UPPSALA UNIVERSITET

ESS weekly meeting (W17)

A. Miyazaki et al.

W17: what was performed

W17 2021			next CM	CM under test	previous CM
			CM03	**CM05**	**CM02**
THU	22-apr	m	reception	4K cooling	discussion on feets fixed by Guillaume
		a	thermalization at FREIA		
FRI	23-apr	m		4K filling, cavity alignment, coupler cold conditioning	
		a			
SAT	24-apr			thermalization	
SUN	25-apr				
MON	26-apr	m	open, shock sensor, LEMO, reception test	2K pumping, f vs P measument (VNA)	
		a	VNA measurement	RF cable calibration	
TUE	27-apr	m	arc detector, e-pickup	CTS, piezo tests, static heat load measurement	
		a			
WED	28-apr	m		static heat load, LLRF interlock setup, cavity conditioning	
		a			

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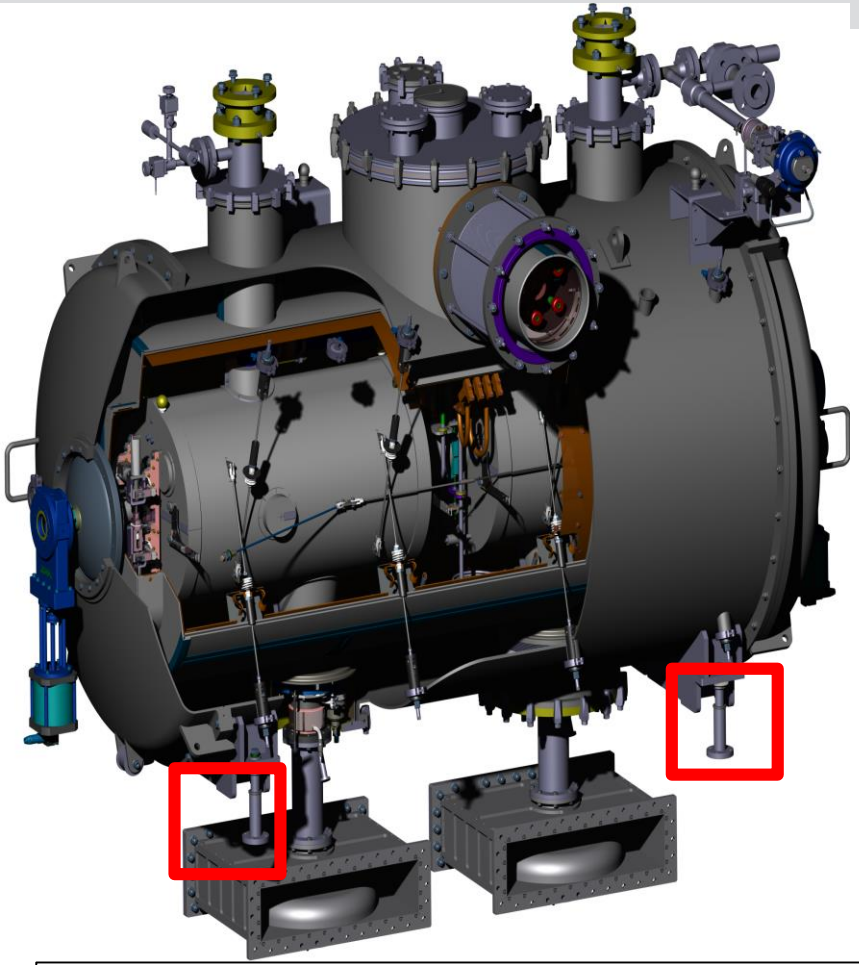
		a			
WED	28-apr	m		static heat load, LLRF interlock setup, cavity conditioning	
		a			

CM02 received by ESS: feet



- Adjustable feet are necessary to unload CM from the box
- Two set of feet are used by FREIA for the test and CM02 was without the set
- A set of feet are shipped with jumper bellows for each CM
- **Solution: Guillaume sends spare feets for CM02 directly to ESS and we will send a set of CM+feet+jumper for CM05 and CM03**

CM02 received by ESS: alignment

Felix asked:
To check the **alignment of the string after transport**, and later **also in the tunnel** we would like to apply the same procedure than you do at FREIA.

Akira answered:
We do not and/or cannot perform such tests because our measurement is **only relative** to compare before/after cooling down

Guillaume, does Felix need to this measurement as he proposed, or is it unnecessary?

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		a	VNA measurement	RF cable calibration	
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		a			
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		a			

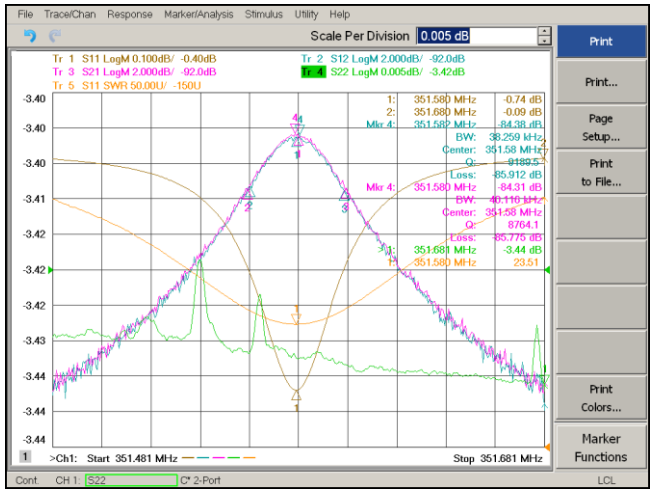
CM03 reception and preparation

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

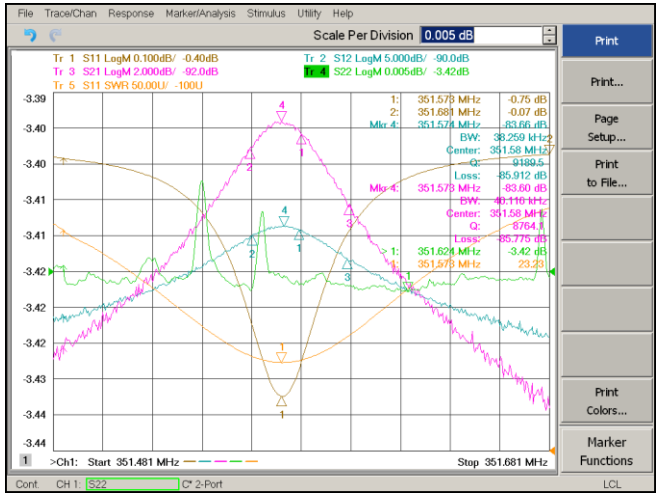
- No major shocks by the new transporter
- shock sensors returned to Orsay
- Distribute workloads to all colleagues to compensate Han Li

CM03 cavities at warm

CAV IN



CAV OUT



At Orsay

2021-03-26	
HP	HP
19,4	19,5
1,90E-03	1,90E-03
PA	PA
PA	PA
RF measurements @ T=300K before testing / [measurement after final cavity alignment]	
Cavity IN	Cavity OUT
DSPK09	**DSPK12**
CPL06	**CPL26**
DWT02	**DWT19**
-0,1161	-0,122
-0,7808	-0,8074
-80,671	-80,507
351,578	351,570
352,154	352,142
0,000	-0,004
39,31	40,06
8942	8770
-1,83	-1,84
13824-010-05	13824-010-06
-3,55	-3,43
3,00E+11	3,00E+11
2,20E+11	2,10E+11
Results (under coupled)	
-0,66	-0,69
-78,8	-78,7
2,43E+05	**2,31E+05**
2,04E+05	**2,10E+05**
1,01E+11	**9,93E+10**
9284	9116
132	129

Our measurement

2021-04-26	
Agilent	
3,70E-03	
PA	
PA	
RF measurements @ T=300K after delivery	
Cavity IN	Cavity OUT
DSPK09	**DSPK12**
CPL06	**CPL26**
DWT02	**DWT19**
-0,09	-0,07
-0,74	-0,75
-84,31	-83,6
351,58	351,573
39,19	39,19
8977	8977
Results (under coupled)	
-0,7	-0,7
-84,3	-83,6
2,49E+05	**2,38E+05**
3,46E+11	**3,07E+11**
9313	9328
132	132

CM03 sensors

All OK

To be uploaded to Atrium

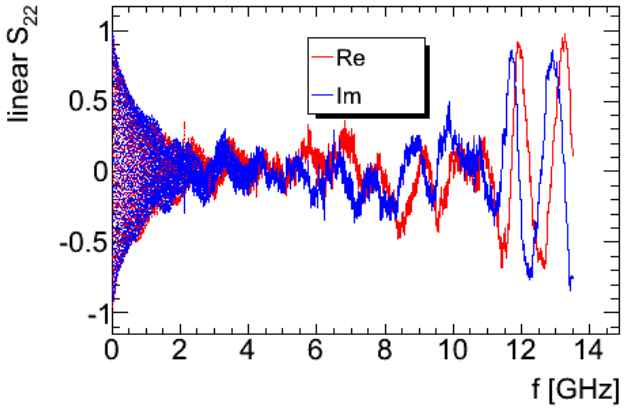
Cables verification CM03 at IJCLab			v1
Socket assembly		Verified by : J.-C. Roux	
Socket name	*PID name*	*Electrical value (Ω) (before shipment)*	*C / NC*
LC01	TT04	66,27	C
	TT05	66,42	C
	TT06	63,58	C
	TT07	66,01	C
	TT08	62,51	C
	TT09	71,25	C
	TT10	108,55	C
	TT11	108,6	C
	TT12	69,44	C
	TT20	108,37	C
	TT21	108,43	C
	TT22	64,23	C
PT Coupler	TT120	108,50	C
	TT220	108,51	C
LC02	EH01	84,17 Ω	C
	EH02	84,74 Ω	C
	EH10	82,54 Ω	C
	EH20	84,74 Ω	C
LC03	SM10	2,46 / 2,49 Ω	C
	LS10	2,14 Ω	C
	SM20	2,51 / 2,40 Ω	C
	LS20	2 Ω	C
LC07	LT01	366,70 Ω	C
	LT02	369,55 Ω	C
Socket name	*PID name*	*Electrical value (µF) (before shipment)*	*C / NC*
LC04	PZ10	13,58 µ	C
	PZ11	13,25 µ	C
	PZ20	13, 20 µ	C
	PZ21	13,52 µ	C

