COMPASS status & near future

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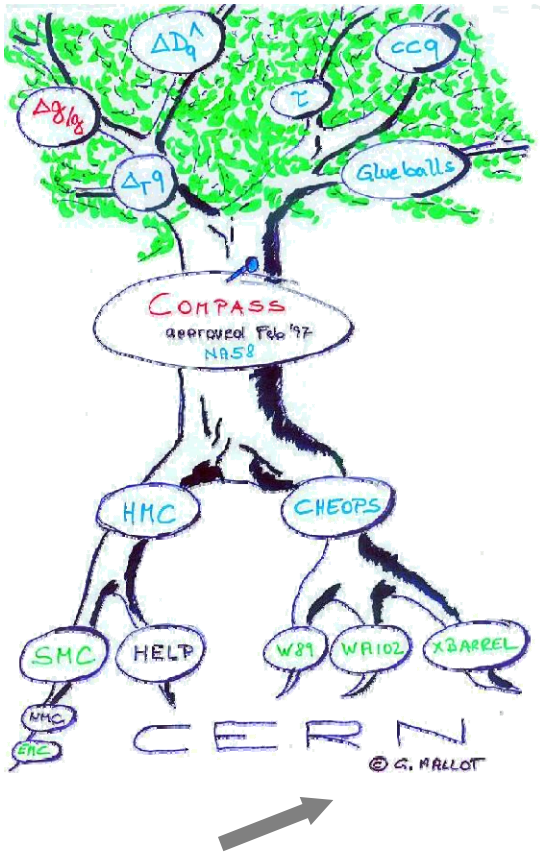
On behalf of the COMPASS Collaboration

Content

- COMPASS, some history
- Spectrometer
- Data taking 2002 to 2004
- Results: highlights & projections
- Near future 2006-2010, SPS beam
- Higher proton intensity, 2010 ->

COMPASS genealogy/calendar



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COMMON
MUON and
PROTON
APPARATUS for
STRUCTURE and
SPECTROSCOPY

1996: last SMC year … and COMPASS proposal
1997: conditional approval
1998: MoU, September
1999 – 2000: construction and installation
2001: commissioning run
2002 -2004: data taking

COMPASS Collaboration

Bielefeld, Bochum, Bonn (ISKP, PI), Burdwan and Calcutta, CERN, Dubna, Erlangen, Freiburg, Heidelberg, Helsinki, Lisbon, Mainz, Moscow (INR, LPI, MSU), Munich (LMU, TU), Nagoya, Prague, Protvino, Saclay, Tel Aviv, Torino (Univ., INFN), Trieste (Univ.,INFN), Warsaw (SINS, TU)

More than 220 physicists from 28 Institutes

Physics programme

Hadron structure and spectroscopy

Muon beam programme

- Quarks and gluon polarisation in polarised (longitudinal) nucleons
- Transverse spin distribution
- Lambda polarisation
- Diffractive vector-meson production

Hadron beam programme

- Polarisibility of pions and kaons (Primakoff reaction)
- Exotics q-states, glue balls
- Semi-leptonic decays of charmed baryons
- Double charmed hadrons

GPDs (DVCS, HEMP) see N.D'Hose talk
- under consideration -

Quark & gluon spin

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

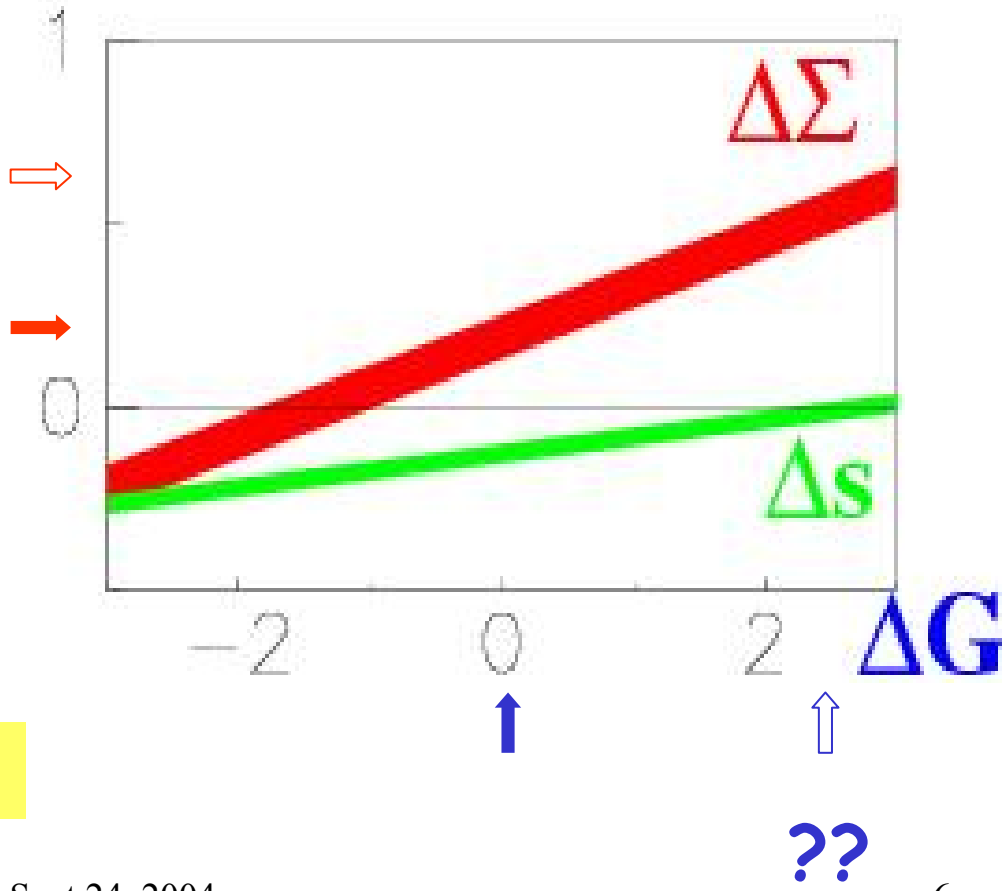
In polarised DIS, one measures flavor singlet axial matrix element

