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LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

MARTA engineering array

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Muon Array with RPC for Tagging Air showers

Eur. Phys. J. C (2018) 78:333
<https://doi.org/10.1140/epjc/s10052-018-5820-2>

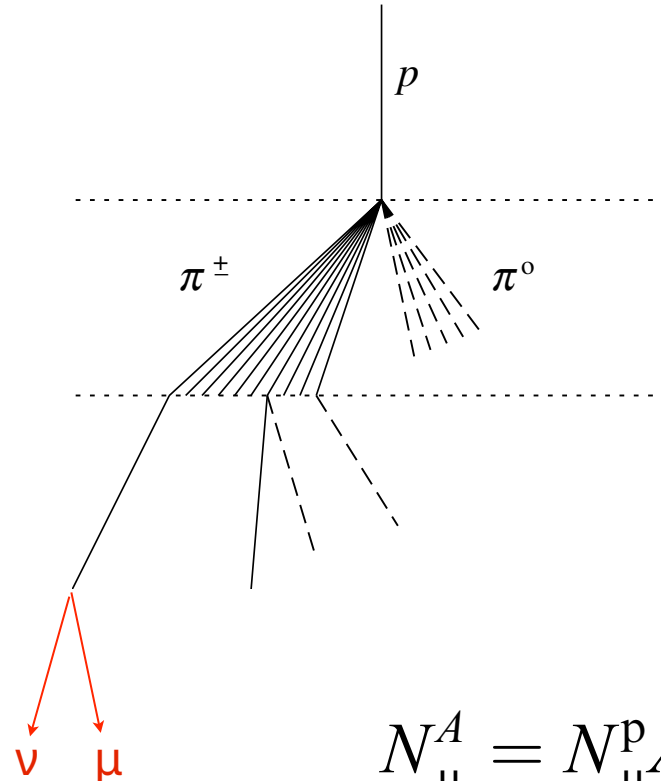
THE EUROPEAN
PHYSICAL JOURNAL C

Regular Article - Experimental Physics

**MARTA: a high-energy cosmic-ray detector concept for
high-accuracy muon measurement**

The importance of measuring muons

- Simple model for development of extensive air showers
- Muons carry information on the primary composition (also on properties of first hadronic interactions, F. Riehn talk)
- Photon showers are poor in muons

