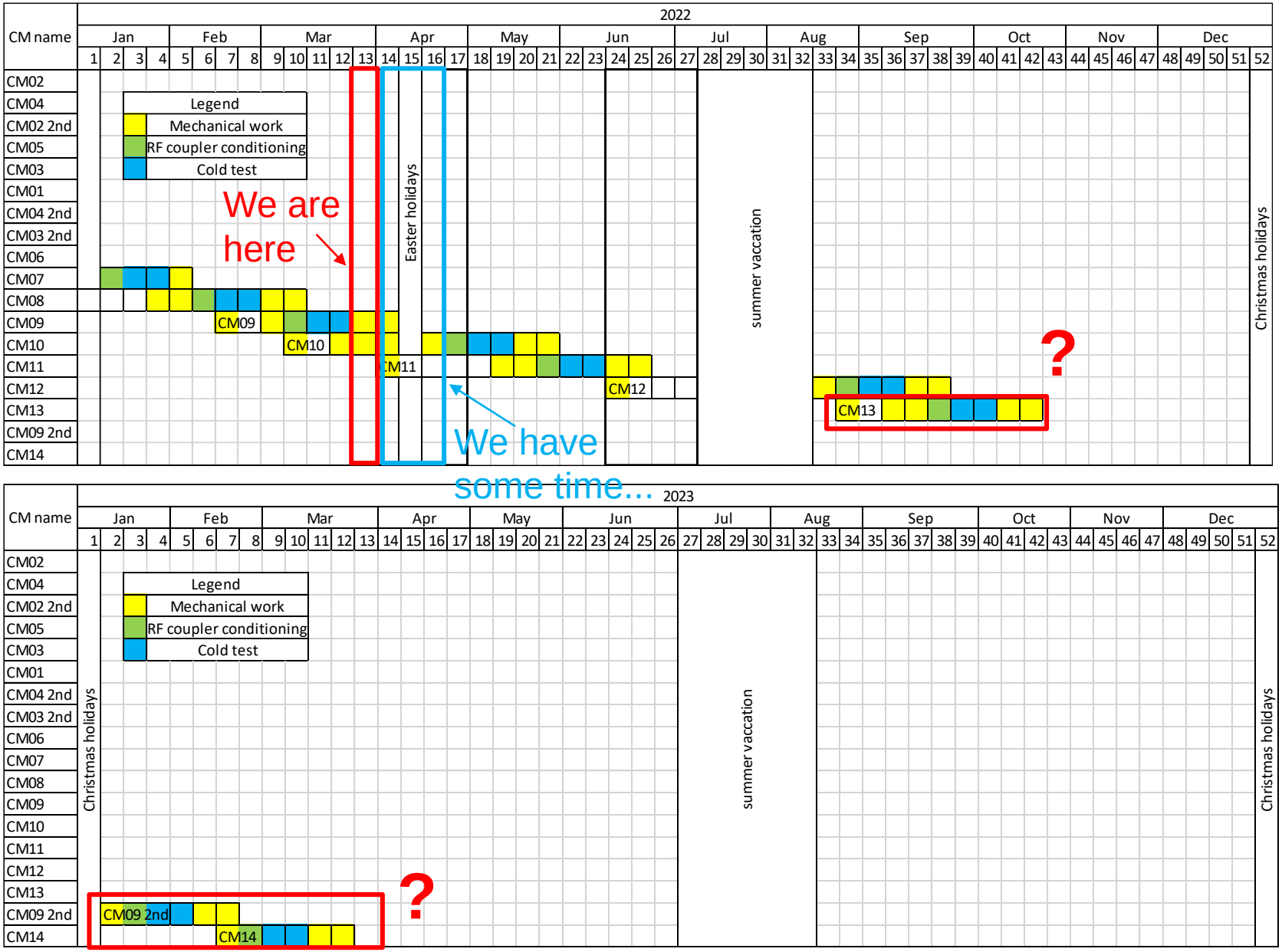
UPPSALA
UNIVERSITET

ESS weekly meeting (2022 W13)

A. Miyazaki et al

Planning updated (preliminary)



Dedicated test of tetrode proposed

General concerns from the Committee

(Major concerns, which might heavily affect the schedule)

Tetrode amplifiers for the Spoke linac

- The tetrode amplifiers for the Spoke linac are still showing insufficient performance and reliability with respect to the project needs. The testing campaign required to point out the problem, however, did not give sufficient results up to now, and the present data do not allow yet a clear diagnosis. According to the present information, the baseline tetrodes might not be able to provide sufficient power for long enough time and might jeopardize the linac operation. Several mitigation actions are possible and should be immedialtely pursued, but **the only one that will allow the achievement of the BOT on schedule is making the present tetrodes work, at least at a reduced power**. This would allow operation at the nominal gradient, although the beam current should be reduced accordingly. It might be also possible to restore the 2 MW beam power on target with a lower current by moving up the installation of RF power in the high beta linac section.

Dedicated test of tetrode proposed

a-TAC21 answer to charges

Accelerator – Charge questions: For the spoke RF stations (tetrode based), advise on the test results so far, propose possible further tests and advice on the options in our plan B and help prioritize them.

Recommendations

Regarding Tetrodes testing program:

- ESS shall intensify the tetrodes testing program, both in DUT number and operation time (24x7 routine automatic conditioning or operator shifts). The target will be to gather enough statistics and thoroughly define the most frequent failure origin (within 1 year). Continue testing tetrodes in Upsala, and, if possible, encourage ESS company in Italy to extend FAT to include lifetime testing for one unit. Life-time testing also shall be specified (suggested 1000 hours at 380 kW into matched load).
- Following the cavity's highest peak power needs and expected network losses, we recommend to limit power to 380kW, to get some safety margin. It is also recommended to use 2 dedicated stations which will run at lower power/voltage levels (say 260kW and 320kW) to established tetrodes 'safe' power/reliability map.
- ESS shall bring more flexibility into the testing program, even if it could conflict with insurance or warranty policy. The lab needs to be allowed to run at lower voltages (low risk), enable ability to swap faulty tubes, allow ability to hi-pot test tubes, and make small changes to the tested amplifier for improved reliability.
- The dedicated test stand for the faulty devices study will be needed to verify all possible solutions on the recovery, like changing the cavity matching (with reducing voltage), measuring HOM etc. These studies will require external experts as well as Thales representatives to consult on site.

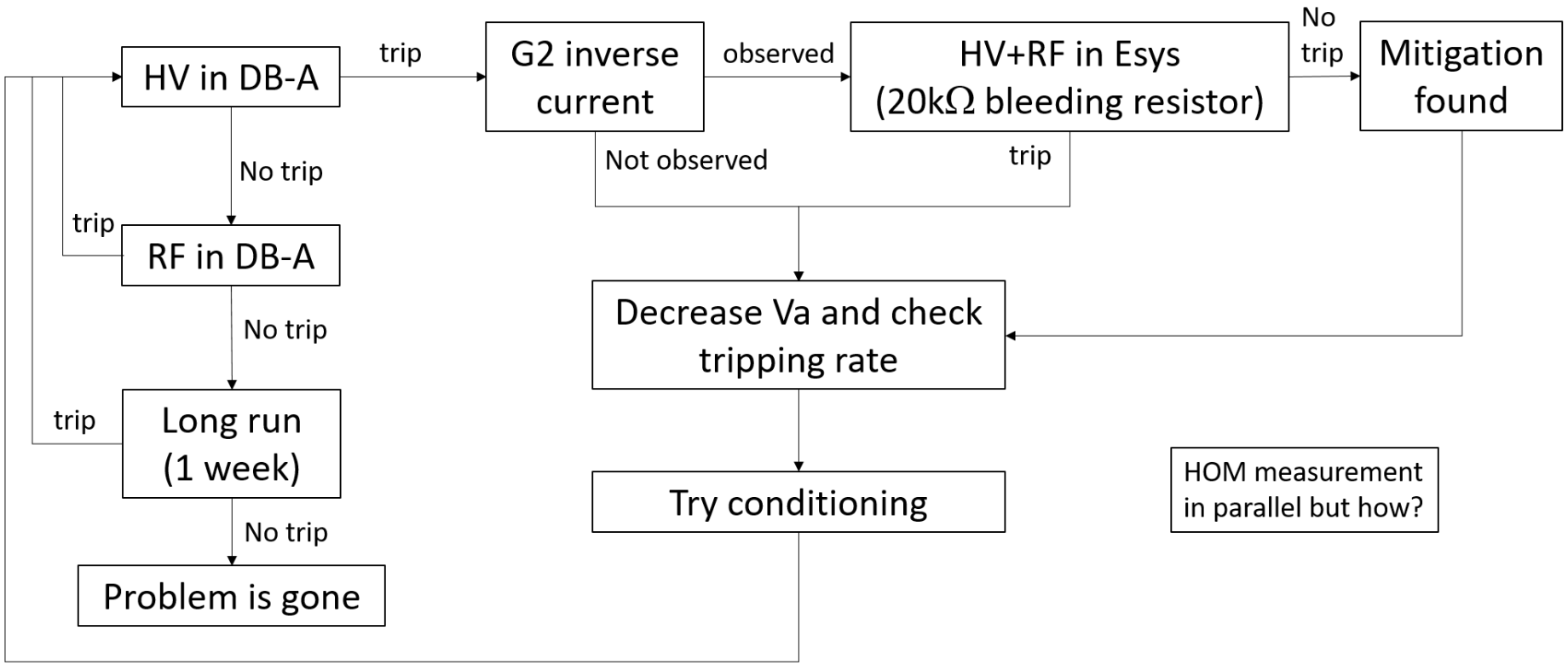
Regarding communication with Thales, direct involvement of Thales is vital to gain the progress in tetrodes reliability. It is critical to work closely with Thales in investigating the necessity of tetrodes modification and corresponding cost and timeline

