SPS DQW Module: Tests & next steps

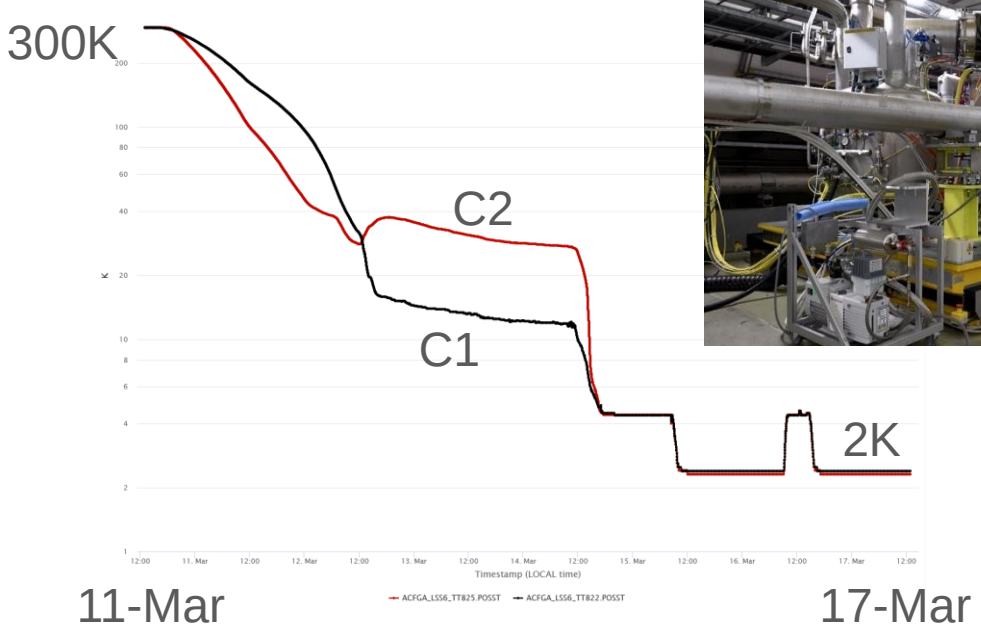
HL-LHC WP4

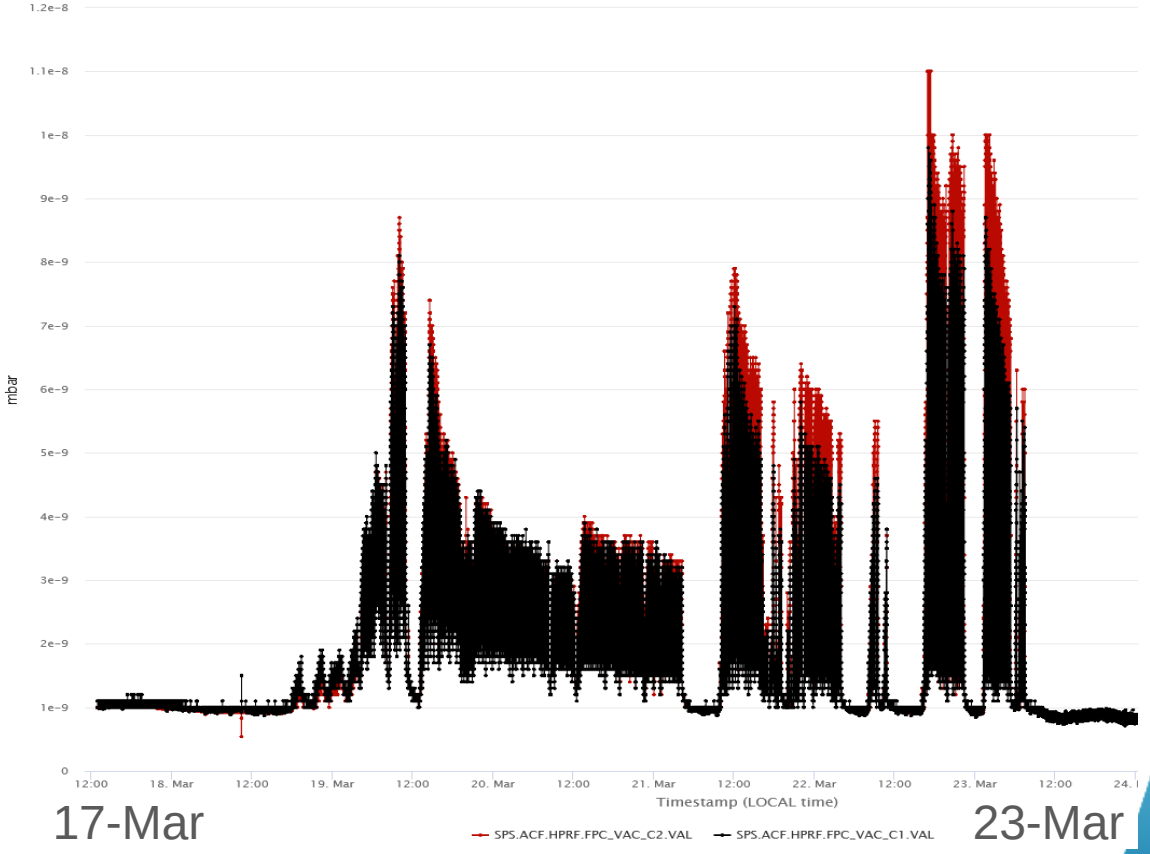
CERN & Collaborations

19 September 2022

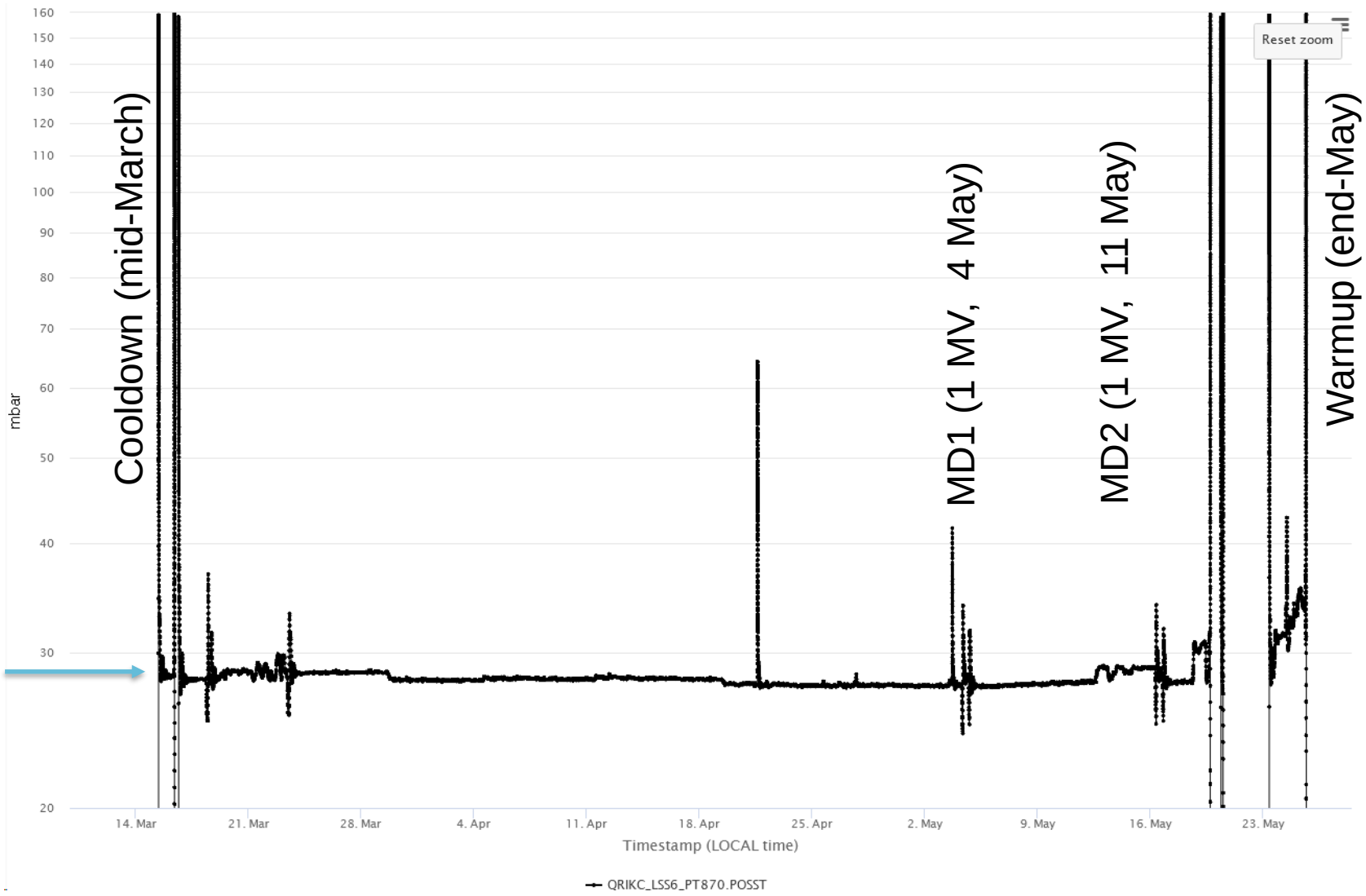
DQW-SPS Re-commissioning, 2022

- Module at 2K Mar-Jun & Sep-Oct
- Scrubbing successfully performed at 26 GeV up to **5-batches of 72 bunches at 1.7×10^{11} p/b**
- 3 out of 4 MDs completed this year, last MD foreseen for Sep 28



