



Commissioning and Calibration of BOS/F MDT Chambers at the LMU Cosmic Ray Facility

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- Programme
- The LMU Cosmic Ray Facility
- Status and Statistics
- Chamber Commissioning
- Chamber Calibration
- Summary
- Near Future Plans



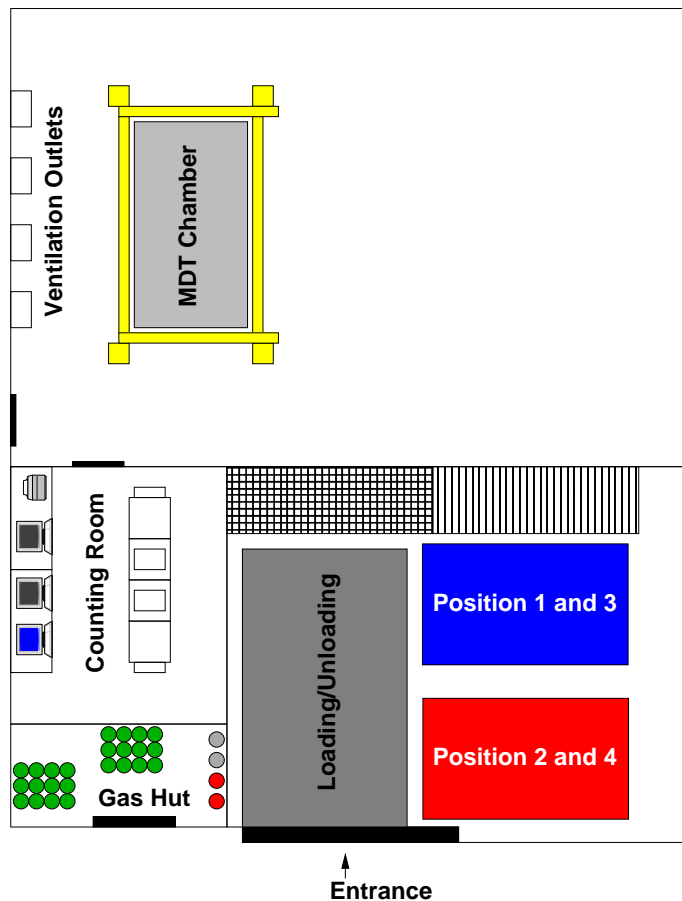
The LMU Cosmic Ray Facility



Programme

Commission and calibrate 88 BOS/BOF chambers produced at MPI (2×3 layers, 72 tubes per layer, $3.8 \text{ m} \times 2.2 \text{ m}$)

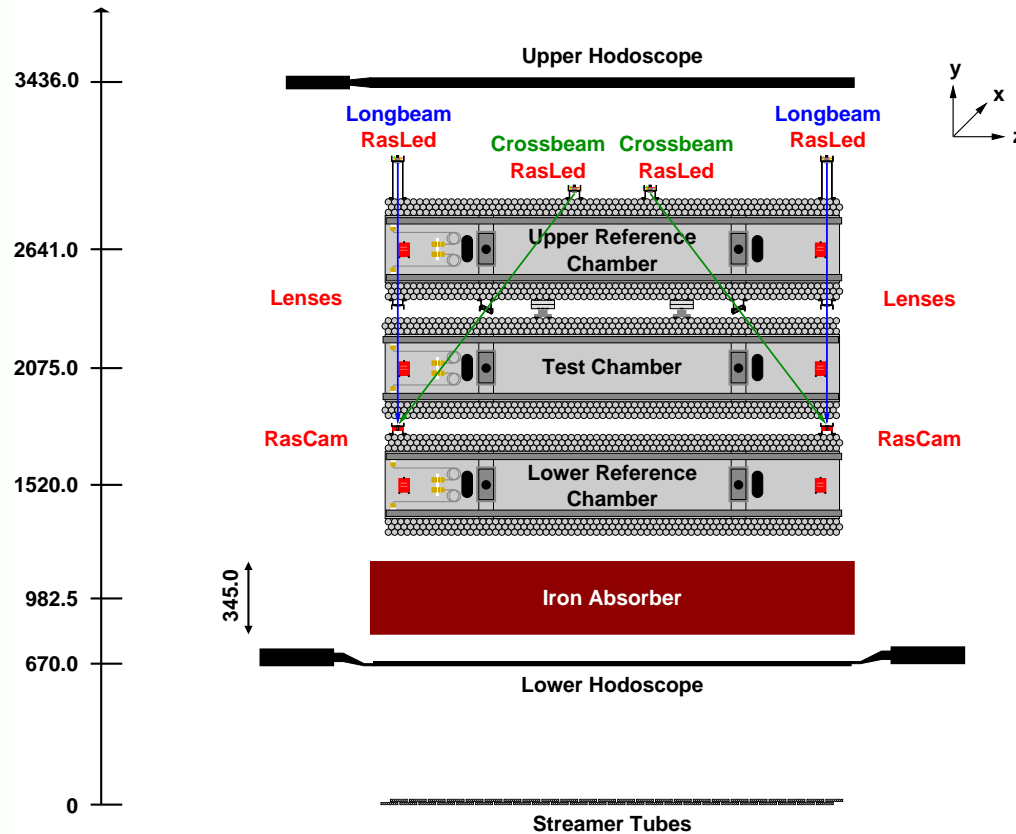
- Measure wire resistance
- Fix leaks / Measure leak rate
- Complete chamber (ground pins, Faraday cages)
- Equip with electronics (currently hedgehog cards only)
- HV Test
- Commission chamber (tube response, homogeneity)
- Calibrate chamber (wire positions, geometry)



