Particle Physics at MPP Munich

Visit of Prof. J. Szwed
Munich - October 27, 2009

Richard Nisius (MPP München)
Richard.Nisius@mpp.mpg.de

$\Delta p \cdot \Delta q \geq \frac{1}{2}\hbar$

$\Delta p \cdot \Delta q \geq \frac{1}{2}\hbar$

The organization of the Max-Planck-Society

MAX-PLANCK-GESELLSCHAFT

— The Max-Planck-Society (MPG) is an independent, non-profit research organisation. The MPG supports research mainly at its own institutes, the MPIs.

— At present, the MPG has 80 research institutions, with more than 13.000 employees of which 4900 are scientists, together with more than 3300 doctoral students, 1300 post-docs, 800 research fellows and guests.

— The research topics are divided into three research sections: These comprise the sections for Biology and Medicine, for Chemistry, Physics and Technics (CPT), and for Humanities.

— Five institutes of the CPT section are located in the Munich area. Namely the MPIs for Astrophysics, Extraterrestrial Physics, Plasma Physics, and Quantum Optics at Garching, und at Munich the MPI for Physics (MPP) the (Werner-Heisenberg-Institut).

The MPP - Mission and history

The mission

— At MPP we perform basic research in elementrary particle and astroparticle physics, both from a theoretical as well as an experimental perspective.

The history

1917 Founded as Kaiser-Wilhelm Institute for Physics in Berlin.
The head of the directorate was Albert Einstein.

1946 Re-founded in Göttingen. Since 1948 the institute is part of the MPG as MPI for Physics (MPP). The director was Werner Heisenberg.

1958 Move from Göttingen to the present location (architect Sep Ruf) at Munich.

1960 Spin-off of the institute for Plasma Physics (IPP) in Garching.

1991 Spin-off of the institutes for Extraterrestrial Physics (MPE) and for Astrophysics (MPA) in Garching.

Some former colleagues

— Peter Debeye, Albert Einstein, Werner Heisenberg, Léon van Hove, Max von Laue, Gerhart Lüders, Carl Friedrich von Weizsäcker, Julius Wess, . . .

The MPP - Personnel and areas of research

Todays colleagues

— The MPP has about 160 staff, comprising 60 researchers, 80 people for the technical services and 20 people for the administration.
— In addition the MPI has on average about 15 visiting scientists.
— At present there are 60 doctoral and diploma students and 20 workshop trainees.

The main research topics

— The research topics comprise theoretical work i.e. particle phenomenology in the areas Electroweak, Quantum Chromodynamic and Beyond the Standard Model, as well as astroparticle physics, e.g. WIMPS and Neutrinos, and String Theory.
— The MPP has major involvements in various experiments conducted at high energy accelerators, as well as in a variety of non-accelerator experiments.
— In addition, together with the MPE, the MPP runs a semiconductor laboratory (HLL) for the development of novel detectors in Munich-Neuperlach.

The MPP has as a broad spectrum of research in theoretical and experimental physics.

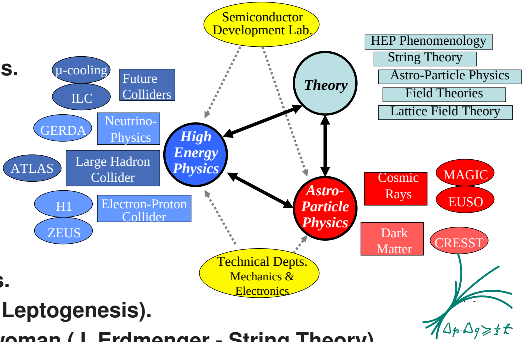
The MPP - Groups and Reseach-Map

Board of directors

- W. Hollik (MD) - Theo. particle physics - Phenomenology.
- R. Lüst - Theo. particle physics - String Theory.
- D. Dvali - Theo. particle physics - Particle cosmology (Jan 2010).
- S. Bethke - Exp. particle physics I.
- A. Caldwell - Exp. particle physics II.
- M. Teshima - Exp. astroparticle physics.

