Muon Monitor Analysis

- Analysis of new data + comparison with old (first NOvA run) data
  - Stability over time
  - Muon Monitors VS beam intensity
  - Centroids over time and with respect to the horn current

- Signals are normalized to the POT, corrected for the pedestals and for the pressure

Data:

- For the first NOvA run (RUN1) we have Nov2014, Jan2015, Mar2015, May/June2015
- For the second NOvA run (RUN2) I processed the data from 23 Oct to 19 Jan
- New beam alignment to the center of the Hadron Monitor for second NOvA run

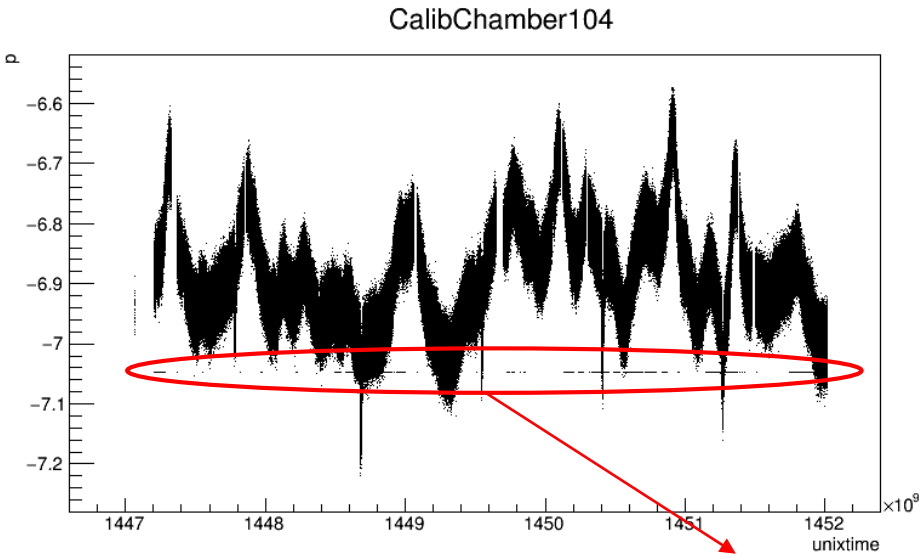
About the calibration chambers:

- There are wrong readings that I have to filter out before applying the correction (see next slide)
- Couldn't do it for few days in January 2016 since the calibration chamber swic was not running

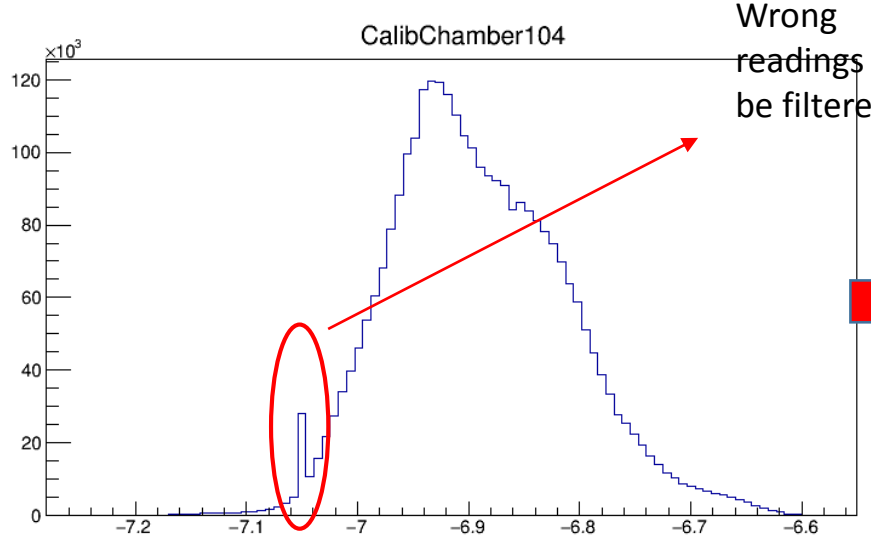
Muon Monitors – Calibration Chambers

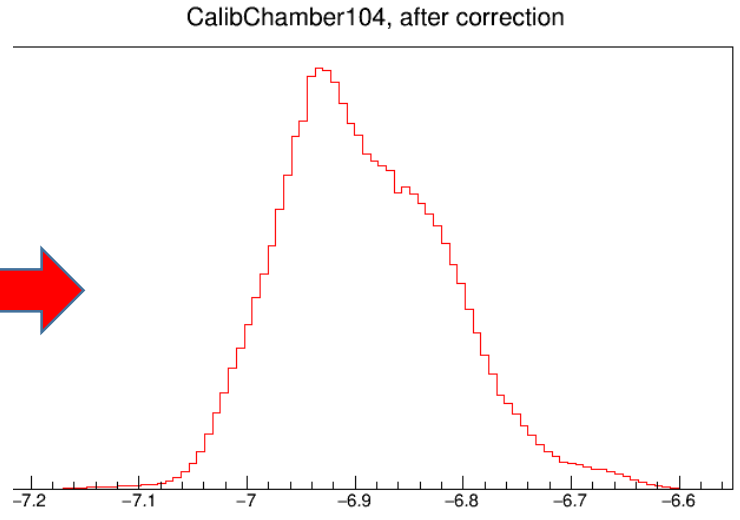
- For all the 3 calibration chambers we need to filter out wrong readings, can't really just cut them since they're in the distribution of the good values
  Here's an example for
  Calibration Chamber104 of MM1

- Plus, there are wrong data clearly out of the distribution, just cut them out and don't compute the corresponding MM signal in those cases

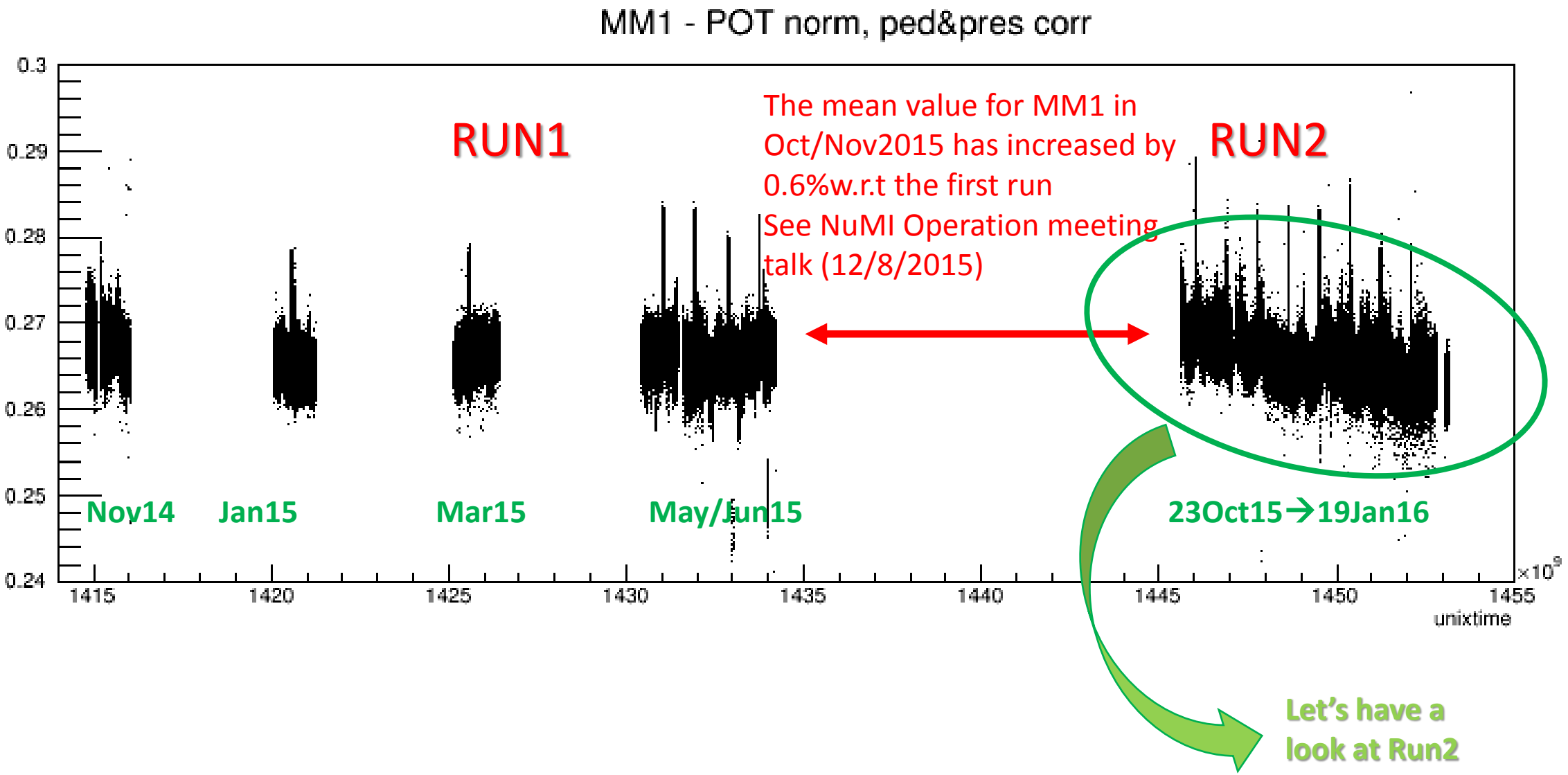


Wrong readings to be filtered





Muon Monitor 1



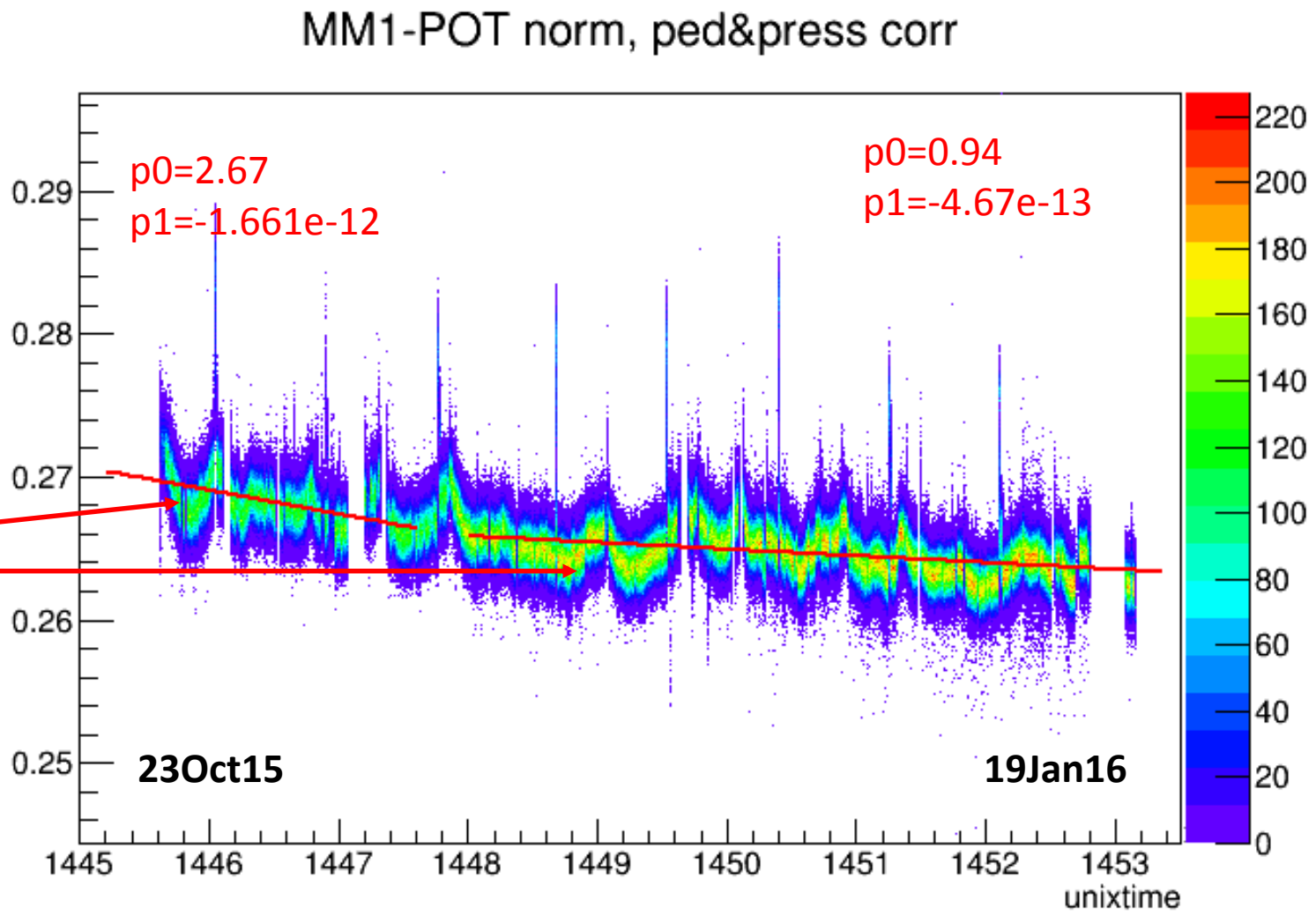
Muon Monitor 1 – Run2

- PERIOD1: At the beginning of the Run only main injector was used with a 1.67s cycle
- From 16 November we had a mixed mode with some cycles in the recycler
- PERIOD2: From 20 November the whole beam is through the recycler with a 1.3s cycle

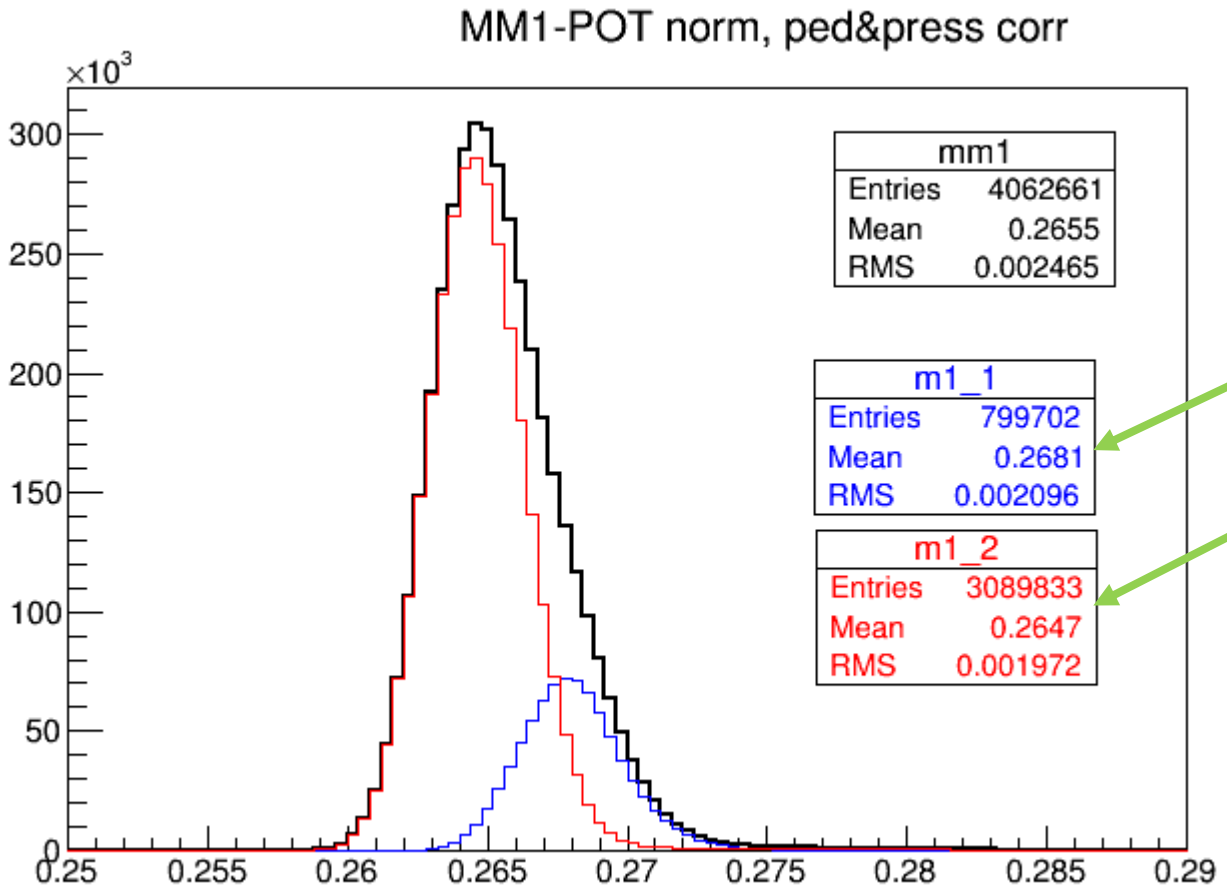
- Fitting separately **period1** and **period2**

→ The signal decrease in period 2 is **0.8%**

- Overall since the beginning of the run there's a 2% decrease

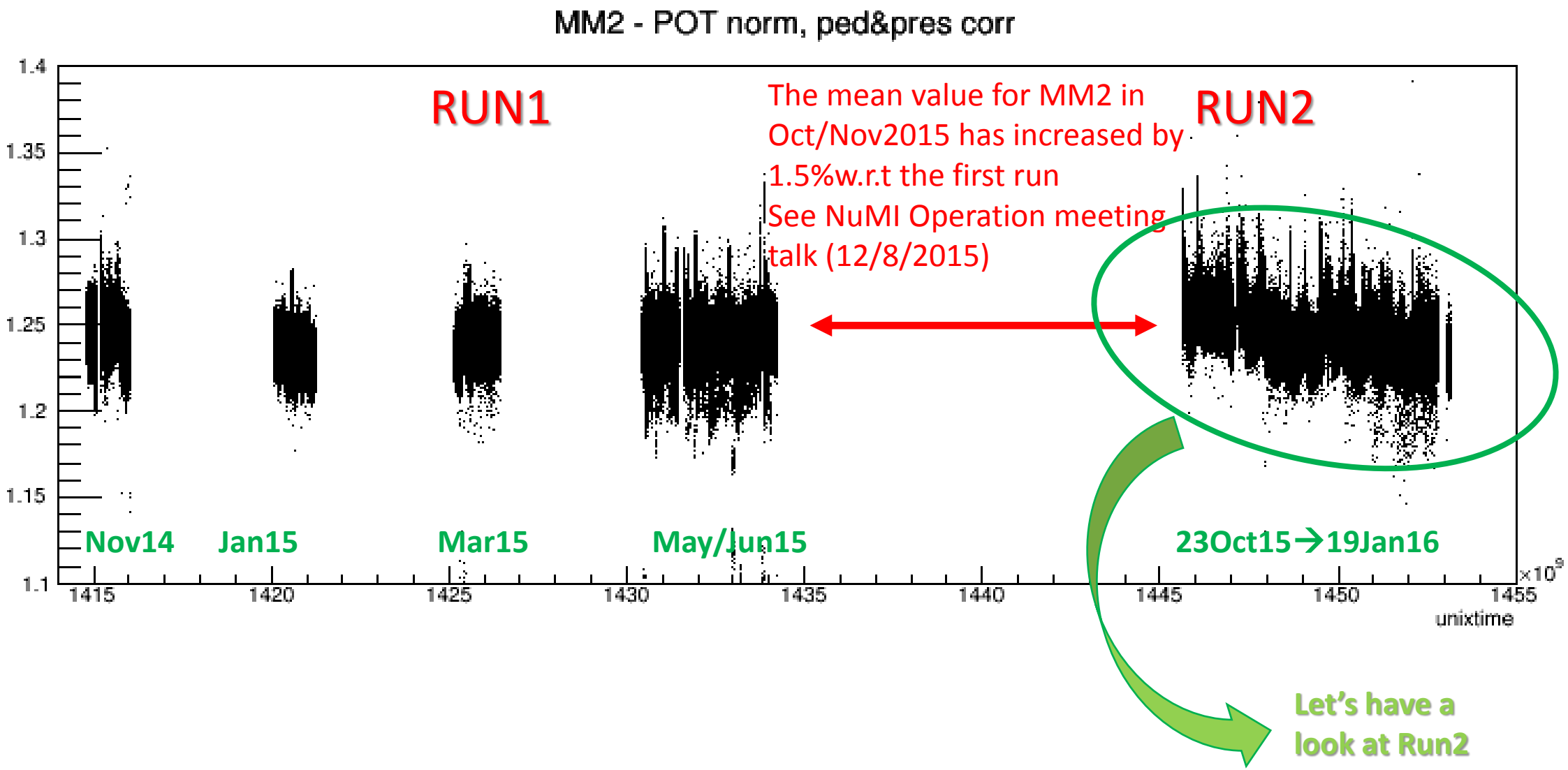


Muon Monitor 1



- The mean value goes from 0.2681 to 0.2647 from **period1** to **period2**
- **Run1** mean value was 0.2662
  → **there's an half % difference w.r.t. period2 of Run2**
- Is there a trend in the signal decrease? Maybe not, we need to look at more data, it would be more clear after about a month or 2 of more data

