CHERCAM: A Cherenkov imager for the CREAM experiment

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Abstract

The CREAM experiment (Cosmic Ray Energetics and Mass) is dedicated to the measurement of the energy spectrum of nuclear elements in cosmic rays, over the range 10^{12} to 10^{15} eV. The individual elements separation, which is a key feature of CREAM, requires instruments with strong identification capabilities. A proximity focused type of Cherenkov imager, CHERCAM (CHERenkov CAMera), providing both a good signature of downgoing Z=1 particles and good single element separation through the whole range of nuclear charges [1], is under development. After a brief introduction, the main features and the construction status of the CHERCAM are being summarized.

Key words: Cosmic rays, Cherenkov detector, charge identification
PACS: 29.40.Ka, 96.40.-z, 96.40.De, 96.50.Pw

1 Introduction

The CREAM experiment addresses open questions on the nature and the origin of charged particles cosmic rays. It has begun to measure high energy cosmic rays at the frontier of the statistical limits accessible to space-based experiments. Measurements of the cosmic ray spectrum of nuclear elements from proton to iron in the energy range $\approx 10^{12}$ to 10^{15} eV, will provide invaluable data on cosmic ray spectral characteristics and/or abundance changes which could be related to the acceleration limit in the shock front of supernovae. They will also provide the first measurements of secondary to primary ratios, like B/C, in this energy domain. The individual nuclear elements separation will allow to probe the current models of acceleration mechanisms, and will provide hints for the interpretation of the "knee" in the inclusive spectrum, and for the physics of cosmic ray galactic transport.

CREAM is planned to be the first experiment to be flown on a new Ultra-Long Duration Balloon (ULDB), currently under development by the NASA.

The experiment includes a set of subdetectors able to measure the particle energy and charge [2]. The energy measurement is performed by means of a hadronic calorimeter with nearly constant resolution over the three orders of magnitude covered. The calorimeter can be combined with a TRD in some flight configurations. The particle charge measurement will cover the range $1 < Z <\approx 30$ with a charge resolution better than 0.3 charge unit expected. This charge resolution will be achieved by means of a combination of scintillation hodoscope, silicon pad counters, and a Cherenkov imager CHERCAM, optimized for charge measurements and providing a constant resolution through the range of nuclear charge.

2 CHERCAM architecture

CHERCAM is a proximity focusing imager derived from the solution developed for AMS experiment, whose principle is illustrated in Figure 1.

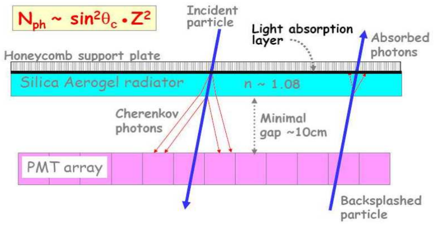

Fig. 1. *Scheme of the Cherenkov imager principle.*

The Cherenkov radiator consists in a 1 cm-thick silica aerogel plane, made of 11x11 cm^2 tiles with a refractive index around 1.07.

The Cherenkov radiator plane is separated by a 10 cm ring expansion gap, from a photon detector plane consisting of a 1600 photomultiplier tubes array (Photonis XP3112), backed with dedicated front-end electronics, power supply, and read-out electronics. The latter employs the same 16-channel ASIC circuit than the one used for the AMS Cherenkov imager [3].

The mechanical structure of the detector is illustrated in Figure 2. The counter is divided into two frames for mechanical reasons. The aerogel will be fixed onto the top lid while the lower frame will contains the photomultipliers array.

3 CHERCAM simulation

The development of a GEANT4 simulation of CHERCAM is in progress, to investigate the detailed features of the detector, validate the technical choices and study the limit of the detector performance. The simulation includes the photomultipliers modeling and contains as physical

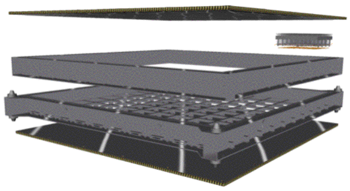

Fig. 2. *Exploded view of the CHERCAM mechanical structure. The detector plane is arranged in* 5×5 *blocks of 64 PMT. Each block is divided into 4 modules of* 4×4 *PMT, each being read out by a single 16-channel FE electronics circuit.*

processes, the Cherenkov effect , the Rayleigh scattering and reflection. The photocathode quantum efficiency is also taken into account according to the data given by the PMT manufacturer.

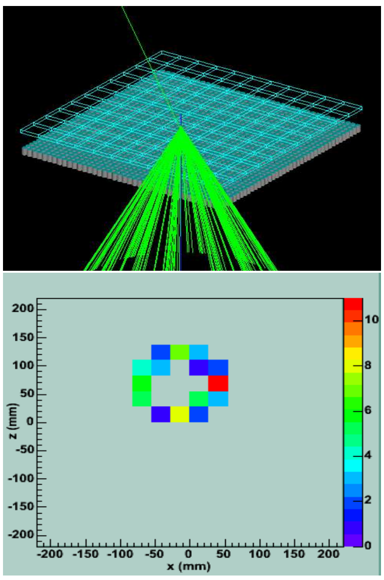

Fig. 3. *Example of a simulated event (top) in the Cherenkov counter (1 TeV Helium) and photon impacts detected (bottom)*

Reconstruction codes are being developed, with a special interest in the control of the geometrical efficiency determination. The first results of the simulation show that a combination of incident particle position reconstruction and ring overlap study can provide a charge reconstruction better than $\Delta Z = 0.3$ over the full range of charges concerned (see figure 4).

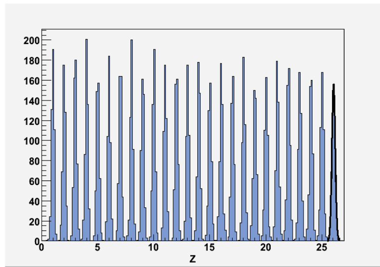

Fig. 4. *Charge reconstruction for 11000 simulated events uniformly distributed in charge.*

4 Conclusion

The development of the CHERCAM subdetector for the CREAM experiment is ongoing. The construction is in progress and two third of the counter are expected to be ready for a beam test at CERN SPS in October 2006. CHERCAM will be integrated in the CREAM detector at the beginning of next year and participate to the 2007 flight campaign.

Part of this program has been conducted under the INTAS contract 03-52-5579.

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