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THE INFLUENCE OF CHERENKOV LIGHT ON THE ELECTROMAGNETIC CALORIMETER OUTPUT SIGNAL

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We estimate the distortation on the electro-magnetic (e.m.) calorimeter output signal by the Cherenkov light in the communication fibers system.

1. Design of the e.m. calorimeter

The e.m. calorimeter used for Monte Carlo calculations was composed of a lot of identical blocks (towers). Each tower has cross dimensions 100*100 mm*mm and consists of Scintillator (Sc) tiles interleaved with Lead (Pb) ones (4mm Pb, 4mm Sc). There are 32 Pb- SC slices in each tower. The front view of its calorimeter is presented on Figure 1.

On one side of each tower there is a channel with fibers. These fibers transmit the light from Sc plates to the photomultiplier (PM). 32 fibers were included inside the channel with cross dimensions 16*2 mm*mm. The diameter of each fiber is 1mm.

We assumed that the fibers are made of a polystyrene core doped with Y-7 or K27 and are clad with PMMA. The typical absorption spectra for the dopants are shown on Figure 2. As can be concluded from the absorption spectra the effective absorption of the Cherenkov irradiation spectrum will lie in the 400-500 nm wave length region. In the simulation we have taken into account of this part of the Cherenkov spectrum. The Cherenkov photon is absorbed immediately in the fibers and isotropic reemission of the photon in wave length region (450 - 600 nm) takes place. The fiber's core refractive index is 1.6 and attenuation length is 1m.

2. Simulation Approximations

1) As one can see from Fig. 2 the dopants (Y-7 and especially K27) absorption spectra do not have a cut-off at 400 nm; they continue in the small wave length region. At the same time the Cerenkov irradiation spectrum intensity increases proportionally with 1/lambda**2, so that a part of the Cerenkov spectrum with lambda < 400 nm may be absorbed by the fibers. For the correct calculation of that effect one needs the dopants absorption spectra for the short wave length regions.

2) We assumed that the Cherenkov photon at 400 nm < lambda < 500 nm is absorbed immediately at the point of origin. For the correct calculation one needs the dependence of the absorption length vs. photon wave length.

3) We have not taken into account Cherenkov photons with lambda < 400 nm which can be accepted by the fibers if they are generated at angles higher than the total reflection angle.

4) At the calculation time we have used the standard Frank - Tamm formula [1] for obtaining the Cerenkov photons number per unit length. We have assumed a constant refractive index n (lambda) = 1.6.

5) We considered that the energy deposition in the Sc tile per 1 photon is 100 eV.

3. Results of Monte Carlo Simulations

The simulation program was based on GEANT 3.14 code. We have taken into account the Cherenkov light which originates in the communication fibers. Figure 3 represents the mean number of cherenkov photons per event at the end of the fibers before

entering the PM vs. distance between the incident particle and the fiber channel. The distance is measured on the Y axis (see Fig. 1). These data were obtained for different energies of incident particles. The two vertical lines show the channel location.

In Figure 4 the relative part of the Cherenkov light in the output signal magnitude is plotted against the distance from the channel for 1 GeV incident gamma. This relative part does not depend on the energy of incident particle as can be concluded from Figure 5, where are presented the average numbers of Cherenkov photons for the different incident coordinates and different energies of incoming particles. So the Cerenkov signal depends linearly on the incident particle energy. This means that the signal amplitude from the tower will be increased (up to 6%) if the particle hits e.m. calorimeter close to the fibers channel.

Figure 6 represents the influence of the Cherenkov light on the e.m. calorimeter energy resolution. As can be seen from the Figure this influence is weak.

Conclusions.

The influence of the Cherenkov light on the e.m. calorimeter response was estimated. This effect will increase the calorimeter signal by 6% (at the distance of 1mm from the fibers channel) and by 1% at (5-6 mm). We note a slight deterioration of the energy resolution (e. g. 14% instead of 12% for photons of 1 GeV) for particles hitting the calorimeter in a small region (1-2mm) near the fibers channel.

