



XVII Conference on Resistive Plate Chambers and Related Detectors

## Outdoor MARTA RPCs performance update

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LABORATÓRIO DE INSTRUMENTAÇÃO  
E FÍSICA EXPERIMENTAL DE PARTÍCULAS  
*partículas e tecnologia*



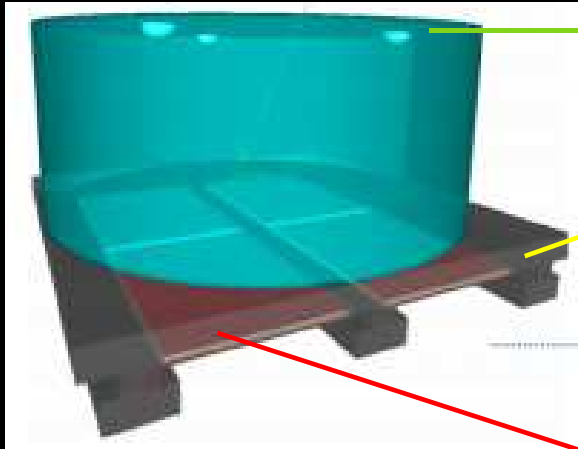
REPÚBLICA  
PORTUGUESA



2024.06879.CERN

## •MARTA Eng. Array at Auger Site

- Station characterization
- Eng Array
- Peter Mazur Station
  - 2019 deployment
  - 2022 first RPC performance
  - 2023 RPC performance and first efficiency data
- Conclusion
- Future work



## Water Cherenkov Detector

### Precast Structure

- Support the water tank
- Absorb electrons
- Housing and mitigate the effect of the harsh environmental conditions on detectors



### Four glass (2 mm thickness) RPCs

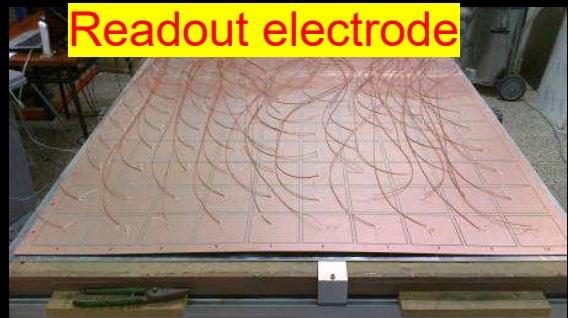
- 1.5x1.2 m<sup>2</sup> active area
- Double 1 mm gap
- Pure R134a
- Low gas flow
- 90% (geometric constrained) efficiency at sea level.
- 8x8 readout pads
- Low sensitivity to photons

# MARTA STATION, The RPC unit

**Sensitive volume**



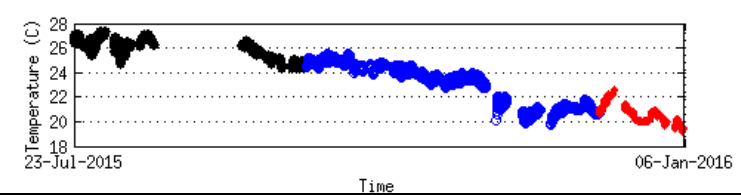
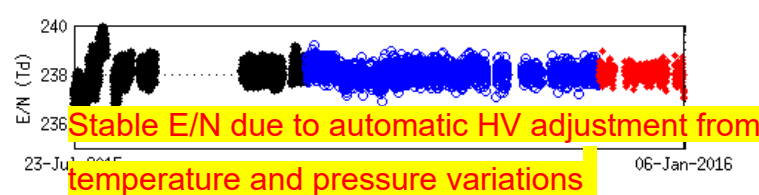
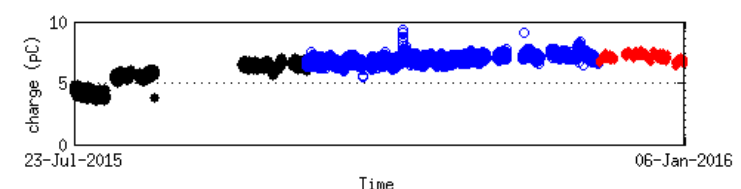
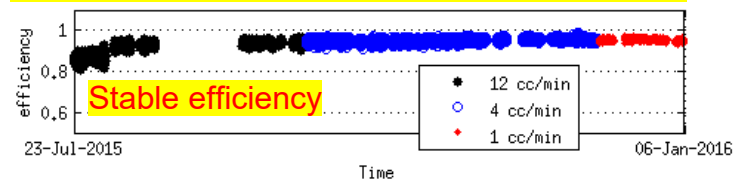
**Readout electrode**



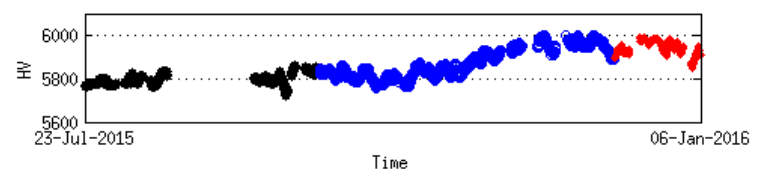
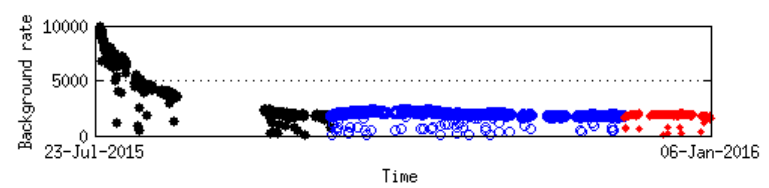
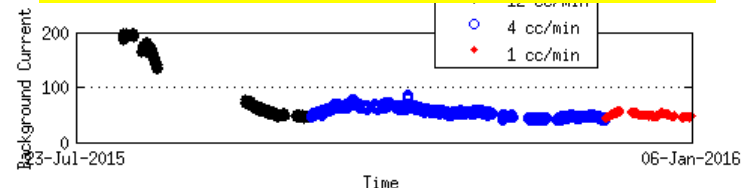
**Complete unit**



