PANIC05
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Transversity signals in two hadron correlation at COMPASS

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on behalf of the

COMPASS Collaboration

Santa Fe, October 27, 2005

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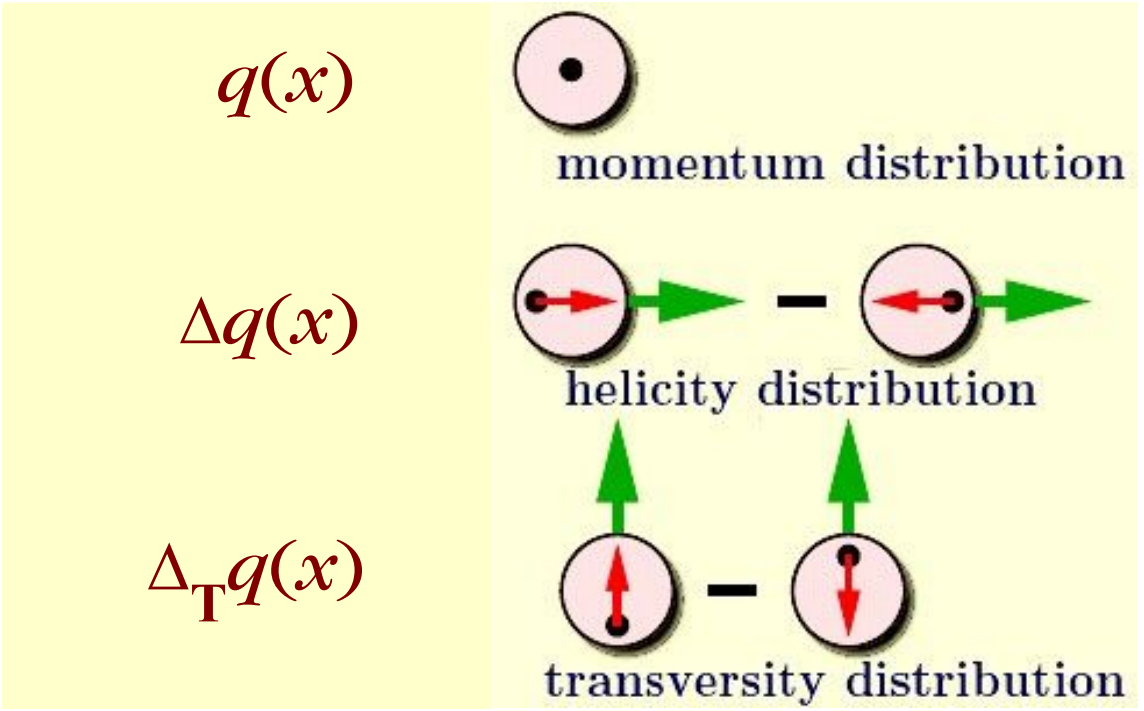
RHEINISCHE FRIEDRICH-WILHELMS-UNIVERSITÄT

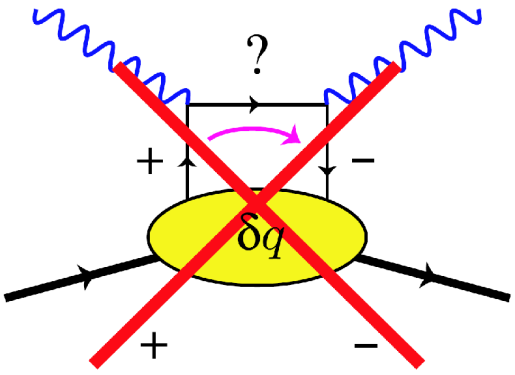
Transverse Spin Physics

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



All of equal importance !

$\Delta_T q(x)$ decouples from inclusive DIS because helicity of quark must flip



$\Rightarrow$ **SIDIS**

Transverse Spin Physics at COMPASS

3 possible quark polarimeters suggested using SIDIS:

- Measurement of transverse polarization of spin $\frac{1}{2}$ baryons

  (e.g. Λ hyperon)

- Azimuthal distribution of single (leading) hadrons

  → presentation today by Andrea Bressan

- Azimuthal dependence of the plane containing hadron pairs

  First results on the effect proposed by e.g.

  Collins et al., Nucl. Phys. B 420 (1994) 565.

  Jaffe et al., Rev. Lett. 80 (1998) 1166.

  (A. Bacchetta and M. Radici, hep-ph/0407345 and references therein)

Transverse Spin Physics in SIDIS

Two processes:

Scattering of the lepton on a quark $\rightarrow$ distribution function

Hadronization of struck quark $\rightarrow$ fragmentation function

Probes for transversity:

1-hadron SIDIS: $\Delta_T q_i(x) \Delta_T^0 D_i^h(z, p_T^{h\,2})$ Collins effect

2-hadron SIDIS: $\Delta_T q_i(x) H_i^{\sphericalangle h}(z, M_h^2)$ Interference FF

Fragmentation functions to be measured at e^+e^- facilities (e.g. BELLE)

presentation today by Akio Ogawa

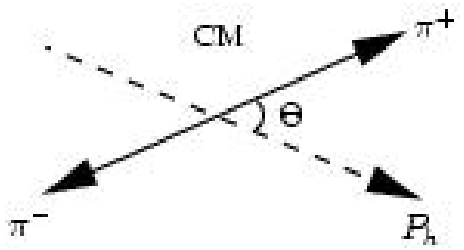
Predicted Asymmetry

In SIDIS $(l\,N \to l'\,h_1 h_2 X)$ 2-hadron production

$\Delta_T q_i(x)$ couples to $H_i^{\sphericalangle h}(z,\zeta,M_h^2,k_T^2,k_T P_T)$ $\qquad \zeta = z_1/(z_1+z_2)$

Integrated over $P_{h\perp}$ this generates a polarized cross section

$$\sigma_{UT} \propto \sum_i e_i^2 |S_T| \sin\theta \sin\phi_{RS}\ \Delta_T q_i(x)\, H_i^{\sphericalangle h}(z,M_h^2)$$



Bacchetta Radici hep-ph/0407345 v1 hep-ph/0412141

The Coordinate System

Breit frame where:

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

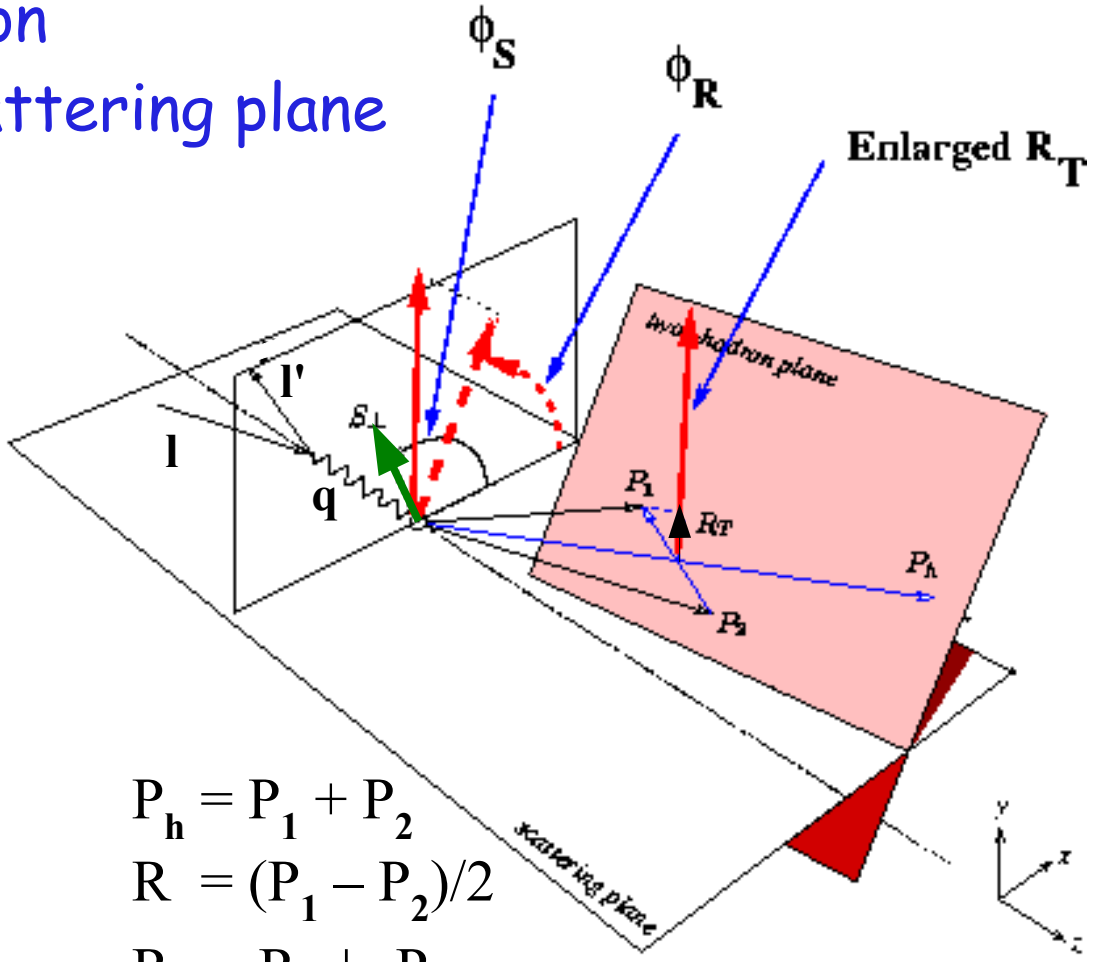
$\phi_{S'}$ = azimuthal angle of spin vector of ***fragmenting*** quark with $\phi_{S'} = \pi - \phi_S$ (spin flip)

ϕ_R = is defined by:

$$\cos\phi_R = \frac{(\mathbf{q} \times \mathbf{l})}{|\mathbf{q} \times \mathbf{l}|} \cdot \frac{(\mathbf{q} \times \mathbf{R_T})}{|\mathbf{q} \times \mathbf{R_T}|}$$

$$\sin\phi_R = \frac{(\mathbf{l} \times \mathbf{R_T}) \cdot \mathbf{q}}{|\mathbf{q} \times \mathbf{l}|\,|\mathbf{q} \times \mathbf{R_T}|}$$

$\phi_{RS} = \phi_R - \phi_{S'} = \phi_R + \phi_S - \pi$



$P_h = P_1 + P_2$

$R = (P_1 - P_2)/2$

$R_T = R \perp P_h$

Predicted Asymmetry

Expected count rate difference:

$$\frac{N^{\uparrow}(\phi_{RS}) - R \cdot N^{\downarrow}(\phi_{RS}+\pi)}{N^{\uparrow}(\phi_{RS}) + R \cdot N^{\downarrow}(\phi_{RS}+\pi)} = A_{UT}^{\sin\phi_{RS}} \cdot \sin\phi_{RS}$$

