

ACCELERATOR R&D WORKSHOP DRESDEN

March 14/15 2013

1.6 mA upgrade –
thermal (and other) problems
during high current cw operation

Rico Schurig
schurig@hzdr.de

electron beam / RF power:

- so far max. 30 MeV / 800 μ A CW
 - 24 kW e- / 6 kW RF per cavity (w/o losses)
- now max. 30 MeV / 1600 μ A CW
 - 48 kW e- / 12 kW RF
- later 40 MeV / 1600 μ A CW
 - 64 kW e- / 16 kW RF

expected/observed problems:

- allowable warm waveguide window temperature
 - breaking warm window is a major threat to the machine, will stop operation for many days or weeks
- warm window arcs - fieldstrength/vacuum related
 - window arcs are annoying, but can “pollute“ the window surface
 - > must break isolation vacuum to change window
- cold window-, fundamental coupler-, HOM coupler temperatures, will coupling change?
 - if fundamental coupling changes, the in loop phase will jump

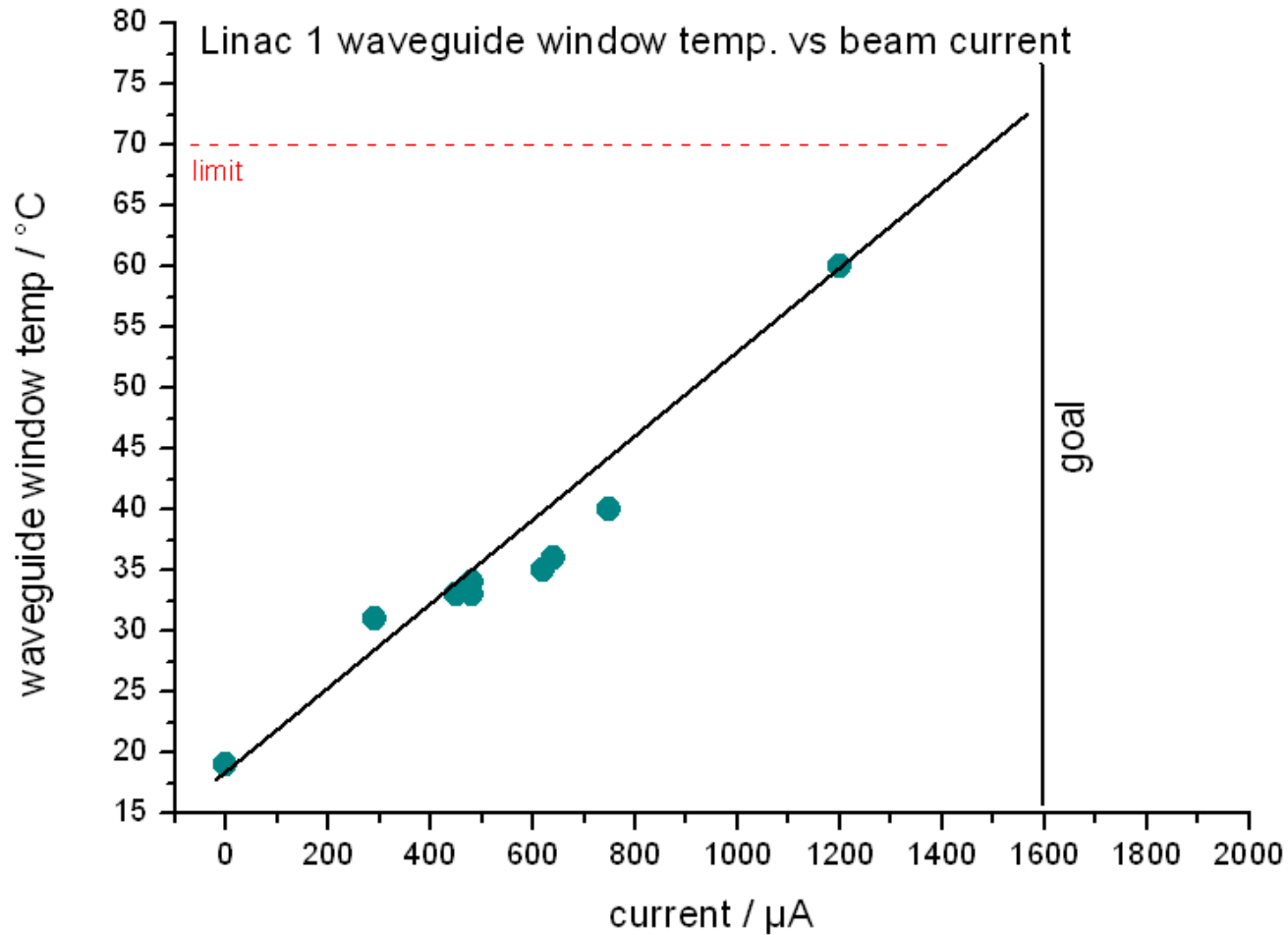
expected/observed problems, continued:

- beam “quality“, long/transv. emittance rises with beam current
 - increase in beam loss, beam line heating, vacuum trips, activation
- will the Beryllium dump windows take the higher power?
 - if they break, takes some days to change them, they are inside the dump shielding, radiation
 - they are expensive

warm waveguide windows

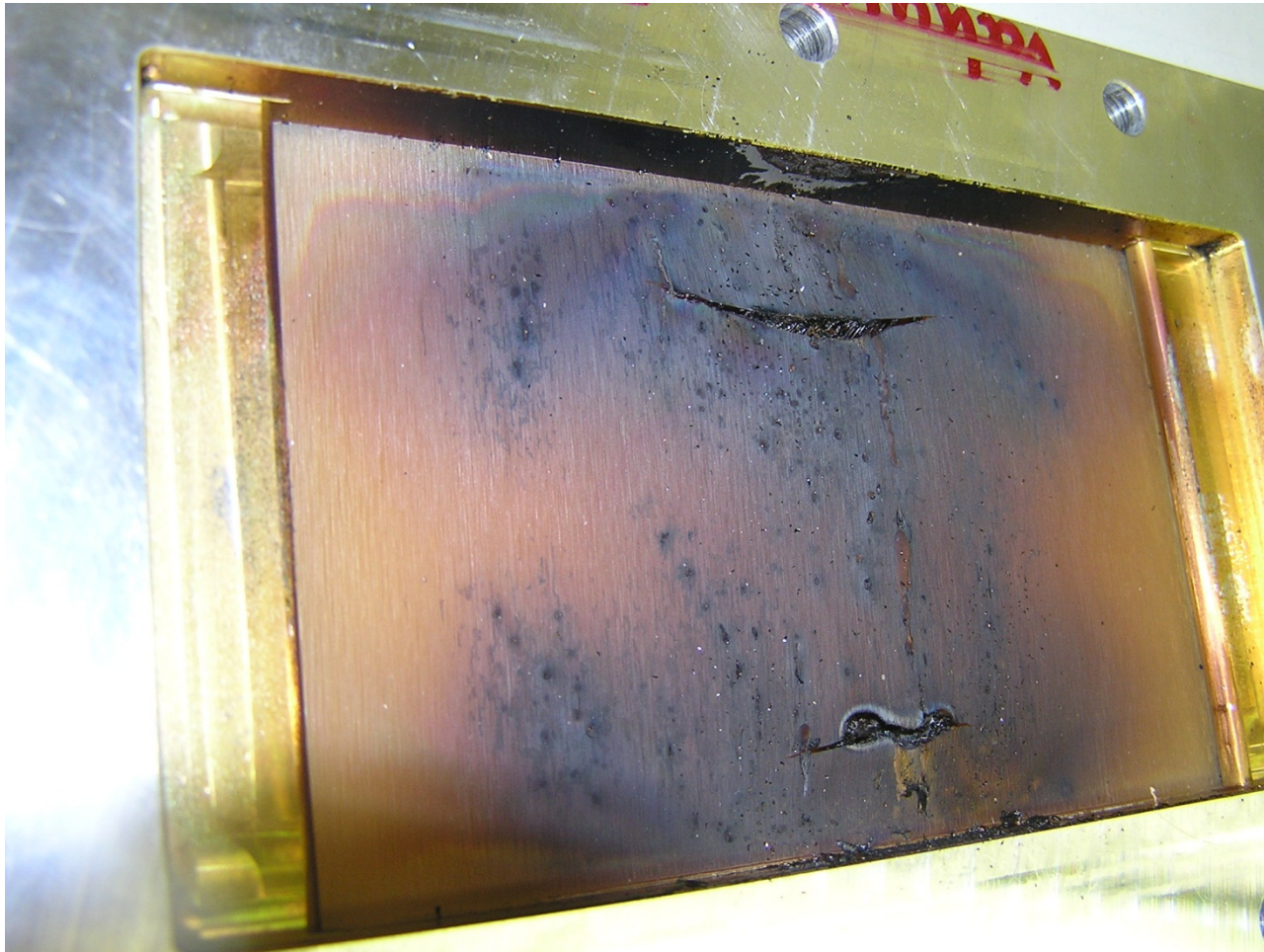
- windows made from Rexolite
 - cross linked Polystyrene
 - tensile strength: 62 Mpa
 - thermal conductivity 1.2 W/m x K
 - diss. factor: 0.0002 @ 1 GHz (4 W @ 20 kW)
 - is operation at 70, 80, 100 °C safe?
- positioned at minimum field at resonance
 - should be maximum field when cavities detuned
 - more light (field) when playing with 3stub tuners ?
- all windows were trained up to 18 kW detuned
 - training effect drops after days..

