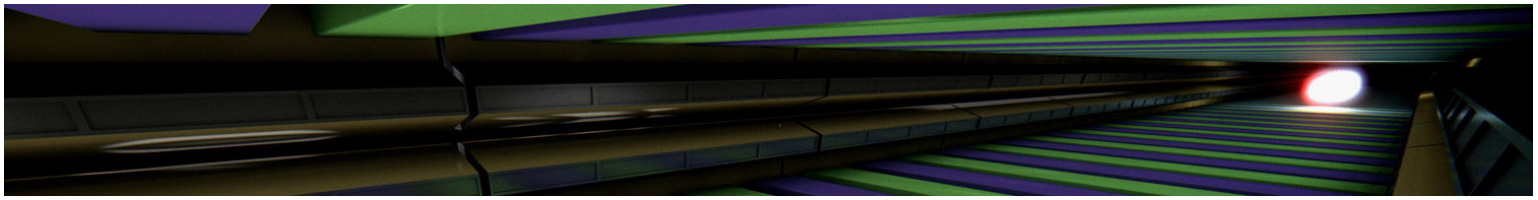
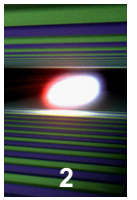


XFEL-Gun Operator Training

F.Brinker

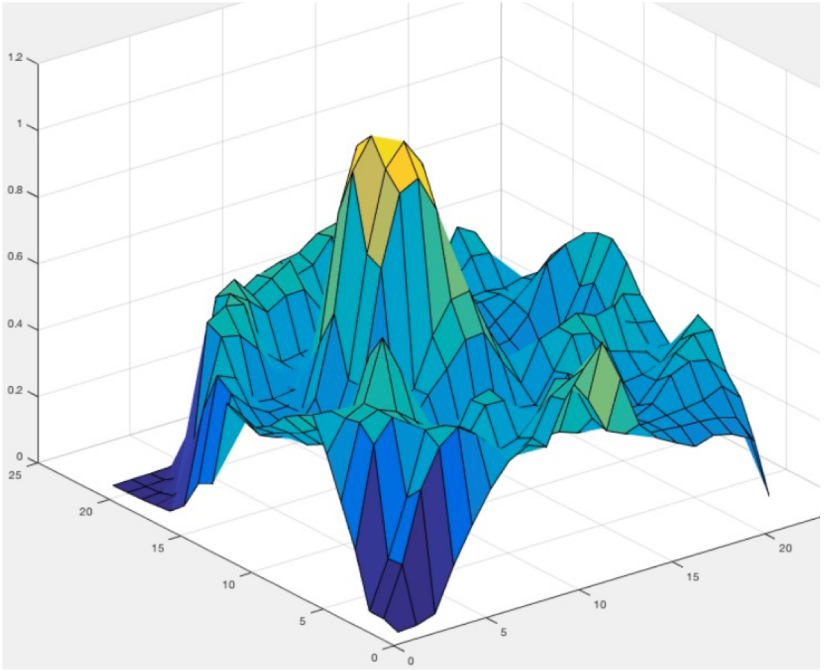
Content

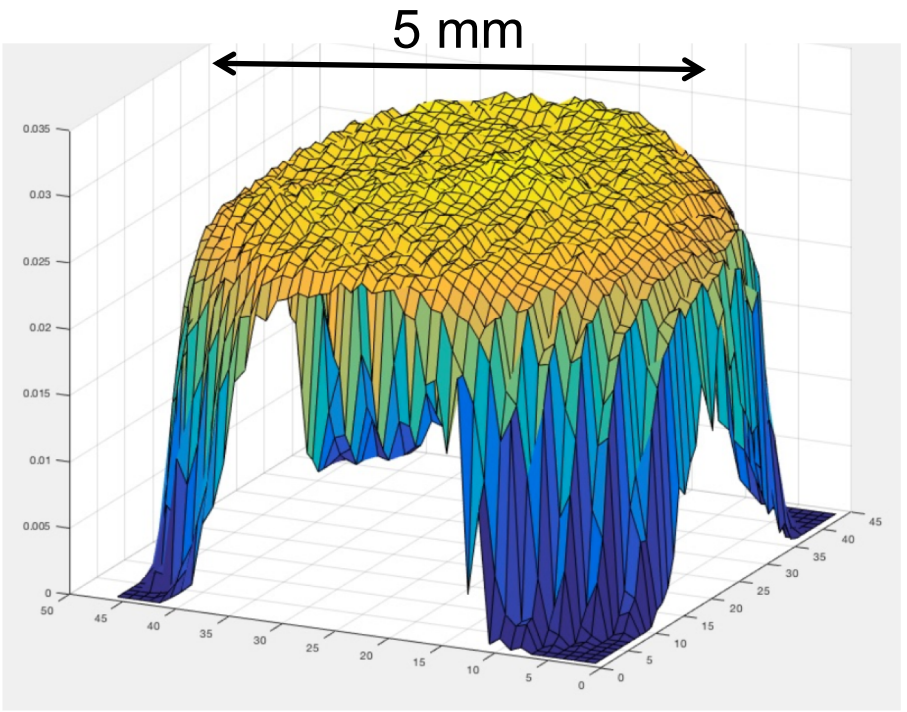


- Cathode
- Interlock systems
- Multi Pactoring
- Temperature regulation
- FSM and Ramp Up procedure

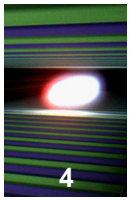
Cathode exchange January 2020, Why?

Messung der Quanteneffizent = wieviele Electronen werden pro Laser Photon freigesetzt

