ATLAS

ATLAS Project Review 2005

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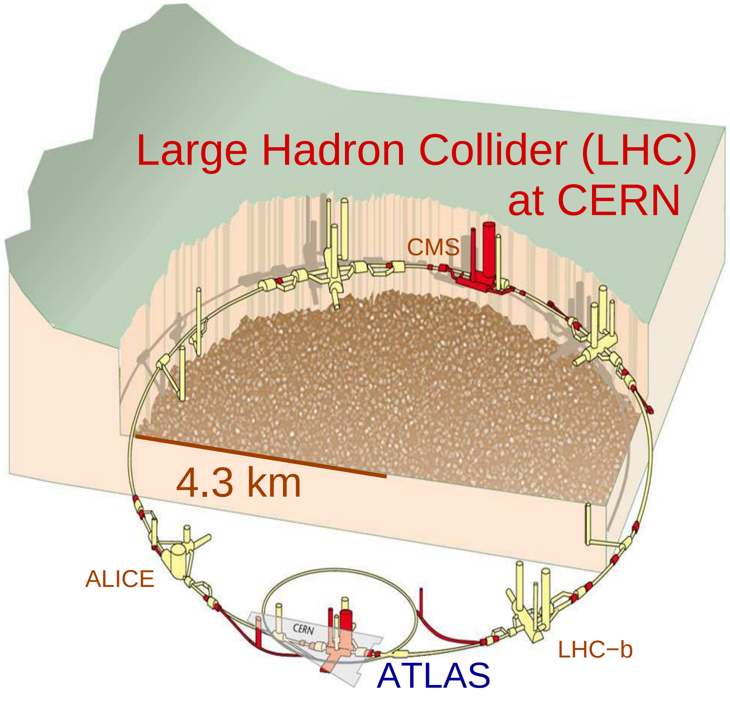
Overview

- LHC and ATLAS
- Semi-Conductor Tracker
- Hadronic Endcap Calorimeter
- Muon Spectrometer
- Computing and Software
- Physics Studies
- Upgrade Studies

LHC and ATLAS

LHC

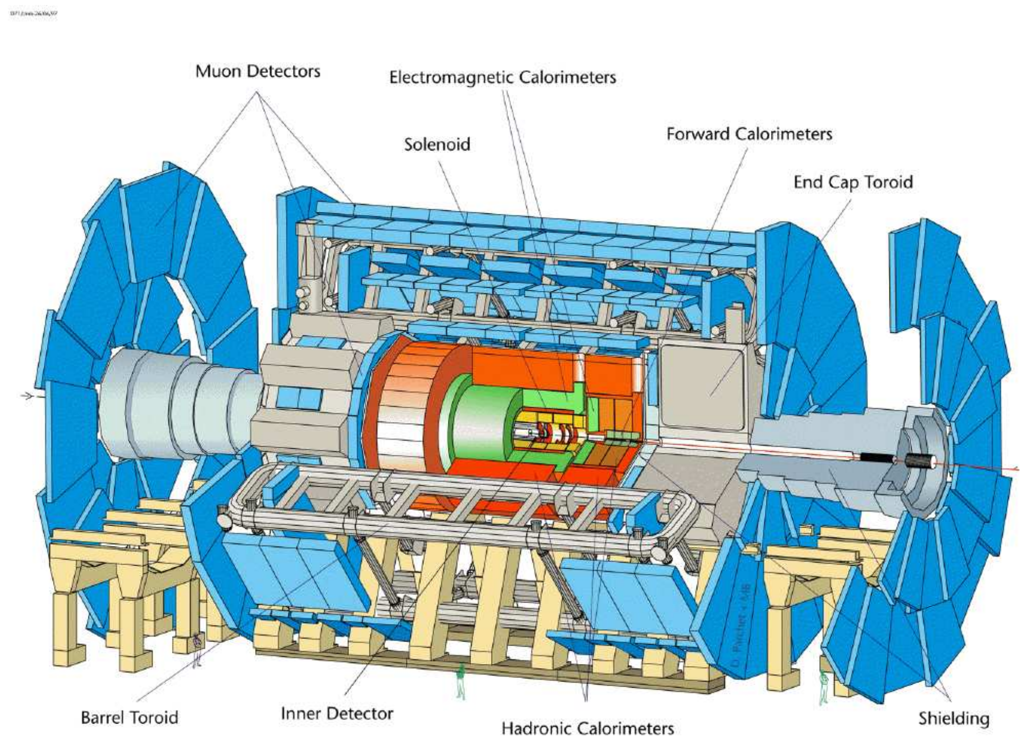


- Proton and heavy ions (Lead, full stripped 82+) beams
- Circumference: 26.7 km
- Nominal beam energy in physics: 7 TeV (protons)
- Beam collision rate: 40 MHz
- Magnetic field at 7 TeV: 8.33 Tesla
- Operating temperature: 1.9 K
- Number of magnets: $\approx$ 9300
  - Number of main dipoles: 1232
  - Number of quadrupoles: $\approx$ 858
  - Number of correcting magnets: $\approx$ 6208
- Gradient of the tunnel: 1.4°
- **4 main experiments: ATLAS, CMS, ALICE, LHCb**

The planned start up year of the LHC is 2007

ATLAS (1)

A Toroidal Lhc ApparatuS



- Diameter: 25 m
- Length: 46 m
- Weight: 7000 t
- 34 Countries
- 153 Institutes
- 1623 Authors
- 1320 Phd Students

MPI Contributions

- Semi-Conductor Tracker
- Hadronic Endcap Calorimeter
- Muon Spectrometer

ATLAS (2)

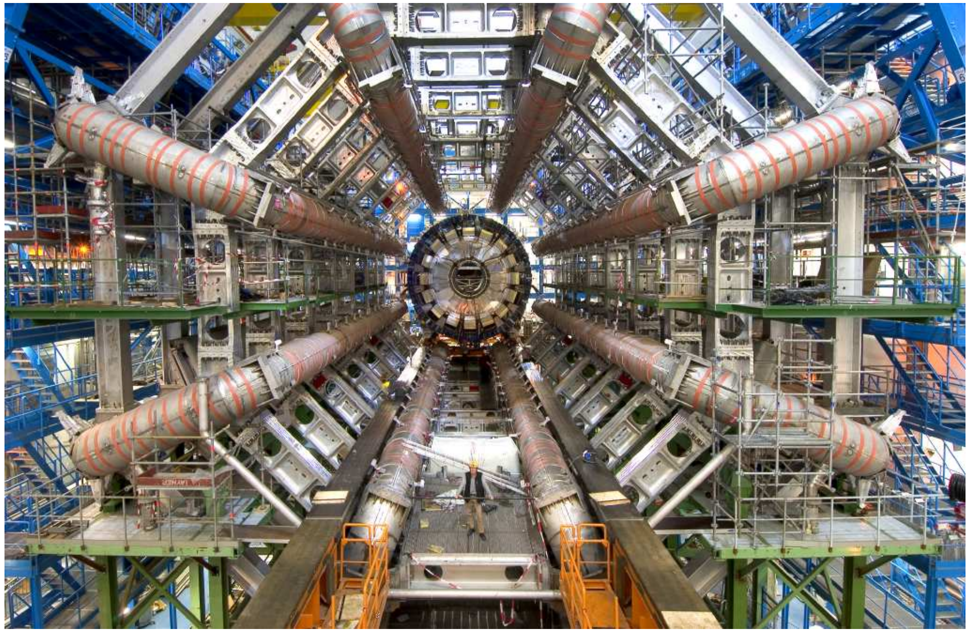
Current Status

- ✔ Barrel toroid installed
- ✔ Barrel SCT finished
- ✔ First SCT Endcap finished
- ✔ Barrel TRT finished
- ✘ Pixel 2/3 finished, but cooling pipe problems; later installation possible
- ✔ Barrel calorimeter in place
- ✔ Endcap calorimeter cold test finished
- ✔ 80 of 1200 muon stations installed, ongoing, chamber assembly will finish this year

ATLAS (3)

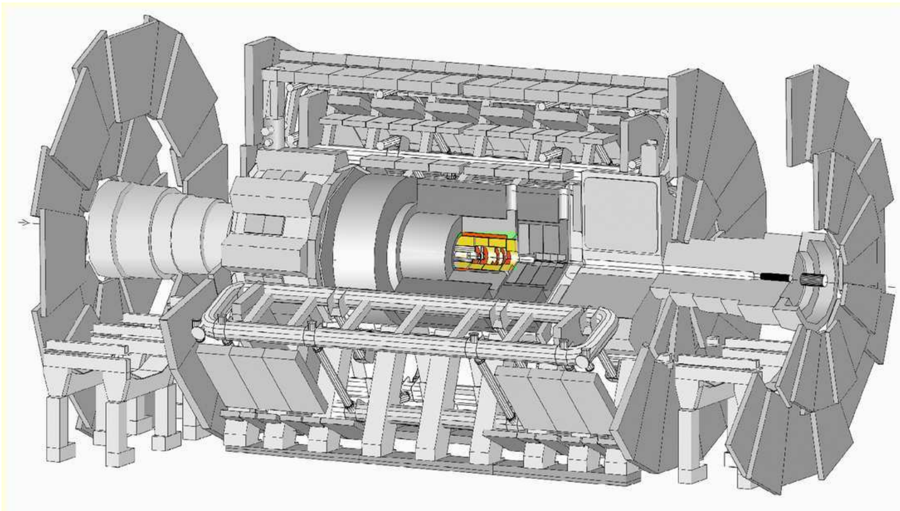
January 2005

During the year. . .



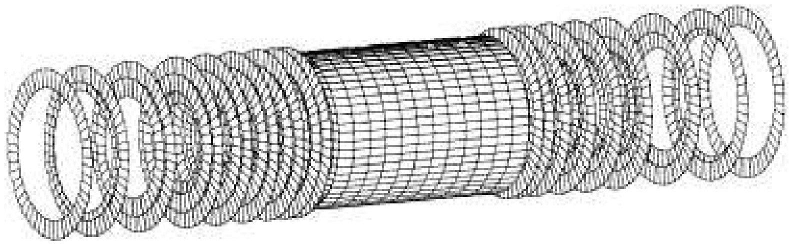
November 2005

The ATLAS Semi-Conductor Tracker

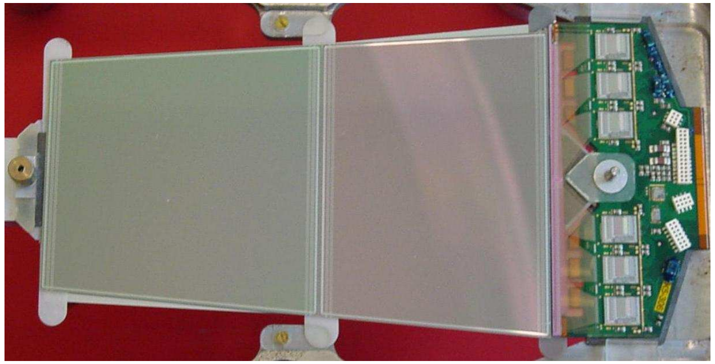


Semi-Conductor Tracker

Layout



An Endcap Module



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

Commitments

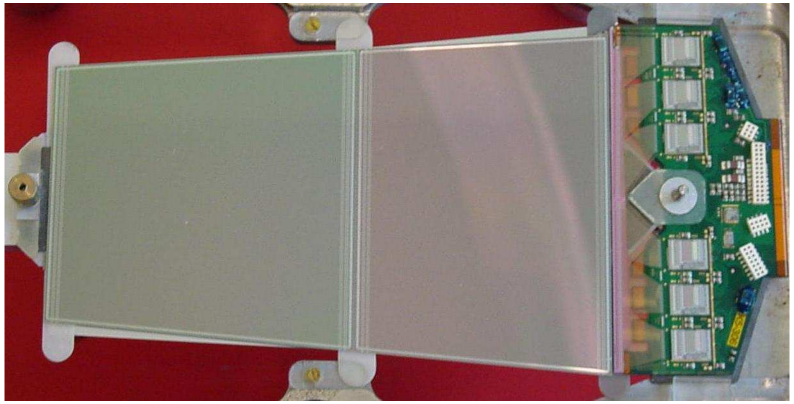
MPI responsible for. . .

