Test, Integration and Commissioning of Monitored Drift Tube Chambers for the ATLAS Barrel Muon Spectrometer

HEP 2005, Lisboa

23rd July, 2005

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Overview

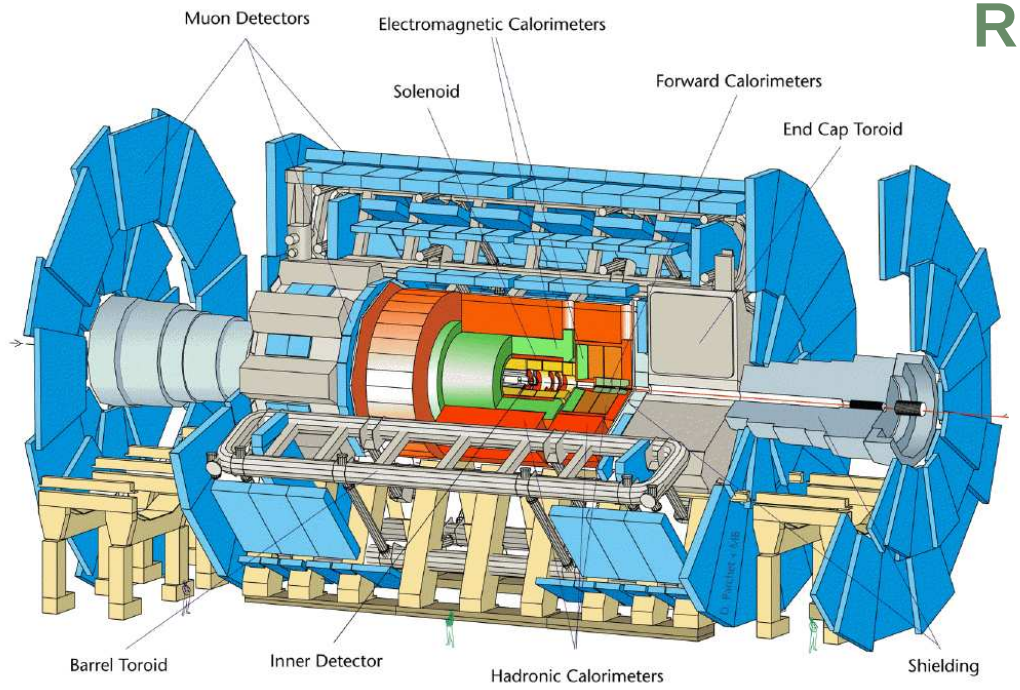
- Introduction
- Tests and Commissioning at the Production Site
- Integration and Commissioning at CERN
- Summary and Outlook

Introduction

Introduction (1)

The ATLAS Muon Spectrometer

- Physics Requirement: $\Delta p_T / p_T < 10\%$ up to 1 TeV
- Stand-alone Operation

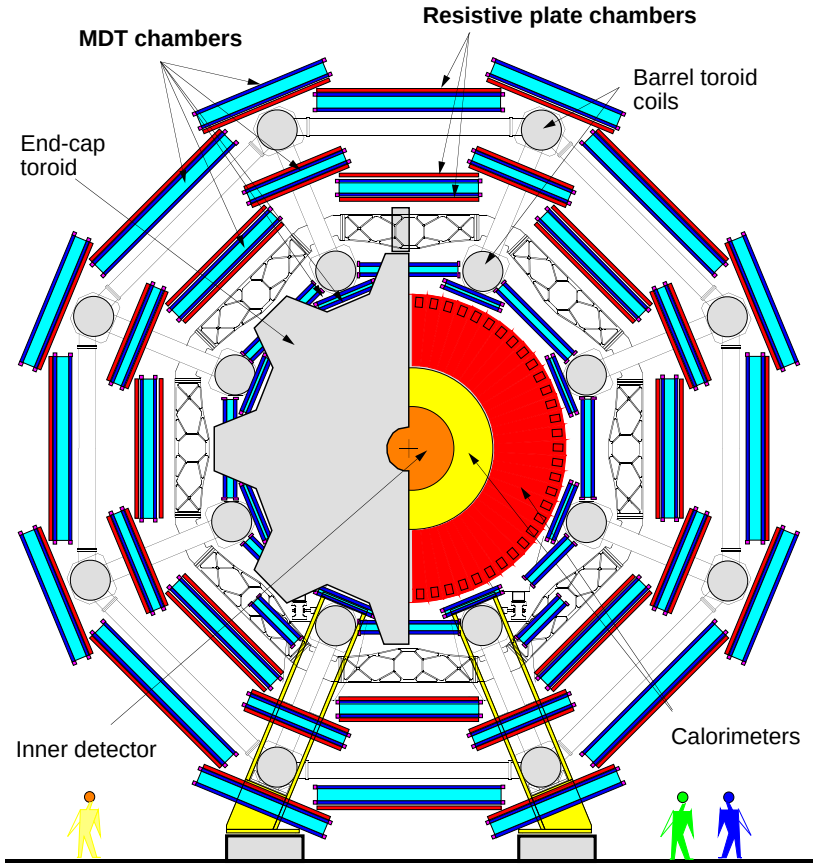


Realization

- Air Core Toroid Magnet System
  - Dimensions: 45 m $\times$ 25 m
    - Area: > 5500 m^2
    - 788 Trigger Chambers
  - 1206 Precision Chambers

