

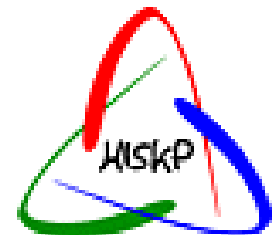
Transversity signals in two hadron correlations at COMPASS

Rainer Joosten, University of Bonn

on behalf of the
COMPASS Collaboration



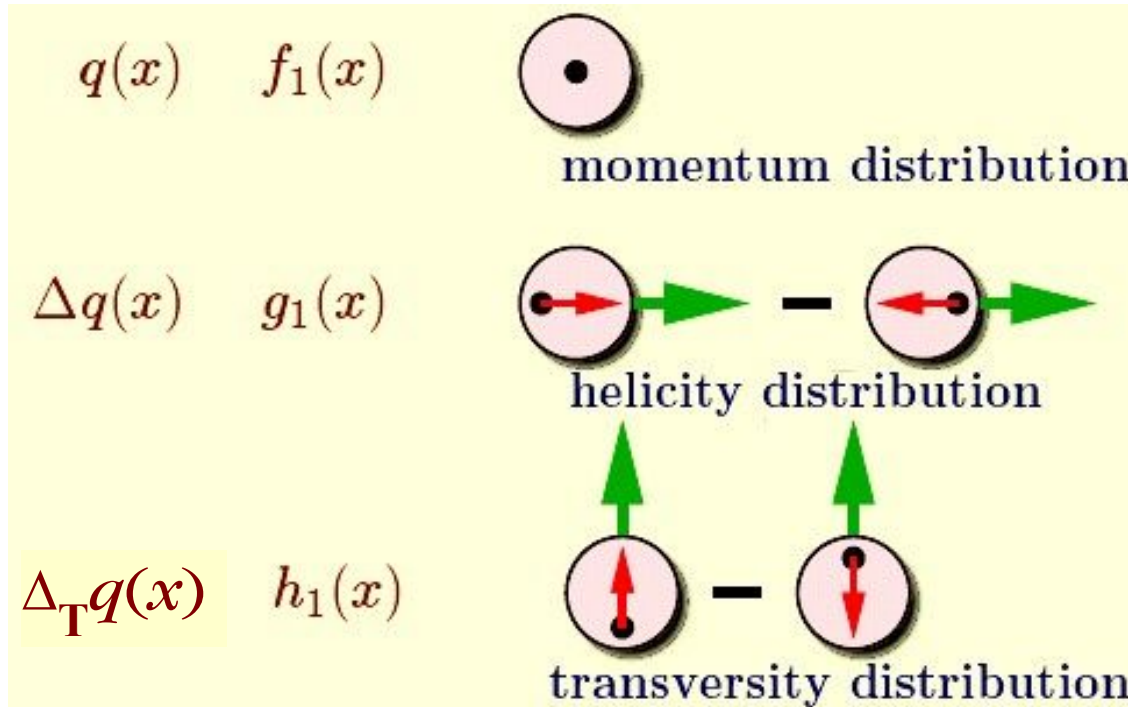
Trieste, October 10-16



Transverse Spin Physics



3 distribution functions are necessary to describe the spin structure of the nucleon at LO:



All of equal importance!

$h_1(x)$ decouples from inclusive DIS because helicity of quark must flip \Rightarrow SIDIS

COMPASS: polarized μ^+ on a polarized ${}^6\text{LiD}$ target

Transverse Spin Physics



3 possible quark polarimeters suggested using SIDIS:

- Measure transverse polarization of Λ
- Azimuthal distribution of leading hadrons ← P. Pagano !
- Azimuthal dependence of the plane containing hadron pairs ← This talk !

The coordinate system



Frame where:

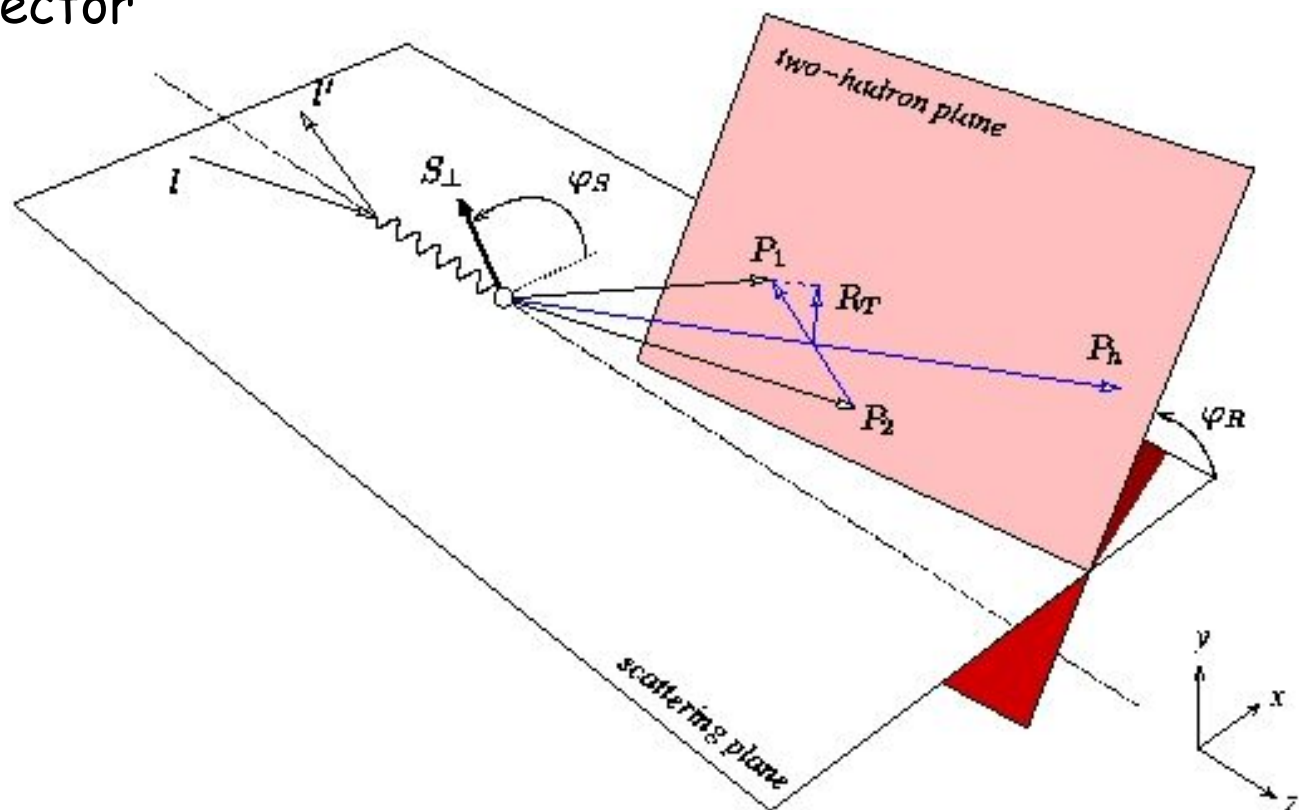
- z is the virtual photon direction
- the x - z plane is the lepton scattering plane

$\varphi_{S'}$ = azimuthal angle of spin vector
of **fragmenting** quark
with $\phi_{S'} = \pi - \phi_S$ (spin flip)

φ_R = azimuthal angle of the
hadron plane

We define:

$$\begin{aligned}\varphi_{RS} &= \varphi_R - \varphi_{S'} \\ &= \varphi_R + \varphi_S - \pi\end{aligned}$$