Cables verification CM03 at UU			v1
Socket assembly		Verified by :	
Socket name	*PID name*	*Electrical value (Ω) (before shipment)*	*C / NC*
LC01	TT04	66,25	C
	TT05	66,35	C
	TT06	66	C
	TT07	63,65	C
	TT08	62,6	C
	TT09	71,4	C
	TT10	106,6	c
	TT11	106,9	C
	TT12	69,5	c
	TT20	106,8	C
	TT21	106,45	C
	TT22	64,35	c
PT Coupler	TT120	107,87	c
	TT220	107,85	c
LC02	EH01	84.6 Ω	c
	EH02	83.9 Ω	C
	EH10	82.5 Ω	C
	EH20	82.4 Ω	C
LC03	SM10	2.3 / 2.3 Ω	C
	LS10	2 Ω	C
	SM20	2.5 / 2.6 Ω	C
	LS20	2.1 Ω	C
LC07	LT01	363,95	c
	LT02	367,55	C
Socket name	*PID name*	*Electrical value (µF) (before shipment)*	*C / NC*
LC04	PZ10	14.68 µ	C
	PZ11	14.53 µ	C
	PZ20	14.35 µ	C
	PZ21	14.52 µ	c

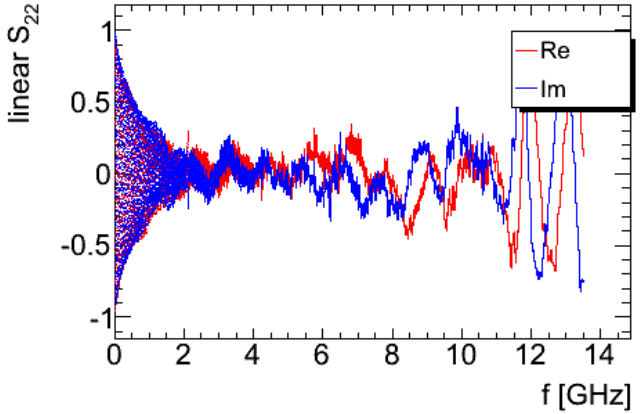
	Before shipment to UU							After delivery @ UU	
Identification number	Thermocoax assembled on Double Wall Tube n°	Cavity string n°	Coupler's serial number	Cavity number	Factory measured values (Ω)	Measured values cryomodule before shipping @ UU (Ohm)	C / NC	Measured values (Ω)	C / NC
AMG59/25	2	3	6	09 (IN)	2,81	3	C	2,7	C
AMG59/04	19	3	26	12 (OUT)	2,53	2,6	C	2,4	C

CM03: Time Domain Analysis of pick-up cable

Frequency domain raw data

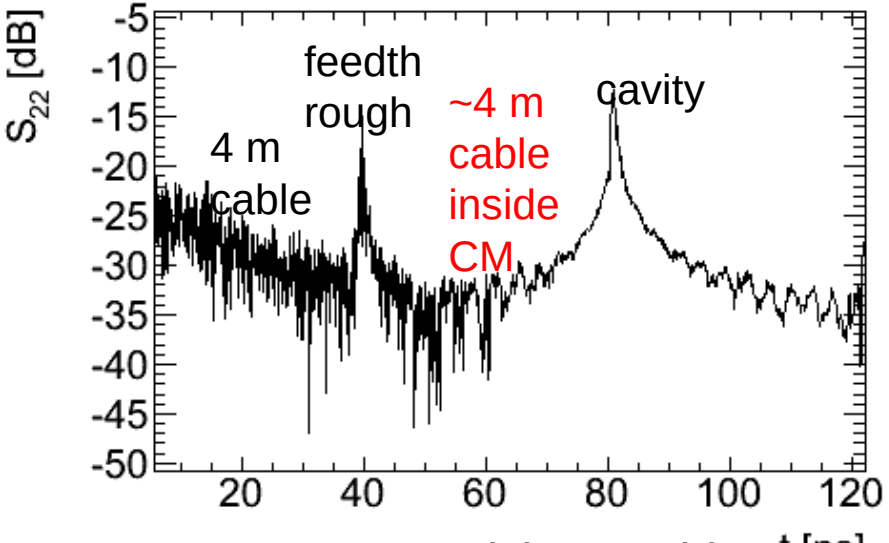


FFT→

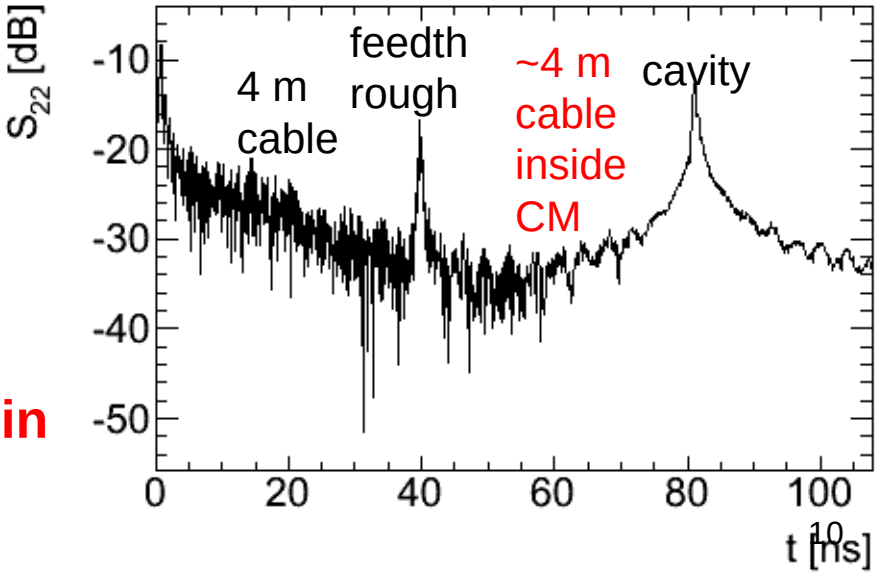


FFT→

CAV IN pick-up cable



CAV OUT pick-up cable



No obvious damage in the cable inside CM

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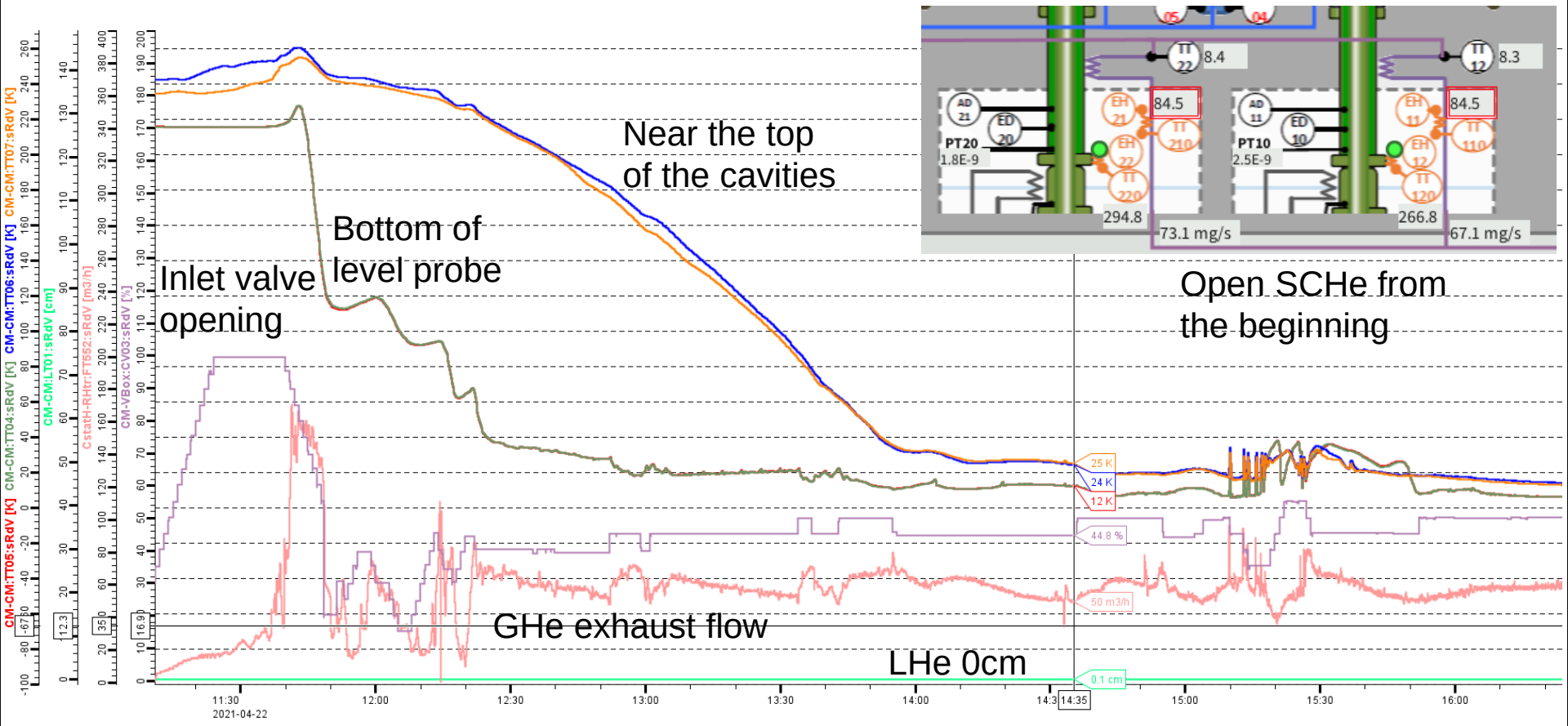
		a			

