DATCHA

How do we know where the muon chambers are?

- General overview ATLAS muon system
- Muon chamber alignment
- Results from test setup DATCHA (cern)

Presented by Marcel Vreeswijk (CERN)

CAT 29 may 1998

Performance requirements

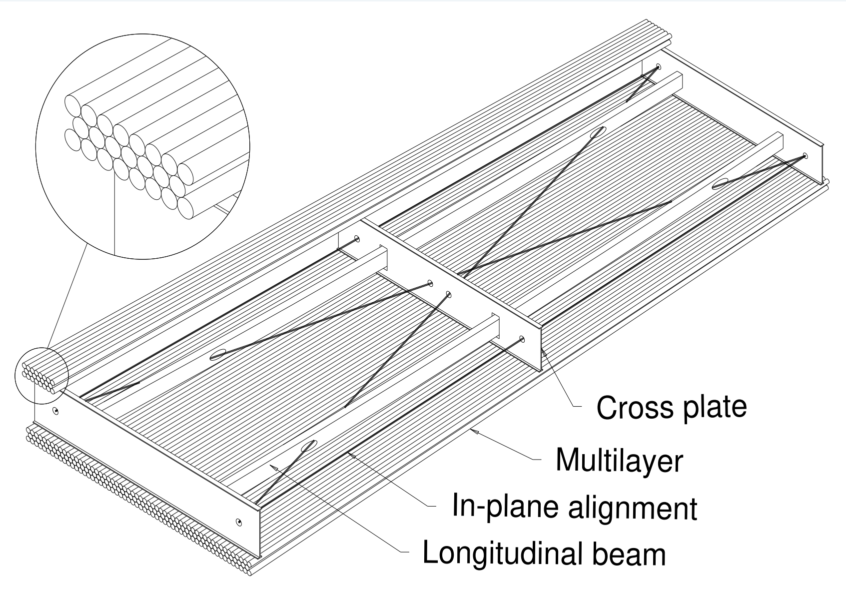
Motivated by physic topics:

- Heavy gauge bosons (W′ and Z′ upto 5 GeV)
  Detect muons in TeV range. Expect wide states on low background, 10% resolution adequate. Requires 50 micron sagitta resolution.
- Higgs boson. Mass range 120 - 170 GeV.
  5 - 50 GeV muons. Expect narrow states, high background. Need 2% resolution. Low multiple scattering. Also, H-> 4 μ requires good hermiticity.
- B physics.
  Trigger, reconstruction, matching with inner tracker.
- Stable SSM particles.
  Good hermiticity

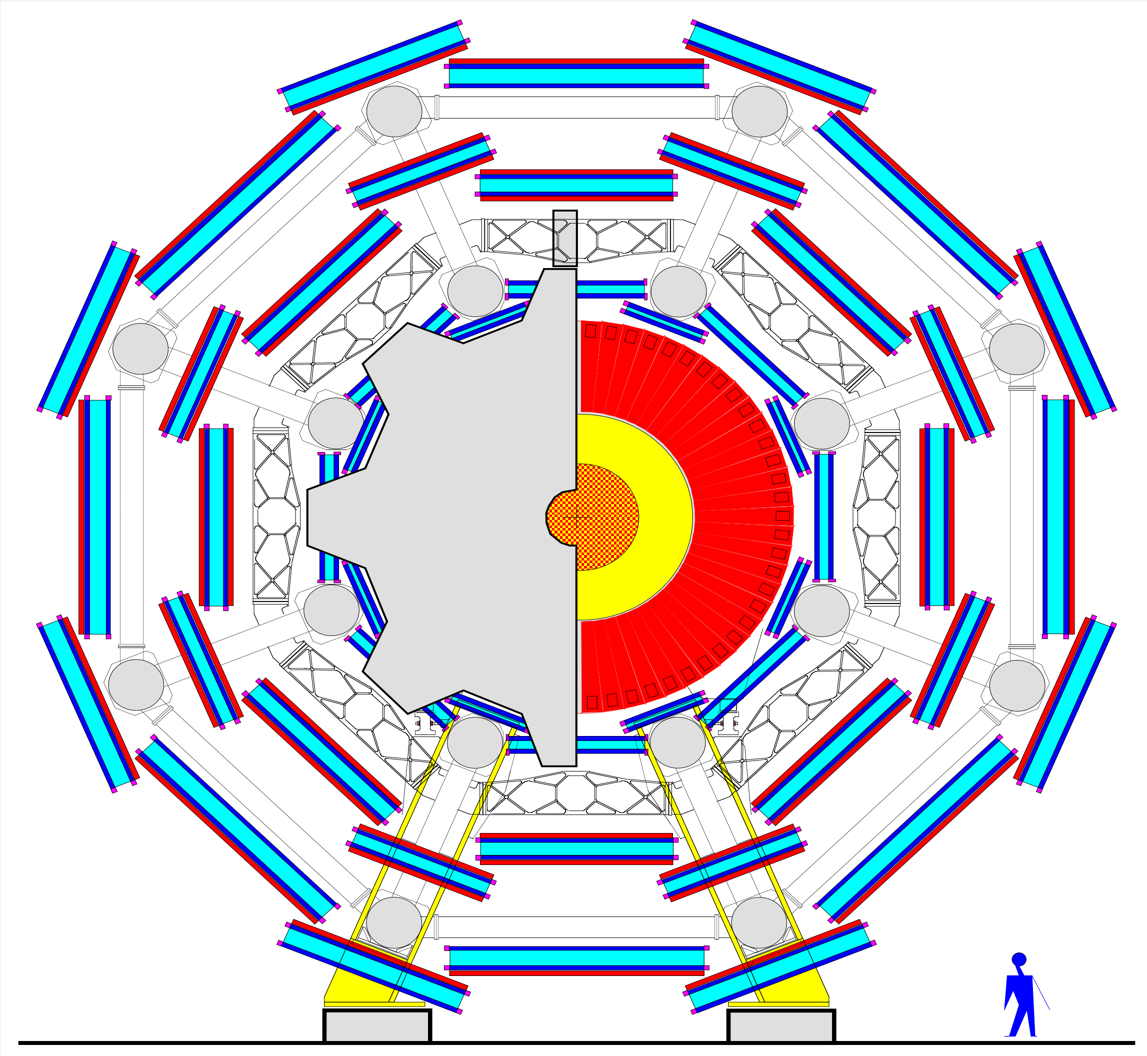
Requires low multiple scattering, high precision and full coverage.

CHOICE: aluminum drift tubes (3 cm diameter) in a 3 Tm field from air-core toroid magnets.

The chambers consist of two multilayers of pressurized aluminium drift tubes. The spacer structure comprises the in-plane alignment system to monitor deformations.



LAYOUT



Scale: inner radius 5 m, outer radius 11 m, length 46 m

370.000 drift tubes, 1200 chambers.

1 barrel toroid (8 coils).

2 end-cap toroids.

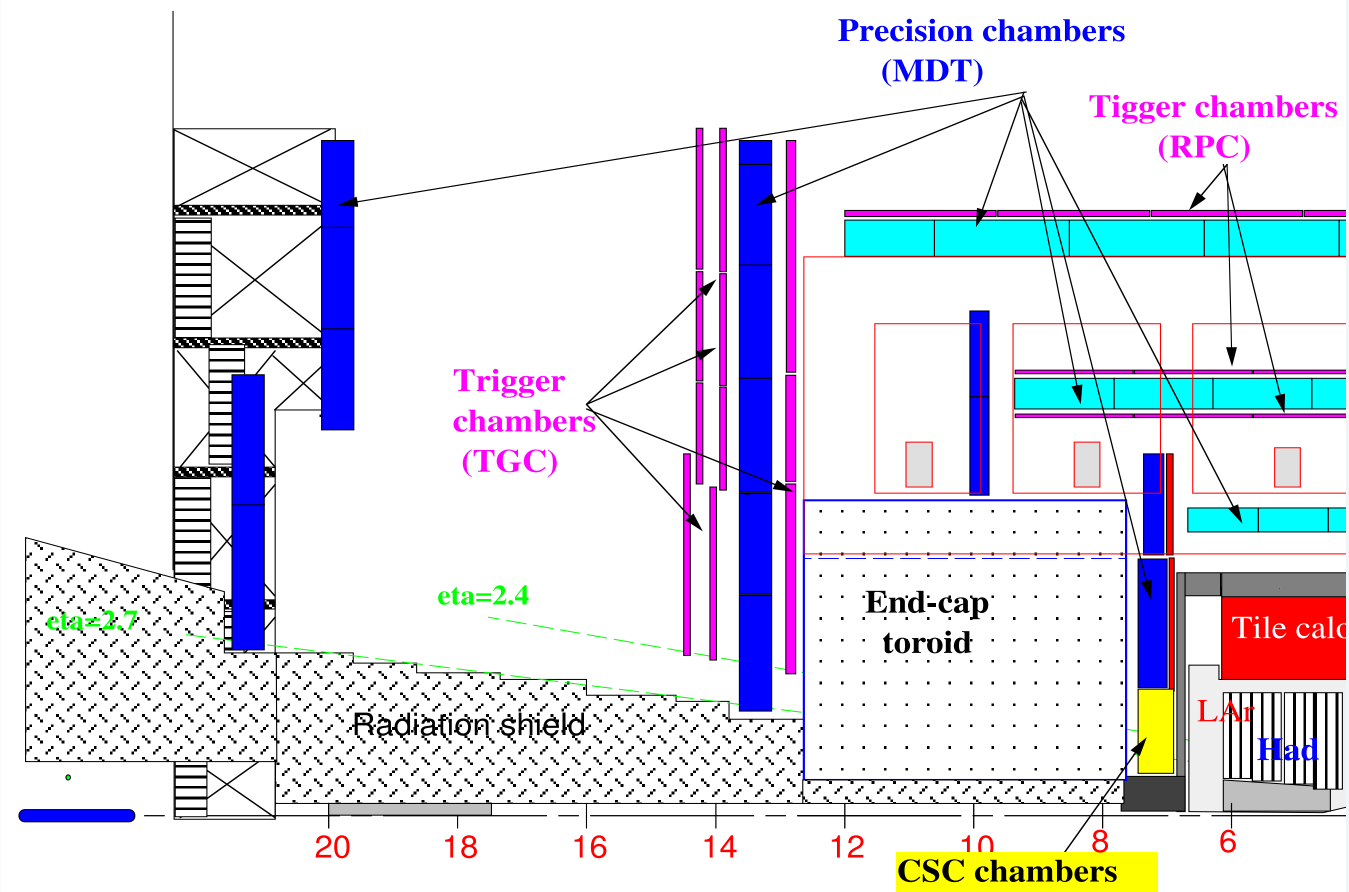
Very forward region is covered with CSC chambers.

