Status Report on Tools Development

Work done by O. Hensler, R. Kammering, T. Limberg, S. Meykopff, C. Schmidt, M. Tischer, M. Vogt and many more

HELMHOLTZ ASSOCIATION

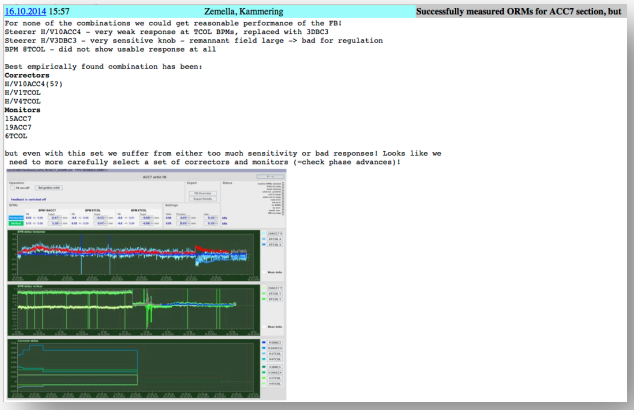
DESY

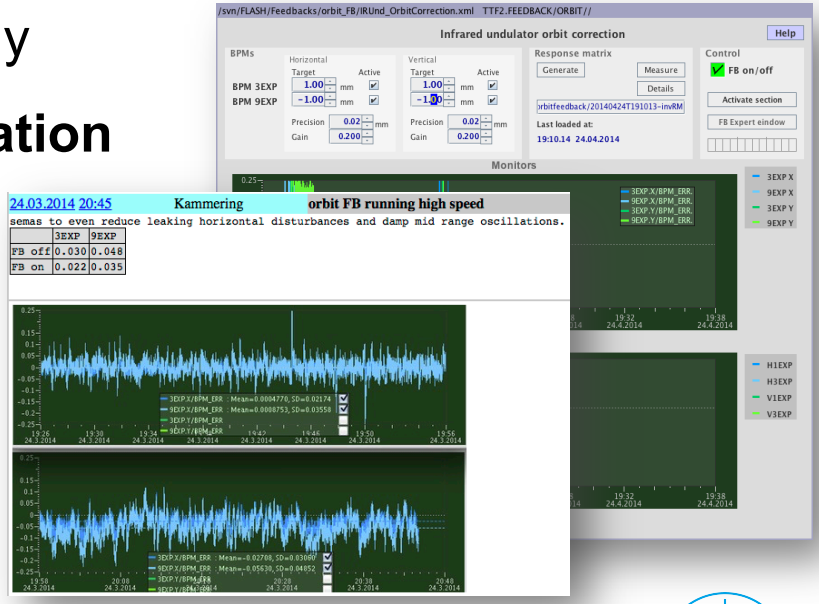
Outline

- Status – “old tools”:
  - Orbit Feedback
  - Slow Longitudinal Feedback
- Advertisement – “new tools”:
  - Sum Voltage Server
  - FLASH2 Undulator Operation Server
  - Energy Gain Server
- Outlook – “big tool”:
  - The VXFEL

Orbit Feedback

- **No** details about **internals** [see e.g.: PCAPAC2010 WEPL015]
  - Global FB
  - FB server loads external provided ORM
  - ORM from *optic toolbox* or measured with *Matlab script*
- **Routinely** used in **EXP** section (THZ undulator), partly in sFLASH section
- **Replaced Matlab** based FB completely
- **Improved** FB to corrector **communication**
- Tested for e.g. injection into septum





Orbit Feedback

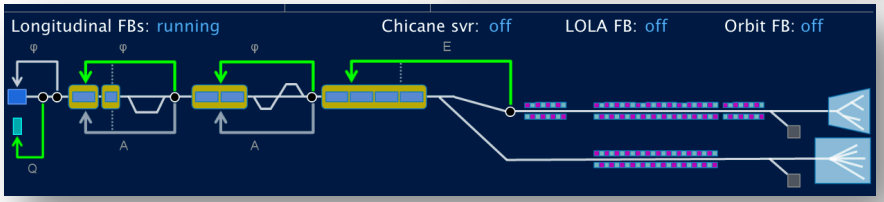
- Still much needs to be done:
  - Conceptual work (when and where to run the FB)
  - GUI (e.g. simplify user interfaces, workflow)
  - RM handling (e.g. include fully automated ORM measurement)
  - Exception handling …
- … and much could be done:
  - Restore orbit on loading machine file (store orbit targets instead of steerer currents)
- But what hurts most are bad conditioned ORM at many locations!

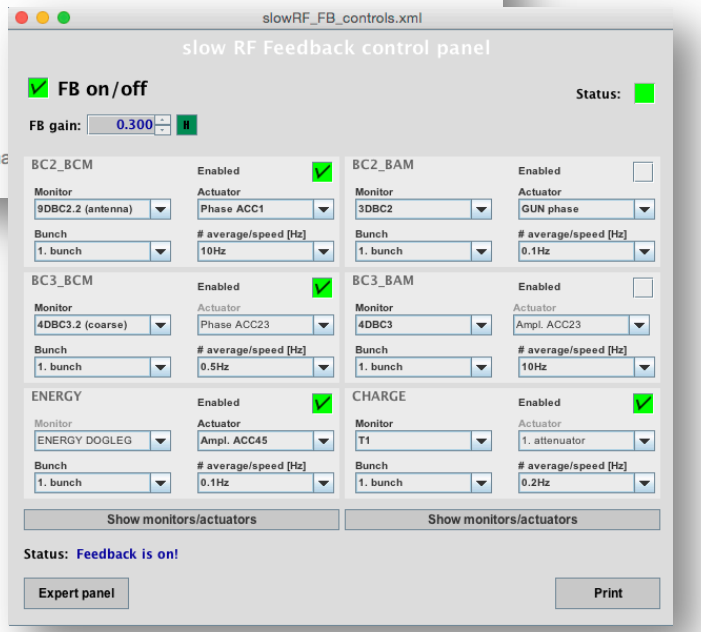
Slow Longitudinal Feedback

- Same here: no details about internals [see e.g.: ICALEPCS 2013 THPPC121]
- **Robustly running 24/7**
- Recalling last status report:

• Needs more **simple GUIs** → on it's way

19. March 2012 FLASH semina





- Done!