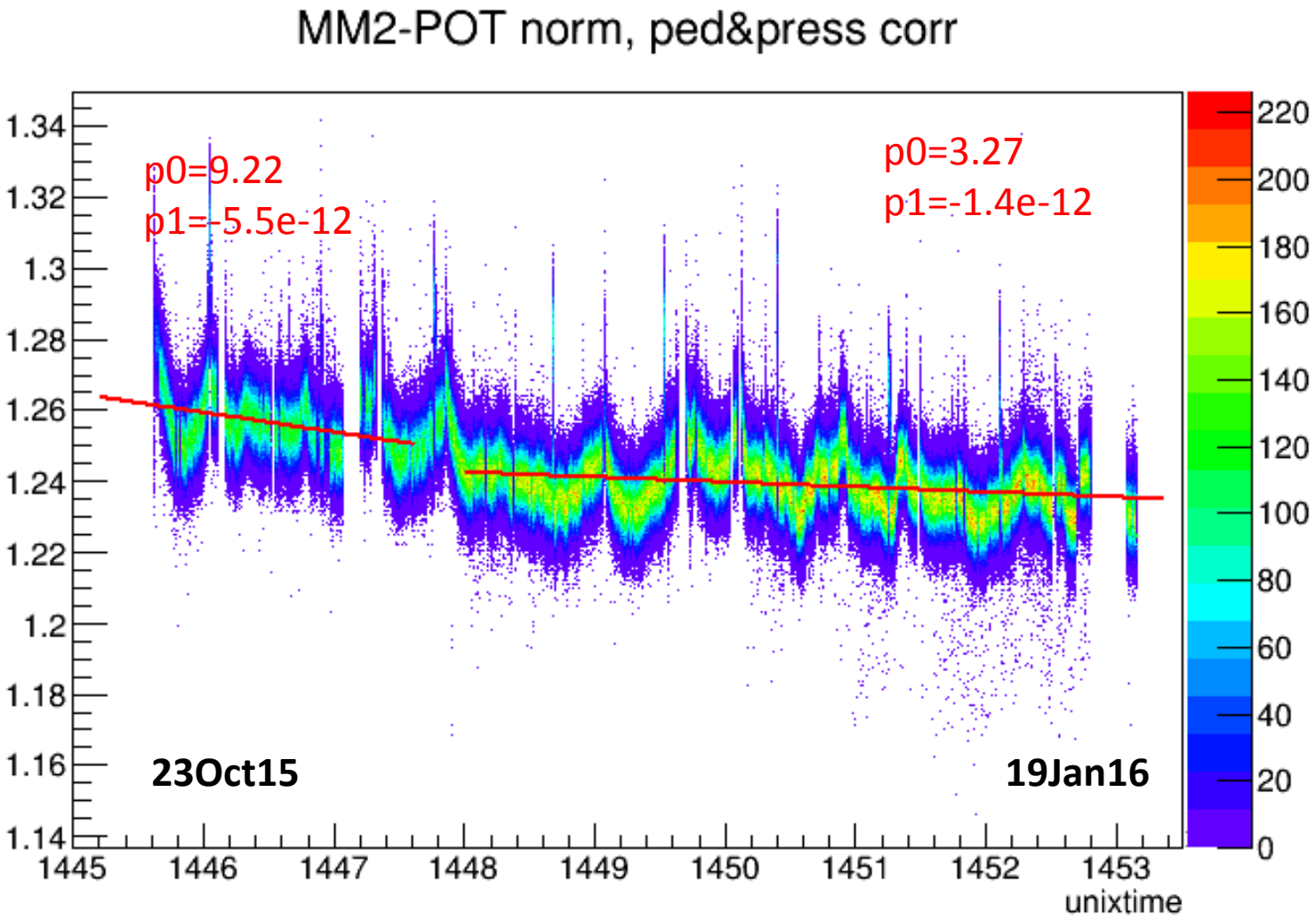
Muon Monitor 2



Muon Monitor 2 – Run2

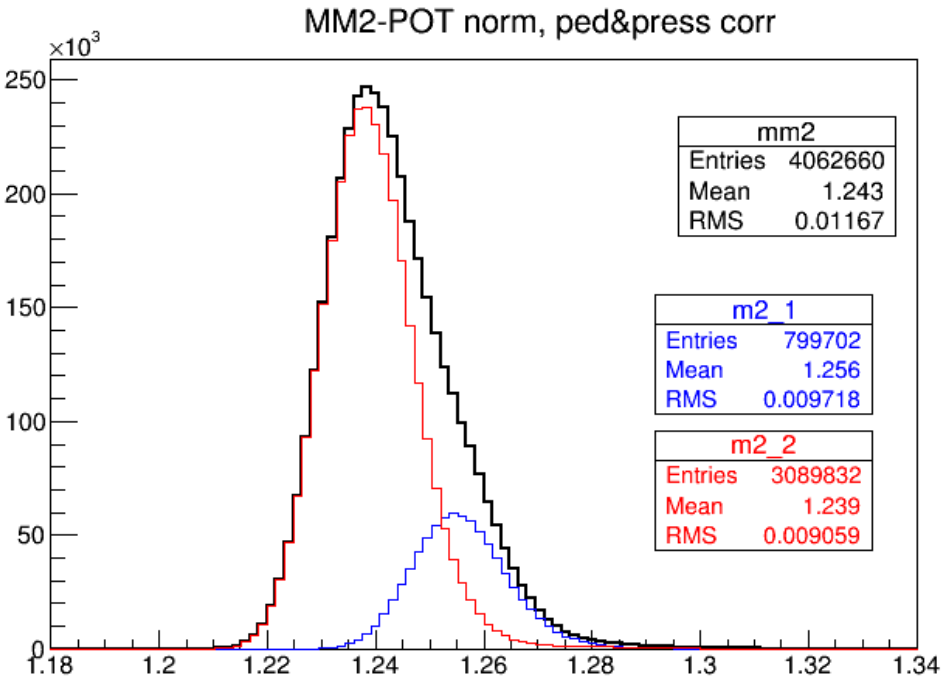
- Same here, two different fits

→ The signal decrease in period 2 is **0.6%**, 2% since the beginning

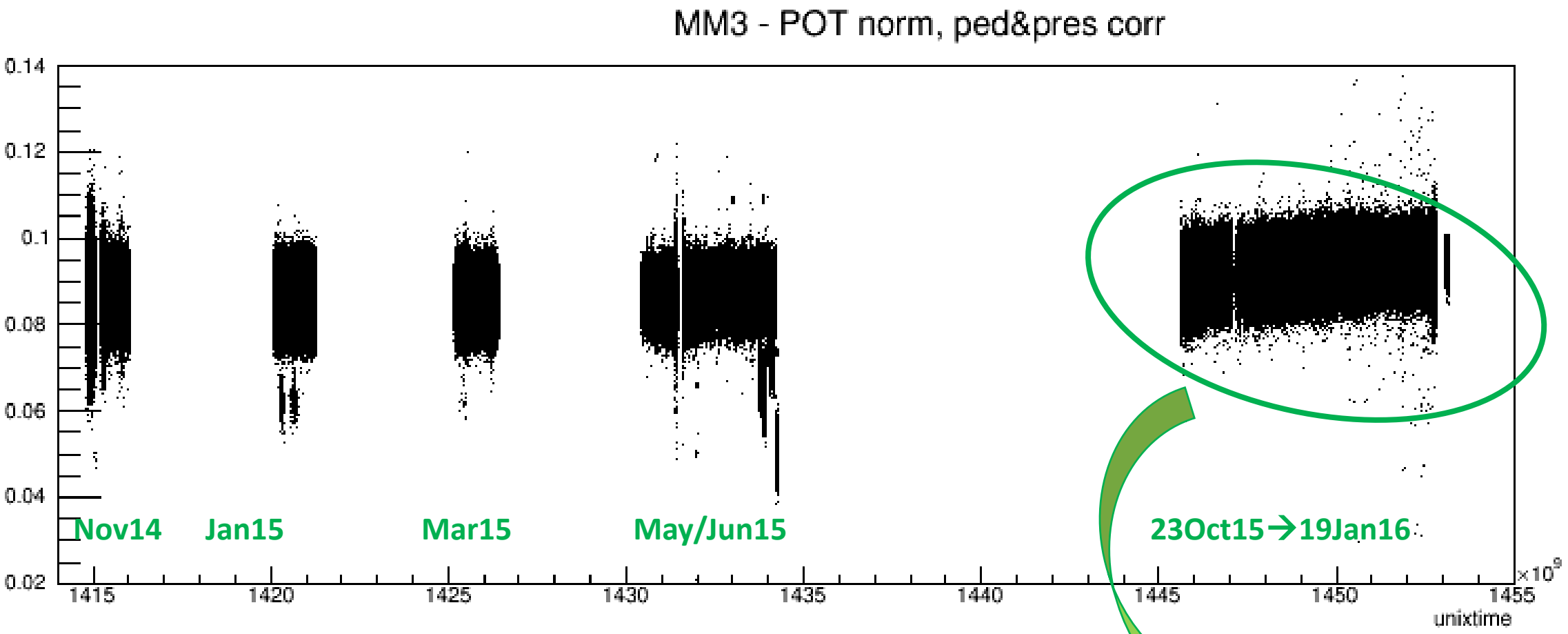


- The mean value goes from 1.26 to 1.24 from **period1** to **period2**
- **Run1** mean value was 1.239 → **In Run2 period2 MM2 has the same mean value**
- Is there a trend in the signal decrease?

  Again, we need to look at more data



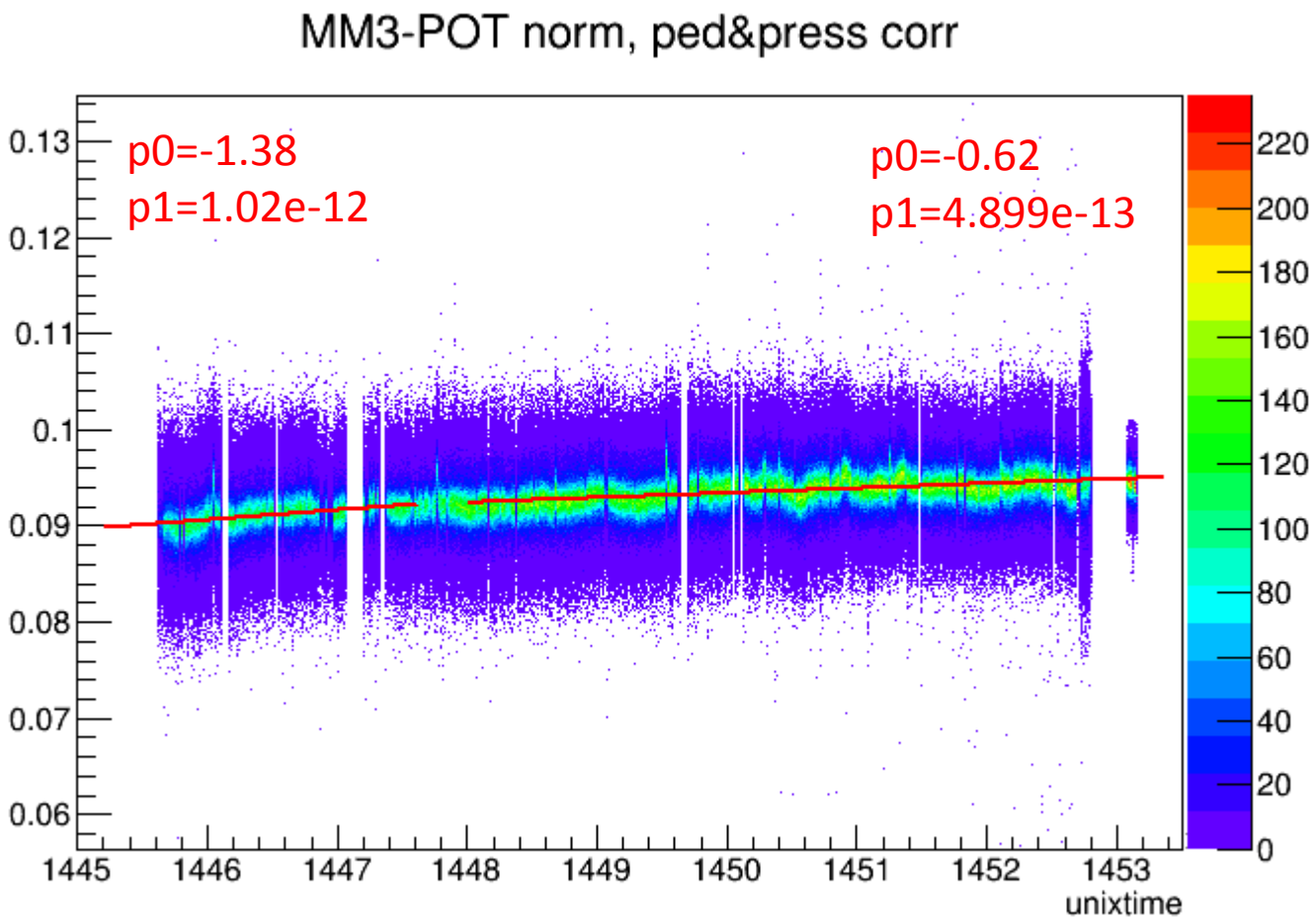
Muon Monitor 3



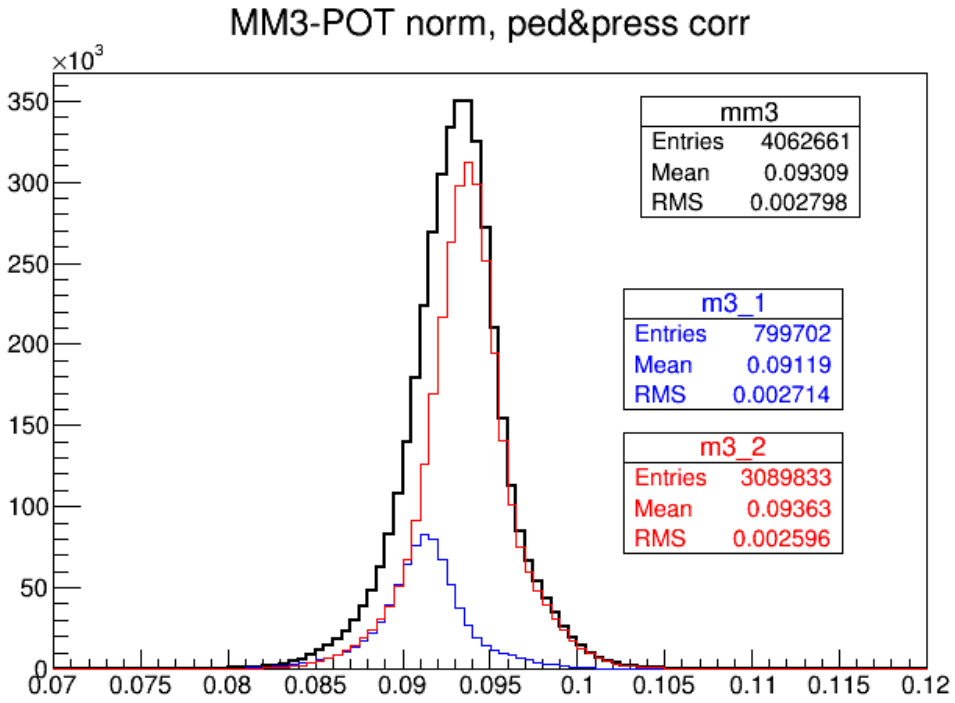
Muon Monitor 3 – Run2

- Same here, two different fits

→ The signal increase in period 2 is **3%**

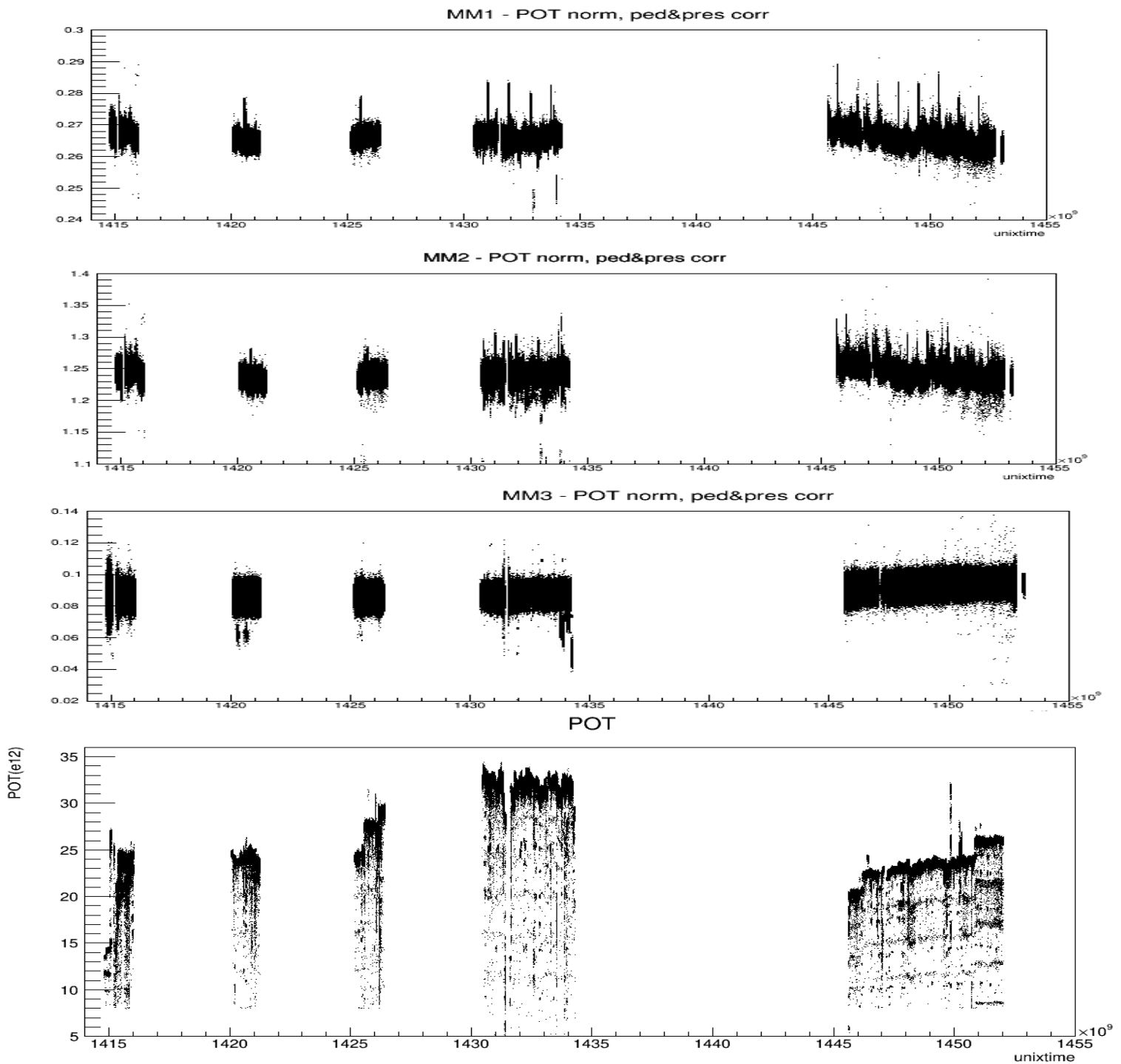


- The mean value goes from goes from 0.091 to 0.093 from period1 to period2
- Is there a trend in the signal increase? Again,we need to look at more data

