HERA, COMPASS, HERMES
spin, low-x, diffraction ...

Krzysztof Kurek, NCBJ

RECFA visit to Kraków, POLAND
May 11-12, 2012

COMPASS (CERN)		*running*
ZEUS (HERA)		*completed*
H1 (HERA)		*completed*
HERMES (DESY)		*completed*

Sources of funds

- Budget of Institutes
  - salaries of physicists and PhD students,
  - all overheads: electricity, heating, phones etc.

  (e.g.: average for NCBJ: 56 kPLN (13 200 k€)/year/person)

  It is not accounted for in experimental budgets.
- Grants from the funding agency (NCN)
  - buildings detectors,
  - contribution to Common Funds,
  - travel and local infrastructure (e.g. computers),
  - supplement to salaries.
- Special grants for support PhD students and young researchers.
- Funds from bilateral agreements (PL-D, PL-F etc.) used for the exchange of physicist between collaborating institutions.
- Funds from UE.

Experiments @ HERA Collider

- Polish institutions & Man power
- Contributions and responsibilities
- Finances
- Physics

unique HERA $e^{\pm}$ p accelerator (920 GeV)

H1 – collaboration of about 350 physicists from 44 institutions,
15 countries

ZEUS – collaboration of about 350 physicists from 53 institutions,
15 countries

Physics – fundamental particles and forces in nature,
nucleon structure, QCD, Electroweak theory

Polish institutions & Man power

The H1 Collaboration:

- The Henryk Niewodniczański Institute of Nuclear Physics, PAS, Cracow,
  physicists with PhD: 3, PhD students: 1, technical staff: 0.3

The ZEUS Collaboration:

- The Henryk Niewodniczański Institute of Nuclear Physics, PAS, Cracow,
- Jagiellonian University, Institute of Physics, Cracow
- University of Warsaw, Institute of Experimental Physics, Warsaw,
- University of Lodz, Lodz,
- AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Cracow,
- National Centre for Nuclear Research, Warsaw

physicists with PhD: 8.75, PhD students: 4, technical staff: 0

Contributions & responsibilities
H1- Polish contribution to the project

Hardware & Software:

- project, accomplishment and installation of the Faraday's cages for the cold electronics of the Liquid Argon (LAr) calorimeter with water-air cooling system, the cabling for the electronic cards for the cold electronics of the LAr calorimeter,
- project and tests of electronic cards for the first level trigger L1 & data acquisition of the backward electromagnetic calorimeter BEMC,
- participation in the construction of the backward spaghetti calorimeter SpaCal and central muon chambers,
- second level topological trigger (L2TT) project (in cooperation with LAL Orsay and MPI Munich)
- modification of the on-line software for the higher level trigger L45

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Status of the project now: Analysis

Contributions & responsibilities
ZEUS - Polish contribution to the project

Hardware & Software:

Cracow:

- Design ,construction and maintenance of the luminosity detectors (LUMI),
- Construction of “Rucksack” - the 3-floor structure for readout and trigger electronics of the ZEUS detector.

Warsaw:

- Construction (1986-1992) and running (1992-2007) of the Backing Calorimeter (BAC) and VETO-Wall detectors.
- Contribution to the common activities of the experiment: technical support, slow control, analysis and simulation software development.