References

[1] Physics Letters B, Vol. 204 (1988) p. 61

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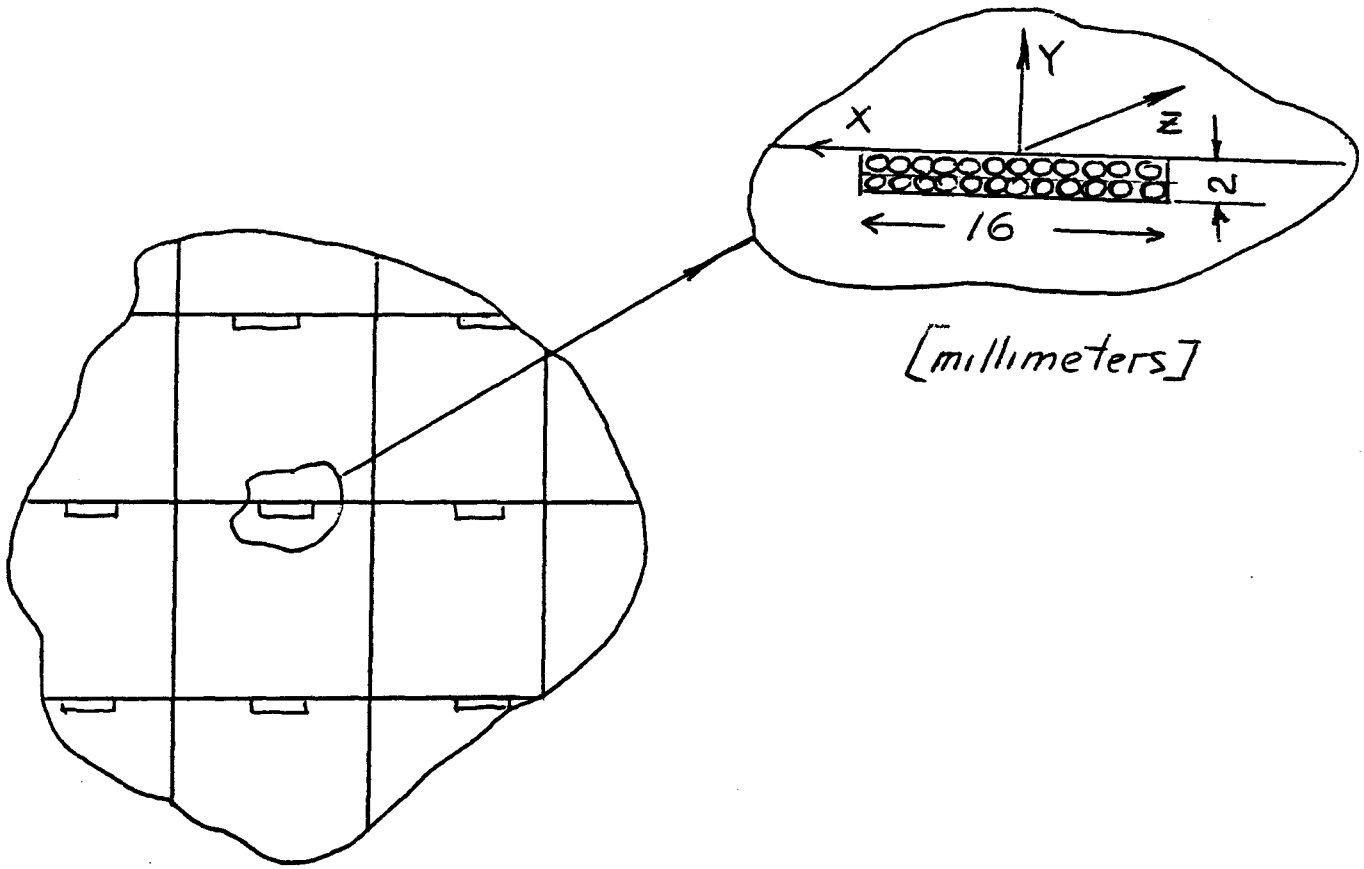

