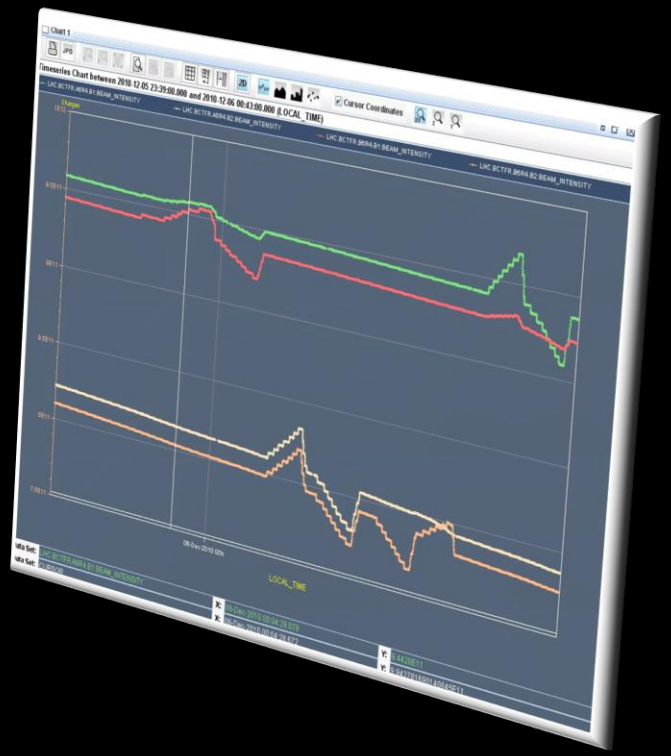


LHC BCTFR: OBSERVED ISSUES 2010

LHC BCT Day – 12/01/2011 – JJ Gras (BE-BI)

Presentation Overview

This presentation will list the different issues encountered with the LHC Fast BCT during 2010 and our working context and strategy during this period.

- The Difficult Context
- The Strategy
- The Observed Issues
- Conclusions

Our Difficult Working Context …

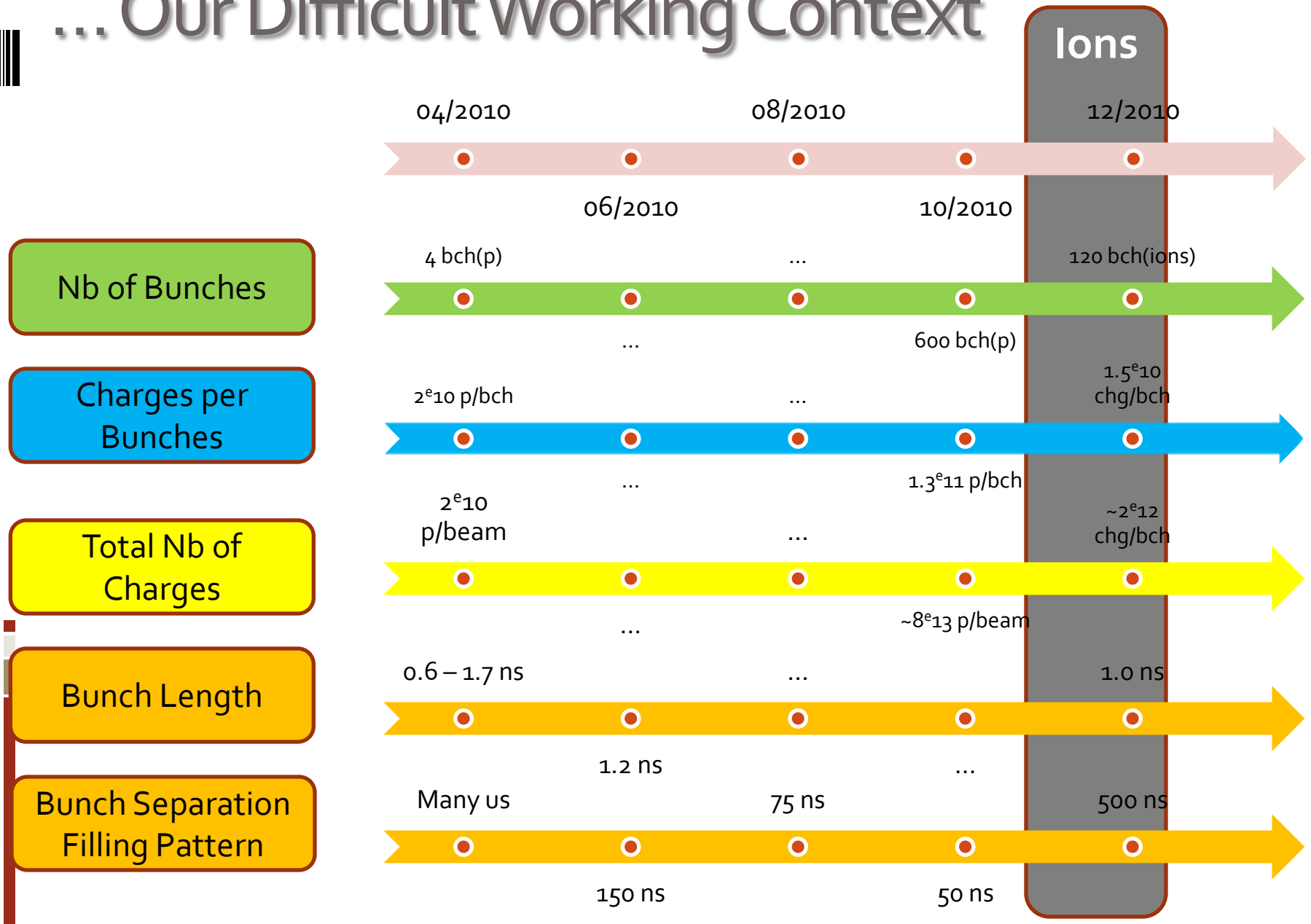
The **progress of machine** commissioning and operation (new bunch/beam intensity and filling patterns every couple of weeks) has been **incredibly fast and steady**.

