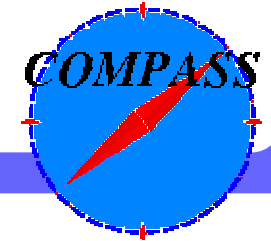# New Results from COMPASS

G. Mallot/CERN-COE

On Behalf of the Compass Collaboration
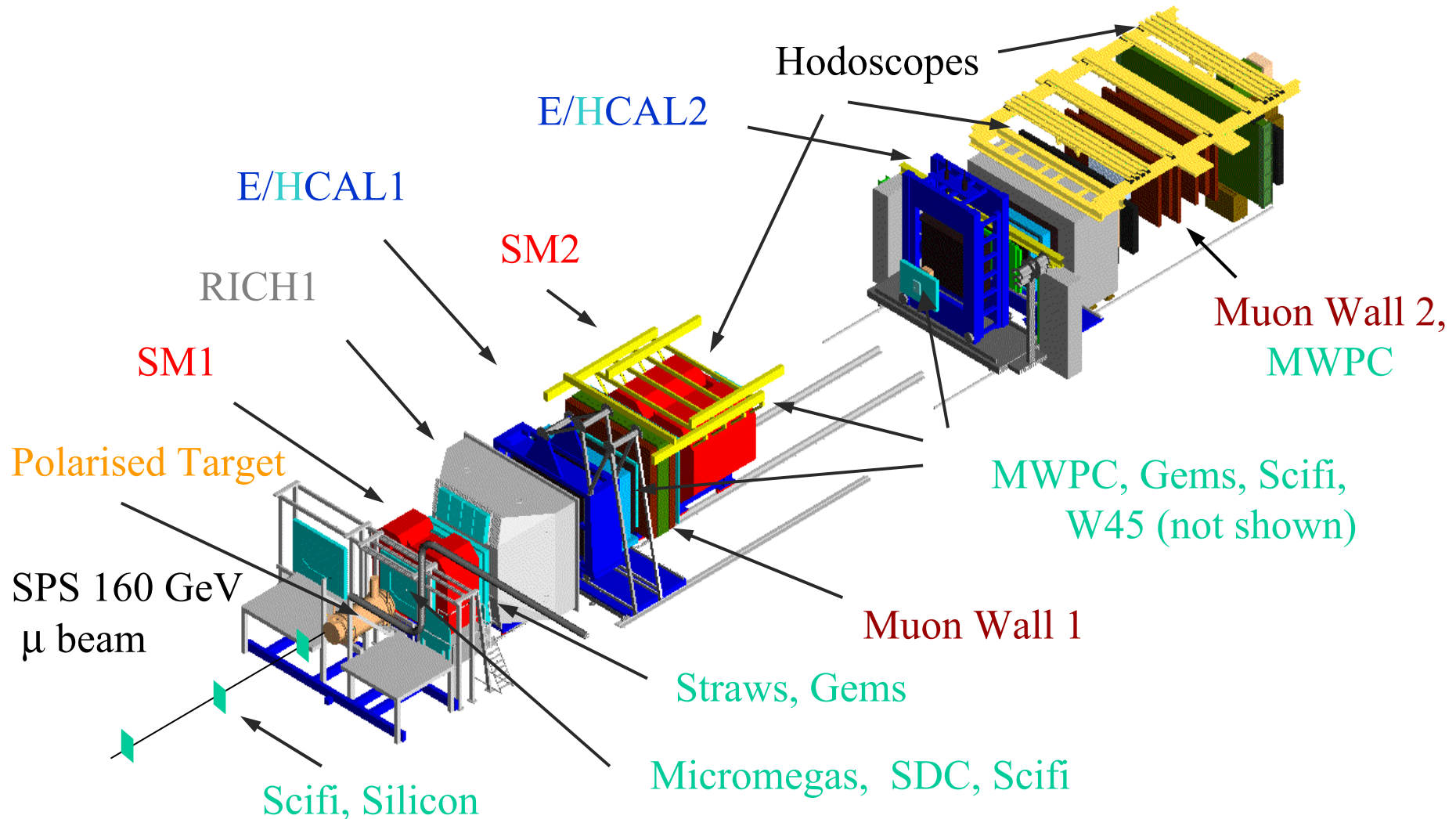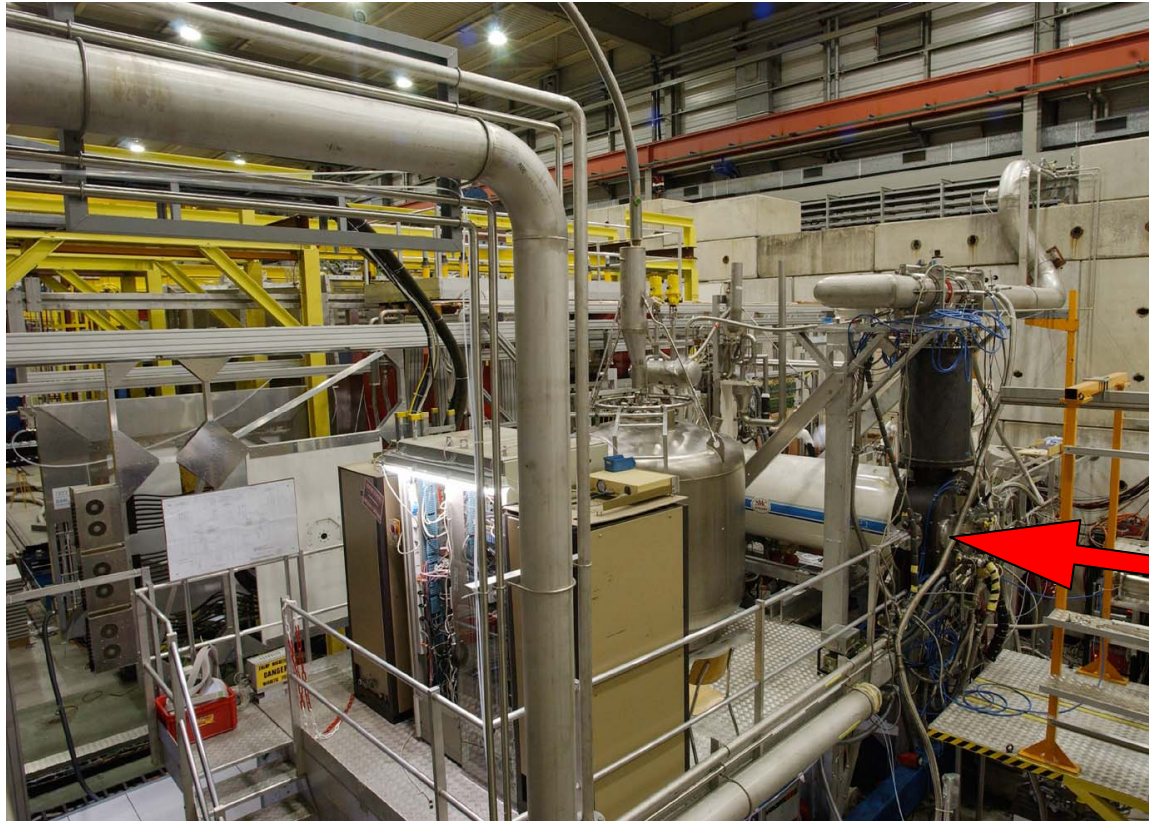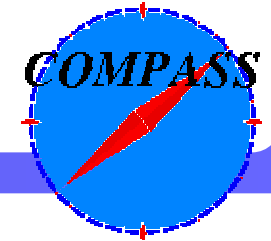
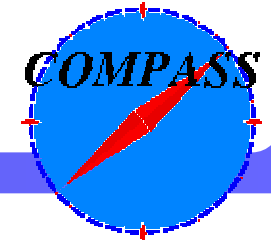ECT* May 10, 2005

Contents

- Experiment

- Physics results

  - Pentaquark

  - transverse asymmetries

  - Gluon polarisation
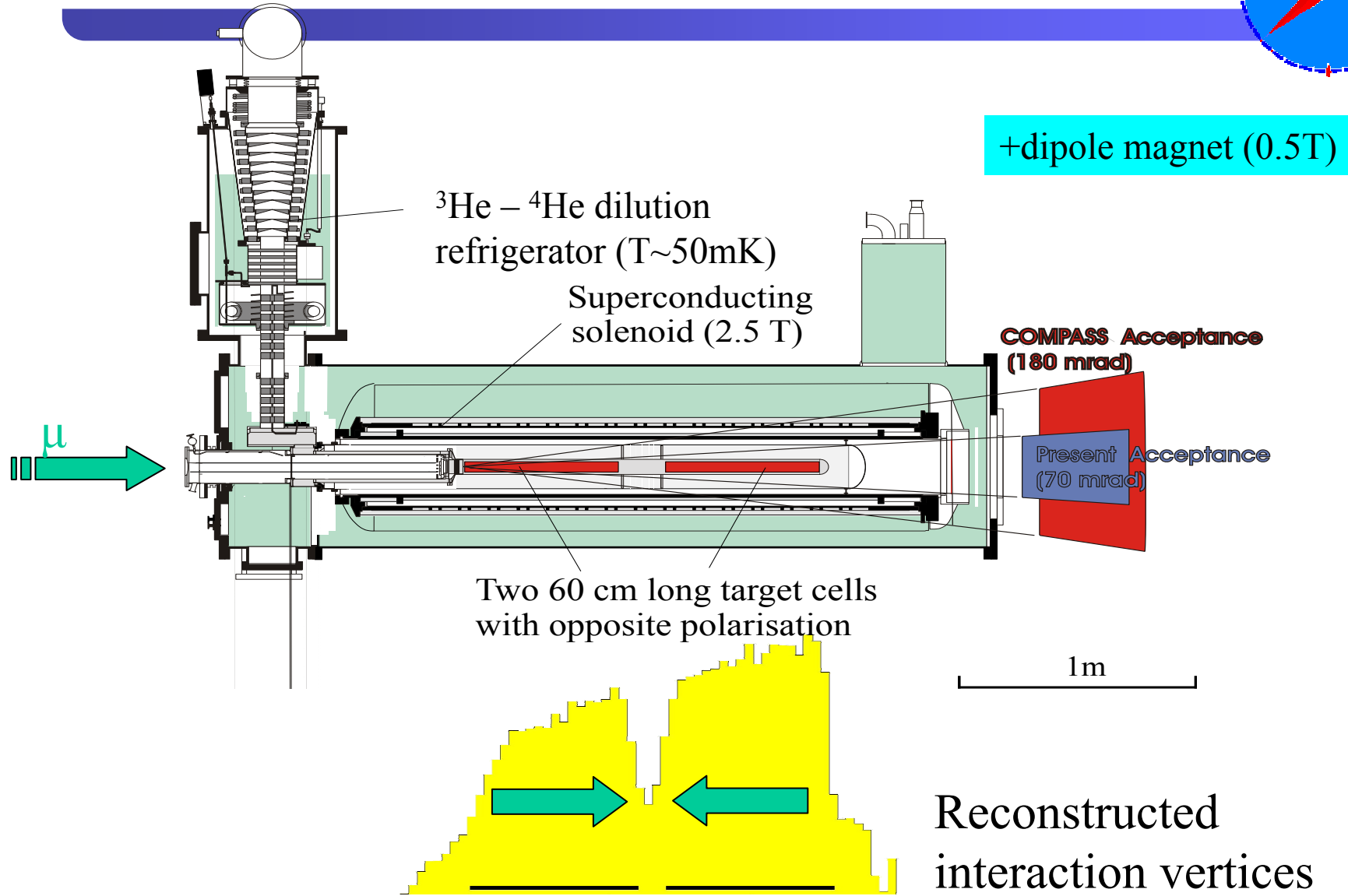
- Spectrometer Upgrades for 2006

G. Mallot

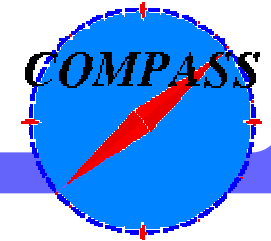ECT* May 2005

The COMPASS Spectrometer

Hodoscopes

E/HCAL2

E/HCAL1

SM2

RICH1

SM1

Polarised Target

SPS 160 GeV
μ beam

Muon Wall 2,
MWPC

MWPC, Gems, Scifi,
W45 (not shown)

Muon Wall 1

Straws, Gems

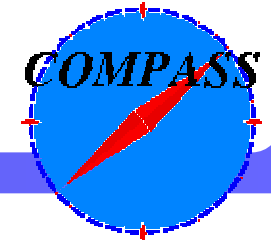Micromegas, SDC, Scifi

Scifi, Silicon

Polarised target

- ^{6}LiD
- $\pm$ 50 % polarisation
- 50 % dilution factor
- 2.5 T
- 50 mK

μ

Target system

+dipole magnet (0.5T)

^{3}He – ^{4}He dilution refrigerator (T~50mK)

Superconducting solenoid (2.5 T)

COMPASS Acceptance (180 mrad)

Present Acceptance (70 mrad)

Two 60 cm long target cells with opposite polarisation
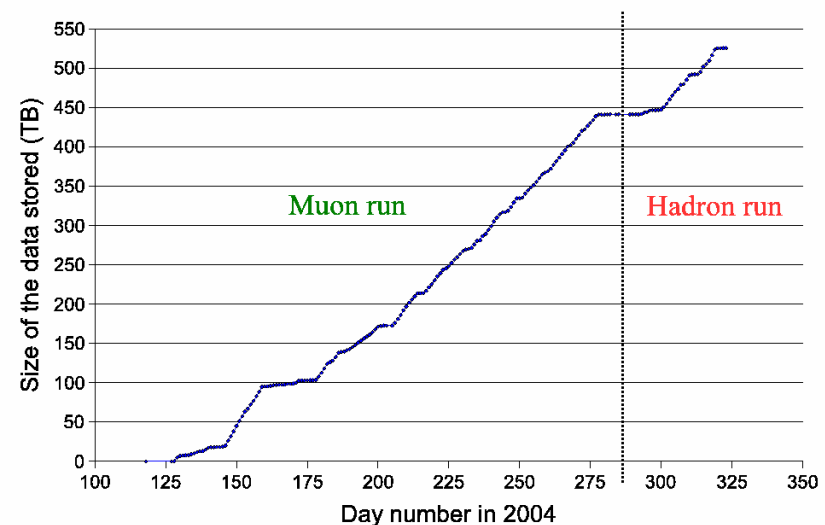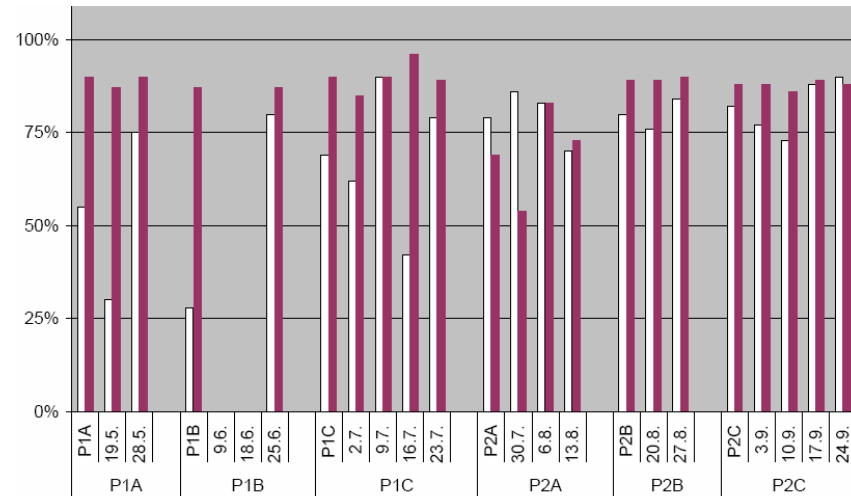
1m

