The Offline Data Quality Monitoring system of the ATLAS Muon Spectrometer
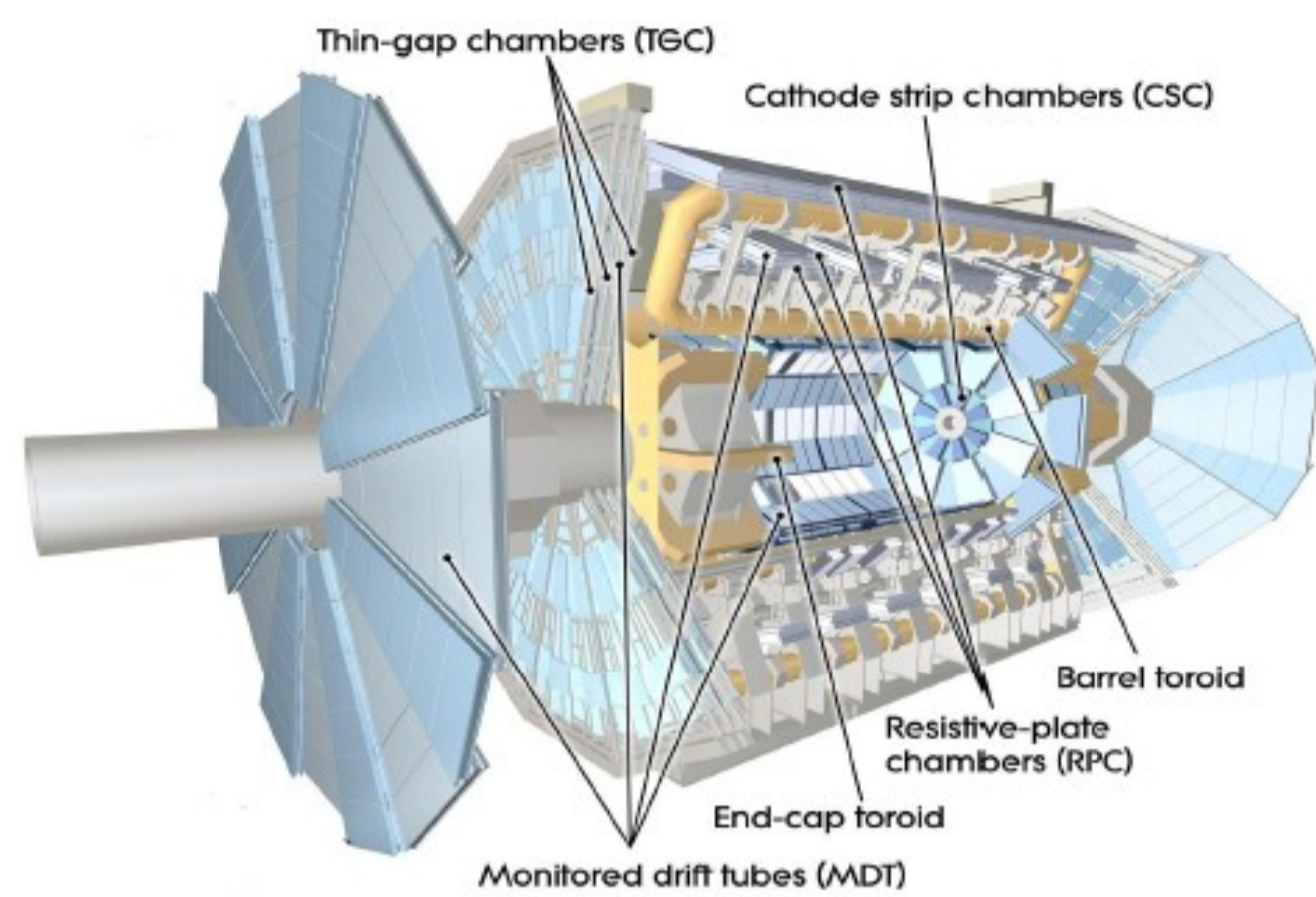
Vasiliki Kouskoura, Aristotle University, Thessaloniki
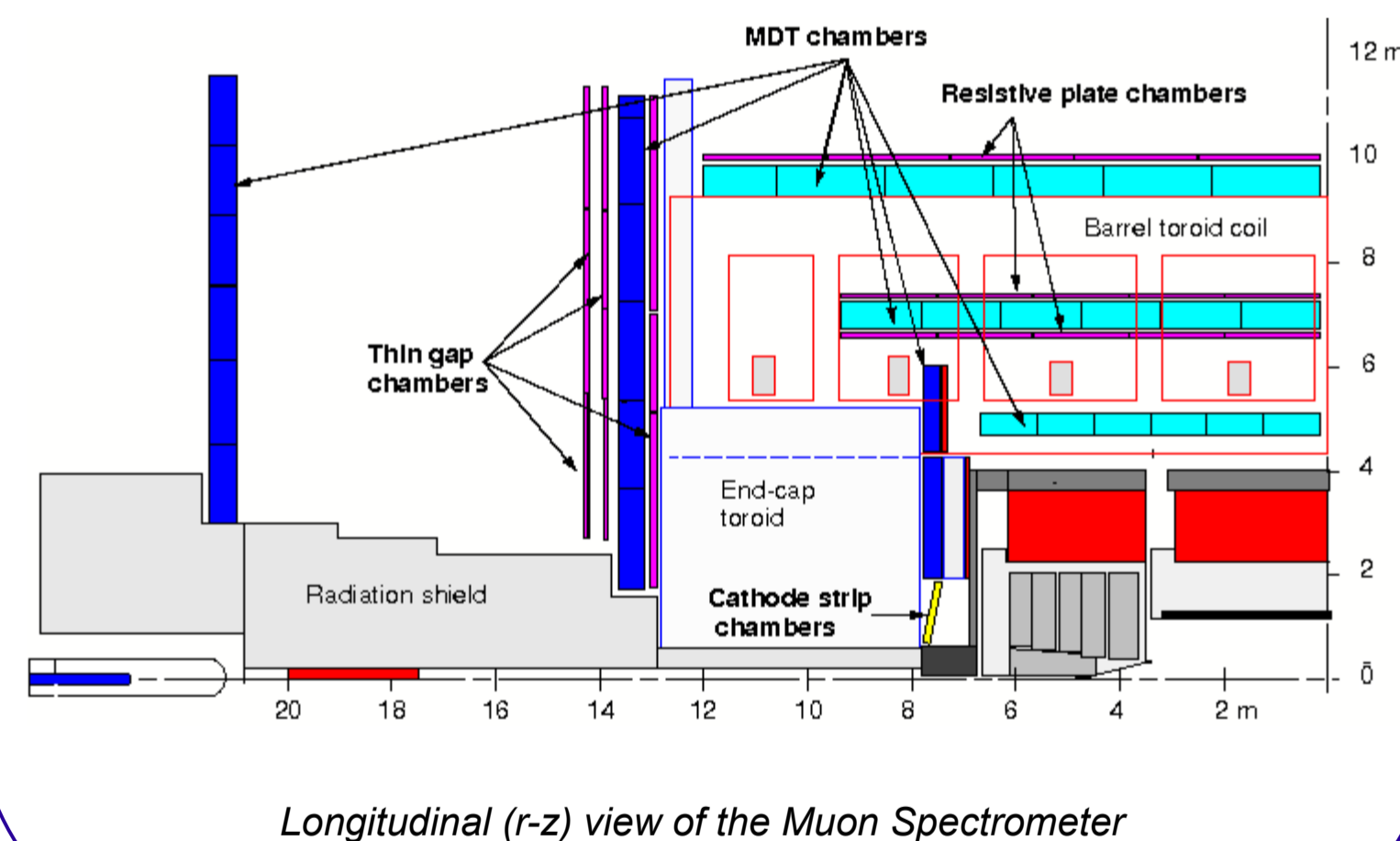
The ATLAS detector has been designed to exploit the full discovery potential of the p-p collisions at LHC, at the center-of-mass energy of 14TeV. Its Muon Spectrometer (MS) has been optimized to measure muons from those interactions with high momentum resolution (3-10% for momentum of 100GeV/c – 1TeV/c). To ensure that the hardware, Data Acquisition (DAQ) and reconstruction software of the ATLAS MS is functioning properly, Data Quality Monitoring (DQM) tools have been developed both for the online and the offline environment.

