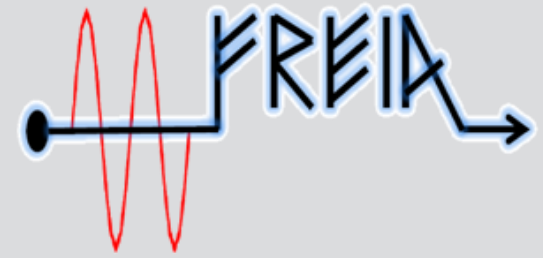




UPPSALA
UNIVERSITET



ESS weekly meeting (W18)

A. Miyazaki et al.



W18: what was performed



W18 2021			next CM	CM under test	previous CM	
			CM03	CM05	CM02	
THU	29-apr	m		RF cable calibration, shock sensor arrived	feet not arrived yet in ESS	
		a		Check by RF power		
FRI	30-apr	m		CAV IN conditioning		
		a		LFD measurement		
SAT	01-maj			make strategy		
SUN	02-maj			check termiantors		
MON	03-maj	m		CAV IN heat load		
		a				
TUE	04-maj	m		doorknob mounting		Cav OUT heat load
		a				
WED	05-maj	m	start warming up			
		a				



W18: what was performed



W18 2021			next CM	CM under test	previous CM
			CM03	CM05	CM02
THU	29-apr	m		RF cable calibration, shock sensor arrived	feet not arrived yet in ESS
		a		Check by RF power	
FRI	30-apr	m		CAV IN conditioning	
		a		LFD measurement	
SAT	01-maj			make strategy	
SUN	02-maj			check termiantors	
MON	03-maj	m		CAV IN heat load	
		a			
TUE	04-maj	m		Cav OUT heat load	
		a		doorknob mounting	
WED	05-maj	m		start warming up	
		a			



VACUUM GAUGE OF CAVITY STRING AT UU				
Date	Time	Pfeiffer TPG2020 (mbar)	Limit	Name of controller
2021-04-26	08:45	3,70E-03	1,00E-01	A.Miyazaki
2021-04-27	08:08	3,80E-03	1,00E-01	E. Pehlivan
2021-04-28	08:03	3,90E-03	1,00E-01	E. Pehlivan
2021-04-29	08:15	3,90E-03	1,00E-01	E. Pehlivan
2021-04-30	08:15	4,00E-03	1,00E-01	E. Pehlivan
2021-05-03	08:08	4,20E-03	1,00E-01	E. Pehlivan
2021-05-04	08:40	4,30E-03	1,00E-01	E. Pehlivan
2021-05-05	08:28	4,30E-03	1,00E-01	E. Pehlivan

- No problem in beam vacuum
- Doorknob mounted
- Cooling water is leak tight
- Ready to move to the bunker once CM05 is out

CM03

Content Summary Edit Relations History Archive

New Filter

data sheet uploaded to Atrium

Items/page 30

Type	Title	Atrium ID	Created	Creator	Modified	Last contributor	Vrs.	State
	Data sheet of CM03: reception, electrical continuity, cavity at warm, beam vacuum	ATRIUM-508730	May 6, 2021	Akira MIYAZAKI	May 6, 2021	Akira MIYAZAKI	0.1	Project
	File sent with Cryomodule CM03 - Fichier envoyé avec le Cryomodule à UU - ASSEMBLING #2	ATRIUM-489156	Mar 19, 2021	Jean NSIMAKETO	Apr 17, 2021	Jean NSIMAKETO	0.9	Project
	Shipping bill CM03 & accessories		Mar 24, 2021	Sylvain BRAULT	Mar 24, 2021	Sylvain BRAULT		
	File sent with Cryomodule CM03 - Fichier envoyé avec le Cryomodule à UU - ASSEMBLING #1	ATRIUM-433623	Oct 20, 2020	Jean NSIMAKETO	Mar 22, 2021	Jean NSIMAKETO	0.11	Project
	Cernox Calibration - Etalonnage cernox		Oct 20, 2020	Jean NSIMAKETO	Jan 6, 2021	Jean NSIMAKETO		



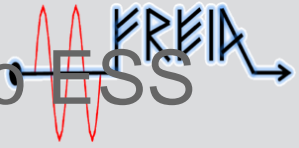
W18: what was performed



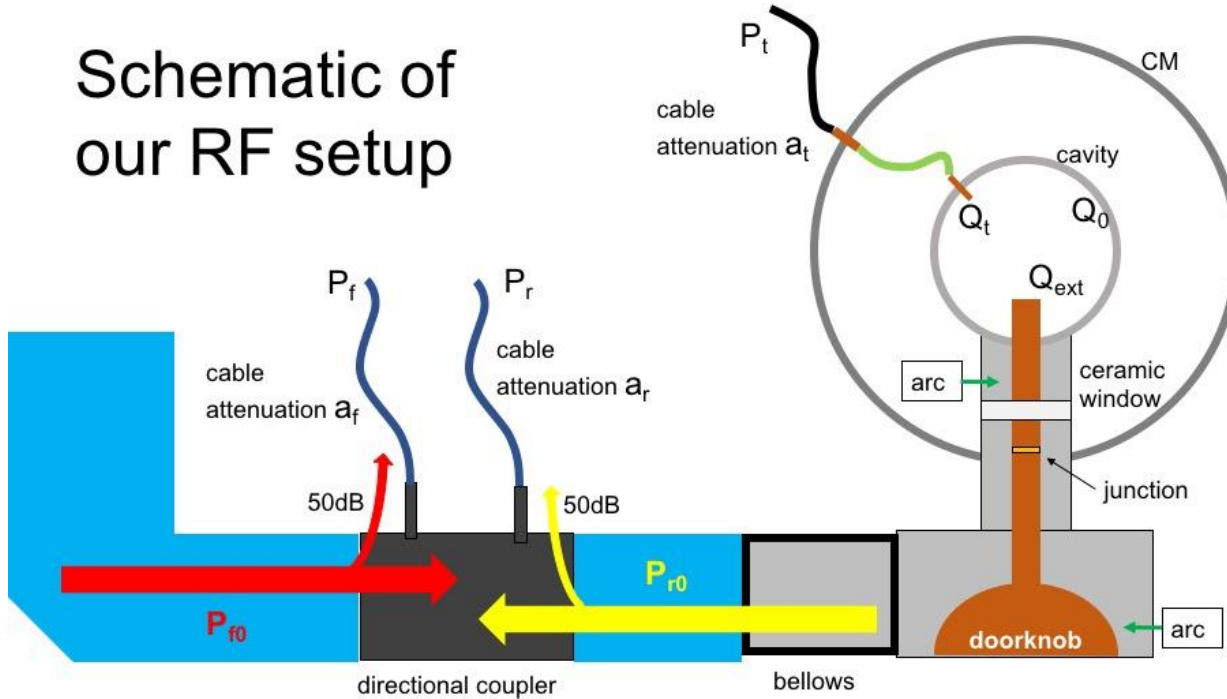
W18 2021			next CM	CM under test	previous CM	
			CM03	CM05	CM02	
THU	29-apr	m		RF cable calibration, shock sensor arrived	feet not arrived yet in ESS	
		a		Check by RF power		
FRI	30-apr	m		CAV IN conditioning		
		a		LFD measurement		
SAT	01-maj			make strategy		
SUN	02-maj			check termiantors		
MON	03-maj	m		CAV IN heat load		
		a				
TUE	04-maj	m		doorknob mounting		Cav OUT heat load
		a				
WED	05-maj	m		start warming up		
		a				



Shock sensors are waiting to send CM05 to ESS



Schematic of our RF setup



$$E_{acc_pk_Pt} = \sqrt{\frac{Q_t P_t}{k\omega}}$$

$$E_{acc_pk_Pf} = \sqrt{\frac{4Q_L P_f}{k\omega}}$$

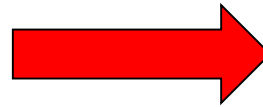
$E_{acc_pk_Pt}$	$E_{acc_pk_Pf}$
5,98785	8,49807

Tuner was fine tuned

The inconsistency in CAV IN (DSPK03) field estimated was presented in W17

Cable attenuations by Akira on April 26th

$a_f = 81.30$ dB
 $a_r = 81.55$ dB
 $a_t = 17.46$ dB

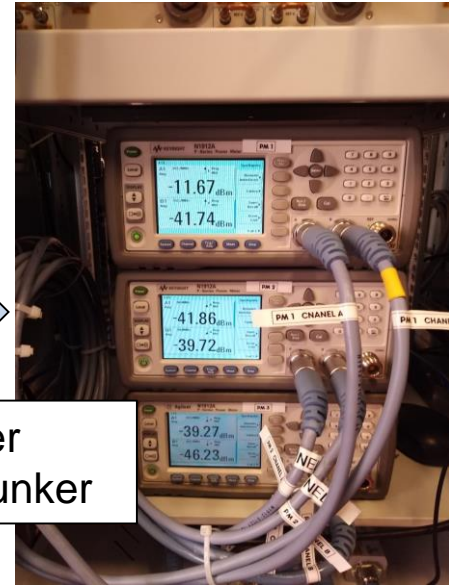
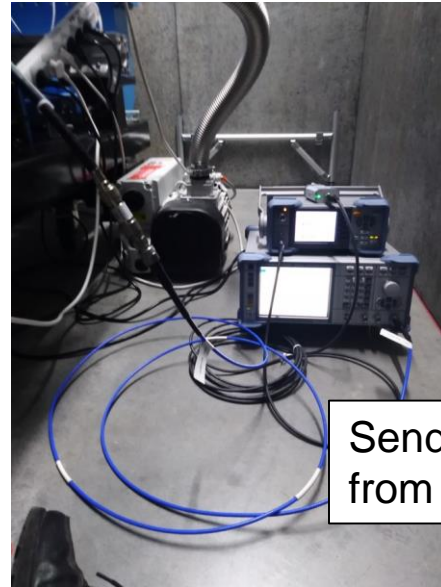
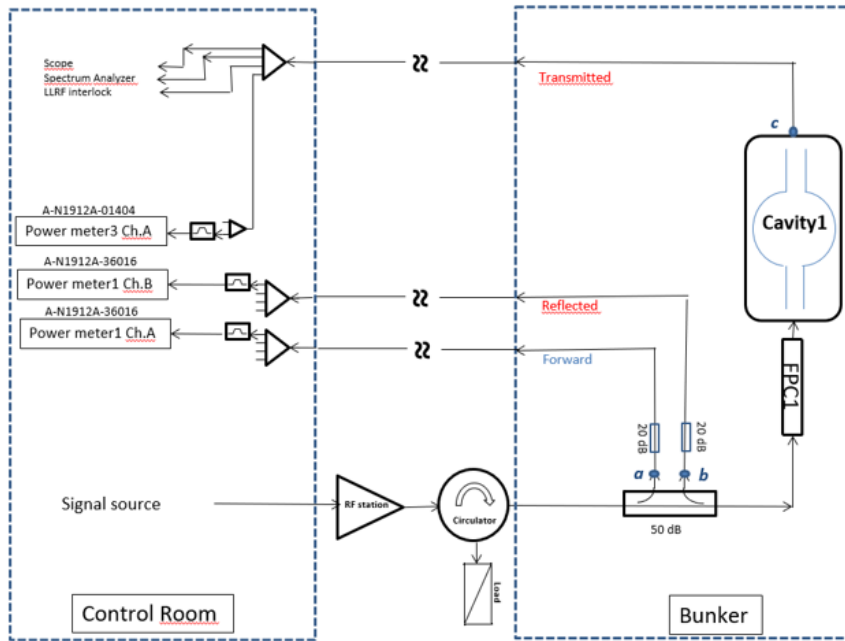