$$a_0 = \Delta\Sigma - (\alpha_s/2\pi) n_f \Delta G$$

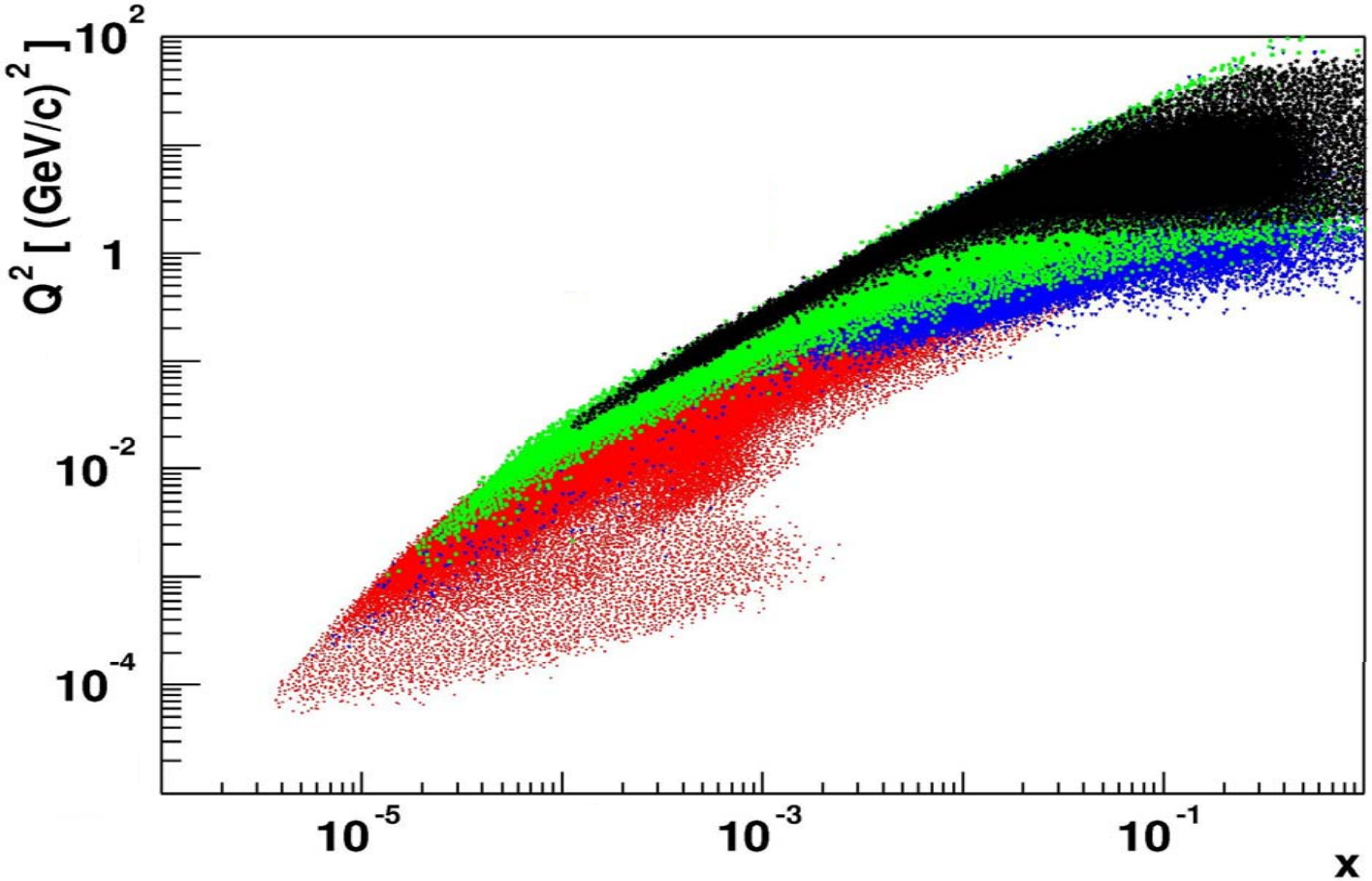
All experiments (SLAC,EMC,SMC, SLAC, HERMES) confirm:

$$a_0 \sim 0.1 \div 0.2$$

Imperative to measure ΔG



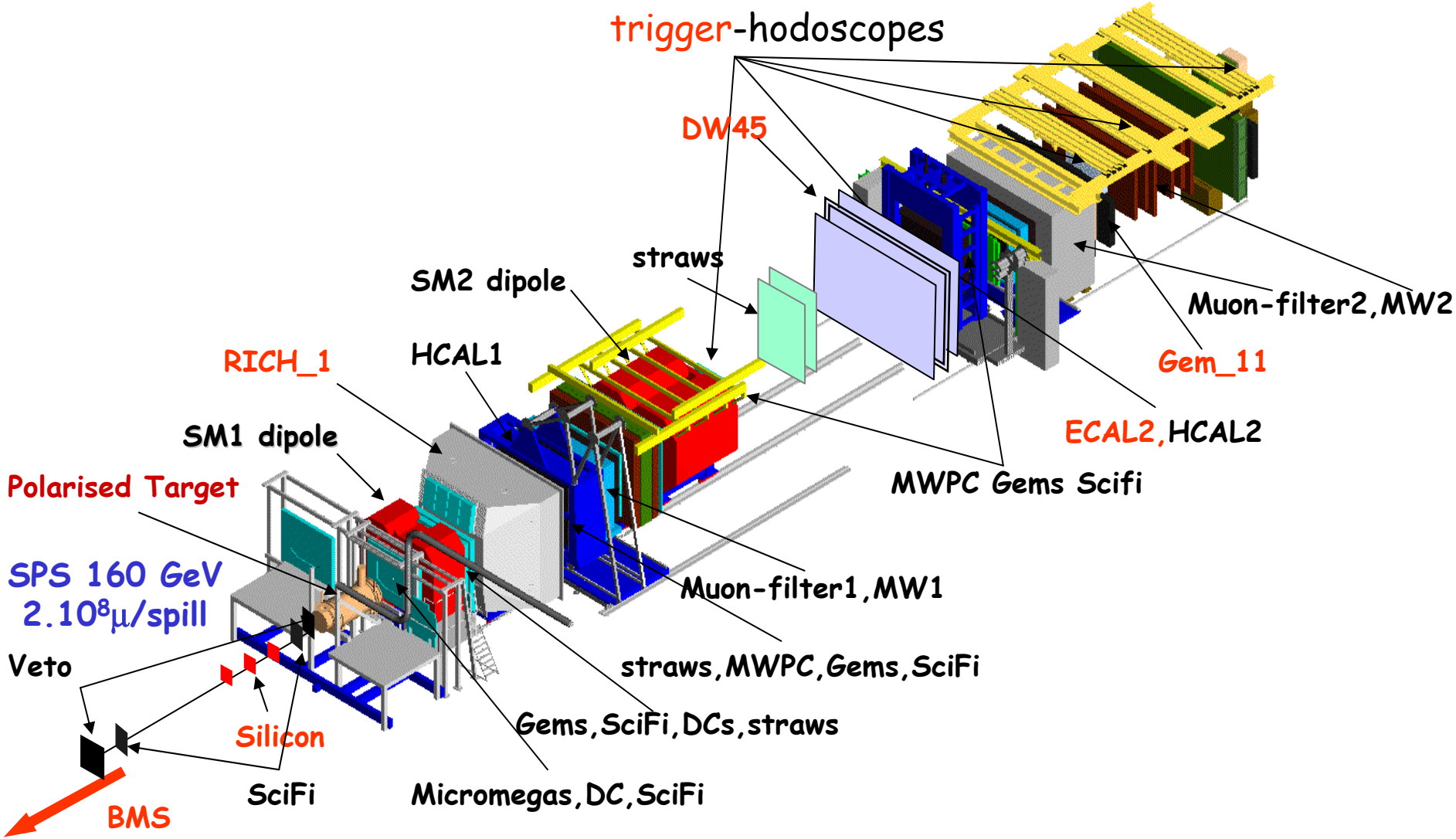
COMPASS acceptance



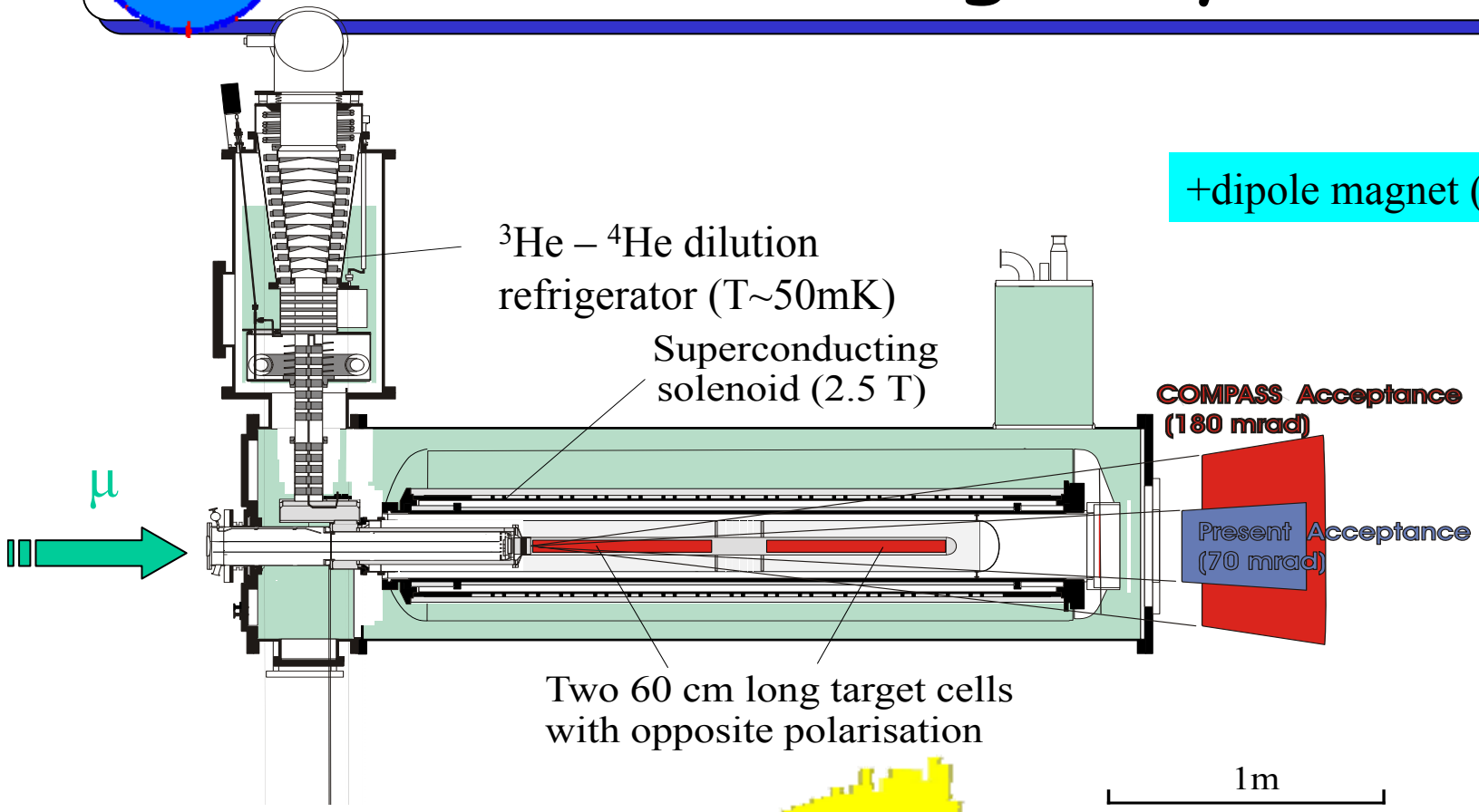
Excellent for non-perturbative & perturbative physics

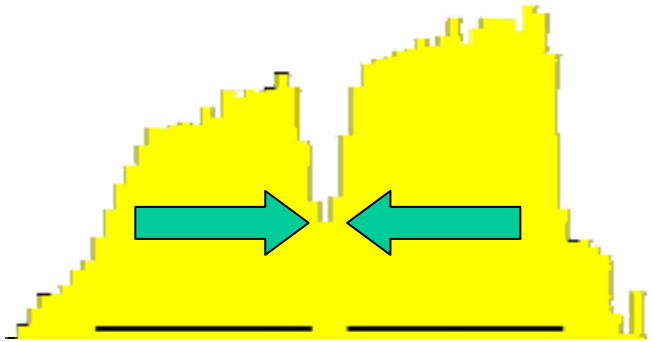
- small x_{Bj} & very small Q^2 → $Q^2 > 100$ (GeV/c)^2

Spectrometer 2002 -> 2004



Polarized target system





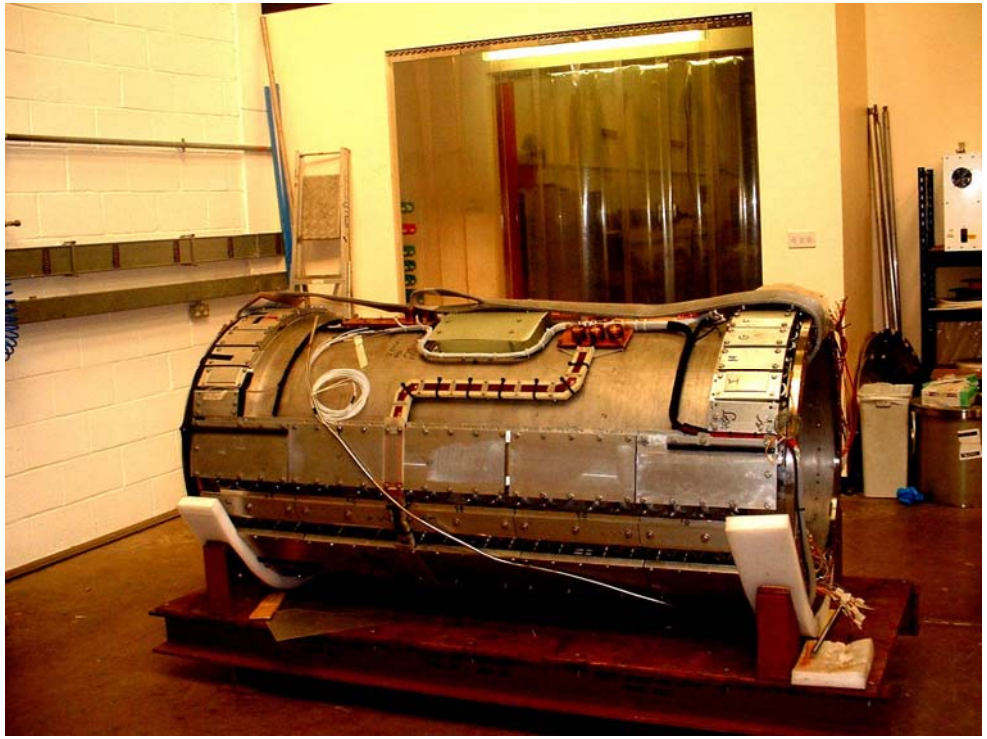
Reconstructed interaction vertices

COMPASS/Oxford-Danfysik solenoid

December 2003 :