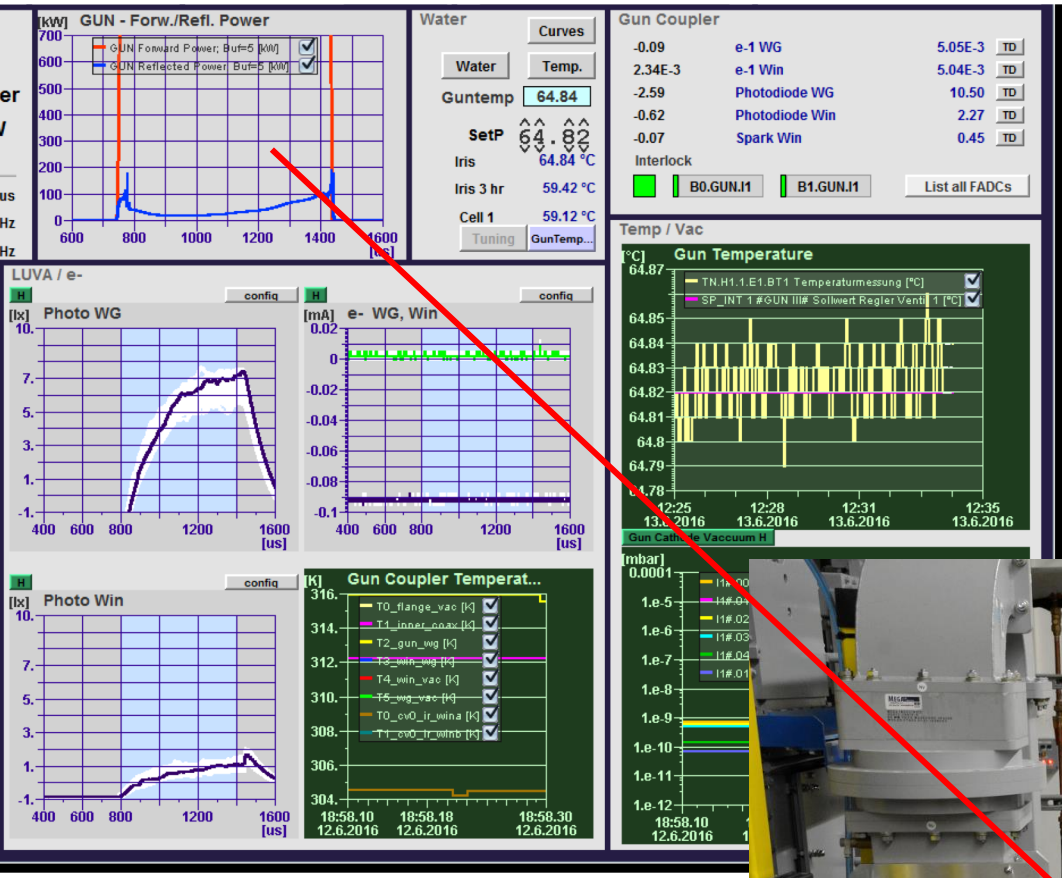


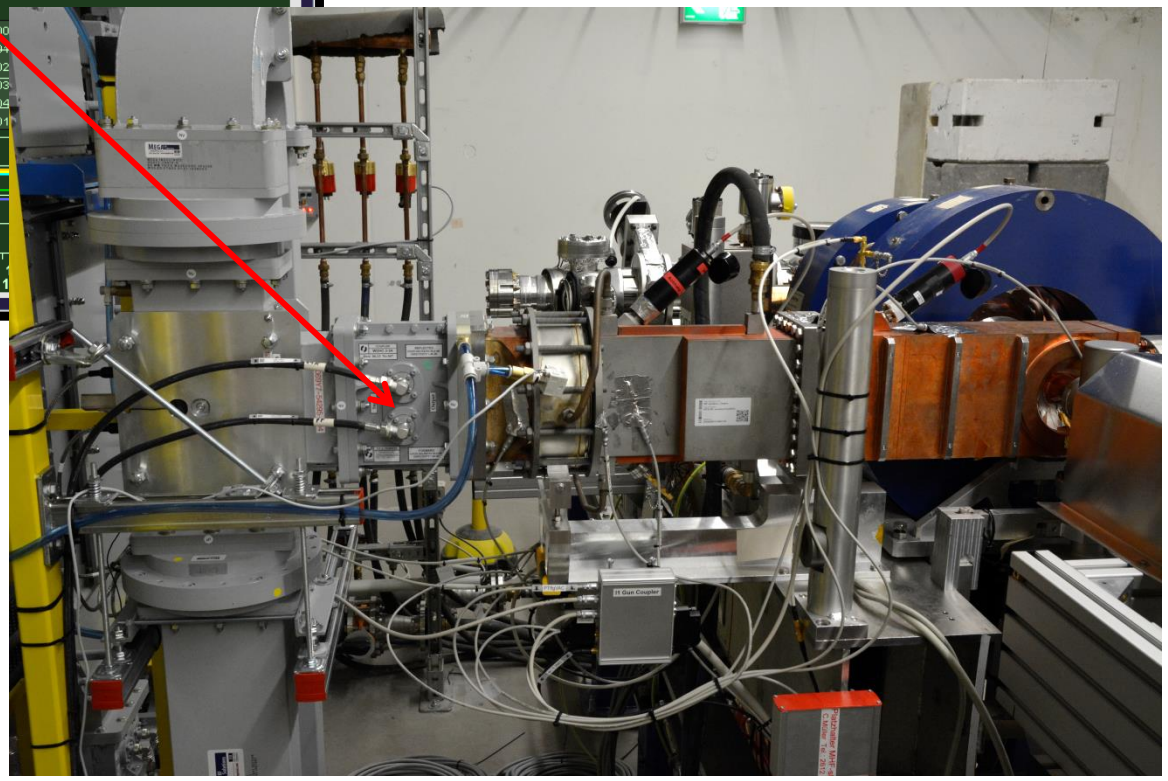


Gun signals and interlocks

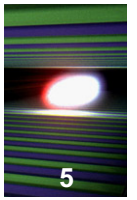


RF measurement

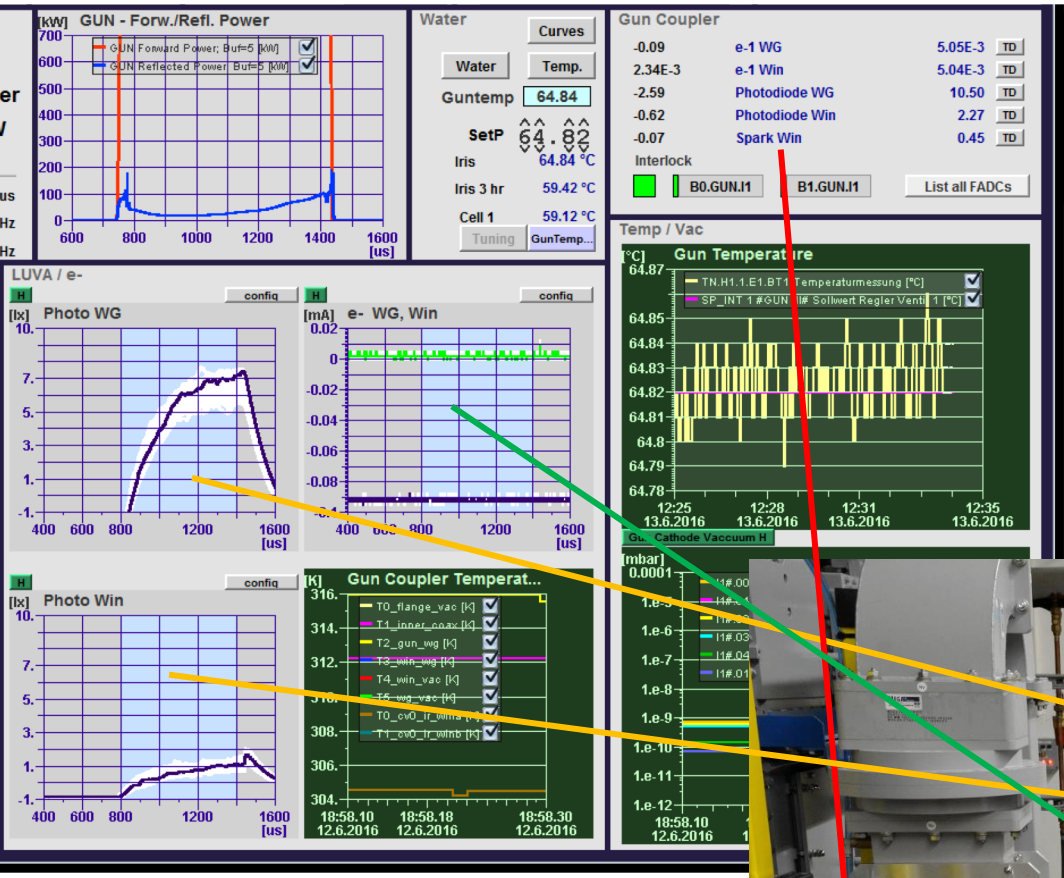


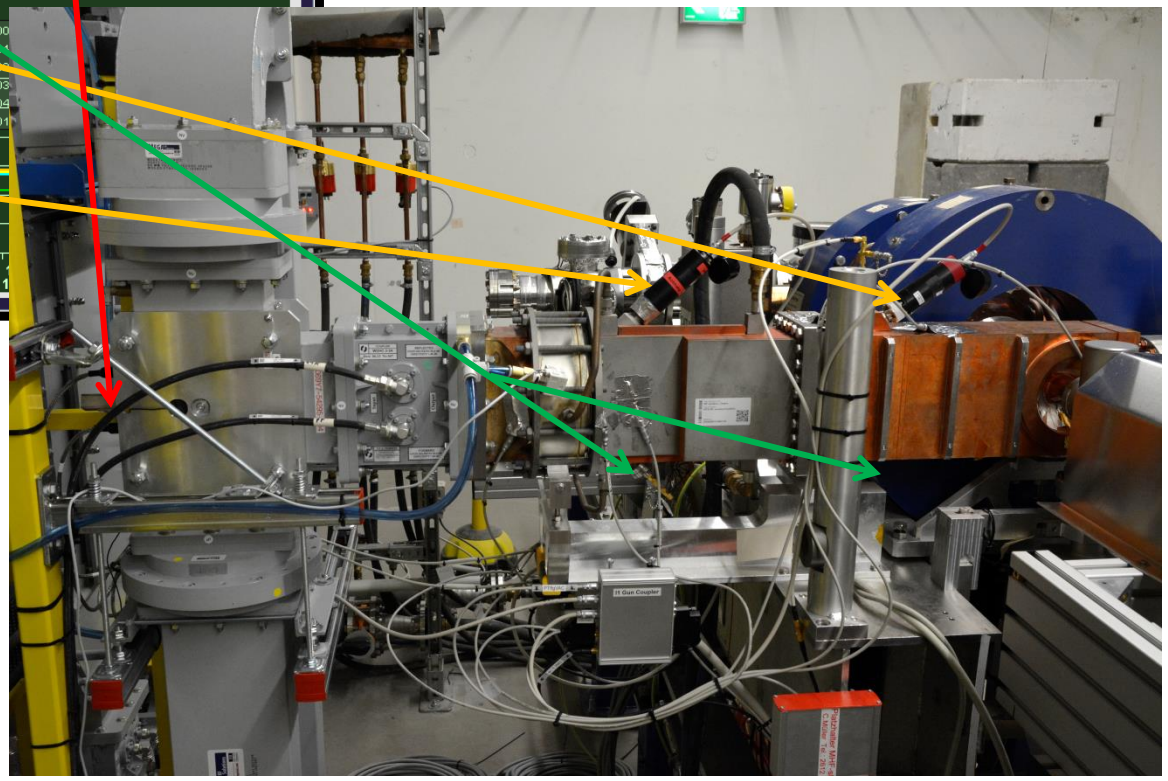


Gun signals and interlocks

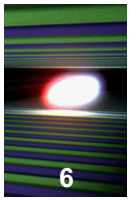


Light and electron detection

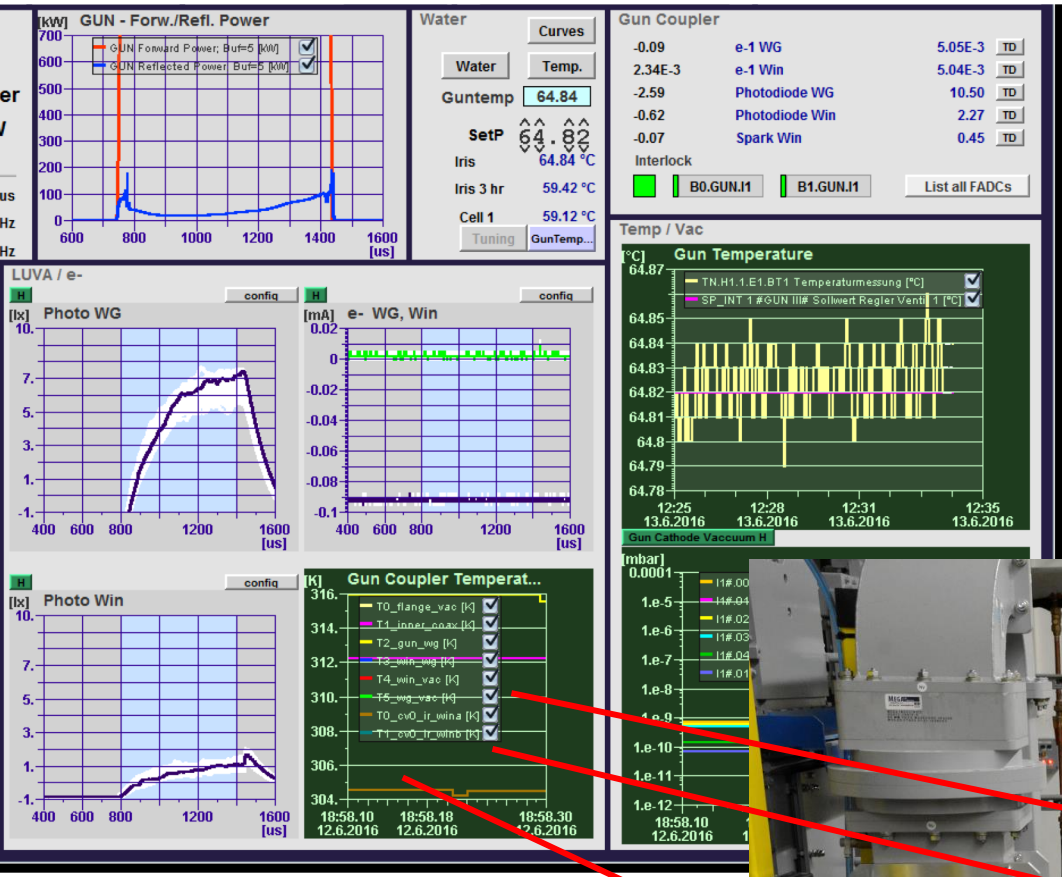


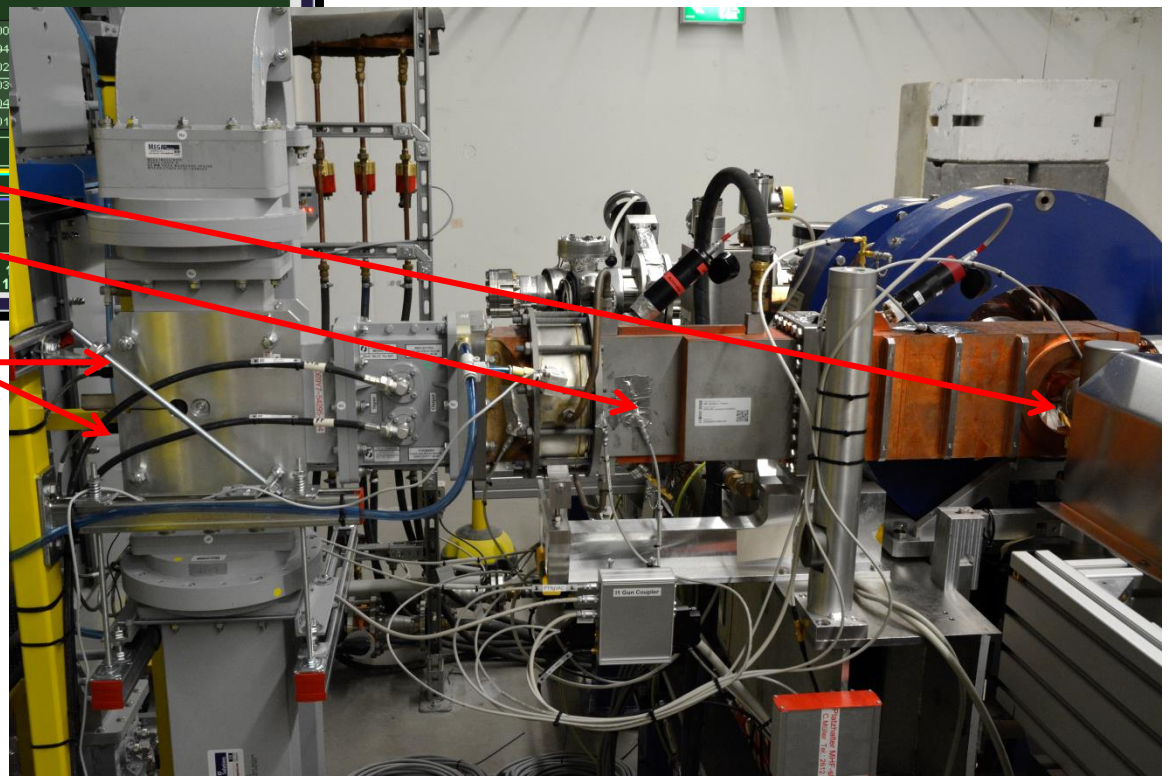


