Structure testing and RF tests stands

Jan Kovermann
CERN

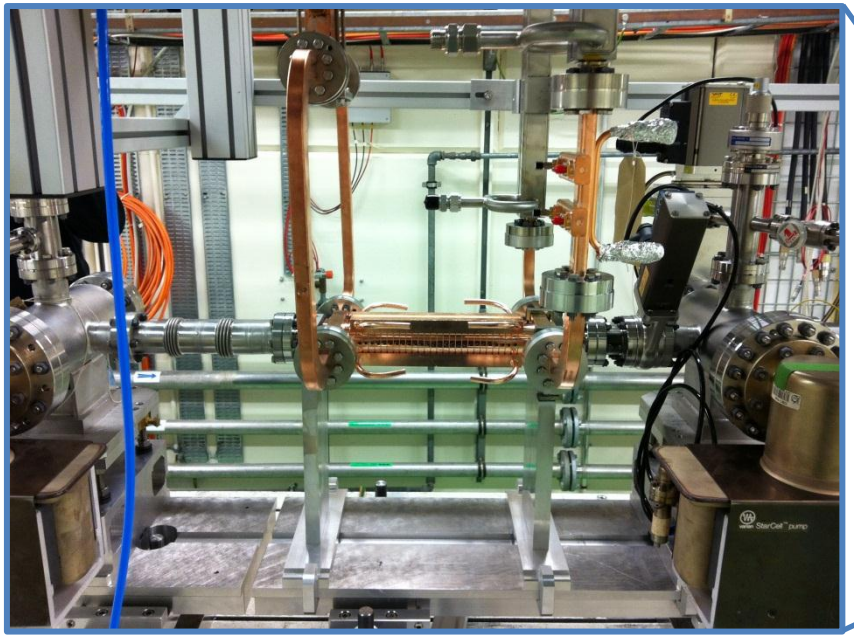
Layout of the CERN x-band test stand (X-box 1)

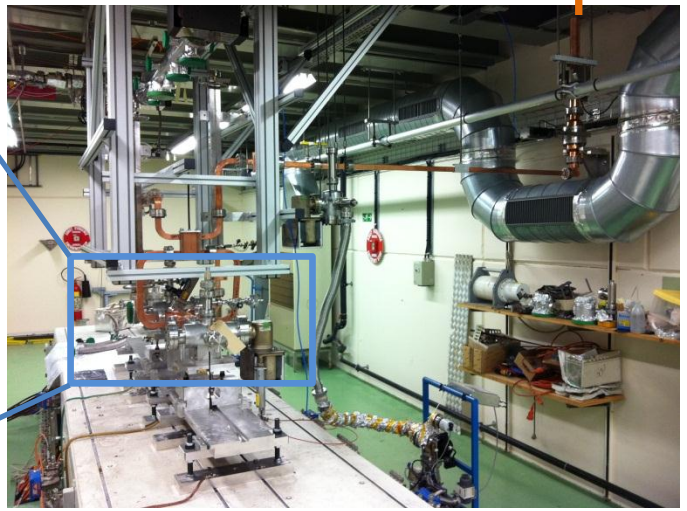
Clockwise from top-left:

- Modulator
- Pulse compressor
- DUT + connections
- Accelerating structure

Gallery

Bunker





Components of X-box 1

Klystron (SLAC XL5, #1 prototype)
50 MW, 1.5us pulse width, 50Hz rep. rate

Modulator (ScandiNova K2-3X solid state, #1 prototype)
Max. 450kV, 350A, 3.5us pulse width, 50Hz rep. rate

Pulse compressor (GYCOM Russia, #1 prototype)
50MW, 1.5us rf → 140MW, 250ns rf

DUT (CLIC T24 accelerating structure)
11.99424GHz, 24 regular cells, 2 coupling cells,
2 symmetric in/out couplers,
100MV/m acc. Gradient @ 42MW rf input power

