

High gradient test results from X-BOX1

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CERN, Switzerland
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- System Layout
- Diagnostics
- BD detection and response
- Structure conditioning progress
- 100MV/m results for 26 cell accelerating structure
- Klystron vacuum/arcng issues
- Future developments

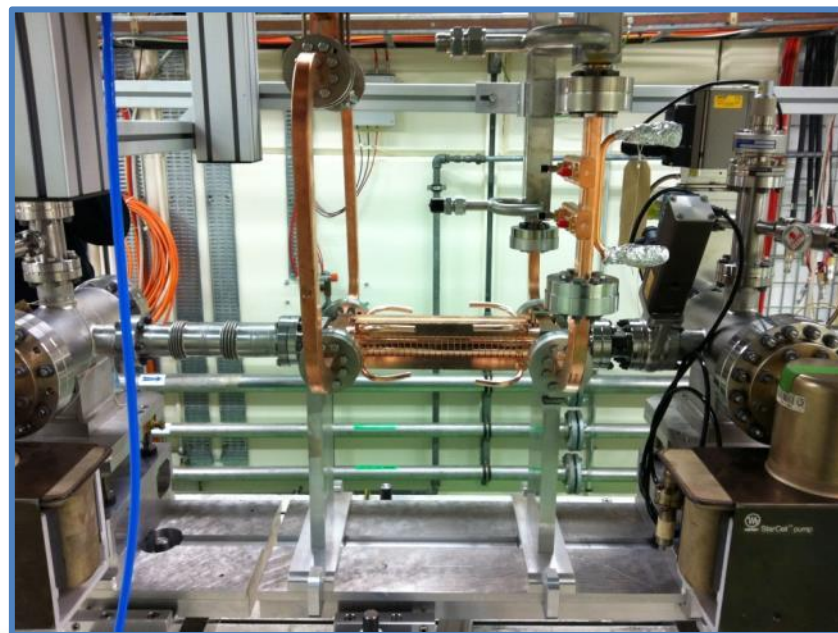
Xbox-1 Layout

Clockwise from top-left:

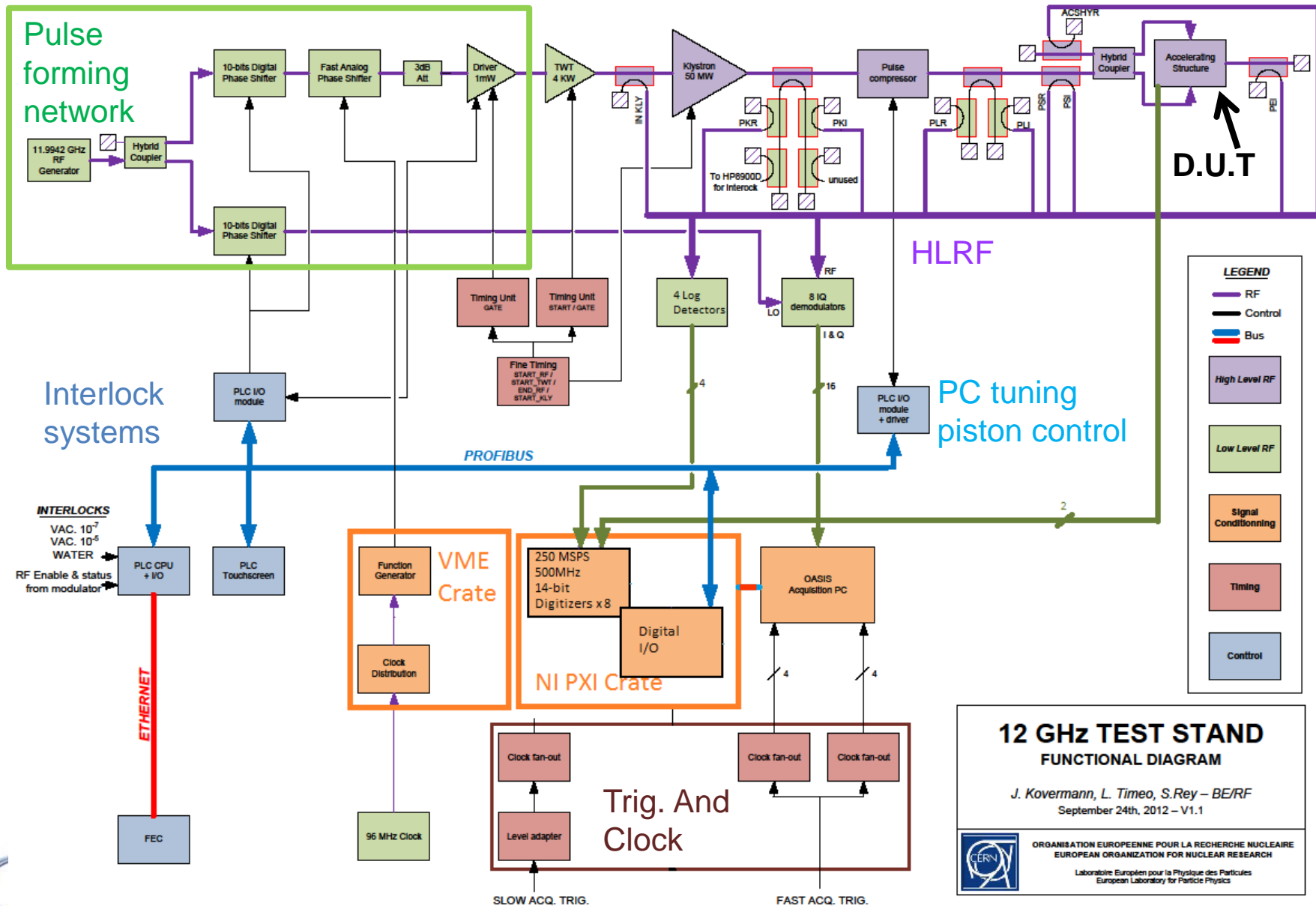
- Modulator/klystron (50MW, 1.5us pulse)
- Pulse compressor (250ns, ratio 2.8)
- DUT + connections
- Acc. structure (TD26CC)