Gun signals and interlocks

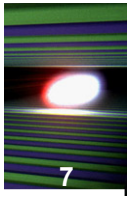


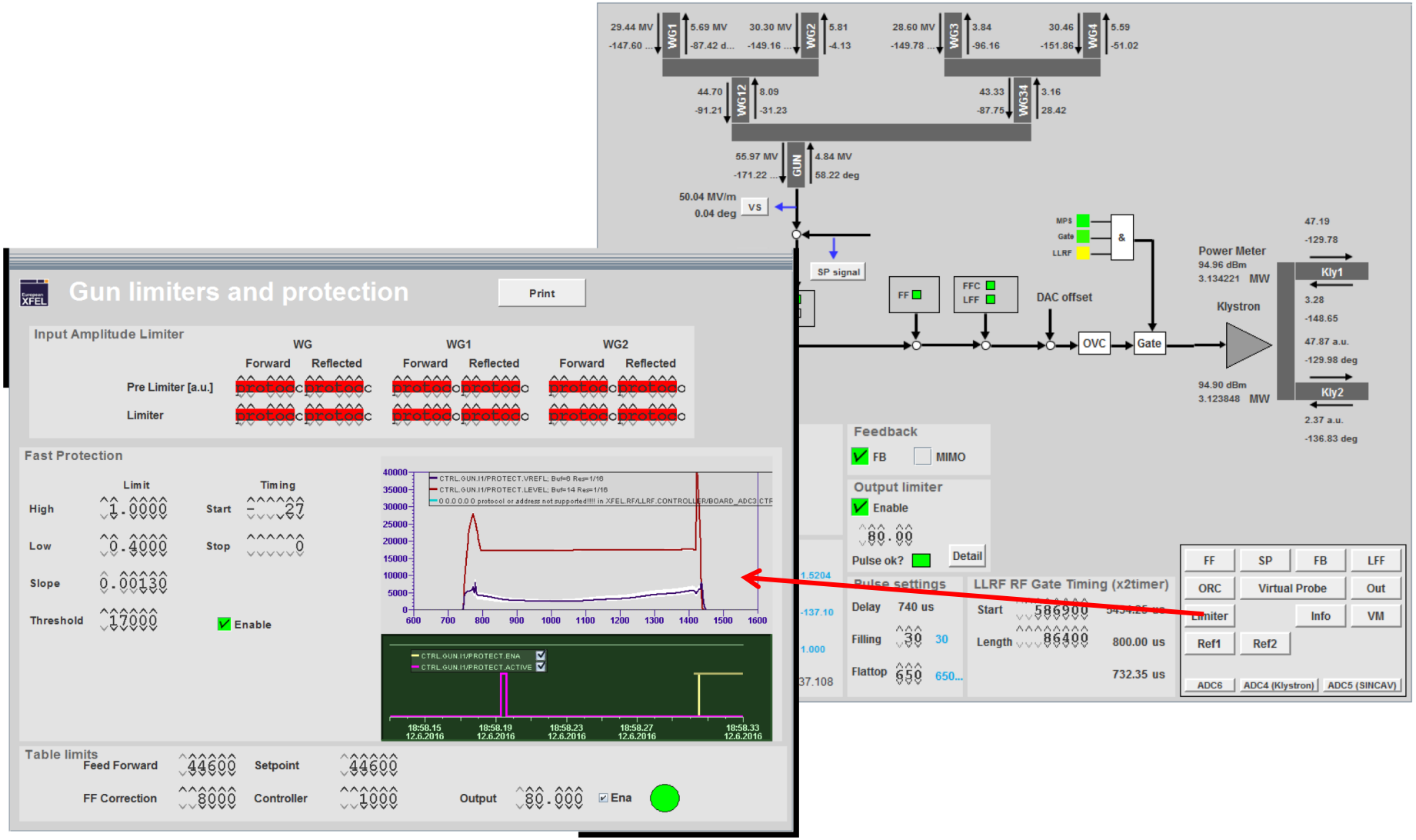
Temperatures



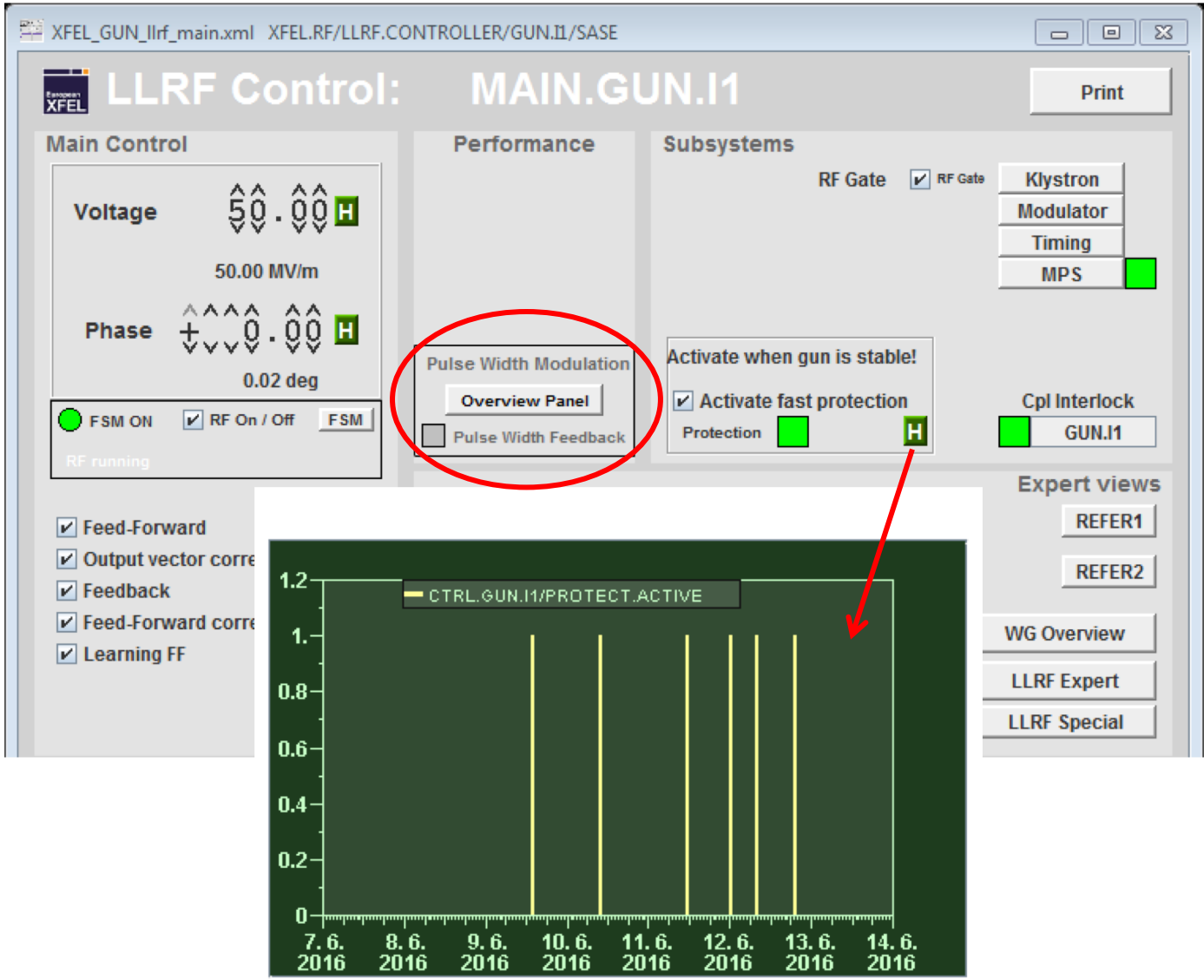


Limits of fast protection

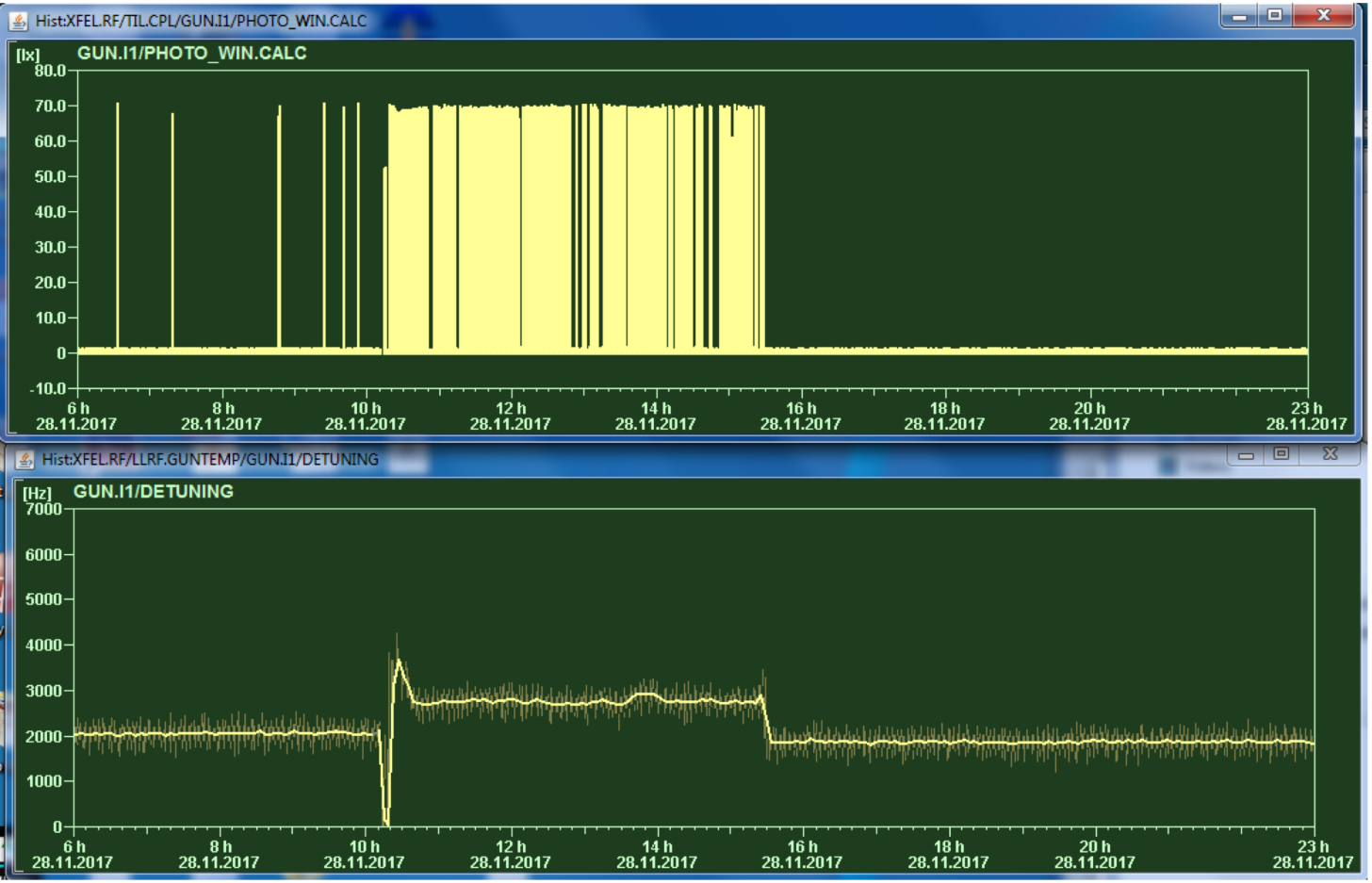




LLRF fast protection – looking at the reflected power



Strong temperature (detuning) dependance of light emission



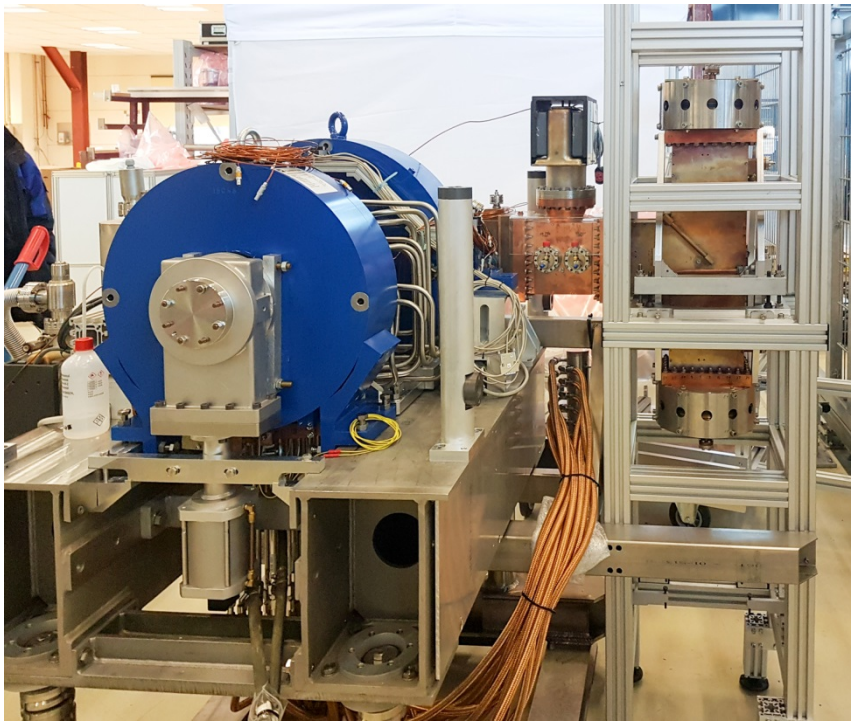
Below 2200 Hz

Much less activity.

