

## COSMIC RAY STUDIES ON THE MIR SPACE STATION: THE EXPERIMENT SILEYE

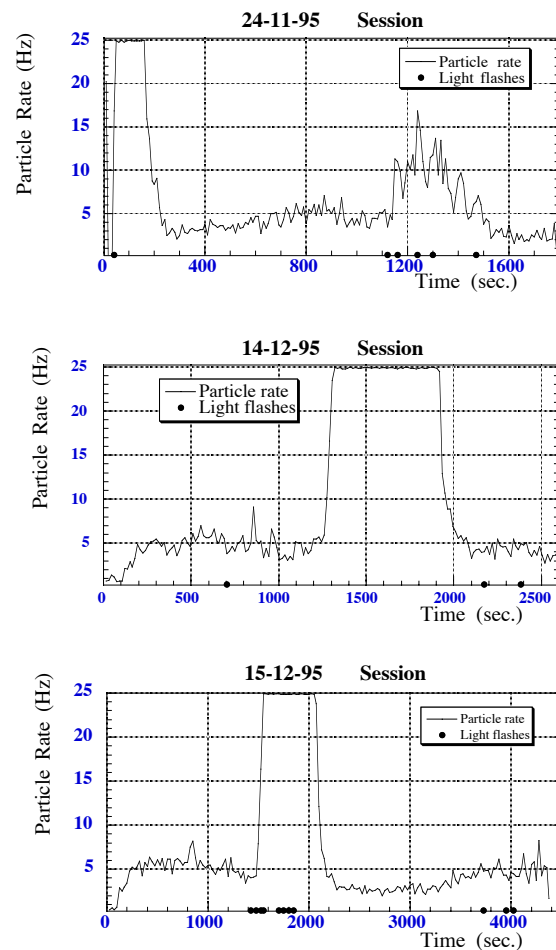
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## ABSTRACT

The Sileye detector can simultaneously measure particle energy losses from 2.5 Minimum Ionizing Particles (MIPs) to 2500 MIPs and determine the coordinates of passing particles with an accuracy of 1.8 mm. This instrument can be used for cosmic rays studies as well as for medical-biological and technological space researches. We will present the results obtained with the first prototype of the apparatus, on board MIR since October 1995, and the performances of the second apparatus, Sileye2, that will be launched in the fall of 1997.

## INTRODUCTION

Since the Apollo missions it was known that the crews, after some minutes of dark adaptation, observed brief white light flashes or pencil-thin streaks of light. The first observation was reported by E. Aldrin during the Apollo 11 mission (W.Z.Osborne et al., 1975). Other observations were later reported by Apollo-Soyuz (T.F.Budinger et al., 1977). The frequency of light flashes (LF) depends on orbit parameters, especially on the latitude, and grows in polar areas and in the area of the South Atlantic Anomaly. LF are practically absent on the equator, where the charged particles' flux is minimum. There are different hypothesis on the generation mechanisms of visual effects, like direct interaction of charged particles with the retina of the eye by ionization (Hoffman et al.1977) or Cherenkov effect in the ocular bulb (G.G.Fazio et al.,1970) or indirect effect from proton knocked out by protons (J.Fremlin, 1970). It was also suggested that scintillation in the eye lens could cause the observed LF's (I.MacAulay, 1971). For a review see G.Horneck 1992. To test these hypothesis we prepared two detectors; the first one is on board MIR Space Station since October 1995 and we already presented the preliminary results (A. Galper et al.,1996) and the second is scheduled for the launch in the fall of 1997.



*Fig. 1: Trigger rate vs. the different position in the orbit.*

## DESCRIPTION OF THE SILEYE APPARATA

The main body of our detectors consists of silicon views. A view is made of a square ( $6 \times 6 \text{ cm}^2$ ) wafer of silicon, divided in 16 strips, each 3.6 mm wide. Two views, orthogonally attached to each other, constitute a plane. We have three planes for a total number of 96 strips. The distance between the silicon planes is 5 cm for the Sileye apparatus and 14 mm for the Sileye2. Each silicon strip is  $380 \pm 15 \text{ }\mu\text{m}$  thick. A more complete description of the Sileye2 apparatus can be found in V.Bidoli et al. 1997. Both the apparata can detect in real time the passage of particles which traverse the eyes and register on the on-board computer the six coordinates and energy depositions from which the direction and proprieties of the particles can be determined. Time of LF occurrence are also stored in a separate file for off-line correlation.

## SILEYE RESULTS

In Fig.1 the time dependence of the detector trigger rate together with the LF registration time is shown for three different one hour sessions. For the 24/11/95 session the beginning of the acquisition coincided with a passage in the SAA area. Here the trigger rate is saturated at about 25 Hz, due to the deadtime of the detector. The second rise of the trigger's rate, at around 1200 s, is connected with the passage at high latitude. Note that all but one of the observed light flashes in this session

were seen in this region, although the trigger rate is much lower then in the SAA. This is a general feature in most sessions but not in all. For example in the 15/12/96 session 5 light flashes were reported in the SAA region. The first stage of the Sileye experiment can be considered as methodical in many respects. In our experiment a rather small growth of registration of LF rate in the SAA (about  $2 \sigma$ ) is observed while it is known that the proton flux in the SAA increases several order of magnitudes in comparison with the equator. The likely conclusion is then that protons are not the main LF source in orbit, and it seems more probable that heavy ions are the initiators. Some differences between the results from Skylab, Apollo-Soyuz and MIR could perhaps be explained with a combination of differences in altitudes, shielding and changes of the solar activity. The latter could possibly also explain why the same subjects see less LS's during the 1995 on MIR than a couple of years ago. but if the tentative conclusion above is correct, it should imply that there was a smaller flux of heavy ions on MIR on 1995 than around 1192-1993.

The experience gained working with Sileye has been used to develop several improvements in the new version of the apparatus (Sileye2). The new device has been developed as a complete software controlled particle detector, using the same geometry as is in the first Sileye but improving mechanics and computer interface. This new system monitors dark adaptation and reaction time and performs some reliability controls on device performances (like gain linearity, detector's noise). The astronaut uses a joystick to register light flashes in order to minimize reaction time. All the physic parameters of the detector (like gain or treshold) are completely software controlled. LEDs were added inside mask to check eye-detector alignment, minimum level of astronaut's light sensitivity and readiness. General device performances are now increased: the treshold can be set up to 75 MIPs and this feature is very useful to avoid saturation in SAA, the maximum acquisition rate is now higher than 60 Hz.

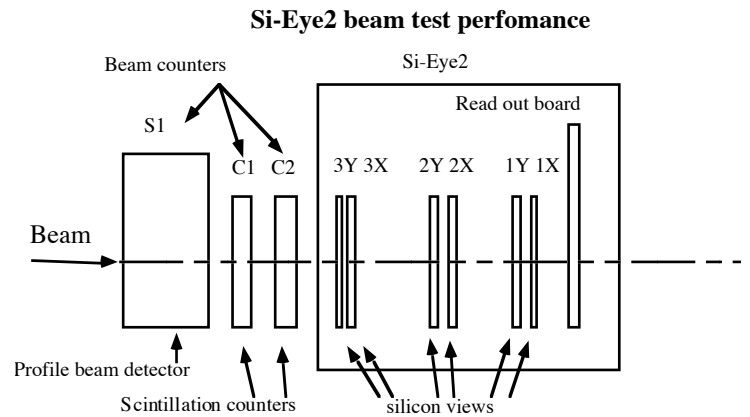


Fig. 2: Beam test set-up.

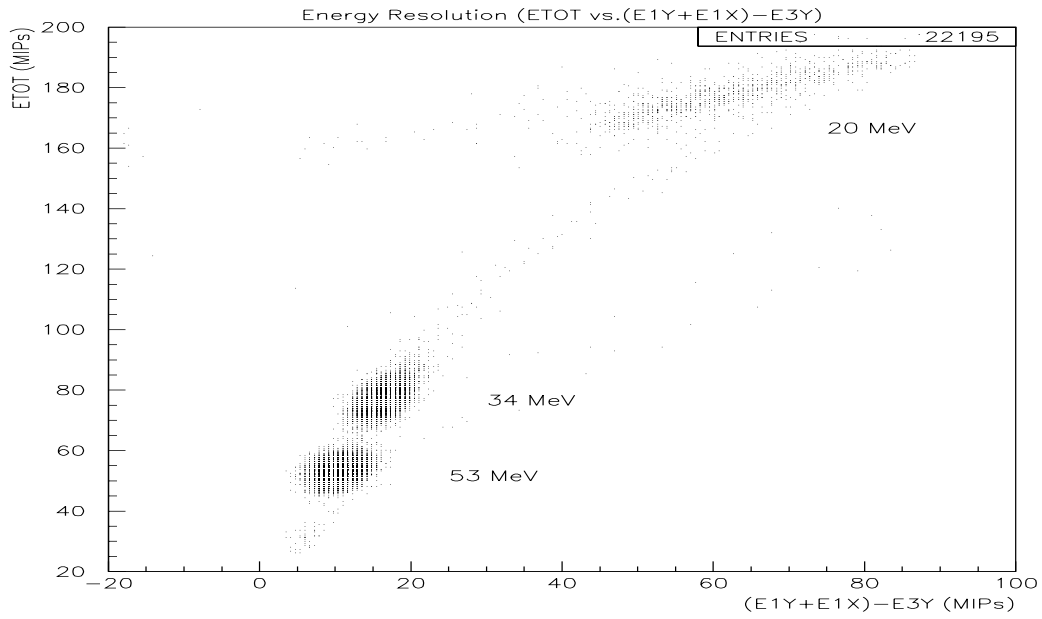


Fig. 3: Distribution of the total detected energy versus the difference between the energy loss in the last plane and in the first view.

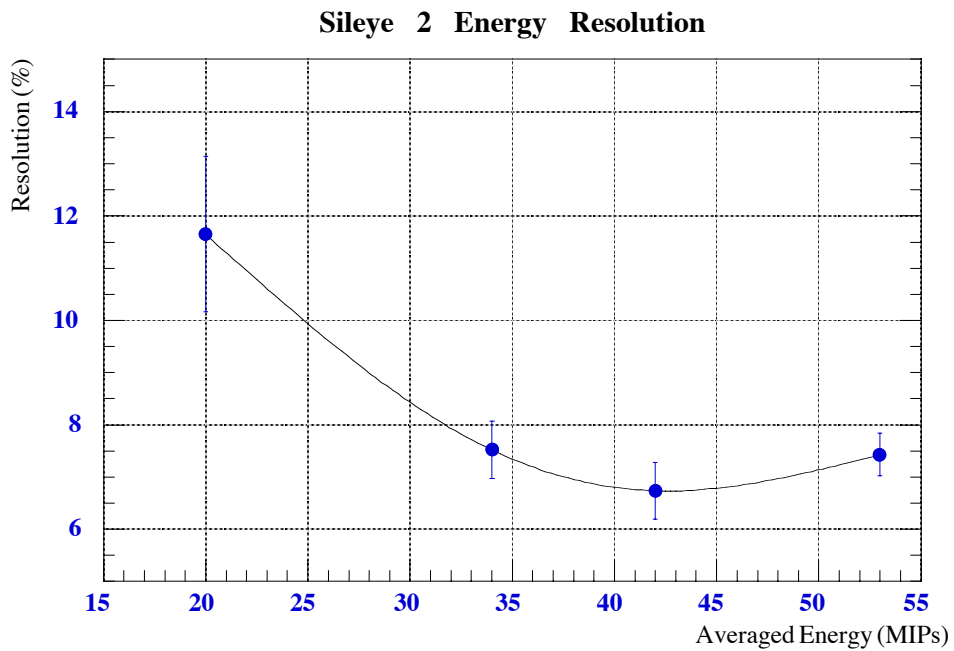


Fig. 4: Energy resolution (R.M.S./E) of Sileye2 as a function of reconstructed proton energy.

## SILEYE2 BEAM TEST RESULTS

The calibration of the device SilEye2 was carried out on a proton beam from the CELSIUS storage ring at TSL, Uppsala. The device is intended for cosmic rays research, therefore there are special requirements for the beam. The basic requirements are a low intensity of the beam, which means not more than 20 particles per second ( $\leq 20$  Hz) and a low background radioactivity level in the beam room. The measurements were done at two different proton energies: 48 MeV and 70 MeV. The detector beam set up is shown in Fig. 2. Different runs have been performed, some with aluminium absorbers, in order to have more different energies. In the 48 MeV runs, protons stop in 5th or 6th silicon detector with big energy losses up to 50 MIP. This feature is very useful for us, because the device is intended for investigations of low energy protons and nuclei in cosmic rays. Most of the calibration runs was performed with vertically incident particles.

In Fig. 3 the distribution of the total detected energy versus the difference between the energy lost in the last plane and in the first view is plotted. It can be seen that the protons' energies are very well separated.

In Fig. 4 the Energy resolution (R.M.S./E) of Sileye2 as a function of reconstructed proton energy is plotted. Only events with straight tracks in both views has been taken into account. This means events which have the hitted strips on the second plane in both views no more than one strip from the fitted line. Events with two or more hitted strips in one layer were excluded.

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