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CaloCube: a new concept calorimeter for the detection of high energy cosmic rays in space

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The direct measurement of cosmic rays spectrum up to the knee region is a crucial point for the improvement of our knowledge on the mechanisms responsible for production, acceleration and propagation of cosmic rays. At present, calorimeters are the best suited detectors to reach this instrumental challenge because they offer good performances in terms of geometrical acceptance and energy resolution. In order to exploit this potential, the design of calorimeters must be carefully optimized to take into account all limitations related to space missions, due mainly to the mass of the experimental apparatus.

CaloCube is a three-years R&D project, approved and financed by INFN in 2014 aiming to optimize the design of a space-borne calorimeter. The basic idea is to develop a cubic calorimeter whose geometry is designed as homogeneous and isotropic as possible, so as to detect particles arriving from every direction in space, thus maximizing the acceptance. Another important feature of the detector is the high granularity, because having a fine 3D sampling capability is necessary to achieve a high discrimination power for hadrons and nuclei with respect to electrons.

In order to optimize detector performances with respect to the total mass of the apparatus, comparative studies on different scintillating materials, different sizes of crystals and different spacings among them have been performed making use of MonteCarlo simulations. In parallel to simulations studies, several prototypes instrumented with CsI(Tl) cubic crystals has been constructed and tested with particle beams (electrons, protons and ions). An overview of the results obtained so far will be shown and the perspectives for future space experiments will be discussed.

In addition, we will present the TIC (Tracker-In-Calorimeter) project, thought as the natural development of CaloCube and financed by the INFN for 2018. The basic idea is to study the feasibility of including several silicon layers at different depths in the calorimeter in order to reconstruct the particle direction. Respect to the traditional approach of using a tracker with passive material in front of the calorimeter, the TIC solution can save a significant amount of mass budget in a space satellite experiment, that can be therefore exploited to improve the acceptance and the resolution of the calorimeter. While the upgrade of the prototype for the beam tests scheduled for this year is currently in progress, we will present the studies realized so far making use of MonteCarlo simulations.

Secondary topics

Applications

Design concepts for future calorimeter at the cosmic frontier

Primary topic

Crystals

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