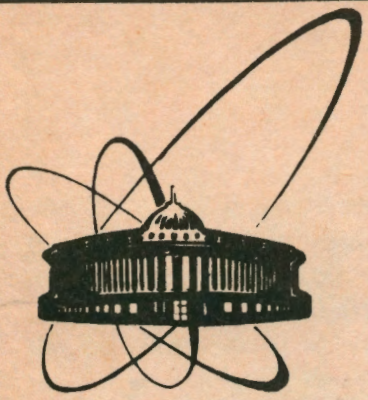

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THE COMPENSATION OF LONGITUDINAL ENERGY LEAKAGE IN THE SHORT ABSORPTION CALORIMETERS

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The articles /1-3/ have already touched the question of the characteristics on the modules of hadron calorimeter HC-600 prototype with cell sizes 150*150 mm^2 and sampling-structure 20 mm steel and 5 mm scintillator. Every calorimeter module consisted of 40 layers (steel+scintillator) with the total length of 100 cm, which corresponded to the nuclear interaction length of about 4.7. The wave length shifter (WLS) carried out the light collection into the photomultiplier (PM).

The factors that defined HC-600 energy resolution were analysed in /4/. In this paper the influence of attenuation length (λ_{WLS}) of WLS on energy resolution of the short absorption hadron calorimeter has been studied.

The contribution of longitudinal fluctuations (σ_{WLS}/E) of the hadron shower development with energy of E(GeV) into the energy resolution of the total absorption calorimeter was determined with /4/:

$$\sigma_{WLS}/E=1-\exp(-kt_o/\lambda_{WLS}), \qquad (1)$$

where $k\leq 1.0$. Moreover, the hadron shower flowing in the longitudinal direction at the short absorption calorimeter led to additional fluctuations of the energy registration.

The results of dependence research (1) are shown in Fig.1 (the points-experimental results with π^--meson beam at energy of 40 GeV, the curves 1+3 - Monte-Carlo calculations). The shower curves for π^--mesons with energy of 10+40 GeV /5/ were used for calculations. The value $k\approx 0.5$ (curve 1) has been obtained for the total absorption calorimeter. The contribution of the longitudinal fluctuations into the energy resolution of the short absorption ($4.7t_o$) calorimeter is characterized with curve 2, which has a minimum about λ_{WLS}=2.5+3.0 m. It proves the possibility to compensate the energy leakage from the calorimeter(when the conversion point of the hadron to the shower approaches PM and the readout signal increases, correspondingly).

So, when the dependence of light collection coefficient (W) on shifter length Z is chosen, the leakage of the hadron shower can be compensated. Curve 3 shows the case when the hadron beam collides with calorimeter ($4.7t_o$) from the side of the photomultiplier /6/. The experimental results (Fig.1) are presented with curve 4 obtained with summing up the calculation data (curve 2) and constant $n \cong 10$. This constant value is formed with the sum of statistical contributions into the energy resolution of the tested hadron calorimeter /4/.

The necessary dependence W(Z) for the real shifter was obtained using neutral filters of variable density according to the calorimeter module length. The filters were placed between the scintillators and WLS. The filter optical density was calculated for every concrete shifter in accordance with determined dependence W(Z). Filters were made of mylar film (10÷15 μm thick) using IBM PC and a plotter. The dependence (2) is shown with the continuous curve in Fig.2:

$$W(Z)=a + b*\exp(-Z/c). \qquad (2)$$

The contributions of the longitudinal shower leakage and fluctuations of conversion point coordinate are minimized with this dependence. For our sampling-structure of the calorimeter a=27±0.4, b=44±1.8 and c=13.4±0.4. The constant "a" corresponds to $\lambda_{WLS}\cong\infty$ at the maximum of cascade curve (pointer in Fig.2) and the second member of dependence (2) describes the compensation of longitudinal leakage for the calorimeter with the absorption length of $4.7t_o$. The investigations have been carried out at π^--meson beam with energy of 40 GeV to observe the compensation effect of the signal amplitude with registration of the hadron shower leakage. The quantity of the longitudinal shower leakage was evaluated from the amplitude of the signal and scintillation counter placed behind the calorimeter. The values of the parameters in (2) have been obtained from the condition to achieve the minimum of energy registration dependence of hadron shower (A) from conversion point (Z_o) with calorimeter length:

$$A(Z_o)=\int_0^{L-Z_o} C(L-(Z_o-Z))W(Z)dz, \qquad (3)$$

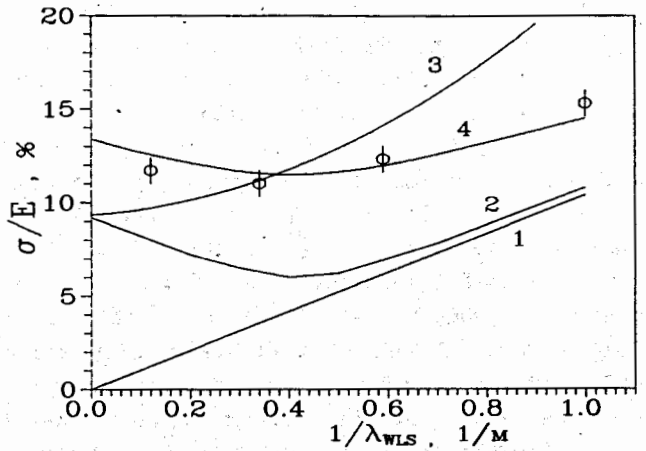


Fig.1. Dependence of calorimeter resolution value σ/E on λ_{WLS}^{-1}: points - experimental data of π^--meson beam at energy of 40 Gev, curve 4 - experimental data fit. Calculated results of contribution value σ_{WLS}/E for calorimeters: 1 - total absorption, 2 - with thickness $4.7t_0$, 3 - as a 2, but with turning for 180^0.

