KASCADE-Grande: the Grande Array

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The KASCADE-Grande experiment is starting data taking at Forschungszentrum Karlsruhe, Germany, with the aim of extending the energy range of KASCADE up to $E_0 \sim 10^{18}$ eV. The new experiment is based on the KASCADE facilities, and two new arrays: Grande and Piccolo, with the respective aims of realizing a large acceptance area and a compact interface triggering system. The characteristics of Grande its performances concerning the dynamic range and timing measurements are presented.

1. Introduction

The purpose of the KASCADE-Grande experiment is to investigate the range of the primary energy spectrum between 10^{16} and 10^{18} eV that, in the hypothesis of a knee occuring at constant rigidity, includes the change of slope of the iron component of primary cosmic rays. The search for this feature of the primary spectrum, the reconstruction of primary cosmic ray composition and studies of hadronic interactions at these energies are the main aims of the experiment. In this paper the status of the new arrays are described. A description of the project and of its characteristics can be found in [1]; a discussion of the reconstruction

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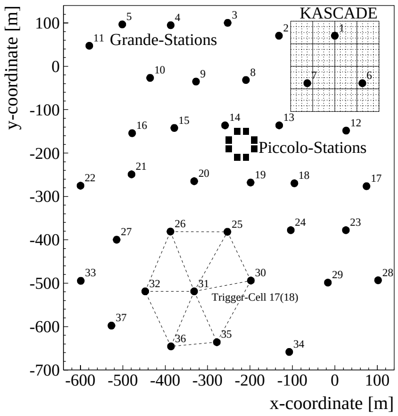

Fig. 1. Layout of the KASCADE - Grande experiment. The dashed lines show one of the cluster used for triggering the Grande array.

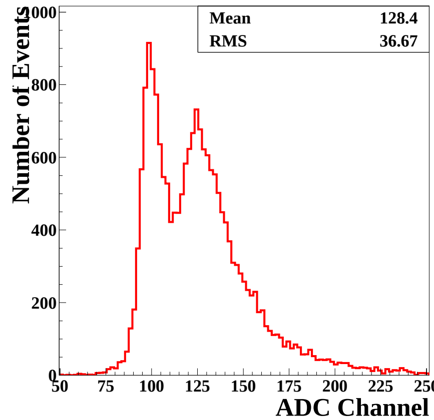

Fig. 2. Single particle spectrum measured in one of the Grande stations.

capabilities of the array is presented in [2].

2. The Grande Array

The Grande array is located at Forschungszentrum Karlsruhe around the KASCADE detectors, made of 37 stations with a mutual distance of 130 m placed in a hexagonal grid covering an area of 0.5 km^2 (figure 1). Each detector has a total surface of 10 m^2 segmented into 16 plastic scintillators 80×80 cm^2 and 4 cm thickness (from the former EAS-TOP experiment [3]). All scintillators are seen by photomultipliers (Philips XP3462, HG, High Gain, in the following) whose signals are summed and used for timing and low particle density measurements ($\sim$ 1.6 pC/m.i.p., at mixer's output). The four central ones are viewed by a second photomultiplier of the same type working at a lower gain (LG, 0.08 pC/m.i.p.), used for highest particle density measurements.

The analog signals of both the HG and LG photomultipliers are fed into two shaping amplifiers (CAEN N442). The charge integrating preamplifier has a decay time of 20 μs, its output is processed by a shaper, with peak time of 8 μs. The gains of different channels are set in order to measure from 0.3 m.i.p. up to $\sim 3 \times 10^4$ m.i.p.. This is obtained through two outputs for HG signals, 25 and 2.5 mV/pC respectively, and one for LG signals, 5 mV/pC. The three outputs are tuned to cover the following particle ranges: from 1 to $\sim$ 200 m.i.p. (*a)*), from $\sim$ 10 up to $\sim$ 2000 m.i.p. (*b)*) and from $\sim$ 200 m.i.p. up to $\sim 3 \times 10^4$ m.i.p. (*c*). The peak height is read, at the end of a 700 m long cable, through a peak ADC (CAEN V785, 12 bits, 8 V full scale).

Detector calibration is performed measuring the single particle spectrum (on ADC scale *a)*) from each station (figure 2), the ADC scales *b)* and *c)* are calibrated using run time data. Figures 3 and 4 show the correlations between ADC scale *b)* and *a)* and scale *c)* and *b)* measured in one station during a $\sim$ 60 hours long data taking. The result of this procedure, i.e. the particle number spectrum measured in one station, is shown in figure 5, which also shows the ranges where the different ADC scales overlap. The detectors m.i.p. spectrum is continuously monitored (to account for possible day-night effects a spectrum is produced every 10 hours).

