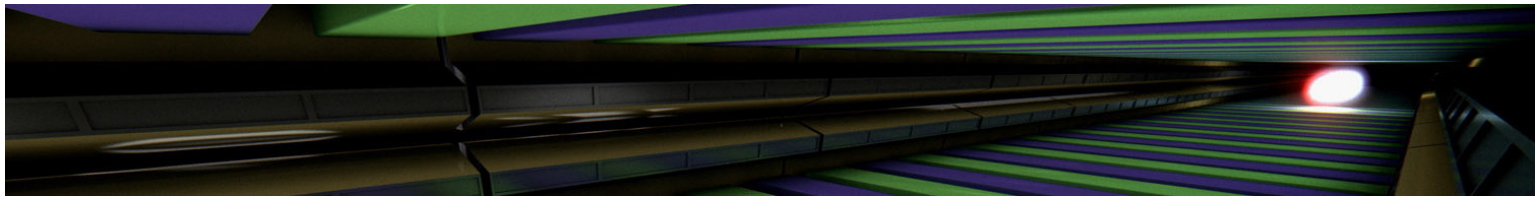
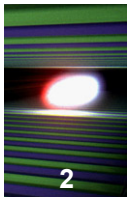


XFEL-Gun Operator Training

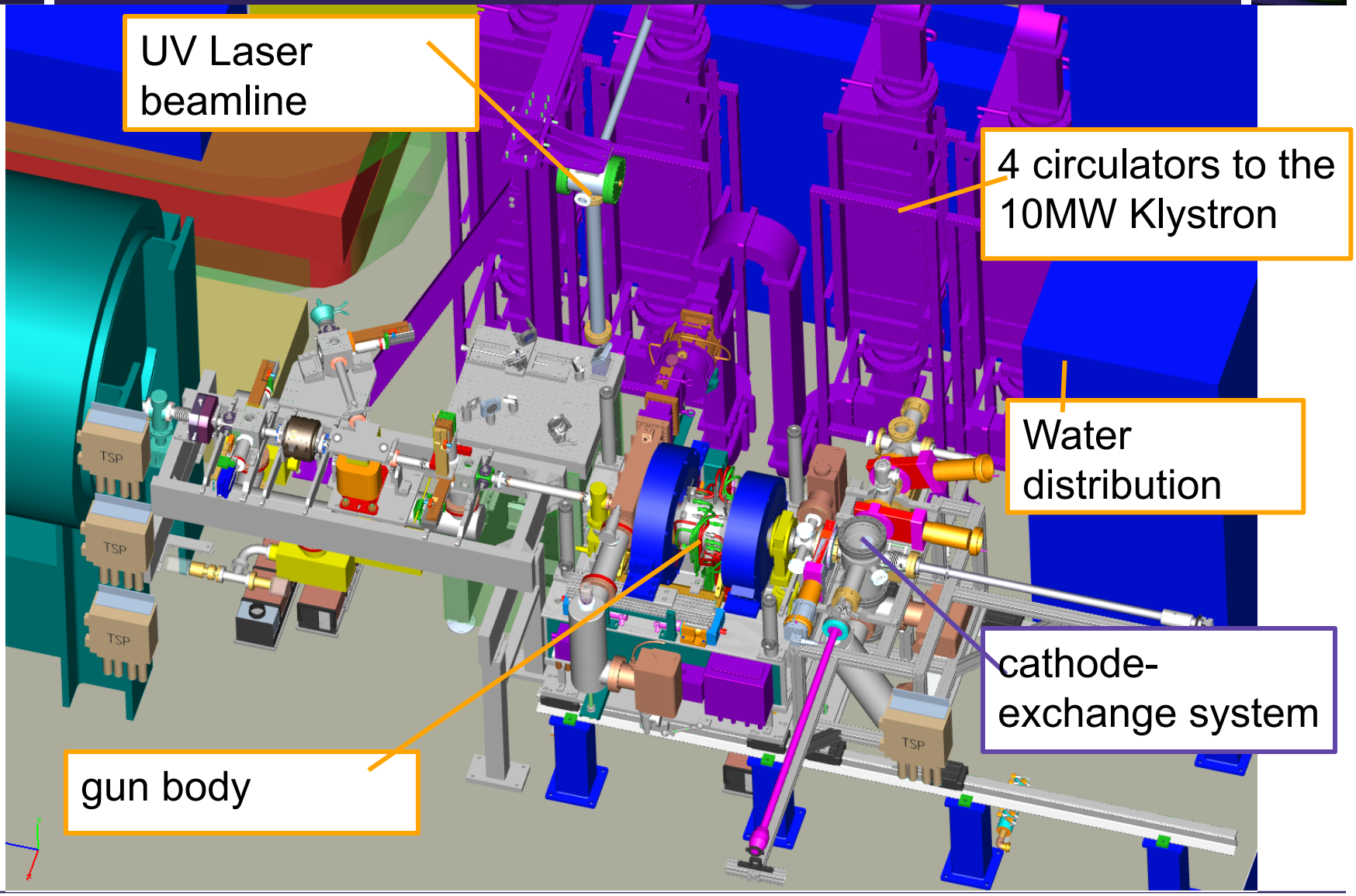
F.Brinker

Content

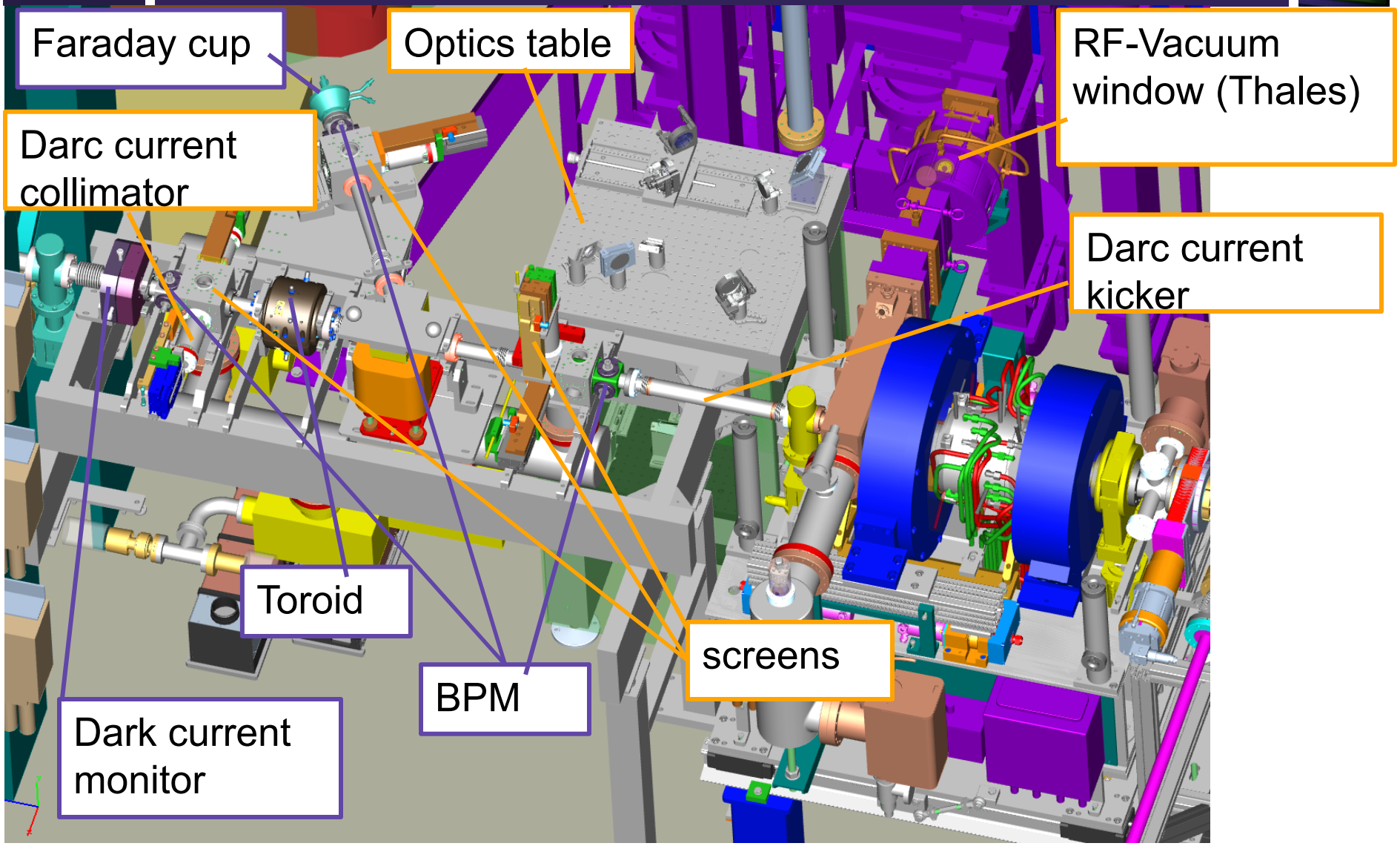


- Overview Gun system
- Typical measurements
- Critical parts
  - RF-window
  - Cathode holder
- Diagnostics and interlock systems
- RF-operation

