Physics beams as seen by BCCMs

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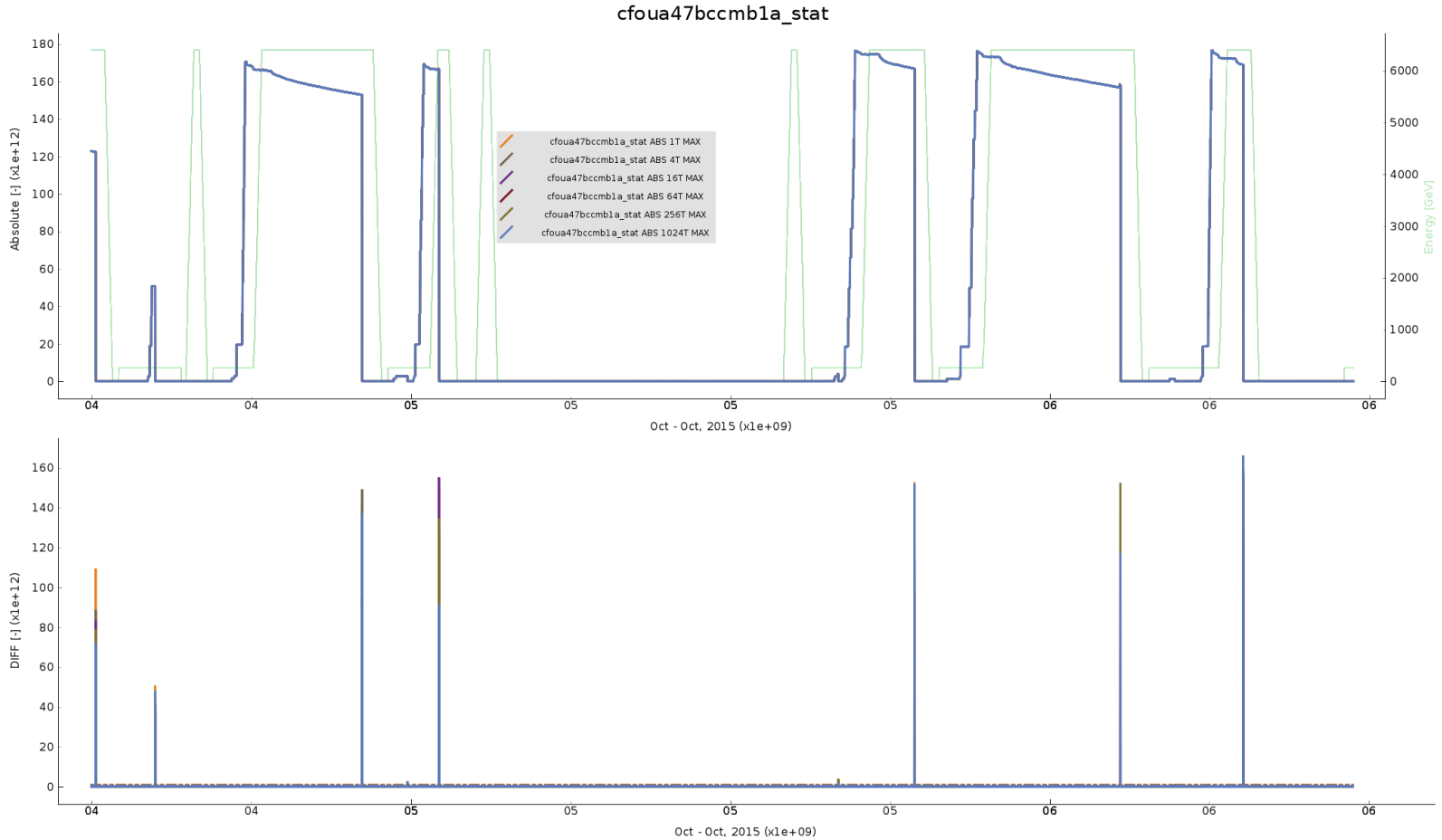
The project status

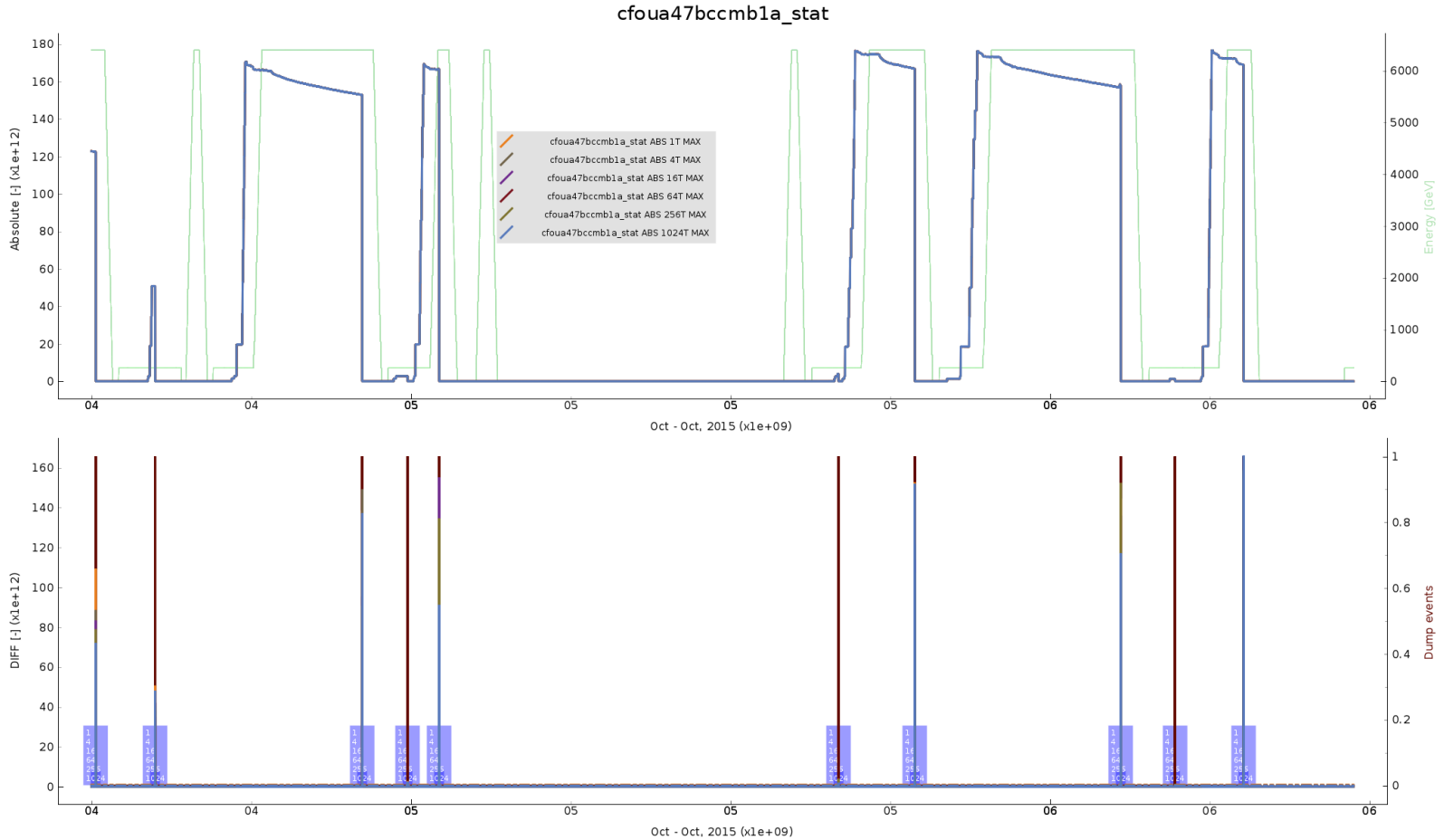
- Last presentation (18 August 2015) discussed the preliminary results of the BCCMs.
- Decision was taken to enable the operational BCCMs so we could analyse the BCCM behaviour in the real environment.
- Relaxed thresholds were programmed into both operational BCCMs:
  - single turn window to 1×10^{12} ch/t
  - all other windows 6×10^{11} ch/t $>$99% detection probability of 1.2×10^{12} ch/t, and not to cause spurious triggers during scrubbing on longer windows.
- Web page created, displaying the BCCMs' measurements for the last 8 hours of run
- TBD:
  - dump of the status pictures, including to the dumps to some storage for direct observation
  - SW $\rightarrow$ XPOC, Timber logging is still not reliable
  - Tightening the thresholds