R = normalization factor

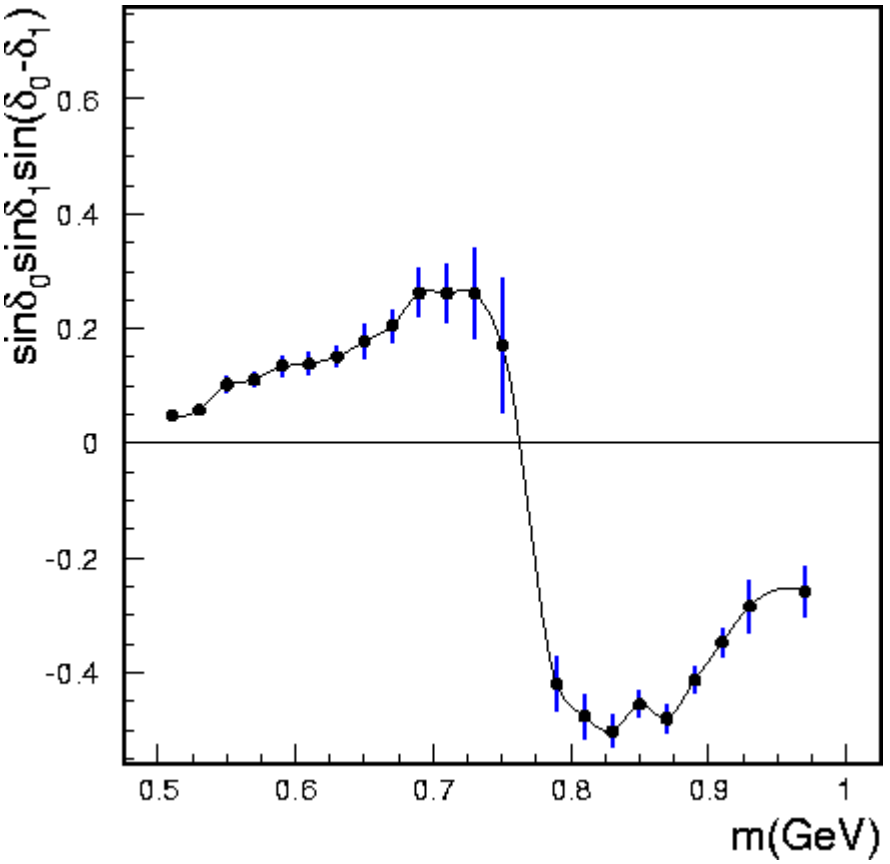
From this we get:

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

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

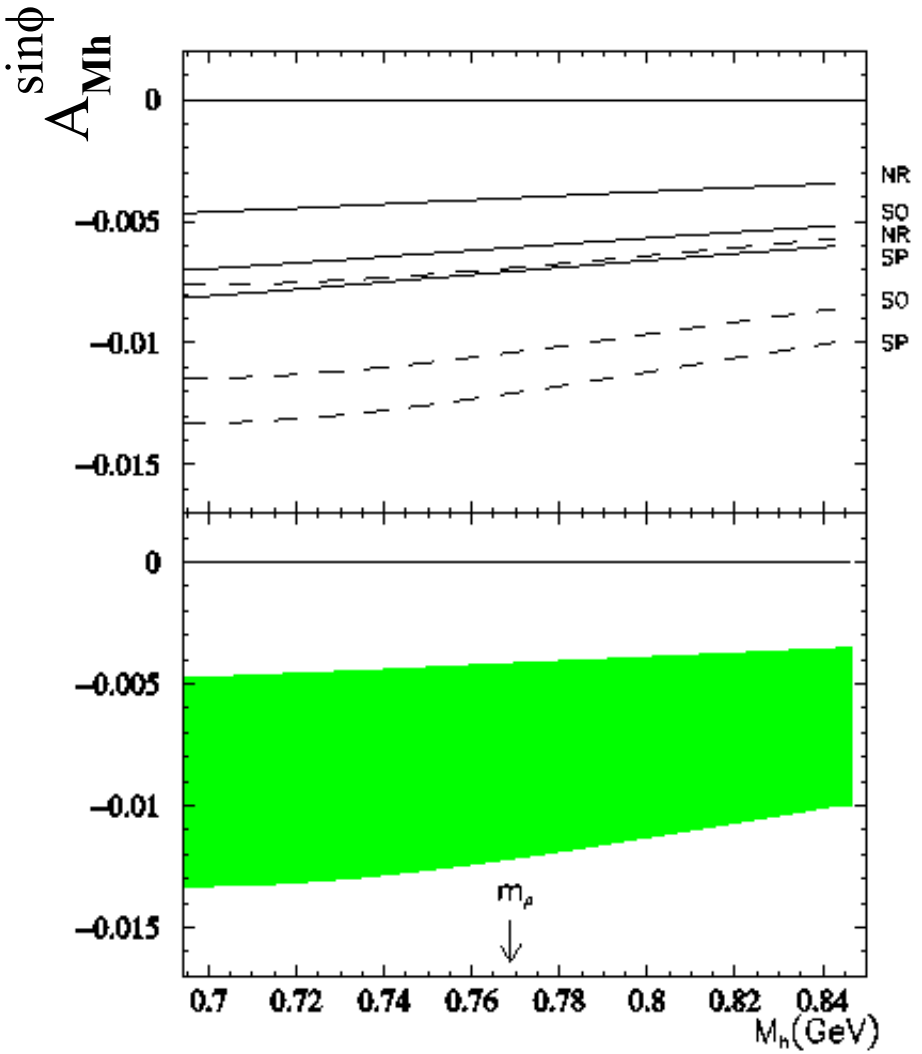
Interference Fragmentation Function $H_q^{\sphericalangle h}(z,M_h^2)$

One model !



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

Another model !



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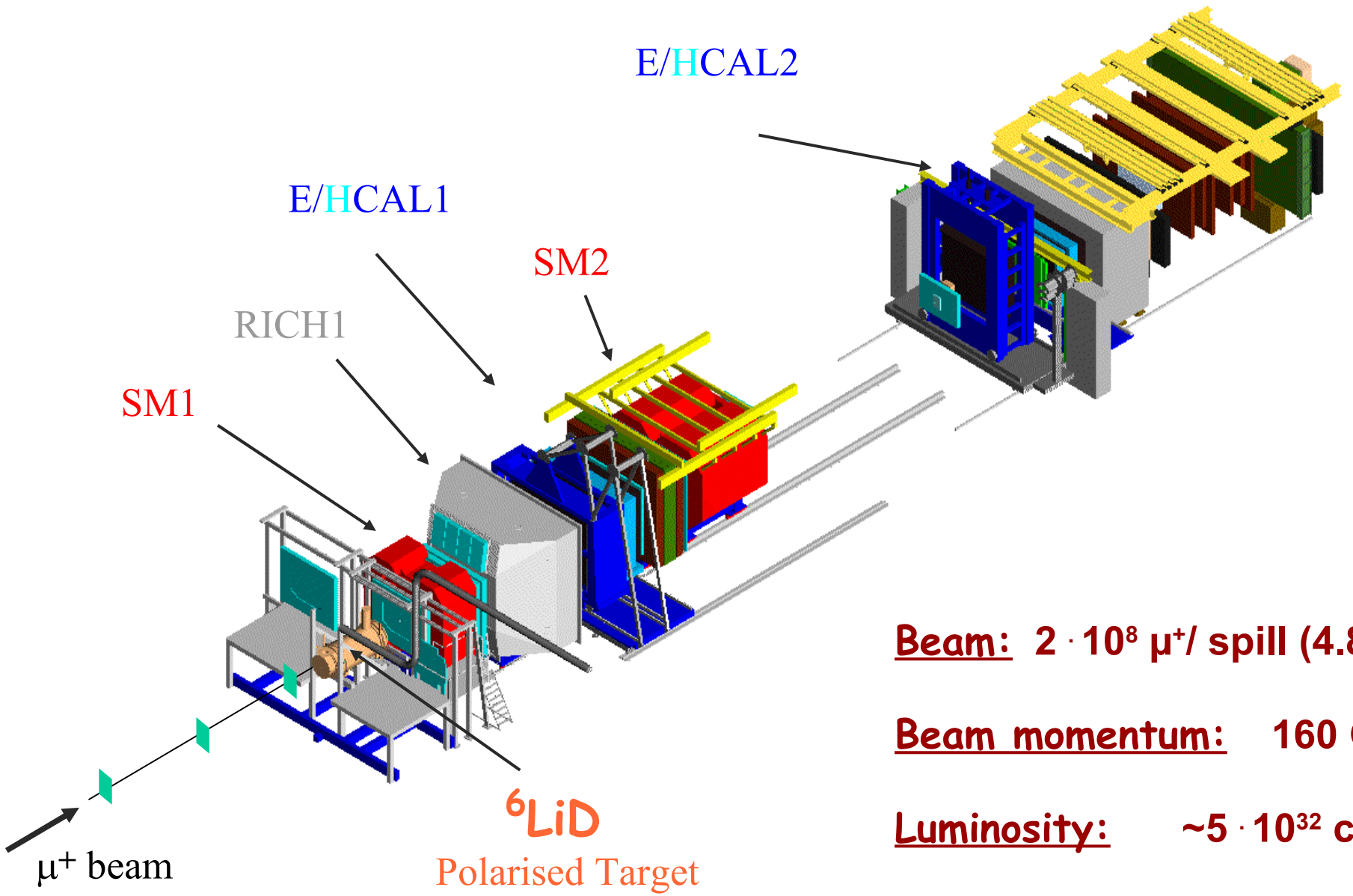
$$H^{\sphericalangle}(z,M^2_{\pi^+\pi^-}) \sim \sin\delta_0 \sin\delta_1 \sin(\delta_0-\delta_1)\hat{H}^{\sphericalangle}(z,M^2_{\pi^+\pi^-})$$

The COMPASS Spectrometer



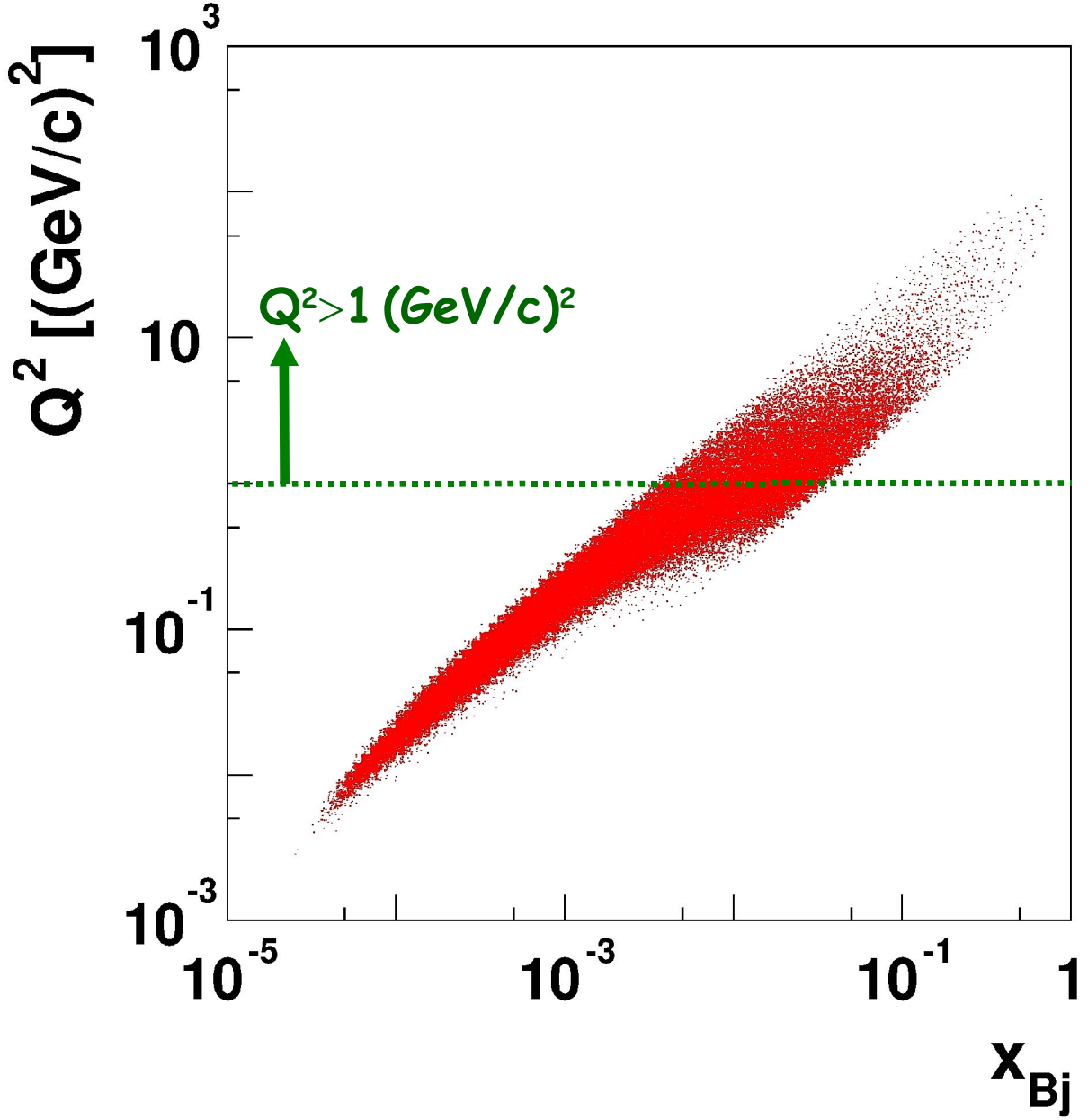
Beam: $2 \cdot 10^8$ μ^+/ spill (4.8s /16.2s

