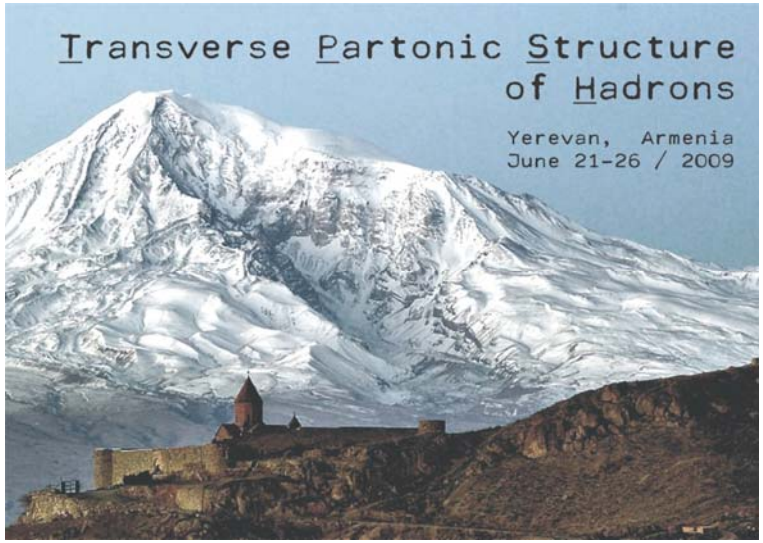
Future Measurements of Transverse Spin Effects in SIDIS at COMPASS



Anna Martin

Trieste University and INFN

on behalf of the COMPASS Collaboration

outlook

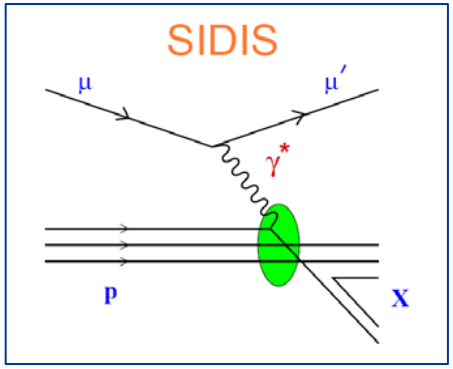
- **COMPASS: a very short reminder**

for a review of all results on transverse spin / momentum effects
see F. Bradamante talk on Monday

- **COMPASS plans for Transverse SSA measurements in SIDIS**

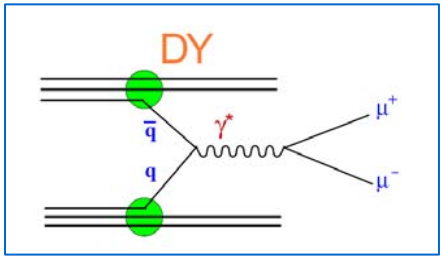
Transverse Spin Structure of the Nucleon

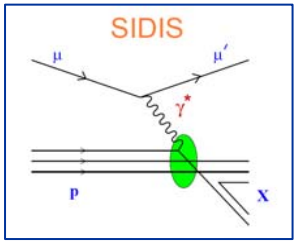
international effort



SIDIS: HERMES at DESY
COMPASS at CERN
spin experiments at JLab

hard pp scattering: spin experiments at RHIC / BNL





and several future projects:

COMPASS at CERN
experiments at JParc / KEK
Panda and PAX at FAIR / GSI
Nica at JINR
SPASCHARM at IHEP

eRHIC, ELIC
ENC at FAIR

COMPASS

fixed target experiment
at the CERN SPS

broad physics programme:

- **nucleon spin structure**
  SIDIS with high energy muon beam
  and L and T polarised targets
- **hadron spectroscopy**
  with high energy hadron beams

COMPASS

fixed target experiment
at the CERN SPS

data taking since 2002:

muon beam
160 GeV

- **deuteron** (^{6}LiD) **polarised target**
  - **2002** **L/T target pol.** 4:1
  - **2003**
  - **2004**
  - ***2006*** ***L target pol.***
- **proton** (NH_3) **polarised target**
  - **2007** **L /T target pol.** 1:1

hadron beam **LH target**

- **2008**
- **2009**

COMPASS – muon beam set-up

high energy beam, large angular acceptance and kinematical range

two stages spectrometer

Large Angle Spectrometer (SM1), Small Angle Spectrometer (SM2)

