

LIP participation in the COMPASS Experiment

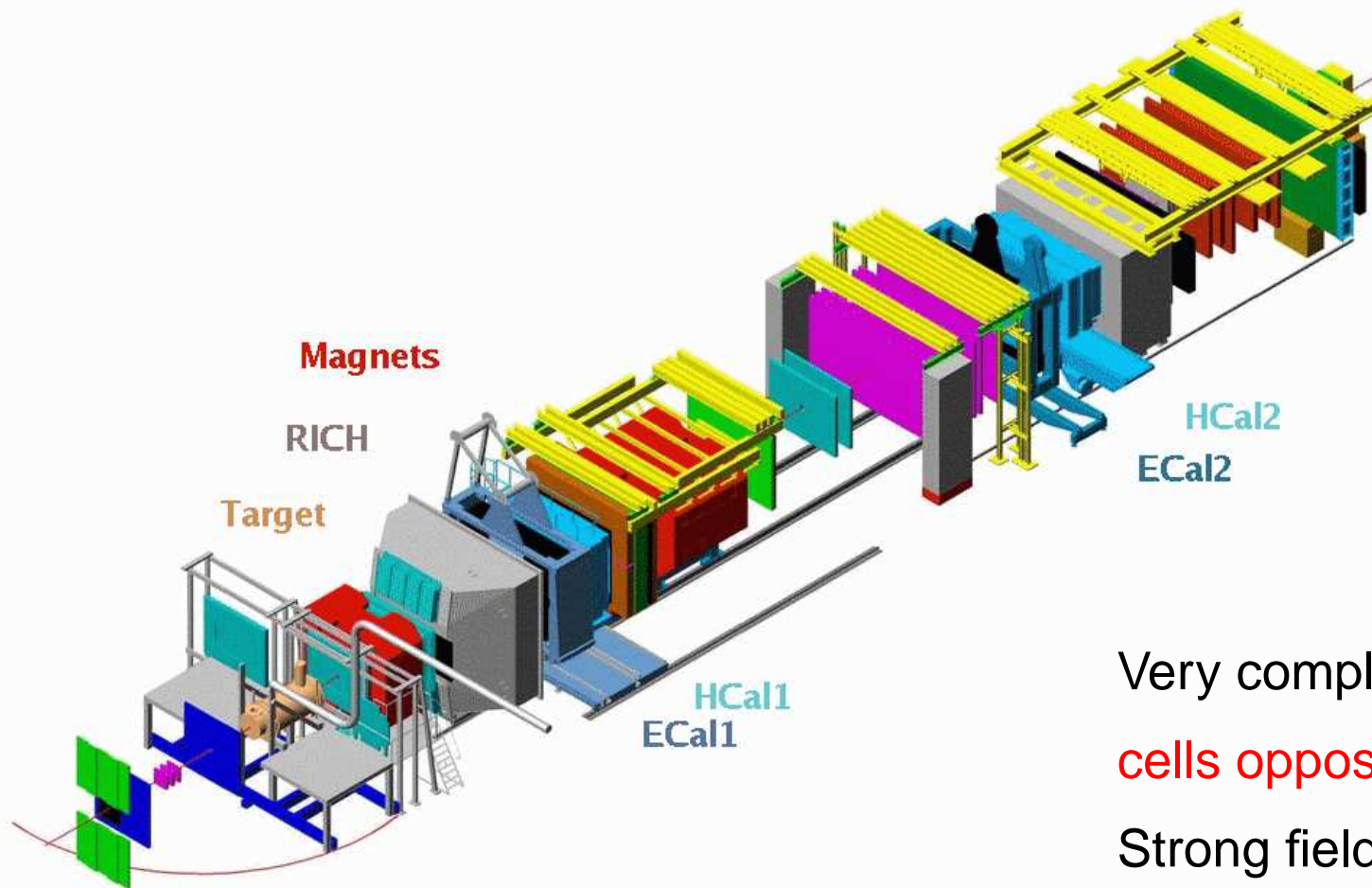
January 2003 – March 2008

Team leader:	Paula Bordalo
Researchers:	Paula Bordalo, João Cruz, <u>Catarina Quintans</u> , Sérgio Ramos, Helena Santos
PhD students:	Celso Franco, Luís Silva
Technical research assistants:	Ana Sofia Nunes, Christophe Pires
Past members:	Maria Varanda, João Bastos (Pos-docs), David Sora, Francisco Mota (tech. research assistants), Katharina Schmidt, Helena Moreira (undergraduate students)