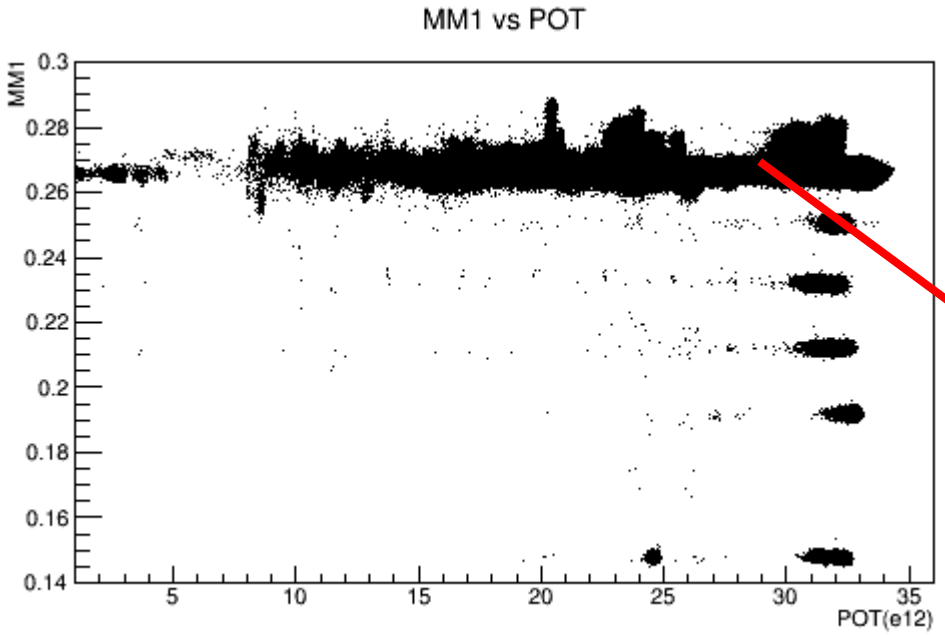


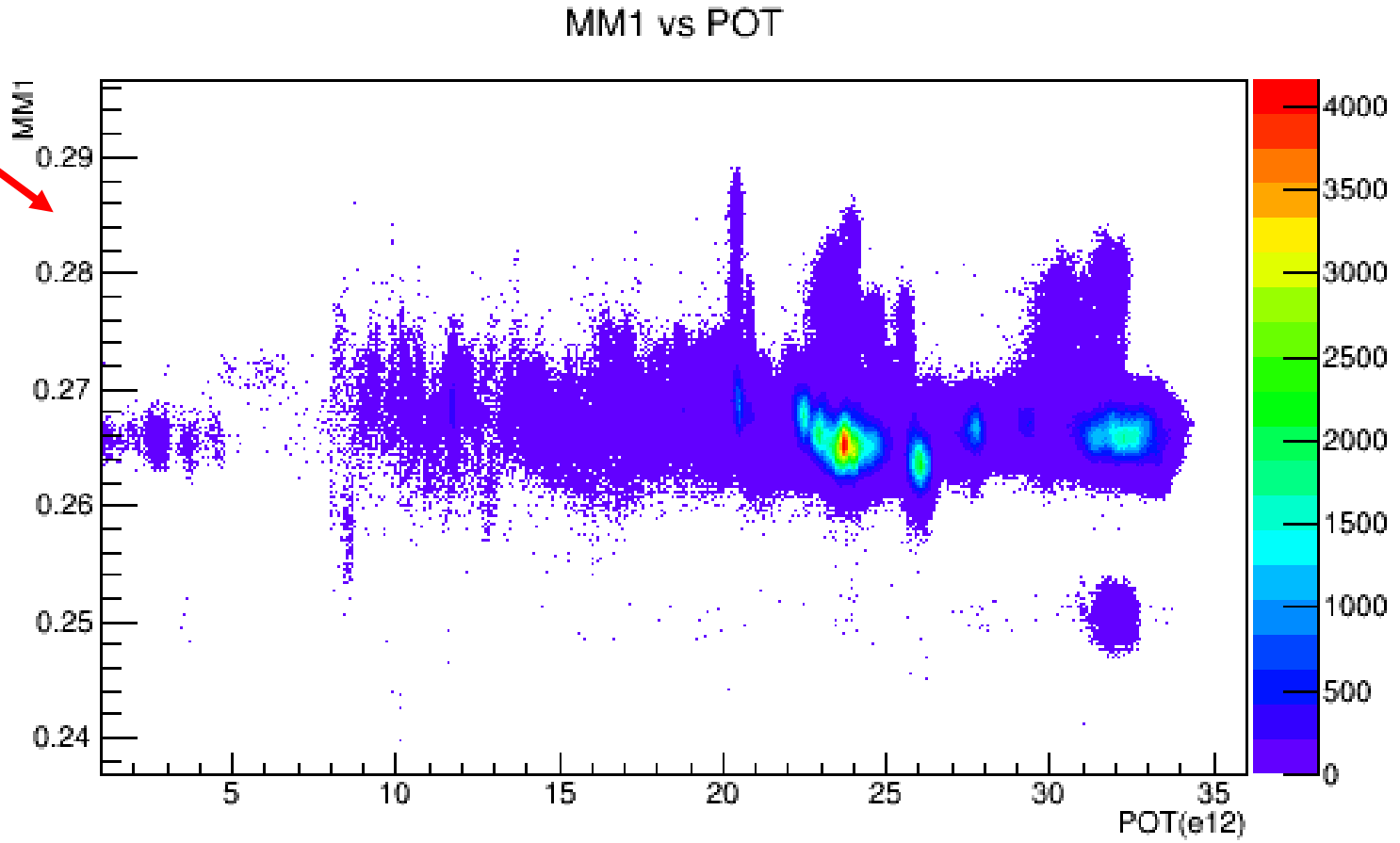
Muon Monitors & POT

…check the MM signal VS the POT to investigate possible saturation problems…

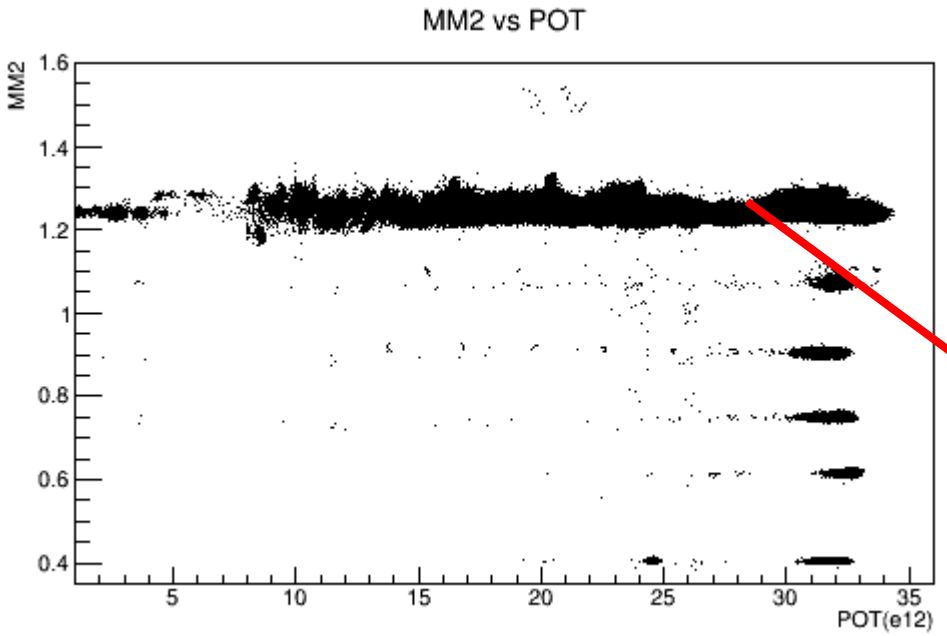


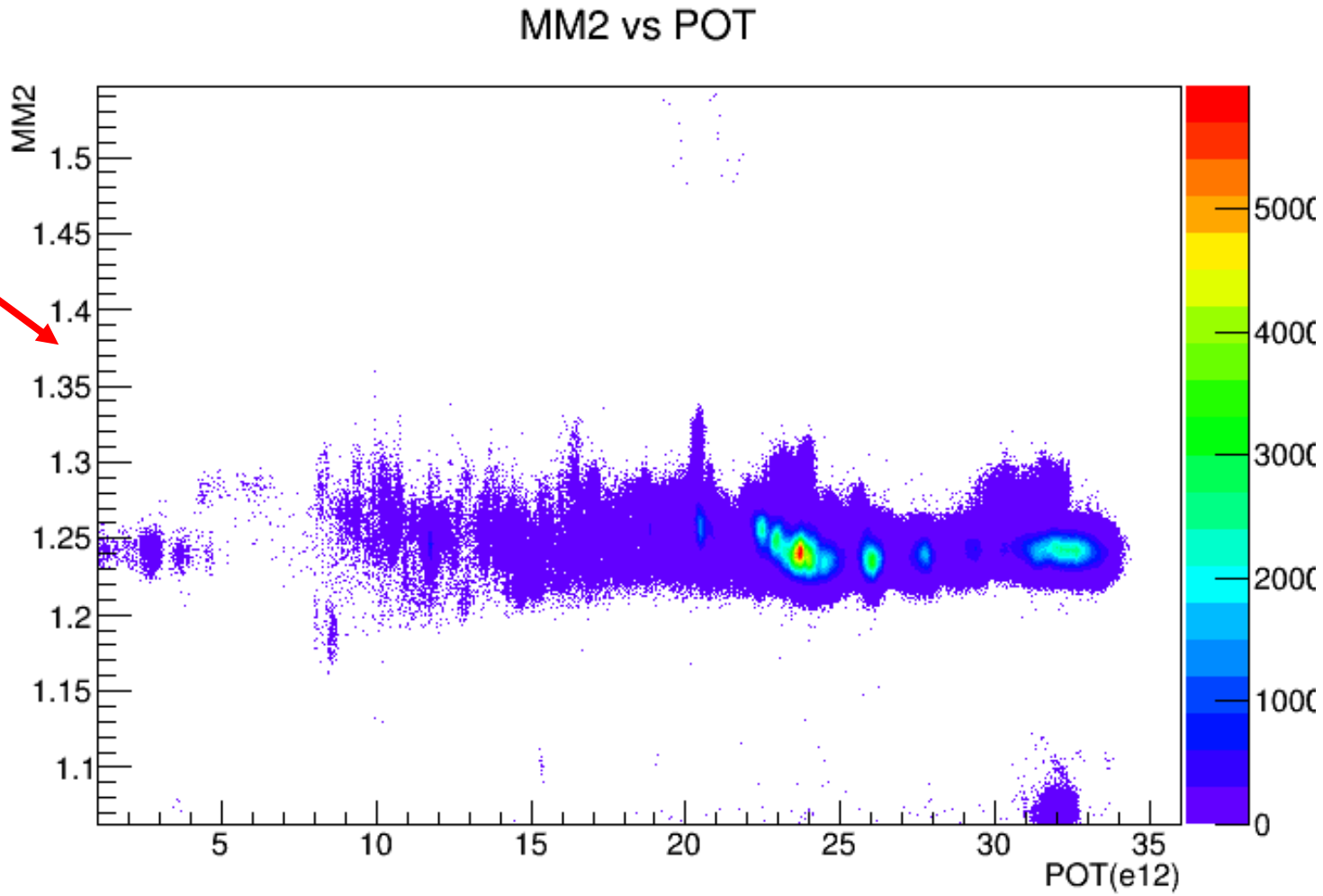
Muon Monitor1 & POT





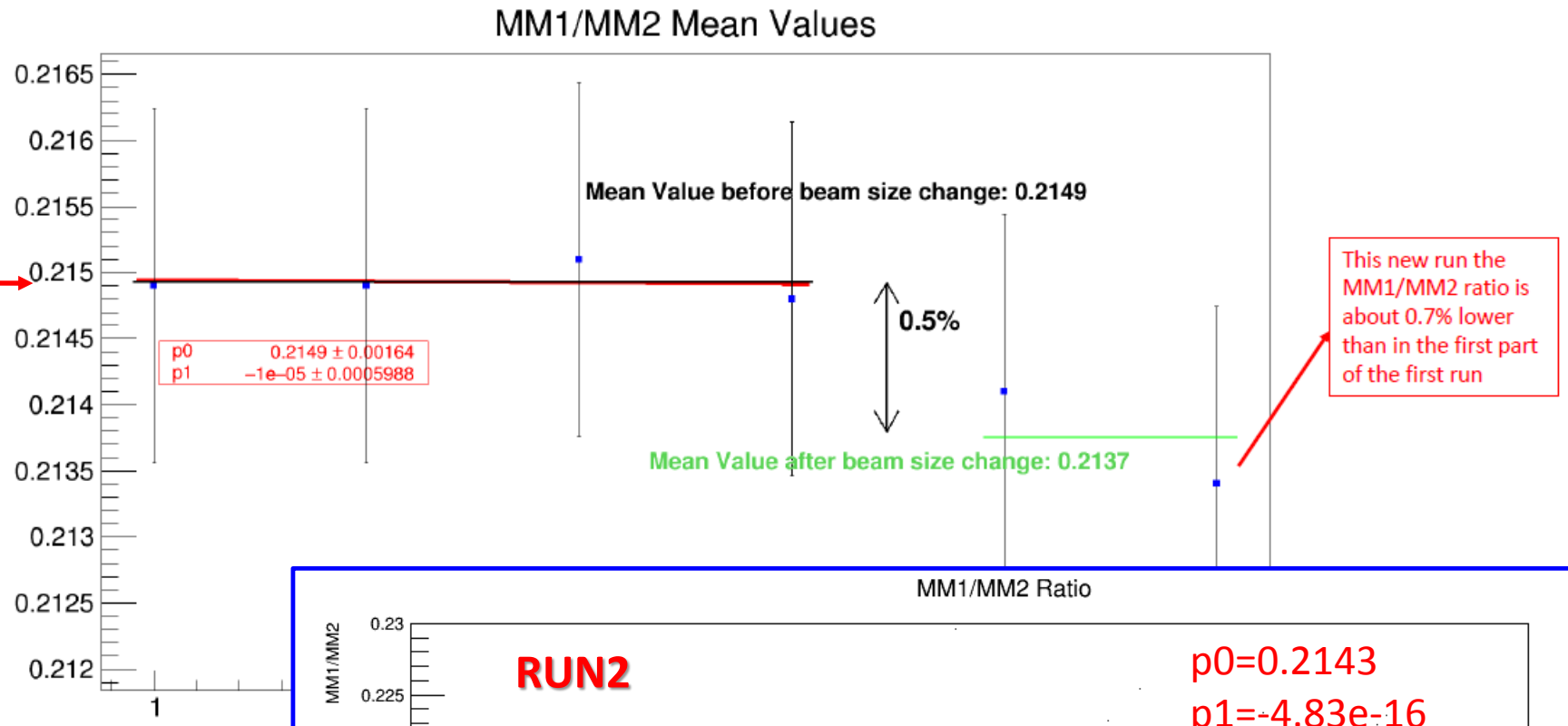
Muon Monitor2 & POT



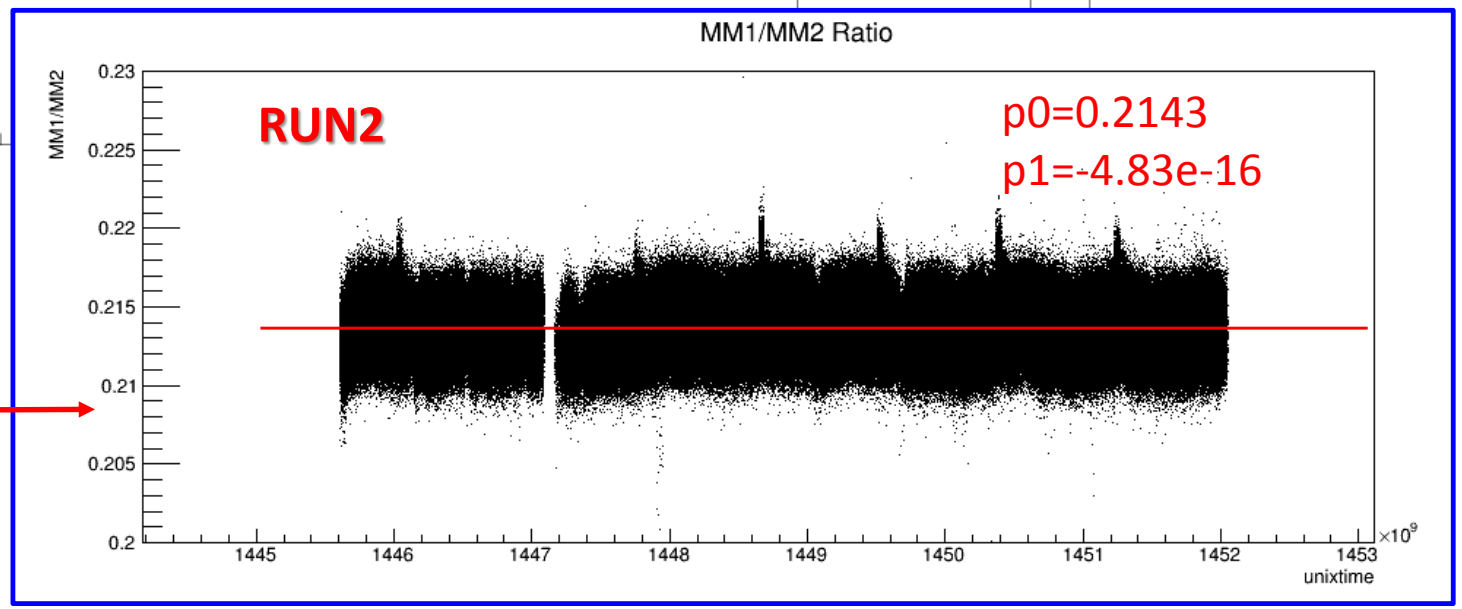


MM1/MM2 Ratio

- The talk for Numi Operations in December shows the comparison w.r.t. RUN1 and the effect of the beam size



