Proton Mass Stability in Run 1

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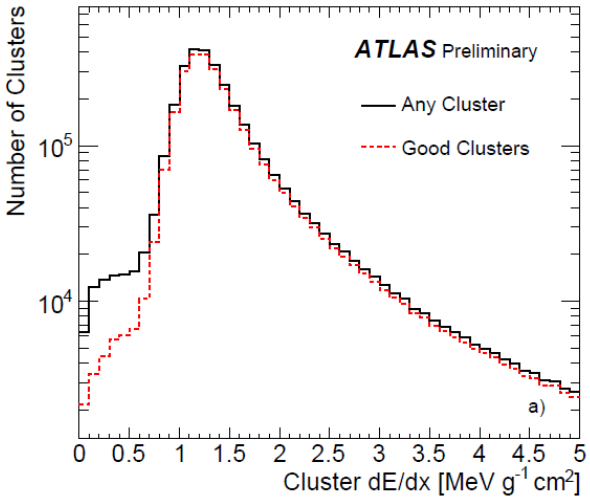
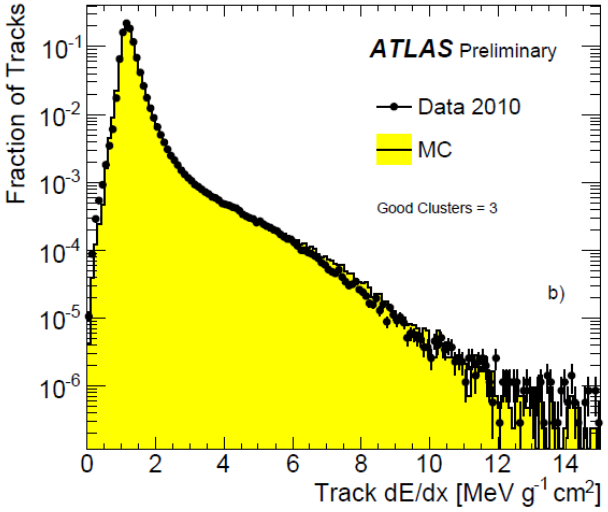
- ✓ dE/dx measurement in the Pixel detector and its use for particle identification has been extensively described in ATL-COM-CONF-2010-109 in http://cdsweb.cern.ch/record/1312965
  - Based on 2010 dataset

- ✓ We have checked how proton mass estimate was stable during 2011 and 2012, while changing luminosity profile and detector conditions.
  - dE/dx calibration (Bethe-Bloch fit) never revised.

Reminder: track dE/dx

- ✓ The charge contained in a cluster normalized to the track path, the Cluster dE/dx, is the quantity relevant for the dE/dx measurement.
- ✓ Only "Good" Clusters are considered:
  - Not on the edge of the module
  - Not associated to very swallow tracks.
- ✓ The track dE/dx is then defined as an average of the individual cluster dE/dx measurements for all the Good Clusters associated to the track (nGC). To reduce the Landau tails, the average is calculated after having removed the cluster(s) with the highest dE/dx:
  - one cluster is removed for tracks with 3,4 good clusters;
  - two clusters for tracks with 5 or more good clusters.





Reminder: particle identification

- ✓ The 5-parameters function describing how the Most Probable Value (MPV) of the specific energy loss depends on $\beta\gamma$ has been defined by searching for a functional form which adequately describes the simulated data.
  - Details of the fit in the additional slides

$$MPV_{\frac{dE}{dx}}(\beta\gamma) = \frac{p_1}{\beta^{p_3}} \ln\left(1 + (|p_2|\beta\gamma)^{p_5}\right) - p_4$$

