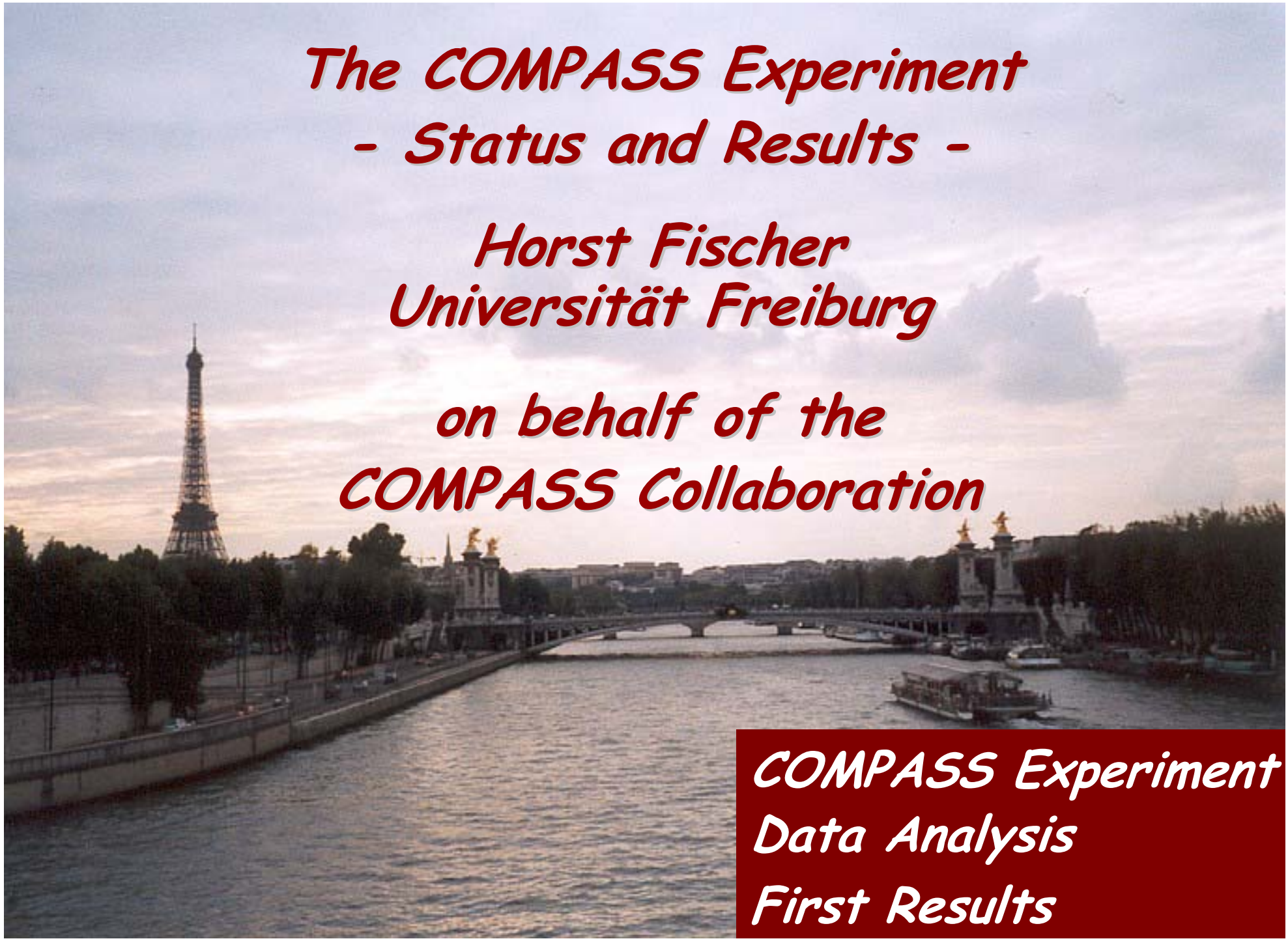


The COMPASS Experiment
- Status and Results -

Horst Fischer
Universität Freiburg

on behalf of the
COMPASS Collaboration

COMPASS Experiment
Data Analysis
First Results

COMPASS - History

COMPASS: THE new fixed target facility at CERN!

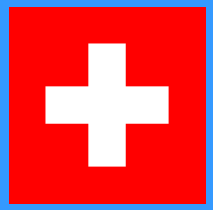
- 1996 COMPASS proposal
- 1997 conditional approval
- 1998 MoU

- 1999 – 2001 construction & installation
- 2001 technical run

- 2002, 2003, 2004 data taking
- in long range planning @CERN at least until 2010

The COMPASS Collaboration
(230 Physicists from 12 Countries)

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



CERN

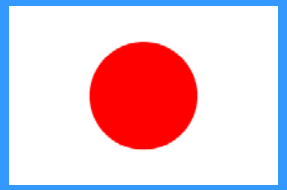
Bielefeld, Bochum,
Bonn (ISKP & PI),
Erlangen, Freiburg,
Heidelberg, Mainz,
München (LMU & TU)

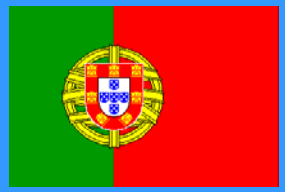
Warsaw (SINS),
Warsaw (TU)

Prag

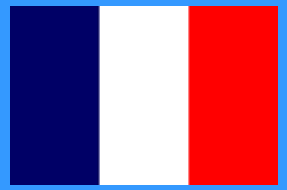
Helsinki

Nagoya



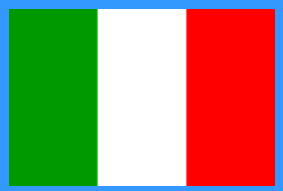


Lisboa



Saclay

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



Tel Aviv

Burdwan,
Calcutta

Physics Goals

Contribute to the understanding of the non-perturbative physics of the nucleon

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

nucleon spectroscopy

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

Why (Spin)-Structure?

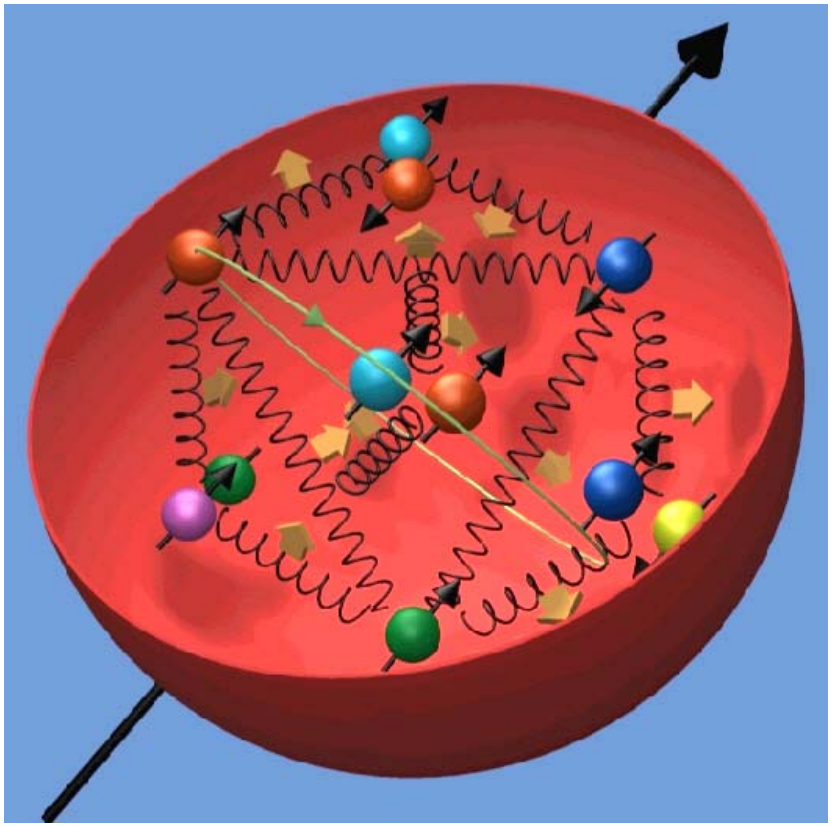
The Nucleon is more complex as we had anticipated…

$$\Sigma x_q \approx 0.5$$

$$\Sigma x_g \approx 0.5$$

$$q_{\bar{d}} > q_{\bar{u}}$$

$$\Delta q_{\bar{d}} \, , \, \Delta q_{\bar{u}} \; ?$$

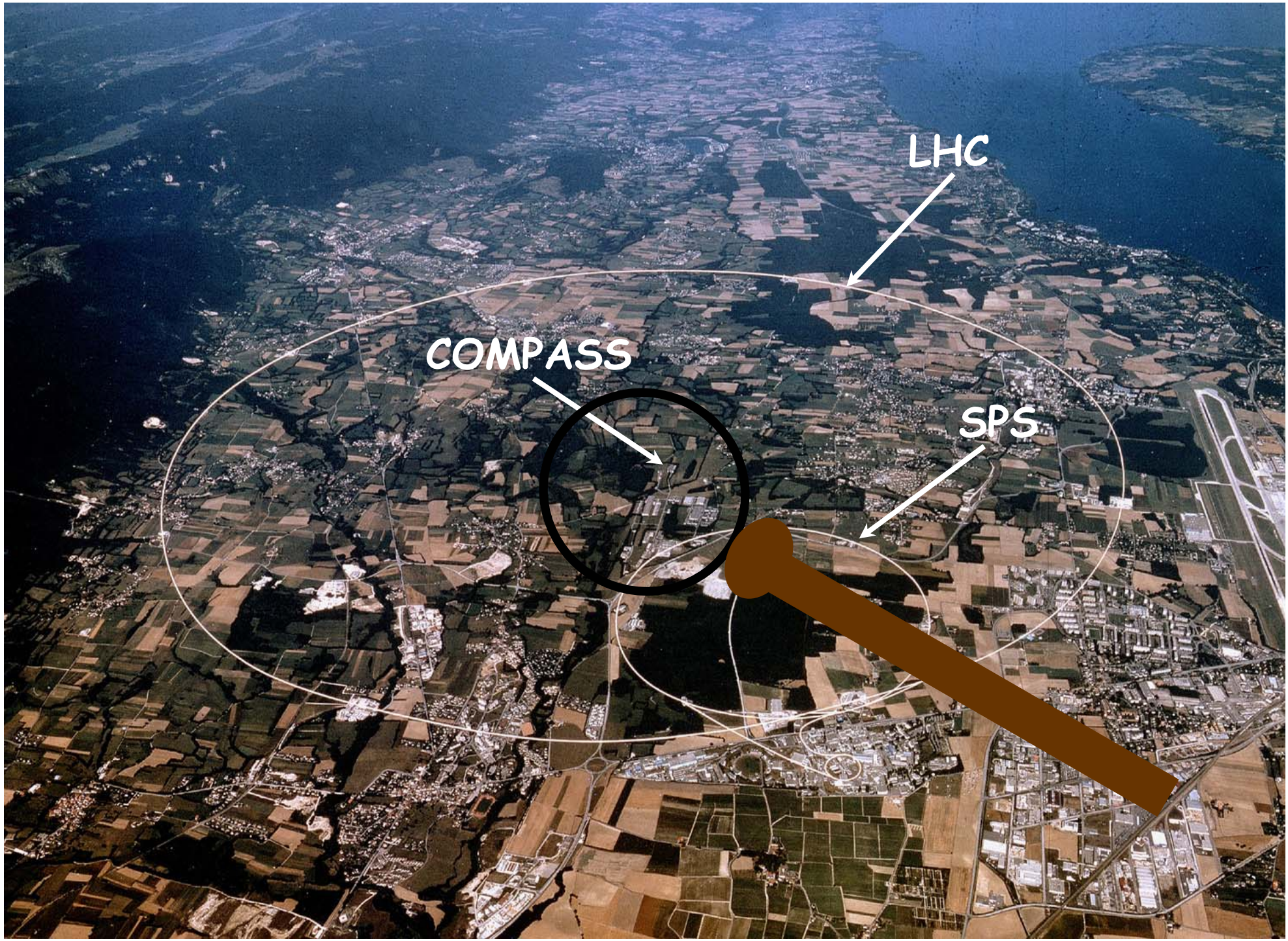


$$\left\langle S_z^N \right\rangle = \tfrac{1}{2} = J_q + J_g$$

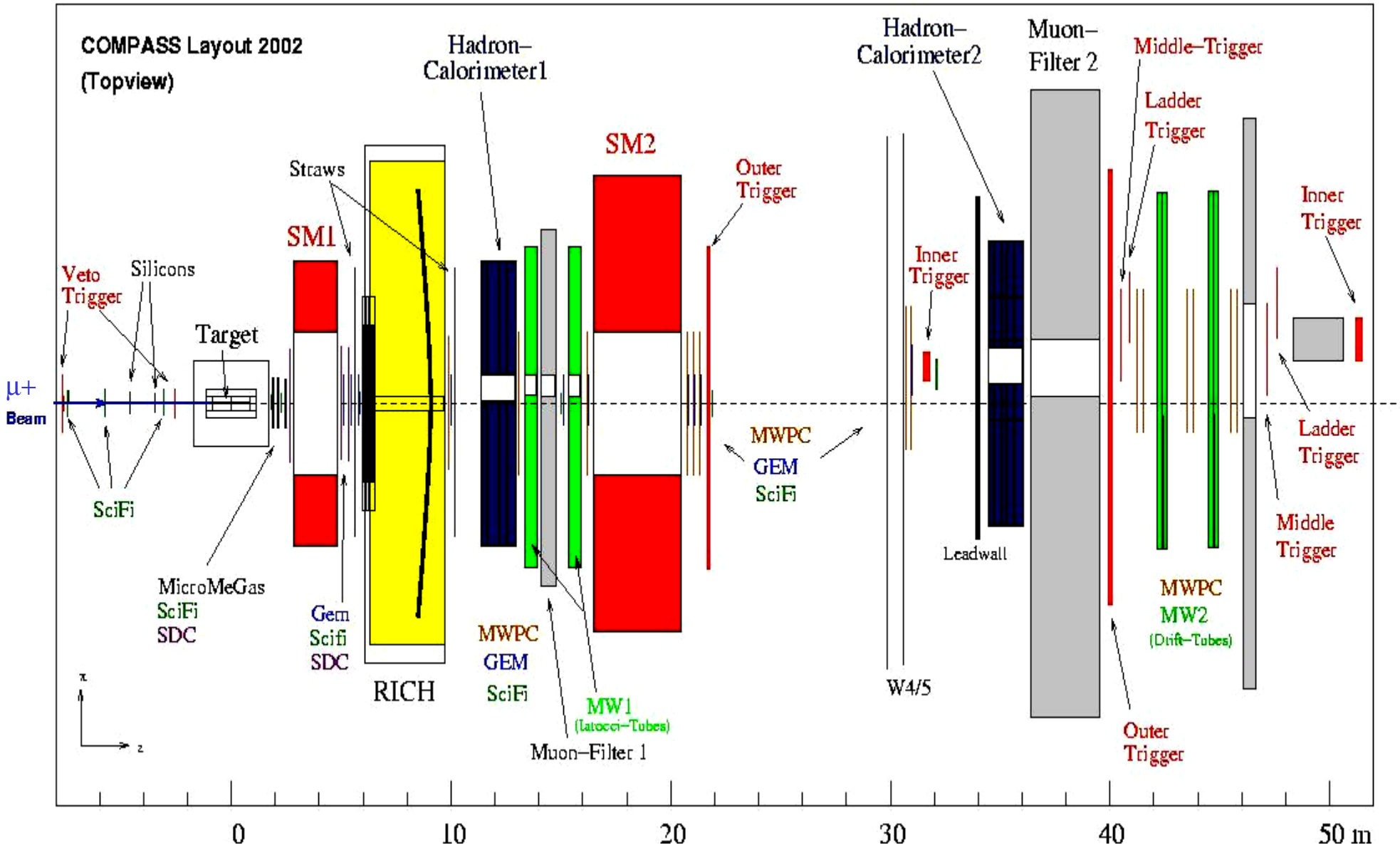
$$= \tfrac{1}{2}\Delta\Sigma + L_q + \Delta G + L_g$$

HERMES ↘ $\Delta\Sigma$ ↖ L_q next generation ↗ ΔG COMPASS ↘ L_g

$$\Delta\Sigma = \Delta u + \Delta\bar{u} + \Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s}$$