Trigger chambers: RPCs in barrel, TGCs in end-caps. (also provide second coordinate)

ATLAS

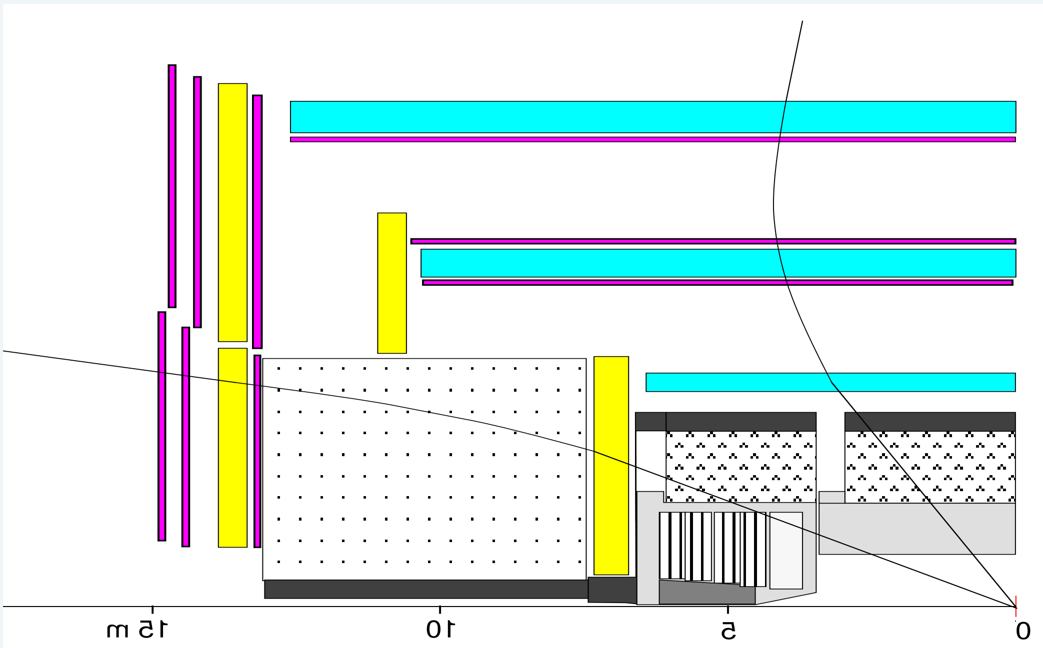
ALIGNMENT OF MUON CHAMBERS

ATLAS Muon Spectrometer



Momentum measurement:

Measure sagitta from 3 points: inner, middle and outer muon chambers.



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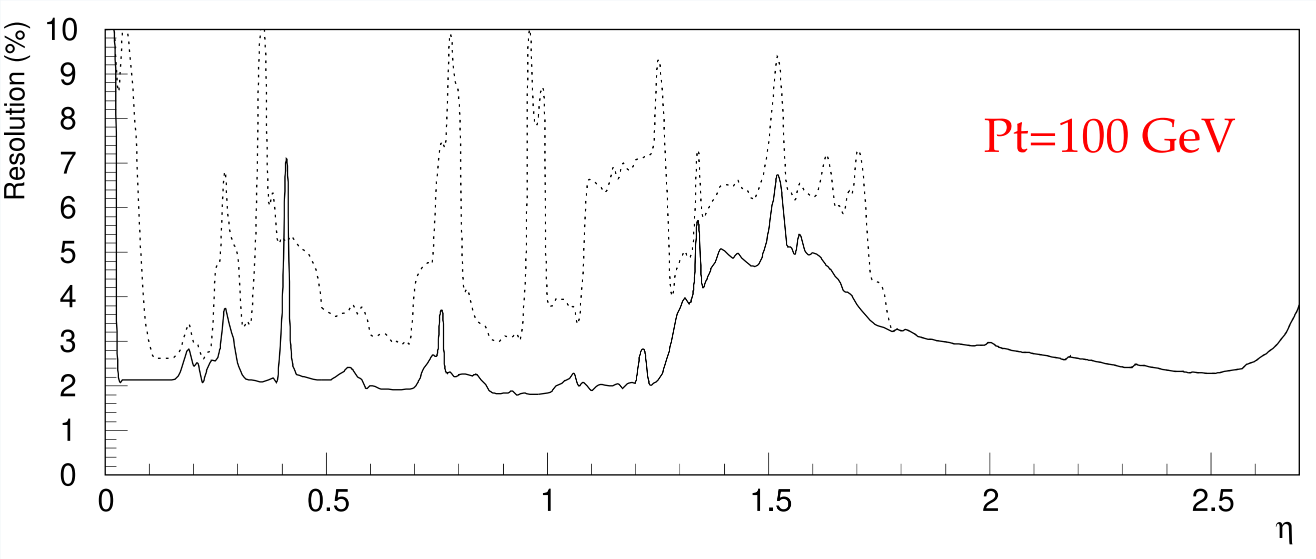
Spectrometer performance

~constant resolution over full rapidity range

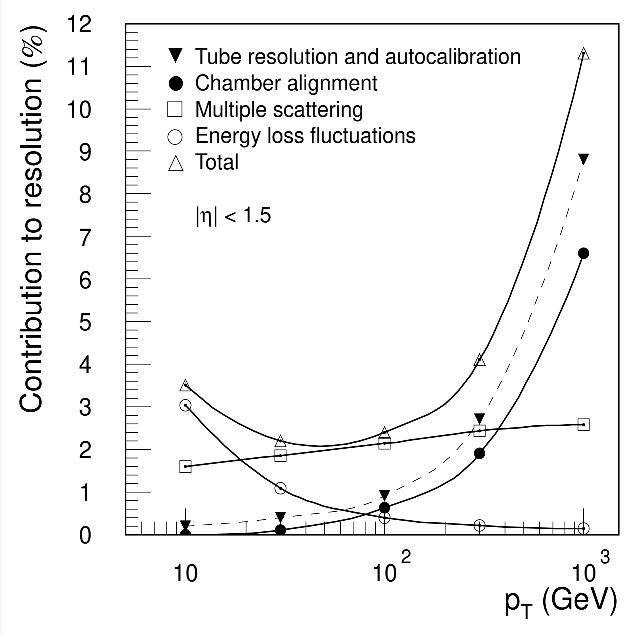


Resolution contributions:

< 30 GeV, energy loss.

30 - 200 GeV, multiple scattering

> 200 GeV, detector resolution.



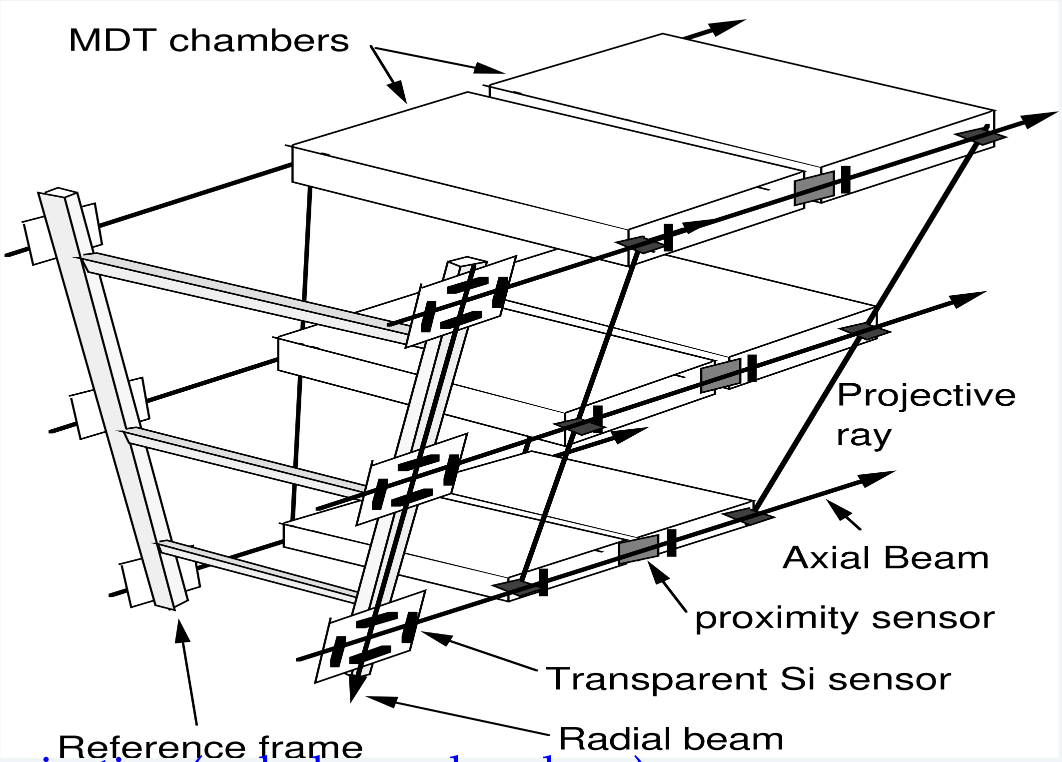
Tracking:

< 10% occupancy, > 97% efficiency

Acceptance 90 - 96%.