warm waveguide window – what temperatures do we reach?

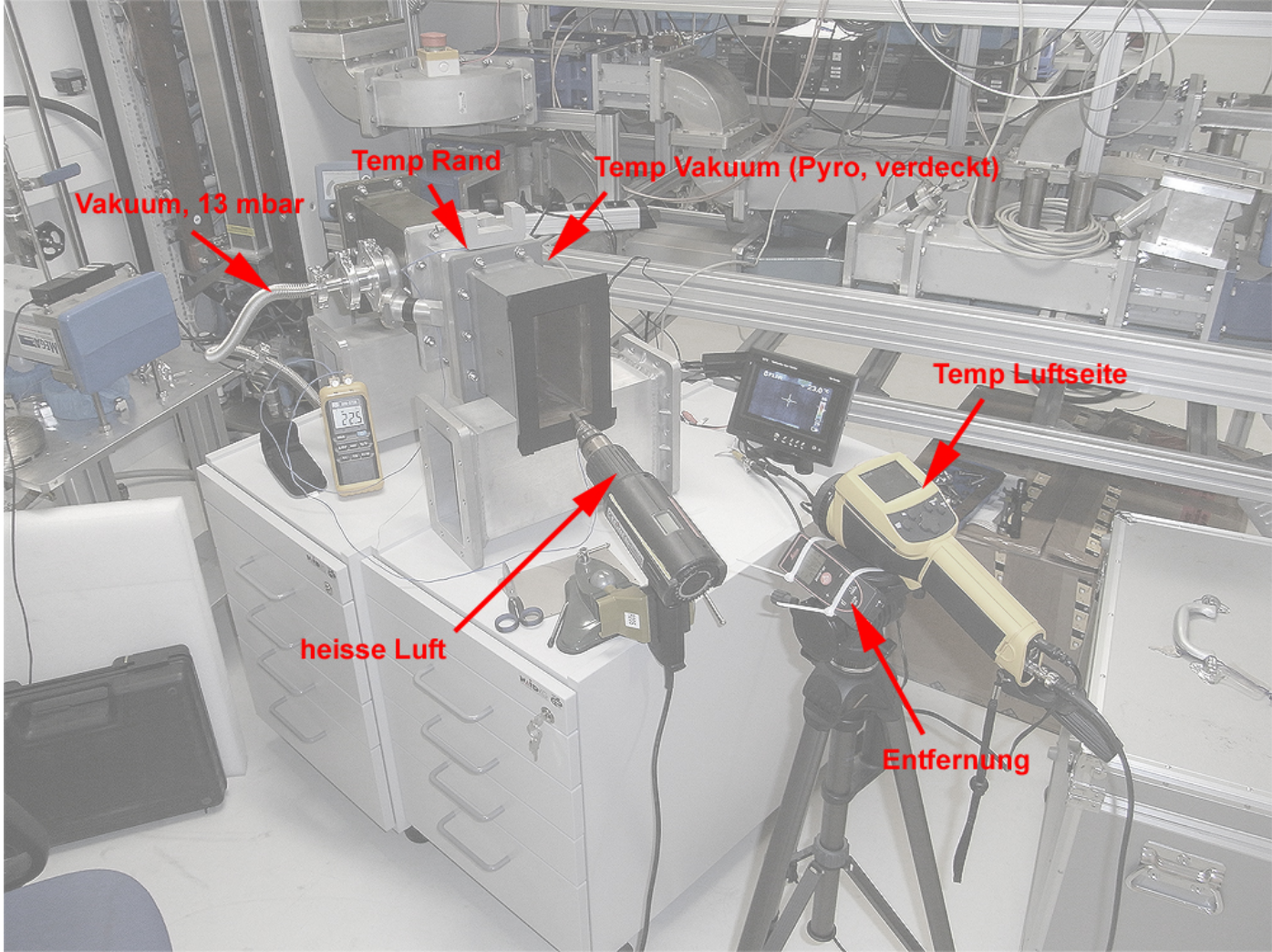




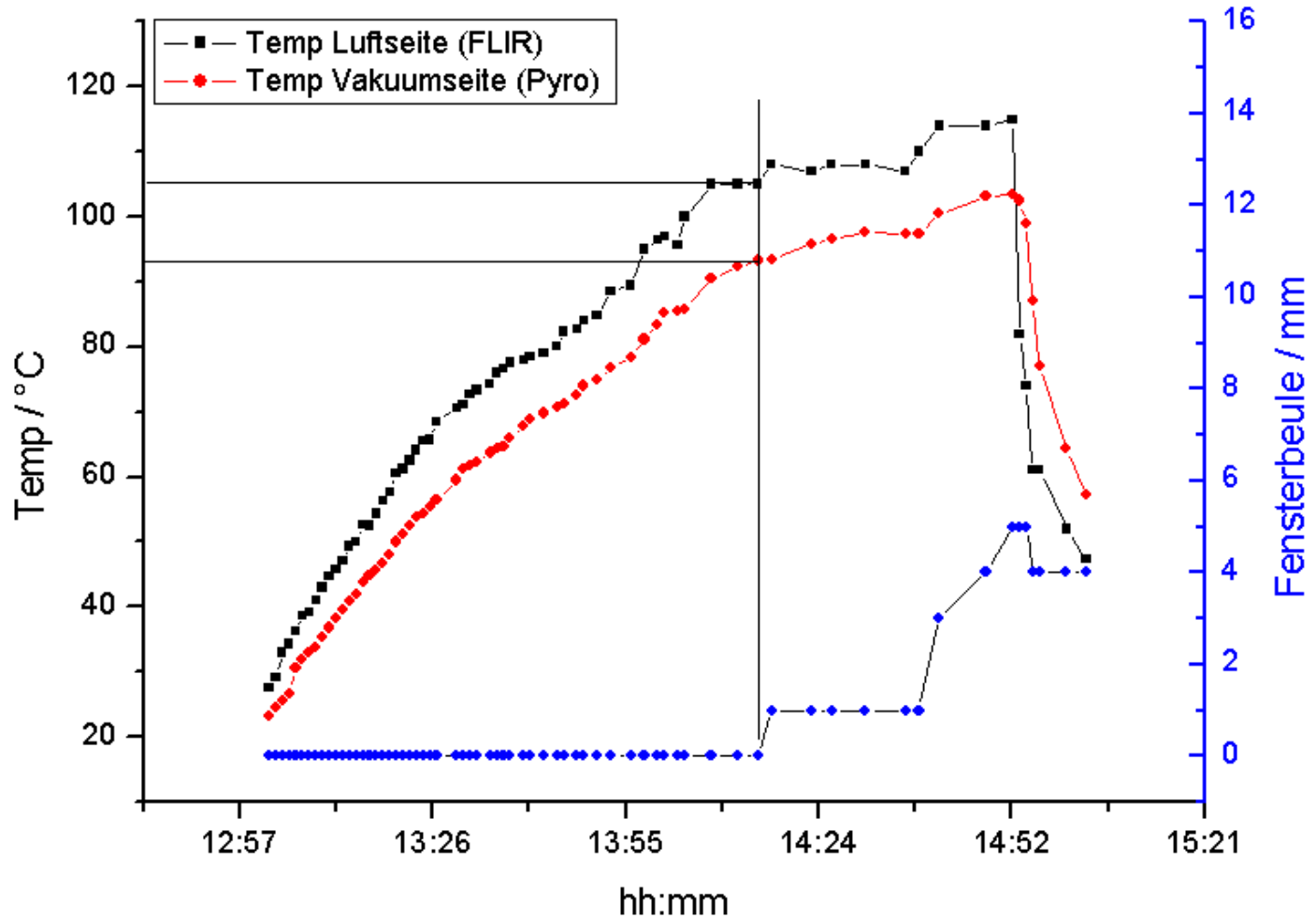
warm waveguide window – what temperatures are safe?



