Semi-Inclusive Spin Asymmetries from COMPASS

A.Korzenev

On behalf of the COMPASS collaboration

Mainz University,

on leave from JINR, LPP

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + \langle L_z \rangle$$

$$\Delta\Sigma = \Delta u + \Delta\bar{u} + \Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s}$$

XVII International Baldin Seminar, Dubna

September 27 - October 1, 2004

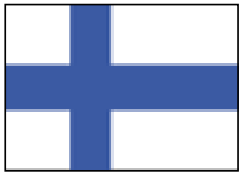
Outline of the talk

- Introduction
  - polarized μ beam
  - Spectrometer
- Inclusive & semi-inclusive DIS asymmetries
  - Inclusive asymmetry measurement
  - Prospect for semi-inclusive analysis
- Summary

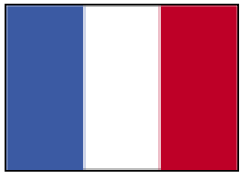
INTRODUCTION

More than 220 physicists from 30 institutes

Prague(CU,CUT, TUL)



Helsinki



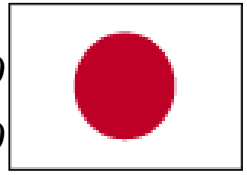
Saclay

Bielefeld
Bochum
Bonn(ISKP&PI)
Erlangen
Freiburg
Heidelberg
Mainz
Munchen(LMU,TU)

Burdwan
Calcutta

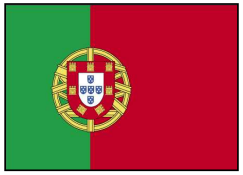
TelAviv

Torino (University & INFN)
Trieste (University & INFN)



