Exotic multi-charge particles beta measurements with ATLAS detector

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Introduction

- Aim of this analysis is to search for highly ionizing particles with electric charge between 2 and 6 in a wide mass range
- Several analysis looking for highly ionising stable massive particles (with multiple charges)
  - "Search for Heavy Long Lived Charged Particles with the ATLAS detector in pp collisions at sqrt(S) = 7TeV"
  - "Search for Massive Long-lived Highly Ionizing Particles with the ATLAS detector at the LHC" (q=6-17)
  - "Search for stable hadronising squarks and gluinos with the ATLAS experiment at the LHC" (SMP with q=1)

•Examples for these are technically simulated using technions or q-ball particles

- ➢supersymmetric coherent states of squarks, sleptons and Higgs fields that may carry some conserved global baryonic (and/or leptonic) charge
- ➢dense blobs of exotic matter with multiple charges
- ➢an observation of these kind of particles would be interesting evidence for physics beyond Standart Model.

(and the picture on the right)

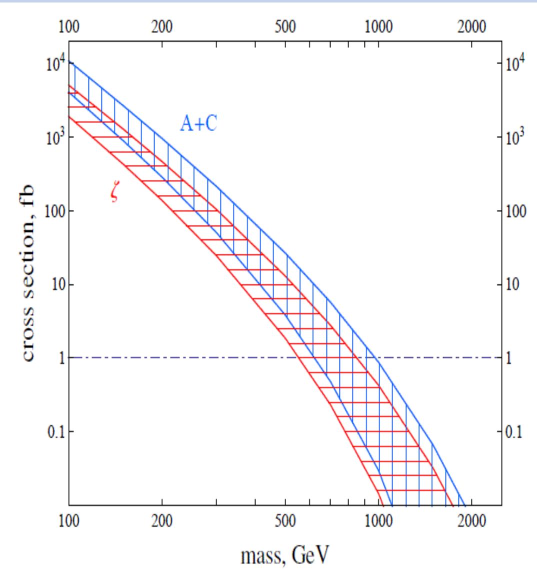
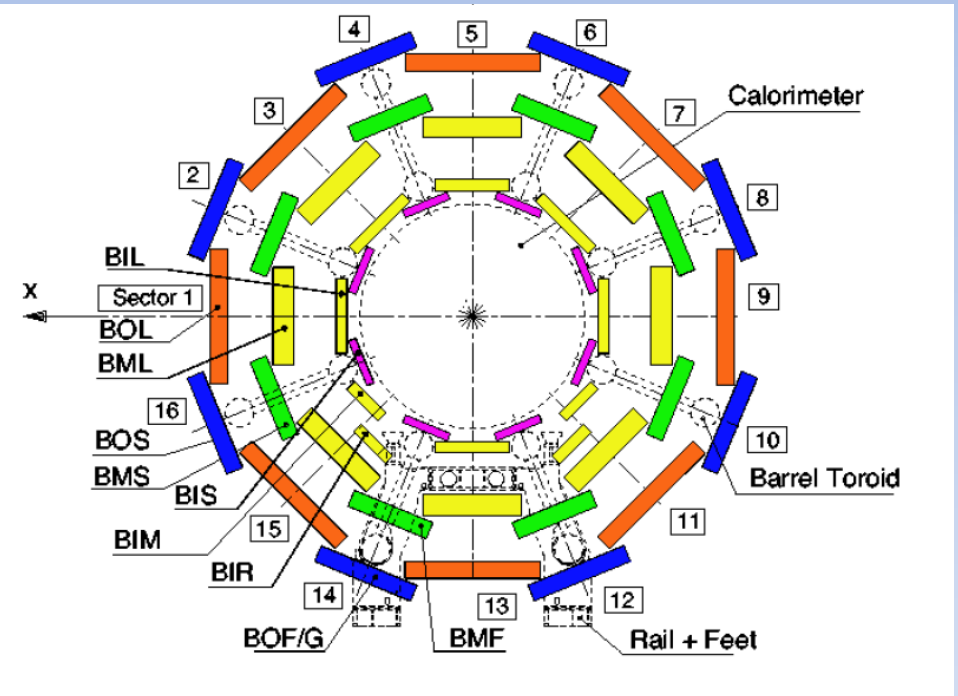
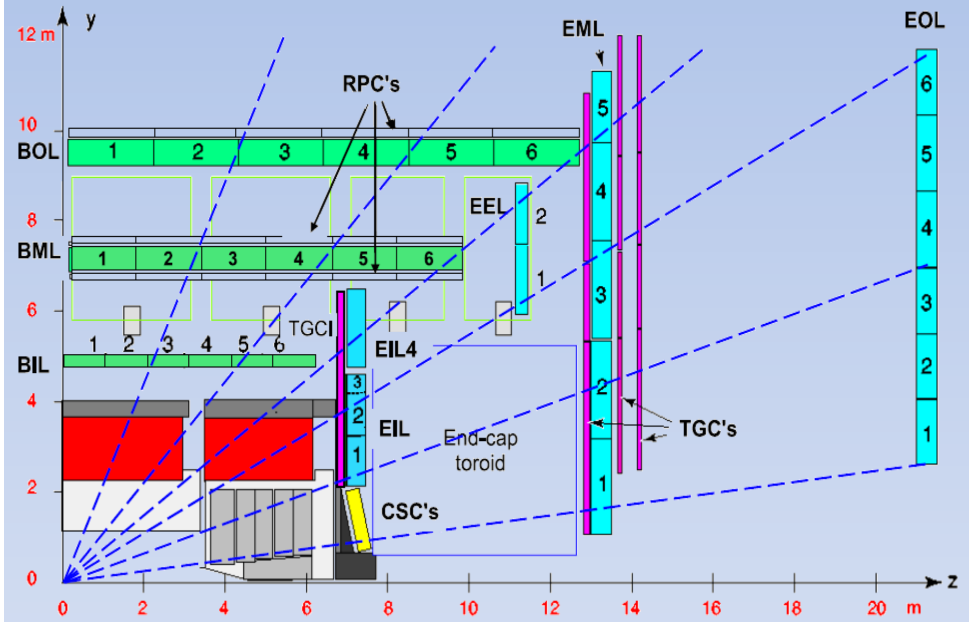


