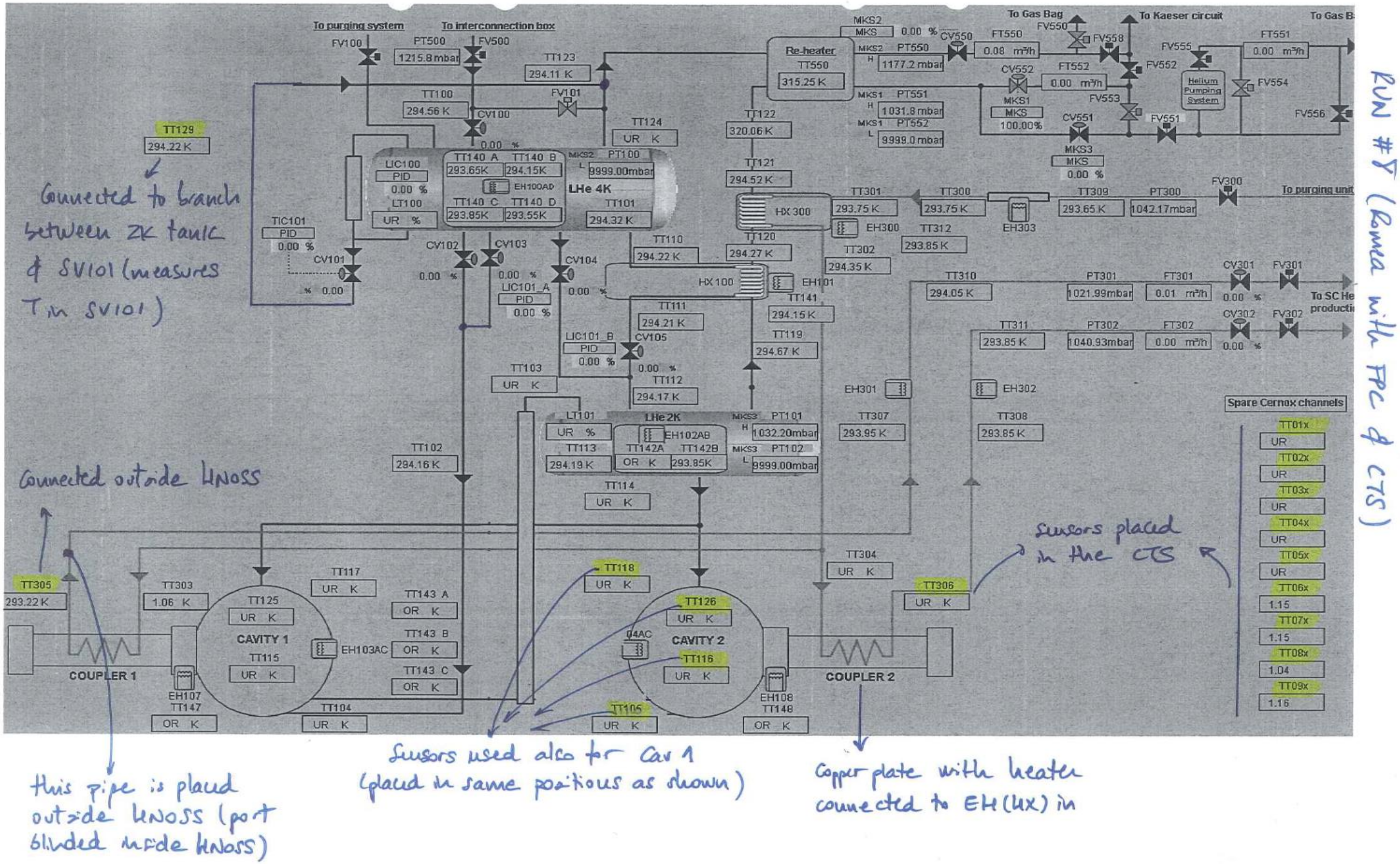
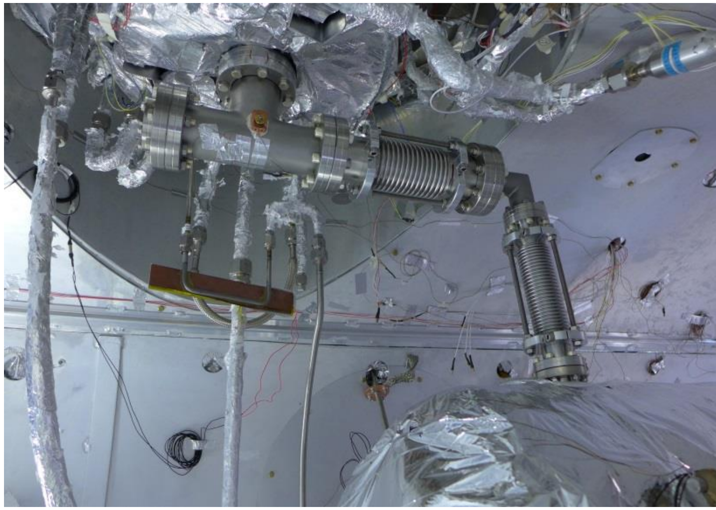
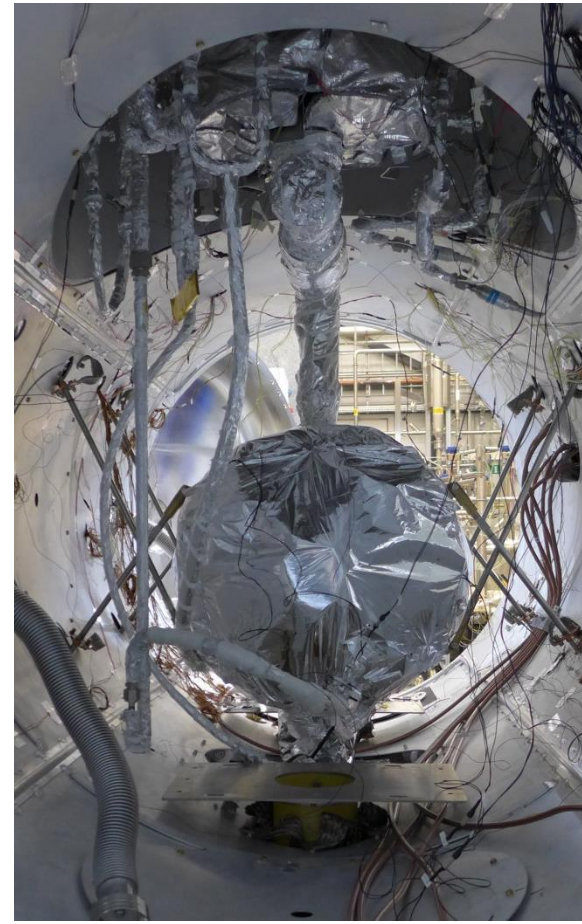
Romea Tests (run #8)
23rd Feb-29th May