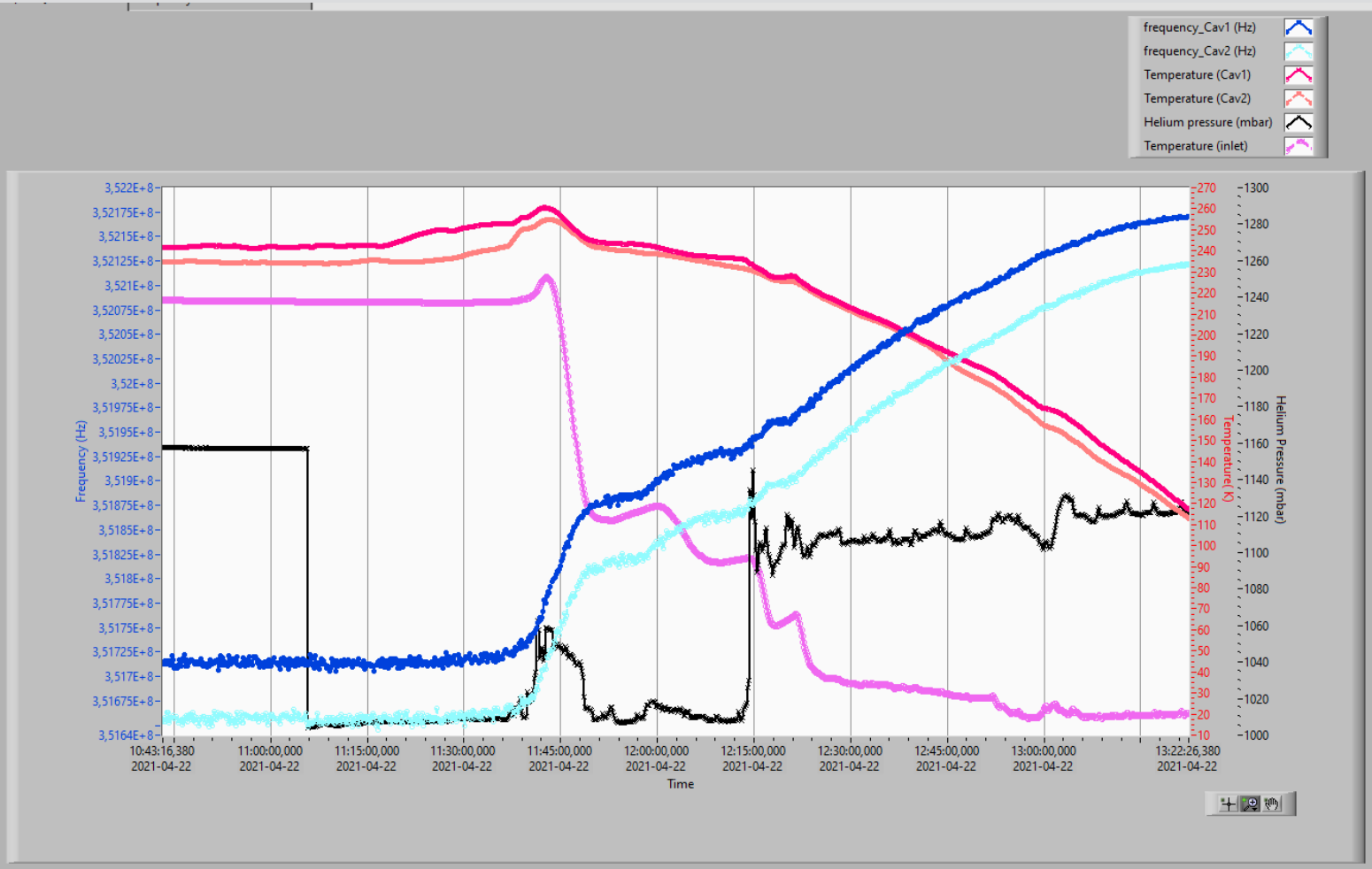
4K cooling



150 K (13:04h) < TT06 and TT07 < 50 K (13:48)

→ rate=2.27 K/min

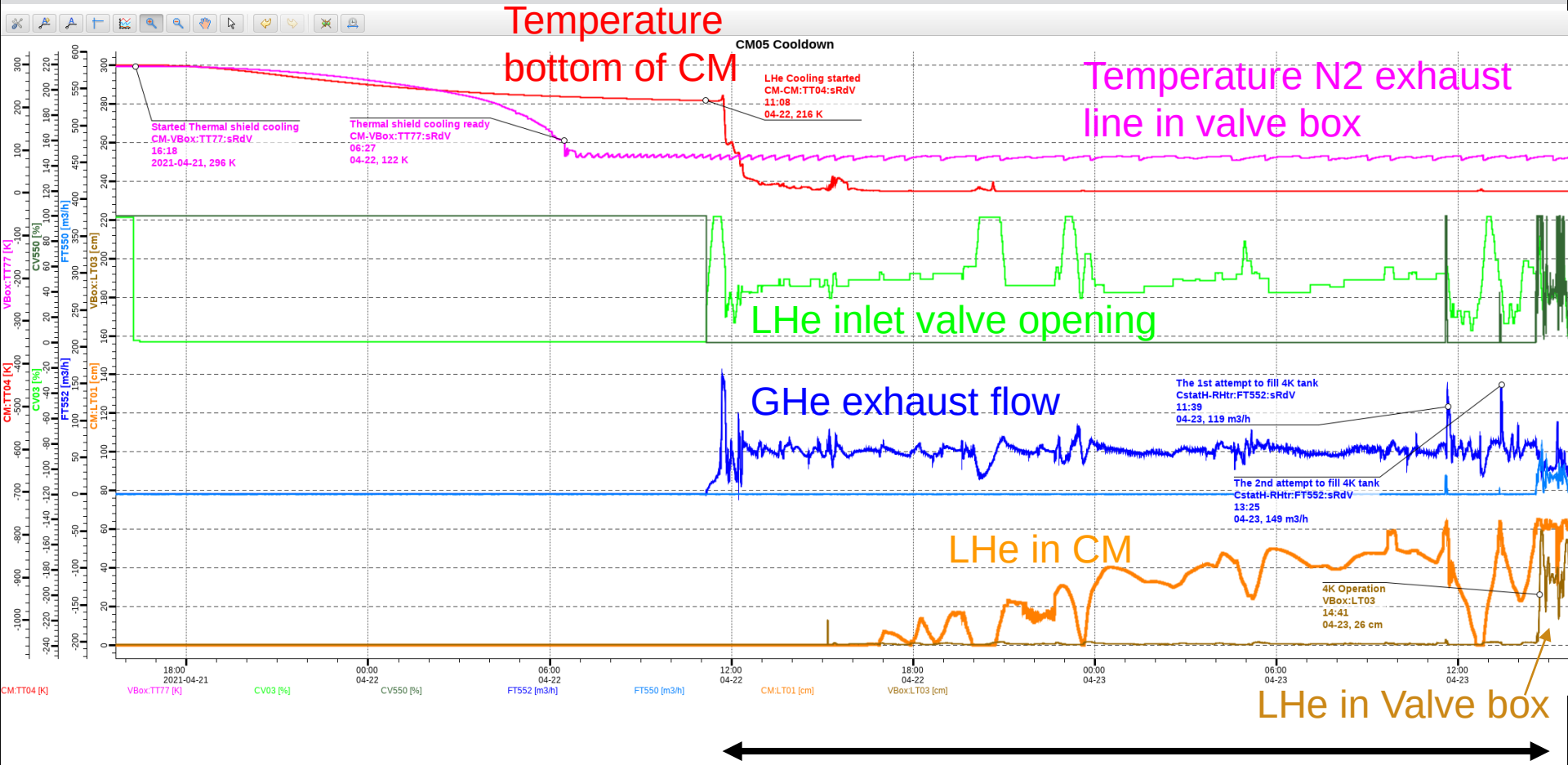
Resonant frequency shift by cooling



Frequency increase by thermal contraction

+450 kHz

4K filling

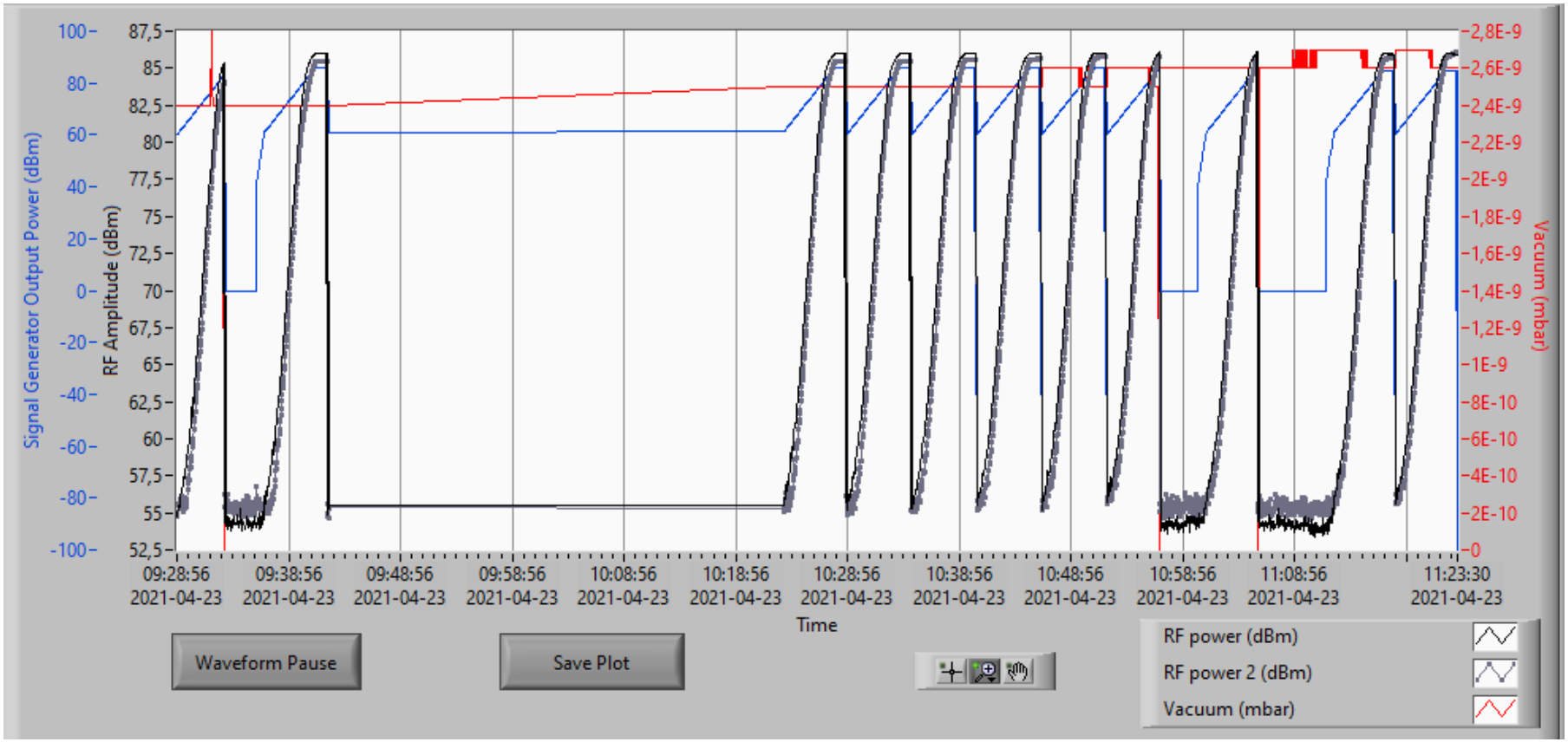


Struggle around 27 hours

4K operation suddenly achieved by Konrad's 3rd attempt

→ Is 27 hours intrinsic or any black magic in parameters?