Remeasured by Mykhailo on April 29th

$a_f = 81.04$ dB
 $a_r = 81.59$ dB
 $a_t = 17.58$ dB

Consistent within 0.3 dB

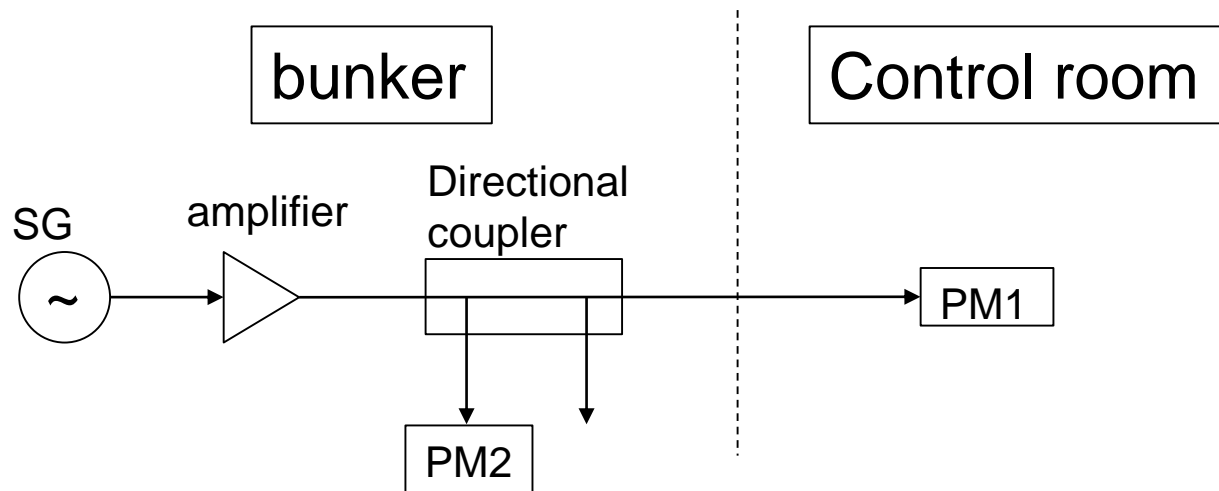
Cable calibration method



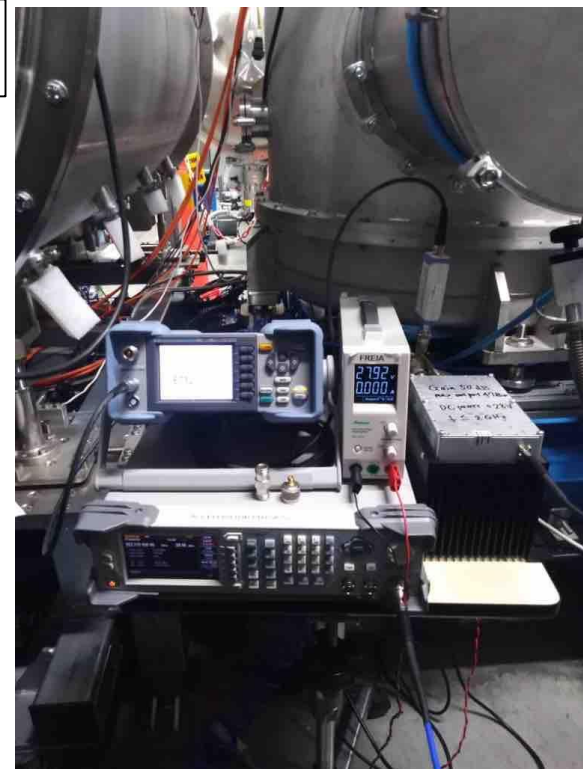
Send power from the bunker

- Standard method (same as CERN not sure of Orsay)
- Warm cables → send +20dB and check power meter reading
- Cable cables (pick-up only) → $S_{11}/2$
- Of course measurement cables are pre-calibrated
- Even if something is burned in the line, we can detect failure (we found burned 20dB attenuator in Feb 2021)
- "50dB" of directional coupler is assumed (never measured)



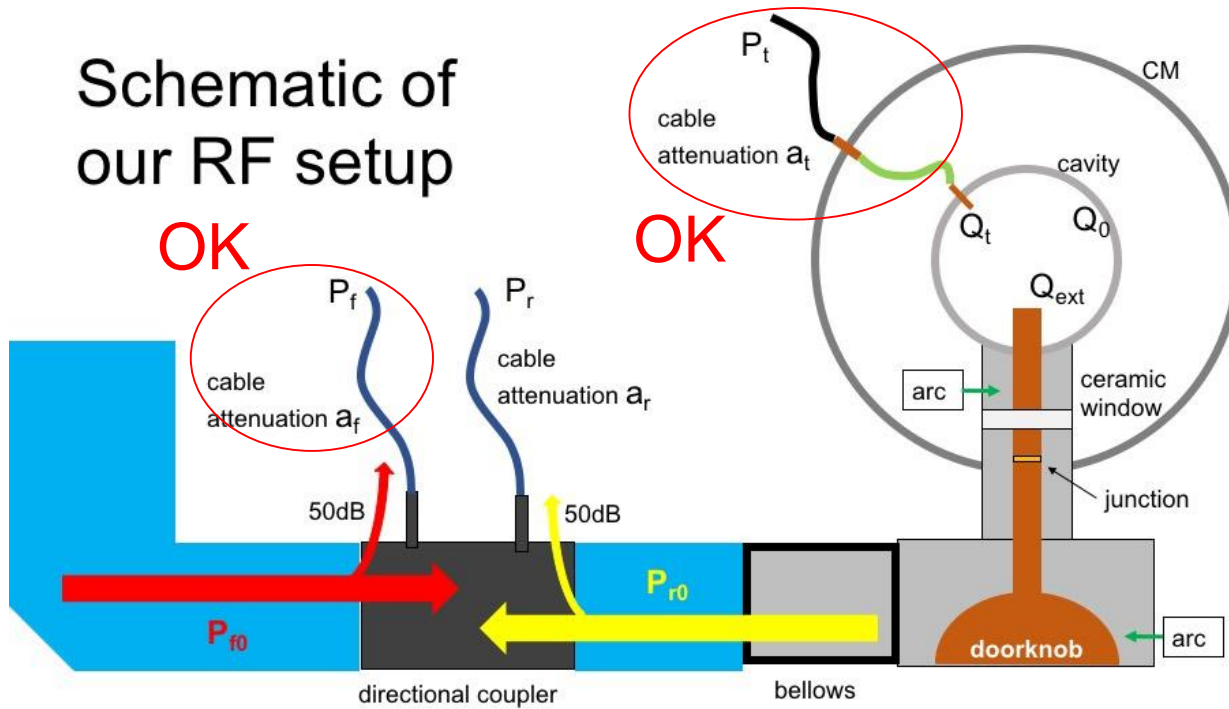


- Calibrate directional coupler in advance
- Send real power i.e. 36 dBm ($400\text{kW}=86\text{dB}$ – WR2300HH directional coupler 50 dB)
- Compare PM1 and PM2
- Same in transmitted power line



No major (>0.5 dB) difference was observed
→ Cable calibration seems OK

Schematic of our RF setup



$$E_{acc_pk_Pt} = \sqrt{\frac{Q_t P_t}{k\omega}}$$

$$E_{acc_pk_Pf} = \sqrt{\frac{4Q_L P_f}{k\omega}}$$

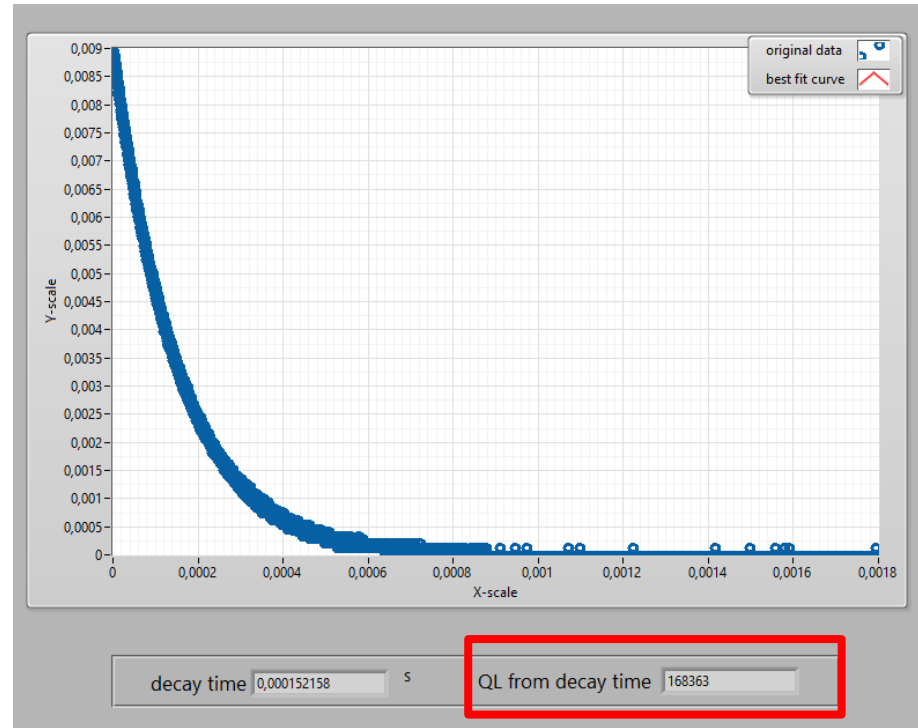
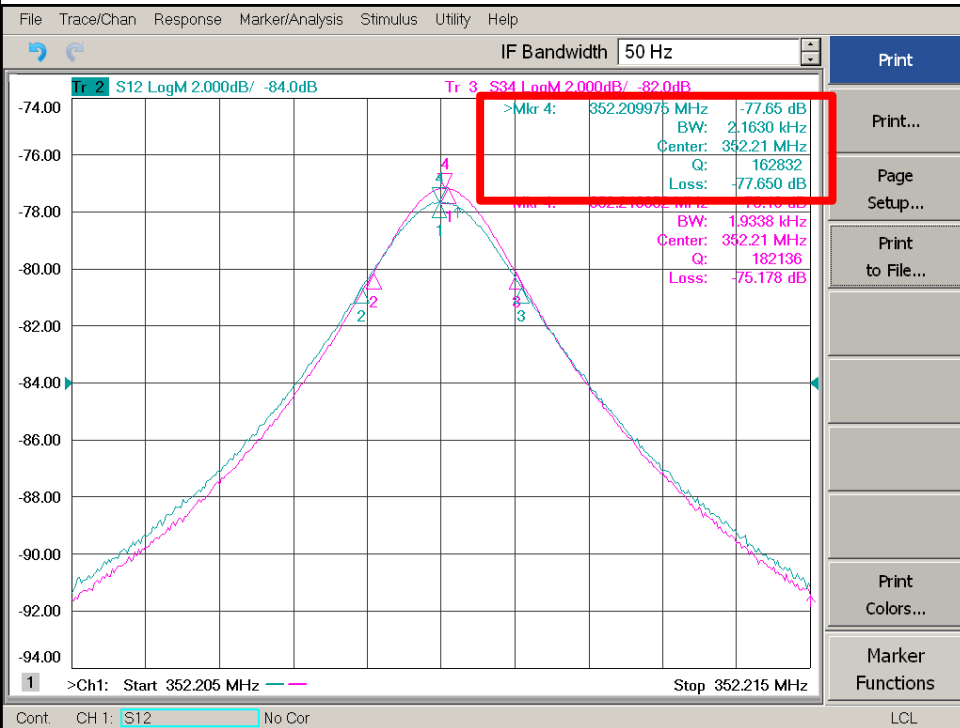
$E_{acc_pk_Pt}$	$E_{acc_pk_Pf}$
5,98785	8,49807

Tuner was fine tuned

How are Q values?

