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ATLAS Muon Spectrometer Alignment

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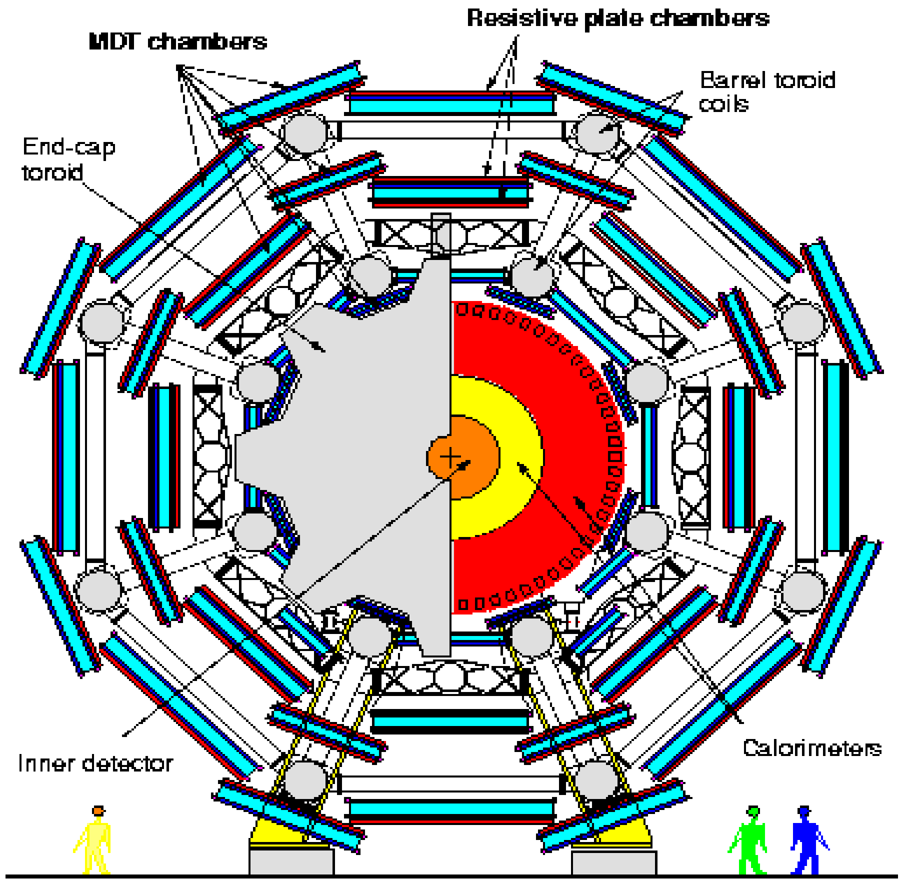
Overview:

- Muon Spectrometer design
- Muon momentum measurement principle
- Optical straightness monitors – RASNIK, BCAM
- Barrel MDT chamber alignment
    - in-plane alignment
    - axial/praxial alignment system
    - projective alignment system
    - reference alignment system
- End-Cap MDT chamber alignment
- Analysis: Z-mass reconstruction, Higgs reconstruction
- Influence of misalignment in the event sample, width

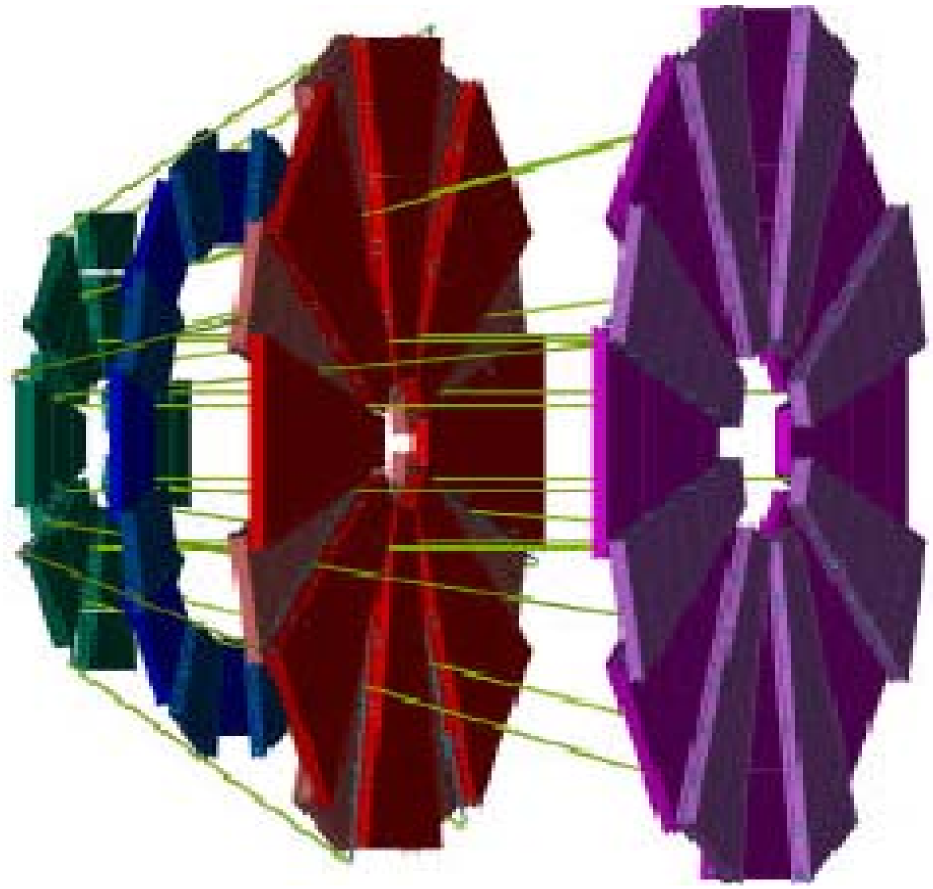
Muon Spectrometer design (barrel)