Coupler cold conditioning (parallel to 4K filling)



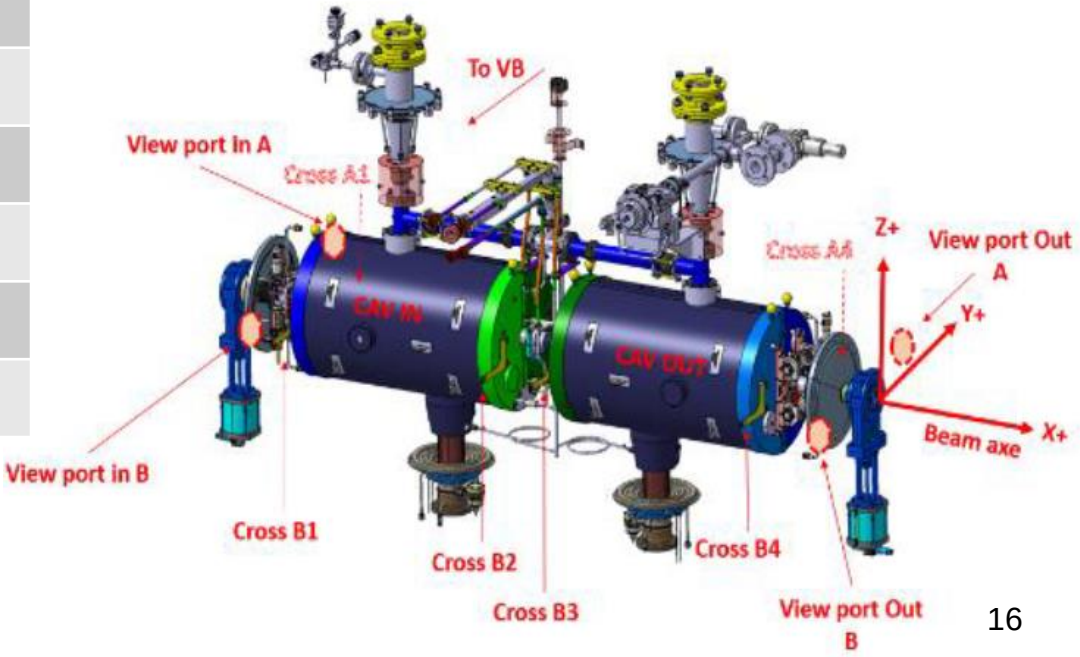
- 2 hours in total
- 30 min intervention to optimize ceramic windows temperature because heater current was not sufficient to regulate their temperature above 280K

Cavity shrinkage measurement

T (K)	Side B	Y (mm)	Z (mm)
300	Cross B1	1.00 (red)	0.01 (red)
	Cross B2	1.10 (red)	0.59 (black)
	Cross B3	0.13 (red)	>1.2 (red)
	Cross B4	1.20 (red)	0.05 (red)
4.2	Cross B1	0.22 (red)	0.12 (red)
	Cross B2	0.18 (red)	0.25 (black)
	Cross B3	1.15 (black)	>1.2 (red)
	Cross B4	0.49 (red)	0.67 (red)
motion	Cross B1	**+0.78**	+0.11
	Cross B2	**+0.92**	+0.34
	Cross B3	**+1.02**	No data
	Cross B4	**+0.71**	+0.62

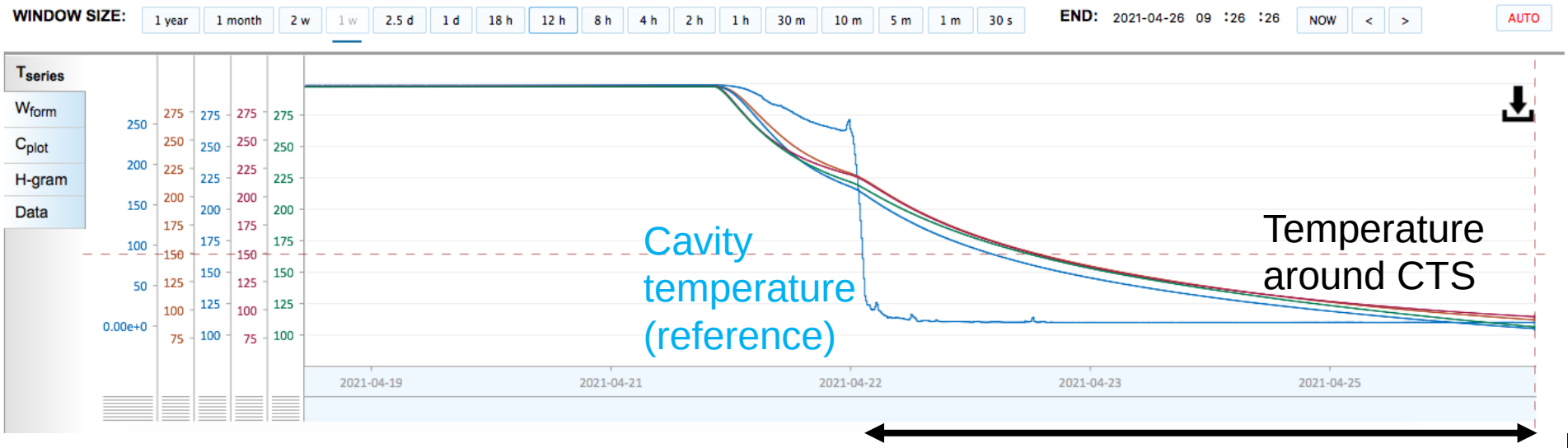
Horizontal

uniform shrinkage 0.86 +/- 0.24 mm (RMS)



Thermalization of CTS over weekend

Del	Plot	Name	DBRType	Units	Processing	Scale	Time (local)	Value	Notes
x	☑	CM-CM:TT06:sRdV	DBR_SCALAR_DOUBLE	K		linear	2021-04-26 **09:09:05**	4.336163783766409	
x	☑	CM-CTS:TT10:sRdV	DBR_SCALAR_DOUBLE	K		linear	2021-04-26 **09:09:05**	91.1765742481203	
x	☑	CM-CTS:TT11:sRdV	DBR_SCALAR_DOUBLE	K		linear	2021-04-26 **09:09:05**	105.08722748759436	
x	☑	CM-CTS:TT20:sRdV	DBR_SCALAR_DOUBLE	K		linear	2021-04-26 **09:09:05**	93.94273966165414	
x	☑	CM-CTS:TT21:sRdV	DBR_SCALAR_DOUBLE	K		linear	2021-04-26 **09:09:05**	106.44300592519124	