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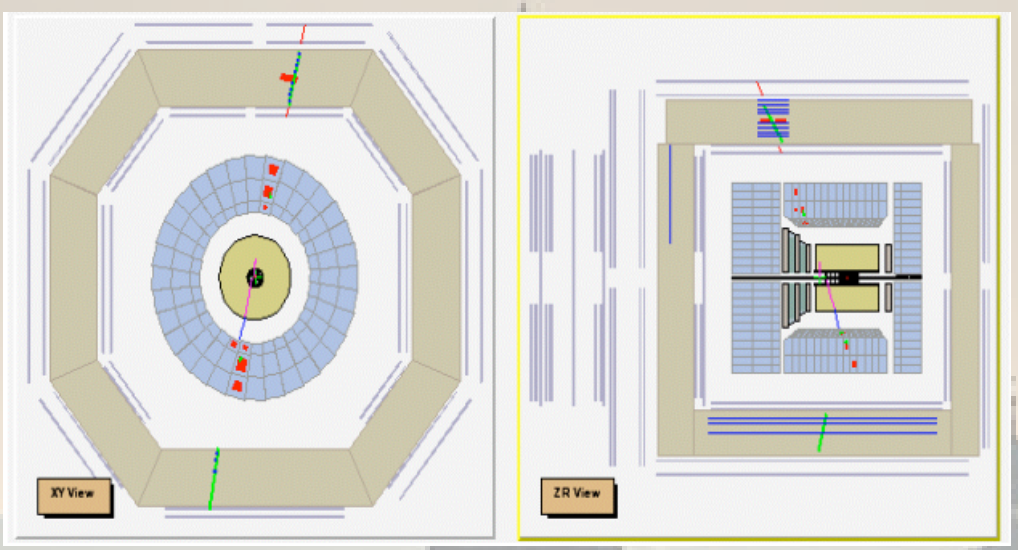
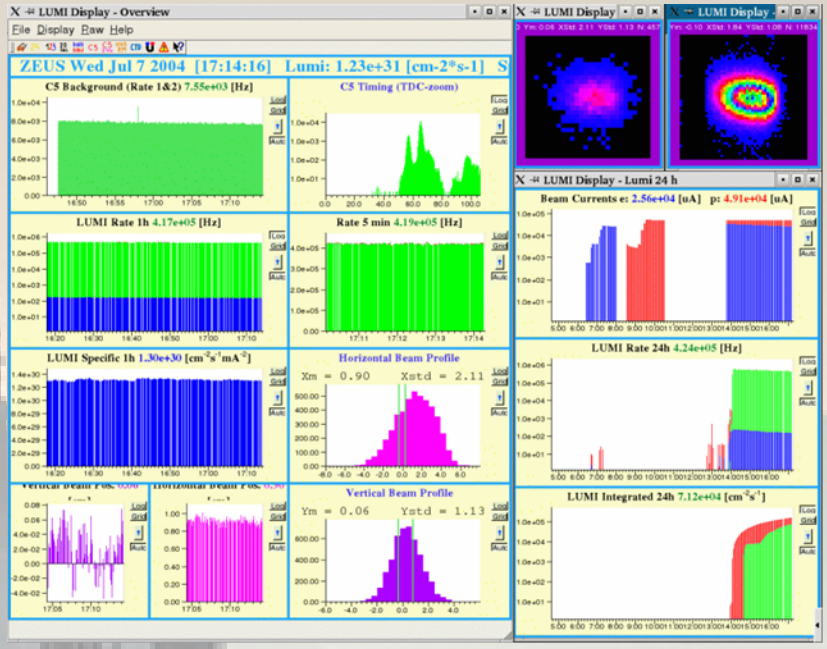
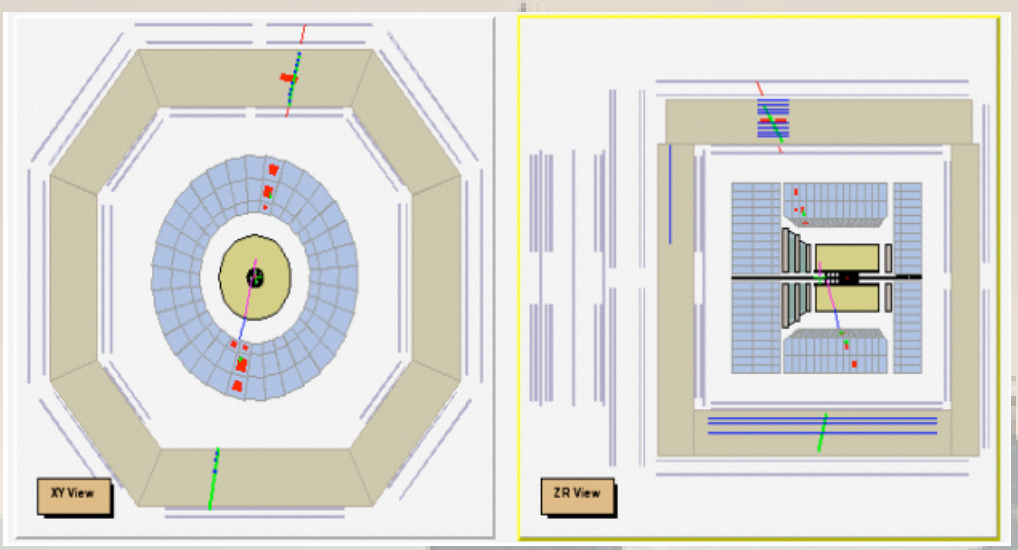


Muon triggered by BAC

LUMI display





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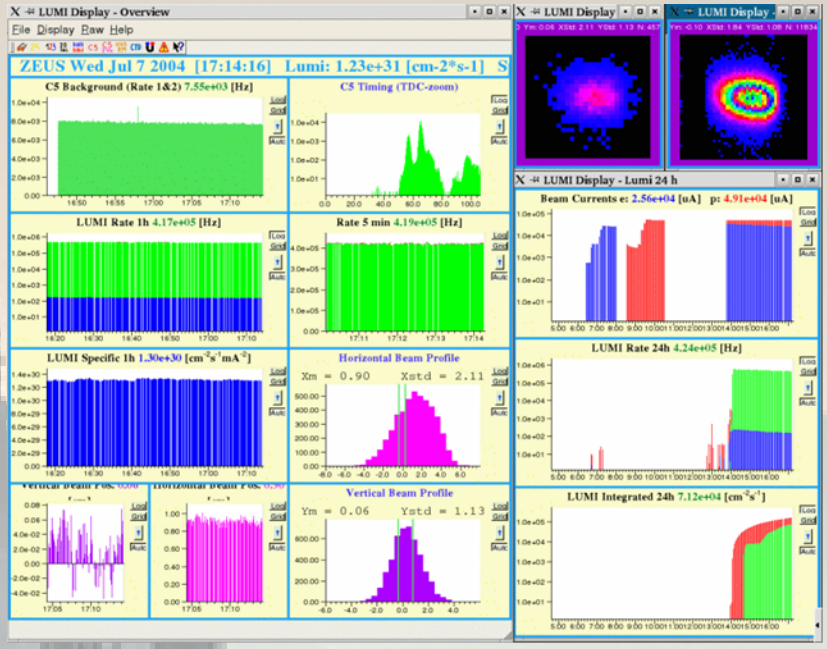