Alignment

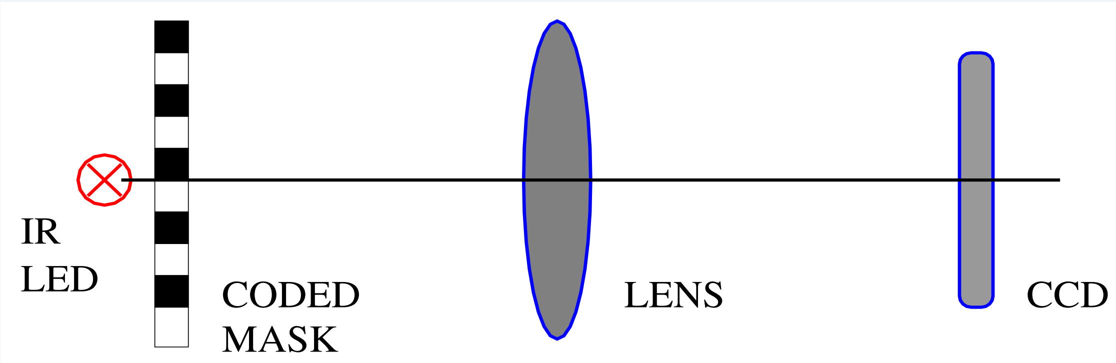
AIM: Alignment contribution to uncertainty on sagitta measurement below 30 µm. (This talk: concentrate on BARREL)



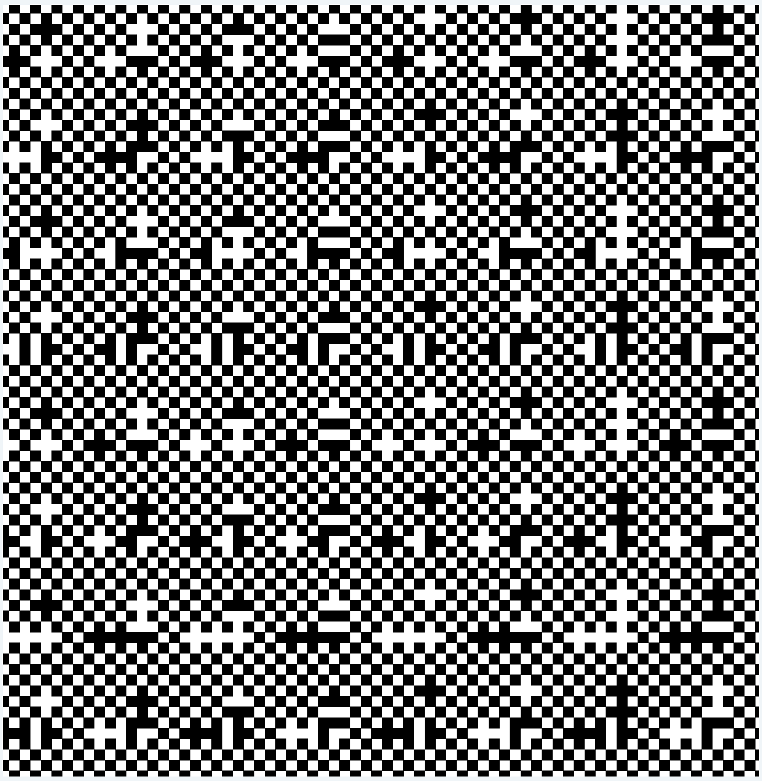
- Projective (only large chambers)
  Position chambers with low precision (1 mm). Monitor 'projective' displacements of tower to correct sagitta measurement. Small towers aligned with tracks (RASNIK). Tested at DATCHA-CERN
- In-plane
  Monitor chamber deformations (gravitational and temperature effects). --> sagitta correction (RASNIK). Tested at DATCHA-CERN
- Praxial/Axial (only large chambers)
  To reduce number of projective rays, an alignment tower is segmented in 2 x 3 chambers. Chamber displacements within tower are monitored with proximity sensors and an axial system (RASNIK).
- Reference frame for global postioning.

RASNIK

RASNIK system



A coded mask is projected onto a CCD camera, which allows to measure relative displacements of the components (1 μm perpendicular to the optical axis).



CCD picture of the mask

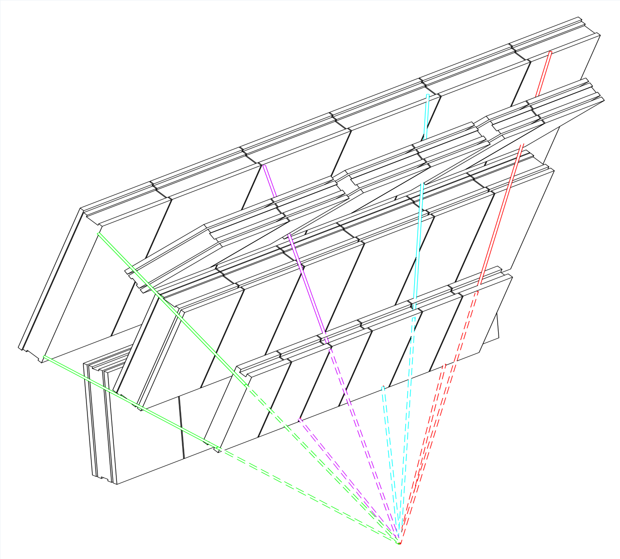
RASNIK provides the relative MASK-CCD rotation around the optical axis (z), the relatvie x, y displacements and the relative distances of components via the magnification.

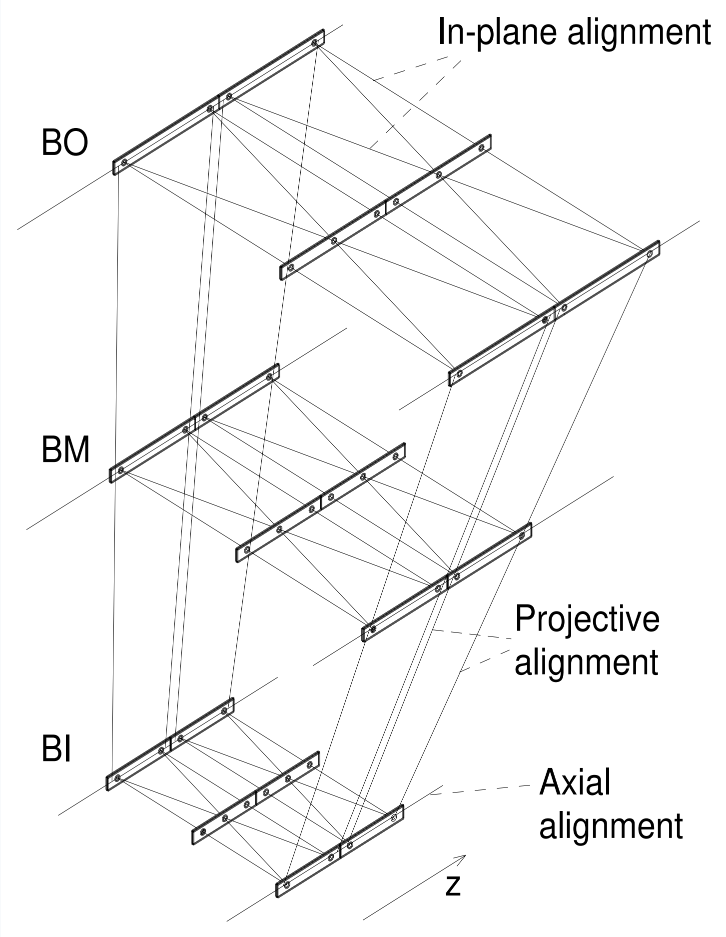
ATLAS

ALIGNMENT OF MUON CHAMBERS

Projective

The RASNIK components for the projective system are mounted on the cornerpoints of the projective alignment towers. Small chambers aligned with tracks.

