Recent results on Polarized Quark and Gluon Distributions at COMPASS

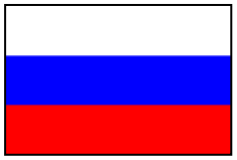
I.Savin, JINR, Dubna
on behalf of the COMPASS Collaboration

Outline

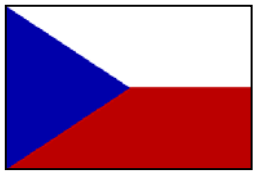
1. Introduction.
2. COMPASS status and data taking in 2002 and 2003.
3. Preliminary results on:
   - A_1^d
   - Δq,
   - ΔG from D° and high-Pt pairs,
   - transversity,
   - Λ and $\overline{\Lambda}$ polarizations.
4. Summary.

(230 Physicists from 12 Countries)

Dubna (LPP and LNP), Moscow (INR, LPI, State University), Protvino



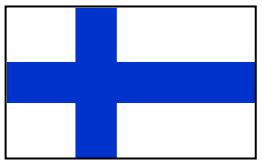
CERN



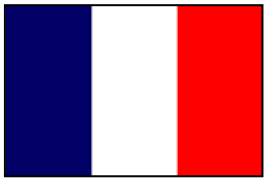
Prag

Lisboa

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



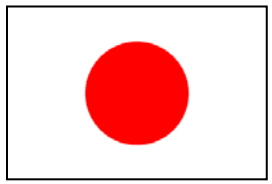
Helsinki



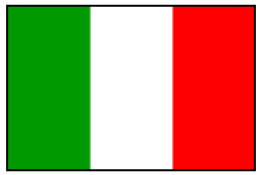
Saclay

Burdwan, Calcutta

Warsaw (SINS), Warsaw (TU)



Nagoya



Torino(University,INFN), Trieste(University,INFN)

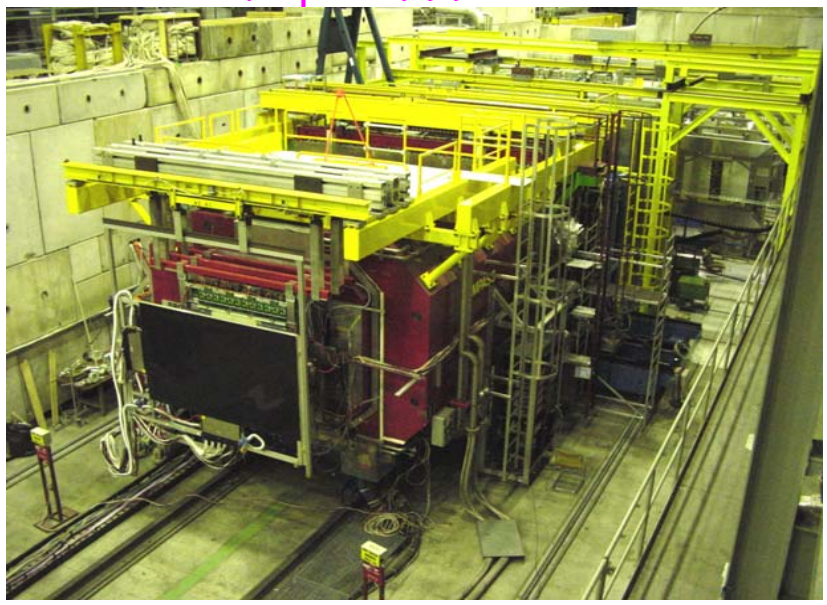
Tel Aviv

COMPASS: COmmon Muon and Proton Apparatus for Structure and Spectroscopy - the new fixed target facility at CERN !

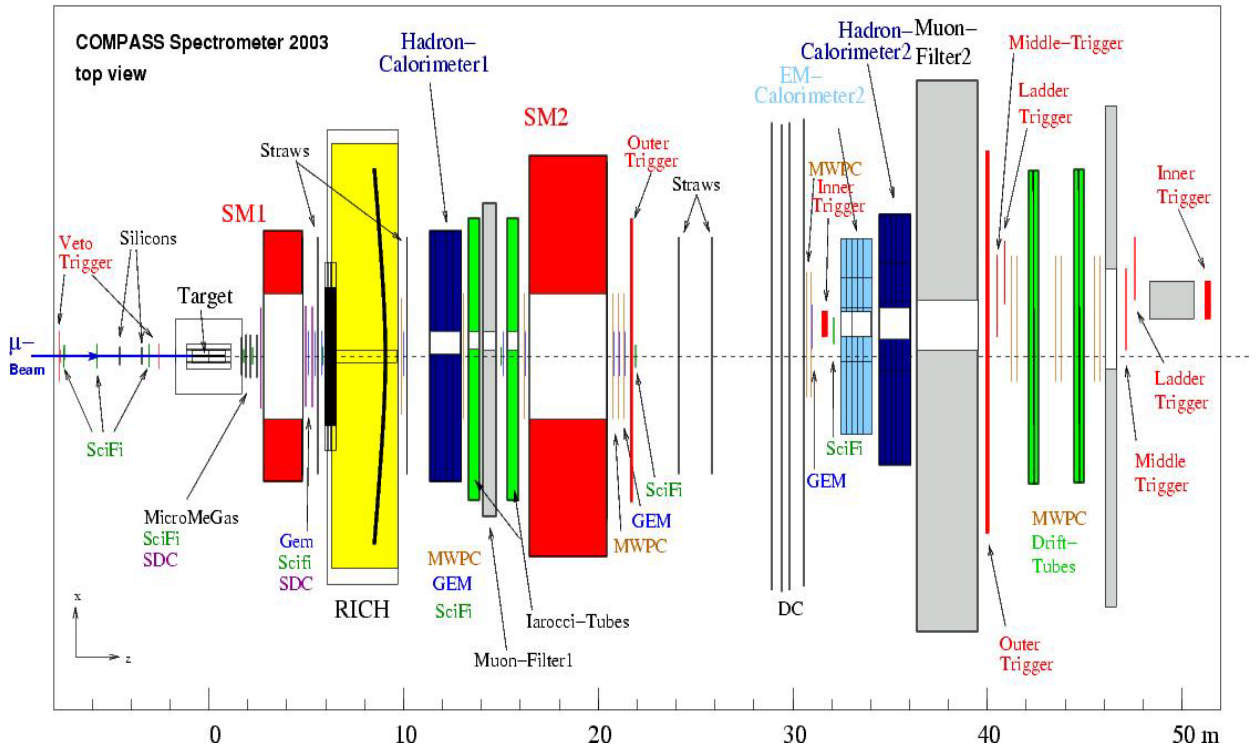
- 1996 COMPASS proposal
- 1997 conditional approval
- 1998 MoU
- 1999 – 2001 construction & installation
- 2001 technical run
- 2002, 2003, 2004 data taking
- in long range planning @CERN at least until 2010

26. June 1998

8. April 1999



COMPASS LAYOUT

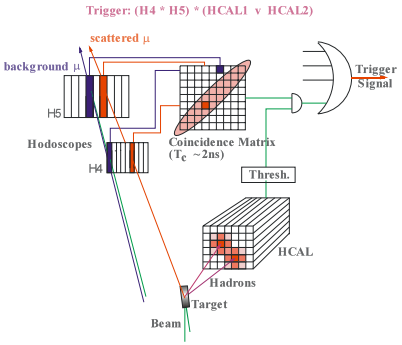


Double arm spectrometer, each with own magnet (SM1 and SM2), various trackers and PID for muons, electrons and hadrons