variety of tracking detectors

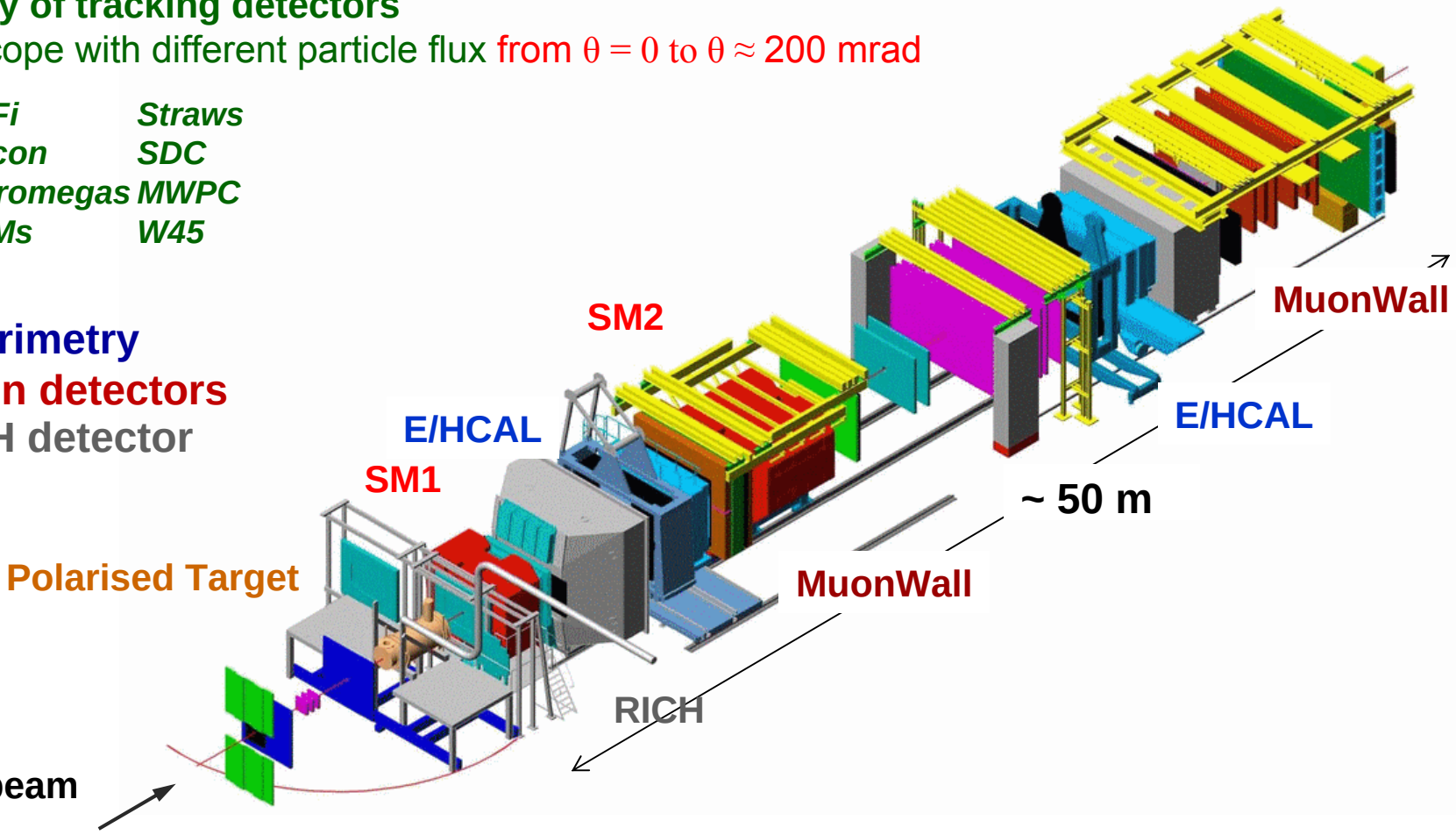
to cope with different particle flux from $\theta = 0$ to $\theta \approx 200$ mrad

