Prototype of the fine-sampling electromagnetic calorimeter *

G.Britvich, S.Chernichenko, Yu.Kharlov, V.Mochalov, P.Semenov, A.Soldatov, A.Soukhikh, M.Ukhanov, and V.Vasilchenko

Institute for High Energy Physics, Protvino, 142281 Russia

The electromagnetic calorimeter modules with fine sampling were constructed in IHEP. The module design were based on the electromagnetic calorimeter for the KOPIO experiment, with additional modification to the energy range of the CBM experiment. The modules were assembled from 380 alternating layers of lead and scintillator plates. Lead plates were doped by 3% of antomony to improve their rigidity. Scintillator plates were made of polysterene doped by 1.5% of paraterphenile. Scintillator was manufactured at the scintillator workshop of IHEP by the molding technology. Scintillation light was collected by the wave-length shifting fibers BCF-91A of diameter 1.2 mm. The fibers penetrated the modules in the longitudinal direction with the step of 9.3 mm forming the grid of 12×12 fibers per module. The physical properties of the modules are presented in the Table 1.

lead plate thickness	0.275 μm
scintillator plate thickness	1.5 mm
number of layers	380
effective radiation length, X_0	34 mm
total radiation length	$20X_0$
effective Moliere radius	59 mm
module size	$110 \times 110 \times 675$ mm^3
module weight	18 kg

Table 1: Physical properties of the module.

The matrix of 3×3 modules was manufactures and studied during the test beam run in December 2006. The scintillation light collected and re-emitted by the optical fibers was detected by the photomultipliers R5800 from Hamamatsu. The signal amplitude was measured by the 16-bit QDC. The matrix of modules was placed on the (x, y)-moving table controlled by a computer. The modules were exposed to a secondary beam of the beam line 2-B of the U70 accelerator in IHEP, Protvino. The beam had a mixed content of negative particles, mainly μ^-, π^- and e^- at momenta from 1 to 19 GeV/c. The electron component of the beam was used for the energy resolution measurements. The beam line 2-B (Fig.1) provided a beam particle tagging with a magnet spectrometer contained 4 drift chambers `DC1` – `DC4` and the dipole magnet `M` with a fixed bending angle of 55 mrad.

The modules were calibrated via exposing them to a 19-GeV/c beam. The best relative calibration coefficients were found by equalizing minimum ionizing particle (MIP) signals, while the absolute calibration was obtained by setting the total measured energy in the 3×3 matrix to 19 GeV. The measured energy spectrum in the ECAL prototype from the 19-GeV/c beam is illustrated by Fig.2 (left plot), the blow-up of the low energy range is shown on the right plot of this figure, where a clear MIP signal is seen.

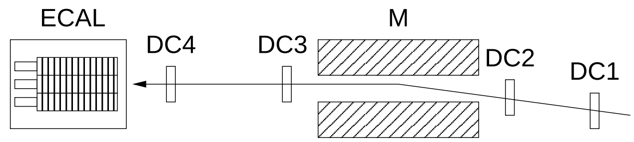

Figure 1: Experimental setup for ECAL modules studies.

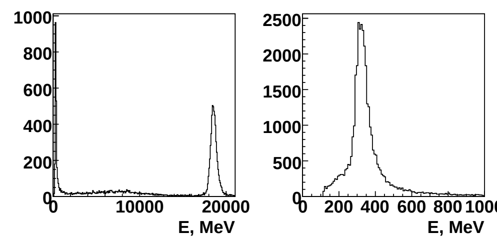

Figure 2: Measured energy from the 19-GeV/c beam.

After calibration, the ECAL prototype was exposed to beams at momenta 1, 2, 3.5, 5, 7, 10, 14 and 19 GeV/c, and the obtained energy resolutions at these energies are shown in Fig.3. The energy resolution of the fine-sampling calorimeter prototype is found to be extremely high compared to conventional sampling calorimeters, and, therefore, can be used for precise spectroscopy measurements of the neutral mesons and the photons.

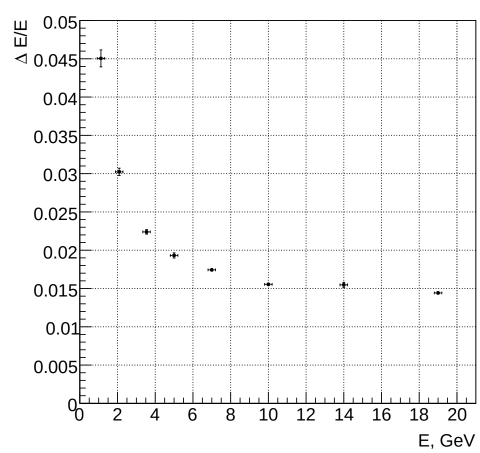

Figure 3: Measured energy resolution.

* Work supported by GSI-CBM