The Future Plans of COMPASS

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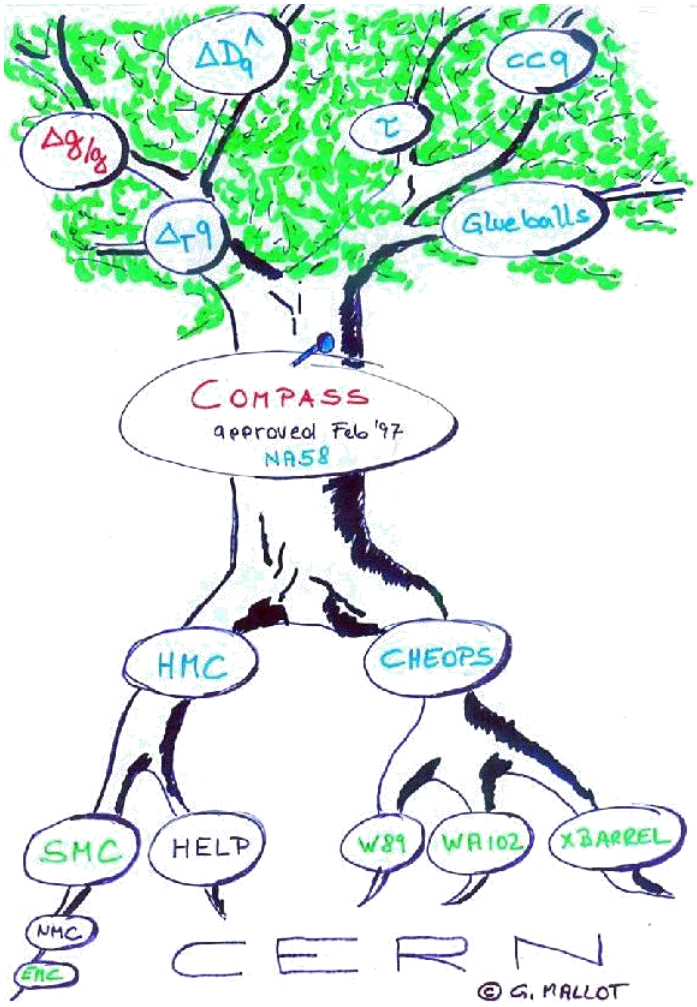
COMPASS: A Facility to study QCD



COMMON
MUON and
PROTON
APPARATUS for
STRUCTURE and
SPECTROSCOPY

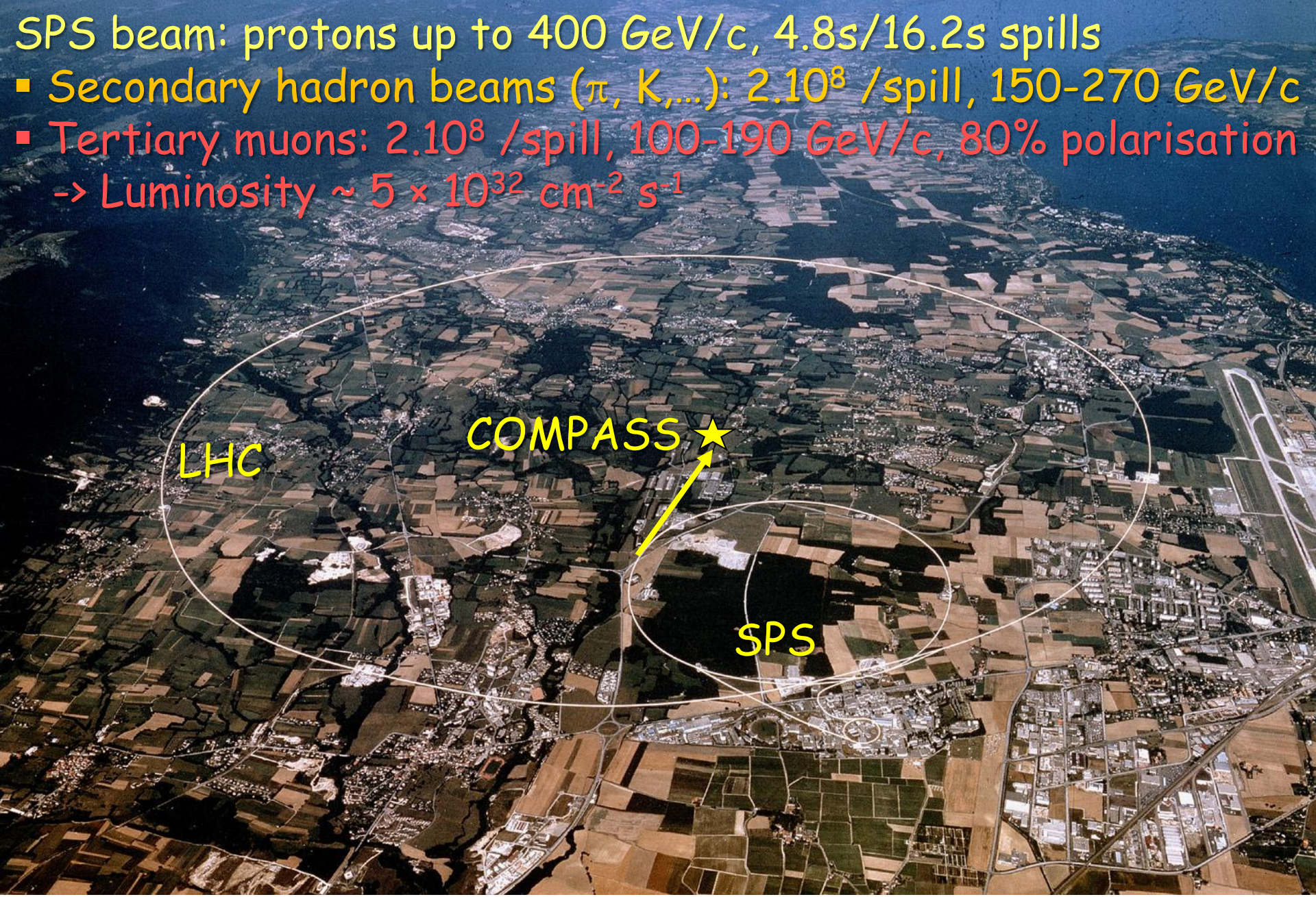
Czech Republic, France, Germany, India, Israel, Italy, Japan, Poland, Portugal, Russia & CERN

~ 240 physicists
from
28 Institutes

SPS beam: protons up to 400 GeV/c, 4.8s/16.2s spills

- Secondary hadron beams (π, K,...): 2.10^8 /spill, 150-270 GeV/c
- Tertiary muons: 2.10^8 /spill, 100-190 GeV/c, 80% polarisation

  -> Luminosity ~ 5×10^{32} cm^{-2} s^{-1}



high energy beam(s), large angular acceptance, broad kinematical range

Future Plans of COMPASS

1. First ideas communicated to CERN/SPC
   CERN/SPC June 2008

2. Decision to prepare a Common Proposal
   COMPASS/GLB July 2008

3. Letter of Intent (LoI) submitted to SPSC
   CERN/SPSC January 2009 (SPSC-I-238 21.01.2009)

4. Proposal in preparation …

LoI content

1. Introduction
2. Proposed Measurements (*)
3. Further measurements of transverse spin effects in SIDIS
4. Precision measurements of the longitudinal spin structure of the proton
5. Generalised Parton Distribution functions
6. Drell-Yan measurements at COMPASS
7. Spectrometer upgrades for the short term and the proposed measurements

(*) Hadron spectroscopy, will be further elaborated in view of results from 2008 & 2009

Transverse spin: Collins, Sivers asymmetries

$$A_{\Phi_{Coll}} = \frac{\sum_q e_q^2 \times \Delta_T q \times \Delta_T^0 D_q^h}{\sum_q e_q^2 \times q \times D_q^h}$$

spin dependent fragmentation of transversely polarized quarks into hadrons

$$A_{\Phi_{Siv}} = \frac{\sum_q e_q^2 \times \Delta_0^T q \times D_q^h}{\sum_q e_q^2 \times q \times D_q^h}$$

Intrinsic k_T dependence of the quark distribution correlated to nucleon transverse spin