Finances (H1 & ZEUS):

present funding - partially supported by
Polish Ministry of Science and Higher Education,
grant /DESY/2009, 2010-2013, 60 kPLN/year (15 k€)

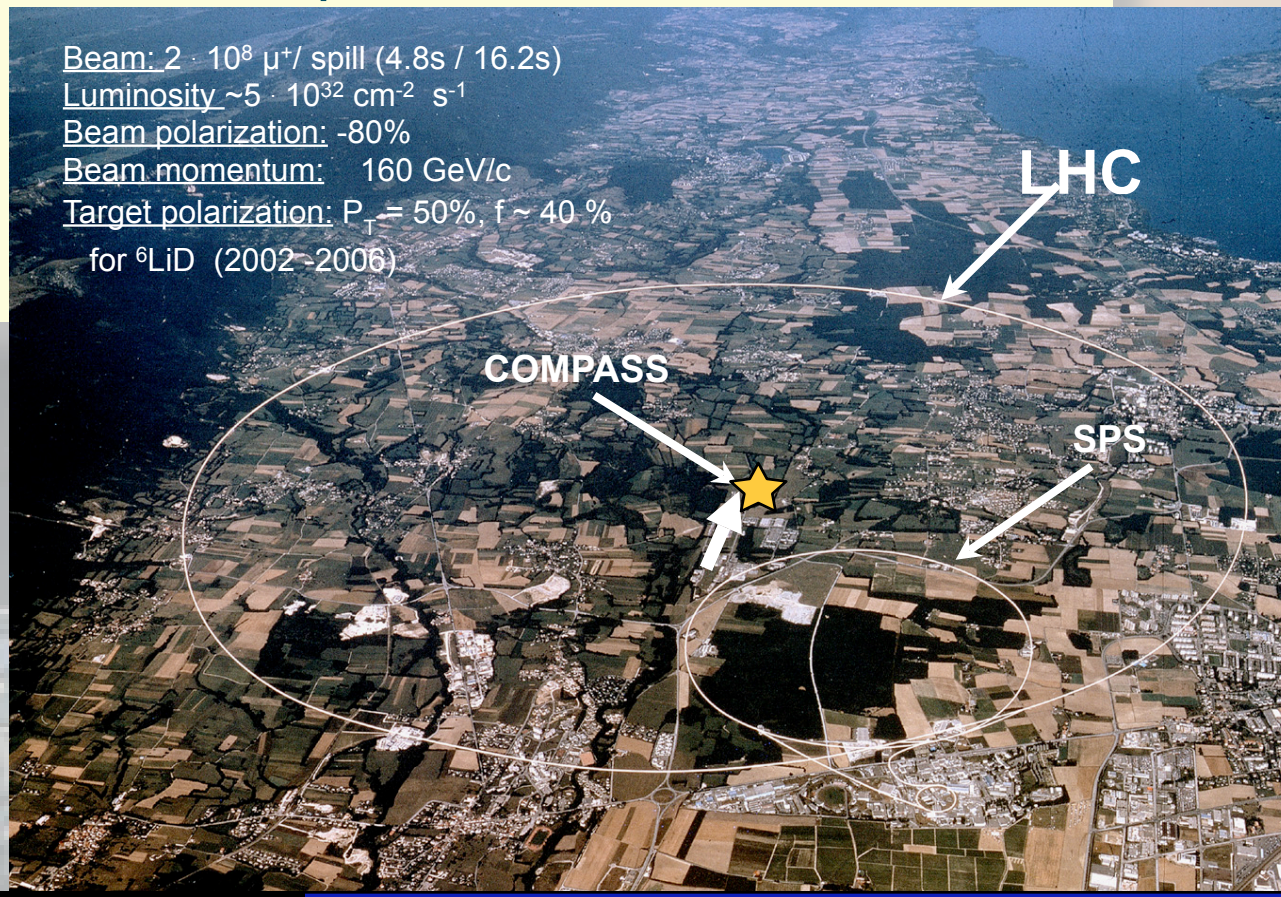
Physics - HERA: QCD machine
Analysis still ongoing

Analysis of hadronic final state in DIS ep
Exclusive processes (e.g. J/ψ meson production in DIS)
measurement of the proton diffractive structure function
measurement of the photon light cone wave function

Diffractive processes:
Photoproduction of Vector Mesons at large momentum transfer
Deeply Virtual Compton Scattering (DVCS)

COMPASS@CERN

- Polish institutions & Man power
- Contributions and responsibilities
- Finances
- Physics



COMPASS Collaboration at CERN

Common Muon and Proton Apparatus

for Structure and Spectroscopy

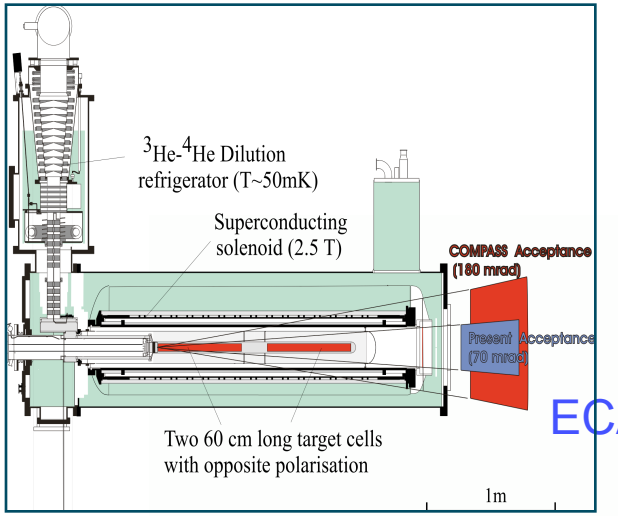
~240 physicists, 30 institutes, 11 countries