- Production of 80 (96) *short middle* modules

  This amounts to all SCT modules of this type

- Production of 320 (384) *long middle* modules

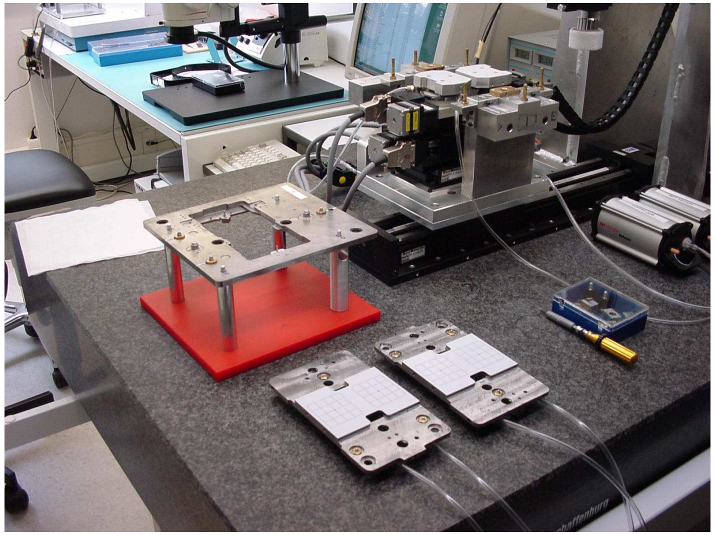
  This amounts to 50% of all SCT modules of this type



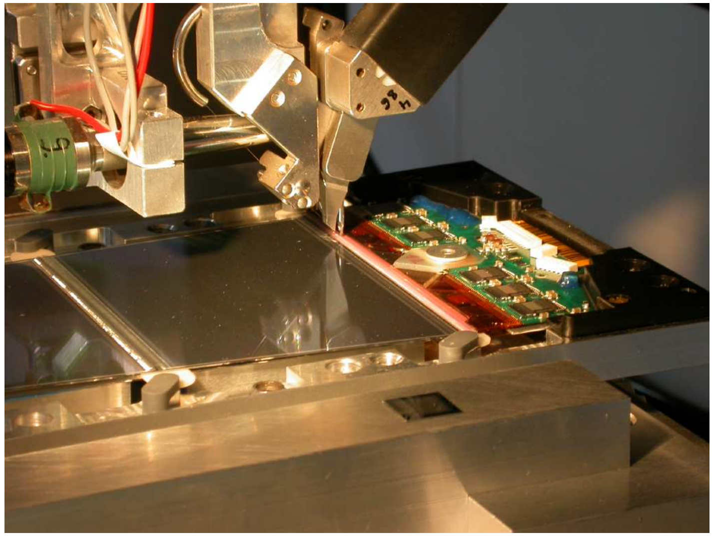
We have built 20% of all endcap modules with a small team of highly motivated people

Module Production

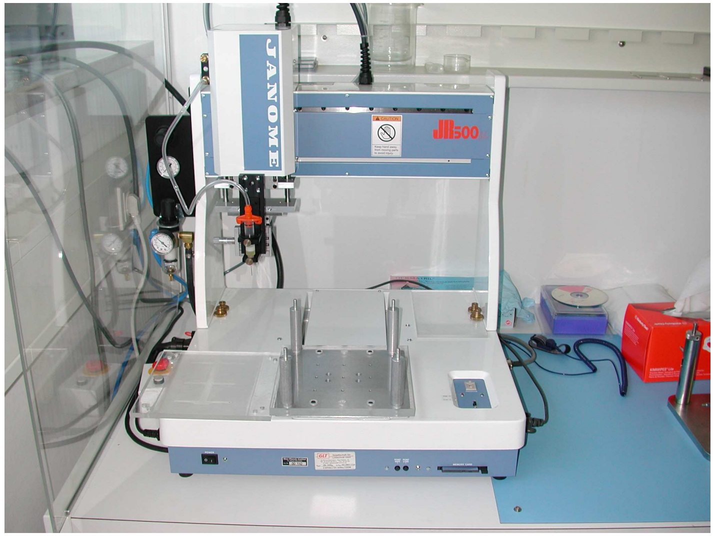
A Robot for Alignment



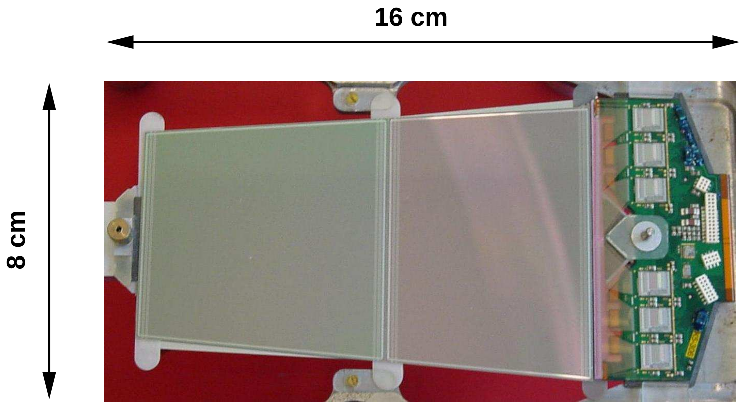
A Bonding Machine



A Glue Robot



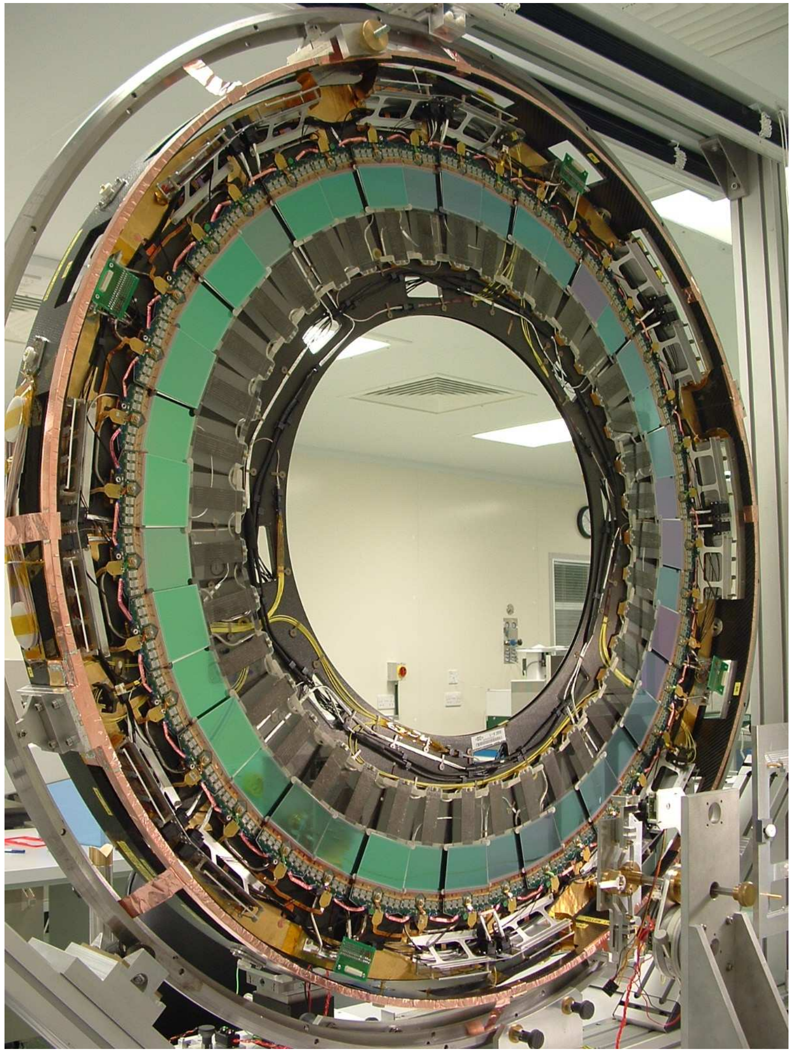
A Finished Module



ATLAS SCT

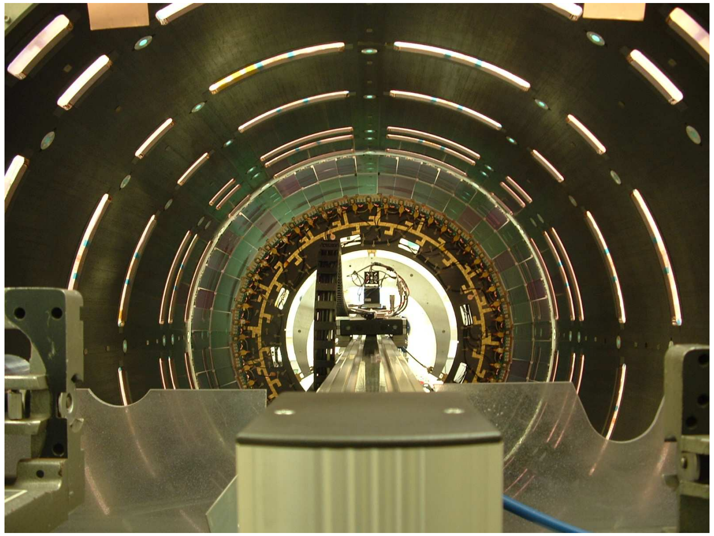
Finished Disks

First of 9 Disks



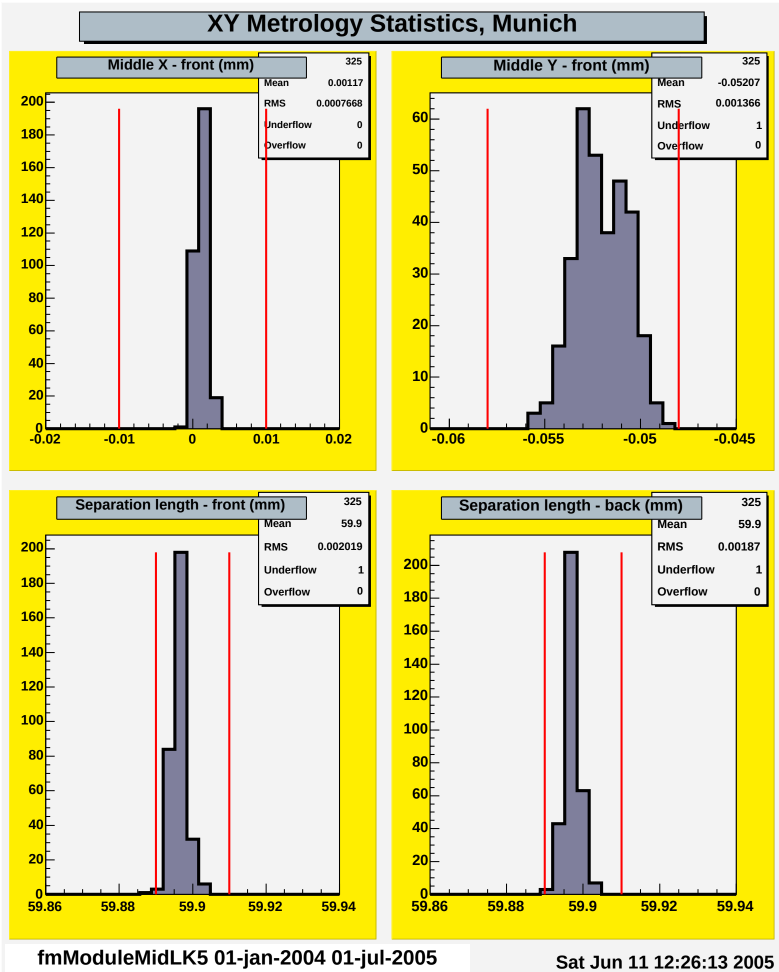
- 424 modules were started
- The efficiency for usable modules was 93%, i.e. well above the 85% required by SCT

