The ATLAS project - status and future

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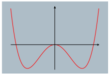
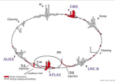
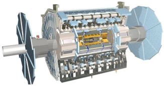
The plan of this presentation



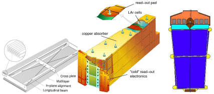
The physics motivation



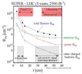
The LHC accelerator



The ATLAS detector



The MPP envolvements and achievements

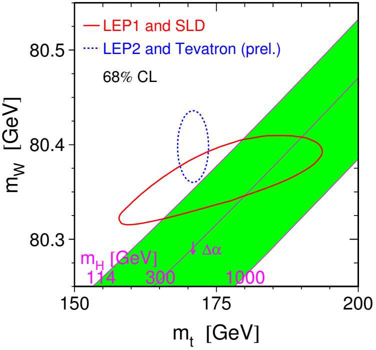


The quest for new silicon detectors for the SLHC

Conclusions and outlook

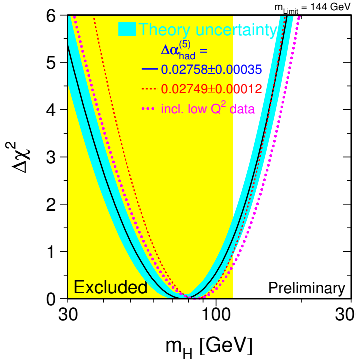
The Standard Model in March 2007

... has been tested precisely, ...



$$M_W = (80.398 \pm 0.025)\ \text{GeV}$$
$$M_{top} = (170.9 \pm 1.8)\ \text{GeV}$$

... but there are also fundamental problems.



— We do not understand what is responsible for the masses of elementary particles. Also the pattern of masses is not understood.

We have two options, either look for the new or better constrain the known.

The LHC - a proton-proton accelerator (2007^{++})

Alice

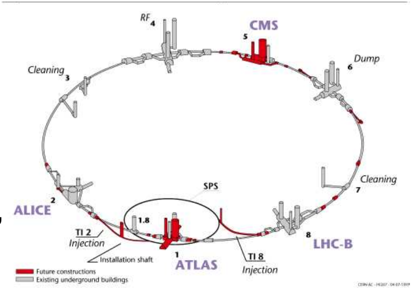
Heavy Ions, ...

LHC-B

Matter $\leftrightarrow$ Antimatter, ...

ATLAS / CMS

Higgs production, ...



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

10 fb^{-1}/ y at start

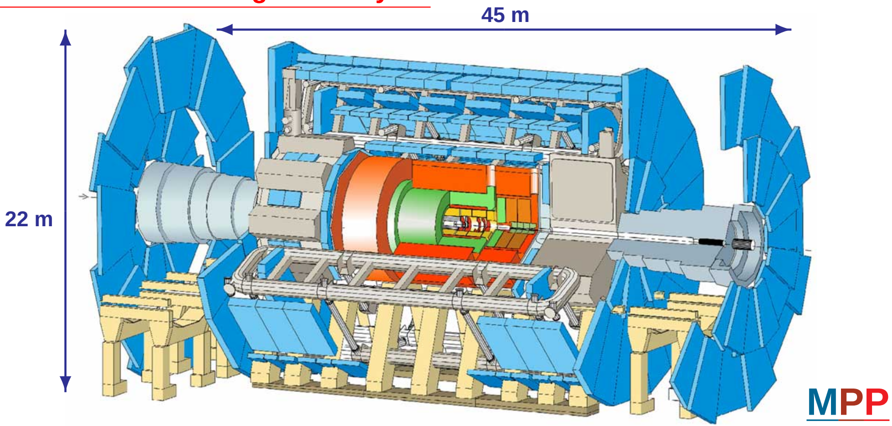
100 fb^{-1}/ y nominal

1–2 fb^{-1} Tevatron today

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

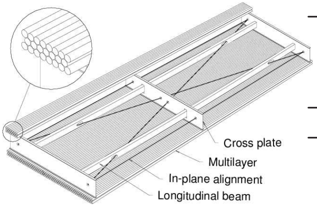
The ATLAS detector - general layout



- — 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)

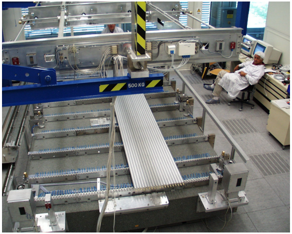
MDT chambers - general layout and performance

Schematic view of an MDT chamber



- 432 tubes of 3.8 m length with 20 μm precision.
- 1728 gas connection.
- 350 kg weight.