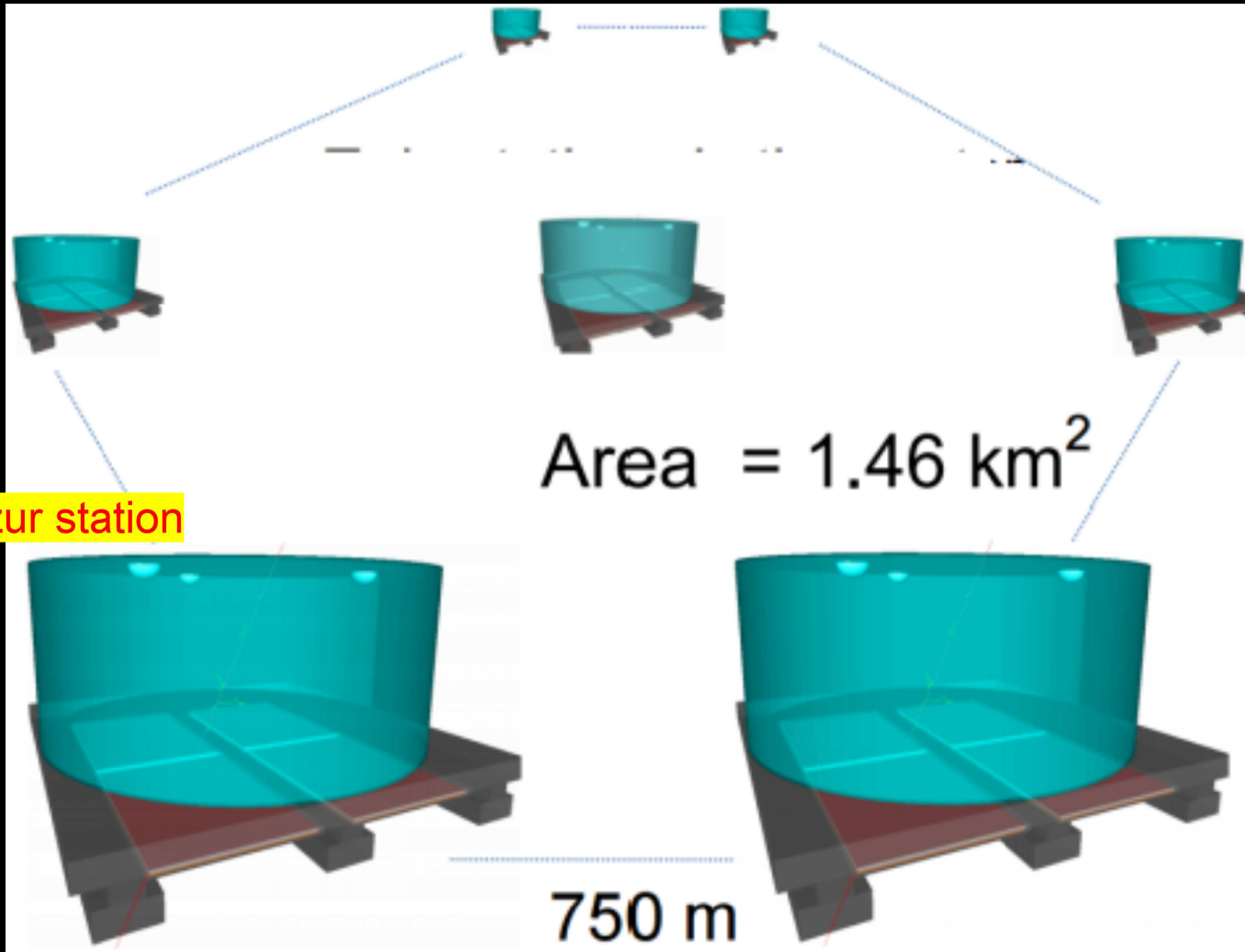
**Performance at sea level indoor**



**Performance at sea level indoor**



To study and improve the resilience and performance of RPCs in outdoor experiments and to prove the physics capabilities of such detectors



