Assessment of the performance of the R&D MARTA station

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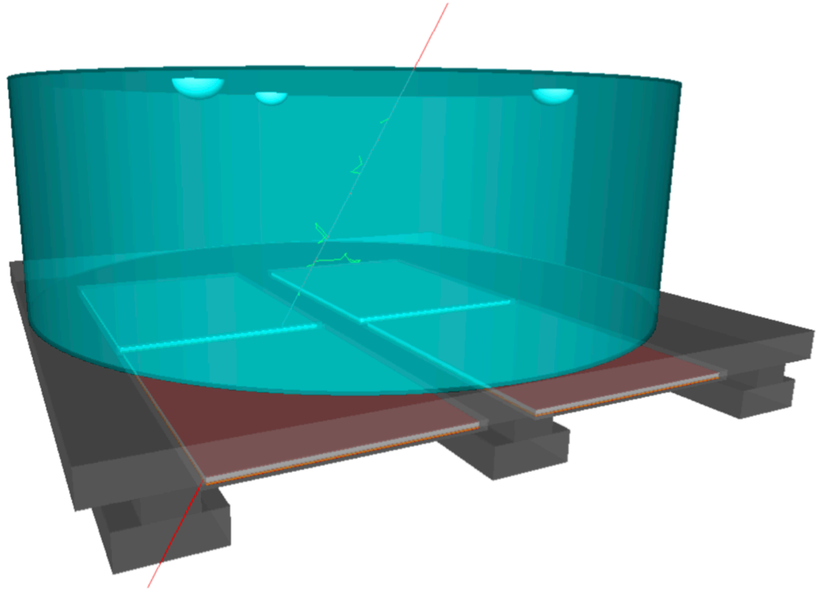
MARTA

Muon Array with RPCs for Tagging Air showers

P. Assis, et al. Eur.Phys.J.C 78 (2018) 4, 333

- Place Resistive Plate Chambers (RPCs) below the water Cherenkov tank (WCD) to directly detect the shower muon component
  - 4 RPCs
  - RPCs dimension $1.2 \times 1.5\,\mathrm{m}^2$
  - 8×8 grid pads



Offline simulation

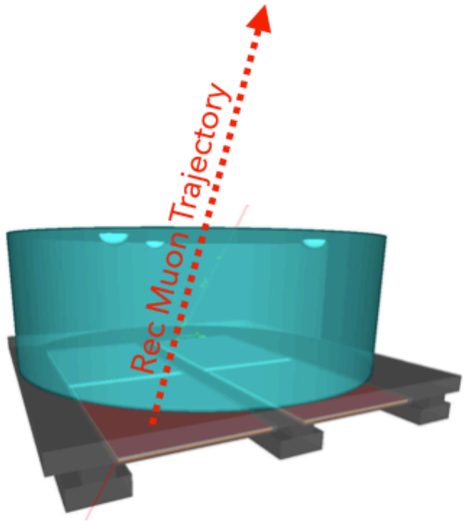
EAS particles energy spectrum

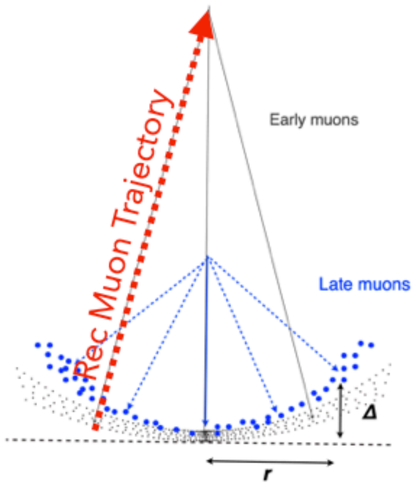
Novel strategies being exploited to access for the first time the energy spectrum of the shower e.m. and muon components

Machine Learning WCD analysis + Muon Production Depth

Use ideas developed in SWGO to reconstruct the muon direction analysing the WCD PMTs signal time trace + RPC hit with ML algorithms

Combine with position extract from arrival delay to the shower front (MPD) to access kinematical delay term, i.e. muon energy spectrum



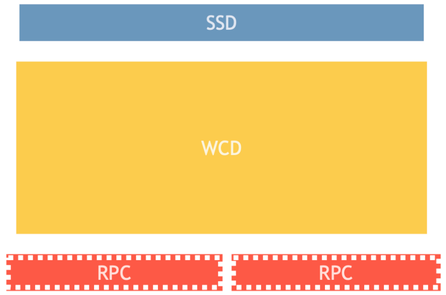


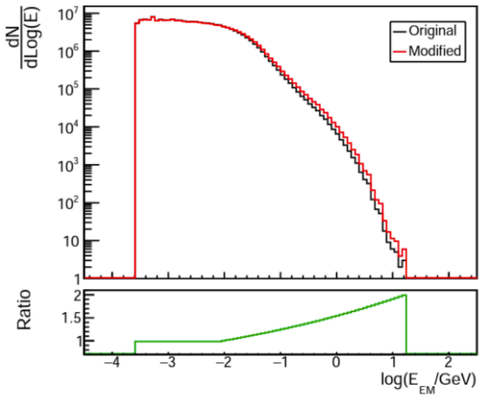
$$z \simeq \frac{1}{2}\left(\frac{r^2}{c\left(t-\langle t_\varepsilon\rangle\right)} - c\left(t-\langle t_\varepsilon\rangle\right)\right) + \Delta - \langle z_\pi\rangle$$

