Transversity signals in two hadron correlation at COMPASS

Rainer Joosten,

Universität Bonn,
Helmholtz Institut für Strahlen- und Kernphysik

on behalf of the
COMPASS Collaboration

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

\[ q(x) \quad f_1(x) \]

\[ \Delta q(x) \quad g_1(x) \]

\[ \Delta_T q(x) \quad h_1(x) \]

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

\[ \Rightarrow \text{SIDIS} \]
Two processes:
Scattering of the lepton on a quark → distribution function
Production of hadrons from struck quark → fragmentation function

Kinematic variables:

- $Q^2 = -q^2 \approx 4 E E' \sin\theta/2$
  - $Q \sim$ resolution
- $\nu = (E_l - E_{l'})$
  - photon energy
- $x_{Bj} = Q^2/2M\nu$
  - momentum fraction of struck quark
- $\gamma = \nu/E_l$
  - inelasticity
- $z = E_h/\nu$
  - exclusivity
Beam: $2 \cdot 10^8 \mu^+$/spill (4.8s/16.2s)

Beam momentum: 160 GeV/c

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

Beam polarization: -76%
The Polarized $^6\text{LiD}$-Target

Polarization: 50%
Dilution factor: 0.38

$^3\text{He} - ^4\text{He}$ Dilution refrigerator ($T \approx 50\text{mK}$)
superconductive
Solenoid (2.5 T) Dipole (0.5 T)

two 60 cm long target cells with opposite polarization

Transverse target polarization:
(dipole field)
changed by microwave reversal
(once a week)
3 possible quark polarimeters suggested using SIDIS:

- **Azimuthal distribution of single hadrons**
  - Talk by F. Bradamante on Tuesday

- **Azimuthal dependence of the plane containing hadron pairs**
  - This talk

- **Measurement of transverse polarization of baryons**
  - (e.g. Λ hyperon) Talk by A. Ferrero on Friday
Transversity Data Sample

Target: $^6\text{LiD}$ (deuterium)

2002:
- 12+7 days of data taking
- 1.8 x $10^9$ raw events

2003:
- 14 days of data taking

2004:
- 14 days of data taking
- $^6\text{LiD}$ (deuterium) doubled

DAQ improved and online filter added

14 days of data taking

Trigger upgrade to gain on large $x_B$ and large $Q^2$ events!

~ 2003 data doubled

2002 data doubled

2002: 12+7 days of data taking

685 raw events
Transverse Spin Physics in 2 hadron production

Azimuthal dependence of the plane containing hadron pairs


In SIDIS 2-hadron production: \(( l N \rightarrow l'h_1h_2X)\)

transversity: \(\Delta_T q_i(x)\)

couples to the „interference fragmentation function“

\[ H_i^{xh}(z,\zeta,M_h^2,k_T^2,k_T P_T) \]

\[ \zeta = z_1/(z_1+z_2) \]
Interference fragmentation function

Integrated over $P_{h\perp}$:

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

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

$\sin \theta$ angle of $h_1$ in the hadron CMS to the direction of $\vec{p}_{h1} + \vec{p}_{h2}$

COMPASS: $\langle \sin \theta \rangle \approx 0.94$

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

$f$ dilution factor; $P$ target polarization; $D_{NN} = (1-y)/(1-y+y^2/2)$ Depolarization factor.
Interference Fragmentation Function $H_q^h(z, M_h^2)$

One model!

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

Another model!


Radici, Jakob, Bianconi, PRD 65, 074031
A more recent model: Radici @ QCD N'06

Model for transversity:

Strat
Soffer, Stratmann, Vogelsang
P.R. D65 (02) 114024

Kor
Korotkov, Nowak, Oganessian
E.P.J. C18 (01) 639

Sch
Schweitzer et al.
P.R. D64 (01) 034013

Wak
Wakamatsu
P.L. B509 (01) 59

Prediction for COMPASS kinematics on deuteron target:
The Coordinate System

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)

\( \phi_R \) = is defined by:

\[
R = \frac{z_1 p_2 - z_2 p_1}{z_1 + z_2}
\]

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

(X. Artru, hep-ph/0207309)
Select all combinations of positive ($h_1$) and negative ($h_2$) hadrons with:

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

Presently no $\pi/K/p$ separation by RICH.
Final Sample

2002-2004:
6.1 $10^6$ combinations

Presently no $\pi/\mathcal{K}/p$ separation by RICH
2-Hadron Asymmetry all +/- pairs

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

2002-2004 data

COMPASS
Select the combinations of leading ($h_1$) and next to leading ($h_2$) hadrons with:

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

**COMPASS** transverse data, hadron pairs production

- **2002-2004:**
  - $6.4 \times 10^6$ pairs

<table>
<thead>
<tr>
<th>Combination</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>+/-</td>
<td>19.2 %</td>
</tr>
<tr>
<td>+/−</td>
<td>34.2 %</td>
</tr>
<tr>
<td>−/+</td>
<td>32.2 %</td>
</tr>
<tr>
<td>Trans−/−</td>
<td>14.3 %</td>
</tr>
</tbody>
</table>
2-Hadron Asymmetries (z ordered pairs)

\[ A_{RS} \]

2002-2004 data

COMPASS

preliminary
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.
RICH identification of the hadrons will be included

**COMPASS in 2007:**

- complementary measurements with proton target planned.

Data (of comparable statistics) will be collected on a transversely polarized proton target ($\text{NH}_3$) and will allow for flavor separation.
**Outlook**

Prediction for proton target:

**Radici (QCD N'06):**

- Spin asymmetry @ COMPASS
- $0.004 < x < 0.4$ ; $0.1 < y < 0.9$
- $Q^2 > 1 \text{ GeV}^2$

![Graph showing spin asymmetry for various models](image)
Thank you