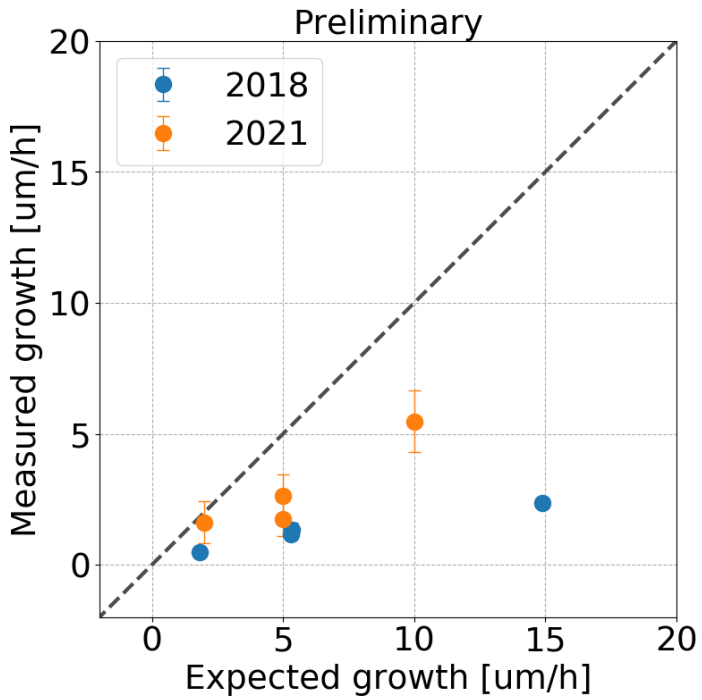


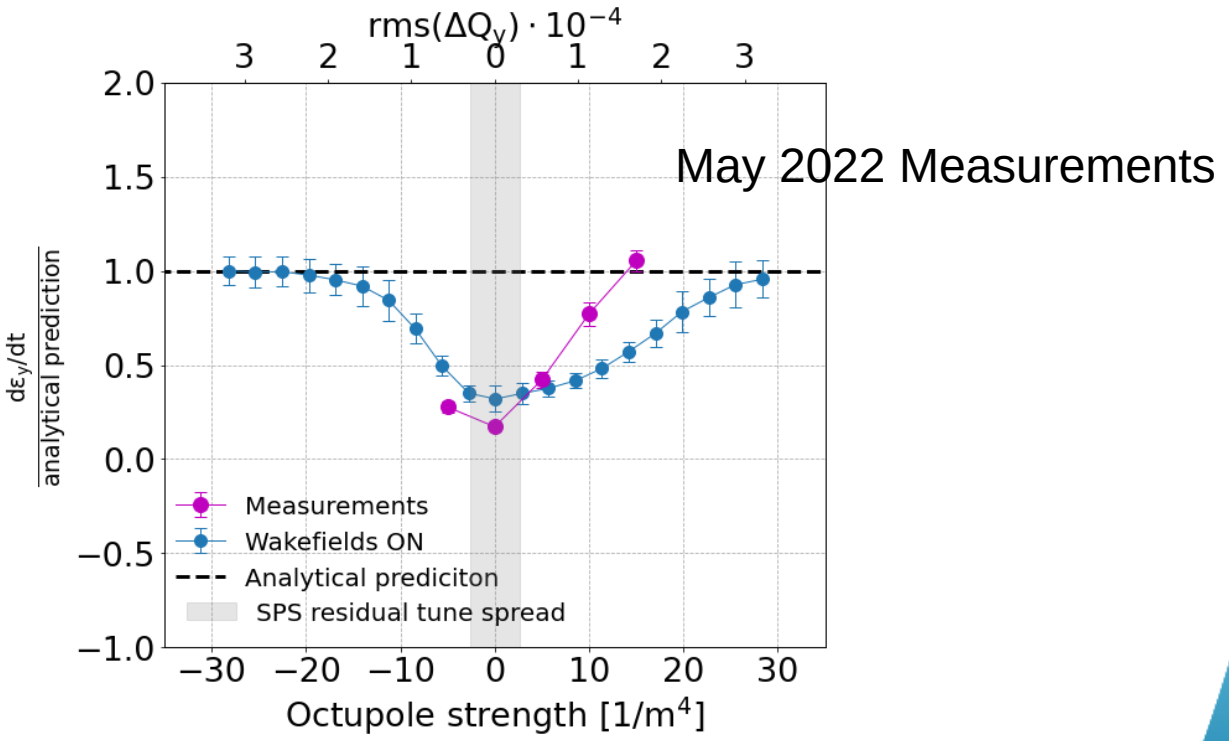
2022 Overview, Period 1



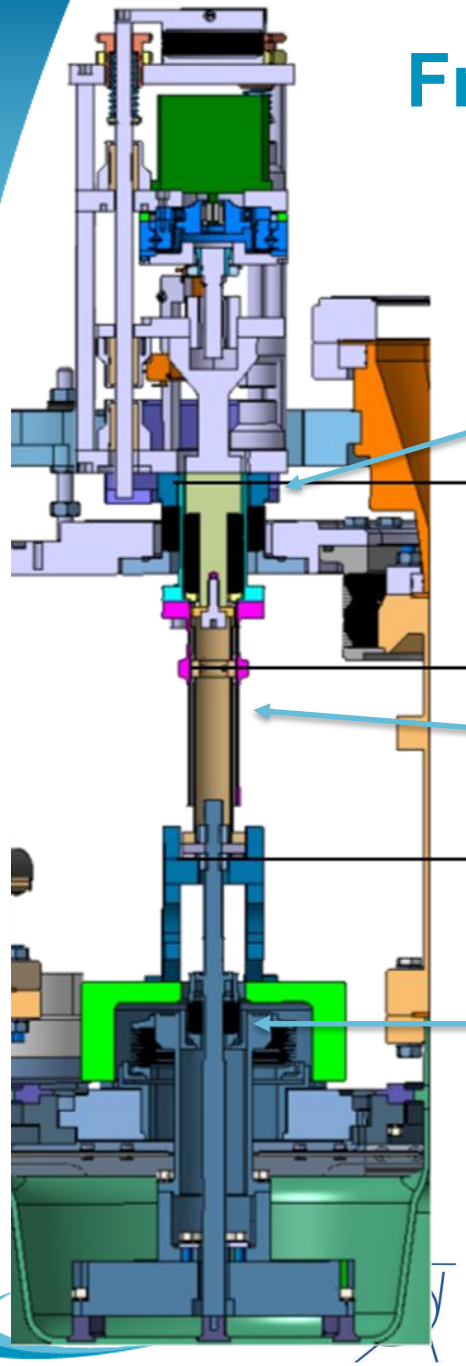
Highlight Result: Emittance Growth with RF noise

- Measured growth smaller by x4 than predicted (2018 & 2022)
- Suppression of emittance growth due SPS machine impedance confirmed – **see talk by N. Triantafyllou Thursday**





Frequency Drifts observed during “Quiet Periods”



Feedthrough bellow: sensitive to pressure (atm)
1% change atm >> ~ 3N *