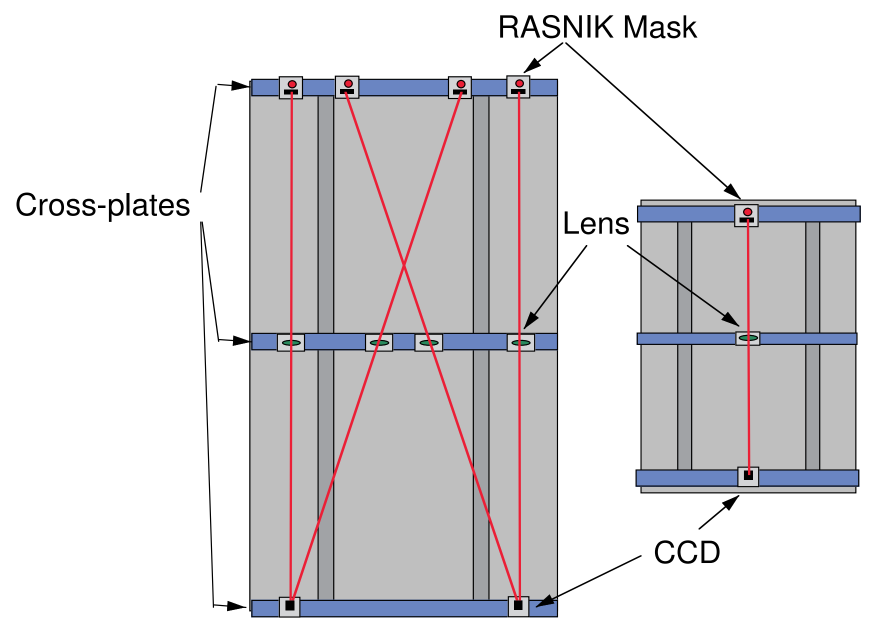




IN-PLANE

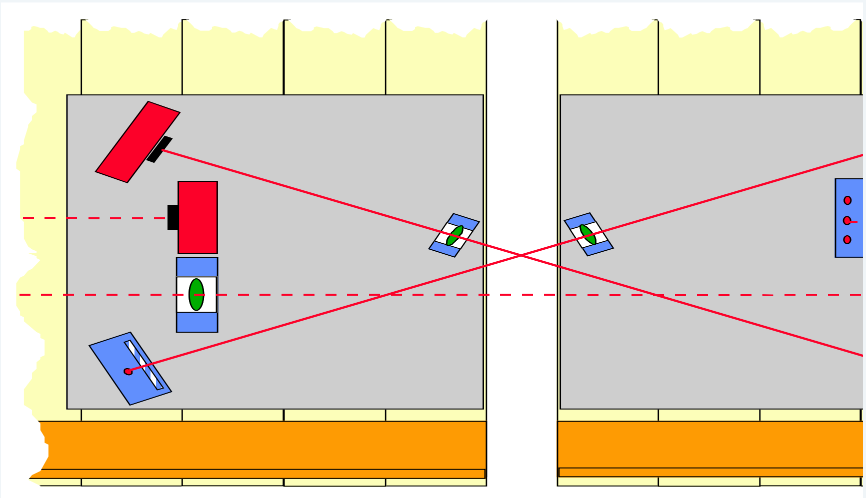
Large chambers are equipped with a 4-ray in-plane system to monitor chamber deformations.

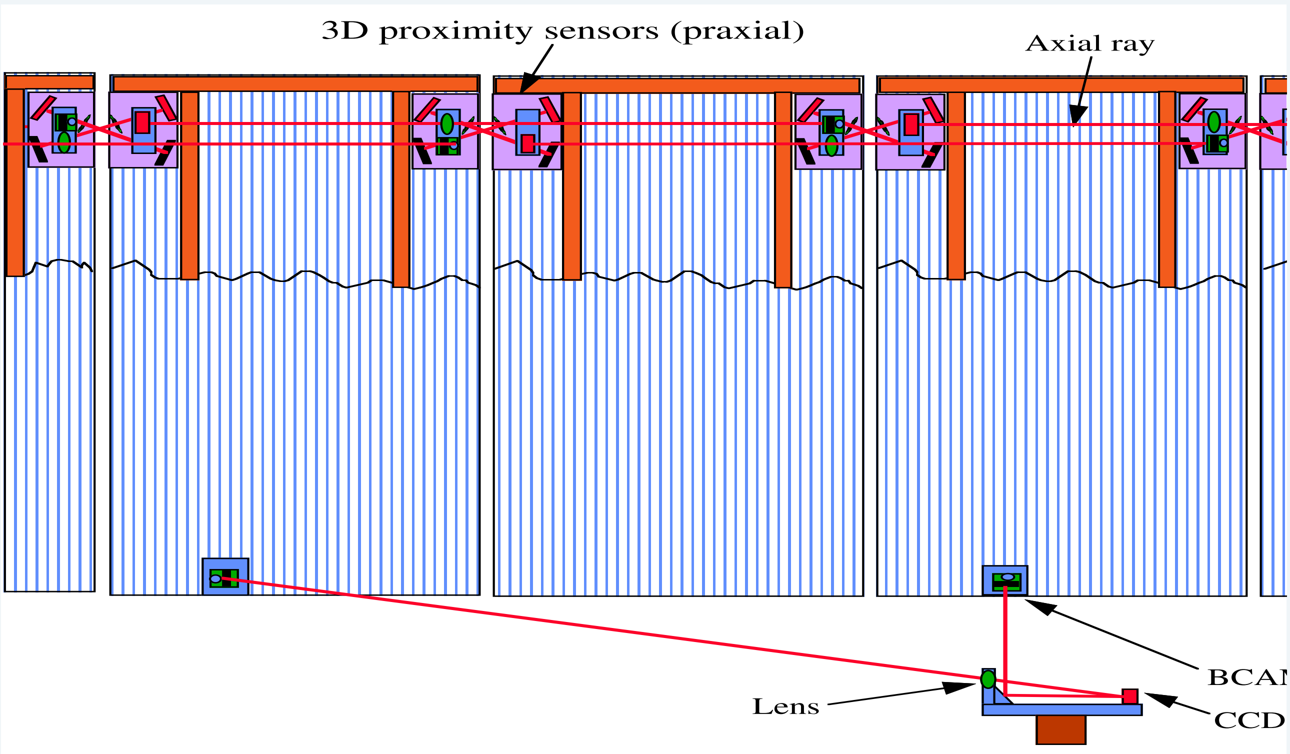
Small chamber have 1-ray system.



Praxial/Axial

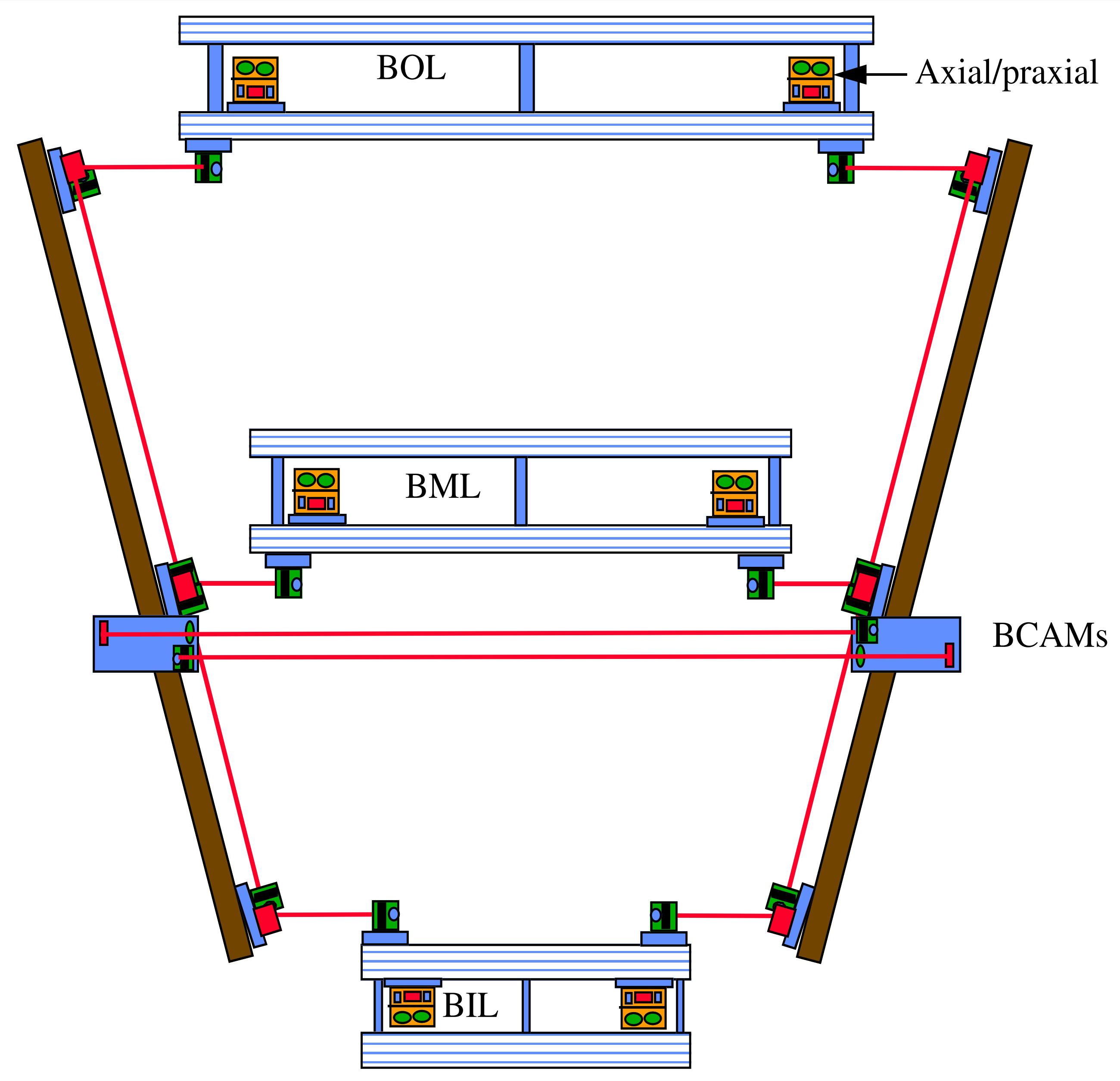
- Axial sensors
  Overlapping RASNIKs
- Proximity sensors - based on RASNIK.