Analysis of the physics run

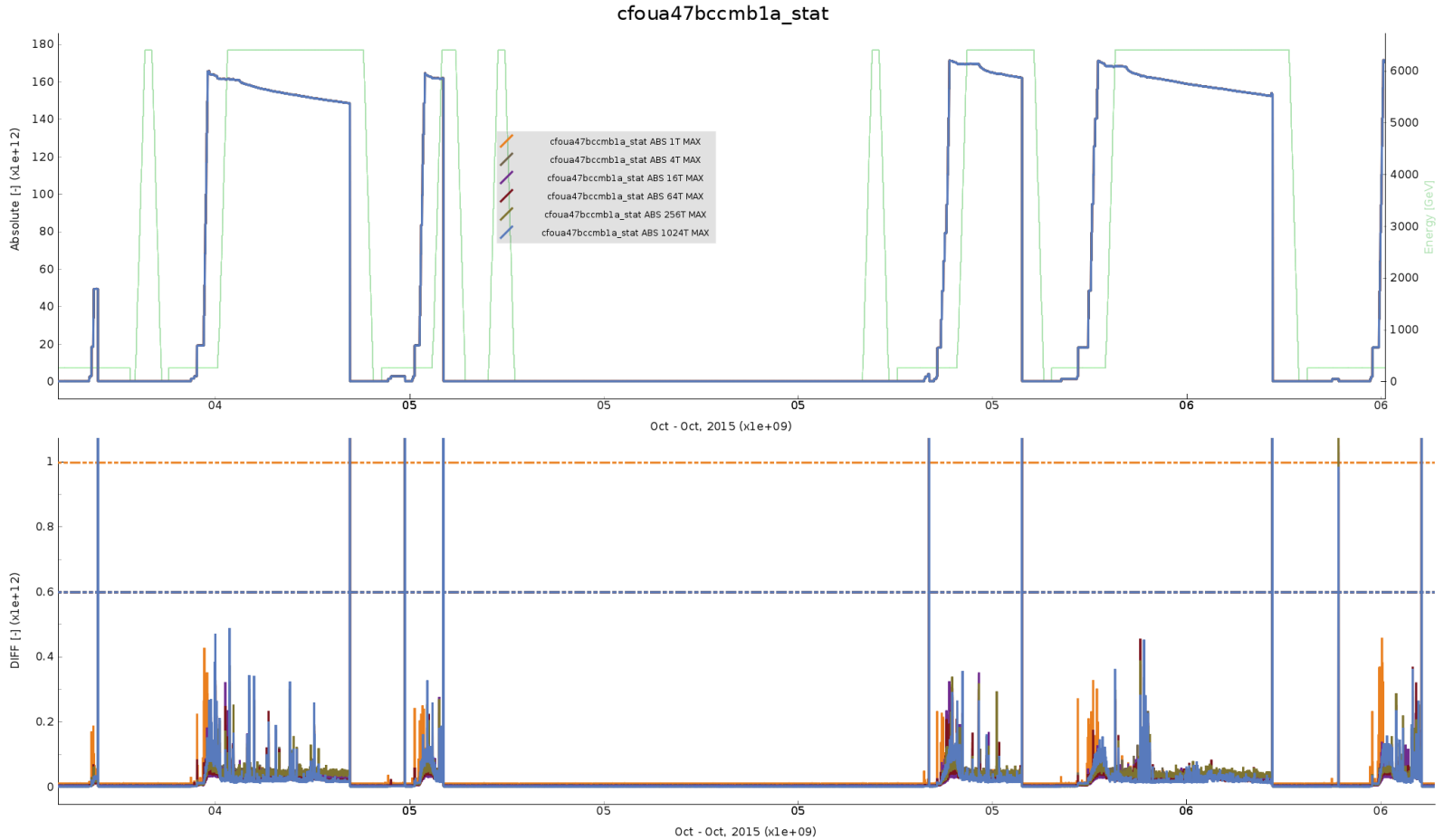
Typical physics run



Typical physics run - dumps

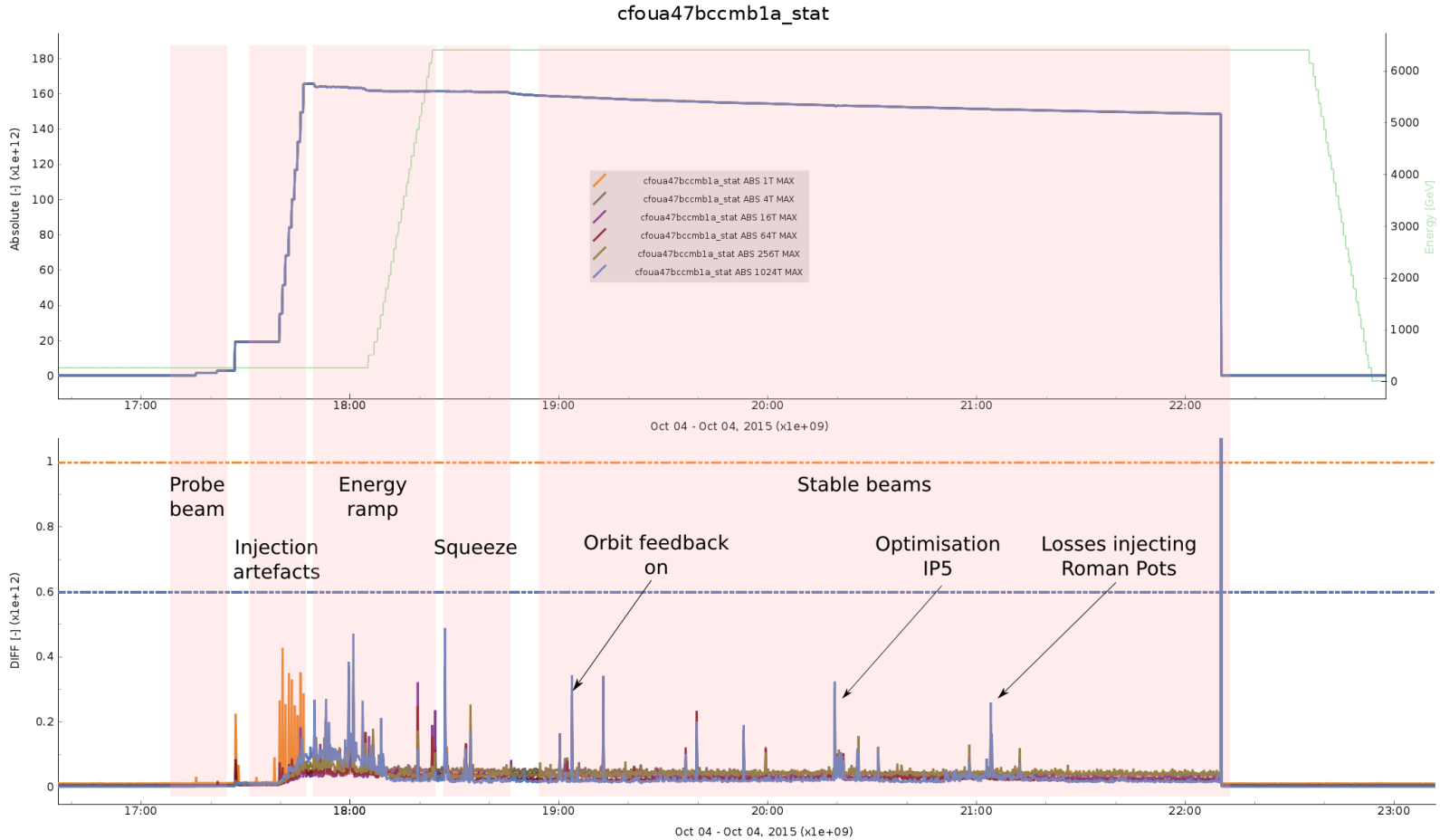


Typical physics run - diffs



Typical DIFF behaviour

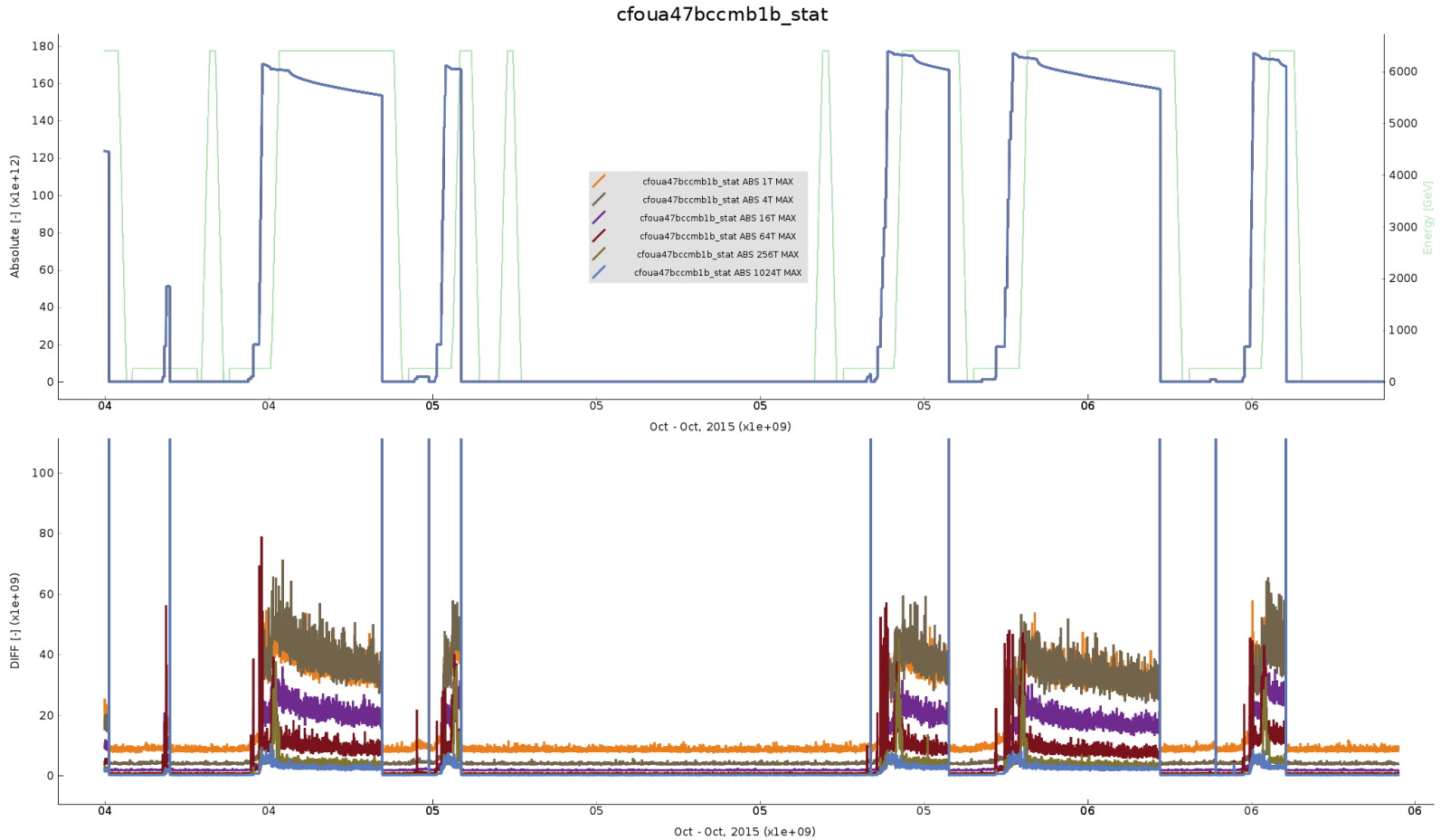
... and if we zoom into a single physics fill we can see:



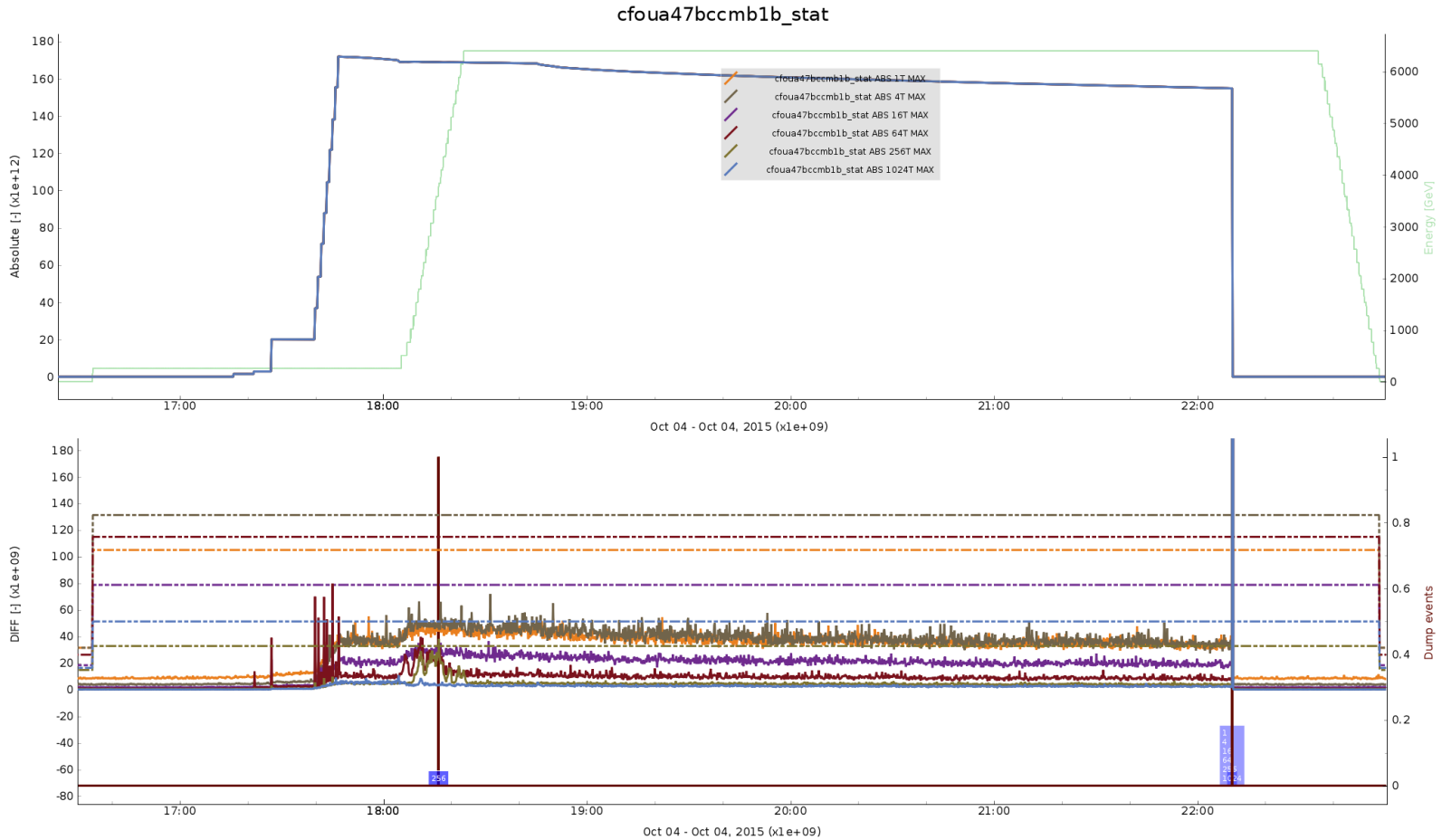
There are many spikes at various stages of the physics run, nothing interesting in the logbook for 'stable beams'. Others generated during injection, collimators moving, squeeze or any beam operation.

DIFF Artefacts

Most of those spikes are artefacts of the FBCT signal, but limiting the threshold setting. Compare to BCTI:



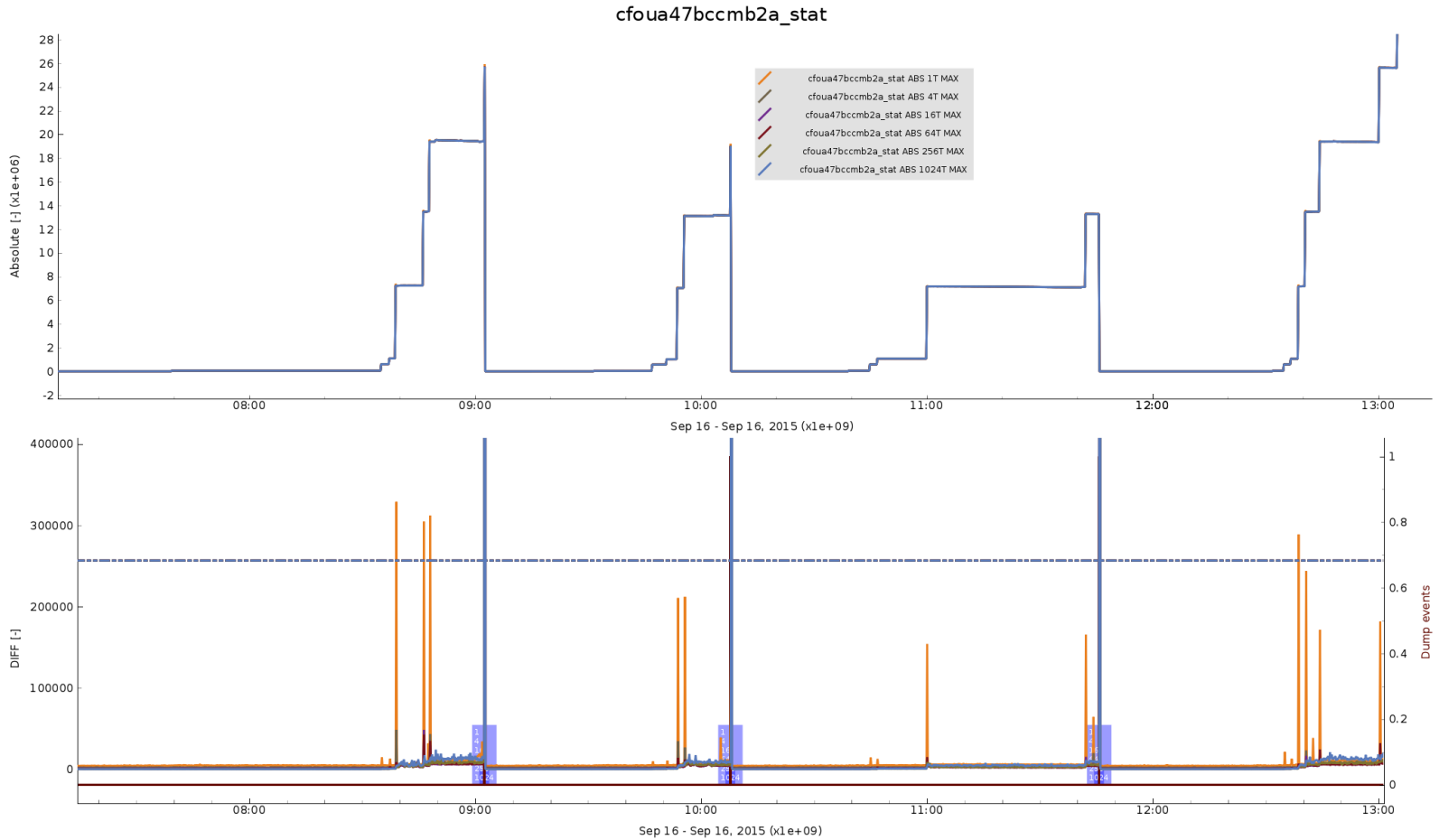
DIFF Artefacts - ICT response



→ Current FBCT threshold settings are conservative, can be tightened, however the FBCT signal imposes lower limit on the threshold setting

BCCM trigger events - analysis

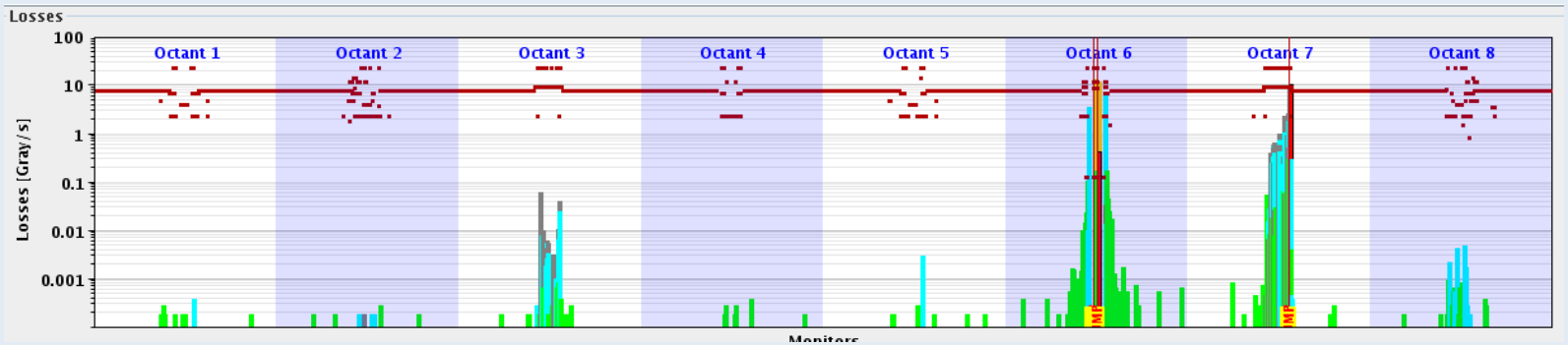
On 16th September there were 3 events detected by the BCCMs, 2 of them were qualified by BCCMs as dumps:



BCCM trigger events - analysis

09:02 - B1 losses triggered by instability, dump triggered by BLMs

Injection of 4th 144-b train triggered fast losses in pt 7, possible instability (but Q' is 15,14)



