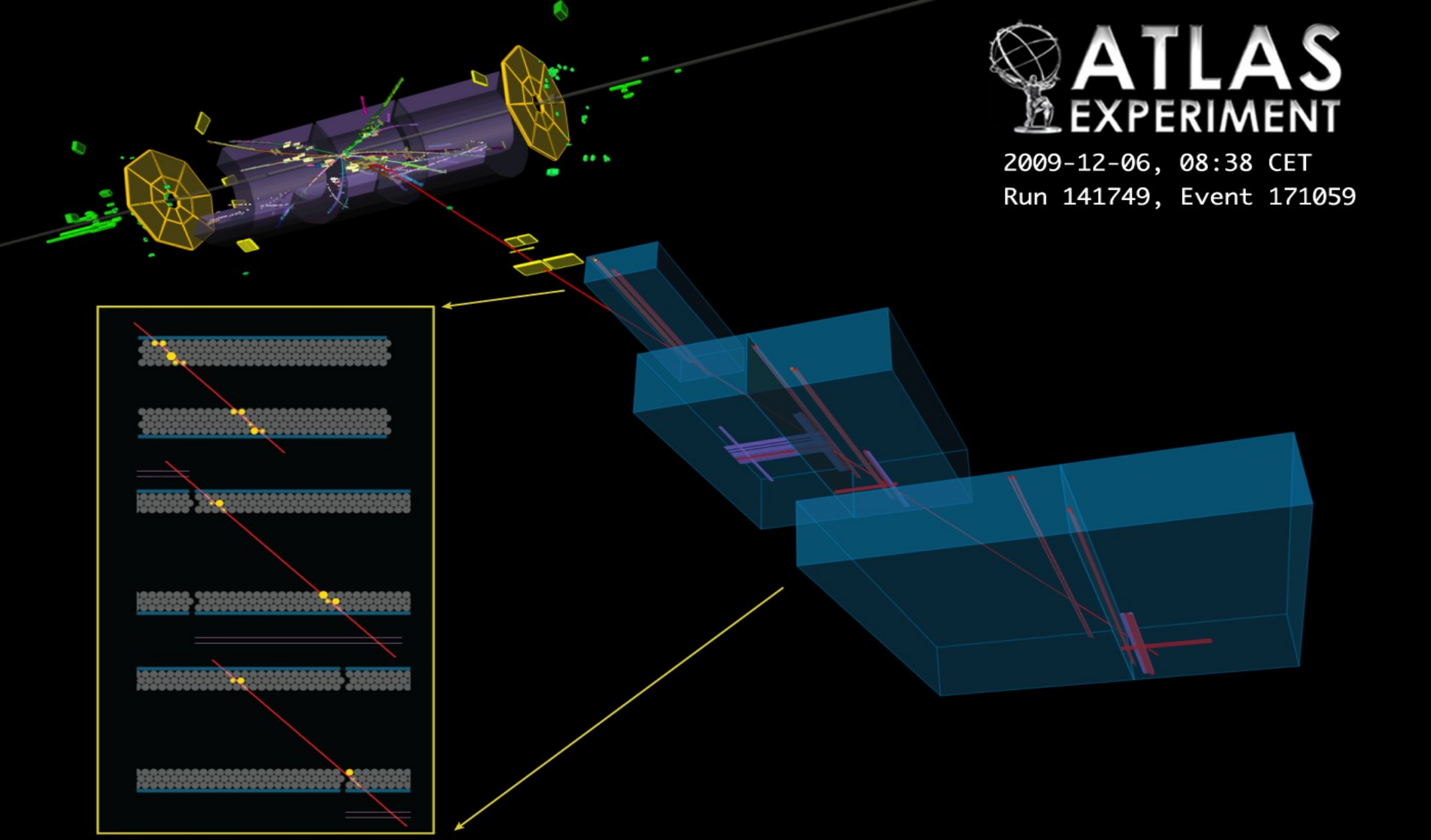
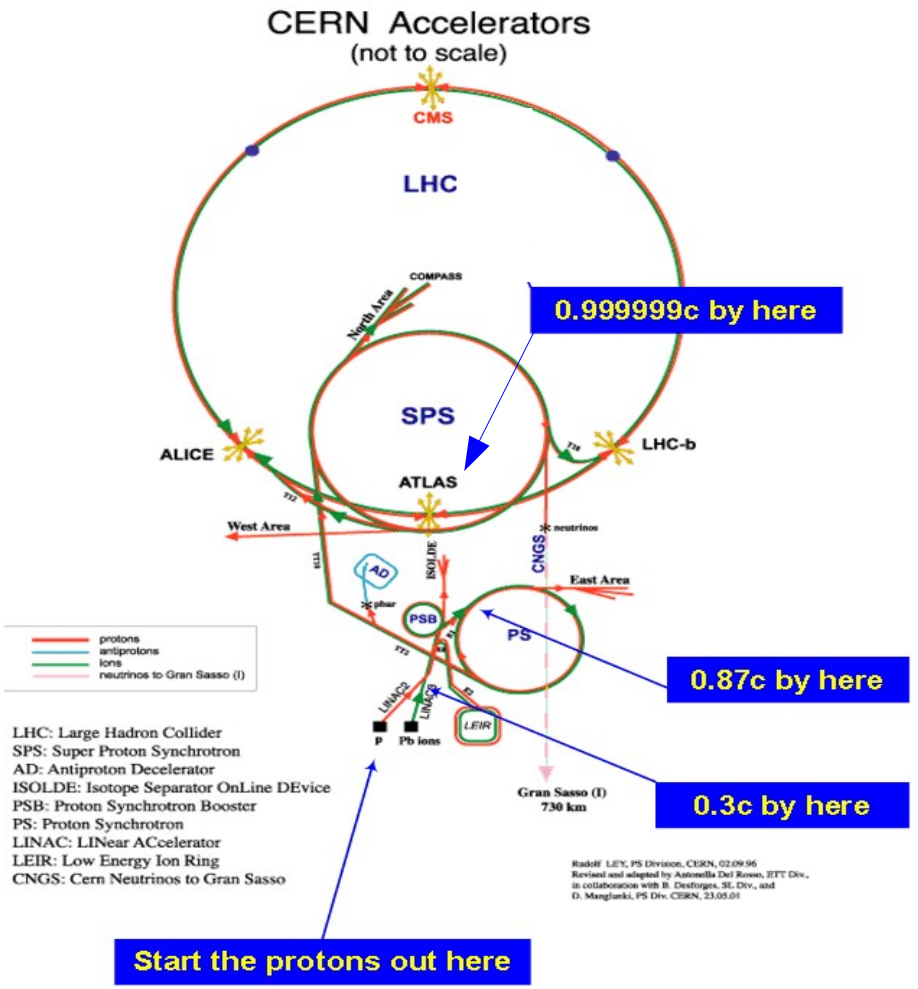


Performance analysis of the muon chambers of the ATLAS experiment at the LHC collider