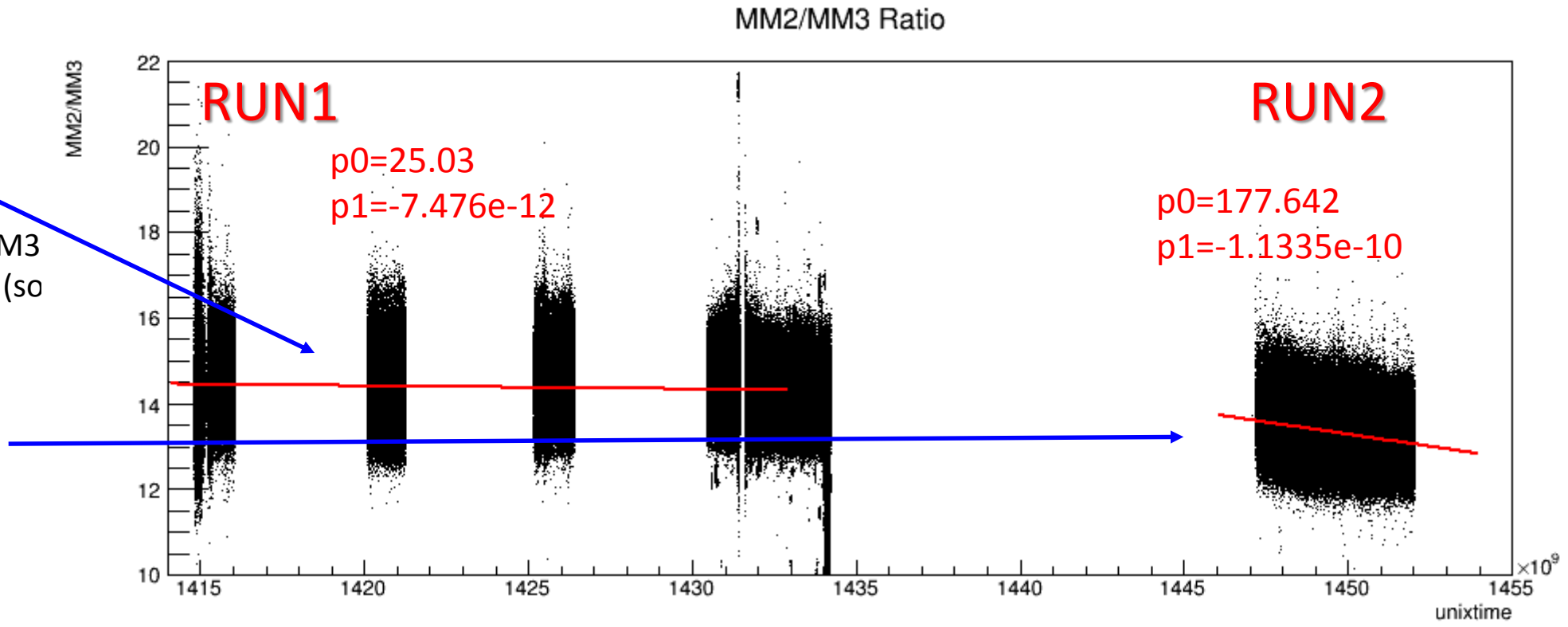
- For RUN2 the MM1/MM2 ratio looks stable (it makes sense, MM1 and the MM2 have the same variation in time…)



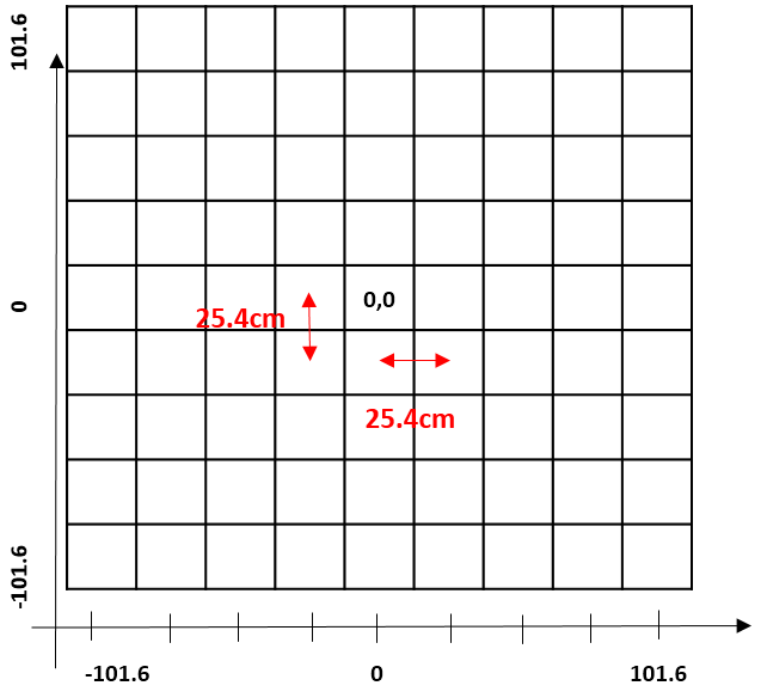
MM2/MM3 Ratio

- During Run1 the MM2/MM3 ratio was stable at the % level
- For RUN2 the MM2/MM3 ratio goes down by 6% (so far…)
  (the MM2 decrease is 0.6%, and the MM3 increase is 3%)

→ Keep monitoring



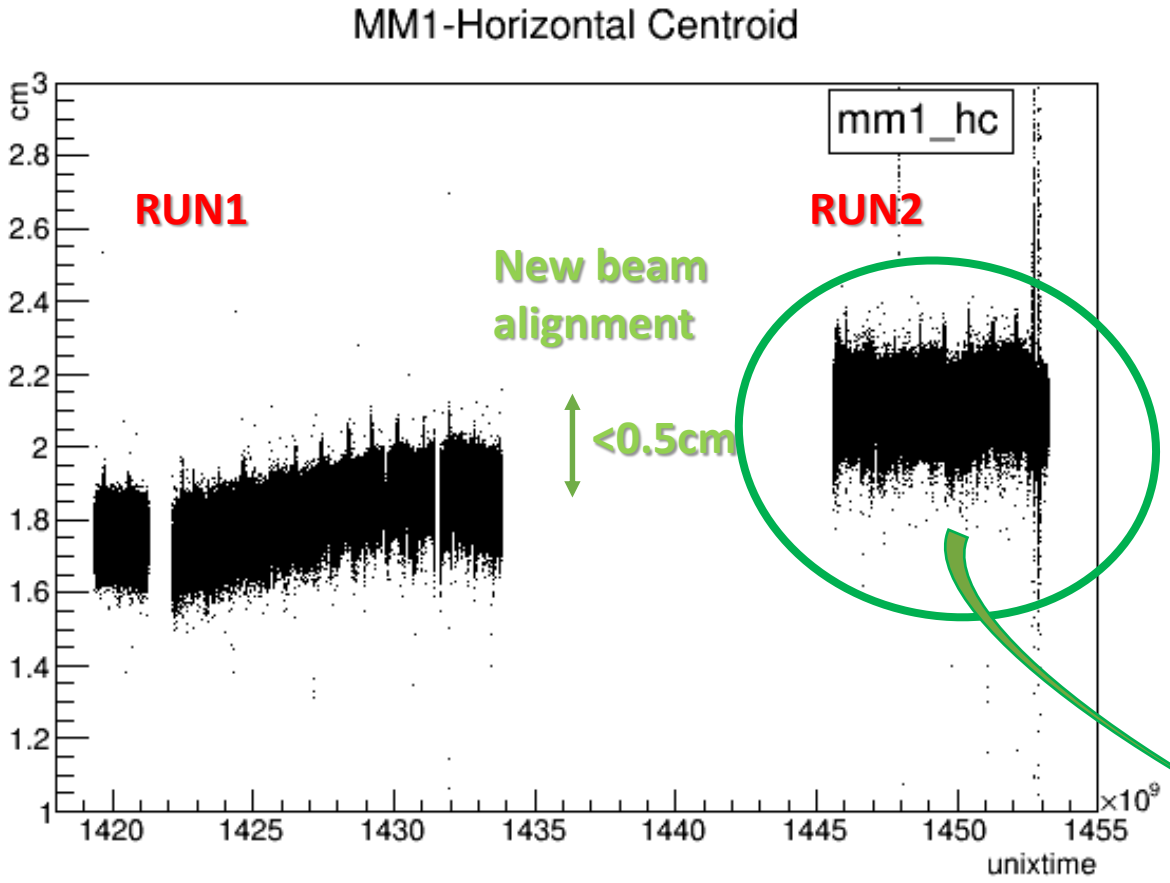
Muon Monitors – Centroids

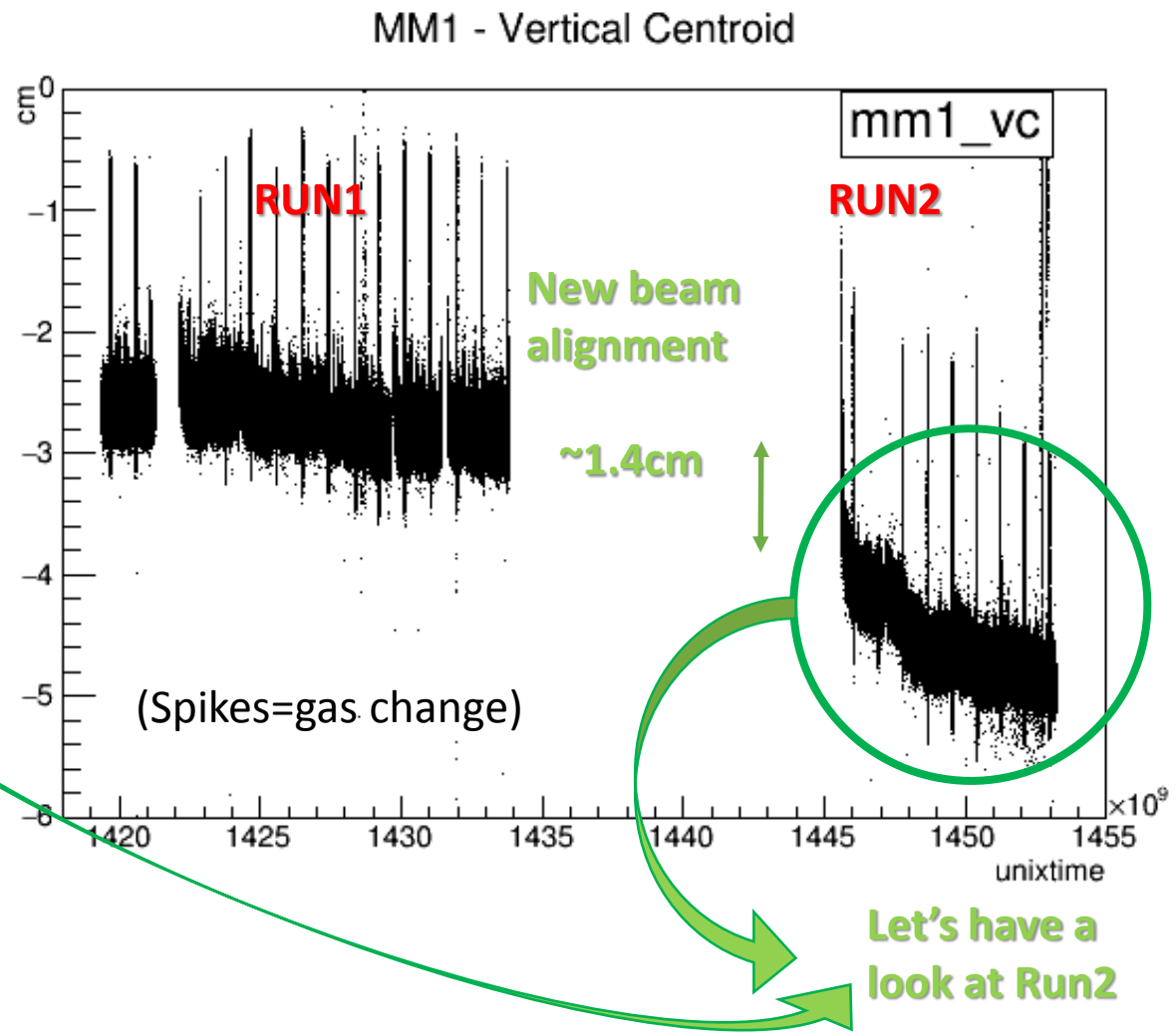


My definition:

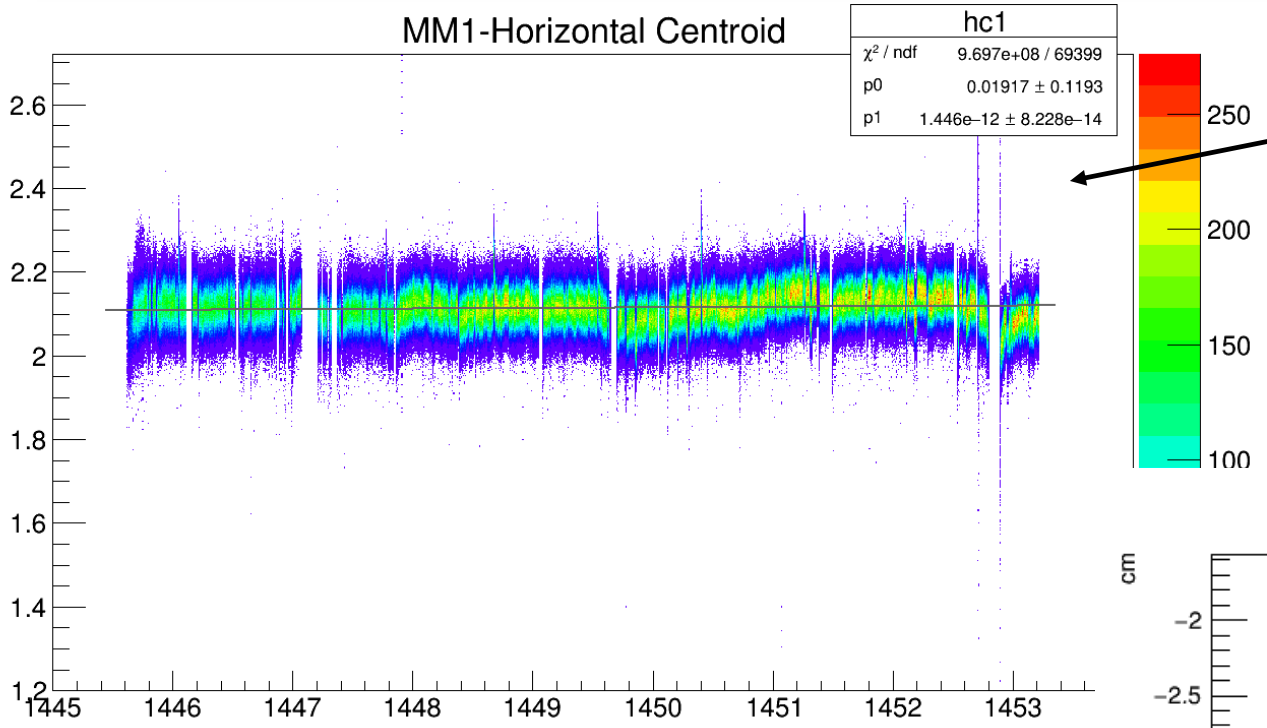
- I defined the horizontal and vertical positions taking the distances from one chamber center to the next chamber center
- The horizontal distance between two chambers is 25,4 cm, same for vertical
- The central chamber corresponds to (0,0) position, negative positions are on the left and on the bottom, positive positions on the right and on the top