Transverse view of the barrel part of the ATLAS muon spectrometer

MTD’s +trigger chambers : alignment for MTD’s

Muon Spectrometer design (end-cap)



View at the wheels in the transition and end-cap regions

Muon momentum measurement principle

- Measurement of the track in at least three different stations.
- ‘***Sagitta***’ – distance from the point measured in the middle station to the straight line connecting the points in the inner and outer stations.
- The precision of the sagitta measurement → direct measure for the precision of the muon momentum (muon with momentum 1 TeV/c has 500 μm sagitta; for this case, the target momentum measurement precision of 10 % translates into a sagitta precision of 50 μm).

➢ The actual precision depends also on the **relative positions** of the three stations (need to be known with an accuracy comparable to the individual chamber measurement precision).

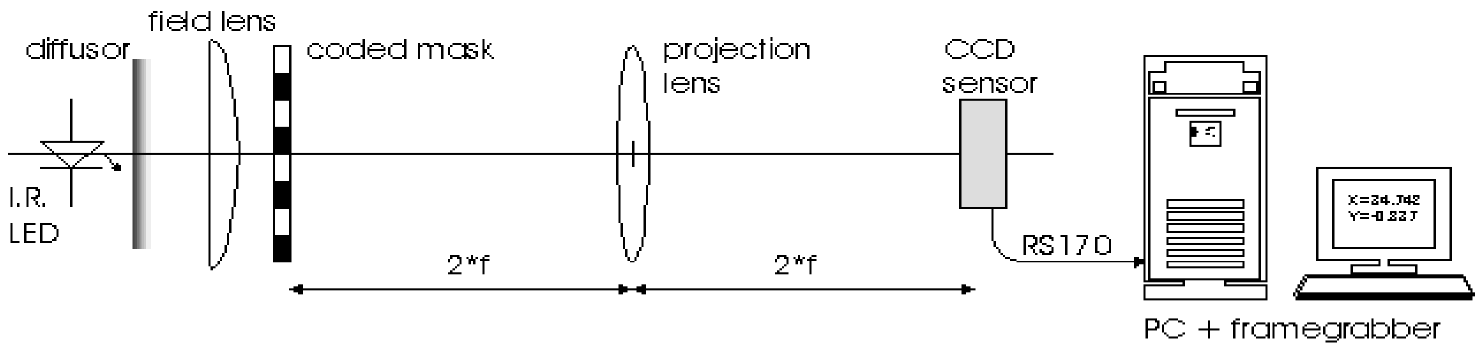
➢ The target total contribution of the chamber point measurements to the sagitta precision is bellow 50 μm.

➢ Impossible to keep the position of the chambers stable to that precision (they are in high B)→ permanent monitoring by alignment systems needed (displacements in the sagitta direction are of the prime importance).

➢http://atlas.web.cern.ch/Atlas/GROUPS/MUON/alignment/muon_align.html

Optical straightness monitors RASNIK and BCAMs

RASNIK (**R**ed **A**lignment **S**ystem **NIK**HEF) consists of an infra-red light source which projects a coded mask via a lens onto an optical image sensor.



Schematic view of the RASNIK alignment monitor

BCAM (**B**earing **C**amera **A**ngle **M**easurement) is optical alignment system which uses camera + lens unit looking at several point light sources and measures angles.