- The **COMPASS experiment at CERN** had its scientific proposal fully approved in 1998. After a few years for building and installing the spectrometer, in 2001 the first Technical Run took place. The data taking for Physics started in 2002.
- In August 2002, a proposal from LIP (P. Bordalo, S. Ramos and C. Quintans) to join COMPASS, taking the full responsibility of the DCS, was presented to the Group Leaders Board of COMPASS.
- The LIP-COMPASS group was accepted, and LIP members participated in the data taking on the fall of 2002.
- LIP joined COMPASS officially in January 2003 (MoU).

COMPASS: COmmon Muon and Proton Apparatus for Structure and Spectroscopy

- Studies of the **nucleon spin structure** (2002 – 2007)
 - with polarized muon beam (μ^+ at 160 GeV/c, $\approx 80\%$ polarized) and polarized targets (${}^6\text{LiD}$ and NH_3)
- Studies of **hadron spectroscopy** (2008 – ...)
 - pilot Run during 4 weeks in 2004
 - with hadron beam (π^-) and several unpolarized targets (**Pb, Cu, C** – and **liquid H₂** in 2008)



Very complex solid state **target**:
cells oppositely polarized.

Strong field and very low temperature
keep the nucleons spin frozen.

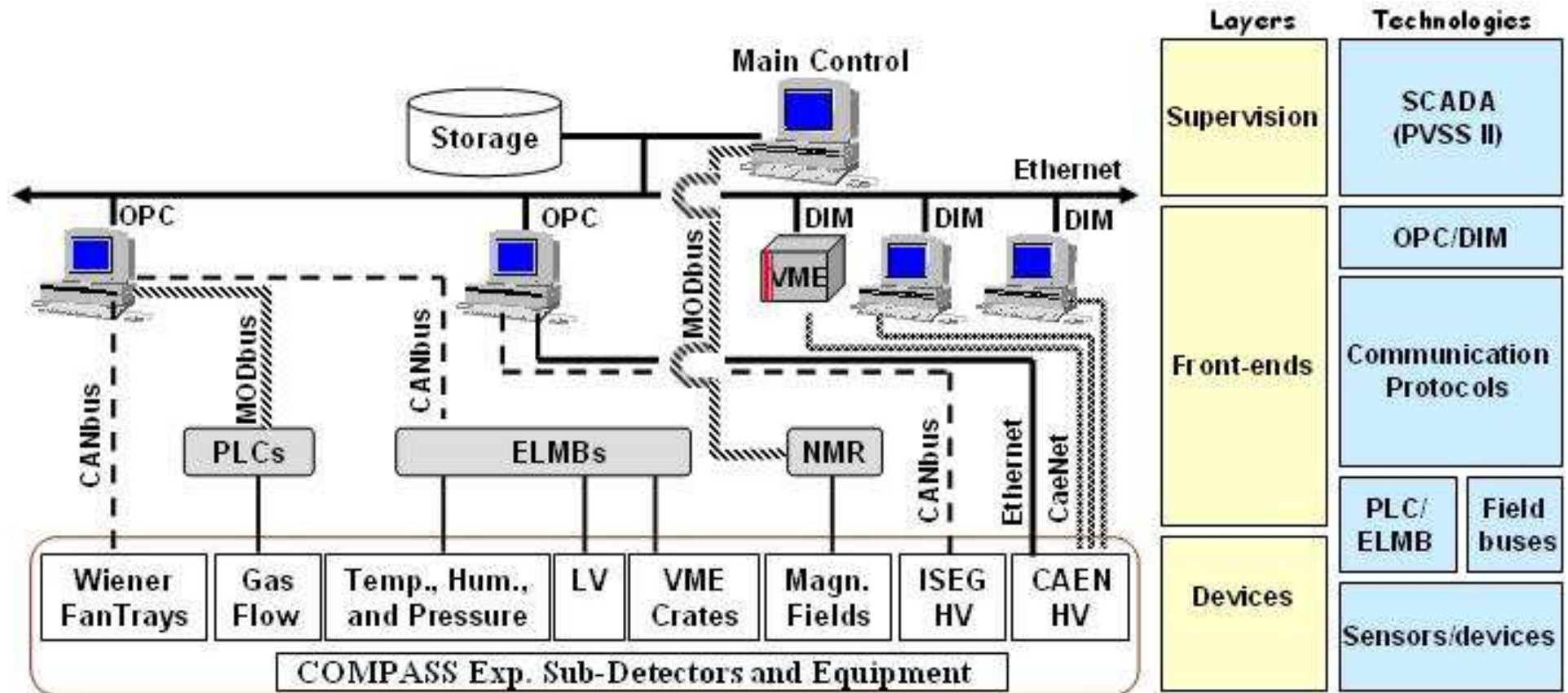
${}^6\text{LiD}$: $P_T \approx 50\%$, $f \approx 40\%$