Fortunately, BCT never prevented machine progress but with the consequence that we never had real opportunities for dedicated MD or access time.

In these conditions, we never had the time to analyze all the arising problems or to solve them properly when we understood their source.

The following slide shows the rapid evolution of critical parameters for beam current measurements during the year. We constantly jumped from one context to another (and so, from one issue to another).

… Our Difficult Working Context



The Strategy

We quickly realized that **the DC and Fast BCT calibrations were giving different results** (by more than 5%) when facing the same beam.

So we tried to apply the following strategy: **Check, trust and fixe systems from what we believed was the most simple to the most complex**, i.e.:

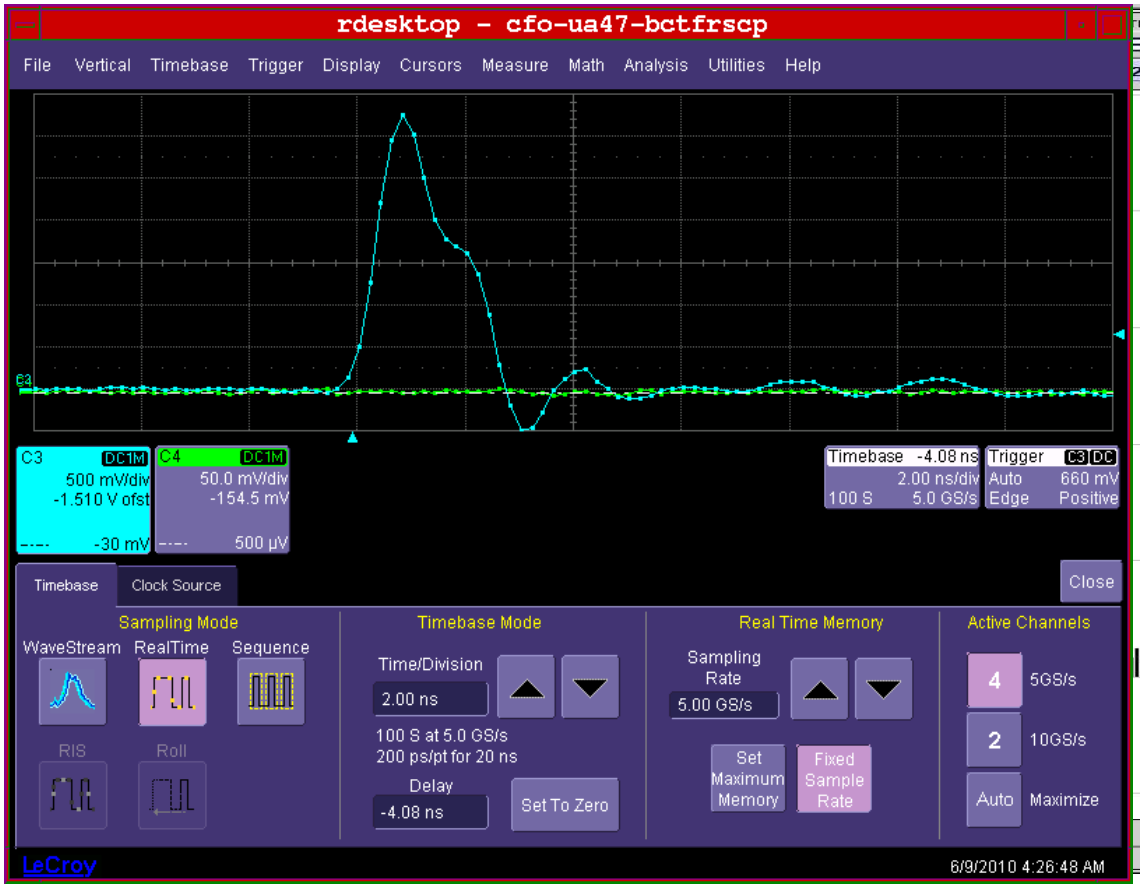
1. DC BCTs (no fast timing, no FPGA code, simple calibration procedure)
2. Fast BCT Low BW channel (complex FPGA code, complex calibration procedure, no bunch phasing necessary, no 'tail' response signal issue)
3. Fast BCT High BW channel (complex FPGA code, complex calibration procedure, accurate bunch phasing necessary, sensitive to tail signal)