Modifications

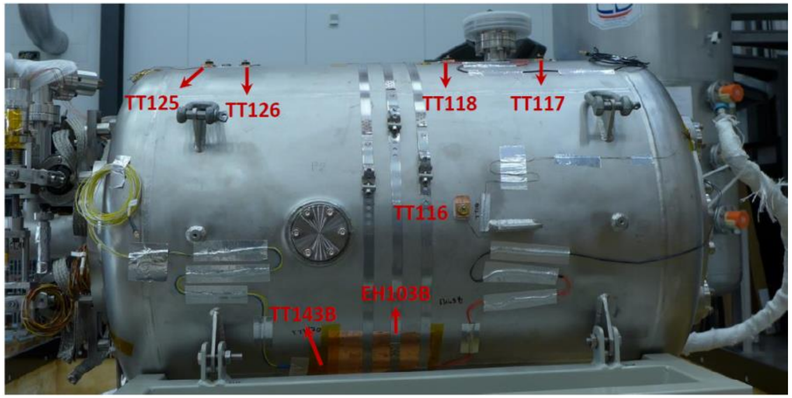


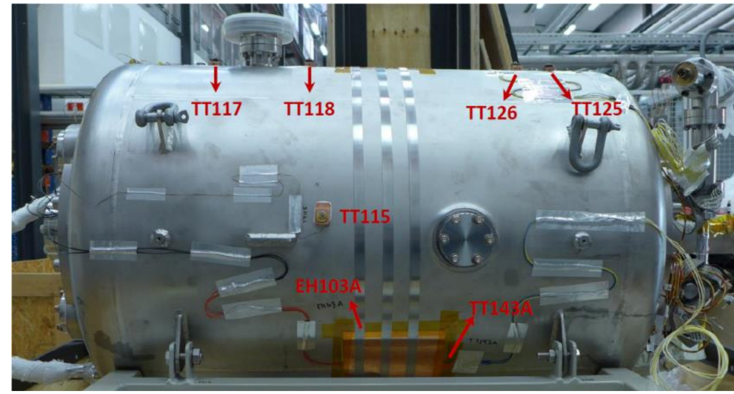
Cryogenic setup

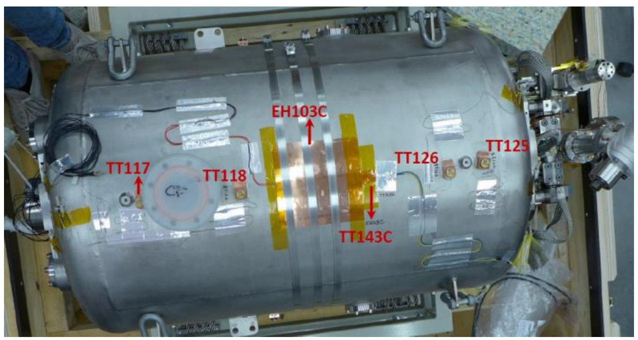


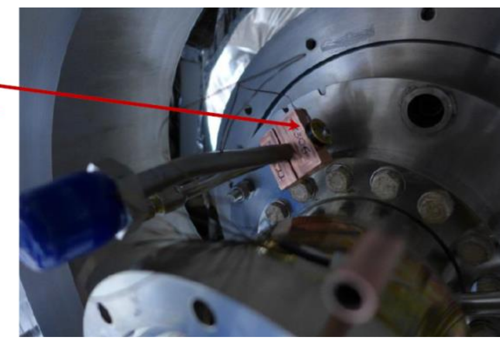


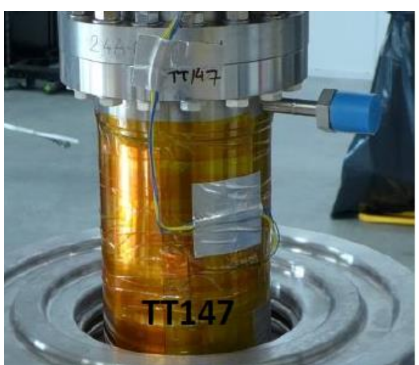
Romea Sensors

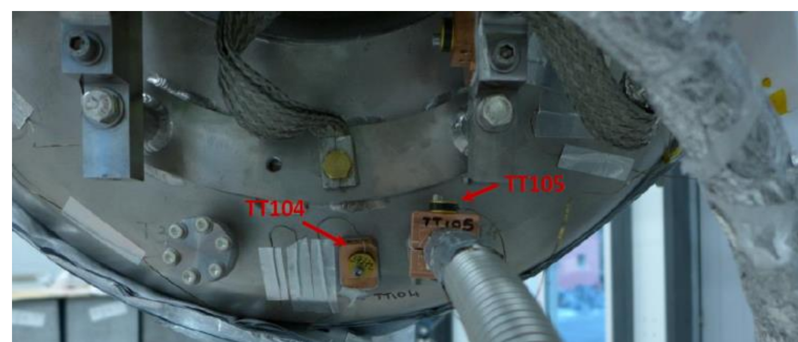






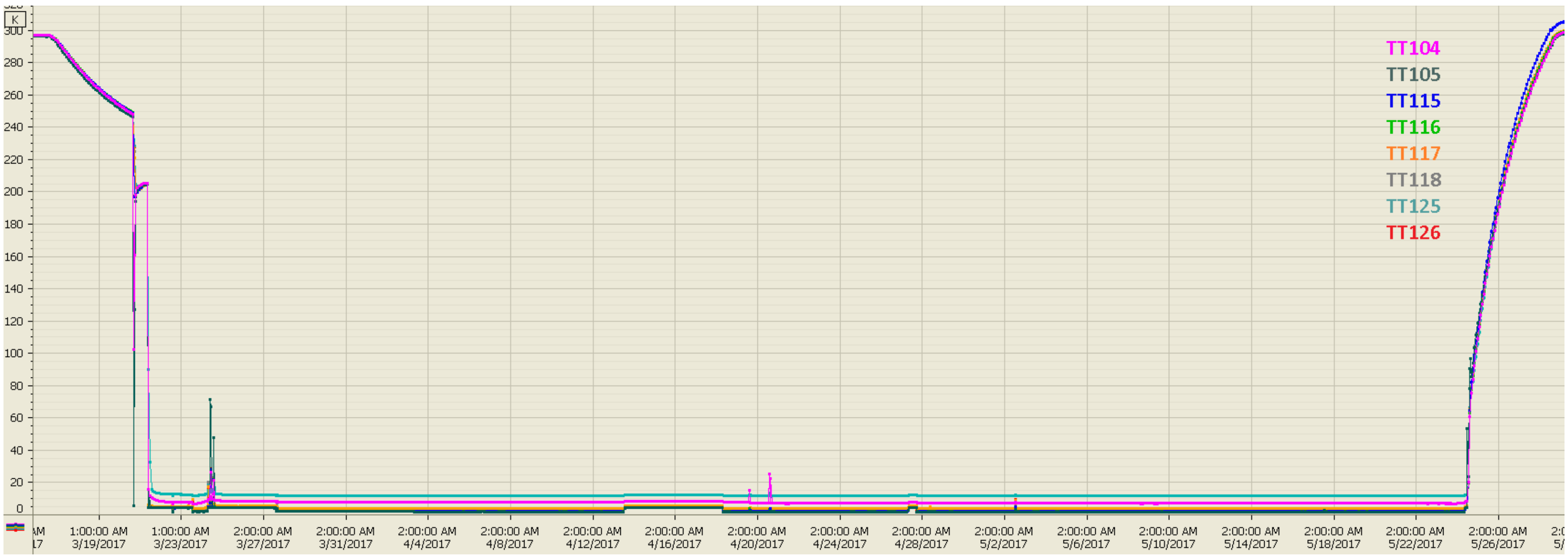






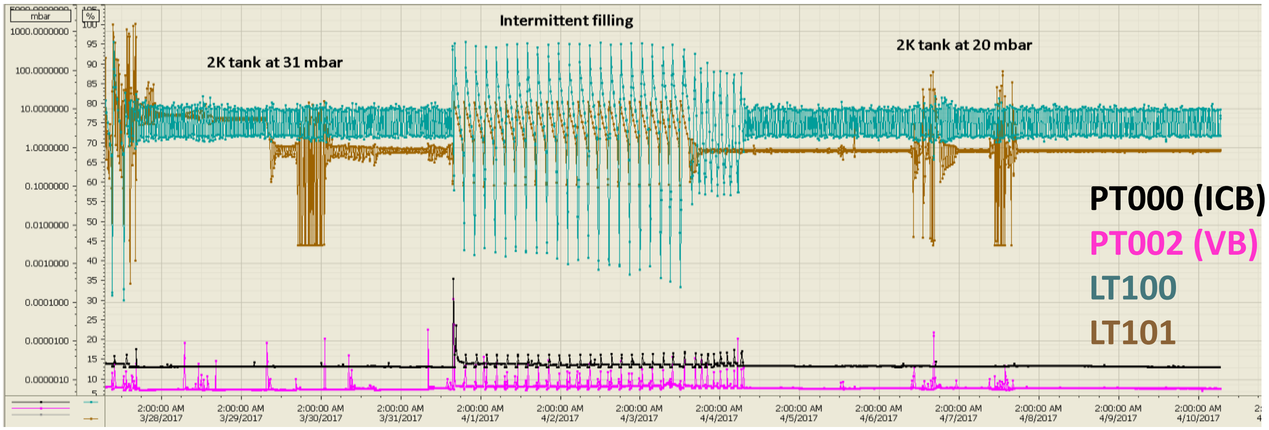
Temperature overview

During the whole run have kept Romea between 4K and 2K except for at the beginning, were the temperature was ca. 20 K for less than an hour.