NH_3 : $P_T \approx 90\%$, $f \approx 15\%$

- Full responsibility of the Detector Control System (DCS)
- Participation in the RICH upgrade
- Participation in Monte-Carlo productions
- Studies of track reconstruction algorithms using cellular automate methods

- The **D**etector **C**ontrol **S**ystem was revised and redesigned, its scope enlarged and its performance increased.
- It uses software tools adopted by most of the CERN experiments, and some specific, COMPASS-dedicated ones.
- Presently, 2 technical research assistants work full time in the DCS. 3 physicists give support (30% time participation).
- Assistance from the IT/CO group at CERN is provided to the DCS team. Over the last 5 years, the COMPASS-DCS has served as test-bench for control solutions to be used by all LHC experiments.

Detector Control System



- The DCS is now being adapted for the control of the new detectors present in the **2008 Hadron Run**

The User Interface of the DCS

DETECTOR CONTROL SYSTEM operator Exit 15:40:09 Friday 04.01.2008

HOME

- SCIFI Silicon
- BMS W45
- MW1 MW2**
- GEM HOD
- RICH RICH_Wall
- MM DC
- MWPC Straw
- DAQ Target
- Magnets Environ
- DCS Ecal2

ALARMS

lev	pr	time	object	alert text	value	ack	det
E	60	Fri 04 Jan 2008 03:39:33 PM C	MW1_C31_5Vp:	UnderVoltage	0.0025 V		...

W45 HV SYSTEM

Station 1 Station 2 Station 3 LV System Temperatures Gas System

Station 4 Station 5 Station 6

The diagram shows a particle detector layout. From left to right: a beam line with a target, followed by a target chamber (MM), a GEM detector (GEM), a RICH detector (RICH), a calorimeter (HCal), a MWPC detector (MWPC), and a high voltage (HV) system (W45). The HV system consists of six stations (Station 1 to Station 6). Other components include a gas barrack with PLC3, and various monitoring systems like BMS, DAQ, and Magnets. The detector is located at the Jura Saleve site.

- Integration of new detectors/equipments in the control system.
- Maintenance and Upgrades of all the software for controls/monitoring.
- Front-ends instrumentation for the interface with the DCS
- Provide permanent support during all the Data Taking period (≈ 6 months Run/year).
- Provide detectors experts with the controlled parameters data, for studies of stability and detectors performance.

The so-called *nucleon's spin puzzle* is a long-standing problem, addressed by COMPASS with its polarized muon **deep inelastic scattering** measurements.

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

↑
quarks
spin
↑
gluons
spin
↑
orbital
ang. mom.