Slow Longitudinal Feedback

- "… **saved our life** in times of gun window trouble!"
  - LLRF FB on GUN amplitude but phase not stable (not constant forw./refl.)
  - Used 1UBC2 BAM to regulate on gun phase (10Hz + high gain finally gave reasonable SASE stability)

16.04.2014 16:42 S. Schreiber, V. Ayvazyan, M. Hoffmann **rf gun llrf feedback**

```
after re-calibration:
 - amplitude is much better and OK, phase is still not OK
ampl 0.1% rms
phase vs 0.1 dg rms

-> therefore we decided to keep the feedback on Pfwd only
this gives us a stable amplitude, but an unstable phase

-> the phase we will try to feedback with 1UBC2 BAM as a monitor
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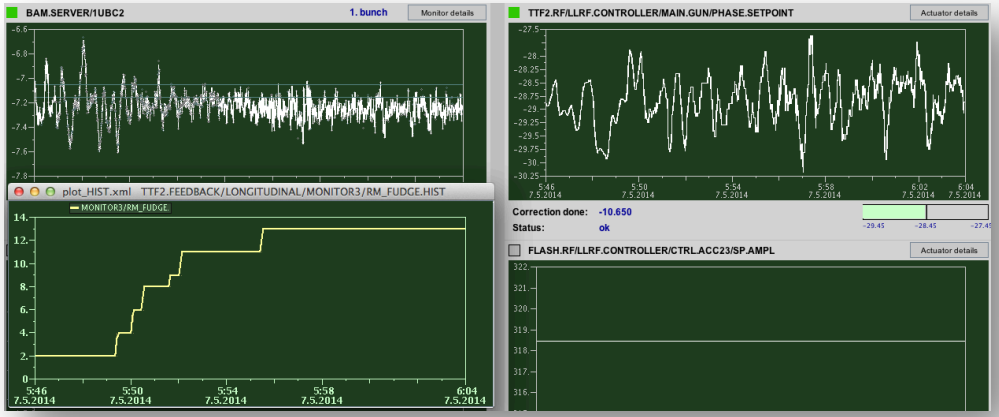
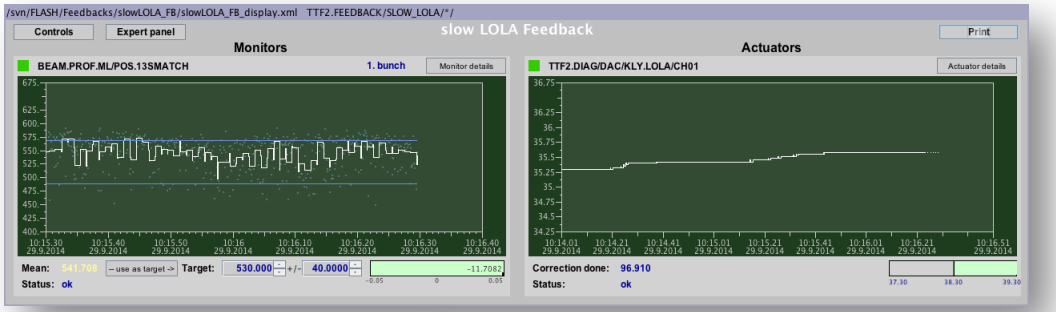
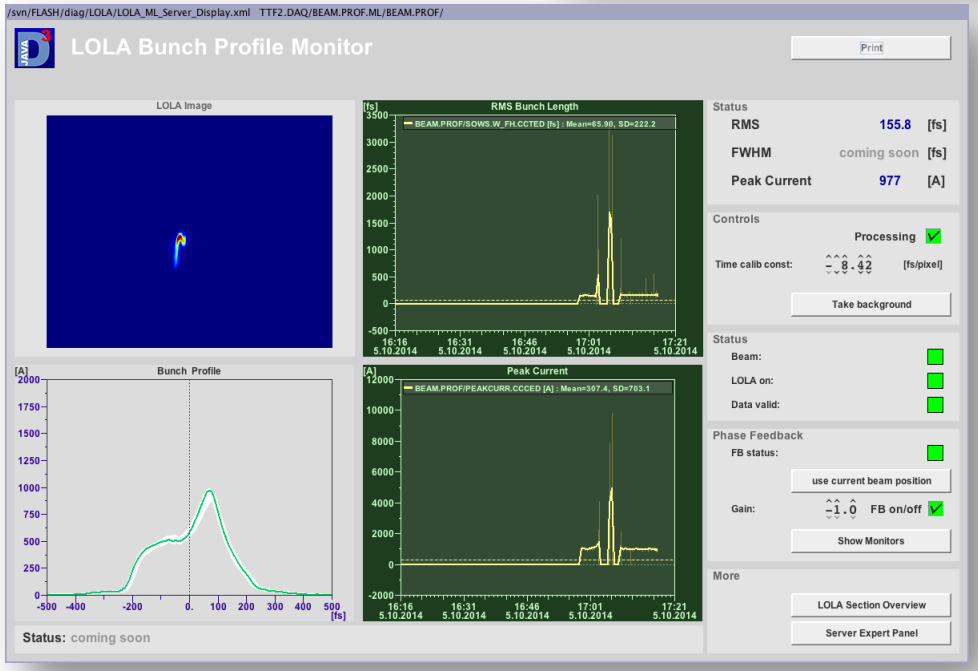


Slow Longitudinal Feedback

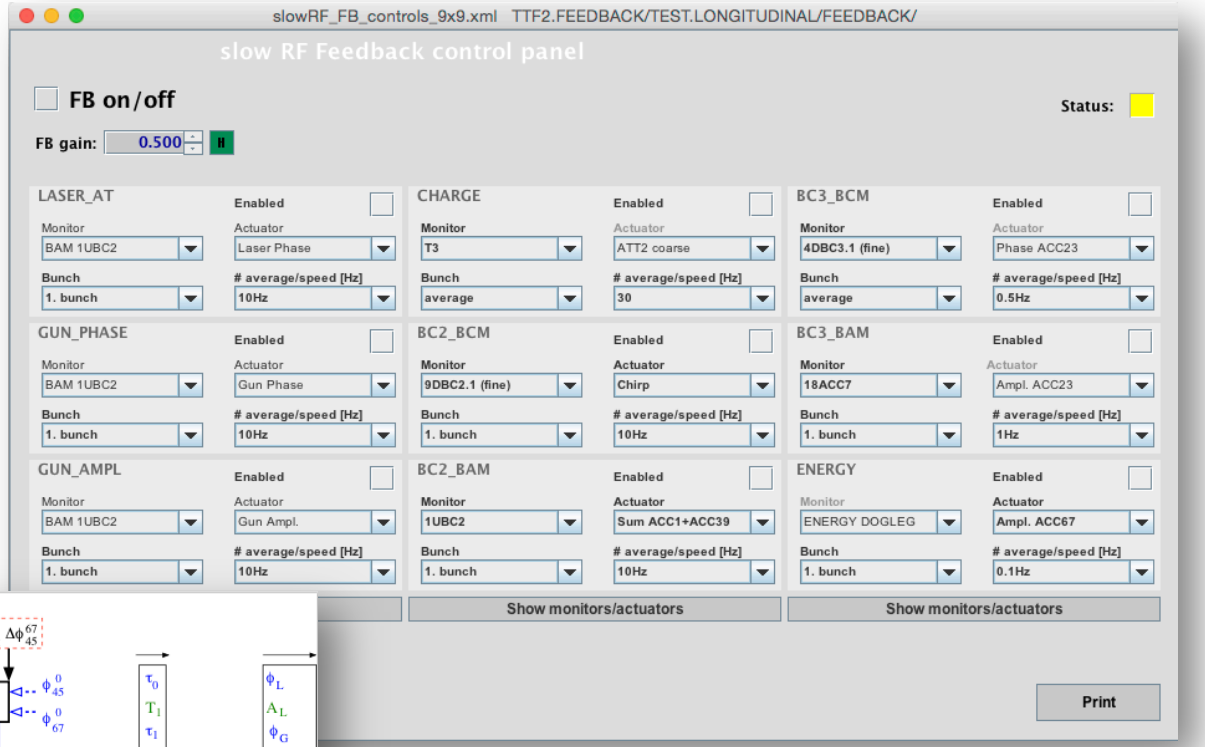
- Generic architecture of the FB allows easily to clone and configured it for other purposes
  - LOLA RF phase FB

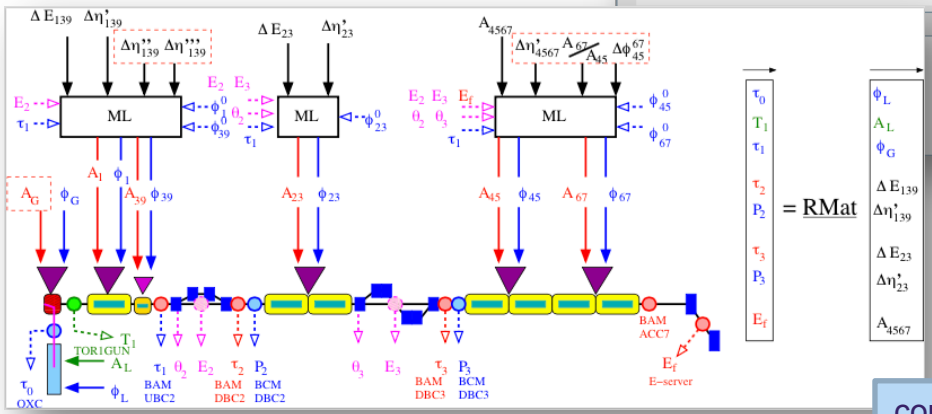




Slow Longitudinal Feedback

- Extension to include more monitors/actuators on the way

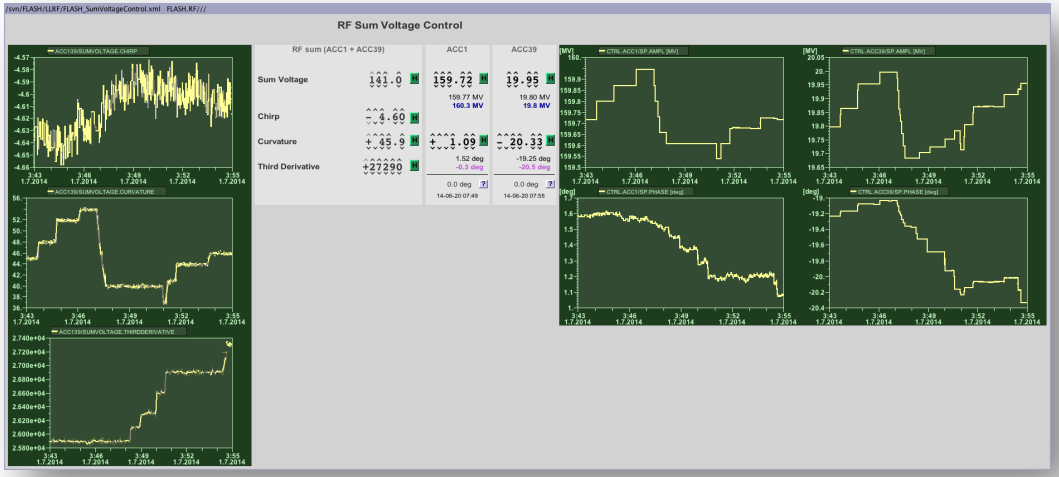




courtesy of M. Vogt

Sum Voltage Server

