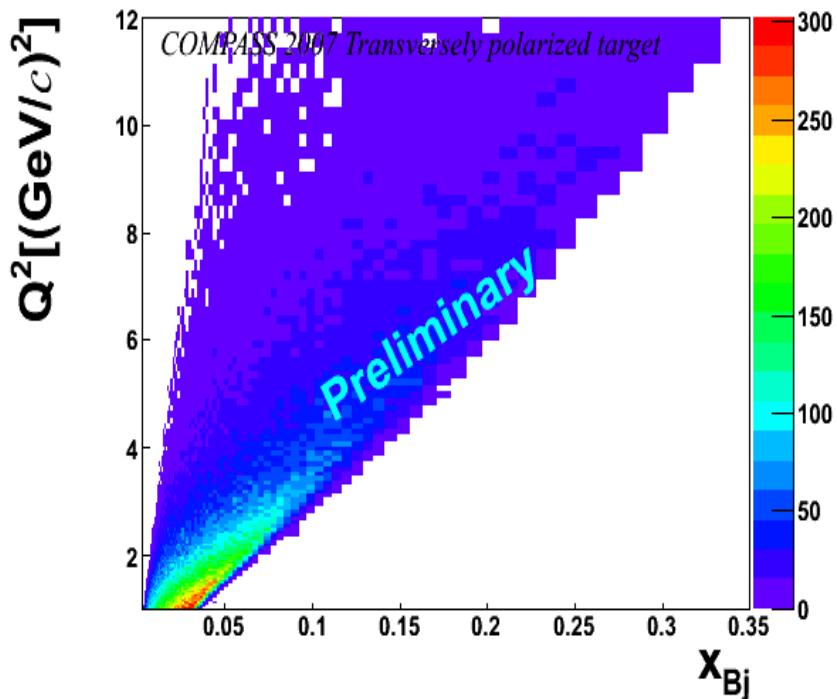
$$A_{UT}^{\sin(\phi - \phi_S)} \sim \frac{Im(\mathcal{E}\mathcal{H})}{|\mathcal{H}|^2}$$
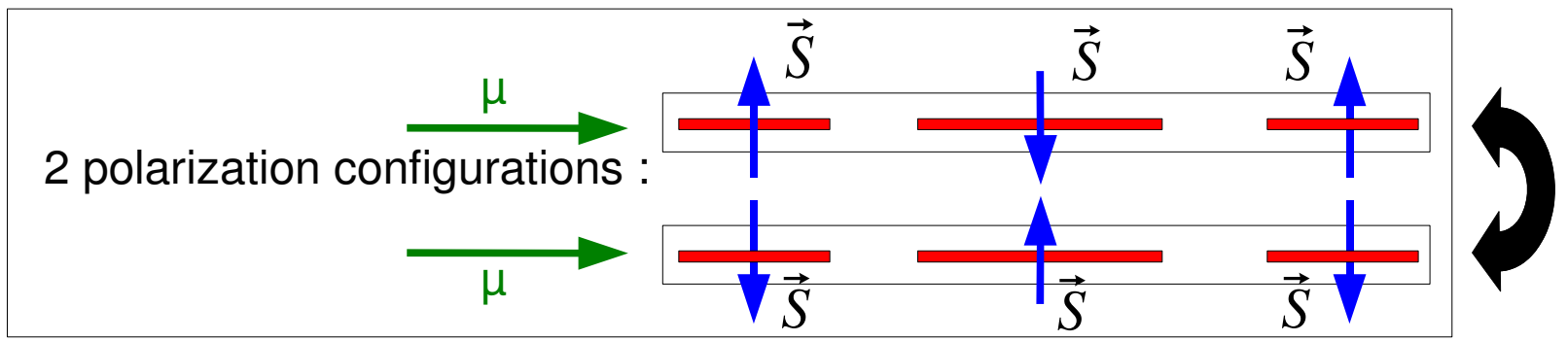
Sensitive to the GPD E