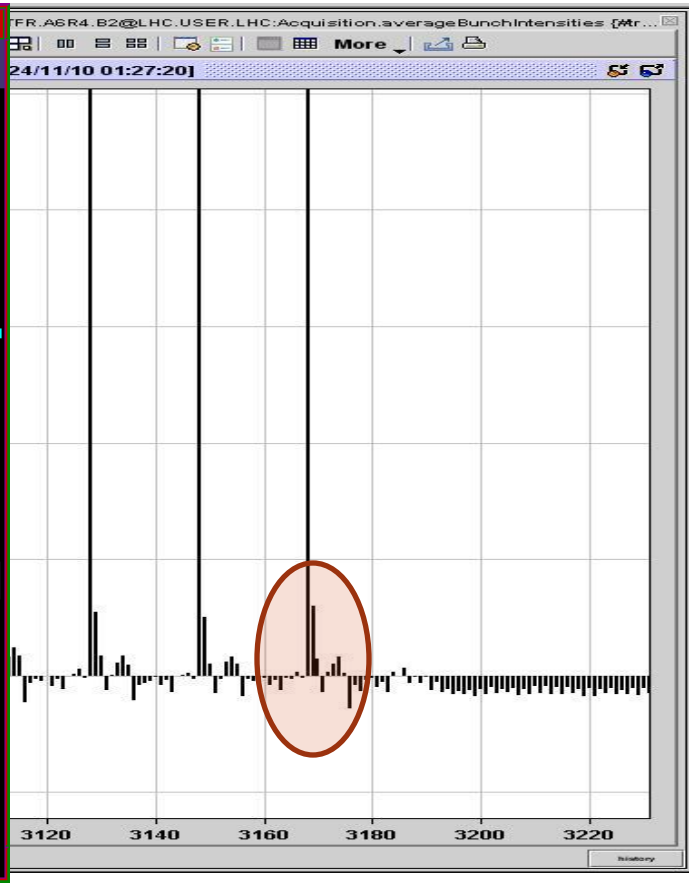
We used the BCT DC to cross-calibrate the 2 others and monitored the possible divergences between them at each new operational step to diagnose new problems. Basically:

- Who's right this time?
- What's wrong with the other and what could we do about it?

Issue #1: The Artificial Tails

- The signal arriving to our integrators has some tails leading to artificial intensity readings in the neighboring 25 ns slots. On some monitors, this can reach a few % of the real bunch intensity.