Introduction (2)

The ATLAS Barrel Muon Spectrometer



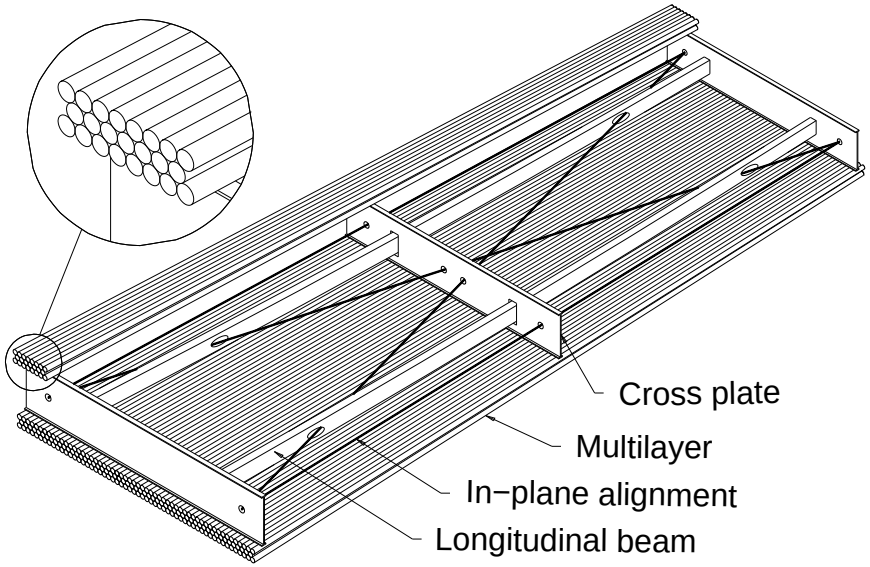
- **3 Point Sagitta Measurement**
  50 μm point resolution needed (including alignment across 10 m)
  - 576 Trigger Chambers: Resistive Plate Chambers (RPCs)
  - 656 Precision Detectors: Monitored Drift Tube (MDT) Chambers

  88 MDT Chambers for outer-most (BOS) stations built at the Max-Planck-Institut für Physik (MPI) and Ludwig-Maximilians-University (LMU) Munich

Introduction (3)

Monitored Drift Tube Chambers

- 2 multilayer of 3 (or 4) drift tube layers
- Support frame of aluminum
- Chamber size: 1-11 m^2



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

Test and Commissioning at the Production Site

At the Production Site...

At MPI

- Wire positions (during construction)
- Layer / multilayer parameters (during construction)
- Inplane alignment monitor calibration (during construction)
- Alignment platform positions
- Leak test
- Wire tension measurement
- Wire resistance measurement
- Chamber test (at storage hall)
- Longterm leak rate measurement (at storage hall)

