Analysis of the microstructure of Cosmic Ray air showers using the HADES RPC ToF wall detectors

J. A. Garzón[*1] *and G. Kornakov*[2] *on behalf of the HADES RPC ToF wall group*
[1]LabCAF, F. Física, Univ. Santiago de Compostela, Spain; [2]Technische Universität Darmstadt, Germany

Abstract

Five days long, in October 2009, during the commissioning of the HADES RPC ToF wall detectors, more than 30 million of events with cosmic ray data were taken with unprecedented accuracy at the Earth's surface. A careful analysis of those data did allow to study the microstructure of cosmic ray air showers and to unveil some evidence of previously unseen features.

The HADES RPC ToF wall commissioning

One of the most important steps in the upgrade of the HADES (High Acceptance DiElectron Spectrometer), aimed at increasing the nuclear masses accessible, was the development of a new time of flight wall based on the modern tRPC (timing Resistive Plate Chamber) technology. The new detector was commissioned using cosmic rays during a couple of months in Fall 2009 close to the HADES cave. During this period, all of the $\sim 1.2\ m^2$ sextants of the detector where operated in couples, one on top of each other, at a distance of roughly $30\ cm$. A very patient work was done in order to synchronize all read out channels, and getting a data sample offering a track time resolution of $\sim 170\ ps$, a mean position resolution of $\sim 5\ cm^2$, a granularity of $\sim 100/m^2$ and a track mean angular resolution of $\sim 4°$.

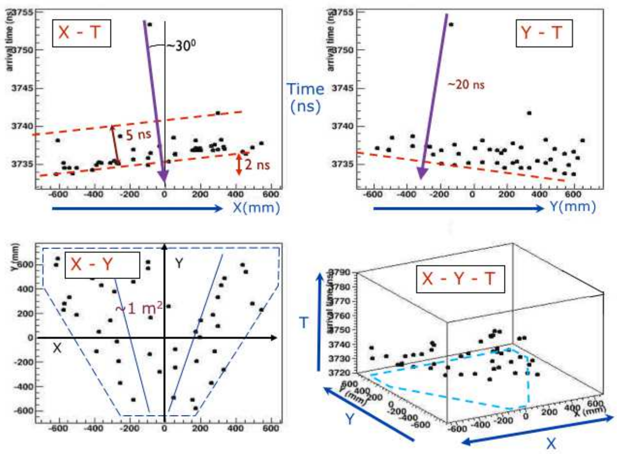

Figure 1: Example of high multiplicity event with all the space-time projections. Most of the particles arrive in a few ns time interval and one isolated particle arrived delayed by $\sim 20\ ns$.

* juanantonio.garzon@usc.es

The analysis of the data

Despite having detector cells of different shapes and sizes and a very odd truncated trapezoidal shape[1], we analyzed the data looking for the main features of the showers. Fig. 1 shows the space-time projections of a typical high multiplicity event.

Some of the most important effects we observed are [1]:

- Most of the high multiplicity showers show a sharp front edge allowing a good estimation of the arrival direction of the shower. A more detailed analysis showed that this direction is very well correlated with the arrival direction of the fastest particles.

- Using well known parameterizations it is possible to get an estimation of the energy of the primary cosmic rays for high multiplicity events. Unfortunately, we didn't have any external detector to perform an appropriate "calibration" of our detector.

- Many of the high multiplicity bundles of particles had a very much narrower time width (a few ns) than the typical widths observed using much bigger detectors with worse time resolution or granularity.

- Many of the bundles of particles detected seem to show a lumpy aspect. Perhaps those structures are due to narrow electromagnetic showers induced by the decay of high energy muons in the atmosphere. If this were the case, a more detailed analysis of the data could allow to make an estimation about the electron/muon ratio and, as a consequence, a guess of the mass of the primary cosmic ray.

In order to go deeper in the understanding of the observed effects, and to confirm or reject them, a spin-off detector, TRAGALDABAS [2], has been installed at the Univ. of S. de Compostela, in Spain, for the regular study of cosmic rays. The detector is also based on the RPC technology and make use of both the HADES RPC wall front-end electronics and the HADES TRB DAQ board.

References

[1] D. Belver et al. *Analysis of the space-time microstructure of cosmic ray air showers using the HADES RPC TOF wall.* JINST 7 (2012) P10007

[2] A. Blanco et al. *TRAGALDABAS: a new RPC based detector for the regular study of cosmic rays.* JINST 9 (2014) C09027

[1]The detectors were designed in order to offer a regular occupancy in central heavy nucleus-nucleus collisions.

 DOI:10.15120/GR-2015-1-MU-NQM-HADES-15