First Disk in Cylinder

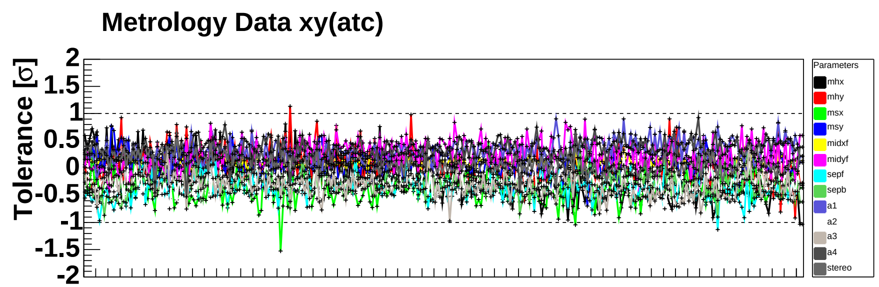


Mechanical Precision

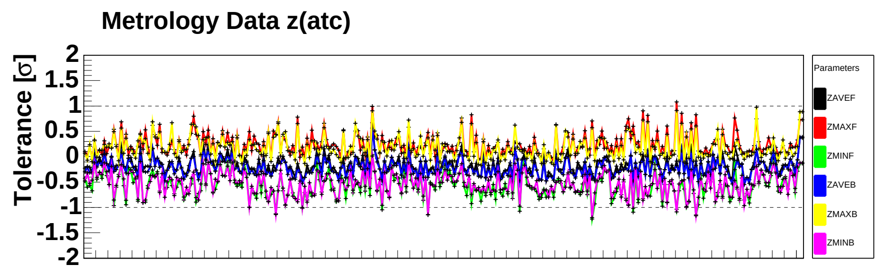
Mechanical precision of *long middle* modules



Parameters within the plane of the module



Parameters for the module thickness



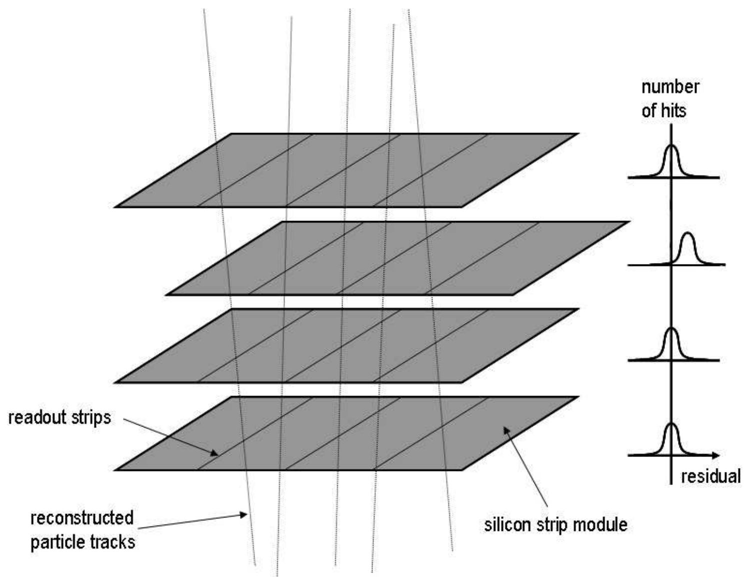
The tight specifications are met with high rate during the entire production

ATLAS SCT

Detector Alignment (1)

Alignment approach for ATLAS Pixel and SCT detectors

- Alignment is the process of deducing the position of each detector module within ATLAS
- Misalignments are corrected for in the track reconstruction software
- The residual (distance between track and hit position) is used as input for track based detector alignment
- Development of an iterative algorithm for track based alignment of the Pixel and SCT detector
- A χ^2-minimization is used to infer the most likely set of alignment parameters
- The approach depends on high quality tracks so it closely follows developments in the ATLAS tracking realm and track selection studies are ongoing



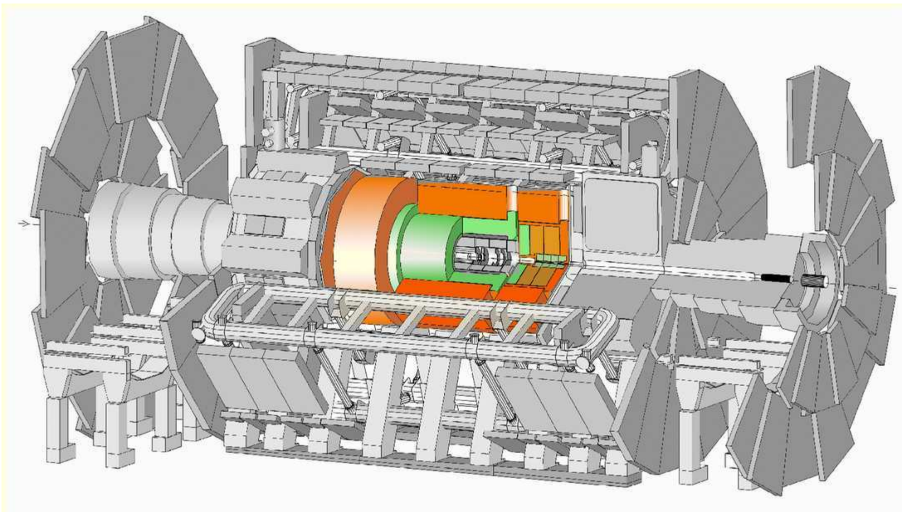
Detector Alignment (2)

Alignment algorithm with ATLAS software framework

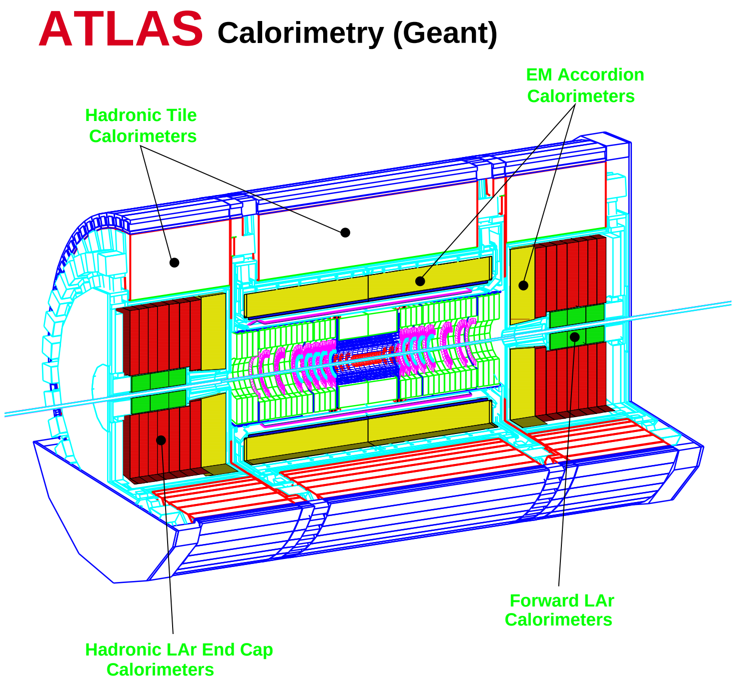
- Alignment algorithm for Pixel and SCT developed within the ATLAS software framework. It is now an offi cial part of the framework.
- Intensive validation studies for SCT alignment performed. Studies for Pixel ongoing.
- Currently achievable SCT alignment accuracy

Alignment Parameter	SCT Barrel 68% CL	SCT Barrel σ_{stat}	SCT Barrel as built	SCT Barrel TDR req.	SCT Endcap 68% CL	SCT Endcap σ_{stat}	SCT Endcap as built	SCT Endcap TDR req.
a_x / μm	48	29	100	12	19	5	50	12
a_y / μm	253	169	100	50	145	57	50	50
a_z / μm	245	149	500	100	1100	300	500	200
a_α / mrad	1.5	1.2			21	8.5		
a_β / mrad	2.6	1.8			13	5.0		
a_γ / mrad	0.33	0.25			0.38	0.13		

Hadronic Endcap Calorimeter



Hadronic Endcap Calorimeter

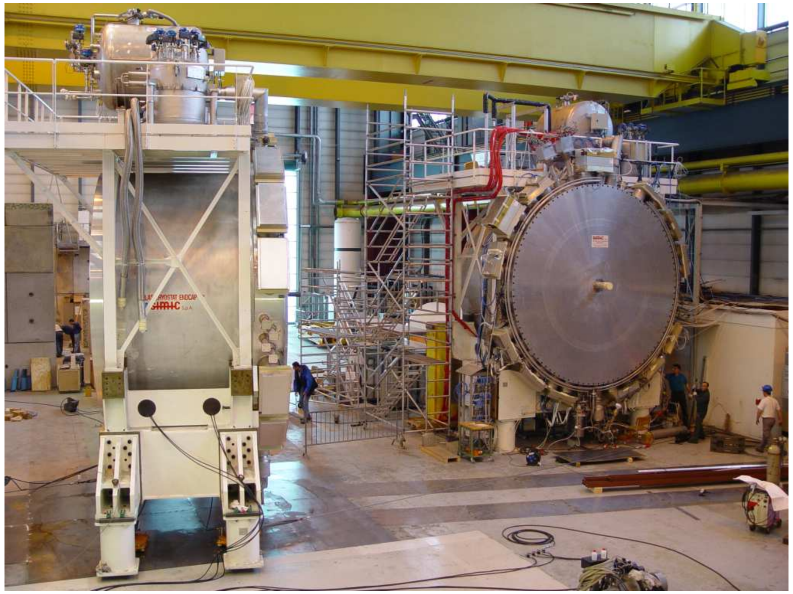


- Space constraints (same cryostat as EECAL)
- High count rate
- High background rate

$\longrightarrow$ Sampling calorimeter LAr/Cu

- Covers $1.5 < \eta < 3.2$
- Resolution: $\Delta\phi \times \Delta\eta = 0.1 \times 0.1$

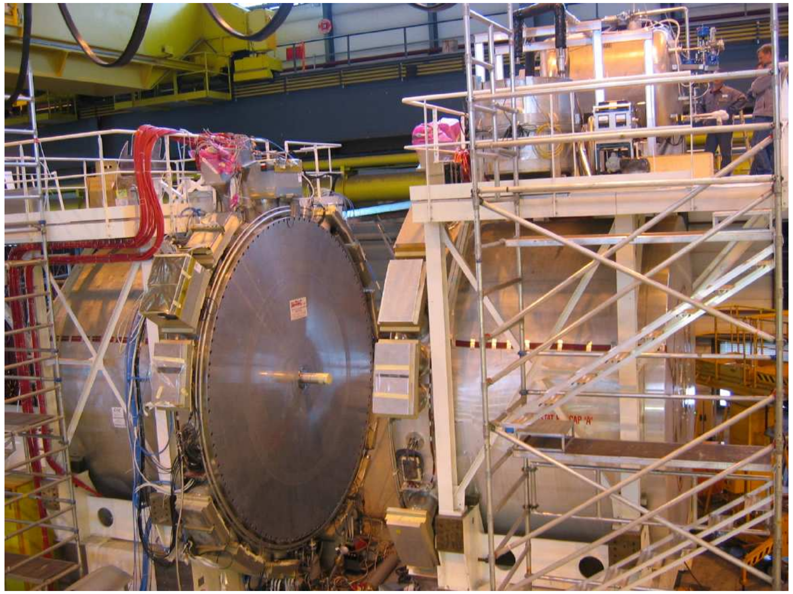
Endcap Cold Test (1)