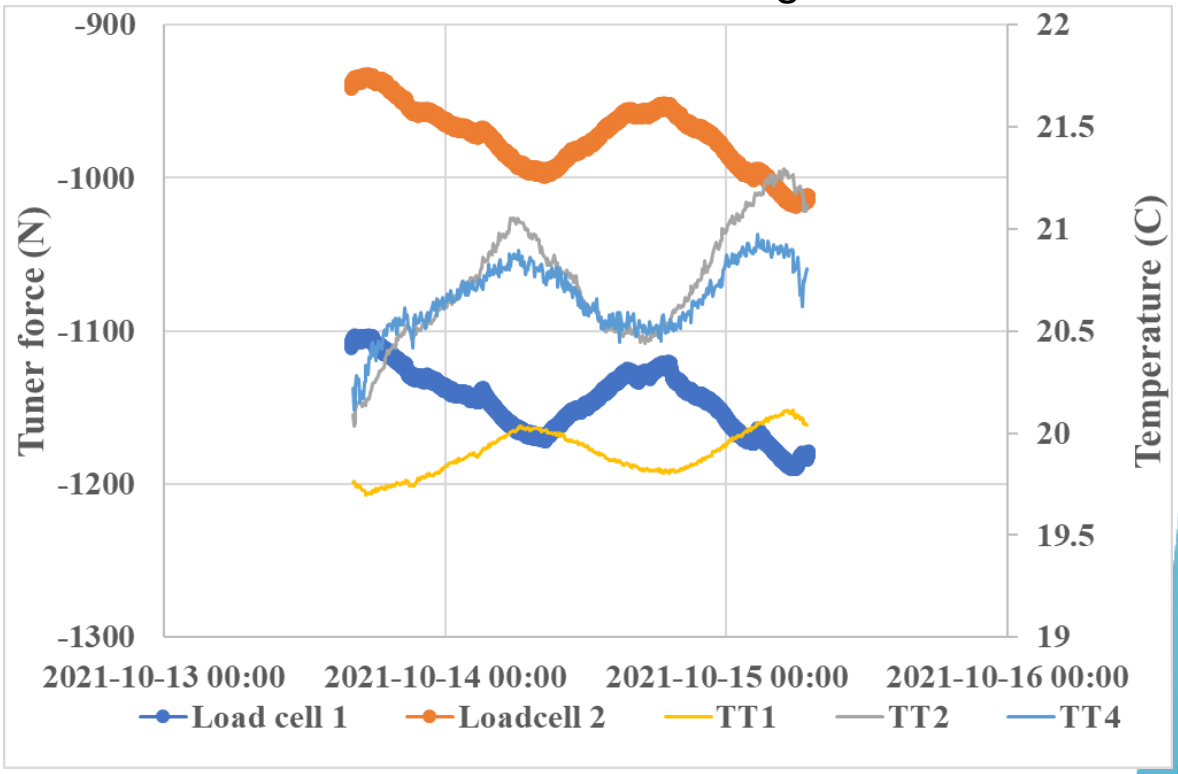
Temperature gradient, change will change tuner load

Thermalisation temperature not measured, refer to FPC thermalisation

He Tank feedthrough + cavity surface.
Sensitive to He tank pressure (and temperature when saturated liquid)
1 mbar >~3 N*

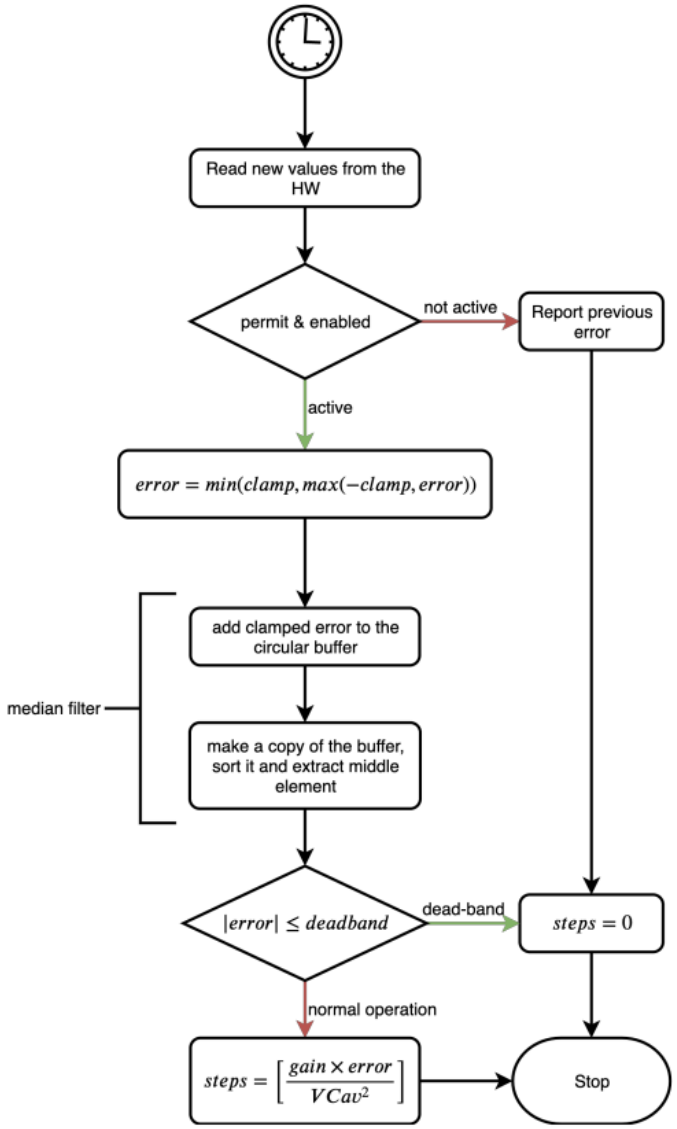
* Rough estimate

2K no tuner changes



Courtesy K. Artoos – Tuner Observations

Tuner Loop Updates



The tuner loop functions on signals from the field antenna (TRAN) and input (FWD)