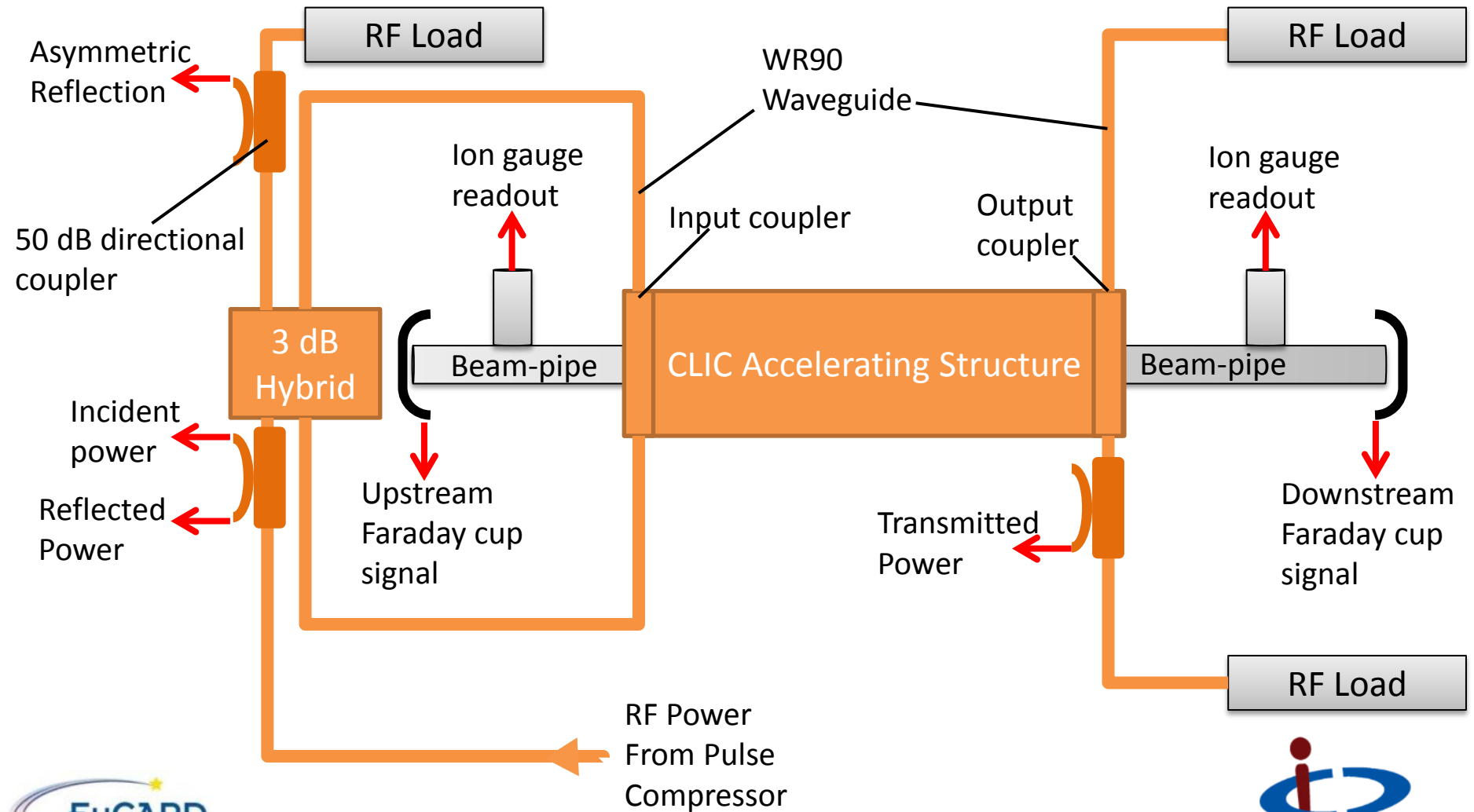


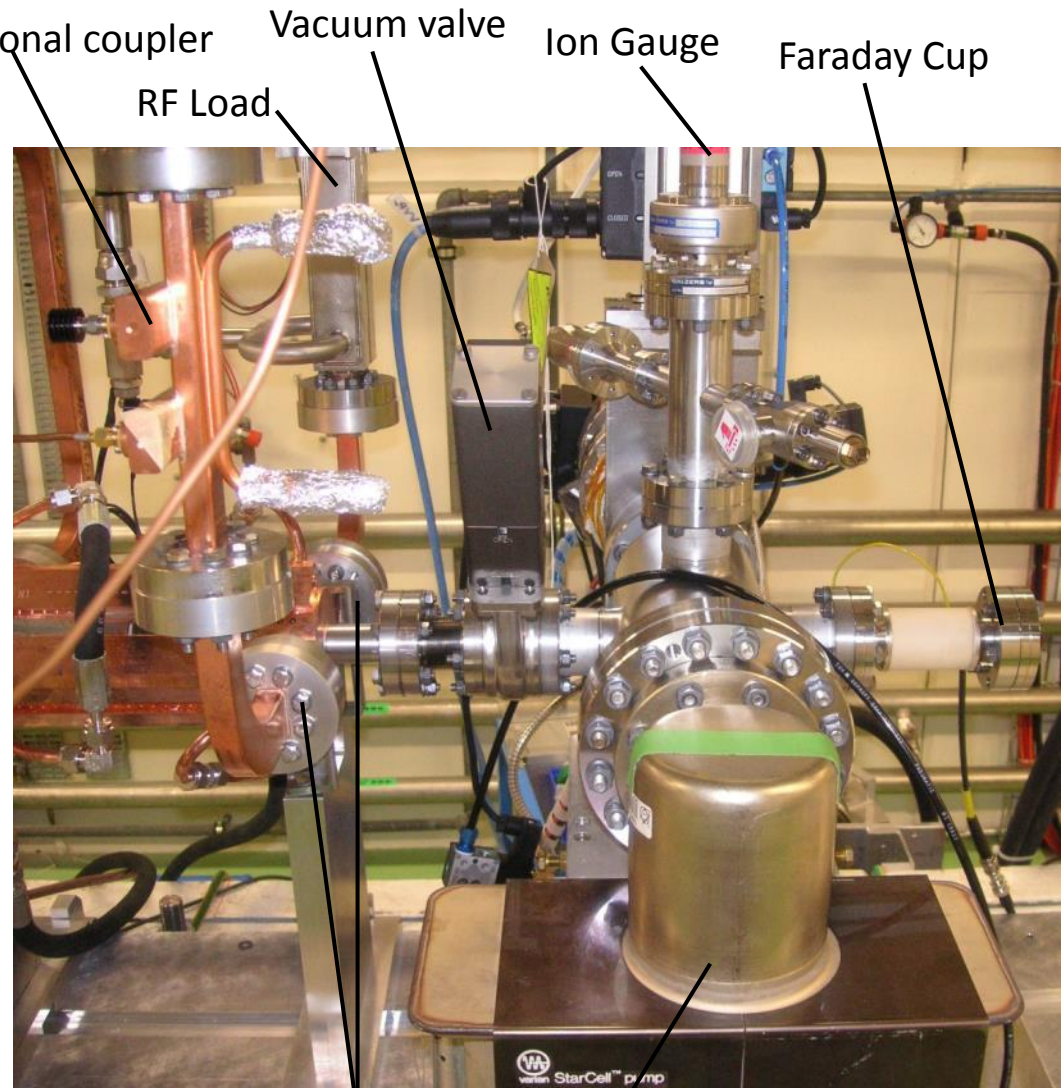
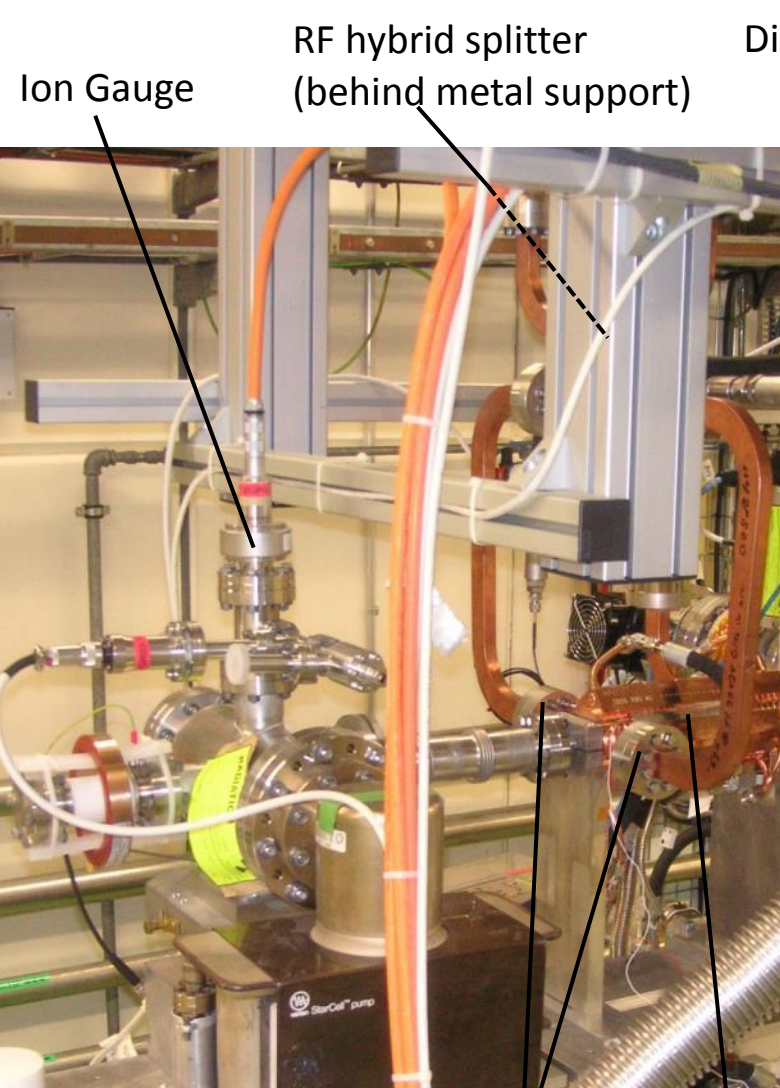
Gallery
Bunker



System Layout and diagnostics







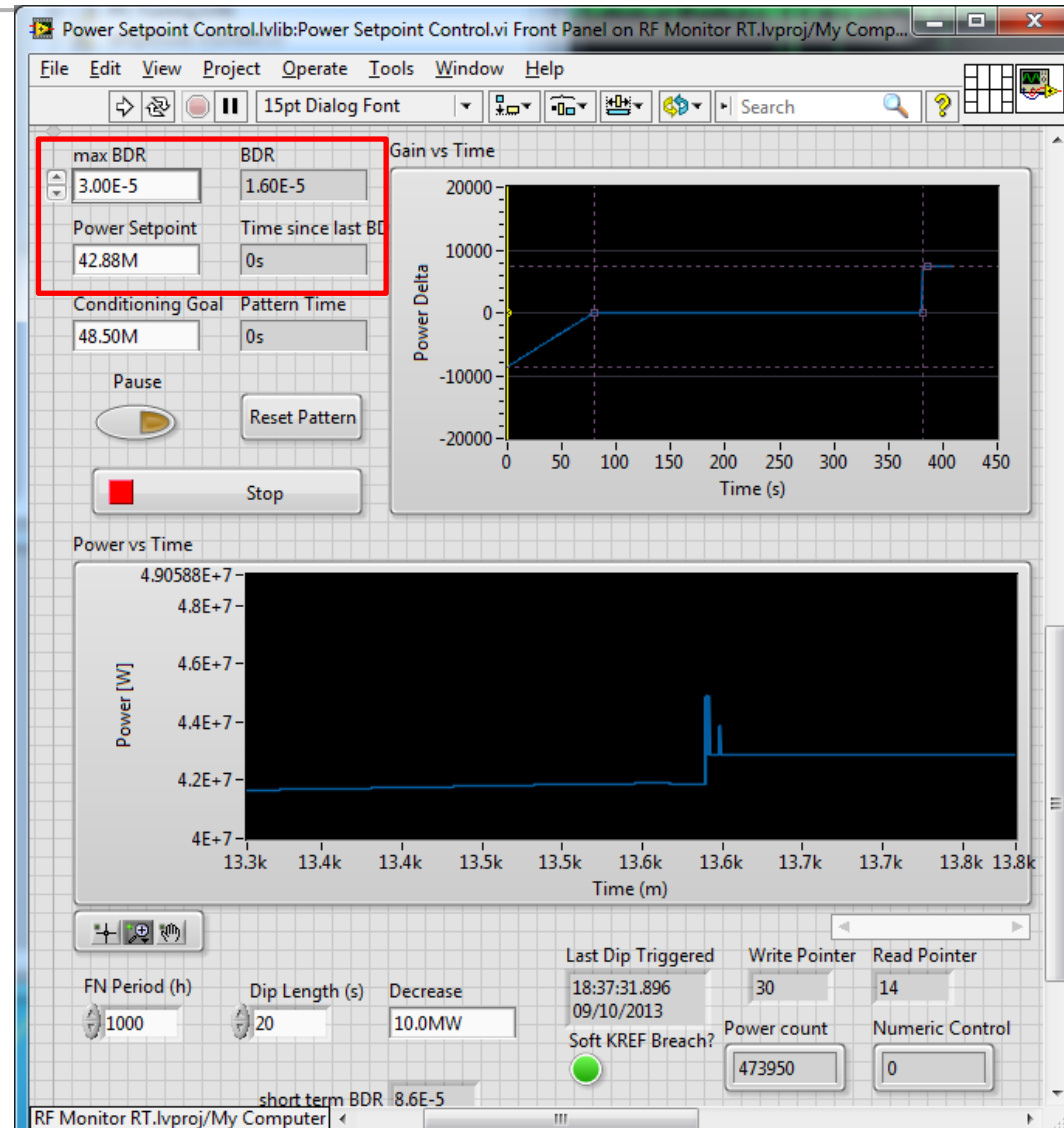
Ion Gauge RF hybrid splitter (behind metal support) Directional coupler Vacuum valve Ion Gauge Faraday Cup
 RF Load

Structure input couplers Temperature probe

Structure output couplers Ion Pump

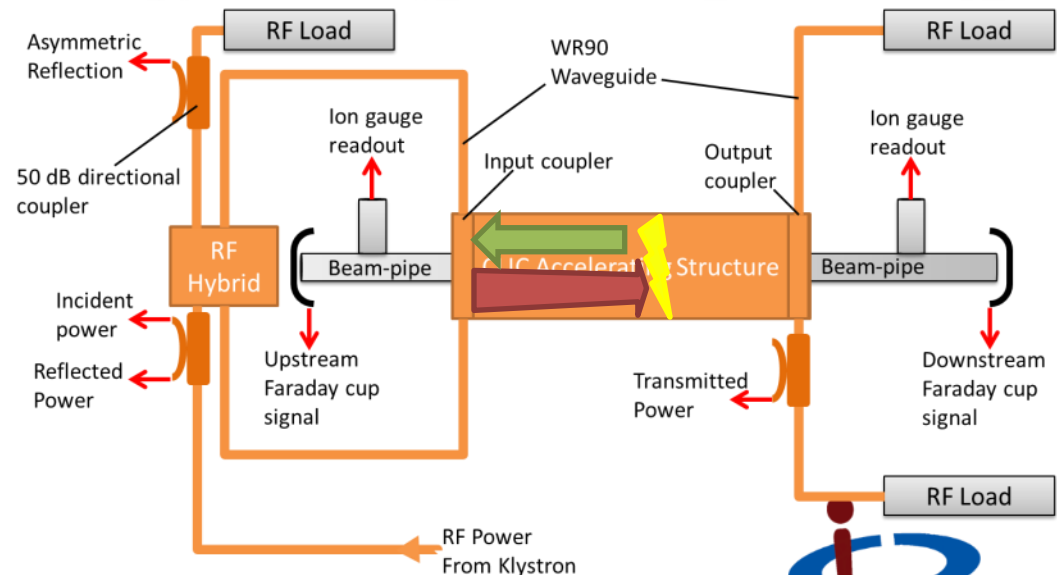
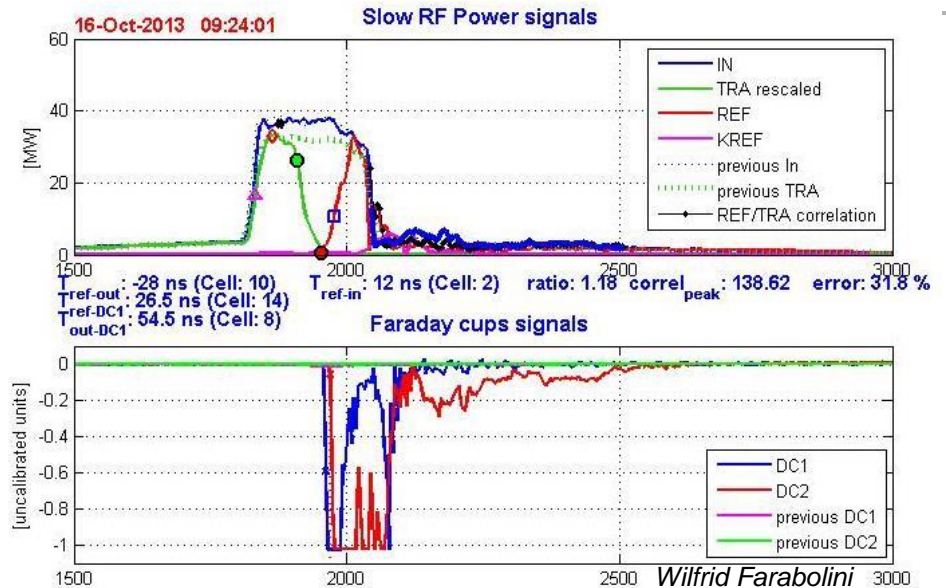
Cavity Conditioning Algorithm

- Automatically controls incident power to structure.
- Short term: +10kW steps every 6 min and -10kW per BD event.
- **Long Term:** Measures BDR (1MPulse moving avg.) and will stop power increase if BDR too high.