88 of 88 BOS MDT chambers built

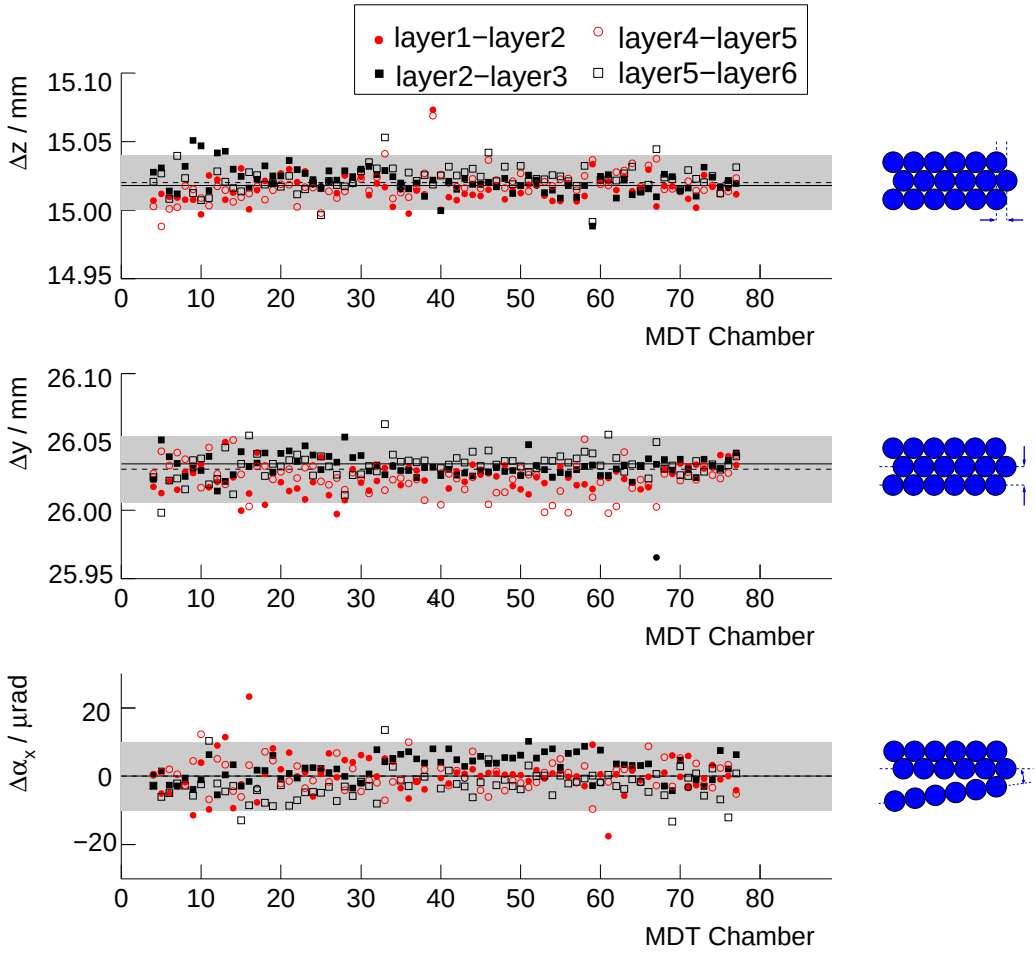
At LMU

- Wire resistance measurement
- Leak rate measurement
- High voltage test
- Front-end electronics test / noise test
- Cosmic Ray Calibration
  - Chamber commissioning (complete functional test, tube response, homogeneity)
  - Chamber calibration (wire positions, geometry)