Beam momentum: 160 GeV/c

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

Beam polarization: -76%

Transversity Acceptance



Kinematic variables:

$Q^2 = -q^2 \cong 4\,E\,E'\,\sin\theta/2$

$\nu = (E_l - E_{l'})$

$x_{Bj} = Q^2/2M\nu$

$y = \nu/E_l$

$z = E_h/\nu$

DIS cuts:

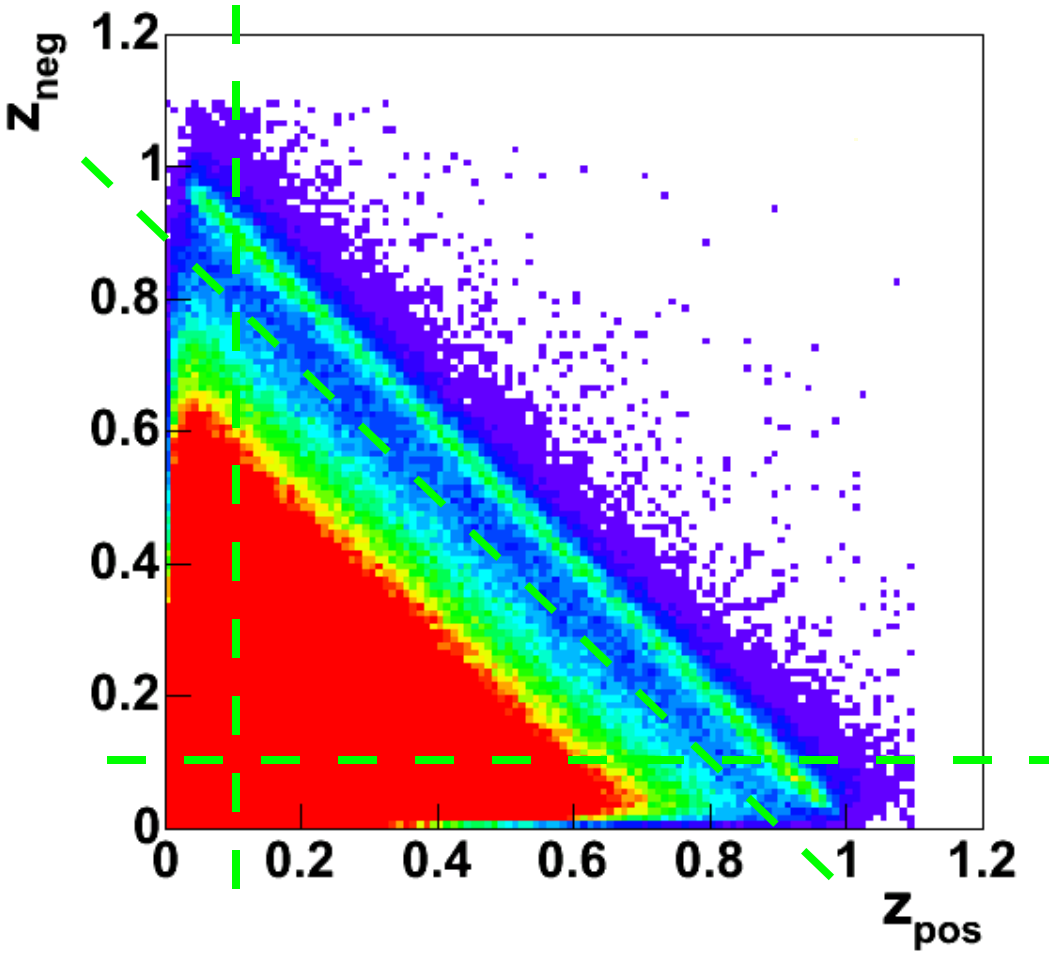
$Q^2 > 1\ (GeV/C)^2$

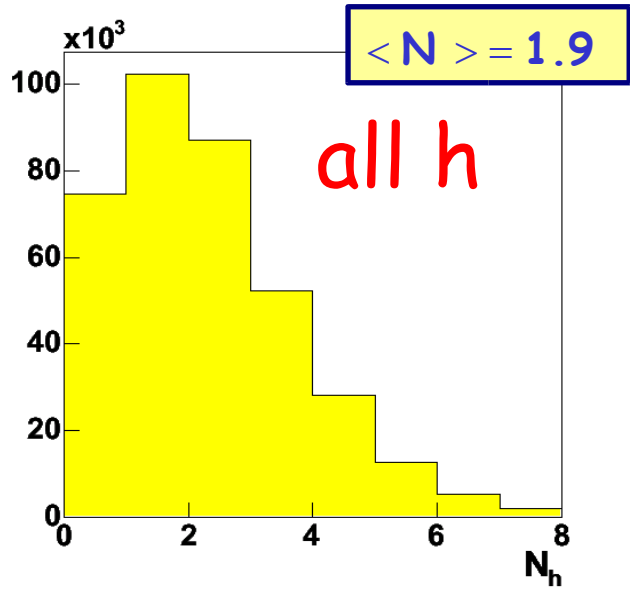
$0.1 < y < 0.9$

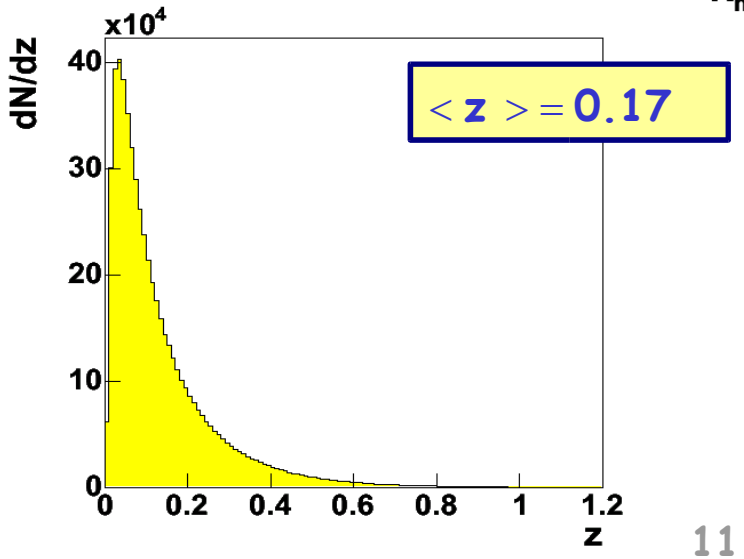
Selection of Hadron Pairs

Select all combinations of positive (h_1) and negative (h_2) hadrons with:

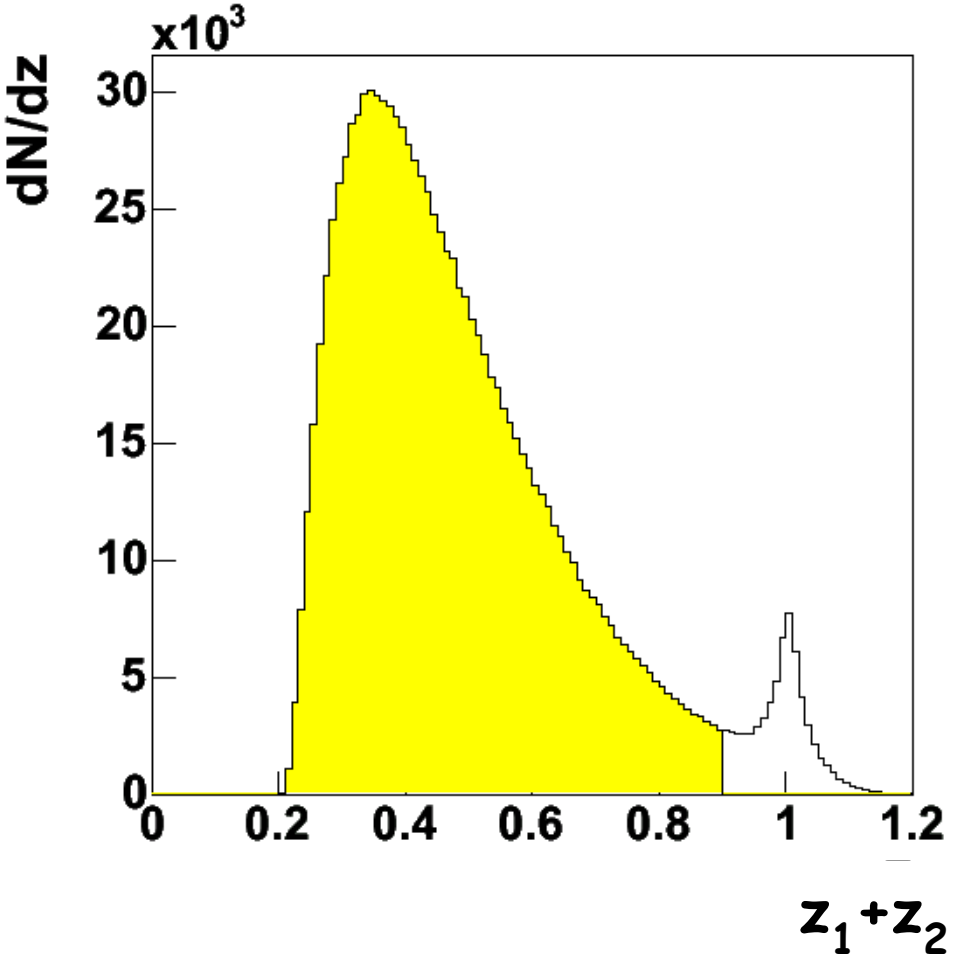
- $z_1 > 0.1$ & $z_2 > 0.1$ and $x_{f1} > 0.1$ & $x_{f2} > 0.1$
- $z = z_1 + z_2 < 0.9$

