Irradiation tests at GIF++ on ATLAS-NSW MM production modules SM1 M#4 [Italy] & SM2 M#5 [Germany]

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Setup / goal @ GIF++

- Making sure humidity was controlled and known
- Chamber was well characterized before being exposed to irradiation
  - @ CS and @ Preparation zone just outside GIF++
- Serial Gas flow [SM1 ⇔ SM2], 5-20 L/h, Ar:CO2 (93:7)
- Not an ageing study, **focus is on HV stability**
- Never exceeded the HV maximum [i.e. 580 V] - *Muon Week Oct 2018 https://indico.cern.ch/event/761784/contributions/3183298/attachments/1739026/2813558/Cleaning_HV_TF_Document.pdf*
- limit voltages to established operating regime 560 – 580V

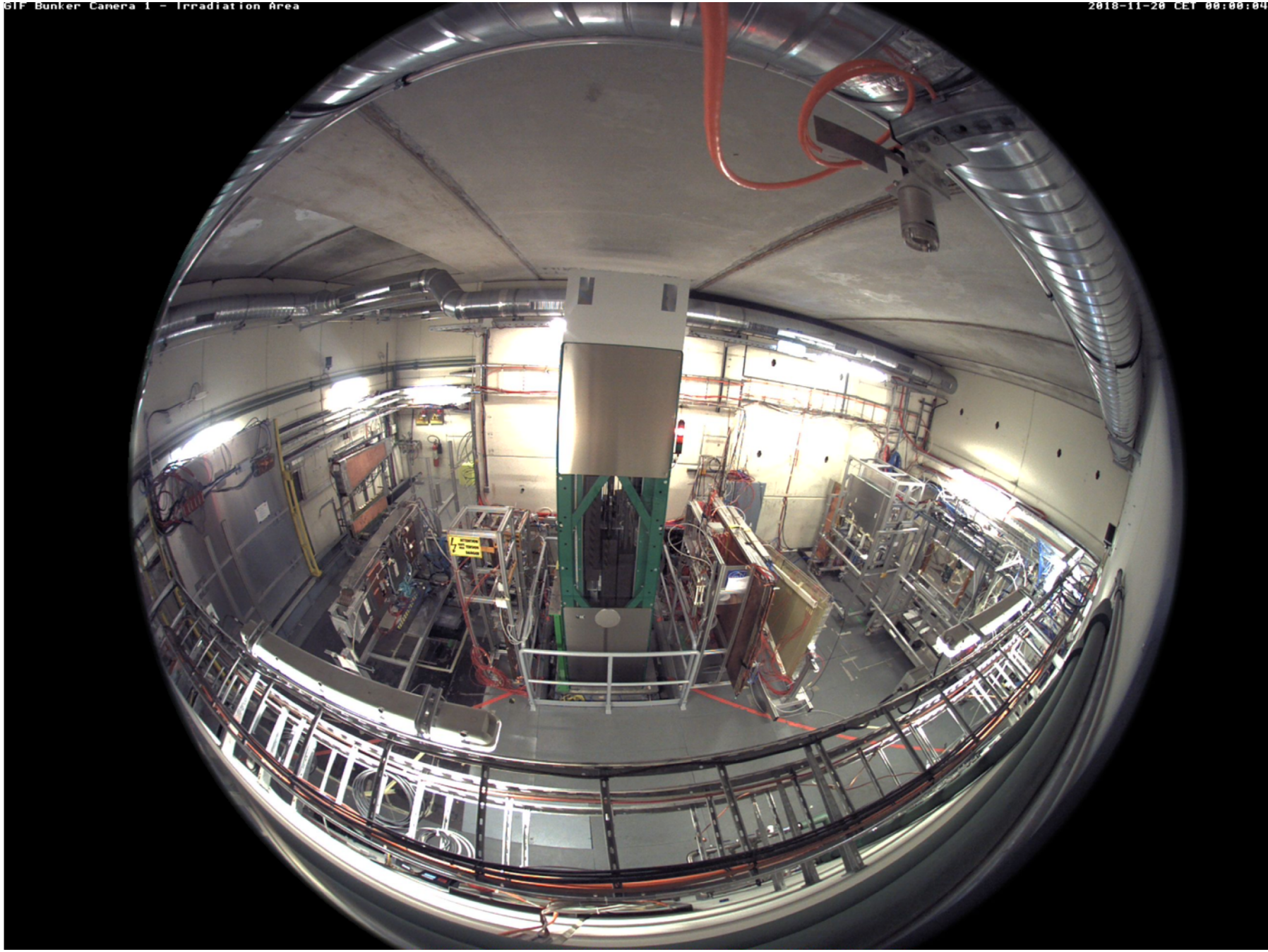
GOAL ➔ Check for anomalous increase in current when switching on irradiation, and/or abnormal increase in spark rate

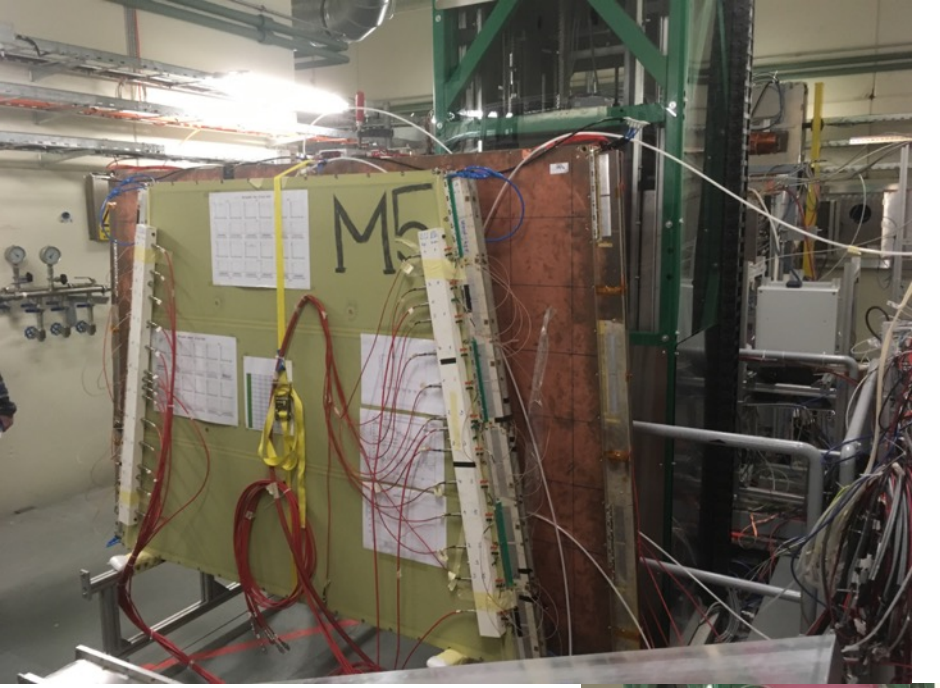
➔ Verify current return to pre-irradiation levels with source off

Typical setup @ the GIF++ bunker

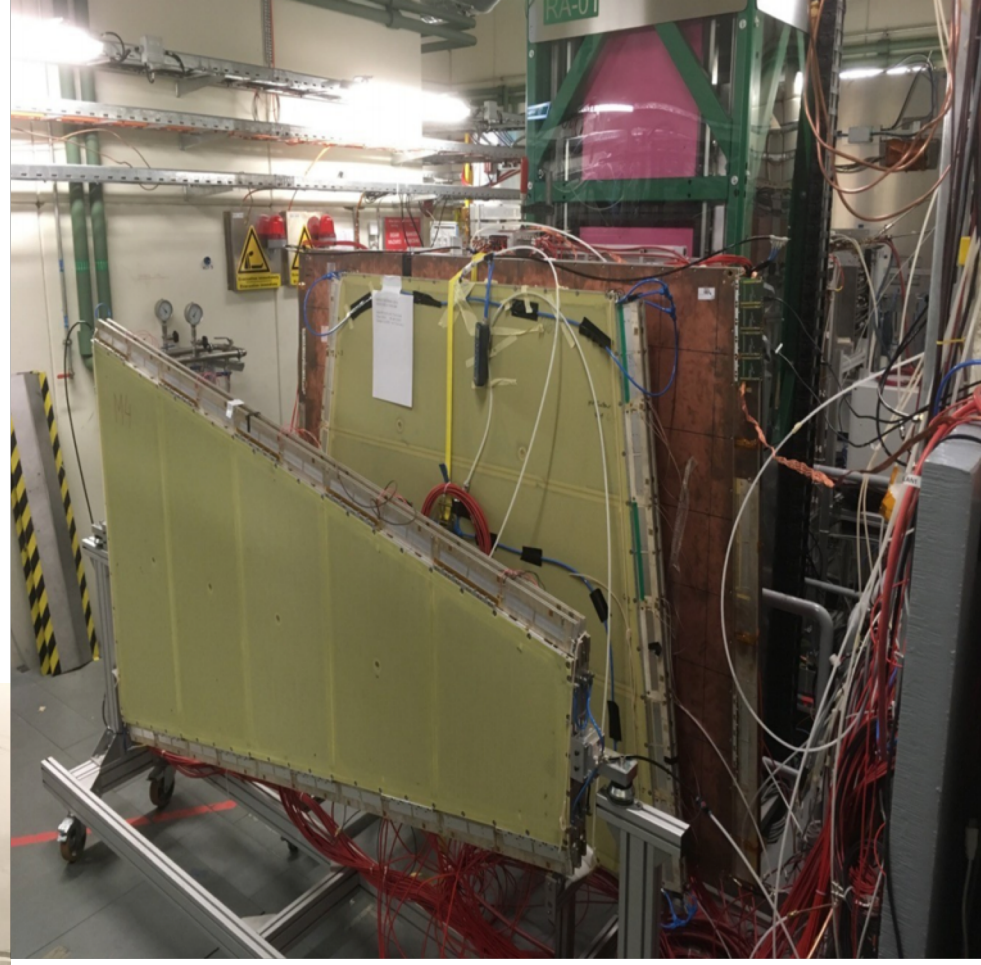
high number of users
[ALICE, CMS…]
➔ demand from users varies i.e. attenuation level, distance from source, shadowing, services…