LHC
COMPASS
SPS

The COMPASS Experiment



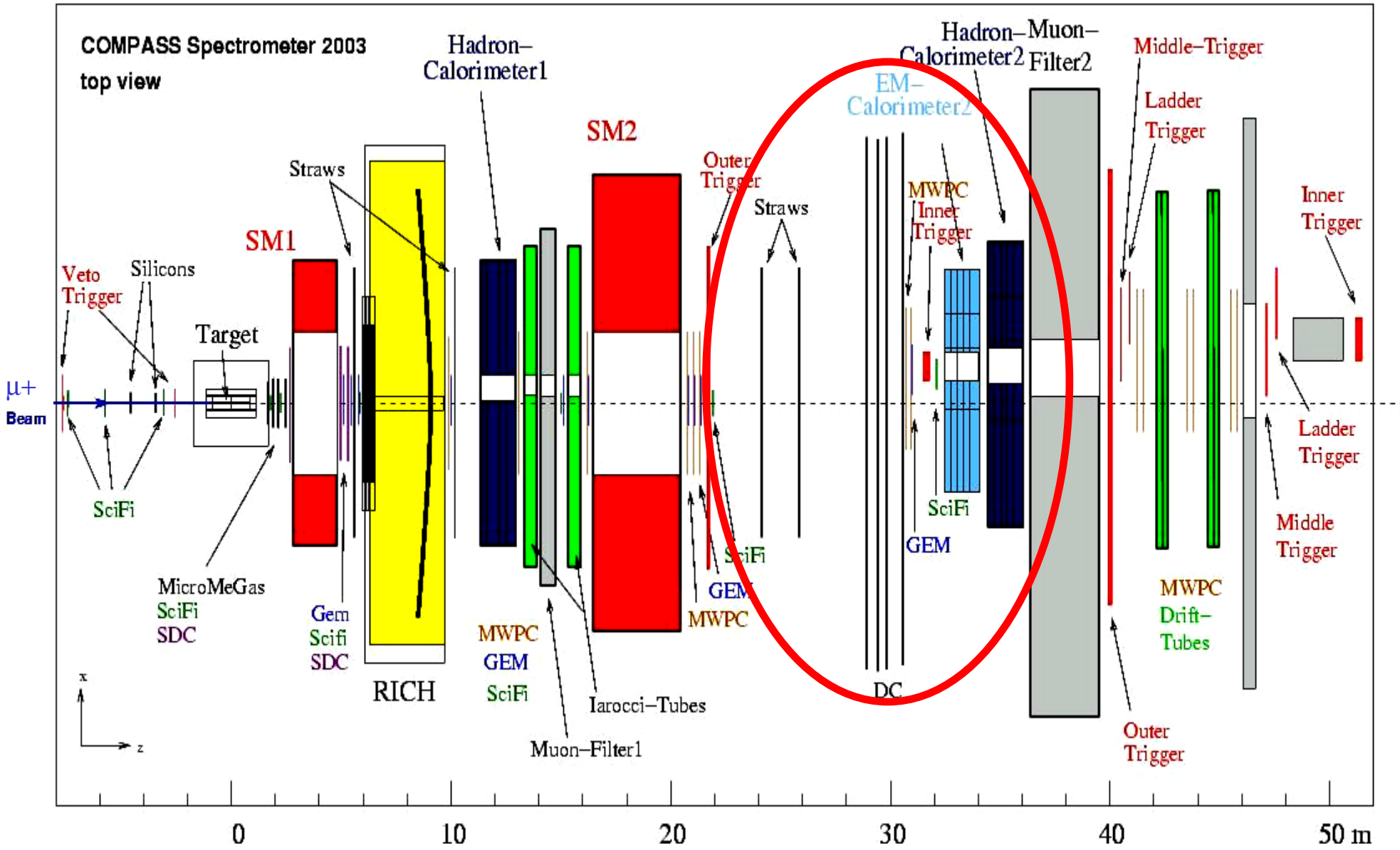
Beam: $2 \cdot 10^8$ μ^+/ spill (4.8s / 16.2s)

Luminosity: ~$5 \cdot 10^{32}$ cm^{-2} s^{-1}

Beam momentum: 160 GeV/c

Beam polarization: -76%

The COMPASS Experiment



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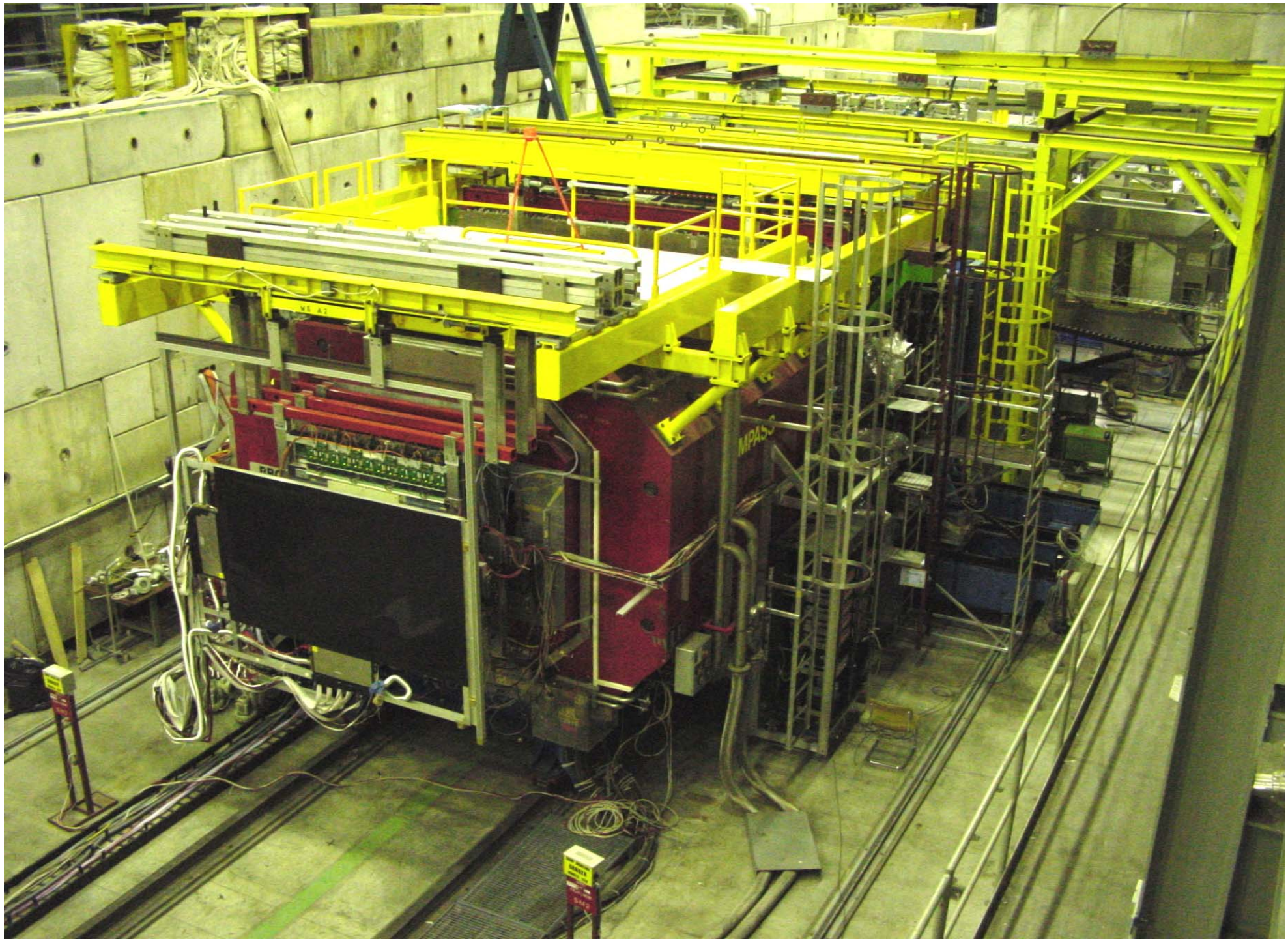
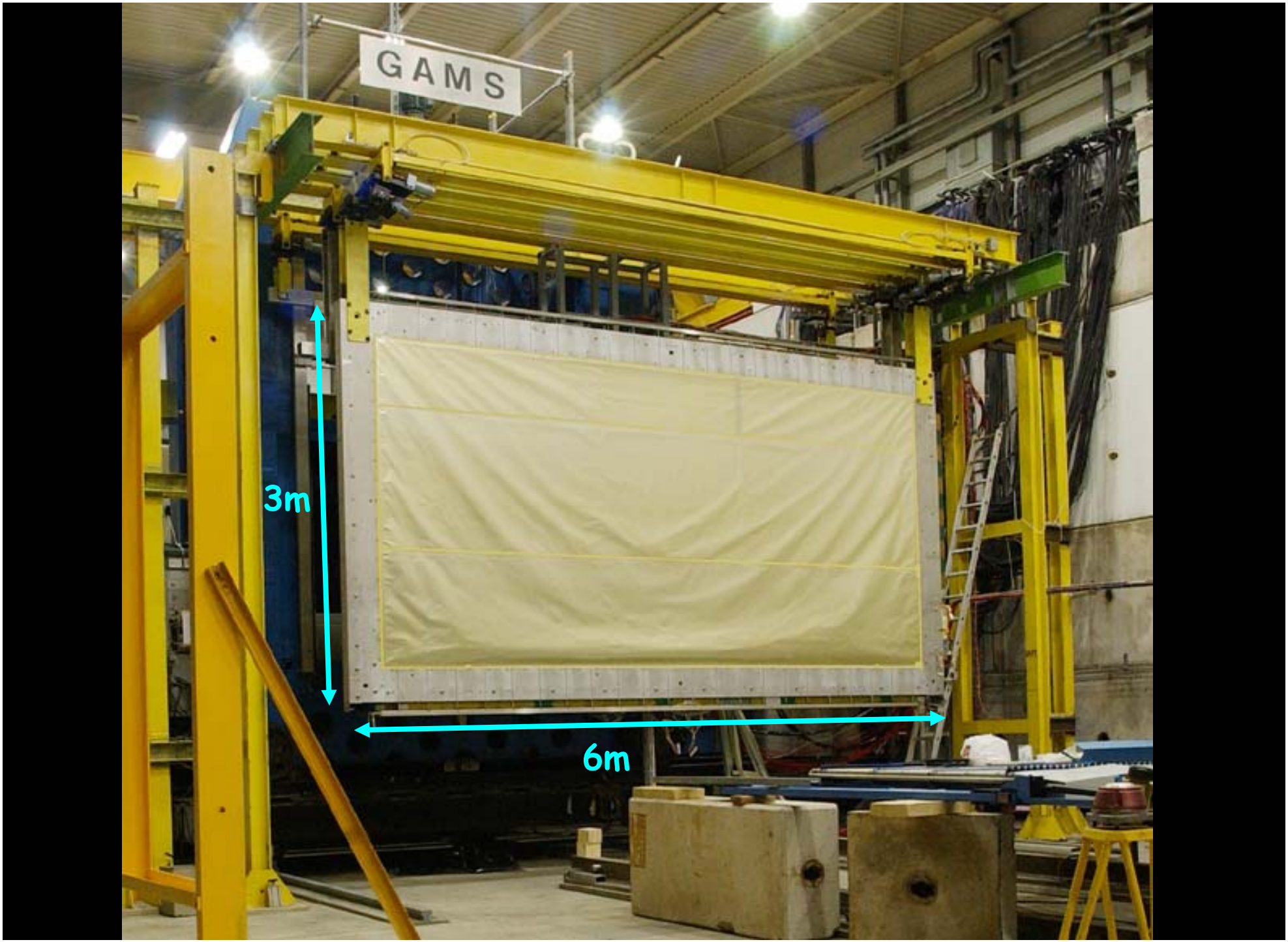
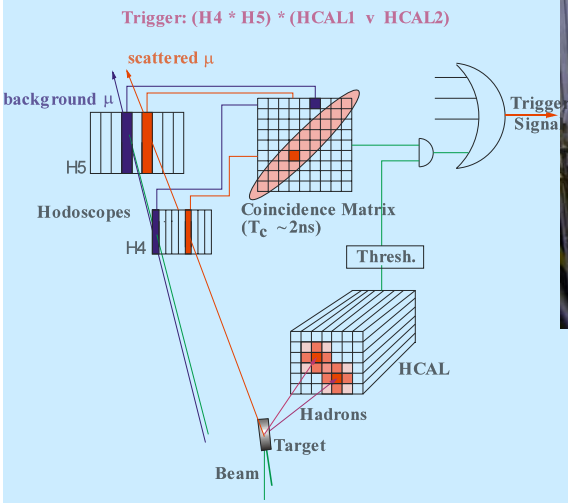
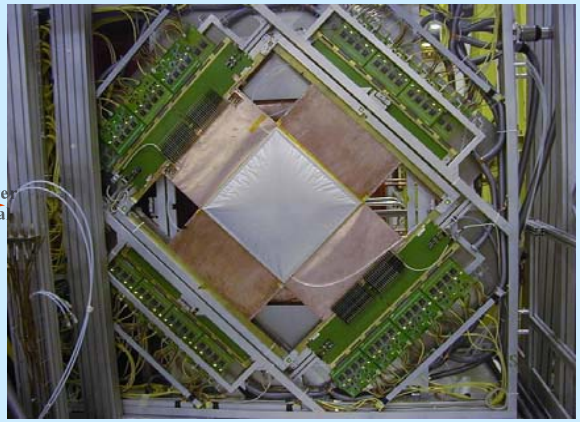



GAMS
3m
6m

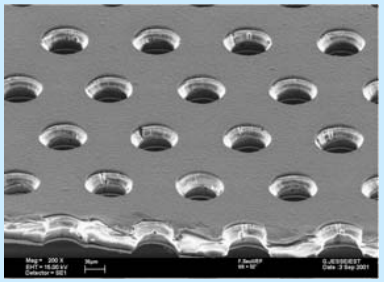
Many new technologies for tracking and PID