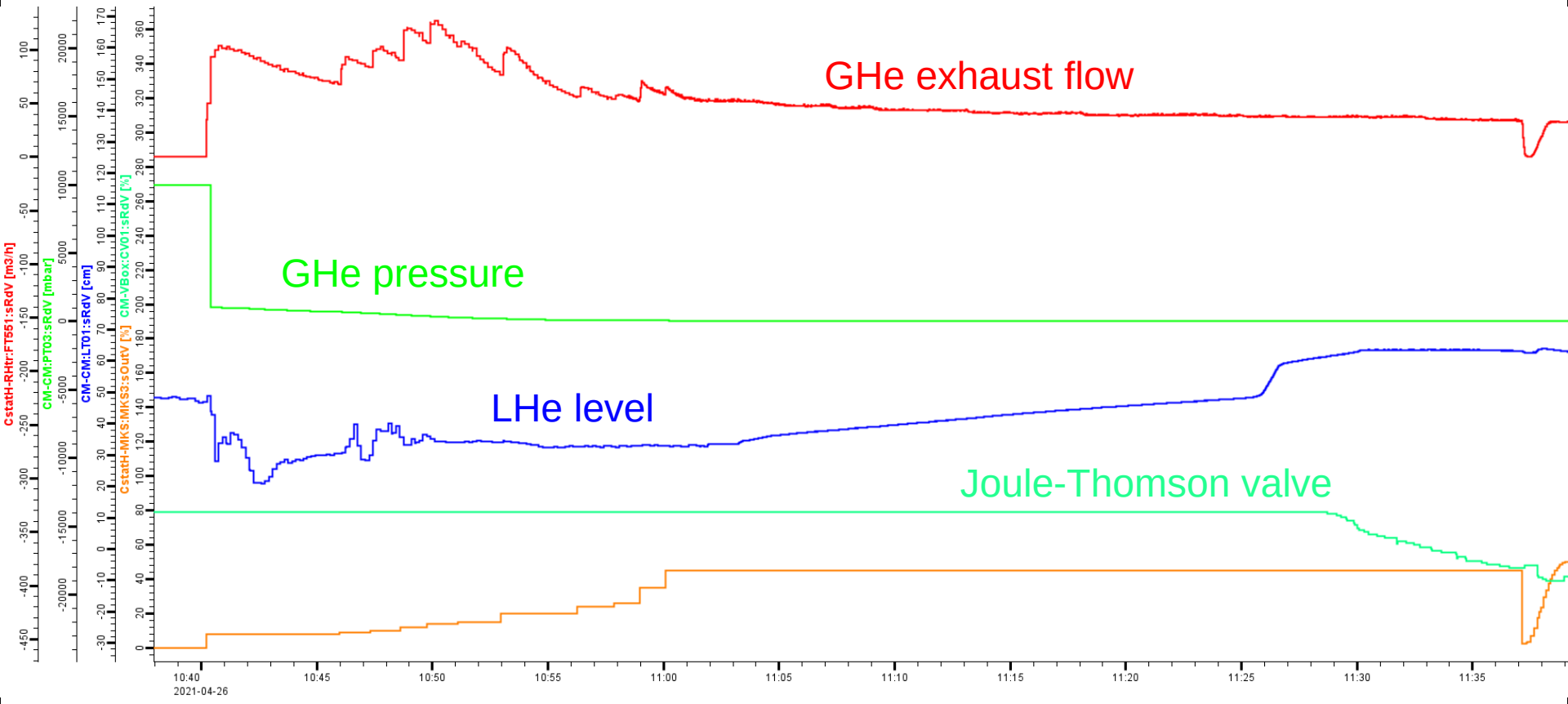


4 days to be ready for CTS tests

- Thursday (cooling down)
- Friday (filling)
- Saturday
- Sunday

Monday 2K pumping

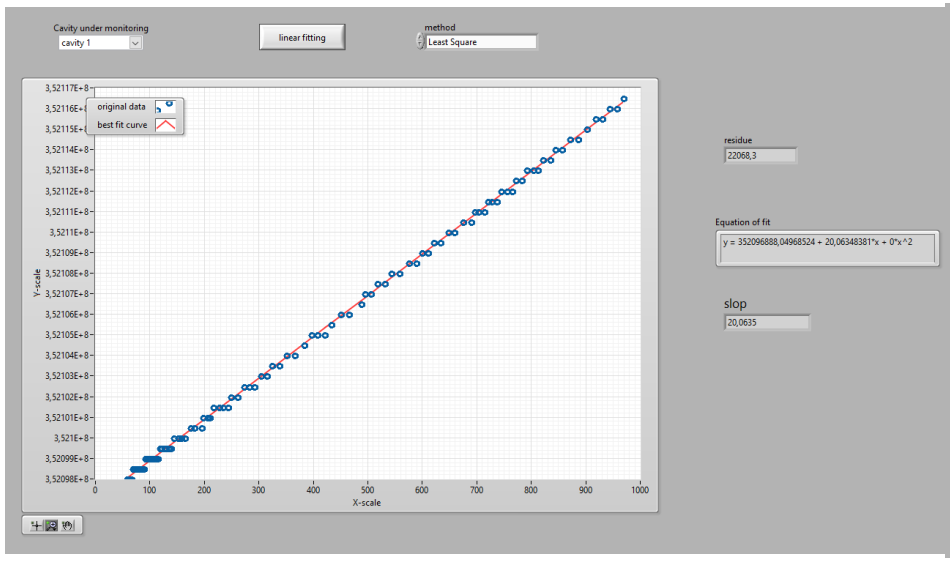
2K pumping



1h to reach 31 mbar

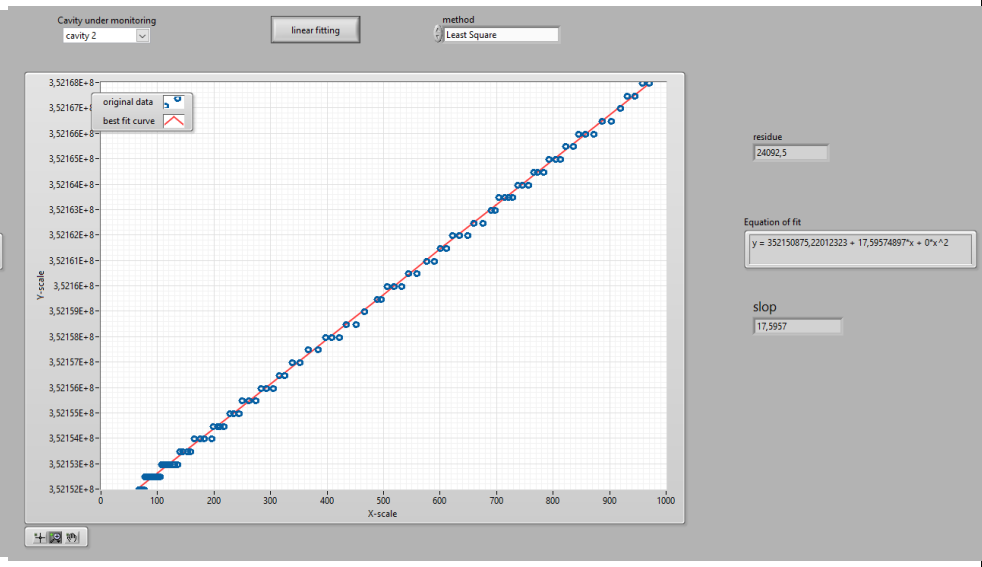
frequency vs p

CAV IN



f/p = 20.06 Hz/mbar

CAV OUT



f/p = 17.60 Hz/mbar

Both are on spec (<20 Hz/mbar)

RF cable calibration

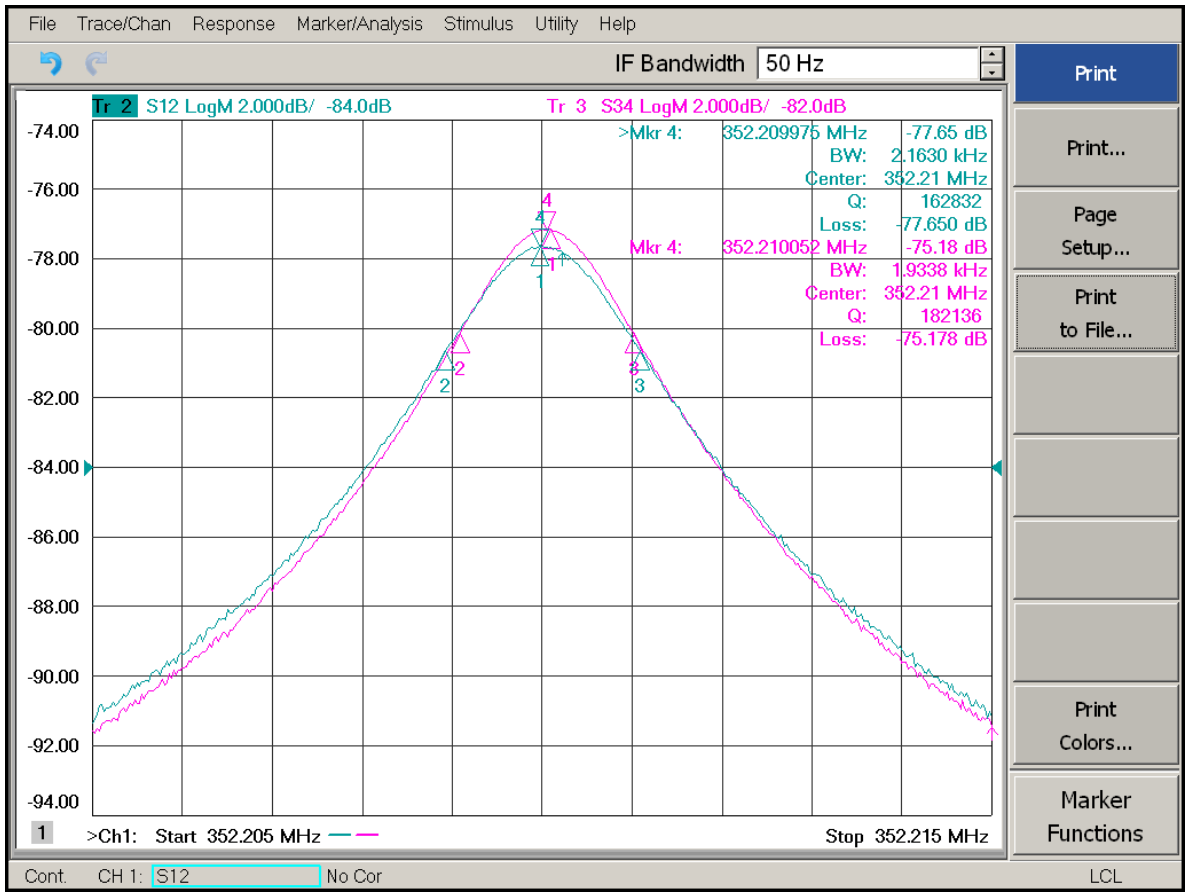
CAV IN
Atten_fwd = 81.30 dB
Atten_ rfl = 81.55 dB
Atten_trans = 17.46 dB

Under debate

CAV OUT
Atten_fwd = 81.16 dB
Atten_ rfl = 81.25 dB
Atten_trans = 17.65 dB

We are recalibrating the cable to be 100% of the accelerating field value

Loaded Q at 2K: frequency domain



CAV IN

QL = 1.63e5 < 1.75 e5

CAV OUT

QL = 1.82e5 < OK

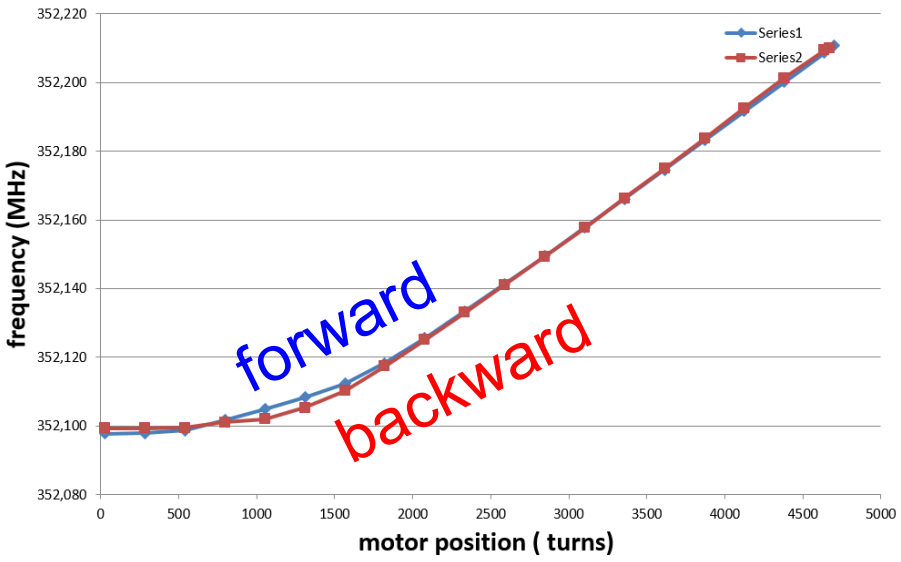
Acceptance (given by beam parameter)

QL = 1.75e5 – 2.85e5

2K	CAV IN	CAV OUT
CM02	**1.54e5**	2.20e5
CM04	1.76e5	**1.55e5**
CM05	**1.63e5**	1.82e5