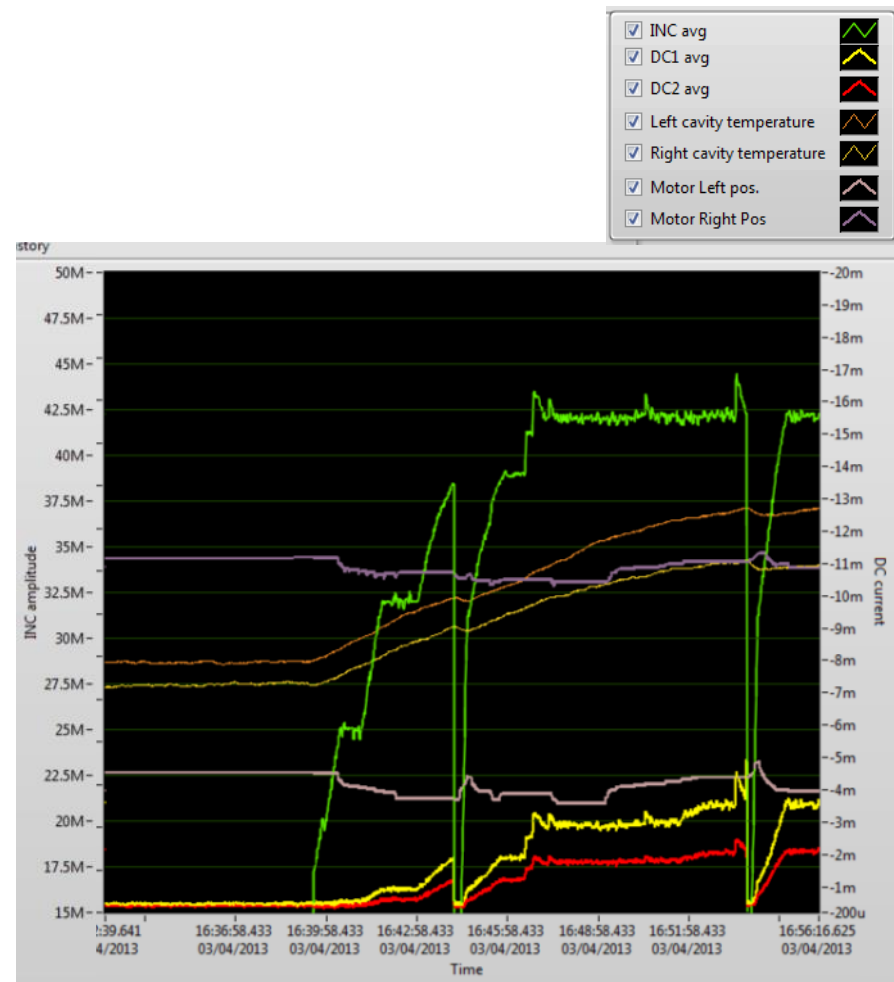
BD Detection: Breakdown

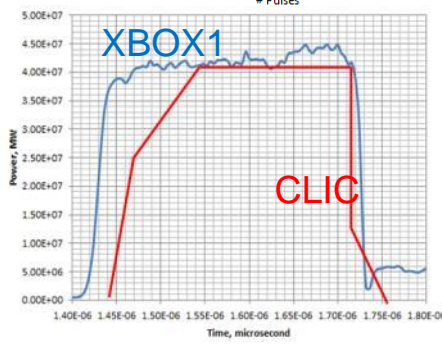
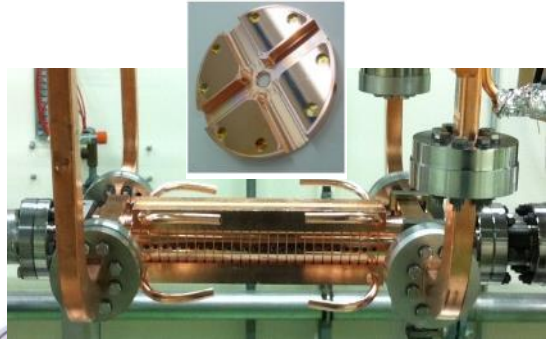
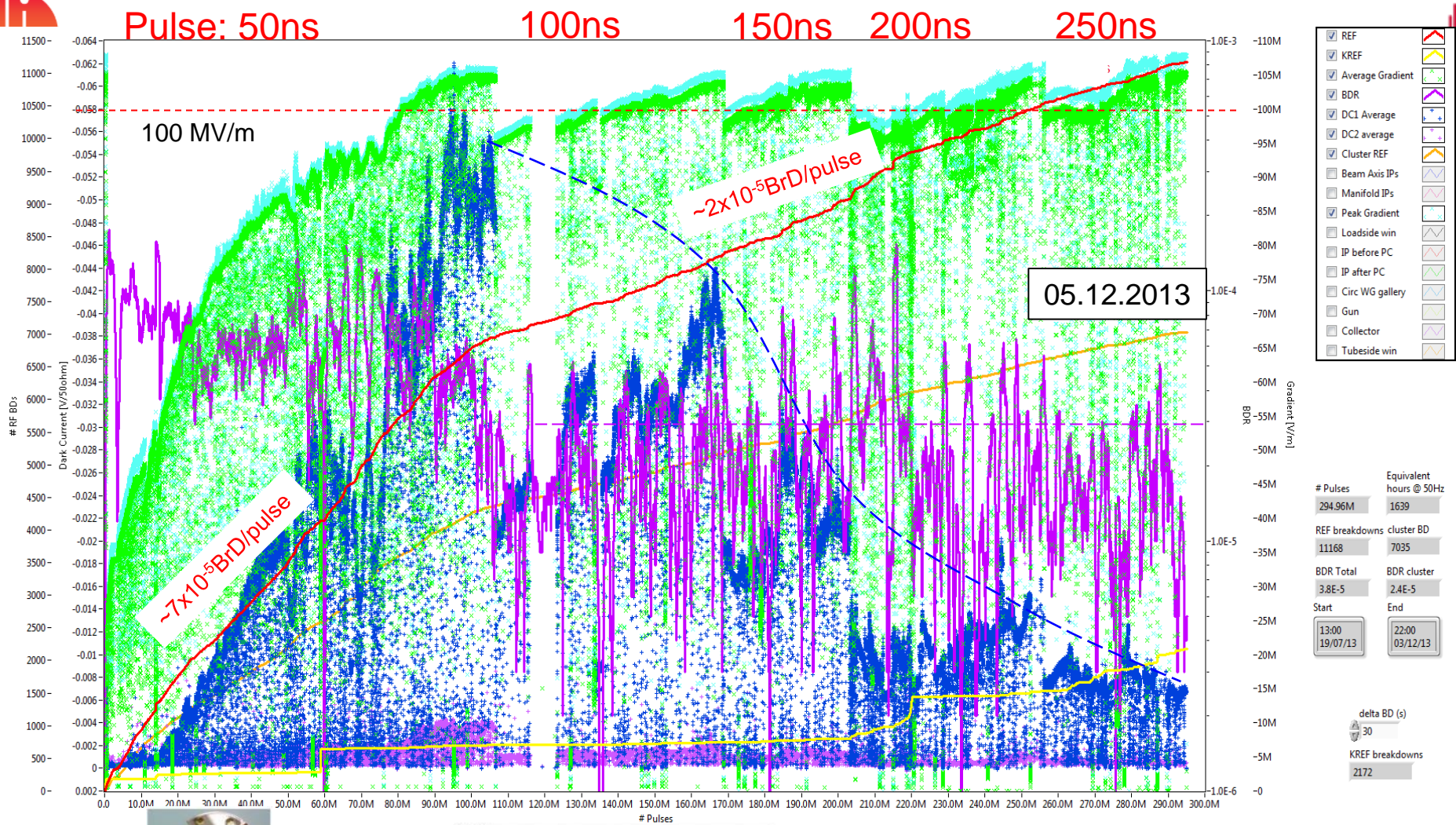
- Transmitted pulse drops as the arc is established.
- Reflected power increases to the same order as the incident pulse.
- Faraday cup voltages are saturated: 100-1000x increase in charge emitted.
- We can use the difference in time between the transmitted power falling and the reflected power increasing to find the BD cell location.
- The phase of the reflected signal is used to pinpoint cell location.



Breakdown: Steps taken

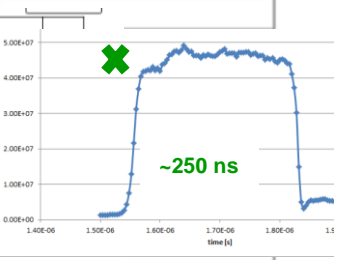
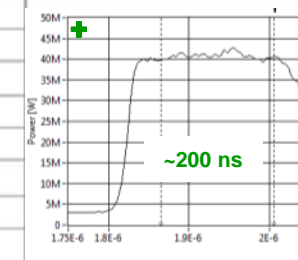
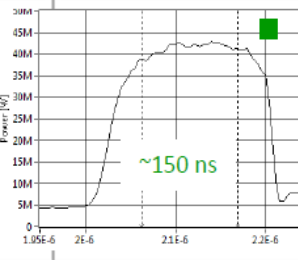
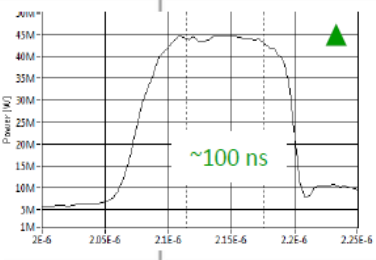
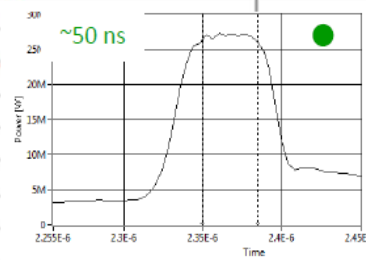
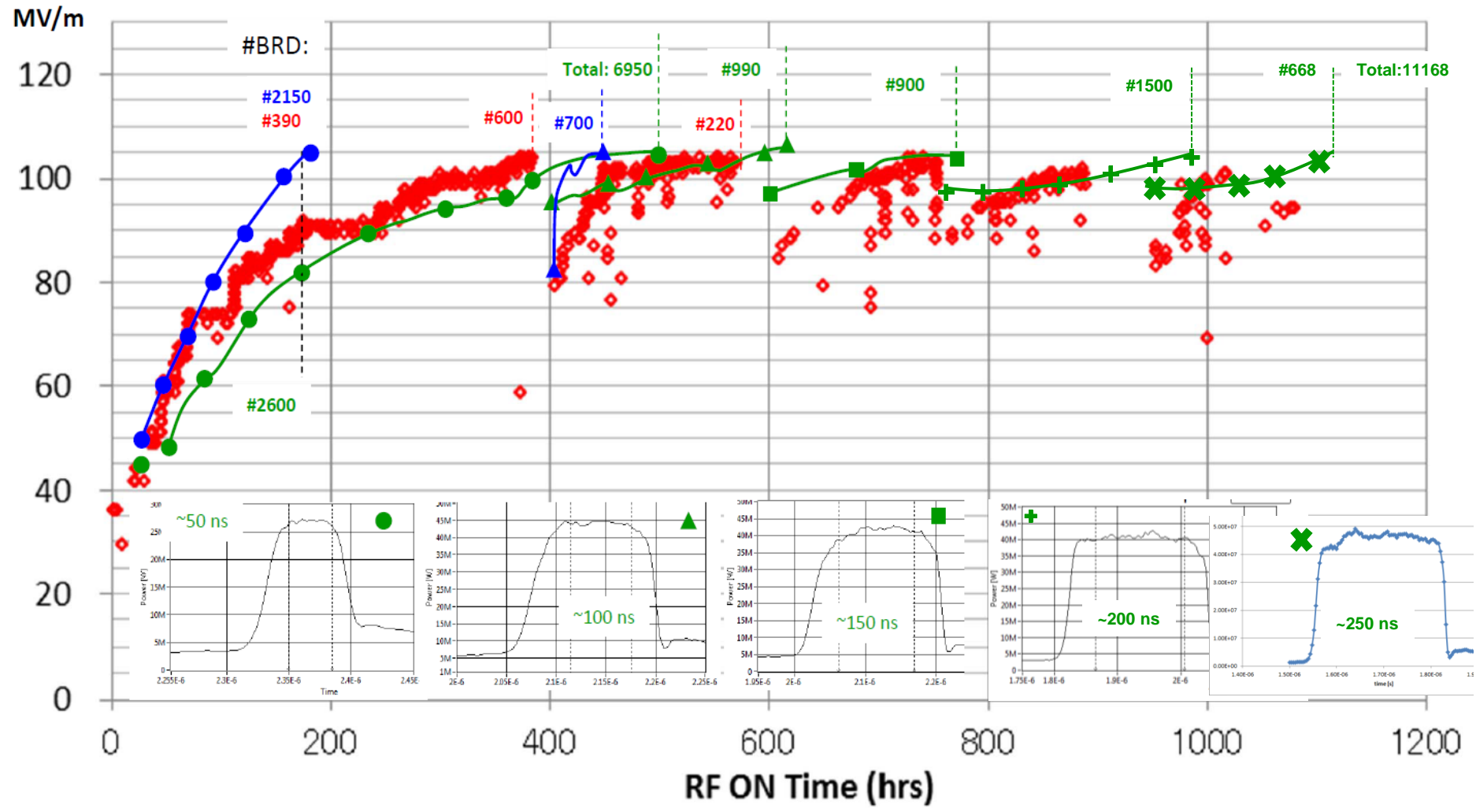
- We stop the next pulse from occurring and wait 2 seconds to let the vacuum level recover.
- All the signals are logged to file for later analysis.
- Over 20-30 seconds we ramp the power from zero back to the power set-point.