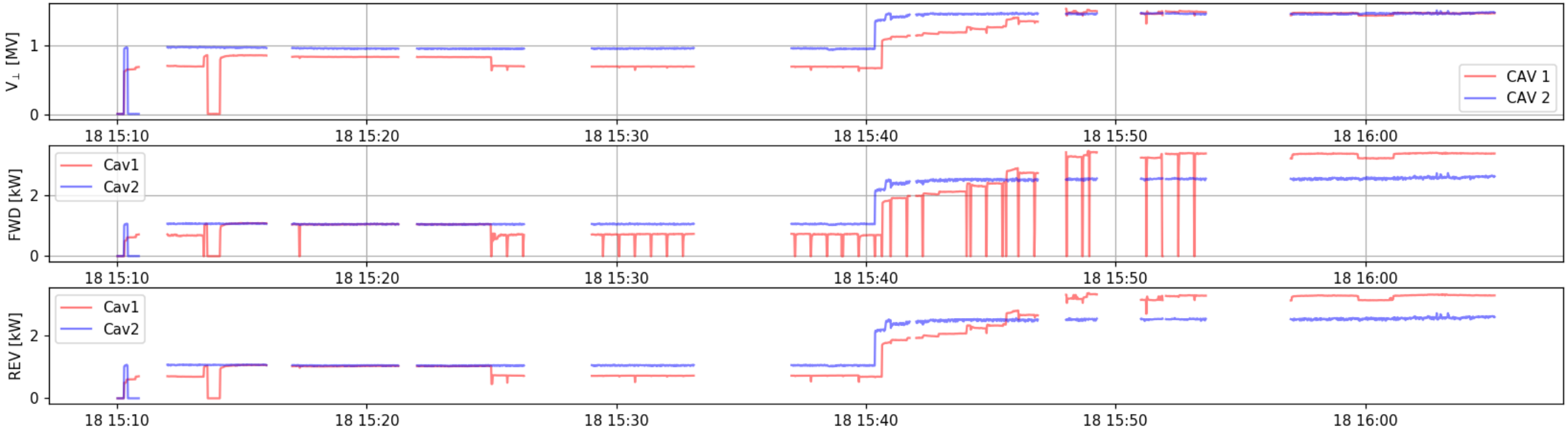
The phase difference is converted to an error signal which is then converted into number of steps based on FB gain and voltage-squared.

This principle was adopted form LINAC4 tuner loop which is identical to what is implemented in SPS-DQW test module

In 2022, the steps were changed with voltage & not V^2like in the past and some minor upgrade

Since, then the appears to have improved stability than in the past. However, the RF-on flattop has to be long enough for the tuner to latch and add correctly which is not true in all SPS cycle

Pushing the Voltage – slowly (May 2022)



