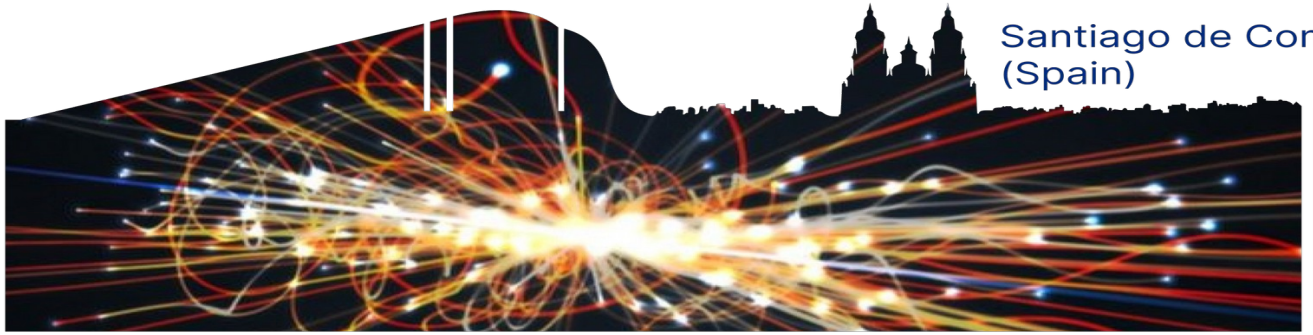


Sealed (zero gas flow) Resistive Plate Chambers: A Case Study from the SND@LHC Experiment

A. Blanco
On behalf SND@LHC and LIP RPC group

This work was supported by Fundação para a Ciência e Tecnologia, Portugal, within the framework of projects CERN/FIS-INS/0006/2021, CERN/FIS-INS/0028/2021

Outlook.

- Motivation for sealed RPCs.
- Sealed RPC concept and first prototypes.
- Large area (1 m^2) results.
- SND@LHC case study.
- Sealed RPCs under strong irradiation condition.

Sealed RPC. Motivation.

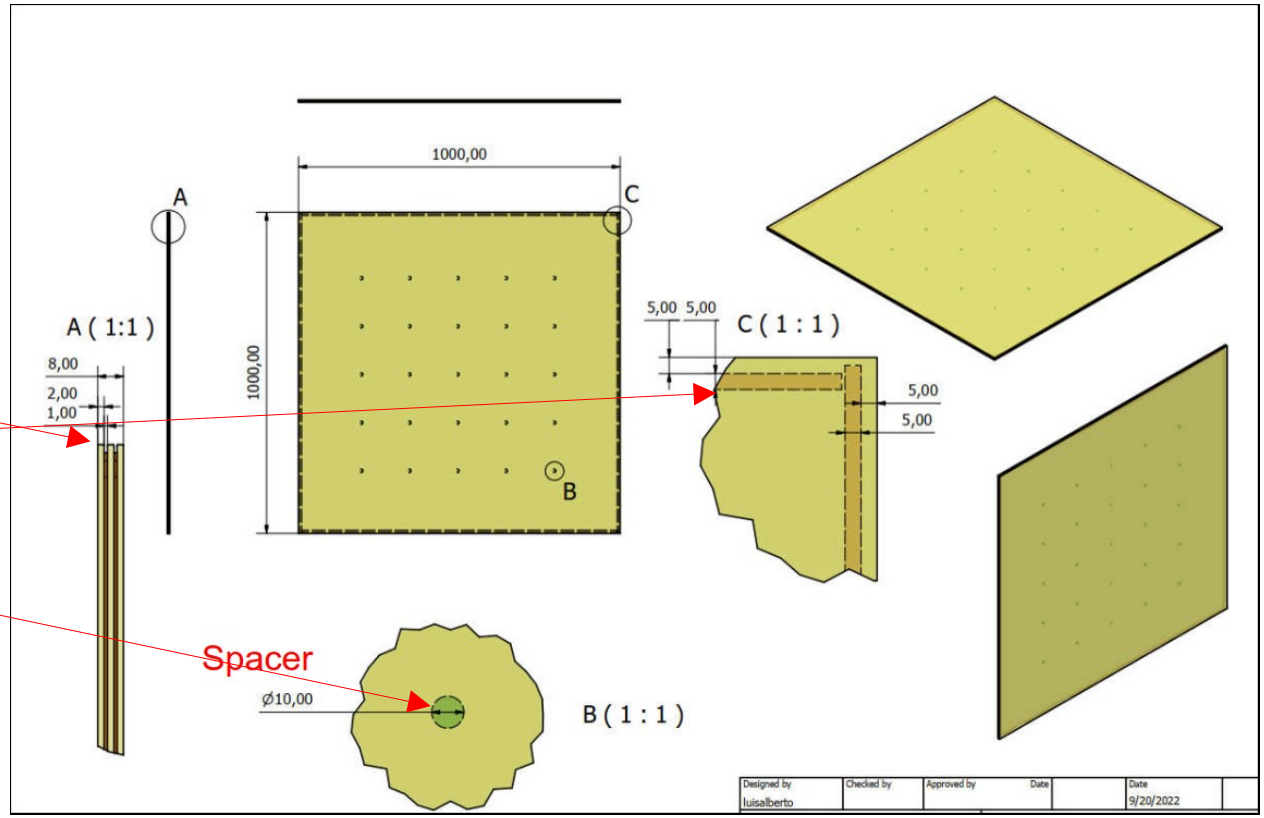
- A possibility for the mitigation of the **HFC phase-out?**, could it be possible to continue using the current HFC gases?
- Without gas system/consumption the **system is much cheaper.**
- **Improved portability and simplified maintenance** => muon tomography, installation of remote systems (Cosmic Ray experiments), hospitals?.
- **Environmental sustainability.**

Sealed RPC. Concept.

Very **simple concept.** Similar construction compared to regular RPCs but **gas can only be in contact with glass** (very stable and inert material).

Everything made with glass

- RPC electrodes.
- Peripheral spacers.
- Central spacers.

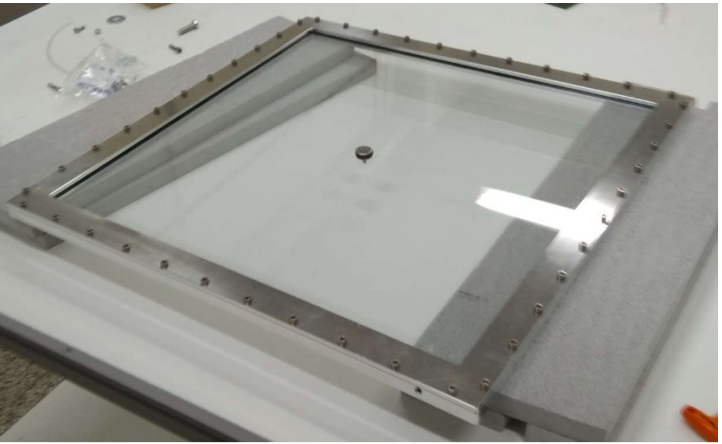


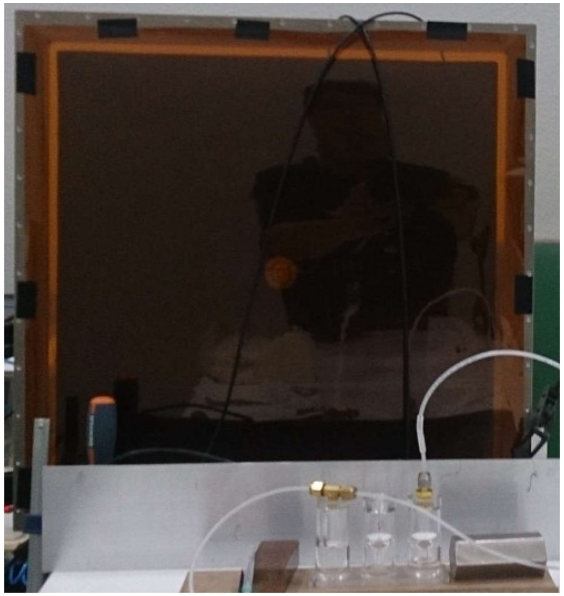
RPC technical drawings

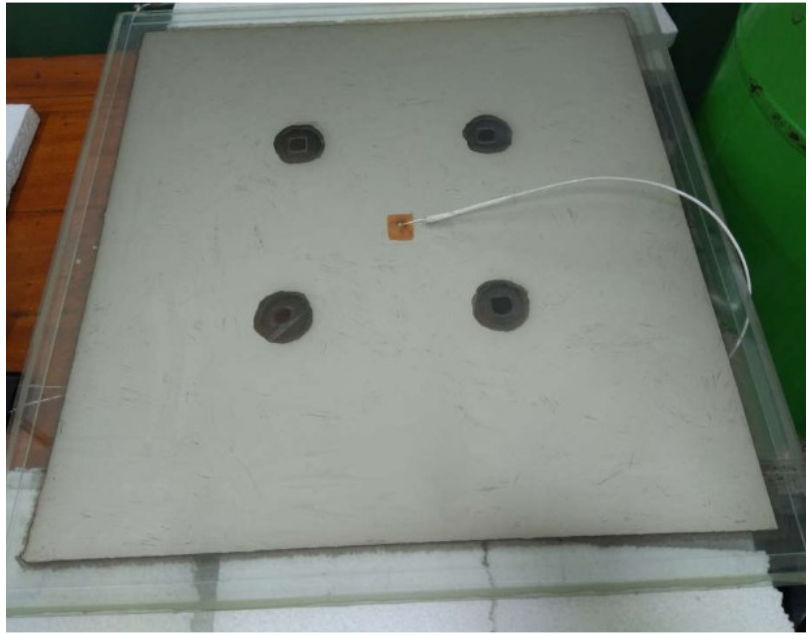
First prototypes.