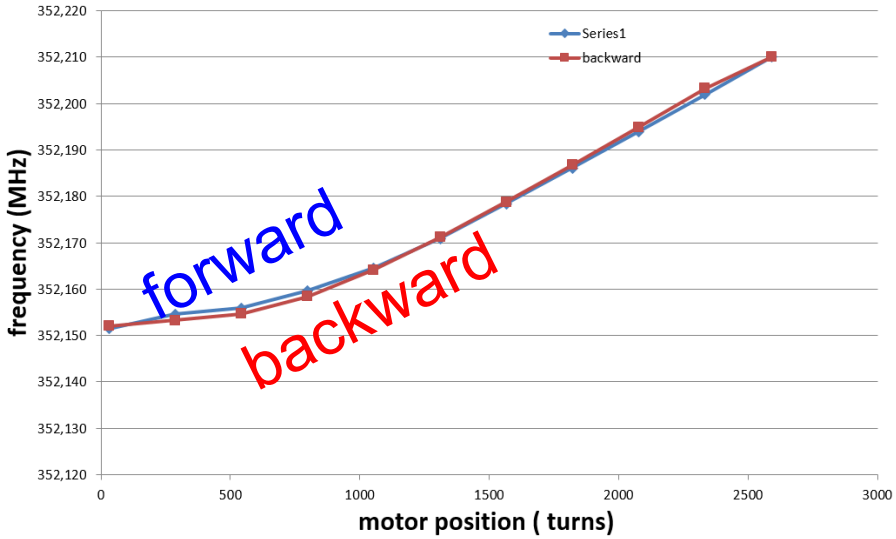
CTS tests: stepper motors

CAV IN



- Reach target frequency 352.21 MHz
- +112.3 kHz tuning
- 4670 turns from limit switch
- Motor position1.824 mm
- Sensitivity in linear zone: 85kHz/mm

CAV OUT



- Reach target frequency 352.21 MHz
- +58.5 kHz tuning
- 2590 turns from limit switch
- Motor position1.012 mm
- Sensitivity in linear zone: 80 kHz/mm

Motor current 0.6A → OK

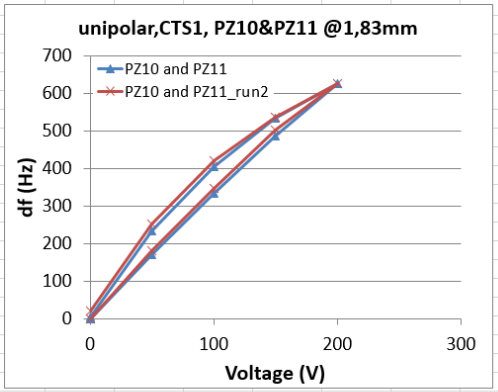
Piezo tests: CAV IN

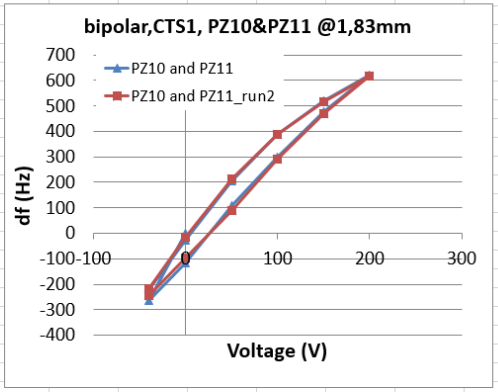
[PZ10 + PZ11]
unipolar: 630 Hz
bipolar: 866 Hz

[PZ10]
unipolar: 540 Hz
bipolar: 670 Hz

[PZ11]
unipolar: 370 Hz
bipolar: 487 Hz

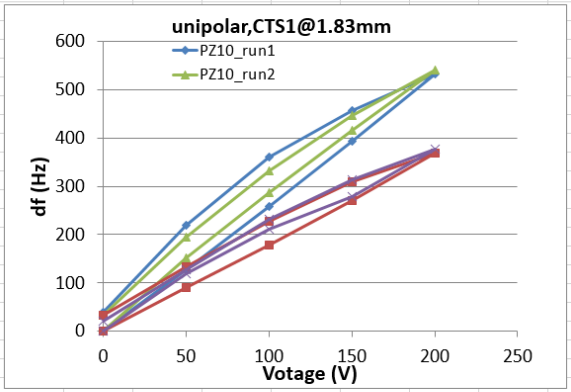
CAV IN BW (Hz)		2177
20210427	TT11=104,0K	
both piezos simulaneously		
Voltage (V)	Phase (°)	df(Hz)
0	132,26	0
50	139,38	172,22489
100	146,13	335,49989
150	152,39	486,92233
200	158,18	626,976
150	154,34	534,09067
100	149	404,922
50	141,97	234,87411
0	132,43	4,1121111
0	132,26	0
50	139,76	181,41667
100	146,67	348,56189
150	153,02	502,16133
200	158,12	625,52467
150	154,43	536,26767
100	149,68	421,37044
50	142,67	251,80633
0	133,07	19,593
0	132,68	0
-40	121,69	-265,8359
0	127,82	-117,558
50	137,16	108,36622
100	145,09	300,18411
150	152,41	477,24678
200	158,32	620,20311
150	154,16	519,57733
100	148,7	387,506
50	141,13	204,39611
0	131,6	-26,124
-40	123,53	-221,3283
0	130,35	0
-40	122,49	-246,4848
0	128,7	-96,27178
50	136,38	89,498889
100	144,71	290,99233
150	152,12	470,232
200	158,13	615,60722
150	154,06	517,15844
100	148,68	387,02222
50	141,53	214,07167
0	132,05	-15,239
-40	123,73	-216,4906
0	130,01	-64,58433
		866,68789

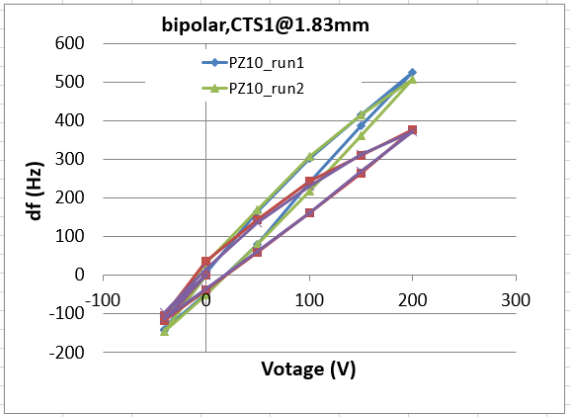




PZ10 only		
Voltage (V)	Phase (°)	df(Hz)
0	115,5	0
50	120,75	126,99167
100	126,22	259,30489
150	131,8	394,27889
200	137,53	532,88122
150	134,37	456,44433
100	130,43	361,14011
50	124,56	219,15133
0	117,08	38,218444
0	116,64	0
50	121,75	151,18056
100	127,33	286,15456
150	132,71	416,29078
200	137,9	541,83111
150	133,95	446,285
100	129,22	331,87156
50	123,51	193,753
0	116,89	33,622556
0	116,77	0
-40	110,98	-140,0537
0	114,78	-48,13589
50	120,07	79,823333
100	126,75	241,40511
150	132,71	385,57089
200	138,49	525,38267
150	133,95	415,56511
100	129,32	303,57056
50	123,6	165,21011
0	117,01	5,8053333
-40	110,86	-142,9563
0	114,7	0
-40	110,74	-145,859
0	114,62	-52,00611
50	120,01	78,372
100	125,78	217,94189
150	131,66	360,17256
200	137,71	506,51533
150	133,96	415,807
100	129,43	306,23133
50	123,73	168,35467
0	118,05	30,961778
-40	112,38	-106,1892
0	115	-42,81433
		671,24167

PZ11 only		
Voltage (V)	Phase (°)	df(Hz)
0	129,32	0
50	133,05	90,224556
100	136,73	179,23967
150	140,48	269,948
200	144,56	368,63867
150	142,13	309,85967
100	138,74	227,85933
50	134,82	133,03889
0	130,69	33,138778
0	130,52	0
50	134,2	118,04178
100	138,06	211,41089
150	140,86	279,13978
200	144,95	378,07233
150	142,31	314,21367
100	138,88	231,24578
50	134,55	126,50789
0	130,19	21,044333
0	129,8	0
-40	124,99	-116,3486
0	128,19	-38,94411
50	132,29	60,230333
100	136,46	161,098
150	140,74	264,62644
200	145,34	375,89533
150	142,6	309,61778
100	139,87	243,58211
50	135,78	144,64956
0	131,27	35,557667
-40	125,47	-104,7379
0	128,35	0
-40	125,18	-111,7527
0	128,34	-35,31578
50	132,37	62,165444
100	136,51	162,30744
150	140,93	269,22233
200	145,11	370,33189
150	142,67	311,311
100	139,32	230,27822
50	135,42	135,94156
0	130,48	16,448444
-40	125,8	-96,75556
0	129,6	0
		487,648





Piezo tests: CAV OUT

[PZ20 + PZ21]
unipolar: 940 Hz
bipolar: 1218 Hz

[PZ20]
unipolar: 585 Hz
bipolar: 720 Hz

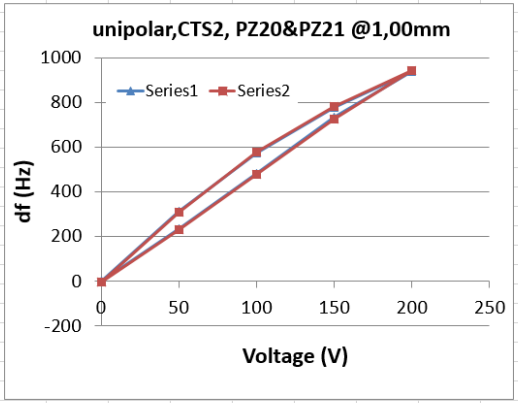
[PZ21]
unipolar: 490 Hz
bipolar: 628 Hz

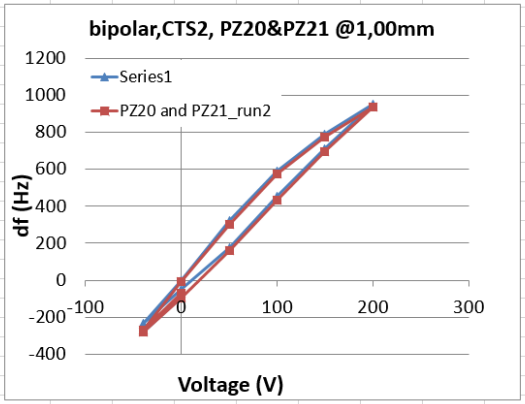
Second measurement

CAV OUT BW (Hz)	1998

20210324 TT21=104K
both piezos simulaneously

Voltage (V)	Phase (°)	df(Hz)
0	45,74	0
50	56,26	233,544
100	67,41	481,074
150	78,72	732,156
200	88	938,172
150	80,7	776,112
100	71,56	573,204
50	59,77	311,466
0	45,86	2,664
0	45,61	-2,886
50	56,13	230,658
100	67,26	477,744
150	78,38	724,608
200	88,07	939,726
150	80,98	782,328
100	71,72	576,756
50	59,6	307,692
0	45,69	-1,11
0	45,43	0
-40	34,89	-233,988
0	43,26	-48,174
50	53,42	177,378
100	65,92	454,878
150	77,37	709,068
200	88,27	951,048
150	81,06	790,986
100	71,99	589,632
50	60,01	323,676
0	45,33	-2,22
-40	33,39	-267,288
0	41,33	-91,02
-40	32,87	-278,832
0	41,08	-96,57
50	52,63	159,84
100	64,84	430,902
150	76,77	695,748
200	87,47	933,288
150	80,25	773,004
100	71,21	572,316
50	59,04	302,142
0	45,07	-7,992
-40	33,35	-268,176
0	42,24	-70,818
		1218,336