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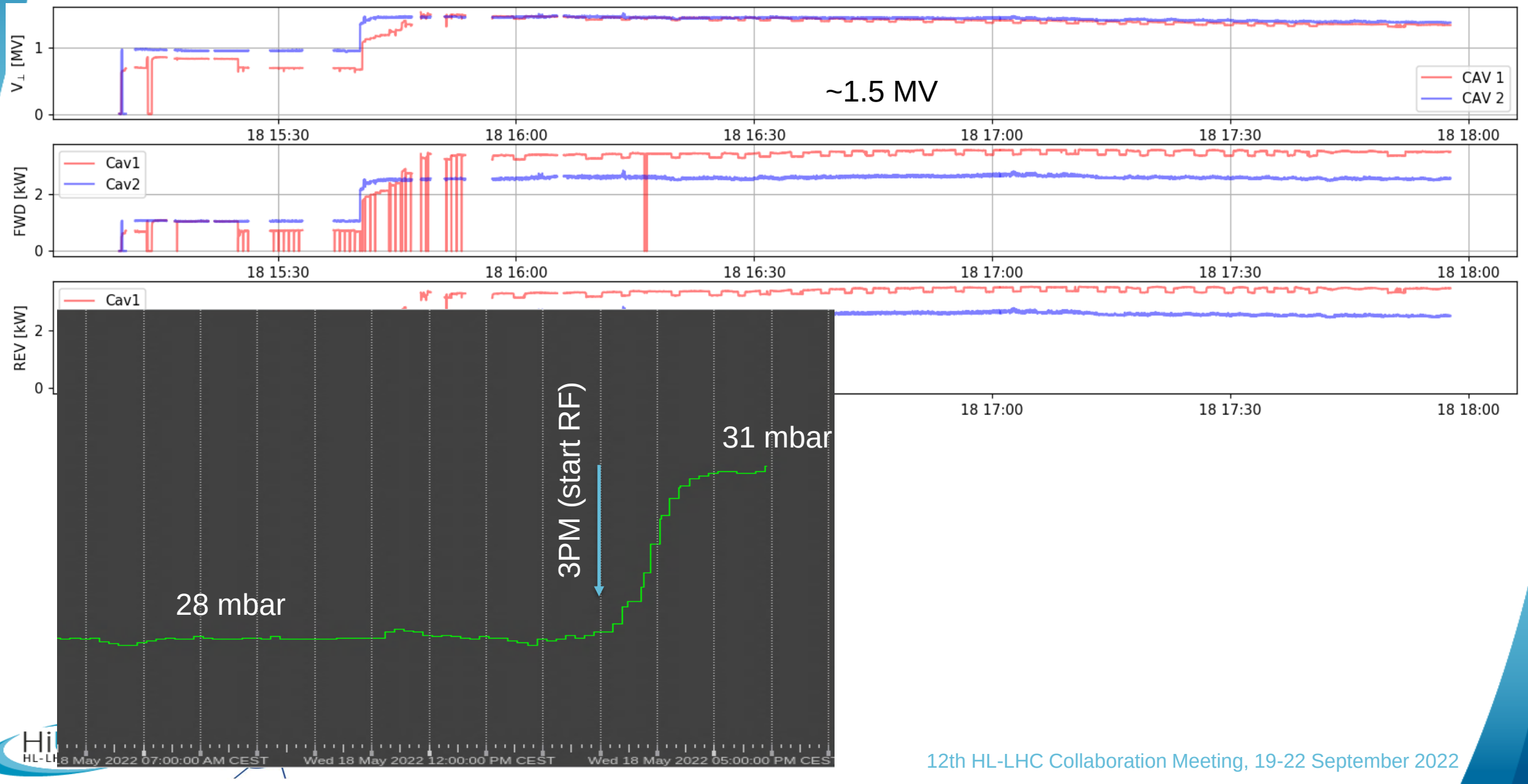
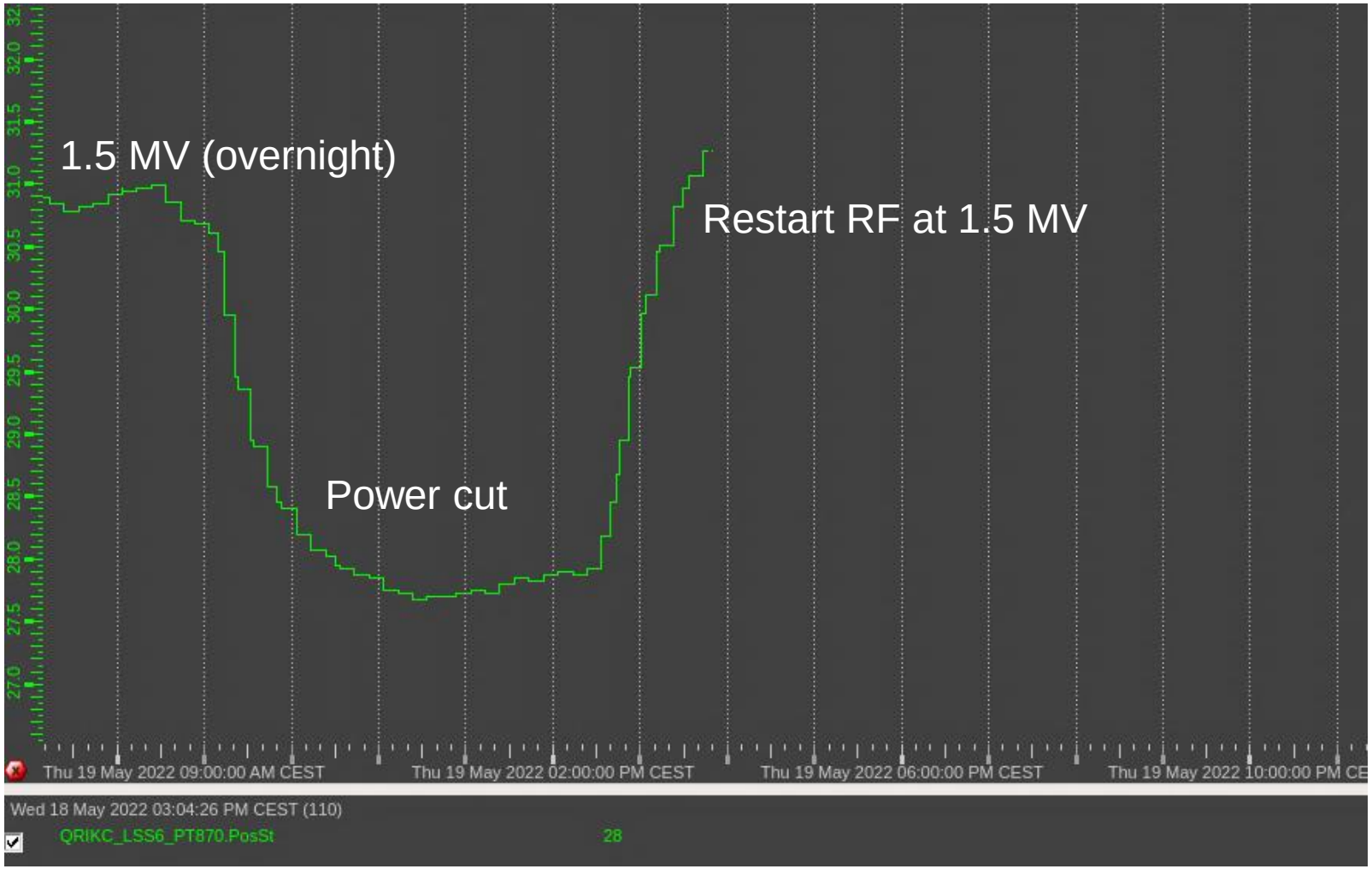
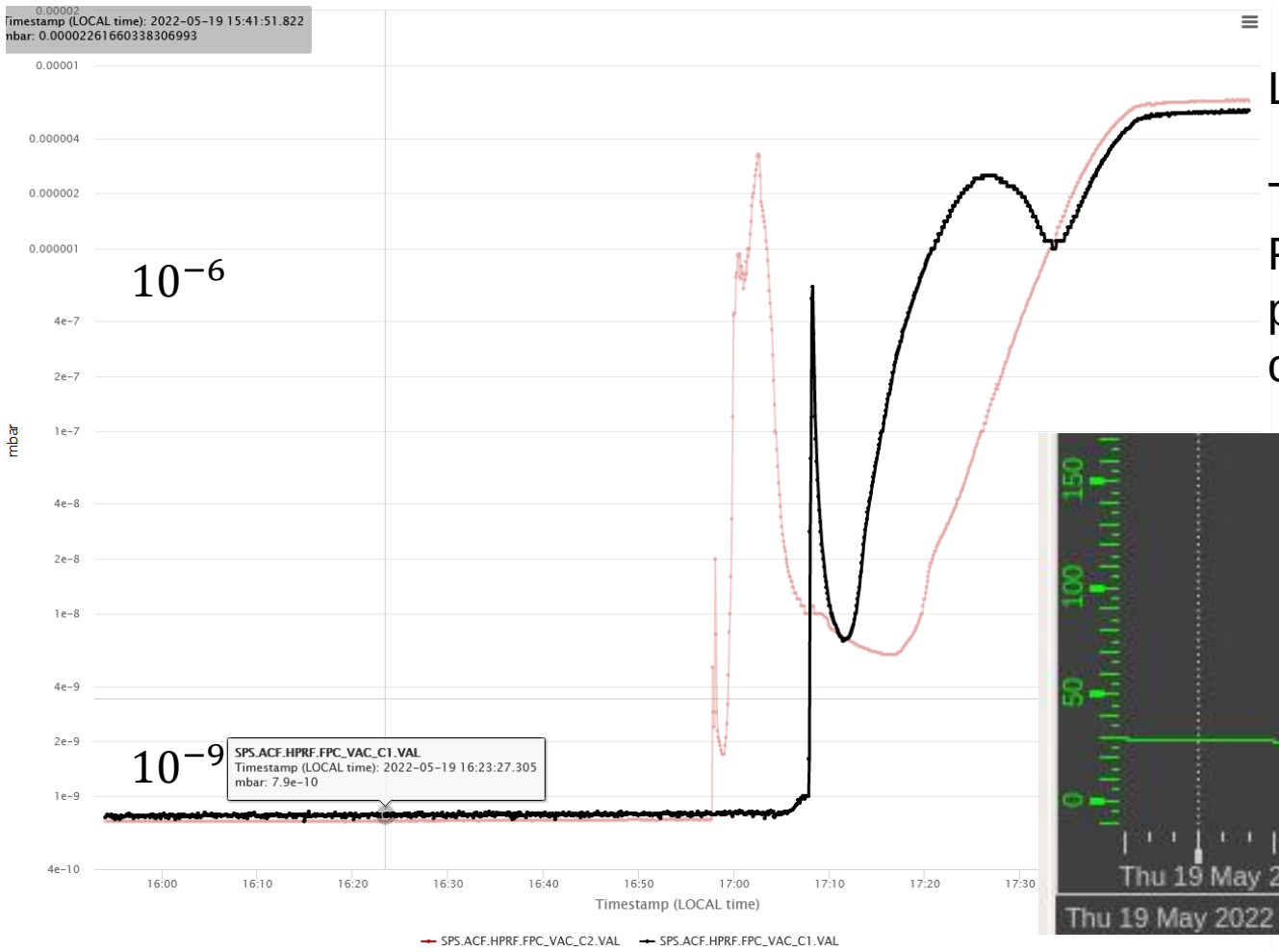