- Inspired by *RF Tweak*
  - Regulate "**physical quantities**" instead of phases and amplitudes (Limberg et al)
  - Implemented in *Sum Voltage Server* by O. Hensler



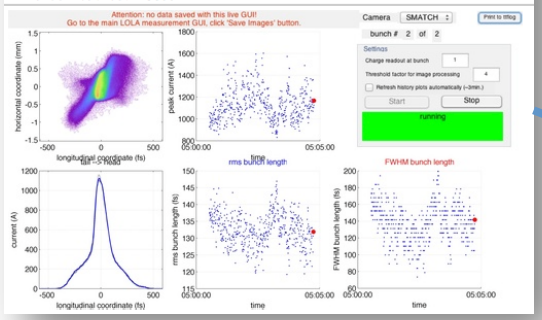
- Not used for long time, until some day …

Sum Voltage Server

- … E. Kot and me

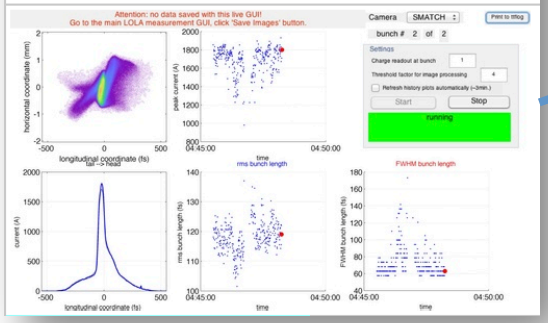
01.07.2014 05:03 Kot, Kammering **"Smooth" compression**

1.2kA, 120uJ, 140fs FWHM, 135fs RMS
Compression: -0.125V
Energy: -8.155ps
Curvature: 44.9
Third derivative: 25800



01.07.2014 04:48 Kot, Kammering **Spike mode**

1.8kA, 60uJ, 70fs FWHM, 120fs RMS
Compression: -0.145V
Energy: -7.755ps
Curvature: 44.9
Third derivative: 27200



01.07.2014 07:00 Kot, Kammering **Summary: Tools development**

This has been an very enlightening shift for us!
Starting with the idea of "just briefly playing around" a bit with the *SUM VOLTAGE server* (we need a better name for this!), we ended up spending the rest of the shift with this. What we did is:

1. Set **BC2 BAM FB** to **regulate on** sum voltage for **ACC1+ACC39**
2. Set **BC2 BCM FB** to **regulate on chirp**

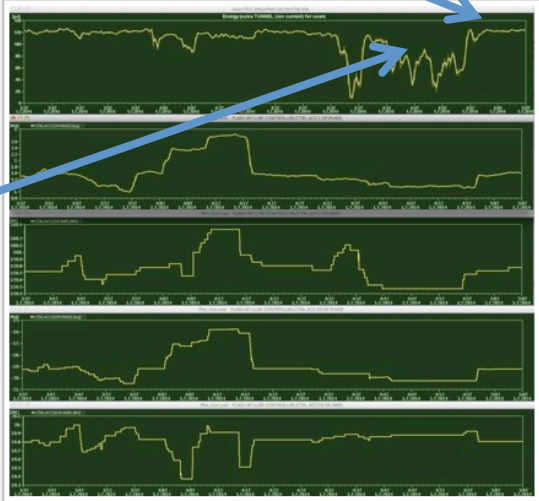
With these FBs active all the time we did several tests:

1. Tests on stability of the machine using these actuators