External scientific member

- H. Abramowicz - Exp. particle physics - Proton Structure.

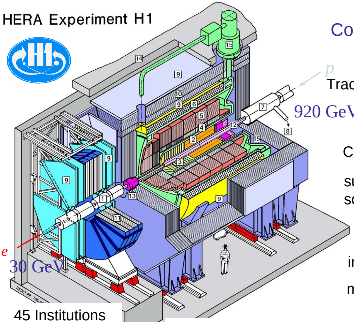


(Junior) research groups

- G. Raffelt - Theo. astroparticle physics.
- Emmy Noether group (M. Plümacher - Leptogenesis).
- MPG programme for highly qualified woman (J. Erdmenger - String Theory).
- MPG independent research group (S. Antusch - Neutrinos and BSM physics).
- Junior research group within a Munich excellence cluster (F. Simon - Detector technology).

The H1 experiment at HERA

Layout of the detector



Components

Tracking chambers [2,3]

Calorimeter (LAr) [4,5]

superconducting solenoidal magnet [6]

iron yoke [10]

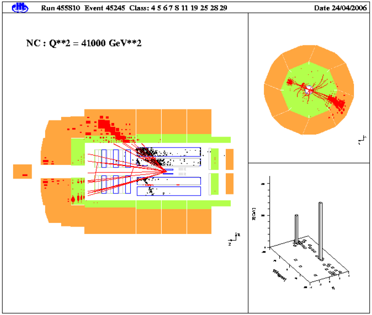
muon chambers [9]

45 Institutions

Poland:
The Henryk Niewodniczanski Institute of Nuclear Physics (PAN, IFJ), Crakow

H1 has successfully taken data from 1992-2007.

A high Q^2 Neutral Current event

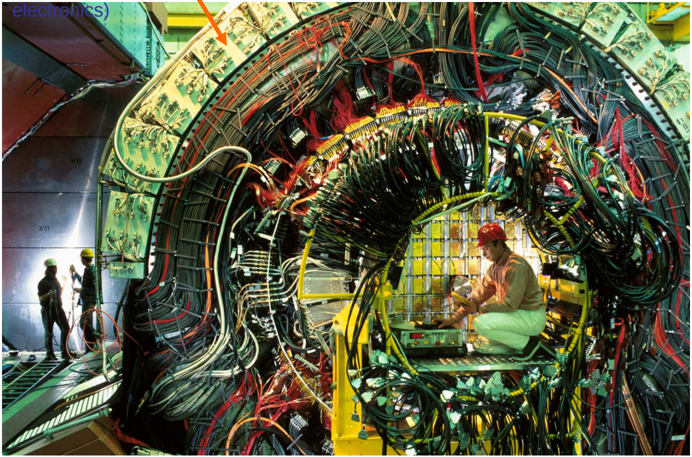


Some research highlights

- — α_s from jets.
- — Neutral Current vs. Charged Current.
- — Measurements of F_2^p and F_L^p.
- — Heavy flavour physices, ...

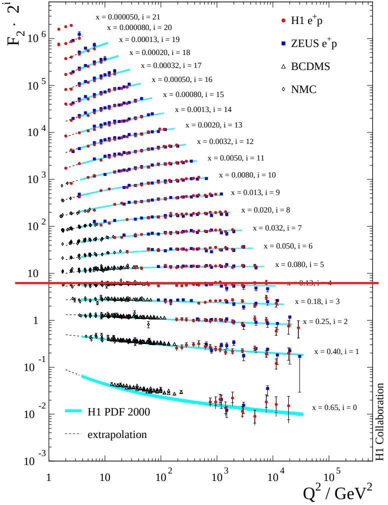
A look into the LAr calorimeter

Crakow Hadware Contribution: LAr Analog Boxes (housing the entire preamp electronics)



After the final shutdown of HERA, the detector has been dismantled in 2008.