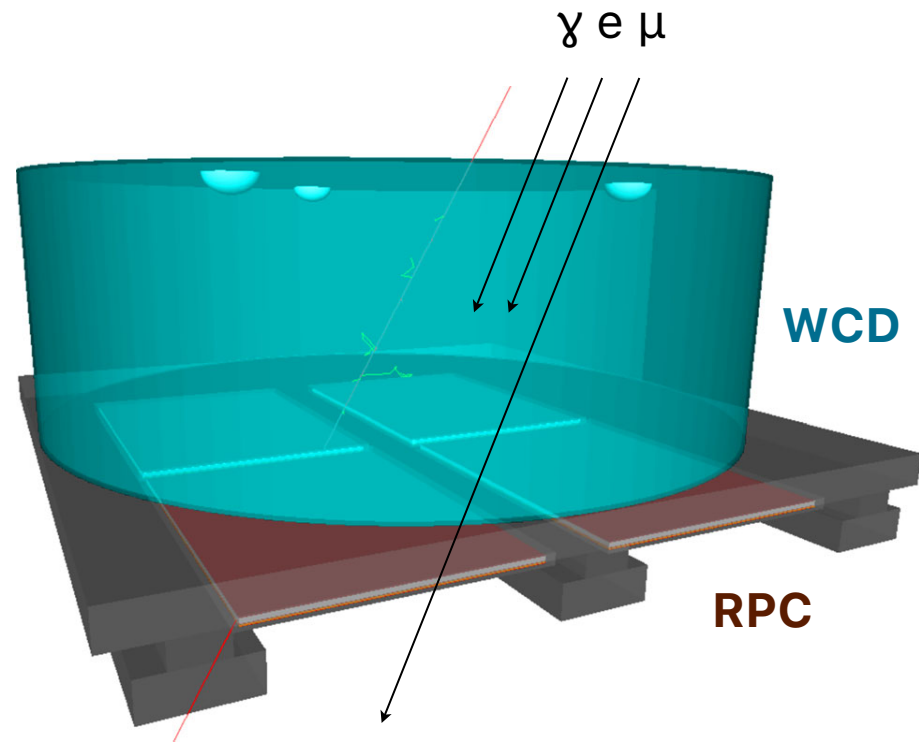


$$N_\mu^A = N_\mu^p A^{0.15}$$

proton vs atomic mass A

Concept

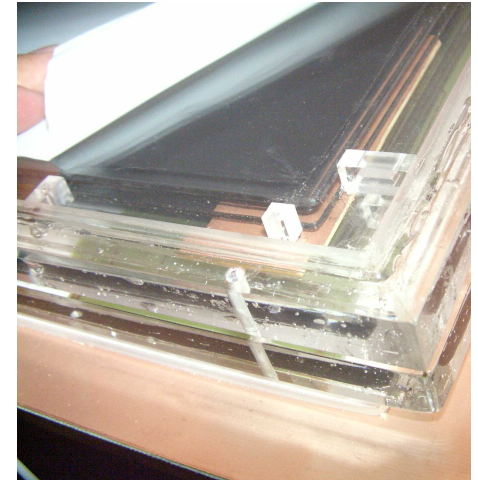
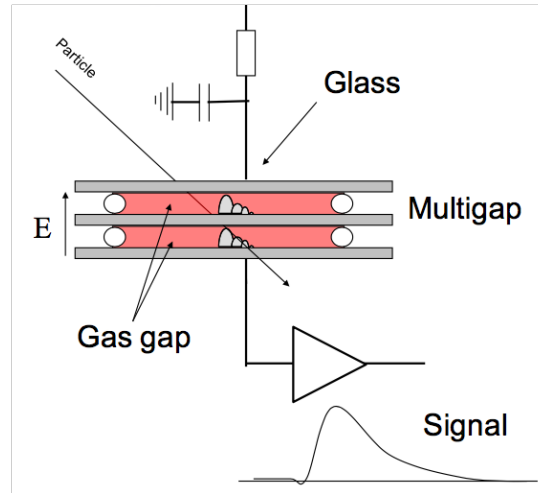
- Original proposal for the Auger upgrade
- WCD shields the electromagnetic component; accurate muon measurement in RPC below



The RPC modules

PoS(ICRC2017)379

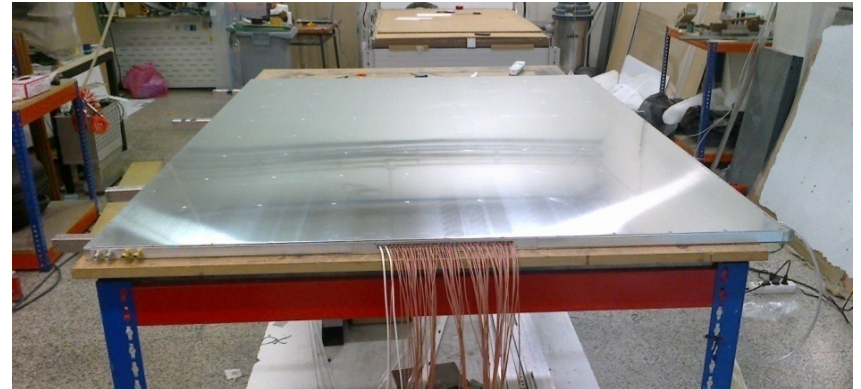
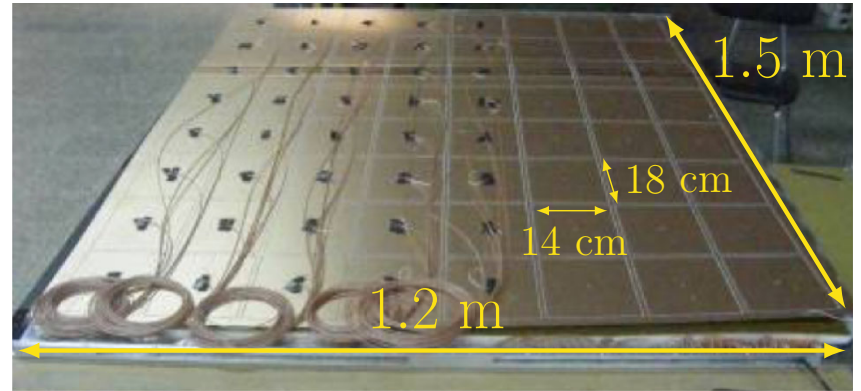
- Resistive Plate Chambers
- Gaseous detector with **very good time resolution**
- Extensive R&D on autonomous stations in LIP-Coimbra (L. Lopes talk)



