The miniTRASGO Cosmic Ray Telescope

XVII Conference on RPCs and Related Detectors

Sep 10th, 2024

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  on March 2024
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  and a look into the future

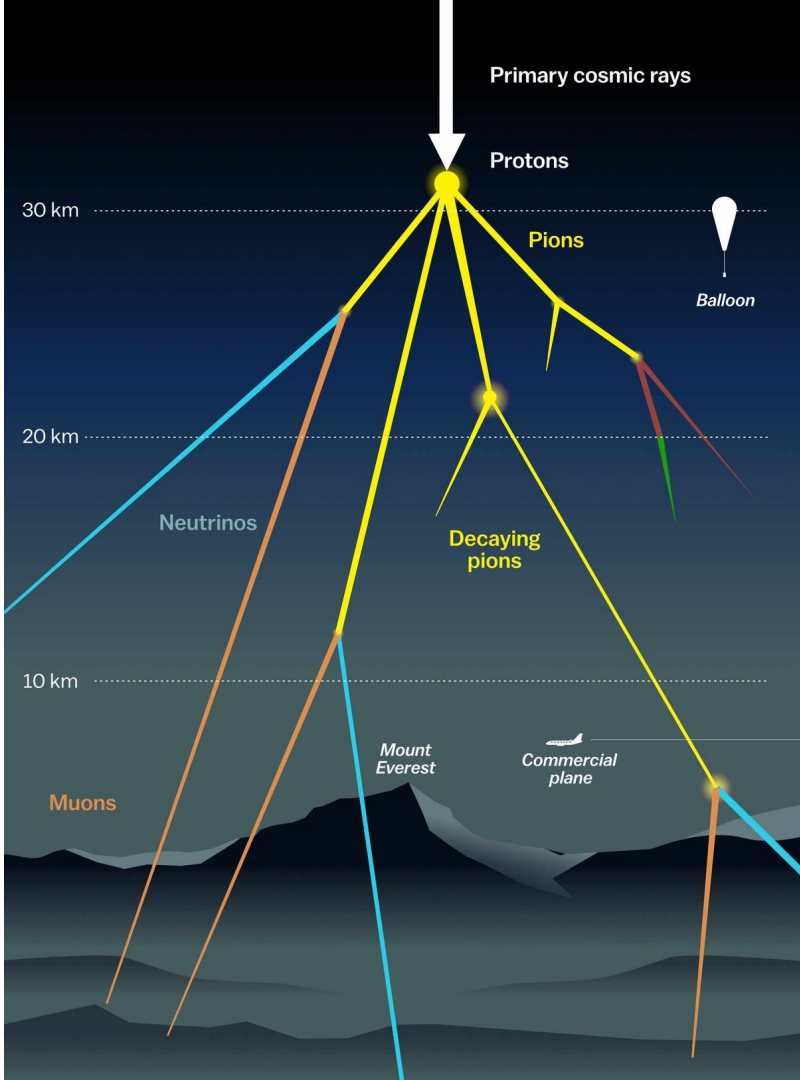
Introduction

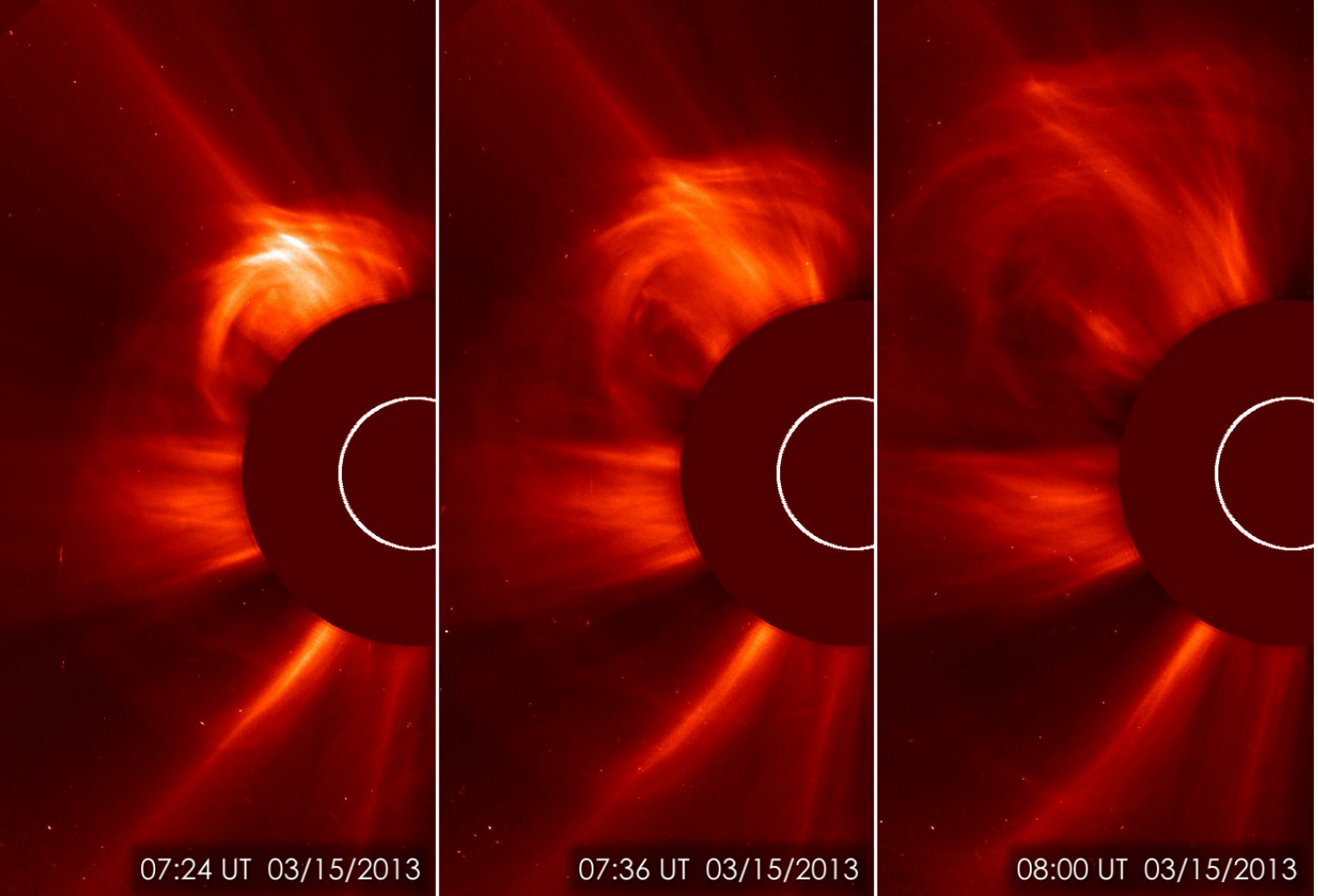
The problem of measuring the Cosmic Rays flux

Primary Cosmic Rays
generate
Extensive Air Showers
typically 20-50 km of altitude

Primary Cosmic Rays are mostly protons and light nuclei…

so they are affected by – *galactic, solar, terrestrial* – **magnetic fields**





Coronal Mass Ejections (CME)

may produce

Forbush Decrease (FD)

Our proposal

The miniTRASGO Cosmic Ray Telescope

The TRASGO project

Muons, electrons…

- Measure **secondary charged cosmic rays** with ***tracking***
  - ***Not only counts, but angular counts!***
- TRASGO concept: **TRAck reconStructinG bOx**

RPC based!

TRISTAN

STRATOS

TRAGALDABAS

The *HUGE* TRASGO ???

The miniTRASGO !

The miniTRASGO !

Main features:

- Versatile and **compact**
- Not cost demanding
  - **<12000 euro!**
- **Standardizable**
- **Stable**

The miniTRASGO !

Main features:

- Versatile and **compact**
- Not cost demanding
  - **<12000 euro!**
- **Standardizable**

Ideal for a network!

But…

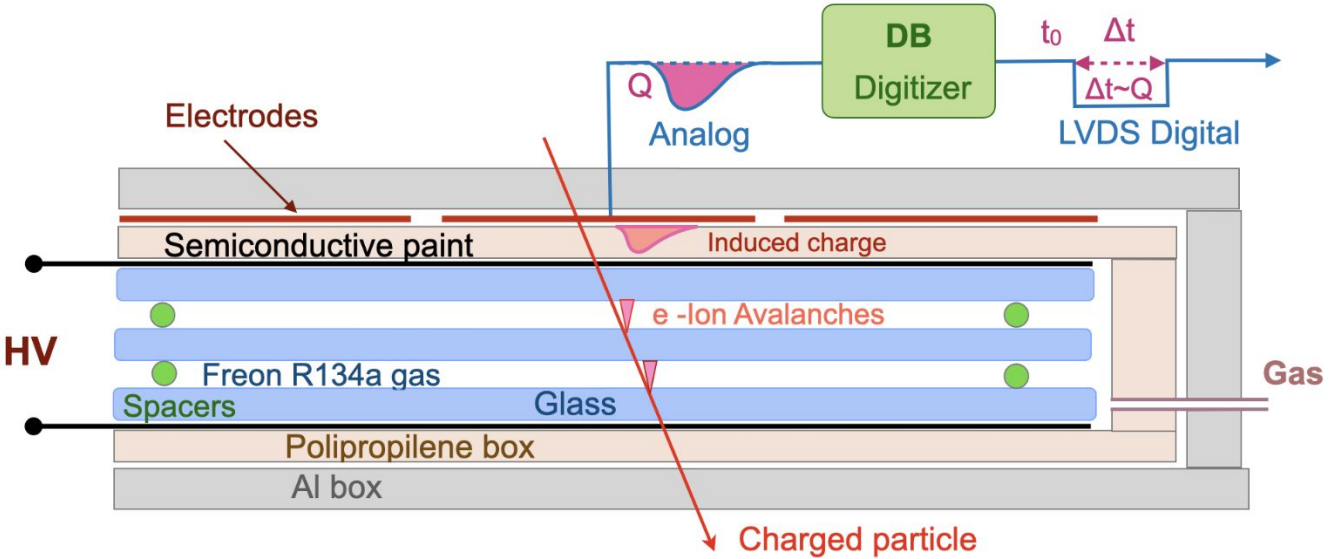
… are they good counting detectors?