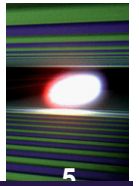
Actual view to the XFEL gun



Actual view to the XFEL gun diagnostics

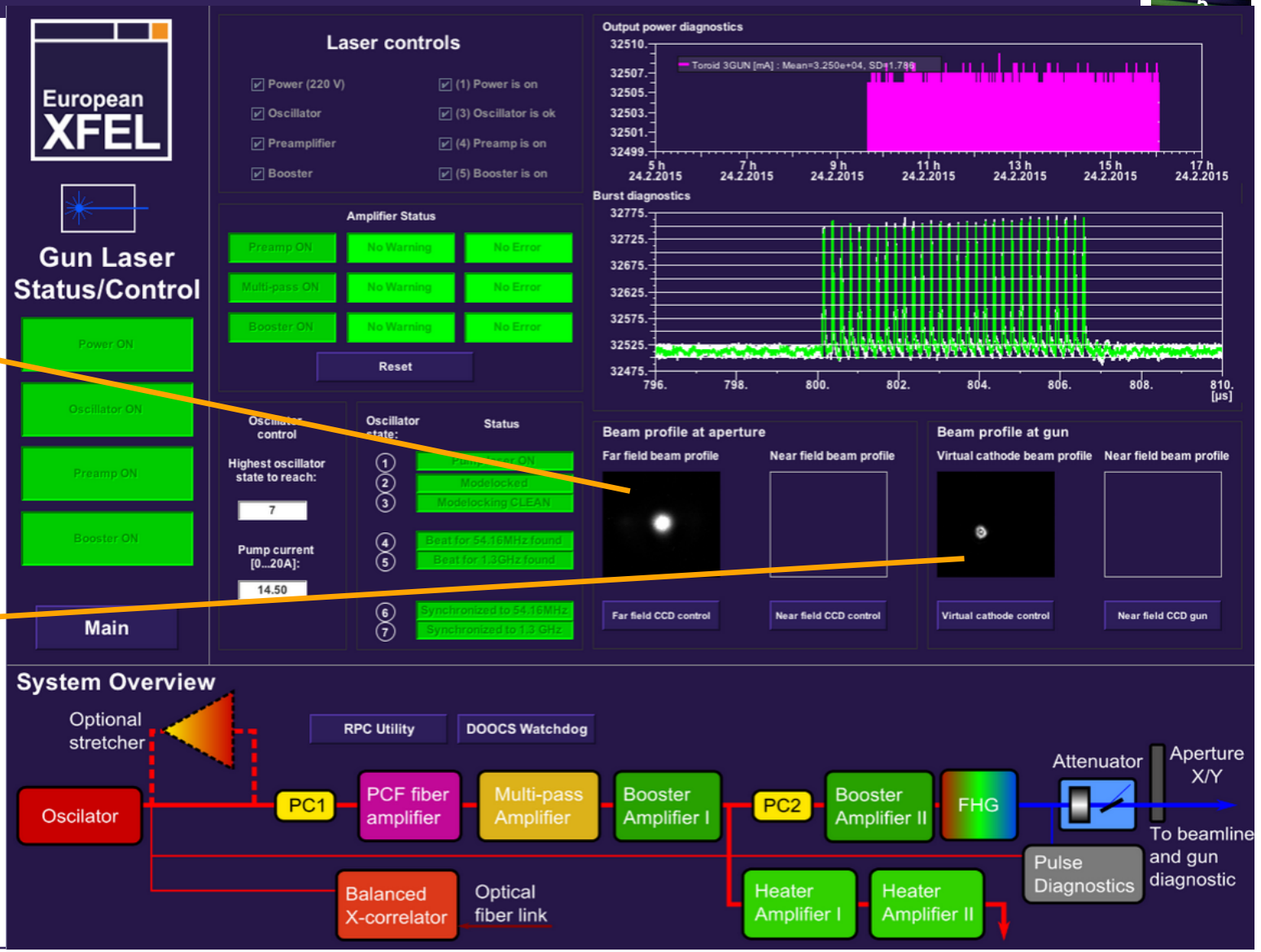


Cathode laser

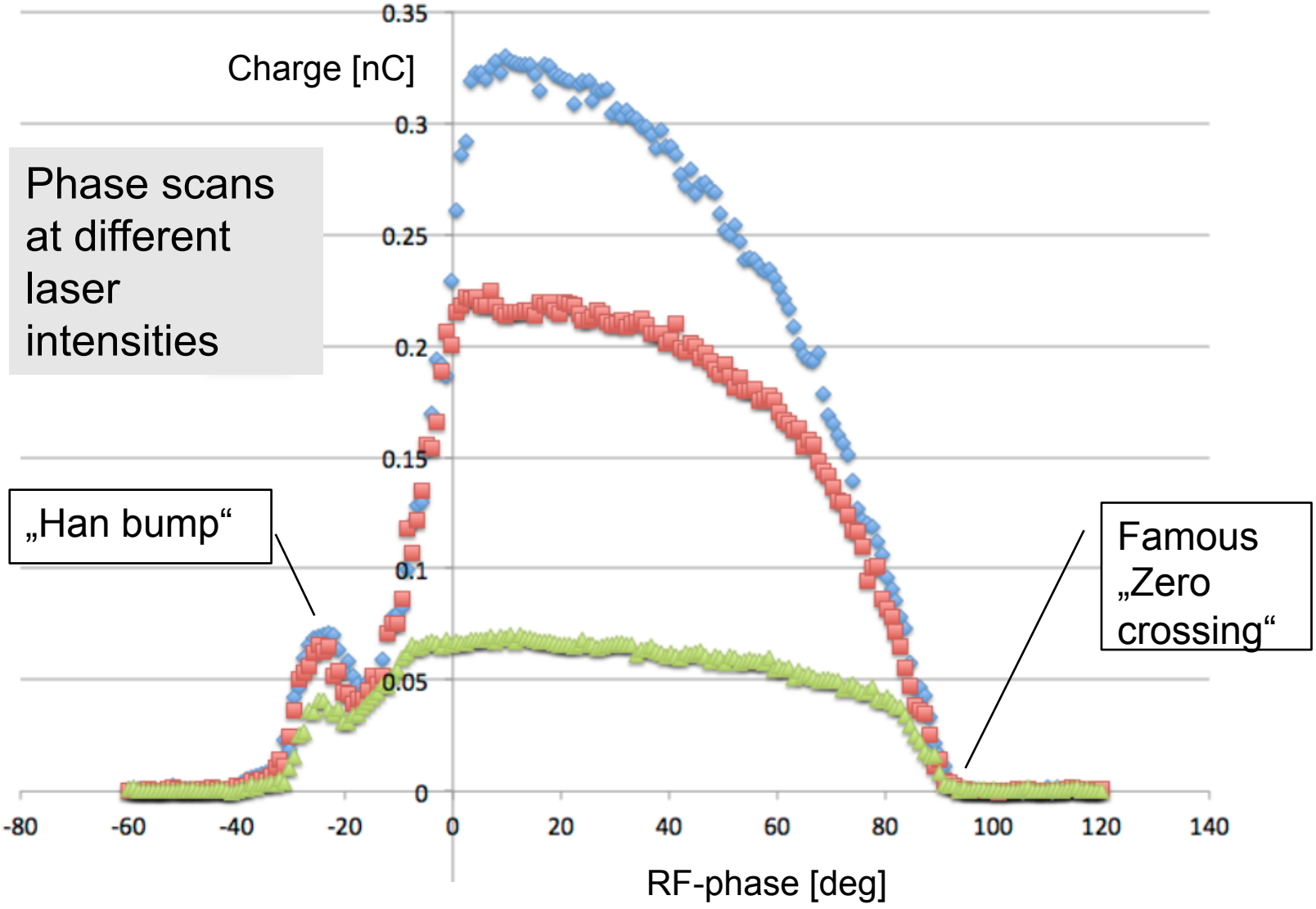


Laser profile before the aperture

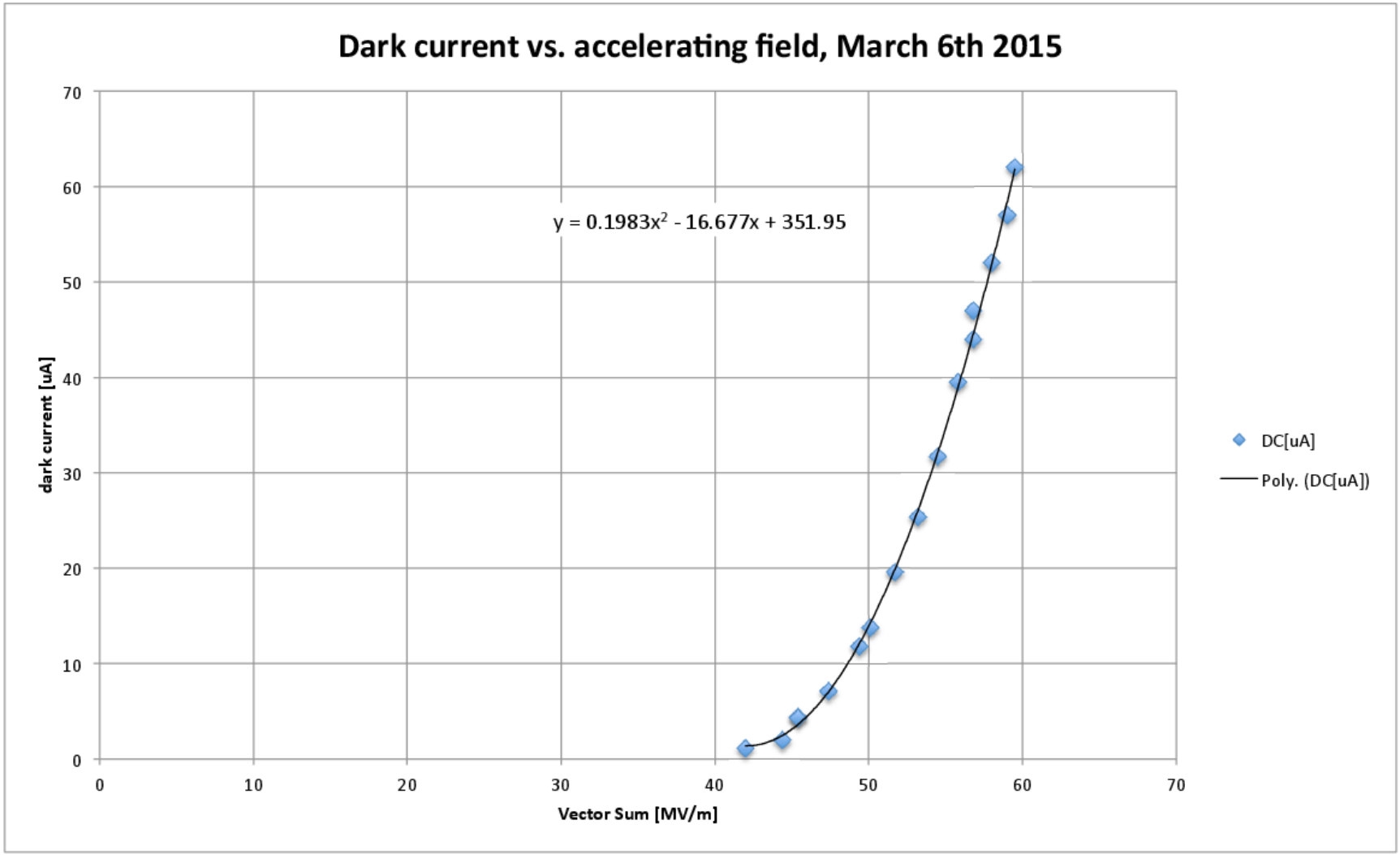
and on the virtual cathode



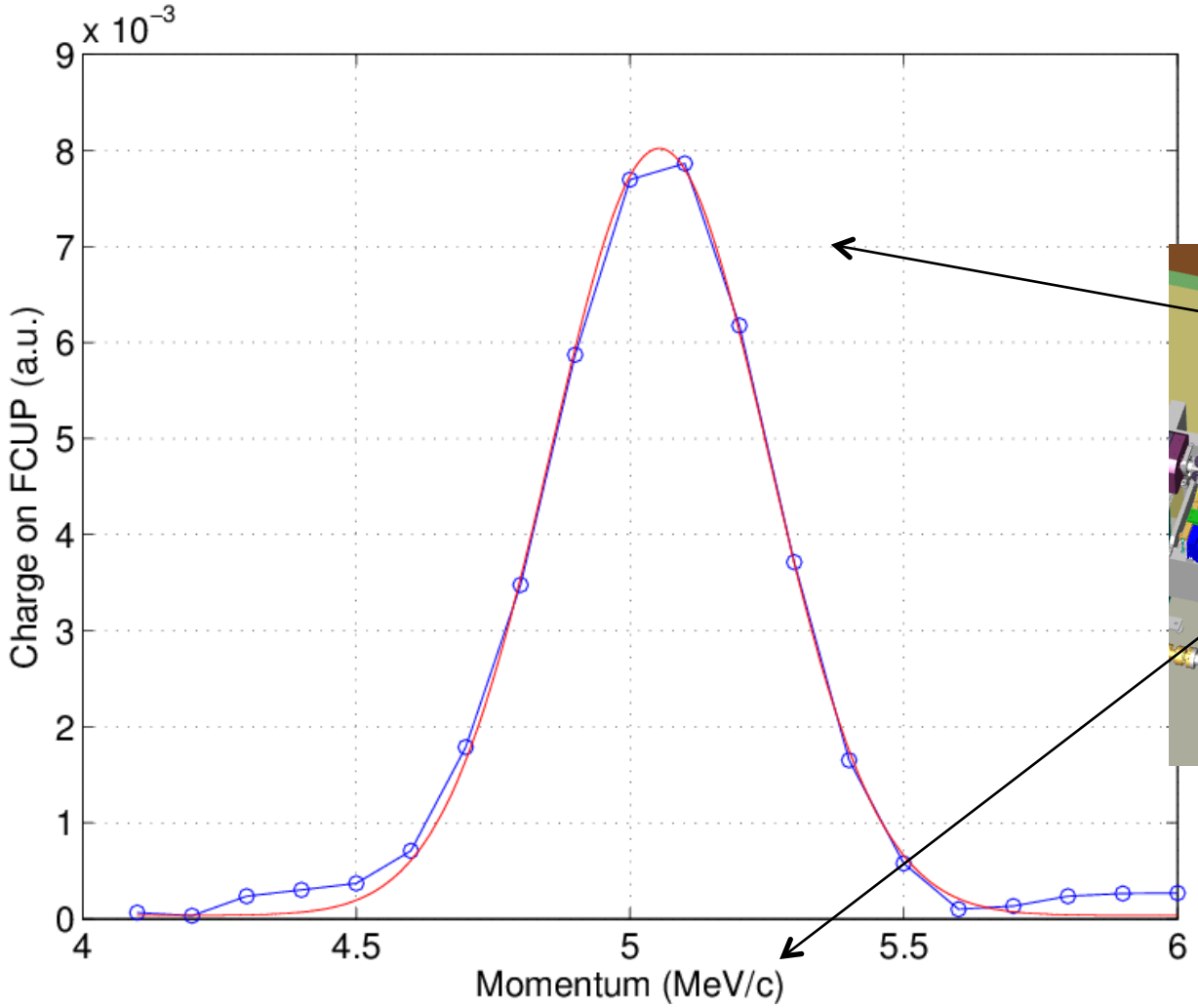
First measurements with beam:
Phase scan for different laser intensities

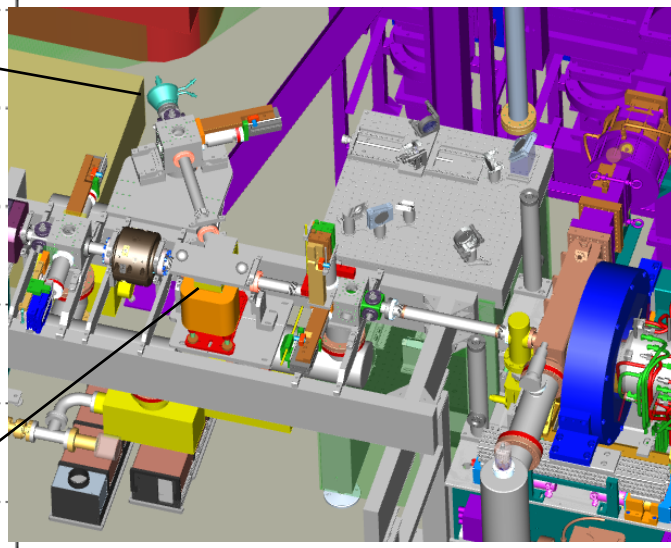


Measurement of dark current

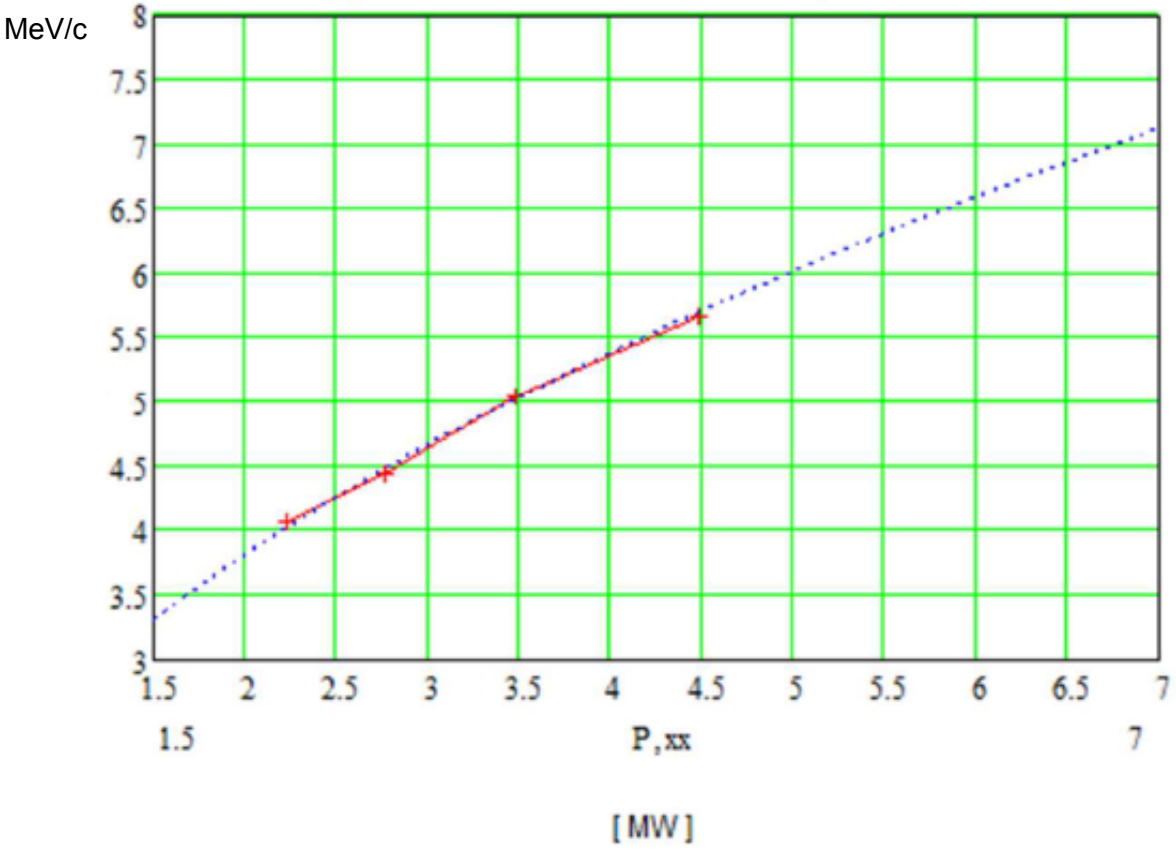


Beam energy measurement with spectrometer magnet





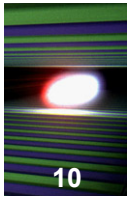
First measurements with beam: Energy measurement