Transverse spin (Collins) proton data

See also A.Bressan talk, Spin Physics session

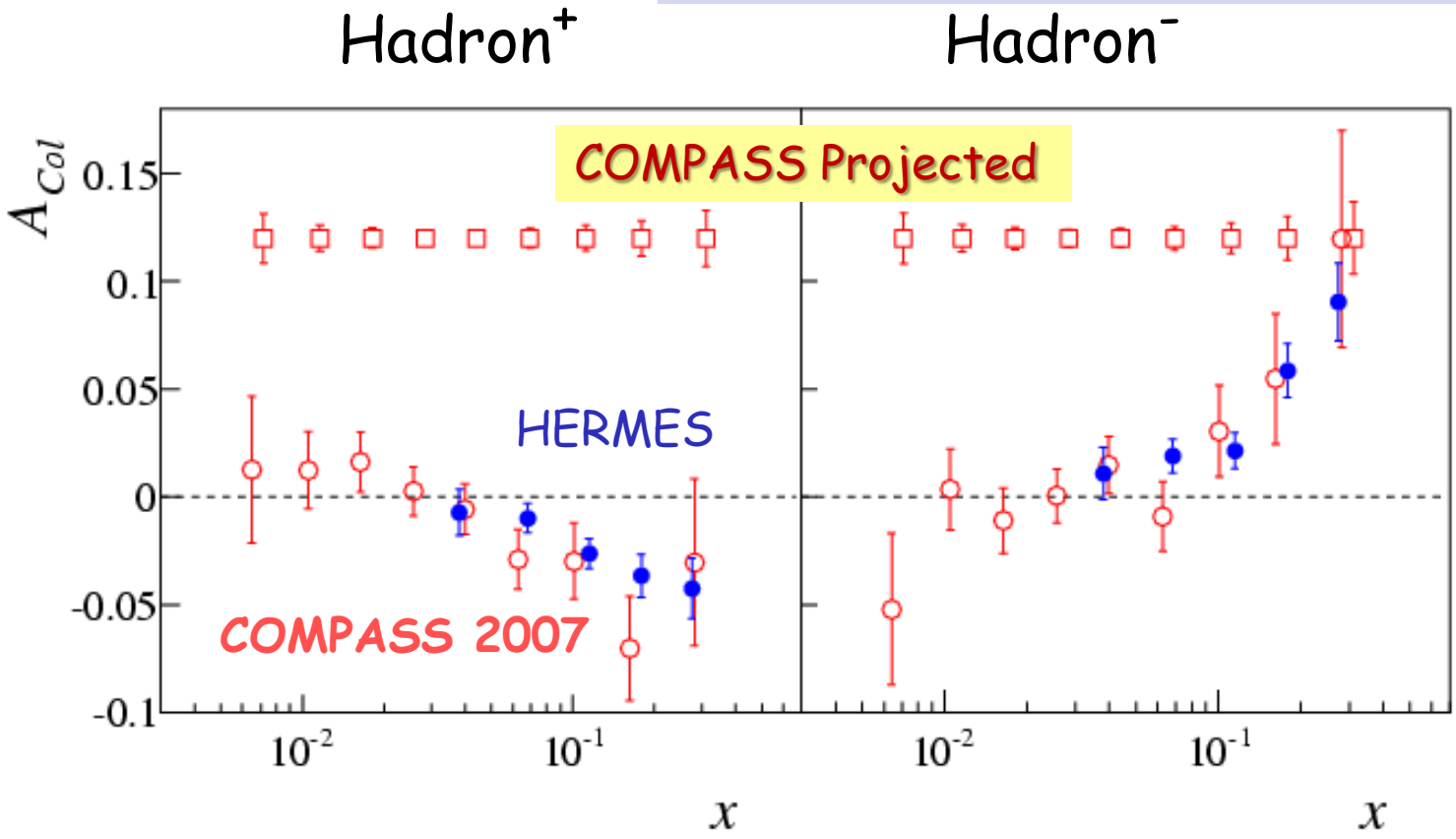


Figure 1: Collins asymmetry on proton for positive (left) and negative (right) hadrons. The closed circles are the HERMES results [3] and the open circles are the COMPASS results [7]. The open squares show the expected statistical errors from the proposed measurements.

Transverse spin (Sivers) proton data

See also A.Bressan talk, Spin Physics session

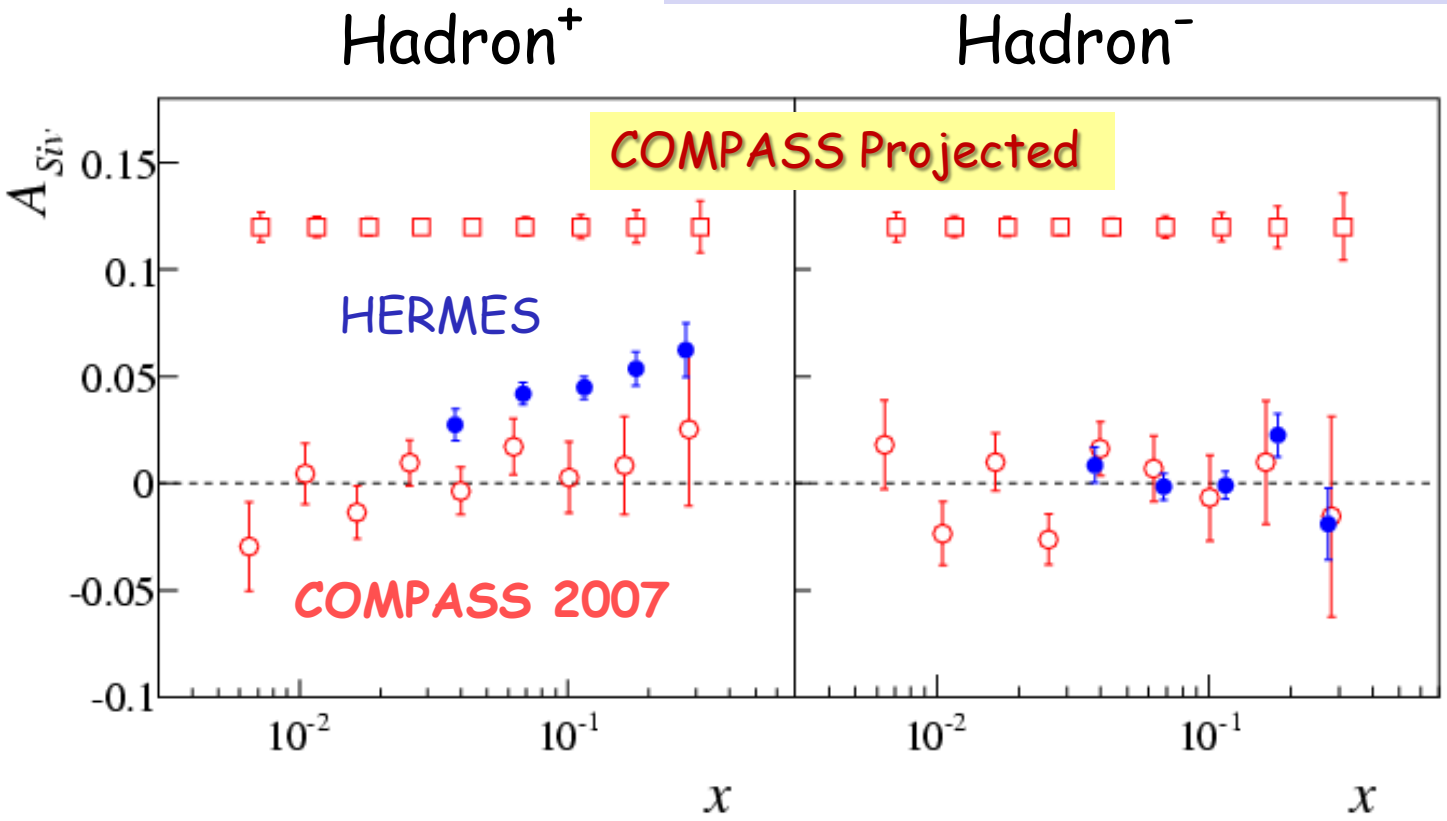


Figure 2: Sivers asymmetry on proton for positive (left) and negative (right) hadrons. The closed circles are the HERMES results [3] and the open circles are the COMPASS results [7]. The open squares show the expected statistical errors from the proposed measurements.