200Hz = 0.01 ° C!

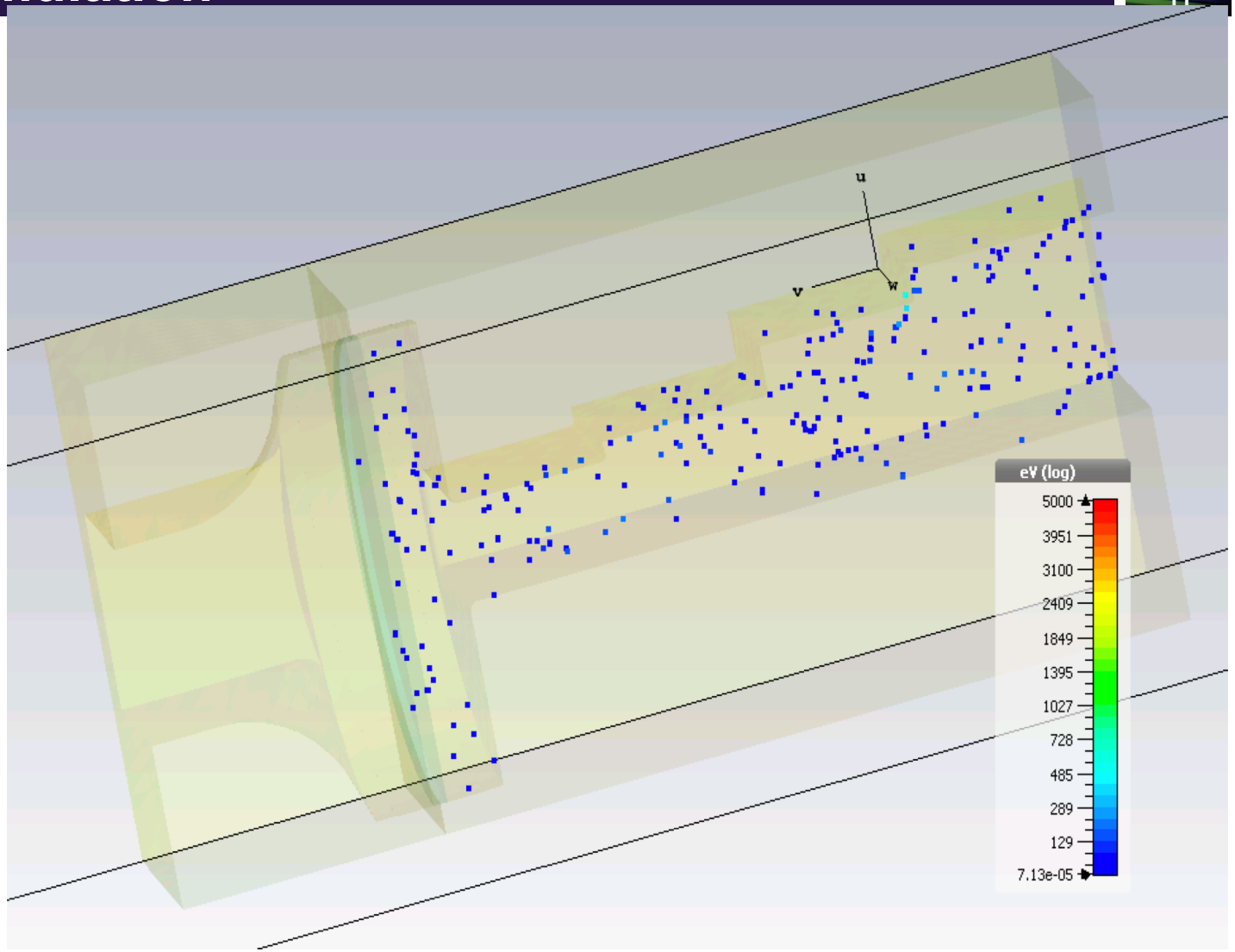
December 2017: Exchange of the gun

- December 2017 the gun has been 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
  - It turned out that the Thales window easily produced multi pactoring with rapid raise of vacuum pressure
  - Could not get rid of this also after longer conditioning



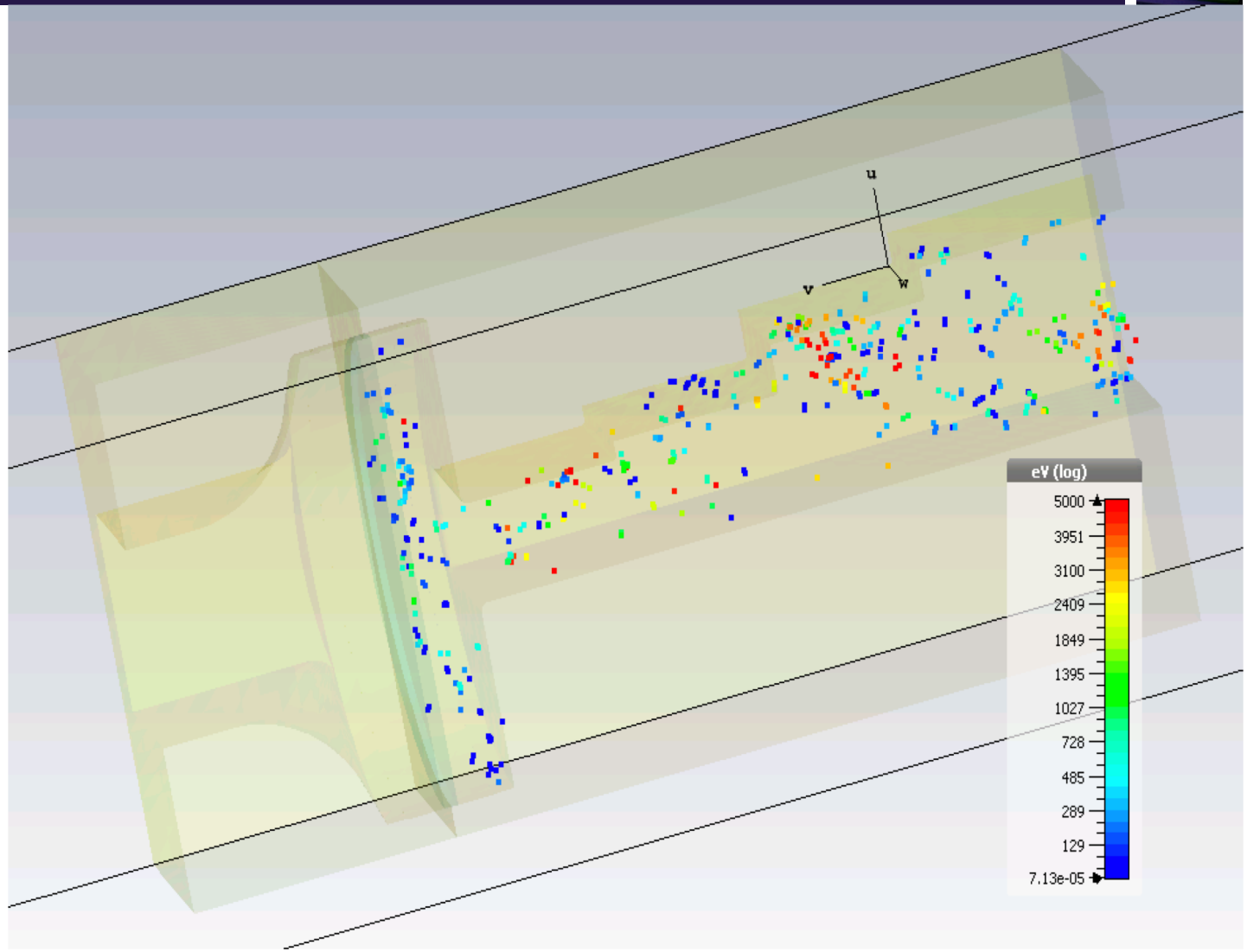
Run Simulation

- t = 0.05 ns
- n = 1,000
- The electrons are distributed pseudo randomly in space at the beginning



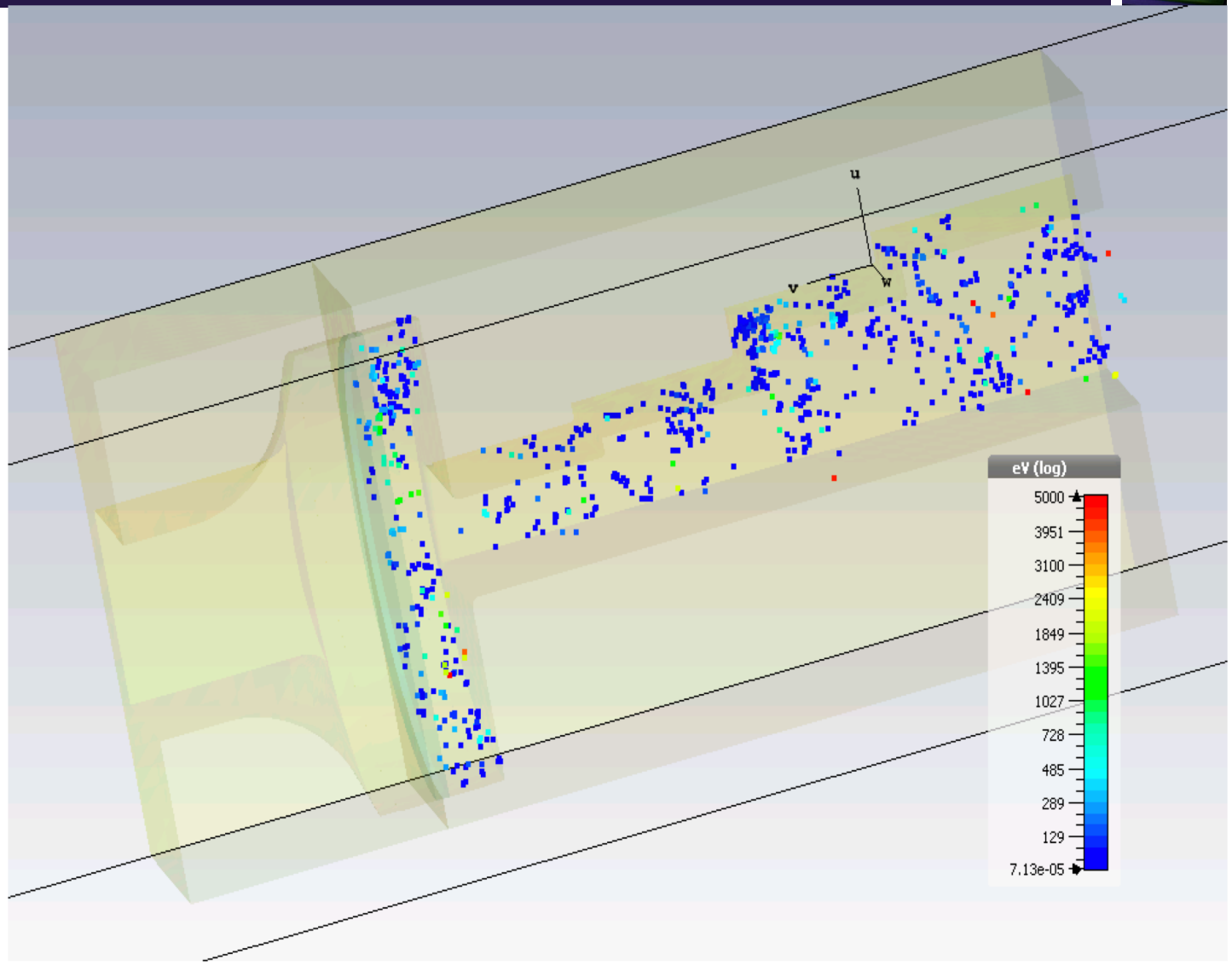
Run Simulation

- t = 2 ns
- n = 1,008
- Electric field accelerate the electrons
- Power = 6.98 MW



