THE ROLAND MAZE PROJECT*

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Actually planned and entering first stages of realisation in US projects joining experimental studies in the area of very high energy physics and cosmic ray physics with the broad educational program directed to high school students inspired us to analyse possibilities of realisation of similar project in Polish conditions.

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1. The Maze Project

Roland Maze was a co-discoverer of Extensive Air Showers of cosmic rays. The array built by him on the roof of Ècole Normale Supérieure in Paris made possible the observation of simultaneous registrations of high energy particles in two detectors separated by ~ 30 m. His name has been placed together with the name of Pierre Auger in the headers of the first papers of 1938 [1] reporting about the discovery.

In early fifties, when the cosmic ray laboratory in Lodz was being formed, Roland Maze closely collaborated with Polish physicists. It is not easy to estimate nowadays his role in creation of the Lodz group and its first scientific achievements. He was together with Aleksander Zawadzki, Juliusz Hibner, Jerzy Gawin and Jerzy Wdowczyk (among others) the co-author of many papers, which established the position of Lodz among distinguished centres of high energy physics in the world.

Comparing the scale and goals of presented project with those of the international and over 100 mln $ Auger Project, it seems justified to call our enterprise the Roland Maze Project, as a tribute to this great scientist.

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1.1. Physical motivation

Cosmic ray studies are recently intensively developed, especially in the region of the upper limit of energy spectrum (see Fig. 1.), where several single cases of particles with energies exceeding 10^{20} eV (≈ 50 J) have been observed. Such energies are 100 mln times higher than those which can be studied in laboratory experiments and most probably higher than those that can ever be achieved in experiments built by human hand. Apart from the obvious, but extremely compound, problem what is going on with matter during collisions with such enormous energy release, the question what astrophysical mechanisms are at all able to produce particles with such energies is also very intriguing. If we add to this that the nature of these particles is also unknown (they can be protons, compound atomic nuclei, gamma quanta, neutrinos or even yet undiscovered new particles predicted by theories beyond the so called Standard Model), it should not be surprising that to find answers to at least some of these questions, just now, the large ground level arrays are being built (Auger Observatory [2]) and quantitatively completely new satellite experiments (OWL, Space Watch, EUSO [3]) of budgets reaching hundreds of mln \$ are being planned.

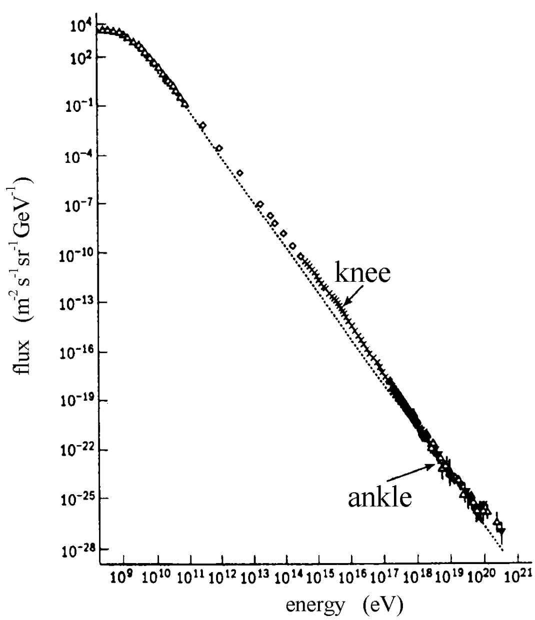

Fig. 1. Cosmic ray energy spectrum.

1.2. Important technical problems

The main difficulty is due to the fact that the flux of particles with energies above 10^{20} eV is of the order of 1 particle per square km per century (or even lower), so the detector area has to be sufficiently large to obtain required result in reasonable time. The biggest actually working experiment AGASA [4] consists of particle counters spread over an area of 100 km^2. During $\sim$20 years of work it has registered 17 such events [5]. In the projected Auger experiment 1600 detectors will be spread over 10 times bigger area. The main goal of such experiments is to determine (or rather estimate) in each registered event the energy of the particle which has initiated in the atmosphere a phenomenon called an extensive air shower, *i.e.* the cascade of particles (mainly photons, electrons and muons) with lateral size at the observation level measured in kilometers. Such estimation is performed basing on measurement of particle density in a shower in a few points separated by several hundreds meters (1.5 km in the Auger experiment). Moreover, measuring the times of shower arrival to different detection points one can determine the direction on the celestial sphere from which the primary particle has come.