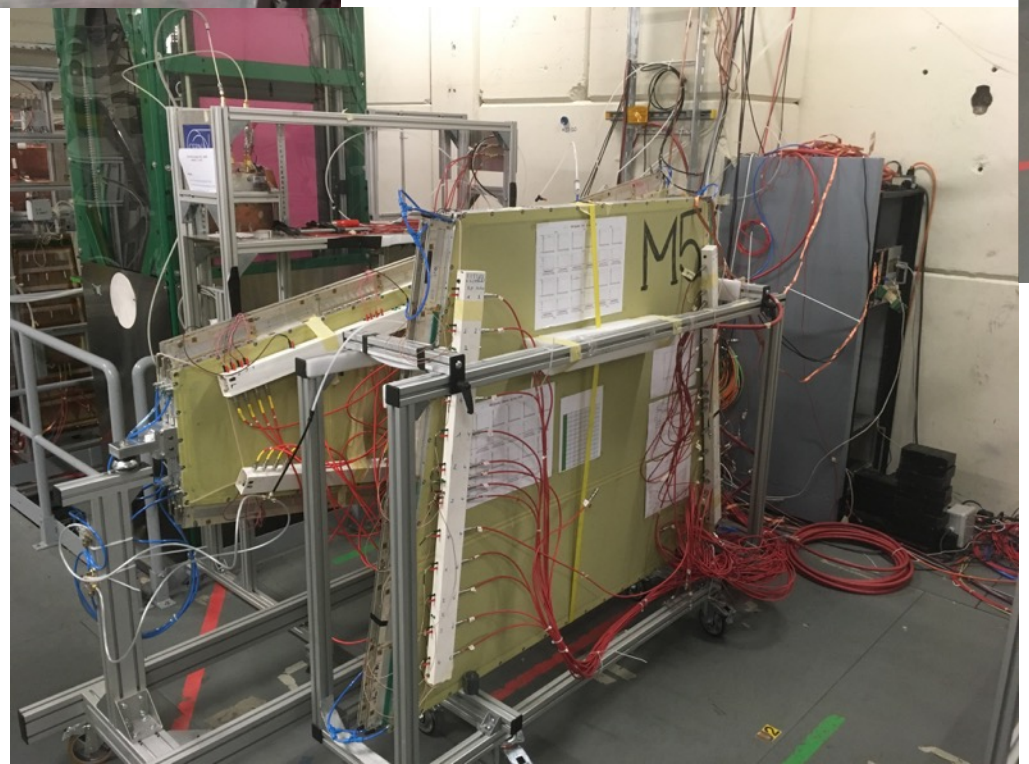
➔ *A big thanks to the M. Jäkel, G. Pezzullo and the entire GIF++ community in letting us being "prime user" during that time.*





Different config during 4 weeks within the GIF++ bunker

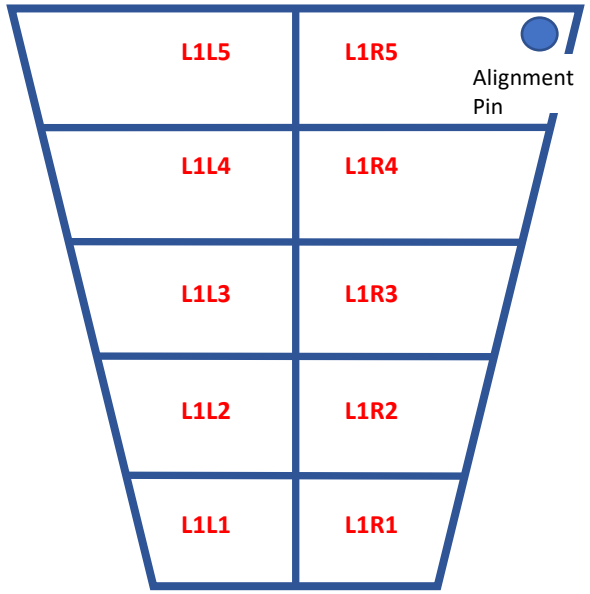




TYPE 1 QUADS

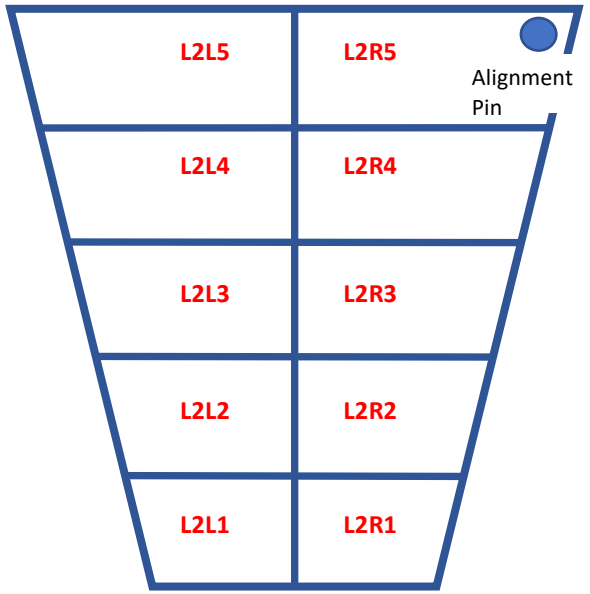
SM1 / LM1 Quads

L1 (ETA 1) - Spacer Frame side

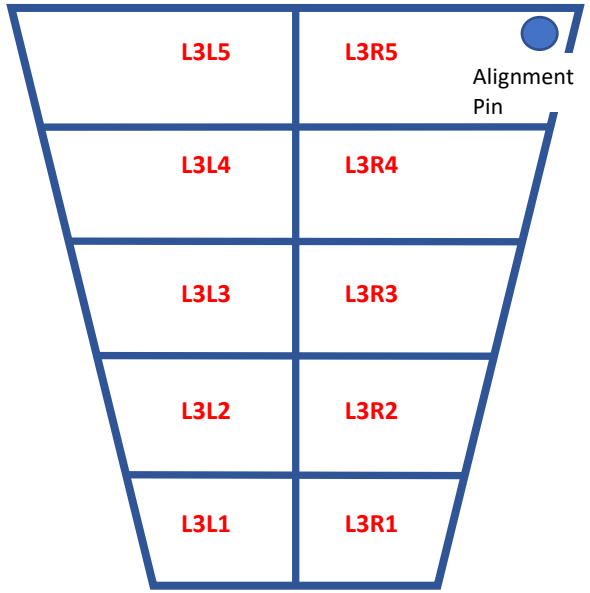


- L1=Eta_Out (1)
- L2=Eta_In (2)
- L3=Stereo_In (1)
- L4=Stereo_Out (2)

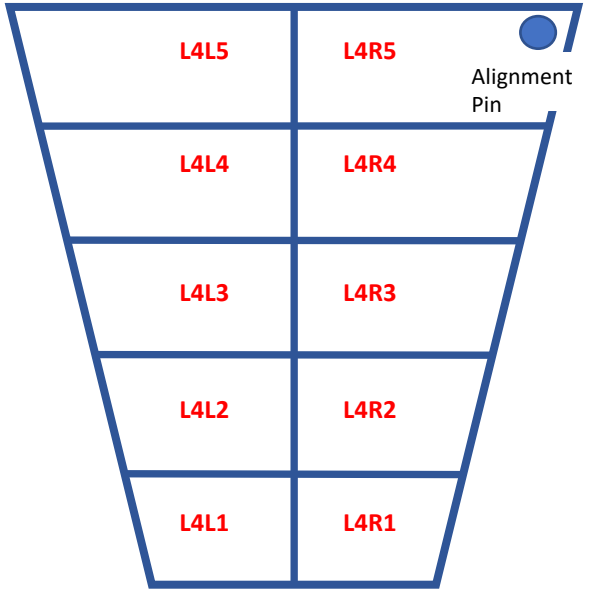
L2 (ETA 2)



L3 (STEREO 1) - Spacer Frame side



L4 (STEREO 2)



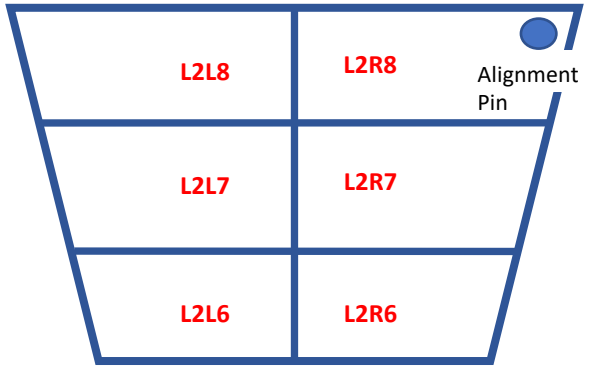
TYPE 2 QUADS

SM2 / LM2 Quads

L1 (ETA 1) - Spacer Frame side

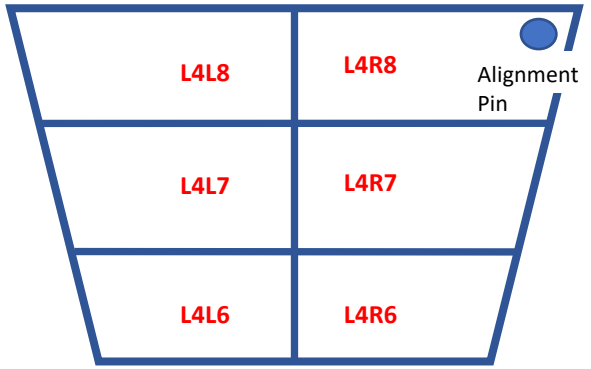
- L1=Eta_Out (1)
- L2=Eta_In (2)
- L3=Stereo_In (1)
- L4=Stereo_Out (2)