RPCs in miniTRASGO

Understanding the device

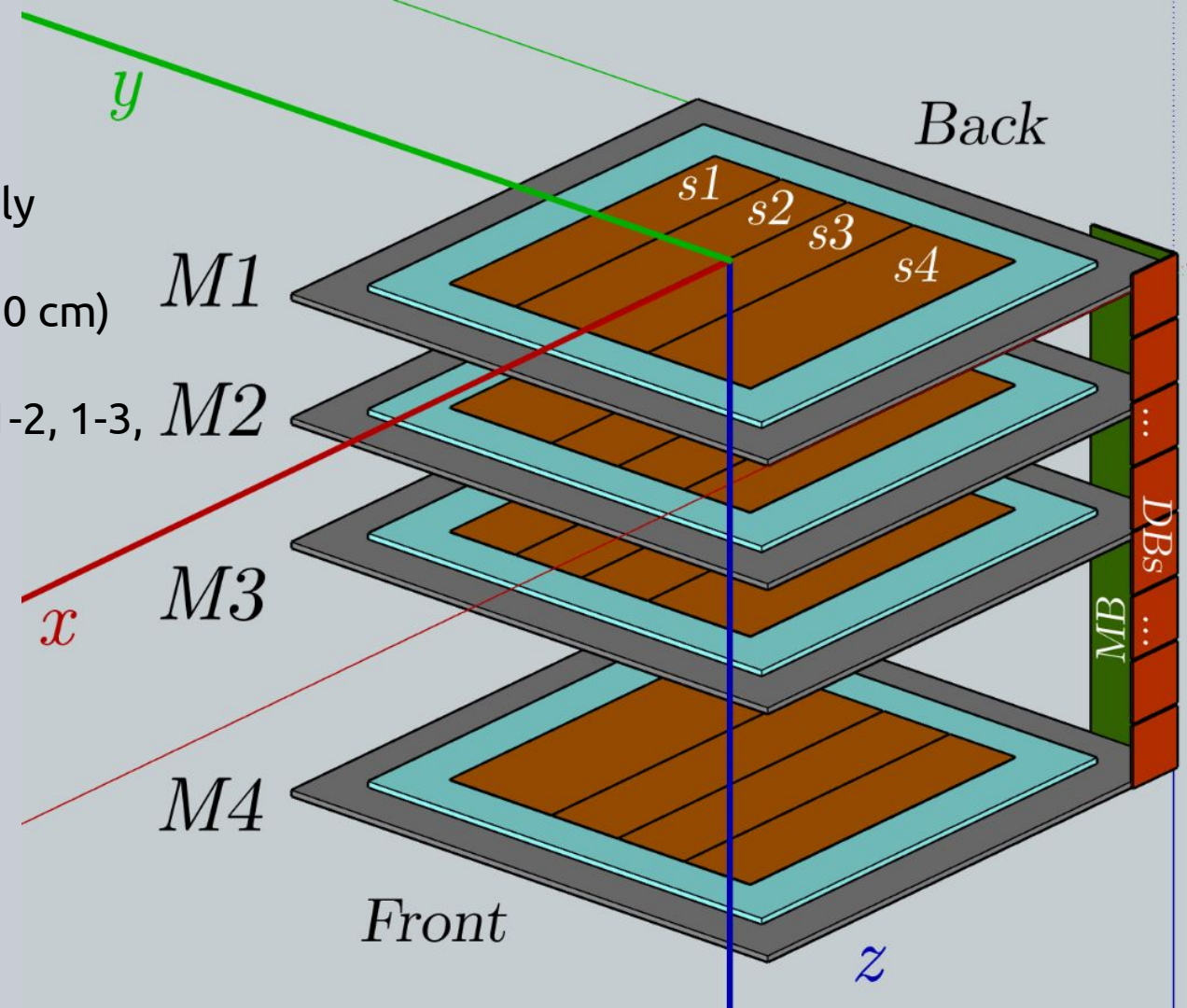
RPC summary

- **4 parallel square Multigap glass RPC**
  - 3 glass layers, 2 mm each
  - 2 gaps, 1 mm each (nylon monofilaments)
- **High Voltage**: WP ~5.52 kV/gap (painted glass)
- **Resistivity**: 10 MΩ/cm² = **10^7 Ω/cm²**
- **Gas**: R134a, flux of 1 kg/month
- **Active area**: 30x30 cm, approx. 0.1 m²



Not evenly spaced (10 and 20 cm)

Trigger: 1-2, 1-3, 2-3, 3-4



Asymmetric parallel Cu strips read in Front and Back

32 channels

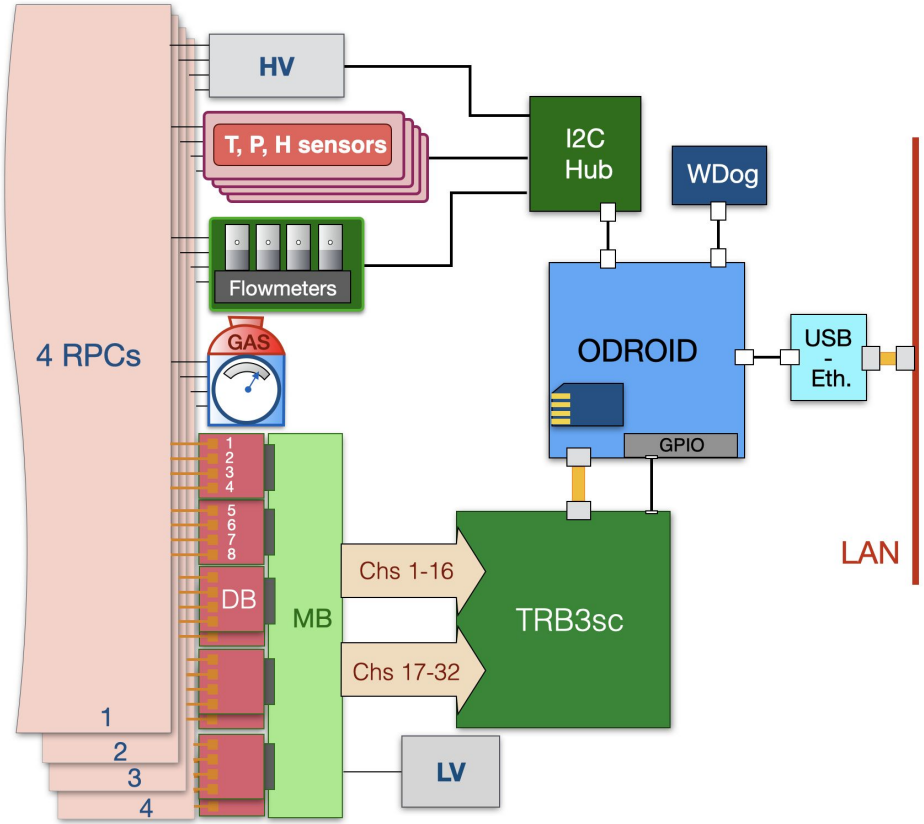
Compact and autonomous

Only three connections:

- **Power** (standard plug)
- **Gas** bottle (15 kg)
- **Ethernet** (not required)

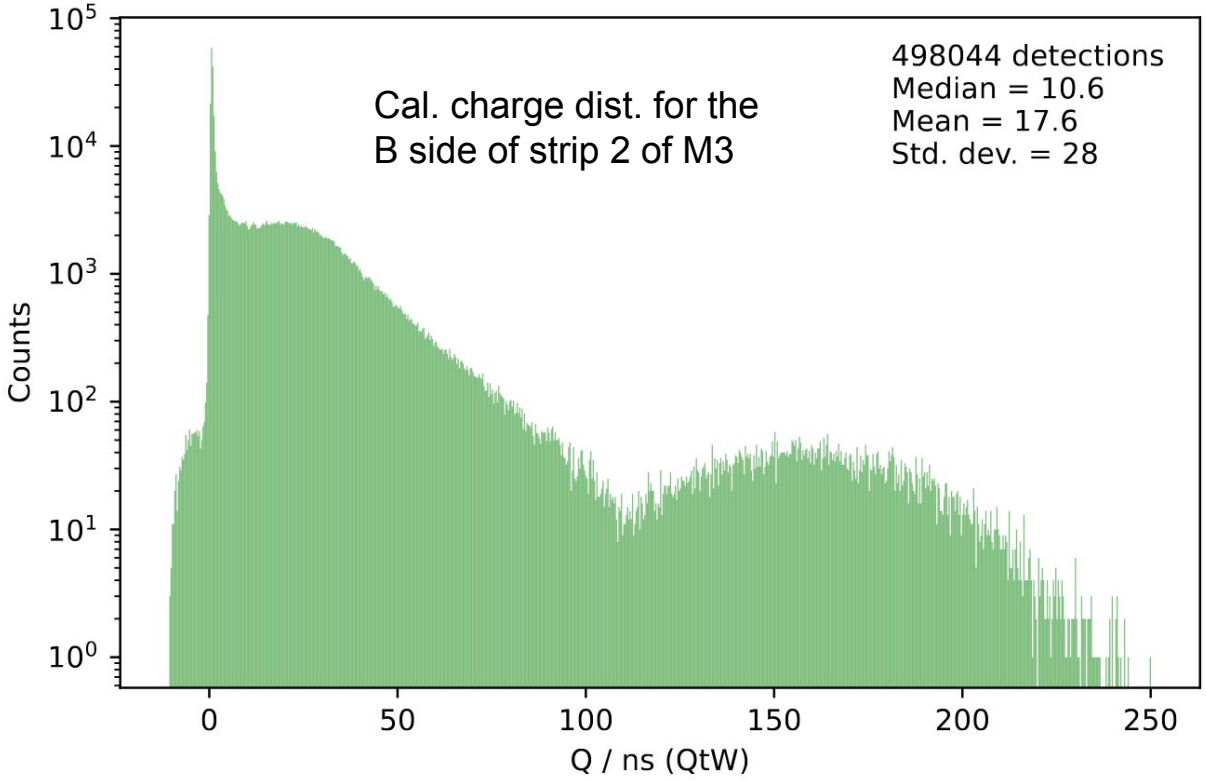
Includes:

- environment sensors, flowmeters, DAQ and a PC for data analysis and storage



Measure: time and charge in F and B per strip

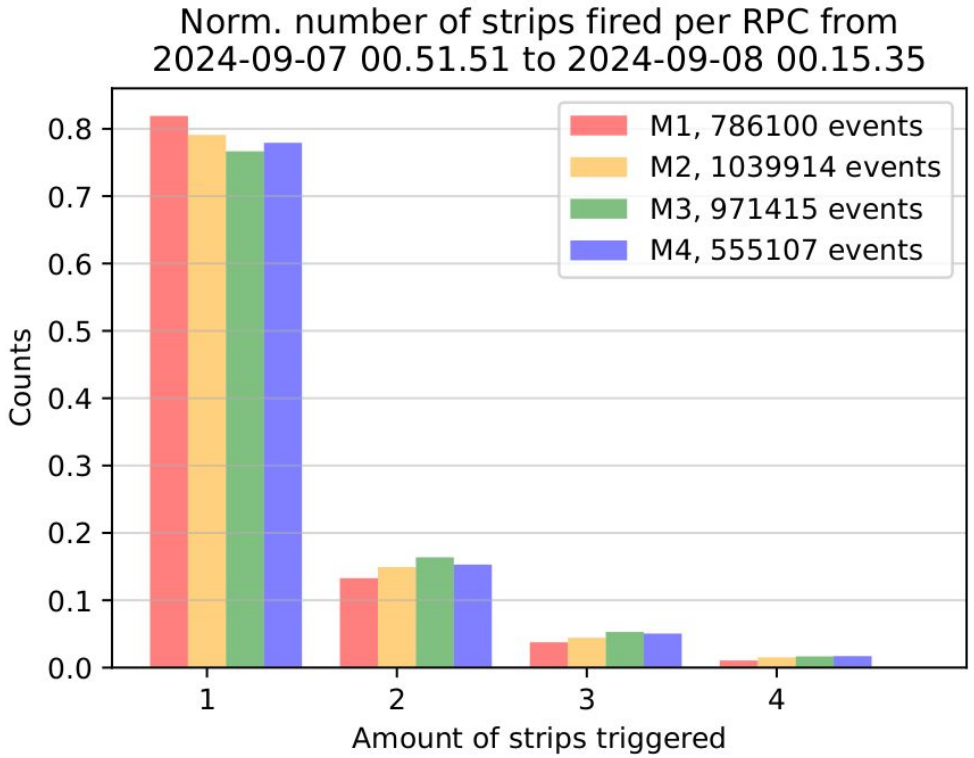
Time sum → Incidence time
Time diff → Position
Charge sum → Total charge
Charge diff → Monitor

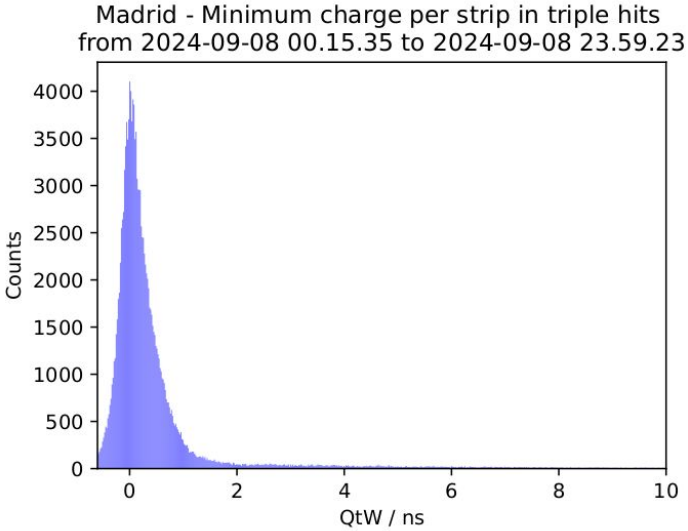


Cluster size

- ~80% of events leave charge in only one strip
- ~10-20 % of events in two strips
- ~5% in three

But first, charge spectra must be understood

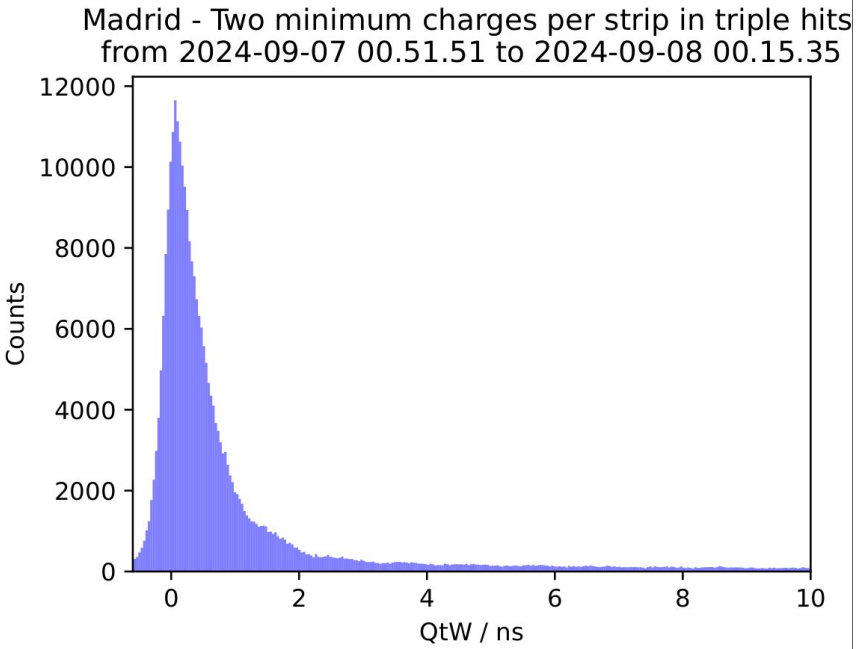




Crosstalk and Cluster Size 3 study

We learn:

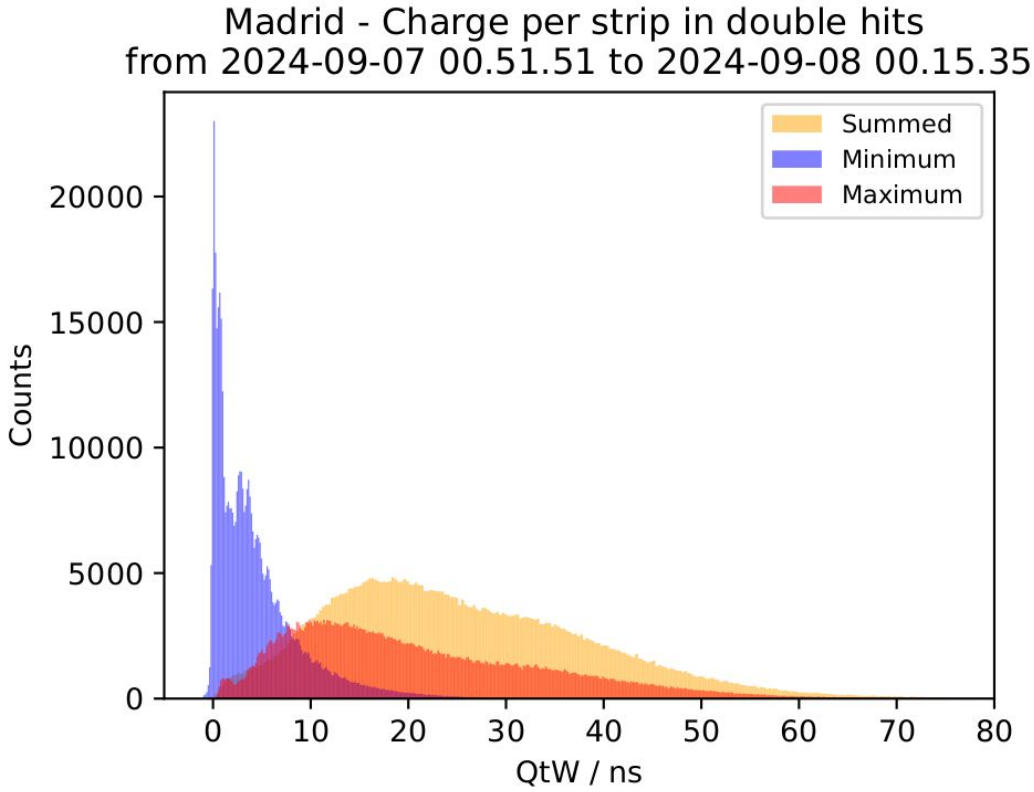
- 1 ns of QtW charge is a reasonable upper bound for the crosstalk charge.
- **Cluster Size = 3 cases are mainly caused by crosstalk, so in practice can be considered Cluster Size = 2**



What about Cluster Size 2?

The same plot reveals a wider distribution:

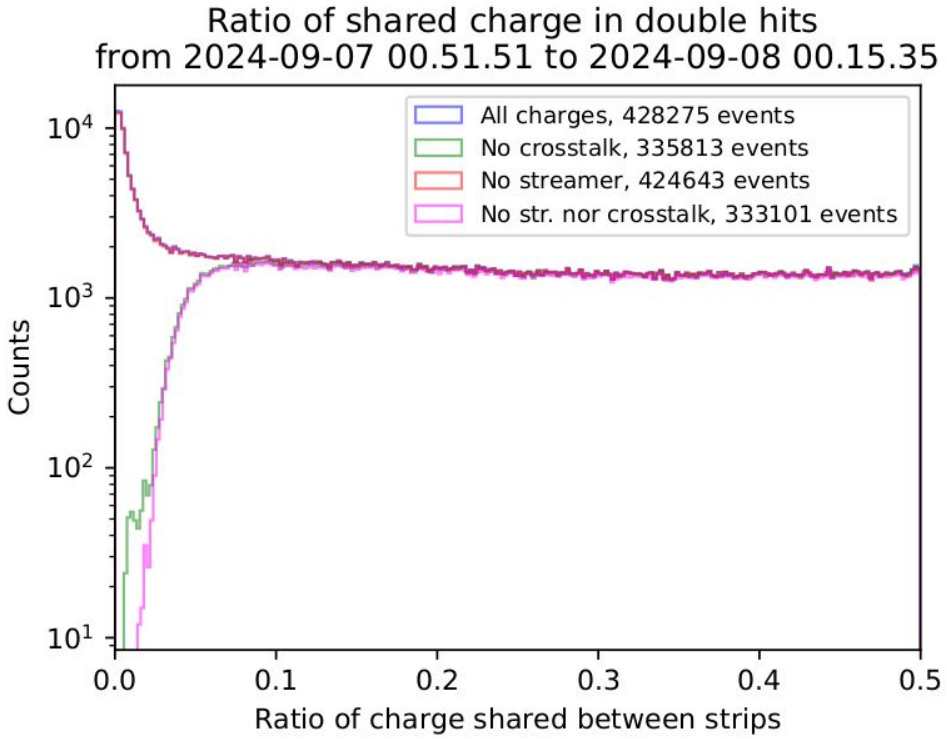
- **There is charge sharing in between two strips, but not three.**
- Induction section can be estimated