Frequency domain

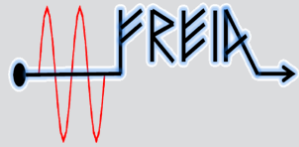
Time domain



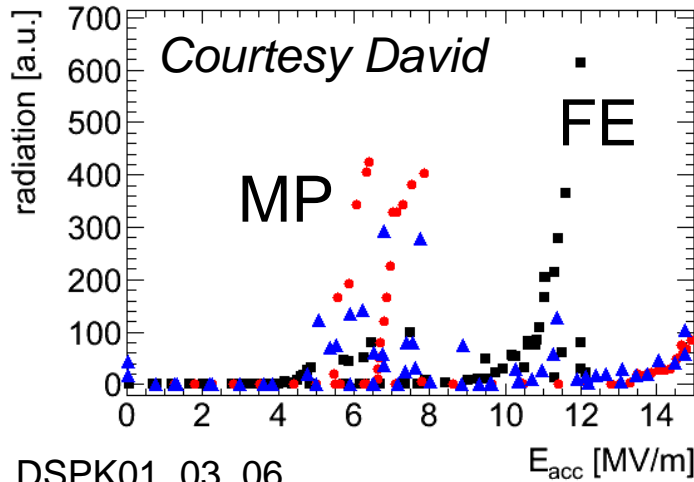
$$Q_L = 1.63 \times 10^5$$

$$Q_L = 1.68 \times 10^5$$

consistent



Multipacting happens at certain E_{acc}

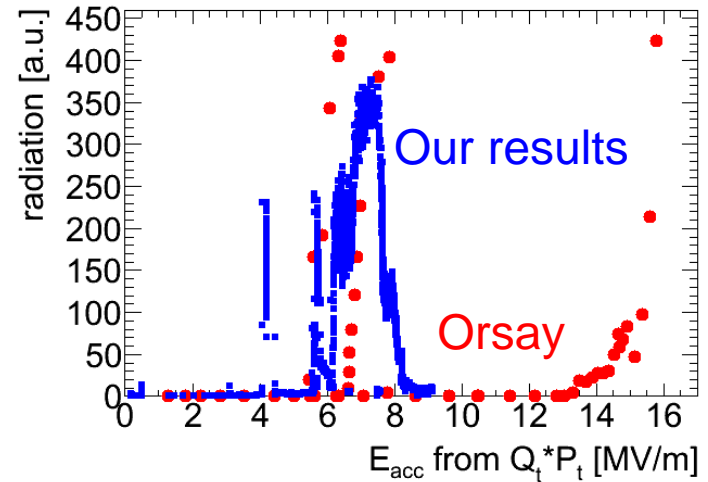


DSPK01, 03, 06
(CM01 CAVIN, CM05 CAVIN, CM01 CAVOUT)

- E_{acc} estimated from Q_t is more consistent with multipacting in Orsay
- E_{acc} estimated from $Q_L * P_f$ seems overestimated

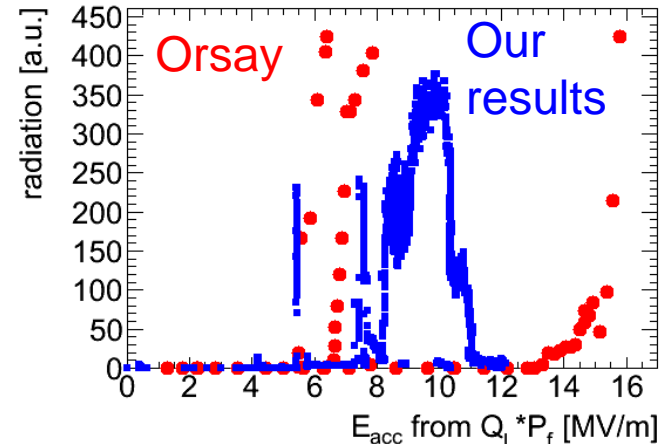
CAV IN using Q_t

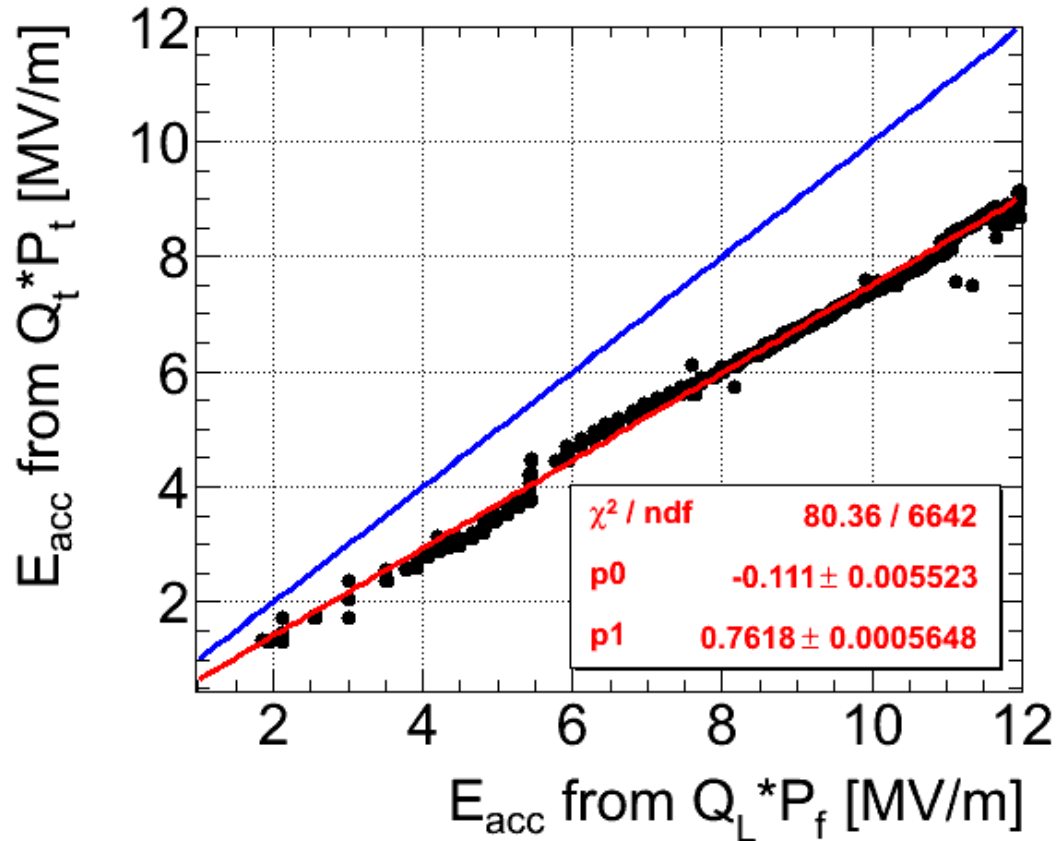
$$E_{acc_pk_Pt} = \sqrt{\frac{Q_t P_t}{k\omega}}$$



CAV IN using $Q_L * P_f$

$$E_{acc_pk_Pf} = \sqrt{\frac{4Q_L P_f}{k\omega}}$$





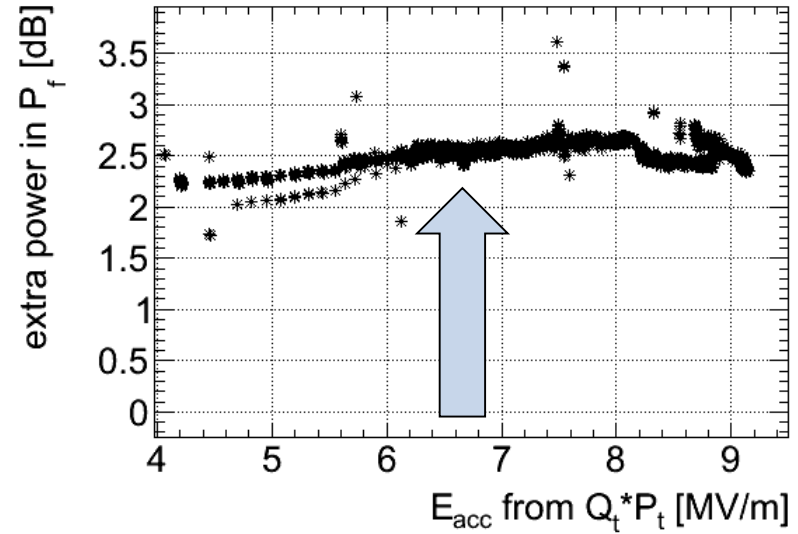
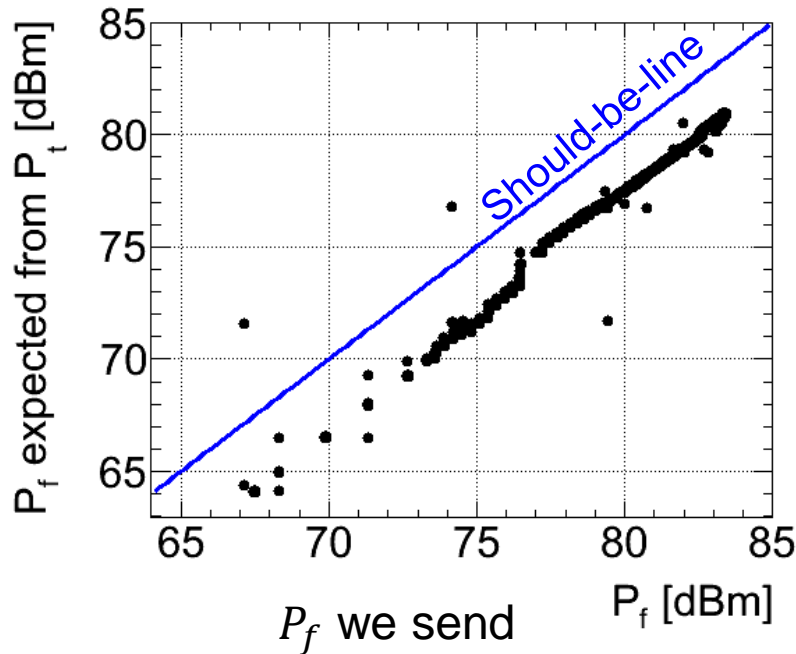
- E_{acc} estimated from $Q_L * P_f$ seems overestimated by 25%
- Since Q_L seems OK, P_f is more doubtful

$$E_{acc_pk_Pt} = \sqrt{\frac{Q_t P_t}{k\omega}}$$

$$E_{acc_pk_Pf} = \sqrt{\frac{4Q_L P_f}{k\omega}}$$

Required P_f to get certain P_t

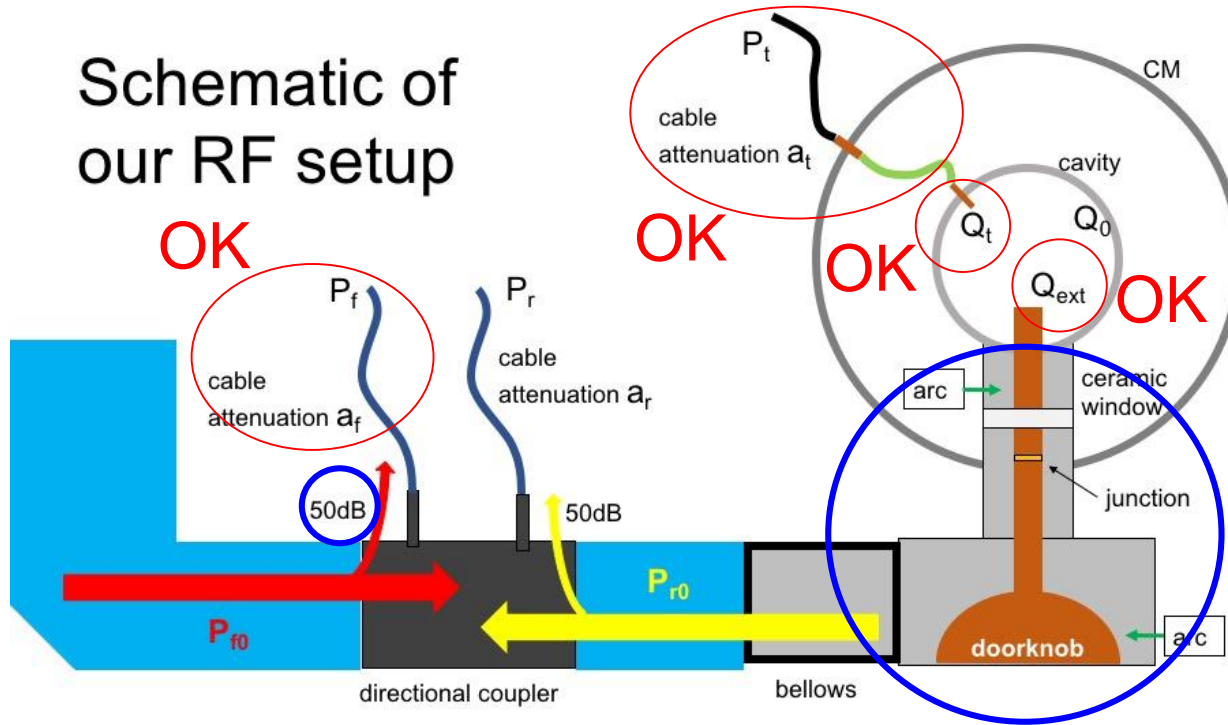
$$P_f' = \frac{Q_t}{4Q_L} P_t$$



We send 2.5 dB higher than required P_f

Is it real or measurement artifact?

