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THE MUONS REGISTRATION EFFICIENCY OF THE **CMS ECAL** PRESHOWER IN THE INTEGRATED TEST

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1 Introduction

Muon beams are sources for getting the calibration constants of an experimental set-up. To estimate the requested number of statistical data, it is necessary to know the registration efficiency of the detector. The Integrated test was made to estimate the quality of work of the CMS Endcap set-up in the conditions of the correlated background, in June 1995 at CERN in the SPS H2 beam. A schematic view of the integrated test detectors is given in Fig. 1.

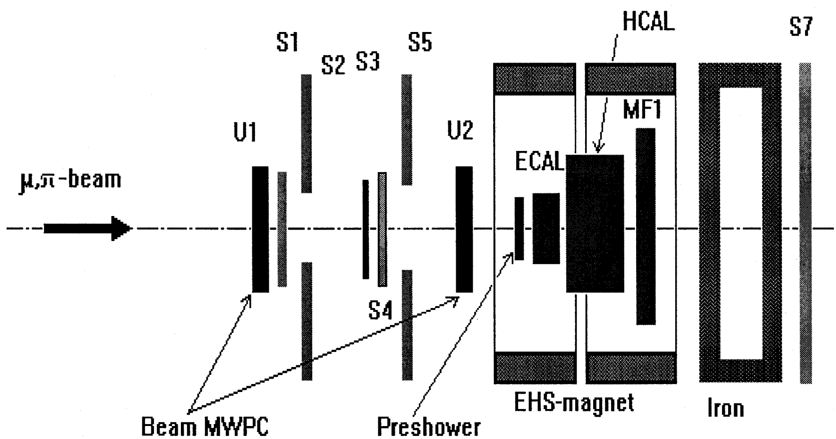

Figure 1: The schematic view of the Integrated test detectors.

The Preshower consists of two layers of lead with the thickness corresponding to $2X_0$ and $1X_0$, interlayed with silicon strip detector planes (see Fig. 2). A geometric size of each plane was 6x6cm^2 (29 strips, each $2mm$ wide, the silicon detector was 400μ thick). The used readout system was the same as in RD36-experiment [1]. The typical signal distribution of muons and pedestal signals is shown in Fig. 3.

2 Muon registration efficiency

In the off-line data processing all muon events with trigger S1xS3xS7 hitting the beam profile were analysed (see Fig. 4). Evidently, that muons crossing the Preshower registration planes are causing an electrical signal in one or two neighbouring strips forming clusters. Here a cluster means the sequence of strips worked out in a row which (with the signal level higher than 3σ, where σ - noise of electronics channel) is limited from the left and right sides by non-worked strips (with the signal level lower than 3σ). A centre of the cluster was defined as an average weighted value. The muons are considered to be qualitatively measured by the preshower planes if:

- a cluster was founded on the preshower plane with a width less than or equal to two strips,
- the deviation of the centre of this cluster on the preshower plane from the direct line drawn across muon coordinates in beam chambers $(U1, U2)$ was less than $3.9mm$ for the preshower Y-plane and was less than $2.9mm$ for the preshower X-plane (see Fig. 5).