Cryo Evolution

Increase in ~0.5 MV → 3 mbar is real



Pushing more: 1.7 MV in both cavities

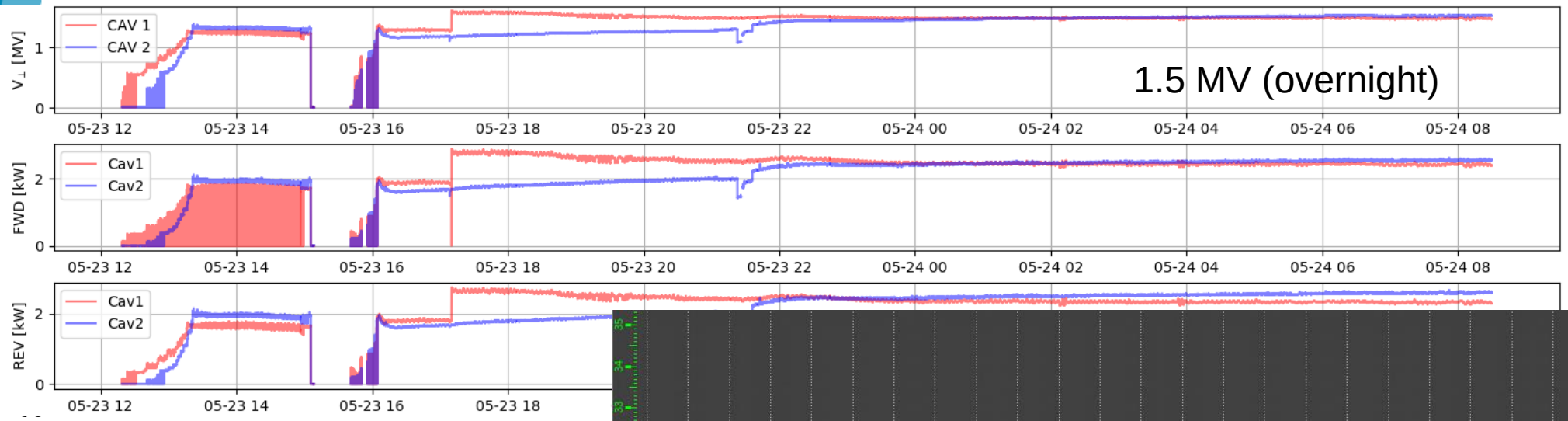


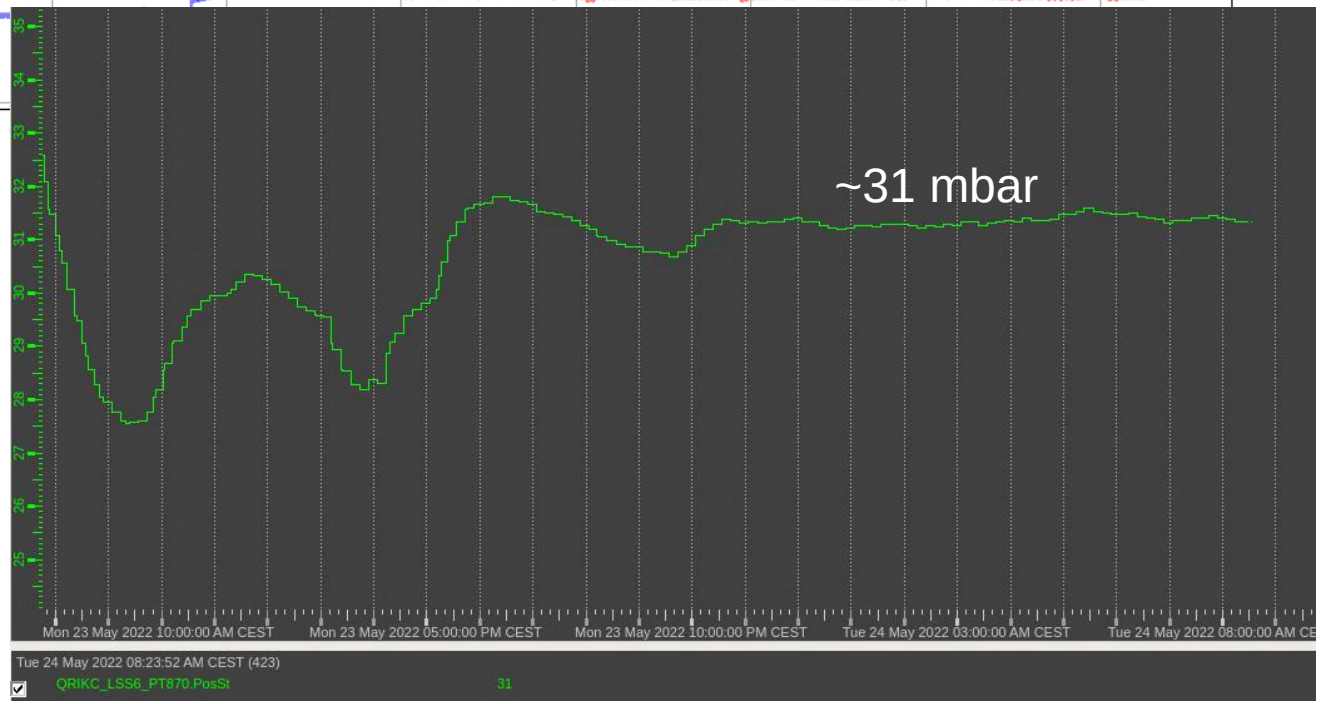
Large vacuum rise, cryo conditions lost

To go higher in voltage, we need to setup a PLL in the RF conditioning loop which is presently done in open loop. This guarantees conditioning on tune with the cavity

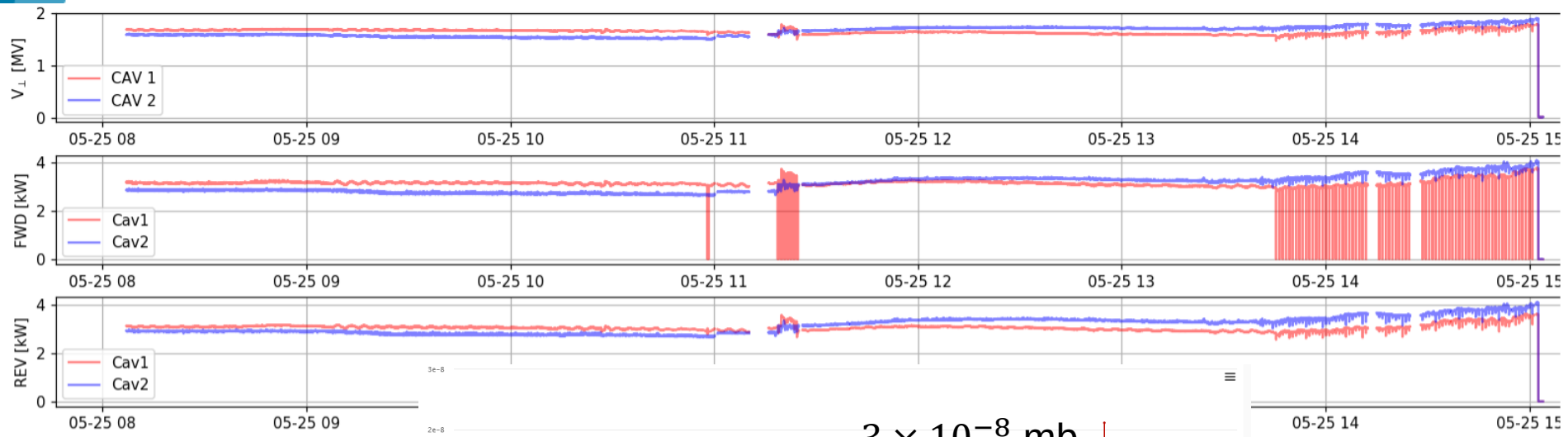
After this incident, turbo pumps turned on ~1day

2 days later


CAV 1
CAV 2
V⊥ [MV]
1.5 MV (overnight)
Cav1
Cav2
FWD [kW]
REV [kW]
05-23 12
05-23 14
05-23 16
05-23 18
05-23 20
05-23 22
05-24 00
05-24 02
05-24 04
05-24 06
05-24 08

