

MARTA: a novel detector at Auger

Ricardo Luz for the Auger group Jornadas do LIP Braga, February 2020

Muon measurement at Auger

Muons constitute one of the best links to the hadronic interactions in the EAS since these are created in the decay of the shower hadrons



Muon measurement at Auger

- The WCD measures a combination of the different components of the showers
- A direct, independent and accurate measurement of the muons allows to:
 - Have composition sensitivity on a shower-by-shower basis
 - Study hadronic interactions at the highest energies
 - Improve the sensitivity to photon primaries
 - Better understand and reduce the systematic uncertainties of many different measurements
- We proposed to measure the muons with RPCs



https://doi.org/10.1140/epjc/s10052-018-5820-2

MARTA Muon Array with RPCs for Tagging Air showers

- Four RPCs are placed inside a concrete structure underneath the WCD
- The mass above will act as shielding for the electromagnetic components
- The two detectors will measure the same particles, and the energies of the muons are mostly the same





MARTA Station

- Each station has four detector modules
- A Central Unit is responsible for the management of the modules and the interface with the WCD
- All the parts of the MARTA station were designed to comply with the strict demands of outdoors operations: limited space, power, minimal maintenance and reliability
- The concrete structure alleviates the significant daily temperature changes
- MARTA takes advantage of the WCD triggers and communications



Station - detector

- RPCs are widely used gaseous detectors of charged particles
- Developed and design by LIP Coimbra
- Each detector has an area of 1.5 × 1.2 m², and two 1 mm gas gap
- Readout plane has 64 14 × 18 cm² pick-up electrodes
- The detector is enclosed inside an aluminium box that also hosts the electronics







https://doi.org/10.1088/1748-0221/9/10/C10023 https://doi.org/10.1088/1748-0221/14/07/C07002 https://doi.org/10.1088/1748-0221/11/09/C09011

Station - electronics

https://doi.org/10.1088/1748-0221/11/08/T08004 https://doi.org/10.1109/TNS.2018.2879089

Readout front-end, high voltage, detector monitoring, central unit, and power supply unit









Station - expected performance

- The number of muons can be estimated as the number hits in the RPC pads within a fiducial area: pads with a mass overburden greater than 170 g/cm²
- Simulated trace of the WCD and RPC signals
- The expected rate of atmospheric particles is in the order of 5 – 7 Hz





Engineering Array

- An engineering array of 7 MARTA stations is being installed in Auger
- Collaboration with Brazil
- It will be used to study:
 - The MARTA concept, mainly how useful the combined measurement can be
 - Assess the RPCs performance in the field
- It can also be used to cross-calibrate other detectors in the array
- The MARTA EA will measure mostly events with primary energy between 10^{16.5} and 10^{18.5} eV.



Engineering Array

- All sensitive volumes and electronics have been produced and shipped to South America.
- 22 RPC modules have been delivered to the observatory, after being assembled in Brazil
- The first station is installed, data taking will start in the next few months
- 4 more stations will be installed this year





Auger's Infield Array Stations with MARTA

Applications – Hodoscope to test new detectors



- Installed in the observatory's assembly building
- It will be used to test the scintillators part of the full array upgrade
- The setup was validated using a small scintillator





Active event sensitivity (normalized)



Applications – Gianni Navarra tank

- RPCs used to study the WCD
- Single muons events were selected and their trajectory in the tank determined
- The signal in the tank is then analysed taking into account the muon trajectory





A collaboration paper is being prepared: "Studies on the response of a water-Cherenkov detector of the Pierre Auger Observatory to atmospheric muons using an RPC hodoscope"

Applications – Muon tomography





See more about it next in Pedro's talk

Thank You

