



RPC 2026
RIO DE JANEIRO

XVIII Conference on Resistive Plate Chambers and Related Detectors

Sealed RPCs, status and perspectives

L.Lopes on behalf of RPC R&D group at LIP



Fundação
para a Ciência
e a Tecnologia

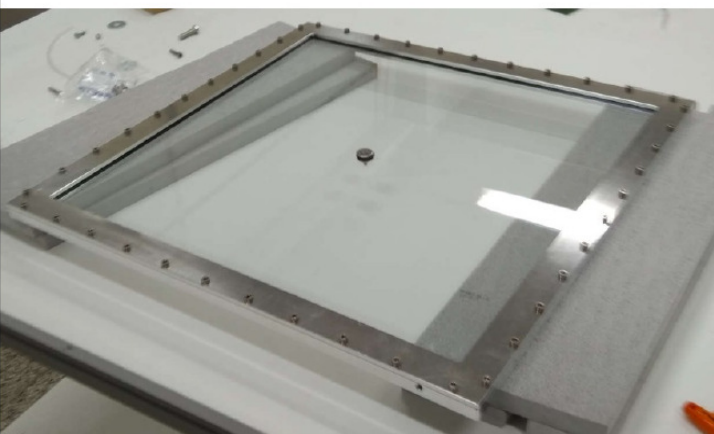
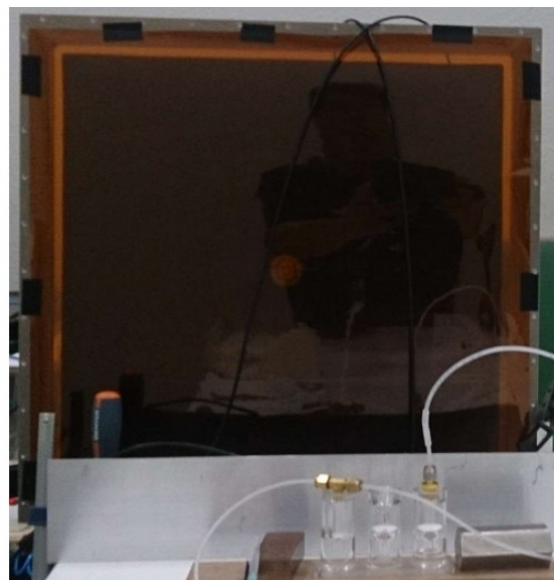
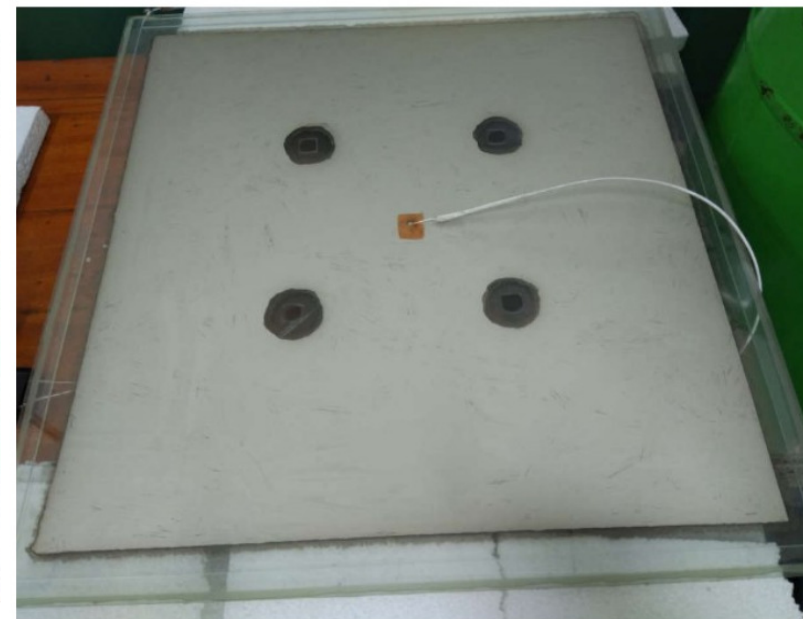
This work was supported by the Portuguese Foundation for Science and Technology (FCT)

- Details about construction.
- Sealed RPC 30x30 cm² module.
- First real application, [SND@LHC](#) case.
- Sealed RPC 100x100 cm² module.

- If Geiger succeed 100 years ago, operating under pressure. Should be possible to do it at **“zero” pressure gradient**.
 - Different Geometry. Yes. Compensate with spacers density.
- But Geiger counters use inert gases. RPCs use very complex gases with high polymerization affinity. Yes. All the component preparation and assembly should be done under **extremely clean conditions**. Follow by **permanent Argon discharge** before fill the gaps with operation gas mixture.
- A possibility for mitigation of the **HFC phase-out?**, could it be possible to continue using the current HFC gases? or even already banned gases?
- This development is also **compatible** (to be tested) **with eco-friendly gases**.
- Without gas system/consumption the **system is much cheaper and simple**.
- **Improved portability and simplified maintenance** => muon tomography, installation of remote systems (Cosmic Ray experiments), hospitals?

New advances in very low gas consumption (2020) [10.1088/1748-0221/15/11/C11009](https://doi.org/10.1088/1748-0221/15/11/C11009)

Outdoor Systems, performance and upgrade (2022) [10.1016/j.nima.2023.168446](https://doi.org/10.1016/j.nima.2023.168446)



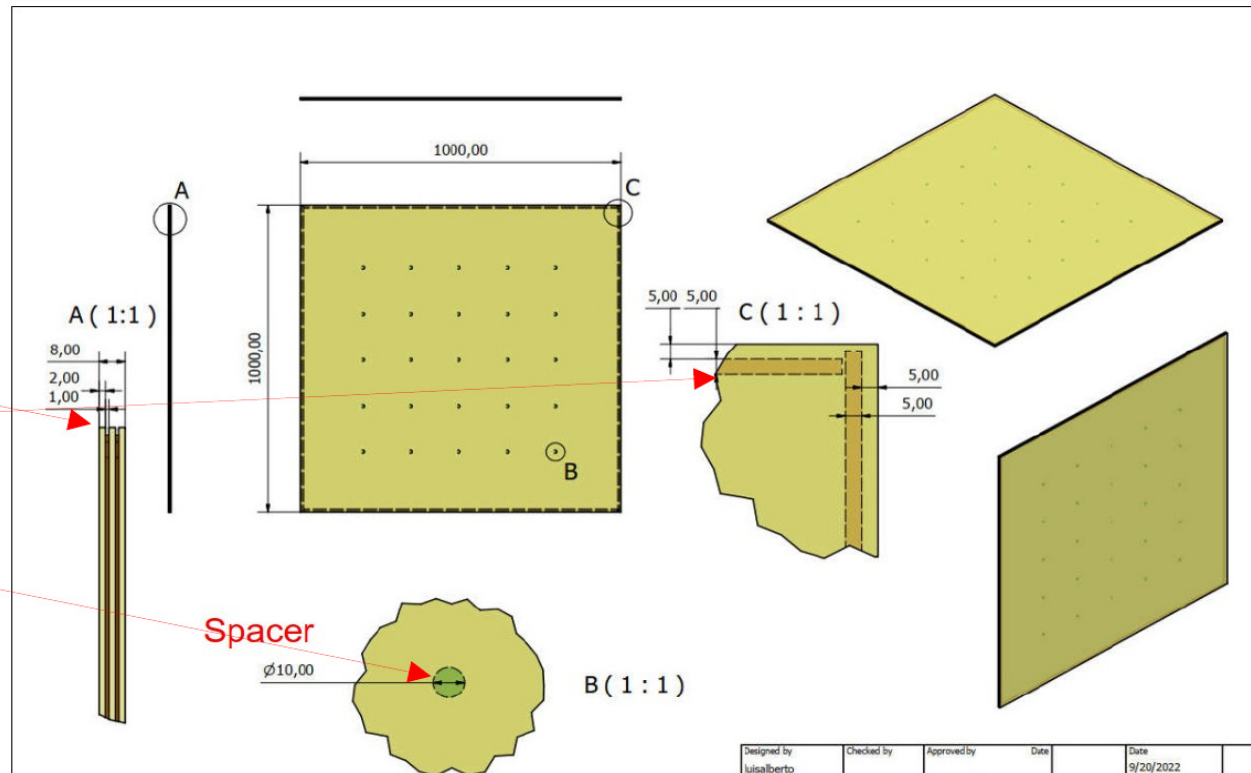
Different constructions with different problems and/or showstoppers and also understanding of the problems

Concept.

Very **simple concept**. Similar construction to conventional RPCs, but the **gas is only in contact with glass** (a highly stable and inert material).

Everything made with glass

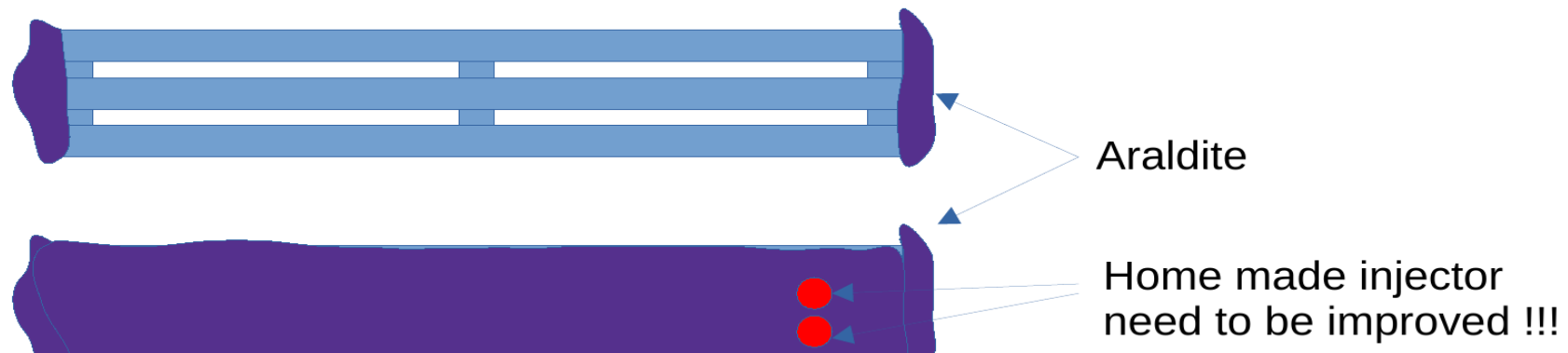
- MRPC electrodes.
- Peripheral spacers.
- Central spacers.