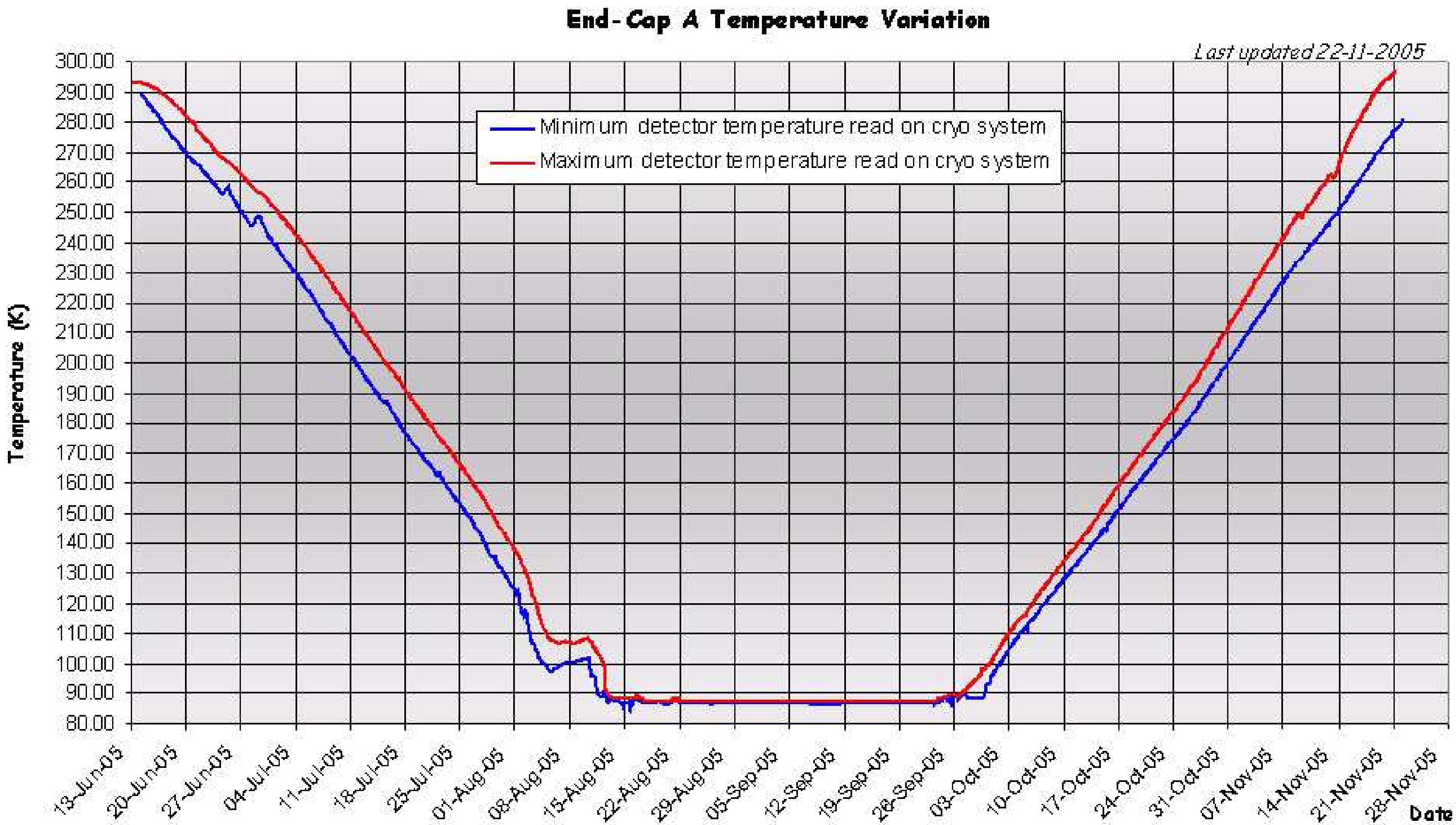
Cold tests of full endcaps are almost the last steps in the QC of the HEC

- QC during module assembly
- Cold QC of each module
- QC of each module prior to wheel assembly
- QC of wheel after assembly
- QC of wheel after rotation
- QC of wheel after insertion
- QC of endcap after closing cryostat

- TDR measurement of all calibration and signal lines
- Cabling check of signal, calibration and HV lines
- Full calibration and delay scan of all signal channels
- Pulse shape analysis of all signal channels
- Full noise measurement including coherent noise
- Long term HV test of all HV channels



Endcap Cold Test (2)



ATLAS HEC

Cold Test Results

Endcap A

- 3 signal channels dead (0.1%)
- 0 calibration lines dead
- 13 HV lines have short in cold (2.5%) Only 3 after emptying cryostat

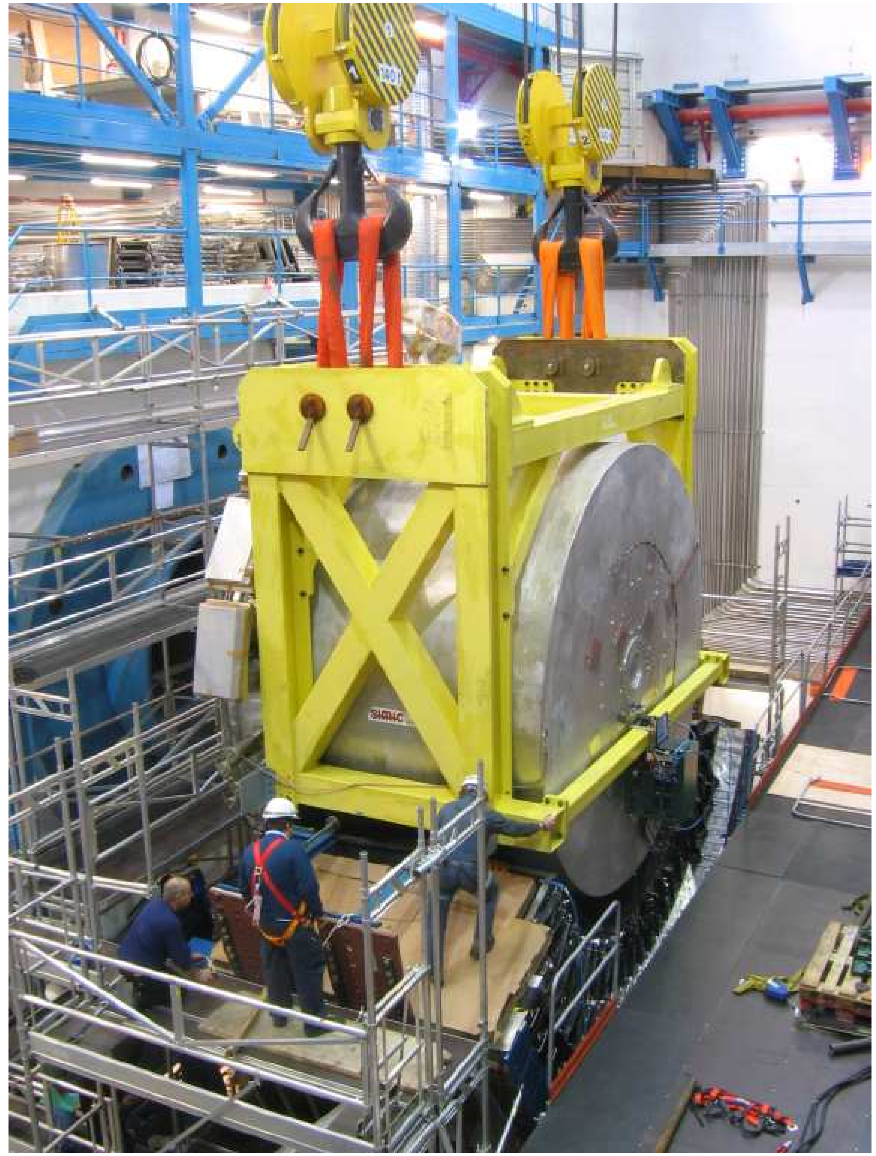
Endcap C

- 3 signal channels dead (0.1%)
- 1 calibration line dead (0.2%)
- 12 HV lines have short in cold (2.5%) Only 3 after emptying cryostat

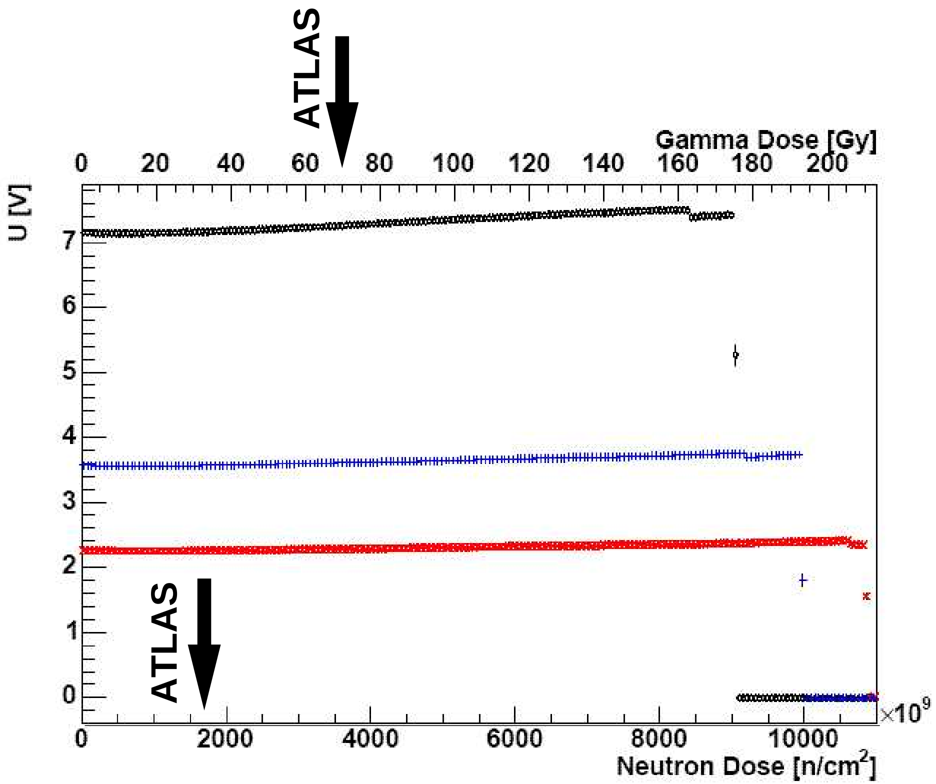
All regions in HEC active: for each gap there are 4 subgaps with individual HV lines

Endcap C on the Way to the Pit

. . . Arrival in the Pit



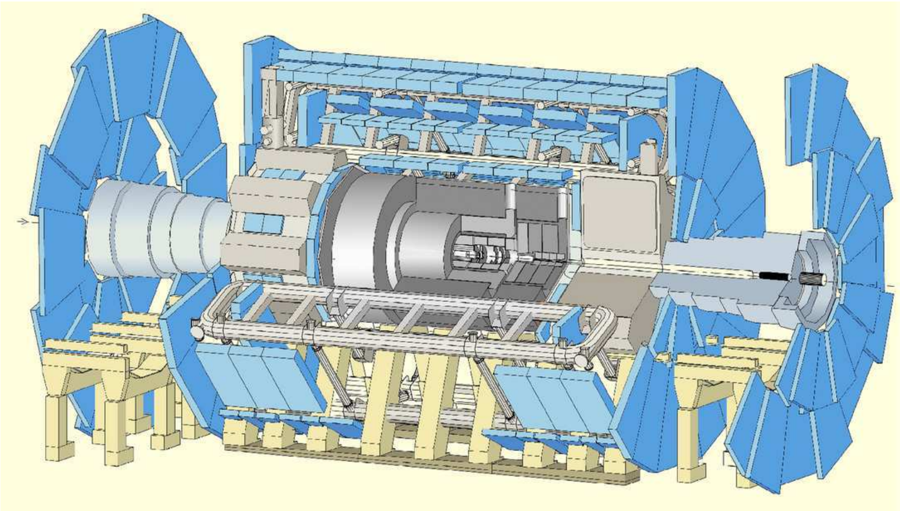
Low Voltage System



Radiation Hardness of DC/DC converters tested in JINR/Dubna!

- Full system test with 4 LV boxes done for endcap
- A fi nal system test (hard- and software) in last tests + installation phase

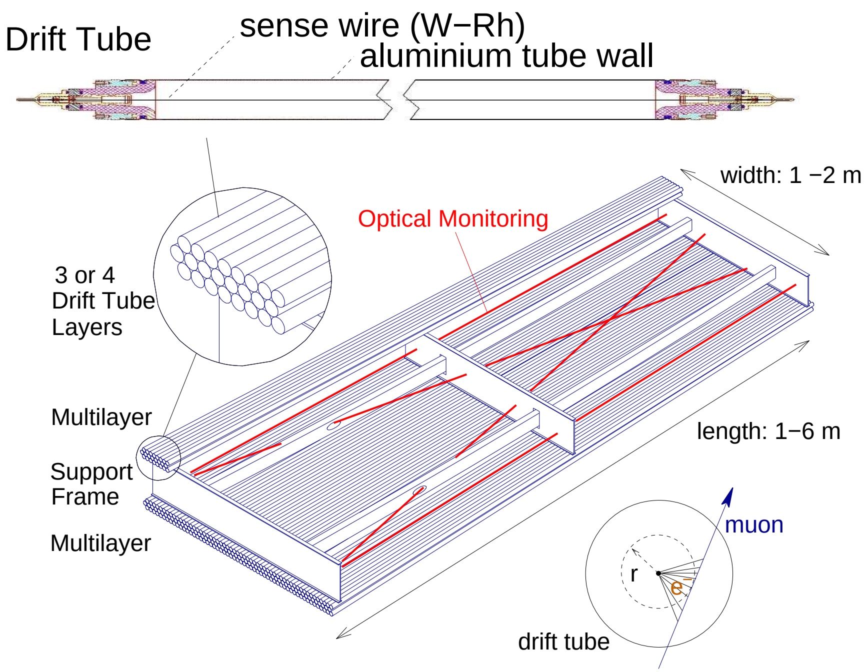
Muon Spectrometer



MDT Chambers

88 Monitored Drift Tube Chambers built at MPI

- 2 multilayer of 3 (or 4) drift tube layers
- Support frame of aluminum



BOS MDT Chamber size: 3.8 m $\times$ 2.2 m

2 $\times$ 3 layers, 72 tubes per layer

- Drift tubes
  - 3 cm diameter
  - Gas mixture: Ar/CO_2 = 93/7
  - Pressure: 3 bar
  - Gas gain: 2×10^4
  - Max. drift time: $\approx$ 700 ns
  - Resolution: $< 100\ \mu$m

Monitored. . .

