AN EAS EXPERIMENT AT MOUNTAIN ALTITUDE FOR THE DETECTION OF GAMMA-RAY SOURCES

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ABSTRACT.

The plan of an extensive air shower experiment 2.200 m above sea level for the detection of 10^{14} - 10^{17} eV gamma-rays from sources in the declination band 0^{o} to $+60^{o}$ is described.

I. INTRODUCTION. Gamma-ray emission beyond 10^{14} eV has been reported of the sources Cygnus X-3 (Samorski and Stamm 1983a, 1983b, Lloyd-Evans et al. 1983, Baltrusaitis et al. 1985a, Bhat et al. 1985), Vela X-1 (Protheroe et al. 1984), LMC X-4 (Protheroe and Clay 1985), Hercules X-1 (Baltrusaitis et al. 1985b), and the Crab nebula (Dzikowski et al. 1981, Boone et al. 1984). For gamma-ray astronomy in this energy range new EAS experiments are needed meeting special requirements, as for example an improved angular resolution to allow better discrimination against the background of normal showers and larger effective detection areas especially for the lower energy range of showers to be detected.

The Kiel group plans to set up a new experiment dedicated to the detection of gamma-ray sources in the energy region 10^{14} - 10^{17} eV, to be run at mountain altitude at a site far south from Kiel.

II. SITE OF THE EXPERIMENT. A suitable site for the new experiment seems to be the Astronomical Observatory on top of the Roque de los Muchachos at the Canary island La Palma, where a relatively plane area of 200 x 200 m^2 is available and the electrical power supply requirements are fulfilled. The geographical position is 28.8^{o} north and 17.9^{o} west, at an elevation of 2.200 m above sea level ($x = 780$ g/cm^2).

At the latitude of this site Cygnus X-3 and Hercules X-1 can be detected under better condition than at Kiel (latitude 54.4^{o}), and in addition three further candidate sources are in the observation field of the experiment, the Crab nebula, Geminga (2 CG 195 + 05) and the 1.5 ms pulsar PSR 1937 + 21, all three known as gamma-ray emitters around 10^{12} eV.

Since showers of same primary energy contain more particles at mountain altitude than at sea level, the energy range at this mountain site can be extended to energies below 10^{15} eV.

III. DETECTOR ARRAY. A plan of the detector array is presented in Fig. 1. In total 56 scintillation counters of 1 m^2 each (scintillators NE 102 A, 5 cm thick) will be distributed over an area of 200 x 200 m^2 and will be equipped with one photomultiplier VALVO XP 2050 each for particle density measurements. In order to cover the large dynamical range required for EAS particle density measurements the signals will be picked up at three different points of successively decreasing gain on the resistor chain of the photomultipliers, giving 3 x 56 = 168 analog informations per shower handled by the same number of analog to digital converters (ADCs).

Fast timing measurements will be performed with the quadratic grid of 6 x 6 scintillation counters in the centre of the array (grid width 10 m). Each of these 36 detectors will be equipped with an additional fast photomultiplier VALVO XP 2041. Since timing modules containing 8 time to digital converters (TDCs) each with common start and individual stops will be used, the 4 x 4 central counters of the 6 x 6 array will provide common start signals for the respective 8 adjacent counters, so that 16 x 8 = 128 time differences will be available for each event. The high redundancy of fast timing channels will ensure reliable operation over long periods.

From the central section of the 6 x 6 counters 25 hard-wired 4-fold coincidences between each 4 adjacent detectors will be formed. Any of the 25 possible 4-fold coincidence signals will trigger the array.