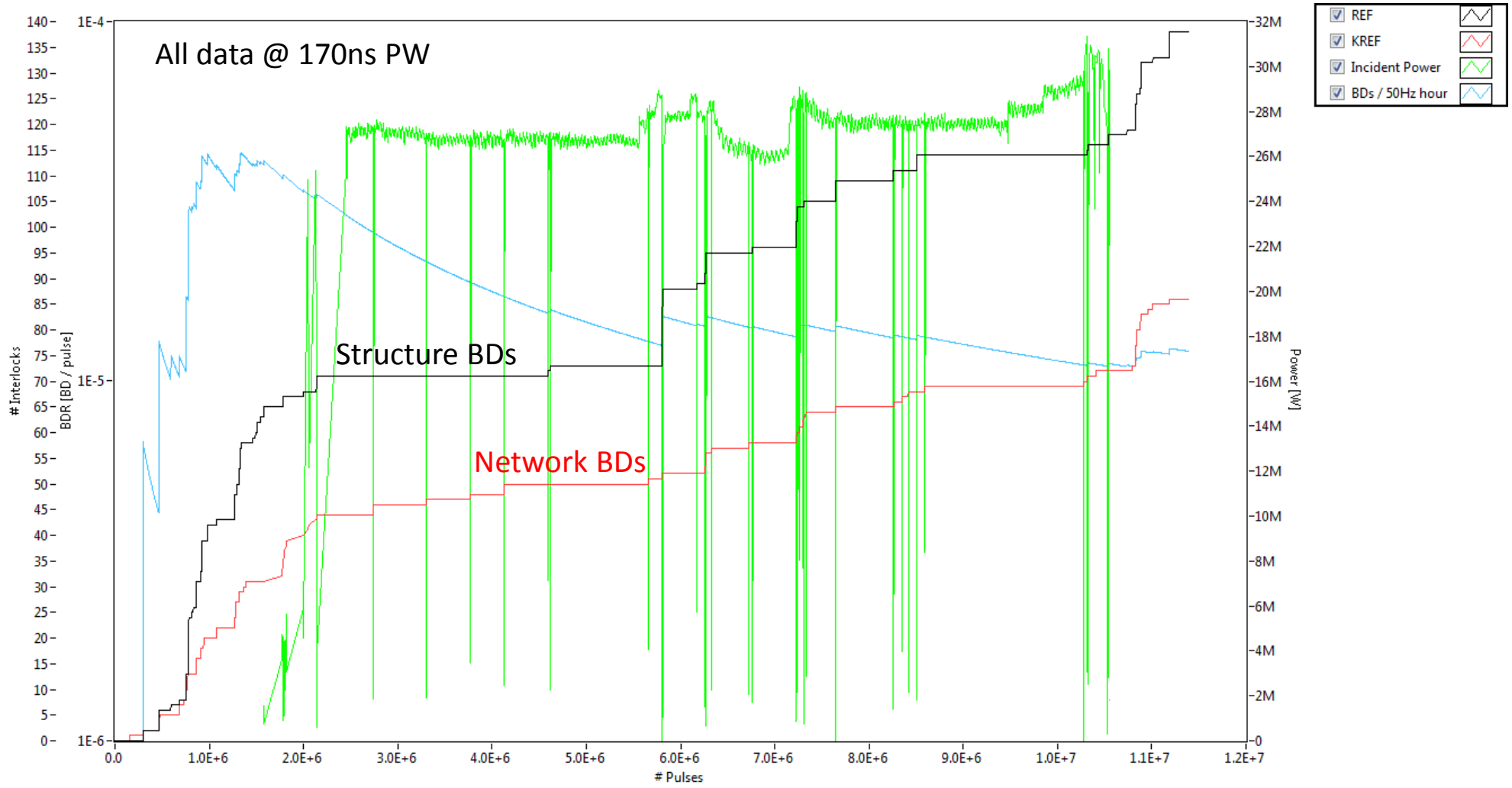
And several other new high-power rf components like valves, directional couplers, mode converters etc.

Status of X-box 1

- Hardware installation finished this summer
- Development of control and DAQ software on-going
- Waveguide network including pulse compressor conditioned up to 20MW av., 1.5us, 50Hz into compressor, 170ns, 30MW, 50Hz out of compressor into structure. Pulse compressor needed about 200h of rf cleaning to reduce outgassing (chem. cleaning/baking not possible)
- SC solid state modulator is running without major problems, pulse-to-pulse stability is excellent (10^-4)
- Klystron output window showed activity when arriving in the 20MW, 1.5us regime, but calmed down after ~25h of conditioning
- T24 structure reached 80MV/m@10^-6/pulse and 170ns PW

24/7 operation still limited due to pulse compressor instability at increased breakdown rate, working on new operating schemes to overcome that limitation