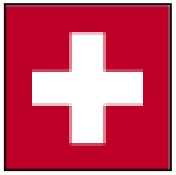
Nagoya

Warsaw (SINS & TU



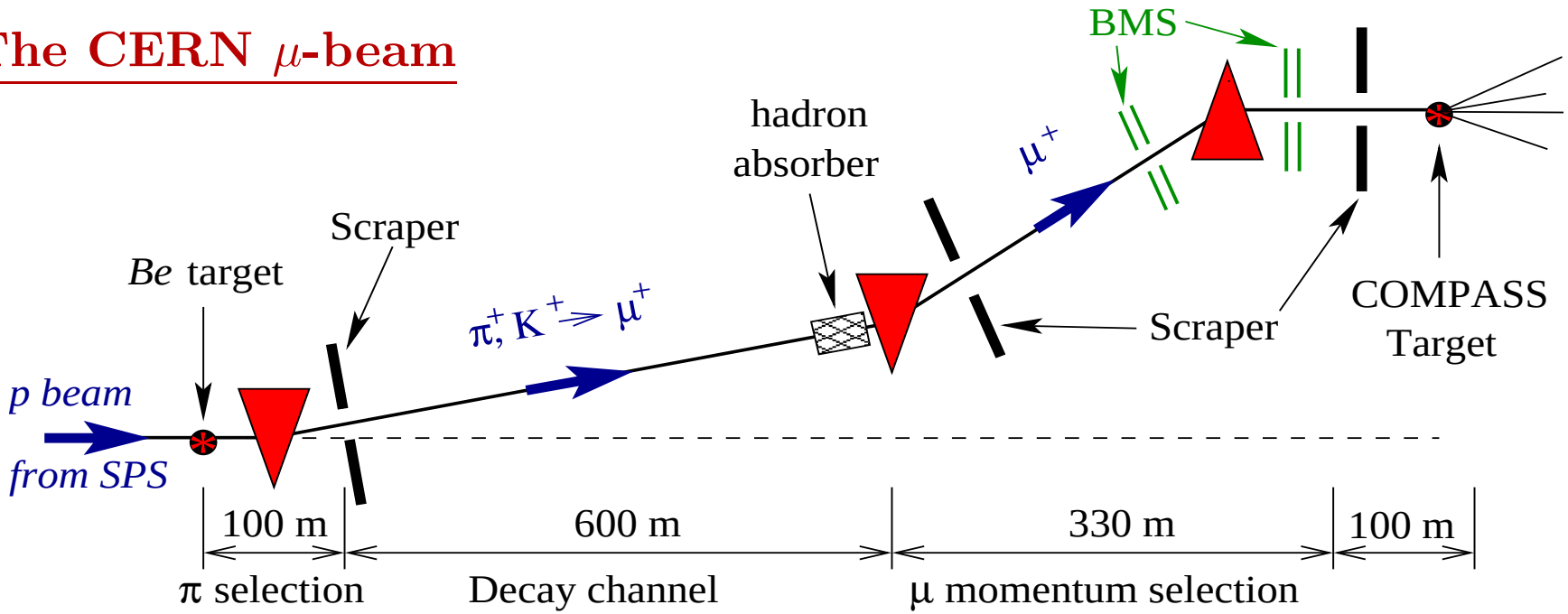
Lisbon

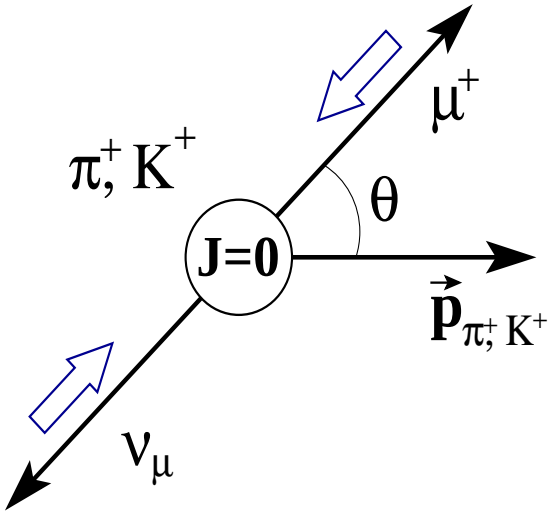
Dubna
Moscow(INR,LPI, State University)
Protvino