sensitive volume
in acrylic box

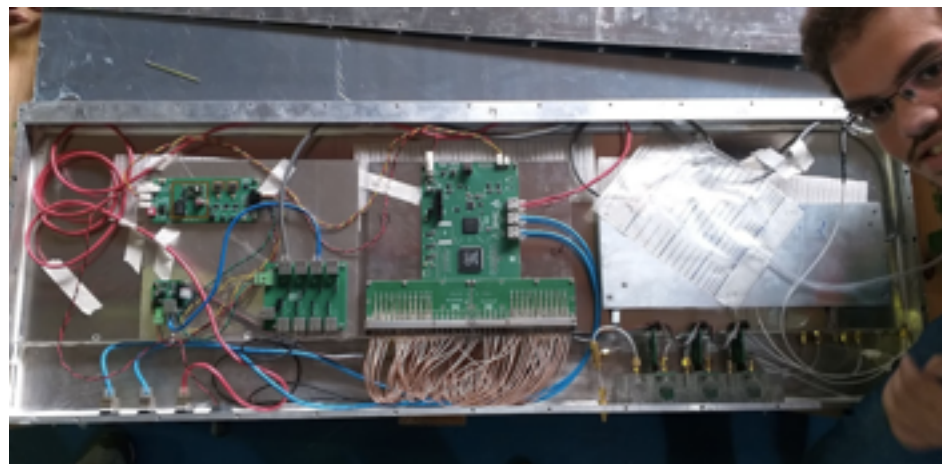
The RPC modules

- Readout plane segmented in pads for **position sensitivity**
- Enclosure in aluminum box
- Assembled in São Paulo



The RPC modules

- MAROC based DAQ developed in LIP-Lisbon
- Annex for electronics and high voltage with **reduced number of feedthroughs**
- Connected and tested in São Carlos



↑ data ↑ power supply ↑ gas

Field experience

- Concrete precast to hold the WCD produced in Malargue
- Less than one day to assemble one MARTA station