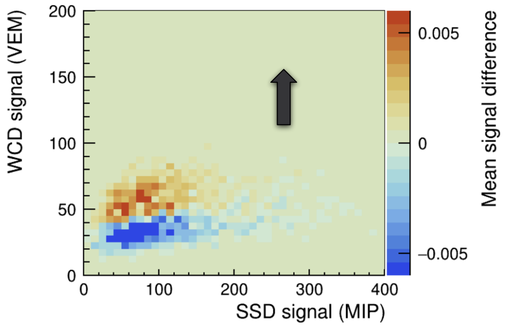
See Ruben Sunday's talk

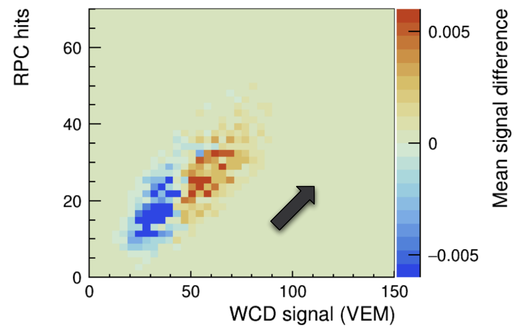
Analysis of MARTA (WCD+RPC) +SSD data

Shower particles are crossing multiple detectors that respond differently to particle type and energy









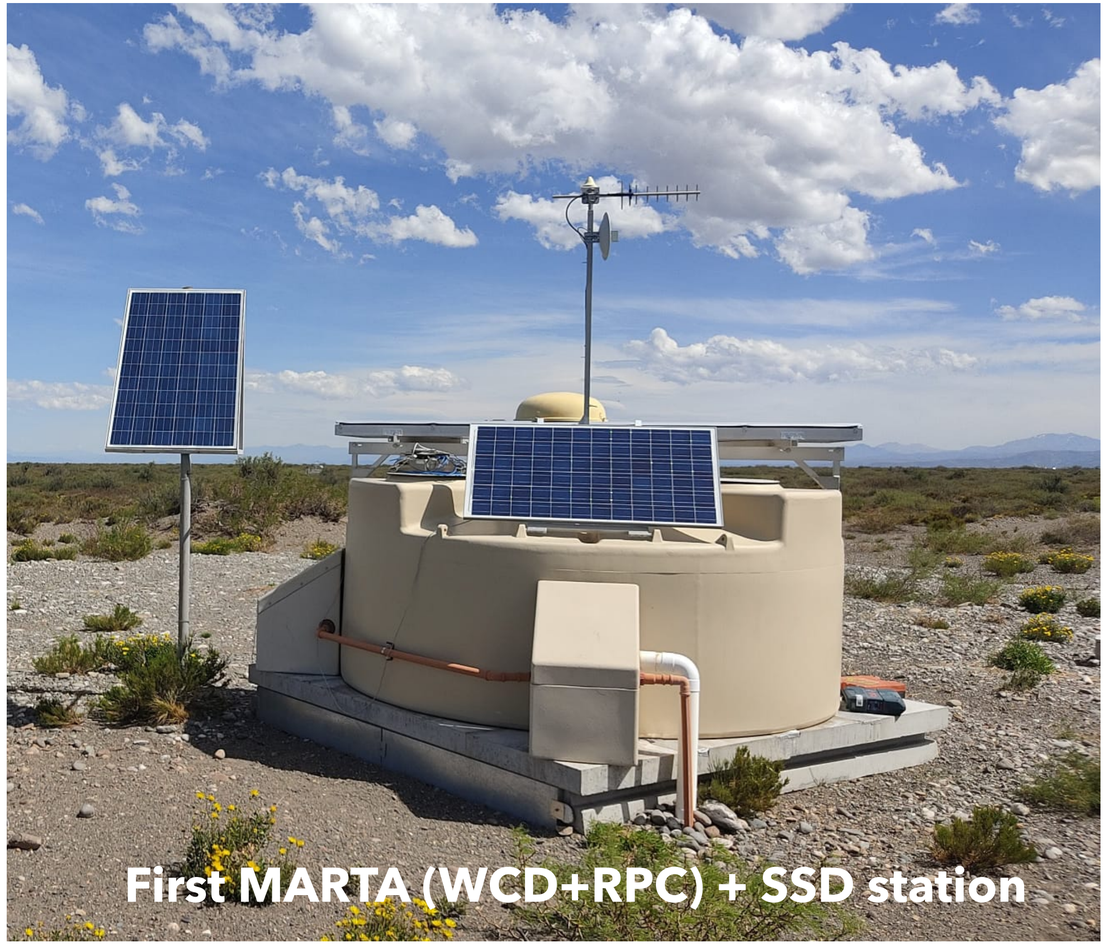
See Milton Sunday's talk

MARTA

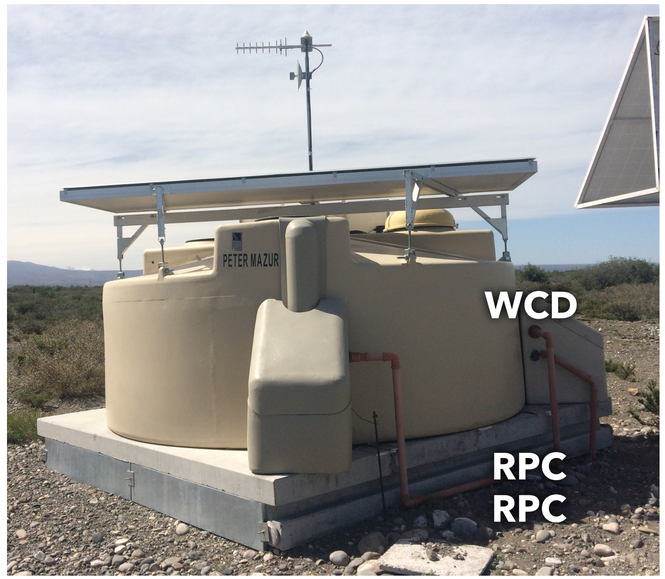
Muon Array with RPCs for Tagging Air showers