MoU CERN/DAPNIA/COMPASS

- finalize instrumentation and magnetic tests

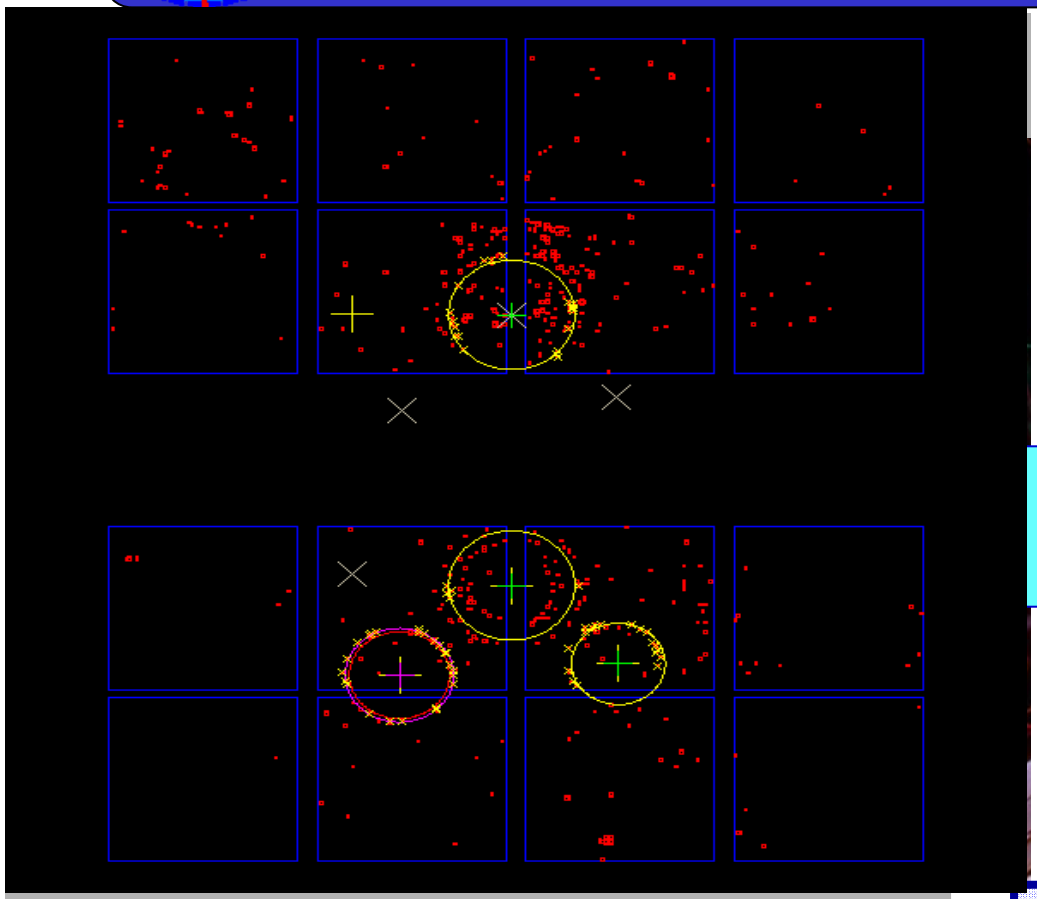


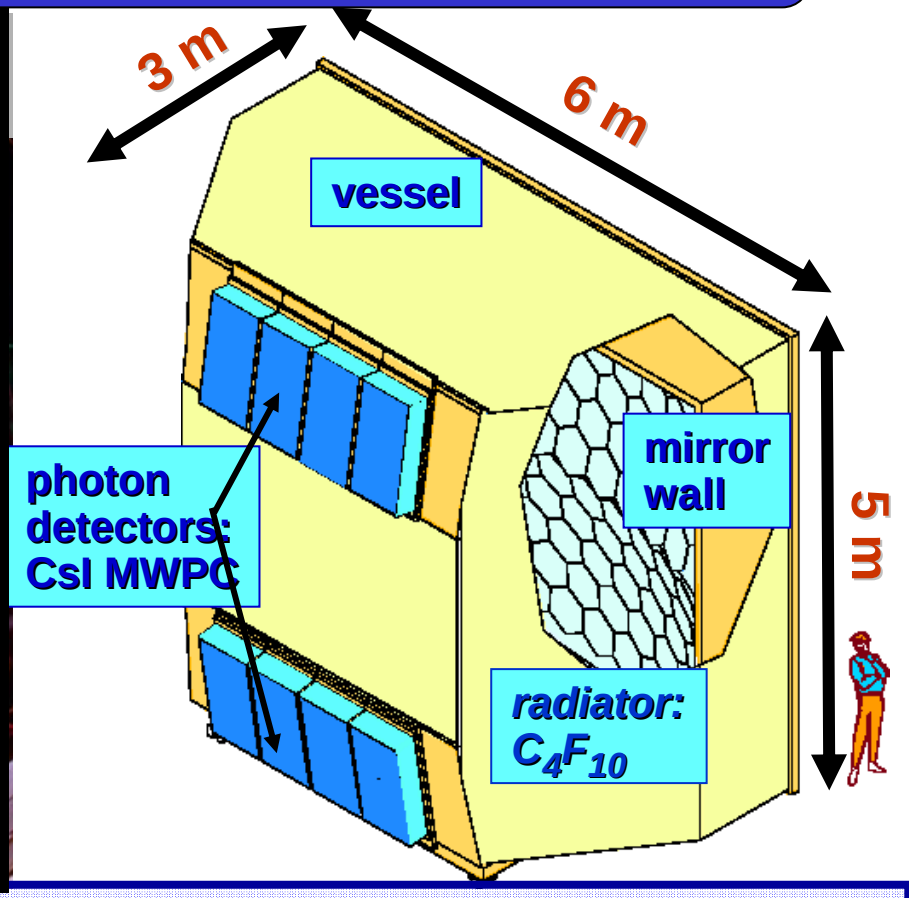
2004 : Agreement with OD

- delivery to Saclay
- perform cold acceptance tests
- delivery to CERN

2005 : Installation CERN, tests, magnetic measurements, polarization

PID with RICH1





Photon detection

5.3 m² MWPCs

16 CsI Photocathodes

84,000 analog readout channels

detection of VUV photons (165-200 nm)

σ =1.2 mrad

σ =0.4 mrad

n ~14

3σ π /K sep.

up to 40 GeV/c

COMPASS objectives

Original programme set for about **5 years** [1] of running at **150 days/year** i.e. **7.2310^5 spills** with 14.4s supercyle and ε_{SPS} = 80%.