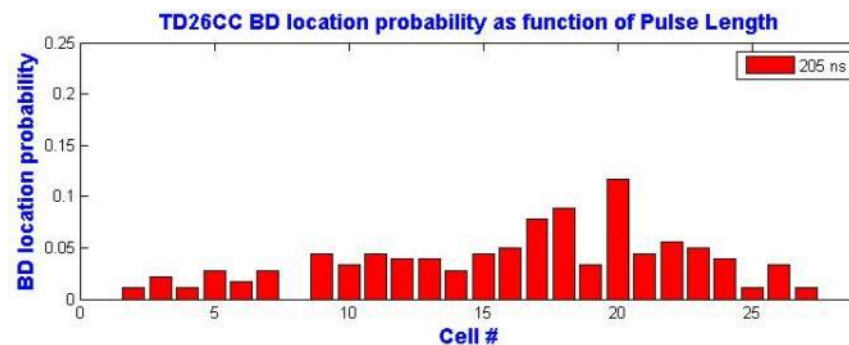
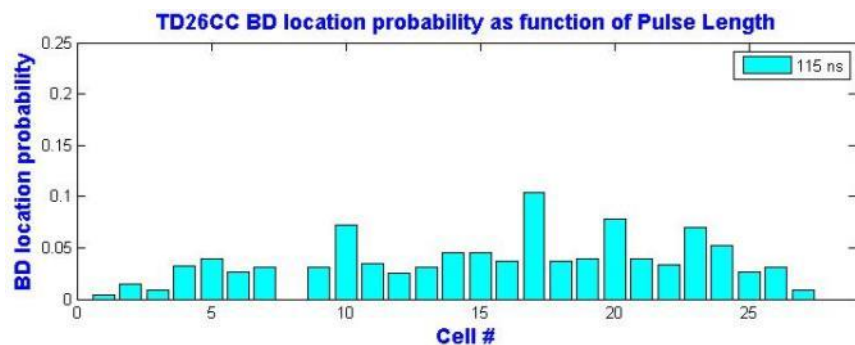
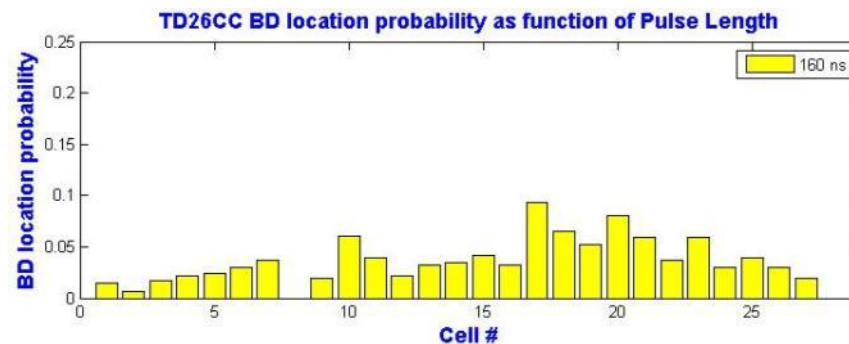
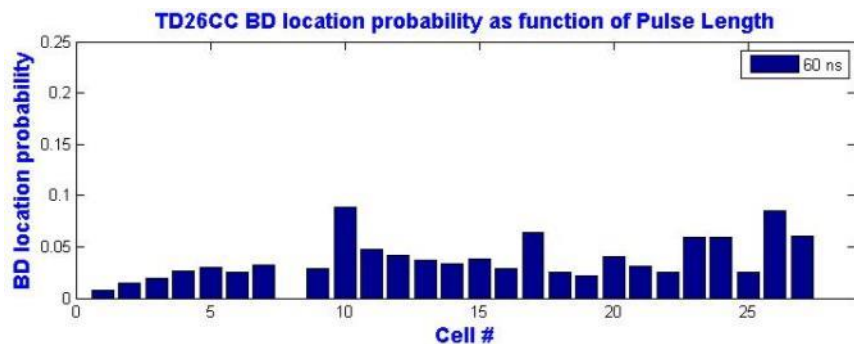
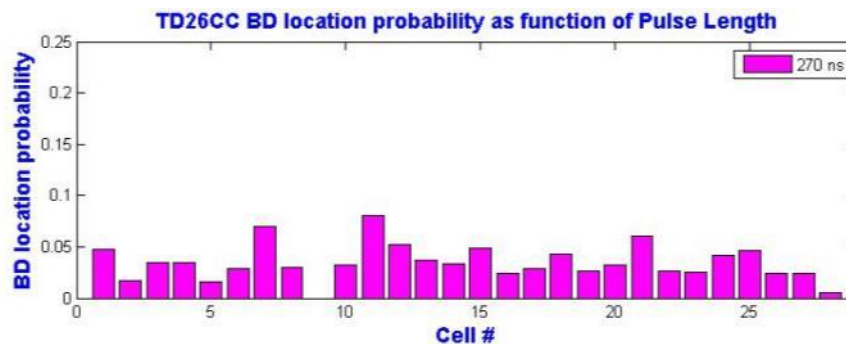


Full-fledged CLIC accelerating structure **TD26R05CC** build by CERN is successfully processed in XBOX1 up to 107 MW/m unloaded accelerating gradient at 250 ns pulses . We have started now study of breakdown rate evolution at the fixed (100 MV/m) gradient.

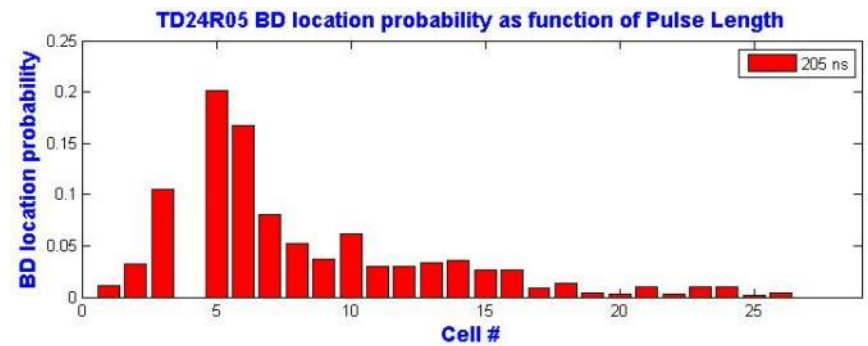
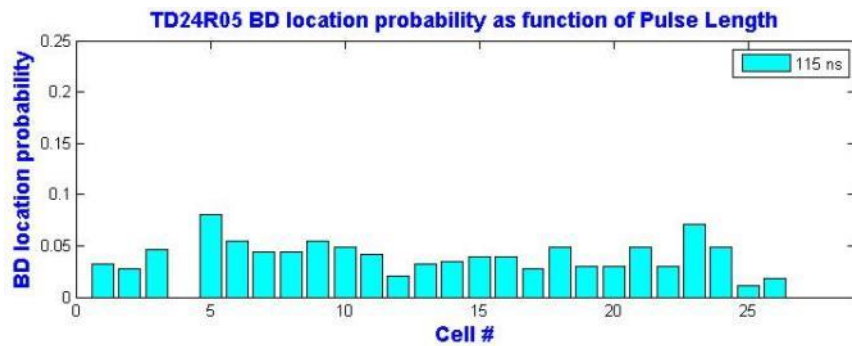
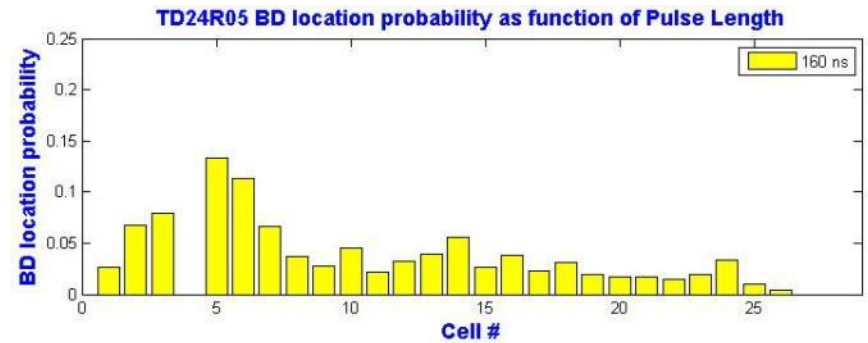
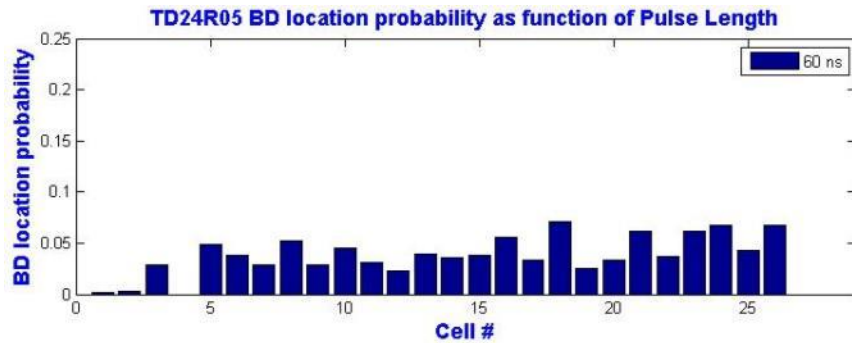
Comparison of the TD24R05(KEK); TD24R05(CERN) and TD26R05CC (CERN) processing histories.