- Main hall
 - 13 m × 9 m × 10 m
 - Stabilized to $(20 \pm 1) ^\circ\text{C}$
(but usually: $\pm 0.2 ^\circ\text{C}$)
- Anteroom
 - 9 m × 7 m × 10 m
 - Space for 3 (4) chambers
 - Stabilized to $(20 \pm 2) ^\circ\text{C}$
 - Chamber preparation
 - Leak rate measurement



Setup (1)



- 2 Scintillator hodoscopes
- Full chamber coverage (8.7 m²)
- 5 segments along tubes
- < 800 ps time resolution
- 7.5 cm track resolution along tube
- Iron Absorber ($\Rightarrow E_{\mu} > 600$ MeV)
- Streamer tubes (energy cut based on multiple scattering)
- 2 Reference chambers certified by X-Ray tomograph
- Optical and capacitive alignment monitors (< 5 μ m precision)
- 70 Hz trigger rate
15-25 M events / chamber
- Test chamber can be moved





Status and Statistics



Status Summary

- Begin of series test: 18.09.03
(Chambers with final VA gas system)
 - Rate: 1 chamber per week (since 11.11.03)
 - 25 chambers measured (4 also shifted),
63 chambers left
 - 24 chambers analyzed (Status of 23.06.04)
- Last chamber delivery to CERN: June 05
- Switch to 2 chambers per week in October

- 3 broken wires (BOS2C16, BOS3C04, BOS3C06)
- 1 broken endplug (BOS3C04)
- 8 endplugs with cracks in Noryl (plug batch PJNR014)
(4 × BOF1A12, BOF1A14, BOS5A02, BOS5A10, BOS5A16)
- 1 leaking tube (BOS2C16)

N.B.: Tubes are/will be disconnected from both, the gas system and the signal/HV hedgehog cards



Commissioning



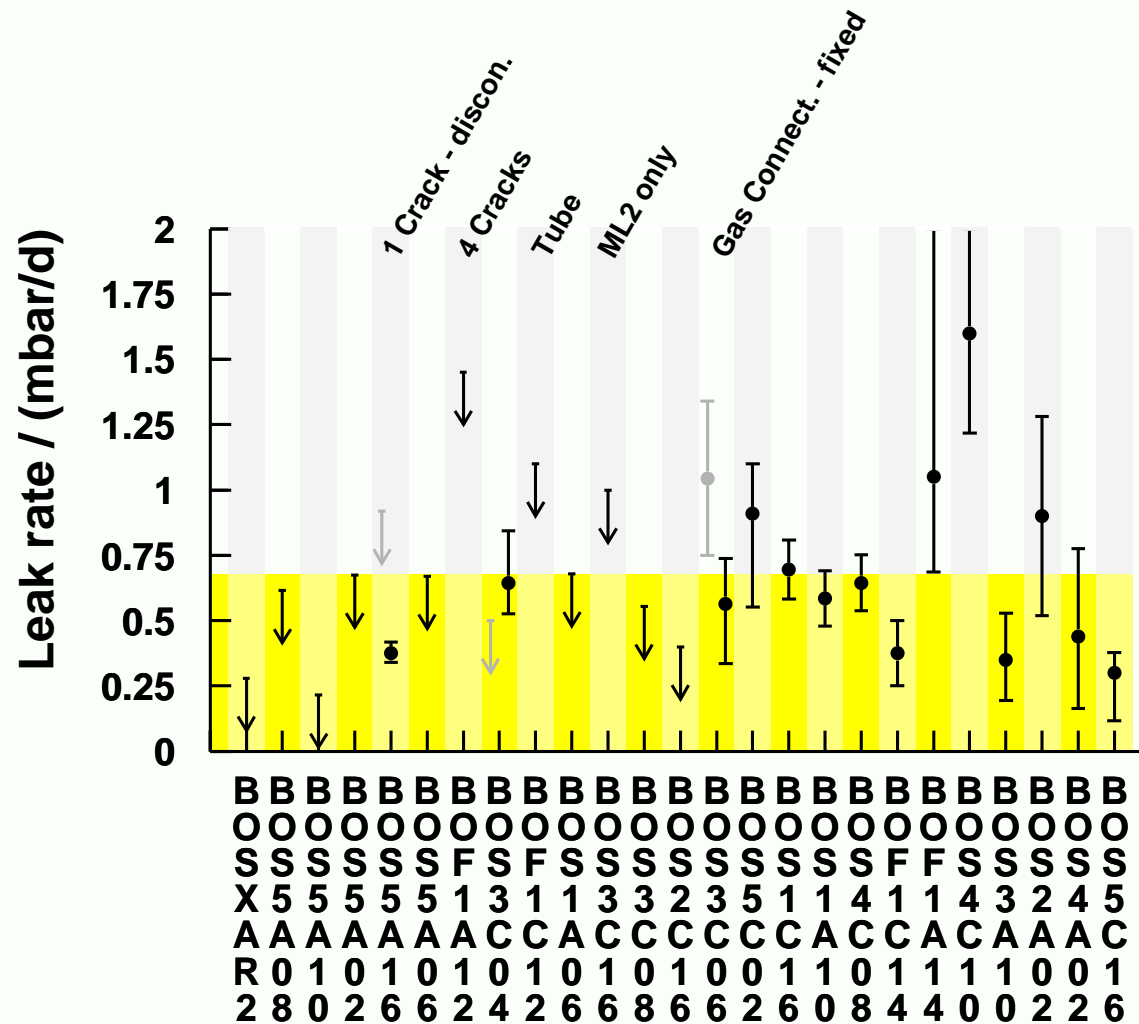
Leak Rate Meas. (1)

- Max. allowed leak rate: 0.68 mbar / d
- Leak test with He leak detector in sniffer mode, Ar/He mixture at 3 bar (2.6 bar Ar, 0.4 bar He)
- Precision pressure measurement for each multilayer separately (MKS Baratron 690A, 0.1 mbar accuracy)
- $\delta T = 0.1 \text{ }^\circ\text{C} \rightarrow \delta p = 1 \text{ mbar}$
⇒ need good temperature measurement / stabilization

Difficult for a chamber of this size!