Figure 1: Production cross sections of A and C-leptons (pairs of both $A^{--}A^{++}$ and $C^{--}C^{++}$) - vertical shading, techni-leptons $\zeta^{--}\zeta^{++}$ - horizontal shading. These shaded strips correspond to 7 TeV $\leq \sqrt{s} \leq$ 14 TeV.

Muon system layout





RPC (Resistive Plate Chambers) arranged from above and from below of MDT (Monitored Drift Tubes) chambers (left picture). TGC - Thin Gap Chambers, CSC Cathode-Strip Chambers.

Muon system

The precision momentum measurement is performed by the Monitored Drift Tube chambers (MDTs).

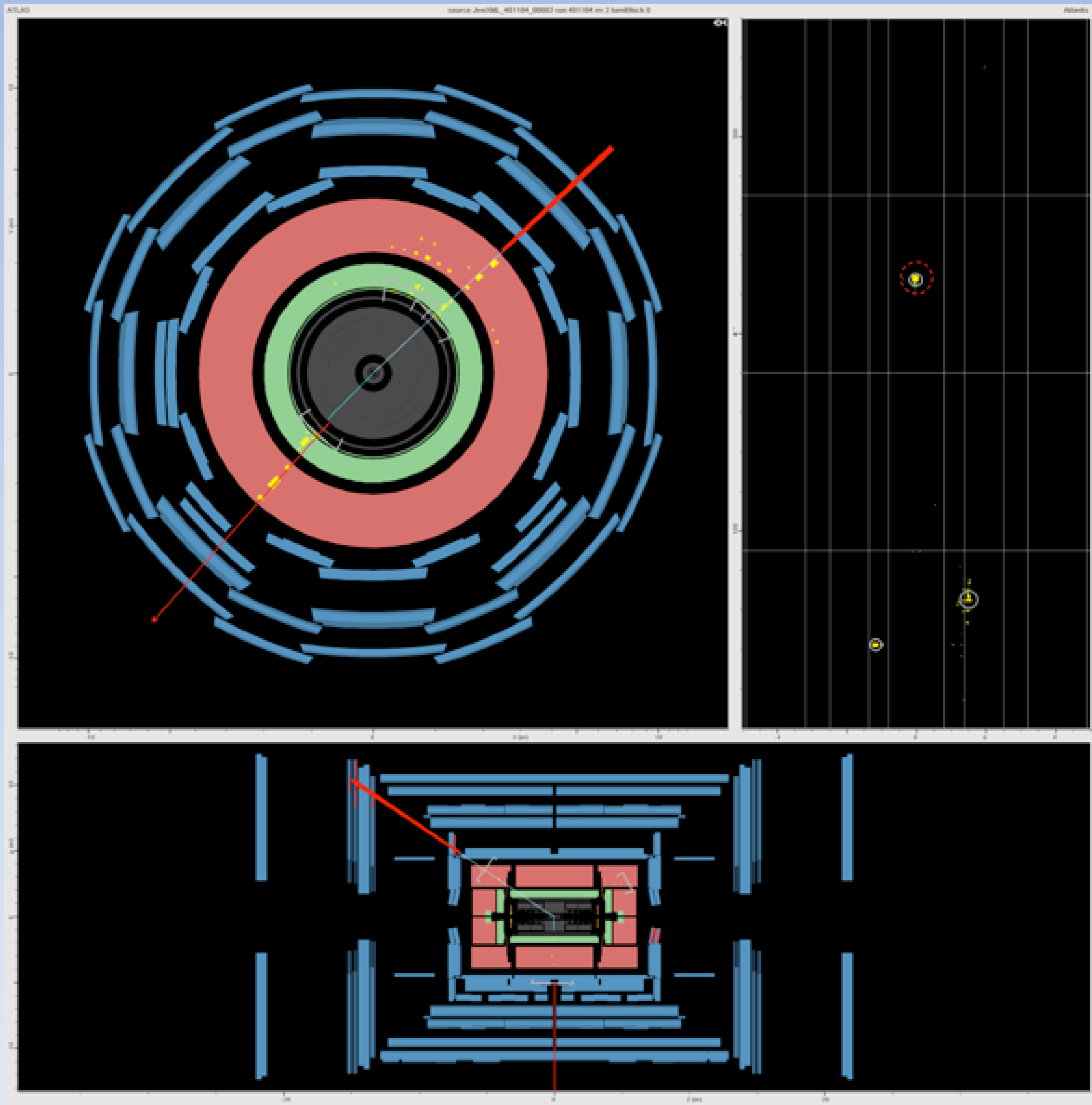
• In the forward region ($2 < |\eta| < 2.7$), Cathode-Strip Chambers (CSC) are used in the innermost tracking layer due to their higher rate capability and time resolution.

• In the barrel region ($|\eta| < 1.05$), Resistive Plate Chambers (RPC) perform this task

•While in the end-cap ($1.05 < |\eta| < 2.4$) this is done by Thin Gap Chambers (TGC).
https://cdsweb.cern.ch/record/1361637?ln=en

Particle signature in muon system of ATLAS

“Back to back” signature of Qball’s production in Drell-Yan process. Track passes through different subdetectors.



Searching for Qballs with ionization loss (dE/dx)

Ionization loss – it's convenient instrument for identification exotic particles and it's represented a lot of variables for estimating the ionization loss in different systems: Pixel, LAr, TRT, MDT.

Searching for Qballs with beta measurement method

The mass is estimated from the β and momentum measurements using the relation M=p/βϒ

The main strategy: improving the β resolution and reducing the tails of the β distribution improve the signal mass width and reduce the background in the signal region. The resolution was optimized by performing a combined fit using estimations from different sub-detectors. https://cdsweb.cern.ch/record/1361637?ln=en