   - modified set point, watched all other key values and SASE
   - applied disturbance by modifying laser arrival time +/- 1ps
2. Using the physical parameters: curvature, and third derivative to modify longitudinal bunch shape
   - tried to *get a feeling* for the these parameters
   - additionally used compression and arrival time to shape the bunch
   - intentionally tried to change between spike mode and more smooth compression

What we learned:
We could maintain very high SASE level, even for degrees of phase changes at ACC1 (+/- 1 deg) and ACC39 (+/- 2 deg) (see plots)! We could use the physical parameters to intentionally *shape the bunch* as one would expect these to be working!

What we could and **should** conclude of this:
We can with the existing tools (all DOOCS servers!) directly switch over from using the old fashion way of modifying phase, amplitude settings to
1. regulate on chirp and sum voltage
2. after this use the physical parameters: curvature, third derivative (plus compression, arrival time) to shape the bunch as needed!

Appendix: All of the studies/tests below where done without control on ACC23 and therefor forced us to purely act on BC2 relevant parameters - in this sense it has even been beneficial that ACC23 could not be controlled ;)



← SASE

← ACC1 phase

← ACC1 ampl.

← ACC39 phase

← ACC39 ampl.

Sum Voltage Server

- Server has been extended to BC3 (simple phase ←→ voltage correction)
- Extended slow longitudinal FB will support use of chirp
- Server providing “normalized BCM signals” has been started

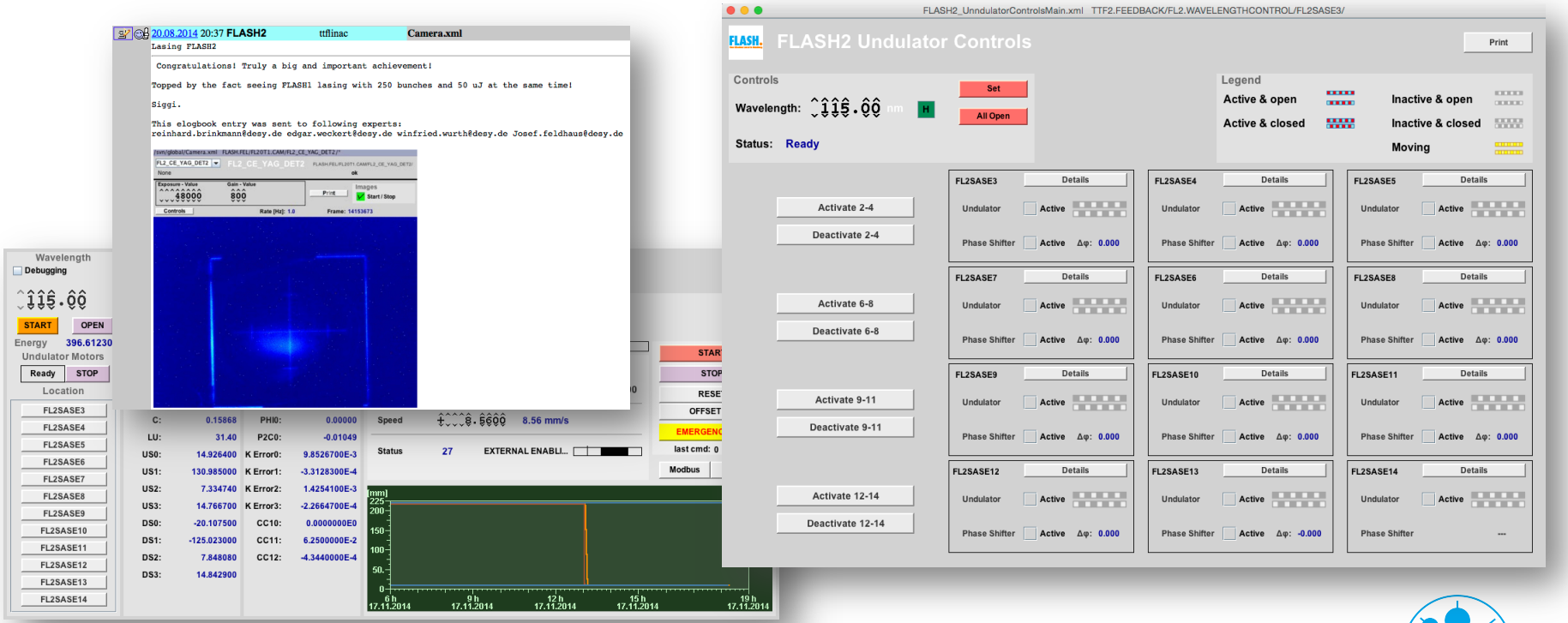
➔ **Set** and **regulated peak current** and **energy** in both bunch compressors

(instead of empirically puzzling around with 6 RF parameters)

FLASH2 Undulator Operation Server

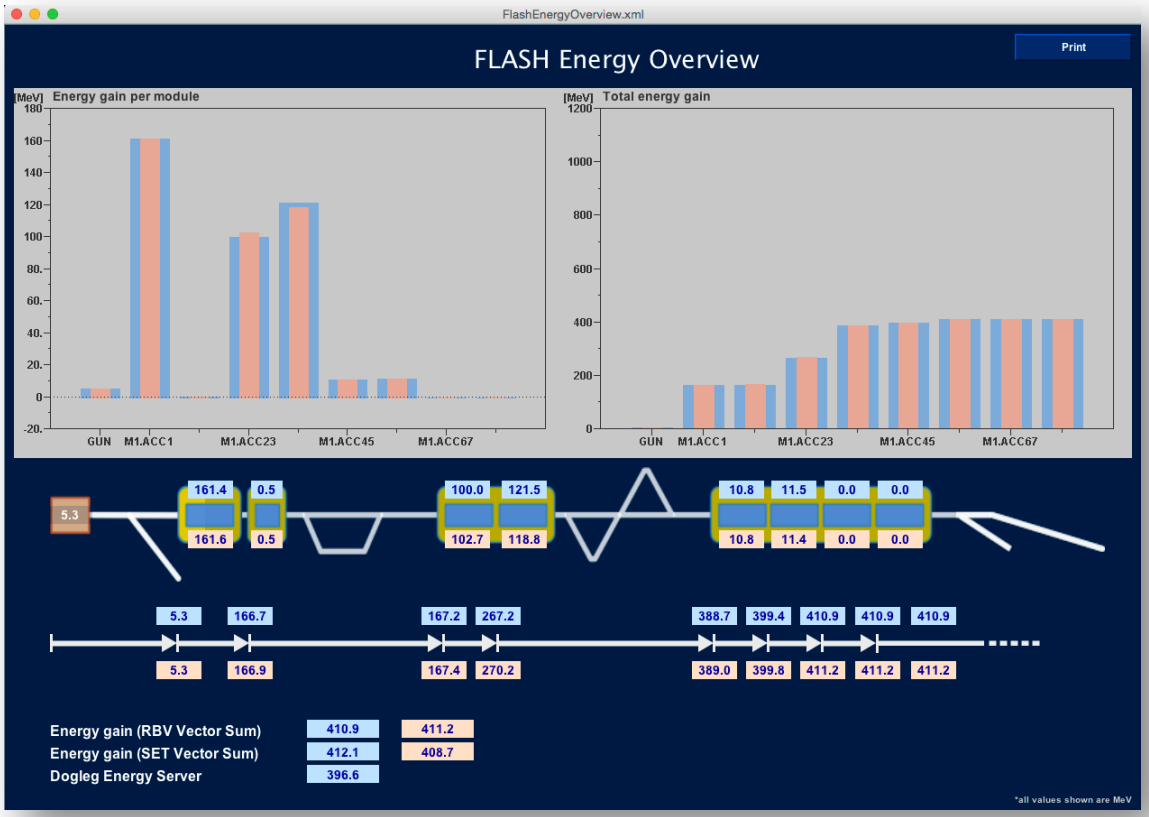
- Motivation / Idea:
  - Don't **set** gaps, but instead the **wavelength**
  - Automatically **adjust phase-shifters** accordingly
  - **Simultaneous operation** of all/several undulators

Formulas provided by M. Tischer, server by O. Hensler



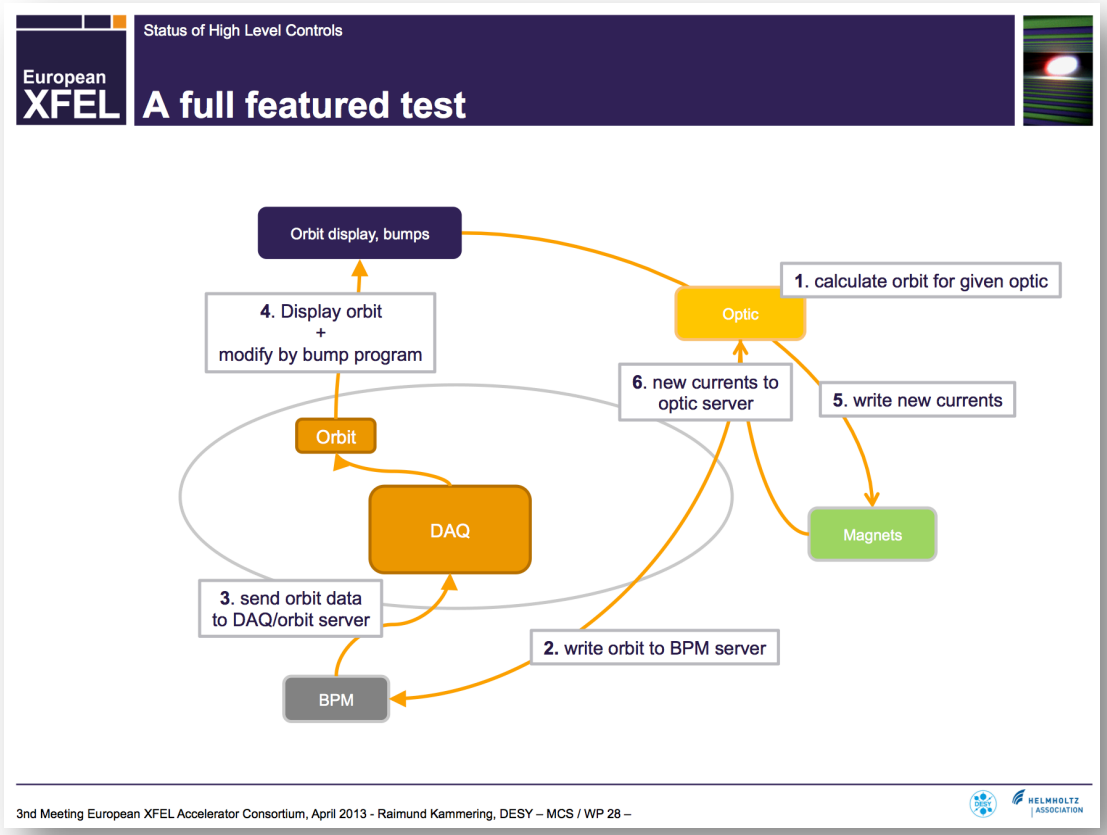
Energy Gain Server

- Calculate off-crest corrected energy gain
- Show energy profile over the whole linac
- Comparison of beam based measurements and LLRF energy



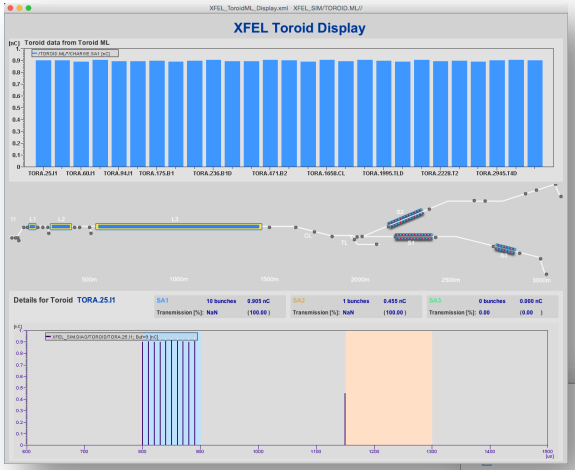
The Virtual XFEL

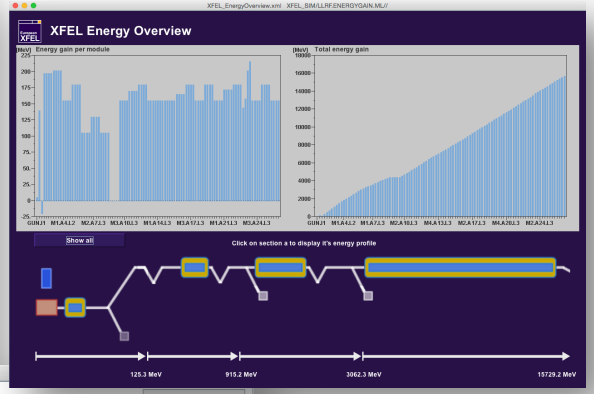
- Started from a simple test scenario – *the may test*