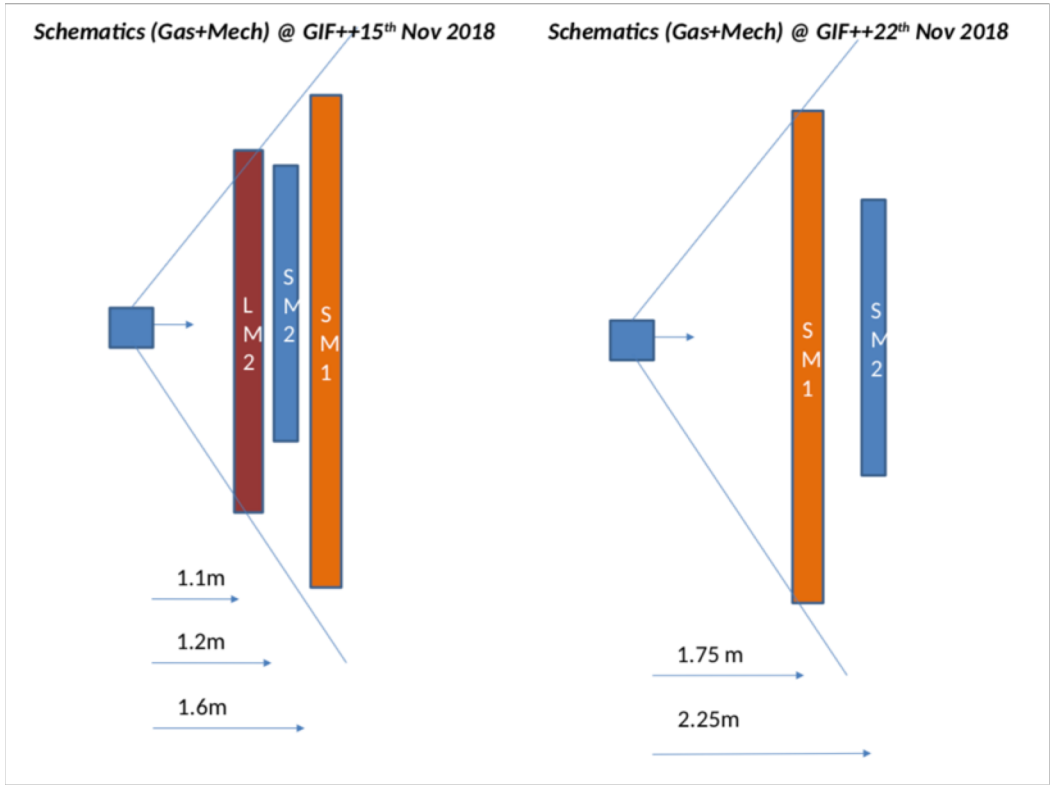
L2 (ETA 2)

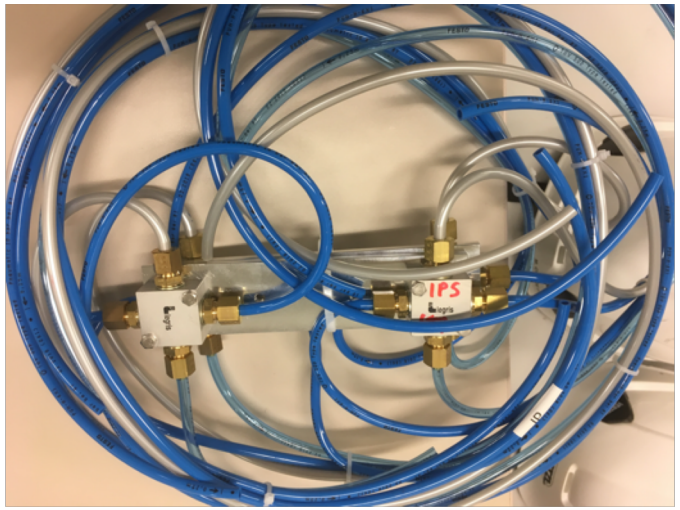


L3 (STEREO 1) – Spacer frame side

L4 (STEREO 2)