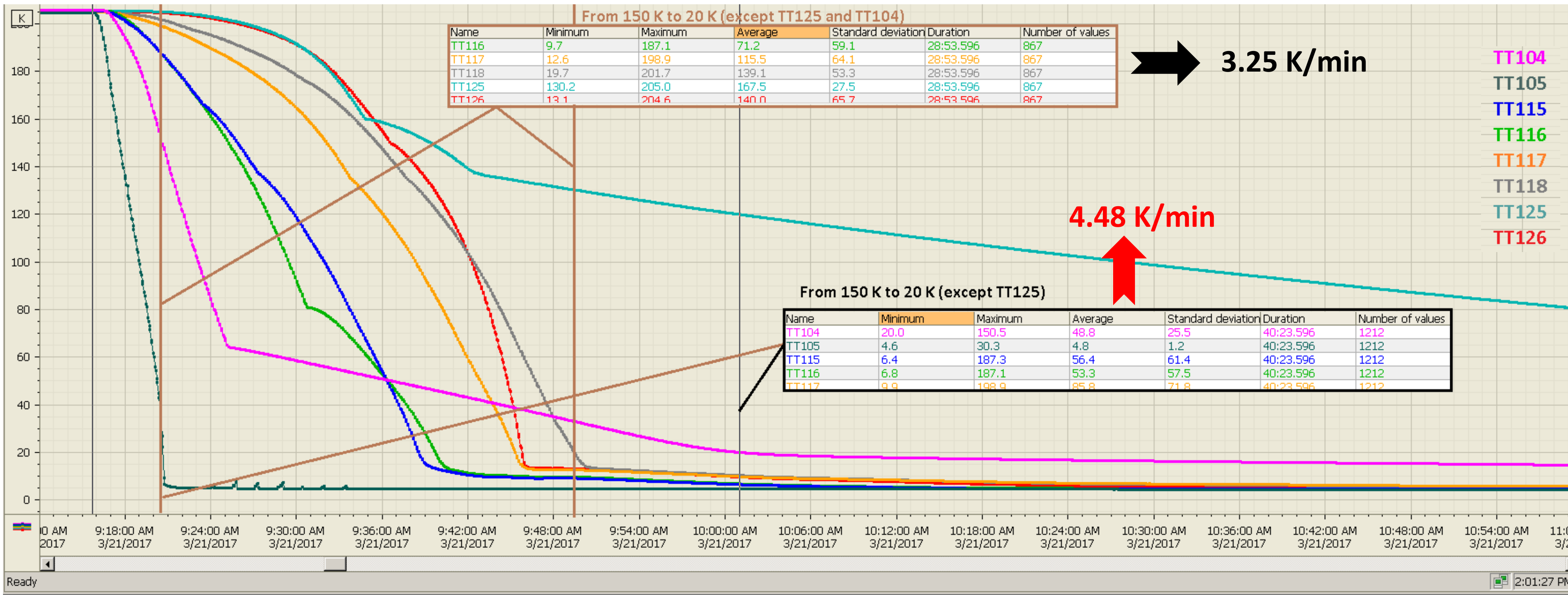
Insulation vacuum

We saw that the insulation vacuum got spikes at the same time in both ICB and HNOSS, especially when intermitten filling.



On closer inspection it looks like the vacuum bursts in the ICB might be due to outgassing. For HNOSS is not that clear since the vacuum ”ondulates” when in regulation mode, so we might have a leak in the 2K circuit (graph shown when at 20 mbar)

Cooldown



From starting point down to 20 K (except for TT125)

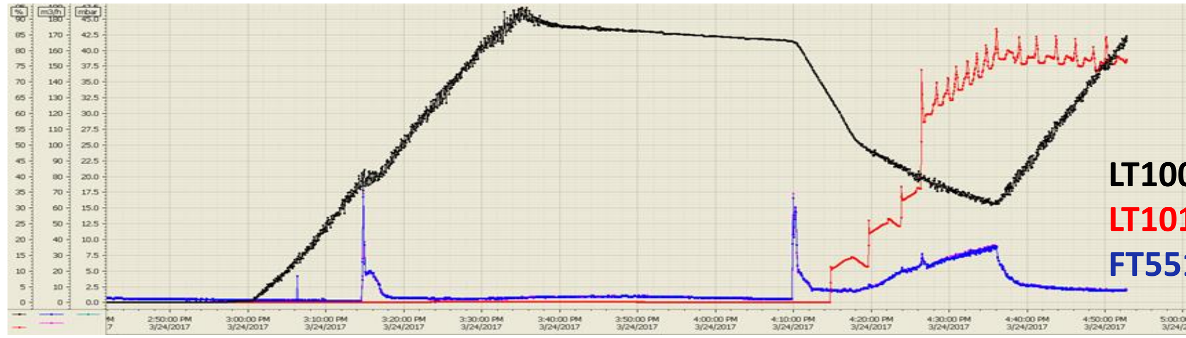
	Name	Minimum	Maximum	Average	Standard deviation	Duration	Number of values
1	TT104	20.0	205.6	63.7	49.6	45:14.000	1358
2	TT105	4.6	204.7	18.3	42.4	45:16.000	1359
3	TT115	6.4	205.2	71.7	73.0	45:16.000	1359
4	TT116	6.8	205.4	69.0	70.8	45:16.000	1359

4.10 K/min

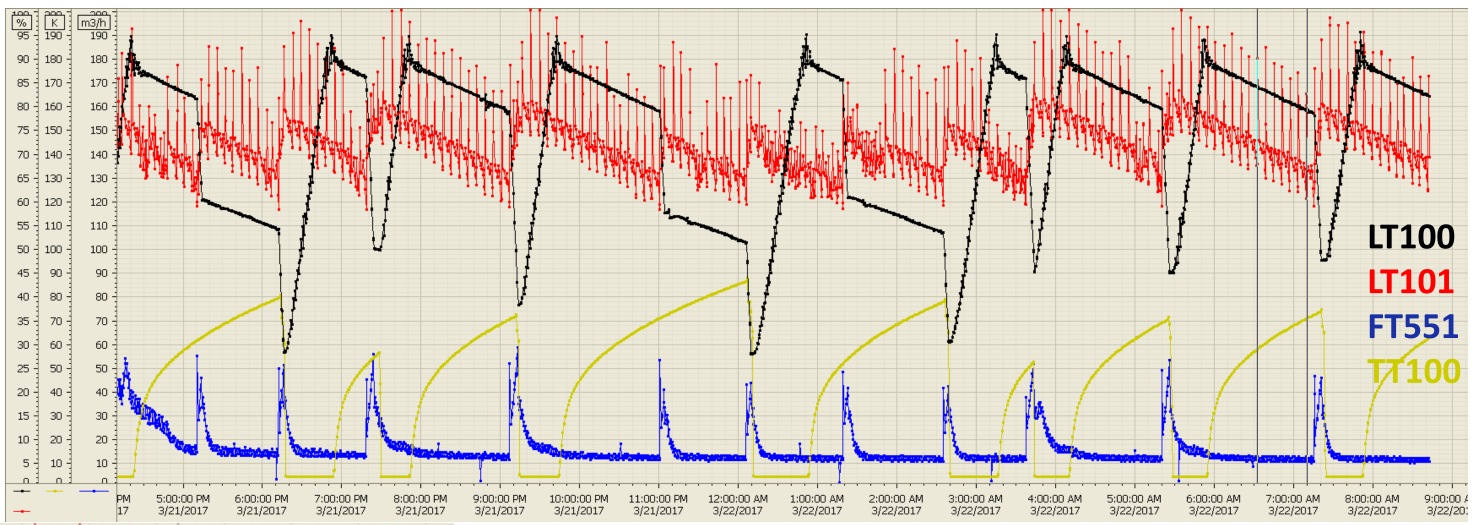
After tests saw that TT104 had come off. Still have not visually checked TT125 but expect a similar outcome.