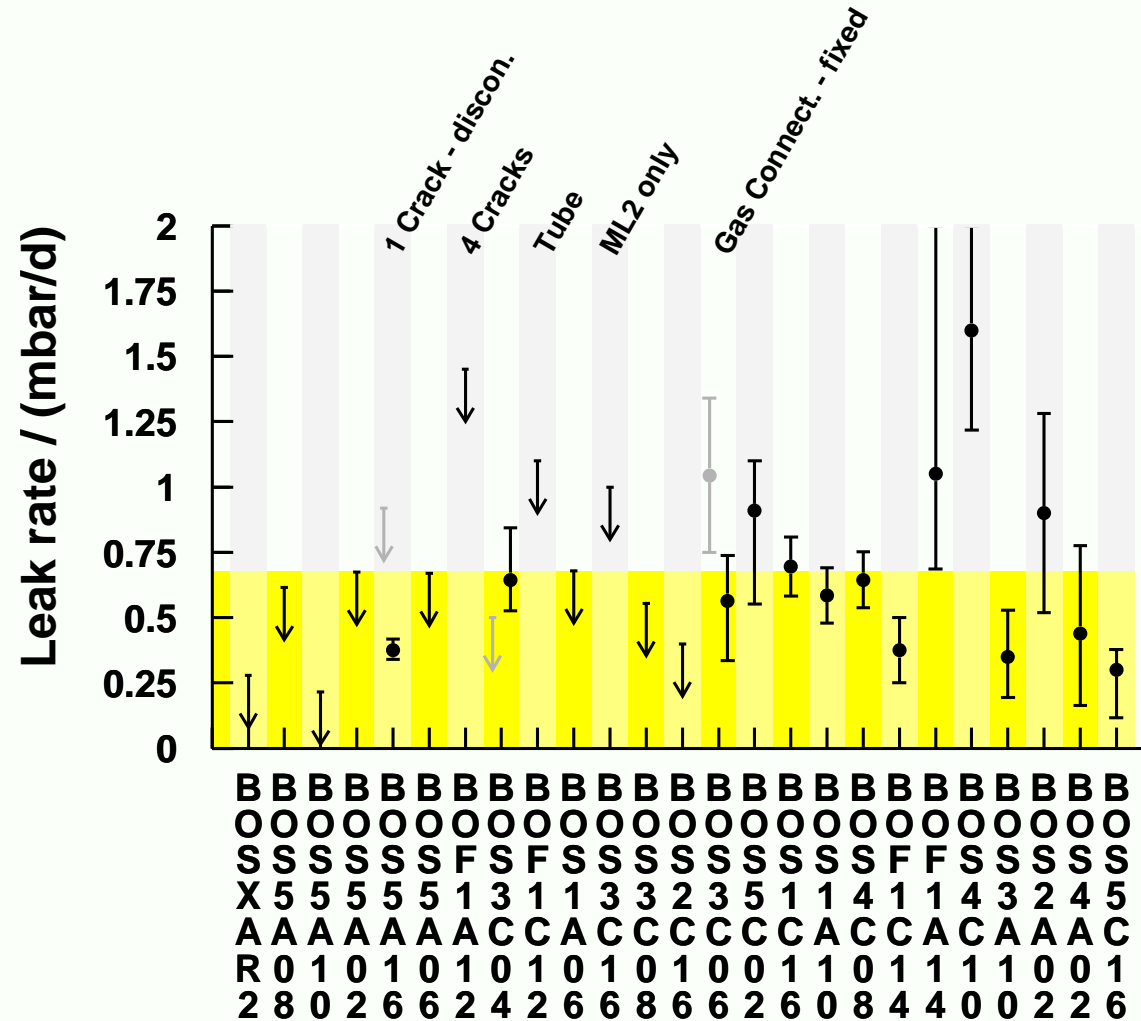


Leak Rate Meas. (2)





Leak Rate Meas. (2)