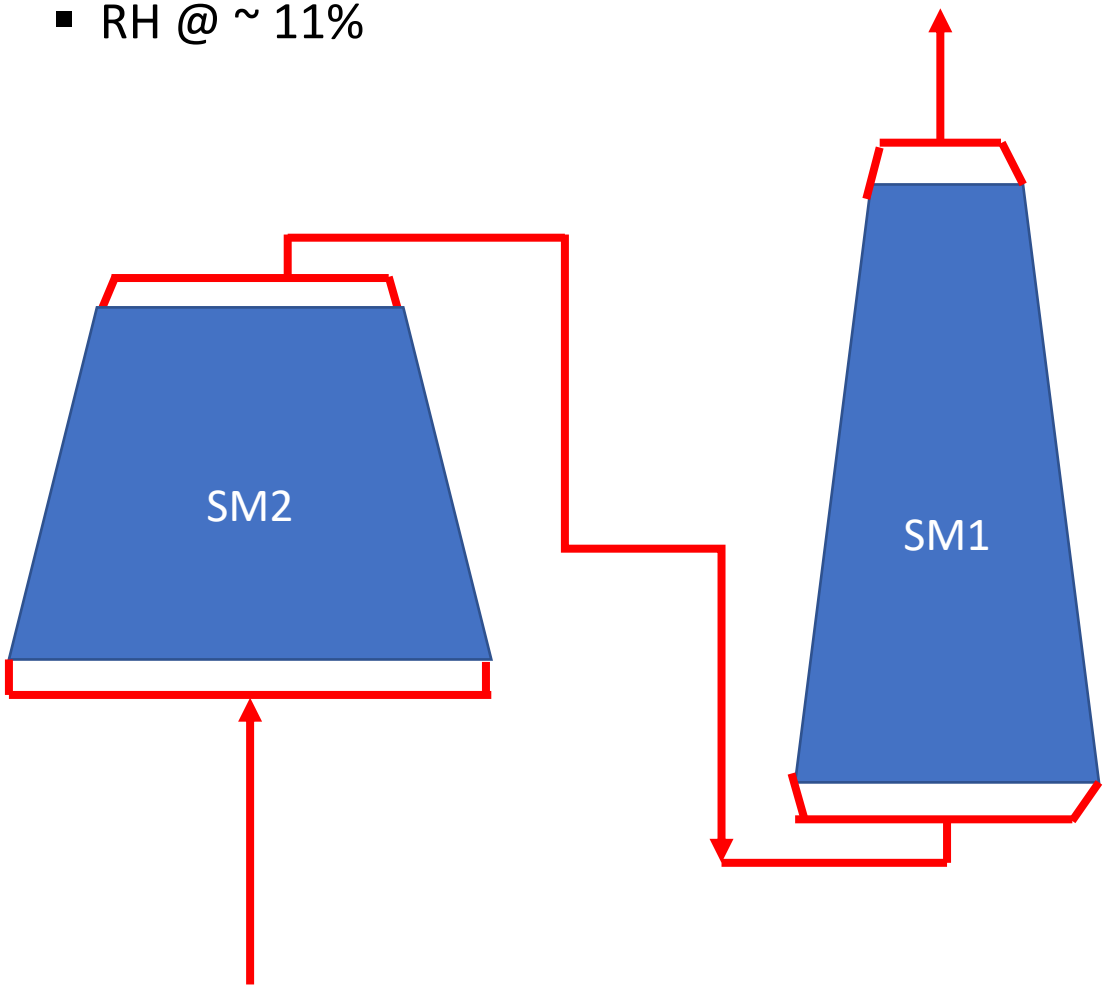






Exhaust to Vaisala – length ~30m / ~ 90 % made of copper / stainless steel

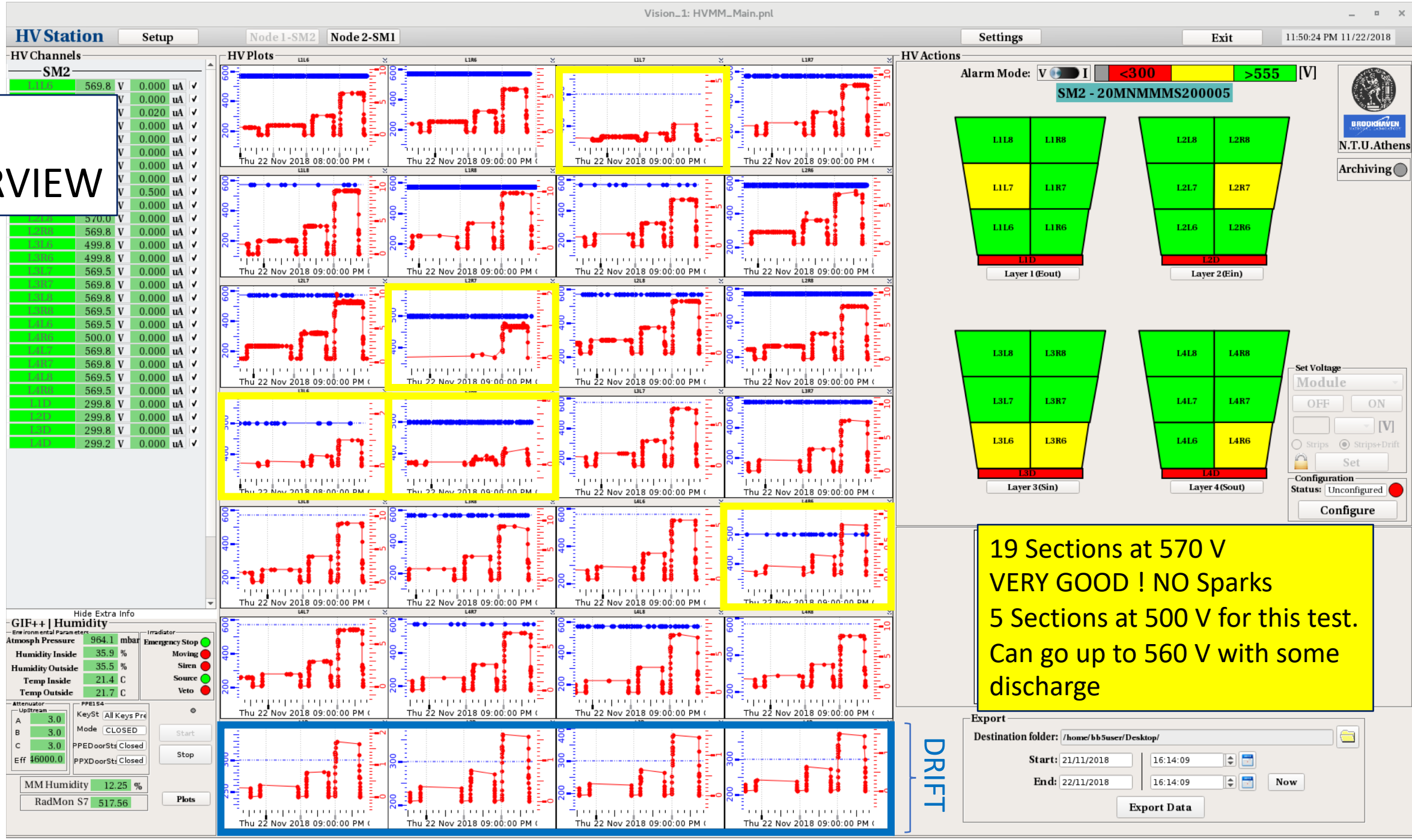
- RH @ ~ 11%



Gas Inlet from mixer – length ~ 30m - gas tubes made of made of ~90% copper / stainless steel

