Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Final Evaluation of the Mechanical Precision of the ATLAS Muon Drift Tube Chambers

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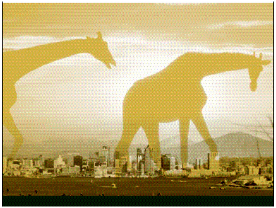
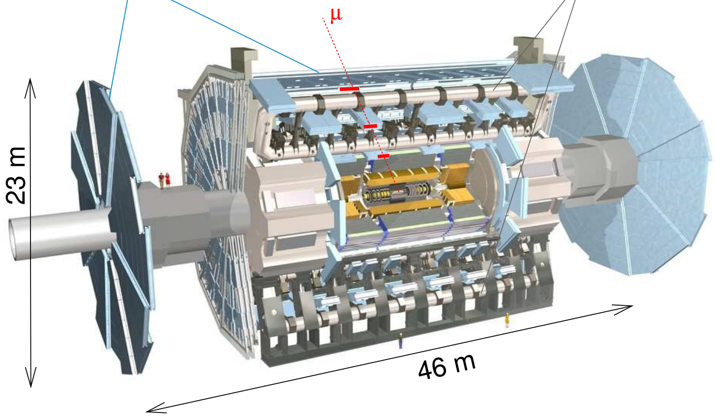


IEEE Nuclear Science Symposium • October 29 - November 4 • San Diego, California

Precision muon momentum measurement in a toroidal magnetic field:

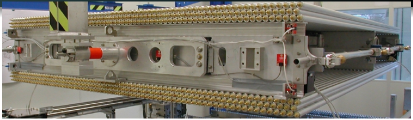


- 2700 trigger chambers (RPC, TGC)
- 1200 precision chambers (CSC, MDT)

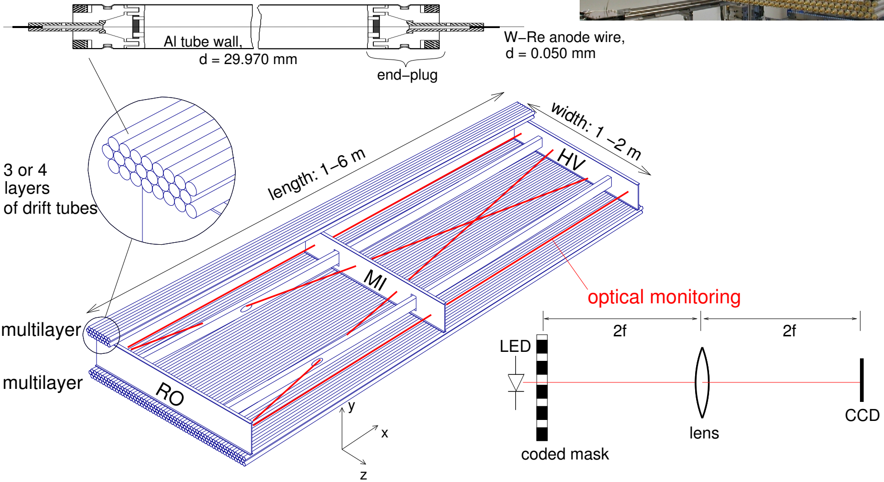
Performance requirements:

$\frac{\Delta p_T}{p_T}$=3-10% in a wide momentum range of p_T=10-1000 GeV/c $\Rightarrow$
track sagitta resolution in a tower of 3 chambers: 50 μm.

Monitored Drift Tube (MDT) Chambers



drift tube: Ar:CO_2(93:7), gas gain $2 \cdot 10^4$ (3080 V)



Required wire positioning accuracy within one chamber: 20 μm (r.m.s)
⇒ elaborate chamber assembly procedure.

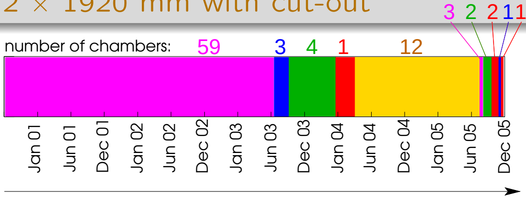
Large-scale MDT Chamber Production

88(+13 reserve) MDT chambers produced at MPI during 2001 - 2005.