RPC technical drawings

Concept.

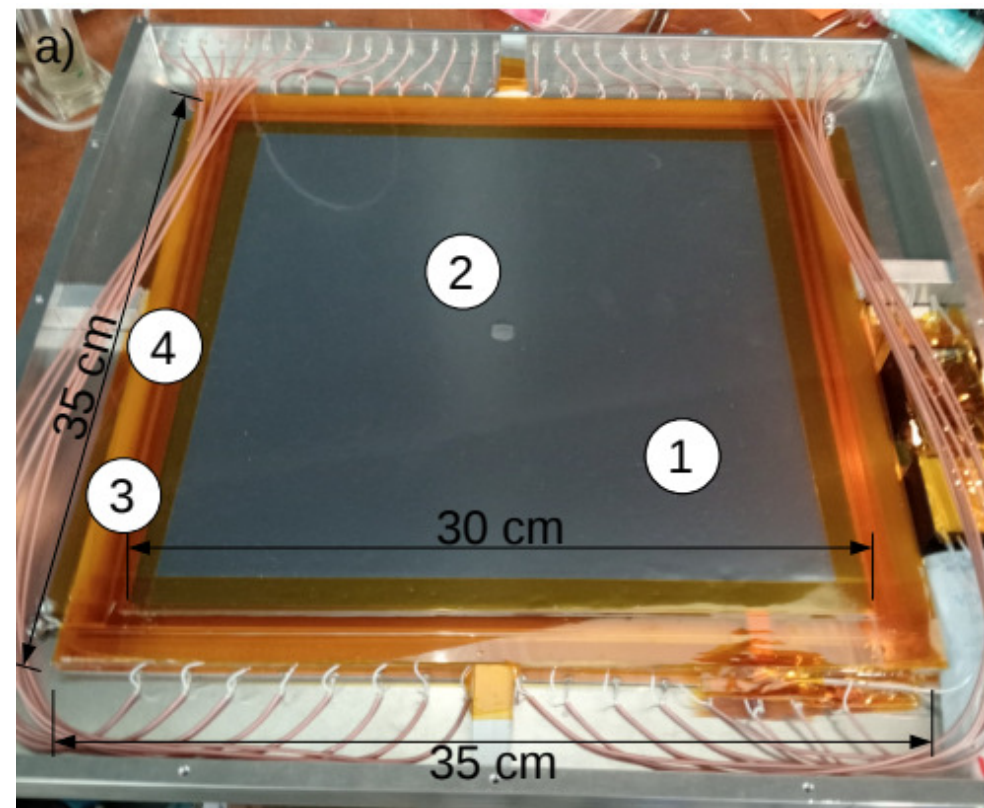
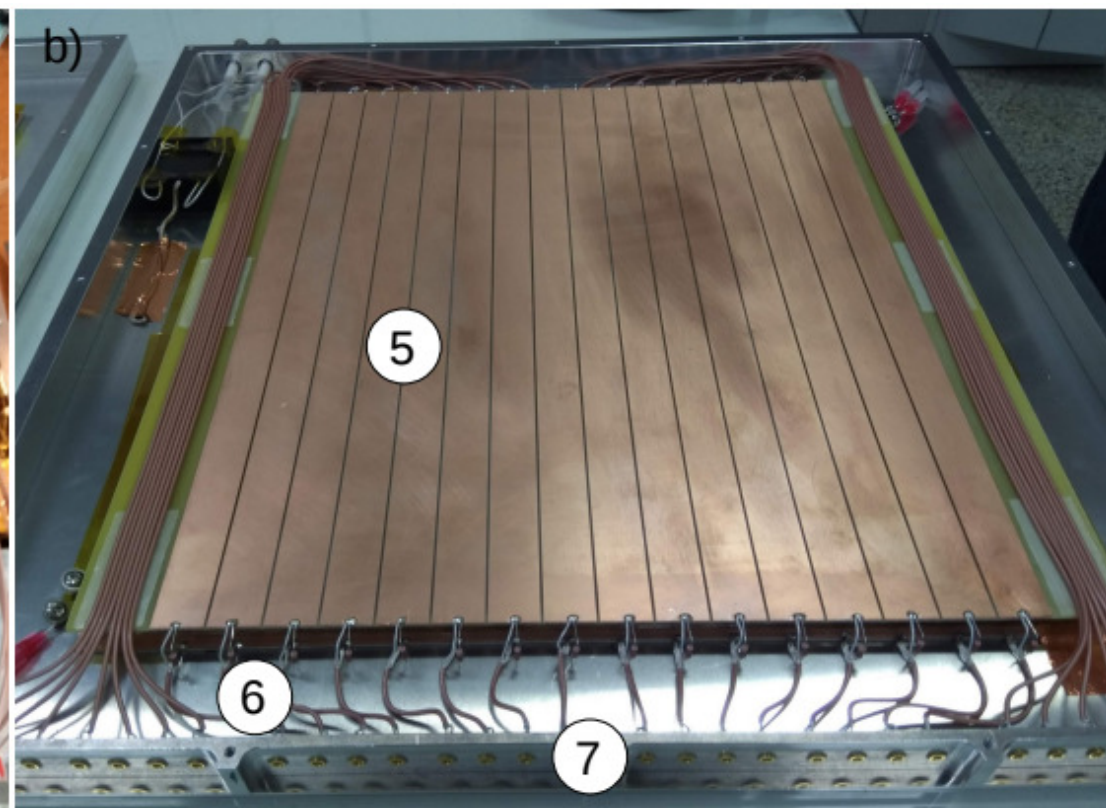
Very **simple concept**. Similar construction to conventional RPCs, but the **gas is only in contact with glass** (a highly stable and inert material).



All **glass components** are **stacked and laterally bonded using Araldite**.
One gas inlet and one outlet are provided for each gas gap.

After assembly, the gas gaps are **flushed with argon for several days**. The detector is **then** conditioned with a **sustained discharge in argon for about two weeks**. **Finally**, the gaps are flushed with the nominal **gas mixture (98% $C_2H_2F_4$ + 2% SF_6) at $\sim 4 \text{ cm}^3/\text{min}$ for several days**.

Sealed RPC 30x30 cm².

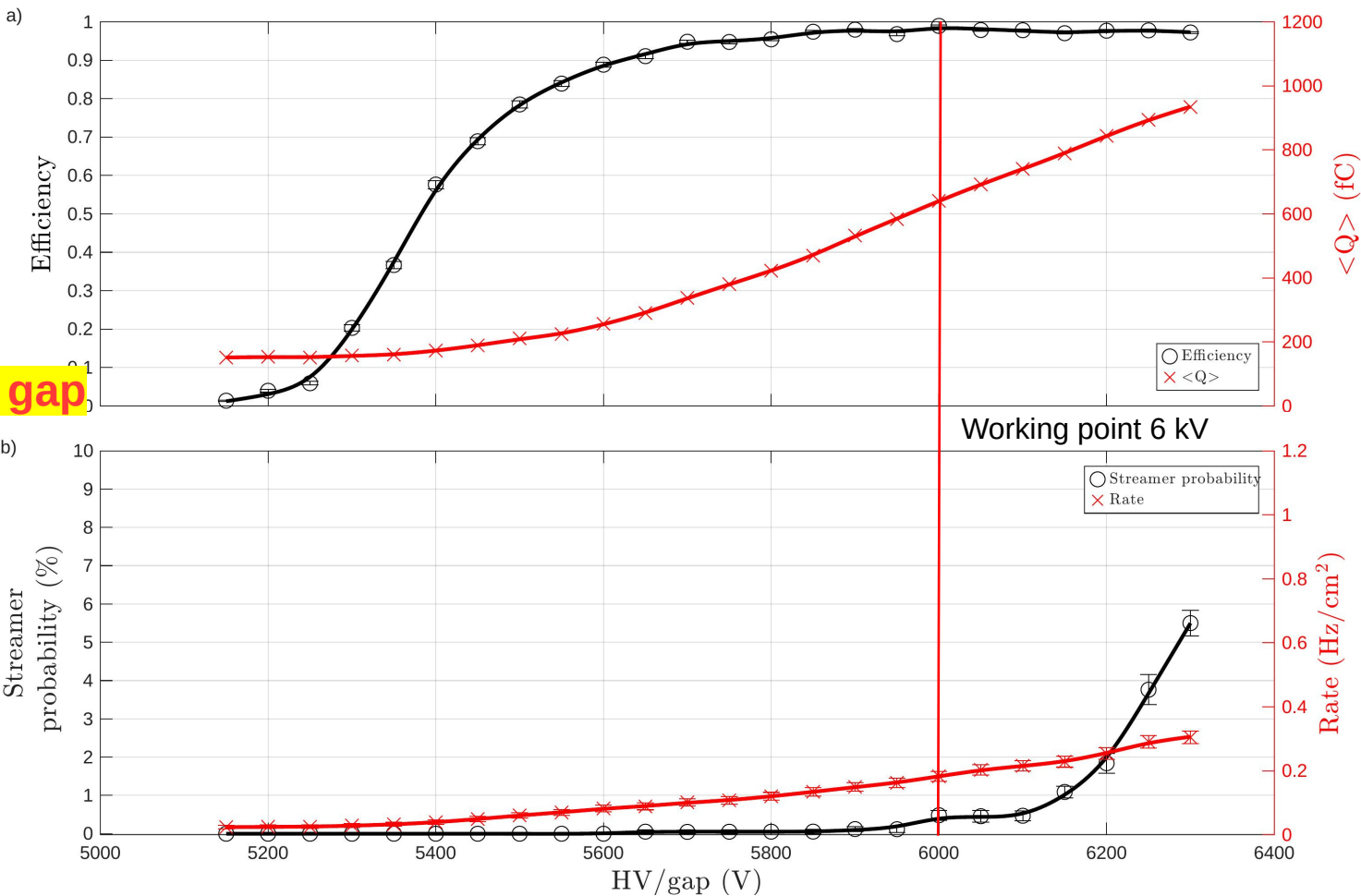


a) 1- HV layer, 2- Circular spacer in the center of the active area, 3- Strip spacer all around the periphery and 4- Mylar and Kapton layers.
b) sRPC plane showing: 5- Readout strip plane, 6- Coaxial cables and 7- MMCX RF feedthrough connectors.