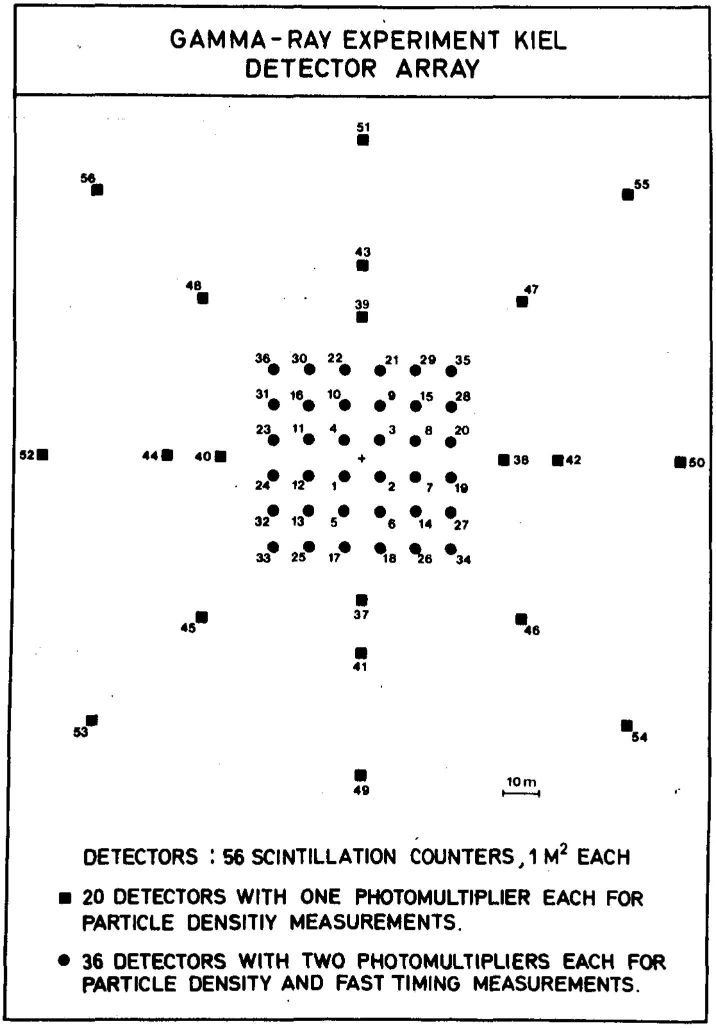

Figure 1. Plan of the EAS detector array for gamma ray observations.