1988: EMC measured the quarks contribution to the spin of the nucleon to be very small !

- The present value is (at $Q^2 = 3 \text{ (GeV/c)}^2$):

$$\Delta\Sigma = 0.30 \pm 0.01(\text{stat}) \pm 0.02(\text{evol})$$

↳ PLB 647 (2007) 8-17

The μ -deuteron asymmetry is measured from the difference between cross-sections from 2 oppositely polarized target cells:

$$A^{\mu d} = \frac{1}{f P_T P_B} \left(\frac{N^{\rightarrow\rightarrow} - N^{\leftarrow\leftarrow}}{N^{\rightarrow\rightarrow} + N^{\leftarrow\leftarrow}} \right)$$

From the measured asymmetries one can conclude that:

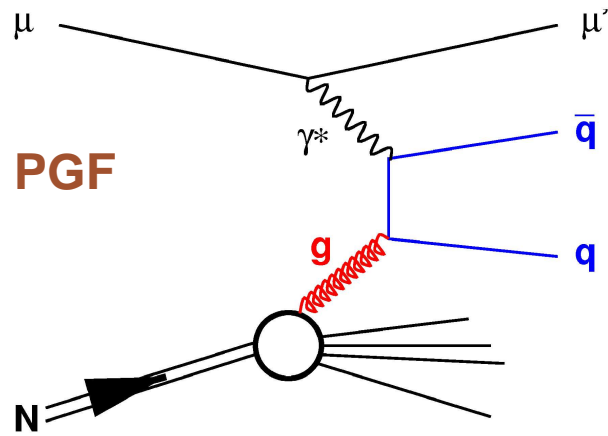
- $\Delta u_v + \Delta d_v = 0.40 \pm 0.07(\text{stat}) \pm 0.05(\text{syst})$ (for $Q^2 = 10 \text{ (GeV/c)}^2$).
- Results seem to favor $\Delta \bar{u} = -\Delta \bar{d}$ (at 2σ CL).

↳ PLB 660 (2008) 458-465

- $\Delta s + \Delta \bar{s} = -0.08 \pm 0.01(\text{stat}) \pm 0.02(\text{syst})$ (for $Q^2 \rightarrow \infty$).

↳ PLB 647 (2007) 8-17

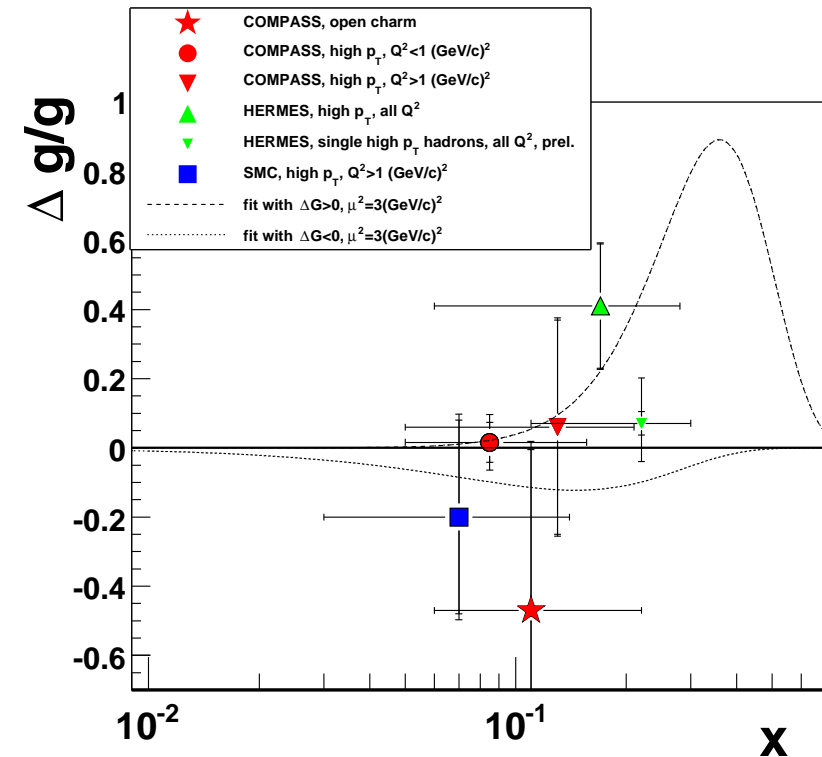
Gluons polarization in the nucleon



The **gluons contribution** to the nucleon spin can be extracted by selecting events from the **photon-gluon fusion** process:

- By selecting pairs of hadrons with high p_T
- By selecting open-charm mesons

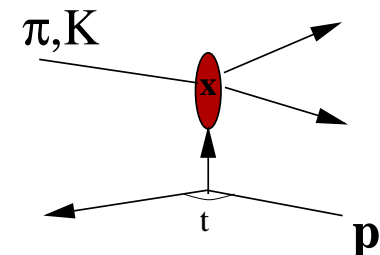
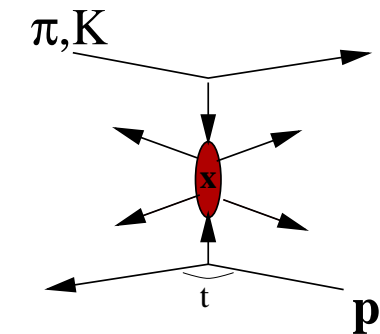
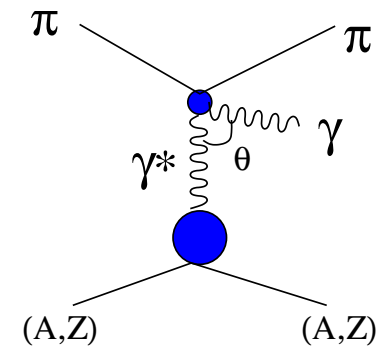
≈ 1/3 of the data still to be analysed.



↳ hep-ex/0802.3023, subm. PRL

COMPASS will use a π^- (95%) + K^- (4%) beam, incident in a liquid H_2 target to study:

- π polarizabilities from Primakoff scattering – which constitute a test of chiral perturbation theory.
- search for glueballs from central production.
- study of J^{PC} -exotic mesons from diffractive production.



- 2 PhD theses being prepared on the extraction of $\Delta G/G$:
 - Analysis of 2002 – 2006 data on high- p_T hadron pairs at $Q^2 > 1 \text{ (GeV/c)}^2$;
 - Analysis of 2002 – 2006 data on open-charm production.
- Strong participation in the analysis of inclusive and semi-inclusive asymmetries, for extraction of the quarks spin contribution and flavor separation.
- Participation in the analysis of J/ψ asymmetries.
- Interest in the analyses of the Hadron Program - first steps in the field of partial wave analysis formalism.
- Participation in the Drell-Yan program effort - simulations of physics and apparatus.

Ideas for new spin physics studies with an upgraded spectrometer are emerging:

- Generalized Parton Distribution functions (**GPDs**)
 - ↪ Using polarized μ beam and unpolarized H target, and a recoil proton detector – to access L_z of quarks.
- Polarized Drell-Yan process (**DY**)
 - ↪ Using hadron beam and polarized NH_3 target, together with a dimuon trigger – to access transversity structure functions.

These will soon be formalized in a new physics proposal.

- The LIP group is well integrated in COMPASS.
- LIP members participate regularly in COMPASS meetings (18 talks given in 2007; 3 talks given in 2008, up to now).
- LIP members represented the Collaboration in International Conferences: 1 talk in 2005; 2 talks in 2006; 3 talks in 2007.
- LIP members participate in the data taking periods (shift duties; exclusive on-call duties for DCS; data taking week coordination).
- Published papers: 5 in PLB (+1 submitted); 2 in EPJ; 1 in NP B; 2 in NIM A; (+1 submitted PRL).
14 conference proceedings.

A fruitful cooperation, which we look forward to continue