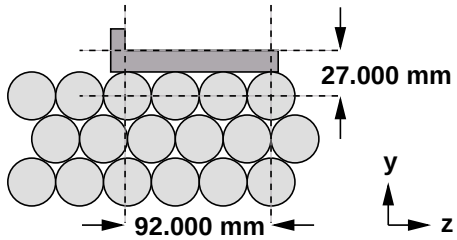
71 BOS MDT chambers commissioned

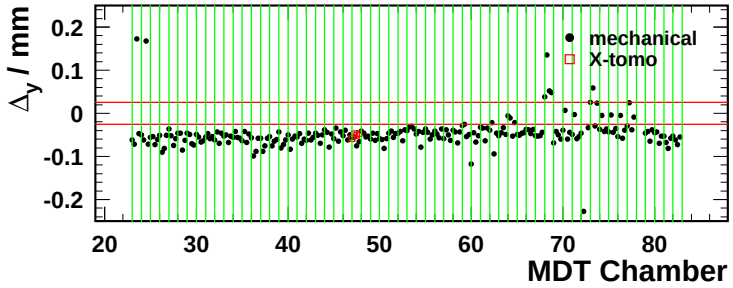
Measurements at MPI

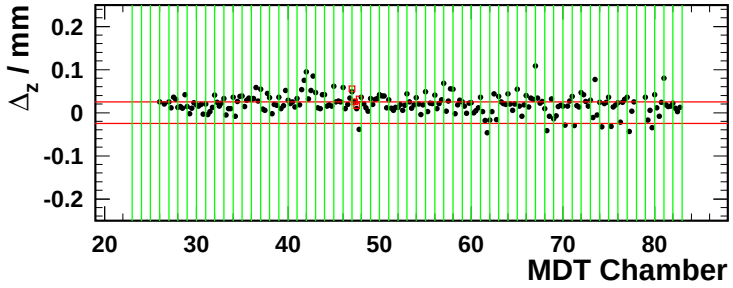
Inter-Layer Parameters



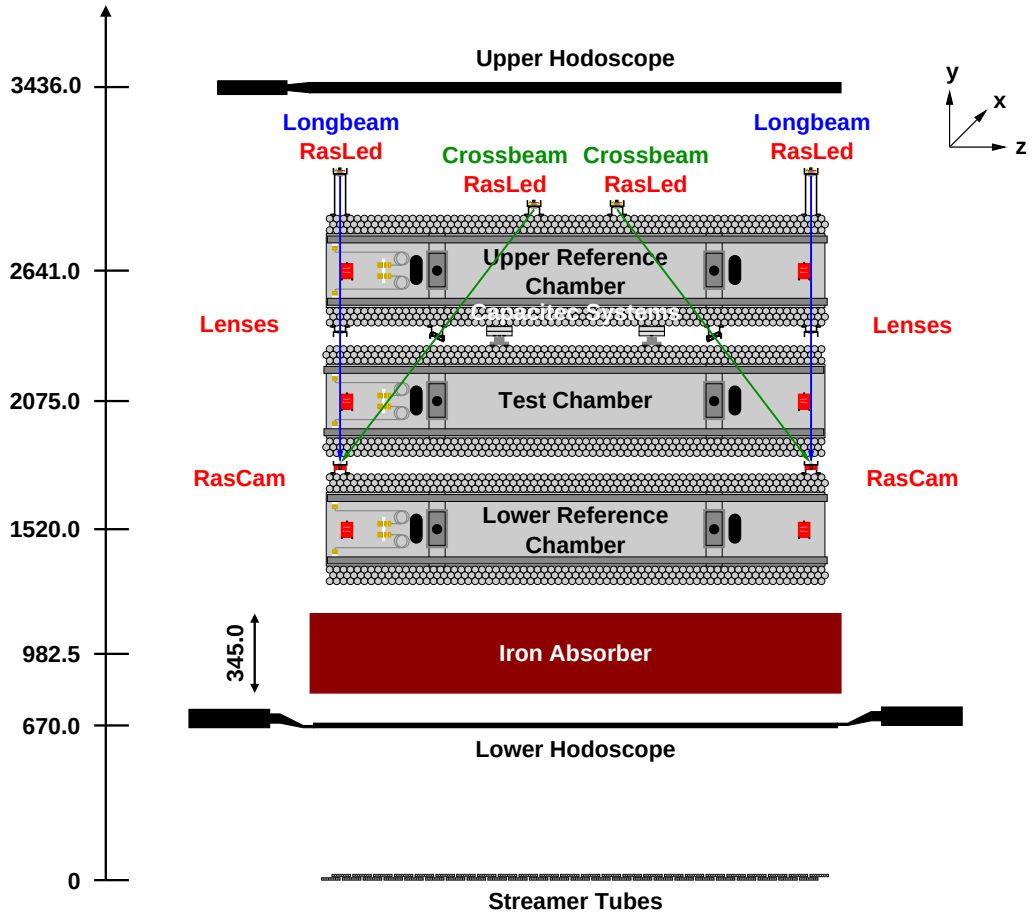
Alignment Platform Positions







The LMU Cosmic Ray Facility



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

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

Setup

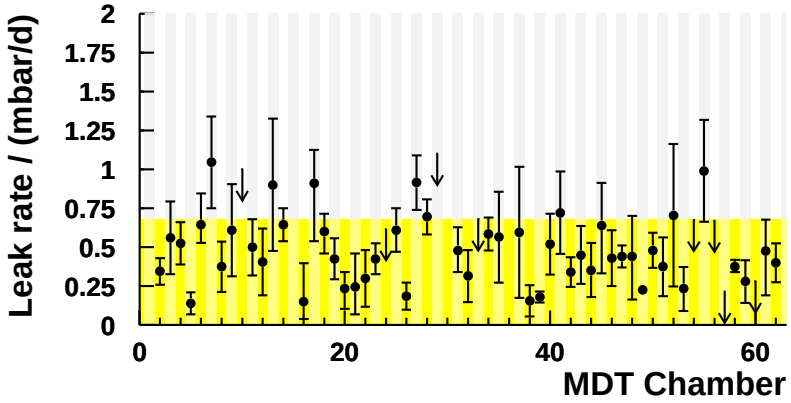
- Cosmic Ray trigger with full chamber coverage (8.7 m^2)
- Reference tracking with 2 MDT chambers
- Optical and capacitive monitoring of relative chamber positions ($< 5\ \mu$m precision)

Methods

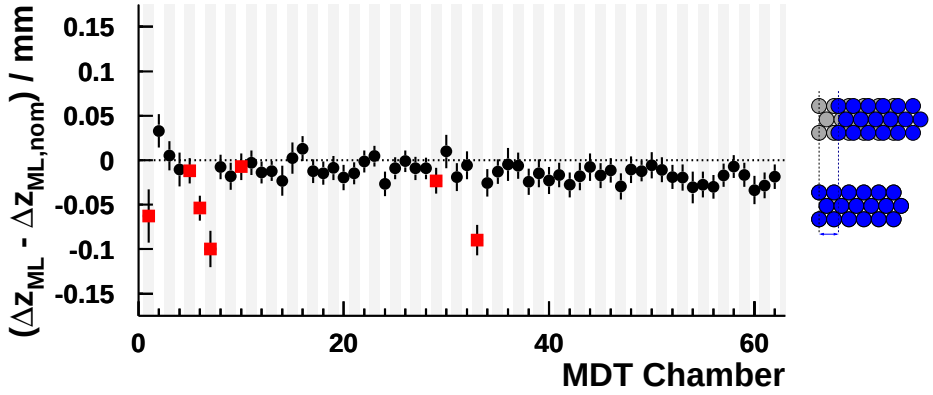
- Chamber Response
  - Measure drift time spectra
  - Derive parameter set from fit to rising/trailing edge
- Wire position measurement
  - Compare measured drift radius with prediction from reference MDTs
  - Precision: $\mathcal{O}(10\mu\text{m})$

