BCM Performance Study and Calibrations for F2/EMC Spring 2018 Experiment

F2-EMC Collaboration

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Hall C Collaboration Meeting

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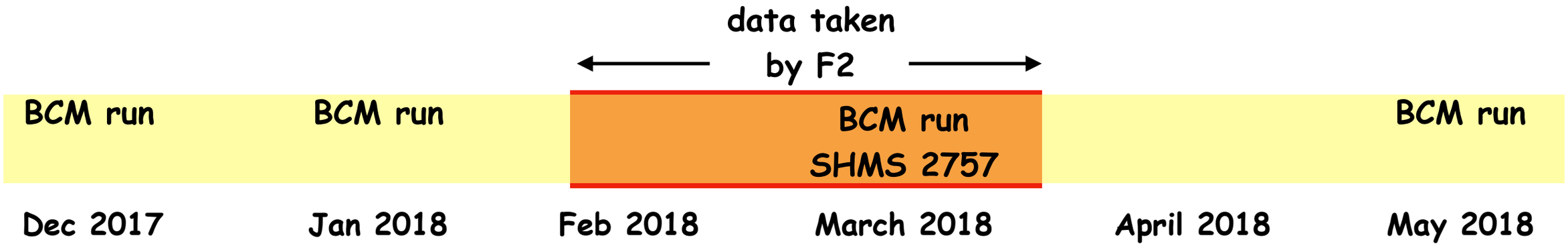
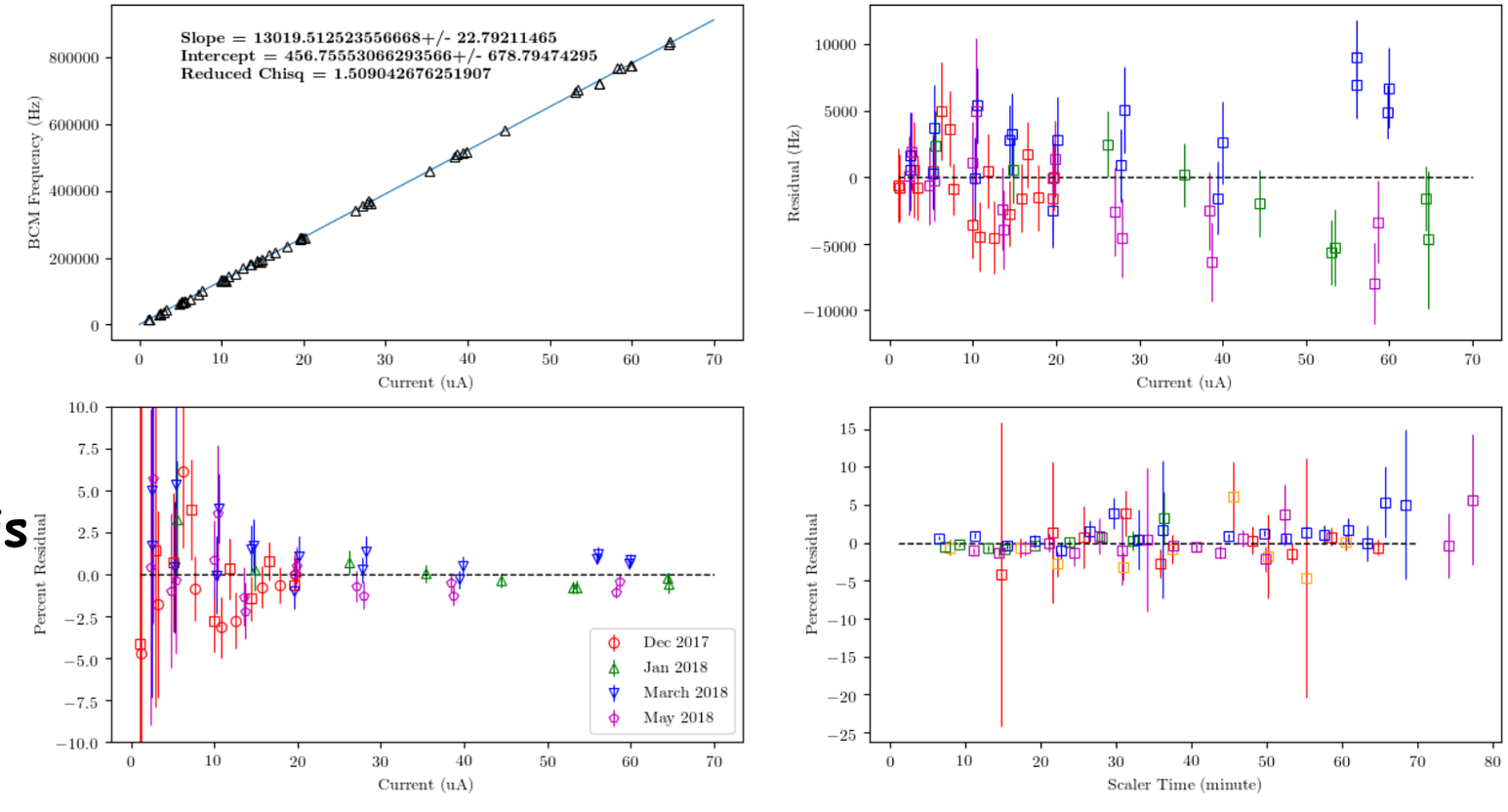


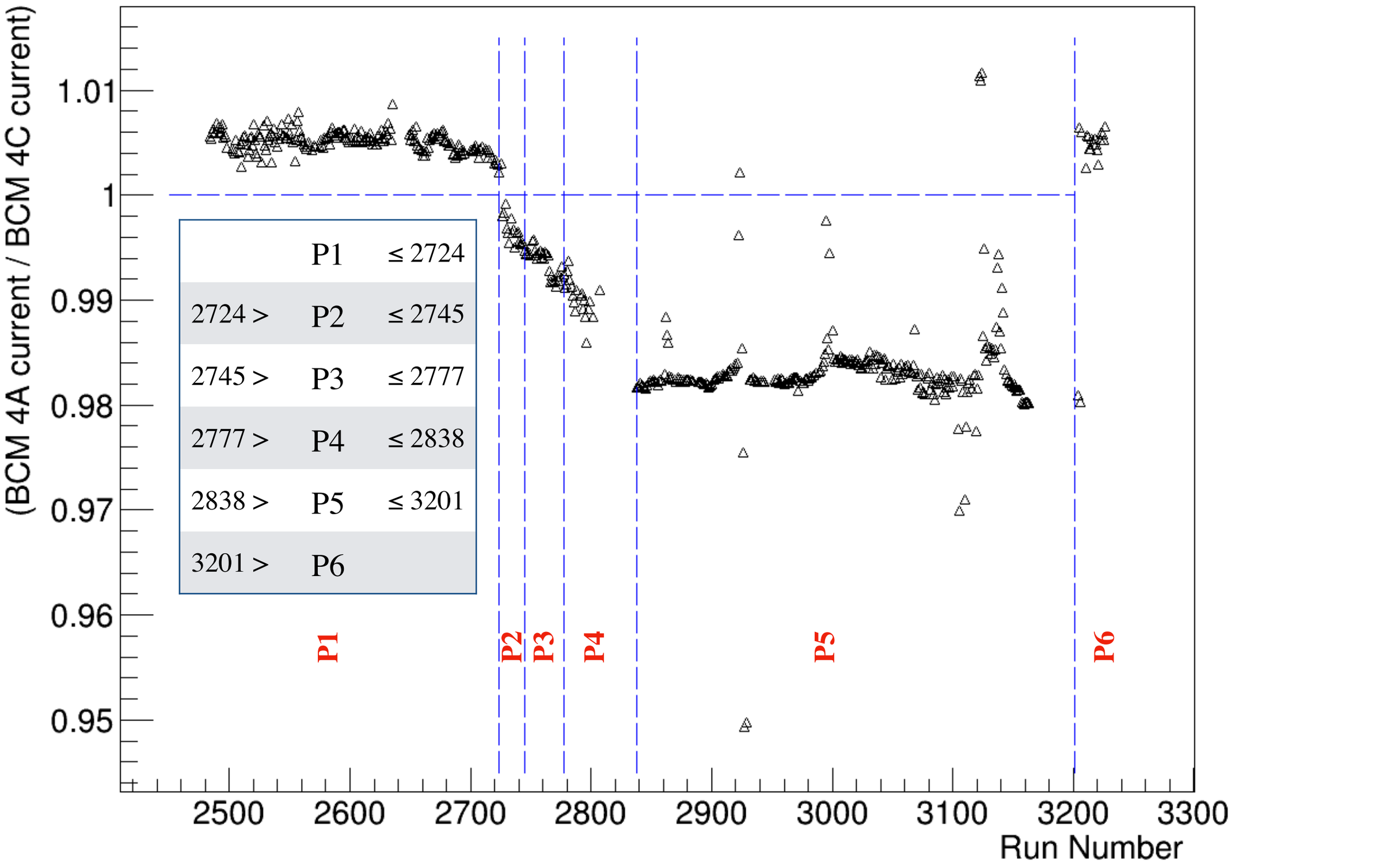
- first each BCM calibration runs was analyzed separately for all the BCMs
- the gain (and offset) was varying from one calibration run to another

- then combining all the runs together a global calibration was performed

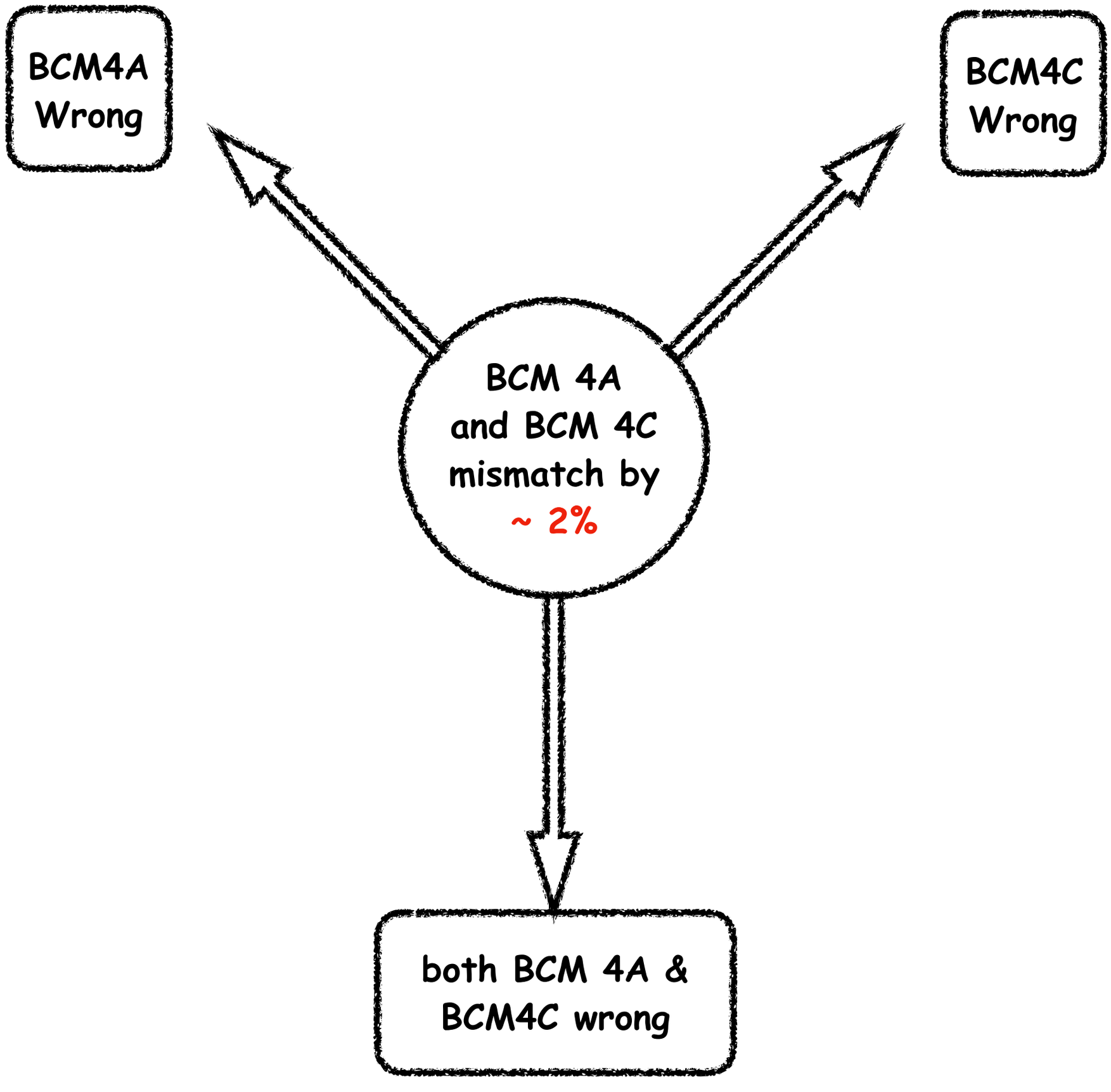
- based on the tension between different data sets it was decided that BCM4A (or BCM4C) current will be used for the analysis