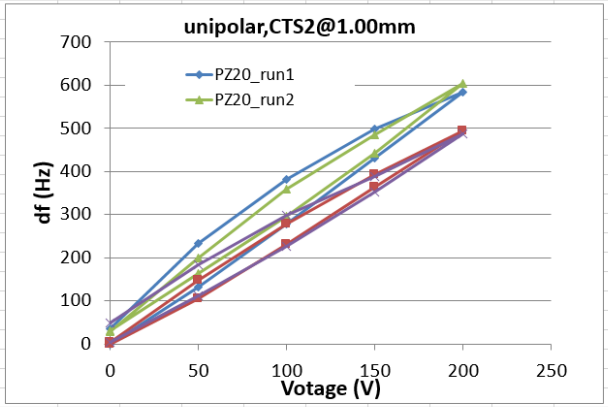


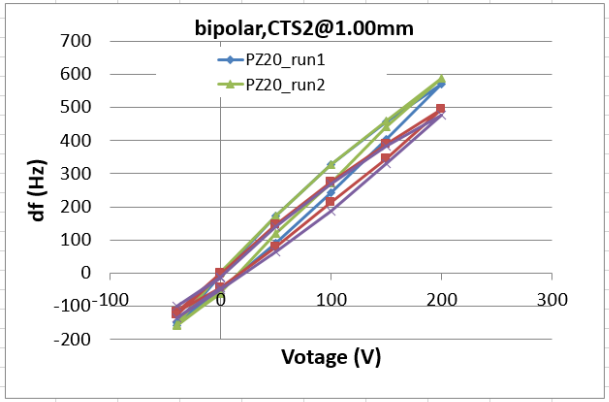
PZ20 only

Voltage (\	Phase (°)	df(Hz)
0	44,97	0
50	50,88	131,202
100	57,52	278,61
150	64,36	430,458
200	71,31	584,748
150	67,41	498,168
100	62,12	380,73
50	55,43	232,212
0	46,52	34,41
0	46,34	30,414
50	52,33	163,392
100	58,25	294,816
150	64,92	442,89
200	72,19	604,284
150	66,86	485,958
100	61,13	358,752
50	53,98	200,022
0	46,26	28,638
0	45,9	0
-40	39,19	-148,962
0	43,7	-48,84
50	49,96	90,132
100	56,85	243,09
150	64,03	402,486
200	71,55	569,43
150	66,46	456,432
100	60,63	327,006
50	53,65	172,05
0	45,65	-5,55
-40	38,82	-157,176
0	43,34	-56,832
-40	38,81	-157,398
0	43,23	-59,274
50	51,26	118,992
100	58,16	272,172
150	65,76	440,892
200	72,44	589,188
150	66,62	459,984
100	60,63	327,006
50	53,68	172,716
0	45,99	1,998
-40	38,84	-156,732
0	43,09	-62,382
		726,828

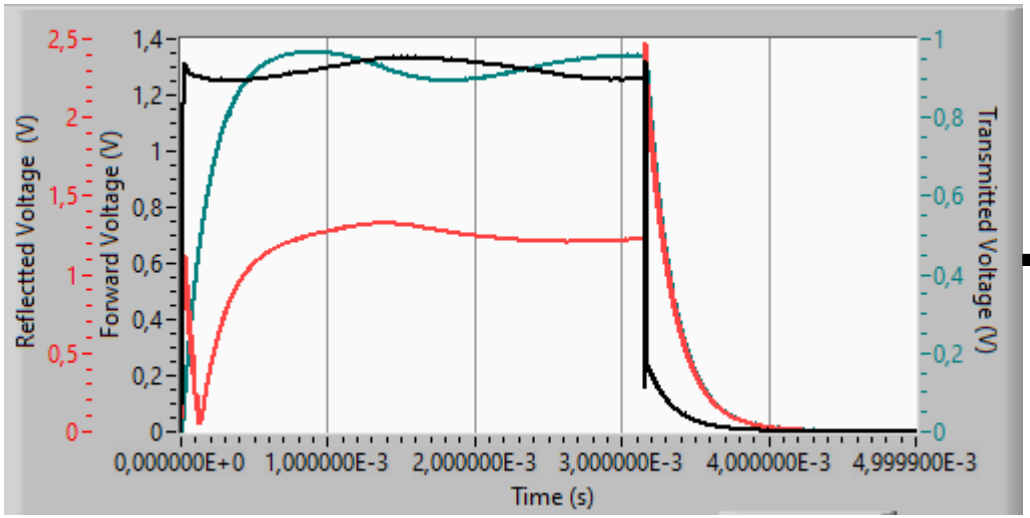
PZ21 only

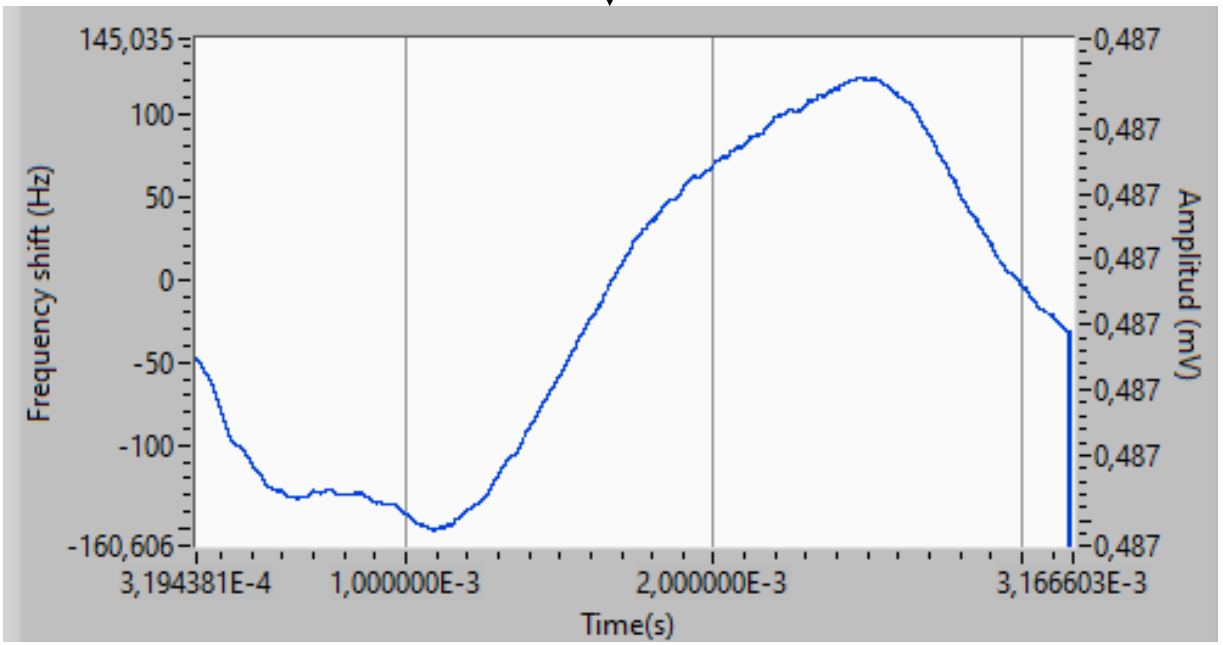
Voltage (\	Phase (°)	df(Hz)
0	43,67	0
50	48,41	105,228
100	54,02	229,77
150	60,03	363,192
200	65,91	493,728
150	61,35	392,496
100	56,17	277,5
50	50,34	148,074
0	43,79	2,664
0	43,82	3,33
50	48,64	110,334
100	53,88	226,662
150	59,49	351,204
200	65,61	487,068
150	61,14	387,834
100	57,08	297,702
50	51,93	183,372
0	45,82	47,73
0	43,67	0
-40	38,36	-117,882
0	41,72	-43,29
50	47,27	79,92
100	53,3	213,786
150	59,17	344,1
200	65,96	494,838
150	61,25	390,276
100	56,02	274,17
50	50,24	145,854
0	43,55	-2,664
-40	37,93	-127,428
0	41,62	-45,51
-40	37,65	-133,644
0	41,37	-51,06
50	46,55	63,936
100	52,16	188,478
150	58,56	330,558
200	65,16	477,078
150	60,96	383,838
100	55,78	268,842
50	49,93	138,972
0	43,17	-11,1
-40	39,19	-99,456
0	43,06	-13,542
		628,482





CAV OUT: Lorentz force detuning @ 9MV/m





-150Hz / +120Hz

<< piezo tuning

CAV OUT reached 12MV/m

No field emission (minor X-rays after MP conditioning)