The COMPASS experiment

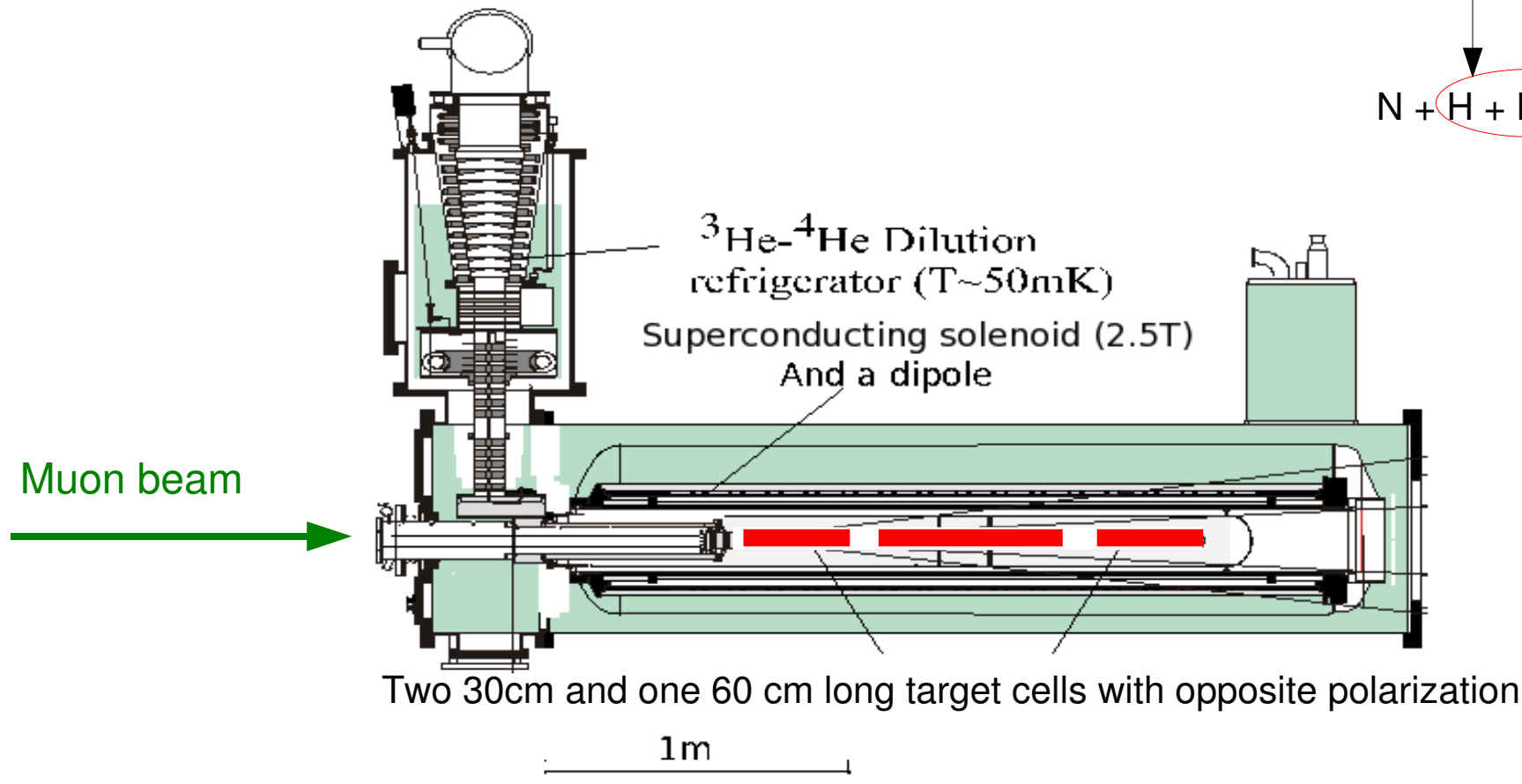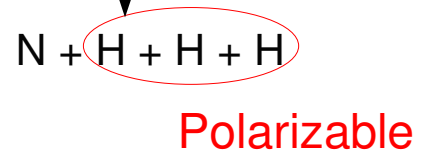Longitudinally polarized muons : 160 GeV/c
2.10^8 μ/spill (4.8s / 16.8s)
P_{Beam}= -80%

COMPASS 2007 Transversely polarized target

Preliminary

$Q^2 [(GeV/c)^2]$

x_{Bj}

Trigger Hodoscopes

ECALs & HCALs

MWPCs

SM2

RICH

Drift Chambers SM1

μ Filters/Walls

NH$_3$ target
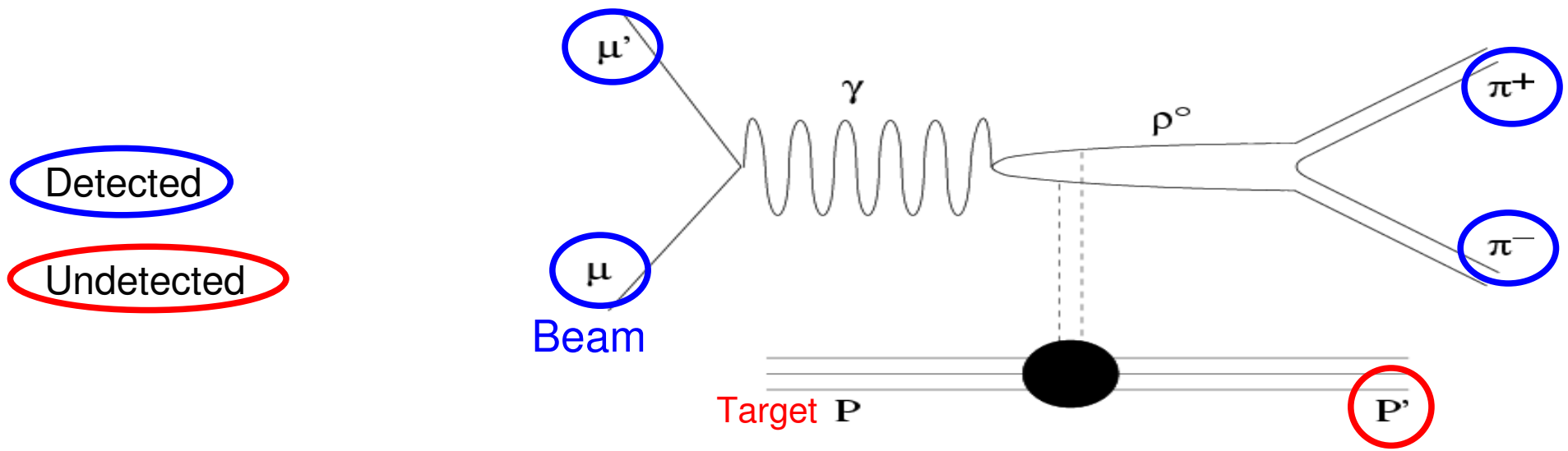
Straws

160 GeV $\vec{\mu}$

Si

SciFi

GEMs

Micromegas

veto

50 m

The COMPASS polarized ammonia target (2007)

Transversely (or longitudinally) polarized proton target : NH_3 $P_T \sim 80\%$

$N + \boxed{H + H + H}$
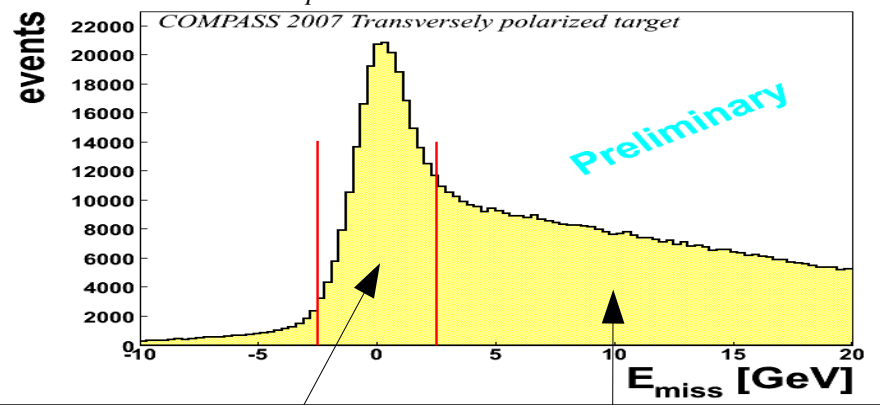
Polarizable

^3He-^4He Dilution refrigerator (T~50mK)