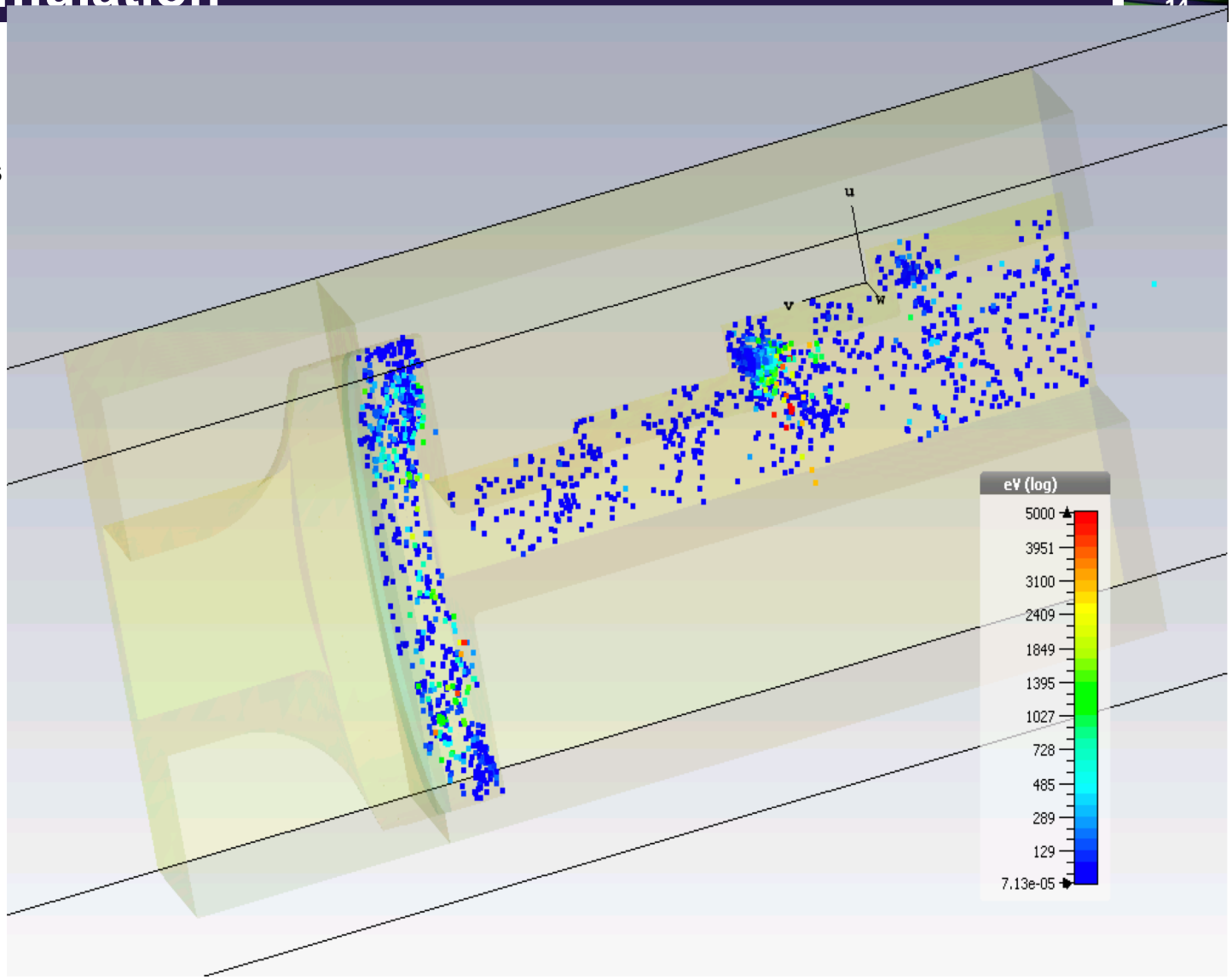
Run Simulation

- t = 10 ns
- n = 1,942
- Number of electrons doubles



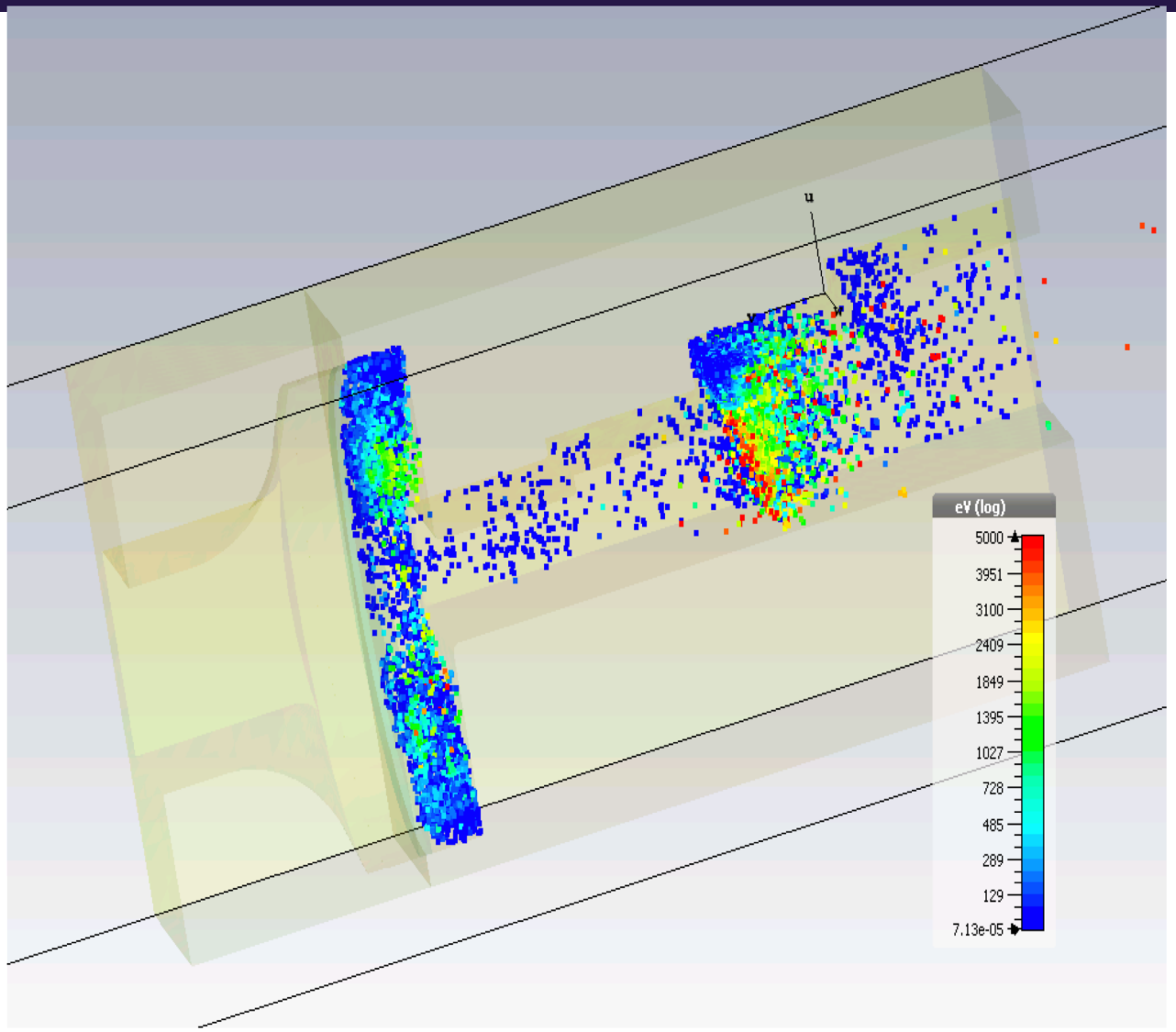
Run Simulation

- t = 20 ns
- n = 3,983
- Number of electrons doubles again



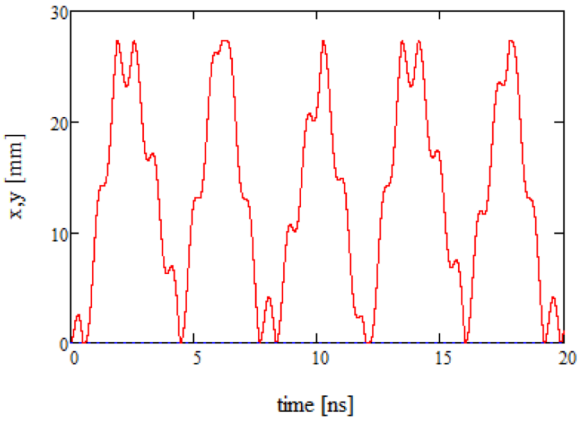
Run Simulation

- t = 40 ns
- n = 56,413
- Number of electrons increase faster
- Electrons are concentrate in some parts
- Important: were the electrons are concentrate depends on the applied power

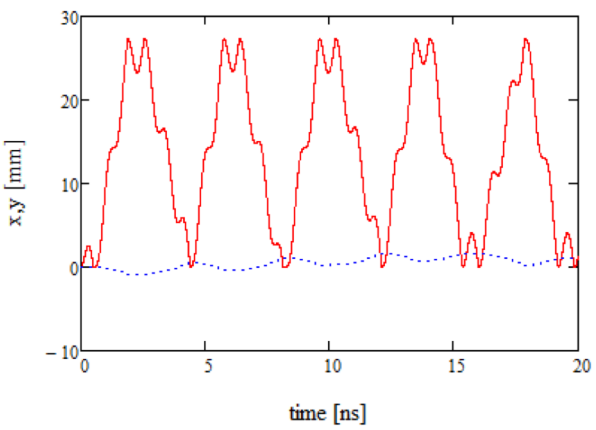


Qualitative calculation of multipacting between copper and ceramic with magnetic field