Trigger-System

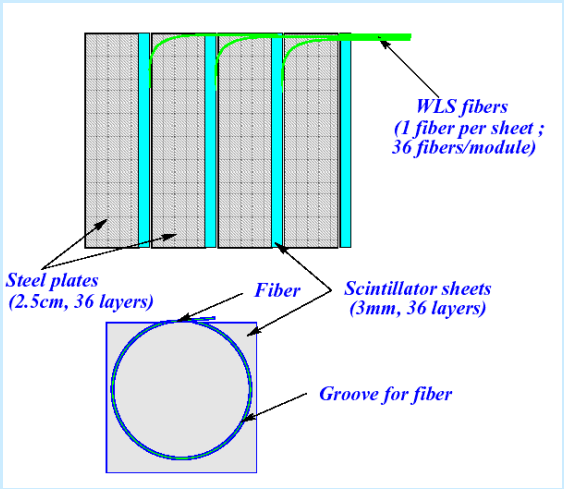


MicroMegas



GEM

Straws

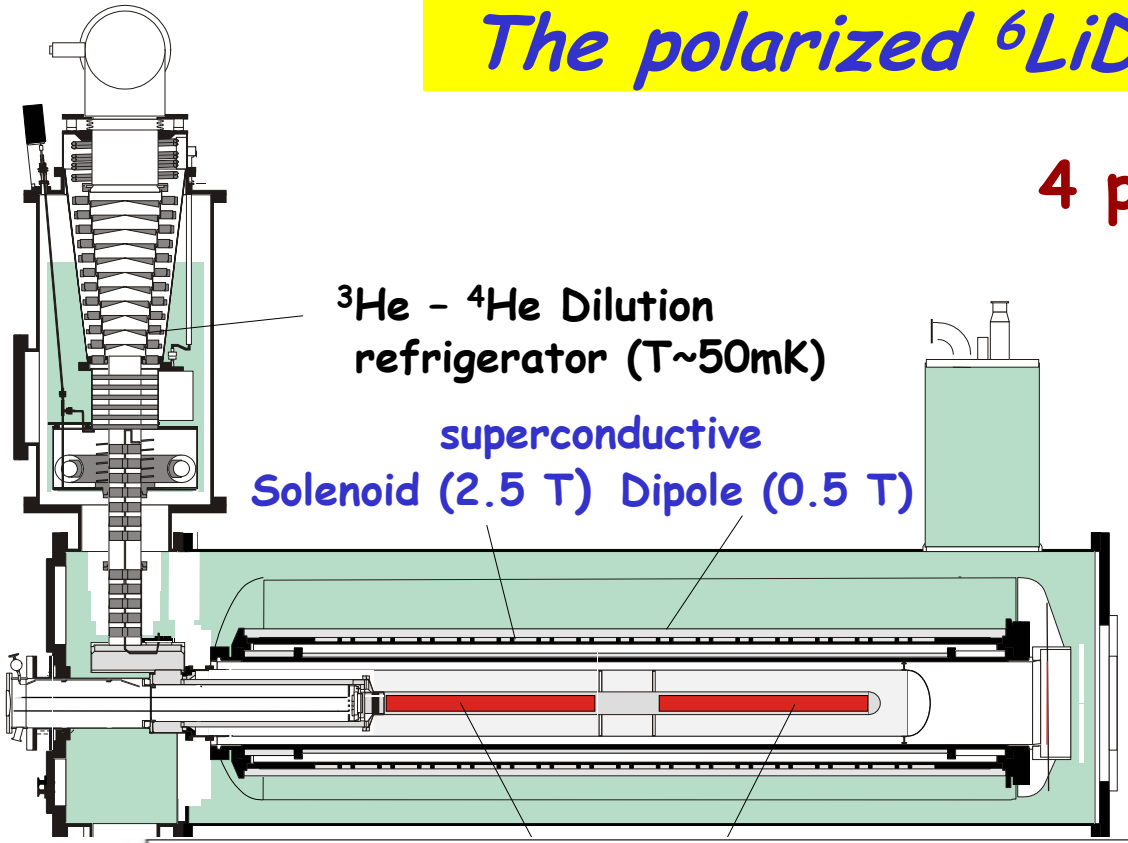


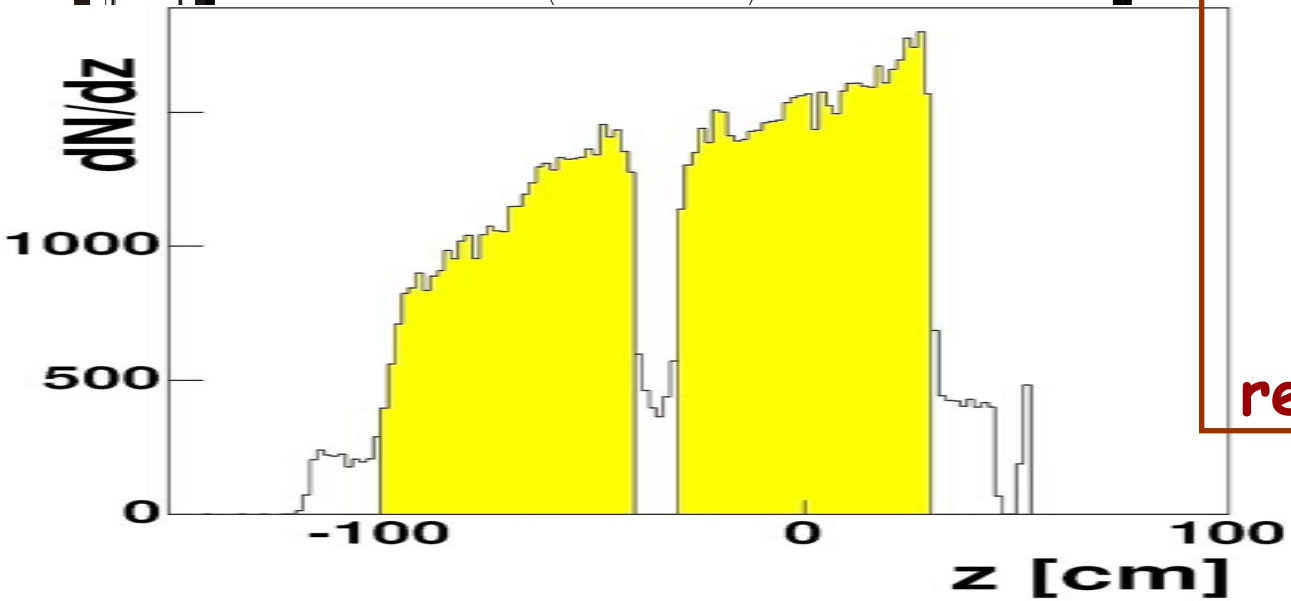
calorimeter readout

Readout electronics

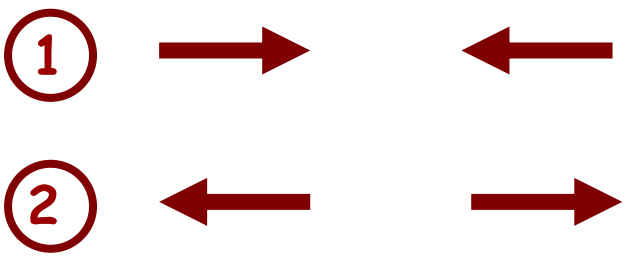
Scintillating fiber trackers

The polarized ^{6}LiD-Target



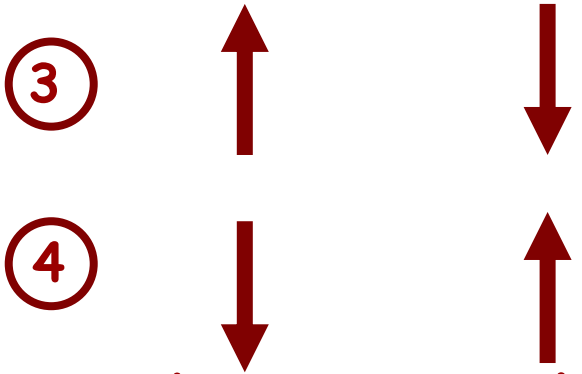


4 possible spin combinations:



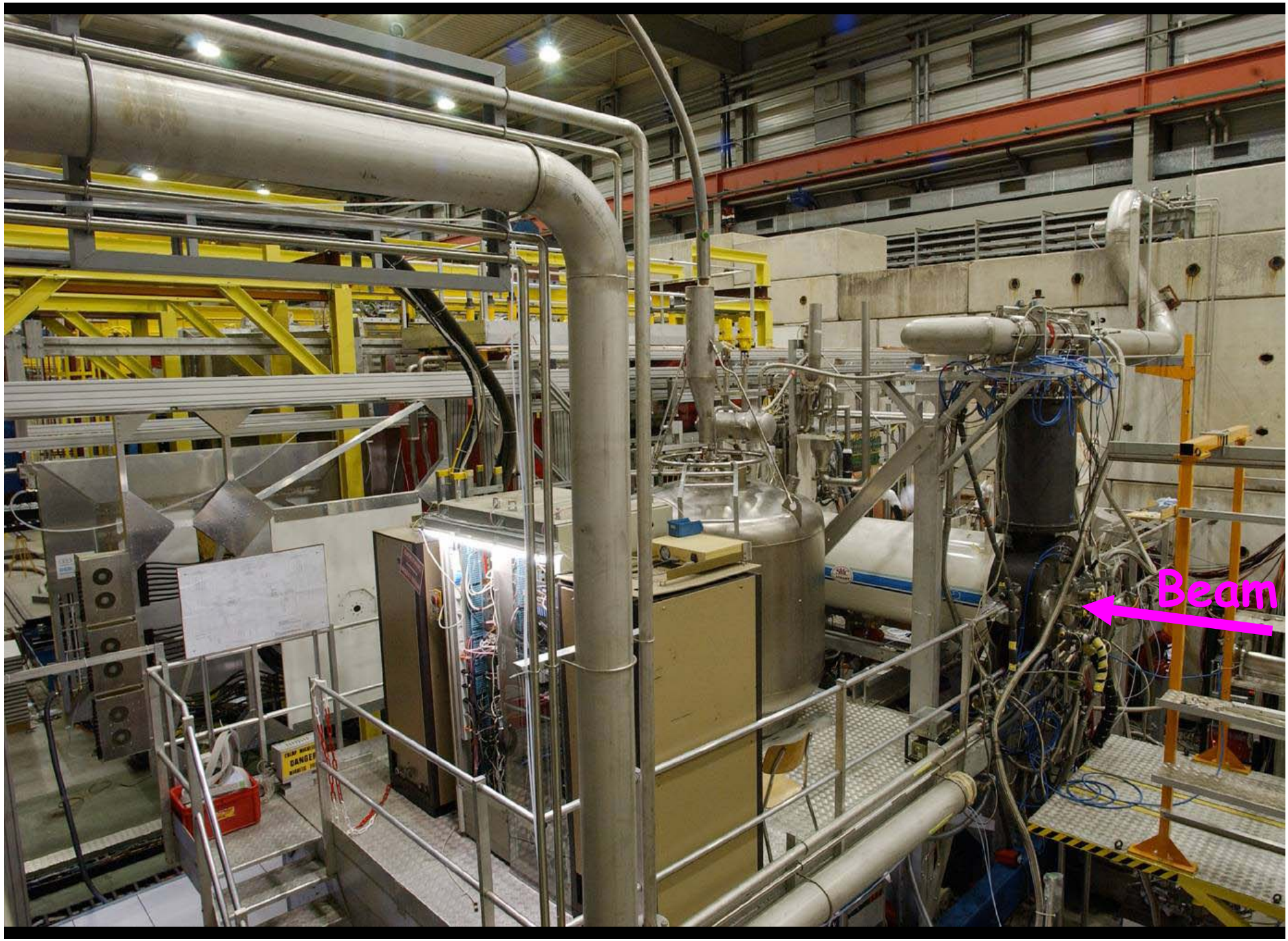
reversed every 8 hours

or:

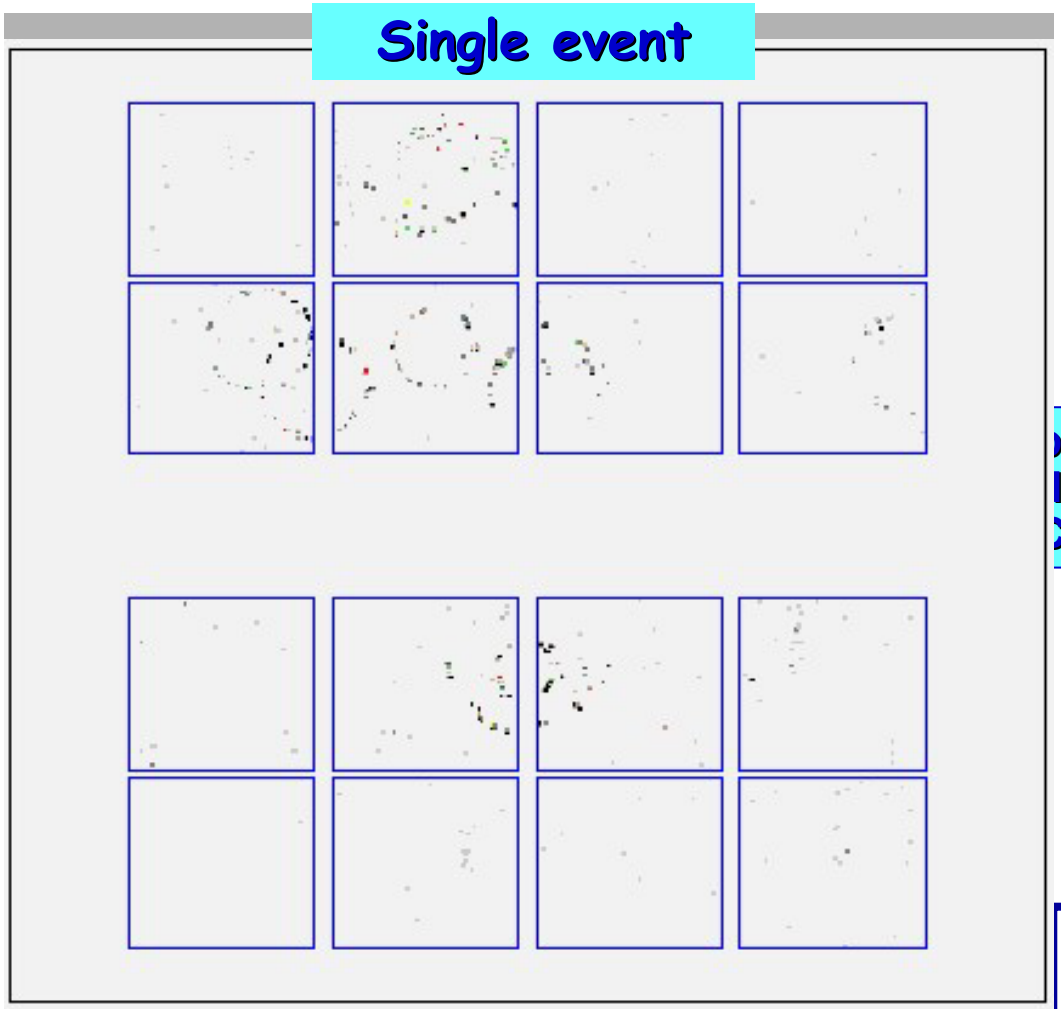


reversed once a week

Polarization: ~50%


Beam

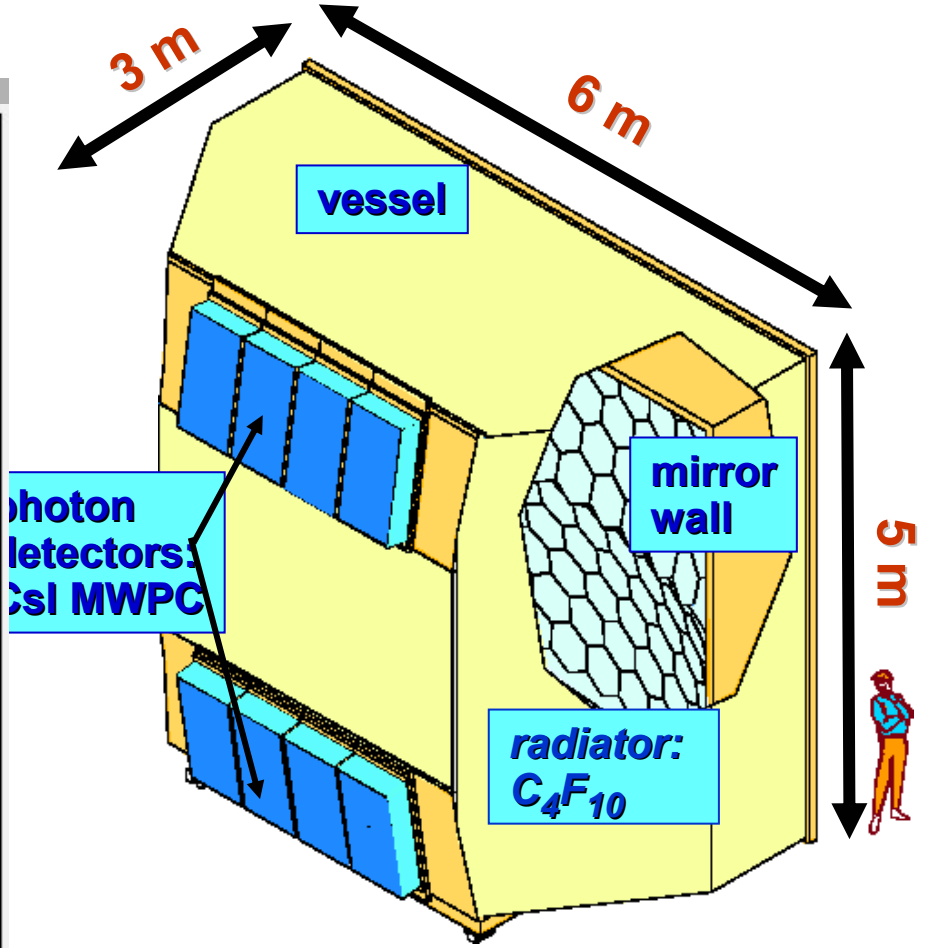
Ring Imaging CHerenkov Counter (RICH)



5.3 m² MWPCs

16 CsI Photocathodes

84,000 analog readout channels

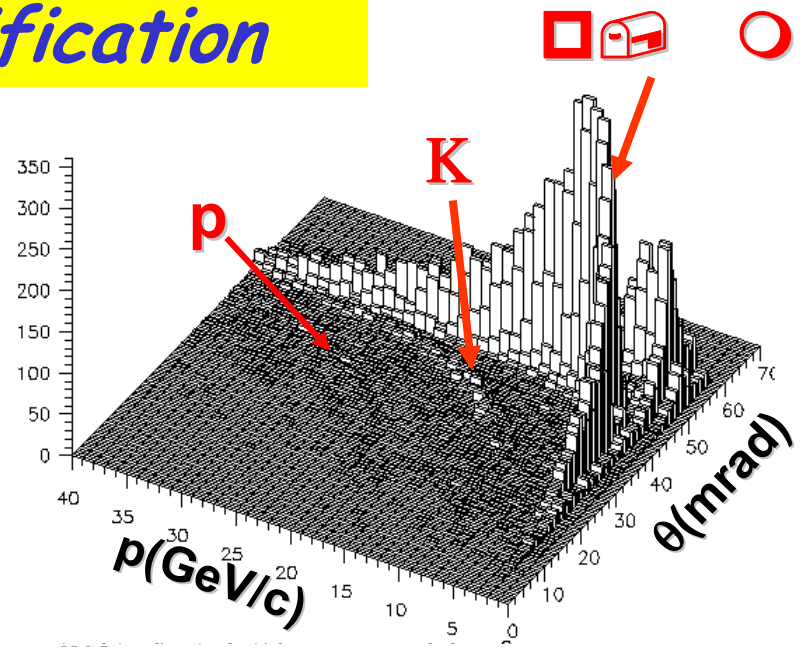


detection of VUV photons (165-200 nm)