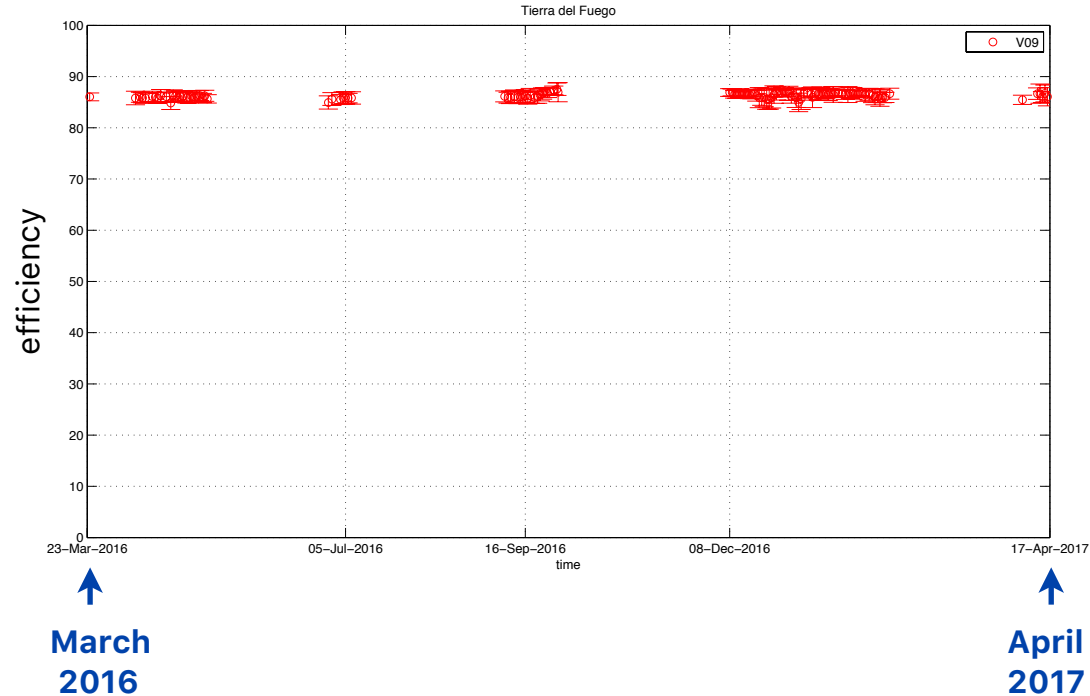
2x2 RPC



Field experience

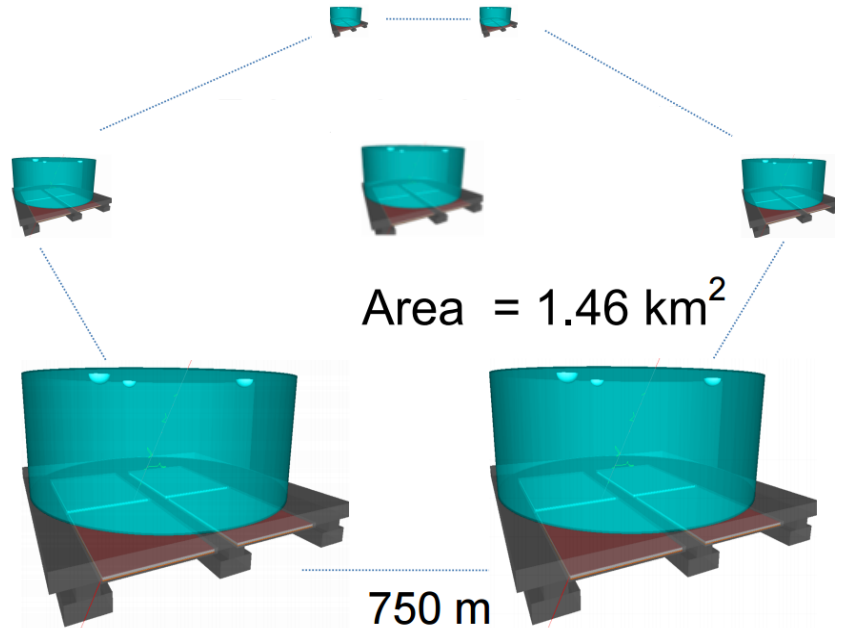
- Prototype RPC and electronics
- Stable, high muon-detection efficiency achieved outdoors in the field
- Gas flux down to 1 cc/min