Schematic of our RF setup



$$E_{acc_pk_Pt} = \sqrt{\frac{Q_t P_t}{k\omega}}$$

$$E_{acc_pk_Pf} = \sqrt{\frac{4Q_L P_f}{k\omega}}$$

Eacc_pk_Pt	Eacc_pk_Pf
5,98785	8,49807

Tuner was fine tuned

The doubt is localized to

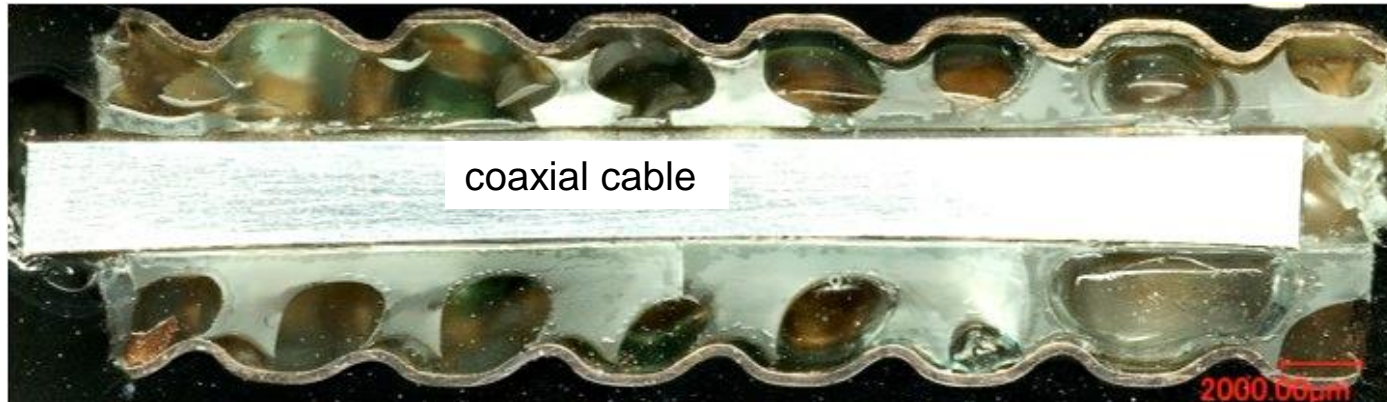
1. Accuracy of 50 dB at the directional coupler
2. Impedance mismatch at somewhere between directional coupler and the cavity, which reflects or dissipate 2.5 dB of P_f before entering the cavity
 - Electrical misconnection, corona discharge ☹☹☹, ...etc



I became sleepless

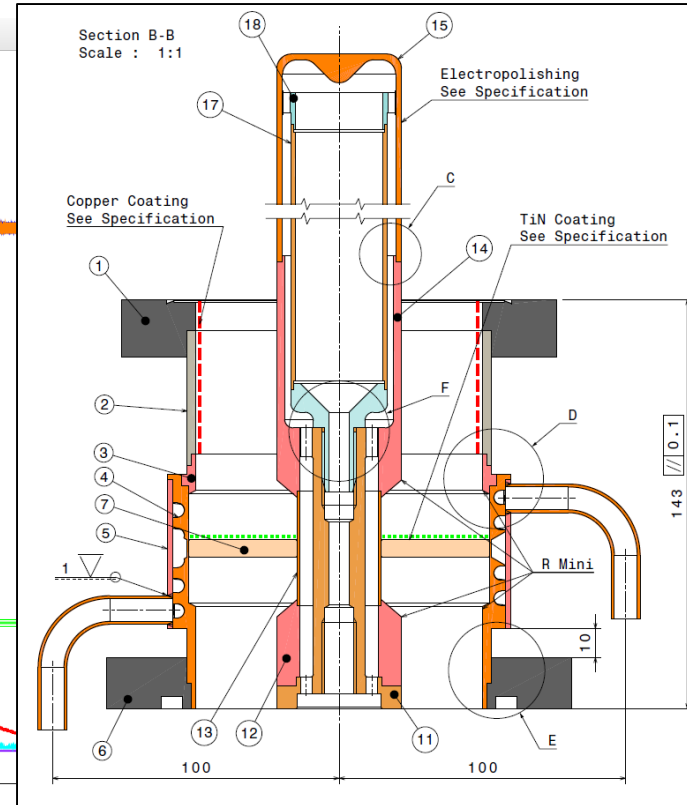
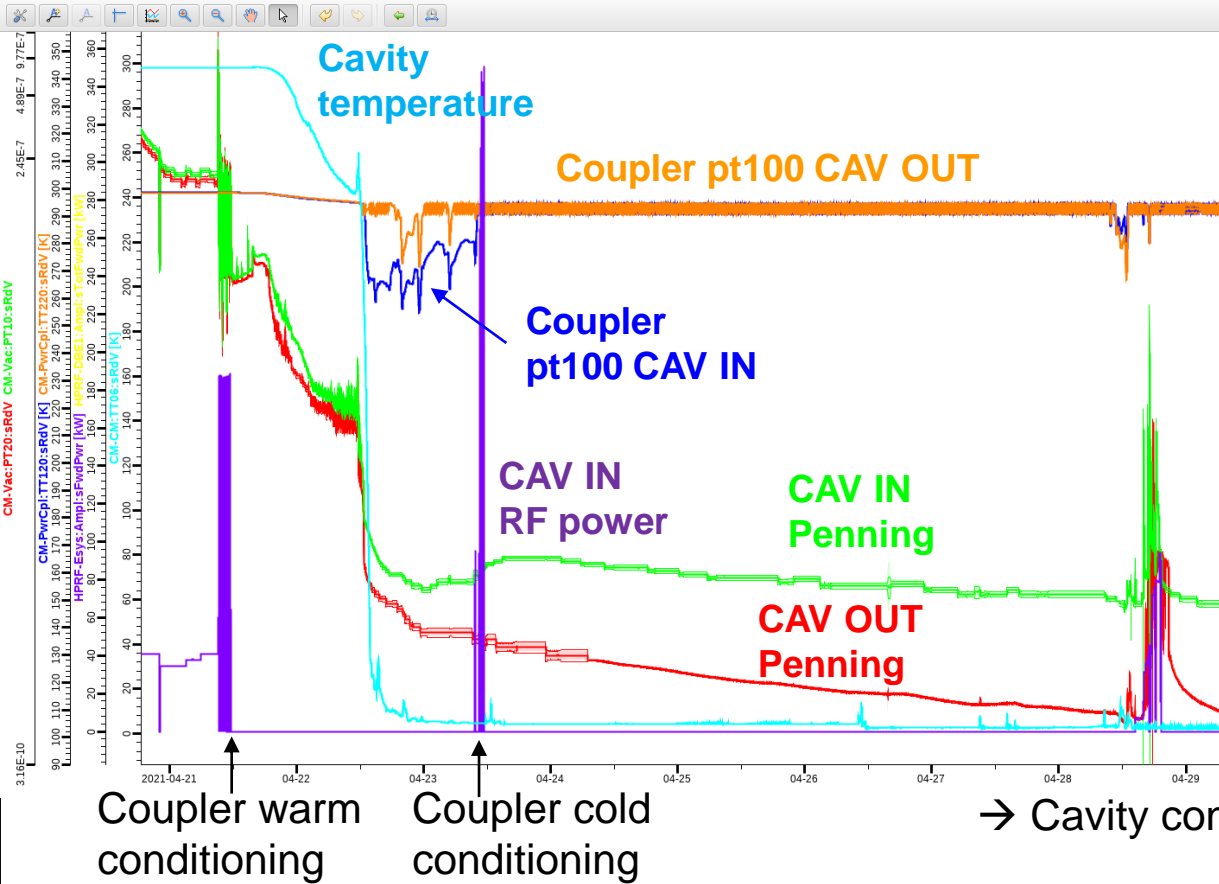


Because the power coupler in my previous project (HIE-ISOLDE @ CERN) was BBQed in a cryomodule ☹️☹️☹️



For more detail, see my presentation in TTC2015 @ SLAC

History of CAV IN coupler



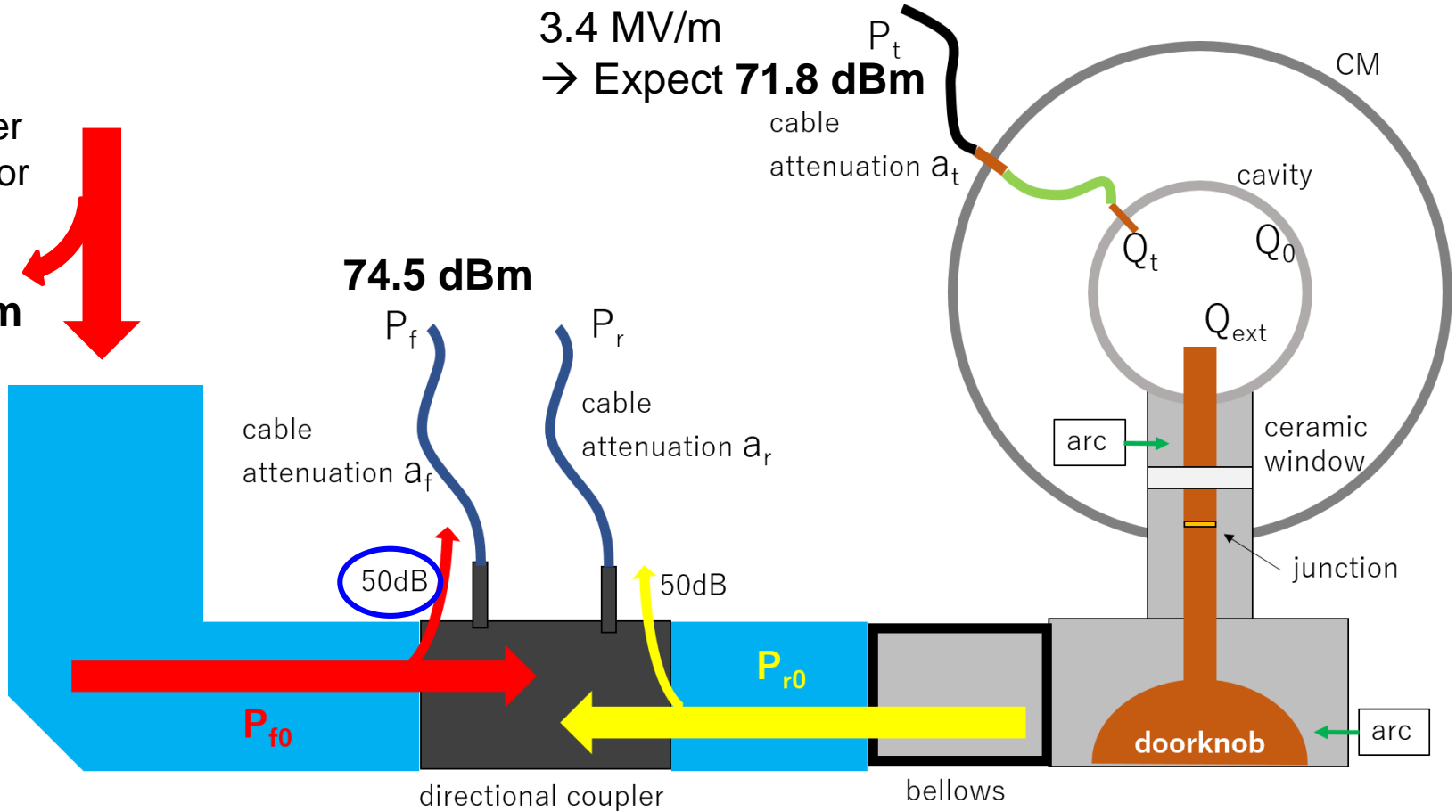
- As reported in W17, heater regulation with 110W was not sufficient to keep the “coupler temperature” above 280K
- The trend of Penning gauges changed → contamination? Leak??