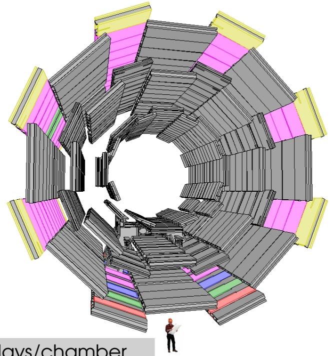
BOS chambers (Barrel Outer Small):

6 layers, 3920 mm length, various widths:

- 62 × 2160 mm
- 4 × 1920 mm
- 6 × 1440 mm
- 4 × 1200 mm
- 12 × 1920 mm with cut-out



production date of 88 BOS MDT chambers (after replacement of 10 with reserve chambers)



6 days/chamber

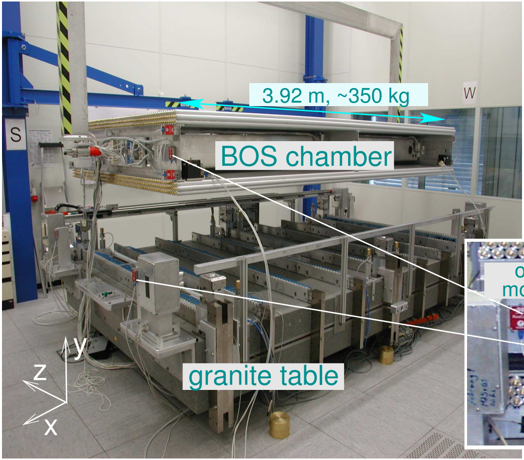
(excluding time for the development and assembly modification)

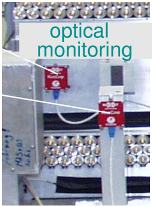
10 of 13 additional reserve chambers were needed as the replacement:

- 4 chambers had multilayers detached from the support frame.
  (Too large global deformations of multilayers after re-gluing.)
- 6 chambers had tubes with cracks in the end-plug material.

MDT Chamber Assembly in the Cleanroom

Layers of drift tubes are glued successively to the support frame.





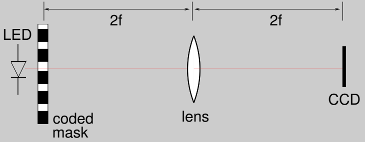
Assembly procedure for each tube layer:

- Wire positioning within the tube: 7 μm.
- Tube positioning on the combs: 5 μm, glue distribution on the tubes.
- Support frame lowered onto the table, 6 positioning towers allow for the positioning accuracy of 5 μm.
- Gravitational chamber deformations compensated using pneumatic actuators.

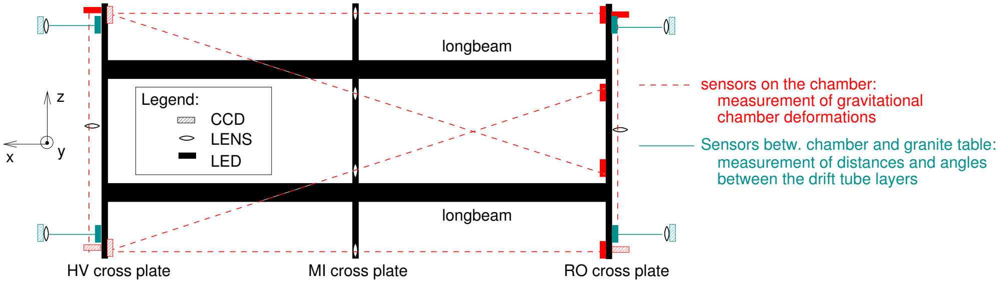
- Mechanichal and optical position monitoring with precision of 10 μm. ⇒

Optical Monitoring of the Chamber Geometry

Optical monitoring system "RASNIK":

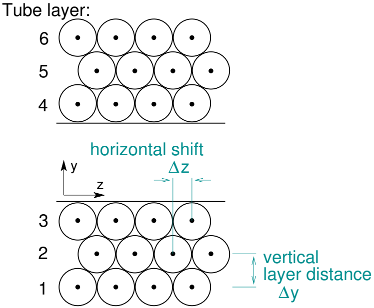


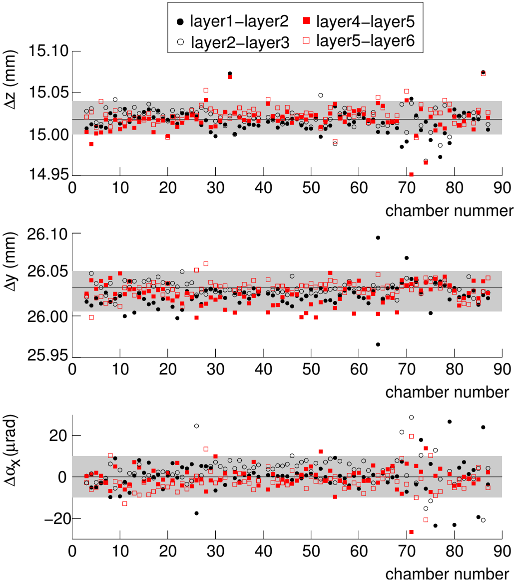
RASNIK lines-of-sight on the chamber and on the assembly table: (top view)