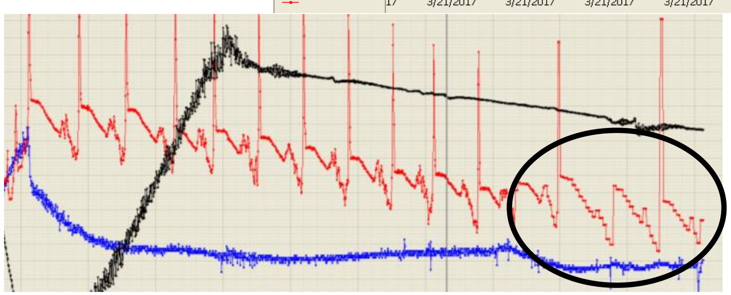
LT101 Spikes (1/2)

1000 mbar, start cooldown of cavity, get spikes in FT551



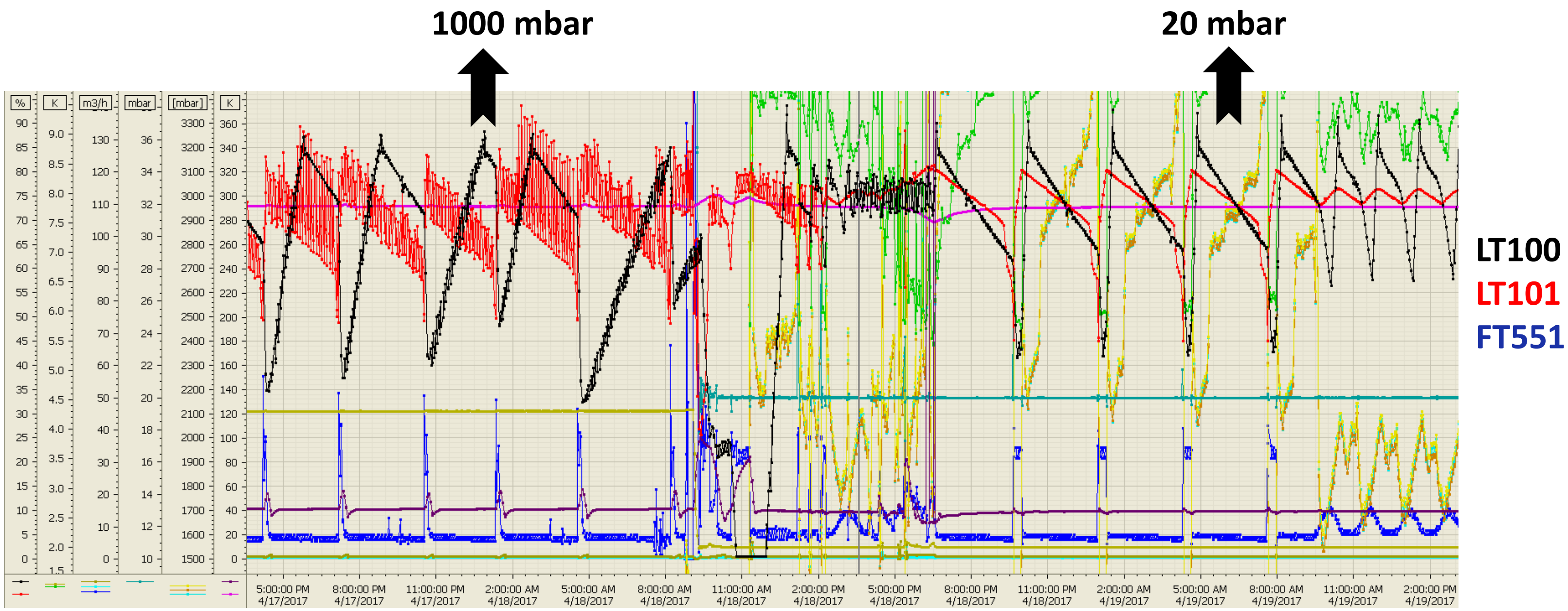
1000 mbar, no RF or heating power, no FT551 spikes, cavity cold for some days already (spikes are ca. 6 min apart)



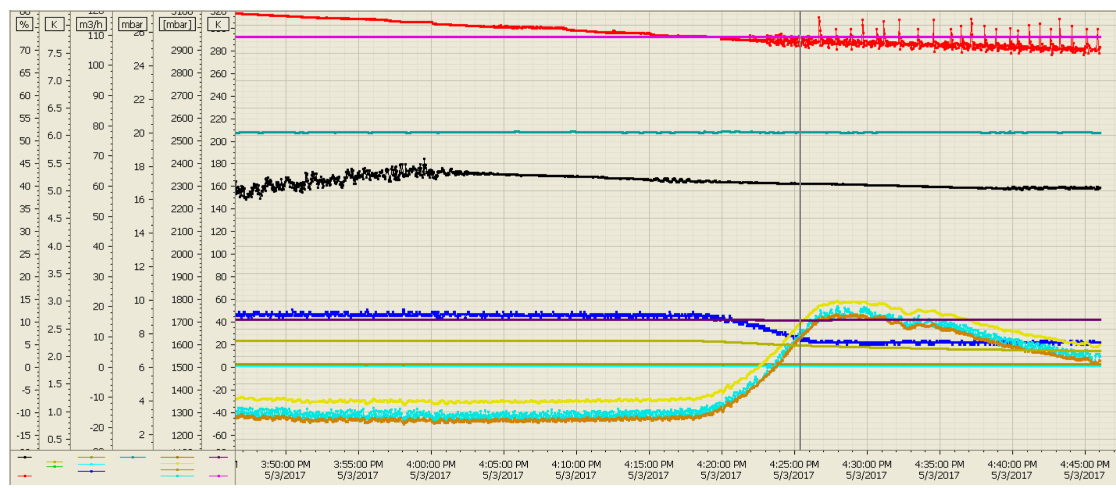


Reduced the sampling in the AMI controller → did not work, still got spikes

LT101 Spikes (2/2)



A couple of times we have got spikes after switching off power (here applied 12W in heat)