Some hints?



Another directional coupler after the circulator

indicates **72.9 dBm**

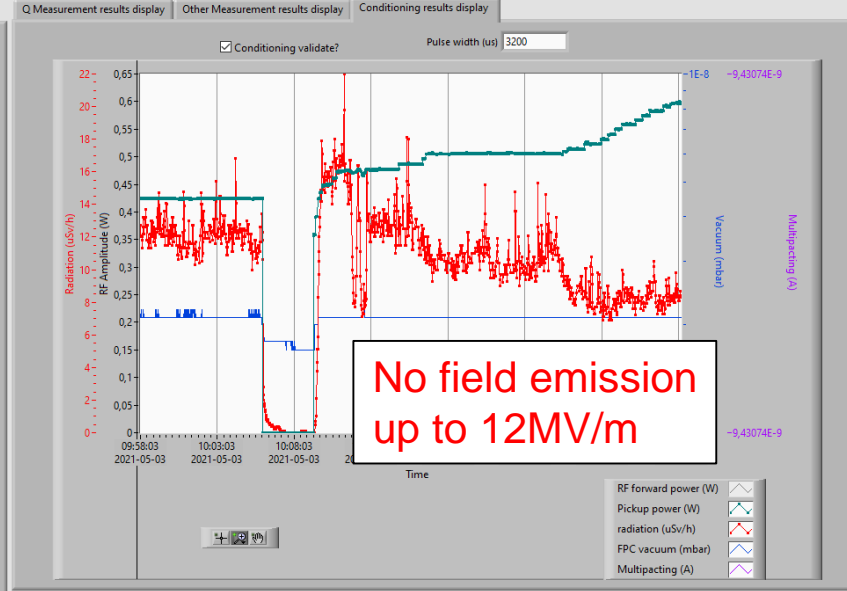
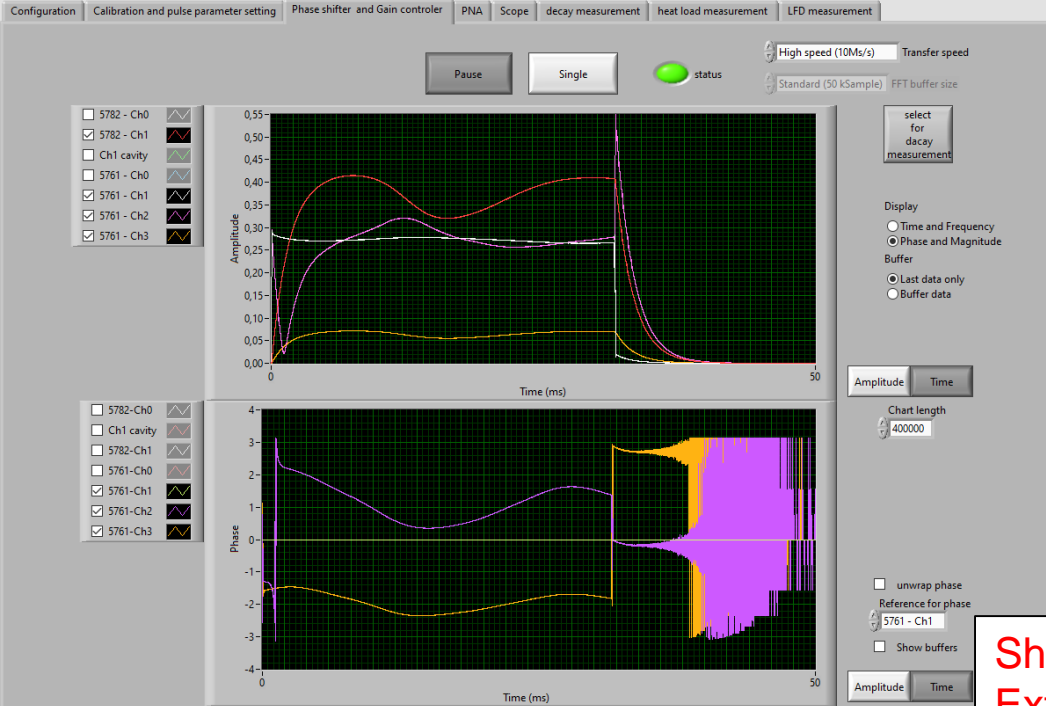


- Via another directional coupler at upstream (10-20 m), the power through the waveguide is 1.6 dB lower than the one from our interest
- 1.1 dB loss or standing-wave effect in the waveguide system might explain the issue
- We will check directional coupler, doorknob, and power coupler after warming up

Anyhow CAV IN reached 12MV/m



UPPSALA UNIVERSITET **FREIA SPOKE HIGH POWER TEST_Cav 1** time: 11:38:00 [HELP] [QUIT]



Should be 215 kW
Extra 112 kW from
somewhere

FPGA setup Mode Mixer freq [MHz] Trigger Real IO 352.1 Trigger input Output mixer frequency [MHz] Period 0 Output enabled Output delay 0 ns Output delay delta 0 ps

PID control Apaptive FF Offsets Feed forward Cavity model FF Quench detection Scale Measure Tau at Time Tau set 115 Enable Reset Quench Warning Tau [us] 164,608 Quench Warning

P_total (W) 0 P_static (W) 0 P_heater (W) 0

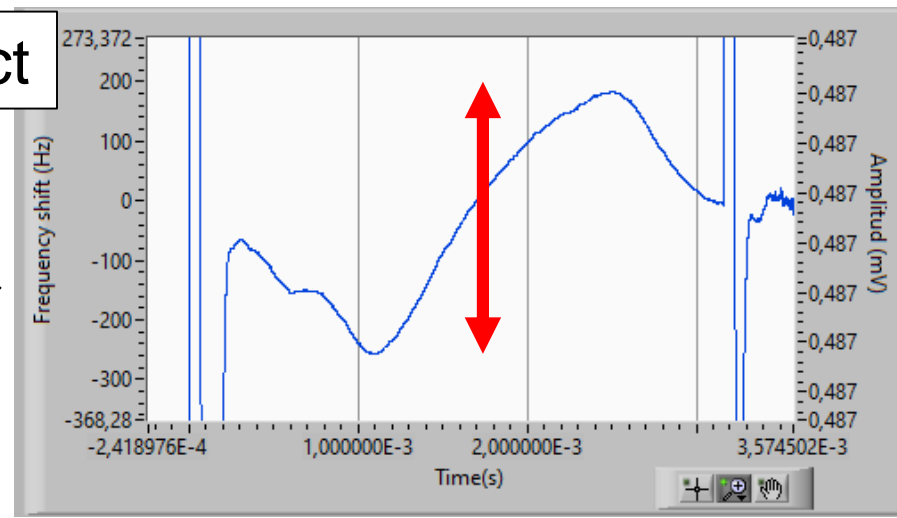
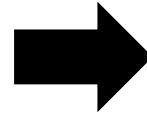
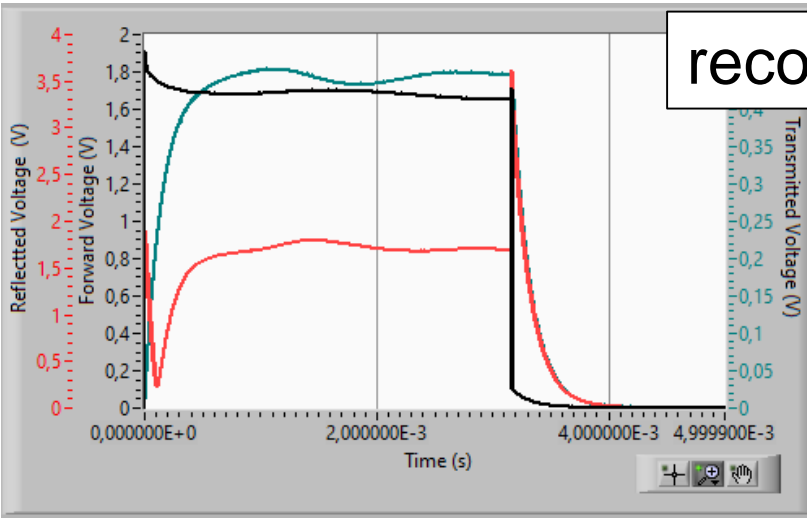
QL 163000 Qt 2,31E+11 real time frequency_fc 0E+0

Pc_dynamic(W) 0 Vc_ave (MV) 0

Pf_max (W)	Q0_Dynamic	Eacc_Dynamic	Eacc_pk_Pt	Eacc_pk_Pf
327402	0	0	12,0098	14,9236

TT04 2,09532 TT06 2,52355 PT02 9999 PT03 30.9

We rely on this

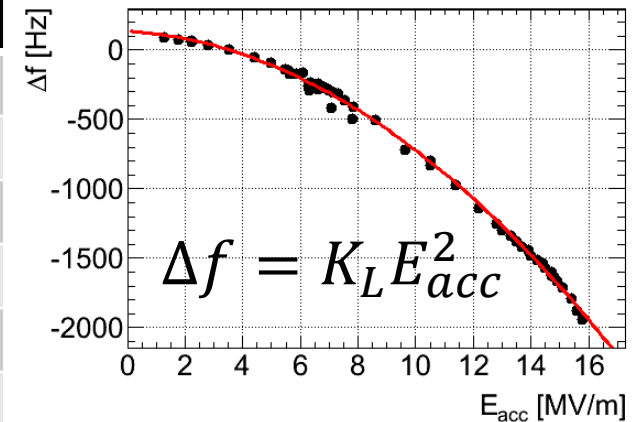


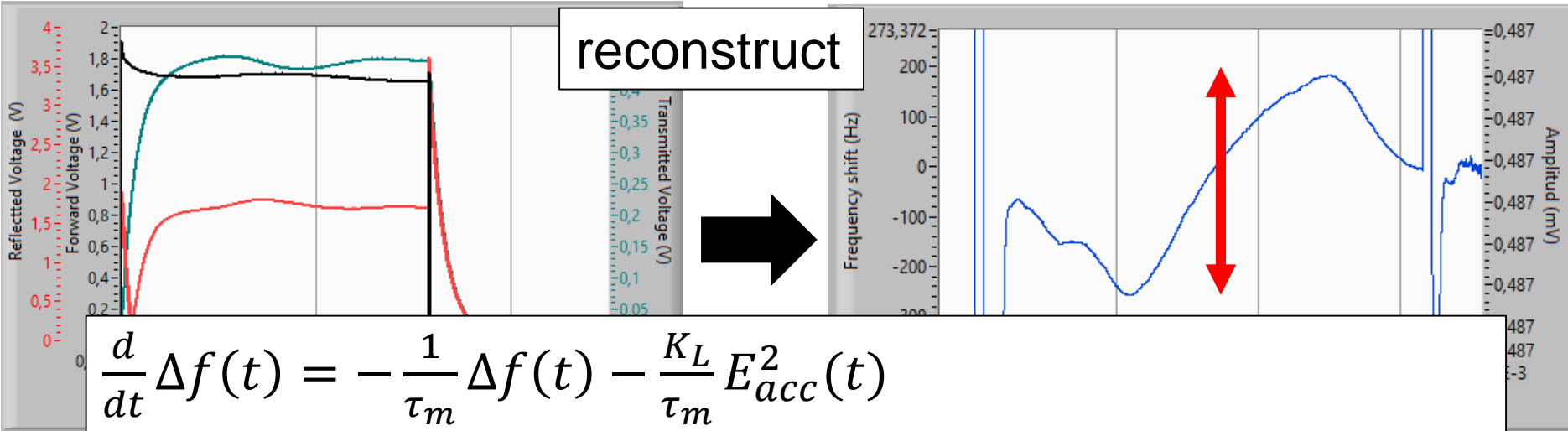
-250Hz / +200Hz @ 9MV/m (estimated from Q_t)