Not a trivial task. First attempts as early as 2020

New advances in very low gas consumption (RPC2020) 10.1088/1748-0221/15/11/C11009
Outdoor Systems, performance and upgrade (RPC2022) 10.1016/j.nima.2023.168446



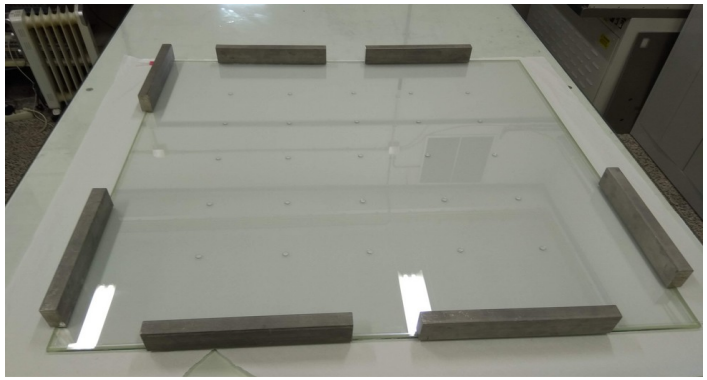




Different constructions with different problems and/or showstoppers and also understanding of the problems

Eur. Phys. J. Plus 138, 1021 (2023)

Assemble process

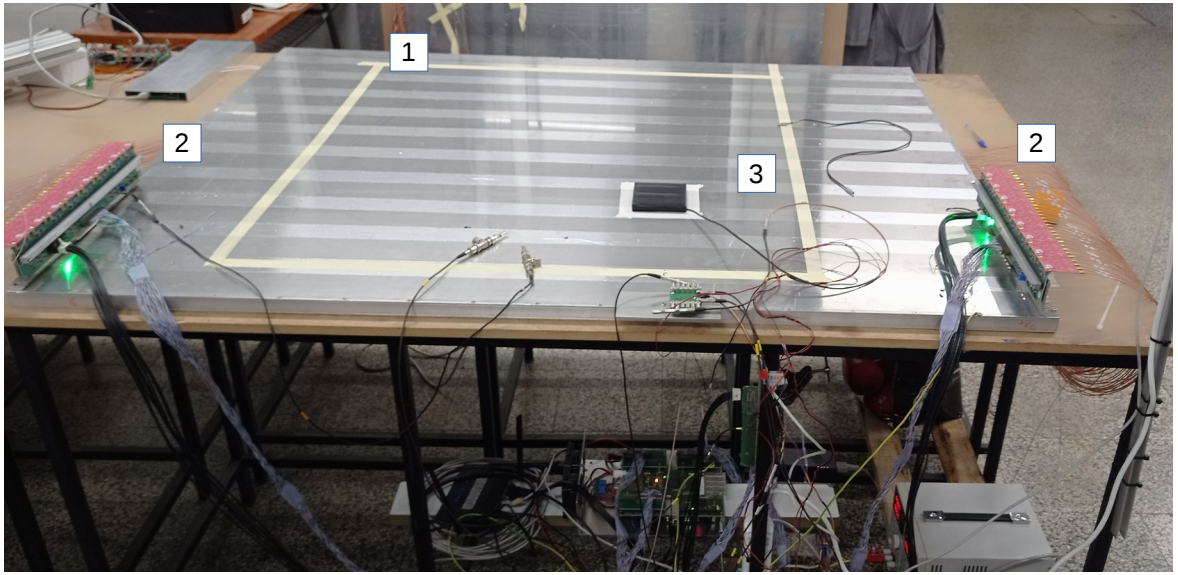


Multi-gap assembly: 5x5 spacer matrix + peripheral strip all around the gaps for sealing.

HV coating applied.

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

Readout by strips + fast FEE in both sides.

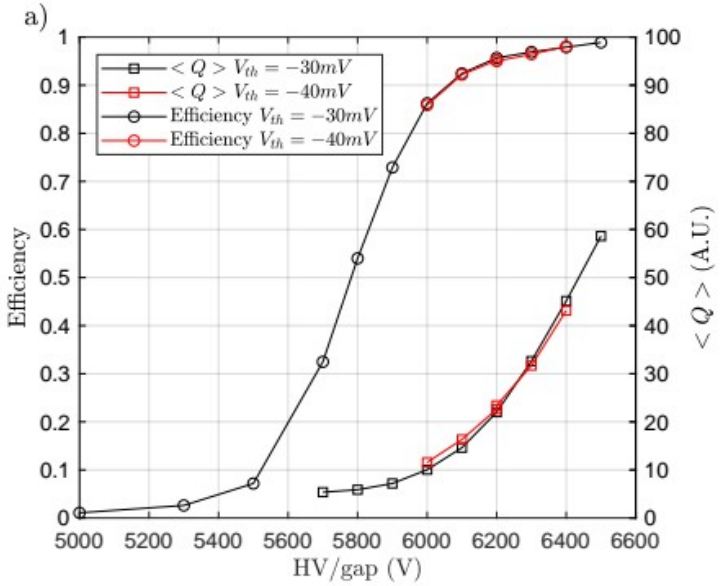


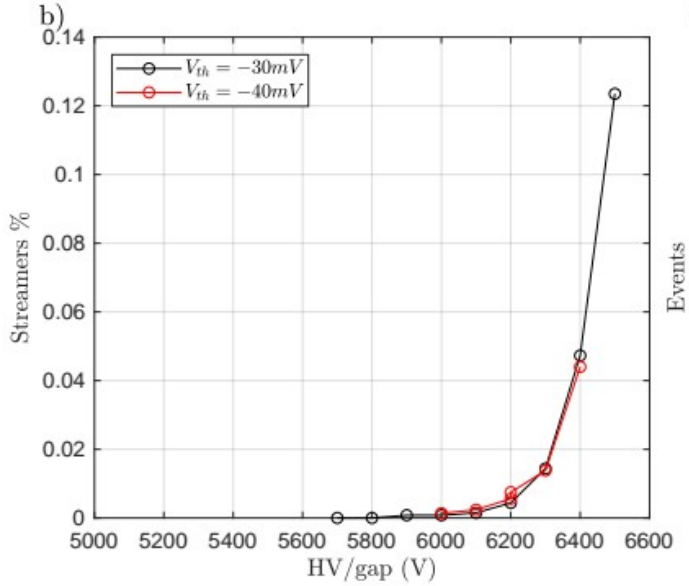
Experimental setup: 1- Active areas of sRPC, 2- FEE, 3- Small muon telescope based on Scintilator + SiPM readout.

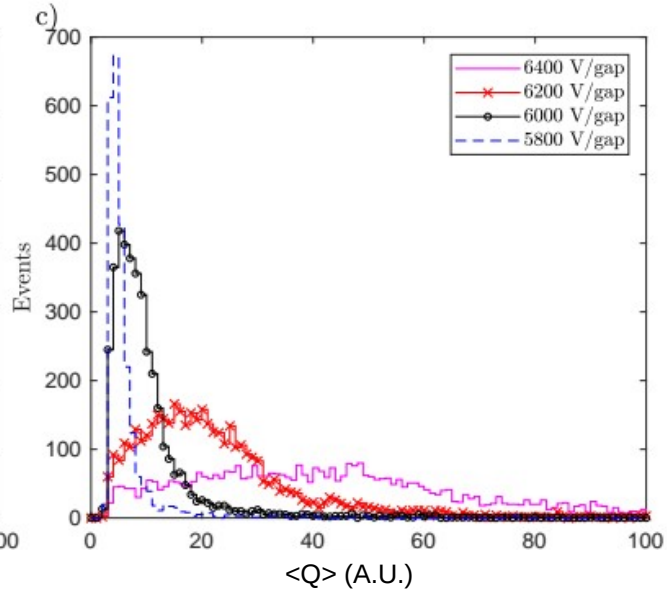
Multi-gap and large area (1 m²) sealed RPC.

Eur. Phys. J. Plus 138, 1021 (2023)

Performance similar to what could be expected from such a detector operated in a continuous gas flow, efficiency higher than 95 % and streamer percentage below 1 %