CERN

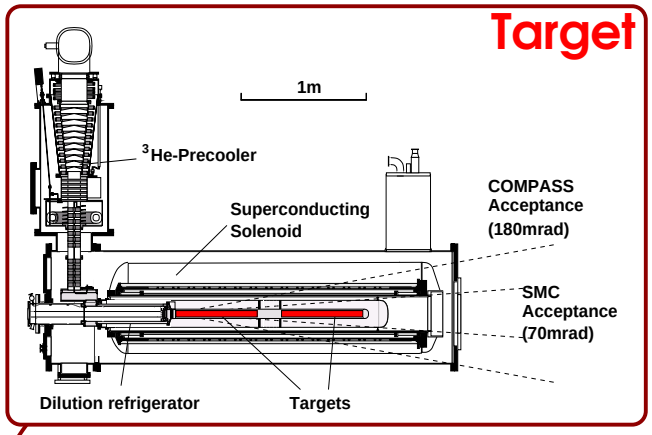
The CERN μ-beam



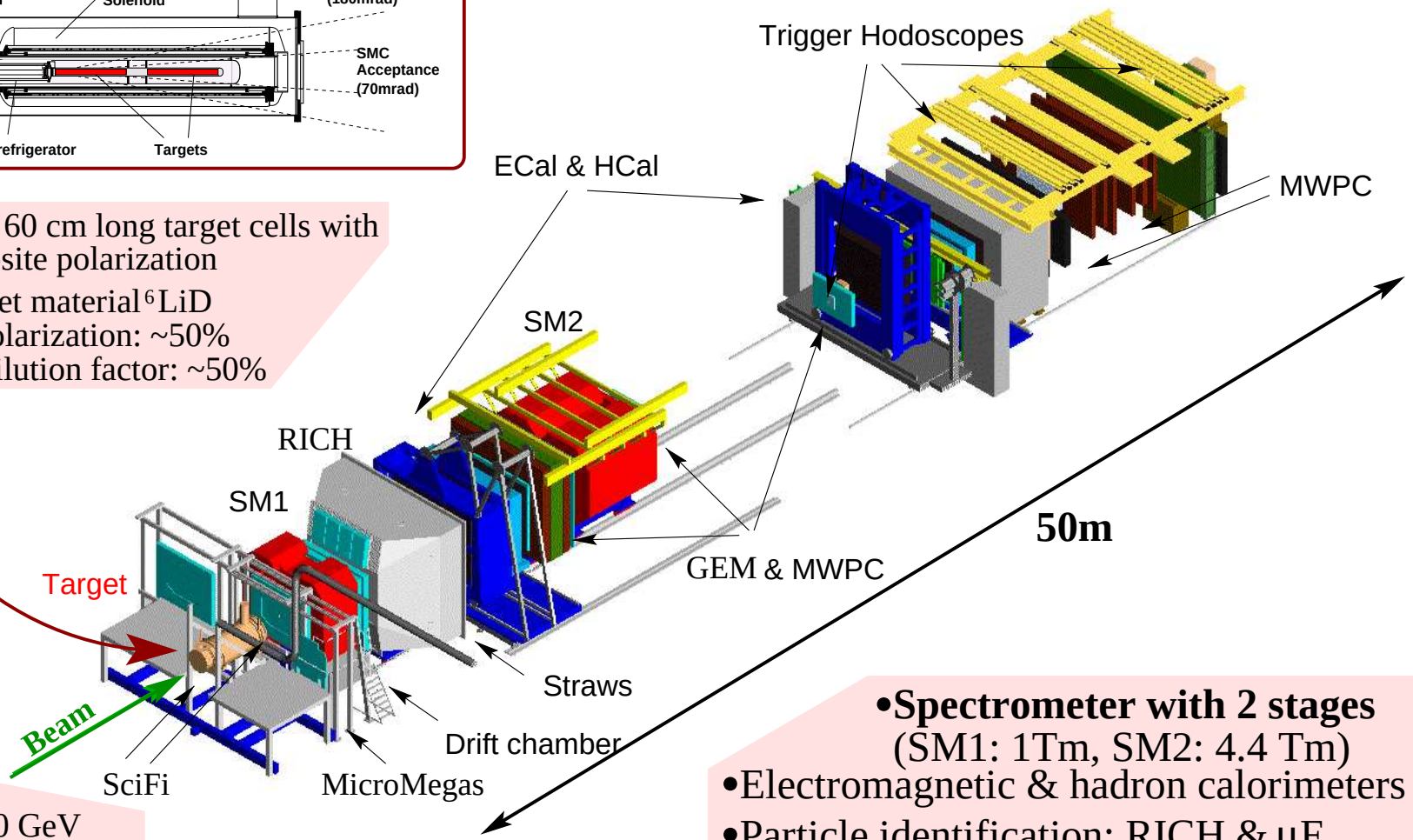


- Energy 160 GeV
- 5s spill every 14.4s
- Intensity $2 \cdot 10^8$ μ/spill
- Natural polarization due to parity violation in the week decay of parent hadrons P_μ =-76%

Spectrometer



- Two 60 cm long target cells with opposite polarization
- Target material ^{6}LiD
  - Polarization: ~50%
  - Dilution factor: ~50%



- μ−beam
  - Energy: 160 GeV
  - Intensity: $2 \cdot 10^8$ μ/spill
  - Polarization: −76%

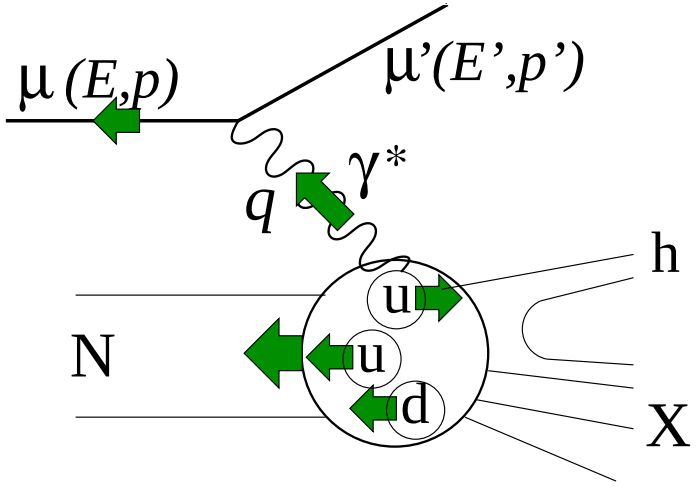
- **Spectrometer with 2 stages** (SM1: 1Tm, SM2: 4.4 Tm)
- Electromagnetic & hadron calorimeters
- Particle identification: RICH & μF