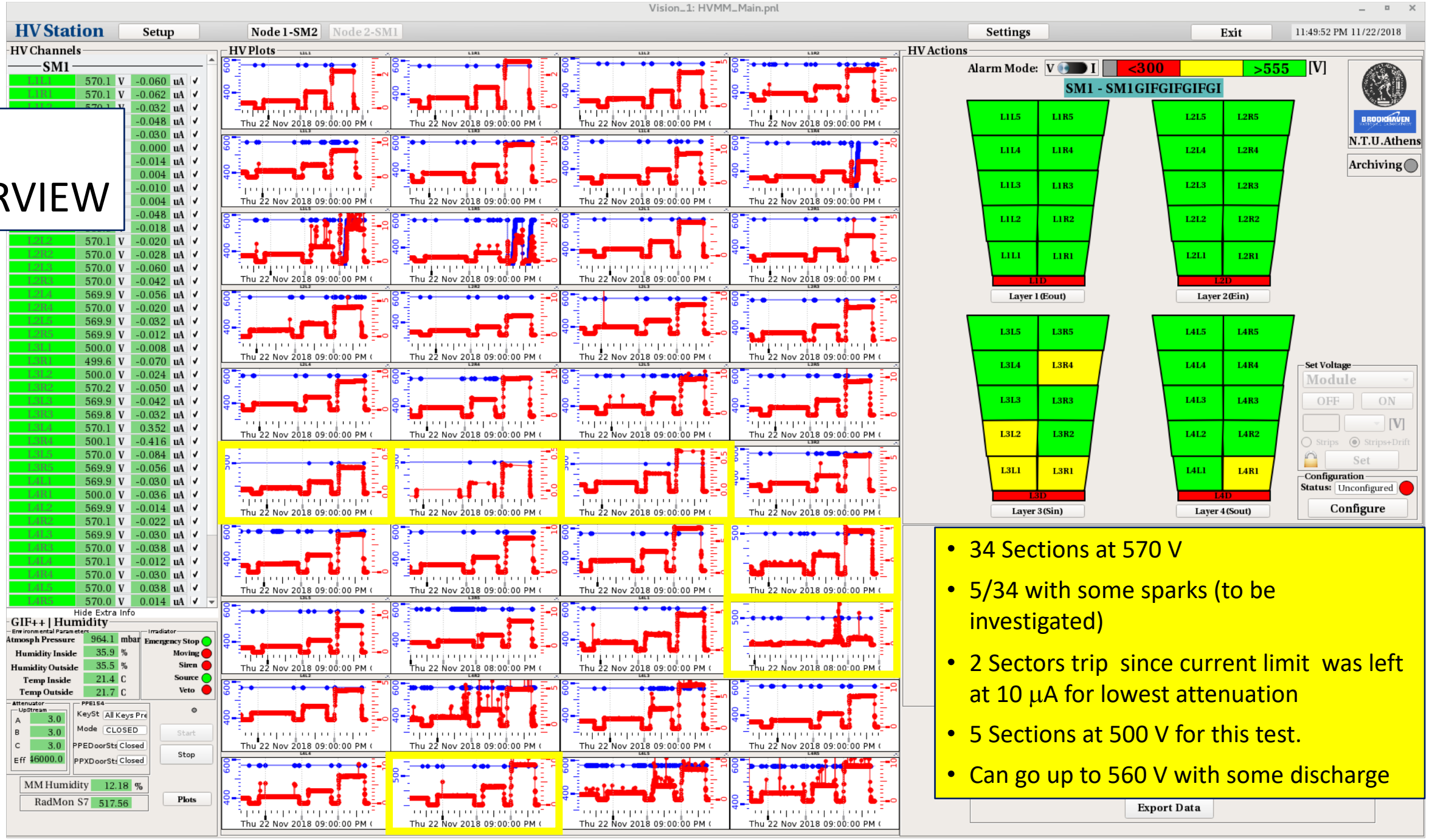
Nov. 22

SM2 OVERVIEW



Nov. 22

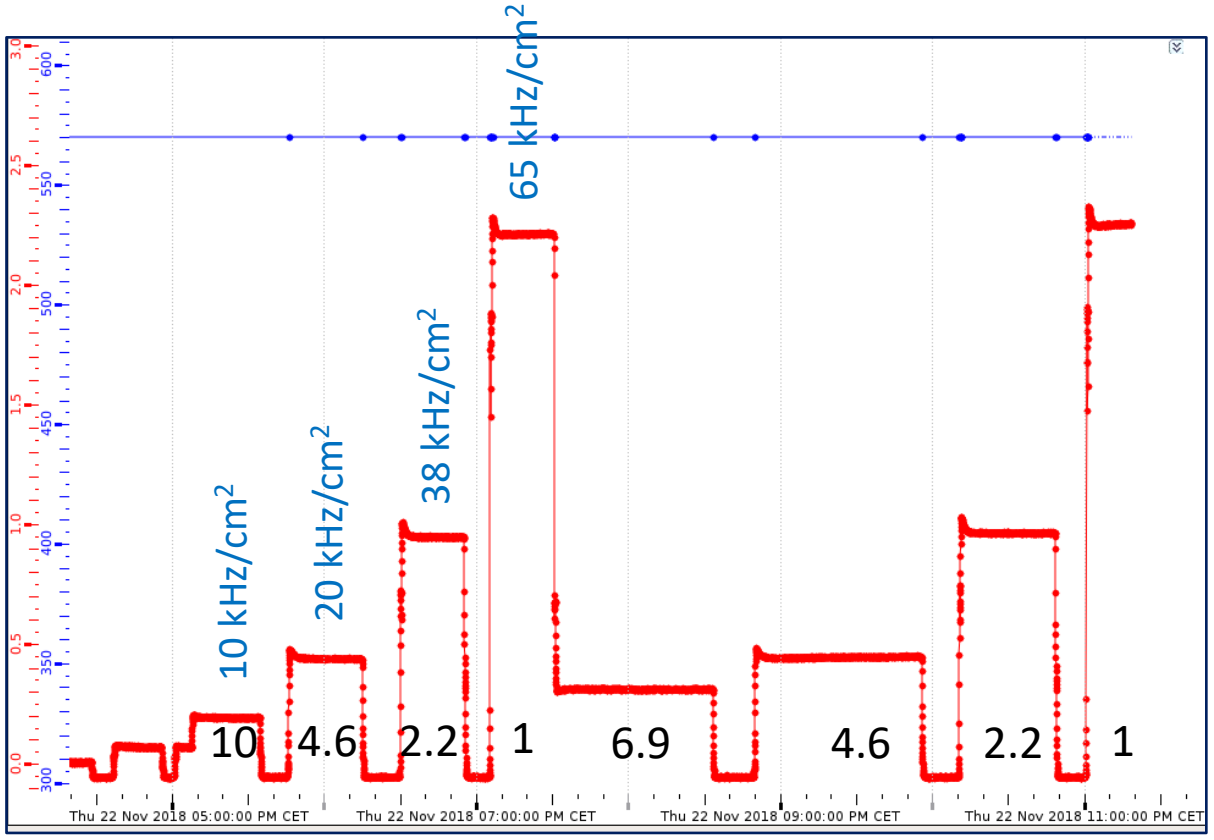
SM1 OVERVIEW



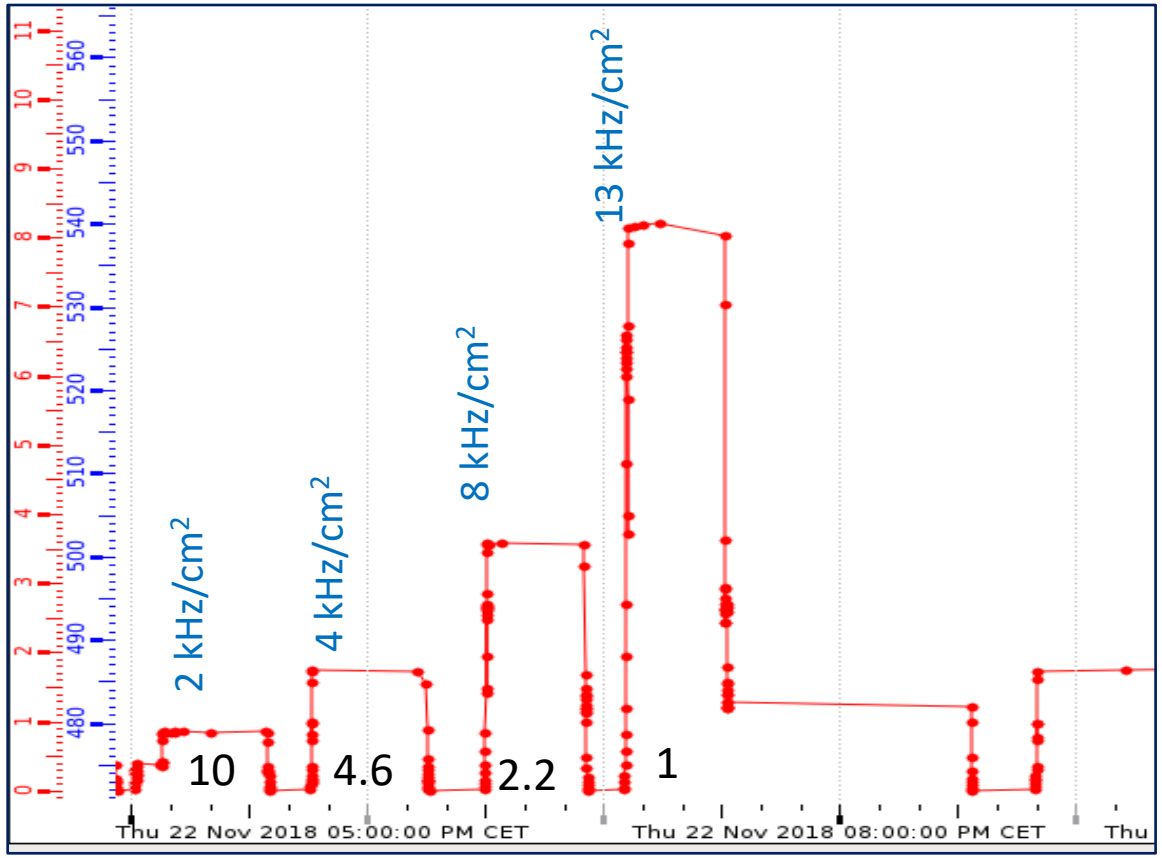
- 34 Sections at 570 V
- 5/34 with some sparks (to be investigated)
- 2 Sectors trip since current limit was left at 10 μA for lowest attenuation
- 5 Sections at 500 V for this test.
- Can go up to 560 V with some discharge

Perfect behaviour of MOST of the HV Sections

SM1 L1L1 (small section)



SM2 L4R8 (largest section)

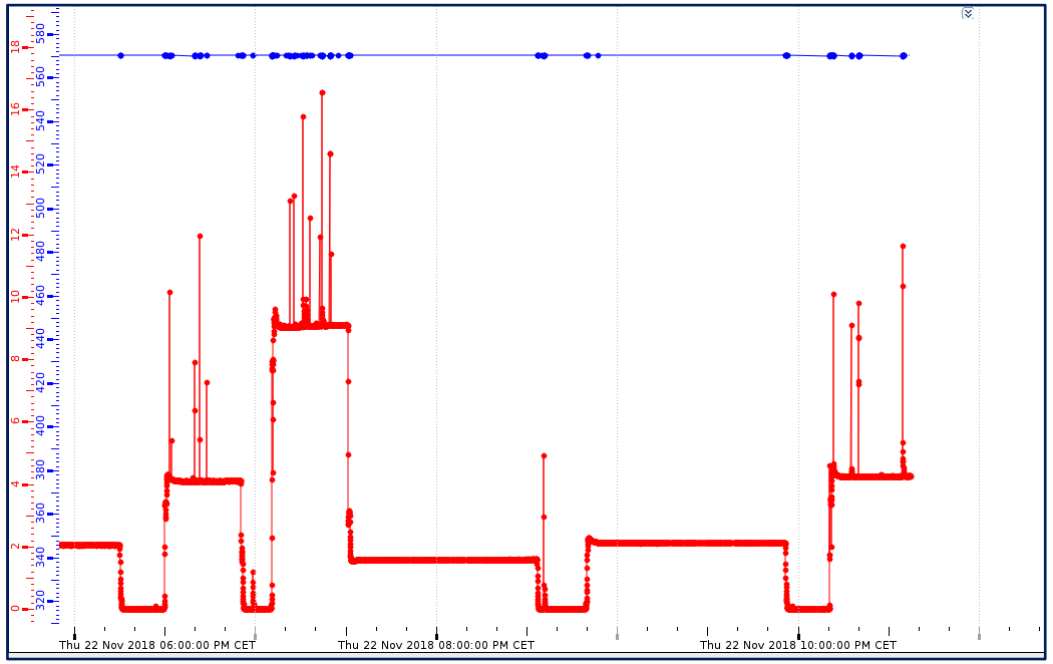


(rates [kHz/cm^2] are rough estimates)

SM1 @ 1.4m from the source ; SM2 @ 2.0 m

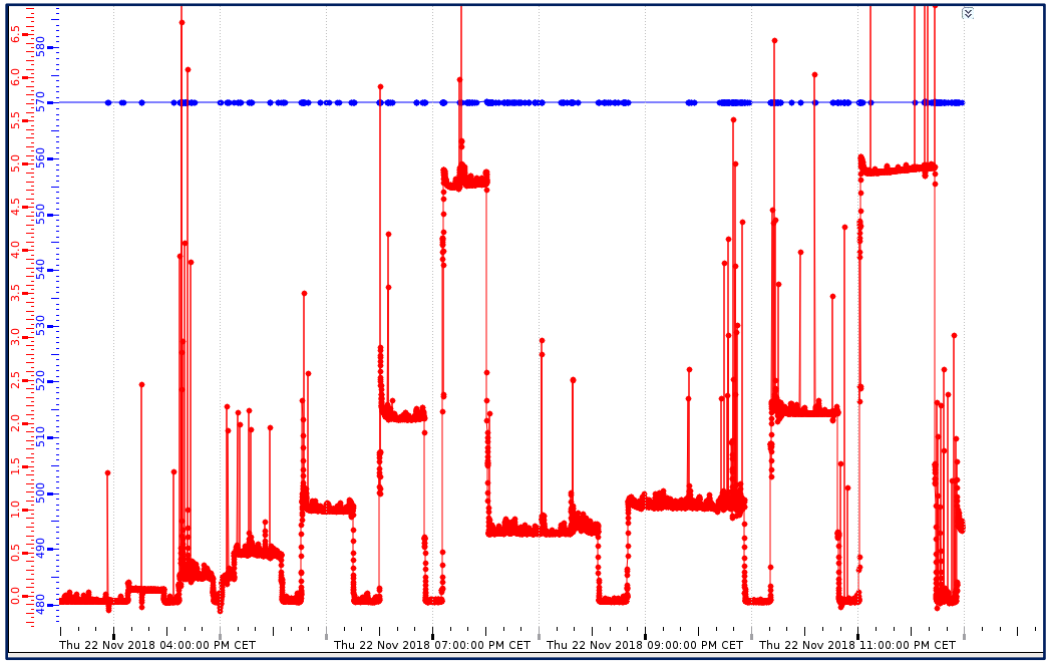
DISCHARGES (on only few sections)

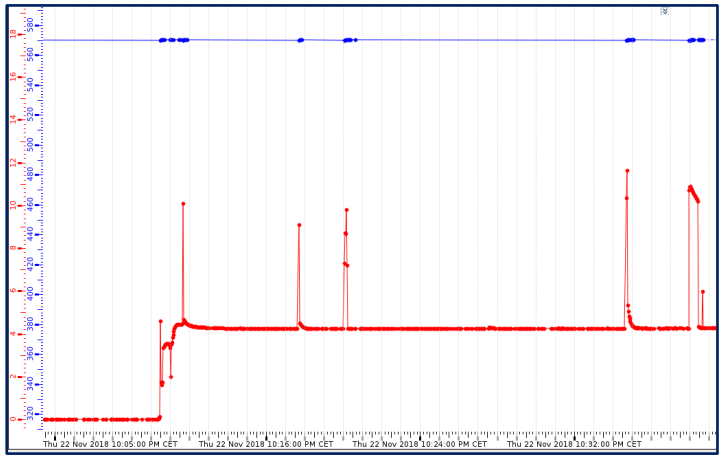
SM1 – L1L5



- Very low frequency (depends on HV Sections)
- Very high charge/current (several μA)
- Duration few sec. Exceptionally up to 30 sec
- Not clear how it scales with irradiation intensity
  - Negligible frequency at low irradiation
  - Develop “discharge trains” from time to time.