Results from LMU

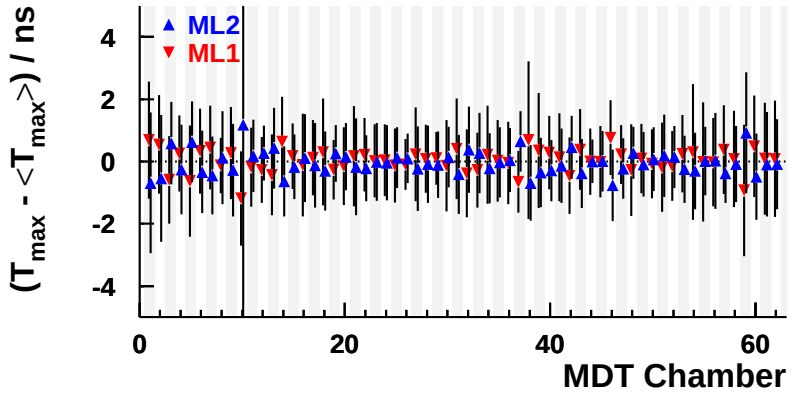
Leak Rate



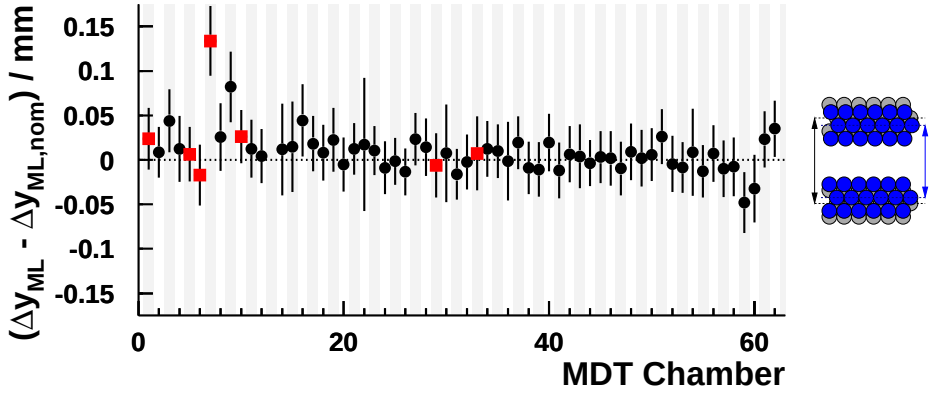
Multilayer z-Shift (HV side)



Drift Properties / Homogeneity



Multilayer y-Distance (RO side)



Integration and Commissioning of ATLAS Barrel Outer Small Muon Stations at CERN

At CERN. . .

Integration

Completion of MDT chamber and mating with trigger chamber

- Install and test additional sensors
- Mount RPC trigger chamber

Commissioning

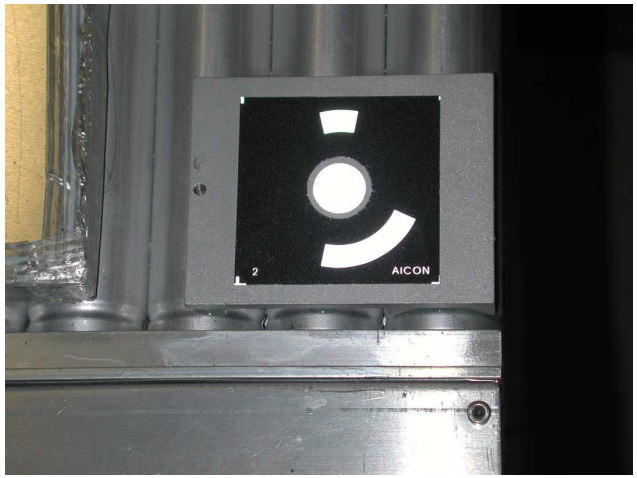
Guarantee required performance of MDT chamber