Longitudinal spin (g_1^d) g_1^p

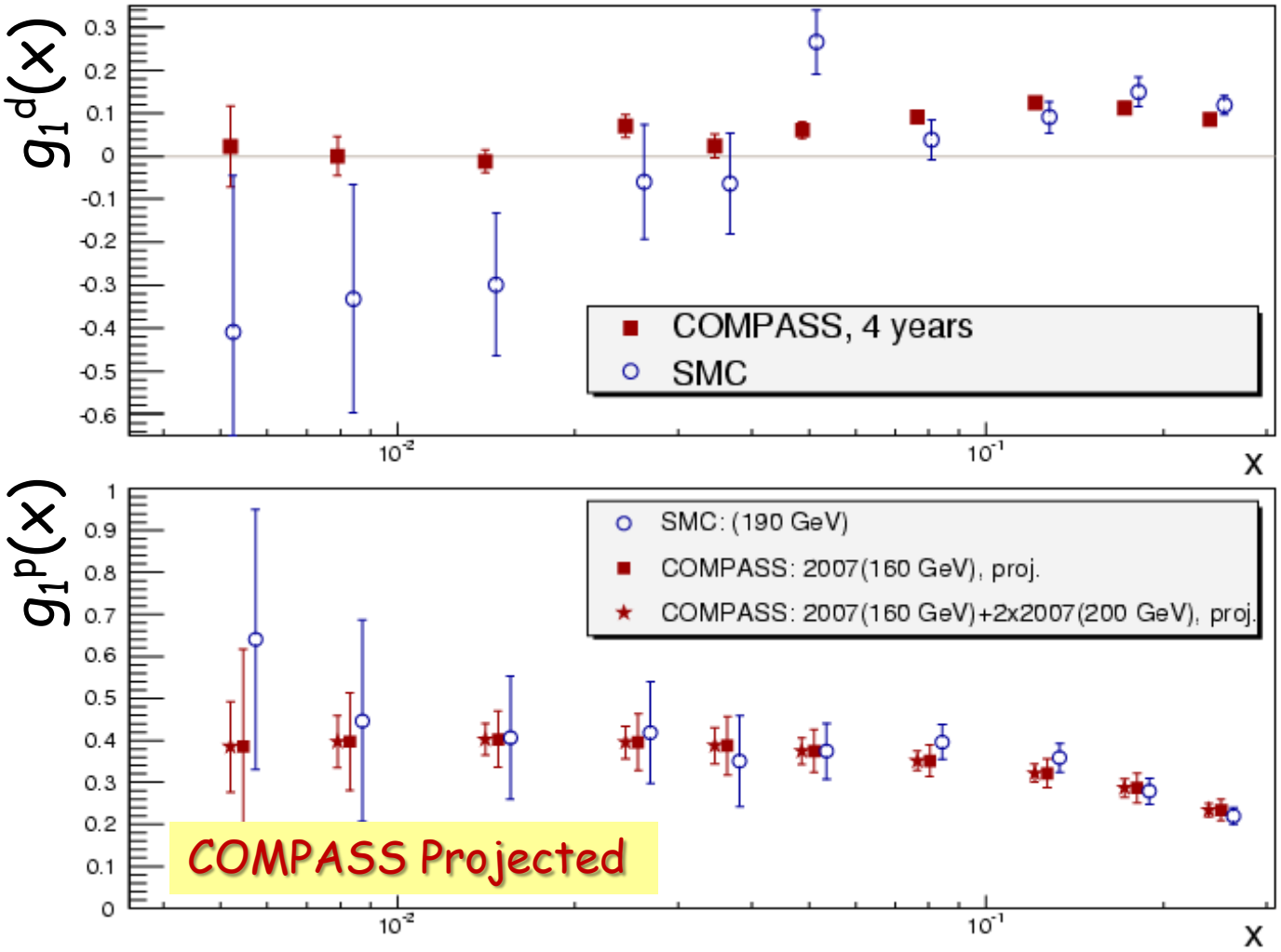


Figure 3: The spin-dependent structure function of deuteron $g_1^d(x)$ and of proton $g_1^p(x)$. For comparison COMPASS points are shown together with SMC measurements. The g_1^d points (top) correspond to full deuteron statistics. For g_1^p (bottom), values are derived from the DSSV [13] polarised PDFs and the errors correspond to the statistics of 2007 and to the total statistics expected after another year of data taking.

Longitudinal spin g_1^{NS}

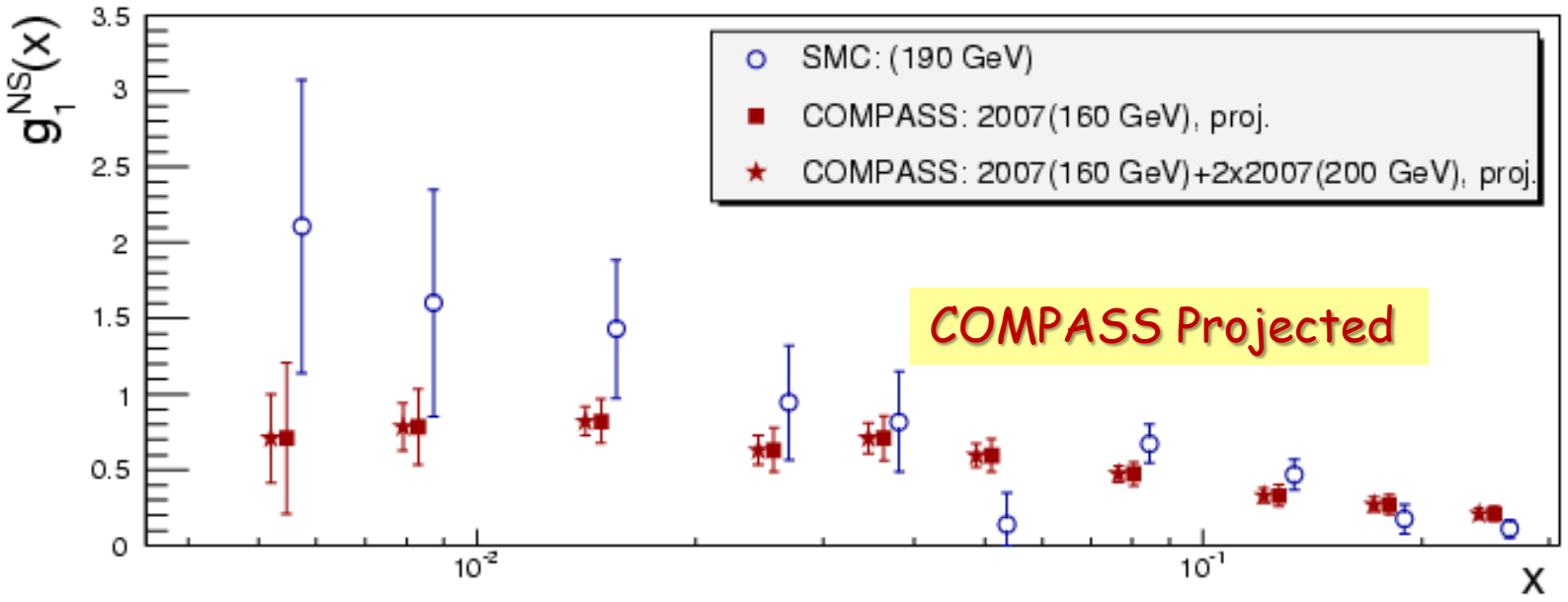


Figure 4: The non-singlet function $g_1^{NS}(x)$. For comparison COMPASS points are shown together with SMC measurements. The COMPASS values of g_1^d and g_1^p and their errors are the same as in Fig. 3.

Request for beam

- Measurements on a **transversely polarised proton** (NH3) tgt
  - **150 days** (1 full year) of SPS beam

- Measurements on a **longitudinally polarised proton** target
  - **150 days** (1 full year) of SPS beam (preferably 200 GeV if same intensity as 160 GeV ?)

- For both T & L running Luminosity is important factor
- Increase substantially Luminosity of SPS M2 beam ?