Regarding commissioning, at this moment we cannot predict the safe power level of tetrodes operation. For the sake of continuation of machine conditioning, ESS could foresee to operate accelerator at a lower current if the tetrode problems are not completely resolved within 2 years. In this scenario, consider to gain beam power for BOT at later sections by operating more modules.

8-11 March 2022 ESS TAC21 21

→ We decided to test the broken (?) tube TH595A 907196 in April

Dedicated test of tetrode proposed



Test procedure was shared with Carlos at ESS

W11 & W12 & W13 progress / W14 plan

week		W11													
date		MON		TUE		WED		THU		FRI		SAT	SUN		
		14-mar		15-mar		16-mar		17-mar		18-mar		19-mar	20-mar		
		m	a	m	a	m	a	m	a	m	a				
present CM	**CM09**	LHe cooling, VNA f vs T	4K filling		coupler cold conditioning	2K pumping	RF calibration	CTS test, RF interlock setup		MP conditioning at target frequency		thermalization			
next CM	**CM10**			reception test VNA											

week		W12													
date		MON		TUE		WED		THU		FRI		SAT	SUN		
		21-mar		22-mar		23-mar		24-mar		25-mar		26-mar	27-mar		
		m	a	m	a	m	a	m	a	m	a				
present CM	**CM09**	heat load measurement at target frequency		start warming up	leak found	investigation of the leak						warming up			
next CM	**CM10**	waiting in the docking area													
next next CM	**CM11**	preparation at Orsay													

We are here

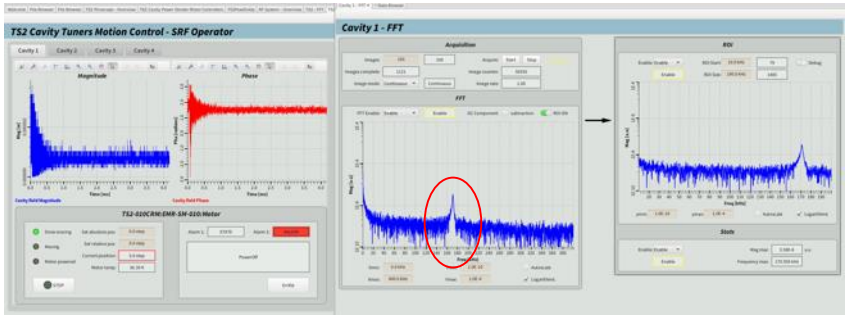
week		W13													
date		MON		TUE		WED		THU		FRI		SAT	SUN		
		28-mar		29-mar		30-mar		31-mar		01-apr		02-apr	03-apr		
		m	a	m	a	m	a	m	a	m	a				
previous CM	**CM09**	warming up completed	disconnect cryogenics, vacuum pumps			swap modules	N2 filling	out going test		waiting in the box					
present CM	**CM10**						doorknob mounting, wait in front of the bunker to fix LT01								
next CM	**CM11**	preparation at Orsay													

Same track?

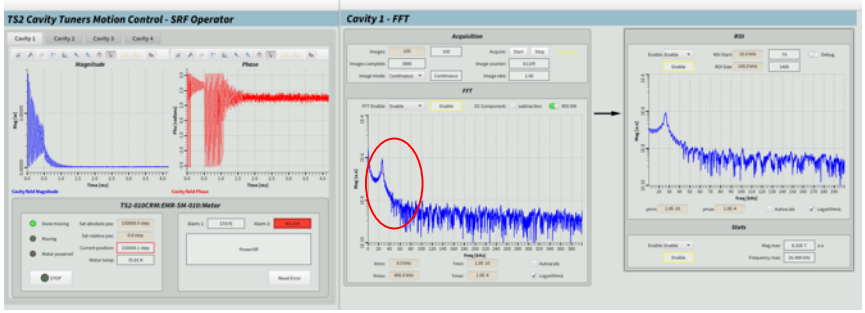
week		W14													
date		MON		TUE		WED		THU		FRI		SAT	SUN		
		04-apr		05-apr		06-apr		07-apr		08-apr		09-apr	10-apr		
		m	a	m	a	m	a	m	a	m	a				
previous CM	**CM09**	waiting in the box		departure to ESS		preparing report		departure to Orsay							
present CM	**CM10**	**When?** fix LT01				move into the bunker		connection and close the bunker							
next CM	**CM11**	transport from Orsay						arrival at UU		reception test					

Can FFT replace VNA?