Mounting of tubes



An assembled chamber

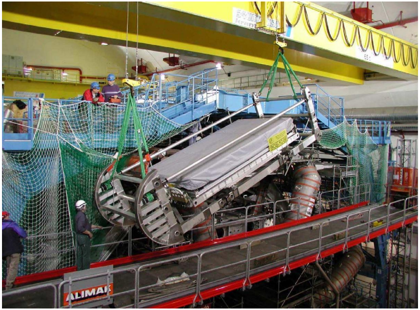
Some properties of MDT chambers

- The single wire resolution is 100 μm and the chamber resolution is 50 μm.
- The p_t resolution for muons is better than 10% up to 1 TeV, and the invariant mass resolution e.g. for $H \longrightarrow ZZ^\star \longrightarrow 4\mu$ ranges from 2-2.4% for M_H ranging from 130-200 GeV.

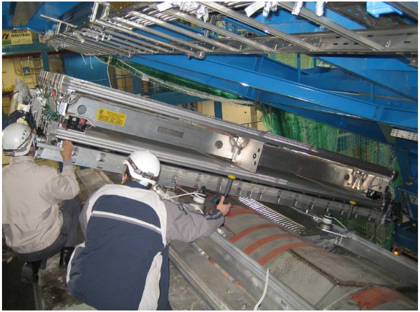
At MPP we have build 88 MDT BOS chambers.

MDT - the integration into ATLAS

Inserting a chamber



Aligning a chamber



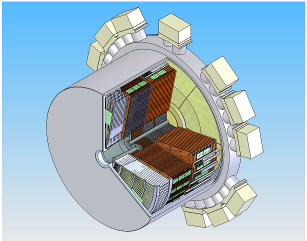
A number of steps are needed for the integration into ATLAS

- Combination of the MDT and RPC chambers and testing of the package.
- Installation of the package into ATLAS and positioning of these large and heavy objects to a precision of 1 mm in a very crowded and unpleasant environment.

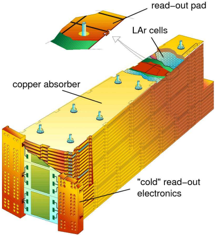
All 88 chambers are mounted, the connection of the gas system is well advanced.

The ATLAS HEC - construction of the wheels

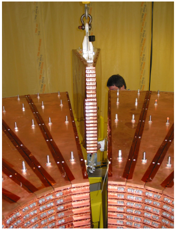
Schematic view of an endcap



Schematic view of a HEC module



Completing a wheel



The ATLAS Hadronic EndCap (HEC)

- The sensitive material is liquid Argon, LAr.
- The absorber is made of 25 mm thick Cu-plates, with a total thickness of about 11λ.
- The measured resolution for e/π showers is:

$$\frac{\sigma(E_e/E_\pi)}{E} = \frac{22/70\,\%}{\sqrt{E/\mathrm{GeV}}} \oplus 0.3/6\,\%.$$

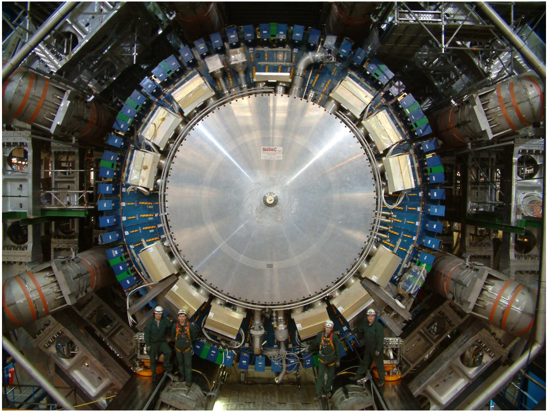
At MPP we have build 27 HEC modules.