New opportunities in the physics landscape at CERN
CERN Workshop MAY 11-13 2009

"Spin crisis", possible scenarios

From COMPASS & RHIC, ΔG not large:

- $\Delta G = |\int \Delta G(x_G)| < 0.4$
- $\Delta\Sigma \approx a_0 = 0.3$

$$a_0 = \Delta\Sigma - \frac{3\alpha_s}{2\pi}\Delta G$$

$\Delta\Sigma$		ΔG		L_q		L_g
$\frac{1}{2}$ = 1/2 × 0.3	+	0.35	+	0	+	0
$\frac{1}{2}$ = 1/2 × 0.3	+	0.0	+	0.35		
$\frac{1}{2}$ = 1/2 × 0.3	-	0.35	+	0.70		

COMPASS/RHIC

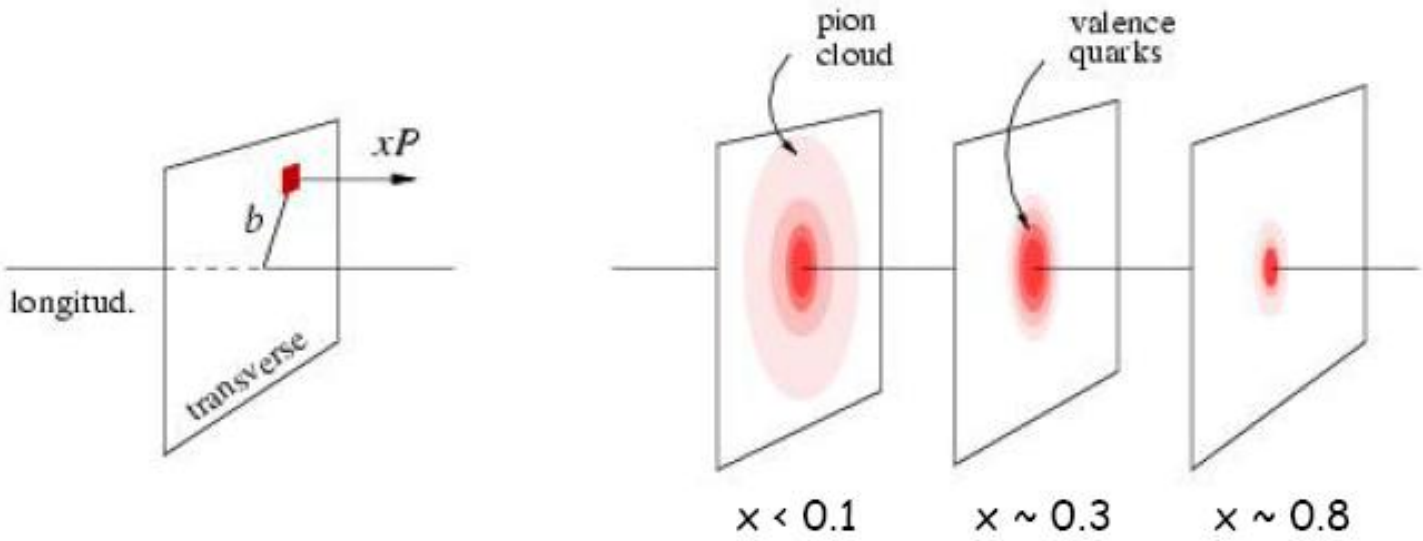
JLab/COMPASS

GPDs program for COMPASS future

Generalised Parton Distribution functions:

- Allow for a unified description of form factors and parton distribution
- Allow for transverse imaging and to access the quark angular momentum

Fourier transform in momentum transfer



gives transverse size of quark (parton) with longitudinal momentum fraction x

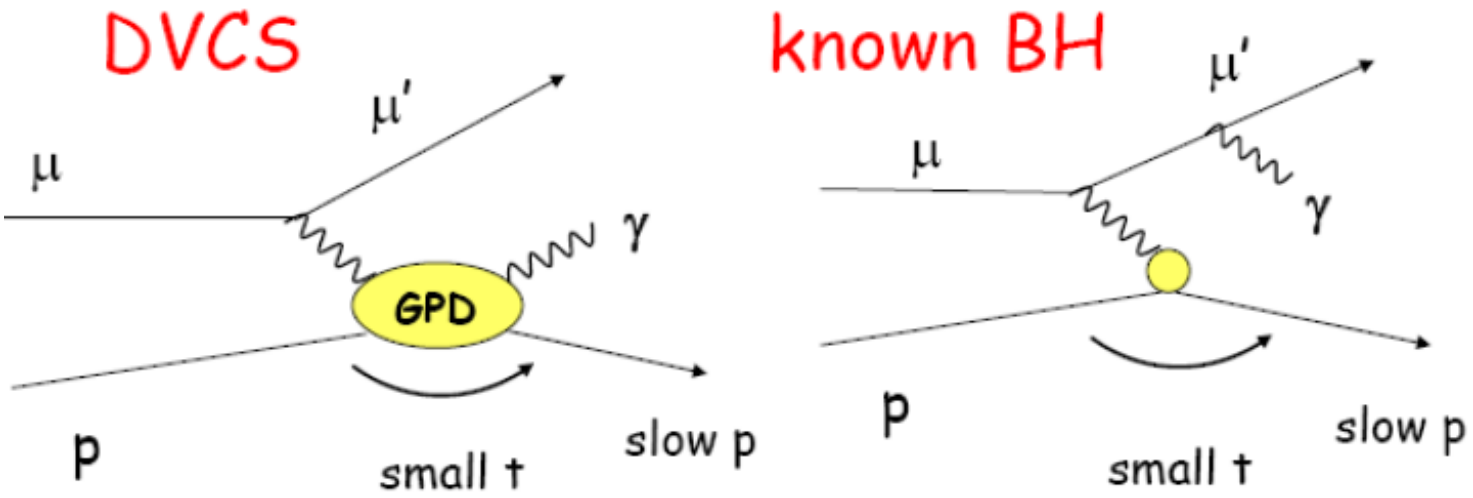
LoI content

Generalised Parton Distribution functions

Study of the nucleon structure via Generalised Parton Distributions by measuring Deeply virtual Compton Scattering (DVCS) and Deeply Virtual Meson Production (DVMP) on both an unpolarised liquid hydrogen target and a polarised target

GPDs program for COMPASS future

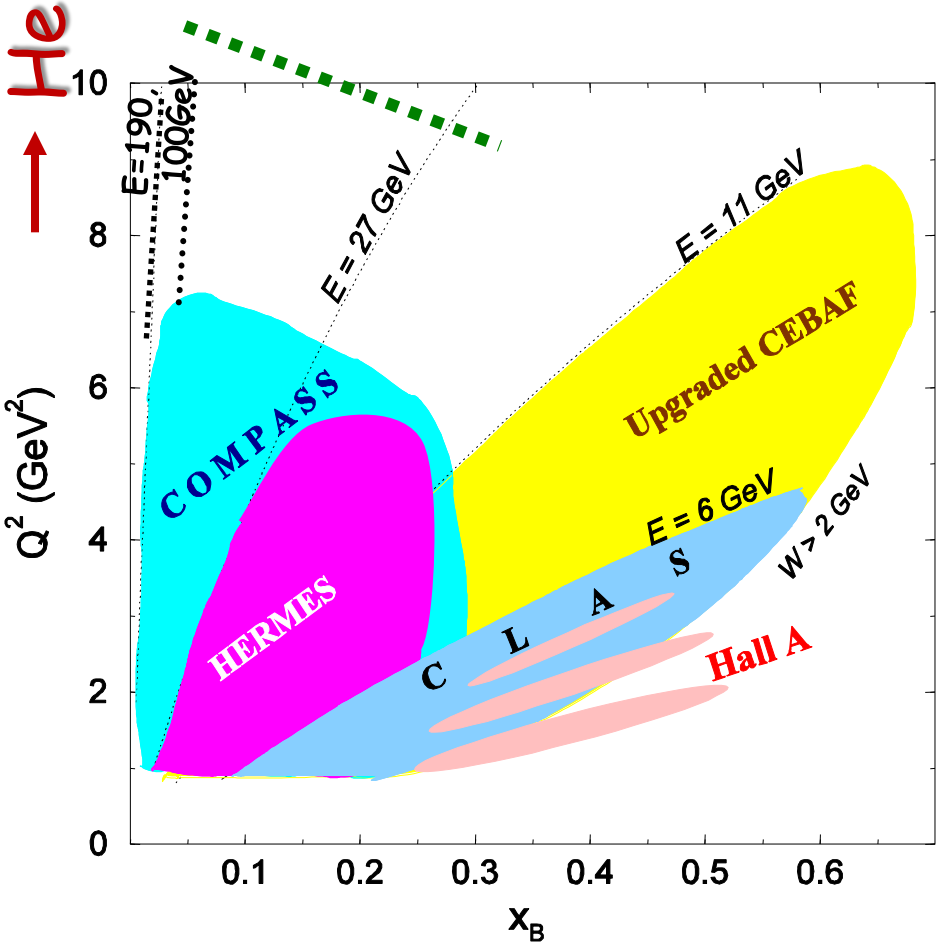
- E_μ between 100 and 190 GeV
  - unique kinematical domain $0.01 < x < 0.1$
  - promising channel: $\mu\ p \rightarrow \mu\ \gamma\ p$
  - $d\sigma\ \alpha\ |T_{BH}|^2 + |T_{DVCS}|^2 + \text{Interference Term}$



Kinematical domain

Hera →

With Luminosity x 2, or more ?