2310^8 μ/spill equivalent to ~ **10^{19} protons/year**.

[1] HMC (**4 years**) - CHEOPS (**2 years**)

Data taking 2002 - 2004

	2002	2003	2004 (Oct 4)	2004
Beam (1)	106days	90d	93d(5) (+16d)	19d
ϵ_{SPS+BL} (2)	.89	.63	~.64	
Preparation	~30d	7d	3d	4d
$\epsilon_{Spectro}$(3)	.77	.83	.87	
Data taking (4)	44d	39d	47d (61d)	15d
muon (L/T)	**33d**/11d	**30d**/9d	**32d**/14d	hadron

(1) Scheduled beam excluding MDs

(2) Inefficiency from SPS, beam line, etc

(3) ~0.90 additional due to time needed to rotate spin and calibrate spectrometer

(4) L/T Longitudinal/Transverse sharing 80/20

(5) Update September 17, 2004

Data taking 2004

Thanks to the **excellent performances** of spectrometer and to the **2 weeks prolongation** of SPS running, our expected goal in statistics for 2004 **is still in reach**

Data taking 2002 - 2004

muon: 2002 + 2003 + 2004 -> 11.3310^5 spills

hadron: 2004 -> ~ 0.5310^5 spills

- If things go very well in 2004, we will have at the end of 2004 ~ **1.5** 3 **proposed year**

Physics results

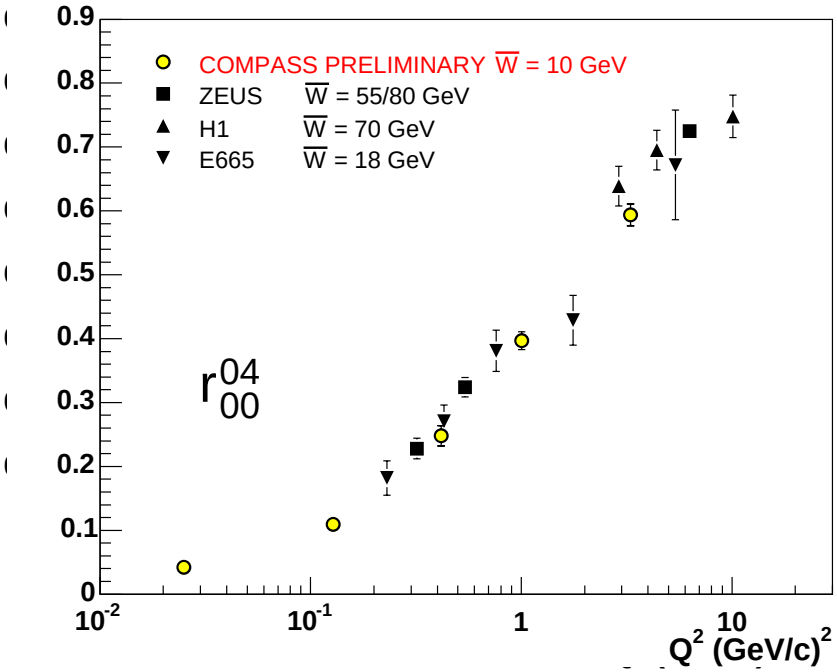
- **Longitudinal spin** :
  - $\Delta G/G$ – from open charm
  - $\Delta G/G$ - Spin asymmetry from high p_T hadrons pairs
  - A_1^d
  - Flavour decomposition of polarized PDF
- **Transverse spin** : Collins/Sivers asymmetry
- Λ & $\bar{\Lambda}$ hyperons, production and polarization
- Vector meson production ρ, φ and J/ψ.
  - Exclusive ρ production

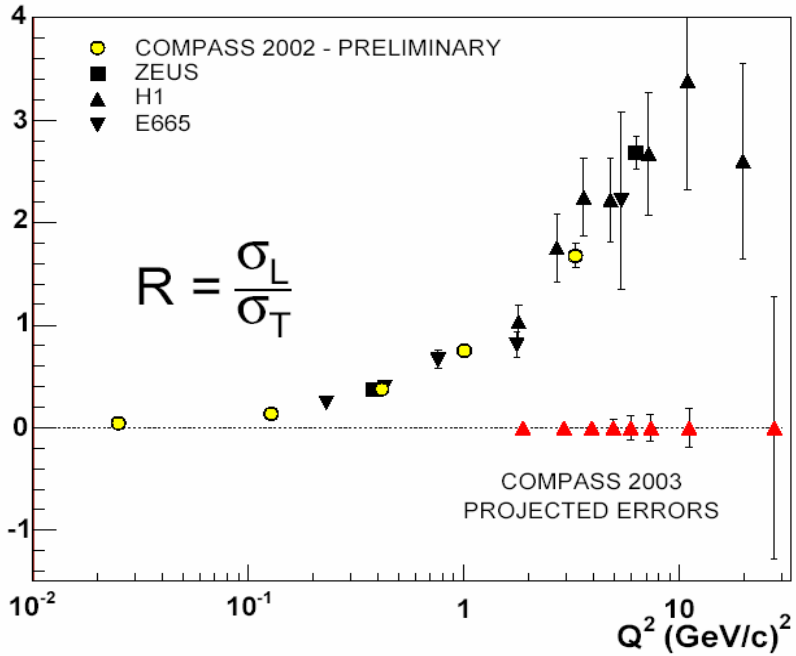
Exclusive ρ^0 production (1)

High precision measurement of spin density matrix element

If SCHC holds ->

$$R = \frac{\sigma_L}{\sigma_T} = \frac{1}{(\epsilon+\delta)} \frac{r^{04}_{00}}{(1-r^{04}_{00})}$$





2002 data (only)