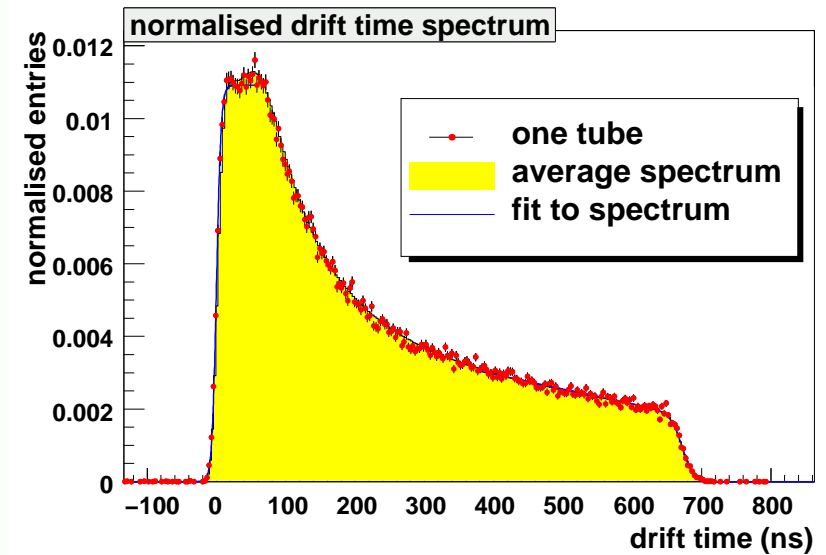


Almost all chambers meet ATLAS requirements



Tube Response

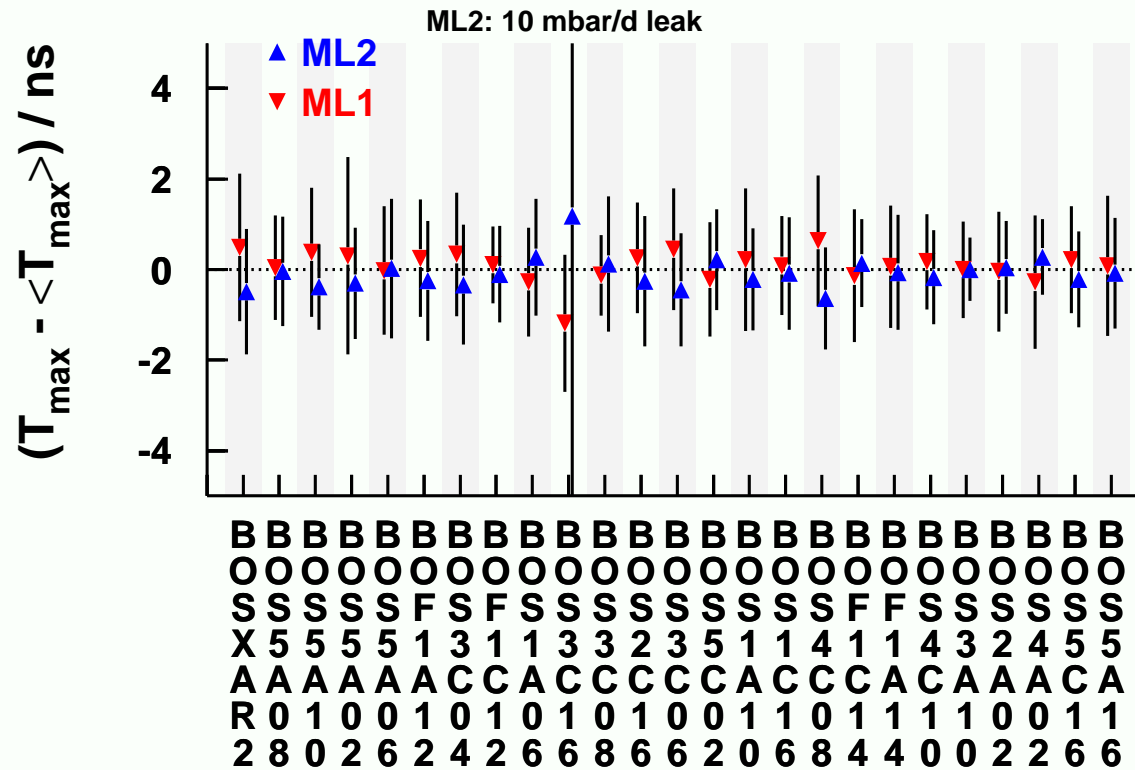
- Measure drift time spectra
- Fit analytic functions at beginning and end
- Parameter set
 - Maximum drift time
 - Rise time
 - Noise level
 - ...