Peter Mazur station

# Peter Mazur Station

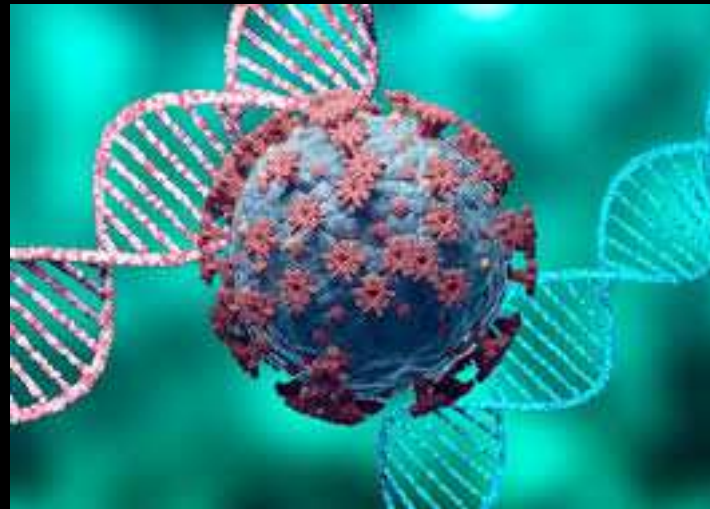
Harsh conditions



Deployment in November 2019



Deployment in November 2019



First results May 2022

# Peter Mazur Station

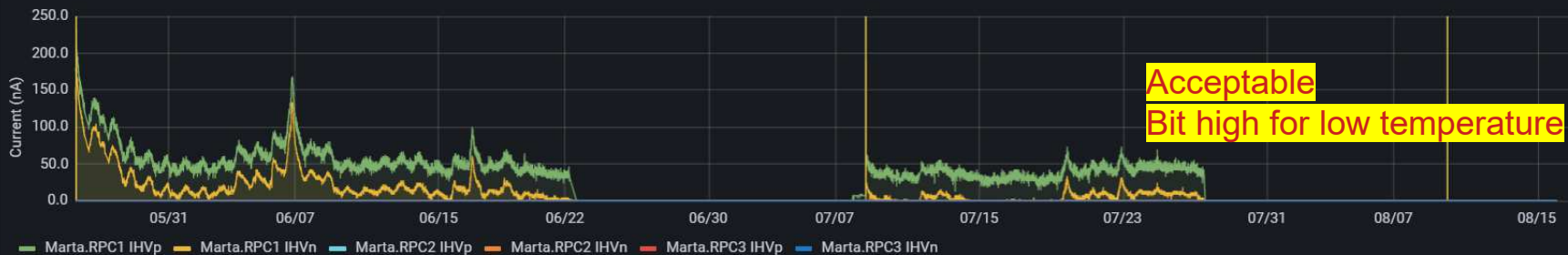


First results May 2022

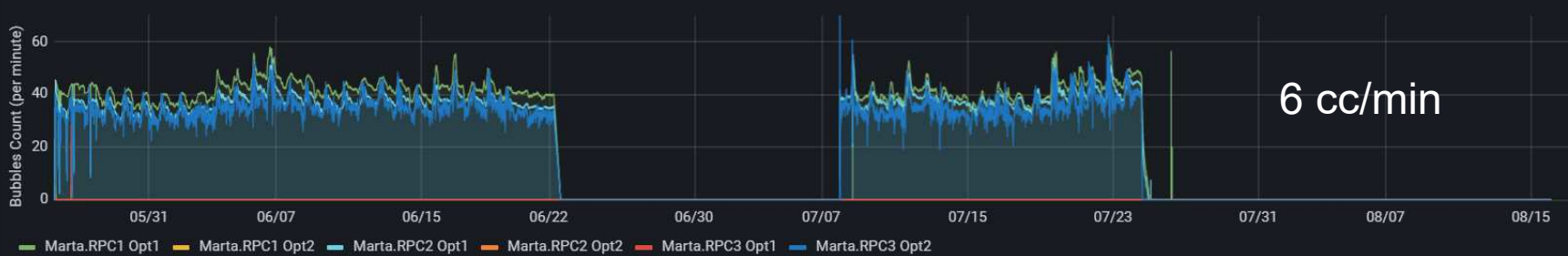
HV Voltage - Peter Mazur



HV Current - Peter Mazur



Bubblers - Peter Mazur



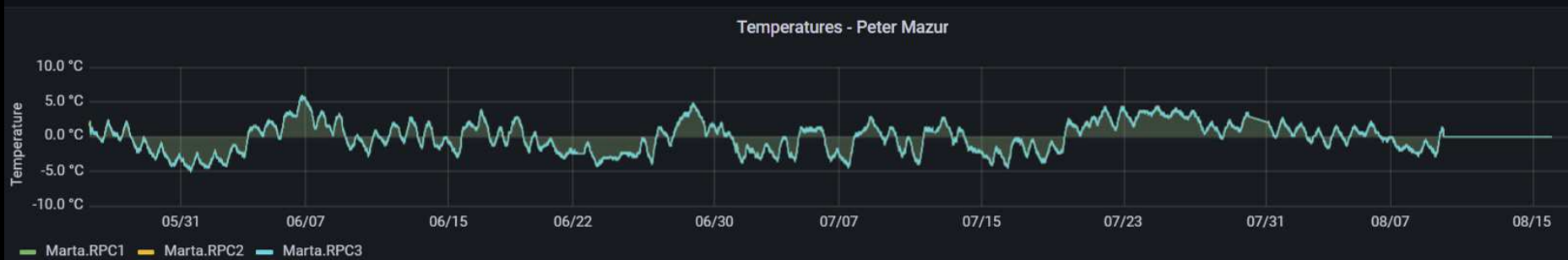
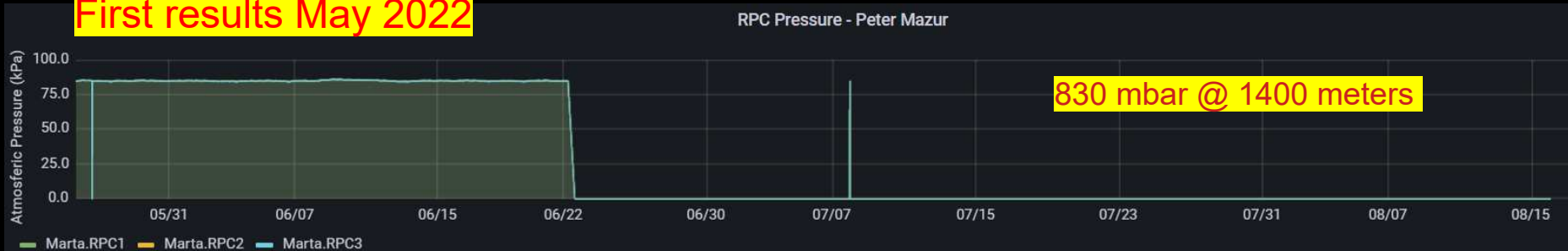
After 2.5 years seems to be all ok. Very high flow, not needed, misconfigured during installation!!



# Peter Mazur Station



First results May 2022



Humidity inside the aluminum boxes is too high... A clear indication of bad "sealing" off the aluminum box.

Could decrease the life time of the sensitive volume, due some permeability through the polycarbonate surfaces and consequent condensation promoted by the large daily temperature excursions.

No DAQ information, impossible to conclude something more, no rate information. Current has different sources, no I(V) curves!!

First results May 2022

- The gas flow was too high and the bottle turned empty after 2 months. Need to turn OFF the HV.
- Some difficulties to find budget to travel to site. Strongly limited possible advances/improvements
- Detectors without gas flowing for more 1.5 years. Were exposed to conditions that promote the rapid degradation of any gas detector.
- But...