Fig. 1

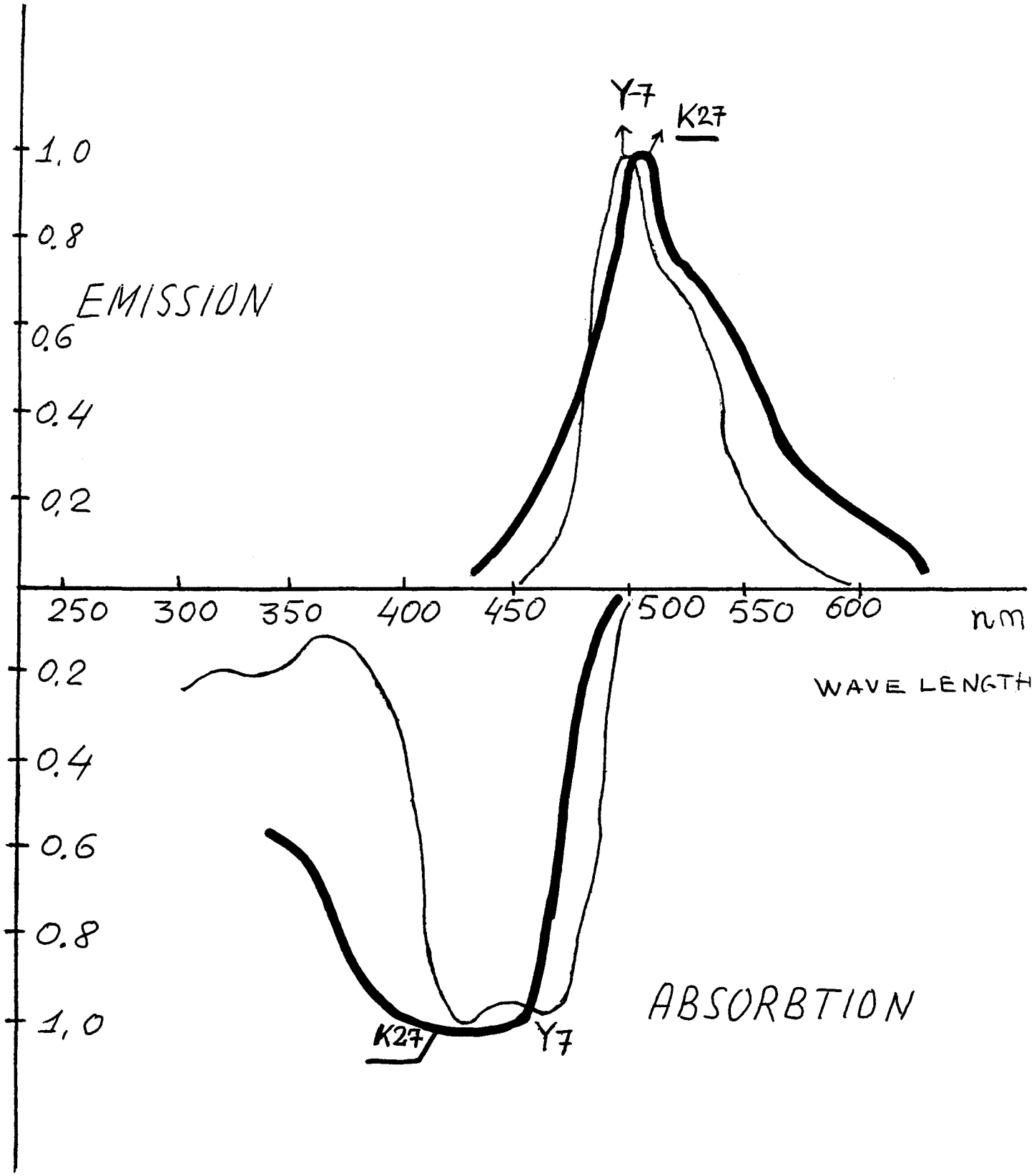
Y7
K27
1.0
0.8
EMISSION
0.6
0.4
0.2
250
300
350
400
450
500
550
600
nm
WAVE LENGTH
0.2
0.4
0.6
0.8
1.0
ABSORBTION
K27
Y7