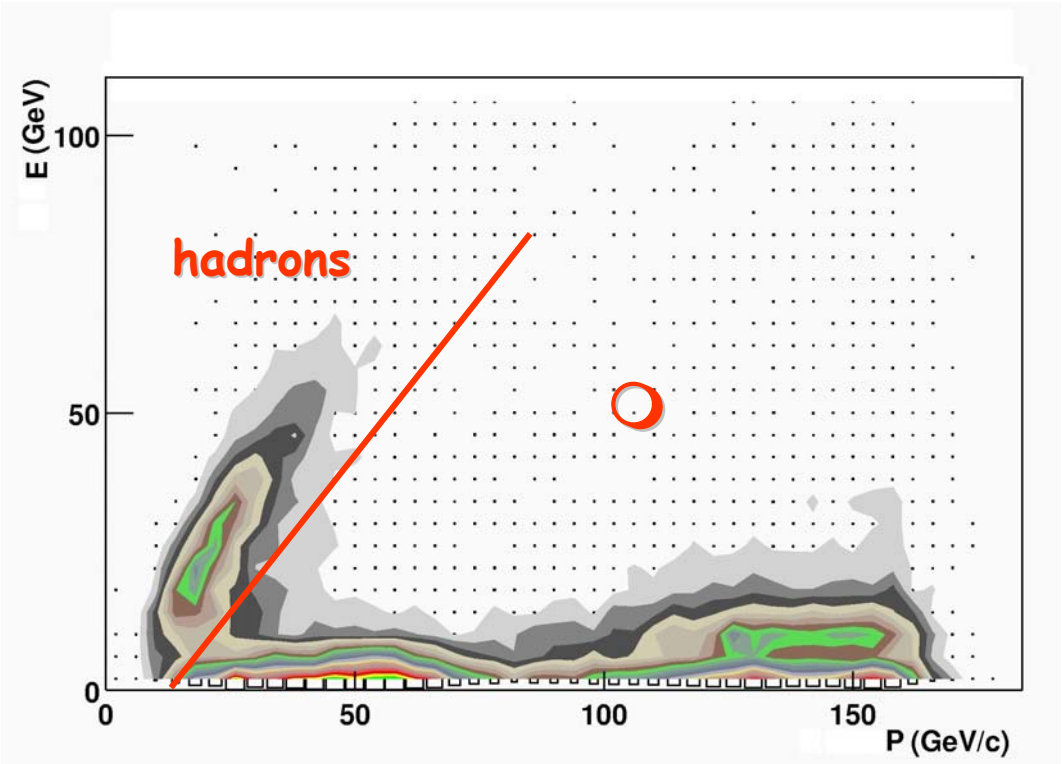
photons/ring n ~14

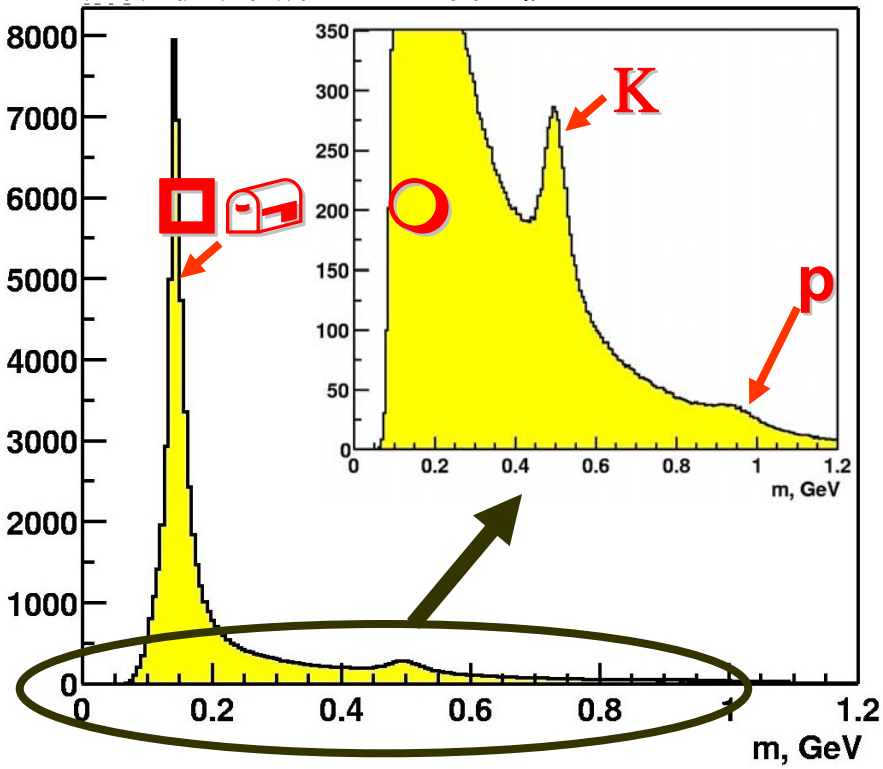
Hadron Identification

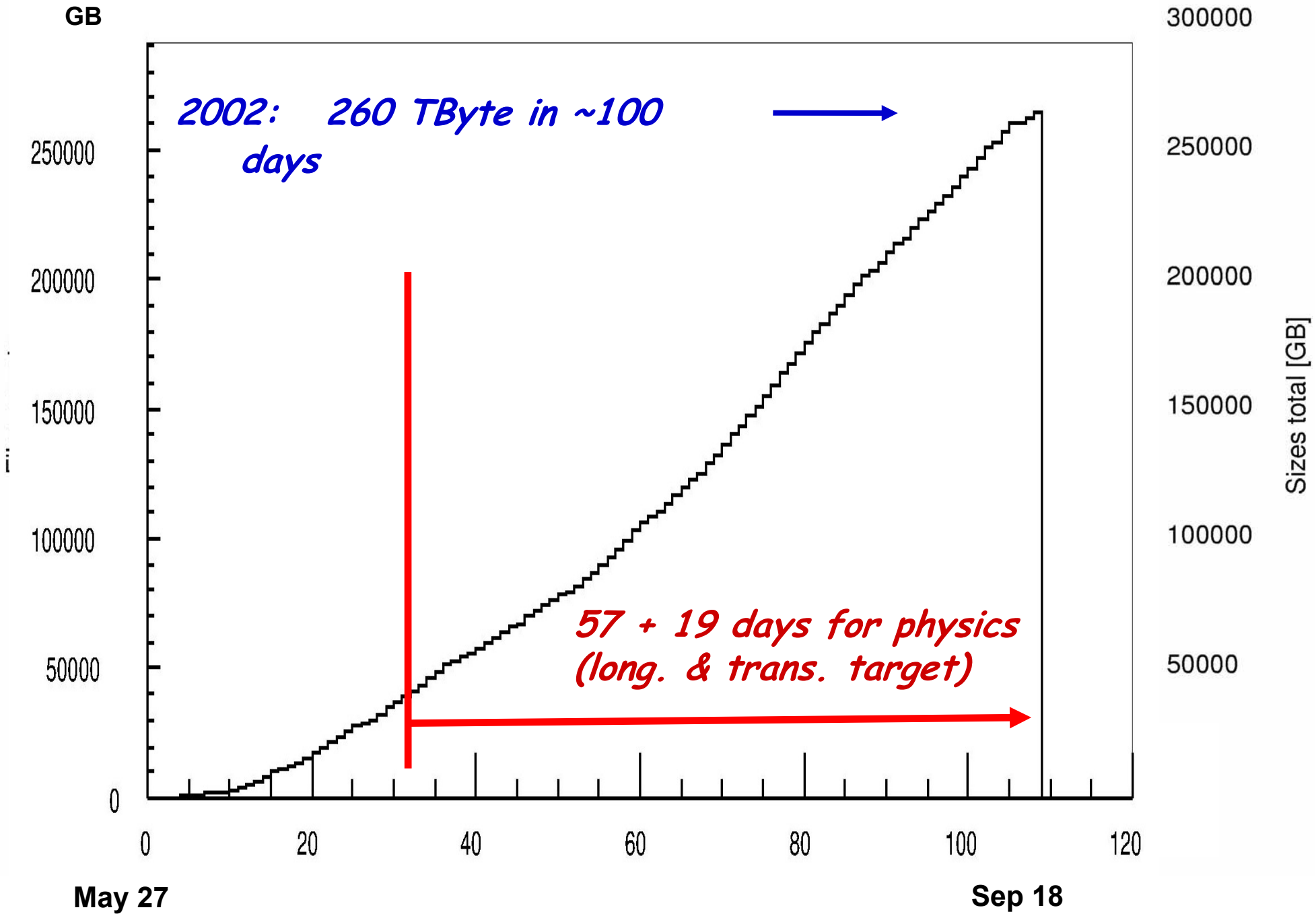
By RICH



…and hadron calorimeters






GB
2002: 260 TByte in ~100 days
57 + 19 days for physics (long. & trans. target)
300000
250000
200000
150000
100000
50000
0
Sizes total [GB]
0
20
40
60
80
100
120
May 27
Sep 18

Satellite Compass Computing

Freiburg
17 kSi2k

GridKa
45 kSi2k

TUM
26 kSi2k

CERN
production site!
LXBATCH/LXSHARE
120 kSi2k

Dubna & Protvino
43 kSi2k

Saclay/Lyon
(27 kSi2k)

Trieste
45 kSi2k

Torino
28 kSi2k

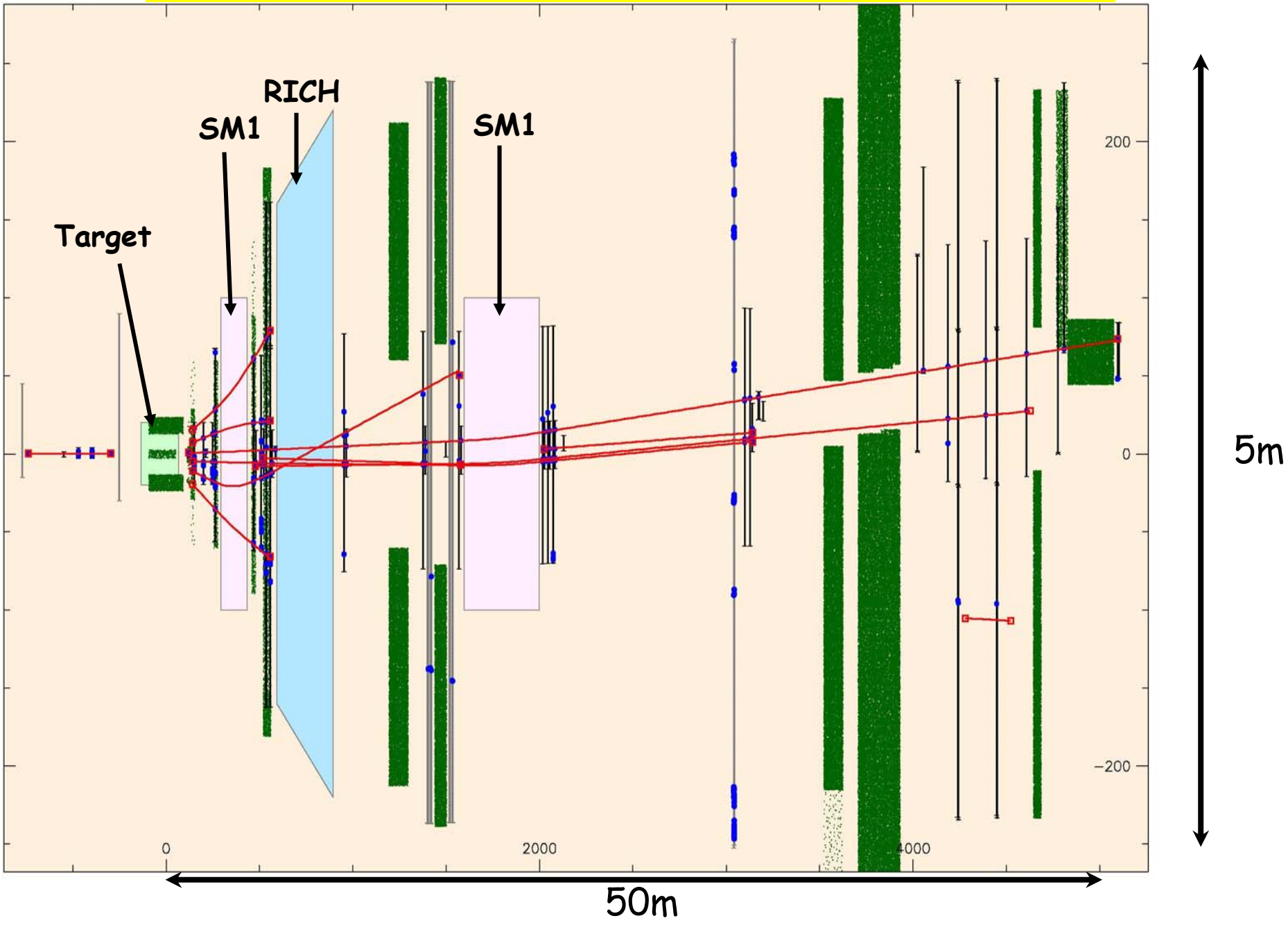
1 Pentium IV 3GHz
~ 1 kSi2k

Event reconstruction:

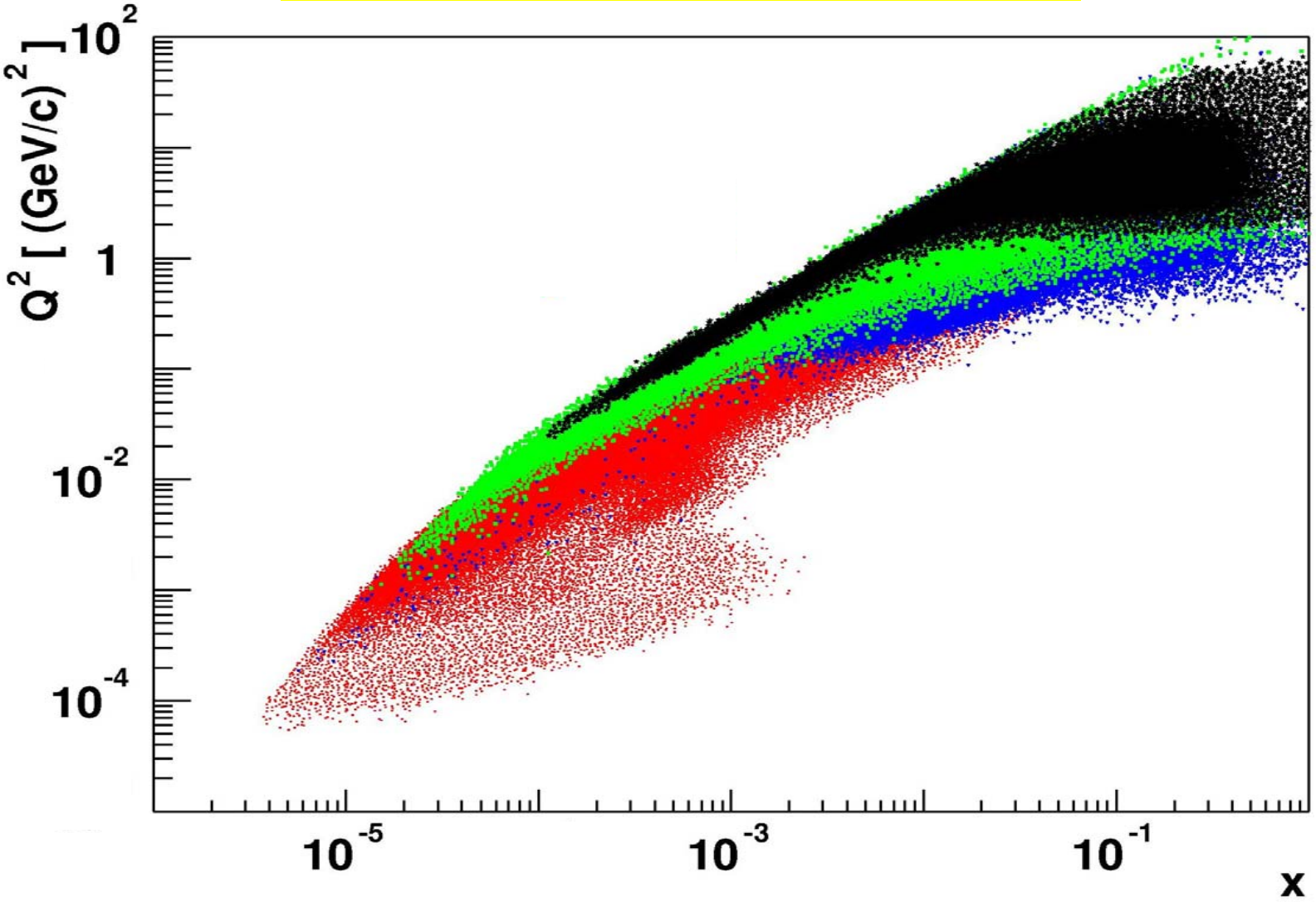
500 TB raw data
→ 500 000 Batch jobs
(1 GByte ~ 8 hours)