Gluons + Sea + Valence

CERN SPS

High energy muon beam

100 / 190 GeV

80% Polarisation

μ^+ and μ^- available (*)

(*) opposite polarization

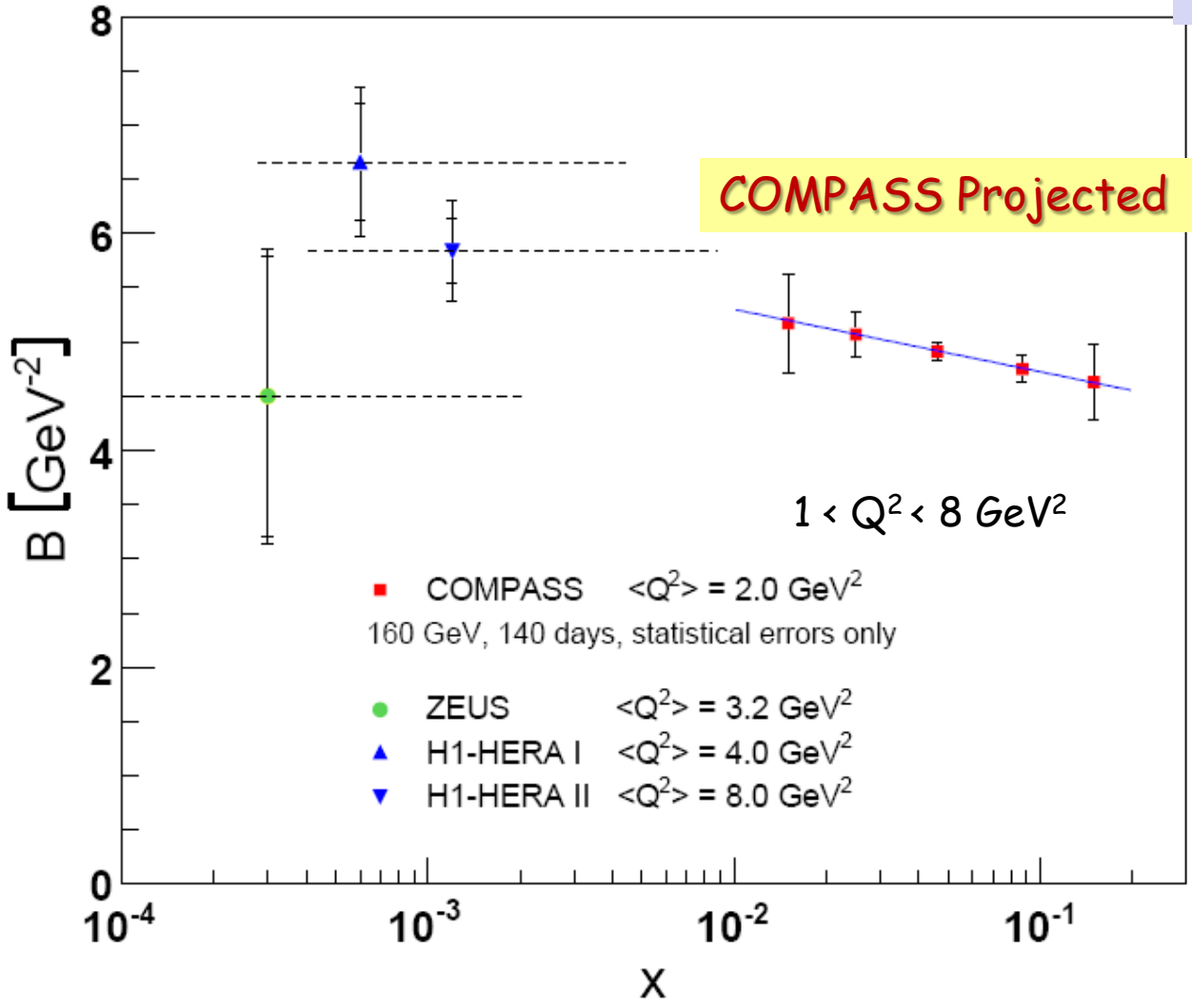
Measurements for COMPASS future

- Phase I (Liquid Hydrogen target + Recoil Proton Detector)
  - **Deeply Virtual Compton Scattering,** measurement of:
    Beam Charge&Spin Sum of cross-sections $S_{U,CS}$
    Beam Charge&Spin Diff. of c-s $D_{U,CS}$
    Beam Charge&Spin Asymmetry of c-s $A_{U,CS}$
  - **Deeply Virtual Meson Production**
- Phase II (Polarised target + RPD)
  - **DVCS & DVMP** on a transversely polarised target.
    Difference of Beam Charge&Spin difference for the two target spin orientations $D_{T,CS}$

t-slope

Using $S_{U,CS}$: $d\sigma_{DVCS}/dt \sim \exp(Bt)$

See also E.Burtin talk, Diffraction + Vector Mesons + Spin Physics (Joint Session)



Input :