- Leak test
- HV test
- Noise test
- Cosmic Ray test

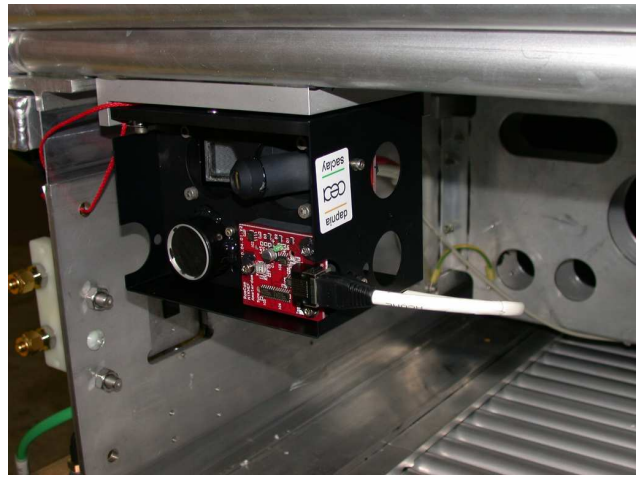
Early installation of 4 BOS stations in February/March 2005

Integration (1)

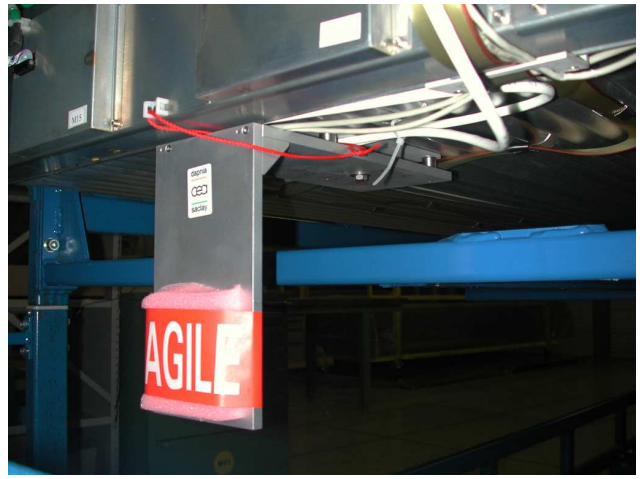
Survey Targets



Alignment Sensors



B-Field Sensors



Integration (2)

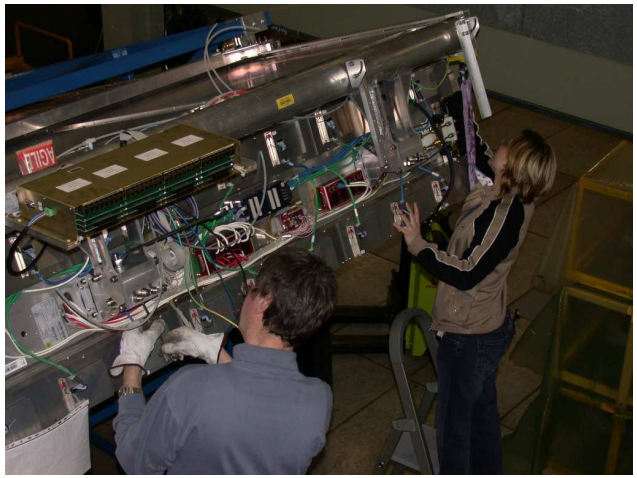
Integration of the RPC Trigger Chamber and MDT Chamber in Common Support Frame

Integration (3)