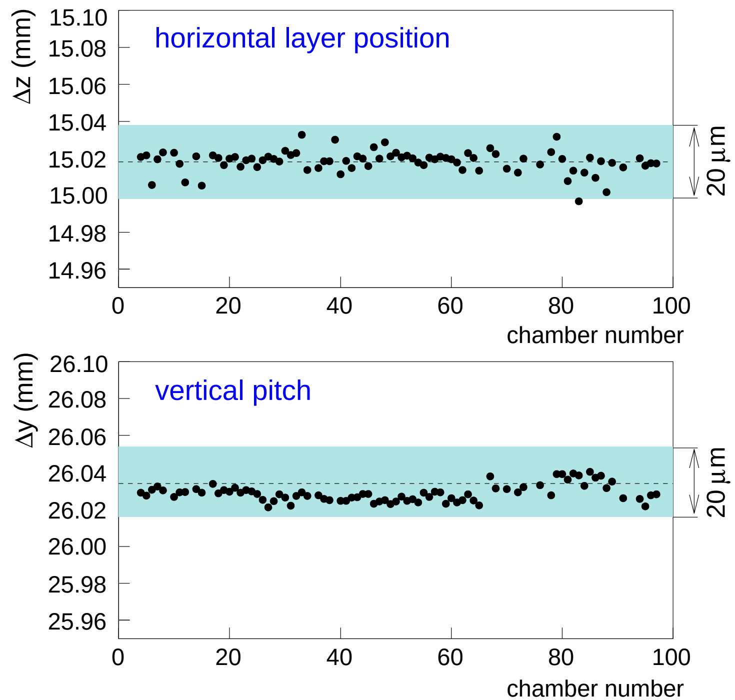
- Optical systems to monitor chamber deformations
- Optical chamber to chamber alignment

MDT Construction (1)

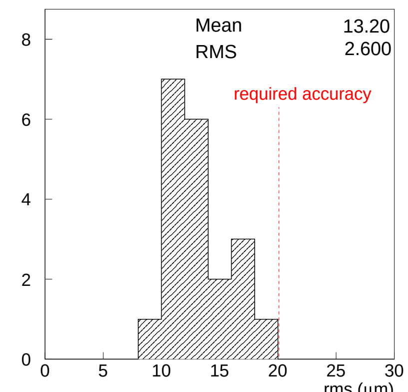
Mechanical Assembly

432 drift tubes in 6 layers assembled in 6 working days

Optical monitoring: Layer positions

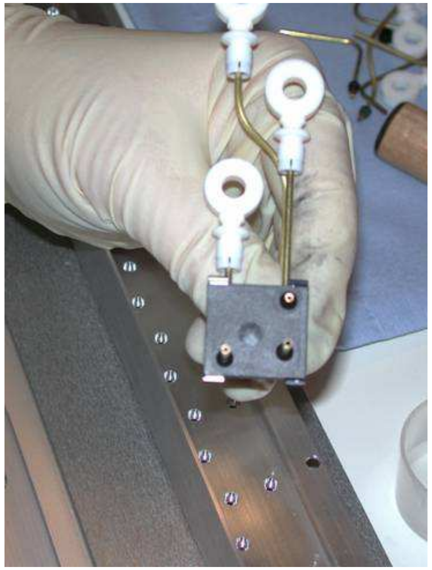


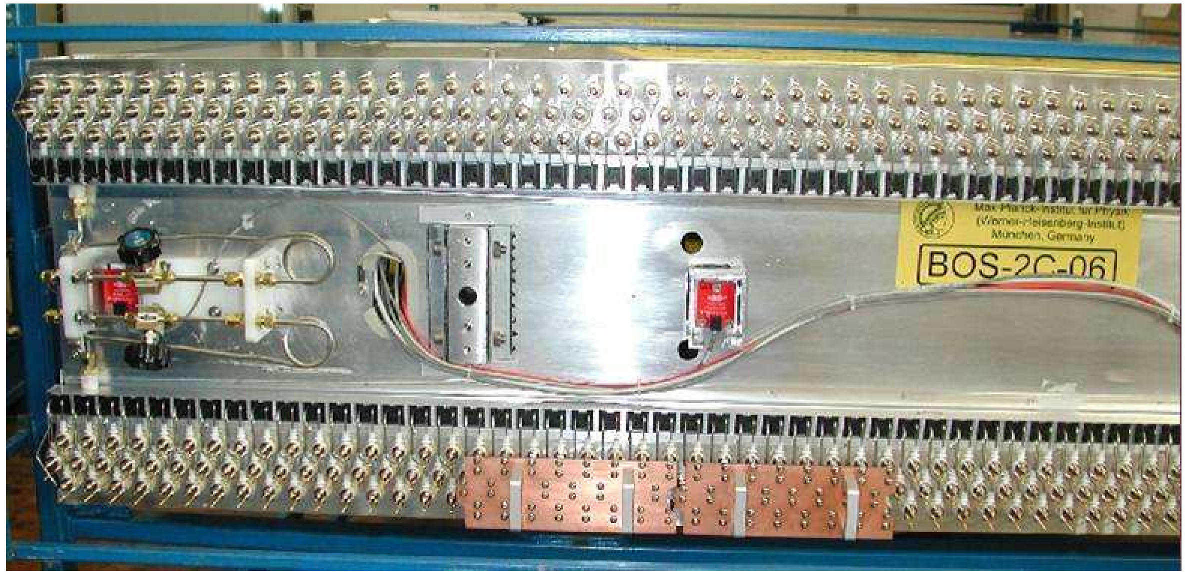
X-ray scan: RMS of wire pos.



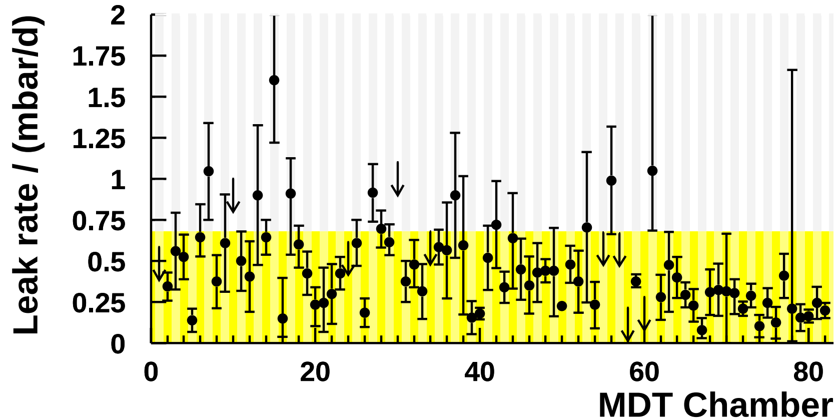
MDT Construction (2)

Mounting of Gas System



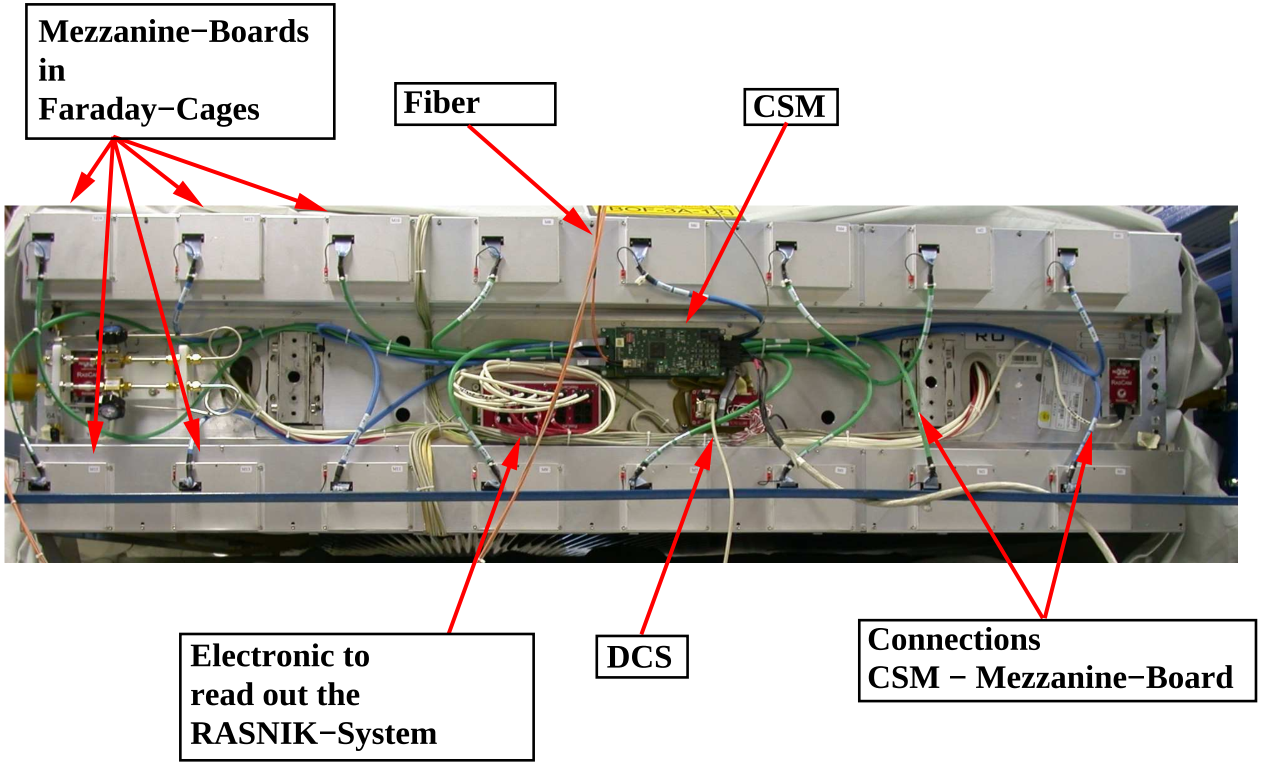


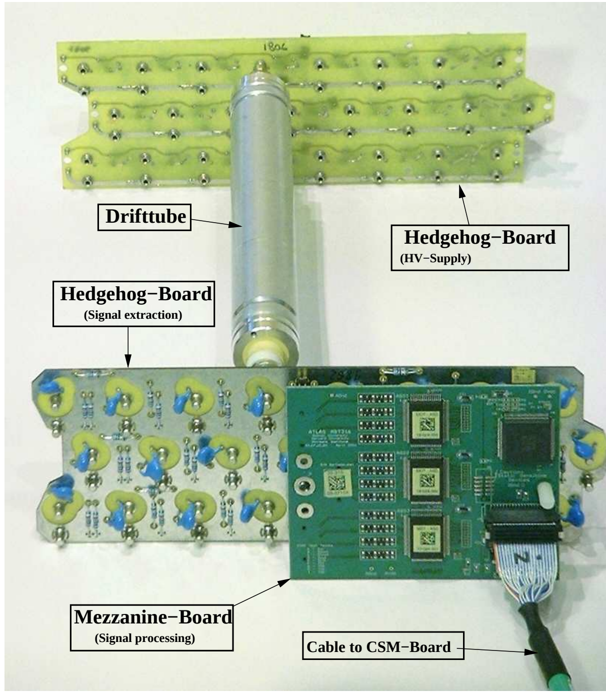
3500 O-Ring seals per chamber
Allowed leak rate: 0.68 mbar/d



MDT Construction (3)