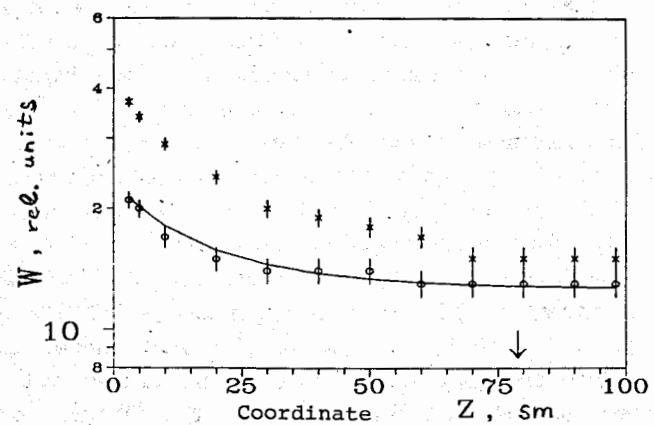
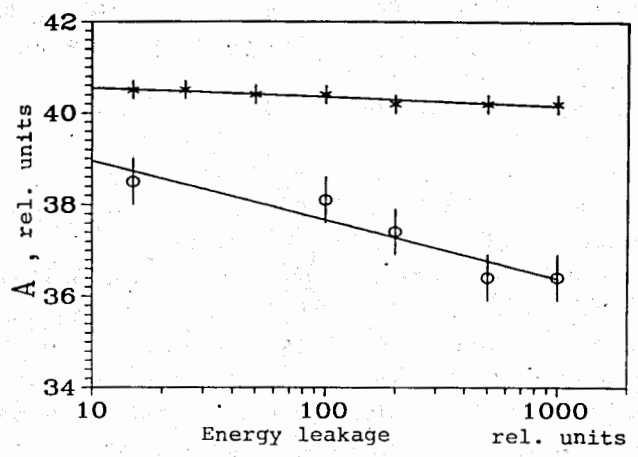
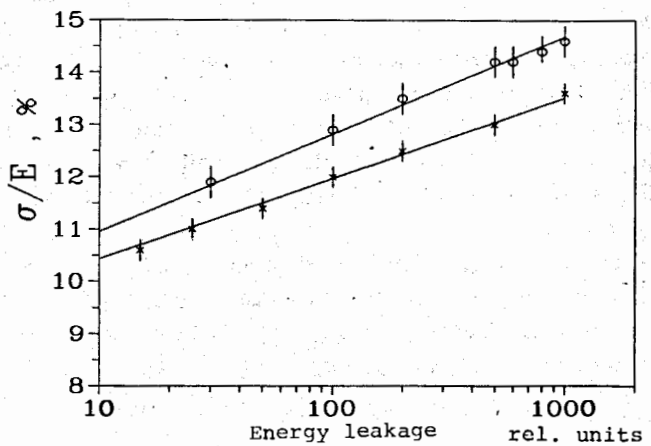


Fig.2. W(Z) dependence on: × - initial shifter, o - WLS with corrective shifter, solid curve - function (2).



a)



b)

Fig 3a,b. The dependences of sum energy deposition (a) and energy resolution (b) on the value of longitudinal energy leakage using WLS with different W(Z): o - λ_{WLS}=12.7 m /1/, × - WLS with characteristic (2).

where C(Z)=dE/dz - cascade curve/5/ - density of energy deposition on the length of the calorimeter with a concrete sampling-structure.

The investigation on compensation effect of signal amplitude registrating hadron shower leakage has been carried out with π^--meson beam at energy of 40 GeV. The value of the longitudinal shower leakage was evaluated with the signal amplitude of the scintillation counter placed behind the calorimeter.

The dependences of full energy deposition in the calorimeters with interaction length of $4.7t_0$ from the value of longitudinal energy leakage are pointed in Fig.3 (WLS of λ_{WLS}=12.7 m /1/ and WLS with characteristic (2). The data have shown that the short absorption calorimeter with optimizing WLS possesses compensation of the longitudinal shower leakage. Also the calorimeter has the better energy resolution (Fig.4). The usage of the discriminating threshold for the signal amplitude of counter S_3 has led to a double decreasing of statistics in the energy range under consideration. The improvement of hadron calorimeter energy resolution (Fig.4) is the result of selection of the showers with the conversion point at the beginning of the calorimeter or with effective increasing of the total attenuation length. The energy resolution is about $\cong$ 10% without shower leakage and is defined with sampling-fluctuations, nuclear fluctuation and photostatistics /4/.

The optimization method of dependence W(Z) on WLS light collection allows one to compensate the longitudinal energy leakage and have the better energy resolution for the short absorption calorimeters in the energy range to be studied. It is very important for the TeV energy range while collider facilities being designed.

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