BCM4A/BCM4C Current vs Run Number Using the Global Fit Params (gain and offset)



- Total Run region were divided into 6 periods depending on this plot


BCM4A
Wrong
BCM4C
Wrong
BCM 4A
and BCM 4C
mismatch by
~ 2%
both BCM 4A &
BCM4C wrong

BCM4A Wrong

BCM4C Wrong

to know which one is correct :
need a third current monitor to compare with

with BCM 1 or BCM 2 not working properly ,
Unser were used as the third current monitor

both BCM 4A &
BCM4C wrong

UNSER :
third current monitor

- to determine which of BCM 4A and BCM 4C is correct , it was needed to compare with a third current monitor

- unfortunately we didn't have BCM 1 or BCM 2 working well , so we wanted to use Unser as the third current monitor

- for that Unser needed to be calibrated

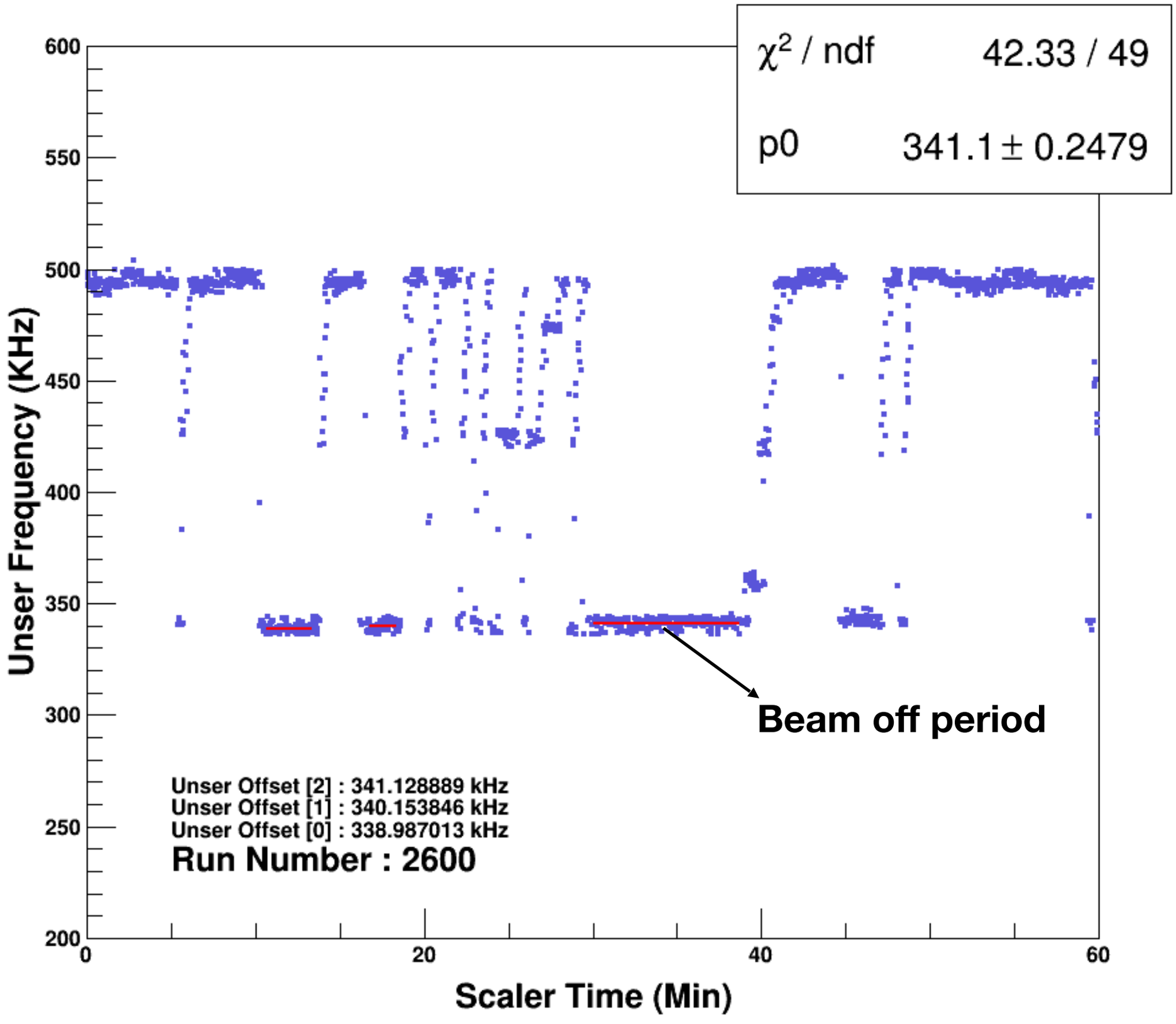
- BUT not enough calibration runs were there during the run period

- several production runs were selected from whole run period, which could be used as the calibration runs (e.g. Run 2518)

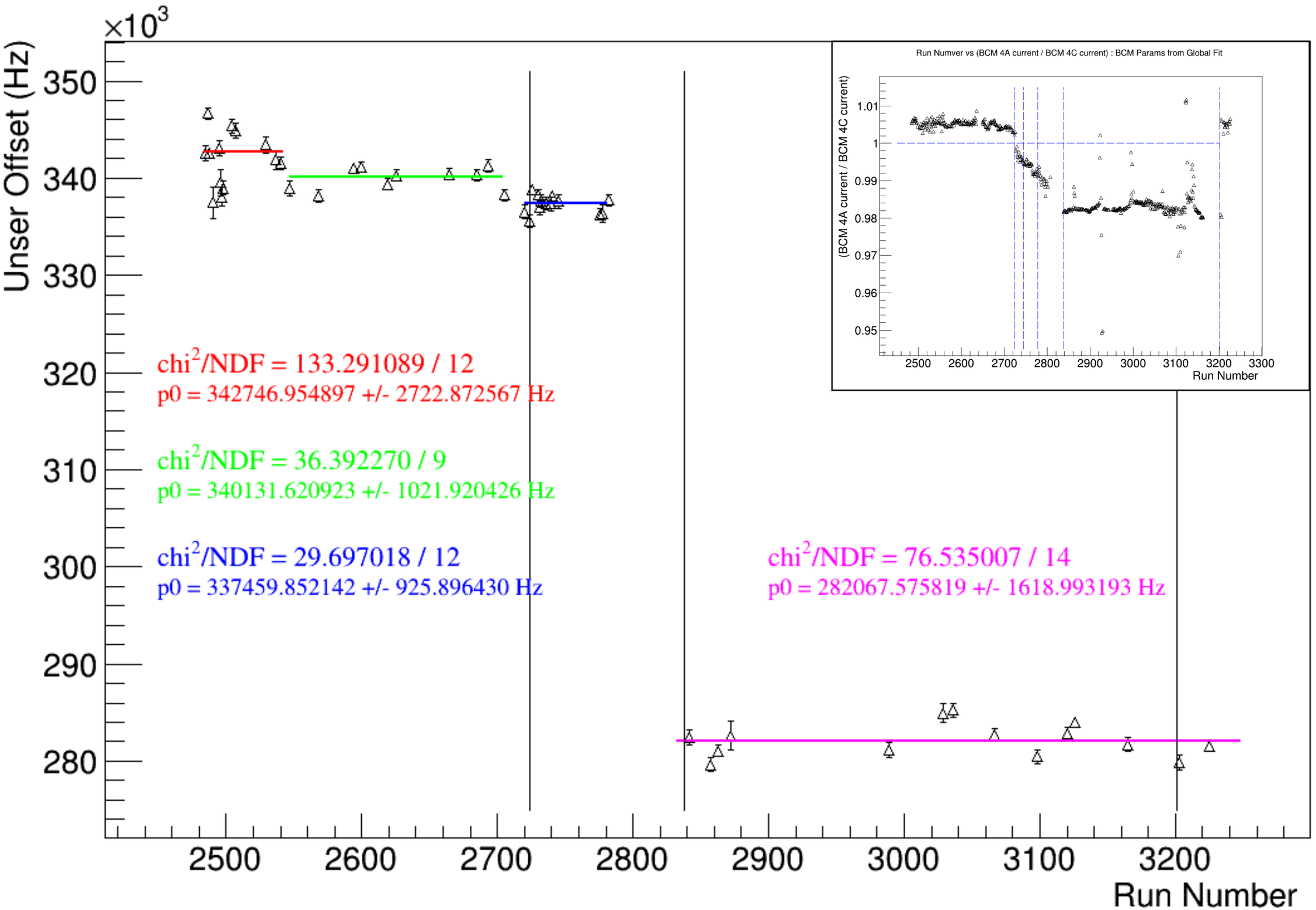
- for each of those runs Unser offset were calculated

Unser offset per run

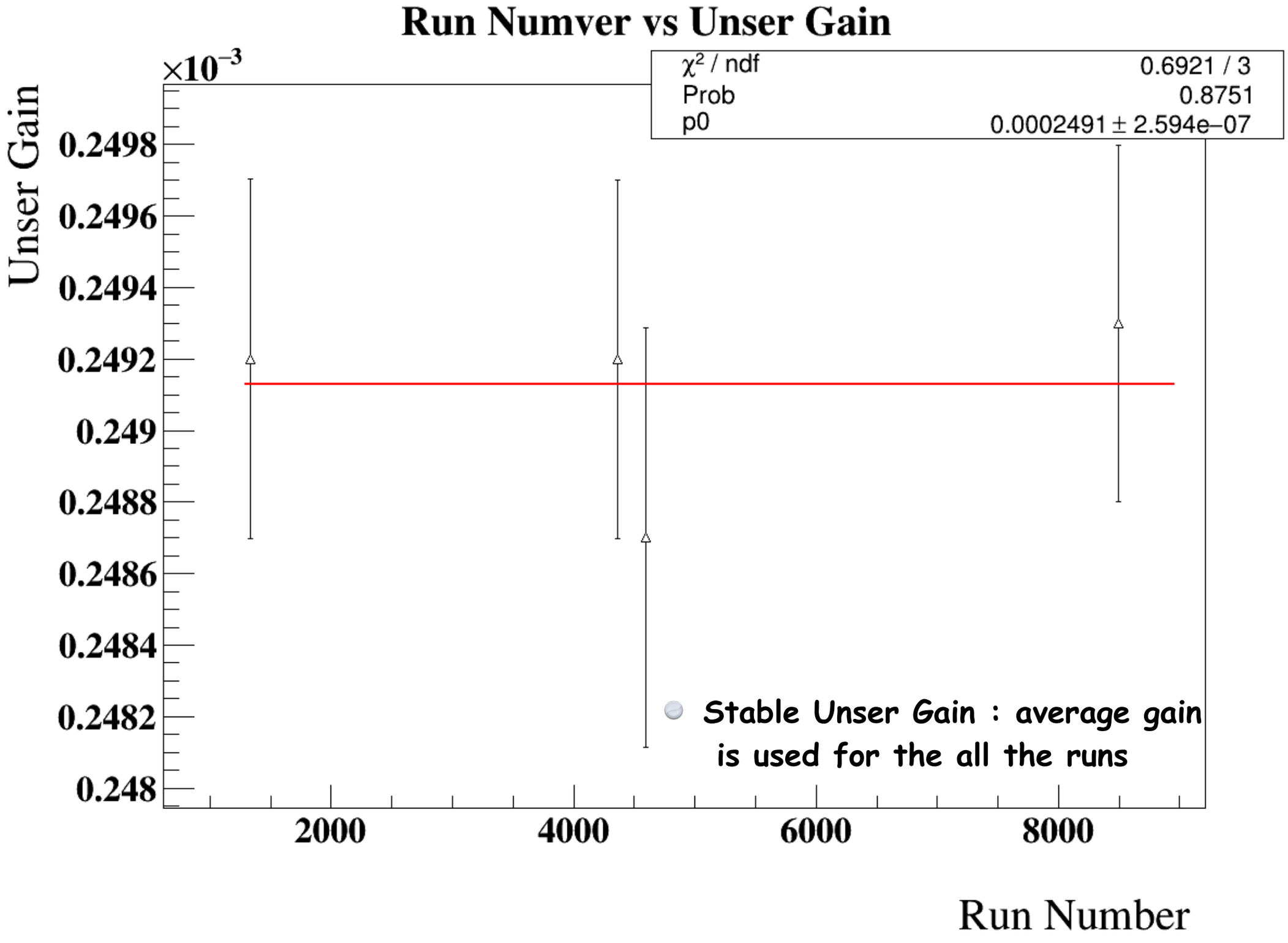
- We know that the Unser offset drifts over time
- As we do not have enough Unser Calibration runs over the whole run period, I found production runs which can be used to get the Unser offset over time
- Fit offset for each current off period within a run
- The Unser offset does not vary much within a run
- Will take an average of Unser offsets within a run
- I did this for several runs through our experiment



