Performance reach and design goals for Beam Current Change System

MPP-BE/BI-MW MPP meeting November 2012

Acknowledgements: D.Belohrad, J.Burdalo, M.Pfauwadel (CERN), M.Werner (DESY)

Brief history and motivation of Beam Current Change System
First results and Observations with beam
Proposal for design goal for post LS1 operation

Brief history of project 1/3

LHC operation after LS1 will pose new challenges to Machine Protection (higher beam energies, tighter collimator settings, lower quench levels, instabilities, UFOs,…)

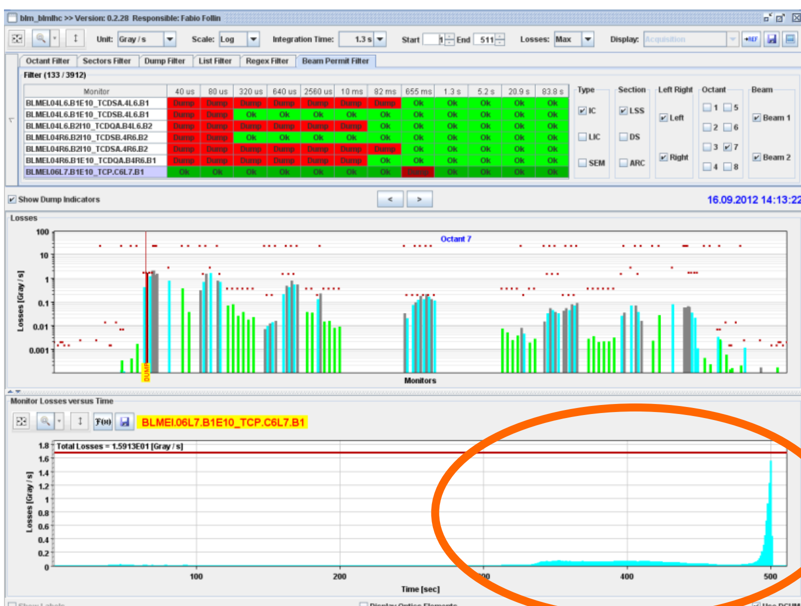
Increased reliance on BLM system for protection

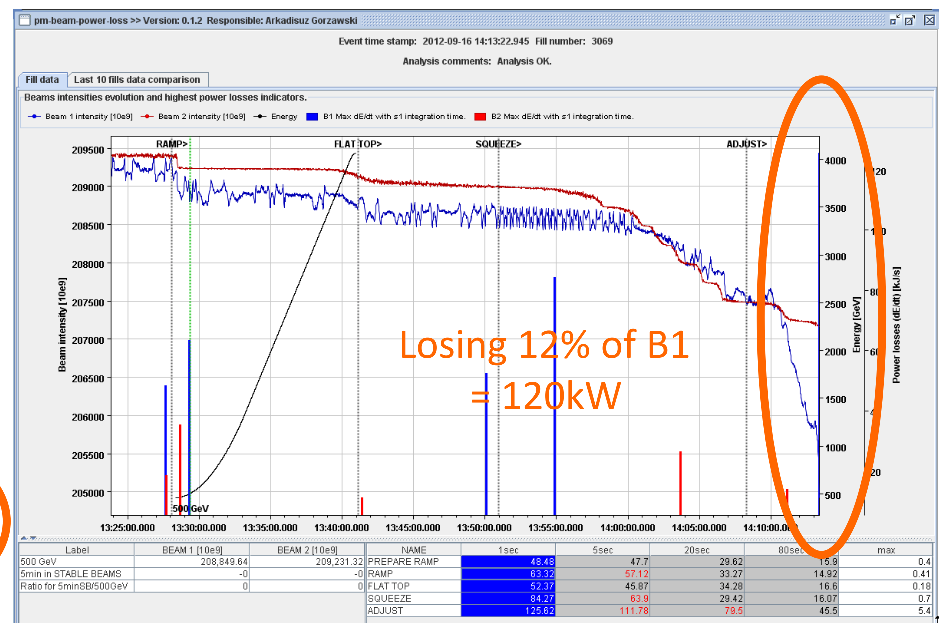
Beam Current Change Monitor was vital part of MPS systems for e.g. HERA

Proposed for use in LHC MPS in 2005 (EDMS Doc. 359172)

With a similar principle, changes of < 0.1% of total beam current could be captured in 10 turns

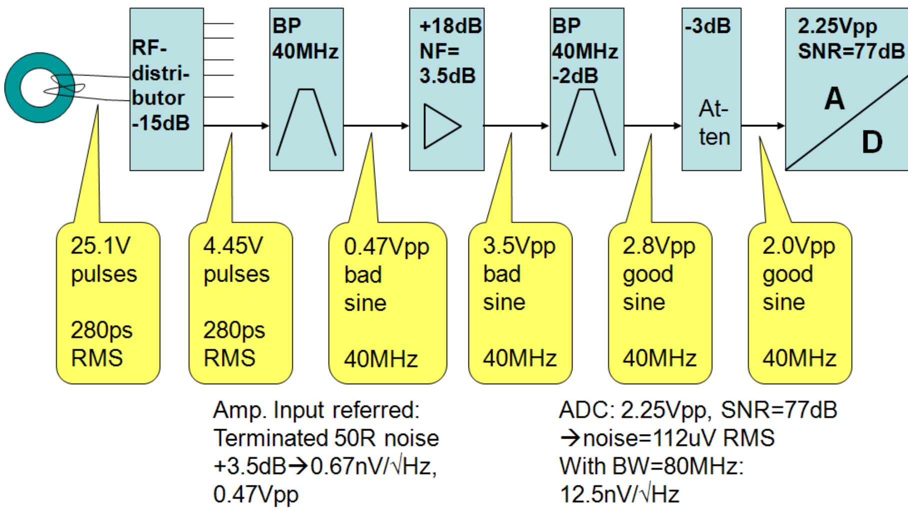
BI started development (with DESY consultancy) mid 2010, for deployment during 2012 run





Brief history of project 2/3

Dynamic range and noise (1)



- Dynamic range and noise will determine (theoretically) achievable detection level

- Detailed design study and noise estimation performed (mid 2012)
- No (theoretical) show stopper to achieve required protection levels

Detailed presentation

Protection levels

Protection level (full beam) **for reaction time = 1 ms**	Number of particles	Part of full beam (4.8*10^14p)
Useful *	$4.8*10^{12}$	10^{-2}
(old Hera system)		10^{-2}
good	$4.8*10^{11}$	10^{-3}
First performance goal of BCM	$4.8*10^{11}$	10^{-3}
damage level (7TeV) *	$1\text{-}2*10^{10}$	$3\text{-}6*10^{-5}$
Theoretical performance limit of BCM (with 1 ADC)	$2.3*10^{9}$	$4.8*10^{-6}$
Full protection (7TeV) *	$1*10^{9}$	$2*10^{-6}$

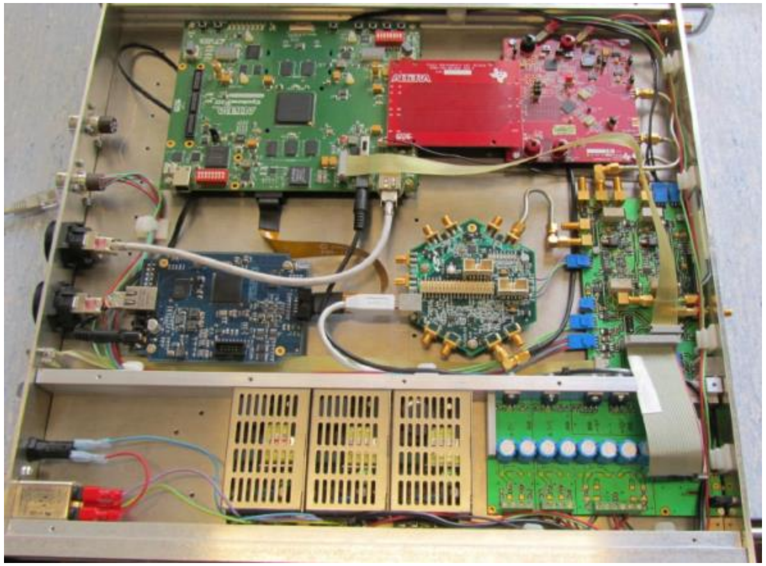
Brief history of project 3/3

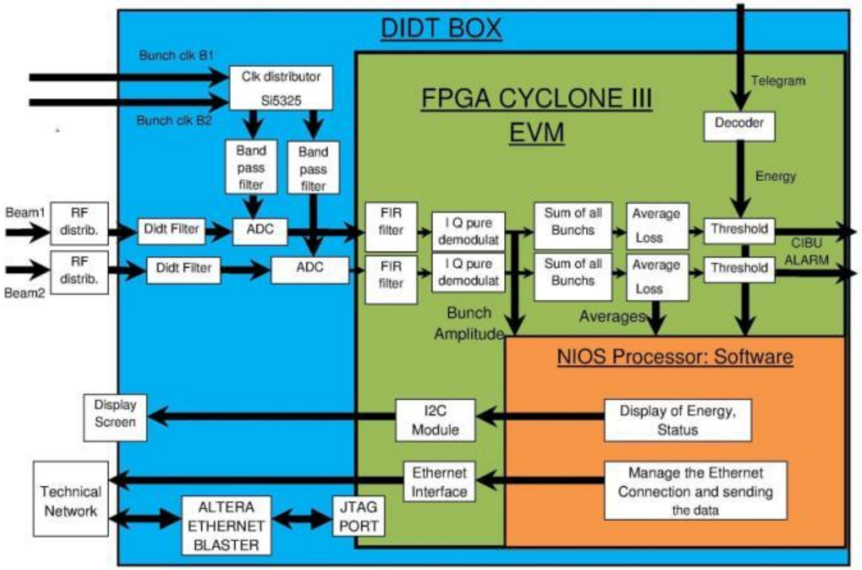
HW conceived and constructed by BI along the lines of the proposal during 2010/11 (based on Altera, A/D development boards)

Remotely programmable through Ethernet

First box installed end of 2011, connection to FESA class early 2012

Data taking and analysis ever since



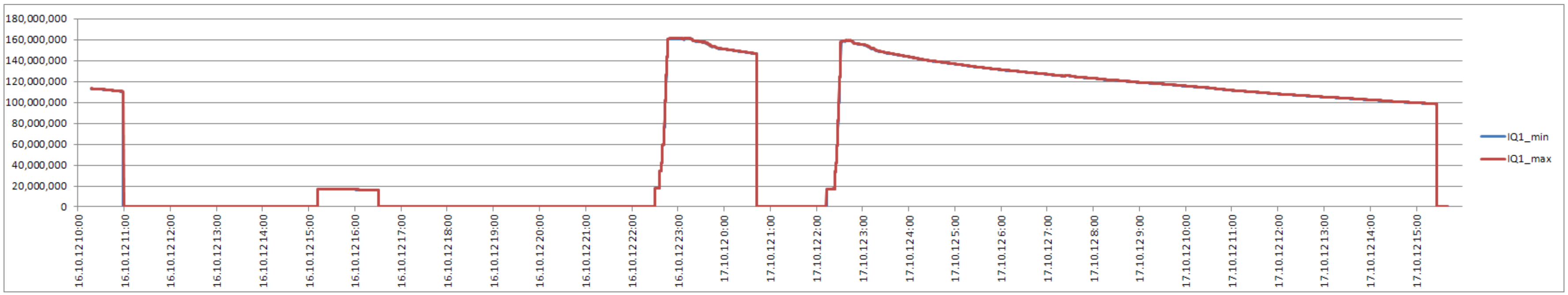


Courtesy of M.Pfauwadel, D.Belohrad – MPP presentation Sept 2011

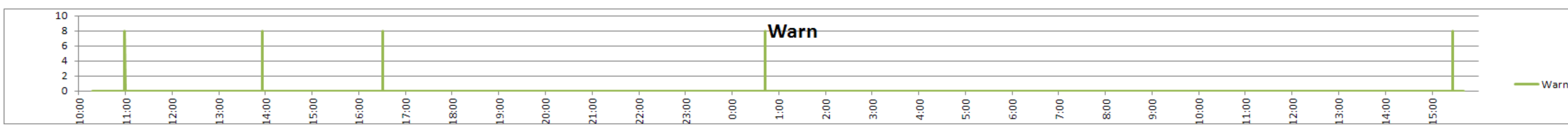
Recent operational experience

Beam dumps generated during 16.-18.10.2012 with threshold of 0.1% on BI HW on System B + firmware MW

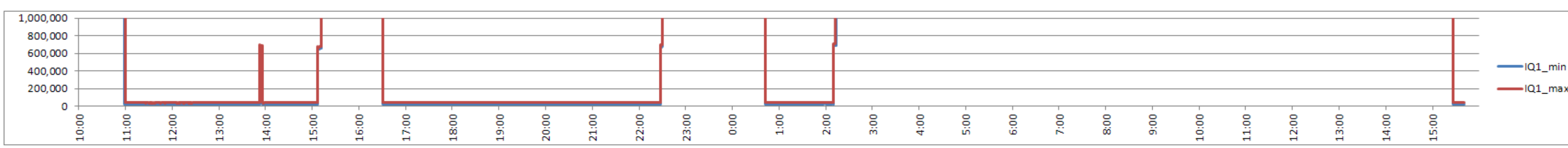
Intensity (max 2.2E14p?)



Alarms

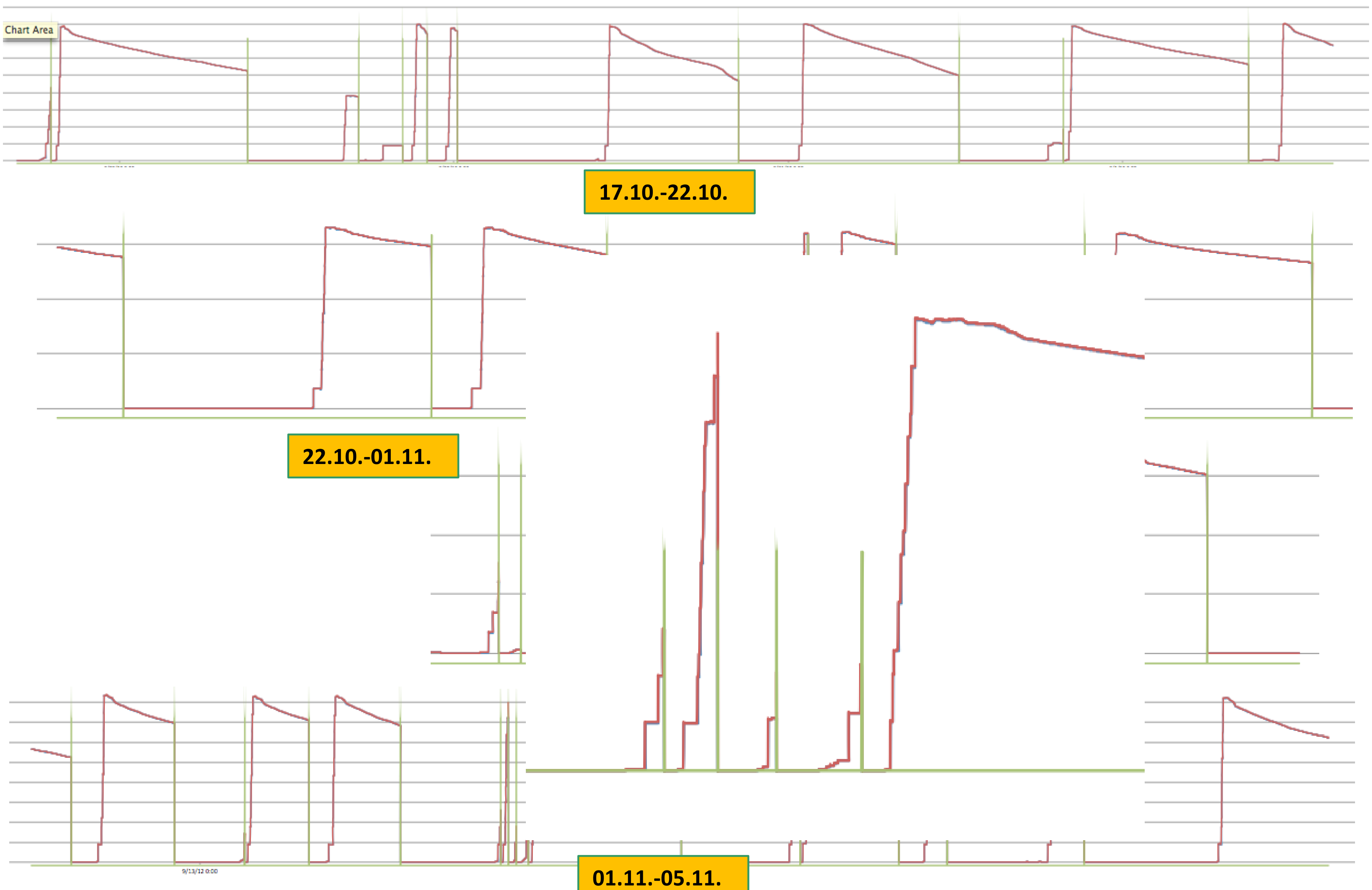


Intensity zoomed



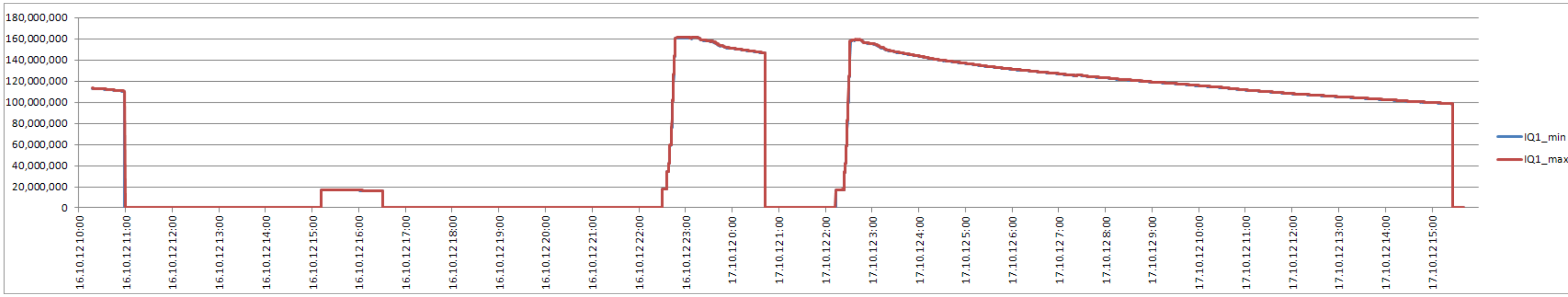
→ Threshold works as expected, no false dumps!