Chamber Homogeneity

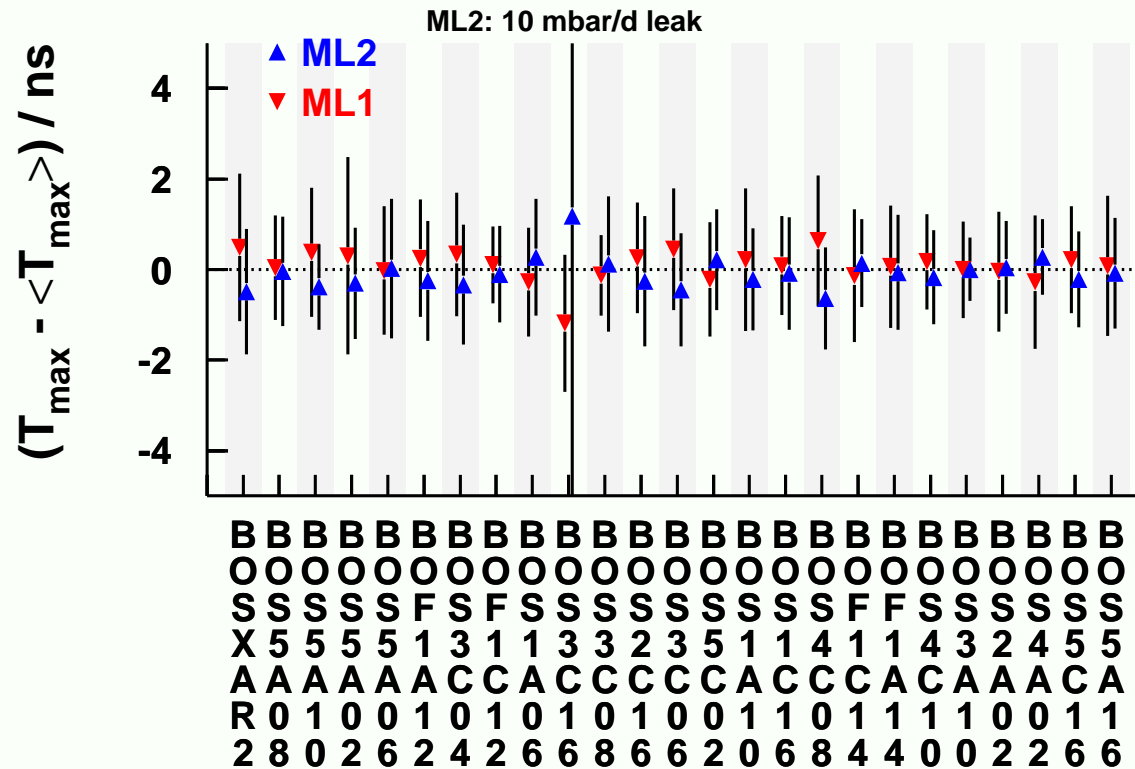
Maximum Drift Time





Chamber Homogeneity

Maximum Drift Time



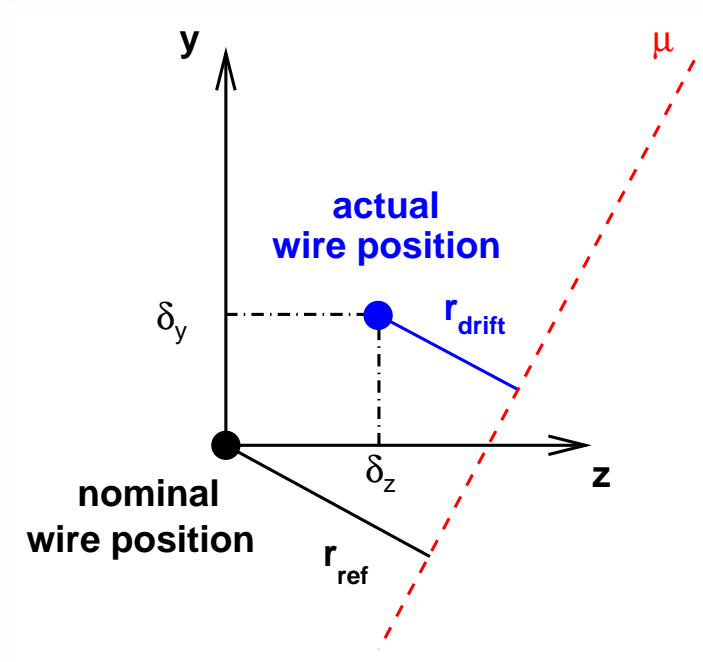
Very good agreement between multilayers



Calibration



Method



- 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

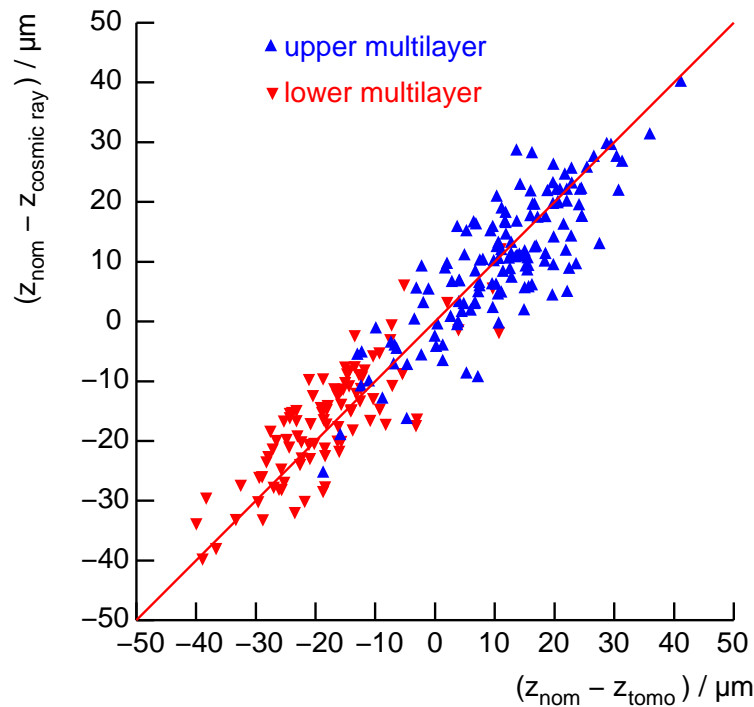
$$\Delta r = r_{\text{drift}} - r_{\text{ref}} \approx \delta_z - m \delta_y$$

- δ_y from linear fit of Δr vs. m
- δ_z from $\langle \Delta r' \rangle = \delta_z - \langle m \rangle \delta_y$ ($\Delta r'$ with corrected y pos.)
- Grid scaling factor γ :
$$z(n) = z_0 + \gamma \cdot g_{\text{nom}} \cdot n$$



Performance

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



BOS5A08

(known production error)

- Perpend. to chamber plane
 - δ_y : $25 \mu\text{m}$
 - $\delta_{y, \text{Layer}}$: $4.5 \mu\text{m}$
 - $\alpha_{x, \text{Layer}}$: $1.7 \cdot 10^{-5}$
- In chamber plane
 - δ_z : $8 \mu\text{m}$
 - $\delta_{z, \text{Layer}}$: $2 \mu\text{m}$
 - g : $0.15 \mu\text{m}$
- Agreement with Monte Carlo



Alignment Platforms (1)