Geometry Monitoring: Neighbouring Tube Layers

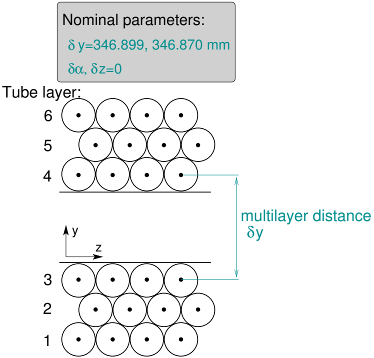
Nominal parameters:
Δz=15.018 mm
Δy=26.034 mm
Δα=0

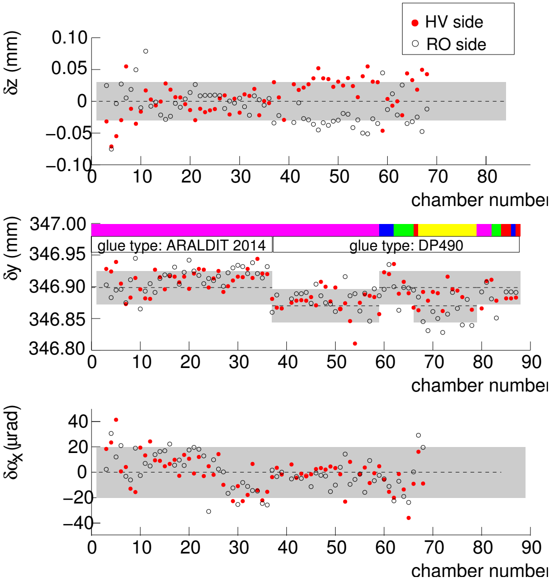




- $\sigma(\Delta z)=9\ \mu m$, $\sigma(\Delta y)=12\ \mu m$, $\sigma(\Delta\alpha)=5\ \mu rad$

Geometry Monitoring: Multilayer Parameters

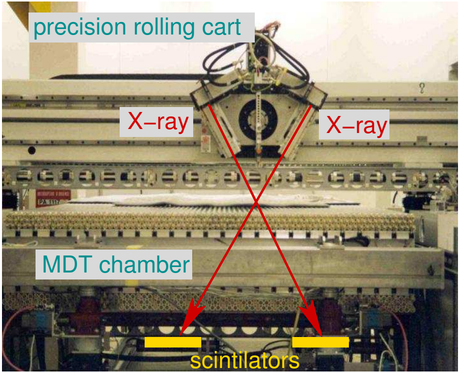




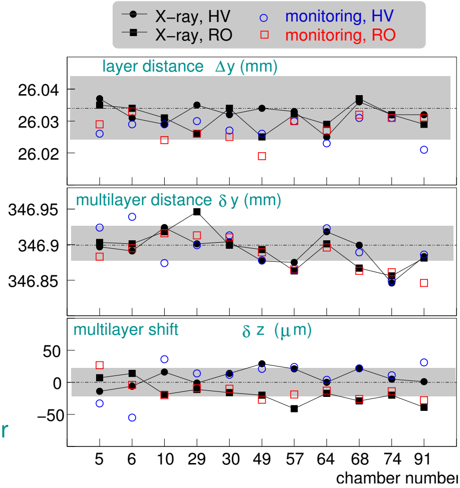
- $\sigma(\delta z)$=20 μm, $\sigma(\delta y)$=20 μm, $\sigma(\delta\alpha)$=30 μrad

Comparison with the X-Ray Measurements

- 15% of chambers measured at the X-ray tomograph at CERN.
- Precision of the wire measurement: 2 μm (stat.) + 2 μm (syst.).