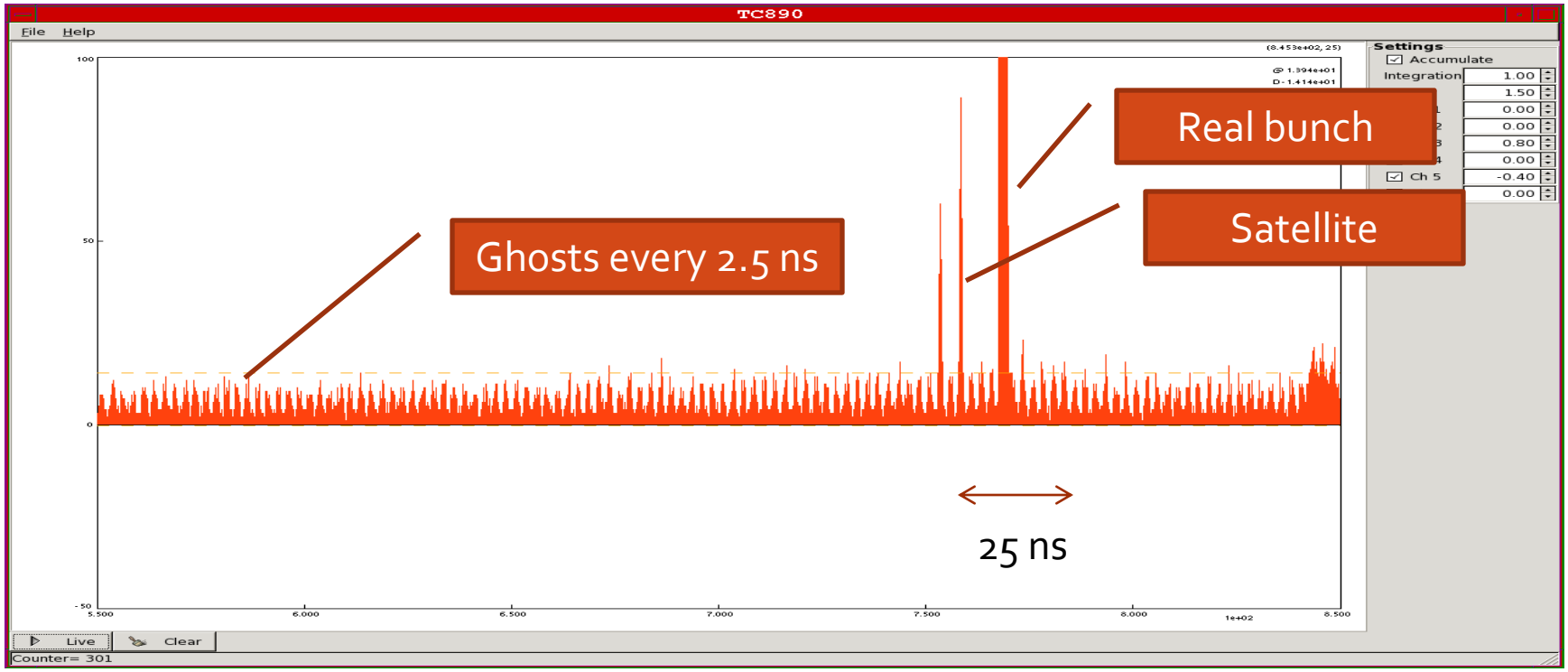




Issue #2: The Satellite and Ghost Bunches

The real bunches can be surrounded with satellites and small ghost bunches. These ghost bunches were in the very bad case bellow ~2000 time smaller than the main bunch. Satellites could reach the 1 % level. The problems are that:

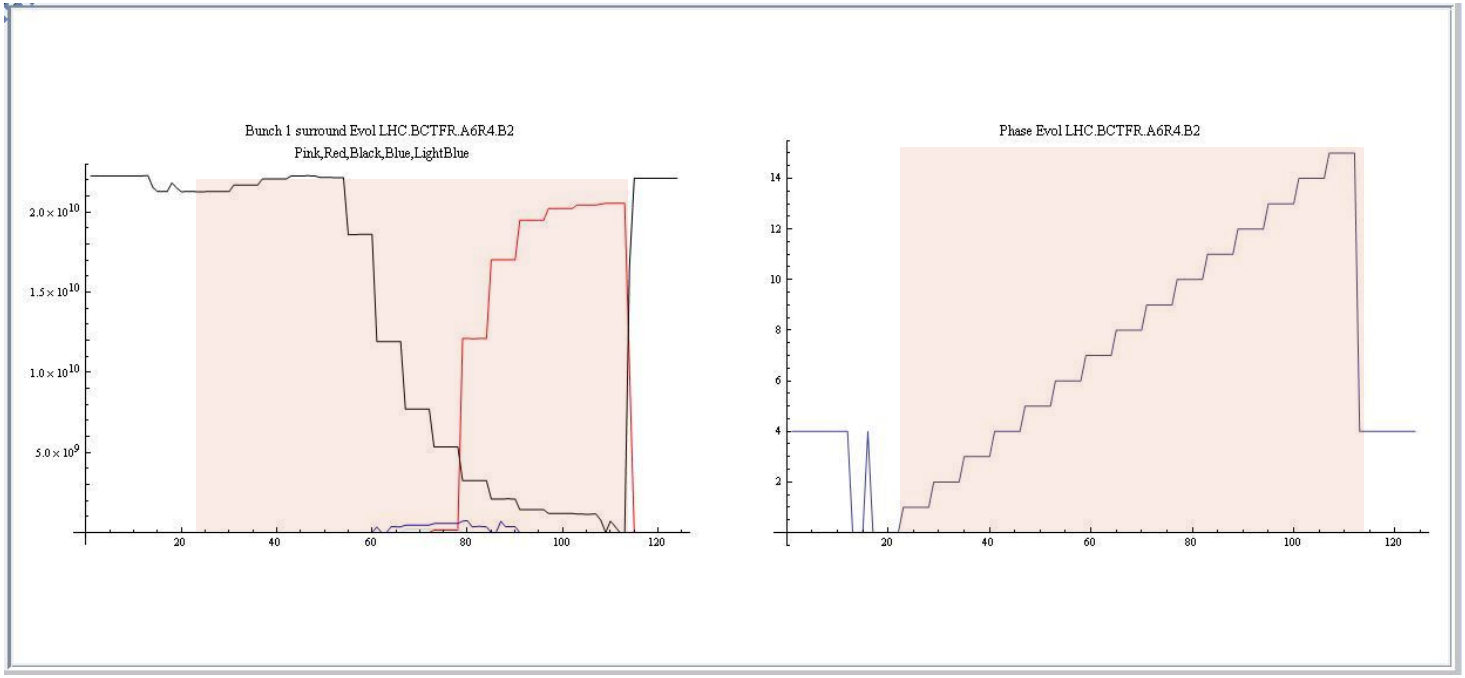
- Ghost are too close to noise level to be measured properly by fast BCTs
- We cannot know if the satellites are part or not of our 25 ns window due to our tail issue.



Issue #3: The Phase Setting and Stability

The 2 previous points makes it particularly difficult to set our bunch phase precisely. In addition, we will have to take into account that this phase can drift over the year by +/- 1ns due to fiber lengthening based on temperature variations.

Plot bellow shows measurement evolution on 2 consecutive 25ns slots while stepping the phase over 25 ns.