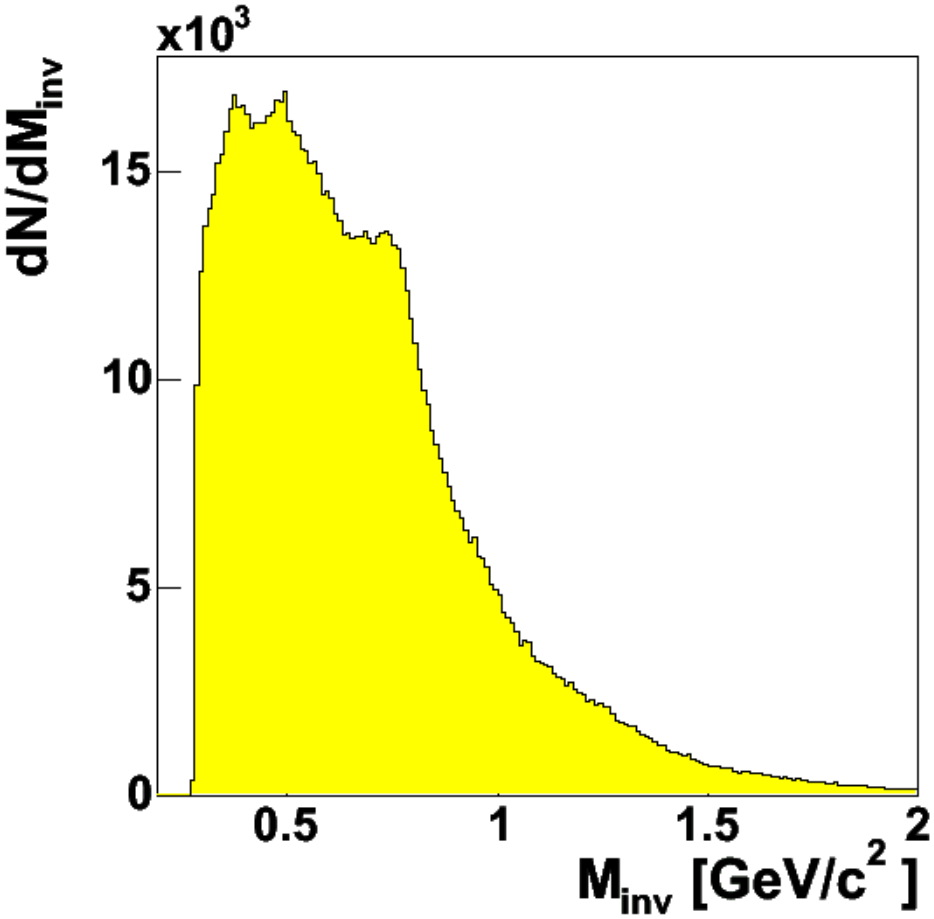






Final Sample



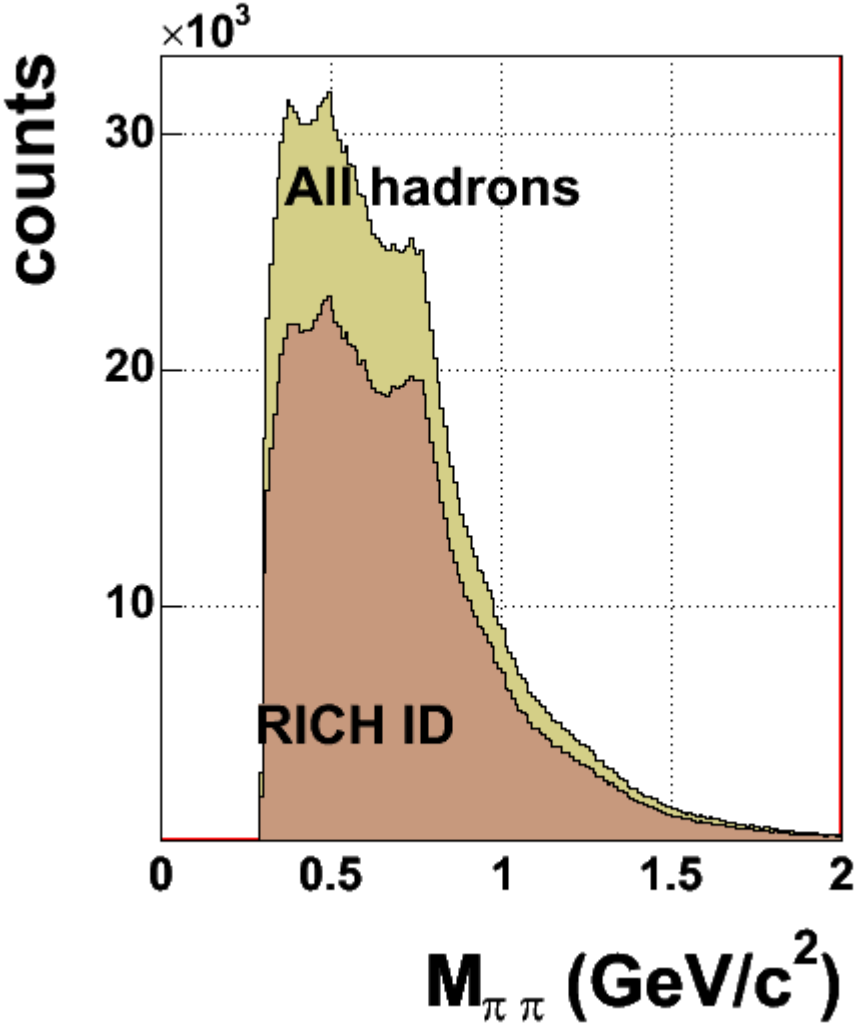


2002-2003:

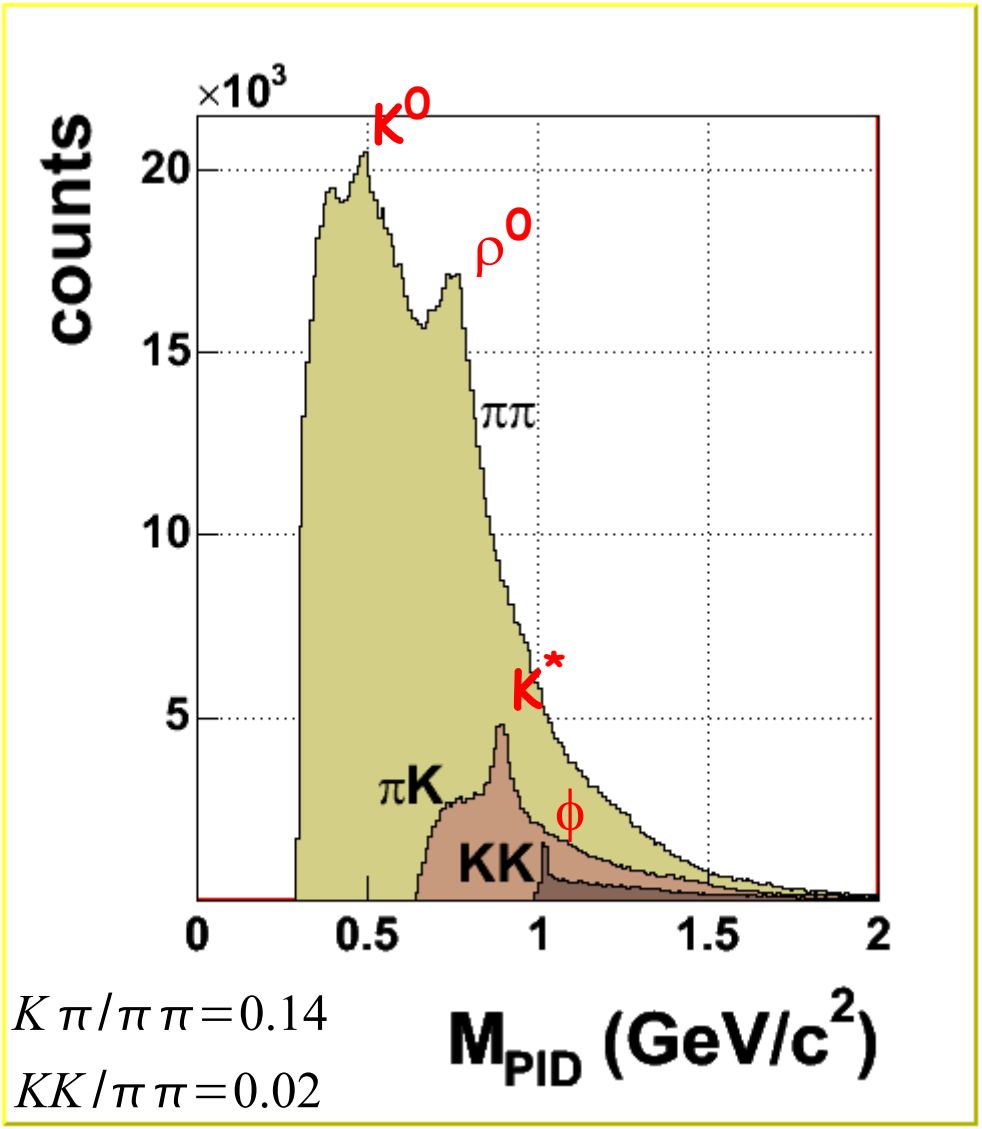
2.8 10^6 combinations

Presently no π / K / p separation by RICH

Using RICH PID



$$\frac{RICH\ ID}{All\ hadrons} = 0.74$$



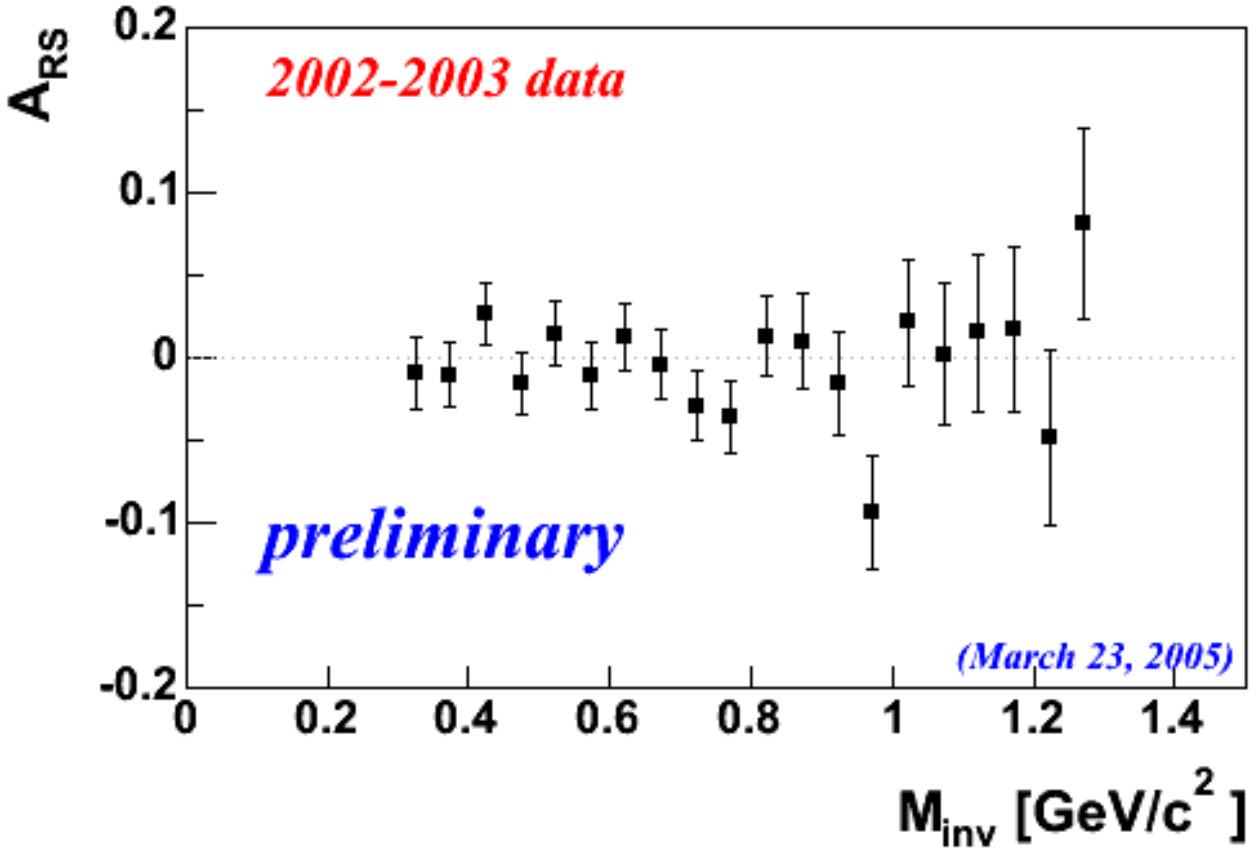
$K\pi/\pi\pi = 0.14$

$KK/\pi\pi = 0.02$

2-Hadron Asymmetry vs M_{inv}

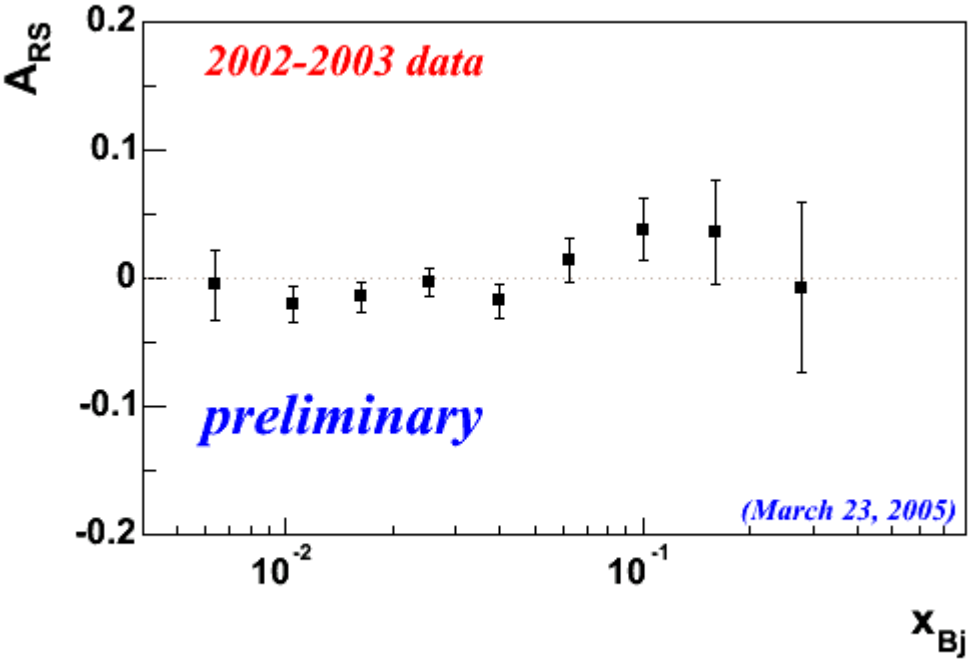
2002-2003 data

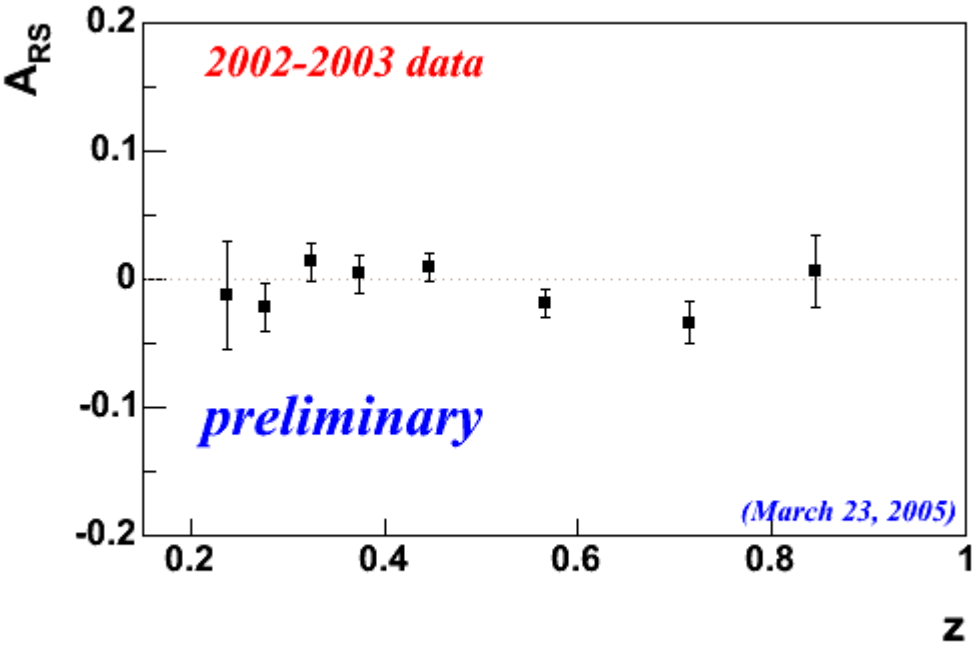
$$A_{RS} = \frac{A_{UT}^{\sin\phi_{RS}}}{D_{NN} \cdot f \cdot P}$$



2-Hadron Asymmetry vs x_{Bj} and z

2002-2003 data





Different hadron-pair selection

different hadron pairs selections are being tried

present idea (based on the string fragmentation model)

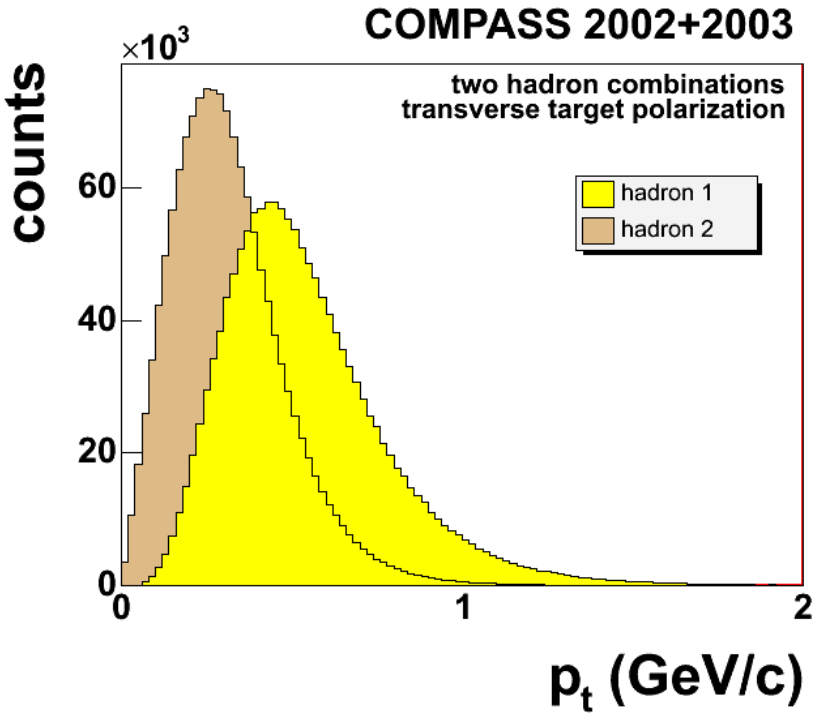
h1 = positive hadron largest p_T

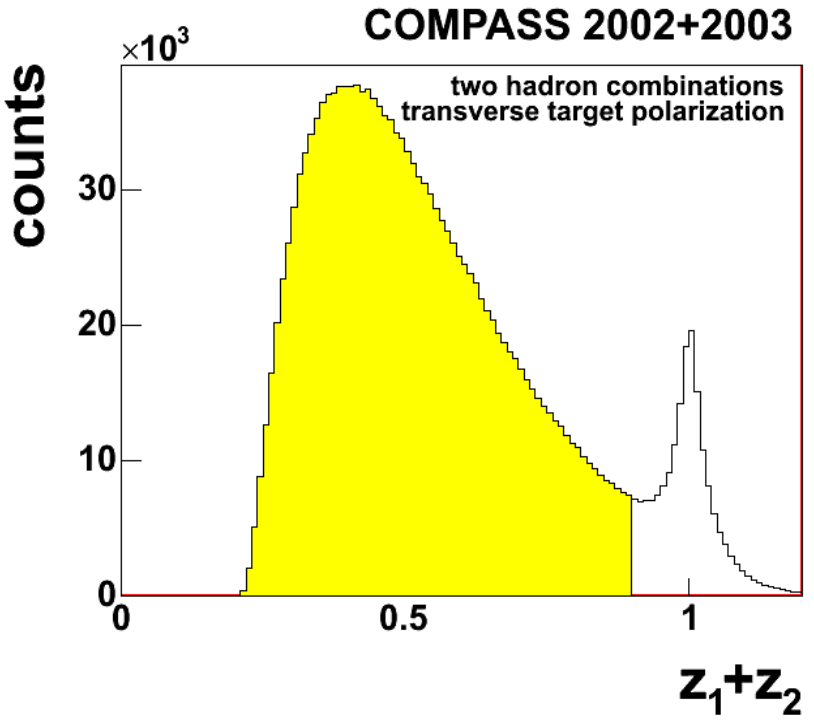
h2 = negative hadron with second largest p_T

or

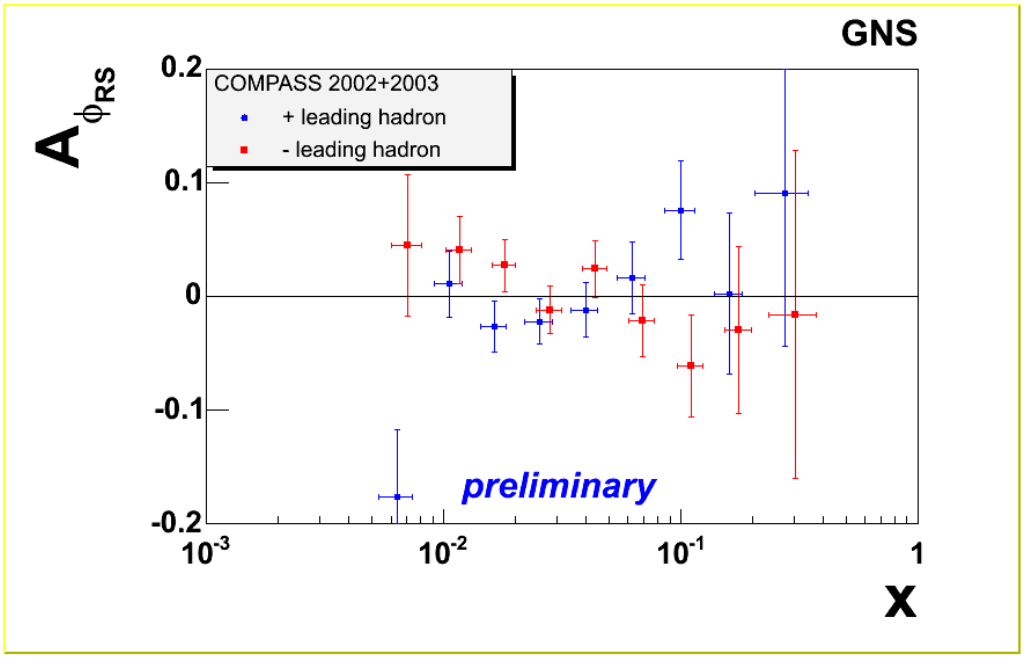
h1 = negative hadron largest p_T

h2 = positive hadron with second largest p_T $\Rightarrow$ (1 entry/event)



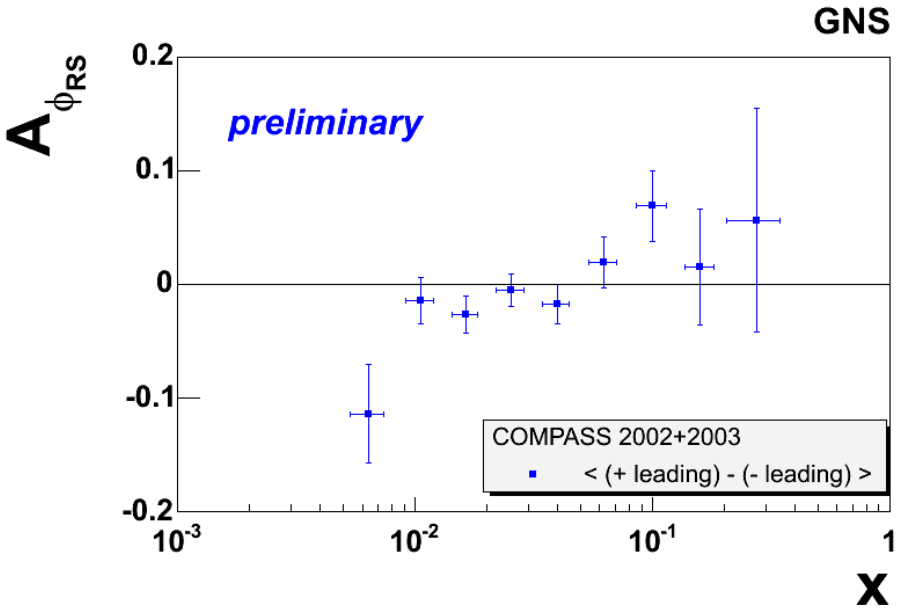


Different hadron-pair selection



Measured asymmetries
2002-2003 data

weighted average assuming
h_1 always positive



Summary

- First results of the analysis of our transverse target data concerning two hadron asymmetries were shown.
- The observed asymmetries are small.
- Systematics checks performed on the data show, that systematic effects are smaller than the statistical error.