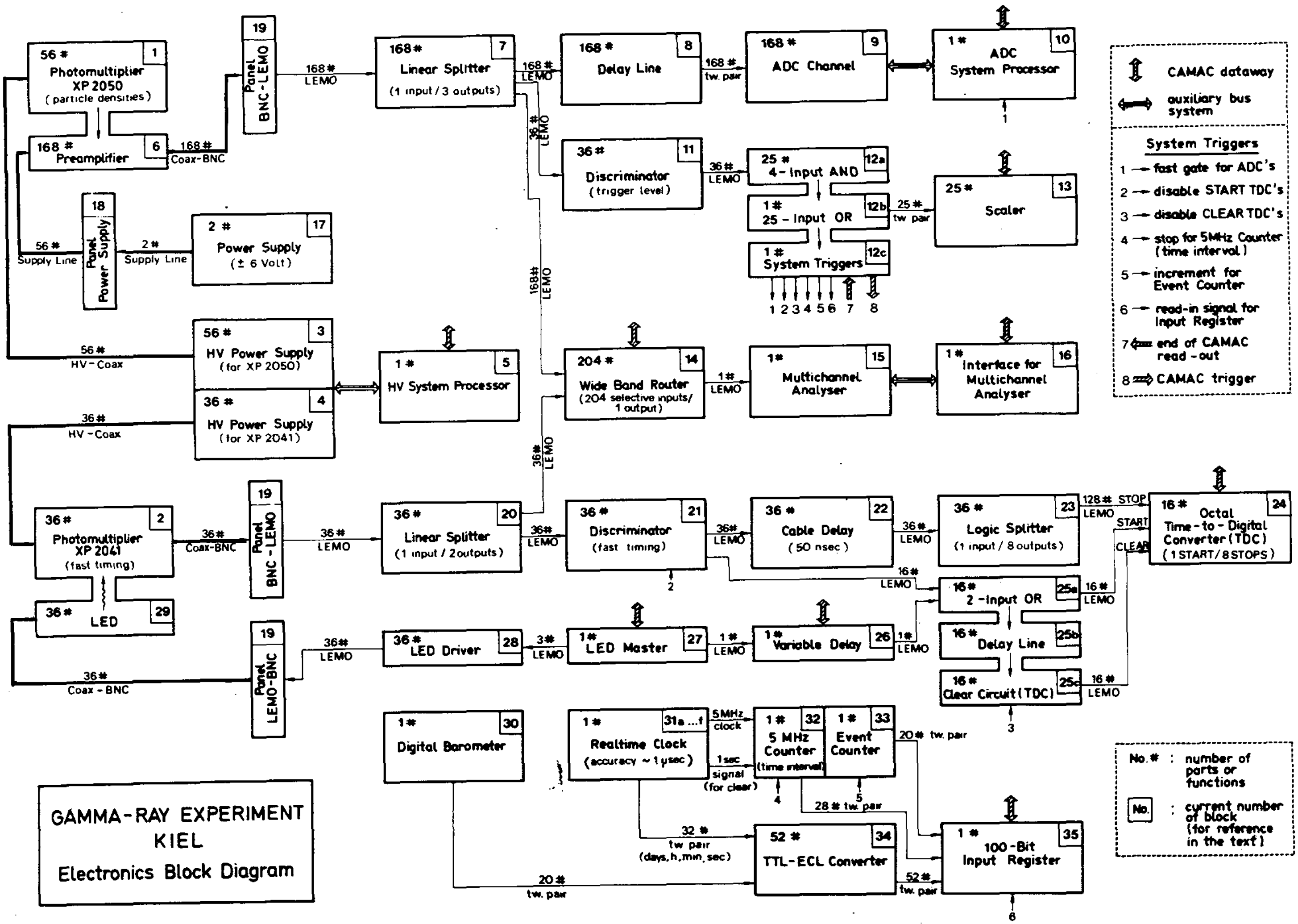

Figure 2. Block diagram of the electronic layout.

According to the relatively small grid width of the detectors in the centre (10 m) and the selected triggering condition all showers of primary energy above 10^{14} eV will be detected, when the core will hit a central area of about 70 x 70 m^2, with an angular resolution of the order of 1 degree at a rate of about 20 events per minute. For primary energies above 10^{15} eV an angular resolution better than 1 degree is expected, at an effective area larger than 100 x 100 m^2.

IV. ELECTRONIC LAYOUT. A detailed block diagram of the electronics is shown in Fig. 2. In all essential parts only reliable commercial micro-electronic systems will be employed. The whole system will be managed and controlled by a PDP 11/24 processor with 256 kB MOS memory and two magnetic disk drives of 28 MB each. The readout and control will be based on standard CAMAC technique. The arrival times of the showers will be determined by means of a high precision real time clock controlled by a Standard Time receiver to allow phase measurements of gamma-rays from pulsars.

Without interrupting or disturbing the air shower measurements the processor will in turn connect via a multiplexer each photomultiplier output to a multichannel analyser, controlling the position of the one-particle-peak and adjusting the PM high voltage, if necessary.

A few times per day the processor will interrupt the measurements at given times for a few seconds for checking the fast timing channels. For this purpose simultaneous test signals will be produced in each fast timing phototube by triggering light emitting diodes (LEDs). By introducing computer regulated time delays between the start and stop signals of all TDCs, the zero point and the linearity of each of the 128 timing channels will be controlled. The various test functions and monitoring of the performance of the experimental equipment will enable a running of the array with a minimum of maintainance.

The authors are gratefully acknowledging the cooperation of Prof. Dr. E. Bagge in the planning phase of this experiment and wish to thank Mr. Ing. K. Sauerland for his engaged support in the electronic design.

REFERENCES.

Baltrusaitis, R.M., et al. 1985a, 1985b, preprints, University of Utah.
Bhat, C.L., et al. 1985, paper submitted to Ap. J. (February 1985).
Boone, J., et al. 1984, Ap. J., 285, 264.
Dzikowski, T., et al. 1981, 17th ICRC (Paris), 1, 8.
Lloyd-Evans, J., et al. 1983, Nature (Letters), 305, 784.
Protheroe, R.J., et al. 1984, Ap. J. (Letters), 280, L47.
Protheroe, R.J., and Clay, R.W. 1985, Nature (Letters), 315, 205.
Samorski, M., and Stamm, W. 1983a, Ap. J. (Letters), 268, L17.
Samorski, M., and Stamm, W. 1983b, 18th ICRC (Bangalore), 1, 135.