Unser : 4 offset values were determined for 4 different run periods

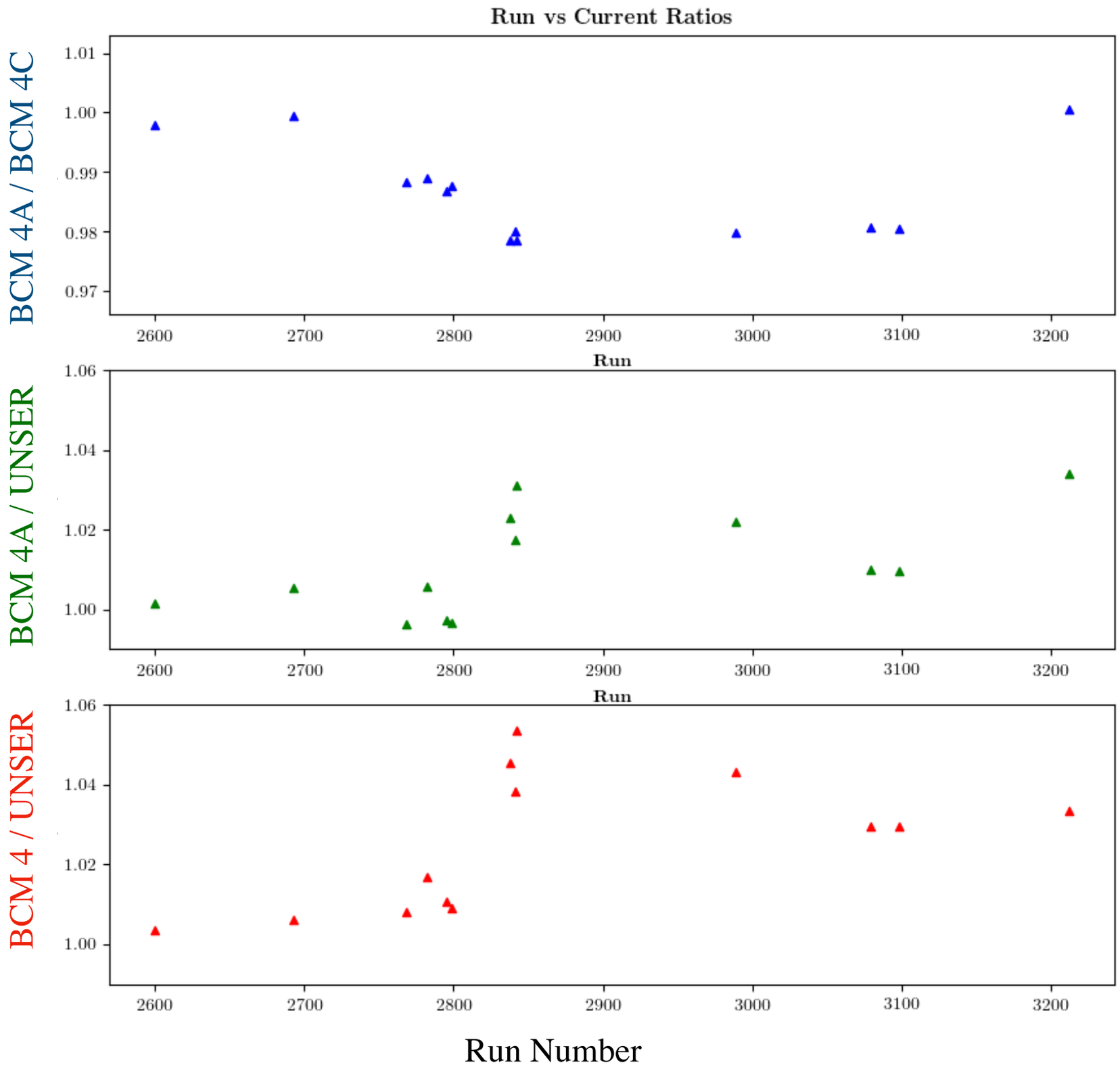


Unser : gain was pretty stable over the whole run period



BCM / Unser current ratio vs Run No

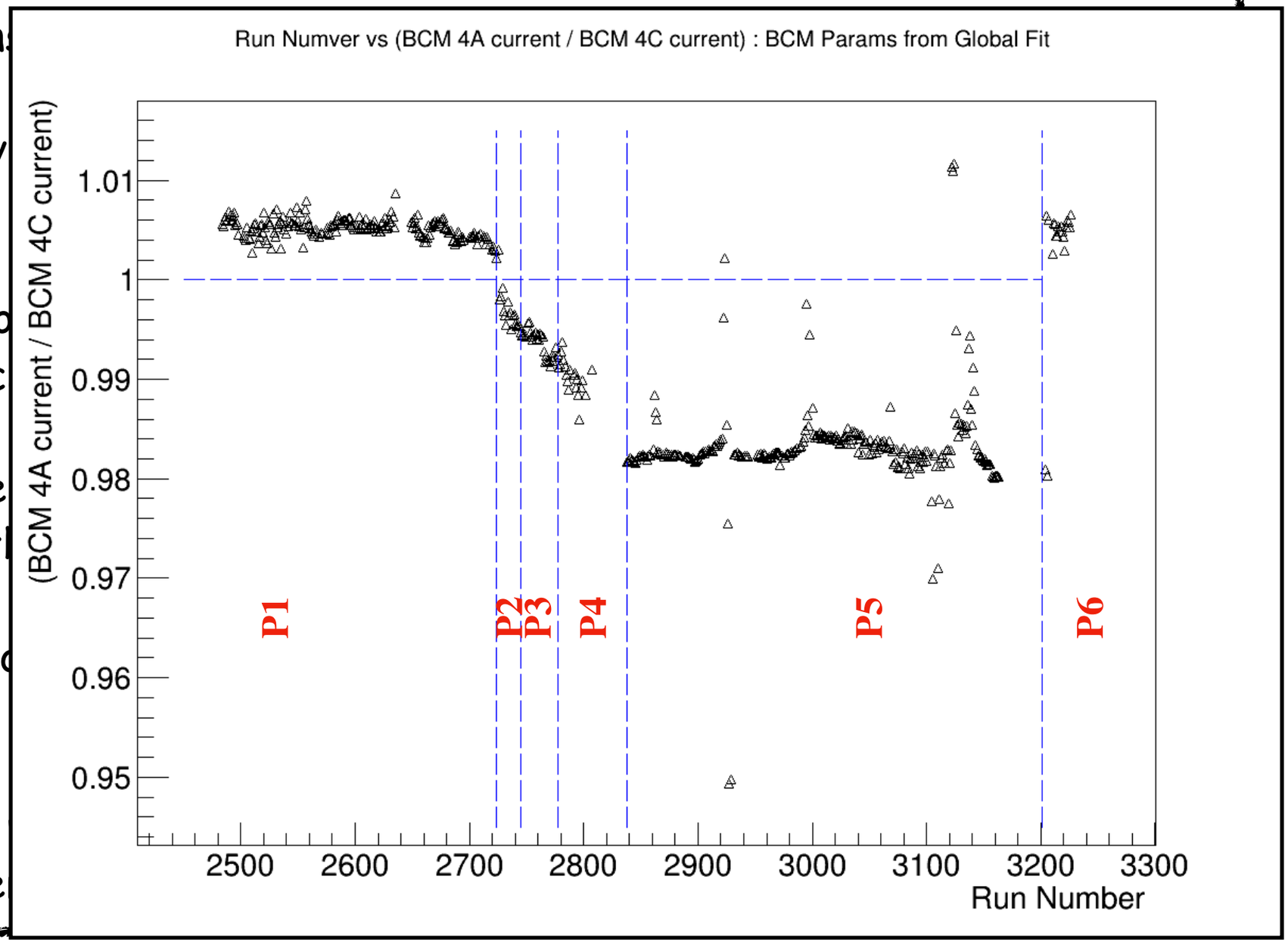
- replayed several runs covering the whole run period
- for Unser : offsets per run are used and gain was the average gain
- for BCMs : offset and gain are used from the global fits
- **shows that both the BCM4A and BCM4C have problems !!!**



Local Calibration using production runs

- for each of the 6 periods, several production runs with more than one off periods were chosen for the local calibration

- Choosing these runs
  - where mcc prov needed
  - also beam canno currents for bc
    - Its is very ofte single run and t
- For Unser off perio (fluctuation)
- Unser frequencies extra systematic e



Local Calibration using production runs

- for each of the 6 periods, several production runs each with more than one beam off periods were chosen for the local calibration

- choosing these runs was **not an easy task** , had to go through all the production runs and were looking for the runs -

  - where mcc provided beam with several down time as **beam-off periods** were needed

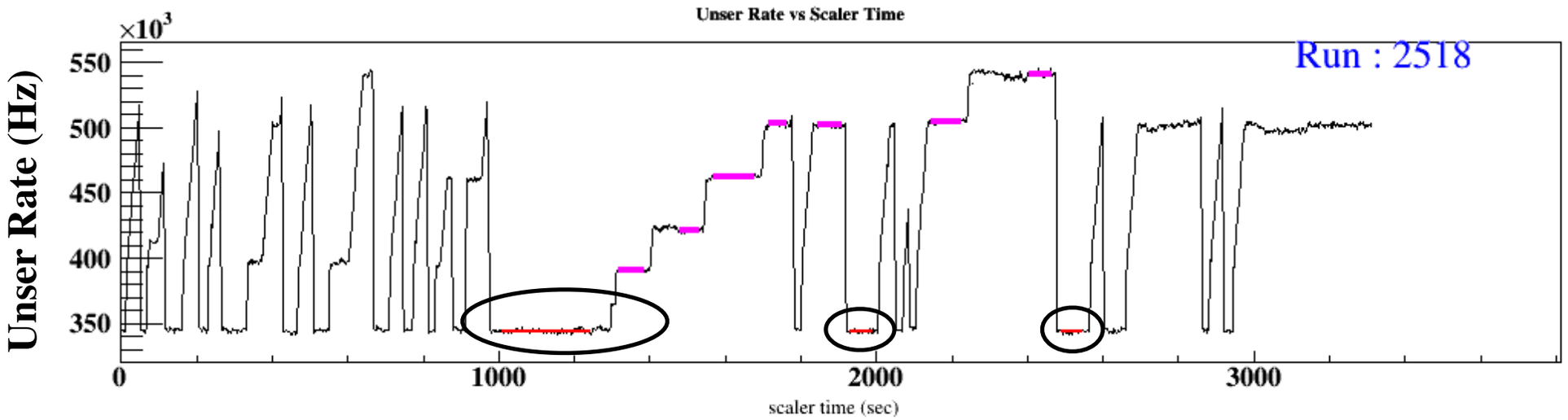
  - also beam cannot be very steady during the run as we wanted **different currents** for BCM calibration

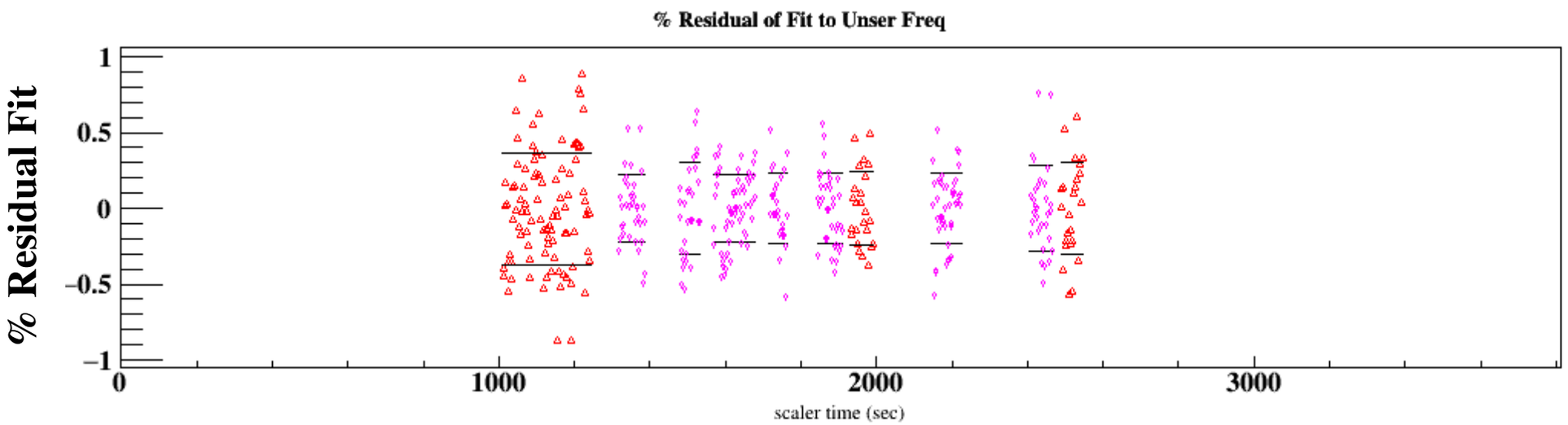
    - Its is very often possible that we can't find different current values for a single run and then several runs needed to be combined together