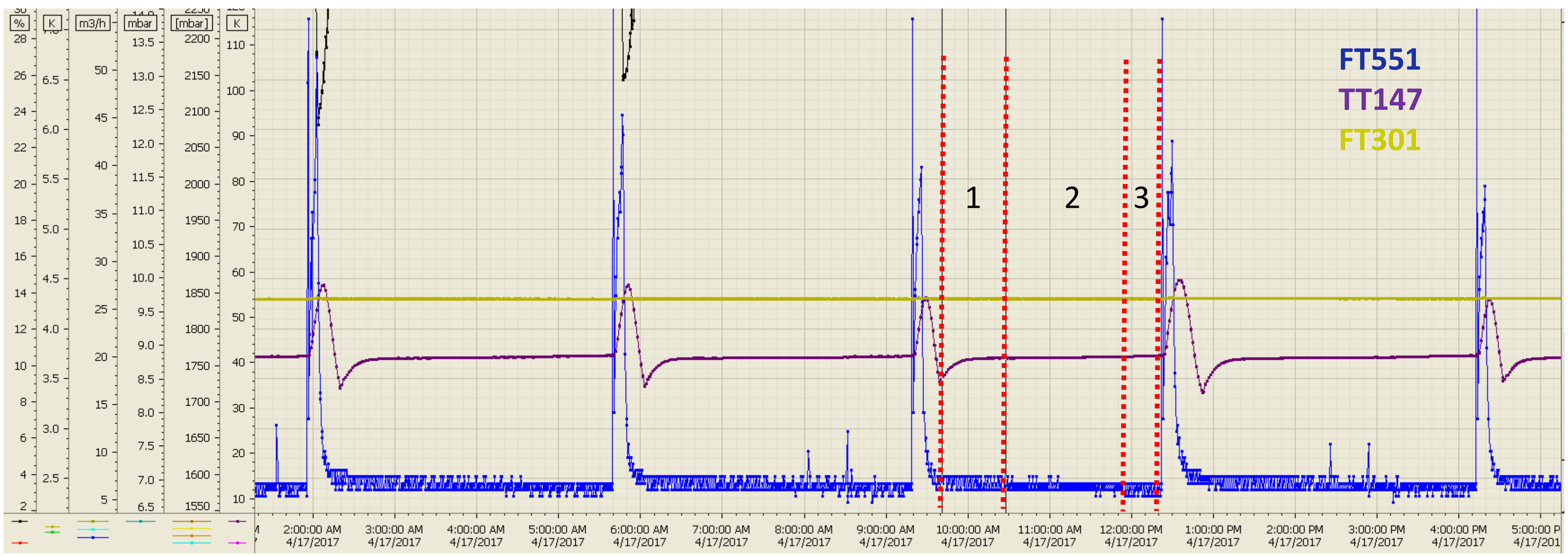


Static Heat Loads 1020 mbar

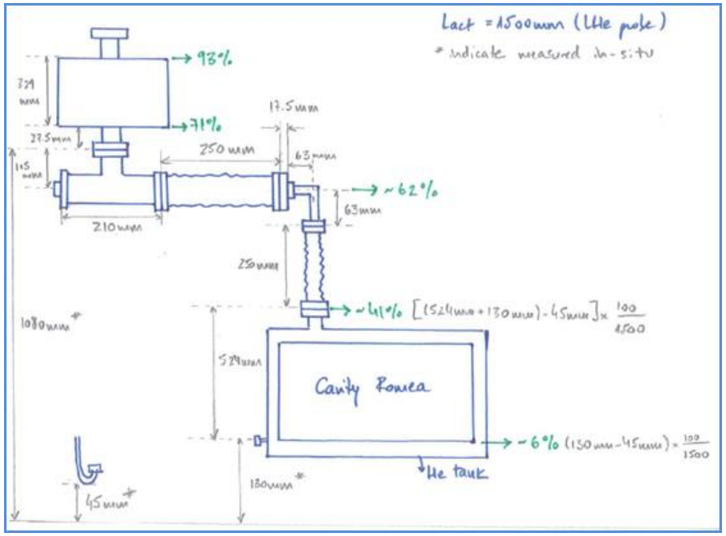
- Because of the spikes, not easy to measure
- Roughly identified three (3) regions
- Note: CV104 was closed and no RF /heat power was applied during measurements

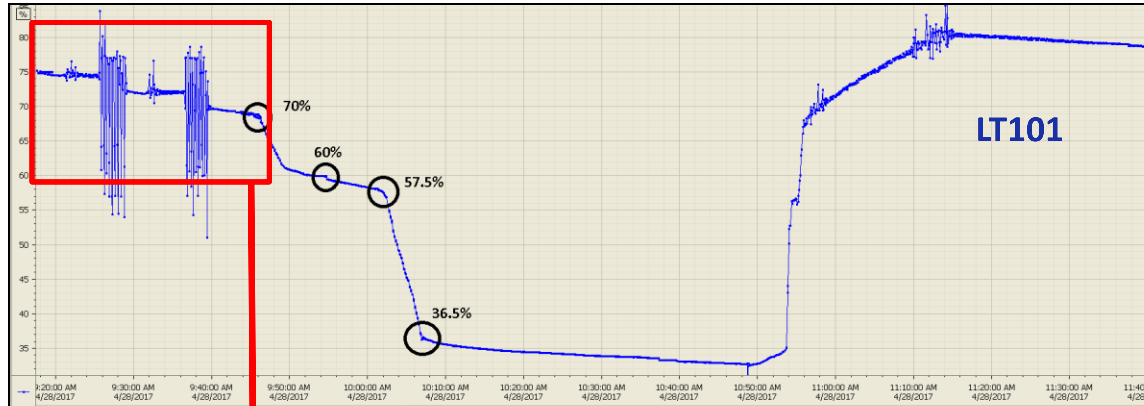
FT551 [m3/h]	Std dev [m3/h]	LT101 Region
6.7	0.3	1
6.4	0.3	2
6.2	0.3	3

Average static heat loads at 4K are 6.5 m3/h

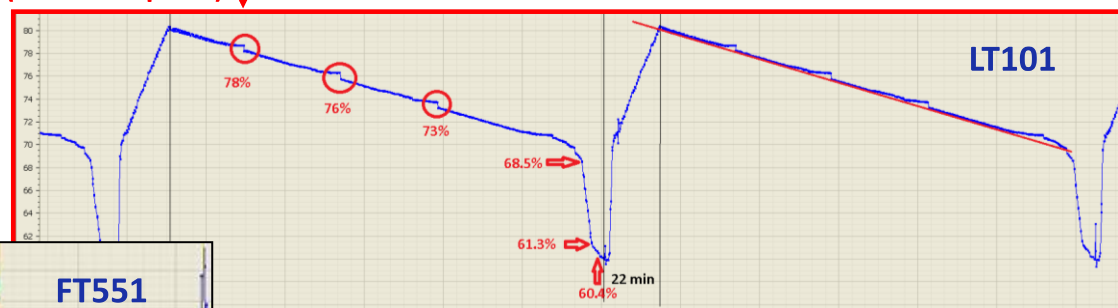


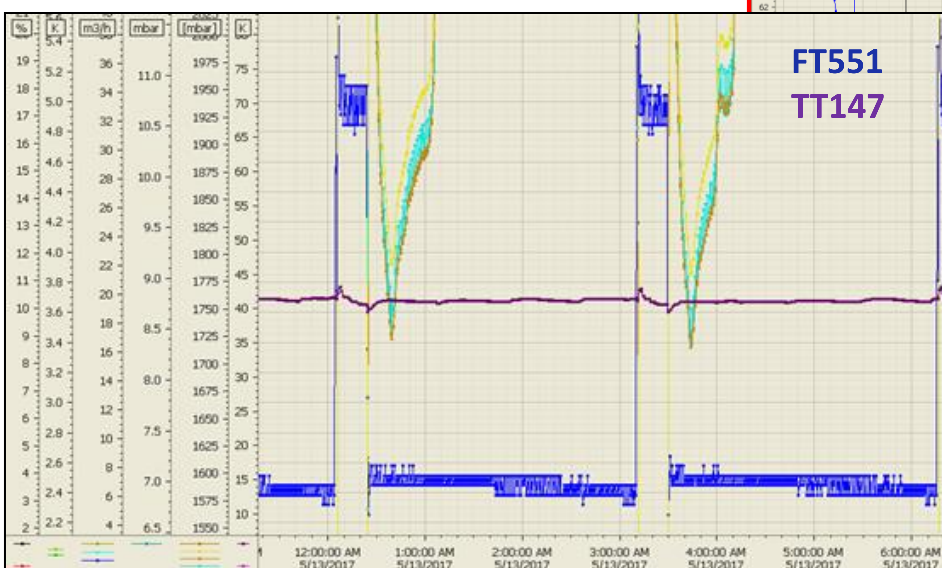
Static Heat Loads 20 mbar





(Without spikes)





Identified four (4) regions with no filling (CV105 off)

FT551	Std dev	LT101	
[m3/h]	[m3/h]	min [%]	max [%]
7.12	0.34	76	80
6.81	0.31	72	76
6.54	0.33	69	72
6.11	0.33	60	69

Effect of CV105 in FT551

At 20 mbar, measured the effect of CV105 on FT551 when varying opening of CV105

Note:

- The 4K tank was at ca. 1.2 bar
- The temperature of the coupler TT147 was kept at a constant temperature
- There was no RF/heat power applied during the experiments

CV105	TT147		FT551	
[%]	[K]	std dev	[m3/h]	std dev
5	42.2	0	8.5	0.3
10	42.1	0	9.4	0.4
15	42.2	0	10.8	0.4
20	42	0.1	12.6	0.4
30	41.8	0	16.2	0.5
50	41.8	0	22.3	0.5
100	41.6	0.3	32.5	0.8

Measurement

−

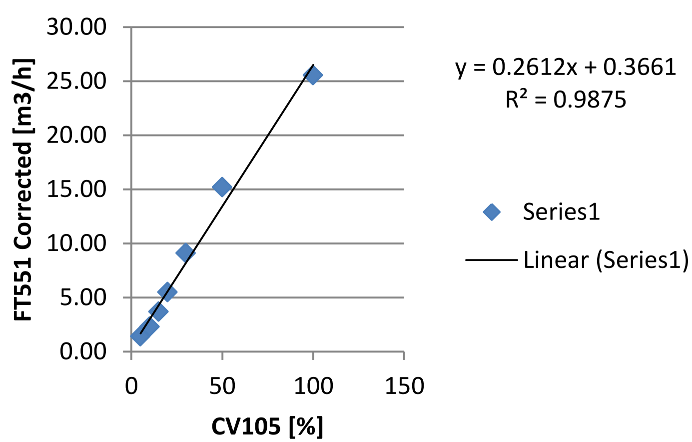
LT101	LT101 correction
[%]	[m3/h]
78-80	7.12
78	7.12
78	7.12
78	7.12
79	7.12
79-80	7.12
73-80	(7.12+6.81)/2=6.96