Outlook

- Including 2004 data will double the statistics
  → sensitivity improvement by factor ~ 1.4

- The analysis is ongoing with a focus on hadron identification using the RICH information.

- Analysing the data using different cuts on the x_{Bj} and z-regions is possible with our gathered statistics and on the way.

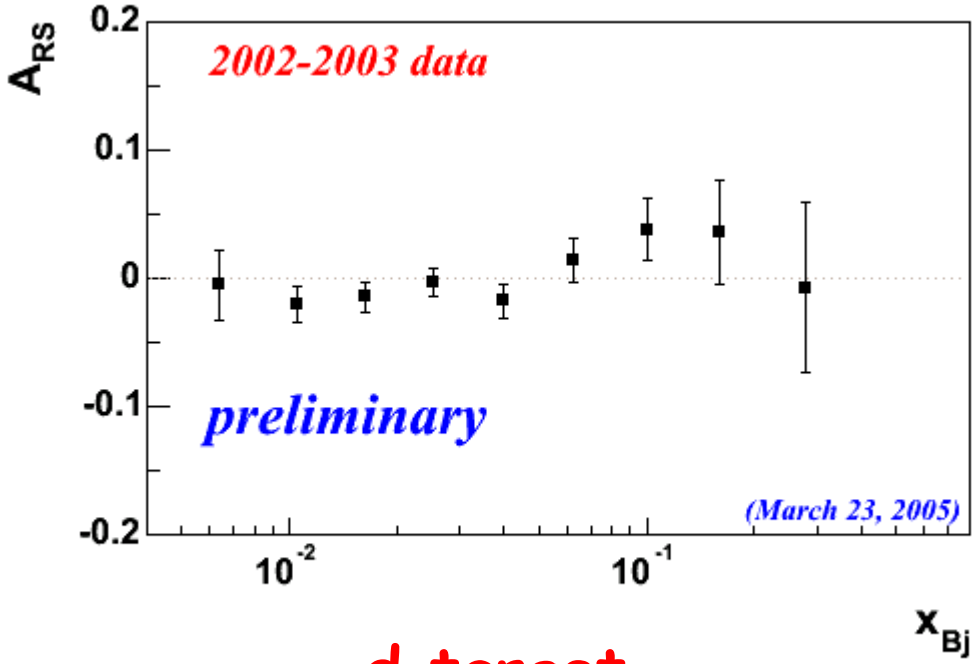
- **COMPASS after 2005:**

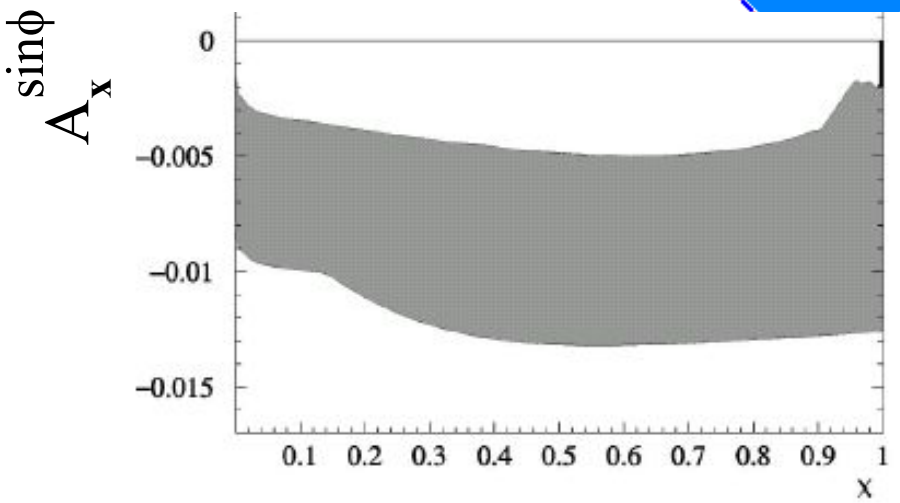
  → **complementary measurements with proton target in 2006.**

Many results on (2-hadron) transverse spin physics can be expected from COMPASS in the next future

END of talk

2-Hadron Asymmetry vs x_{Bj} and z





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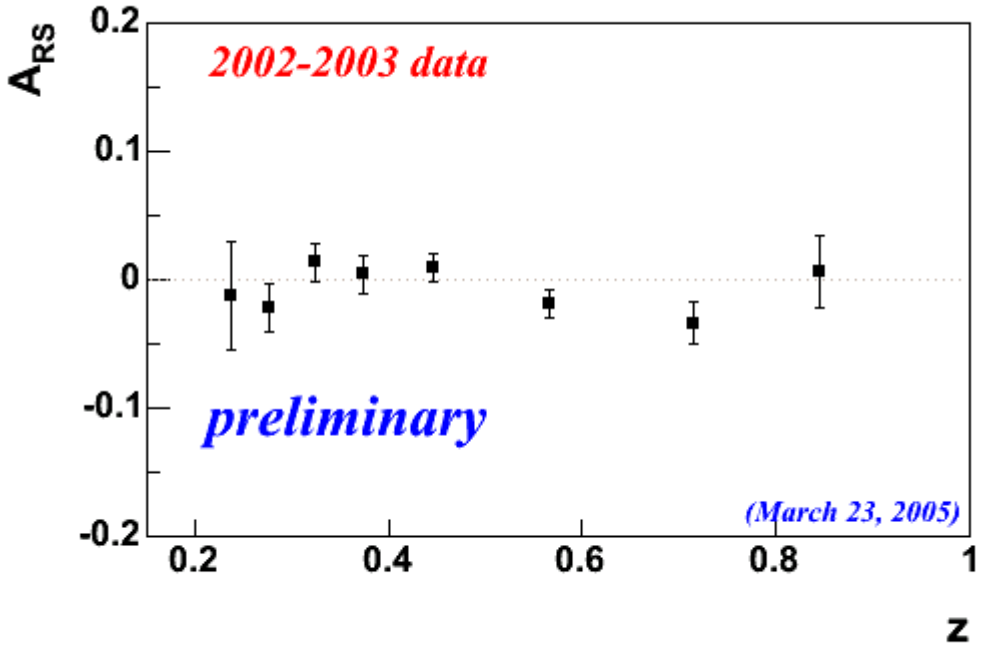
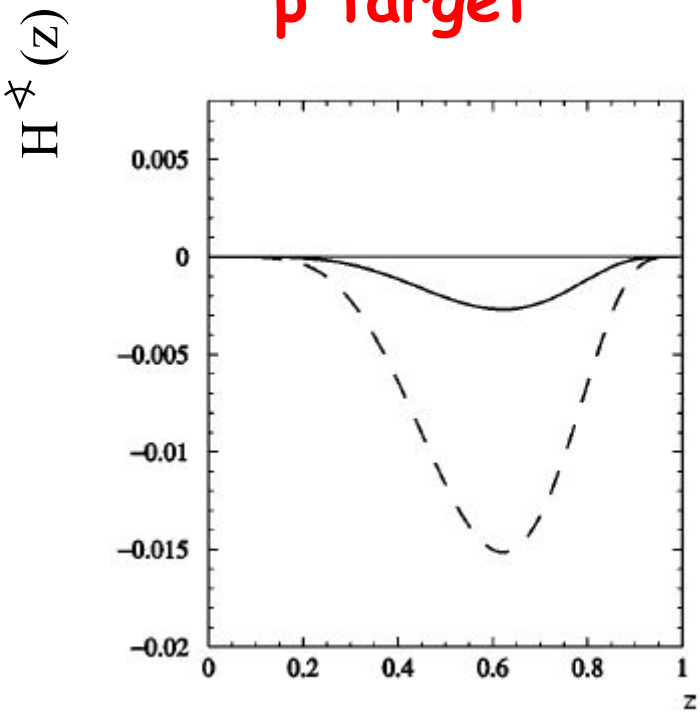
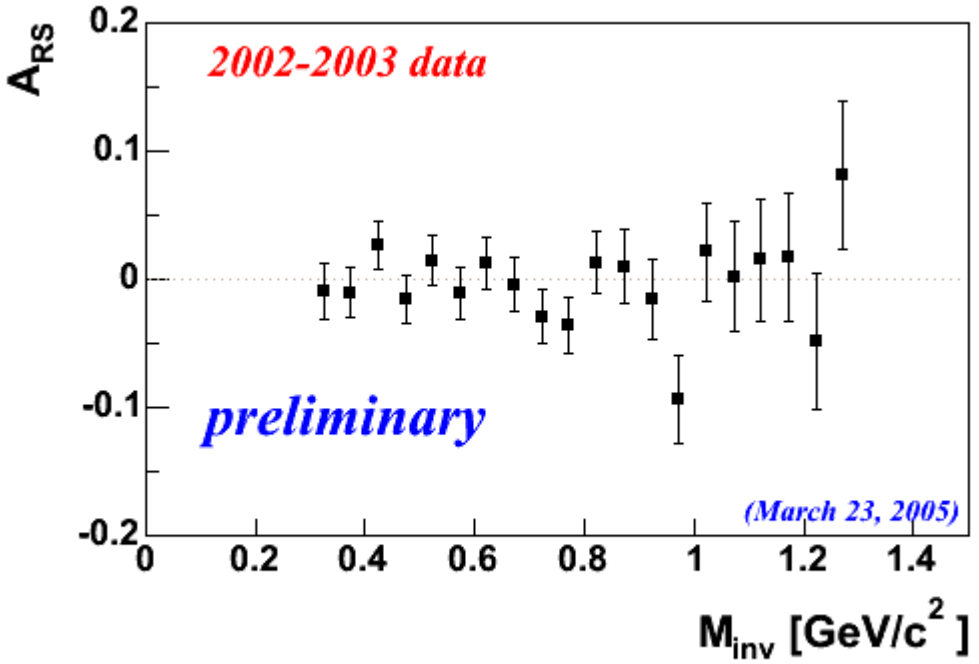
d target