A. Bacchetta and M. Radici,
Proceedings of the DIS 2004,
hep-ph/0407345

Transverse Spin Physics



The fragmentation function of a quark q into a pair h of two hadrons h_1 and h_2 can be written as:

$$D_q^h(z, p_T^h) + H_q^{\otimes h}(z, p_T^h) \sin\varphi_{RS}$$

spin dependent part

$$\begin{aligned}\varphi_{RS} &= \varphi_R - \varphi_{S'} \\ &= \varphi_R + \varphi_S - \pi\end{aligned}$$

Causing a count rate difference:

$$\frac{N^+(\varphi_{RS}) - N^-(\varphi_{RS})}{N^+(\varphi_{RS}) + N^-(\varphi_{RS})} = A_{UT}^{\sin\varphi_{RS}} \cdot \sin\varphi_{RS}$$

From this we get:

$$\frac{A_{UT}^{\sin\varphi_{RS}}}{D_{NN} \cdot f \cdot P} = A_{\varphi_{RS}} = \frac{\sum_i e_i^2 \Delta_T q_i(x) H_i^{\otimes h}(z, M_h^2)}{\sum_i e_i^2 q_i(x) D_i^h(z, \vec{M}_h^2)}$$

f dilution factor; P target polarization; $D_{NN} = (1-y)/(1-y-y^2/2)$ Depolarization factor

Interference fragmentation function



Example $\pi^+\pi^-$ fragmentation:

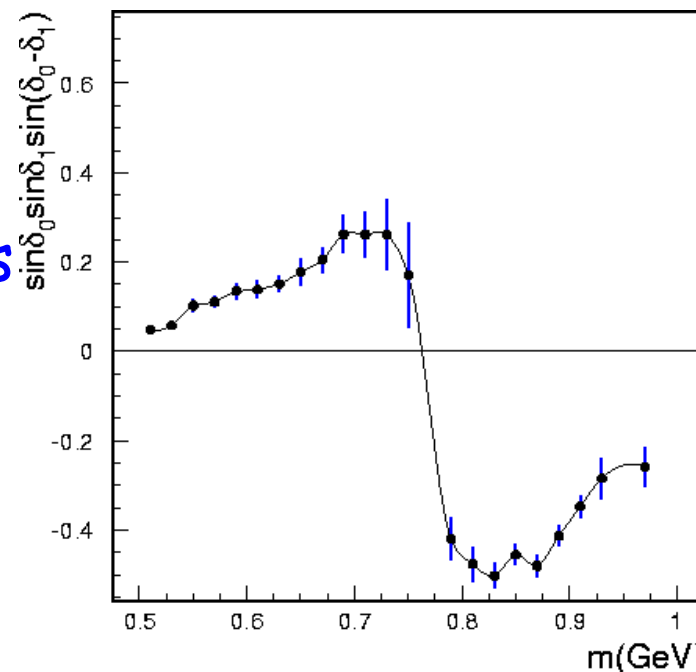
- $\pi^+\pi^-$ can be produced via the σ ($I=0, L=0$) and ρ ($I=1, L=1$) resonances
- Final state is a superposition of two resonant states with different relative phases

$$|\pi^+\pi^-, X\rangle = e^{i\delta_0} |\sigma, X\rangle + e^{i\delta_1} |\rho, X\rangle$$

leading to:

$$H^\ddagger(z, M^2_{\pi^+\pi^-}) \sim \sin \delta_0 \sin \delta_1 \sin(\delta_0 - \delta_1) \hat{H}^\ddagger(z, M^2_{\pi^+\pi^-})$$

δ_0, δ_1 depend on $M^2_{\pi^+\pi^-}$ and can be obtained from $\pi\pi$ phase shifts



R. L. Jaffe, X. Jin and J. Tang,
Phys. Rev. Lett. **80**, 1166 (1998)

Data Sample



2002: 12+7 days of data taking (total)
with transversely polarized ${}^6\text{LiD}$ target
(separate analysis for both periods of data taking)

- ➡ $1.8 \cdot 10^9$ events
- ➡ $1.3 \cdot 10^6$ events after all cuts (preliminary)

2003: 14 days of data taking
with transversely polarized ${}^6\text{LiD}$ target

2003 trigger upgrade to gain sensitivity
on large x_{Bj} & large Q^2 events !

- ➡ 2002 data doubled

2004: 14 days of data taking

DAQ improved and online filter added

- ➡ ~ 2002+2003 data doubled

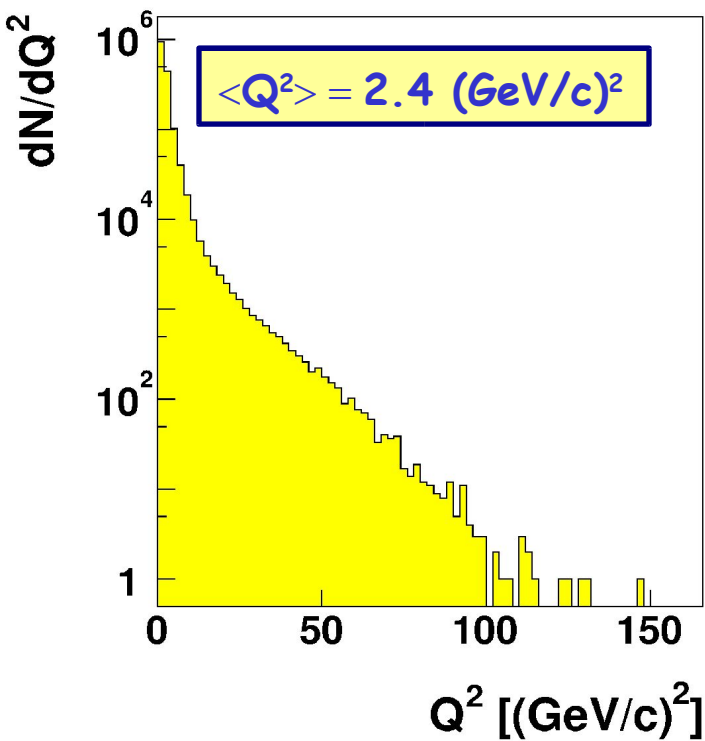
Event selection (1)



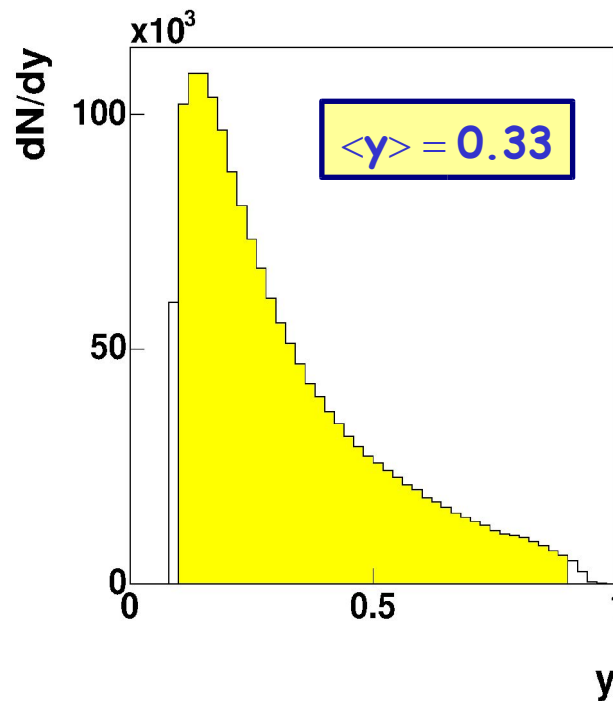
● Primary vertex with identified μ, μ'