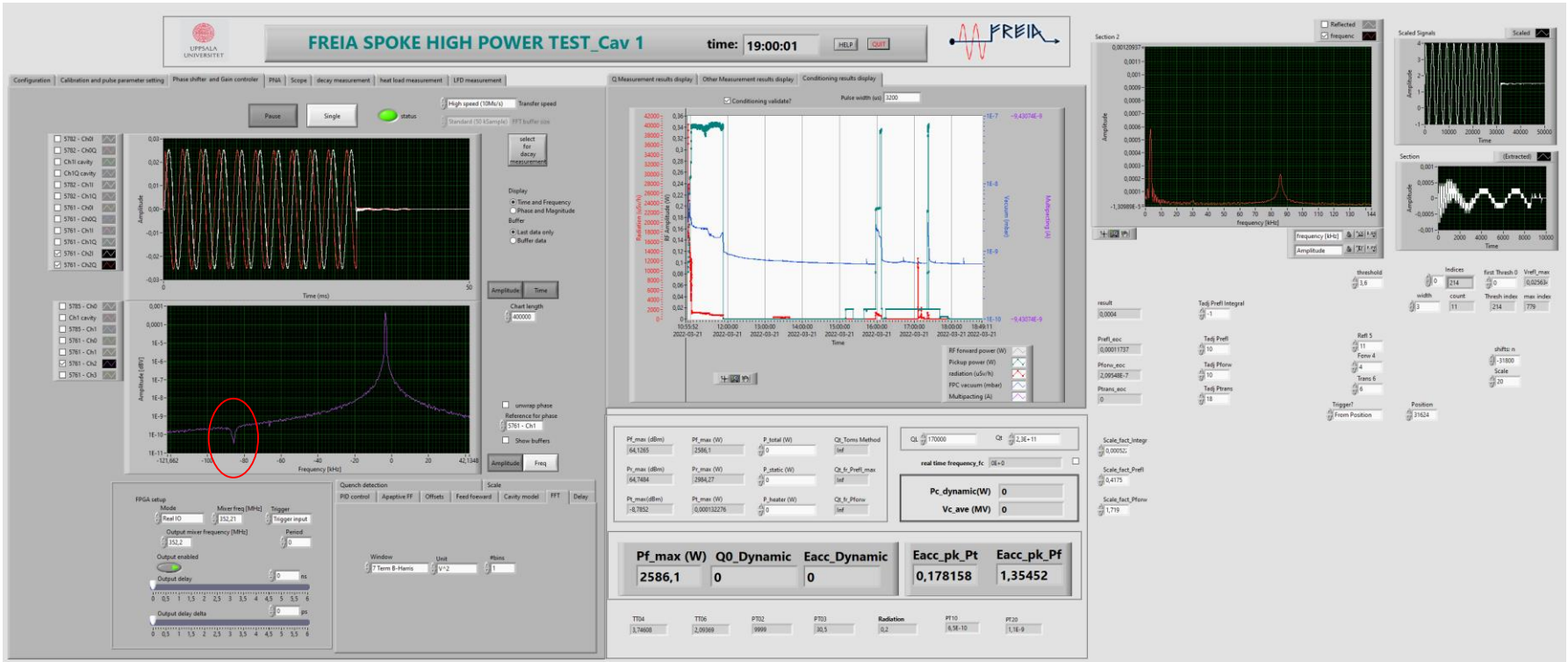
ESS uses FFT for the tuner test



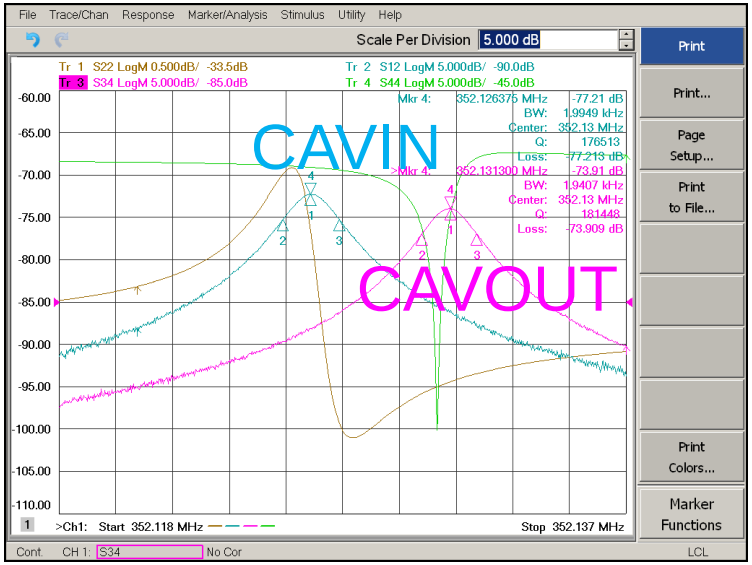
From TAC slides by Cecilia



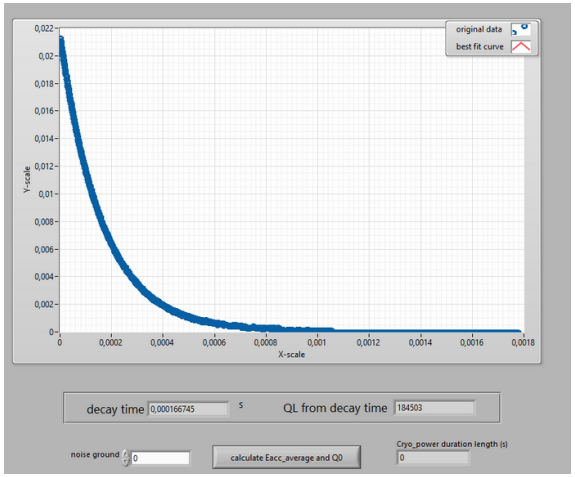
FREIA LLRF is equipped with the same function (but not used so far)



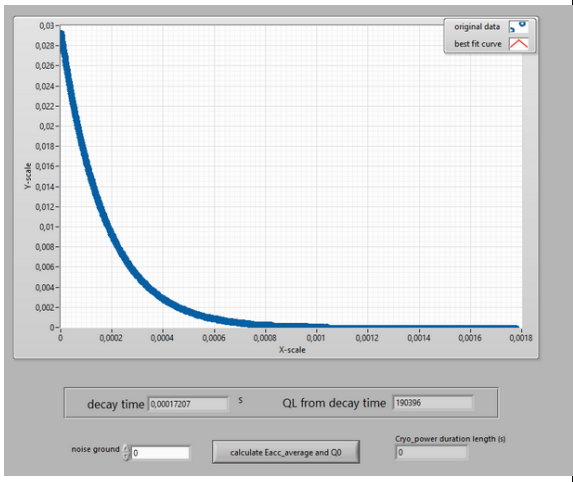
CM09: Q_L from VNA vs field decay



CAVIN



CAVOUT



	CAVIN	CAVOUT
BW Γ [kHz]	1.99	1.94
Q_L (VNA)	1.77e5	1.81e5
τ [us]	167	172
Q_L (field decay)	1.85e5	1.90e5