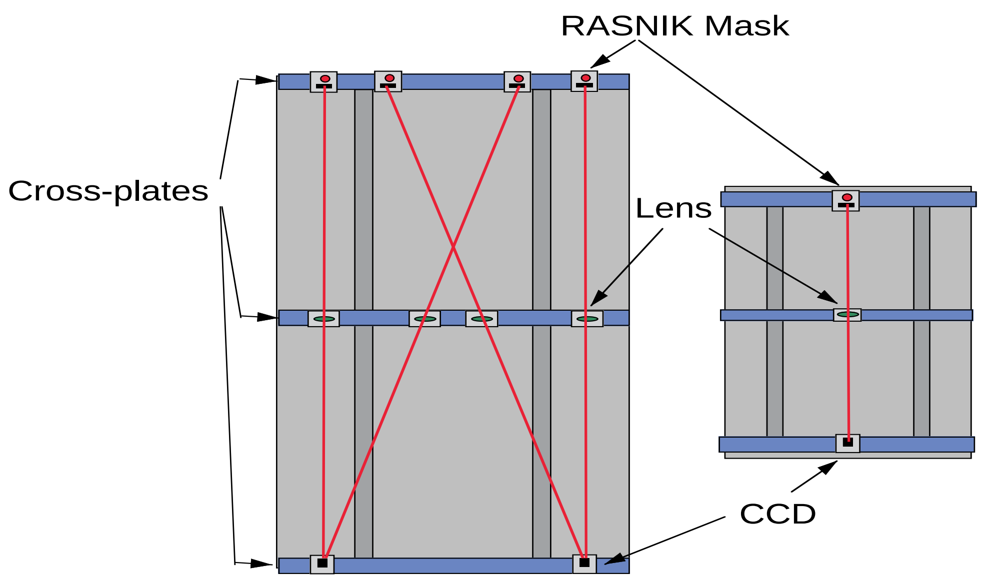
Barrel chamber alignment

The barrel alignment system consists of 4 mechanically independent (from the point of view of their implementation on the MDT chambers) subsystems:

- The in-plane alignment system of the MDT chambers
- The axial/praxial system
- The projective alignment system
- The reference system for the absolute chamber positioning

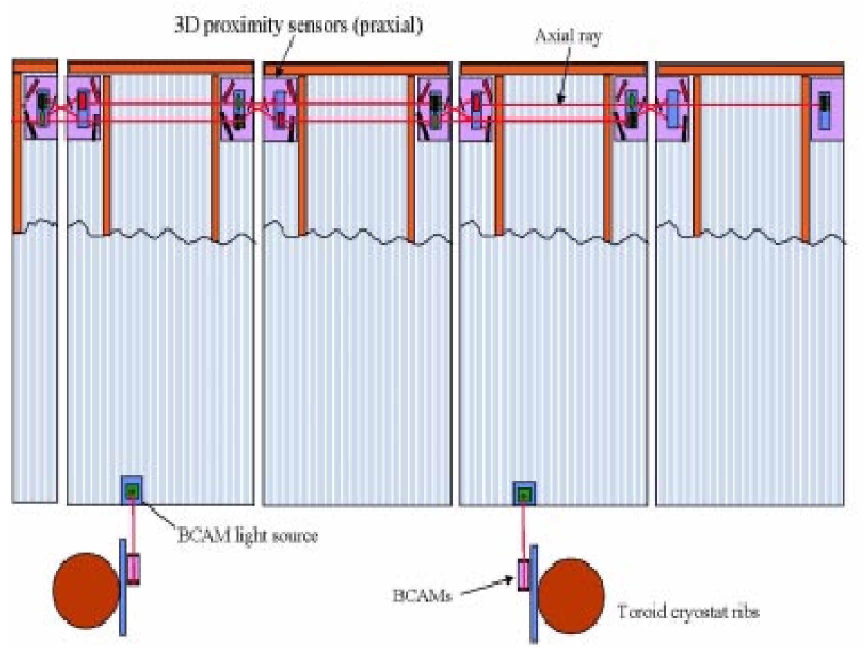
The in-plane system

- Is used to monitor and to correct for the MDT chamber deformations (torque and gravitational sag effects) which has direct influence on the wire position.
- Based on 4 RASNIK lines connecting the 3 cross-plates.
- Small chambers – unique RASNIK sufficient

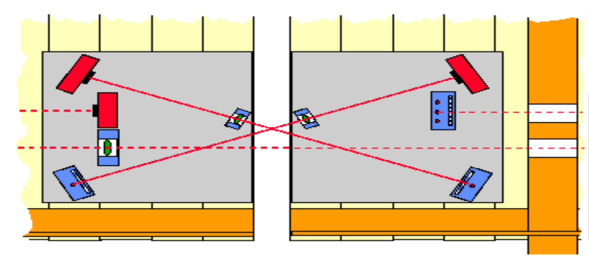


The praxial system
(proximity+axial)

- Used to unite a layer of chambers (6 MDTs in most sectors) to form a single 'rigid' layer.
- *Axial* system: overlapping RASNIKs running parallel to the *z*-axis on each side of the chambers.
- *Proximity* system: 3D proximity sensors which measure both the relative position and the orientation of two neighboring platforms
- Praxial prototype – resolutions better than 10 μm and 30 μrad can be achieved.