16.2. :

Measurement of beam momentum depending on RF-power

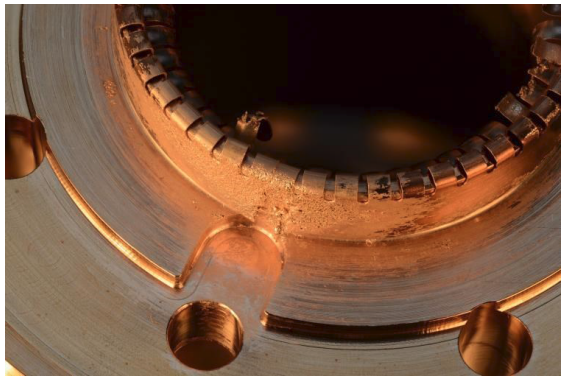
critical parts



- Cathode plug and RF-spring
- RF-Window

Short History of the XFEL Gun in HH

- 1. RF operation Dezember 2013
  - Successful test of RF-system
  - 5.5 MW, 650 us reached
  - Limit : light at the window
  - Massive damages on the cathode RF spring
- 2. RF operation September 2014
  - Successful test of the improved cathode spring system
  - 4.8 MW, 400us reached
  - Limit : vacuum leak at the window
- 3. RF operation Dezember 2014
  - Short test of glued window
  - 4.8 MW, 400us reached
  - Limit : vacuum leak at the window



(See last years talk)

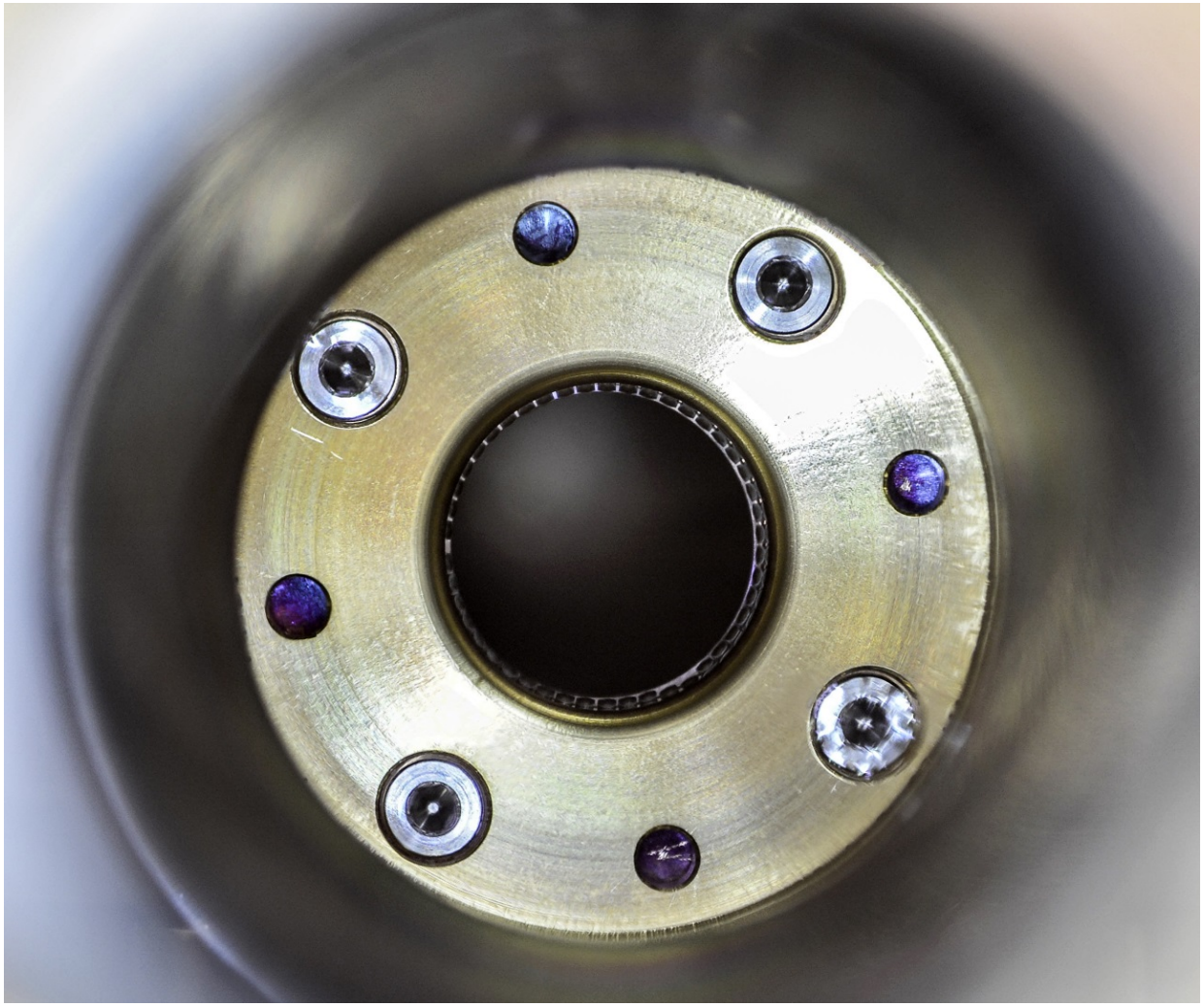
- 1. Beam operation February 2015
- 2. Beam operation April/May 2015

View from the backside into the cathode holder with the spring (still under vacuum)

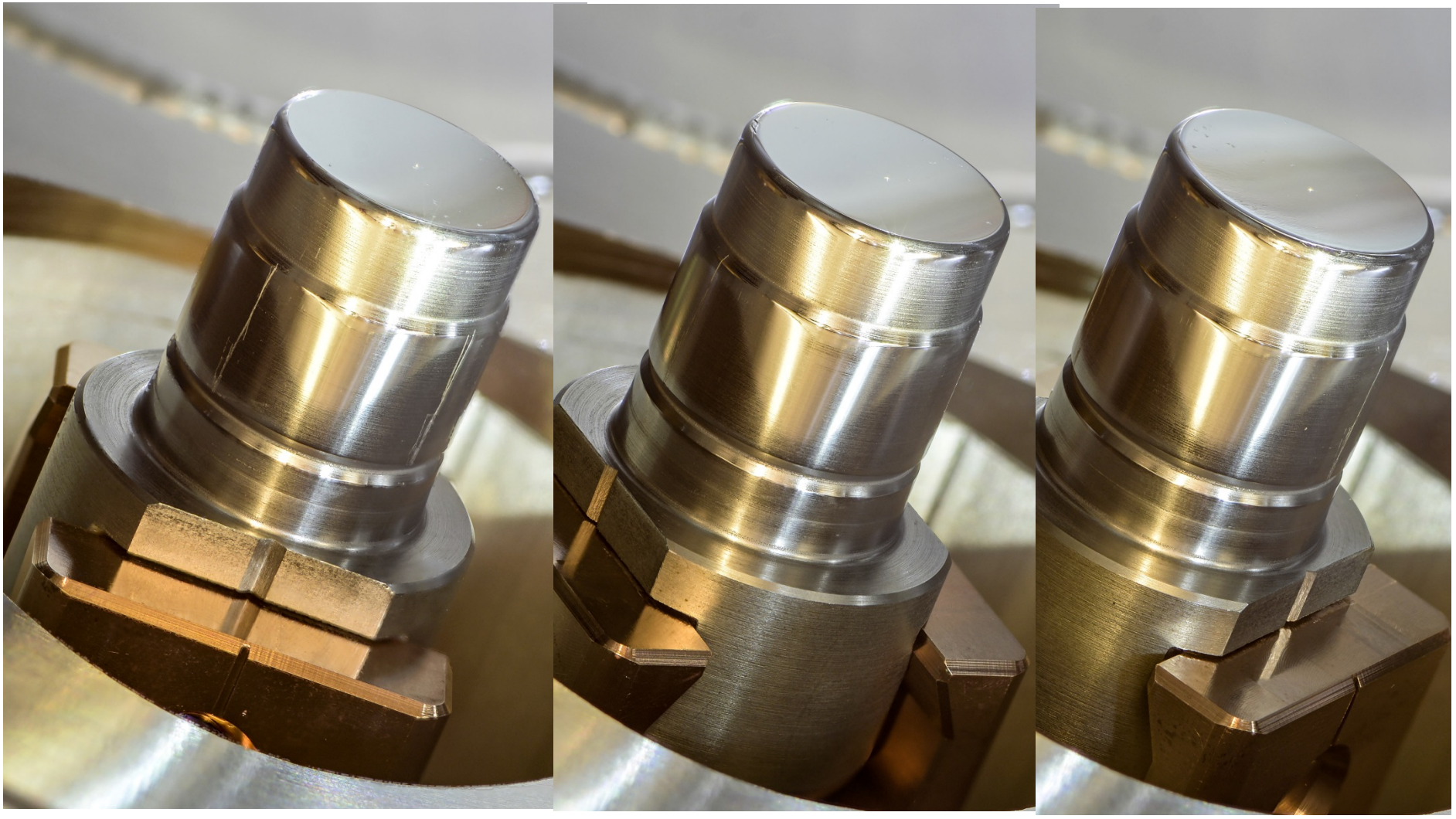
Assumption: the trouble came from a bad contact between the holder, spring and plug.

The cathode spring system had been replaced by a system where all contact surfaces had been polished and/or gold plated. (same geometry)

No signs of damage so far after 88-days of operation

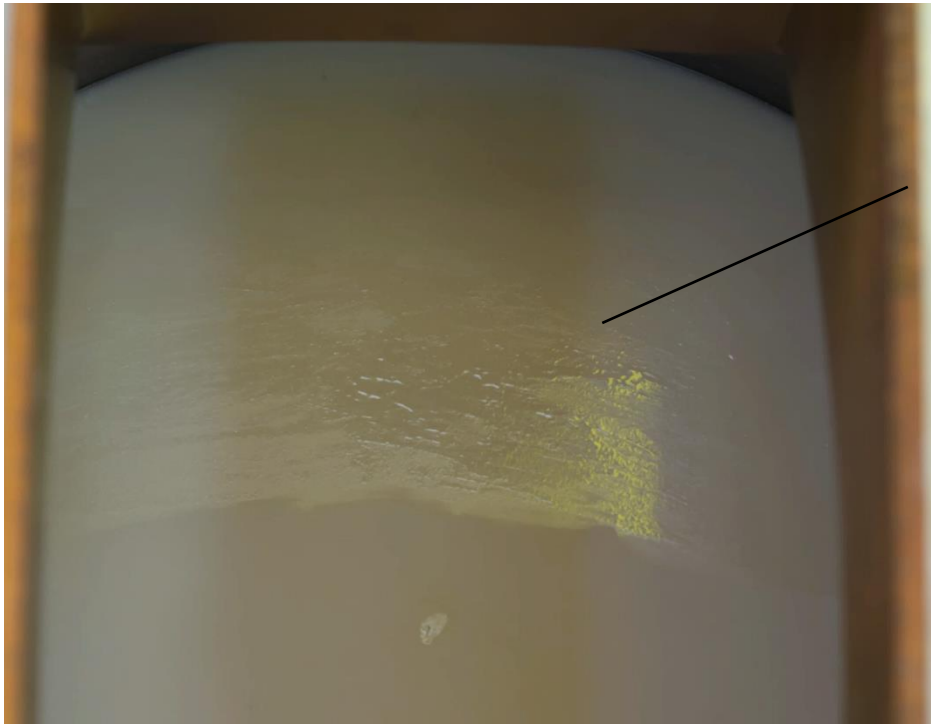


Cathode plug without any damages or marks after the December run



Examination of the leakage after September run 2014 (typ. 4.8MW, 400 us):

- While the cathode spring test had been successful the RF-window developed a leakage after some days
- Since a new Thales window was not available at that time it has been tried to localize and fix the leakage
- Surprisingly it was not the brazing but the ceramics which got leaky

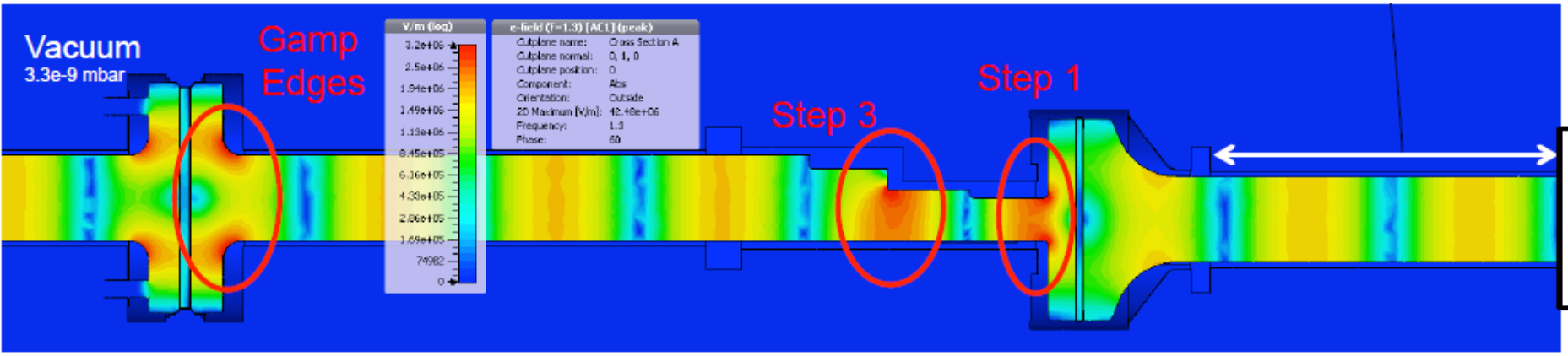


Ceramic disk from air side

Test run on the window test stand with the Thales6 and one Gamp-window

- Test with 6.5 MW, 900 us travelling wave
- Test with full reflection:
  - 20 µs pulse length (+ 35%)
  - 10 Hz
  - 2-6 MW RF-power
  - Distances to the reflector were varied