Static heat load measurement

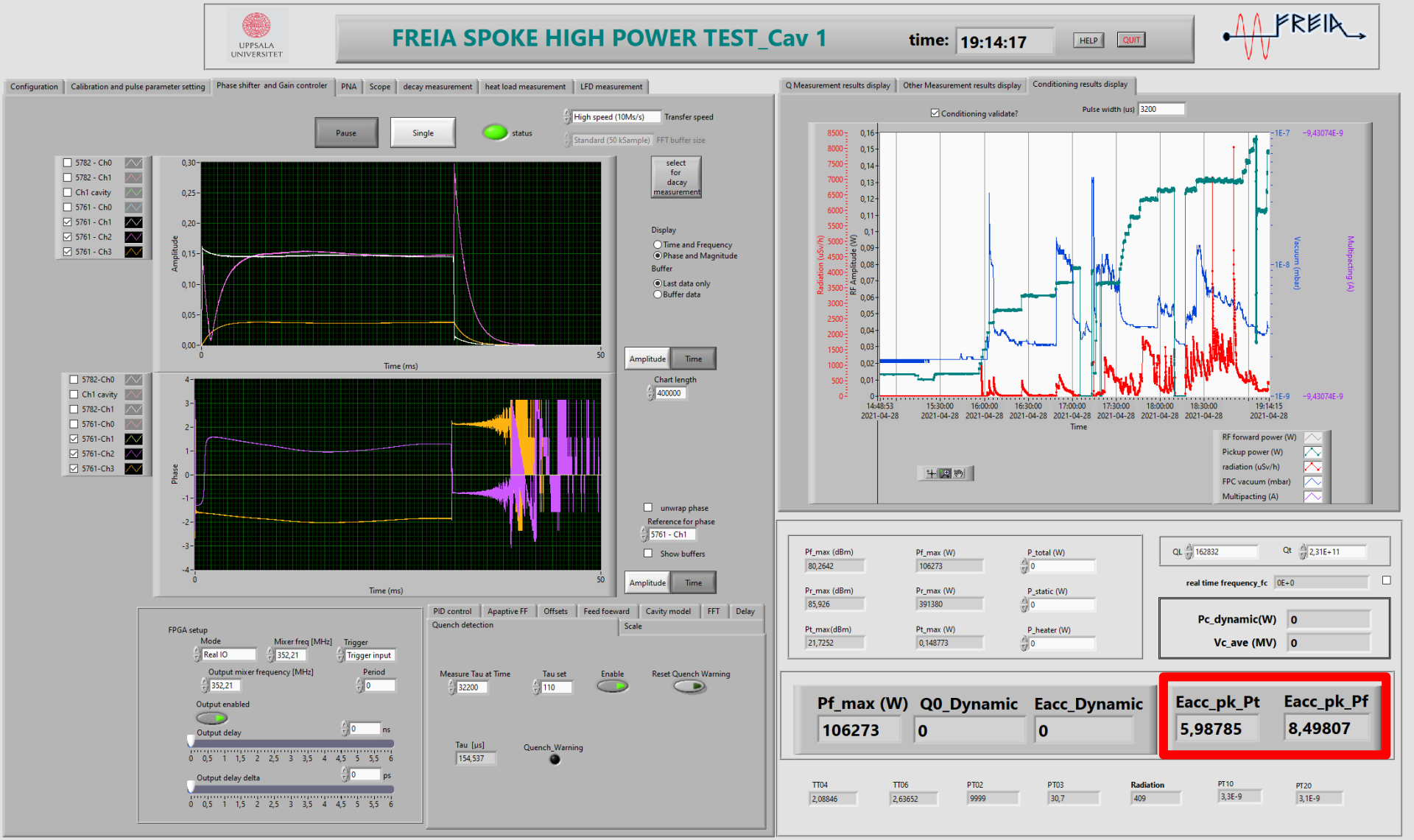
Test 1 (during CTS tests)
Measured from 09:07 to 09:11:
FT551= 14.80 m3/h (std dev 0.35 m3/h)
PT03_min= 30.40 mbar
PT03_max= 32.30 mbar
LT01_min= 48.5 cm
LT01_max= 58.97 cm
May be too low
CV551=17%
CV03=29%
Static heat load: 15,84 (37) W

Test 2 (CTS fully engaged)
Measured from 14:11 to 14:16
FT551 = 13,7 m3/h (Std.dev. 0.24m3/h)
PT03 Min: 30.2 mBar
PT03 Max: 30.8 mBar
LT01 Min: 58,92 cm
LT01 Max: 60,62 cm
CV551 17%
CV03 30%
Static heat load: 14,66 (25) W

Test 3 (CTS fully engaged)
Measured from 08:31 to 08:34:
FT551= 12.47 m3/h (std dev 0.29 m3/h)
PT03_min= 30.90 mbar
PT03_max= 32.40 mbar
LT01_min= 60.58 cm
LT01_max= 61.58 cm
CV551=17%
CV03=30%
Static heat load: 13,34 (31) W

→ 13.3-14.7 W OK

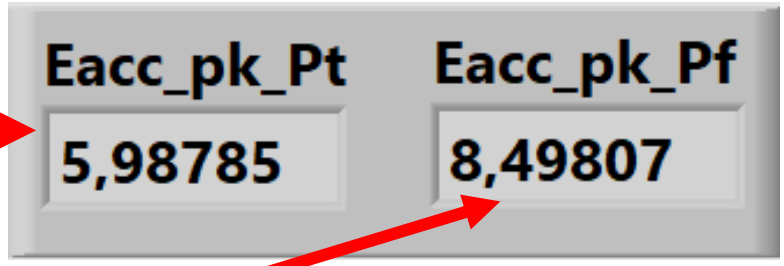
Doubt in CAV IN calibration



CAV IN: two methods to estimate E_{acc}

From pick-up power

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



This is always valid

From forward power

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

k and ω are determined by cavity geometry

This is valid if 1) coupler is strongly over coupled (OK) and 2) cavity is perfectly tuned (checked)

Atten_fwd = 81.30 dB
Atten_ rfl = 81.55 dB
Atten_trans = 17.46 dB

We need **factor two wrong** in either power (3dB) or Q

- We recalibrate RF cables to get proper transmitted power P_t and P_f
- Q_L is from VNA (1.6e5)
- Q_t is from Orsay (2.31e11) which could vary or be uncertain

We need to study the source of errors before we proceed to the next step

Potential issue
pick-up antenna Q_t could get loose by transportation or cooling down

Q_t in vertical tests

IOP Publishing
Supercond. Sci. Technol. 32 (2019) 025002 (10pp)
Superconductor Science and Technology
https://doi.org/10.1088/1361-6668/aaf049

Determination of the Bardeen–Cooper–Schrieffer material parameters of the HIE-ISOLDE superconducting resonator

A Miyazaki[1,2] and W Venturini Delsolaro[1]

[1] CERN, Switzerland
[2] University of Manchester, United Kingdom

- The typical method (David's method at Orsay is the same) to evaluate Q_t in vertical tests contains source of error
- Because of phase mismatch and standing-wave, estimated Q_t depends on coupling coefficient $\beta = Q_0/Q_{ext}$

$$Q_L = \omega\tau, \tag{A.1}$$

where ω is the angular resonant frequency $\omega = 2\pi f$. With the same configuration as the field-decay measurement, the steady state powers (P_f, P_r, P_t) were measured, and the coupling coefficient was calculated by

$$\beta = \frac{1 \pm \sqrt{P_r/P_f}}{1 \mp \sqrt{P_r/P_f}}, \tag{A.2}$$

where the upper sign is used for over-coupling, and the lower sign is used for under-coupling case. The power consumption in the cavity P_c is

$$P_c = P_f - P_r - P_t. \tag{A.3}$$

The coupling coefficient of the pick-up port β_{pick} was also evaluated as

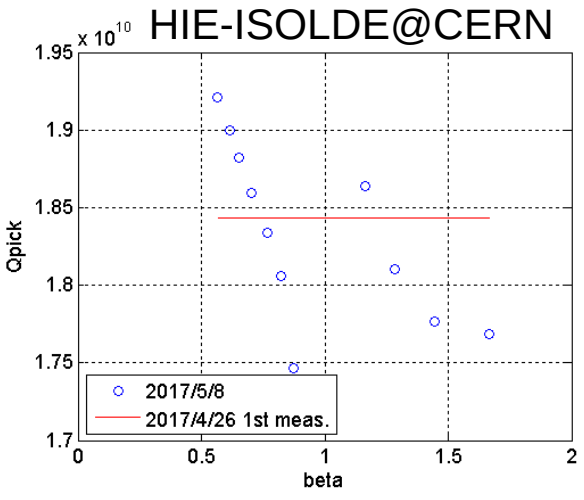
$$\beta_{pick} = \frac{P_t}{P_c}. \tag{A.4}$$

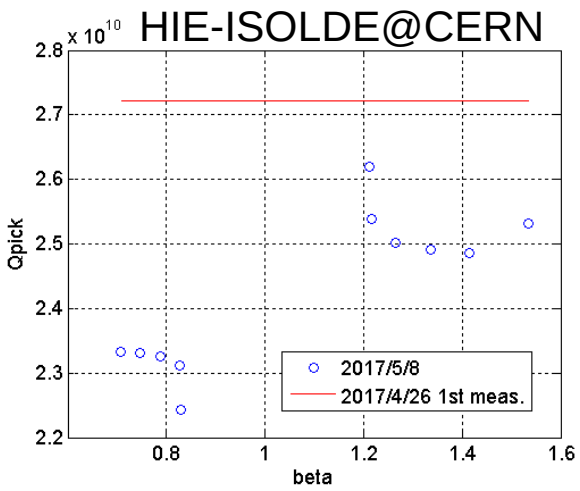
Then, the cavity quality factor was calculated by

$$Q_0 = Q_L(1 + \beta + \beta_{pick}), \tag{A.5}$$

and the quality factor of the pick-up port is given by

$$Q_{pick} = \frac{Q_0 P_c}{P_t}. \tag{A.6}$$





- Comparing 2K (high β) and 4K (low β) gives some insight
- Still 30% error is maximum
- Factor two sounds too much

Plan: W18

W18 2021			next CM	CM under test	previous CM
			CM03	**CM05**	**CM02**
THU	29-apr	m		RF cable calibration	
		a			
FRI	30-apr	m			
		a		Valborg	
SAT	01-maj				
SUN	02-maj				
MON	03-maj	m	doorknob mounting	CAV IN conditioning	
		a		dynamic heat load measurement	
TUE	04-maj	m			
		a			
WED	05-maj	m		start warming up	
		a			

- When will be the potential arrival of the next next CM (CM06?) ?
- CM05 might be ready to ship in the end of W19 (May 13th)
- Reception of the next next CM must be after CM05 shipping