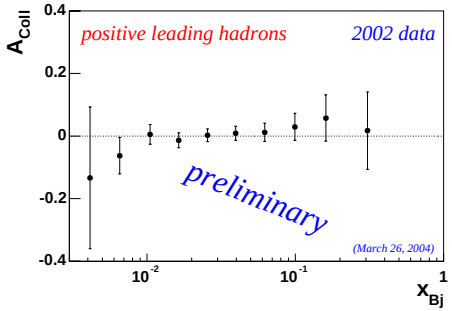
Transverse spin Collins asymmetry

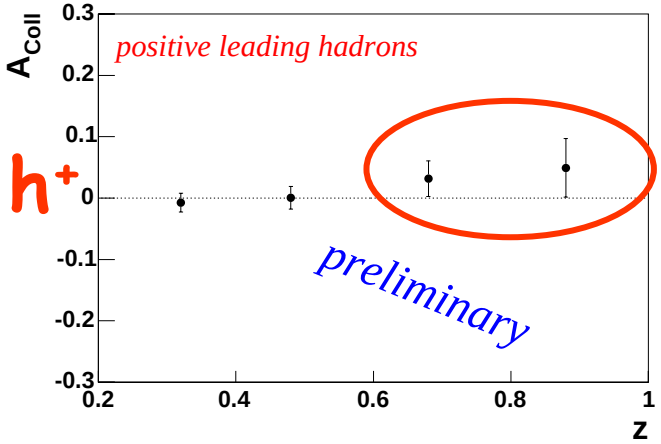
$\Phi_C = \Phi_h + \Phi_S - \pi$

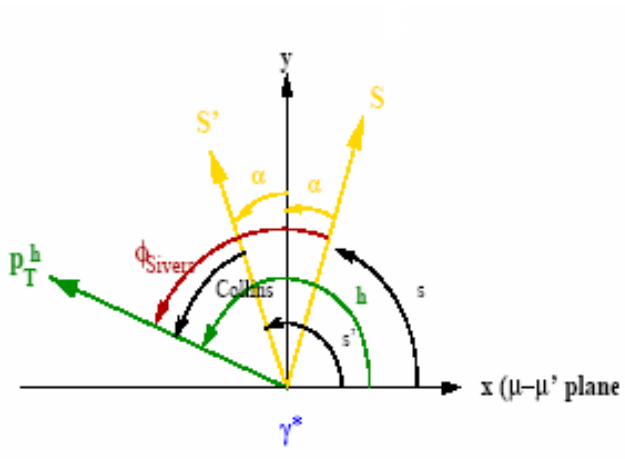
$A_{\Uparrow\Downarrow} = A_0 \pm A_1 \sin(\Phi_C)$

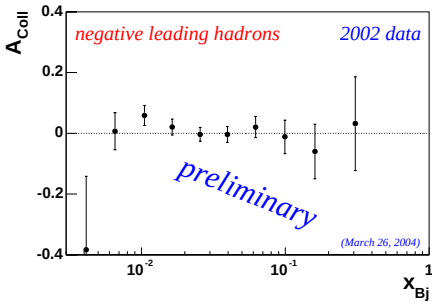
$A_{Coll} = A_1 / (D_{NN}.f.P)$

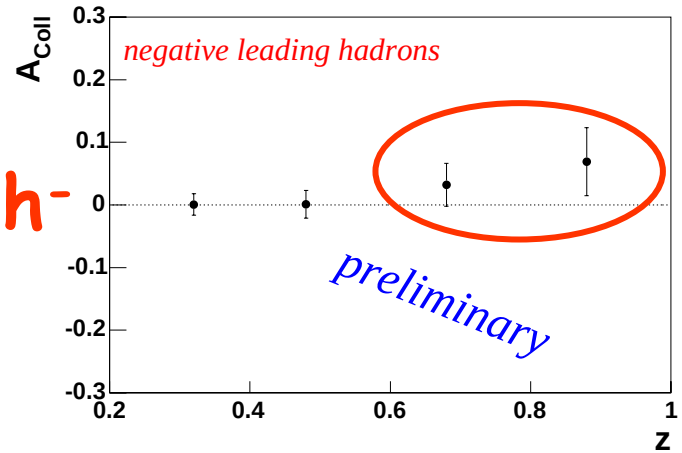
$A_{Coll} \Longleftrightarrow h_1^q(x,Q^2)$











x_{BJ}

z_{had}

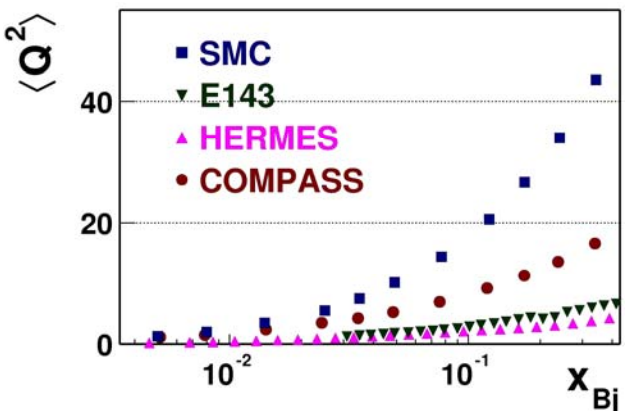
A_1^d from inclusive scattering

2002 data only

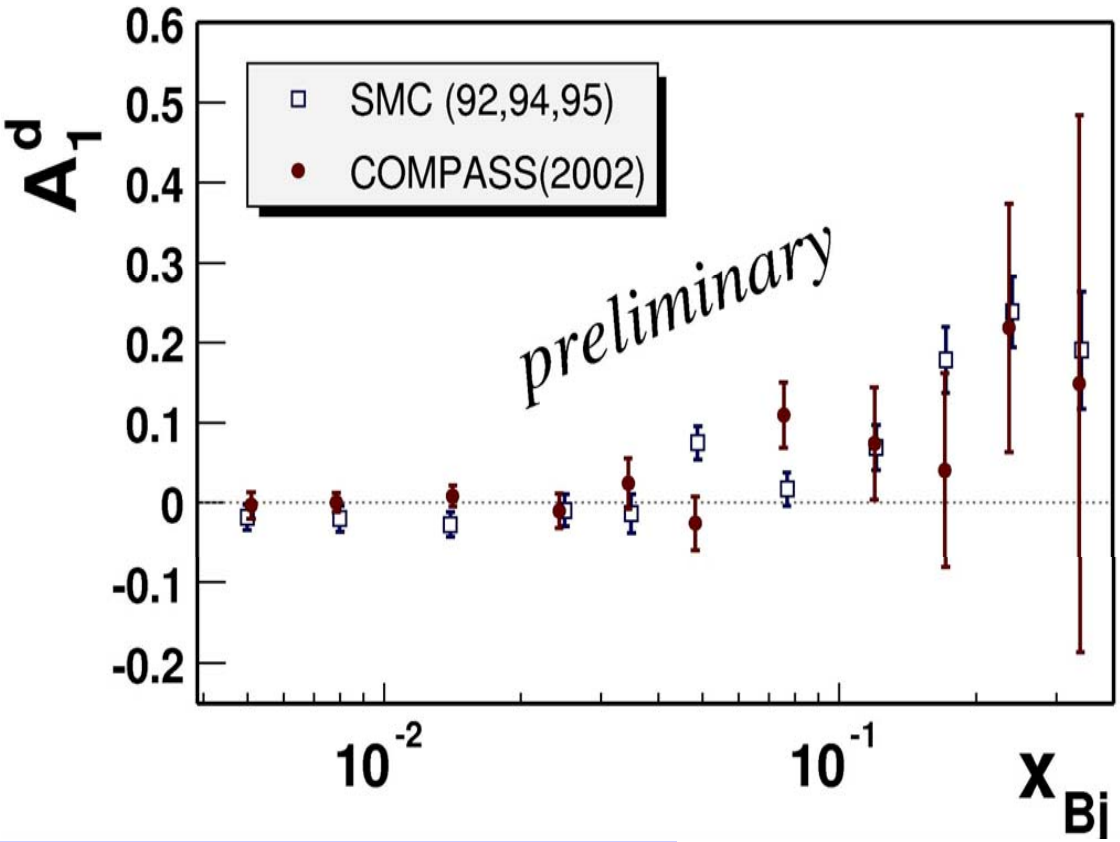
6.5 10^6 DIS evts

$Q^2 > 1$ GeV/c^2

$0.1 < y < 0.9$

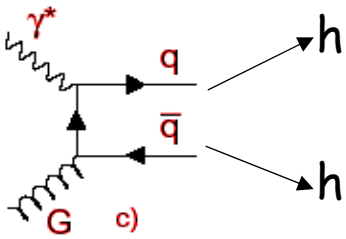


"Longitudinal spin virtual photon asymmetry"