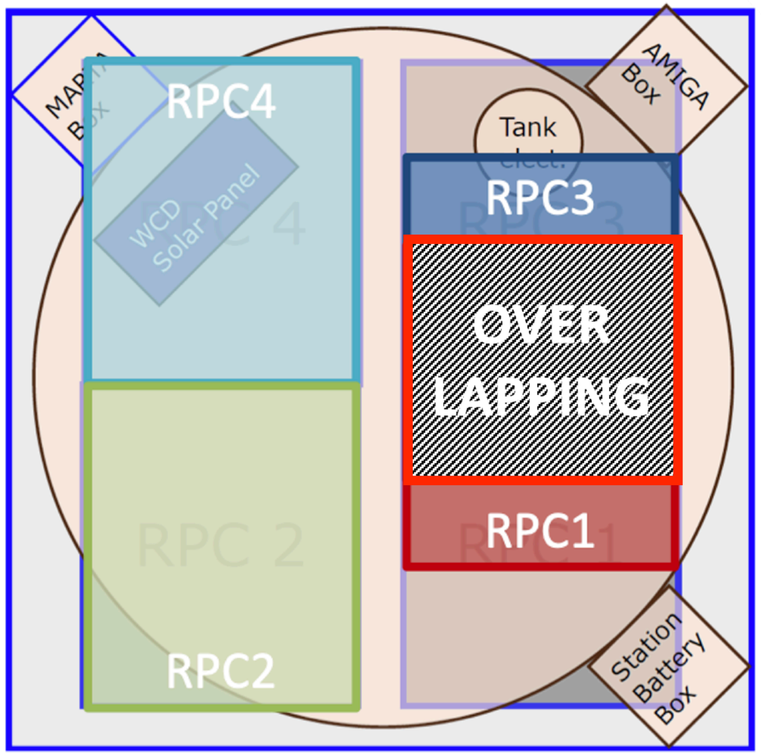
P. Assis, et al. Eur.Phys.J.C 78 (2018) 4, 333

- Place Resistive Plate Chambers below the water Cherenkov tank to directly detect the shower muon component
- First station fully commissioned and taking data (Dec 23)
- Due to the COVID pandemics the RPC were in the field without gas for ~ 2 years!


First MARTA (WCD+RPC) + SSD station

The Peter Mazur SD-MARTA station



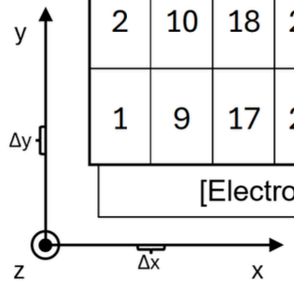


- Trigger to the RPCs is given by the WCD
- Two RPCs were placed in an overlap position so that efficiency measurements were possible

MARTA's first data acquisition

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

[Electronics, HV, gas]

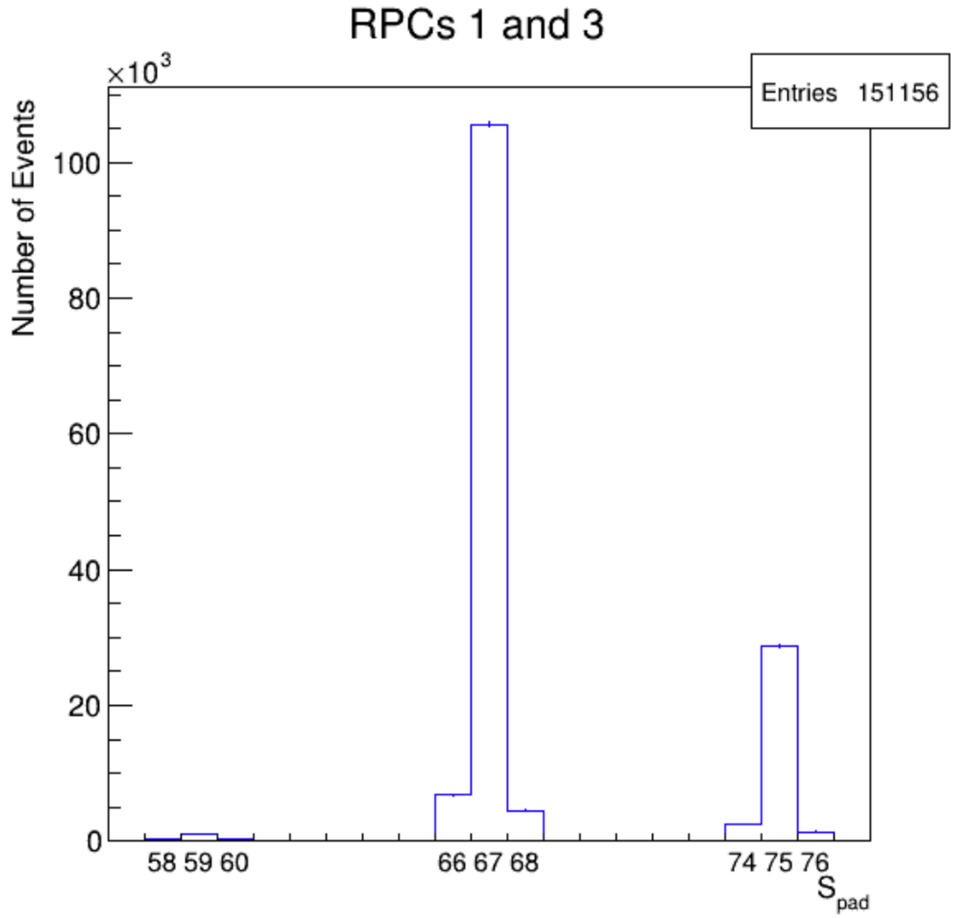


[Electronics, HV, gas]