Scaling violations of F_2^p and the gluon density

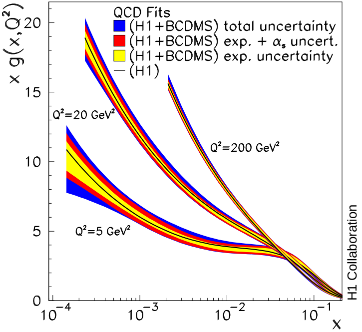


The kinematic coverage

$$1.5 < \langle Q^2 \rangle < 30000 \text{ GeV}^2$$

$$0.000050 < \langle x \rangle < 0.65$$

— The gluon density is determined from the scaling violation of F_2^p.



The precise knowledge of the proton structure is valuable for the LHC experiments.

The LHC - A proton-proton accelerator (2008^{++})

Alice

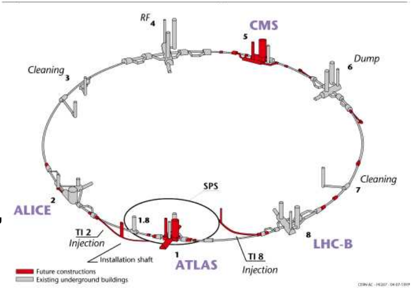
Heavy Ions, ...

LHC-B

Matter $\leftrightarrow$ Antimatter, ...

ATLAS / CMS

Higgs production, precise SM physics for $W^{\pm}$ and Top-Quark, and the unknown.



Technical details

L = 26.7 km
E_p = 7 TeV
N_p = $1.1 \cdot 10^{11}$/ beam
t_{BC} = 25 ns
N_{ev} = 25/BC

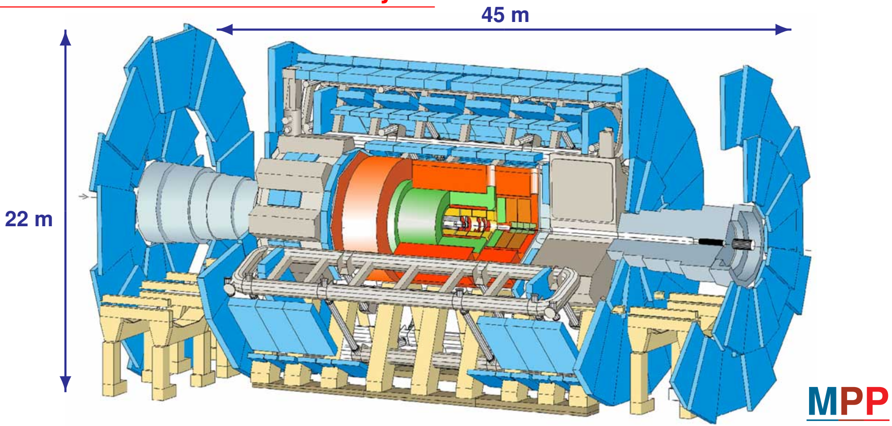
Lumi expectations

0.2 fb^{-1}/ y at start
100 fb^{-1}/ y nominal

The heart of the LHC - the super conducting magnets

Length	15 m
Weight	23.8 t
B-field	8.3 T
Temperature	1.9 K
Current	12000 A
Energy	7.1 MJ

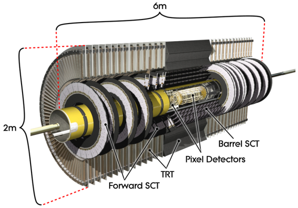
The ATLAS detector - General layout



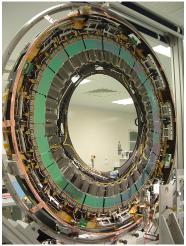
- Silicon tracker (Pixel, SCT)
- Transition radiation tracker (Xe)
- Central solenoid ($B = 2$ T)
- Electromagnetic calorimeter (Pb, LAr, 25 X_0)
- Hadronic tile calorimeter (Fe, Szi, 11 λ)
- Hadronic end cap (Cu, LAr, 11 λ)
- Forward calorimeter (Cu/W, LAr, 11 λ)
- Air toroid magnet ($B = 4$ T)
- Muon spectrometer (MDT/CSC, RPC/TGC)