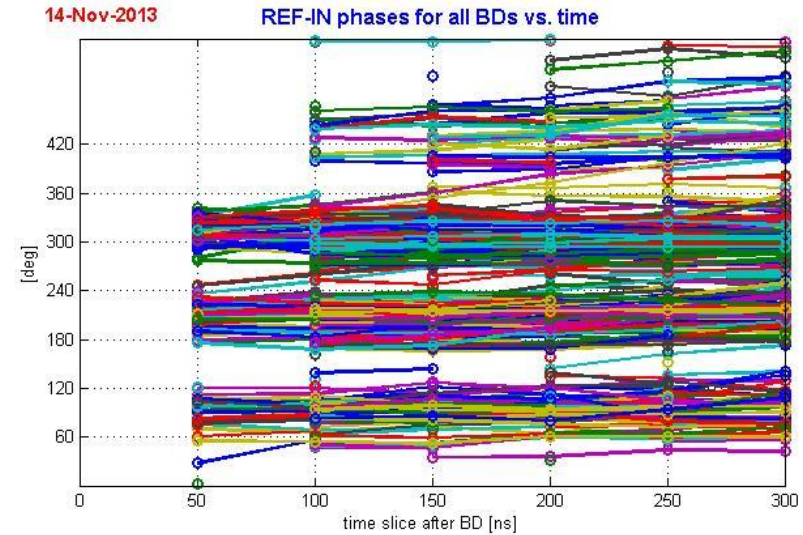
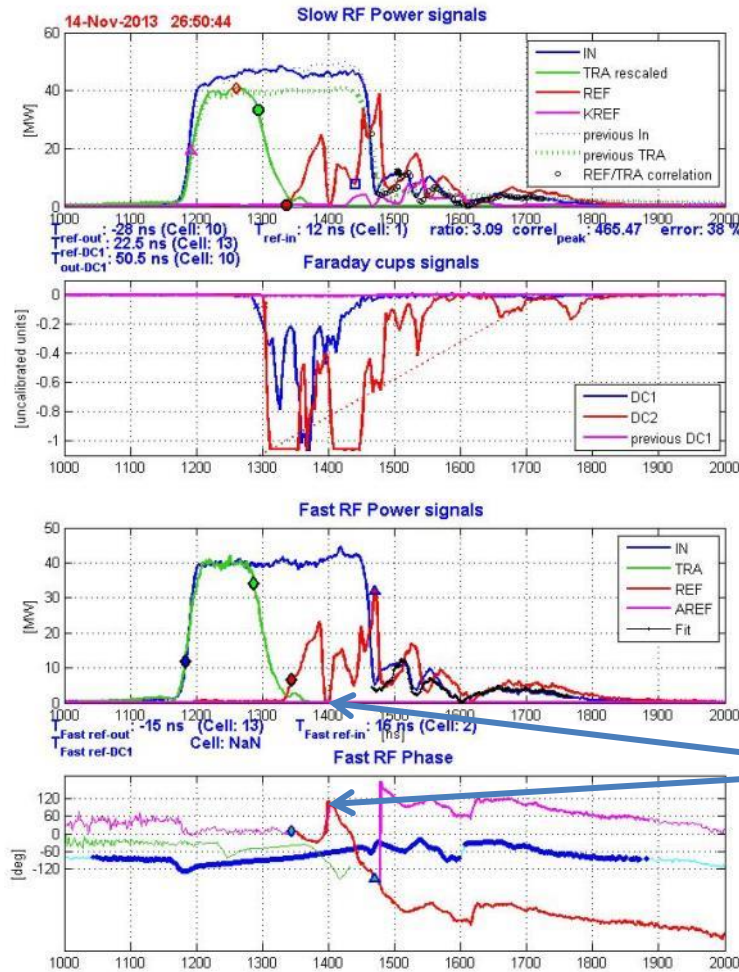
BD cell location: TD26CC



BD cell location: TD24R05



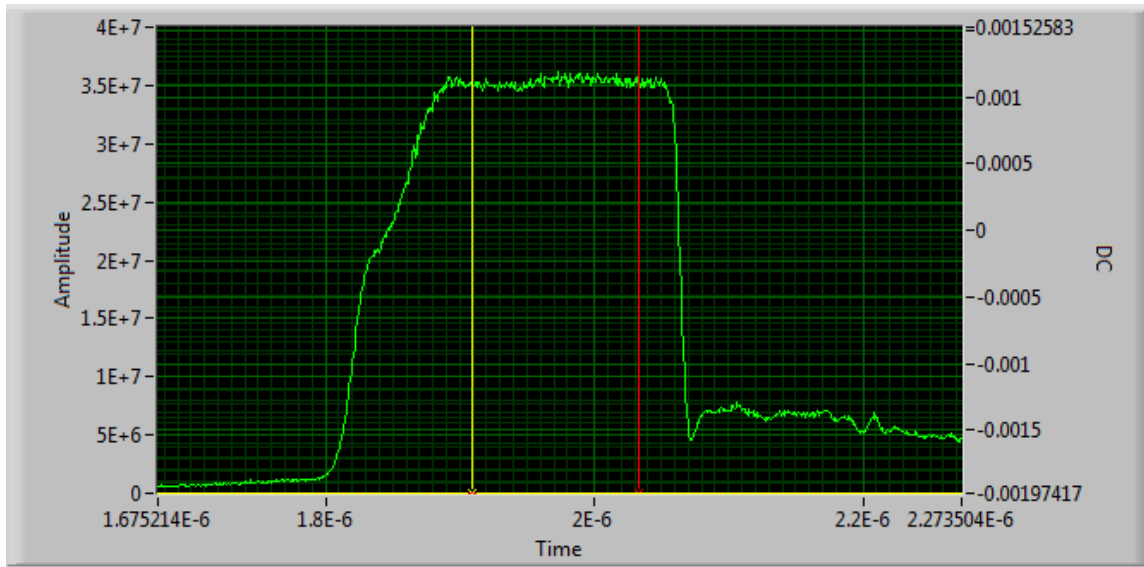
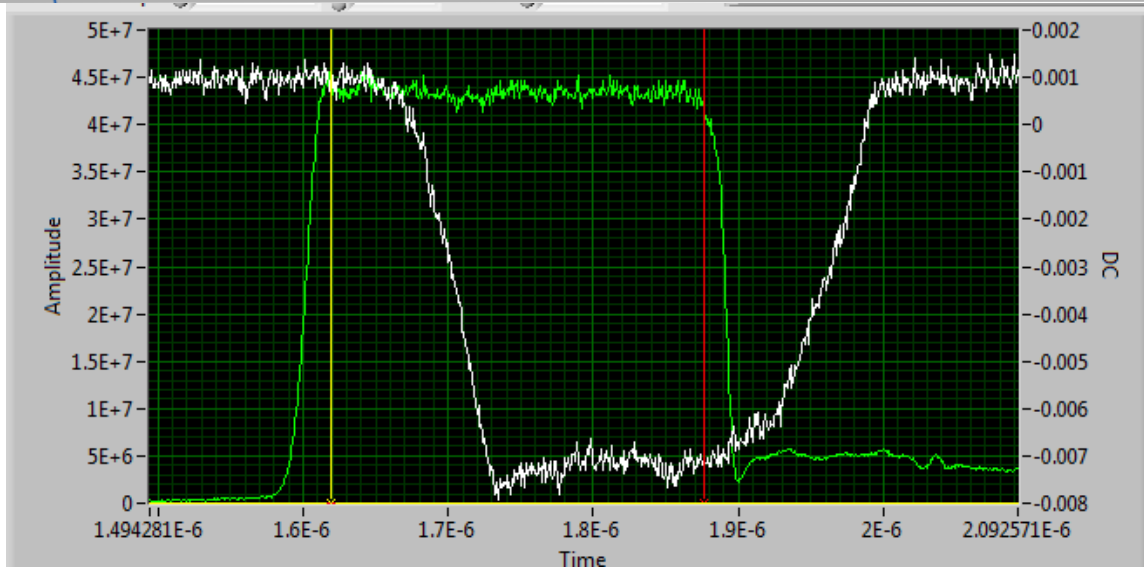
Reflected phase are grouped and separated by $2\pi/3$



About 25% of BDs see a drift in position:

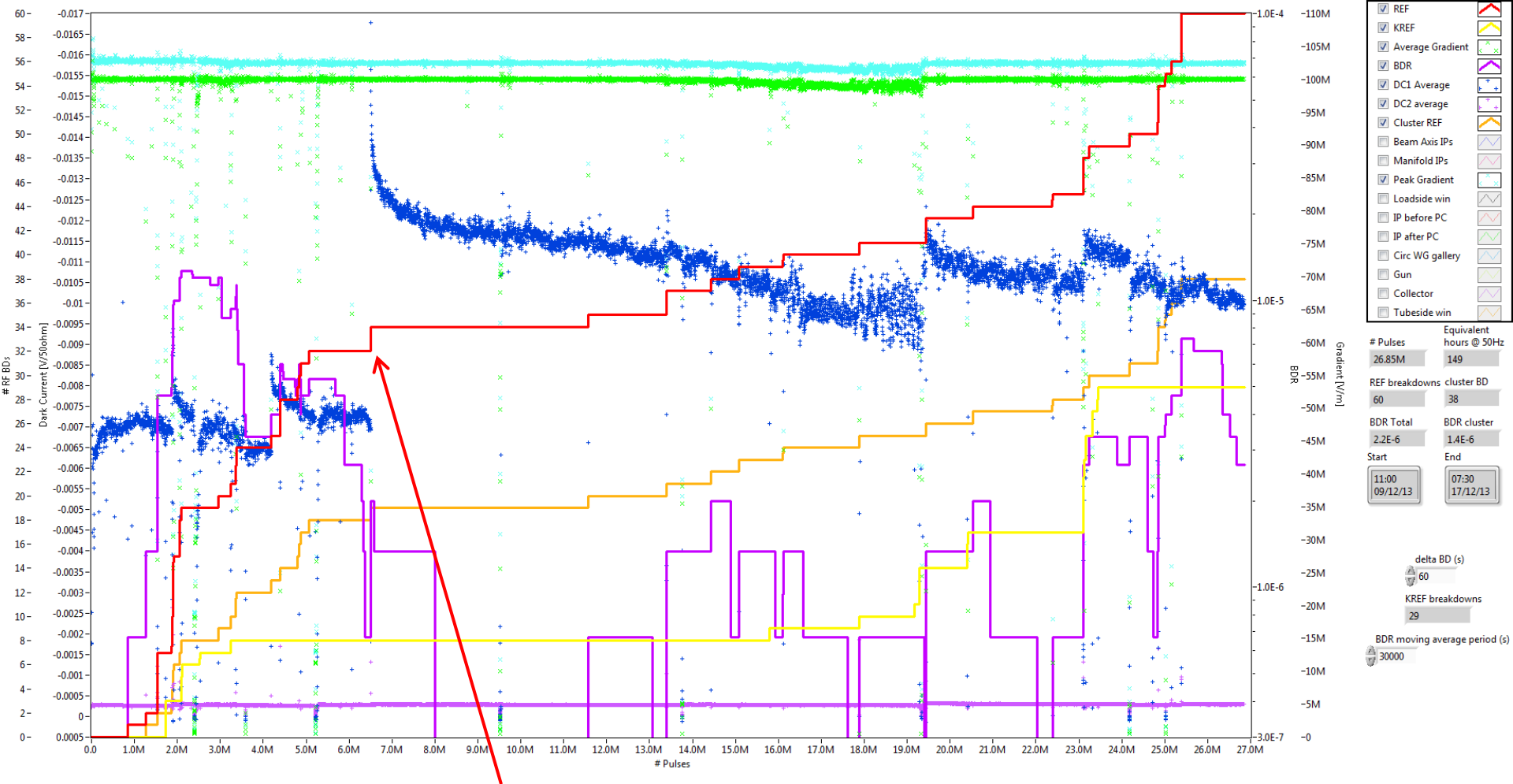
- REF pulse is split in 2 parts that shows 2 different phases
- The overall phase change is always negative → BD arc is moving towards the input.