Installation of Read-Out Electronics

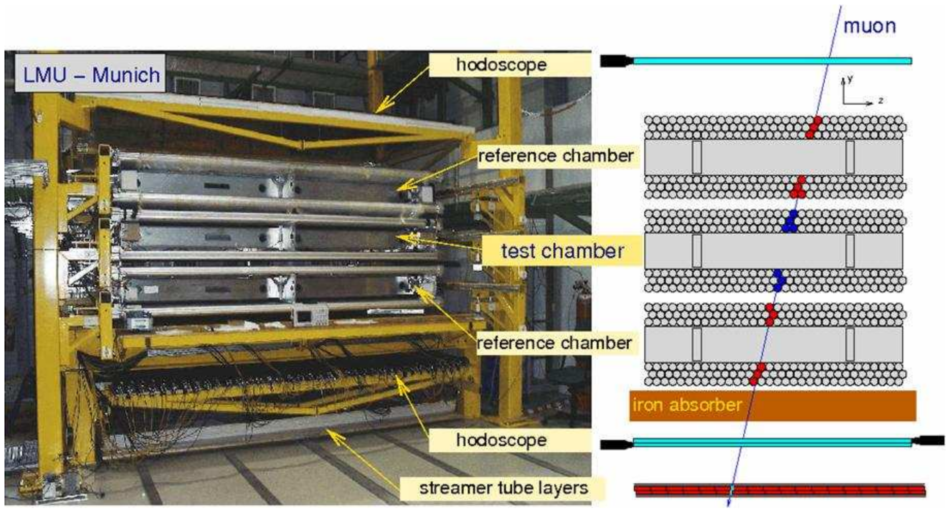




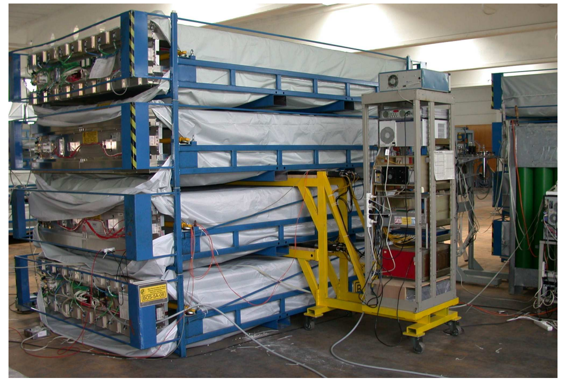
MDT Construction (4)

Cosmic Ray Test

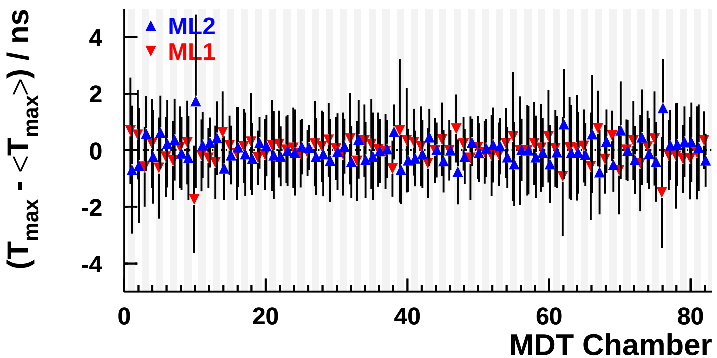
LMU Garching



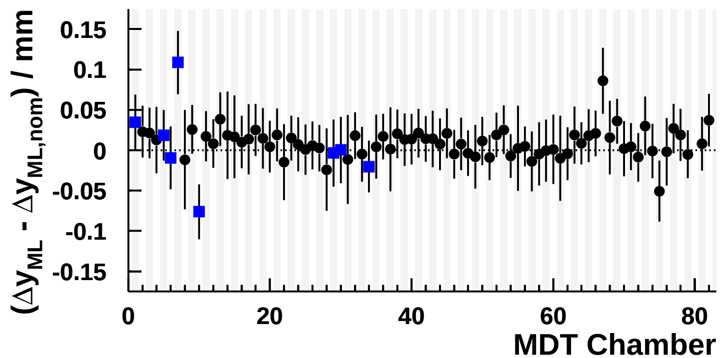
Storage hall Eching



Drift time stability

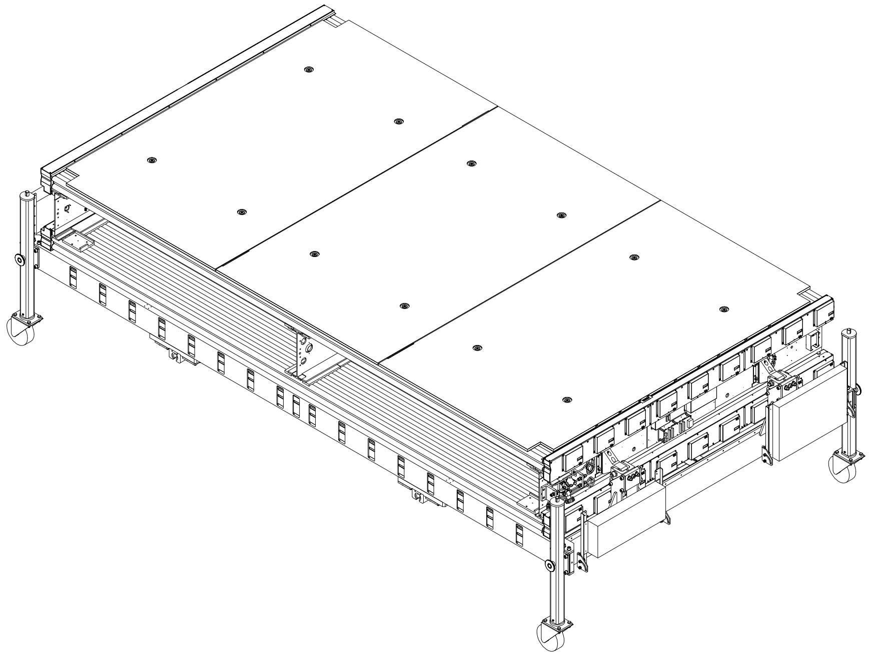


Reconstructed layer pos.



MDT Construction (5)

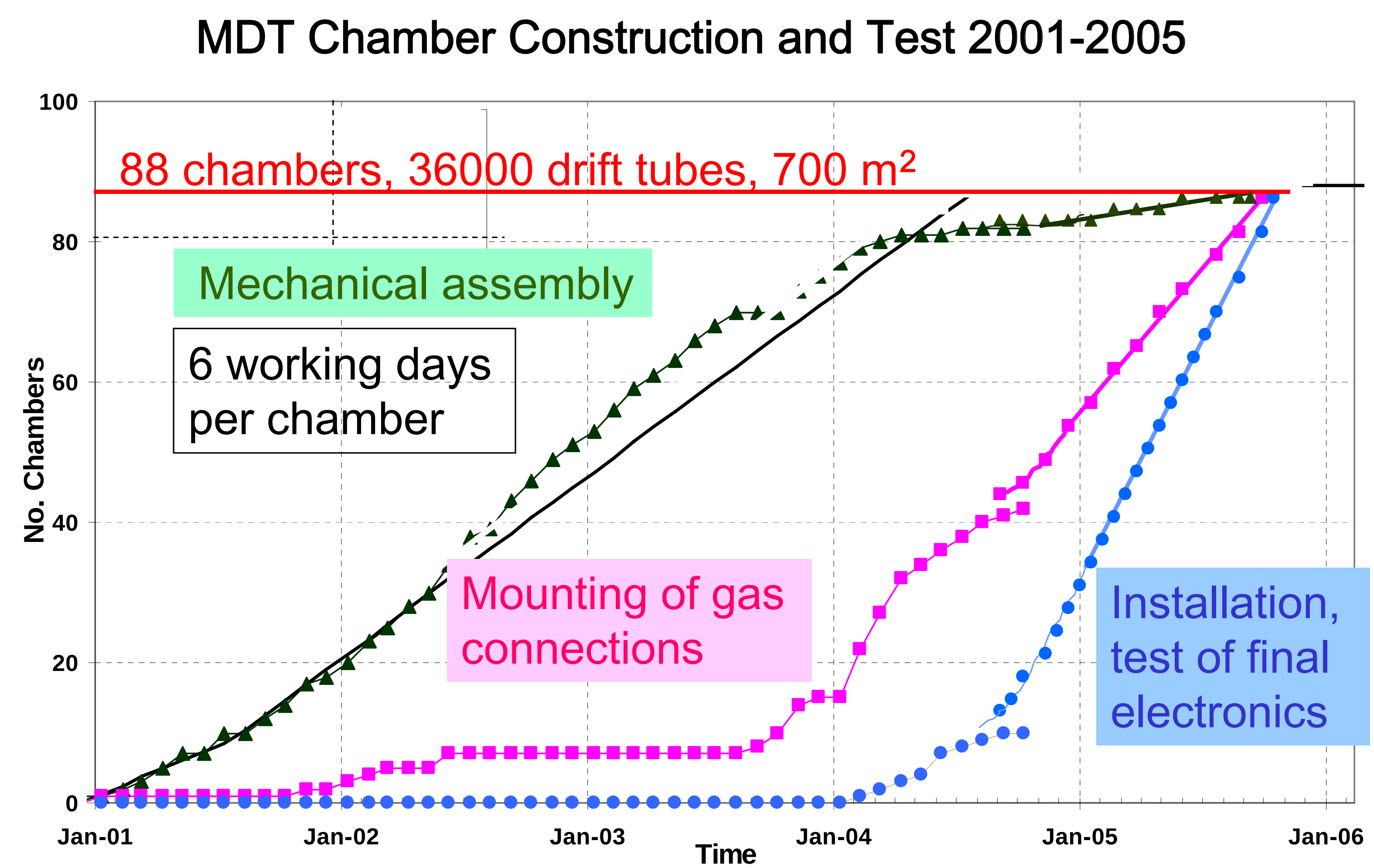
Assembly of MDT/RPC Common Supports



106 supports assembled and transported to CERN

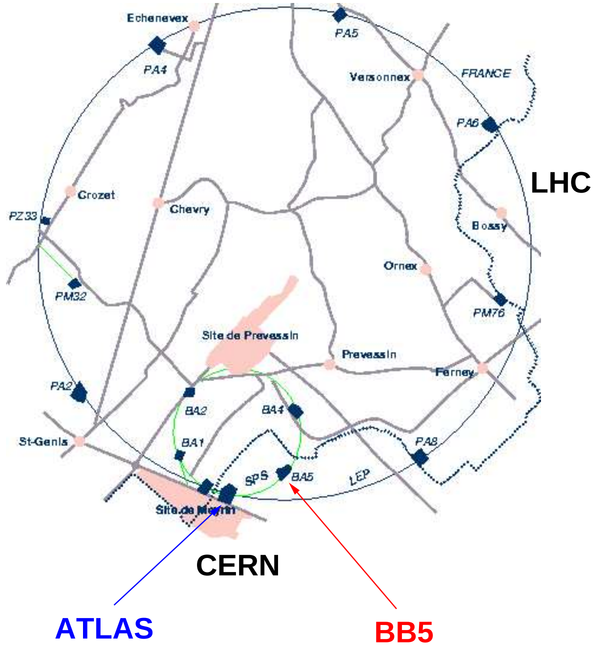
MDT Construction (6)

MDT Construction (7)



Chamber construction completed in December 2005.