BCCM trigger events - analysis

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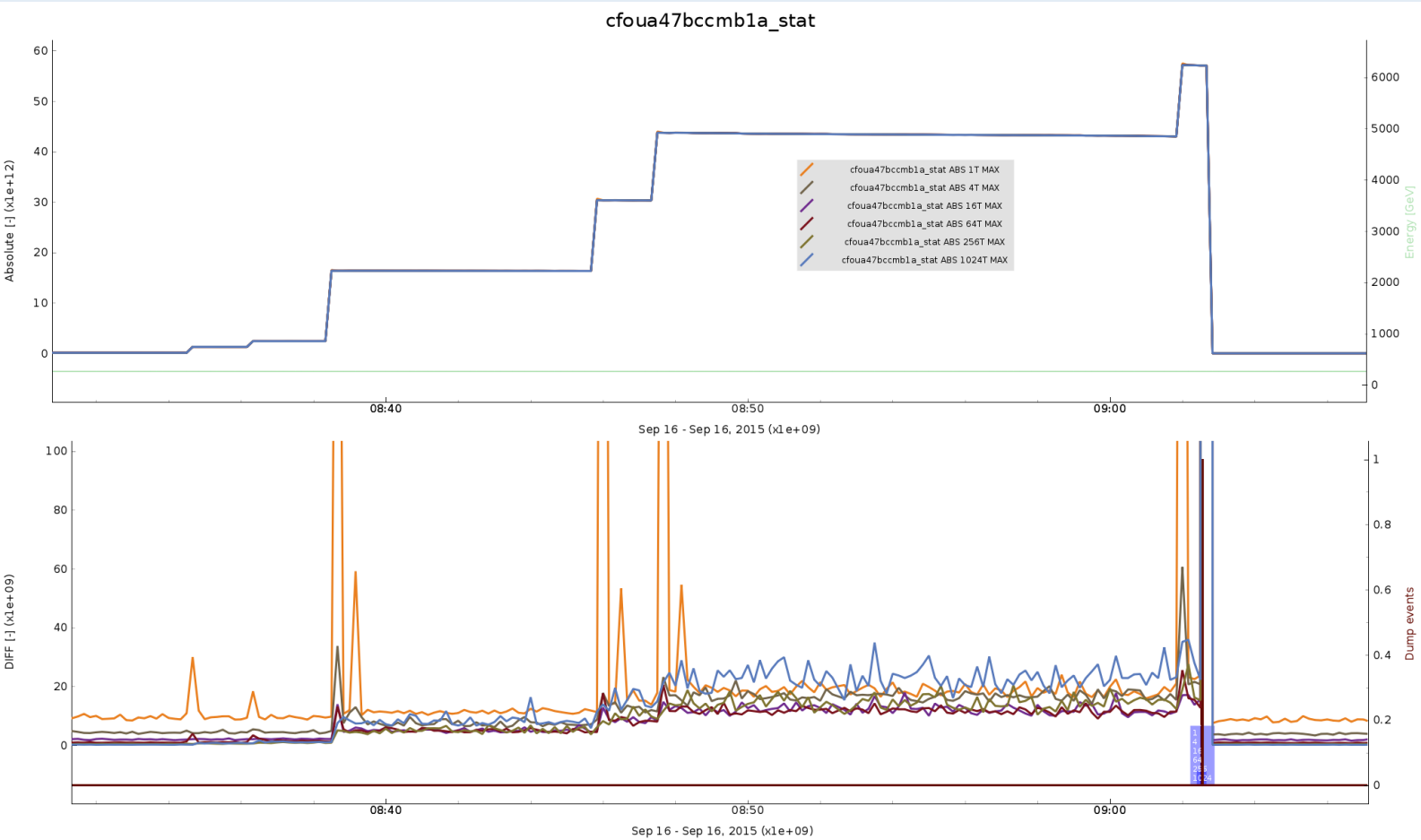

BCCM trigger events - analysis

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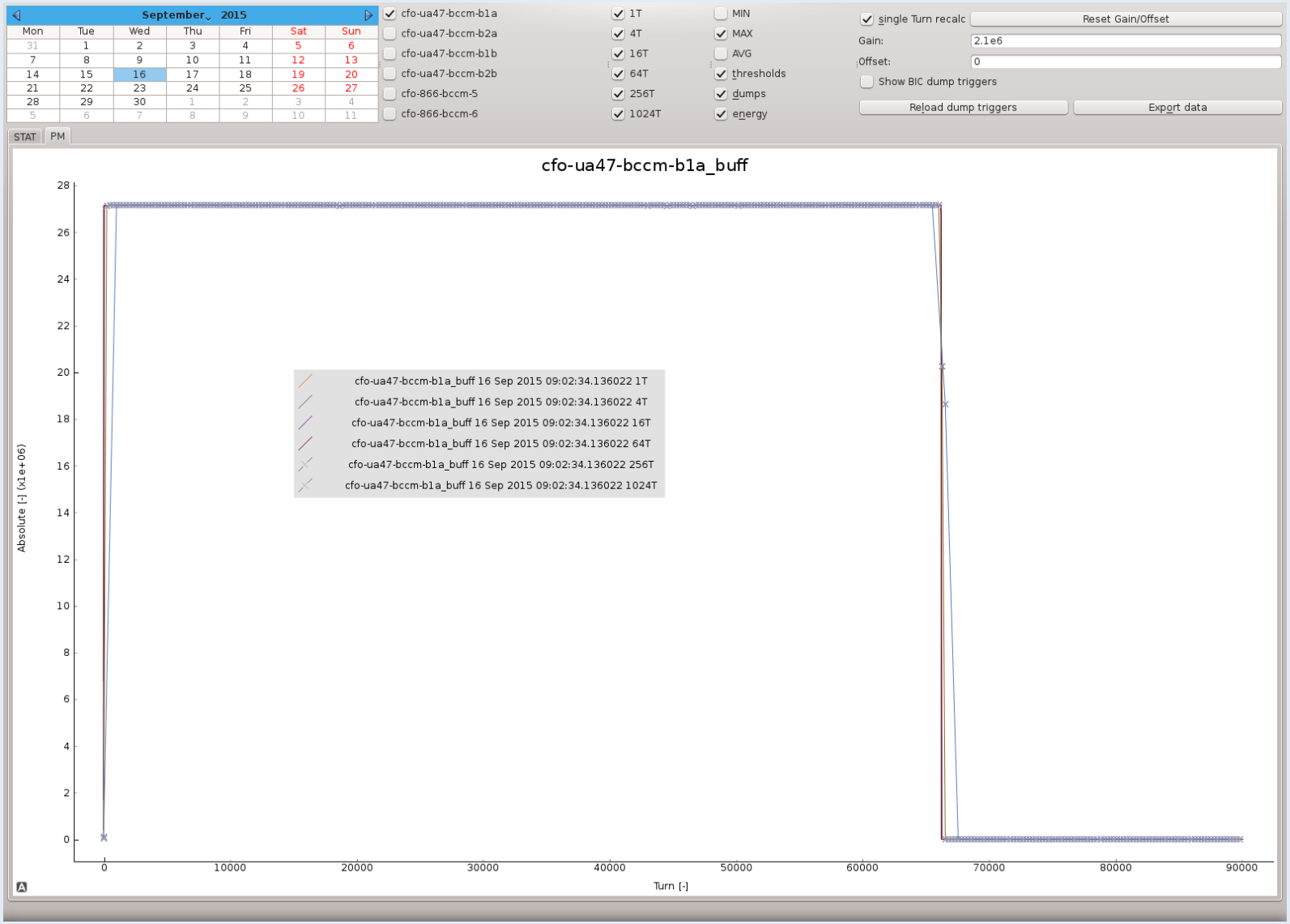