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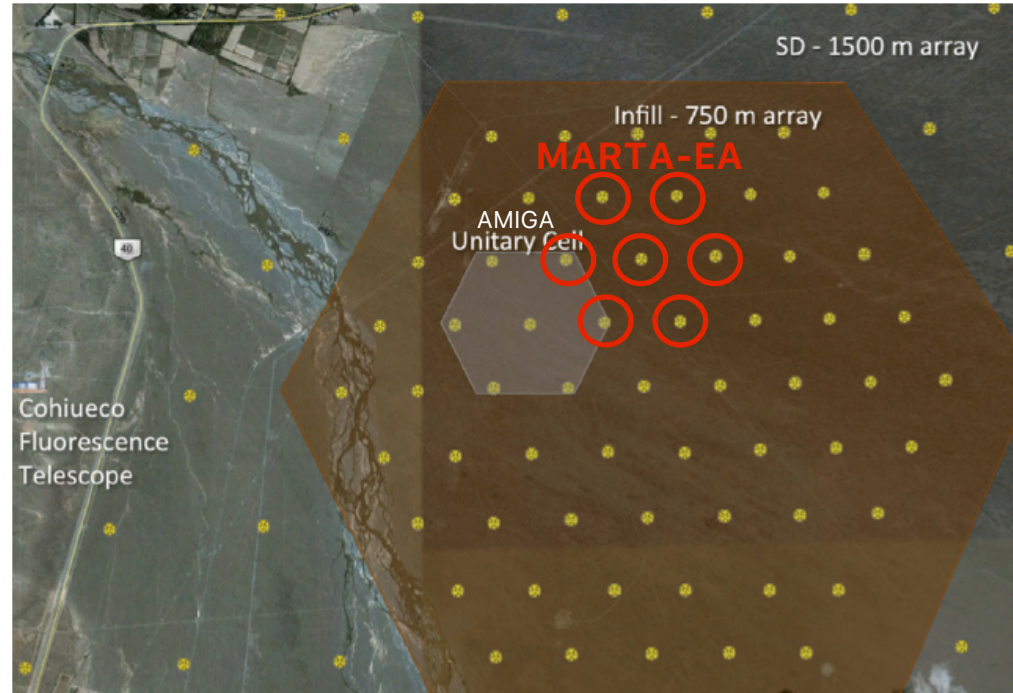
MARTA - EA

- Approved for installation on Auger hexagon:
MARTA-Engineering Array
- 7 stations → 28 RPC
- Maximize statistics with low energy showers → **Infill** region (750m station spacing)



MARTA - EA: location

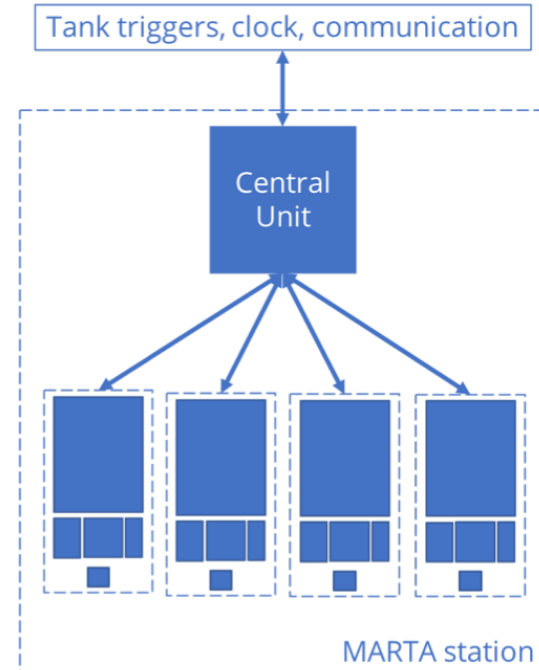
- Power, communications and synchronization provided by AMIGA
- Also at the site of the SSD-EA and AERALET
- Under the field of view of HEAT



MARTA - EA: status

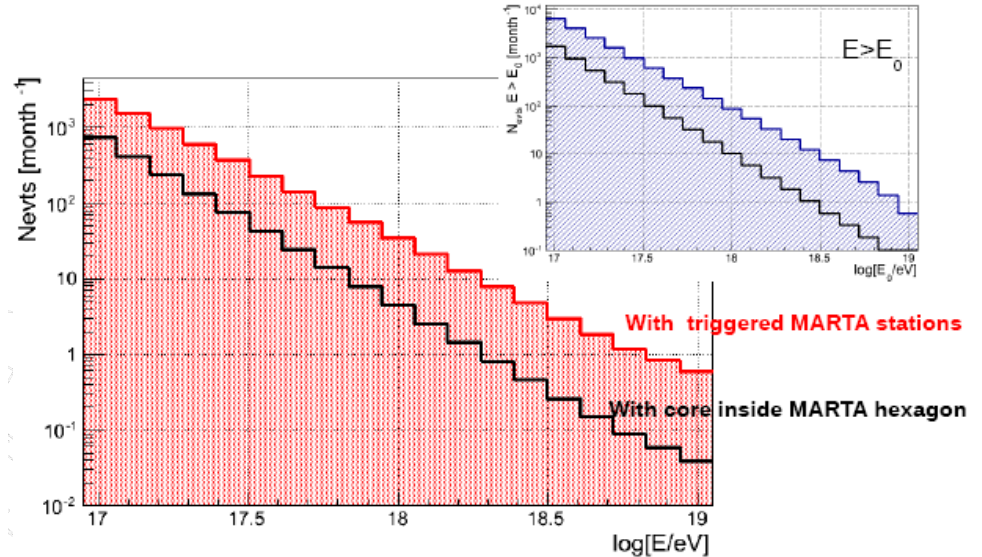
- Sensitive RPC volumes: ✓
- DAQs + power supplies: ✓
- Concrete precasts: ✓
- Assembled and arrived at Malargue: **22 RPC units**
- Installation in the field: **expected in September**