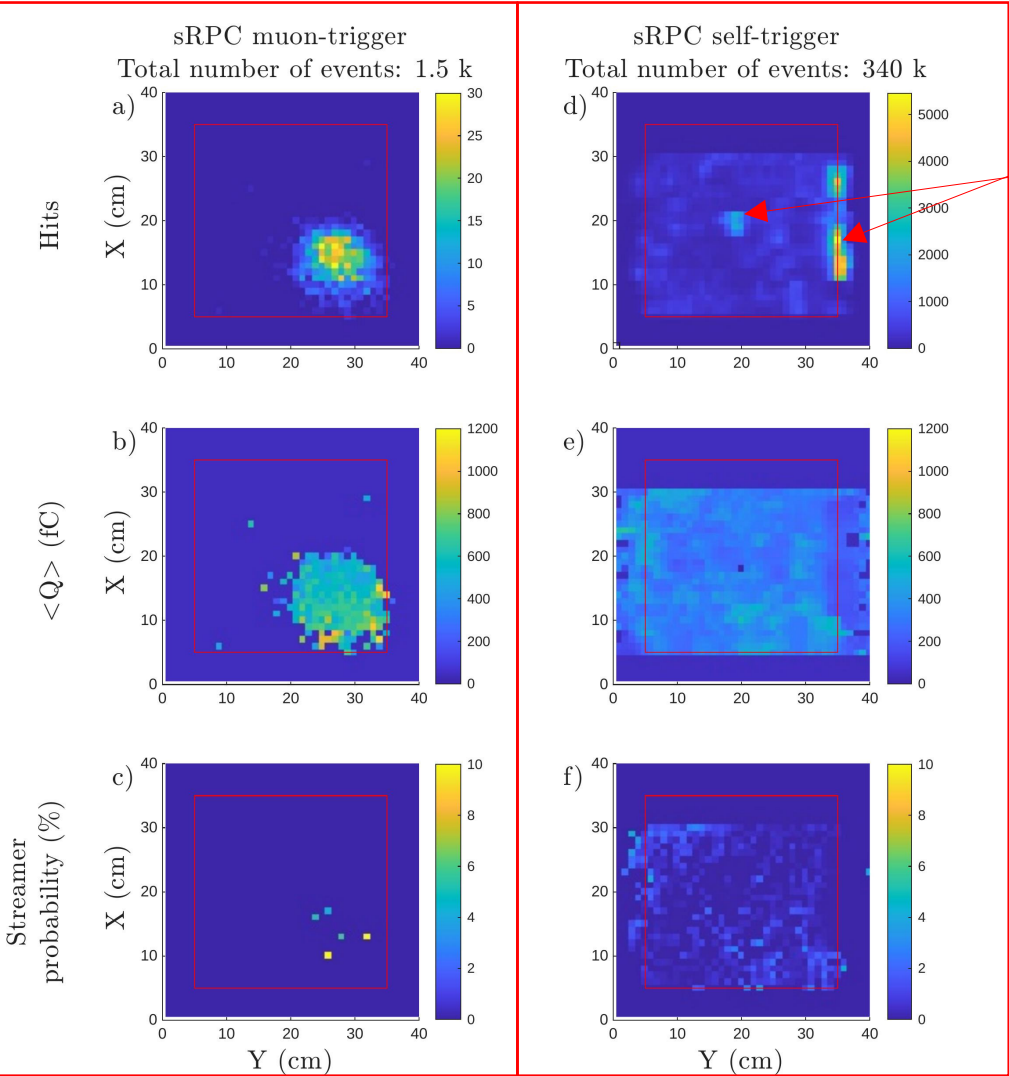
98 % C₂H₂F₄ + 2 % SF₆

[10.1016/j.nima.2025.170396](https://doi.org/10.1016/j.nima.2025.170396)
[10.1016/j.nima.2025.170743](https://doi.org/10.1016/j.nima.2025.170743)

Performance similar to what could be expected from such a detector operated in a continuous gas flow, efficiency higher than 98 % and streamer percentage below 1 %



Scintillator
(muon)
trigger



Self trigger

Hit map, with some “hot spots” in regions where spacers are located

Average charge map, uniform

Streamer probability map

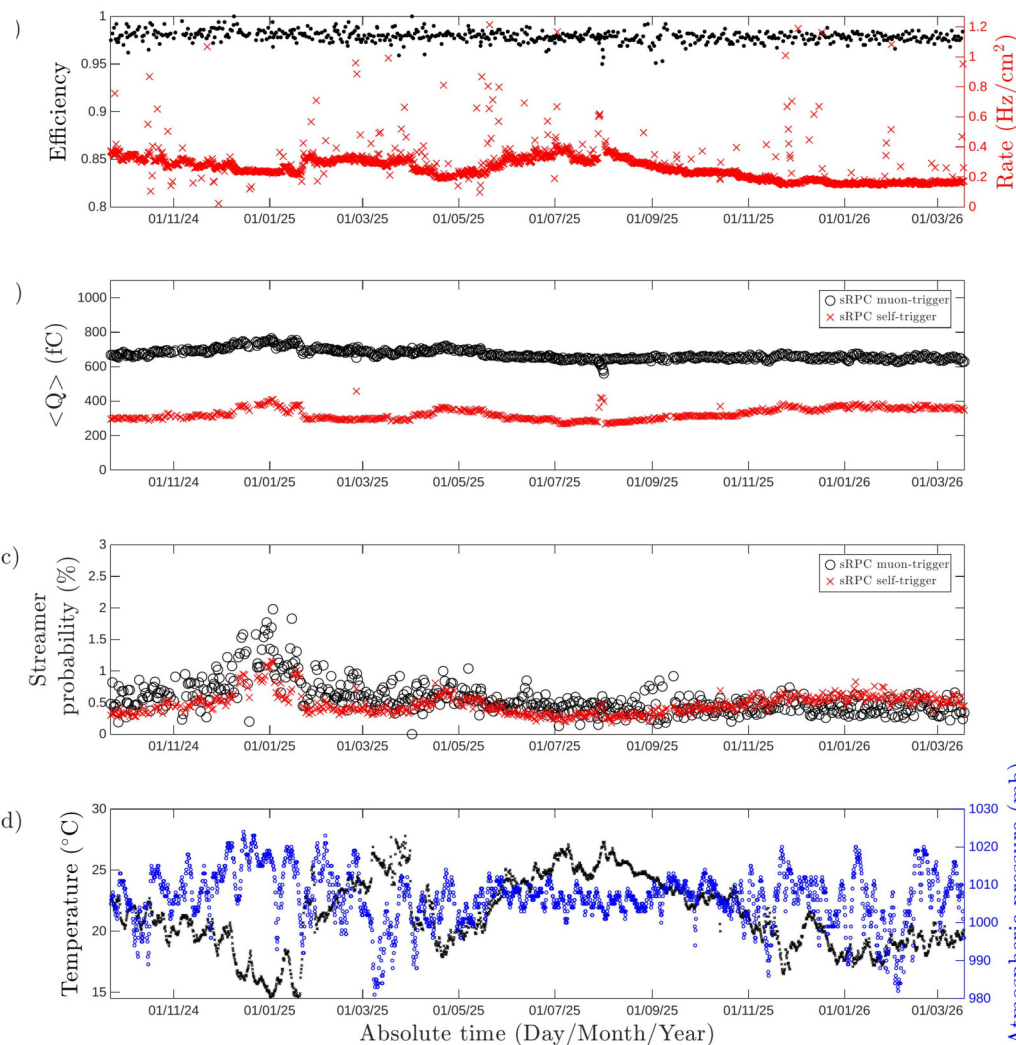
Sealed RPC 30x30 cm².

More than **600 days** of operation with the same gas mixture.

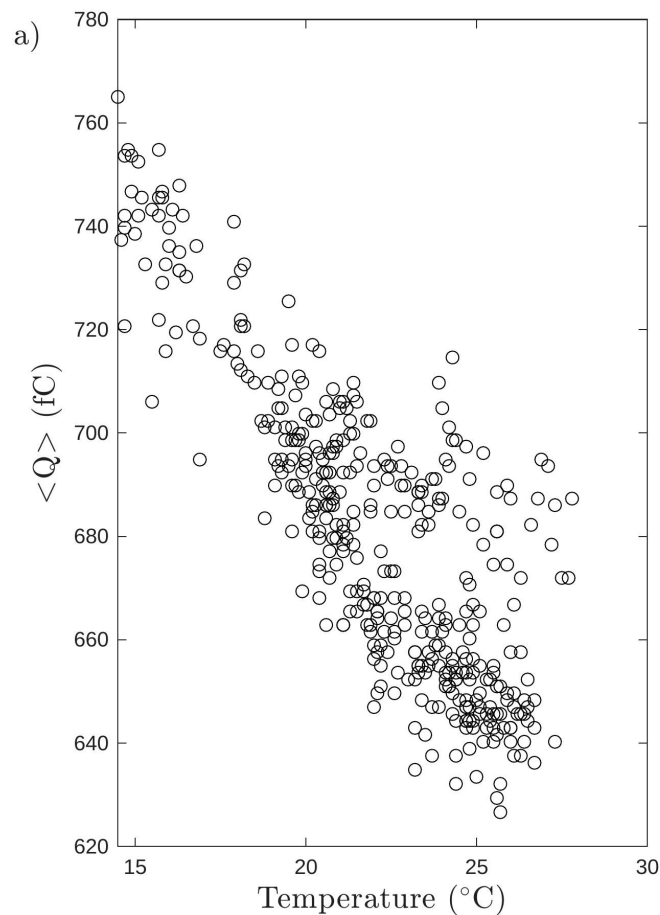
No signs of detector degradation.