BCCM trigger events - analysis

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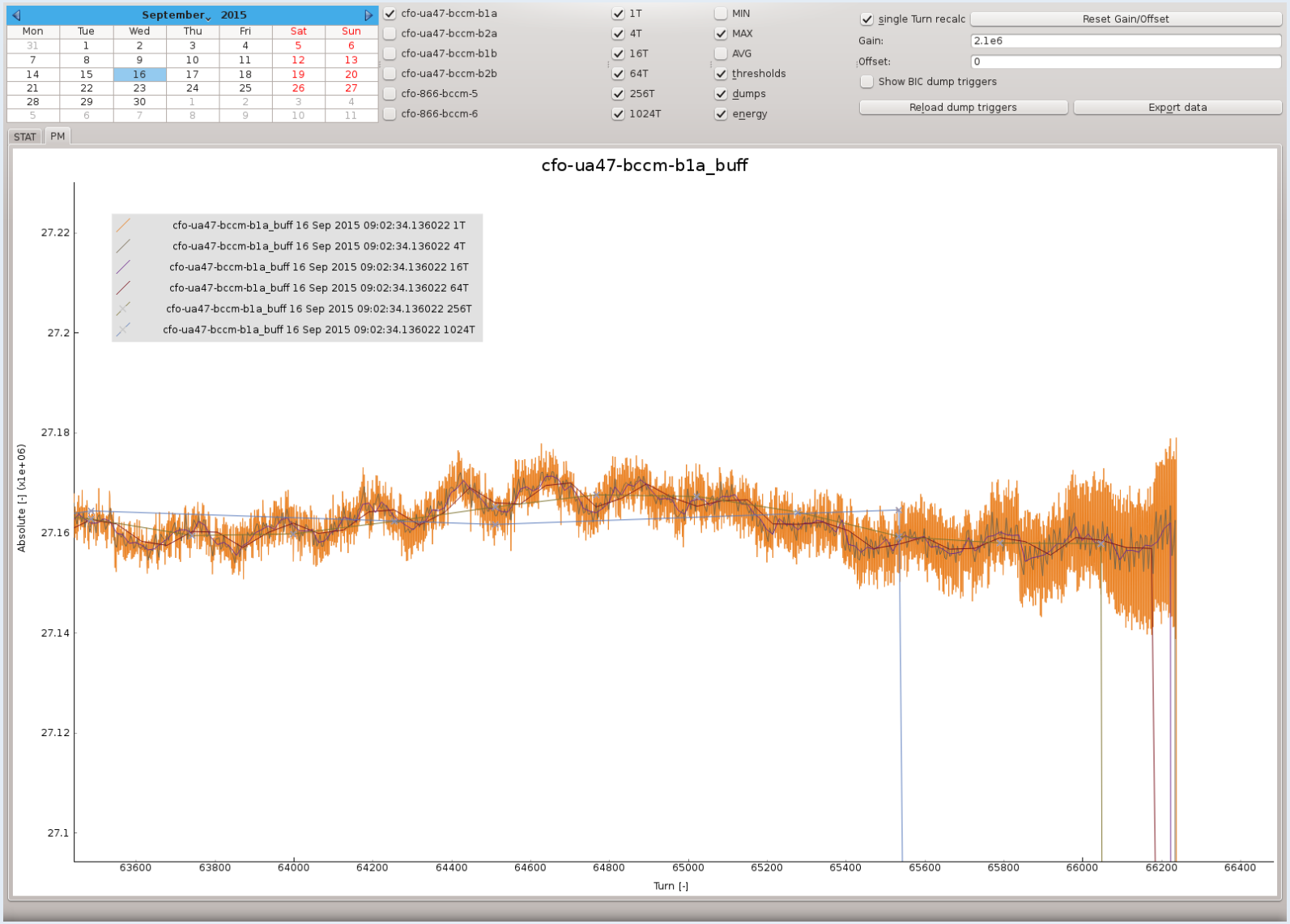
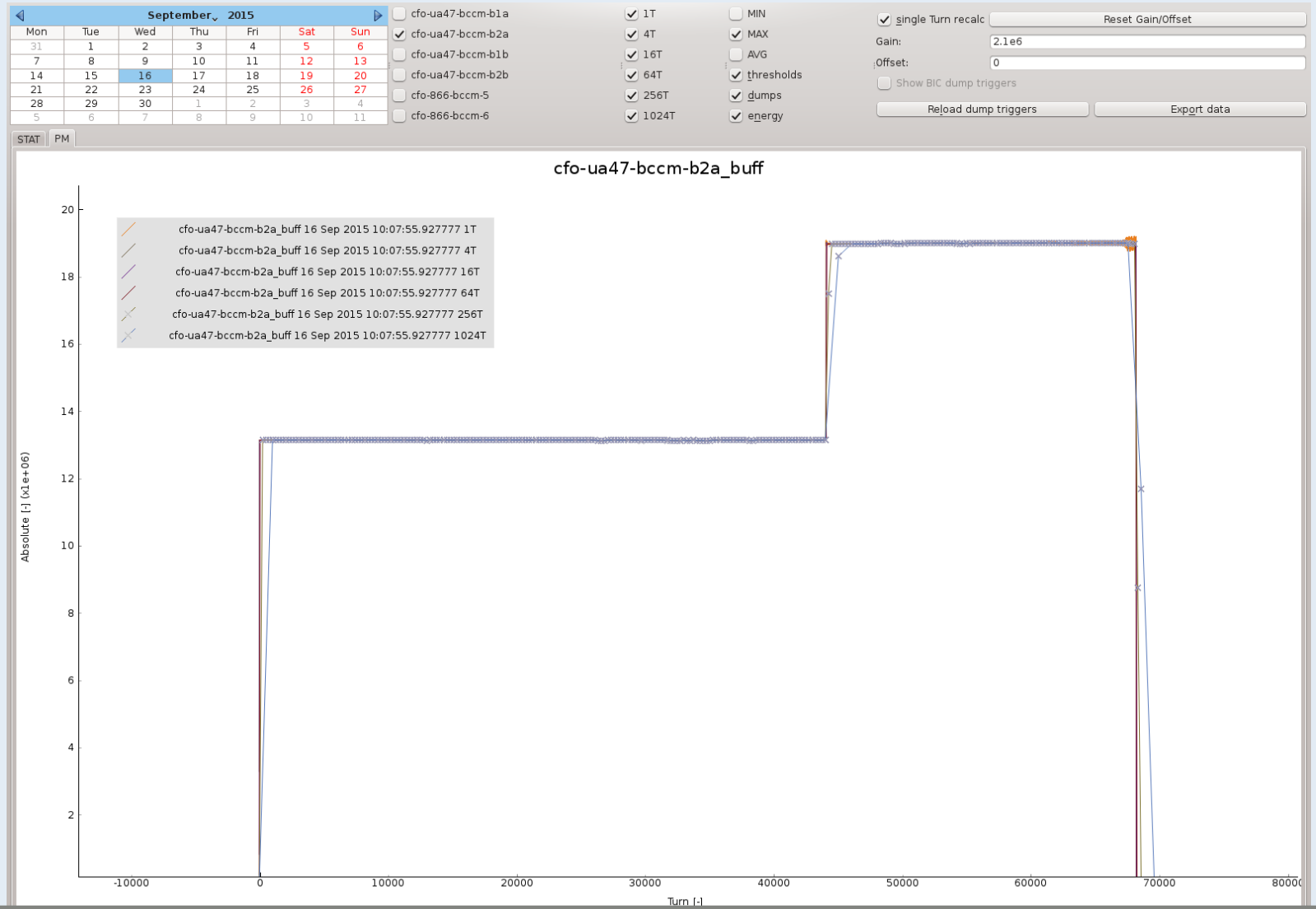


BCCM trigger events - analysis

10:07 - B2 losses due to ADT malfunctioning, triggered by BCCM



BCCM trigger events - analysis

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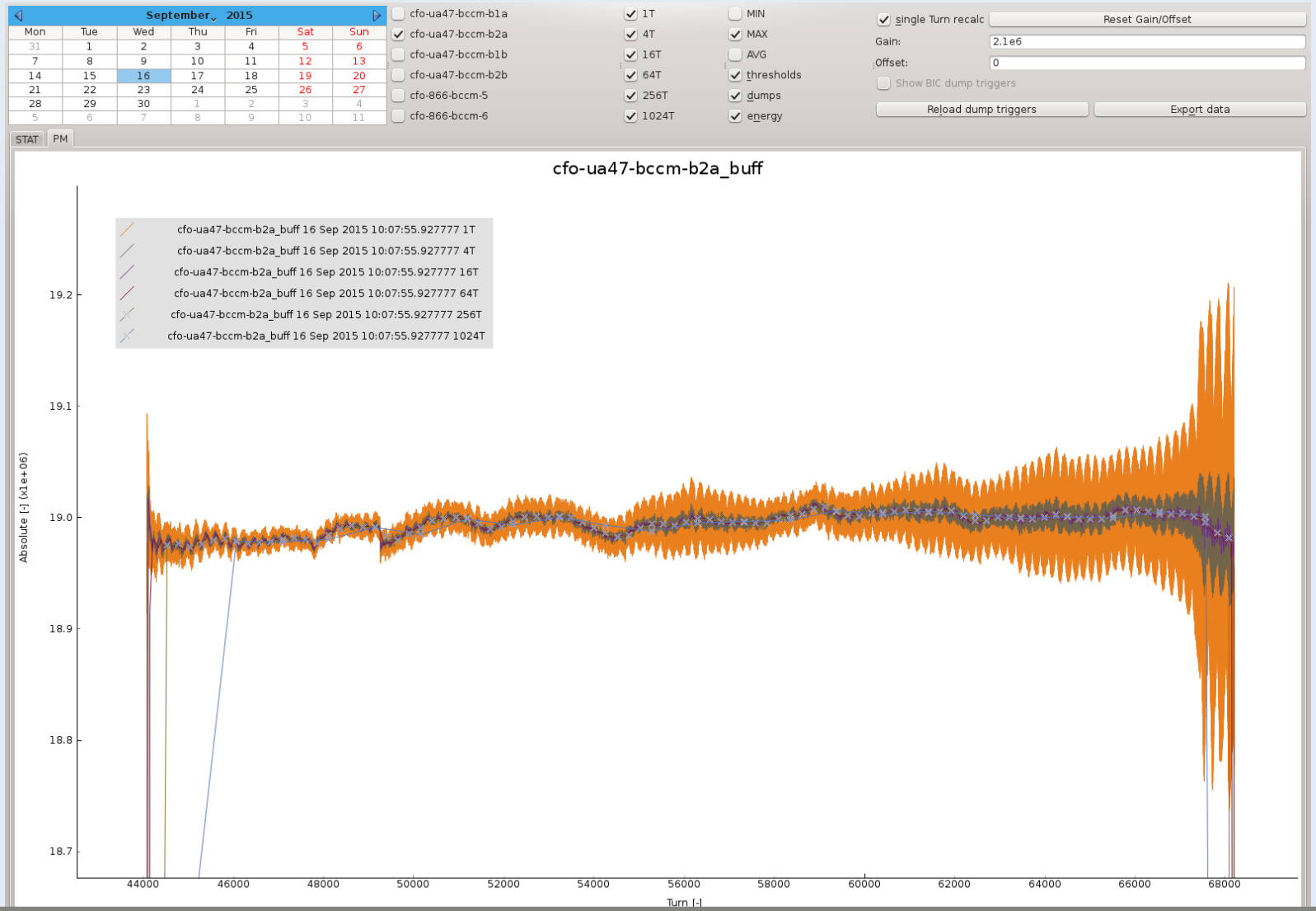
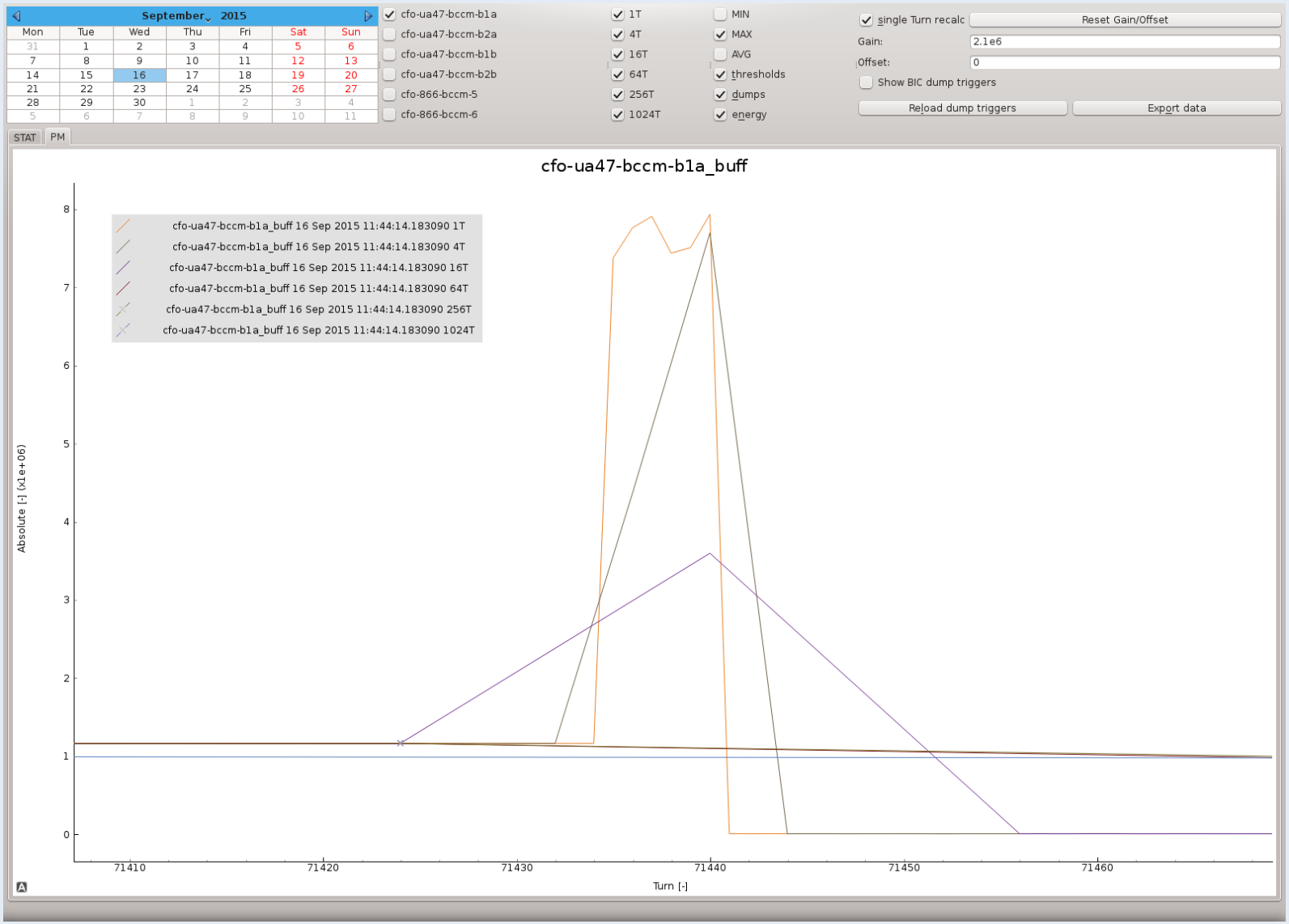