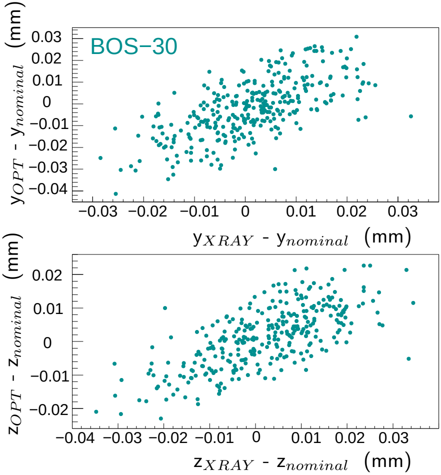


measurement of the intensity along the chamber



Reconstructed Wire Positions

- optical monitoring parameters + wire position within each tube = reconstructed wire position (y_{opt}, z_{opt}) within one chamber



All X-rayed chambers:

$\sigma(P_{Xray} - P_{opt}) = 11.3\ \mu m$

$\sigma(P_{Xray} - P_{nominal}) = 13.8\ \mu m$

$\sigma(P_{opt} - P_{nominal}) = 16.5\ \mu m$

$\Downarrow$

Accuracy of the wire positions using optical monitors:

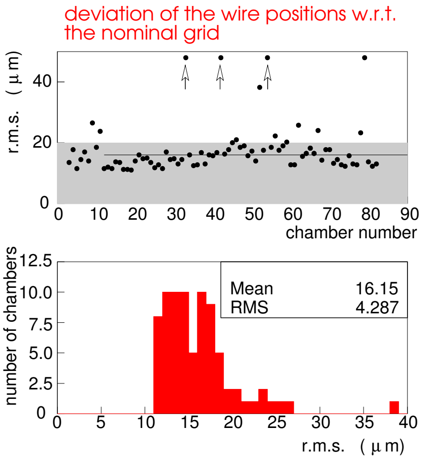
$\sigma_{opt} = \sigma(P_{opt} - P_{true}) = (11 \pm 1)\ \mu m$

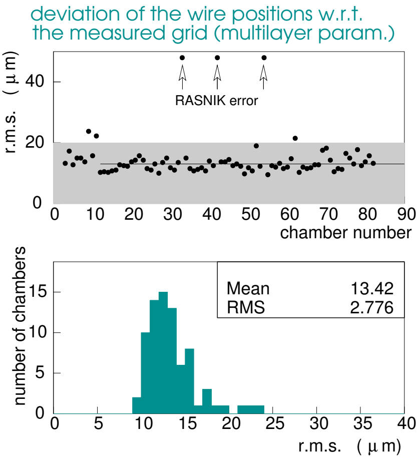
- optical monitoring sensitive to the deviations of geometry

Mechanical Chamber Accuracy

ATLAS software allows for the implementation of the measured multilayer parameters, instead of assuming the nominal geometry.

⇒ improving the knowledge of wire positions using optical monitoring

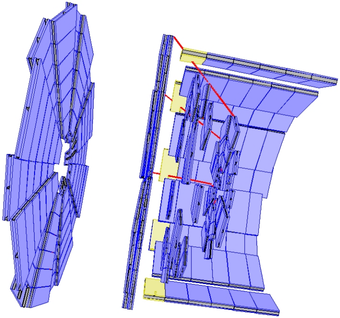


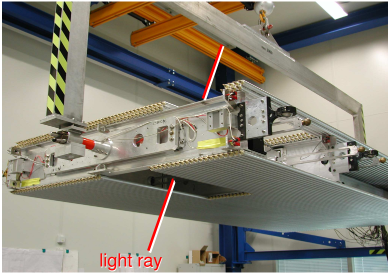


Mechanical chamber accuracy is well within the tolerances.

Cut-out Chambers

Cut-outs at the barrel ends, to make way for optical alignment rays.

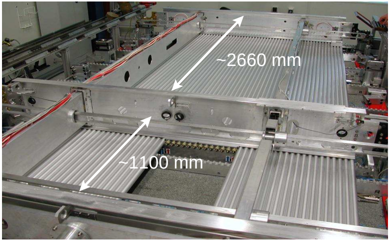




Significant changes in the chamber design and assembly procedure.

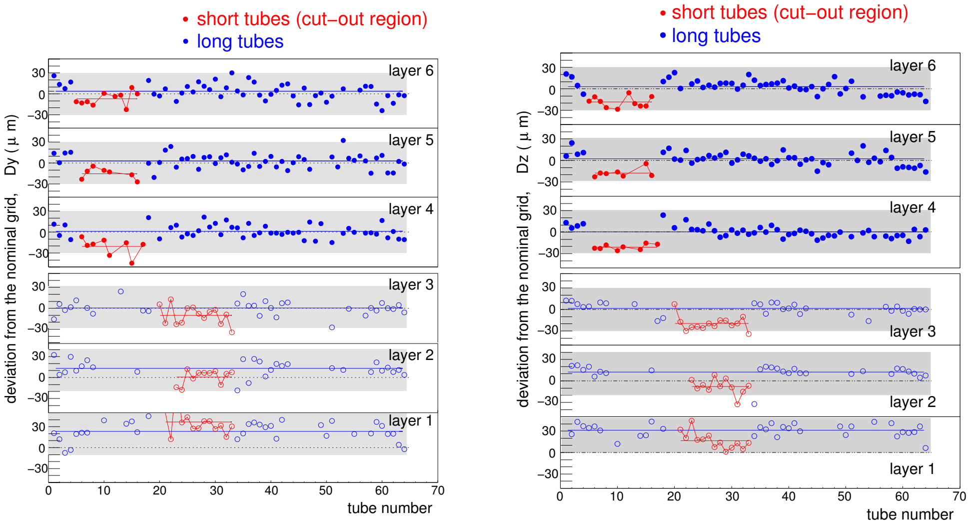
After one year of development and tests, 3 dummy chambers...