- Under development: **central unit**, data analysis software framework



MARTA - EA: events

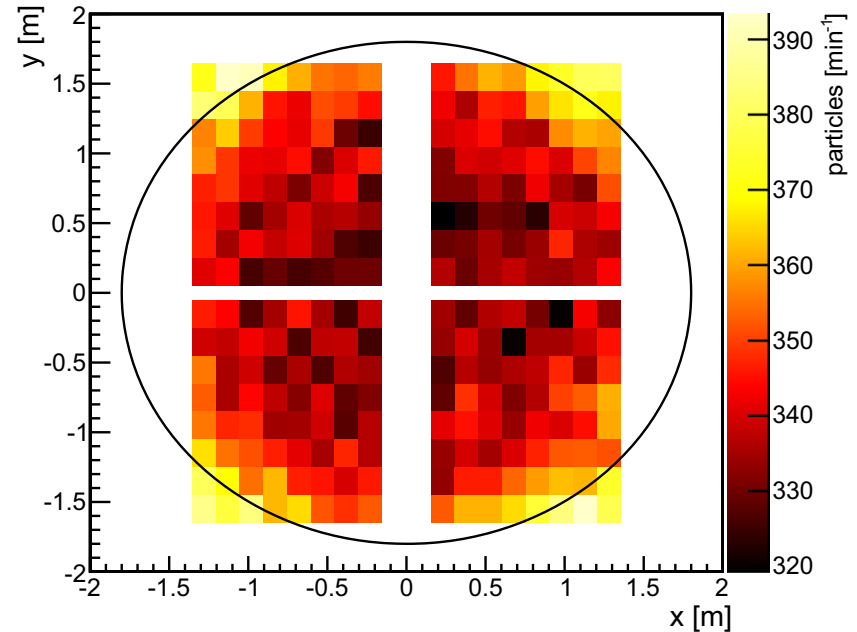
- Trigger provided by SD
- Data per pad will consist of: **hit/no-hit per 12.5 ns**
- About **1000 events per month** at **10^{17} eV**