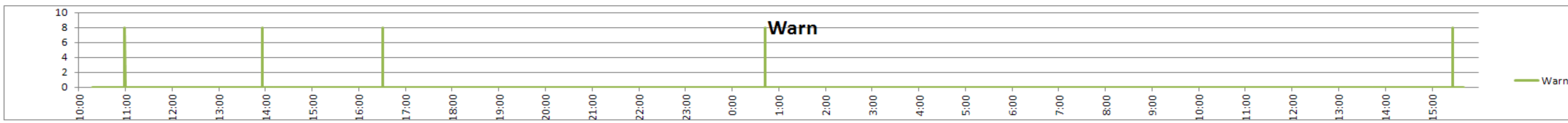
Stability over past 3 weeks with 0.1%

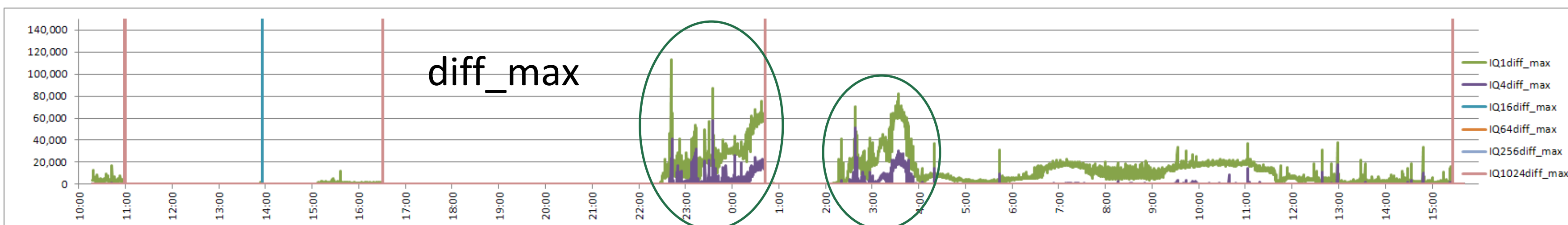


Possible threshold during SB

Intensity (max 2.2E14p?)







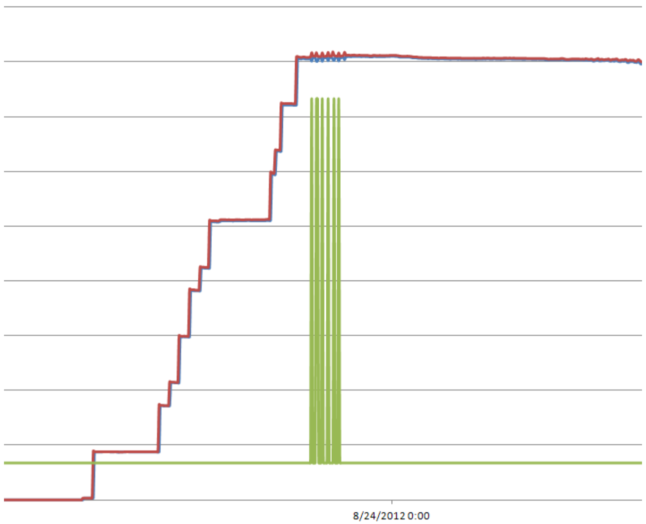
0.10%   0.07%

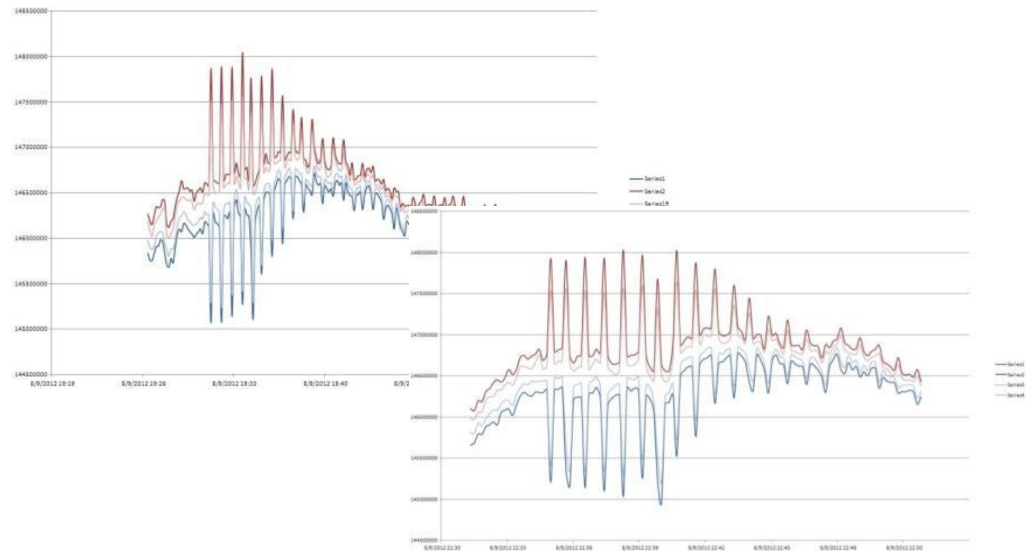
0.04%

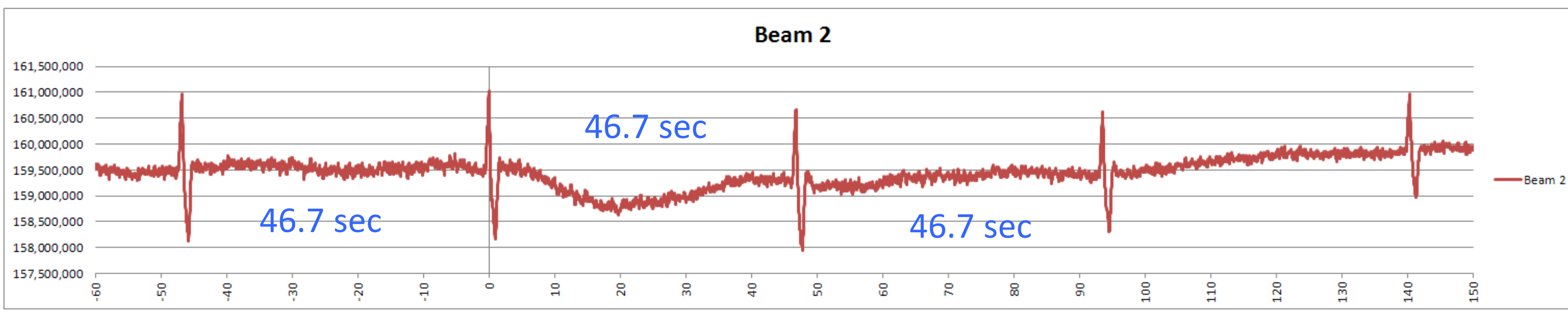
Noise around and after injection – caused by position dependence

With present toroid, a threshold down to 0.04% (plus headroom) could be set for stable beams

Suspected position dependence of Toroid







- Effect originating from pulsing TI2/TI8 transfer lines which continue after end of LHC injection (when super-cycle changed current is reduced to 3% of I_nom)
- Orbit changes of some 10um, FBCT sensitive to such transient orbit perturbations -> Current system limitation

Single Turn and continuous losses

The current BCM HW + MW fimware will (with actual parameters will generate a dump signal for a high intensity beam (2.2E14)

- after a single loss above 0.1%
- after 10 turns of a continuous loss above 0.02% per turn

Threshold is hit for following conditions:

ΔT	Total loss during ΔT	Loss per turn during ΔT
1 turn	**0.10 %**	0.10 % per turn
2 turns	0.11 %	0.055 % per turn
4 turns	0.13 %	0.033 % per turn
8 turns	0.17 %	**0.021 % per turn**
16 turns	0.25 %	0.016 % per turn
100 turns	1.09 %	0.011 % per turn

Current system parameters (not to be used for ‚final' operation):
threshold = 0.09%, track speed = 2E14p per sec,
no averaging

Derived Design Goals of BCM

With the actual unchanged implementation of the (inital) BCM HW + Desy firmware for an intensity of 2.2E14 (with a fast „track speed“ of 2E14p per sec.)

- A threshold of 0.10% has not generated any fake dumps during the observed time window of 3 weeks
- A threshold of **0.15%** beam loss over 1 turn is set as initial design goal for the BCM
- Optimizing for fast losses rather than slow (lower) losses

Future improvements

- **With energy + time (beam mode) dependency thresholds** could be **0.06%** for stabe beams @ high energy and an intensity of 2.2E14 (derived from the diff_max measurements). A dependence on beam mode is not recommended for reasons of simplicity.

- **Intensity dependent treshold:** Recommended, as perturbations seem proportional to total beam intensity (not clear why?), hence for lower intensities a considerably lower threshold could be set. ‚Easy‘ as no additional dependency needed to do this.

- **By reducing the position dependence of the toroid** and more R&D a threshold of below 0.03% seems to be realistic (additional tests with full intensity and beam energy required).

Conclusion and outlook

- Very promising results with system in past months, confirming design principle + initial performance goals
- BI is currently finalising the operational system to have a fully operational system (the latest) for post LS1 startup
- BCM connected to MASKABLE BIS input (to allow masking with SBF)
- Question to operation: Could such an addition system impose a limitation for operation (e.g. loss-maps, MDs,...)
  - Do we need to look at a (dependable) way to remotely change thresholds?
- Anything else we might want to include/have to think of?

Fin

Thanks a lot for your attention!

BI/MPE meeting 1st of June 2012

.. DIDT system - known issues ..

Two main issues identified:

- Problems linked to bunch position and bunch length dependence of the FBCTs, along with various noise signals captured by the FBCTs due to electro-magnetic coupling of the transformers to external noise sources.
- Un-explained behaviour of the DIDT system under 'some' conditions. This is mostly represented by short and long term noise present at the output signals of the DIDT box and drifts in the offset

These issues are currently determining the resolution of the threshold setting.

Observation: the DIDT seems to be more sensitive to non-linearities in the transformer response than the fast intensity measurement itself. Probably due to different signal processing bandwidths.

Courtesy of M.Pfauwadel, D.Belohrad

.. example FBCT noise ..

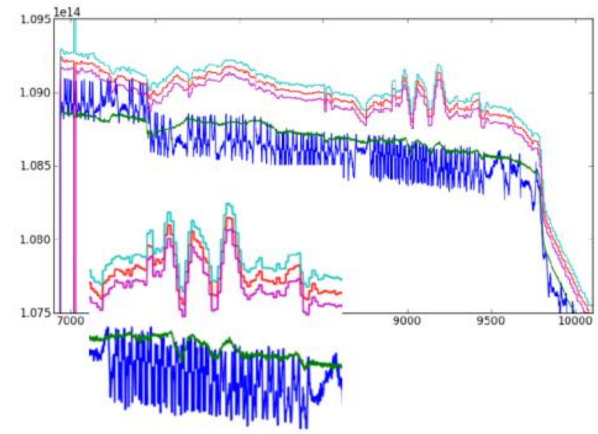


Figure: Noise induced by FBCT (green=FBCT, cyan/red/mag=DIDT)

.. unexplained DIDT noise increase ..

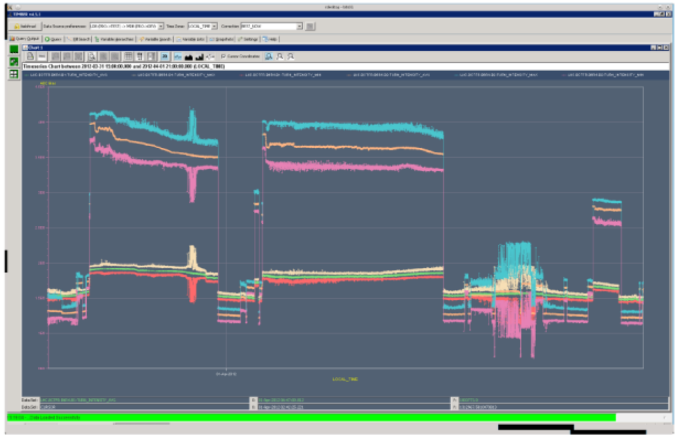


Figure: Noise acquired by DIDT (1pt≈average over 8000 turns sampled)

Minutes of meeting

Dear All,

Thank you for your presence at last week's dI/dt meeting.
Below you can find my notes and agreed follow-up actions:

- dI/dt system now fully implemented, with only the CIBU connection remaining to be coded in the firmware.
  - Will be done between now and the June TS (ACTION: Mathias P.)
- System A
  - Will be made "operational" using the latest firmware once the CIBU connection is coded
  - System will be connected to the CIBU, but the channel will remain masked
  - Will be used for long term analysis of dI/dt behaviour
  - Will initially have a single threshold implemented for all averages and energies. The aim is for 1e11 but exact level to be calculated from acquired data (ACTION: Mathias P.)
  - Should have PM pushed every time it triggers even when no global PM (ACTION: Lars Jensen)
- System B
  - Will be installed during the June TS running Mathias Werner's FPGA code (ACTION: TE-MPE)
  - Acquisition via PC.
  - Should store the data in the same format as the A system to allow direct comparison (ACTION: TE-MPE)
  - Will remain in the machine for 1-2 weeks to allow data to be taken with and without beam. After this time TE-MPE will request an access to re-connect the system to the BI acquisition system. (ACTION: TE-MPE)
  - BE-BI will then re-load its own firmware onto this system to allow continued development, taking into account any results from the tests performed using Mathias W.'s implementation.
- Other issues
  - Eventual energy scaling of thresholds can be performed either via a formula (if this can be coded in the FPGA) or via a look-up table. The maximum number of energy levels does not need to exceed that used by the BLM system. (ACTION: Mathias P.)
  - Noise issues will continue to be investigated by BE-BI. (ACTION: David & Mathias P.)
  - Slow offset drift also to be fully understood. (ACTION: BE-BI)

David & Mathias P. will arrange to meet Mathias W. for ½ a day during his visit next week to show him the results obtained so far and get his input or suggestions for further improvement.

Please let me know if you agree to this or have any comments or corrections to make.
Otherwise I will post this summary as minutes of our meeting on the BI Technical Board website.
Thanks,

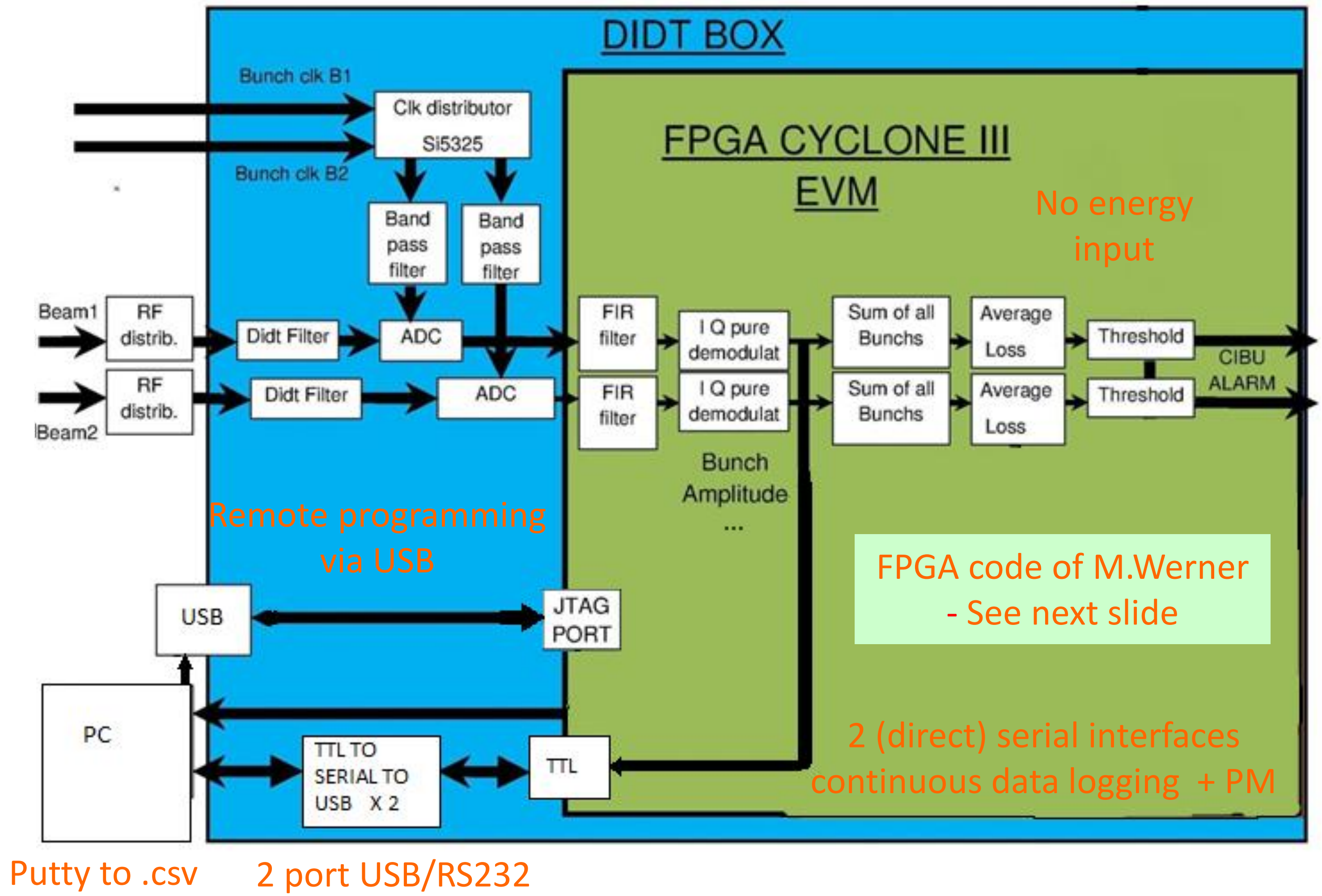
Rhodri

3 MPE actions identified and follow up …

Timeline of investigations performed

- June 1st: Meeting with BI
- June 4-6 visit of Matthias W. for CLIC MPS Workshop -> First evaluations of System C in lab
- Finalisation of serial interface + installation prep (finishing BI prototype)
- 25-28 June: System re-installed on B1 of System C during TS #2 -> Noise measurements in the tunnel
- Continuous data logging as of 29th of June on B1 of System C
- 5 July: ‘SW Dump’ signal added to data Logging
- 25 July: DIDT system removed from LHC for filter improvements by BI
- 09 August: DIDT system re-installed into LHC on B2 of system C (unfortunately no gain observed) + firmware upgrade with IQ<n>diff_max functionality
- 15 August: Firmware upgraded with PM functionality
- Threshold adjustments and optimisations
- 19 September: Connection to CIBU

‘Modifications’ of DIDT box on System C

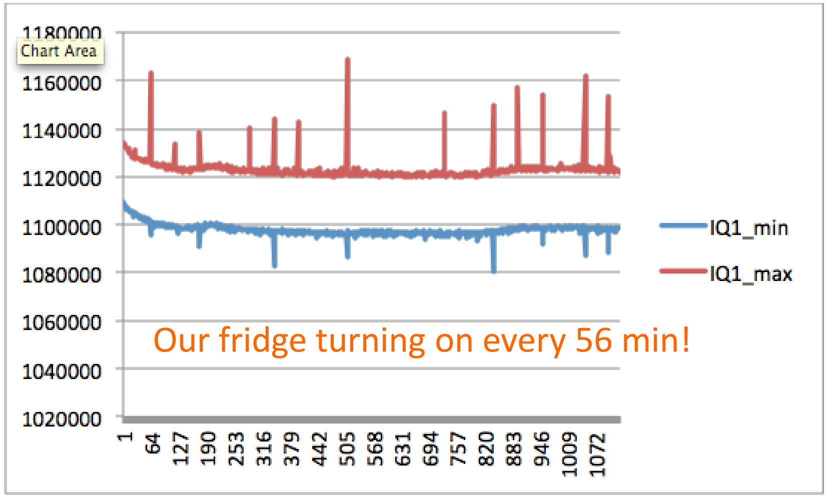


‘DESY’ FPGA code

- Started with a separate I and Q demodulation, later added a “pure IQ demodulation” plus low width 40 MHz bandpass (special design for high resolution). Tests showed that phase control will probably not improve the performance.
- Averager: special low latency design (internally averaging windows are subdivided in 16 sliding windows)
- Threshold comparator: tracking design with variable tracking speed and individual thresholds for each averaging stage
- Minimum/Maximum display: neatless data acquisition to detect all events
- Post Mortem Recorder
- Logging of Min and Max of I, Q and IQ averaged over 1, 4, 16, … 16384 turns
- Main “DSP engine” is clocked by only 40 MHz → easier implementation
- No microprocessor → less complex, fast compilation
- “diff_max” as key to derive the correct thresholds