Correction depending on level

=

FT551 corrected	
[m3/h]	**% from total**
1.38	**16.27**
2.28	**24.29**
3.68	**34.10**
5.48	**43.52**
9.08	**56.07**
15.18	**68.09**
25.54	**78.58**

Flow from CV105 only



Effect of TT147 in FT551

At 20 mbar, measured the effect of TT147 on FT551 when varying opening of FT301
Note:
- CV105 was kept closed
- There was no RF/heat power applied during the experiments

TT147		FT551	
[K]	std dev	[m3/h]	std dev
42.4	0.1	6.5	0.3
81-91.5		7.07	0.34
85-90		8.3	0.4
32.1	0	7.2	0.3
31.9	0.1	6.9	0.3

Measurement

−

LT101	**LT101 correction**
[%]	[m3/h]
68-72	(6.81+6.54)/2
67.5-68	6.11
79-80	7.12
76-77	7.12
73-74.6	6.81

Correction depending on level

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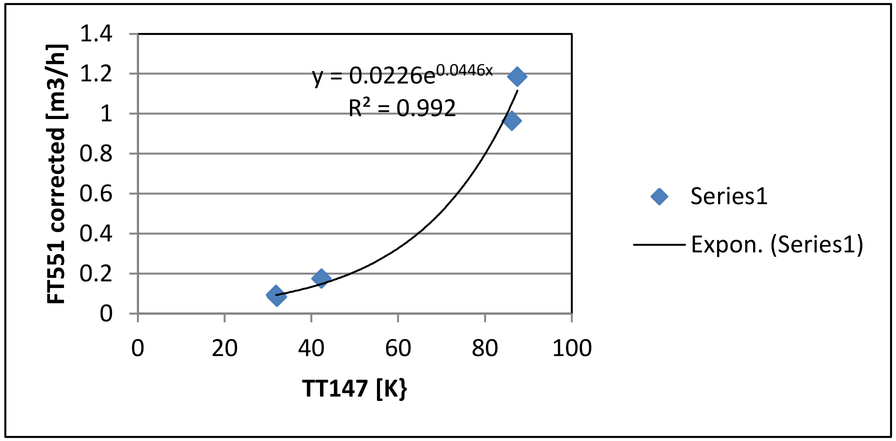
FT551 corrected
[m3/h]
0.175
0.96
1.18
0.08
0.09

Effect of TT147



From this experiment we concluded that the effect of TT147 on FT551 is minimal below 90K (less than max 1W).

Effect of Heat Power in FT551

At 20 mbar, measured the effect of heat power on FT551 when connecting EH103AB to an external power supply and vary the voltage.

Note:

- The correction for the voltage at the heater side was found to be 0.942
- CV105 was kept closed
- TT147 was kept well below 90K

Measurement

EH103	FT551	
[W]	[m3/h]	std dev
2	8.2	0.3
4	10.8	0.4
8	13.8	0.4
10	14.7	0.5
12	17.3	0.5
12	17.5	0.5
12	17.3	0.5

→

Correction depending on power

EH103 correction	FT551	
[W = m3/h]	[m3/h]	std dev
1.88	8.2	0.3
3.77	10.8	0.4
7.54	13.8	0.4
9.42	14.7	0.5
11.30	17.3	0.5
11.30	17.5	0.5
11.30	17.3	0.5

−

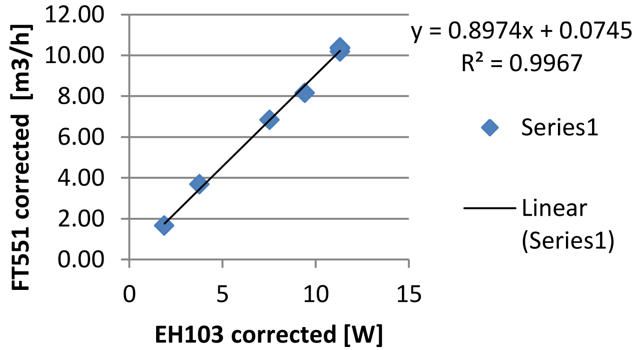
Level correction

LT101	LT101 correction
[%]	[m3/h]
70-72	6.54
79-80	7.12
75-77	(7.12+6.81)/2=6.96
70-72	6.54
77-80	7.12
76-79	7.12
74-80	(7.12+6.81)/2=6.96