Fig. 2

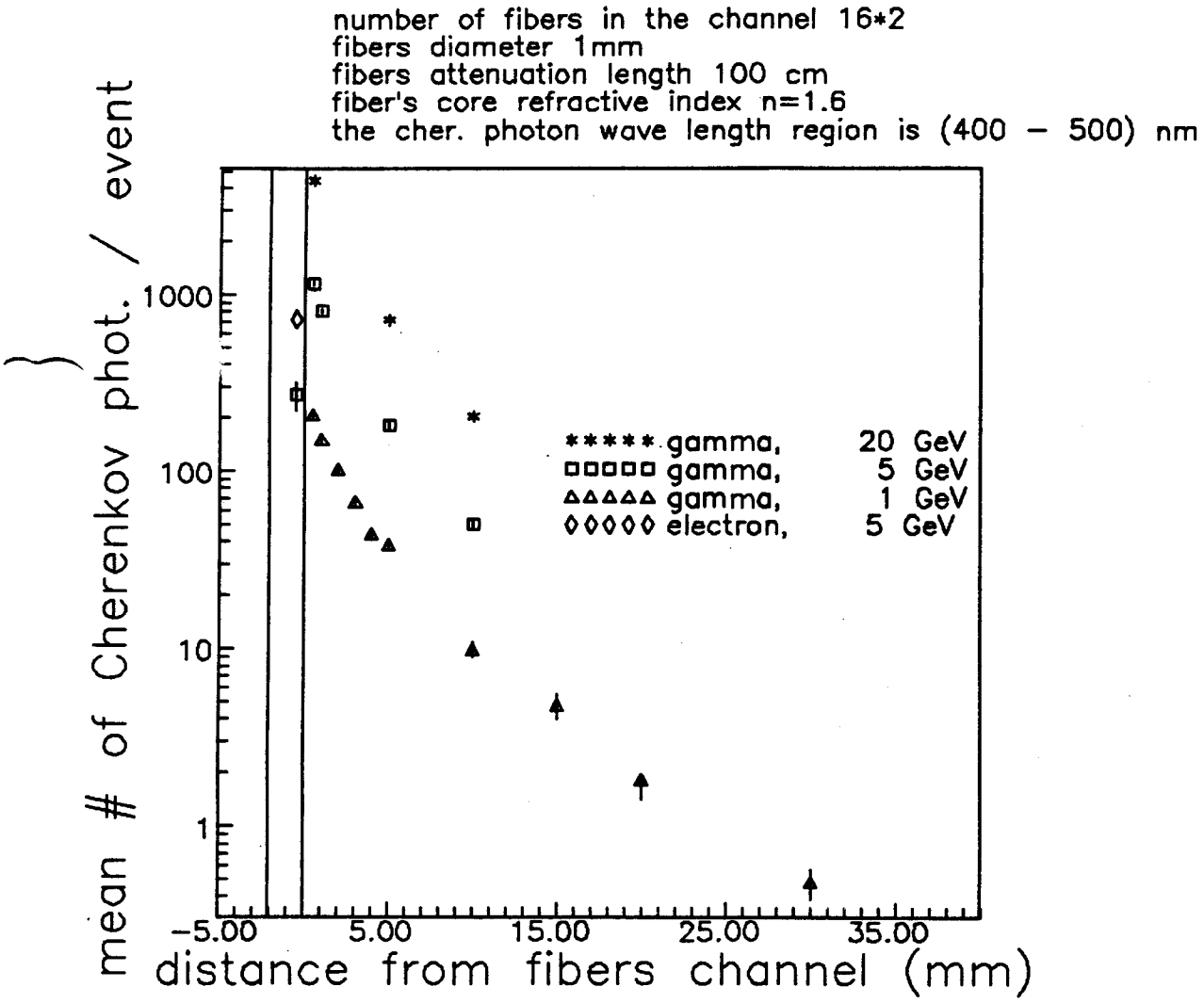
number of fibers in the channel 16*2
fibers diameter 1mm
fibers attenuation length 100 cm
fiber's core refractive index n=1.6
the cher. photon wave length region is (400 – 500) nm
mean # of Cherenkov phot. / event
1000
100
10
1
-5.00
5.00
15.00
25.00
35.00
distance from fibers channel (mm)
*****.gamma, 20 GeV
□□□□□ gamma, 5 GeV
ΔΔΔΔΔ gamma, 1 GeV
◊◊◊◊◊ electron, 5 GeV