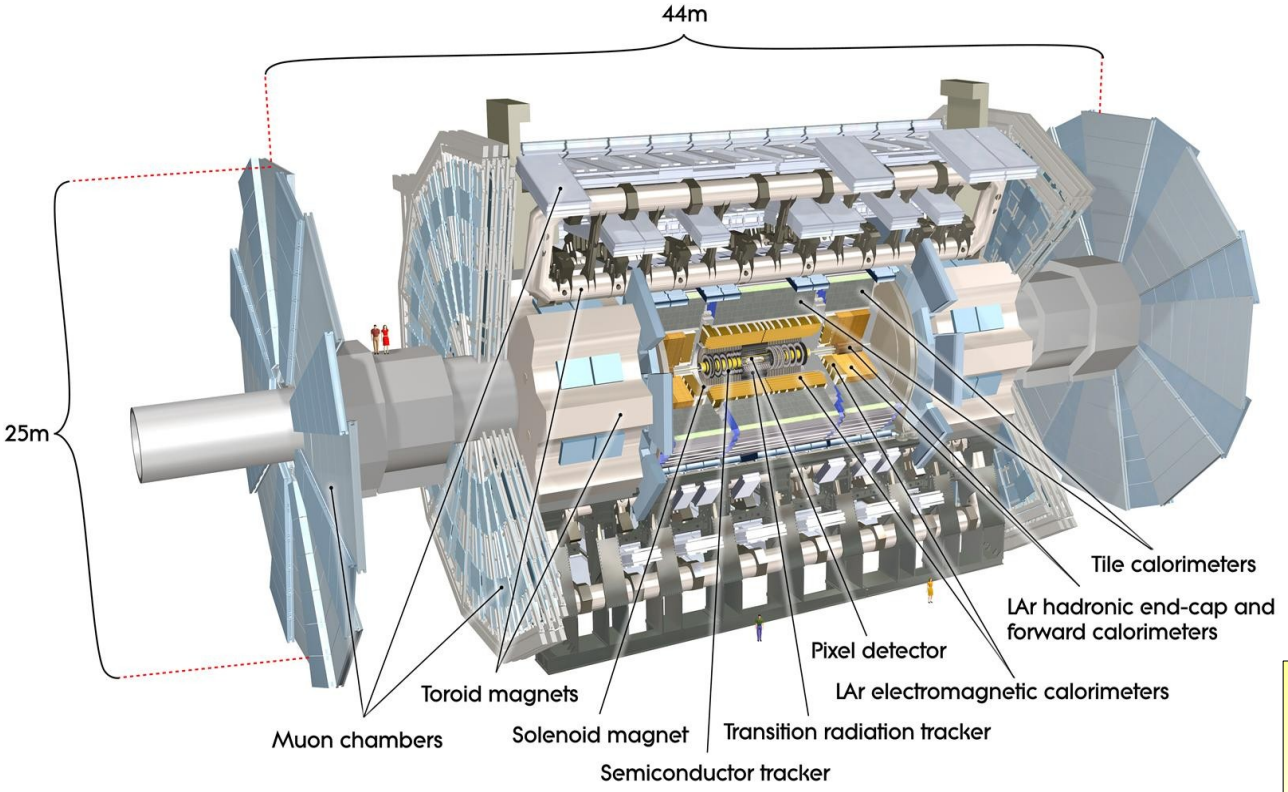
Marco Vanadia – Sapienza, University of Rome

The LHC Collider



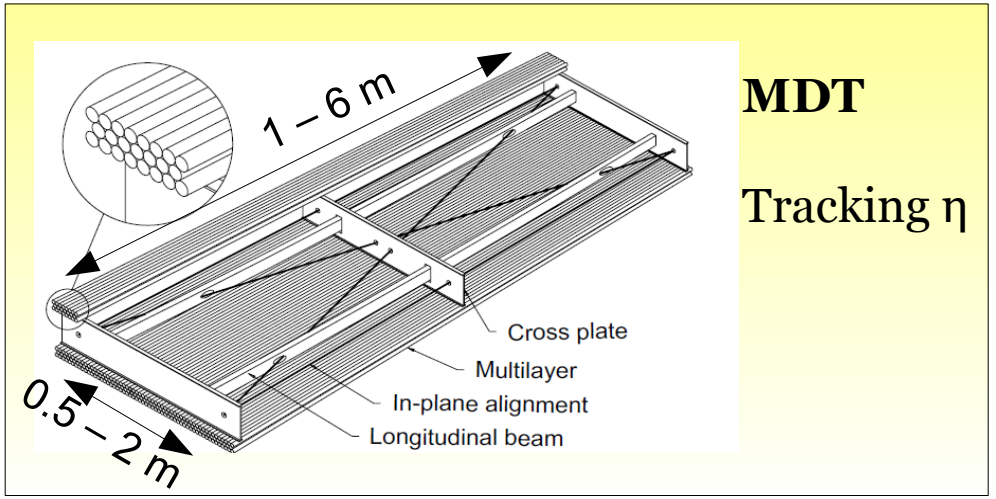
- **pp collider**
- **High √s**
  - goal 14 TeV (7+7)
- **High Luminosity**
  - goal $L=10^{34}cm^{-2}s^{-1}$
  - collisions every 25 ns, requires complex trigger
- **6 experiments**
  - SM studies
  - Search for Higgs Boson
  - SUSY
  - Exotic processes
  - …

The ATLAS detector



- **Inner Detector**
  - Pixel
  - Strip
  - Transition Radiation Tracker
- **EM Calorimeter**
  - Ar+Pb accordion
- **Hadronic Calorimeter**
  - Scintillator + WLS Barrel
  - Ar+Pb accordion Endcap
- **Muon Spectrometer**
  - Works in toroidal B field
  - Air core magnets