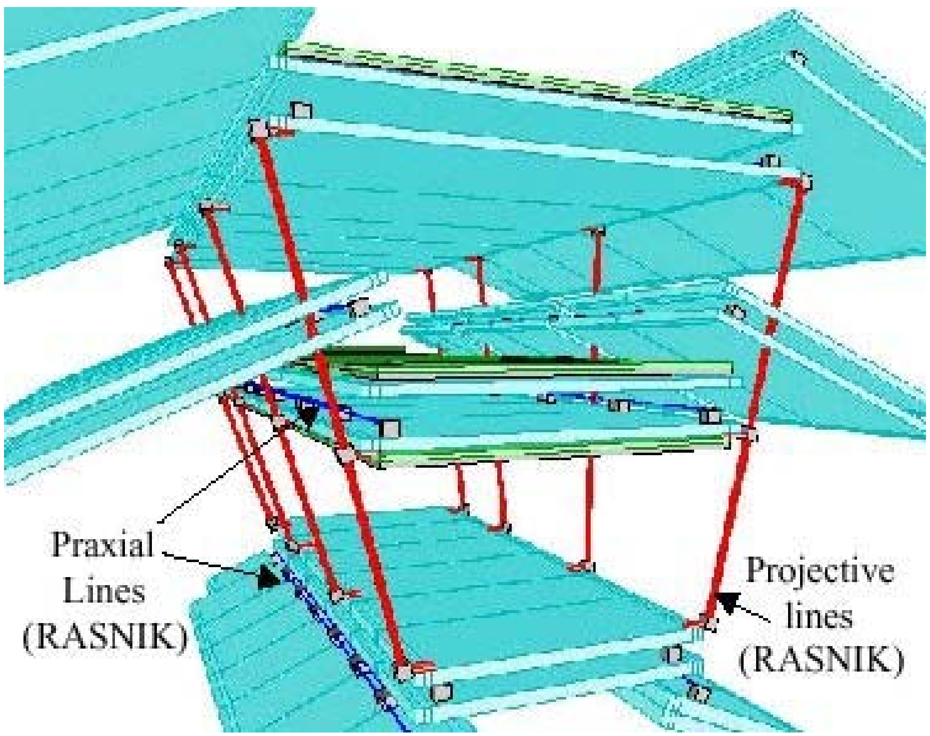
Implementation of the axial rays and the proximity sensors



Axial-praxial plates at the border between two adjacent MDTs

The projective system

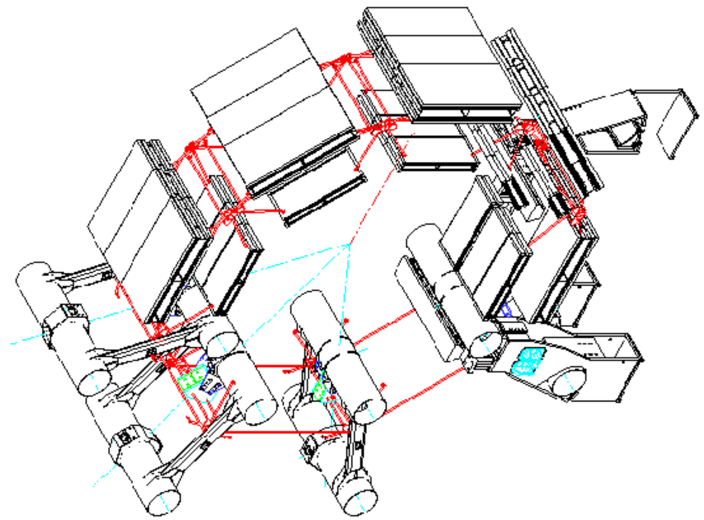
- The most important one → direct impact on the correction to the measured muon track sagitta.
- Monitors the relative displacements of the three MDT chambers

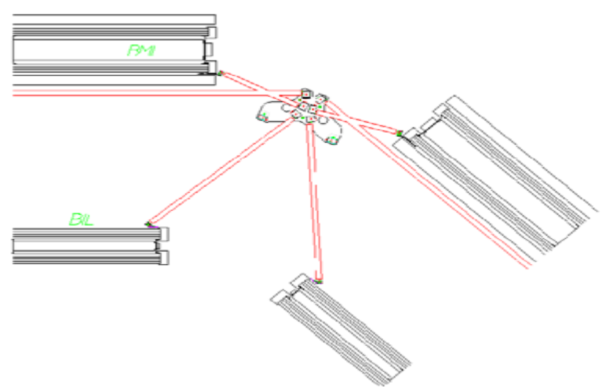


3D view of a standard sector. It features the projective and the praxial systems.