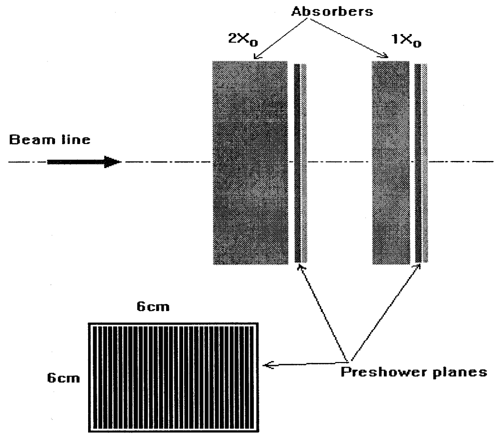

Figure 2: Common view of the Preshower planes

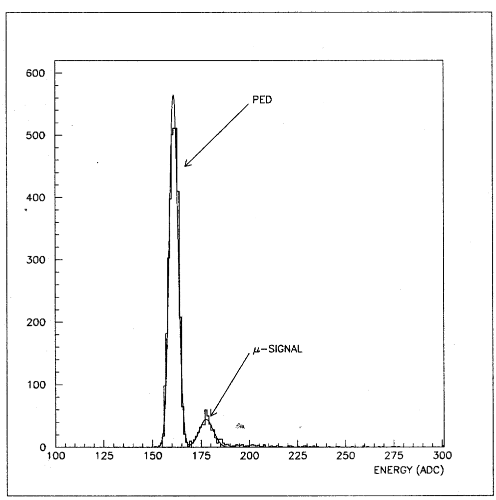

Figure 3: Distribution of muon signals in the single strip

Under the muon registration efficiency we mean the ratio of qualitatively measured muons to the total number of identified muon events.

By the experimental data processing it was obtained that the muon registration efficiency for the PS plane was 93% (see Fig. 6).

3 Ionisation losses of high energy muons in the preshower planes

A charged particle loses a part of its energy while traversing a medium due to collisions with atom electrons. Vavilov [2] derived an accurate solution of the problem of ionisation losses of heavy particles in thin absorbers, i.e. when the typical energy loss is much smaller than the particle initial energy. The distribution obtained, corresponding to the density function, was called Vavilov's distribution $(V(x))$.
The algorithm for the Vavilov's distribution was realised by B.Schorr[3]. Fig. 7 shows the experimental distribution of the energy losses fitted by this function. Unsatisfactory fit quality exits due to significant electronics noise (2.0 $\div$ 3.6 ADC channels). If we take into account the normal distribution of electronics noise (a function density is $N(x)$), we get a new density function of the ionisation losses:

$$W(x) = \int V(y) * N(y - x, \sigma^2) dy.$$

Fig. 8 demonstrates (a solid line) fitting results by $W(x)$ function and for comparison there are also fitting results by the standard $V(x)$ function[3].

In particular, papers [2, 3] point out that the probability density function of charged particle energy losses, passing through thin layers of the medium, is characterised by parameters κ and β^2, where
$\kappa = \xi/\varepsilon_{max}$ is a ratio of mean energy losses of charged particles to the largest possible transferring energy in a single collision with the atomic electron of the matter.
It is confirmed that Vavilov's distribution is correct in the following intervals of the parameters mentioned above:

$0.01 \leq \kappa \leq 10.0$ and $0 \leq \beta^2 \leq 1$

For $\kappa \leq 0.01$ Vavilov's distribution becomes Landau's distribution form, and for $\kappa \geq 10.0$ Vavilov's distribution becomes a normal Gaussian distribution form[2].

As a result of simulation by GEANT3.21[4] and of the experimental data processing, it is shown that the used fit function (Vavilov's distribution) on the parameters and form, approaches Landau's distribution.

Fig. 9(dashed line) illustrates the experimental distribution and the fit result by means of Landau distribution function (L(x)) regardless the electronics intrinsic noise.
The following expression was used to take into account electronics noise:

$$W(x) = \int L(y) * N(y - x, \sigma^2) dy$$

Fig. 9(solid line) shows the results of the experimental data fit by this function.

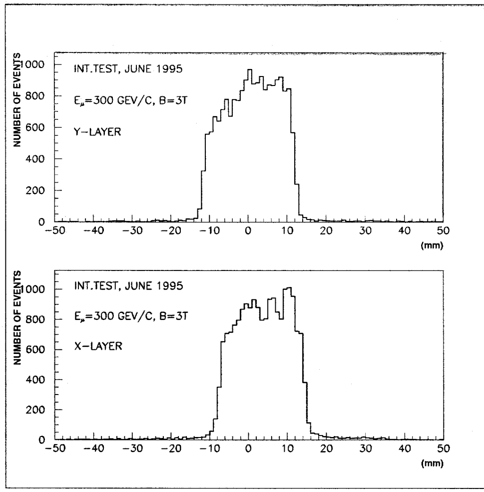

Figure 4: Beam profiles distribution.