SciFi	*Straws*
Silicon	*SDC*
Micromegas	*MWPC*
GEMs	*W45*

calorimetry

muon detectors

RICH detector



COMPASS results - muon beam

SIDIS on transversely polarized proton and deuteron (unique)

important results on

- **Collins asymmetry** ⇦
- **2 hadron asymmetry**
- **Λ polarization**
- **Sivers asymmetry** ⇦
- **other TMD asymmetries**
- **unpolarised azimuthal asymmetries**
- **exclusive ρ asymmetries**

see F. Bradamante talk on Monday

here just a reminder

COMPASS results - Collins asymmetry

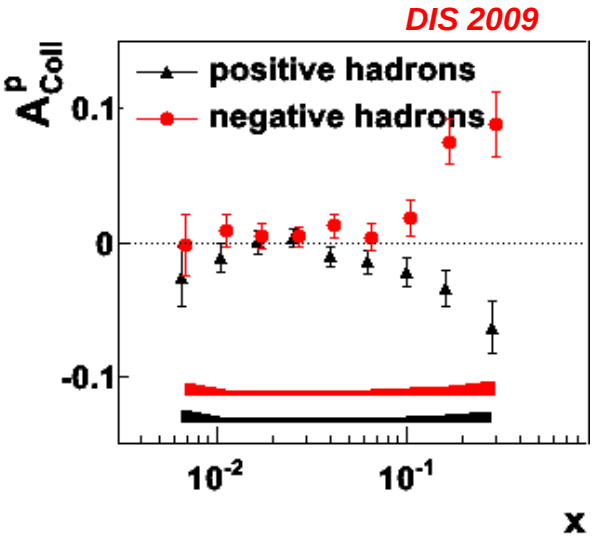
- **deuteron**: final results from all 2002-2004 data

  asymmetries compatible with zero over the whole x range (0.004- 0.5)

  → cancellation between u and d quark in the deuteron

- **proton**: preliminary results from all 2007 data:

  large signal (~ same strength than HERMES) in the valence region



also, preliminary results for the 2 hadron asymmetry: large signal

(~ 3 x HERMES measured value)

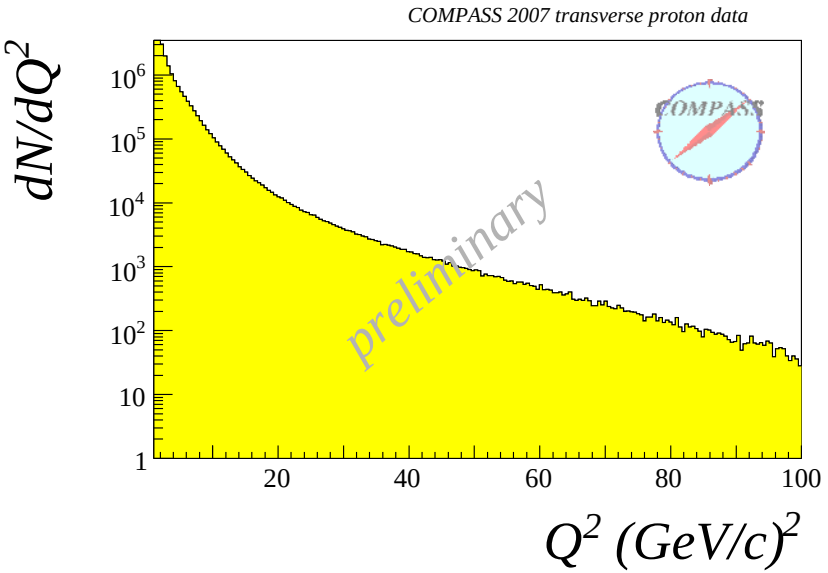
an important and not obvious result,

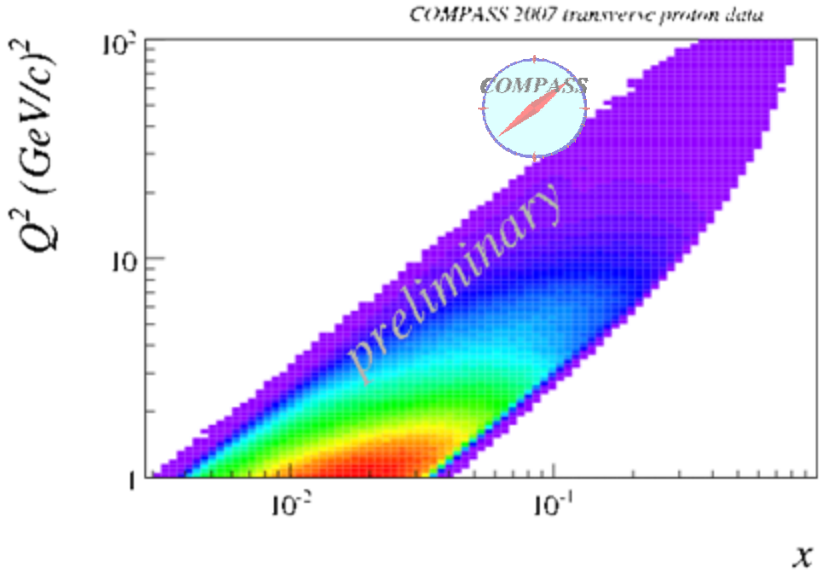
given the different energies of HERMES and COMPASS and consequently the different Q^2 values in the valence region