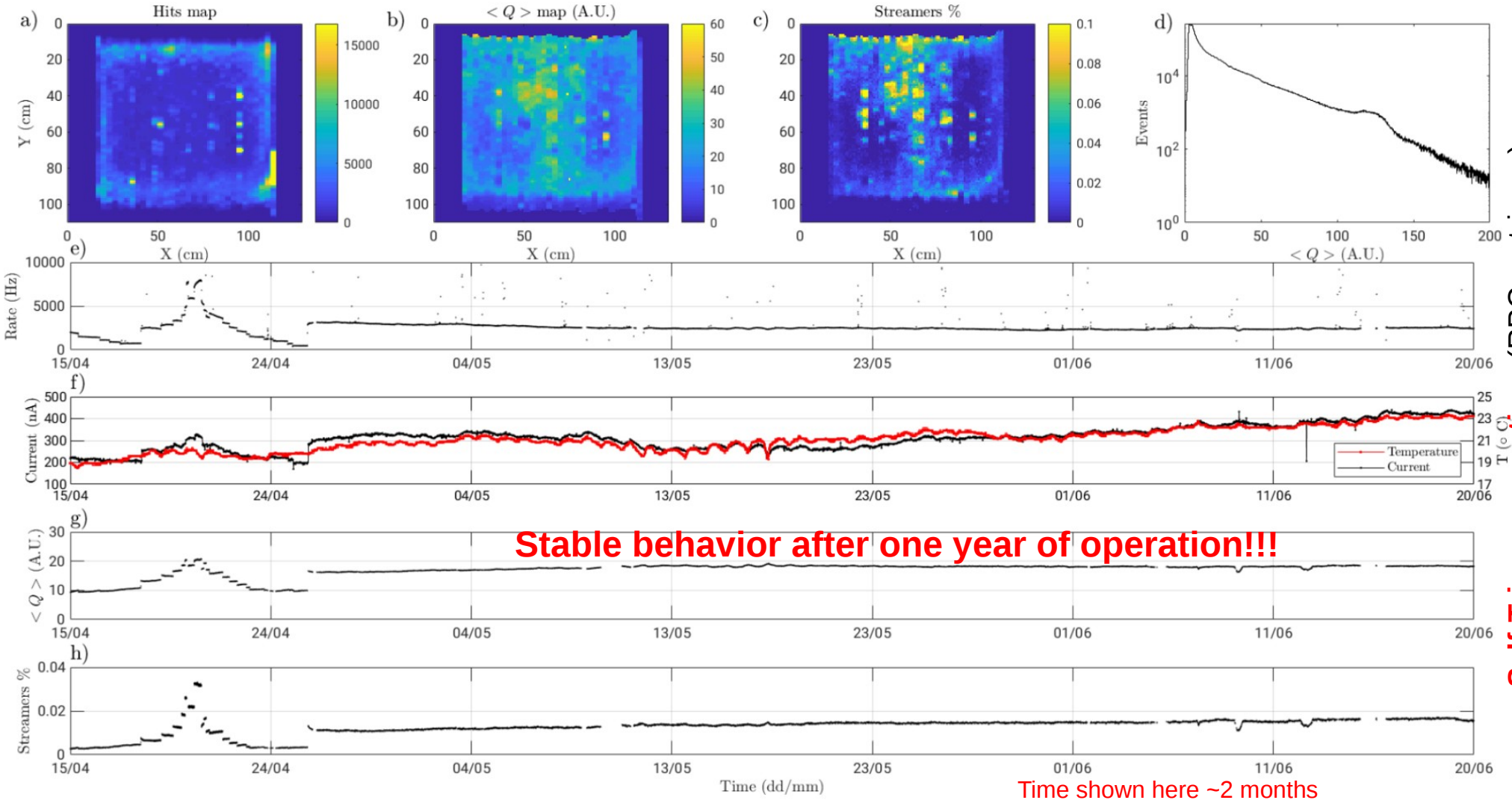






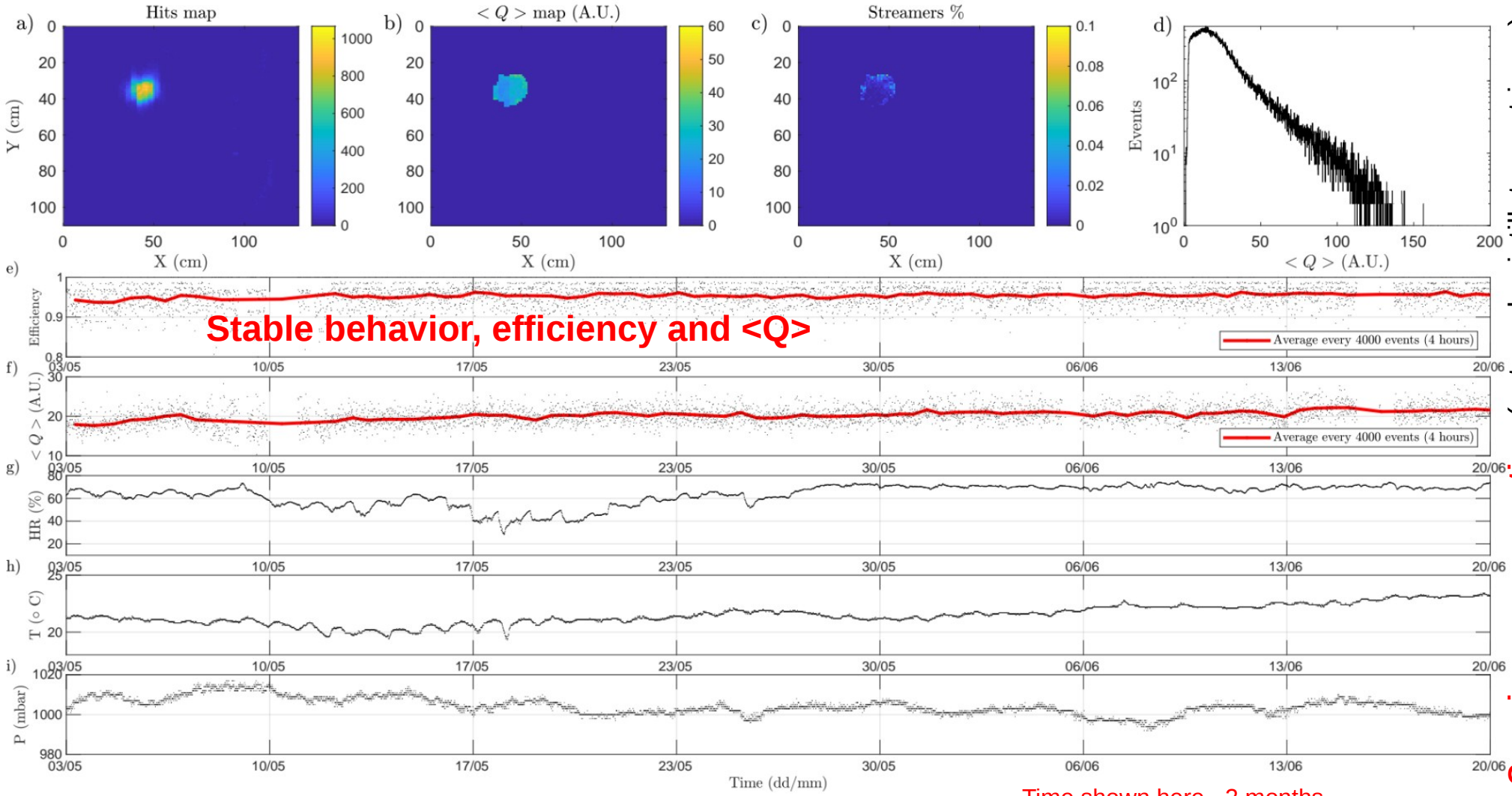
Multi-gap and large area (1 m²) sealed RPC.

Eur. Phys. J. Plus 138, 1021 (2023)



Multi-gap and large area (1 m²) sealed RPC.

Eur. Phys. J. Plus 138, 1021 (2023)



Stable behavior, efficiency and <Q>

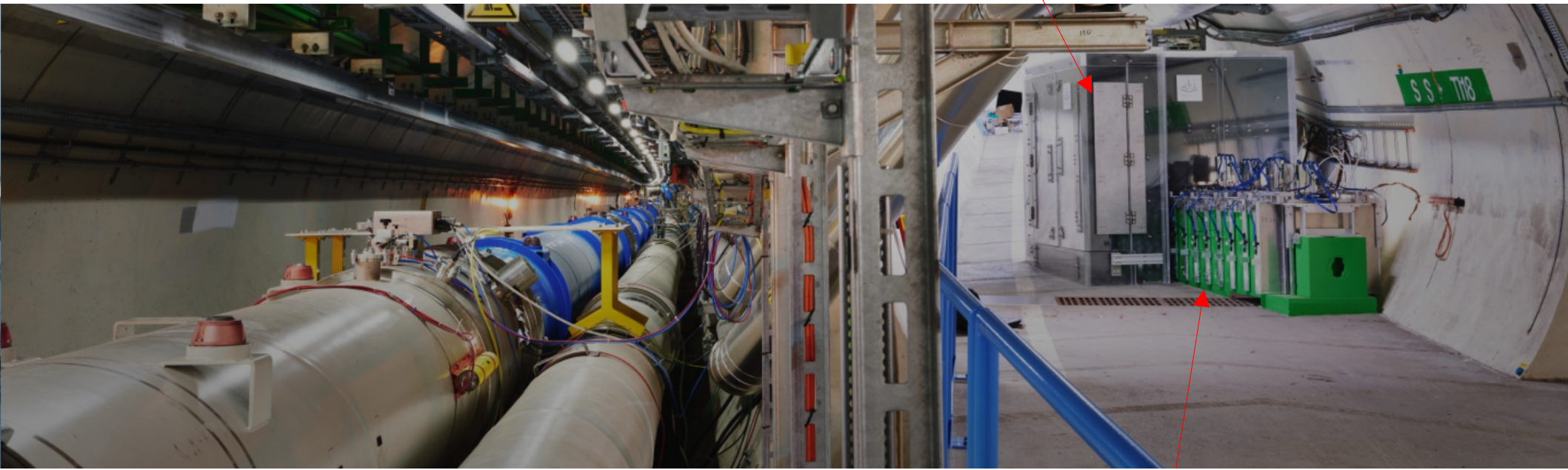
Cosmic muons operation (external scintillator as trigger)

Time shown here ~2 months

SND@LHC an opportunity to test sealed RPCs in an experiment.

SND-LHC Scattering and Neutrino Detector at the LHC is a recently approved, compact and stand-alone experiment to perform **measurements with neutrinos produced at the LHC** in a until now unexplored pseudo-rapidity range of $7.2 < \eta < 8.4$ complementary to all the other experiments at the LHC, including FASER.

Cold box including: tungsten target and nuclear emulsions + SciFi trackers



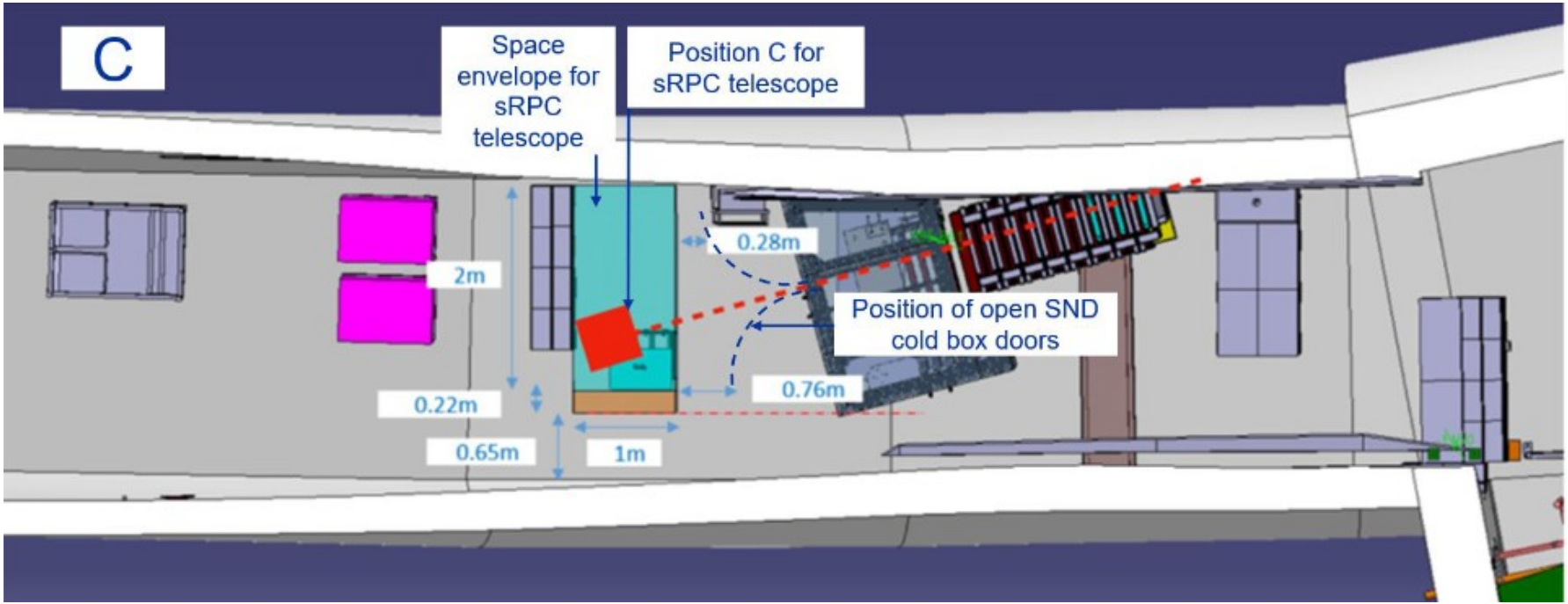
SND@LHC view, installed close to LHC machine

Muon detector based on scintillators

SND@LHC an opportunity to test sealed RPCs in an experiment.

However, the **majority of recorded events consists of muons** arriving from the particles produced in proton-proton collisions at ATLAS interaction point. Since these muons are the **main source of background** for the neutrino search,it is **important to do a measurement of the muon flux.**

Muon flux measured with scintillator ~2-3 Hz/cm²



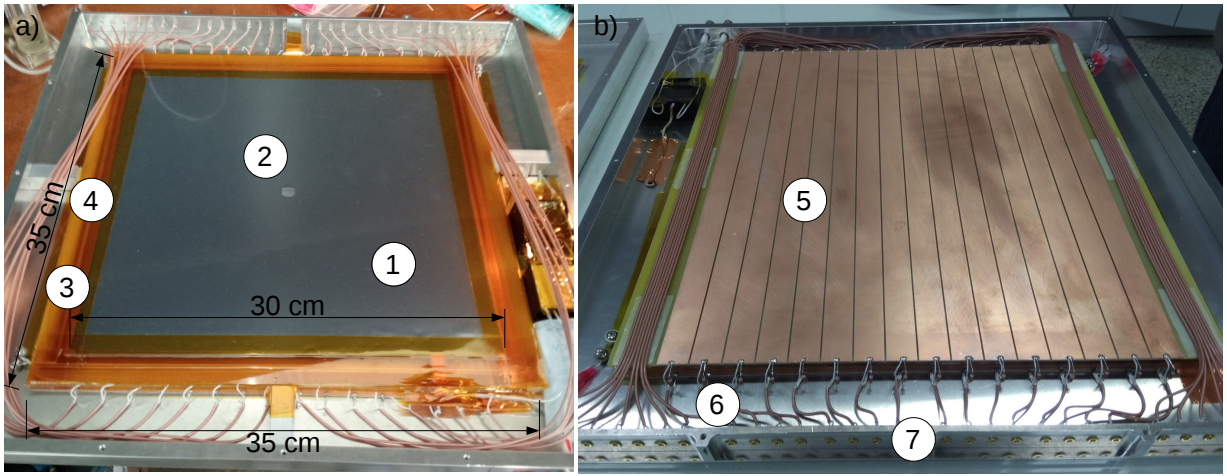
Top view of SND@LHC location. Location for the measurement of the muon flux background.