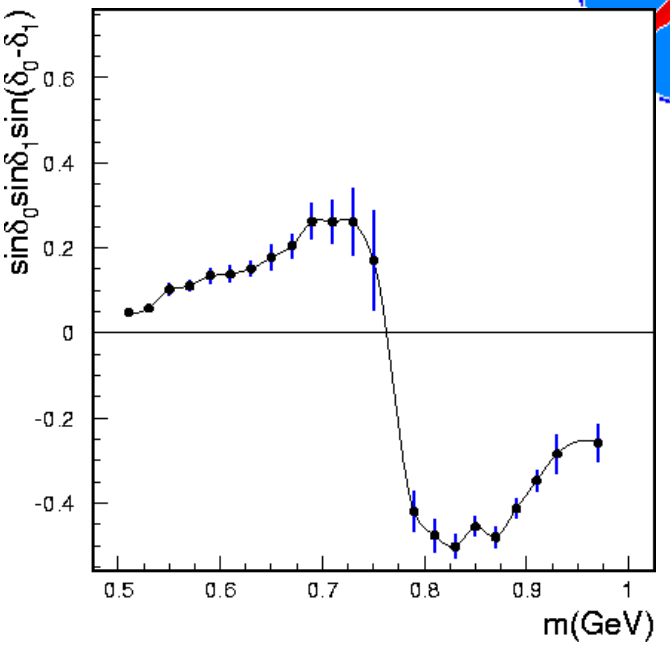
p target



2-Hadron Asymmetry vs M_{inv}



d target



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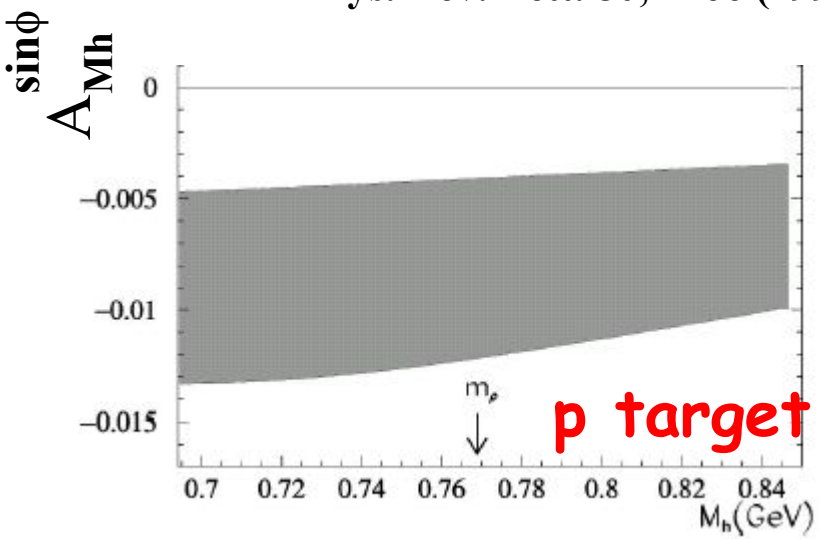
Phys. Rev. Lett. 80, 1166 (1998)



p target

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Data Sample

2002: 12+7 days of data taking
with transversely polarized ^{6}LiD target

- $1.8 * 10^9$ raw events

2003: 14 days of data taking

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

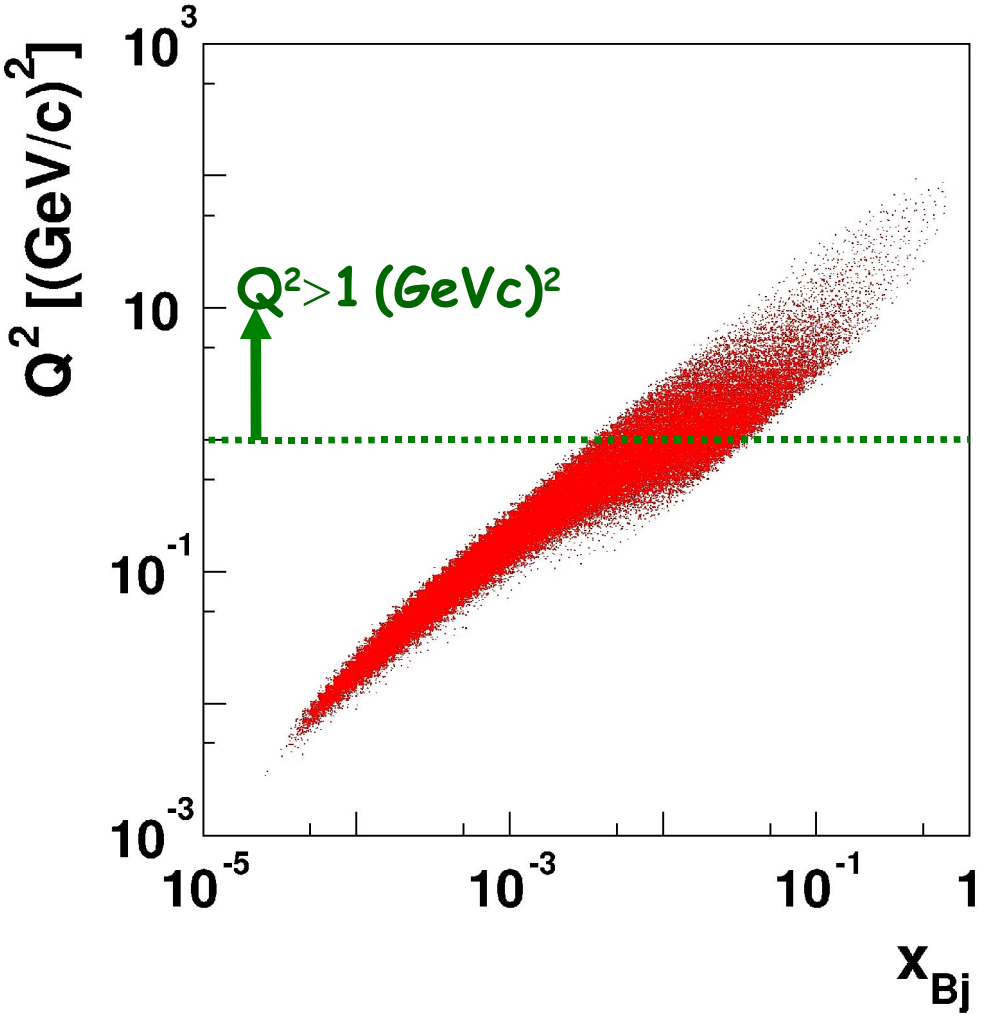
- 2002 data doubled

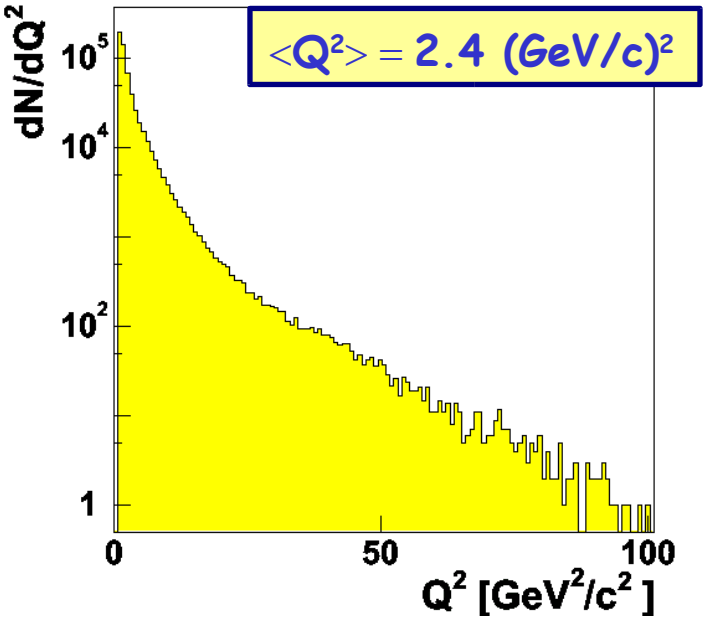
2004: 14 days of data taking

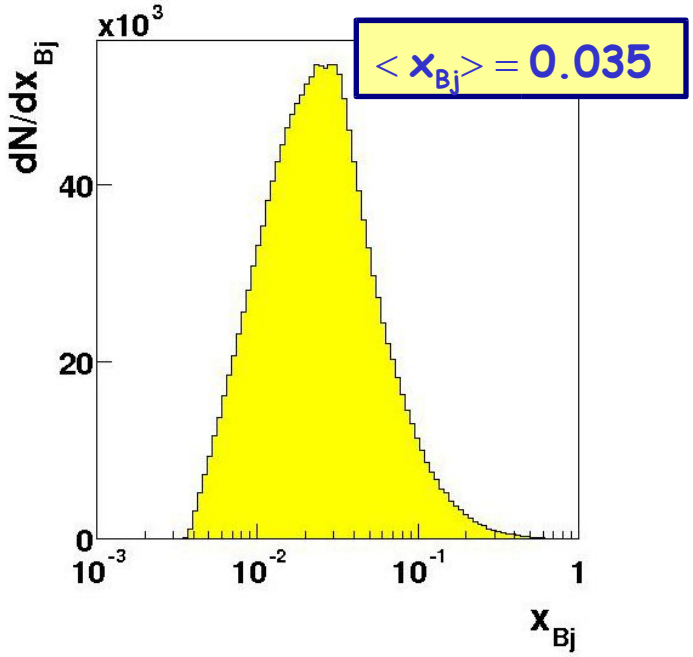
DAQ improved and online filter added

- ~ 2002+2003 data doubled

Transversity Acceptance







Q^2 $\quad y = (E_l - E_{l'})/E_l$

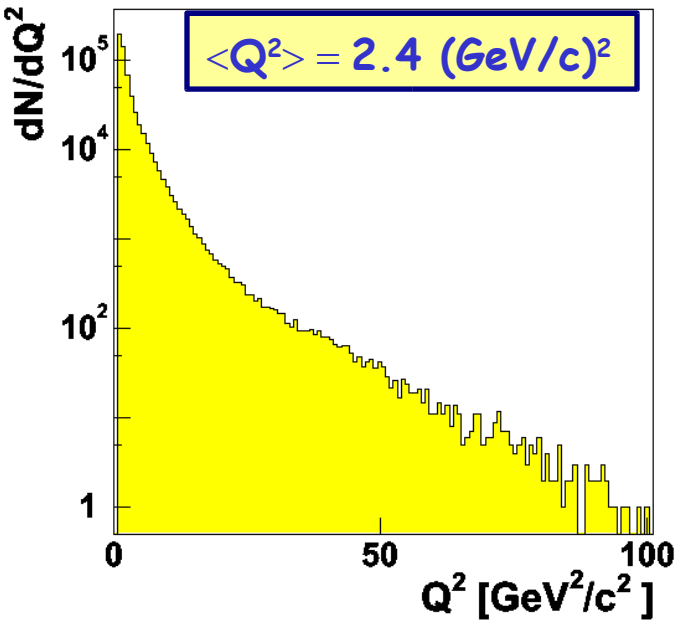
$x_{Bj} = Q^2/2M(E_l - E_{l'})$ $\quad z = E_h/(E_l - E_{l'})$

Event Selection - DIS Sample

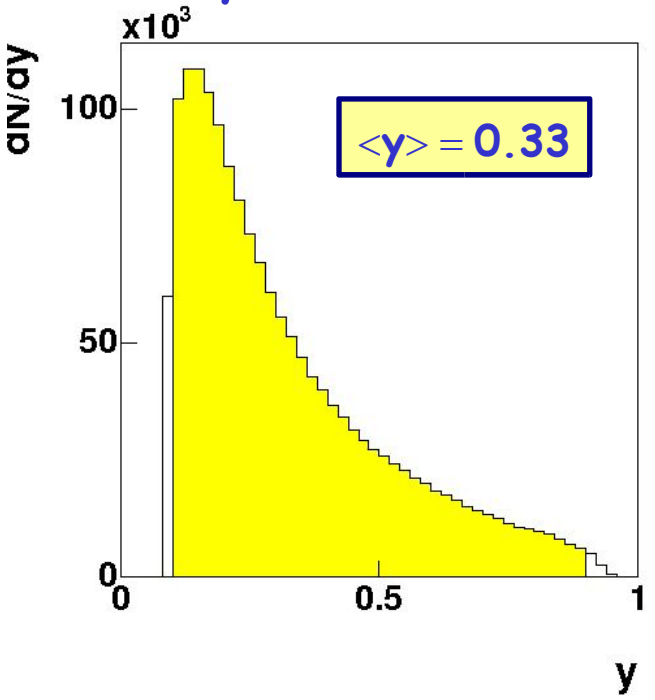
- Primary vertex with identified μ, μ' within target cell