Process in parallel
as much as possible
(presently: ~1000 CPUs)

… from online event display



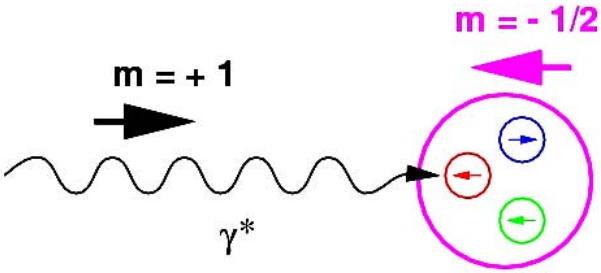
COMPASS Acceptance

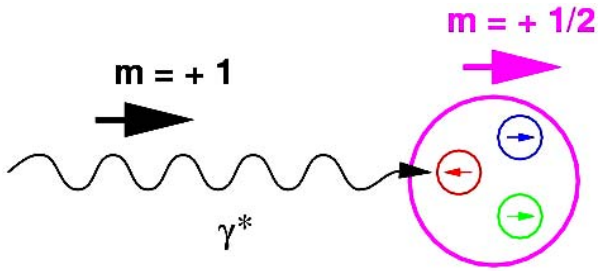


Excellent for non-perturbative & perturbative physics

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

Double Spin Asymmetry





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

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

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

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

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

Virtual Photon Deuteron Asymmetry

COMPASS:

- 2002 data only

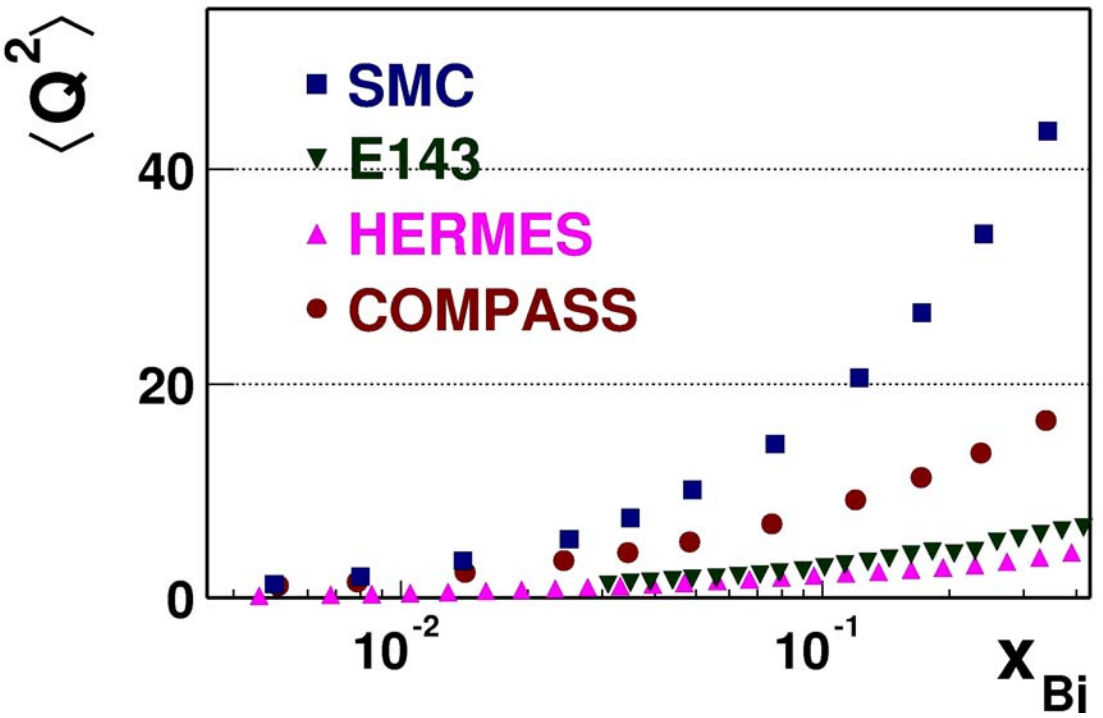
  6.5 Million DIS events

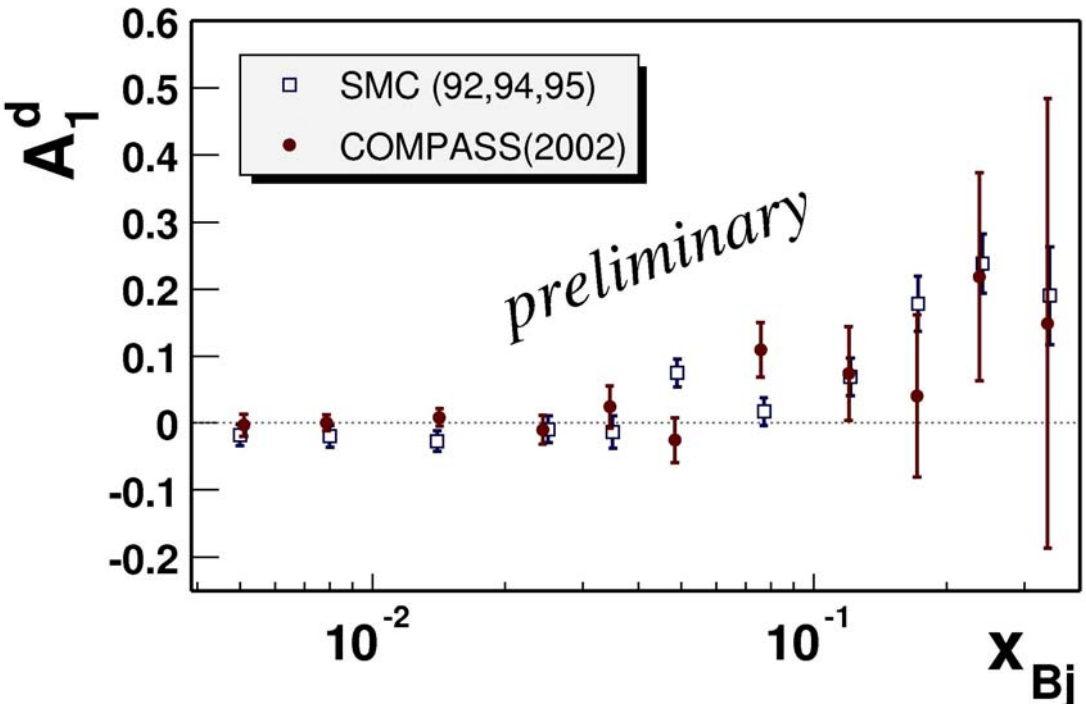
  $Q^2 > 1\ (GeV/c)^2$

  $0.1 < y < 0.9$

expect *4 statistics
by end of 2004

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





Flavor Decomposition

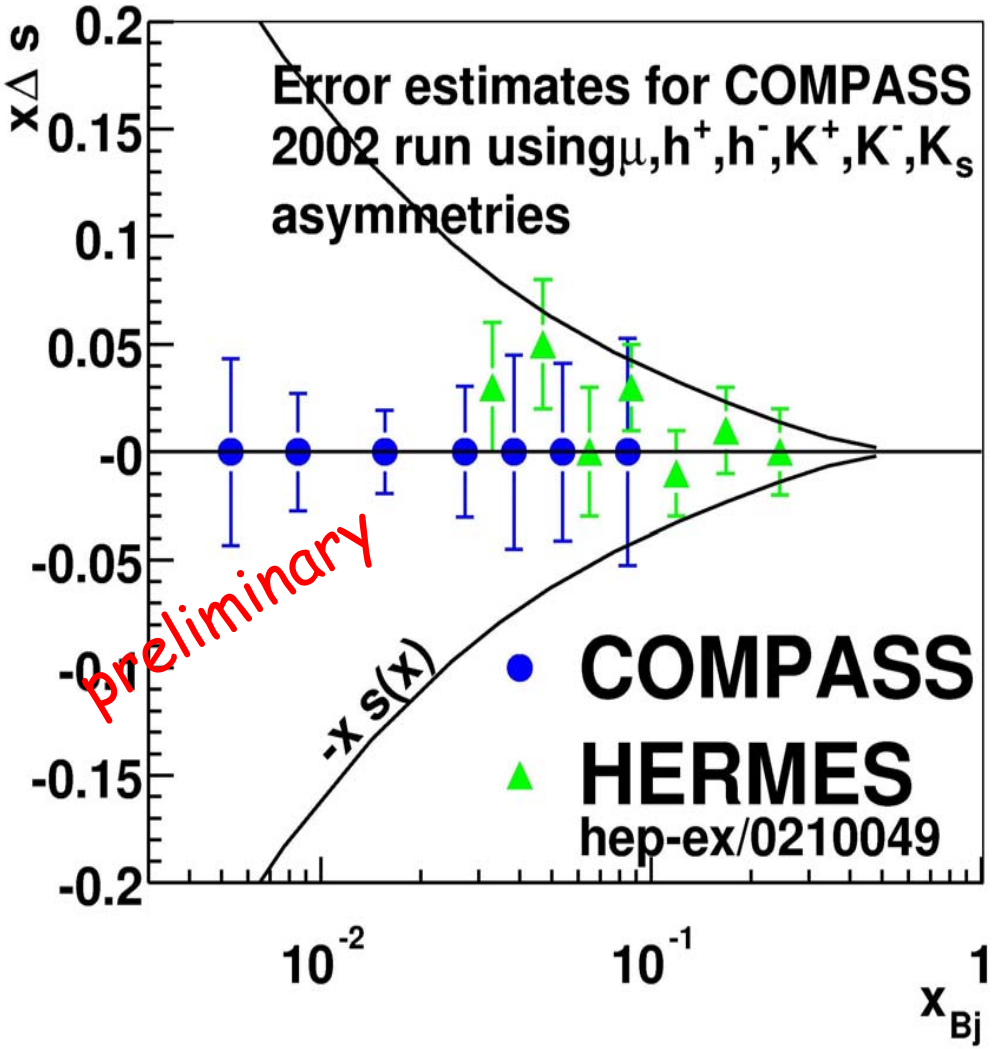
$$\Delta\Sigma = \Delta u + \Delta\bar{u} + \Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s}$$

- Extraction of $\int \Delta q_f$
- Of particular interest: $\int \Delta s$
- semi-inclusive events
  with $Q^2 > 1\ (GeV/c)^2$
- h^+, h^-, K^+, K^-, K_s → $\int \Delta s$
  without proton target!
- Kinematics range …

COMPASS: $x_{min} = 0.003$

HERMES: $x_{min} = 0.02$

RHIC: $x_{min} = 0.04$



Measurement of Gluon Polarization

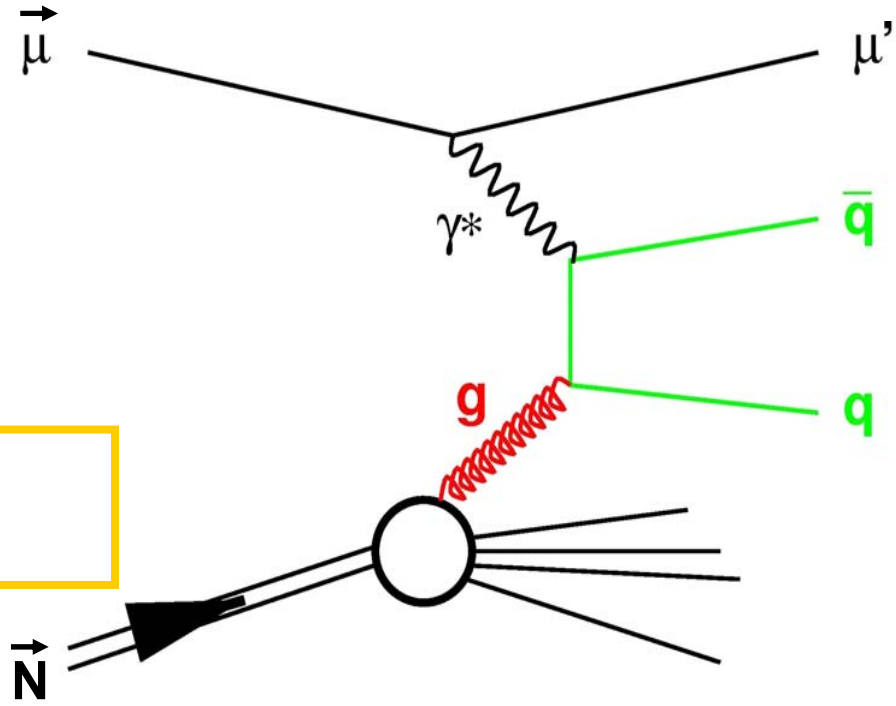
Direct measurement of $\Delta G/G$:

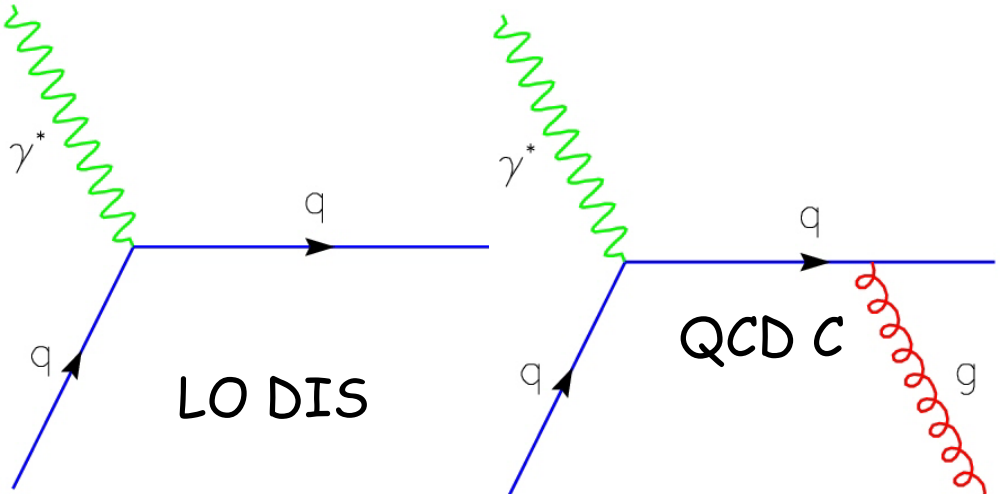
Photon-Gluon-Fusion:

- Cross section difference of 2+1 Jet-events
- in COMPASS: Events with 2 hadrons with high p_T