Reconstructed interaction vertices
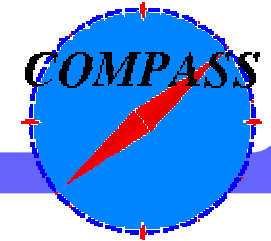
2004 muon data taking

- ## May 17 – October 4
  - beam scheduled: 110 days
  - beam delivered: 74 days
    i.e. 67 %
    - accelerators 73%
    - transfer line 92 %
  - COMPASS 86 %
  - sharing
    - longitudinal 78 %
    - transverse   22 %
  - 450 TByte collected

- ## open charm data
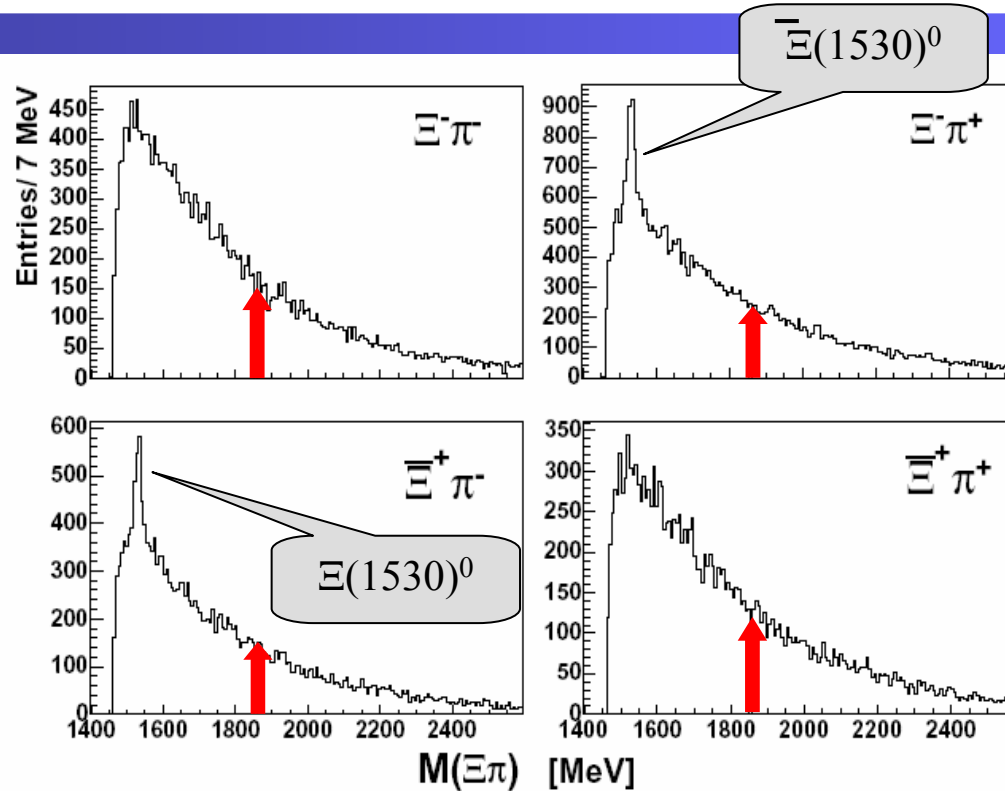 - at least doubled
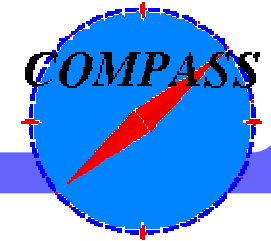
$\Phi(1860)$ Pentaquark search

- **motivated by NA49 report of pentaquark candidate**
  - COMPASS has large sample of the double-strange Ξ^- baryon (18000 Ξ^-, 11000 Ξ^+) from 2002/3 data
  - search for $\Xi^- \pi^-$ resonance
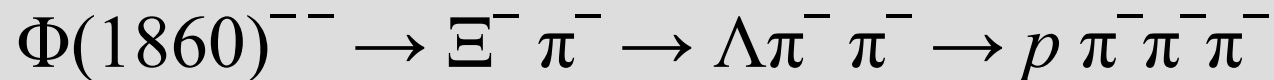
$$\Phi(1860)^{--} \rightarrow \Xi^- \pi^- \rightarrow \Lambda \pi^- \pi^- \rightarrow p\, \pi^- \pi^- \pi^-$$

- **compare to yield of** $\Xi(1530)^0 \rightarrow \Xi^- \pi^+$
  - opposite-sign pairs: 1700 and 920 evts
  - like-sign evts <79 and <89 at 99% CL

Φ(1860) Pentaquark search
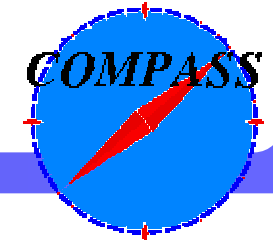

- compare to yields
  - opposite-sign pairs: $\Xi(1530)^0 \rightarrow \Xi^- \pi^+$, 1700 and 920 evts
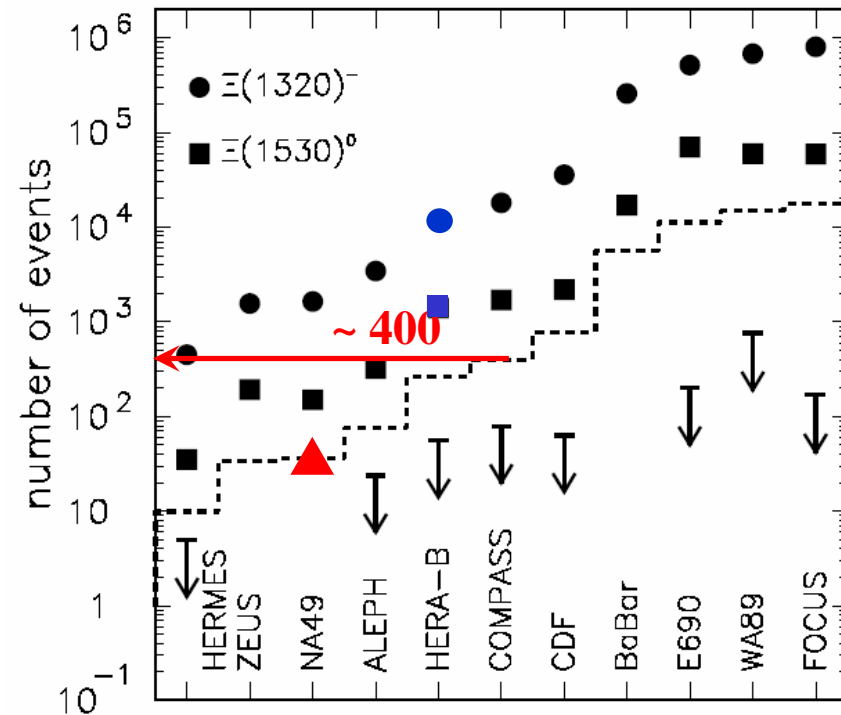 - like-sign pairs: evts <79 and <89 at 99% CL
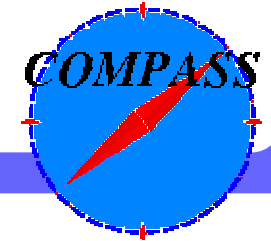
$\Phi(1860)$ Pentaquark search

- All experiments see about same ratio of $\Xi(1530)^0 / \Xi^-$ assuming such a fixed ratio also for Φ/Ξ^- we should see about 400 events

No $\Phi(1860)$ pentaquark
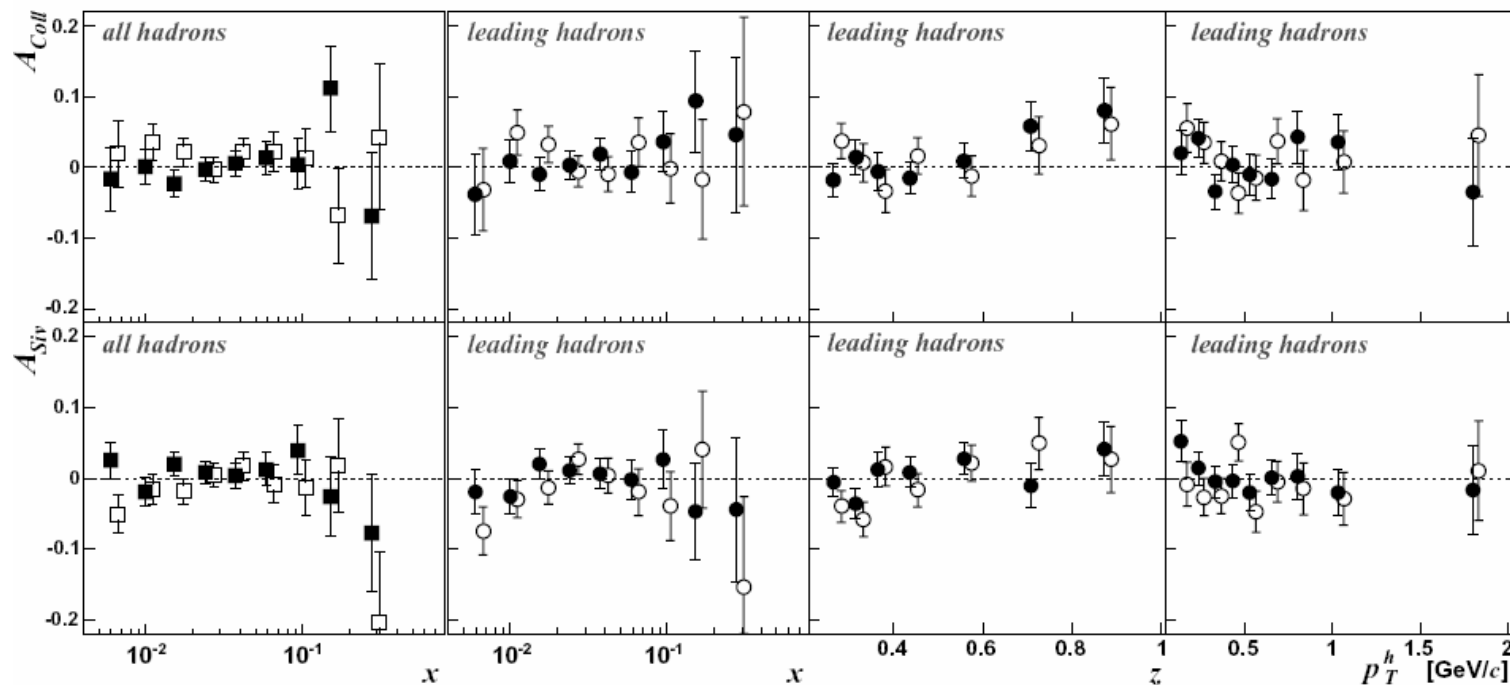at the level reported by NA49
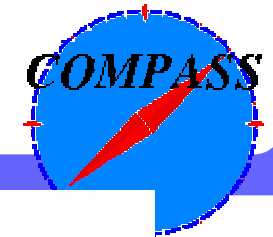
Towards transversity

- single spin transverse asymmetries (2002 data)

  – Collins: related to transverse quark distributions

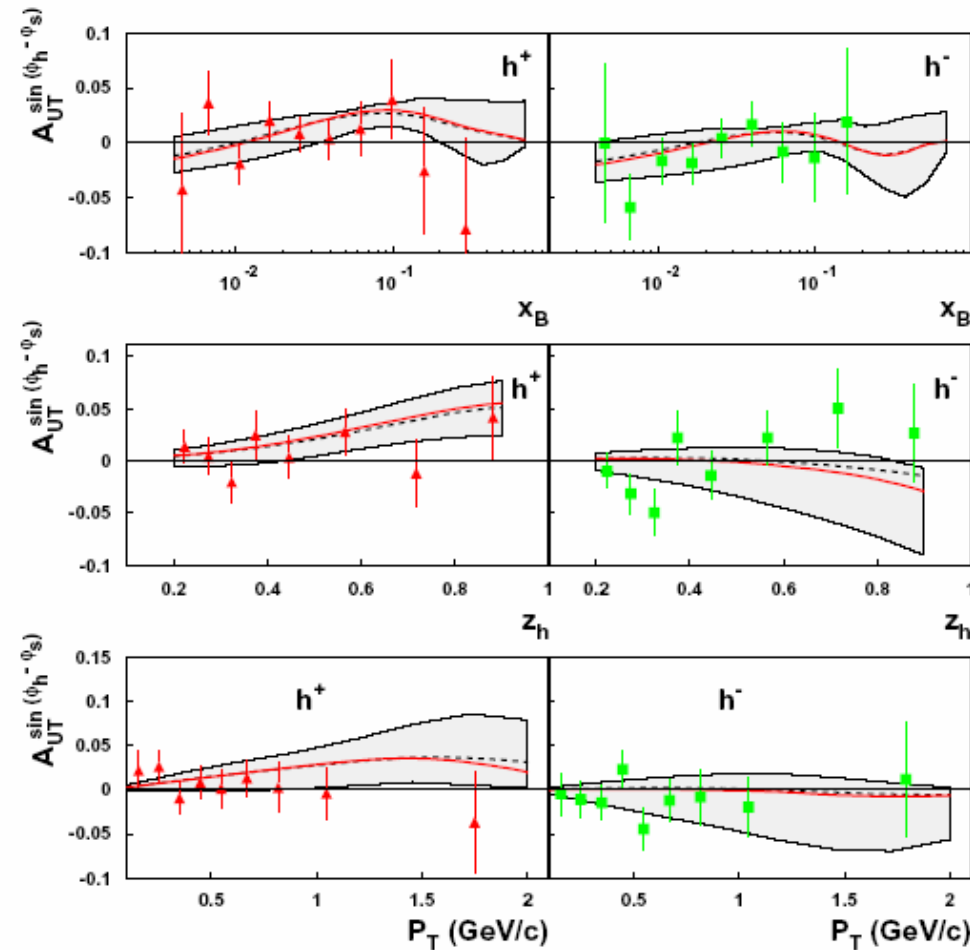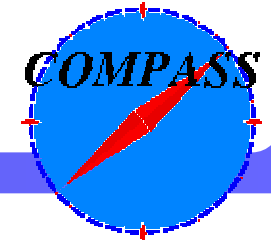 – Sivers: related to intrinsic k_T