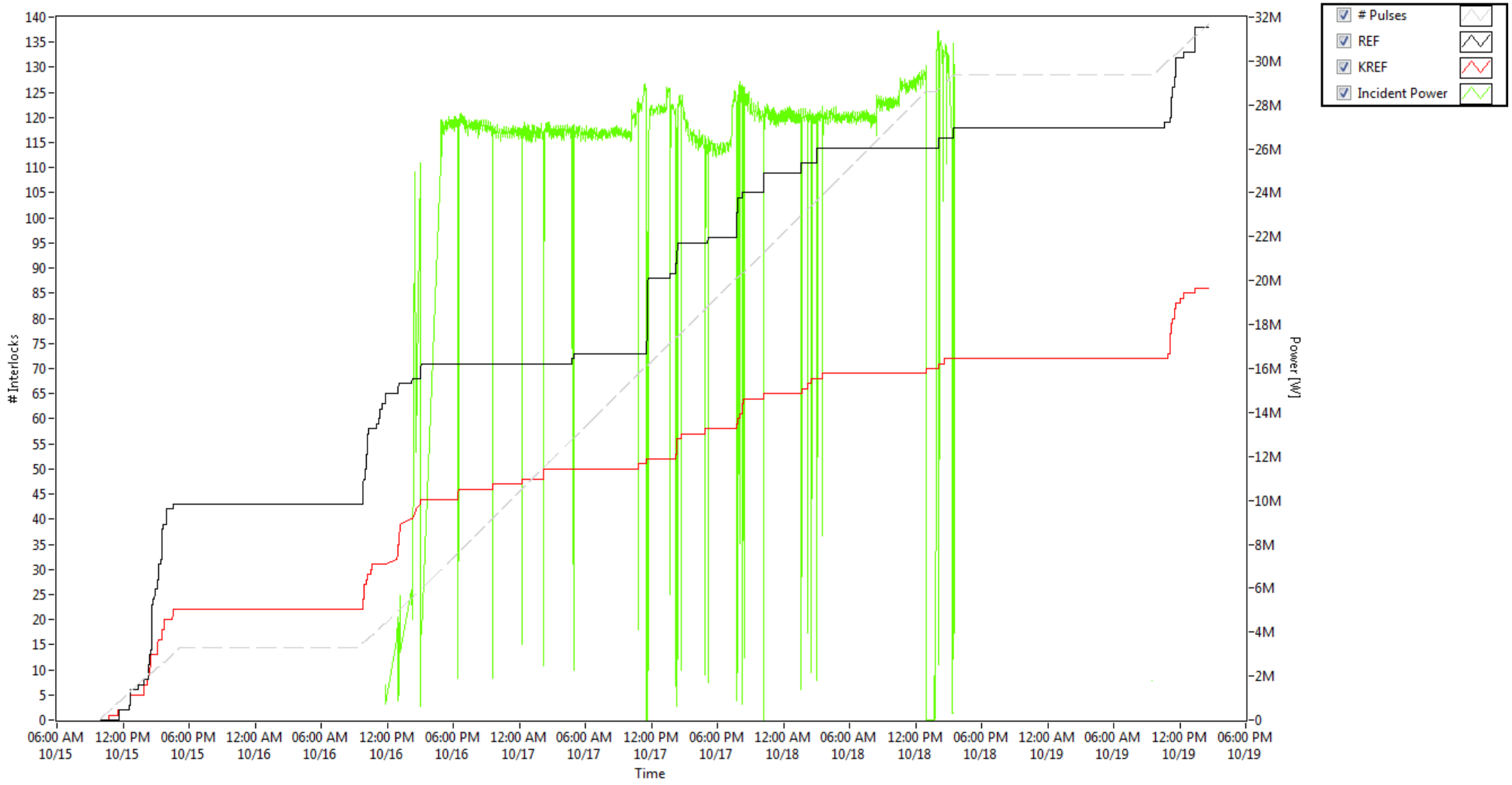
Current results with new X-box 1 DAQ system



11385142 pulses (63h@50Hz), 138 structure BDs, 86 system BDs

DAQ system logging deployed first time mid of October, but software development not yet completely finished! Just starting to take data!