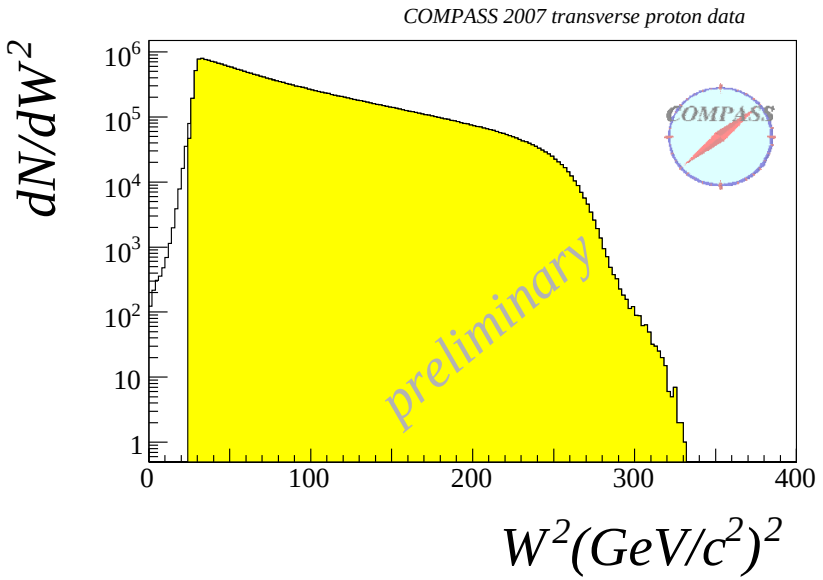
SIDIS kinematics

COMPASS

- **160 GeV muons**
- **W>5 GeV/c²**
- **0.1<y<0.9**



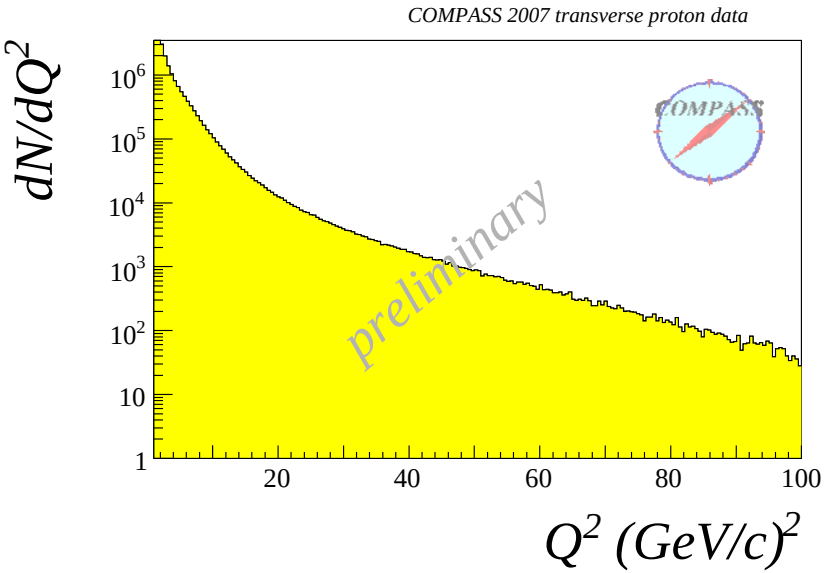




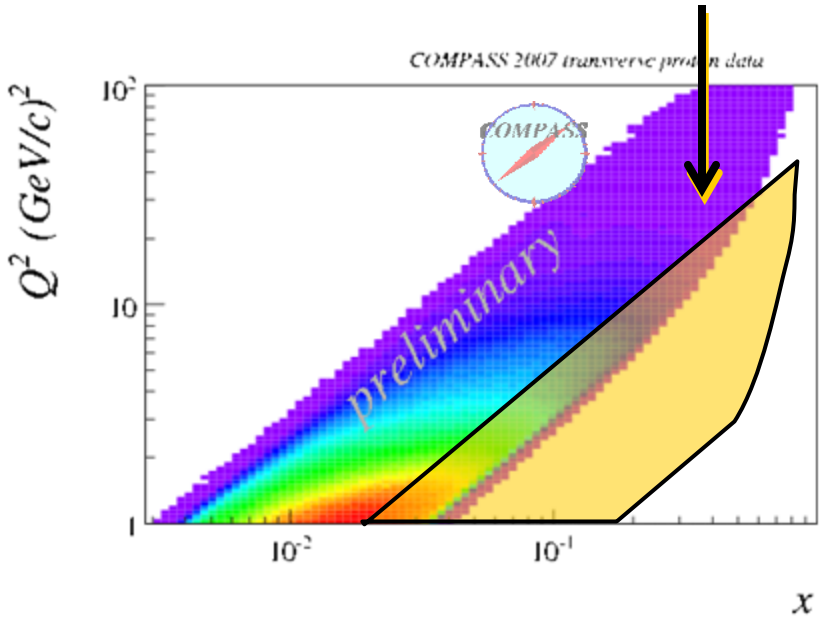
SIDIS kinematics

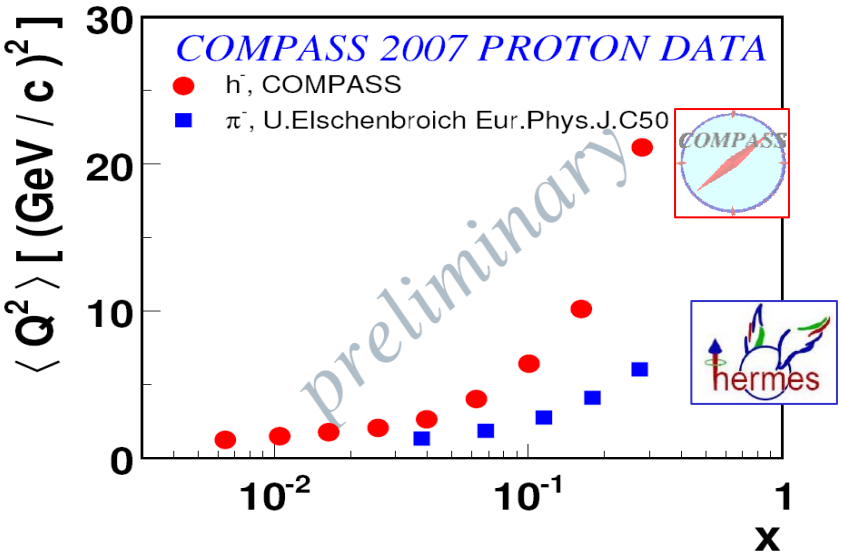
COMPASS

