Calibration and Alignment of the ATLAS Muon Spectrometer at MPI
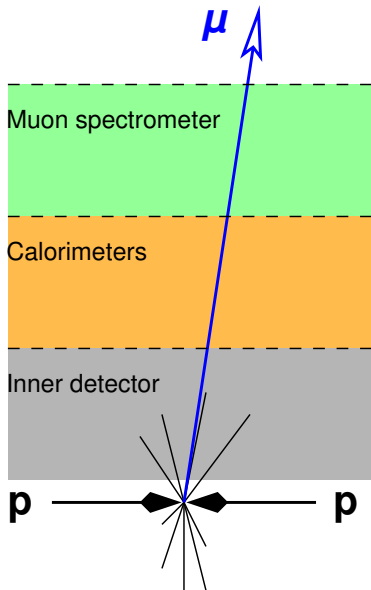
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ATLAS-Besprechung am 10.12.2007

1. Muon detection in the ATLAS experiment.
2. Muon calibration and alignment tasks.
3. Calibration of the muon spectrometer.
4. Alignment of the muon spectrometer.
5. Summary.

- Muon track in the muon spectrometer.

- Energy deposition in the calorimeters.

- Muon track in the inner detector.

Muon calibration and alignment tasks

Requirements for an unbiased momentum muon momentum measurements

Inner detector:
- Correct magnetic-field map.
- Aligned inner detector.
- Calibrated transition radiation tracker (r-t relationship).

Calorimeters:
- Correct measurement of the energy loss of the muons.

Muon spectrometer:
- Correct magnetic-field map.
- Calibrated monitored drift-tube chambers (r-t relationships).
- Internally aligned muon spectrometer.
- Alignment with respect to the inner detector.

Muon calibration and alignment tasks

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Responsibilities of the MPI muon group:
- Calibration of the monitored drift-tube chambers.
- Internal alignment of the muon spectrometer with tracks.

Calibration of the MDT chambers

Regular calibration tasks

- Weekly synchronization of all drift-tube channels.
- Daily determination of the r-t relationship of each chamber.
- Daily determination of the spatial resolution of each chamber.

Calibration of the MDT chambers

Basic difficulties

- The operating conditions are not uniform over an entire MDT chamber in some regions of the spectrometers. $\rightarrow$ Non-uniformity of $r(t)$.
- Main sources of the non-uniformity:
  - non-uniformity of the magnetic field ($\lesssim \pm 0.4$ T),
  - non-uniformity of the temperature (1-2 K),
  - non-concentricity of the anode wires in the end-cap chambers ($\lesssim 600$ μm).

Calibration strategy

Application of time corrections for the non-uniformity of the operating conditions in order to keep one r-t relationship per chamber.

Calibration of the MDT chambers

Calibration with muon tracks

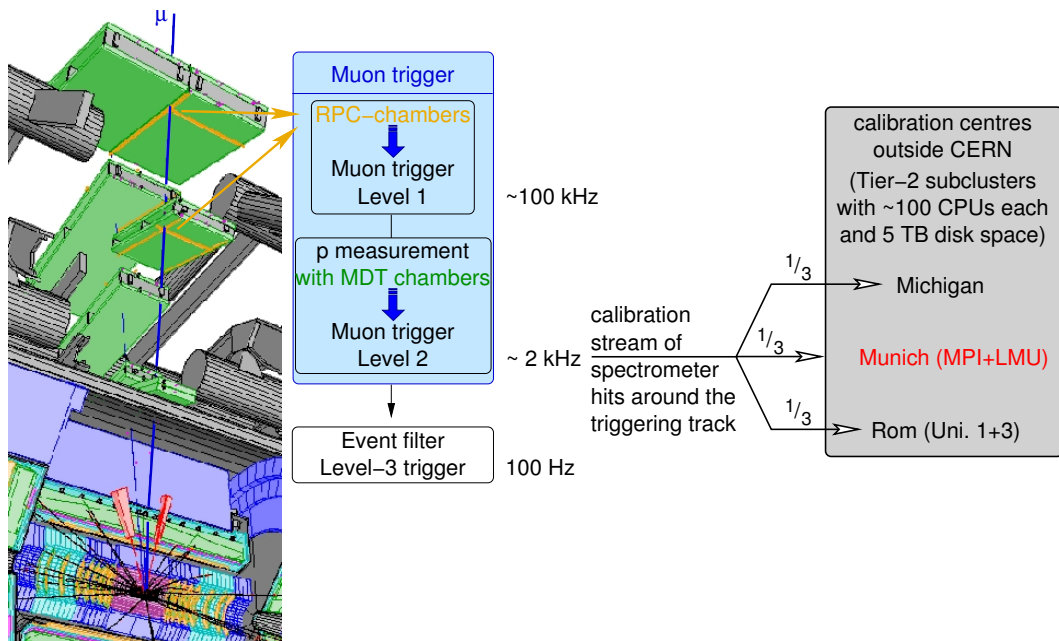The MDT chambers are calibrated with muon tracks.
Number of required muon tracks:

- Synchronization of drift tubes:
  20,000 hits per tube $\hat{=}$ muon rate of $\approx$2 kHz.
- Determination of r-t relationships and single-tube resolution:
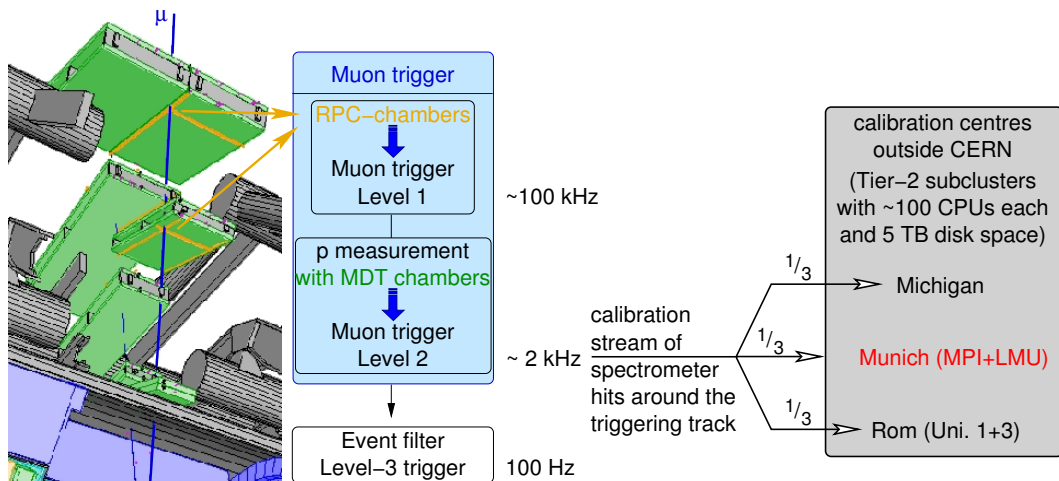 $\leq$10,000 tracks per chamber $\hat{=}$ muon rate of $\approx$50 Hz.

$\Rightarrow$ ATLAS trigger rate of 100 Hz unsufficient.

$\Rightarrow$ Calibration stream with 2 kHz rate is required!

μ

Muon trigger

RPC–chambers

Muon trigger
Level 1

~100 kHz

p measurement
with MDT chambers

Muon trigger
Level 2

~ 2 kHz

calibration
stream of
spectrometer
hits around the
triggering track

Event filter
Level–3 trigger

100 Hz

calibration centres
outside CERN
(Tier–2 subclusters
with ~100 CPUs each
and 5 TB disk space)

$^1/_3$ Michigan

$^1/_3$ Munich (MPI+LMU)

$^1/_3$ Rom (Uni. 1+3)

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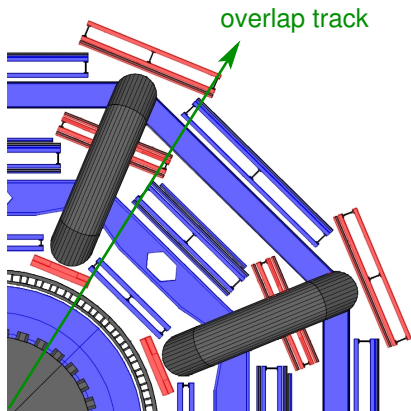
$1/3$ → Michigan

$1/3$ → Munich (MPI+LMU)

$1/3$ → Rom (Uni. 1+3)

Status

- O.K.: online creation of the calibration stream.
- Missing: automatic transfer of the stream to the calibration centres.