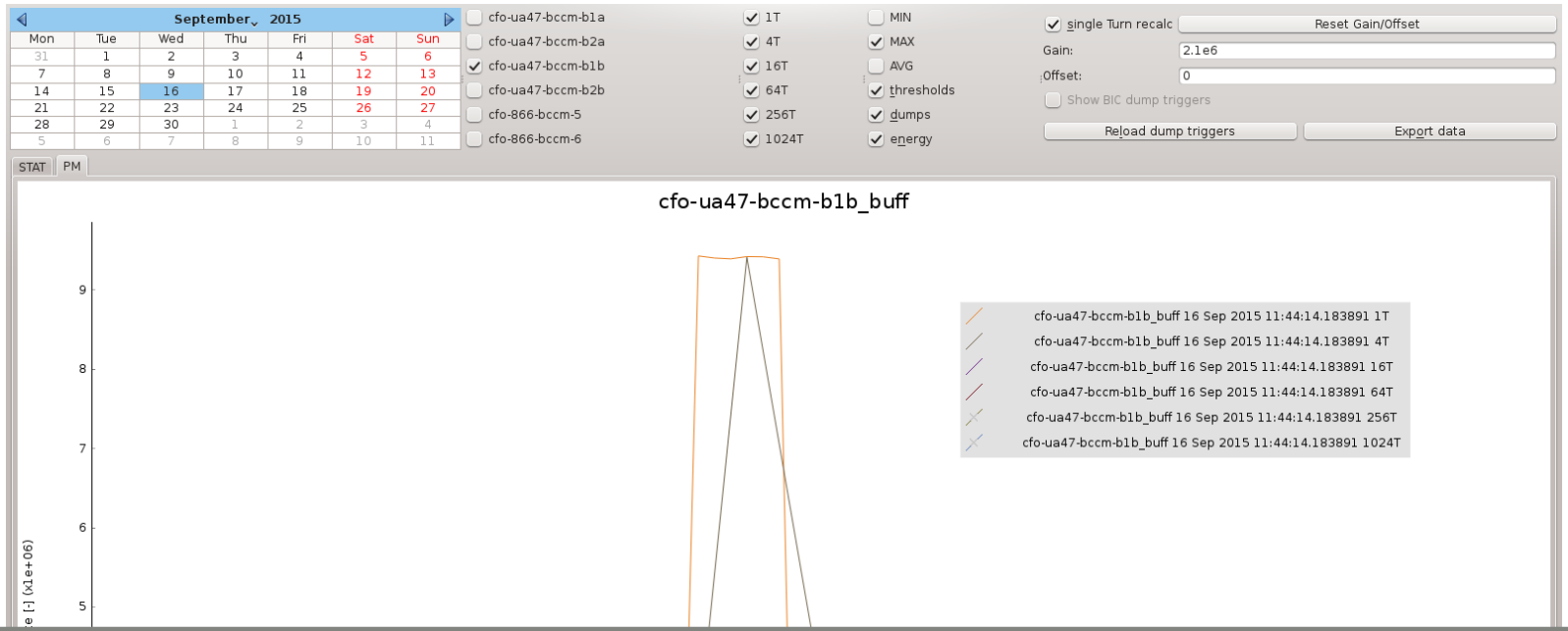
BCCM trigger events - analysis

11:44 - B1 injection oscillations, triggered by BCCM



BCCM trigger events - conclusion

- The two spurious triggers were caused by the 'ability' of the FBCT to track the position change
- Change of the position results in a change of the 40MHz component amplitude, which is intercepted by the BCCMs
- This time the change was quite substantial, which results in DIFF for 1T to cross the defined 1e12 threshold.
- The effect is much less pronounced in the new devices, e.g. BCTI 7×10^{10} ch/t:



Analysis of the thresholds settings

Lower thresholds? - the method

... so ... in order to get the maximum DIFFs for the machine run the DIFFs are split into 2 cases:

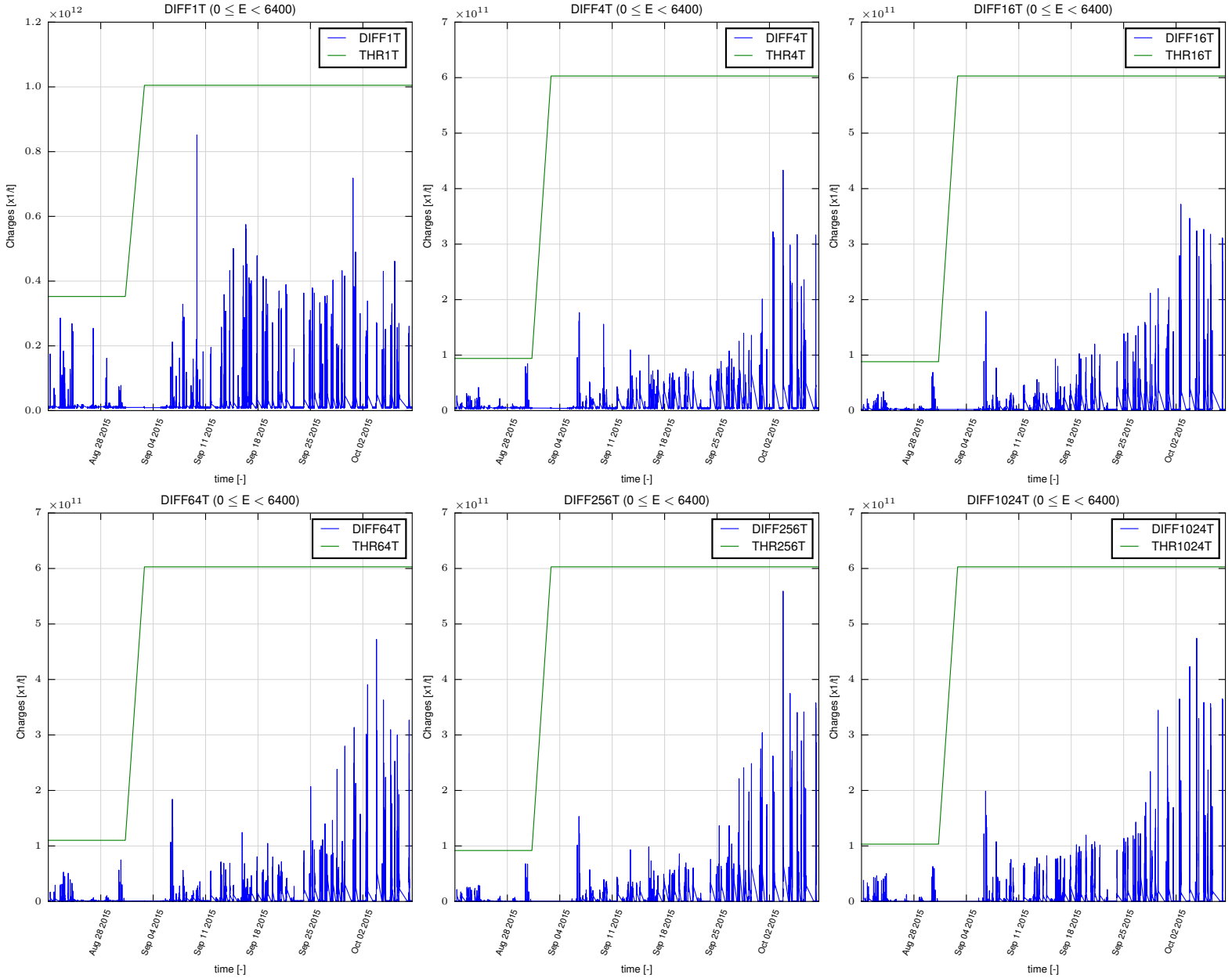
- DIFFs at injection energy or ramping
- DIFFs at flat-top during physics run.