ATLAS muon spectrometer chambers

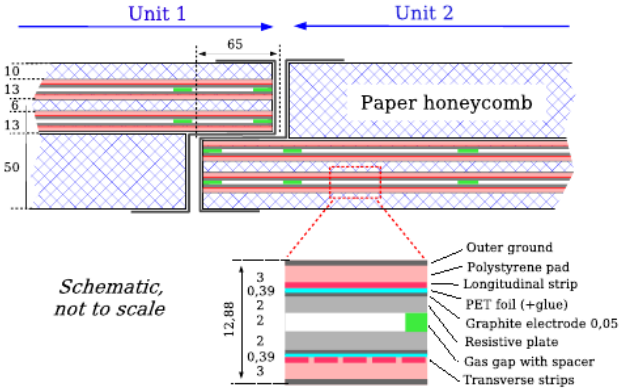


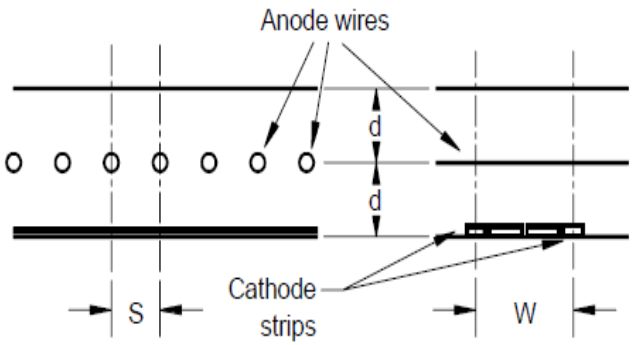
MDT

Tracking η

RPC

Trigger
Tracking η
Tracking Φ



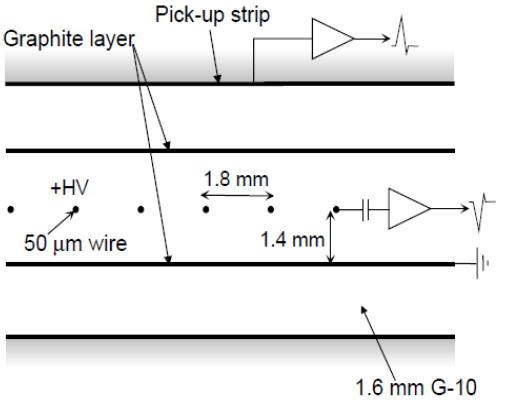


CSC

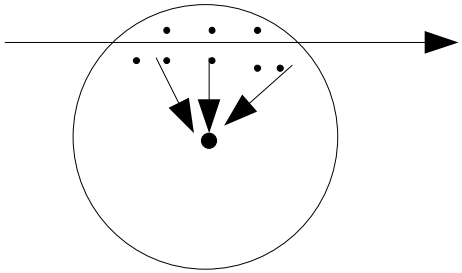
Tracking η
Tracking Φ

TGC

Trigger
Tracking η
Tracking Φ

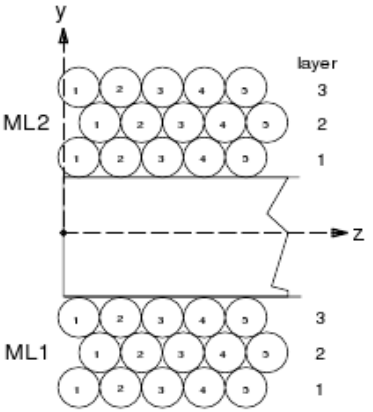


ATLAS MDT chambers



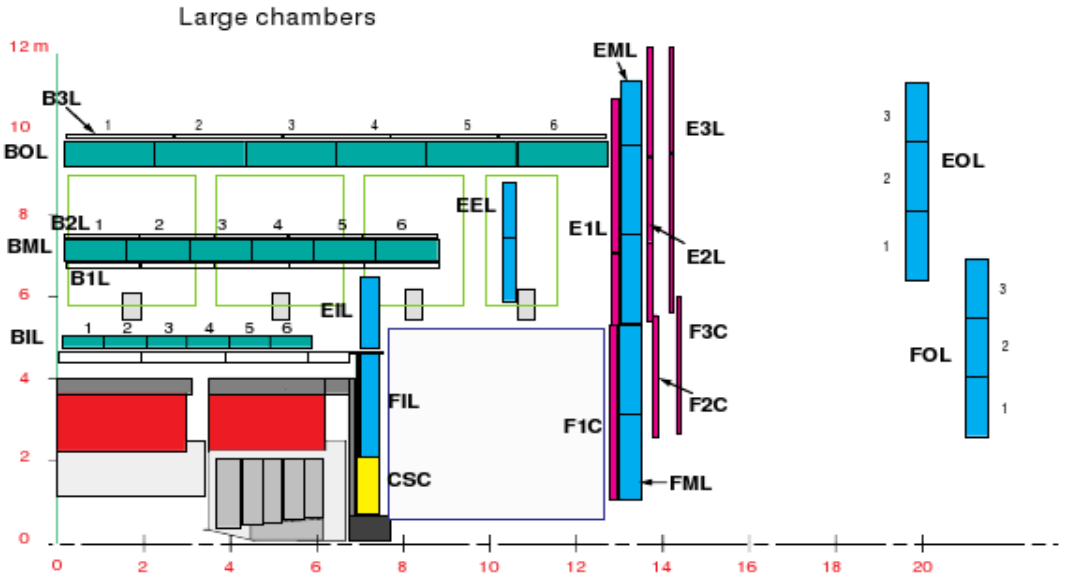
Drift Tubes

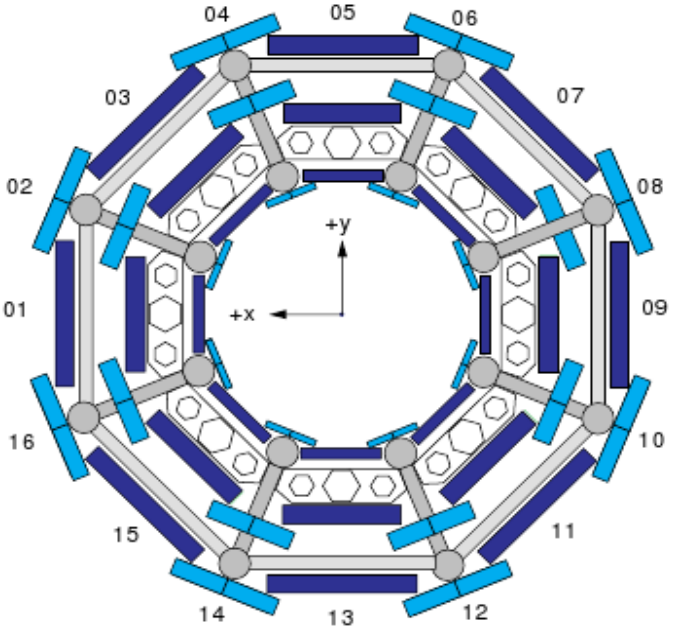
Radius = 15 mm
Ar/CO_2 - 93/7 - 3bar
Anodic wire 3080V



1-2 Multilayers
3-4 Layers

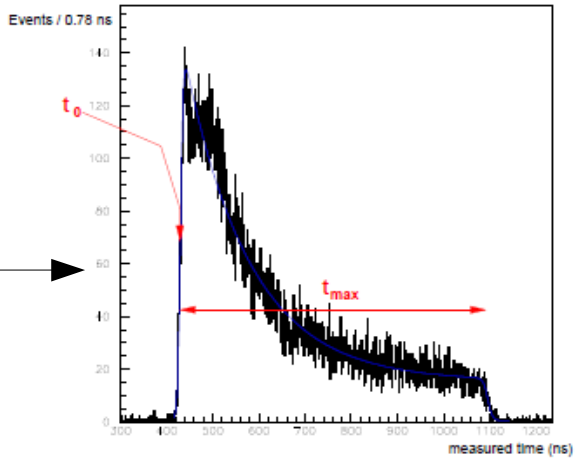
Readout:
mezzanine cards
(ASD, ADC, TDC)

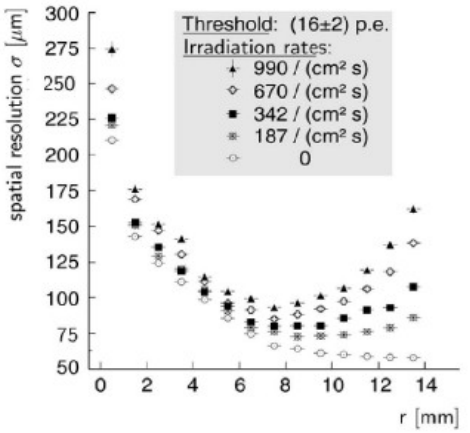




Track reconstruction:
Needs r(t) relation, t_o and t_{MAX} per tube

Input:
- ADC Spectrum
- TDC Spectrum
- Second coordinate (from TGC, RPC)