Fig 3

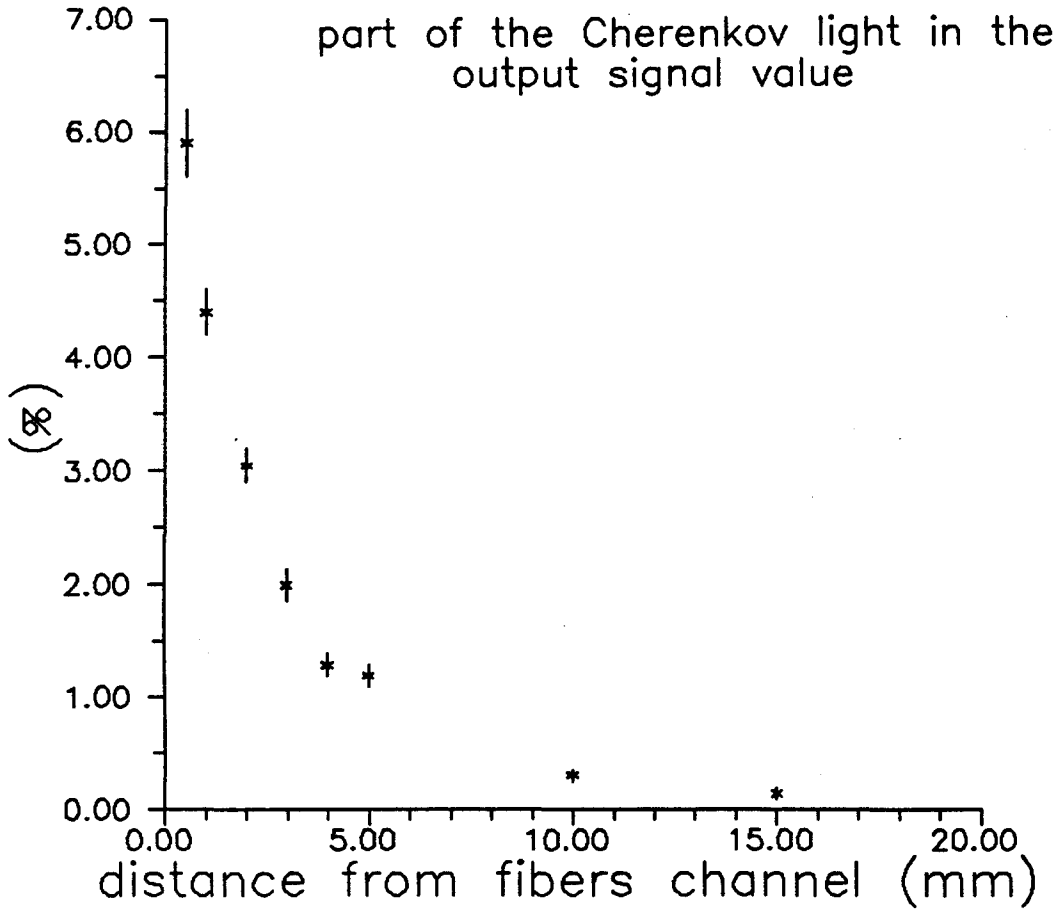
part of the Cherenkov light in the output signal value
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
(%)
0.00
5.00
10.00
15.00
20.00
distance from fibers channel (mm)