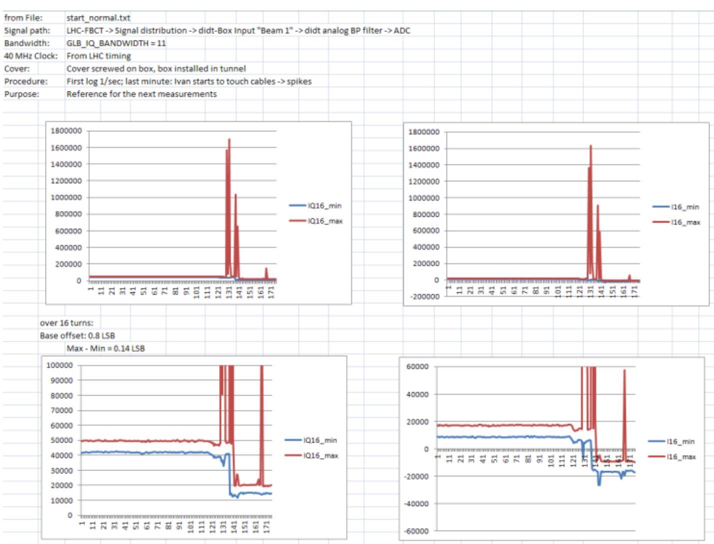
Initial Lab tests

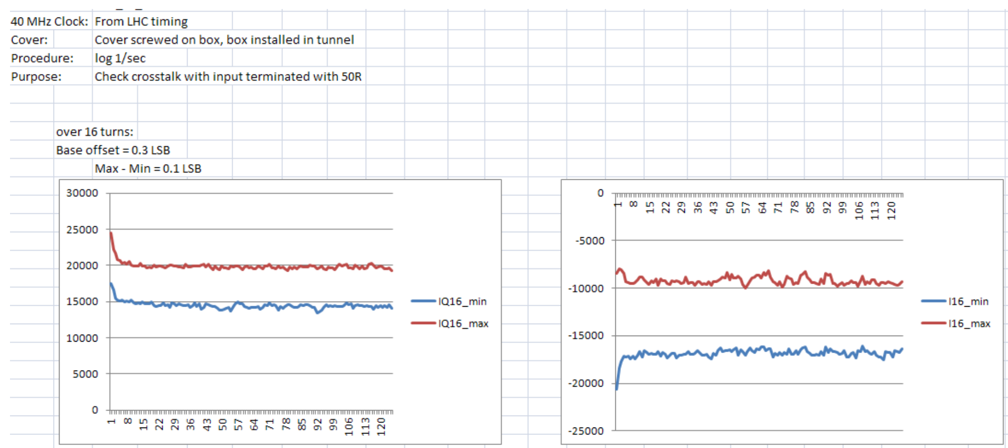
- Initial measurements of bandpass filter and base noise in lab, using signals from the Si5326 board and signal generator
- Measurements to check linearity of Bandpass filter (clipping detected)
- Measurements to check 40 MHz crosstalk inside the box
- Multiple measurements sweeping phases, amplitudes and values of attenuation
- Found bandpass not well calibrated on the 40MHz, in conjunction with additional 6dB on System C in the tunnel decreasing effective input range at the ADC to 10-20% (still the case today; since connected to B2 twice the signal? -> No signal splitting?)
- In lab, noise levels in the expected range, however unexpectedly high 40MHz crosstalk coming from the bandpass-filter (wrt to the ADC), might be from digital electronic (FPGA), possibly due to design of the filter board or the layout of the box



Noise measurements in tunnel

- Noise floor in the tunnel found around a factor of 3 higher than in the lab
- Seemingly coming from crosstalk of 40 MHz component to the signal(s) inside and outside the box, leading to an offset in the display
- Based on first noise measurements, we set initial thresholds to 4e11p for 1 turn (max loss rate of 6e11p/sec), and 2e11p for 256 turns (max loss rate 3.7e10p/sec)

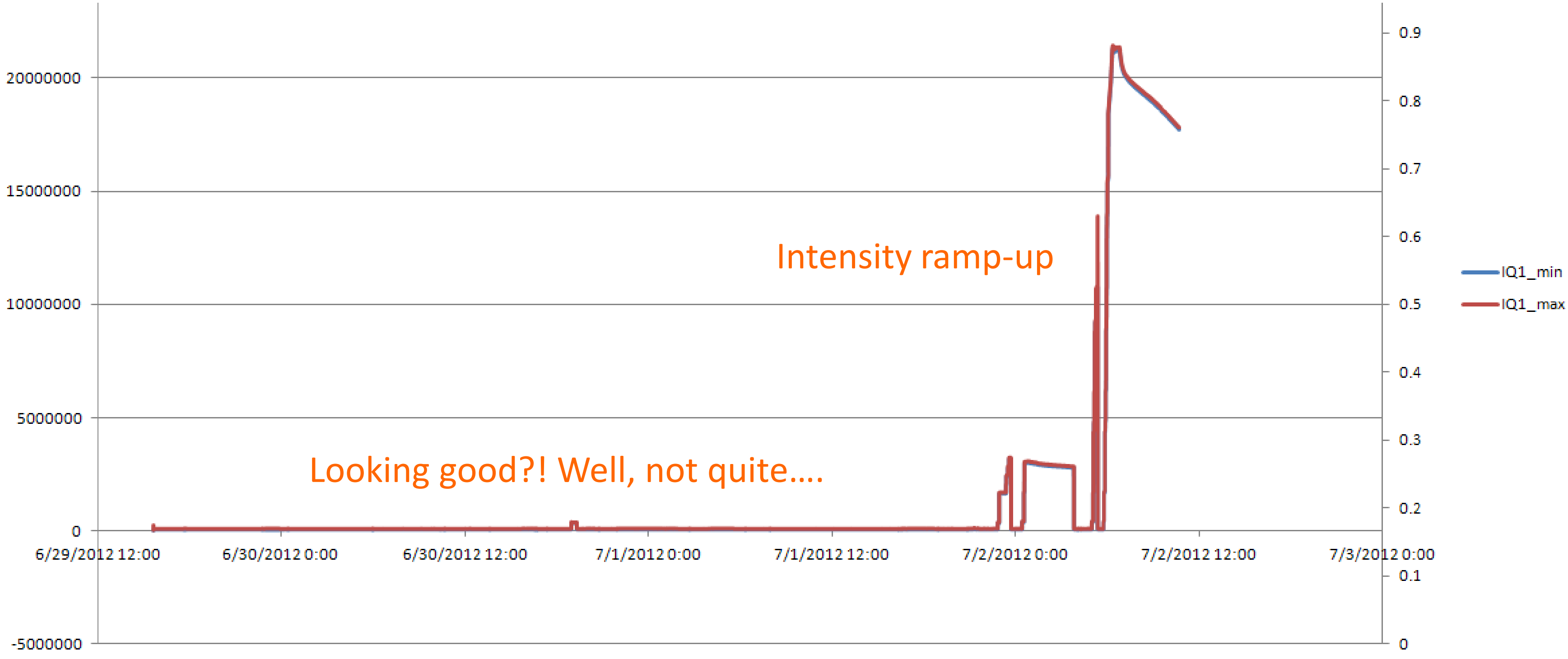




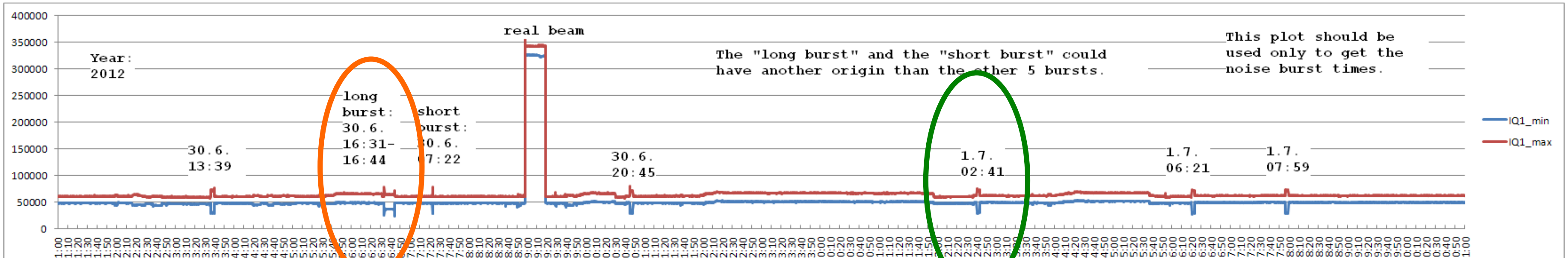
	Base offset [LSB]	Max - Min (over 16) [LSB]	sqrt(I^2+Q^2) [LSB]
50R -> ADC	0.08	0.07	0.02
50R -> filt -> ADC (lab)	0.08	0.1	0.06
50R -> filt -> ADC (tunnel)	0.3	0.1	0.23
FBCT -> filt -> ADC (tunnel)	0.8	0.14	0.8

1st Data

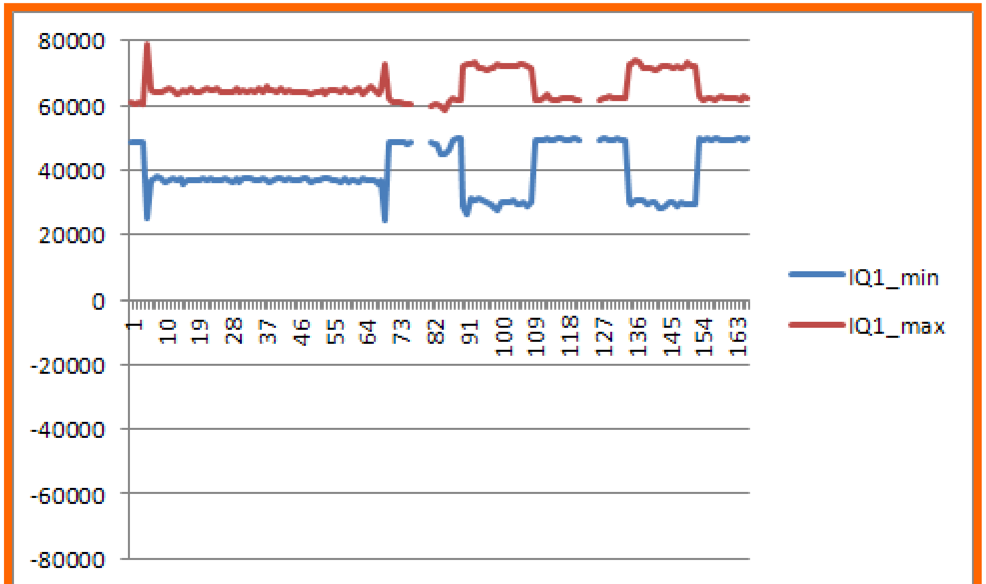
- First data recorded as of end of TS#2
- IQx_min/max: sqrt(I^2+Q^2) every 25ns, interleaved averages over x turns, minimum/maximum of all interleaved averages of the last logging interval, with x = 1, 4, 16, 64, 256, 1024, 4096 and 16384 turns
- Idem for individual I and Q components and I/Q_samp (**I/Q**-value every 25ns, averaged over **x** turns, only one of these samples is used)



Noise burst at injection energy

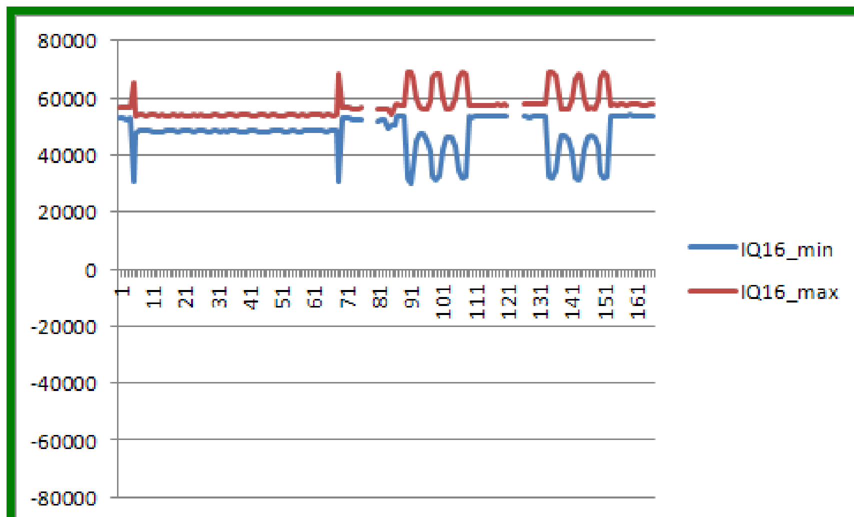


- Repetitive noise bursts at at injection level at random moments?

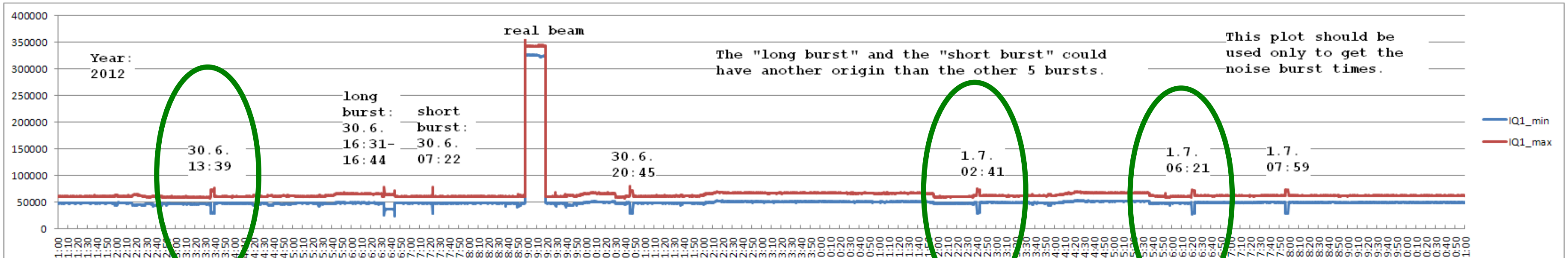


Single long noise burst

Short noise bursts, appearing repeatedly…



Short bursts = RF LBDS checks…



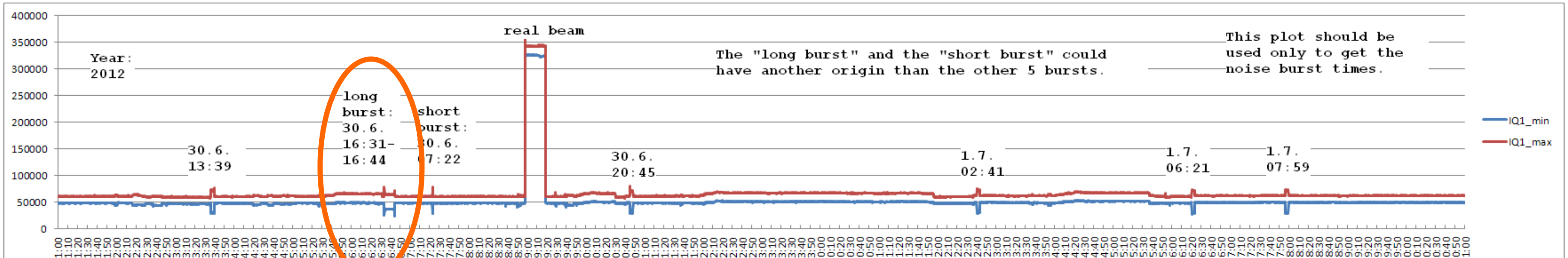
108	13:35	SUP	LHC SEQ: B1&B2 transfer line coll at injection settings
109	13:35	SUP	LHC SEQ: BLM MCS and SANITY CHECKS finished
110	13:36	SUP	ELOGBOOK: STARTING B1 MKISS
111	13:36	SUP	ELOGBOOK: STARTING B2 MKISS
112	13:37	SUP	LHC SEQ: B1&B2 injection protection coll at injection settings
113	13:37	SUP	LHC SEQ: B1&B2 ring cleaning coll at injection settings
114	13:38	SUP	LHC SEQ: B1&B2 dump protection coll at injection settings
115	13:39	SUP	LHC SEQ: RF LBDS frequency checks done
116	13:41	SUP	LHC SEQ: resynchronize RF beam control SPS connected finished

49	02:35	SUP	LHC SEQ: BIS pre-operational checks finished
50	02:38	SUP	LHC SEQ: BPMLHC calibration finished. Overall result: SUCCESS Chosen bunch spacing: (B1 & B2) BUNCH_1 (manually chosen) (For more details see BI-LHC ELogBook)
51	02:43	SUP	LHC SEQ: DC BCT calibration finished. Overall result: SUCCESS
52	02:43	SUP	LHC SEQ: RF LBDS frequency checks done
53	02:43	SUP	LHC SEQ: BLM MCS and SANITY CHECKS finished
54	02:45	SUP	LHC SEQ: resynchronize RF beam control SPS connected finished
55	02:50	SUP	LHC SEQ: Load coll energy thresholds (B1&B2 ring, tcdq) finished
56	02:50	SUP	LHC SEQ: B1 Collimators to parking starting

112	06:16	SUP	LHC SEQ: BPMLHC calibration finished. Overall result: SUCCESS Chosen bunch spacing: (B1 & B2) BUNCH_1 (manually chosen) (For more details see BI-LHC ELogBook)
113	06:17	SUP	LHC SEQ: B1&B2 injection protection coll at injection settings
114	06:17	SUP	LHC SEQ: B1&B2 ring cleaning coll at injection settings
115	06:18	SUP	LHC SEQ: DC BCT calibration finished. Overall result: SUCCESS
116	06:18	SUP	LHC SEQ: B1&B2 dump protection coll at injection settings
117	06:21	SUP	LHC SEQ: BLM MCS and SANITY CHECKS finished
118	06:23	SUP	LHC SEQ: RF LBDS frequency checks done
119	06:25	SUP	LHC SEQ: resynchronize RF beam control SPS connected finished
120	06:27	SUP	ELOGBOOK: STARTING B1 MKISS

- Short spikes caused by RF LBDS frequency checks
- Verification of LBDS to be locked on correct bunch clock
- Alters RF frequencies by +-1000Hz, thus effect on DIDT
- No (major) issue as happens before BPL are closed

Long bursts = RF investigations



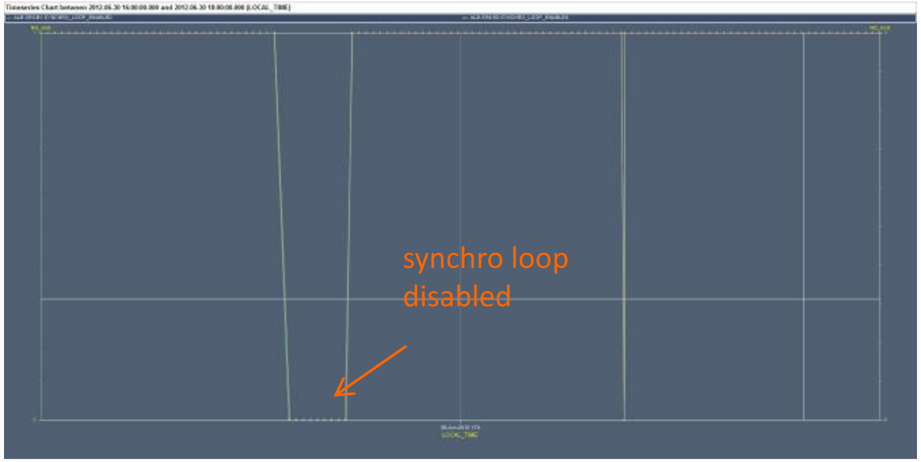
Dear Markus,

We (Daniel, Philippe, and myself) have looked at all the steps of our debugging and actions on Saturday June 30th. I am fairly confident that the activity you see from 16:31 to 16:44 and on 17:22 is just part of the RF synchronization done through the sequencer. If you look at the attached image, you can see that the synchro loop was disabled at exactly the same time periods. This means that the VCXO is free-running during that time and it is no surprise that there is an effect on the RF reference signal.