SND@LHC. Sealed RPC small telescope @ lab.

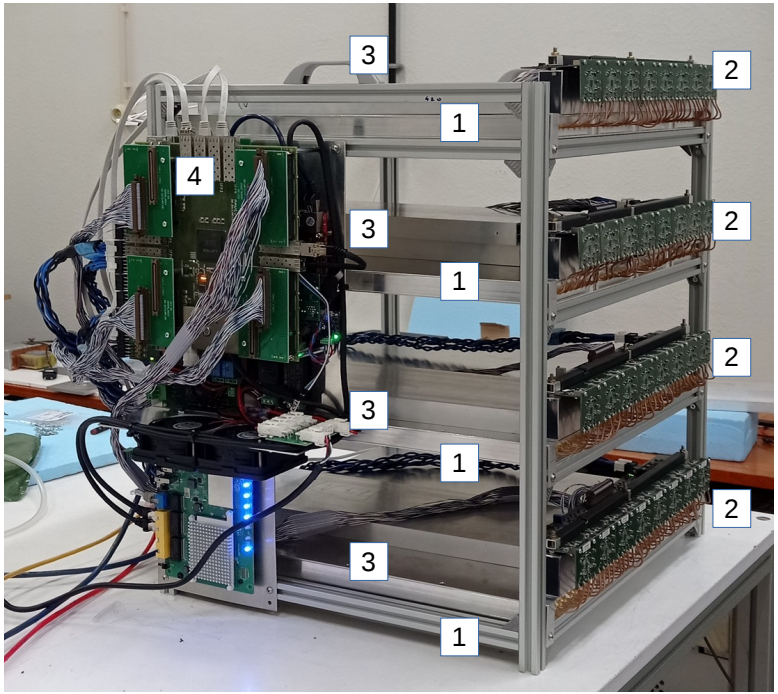
Submitted to NIMA

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

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



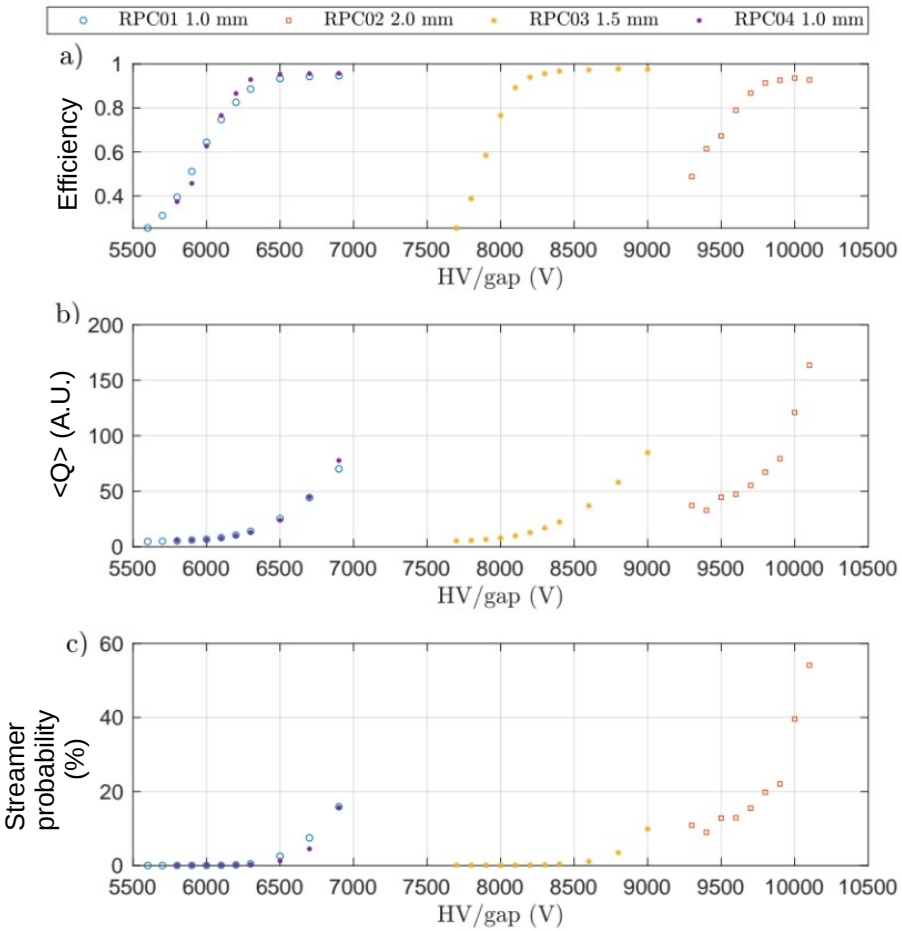
a) 1- HV layer, 2- Circular spacer in the center of the active area, 3- Strip spacer all around de the periphery and 4- Mylar and Kapton layers.
b) sRPC plane showing: 5- Readout strip plane, 6- Coaxial cables and 7- MMCX RF feedthrough connectors.

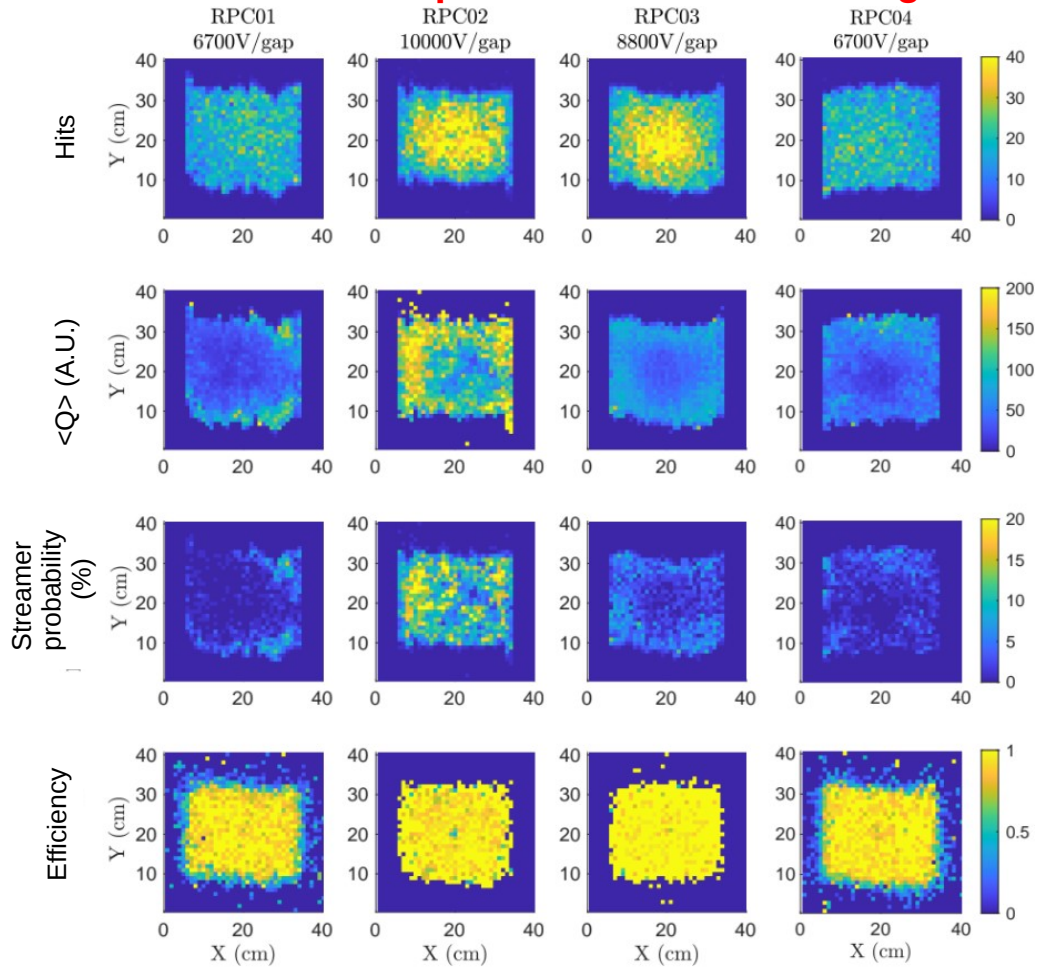


1- sRPC planes, 2 – FEE used to readout the signals from sRPC, 3 – High Voltage PS system, 4 – DAQ, computer and power supplies.

Submitted to NIMA

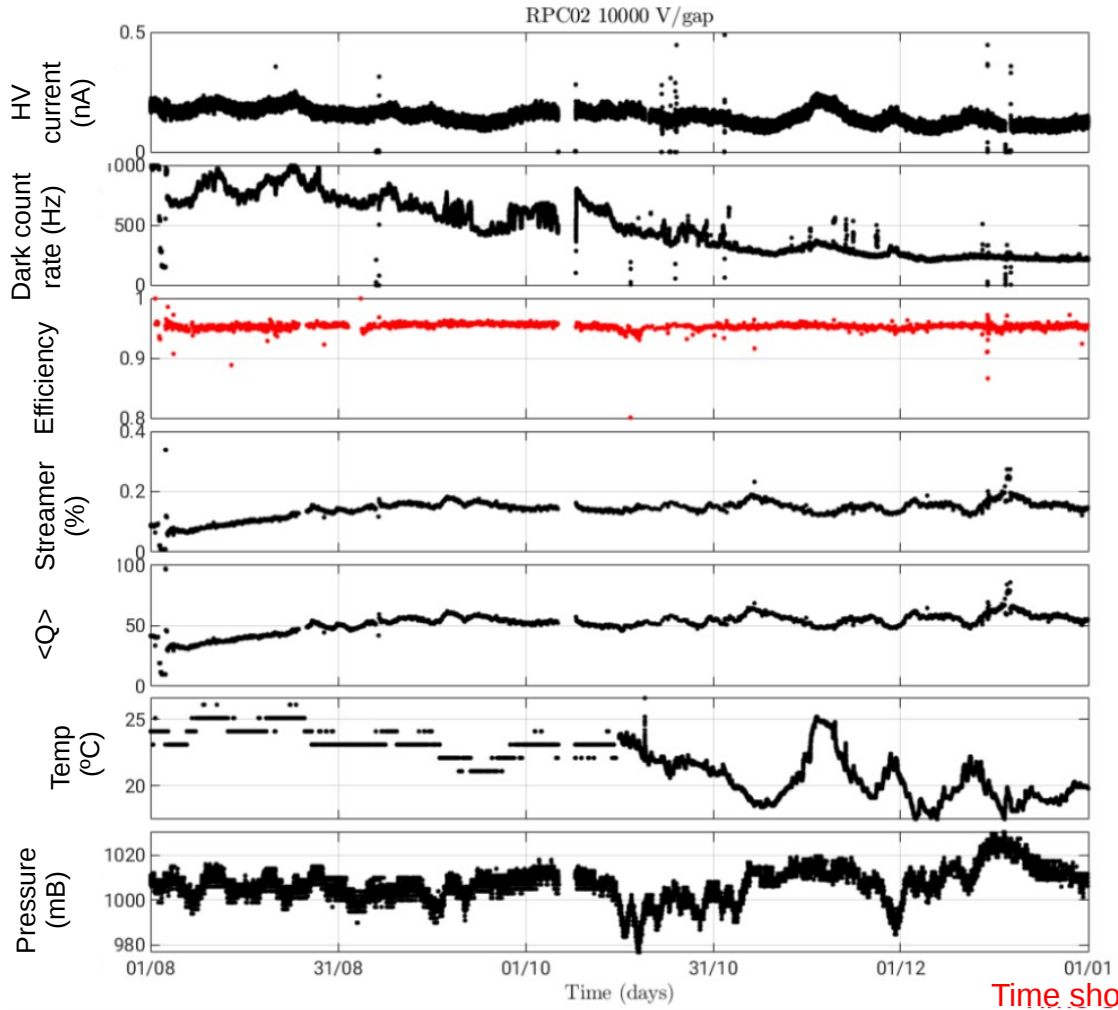
Performance similar to what could be expected from such a detector operated in a continuous gas flow