New Developments



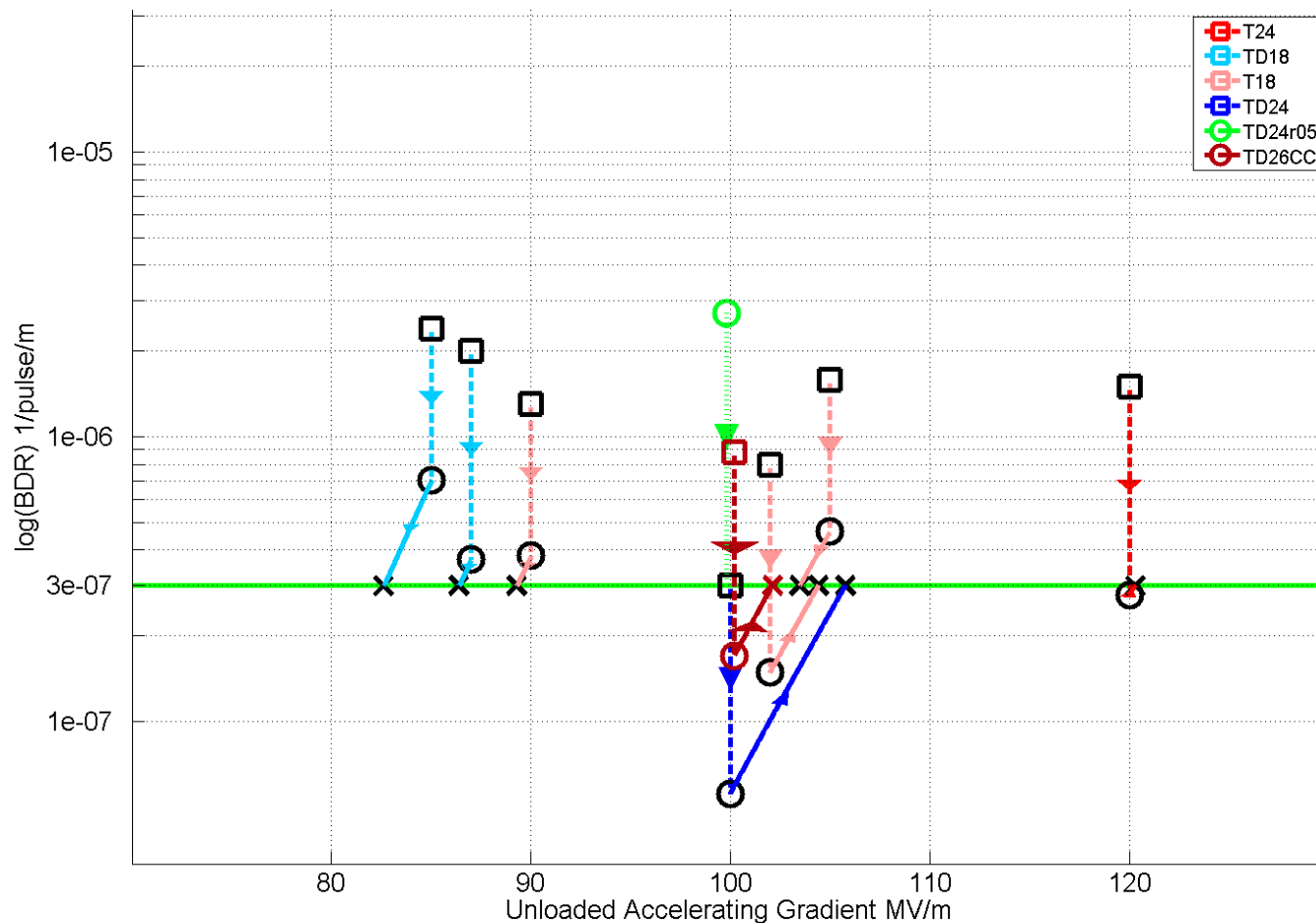
- Dark current signal has been split and sampled at 1.25GSPS. Also we've added incident RF signal diode. Used to collect data for stress model analysis of the 100 pulses leading up to a BD event. (Collaboration with Uni. Jerusalem)
- We have successfully demonstrated that we can produce a CLIC pulse shape using the pulse compressor and the phase programmer.

Recent 100MV/m run



Large BD triggers period of lower BDR but increases dark current. Also after this period there are less cluster events 45% vs. 25%.

