Calibration of the ATLAS Muon Chambers

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Introduction

ATLAS Muon Spectrometer

Standalone Muon Spectrometry

- $\Delta p_T / p_T < 10\%$ up to 1 TeV
- Coverage $|\eta| < 2.7 (|\theta| < 86^\circ)$

Layout

- superconducting air coil toroid
- trigger chambers: RPC (barrel), TGC (end-cap)
- precision chambers: **MDT**, CSC (inner end-cap)

B-field in air reduces multiple scattering, but high precision tracking ($50 \mu\text{m}$) is required.

MDT - Drift Tube Chambers

Drift Tube

- Ar/CO₂(93/7) @ 3 bar absolute
- $\varnothing_{\text{Tube}} = 30 \text{ mm}$ $\varnothing_{\text{Wire}} = 50 \mu\text{m}$
- HV= 3080
- Gas Gain: $2 \cdot 10^4$
- Resolution: $80 \mu\text{m}$
Requires rt-precision of $20 \mu\text{m}$

MDT-chamber

- 2 multi-layers with 3 or 4 layers.
- surface $0.5 - 11 \text{ m}^2$
- Monitoring of geometry, temperature, B-field.

Resolution Requirements

First Collisions

- $p_T < 100 \text{ GeV}$
⇒ Resolution dominated by MS, and energy loss.
- required rt-precision:
 $O(100 \mu\text{m})$

Design Parameters

- p_T in TeV-range
⇒ Resolution dominated by spacial resolution.
- required rt-precision:
 $O(20 \mu\text{m})$

- Compensate for signal-propagation time in cables and electronics
- Required precision 0.5 ns.

Fit Fermi-like functions to leading and trailing edges of the drift time spectrum.

- Fit regions and start values are automatically determined.
- Leading edge position is the calibration.
- Slopes and length of spectrum are input to DQA.

Integration of drift-time spectrum

- Gives start rt with precision $O(100 \mu\text{m})$

Auto-calibration

- Fit segments using input rt.
- deviation of r_{drift} from r_{segment} gives correction.
- iterate.

Resolution Determination

- Fit segment omitting one tube
- $\sigma(\text{residual}) = \sigma(r_{\text{drift}}) \oplus \sigma(r_{\text{segment}})$
- iterate.

Required precision $20 \mu\text{m}$ - to be done within 24 h after data-taking

One rt-relation is fitted by chamber. To compensate for effects, that are inhomogeneous inside one chamber, rt-correction functions are applied.

- wire-sag
 - Barrel: Bend tubes, so that the wire is always in the middle.
 - End-Cap: Apply rt-correction.
- temperature
- magnetic field

Calibration Stream

Calibration During Commissioning with Cosmics

t_0 -Performance

Method

- Fill a drift time spectrum with high statistics using cosmic data.
- Use this spectrum as input probability distribution, and create random drift times.
- Fill for a given fit statistics 20000 spectra.
- Analyse distribution of fitted t_0 .

- Required precision reached with 10000 hits per fit.
- Systematic deviation of t_0 is negligible.

Per tube fit cannot be done with first data. Use cosmics and tof-corrections, or cosmics and per chamber t_0 .

Residual Distribution

- Residual: $r_{\text{segment}} - r_{\text{drift}}$.

← Mean value and width of residual distribution vs r . Mean value shows systematic deviation.

- Precision of rt-distribution is $20 \mu\text{m}$

B-Field Correction

Necessity

- Correction to *gasmonitor-rt* for first collisions.
- B-field is not constant inside one chamber.
→ 200 μm rt-error for some chambers if not corrected

Strategy

- Do rt-calibration with B-field corrected drift times.
- Test: Look at middle chamber, to check systematic effect of b-field on rt-relation.

B-Field Correction

Apply an r_t -relation obtained from a run where the toroid was off to a run where the toroid was on:

No B corrections

With B corrections

Rt-resolution of 20 to 50 μm .

Calibration of First Collisions

Strategy

$10^{29} \text{ cm}^{-2}\text{s}^{-1} @ 7 \text{ TeV} \approx 100 \text{ Segment per Chamber in 2 days}$

- Use segment t0 in reconstruction.
- Use gas monitor rt and corrections.

$10^{30} \text{ cm}^{-2}\text{s}^{-1} @ 7 \text{ TeV} \approx 1000 \text{ Segment per Chamber in 2 days}$

- Use segment t0-fitting in calibration to determine a chamber-wise t0.
- Use gas monitor rt and corrections.

$10^{31} \text{ cm}^{-2}\text{s}^{-1} @ 7 \text{ TeV} \approx 10000 \text{ Segment per Chamber in 2 days}$

- Fit t0 for a longer period.
- Standard rt-calibration.

Rt precision will be at $100 \mu\text{m}$ for $10^{30} \text{ cm}^{-2}\text{s}^{-1}$ and below. Design rt-precision of $20 \mu\text{m}$ is reached at $10^{31} \text{ cm}^{-2}\text{s}^{-1}$

Gas Monitor Chamber

Residuals:
 σ vs assumed chamber temperature

Precision of rt-relation: $90\text{ }\mu\text{m}$

- rate $20\text{ Hz} \Rightarrow 2\text{-rts per hour.}$
- Apply B and T corrections.

- Infrastructure and algorithms for the calibration of the drift tube chambers are in place and tested with cosmics.
- Precision of the calibration will be as foreseen at luminosities greater than $10^{31} \text{ cm}^{-2}\text{s}^{-1}$ @ 7 TeV
- For first collisions, the rt precision will be at $100 \mu\text{m}$.