Rotation of Muon Station

Sag Compensation

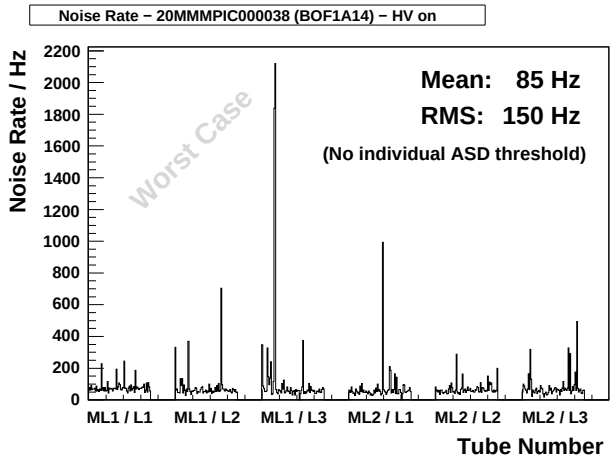
MDT Alignment



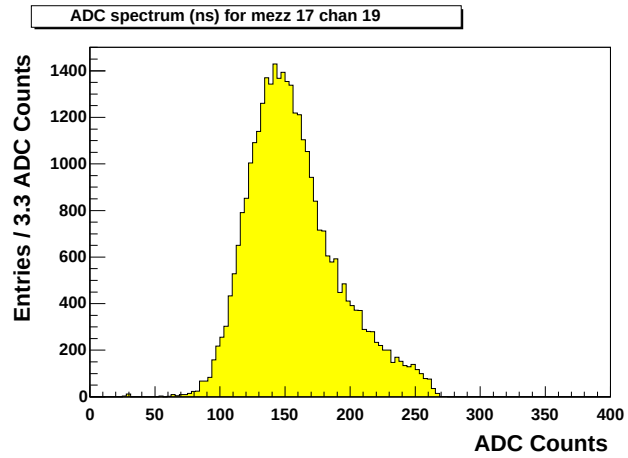
Fully Integrated Muon Station

Commissioning — Results

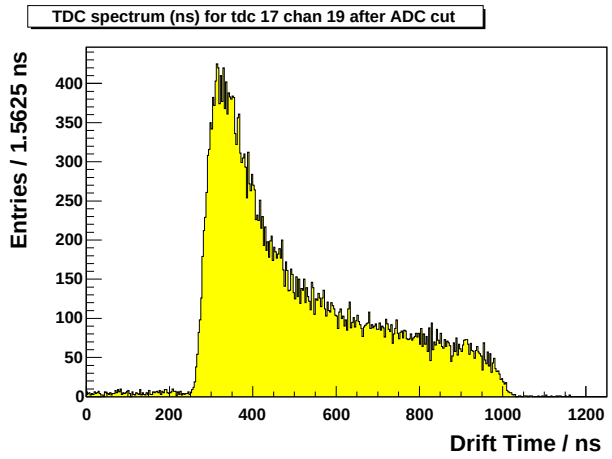
Noise Test



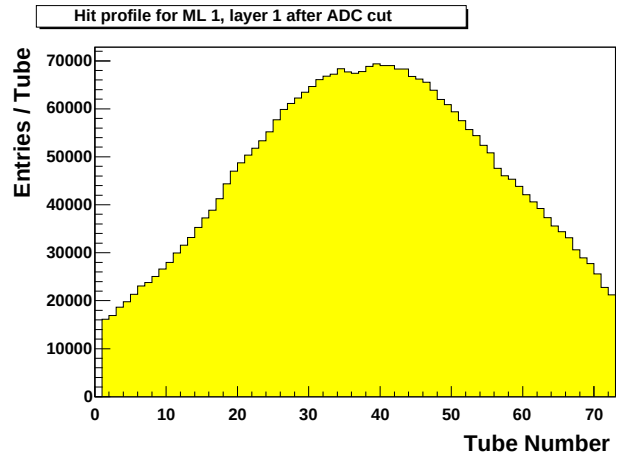
ADC Spectrum



TDC Spectrum



Hit Map



All 4 early installation BOS MDT chambers passed all tests

Summary and Outlook

Summary & Outlook (1)

Stringent tests at production sites and at CERN ensure required performance of ATLAS MDT chambers

- 88 BOS MDT chambers built and tested at MPI
- 71 MDT chambers commissioned and calibrated at LMU so far
  - Uniform response of all chambers
  - Consistent chamber geometry
- First BOS muon stations successfully integrated and tested at CERN
- 4 BOS muon stations successfully installed in ATLAS

. . .

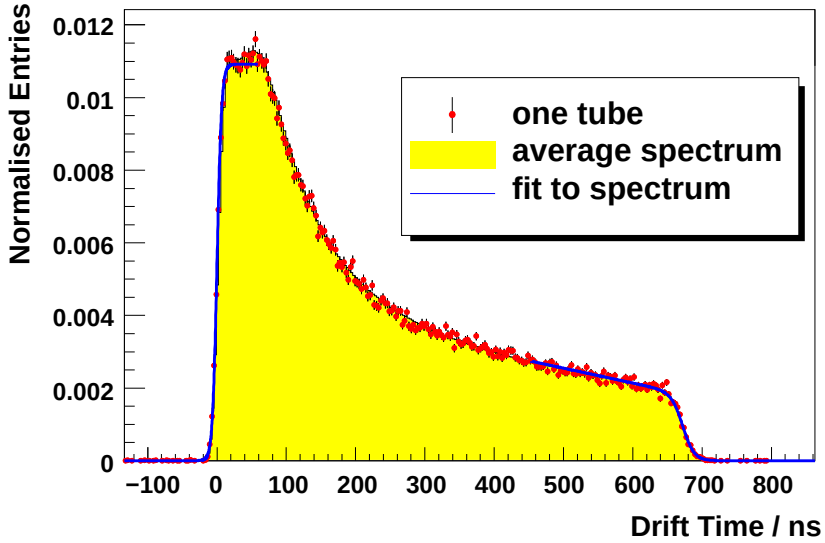
- Integration of remaining 84 BOS muon stations was resumed last week at CERN
- Installation starting in September 2005

Summary & Outlook (2)

Thank you to all who helped building, testing, integrating and installing, especially S. Leber, U. Schorer, R. Sedlmeyer, H. Wetteskind and J. Zimmer, U. Landgraf and S. Zimmermann