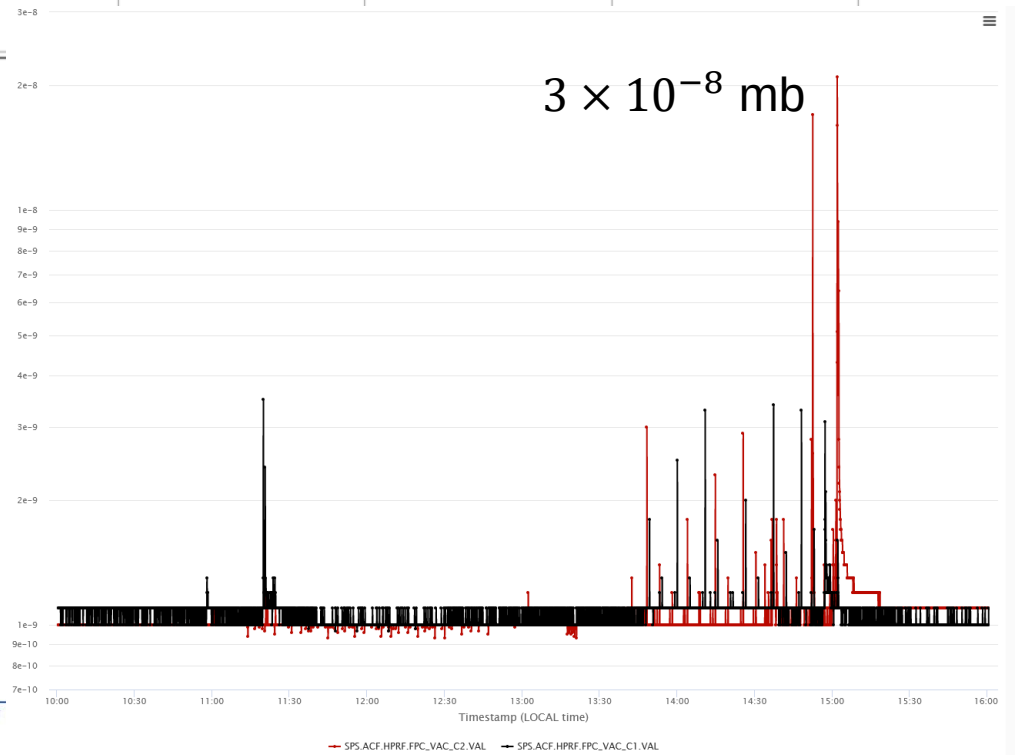

~31 mbar
Mon 23 May 2022 10:00:00 AM CEST
Mon 23 May 2022 05:00:00 PM CEST
Mon 23 May 2022 10:00:00 PM CEST
Tue 24 May 2022 03:00:00 AM CEST
Tue 24 May 2022 08:00:00 AM CE
Tue 24 May 2022 08:23:52 AM CEST (423)
QRIKC_LSS6_PT870.PosSt
31