The reference system

- Reference frame for the measurement of the chamber layer positions with a precision of about 400 μm.
- Consists of a set of stainless steel plates mounted on the toroid cryostat ribs, carrying a set of cameras (BCAMs) pointing at optical targets placed on the chambers or on the other plates.
- Neighbouring plates on the same coil are connected by two double camera-led systems.



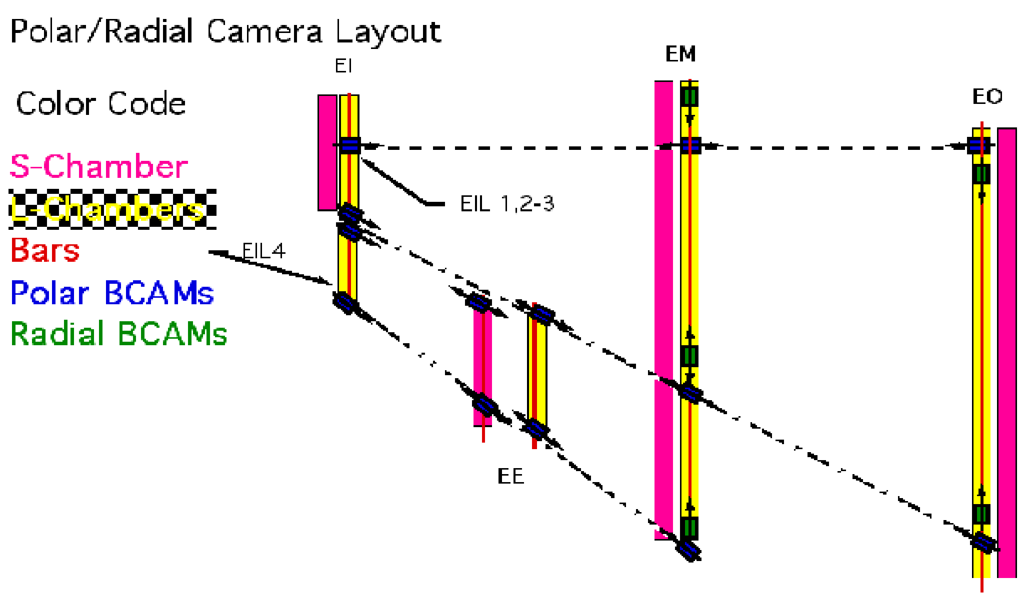


Reference system with its connections to the MDT layers

End-cap chamber alignment

- The projective philosophy cannot be used in the forward and transition regions because the end-cap toroid cryostats prevents the implementation of a large number of projective light paths.

- The alignment scheme relies on a system of mechanically and thermally stable, radial reference bars made from inert material.



End-Cap alignment system

- The bars are aligned using a optical straightness monitors (RASNIK and BCAM) → reference grid.

- Chamber positions are referred to this grid via the proximity system.

- The combination of these elements allows one to have EC alignment system which is both an **absolute** and a **relative**.

- Using the BCAMs – EC alignment system measures the absolute positions and orientations of chambers to better than a few hundred microns and few hundred microrads → sufficient for obtaining sagitta corrections at the level of 40 μm.

Analysis :

Aim:

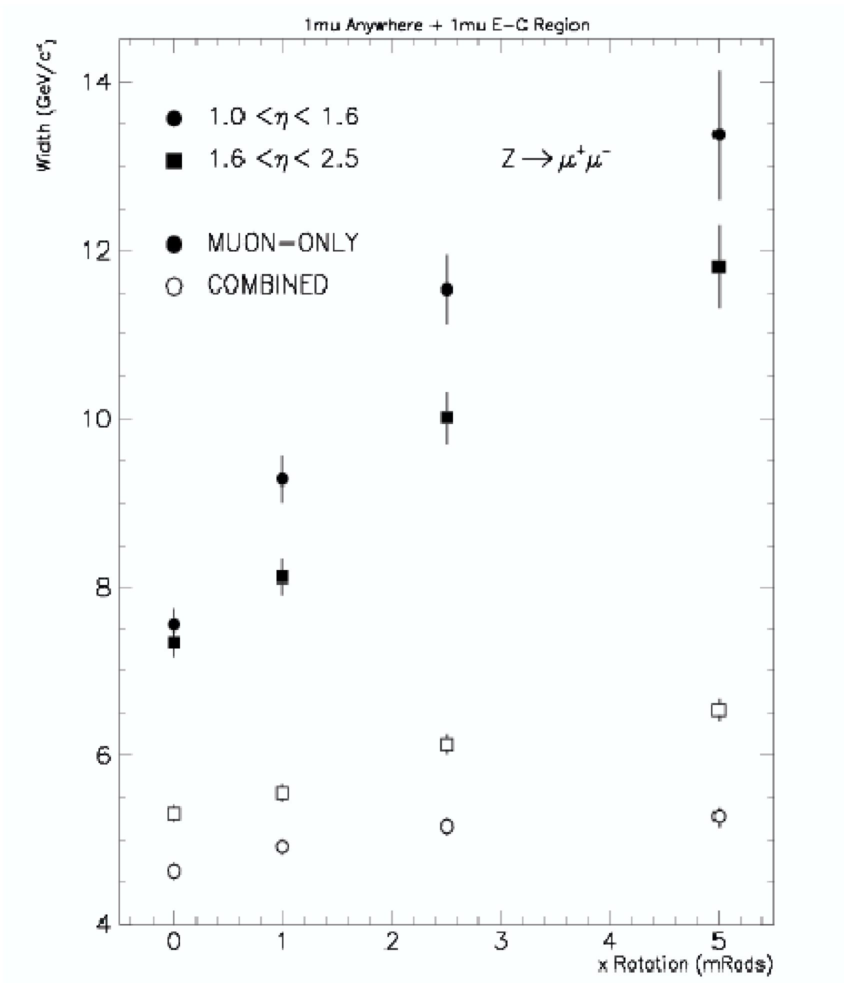
- Study the effect of misalignments on the reconstruction of $H \rightarrow 4$ or 2 muons
- Probe such misalignments using Z boson

Rotations:

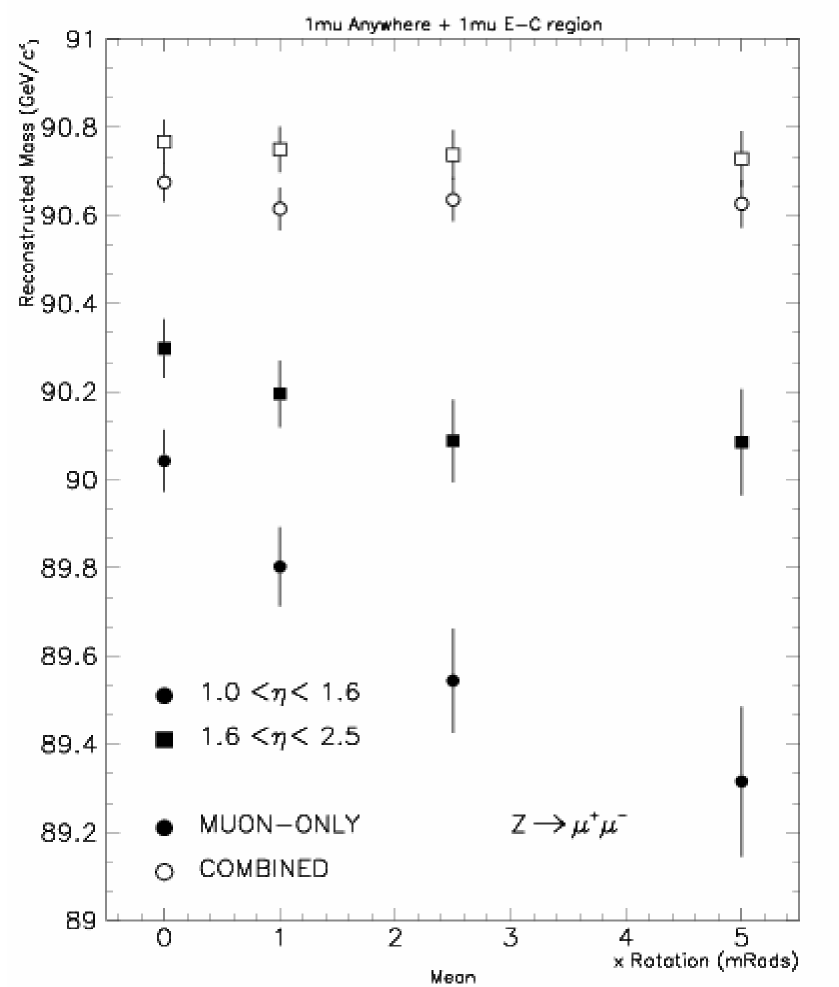
- Each EC sector (EI, EM, EO) by the same angle around axis perpendicular to the beams (axes parallel to themselves)

- Rotations : 1 and 2.5 mrad compared to no rotation case.