The ATLAS Muon Spectrometer

Longitudinal (r-z) view of the Muon Spectrometer

Comprises three subsystems:
1. **Barrel Toroid** and **End-Cap Toroid** providing a **magnetic field** of **0.5-1Tesla**
2. **Precision detectors**
   • **Monitored Drift Tubes (MDT)** in the Barrel and End-Cap region ($|\eta|$<2.7)
   • **Cathode-strip Chambers (CSC)** in the Innermost End-Cap station (2.0<$|\eta|$<2.7)
3. **Trigger chambers**
   • **Resistive Plate Chambers (RPC)** in the Barrel region ($|\eta|$<1.05)
   • **Thin Gap Chambers (TGC)** in the End-Cap region (1.05<$|\eta|$<2.4)

Offline Monitoring in ATLAS Muon Spectrometer

Monitoring can be performed in parallel to the event reconstruction chain, which for muons is:
• conversion of the byte stream into "Prepared" Raw Data objects
• pattern recognition and segment reconstruction
• track reconstruction
• physics objects reconstruction in combination with other detectors

Monitoring is done in three levels
• **Raw data monitoring**
• **Segment and Track monitoring**
• **Physics monitoring**
Each level plays significant role in software commissioning with cosmic muons and simulated data

Online Monitoring
Is perfotmed on a random subset of the events being recorded, to quickly spot problems, after only few seconds of data taking
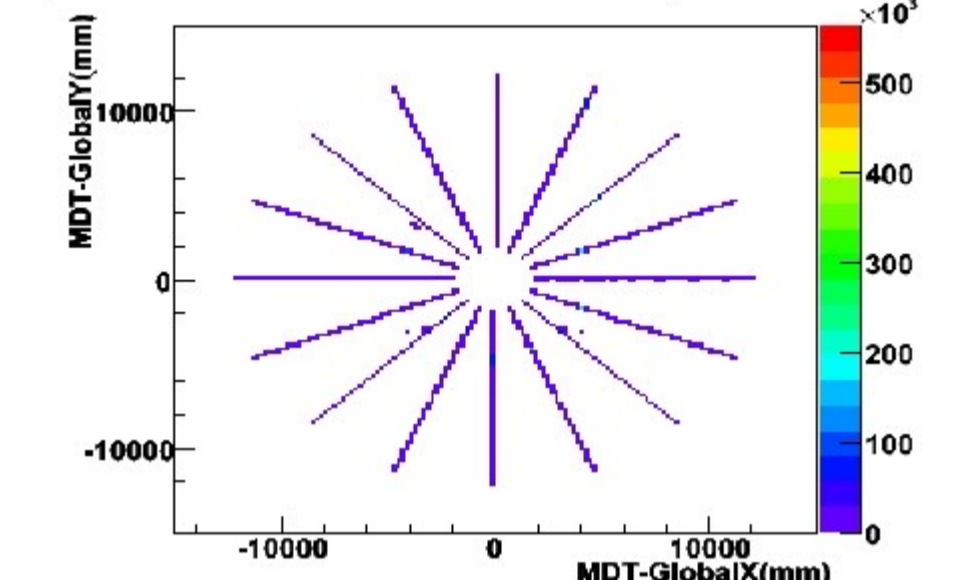
Raw Data Monitoring
Quantities that are related to Raw data information of the detector (hits) are checked. The main purpose is to test the full read-out chain from online to offline.
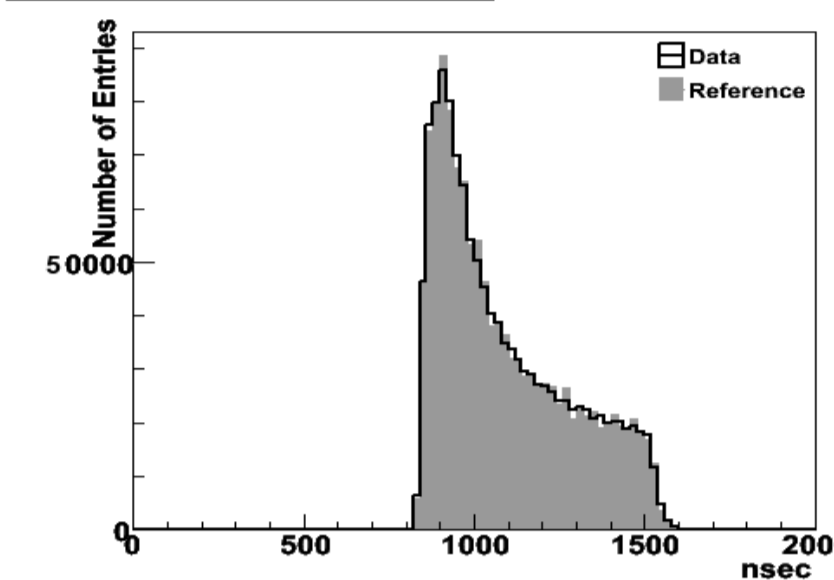


Typical MDT TDC spectrum. Noise has been subtracted.