Inclusive & semi-inclusive DIS asymmetries

Polarized DIS

- the goal of measurement is

$$A_1 \equiv A^{\gamma N} = \frac{\sigma_{1/2} - \sigma_{3/2}}{\sigma_{1/2} + \sigma_{3/2}} \overset{\mathbf{LO}}{=} \frac{\sum_q e_q^2 (q^{\uparrow\Uparrow} - q^{\downarrow\Uparrow} + \bar{q}^{\uparrow\Uparrow} - \bar{q}^{\downarrow\Uparrow})}{\sum_q e_q^2 (q^{\uparrow\Uparrow} + q^{\downarrow\Uparrow} + \bar{q}^{\uparrow\Uparrow} + \bar{q}^{\downarrow\Uparrow})} = \frac{\sum_q e_q^2 (\Delta q + \Delta\bar{q})}{\sum_q e_q^2 (q + \bar{q})}$$



- In terms of of structure functions

$$A_1 = \frac{g_1 - \gamma^2 g_2}{F_1}$$

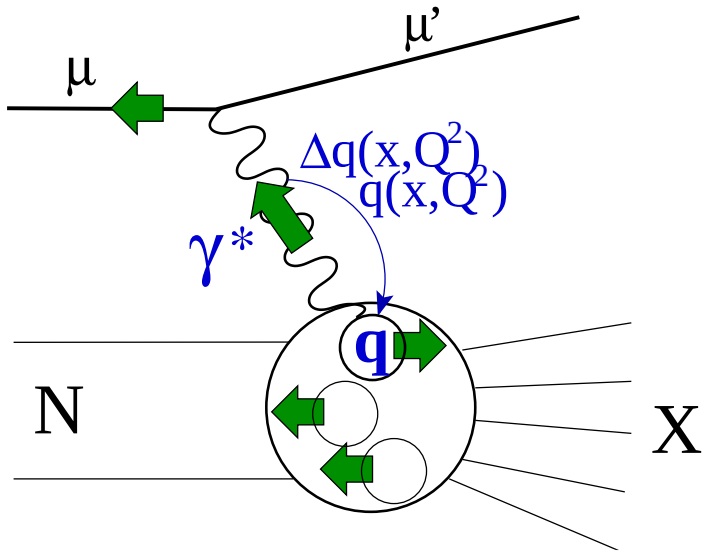
- the muon-nucleon asymmetry $A^{\mu N}$ is measured

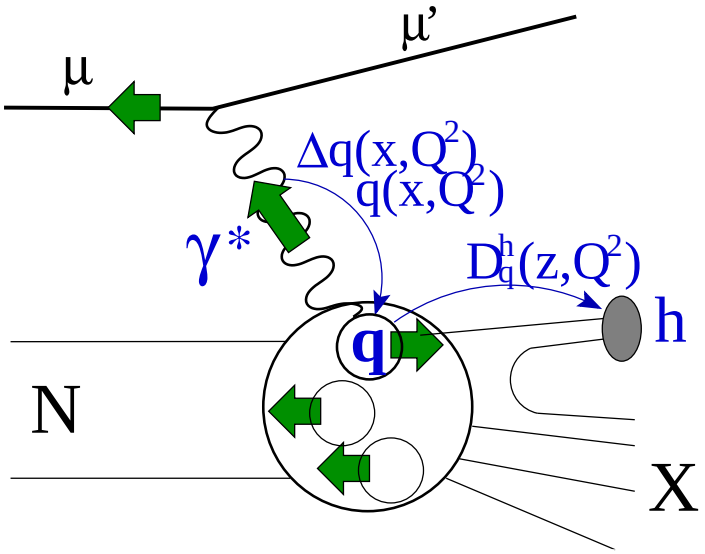
$$A_1 = \frac{1}{D} A^{\mu N} = \frac{1}{D f P_t P_b} \cdot \frac{N^{\uparrow\downarrow} - N^{\uparrow\uparrow}}{N^{\uparrow\downarrow} + N^{\uparrow\uparrow}}$$

What is detected in final state?