● h^+ ○ h^-

Sivers effect

- consistent with model describing HERMES p and COMPASS d data

M. Anselmino,[1] M. Boglione,[1] U. D'Alesio,[2] A. Kotzinian,[3] F. Murgia,[2] and A. Prokudin[1]
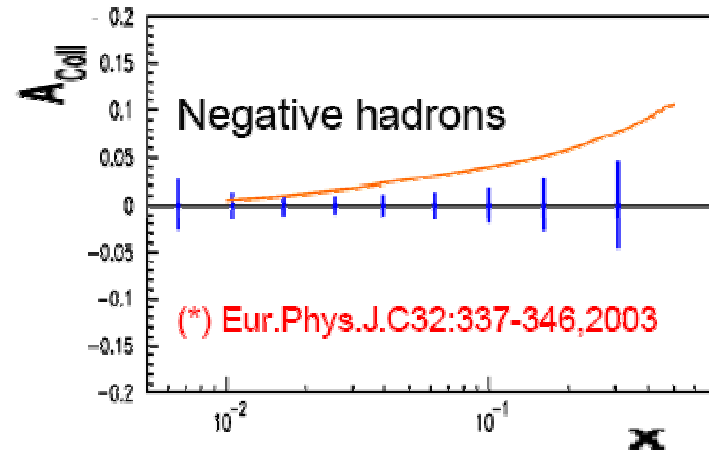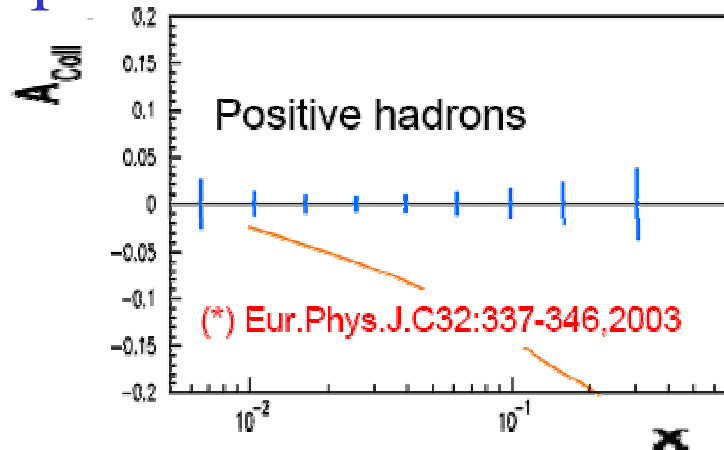
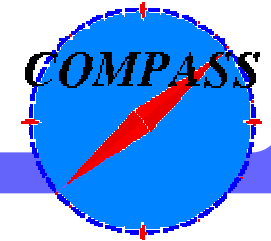arXiv:hep-ph/0501196

# Prospects for Collins asym.

- ## 2002-2004 deutron
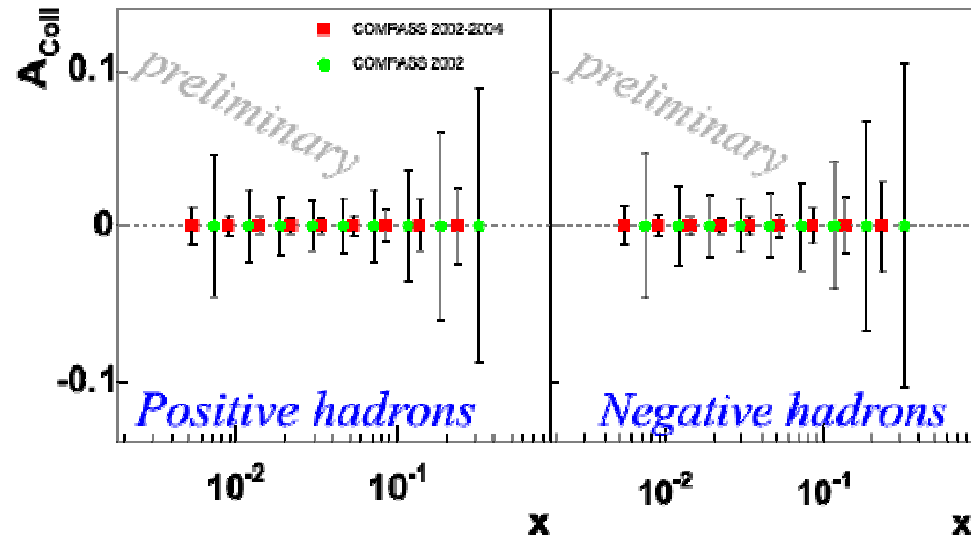
- ## 2006 proton data

Quark polarimeters

- **all asymmetries compatible with zero**

- **measure product of chiral-odd FF and PDF**
  - is the analysing power of Collins FF small?
  - or are the transverse parton distributions small

- **try other polarimeters**
  - interference FF of two hadrons
  - lambda polarisation

2002 transversity data, $Q^2 > 1$ $(GeV/c)^2$

Λ

5855 ± 111

$m(p\,\pi^-)$ $[GeV/c^2]$
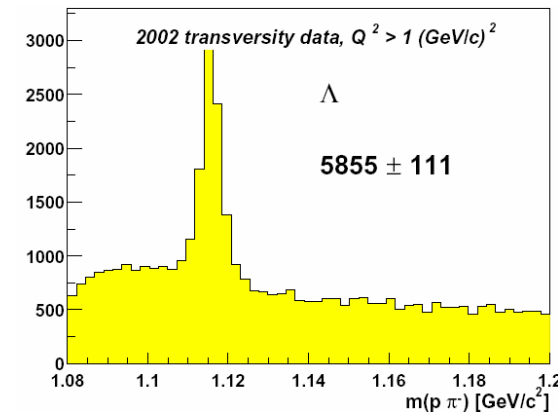
2 hadron interference FF
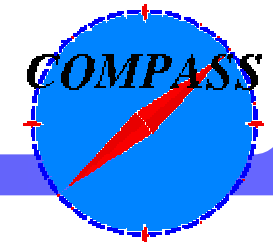
- spin-dependent part in two-hadron fragmentation

$$H_q^{\sphericalangle h}(z, M_h^2)\, \sin\varphi_{RS}$$

with
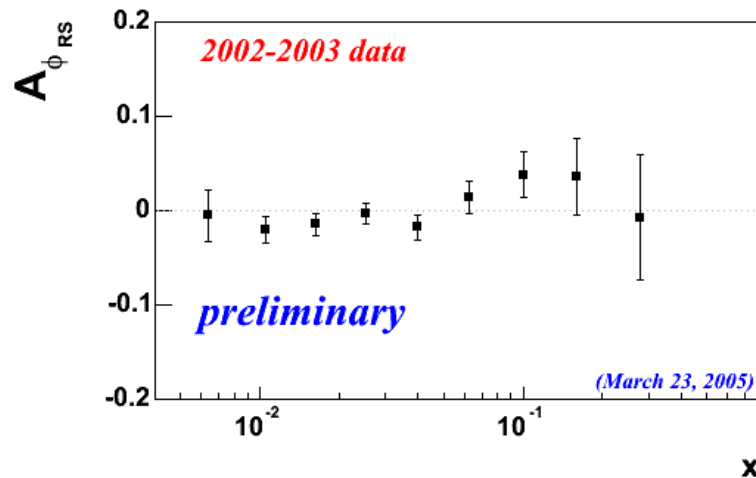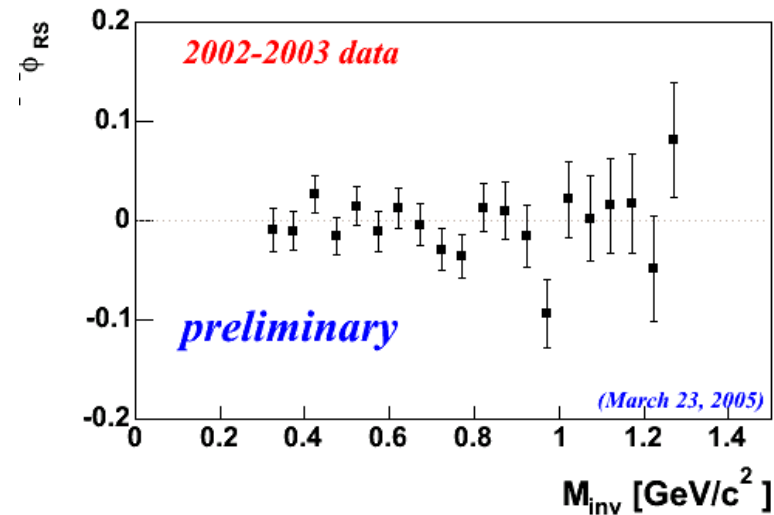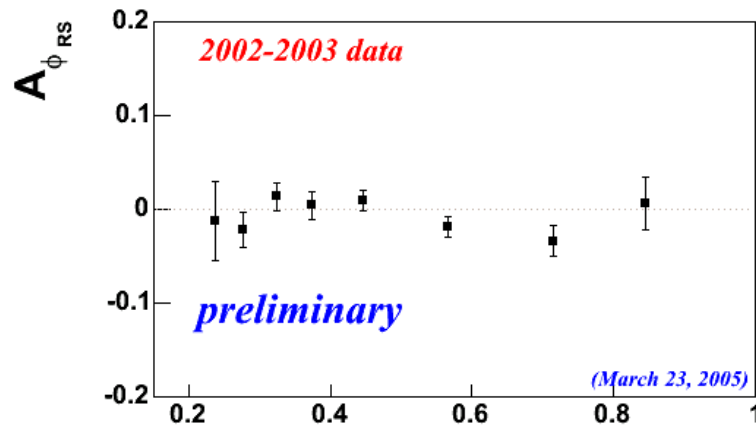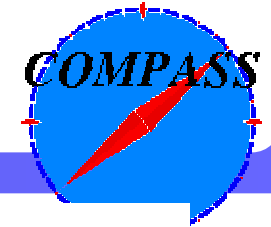
$$\varphi_{RS} = \varphi_R + \varphi_S - \pi$$

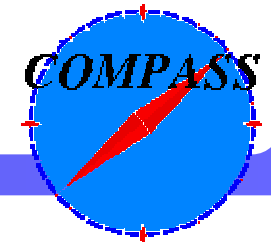and two-hadron invariant mass M_h^2
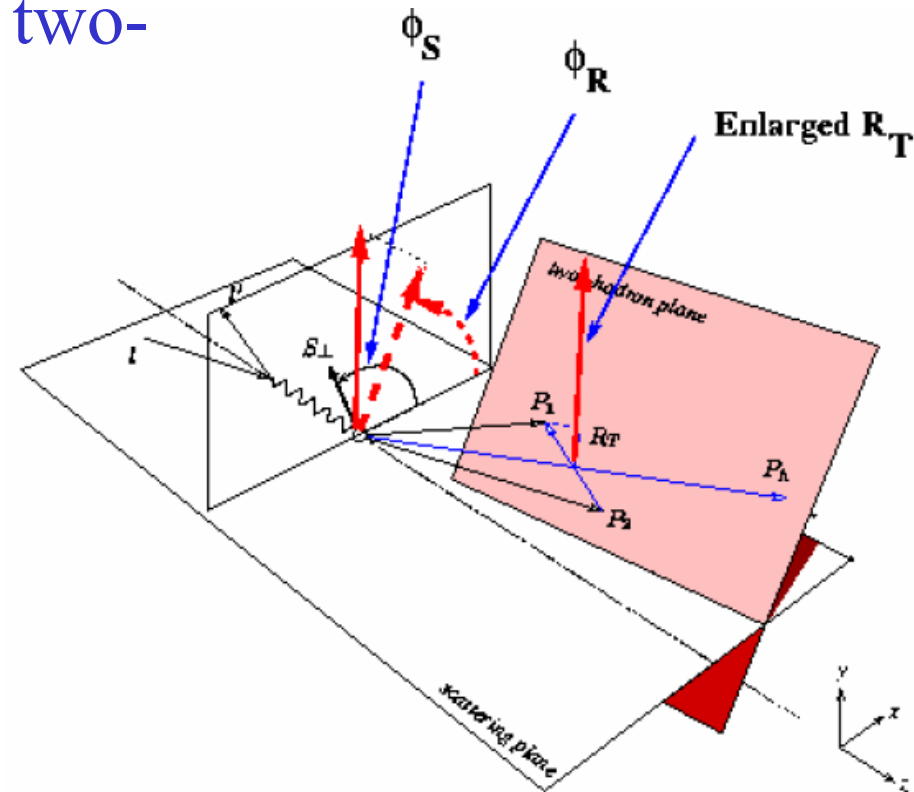
2 hadron asymmetries
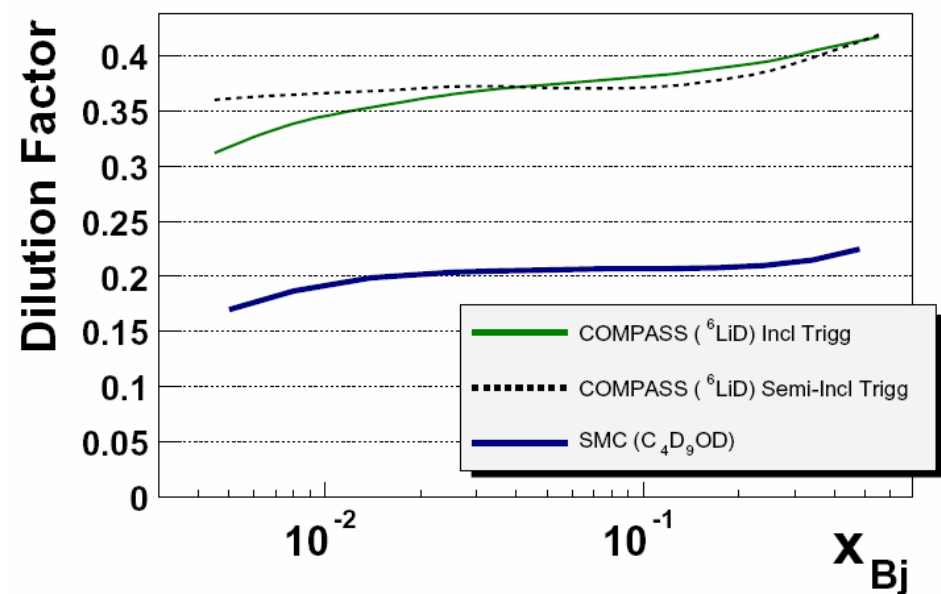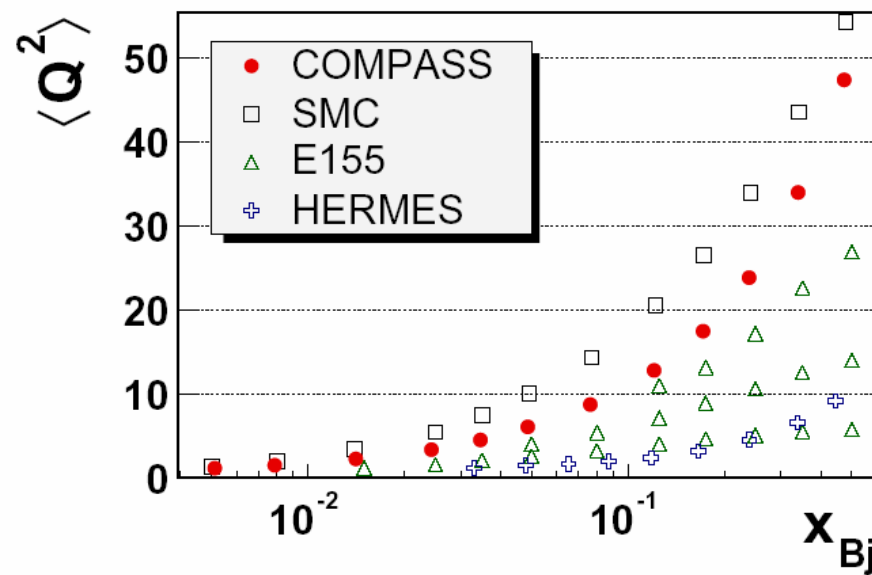