November 2023

# Peter Mazur Station

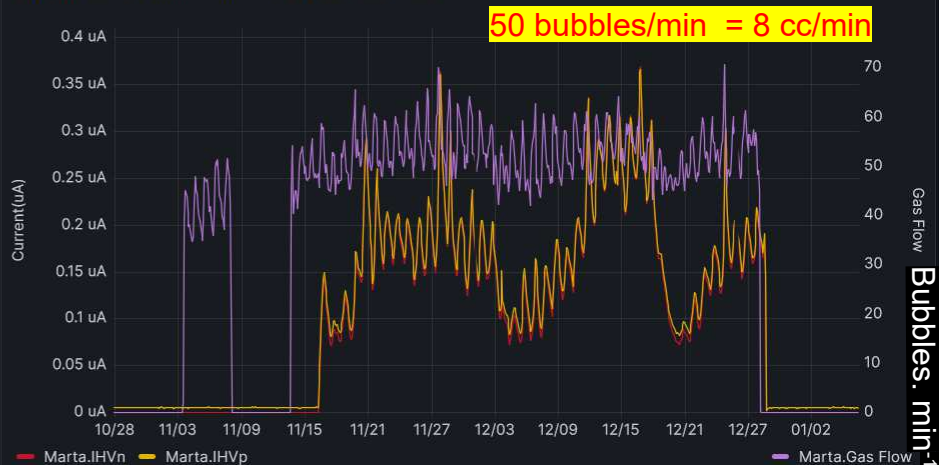


## November 2023 Raw data

Current over Pressure and Temperature - Peter Mazur - RPC3



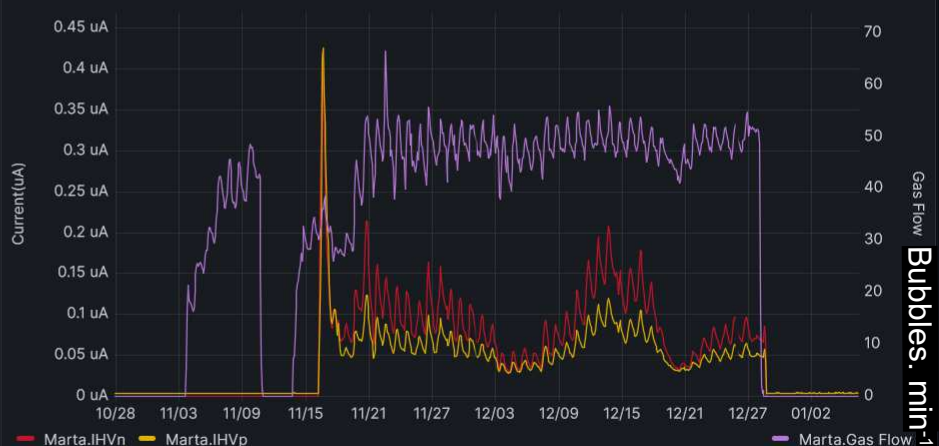
Current over Bubbler Counts - Peter Mazur RPC3



Current over Pressure and Temperature - Peter Mazur - RPC4



Current over Bubbler Counts - Peter Mazur RPC4



Currents correlated with temperature and within acceptable mean values under 200 nA/chamber

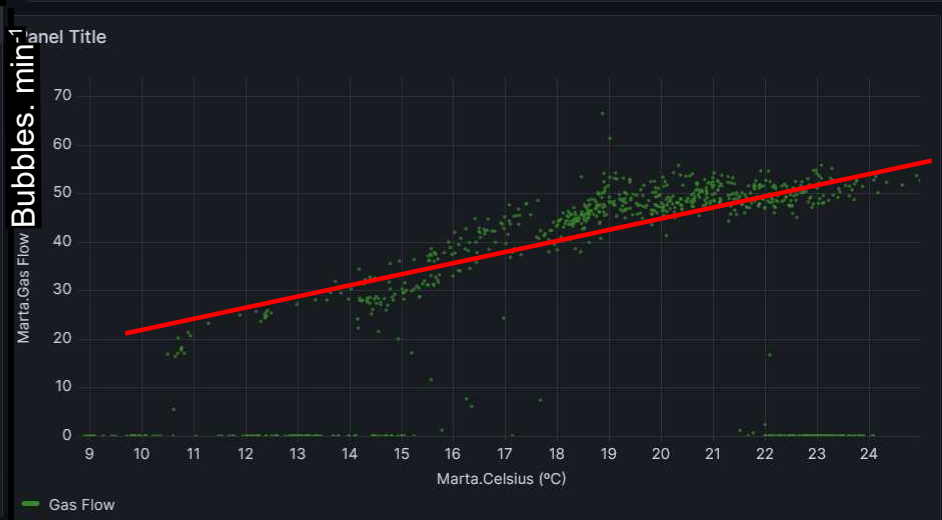
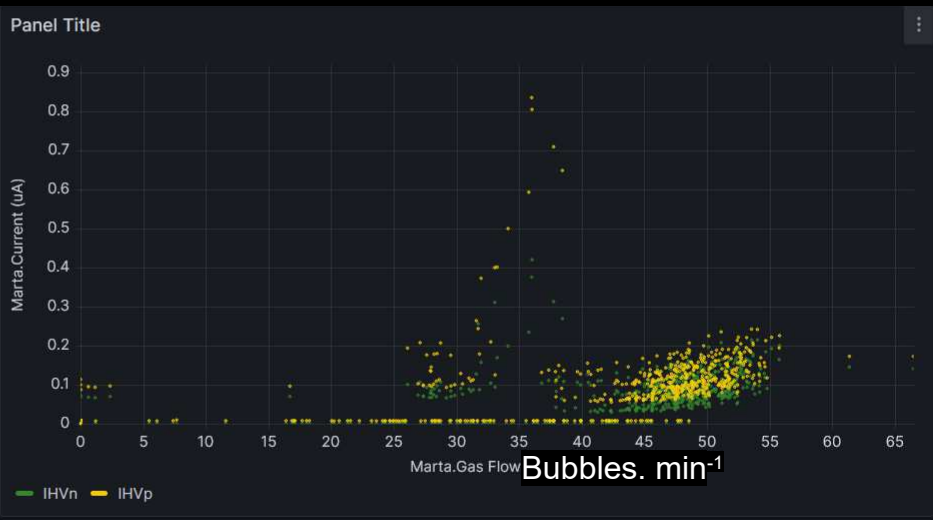
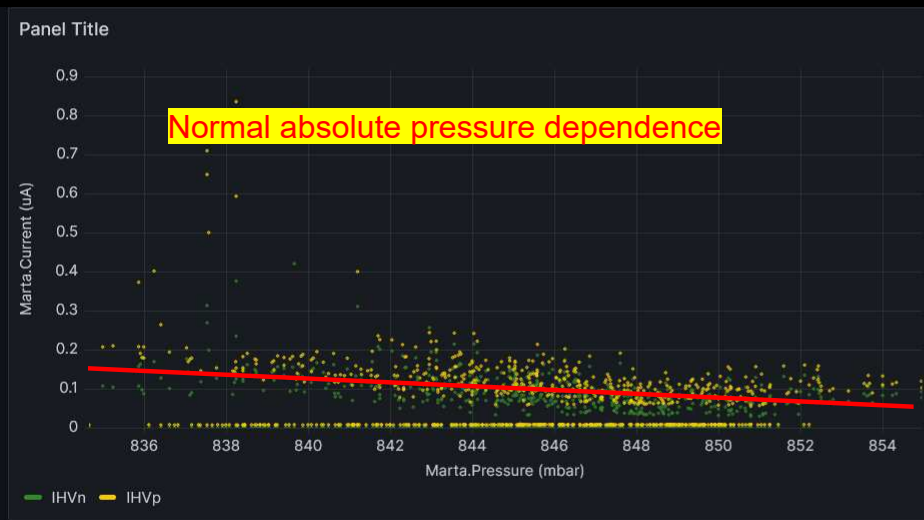
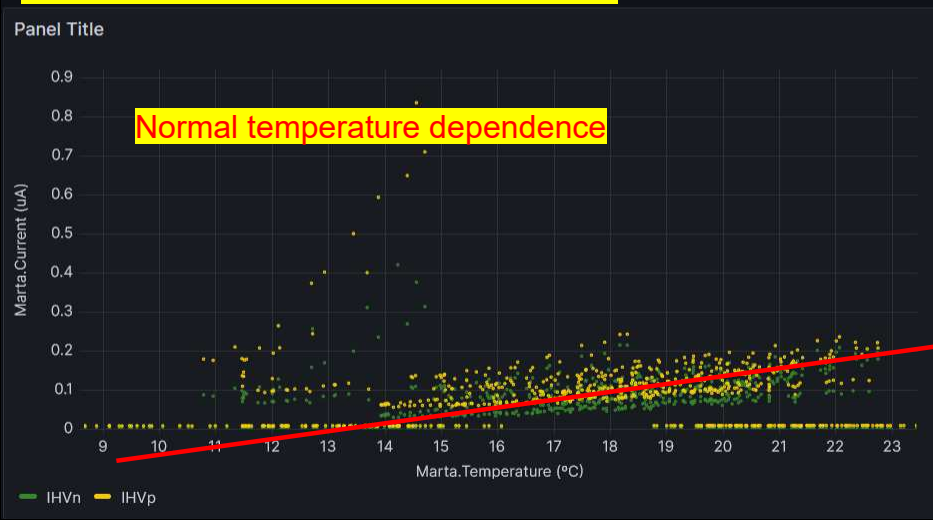
High gas flow to promote fast chamber gas volume exchange to turn on HV as soon as possible.