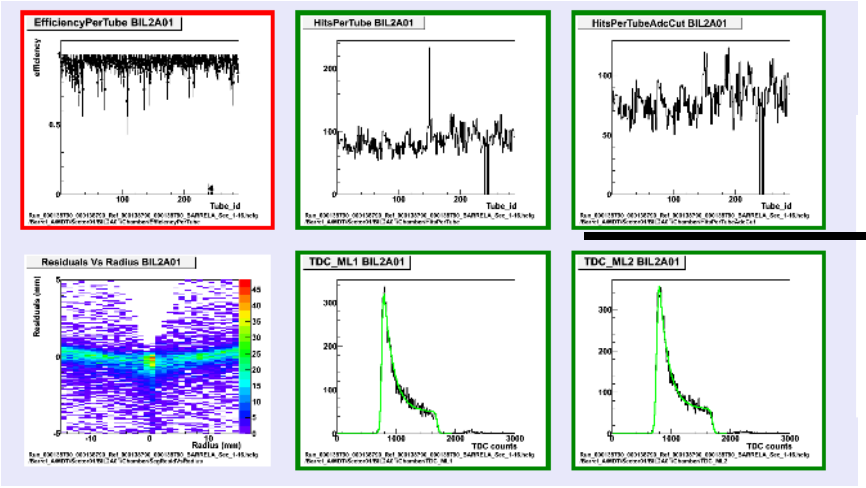


Requires high statistics:

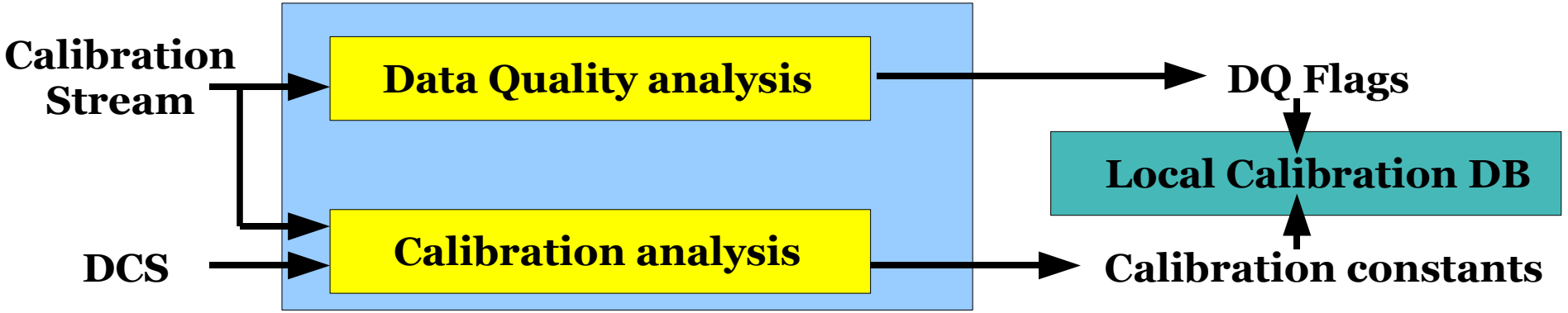
Dedicated data stream from trigger L2 with only muon fragments of the events

Output:
- TDC spectrum constants
- Mean charge per channel q_o
- σ(r)
- r(t) relation

MDT Data Quality at Calibration Centres

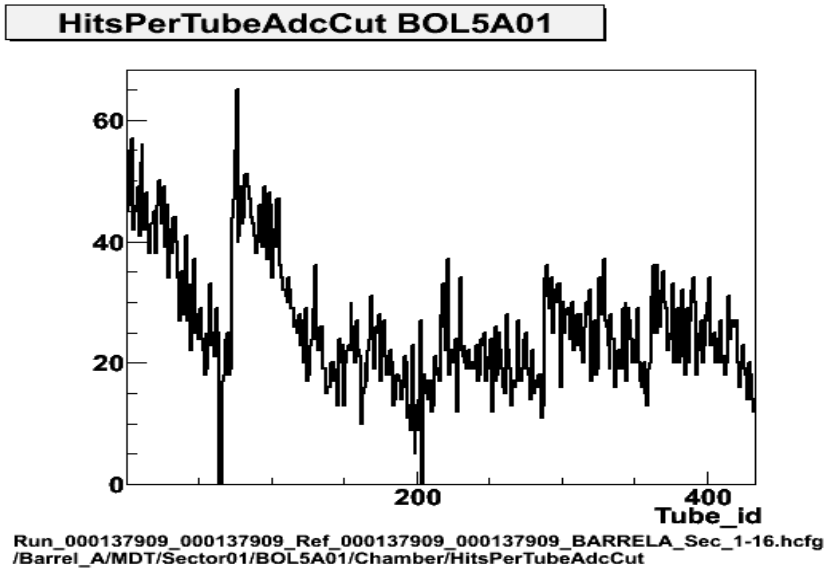


Analysis on ADC, TDC, Occupancies, Efficiencies... → **DQ Flags** → **Evaluation on muon spectrometer status and behaviour**



Tier2: Michigan, Munich, Rome

Search for dead MDT channels

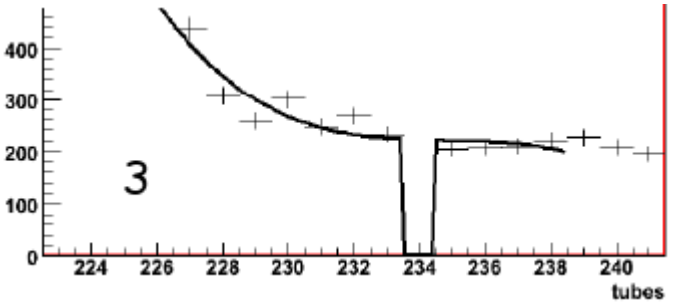


Search for dead (inefficient) channels using tubes hits occupancies

MONITORING
FLAG
RECONSTRUCTION

Existing ATLAS software

- **DEA (→ T. Baroncelli)**
- **GnaMon (→ P. Fleischmann)**

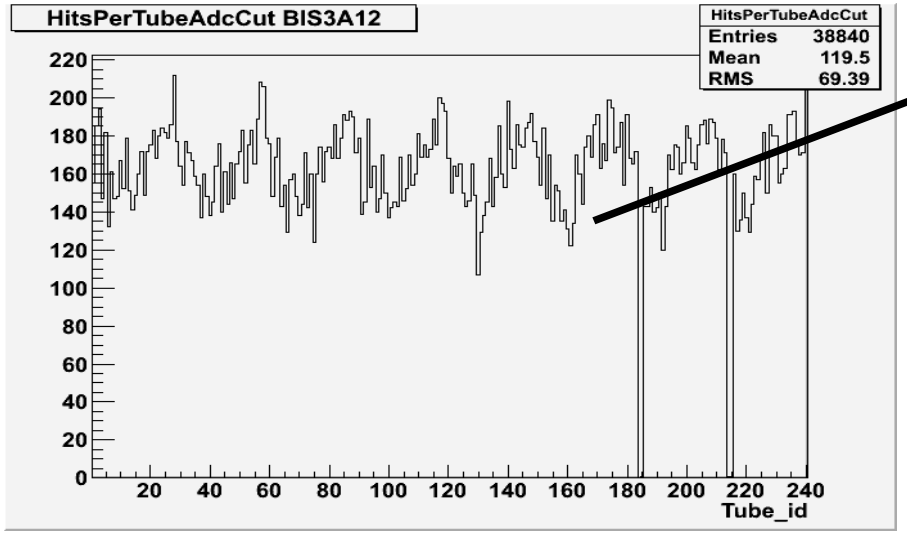


Statistical based search:

Poisson distribution

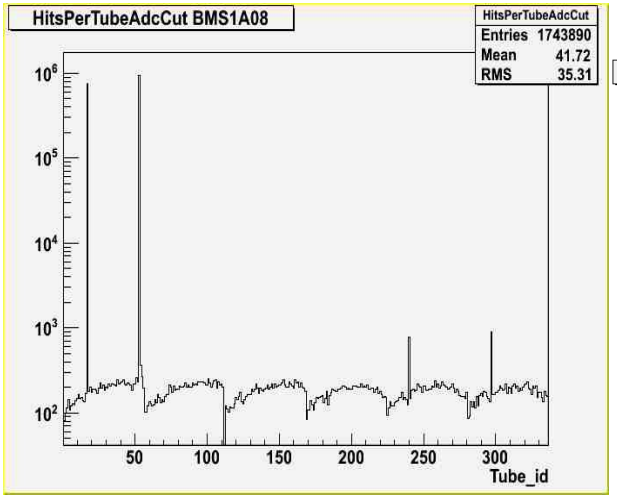
$$P(m,\lambda) = \frac{e^{-\lambda}\lambda^{m}}{m!}$$

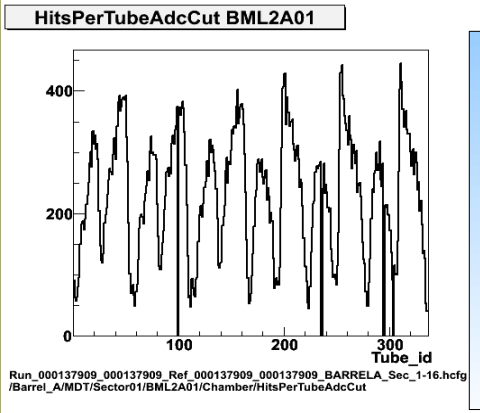
Mean = λ
Stddev = √λ



Calculate mean
↓
Measure λ
↓
Find tubes that are dead with a fixed CL

Main issues
- Noisy channels
- Many dead channels
- Big fluctuactions (cosmic only?)





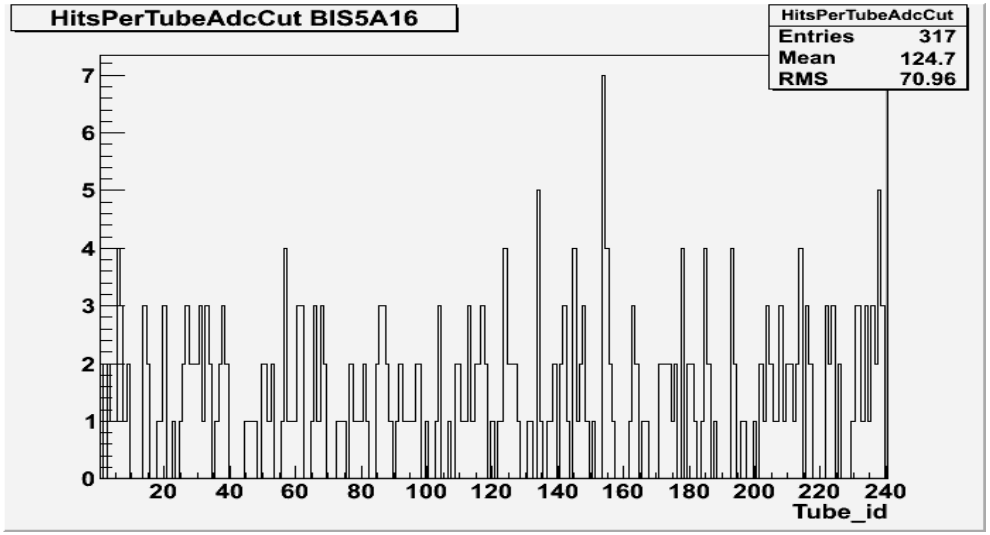
So we use MED & MAD

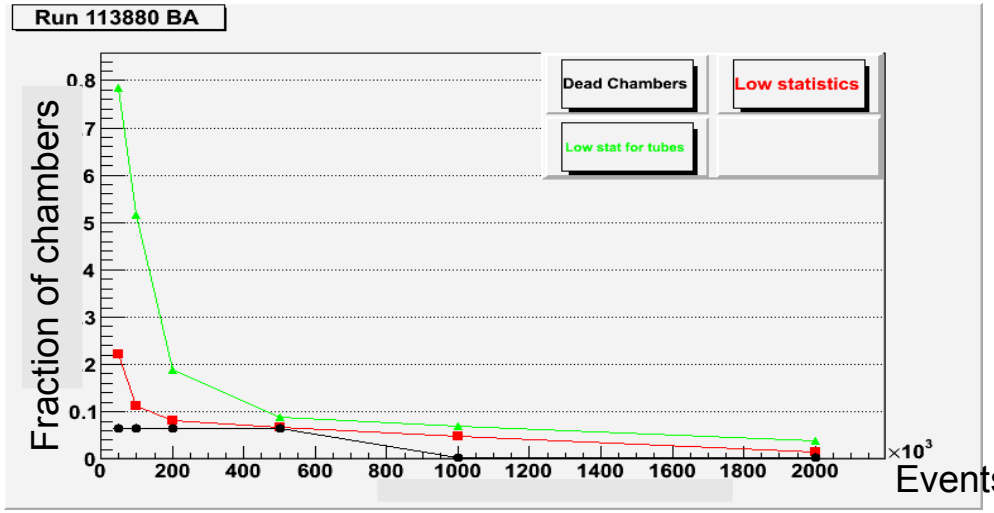
$MED(\lambda) \approx \lambda + 1/3$
$MAD(\lambda) \approx 0.68\,\lambda^{1/2}$

Search for dead MDT channels

Strategy

- Check sequence in order to find what is the problem (HV, Gas, Wire…)
- Check only if histogram has enough statistics
- Produce a list of dead chambers, MLs, layers, mezzanines, tubes
- Flag chamber status