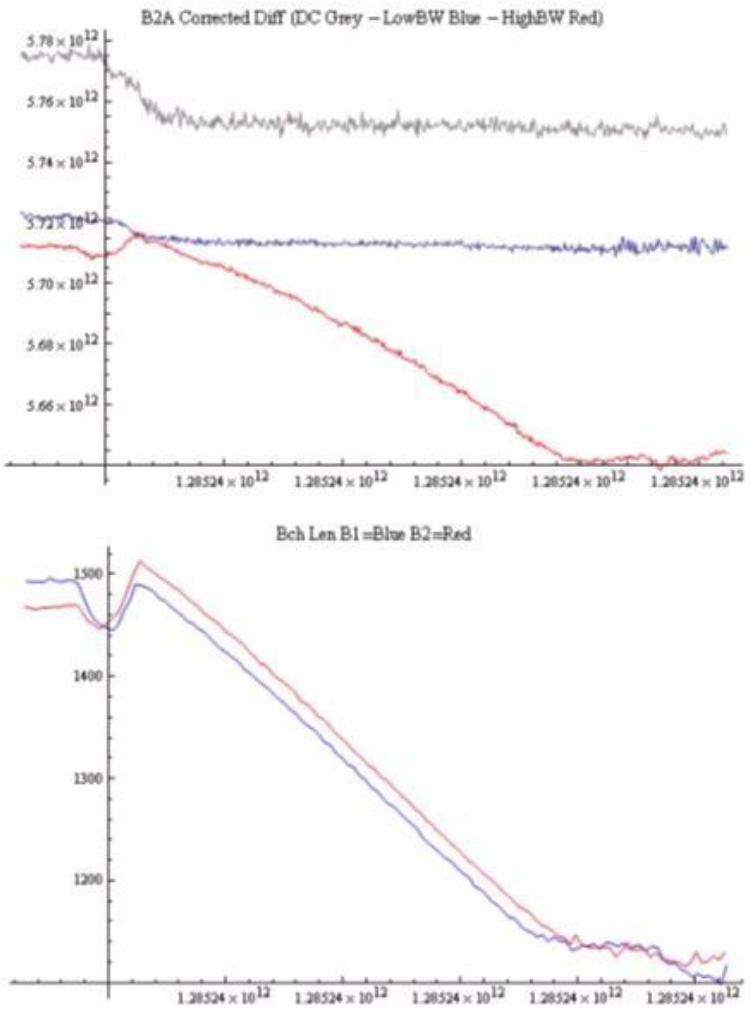
Issue #4: The Bunch Length Dependency

With nominal bunches, we also quickly realized that our high bandwidth fast BCT were sensitive to bunch length.

This plot shows on top the evolution of the DC in grey, low BW fast BCT in blue and high BW fast BCT in red while ramping.

Bottom plot shows the evolution of beam 1 and 2 bunch lengths during that time.

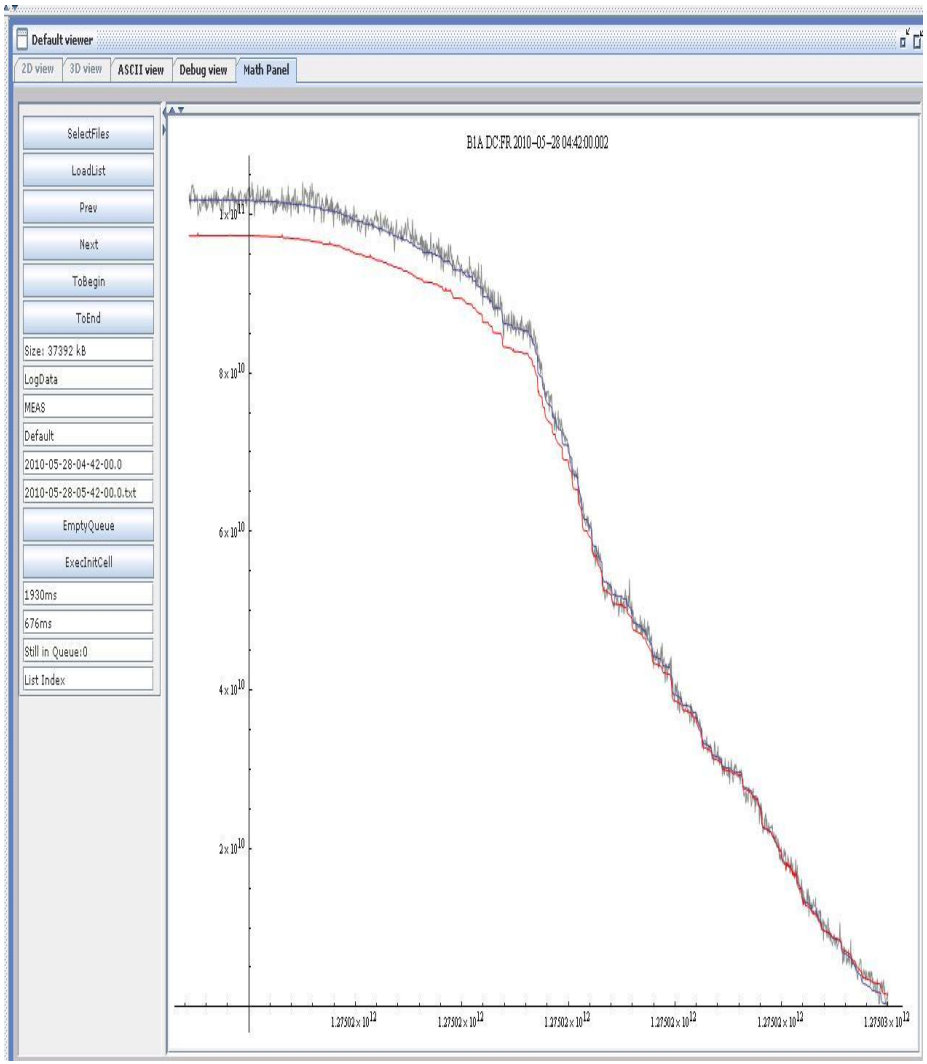
High BW drops by 1% while the others stay stable.