All 4 chambers were surprisingly in perfect working conditions after four years with only 2 months with counting gas !!

# Peter Mazur Station



November 2023 Raw data



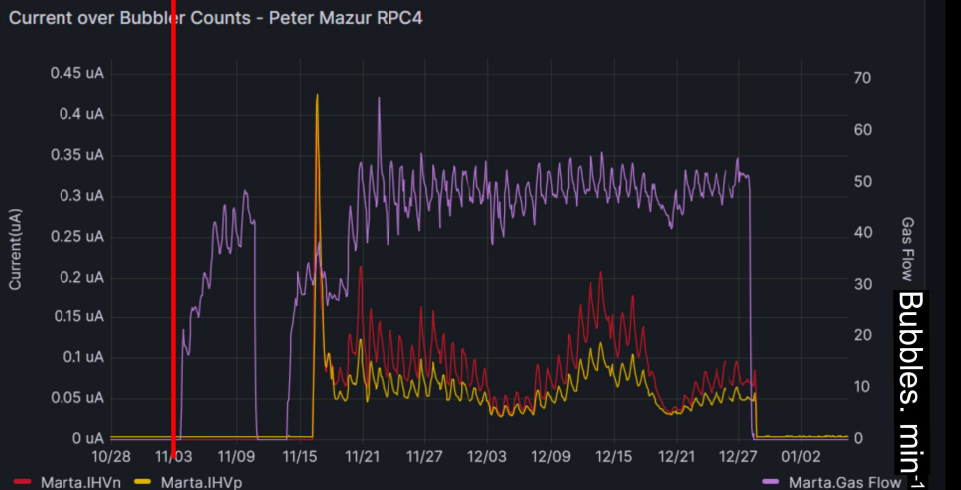
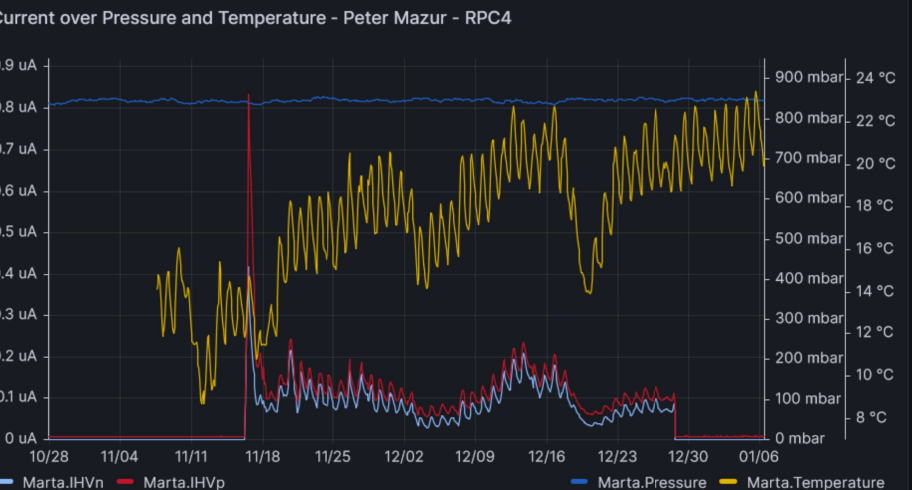
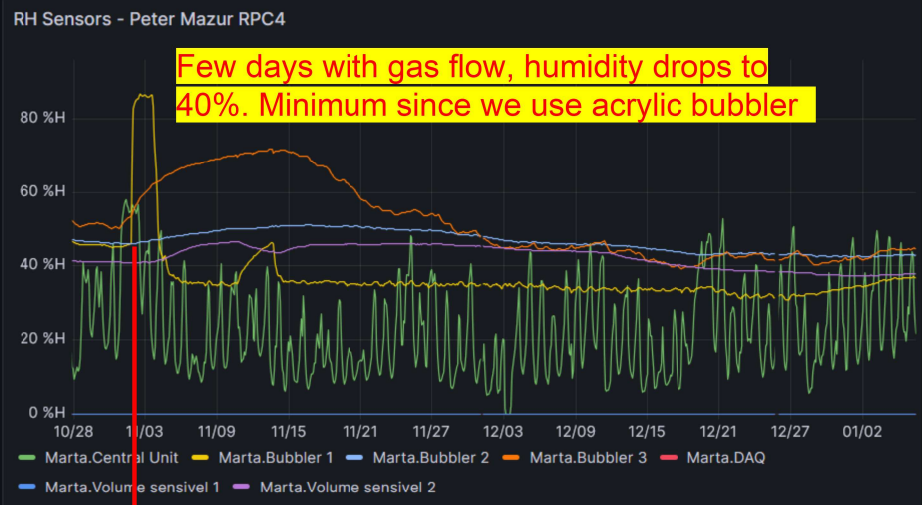
Currents correlated as expected with temperature and absolute pressure