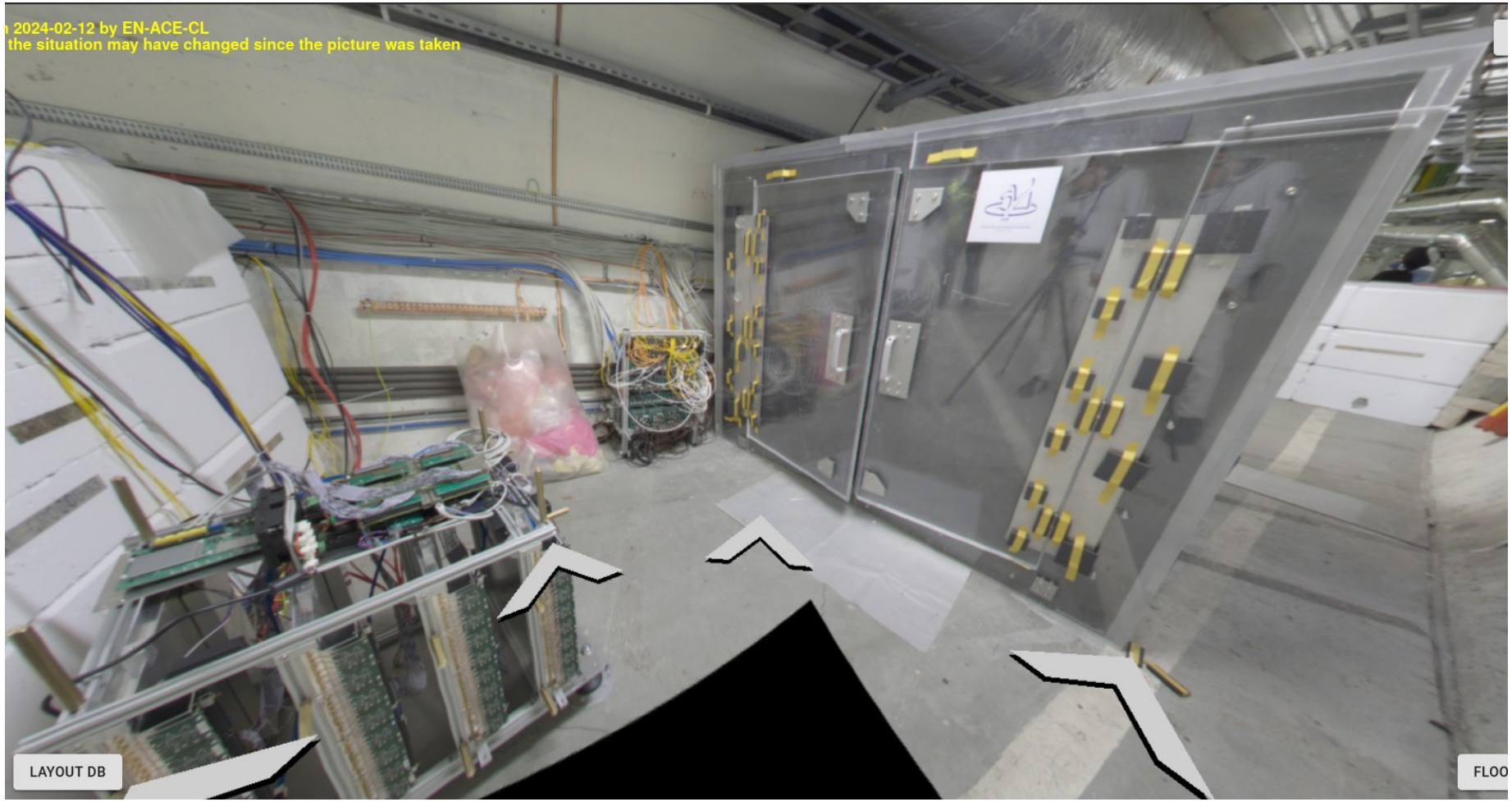
Submitted to NIMA

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



Time shown here ~5 months

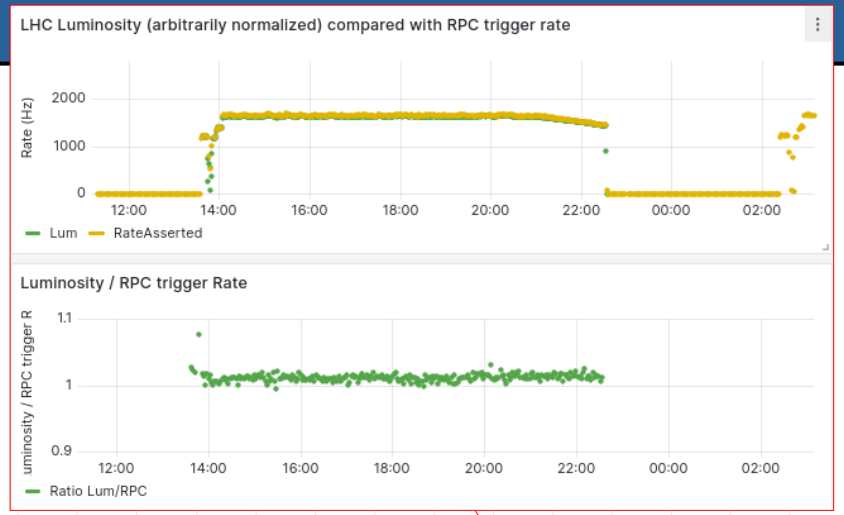
SND@LHC. Sealed RPC small telescope @ CERN.

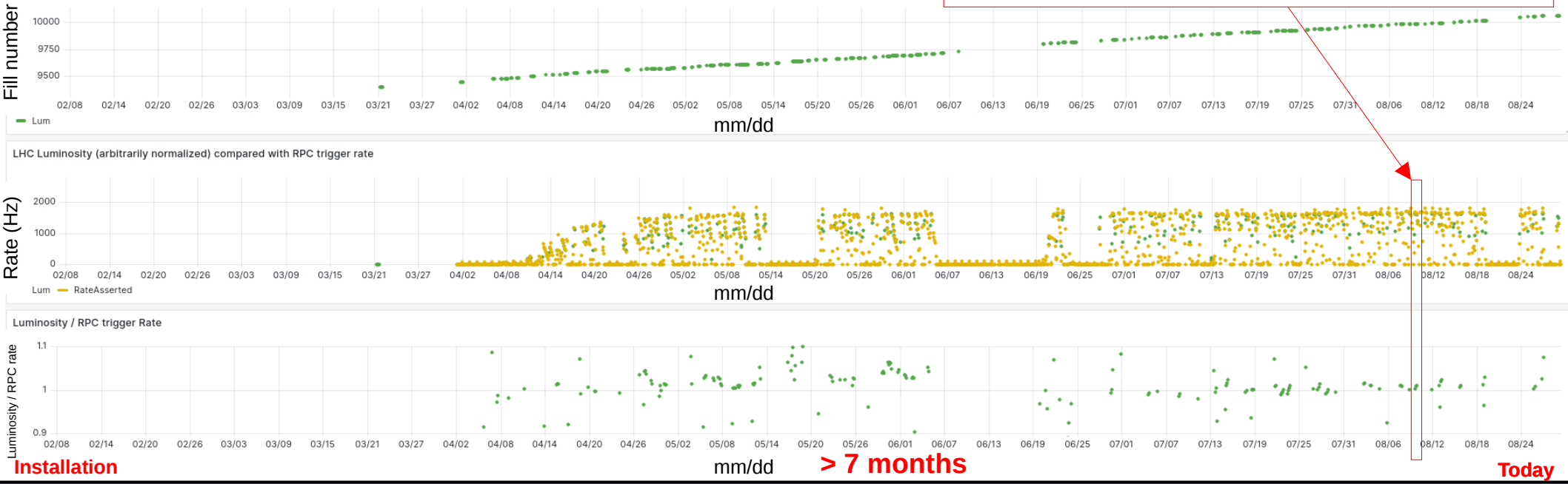


SND@LHC. Sealed RPC small telescope @ CERN.

Installation performed on Feb 2024
Full operative 24/7 since then.

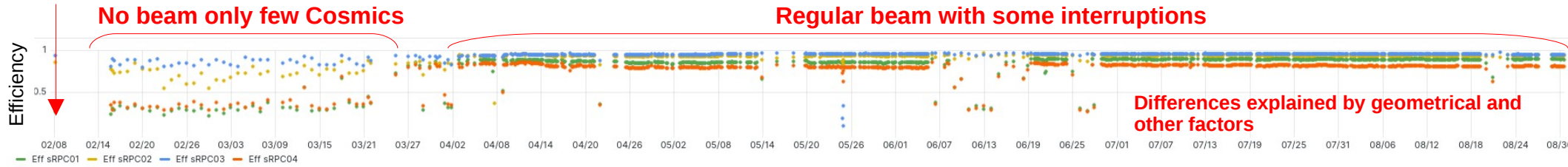
Luminosity (ATLAS) and raw trigger rate follow same trend. Ratio ~ 1.
No signal of degradation.
Raw data now correction applied.





SND@LHC. Sealed RPC small telescope @ CERN.