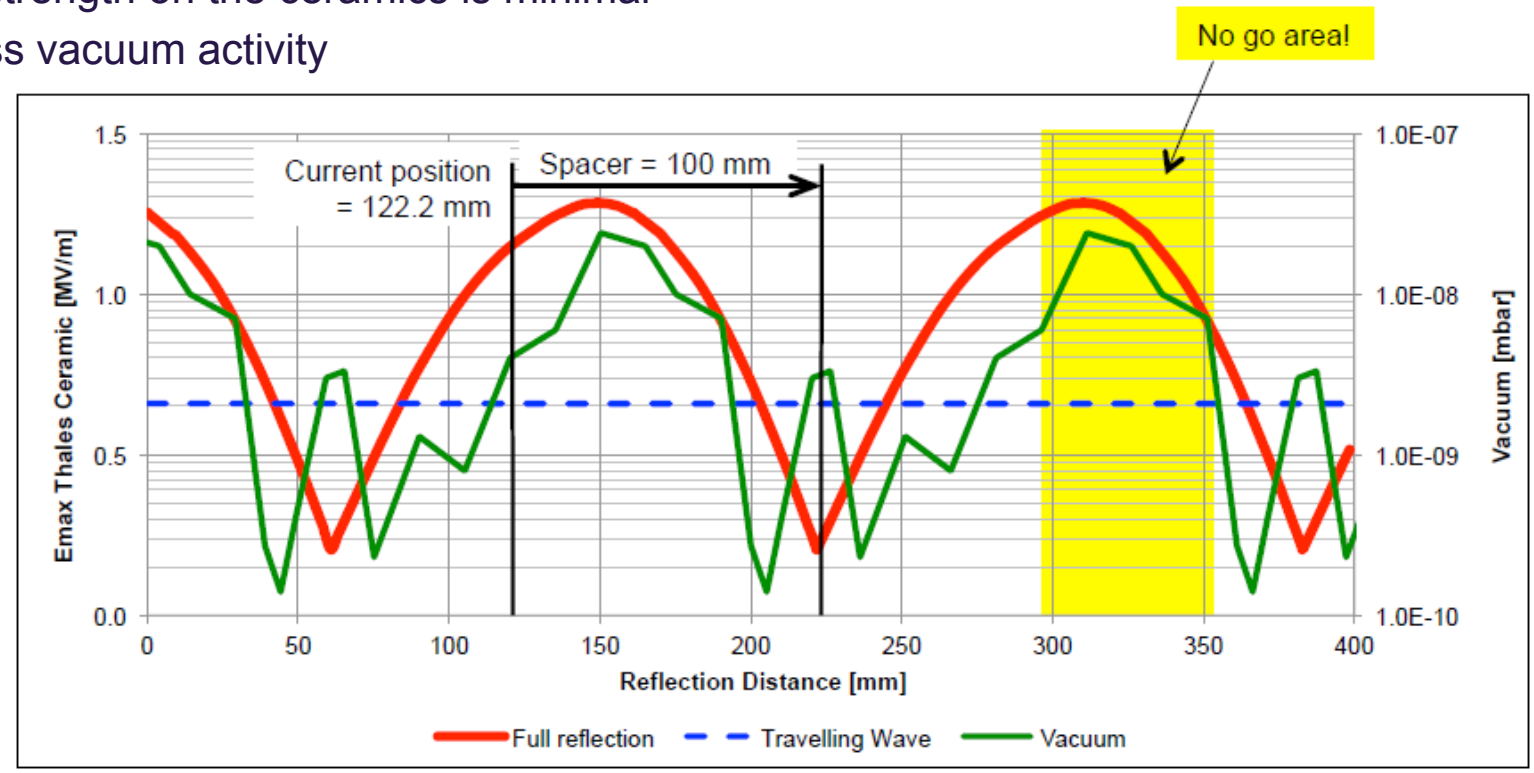
After about 1.5 weeks the conditioning was stopped – no vacuum break outs, no light from Thales, still continuous light from Gamp



Simulation for the test stand configuration: M.Bousonville

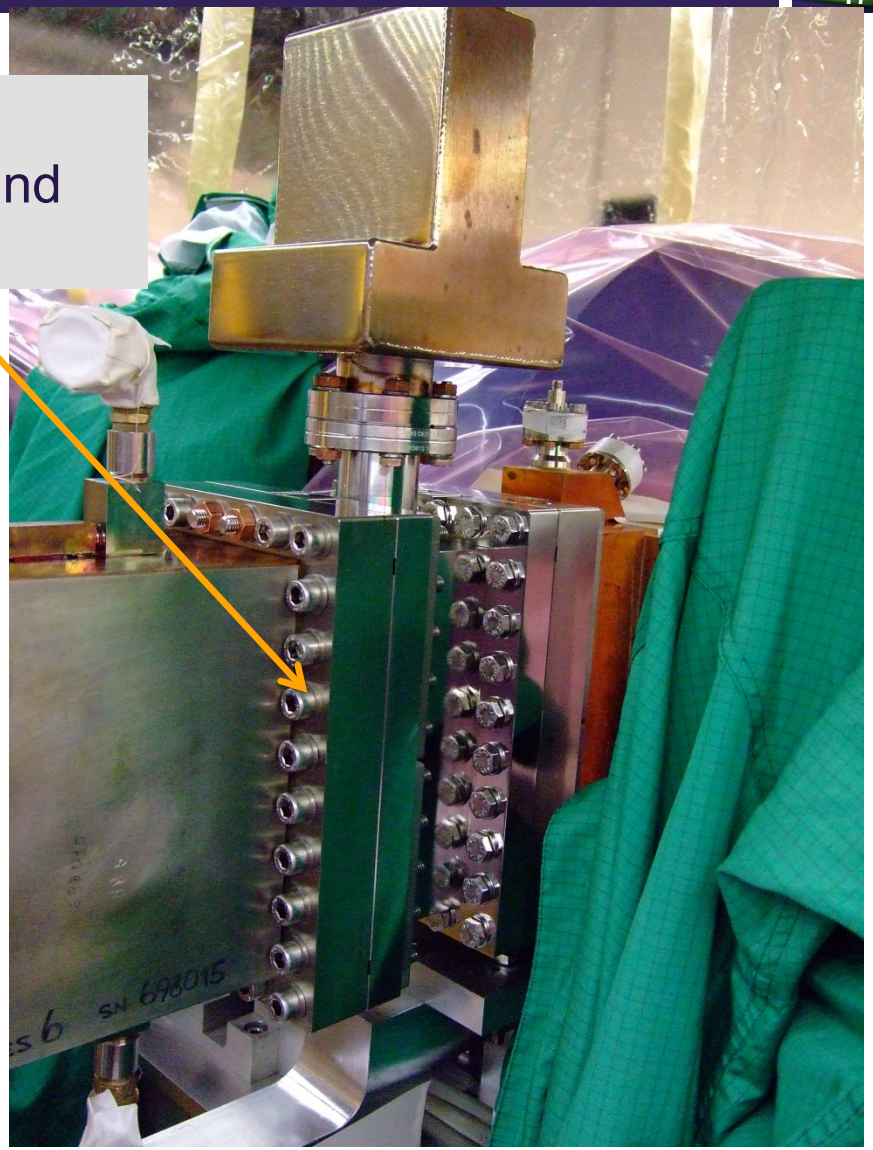
Dependance of field strength and vacuum activity on window Position [D.Kostin, M.Bousonville]

- Actual position
  - field strength on the ceramics is nearly at maximum
  - medium vacuum activity
- with 100mm shift:
  - field strength on the ceramics is minimal
  - bit less vacuum activity



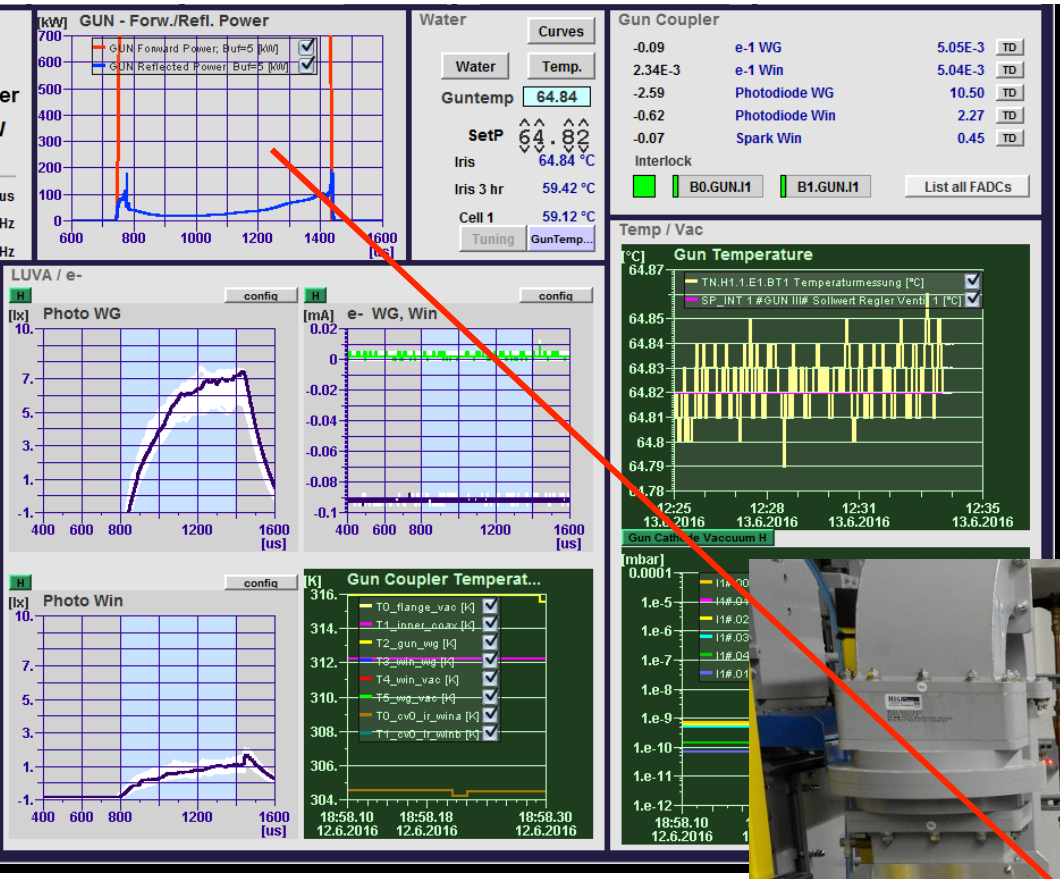
Exchange of RF-window, March ’15 with 100mm insertion

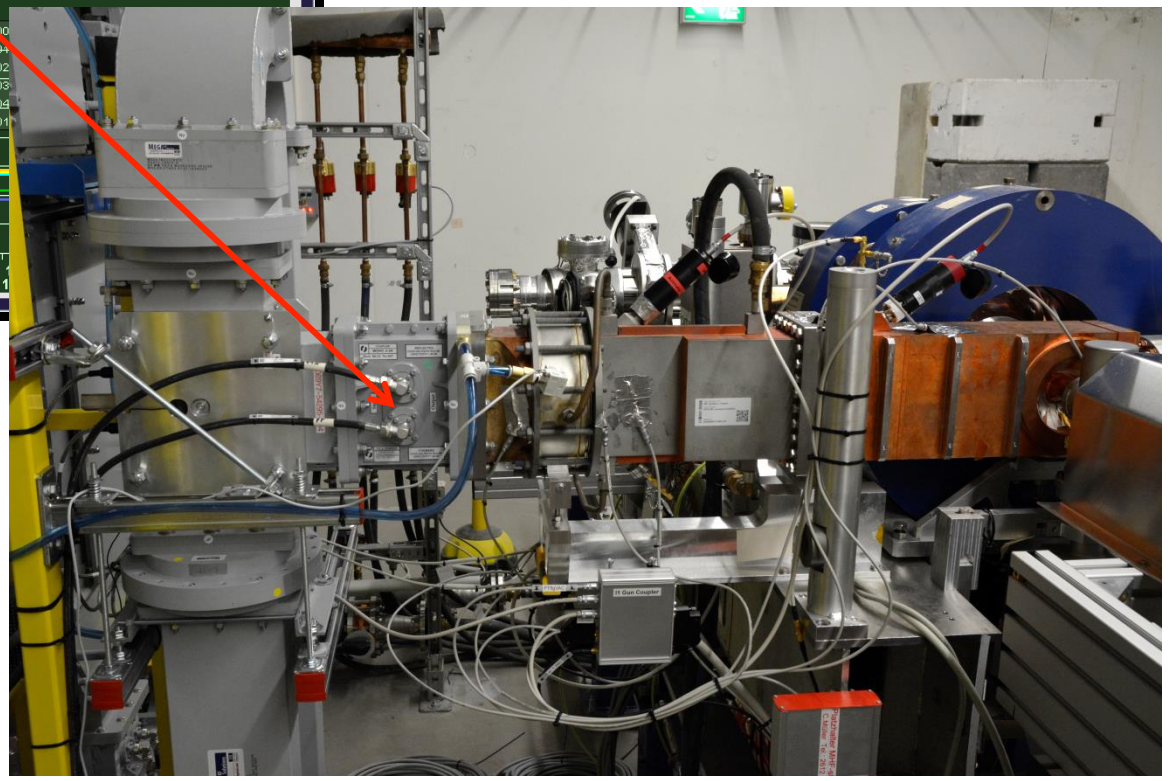
100mm vacuum waveguide between Thales RF-window and coupler