$B(x) = b_0 + 2\,\alpha' \ln(x_0/x)$

$\alpha' = 0.125$ GeV^{-2} from J/Ψ

160 GeV μ beam

2.5m LH_2 target

140 days

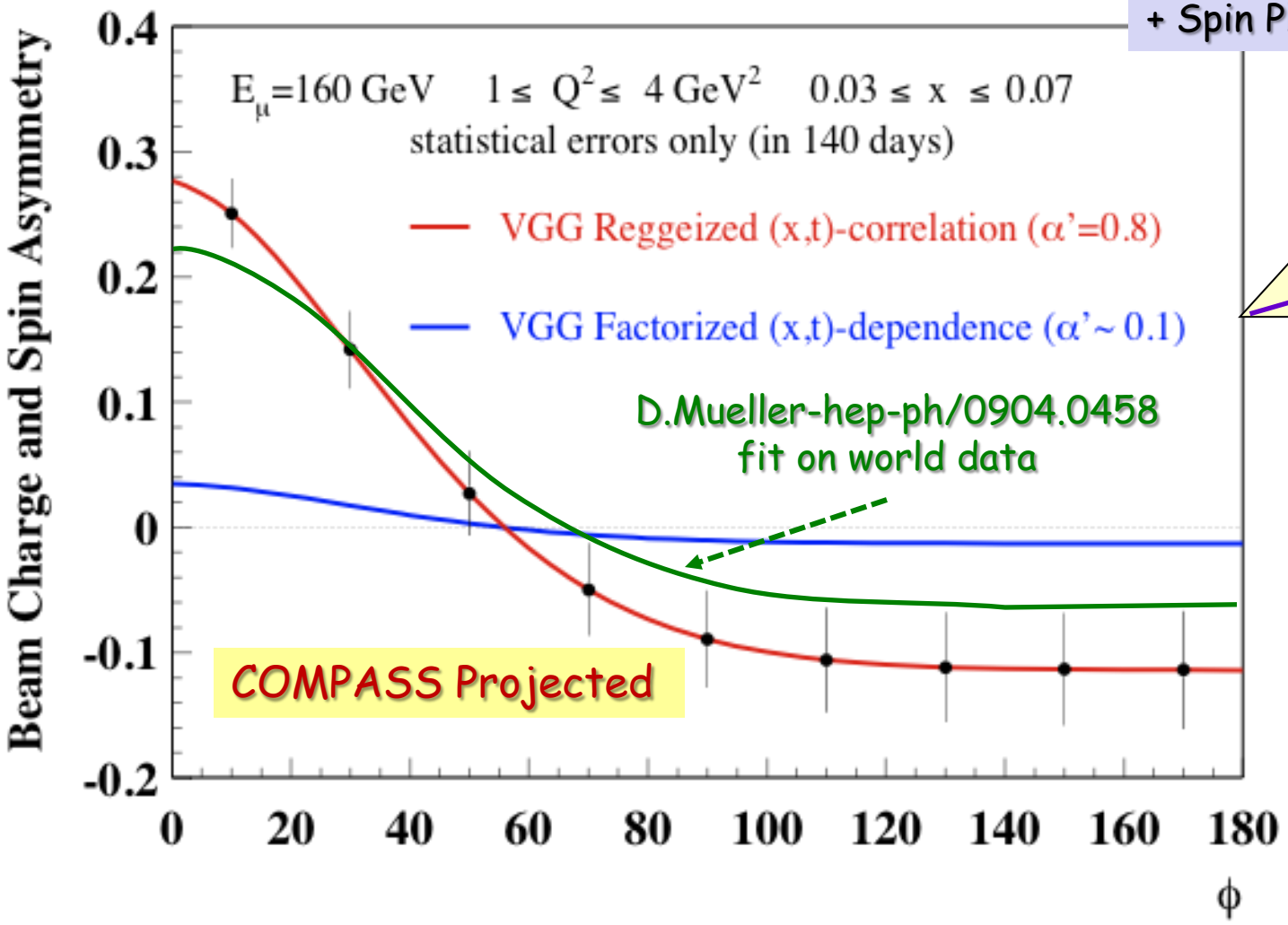
$L = 1222$ pb^{-1}

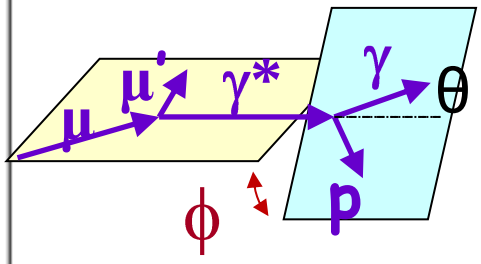
$\varepsilon_{GLOBAL} = 10$ %

Beam Charge Spin Asymmetry

Using BCSA = $D_{U,cs}$ / $S_{U,cs}$

See also E.Burtin talk, Diffraction + Vector Mesons + Spin Physics (Joint Session)





160 GeV μ beam
2.5m LH_2 target
140 days
L = 1222 pb^{-1}
ε_{GLOBAL} = 10 %

Experimental setup upgrade (DVCS)

To be designed and built

Phase I

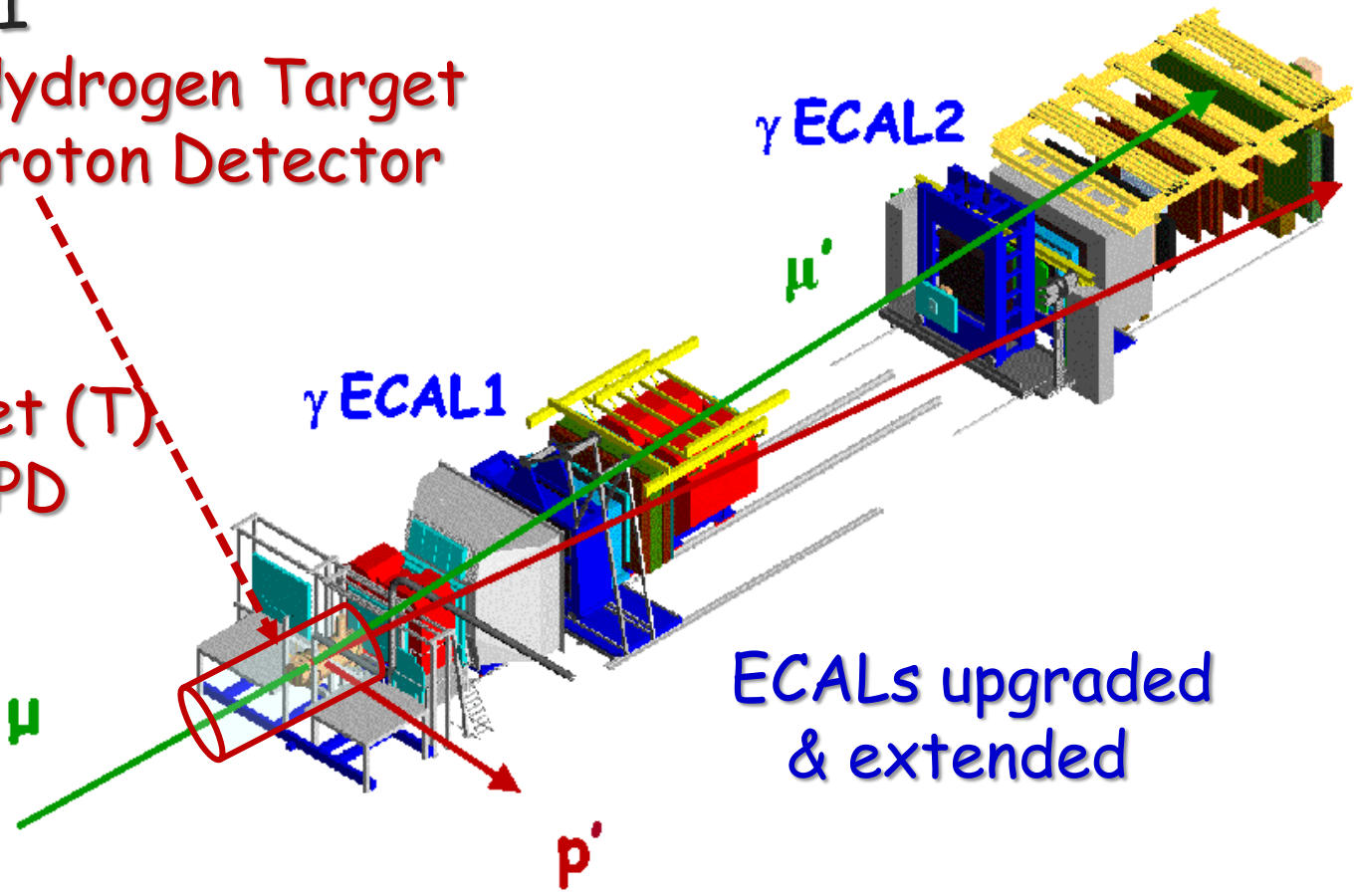
~ 2.5 m Liquid Hydrogen Target

~ 4. m Recoil Proton Detector

Phase II

Polarised target (T)