Superconducting solenoid (2.5T) And a dipole

Muon beam

Two 30cm and one 60 cm long target cells with opposite polarization

1m

2 polarization configurations :

μ

$\vec{S}$ $\vec{S}$ $\vec{S}$

μ

$\vec{S}$ $\vec{S}$ $\vec{S}$

Exclusive ρ^0 production : Event selection

Detected

Undetected

μ'

γ

ρ°

π⁺

μ

π⁻

Beam

Target **P**

P'

Recoil proton (p') is not detected,
Check if the proton is intact :

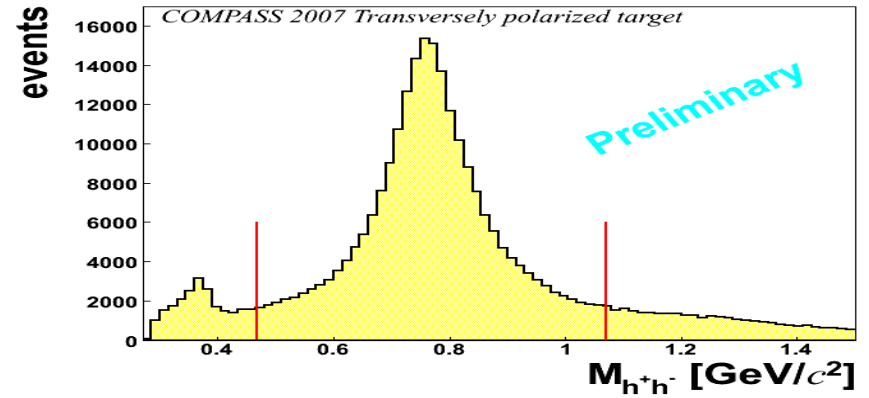$$E_{miss} = \frac{M_X^2 - M_{proton}^2}{2 M_{proton}} \in [-2.5, 2.5] \, GeV$$
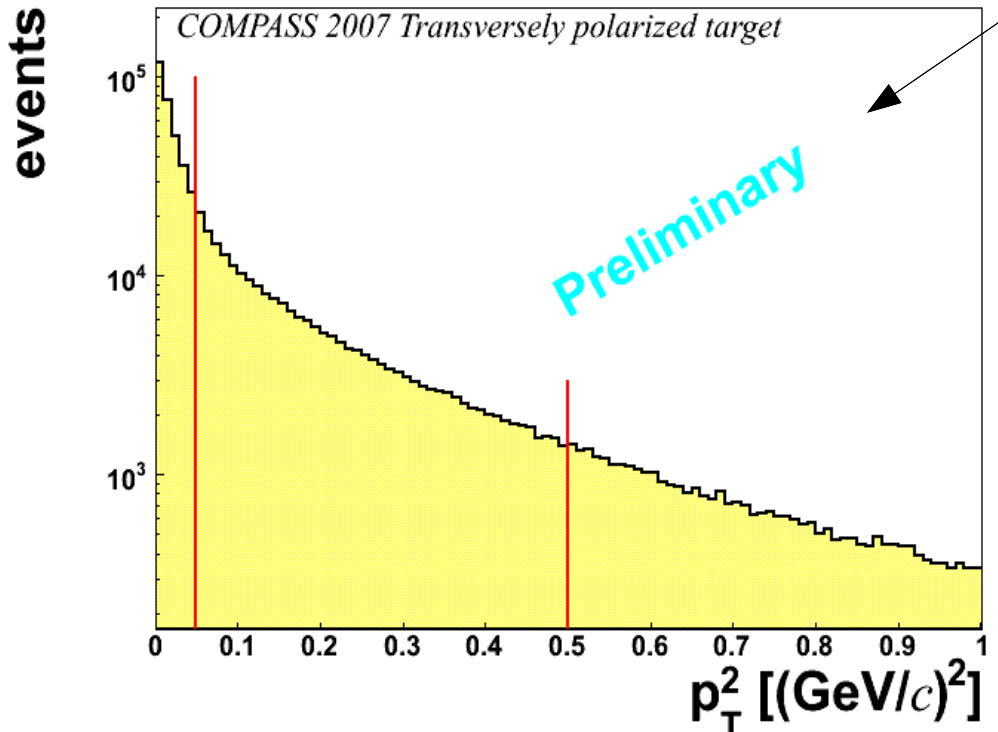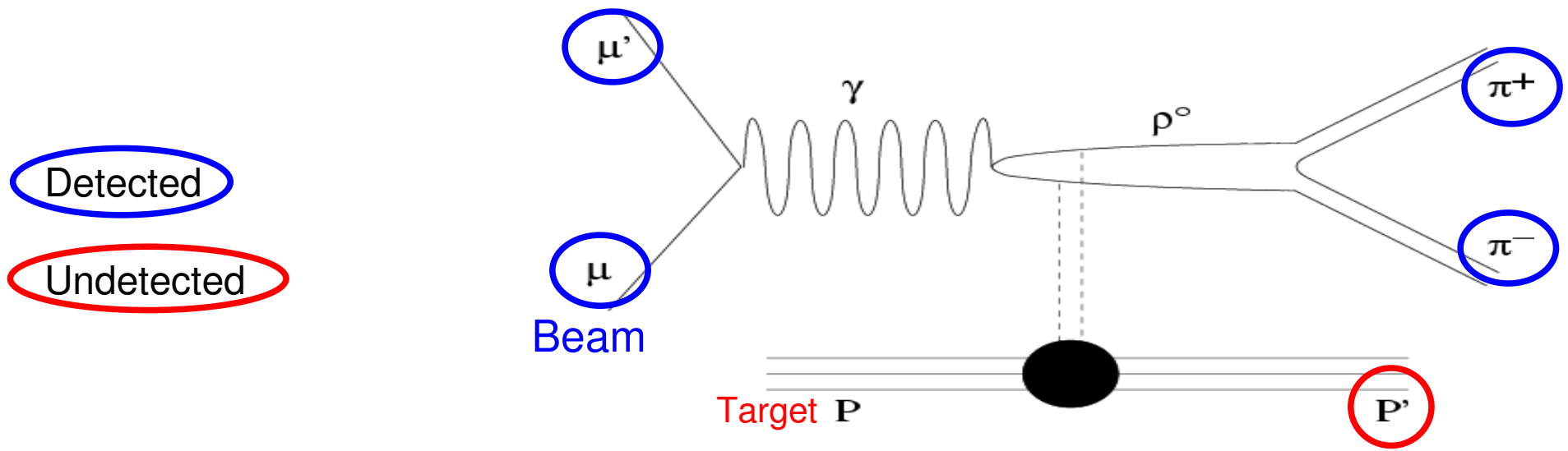