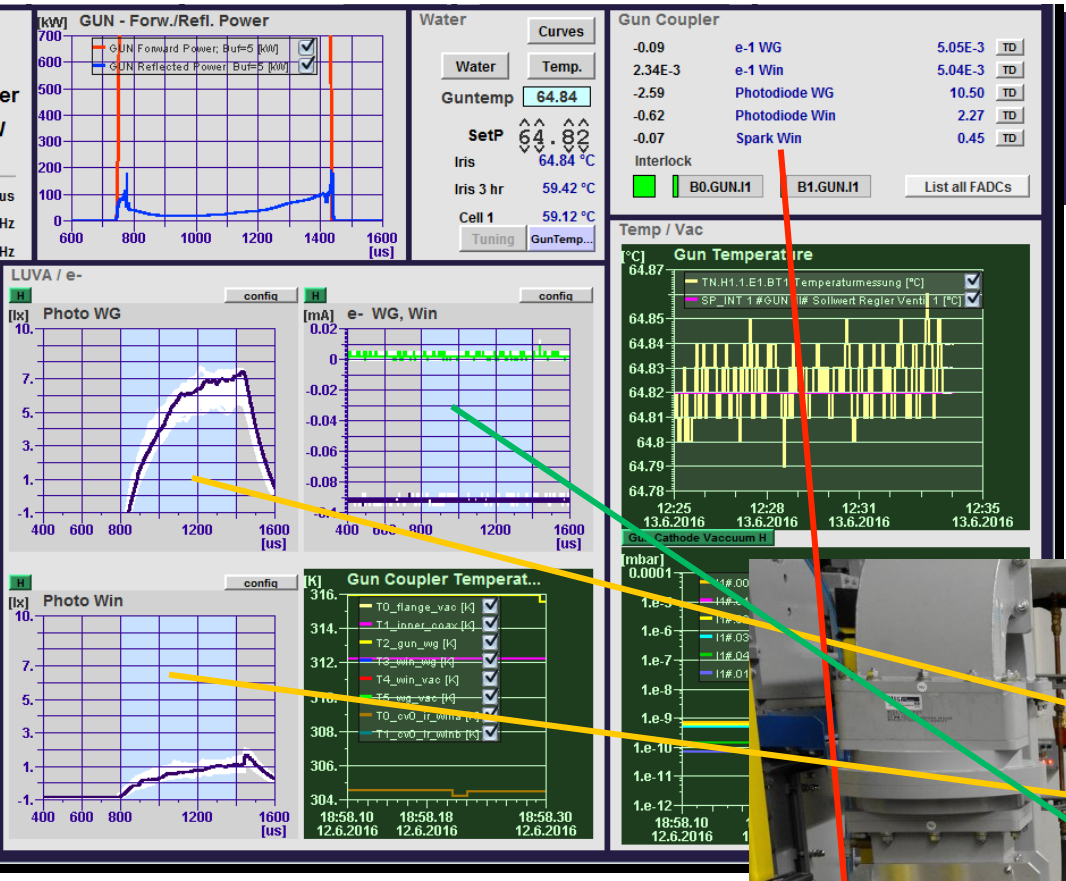
- Massive reduction of field strength on the ceramic
- Significant improved pumping speed with additional IGP

