Accelerator Tests of the KLEM Prototypes

G.Bashindzhagyan,[1] J.H.Adams,[2] P.Bashindzhagyan,[1] N.Baranova,[1] M.Christl,[2] A.Chilingarian,[3] I.Chupin,[6] J.Derrickson,[2] L.Drury,[4] V.Eganov,[3] N.Egorov,[5] V.Ezhov,[1] S.Golubkov,[5] V.Grebenyuk,[6] N.Hasebe,[7] L.Howell,[2] A.Kalinin,[6] D.Karmanov,[1] M.Korolev,[1] N.Korotkova,[1] Y.Kozlov,[5] Z.Krumshtein,[6] M.H.Lee,[8] M.Merkin,[1] H.Nanjo,[9] A.Nozdrin,[6] D.Nozhnin,[1] A.Pakhomov,[1] M.Panasyuk,[1] I.H.Park,[10] A.Podorolsky,[1] D.Podorozhnyi,[1] E.Postnikov,[1] T.Roganova,[1] O.Saavedra,[11] A.Sadovski,[6] A.Sidorov,[5] M.Simon,[12] L.Sveshnikova,[1] A.Thompson,[4] L.Tkatchev,[6] A.Turundaevsky,[1] A.Voronin,[1] and J.Watts[2]
(1) Skobeltsyn Institute of Nuclear Physics, Moscow State University, Russia
(2) NASA Marshall Space Flight Center, Huntsville, Alabama, USA
(3) Yerevan Physics Institute, Armenia
(4) Dublin Institute for Advanced Studies, Ireland
(5) Research Institute of Material Science and Technology, Zelenograd, Russia
(6) Joint Institute for Nuclear Research, Dubna, Russia
(7) Waseda University, Japan
(8) IPST, University of Maryland, College Park, Maryland, USA
(9) Hirosaki University, Japan
(10) Ewha W. University, Korea
(11) Torino University, Italy
(12) University of Siegen, Germany

Abstract

The Kinematic Lightweight Energy Meter (KLEM) device is planned for direct measurement of the elemental energy spectra of high-energy (10^{11}-10^{16} eV) cosmic rays. The first KLEM prototype has been tested at CERN with 180 GeV pion beam in 2001. A modified KLEM prototype will be tested in proton and heavy ion beams to give more experimental data on energy resolution and charge resolution with KLEM method. The first test results are presented and compared with simulations.

1. Introduction

First KLEM prototype test performed in 2001 confirms that the KLEM method really works. But very important task is to test the method with higher energy particles and particularly with heavy ions. Indium run at CERN SPS in 2003 gives an outstanding opportunity to test new prototype with various ions of

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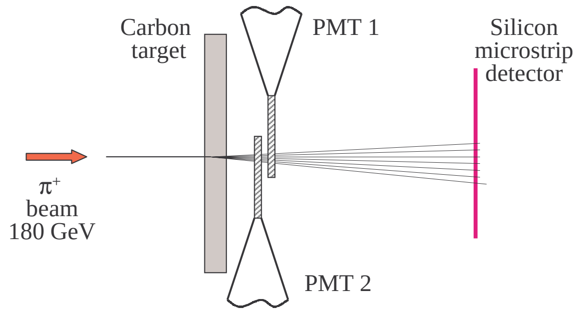

Fig. 1. First KLEM prototype configuration.

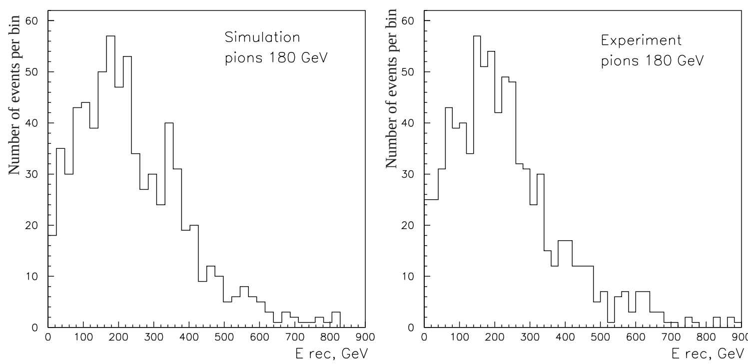

Fig. 2. Reconstructed energy distributions for 180 GeV pions.

the same rigidity $\sim$ 300 GeV/Z. It corresponds to real satellite experiment energy range. Simultaneously we plan to test 4 silicon layer charge measuring system. Data analysis will help to optimize a charge measuring system structure for real experiments.

2. First Test of the KLEM Prototype

The first test of the simple KLEM prototype has been performed at the CERN SPS test-beam with 180 GeV pions during 2001. The main objective of the first test was to compare experimental results with calculations obtained under the same conditions. This accelerator test did not allow checking of the KLEM method at really high energies (10^{12}-10^{16} eV) planned for eventual cosmic ray application. However an agreement between experimental results and simulations at the available energies increases confidence in the validity of the simulations for higher energies.