  - Check performance of DAQ chain for full number of BPMs @ XFEL

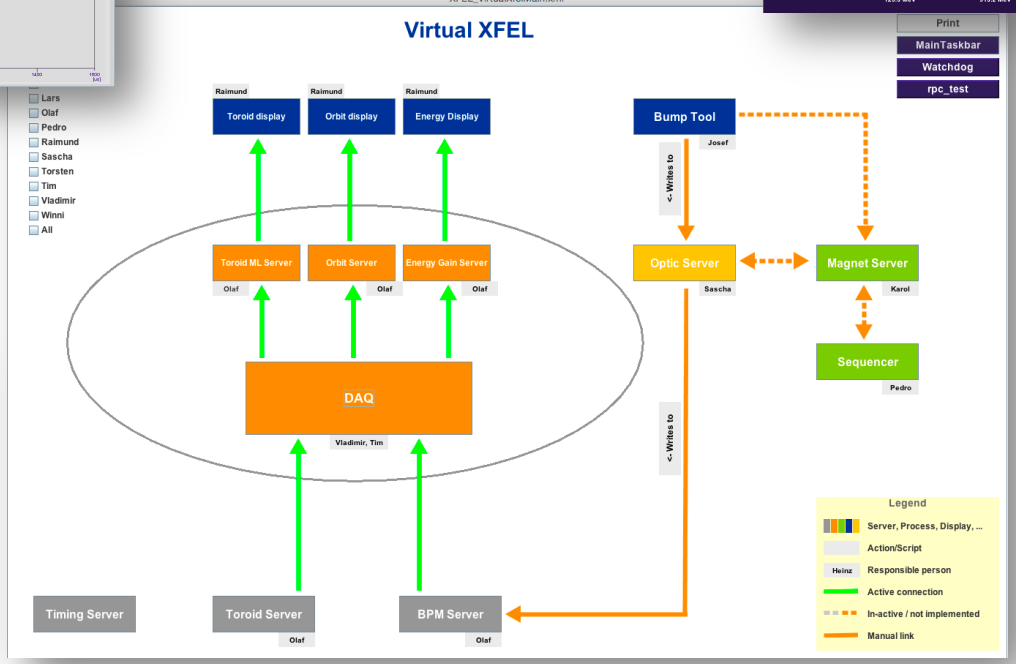


The Virtual XFEL

> We ended up having a fully featured test environment







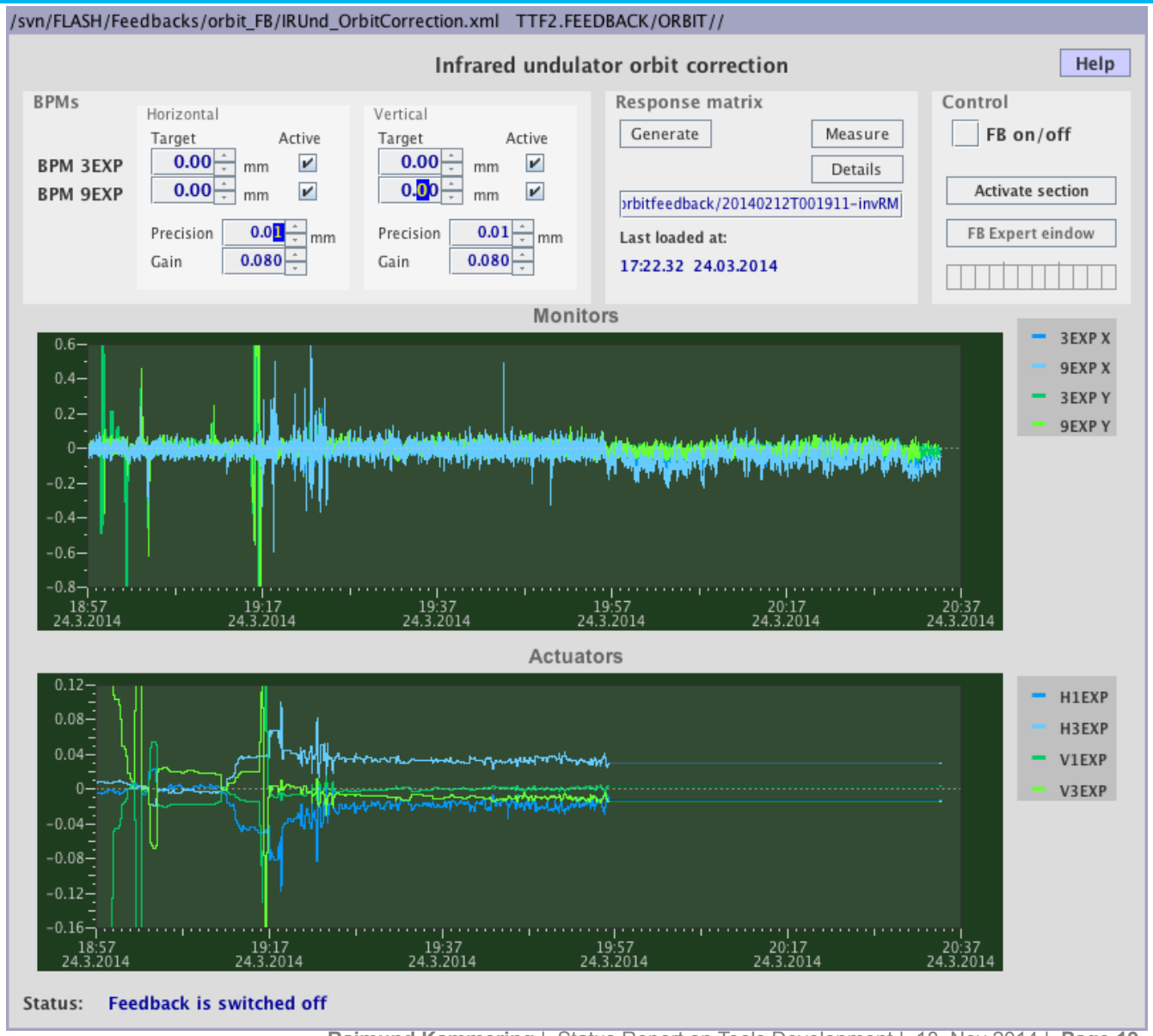
The Virtual XFEL

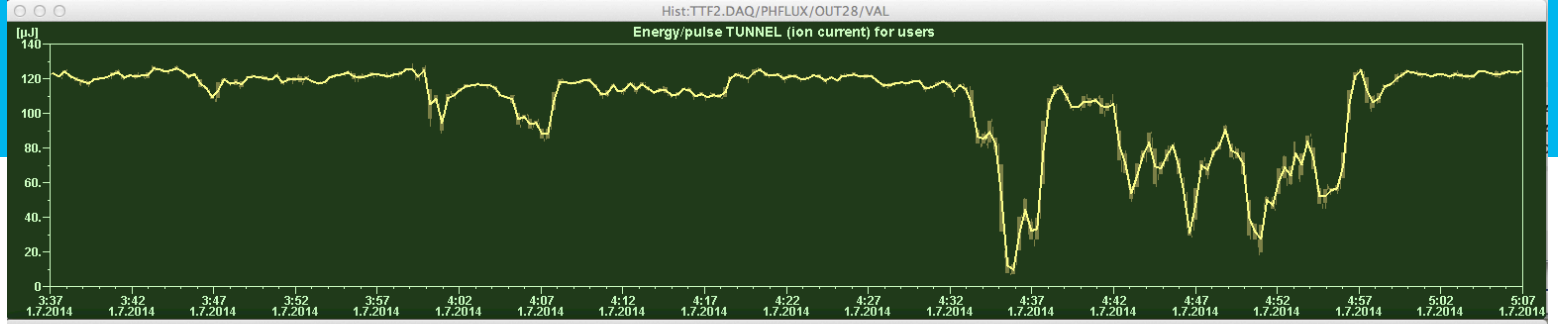
- Allowed not only to do tests we had in mind, but
  - Test complex **bunch pattern** handling for n-beamlines (here 3 so far)
  - **Design**, test and debug high-level **displays**
  - **Test interfaces** between high level software components
  - And last but not least: **Test physics** using optics server, bump tool, …
  - **No** simulation of **longitudinal phase** space so far
- Do basic tests of tools on virtual machine, saving (much) machine time

Summary

- Not much time for tools development has been available
- Orbit feedback partly well accepted and running fine …
  - … but still far from where one would like to be (set orbit and forget)
- Slow longitudinal FB runs very stable and is well accepted by all operators
  - Extension and switch over to physical quantities is ongoing (need real machine time)
- Introduction of many small tools eases operation
  - Iteration of introducing a tool ←→ verify usability is essential