warm waveguide window – what Temp is safe?

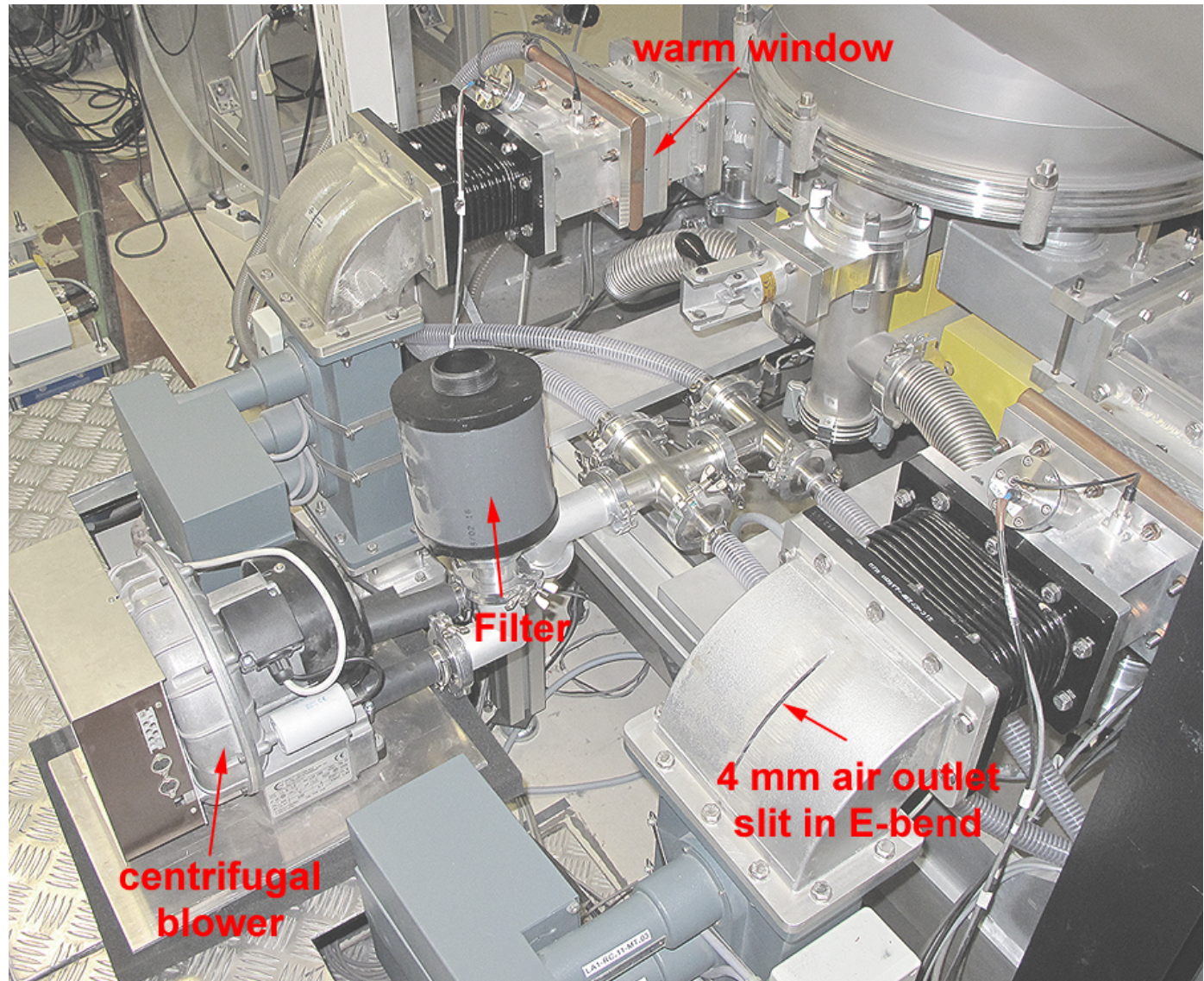


warm waveguide window – above 90 °C window is bending

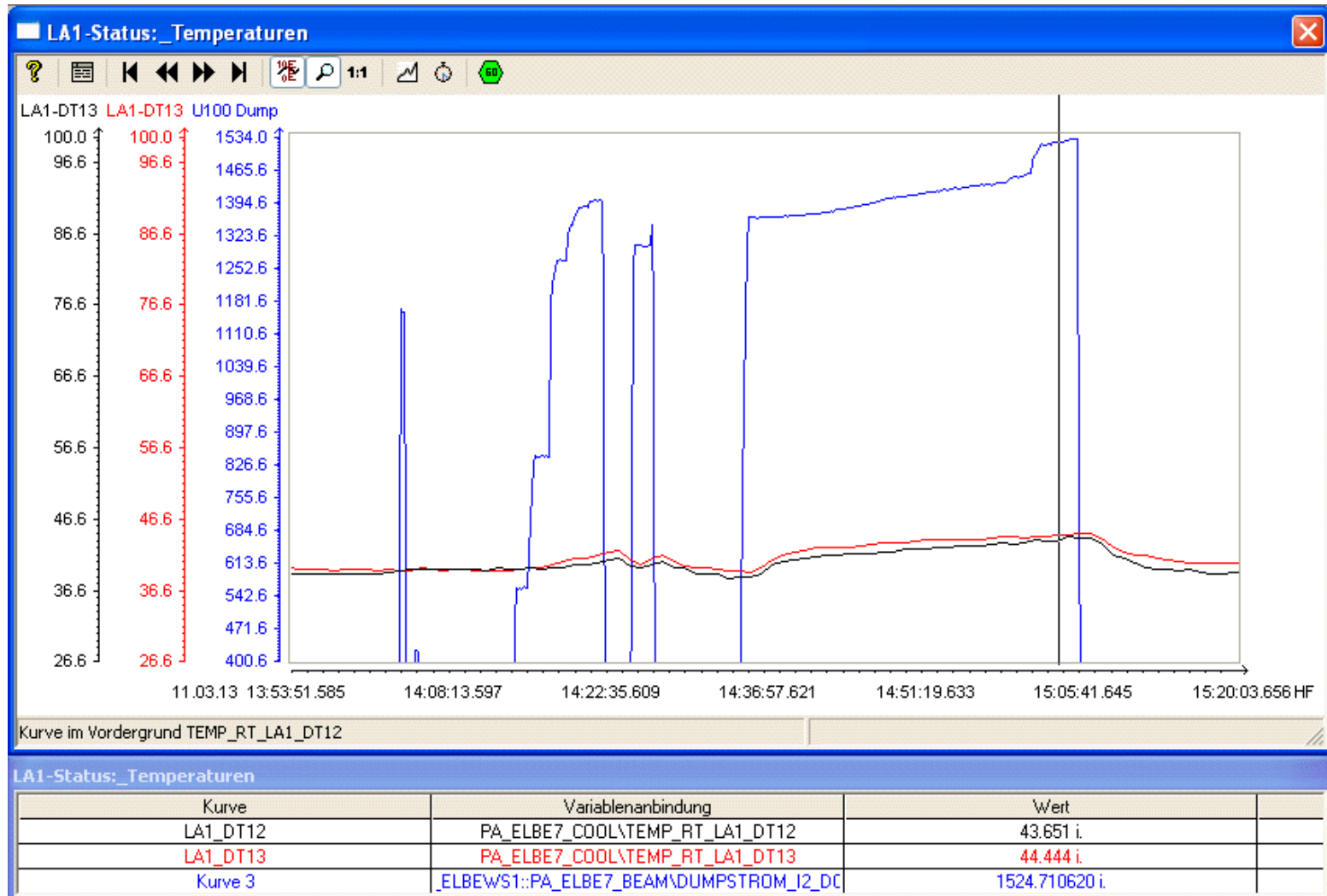


Cooling at LA1:

- filter is important
- 150 l per min flow
- slits in E bends



warm waveguide window – with cooling no problem any more



warm waveguide windows arcing

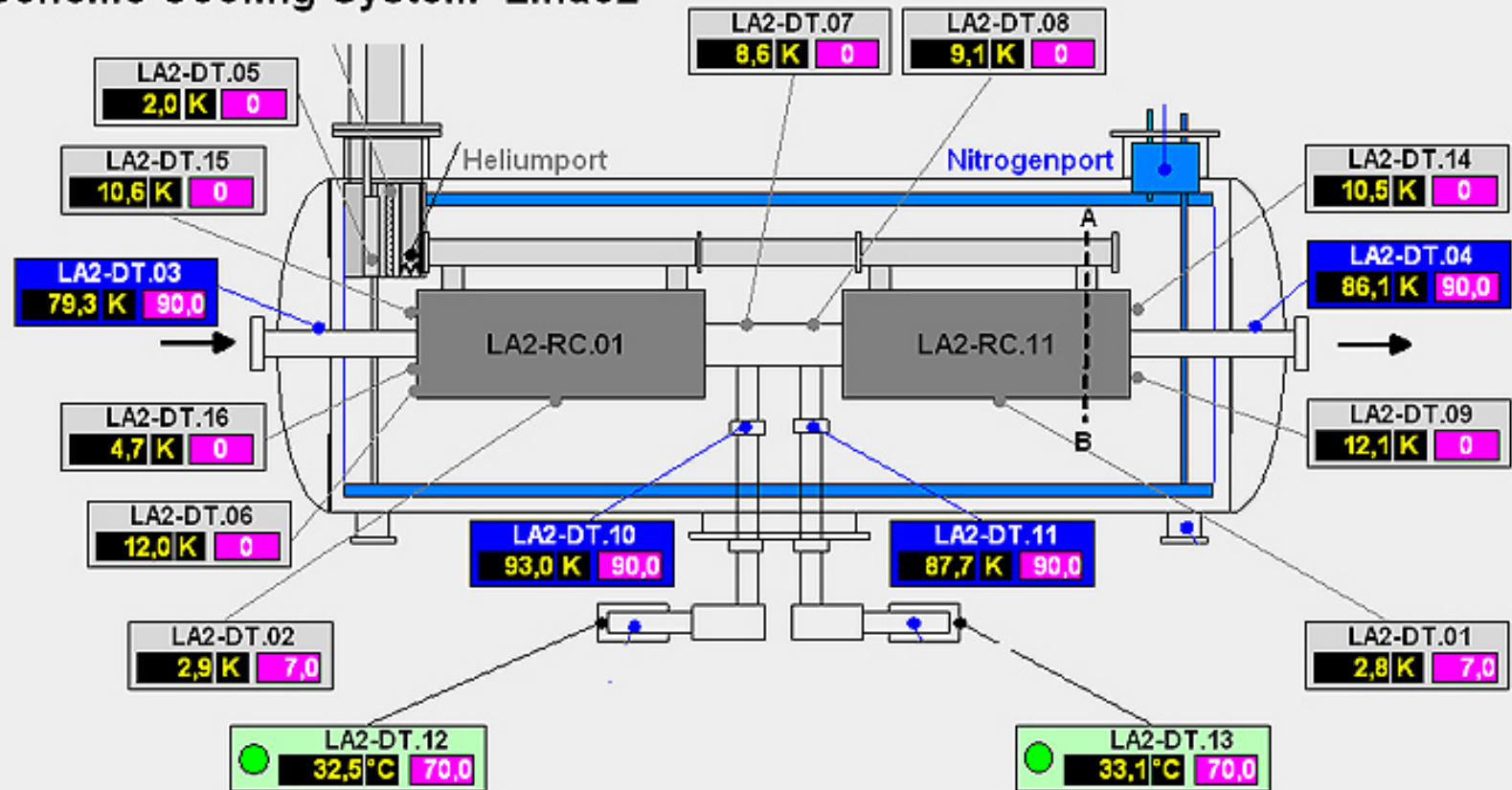
- arcs / light is measured with pyro detectors (caution: they are also sensitive to beam loss)
- above certain light threshold, LLRF controller switches off within ms