Exclusive peak   Non exclusive background

Exclusive ρ_0 Production

Invariant mass selection

$$0.3 < M_{h^+h^-} - M_\rho < 0.3 \, GeV$$
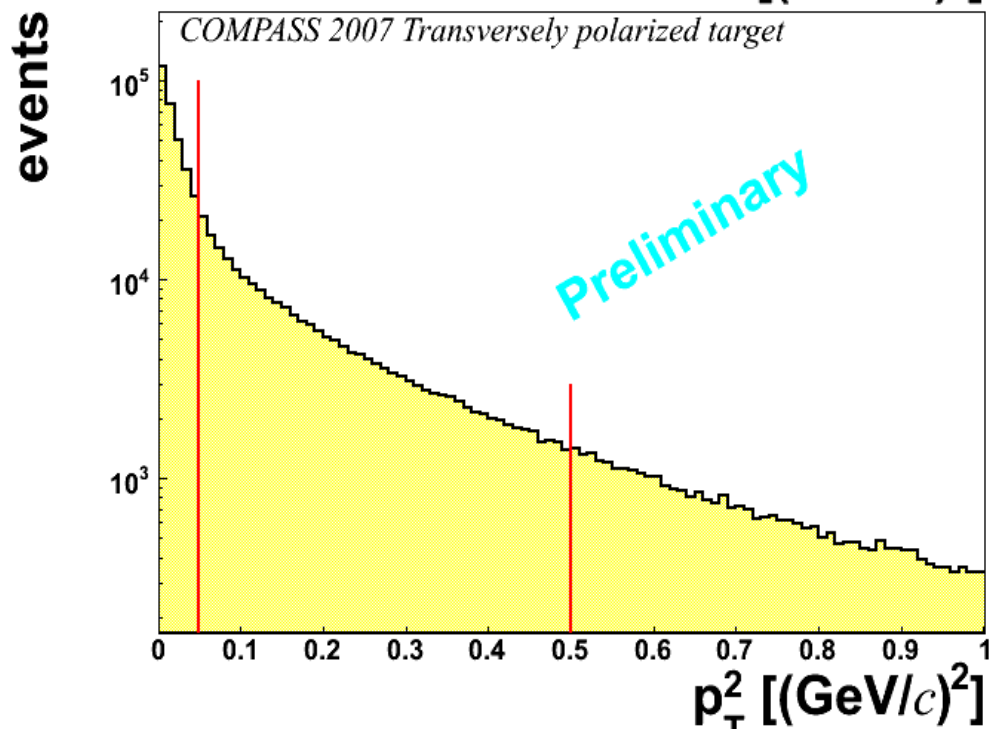
Exclusive ρ^0 production : Event selection

Detected

Undetected

Beam

μ'

γ

ρ°

π^+

μ

π^-

Target **P**

P'