Cf. other cavities's dynamic LFD @ 9MV/m

DSPK03 (courtesy David)

Cavity	LFD [Hz]	Motor turns	K_L [HzMV ⁻² m ²]
CM02 CAV IN	300	3072 (1.20 mm)	-6.3
CM02 CAV OUT	270	4475 (1.75 mm)	-6.8
CM04 CAV IN	280	3617 (1.41 mm)	?
CM04 CAV OUT	300	3159 (1.23 mm)	?
CM05 CAV IN	-250 / +200	4670 (1.82 mm)	-7.3
CM05 CAV OUT	-150 / +120	2590 (1.01 mm)	?





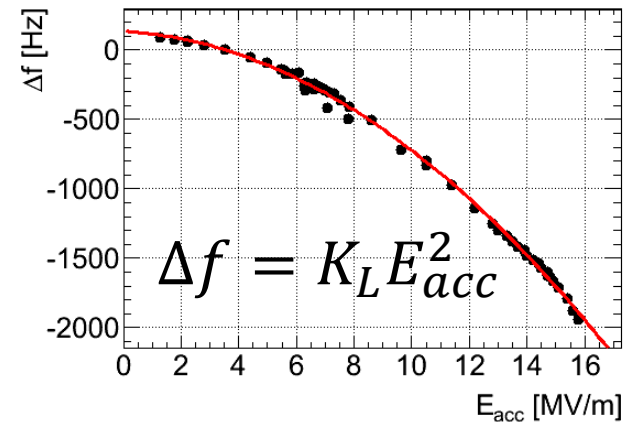
$$\frac{d}{dt} \Delta f(t) = -\frac{1}{\tau_m} \Delta f(t) - \frac{K_L}{\tau_m} E_{acc}^2(t)$$

$$\frac{d}{dt} E_{acc}(t) = -[\omega_{1/2} - i2\pi\Delta f(t)] E_{acc}(t) + 2\omega_{1/2} V_f(t)/L_{acc}$$

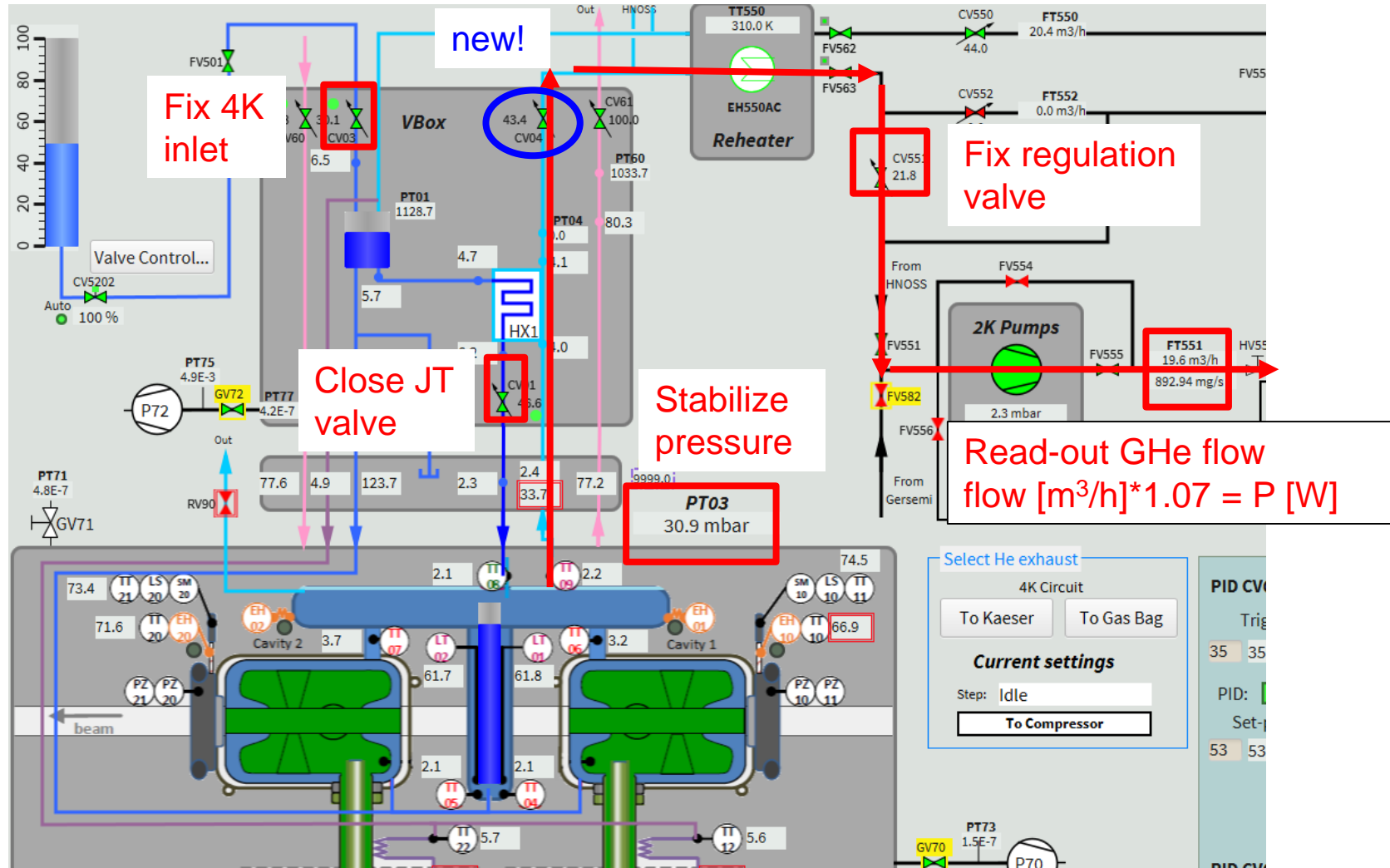
Cf. other cavities dynamic LFD @ 91MV/m

DSPK03 (courtesy David)

Cavity	LFD [Hz]	Motor turns	K_L [HzMV ⁻² m ²]
CM02 CAV IN	300	3072 (1.20 mm)	-6.3
CM02 CAV OUT	270	4475 (1.75 mm)	-6.8
CM04 CAV IN	280	3617 (1.41 mm)	?
CM04 CAV OUT	300	3159 (1.23 mm)	?
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CM05 CAV OUT	-150 / +120	2590 (1.01 mm)	?

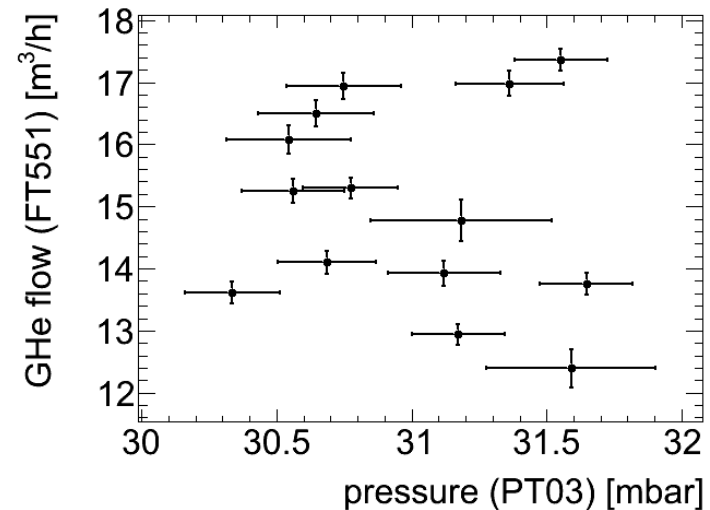
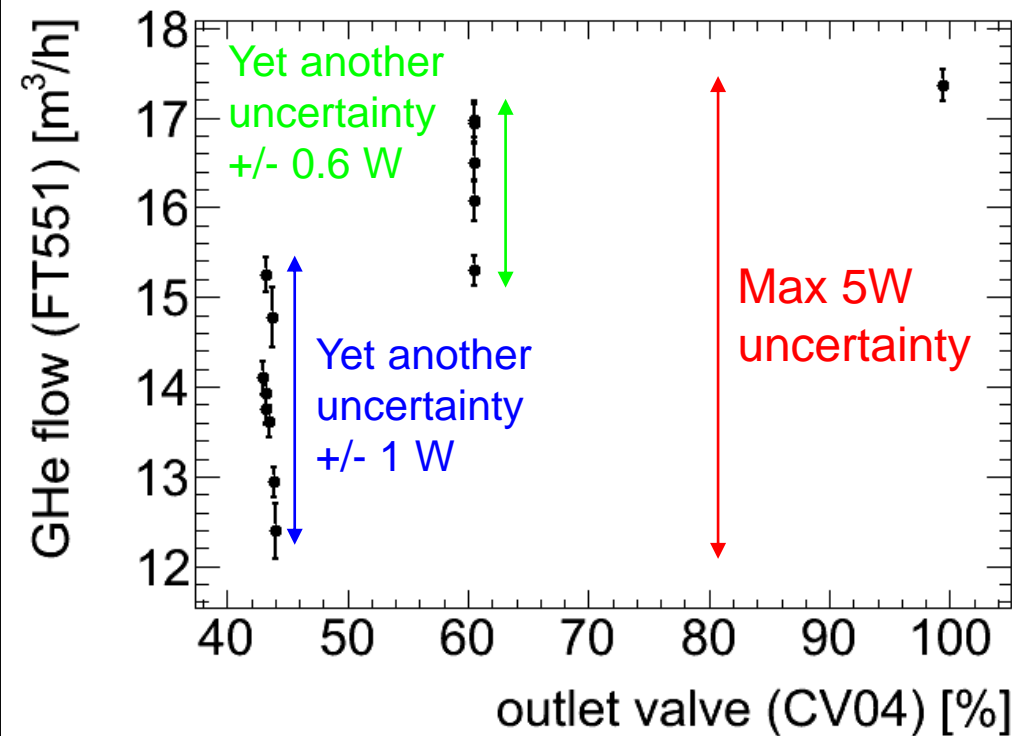


Our standard method



GHe flow depends on outlet valve

- Even if the cryomodule pressures is stabilized around 31 mbar, the flow is systematically increased by the outlet valve opening
- No correlation to the pressure but strong correlation to outlet valve opening