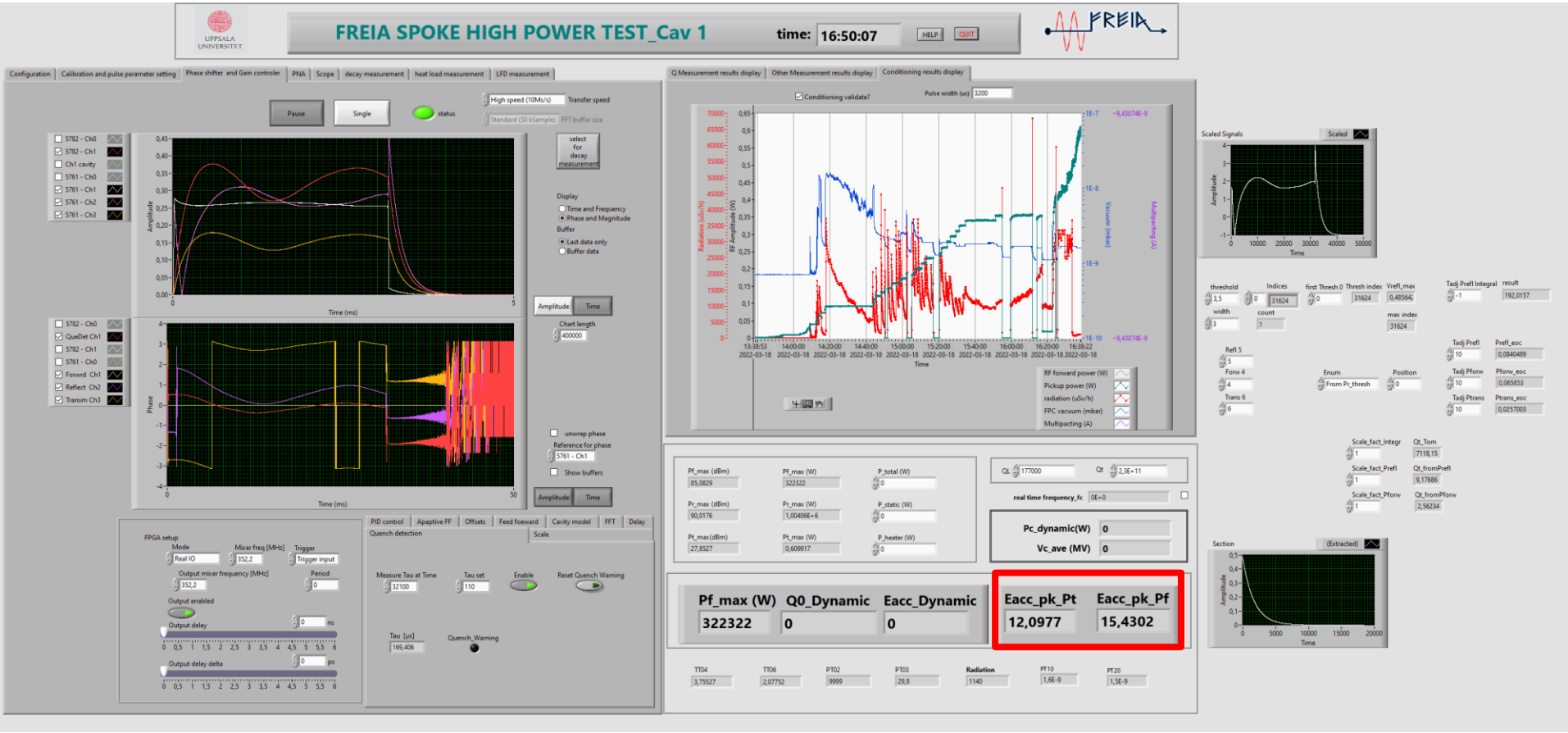
$$V(t) \propto e^{-t/\tau_L}$$

$$\tau_L = \frac{1}{\pi\Gamma}$$ Fourier transform

$$Q_L = \frac{f_0}{\Gamma}$$

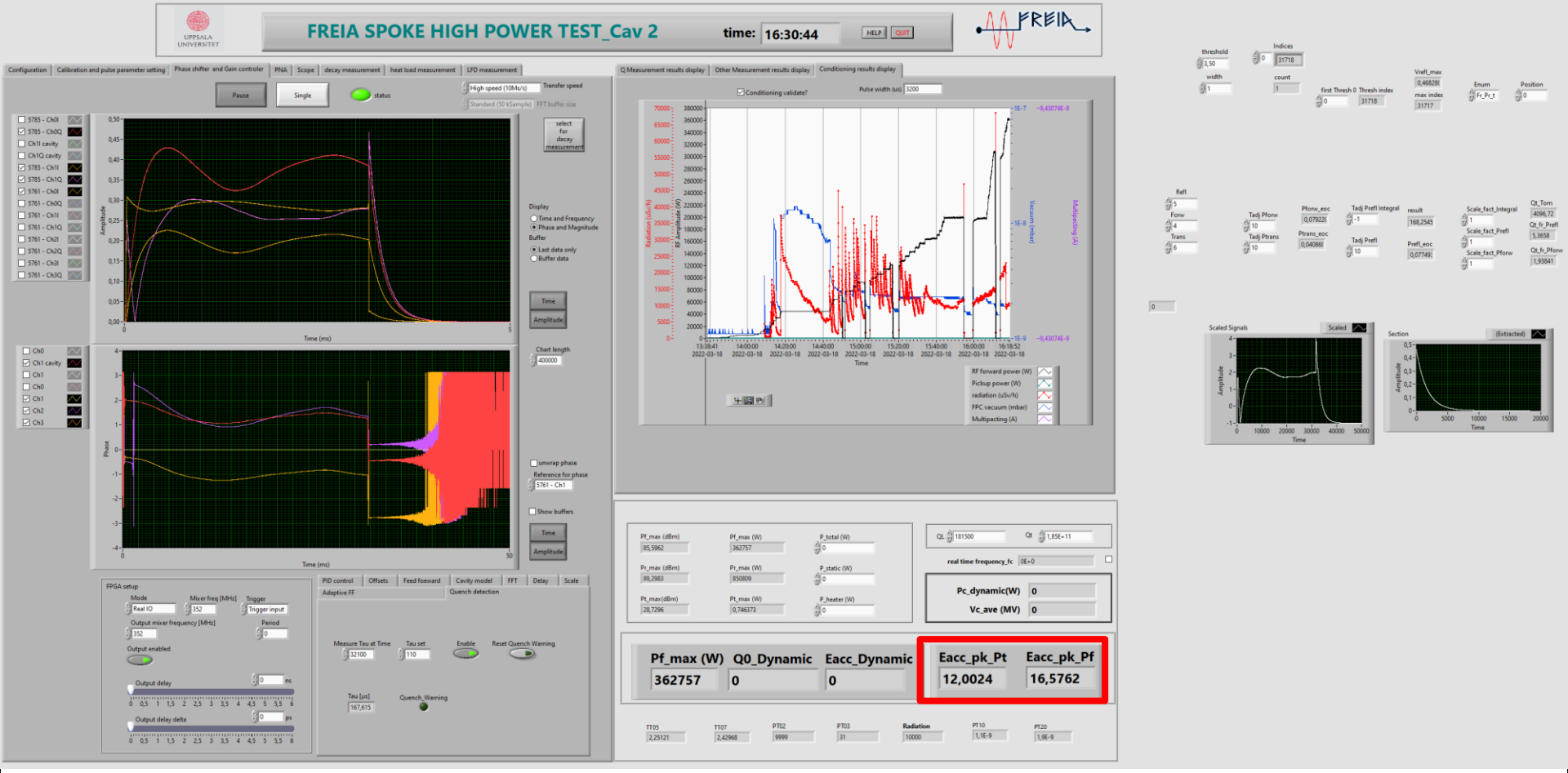
As usual, the values estimated from the field decay are larger