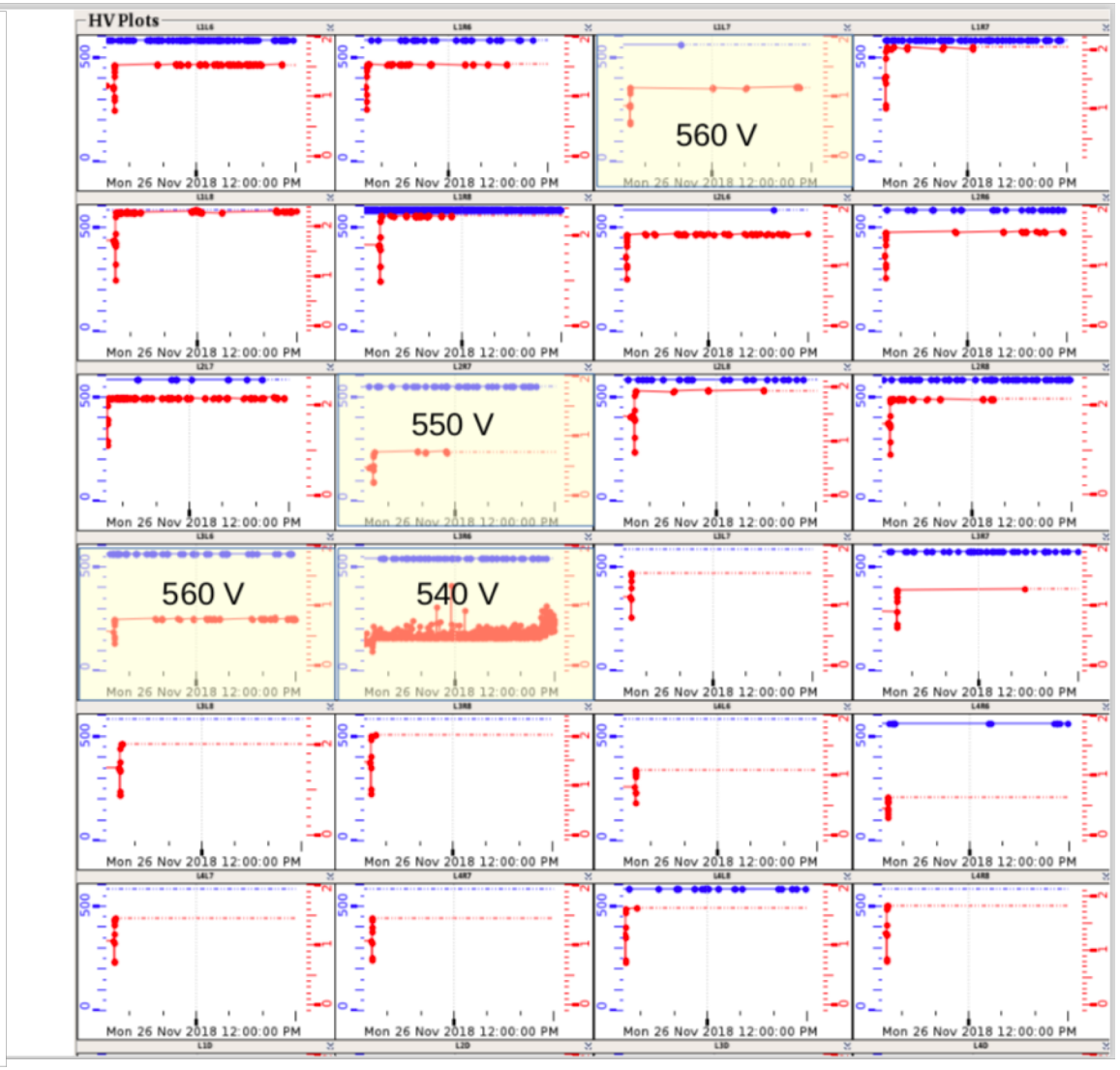
SM1 – L4R2





Spark duration few sec. Here one case up to 30 sec

Nov. 26th Test SM1 and SM2 at 580 V -- Att. 4.6 → SM1 at 20 kHz/cm^2 – SM2: 4 kHz/cm^2