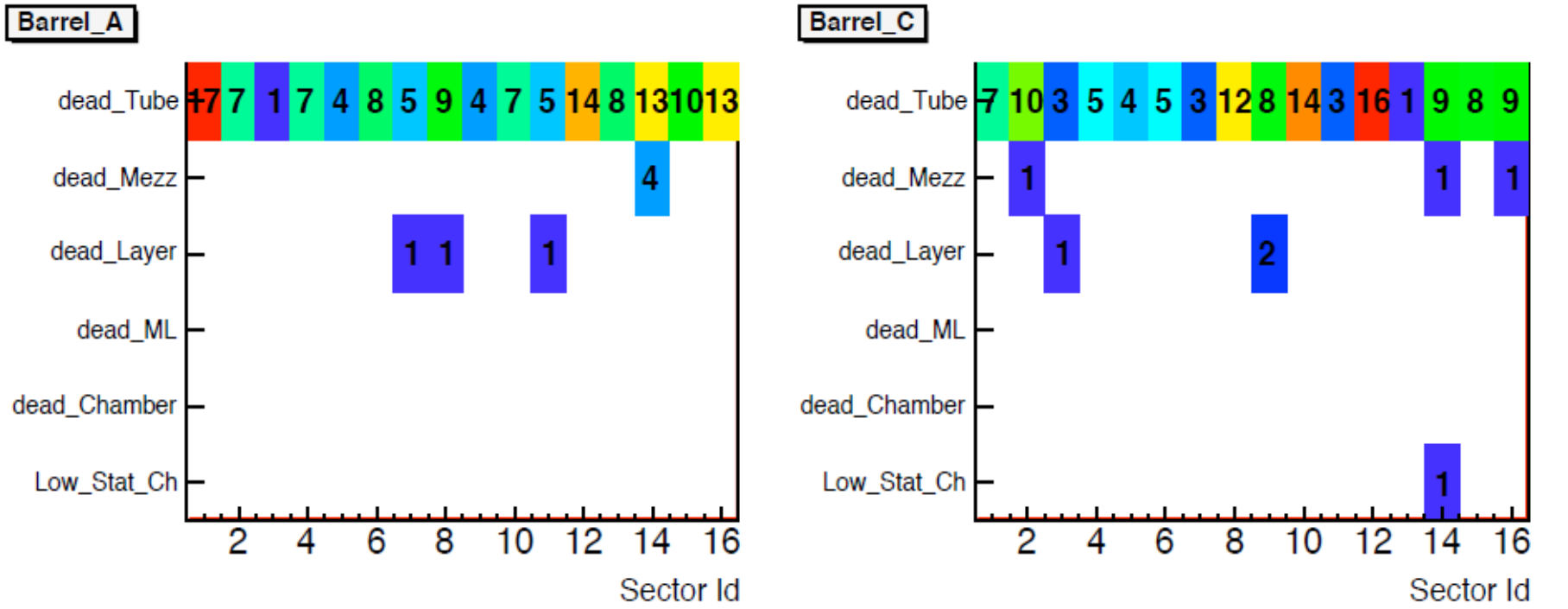




Conclusions

- Test on cosmic rays data: OK
- Improvement in efficiency and reliability
- Low statistics requested for the analysis
- **Now fully inserted in Tier2 software**

Search for dead MDT channels



Example of dead channels analysis output

Offline reconstruction:

Hit

↓

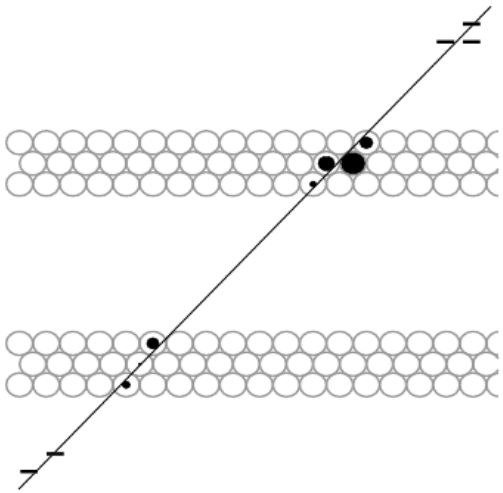
Pattern

↓

Segments

↓

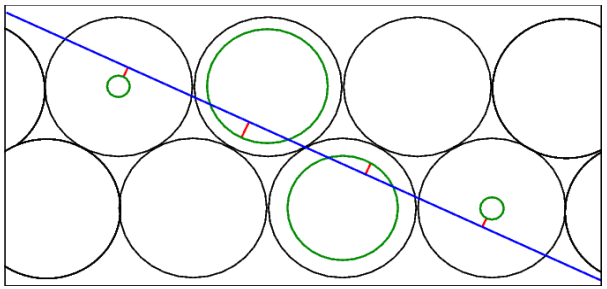
Tracks

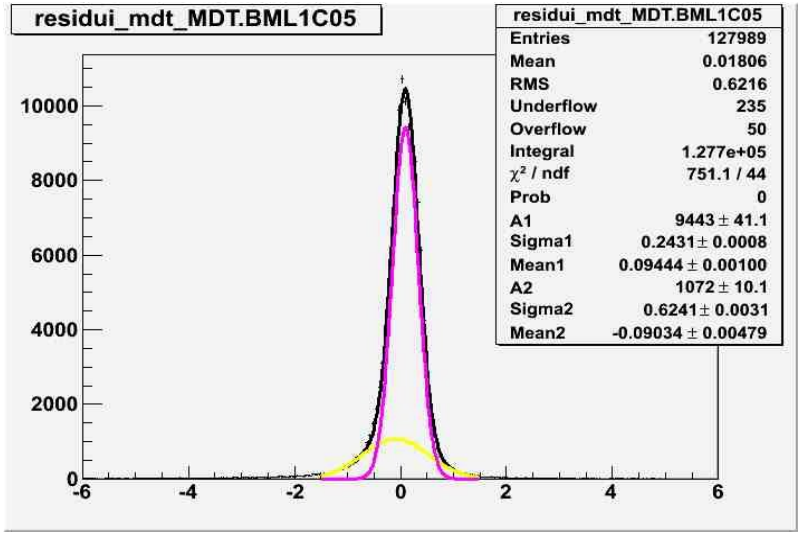


NEW DQ Analysis:

- Segment residuals
- Track analysis
  - Basic monitoring histograms
  - Residuals analysis

Segment residual analysis:



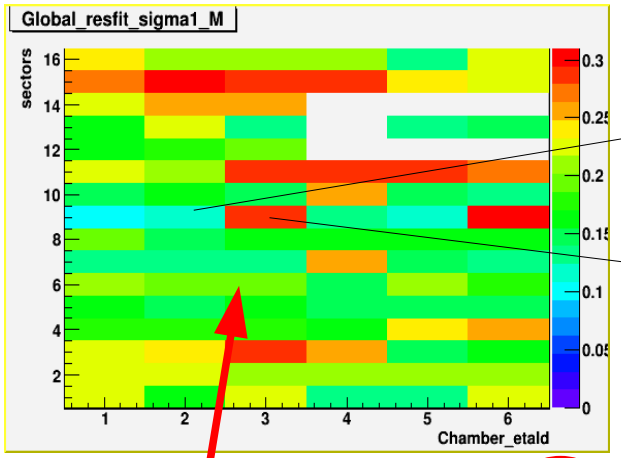


Fit of distribution:

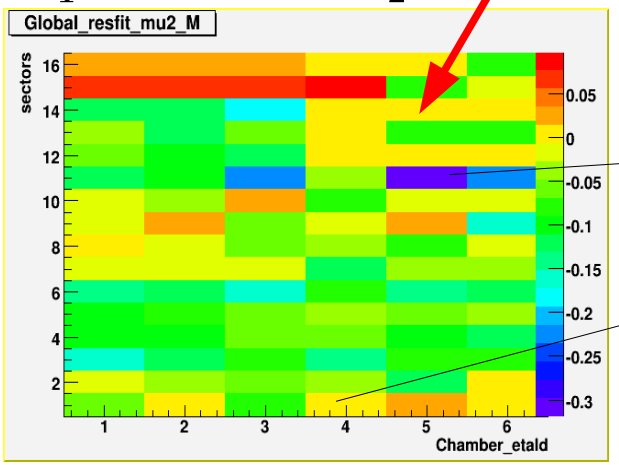
Gaussian + tails
(MS, uncorrelated hits)