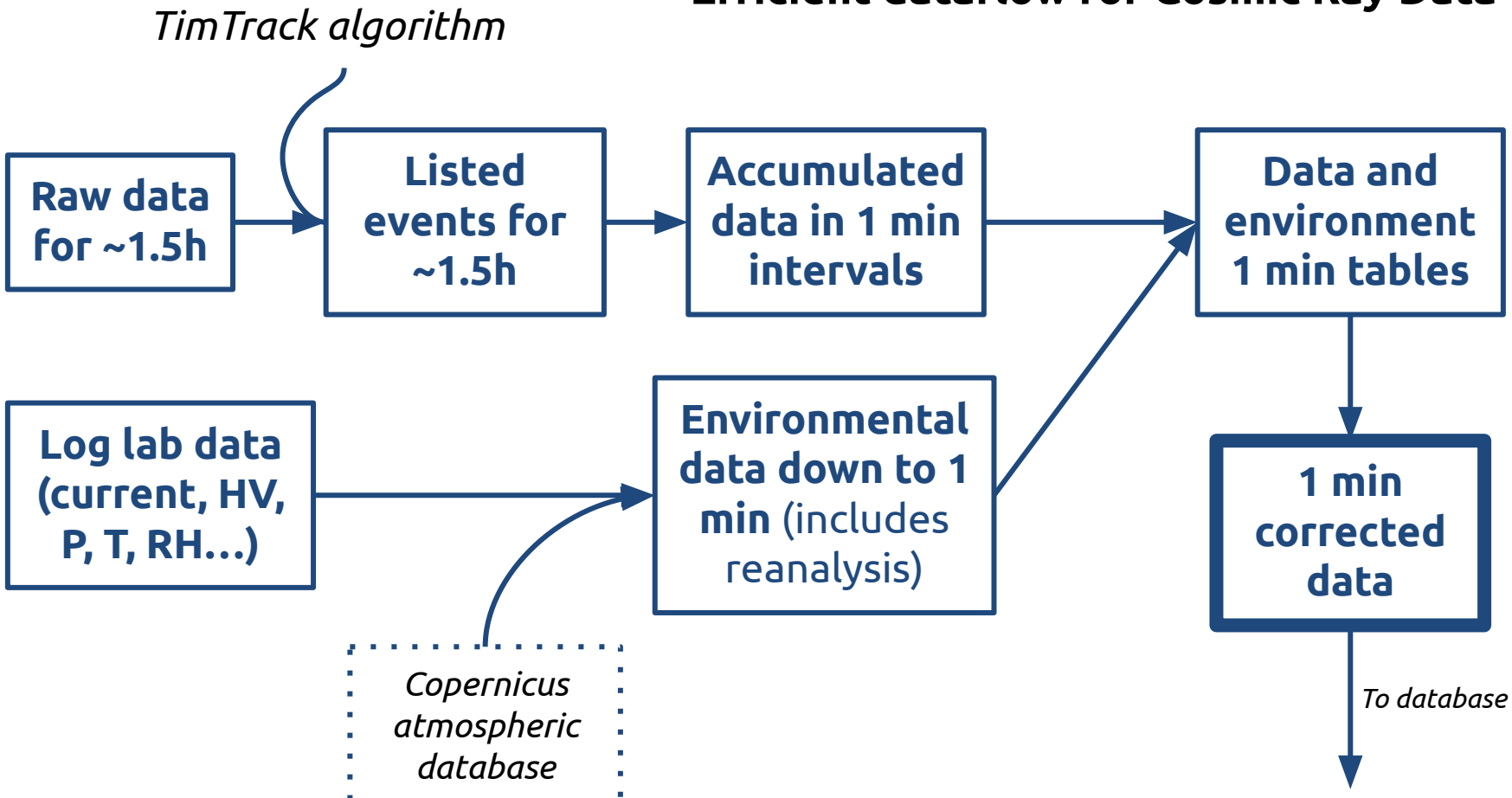
And sharing goes uniformly from 10% to the 50% of charge

If the mean strip width is **63 mm**:

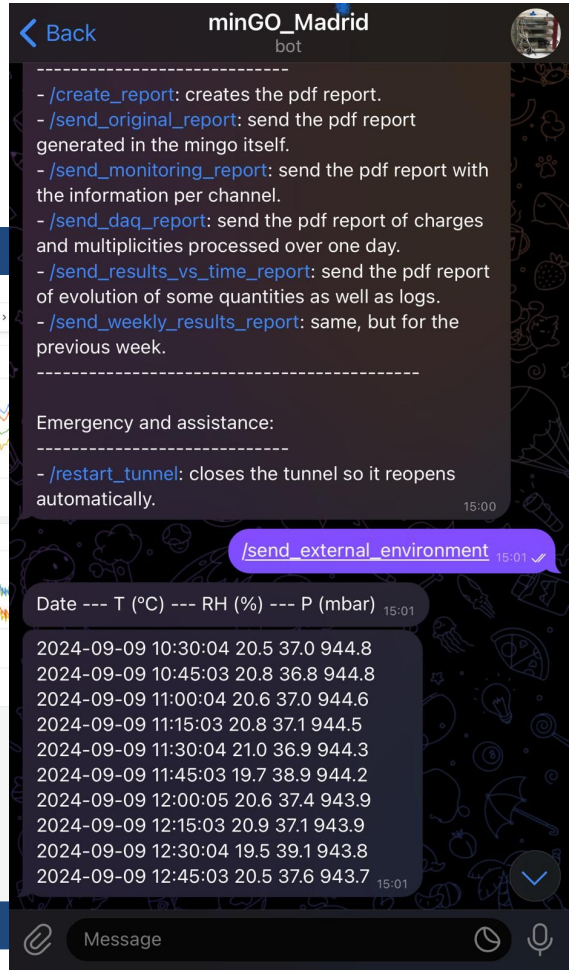
- Induction section = 2 × 9.8 mm = 20 mm = **~2 cm**
- Consistent with the resistivity of these RPCs: **10^7 Ω/cm²**



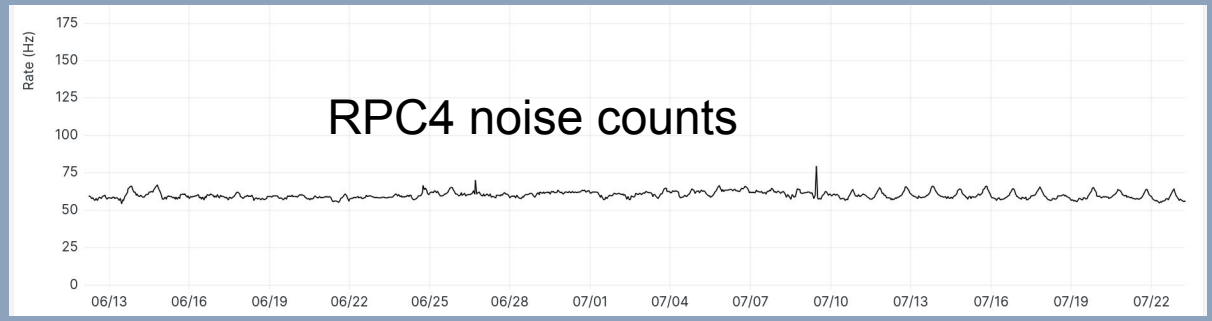
Efficient dataflow for Cosmic Ray Data

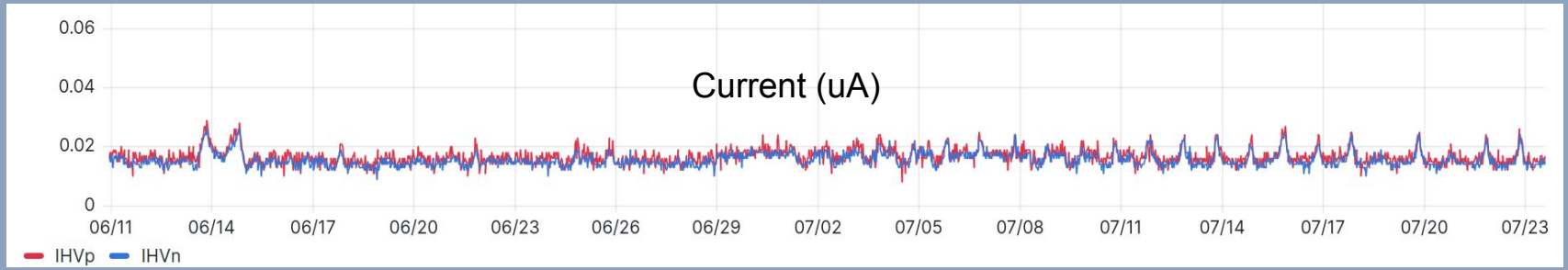


Grafana and Telegram control

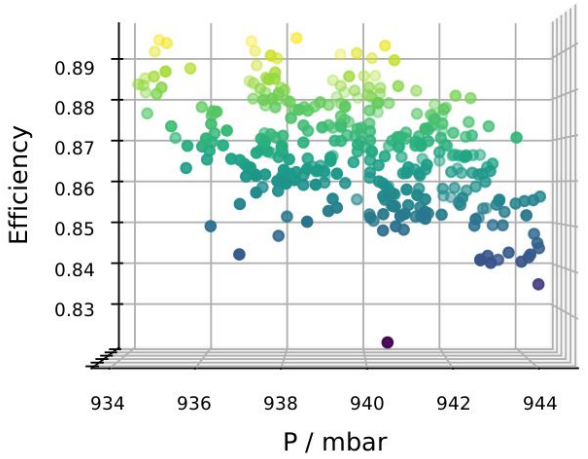


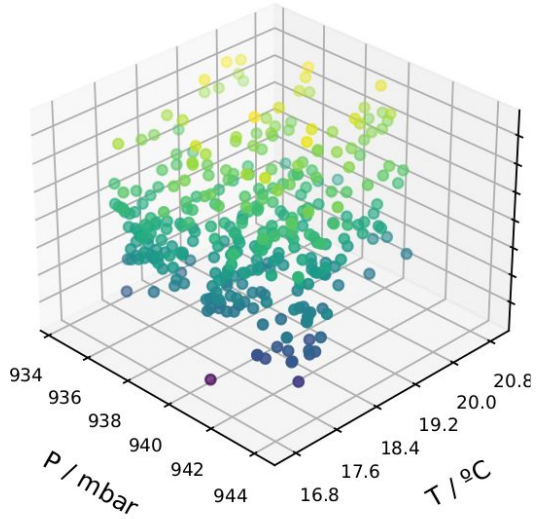
The system is stable

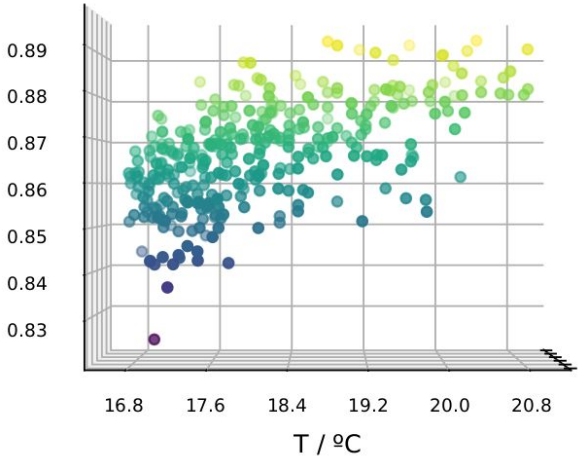




Efficiency: dependence on Temp and Pres...