Issue #5: High BW Channel Saturation at High Bunch Intensity

Approaching nominal bunch intensity, we also noticed that the high BW fast BCT were partially saturating well before nominal intensity.

The plot shows the evolution of DC BCT in grey, low BW fast BCT in blue and high BW fast BCT in red during a nominal bunch scraping MD.

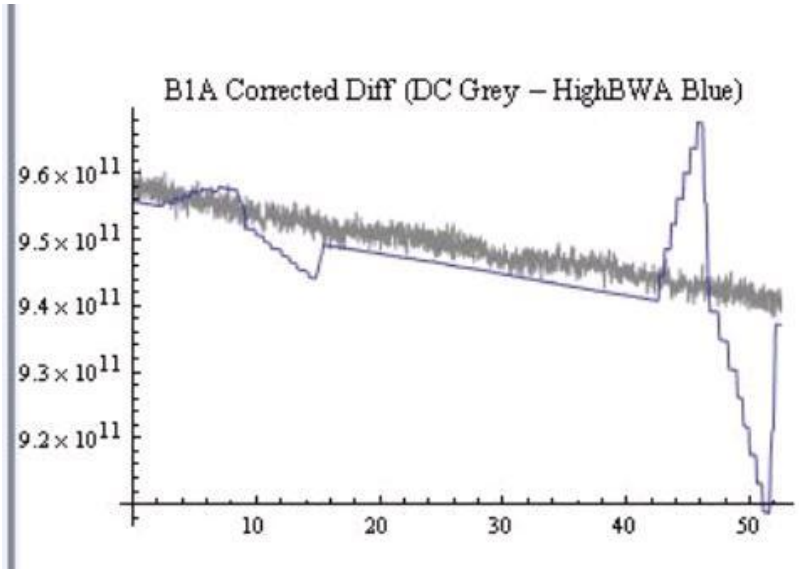


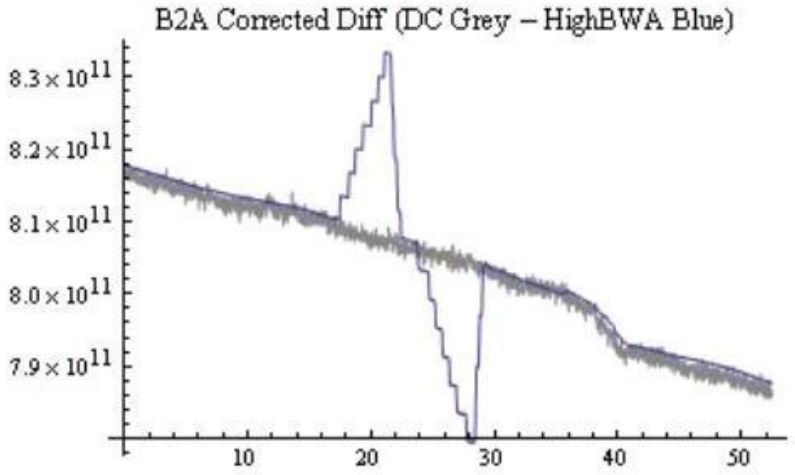
Issue #6: The Bunch Position Dependency

We finaly realized that our fast BCT measurements also depend significantly from beam position.

The plot below shows the evolution of the DC in grey and the high BW fast BCT in blue for beam 1 and beam 2 during position bumps.

The variation has been estimated around 1%/mm.





Conclusions

The described issues explain why our attempts to calibrate directly the fast BCTs failed so far.

We will have to continue relying on cross-calibration on well know conditions until the bunch length and position (and filling pattern?) fast BCT dependencies are solved or at least controlled.

But in the end, our 25 ns integration mecanism will still not be able to filter /estimate the close satellite bunches and it will be difficult to reach the <1% absolute accuracy requested for the VdM scans in all conditions .