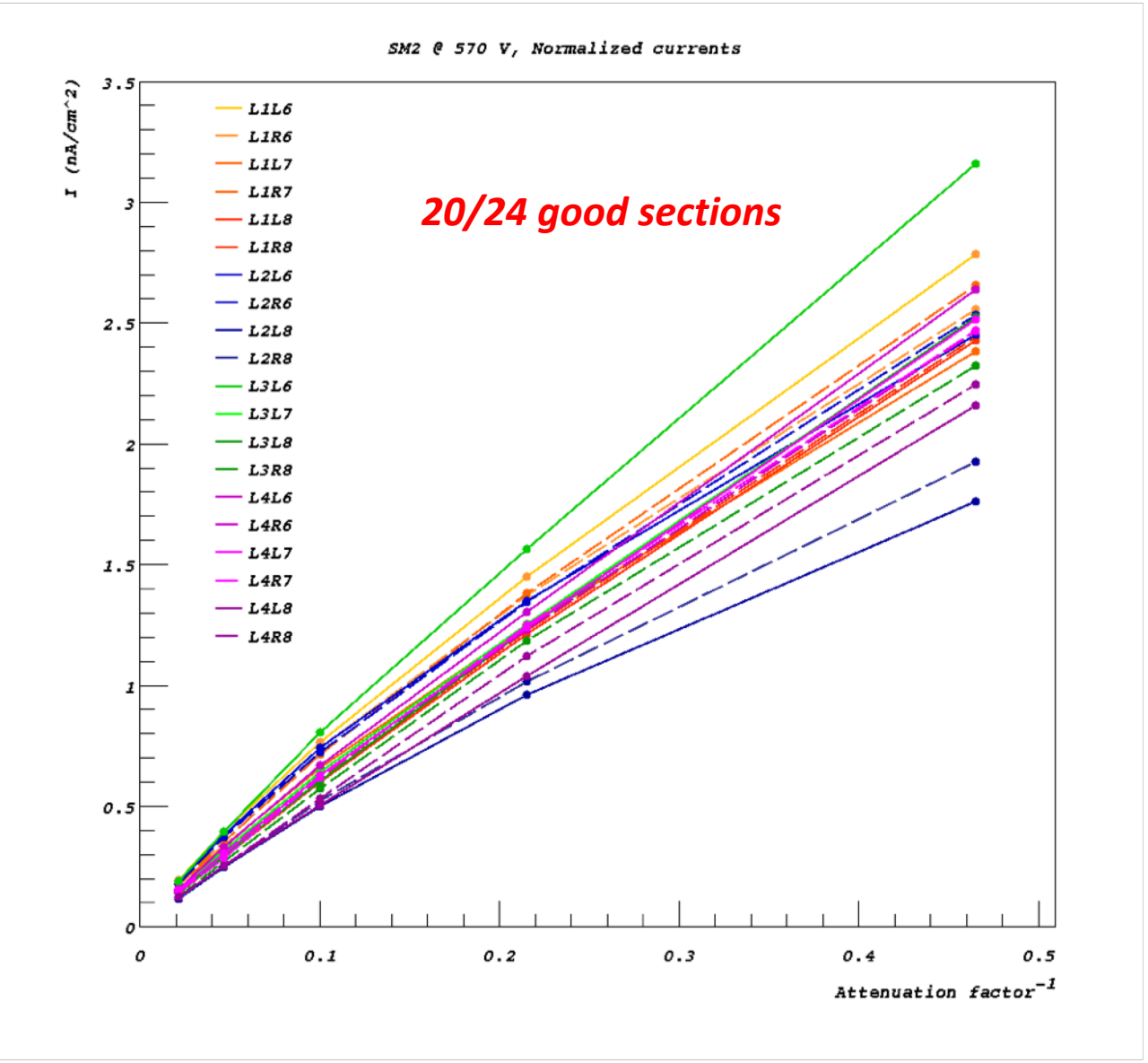
SM1 at 580 V

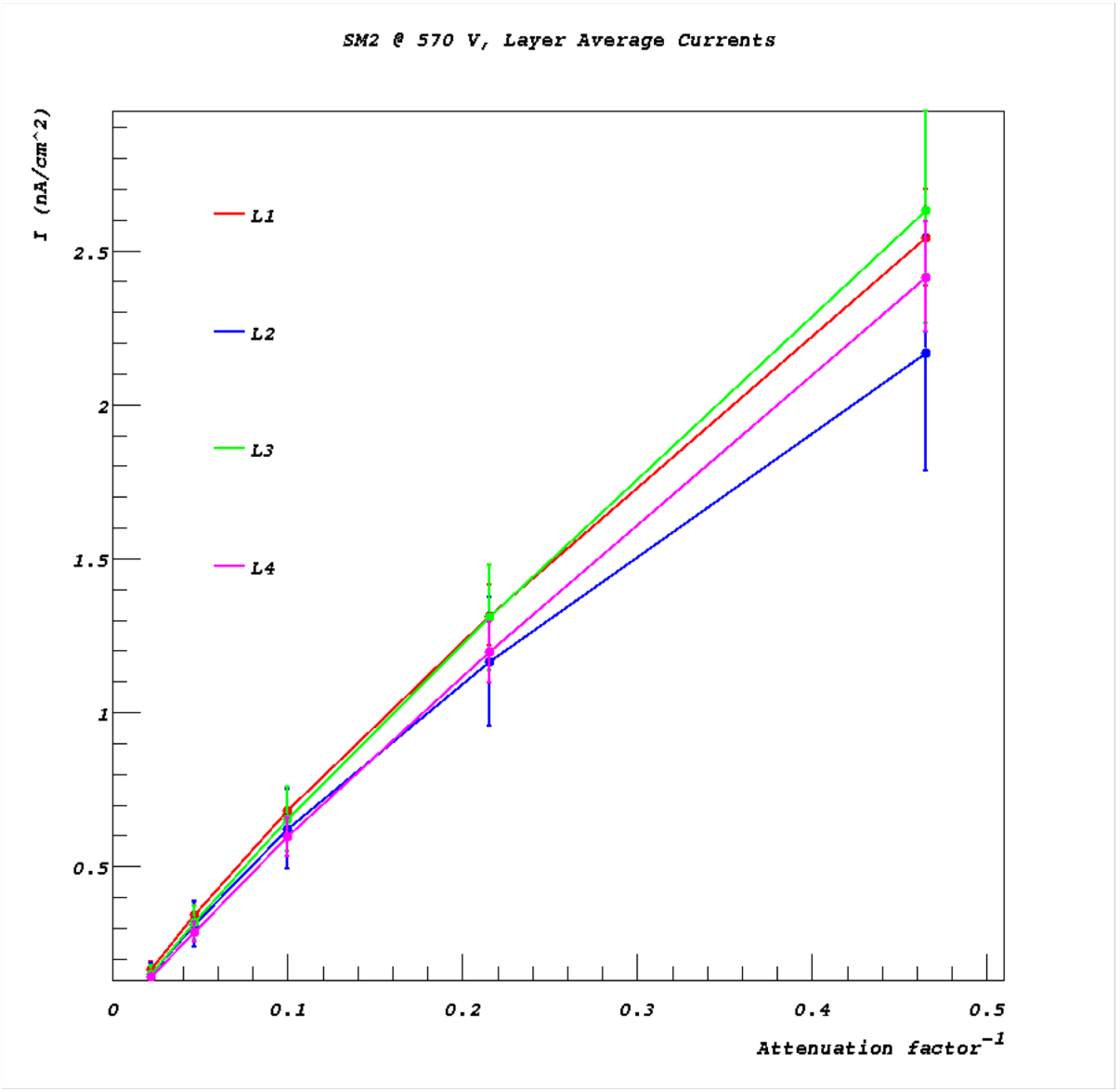
- 2 Sections at reduced HV.
- 2 sections with sudden increase of current

SM2 at 580 V

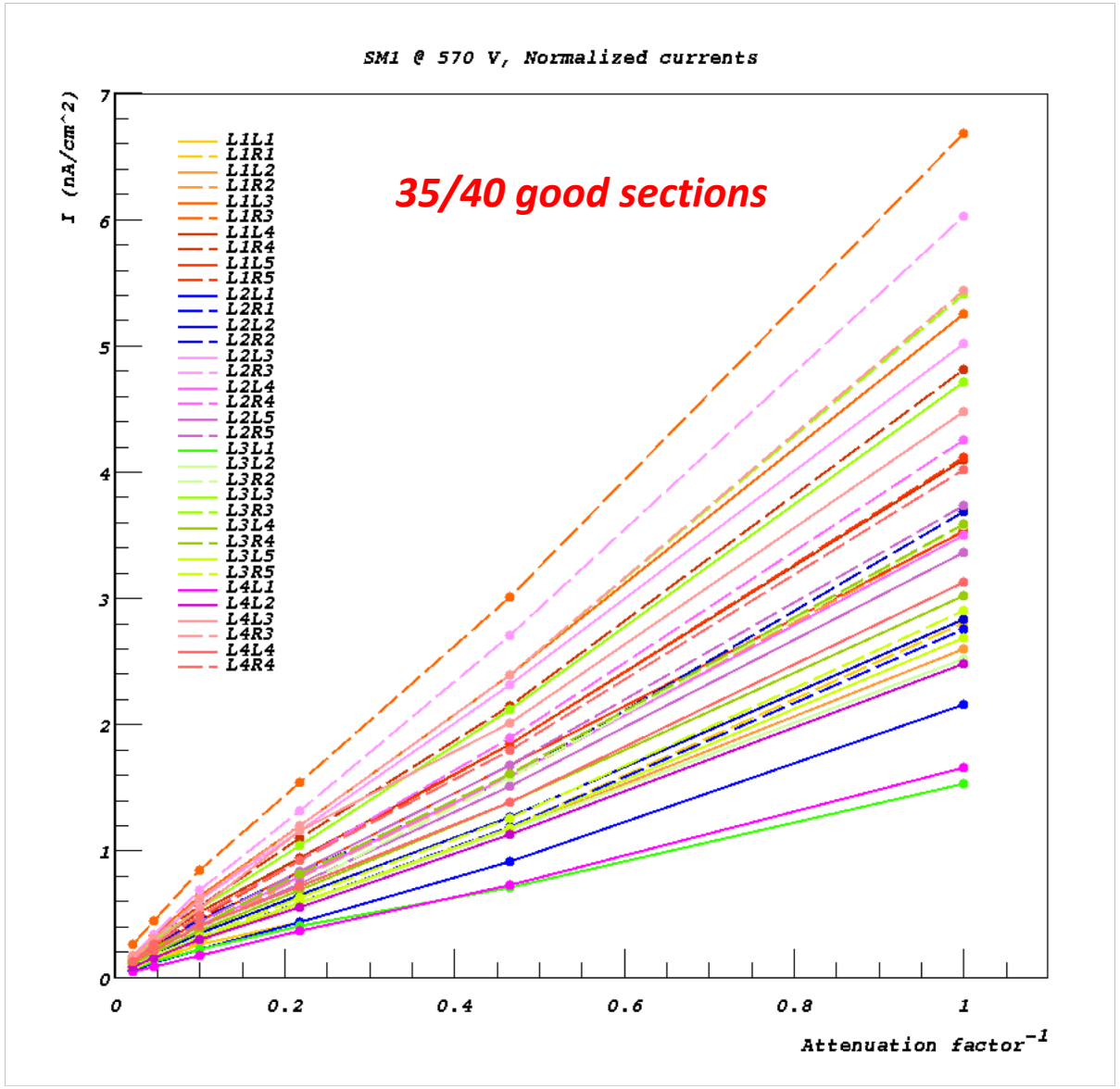
- 4 Sections at reduced HV.

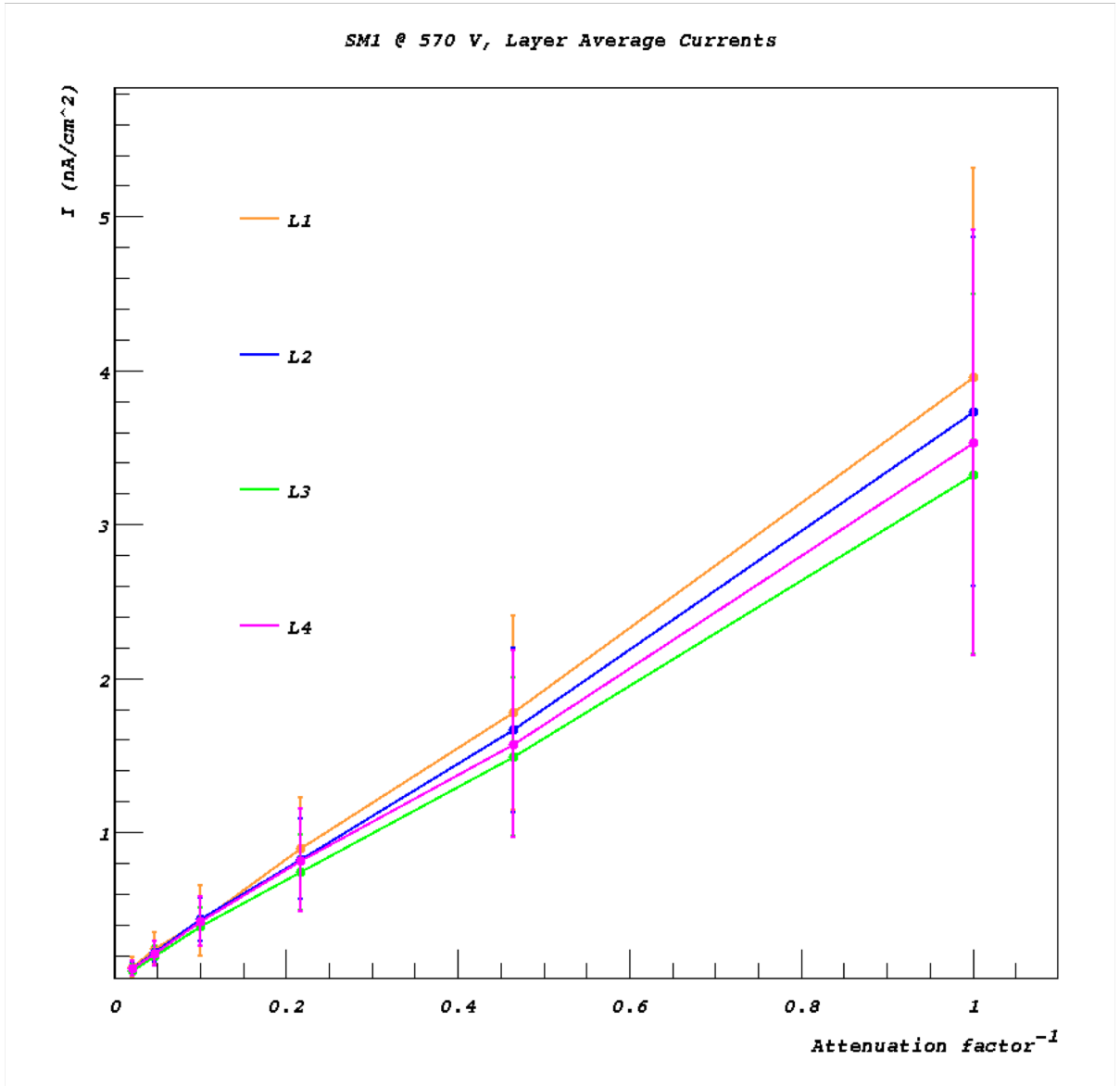
Linearity of currents/gain Vs Irradiation rates (inverse of attenuation)
- ***SM2 570 V @ 10L/h***