XY map of EndCap MDT occupancy (number of hits), reflecting the geometry of the MS

Segment Monitoring
After each reconstruction algorithm has performed a pattern search and built segments (i.e. sets of hits in a single station) their parameters are recorded. Quantities that are monitored are:
• Segment multiplicity, hit on segment multiplicity, occupancies
• Fit quality
• Hit residuals
• Chamber and tube efficiencies
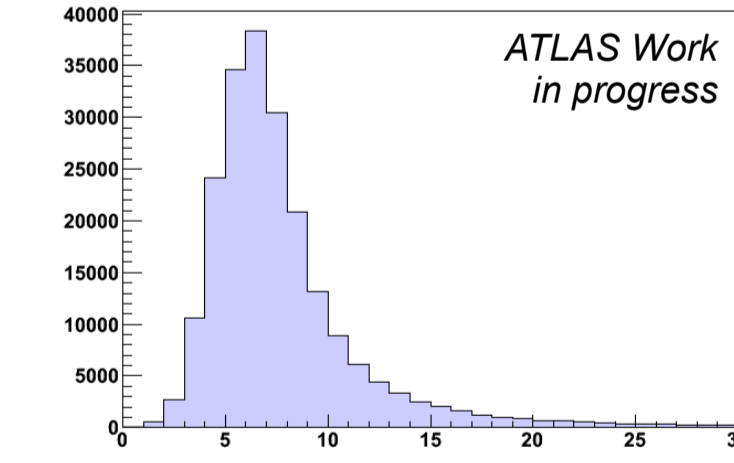This way problems are spotted early in the reconstruction chain.
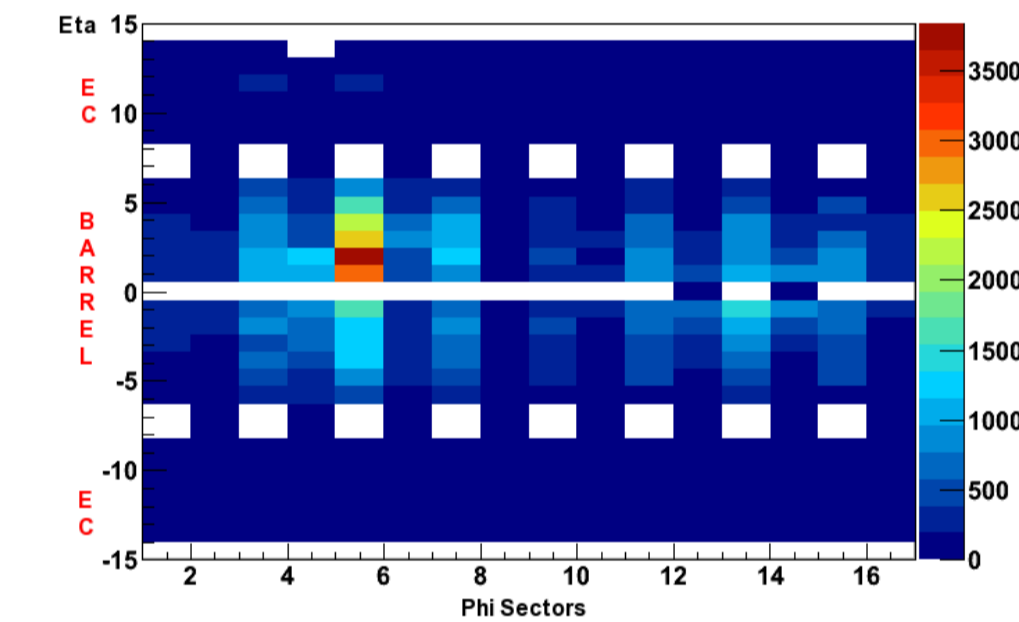
η/φ map of reconstructed segments. The concentration of segments on the top of the detector is characteristic of cosmics.
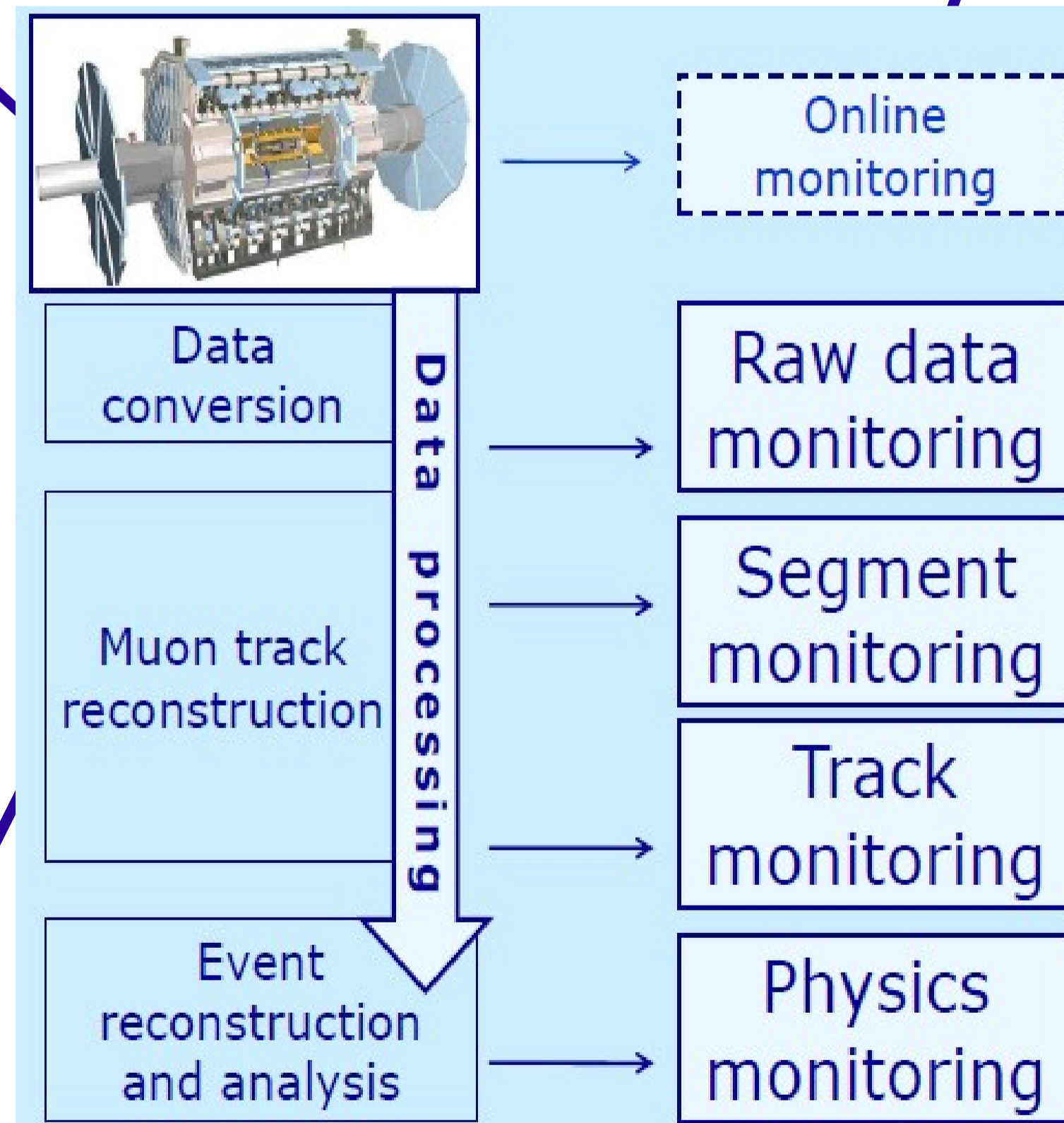
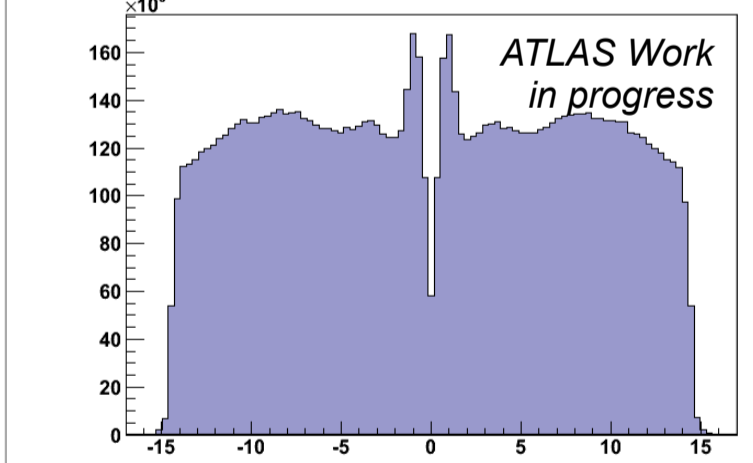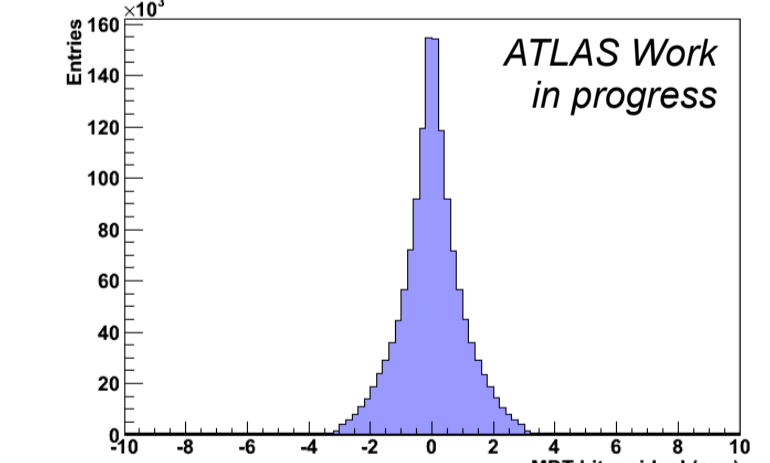Multiplicities on segments (cosmic events)