Apparent current gas flow dependence is "not" real. The flow is influenced by the vapor pressure of the gas in the bottle, which has the same type of dependence on temperature.

# Peter Mazur Station



## November 2023 Raw data



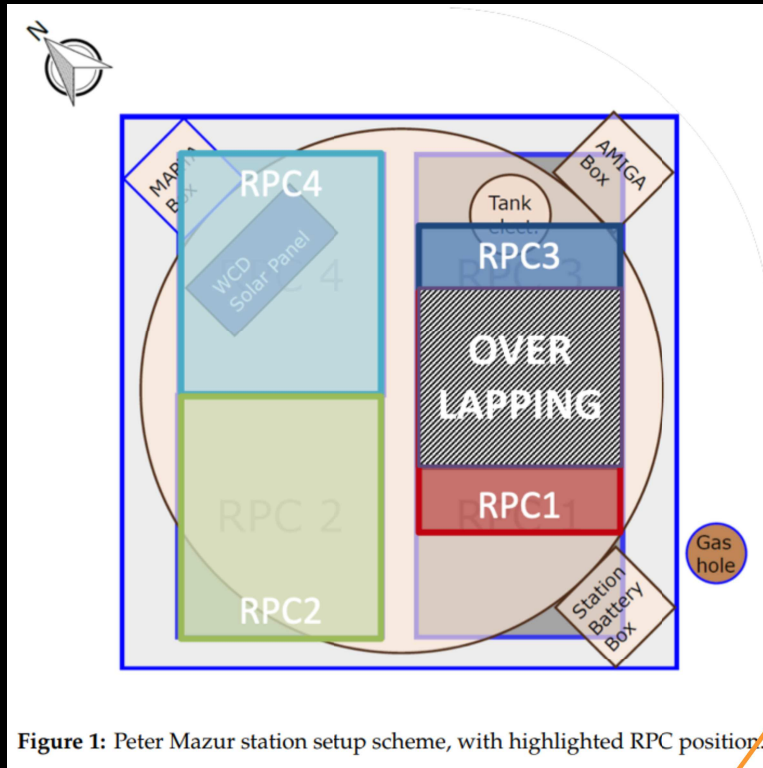
The sensitive volumes seems to be very well constructed and robust, after days (3-4 volumes per day) with gas flowing the Humidity drops to minimum values and is possible to turn ON the HV

Unfortunately the aluminum boxes were not correctly "sealed", decreasing the protection of the sensitive volume to condensation and to the harsh ambient conditions. But this allow us to be a bit more relax about the robustness/resilience of the design/construction

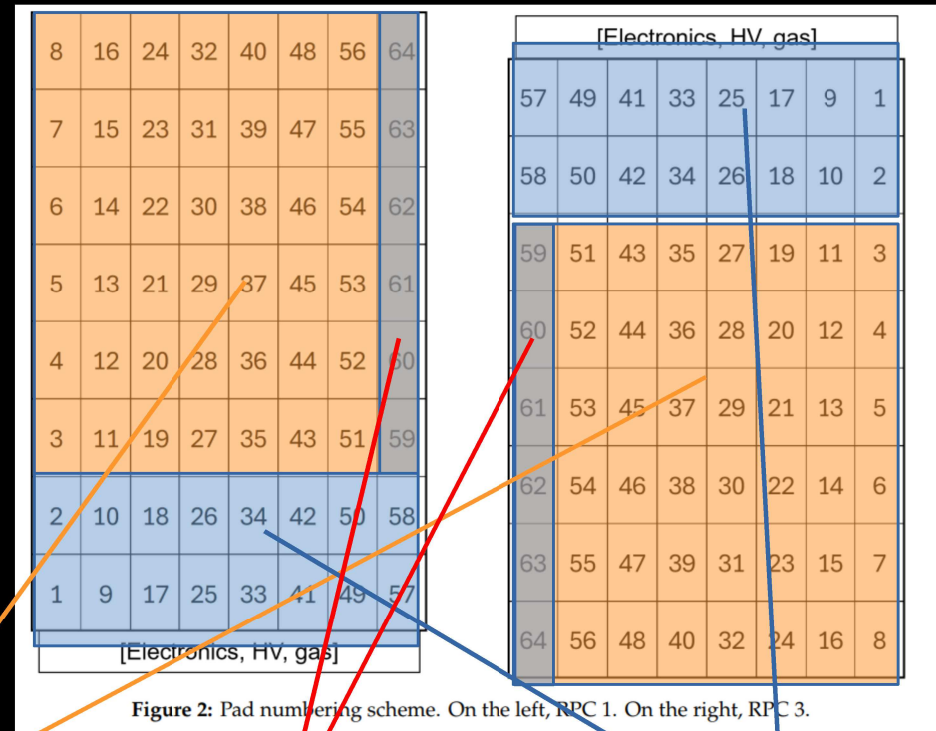
# Peter Mazur Station

## November 2023 Efficiency measurement

### RPC3 and RPC1 overlapping



Only single hit events, meaning events in which each active RPC had at most one and only one active pad