Installation



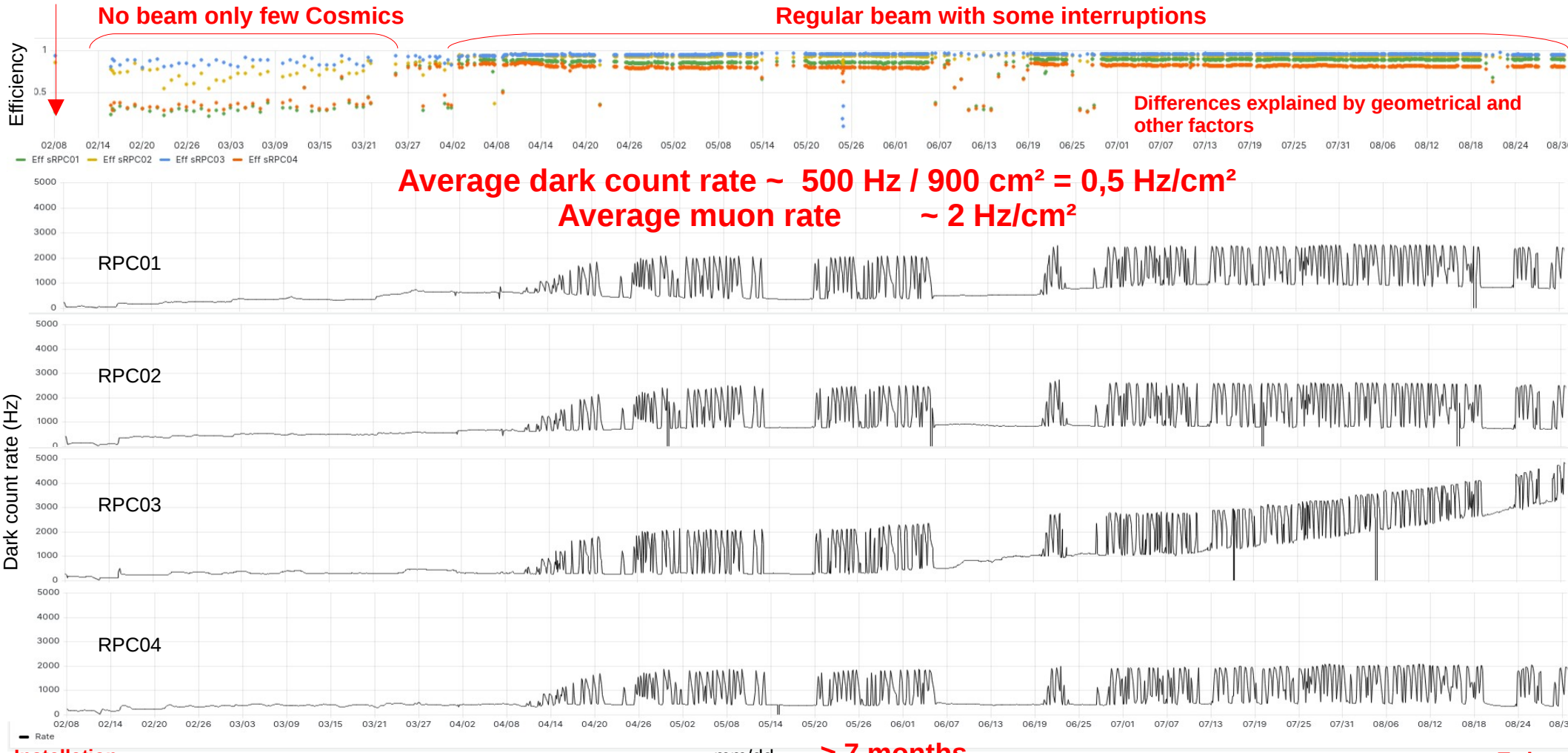
Installation

> 7 months

Today

SND@LHC. Sealed RPC small telescope @ CERN.

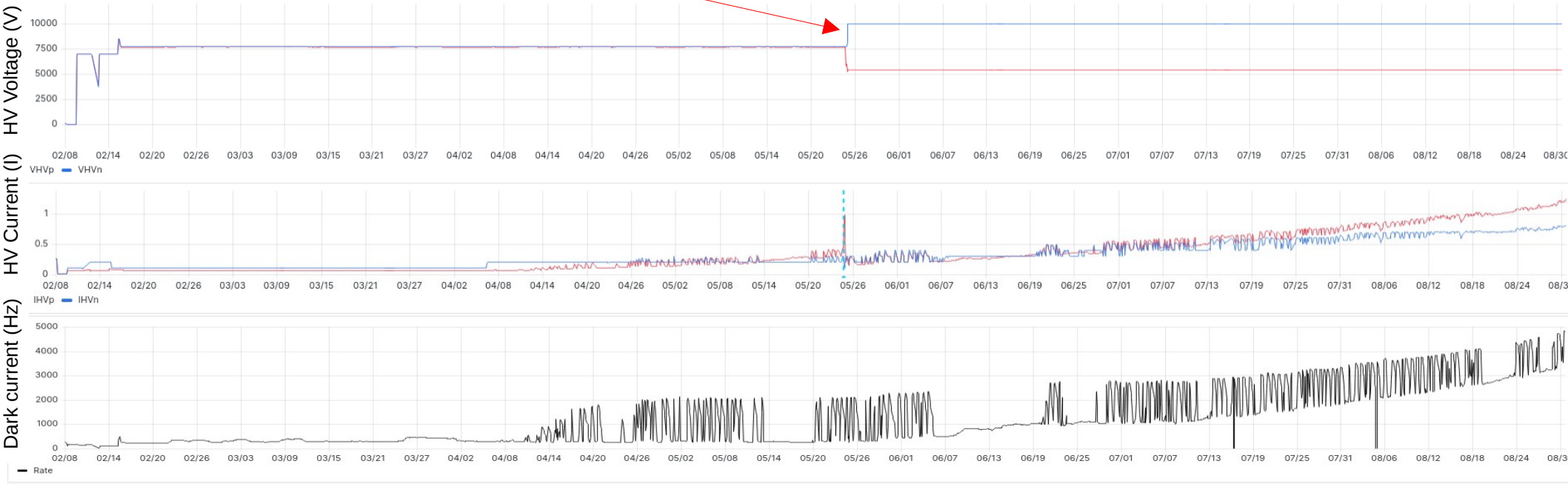
Installation



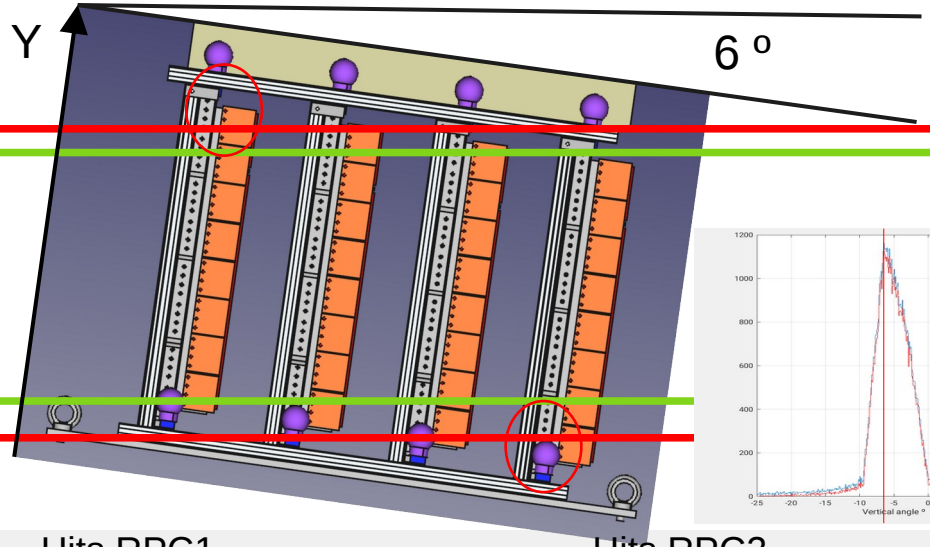
SND@LHC. Sealed RPC small telescope @ CERN.

Problem on RPC03.
There was a HV insulation problem that forced to balance the HVs.

It is not clear if the degradation observed has something to do with gas sealing, insulation problem or other phenomena.



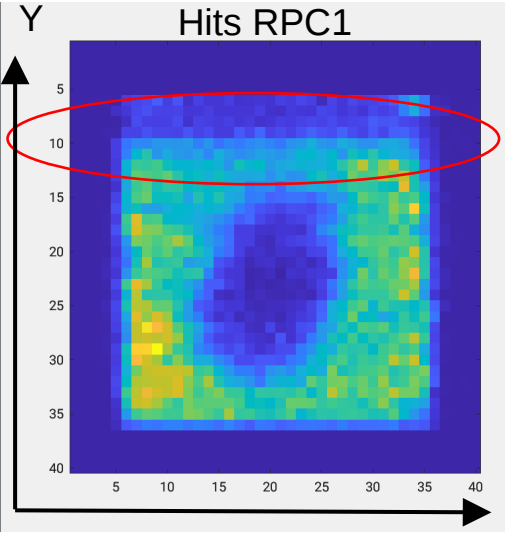
SND@LHC. Sealed RPC small telescope @ CERN. Efficiency geometry factors.



Deficit of events shown on Hit maps

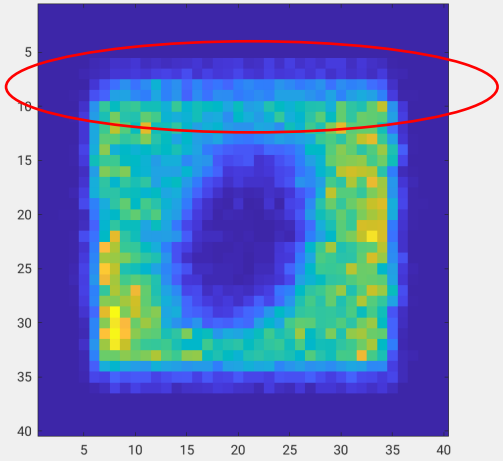
Not recorded muon (hit only two planes)

Recorded muon (hit three or more planes)