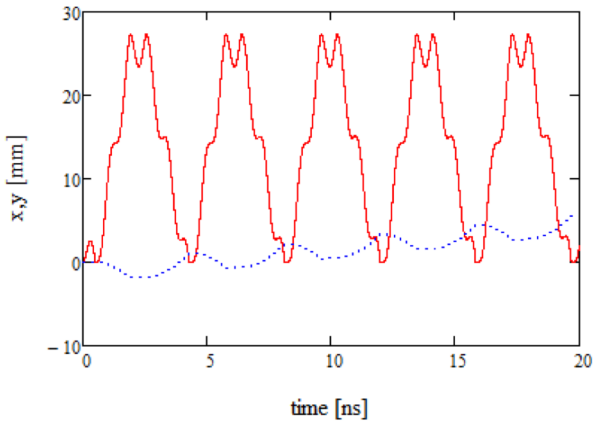
$E_0 \equiv 0.86 \frac{MV}{m}$ Bz = 0 mT

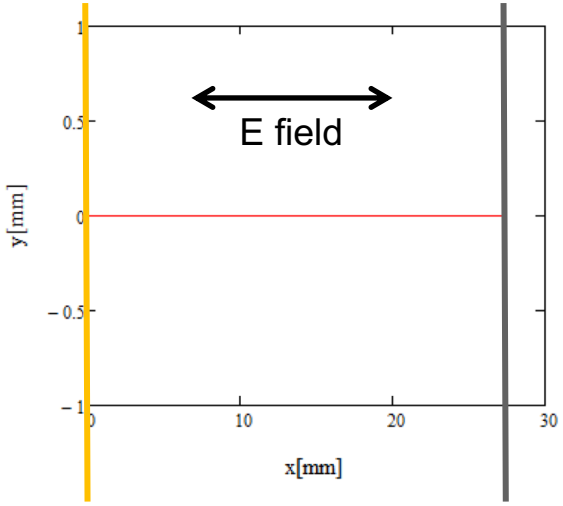


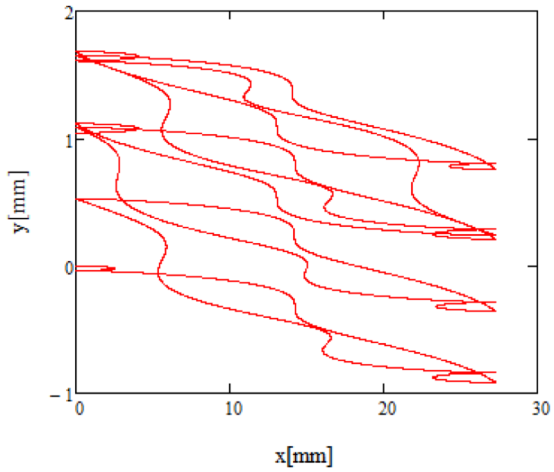
$E_0 \equiv 0.86 \frac{MV}{m}$ Bz = 0.3 mT

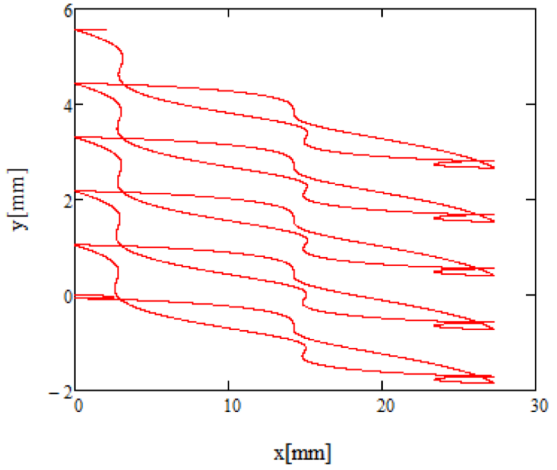


$E_0 \equiv 0.86 \frac{MV}{m}$ Bz = 0.6 mT



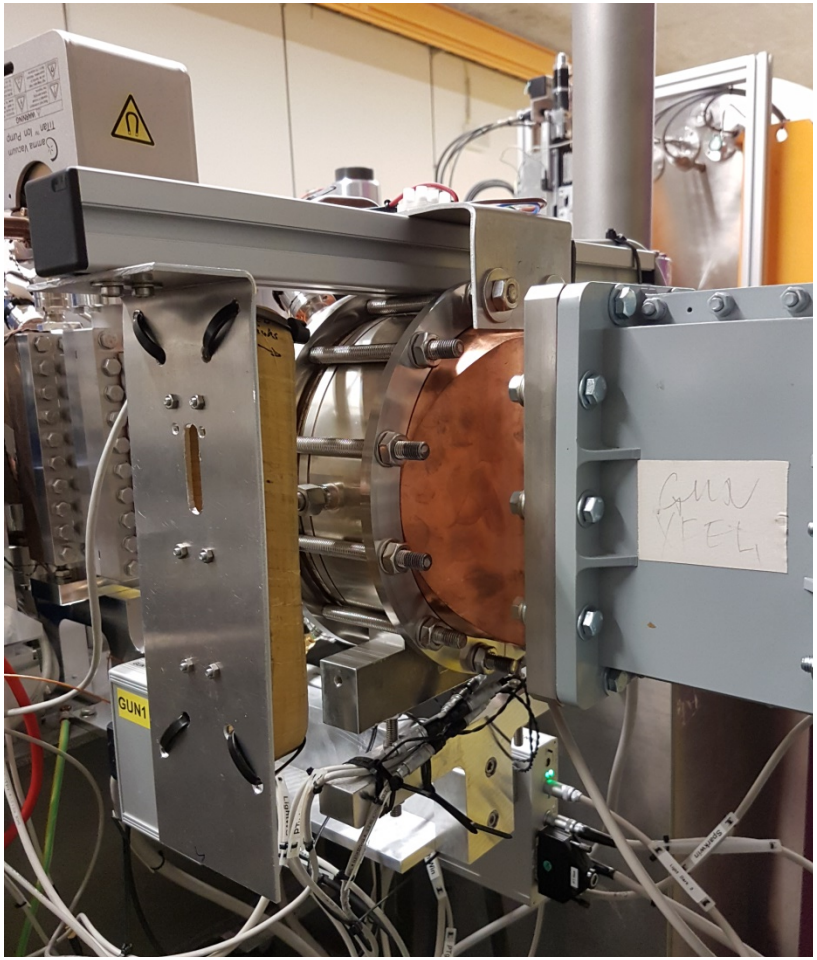


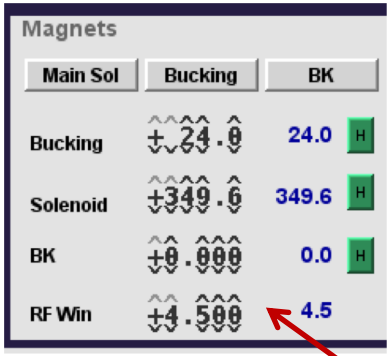




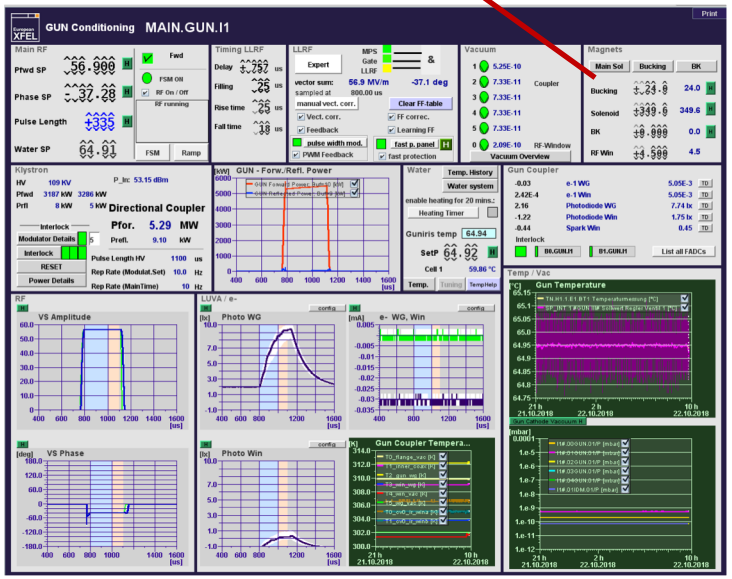
copper ceramic

Preliminary installation of air coils at the gun vacuum window – successful suppression of MP