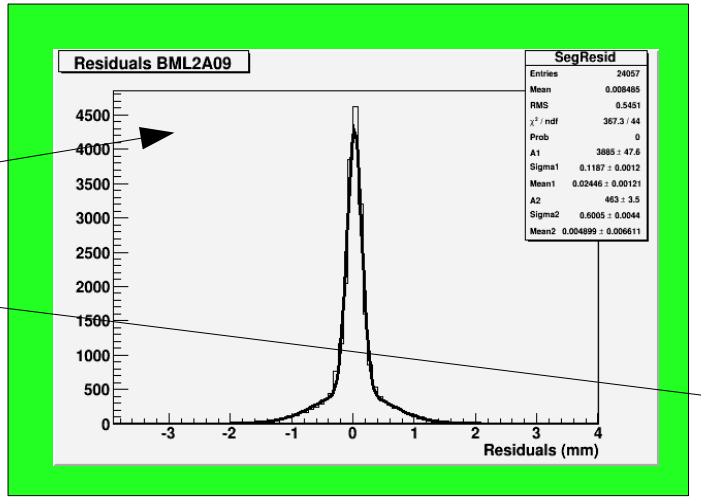
Double Gaussian

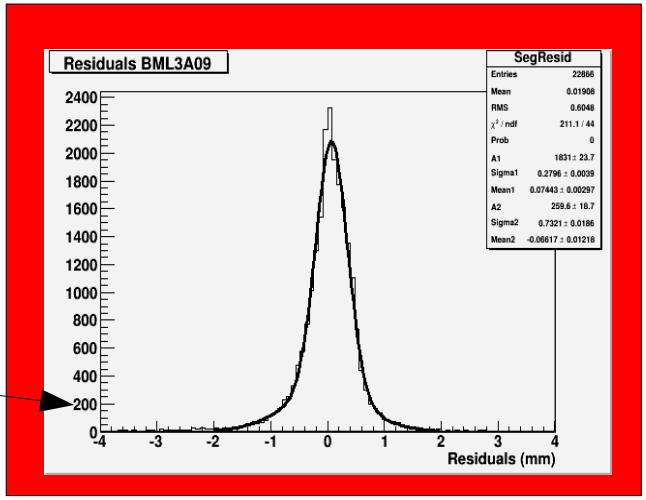
MDT Segment analysis

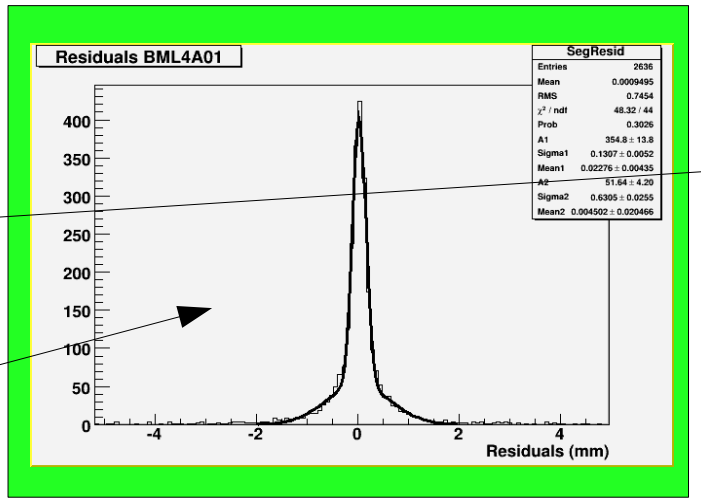


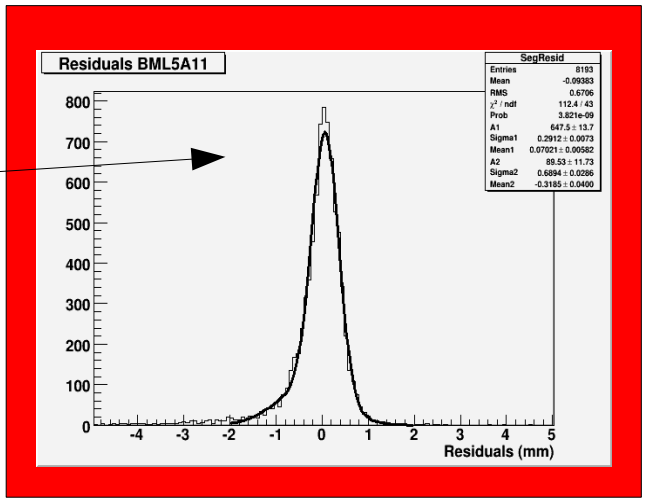
$$A_1 e^{\frac{-(x-\mu_1)^2}{2\sigma_1^2}} + A_2 e^{\frac{-(x-\mu_2)^2}{2\sigma_2^2}}$$





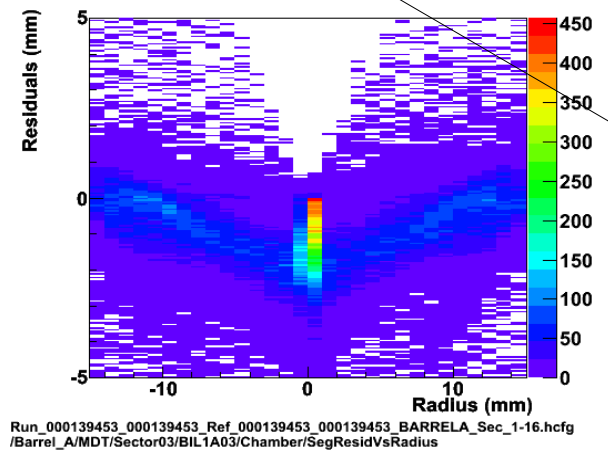


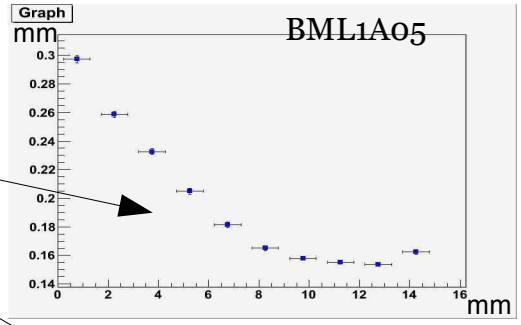


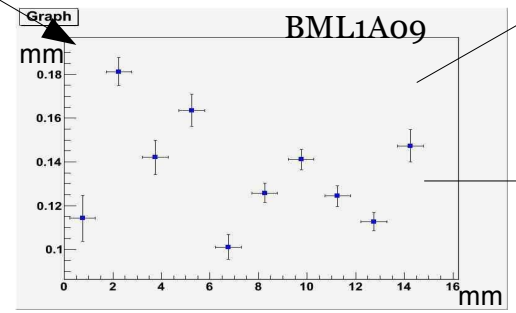


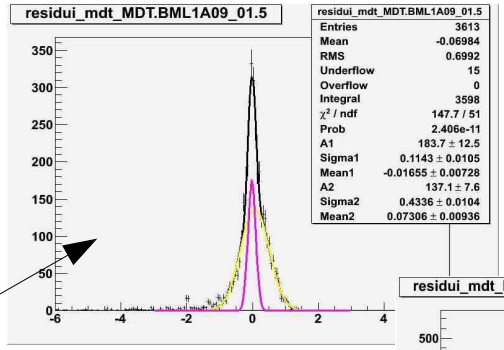
MDT Segment analysis

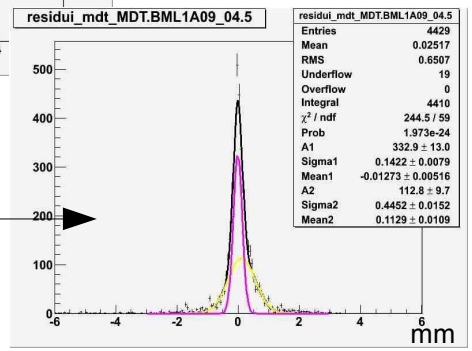
$$A_1 e^{\frac{-(x-\mu_1)^2}{2\sigma_1^2}} + A_2 e^{\frac{-(x-\mu_2)^2}{2\sigma_2^2}}$$