Incoherent ρ_0 Production

COMPASS 2007 Transversely polarized target

Preliminary

events

p_T^2 [$(GeV/c)^2$]
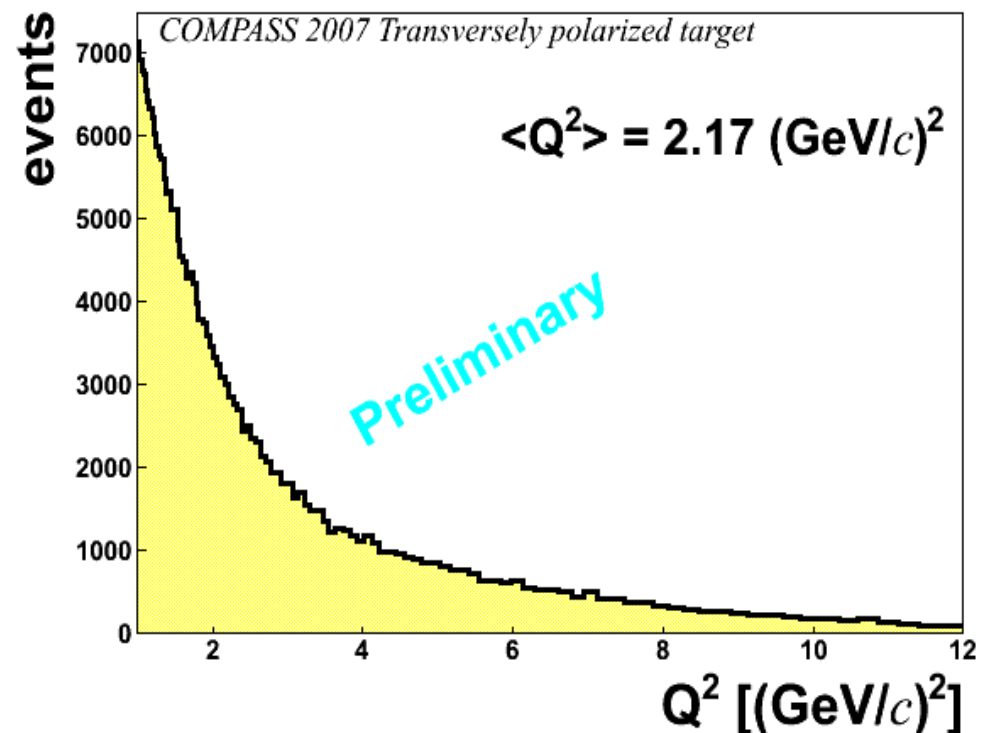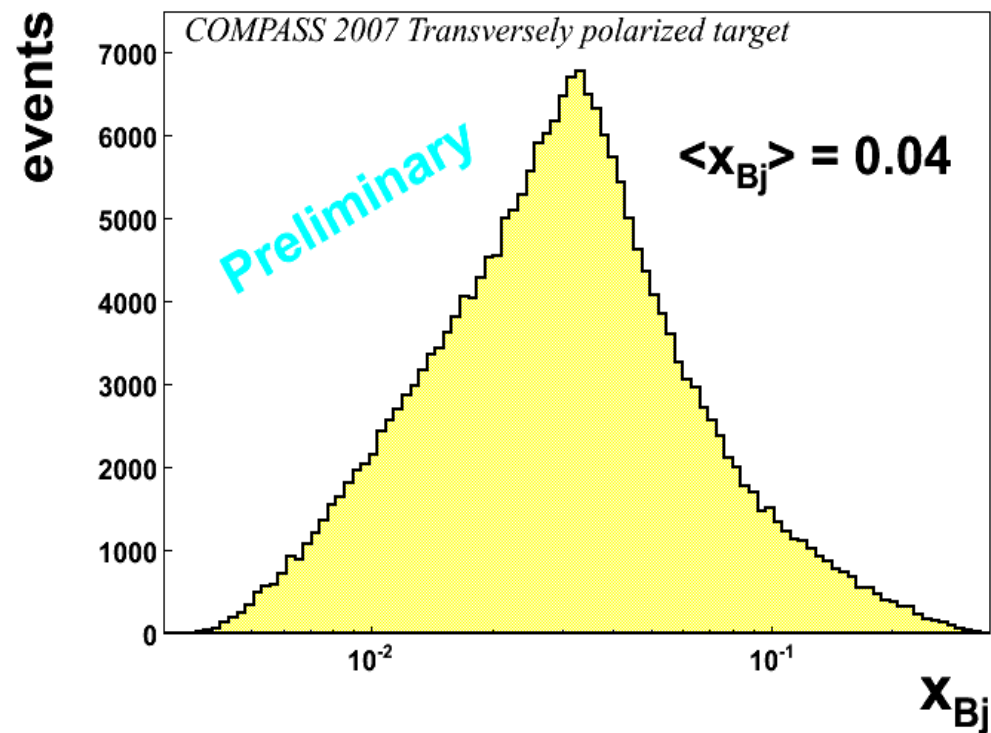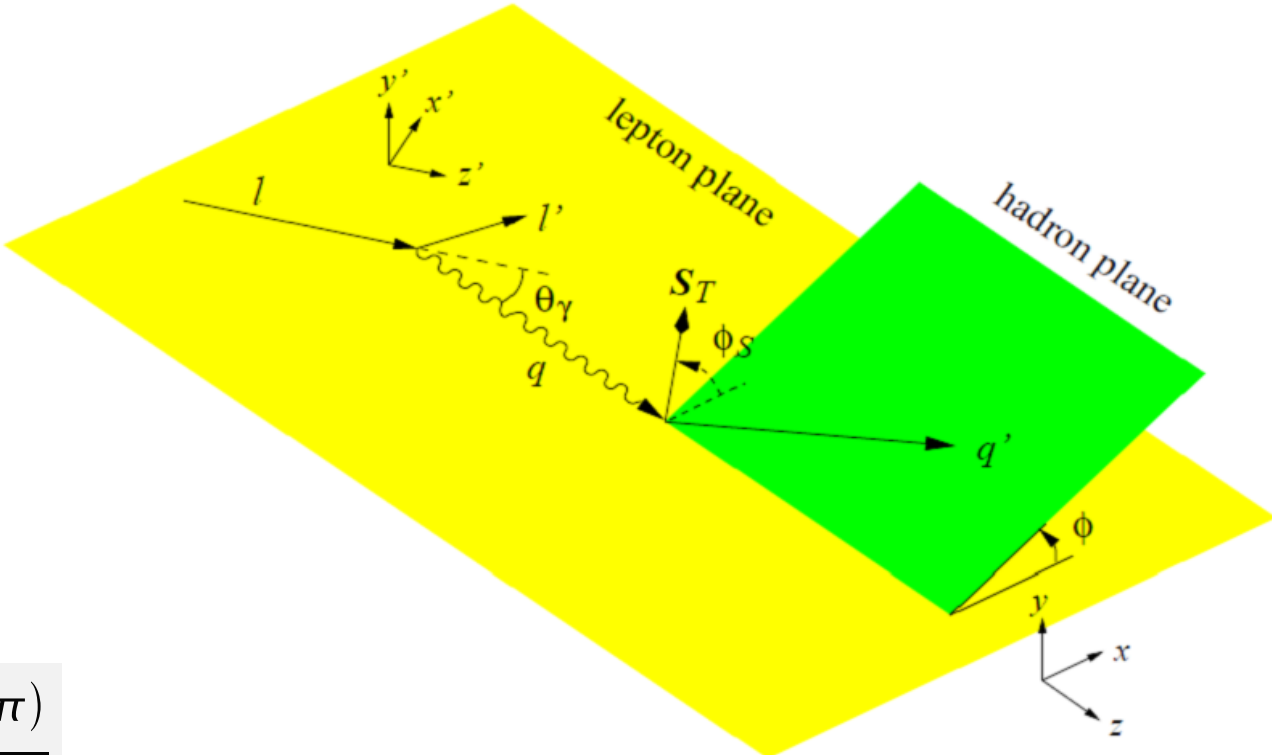
Coherent scattering on nitrogen rejected
by selecting events with $p_T^2 > 0.05$ $(GeV/c)^2$