CM09: CAVIN reached 12 MV/m



Free of field emission after conditioning up to 12 MV/m

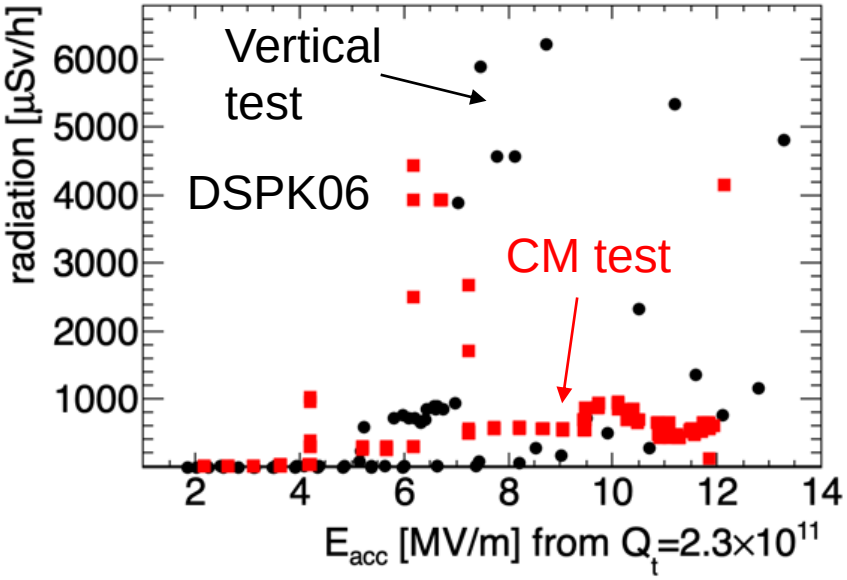
CM09: CAVOUT reached 12 MV/m



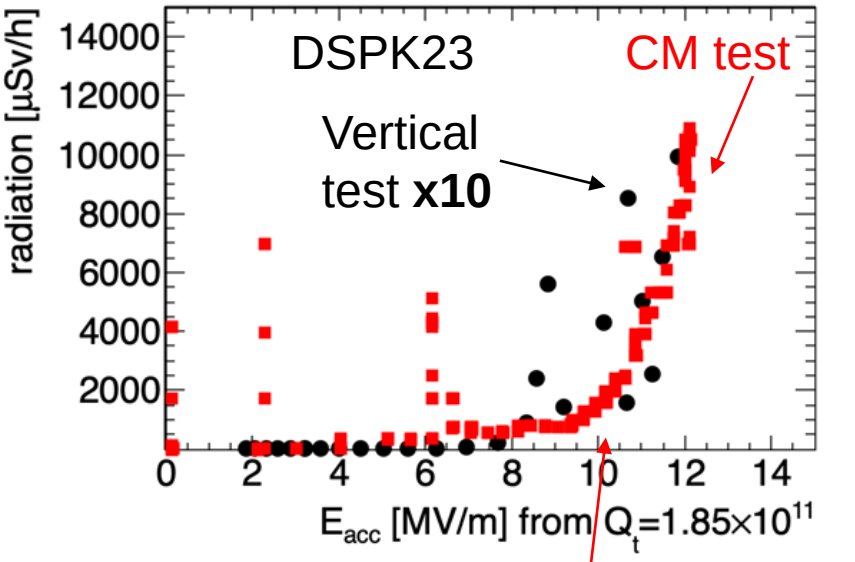
Field emission above 10 MV/m

CM09: field emission in CAVOUT

CAVIN



CAVOUT

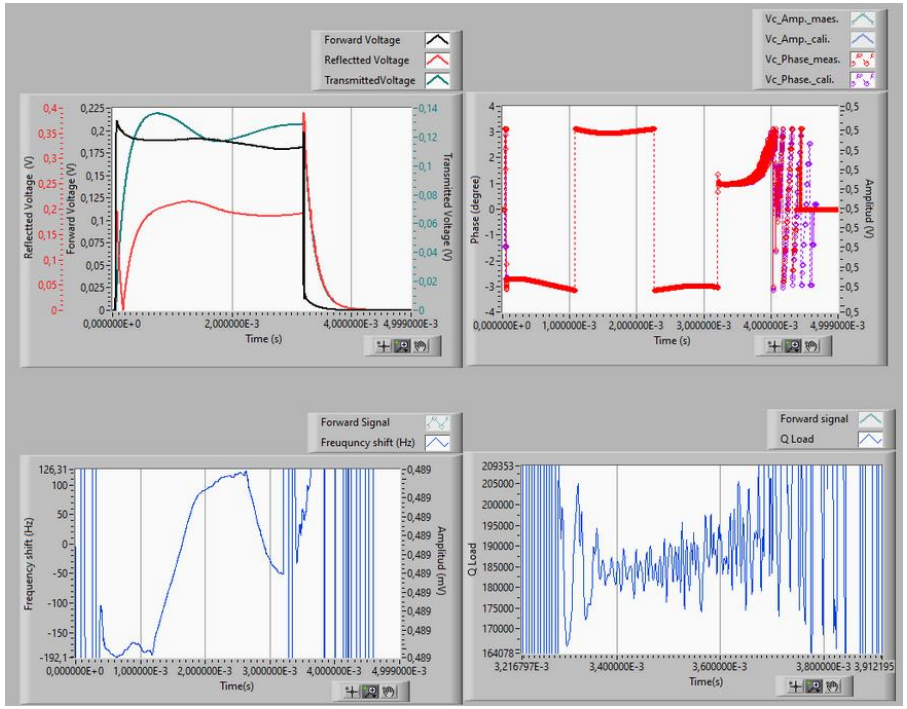


Onset 10 MV/m

- Position of the radiation monitor is not calibrated
- For the CM test, a radiation monitor is in a symmetric position between CAVIN and CAVOUT
- We anyway reached 12 MV/m in both cavities with the most conservative E_{acc} calibration

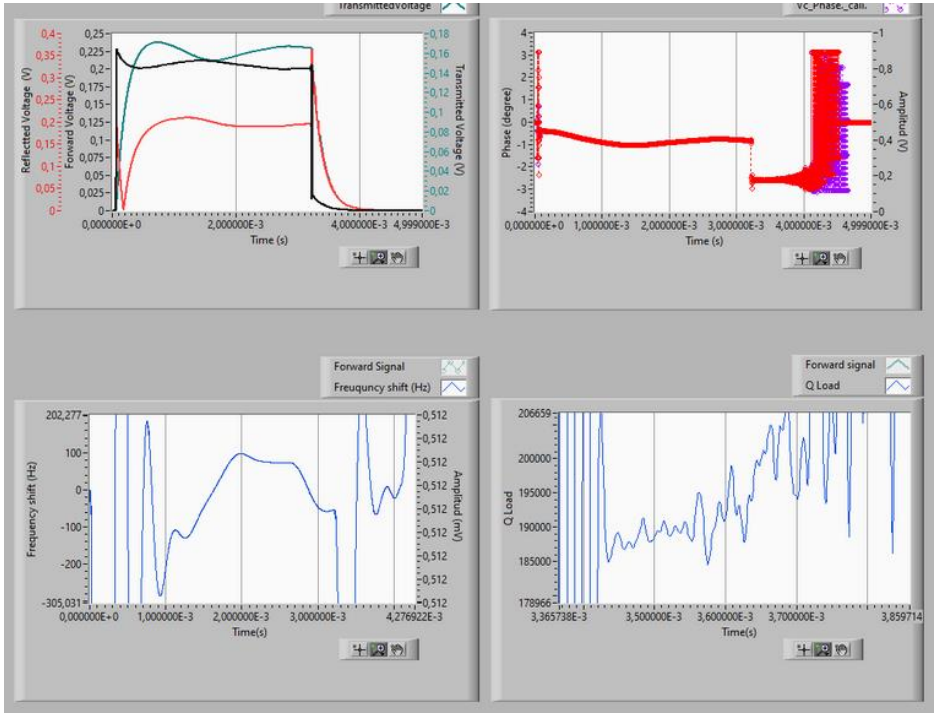
CM09: Lorentz Force detuning @ 9MV/m

CAVIN



df = +126 / -192 Hz
abs(df) = 318 Hz

CAVOUT



df = 100 / -150 Hz
abs(df) = 250 Hz

Cf. CM09 CAVIN seems softer than others

	CAVIN	CAVOUT
df/dp [Hz/mbar]	20.02	11.31
Motor sensitivity [Hz/mm]	95.7	84.2
Piezo sensitivity [Hz/V]	6.35	5.41
K_L [Hz/(MV/m)^2]	-8.20	-6.81
Dynamic LFD [Hz]	318	250

Soft CAVIN Confirmed (?)

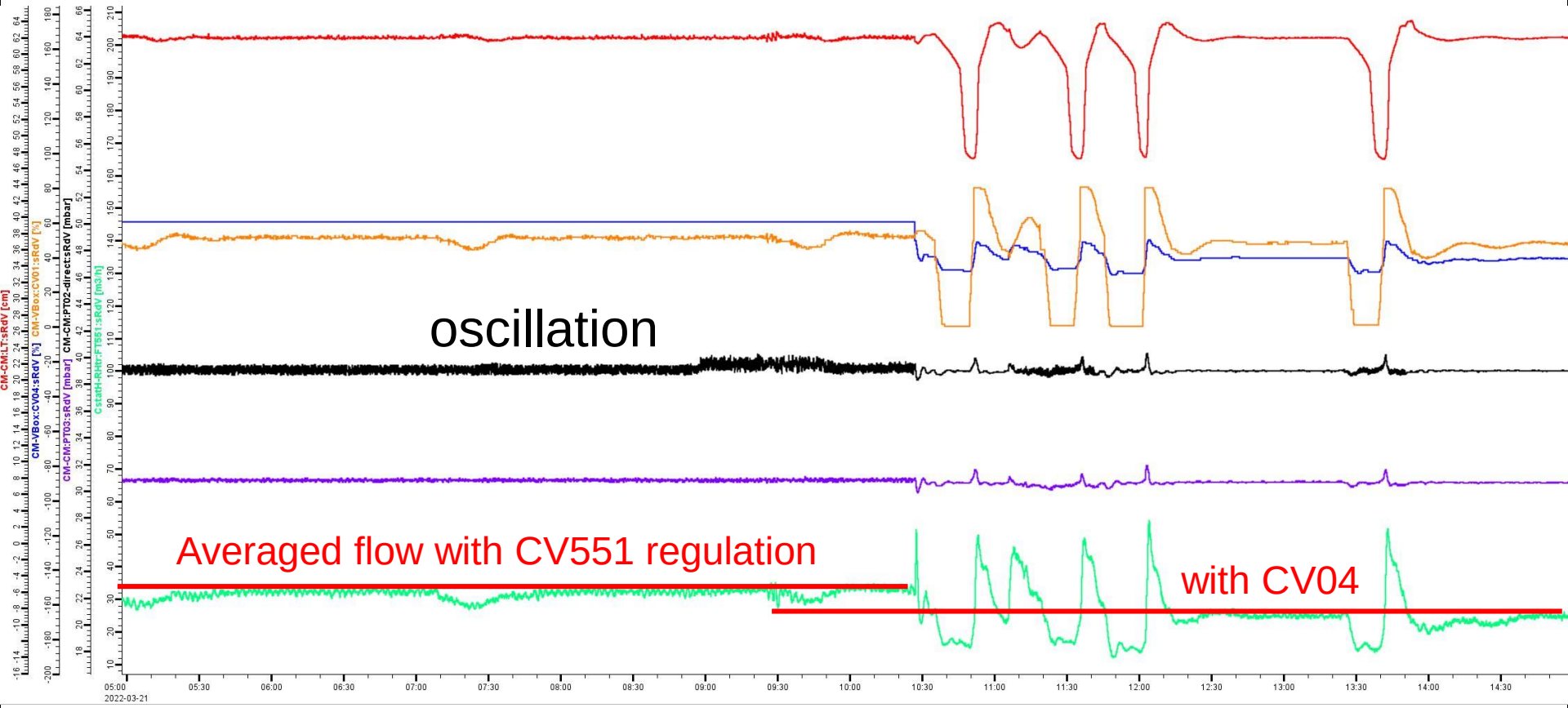
CM09: heat load measurement

	static	9MV/m at CAVIN	9MV/m at CAVOUT	9MV/m for both
Flow [m^3/h]	16.70	15.04	15.29	17.24
P [W]	17.87	16.09	16.36	18.44
σ [W]	0.7	0.86	0.83	0.61