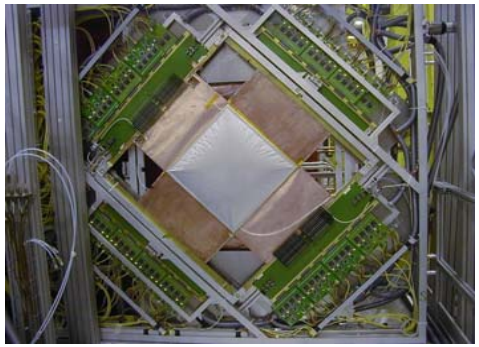
Beam: $2 \cdot 10^8$ μ^+/ spill (4.8s / 16.2s) **Beam momentum:** 160 GeV/c

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

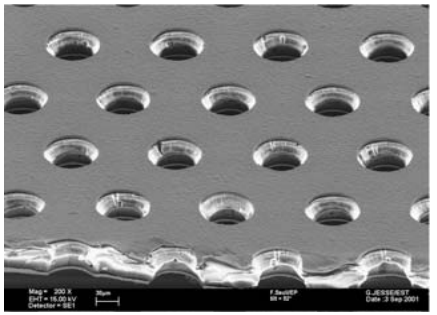
New technologies



Trigger-System

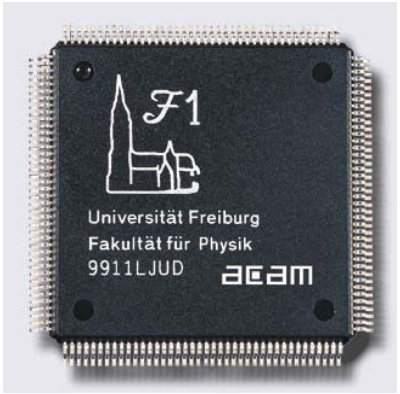


MicroMegas

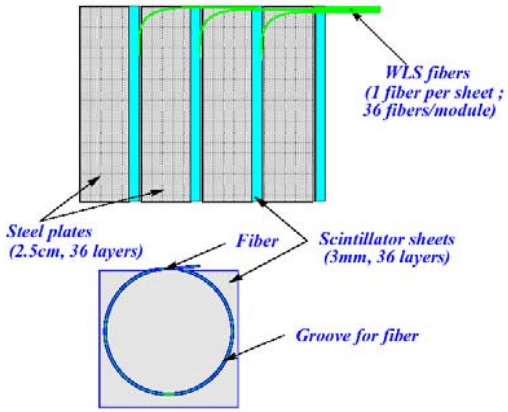


GEM

Straws



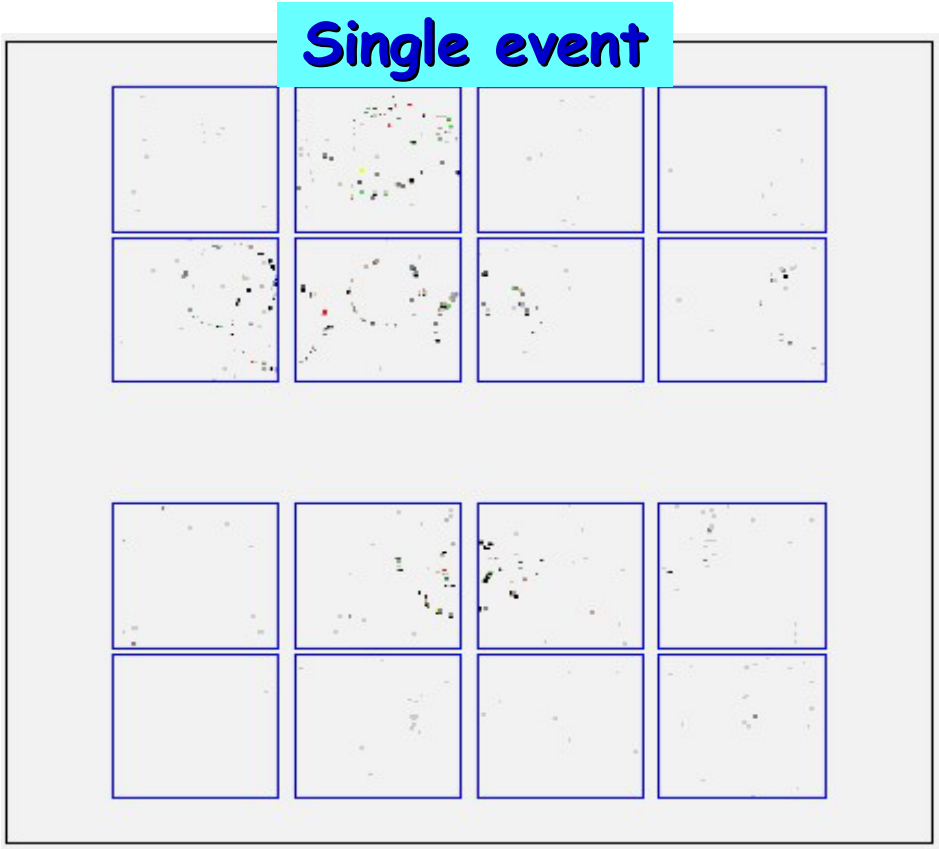
Readout electronics

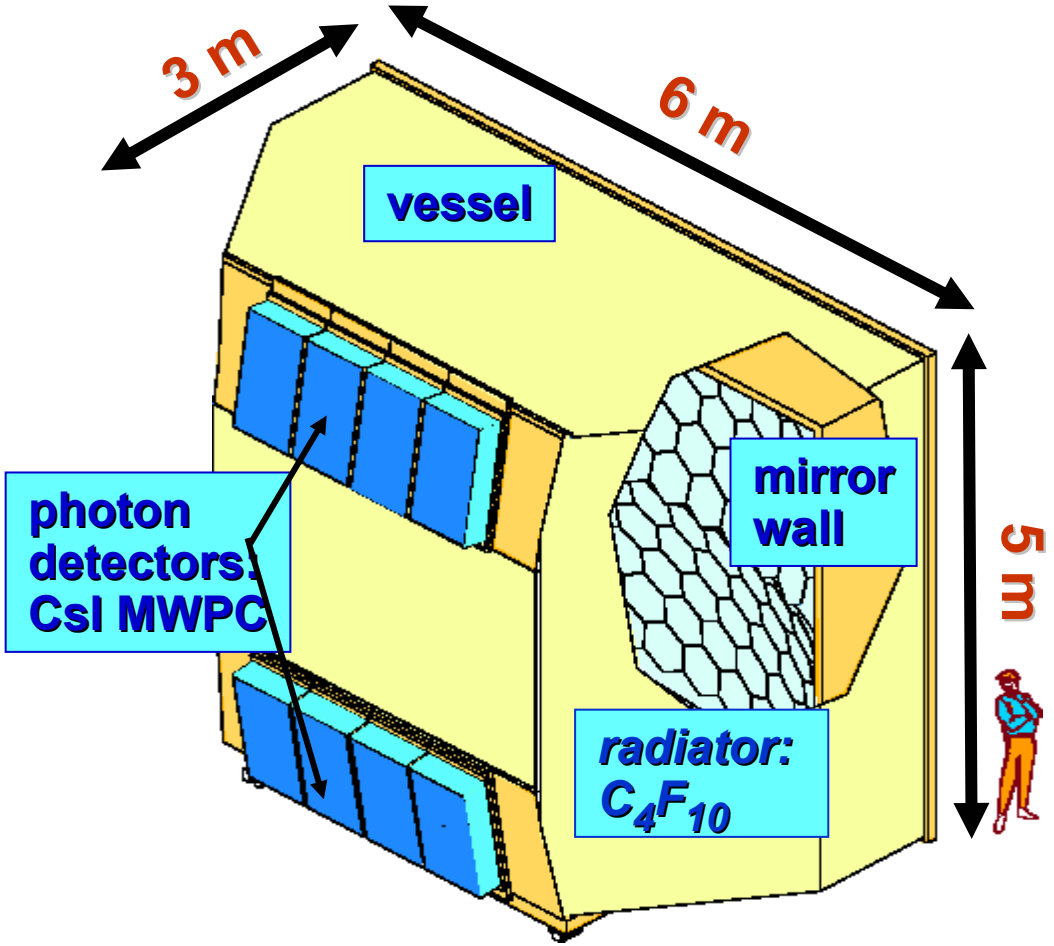


Calorimeter readout

Scintillating fiber trackers

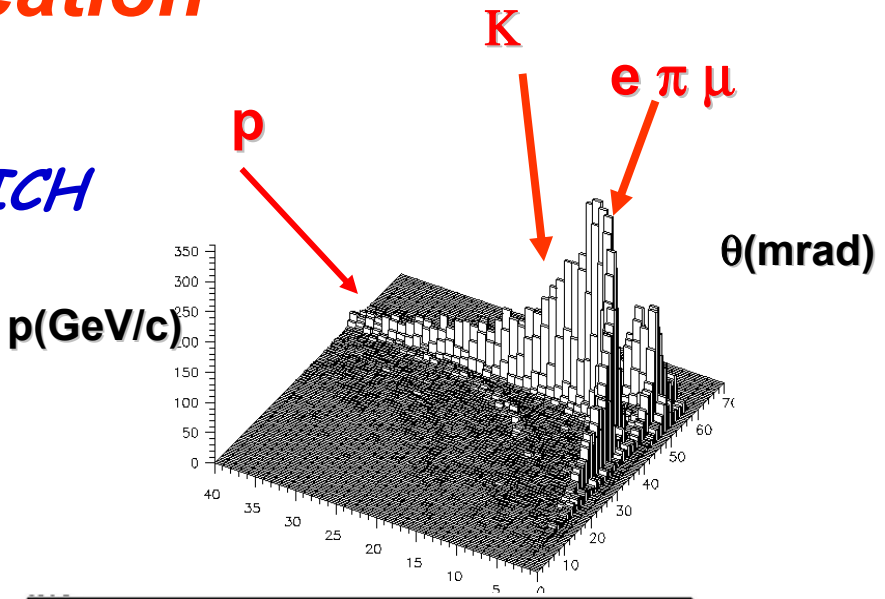
Ring Imaging CHerenkov Counter (RICH)