- 2002 and 2003 data
- precise measurement of few %
- systematics seems well under control
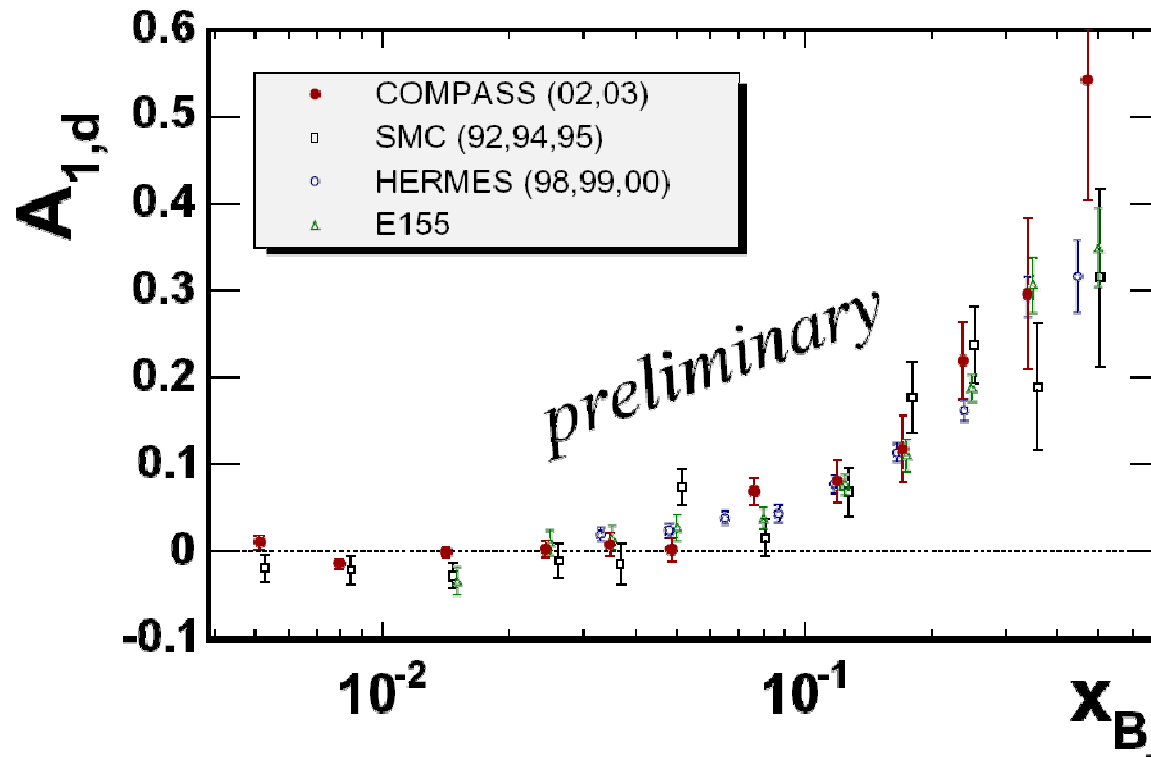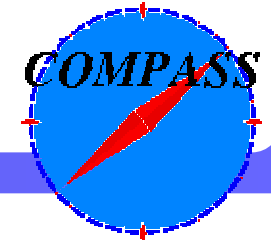- also compatible with zero
- interesting to see proton in 2006

New g_1 data for the deuteron
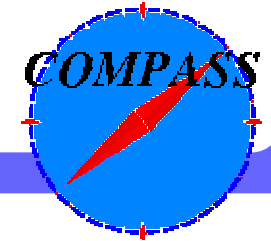
- 2002 and 2003 data analysed

New g_1 data for the deuteron

- most precise measurement for $0.004 < x < 0.03$
- less negative in this region

QCD fit à la SMC

- fit to all p, d and n data
  - g_1, $Q^2 > 1$ GeV^2
  - NLO ($\overline{MS}$)
  - $Q^2_0 = 4$ GeV^2
  - x–Q^2 grid, no HT
  - χ^2 prob. 0.14
  - E155 p: normalisation fitted to 1.13±0.02
- precision of a_0 improves by factor 2
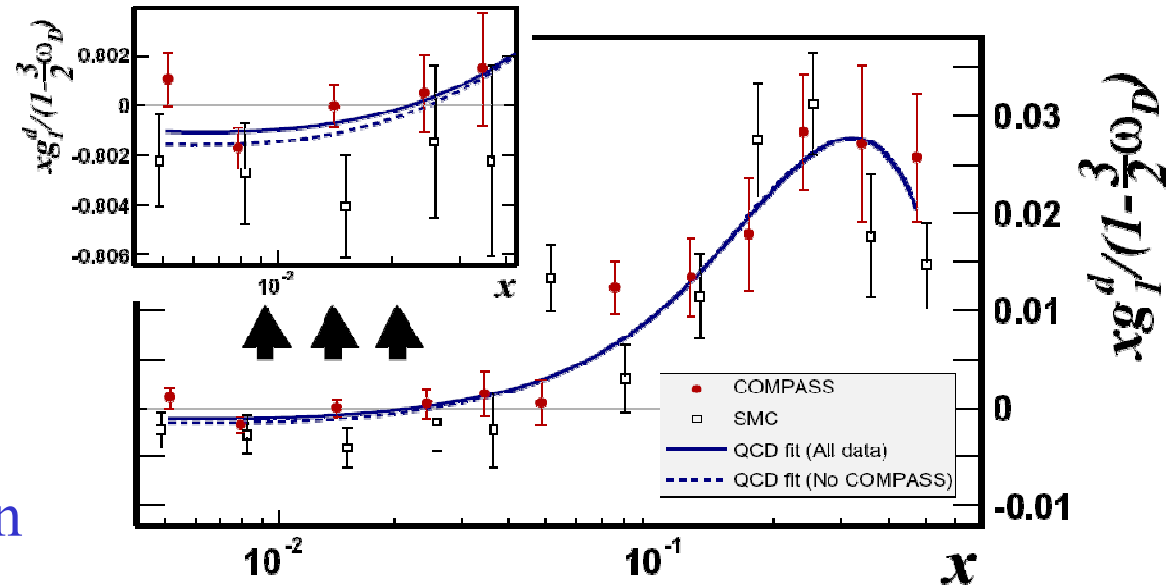
$$a_0 = \Delta\Sigma(\overline{MS}) = 0.237^{+0.024}_{-0.029}$$

without COMPASS data: $0.202^{+0.042}_{-0.077}$

LSS'05 effect of new data

- ● with COMPASS data
  - – ΔG decreases a bit
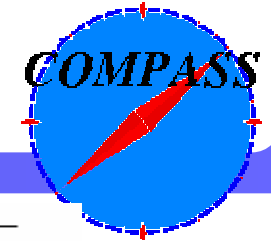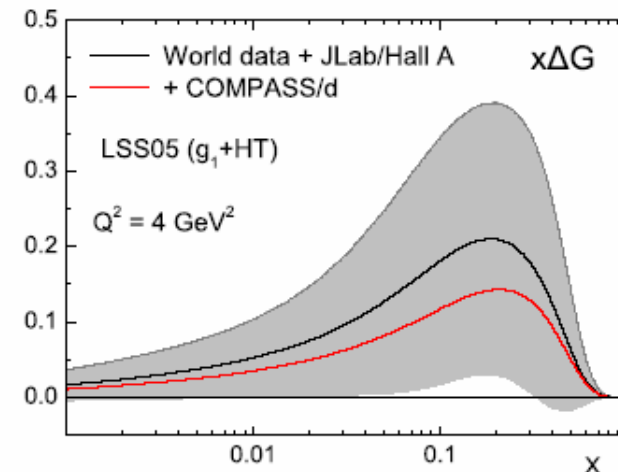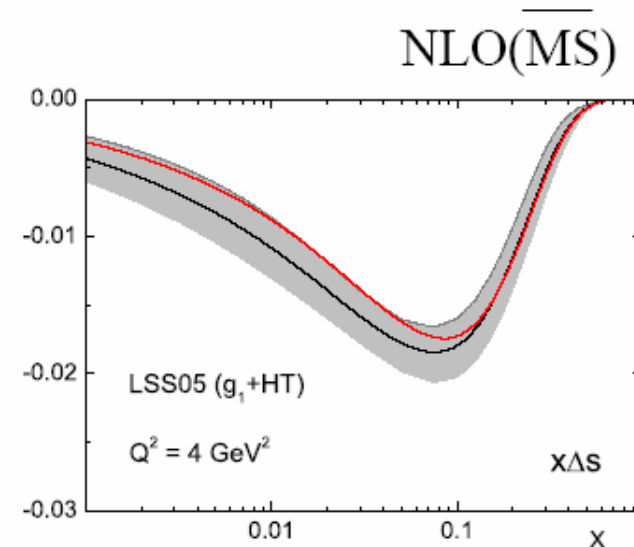 - – Δs decreases a bit

NLO($\overline{\text{MS}}$)

LSS05 (g₁+HT)

$Q^2 = 4\ GeV^2$

xΔS

0.5
World data + JLab/Hall A
+ COMPASS/d
xΔG

LSS05 (g₁+HT)
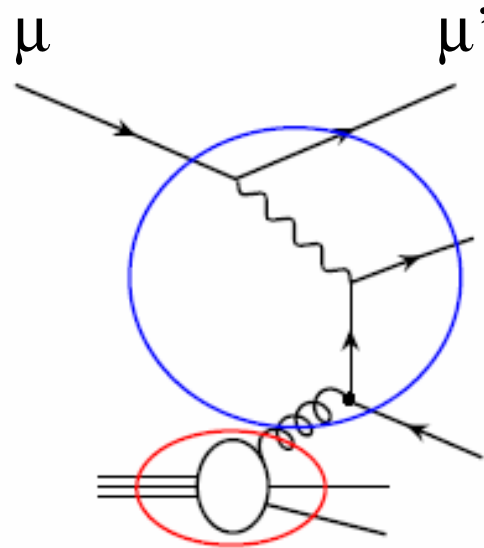
$Q^2 = 4\ GeV^2$

hep-ph/0503140

Gluon polarisation

COMPASS

- Gluon polarisation is measurable in photon-gluon fusion process
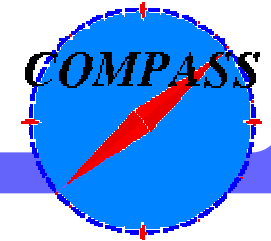
μ μ'

$$A_{\parallel} = R_{pgf} \langle \hat{a}_{pgf} \rangle \frac{\Delta G}{G}$$

- measure $A_{\parallel}$

- calculate R_{pgf} and $\langle \hat{a}_{pgf} \rangle$
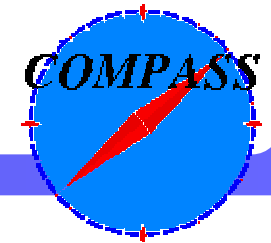
  using Monte Carlo

Gluon polarisation: pgf
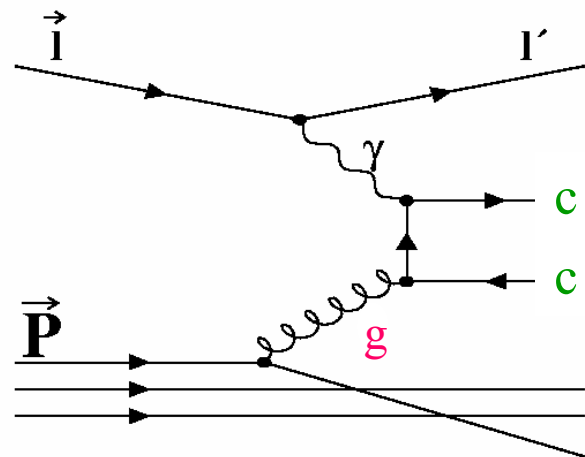
- three main lines of leading-order analysis:

  - open charm production: single D meson   AROMA
  - high-p_T hadron pairs with $Q^2 > 1$ GeV^2 LEPTO
  - high-p_T hadron pairs with $Q^2 < 1$ GeV^2 PYTHIA

- look at NLO

  - single high-p_T with $Q^2 \sim 0$ Regensburg
  - calculations for $Q^2 > 0$ under way

Open charm at COMPASS

- Photon-gluon fusion: 1.2 D^0 per PGF $c\bar{c}$ event

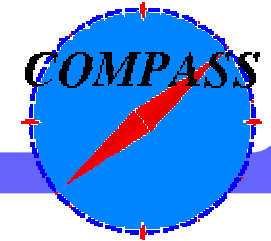$$D^0 \Rightarrow K^- \pi^+ \qquad \text{BR 4 \%}$$

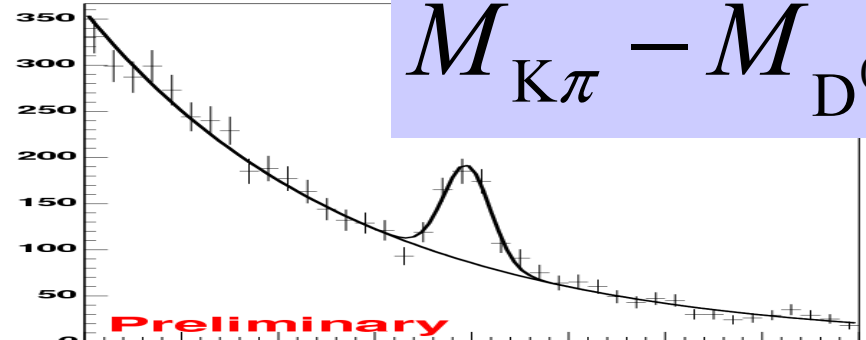$$\text{or:} \quad D^{*+} \Rightarrow D^0 \pi_s^+$$

$$\Rightarrow K^- \pi^+ \pi_s$$

D^0 from D^* about 20 %

$D^{*+} \to D^0 \pi_s^+$ tagging

$D^* \to D^0 \pi_s$

$\quad \to K\pi\pi_s \ (+cc)$

$M_{K\pi} - M_{D^0}$

$\Delta M_{K\pi\pi} = M_{K\pi\pi_s} -$
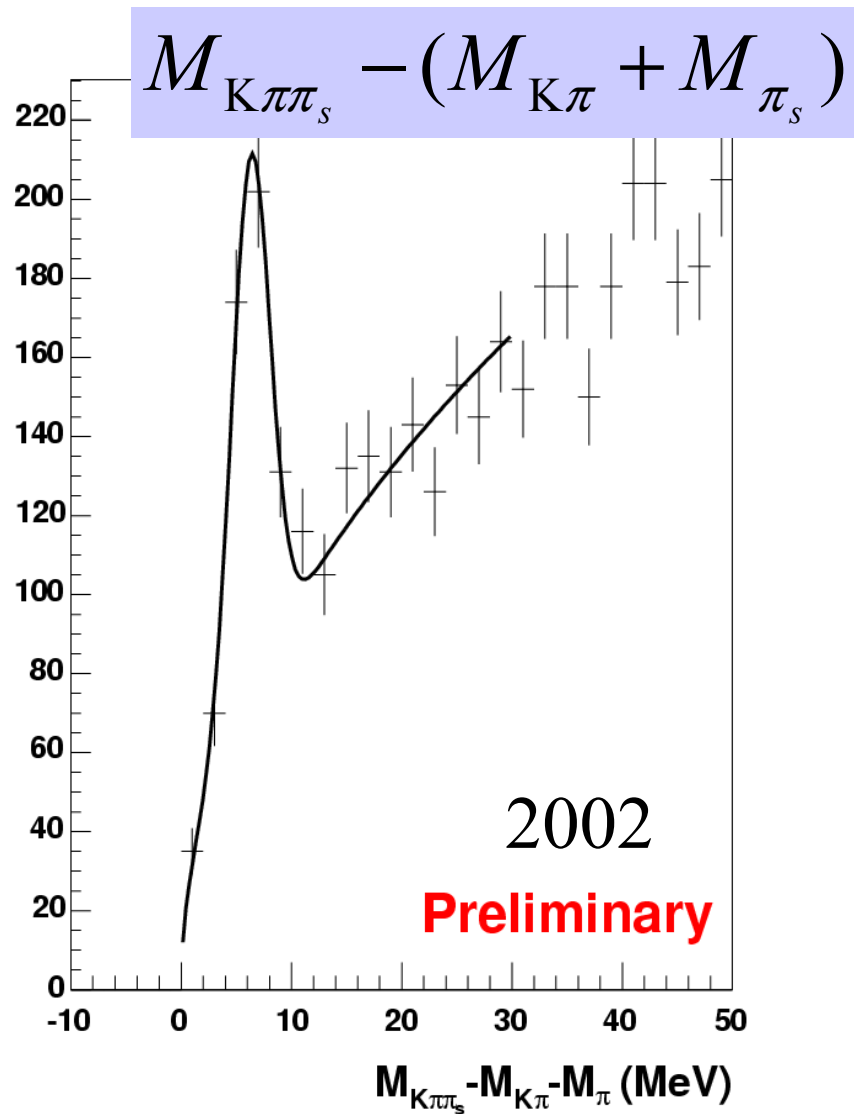
$(M_{K\pi} + M_{\pi_s})$

Preliminary

Preliminary
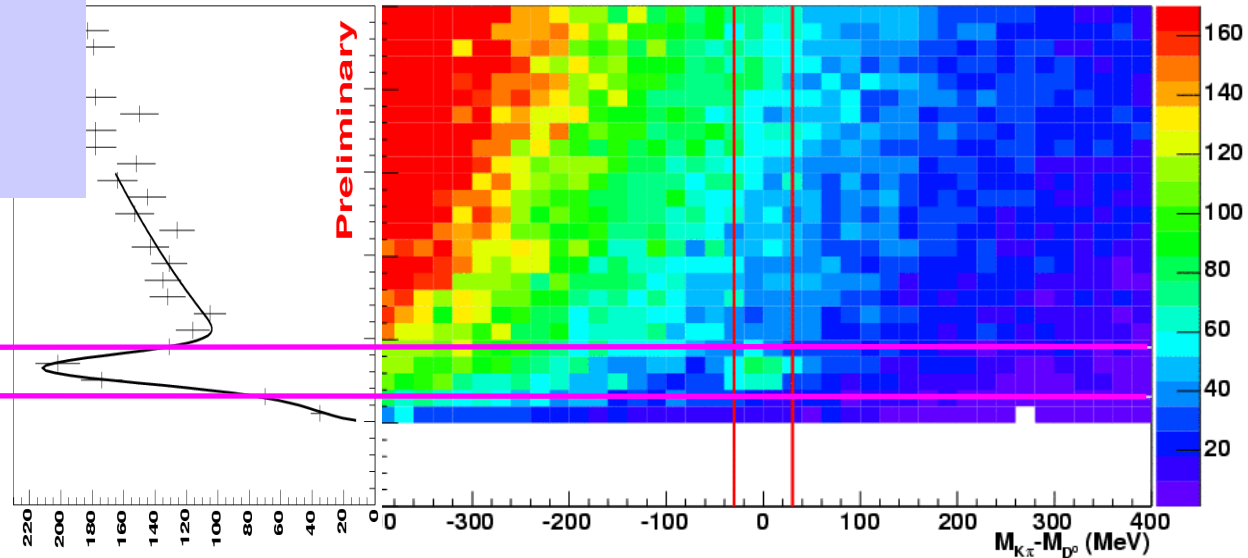
Choose:
$3.1 < \Delta M_{K\pi\pi} < 9.1$ MeV

$M_{K\pi} - M_{D^0}$ (MeV)

- 2002 and 2003 data analysed, only 2002 shown

$D^{*+} \to D^0 \pi_s^+$ tagging

COMPASS

$M_{K\pi\pi_s} - (M_{K\pi} + M_{\pi_s})$

$M_{K\pi} - M_{D^0}$

2002

Preliminary

$M_{K\pi\pi_s} - M_{K\pi} - M_\pi$ (MeV)

$3.1 < \Delta M_{K\pi\pi} < 9.1$ MeV

2002

Preliminary

$M_{K\pi} - M_{D^0}$ (MeV)
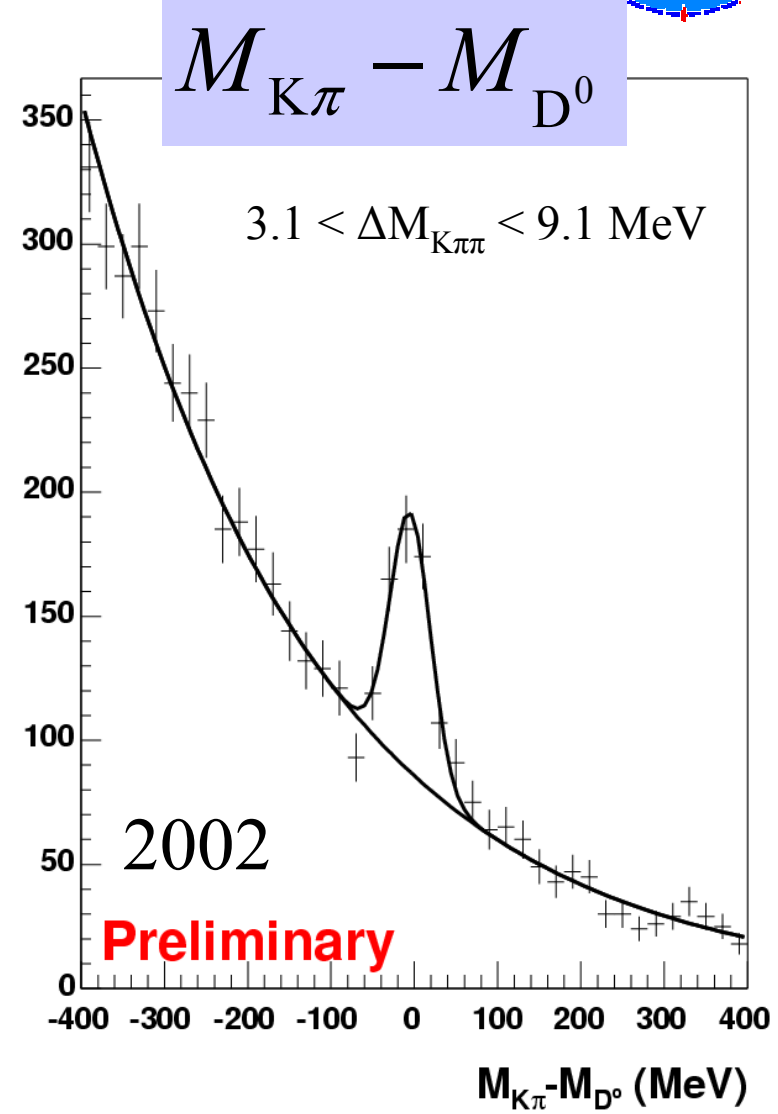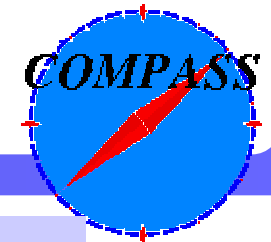
Open Charm: D's from $D*$'s

- requiring the slow pion in $D^* \to D\,\pi_s \to K\,\pi\,\pi_s$
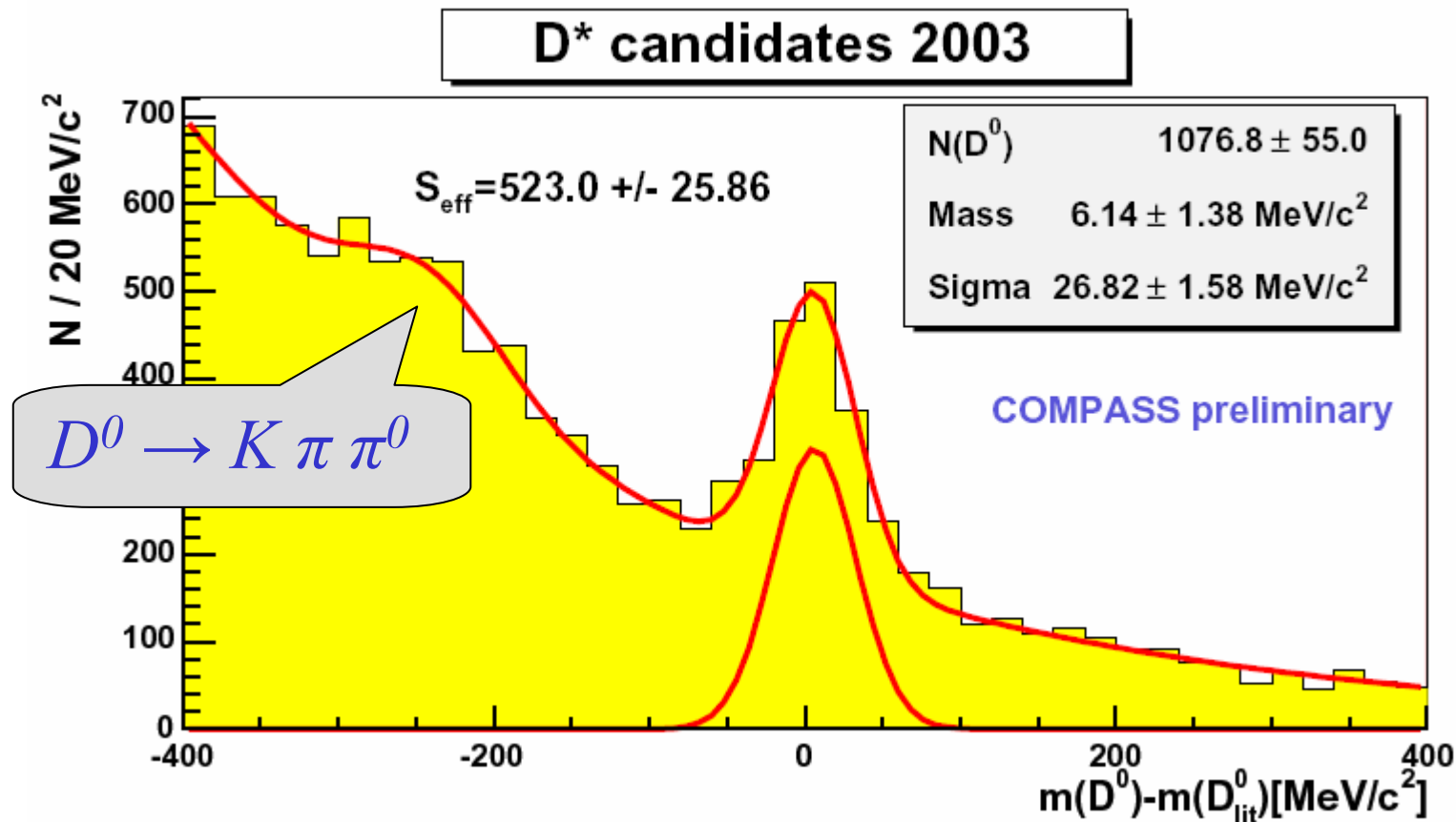
Open Charm: MC studies