Towards 2 MV



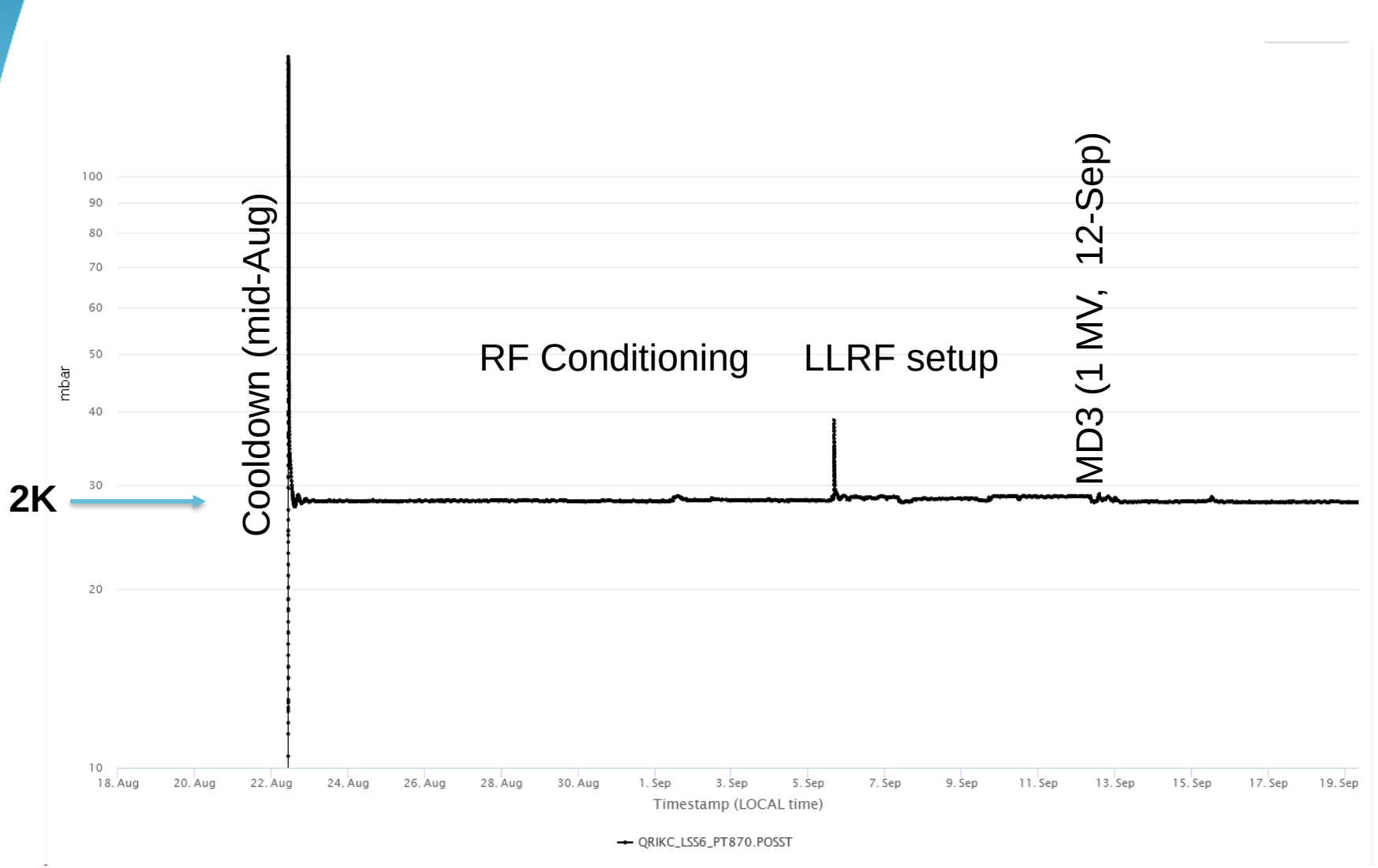
Very slow increase in steps of 0.01 MV

Cav 1 ~1.9 MV
Cav 2 ~1.8 MV



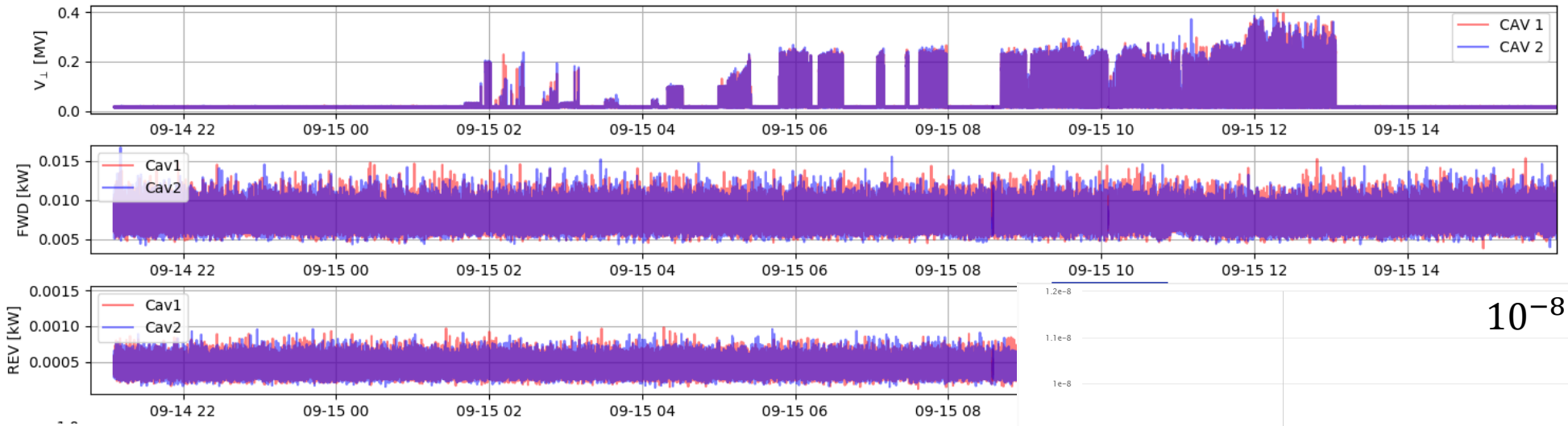
Voltage oscillations visible even on SEL. RF Conditioning needed

2022 Overview, Period 2

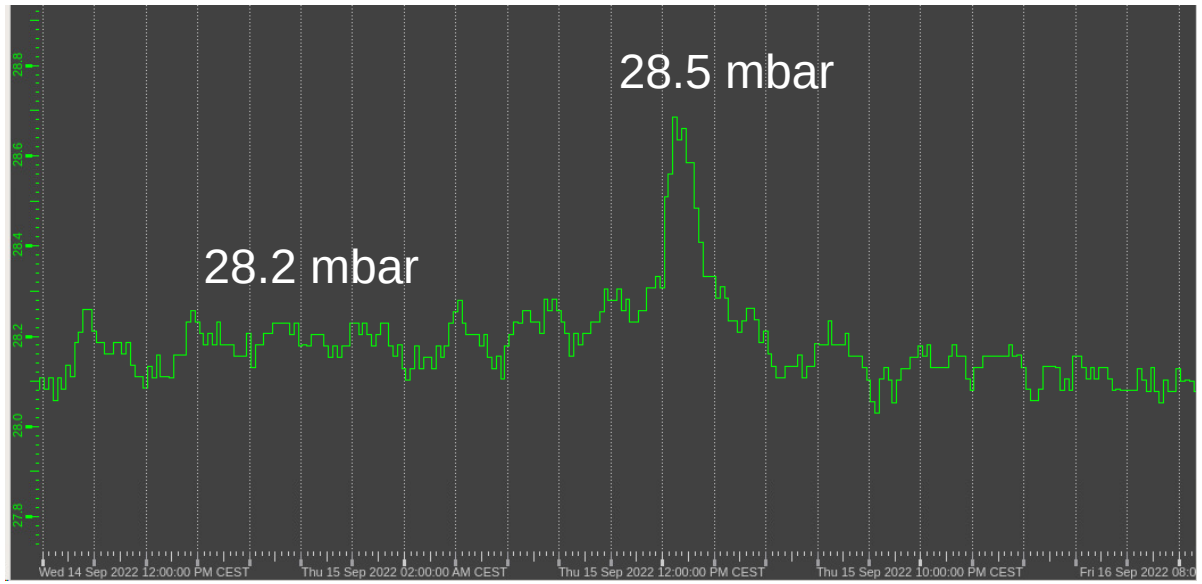


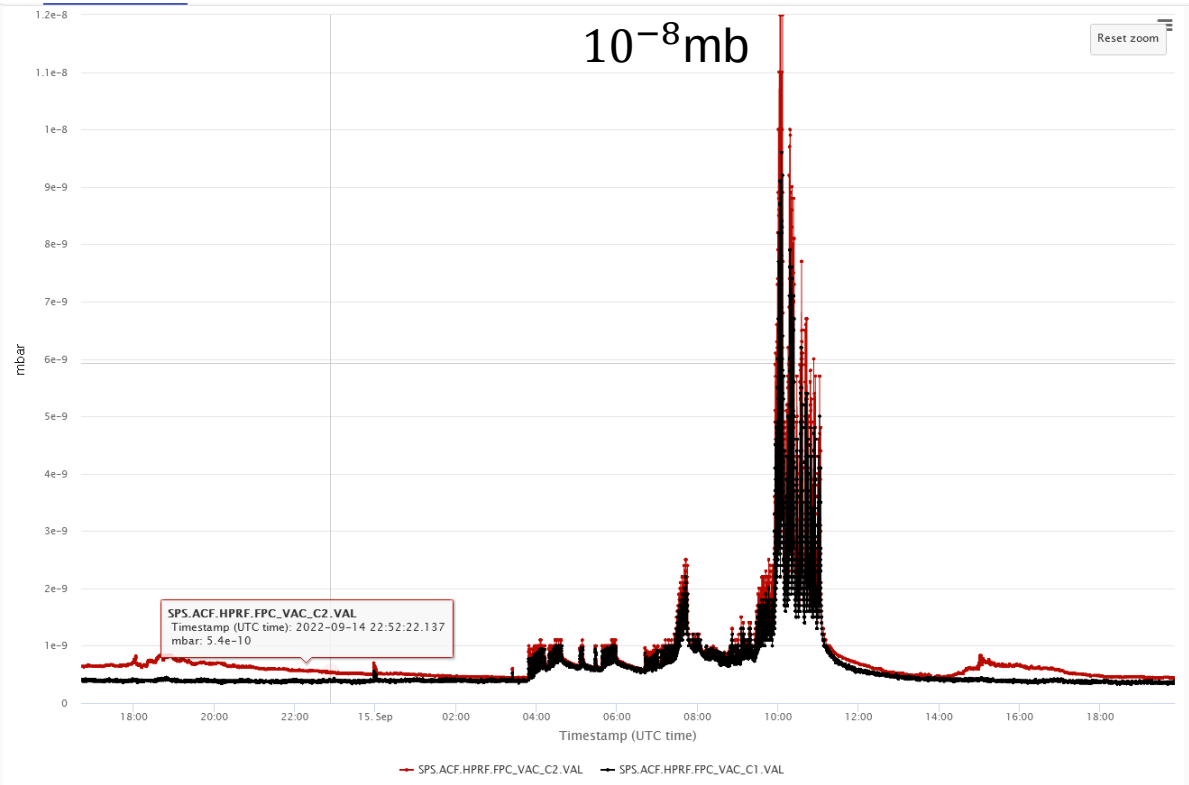
Warmup (expected mid-Oct)

15-Sep (COLDEX MD, Crabs off but Scrubbing)



Up to 4 batches 72b
Intensity $\sim 1.2 \times 10^{11} p/b$





Some comments

- The cool-down of the module and stability at 2K well understood and feasible ~2 weeks
  - Note that each thermal cycle or warm up has to be closely coordinated with vacuum for TMPs to be opened/closed
- RF conditioning up to 10 kW (but low voltage) also relatively fast after thermal cycle ~1 week or less
  - To move to 2MV and higher, we need special setup with RF conditioning
- LLRF setup including closing feedback has improved dramatically and up to 1 MV can easily be done ~ 1day
  - A setup to start with SEL and lock to driven loop is being implemented for easier freq finding and setup (“automatic sequencer”)
- No effect seen yet at low voltage with sector valves opened and closed several times & strong beam conditioning of the bypass