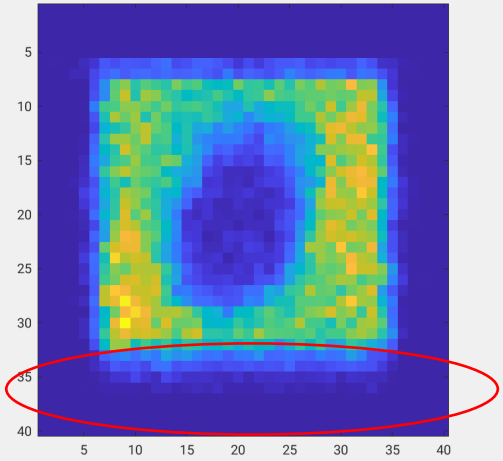


Hits RPC1

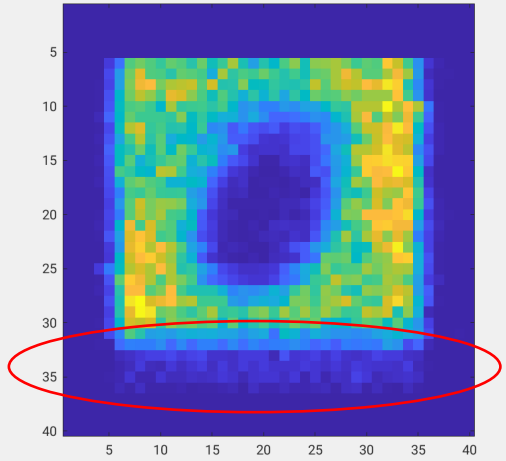
Hits RPC2



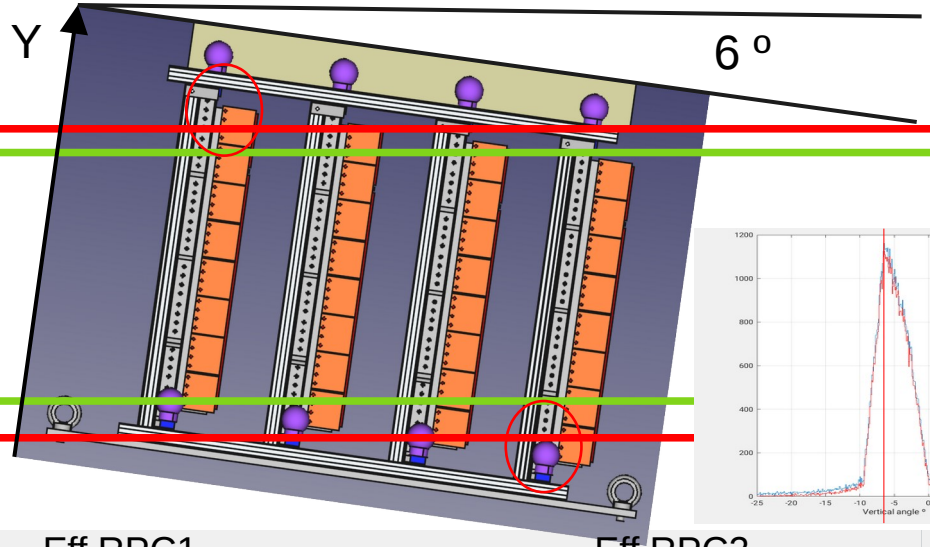
Hits RPC3



Hits RPC4



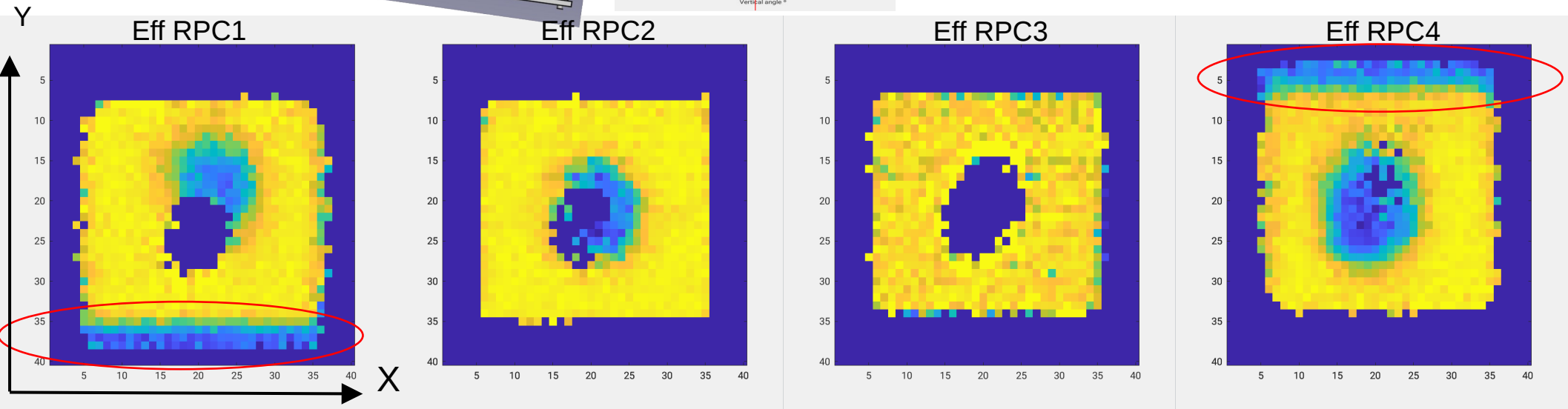
SND@LHC. Sealed RPC small telescope @ CERN. Efficiency geometry factors.



Deficit of events shown on Hit maps

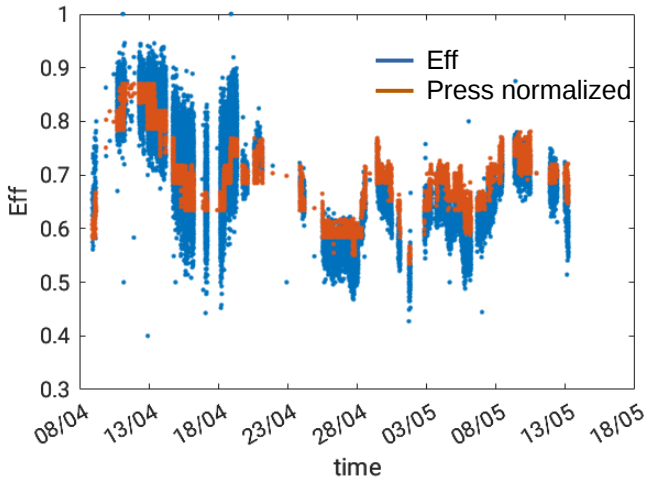
Not recorded muon (hit only two planes)

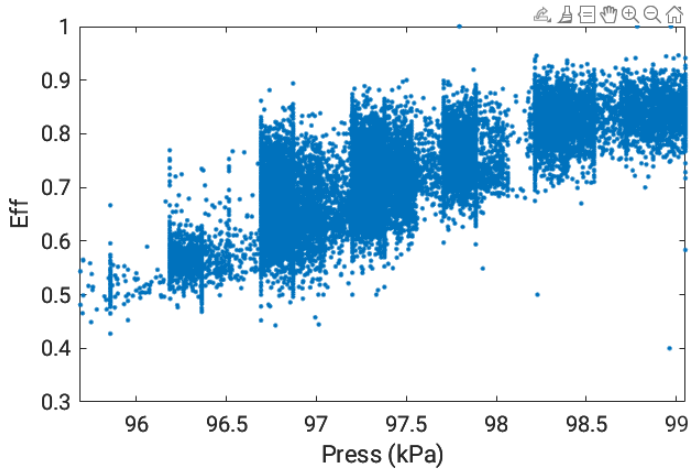
Recorded muon (hit three or more planes)

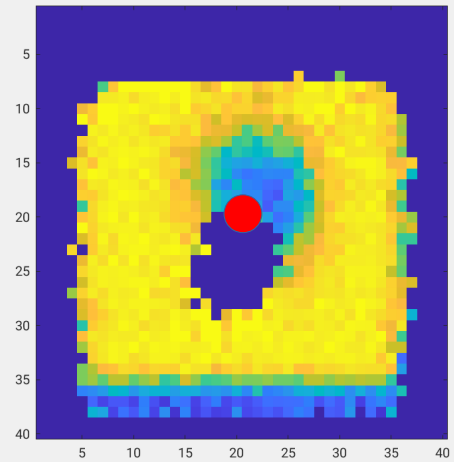


SND@LHC. Sealed RPC small telescope @ CERN. Efficiency other factors.

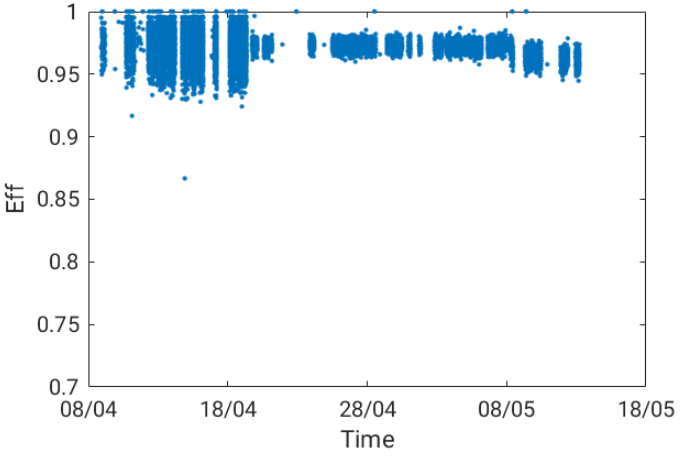
Center

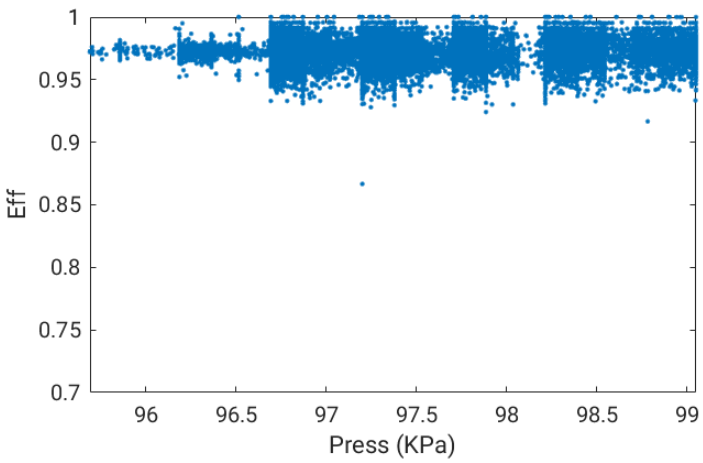


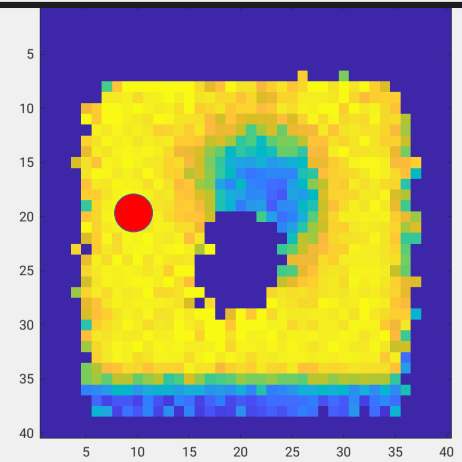




Peripheral



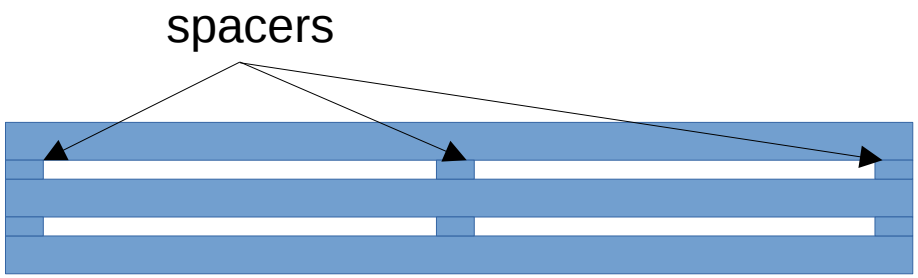




Huge variation of **efficiency** on the center of the chamber **correlated with Atmospheric Pressure**

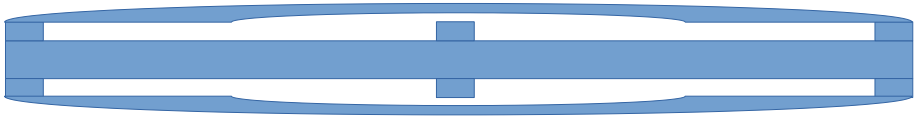
SND@LHC. Sealed RPC small telescope @ CERN. Efficiency other factors.

Cross-section of
a sRPC chamber



3 glass electrodes
2 gas gaps

P ↓ the chamber could change the gap width in the center
if the central spacer is not glued anymore
Sealed RPCs are not atmospheric detectors



Center spacer is not glued and eventually fragile

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

Sealed RPC under strong irradiation.