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

3 + 64 = **67**

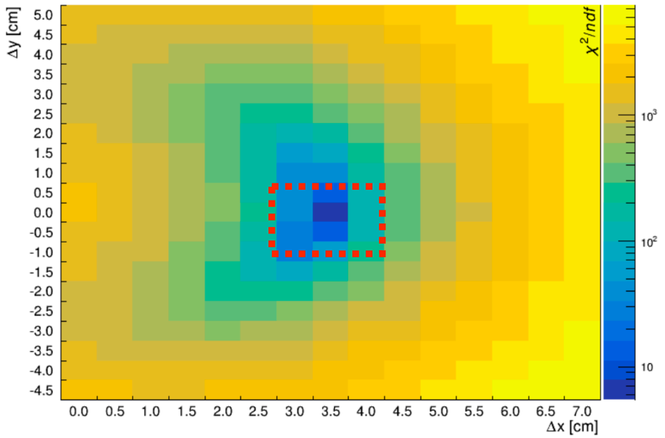
11 + 56 = **67**

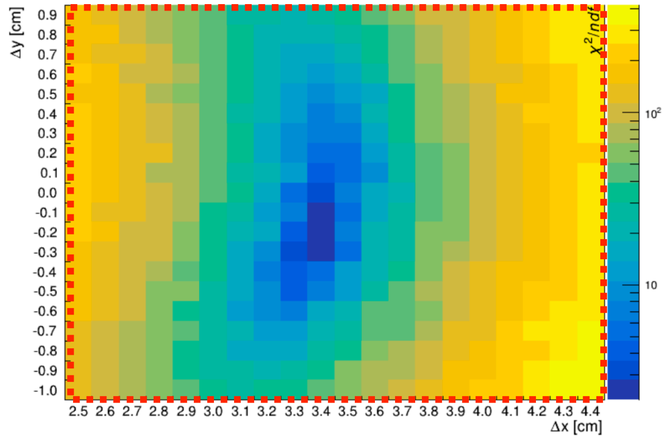


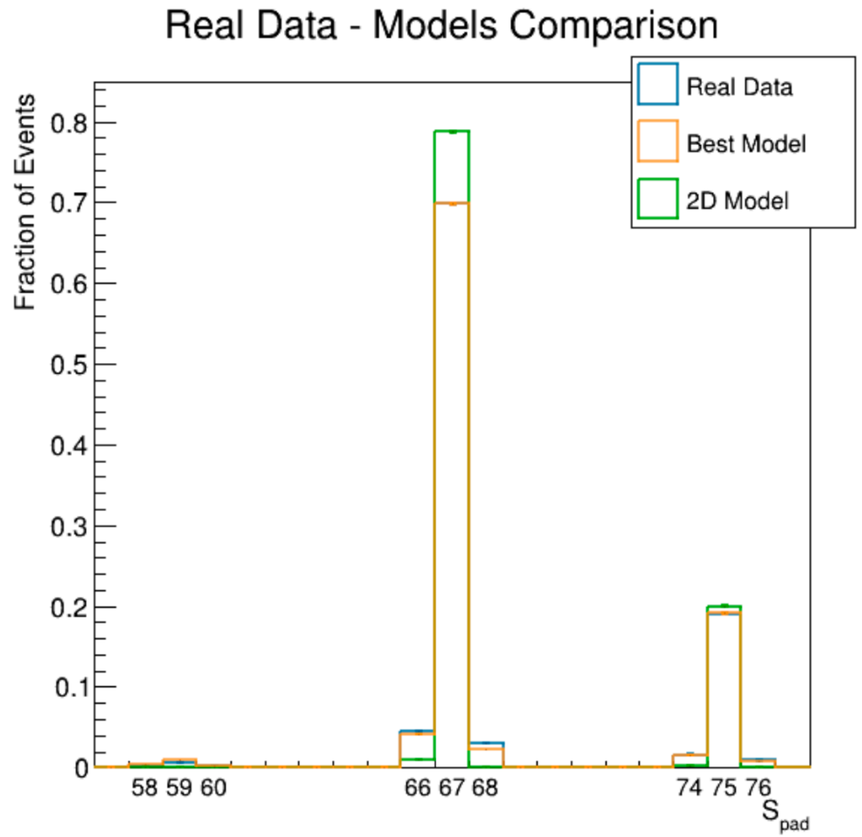
Approximately 18.5 hours of acquisition

Suggestion of a RPC misalignment

Correct for RPCs relative misalignment



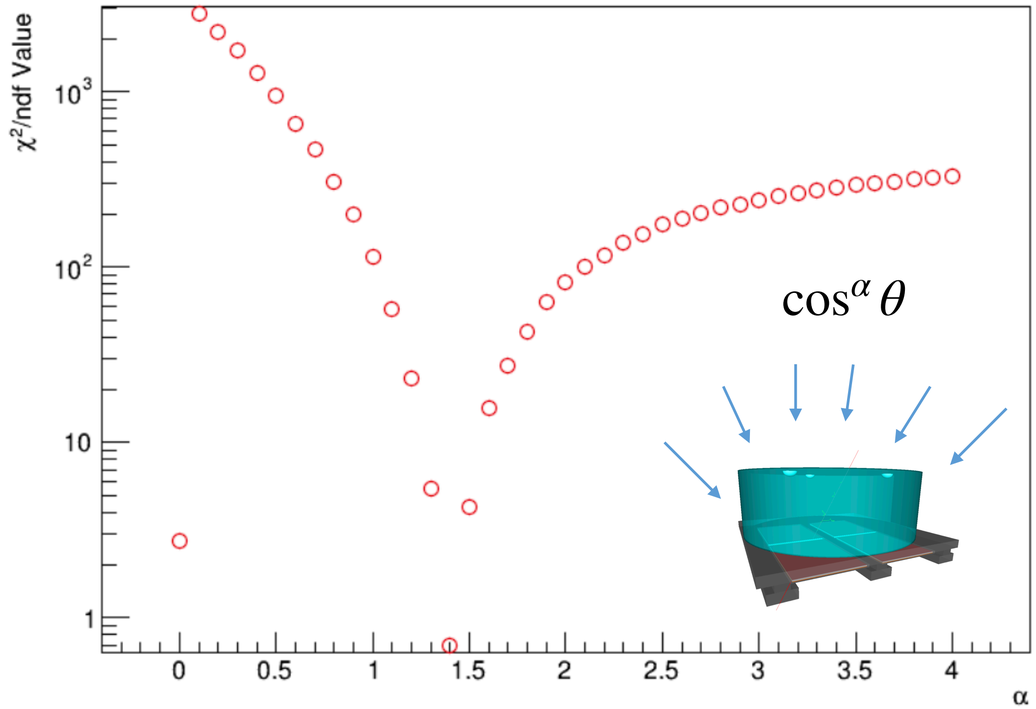


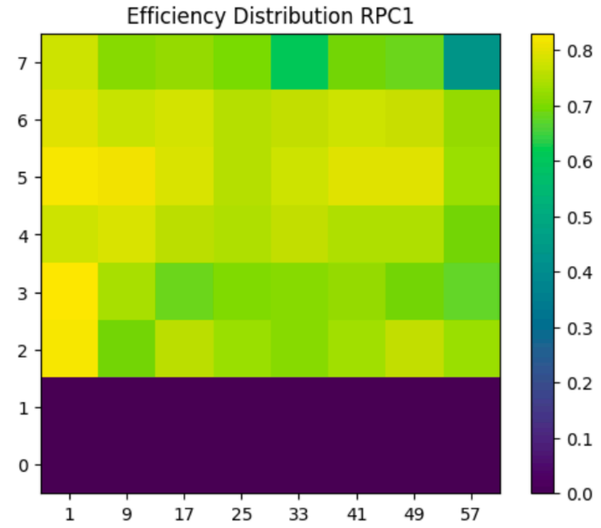


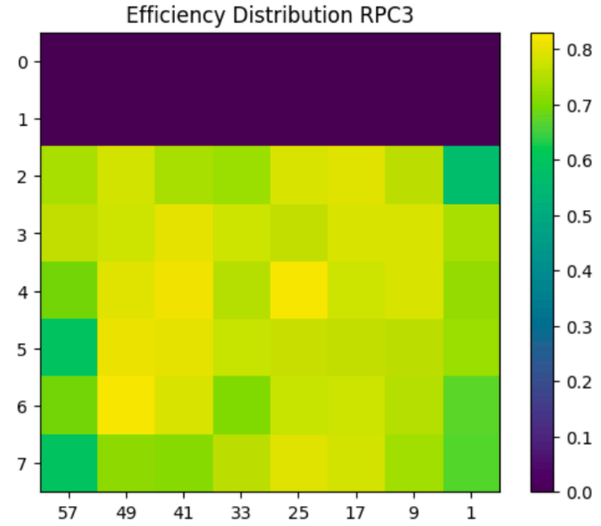
- **Use a simple MC code to look for potential misalignments between RPC1 and RPC3**
- Inject muons according to $\cos^{\alpha}\theta$ and collect *triggered* pads
  - Necessary to account for RPCs vertical separation
  - Best fit $(\Delta x, \Delta y) = (3.4 \pm 0.1, -0.2 \pm 0.1)\,\mathrm{cm}$

RPC pad efficiency calculation

$$\varepsilon_n = \frac{N_{\text{efficient}}}{\sum_{S_{\text{pad}}} N_{\text{trigger}} \cdot \varepsilon_{S_{\text{pad}}}}$$