The big picture

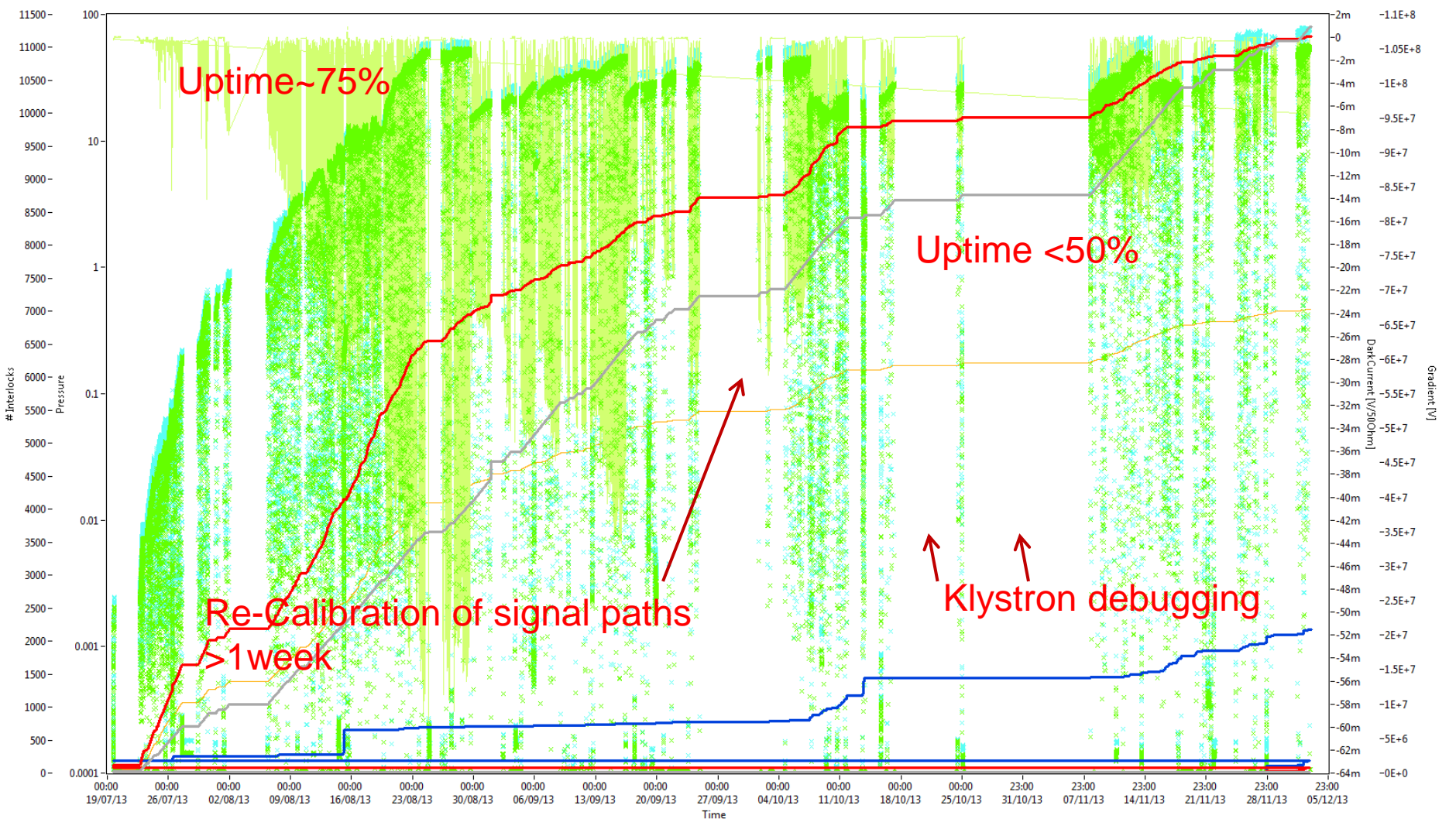


□ - Measured Values

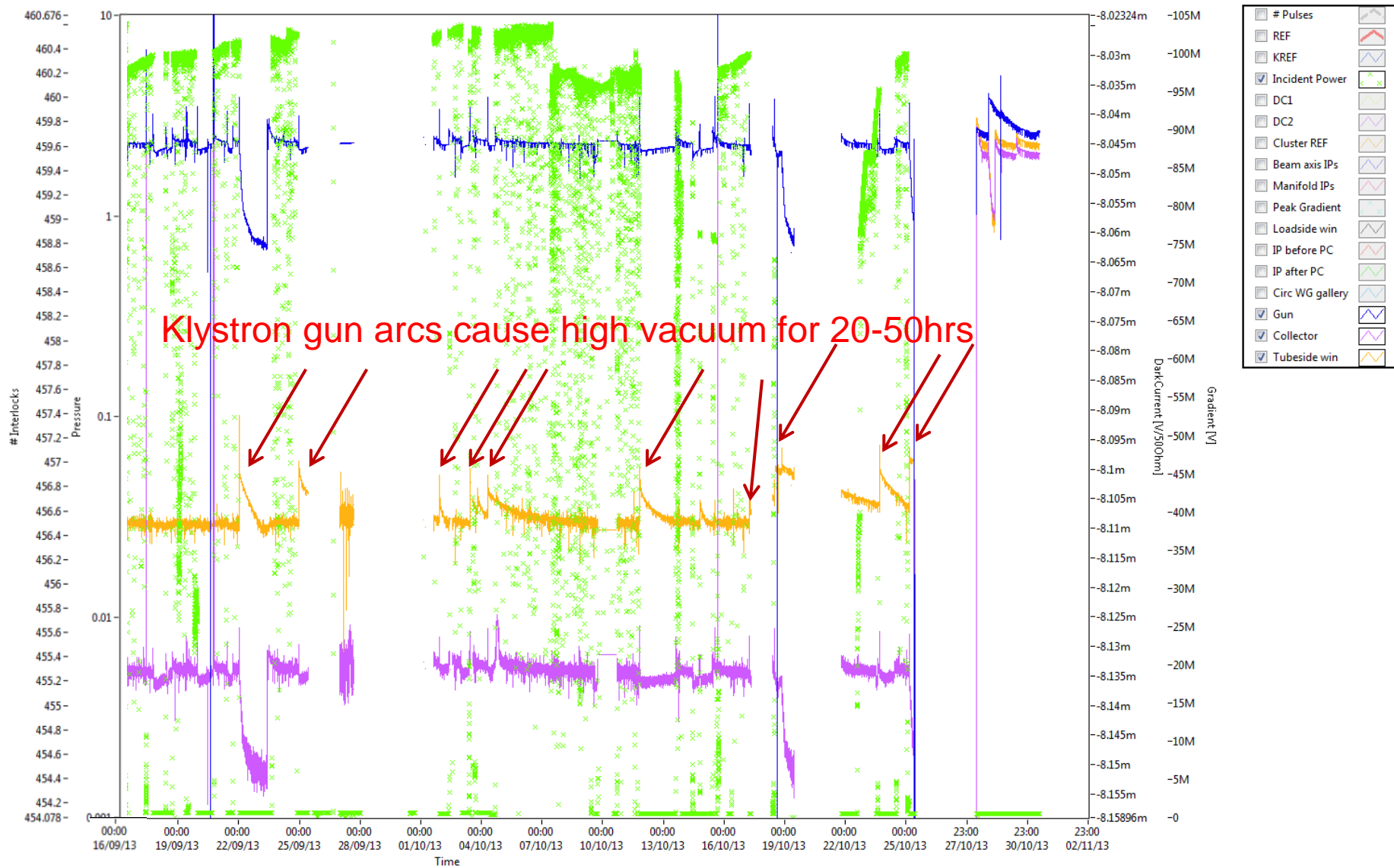
○ - Rescaled by pulse width

× - Rescaled to 100MV/m

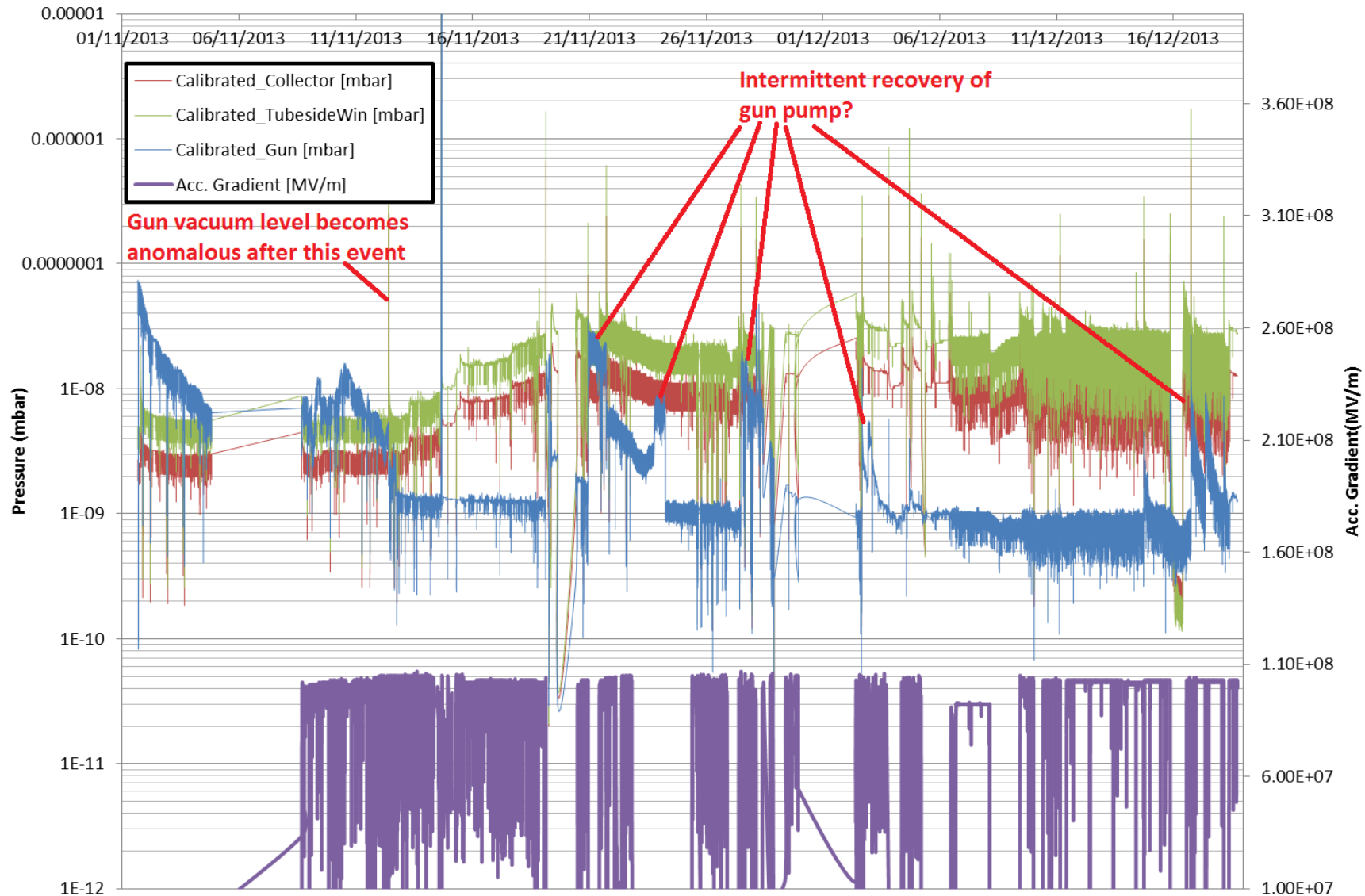
Results: TD26CC UP-TIME



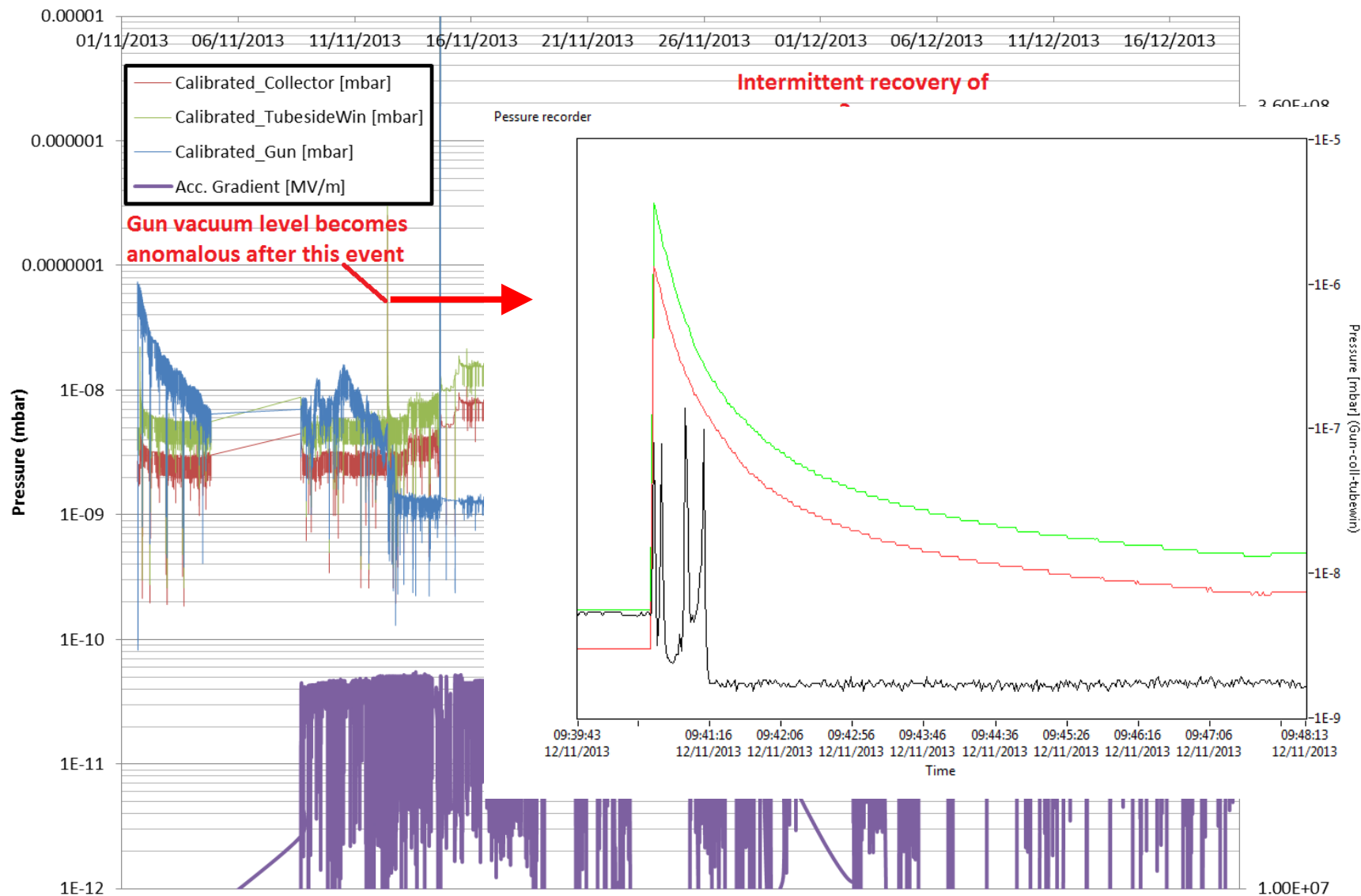
Klystron Vacuum + Gun Arcs



Klystron Vacuum + Gun Arcs



Klystron Vacuum + Gun Arcs



Xbox-1: Future Developments

- We will remove the XL5 from XBOX-1 to look at the gun ion pump. Regardless of the conclusion it will be moved to XBOX-2 for system testing and conditioning at low powers <20MW.
- The new CPI XL5 tube (arrival in 2-3 weeks) will be put into the XBOX-1 test stand.
- The new tube will be tested up to full power and pulse width using the new load tree (pictured, vacuum leak checked and LLRF tested OK, now prepping for bake-out).
- The load tree will be moved to CTF-2 to condition the rest of the WG network.
- Connect klystron to dog-leg WG in order to start dog-leg waveguide commissioning in preparation for the beam loading experiment.

See Alberto Degiovanni's talk later today for:

- Continue to develop phase measurement analysis.
- Utilise other methods for BD cell location: dark current signals and X-rays emitted during BD.
- Soon to have installation of dark current energy spectrometer
→ Should give better indication of the energies involved in accelerating electrons and ions during a BD. As yet unclear if this will run on XBOX-1 or 2.
- Quicker/better method of calibration to be devised (less downtime).
- Continue conditioning of the TD26CC structure?



