Muon identification procedure for the ATLAS detector at the LHC using Muonboy reconstruction package and tests of its performance using cosmic rays and single beam data

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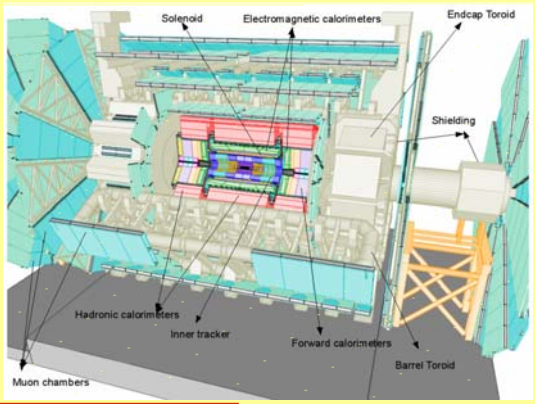
1. The ATLAS Detector

Length ~45 m Height ~22m Weight ~7000 tons

Muon system: (precision chambers + triggers in air core toroids B=0.5T mean value), $\sigma/p_T \sim 7$ % at 1 TeV standalone (e.g. H,A→μμ, H→4μ)

Electromagnetic Calorimeters: (Pb-liquid argon) $\sigma/E \sim 10\%/\sqrt{E}$, uniform longitudinal segmentation Provides: e/γ identification, energy and angular resolution, γ/jet , γ /π_0 separation (e.g. H→γγ)



Inner Detector: (Silicon pixels + strips + TRT→particle ID (e/π)) B=2T, $\sigma/p_T \sim 4\times10^{-4}\ p_T \oplus 0.01$ (e.g. H → bb)

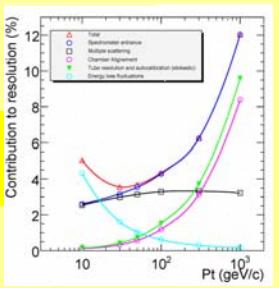
Hadronic Calorimeters: (Fe scint Cu-liquid argon) Jet, $E_{T miss}$ performance (e.g. H →ντ, H→bb)

2. The ATLAS Muon Spectrometer

The ATLAS Muon Spectrometer is designed to detect (trigger) tracks in the region of $|\eta| < 2.7$ (2.4). It consists of one barrel ($|\eta| <1.1$) section and two endcaps ($|\eta| >1.1$).
Four types of technologies are used and arranged in space such that particles go through three stations of chambers fitted in the air-core superconducting toroidal magnets.

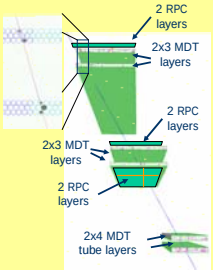
- Monitored Drift Tubes (MDT) precision chambers
  - 1150 chambers, 354k tubes in total that measure the position of the track in the bending (η) plane
  - 80 μm precision per tube
- Cathode Strip Chambers (CSC)
  - 32 chambers in total ($|\eta| >2$)
  - 60 μm precision in the bending plane, 5 mm in the transverse plane (φ)
- Resistive Plate Chambers (RPC) for trigger
  - 544 chambers in total in the barrel
- Thin Gap Chambers (TGC) for trigger
  - 3588 chambers in total in the endcap
  - Both trigger chambers provide measurements in the (η) and (φ) plane of the track, with a resolution of ~1cm

A muon track in ATLAS is measured with 2 or 3 drift tube chambers.
Station alignment: requirement of ~11% resolution on P_T for a μ of 1TeV
Optimal reconstruction is achieved with tracks measured with 3 drift chambers leading to track curvature 400-700 μm, and alignment to ~40 μm



Analytic estimation of different contributions to the μ resolution versus Pt

3. Muon Reconstruction



"Muonboy": standalone reconstruction algorithm

Steps of pattern recognition (segment / track reconstruction)

1. Identification of regions of activity defined by cones (pointing to Interaction Point IP) around crossing RPC/TGC η,φ strips
2. Reconstruction of local straight track segments inside these cones
3. Combination of track segments to form track candidates
   - Seeding segment must have φ strip information
4. Use of a global refit of candidate tracks through the full system
   - Starting momentum of candidate tracks estimated from angle of seeding segment

Backtracking down to the beam region

- Backtracking of muon track to the Interaction Point takes implies an accurate knowledge of the amount of material traversed by the muon
  - Muon momentum is corrected by energy loss parameterization

Output parameters

- Track parameters (q/p, η, φ, d0,a0) + Covariance matrix which are errors on tracking procedure that take account for multiple scattering and fluctuations in energy losses

"Staco", "Mutag": combined reconstruction algorithms

Combined muons

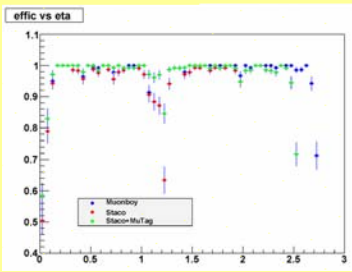
•Staco: Combine the parameters of Muonboy tracks from the Muon System backtracked to the interaction point with the ones from Inner Detector tracks.

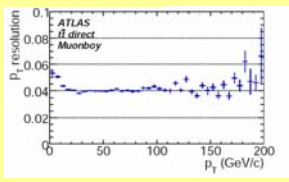
Tagged muons

•Mutag: Tag of Inner Detector tracks by matching them with Muonboy segments applying criteria on segment quality and number of hits in the segment

4. Performance on Simulation

Efficiency vs eta from standalone and combined μ reconstruction Single muon tracks of Pt=100 GeV





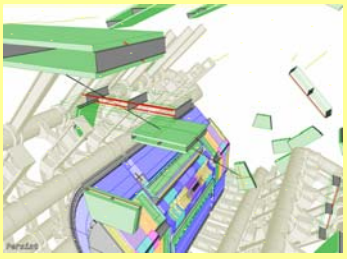
Resolution vs Pt in standalone μ reconstruction on tt samples

5. Adaptation of Muonboy algorithm for cosmic rays

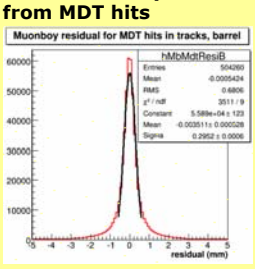
Steps of pattern recognition (segment / track reconstruction)

1. No regions of activity identified, no constraint to the IP
2. Reconstruction of local straight track segments everywhere
3. Combination of track segments to form track candidates from all segments
4. Use of a global refit of candidate tracks through the full system
   - Scan different values of momentum

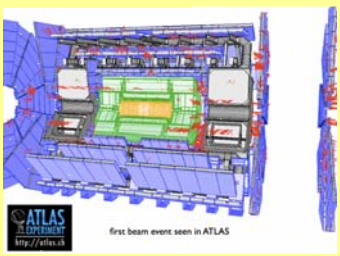
Cosmic ray muon track in the absence of toroid magnetic field



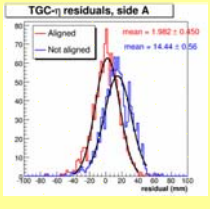
Residuals on muon tracks from cosmic rays calculated from MDT hits



6. Performance on cosmic events and first LHC single beam data



During the first LHC single beam events in 2008 (collimator splashes) thousands of local track segments were reconstructed in the muon chambers.



Residuals on muon tracks from cosmic rays calculated from TGC hits with (without) the alignment corrections of the TGC wheel.

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