Stable efficiency, dark count rate, average charge and streamer probability

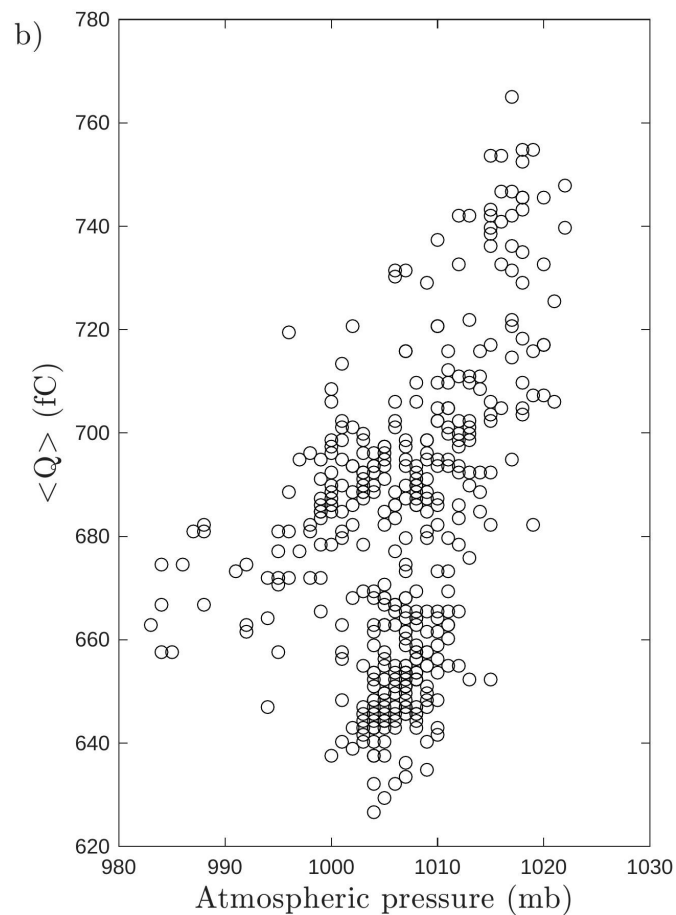
Laboratory **temperature** and atmospheric **pressure** correlate with the charge.



T ↑ Q ↓



P ↑ Q ↑



This can be interpreted as a **mechanical deformation** of the detector.

The **efficiency is not affected**, since we are operating on the plateau.

Sealed RPC 30x30 cm² under strong irradiation.

Same RPC (same gas) before **542 days** of operation

Irradiation facility @ Santiago de Compostela

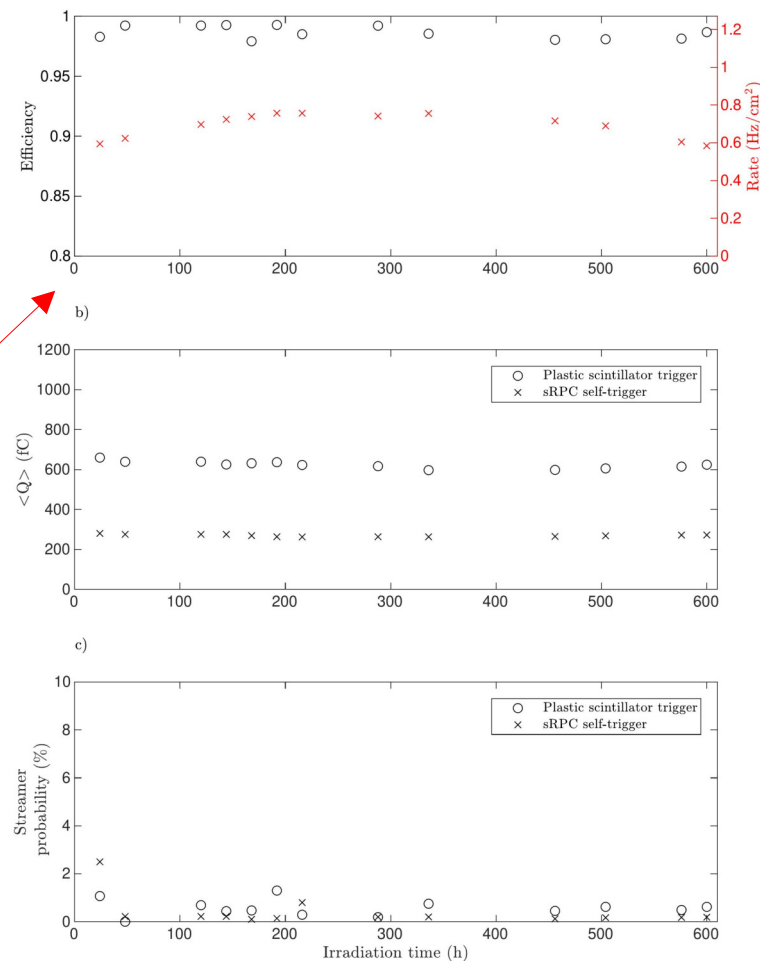


**Irradiation with ⁶⁰Co
during 24 days (22h/day)
@ 60 Hz/cm²**

Muon trigger analysis 2h/day
after 22h of ⁶⁰Co irradiation

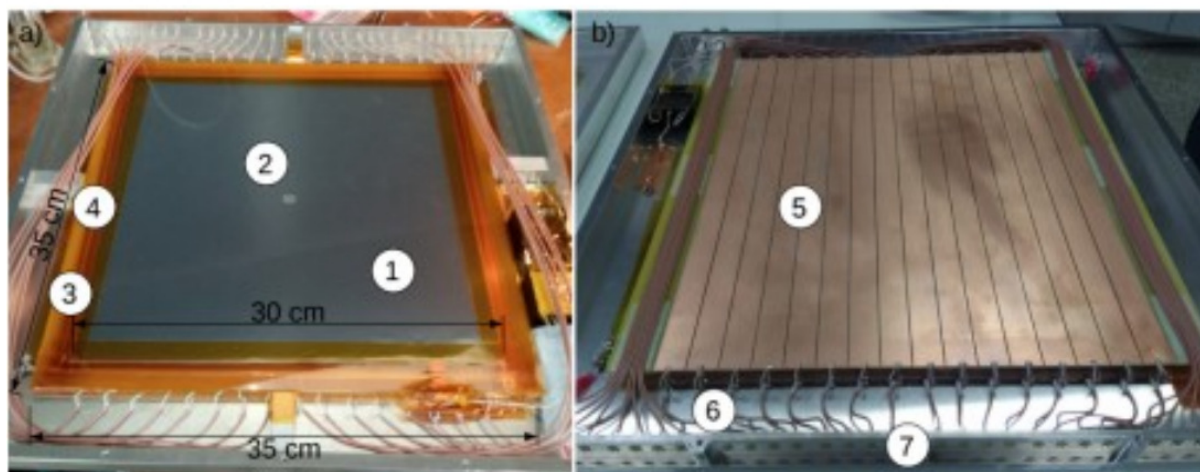
**No signs of detector
degradation.**

Corresponds to 1435 days
of operation in a Cosmic
Ray experiment



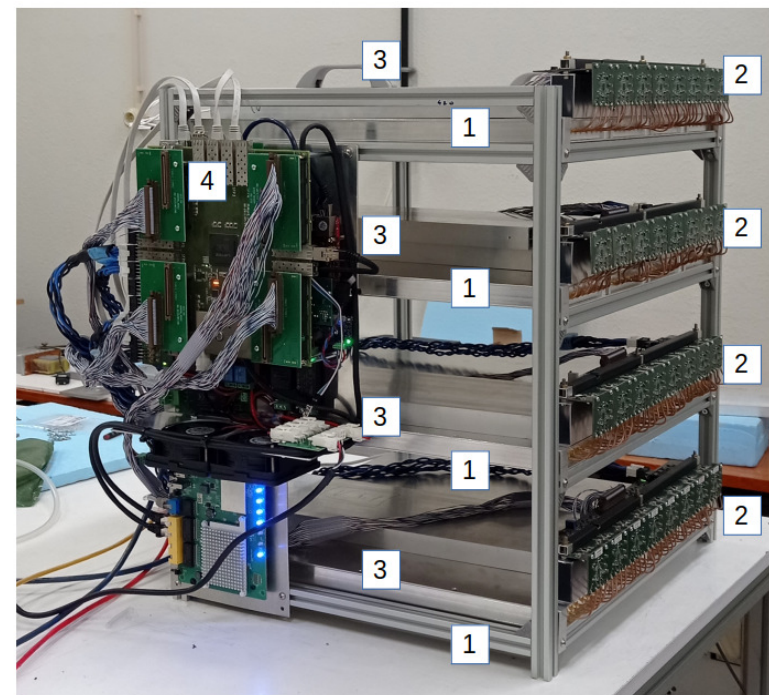
Sealed RPC 30x30 cm². Small telescope @ SND@LHC.