The single detector is essentially a very simple device. It usually consists of a few scintillation (or Cherenkov) counters connected to the electronic system with a simple coincidence trigger and converters of time and amplitude of signals to digital codes. The essence of large area experiments is a method of synchronization and communication between detectors and a system of collecting and storing the data. A non-trivial problem is also maintaining stable and reliable performance of the system (service) and providing power supply to the detectors separated in total by tens of kilometers.

2. Concept of the Maze Project

In the proposed experiment the detection points would be placed in the buildings of Lodz high schools. Their net is dense enough (see Fig. 2) to make possible the observation of particles starting from energies of 10^{18} eV, for which expected frequency of interesting registrations is much greater (several thousands times) than for the cases from the narrow region above 10^{20} eV. So, one can expect first interesting experimental results already in the preliminary stage of realisation of the project with a small number of detection points. While the large experiments are dedicated exclusively to big science, in our Project each station (school) would constitute autonomous air shower array. Small, but developed enough to provide results which could themselves serve as the material to interesting studies related to cosmic ray physics and to independent developing of data analysis methods.

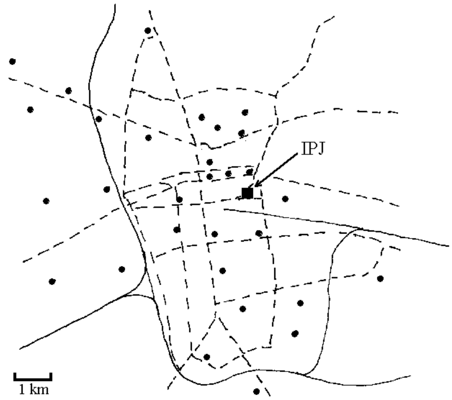

Fig. 2. Map of high schools in the Lodz region.

For available spacing between detectors in a station (of the order of $\sim$ 10 m) the chance of observing highest energy showers in one separate station is very small, but a special trigger system may provide full efficiency of registration of showers with energies $\sim 10^{15}$ eV falling on the detection area (100 m^2). For a specific realisation (discrimination levels) one can obtain sensible frequency of events counted in 1 min^{-1}. To make possible the independent observations in a separate station (high school) each of them should be equipped with 4 scintillation counters of area $\sim$ 1 m^2. The electronic system should enable us to measure the relative times with accuracy of $\sim$ 5 ns (that would give angular resolution of $\sim 5°$) and to measure the signal amplitudes from all the detectors. The system of converters and master elaboration would be connected to a PC-class computer, on which preliminary data analysis and storing would be performed. The scheme of a single detection station is shown in Fig. 3.

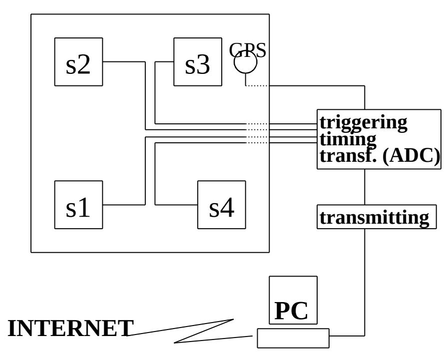

Fig. 3. The schematic view of the single Maze Project station.

To make possible the coordination of work of all the stations, which is the essence of described Project, the GPS system seems at the moment to be the best for time synchronization. In the standard version GPS provides absolute time with sufficient accuracy ($\pm$ 300 ns) to synchronize events in different stations. It seems reasonable to increase accuracy to several nanoseconds to make possible the additional determination of particle direction in cases of simultaneous registrations in several stations that are expected for the highest energy showers, studies of which are the main scientific goal of this Project.

Communication between stations would be realised via Internet (Fig. 4). Permanent connection to the net is not demanded, as the data stored in computer memory can be sent to the central server only once per some time. The server would put the data in order, store and archivise them, and make accessible for each group on demand. In this way each group taking part in the realisation of the Project would be able to independently analyse the whole gathered data and perform its own original studies.