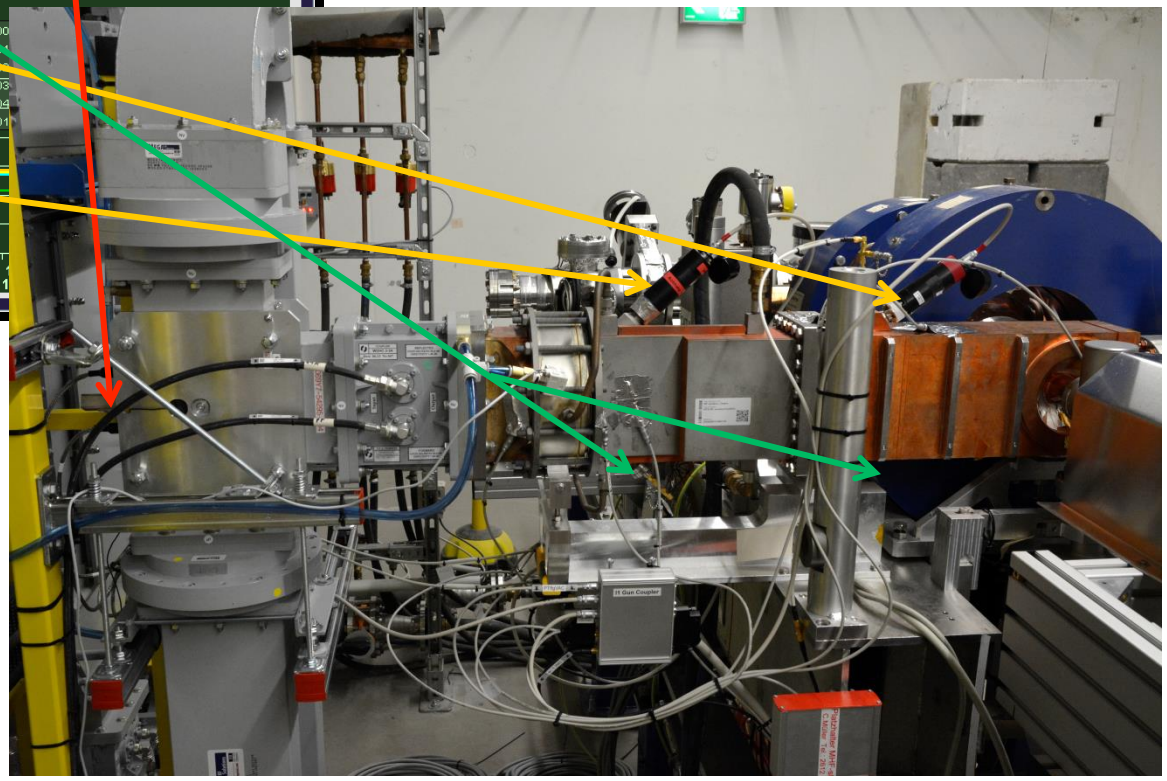
Gun signals and interlocks



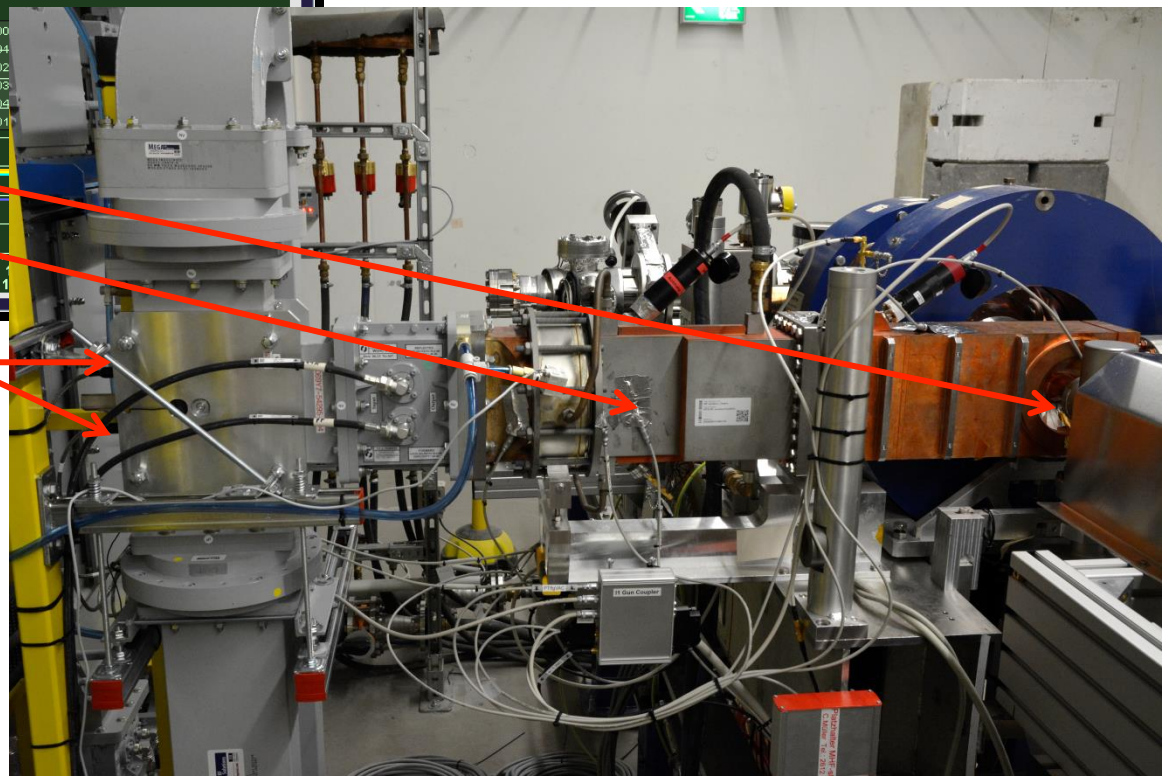


Gun signals and interlocks

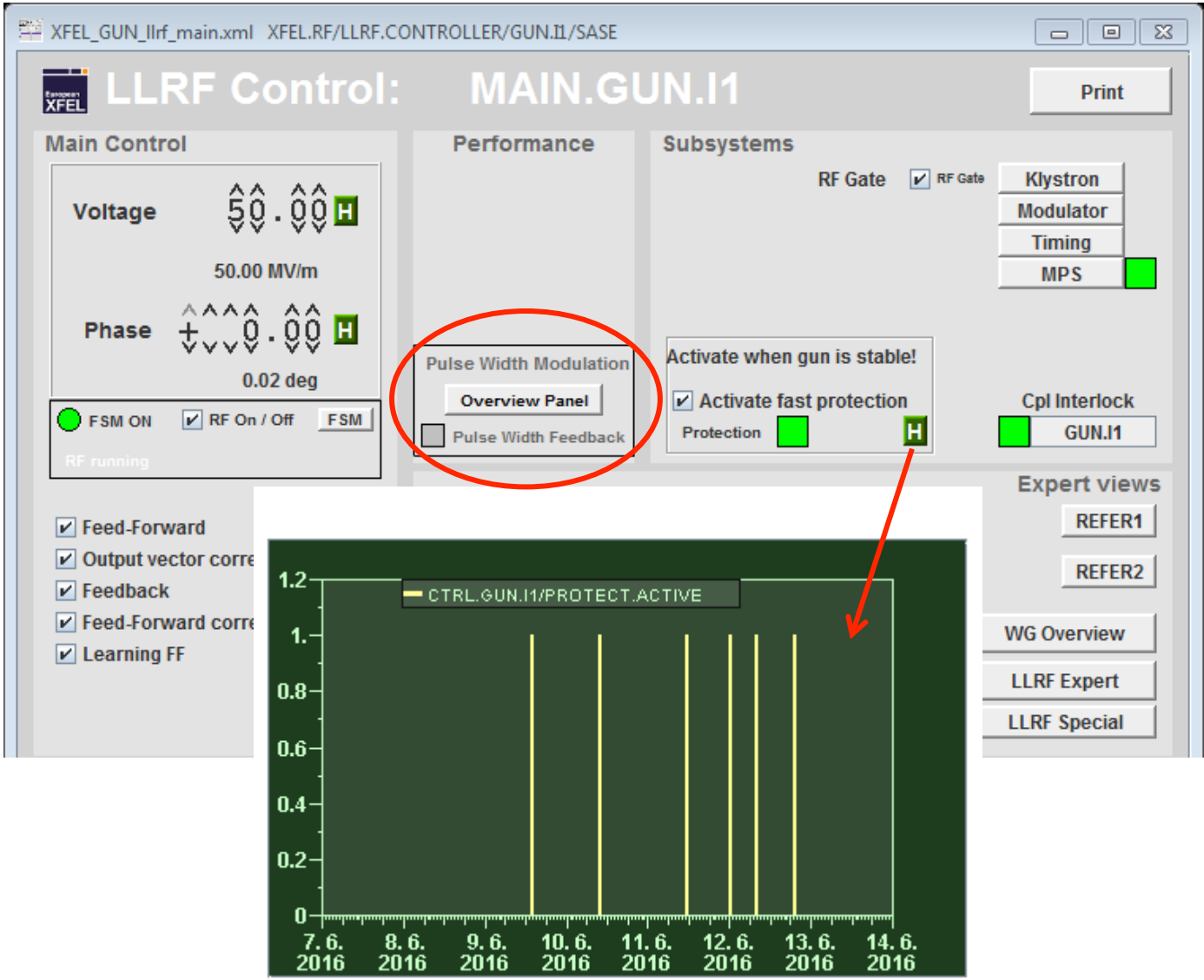




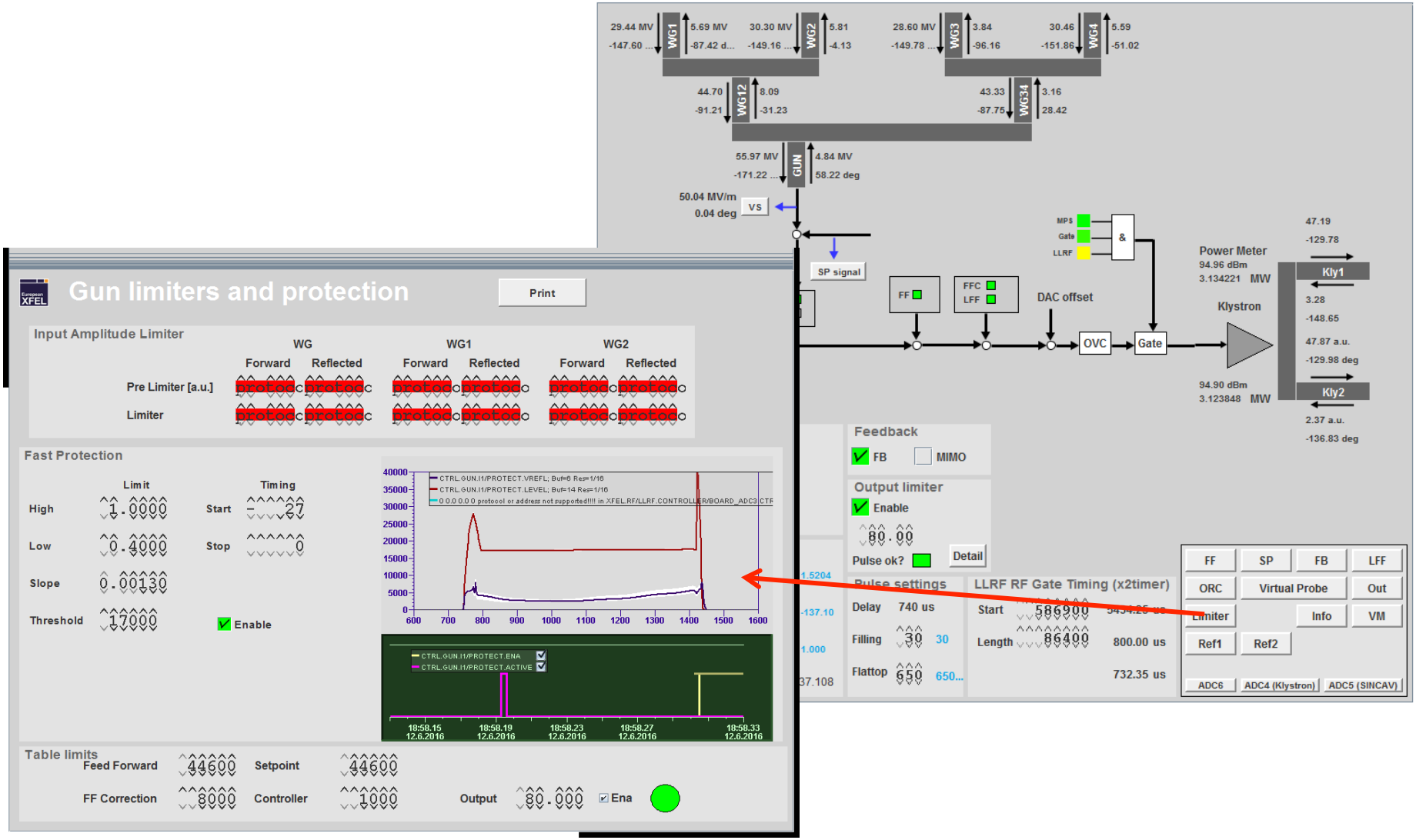
Gun signals and interlocks



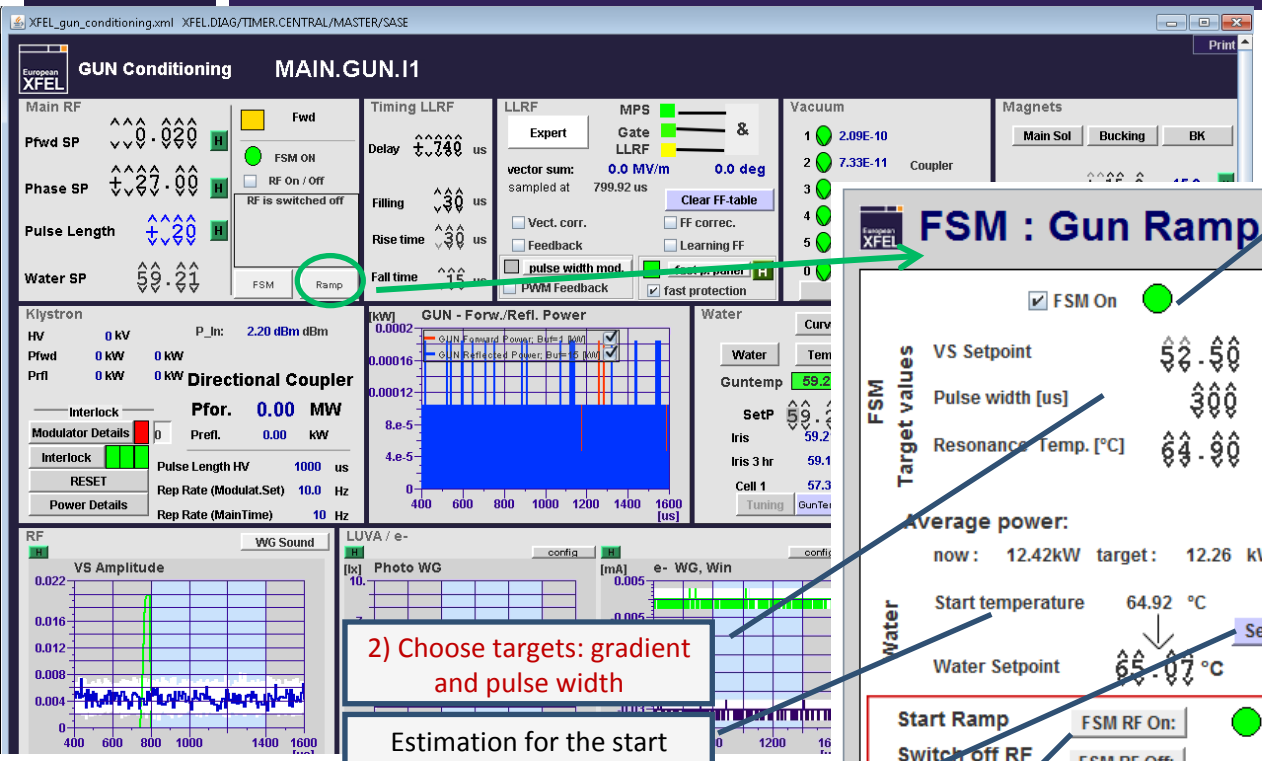
LLRF fast protection – looking at the reflected power



Limits of fast protection



Fast Gun Ramp Up – new FSM version



1) FSM On

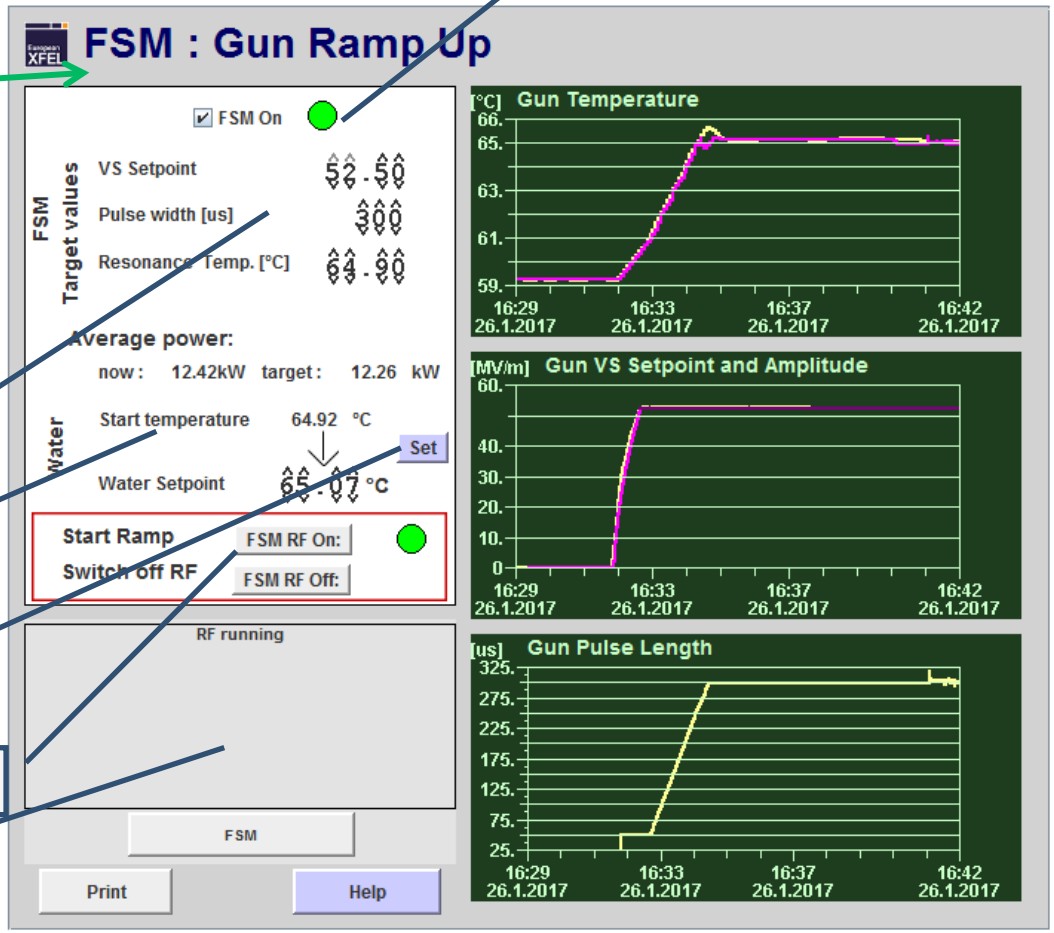
2) Choose targets: gradient and pulse width

Estimation for the start temperature

3) Set start temperature and wait until it's reached (~0.2 C)

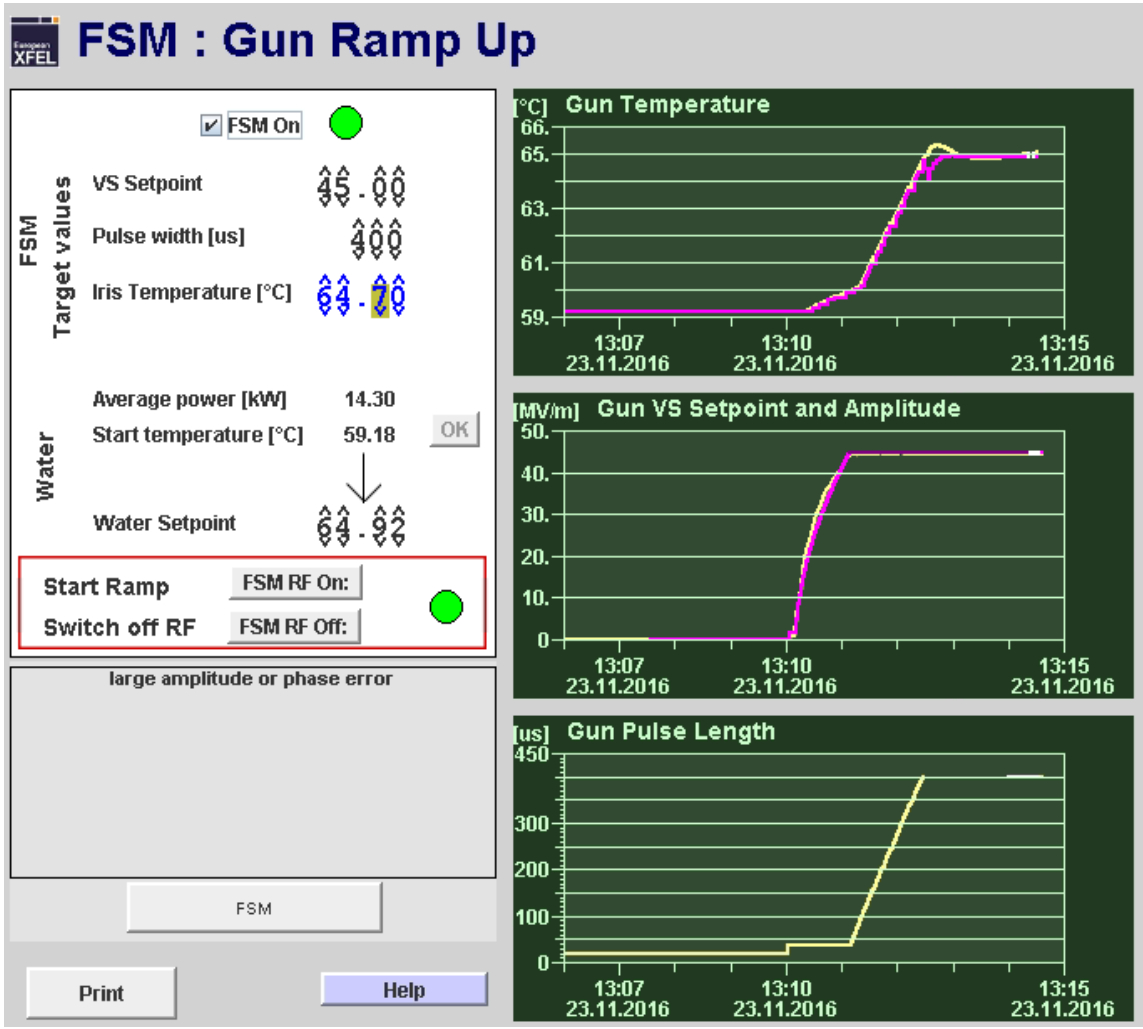
4) Start ramp by switching FSM RF On

FSM messages

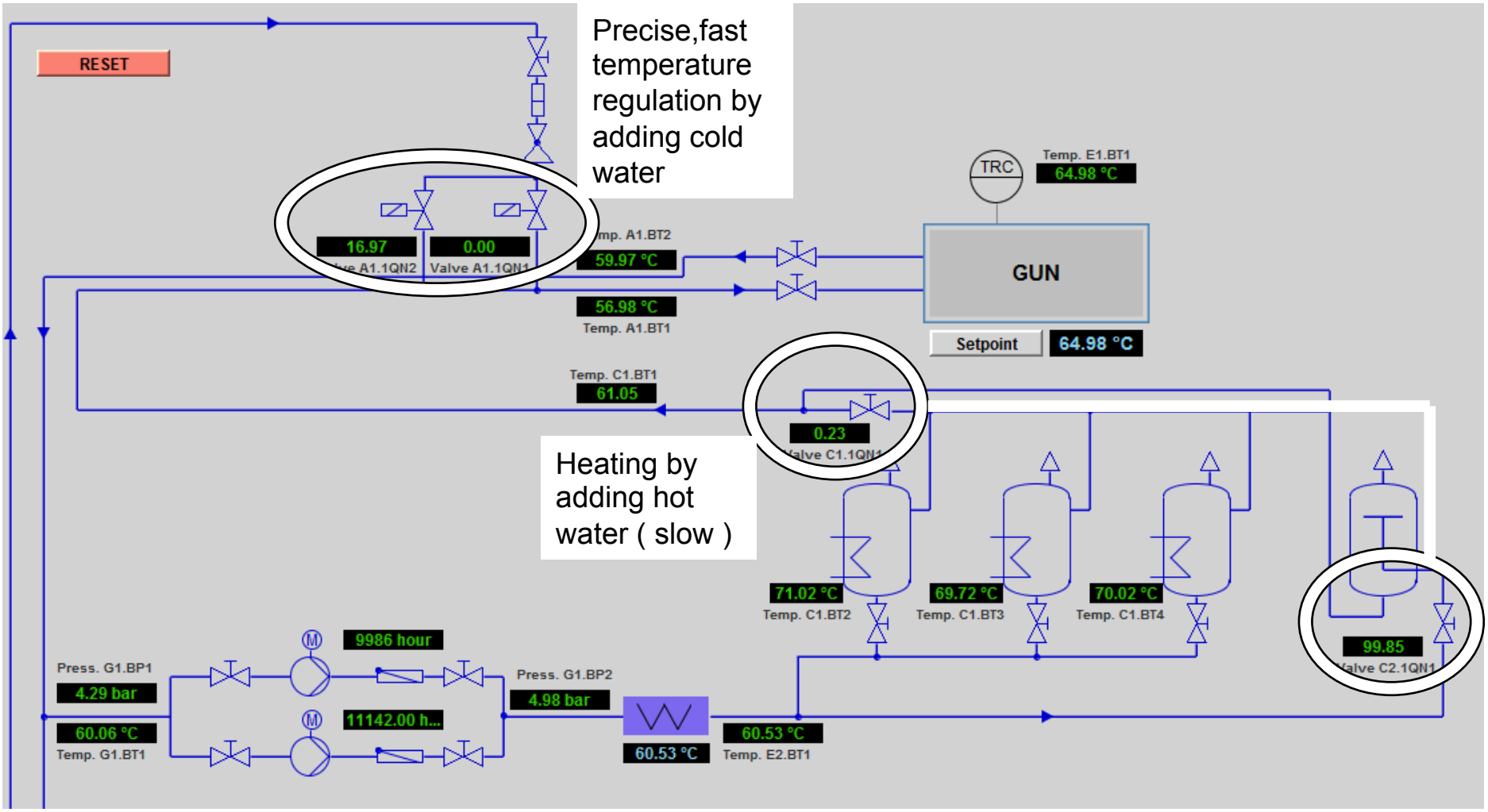


Fast Gun Ramp Up – new FSM version

1. The FSM **sets the Gun frequency** on the actual resonance frequency defined by the temperature
2. Gradient and pulse length are ramped up
   - The temperature set point tracks the actual temperature which rises with RF power
   - The frequency is kept on resonance to avoid reflections
3. After reaching the target values, the FSM is waiting for the temperature to stabilize before setting the frequency to nominal.
4. When Set points for amplitude and phase are close to the measured values the feedback and learning feed forward are started plus the pulse width modulation
5. From now on the gun parameters can be changed by hand as usual