- Four sRPC planes ~50x50x50 cm³
- MRPC active area 30x30 cm²
- Different gap widths for testing



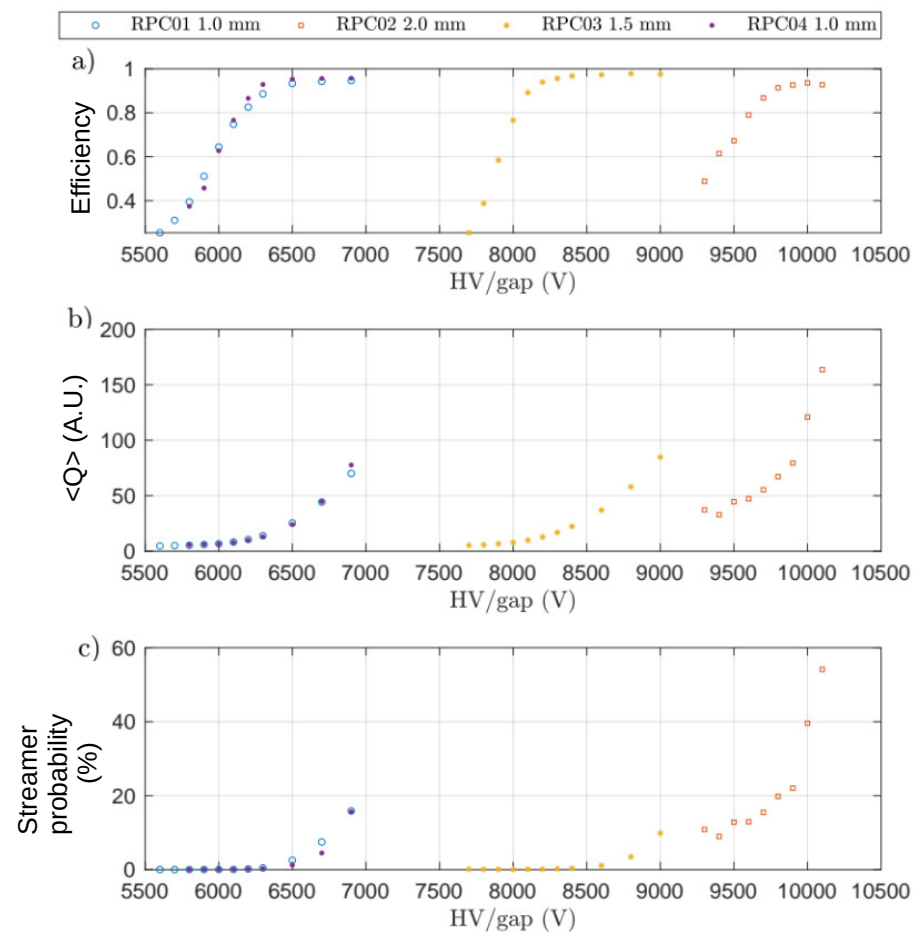
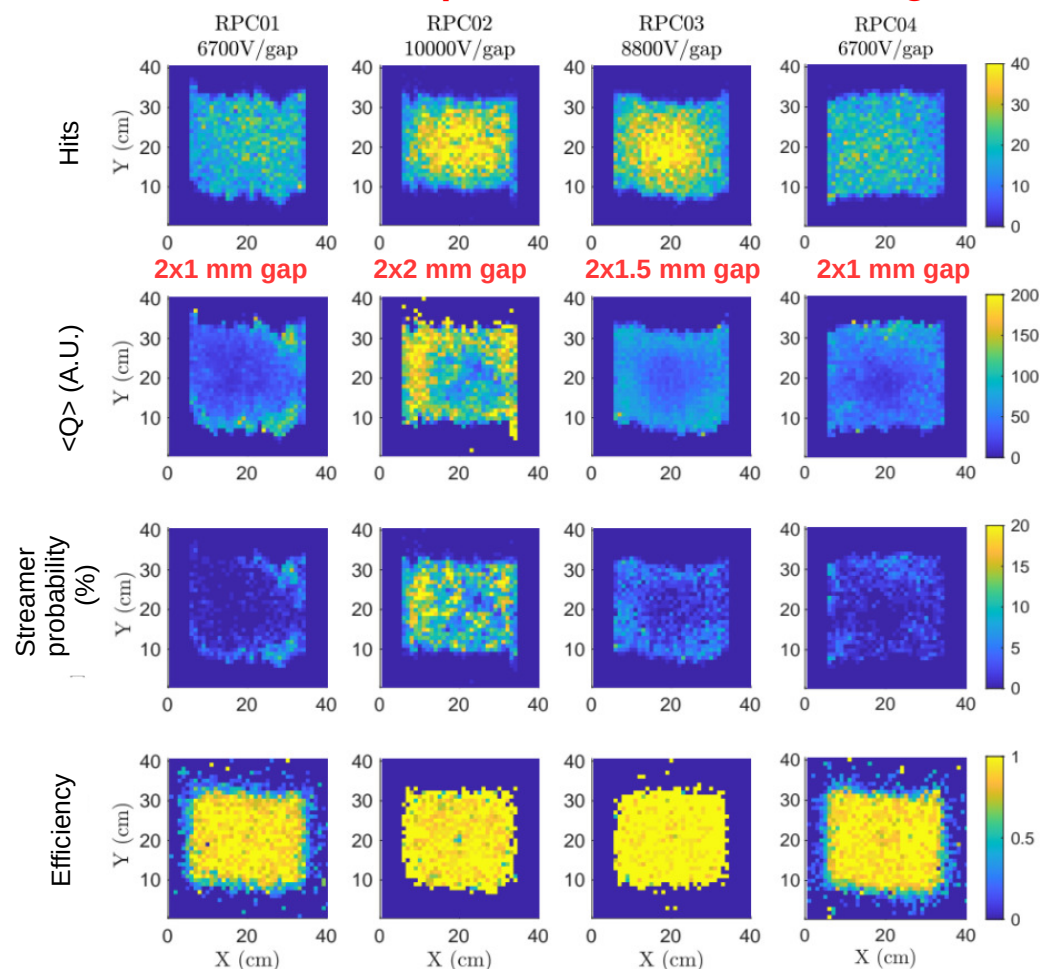
a) 1- HV layer, 2- Circular spacer in the center of the active area, 3- Strip spacer all around de the periphery and 4- Mylar and Kapton layers.
b) sRPC plane showing: 5- Readout strip plane, 6- Coaxial cables and 7- MMCX RF feedthrough connectors.

- ~ 60° opening angle, tracking capabilities ~ 1 cm²
- 300 ps timing precision
- Portable
- Autonomous operation



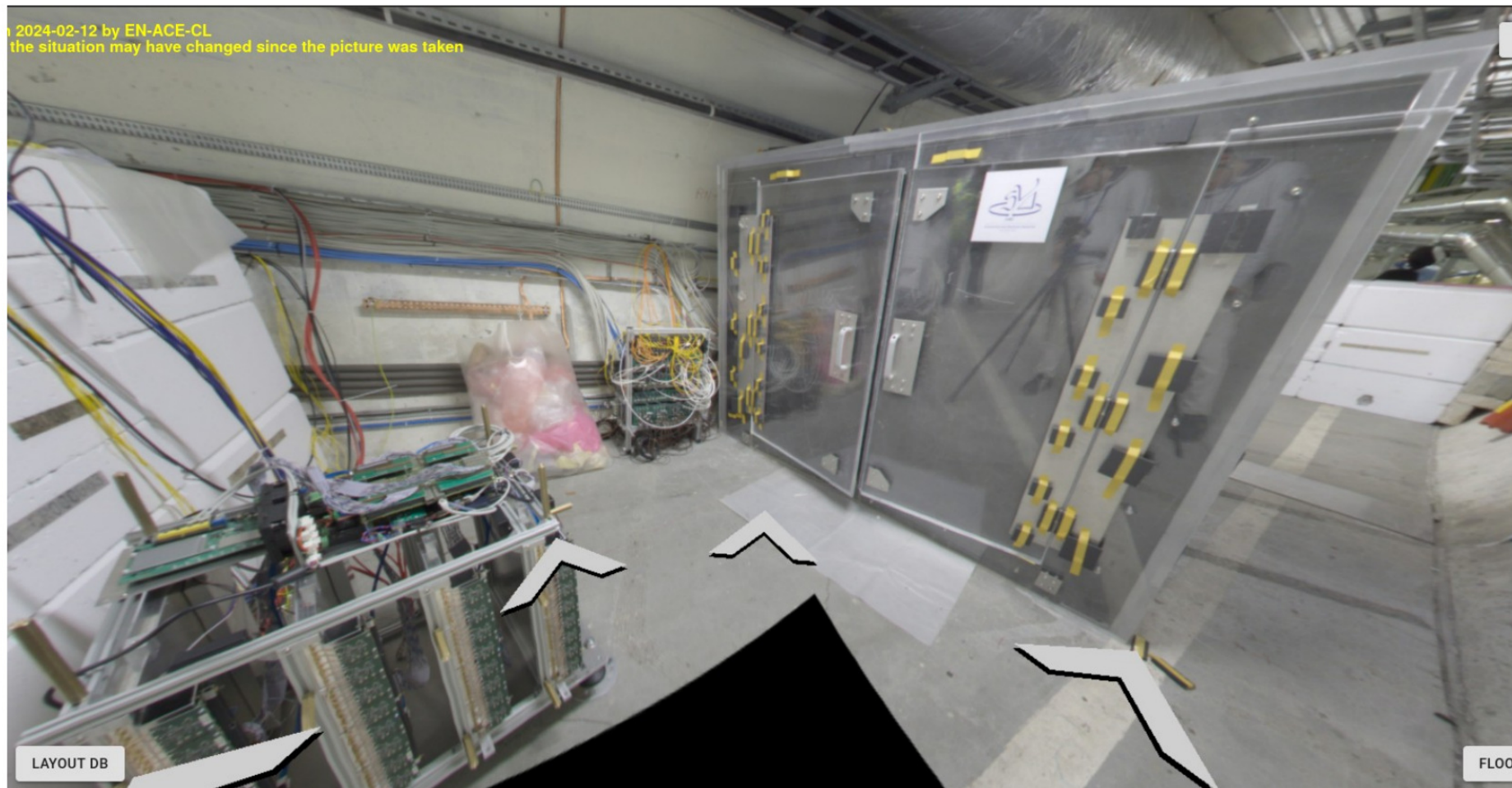
1- sRPC planes, 2 – FEE used to readout the signals from sRPC, 3 – High Voltage PS system, 4 – DAQ, computer and power supplies.