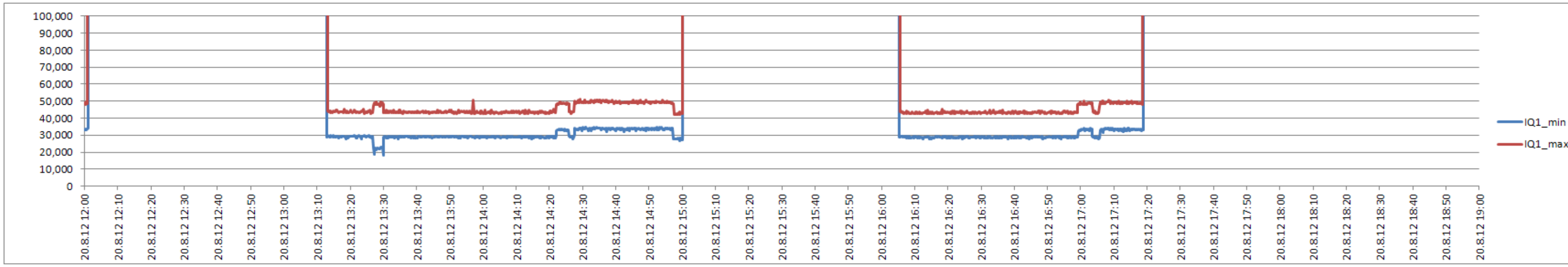
If this is correct, then you should see very similar signatures every time the RF synchronization is run through the sequencer (could you please confirm this?). If this is truly the case, you probably have to take it into consideration in your interlock system.

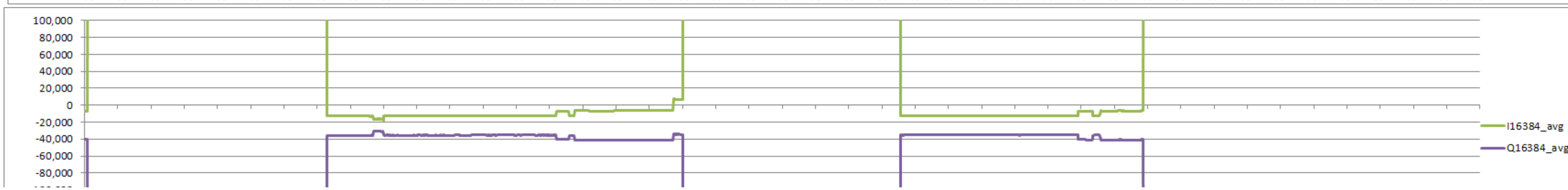
Please let me know if you need any more information.

Regards,
Themis

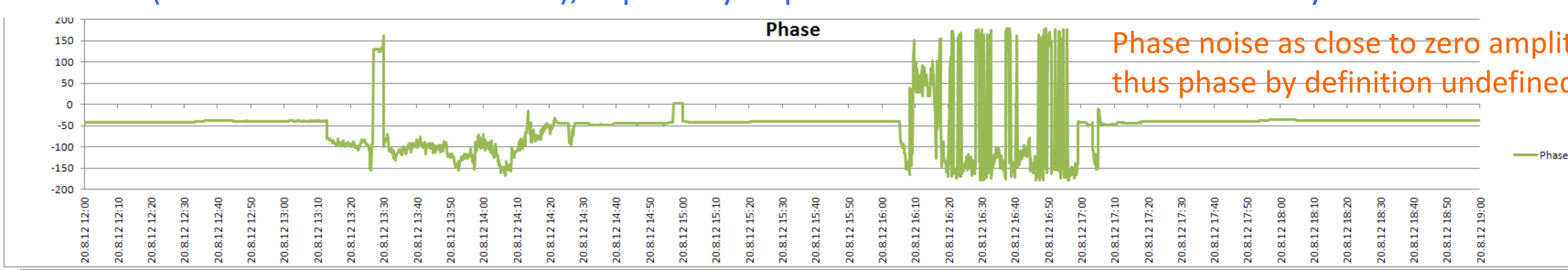


Behaviour with small intensities…

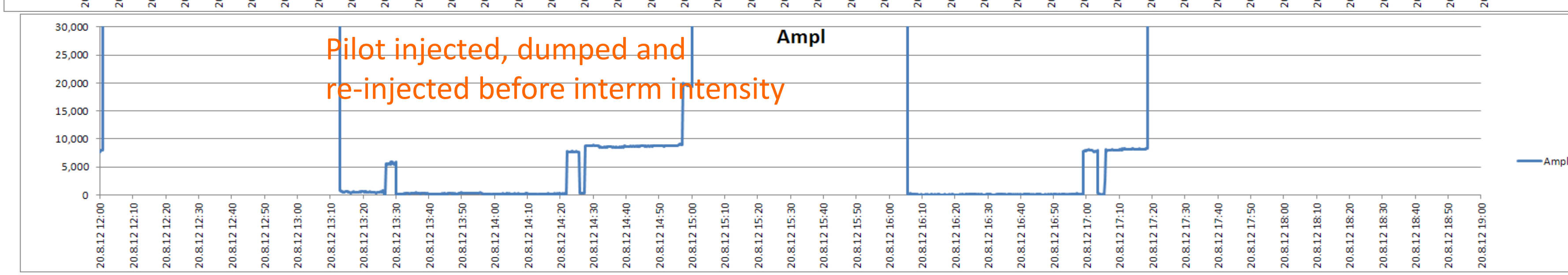




Decomposition and logging of I/Q values allows for full reconstruction of amplitude and phase behavior (i.e. zero offset subtraction), especially important to understand low intensity behavior

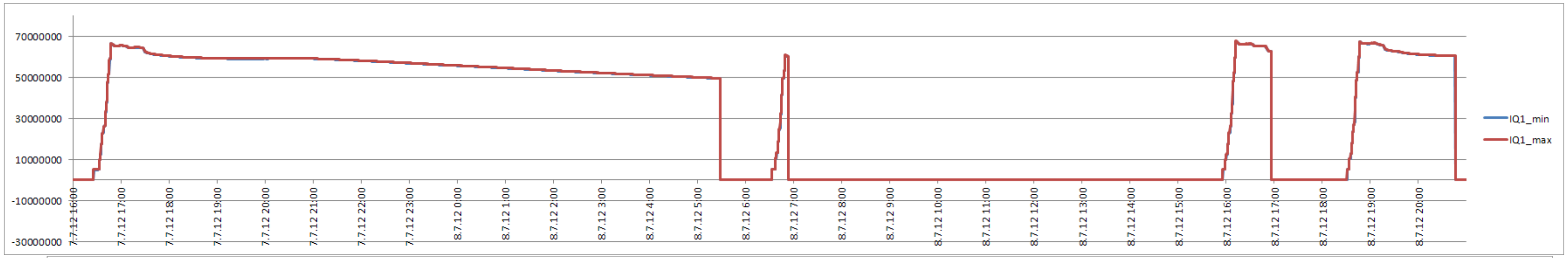


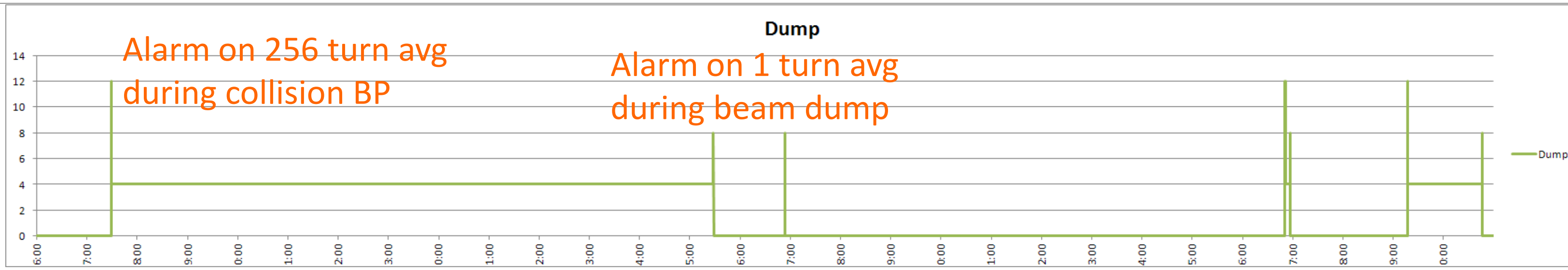
Phase noise as close to zero amplitude, thus phase by definition undefined



Pilot injected, dumped and re-injected before interm intensity

05.07.2012 – Dump signals added





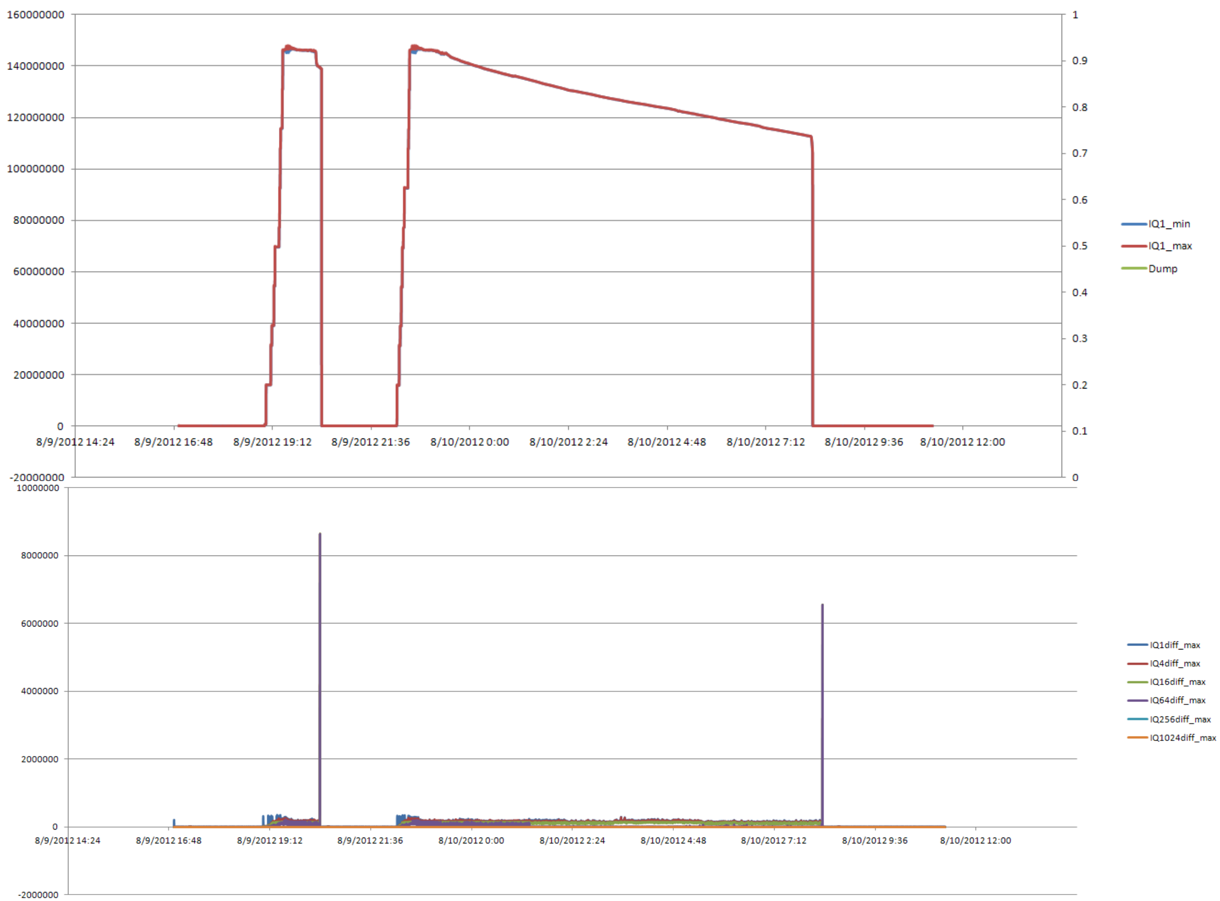
Added logging for warning and dump indication, number above "7" means a dump signal.

- "8" is a dump from averaging over 1 turn (threshold of about 4e11 p and long term maximum loss rate of 6e11 p/sec)
- "12" is a dump from averaging over 256 turns (threshold of about 2e11 p with a long term maximum loss rate of 3.7e10 p/sec). As the loss rate at some points was up to 5.5e10 p/sec, an alarm was triggered.

===> Works just fine, long term maximum loss rate to 1.5e11 p/sec in order to avoid false dump signals, this tested and again readjusted in the next high intensity runs

IQ<n>diff_max added on 09.08.2012

- As next step better understanding of dump thresholds and respective margins in different avg windows needed
- Firmware upgrade with IQ<n>diff_max functionality
- Indication of which threshold would be hit at any moment for different averaging stages

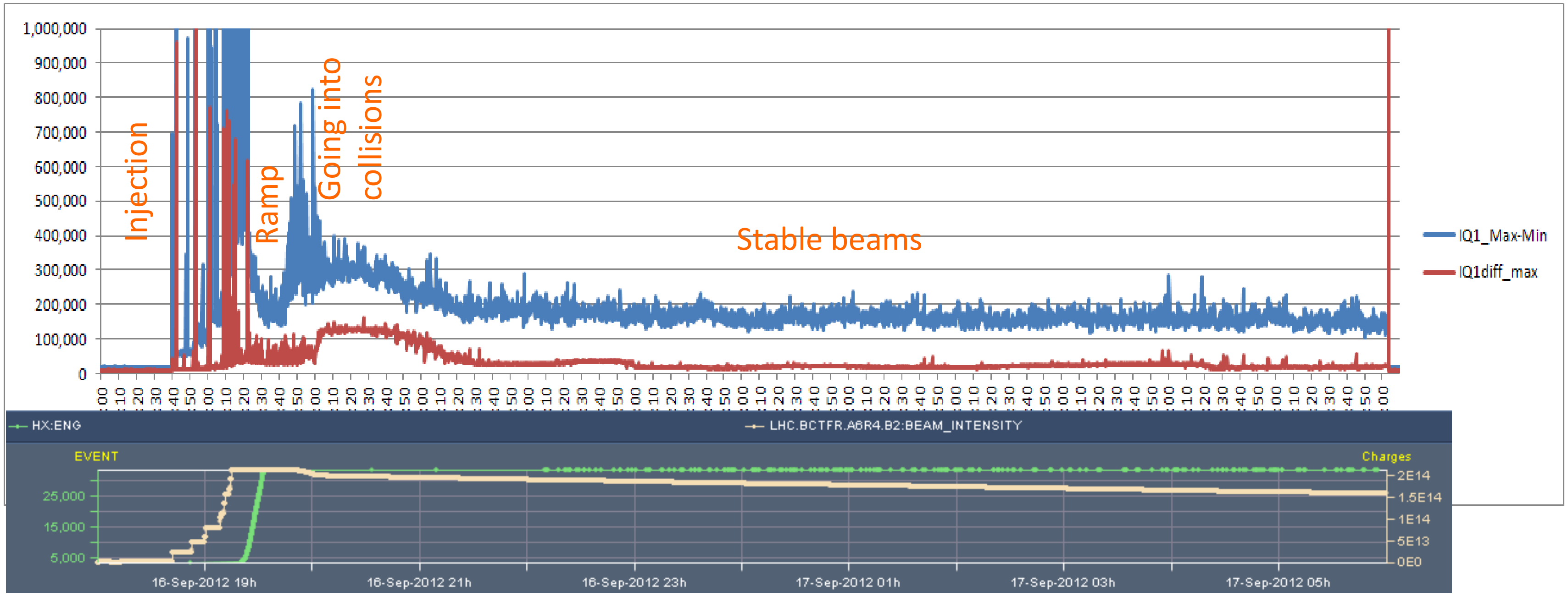


IQ<n>diff_max added on 09.08.2012

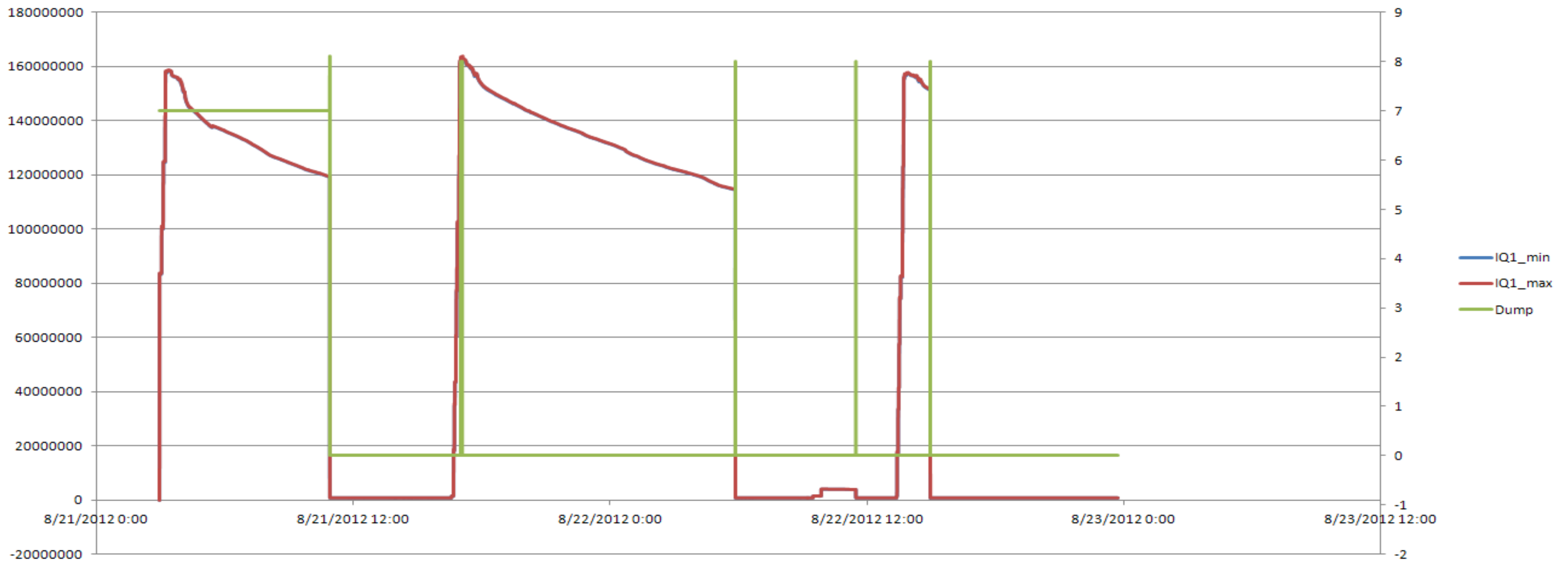
- IQ<n> diff_max functionality calculates neatlessly the maximum of the values presented to the dump threshold comparator over the complete logging interval, individually for each averaging stage