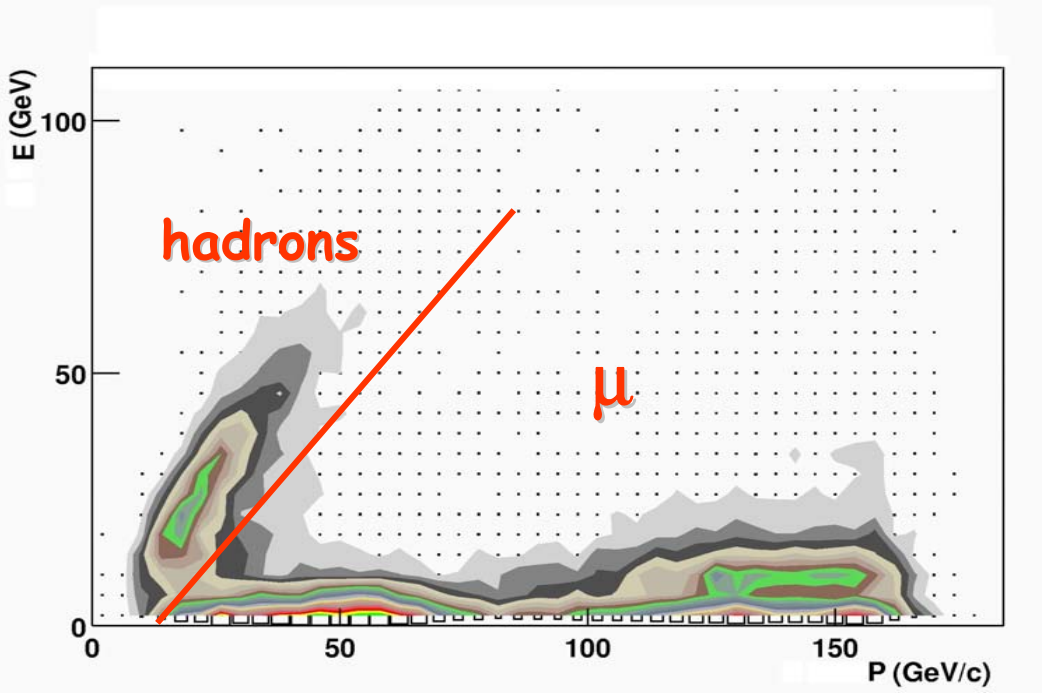


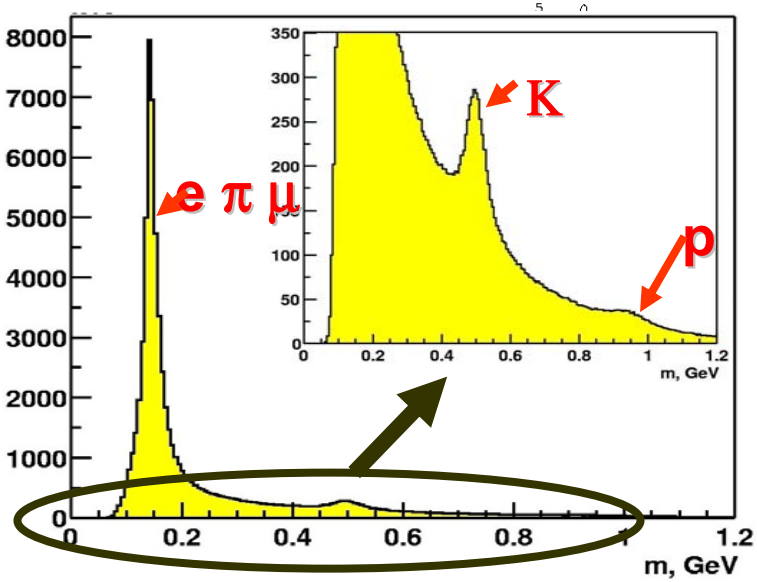
Hadron Identification

By RICH

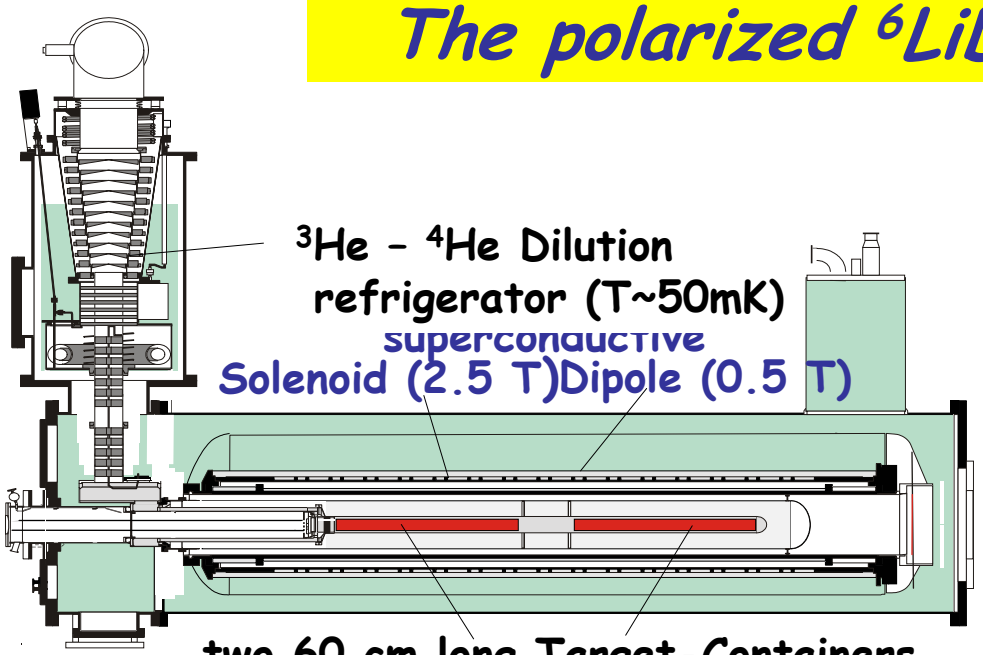


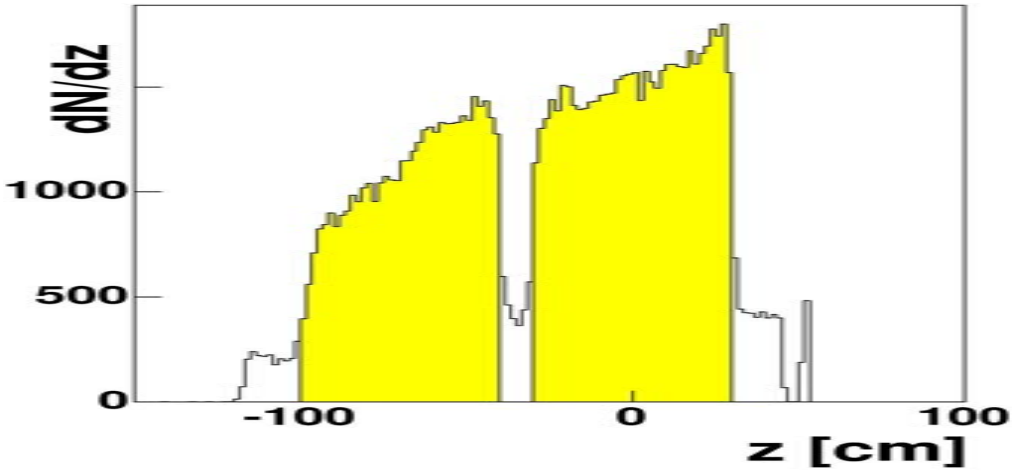
...and hadron calorimeters



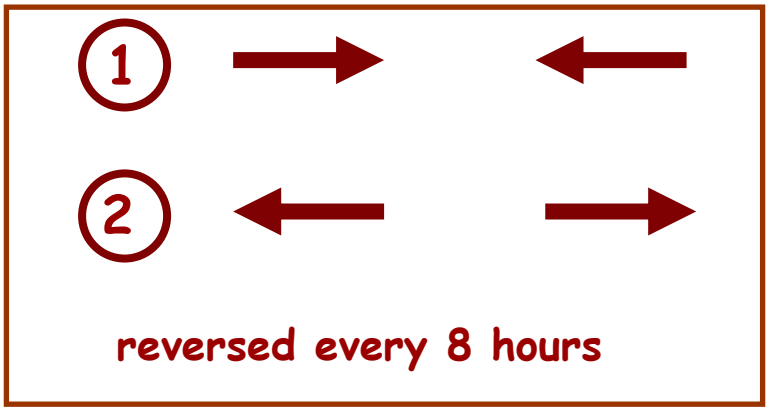


The polarized ^{6}LiD-Target

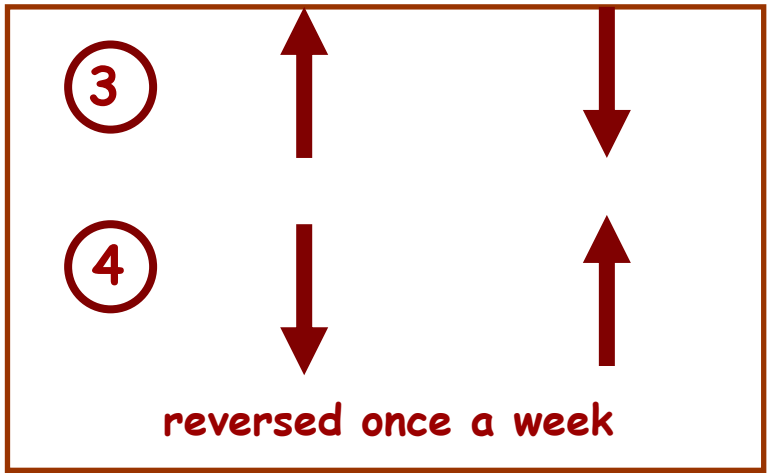




4 possible spin combinations:



or:



Polarization: ~50%

COMPASS physics goals

nucleon spin structure

- **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

Continuation of spin physics studies initiated at CERN by the EMC and SMC

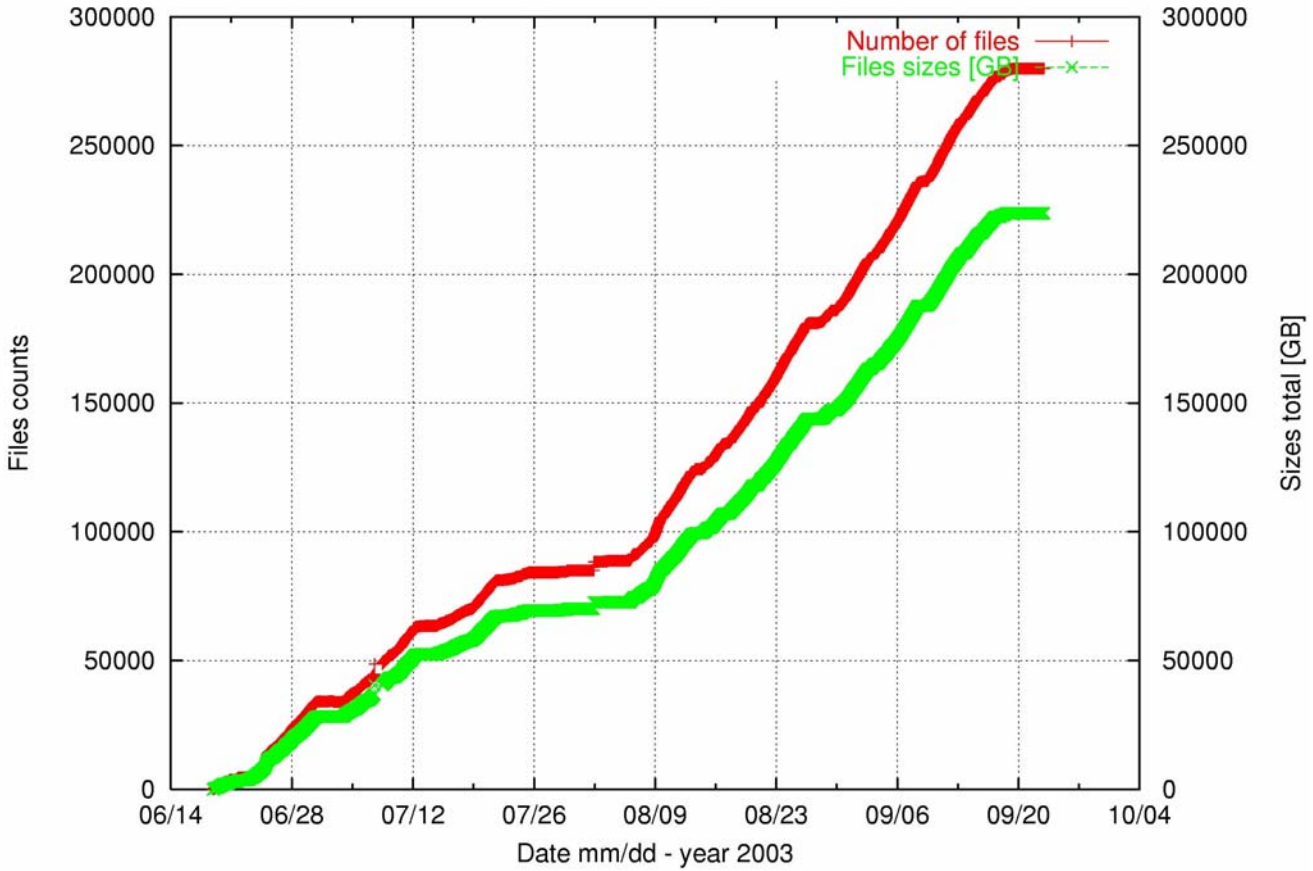
nucleon spectroscopy

- Primakoff-Reactions
  - polarizability of π and K
- glueballs and hybrids
- charmed mesons and baryons
  - semi-leptonic decays
  - double-charmed baryons

DATA TAKING IN 2002-2004 FOR SPIN PHYSICS

2002 & 2003:

- 500 TByte Data
- 10^{10} Events
  longitudinal polarization
- $3 \cdot 10^{9}$ Events
  transverse polarization
- 0.1% with $Q^2 > 1$ $(GeV/c)^2$
  (after all cuts)

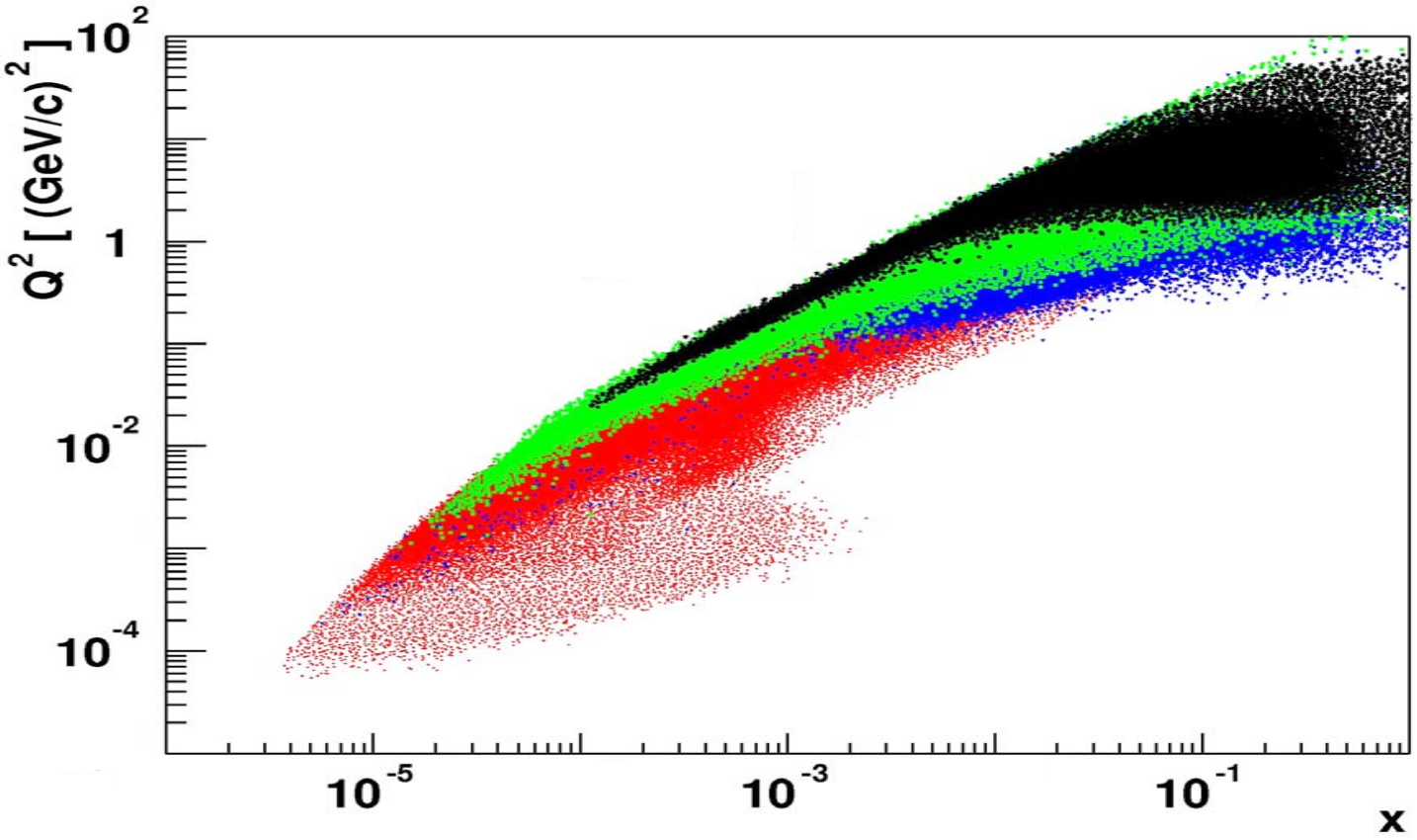


2002: 80 days, 80% eff. spectrometer&beam

2003: 100 days, 80% eff. spectrometer. 60% beam 5 billions events on tapes per year

2004: in progress.

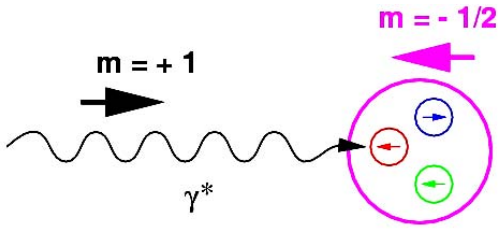
COMPASS Acceptance

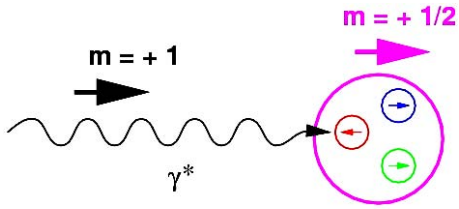


Excellent for non-perturbative & perturbative physics

- *small x_{Bj}*
- *very small Q^2 → $Q^2 > 100\ (GeV/c)^2$*

Virtual Photon-Deutron Asymmetry





$$\sigma_{1/2} \sim \sum_i e_i^2 q_i^+ \qquad \sigma_{3/2} \sim \sum_i e_i^2 q_i^-$$

$$A_1 = \frac{\sigma_{1/2}{}^- \sigma_{3/2}}{\sigma_{1/2}{}^+ \sigma_{3/2}} \approx \frac{\sum_i e_i^2 \left(q_i^+ - q_i^-\right)}{\sum_i e_i^2 \left(q_i^+ + q_i^-\right)}$$

$$g_1(x) = \tfrac{1}{2} \sum_i e_i^2 \left(q_i^+ - q_i^-\right)$$

$$F_1(x) = \tfrac{1}{2} \sum_i e_i^2 \left(q_i^+ + q_i^-\right)$$

$$A_1(x) \approx \frac{g_1(x)}{F_1(x)}$$

REMIND: precision data on g_1 are needed for QCD analysis, Δq and ΔG

Virtual Photon Deuteron Asymmetry

COMPASS:

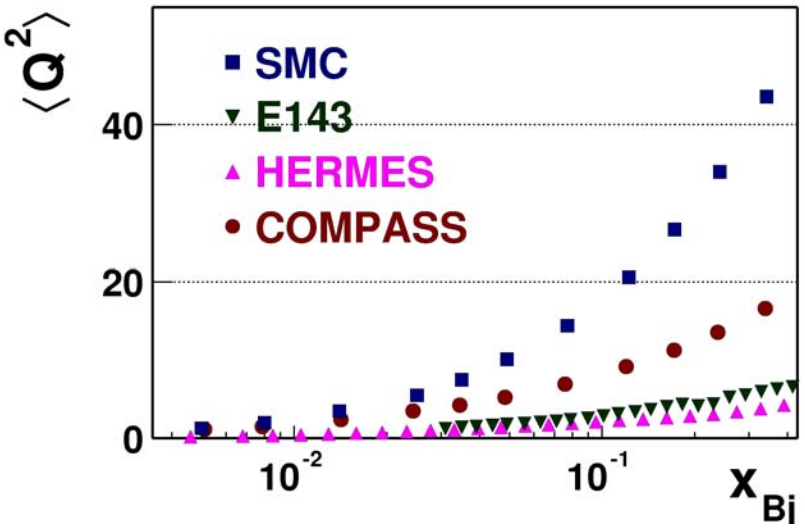
- 2002 data only

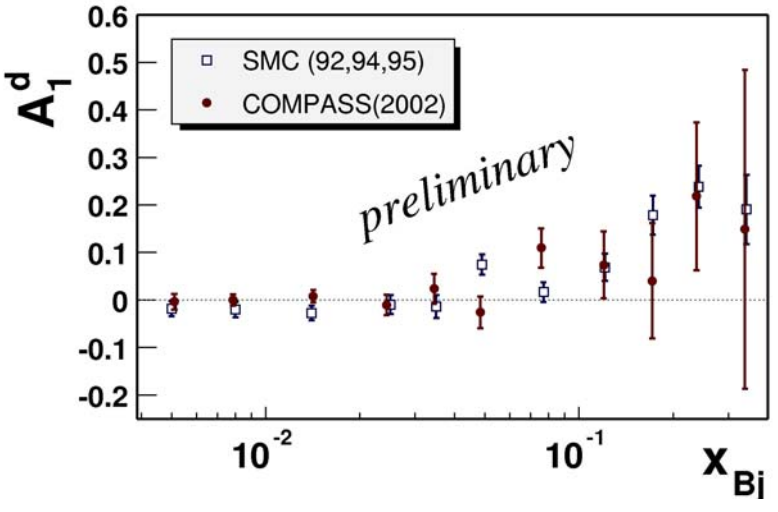
  6.5 Million DIS events

  $Q^2 > 1\ (GeV/c)^2$
  $0.1 < y < 0.9$

expect *4 statistics
by end of 2004

(Data displayed at experimental $\langle Q^2 \rangle$ of every x_{Bj} bin)





GLUON CONTRIBUTION TO THE NUCLEON SPIN

Can be determined:

- From QCD analysis of structure functions $g_1^p(x,Q^2), g_1^n(x,Q^2)$

(remind

SMC: $\Delta G(1GeV^2) = 0.99^{+1.17}_{-0.31}\ {}^{+0.42}_{-0.22}\ {}^{+1.43}_{-0.45}$

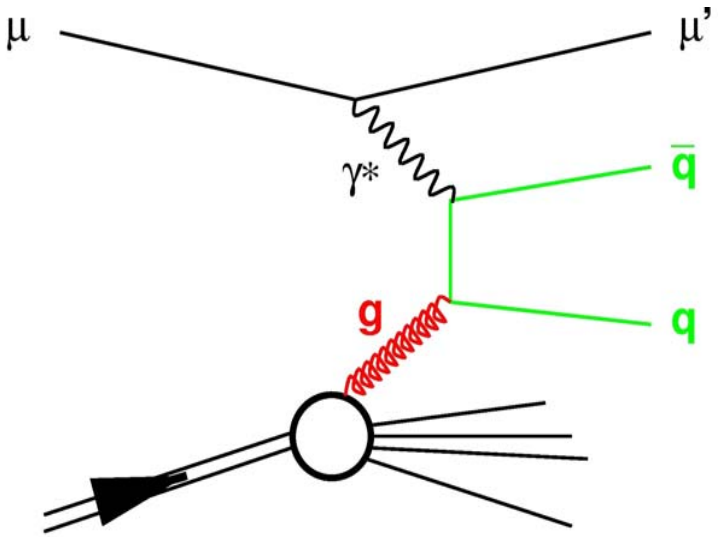
stat syst th

E155: $\Delta G(5GeV^2) = 1.6 \pm 0.8 \pm 1.1$)

- From SIDIS reactions on polarized targets induced by Photon-Gluon Fusion (PGF), particularly:

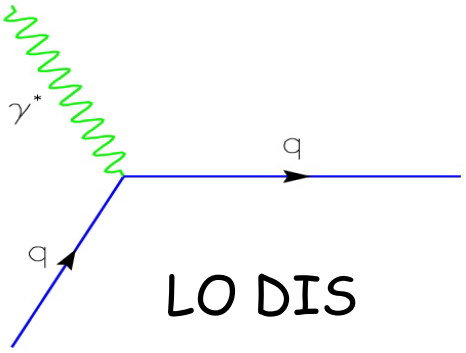
  - production of charmed or strange particles,
  - hadron pairs with high P_T

PGF diagram

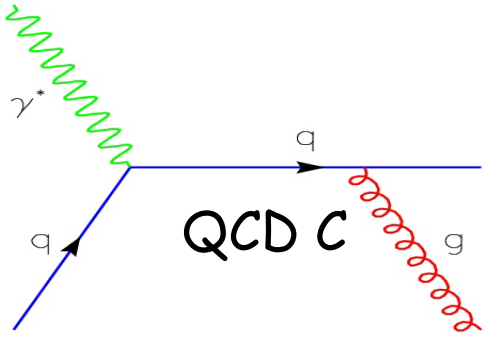


q=c: open charm

q=u,d,…: high p_T pairs



LO DIS



QCD C

Background for high p_T pairs

Asymmetry for high p_T pairs

$$A^{\gamma^* d} = -0.065 \pm 0.036 \pm 0.010 \text{ (syst)}$$

↑

experimental
false asymm.