The way how to estimate is to :

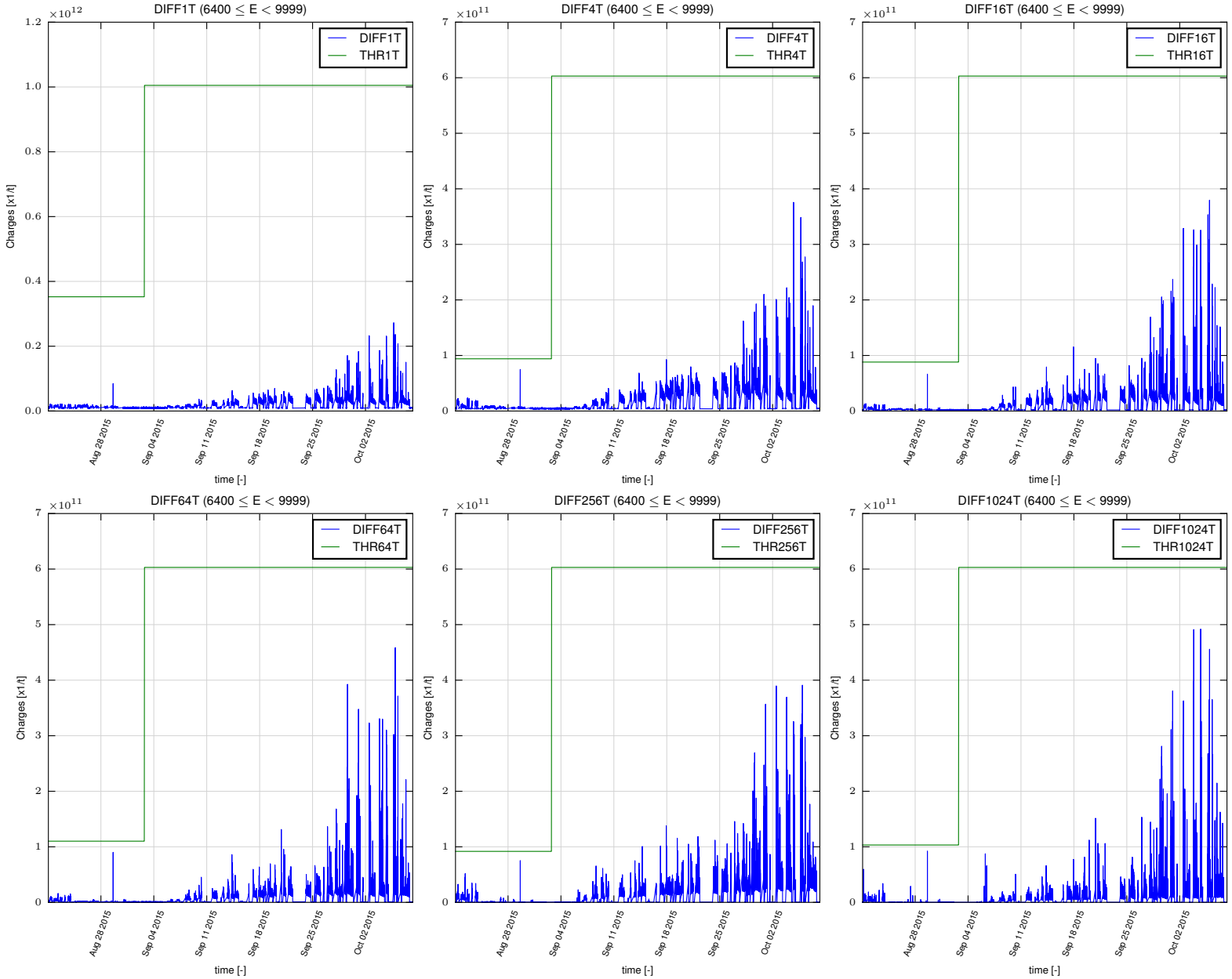
- take the data measured last ... 2 months ...
- filter from the DIFFs all beam dump events, as those are excessively high compared to the signal we are looking for
- filter the DIFFs as well to contain the data at specific energy
- for a given observation window display the DIFF wrt thresholds currently implemented

As we want to have actually two different thresholds - for all energies up to flat-top, and flat-top - the energy filtering results in two measurement sets.
$\rightarrow$ Let's see:

FBCTs DIFFs at up-to flat-top energies



FBCTs DIFFs at flat-top



Noise floor for FBCTs?

When looking at the graphs, at injection the thresholds should stay as they are: 1×10^{12} ch/t lost in 1T, 6×10^{11} ch/t for all other windows. At flat-top we might lower the thresholds to:

Turn	Threshold
1T	4×10^{11} ch/t
4T	5×10^{11} ch/t
16T	5×10^{11} ch/t
64T	5×10^{11} ch/t
256T	5×10^{11} ch/t
1024T	leave unchanged 6×10^{11} ch/t

Limitations are given mostly by position dependency. Manually trimming orbit results easily in spikes exceeding 3×10^{11} on 1024T.

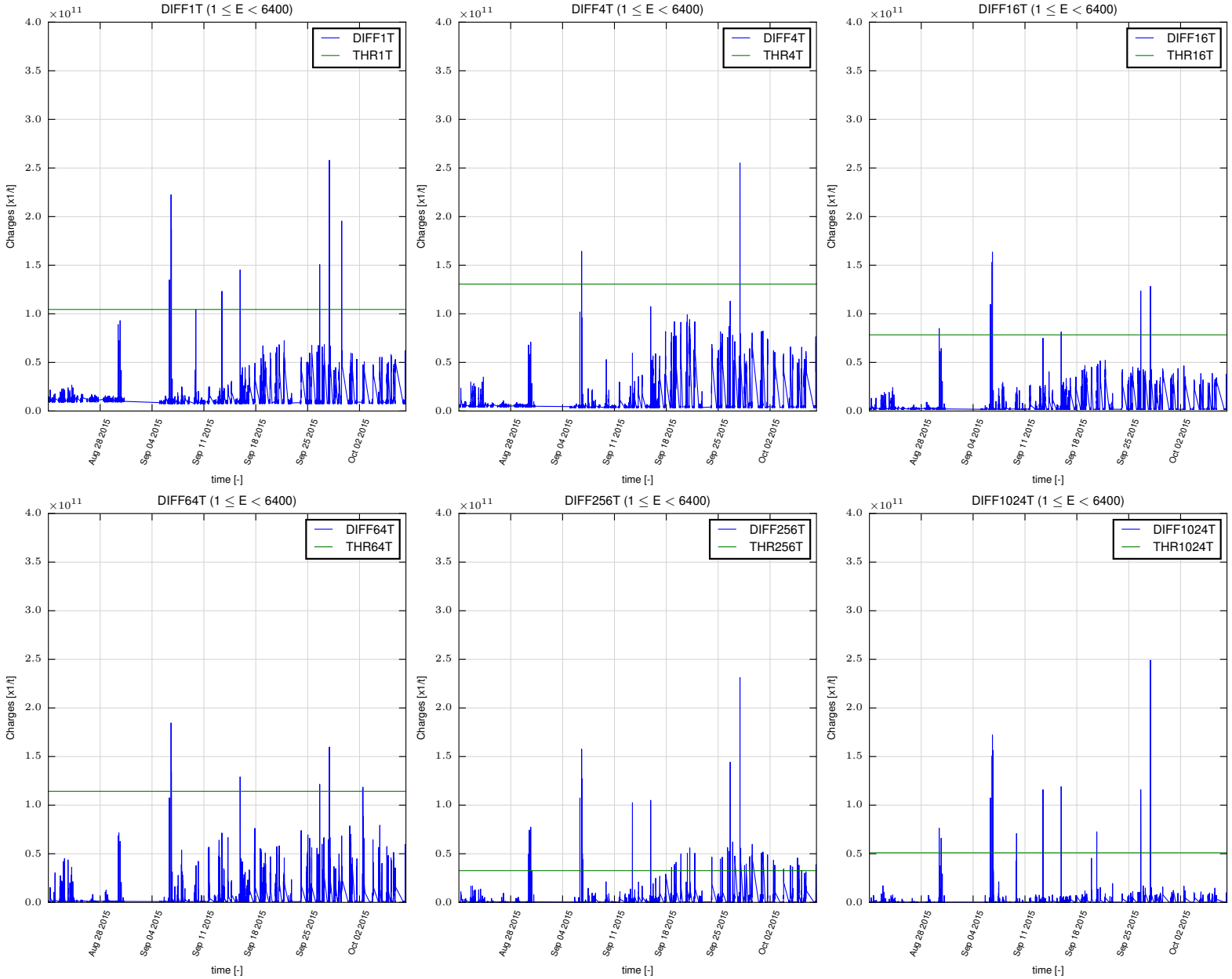
Does it get better with BCTI?

So how about 'experimental' BCTI?

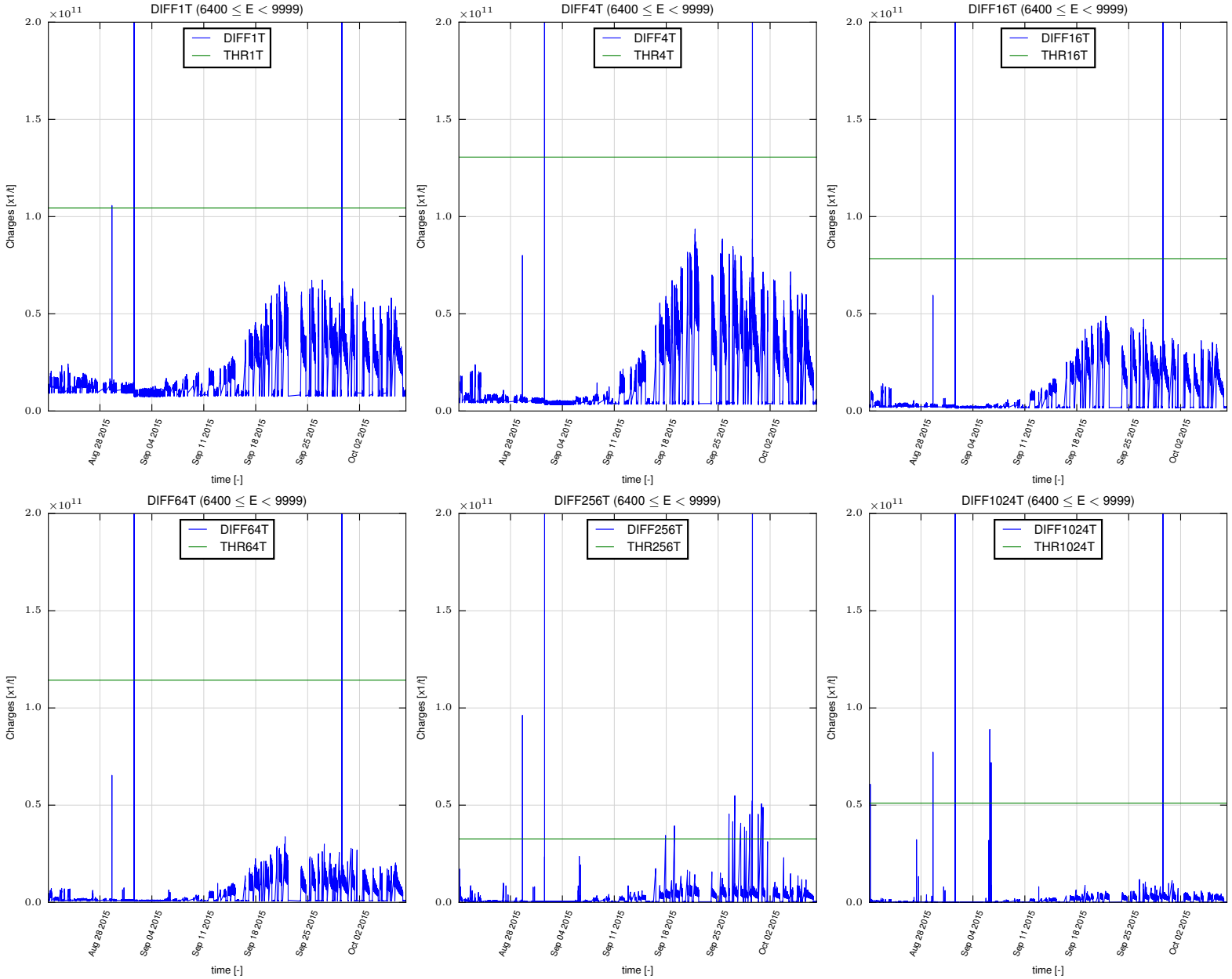
- the same data sets were taken
- however dump filtering from systemA was used: the BCTI uses very low thresholds, which causes spurious dumps, and those would be filtered away if the same algorithm as with FBCT would be applied
- following graphs might be misleading as I cannot guarantee, that all the dump events for pilot are removed from the graphs, however the graphs show the worst case $\rightarrow$ it might be better than that.