Alignment of the muon spectrometer barrel

overlap track

- Absolute optical alignment $\sim 100\ \mu$m in most areas of the barrel.
- Absolute optical alignment $>500\ \mu$m in some areas where platform positions are not known with sufficient accuracy.
- Relative alignment of large barrel towers with optical sensors.
- Missing optical precision measurements for small chambers.
- Role of muon tracks:
  - Absolute alignment of large towers.
  - Alignment of small towers with respect to large towers with overlap tracks.

Alignment of the end cap
with the spectrometer barrel

Alignment of
BEE chambers
with the end cap
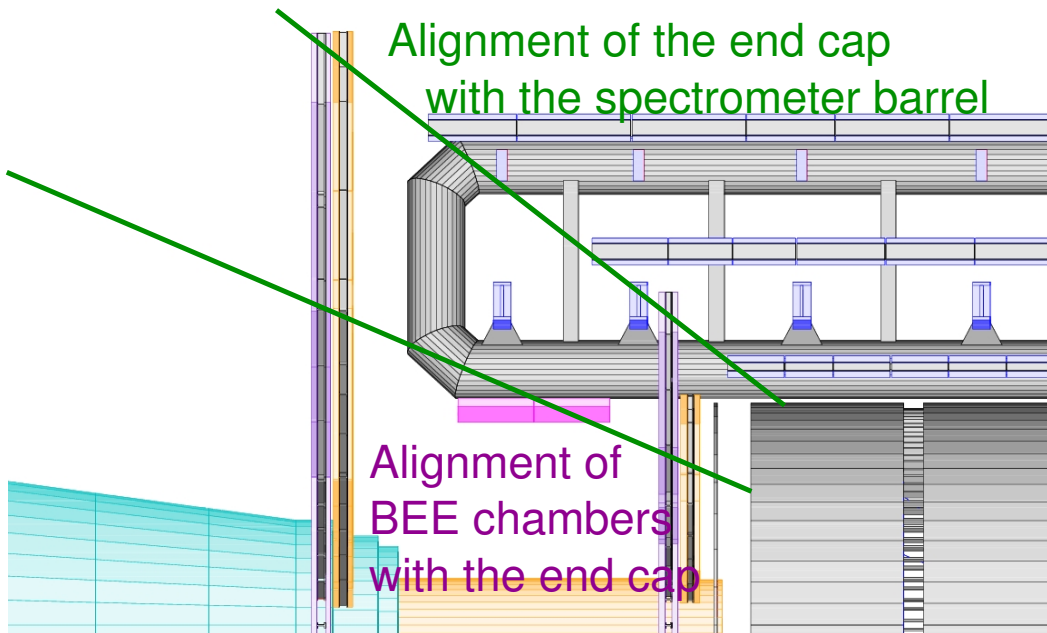
Status of the alignment with tracks

Ready

- Algorithm for the initial alignment with straight tracks (toroid off).
- Algorithm for alignment with overlap tracks.

Missing

- Calibration stream for overlaps.
- Conversion of the alignment constants into AMDB format.
- Conditions database replication.

Summary

- Single muon tracks at a rate of $\sim$1 kHz are required for the calibration and the alignment of the muon spectrometer.
- A muon calibration stream will be produced at the output of the muon level-2 trigger with the required rate.
- The muon calibration stream data will be analyzed in three calibration centres, Michigan, Munich, and Rome.
- The stream for the MDT chamber calibration and the initial alignment with tracks is ready.
  The stream with overlap tracks is missing.
- Database replication is missing, will start in January 2008.
- If the stream could also contain inner detector and calorimeter hits, it could be used for the calibration of the entire muon reconstruction.