Muon Monitor1 – Centroids



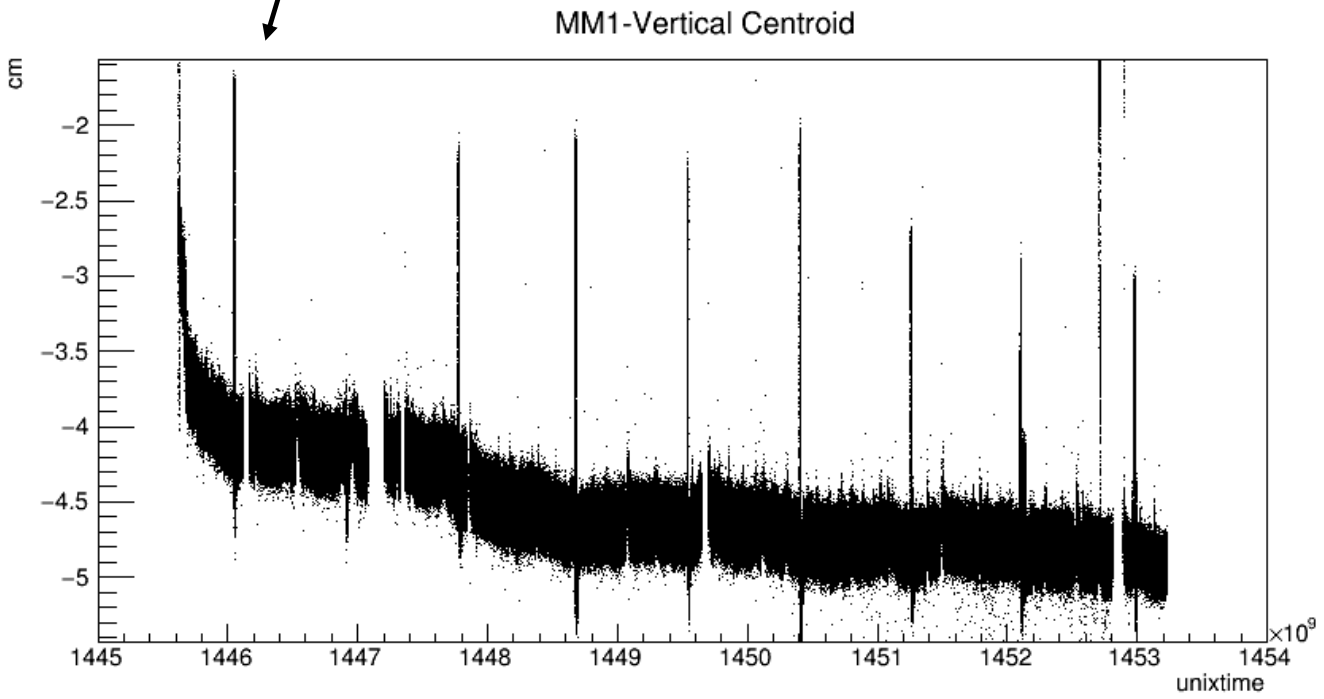


Muon Monitor1 – Centroids



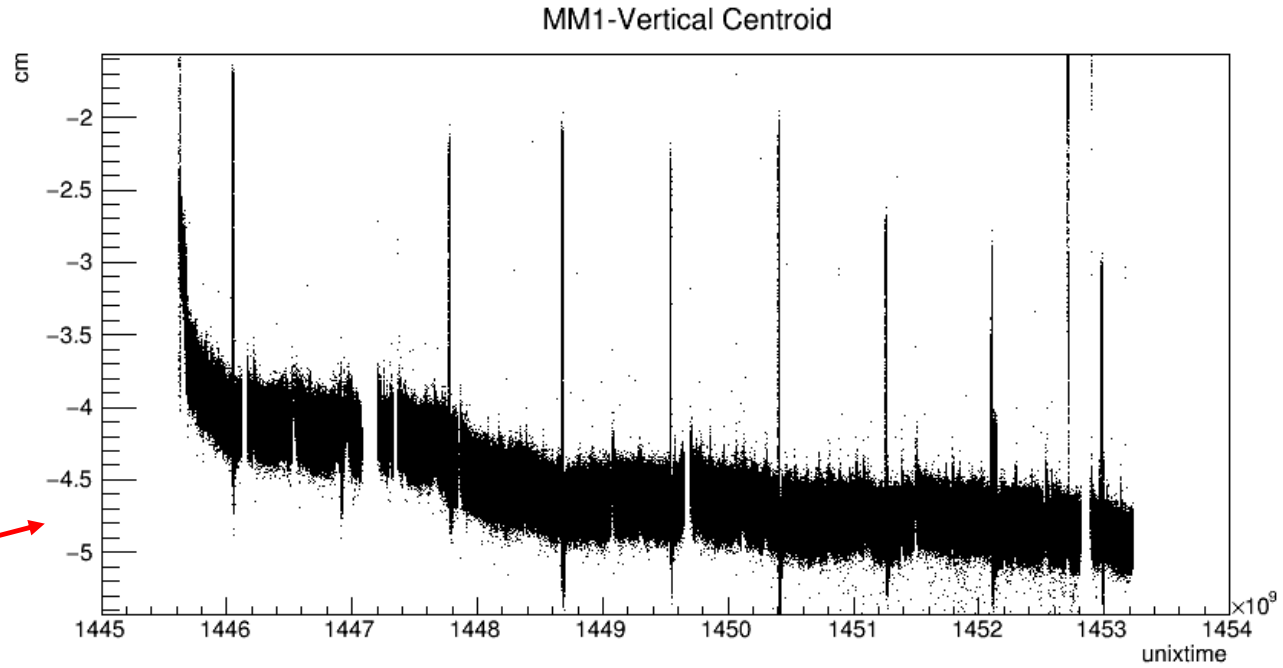
Horizontal centroid looks stable

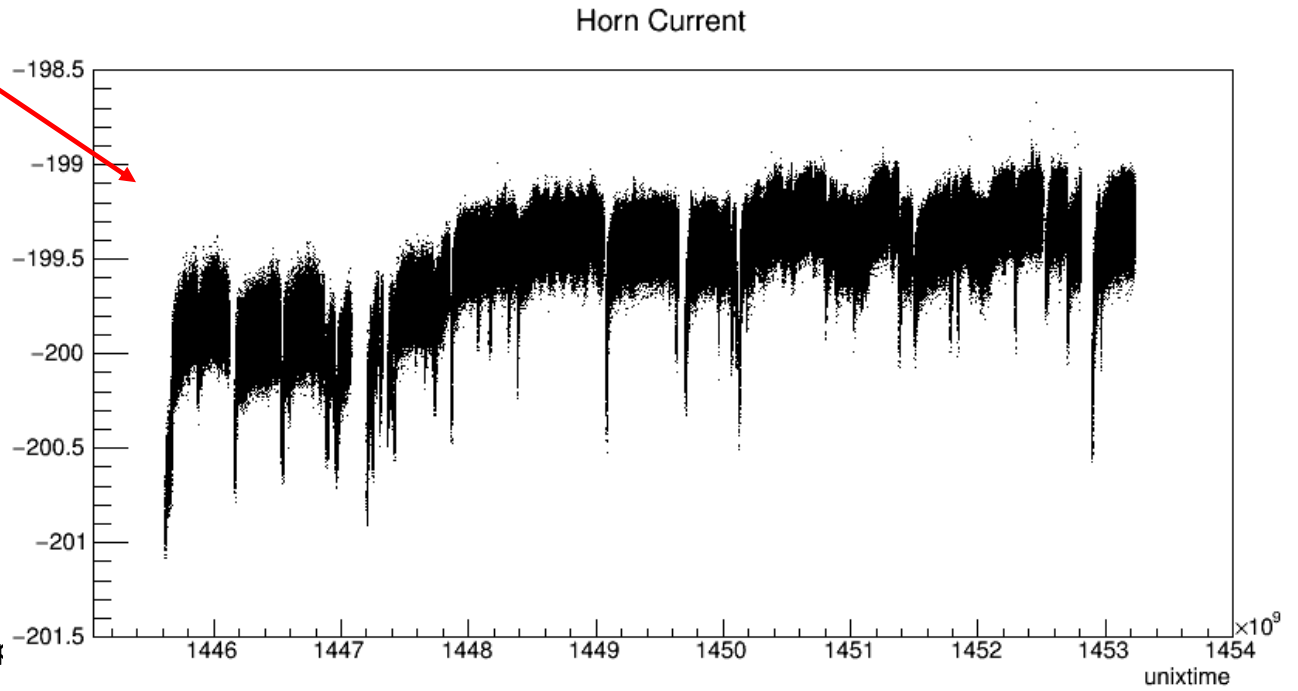
Vertical centroid has about 1.5 cm decrease since the start of the run



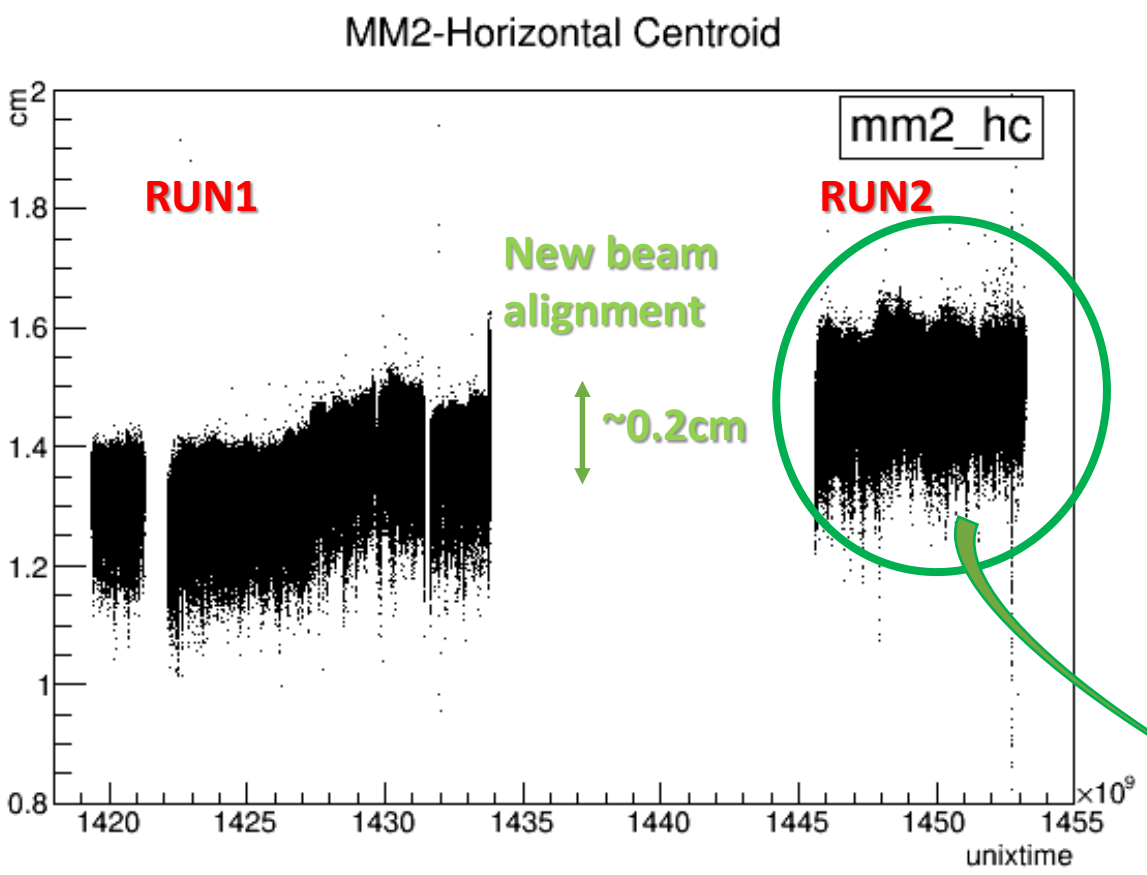
Muon Monitor1 – Vertical Centroid

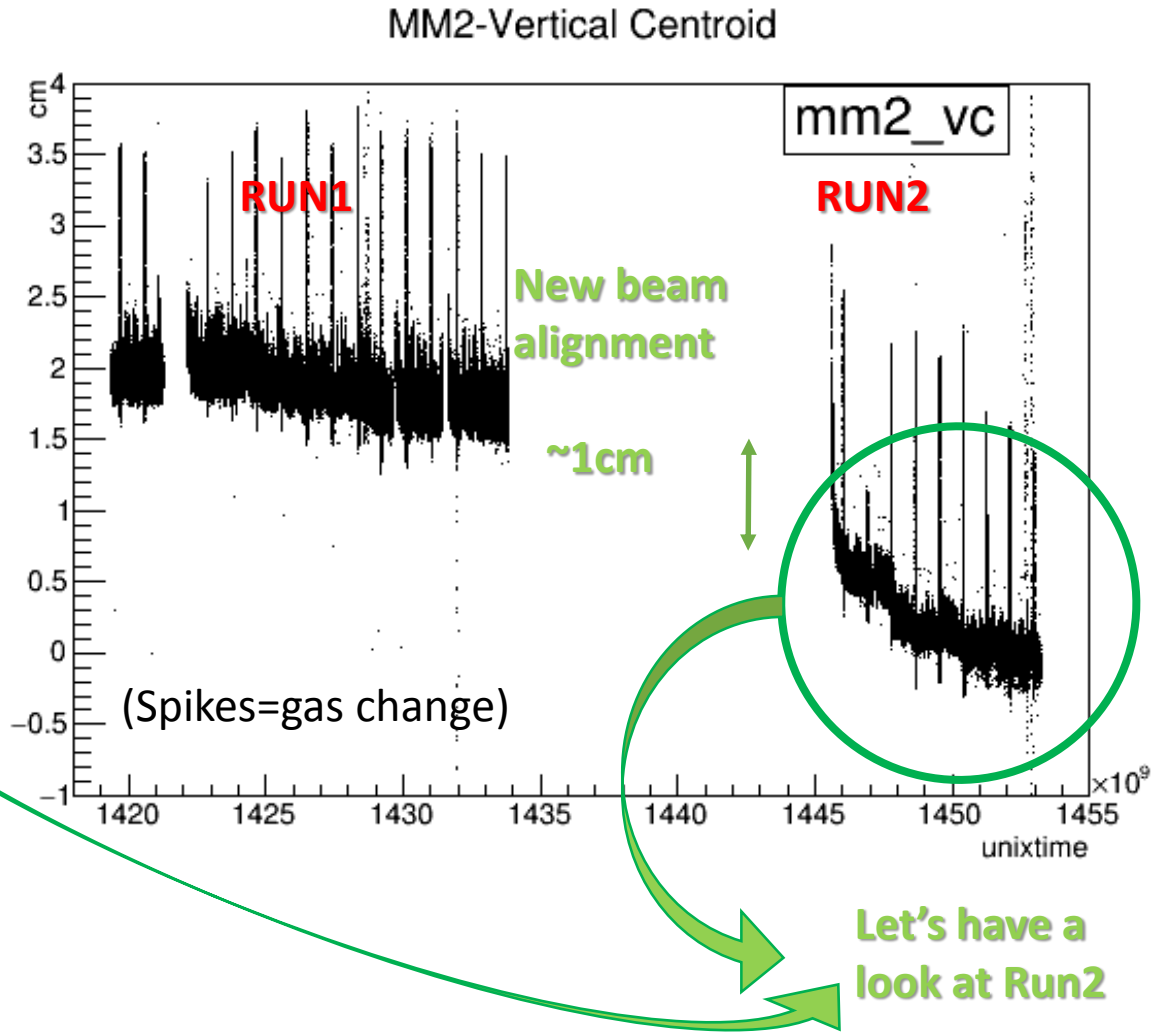
- … 1.5cm it's not much but we should monitor the trend
- The vertical centroid behavior is related to the Horn (we saw it already in the past)
- The horn current decreases when the repetition rate increases and we had different cycle modes at the beginning of the run (See slide 5)