Very fresh results

Irradiation facility @ Santiago de Compostela

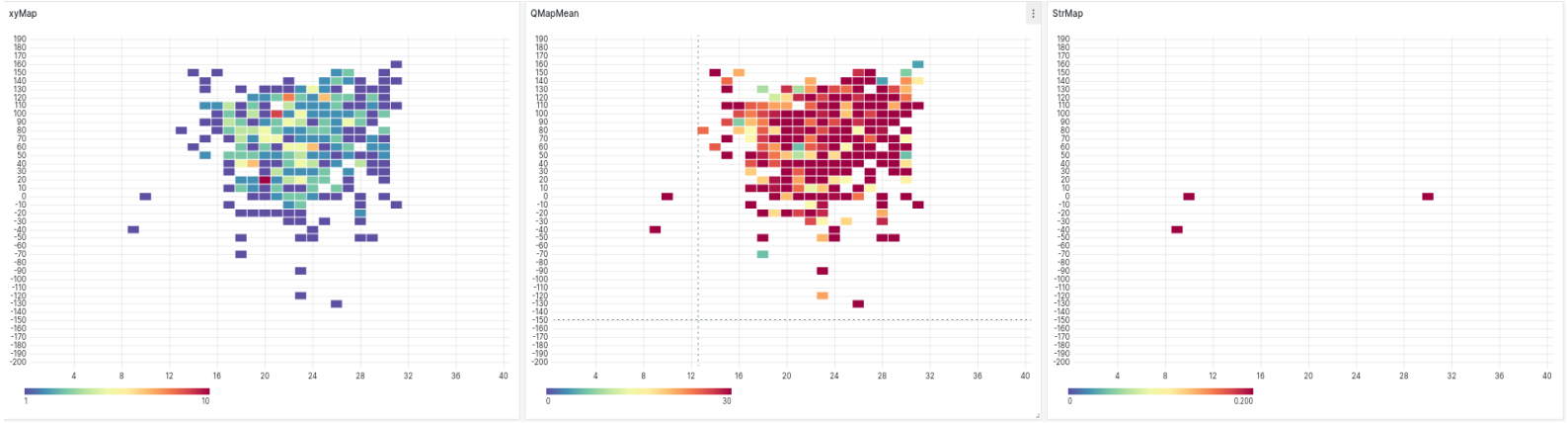
^{60}Co Source

sRPC plane + muon telescope

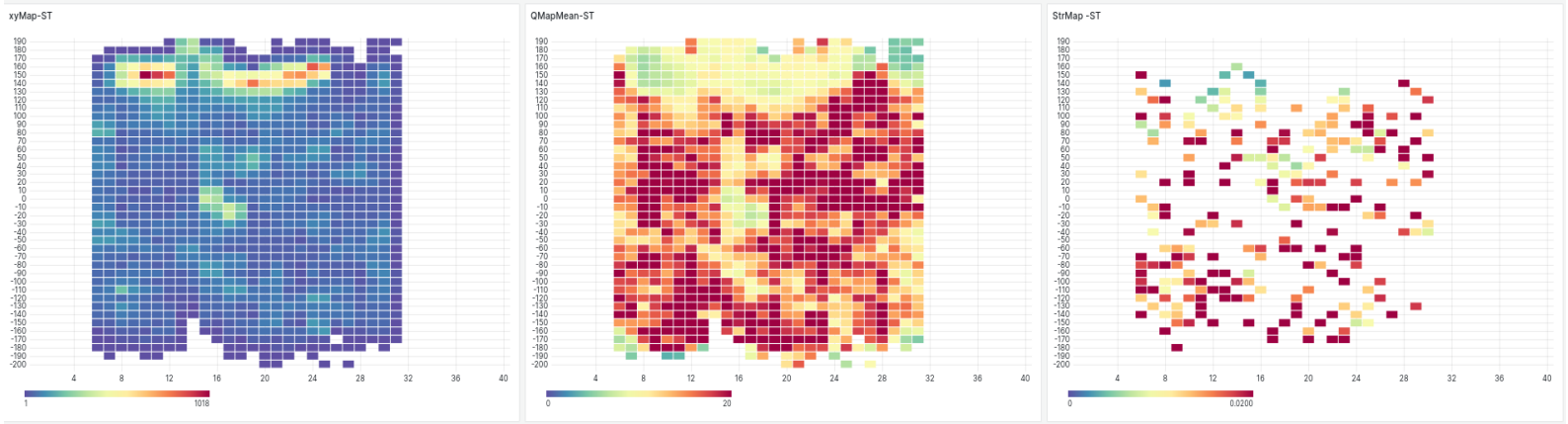
Sealed RPC under strong irradiation.

Very fresh results

Cosmic muons operation (external scintilator muon telescope as trigger)



Self-Trigger operation (RPC as trigger)



XY maps

Hits <Q> (A.U.) Streamer probability

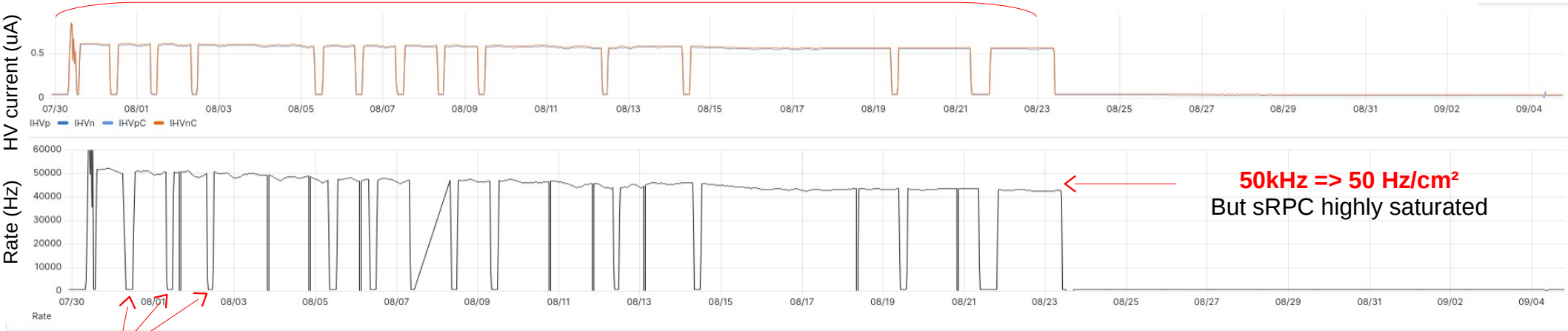
Sealed RPC single module. Irradiation facility.

Very fresh results

Due to limitation on the capability to attenuate the ^{60}Co / limitations on the count rate capability of this RPC

^{60}Co was keep active 20h/day and muon data was taken 4h / day

23 days of irradiation



50kHz => 50 Hz/cm²

But sRPC highly saturated

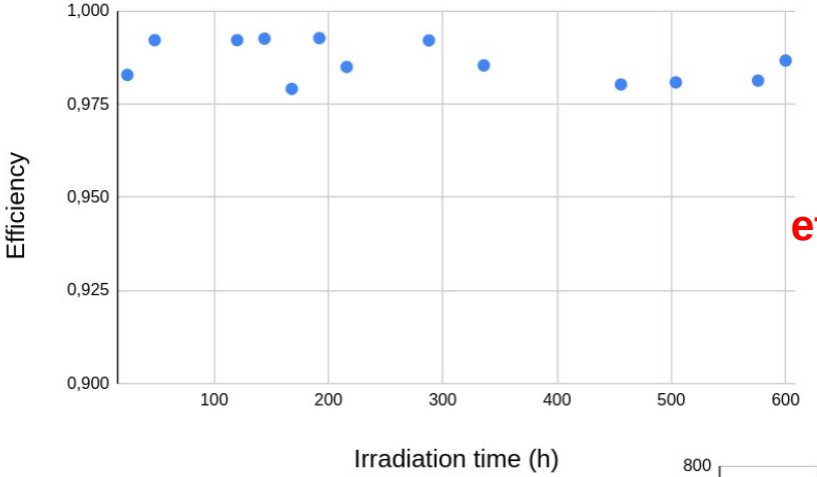
4h stops for muon data taking

On a HV current basis, this is equivalent to more than three years of operation under Cosmic Ray irradiation

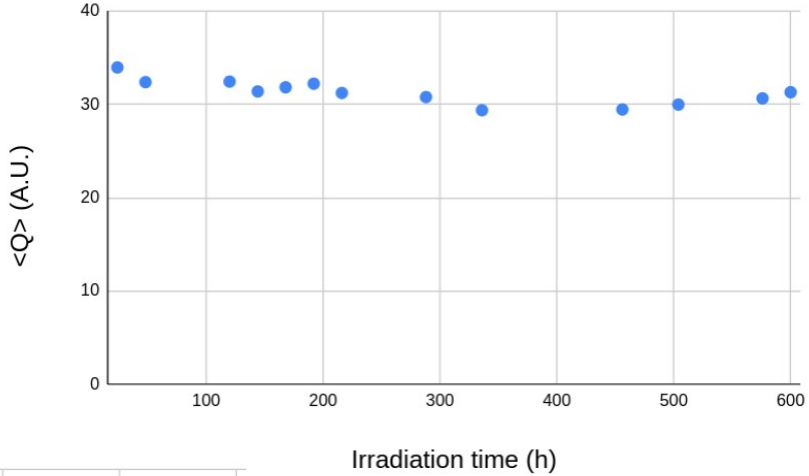
Sealed RPC single module. Irradiation facility.

Very fresh results

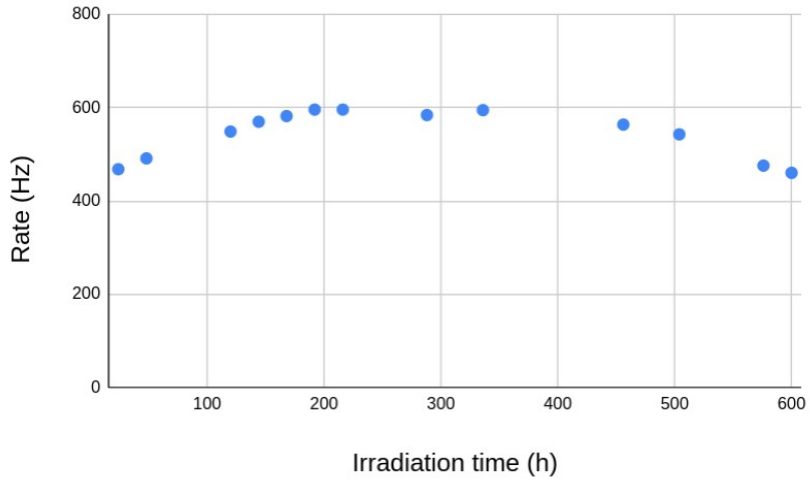
Response of sRPC to Cosmic muons (4h/day stops)



No noticeable variation of efficiency or <Q>



Variation of dark count rate not correlated with irradiation time?



Conclusions.

Sealed RPC technology seem to be possible.
With a reasonably simple implementation.

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

SND@LHC first real application for sRPC.

Preliminary result point to the **possibility of operation for more than several year** with Cosmic Rays.