Non-exclusive background reduced
by selecting events with $p_T^2 < 0.5$ $(GeV/c)^2$

Exclusive ρ^0 production : Event selection

COMPASS 2007 Transversely polarized target

Preliminary

$<x_{Bj}> = 0.04$

COMPASS 2007 Transversely polarized target

$<Q^2> = 2.17$ $(GeV/c)^2$

Preliminary

COMPASS 2007 Transversely polarized target

$<W> = 8.1$ GeV

Preliminary

COMPASS 2007 Transversely polarized target

Preliminary

x_{Bj}

Q^2 $[(GeV/c)^2]$

W (GeV)

p_T^2 $[(GeV/c)^2]$

Transverse Target Spin Asymmetry : The extraction

$(\phi\text{-}\phi_S)$: Angle between target spin and hadronic plane

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

Flux   Acceptance   Dilution factor   Mean target polarization

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

A_{UT} measurable by one target and one polarization

With only one target with one polarization, $A_{UT}^{(exp)}$ is sensitive to acceptance effects

➔ **Asymmetry extraction from double ratio method with 3 targets with 2 polarizations**

$$\frac{N^{\uparrow}_{Up/Down}(\phi-\phi_s)N^{\uparrow}_{Center}(\phi-\phi_s)}{N^{\downarrow}_{Center}(\phi-\phi_s+\pi)N^{\downarrow}_{Up/Down}(\phi-\phi_s+\pi)} = \frac{F^{\uparrow}_{Up/Down}F^{\uparrow}_{Center}}{F^{\downarrow}_{Center}F^{\downarrow}_{Up/Down}}\frac{a^{\uparrow}_{Up/Down}(\phi-\phi_s)a^{\uparrow}_{Center}(\phi-\phi_s)}{a^{\downarrow}_{Center}(\phi-\phi_s+\pi)a^{\downarrow}_{Up/Down}(\phi-\phi_s+\pi)}\frac{(1+f\langle P_T\rangle A_{UT}^{\exp}\sin(\phi-\phi_s))^2}{(1-f\langle P_T\rangle A_{UT}^{\exp}\sin(\phi-\phi_s))^2}$$
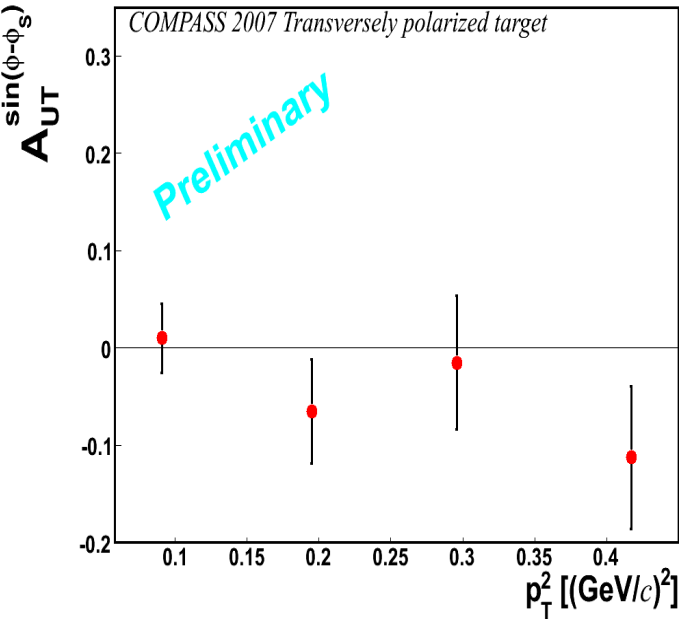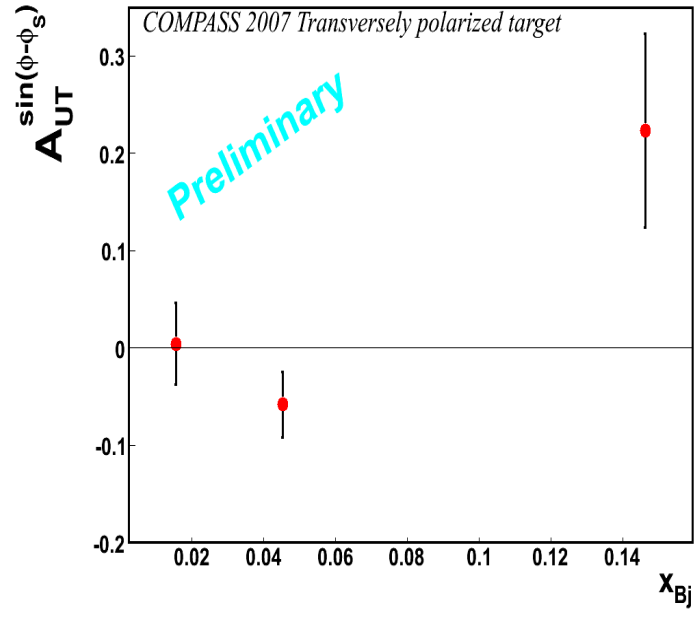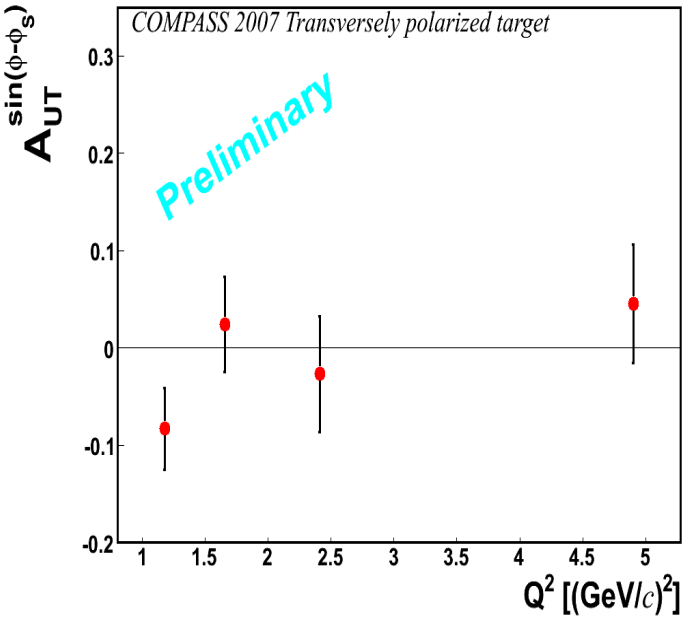
Transverse Target Spin Asymmetry : Results on NH_3 target (2007)