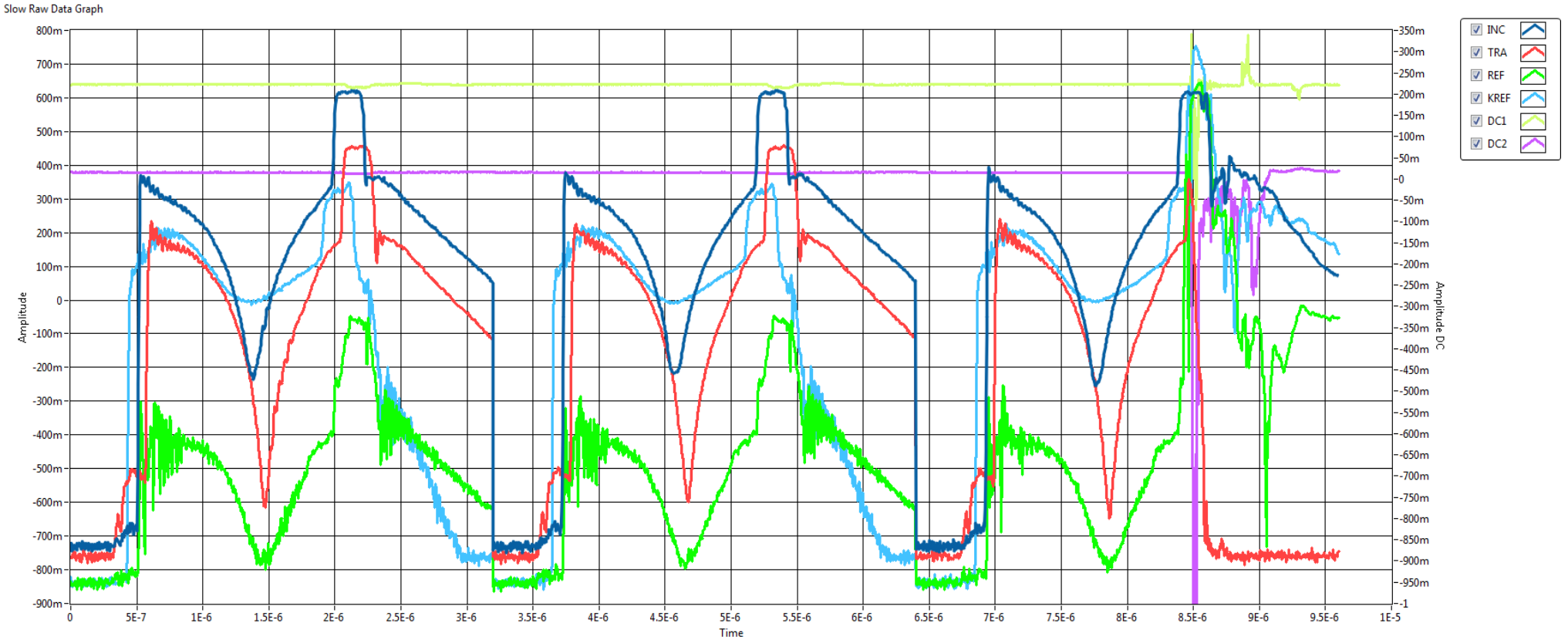
Current results with new X-box 1 DAQ system



In real time, several hours of running missing due to instable pulse compressor:

BDs stop rf, pulse compressor cools down and detunes, compensation using frequency tuning seems to increase structure BDR

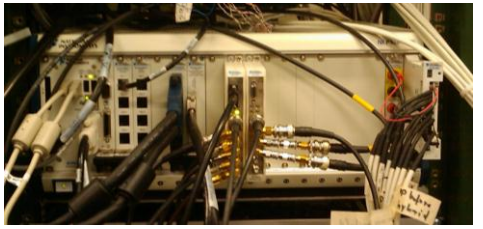
Current results with new X-box 1 DAQ system



Phase modulation for pulse compression works well, rf flat top can be easily controlled using the dark current emission waveform. Logarithmic power detectors ease operation at all power levels and help to obtain good power resolution without saturation effects during breakdown.

New X-box 1 DAQ system

Based on NI LabView and NI PXI hardware



50dB log detector into 14bit 250MSps/s ADC for controls

Last interlock event display (plus two previous pulses)

Interlock levels, calibration etc.

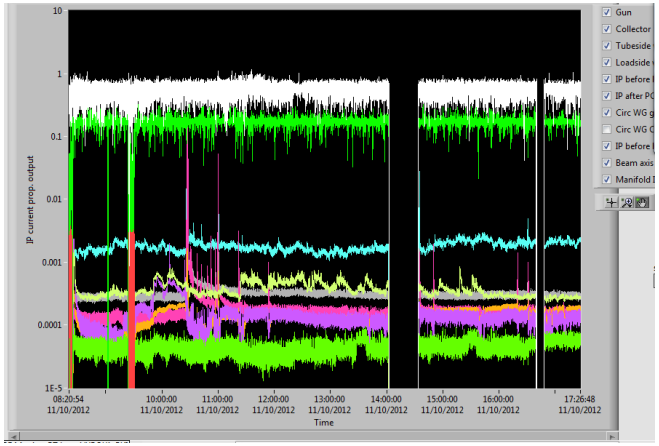
Power, DC, beta history

Single shot FN-plot

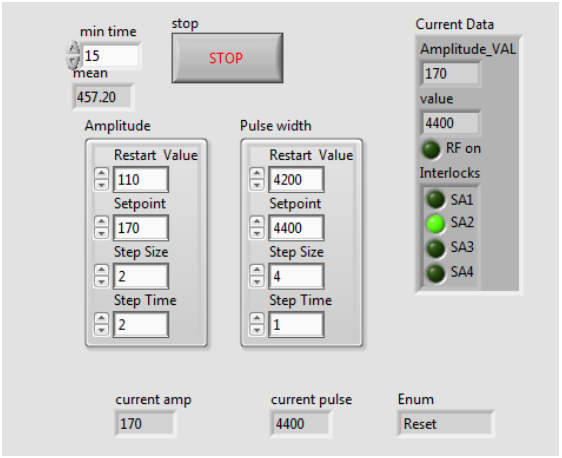
All at 50Hz rep. rate! 400Hz possible!