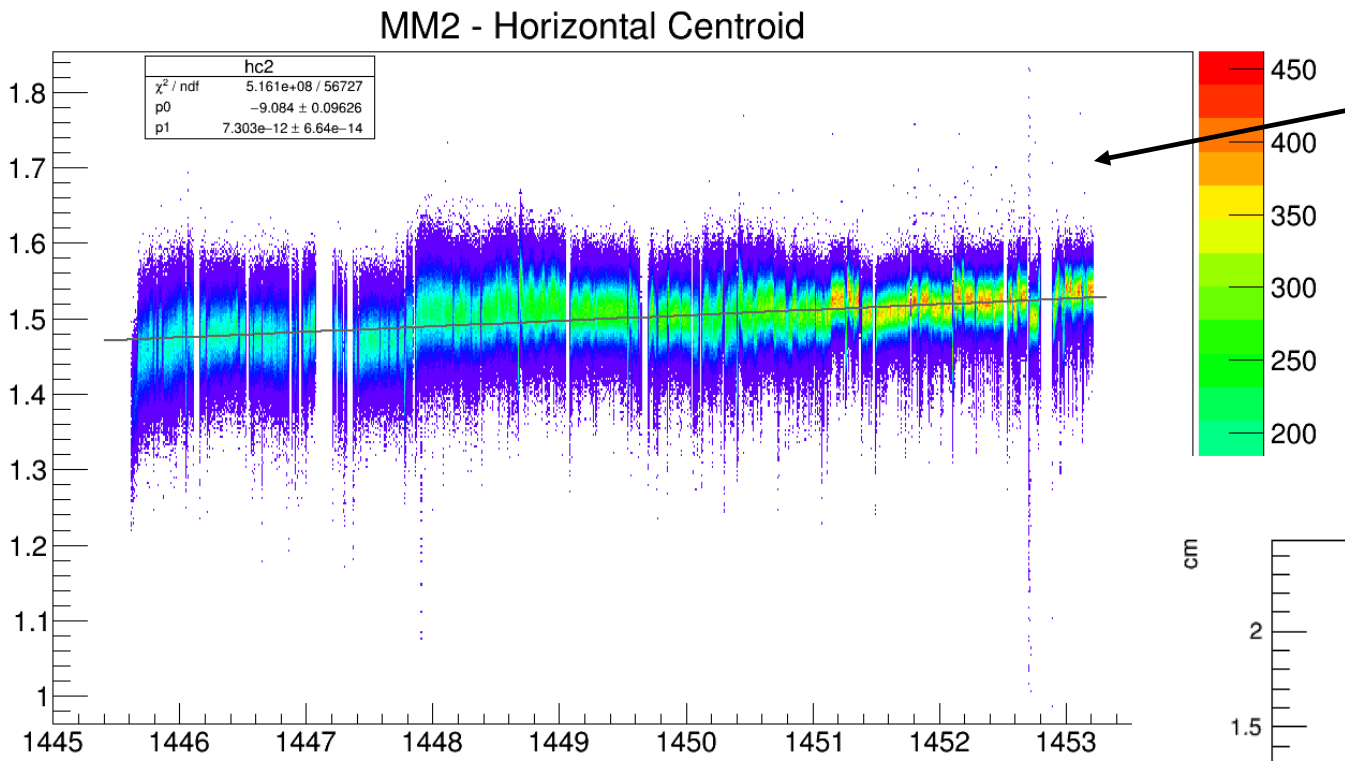
Muon Monitor2 – Centroids





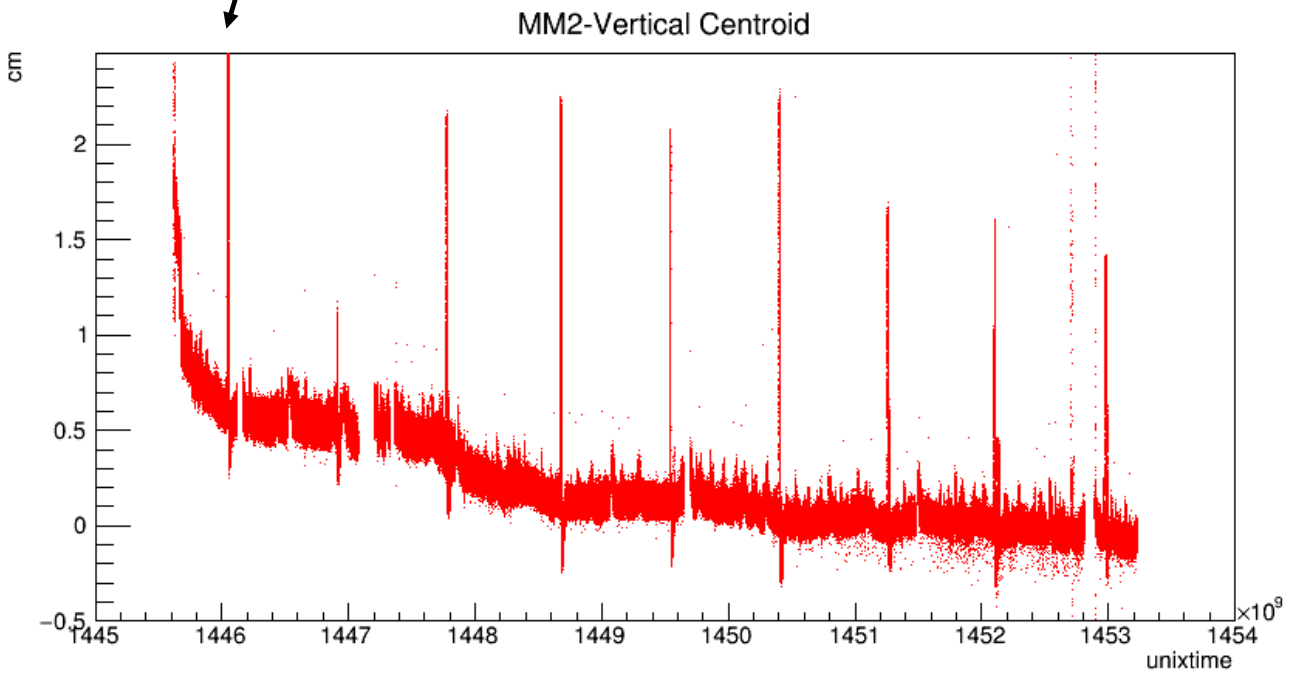
Let's have a look at Run2

Muon Monitor2 – Centroids



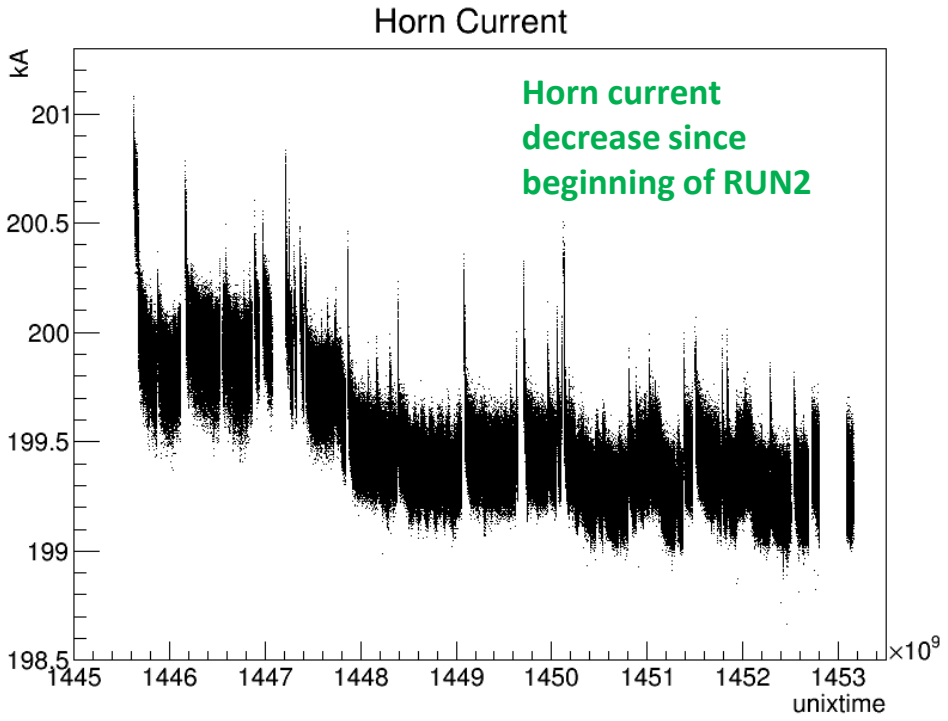
Horizontal centroid looks stable

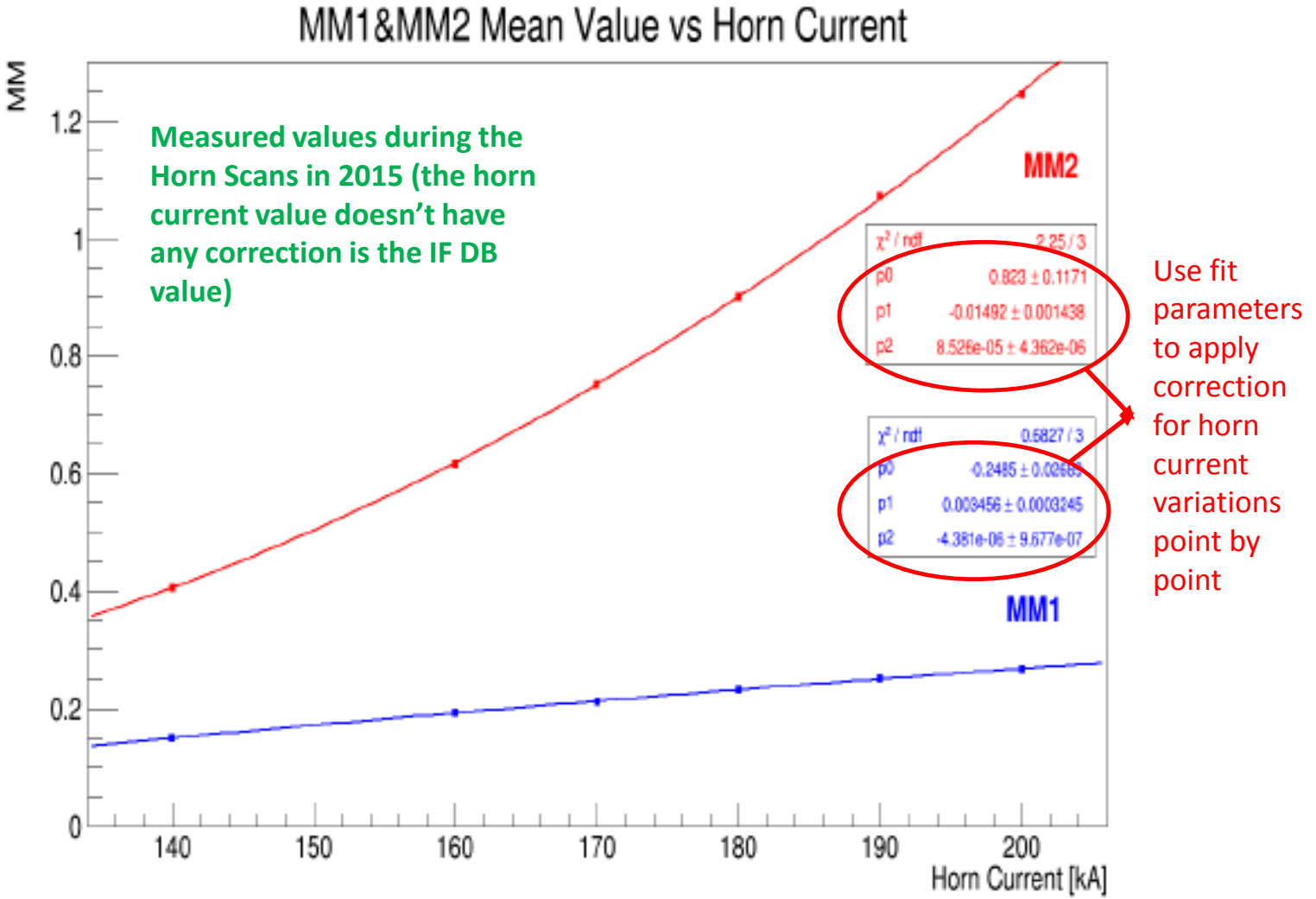
Vertical centroid has about 1 cm decrease since the start of the run, same considerations made for the MM1 for the correlation with the horn
→keep monitoring it



Muon Monitors and Horn Current

The MM signal is correlated with the horn current and I analyzed the MM data during the horn current scan last year
→ so we can check what happens applying a correction for the current variation and see whether that can explain what we see





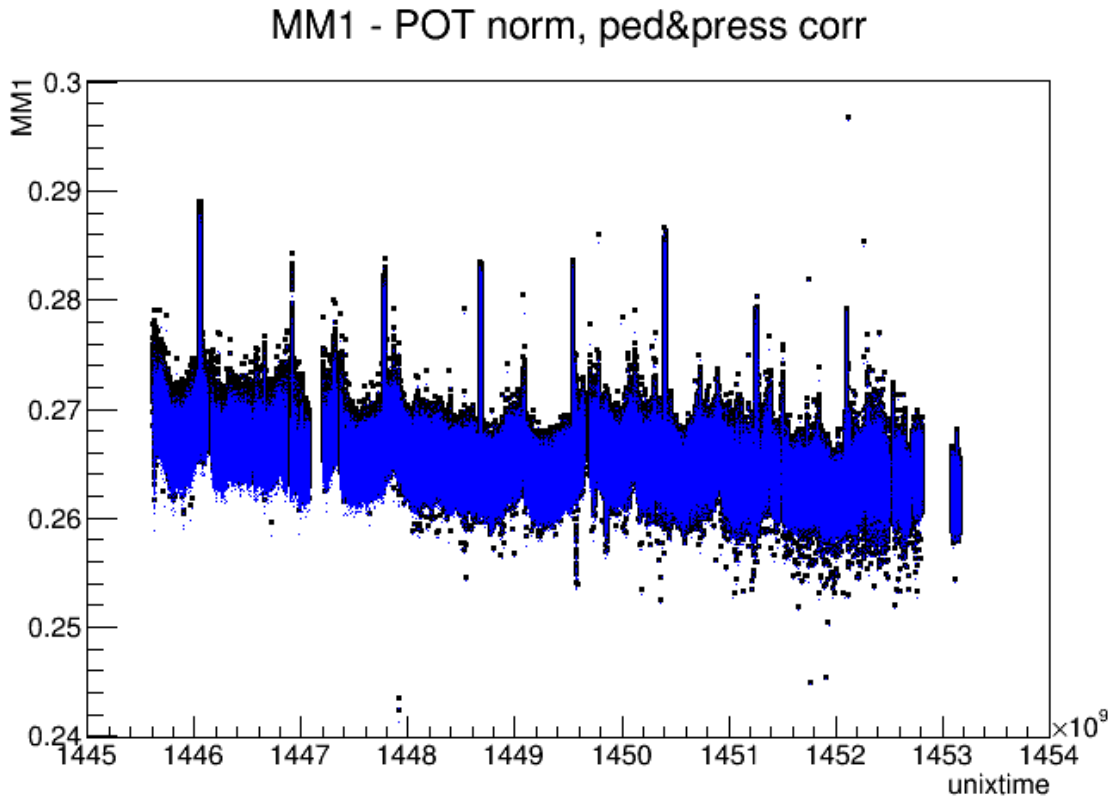
Muon Monitors
Corrected for the horn current and normalized to the nominal value

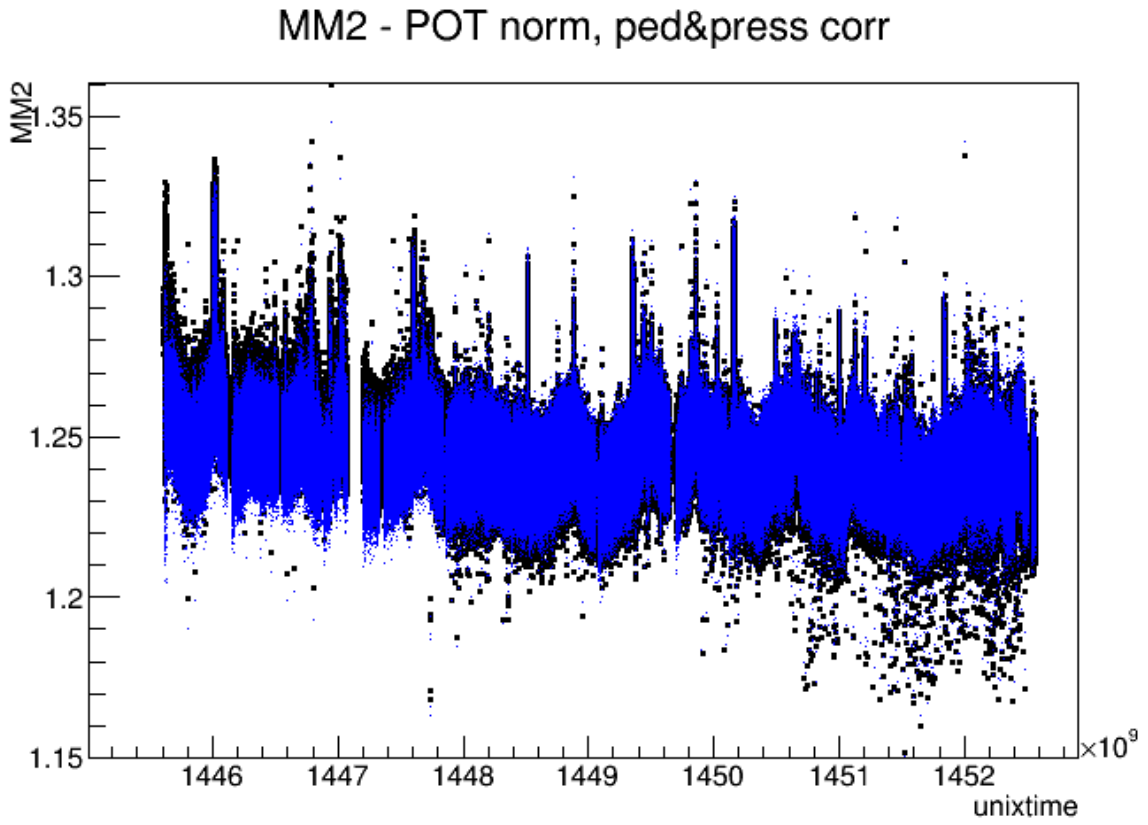
The correction applied is

$m' = m_{measured} - m_{expected} + m_{nominal}$ → MM1 nominal value from Run1: 0.2699
MM2 nominal value from Run1: 1.244

$m_{expected}$: from fit

Comparison measured normalized

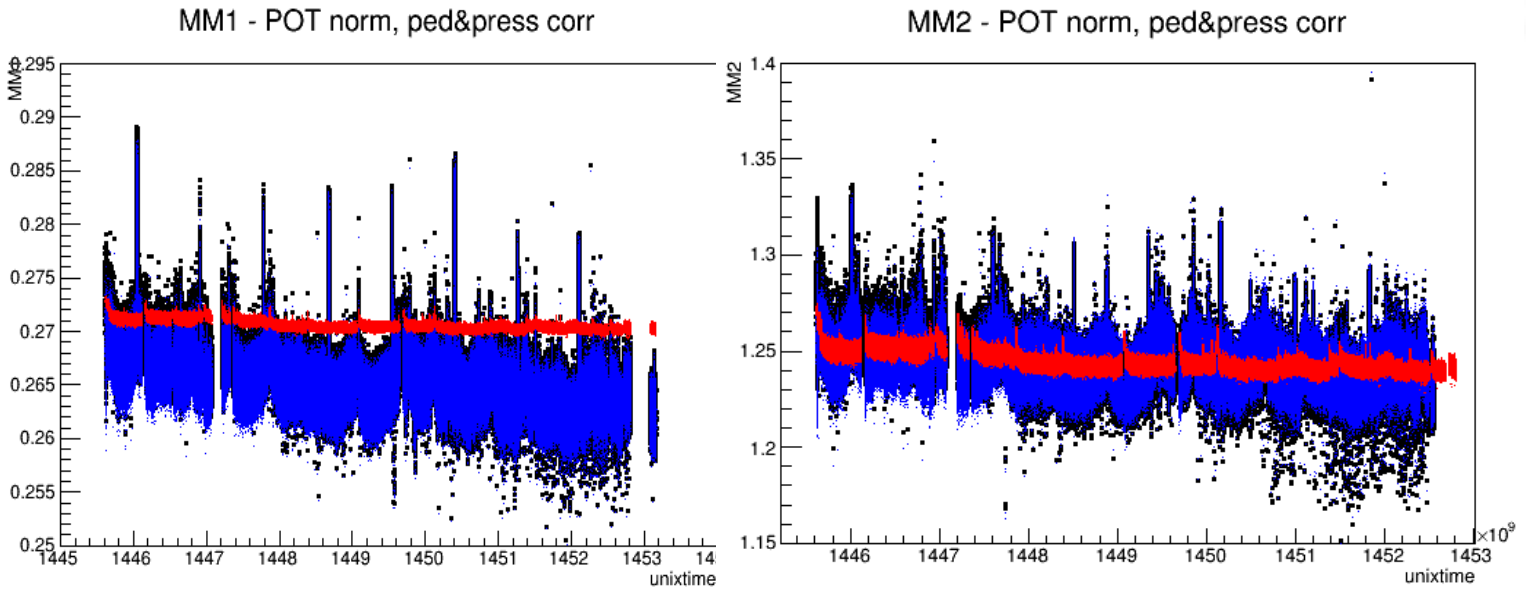


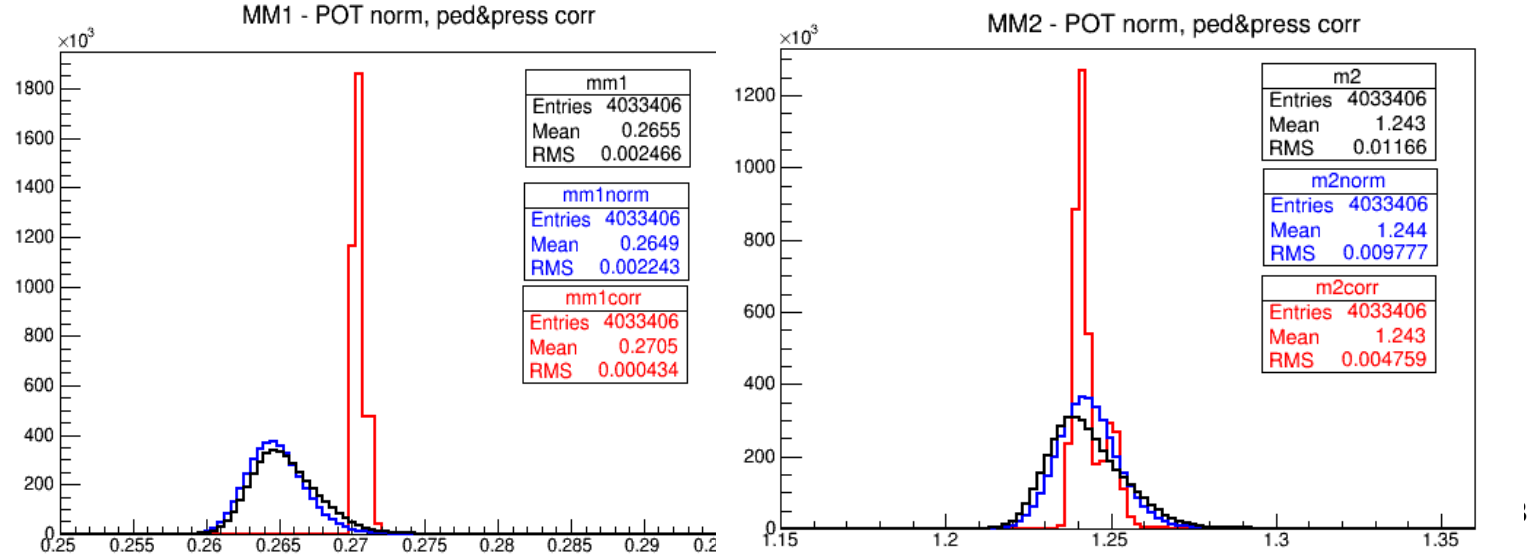


Muon Monitors
Corrected for the horn current and normalized to the nominal value

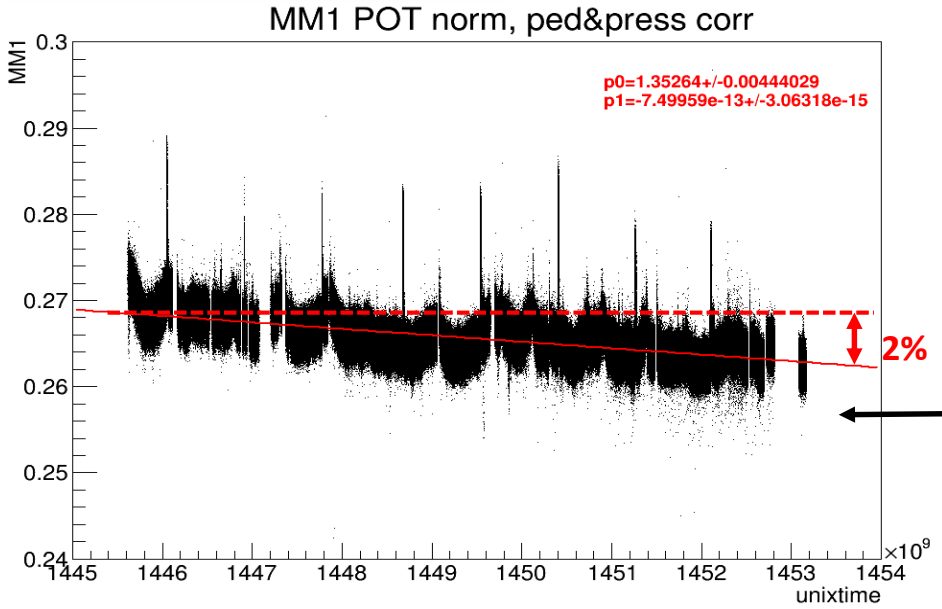
$m' = m_{measured} - m_{expected} + m_{nominal}$