Additional Slides

Drift Time Spectra



Leading edge

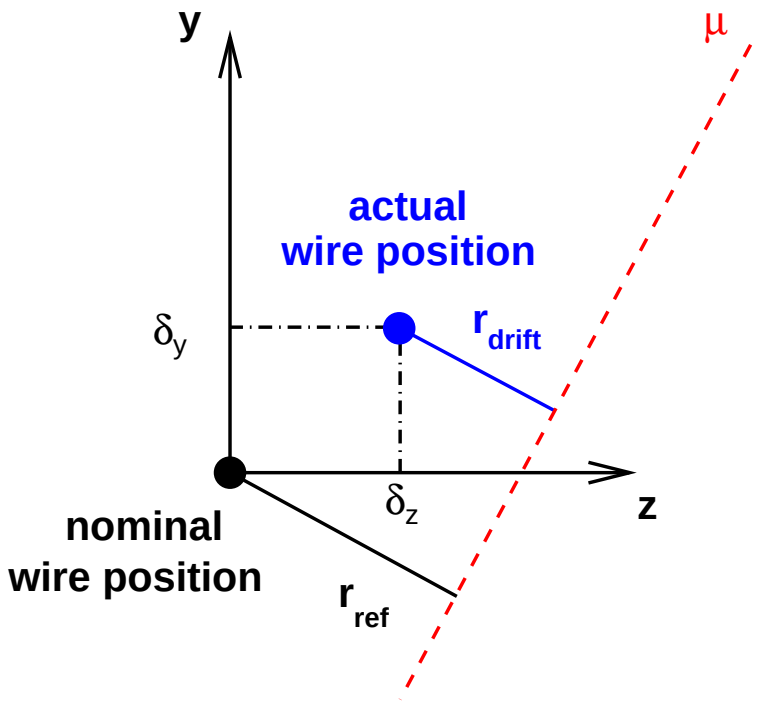
$$F(t) = p_0 + \frac{A_0}{1 + \exp\left(\frac{t_0 - t}{T_0}\right)}$$

Trailing edge

$$G(t) = p_m + \frac{\alpha_m \cdot t + A_m}{1 + \exp\left(\frac{t - t_m}{T_m}\right)}$$

Back

Wire Position Meas.

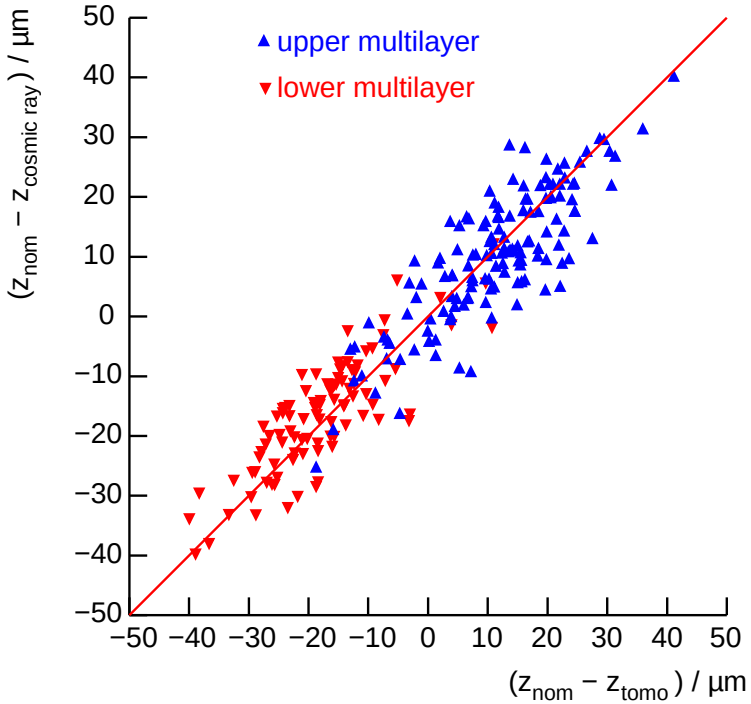


$$y = y_0 + m^{-1} \cdot z$$

- Wire positions derived from comparison of predicted drift radius r_{ref} (weighted average reference tracks) and measured drift radius r_{drift} in the test chamber
  $\Delta r = r_{drift} - r_{ref} \approx \delta_z - m \cdot \delta_y$
- δ_y from linear fit of Δr vs. m
- δ_z from $\langle \Delta r' \rangle = \delta_z - \langle m \rangle \cdot \delta'_y \approx \delta_z$ ($\Delta r'$ with corrected y pos.)
- Grid scaling factor γ:
  $z(n) = z_0 + \gamma \cdot g_{nom} \cdot n$

Back

Performance



BOS5A08
(Exceptional chamber with known production error)

Comparison of measurements of Cosmic Ray Facility with X-Ray Tomograph gives accuracy

- Perpend. to chamber plane
  - δ_y: 25 μm
  - $\delta_{y,\ Layer}$: 4.5 μm
  - $\alpha_{x,\ Layer}$: 17 μrad
- In chamber plane
  - δ_z: 8 μm
  - $\delta_{z,\ Layer}$: 2 μm
  - g: 0.15 μm
- Agreement with Monte Carlo

Back