β estimating in the Muon Drift Tubes

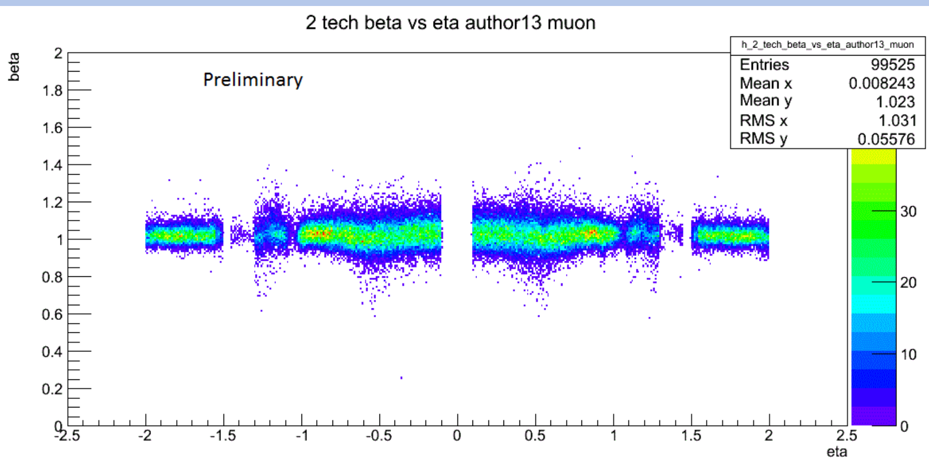
An MDT segment is reconstructed as a line tangent to the radii in the different layers, after the radii were estimated from the drift time. The estimated drift time is $t_{measured}$ - t_0, and the radii, R($t_{measured}$ -t_0), but t_0 is based on particles passing the detector at the speed of light. Slow particles have a longer time-of-flight, and therefore, in order to obtain a good segment fit, t_0 must be computed from their arrival time to the detector. https://cdsweb.cern.ch/record/1361637?ln=en

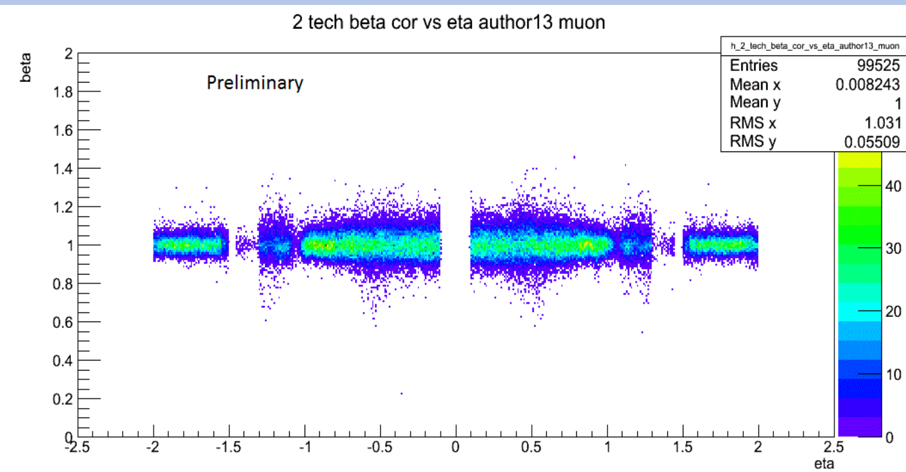
β estimating in the Muon Drift Tubes

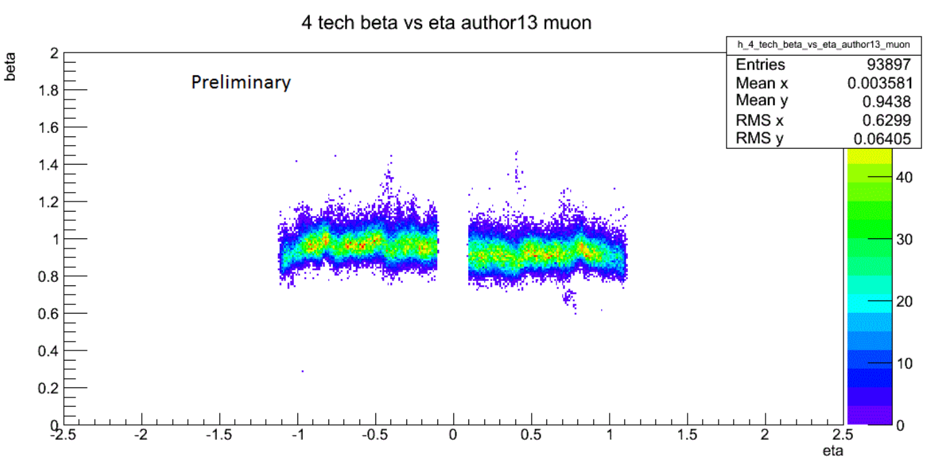
The χ^2 measures the difference between the measured ToF and the ToF corresponding to the arrival time of a particle traveling with the hypothesized . The signal propagation time along the RPC strip is subtracted to obtain the measure of ToF. The measured ToF is assigned an error which is estimated from the width of the distribution representing the difference between the measured muon ToF and the expected muon ToF. https://cdsweb.cern.ch/record/1361637?ln=en