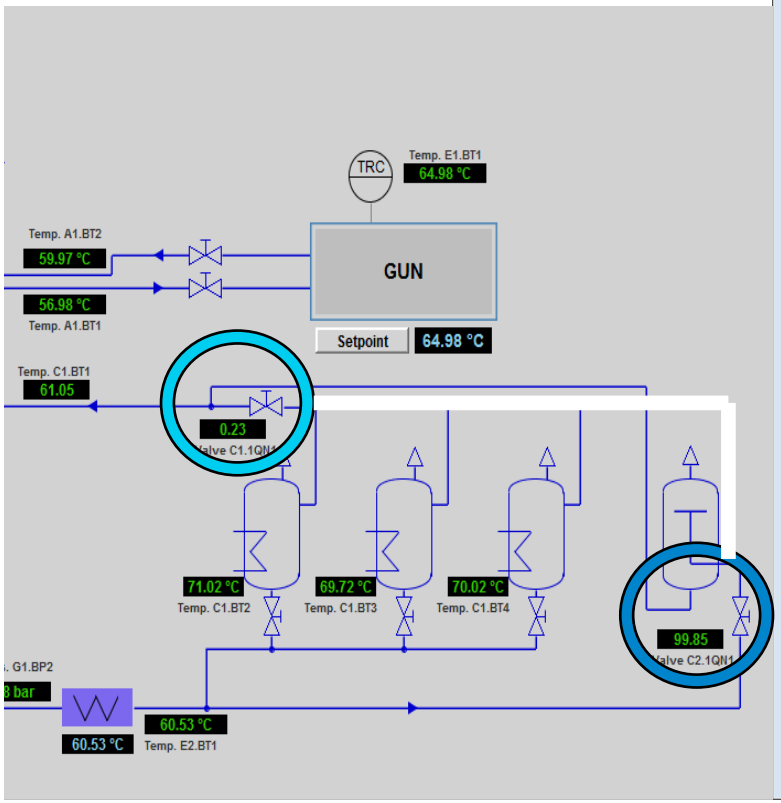


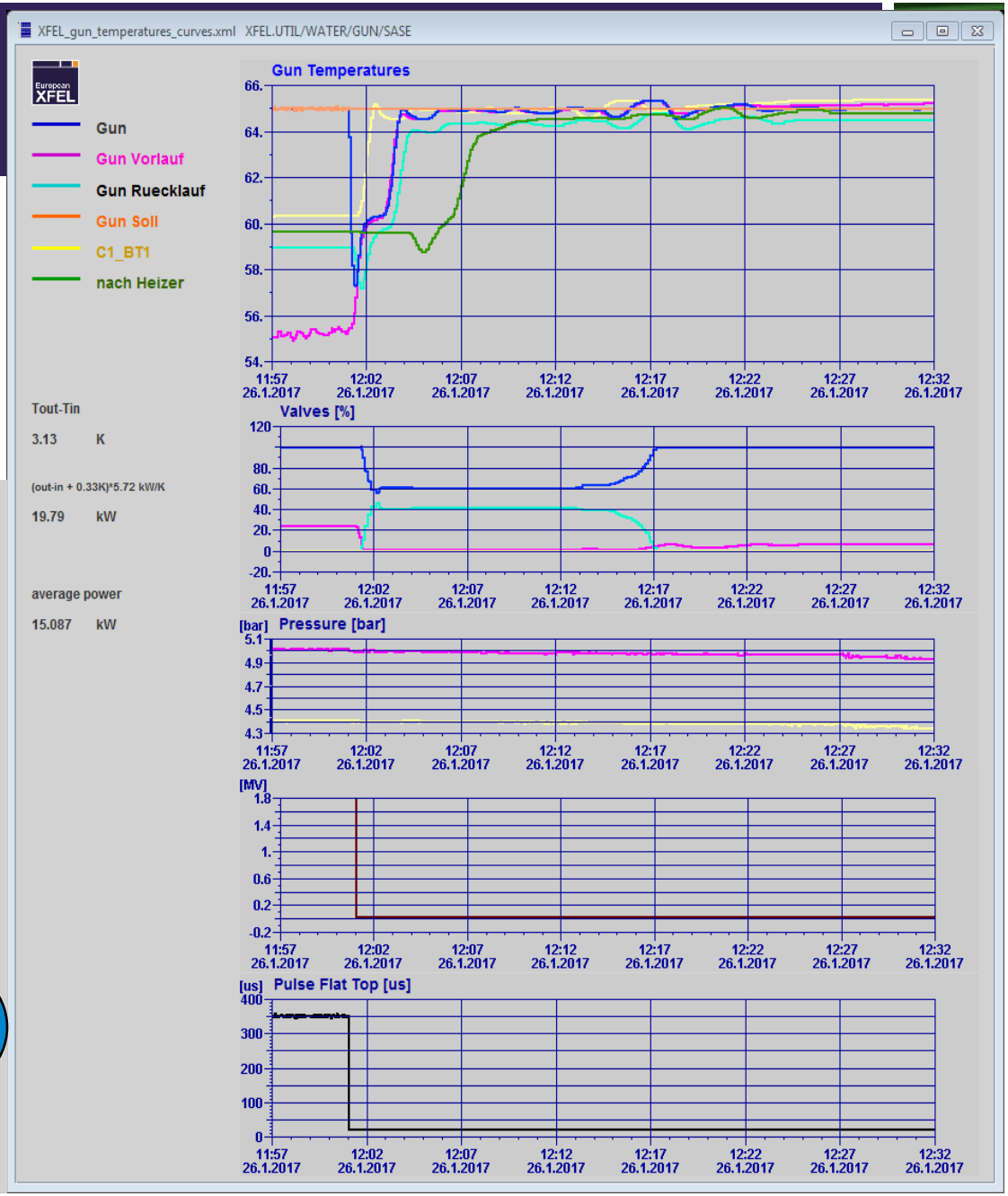
Water temperature regulation



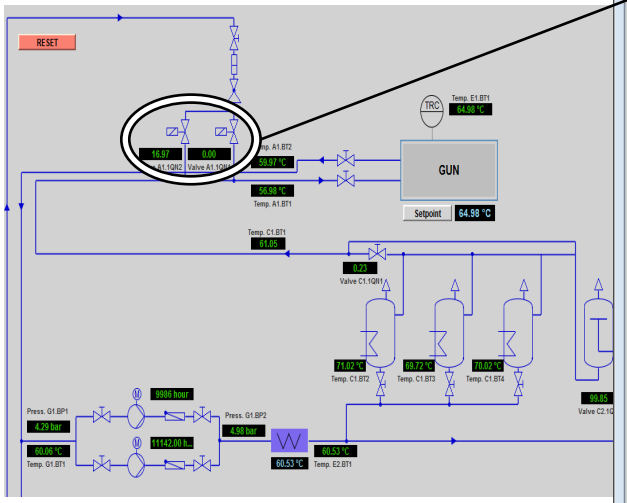
European XFEL

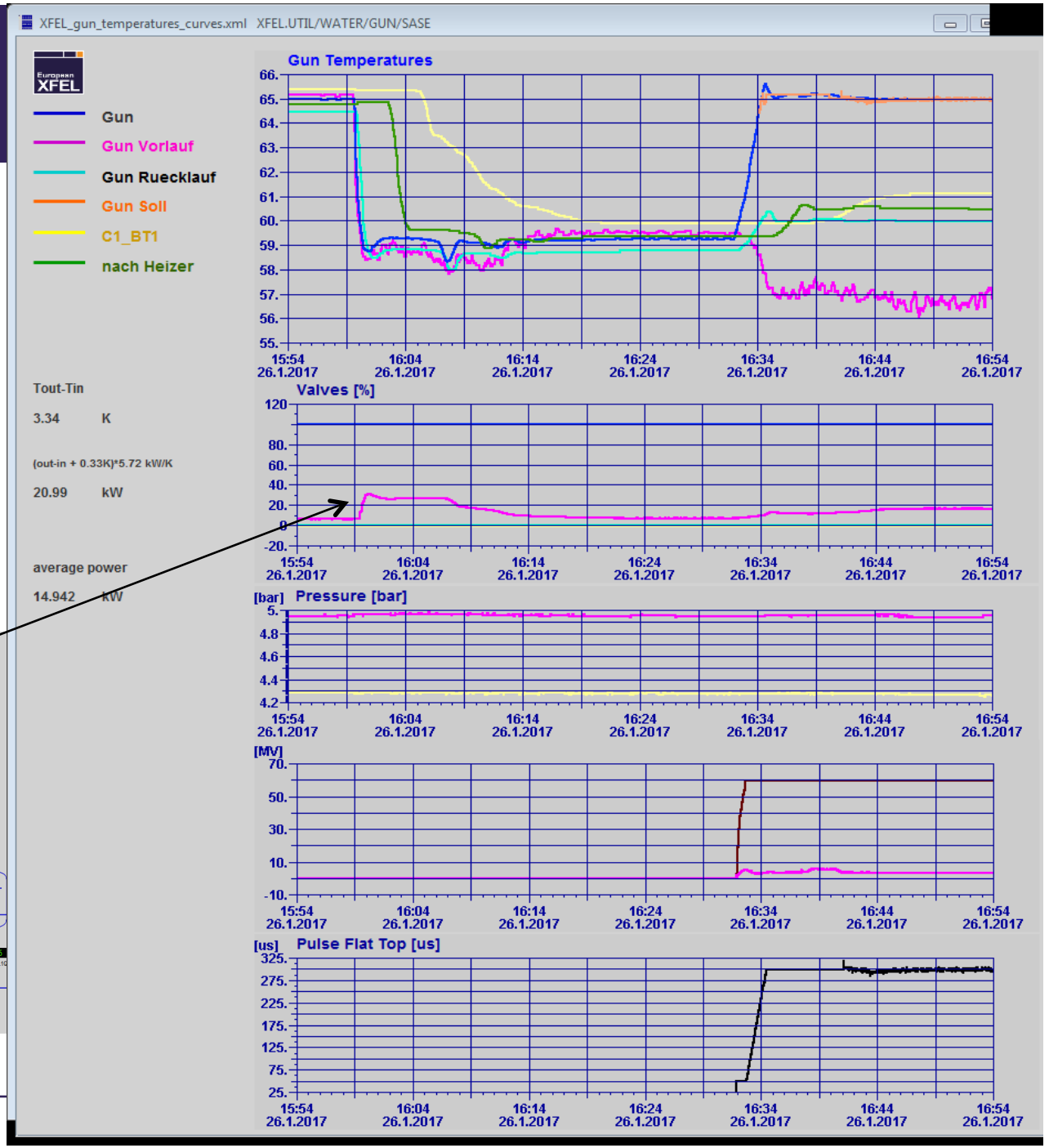
Heating up by adding hot water from the tanks