Inclusive DIS

- Detected particle: μ, μ'
- $A_1 = \dfrac{\sum_q e_q^2(\mathbf{\Delta q(x)+\Delta \bar{q}(x)})}{\sum_q e_q^2(q(x)+\bar{q}(x))}$
- only $\Delta q + \Delta \bar{q}$ can be measured

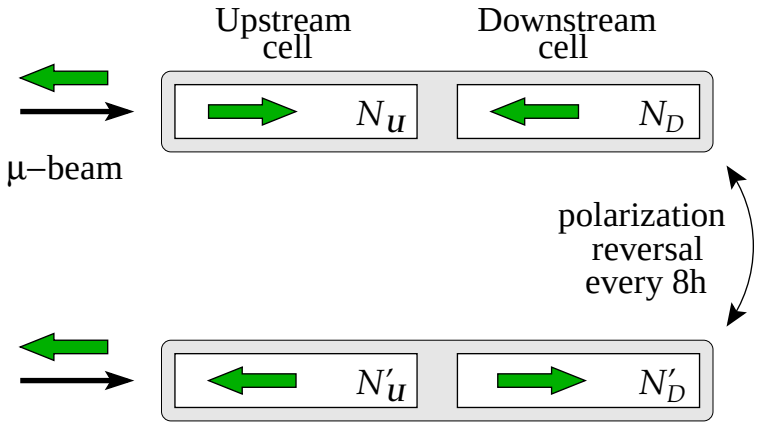


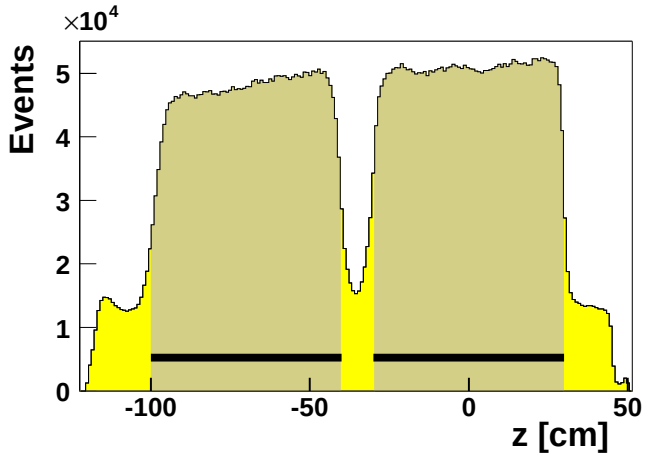


Semi-Inclusive DIS

- Detected particle: μ, μ', h, ...
- $A_1^h = \dfrac{\sum_q e_q^2(\mathbf{\Delta q(x)} \int \mathbf{D_q^h dz} + \mathbf{\Delta \bar{q}(x)} \int \mathbf{D_{\bar{q}}^h dz})}{\sum_q e_q^2(q(x) \int D_q^h dz + \bar{q}(x) \int D_{\bar{q}}^h dz)}$
- $D_q^h \neq D_{\bar{q}}^h \Rightarrow$ quarks and anti-quarks separation

Measurement of asymmetry





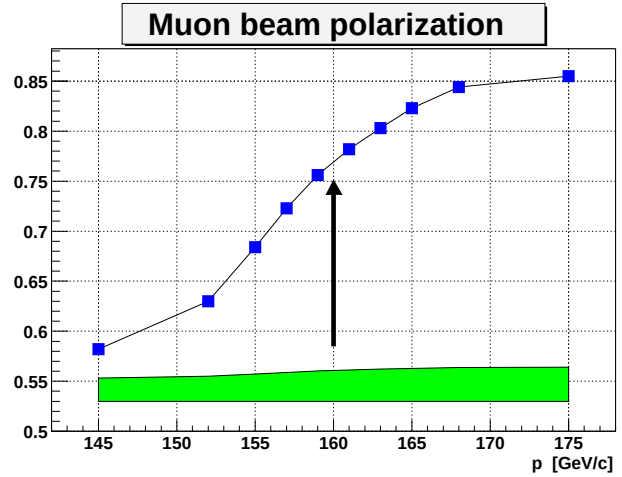
- Polarization reversal every 8 hours to cancel systematics due to day-night effects.
- To get rid of the influence of geometrical acceptance data with opposite polarization are combined