- **160 GeV muons**
- **W>5 GeV/c²**
- **0.1<y<0.9**



28 GeV/c
W>1.8 GeV/c²





COMPASS results - Collins asymmetry

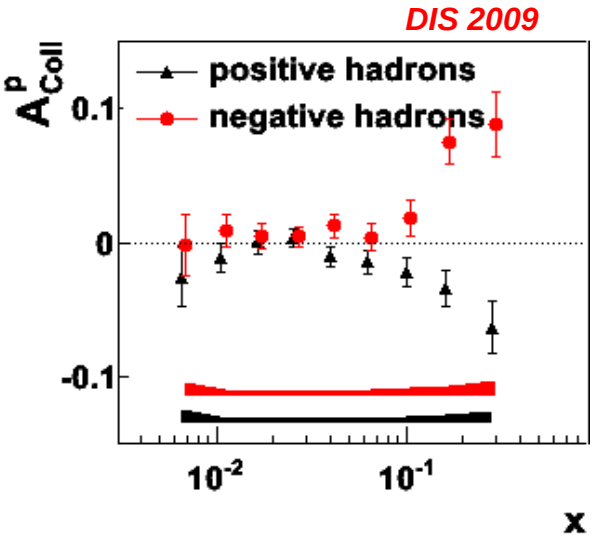
- **deuteron: final results from all 2002-2004 data**

  asymmetries compatible with zero over the whole x range (0.004- 0.5)