Fig 4

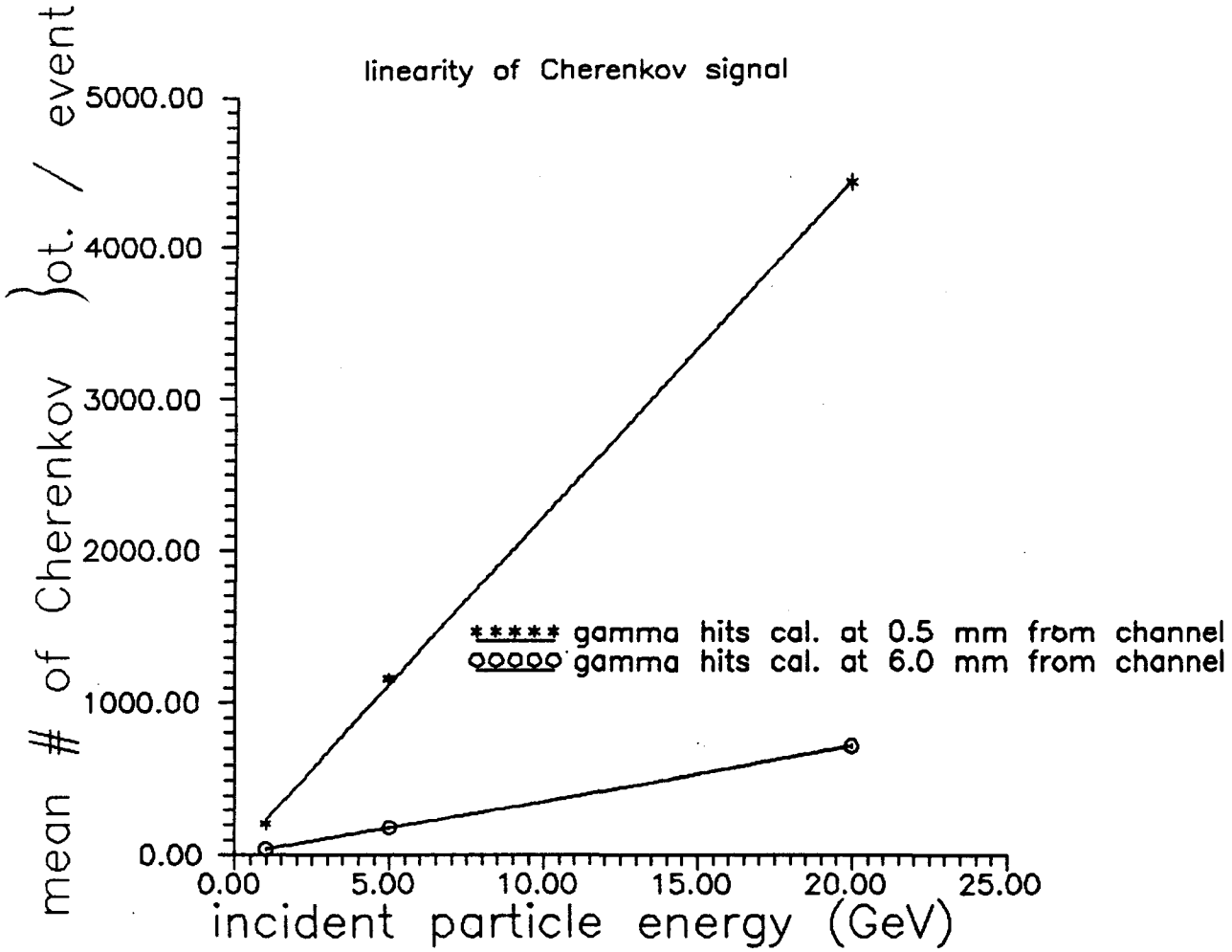
linearity of Cherenkov signal
mean # of Cherenkov }ot. / event
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
0.00
5.00
10.00
15.00
20.00
25.00
incident particle energy (GeV)
***** gamma hits cal. at 0.5 mm from channel
ooooo gamma hits cal. at 6.0 mm from channel