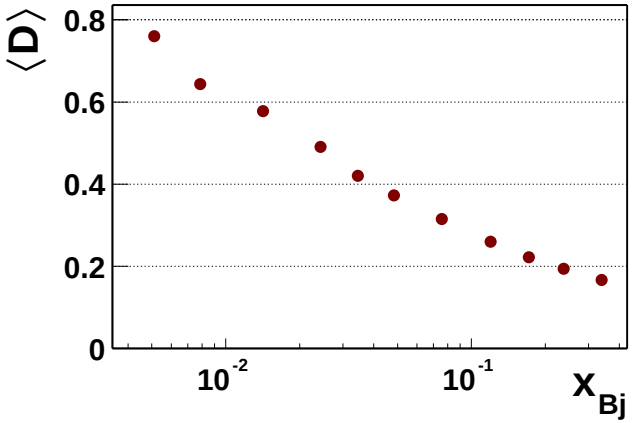
$$A^{\mu N} = \frac{1}{2}\left(\frac{N_U - N_D}{N_U + N_D} - \frac{N'_U - N'_D}{N'_U + N'_D}\right)\frac{1}{P_t P_b f}$$

- To account for the detector instability groups of runs which are close in time are combined together
- Events are weighted with $w = fDP_b$ what gives decrease of statistical error $\sim 10\%$.

Parameterization of beam polarization

- MC simulation of the beam line
- momentum range: $[140, 180]$ GeV/c.
- systematics uncertainty is 3%
- Average polarization is 76%





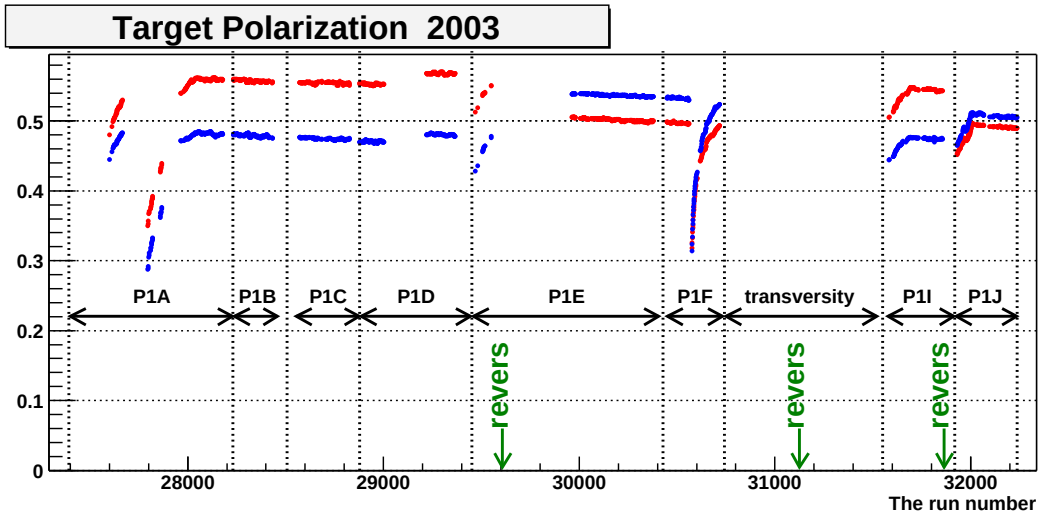
Depolarization Factor

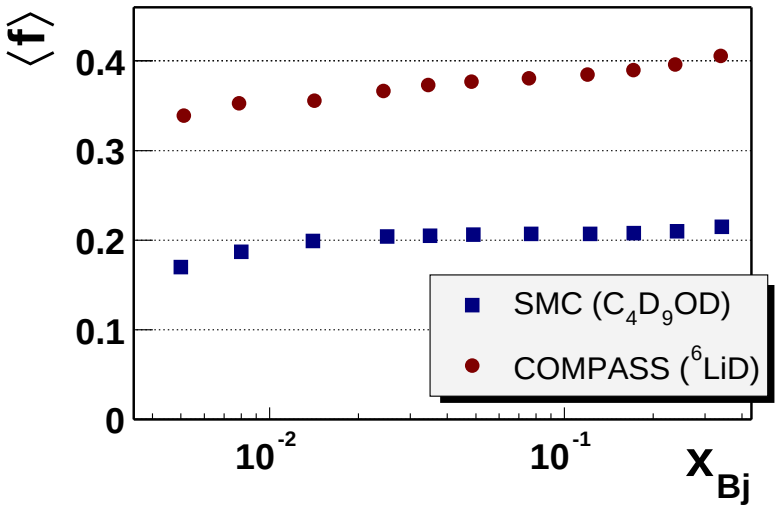
- it accounts for polarization transfer from μ to virtual photon