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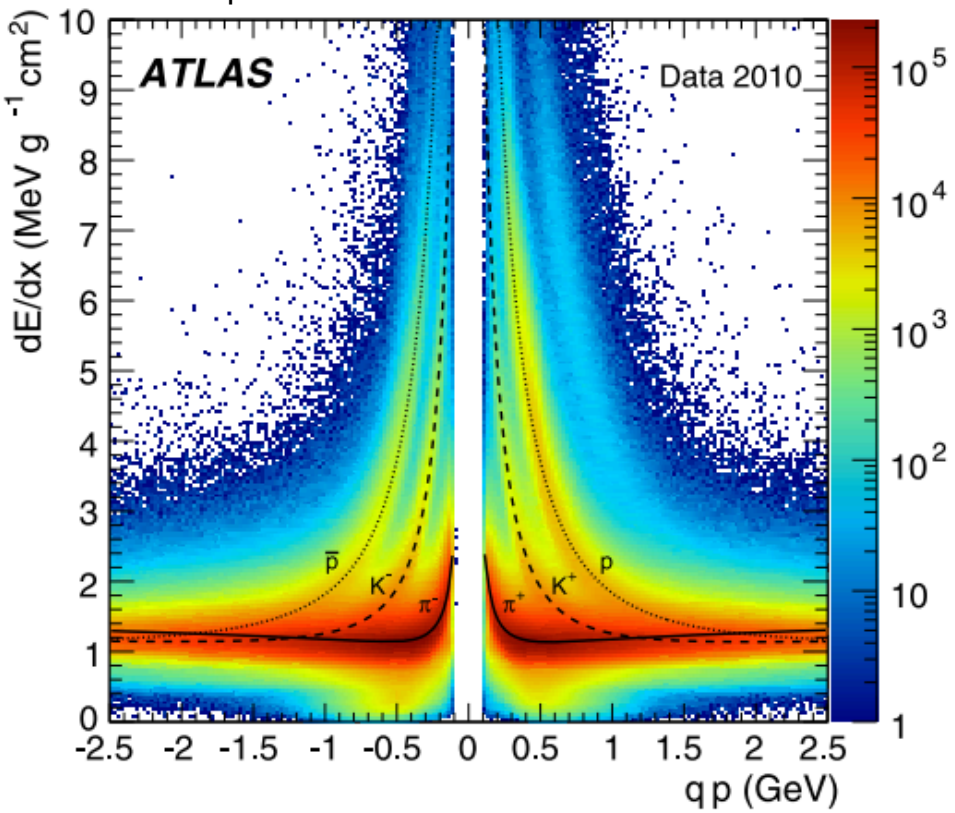
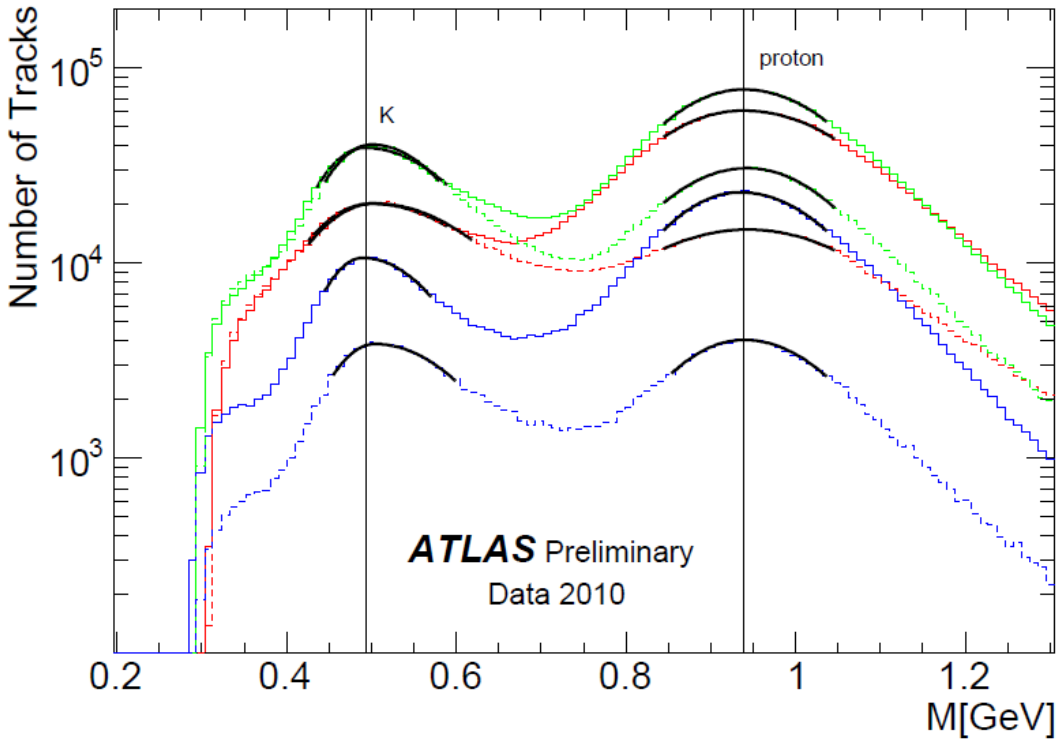
updated from CONF note



- ✓ Fit independently for data and MC without any a priori knowledge of the particle ID for 6 cases:
  - nGoodCluster category (nGC = 2, 3, 4+)
  - Positively and negatively charged tracks

Reminder: particle identification

- ✓ For all tracks having a reconstructed momentum p and a measured specific energy loss dE/dx, a mass estimate M is obtained by numerically solving the equation MPV(p/M) = dE/dx for the unknown M.
  - If dE/dx< 1.9 MeV $g^{-1}cm^2$ the measured dE/dx is compatible with the value expected for a MIP and the mass estimate M is arbitrarily assigned a value M = $M\pi$