The ATLAS HEC - integration into ATLAS

Rotating a wheel

The endcap cryostat

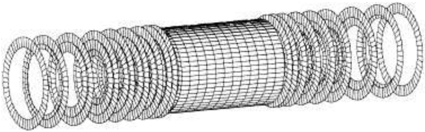
One endcap installed in ATLAS



The first endcap already records cosmic data

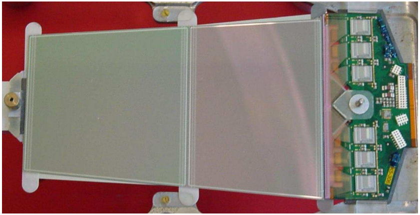
The ATLAS SemiConductor Tracker (SCT)

The Layout



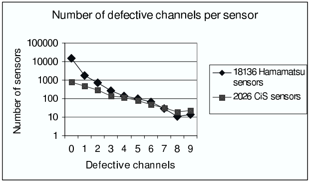
— Barrel: 4 layers.
— Endcaps: 2x9 discs.
— Modules: In total 4088, barrel 2112, endcaps 1976 (four types).
— Resolution: 16 μm (perpendicular) und 580 μm (parallel) to the strips.

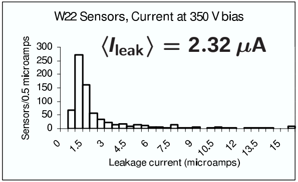
An Endcap Module

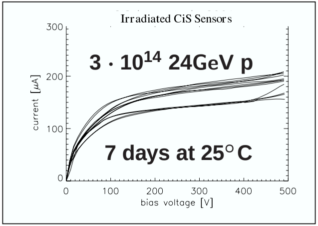


— 768 single sided p-in-n strips with 50-90 μm pitch.
— Two sided hybrid with 6 chips per side, binary read-out.
— Mounting points with 20 μm precision.

SCT - the HLL participation

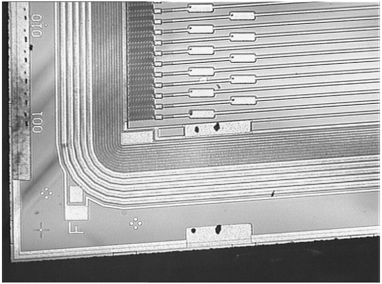






The contributions

- Sensor design and technology transfer to CiS.
- Procurement of the CiS sensors.
- Performance tests of the CiS sensors.



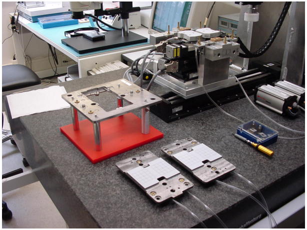
The specifications

- Number of defect channels below 10 / 768.
- $I_{\rm leak}(20^\circ C) < 20\ \mu A$ at 350 V before irradiation.
- $I_{\rm leak}(-18^\circ C) < 250\ \mu A$ at 450 V after irradiation.

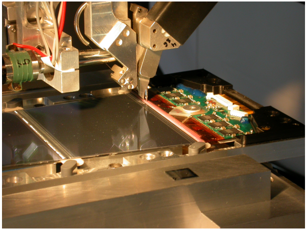
The CiS wafers are successfully used in about 20% of the endcap modules.