- Virtual XFEL is a vital tool for developing and testing higher level software and GUI concepts
  - Here FLASH also gains a lot from (V)XFEL

Thank you for your attention!


/svn/FLASH/Feedbacks/orbit_FB/IRUnd_OrbitCorrection.xml TTF2.FEEDBACK/ORBIT//
Infrared undulator orbit correction
Help
BPMs
Horizontal
Target
Active
BPM 3EXP
BPM 9EXP
0.00
mm
Precision
0.01
Gain
0.080
Vertical
Response matrix
Generate
Measure
Details
orbitfeedback/20140212T001911-invRM
Last loaded at:
17:22.32 24.03.2014
Control
FB on/off
Activate section
FB Expert eindow
Monitors
3EXP X
9EXP X
3EXP Y
9EXP Y
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
18:57 24.3.2014
19:17 24.3.2014
19:37 24.3.2014
19:57 24.3.2014
20:17 24.3.2014
20:37 24.3.2014
Actuators
H1EXP
H3EXP
V1EXP
V3EXP
0.12
0.08
0.04
-0.04
-0.08
-0.12
-0.16
Status:
Feedback is switched off


Hist:TTF2.DAQ/PHFLUX/OUT28/VAL
Energy/pulse TUNNEL (ion current) for users
[µJ]
140
120
100
80
60
40
20
0
3:37 1.7.2014
3:42 1.7.2014
3:47 1.7.2014
3:52 1.7.2014
3:57 1.7.2014
4:02 1.7.2014
4:07 1.7.2014
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4:17 1.7.2014
4:22 1.7.2014
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4:57 1.7.2014
5:02 1.7.2014