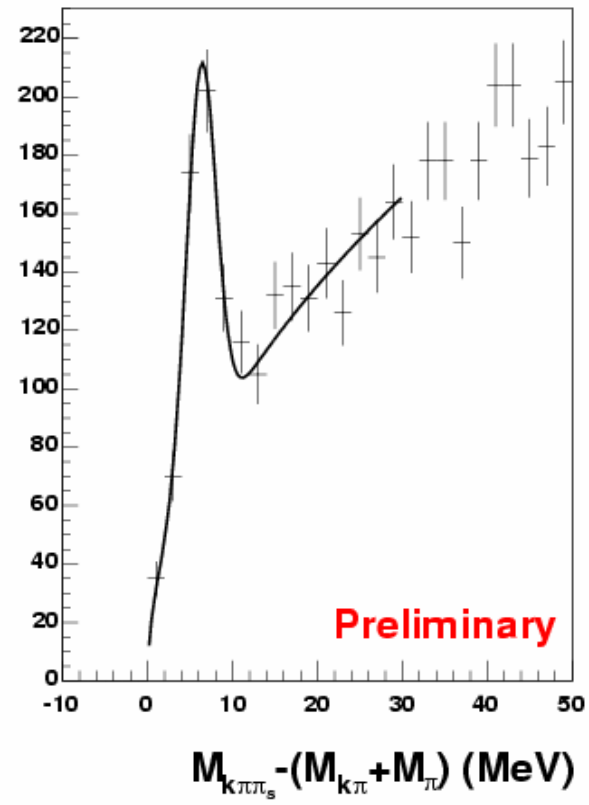
MC studies are needed to subtract the background before estimations of $\Delta G/G$. But assuming R_PGF~1/4:

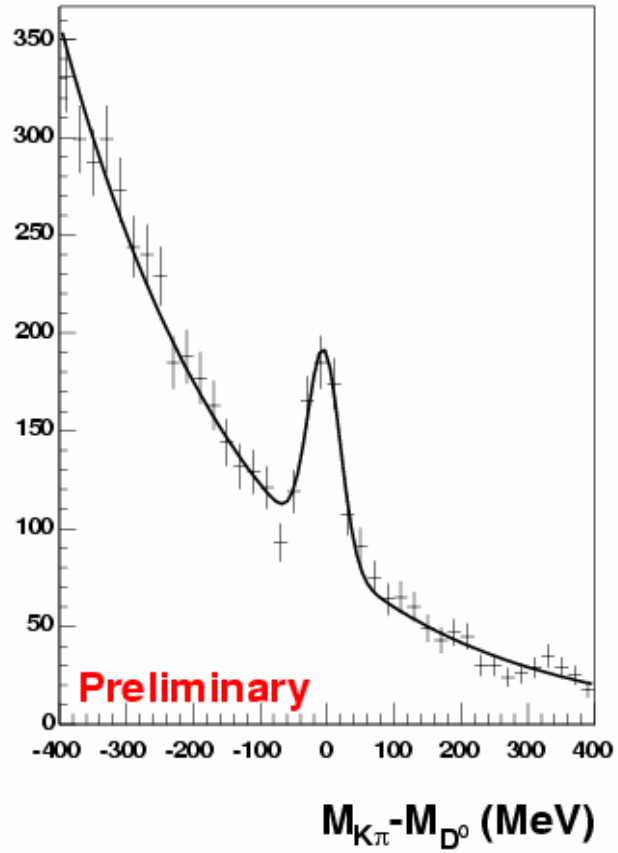
$\sigma(\Delta G/G) \sim 0.17$

… $\Delta G > 0$.

Open charm reconstruction

•Part of the 2002 data:

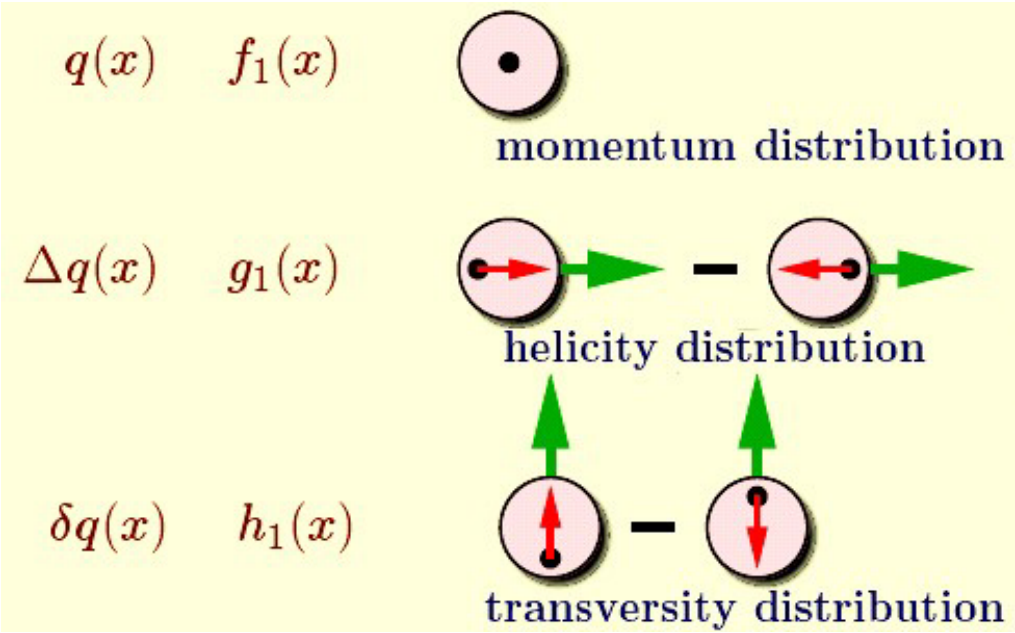




•2002-2004 data prospects: $\sigma(\Delta G/G) \approx 0.25$

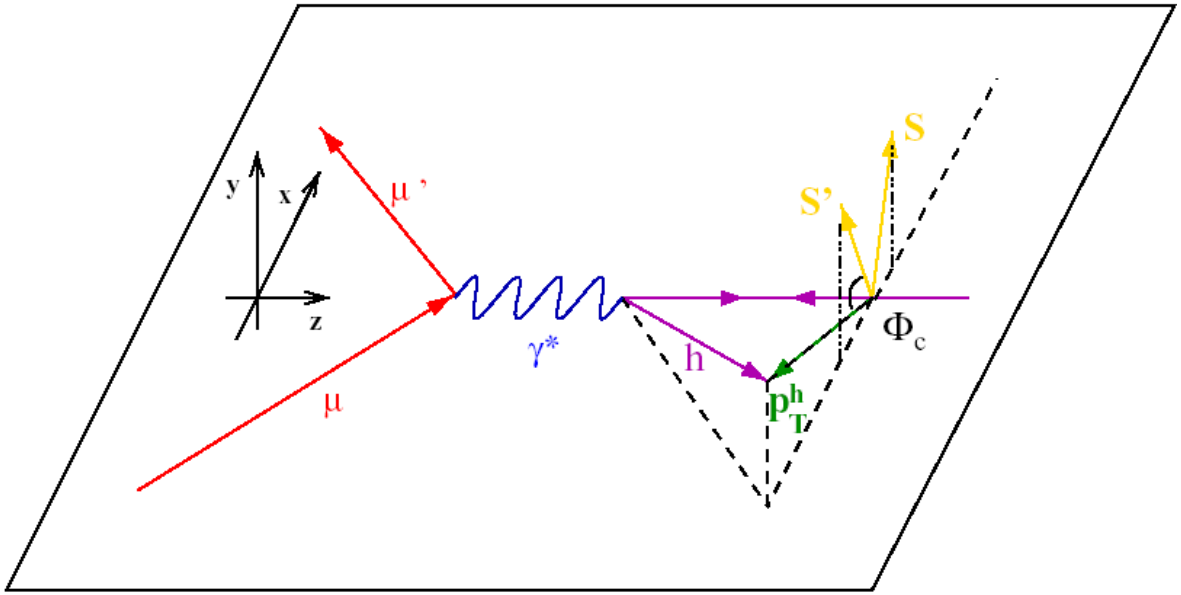
Transverse Spin Physics

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



$h_1(x)$ can be accessed via SIDIS $\mu + \vec{N} \rightarrow \mu' + h + X$

Access to h_1



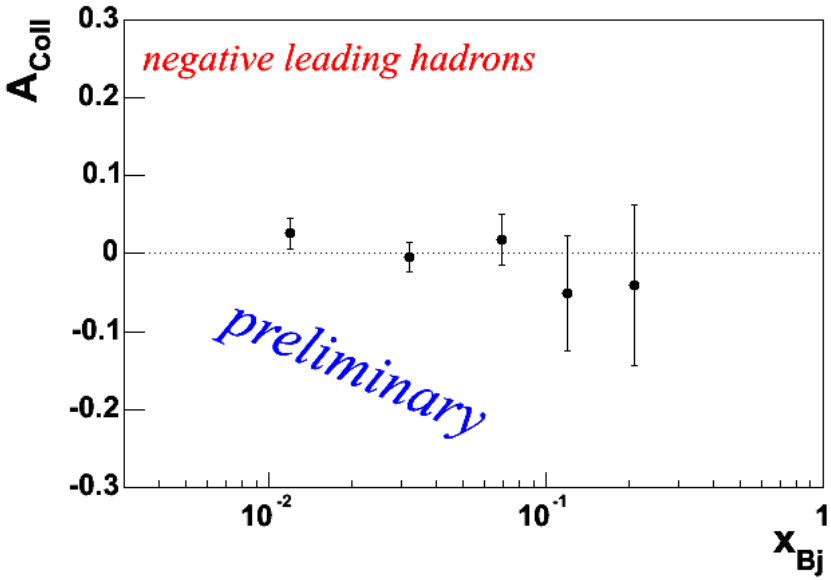
$$\Phi_C = \Phi_h - (\pi - \Phi_S)$$

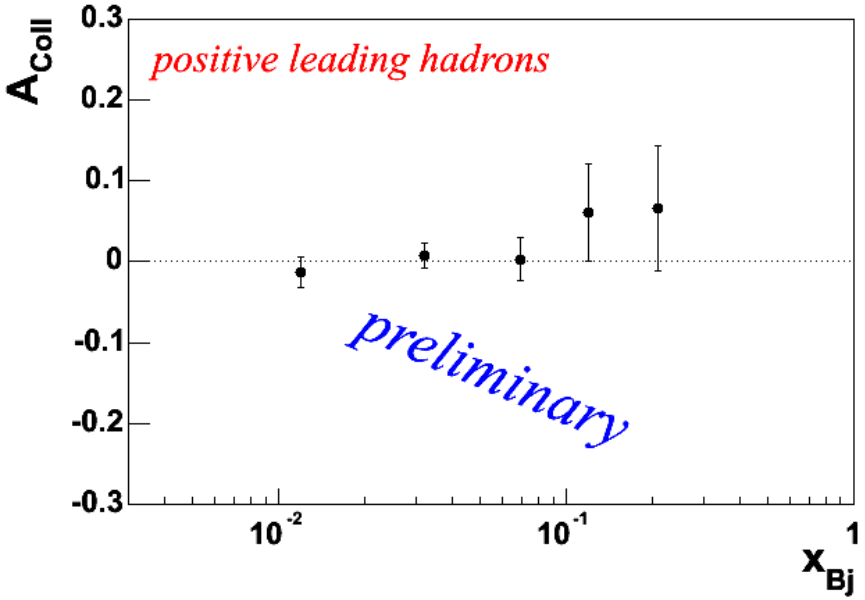
$$N_{\uparrow\downarrow}(\Phi_C) \propto (1 \pm coeff.H(x,z)\sin\Phi_C)$$

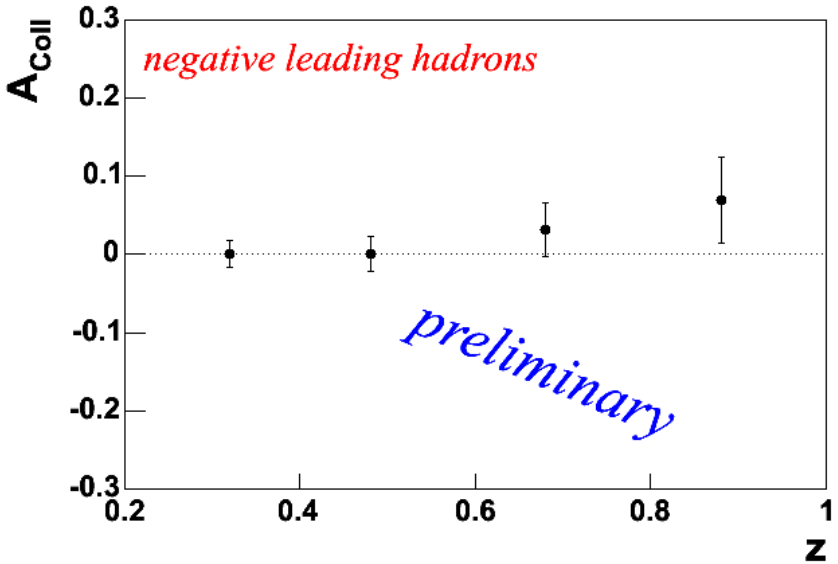
$$H(x,z) \propto h_1(x) \cdot H_1^{\perp}(z),$$

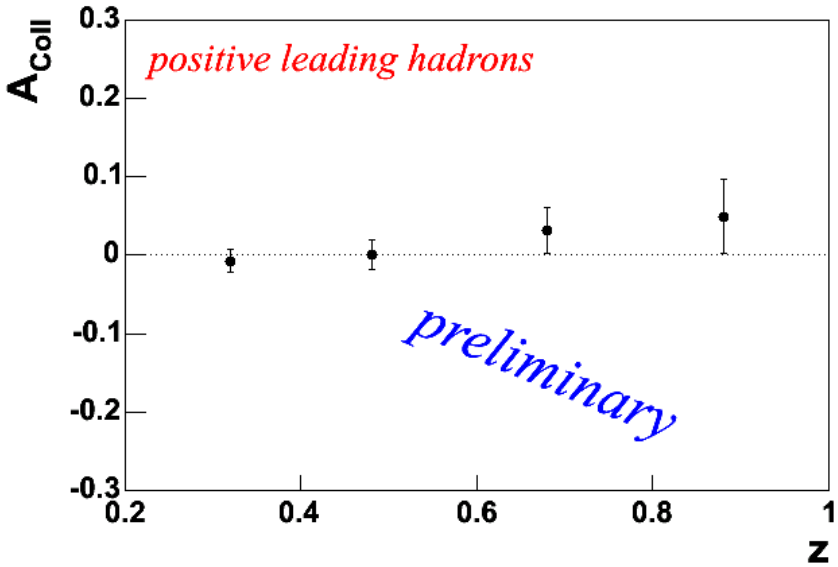
$H_1^{\perp}(z)$ - Collins PFF

First Results on Collins Asymmetries









Summary

- **DIS & SIDIS:**
  COMPASS will cover the small-x range to x=0.003 @ $Q^2>1$ $(GeV/c)^2$
  with > fourfold statistics of SMC
- **High-p_T:**
  First results from COMPASS on deuterons
- **Open charm:**
  possibility for D^0 reconstruction in massive target demonstrated
  → collect more statistics
- **Transversity:**
  first measurement of Collins Asymmetry on
  transverse polarized deuteron target
- $\Lambda \& \overline{\Lambda}$ **production:**
  extraction of spin transfer on its way
- **Many other channels are in progress.**

COMPASS IS ON GOOD TRACK TO ACCOMPLISH ITS GOALS