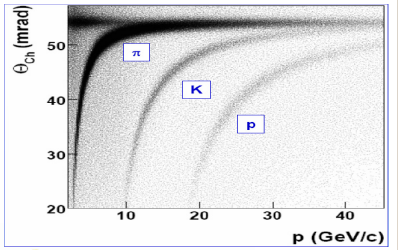
unique facility: polarised $\mu^{\pm}$ beams(100-280 GeV), hadron beams, unique polarised target

CERN muon beam line experiments: started 1979:
BCDMS, EMC, NMC, SMC, COMPASS, COMPASS-II

Physics:

- muon program:
  - spin structure of the nucleon, quark and gluon polarisation,
  - Transversity, Collins & Sivers effects, TMDs study
  - DVCS, hard exclusive meson leptoproduction - GPDs study (C-II)
- Hadron program (hadron beams)
  - hadron spectroscopy, diffractive and central production,
  - Primakoff, Drell-Yann on transversely polarised NH_3 target (C-II)





Trigger Hodoscopes

ECALs & HCALs

MWPCs

SM2

RICH

SM1

Drift Chambers

^{6}LiD target

μ Filters/ Walls

Straws

50 m

GEMs

Micromegas

Si

SciFi

veto

160 GeV μ

- ~ 350 planes
- 180 mrad acceptance
- π, K, p separation (from 2, 9, 17 GeV up to ~ 50 GeV)

Polish institutions & Man power

The COMPASS Collaboration (muon program)

- Warsaw University of Technology, Institute of Radioelectronics, Warsaw,
- University of Warsaw, Institute of Experimental Physics, Warsaw,
- National Centre for Nuclear Research, Warsaw

physicists with PhD: 8 (4-NCBJ, 3-WUT, 1-UW)
PhD students: 6 (4-WUT, 2-NCBJ)
technical staff: 0
undergraduate students: 14 (4 master degrees, 2 licentiates, 8 summer students)

Contributions & responsibilities
Polish contribution to the project

COMPASS-II: 2012-2016

The proposed program requires major upgrades of the existing set-up, in particular the construction of a new 4m long recoil proton detector (RPD) and a large angle electromagnetic calorimeter (ECAL0).

- RPD-CAMERA detector: in collaboration with Saclay & Mainz,
- ECAL0: TUW - front-end electronics (project + construction), photo-detectors & cables (in collaboration with JINR, Dubna)
  ~400 kPLN (100 k€)

Hodoscopes (electronics upgrade) and others,

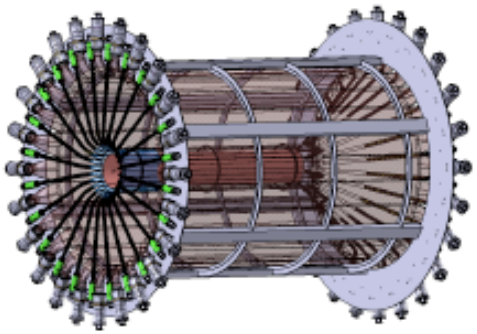
total amount: ~220 kCHF

main responsibilities:

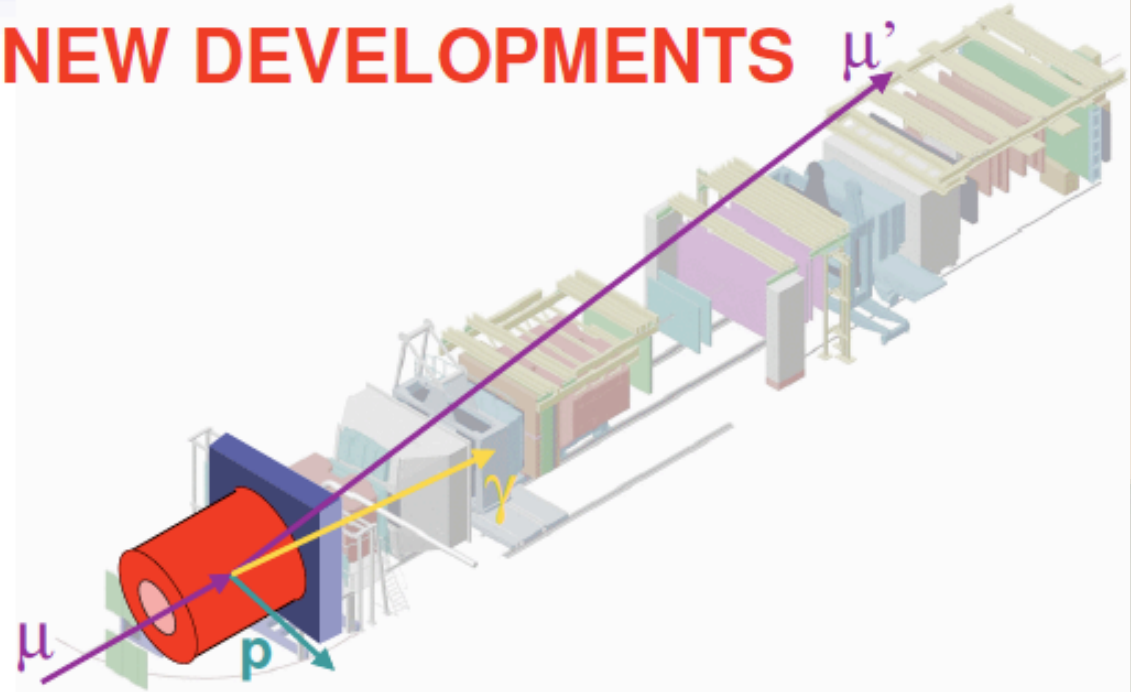
- Analysis of the data collected so far (COMPASS) and of the data to be collected for COMPASS-II, in particular those for the GPD program (i.e. on DVCS and exclusive meson production).
- Participation in the construction and commissioning of the RPD and ECAL0.