New X-box 1 DAQ system

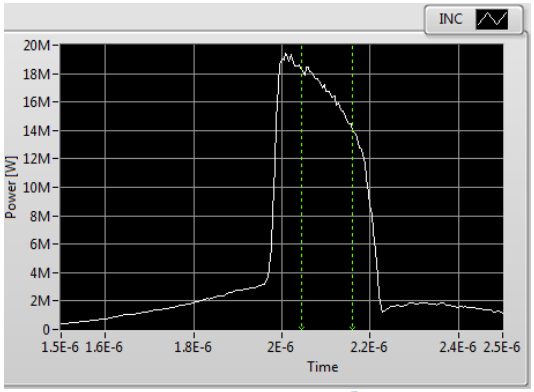
Based on NI LabView and NI PXI hardware

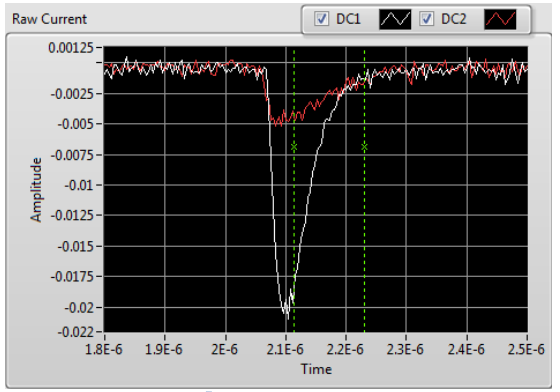


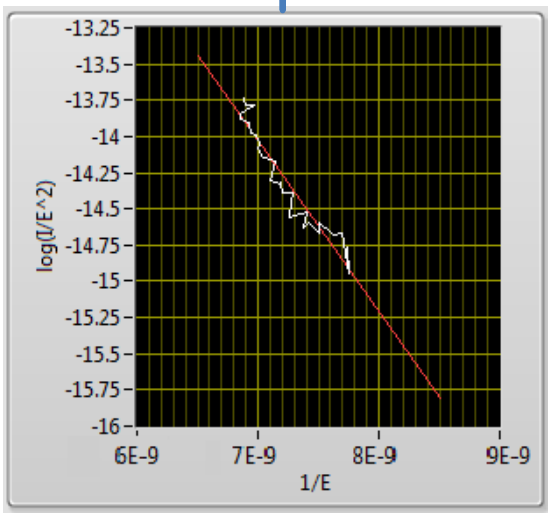
Vac history plot



Automatic conditioning



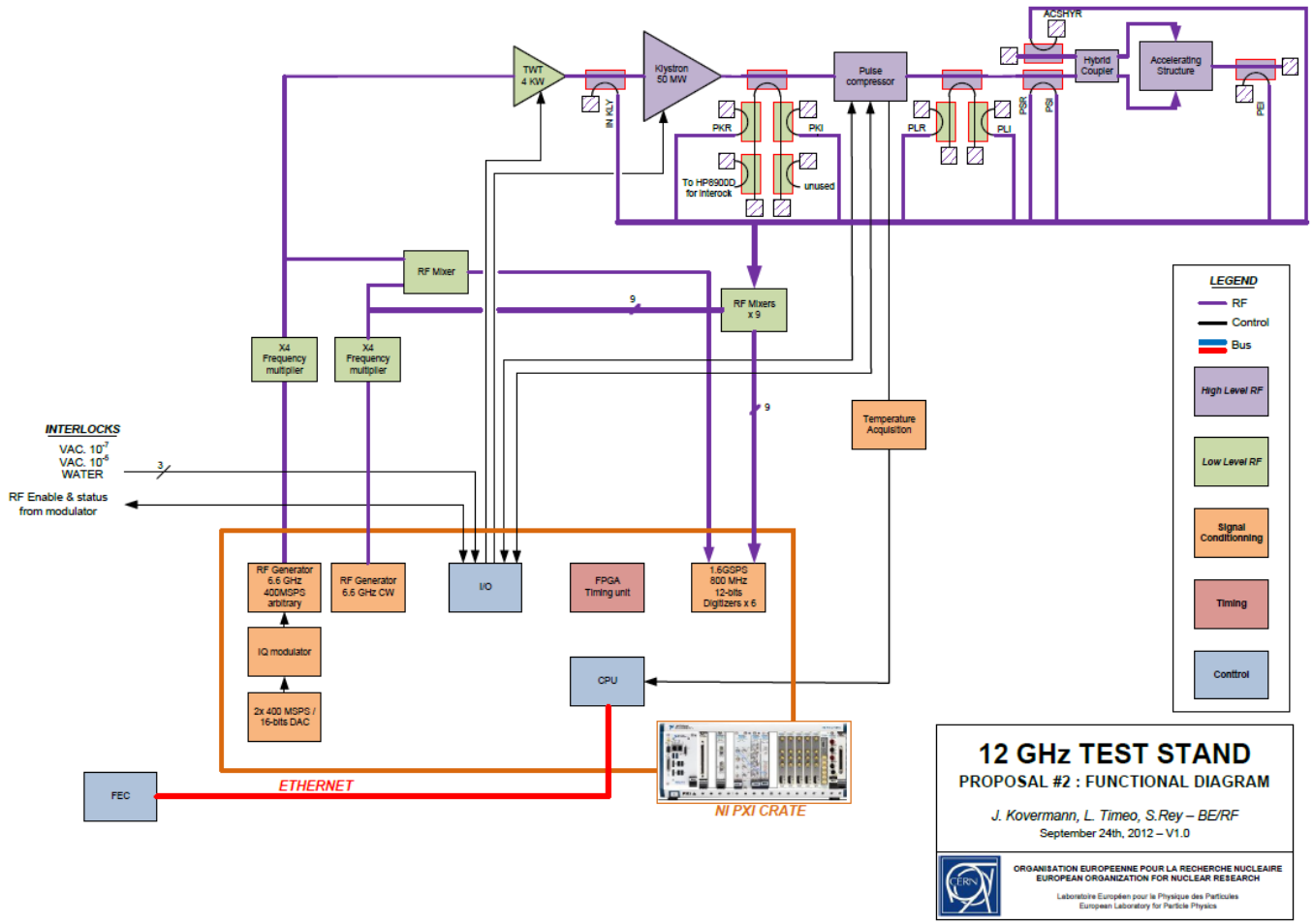




Beta = 70 +/- 5

Development of improved DAQ system for Xbox 2

- Improve rf DAQ by using faster ADCs with higher dynamic range (1.6Gsps/s, 800MHz analogue BW)
- Decrease system complexity and calibration issues by using a down mixing and direct IF sampling scheme