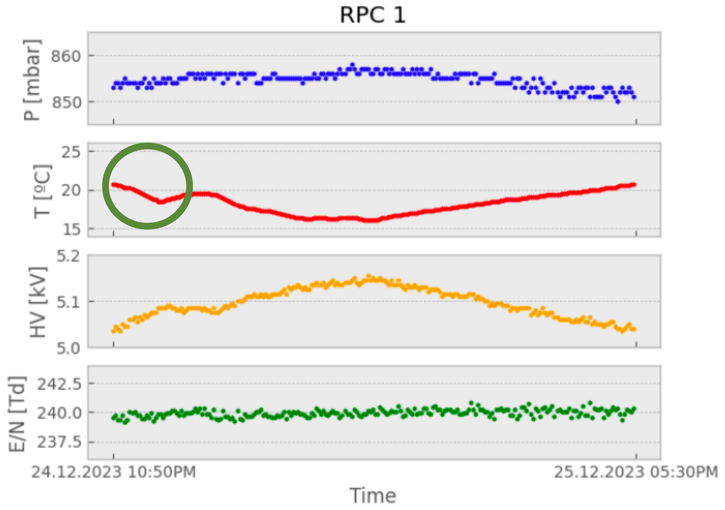


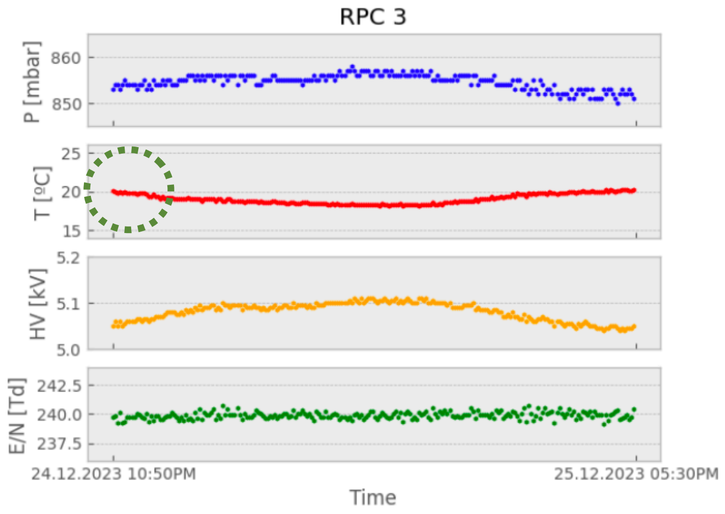


High-level of efficiency uniformity between pads

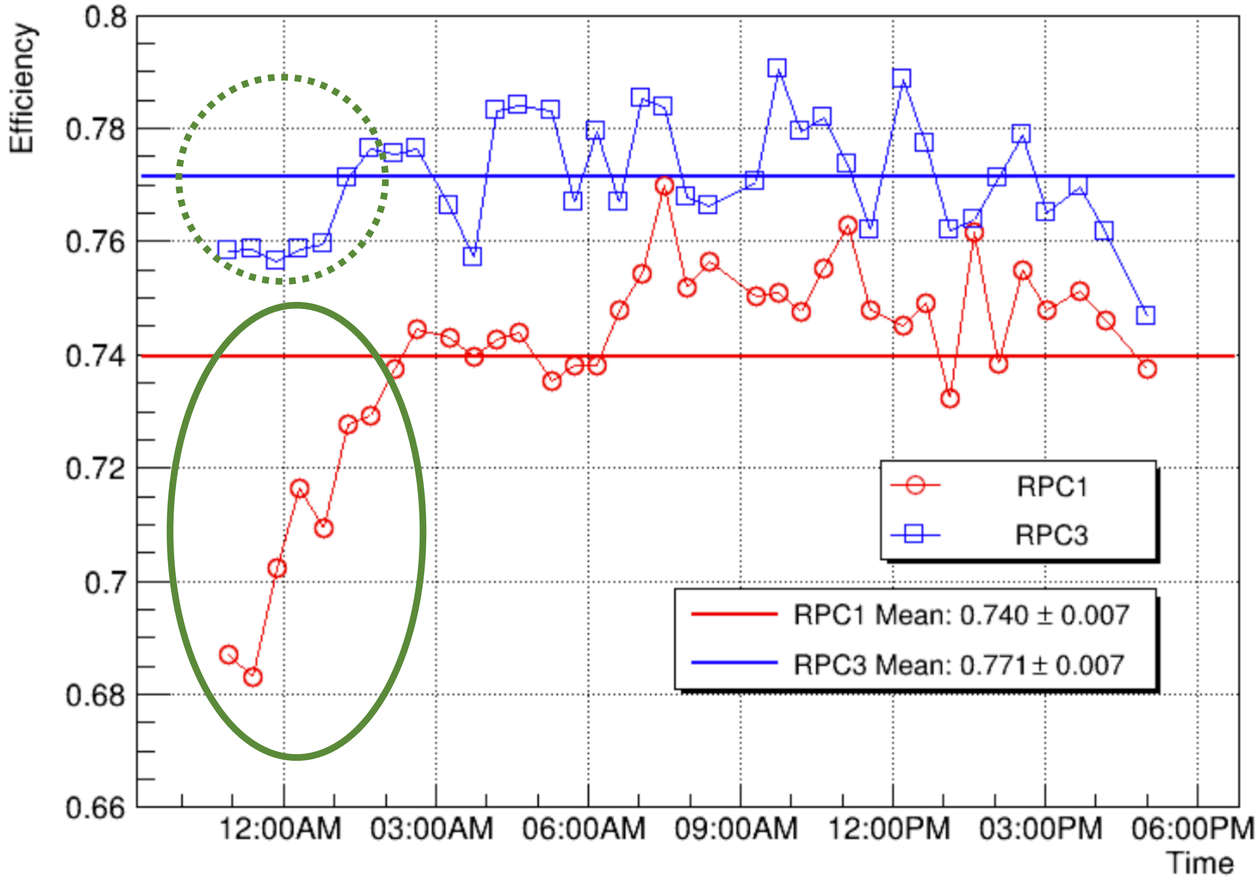
- Agreement between data and simulation RPC pads distribution depends on muon injection distribution (best agreement for $\alpha \approx 1.5$)
- **Efficiency calculation** is done accounting for **pad geometric efficiency**