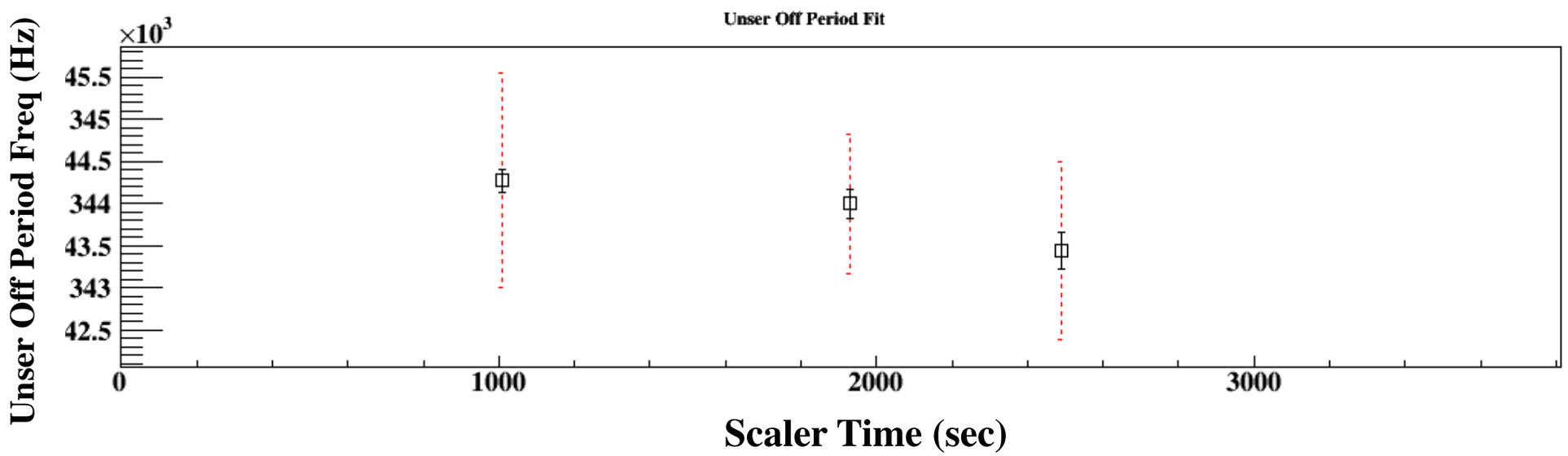
- for Unser beam off periods and BCM beam on periods extra systematic errors were added due to the noise (fluctuation)

- for the systematic error - frequencies were histogramed and standard deviation were used as an extra error

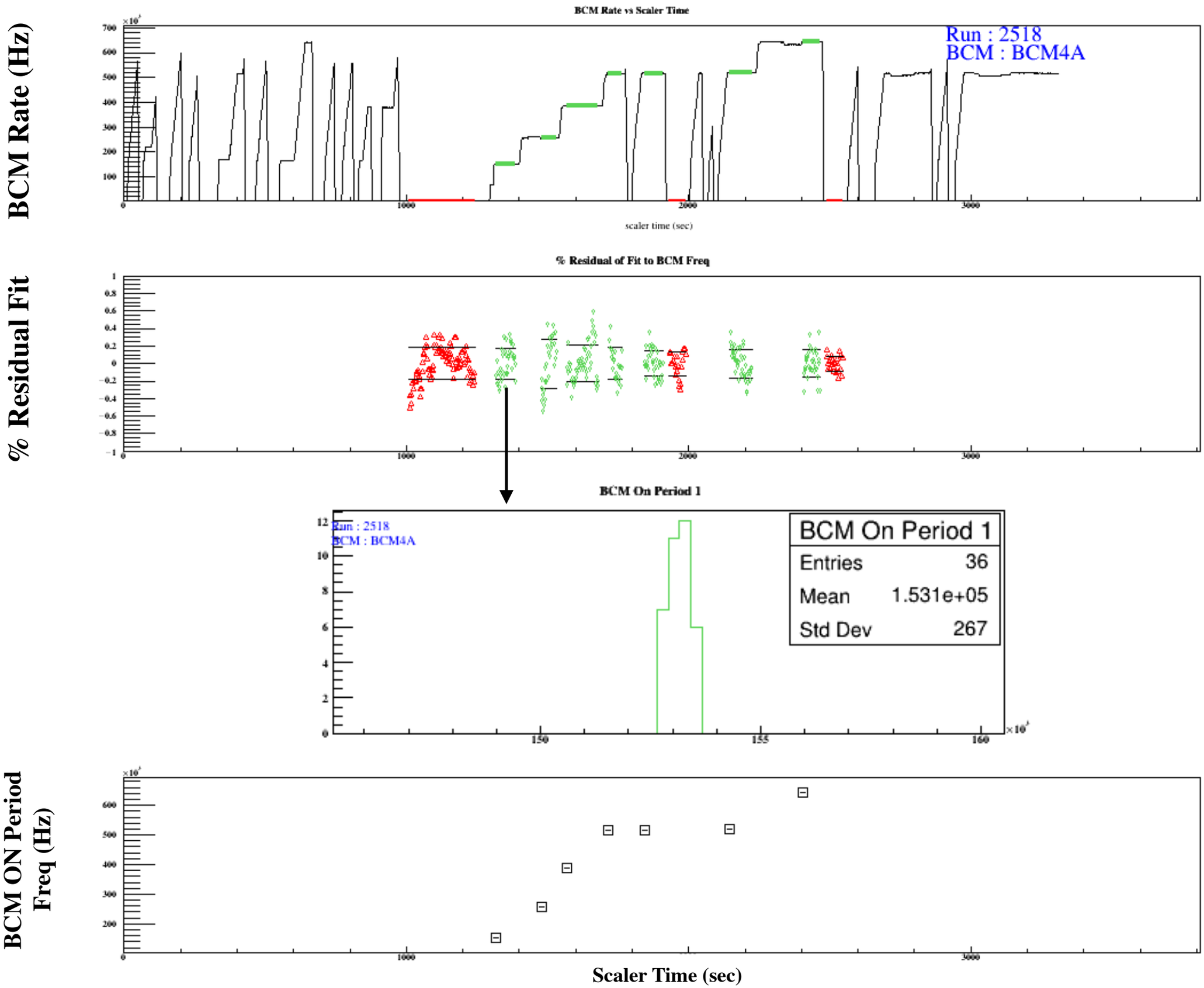
Run 2518 (production run) used as one of the calibration runs