- arcing is a coming and going problem, not really understood
- linac1 has additional vacuum pump since summer 2012
- vacuum increased from $2\text{E-}6$ to $7\text{E-}7$, probably not enough?

warm waveguide windows arcing

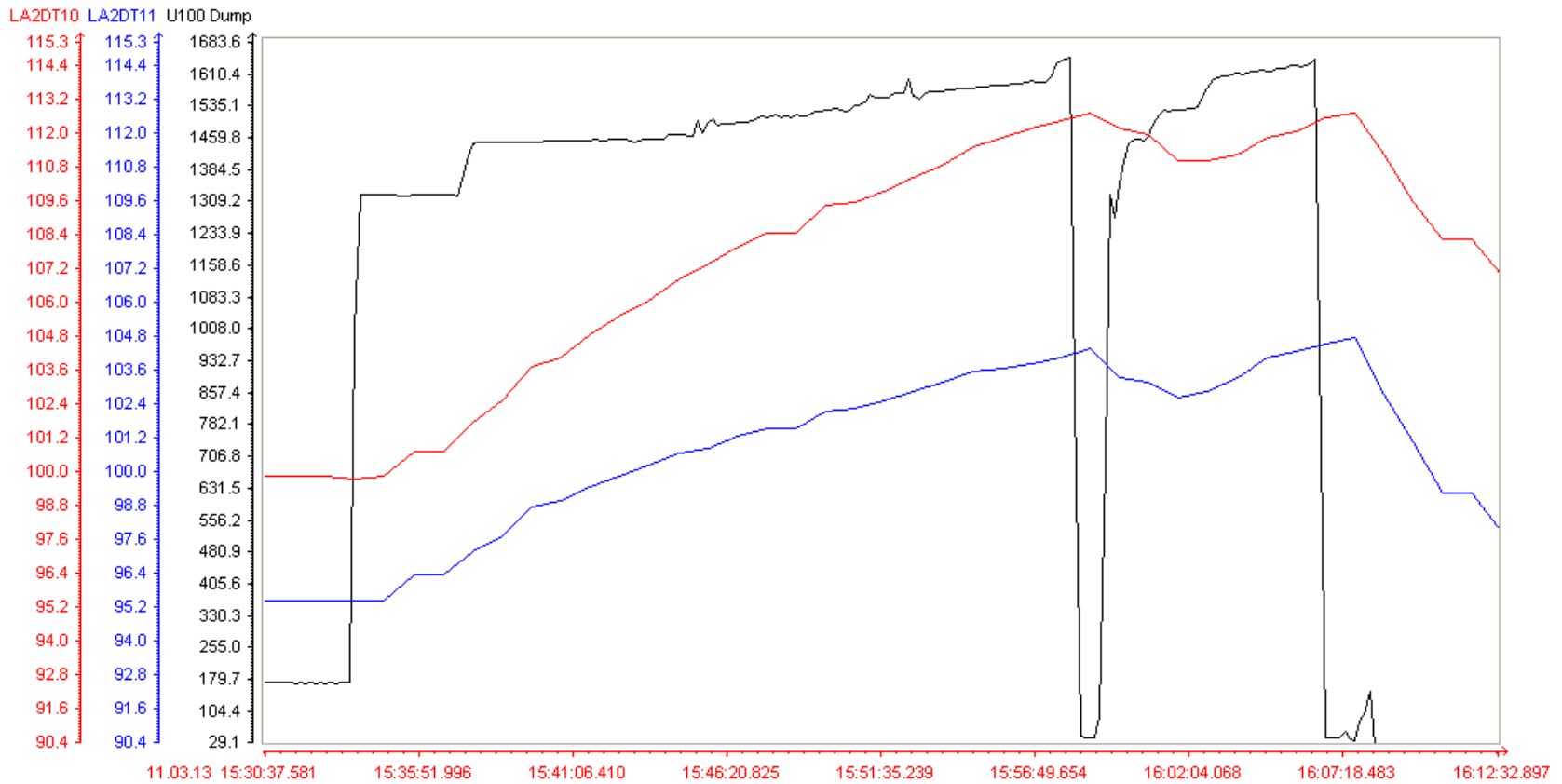
- windows training procedure:
 - switch rf to pulsed mode
 - detune cavity several 100 Hz
 - until all power reflected
 - move the rf phase at the window with 3stub tuner
 - increase rf power
 - wait and see
- all windows were trained up to 18 kW in Oct. 2012
- last week two cavities would not go above 12 kW
- very time consuming procedure