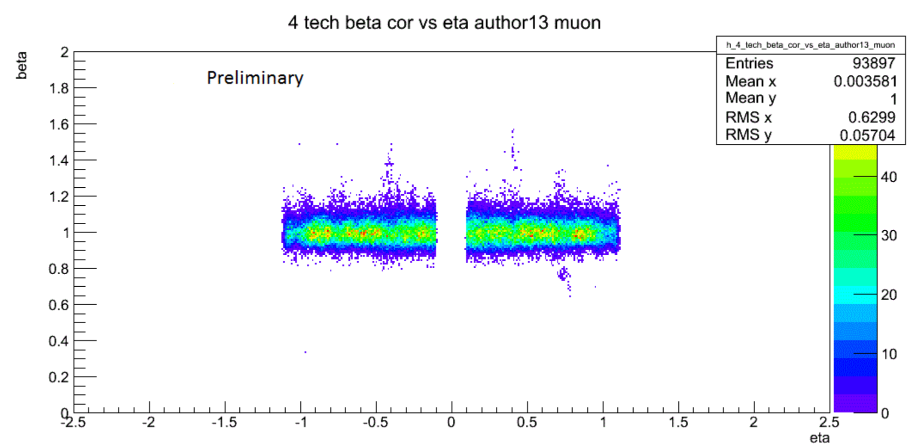
Calibrations for MDT and RPC beta measurement technologies (Z->mu+mu)

Upper pictures – effect of eta calibrations for MDT beta (left picture – before, right picture – after calibration)
Bottom pictures – effect of eta calibration for RPC beta (left picture – before, right picture – after calibration)









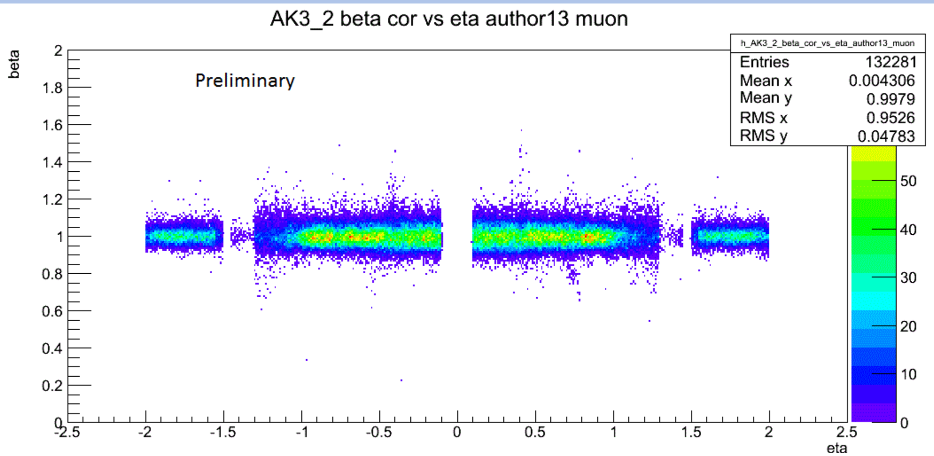
Combination of different technologies is calculates like a weighted mean:

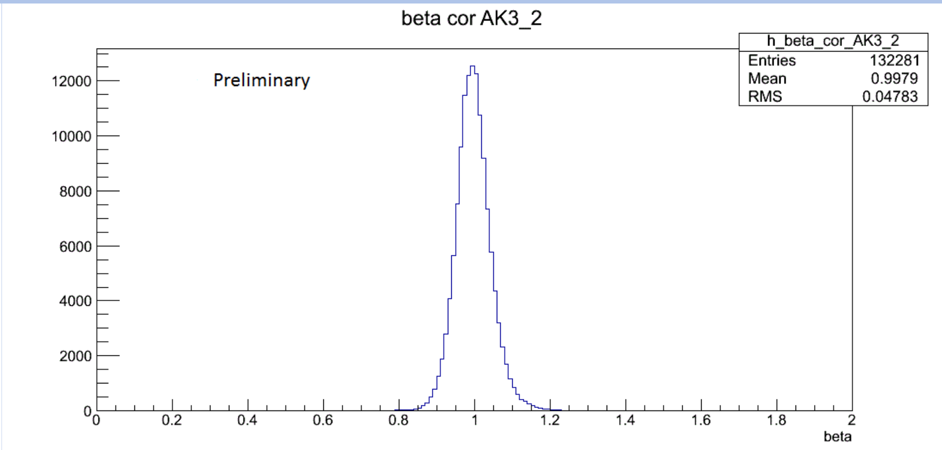
$$beta_{comb} = \frac{beta_{mdt} \times \frac{1}{\sigma^2(beta_{mdt})} + beta_{rpc} \times \frac{1}{\sigma^2(beta_{rpc})}}{\frac{1}{\sigma^2(beta_{mdt})} + \frac{1}{\sigma^2(beta_{rpc})}}$$