The ATLAS SemiConductor Tracker SCT

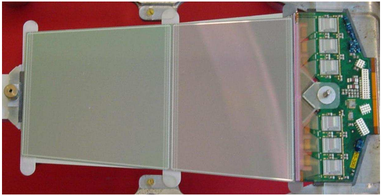
The general layout



An SCT Endcap-Disc

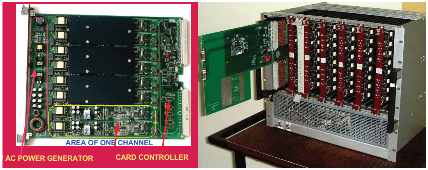


One of 420 MPP SCT modules



— 4 layers, 2x9 discs, 2112(B) + 1976(EC) modules, with a resolution of 16(580) μm $\perp$ ($||$) each.

The HV System of the ATLAS SCT

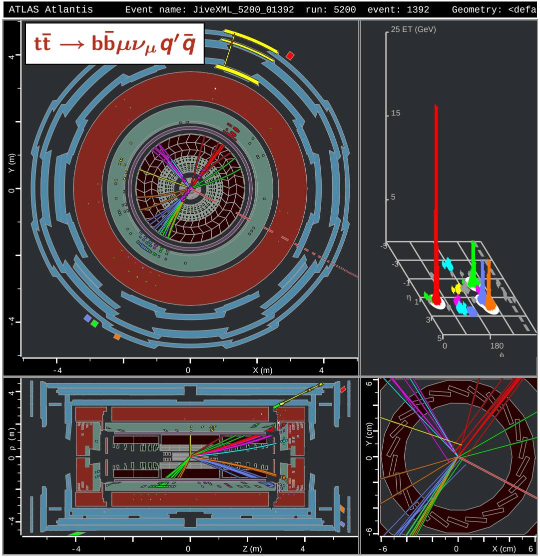


— HV hardware design, crate controller and backplane by Edward Górnicki and Stefan Koperny, Kraków.

— HV firmware and crate controller software by Piotr Malecki and Ewa Stanecka, Krákow.

— The system was used from module construction up to the final SCT detector.

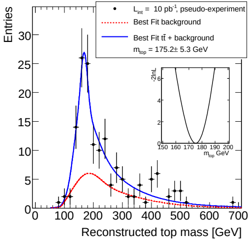
Top-Quark Measurements at the LHC



Comparison to Tevatron

- Higher $\mathcal{L}_{\rm int}$ und $\sigma_{t\bar{t}}$.
- Less background from $W^{\pm}$ + n-jets but more from multiple interactions.
- Better b-jet identification (boost).
- More granular calorimeters.

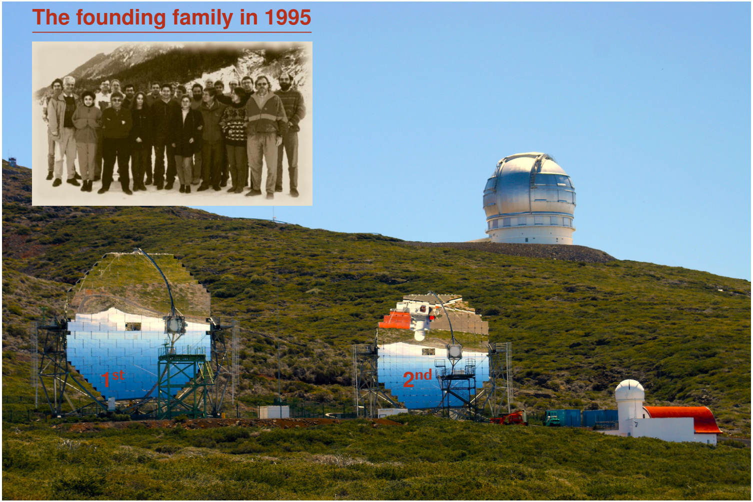
Expected Mass in 2010



- Initially the sys. error will be about 7 GeV.