cold coax windows, HOM coupler temperatures

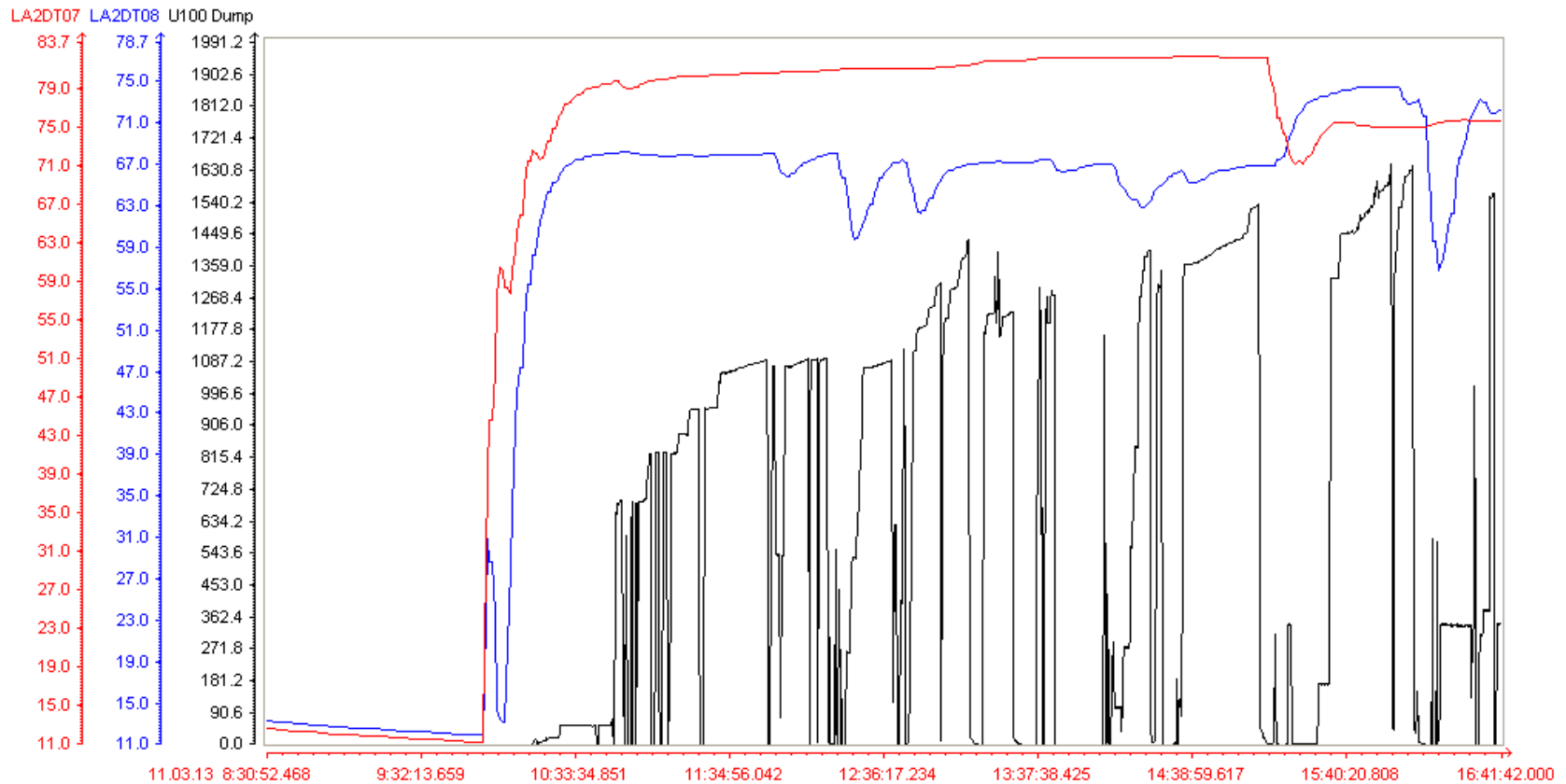
Scheme Cooling System Linac2



cold coax window temperatures



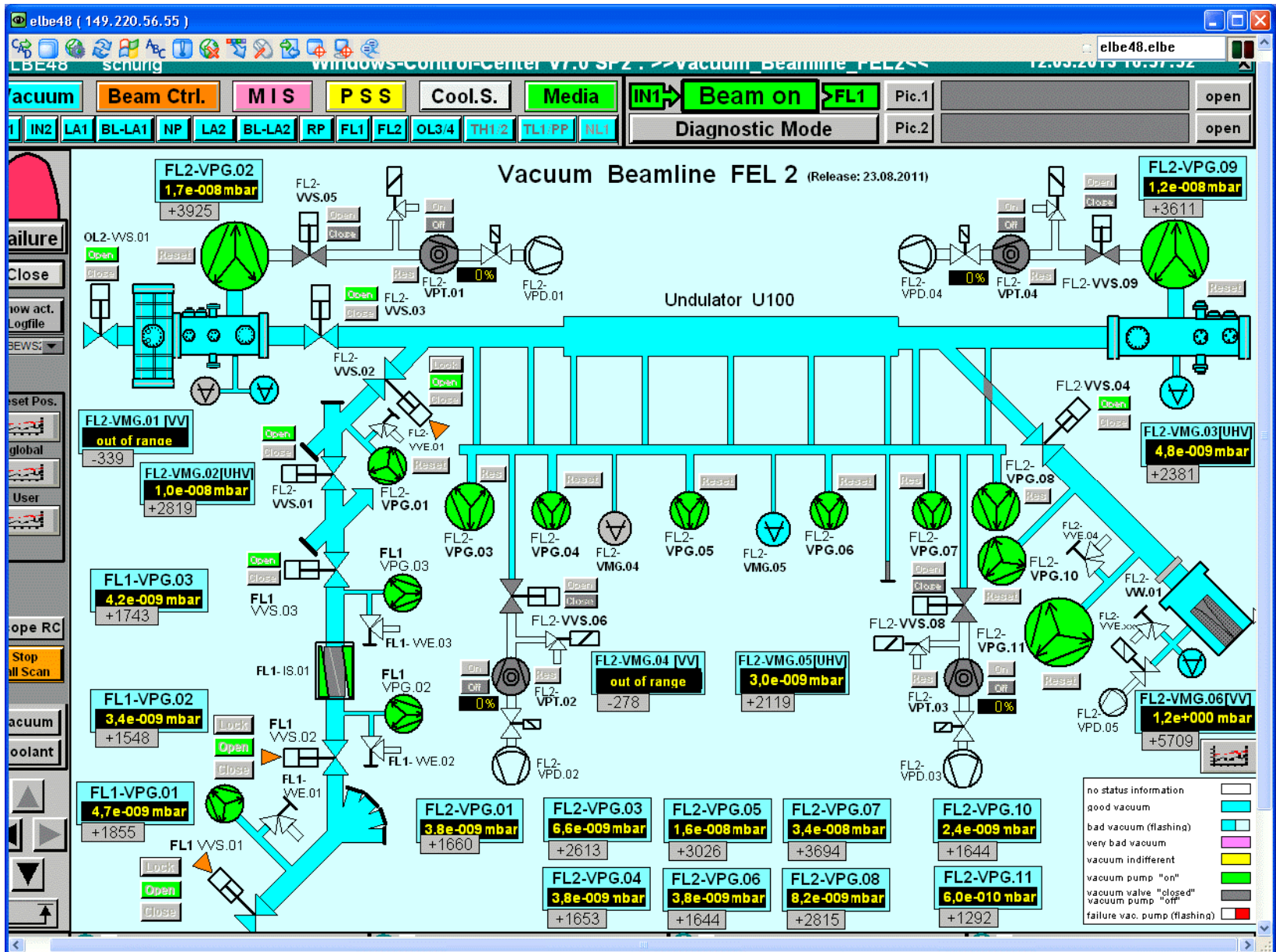
HOM coupler temperatures

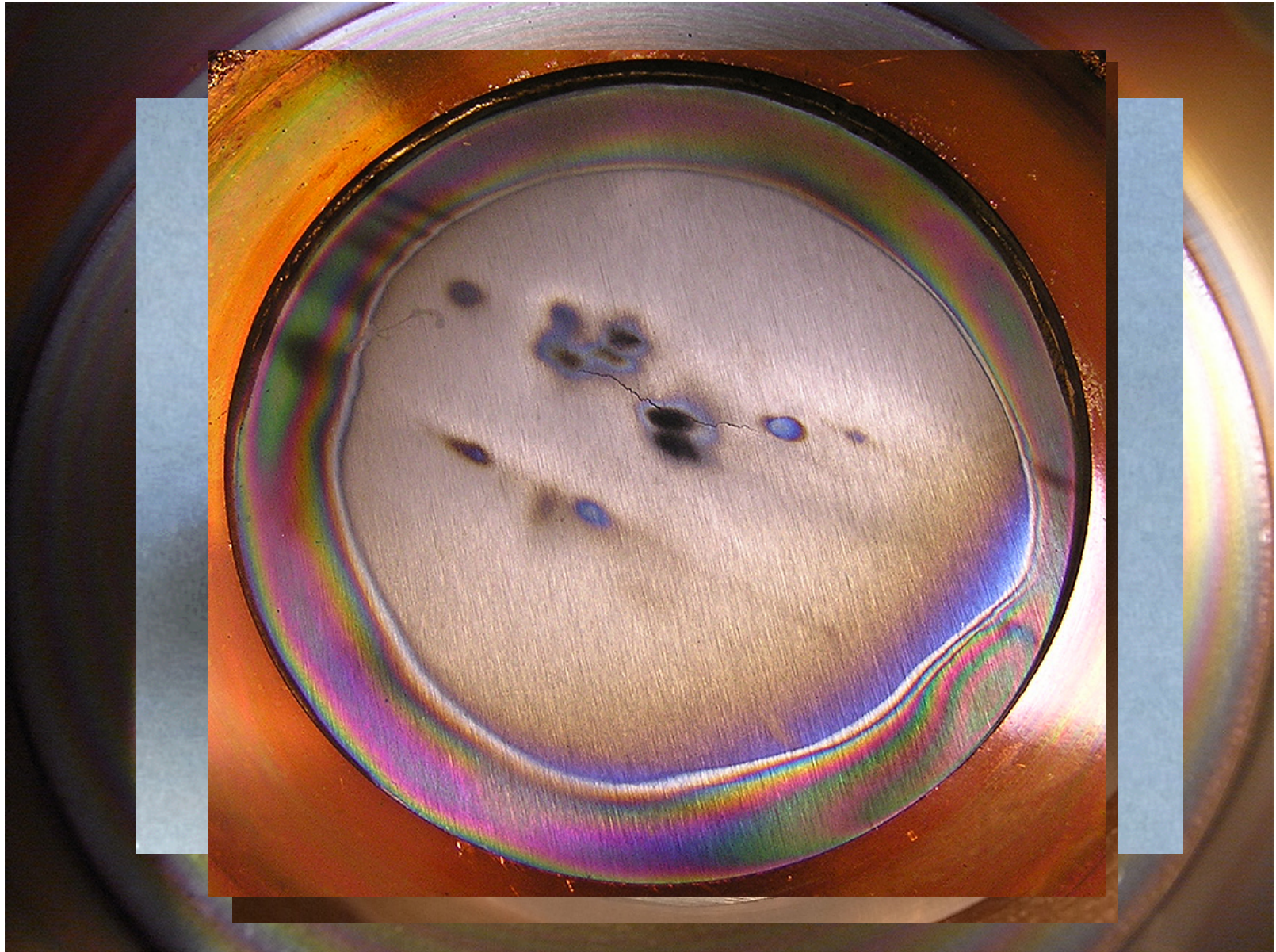




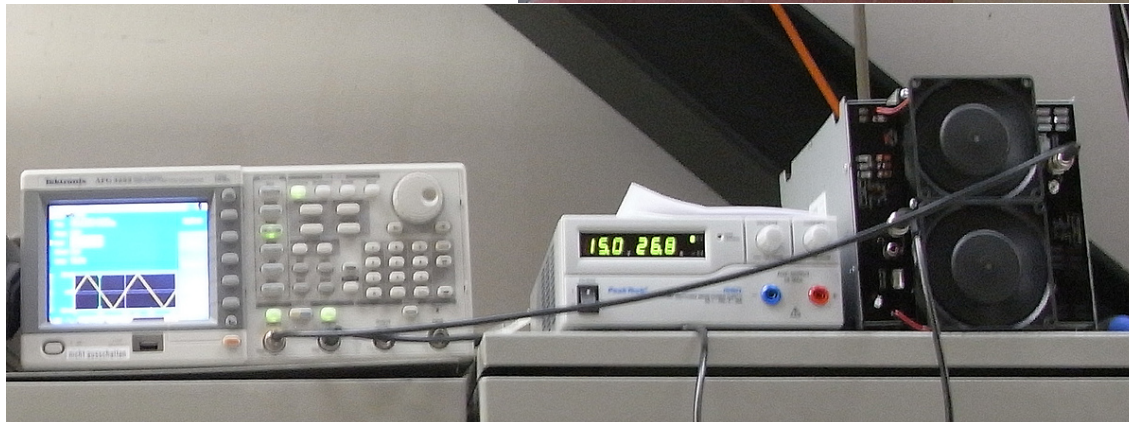
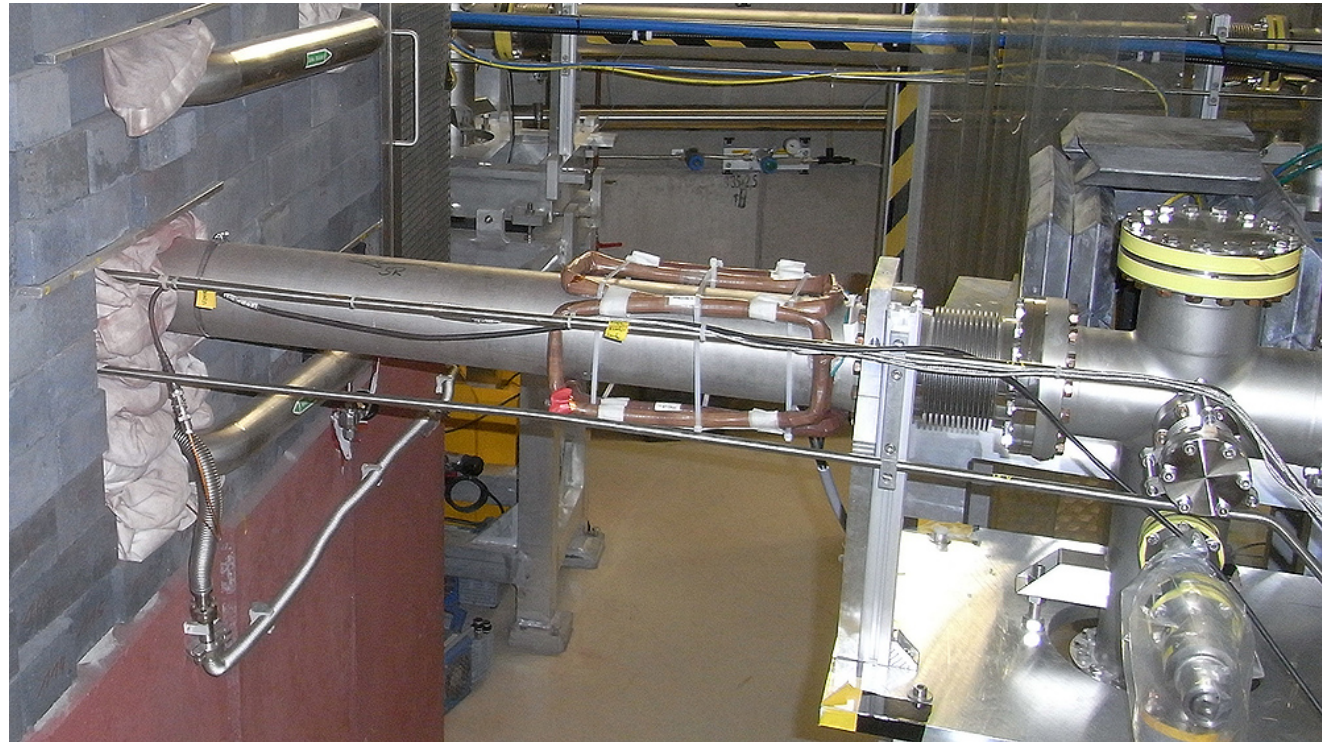
Problem Beryllium window:

- separates $10E-9$ (particle free) beamline from $1E-3$ dirty dump vacuum
- abt. 300 W are dumped in the window
- with FEL on (dE) some horizontal beam distribution, but no vertical
- broke several windows, expensive!
- probable solution: wobble beam on the window to spread heat load