- Low-level synthesis of driving rf signal with I/Q modulator and two 400Msps/s DACs allows very flexible pulse shaping
- Only one PXI crate for timing, interlocks, low level rf synthesis and rf data acquisition
- All interlocks as FPGA logic with watchdog and multiple instances gives high reliability
- Independent of CERN control system
- Operation at 400Hz repetition rate seems feasible



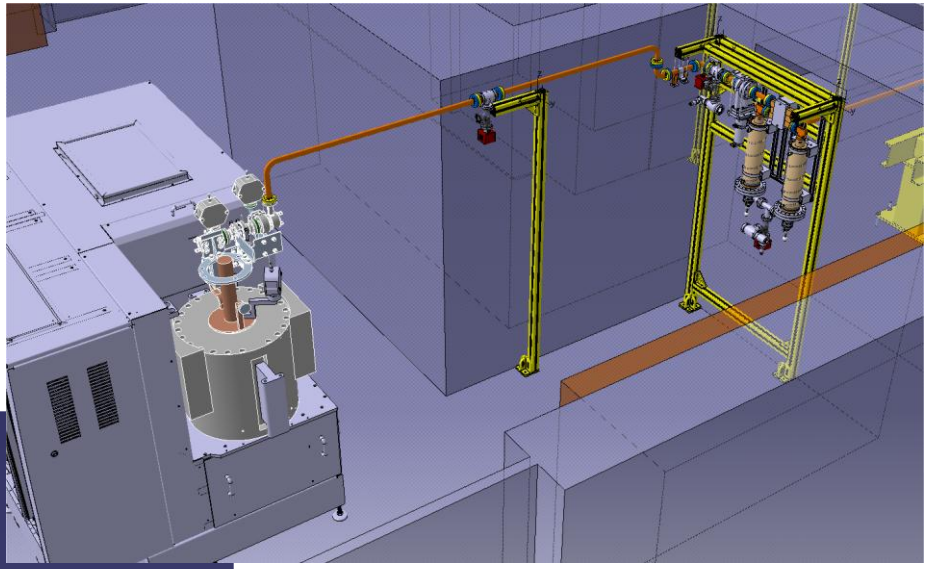
➔ Proof of concept until beginning of 2013