NEW DEVELOPMENTS

Future Target & RPD



- 2.5m long LH2 target
- 4m long TOF barrel
- recoil proton ID by TOF and dE/dx
- GANDALF boards:
  1 GHz digitization
  ENOB: 12bit



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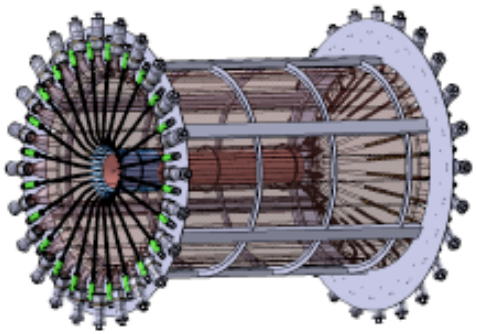

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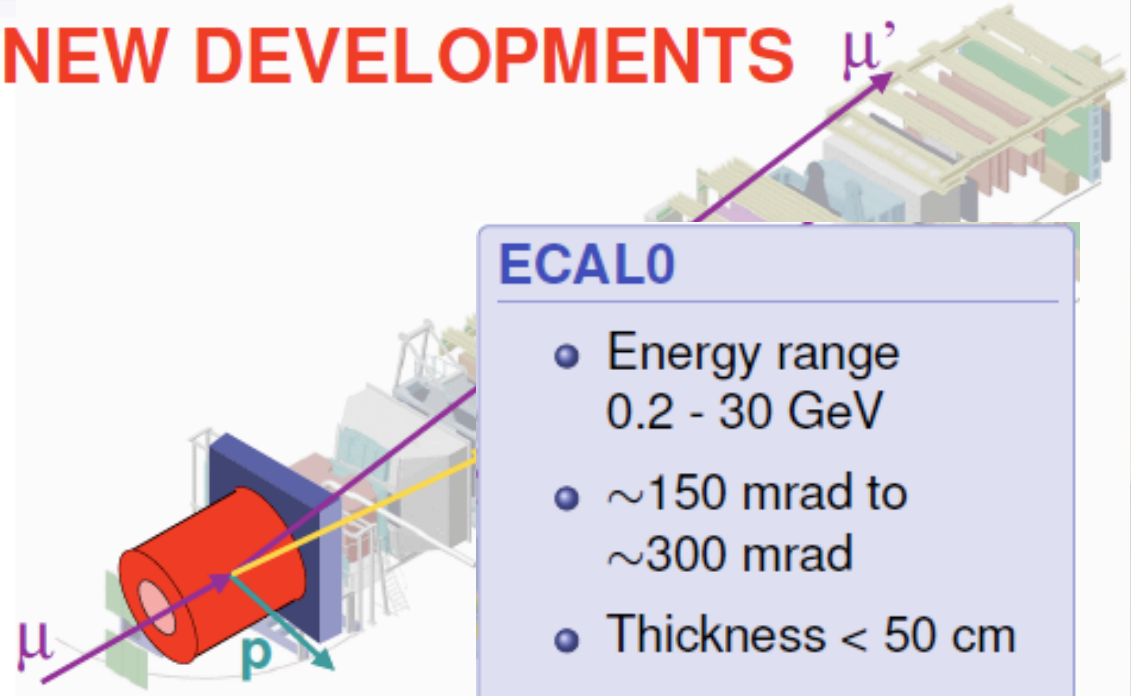
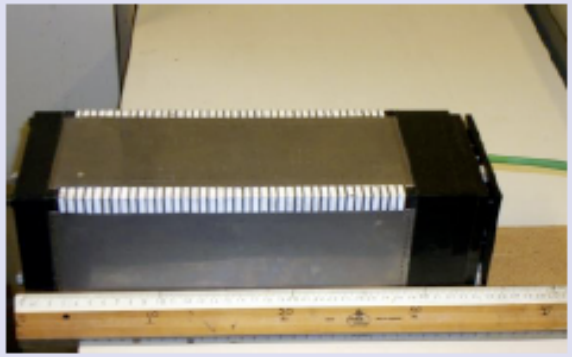


ECAL0

- Energy range 0.2 - 30 GeV
- ~150 mrad to ~300 mrad
- Thickness < 50 cm
- Resolution $< 10\%/\sqrt{E}(\mathrm{GeV})$