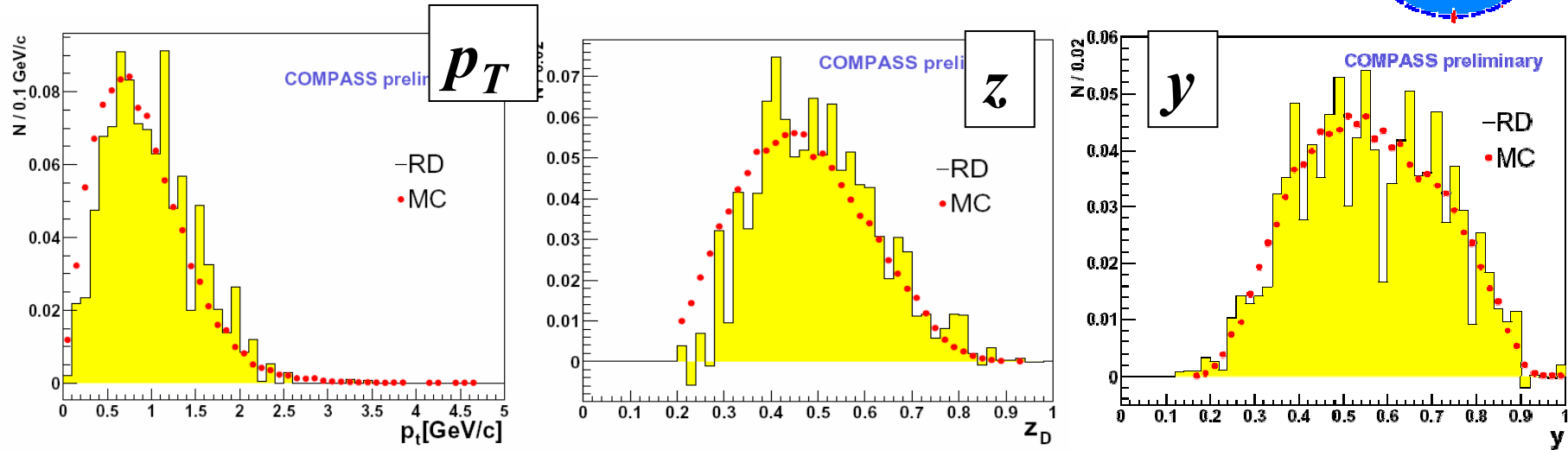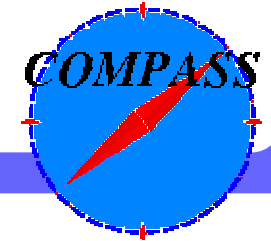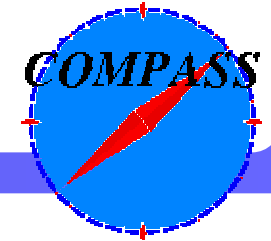- AROMA Monte Carlo, pgf only
- background subtracted 2003 data (side bands)
- **D**'s indeed from pgf ? Data understood?
- good agreement data / MC
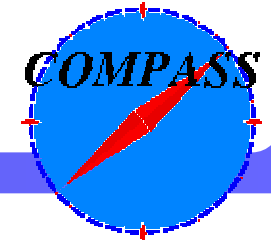- hard *z*-distribution

Open charm: MC

- **Correlation** of generated and reconstructed a_{LL}
- analysis uses event weighting with a_{LL} deduced from kinematic variables
- also only one hadron from pgf reconstructed good correlation
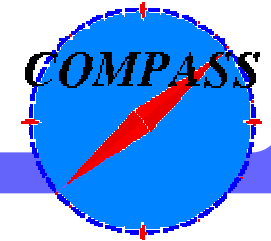- average $x_g \approx 0.15$

COMPASS preliminary
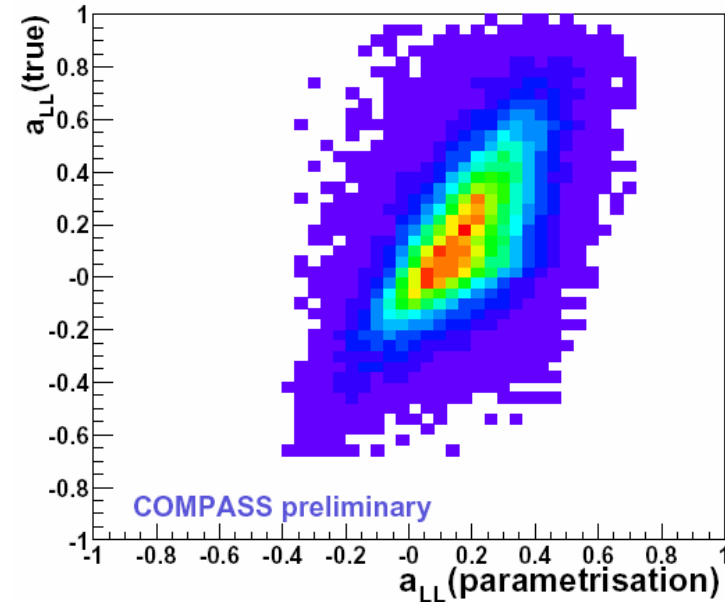
Open charm

- improvement of apparatus and software
  - factor 4.6 achieved in efficiency wrt initial 2002 data/analysis
  - still expect about factor 2 for data already taken:
    - event selection, stability cuts, D^0 below threshold, more channels,
    - about 1.2 - 1.3 of that possible now

- progress of data taking
  - arbitrary units for equiv. events
  - estimate for 2006 with
    - total factor 3.6
    - new magnet (1.3)
    - Rich upgrade (1.6)
    - 100 days of beam (1.3)
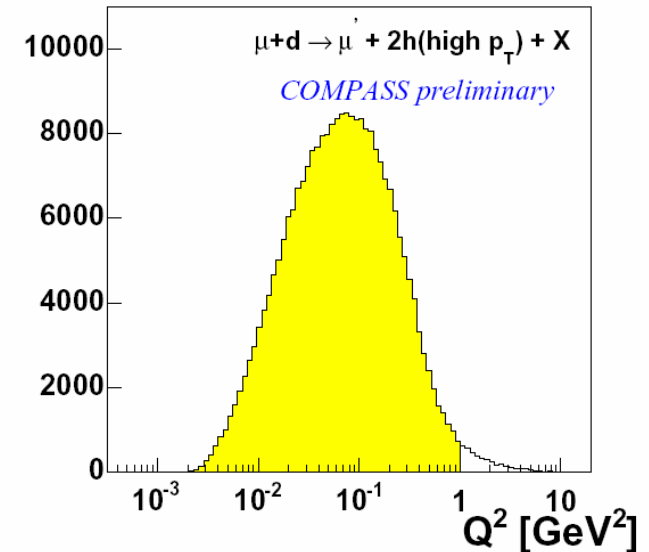   - Ecal (1.2)
    - K below threshold (1.1)

■ per year ■ accumulated

estimate

2002   2003   2004   2006
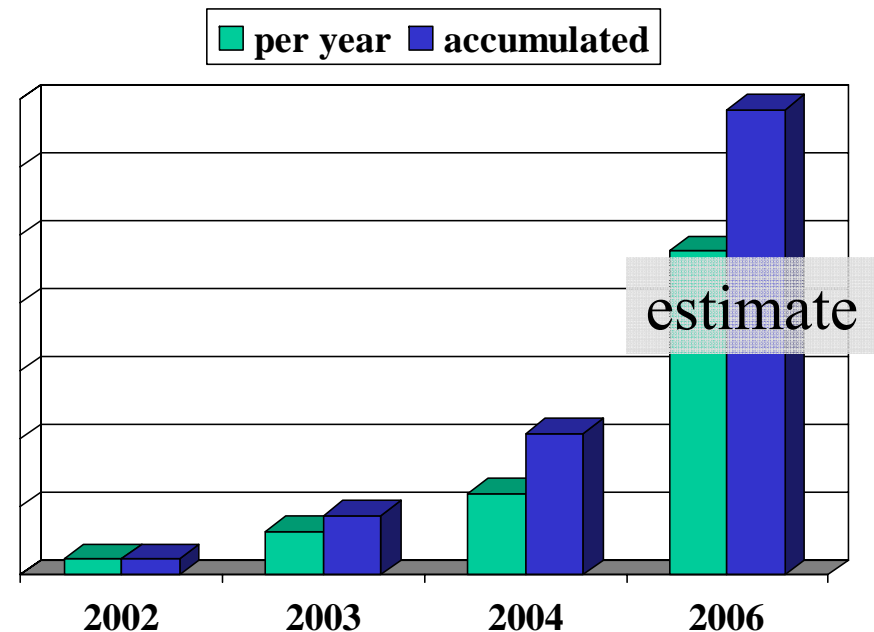
High-p_T pairs

- $Q^2 > 1 \text{GeV}^2$ 28000 evts
- $Q^2 < 1 \text{GeV}^2$ 250000 evts
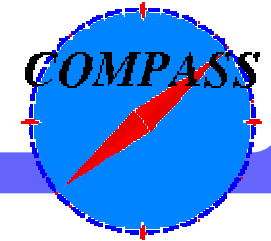
- 2002 and 2003 data
  - $p_{T,1}$, $p_{T,2} > 0.7$ GeV, $p^2_{T,1} + p^2_{T,2} > 2.5$ GeV^2,
  - for statistical reasons use $A_{\parallel} / D$
  - D depolarisation factor, $D \simeq \dfrac{y(2-y)}{y^2 + 2(1-y)}$
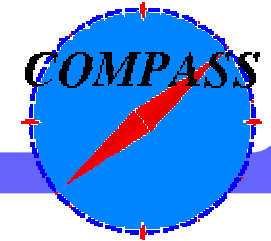 - exact formula used in analysis

High-p_T pairs: $Q^2 > 1 \text{GeV}^2$

- $x_{Bj} < 0.05$, can neglect QCD Compton and LO
- LEPTO tuning à la SMC high-p_T
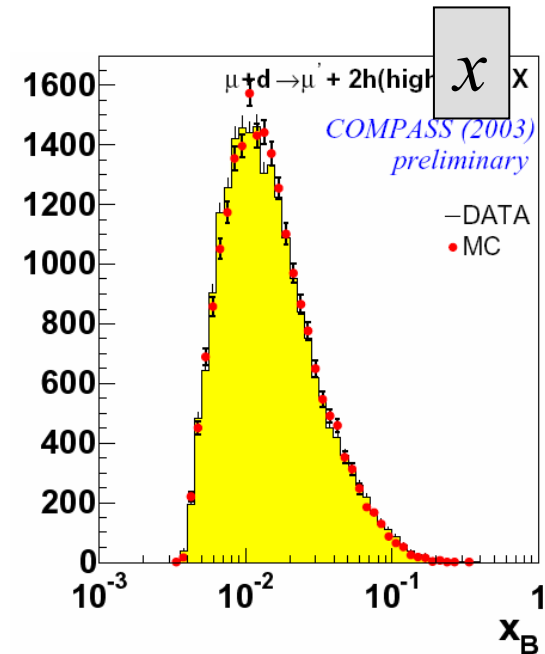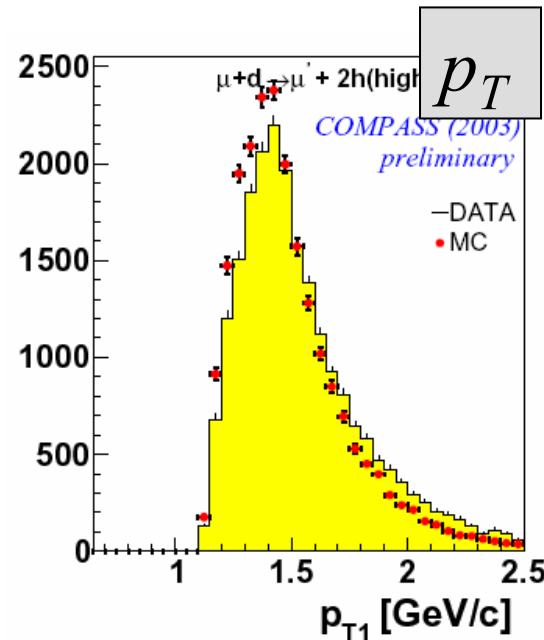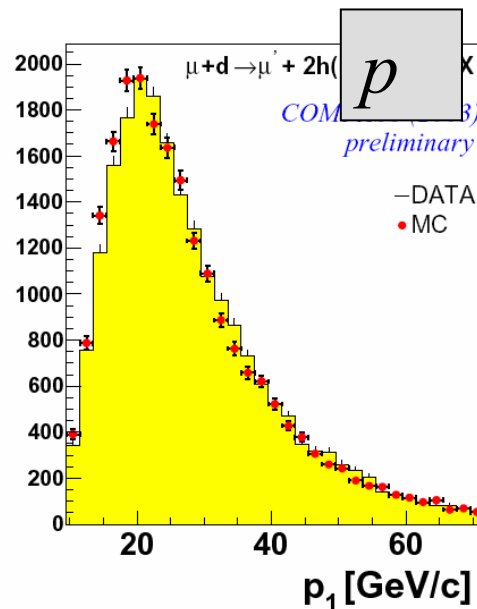
High-p_T pairs: $Q^2 < 1\text{GeV}^2$

- more difficult than large Q^2
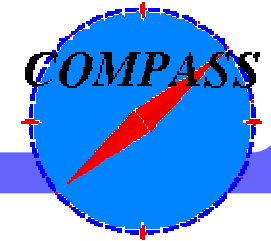- contributions from resolved photons
  - spin dependent structure of the photon
    - perturbative part calculable
    - non-perturbative part:
      - min/max VMD scenarios
      - tuning of intrinsic k_T partons in the photon
- nucleon parameters
  - tuning of fragmentation functions
  - tuning of intrinsic k_T in nucleon