$Z \rightarrow \mu^+\mu^-$

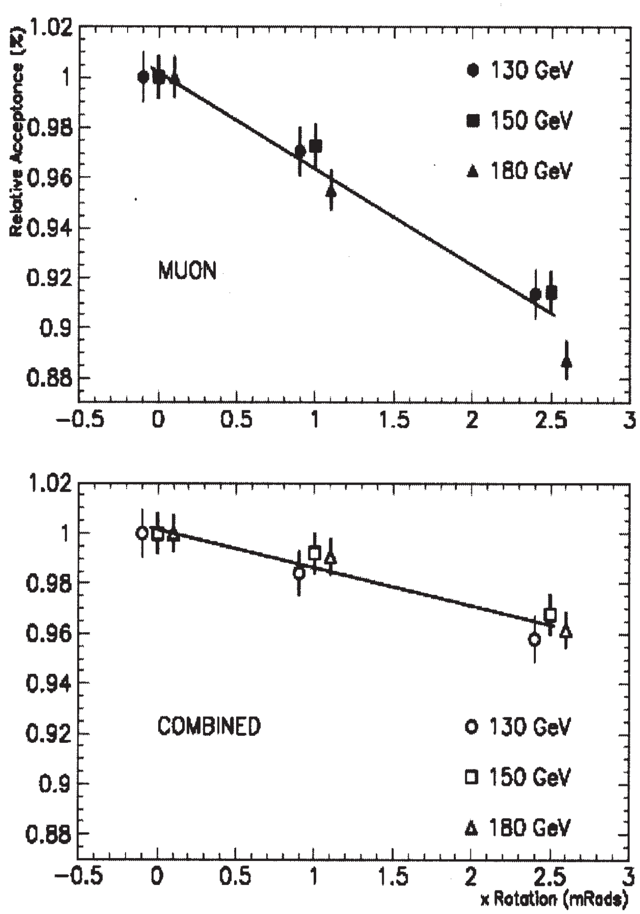


The increase of the width of the reconstructed Z mass as a function of the size of rotation