So, the measurements:

BCTI DIFFs at up-to flat-top



BCTI DIFFs at flat-top



BCTI/BCTW thresholds limits - conclusions

BCTI allows considerable reduction of the thresholds: at injection we can go as low as 3×10^{11} ch/t for all windows, at flat-top down to 1.5×10^{11} without causing a spurious dump.

Conclusions

- the operational BCCMs using conservative thresholds work OK
- two spurious dumps detected since end of August, their origin is known
- the operational BCCM thresholds can be lowered to roughly 5×10^{11} for most windows at flat-top
- the FBCT fed BCCMs are now clearly limited by the quality of the FBCT signal

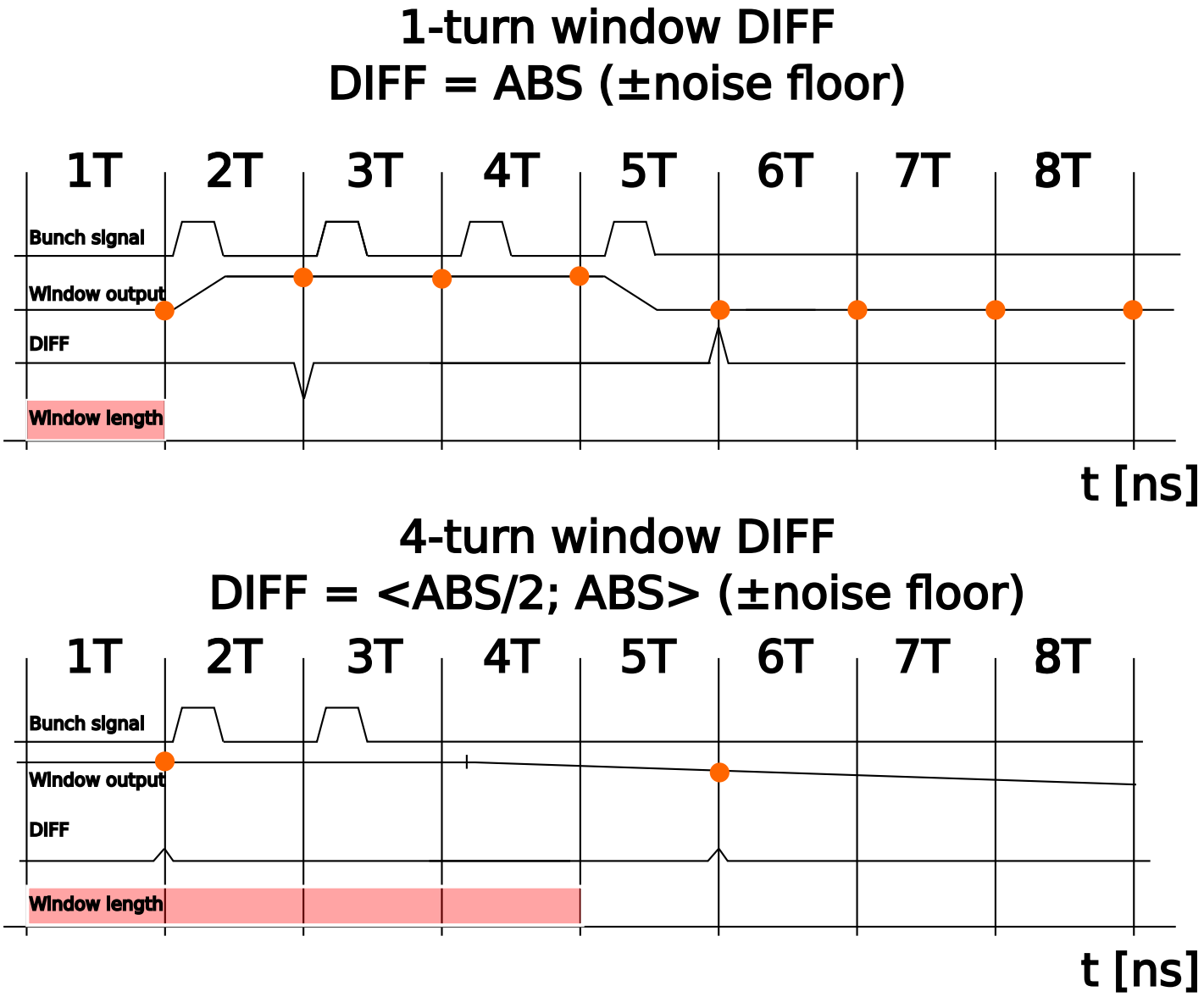
Proposal

- change the thresholds of the operational BCCMs to correspond to the table shown in this document
- change the thresholds for the development BCCM to 'some high value', which detects correctly the beam dumps, but does not cause the spurious dumps, let it run freely, after 2 months redo the graphs shown here for ICT, using ICT dump events

Thank you for your attention

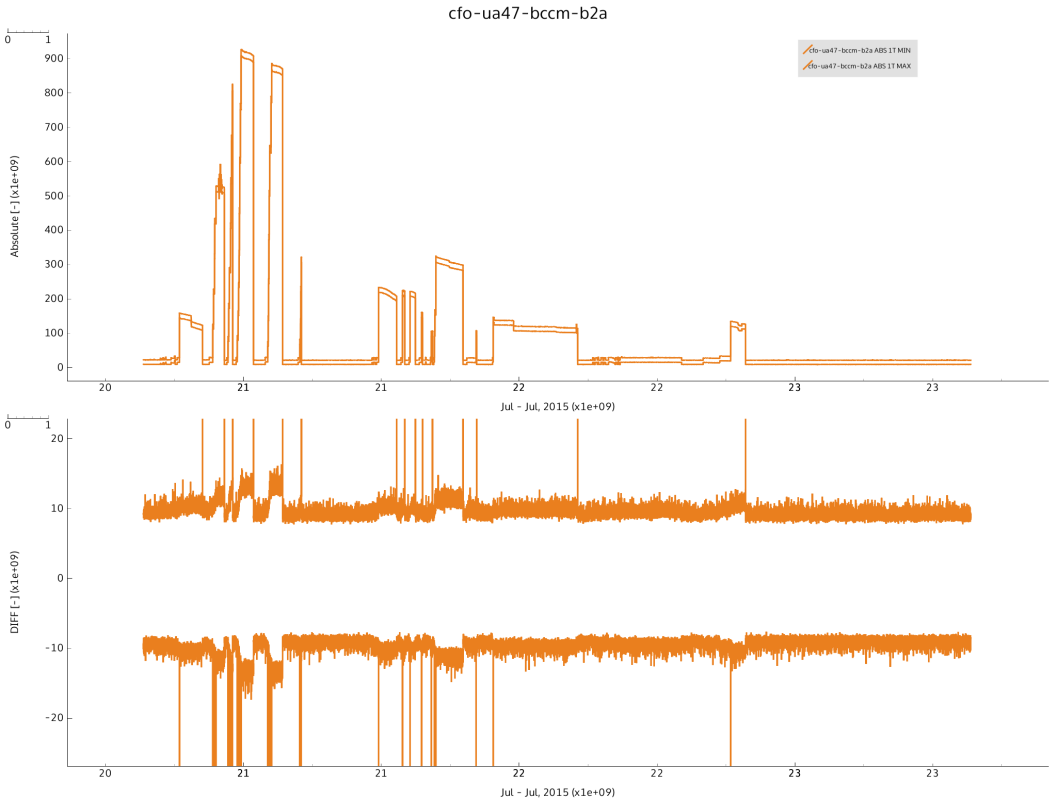
Additional slides follow

How the threshold is setup



Setting the threshold - 1T explanation

- On a single turn the value of DIFF should be a replica of ABS, taking into account the noise figures:



- for 1T window the noise is non-negligible, amplitude $\pm 1 \times 10^{10}$ ch/b.

Setting the threshold - other windows

- On other windows, the DIFF value can be anywhere between half and max ABS, as well taking into account the noise floor, which increases uncertainty.

What does that mean?

- If we want to setup the threshold to e.g. 3×10^{11} lost in single turn:
  - for the 1T window, with 1×10^{10} noise amplitude we have to set the threshold to (3×10^{11}) - $2\cdot(1\times10^{10})$ to have a 100% certainty to catch 3×10^{11} and 'some' certainty to catch 2.8×10^{11}
  - for all other windows, e.g. for 4 turn window - the DIFF for 3×10^{11} (per-turn) can be anywhere between 1.5×10^{11} to 3×10^{11}, again including the noise, which is however in higher turn window-lengths less dominant ($4T = \approx 5\times10^{9}$). So to catch 3×10^{11} with $>99\%$ probability the threshold has to be set roughly to 1.5×10^{11}.