By geometry

Perfect overlapping

[70, 80]% overlapping

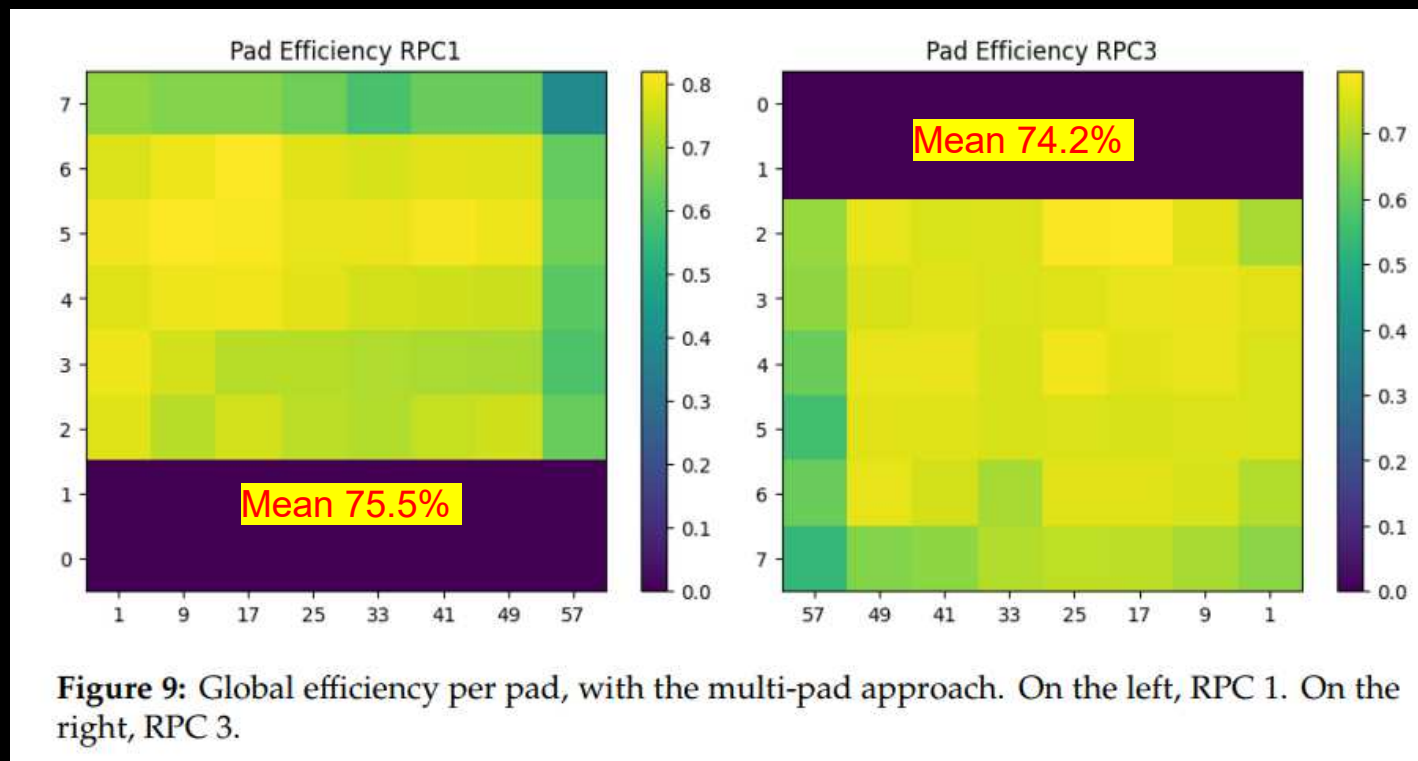
No overlapping

## November 2023 Efficiency measurement

Uniform efficiency

8	16	24	32	40	48	56	64	[Electronics, HV, gas]							
7	15	23	31	39	47	55	63	57	49	41	33	25	17	9	1
6	14	22	30	38	46	54	62	58	50	42	34	26	18	10	2
5	13	21	29	37	45	53	61	59	51	43	35	27	19	11	3
4	12	20	28	36	44	52	60	60	52	44	36	28	20	12	4
3	11	19	27	35	43	51	59	61	53	45	37	29	21	13	5
2	10	18	26	34	42	50	58	62	54	46	38	30	22	14	6
1	9	17	25	33	41	49	57	63	55	47	39	31	23	15	7
[Electronics, HV, gas]								64	56	48	40	32	24	16	8

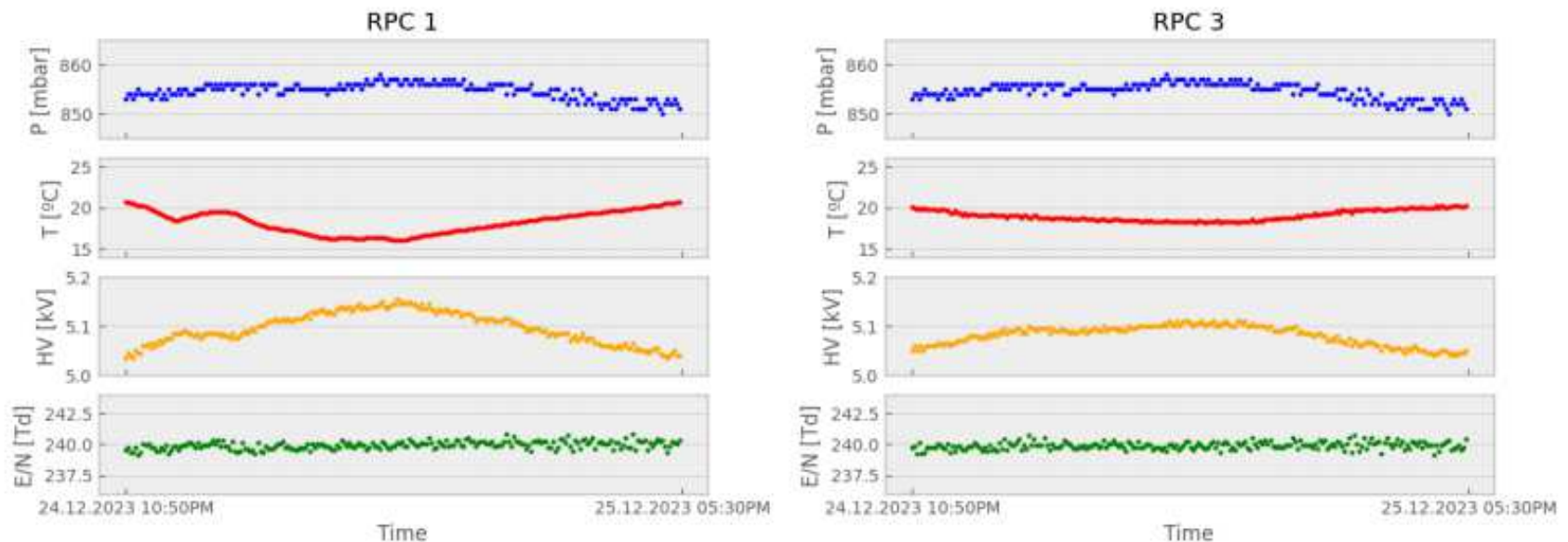
Figure 2: Pad numbering scheme. On the left, RPC 1. On the right, RPC 3.