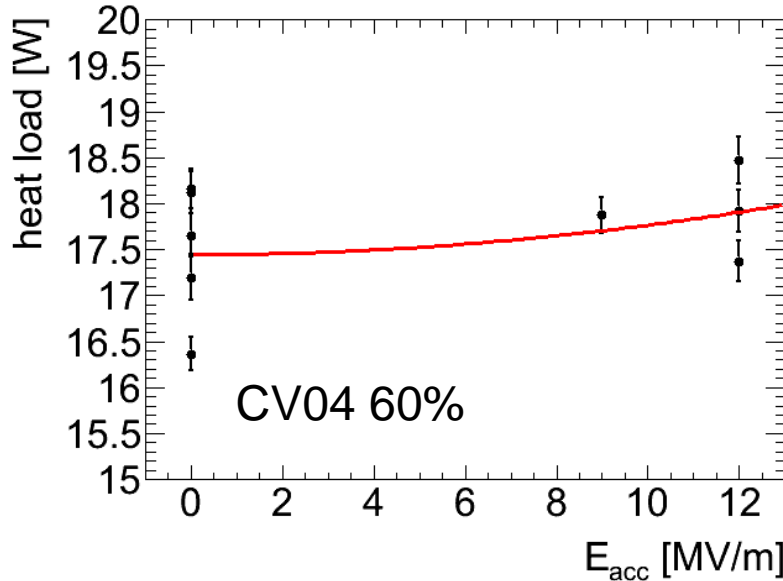


Once we understand the cause of uncertainty, we will be able to correct it

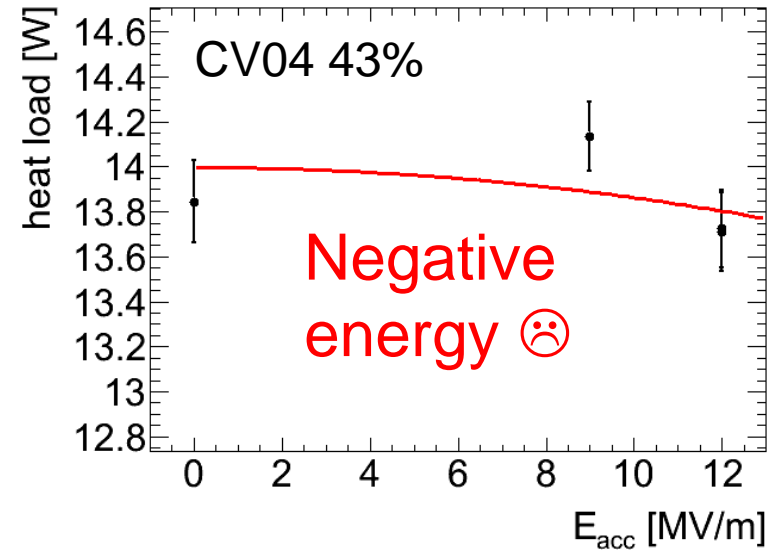
- We do not know which valve opening reflects the true heat load (5W uncertainty)
- All the other cryomodules were measured with CV04=43% condition with 1.6 W (tentative) relative uncertainty



CAV IN



CAV OUT



Parabolic fitting $P_{tot} = P_{stat} + P_{dynamic} = P_{stat} + A \times E_{acc}^2$ failed

	CAV IN	CAV OUT
P_{stat} [W]	17.46 ± 0.10	14.00 ± 0.16
$P_{dynamic}$ @9MV/m [W]	0.26 ± 0.09	-0.11 ± 0.12
Q_0	(1.3×10^{10})	$(> 1.4 \times 10^{10})$
Q_0 with \pm syst. (tentative)	$> 2.4 \times 10^9$	$> 1.7 \times 10^9$

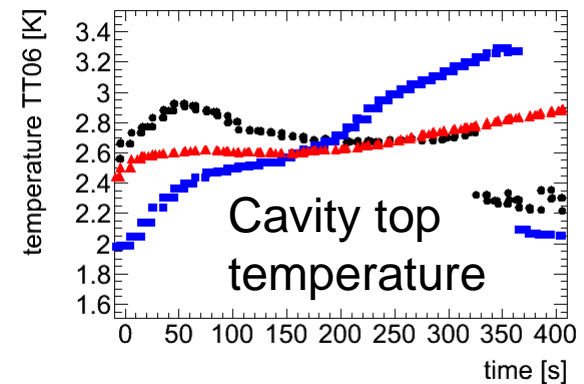
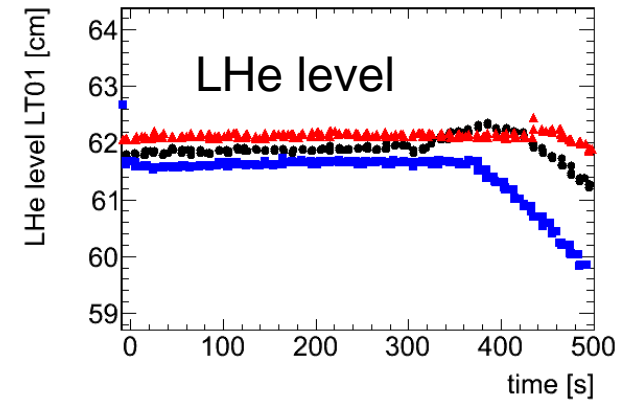
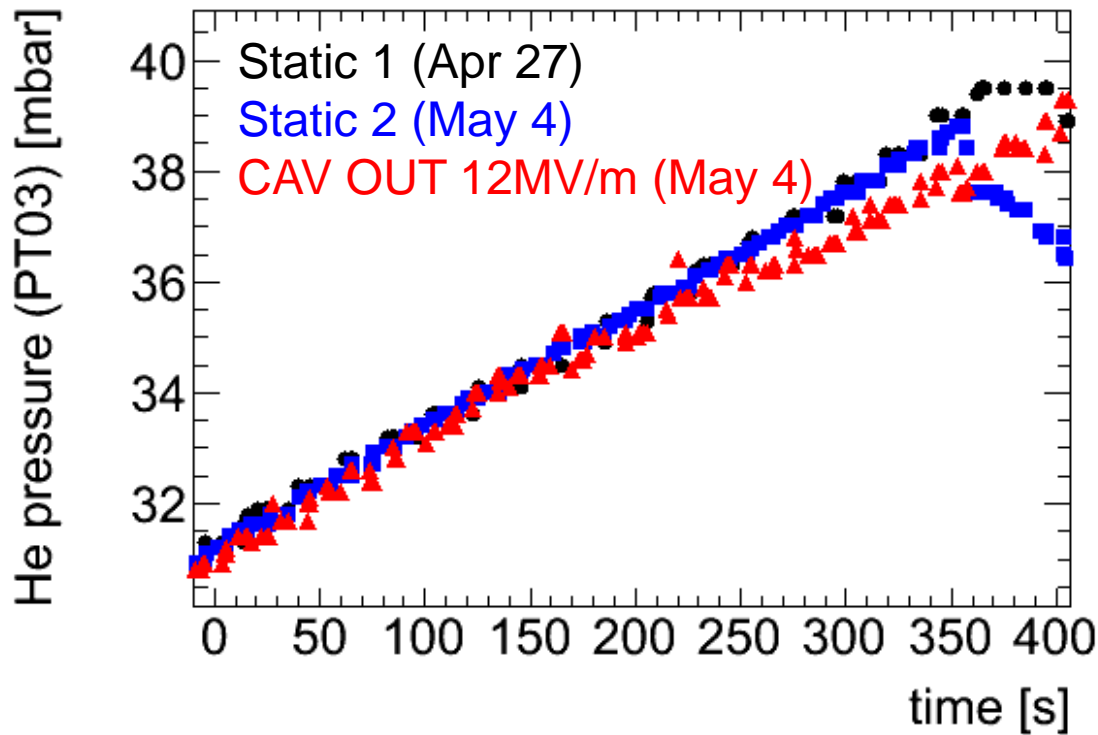
0 consistent

Anyway OK

(spec. $> 1.5 \times 10^{10}$)

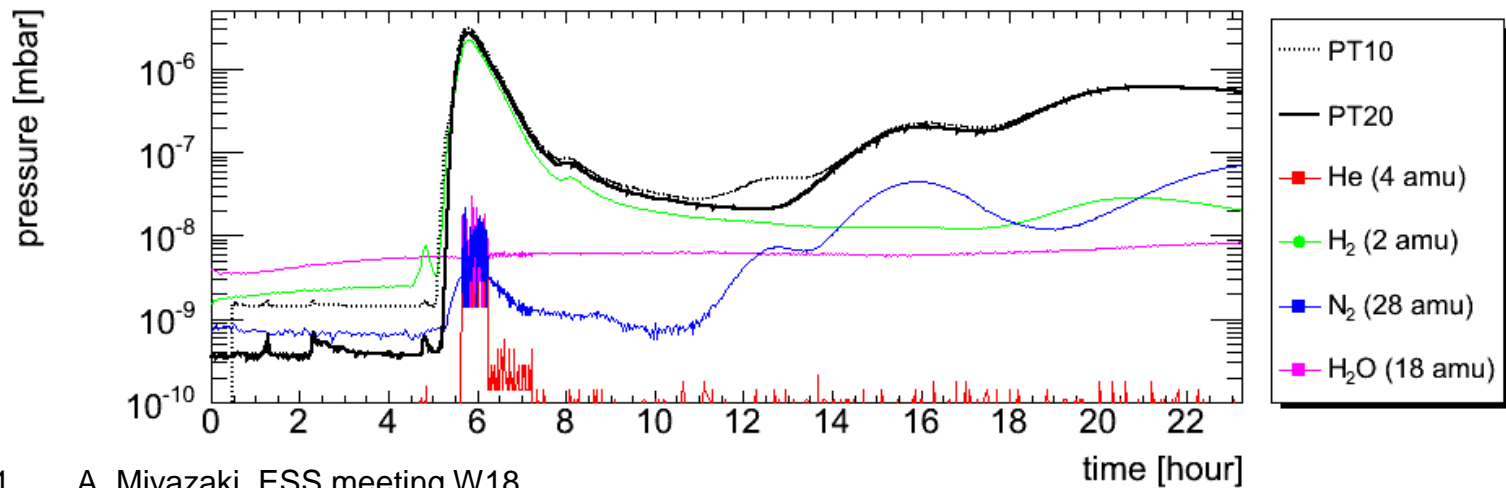
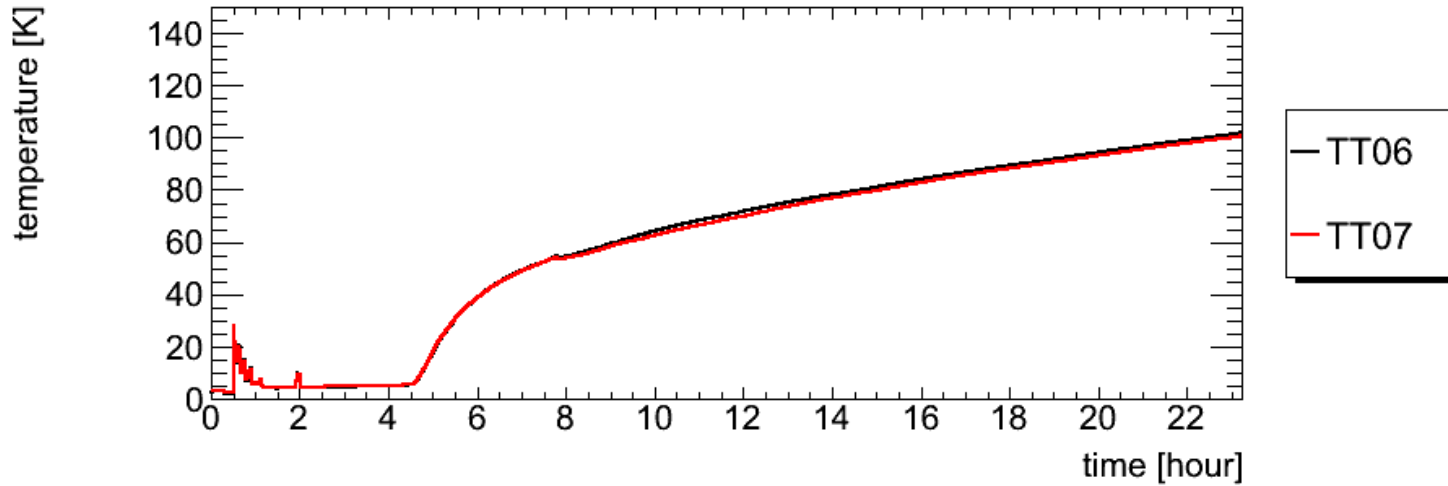