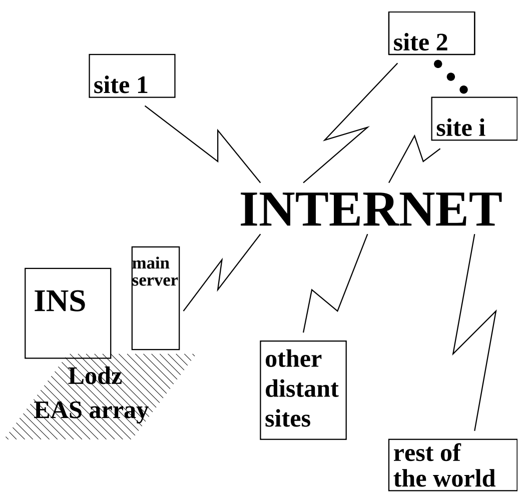

Fig. 4. The idea of the Maze Project network.

The first stage of the Project realisation would be devoted to detailed design of detectors and the basic software for the station. In the same time, a series of lectures in high schools will be organized to introduce students and teachers to the area of high energy physics, astrophysics and cosmic ray physics, and also to demonstrate assumptions and capabilities of the Maze Project. In the course of the works on prototype stations and software the seminars devoted to particular solutions would be organized for teachers and students.

In the initial phase 2–4 prototype stations would be built and successively started. After several months of work (counting also necessary tests) the system should be sufficient to confirm the realised concept by showing physical registrations of very high energy showers, and correct and stable work of the whole system.

In the proposed version of the Maze Project the detection stations would be separated by distance from half to two kilometers. Larger separation would cause that a station would never (?) in practice register an event in coincidence with any other, so it could realise only self-sufficient tasks, severely narrowing the sense of the whole enterprise. However, it is possible to formulate a serious research problem (from cosmic ray physics area) also for distant detection points. Quite recently reports about simultaneous registrations of extensive air showers in arrays separated by even hundreds of kilometers have appeared in the world literature ([6]). The idea explaining such phenomenon has been put forward by Gerasimova and Zatsepin [7] already a long time ago. It is assumed that the showers have been initiated by the fragments of atomic nucleus produced far above the Earth atmosphere, which managed to separate. Experimental studies are being carried out actually to deny or confirm earlier reports.

It is evident that there are no principal obstacles to enlarge the activity in the frame of the Maze Project outside the borders of Lodz and start constructing the detection nets (a few interested schools in one town would be sufficient) at big distances and analysing the data gathered by them from specific point of view. We may expect that similar projects will start also in other countries, for sure at first in US. The exchange of information, concepts, results and achievements via WWW would be undoubtedly valuable. It is not unlikely, that the global network for observation of Gerasimova–Zatsepin effect could bring very interesting physical results.

Other similar projects around the world are enlisted below:

ALTA — University of Alberta, Canada [8].

WALTA — University of Washington, Seattle [9]. Up to the year 2002 installing of 10–20 detection points is planned.

CHICOS — Caltech, California State University, University of California, Irvine [10]. Plans assume that 10 000 students and 300 teachers will be involved.

CROP — University of Nebraska [11]. The project will engage 30 schools.

SCROD — Northeastern University, Boston [12]. The prototype of single detector has been designed and successfully tested.

3. Summary

We summarize only one aspect of the Maze Project: the cosmic ray energy spectrum above 10^{18}eV, we would like to point out that the collection area of the Maze experiment is comparable to the biggest existing air shower array AGASA. Some of our solutions (*e.g.*, four independent detectors in each station) make our planned array even better, or at least different. The results on energy spectrum from our project are expected to be of similar quality as those of other experiments published nowadays in top physics journals and should enrich the still insufficient statistics of ultra high energy cosmic ray events. Additionally, the access to raw data and measurement details gives an excellent opportunity to study important physical problems on much deeper level that it is possible now with only partially published data from other groups like, *e.g.*, AGASA. This opens a new wide area for theoretical interpretation of cosmic ray spectra and giant air shower properties.

The second important aspect for the Maze Project is its educational impact which could be even more important than the scientific one.

The experience gathered for about forty years by the people in Lodz laboratory gives the perspectives for the successful realisation of the Project.

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