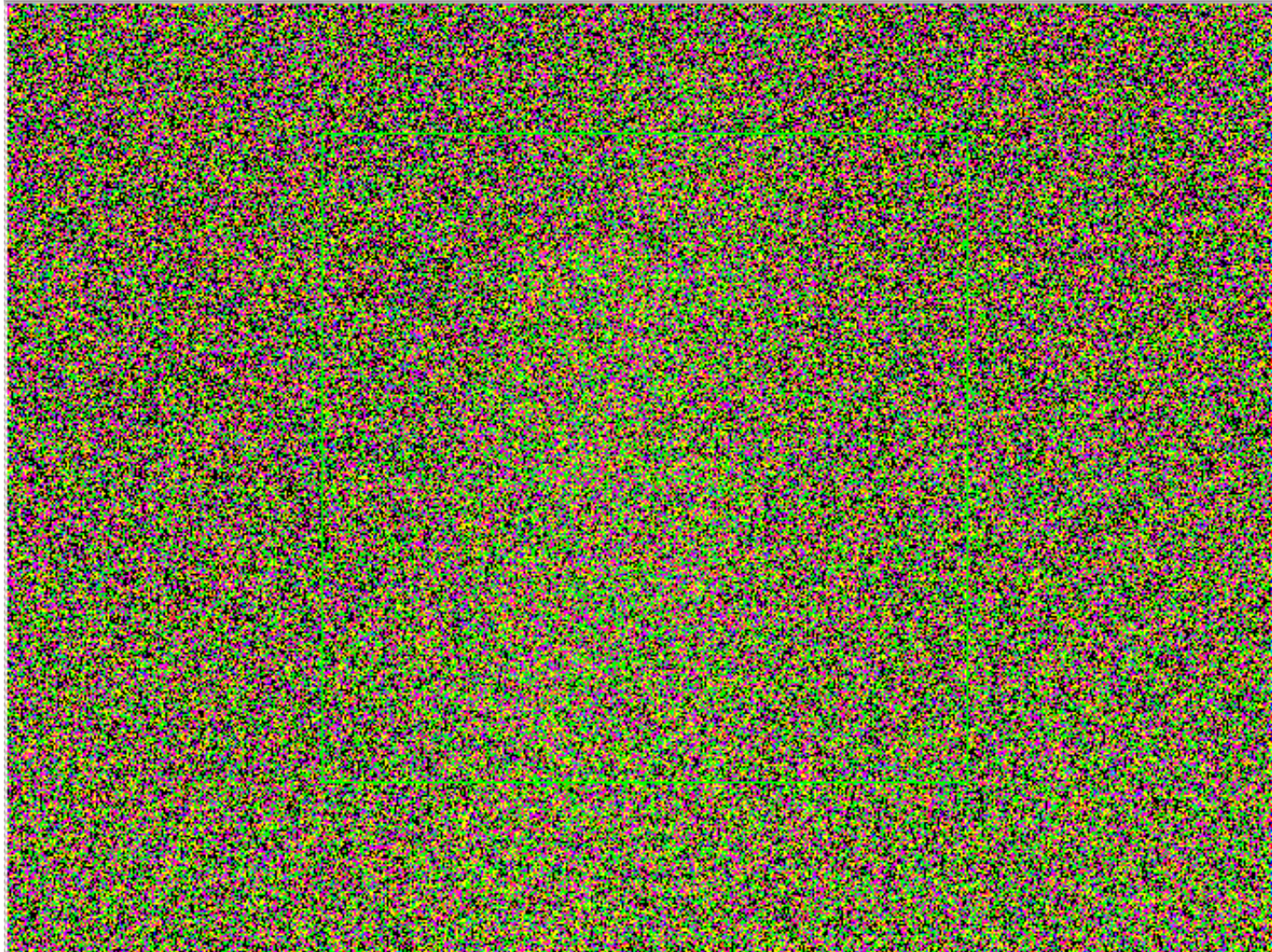


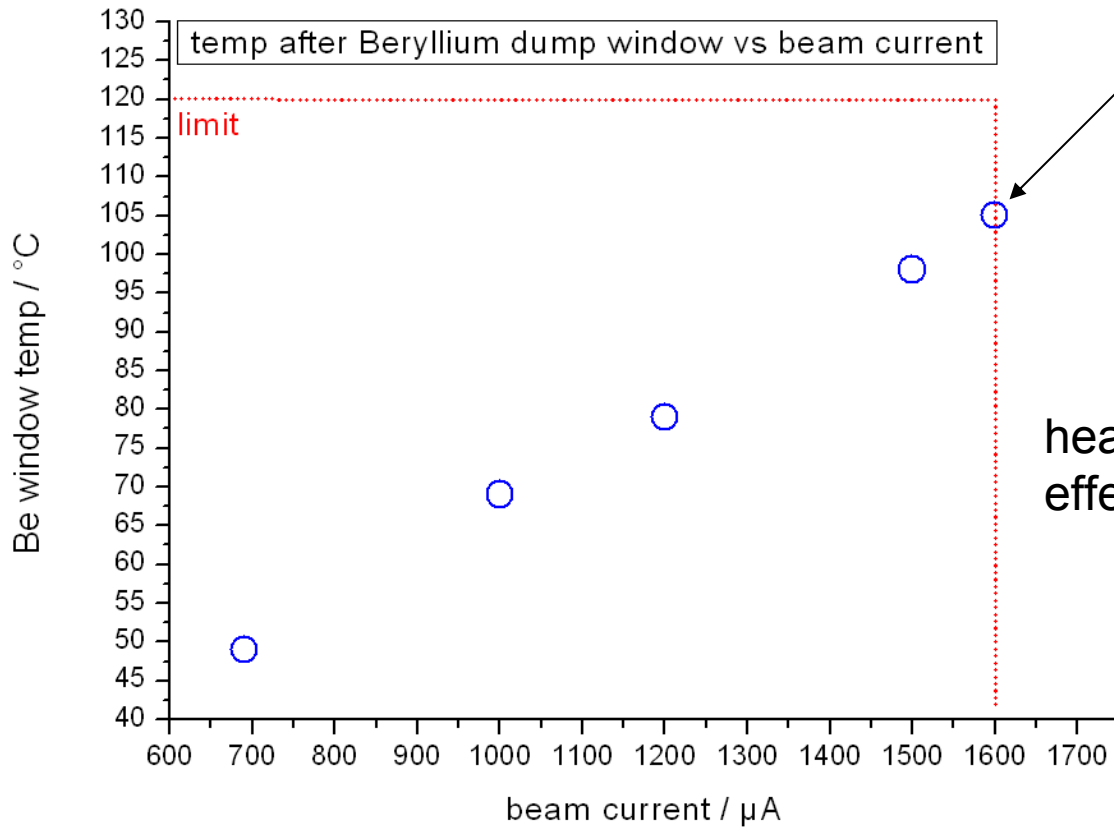


- hor./vert. steerer
- 120 turns
- $L \sim 9 \text{ mH}$
- $\sim 4 \text{ A @ } 70 \text{ Hz / } 15 \text{ V}$
- def. angle $\sim 15 \text{ mrad}$
- distance 1 m
- > $\pm 15 \text{ mm}$ wobbling
- add DC offset



Be dump window beam wobbling





- not a stationary value
- will rise after longer CW beamtime

heat radiated back from dump
effects Be-window to what extend?

Conclusions:

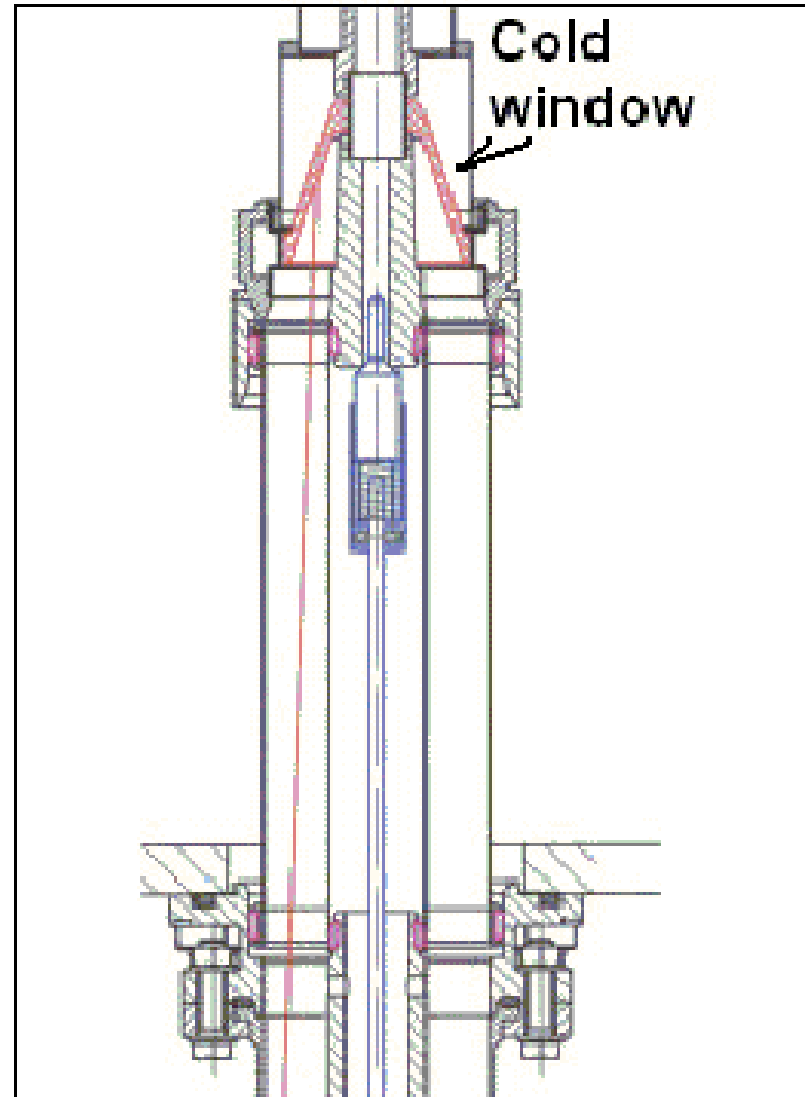