Kinematical cuts:

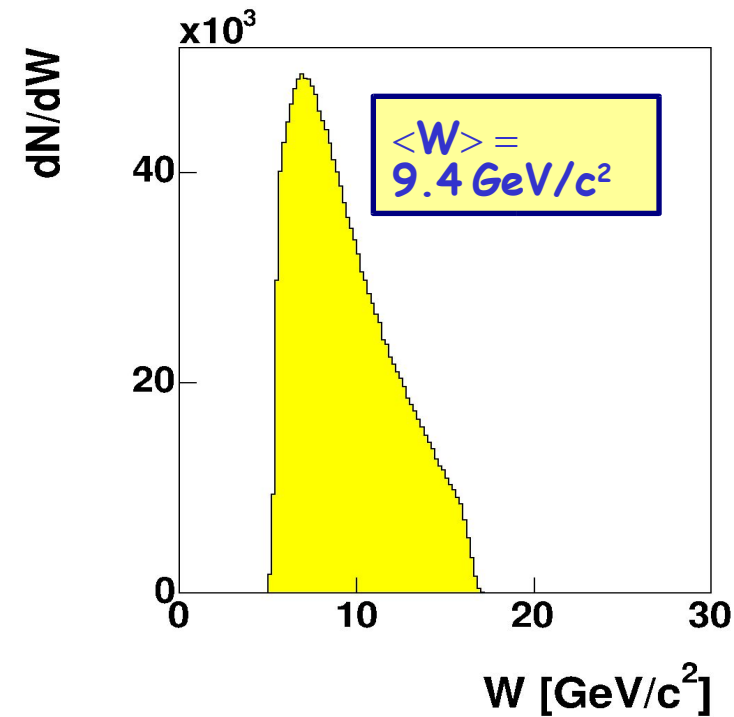
● $Q^2 > 1 \text{ (GeV/c)}^2$



● $0.1 < y < 0.9$



● $W > 5 \text{ GeV/c}^2$



Event selection (2)



Selection of hadron pairs:

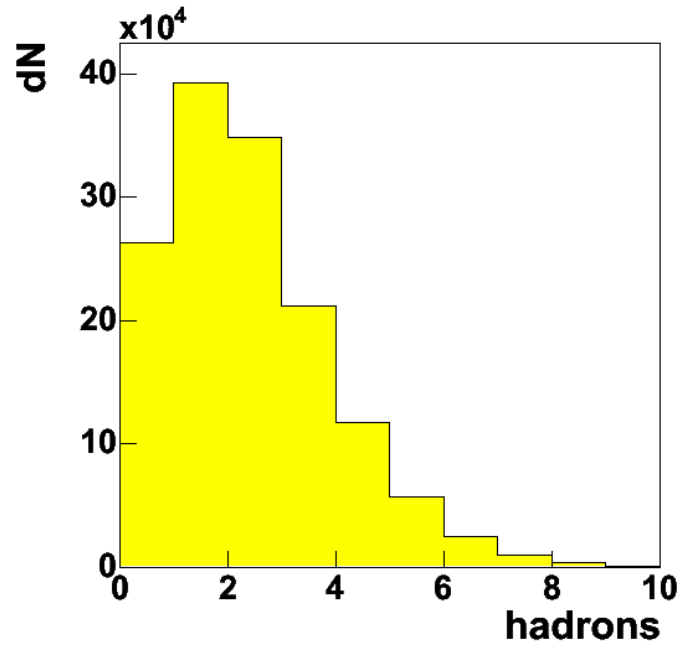
→ leading (lh) and next to leading hadron (nlh) with

- Penetration $< 10 X_0$
- Track quality $\chi^2_{\text{red}} < 10$

Presently no $\pi / K / p$ separation by RICH

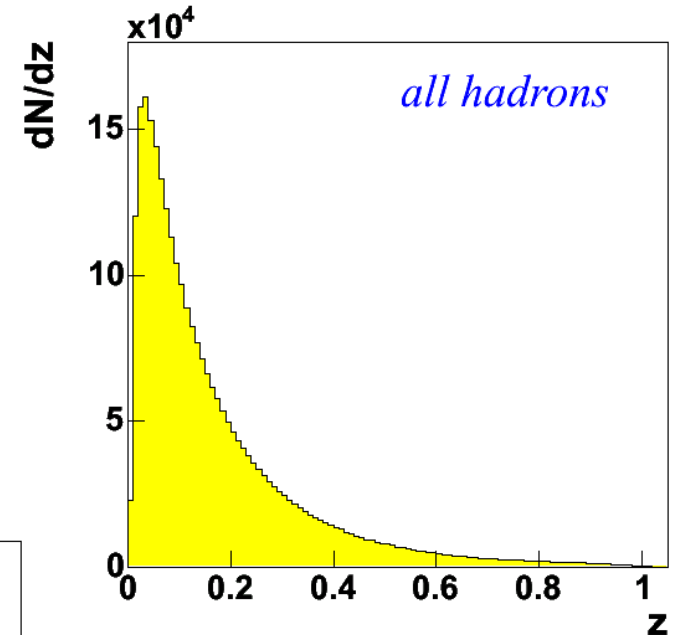
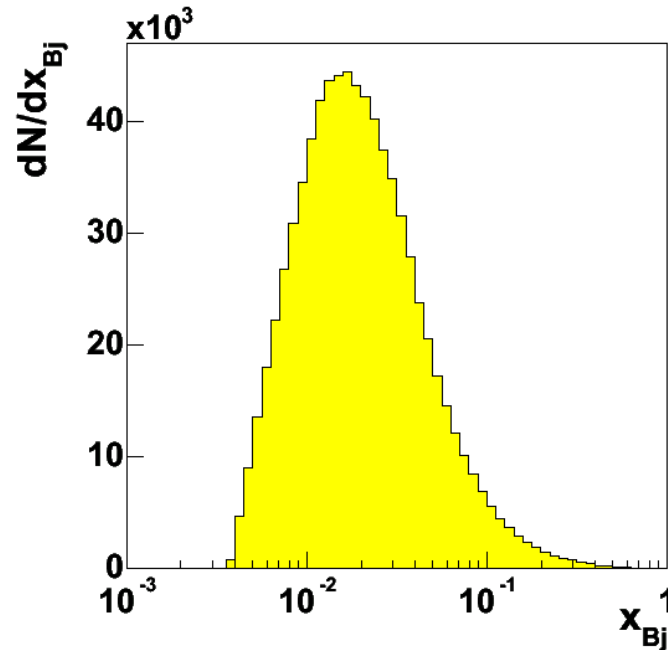
- Cut on lh based on kinematics: $z > 0.25$