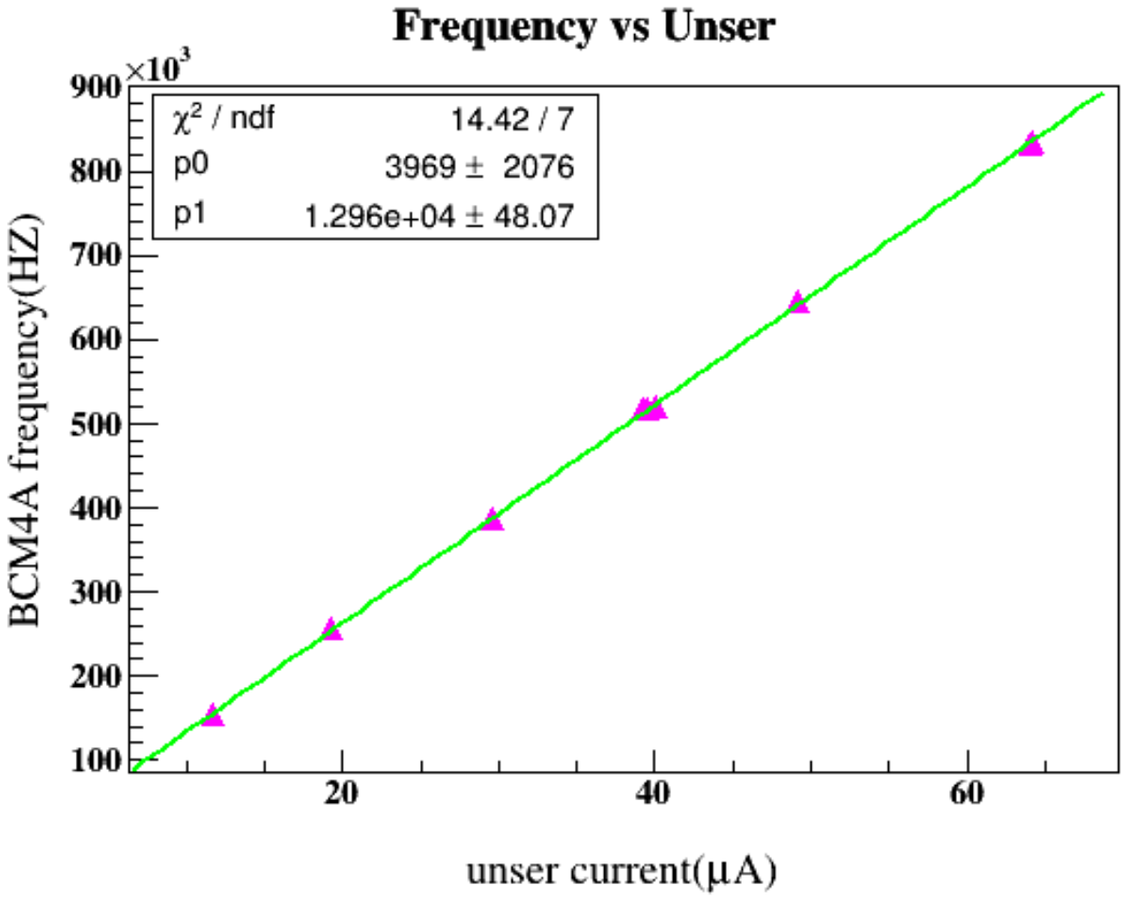


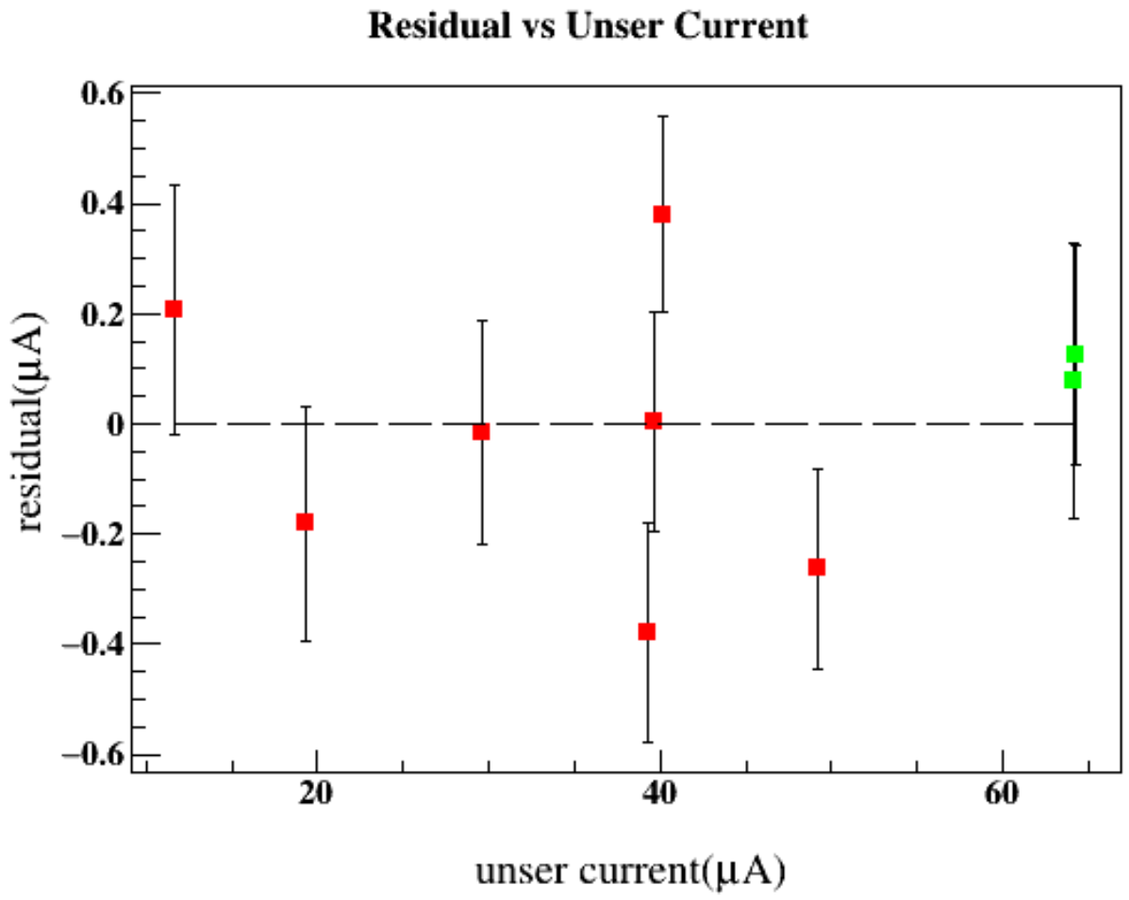


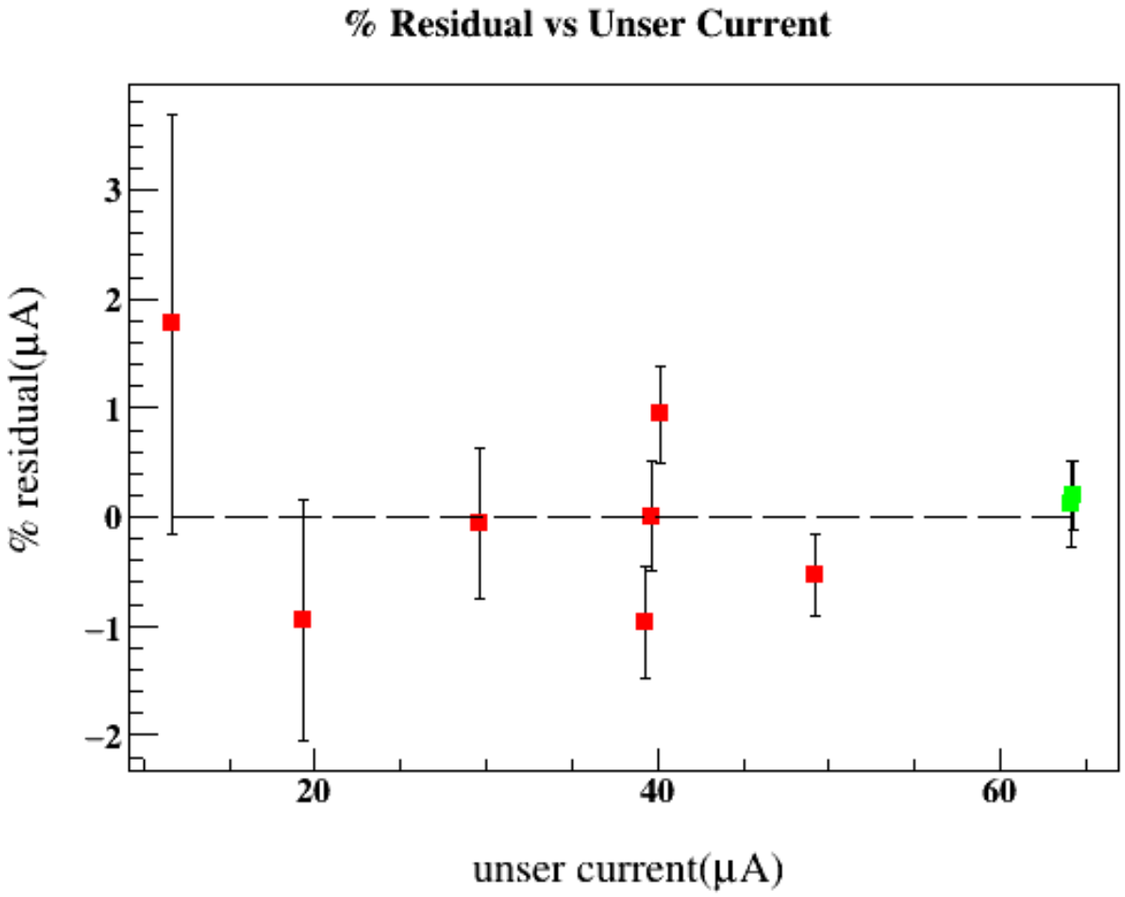


Run 2518 (production run) used as one of the calibration runs to calibrate BCM









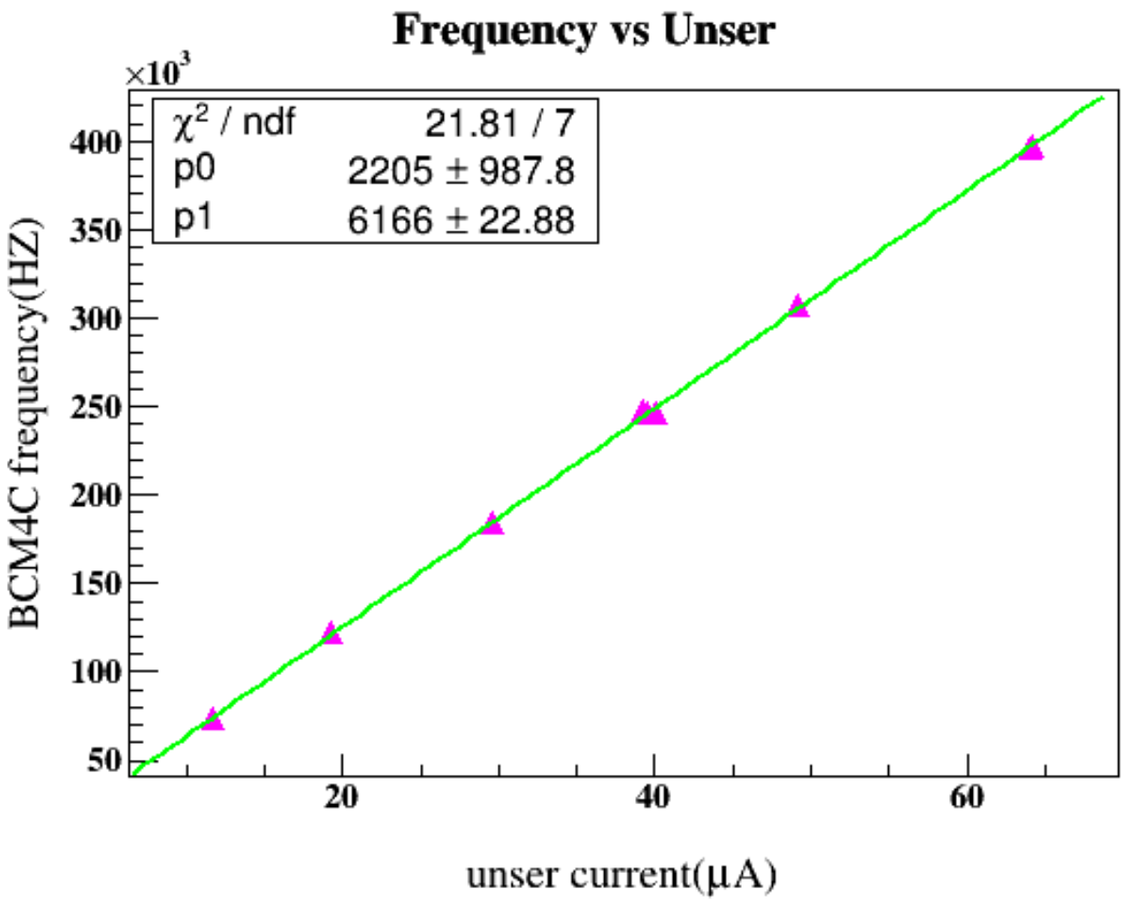
PERIOD : P1

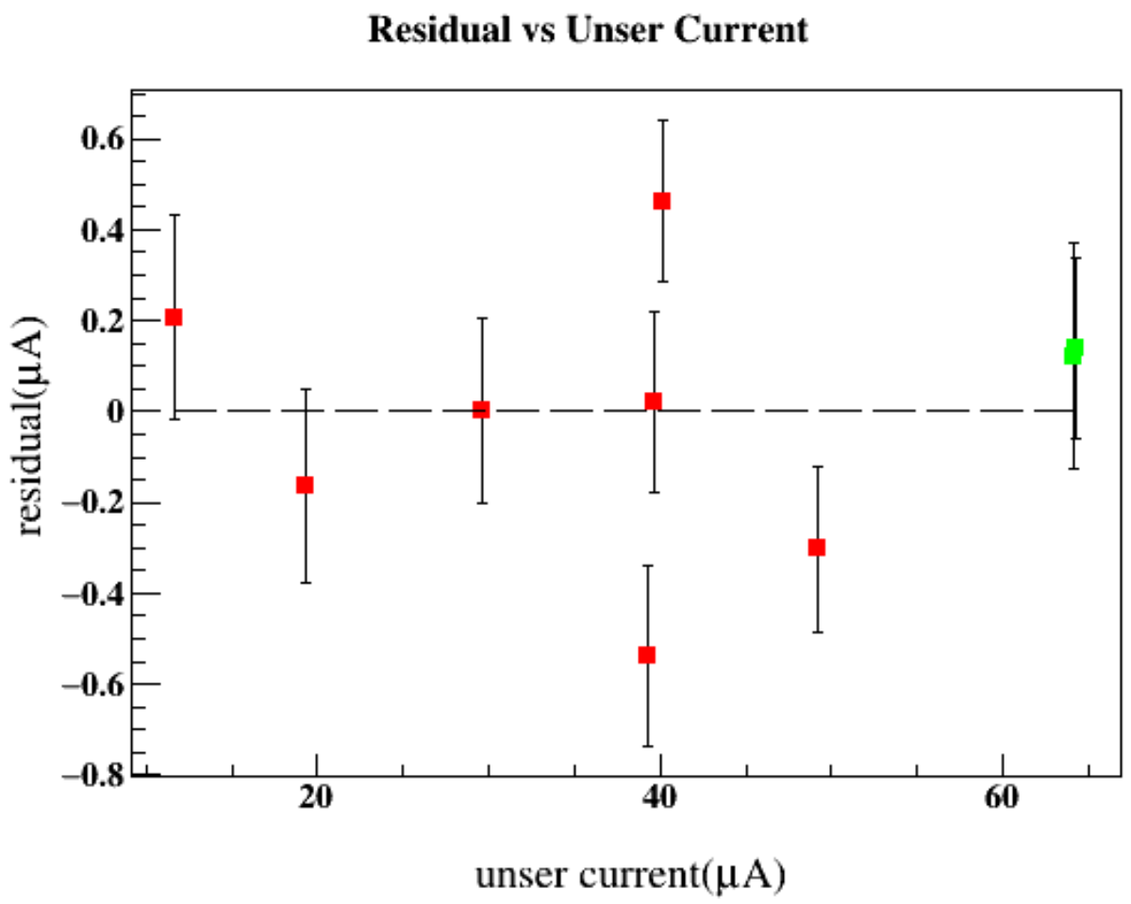
Run : 2518

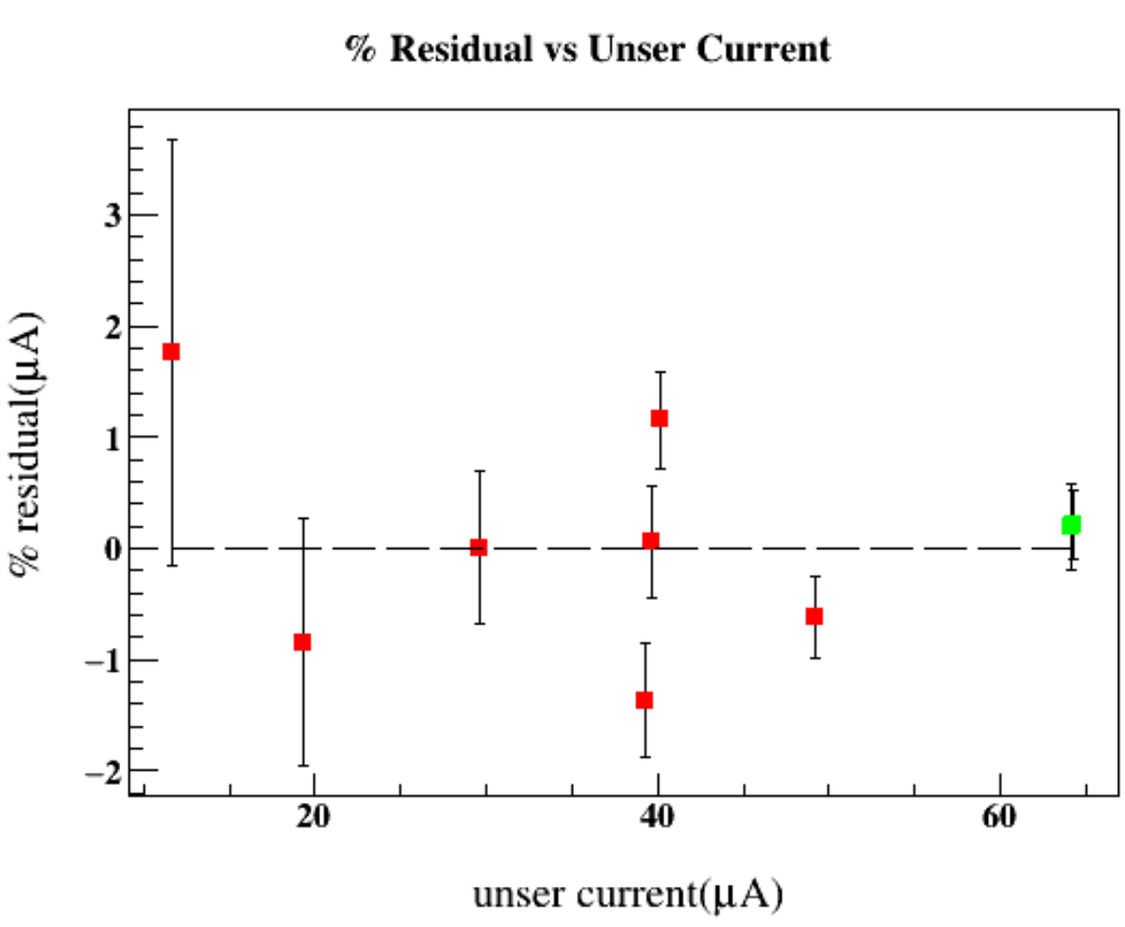
Run : 2675

BCM 4A : Period 1

$I_{unser} = (\nu_{on} - \nu_{off}) / gain_{unser}$







PERIOD : P1

Run : 2518

Run : 2675

BCM 4C : Period 1

List of Gains and Offsets along with corresponding errors for all periods

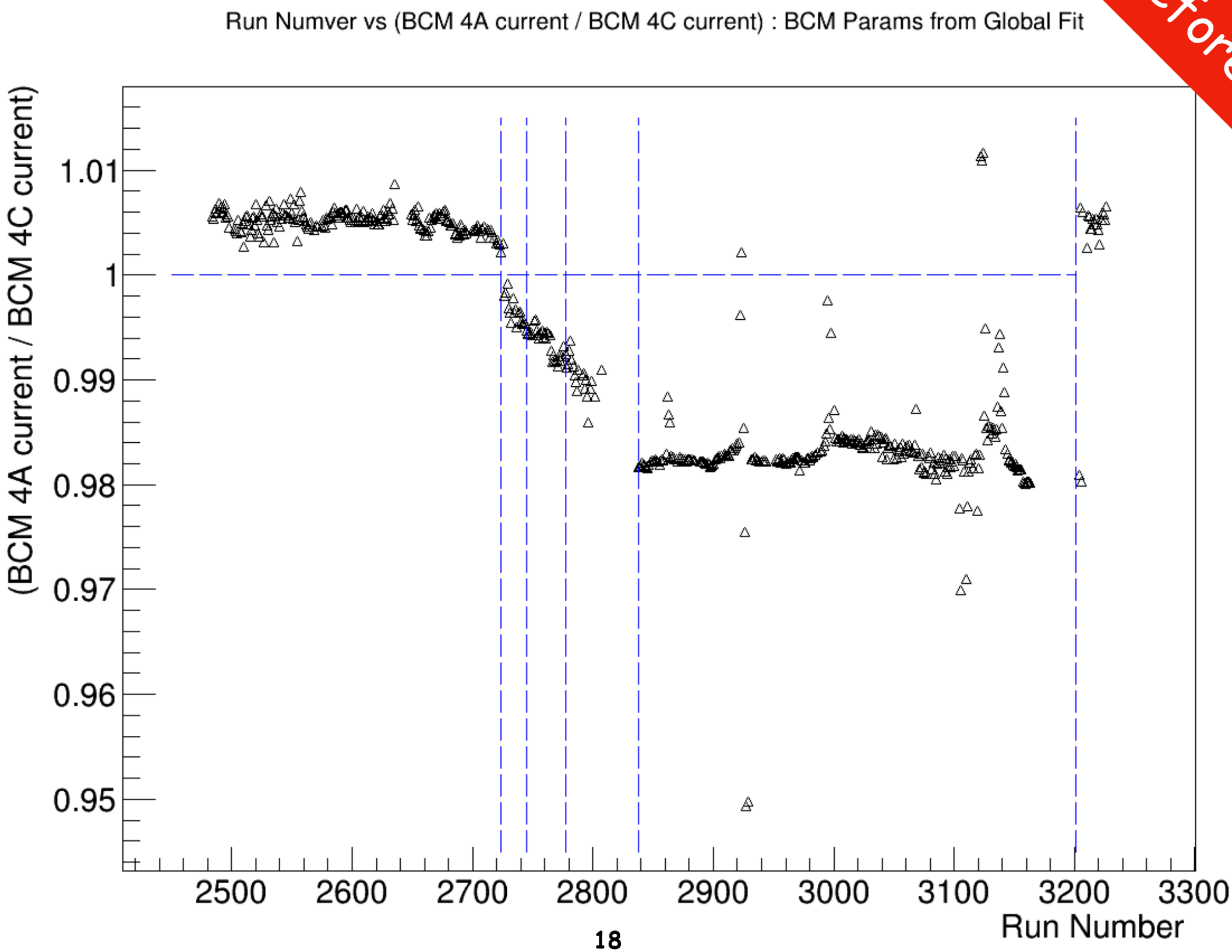