What is needed for module production

A robot for alignment

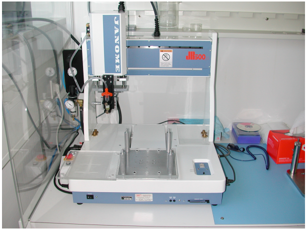


A bonding machine



Skilled personnel

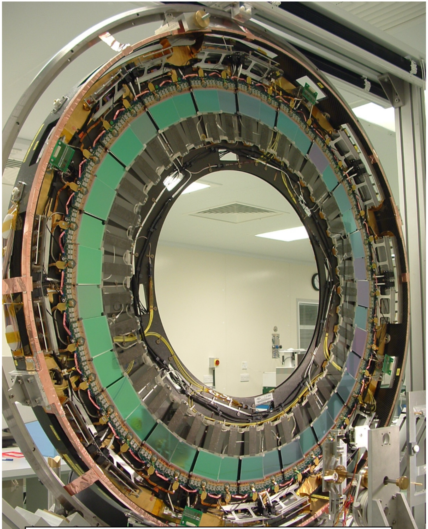
A glue robot



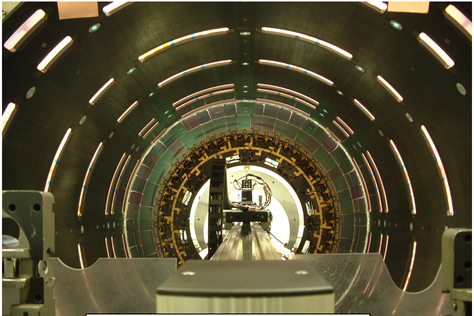
A survey machine

SCT - from modules to superstructures

- At MPP we produced 96 *short middle* and 328 *long middle* modules.
- The MPP modules amount to all (50%) of the SCT short (long) middle modules.
- The efficiency for modules within all specs. was 93%, well above the 85% required by SCT.

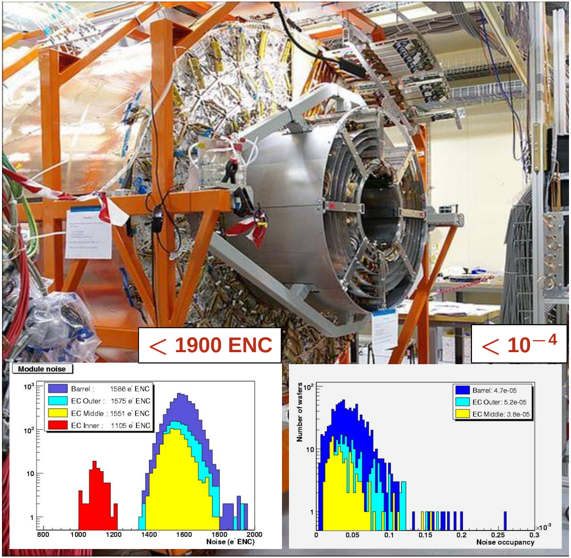


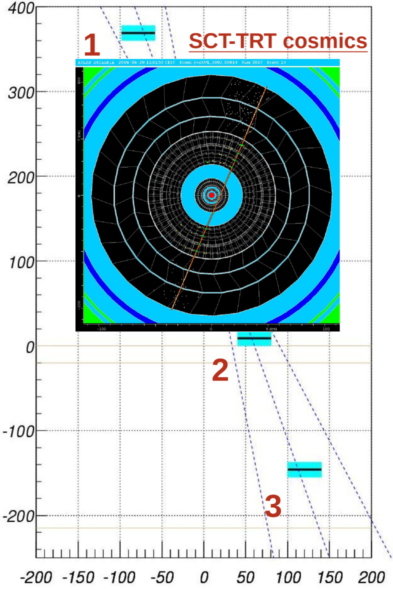
First of 9 discs with MPP modules.



The first disc in a cylinder.

The SCT commissioning at the surface

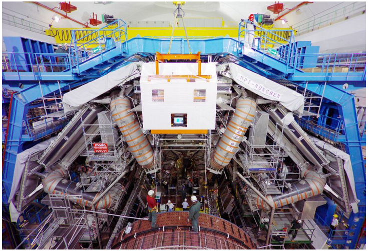


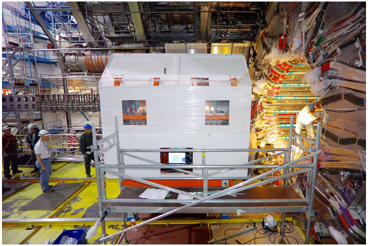


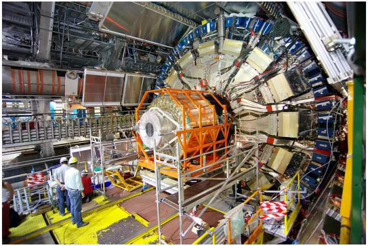
Both detectors are in good shape.