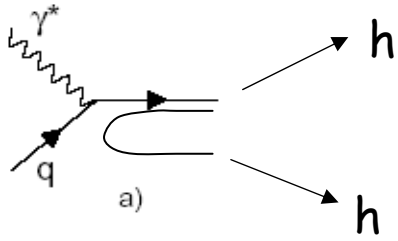


beam time COMPASS / beam time SMC = 1 / 7

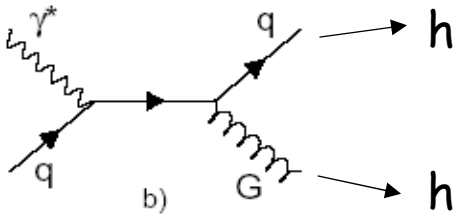
$\Delta G/G$ from high p_T hadrons pairs



Photon Gluon Fusion (PGF)



Leading process



Gluon radiation (Compton)

preliminary (2002 data)

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

Assuming (Phytia-LO) : R_PGF ~ $\frac{1}{4}$

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

"$\Delta G/G$" = 0.**

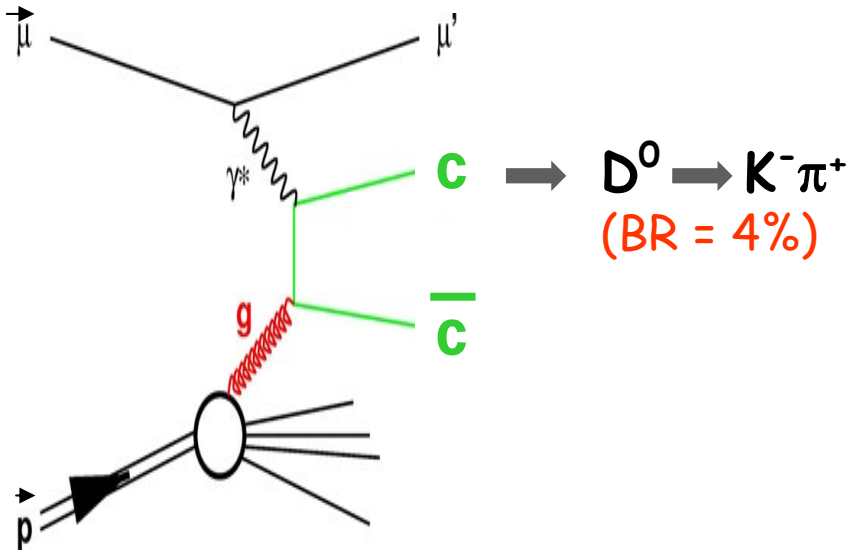
ΔG/G from open charm

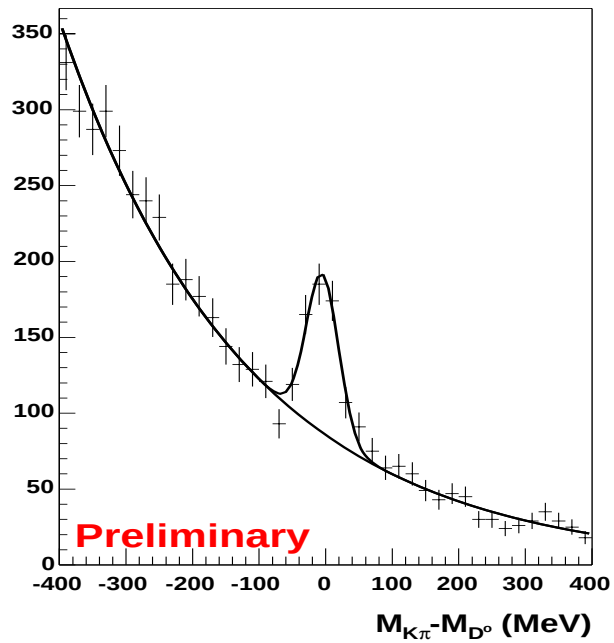
Photon-Gluon-Fusion: 1.2 D^0 per **PGF** $c\bar{c}$ event

$\frac{3}{4}$32002 (25 "days")

317 $(D^*)D^0$

$S_{EFF}^{(*)} \sim 120$





$^{(*)}S_{EFF}=S/(1+B/S)$

$\Delta G/G$ from open charm

$$\sigma(\Delta G/G) = 1/(FoM^{1/2})$$

$$FoM = (P_\mu \; 3 \; P_T \; 3 \; f \; 3 \; \langle a_{LL} \rangle)^2 \; 3 \; [S_{EFF}=S/(1+B/S)]$$

$$(\sim.76 \; 3 \; \sim.50 \; 3 \sim.40 \; 3 \; \sim.22 \;)^2 \; 3 \quad S_{EFF}$$

$$FoM_{2002} \sim 0.001163 \; 120 = \mathbf{0.14}$$

$$FoM_{2002} \; -> \; \sigma(\Delta G/G) \sim 2.7$$

Figure of Merit, assessment/improvement 2002 -> 2003 -> 2004

- Very big effort made to obtain a detailed understanding of our **FoM (tracking, RICH reconstruction** … etc) see COMPASS note 2004-2

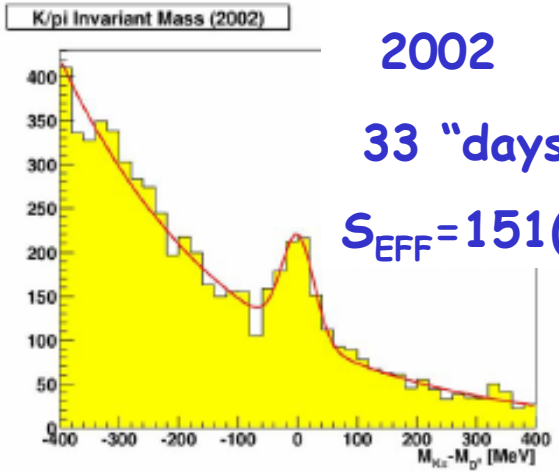
Figure of Merit, assessment/improvement 2002 -> 2003 -> 2004

- μ flux : 1.28 instead of 1.16
  still rotation data
- D^*/μ : 2.5 instead of ≈ 4
  all improvements not implemented for all periods
  more work needed: Tracking, RICH, Calo T
- S/B: 1.26 instead of 1.45
  RICH, δM
- $\langle a_{LL} \rangle$: 0.76 instead of 1
- weighting: 1.5 instead of 2.7
  implement S/B and Gaussian weighting
- total 4.6 instead of 18 $\Rightarrow$ 3.9 missing.