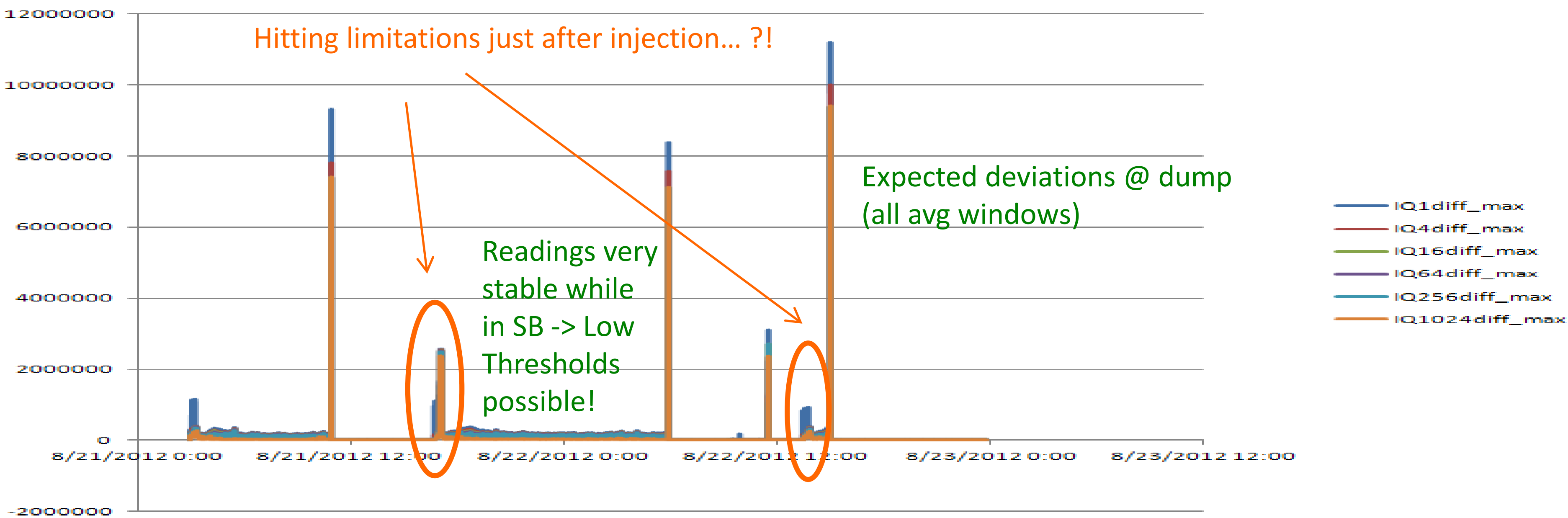
- This is exactly the threshold which would be hit during this log interval, so the energy and beam current dependence of the thresholds can be derived to optimize them

- This value is generally very different from the difference between Minimum and Maximum of a logging interval

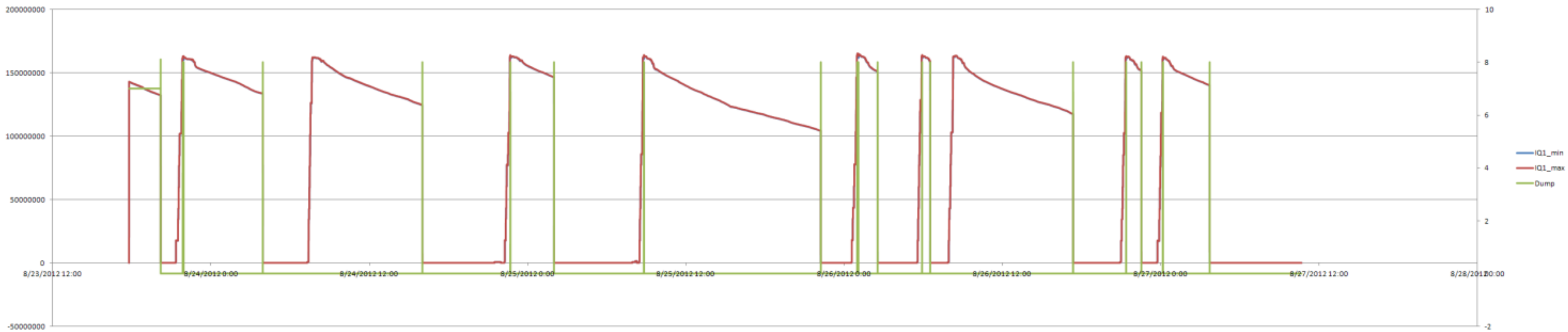


Threshold probing…

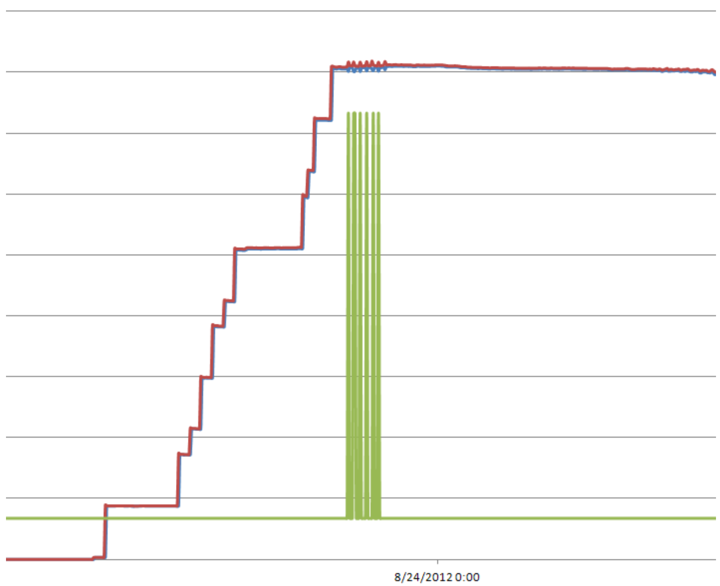


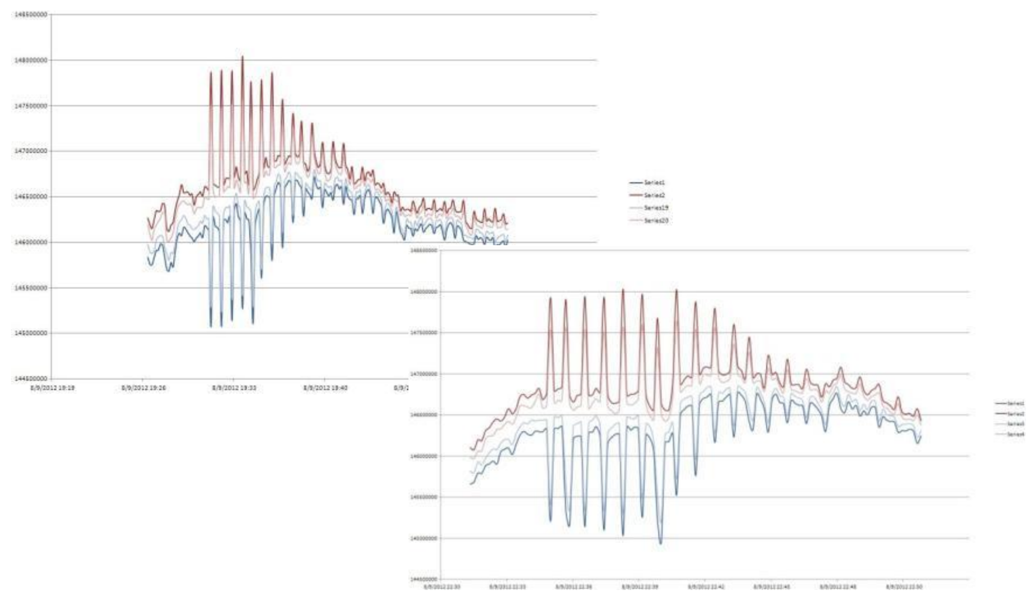


Reproducible effect right at end of injection process



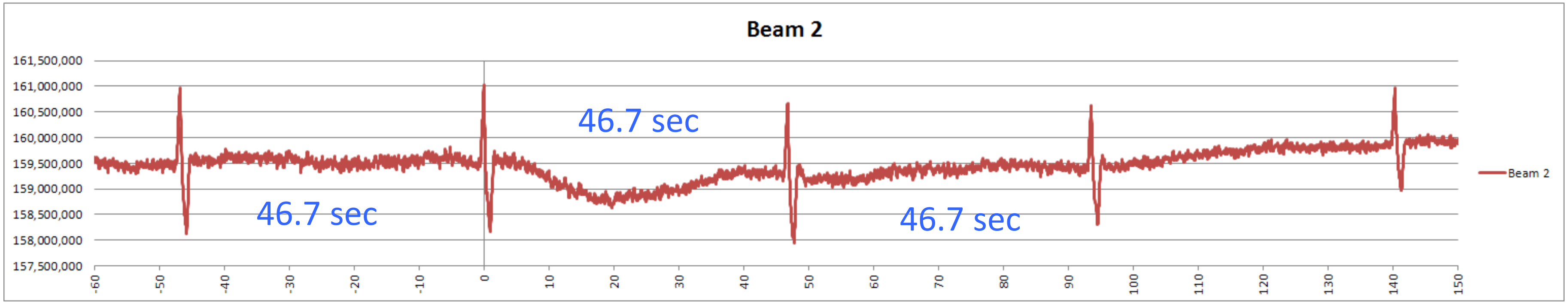
- In mid August, system ran already without any spurious dumps (during SB) with threshold of 7E11/~2E14 = 0.35% (still with slow tracking which causes more noise than fast tracking)
- Reproducible oscillations in IQ1_avg at end of injection process (before ramp)
- 10 second min/max logging data not sufficient to resolve true time structure of oscillation

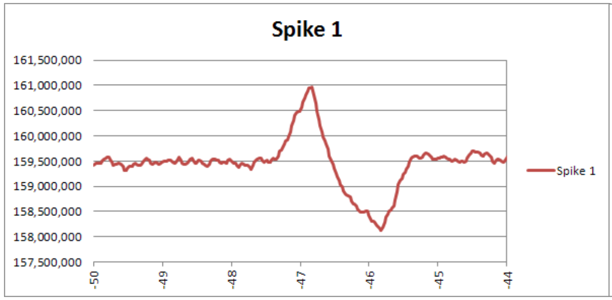


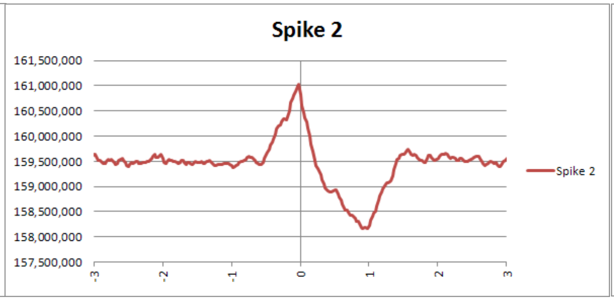


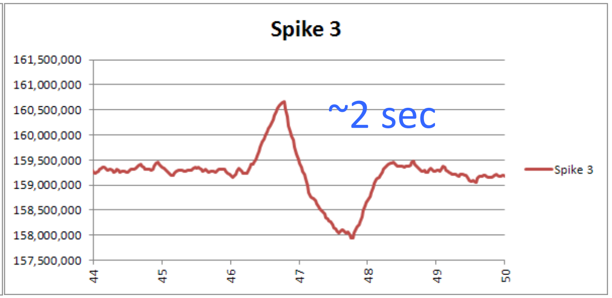
15.08.2012 – PM Data

- Importance of continuous logging, current BI logging only 0.7oo10sec visible (i.e. 4oo5 spikes)?
- Added PM functionality, sending 6 min of data (16384 samples, 22.7ms) over 2nd serial port in case of dump -> Nice time resolution of oscillation



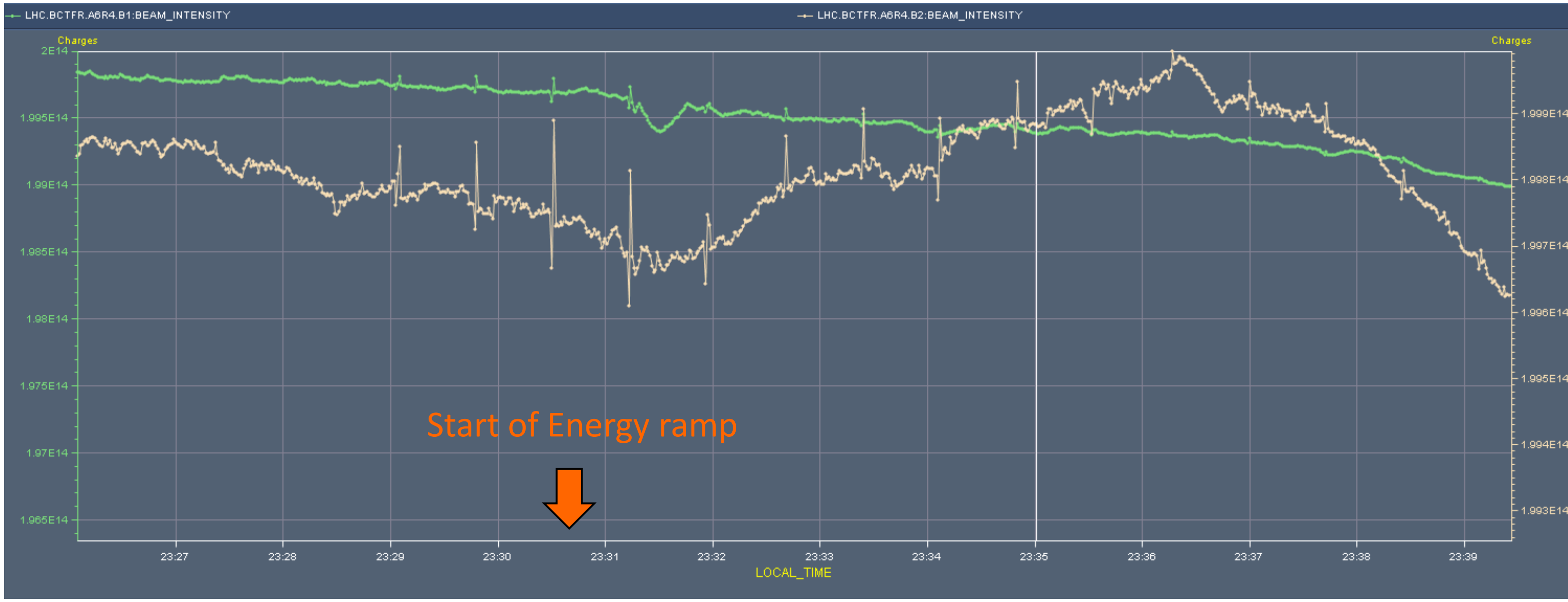






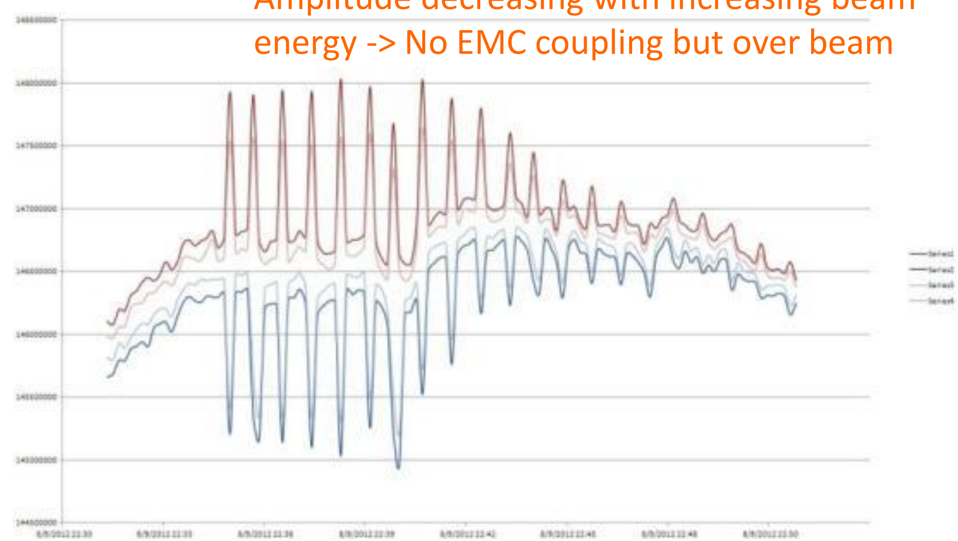
- Effect originating from pulsing TI2/TI8 transfer lines which continue after end of LHC injection (when super-cycle changed current is reduced to 3% of I_nom)
- Last magnets in these TL have well known effect on orbit of LHC
- ~ 30um rms orbit changes observed
- FBCT sensitive to such transient orbit perturbations

Effect of DIDT measurement only?