=

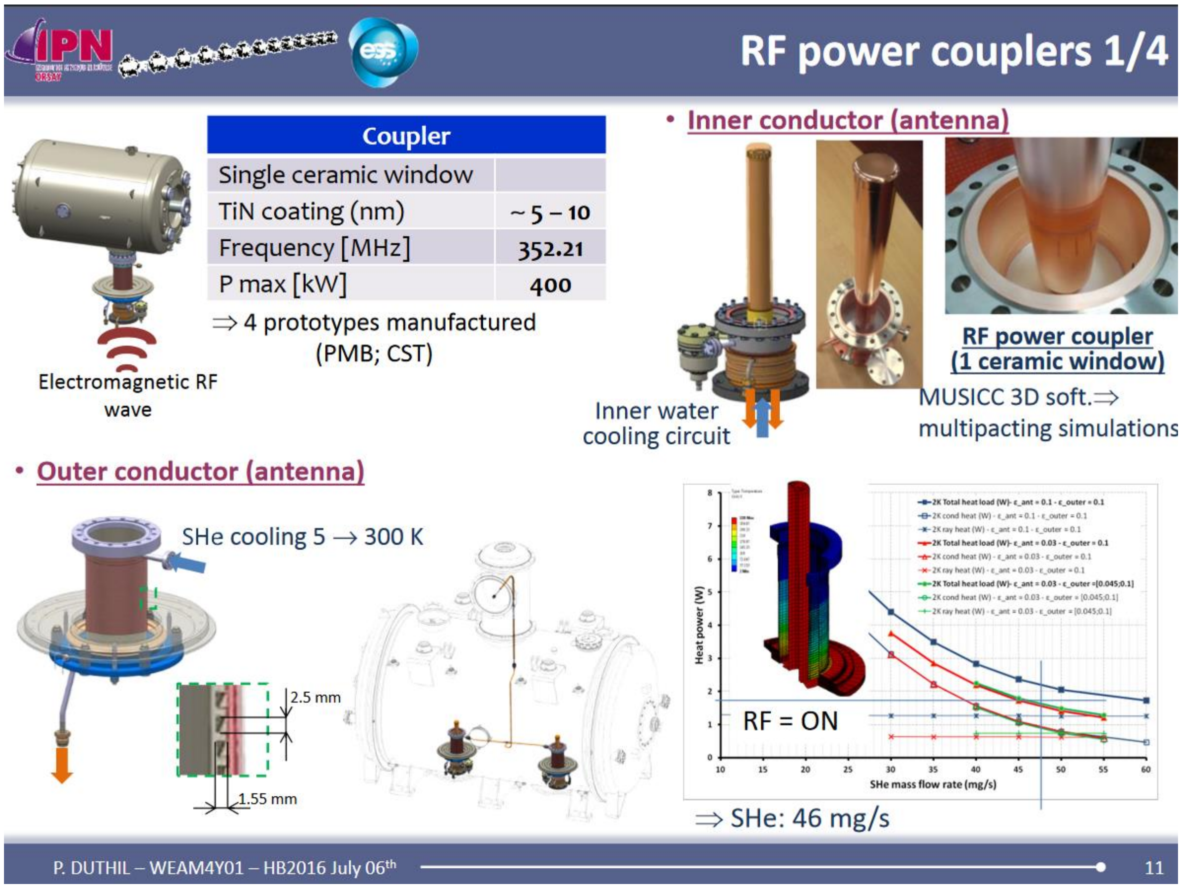
Power dissipated by the cavity

FT551 corrected
[W = m3/h]
1.66
3.68
6.84
8.16
10.18
10.38
10.34



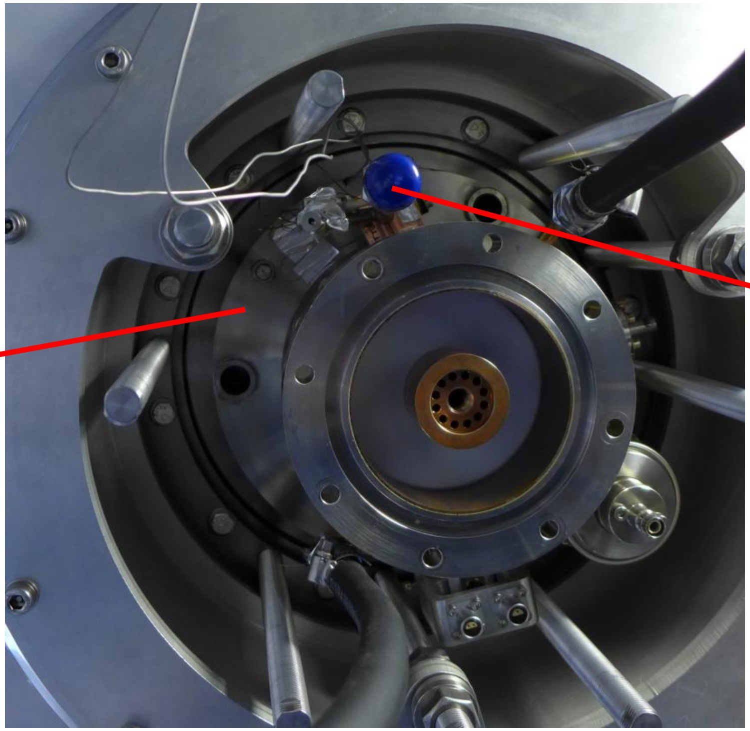
ScHe Circuit (1/4)

- Note:
  - TT304 and TT306 (for coupler 2) were not in place
  - All RF measurements have been done with CV105 closed
  - IPNO set at inlet temperature of and outlet of 300K and with a flow of 46 mg/s



ScHe Circuit (2/4)

- First, we tried temperature regulation for only Coupler 1 and set it to 9K, but TT305 was at 266K despite the FPC having a heater on the last flange before the ScHe is sent out (76 W in power). Had to add an extra heater band and wrap it around the line to avoid it from freezing.



- The regulation of the valves CV301and CV302 has to be fine-tuned: there are big variations in openings and thus in temperature while trying to regulate it to the set point.

ScHe Circuit (3/4)

- Decided to regulate on constant flow instead. Kept it at 0.4 m3/h for coupler 2 and at a minimum of 0.8 m3/h for coupler 1 if no RF/heat power is applied.

- The maximum flow we have set coupler 1 to has been 1.2-1.4 m3/h, when going through either regions of high multipacting or when at high fields.

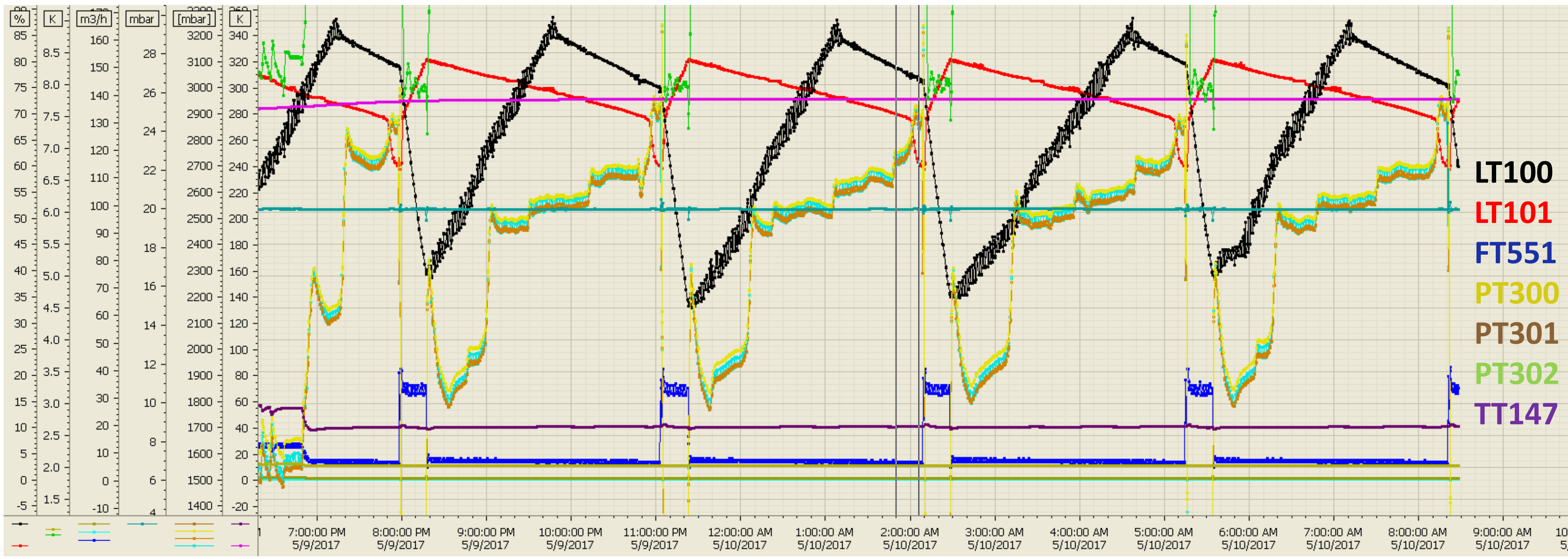
  → According to IPNO 0.4 m3/h for no RF power is already quite much, but it was the minimum to keep TT147 below 50 K. Are these values reasonable?

- In the future we will install an extra Cernox sensor at the interface between the cavity and the FPC since we had no idea how much heat the coupler (at T_{room}) was bringing into the cavity. Also, This sensor might be better for regulating the temperature of the FPC instead of TT303.

  → According to the tests previously done measuring the effect of TT147 in FT551 (slide 11) as long as TT147 is kept below 90 K the extra heat load given is quite negligible. Still it seems counter intuitive to have such a mass at Troom connected to 2K via thermalization at 40K (usually). Does this make sense?

ScHe Circuit (4/4)

- It was not possible to keep the pressure in the ScHe system constant: when the 2K tank fills the parameters in the ScHe system vary drastically and it takes quite some time for them to be back to normal. Also, when PT300 increases over 3.5 bar the SV to the recovery system opens, reducing the pressure.

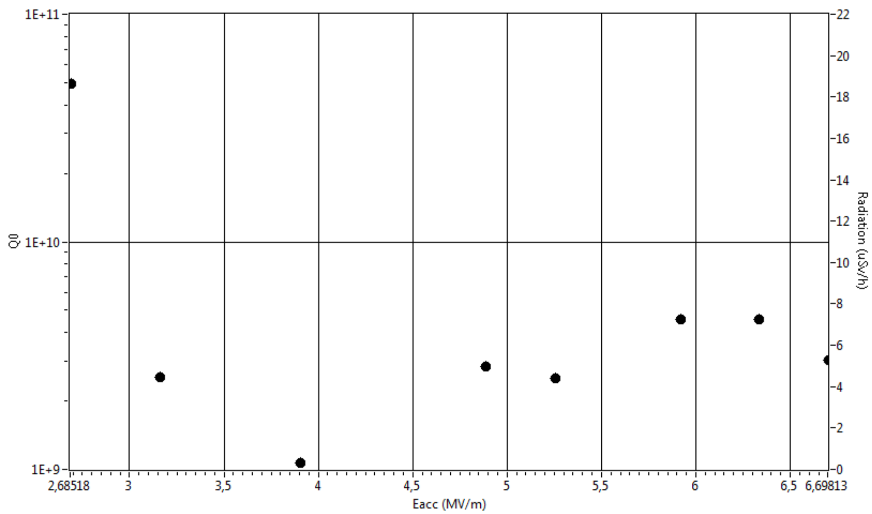


- <u>How does the valves CV301 and CV302 regulate</u>? When the system is being filled with GHe these valves reduce their opening and once the filling has stopped they open again to the given flow.