- Close both inlet (CV01 JT valve) and outlet (CV04)
- Less parameters than flow measurement
- Check pressure rise

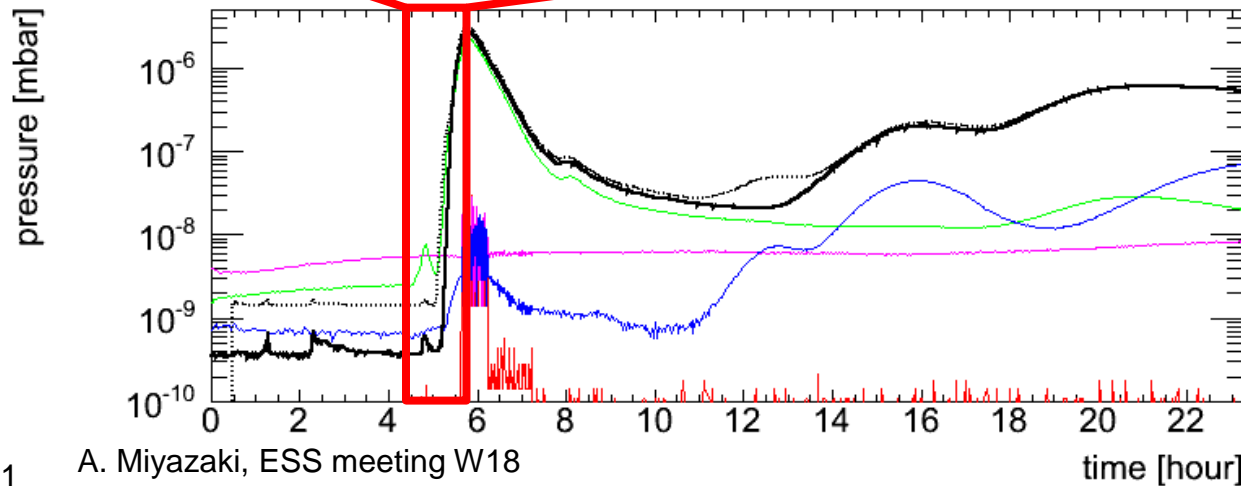
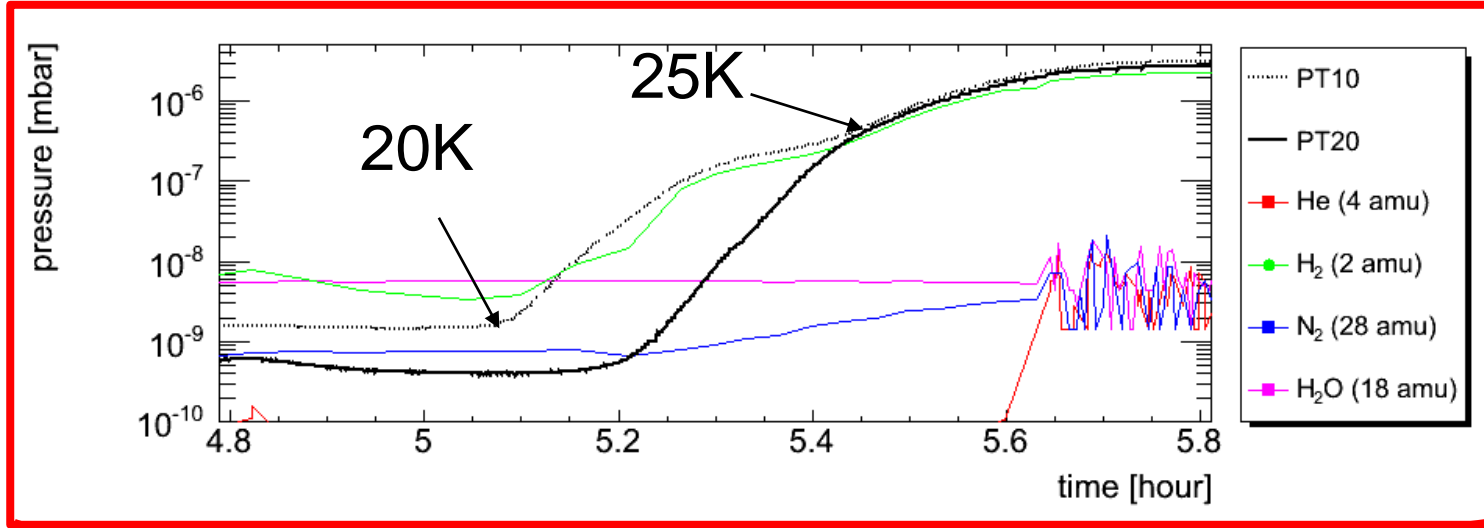


Reproducible but no resolution for RF power dissipation <1W

Warming up in progress



Warming up in progress

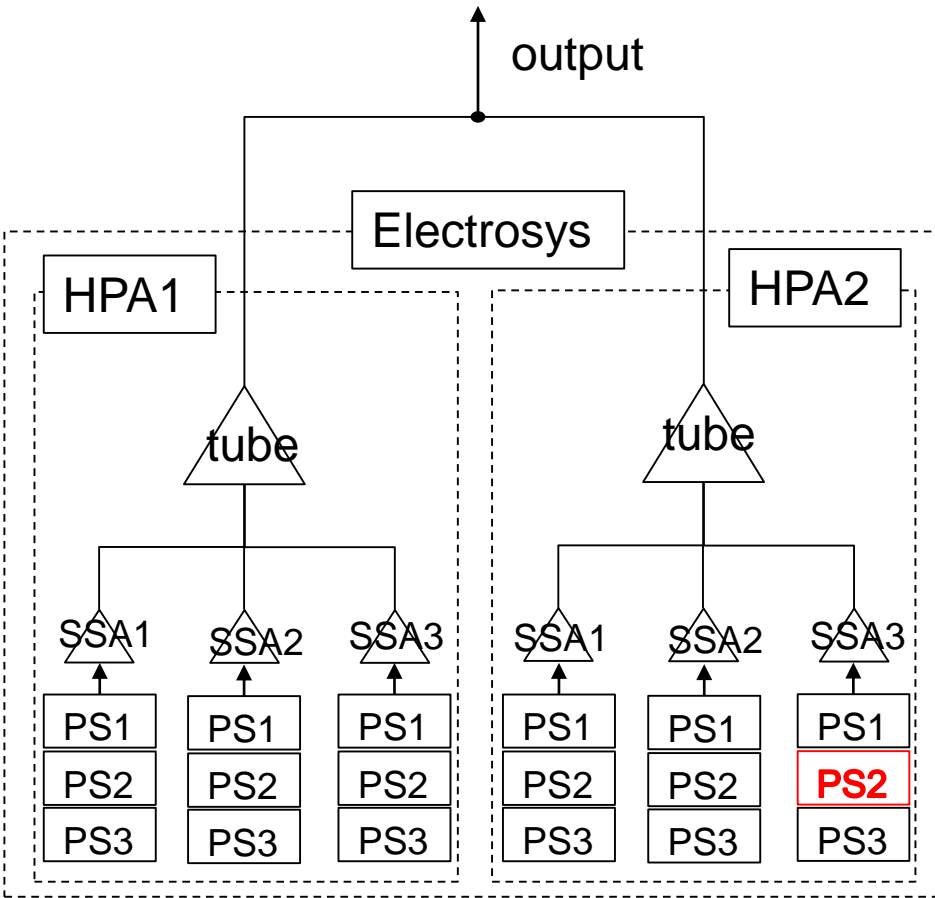


**PT10 CAV IN
coupler more
contaminated?**

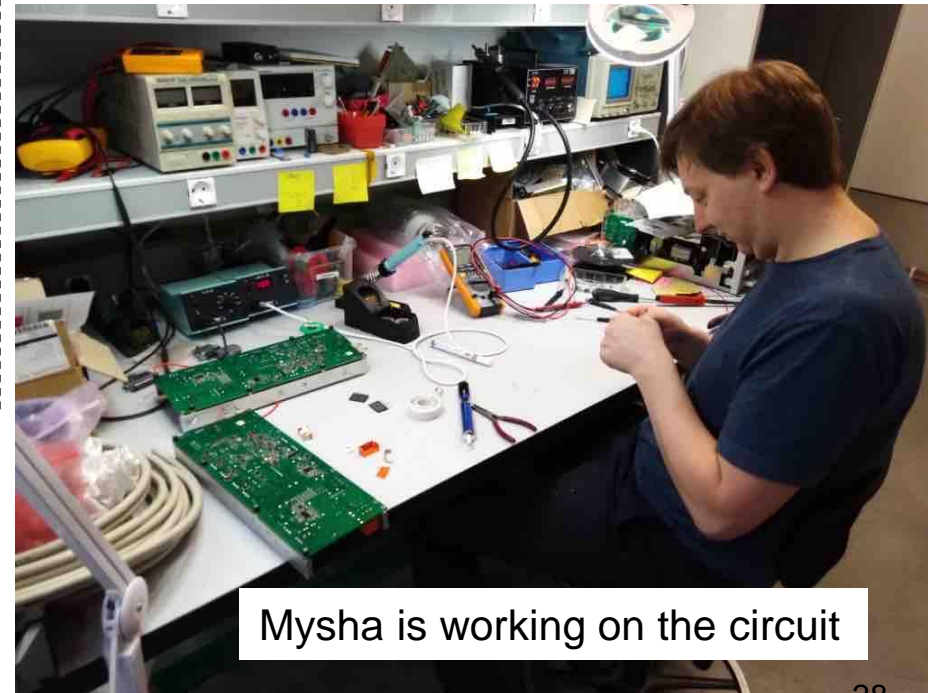
Electrosys is being repaired



Issue found in W15



(This error does not trip interlock)



Mysha is working on the circuit

- Delivery of spare PSs around middle of May
- No major impact to the project



Plan W19 & W20



W19 2021			next next CM	next CM	CM under test	
			CM01	CM03	CM05	
THU	06-maj	m a	prepared at Orsay		warm up	
FRI	07-maj	m a				
SAT	08-maj					
SUN	09-maj				swap: CM03 in front of the bunker, CM05 in the docking area	dismount bellows
MON	10-maj	m a				investigation of fault
TUE	11-maj	m a				
WED	12-maj	m a				

Tentative plan because we have not understood the origin of 2.5 dB

Measure waveguide system to explain missing 2.5 dB

W20 2021			next next CM	next CM	CM under test	
			CM01	CM03	CM05	
THU	13-maj	m a	longer weekend			
FRI	14-maj	m a				
SAT	15-maj					
SUN	16-maj					
MON	17-maj	m a	ready for shipping to Uppsala?	move to bunker connect cryogenic bellows	investigation of fault	
TUE	18-maj	m a		vacuum connection		doorknob
WED	19-maj	m a			Vacuum pumping	out-going test

If burned mark and/or impedance issue in CAV IN coupler is found, we need to change the plan

- **CM03 coupler conditioning after May 20th**
- **In the best case, CM05 ready for shipping after May 19th**
- **CM01 must arrive after CM05 departure**