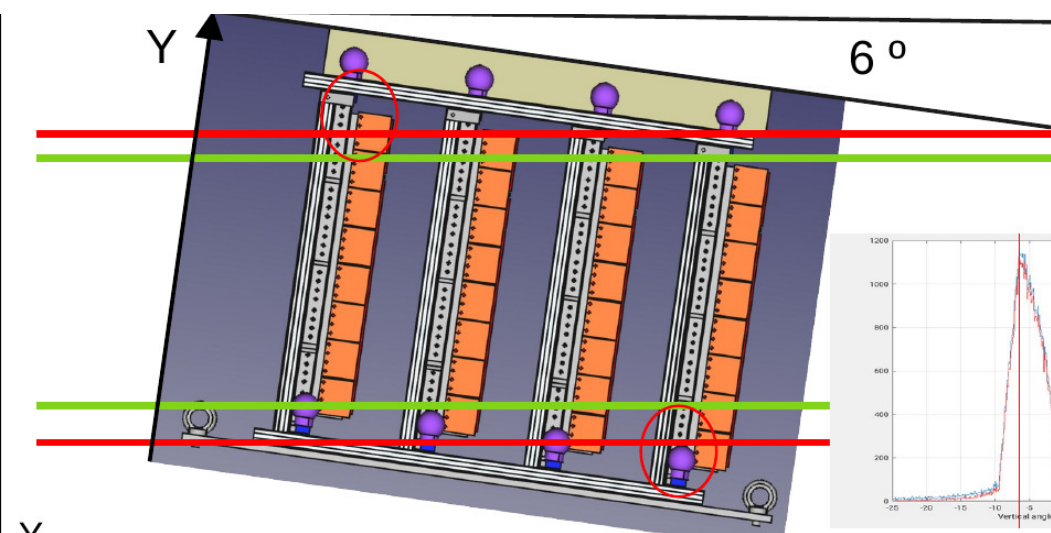
Performance similar to what could be expected from such a detector operated in a continuous gas flow



[10.1016/j.nima.2025.170396](https://doi.org/10.1016/j.nima.2025.170396)

Sealed RPC 30x30 cm². Small telescope @ SND@LHC.

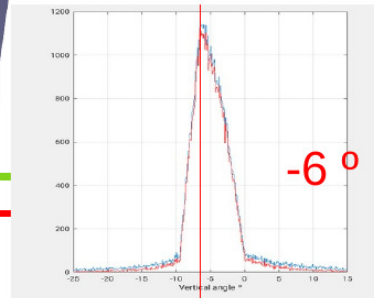
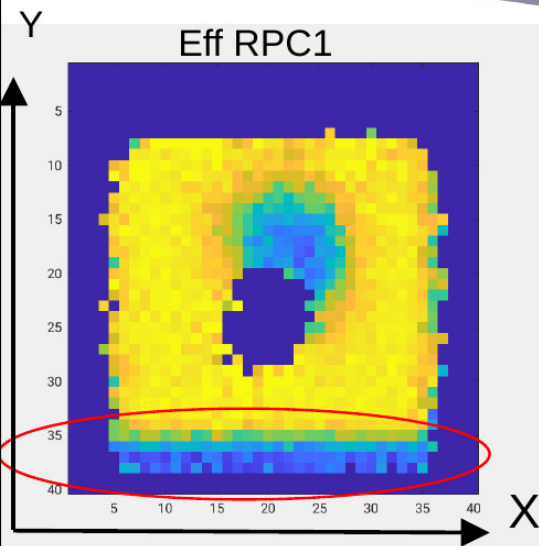
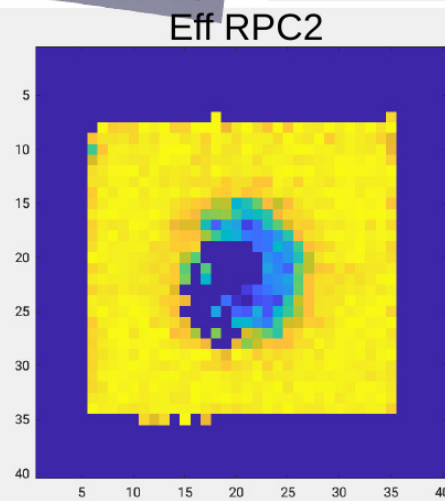
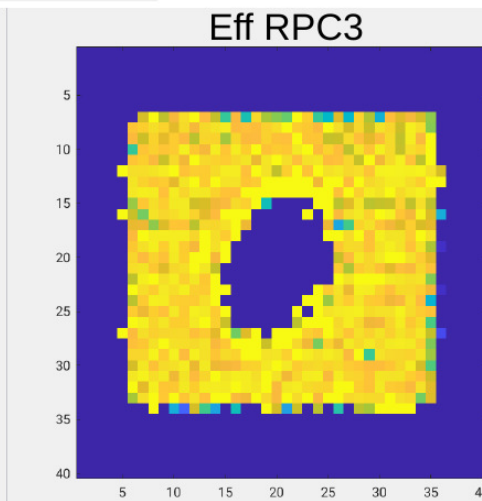
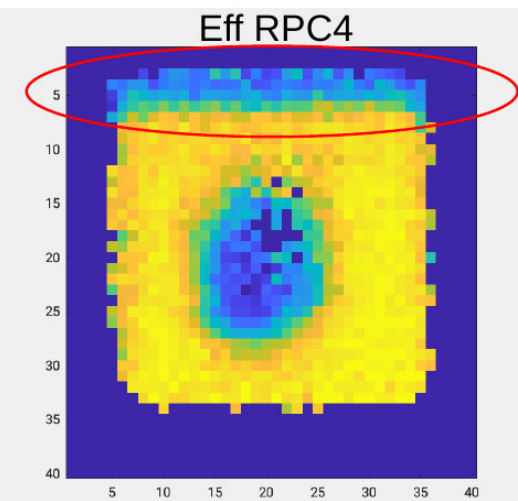


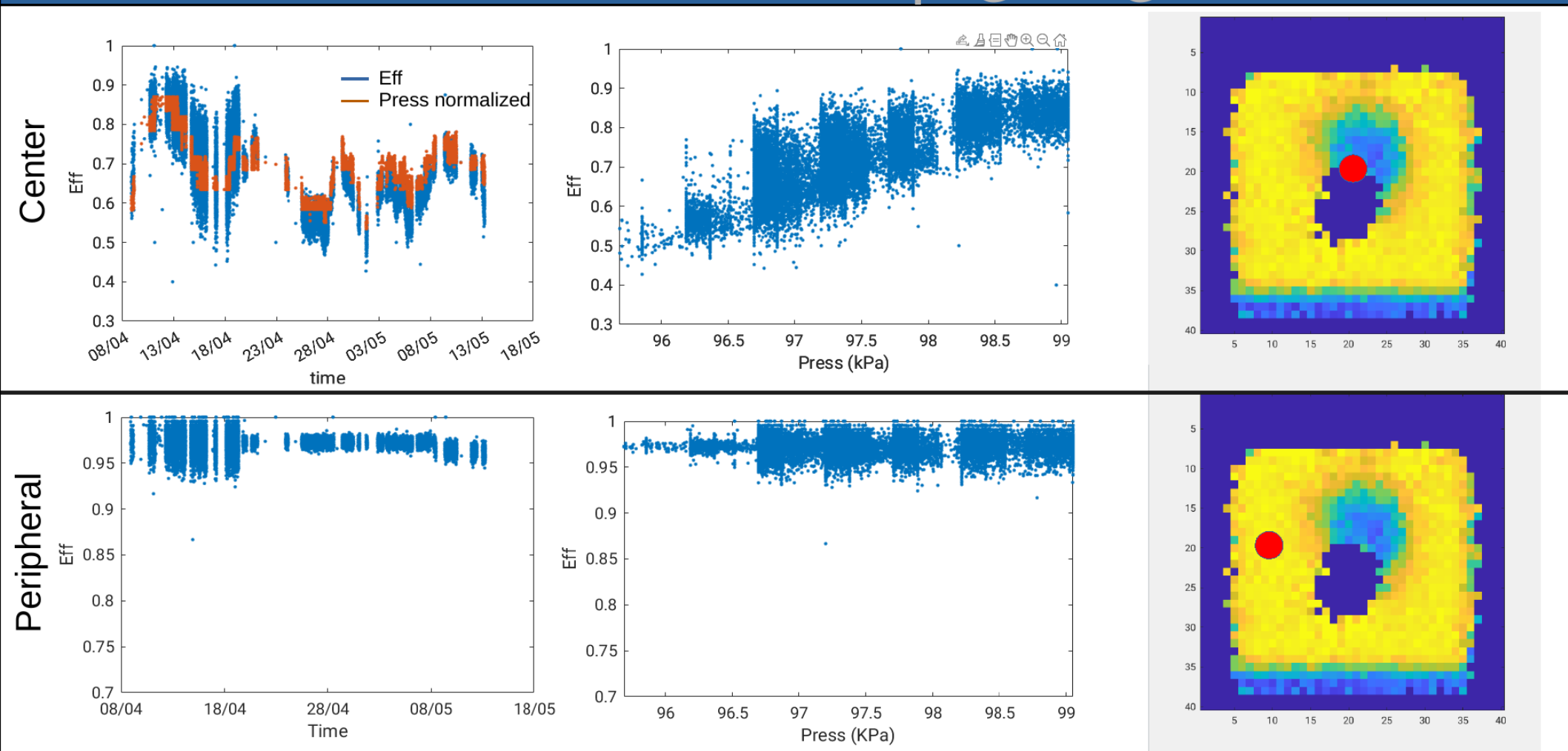


Deficit of events shown on hit maps

Not recorded muon (hit only two planes)

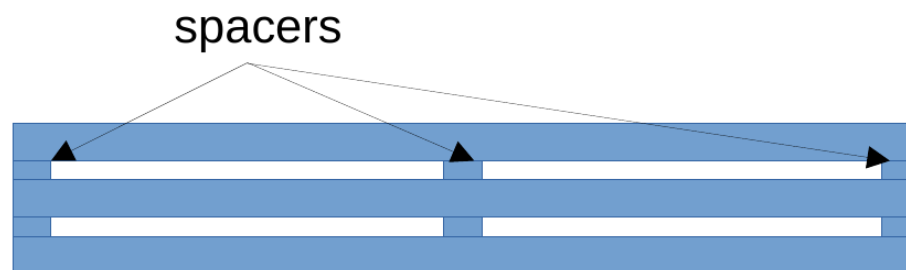
Recorded muon (hit three or more planes)





Huge variation of **efficiency** on the center of the chamber **correlated with Atmospheric Pressure**

Cross-section of
a sRPC chamber



3 glass electrodes
2 gas gaps

Atmospheric P ↓ the chamber could change (increase) the gap width in
the center

if the central spacer is not glued anymore
Sealed RPCs are not atmospheric detectors



The central spacer is not glued and eventually fragile.
This most likely occurred during transport from Coimbra.