- Nuno remotely joined this test
- We shared the procedure and made a consensus that the method itself is correct
- The static heat load is high
- RF power dissipation is zero consistent as usual the case

One finding about static heat load

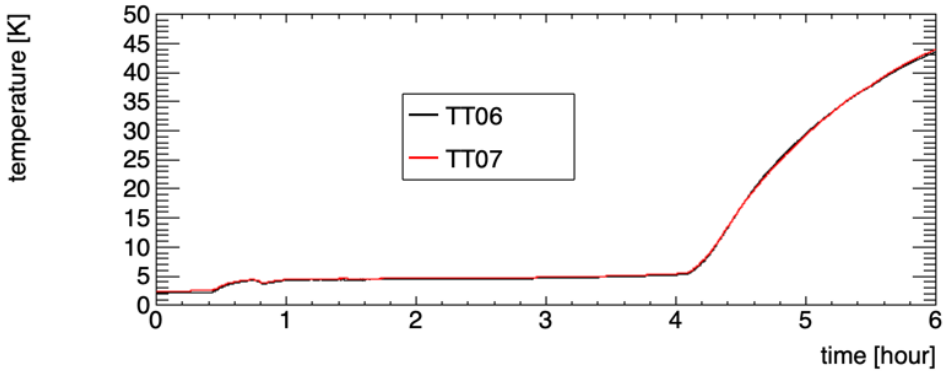
Courtesy Nuno

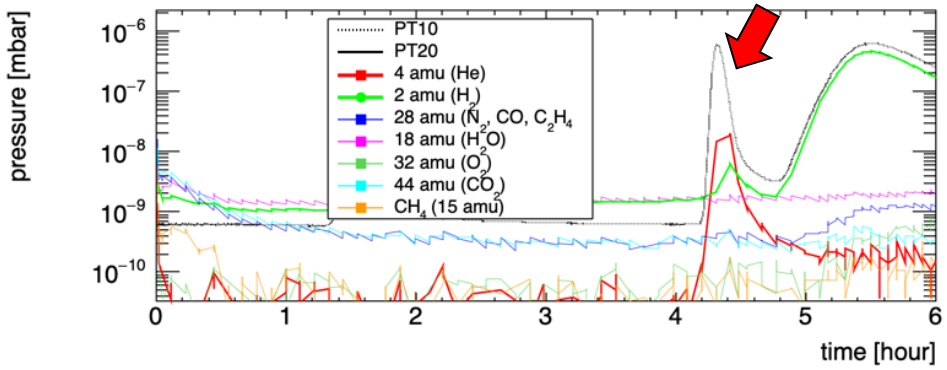


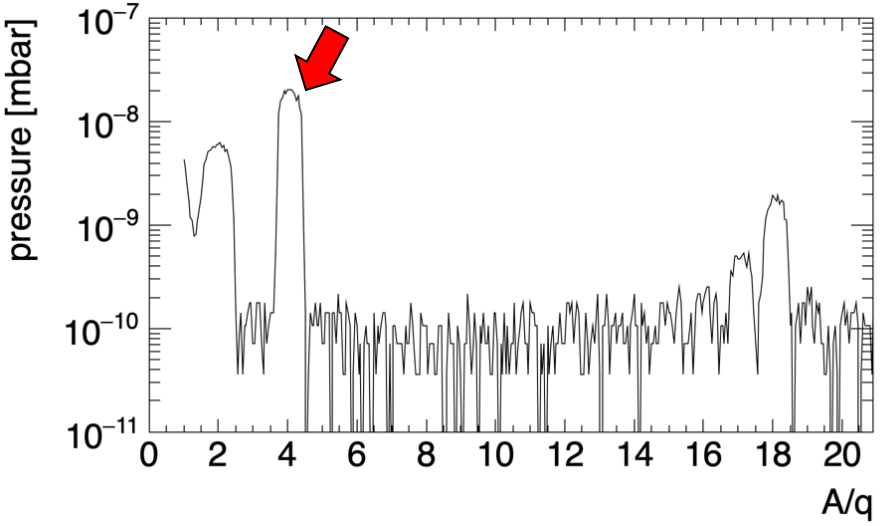
- There seems like 6-8 W more consumed with CV551 regulation (valve after reheater) than CV04 (in VBox)
- This phenomenon is associated with oscillation → ***Taconis?***