Hadron sample



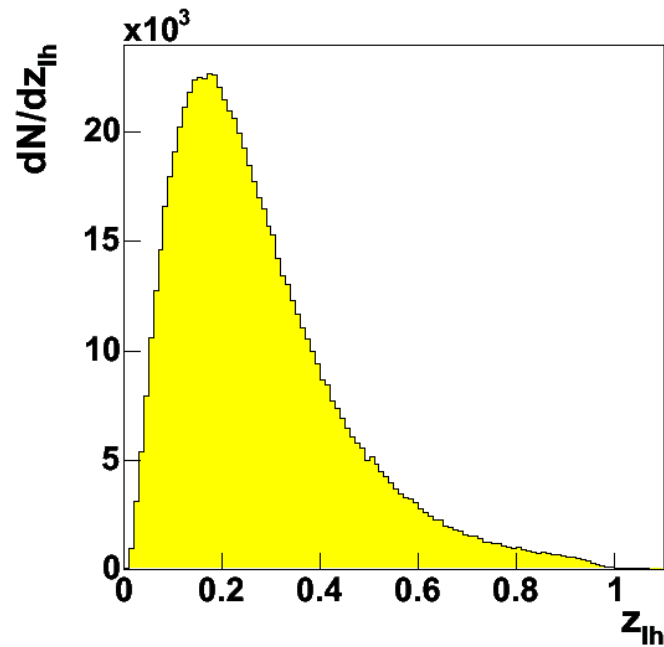
$$\langle N \rangle = 1.9$$

$$\langle x_{Bj} \rangle = 0.031$$

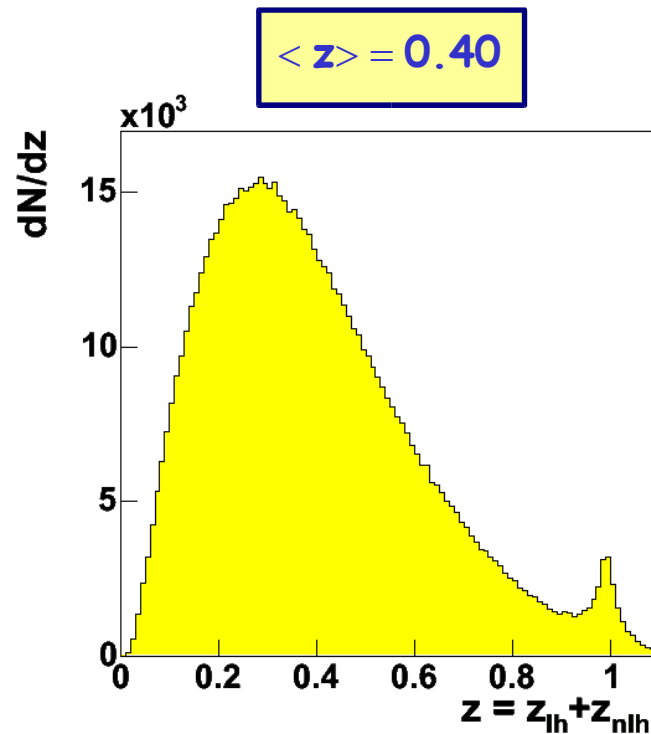


$$\langle z \rangle = 0.17$$

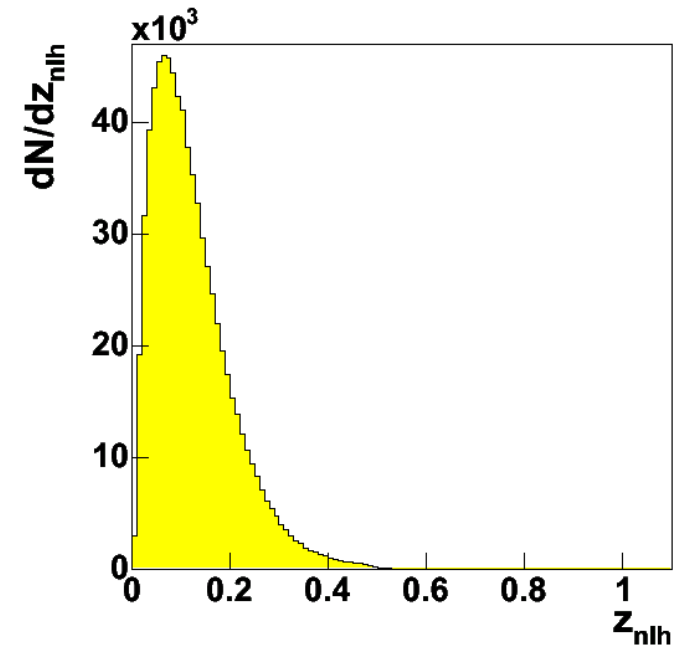
Hadron sample



$$\langle z_{1h} \rangle = 0.28$$



$$\langle z \rangle = 0.40$$

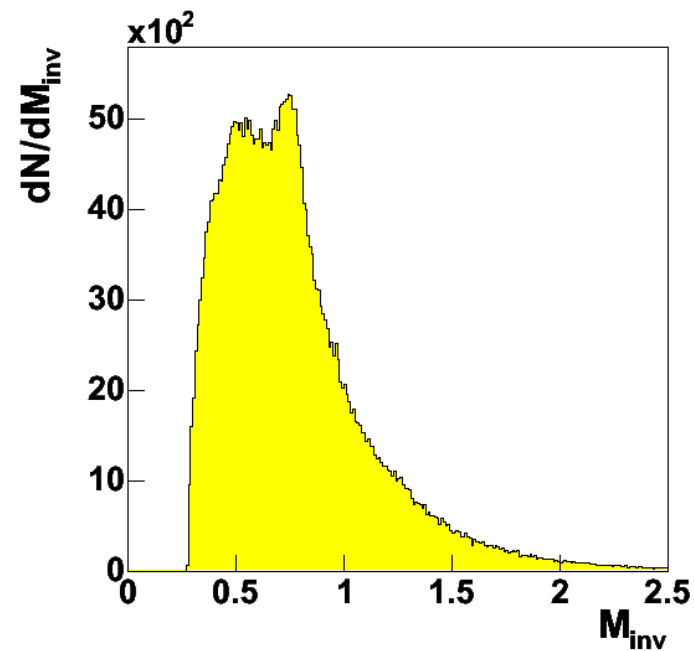
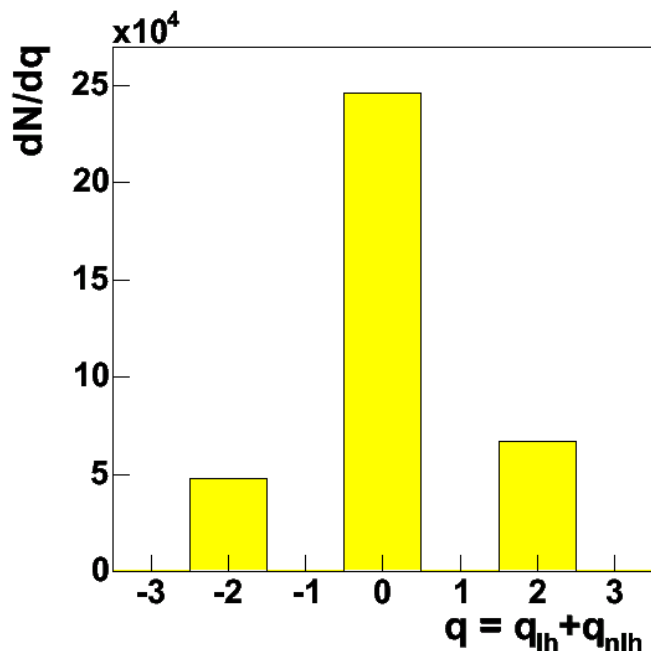


$$\langle z_{n1h} \rangle = 0.12$$

Final sample



$$z_{lh} > 0.25$$



Final 2002 data statistics:

1st period

2nd period

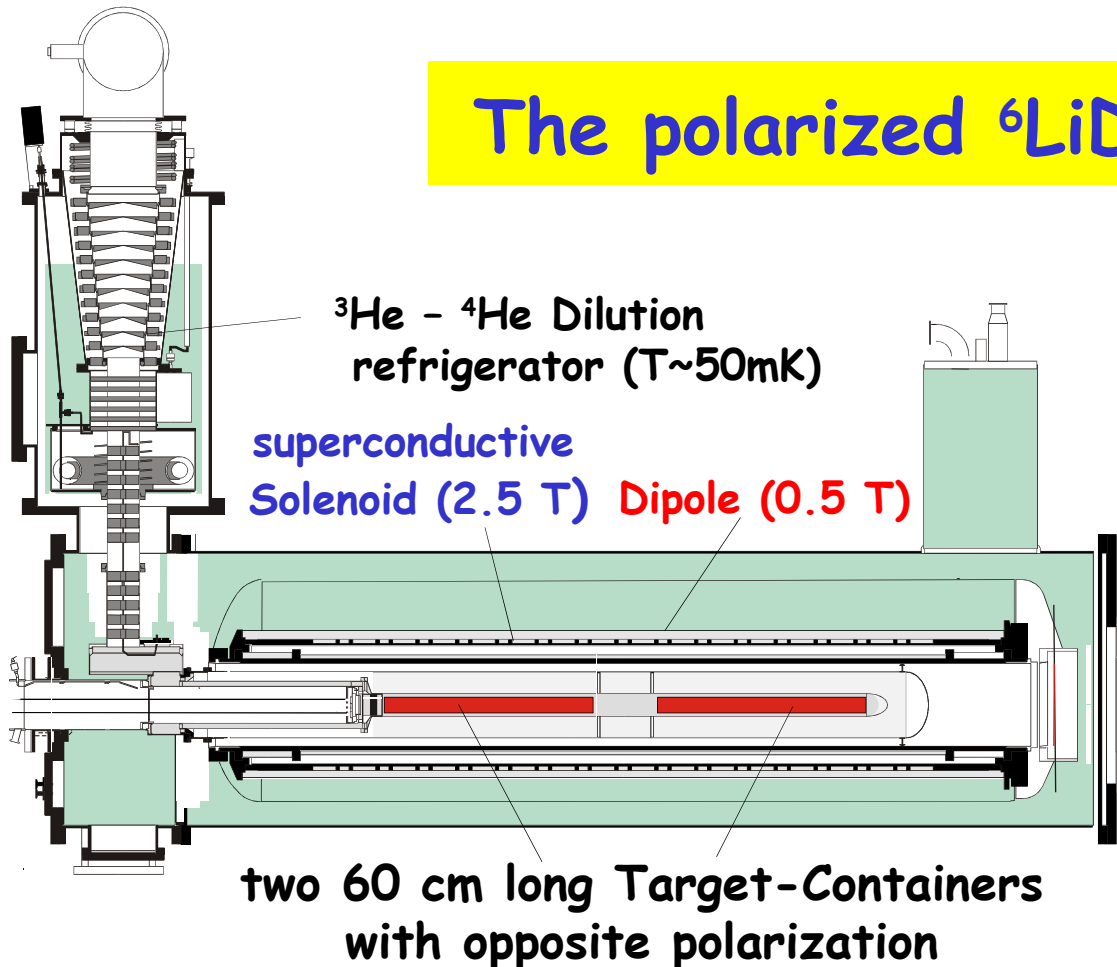
1st orientation 2nd orientation

1st orientation 2nd orientation

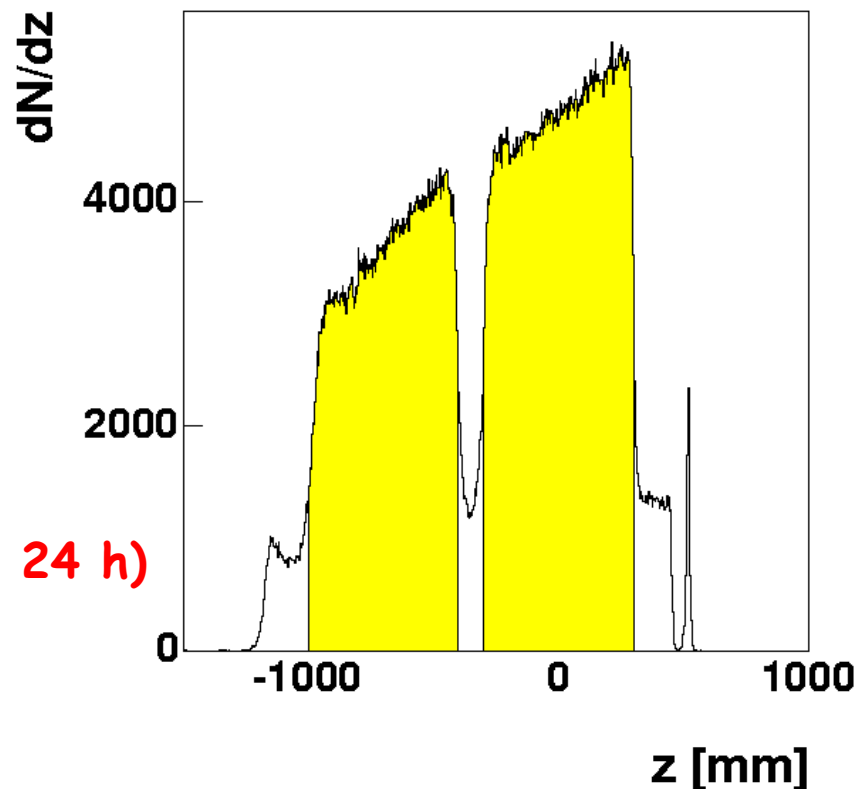
cell1	137k	141k	72k	123k
cell2	224k	231k	117k	195k



The polarized ${}^6\text{LiD}$ -Target



Polarization: 50%
Dilution factor: 0.38



During data taking for transversity:

dipole field always on and \uparrow
polarization changed by microwave reversal (~ 24 h)

Relaxation time:
transversal running > 2000 hrs

Asymmetry calculation



For each polarization and target cell we measure:

$$N(\varphi_{RS}) = N_0 \{ 1 + A_{UT}^{\sin\varphi_{RS}} \cdot \sin\varphi_{RS} \} \cdot F_{\text{acc}}(\varphi_{RS})$$

To cancel out the acceptance function F_{acc} we additionally measure with opposite spins and subtract the normalized data-sets.