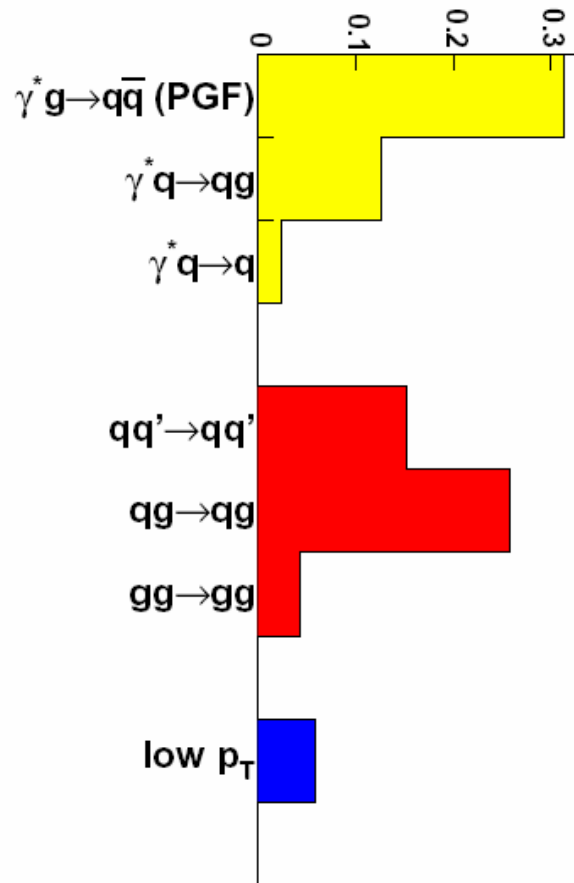$P^2 = 0\ \text{GeV}^2$

$P^2 = 1\ \text{GeV}^2$
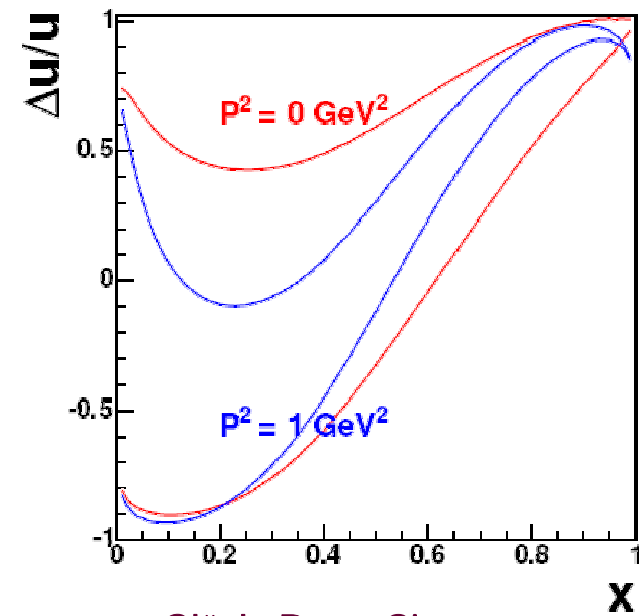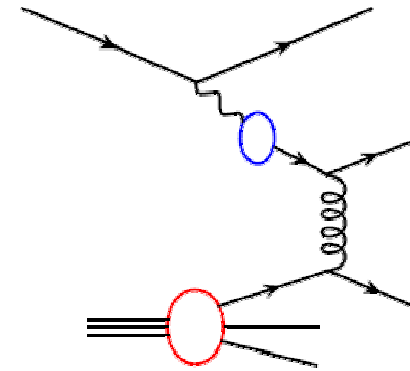
Glück, Reya, Sieg

Resolved photon contributions

PYTHIA

$$\frac{A_\parallel}{D} = R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \left(\frac{\Delta G}{G} \right)^d$$
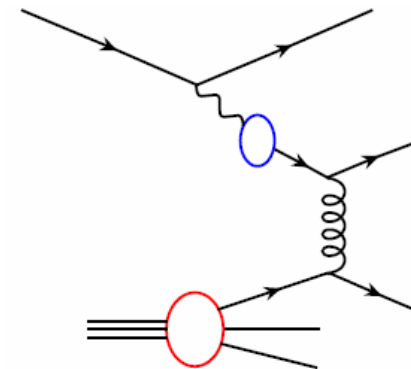
$$+ \ldots$$

$$+ R_{qq'} \left\langle \hat{a}_{qq'} \right\rangle \left(\frac{\Delta q}{q} \right)^d \left(\frac{\Delta q'}{q'} \right)^\gamma$$
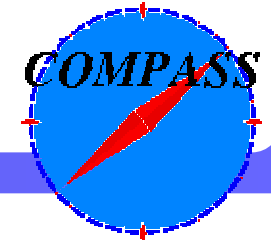
$$+ \ldots$$

e.g.:
qq'→ qq'

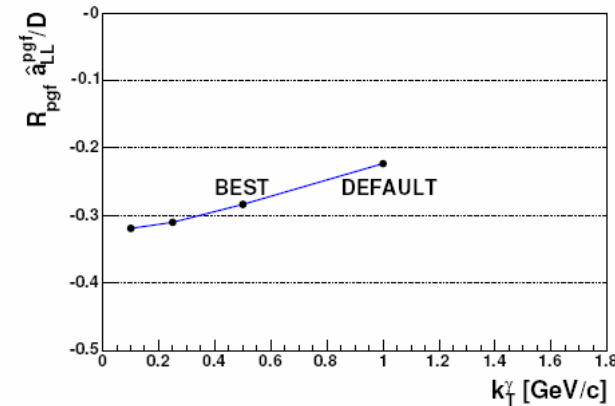G. Mallot

Example: k_T tuning

nucleon   photon
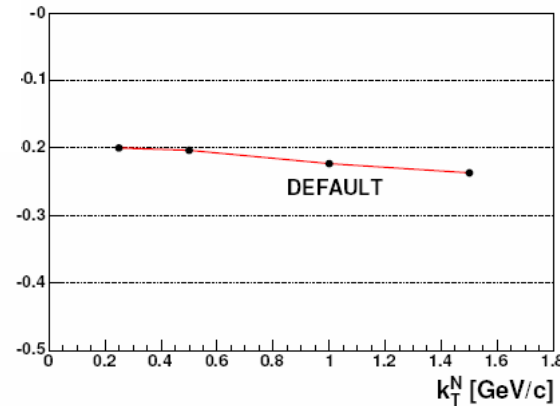
- **systematic error**
  - determined using 15 independent MC simulations
  - exploring the parameter space
    - in k_T of nucleon and photon
    - fragmentation functions
    - parton shower on/off,
    - renormalisation scale

Data versus MC

Ladder trigger, 1st hadron

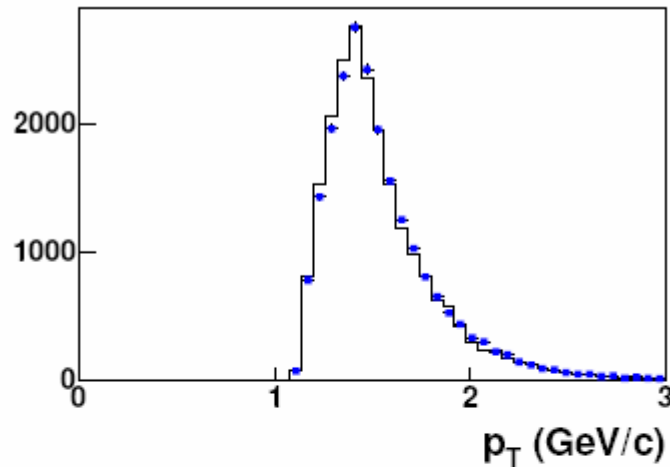p_T (GeV/c)
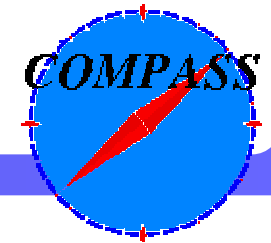

Ladder trigger, 1st hadron

p_T (GeV/c)
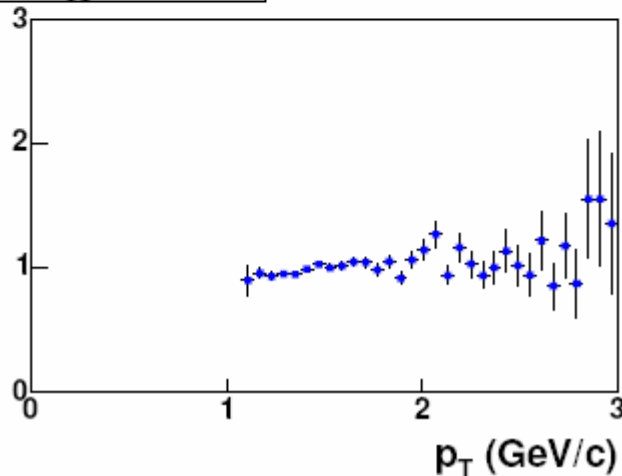
- excellent to good agreement for all kinematics variables

- weight events with

$$1/D \sim A_{LL,} \qquad \langle D \rangle = 0.64$$

- let's get

$$\frac{\Delta G}{G}$$

Gluon polarisation

$Q^2 > 1\,\mathrm{GeV}^2$:

$$\frac{A_\parallel}{D} = -0.015 \pm 0.080\,(\text{stat.}) \pm 0.013\,(\text{syst.})$$

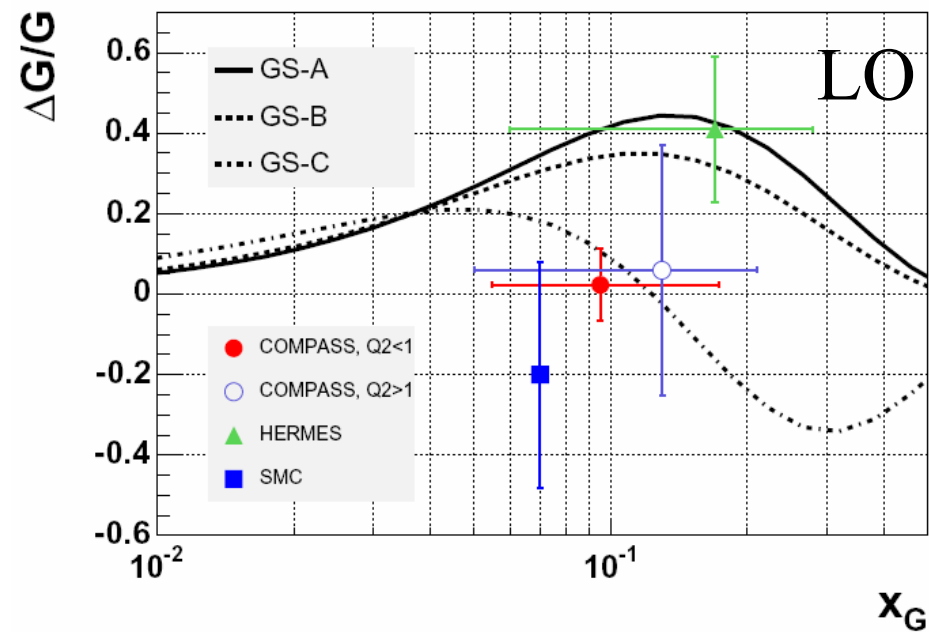$$\frac{\Delta G}{G} = 0.06 \pm 0.31\,(\text{stat.}) \pm 0.06\,(\text{syst.})$$

$Q^2 < 1\,\mathrm{GeV}^2$:

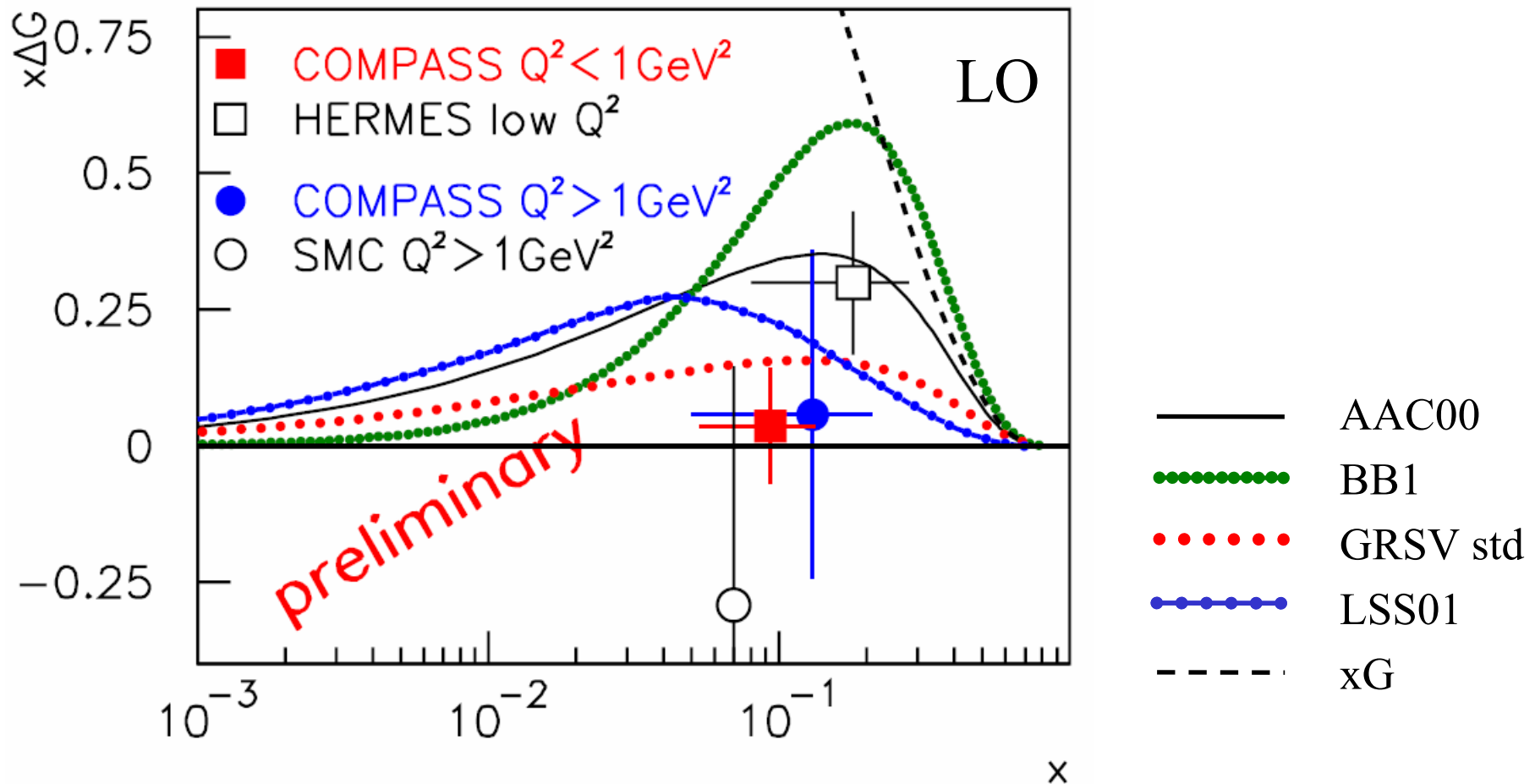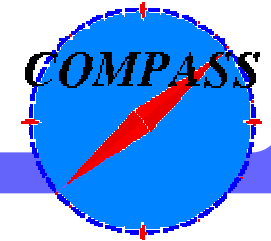$$\frac{A_\parallel}{D} = 0.002 \pm 0.019\,(\text{stat.}) \pm 0.003\,(\text{syst.})$$

$$\frac{\Delta G}{G} = 0.024 \pm 0.089\,(\text{stat.}) \pm 0.057\,(\text{syst.})$$
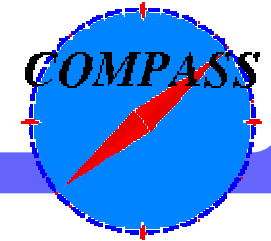
Gluon polarisation ΔG/G (LO)