Finances:

- NCN grant 2011/01/M/ST2/02350, funding – 3 740 kPLN (890 k€) for 36 months, December 2011 – December 2014

- EU grant "7th Framework Program", project HadronPhysics3, working package WP23", funding – 31.5 k€ (EC funding) + 10.5 k€ (Complementing resources) for 36 months, January 2012 – December 2014

Physics - spin structure of the nucleon
Analysis ongoing, COMPASS-II data taking starts now (today :-)

- Confirmation of the “spin crisis”
- Precise measurement of the spin structure function g_1
- Full flavour separation with high precision
- Precise data on transversely polarised target
- Direct gluon polarisation measurement
- Exclusive reactions (vector mesons on polarised long. abd trans. targets)

Important lesson from 25 years of polarised DIS experiments:

fast moving nucleon is a 3D object !

Complementary measurements:
TMDs measurements (transversely polarised target) - 3D in momenta space
GPDs - 3D in mixed coordinate-momentum space

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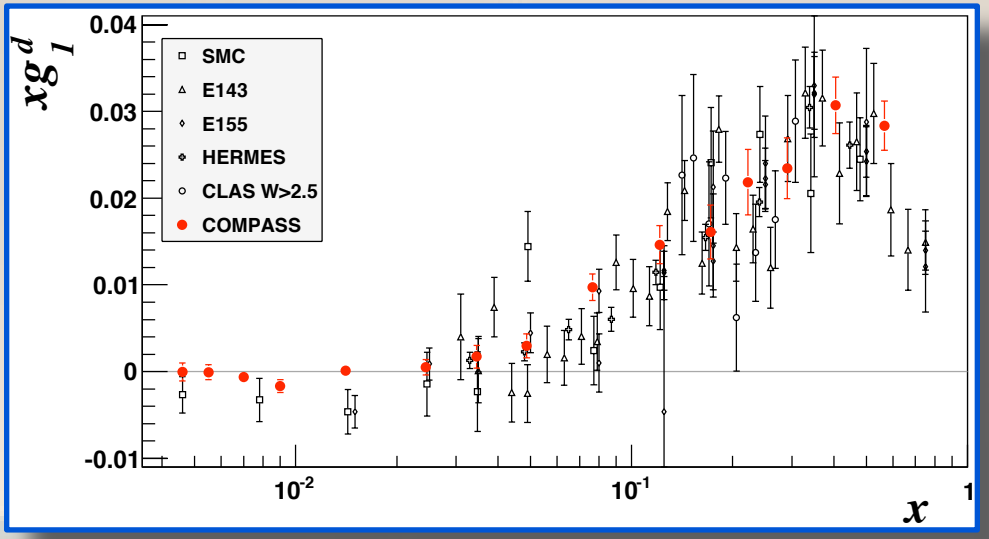
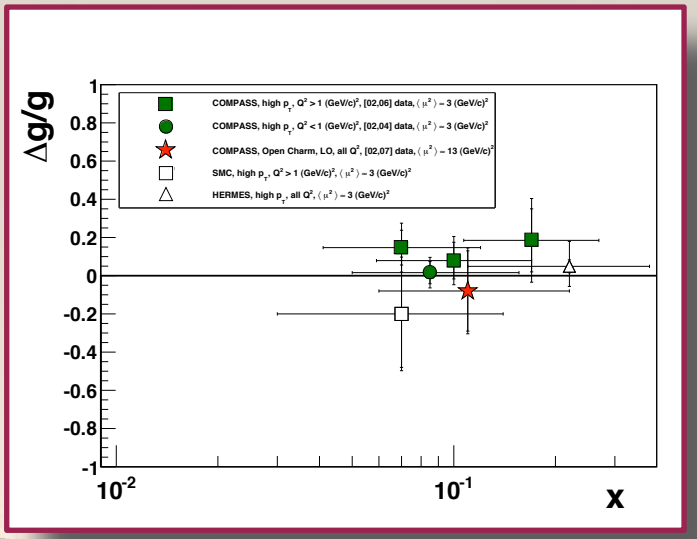
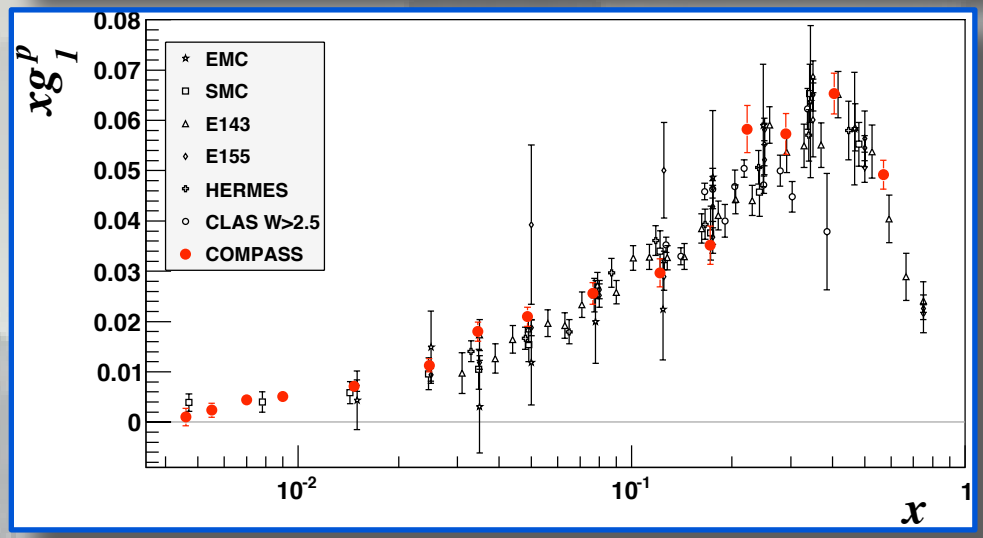
Spin provides a unique opportunity to probe the inner structure of a composite system such as the proton