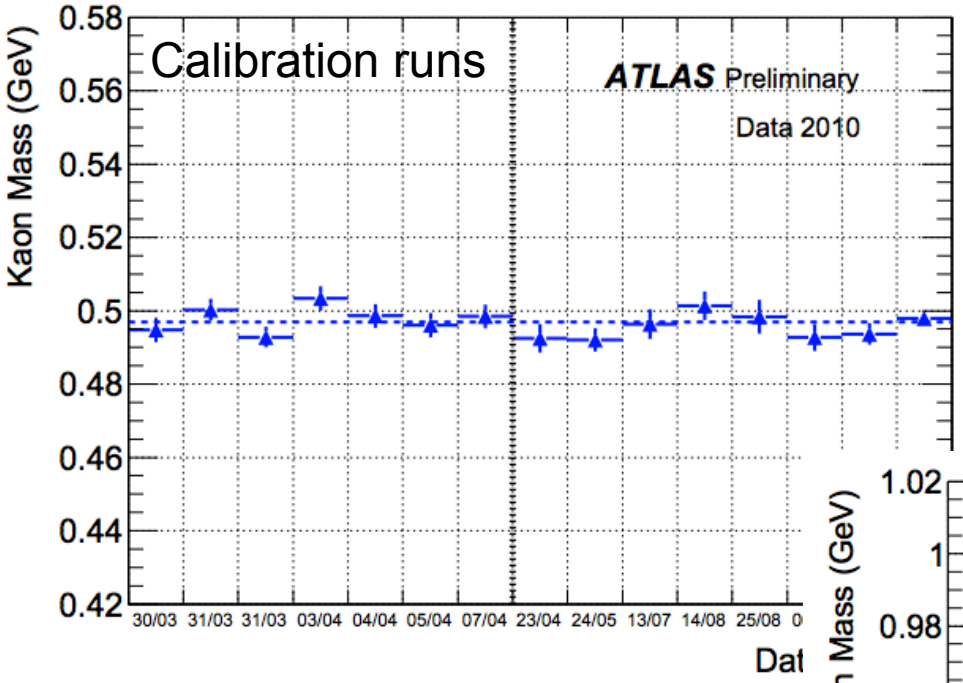
Tracks with
p in (0.3,1) GeV
and dE/dx >
1.9 MeV $g^{-1}cm^2$