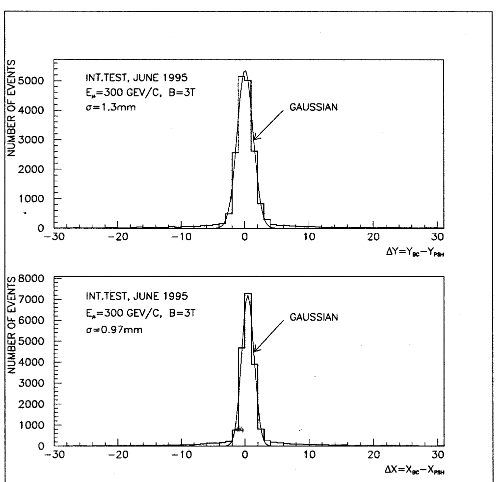

Figure 5: Distribution of the residuals

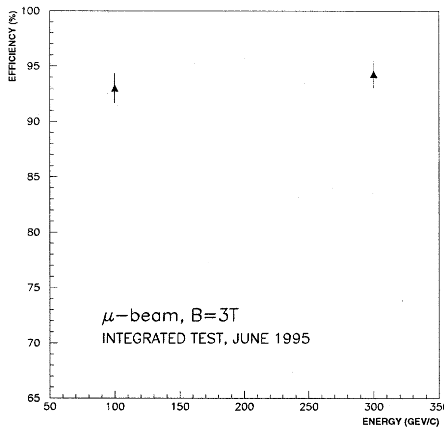

Figure 6: Registration efficiency of the Preshower.

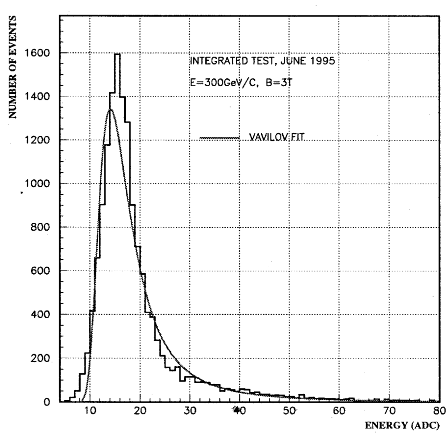

Figure 7: Experimental distribution of the visible muon energy losses in the PS plane: (histogram) - experimental data, (solid curve) - fit by the pure Vavilov function)

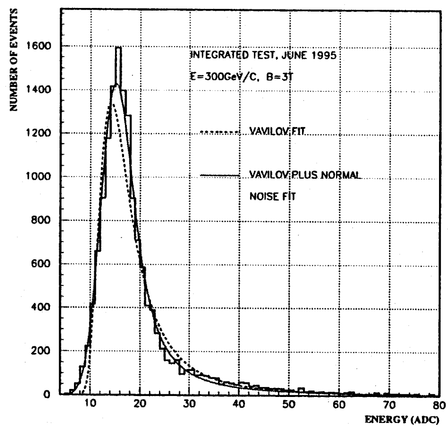

Figure 8: Experimental distribution of the visible muon energy losses in the PS plane: (histogram) - experimental data, (dashed curve) - fit by the pure Vavilov distribution/function, (solid curve) - fit by the Vavilov distribution taking into account the intrinsic electronics noise.