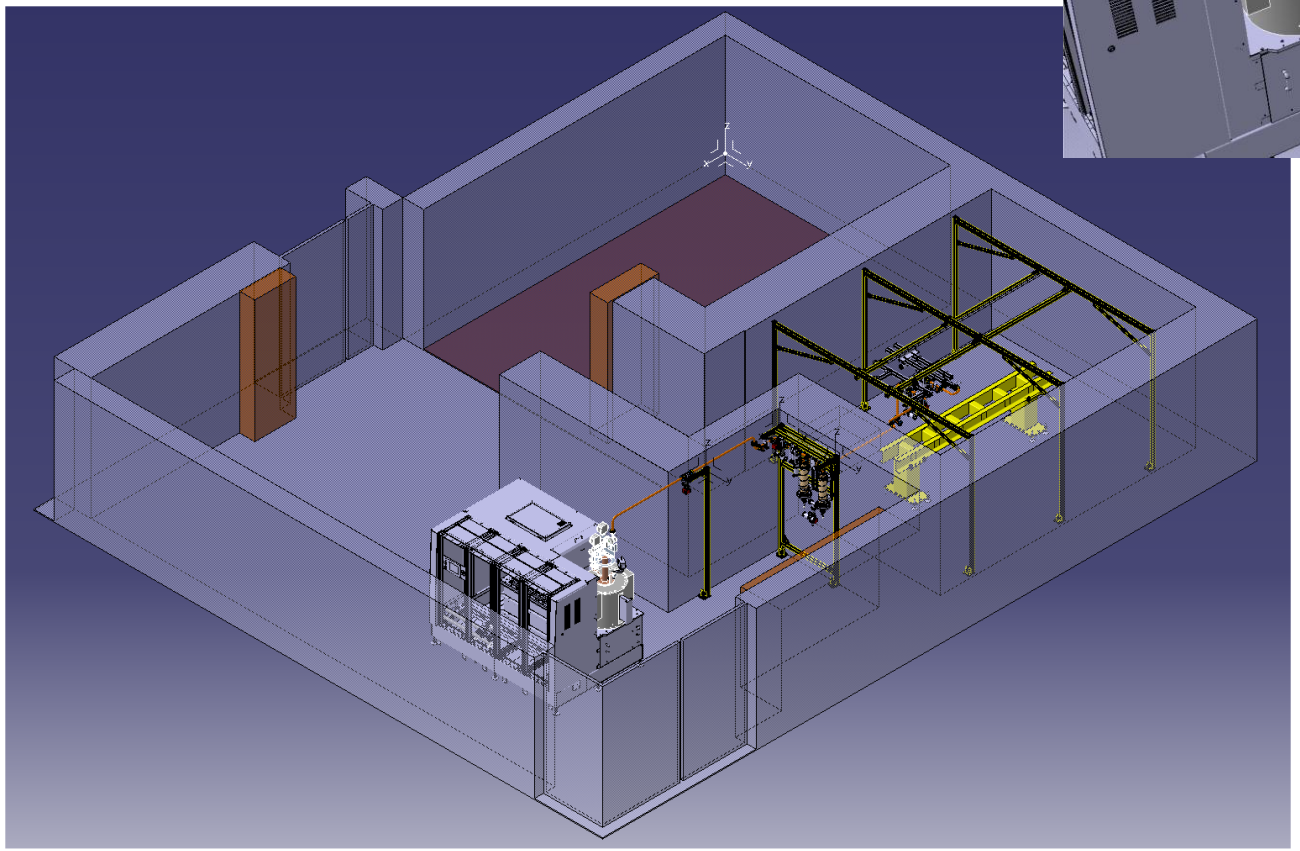
Future CERN RF test-stands progress

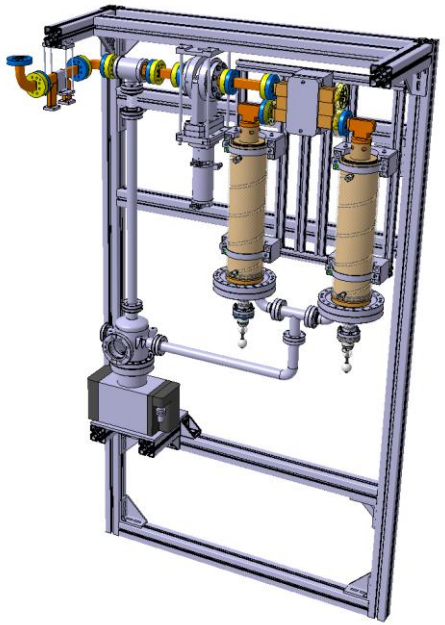
50 MW klystron station #2 (X-Box 2).

1. 50 MW CPI klystron. Some brazing problems in production of the first tube. Hopefully final brazing will be done towards end of October 2012. If successful, the testing will start in December 2012. The delivery to CERN is expected in March 2012.
2. "ScandiNova" HV modulator has been ordered from the company. Following the schedule, it will be delivered to CERN in March 2013.
3. New SLED type RF pulse compressor. All the pieces are fabricated at CERN. Going trough the final brazing steps. Ready for the low RF power tests in November 2012.
4. The various RF components of are ordered from the industry. First prototypes will arrive to CERN in November 2012 for the acceptance RF check. The rest will be delivered to CERN before March 2012.
5. The detailed 3D layout and integration of the test stand are ready.