nGC = 2
nGC = 3
nGC ≥ 4

solid line: positive charge
broken line: negative charge

K and p mass obtained with an asymmetric fit of the peak

Reminder: particle identification

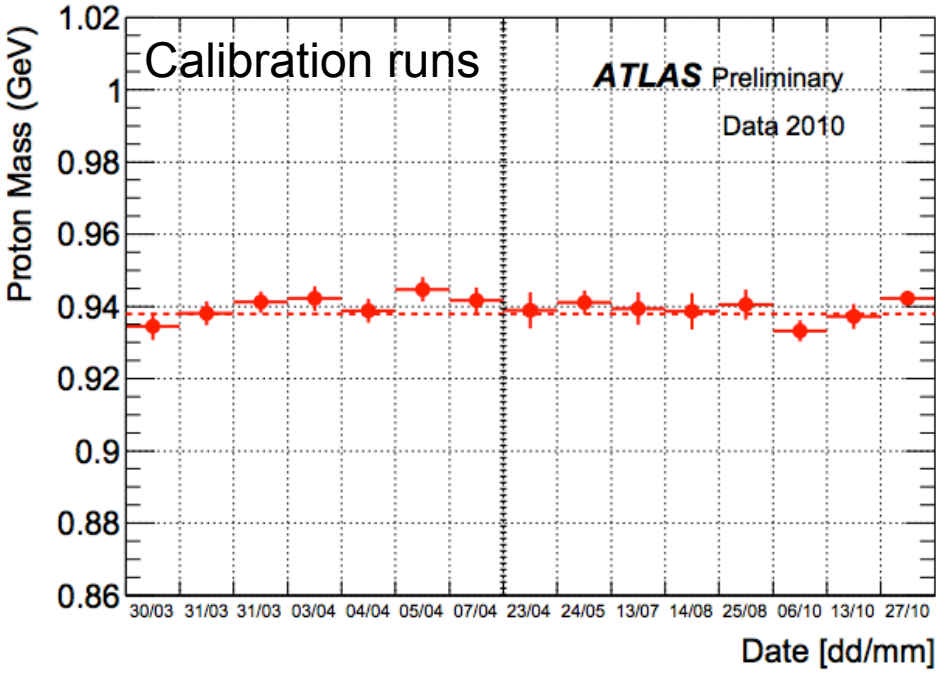


L ~10^{32} $cm^{-2}s^{-1}$

L ~10^{31} $cm^{-2}s^{-1}$

L ~2 x10^{29} $cm^{-2}s^{-1}$

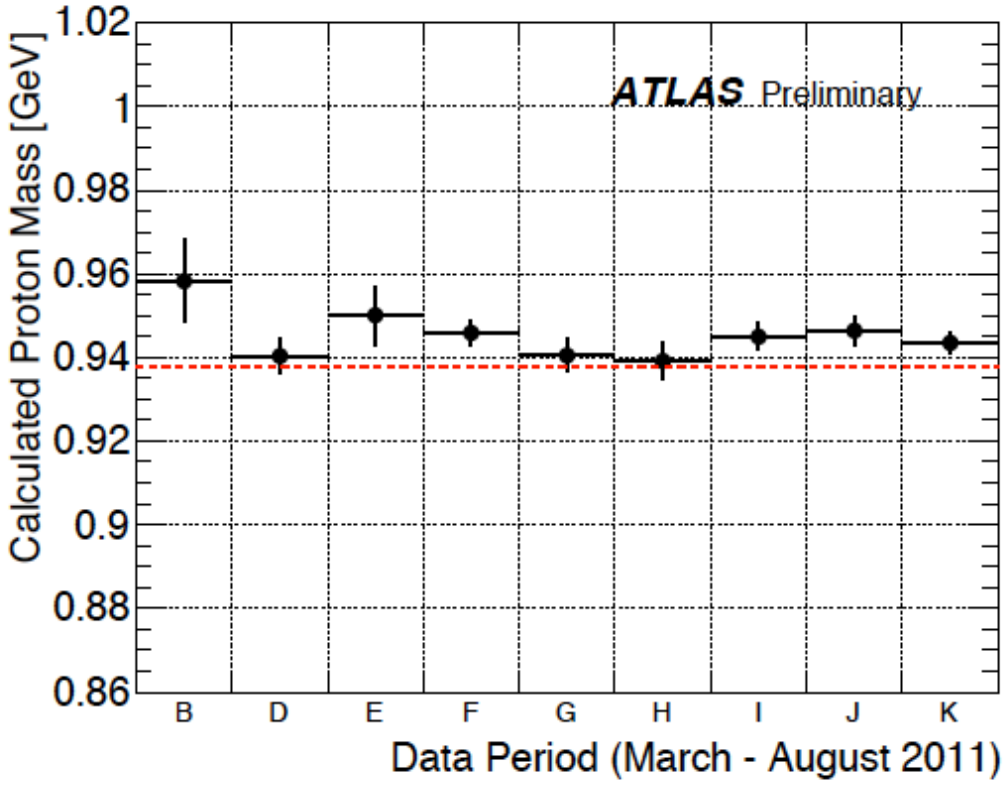
~ 10^{27} $cm^{-2}s^{-1}$



Mass peaks of kaons and protons are stable during the 2010 run with different beam conditions and Pixel configurations (BC read-out window).

Update for 2011

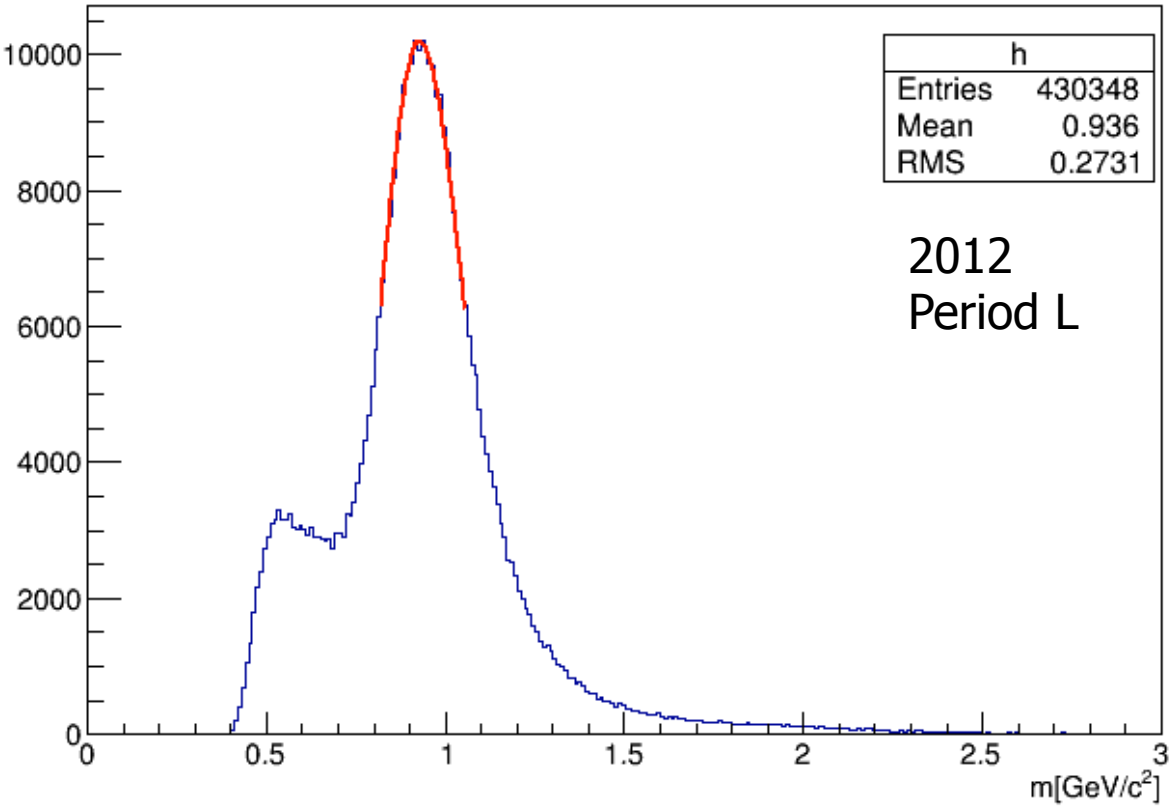
- ✓ Stability in 2011 approved in the R-hadron searches, specifically in ATLAS-CONF-2012-022.