Fig 5

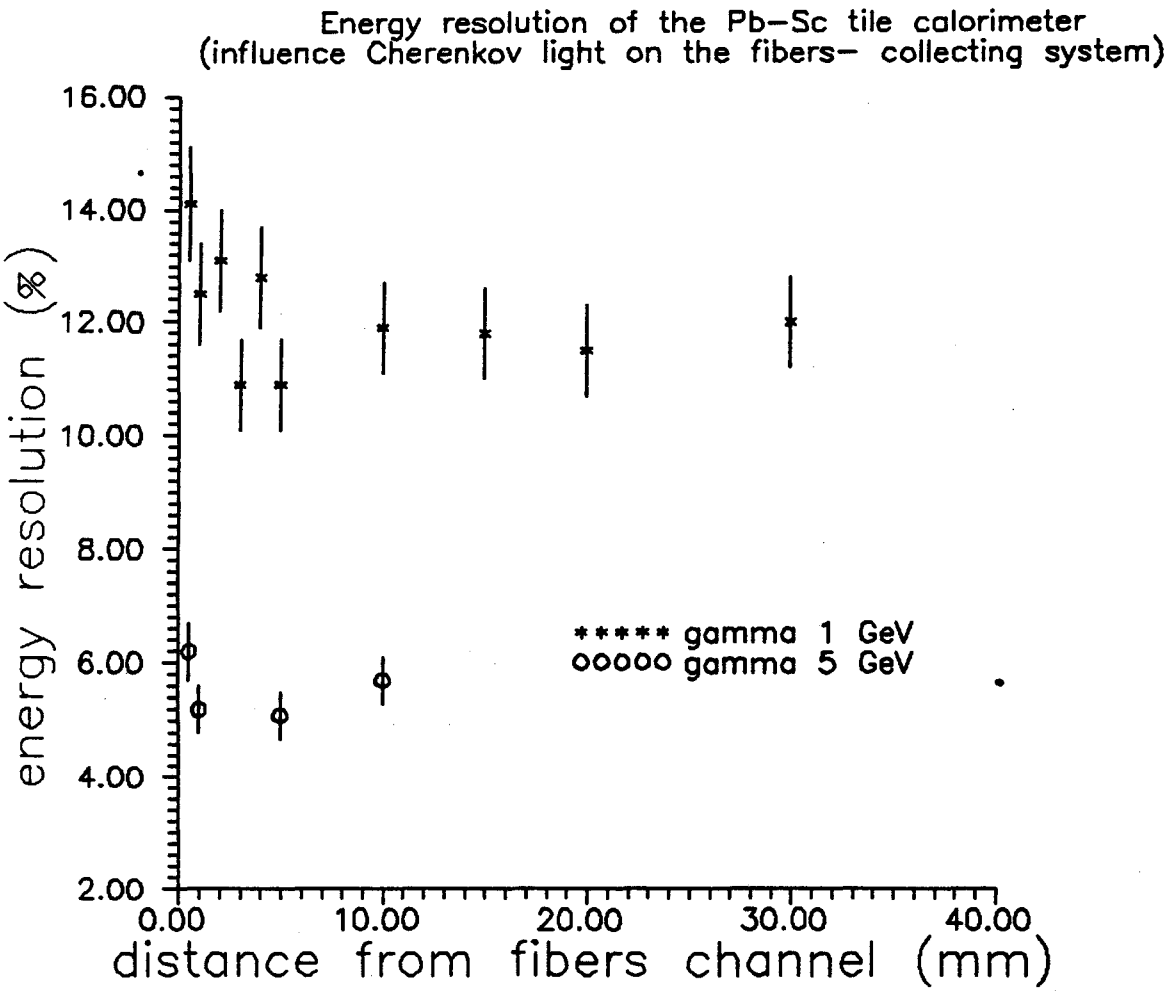
Energy resolution of the Pb–Sc tile calorimeter
(influence Cherenkov light on the fibers– collecting system)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
energy resolution (%)
0.00
10.00
20.00
30.00
40.00
distance from fibers channel (mm)
***** gamma 1 GeV
ooooo gamma 5 GeV

Fig 6