X-Box#2 at one of its possible location.

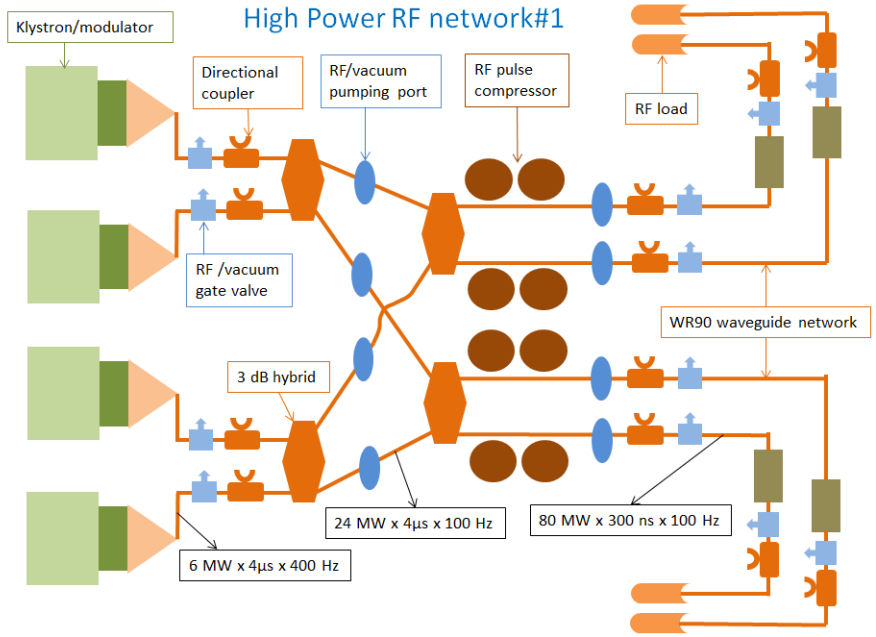




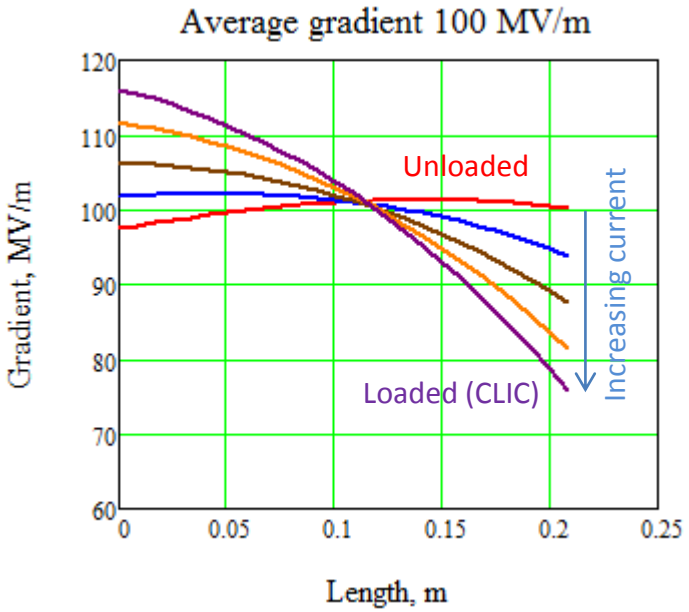


4x (6 MW + SLED) cluster station (X-Box#3).

1. Market survey completed. Three klystron manufacturing companies are qualified. Invitation for tender is now prepared. We expect to go to finance committee in March 2013 for approval with delivery of 4 turnkey 6 MW klystron / modulators for Q2/Q3 2015.
2. The RF components are similar to the ones used in X-Box-2. Some of them are already in the production pipeline.
3. The detailed 3D layout and integration of the cluster test stand is under way.



Dog-leg test area for the experiments with beam loading



Testing of accelerating structure with nominal beam loading is a missing block in our testing program. Such a test will be done using CTF3 drive beam and RF power delivered from X-box#1 via modified 30 GHz low loss transfer line.

1. All overmoded RF components (designed and fabricated in CEA) are in stock.
2. The accelerating structure (T24) is prepared and placed on its final girder.
3. The other RF components (pumping ports, gate valves) are ordered from the industry and will arrive to CERN in November 2012.
4. The installation of the T24 on the beam line will be done during 2013 winter shutdown.
5. The RF low loss transfer line network from CTF2 to CTF3 will be modified in May 2013.

Dog-leg test layout