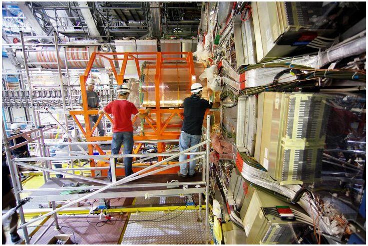
ID barrel installation – from the surface building to the access shaft

ID barrel installation – from the shaft to the final position within ATLAS

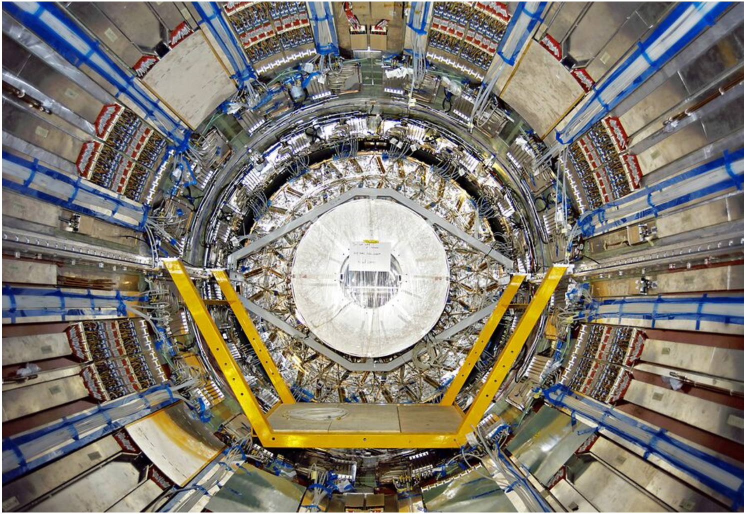






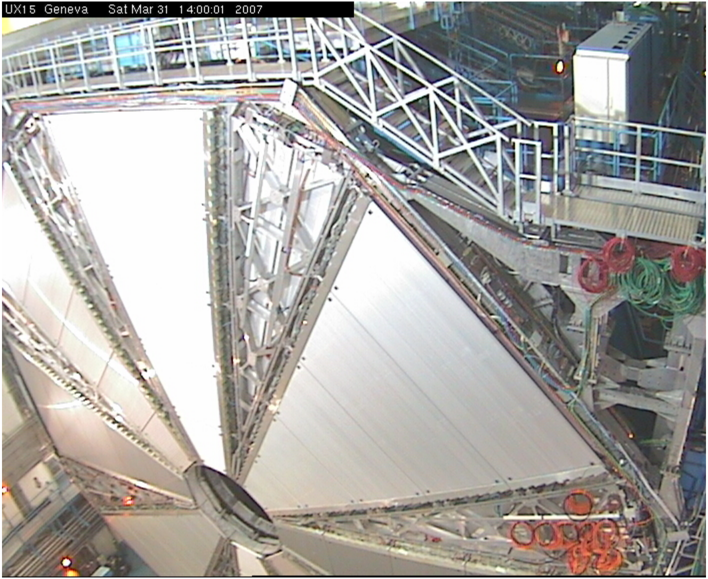


The ID barrel within ATLAS



The SCT barrel was installed within ATLAS on August 23+24, 2006.

The ATLAS Installation



30.06.2003
30.09.2003
31.12.2003
31.03.2004
30.06.2004
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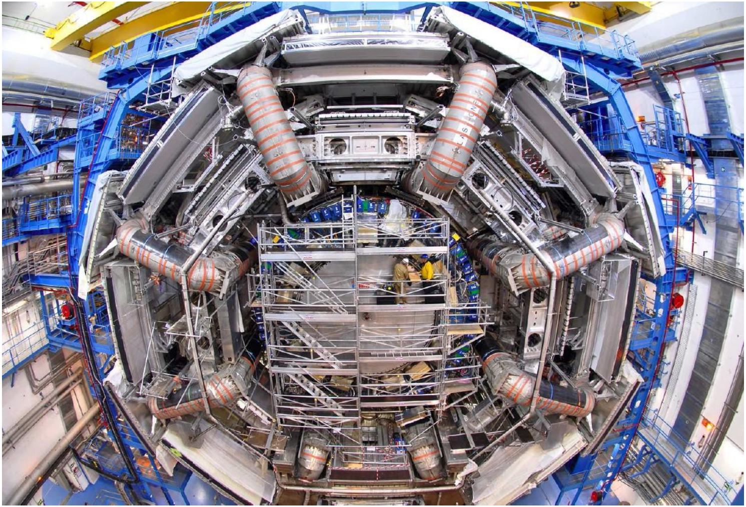
30.06.2005
30.09.2005
31.12.2005
31.03.2006
30.06.2006
30.09.2006
31.12.2006
31.03.2007

There are only four more month to go.