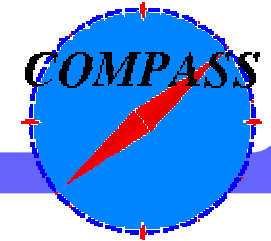$\Delta G/G$ is small around $x_g \approx 0.1$
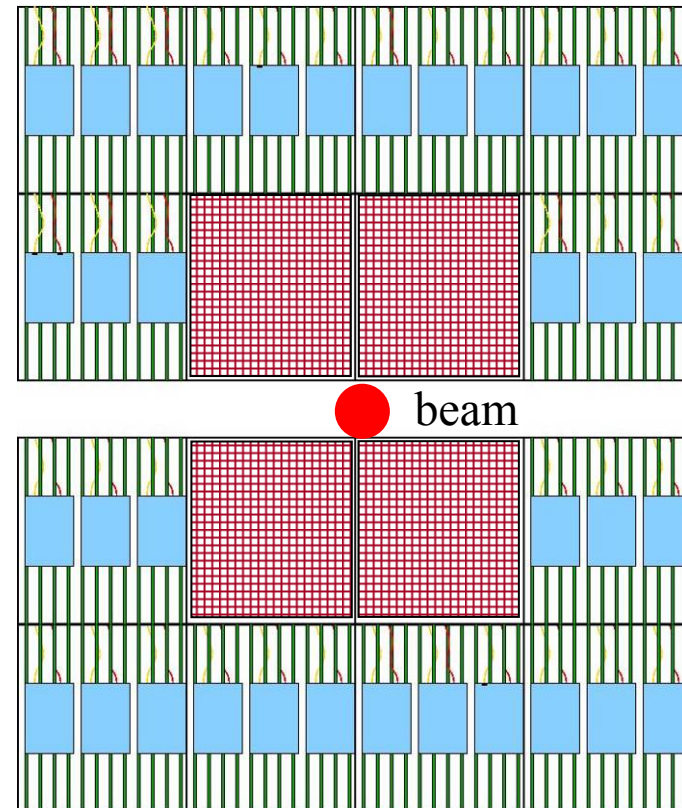
Gluon helicity ΔG (LO)
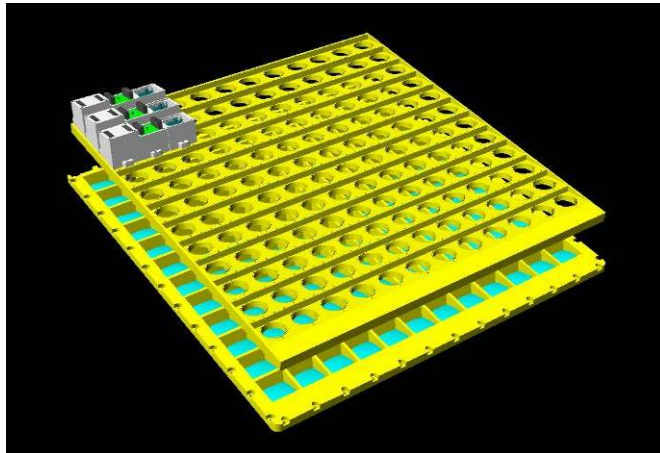
2006

Spectrometer Upgrade

RICH upgrade for 2006

- **central region 'maPMT':**
  - multi-anode PMTs
  - lens system
  - MAD4 preamp
  - F1 TDCs, excellent time resolution

- **outer region 'APV':**
  - keep CsI photodetector
  - new readout based on APV chips
  - good time resolution

- **'no' DAQ dead time**

beam

RICH maPMT
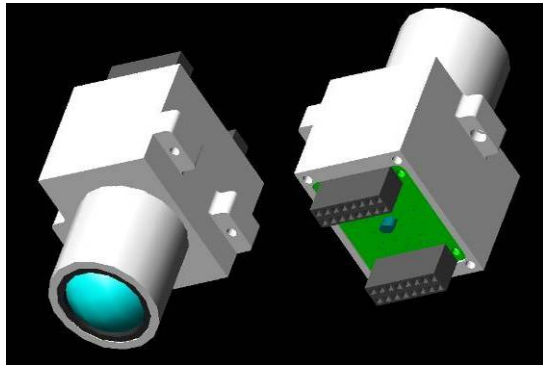
INFN, Freiburg,++

- elements tested in T11 beam
- approved by INFN in April
- design of optics finished
- PMs order (600)
  - delivery schedule Q3 2005 till Jan 2006
- decide mid 2005 on modification of chambers
  - non destrucive, but hard to undo
- finish construction in 2005

APV RICH project

- ## R/O successfully tested
  - during 2004 on the Rich

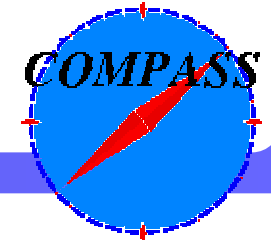- ## Design and optimisation:
  - done

- ## preproduction and test
  - Q2/05

- ## production
  - Q3-4/05

- ## installation and test
  - Q1 /06

dR (hit-ring) [cm] VS time [25 ns units]

dR, cm   Trigger time
                x25ns
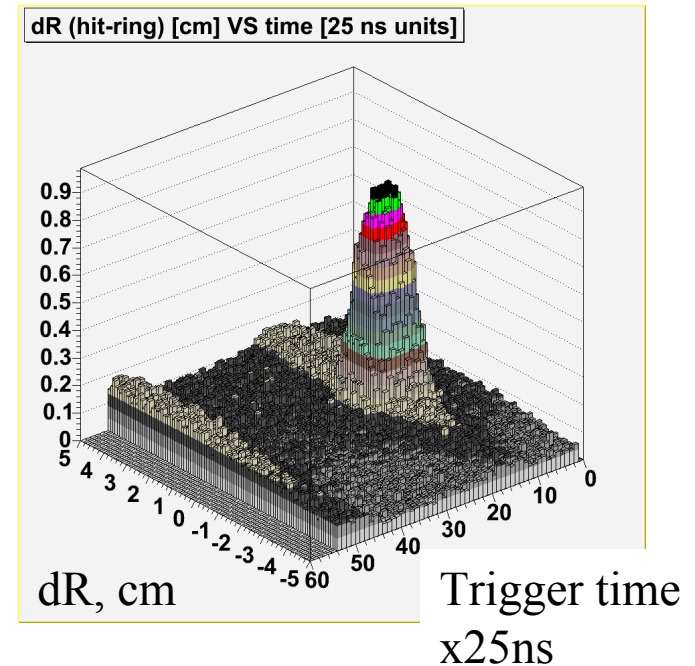
TU Munich, Saclay

Large drift chamber DC4
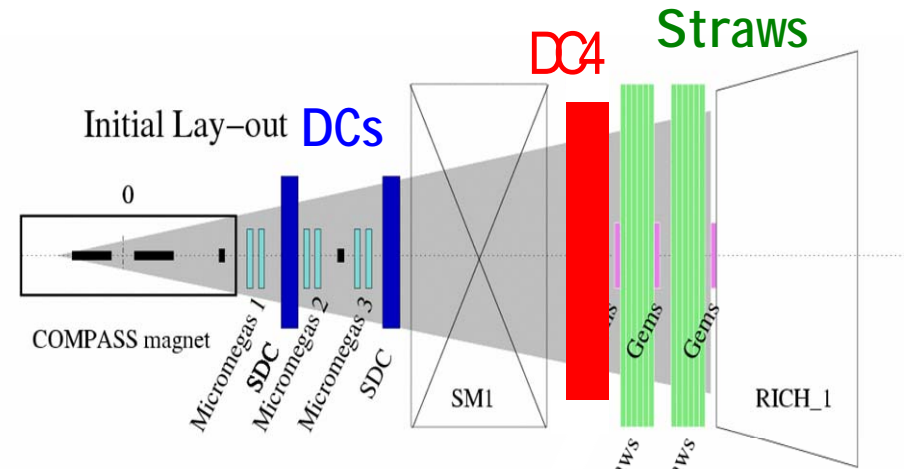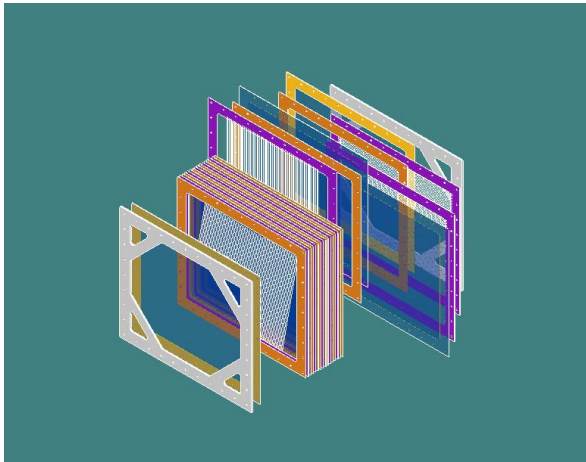
- **Chamber under construction by SACLAY**
  - frames August
  - assembly and test Q4/05-Q1/06
  - operational April 2006

OD target magnet

- **Delivered to Saclay dec 2004**
    - cold leak appeared at first cooling
    - fixed now
    - now filled with LHe
- **well in time for 2006, unless …**

Filling with helium since 7:00 am, 29.4.05

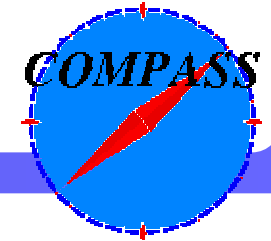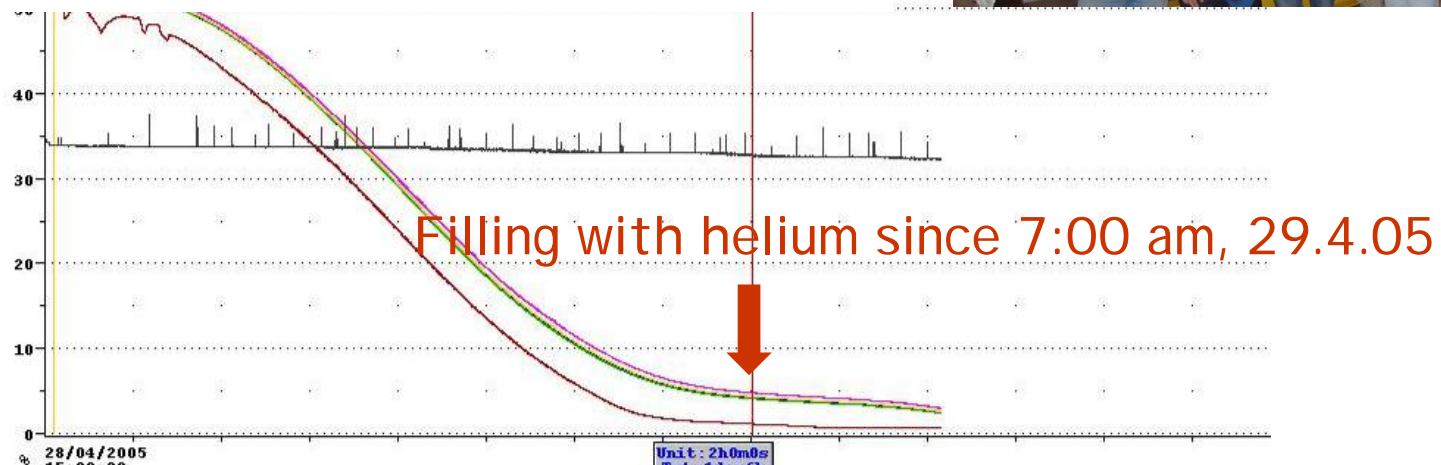Leak rate = 0.5 10^{-8} mb l/s (very low)

ECAL1

- new plan to equip entire ECAL1 for 2006 (Protvino)
  - reduced number of channels (1500)
  - SADC readout being built (TU Munich)
  - looks realistic, details and finances to clarify
- Also beneficial for open charm

$$D0 \rightarrow K\, \pi\, \pi^0$$

RICH-Wall

- Iarocci-type drift tubes (INFN/Dubna)
- chambers delivered
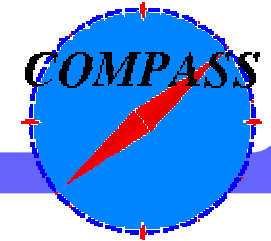- to be assembled and installed
- will work as preshower for ECAL1

Running strategy

- ## 2006 muon running

  - 100 days longitudinal with ^{6}LiD target
  - 30 days transverse with NH_3 proton target

- ## 2007 hadron running

  - central production with ~ 300 GeV proton beam and LH_2 target, option of parasitic or partial Primakoff

Summary

- **First physics data from COMPASS**

- **Do proton and neutron contribution cancel in transverse asymmetries?**

- **Sensitive measurement of $\Delta G/G$**

  - Seems to be small

  - Or is there a sign change in $\Delta G/G$?

- **Good prospects for 2006**