We were very happy to start waring up

And deeply depressed…

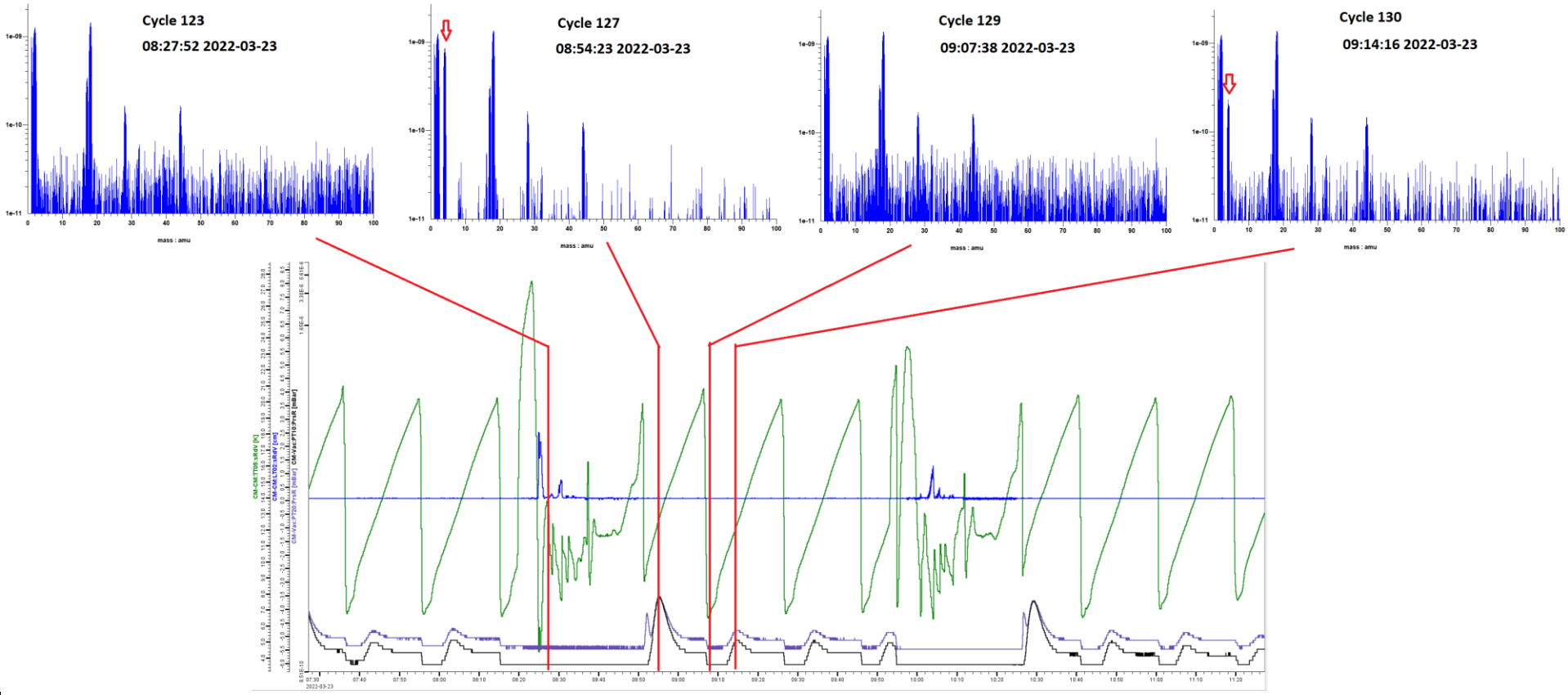






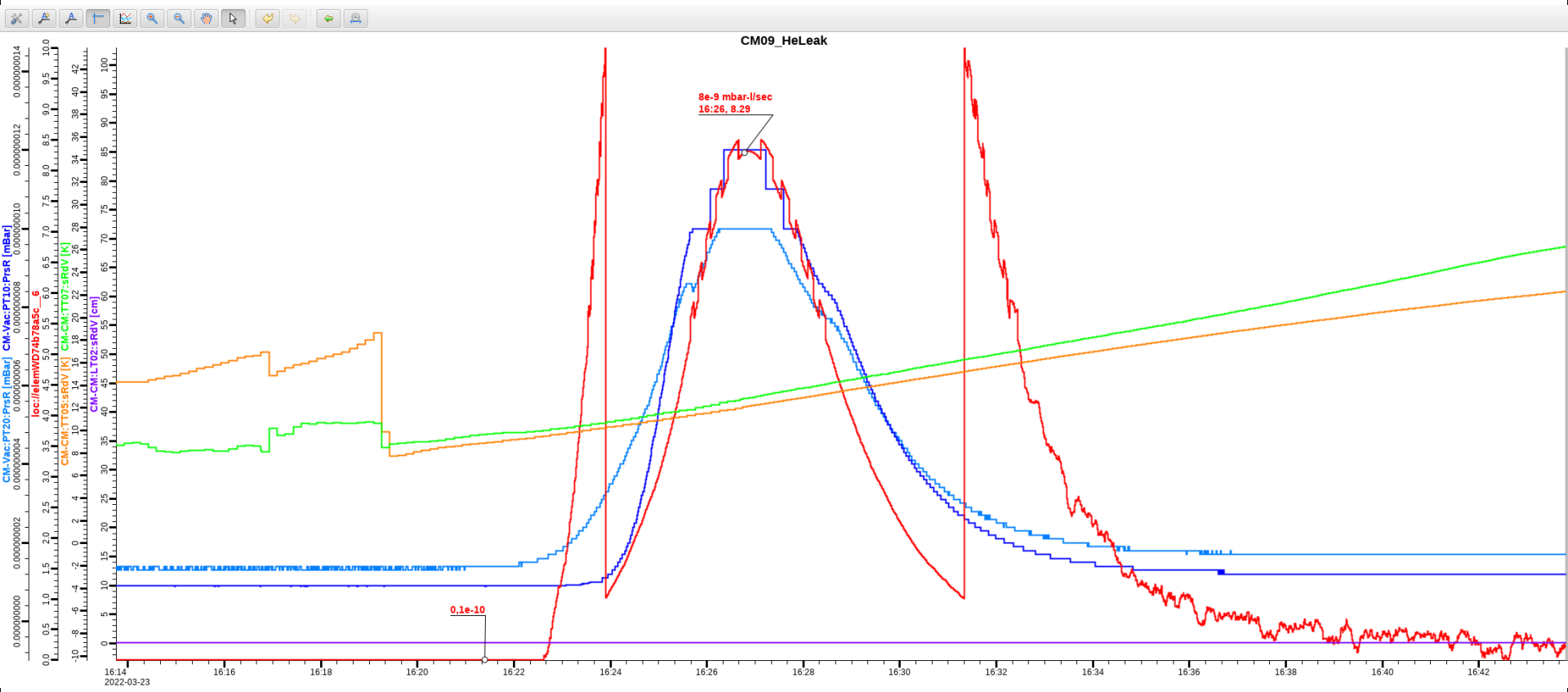
CM09: leak was confirmed 1/3

He peak reproduced during thermal cycles



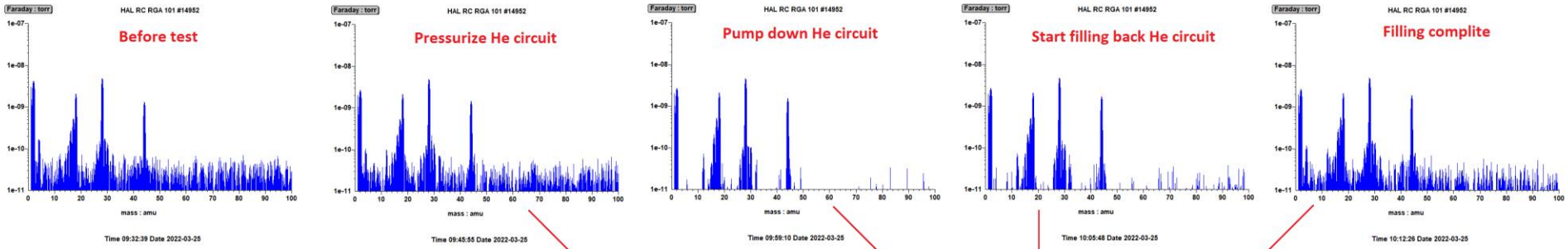
CM09: leak was confirmed 2/3

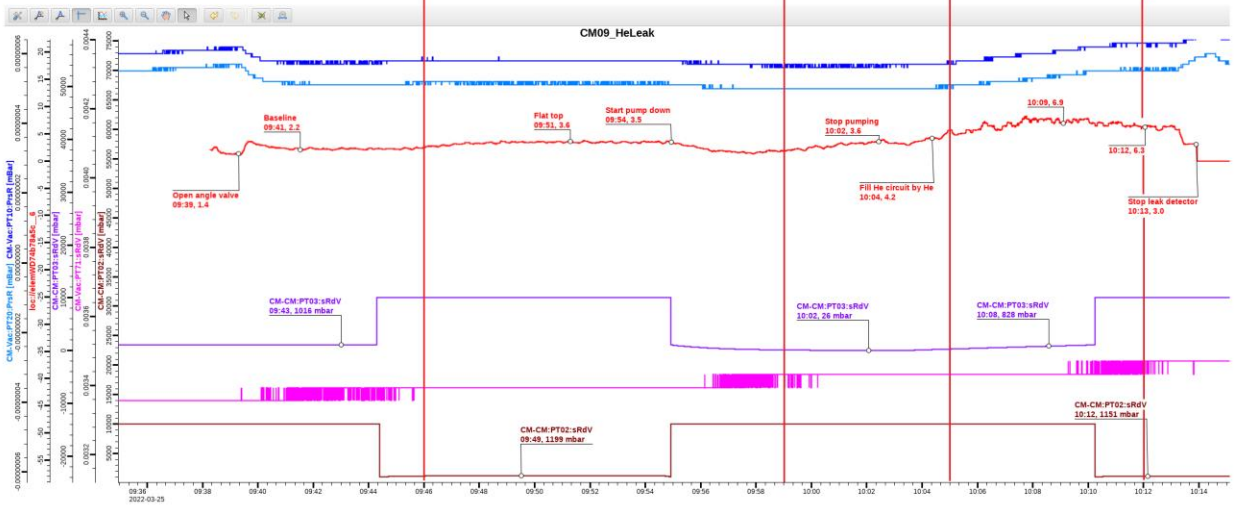
Leak detector detected He



CM09: leak was confirmed 3/3

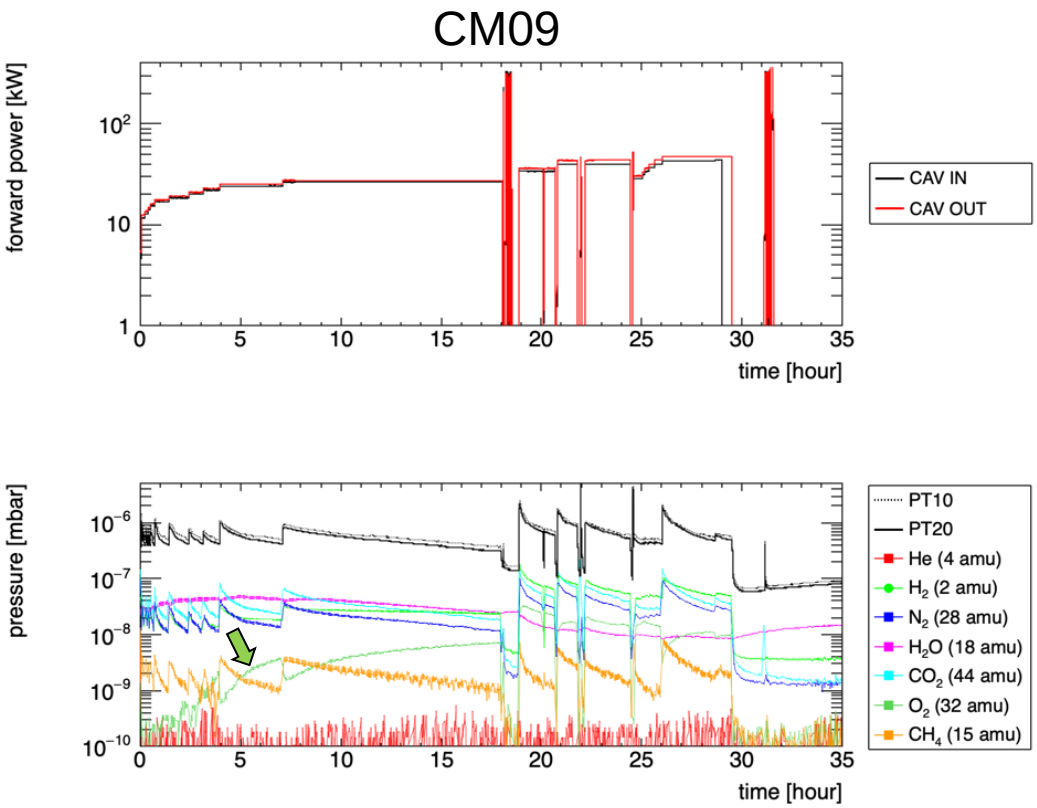
He peak is correlated to the pressure in He circuit