For ATLAS by now physicists dreams meet reality

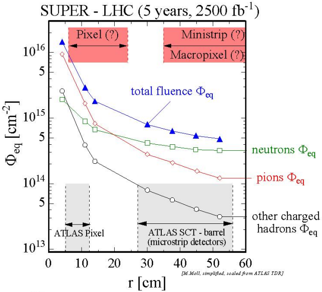


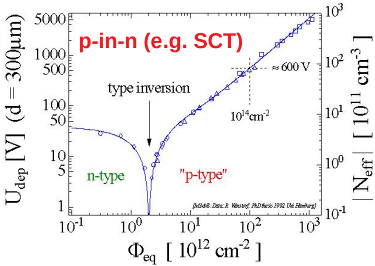
The ATLAS installation work is very well advanced, status Feb 2007.

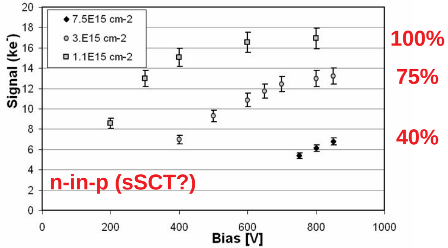
The quest for new silicon detectors

SLHC Conditions from 2015?

- Luminosity: $L = 10^{35}\text{cm}^{-2}\text{s}^{-1}$
- Integrated Luminosity (5y):
  $\mathcal{L}_{\text{int}} = \int dtL = 2500\ \text{fb}^{-1}$
- Fluence: $\Phi_{eq}(4\text{cm}) = 1.6 \cdot 10^{16}\ \text{cm}^{-2}$
- Occupancy: 5–10 k tracks per event





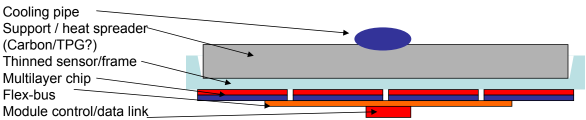


- High depletion voltage, large leakage currents and severe charge carrier trapping.

The severe radiation and increased occupancy ask for new detector concepts.

The proposed novel pixel detector concept

A sketch based on first ideas



The key features

— Thin planar silicon sensors.

— SLID interconnection (IZM).

— Vertical integration of the read-out electronics.

Some expected improvements

— Live fraction of more than 90%

— No cantilever needed for read-out.

— Wider modules, i.e. less staves would be needed.

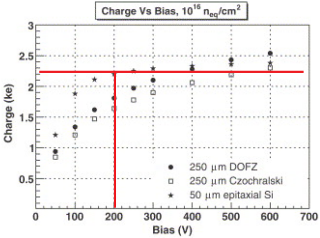
— Si-radiation length of only about 0.12% X_0.

— Depletion voltage is about 100 V at $\Phi_{eq} = 10^{16}\text{cm}^{-2}$.

— The final charge is similar to thick sensors, albeit at a much lower voltage.

— The challenge is the small signal size.

Simulation (T.Lari)



The concept needs very good, low noise electronics.

Conclusions and Outlook

- The main physics goal at the LHC is the study of electroweak symmetry breaking, i.e. the discovery of the Higgs-Boson.
- Other important topics are searches for physics beyond the Standard Model as well as measurements of the W-Boson and Top-Quark masses.
- The MPP has made substantial contributions to the construction of the ATLAS experiment within the MDT, HEC and SCT groups.
- The expertise of the HLL staff and the good collaboration of MPP and HLL have been essential for the success of the SCT project.
- LHC will start up still this year. In parallel, the upgrade project of the machine (SLHC), and R&D work for a completely new more radiation tolerant inner detector is underway.
- For MPP/HLL to play a key rôle in the detector development, a concept for a novel pixel detector design has been made, and first R&D steps have been taken.

The exciting data taking period of ATLAS is about to start, which means that preparations for the future detectors should gain speed.