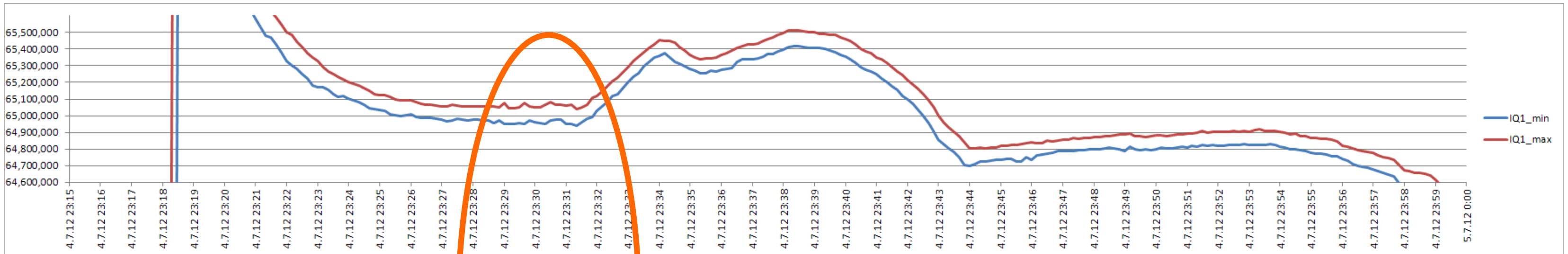


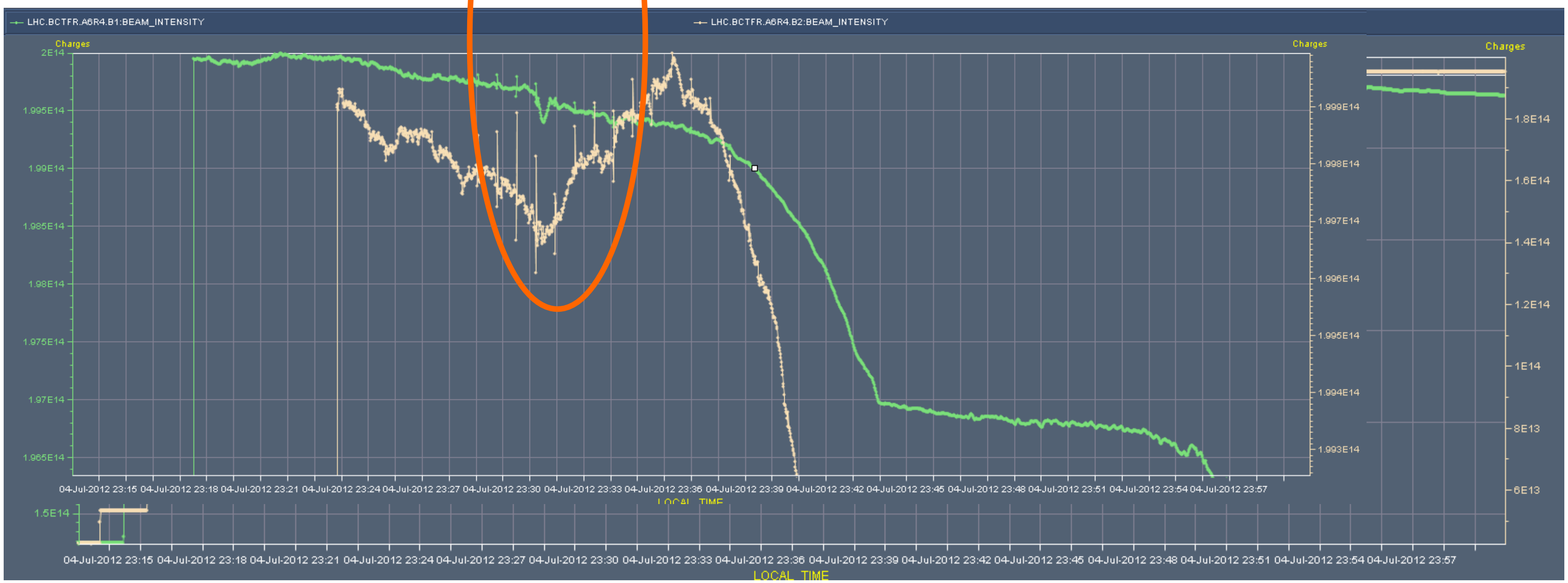
- Oscillations already present in FBCT signals of B1 and B2!
- DIDT signal more affected due to higher position dependency of FBCT at 40 MHz (lower permeability of ferrite)?
- Mitigations: Additional digital filter, new toroid or change of SC in SPS

Amplitude decreasing with increasing beam energy -> No EMC coupling but over beam



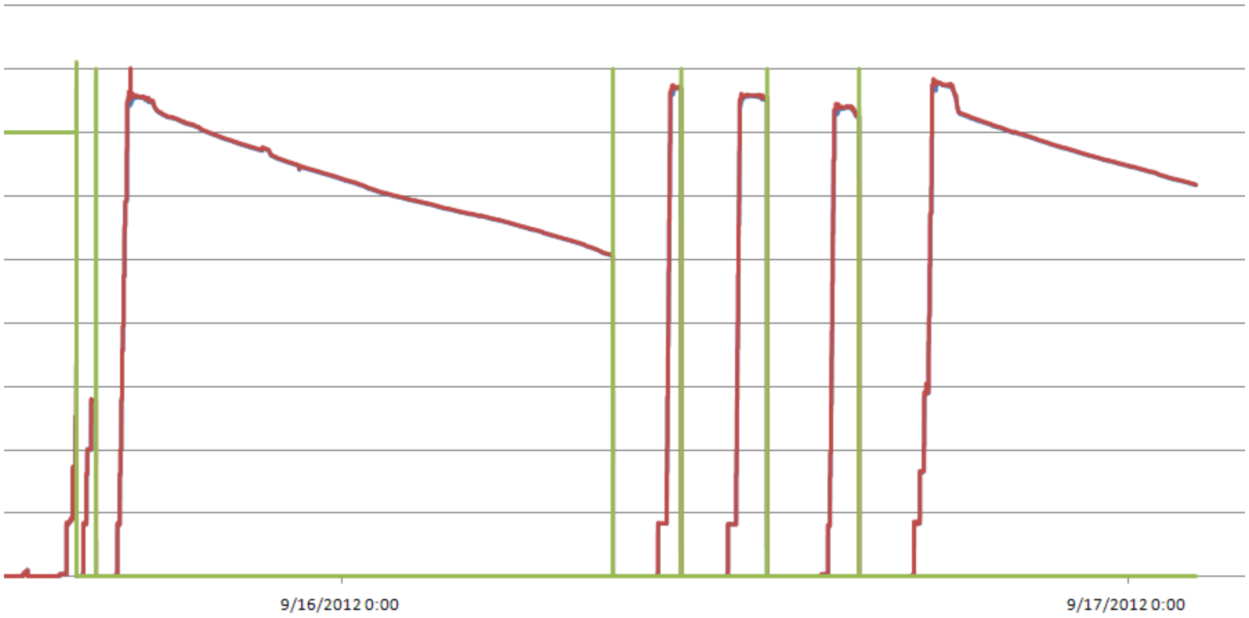
Going back at data end July…





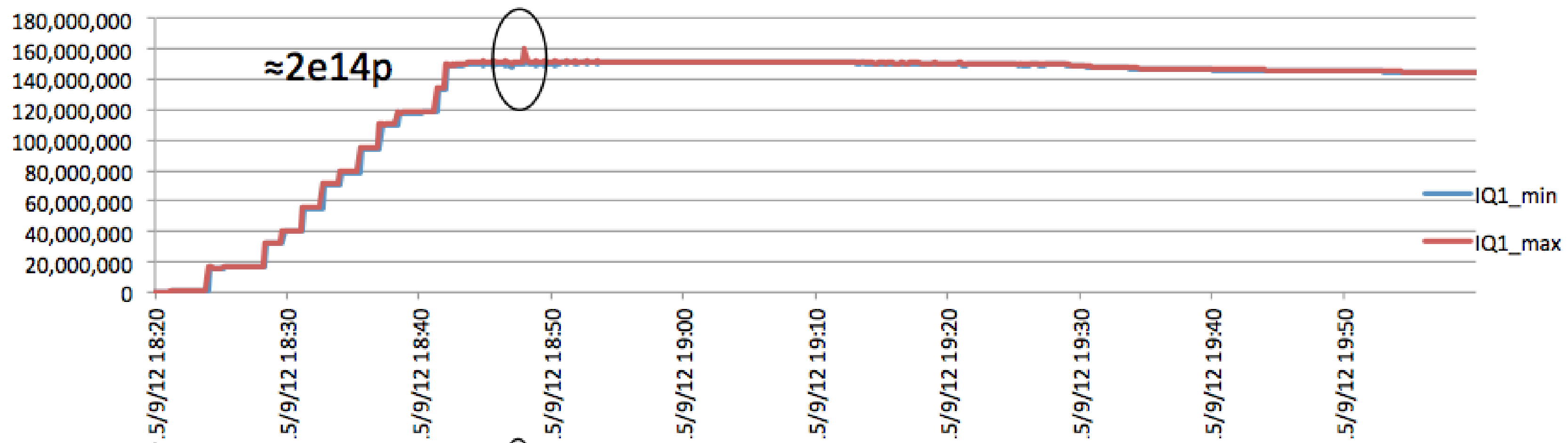
- Went back to July data, with DIDT connected until July 25th to B1 & thus new toroid?!
- Oscillations present but with much less amplitude (which is why we only saw this after connecting to B2 with 'standard' FBCT)
- Maybe a solution for the DIDT to further investigate? Also DESY has developed a toroid that shows little position dependency @ 40 MHz

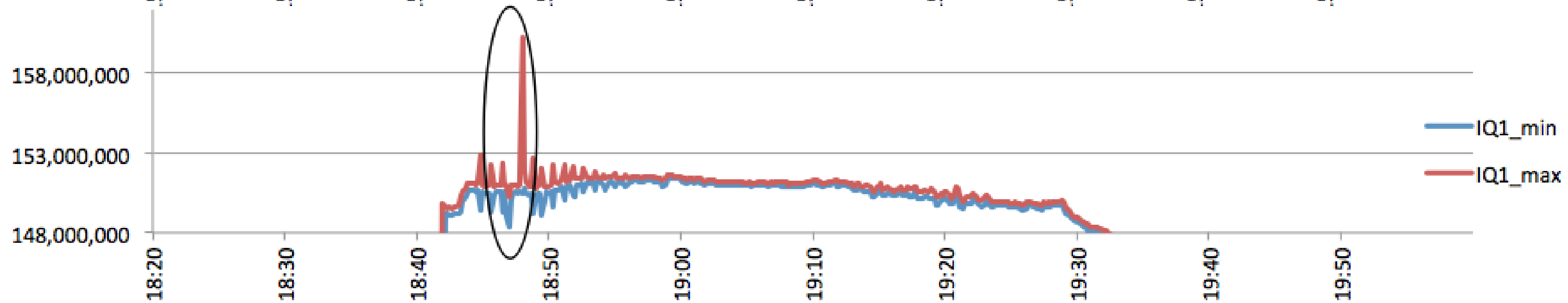
Last fills before TS#3…

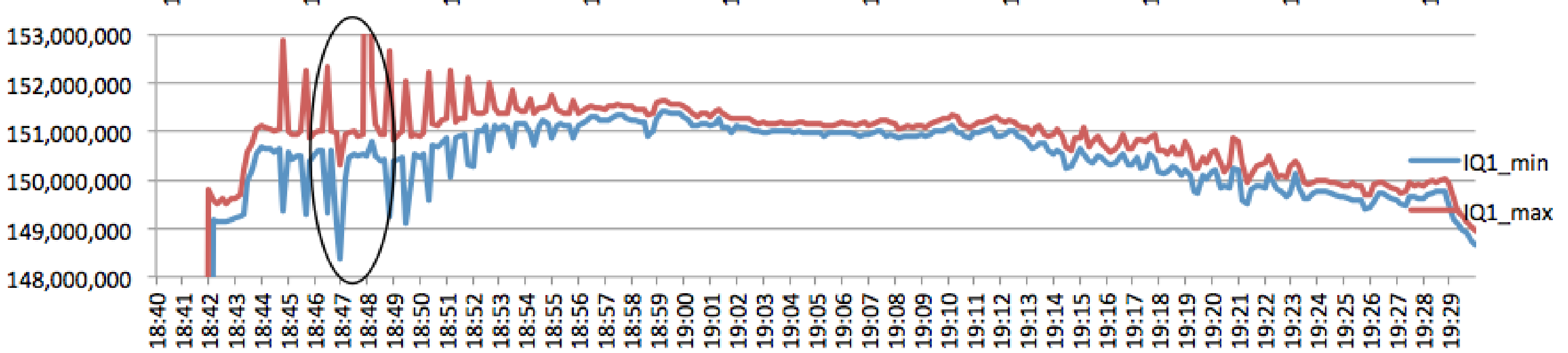


- Had increased (as temporary mitigation) tracking speed to avoid triggers on SPS-TL events
- Further tightening of IQ1 thresholds will become possible with new tracking filter
- New effect manifested itself which was previously believed to be part of SPS-TL cross-talk (as happens roughly at same time)

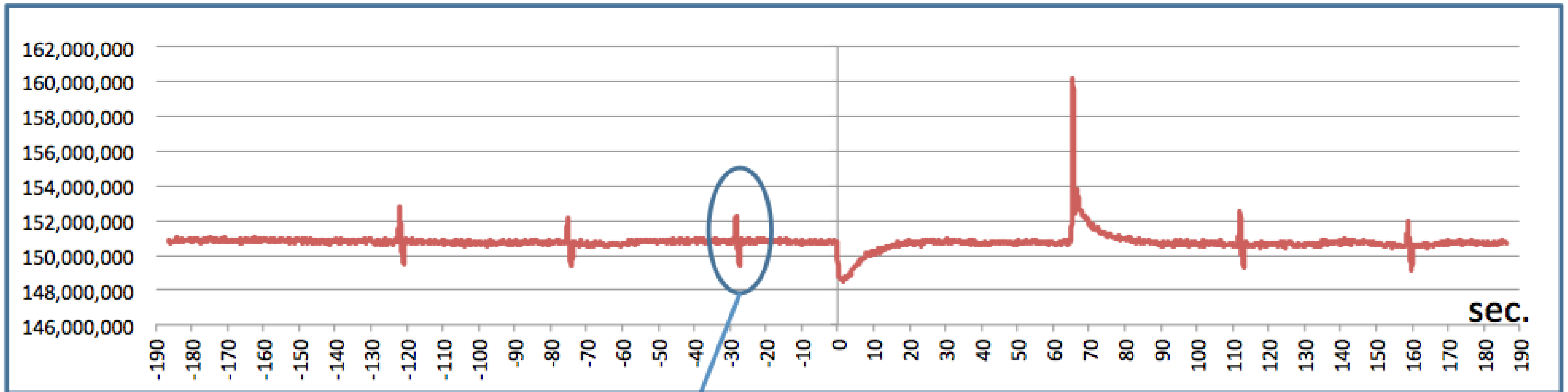
Unidentified Spikes on 15.09.12 @ 18:46:20