Reference sytem

Allows global chamber alignment, needed for track reconstruction and determination of magnetic field.



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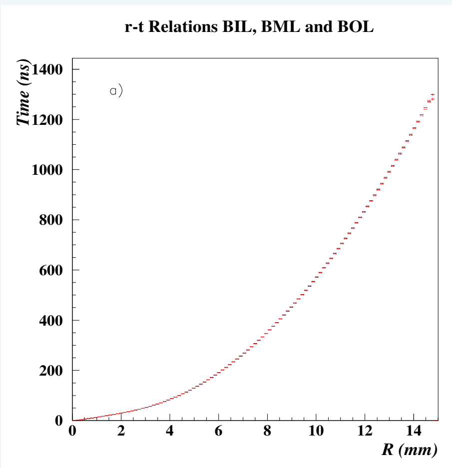
a cosmic ray test facility for the ATLAS muon spectrometer

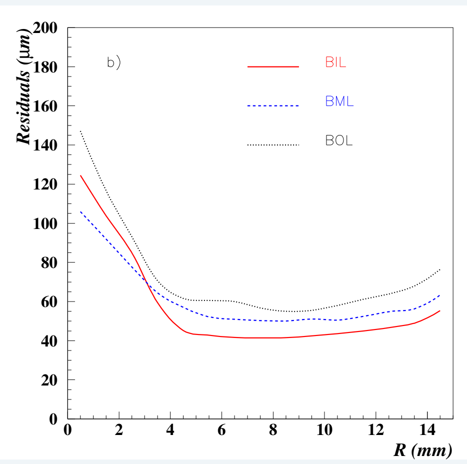
Muon track reconstruction

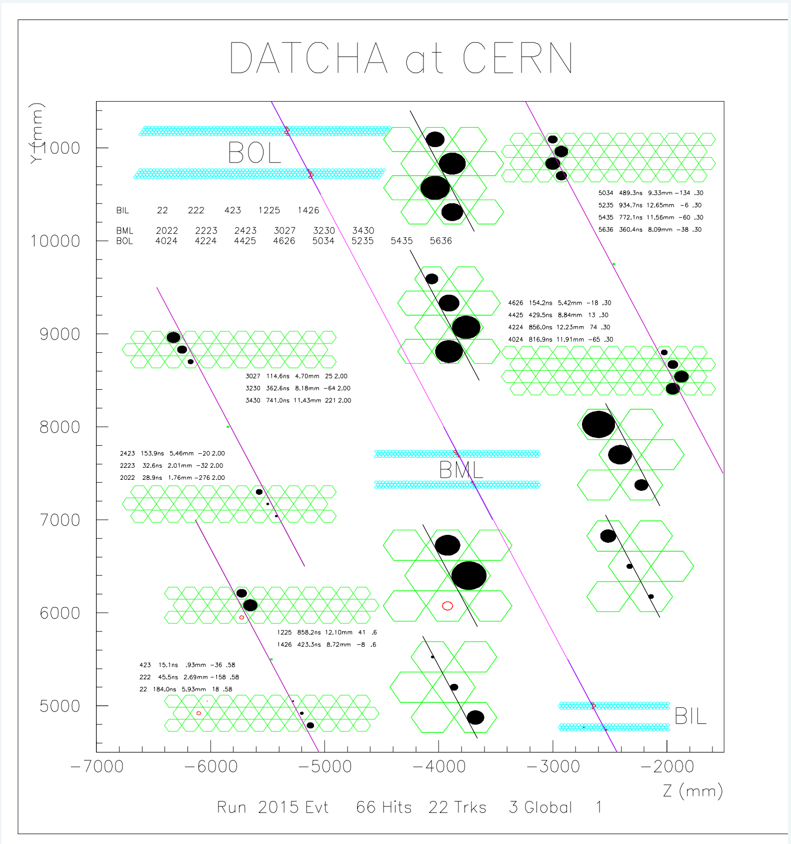
The overall timing of a traversing muon is set by the scintillator hodoscope with an accuracy of 1 ns. The track reconstruction takes into account several effects which influence the measured drift times:

- The signal propagation time along the wire of a tube,
- The time of flight of the cosmic muon.

The distance-time relation is determined in an autocalibration procedure. Track segments for each chamber are obtained in line to circle fits,.







The rms values of the hit residuals are about 60 μm for R > 3 mm.

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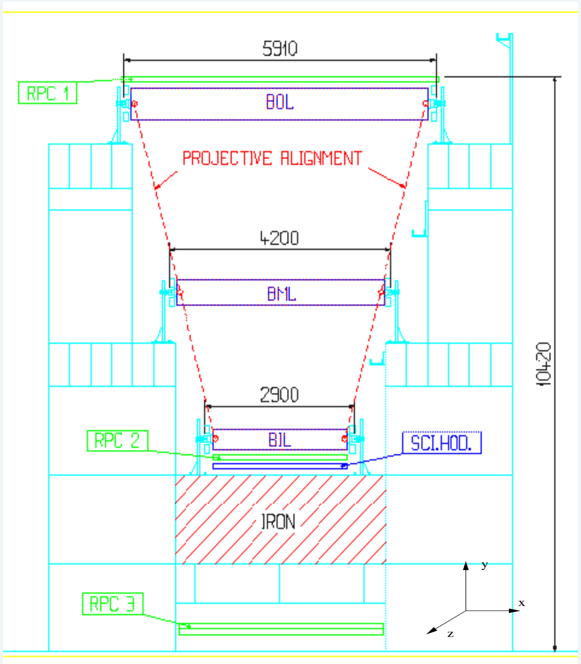
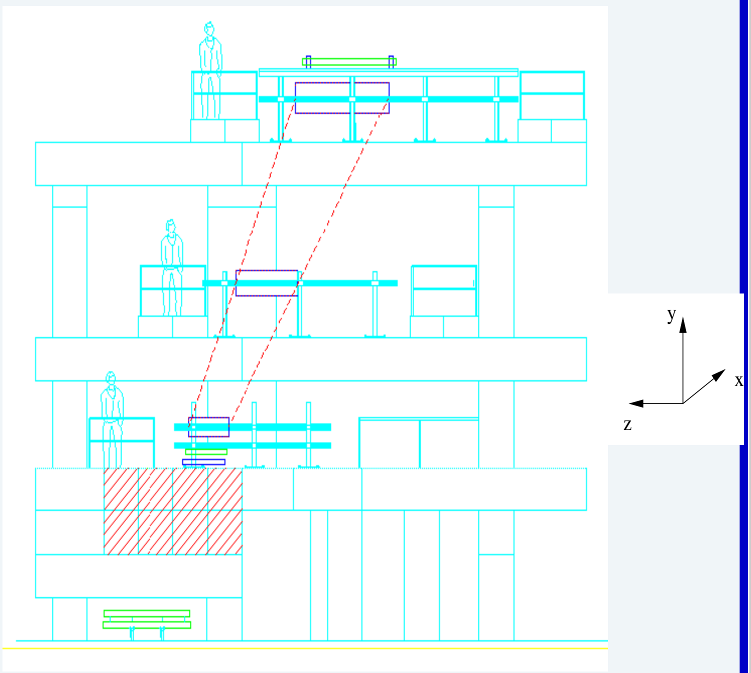
LAYOUT