Associated RPD

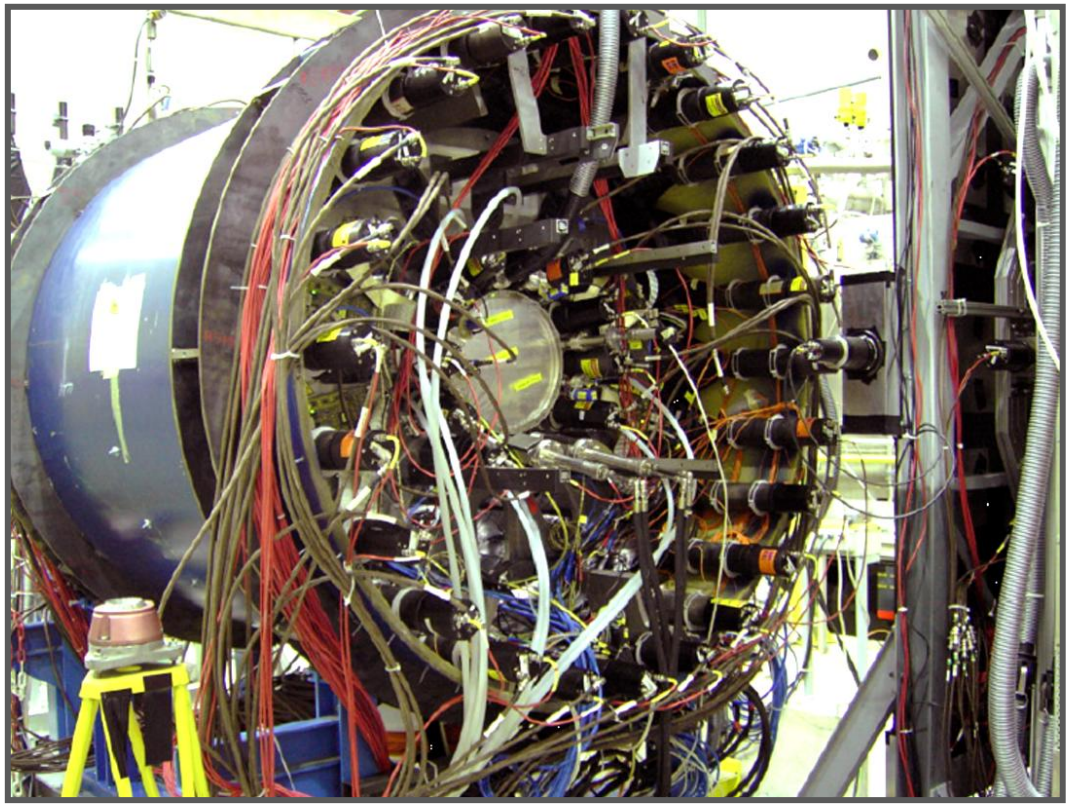


ECALs upgraded & extended

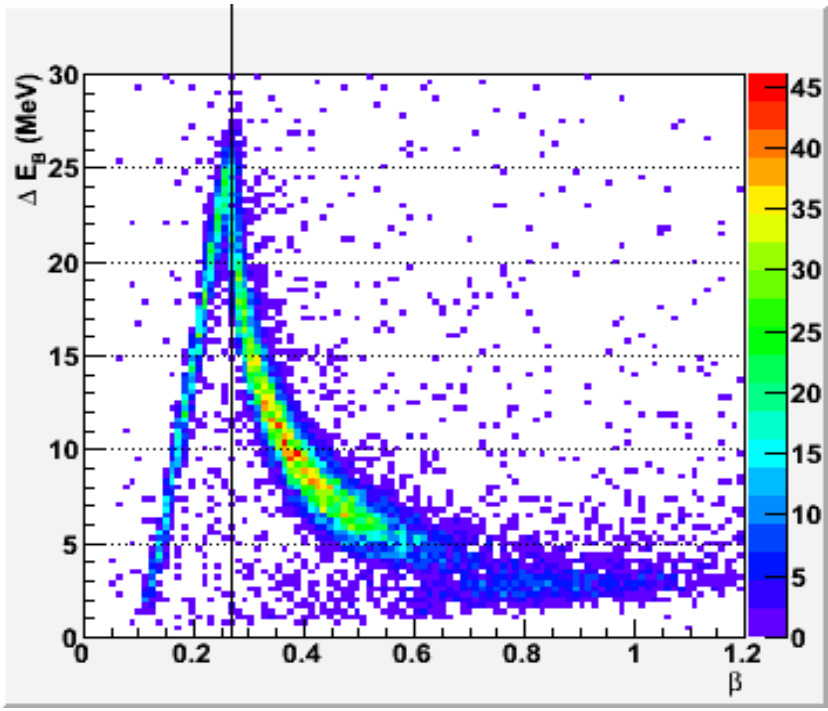
Recoil Proton Detection

2008-2009 hadron run

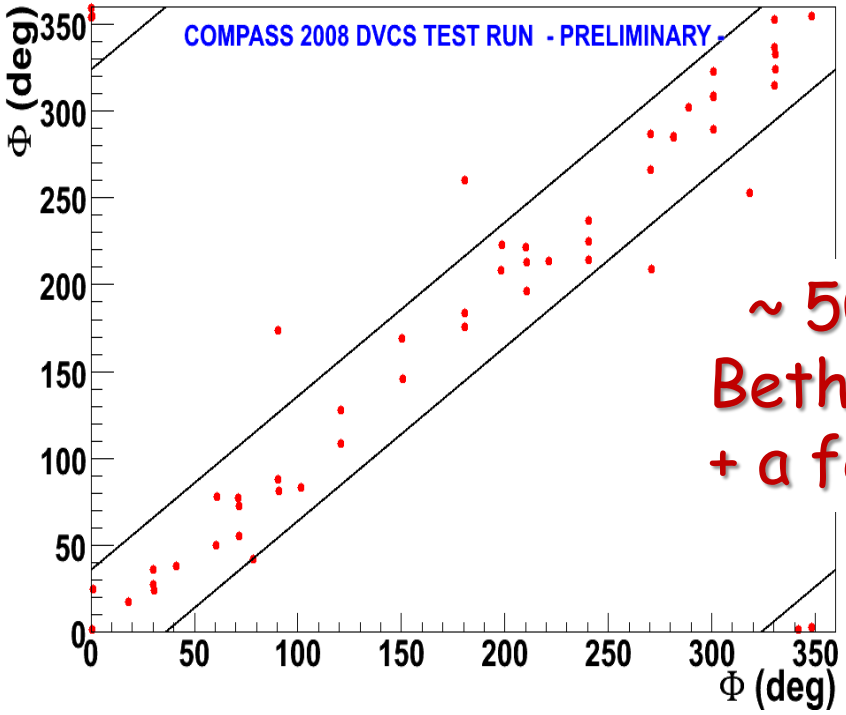
"Small size" RPD and LH2 target for hadron run



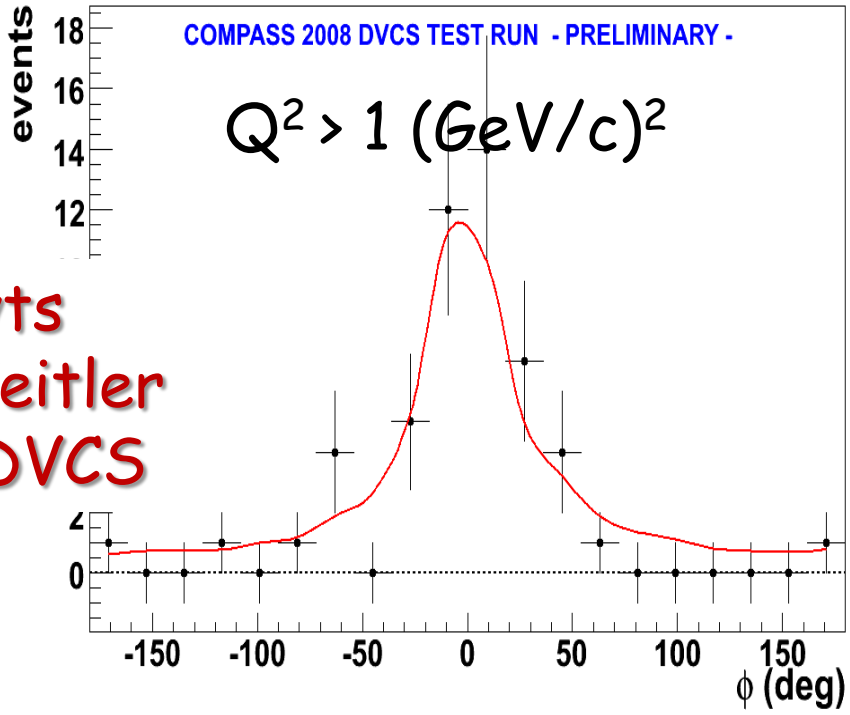
Proton identification in RPD
Elastic scattering (hadron beam)



1 day DVCS test run with $\mu^{+/-}$ in 2008



~ 50 evts
Bethe-Heitler
+ a few DVCS

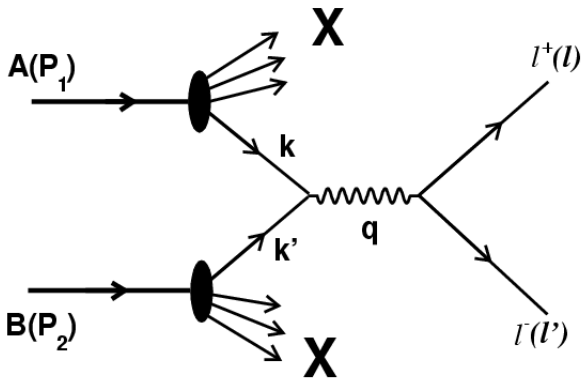


- Exclusive γ production with recoil proton
- Clear Bethe-Heitler signal

- DVCS measurements at CERN would largely benefit from substantial increase in luminosity.

