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Holographic Cosmic Ray Observatories (HOGROs)
A new approach to measuring primary cosmic rays

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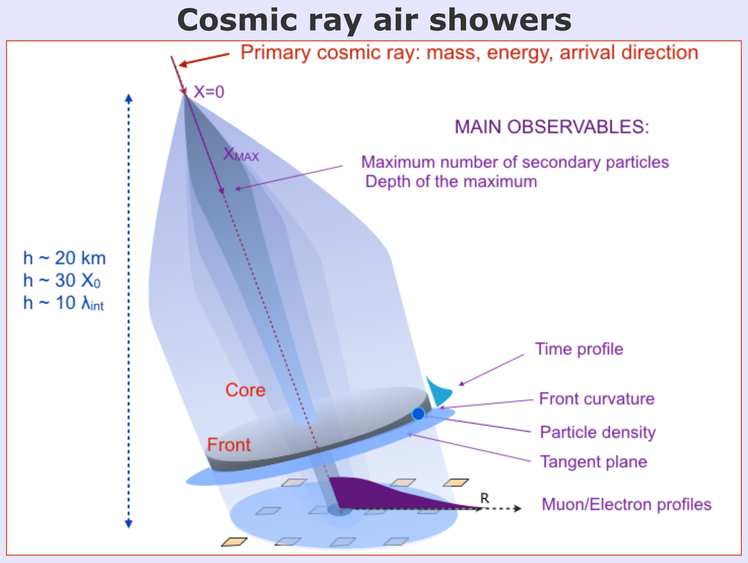
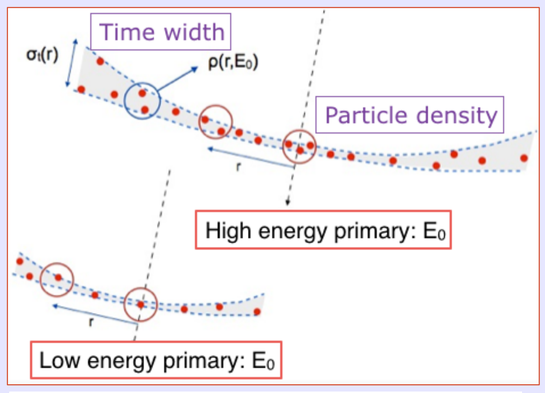
Introduction: The development of new generation high performance tracking detectors based on the RPC (Resistive Plate Chamber) technology opens the possibility of developing affordable stations able to provide simultaneously good estimates of the parameters defining primary cosmic rays: mass, energy and arrival direction. Independent measurements of the properties of a primary cosmic ray performed by a small set of such detectors would perhaps improve the existing methods. A comparison is done between the proposed method and the holographic photography.

Cosmic ray air showers

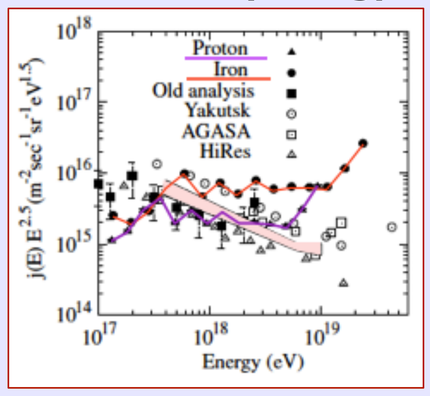


Primary cosmic rays are described by its mass, energy and arrival direction. High energy cosmic rays are usually analyzed indirectly from their air shower properties using large arrays of ground based stations.

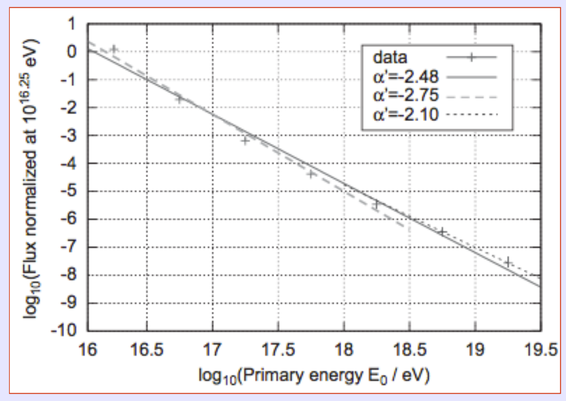
Cosmic ray energy



The energy of a high energy primary cosmic ray can be estimated from the time width and the particle density



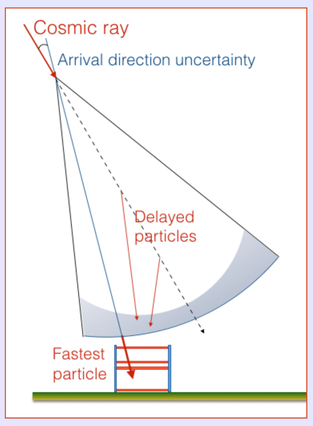
Energy spectrum estimated with a single detector [2]