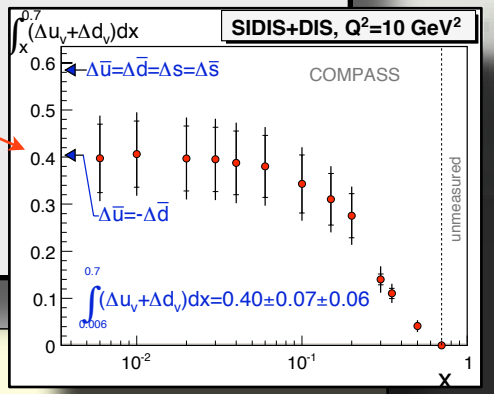




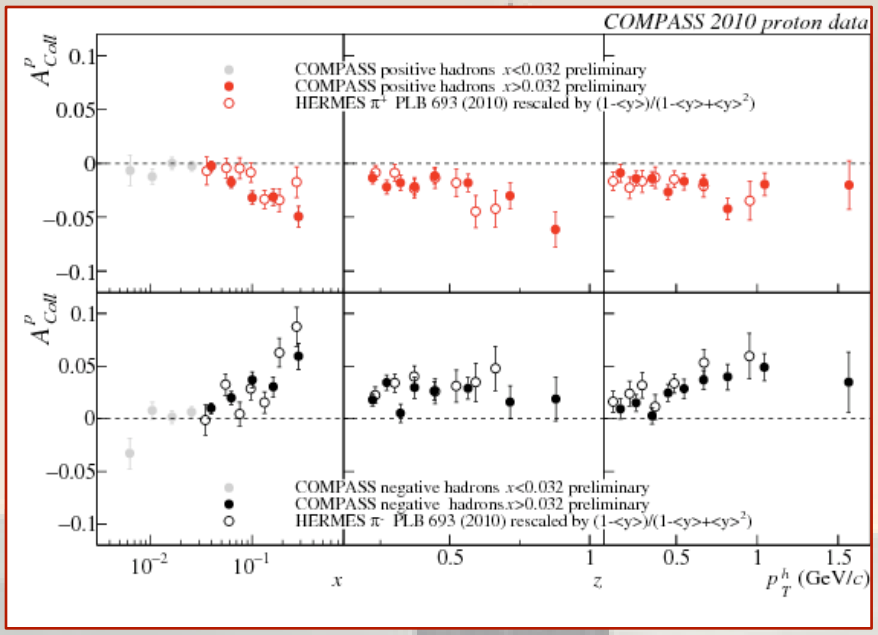
$$\Delta\bar{u} = \Delta\bar{d} = \Delta s = \Delta\bar{s}$$

$$\Delta\bar{u} = -\Delta\bar{d}$$

Difference asymmerties



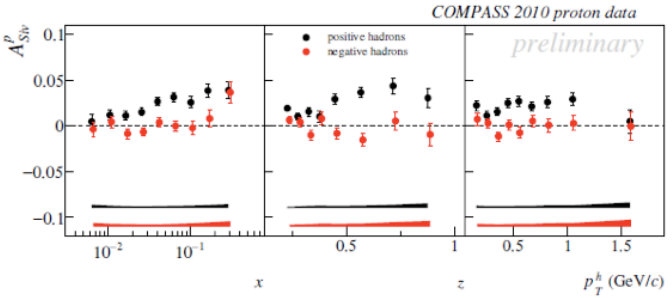
$$\hat{a}_{0|Q^2\to\infty} = 0.33 \pm 0.03(stat) \pm 0.05(syst)$$ - 1/3 of 1/2



Collins and Sivers effects

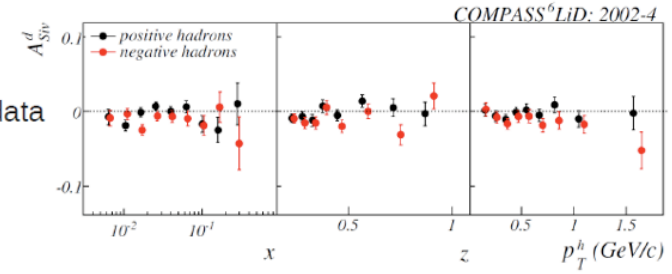
Non-zero Sivers indicates non-zero orbital angular momentum of partons ! (TMDs 3D picture)

2010 proton data



positive signal for positive hadrons

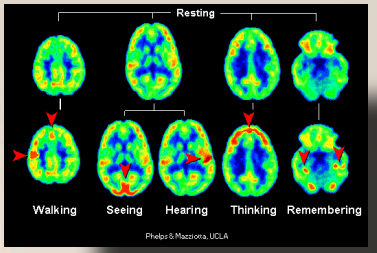
2002-04 deuteron data

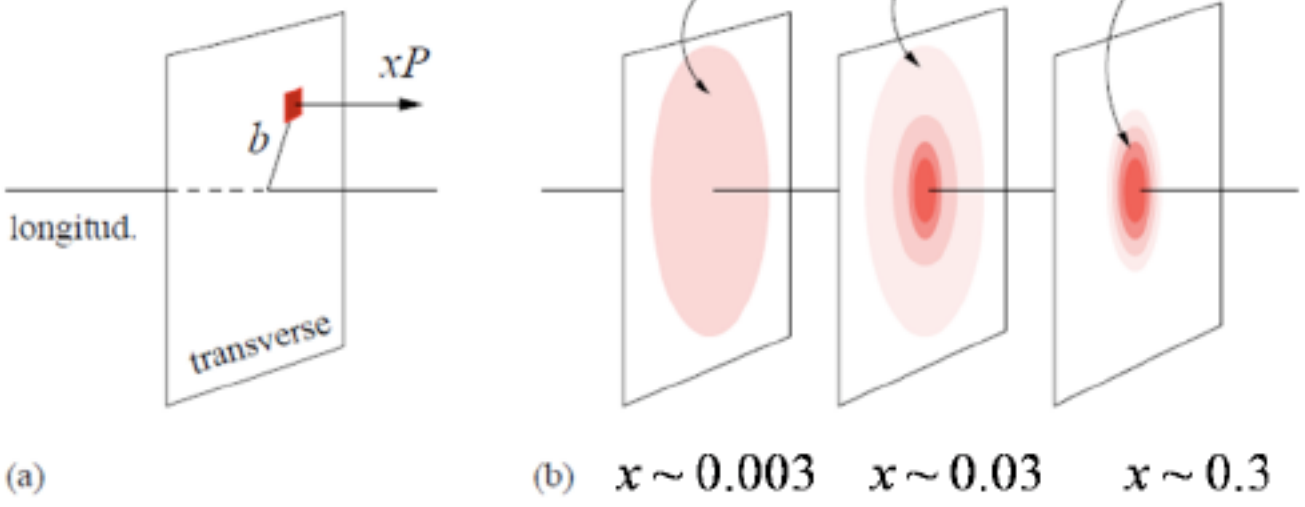


Asymmetries compatible with zero

NPB 765 (2007)

COMPASS-II
Towards nucleon “tomography”
GPDs measurement - angular momenta of partons
(3D - slices in longitudinal momentum)





enario

HERMES @ DESY

- Polish institutions & Man power
- Contributions and responsibilities
- Finances
- Physics

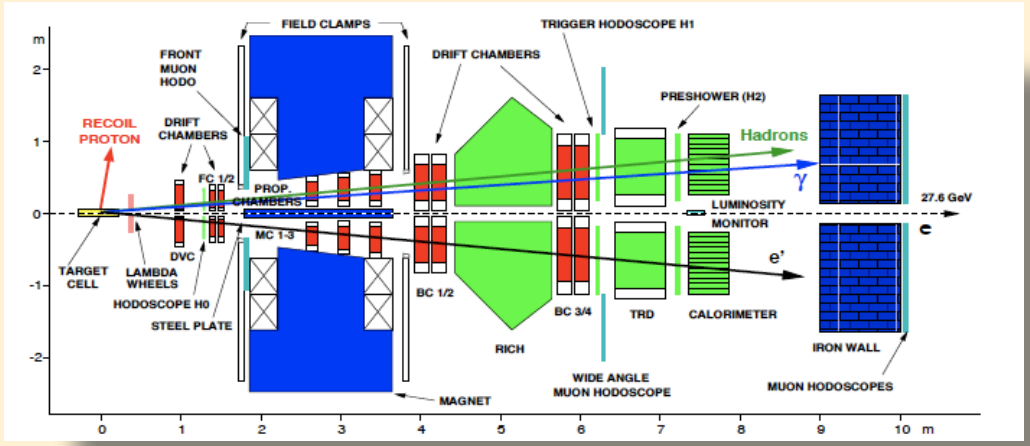
HERMES@DESY

~140 physicists, 13 countries

fixed target with HERA electron beam:
polarised e± beam (27.6 GeV) on gaseous polarised targets

Physics:
- spin structure of the nucleon, quark and gluon polarisation,
- Transversity, Collins & Sivers effects, TMDs study
- DVCS, hard exclusive meson leptoproduction - GPDs study

complementary program to SMC & COMPASS



Polish institutions & Man power

The HERMES Collaboration

- National Centre for Nuclear Research, Warsaw

physicists with PhD: 4 PhD students: 0 technical staff: 0

Finances:

- NCN grant, DESY HERMES. 2010- 2012 funding – 168 kPLN (40 k€)

Contributions & responsibilities
Polish contribution to the project

data acquisition system, software for reconstruction events inside polarised target magnetic field

Physics
Analysis ongoing

Analysis of Spin Dependent Matrix Elements (SDME) of Ω and φ mesons,
SDME in electroproduction of ρ^0 meson, ρ^0 meson production on Xe and Kr targets,


Thank you for your attention