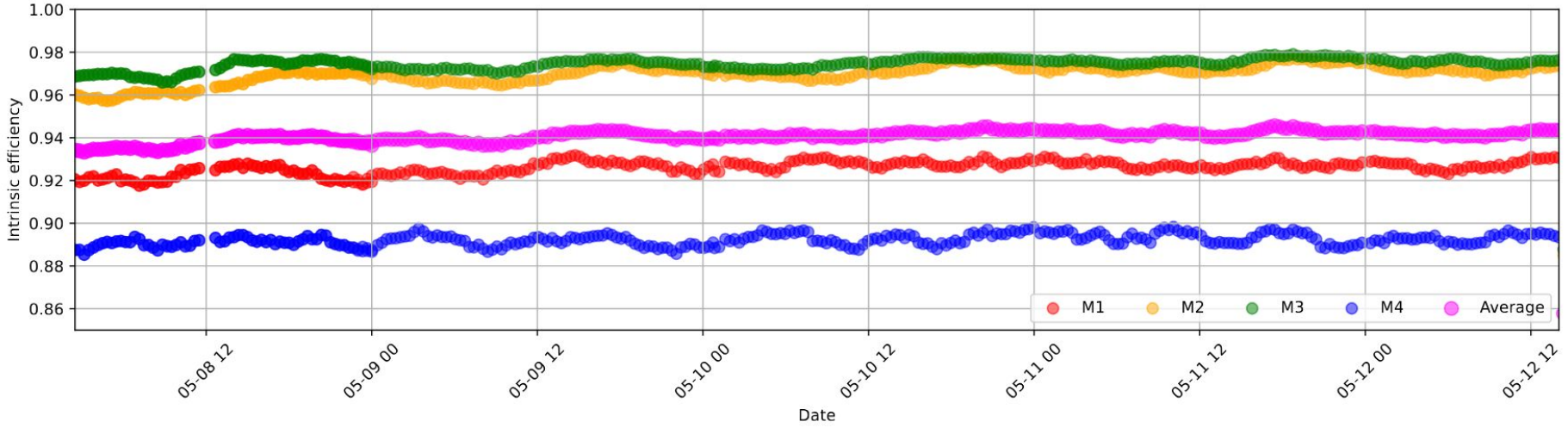


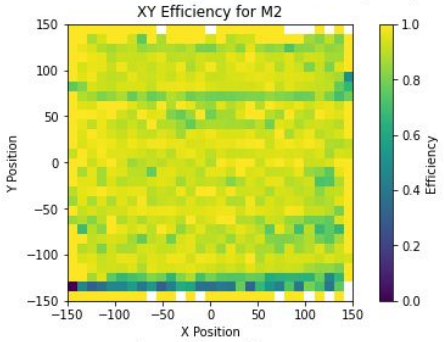


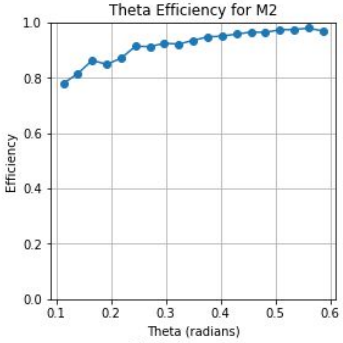


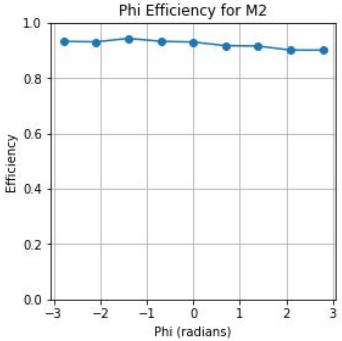
Data from the bot! → **minGO_Madrid_bot in Telegram**

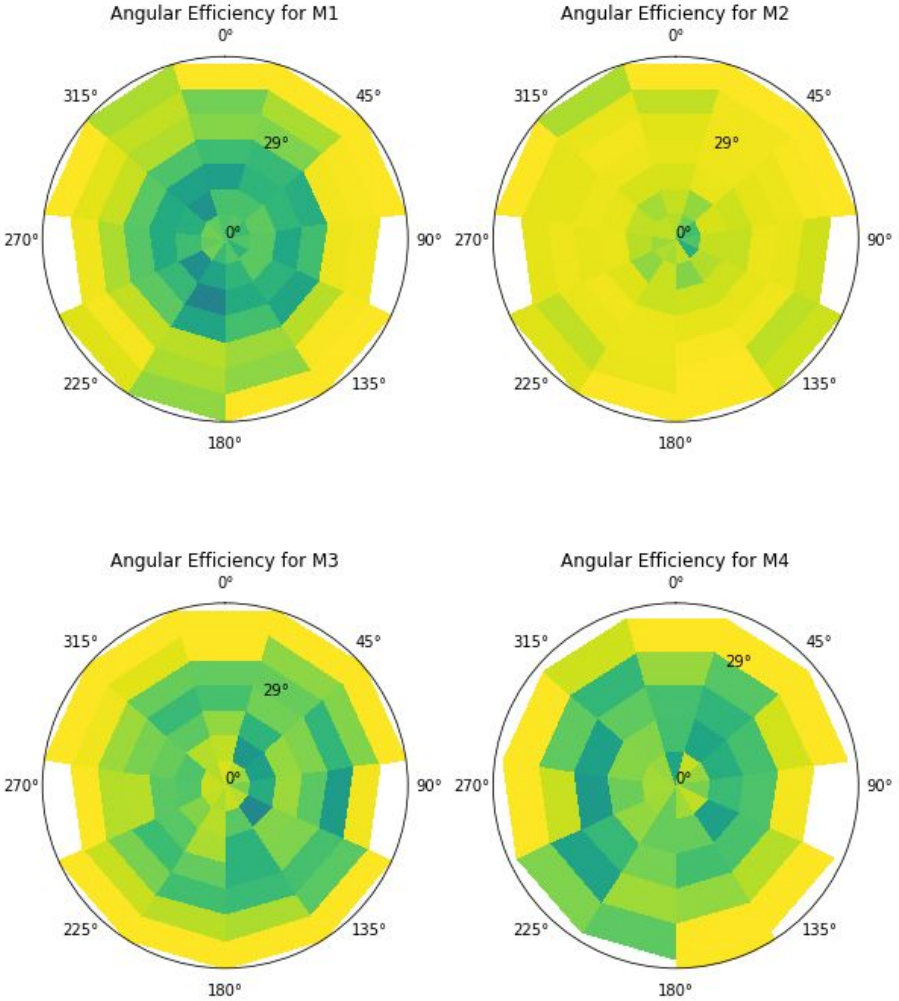
… but efficiency over several days has no large variations




XY Efficiency for M2
Y Position
X Position
Efficiency

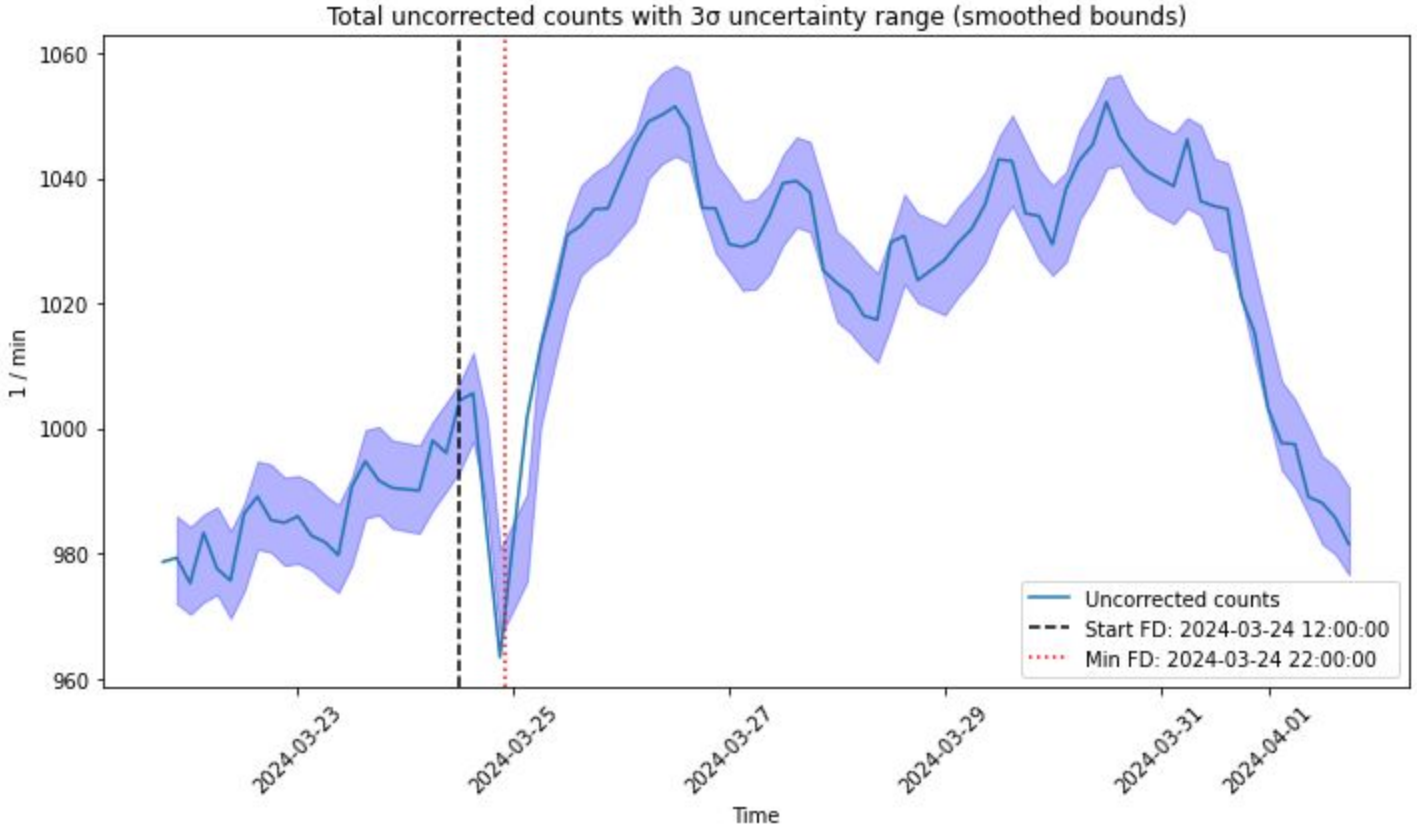

Theta Efficiency for M2
Efficiency
Theta (radians)