Final design ⇒



- MI cross plate not in the middle.
- Positioning towers moved.
- New RASNIK masks and lenses.
- Position of short tubes very sensitive to gravitational sag compensation.

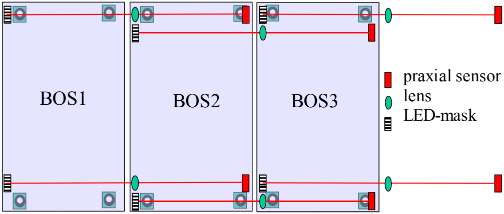
Mechanical Accuracy of the Cut-out Chambers

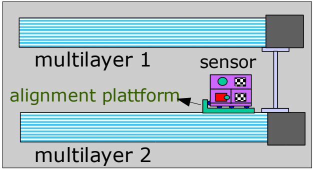


Cut-out region is only slightly shifted w.r.t. the long tubes, within the strict tolerances.

Positioning of Alignment Platforms

Praxial sensors for optical monitoring of chamber positions within one barrel layer:

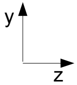




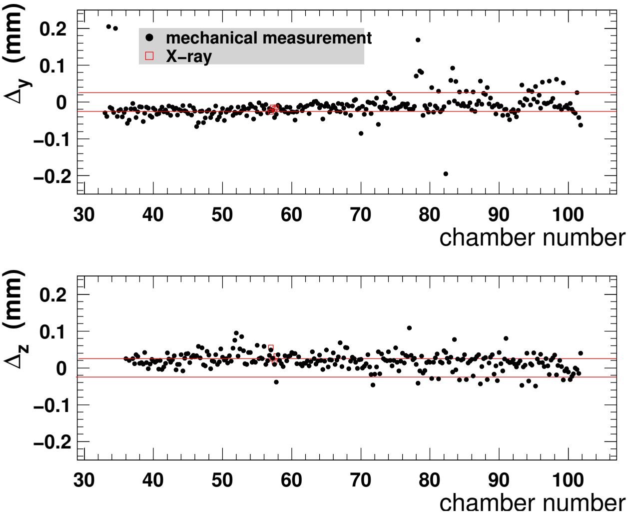
Alignment platforms are glued to the inner layer of drift tubes.

Measurement of the platform positions

- Precision:
  50µrad / 5µm in θ_x, θ_z and y
  100µrad / 10µm in θ_y and z



Platform Positioning Accuracy



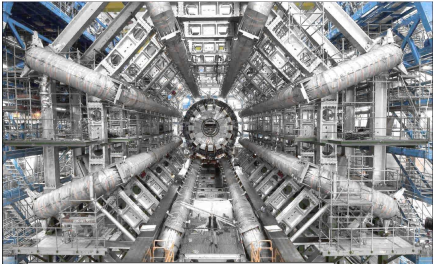
Spread of the measured platform positions exceeds the nominal values by up to a factor of two.

⇒ Position measurement important in order to correct for the deviations.

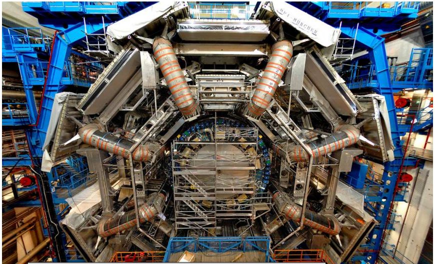
(Not) The End

Challenging longtime production of Monitored Drift Tube Chambers for the ATLAS detector has been successfully completed.

- Optical monitoring during the chamber assembly and the measurements at the X-ray tomograph at CERN certify the mechanical chamber accuracy.
- Installation into the ATLAS detector is well under way. (All 88 BOS chambers already installed.)



ATLAS muon spectrometer (August 2005)



ATLAS muon spectrometer (October 2006)