$$D \simeq \frac{y(2-y)}{2-2y+y^2}$$

Target polarization

$$P_t = \frac{\sum^{runs} |P_u| N_u + \sum^{runs} |P_d| N_d}{\sum^{runs} N_u + \sum^{runs} N_d}$$





Dilution Factor f

- it gives the fraction of polarized material in the target

$$f = \frac{n_d \sigma_d}{n_d \sigma_d + \sum_A n_A \sigma_A}$$

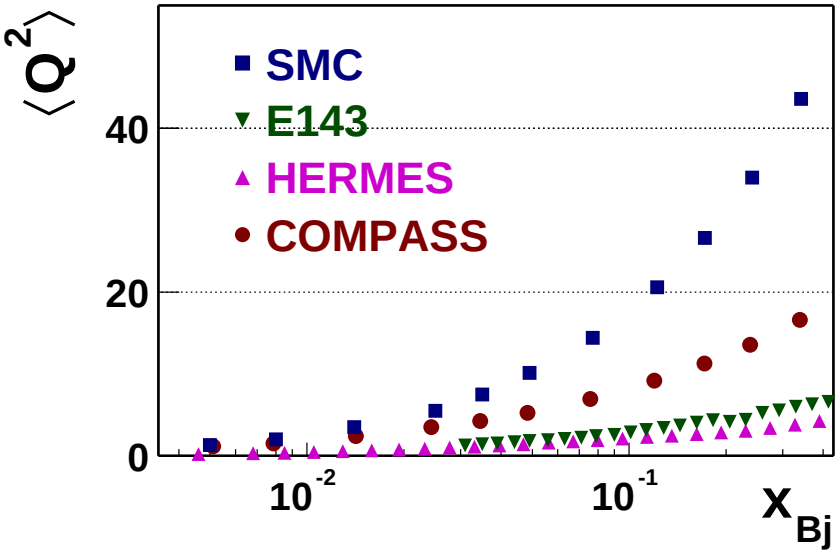
- Naive: ^{6}LiD$\approx$ 2D + $\alpha \Rightarrow f \approx 0.5$

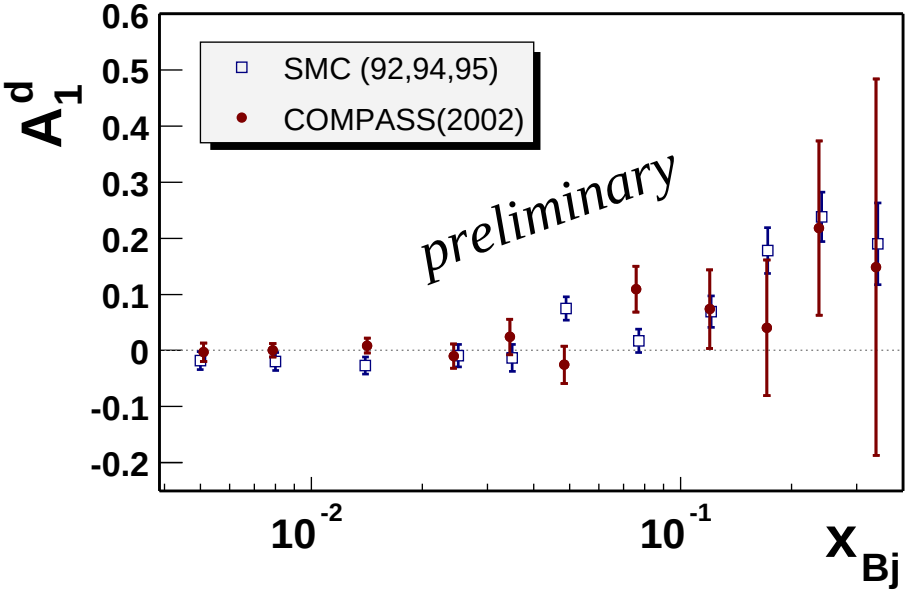
Inclusive Asymmetry A_1

- No hadron tagging

$$A_1 = \frac{\sum_q e_q^2(\mathbf{\Delta q(x) + \Delta \bar{q}(x)})}{\sum_q e_q^2(q(x) + \bar{q}(x))}$$