(Considering the fluctuation around mean as error for the BCM on periods)

BCM4A	gain	Δgain	offset	Δoffset
P1	13000.0	111.1	2528	4025
P2	13370.0	310.5	-20940	16290
P3	12930.0	125.1	-48.96	5424
P4	12770	189.8	10210	10120
P5	13210	277	-2481	13070
P6	13150	262.2	-2974	13810

BCM4C	gain	Δgain	offset	Δoffset
P1	6182	54.58	1504	1941
P2	6388	153.1	-8236	8047
P3	6222	62.52	499.8	2696
P4	6145	95.02	7451	5054
P5	6435	134.9	-1078	6364
P6	6248	124.5	-765.7	6540

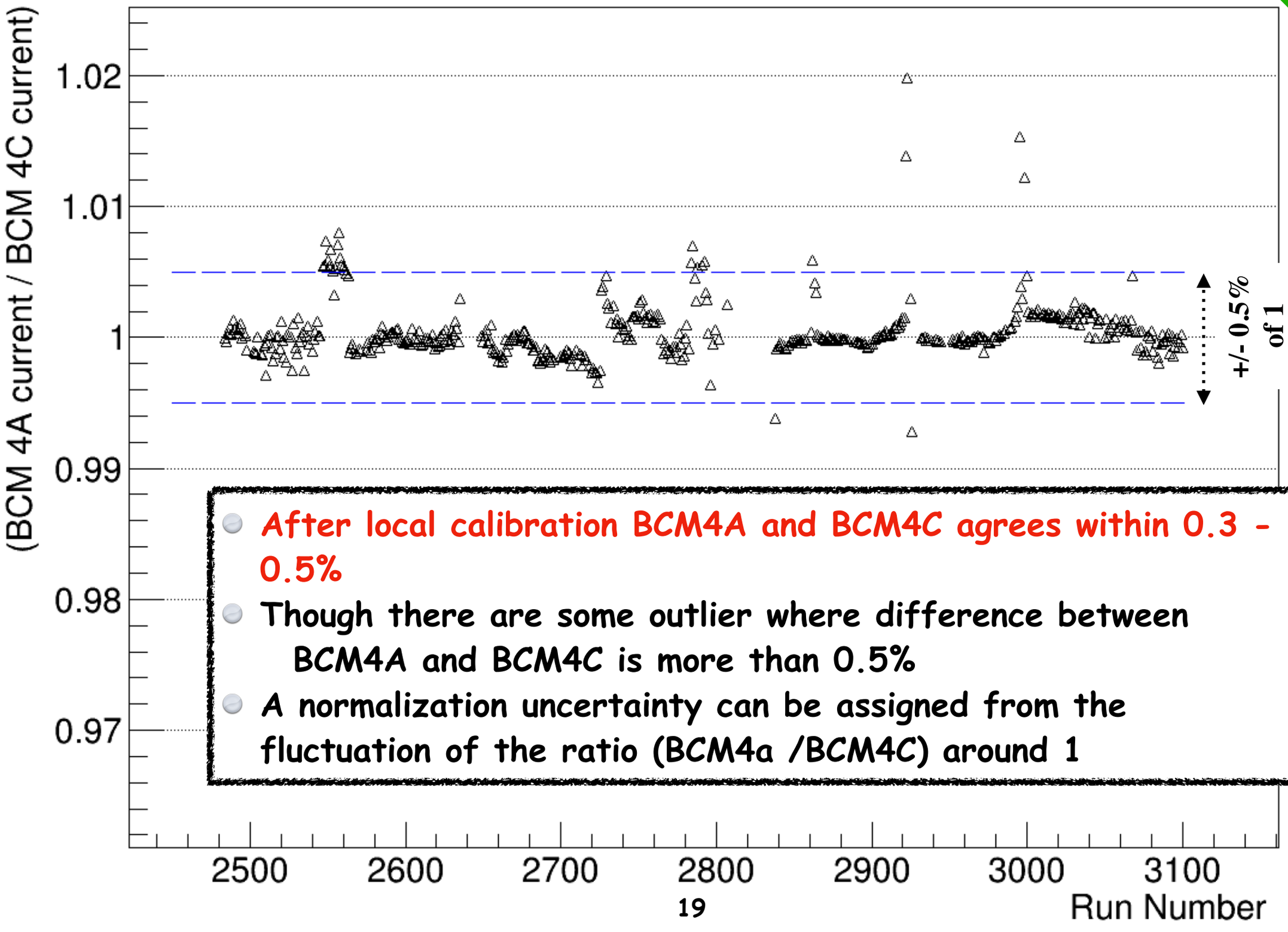
Parameters used from BCM global Fit

before



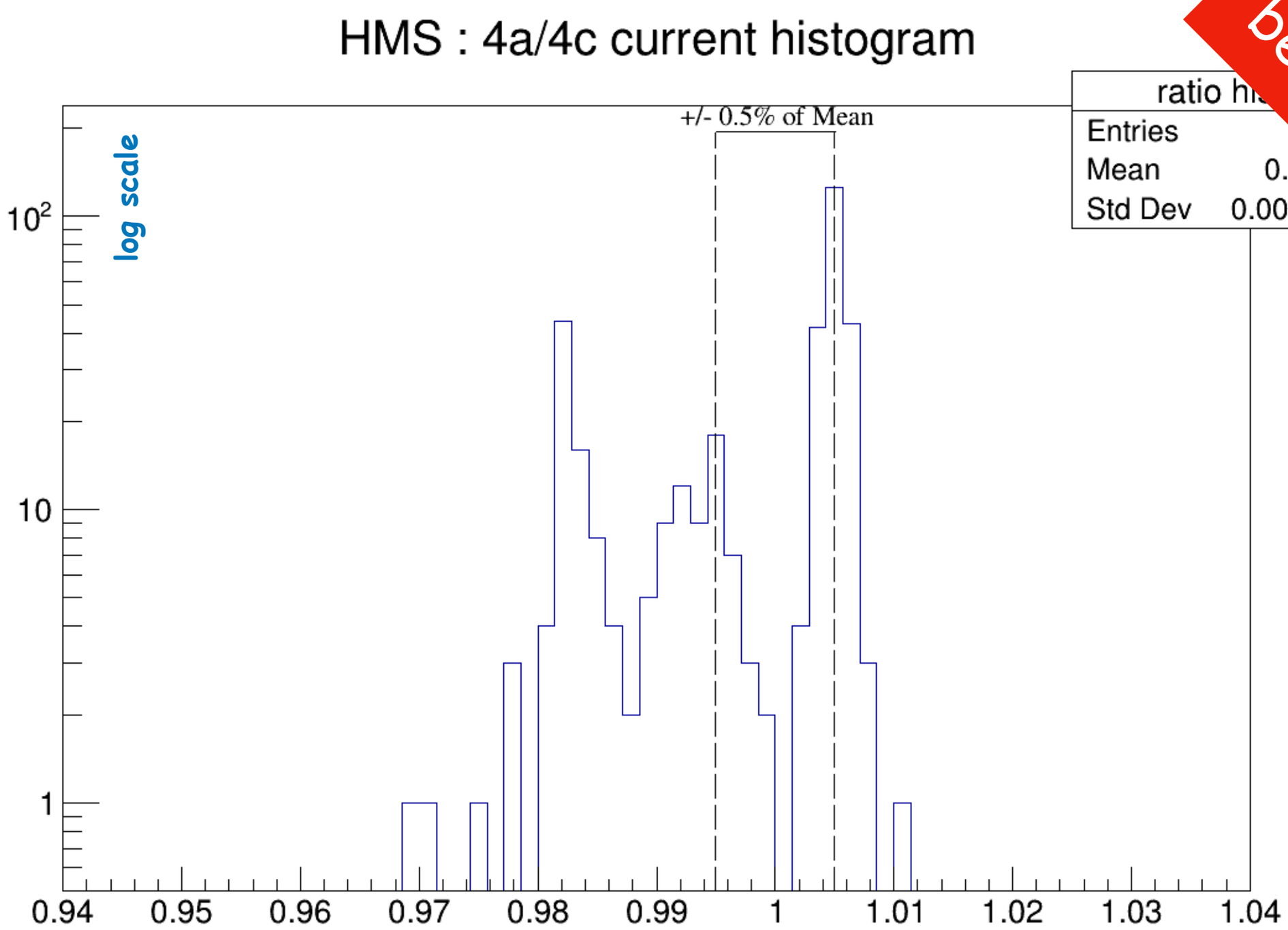
Parameters used from BCM local calibration