- measured
- normalized
- expected

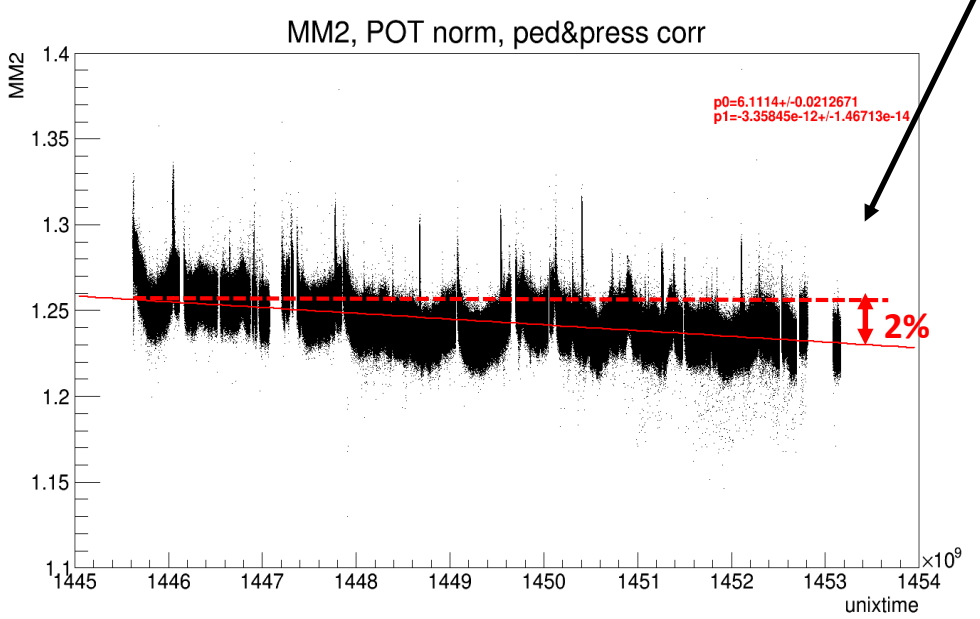




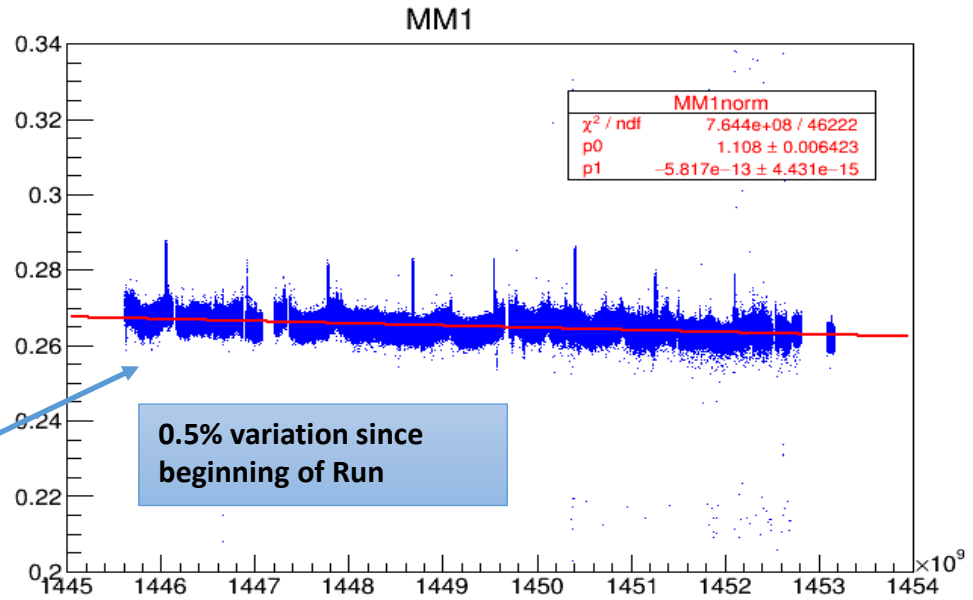
Muon Monitors

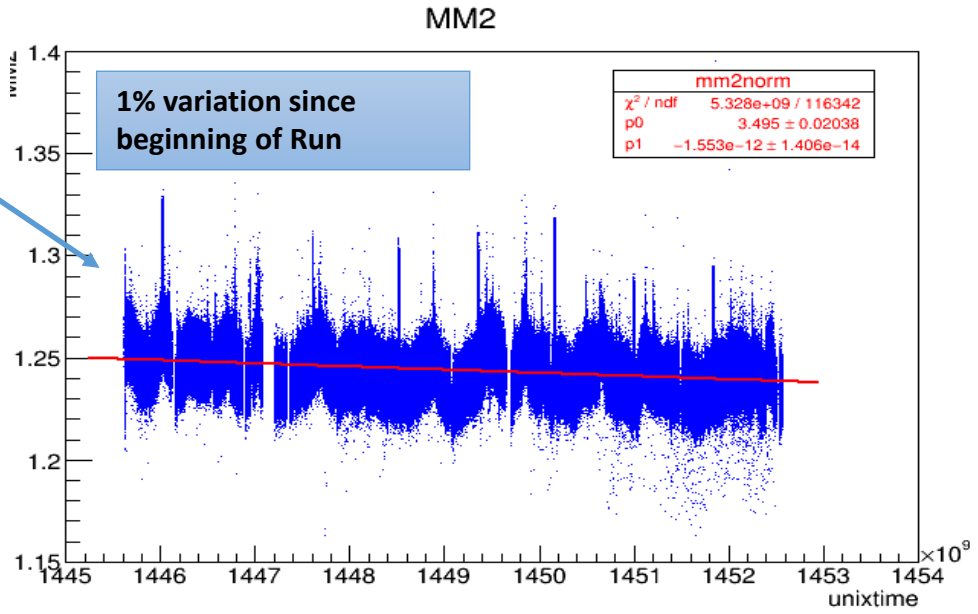


measured



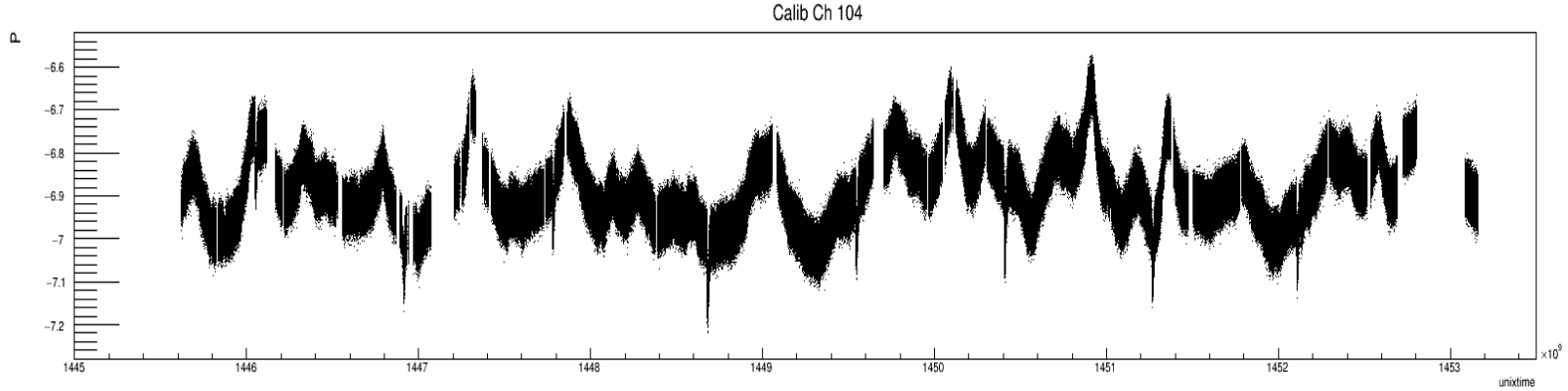
Corrected for the horn current and normalized to the nominal value