Thank You

Extra Slides

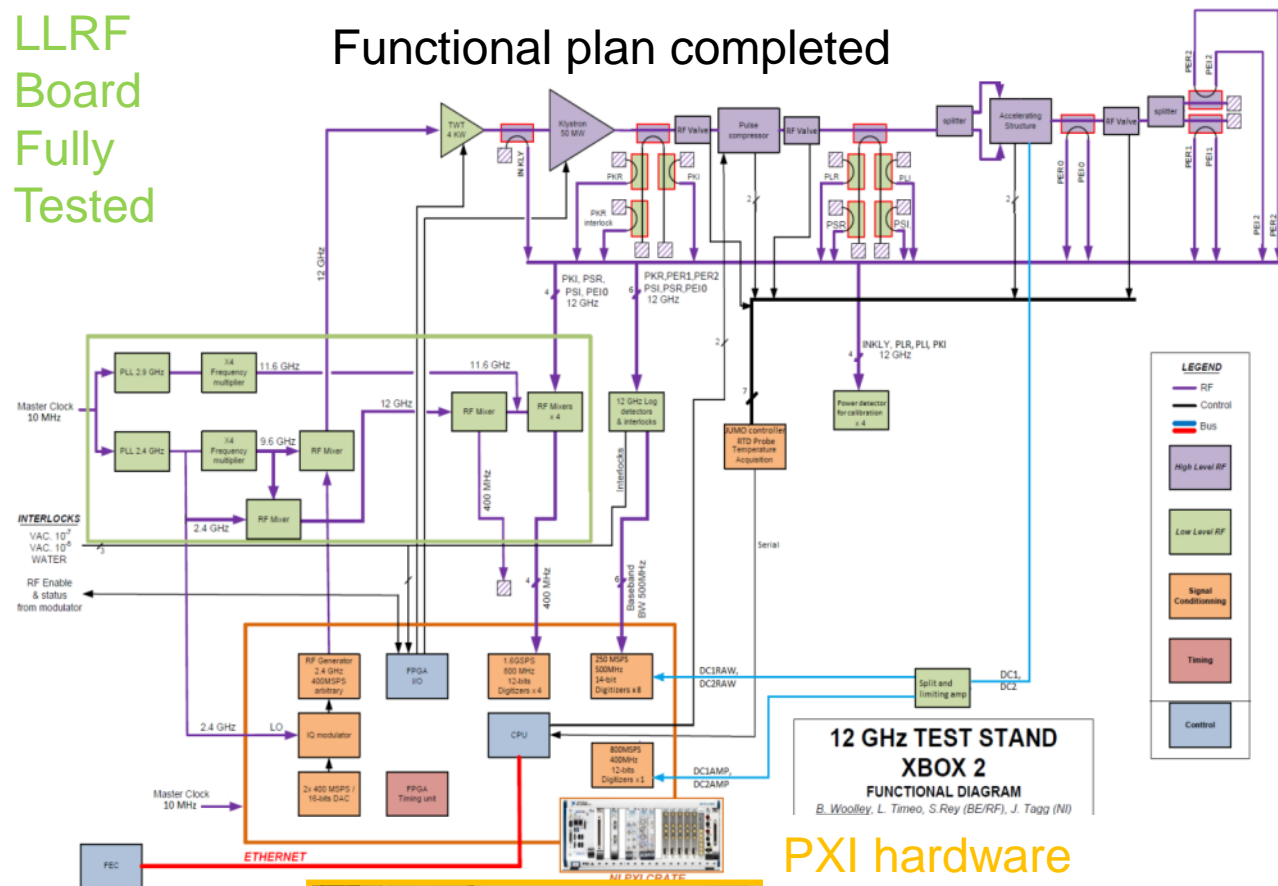


LLRF Board Fully Tested

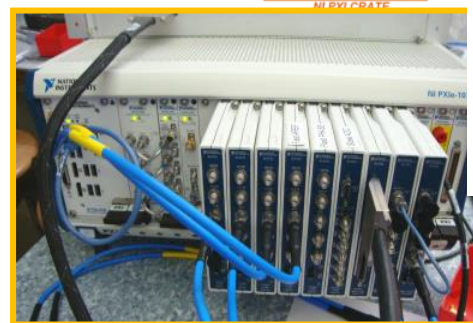


CPI-XL5 tube fully conditioned at SLAC

Functional plan completed

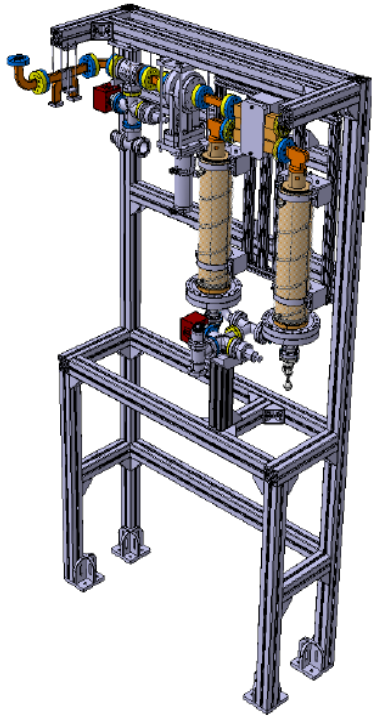


PXI hardware purchased and Software partially completed

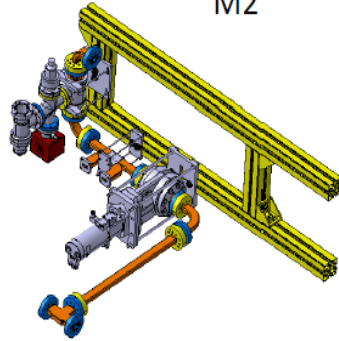


RF components & RF network integration

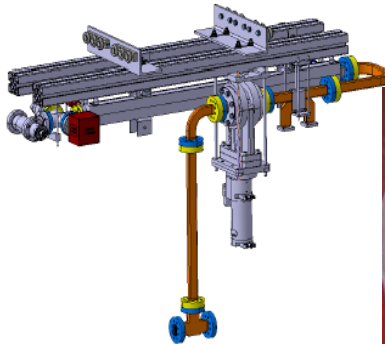
M1



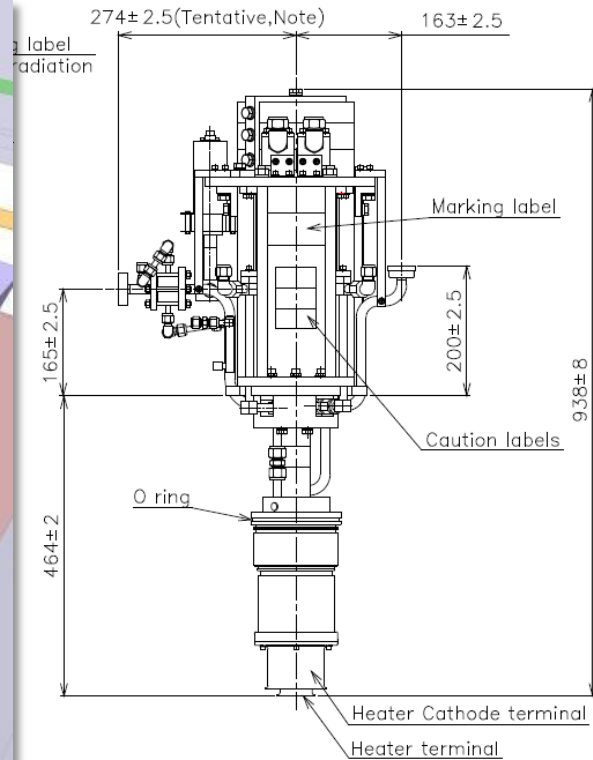
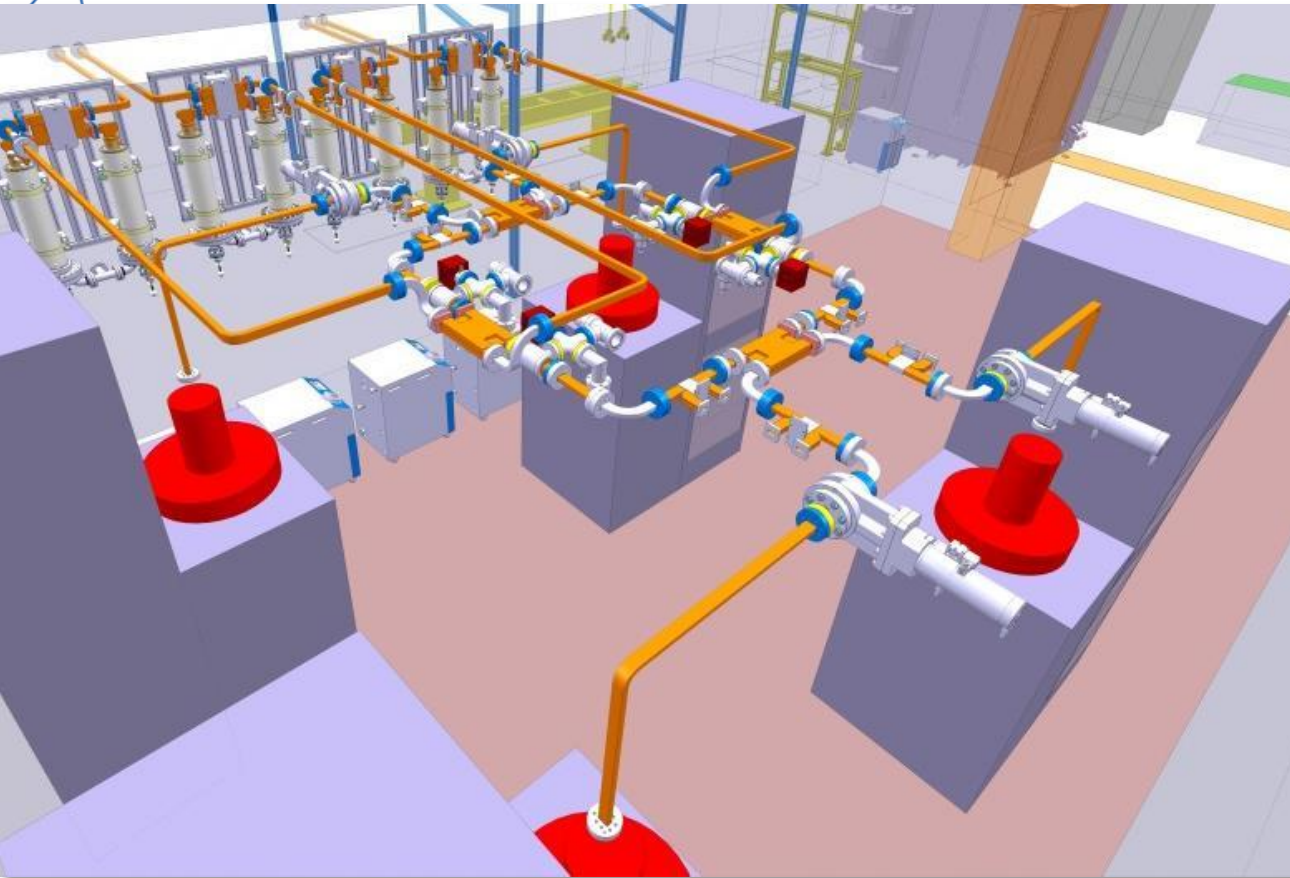
M2



M3



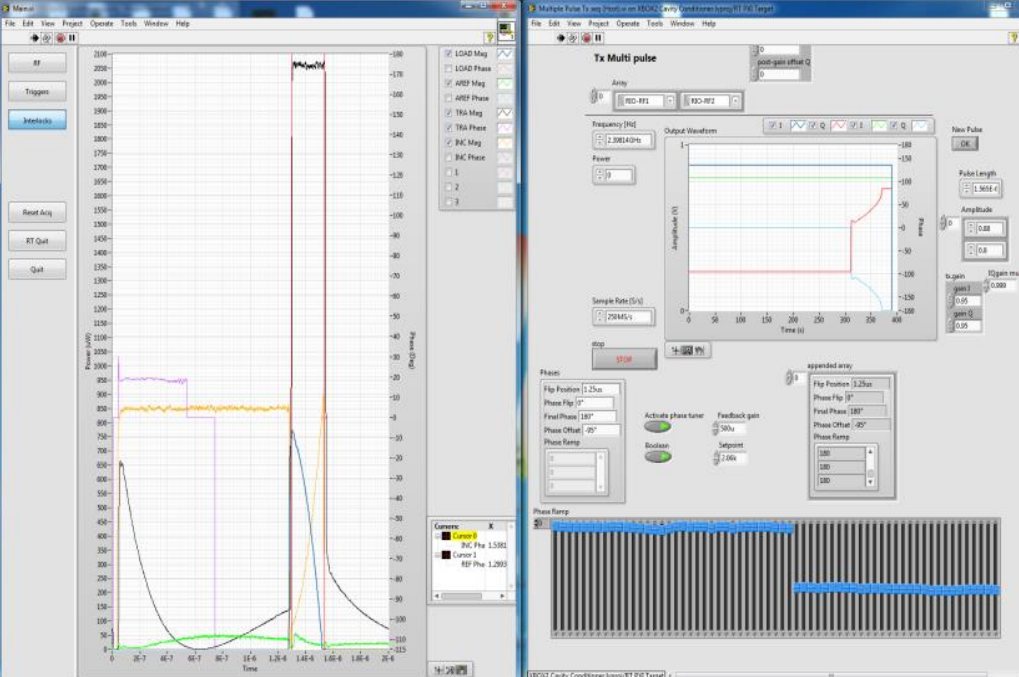
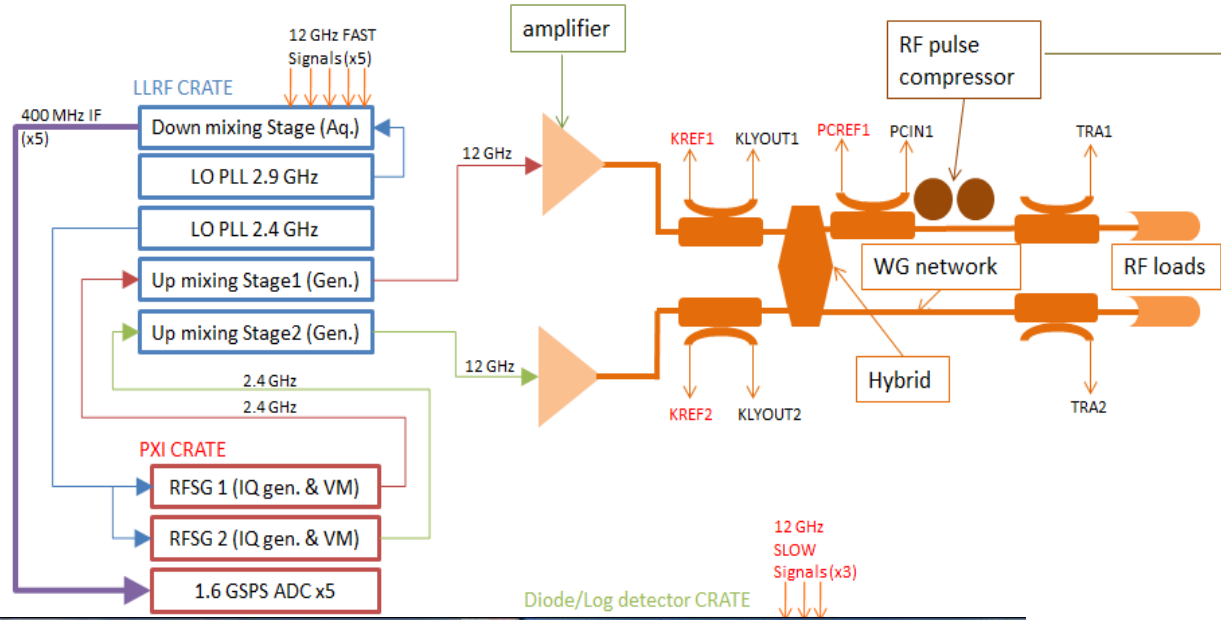
Future Developments: XBOX-3



- 4 turn-key 6 MW, 11.9942 GHz, 400Hz power stations (klystron/modulator) have been ordered from industry.
- The first unit is scheduled to arrive at CERN in October 2014. The full delivery will be completed before July 2015.



Online automatic adjustment of the compressed pulse (arbitrary) shape.



Created using Wink

Summary

- TD26CC structure is conditioned up to 103MV/m for required CLIC pulse shape and BDR.
- Gun arcs in the klystron have slowed progress.
- Work and planning to greatly expand our testing capability is well underway.

Thank you for your attention!

Future LLRF Generation and Acquisition for X-band test stands