- Data of 2002 are shown
- $6.5 \cdot 10^6$ DIS events
- COMPASS/SMC beam time is $\sim 1/7$





Kinematics cuts:

- $0.1 < y < 0.9$
- $Q^2 > 1\ \mathrm{GeV}^2/c^2$

Kinematics range: $0.003 < x_{Bj} < 0.4$

Semi-inclusive asymmetries

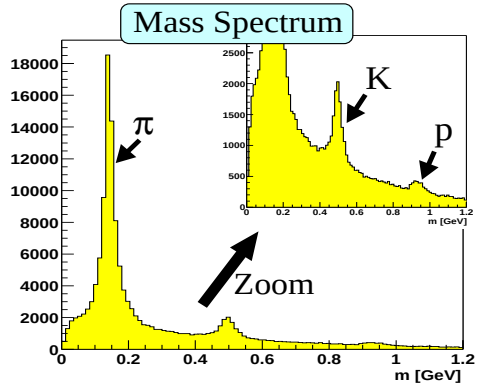
Asymmetries which we measure

$$\vec{A}_1 = \{ A_1, A_1^{h+}, A_1^{h-}, A_1^{K+}, A_1^{K-}, A_1^{K_S^0} \}$$

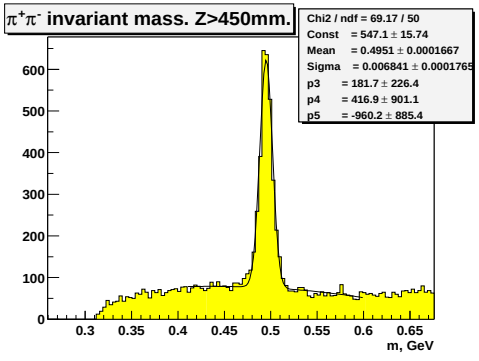
Inclusive Asymmetry

90% of hadrons are pions

RICH PID
Threshold: p_K>9 GeV



Secondary vertices produced by track coming from interaction point



Extraction of parton densities Δq

- Asymmetries which we measure:

$$\vec{A}_1 = \{A_1,\ A_1^{h+},\ A_1^{h-},\ A_1^{K+},\ A_1^{K-},\ A_1^{K^0_S}\}$$

- $A_1^h = \dfrac{\sum_q e_q^2(\mathbf{\Delta q(x)} \int D_q^h dz + \mathbf{\Delta \bar{q}(x)} \int D_{\bar{q}}^h dz)}{\sum_q e_q^2(q(x) \int D_q^h dz + \bar{q}(x) \int D_{\bar{q}}^h dz)}$ can be rewritten in matrix form as:

$$\boxed{\vec{A}_1 = \mathcal{B}(q(x), D_q^h(z)) \cdot \vec{\Delta q}}$$

- Deuteron is isoscalar ($u^p = d^n$, $d^p = u^n$) $\Rightarrow$ limited flavor separation:

$$\vec{\Delta q} = \{\Delta u + \Delta d, \Delta \bar{u} + \Delta \bar{d}, \Delta s\}$$

  assuming $\Delta s = \Delta \bar{s}$

- If combined with data from *proton* target **full** flavor separation is possible:

$$\vec{\Delta q} = \{\Delta u, \Delta \bar{u}, \Delta d, \Delta \bar{d}, \Delta s, \Delta \bar{s}\}$$

Summary

- The first results on inclusive asymmetry A_1 with statistics of 2002 have been shown.
- Release of asymmetries A_1, A_1^{h+}, A_1^{h-} for statistics of 2002+2003 at the beginning of October.
- A_1^{K+}, A_1^{K-}, $A_1^{K_S^0}$ in progress.
- A lot of data to be analyzed
  - DST is produced for 2002, 2003
  - Data taking of 2004 is about finished
- Good perspective and upgrade of spectrometer after 2005.