2011/2012 data

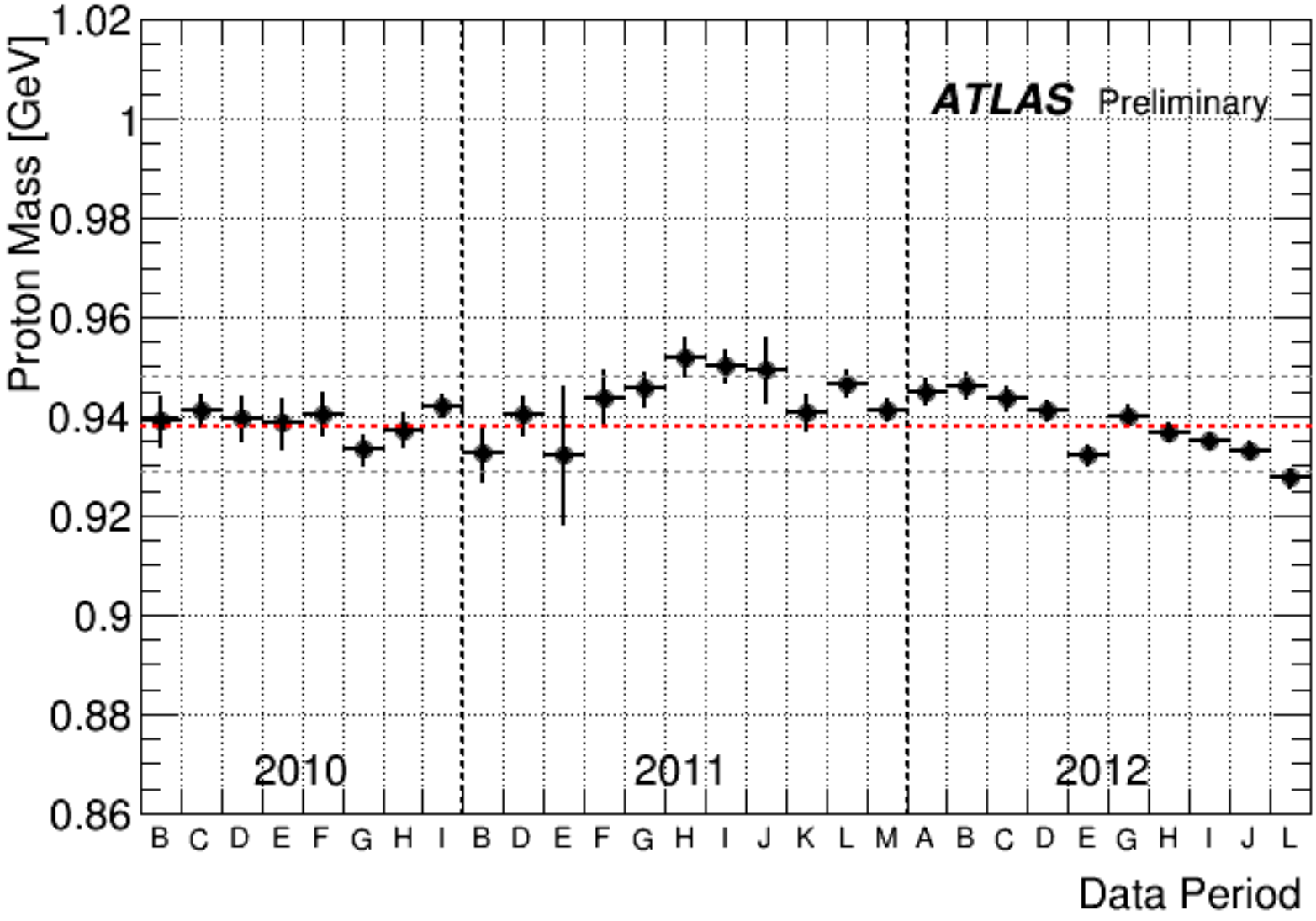
- ✓ Track selection as in 2010 put pt cut:
  - p_T >400 MeV (impossible to meaningfully fit the Kaon mass)
  - nGC>=2, nSCT>= 6, d0<100mm, p in (0.3,1) GeV, dE/dx >1.9 MeV $g^{-1}cm^2$

- ✓ D3PD from SUSY group
  - Put some bias in the selection of events, not for tracks.
- ✓ One entry per data period, spanning huge amount of data wrt to 2010 and instantaneous luminosity.
- ✓ The detector in the meanwhile was retuned in threshold and TOT. Proton mass in the 1% along all Run 1 data-taking.



Mass proton stability

For Approval



Spares

Data Samples 2010

- ✓ The data used consist of about 12 million events at $\sqrt{s}$ = 7 TeV, using the first ~190 μb^{-1} of proton-proton collisions provided by the LHC; the maximum instantaneous luminosity was approximately $1.9 \times 10^{27} cm^{-2} s^{-1}$ (D3PD Minimum Bias datasets).
- ✓ Tracks are reconstructed offline with release 15.6.7.8 within the full acceptance range $|\eta|<2.5$ with
  - p_T >100 MeV
  - $|d_0|$ < 100 mm
- ✓ In these events we apply track selection cuts to reject mis-measured p_T tracks or fakes:
  - nSCTHits>=2/4/6 if p_T < 200 MeV/ 200 MeV < p_T < 300 MeV/ p_T > 300 MeV
  - track-fit χ^2 probability > 0.01 if p_T >10 GeV

  A sample of 3.2 10^8 tracks has been selected.