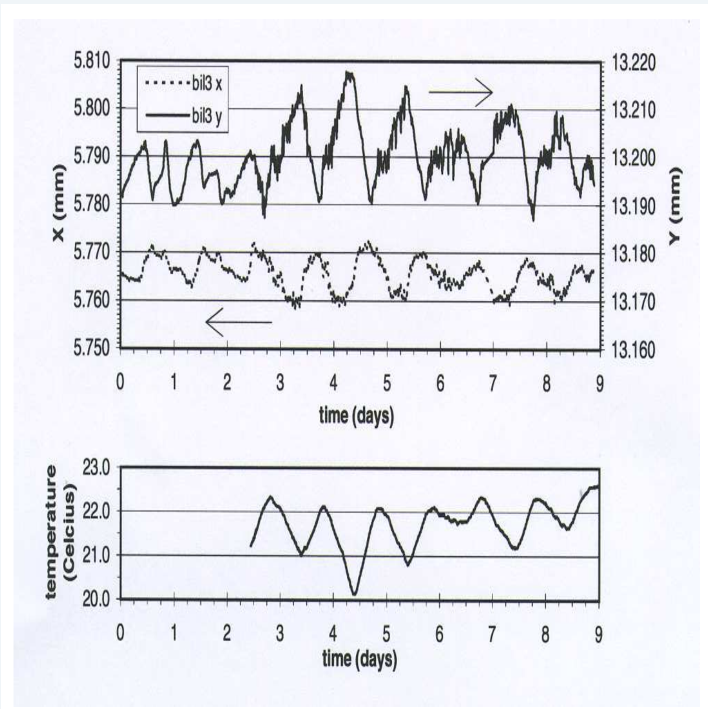




Alignment system

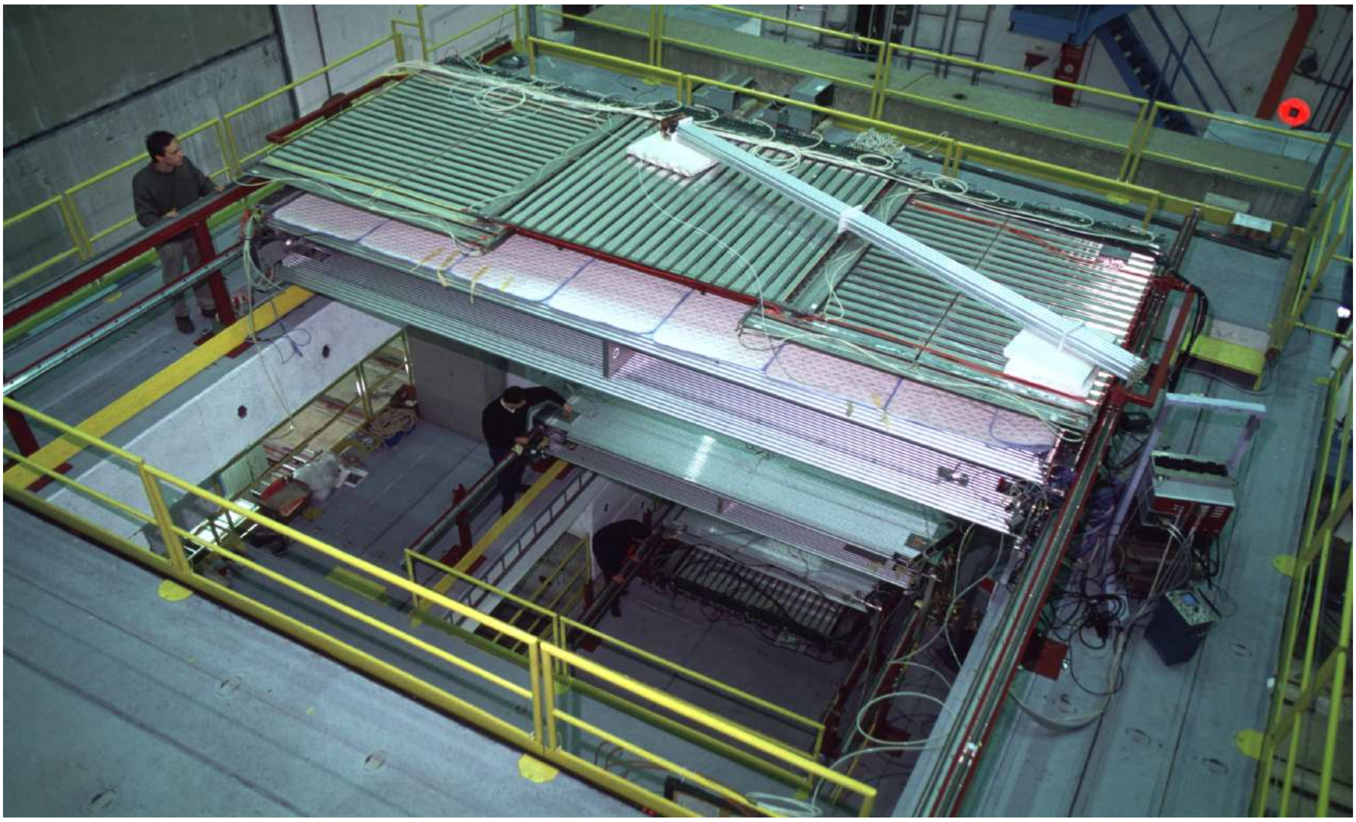
The projective alignment system consists of RASNIK monitors mounted on the cornerpoints of the MDT chambers

The three protype chambers are equipped with a 4-ray in-plane alignment system (RASNIK).



SETUP

The DATCHA setup at CERN became operational in the summer of 1997. The setup consists of three full size Monitored Drift Tube (MDT) chambers corresponding to a full size barrel tower.



AIM:

Check alignment system using cosmic muon tracks

Operation

- Gas mixture Ar/CO_2 80/20 + 2500 ppm $H_2$0
- Pressure: 2 bar absolute
- HV 3250 V, corresponding to a gain of 40.000
- Discriminator threshold: 60 mV, corresponding to the 15th primary ionisation electron.
- Trigger: RPCs + scintillator hodoscope, 1 ns resolution.

Alignment analysis

Aim: check RASNIK alignment with straight muon tracks

Adopted Procedure:

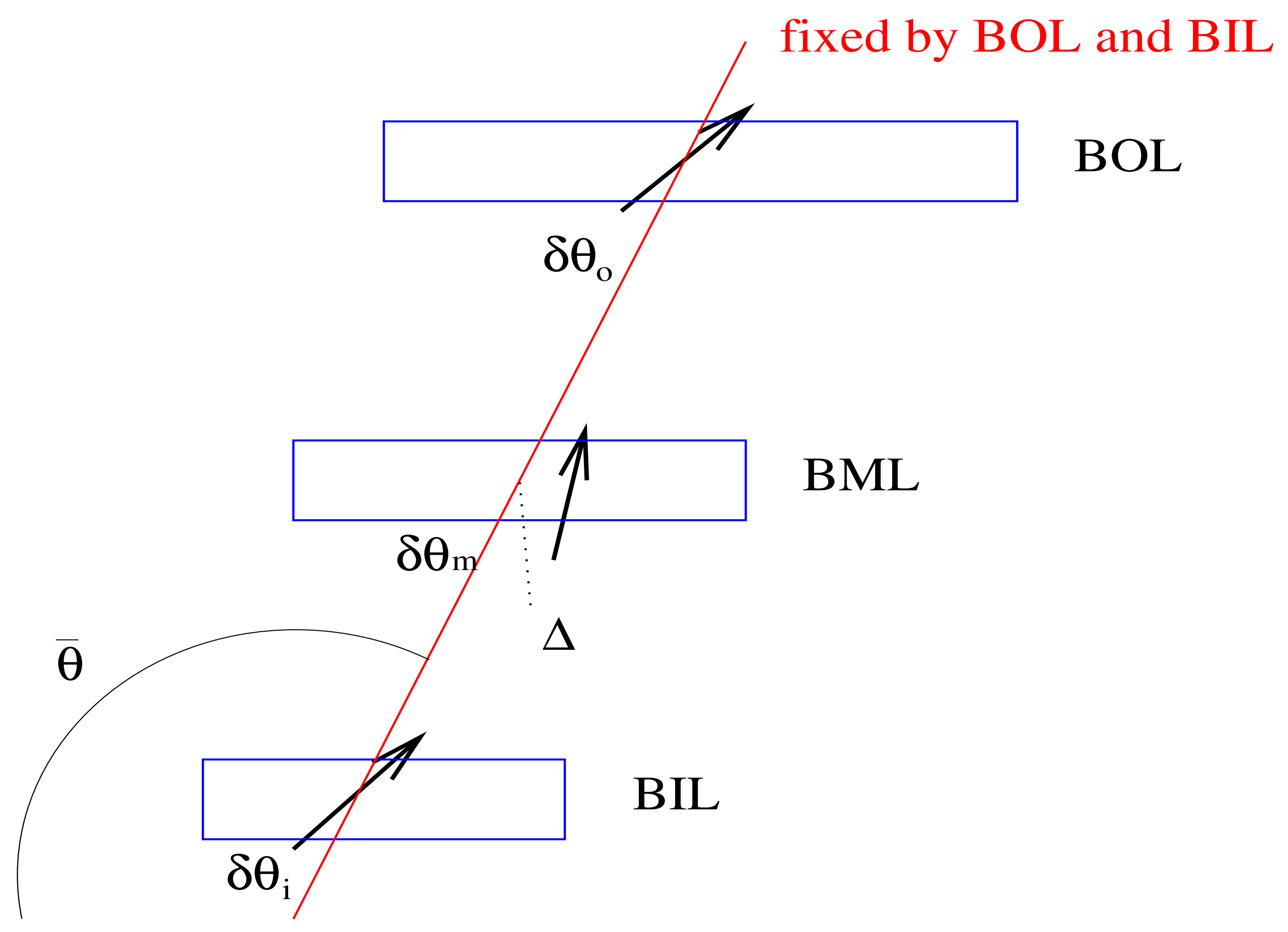
1. Extract DATCHA geometry (= chamber positions + deformations) from straight muon tracks.
2. Calibrate RASNIK components. (not covered in this talk)
3. **Final check:** Compare muon geometry with RASNIK geometry using runs with displaced, rotated and deformed chambers.

NB:

Positioning and calibration of RASNIK components is unknown for the DATCHA prototype chambers. (baseline ATLAS: calibration within 30 μm)

1. Geometry from muons

The DATCHA geometry is extracted from straight muon tracks. The fitting procedure uses the track segments from the muon reconstruction.



Fitting Procedure uses:

- Muon tracks should be straight line. (Δ=0)
- Angles should be the same.

Uncertainties are dominated by multiple scattering: σ_Δ=1 mm, σ_θ= 1 mrad.