Monitoring with atmospheric muons

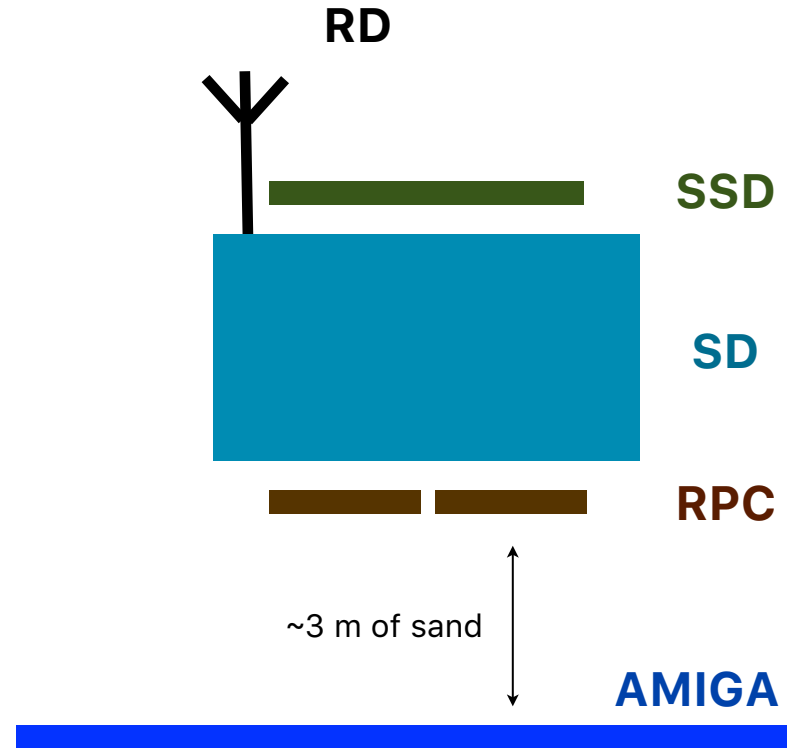
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- Calibration of the efficiency of the pads with the atmospheric muon flux
- Statistical precision of 1% every half an hour



Detectors cross calibrations

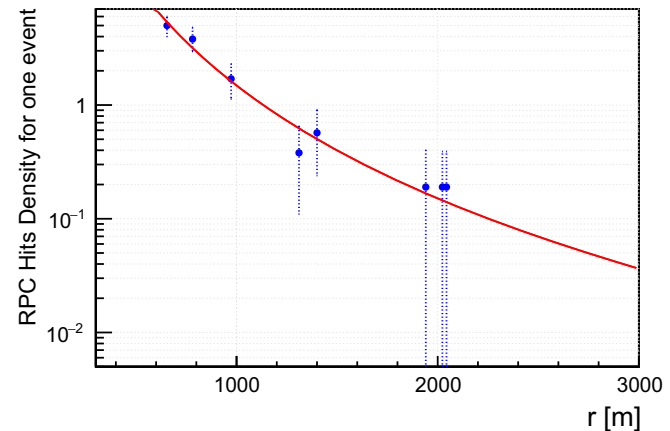
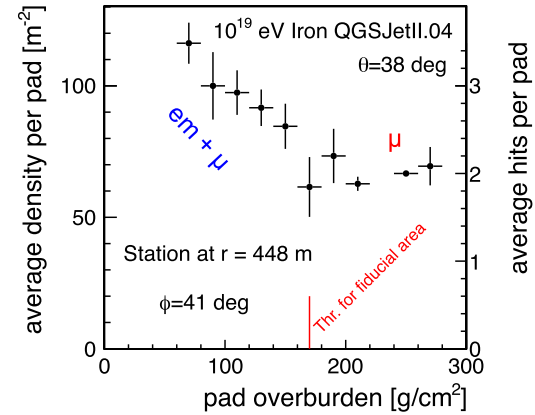
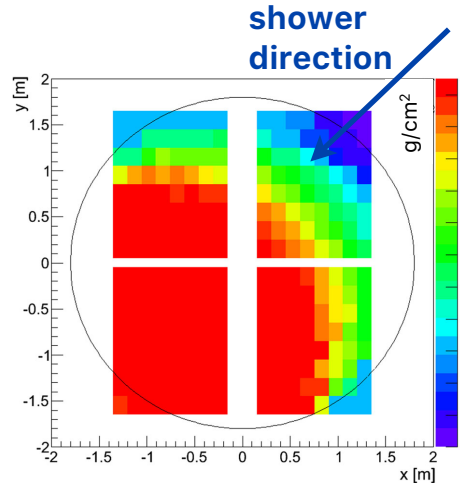
- Possibility for systematics studies and cross calibrations with remaining detectors



Measurement of the number of muons

- Analyses validated with simulations at 10^{19} eV: fiducial area definition, LDF and N_μ evaluation

- 10^{17} eV shower: equivalent proton first interaction center-of-mass energy ~ 14 TeV



RPC hodoscopes

- Setup in Malargue for SSD quality control



- Setup to study a test WCD response to atmospheric muons





Thanks

Acknowledgements:

