INVESTIGATION OF COSMIC RAYS IN VERY SHORT TIME SCALES

J. Peltonen, E. Valtonen, J.J. Torsti, H. Arvela, M. Lumme,
M. Nieminen and E. Vainikka

Wihuri Physical Laboratory, University of Turku, and
Department of Physical Sciences, University of Turku,
SF-20500 Turku, Finland

ABSTRACT

We have constructed a fast databuffer system, where cosmic ray events in the Turku hadron spectrometer, including particle arrival times, are recorded with time resolution of 100 ns. The databuffer can be read continuosly by a microprocessor, which preanalyses the data and transfers it to the main computer. The time span, that can be analysed in every detail,is a few seconds.

The high time resolution enables a study of time correlated groups of high energy particles. In addition the operational characteristics of the spectrometer can be monitored in detail.

1. The spectrometer

The Turku hadron spectrometer consists at present of a double neutron monitor combined with plastic scintillators. The spectrometer has been used to measure the energy spectra of neutrons and protons in the energy range .05 - 1000 GeV. Detailed description of the apparatus and its future development is given in paper /1/ presented at this conference.

2. The data collection system

Two identical microprocessor units are used in the Turku hadron spectrometer to collect the cosmic-ray events. Both units can record the status of the spectrometer with time resolution of 50 µs. This time resolution already enables a detailed study of very rapid cosmic-ray phenomena. It is also possible to study the spectrometer characteristics in detail.

The two microprocessor units have different tasks. Unit 1 calculates the hadronic spectra and monitors the hadron and muon flows through the spectrometer. Unit 1 is programmed to study energy dependent variations of hadron and muon intensities in time scales $>$ 30 s. A detailed description of the microprocessor 1 and of its software was given in /2/.

Unit 2 can be used parallel with unit 1. Its time resolution can be improved by adding a fast data buffer. This data buffer records spectrometer events, including particle arrival times, with time resolution of 100 ns.

The overall diagram of the data collection system is given in fig. 1.

2.1. A fast data buffer

The heart of the buffer memory is a DUALPORTED FIFO-memory type IDT-7201-S-80-C from Integrated Device Tecnology (identical to better known MK4501 from Mostek) This memory component is very handy in data buffering applications. The READ-WRITE-operations can be done truly asyncronously and independently. Besides, these new memories are fast (cycle time 100 ns or even better) and easily cascadable.

The schematics of the data buffer is given in fig. 2. The 8 parallel FIFOs form a memory of 64*512. This memory can be triggered from 6 sources. On every trigger the logic generates a common WRITE-pulse and 64-bits of data is latched in, including the data of the time counters. The status and control signals are connected to microprocessor, which can acces the READ-side of the FIFOs.

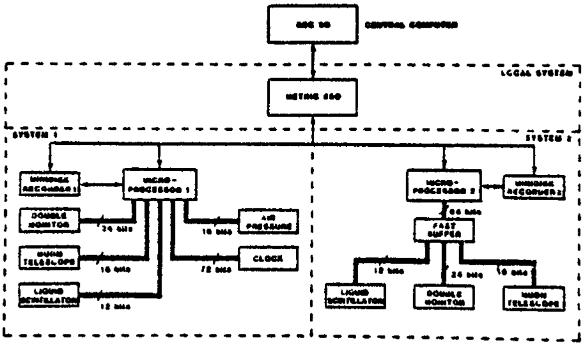

Fig 1. The overall diagram of the control system.

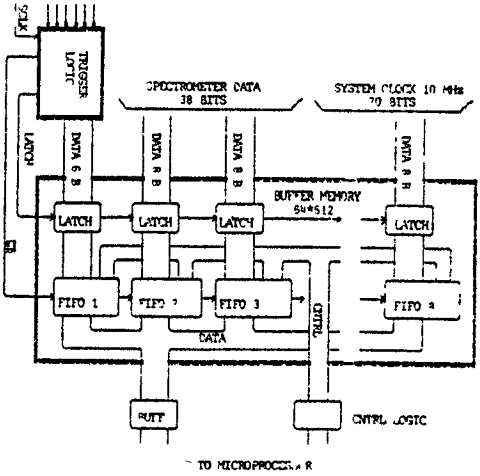

Fig. 2. Schematic of the data buffer.

3. Some results and discussion

Until now, the system 2 has been used only for some simple, mainly instrumental measurements. Two examples of these measurements are shown in figures 4 and 5. The study of more interesting problems, like long tails of extensive air showers and time behaviour and detection of high energy bursts (γ-ray bursts) requires longer measurements.

In fig.3 , the measured time intervals between charged particles coming into our spectrometer are shown. According to Poisson-statistics we should have exponential distribution of the form A*exp(-kt) . As one can see from figure 3, the measured time distribution is strictly Poissonian when $t > 20$ µs. At shorter time intervals there is, however, an excess of events, compared with the Poisson distribution. We believe that most part of these events can be explained by afterpulses from the photomultipliers. The exact portion of afterpulses and the role of some other possible phenomen in these events are being investigated.

In fig. 4, there is shown the time distribution of charged particles that arrive at the spectrometer before the first evaporation neutron is registered in the monitors. It can be seen that most of the particles arrive at times $t < 250$ µs. This time distribution is important, since we separate muons from protons and pions by assuming certain maximum reaction delay.

The Turku hadron spectrometer will be used in future as a central detector of an air shower array /1/ . In addition, there will be position and direction sensitive detectors in the spectrometer. With the fast recording system described and with some additional electronics we can analyse cosmic ray showers and bursts in detail.

References

/1/ E. Valtonen, J.J. Torsti, H. Arvela, M. Lumme, M. Nieminen, J. Peltonen and E. Vainikka, paper HE 4.6-8 in this conference,

/2/ Lumme, M., Nieminen, M., Peltonen, J., Torsti, J.J., Vainikka, E., and Valtonen, E., Proc. 18th Int. Conf. Cosmic Rays, Bangalore, 8, 182-5 (1983).

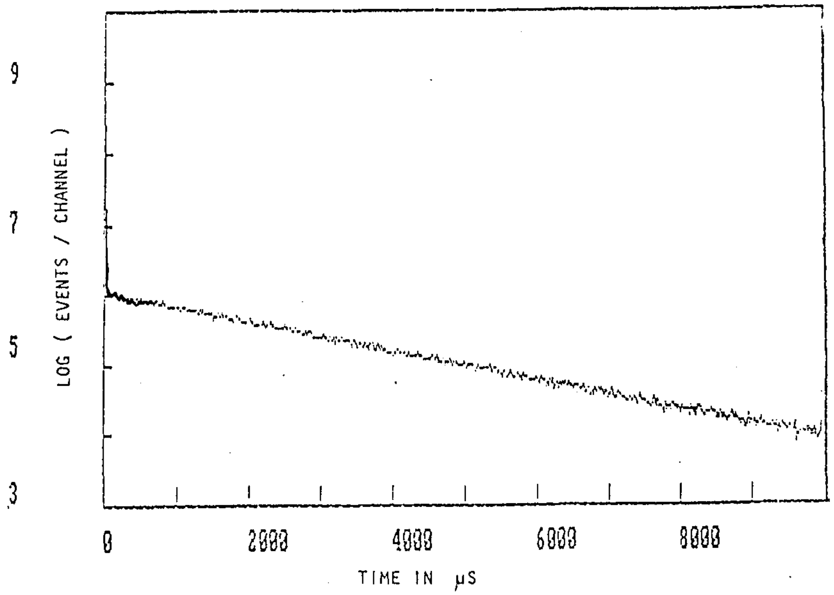

Fig. 3. The time interval distribution of charged cosmic-ray particles in the Turku hadron spectometer.

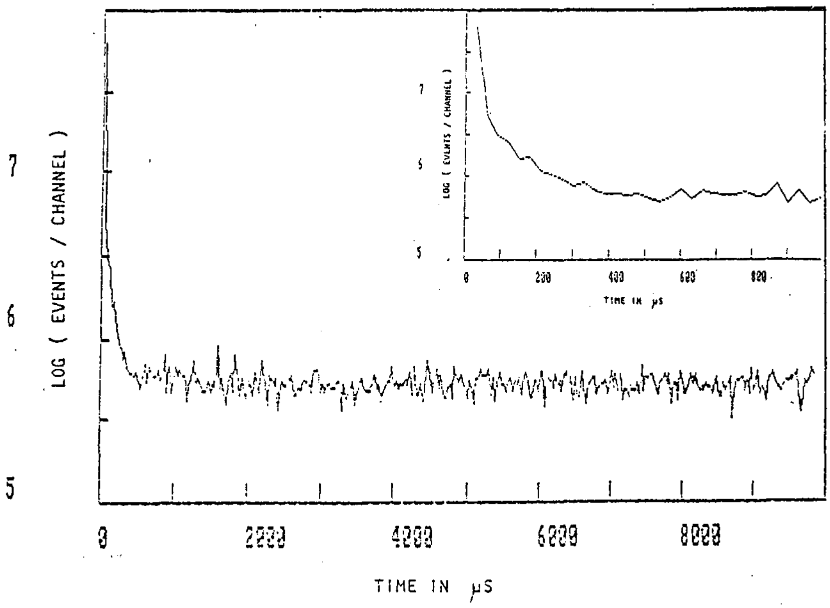

Fig. 4. The time distribution of charged particles arriving at the spectrometer before the first neutron is detected in the neutron monitors. This time distribution is used to separate protons and pions from muon background.