  → cancellation between u and d quark in the deuteron

- **proton: preliminary results from all 2007 data:**

  large signal (~ same strength than HERMES) in the valence region



also, preliminary results for the 2 hadron asymmetry: large signal

(~ 3 x HERMES measured value)

an important and not obvious result,

given the different energies of HERMES and COMPASS and consequently the different Q^2 values in the valence region

not a higher twist effect

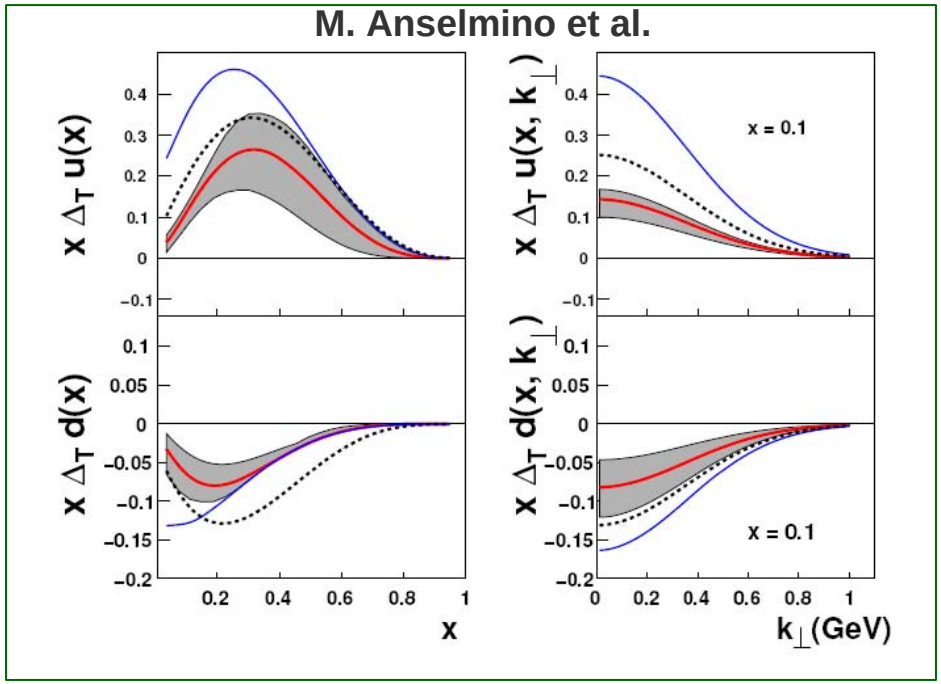
Transversity DF extraction from SIDIS

using

HERMES (p) and COMPASS (d) pion data,

and BELLE data,

first extraction of the
transversity DF
and of the Collins FF



A MAJOR RESULT!

Transversity can be extracted from SIDIS data

Collins asymmetry - conclusion

transversity is measurable, but the work is just starting

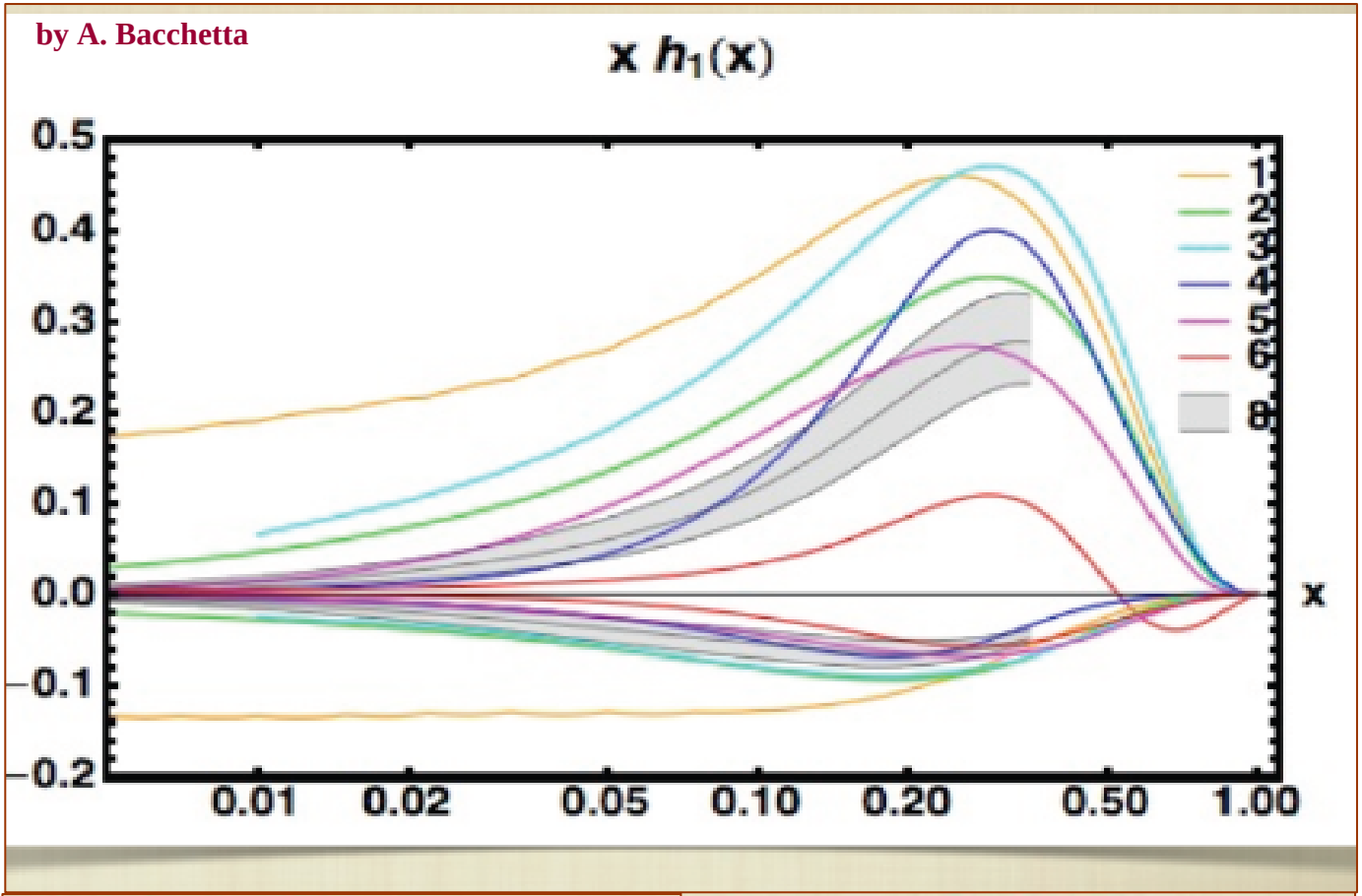
- **“we are far from the situation we have in the longitudinal case”**
- **there are many open points**
- **much more data are needed**