Kinematical cuts:

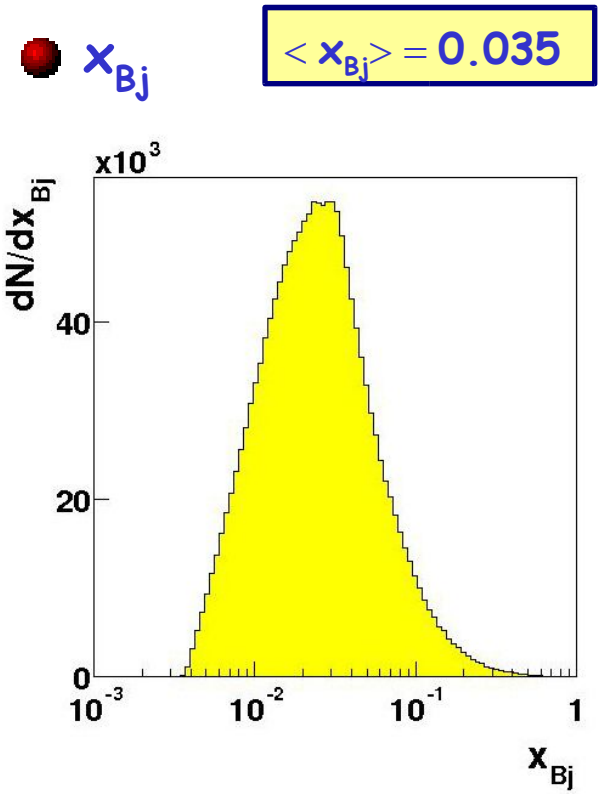
- $Q^2 > 1\ (GeV/c)^2$



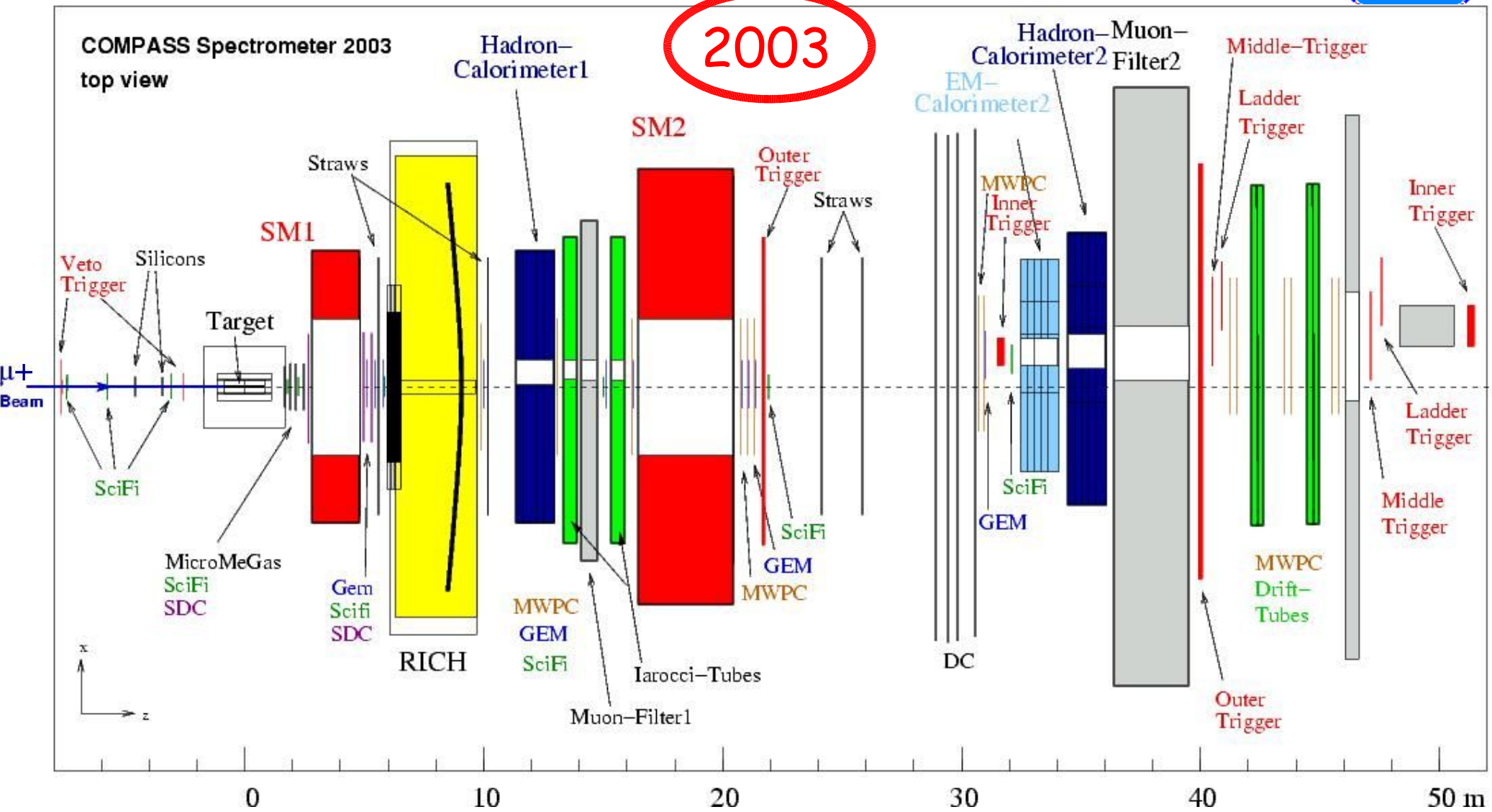
- $0.1 < y < 0.9$



- x_{Bj}



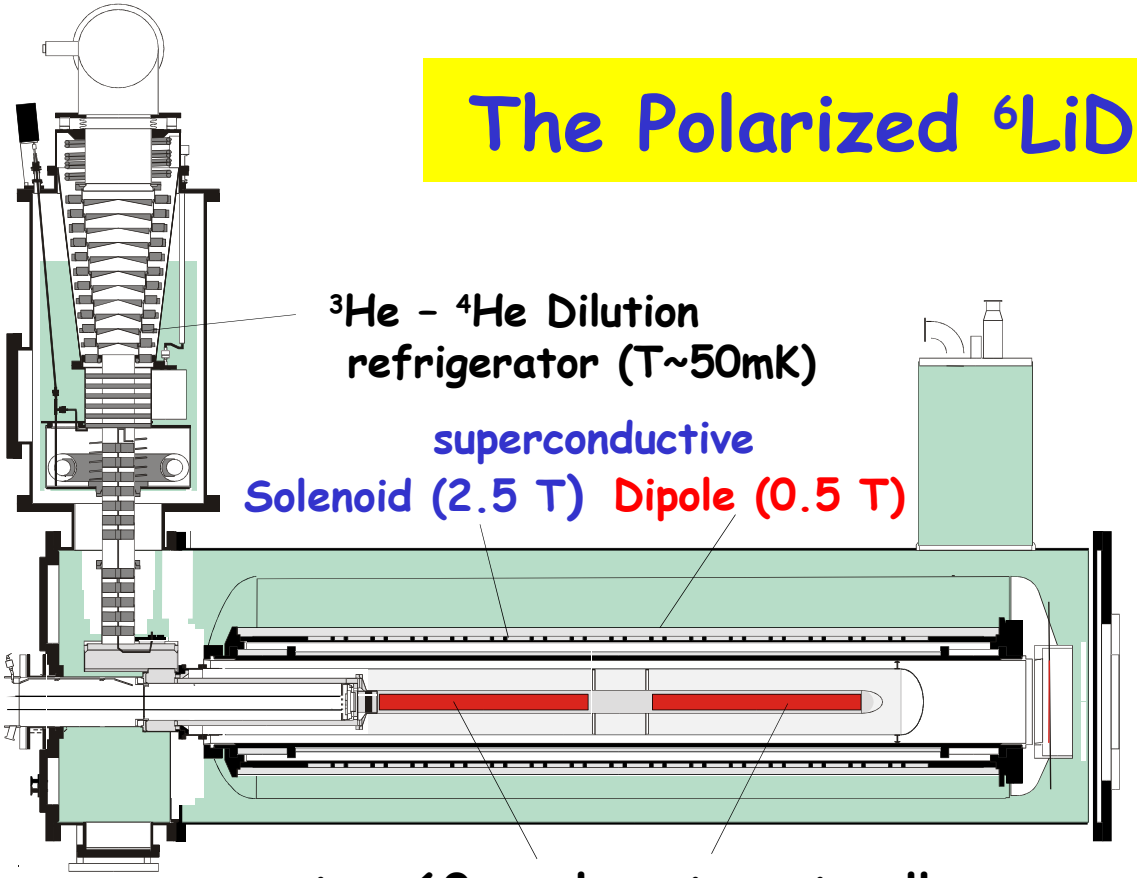
The COMPASS Experiment



Beam: $2 \cdot 10^8$ μ^+/ spill (4.8s / 16.2s) **Beam momentum:** 160 GeV/c

Luminosity: ~$5 \cdot 10^{32}$ cm^{-2} s^{-1} **Beam polarization:** -76%

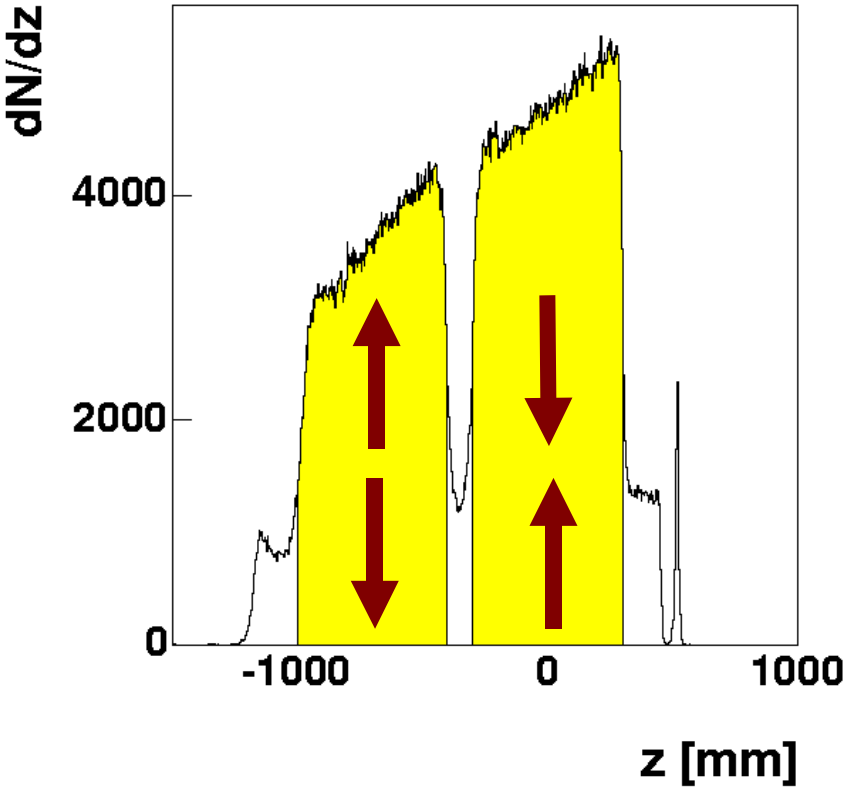
The Polarized ^{6}LiD-Target



Polarization: 50%
Dilution factor: 0.38

Relaxation time:

transversal runnina > 2000 hrs



Transverse target polarization:

(dipole field)

changed by microwave reversal

(once a week)