The counting rate asymmetry is then calculated for φ_{RS} bins by:

$$A_N(\varphi_{RS}) = \frac{N^+(\varphi_{RS}) - R \cdot N^-(\varphi_{RS})}{N^+(\varphi_{RS}) + R \cdot N^-(\varphi_{RS})} \quad \text{where} \quad R = \frac{N^+_{\text{tot}}}{N^-_{\text{tot}}}$$

The result is then fitted by: $A_0 + A_{UT}^{\sin\varphi_{RS}} \cdot \sin\varphi_{RS}$

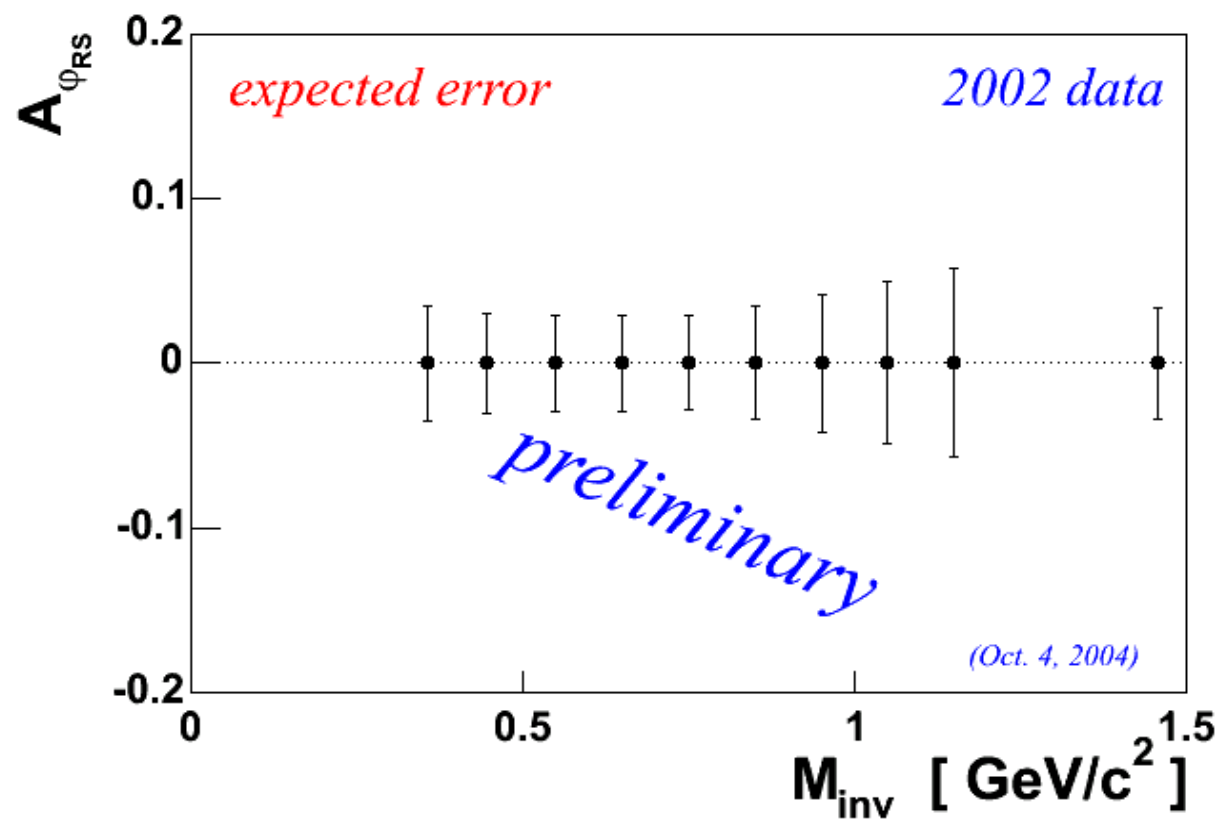
So that we get:

$$A_{\varphi_{RS}} = \frac{A_{UT}^{\sin\varphi_{RS}}}{D_{NN} \cdot f \cdot P}$$

Expected asymmetry error (2002 data)



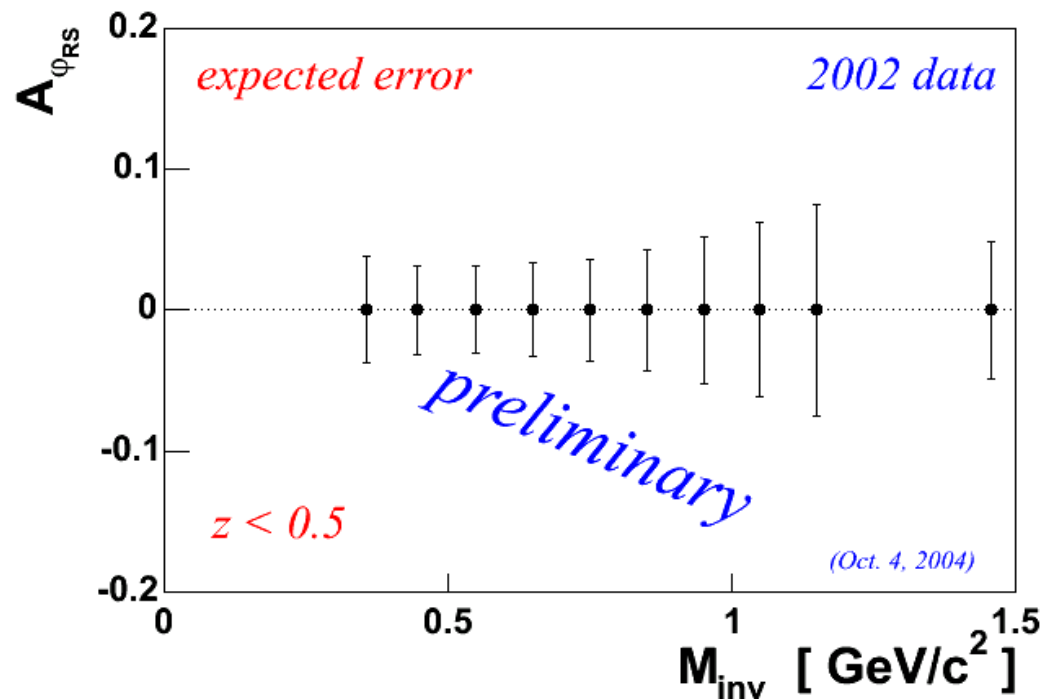
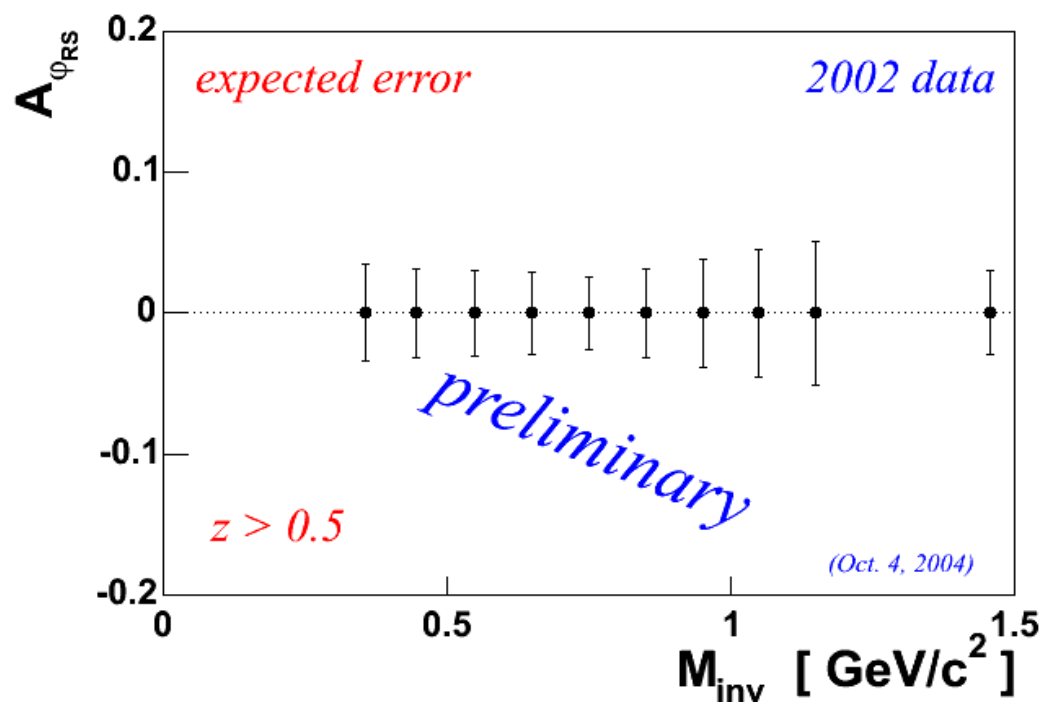
$$\Delta A_{\varphi_{RS}} = \frac{\Delta A_{UT}^{\sin\varphi_{RS}}}{D_{NN} \cdot f \cdot P} \leftarrow \sim 6$$