$A^{\gamma_N d} = -0.065 \pm 0.036\,(stat.) \pm 0.01\,(syst.)$

Details: → Colin Bernet

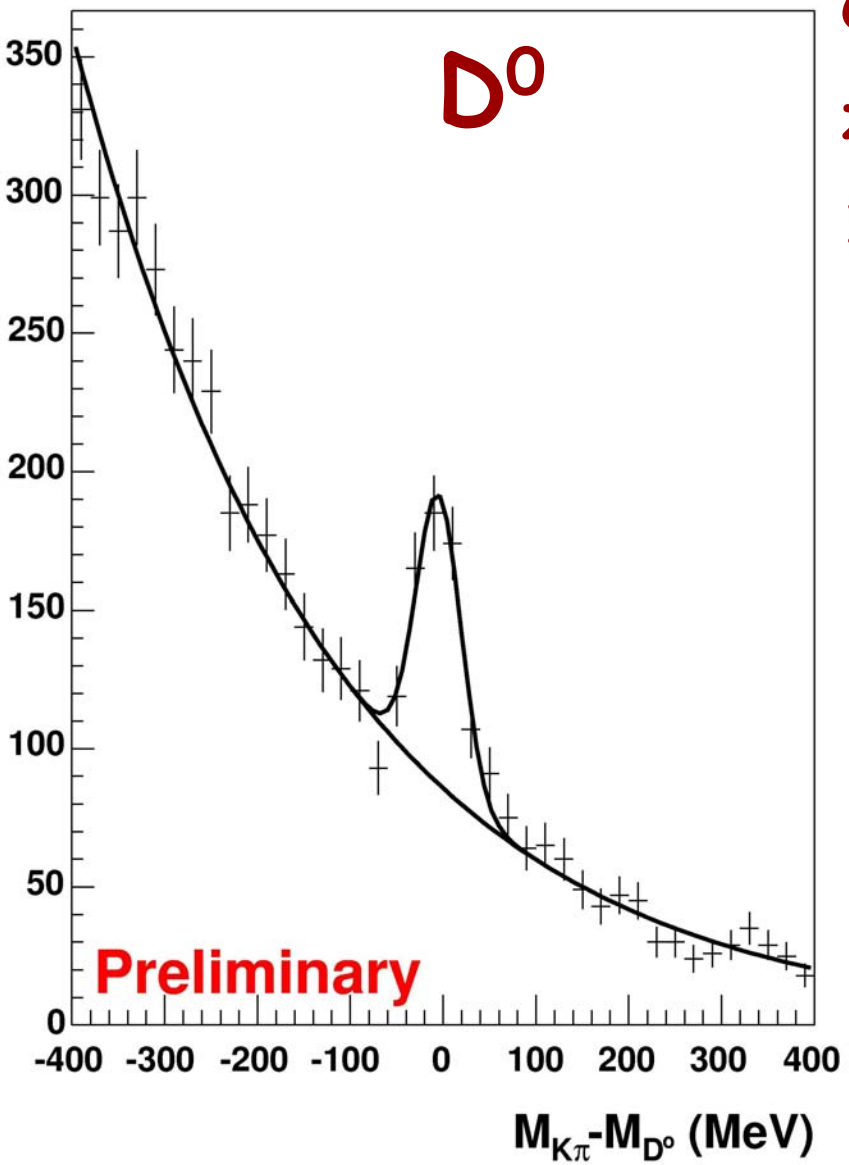




e
inside massive target
ared to background

- $D \rightarrow K\pi$ ... $D^0\pi \rightarrow K\pi\pi$

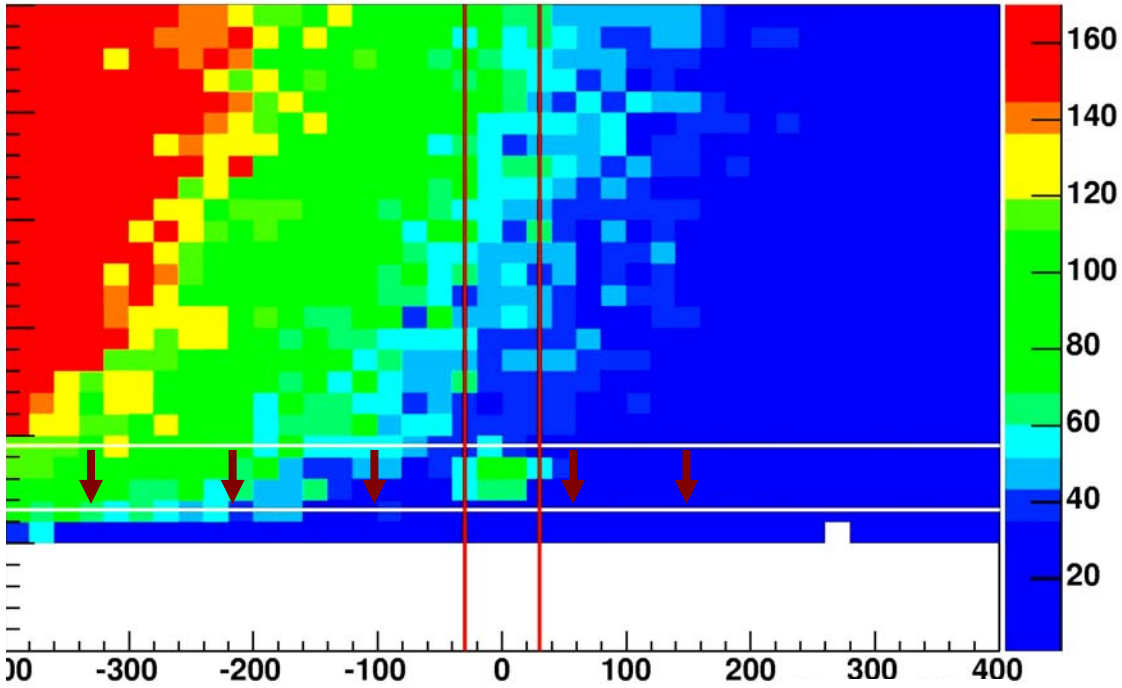
Open charm reconstruction



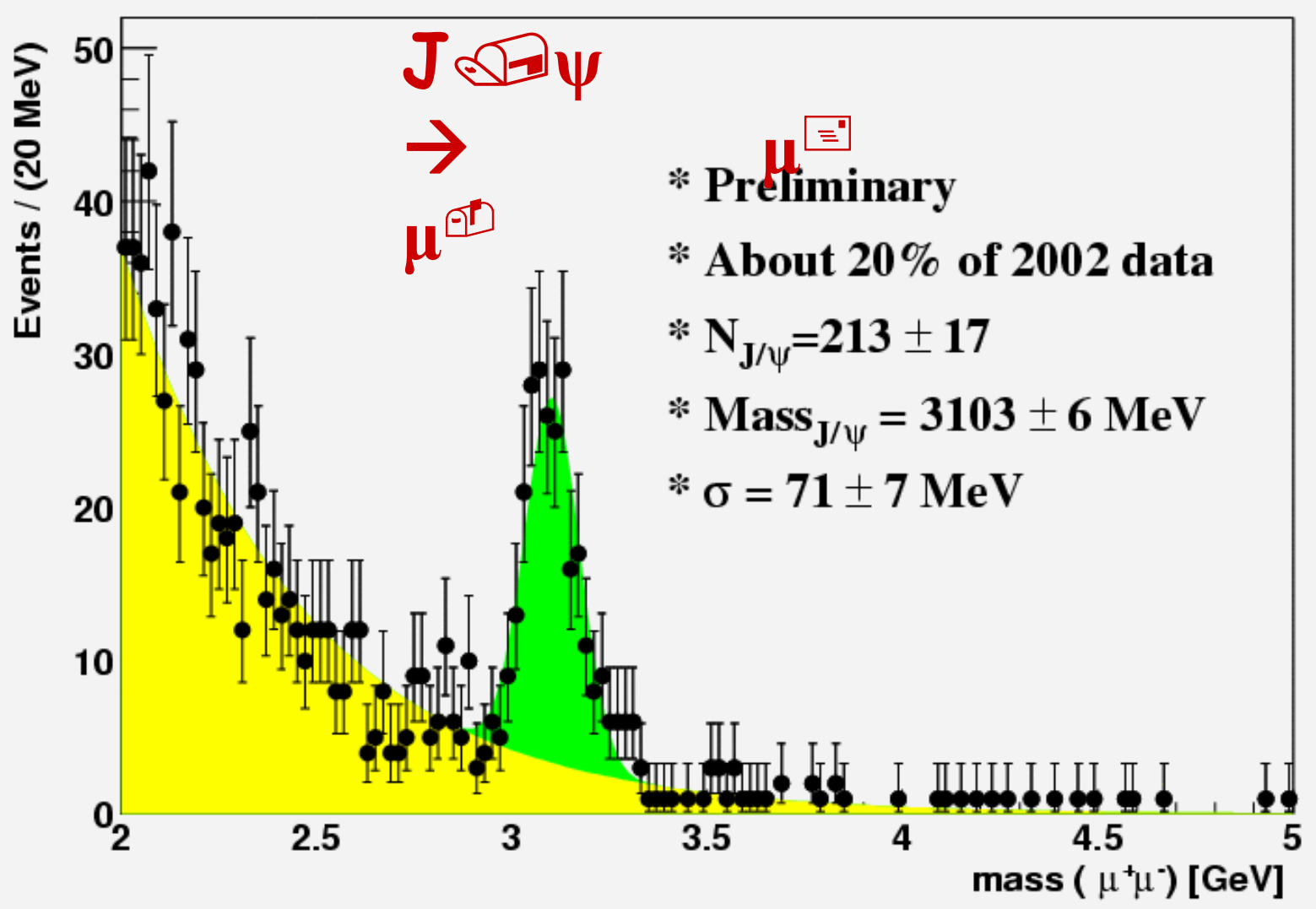
Cuts:

$z_D > 0.2$, $|\cos \theta^*| < 0.85$ (Background

$10 < p_K < 35$ GeV/c (RICH PID)