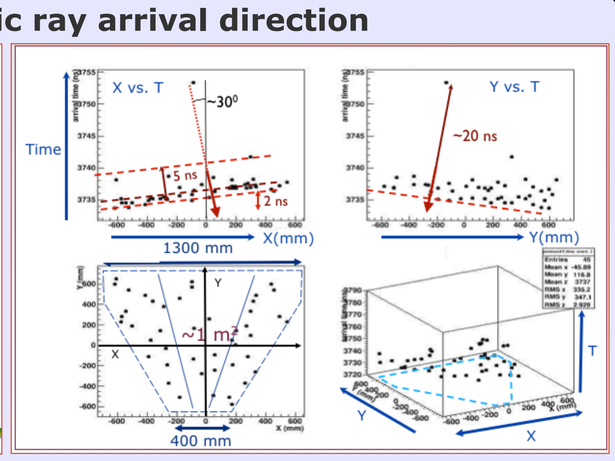


Energy spectrum estimated with a small array of detectors [3]

Cosmic ray air showers show some universal features allowing a few detectors to make good estimation of a primary cosmic ray energy with the help of existing parameterizations or ad-hoc simulations. J. Linsley [1] proposed "Instead of attacking the problem by assembling all the available resources in one place" the use of "numerous inexpensive mini arrays operating independently of each other". Several initiatives did use the Linsley method for estimating the primary cosmic ray energy with a single detector [2] or a small array of detectors [3].

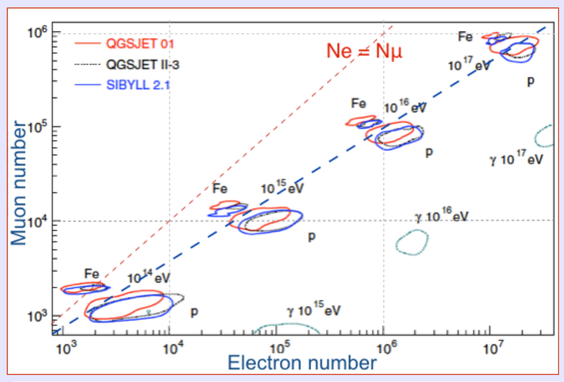
Cosmic ray arrival direction



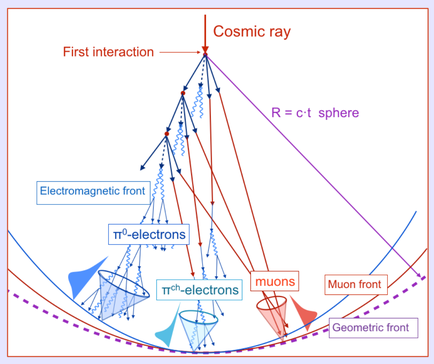


Analysis of high multiplicity air showers performed at the HADES experiment [4] (GSI, Darmstadt) show that a single high performance tracking detector may provide a good estimate of the arrival direction of the primary cosmic ray.

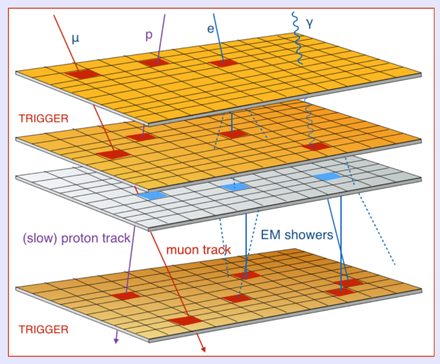
The mass problem



Electron vs. muon ratio for primary cosmic rays of different mass and at different energies [5]



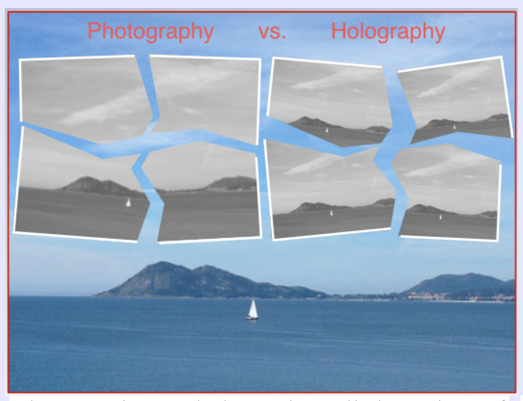
Electron and muon main components of a typical air shower