MDT hit-on-segment drift radius. The flatness of this distribution is a test of the quality of the calibration. (cosmic events)

MDT hit-on-segment residual (cosmic events)

Data processing
Data conversion → Raw data monitoring
Muon track reconstruction → Segment monitoring → Track monitoring
Event reconstruction and analysis → Physics monitoring
Online monitoring

Muon Reconstruction
The main steps that are followed are:
1. Pattern recognition: collection of hits in chambers per multilayer
2. Segment reconstruction: linear fit on the hit collection
3. Track finding: combination of segments
4. Track fitting, calculating track parameters
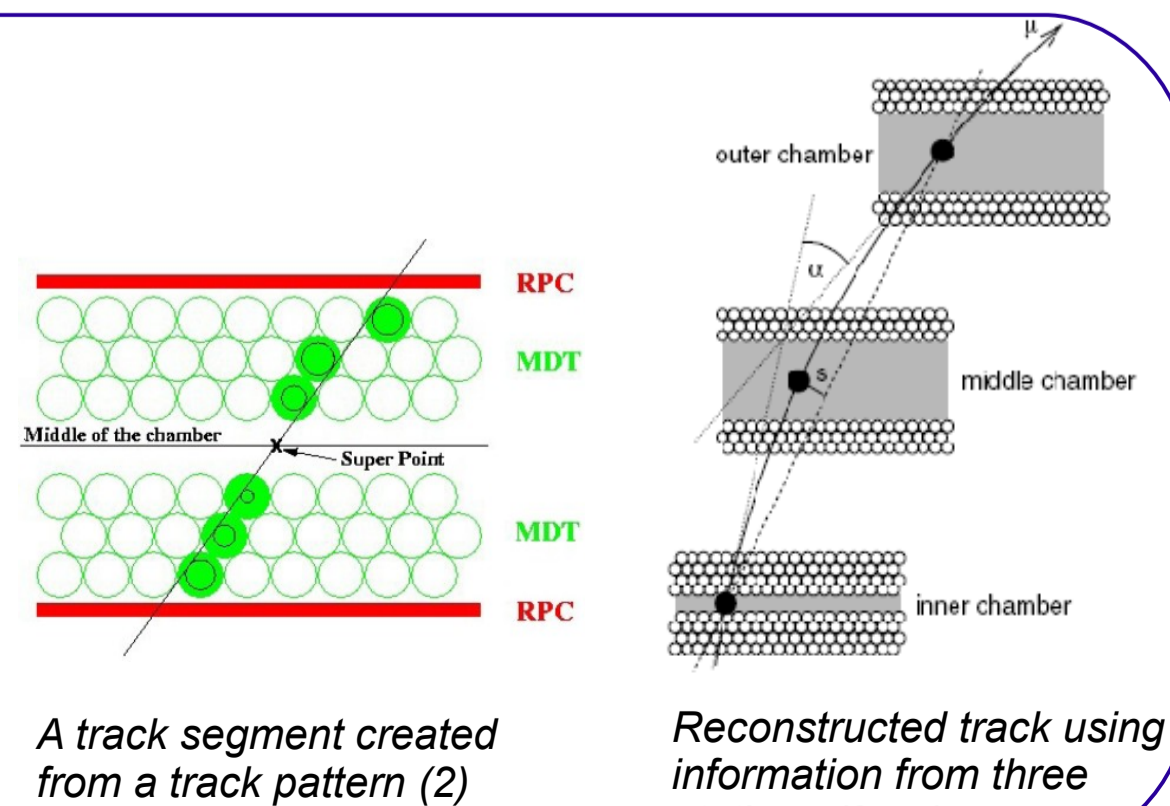
A track segment created from a track pattern (2)