1. Geometry from muons (cont)

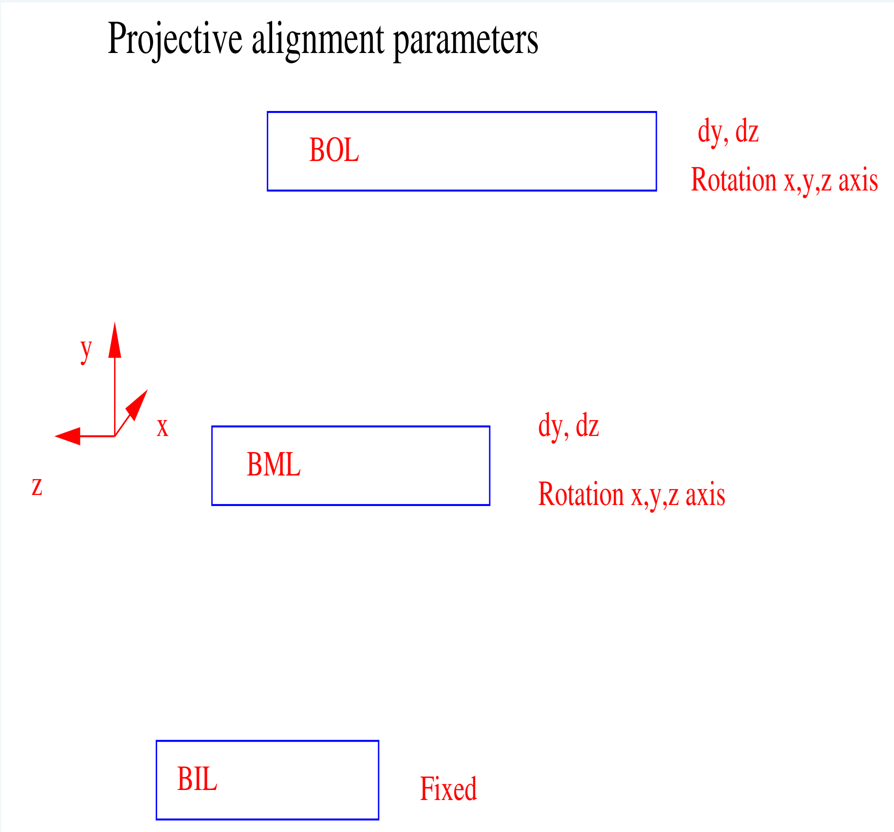
Definition of parameters:

'Projective parameters' (related to projective alignment)

These parameters should allow chamber to move and rotate in all directions. However,

- movement in x, along the wires cannot be measured from the muon analysis, set to zero.
- System as a whole translation + rotation invariant, which constrains one of the chambers, we fixed the BIL.

this results in 10 projective parameters.

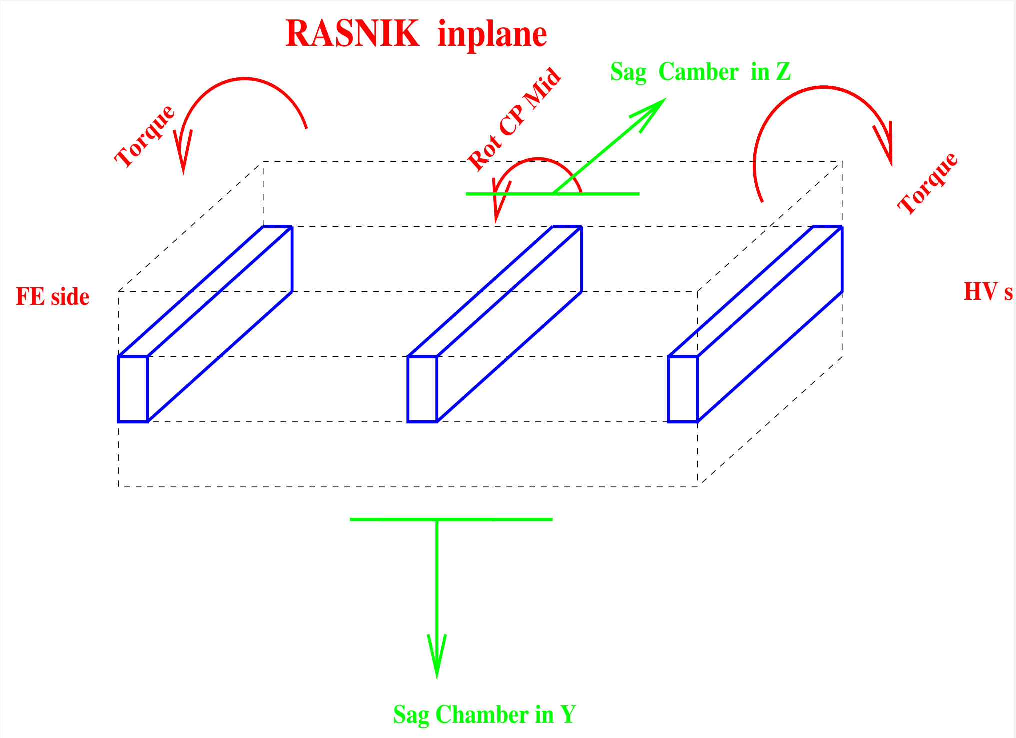


1. Geometry from muons (cont)

Definition of parameters:

'In-plane parameters' (related to in-plane alignment)

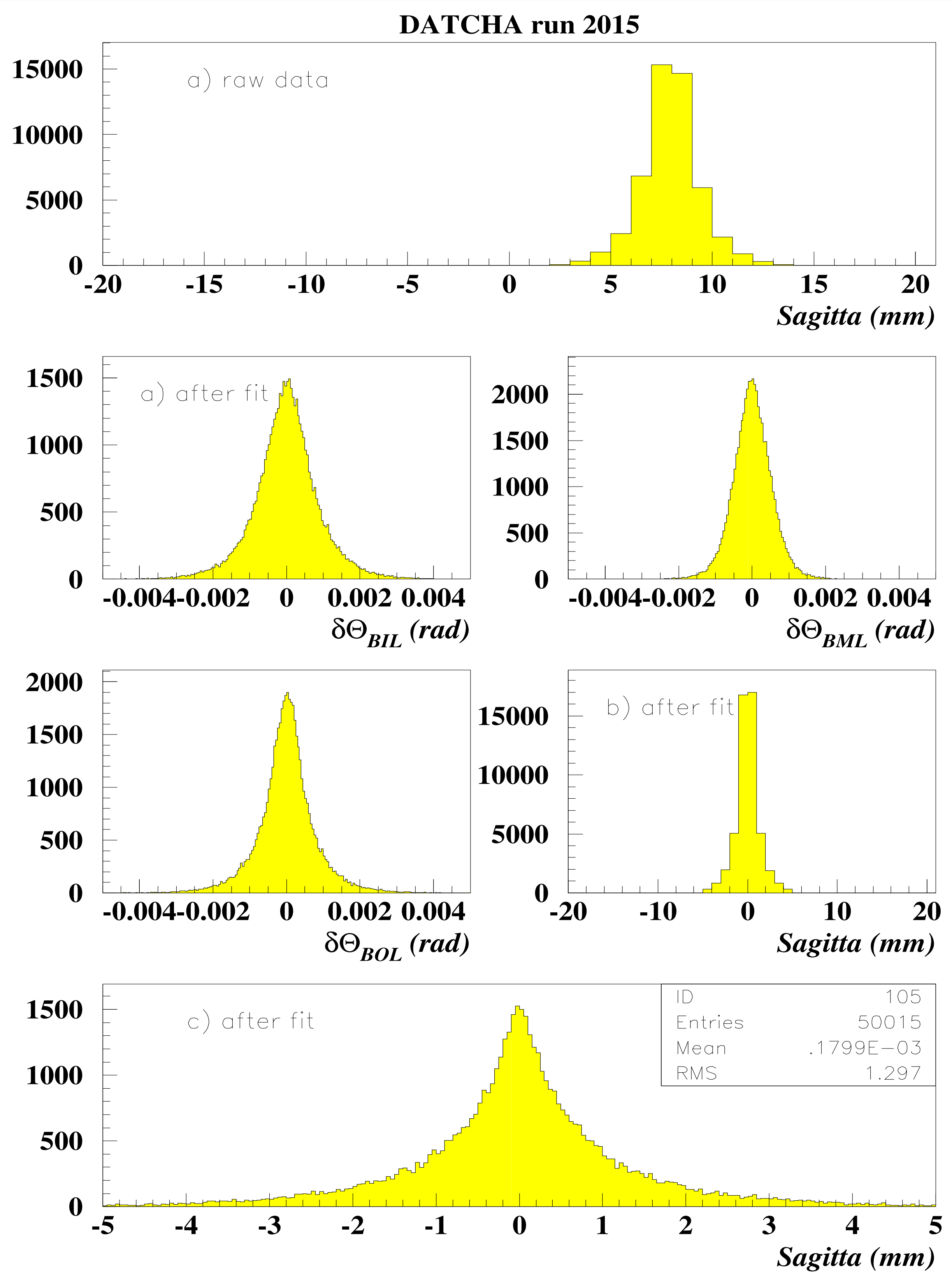
These parameters describe possible chamber deformations.



- For the BML and BOL we need 4 + 4 parameters to describe the internal deformations.
- The BIL chamber is an exception. This chamber has no central wire locators. Hence, the position (sag) of the middle cross-plate is irrelevant for the wire position and we need only to account for the Torque (1 parameter).

In total we have 10 projective + 9 in-plane = 19 parameters.