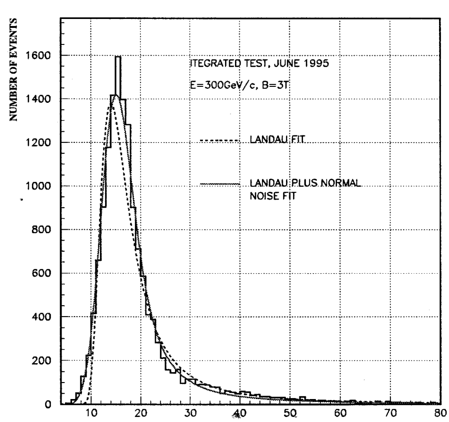

Figure 9: Experimental distribution of the visible muon energy losses in the PS plane: (histogram) - experimental data, (dashed curve) - fit by the pure Landau distribution function, (solid curve) - fit by the Landau distribution taking into account the intrinsic electronics noise.

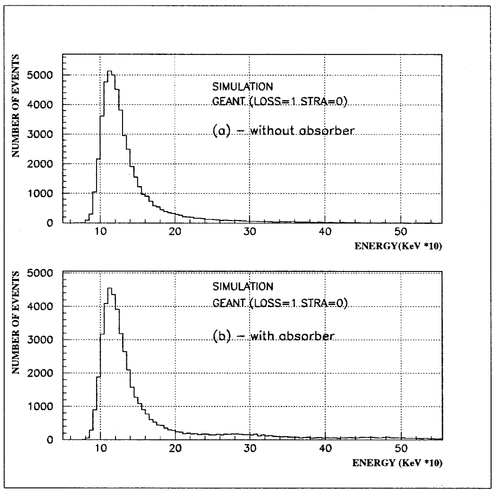

Figure 10: Distribution of the simulated muon energy losses in the PS plane: (a) - PS without lead absorbers, (b) - PS with lead absorbers.

GEANT3.21 was used to simulate the influence of secondary high energy particles which were produced in lead absorbers (inactive layer) of the PS and reached the strips (active layer) of the PS.

The usage of the lead absorbers (inactive layer) results in formation of a long lifted tail in energy losses distribution of the high energy muons (see Fig. 10 - without the lead absorber(a) and with it(b)).

4 Conclusions

After data processing we can conclude the following:

1. Muon registration efficiency for PS plane is 93%.
2. The description of the energy losses of muons in the Preshower by Landau's distribution regarding the influence of electronics intrinsic noise is better than by Vavilov's one. Note that fitting by means of Landau's distribution is more economic for processing time.
3. GEANT3.21 simulation has shown that the increased tail appears in the energy losses distribution in the active layer of the PS because of the inactive absorber layers.

References

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Acknowledgements

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Авезов А.Дж. и др. E1-2000-6

Эффективность регистрации мюонов предливневым детектором электромагнитного калориметра установки CMS

Эффективность регистрации мюонов предливневым детектором (ПД) была оценена по экспериментальной информации интегрированного текста, являющегося прототипом торцевой части установки CMS. Показано, что эффективность регистрации мюонов с энергией от 100 до 300 ГэВ плоскостью ПД в аксиальном магнитном поле 3 Т составляет 93 % и определяется, в основном, величиной шума электроники съема данных — чипами AMPLEX SICAL. Исследовано распределение ионизационных потерь: энергии мюонов в регистрирующих плоскостях ПД и предложен математический метод для описания этих потерь, учитывающий собственный шум электроники. Приводится сравнение экспериментальных данных с результатами математического моделирования.

Работа выполнена в Лаборатории физики частиц ОИЯИ.

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Avezov A.D. et al. E1-2000-6

The Muons Registration Efficiency of the CMS ECAL Preshower in the Integrated Test

The muon registration efficiency of the preshower was estimated from experimental data of the integrated test of the module, that is a prototype of CMS End-cap detector. It is shown that the muon registration efficiency of the preshower plane is 93 % for the muon particles with the energy from 100 to 300 GeV in 3 Tesla axial magnetic field. It was mainly defined by the noise value of the electronics devices — AMPLEX SICAL chips. The muons energy loss distribution in the preshower planes was investigated.

A mathematical method was proposed to describe the distribution of the energy losses taking into account the intrinsic noise of the electronics devices. A comparison of the experimental data with the simulation results was made.

The investigation has been performed at the Laboratory of Particle Physics, JINR.

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