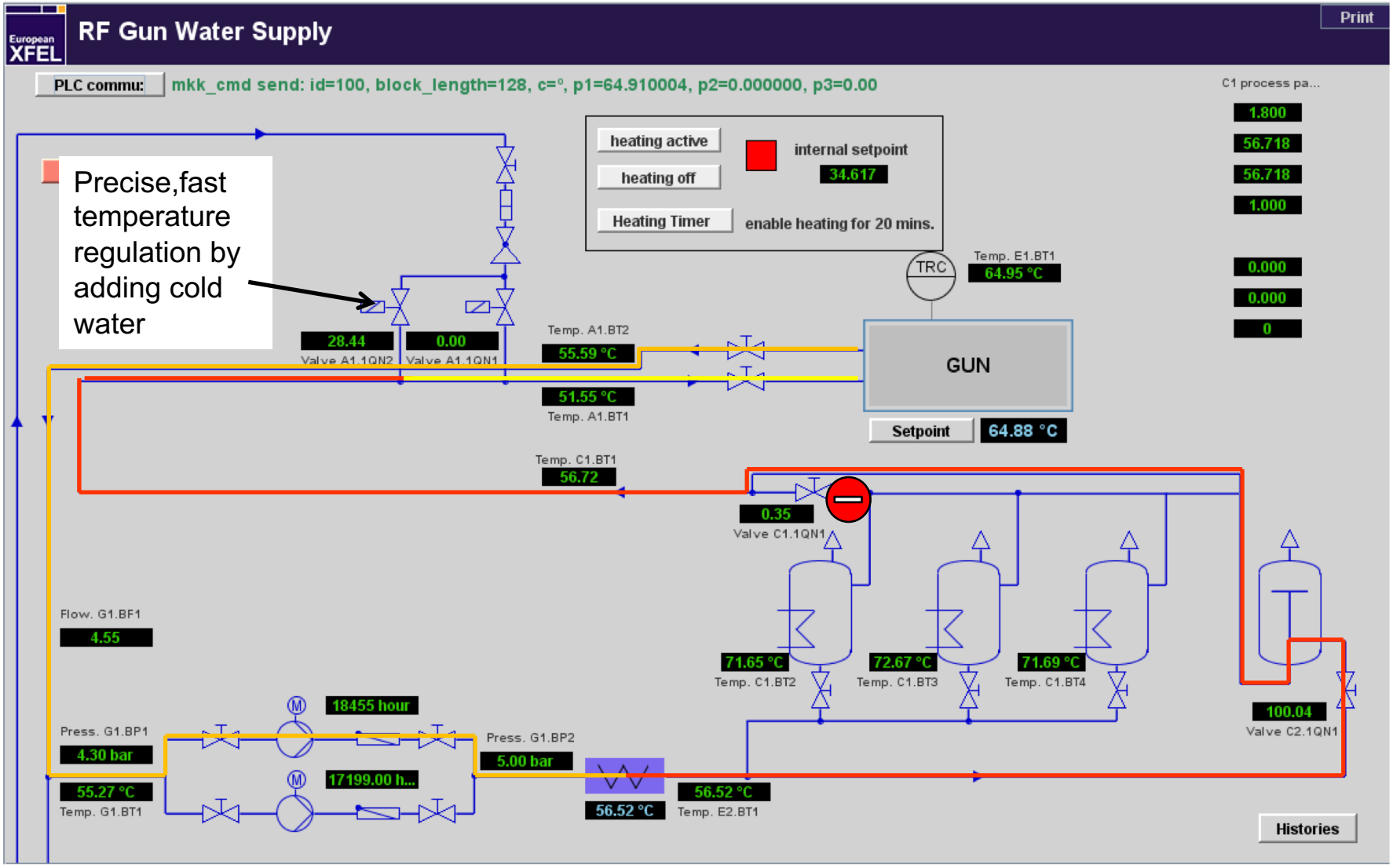




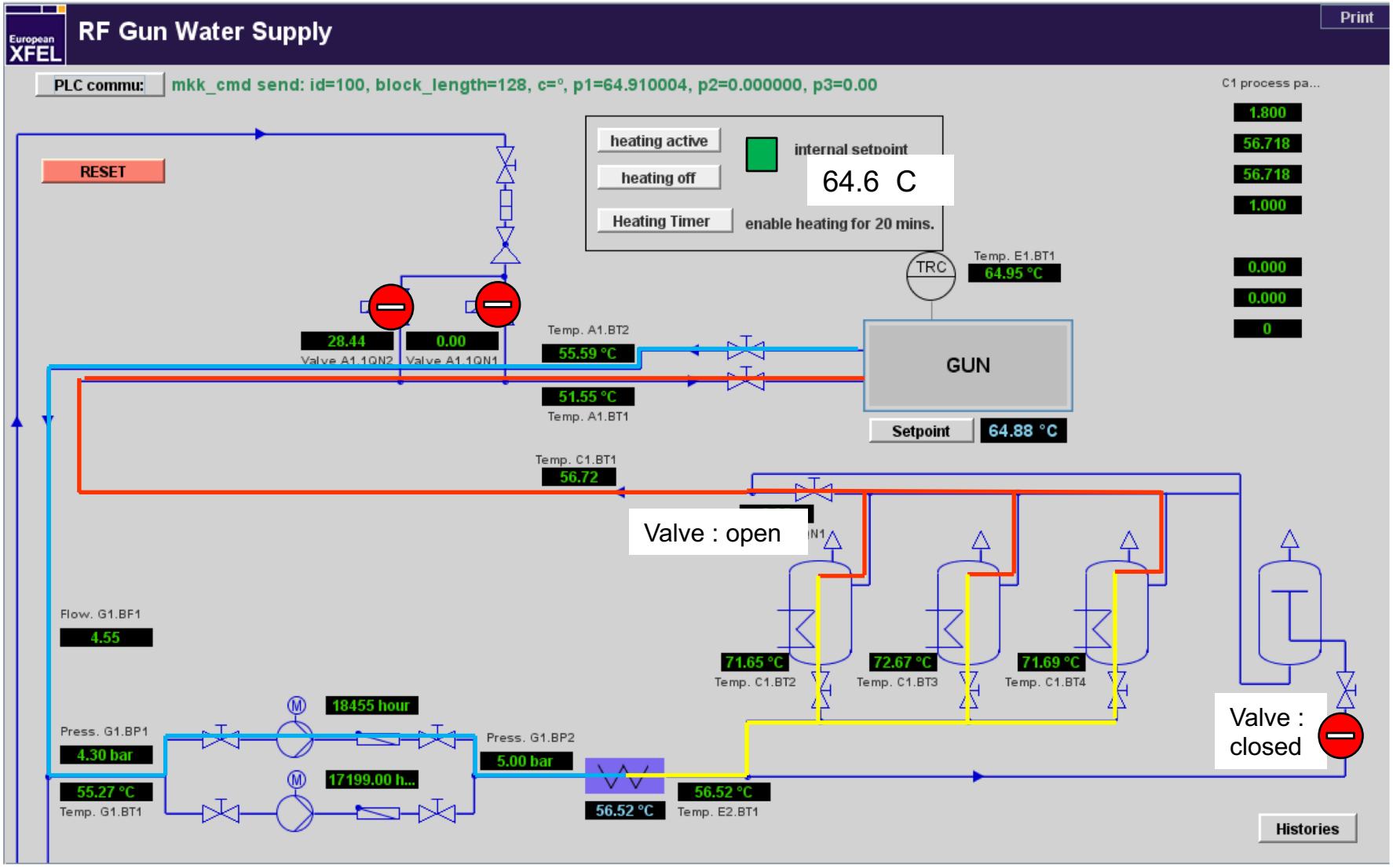
5A ~ 1mT



Water temperature regulation – gun operation

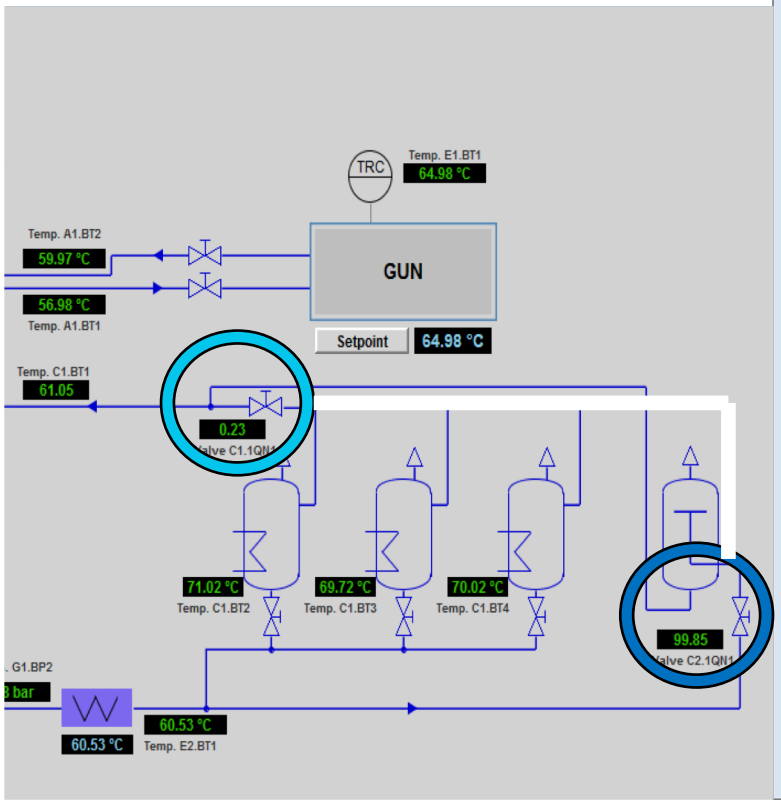


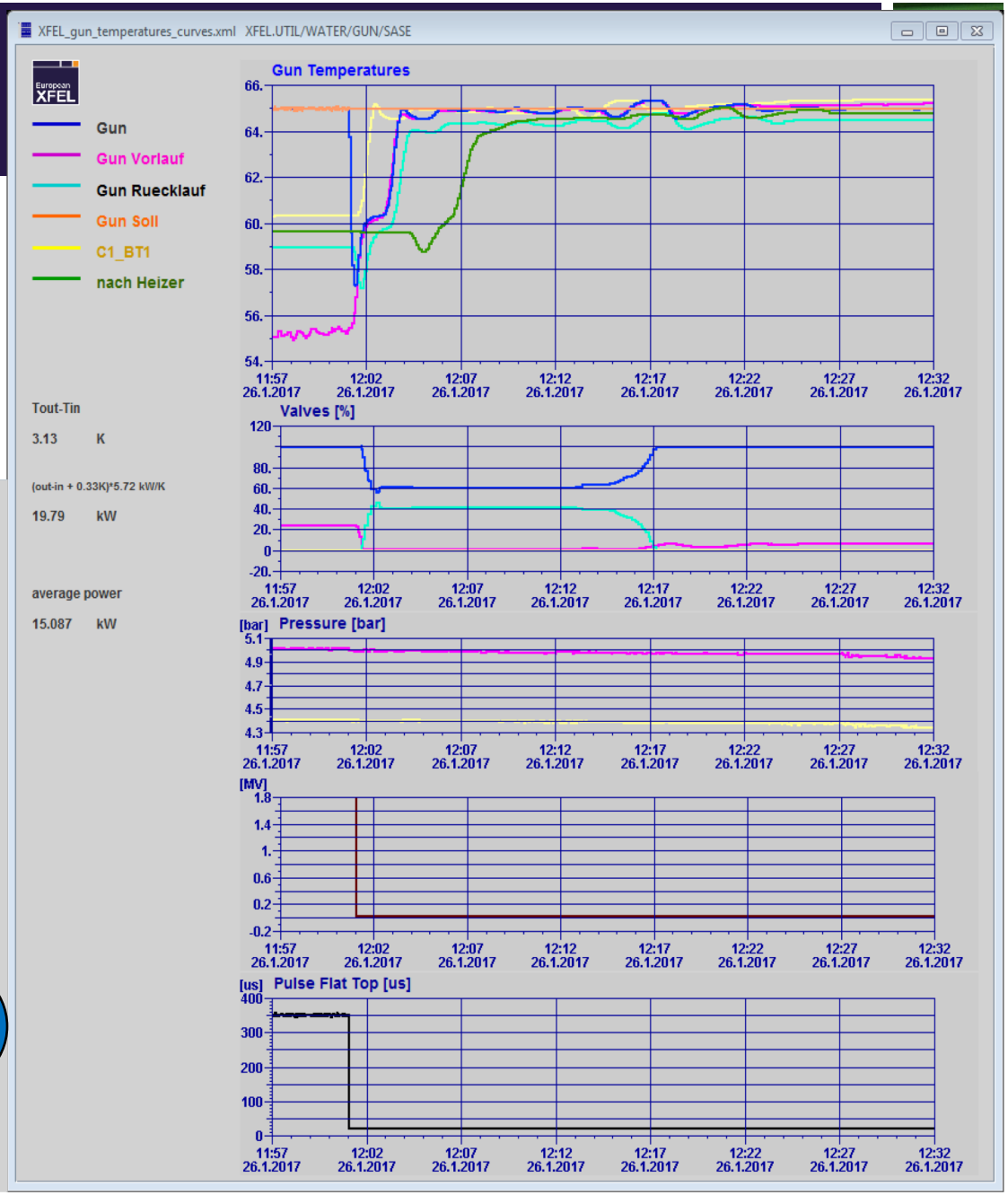
Water temperature regulation – heating up for some time