1. Geometry from muons (cont)



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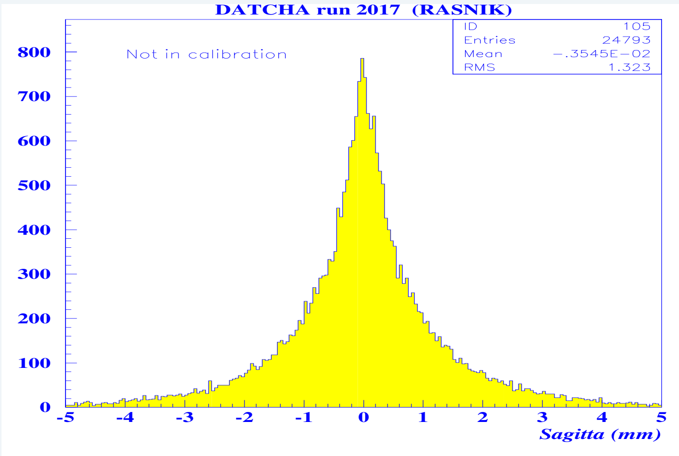
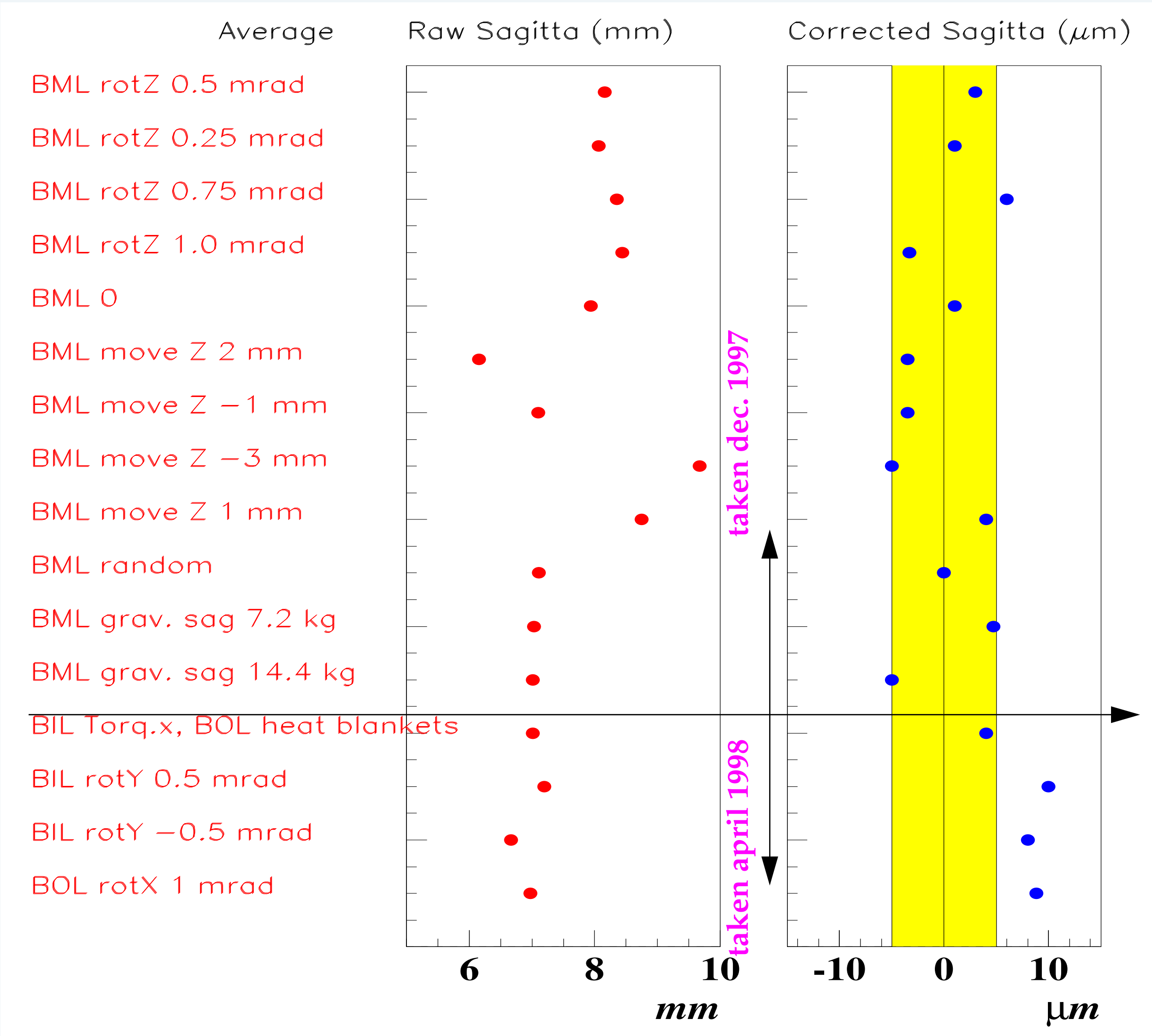
3 & 4. Muons vs Alignment

After calibration the alignment system is used to correct the measured muon sagitta.

Chambers were moved and rotated which induced sagitta variations upto 2000µm, can be corrected by RASNIK.

Corrections based on one calibration set.

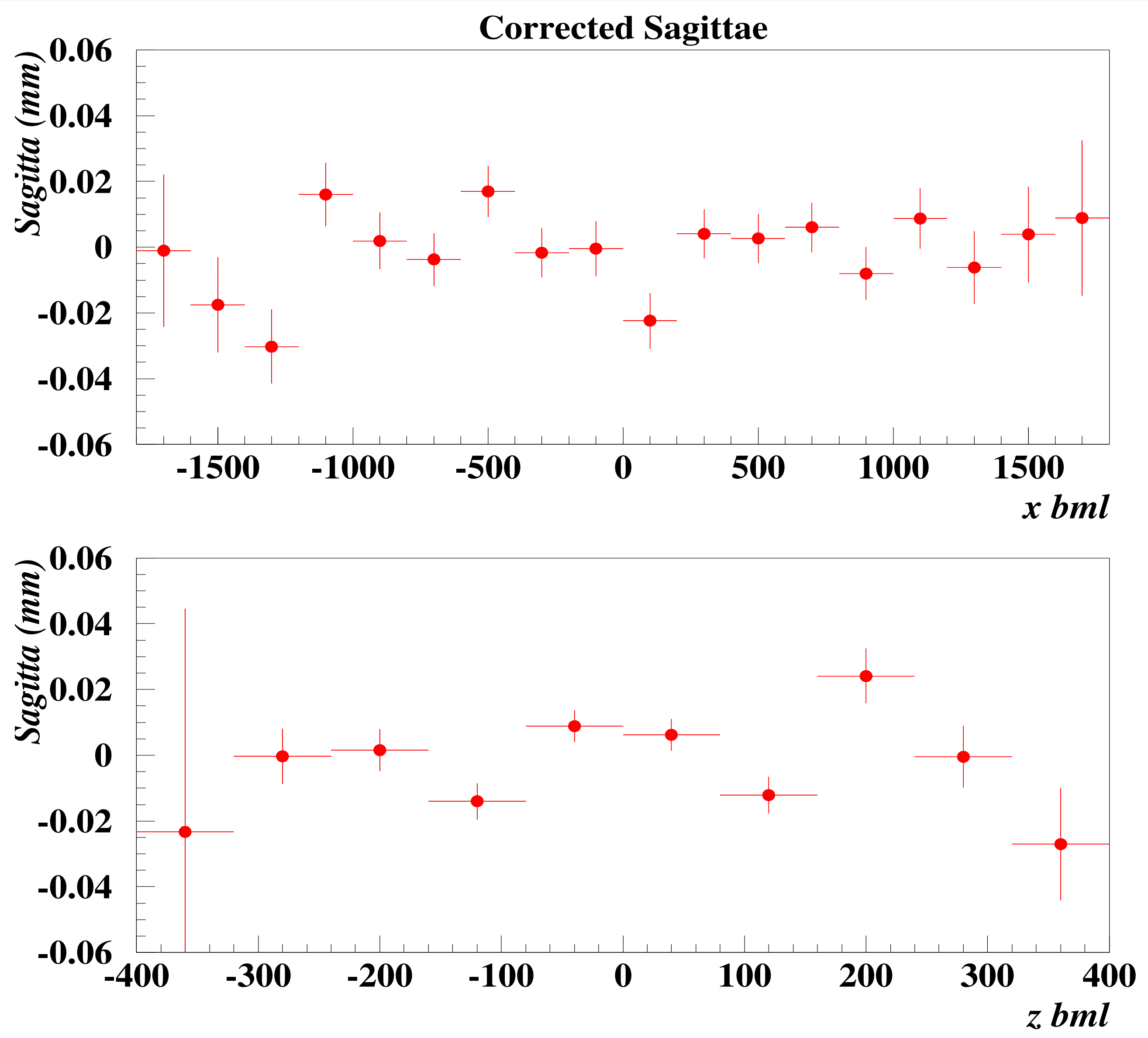




4. Muons vs Alignment (cont)

The corrected sagitta should be independend on the impact position on the chambers. This was checked for all runs.

To increase statistics we combined 10 runs (500k evts) and study the sagitta correction as function of the impact position on the BML.



Alignment system monitors chamber translations, rotations and deformations. Sagitta corrections possible for all impact positions

Conclusions

- DATCHA: from reconstructed muon tracks we have calibrated the DATCHA RASNIK components.
- **DATCHA results demonstrate that the RASNIK alignment system is well suited to monitor chamber movements, rotations and deformations in ATLAS.**