Expected asymmetry error (2002 data)



$$z = z_{lh} + z_{nlh}$$



Conclusion & Outlook



- The analysis of our transverse target data concerning two hadron asymmetry signals started.
- The gathered statistics and estimated errors from the 2002 data are promising.
- Including 2003 & 2004 data
→ sensitivity improvement by factor ~ 2 expected
- The analysis is ongoing, and:

First results on two hadron correlations on a transversely polarised target can be expected in spring 2005



END of talk

Physics Goals at COMPASS



Contribute to the understanding of the non-perturbative physics of the nucleon

Nucleon spin structure

(in SIDIS with polarized muon beam and target)

- Gluon Polarization $\Delta G/G$
- Transverse spin structure function $h_1(x)$
- Flavor dependent polarized Quark helicity densities $\Delta q(x)$
- Spin dependent fragmentation functions ΔD_q^Λ
- Diffractive VM-Production

Nucleon spectroscopy

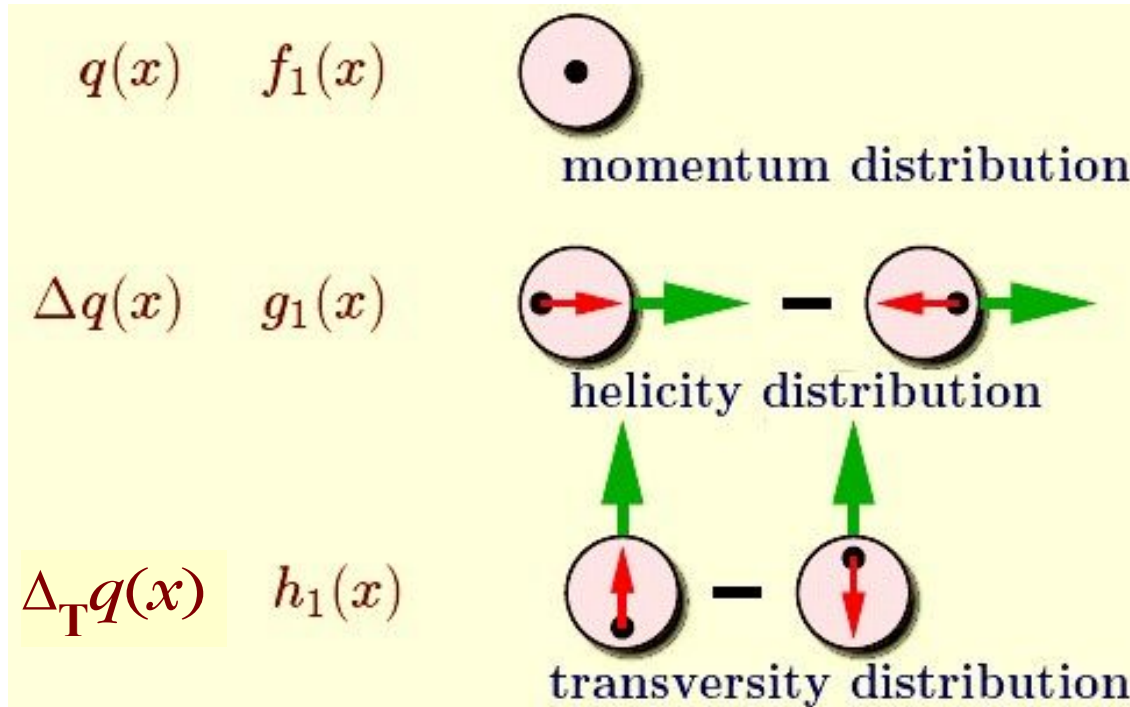
(hadron beams)

- Primakoff-Reactions
 - Polarizability of π and K
- Glueballs and hybrids
- Charmed mesons and baryons
 - semi-leptonic decays
 - double-charmed baryons