At CERN. . . (1)



Test and Commissioning

- Leak test
- HV test
- Noise test
- Cosmic Ray test (after integration)

Integration of Muon Station

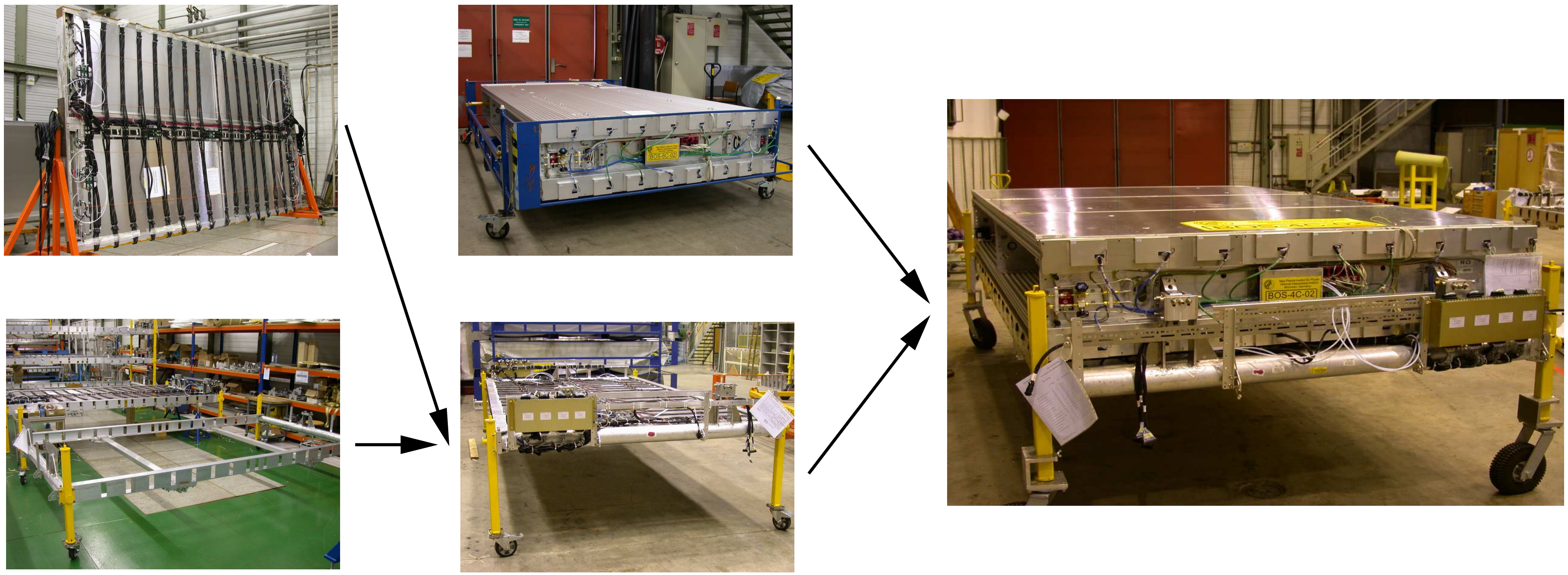
- Install and test additional sensors
- Mount RPC trigger chamber in common support
- Mount MDT chamber on common support
- Adjustment of MDT chamber

Integration (1)

Integration of the RPC Trigger Chamber and MDT Chamber

Most complicated muon stations to integrate due to common support frame (station position outside magnet coils)

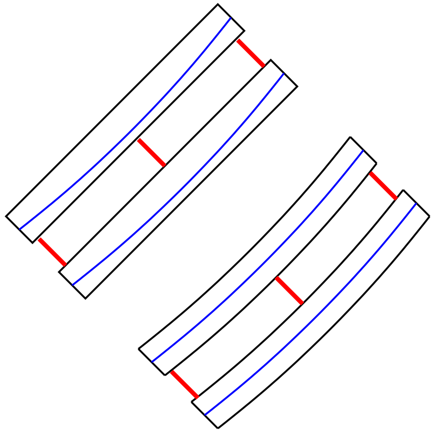
Different than any other ATLAS MDT station



Integration (2)

Rotation of Muon Station

Sag Compensation



MDT Alignment

Fully Integrated Muon Station

Statistics & Results

Failure Rates

Item	Total Number	At Munich	At CERN	Total Percentage
Disc. Tubes	30260	13	0	0.04
Broken Wires	30260	10	1	0.04
Exch. HV HH cards	1260	0	5	0.40
Exch. RO HH cards	1260	0	3	0.24
Exch. Mezz. cards	1260	0	21	1.66
Exch. HV Split. boxes	74	0	2	2.7
DCS boxes	74	0	2	2.7
Exch. RasCams	128	0	1	0.78

74 BOS MDT chambers already passed all MDT tests

61 BOS MDT chambers already passed cosmic ray test without any failure

Installation

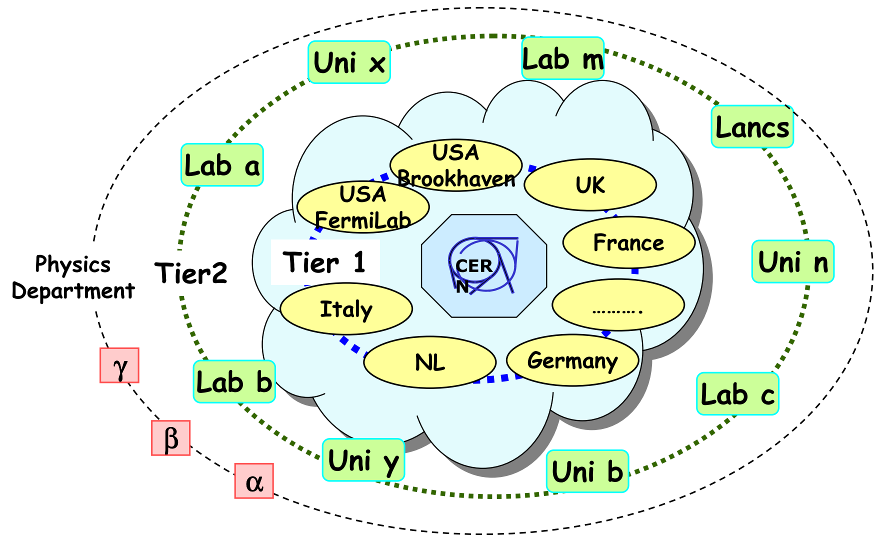
4 BOF MDT chambers installed in ATLAS in February

BOS/F Installation resumes in January 2006

Computing and Software

Computing and Software (1)

ATLAS GRID computing structure



- ATLAS Tier-1 center at FZ Karlsruhe (GridKa)
- 3 Tier-2 computing centers in Germany
  - Munich (Garching): 50% MPI (RZG), 50% LMU (LRZ)
  - DESY
  - German university cluster

Computing and Software (2)

Detector-specific software

- Inner Tracker
  - Robust algorithm for silicon tracker alignment with tracks
- Calorimeter
  - Topological energy cluster reconstruction algorithm
  - Calibration of hadronic shower response based on test beam studies
  - Calorimeter simulation: GEANT4 validation for HEC
  - Detector control system for HEC (temperature, low voltage)
- Muon Spectrometer
  - Fast algorithm for r-t calibration with tracks
  - B-field and background rate corrections based on test beam studies
  - Alignment of the muon detectors and of muon spectrometer to inner tracker with tracks
  - Muon reconstruction (especially at high background rates)
  - Muon spectrometer simulation: geometry, material validation, coordination
  - Control system for MDT front-end electronics

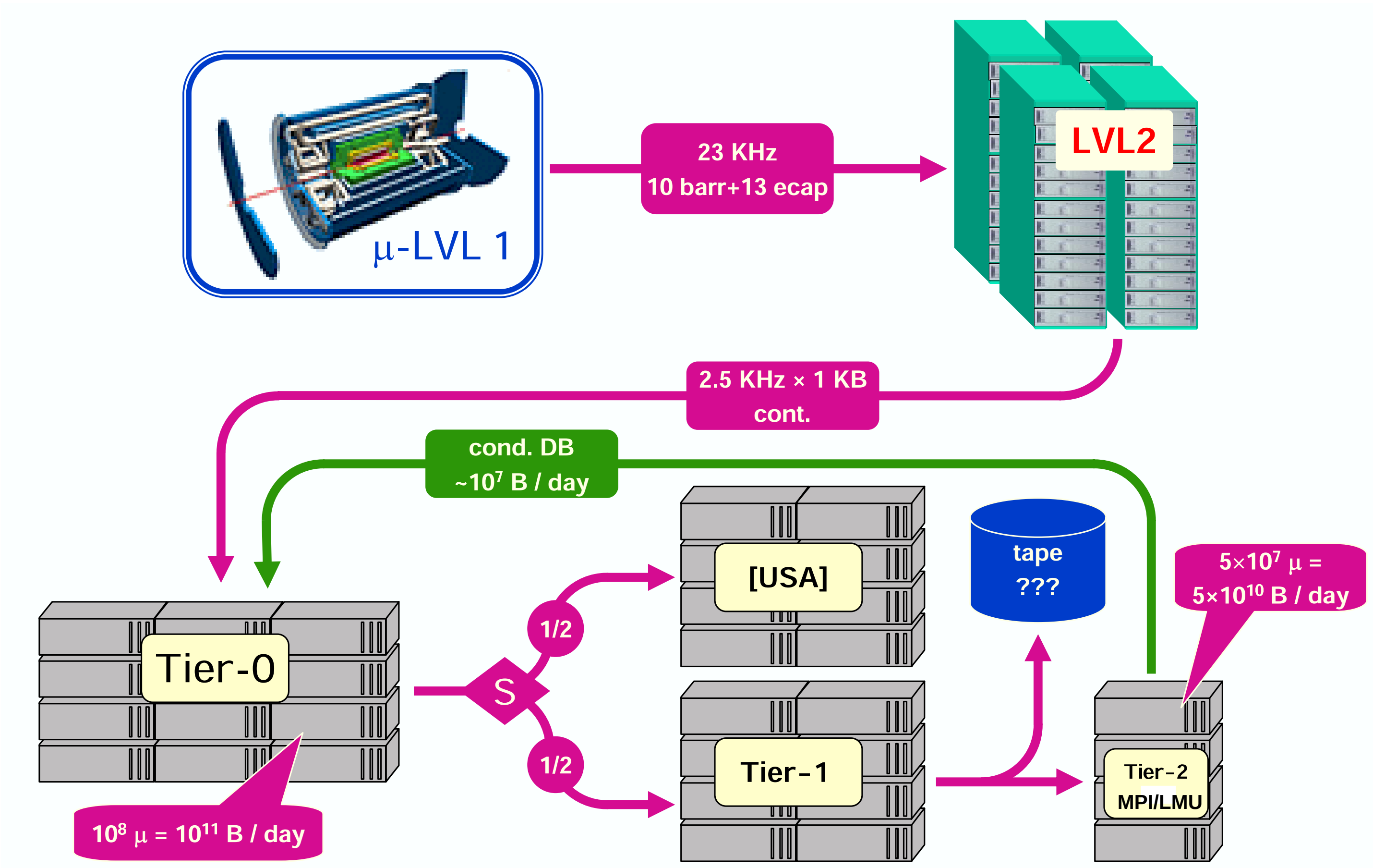
Computing and Software (3)

All subdetectors

Combined test beam studies of ATLAS detector section

Computing and Software (4)

Muon Spectrometer Calibration & Alignment Center



Computing and Software (5)

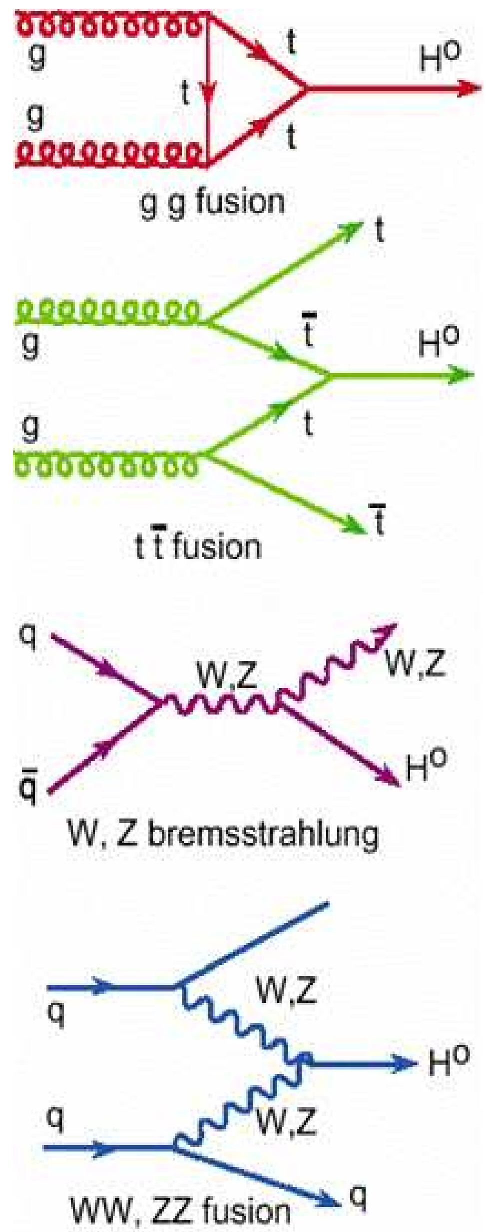
Software Infrastructure

- Coordination of ATLAS detector commissioning software with cosmics 2006/2007
  Strong participation of all MPI subdetector groups in commissioning effort
- Participation in the management of the central MC production system via the GRID

Physics Studies

Physics Studies (1)