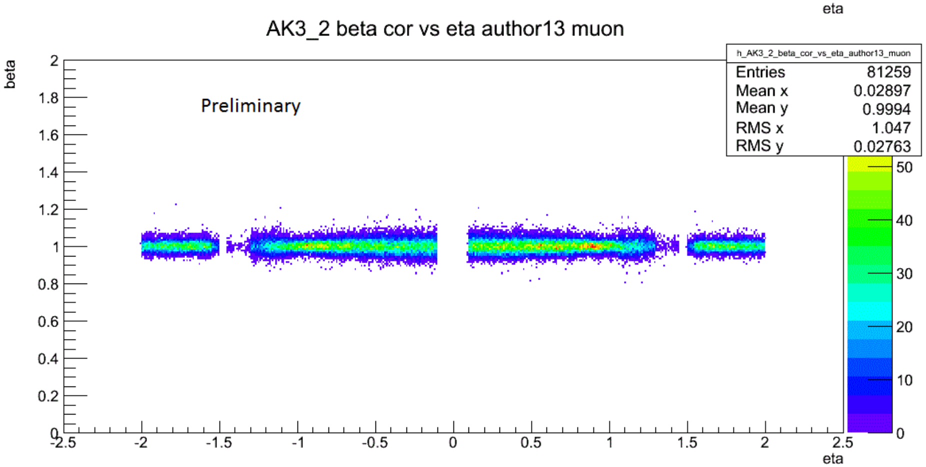
σ of general beta distribution for each subdetector used as weight for this subsystem in final distribution

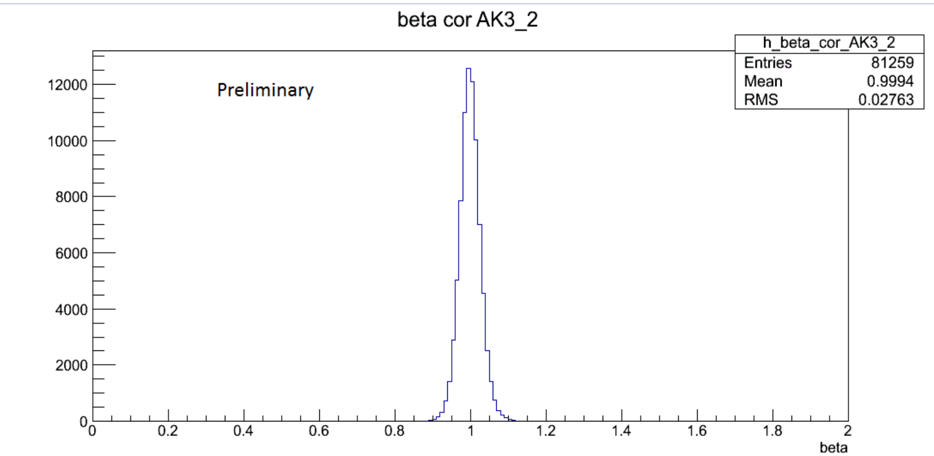
Combination of MDT and RPC beta measurement technologies

Upper pictures – combination of MDT+RPC beta for data (Z->mu+mu) (left picture – before, right picture – after calibration)
Bottom pictures – combination of MDT+RPC beta for MC (left picture – before, right picture – after calibration)









Still not perfect agreement between results for data and MC (different sigmas) ☹

Sammary

- Best estimation of beta has been received with combination of MDT and RPC beta like weighted mean
- Resolution of the combined beta estimation should be improved
- Agreement between results for the MC and data should be improved
- We will search for effects of constructed estimator for Qballs