75% why?

November 2023 Efficiency measurement

$$\frac{E}{N} = 0.01381 \cdot \frac{V_{\text{eff,volts}}}{d_{\text{cm}}} \frac{T_{\circ\text{C}} + 273.15}{P_{\text{mbar}}} \quad [\text{Td}],$$



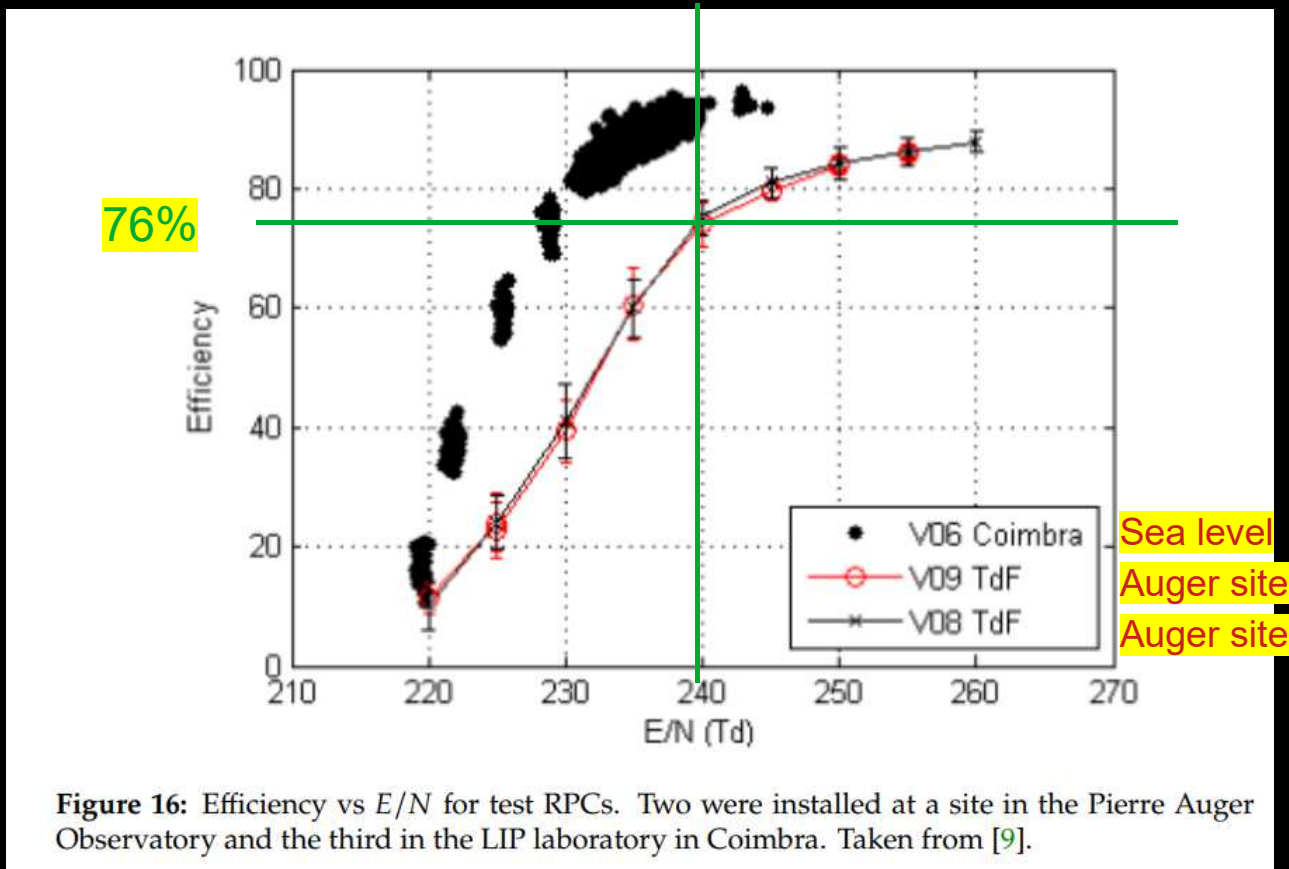
Mean E/N = ~240Td

**Figure 13:** Dynamic adjustment of the high voltage in response to pressure and temperature variations to maintain constant reduced electric field. On the left, RPC 1. On the right, RPC 3.



## November 2023 Efficiency measurement

Same measurement with different front end electronics at Auger site



To achieve the same efficiency at low absolute pressure we need to increase the gas thickness to get the “same” gas gain.

Most simple and economic way is to increase the gap width. For trigger applications should be ok.

## •Conclusions from Peter Mazur station

- The four RPCs are in the field since November 2019, during 4 years only 4 months with gas flow.
- All four show acceptable currents, below 150 nA, similar to the ones measured indoor at the lab
- Efficiency measurements confirm the good performance of at least 2 chambers.
- Unfortunately only a few months with HV ON limit the ageing studies/conclusions about the resilience of these detectors for remote/outdoor/standalone Astroparticles experiments. We should make a strong and decisive push to solve DAQ stability and gas supply to give important validation steps.
  - Long data taken periods, complete year would be important
  - Only with continuous data will be possible to study the influence of the gas flow rate in the performance.