Reconstructed track using information from three stations (3 - 4)

Physics Monitoring
The main purpose of Physics Monitoring is to study physics quantities of reconstructed objects that can me used in analysis, by checking calibration constants and long-term stability.
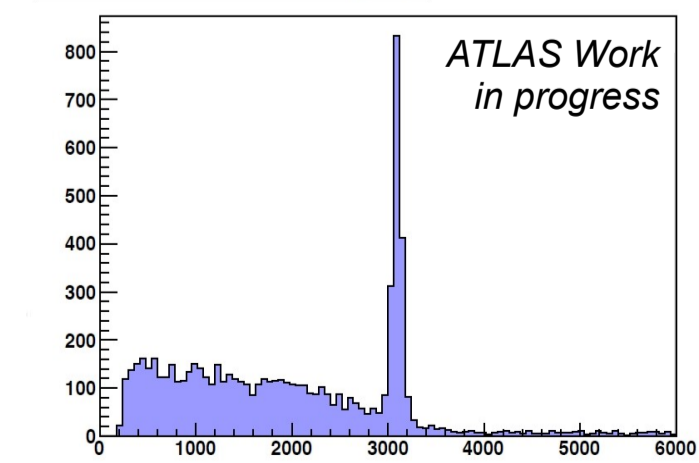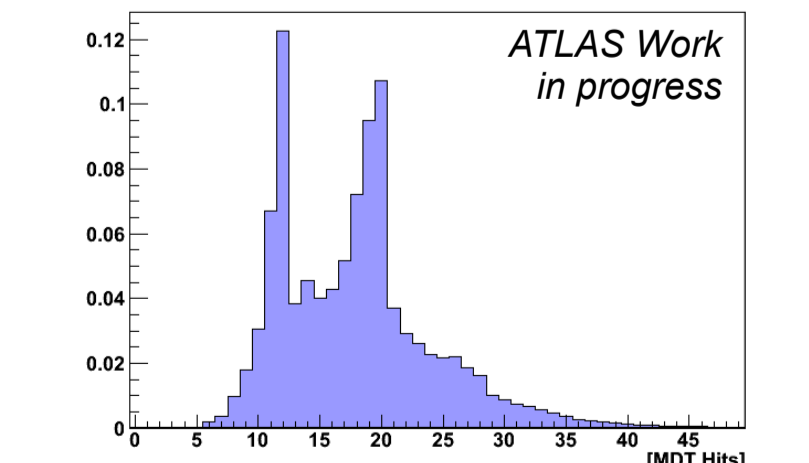
J/ψ peak in di-muon invariant mass spectrum from simulated data

Track Monitoring
Monitoring of reconstructed tracks in the MS. The important issue is to monitor muon reconstructed quantities, as well as to check the calibration, alignment constants and magnetic field.

The two peaks correspond to 2 and 3 MDT chamber tracks respectively (cosmic events)

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