Verify location of the alignment platforms

● Setup

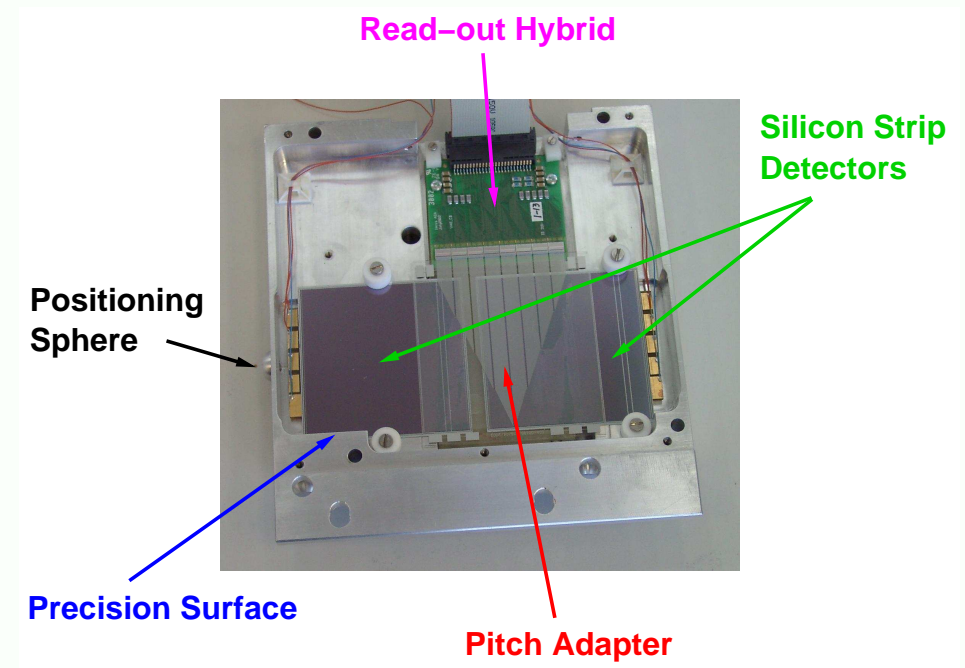
- Silicon microstrip detectors
Size: $2 \times (6.4 \text{ cm} \times 6.4 \text{ cm})$
Pitch: $120 \mu\text{m}$
- Positioning with precision surfaces and spheres
Calibration on reference chambers
- Dedicated scintillator trigger
Increased trigger rate (1 Hz) and angular acceptance

● Method:

Compare hits in silicon detectors with track prediction of adjacent multilayer

● Expected precision: $\approx 30 \mu\text{m}$

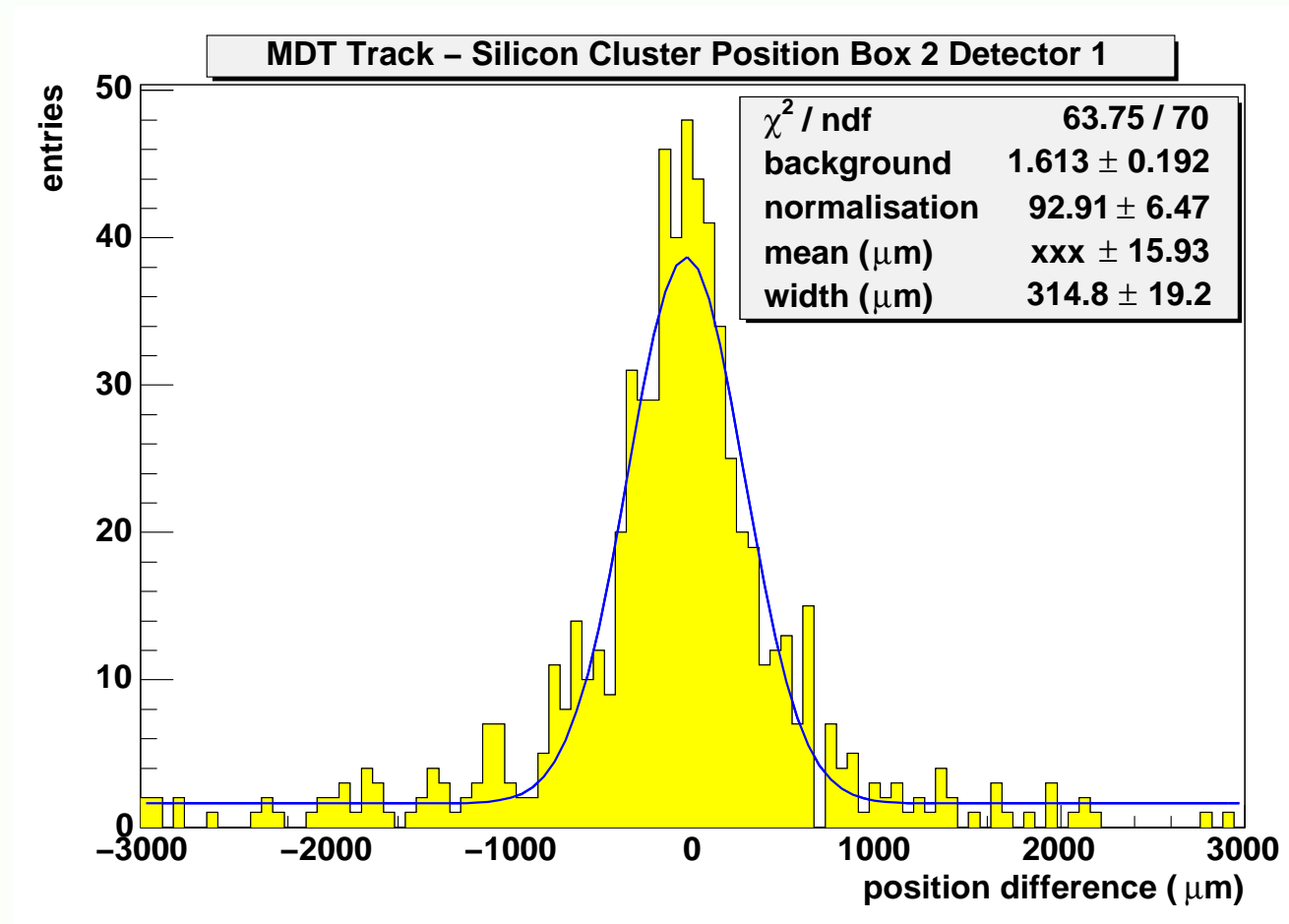
● Lots of problems. . .