Q_0 measurement

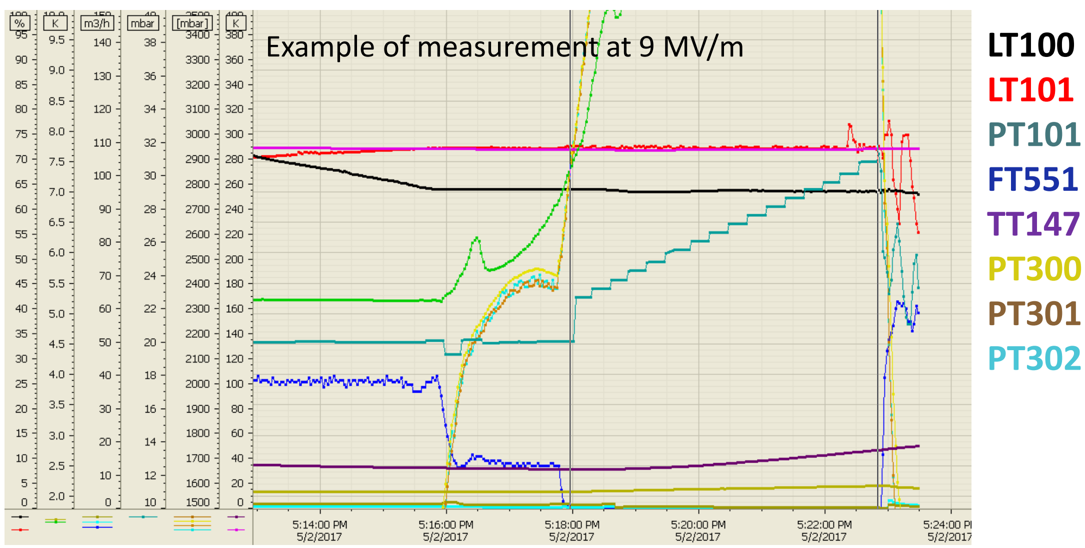
- The measurement for Q_0 was done at 20 mbar and by keeping CV105 closed (no filing of the 2K tank) during measurements
- Two methods were used to calculate the Q_0 slope:
  - By using the dynamic heat load given by FT551 (evaporation method)
  - By the pressure rise method

- **Evaporation method**
  - The level was kept between 73% and 77%
  - After the corresponding RF power was applied, the system was left to stabilise: stable pressure, stable flow and TT147 below 40 K (if possible)
  - The value given by FT551 at the time was used to calculate Q_0



Q_0 measurement

- **Pressure rise method**
  - The level in the 2K tank was kept between 60% and 80%
  - Initial calibration with varying heating power is done.
  - After calibration, the desired RF power was applied and the system was left to stabilise only in pressure. This was because it took a long time to bring TT147 down and since TT147 had not so much effect on the flow when kept below 90K.
  - Once the pressure was stable, the outlet valve CV552 would be closed and, after thirty (30) seconds, the RF team would measure the pressure rise for three (3) minutes.
  - The first thirty seconds were never recorded because they showed a different slope. After ca. 30 s then the slope was constant . <u>What is the reason behind for the change in slope?</u>

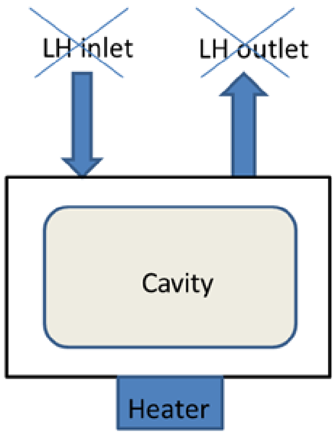


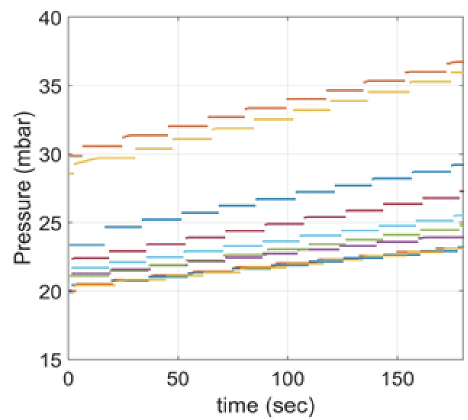
Q_0 measurement

- Measurement method for the pressure rise

➤ Calorimetrical measurement of Q_0

- ✓ close inlet and outlet valves of the cryomodule
- ✓ record the pressure as a function of time
- ✓ apply a known amount of resistive heat to the helium
- ✓ again record the pressure a function of time



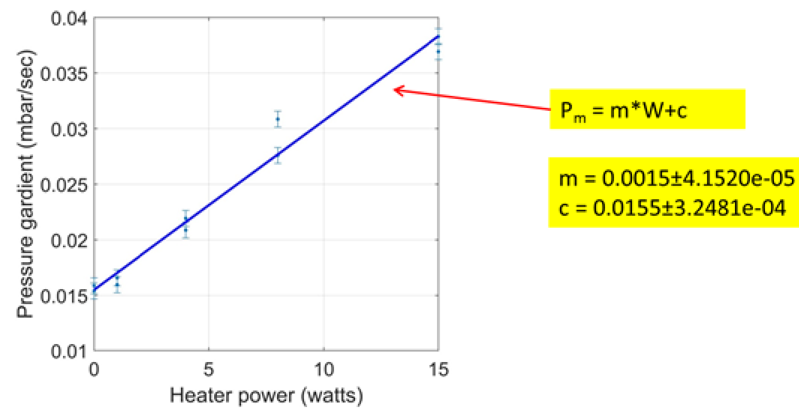


Pressure curve vs Applied Power

Courtesy of H. Li

➤ Calorimetrical measurement of Q_0 cont.

- ✓ build the calibration curve: the rate of pressure rise vs. heat
- ✓ load apply RF to the cavity, record the pressure rise
- ✓ calculate the dynamic RF load using the calibration curve



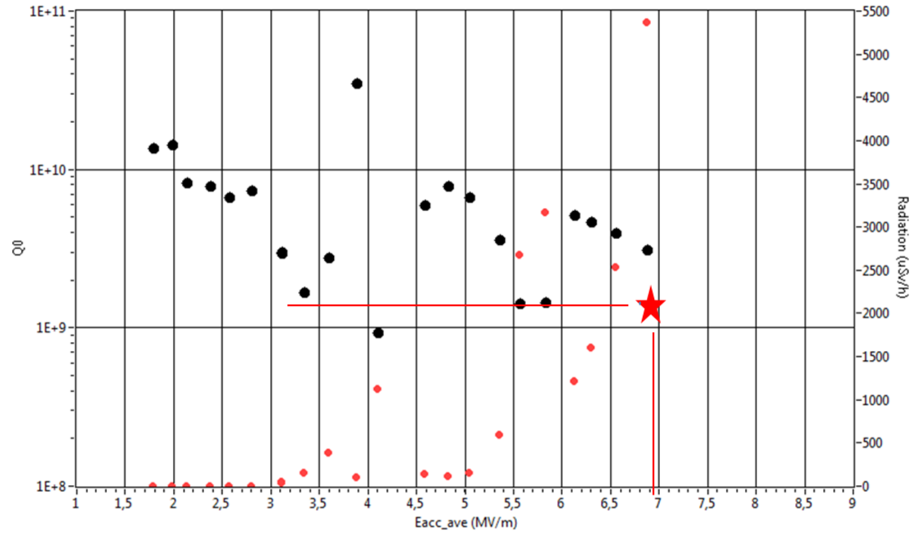
Courtesy of H. Li

Static Heat load = 0.0155/0.0015 = 10.3W

Q_0 measurement

- Q_0 slope obtained via pressure rise method

Test of dressed cavity equipped with the FPC and CTS



- ✓ Low-field Q_0 factor of 1.6×10^{10}@ 2 K
- ✓ Q factor of 3×10^{9}@ Eacc_peak=9MV/m
- ✓ Several multipacting regions were found

Courtesy of H. Li

Evaporation vs P rise

- From these two different methods we get two different values for the static heat load of the cavity:
  - Evaporation method: 6 W – 7 W
  - Pressure rise method: 10 W
- <u>How can we explain the difference?</u>
  - The hydrostatic pressure at the top of the cavity would be $P_{top} = P_{tank}$ + 6.5 mbar and at the bottom $P_{bottom} = P_{top}$ + 7.4 mbar . To have a change from superfluid helium to normal helium the temperature must be 2.17 K (49 mbar), which would mean a maximum pressure of 35.1 mbar in the 2K tank. For some measurements, the pressure has not increased over 35 mbar and still we get a static heat load of 10 W…
  - During these measurements the ScHe circuit inreases rapidly in pressure and TT1147 warms up, but remains below 90 K.