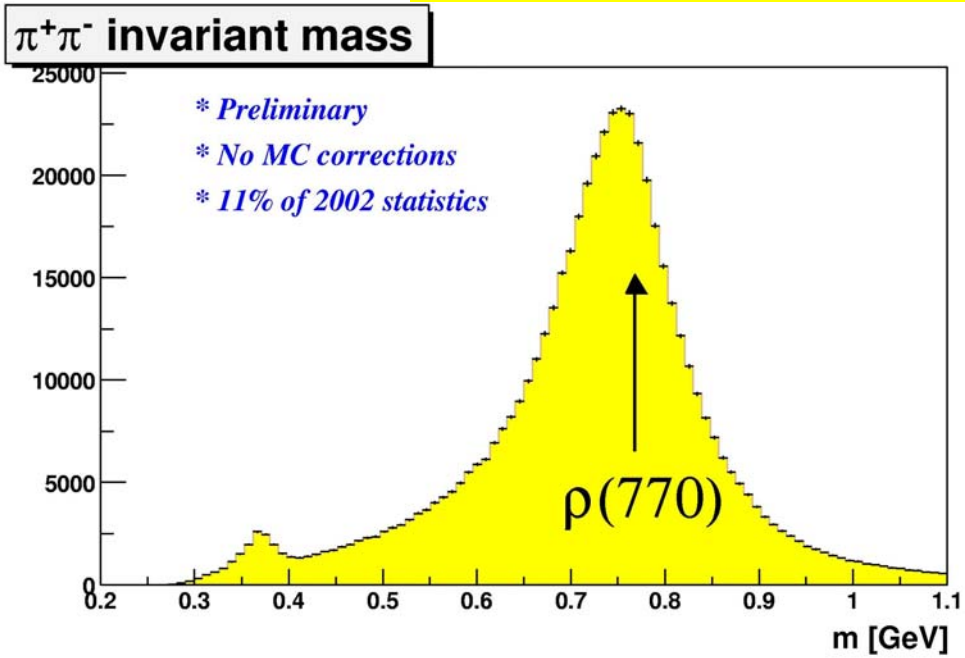
J/ψ Production

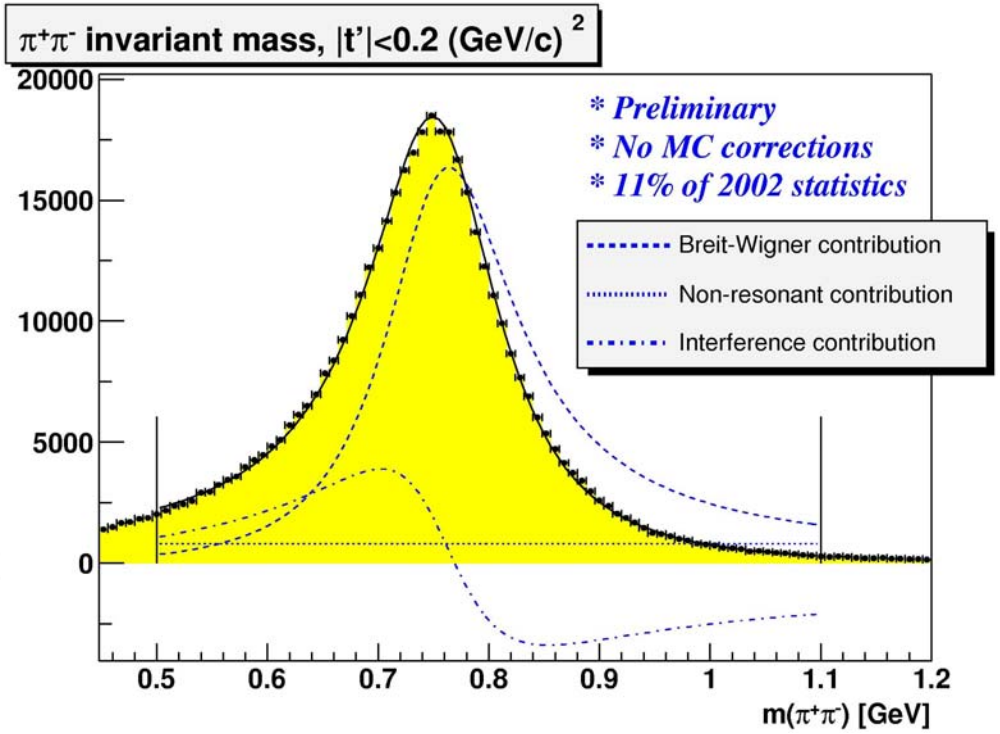


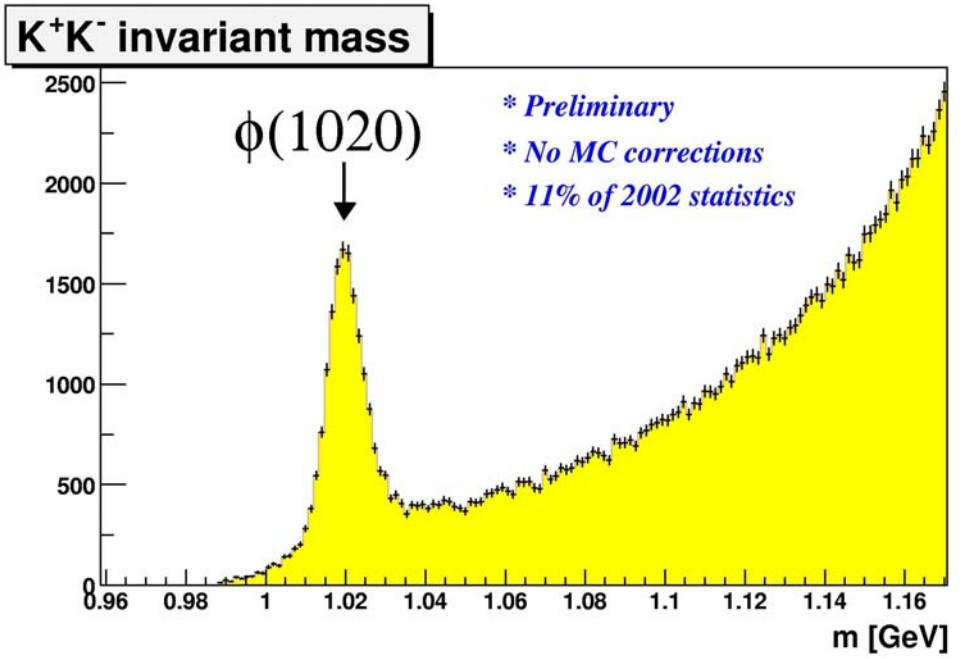
2002: mostly "elastic" background

2003: dedicated trigger (2*yield)
- study diffractive and elastic processes

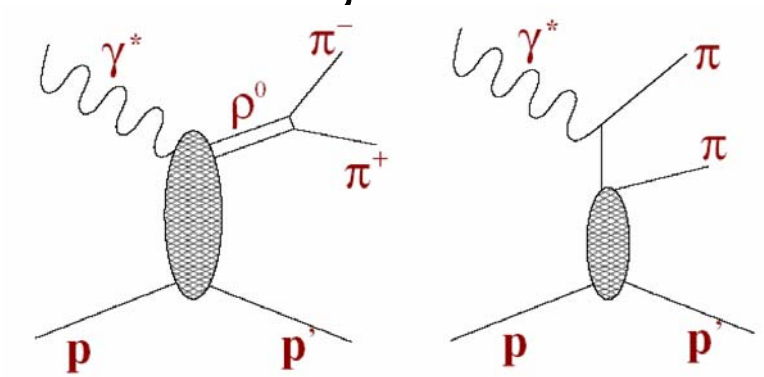
Diffractive Vector-Mesons



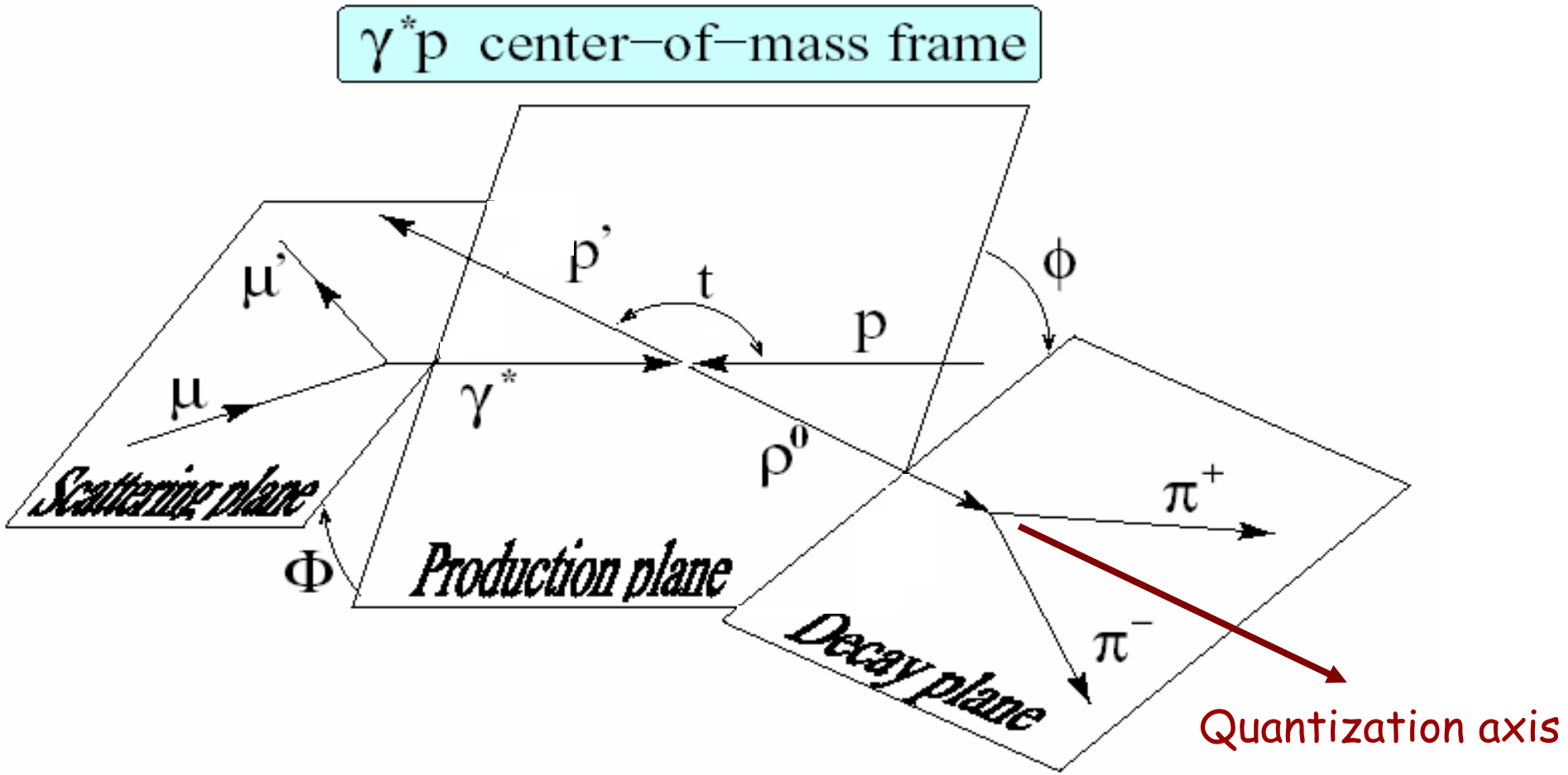




Shift of ❒□ mass because of interference of resonant production with background



Angular distributions

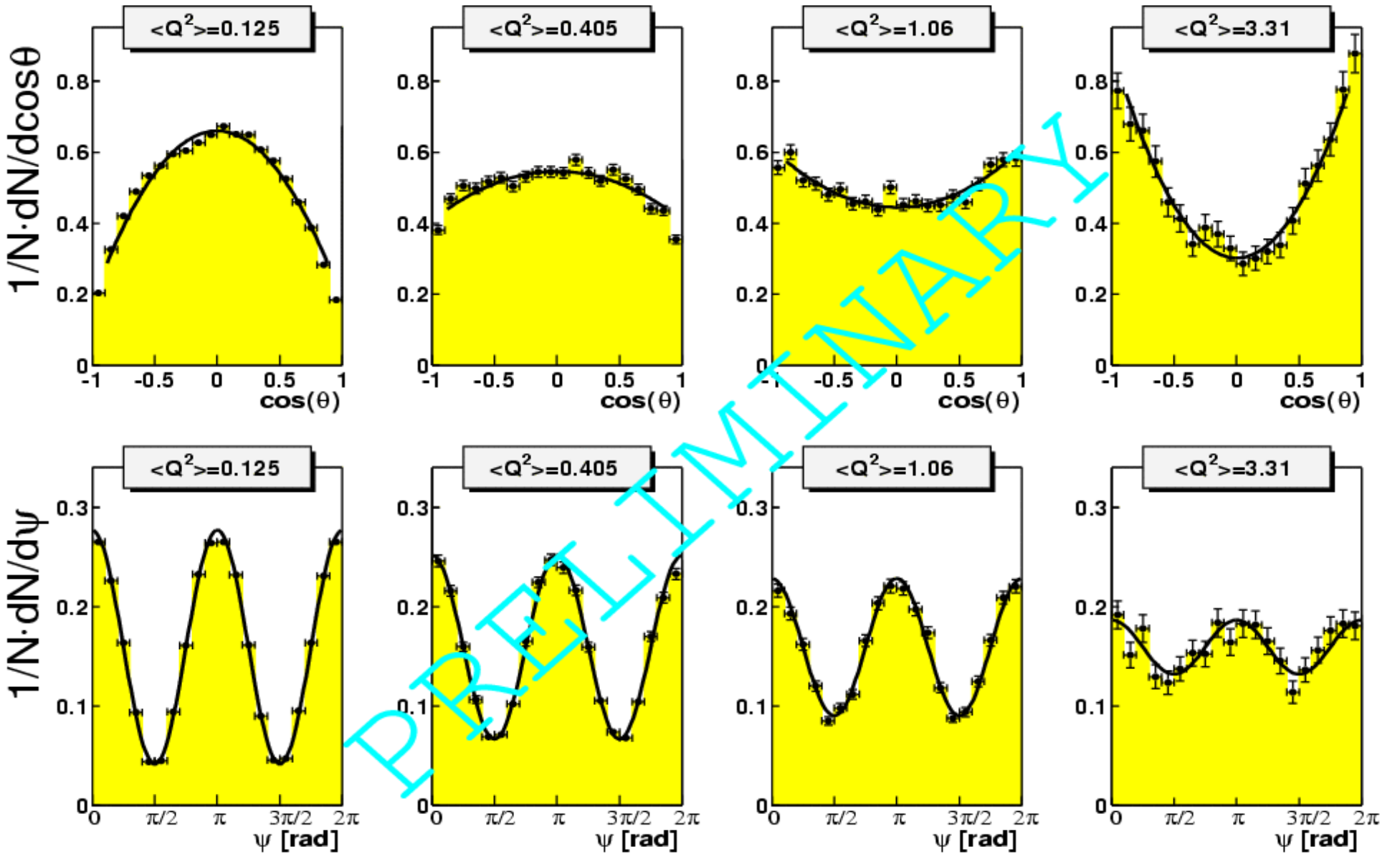


✈ : polar angle of □+ in VM rest frame

✡ ▣ ↗☞: angle between VM decay plane and scattering plar

→ integrate W(cos❑☜↗☜☞☜✡) and study one dimensional pro

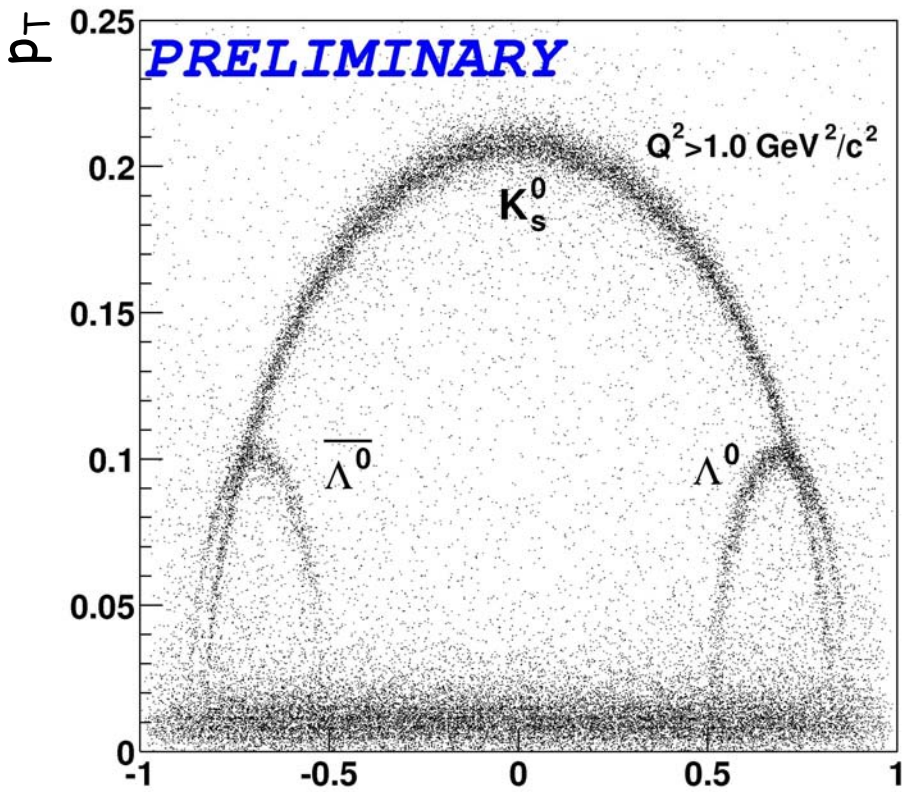
Angular distributions



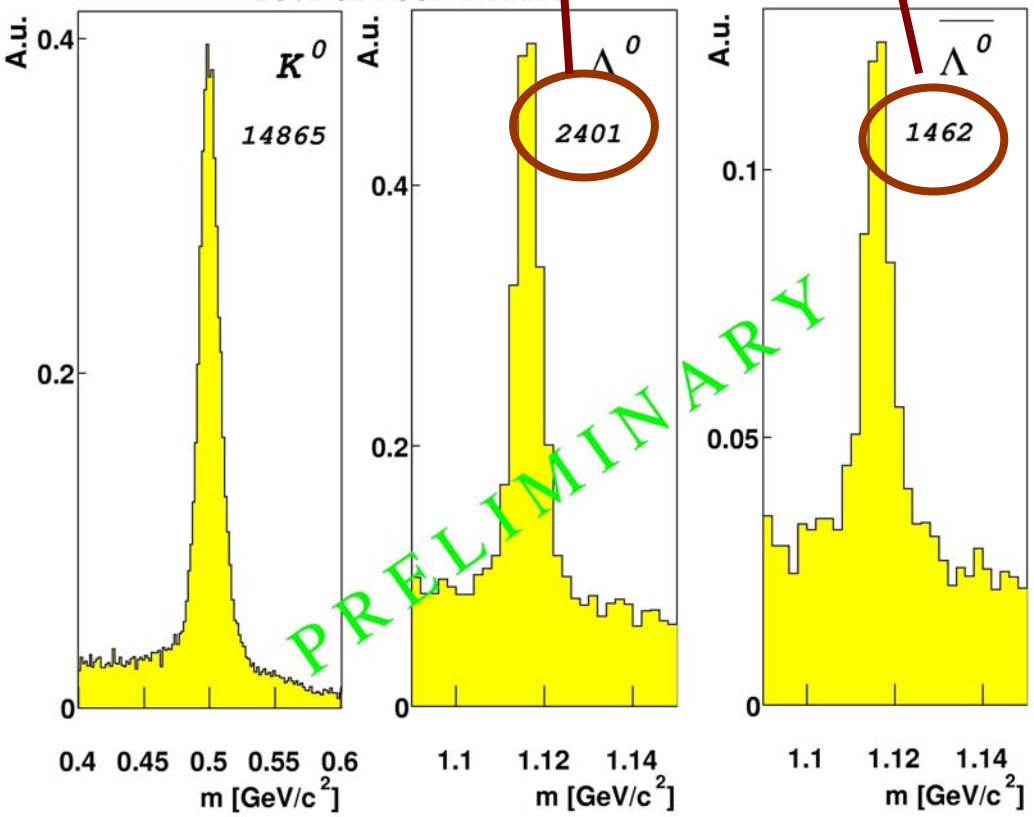
PRELIMINARY

Q^2 = 0.1 (GeV/c)^2 → Q^2 = 3 (GeV/c)^2

Measurement of ☺ and ☺



N(⌨) ~ 2 * N($\overline{⌨}$)



Total statistics 2002: 12000 ☹ , 7000 ☹ ⌨ * 2 i

Physics objectives

- Target Fragmentation region ($x_F < 0$):
  - negative longitudinal polarization of ☹ predicted

    Ellis, Kharzeev, Kotzinian Z. Physik **C69** (1996) 467

    - may test polarized strangeness content of nucleon

    BUT: acceptance poor for COMPASS

- Current fragmentation region ($x_F > 0$):
  - Study of spin transfer from photon to baryon
  - measure ☹ Spin structure

    NQM: 👎u☹ 💾 👎d☹ 💾 📁📪 👎s☹ 💾 📂

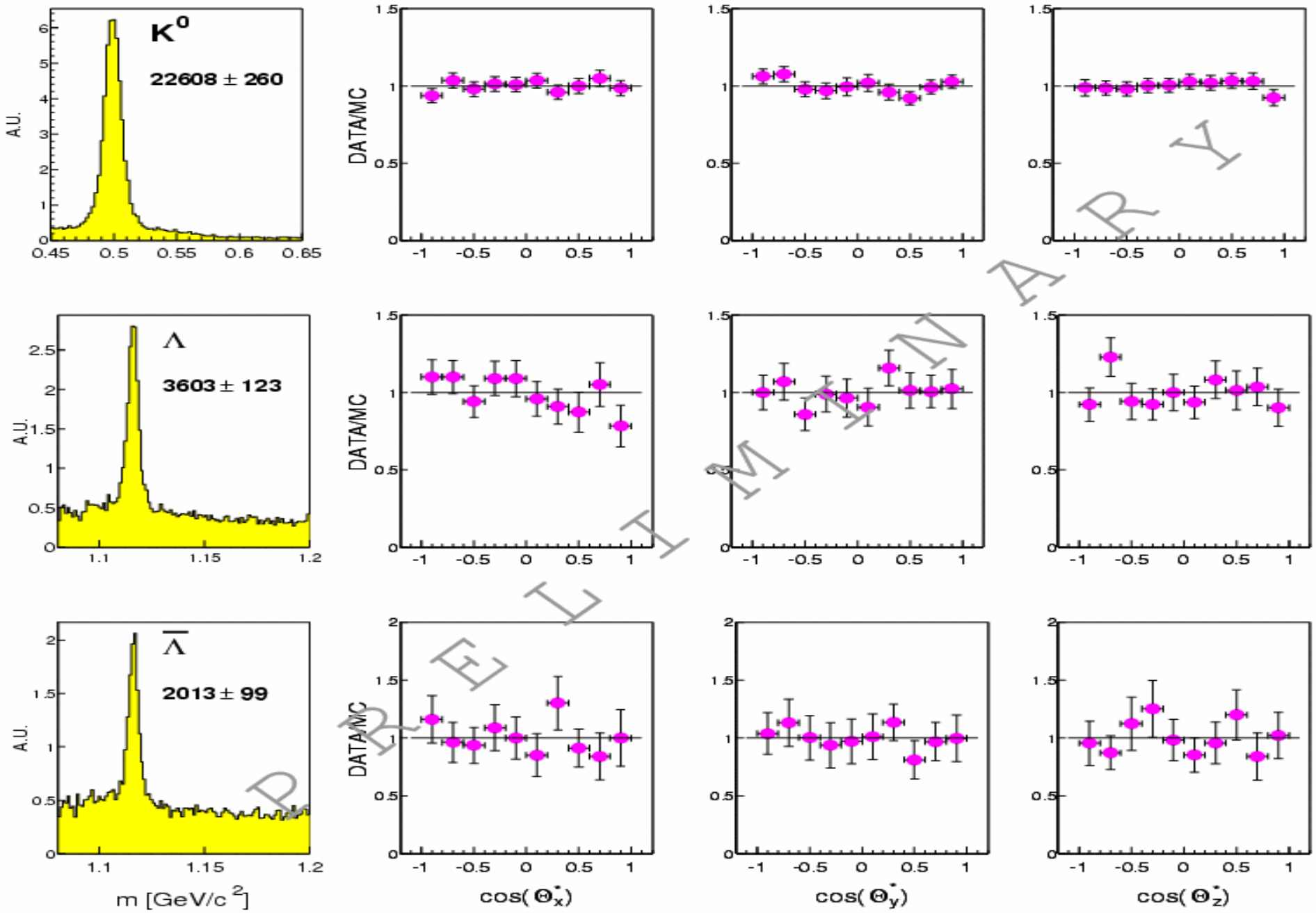
    Burkhardt, Jaffe PRL **70** (1993) 2537 :