after

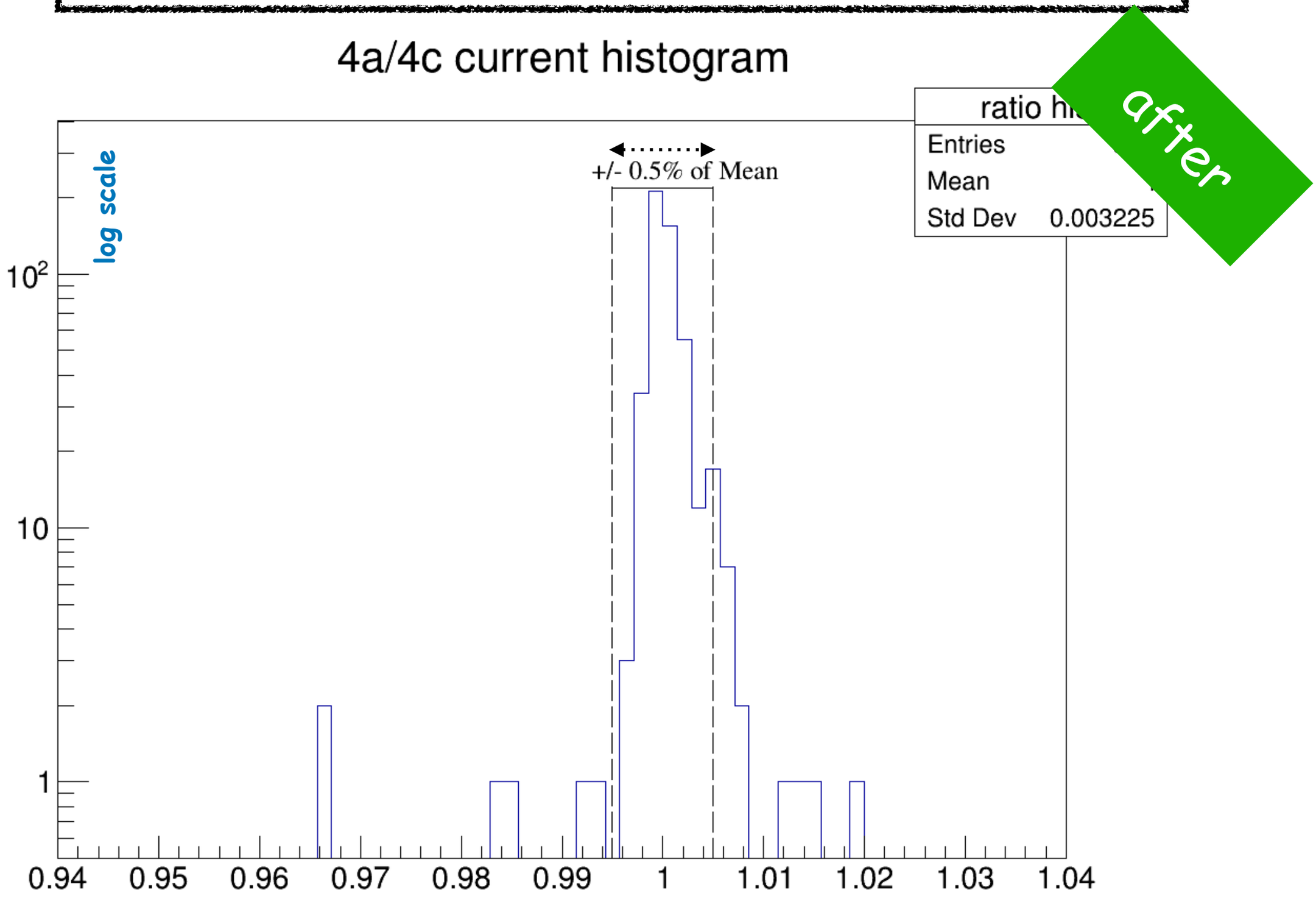


- After local calibration BCM4A and BCM4C agrees within 0.3 - 0.5%
- Though there are some outlier where difference between BCM4A and BCM4C is more than 0.5%
- A normalization uncertainty can be assigned from the fluctuation of the ratio (BCM4a /BCM4C) around 1

Parameters used from BCM global Fit

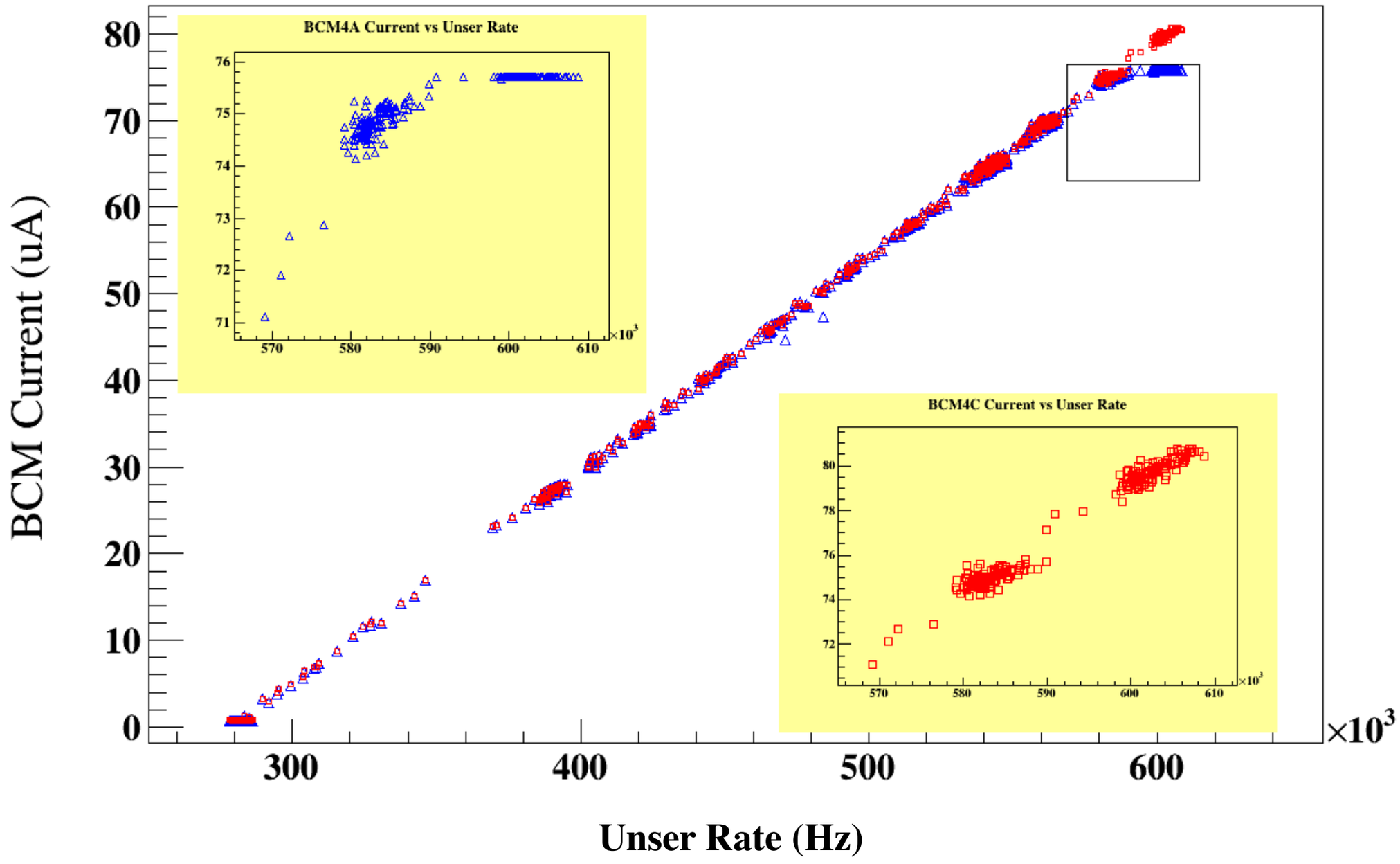


Parameters used from BCM local calibration



Beware of Saturation

- Do not include the runs in calibration where BCM is saturating



- BCM4A is saturating, so BCM4C should be used for these selected runs
- These runs were not used in the calibration

Current Error : Gain and Offset errors were propagated to current

Gain & Offset are anti-correlated

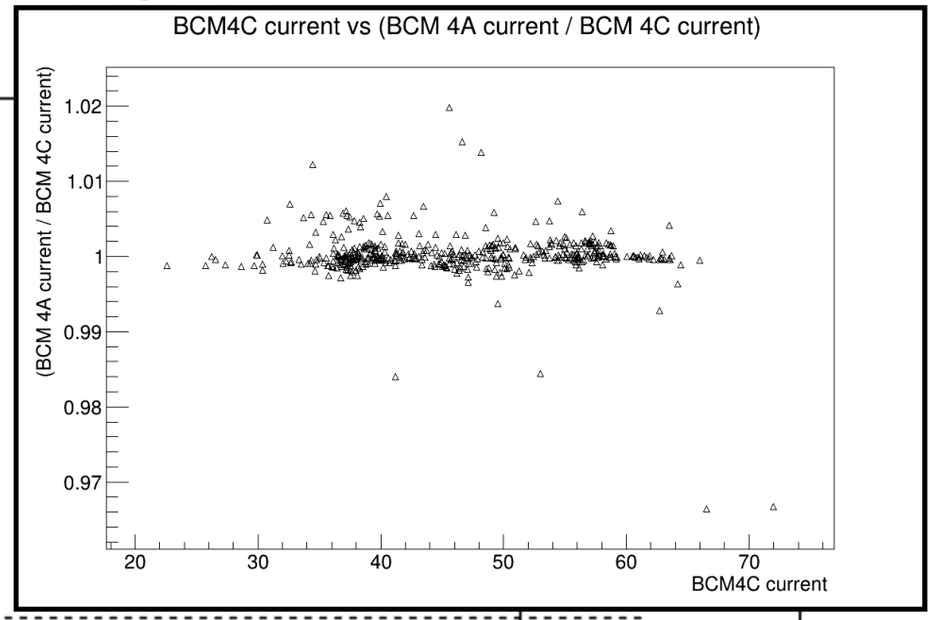
- $I_{bcm} = (v_{on} - v_{off}) / gain$

- $(\Delta I_{bcm})^2 = (\delta I_{bcm} / \delta v_{off})^2 / (\Delta v_{off})^2 + (\delta I_{bcm} / \delta gain)^2 / (\Delta gain)^2$
  $+ 2\,(\delta I_{bcm} / \delta v_{off})\,(\delta I_{bcm} / \delta gain)\,COV\{v_{off}\ ,\ gain\}$

- $(\Delta I_{bcm})^2 = (\Delta v_{off} / gain)^2 + (I_{bcm})^2\ .\ (\Delta gain / gain)^2 + 2.\ I_{bcm}\ .\ COV\{v_{off}\ ,\ gain\} / gain^2$