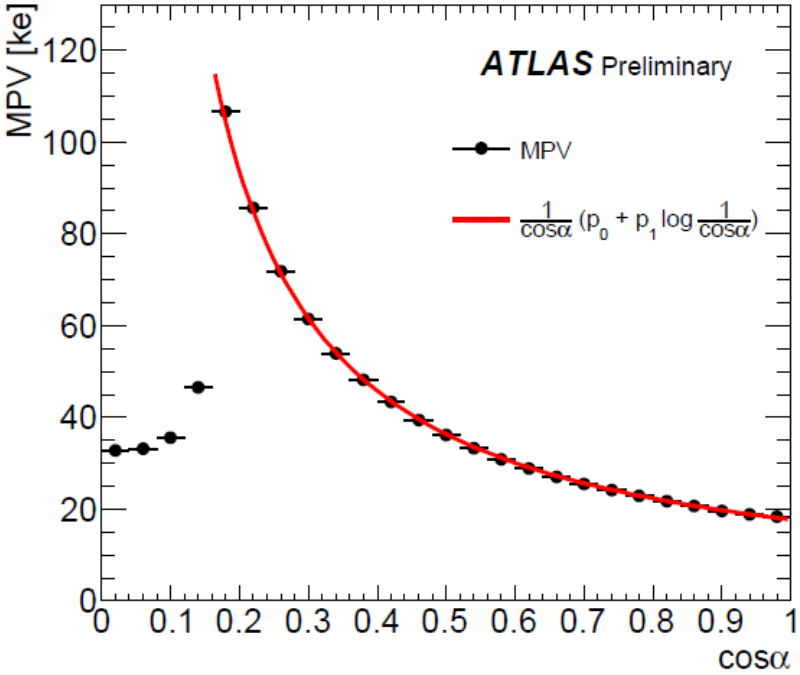
Cluster Selection

- ✓ Fiducial volume cuts are applied to avoid regions in which the charge is not completely collected in the clusters associated to tracks, such as the edge of the detector and the ganged region.
  - $0.55\ \text{mm} < |x_{Loc}+d_L| < 8.15\ \text{mm}$
  - $|y_{Loc}| < 30\ \text{mm}$

x_{Loc}, y_{Loc} are the local coordinates of the cluster baricentre with respect to the geometrical centre of the module. d_L denotes a shift to take into account the Lorentz angle and is set to 50/0 μm in the Barrel/EndCap.

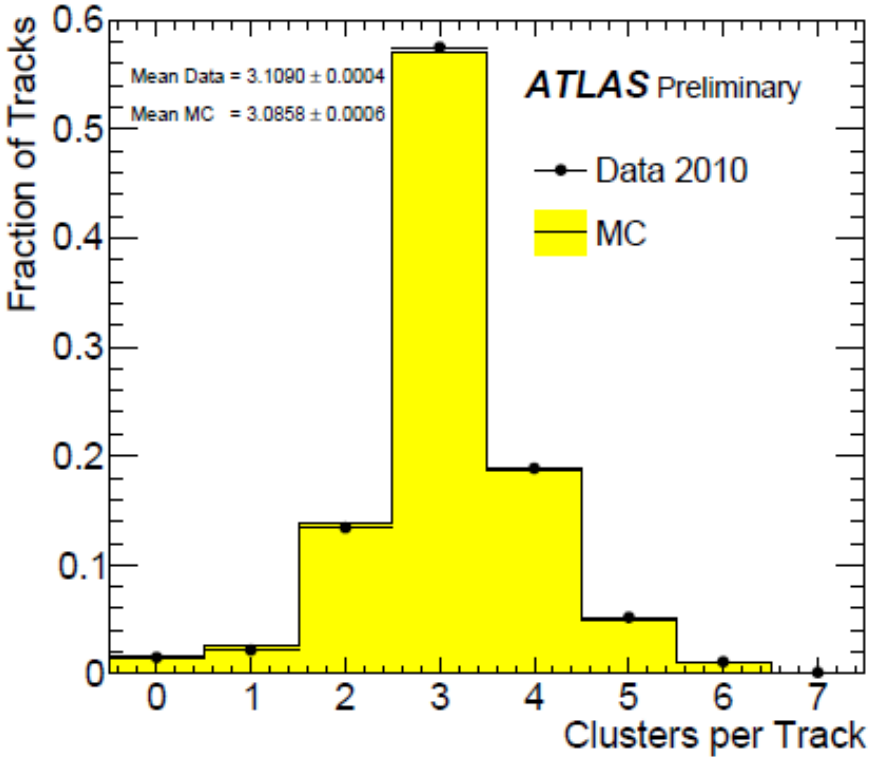
- ✓ Moreover clusters associated to very shallow tracks contain less charge than expected according to geometrical correction as part of the signal can be under threshold.
  - $\cos\alpha > 0.16$