    👎u☹ 💾 👎d☹ 💾 📪📁📠📄📄📪 👎s☹ 💾

    📁📠🖱

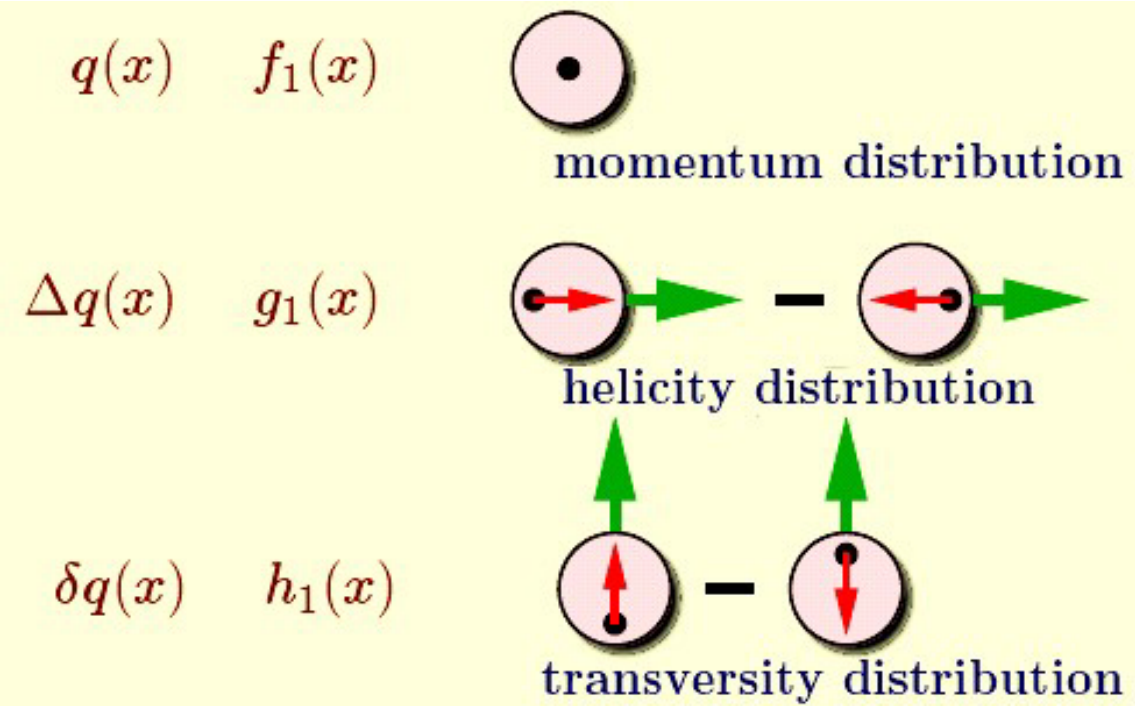
    ☎based on information coming from flavor SU(3) octet axial charges from hyperon decays)

☹ and ☹̄ Polarization



Transverse Spin Physics

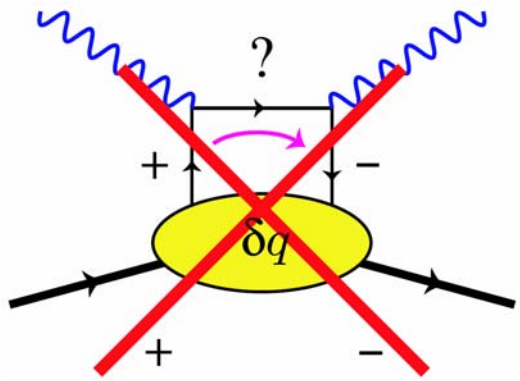
3 structure functions are necessary to describe the spin structure of the nucleon at LO:



All of equal importance!

$h_1(x)$ decouples from leading twist DIS because helicity of quark must flip

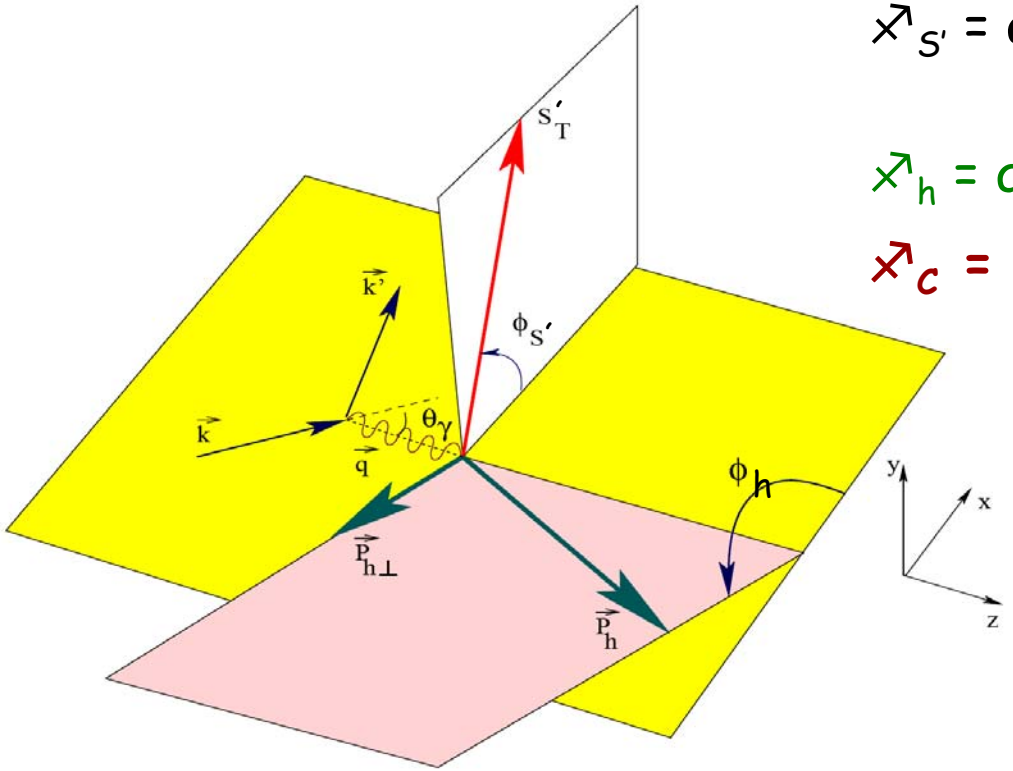
No mixture with Gluon



Transverse Spin Physics

3 possible quark polarimeters suggested:

- Measure transverse polarization of ☹
- Azimuthal dependence of the plain containing leading & next to leading hadrons
- Azimuthal distribution of leading □



$\nearrow_{S'}$ = azimuthal angle of target spin vector **after** scattering

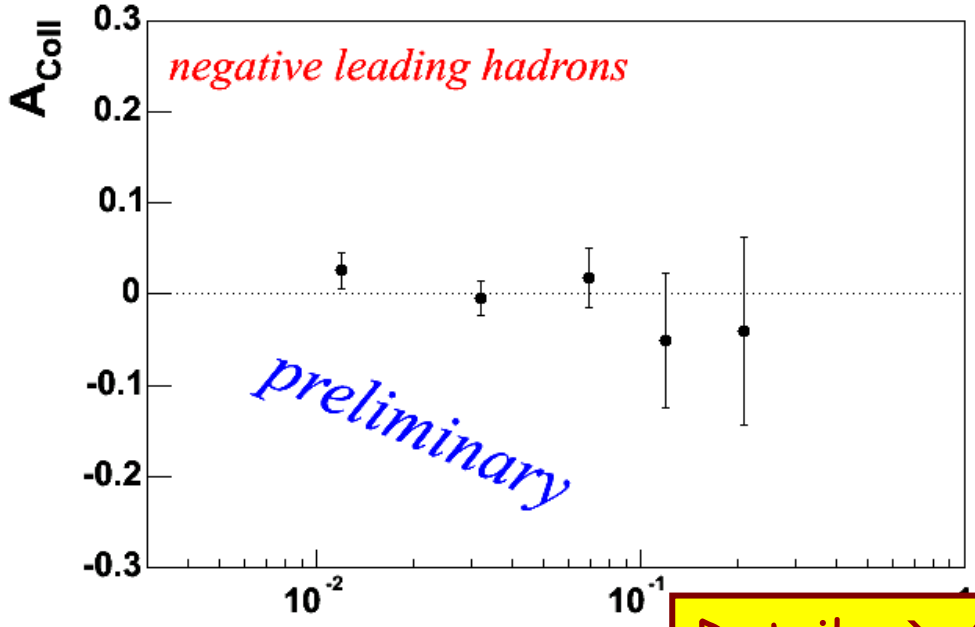
$\nearrow_h$ = azimuthal angle of hadron

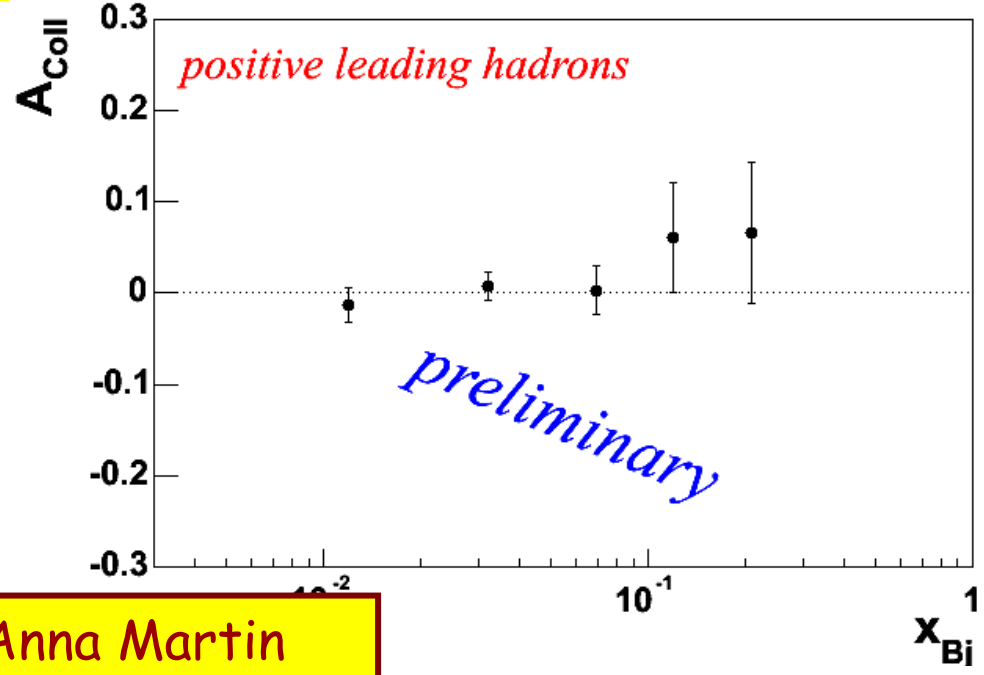
$\nearrow_c = \nearrow_h - \nearrow_{S'}$

$$A_{Coll} = \frac{A_{UT}^{\sin\phi_c}}{D_{NN} \cdot f \cdot P}$$

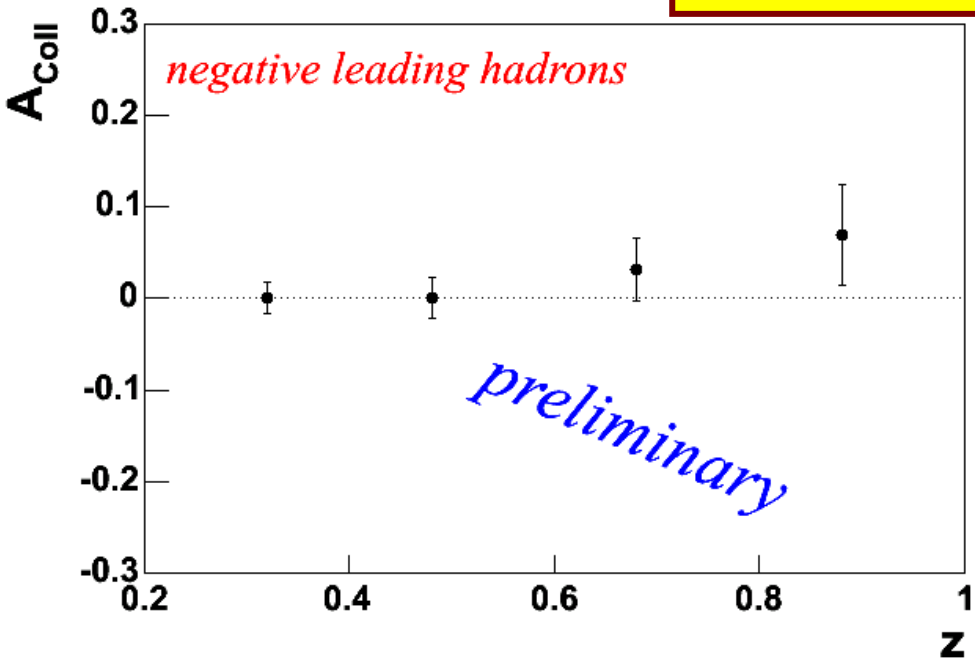
$$\propto \frac{\sum_q e_q^2 h_1^q(x,Q^2) \cdot H_1^{\perp(1)q}(z,Q^2)}{\sum_q e_q^2 f_1^q(x,Q^2) \cdot D_1^q(z,Q^2)}$$

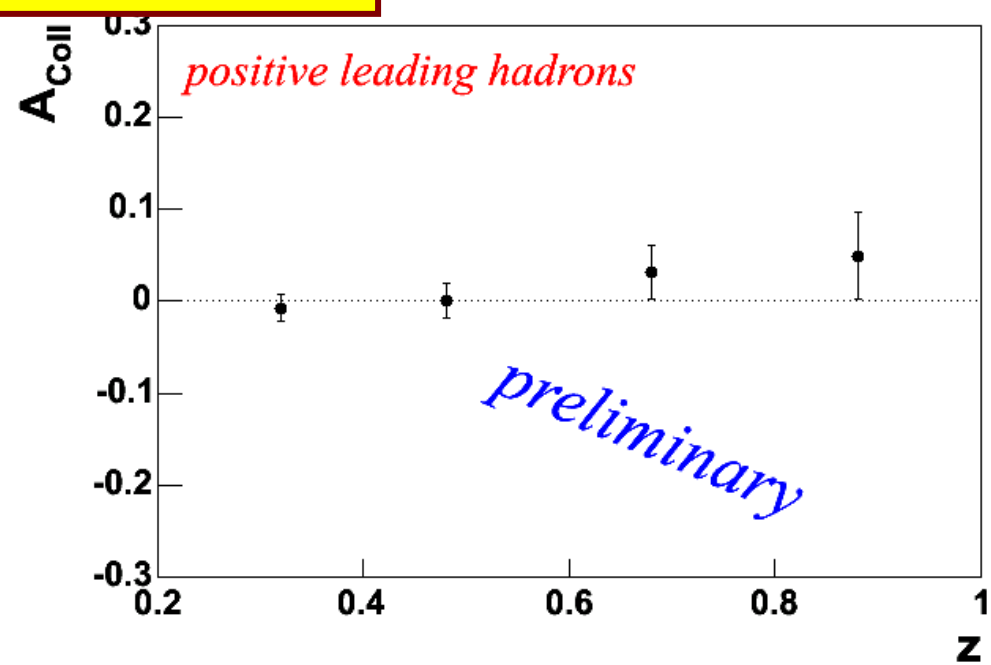
First Results on Collins Asymmetries





Details → Anna Martin





Summary

- **Open charm:**
  possibility for D^0 reconstruction in massive target demonstrated
  llect more statistics
- **High-p_T:**
  First re m COMPASS
- **Transversity:**
  first measuremen lins Asymmetry on
  transverse polarized d target
- **DIS & SIDIS:**
  COMPASS will cover the small-x x=0.003 @ $Q^2>1$ $(GeV/c)^2$
  with > fourfold statistics of SMC
- ☹ **production:**
  extraction of spin transfer on its way
- **VM production:**
  data cover the range from $Q^2 < 10^{-4}$ $(GeV/c)^2$ to $Q^2 > 10^2$ ( )^2,
  study the interesting physics in the transition region
- **unpolarized physics**

  different analyses (Cahn, k_T, etc.) in pipeline

COMPASS is on good track to accomplish its goals