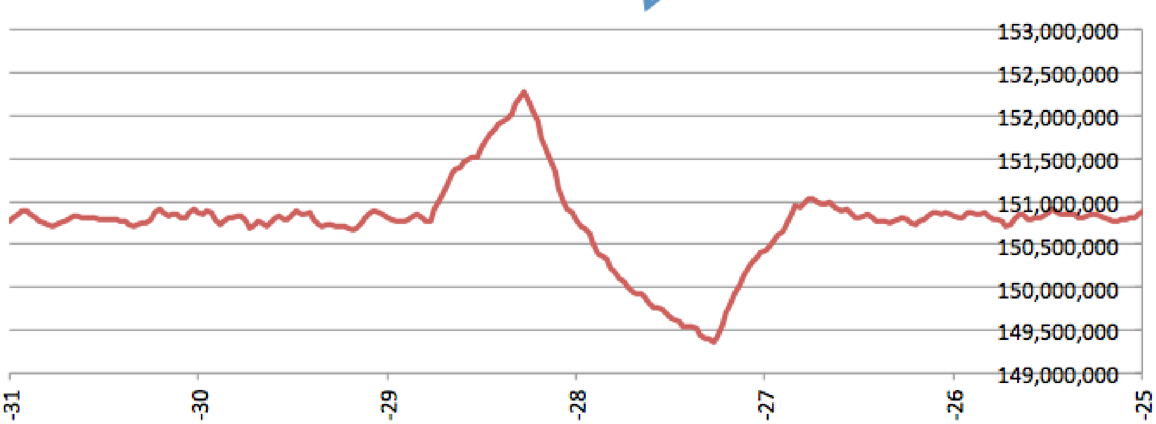






Post Mortem on 15.09.12 @ 18:46:20

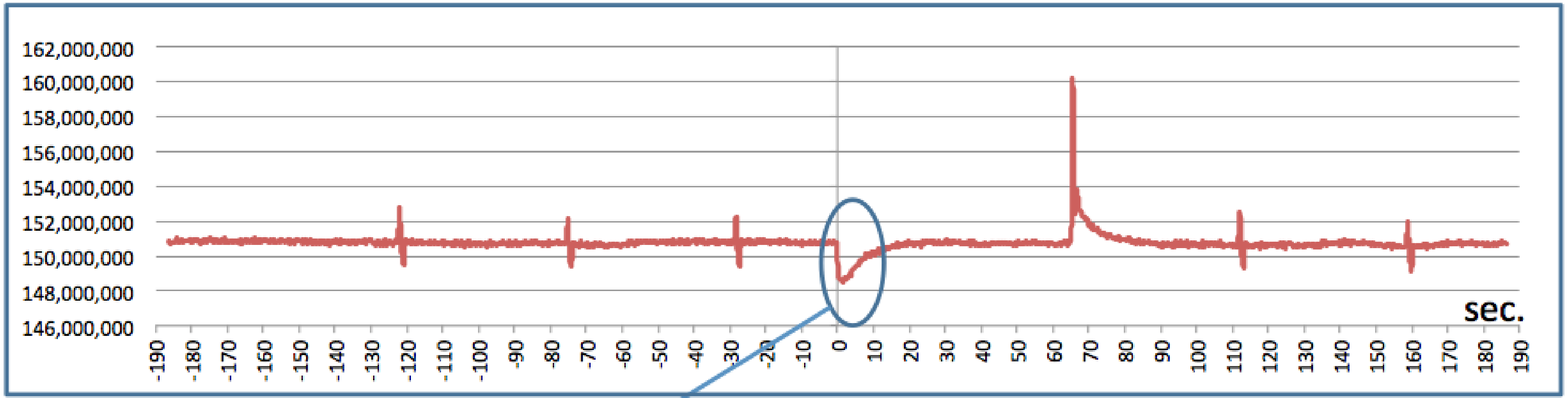


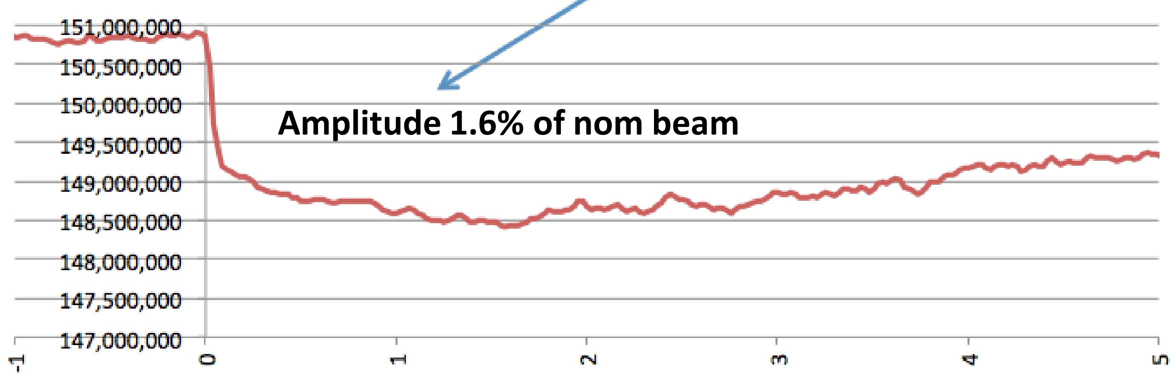


4:20 min after last injection

The known spikes from SPS. Fast tracking can follow → no problem

Post Mortem on 15.09.12 @ 18:46:50

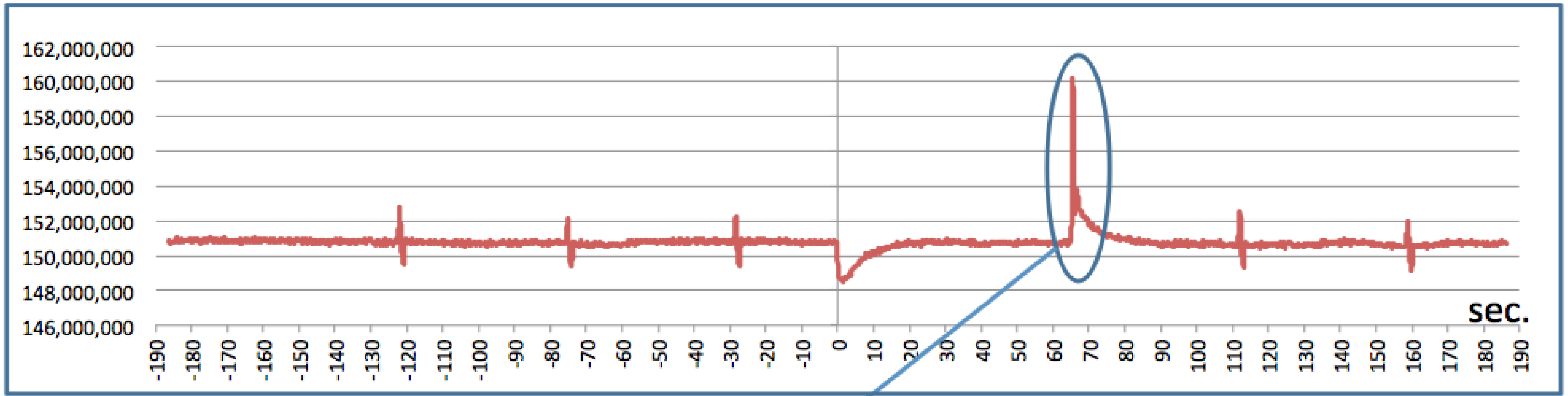


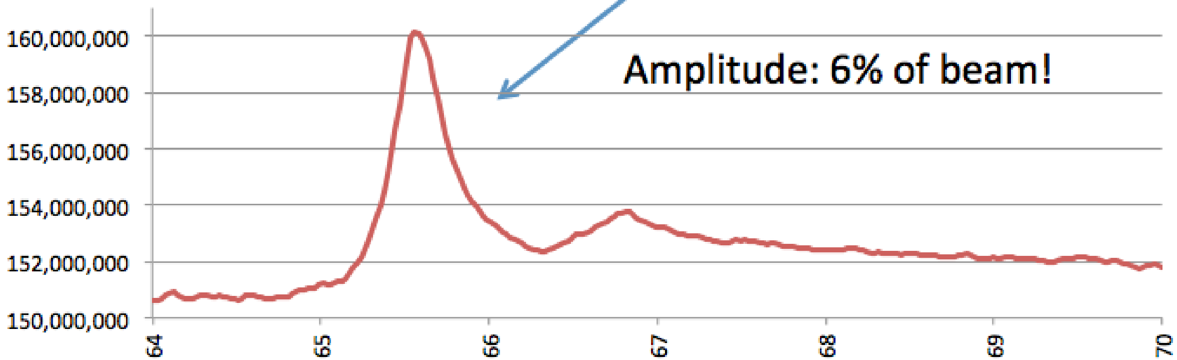


4:50 min
after last
injection

Fast step down (unnown origin) → false dump!

Post Mortem on 15.09.12 @ 18:48:00

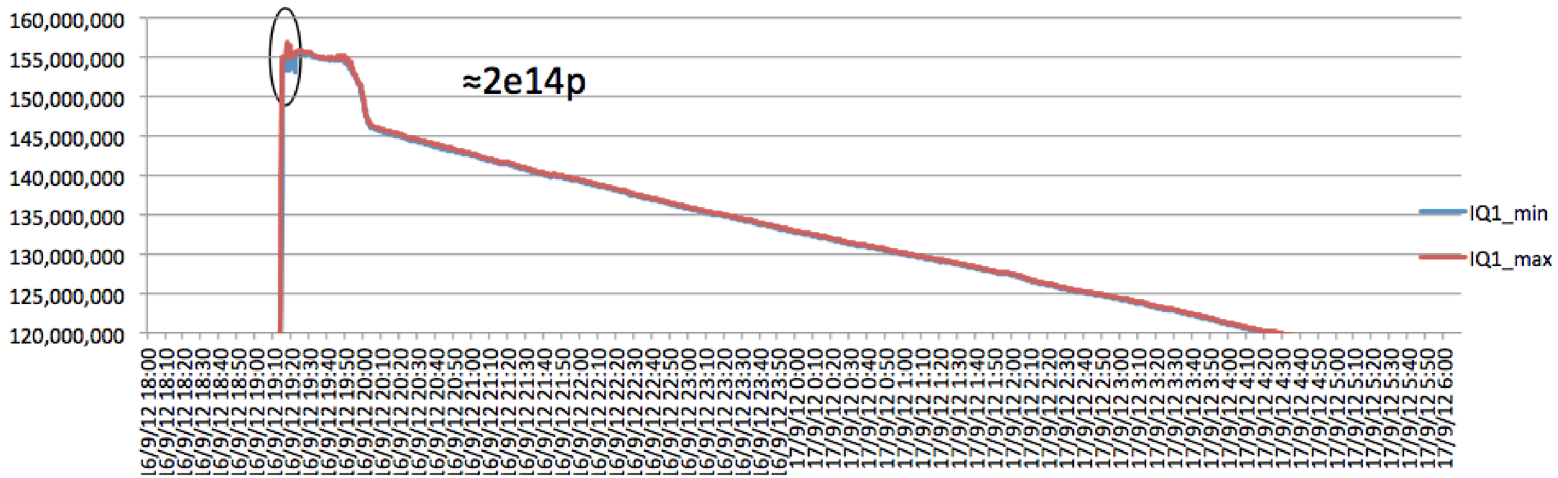


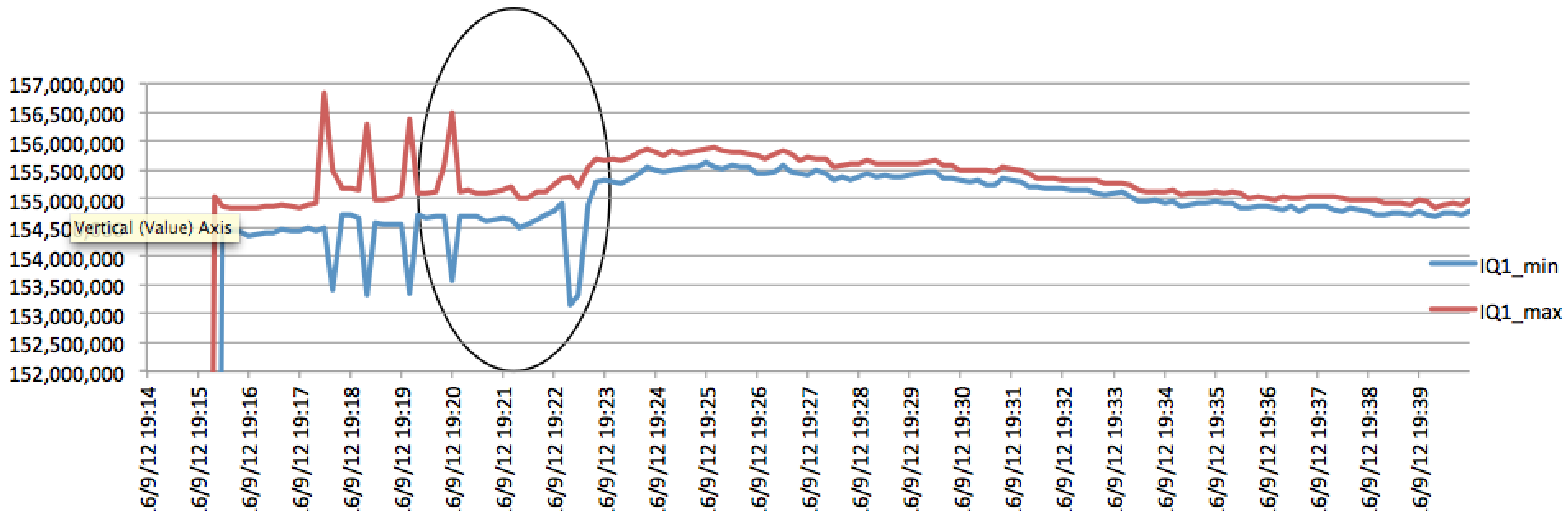


6:00 min after last injection

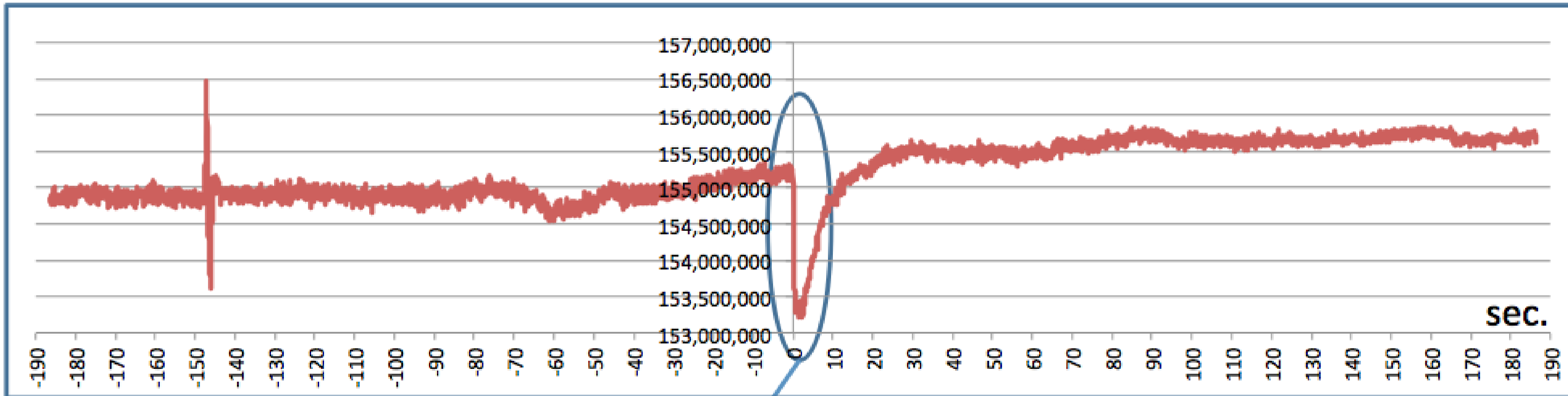
Fast and high spike (unnown origin) → false dump!

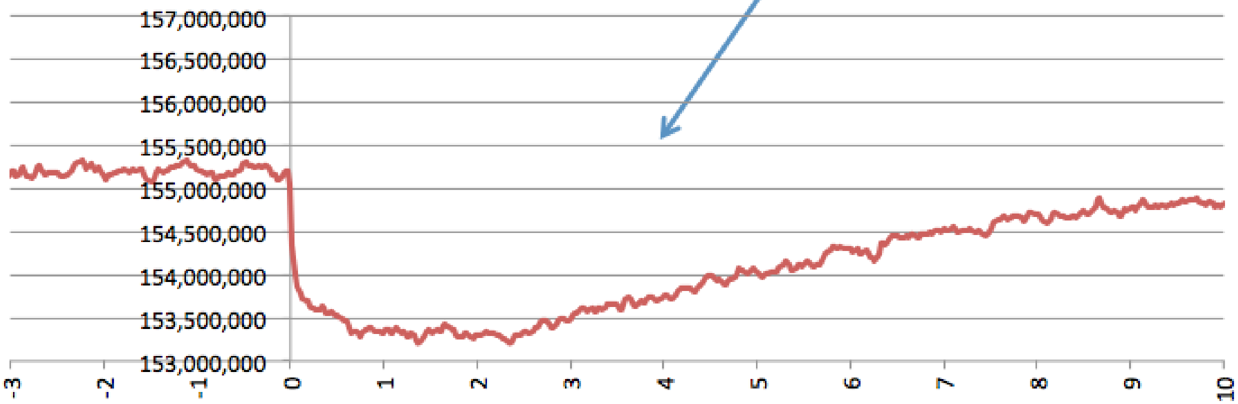
Post Mortem on 16.09.12 @ 19:22





Post Mortem on 16.09.12 @ 19:22



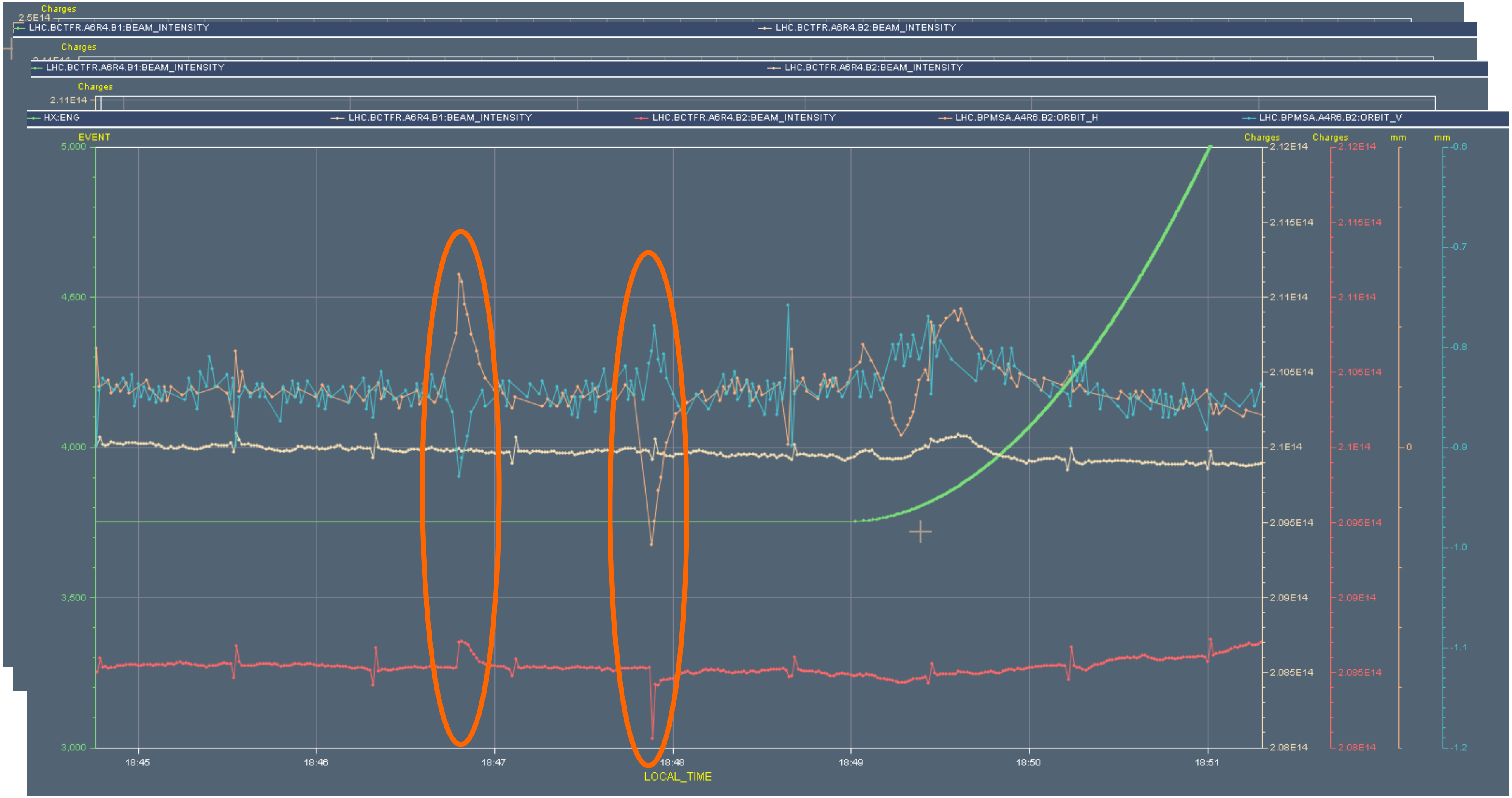


7:00 min
after last
injection

This negative pulse lasts several seconds: is it visible on the FBCTs?

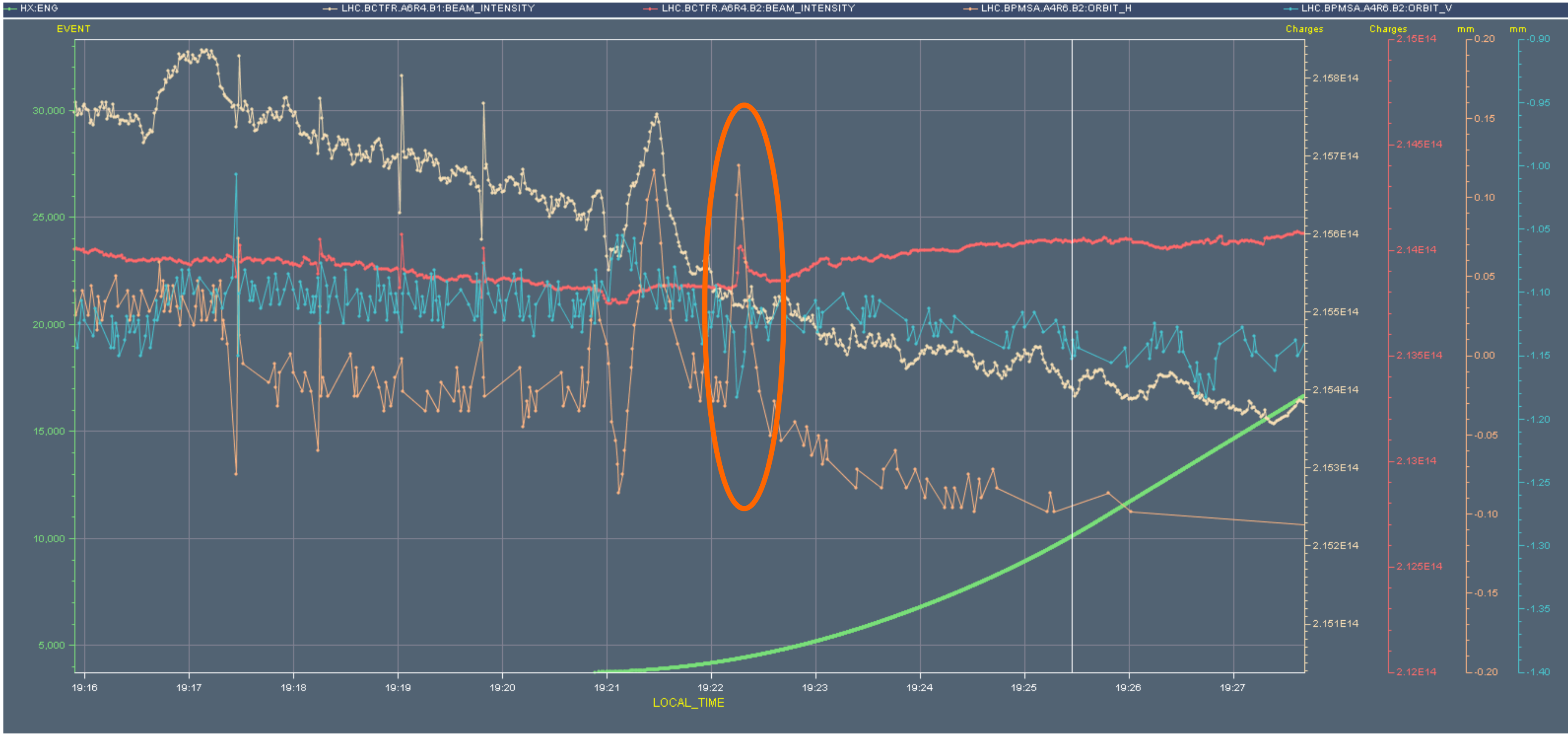
Fast step down (unnown origin) → false dump!