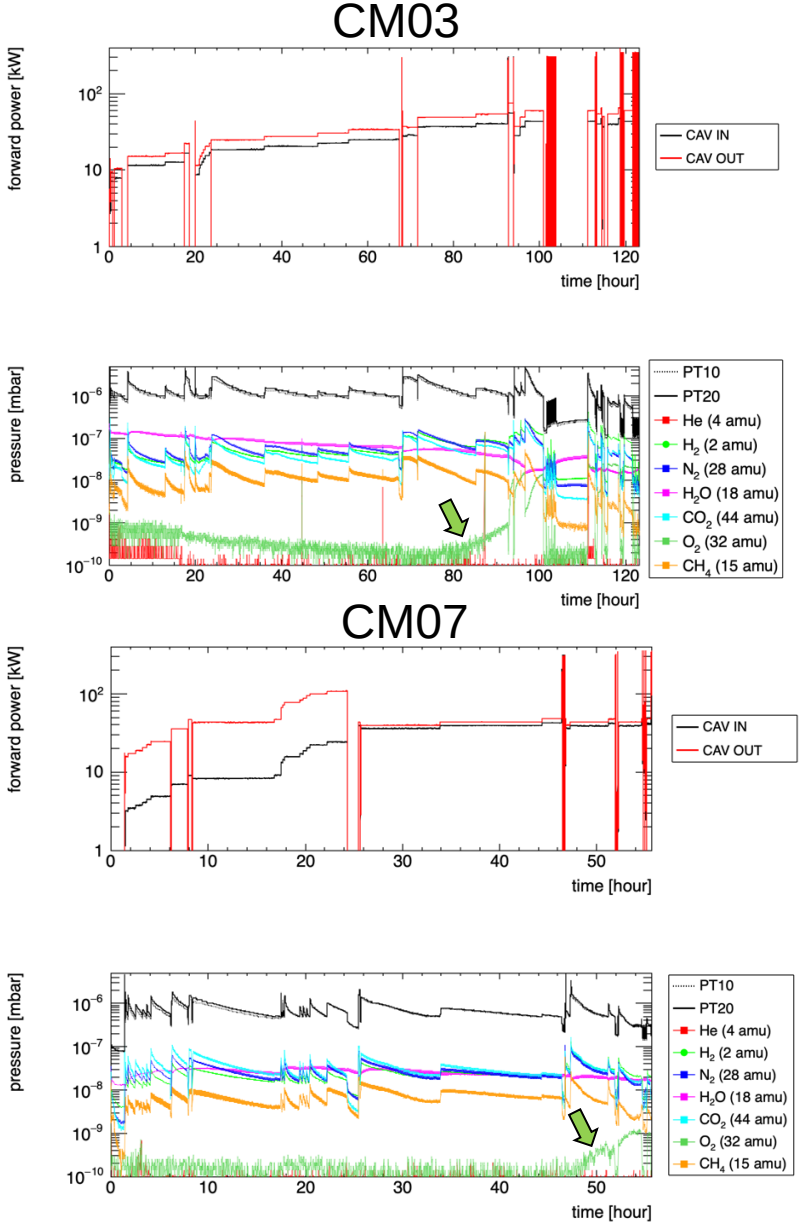




Even at warm

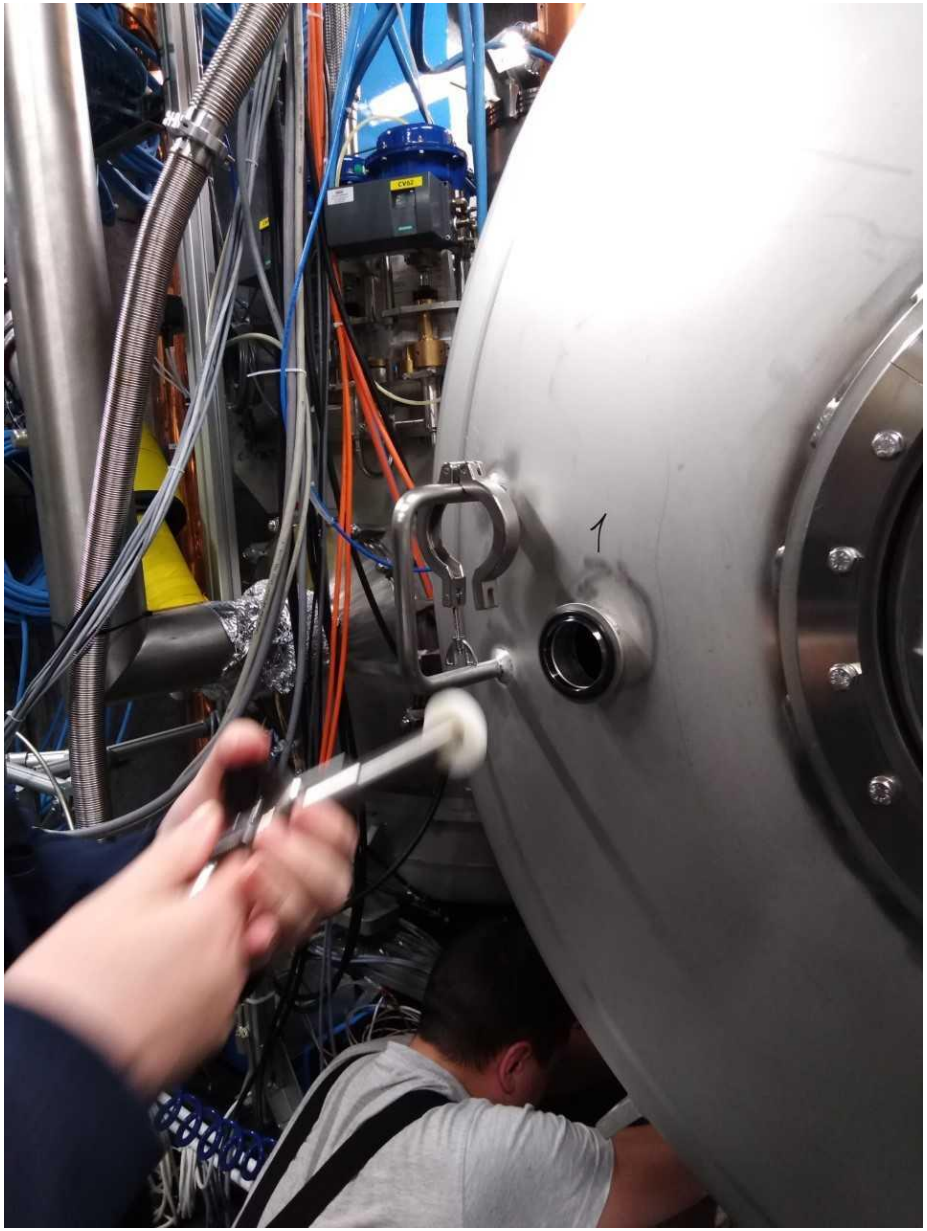
Cf. Coupler conditioning was exceptional





- The 32 amu signal (one candidate is O_2) appeared from the shortest pulse 50 us
- This signal is often observed in longer pulse length (>1 ms)
- This signal is anti-correlated to other molecules (H_2, CH_4, 28 amu, CO_2, …)
- Any relation to the leak??

The support on window did not fit



- The support was sticking out by 1 cm
- No issue recorded at the reception
- Did something move during our test?