- Percent Error = $(\Delta I_{bcm} / I_{bcm}) \times 100.00$

Current Error : BCM4A : P1



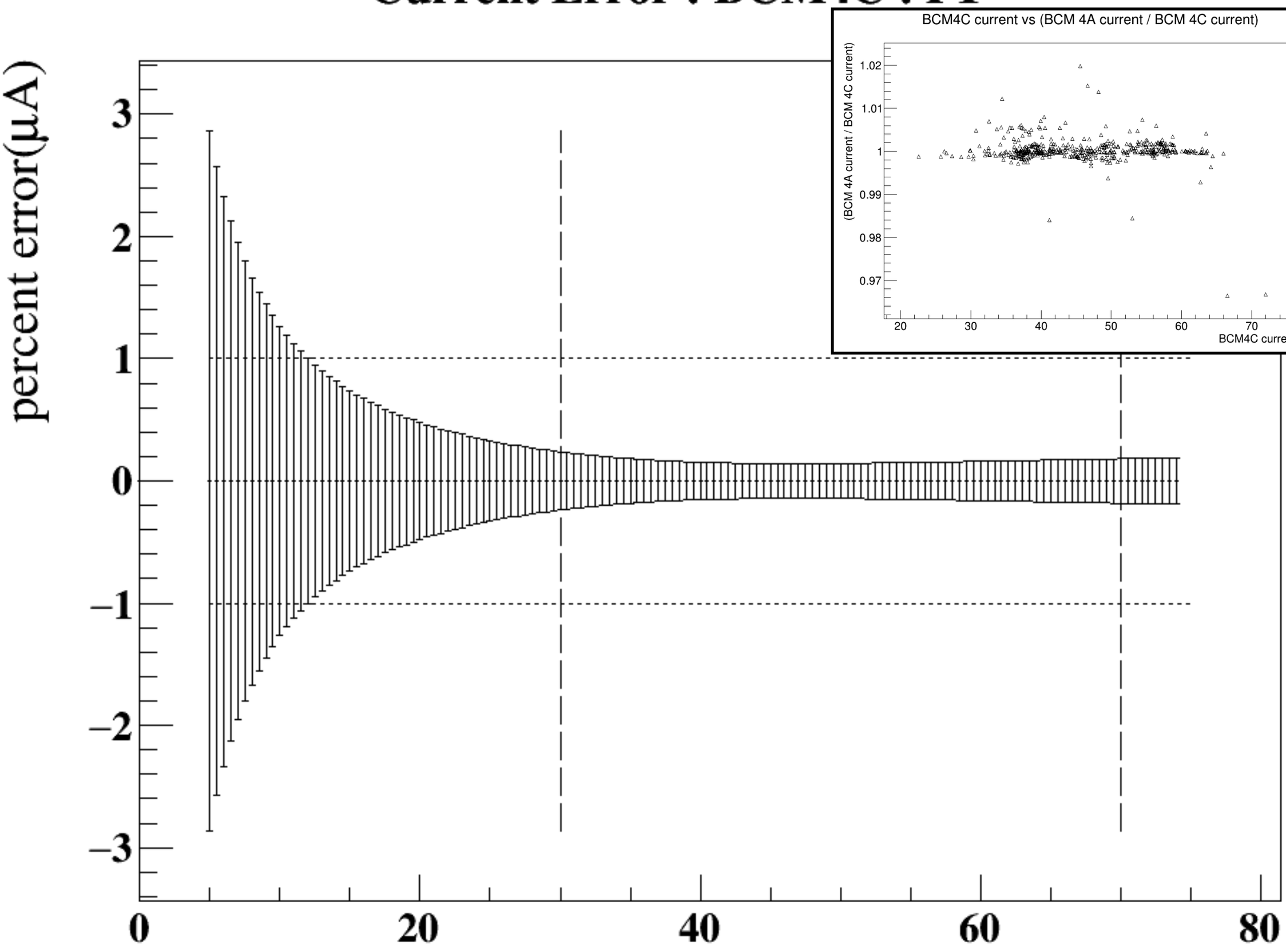
percent error(μA)

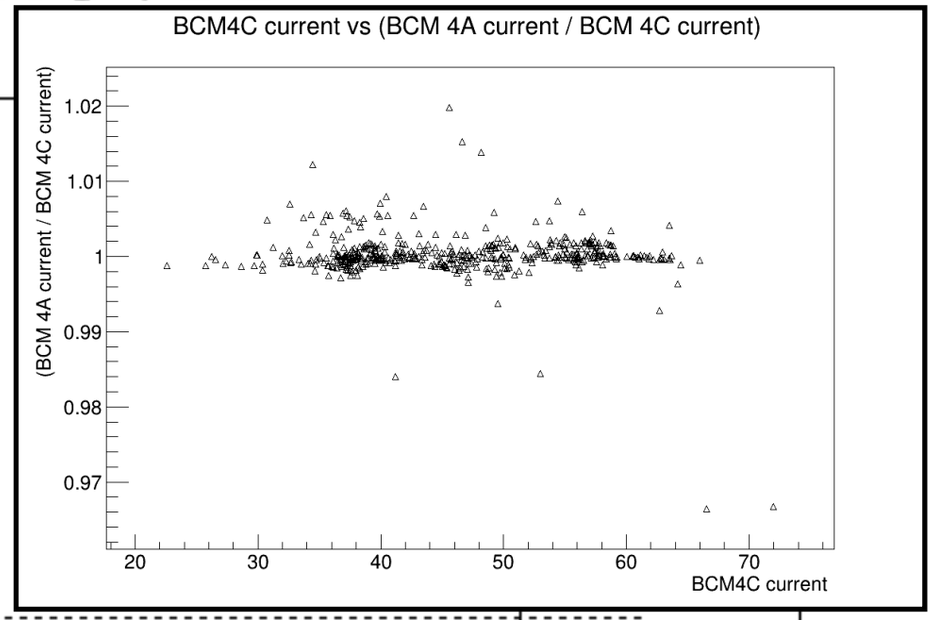
3
2
1
0
−1
−2
−3

0
20
40
60
80

current (μA)

Current Error : BCM4C : P1





Conclusion

- start with a set of BCM parameters analyzing the most recent BCM run before taking data
- monitor online the BCM current ratio's while taking data
- as soon as there is any considerable (2% is huge for the precision experiment like F2 !) disagreement between two BCMs try to take more BCM calibration run
- for precision experiments like f2 , ~2% difference in current (using BCM global fit) between two BCMs is NOT desirable
- so when global fit failed, local BCM calibrations were done with real production runs for all different 6 periods separately
- after local calibration BCM4A and BCM4C agreed within a ~0.5% level for current

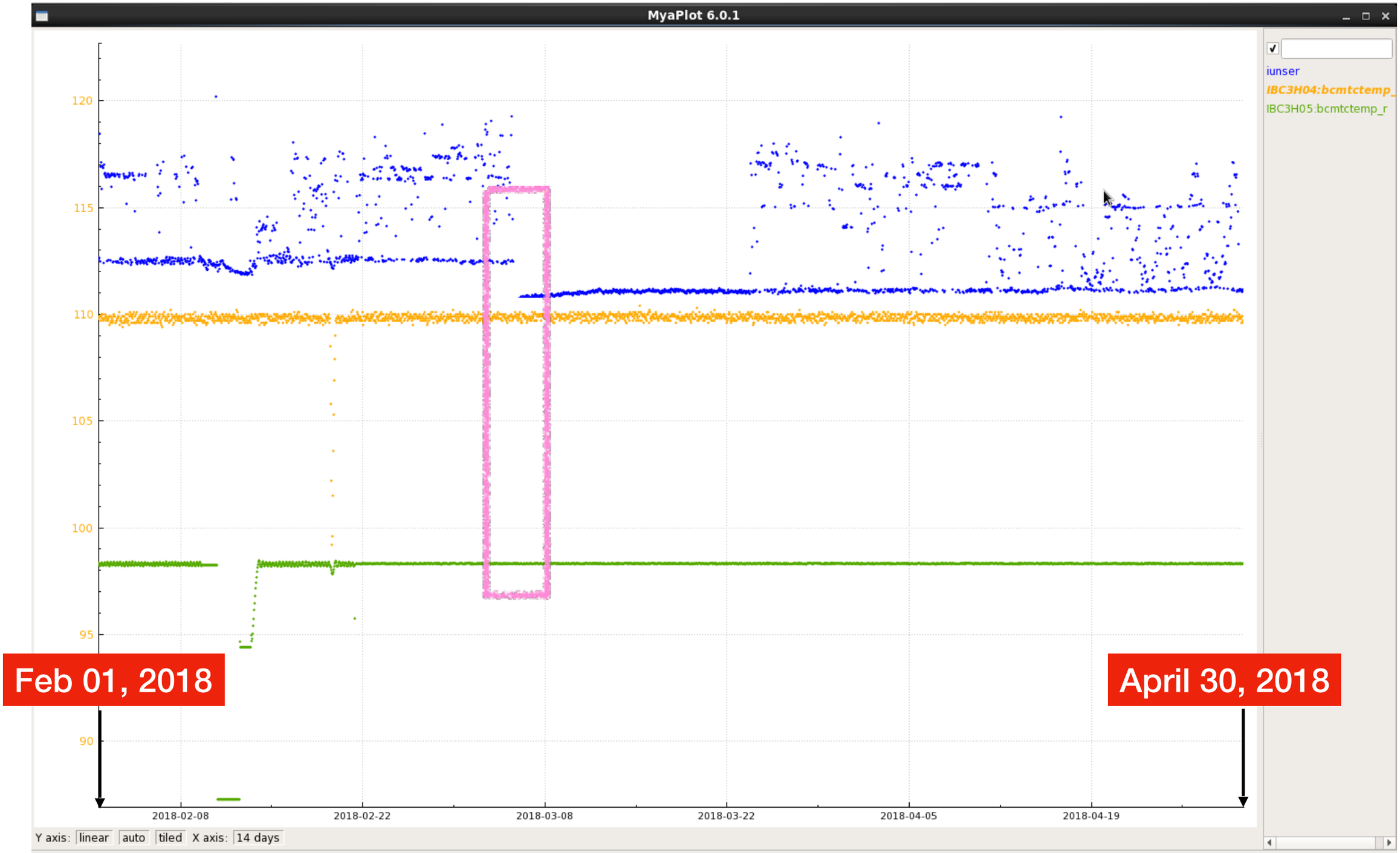
Acknowledgement

Thanks to Eric Christy & Simona Malace

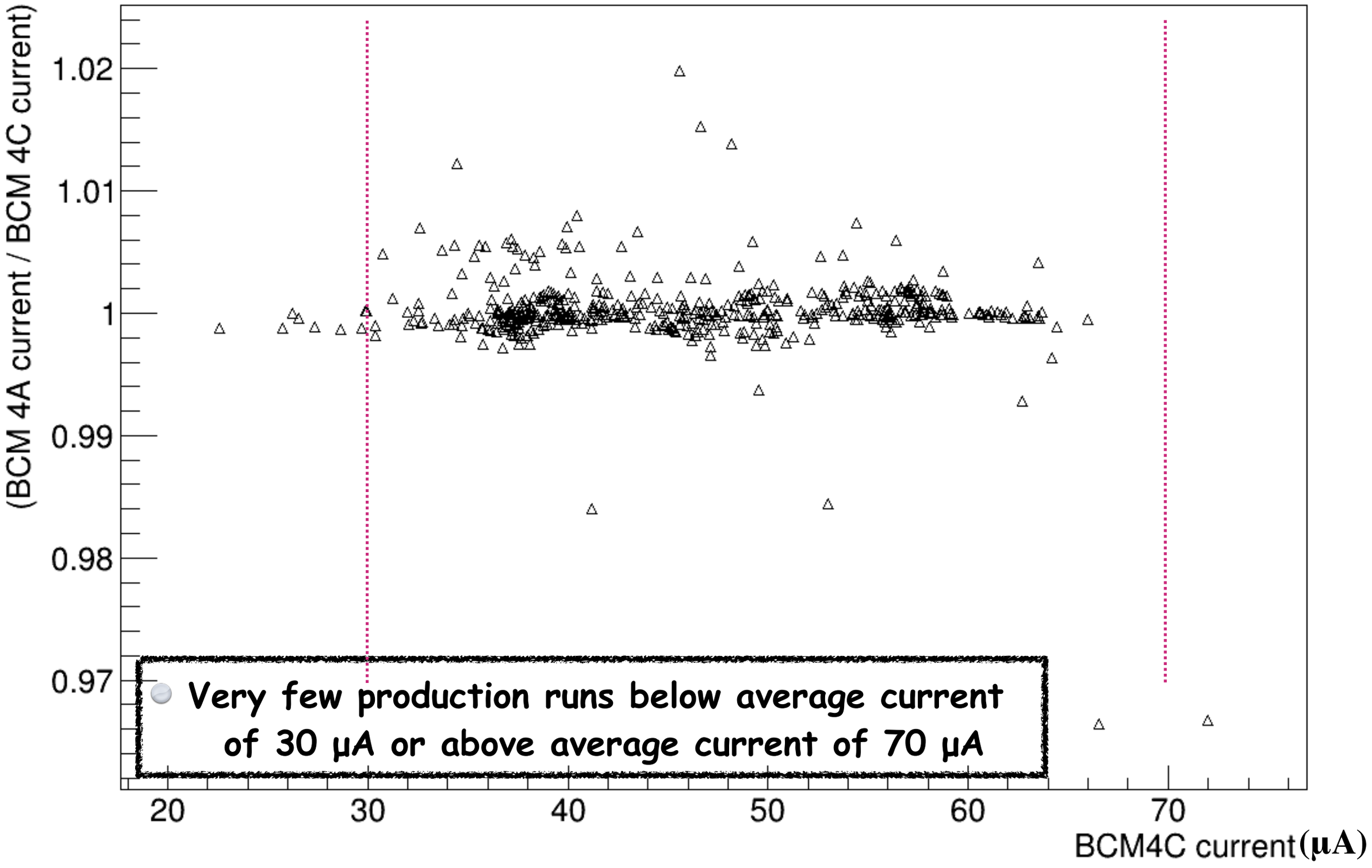
Thanks for your attention !

Back up Slides

No correlation between the temperature and the Unser offset jump



- IBC3H04:bcmctemp_r : temp of bcm1, bcm2, unser
- IBC3H05:bcmctemp_r : temp of digital receivers (bcm 4a, bam 4b , bam 17)


BCM4C current vs (BCM 4A current / BCM 4C current)
(BCM 4A current / BCM 4C current)
1.02
1.01
1
0.99
0.98
0.97
20
30
40
50
60
70
BCM4C current (μA)
Very few production runs below average current of 30 μA or above average current of 70 μA