Alignment Platforms (2)

A first look at data



Measurement time: 1 day



Summary and Near Future Plans



Summary

- LMU Cosmic Ray Facility operated in series test since September 2003
- Chamber commissioning (leak rate, electronics, homogeneity)
- Chamber calibration (wire positions, geometry)
- Current rate: 1 chamber per week
- 25 Chambers measured so far
- Rate will be raised to 2 chambers per week



Near Future Plans (1)

Final Electronics

Setup currently still uses mezzanine light cards and CSM 0 modules

- Test chambers will be equipped with final electronics, cabling
 - Read-out working
 - Have to combine data streams
 - Test read-out next week

For chambers already measured at the Cosmic Ray Facility

- Check final electronics at MPI storage hall with pulser
 - Injection at HV side
 - Vary input charge to determine homogeneity of channel thresholds



Near Future Plans (2)

Further measurements at the MPI storage hall

- Longterm leak rate measurement
 - Monitor leak rate of 4 MDT chambers concurrently
 - Use on-chamber temperature probes read-out via DCS box
 - First test (2 pressure sensors only, no temperature measurement) successful
 - Some hardware missing, delivery expected end of July
 - Start measurements within the next few weeks



Near Future Plans (3)

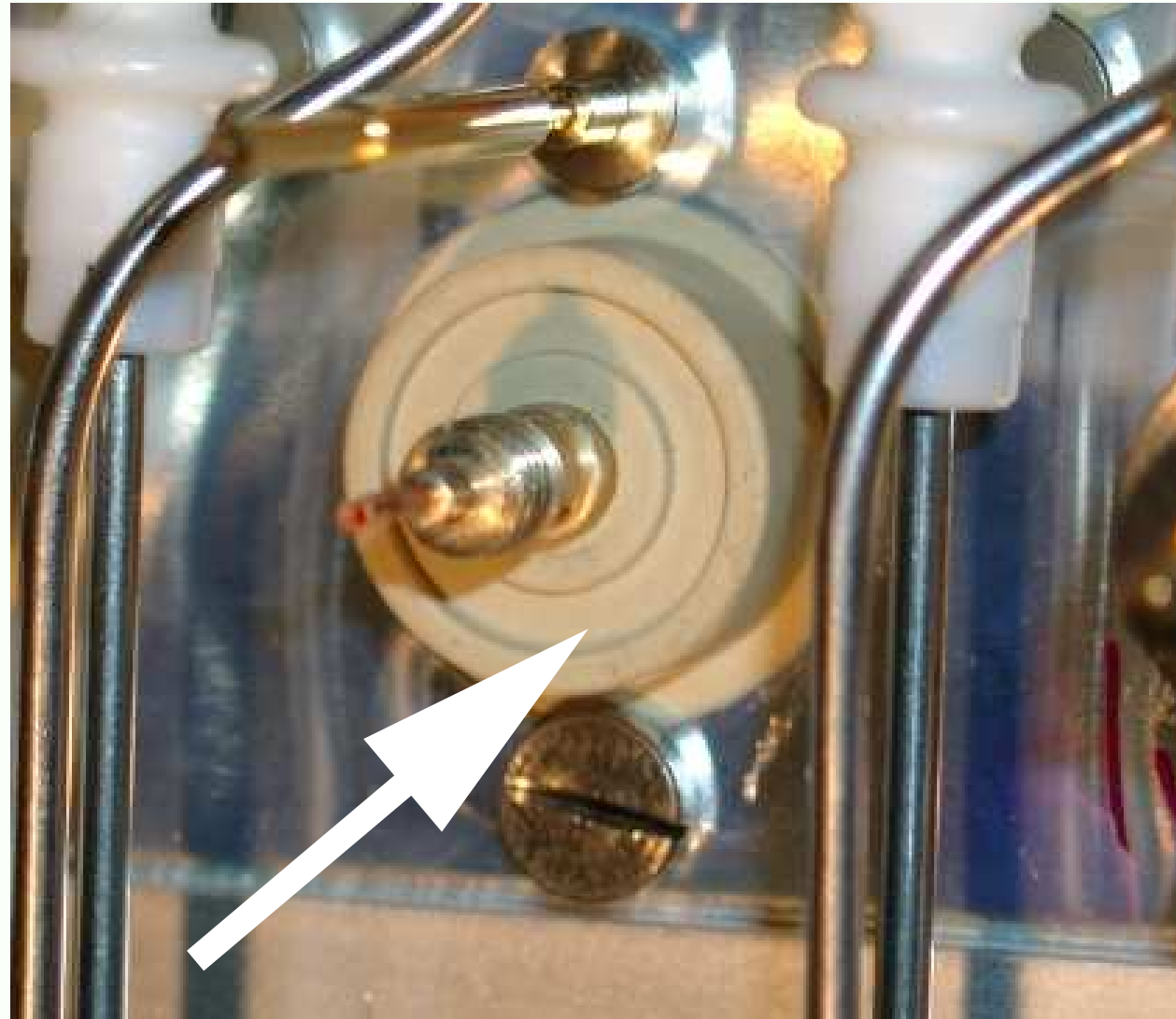
Mobile Cosmic Ray Test Stand

- Forseen as backup chamber test in MPI storage hall
- 2 scintillator hodoscopes
 - Area: $0.3 \text{ m} \times 2.4 \text{ m}$
 - Scintillators read out at both sides
- Trigger logic
- MDT read-out using final electronics
- Gas mixing and distribution system for 4 chambers
- HV system for 4 chambers
- Should be operational mid to end of August
- 2 days data taking sufficient for drift time spectra
- Might be used at CERN