The microstrip detector plane was mounted at a distance h = 7.5 cm from the middle of the carbon target (Fig. 1). Two small scintillators with photomultiplier tubes PMT1 and PMT2 were fixed just behind the carbon target. Coincidence of both scintillator signals generated very simple trigger.

The main problem of the off-line analysis was to distinct a real hadron interaction in the target from very strong background. The only way to do it was to make a cut on secondary particle multiplicity per event. Fig. 2 shows two reconstructed energy distributions under the same multiplicity cut for 180 GeV pions. First plot obtained in simulations, second one in the experiment. One can see that experimental results and simulation are in a good agreement. Relative energy error for experimental data (67%) is very close to those obtained from simulations (65%). This result confirms that the KLEM method really works and simulation gives reliable data in at least low energy region.

3. New Setup Structure

The second layer of microstrip detectors with orthogonal strip direction have been made and placed at 8 mm behind the first one (Fig. 3).

The system for precise charge measurements has been made and positioned in front of the setup. It consists of 4 silicon pad layers and hybrid electronics. Each layers of the charge system has two electronic channels. "Fast" (∼100 ns shaping time) channel is used to generate trigger. "Slow" channel works with the same shaping time (∼1 μs) as microstrip detectors and used for charge measurements.

4. Trigger

We plan to register all the particles with ionization above 0.3 m.i.p. threshold in charge system and to separate the interactions off-line. A huge number of non-interacting ions in raw data will help to calibrate the whole system including electronics and to know the beam profiles.

5. Electronics

New readout electronics has been developed to improve an accuracy of measurements and calibrations. Electronics block-diagram is shown in Fig. 4.

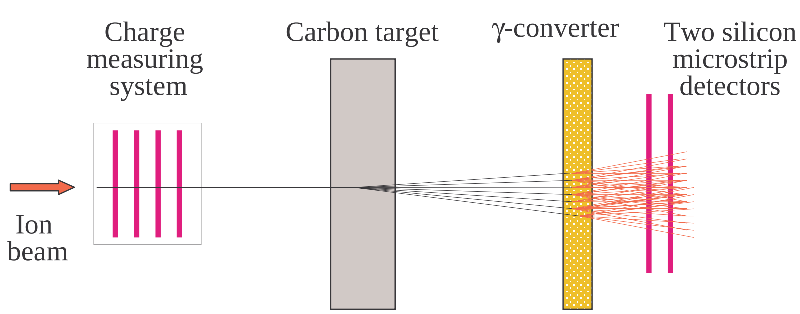

Fig. 3. New KLEM prototype configuration.

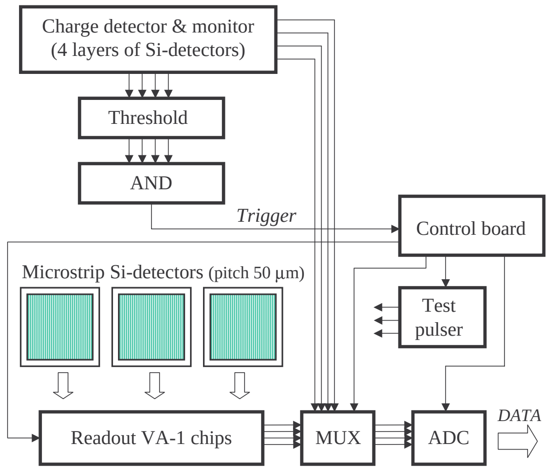

Fig. 4. Electronics block-diagram for a new KLEM prototype.

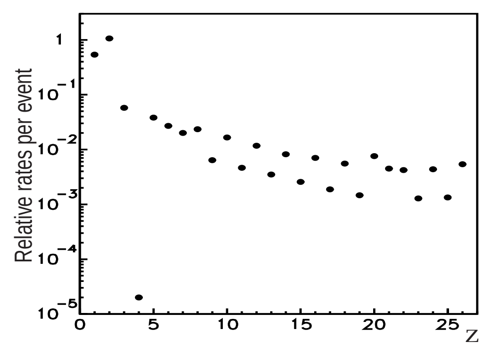

Fig. 5. Relative rates for various ions generated in beryllium target.

Readout system is relatively slow because it designed for cosmic ray application. The information will be stored on computer hard disk and duplicated on CDs.

6. Expected Results

Indium beam interactions in different targets have been simulated. Various fragments rates at different rigidities have been calculated to select the most profitable rigidity. It has been found that at the rigidity range 300-350 GV the highest rates for most of fragments are expected. The Fig. 5 shows relative rates for ions with Z=1-26 generated in beryllium target.

References

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2. Adams J., Bashindzhagyan G. et al. 2001, Adv. Space Res. 27, No.4, p. 829 (Published by Elsevier Science Ltd on behalf of COSPAR)