more COMPASS SIDIS data on transversely polarised p will allow

- **to map the Q^2, z, and p_T dependence**
- **to measure with high precision the asymmetries for pions and kaons**
  → flavour separation
- **to performe precise measurements over a wide x range**
  → constrains on the transversity parametrization
  → measurement of the first moments

transversity distribution

by A. Bacchetta



[1] Soffer et al. PRD 65 (02)
[2] Korotkov et al. EPJC 18 (01)
[3] Schweitzer et al., PRD 64 (01)
[4] Wakamatsu, PLB 509 (01)
[5] Pasquini et al., PRD 72 (05)
[6] Bacchetta, Conti, Radici, PRD 78 (08)
[7] Anselmino et al., PRD 75 (07)
[8] Anselmino et al., arXiv:0807.0173

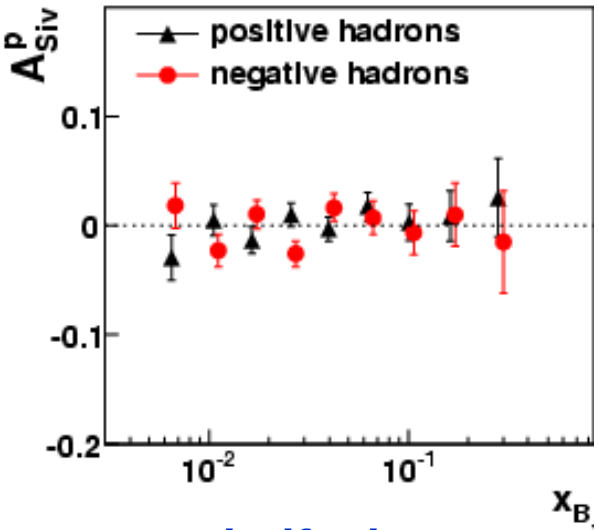
COMPASS results - Sivers asymmetry

- **deuteron**: final results from all 2002-2004 data

  asymmetries compatible with zero over the whole x range (0.004- 0.5)

  → cancellation between u and d quark in the deuteron

Transversity 2008



- **proton**: preliminary results from all 2007 data
  - no signal
  - marginal compatibility with HERMES π^+ data

an "intriguing result" !