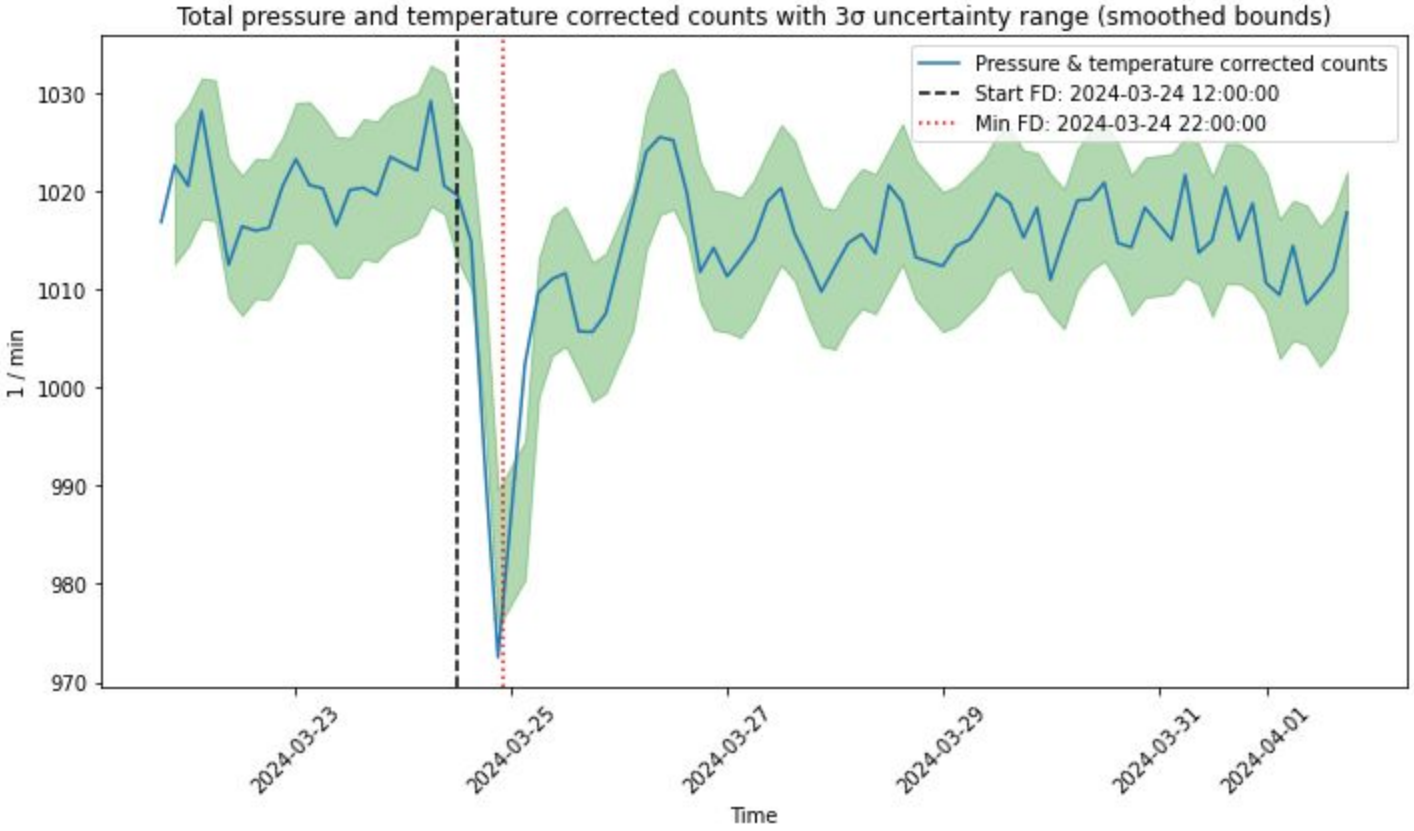

Phi Efficiency for M2
Efficiency
Phi (radians)

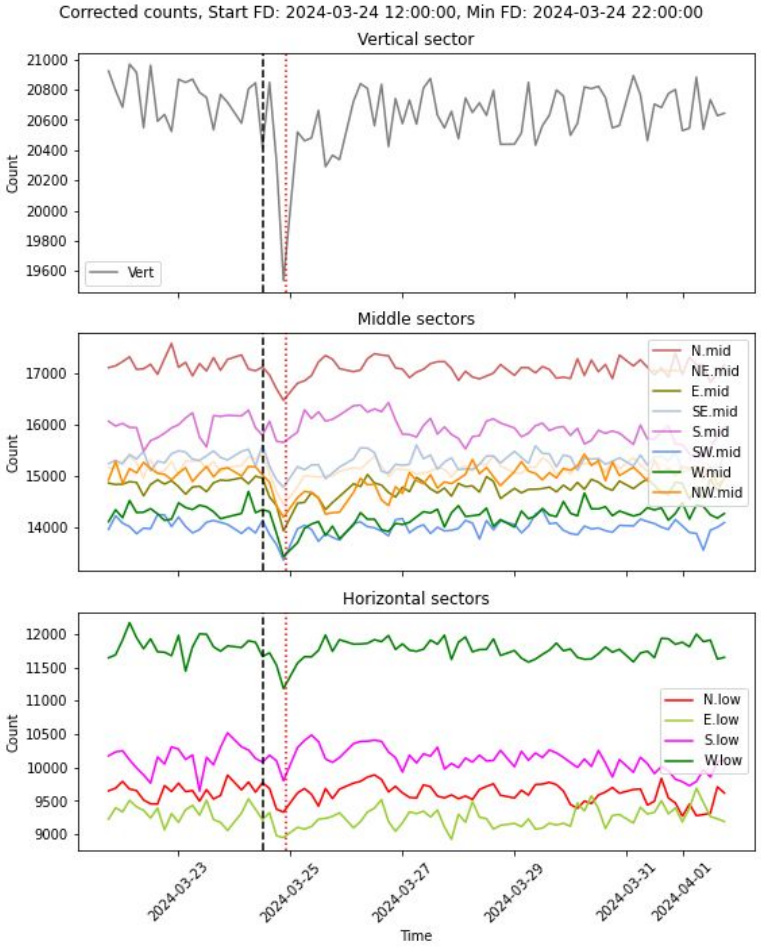

Angular Efficiency for M1
Angular Efficiency for M2
Angular Efficiency for M3
Angular Efficiency for M4
Efficiency

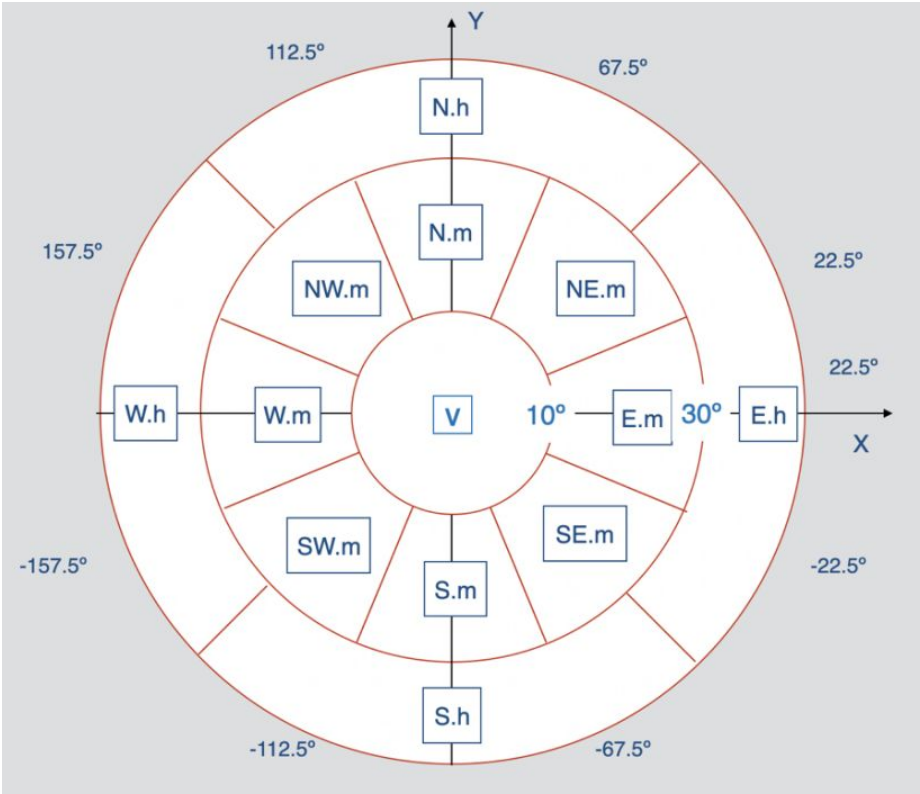
Forbush Decrease

On March 2024

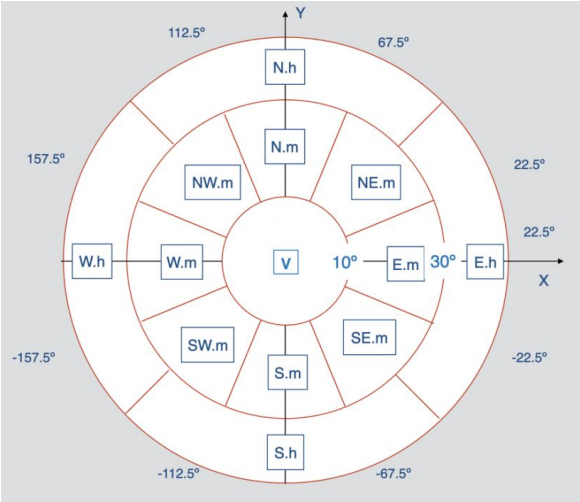

Total uncorrected counts with 3σ uncertainty range (smoothed bounds)
1060
1040
1020
1000
980
960
1 / min
2024-03-23
2024-03-25
2024-03-27
2024-03-29
2024-03-31
2024-04-01
Time
Uncorrected counts
Start FD: 2024-03-24 12:00:00
Min FD: 2024-03-24 22:00:00