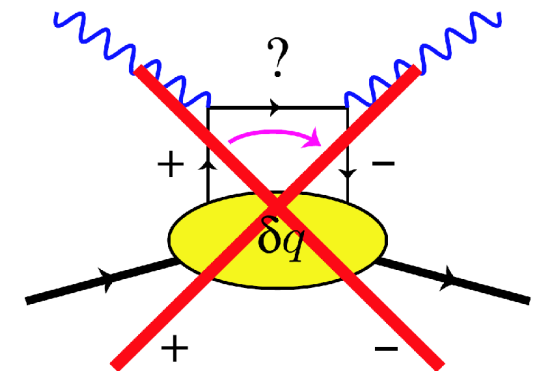
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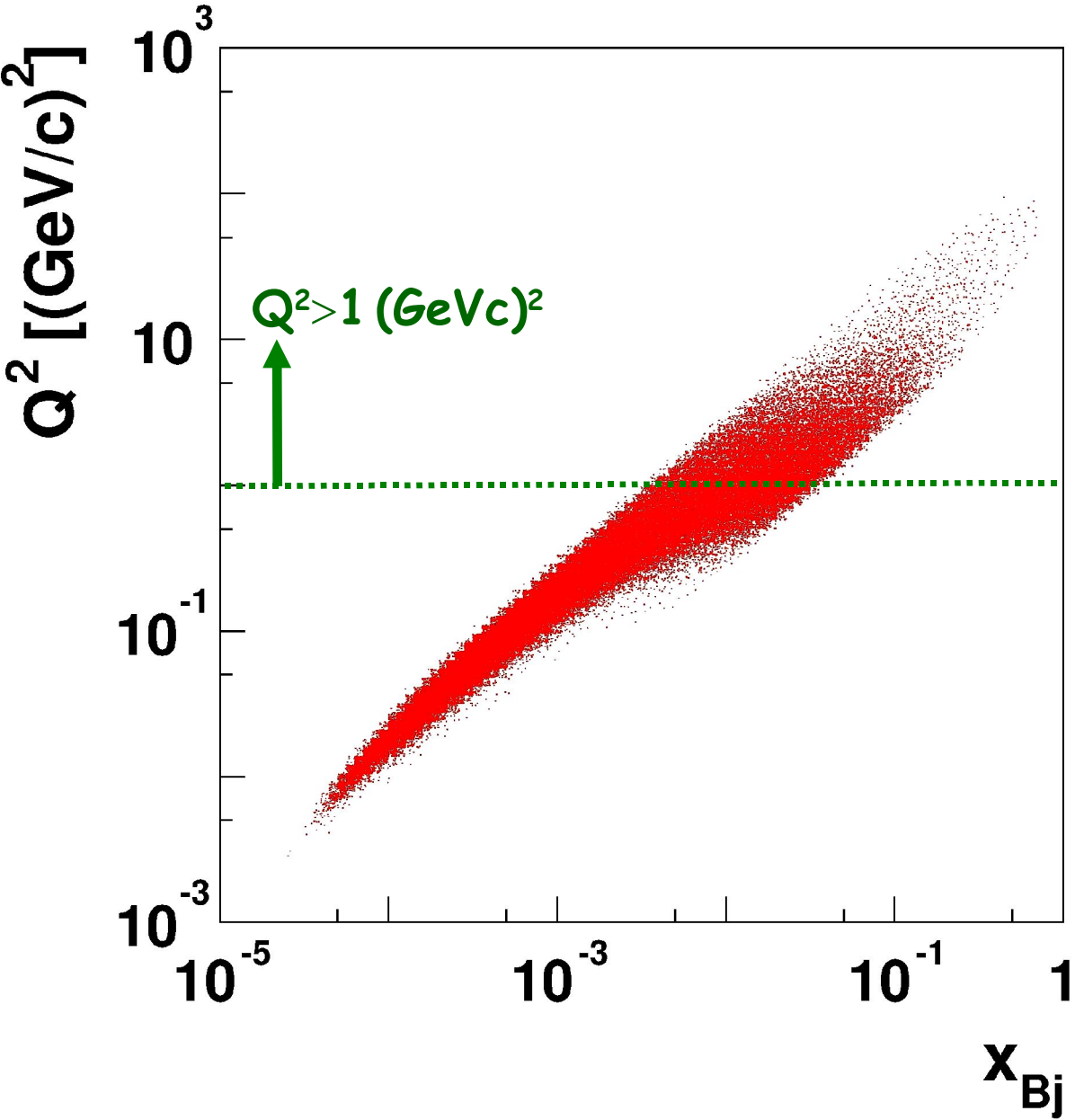
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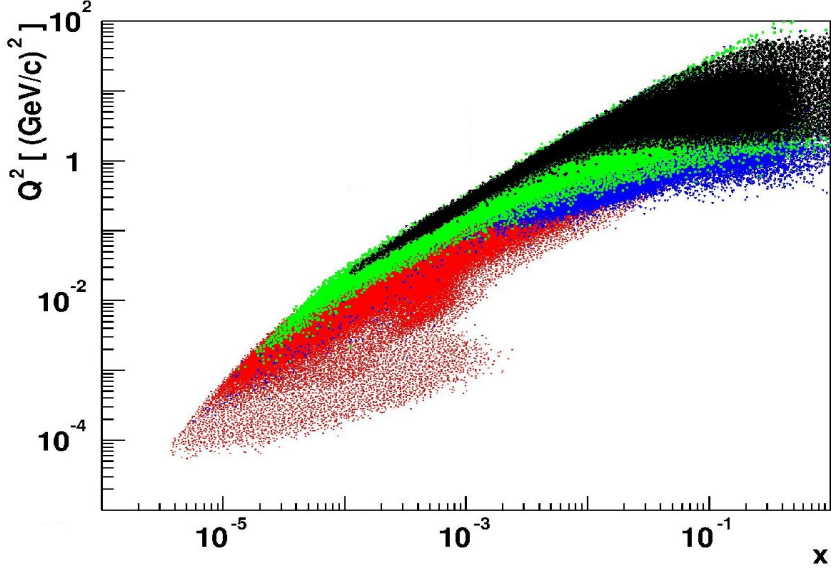
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\Rightarrow SIDIS

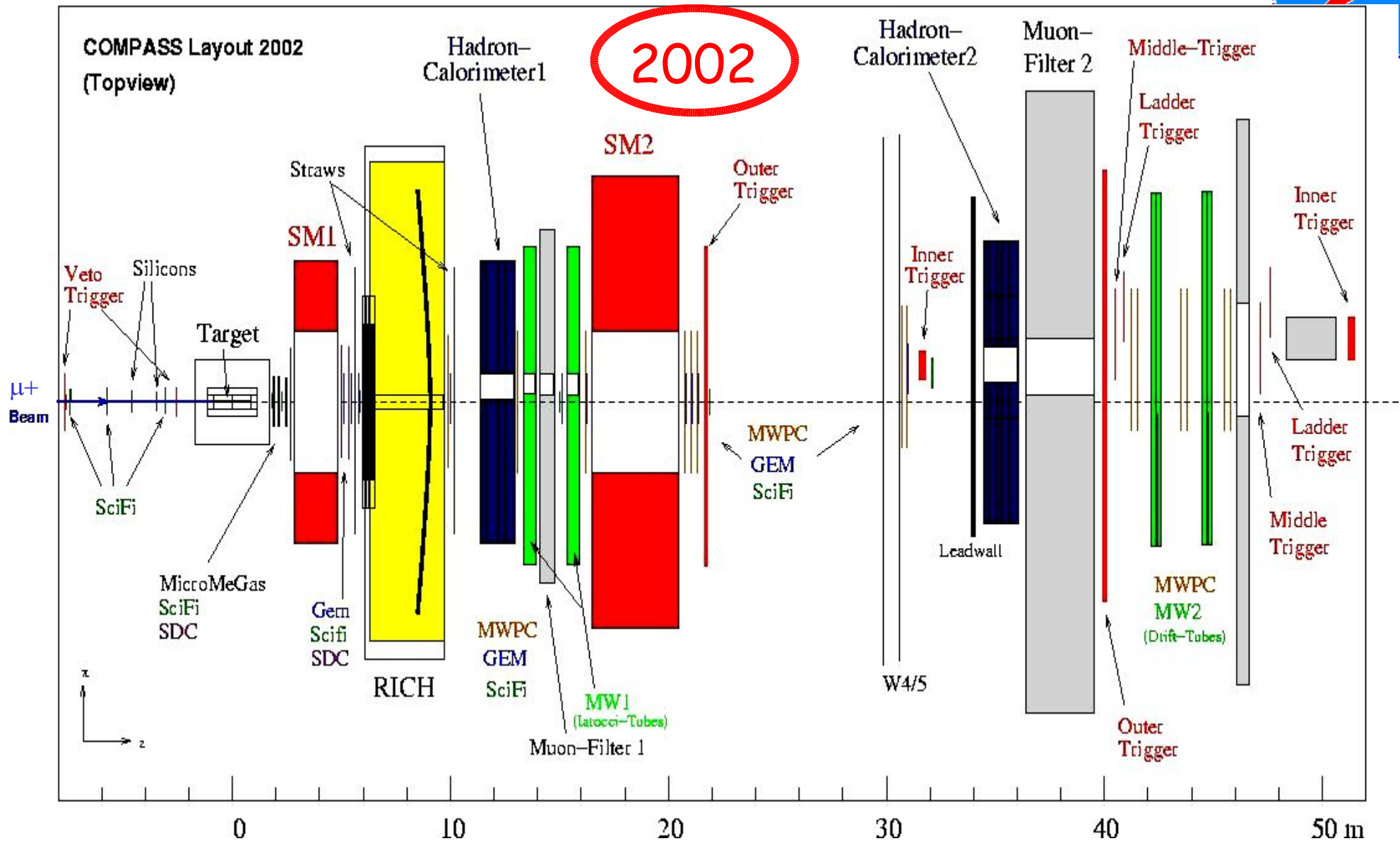
Transversity Trigger



Standard trigger:



The COMPASS experiment



Beam: $2 \cdot 10^8 \mu^+$ / spill (4.8s / 16.2s)

Luminosity: $\sim 5 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$

Beam momentum: 160 GeV/c

Beam polarization: -76%