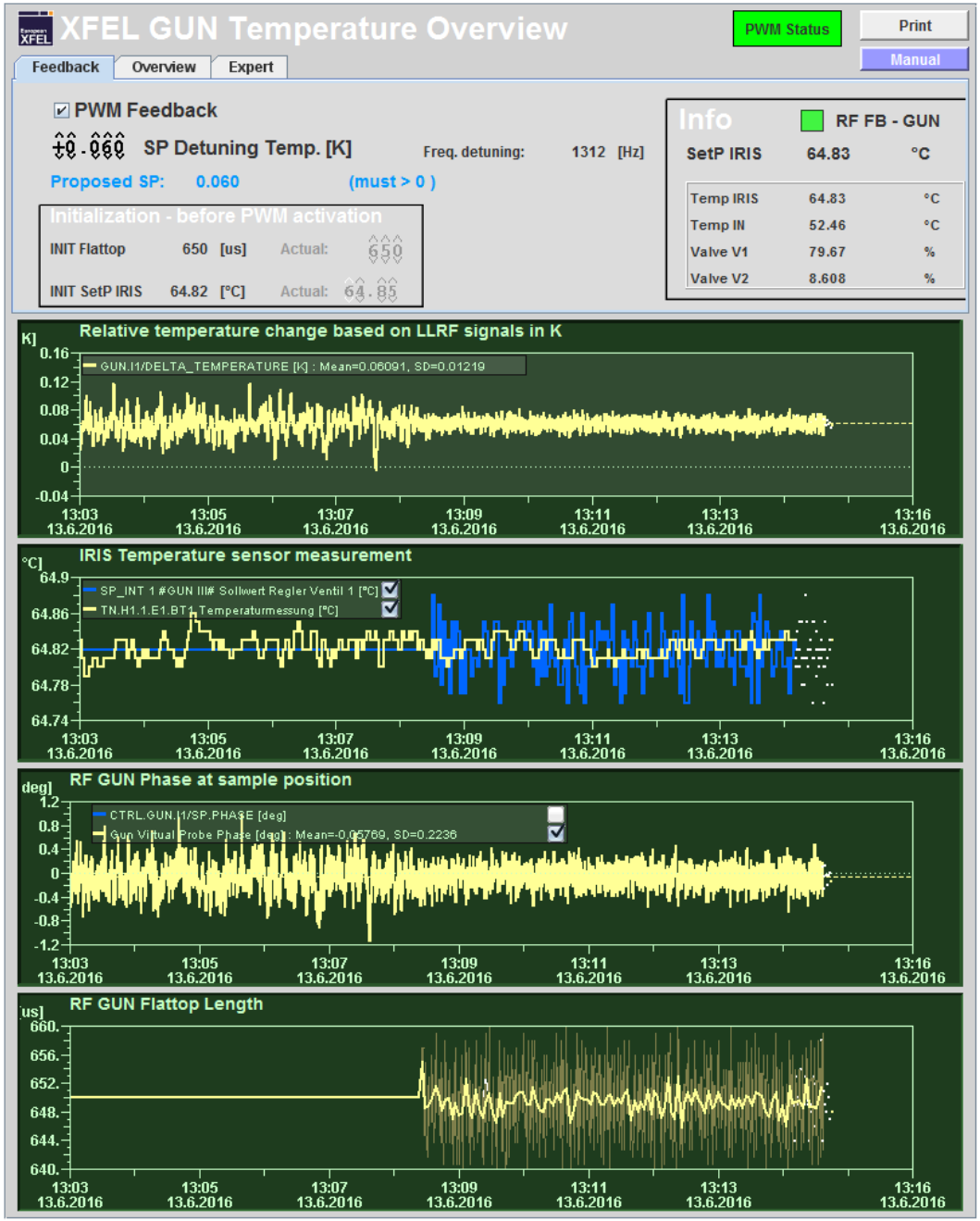
Cooling down with cold water



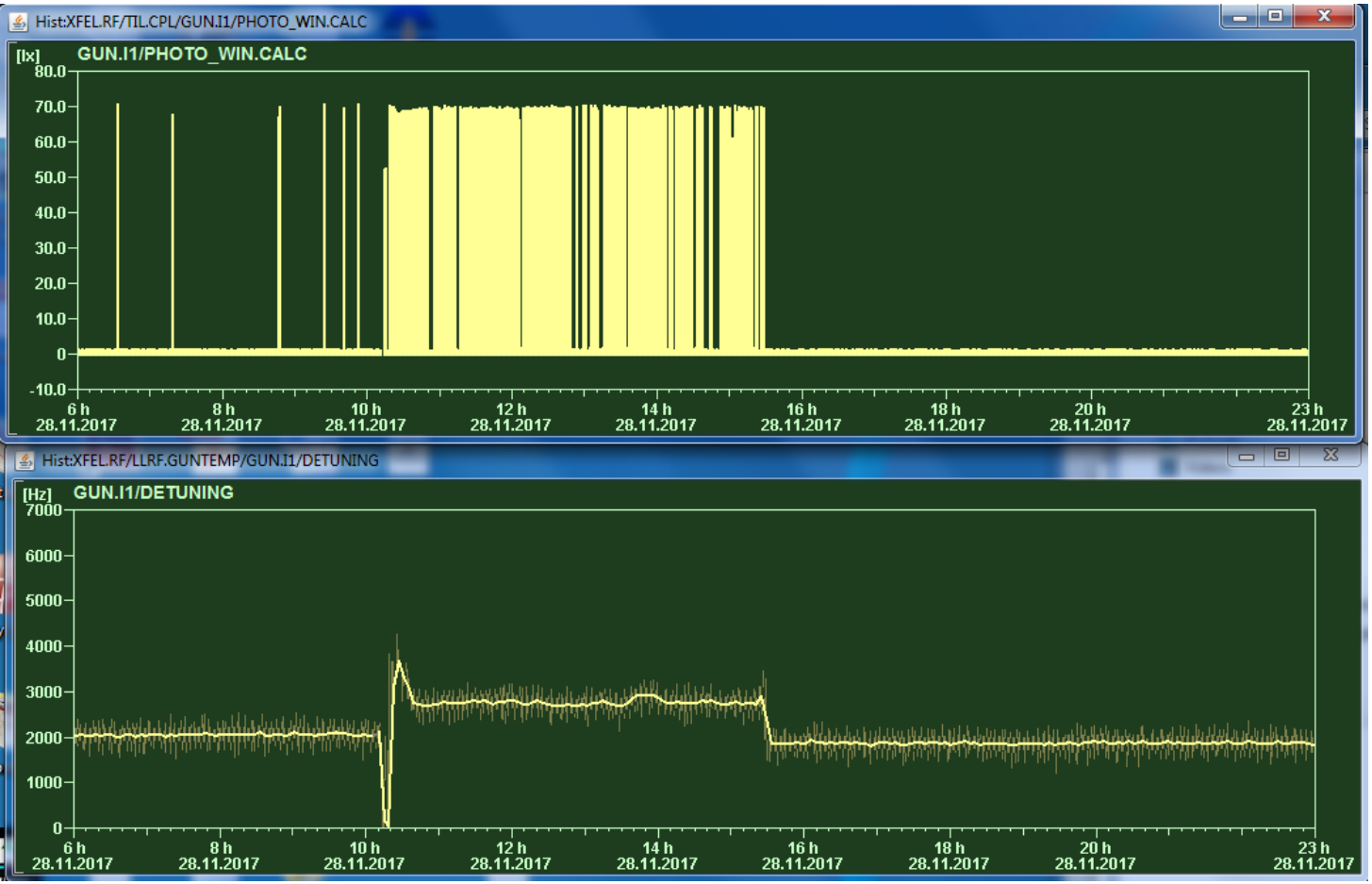


Pulse width modulation

- Fast measurement of gun temperature (0.1sec vs. 7 sec)
- compensate temperature deviations with the RF pulse width



Strong temperature (detuning) dependance of light emission



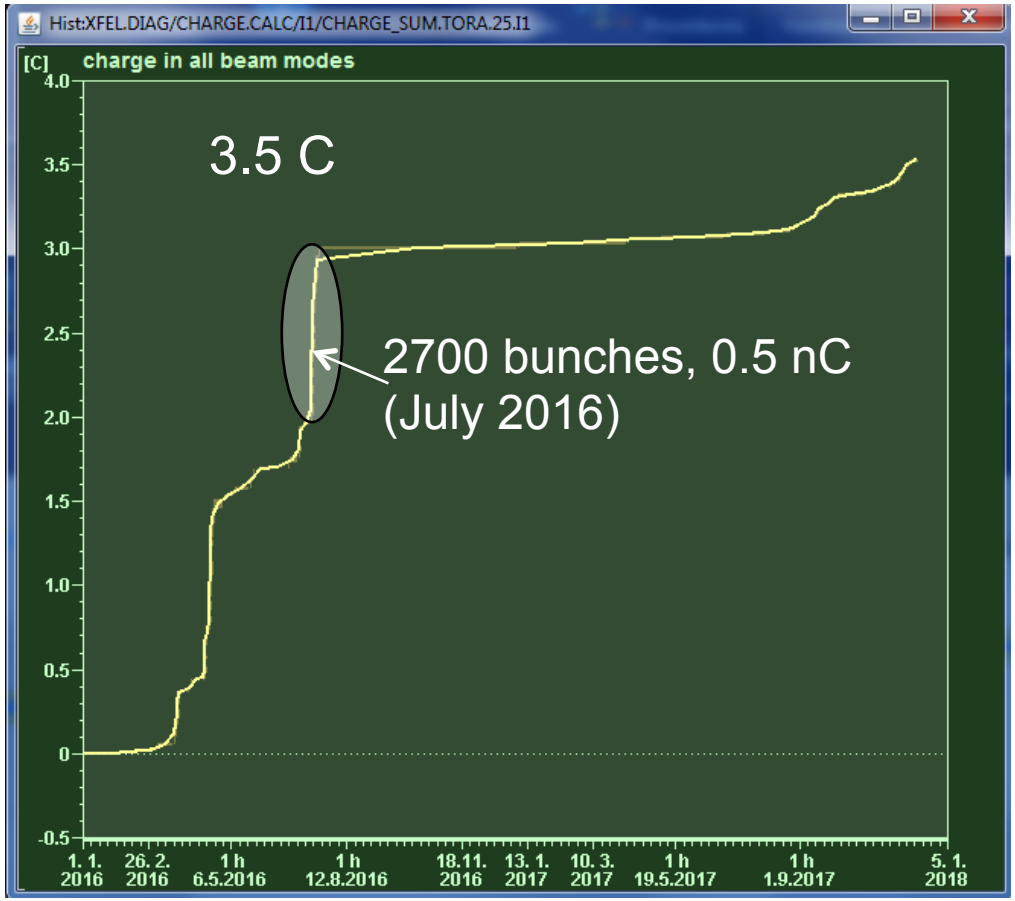
Below 2200 Hz

Much less activity.

200Hz = 0.01°C!

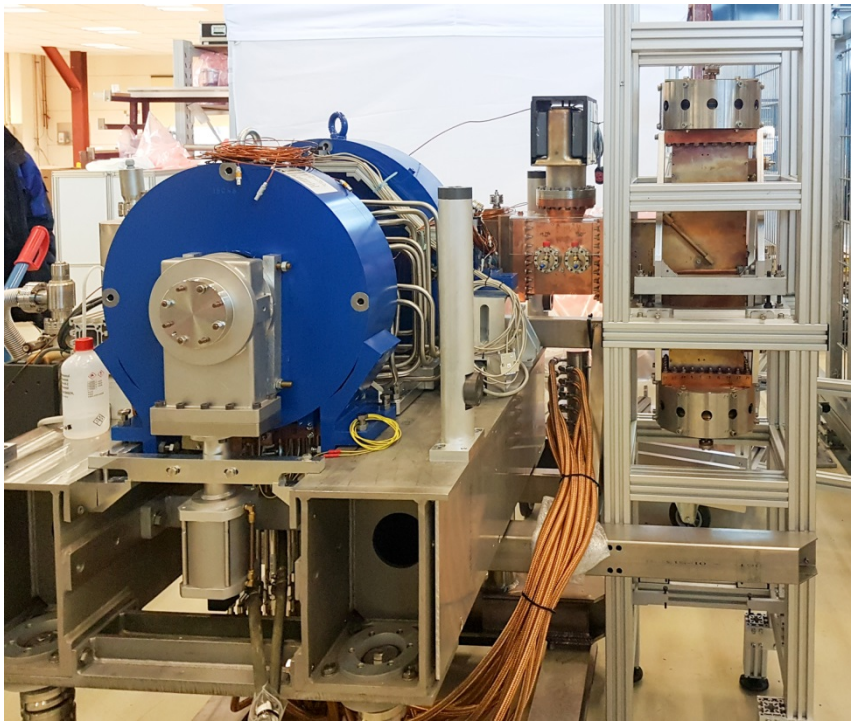
Charge delivered from Gun 4.3 since Jan 2016:

- Practically no interlocks since 2 years during the runs
- Light interlock at the window vacuum side was disabled – but the vacuum threshold stood at $3 \cdot 10^{-10}$ mbar



December 2017: Exchange of the gun

- This December the gun will be exchanged with the Gun 4.6, which has been conditioned at PITZ
- The two guns are identical beside a different cathode spring design (watchband reloaded at 4.6)
- The goal is to have two identical guns available which proved to deliver beams for SASE
  - Before the installation the two Gamp windows have been exchanged by one Thales window
  - Reconditioning will be necessary at beginning of next year for one week



(re-) conditioning starting ~Jan 4th

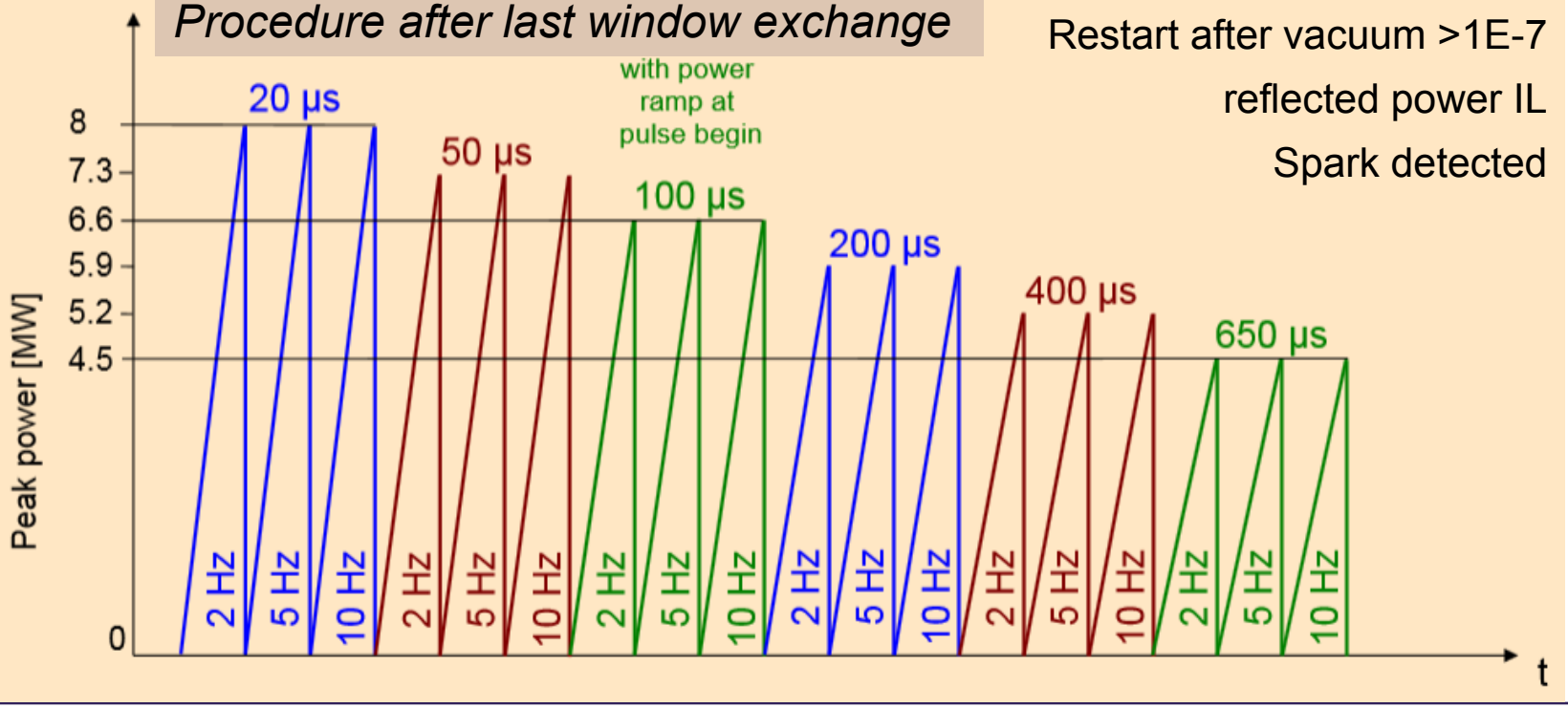
1. Startup **without frequency detuning**
2. Starting with short pulses, low rep rate and high power
3. Encreasing the rep rate and the pulse length while reducing the peak power
4. Restart with short pulses after interlocks
5. Exact parameters will be defined

Procedure after last window exchange

Restart after vacuum >1E-7

reflected power IL

Spark detected




Thank you !