Perturbations seen on FBCT?



- Again position dependency of FBCT (see orbit at interlocked BPMs) due to shaky beams at start of the ramp (+-100um in both H/V!)

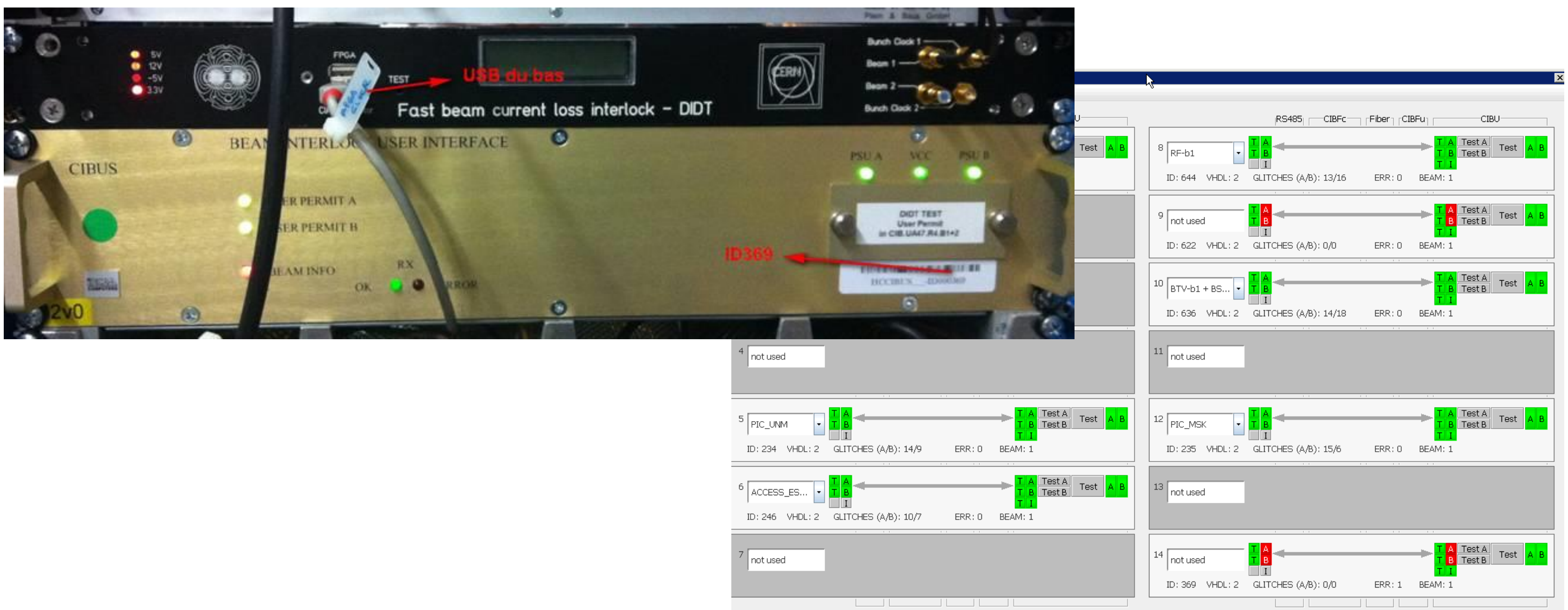
Perturbations seen on FBCT?



- Idem for 2nd event…

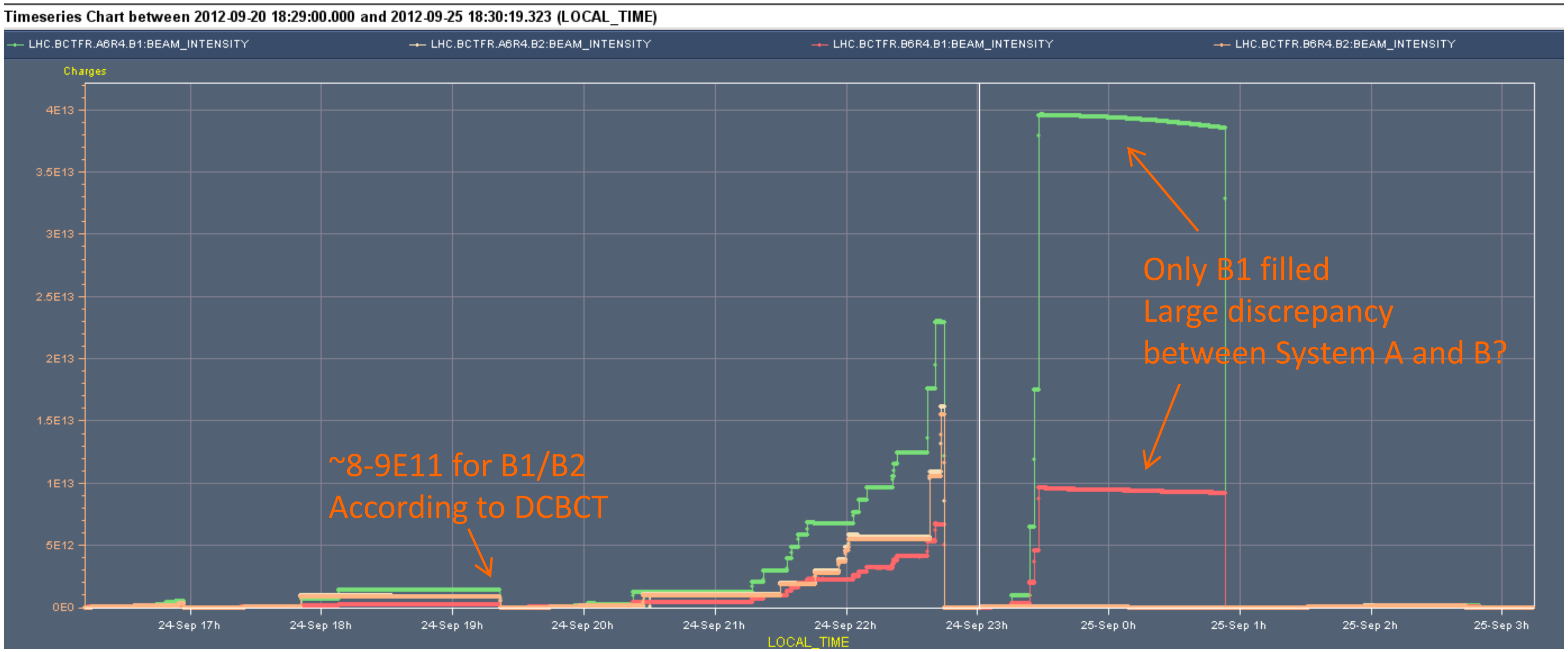
During TS#3

- Implemented and commissioned CIBU interface to validate timing behavior of dump signal
- Installed instead of 'old' CIBF (for previous transmission of BPF to SMP)
- Possible cross-over of A/B permit signals between B1 and B2 detected
- Inversion of dump signals (if DIDT OK => FALSE at CIBU output)!



- New tracking filter prepared (but not yet loaded) to avoid false dumps at injection due to low thresholds

Data taking post TS#3

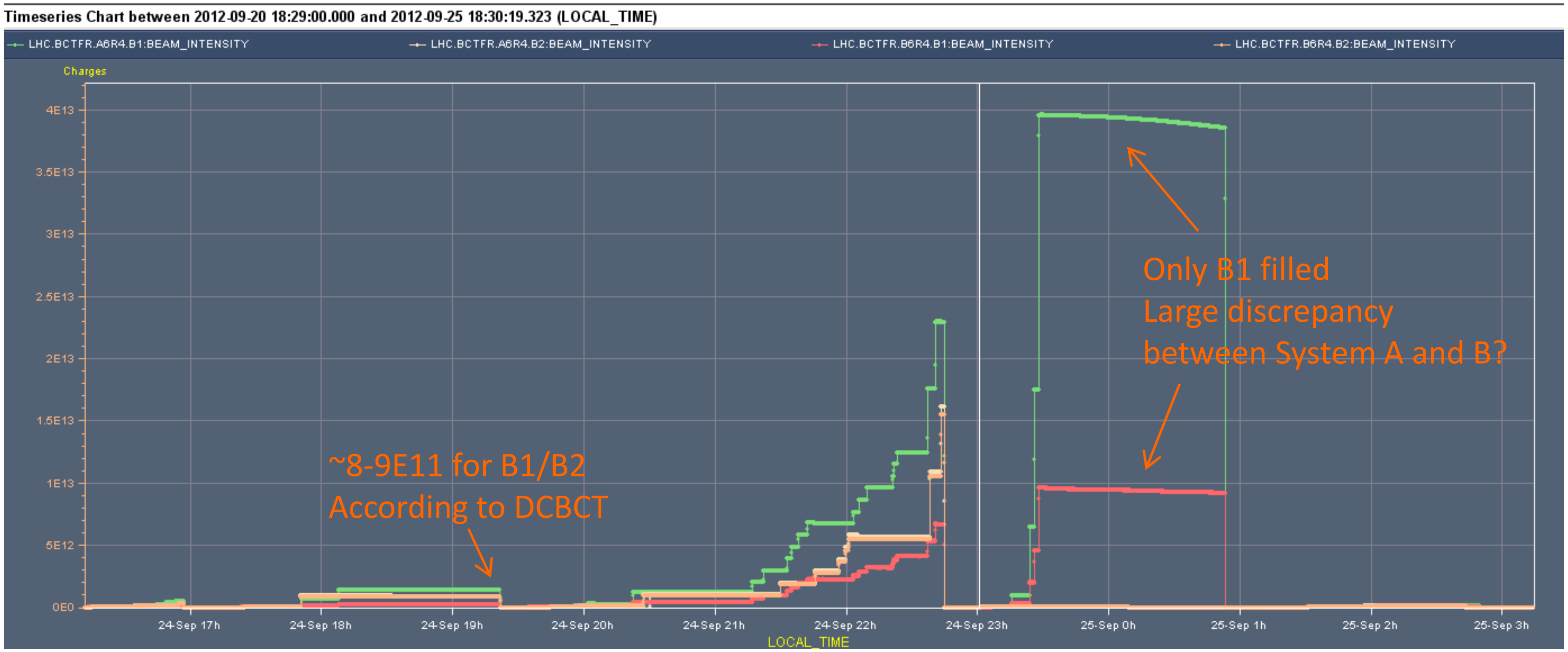


Event 1:

CIB.UA47.R4.B2,True True,24 Sep 2012 19:21:55,371786,DISABLED PERMIT: Channel 14: B T -> F
CIB.UA47.R4.B2,True True,24 Sep 2012 19:21:55,371786,DISABLED PERMIT: Channel 14: A T -> F
…
CIB.UA47.R4.B2,True True,24 Sep 2012 19:21:44,363446,DISABLED PERMIT: Channel 14: B F -> T
CIB.UA47.R4.B2,True True,24 Sep 2012 19:21:44,363445,DISABLED PERMIT: Channel 14: A F -> T

- Only System C dumps?!
- Should be sufficient intensity for A system threshold?

Data taking post TS#3

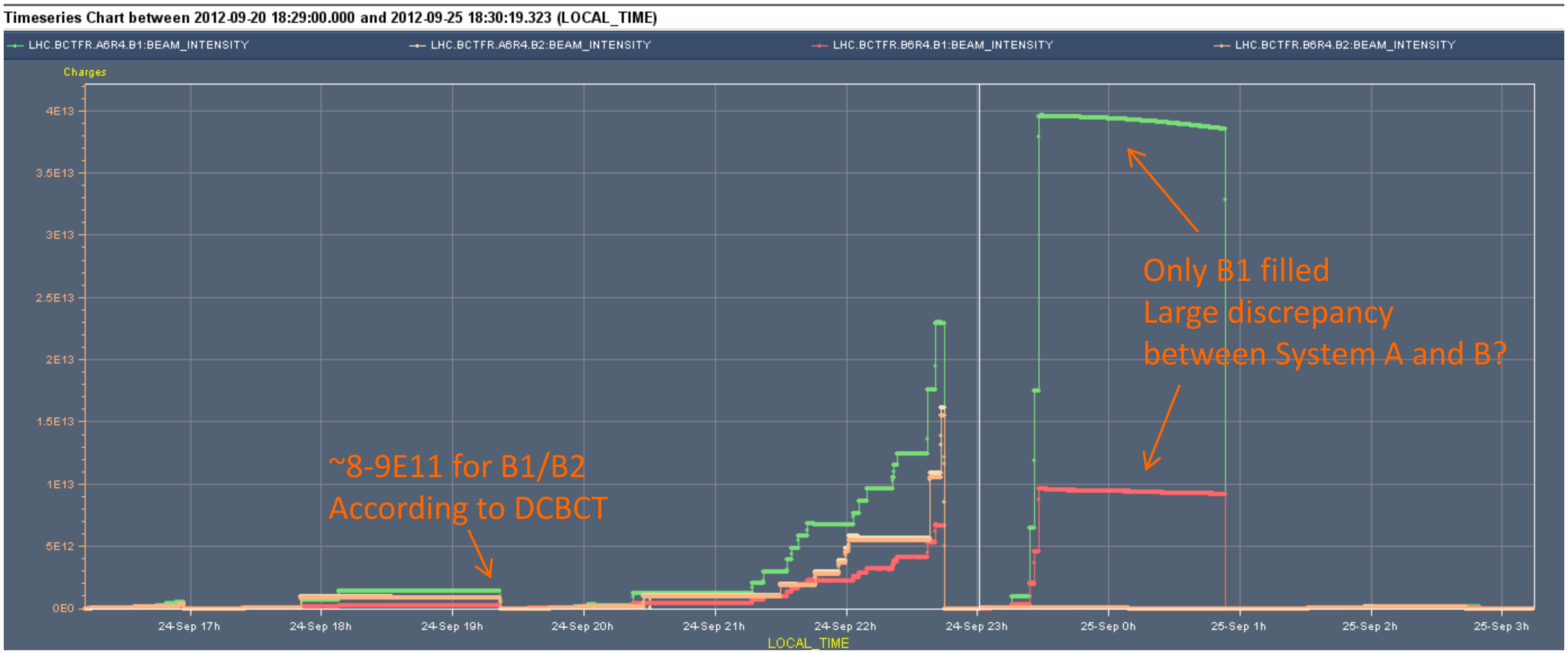


Event 2:

CIB.UA47.R4.B2,True True,24 Sep 2012 22:45:15,628366,DISABLED PERMIT: Channel 14: B T -> F
CIB.UA47.R4.B2,True True,24 Sep 2012 22:45:15,628366,DISABLED PERMIT: Channel 14: A T -> F
CIB.UA47.R4.B2,True True,24 Sep 2012 22:45:04,759018,DISABLED PERMIT: Channel 9: B T -> F
CIB.UA47.R4.B2,True True,24 Sep 2012 22:45:04,759018,DISABLED PERMIT: Channel 9: A T -> F
…
CIB.UA47.R4.B2,True True,24 Sep 2012 22:45:04,490579,DISABLED PERMIT: Channel 9: A F -> T
CIB.UA47.R4.B2,True True,24 Sep 2012 22:45:04,490579,DISABLED PERMIT: Channel 9: B F -> T
…
CIB.UA47.R4.B2,True True,24 Sep 2012 22:45:04,490250,DISABLED PERMIT: Channel 14: B F -> T
CIB.UA47.R4.B2,True True,24 Sep 2012 22:45:04,490250,DISABLED PERMIT: Channel 14: A F -> T

- Both systems dump!
- System C triggers 329us earlier
  - Effect of short latency filter
  - Is the 1 turn threshold really connected to the CIBU in System A?

Data taking post TS#3



Event 3:

CIB.UA47.R4.B1,True True,25 Sep 2012 00:53:22,992076,DISABLED PERMIT: Channel 9: A T -> F
CIB.UA47.R4.B1,True True,25 Sep 2012 00:53:22,992075,DISABLED PERMIT: Channel 9: B T -> F
….
CIB.UA47.R4.B1,True True,25 Sep 2012 00:53:22,723636,DISABLED PERMIT: Channel 9: B F -> T
CIB.UA47.R4.B1,True True,25 Sep 2012 00:53:22,723636,DISABLED PERMIT: Channel 9: A F -> T

- Only Beam 1 is filled
- System dumps OK

Situation today

- System is working reliably close to initial target thresholds, ie 0.35%, with initial HW + filter design
- Seamless Logging of Min /Max for all averaging stages (over 1, 4, 16, 64, 256, 1024, 4096 and 16384 turns)
- Separate I and Q demodulation has shown very useful for low intensity events
- Post Mortem Recorder with adjustable resolution, allowing analysis of precise records of events that could cause false dumps
- Down to 0.1% resolution 3 types of perturbations observed and identified (injection, SPS-TL and orbit changes @ start of ramp)
- No random noise or spurious dump observed during the past 10 weeks of running!
- Settings of thresholds and tracking speed individually for each averaging stage.
- Short latency of less than 0.2 turns for big sudden losses
- Logging of the "diff_max" for every averaging stage, being a precise measure for the correct thresholds of every averaging stage. Great tool to pinpoint which thresholds are necessary as a function of machine status, charge and energy.
- Our conclusion:
    - Very good progress with understanding of system and its performance reach/limitations
    - Principle will work for the LHC! Sole show-stopper to achieve design threshold of 0.1% is the large position dependency of the FBCT toroid at 40 MHz.
    - For lower thresholds other limitations may/will appear once position dependence improved

Next steps… 1/2?

- 1st priority : Data comparison
  - Does the BI System ‘see’ the same perturbations with the same amplitudes (if not in Logging, Dump signals should be identical for identical thresholds + tracking speed)?
  - Is there anything else that we did not yet observe?
  - How is the dump algorithm implemented in detail?
  - What is the tracking speed used?
  - Are there any measurements that show better behavior with the new filter (5GHz)?
  - Why do we see twice the signal amplitude on B2 wrt to B1 on System C?
  - Understand difference in threshold and time of two dump signals? Is the 1 turn average connected to the dump comparator?

- Even without solving the position dependence, existing system can/should be improved:
  - Remove RF signal splitting (done on System C) + Tune bandpass filter -> 100% of ADC input range (instead of 10%)
  - Energy dependent thresholds
  - Beam current dependent thresholds
  - Masking of ‘empty bunch slots’
  - Improve noise base (probably difficult without HW re-design)

Next steps…2/2?

- Machine Development
  - Propose to focus on study of position dependency of FBCT and new toroid design (Single bunch in machine, connect FBCT raw signal with 250-500MHZ low-pass filter to Oscilloscope and move beam by +/-5mm to study possible resonance in pulse-response of FBCT)
  - Connect a DIDT to the ICT?
  - To exclude differences/noise in measurement chains swap DIDT systems between System A and C?

- Our involvement
  - Non-negligible effort in the past 10 weeks to gather these results which we hope to be useful for further progress towards an operational system
  - How to proceed from this point?

Fin

Thanks a lot for your attention!