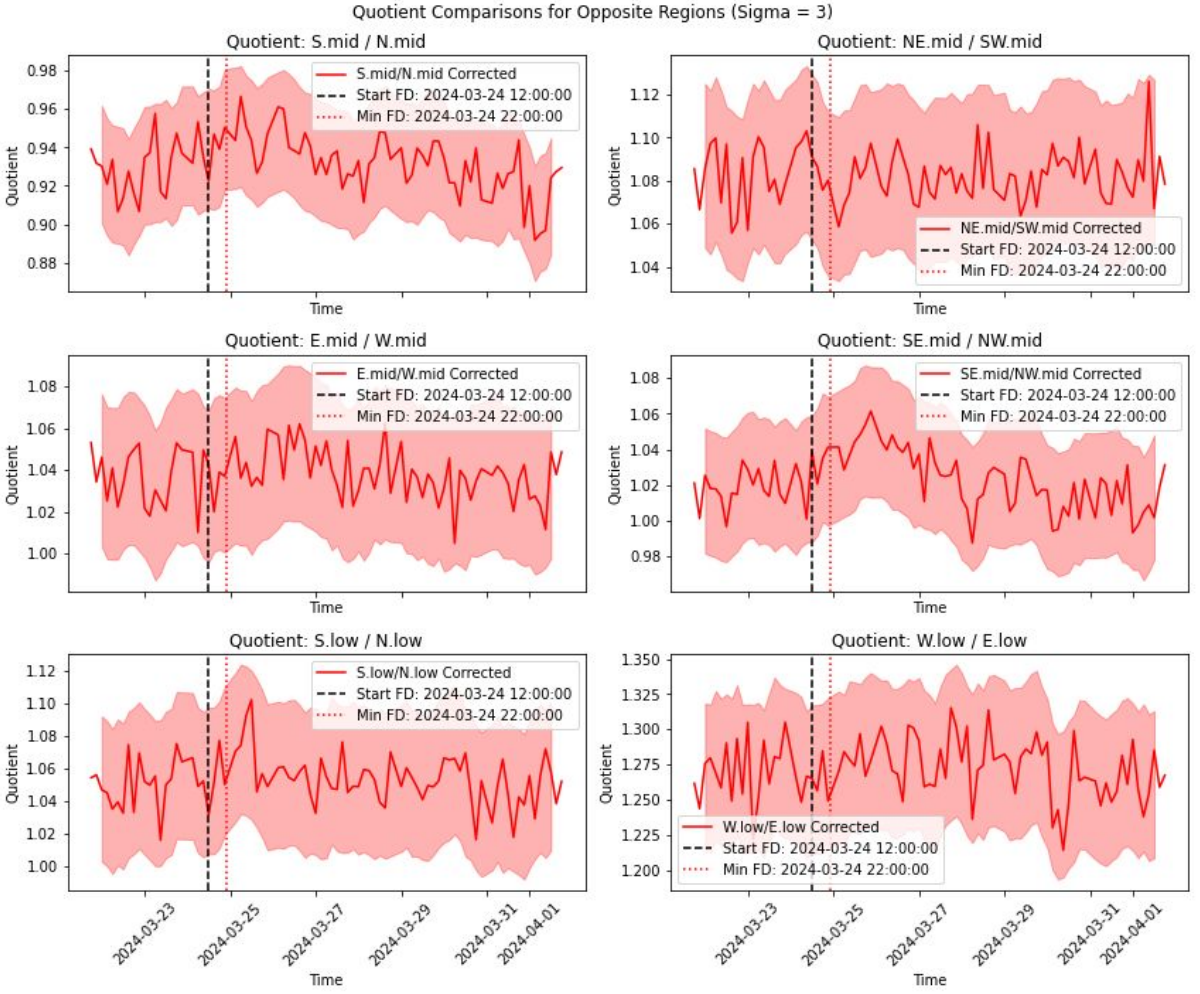

Total pressure and temperature corrected counts with 3σ uncertainty range (smoothed bounds)
Pressure & temperature corrected counts
Start FD: 2024-03-24 12:00:00
Min FD: 2024-03-24 22:00:00
1 / min
1030
1020
1010
1000
990
980
970
2024-03-23
2024-03-25
2024-03-27
2024-03-29
2024-03-31
2024-04-01
Time


Corrected counts, Start FD: 2024-03-24 12:00:00, Min FD: 2024-03-24 22:00:00
Vertical sector
Count
Vert
Middle sectors
N.mid
NE.mid
E.mid
SE.mid
S.mid
SW.mid
W.mid
NW.mid
Horizontal sectors
N.low
E.low
S.low
W.low
2024-03-23
2024-03-25
2024-03-27
2024-03-29
2024-03-31
2024-04-01
Time

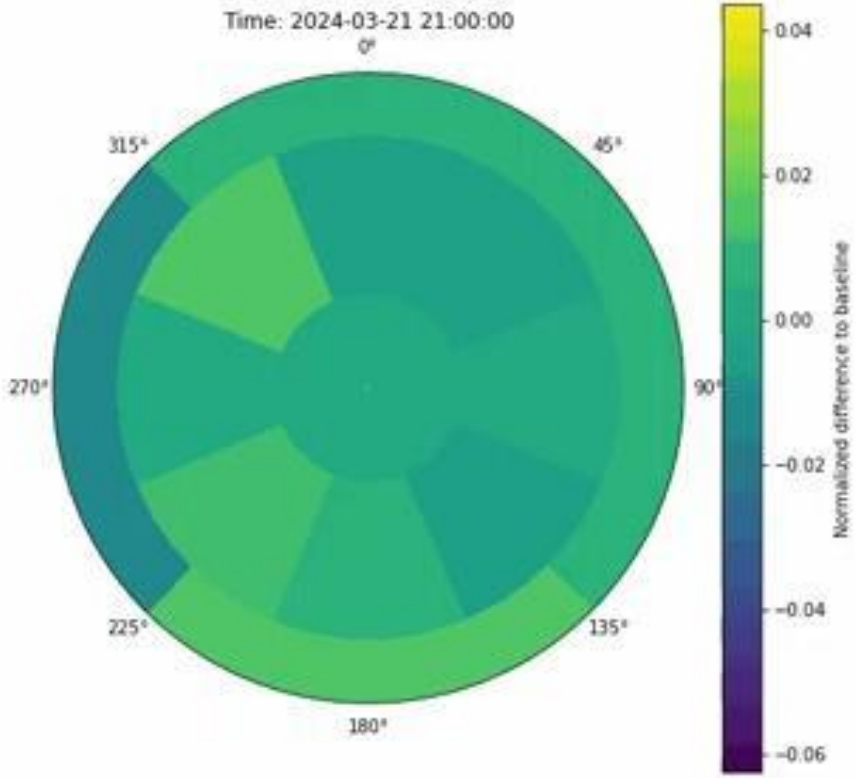

Y
X
112.5°
67.5°
157.5°
22.5°
-157.5°
-22.5°
-112.5°
-67.5°
N.h
N.m
NW.m
NE.m
W.h
W.m
V
10°
E.m
30°
E.h
SW.m
SE.m
S.m
S.h

Asymmetries in angular regions





FD starts on March 24th at 12:00 CET
Reaches the minimum at 22:00 CET, **10 hours later**



Averaging 3h

Conclusions

and a look into the future

Future prospects

- **Stable, not expensive, standardizable** secondary charged cosmic ray detector **presented**
- *Forbush Decrease* detection

  → **good counting detector**
- **Tracking** allows

  → **robust rates** and **original angular studies**
- **Working as a network (next talk)**

  → open the realm of **muon Earth coverage**

Thank you! Questions?

The miniTRASGO Cosmic Ray Telescope

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Back-up slides

for those curious

Analysis of Event Distribution

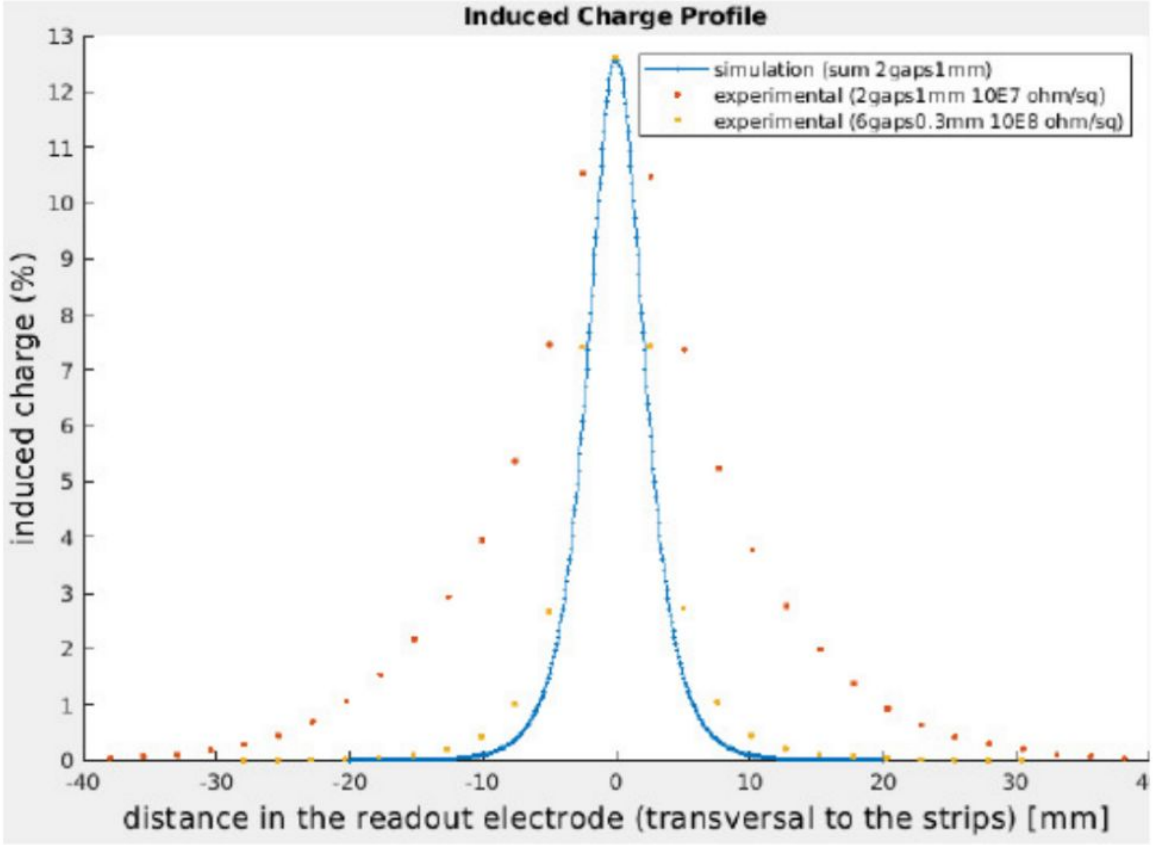
- **80%** of total events are in only one strip.
- **20% in two strips, we check numbers in histogram of charge ratio min/max**:
  - **78%** are double adjacent sharing charge → **15%** of total events.
  - **23%** are actually single hits → **5%** of total events.