Update 29.07.2004

COMPASS note 2004-2, projection

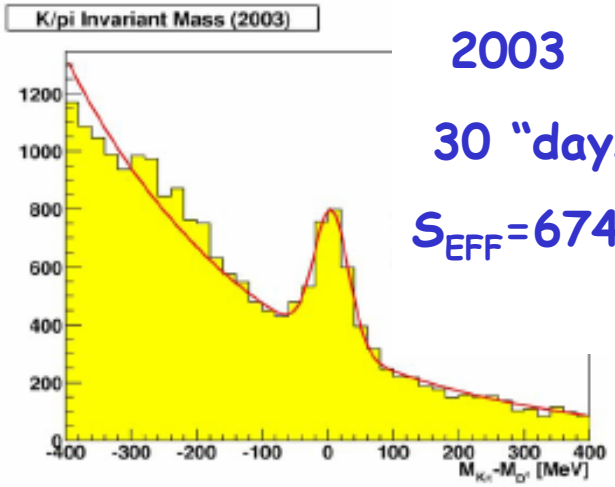
Figure of Merit, assessment/improvement 2002 -> 2003 -> 2004



2002

33 "days" (L)

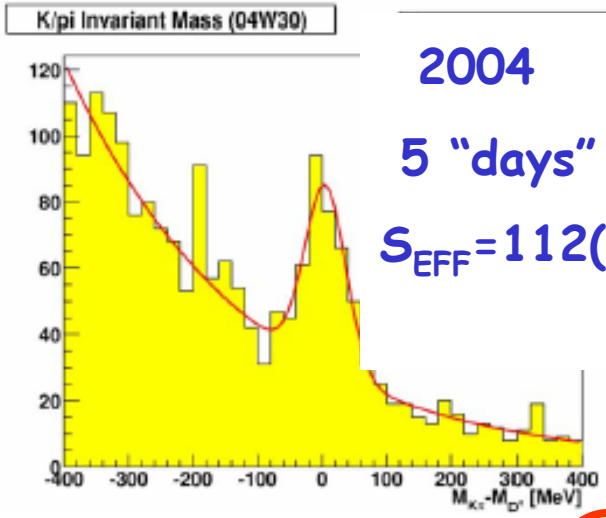
S_{EFF}=151(8)



2003

30 "days" (L)

S_{EFF}=674(17)



2004

5 "days" (L)

S_{EFF}=112(7)

2002 -> 2003(4)

S_{EFF}/day 3 4.9

18 / 4.9 = 3.6

- total 4.6 instead of 18 ⇒ 3.9 missing.

Projection for $\sigma(\Delta G/G)$ from D^0

$FoM_{2002} = 0.14$

$3\ R_{nb\ of\ days} = 112/25$

$3\ r_{FoM} \sim 18$

$3(D^0+D^*)/D^* \sim 1.5$

$FoM_{(2002\ -\ 2004)} \sim 17 \longrightarrow \sigma(\Delta G/G) = 0.24$

Projection for $\sigma(\Delta G/G)$, D^0 & high P_T

If 2004 **statistic** & **FoM** as expected **projection** for 2002+2003+2004 data :

$\sigma(\Delta G/G)$ = **0.24** (D^0)

$\sigma(\Delta G/G)$ = **0.05** (high p_T <u>all Q2</u>)

$\sigma(\Delta G/G)$ = **0.16** (high p_T <u>Q^2>1GeV^2</u>)

$\sigma(\Delta G/G)$ proposal = 0.14

σ_{syst} from resolved γ
+
LO/NLO ??

HELP from theorists !!

COMPASS near future (2006 ->), goals

- Increase global efficiency (FoM/day) by factor ~ 2 :
  - Larger acceptance with OD magnet
  - Improve RICH efficiency/purity
    (software & hardware for central photon detectors)
  - Improve tracking

- Take proton data (NH_3 target)
  - Flavor separation of $\Delta\Sigma$ & transversity

COMPASS near future (2006 ->)

Hadrons: 2.53150 days (proposal)

Muons, 2 scenarios:

1. NH_3[1] 150 days (proposal) → 0.17
2. $^6LiD + NH_3$ 23150 days
   - $^6LiD/NH_3$ (50/50) → 0.11

D^0 -> $\sigma(\Delta G/G)$[2]
0.17
0.11

[1] $FoM(NH_3) \sim 0.33 FoM(^6LiD)$

[2] assuming FoM33.932

$\sigma(A_{Collins})$ reduced by 3 ÷ 6 for proton and D

Beam from SPS beyond (2006 ->)

From CERN-AB-2004-022 OP/RF

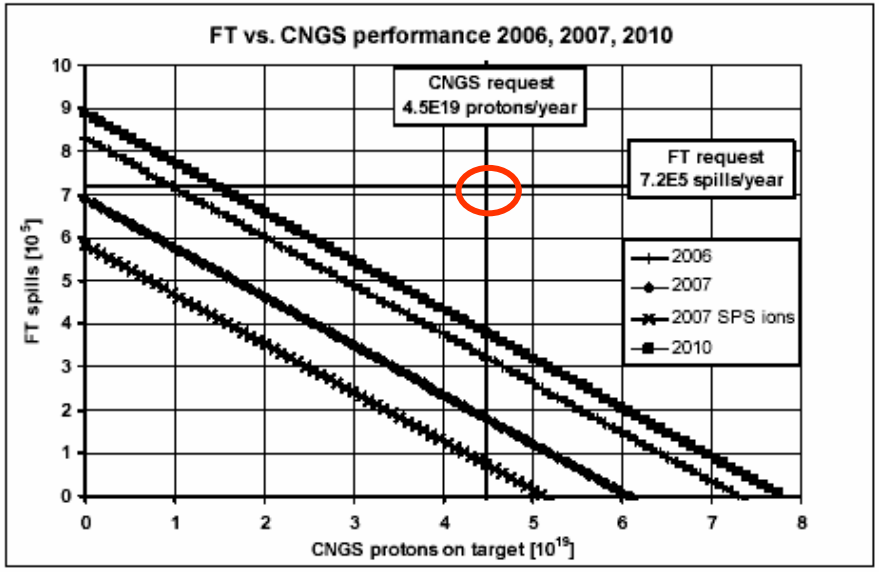


Figure 3.1: FT versus CNGS performance as a function of SPS physics time distribution.

FT request:

150 days/year

~ 7.2 $3 10^5$ spills/year

- Separation of CNGS/FT operations ?
- **Increase available proton flux ?**
- Longer SPS operation

CNGS request:

4.5 $3 10^{19}$ protons/year

COMPASS beyond 2010

- **Increase available proton flux by a factor of ~ 5**
  - Only solution for dilemma of beam sharing ?
  - Longitudinal physics, $\Delta G/G$ at several x_G, ($\Delta G/G$) from $g_1(x,Q^2)$ evolution
  - Transverse physics, x_B, z_h, Q^2 & p_T dependence of Collins asym., T-distribution for s quark ... etc

- **Requires major upgrade of:**
  - M2 beam line & COMPASS spectrometer