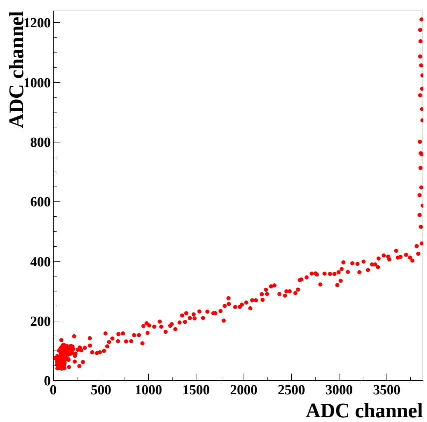

Fig. 3. Correlation of the ADC scales *b)* vs. *a)*

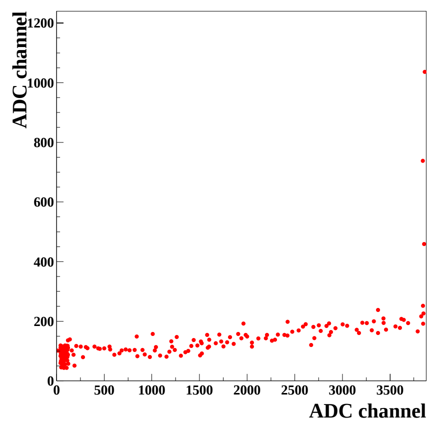

Fig. 4. Correlation of the ADC scales *c)* vs. *b)*

Timing is measured through a TDC CAEN V767 which allows to open a time window around a trigger signal provided by the OR of the 18 clusters. All firing times from all detectors inside a window of $\pm$ 5 μs around the trigger are measured. The time resolution between signals of the same channel is 300 ns. The TDC step is 0.78 ns/channel. Timing and triggering signals from stations are generated by a double threshold discriminator: the lower one is used for timing (set at $\sim$ 0.1 m.i.p.) and the higher one for triggering ($\sim$ 0.3 m.i.p.).

The Grande array is triggered by both the Piccolo array and internally. For the internal trigger the detectors are divided in clusters of hexagonal shape, with six stations surrounding a central one. The minimum trigger requirement is the fourfold coincidence of a central and three neighbouring stations in one hexagon. The array is thus divided into 18 interconnected clusters, the trigger rate is $\sim$ 5 Hz. The event rate of a sevenfold coincidence (i.e. a whole cluster) is 0.4–0.5 Hz. Figure 5 shows the distribution of the event rate as a function of the number of clusters fired. It can be noticed that there is an event every $\sim$ 10 minutes where all clusters have triggered.

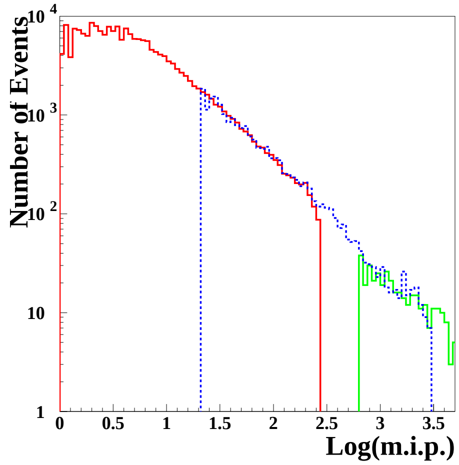

Fig. 5. Particle number spectrum measured in a 60 hours long data taking.

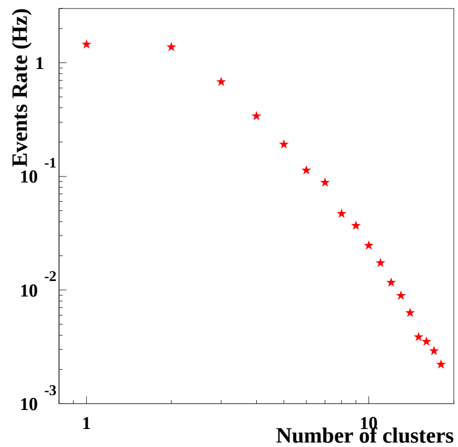

Fig. 6. Event rate vs. number of clusters triggered.

3. The Piccolo Array

Piccolo is a compact array of 8 stations on a squared grid at 25 m distance from each other. Its main task is to provide a fast external trigger to Grande and all the KASCADE detectors allowing to record coincident events with all the detectors of KASCADE-Grande. Each Piccolo station is equipped with 12 scintillator plates, 310×30 cm^2 organized in 6 modules, each read out by two photomultipliers. The trigger condition, optimized with Monte Carlo simulations, is the coincidence of at least 5 modules distributed in at least 4 different stations.

4. Conclusions

The status of the Grande and Piccolo arrays of the KASCADE-Grande experiment has been presented, both are ready for data acquisition and their simultaneous operation will begin in June 2003. In three years of data taking about 250 events with energy $> 10^{18}$ eV are expected.

1. Bertaina M. et al. 2001, Proc. 27^{th} ICRC (Hamburg), 792; Haungs A. et al. 2003, Proc. 28^{th} ICRC (Tsukuba), these proceedings; Kampert K.H. et al. 2003, Nucl. Phys. B (Proc. Suppl.) In Press.
2. Glasstetter R. et al. 2003, Proc. 28^{th} ICRC (Tsukuba), these proceedings.
3. Aglietta M. et al. 1988, Nucl. Instr. and Meth. A 277, 23.