The data will arrive very soon.

MAGIC - The telescope(s) at the Roque de los Muchachos (La Palma)

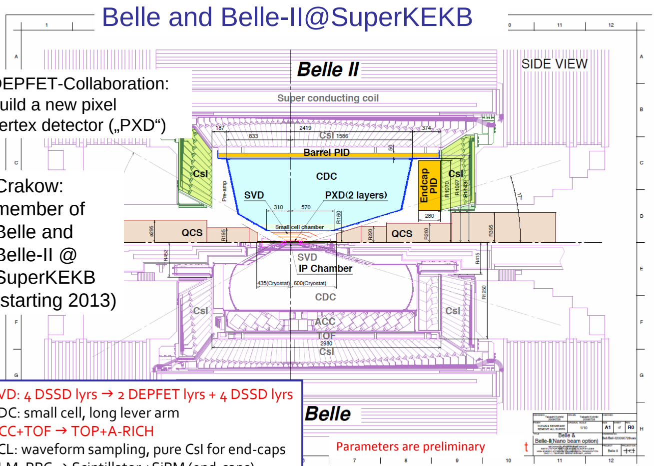


- It started with a small scale model

- 1^{st} telecope: summer 2003 $\varnothing = 17$ m $A = 240$ m^2
- 2^{nd} telecope: spring 2009
- Uni Lodz: M. Giller, W. Bednarek J. Sitarek(PhD)

Data taking from summer 2003 monocular, and binocular from spring 2009.

The Belle and Belle-II detectors at KEK



DEPFET-Collaboration: build a new pixel vertex detector („PXD“)

Crakow: member of Belle and Belle-II @ SuperKEKB (starting 2013)

SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling, pure CsI for end-caps
KLM: RPC → Scintillator +SiPM (end-caps)

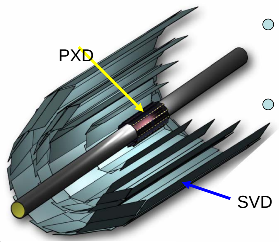
An upgrade for even higher luminosities with a new vertex detector is underway.

The planned inner detector for Belle-II

Vertex Detector for Belle-II

Crakow:
Power supply / control

Nano beam option: 1 cm radius of beam pipe

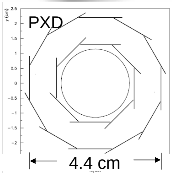


„PXD“

- 2 layer Si pixel detector (DEPFET technology)
  (R = 1.3, 2.2 cm) monolithic sensor
  thickness 50 µm (!), pixel size ~50 x 50 µm²

- 4 layer Si strip detector (DSSD) ← „SVD“
  (R = 3.8, 8.0, 11.5, 14.0 cm)

Significant improvement in z-vertex resolution

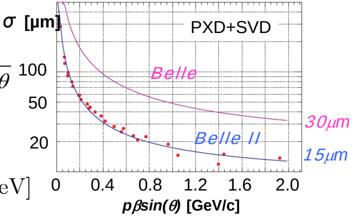


$$\sigma = a + \frac{b}{p\beta \sin^{5/2}\theta}$$

Belle II:

$$a = 8.5[\mu m]$$

$$b = 9.6[\mu m \, \mathrm{GeV}]$$



The schedule to build this complicated device based on MPP technology is very tight.