Cracked Endplugs



[Back](#)



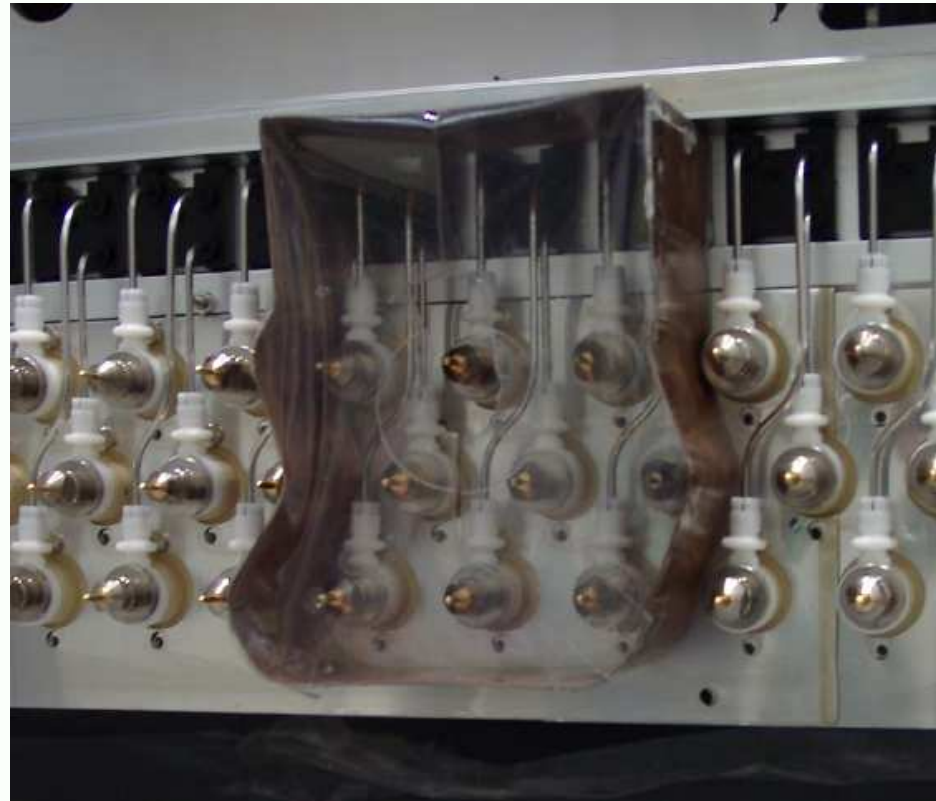
Disconnected Tube



[Back](#)



Mask to localize search

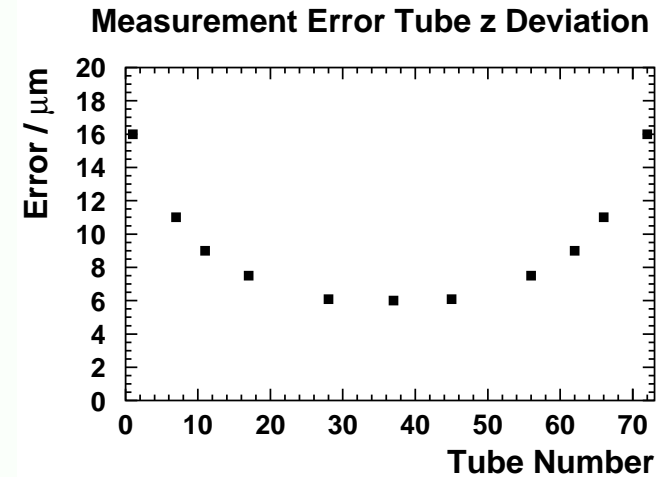


[Back](#)



Performance (2)

- Measurement in middle position
 - y-position of about 60% of the wires
 - z-position of about 80% of the wires (100% with worse resolution at the edges)

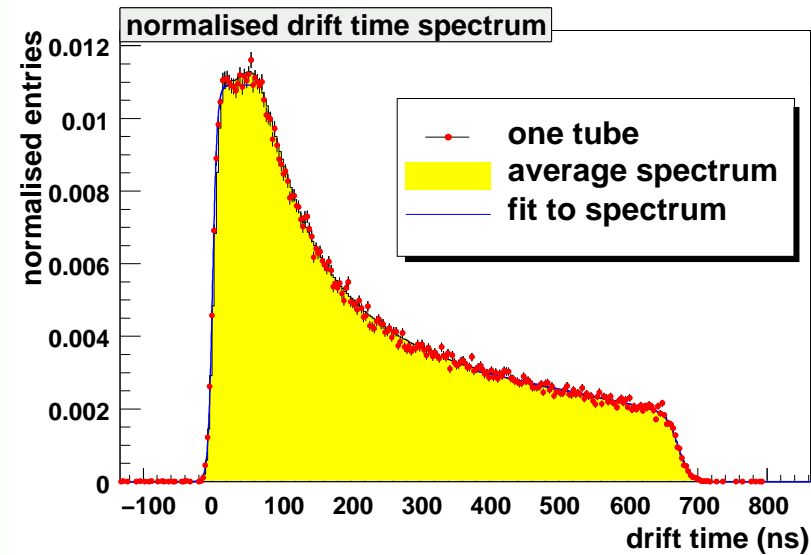


- Measurement in middle position and left or right shifted position
 - y-position of about 80% of the wires
 - z-position of about 90% of the wires (100% with worse resolution on right/left edge)
- Measurement in middle position and both shifted position
 - y-position of 100% of the wires
 - z-position of 100% of the wires

Back



Fit Functions



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