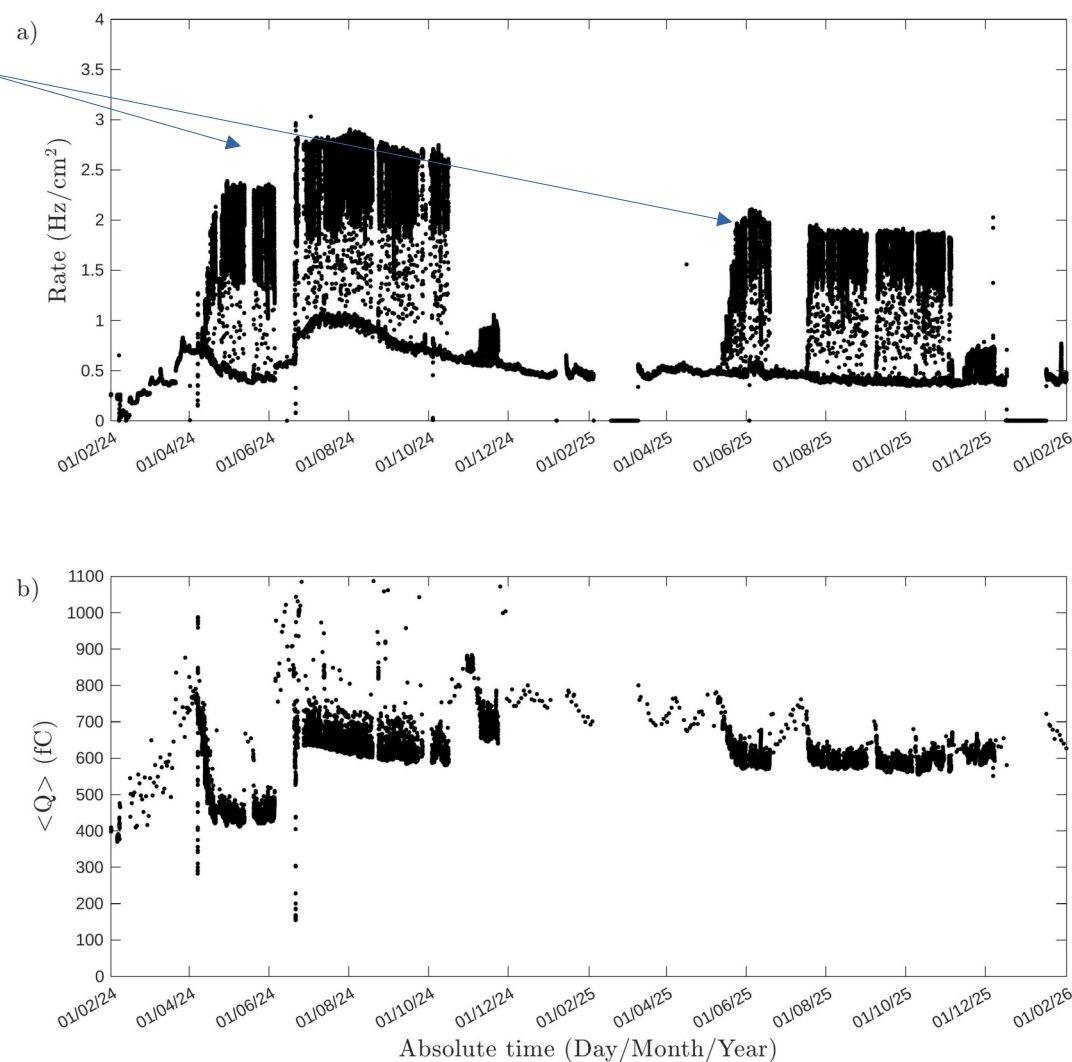
This has to be fixed!!!

Huge variation of **efficiency** on the center of the chamber **correlated with Atmospheric Pressure**

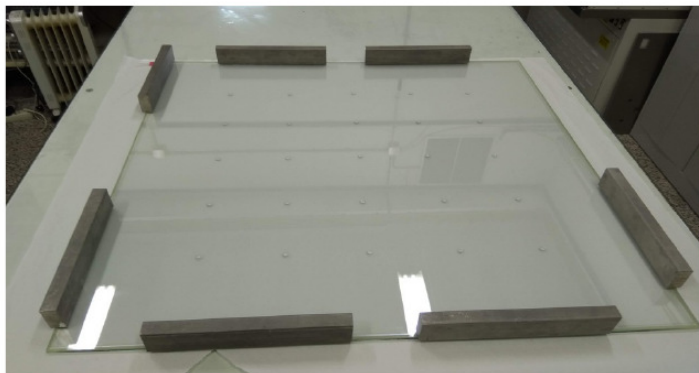
More than **800 days** of operation with the same gas mixture.

No signs of detector degradation.

Beam on



Assemble process



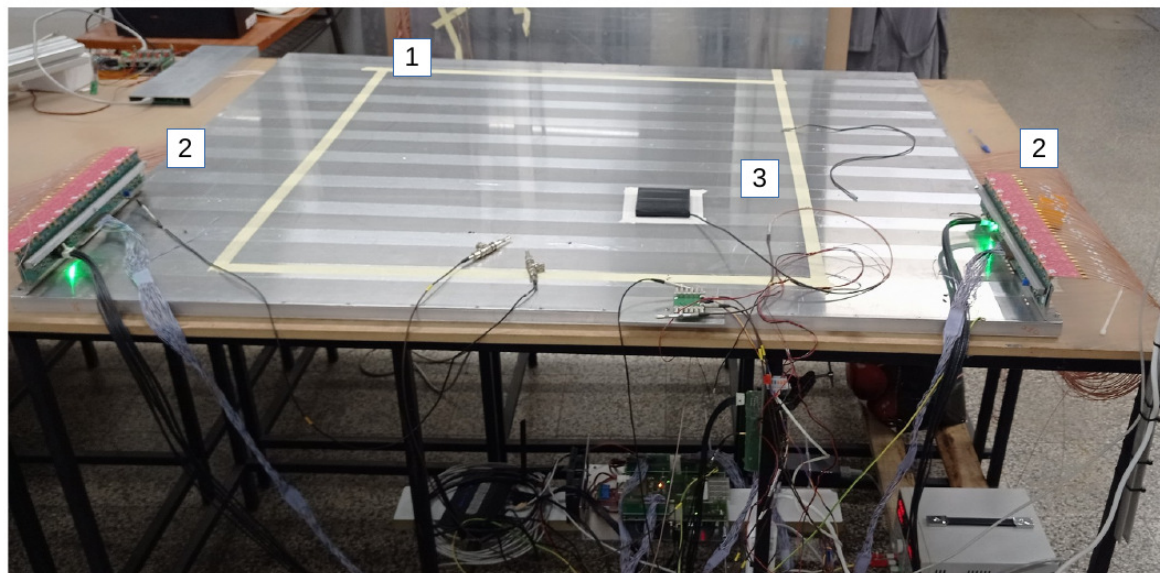
Multi-gap assembly: 5x5 spacer matrix + peripheral strip all around the gaps for sealing.



98 % C₂H₂F₄ + 2 % SF₆

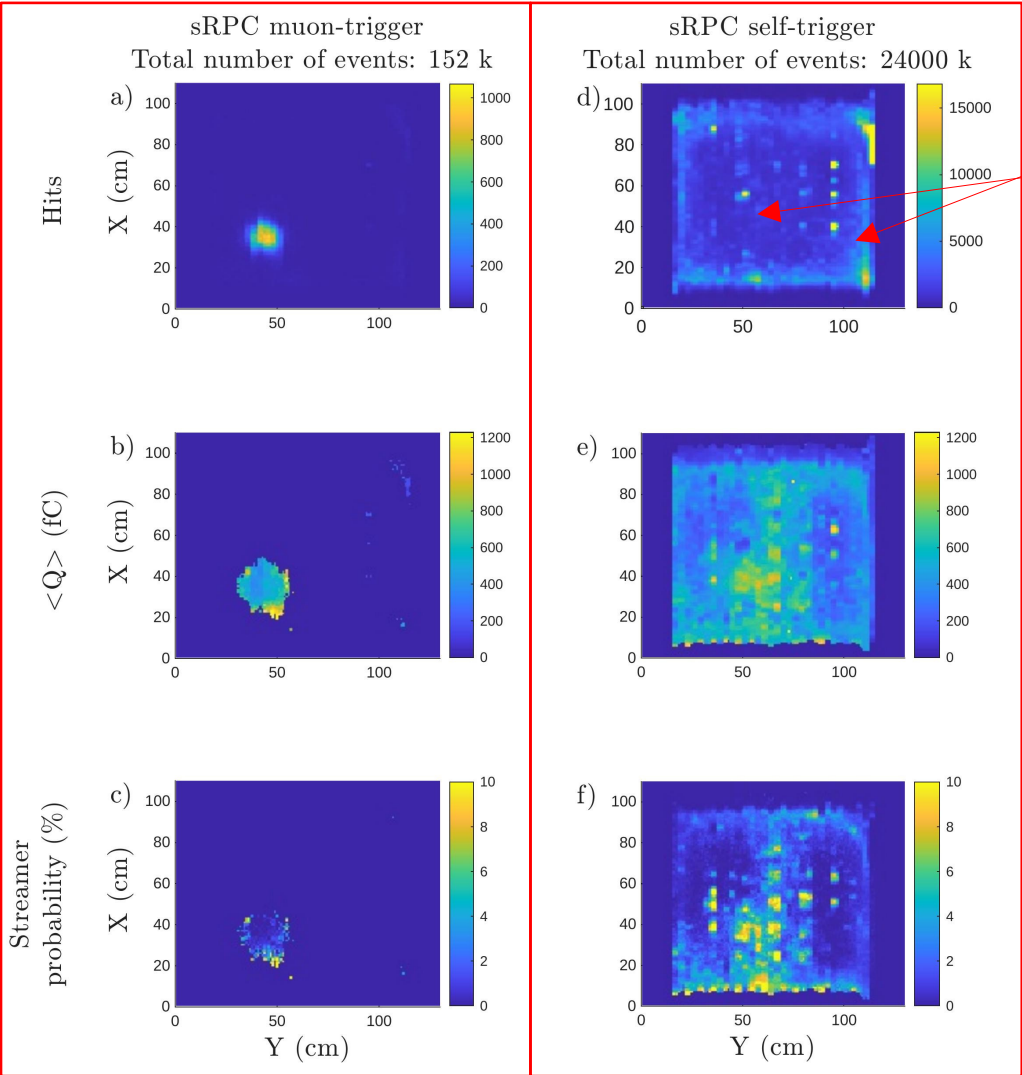
**Large area implementation => 1 m².
2 x 1 mm multi-gap.**