A certainly incomplete list of Theory Collaborations

2. XVII Cracow–Munich–Seminar

Nr. XVII 1990

Die Krakau–München–Seminare finden seit vielen Jahren abwechselnd in Krakau und München statt. Die diesjährige Veranstaltung wurde vom 24.–26. April in München durchgeführt; es nahmen 16 Physiker aus Polen und ca. 30 aus München teil.

Vorträge

H. Palka	Search for the Higgs particle in DELPHI.
J. Thomas	Search for the ultralight Higgs with ALEPH.
R. Settles	Latest ALEPH results on tests of the electroweak model.
J.H. Kühn	QCD corrections to the Z decay rate.
W. Hollik	Indirect search for new physics with LEP.
S. Scholz	New results on τ-decays from CELLO.
A. Santamaria	τ decays to pions.
W. Skrzypek	Is there a better way of exponentiating in QED?
K. Rybicki	Recent results on charmed particles.
U. Katz	Parton distributions from the scattering of (anti-)neutrinos on protons and deuterons.
N. Schmitz	Intermittency in deep inelastic μp scattering.
B. Wosiek	Analysis of the factorial moments in nucleus-nucleus interactions.
K. Fialkowski	Evidence for intermittency and standard correlation effects.
W. Ochs	Intermittency and cascade processes.
D. Strozik-Kotlorz	Small x behaviour and its phenomenological implications for HERA.
J. Szwed	Models of hadron polarisation.
P. Malecki	Forward hemisphere in hadron nucleus collisions.
K. Olkiewicz	Inclusive y and p_t distributions in h-Al and h-Au interactions at 250 GeV.
S. Söldner-Rembold	Deep inelastic μXe scattering at 490 GeV.
M. Jezabek	Sprectra of baryons and antibaryons in constituent quark models.
A. Kotlorz	Quark matter with pion condensate.
K. Golec-Biernat	Integrable many body hamiltonian systems.
M. Frank	Study of single superconducting grains for a neutrino and dark matter detector.
E. Lorenz	Status of HEGRA experiment.
L. Stodolsky	Speculations concerning very high energy photon interactions.
E. Lorenz	The LHC project.

Organisation: W. Ochs
N. Schmitz

A long tradition since at least 1974.

— **Kraków-München-Seminar (1974-1990)**
L. van Hove, A. Bielas (KRaków)

— **Macroscopic Quantum Systems**
L. Stodolsky, J. Wosiek (Kraków), P. Korcyl (KR)

— **Top-quark Decays**
W. Hollik, M.Jezabek (KR)

— **Multiparticle Dynamics**
W. Ochs, J. Wosiek (KR)

— **Dark Matter and Susy**
L. Stodolsky, S.Pokorski (WA)

— **Photon Production in hadronic Collisions**
W. Ochs, M. Krawczyk (WA)

— **Marie-Curie RTH *heptools***
T. Hahn, W. Hollik, A. Hoang, S. Jadach (KR),
A. von Hameren (KR), M. Krawczyk (WA)

— **Transfer of knowledge in theoretical Astro-particle Physics (Early Universe, Dark Matter)**
G. Raffelt, S.Pokorski (WA), M.Olechowski (WA)

Conclusions

1. The MPG is one of the main columns in the field of basic research in Germany. The research of the MPG is conducted by the MPIs.
2. The MPP Munich (Werner-Heisenberg-Institut) covers a very broad spectrum of basic research in experimental as well as theoretical particle and astroparticle physics. Some examples of which have been presented.
3. The MPP made large contributions to the construction and commissioning of three sub detector components of ATLAS. We are eager to soon explore the physics potential of the LHC.
4. The detector development of the MPP+HLL has a bright future within the Belle-II and sLHC programs.
5. The MPP-Poland theory collaborations have a long tradition since the start of the Kraków-München-Seminar in 1974.
6. Scientists at MPP experience many close and fruitful collaborations for teir research activities in theoretical and experimental physics.

Dear Prof. Szwed, I hope you enjoy your stay in Munich.