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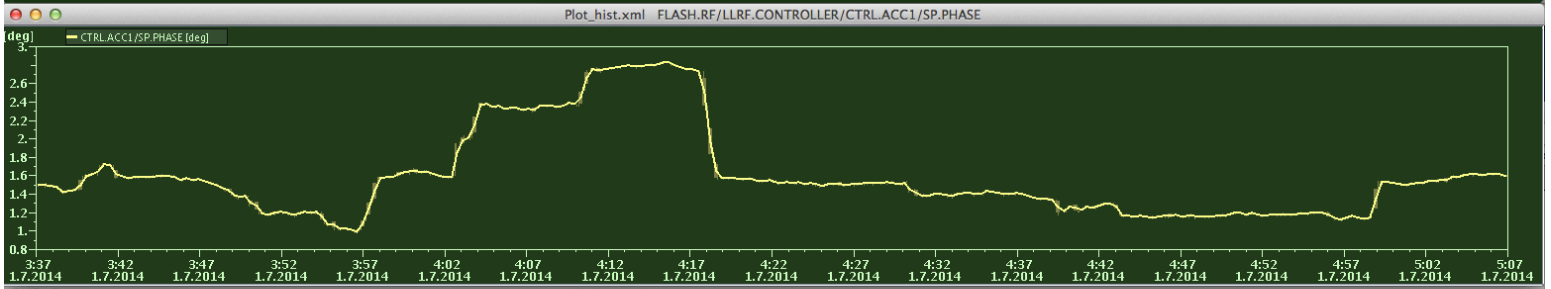
Plot_hist.xml FLASH.RF/LLRF.CONTROLLER/CTRL.ACC1/SP.PHASE
[deg]
CTRL.ACC1/SP.PHASE [deg]
3.
2.6
2.4
2.2
2.
1.8
1.6
1.4
1.2
1.
0.8
3:37 1.7.2014
3:42 1.7.2014
3:47 1.7.2014
3:52 1.7.2014
3:57 1.7.2014
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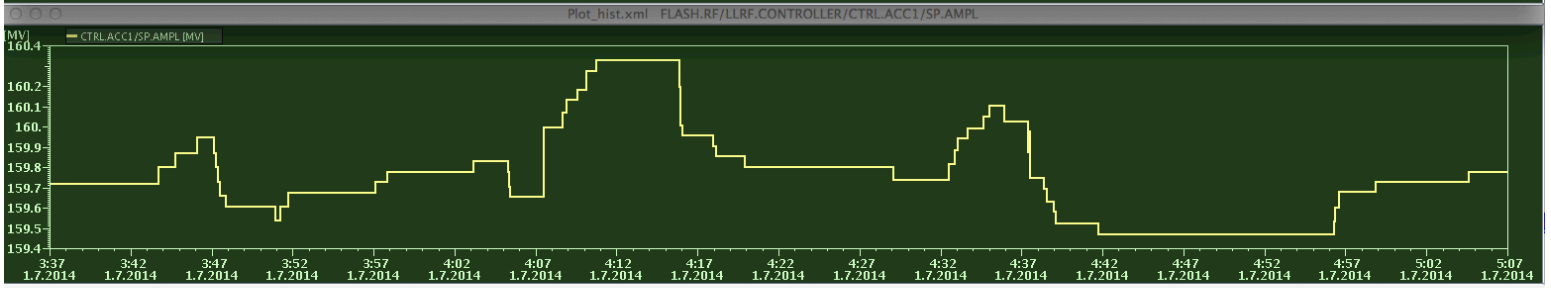
Plot_hist.xml FLASH.RF/LLRF.CONTROLLER/CTRL.ACC1/SP.AMPL
[MV]
CTRL.ACC1/SP.AMPL [MV]
160.4
160.2
160.1
160.
159.9
159.8
159.7
159.6
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159.4
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3:42 1.7.2014
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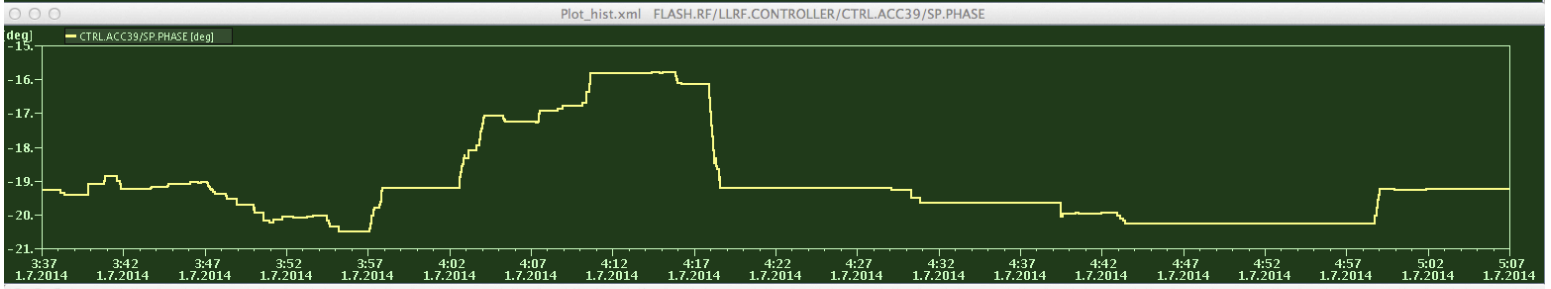
Plot_hist.xml FLASH.RF/LLRF.CONTROLLER/CTRL.ACC39/SP.PHASE
deg]
CTRL.ACC39/SP.PHASE [deg]
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-16.
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3:37 1.7.2014
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3:47 1.7.2014
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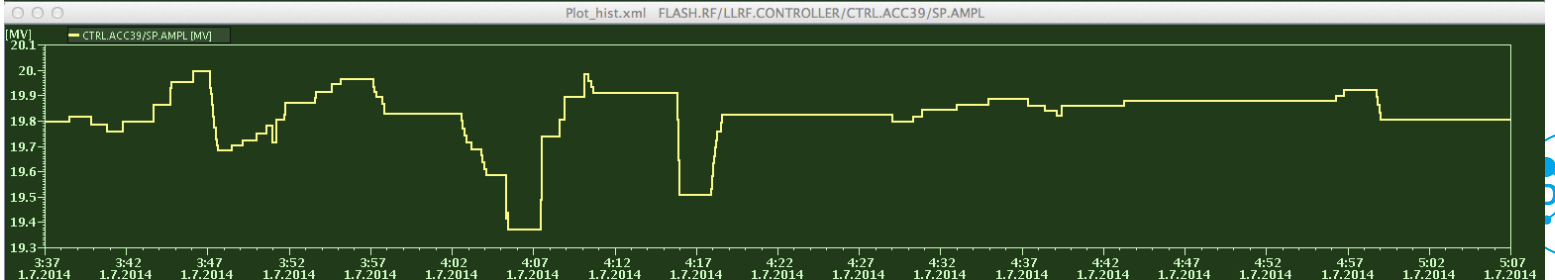
Plot_hist.xml FLASH.RF/LLRF.CONTROLLER/CTRL.ACC39/SP.AMPL
[MV]
CTRL.ACC39/SP.AMPL [MV]
20.1
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