Study of the distribution in function of r_{drift}

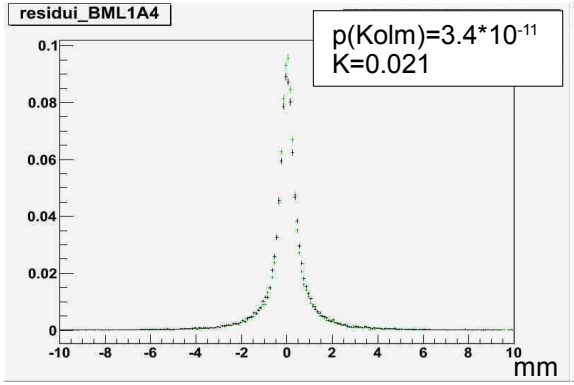
Comparison with reference

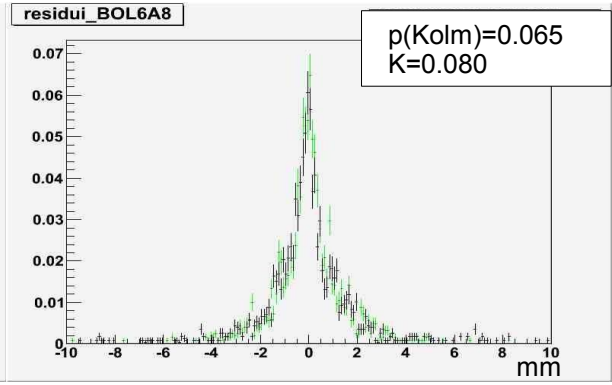
Systematic errors

$$\kappa = \frac{\sum_j^N |h_j^1 - h_j^2|}{2} < 0.050$$

OR

Kolmogorov test



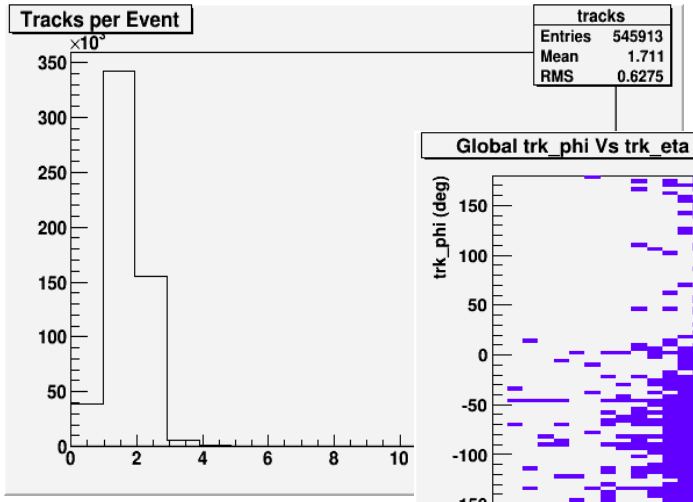


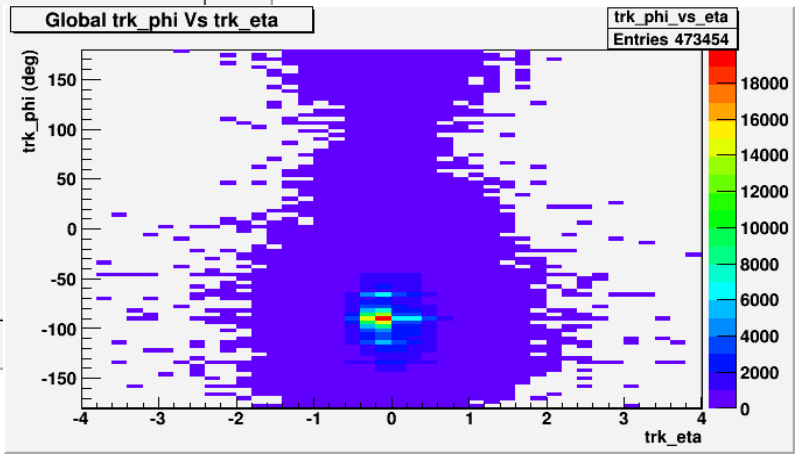
Track analysis:

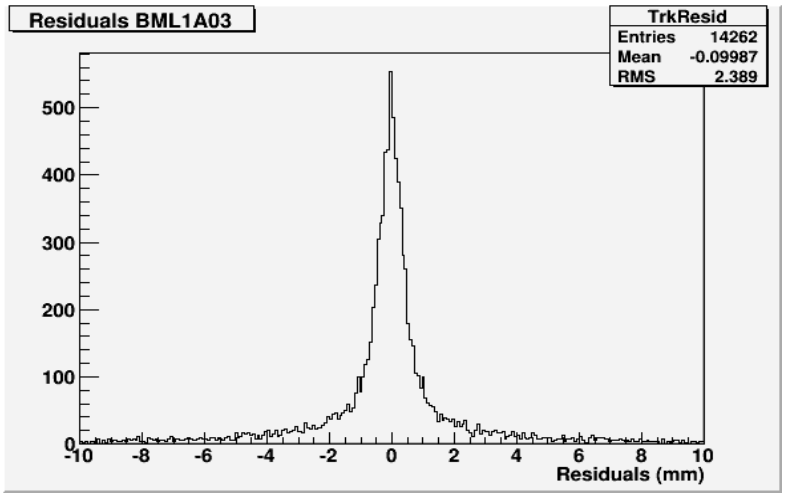
→Inserted in Tier2 software during my thesis

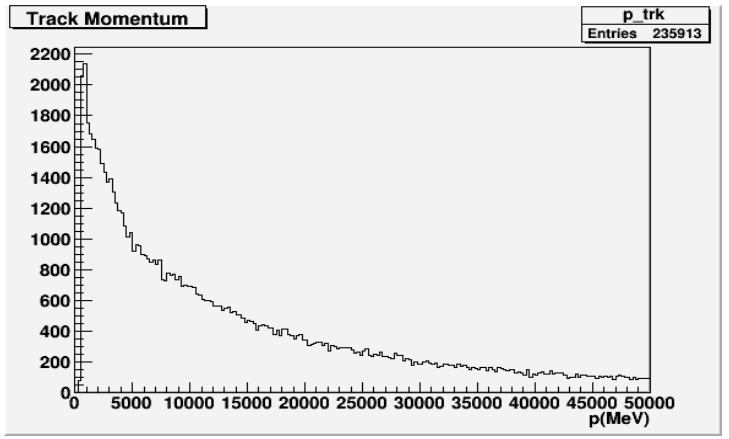
→First of all, introduced basic monitoring histograms

→Replicated residual analysis performed for segments on tracks









Conclusions

New DQ Analysis:

- Dead channels analysis fully inserted and tested in Tier2 software
- Track analysis inserted in Tier2 software (→ Daniele Capriotti)
- Segment and track analysis code inserted in the software, needs further investigation with collision data

Technical work performed:

- Rewritten many of Muon DQ software packages (Athena framework)
- Fixed bugs in DQ analysis of BEE, BOG, BOF, BIR chambers
- DQ tree and histograms layout
- Software for automatic feedback as a pdf presentation from DQ

Detector status results:

- Cosmic data test with my software showed a detector in health, ready for collision data taking
- Here I show results obtained on run 131576 26/9/2009, -1 milion events

Dead Chambers	0.0%
Low Stat Chambers	2.3%

Objects	Deads	Total Deads
ML	0.28%	0.28%
Layer	0.10%	0.38%
Mezzanines	0.07%	0.33%
Tubes	0.12%	0.52%