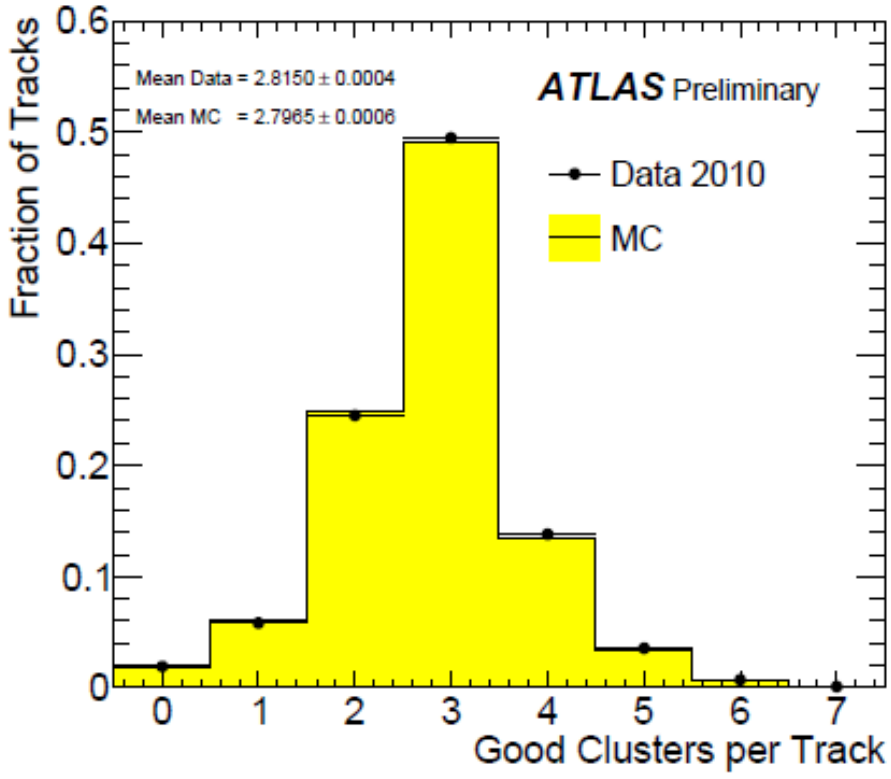
α is the spatial incident angle wrt the normal to the module surface



Cluster Selection

- ✓ The fraction of clusters that survives these cuts (Good Clusters) is 91%.
  - The reduction is dominated by the fiducial volume cuts, only 0.4% is the loss due to the local incident angle cut.
  - The number of tracks for which the track dE/dx is not measurable (assuming that at least two good clusters are required) is reduced only by 3%





Track dE/dx

- ✓ The track dE/dx is then defined as an average of the individual cluster dE/dx measurements (charge collected in the cluster, corrected for the track length), for all the Good Clusters associated to the track (nGC). To reduce the Landau tails, the average is calculated after having removed the cluster(s) with the highest dE/dx:
  - one cluster is removed for tracks with 3,4 good clusters;
  - two clusters for tracks with 5 or more good clusters.
- ✓ A track dE/dx resolution of ~12% is measured using particles with p>3 GeV (dE/dx plateau for π's) . Mean and sigma are obtained from a gaussian fit to the data.

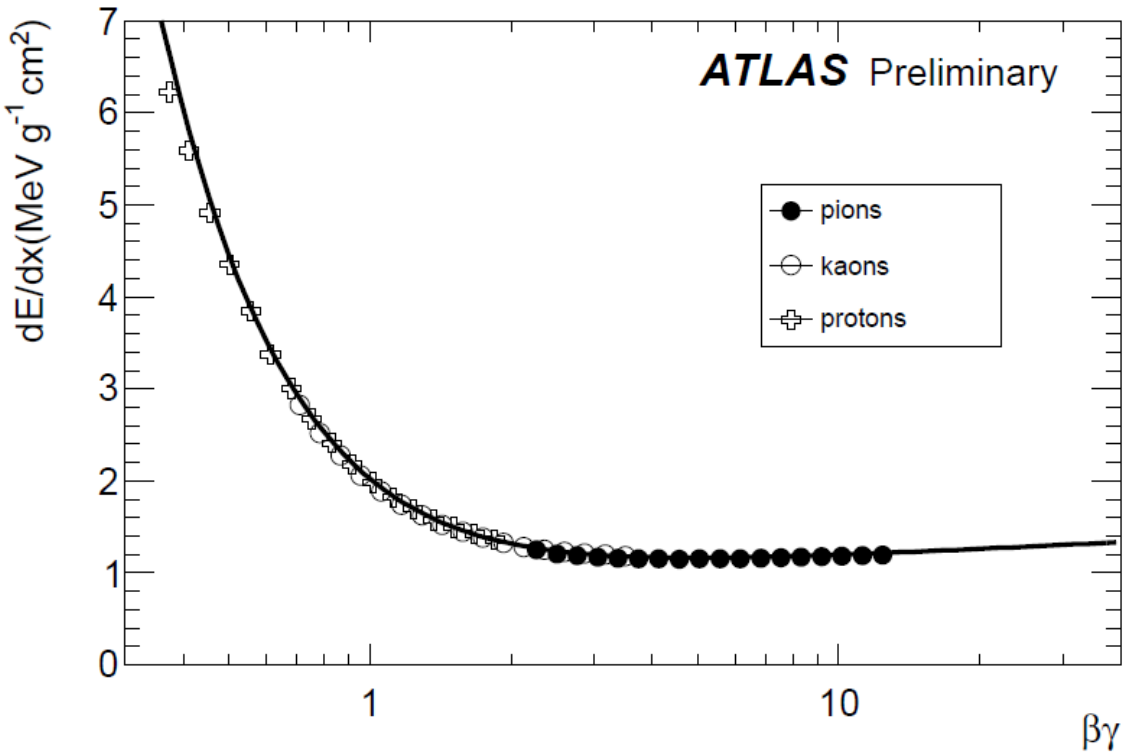
# of Good Clusters	# of GC excluded	Mean (MeV g^{-1} cm^2)	Resolution %
1	0	1.253 ± 0.004	16.2 ± 0.4
2	0	1.169 ± 0.001	13.9 ± 0.1
3	1	1.202 ± 0.001	10.9 ± 0.1
4	1	1.230 ± 0.001	10.1 ± 0.1
≥ 5	2	1.256 ± 0.001	9.5 ± 0.1