- **Higgs Boson Searches (SM and MSSM)**
  Main discovery channels for low mass Higgs
  - $H \rightarrow ZZ^{\star} \rightarrow \mu\mu\mu\mu, ee\mu\mu, eeee$
  - $(qq)\ H \rightarrow (qq)\ WW \rightarrow (qq)\,\ell\nu\ell\nu$
  - $qq\,H \rightarrow qq\,\tau\tau$
  - $tt\,H \rightarrow tt\,bb, W\,H \rightarrow W\,bb$
  - Study of Higgs spin and CP measurement in several channels
  - MSSM: $(bb)\ H/A \rightarrow (bb)\ \mu\mu,\ (bb)\ \tau\tau$
- **SUSY searches** inclusive searches, multi-muon final states, LSP
- **Top quark physics** top mass measurement
- **SM, QCD studies**
- **Beyond SM searches** leptoquarks



Physics Studies (2)

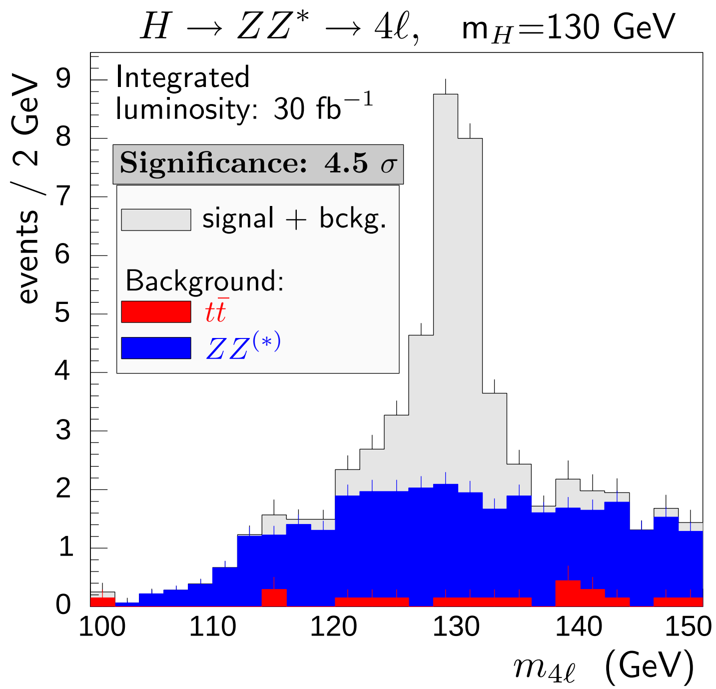
Analysis Tools

- b-tagging
- τ identification
- Jet reconstruction
- Missing transverse energy reconstruction
- Detector calibration with Z $\rightarrow$ ee, $\mu\mu$, $\tau\tau$ decays and tt

In collaboration with German university network for ATLAS

Regular physics workshops with theory groups

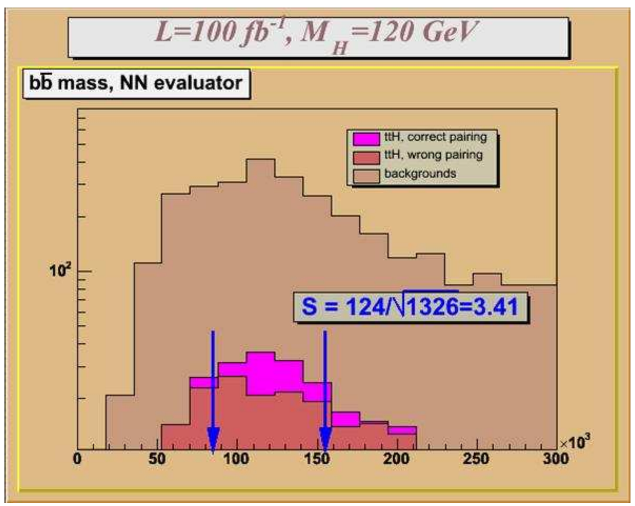
Physics Studies (3)

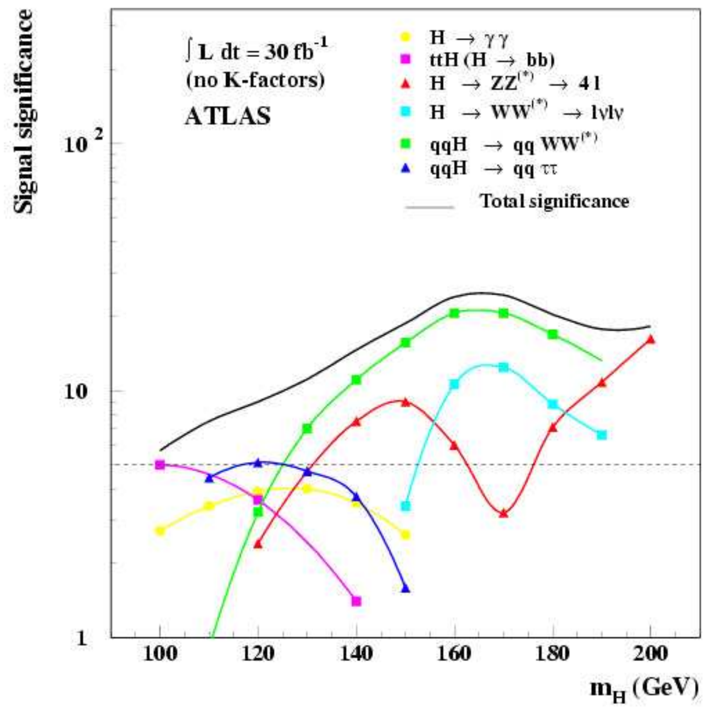


SM Higgs Searches

Large SM backgrounds

Neural network discriminators



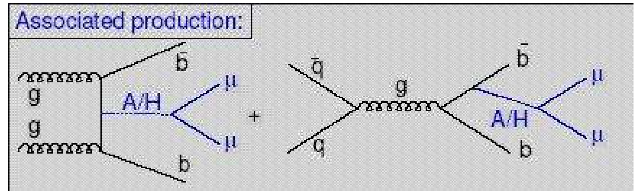


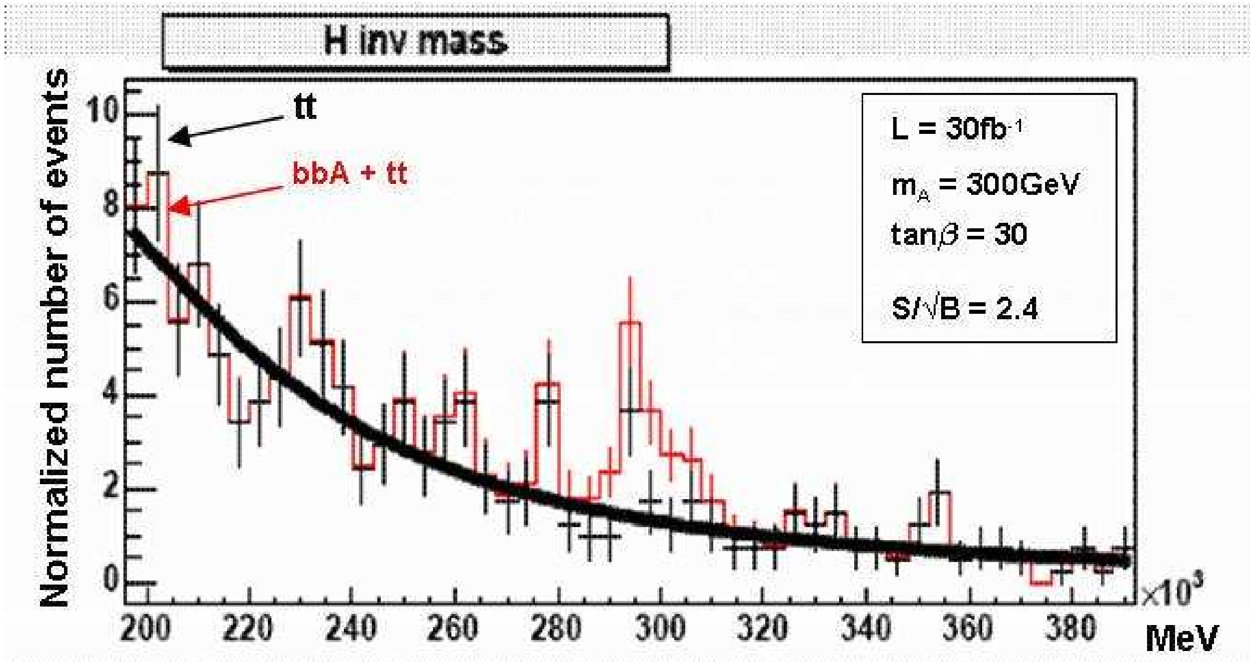
Physics Studies (4)

MSSM Higgs Searches

Full ATLAS detector simulation,

bb H/A $\rightarrow$ bb $\mu\mu$





Upgrade Studies

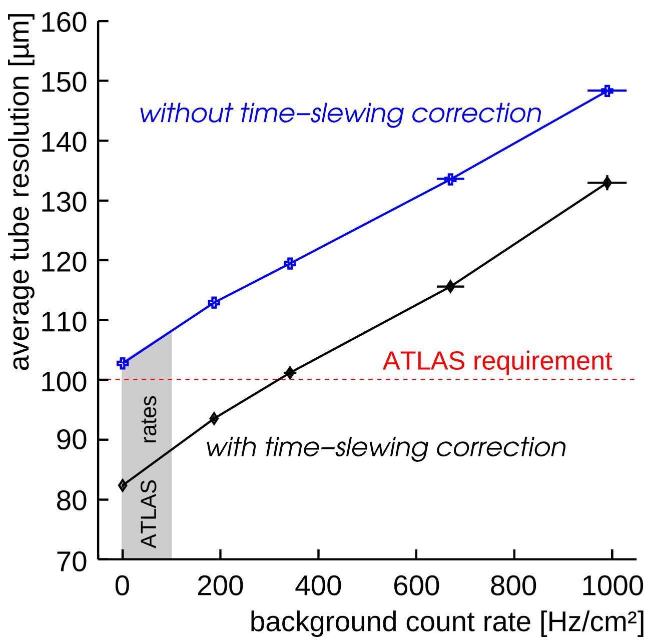
Upgrade Studies (1)

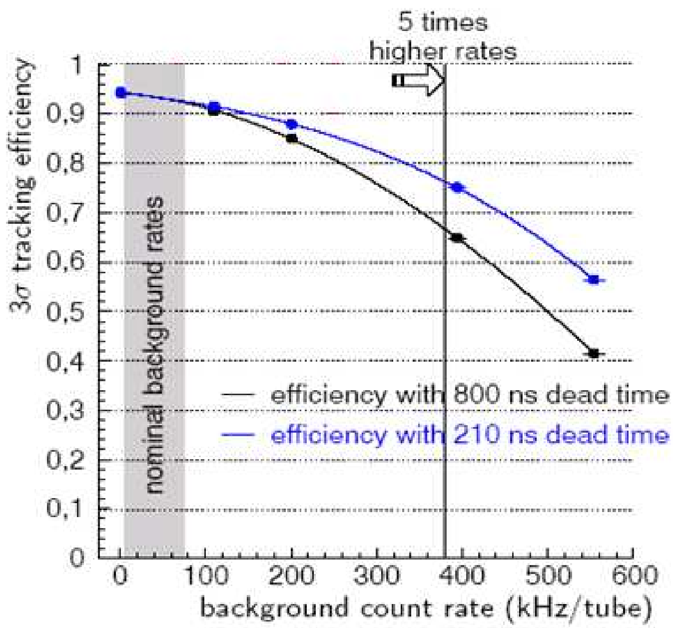
For LHC design luminosity and beyond

- Inner Tracker
  - Participation in silicon detector radiation hardness studies for high-luminosity LHC upgrade (HLL in RD50 Collaboration)
- Calorimeter
  - Study performance of endcap calorimeter modules at high rates at IHEP Protvino (INTAS project)
  - Development of new more radiation hard HEC front-end electronics (HEC cold electronics at the limit for high-luminosity at LHC)
- Muon Spectrometer
  - Studies of MDT chamber resolution and effi ciency at high rates with γ-irradiation facility at CERN
  - Response of drift tubes to neutron irradiation
  - Expansion of readout bandwidth and front-end electronics upgrades
  - Development of faster drift tube detectors (smaller tube diameter)

Upgrade Studies (2)

MPI/LMU test beam setup in the
γ-Irradiation Facility at CERN
(γ-source + muon beam)





Summary

Summary

- Great progress at all subdetectors
- Installation in ATLAS has started
- Moving on to commissioning and physics in 2006
- Already thinking about upgrades ;-)

Thanks to all people who contributed to a successful year for ATLAS at MPI, especially our engineers and mechanical and electrical workshop staff