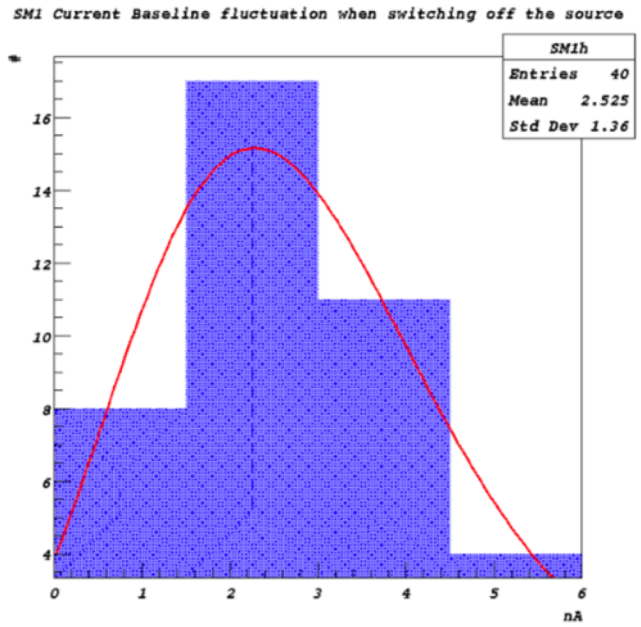
Linearity of currents/gain Vs Irradiation rates (inverse of attenuation)
- ***SM1 570 V @ 10L/h***

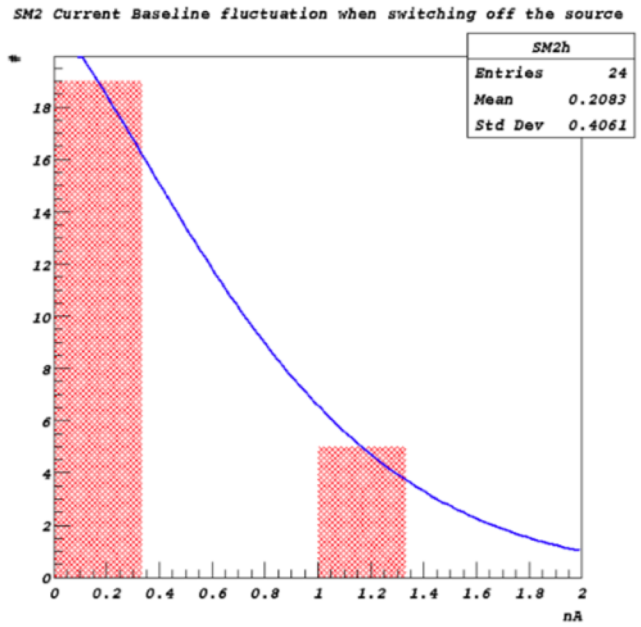




SM1-SM2
main results

- both chambers stable at 560-570-580 V with few spiky channels
- tested at high rates:
    - → both at rate > 60 kHz/cm2
        - → SM2: 34/40 very good sectors (no spikes)
        - → SM1: 19/24 very good sectors (no spikes)
- uniform currents: std dev per layer < 10% for both SM1 and SM2
- dark current stability below the resolution of HV cards



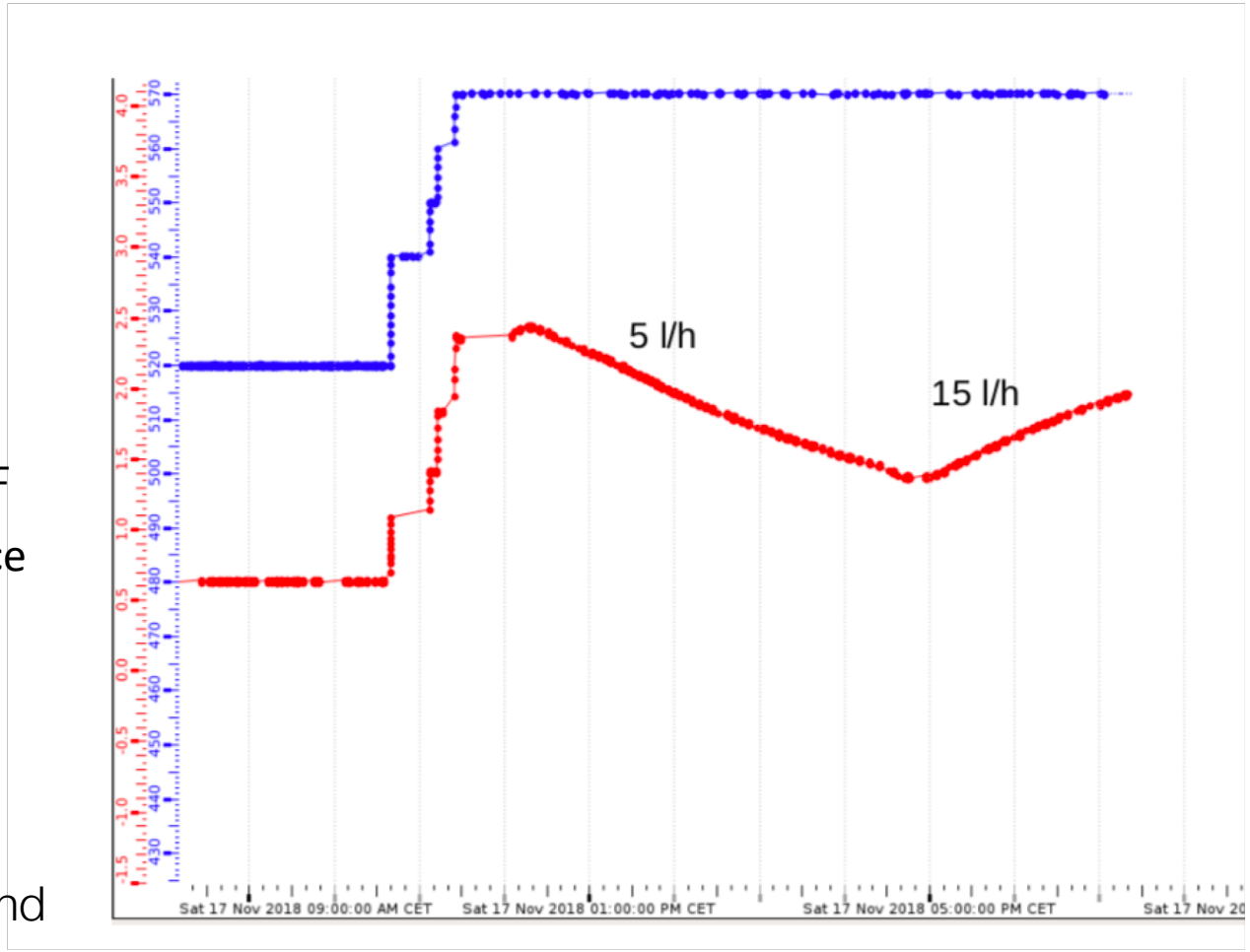


Strong Dependence of gain/currents Vs Gas flow

Investigating chamber gas leaks meas. done on the 21 Nov 2018 in the bunker

- SM2 leak 2xNSW_LIMIT at LMU and confirmed at GIF
  - **QL = 55 mL/h --> 2.1 x Acceptance Limit (Acceptance Limit: 25.9 mL/h)**
- SM1 leak ~2.5 x NSW_LIMIT at Frascati
  - **QL = 23mL/h (Acceptance Limit: 23.3 mL/h)**

Investigation underway as a few issues happened and will be shared soon



- SM1 M#4 and SM2 M#5 tested at the GIF++
  - **clean** and **linear** response to the irradiation
- 21/24 and 35/40 good channels
- Recovering « difficult channels » after irradiation…
- Tested up to **high particle fluxes**: very clean response, very few « spiky » channels
- Very good **stability** (tested up to 48 hours during each WE @ attenuation 6.9), only few tripped
- Still preliminary results
- Investigations on the gas flow contribution to efficiency
- SM1 and SM2 tested at 580 V with very good results

FUTURE PLANS AT GIF++ for ATLAS-NSW

- Some upgrade for our working env. will be performed
- GIF++ bunker is going to be upgraded “floor plan wise” with the addition of ~100 sq.meters upstream

  [planning is April / May 2018]
- Long term irradiation on a production module is foreseen
- By sampling, a fraction of production modules is projected to be tested at GIF.
  - A universal trolley to accommodate two modules independently of any type
  - the first “n” modules per construction site should be tested - then it could become a random pick
  - Time estimatation to test any type of 2 modules is one week