Readout by strips + fast FEE in both sides.



Experimental setup: 1- Active areas of sRPC, 2- FEE, 3- Small muon telescope based on Scintillator + SiPM readout.

Scintillator
(muon)
trigger



Self trigger

Hit map, with some “hot spots” in regions where spacers are located

Average charge map, ~ uniform

Streamer probability map

Sealed RPC 100x100 cm².

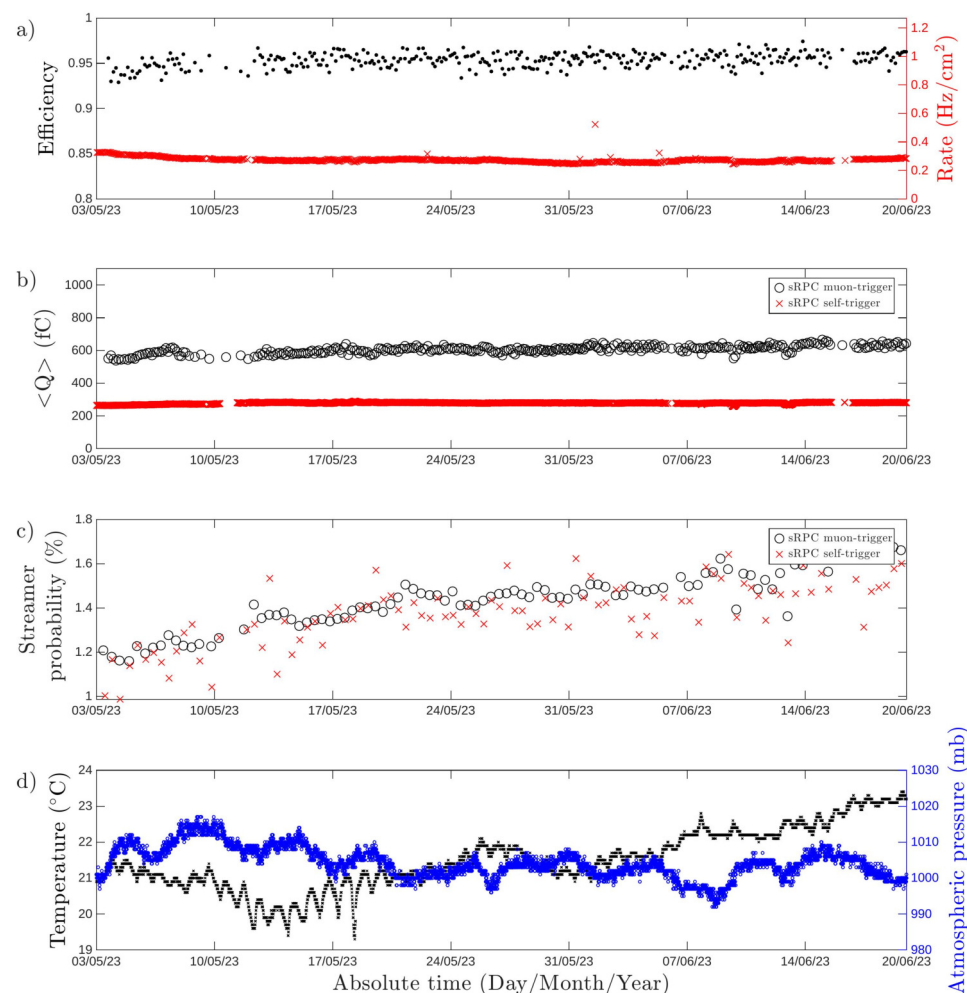
More than **50 days** of operation with the same gas mixture.

No signs of detector degradation.

Significant non-uniformities across the detector surface.

These can be interpreted as mechanical deformations of the detector structure.

After approximately one year of operation, the detector ceased functioning, exhibiting a rather abrupt increase in both dark counting rate and operating current and becoming non-operational within approximately two days.



- **Improve construction.**

Eventually solder the glass and do not glue.

Improve a lot the gas inlets this will allow to use standard gas connectors.

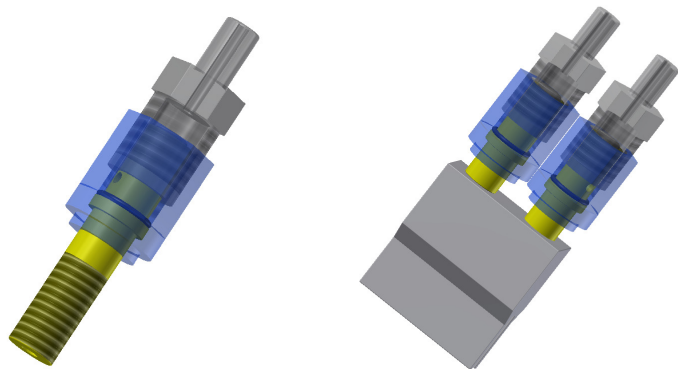
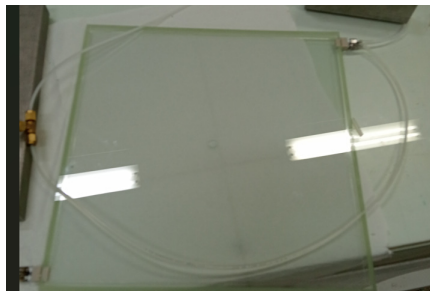
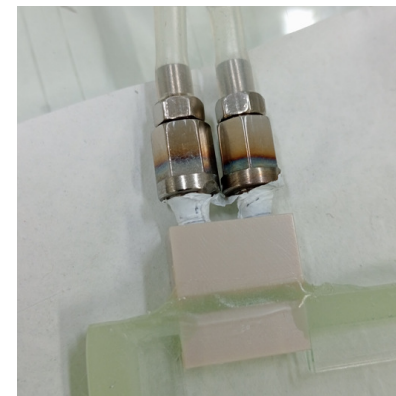
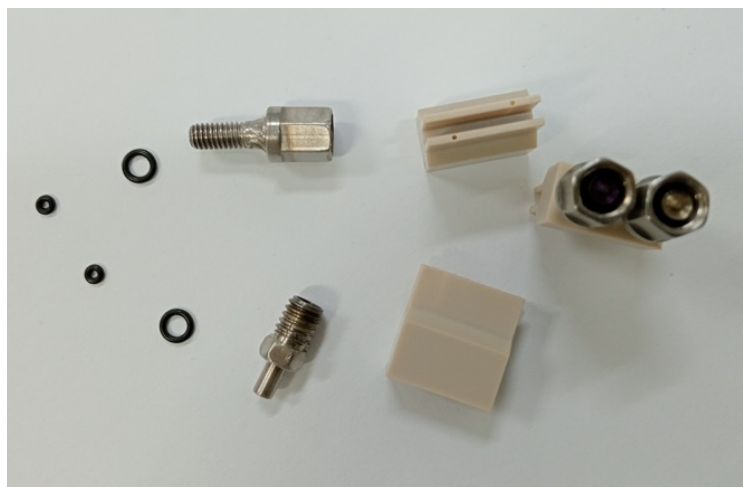
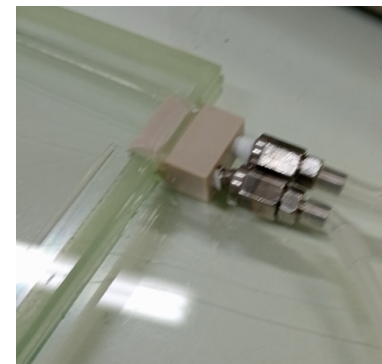
- **Continue testing** the chambers to test the longevity.

- **Incorporate timing gaps.**



Sealed RPCs next steps.

- Improve a lot the gas inlets, need to be able to fill, re-fill and open for safe transport due to absolute pressure variations. **One step less...**



Tested at 6 bar over more than a month. No leaks observed.

Conclusions.

Sealed RPC technology appears to be feasible at low particle fluxes with a relatively simple implementation in medium (30x30 cm²) and large (100x100 cm²) size.

Performance is comparable to that expected from **a detector operated with continuous gas flow.**

SND@LHC represents the first long-term application of sealed RPC technology, with more than two years of operation.

Next steps: incorporation of timing gaps and operation at high particle fluxes and outdoor.

All these results have been **accepted for publication in a special issue of Frontiers** in Detector Science and Technology entitled "Next-Generation Gaseous Detectors: The Impact of Resistive Technologies".