Efficiency stability



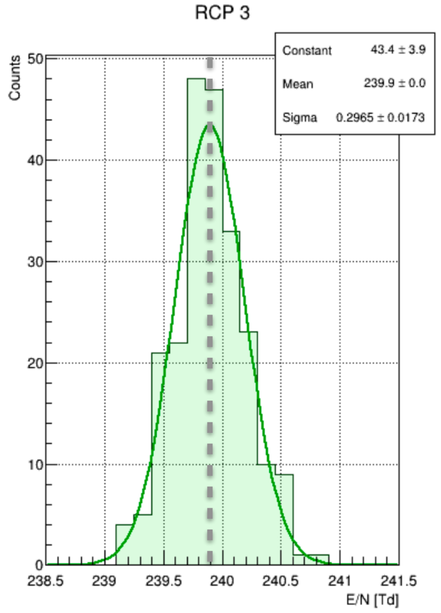


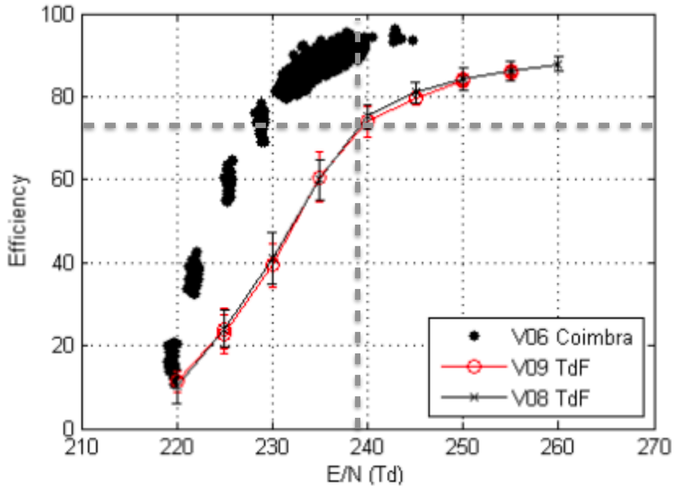
$$\frac{E}{N} = 0.01381 \cdot \frac{V_{\text{eff}}}{d} \frac{T + 273.15}{P} \quad \text{[Td]},$$

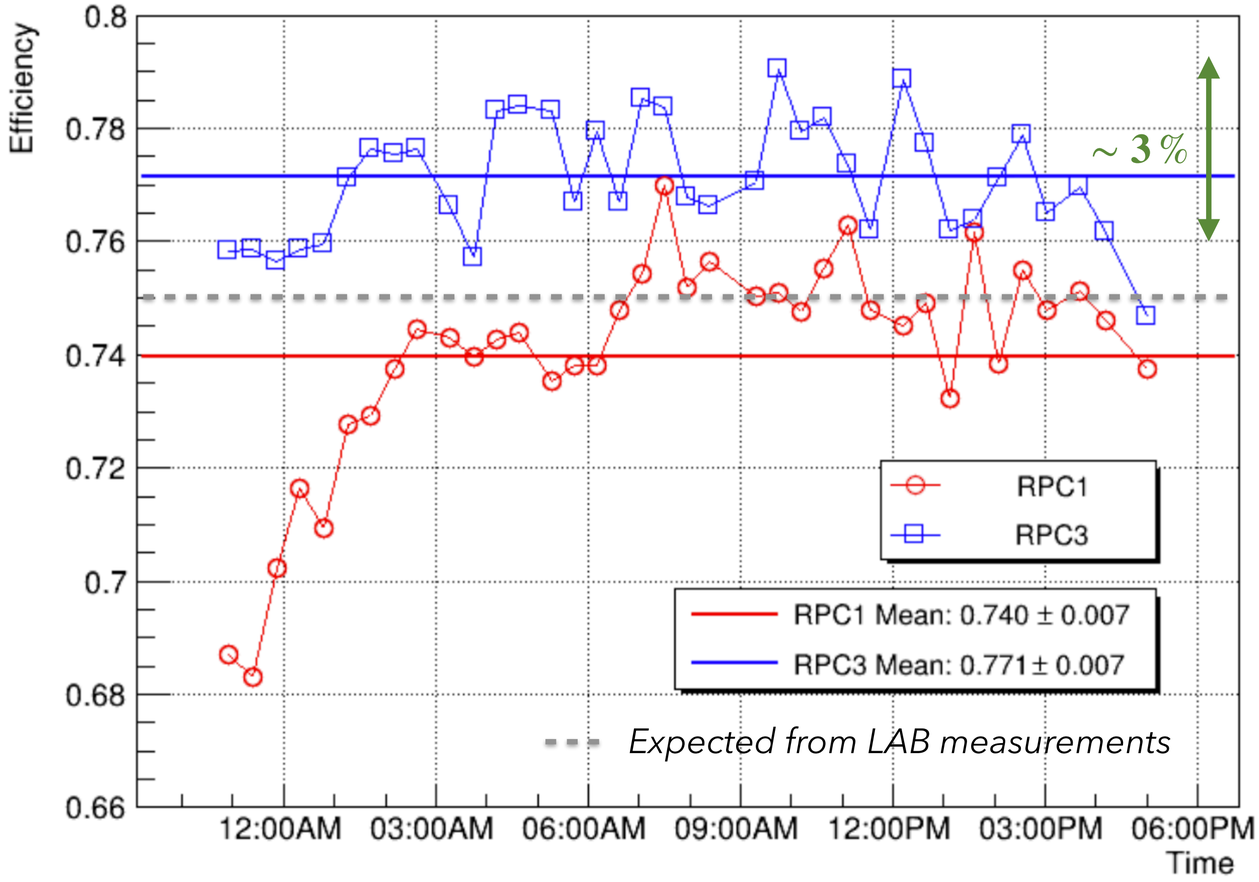


- RPC's HV adjusted to cope with temperature and pressure variations and maintain E/N stable
- The variation of efficiency RPC1 can be explained by potential problem with its temperature sensor