COMPASS results on a PROTON target

$$A_{UT}^{\sin(\phi-\phi_s)} \text{ compatible with } 0$$

Small value ($A_{UT}(\rho) \simeq 0.02$) predicted by Goloskokov and Kroll (EPJC59 2009)

(hep-ph/0809.4126)

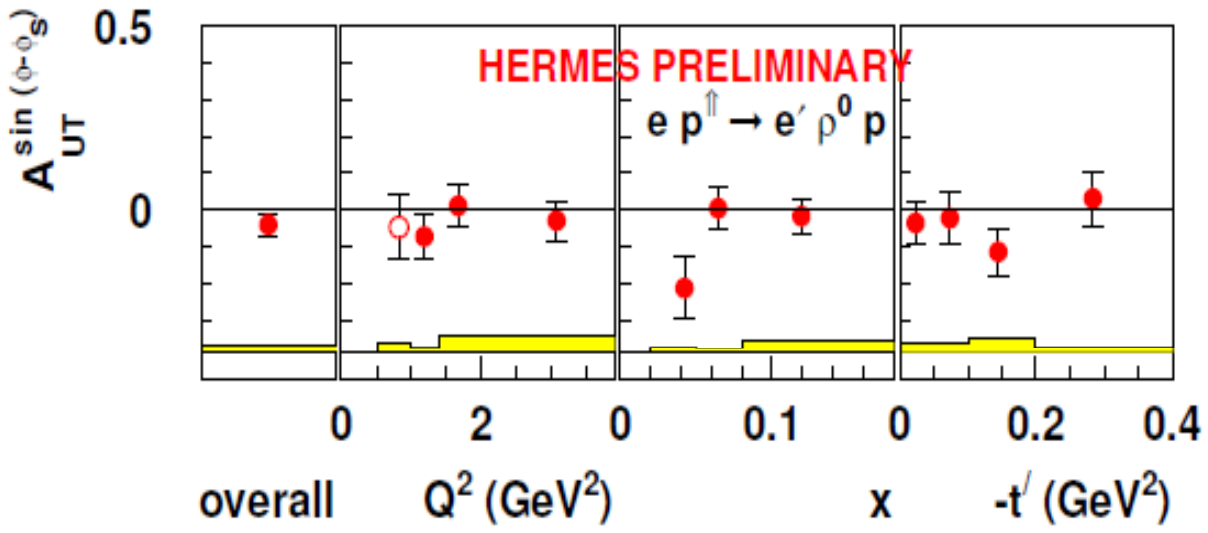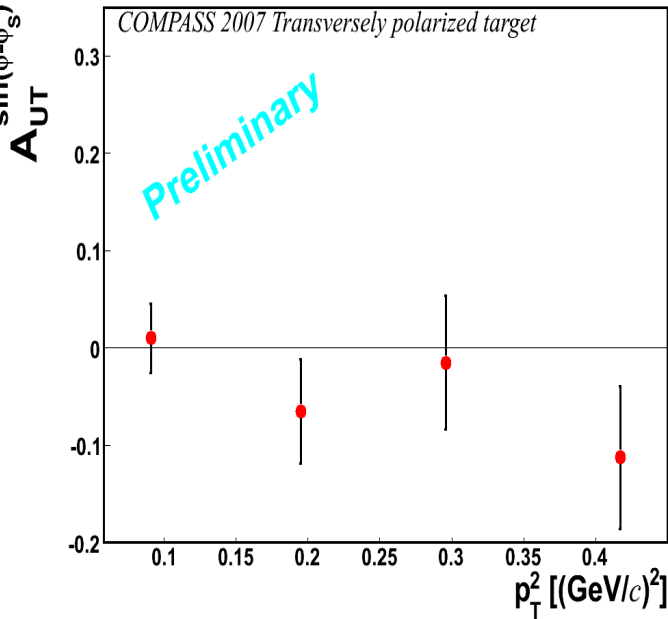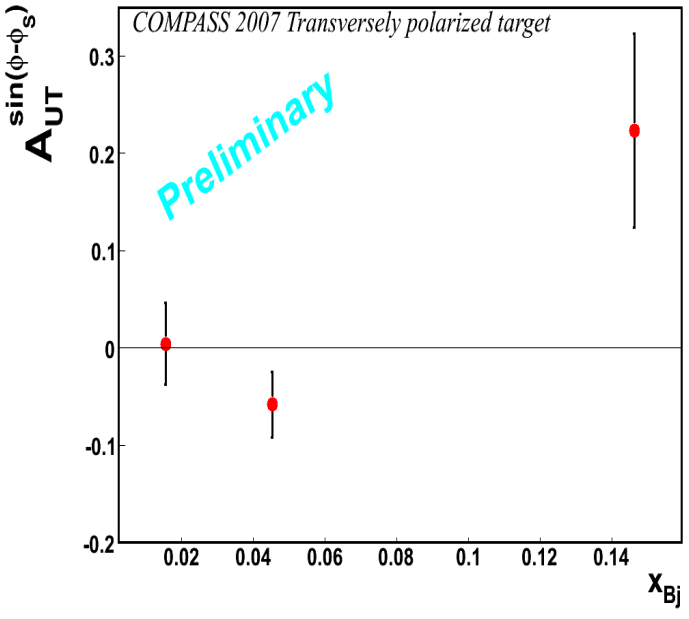Larger value ($A_{UT}(\omega) \simeq 0.1$) predicted by Goloskokov and Kroll