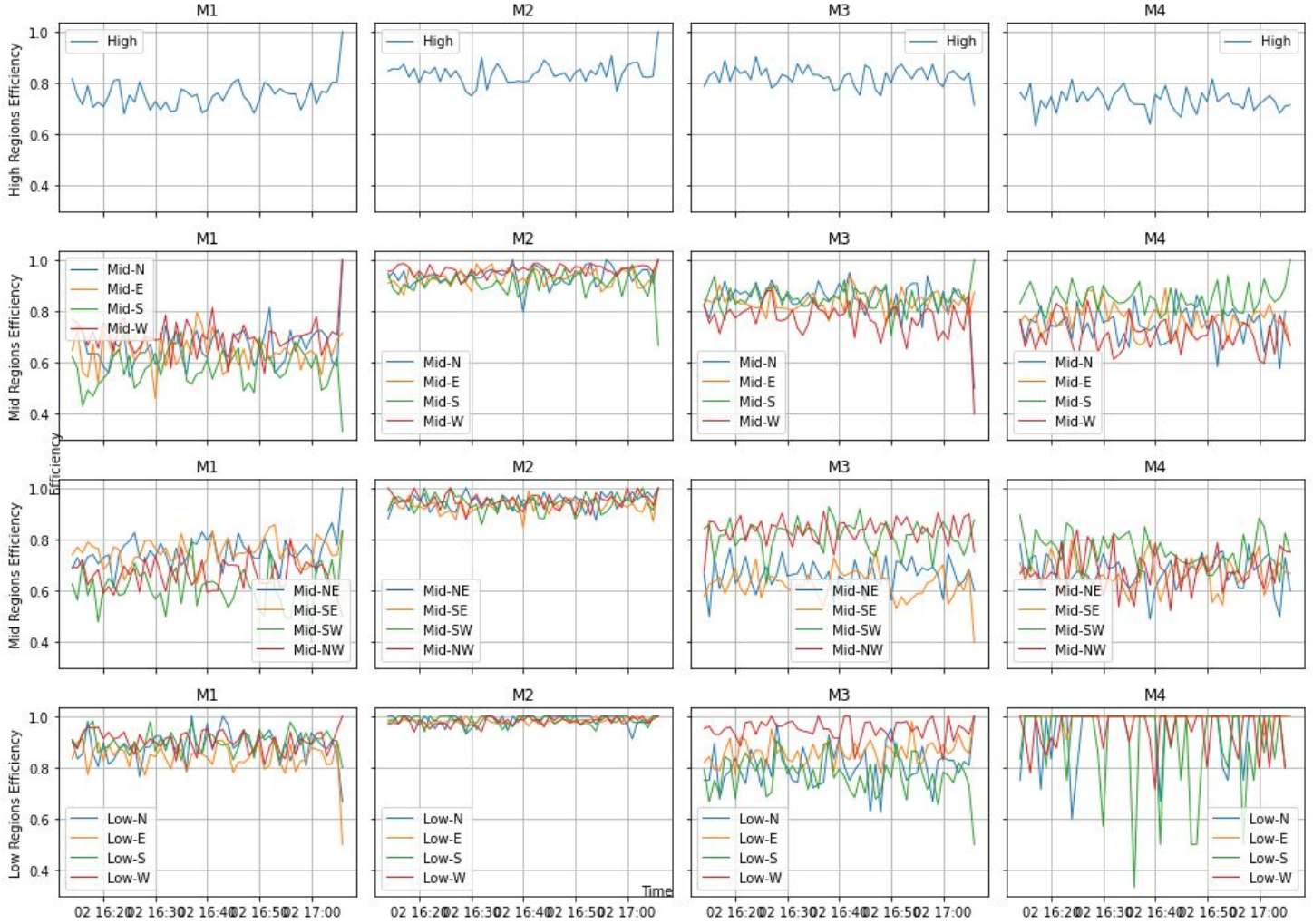
Classification Breakdown

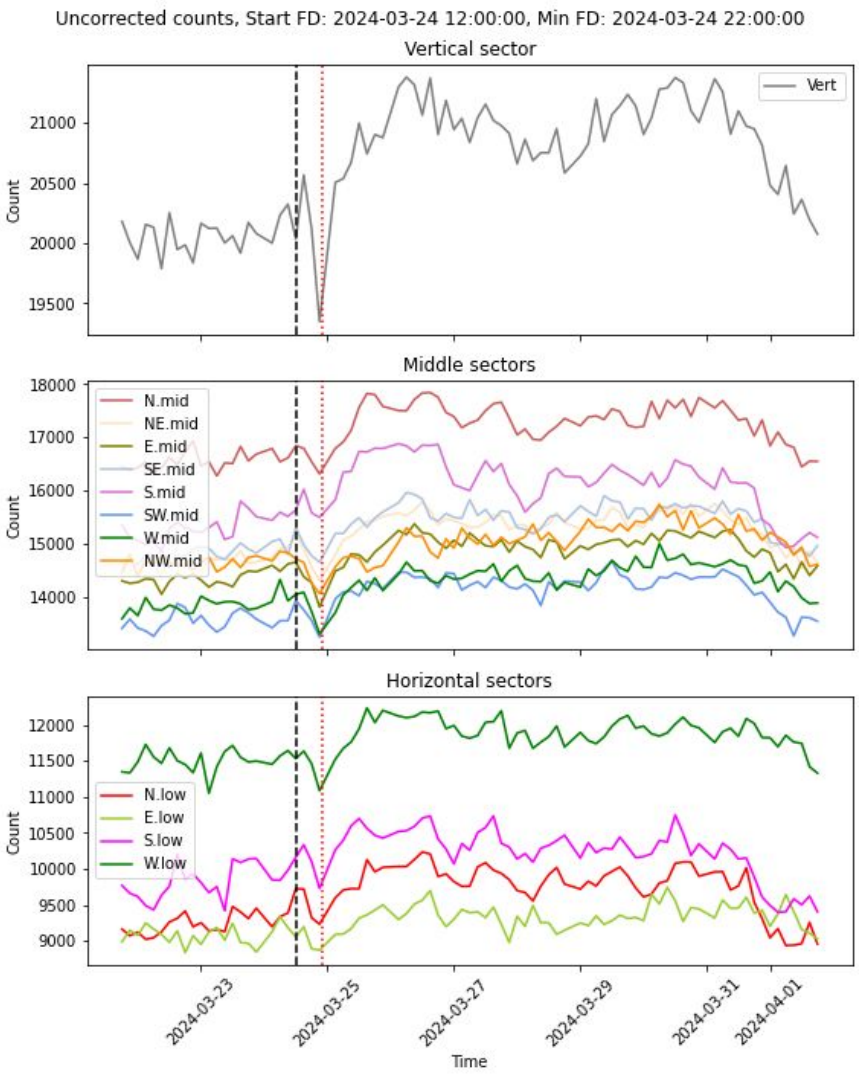
- **85%** of total events = one particle in the interior of one strip (80% + 5%).
- **15%** of total events = one particle between two strips.

Ionization Section

- If the mean strip width = **63 mm**:
  - Ionization section = **2 × 9.8 mm = 20 mm (2 cm)**.
  - Consistent with the resistivity of these RPCs


Induced Charge Profile
simulation (sum 2gaps1mm)
experimental (2gaps1mm 10E7 ohm/sq)
experimental (6gaps0.3mm 10E8 ohm/sq)
induced charge (%)
distance in the readout electrode (transversal to the strips) [mm]
0
1
2
3
4
5
6
7
8
9
10
11
12
13
-40
-30
-20
-10
0
10
20
30


M1
M2
M3
M4
High
High Regions Efficiency
Mid-N
Mid-E
Mid-S
Mid-W
Mid Regions Efficiency
Mid-NE
Mid-SE
Mid-SW
Mid-NW
Low-N
Low-E
Low-S
Low-W
Low Regions Efficiency
Time
02 16:20
02 16:30
02 16:40
02 16:50
02 17:00


Uncorrected counts, Start FD: 2024-03-24 12:00:00, Min FD: 2024-03-24 22:00:00
Vertical sector
Vert
Count
21000
20500
20000
19500
Middle sectors
N.mid
NE.mid
E.mid
SE.mid
S.mid
SW.mid
W.mid
NW.mid
Count
18000
17000
16000
15000
14000
Horizontal sectors
N.low
E.low
S.low
W.low
Count
12000
11500
11000
10500
10000
9500
9000
2024-03-23
2024-03-25
2024-03-27
2024-03-29
2024-03-31
2024-04-01
Time

DAQ Overview

- **Front-end electronics (FEE)**: Developed for the **HADES detector** (GSI).
  - Daughterboards (DB): Converts RPC signals into LVDS (Low Voltage Differential Signal) using Hidronav technology. Key features:
  - Motherboard (MB): Powers DBs and transfers LVDS to the TRB.
- **TRB3sc** (Time-of-Flight Reconstruction Board): From HADES experiment.
  - **32** Time-to-Digital Converters (TDC).
  - Inputs LVDS from DB.
  - Outputs **digital timestamp** and **signal length** via USB.