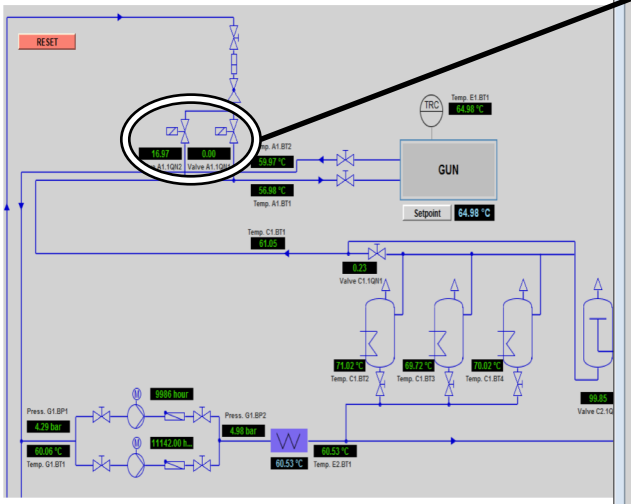
European XFEL

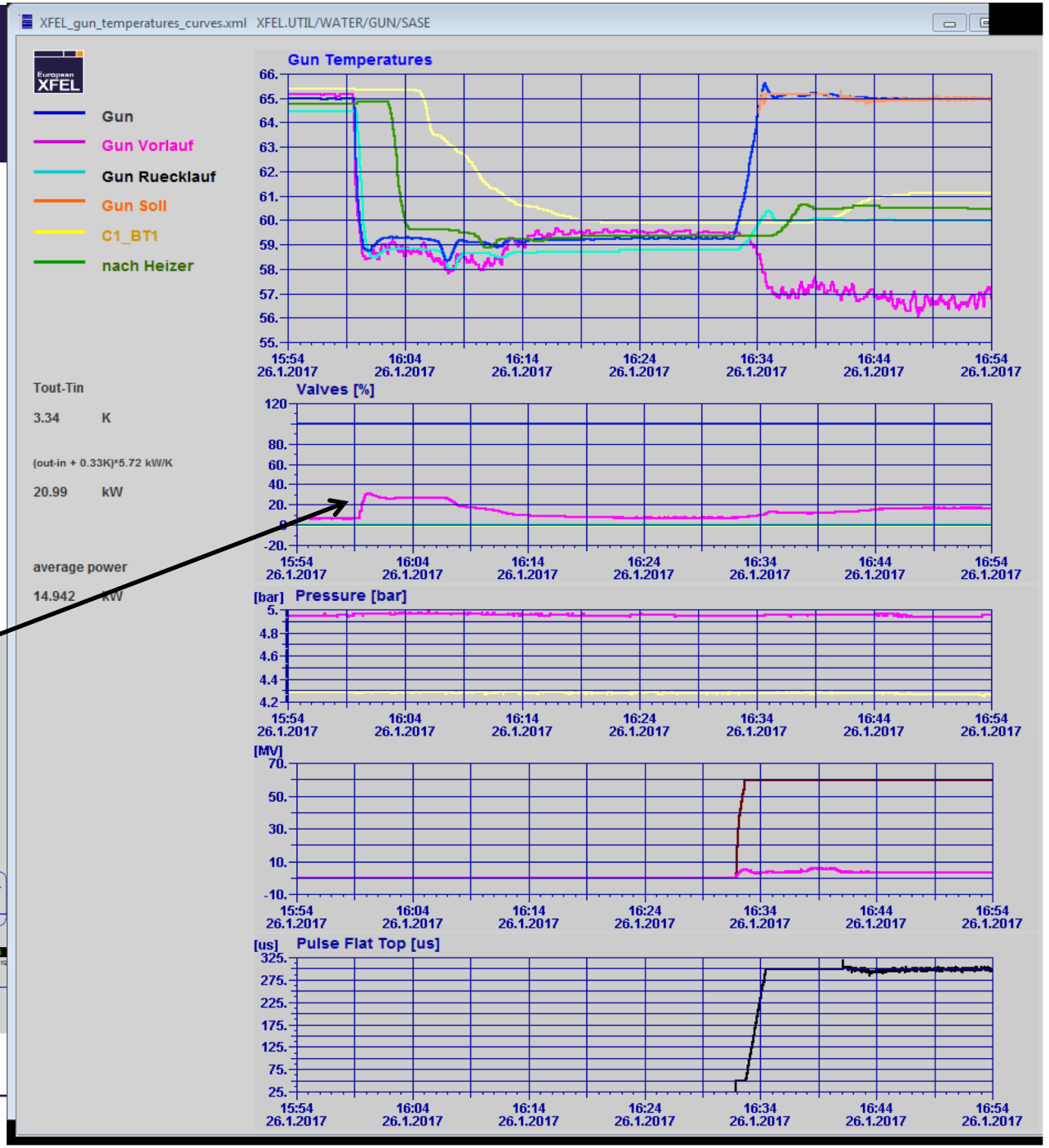
Heating up by adding hot water from the tanks





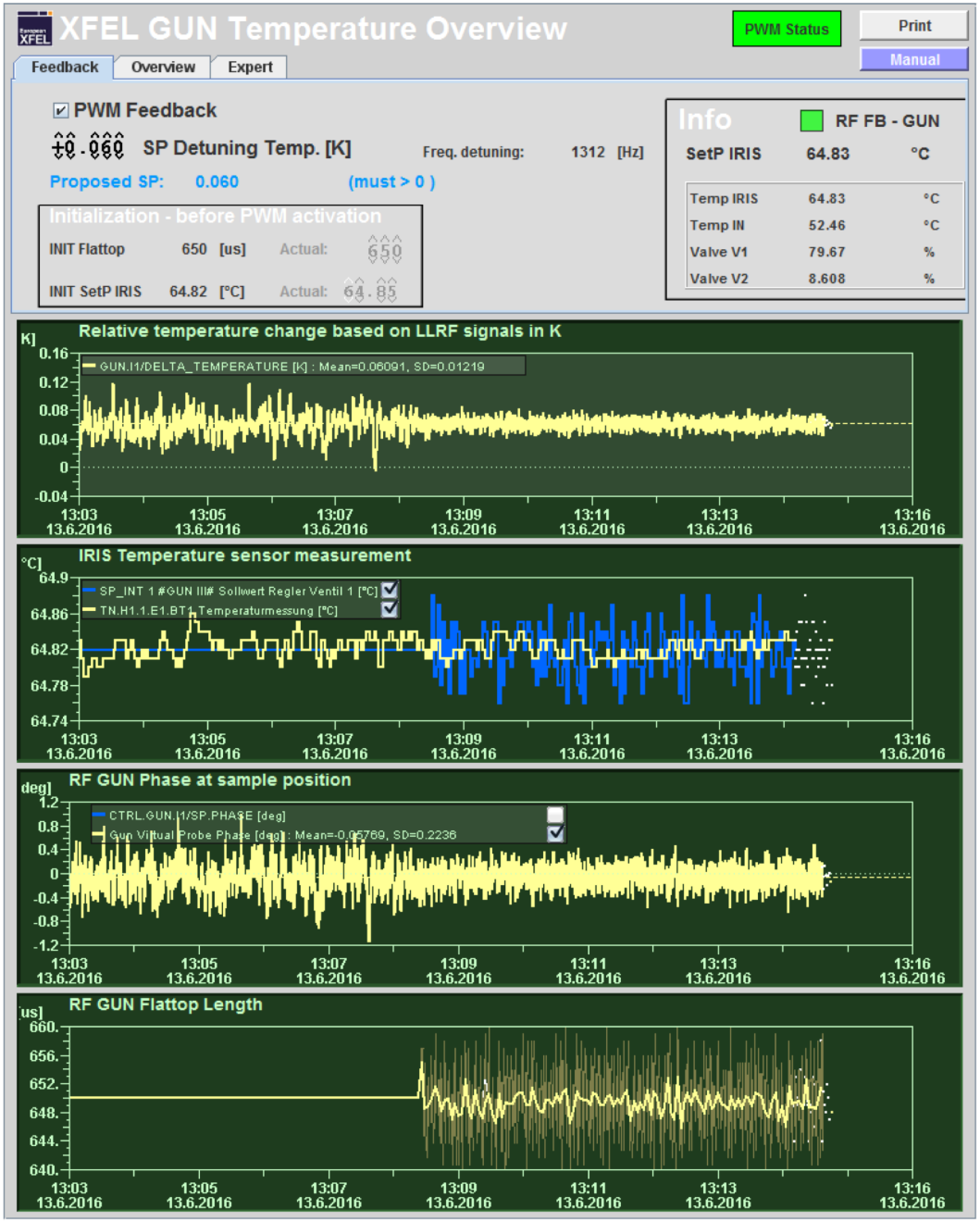
Cooling down with cold water





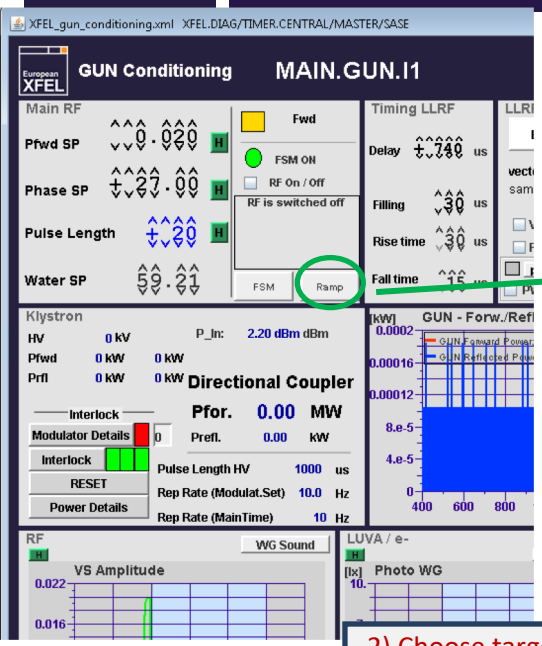
Pulse width modulation

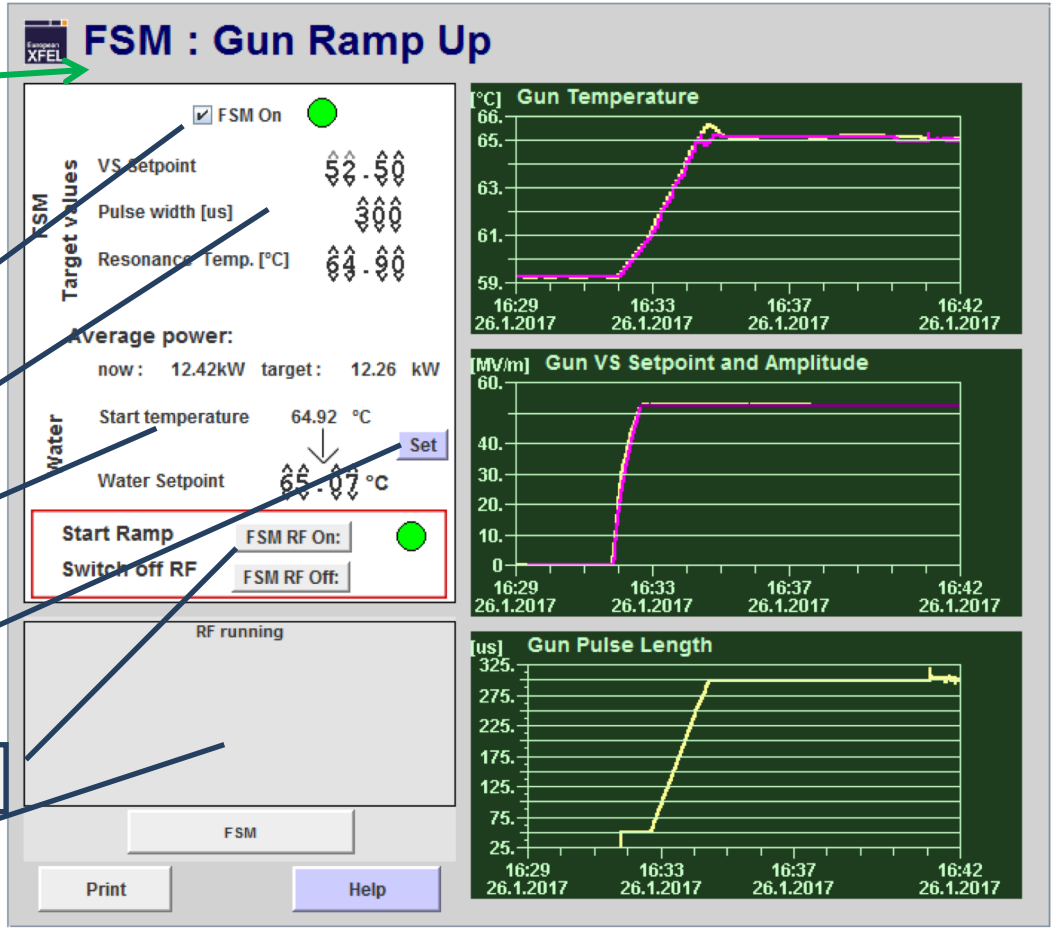
- Fast measurement of gun temperature/detuning (0.1sec vs. 7 sec)
- compensate temperature deviations with the RF pulse width
- Compensate for cooling water drifts after ramp



Fast Gun Ramp Up – by FSM

Typically the parameters are taken from the last run!





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

Only for new parameters!

Fast Gun Ramp Up – by FSM

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. The pulse width modulation is started to compensate for temperature drifts
5. When Set points for amplitude and phase are close to the measured values the feedback and learning feed forward are started. From now on the gun parameters can be changed by hand as usual
6. “RF off “ switches the gun off – the temperature setpoint follows the actual temperature, therefore we end up already with the correct starting point to come back with the same parameters