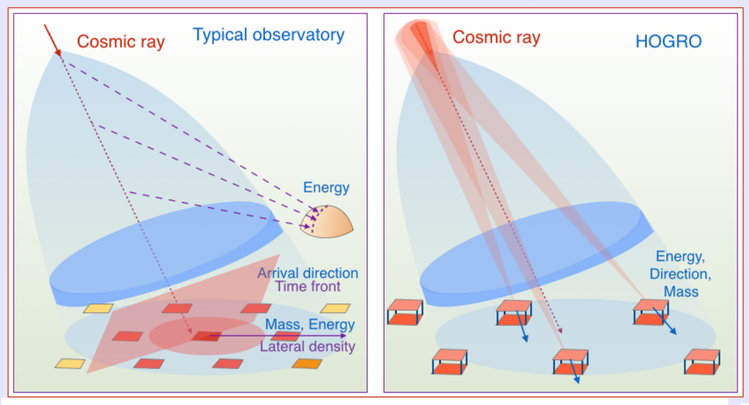
Layout and identification capability of a typical Trasgo detector [6,7]

The mass of the primary cosmic ray (photon, proton, a medium or a heavy nucleus) is usually estimated statistically with the help of MonteCarlo programs. One of the used signatures is the muon/electron ratio. A high-granularity, high time-resolution tracking detector could measure both electrons and muons and also separate soft and hard electromagnetic components.

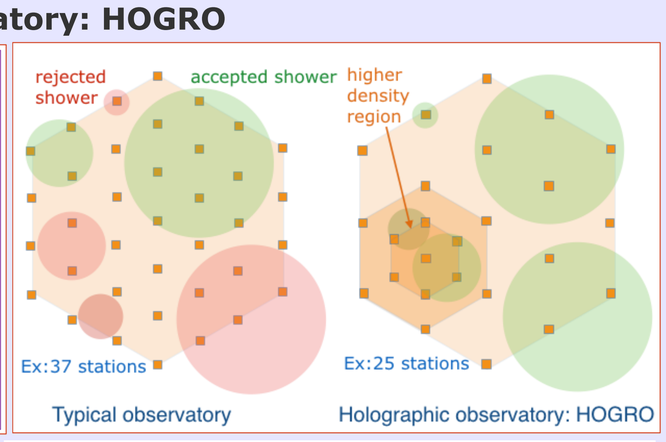
HOloGRaphic Observatory: HOGRO



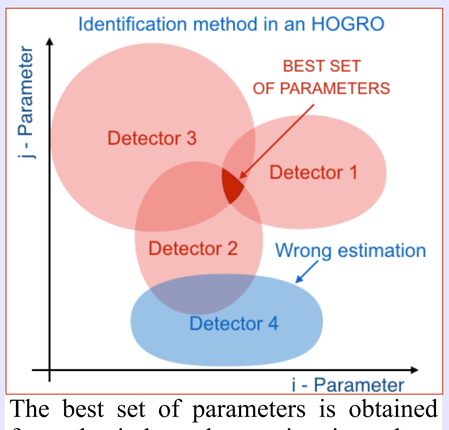
Photography vs. holography. All the points of an holography give information of the image.



A typical observatory vs. an HOGRO. All the HOGRO's stations do provide estimations of the three parameters of the primary C.Ray.



Example of layouts of a typical observatory and an HOGRO. HOGROS may work with lower densities of detectors.



The best set of parameters is obtained from the independent estimations done by all the stations.

The development of high resolution detectors able to provide independent estimates of the parameters of a primary cosmic ray would open the possibility of developing a new kind of cosmic ray observatories we call Holographic Observatories, HOGROs. In parallel with holography, where every point of the plate contains the whole information of the image, every detector of the observatory would provide an estimation of all the parameters of the detected cosmic ray. The more detectors have been fired by the shower, the better the estimate would be. Such observatories would provide several advantages respect traditional observatories (perhaps at a higher cost)

- HOGROS would need smaller density of detectors
- An HOGRO with zones having different density of detectors would allow to cover a wider range of energies of the primary cosmic ray.
- HOGROS do not need a regular layout of detectors. Then, they can be easily installed in research laboratories, universities, etc.
- Incompatible parameter estimations among detectors would allow to improve parameterizations and MonteCarlo codes.
- Better parameterizations and a better knowledge of the inner properties of an air shower space-time structure may allow HOGROS to perform very much better estimations that the ones reachable by traditional observatories.

Summary & Conclusions

We propose to update and to improve the proposal of J. Linsley of using independent mini arrays for the measurement of high energy cosmic ray using new generation high performance tracking detectors, or Trasgos. We will follow the next steps:

- Improve our knowledge of the properties of cosmic ray air shower using both simulated events [see Poster: S. García et al.: *Systematic analysis of the properties of low energy cosmic ray extensive air showers*. This conference] and identify new observables able to provide a better estimation of the parameters.
- Determine what are the minimum performances and size needed for single tracking detector to provide a fair estimate of the parameters of the primary cosmic ray
- Develop multivariate techniques for the better estimation of the parameters of the primary cosmic ray

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