- ✓ % of all tracks), these cases are therefore excluded from the analysis.

Choice of the dE/dx Fit Function

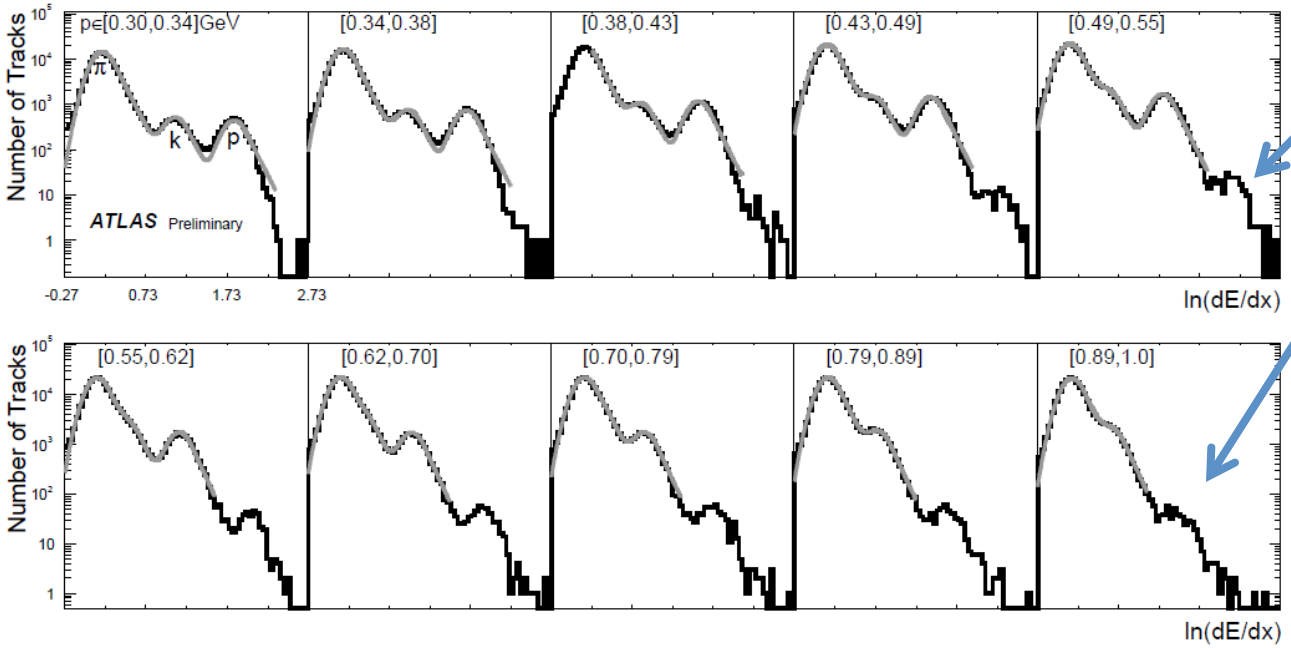
- ✓ The 5-parameters function describing how the Most Probable Value (MPV) of the specific energy loss depends on $\beta\gamma$ has been defined by searching for a functional form which adequately describes the simulated data.

$$MPV_{\frac{dE}{dx}}(\beta\gamma) = \frac{p_1}{\beta^{p_3}} \ln\left(1 + (|p_2|\beta\gamma)^{p_5}\right) - p_4$$



Energy Loss Fit

- A Crystal Ball function is used to model the dE/dx distribution for each of the three input mass hypotheses (π, K, p) in 10 (logarithmic) momentum slices, starting at 300 MeV and ending at 1 GeV. The MPV of the peaks are required to follow the 5-parameters function.



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