MARTA overall efficiency







- Global efficiency compatible with LAB measurements
- **Efficiency variations at the level of $\sim 3\,\%$**

Summary

- **First MARTA station commissioned and has been shown to have a stable operation efficiency ($\sim 3\,\%$)**

- Analysis of shower events with MARTA are currently being done

- Small detector interventions will be done during this meeting to make the apparatus more stable and allow for a continuous data acquisition

Acknowledgements

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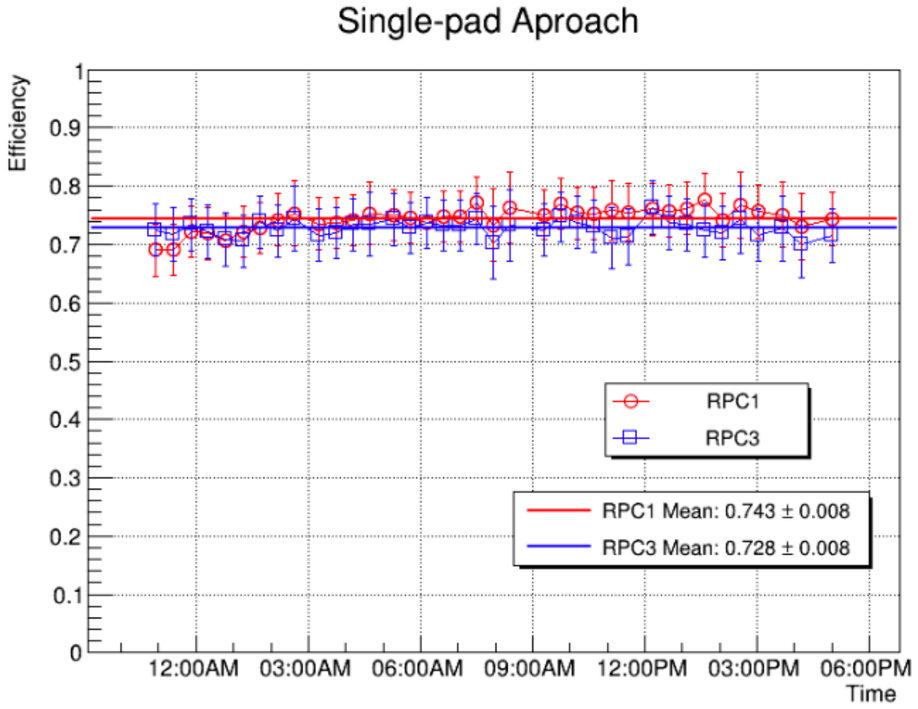
REPÚBLICA PORTUGUESA

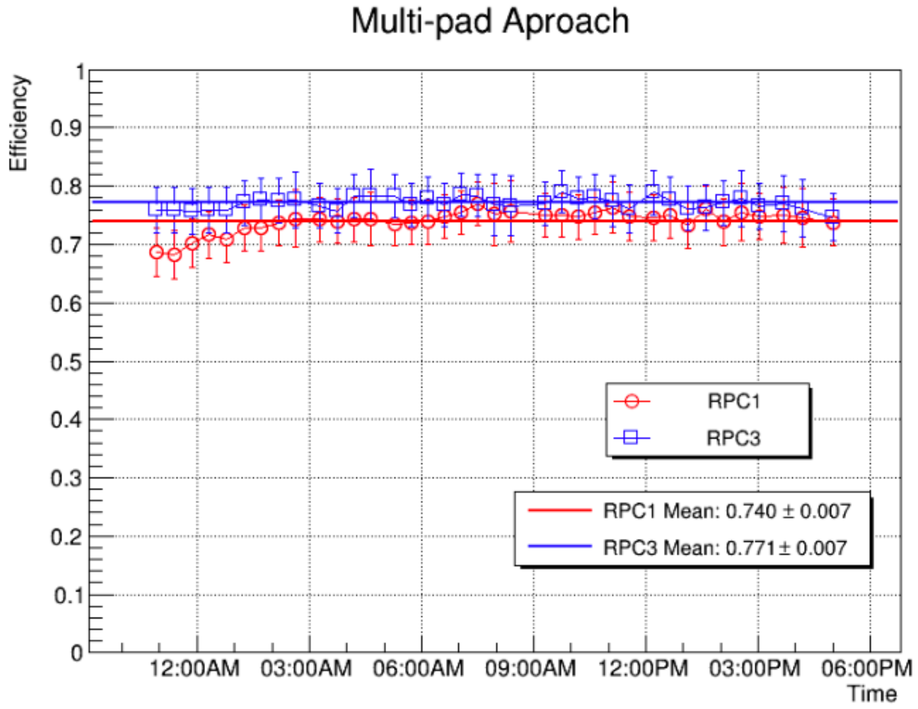
LIP

TÉCNICO LISBOA

Backup slides

Single vs. Multi-pad efficiency calculation





$$\varepsilon_{\mathrm{n}} = \frac{N_{\mathrm{efficient}}}{N_{\mathrm{trigger}} \cdot \varepsilon_{67}}$$

$$\varepsilon_{\mathrm{n}} = \frac{N_{\mathrm{efficient}}}{\sum_{S_{\mathrm{pad}}} N_{\mathrm{trigger}} \cdot \varepsilon_{S_{\mathrm{pad}}}}$$