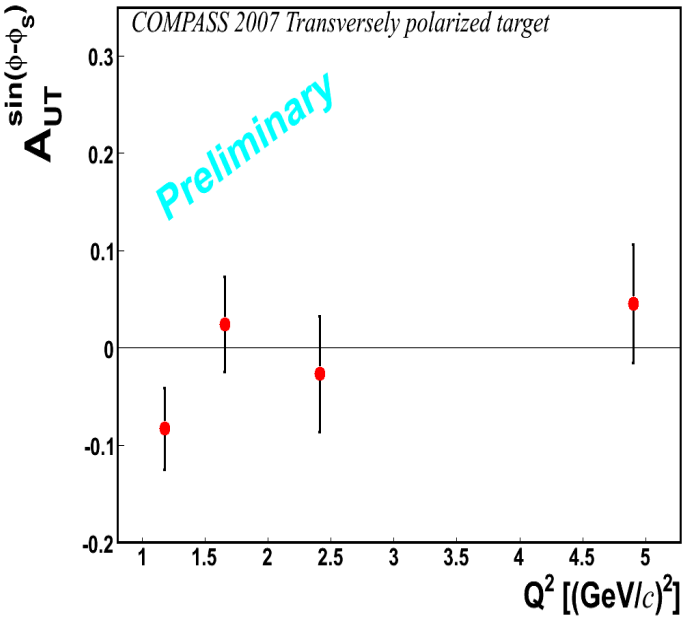# Transverse Target Spin Asymmetry : Results on NH$_3$ target (2007)

COMPASS results on a PROTON target

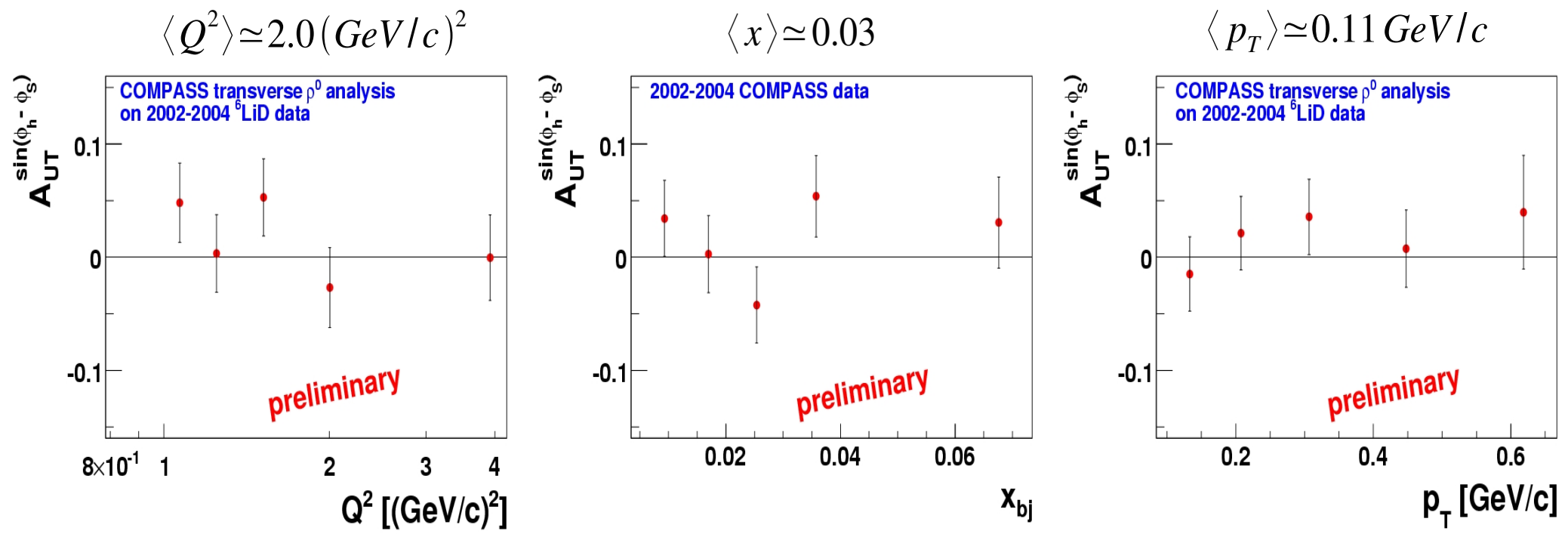$$\langle Q^2\rangle \simeq 2.2\,(GeV/c)^2 \qquad \langle x_{Bj}\rangle \simeq 0.04 \qquad \langle p_T^2\rangle \simeq 0.18\,(GeV/c)^2$$

A.Rostomyan et al.
hep-ex/07072486
DIF08,AIP conf proc 1105 (2009)

Transverse Target Spin Asymmetry : Results on ^{6}LiD target (2004)

COMPASS results on a PROTON + NEUTRON target
without coherent/incoherent scattering separation

$\langle Q^2 \rangle \simeq 2.0 \, (GeV/c)^2$

$\langle x \rangle \simeq 0.03$

$\langle p_T \rangle \simeq 0.11 \, GeV/c$

$A_{UT}^{\sin(\phi - \phi_s)}$ compatible with 0

Summary :

A_{UT} compatible to zero with a PROTON/DEUTERON target

In progress :
- Transverse / longitudinal γ^* separation (by angular distribution)
- Simulations to determine acceptance and background
- Determination of SDME to control the SCHC
- Same work for exclusive ω and ϕ production