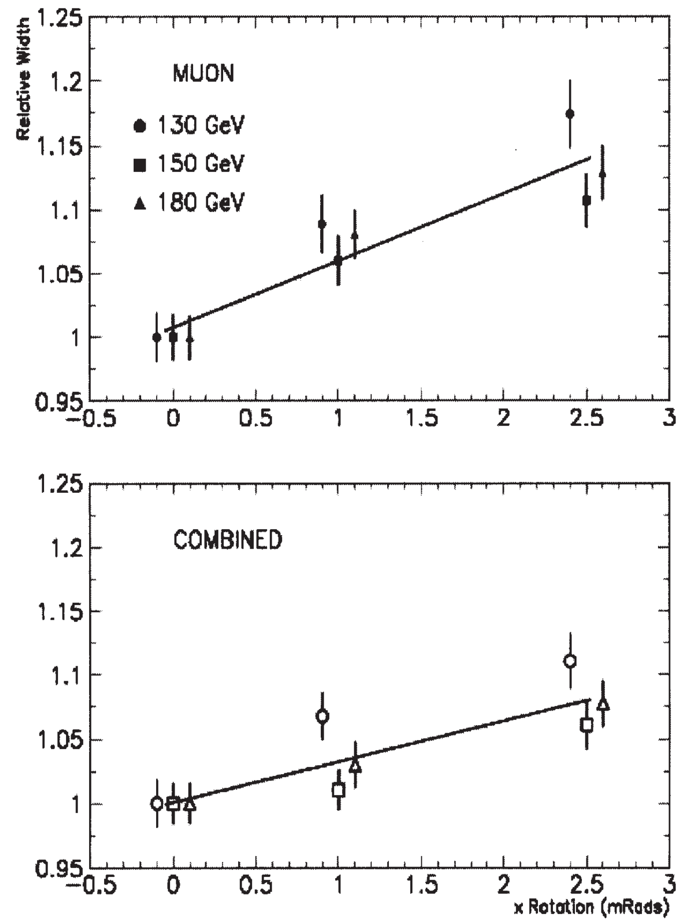


The reconstructed Z-mass as a function of the size of the rotation

SM Higgs $H \to \mu^+\mu^-\mu^+\mu^-$

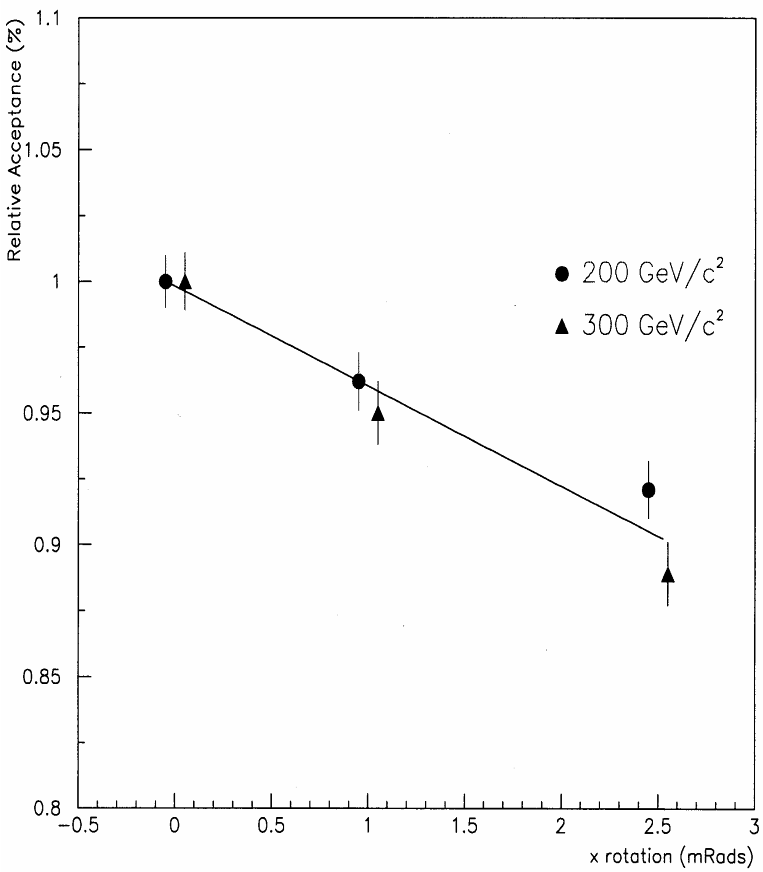


The relative decrease of the number of accepted reconstructed H for three different masses

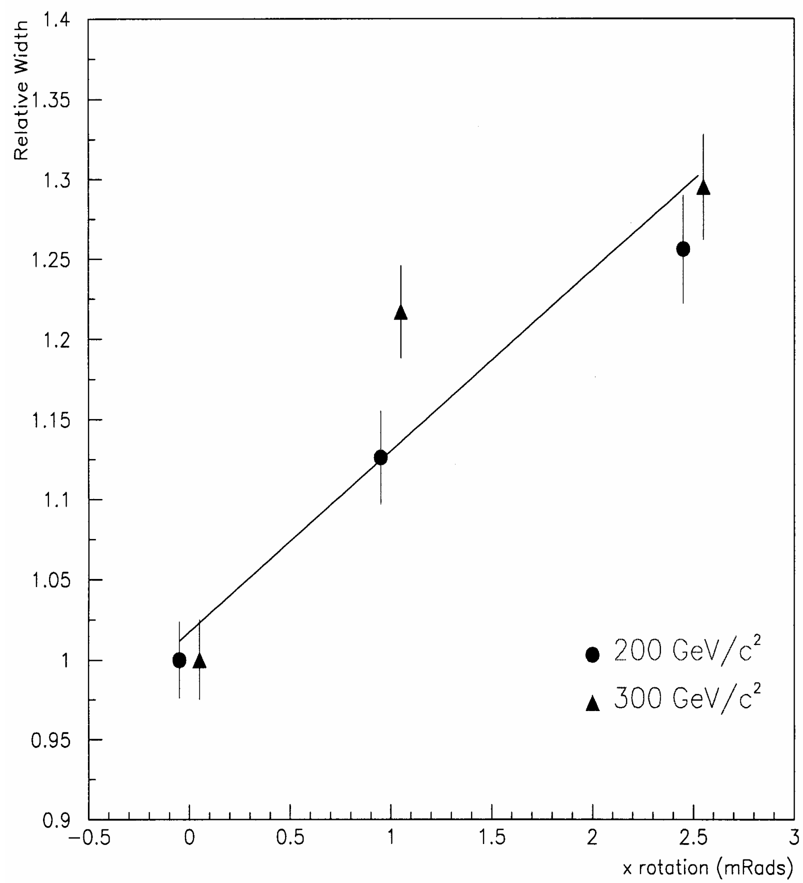


The relative increase of the width of the reconstructed H for three different masses

MSSM Higgs *H/A* → $\mu^+\mu^-$



The relative decrease of the number of accepted reconstructed MSSM H/A for two different masses



The relative increase of the width of the reconstructed MSSM H/A for two different masses

Conclusions:

- *USED LARGE ROTATIONS TO STUDY THE EFFECT*
- If the *max* rotation exceeds few hundreds microrads it will be detected by the sophisticated alignment systems
- ***0.5*** *mrad EC* rotation ,with respect to the axis perpendicular to the beams, reduces SM Higgs signal by ~ 1-2%
- The MSSM *H/A* signal reduced by ~ 2-3 %
- A study of specific sample of *Z* events with at least one muon in the misaligned region can reveal the problem, in order to be corrected *off-line*.