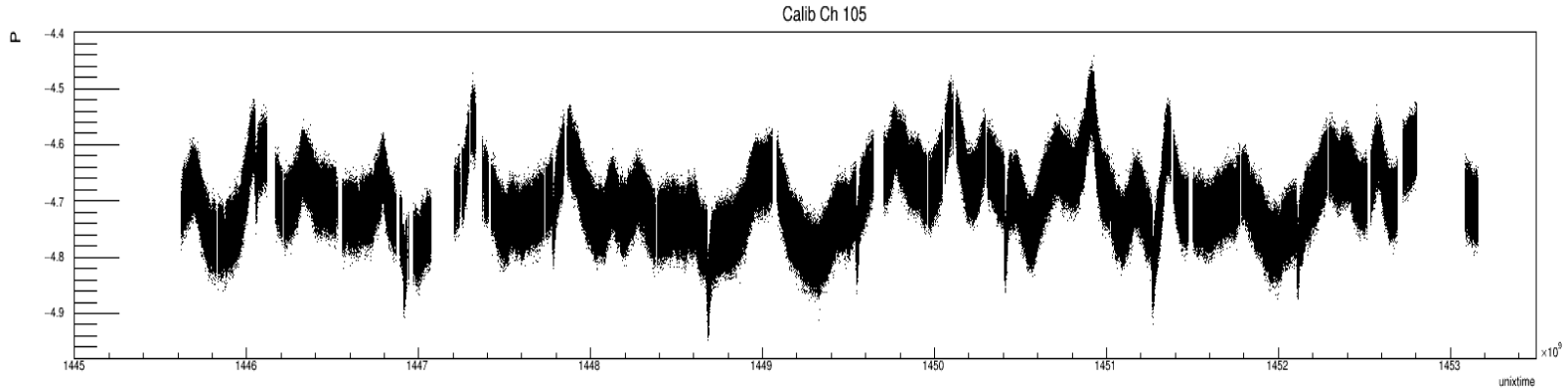


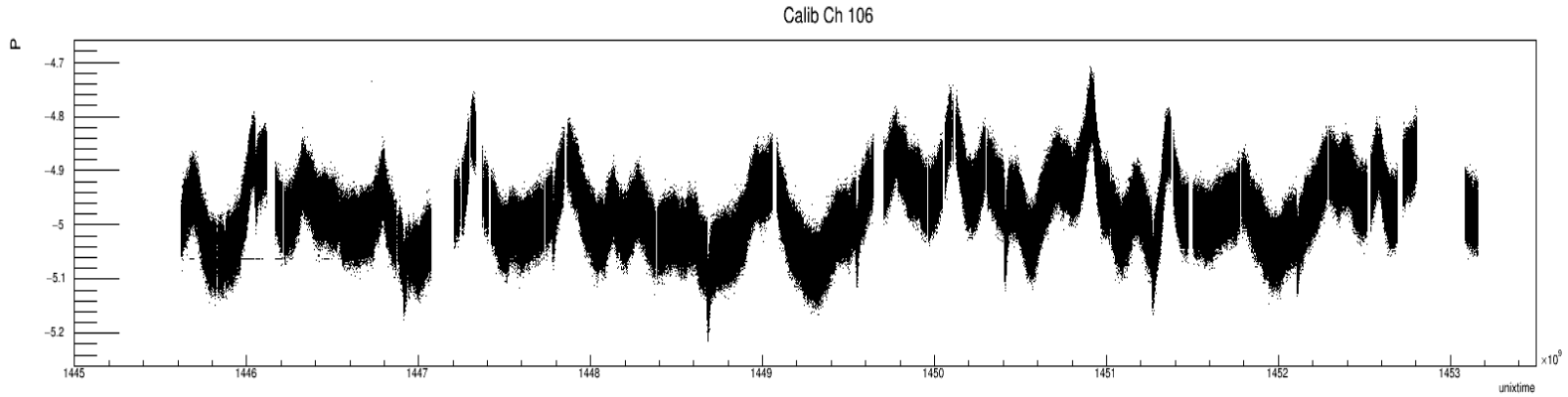


BackUps

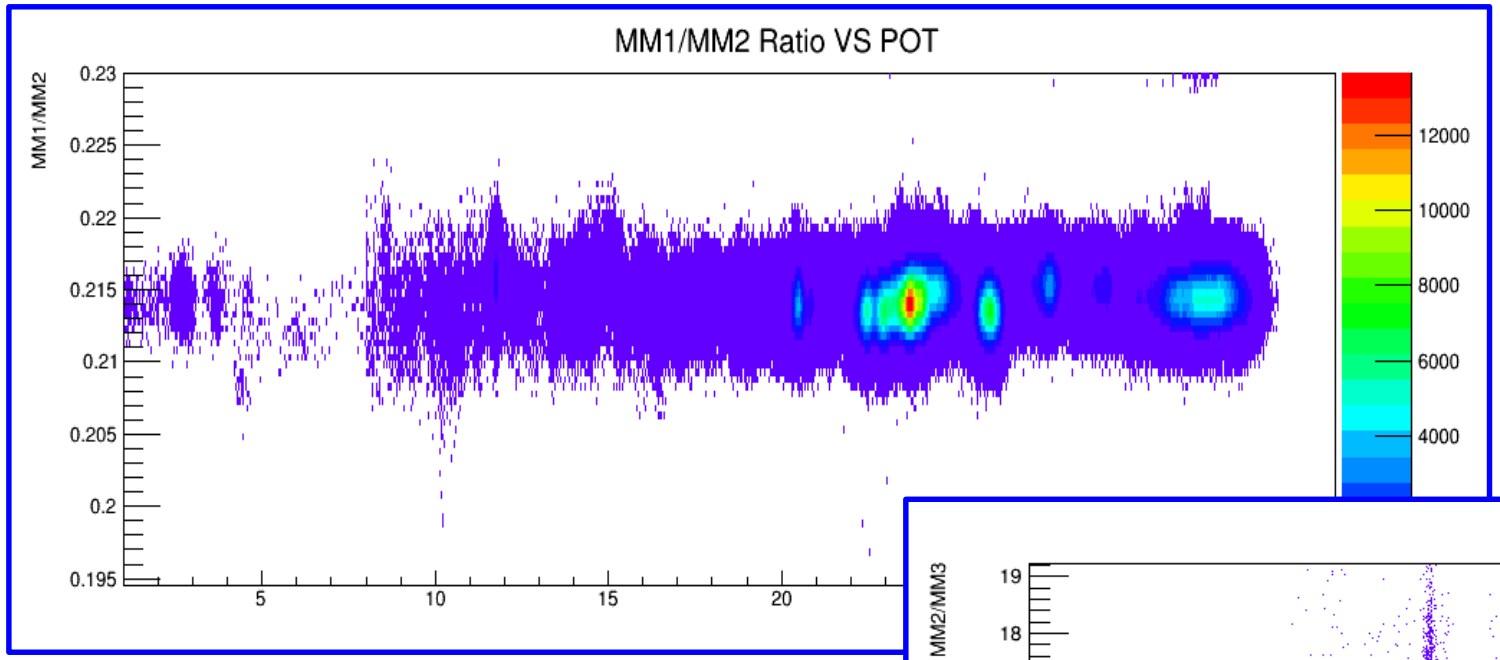
Calibration Chambers Run2

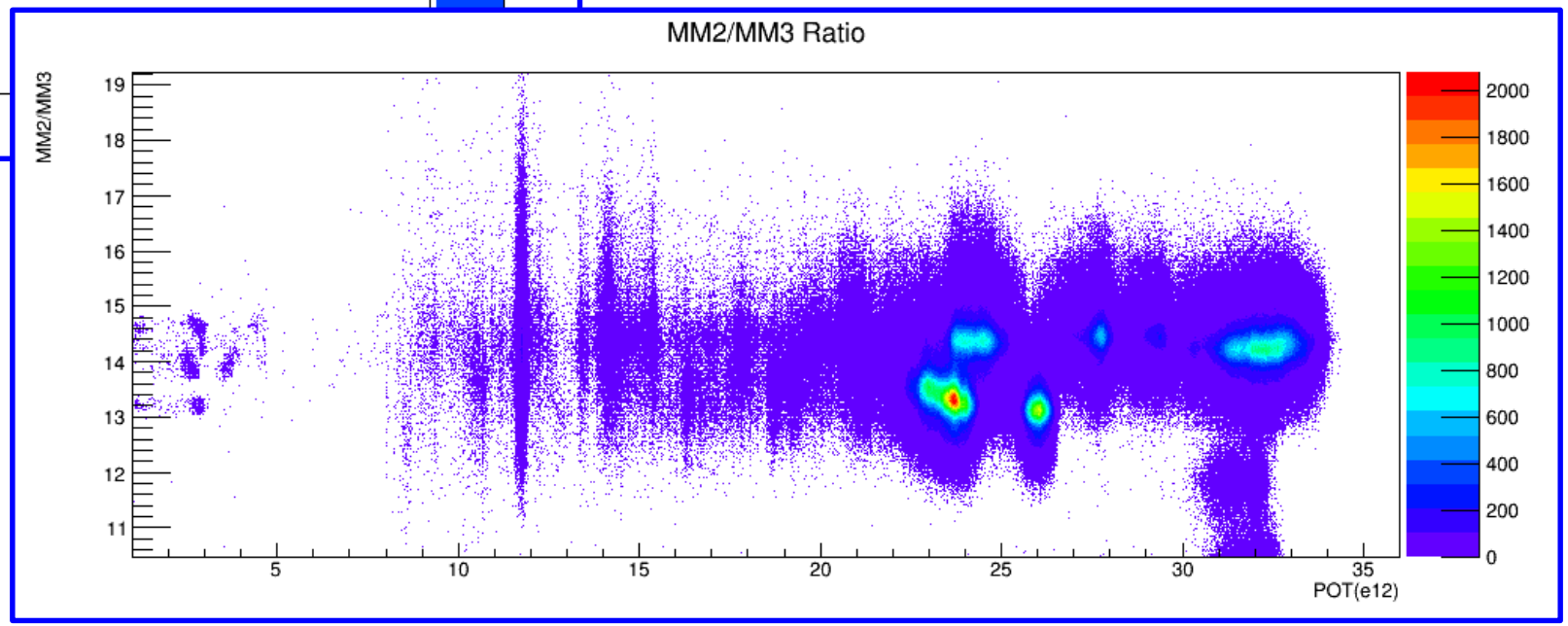






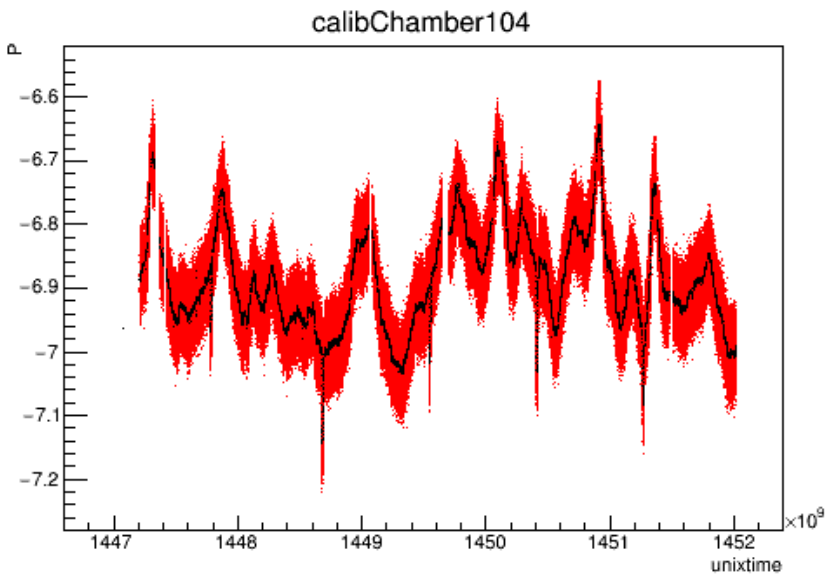
Ratios VS POT

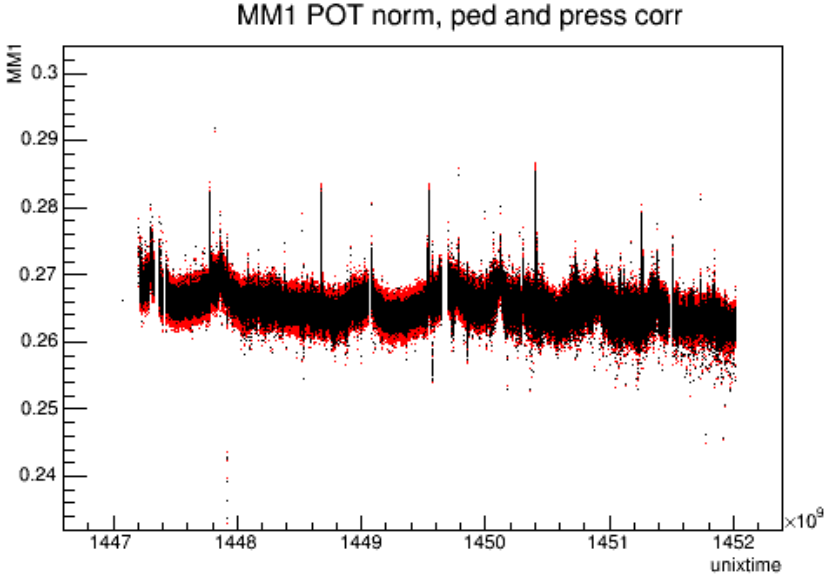


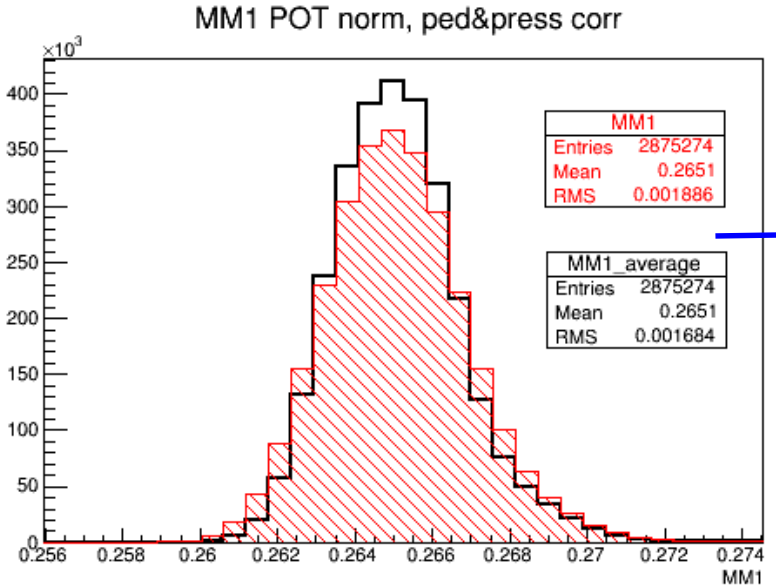


Calib Chambers Correction

If we average the Calib Chambers over 5 minutes



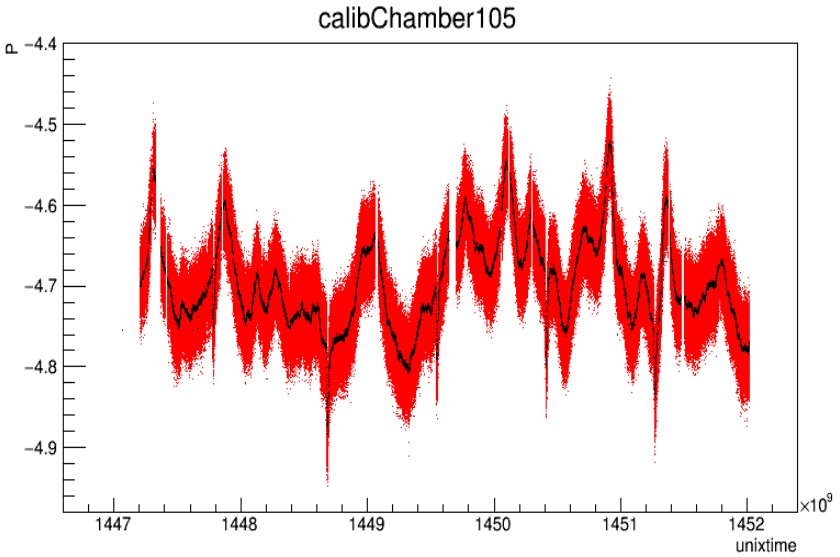


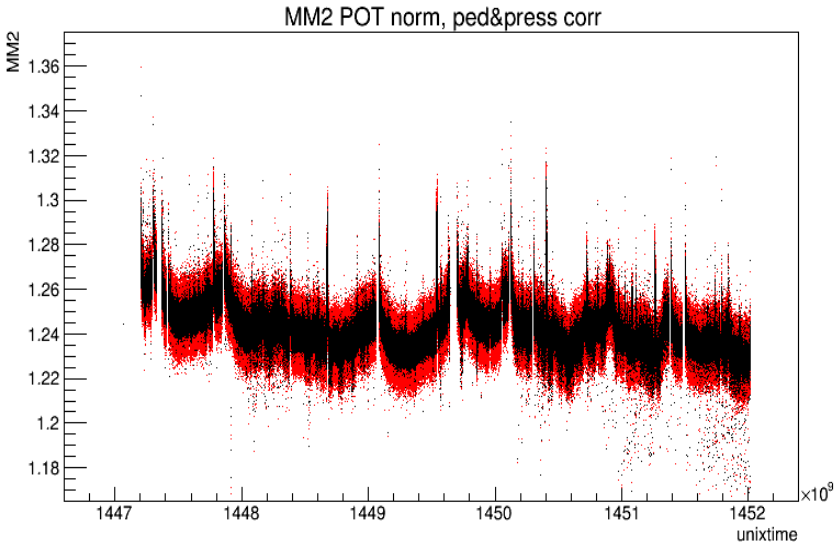


10% difference

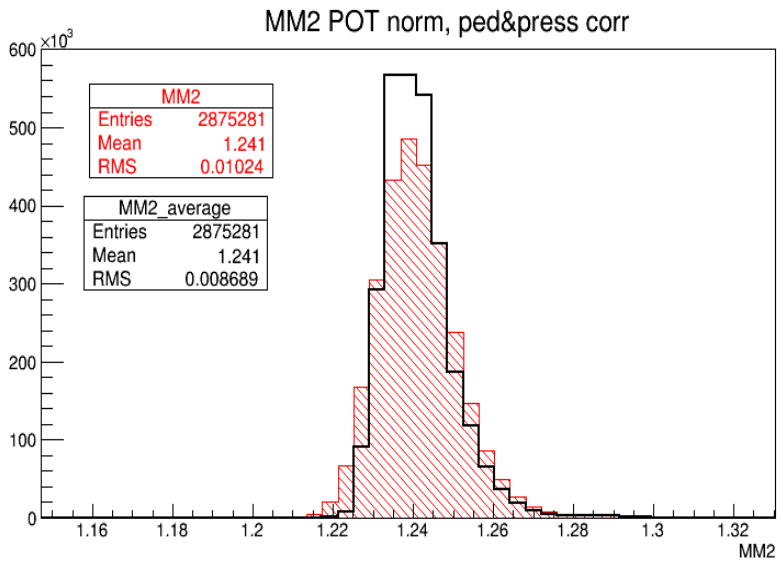
Calib Chambers Correction

If we average the Calib Chambers over 5 minutes

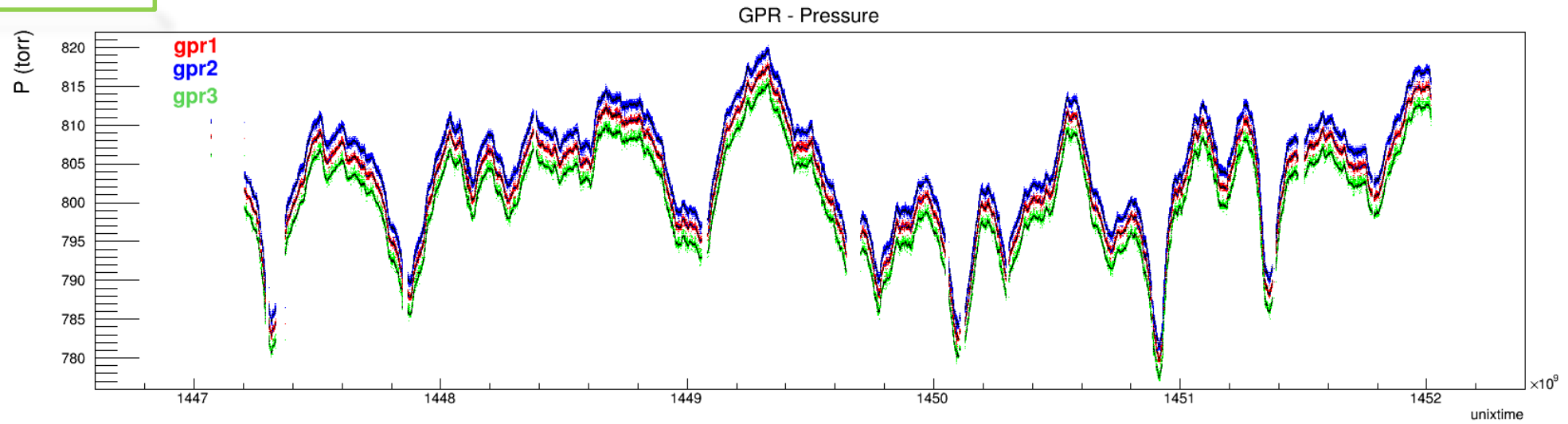




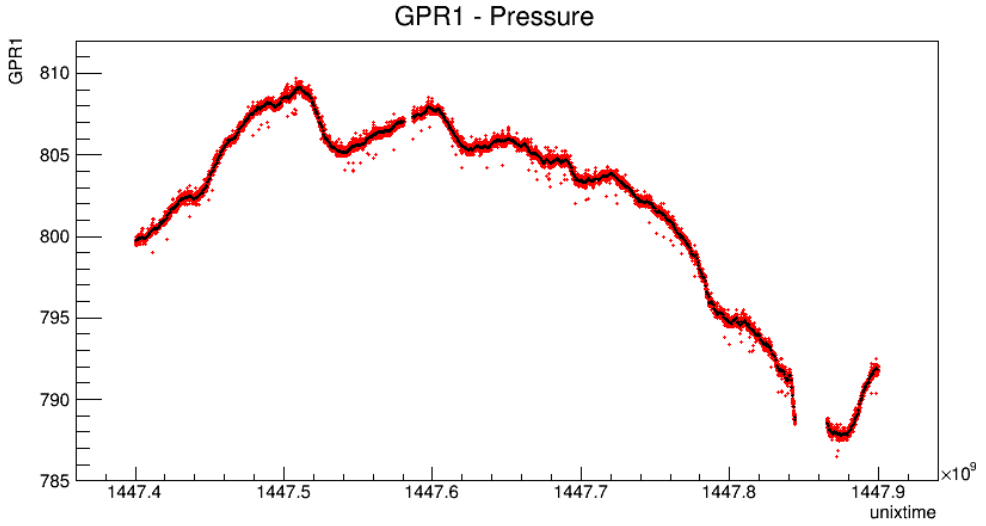
20% difference

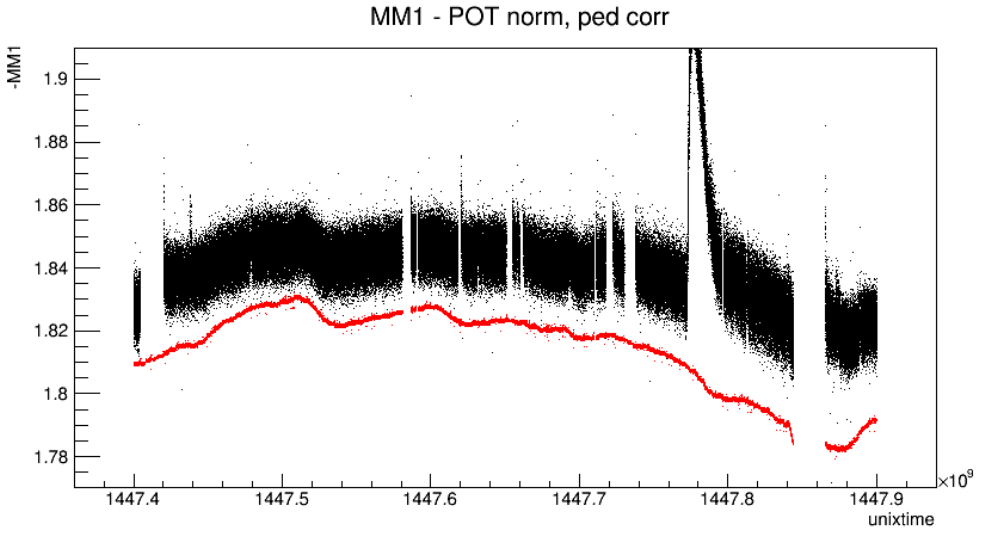


GPR Correction

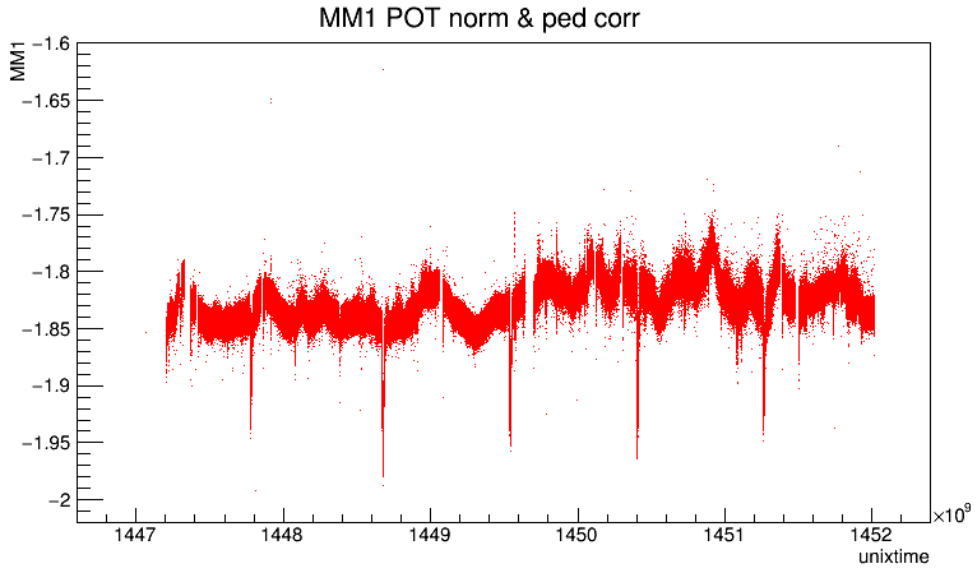


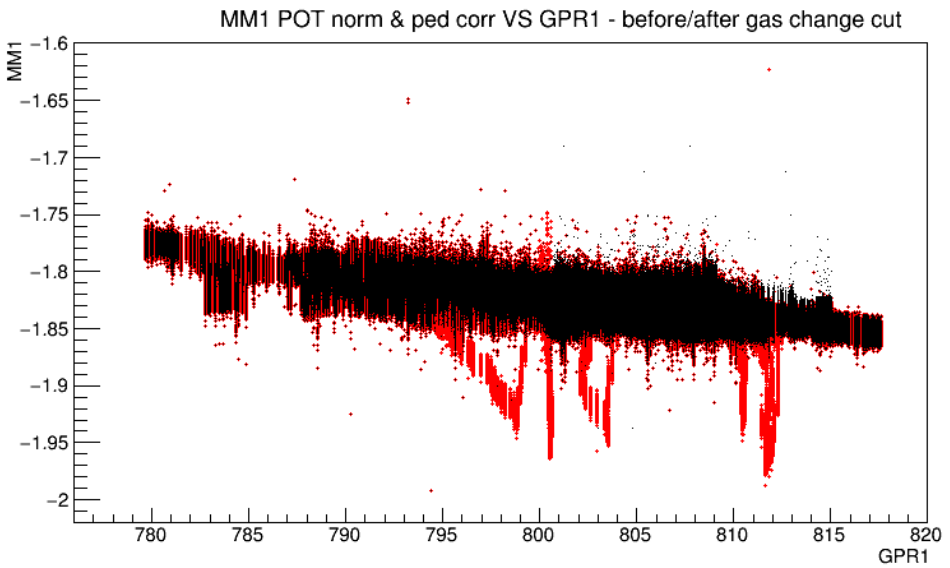
Filtering over 10 mins

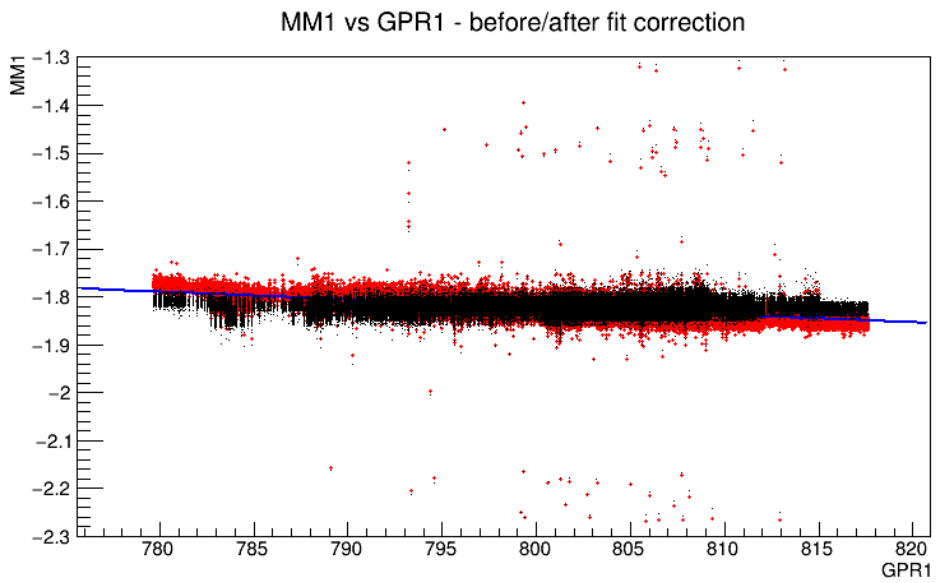


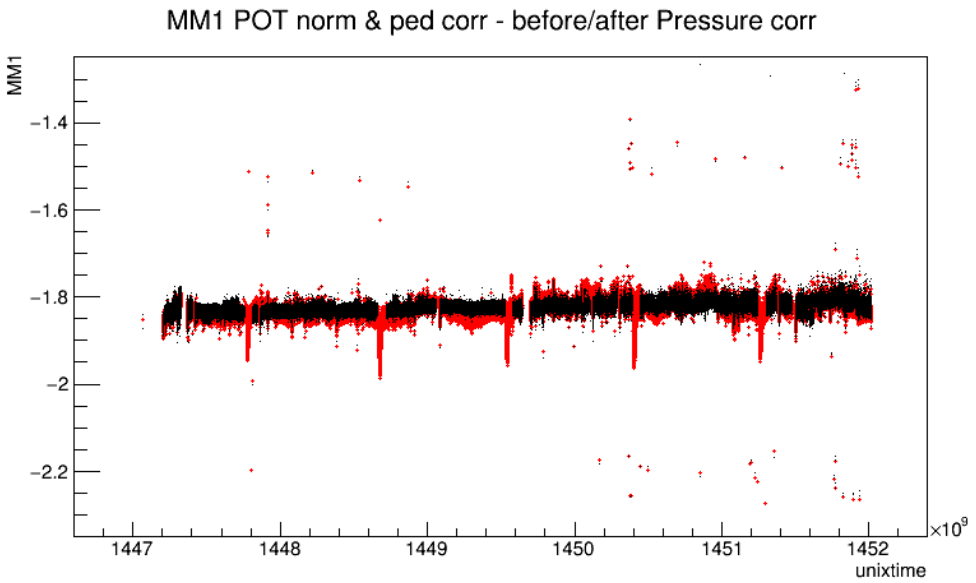


GPR Correction









GPR Correction

5% improved w.r.t. calib chambers