5. Drell-Yan measurements at COMPASS

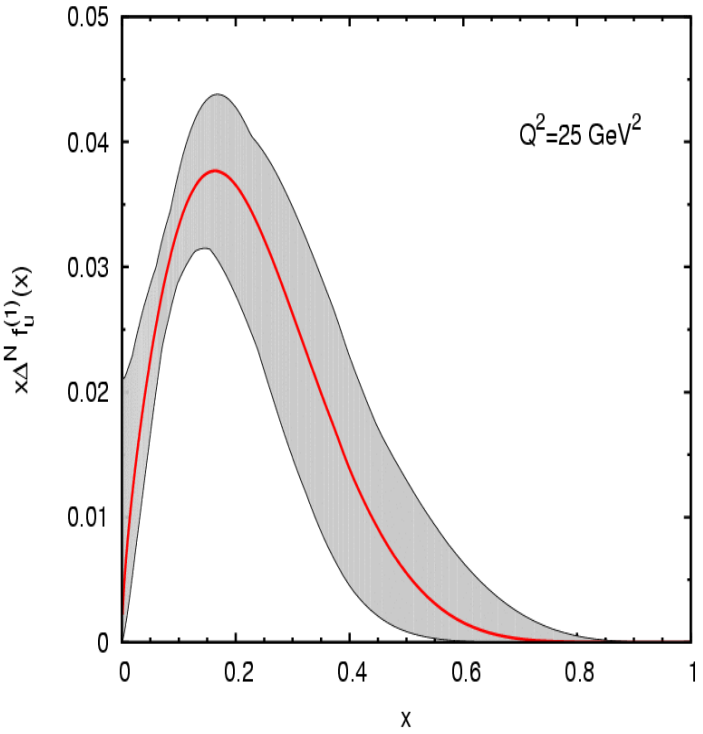
$$\pi + p\Uparrow \rightarrow l\bar{l} + X$$



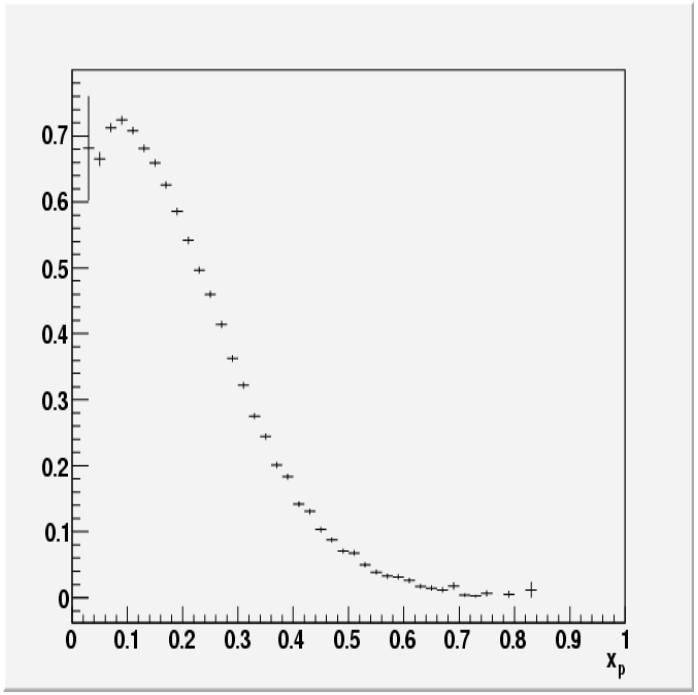
Drell-Yan ($\pi p\Uparrow$) gives direct access to chiral odd and time-reversal (T) odd PDFs

Measurements of TMDs using Drell-Yan

For Drell-Yan at COMPASS the cross-section for $q\bar{q}$ annihilation is dominated by valence region



1st moment of Sivers function for u quark (Q^2 = 25 GeV^2)



COMPASS acceptance in x_p for 190 GeV π

Drell-Yan studies for COMPASS future

- Unpolarised Drell-Yan
- J/Ψ production, J/Ψ-DY duality
- Transversely polarised DY
  - Measurement of Single Spin Asymmetries in DY

$$f_{1T}^{\perp}\Big|_{DY} = -f_{1T}^{\perp}\Big|_{DIS} \quad \text{and} \quad h_1^{\perp}\Big|_{DY} = -h_1^{\perp}\Big|_{DIS}.$$

Sivers function

Boer-Mulders function

Sivers asymmetry A_{UT} using DY

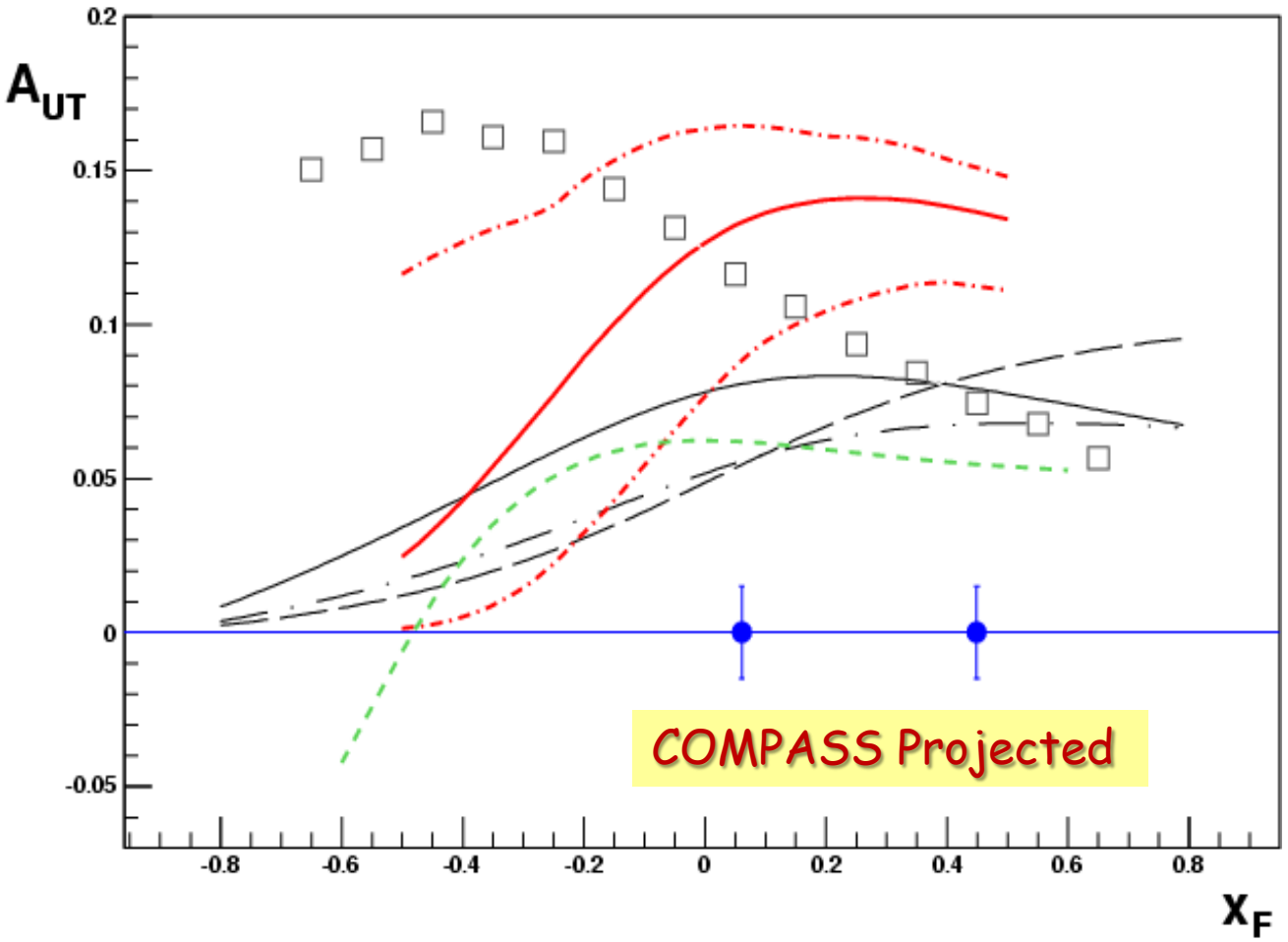


Figure 9: Theoretical predictions and expected statistical errors (filled circles, blue) for the Sivers asymmetry A_{UT} for the DY process $\pi^- p^\uparrow \to \mu^+\mu^- X$ as a function of $x_F = x_\pi - x_p$ in the dimuon mass region $4 < M_{\mu^+\mu^-} < 9\ \mathrm{GeV}/c^2$. Sightly different definitions were used by the various groups (see text).

Experimental setup upgrade (DY)

To be designed and built:

- hadron absorber downstream of polarised target
  to stand the required (hadron) luminosity ~ 2×10^{13} s^{-1} cm^{-2}
- new optimized trigger system for $\mu^+\mu^-$ pairs

For longer term:

- a feasibility study of RF separated anti-proton and kaon beams at the M2 beam line is in progress.
- A beam of ~ 10^7 $\bar{p}$ s^{-1} is within reach

LoI -> Proposal

Further measurements of transverse spin effects in SIDIS

Precision measurements of the longitudinal spin structure of the proton

Generalised Parton Distribution functions

Drell-Yan measurements at COMPASS

Conclusions

COMPASS is preparing to tackle new central issues:

- Transverse spin effects
- Generalised Parton Distributions

Hoping for fruitful discussions at …

New opportunities in the physics landscape at CERN
CERN Workshop MAY 11-13 2009