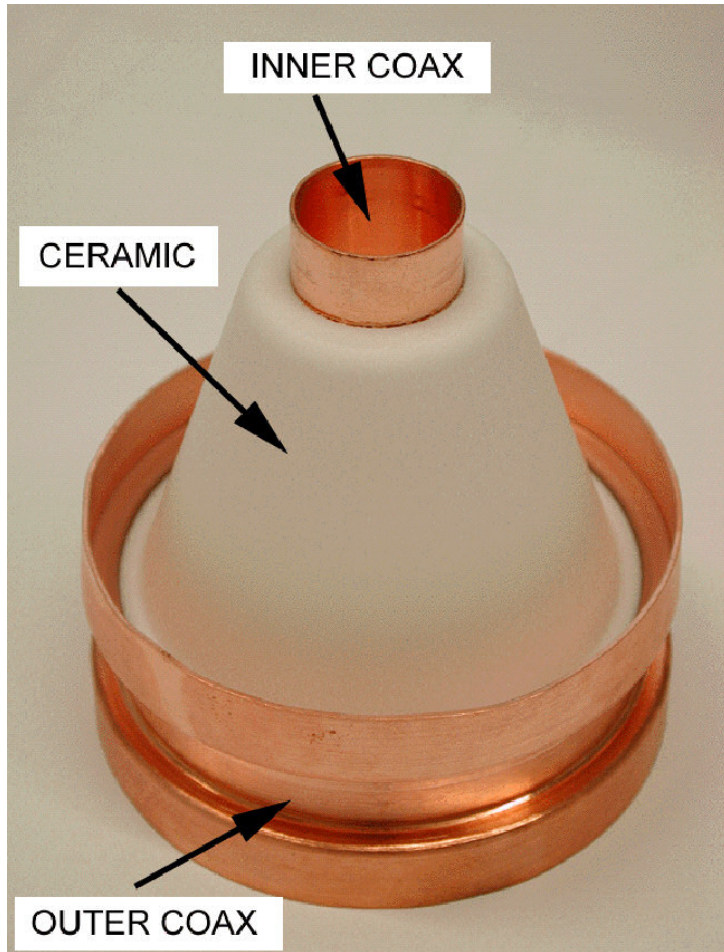
- warm waveguide window problem solved
 - > *light interlocks remain major problem*
- cold coax window and HOM coupler temp.
 - > *so far no problems observed*
- Be-dump window problem solved (we hope)
 - > *if not, maybe redesign of dump area*
- beam loss might be problem for longer cw runs
 - > *measure beam properties, recalculate beam transport at 1.6 mA*

not only heating – also
radiation damage
is a problem..

whats wrong with this
cooling fan?

THANKS!





another broken
Be window