conclusion: new high energy data are necessary to clarify the energy dependence suggested by the COMPASS proton results

new data will also allow to perform precise measurements of the K asymmetry

future COMPASS measurements

motivations

- **SIDIS at high energy provides unique information on the transverse spin and intrinsic momentum structure of the nucleon**
  - high energy and high Q^2, a guarantee for the **hard scale**
  - "easy" flavour separation
  - simple interpretation
  - *access to all the TMD structure functions*
  - broad x range
  - complementary to hard hadron-hadron scattering
- **the high energy muon beam and the COMPASS spectrometer are unique facilities**
- **CERN is the only place where in the next few years SIDIS measurements can be made at high energy**

in the short term, new COMPASS measurements are needed

- **to perform more precise measurements of the Collins asymmetry**
- **to clarify the compatibility of the HERMES and COMPASS measurements of the Sivers asymmetry**

plus precise measurements for all other channels

future COMPASS measurements

- **Letter of Intent** [COMPASS Collaboration]
  CERN-SPSC-2009-003 SPSC-I-238, 21 January 2009:
  - **physics case for further SIDIS data taking with the 160 GeV muon beam and the transversely polarised NH_3 target**
  - further SIDIS measurement with longitudinally polarised NH_3 target
  - Drell-Yan measurements (→ *C. Quintans*)
  - DVCS measurements (→ *Y. Bedfer*)

    all presented at the CERN Worshop
    "New opportunities in the physics landscape at CERN", May 11-13, 2009.

- **Addendum 2 to the COMPASS Proposal,** ***June 20, 2009***

  REQUEST TO CERN:
  - **one full year of run (140 days of data taking) with transversely polarised NH3 target with the present muon beam and COMPASS spectrometer**
  - one year with longitudinally polarised target

  starting in 2010 with the transverse part

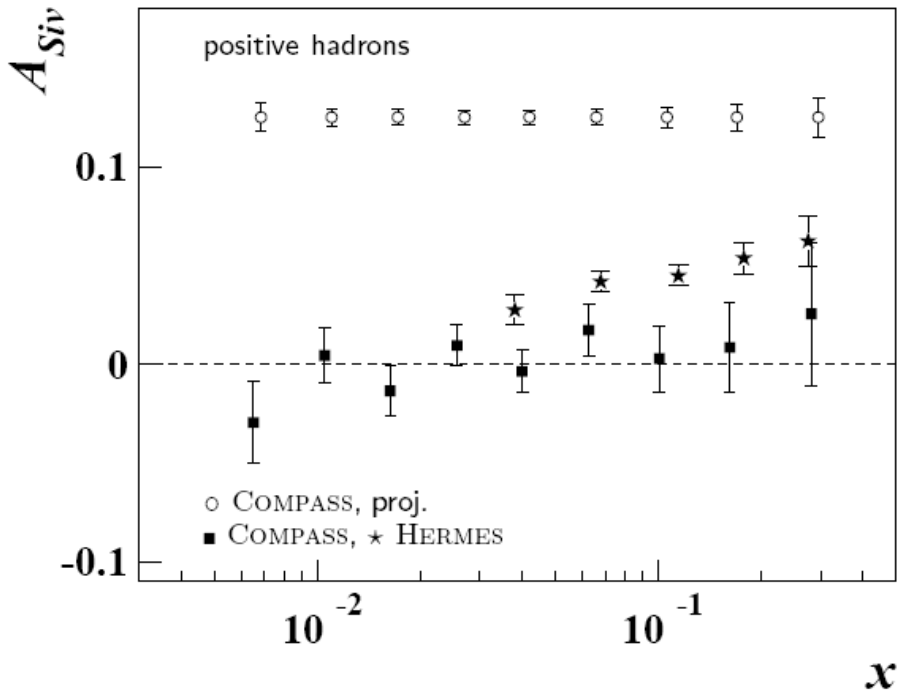
future COMPASS measurements

in 140 days of data taking COMPASS will perform

very precise measurements of transverse spin effects

over the whole x range (0.004 – 0.5)

projected statistical errors for the Sivers asymmetry



□ **COMPASS 2010 h^+, projection**

★ HERMES π^+, DIS2007

■ COMPASS h^+, Transversity 2008

a factor of 3 with respect to the released COMPASS data

more distant future

the 2010 measurement would mostly conclude the exploratory phase of transverse spin effects in SIDIS

more systematic measurements in SIDIS will be needed

today: COMPASS
JLab (6 GeV → 11 GeV)

future projects: eRHIC or ELIC
ENC at FAIR

in the mean time CERN could play an important role

".. we are investigating the possibility to increase significantly the muon beam intensity. If the outcome is positive it will be worthwhile to resume with an upgraded COMPASS-like apparatus the SIDIS measurements both with proton and deuteron transversely polarised target."

(January 2009 LoI)

thank you