CsI RESULTS OF THE ABSORBER TEST EXPERIMENT FOR THE ALICE DIMUON SPECTROMETER

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Abstract

The lateral punch-through produced by the interaction of a π 's beam with a lead absorber has been measured. The experimental results are compared to the GEANT predictions in order to normalise the dimuon spectrometer simulations. Extrapolation of the results to the shielding of the ALICE detector will serve to estimate the rate of background hits produced by the central Pb-Pb collisions at LHC.

1 Goal of the Test

One of the important working points of the dimuon spectrometer in ALICE [1] [2] requires a good estimation of the background hits in the tracking chambers. Without pipe shielding, the GEANT simulations exhibit, in the tracking and the trigger chambers, a too high particle density which comes from the interactions of the secondaries produced in the collision with the beam pipe at low angles. Addition of the beam pipe shielding strongly reduce this background production. However, the GEANT simulations still indicate a non-negligeable rate of background hits in the detector layers. The segments of track issues mostly from the low energy shower residues produced by the interaction of

the secondaries in the beam pipe shielding of the ALICE dimuon spectrometer.

In the test we have used a simplified absorber geometry to measure the lateral emission of particles obtained by the interaction of a π's beam with the absorber. The comparison of experimental results with the GEANT test simulations will give informations in order to normalise the results of the simulations for the dimuon spectrometer.

2 Experimental Set-up

In the rapidity region of the dimuon spectrometer, the physics generators [3] [4] [5] commonly used to simulate the central Pb-Pb collision in ALICE show that the energy density deposited in the beam shielding could be approximated by the interactions of 100 π of 100 GeV in the absorber material. Reduction of this extrapolation to the experimental condition is given in the figure 1 which shows the lay-out of the absorber test.

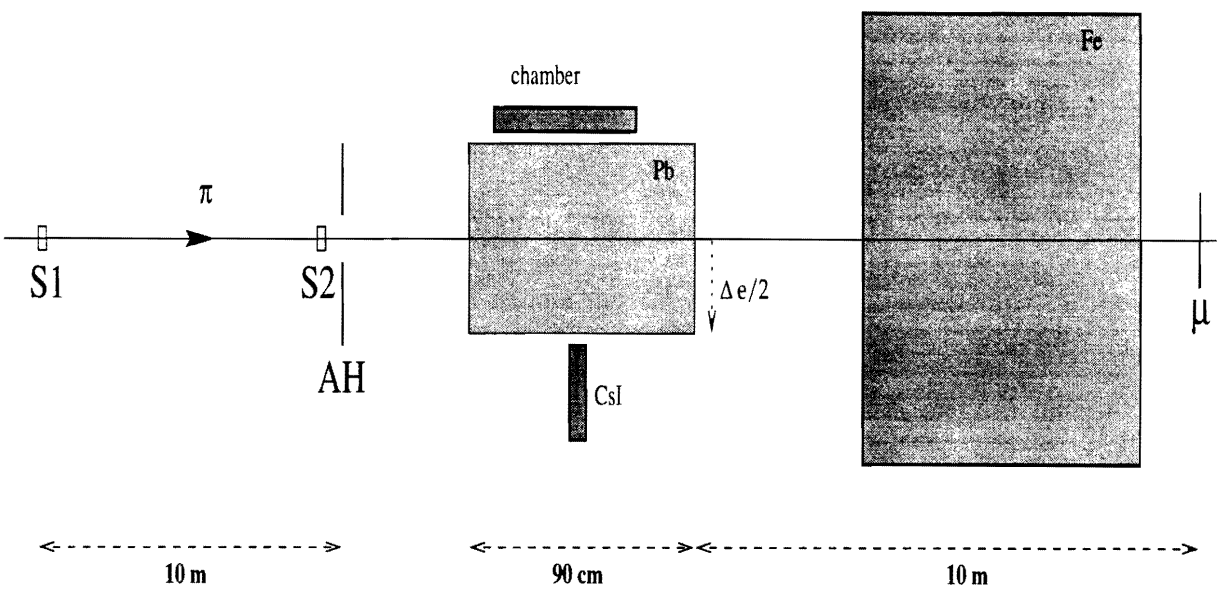

Figure 1: Experimental setup used for the ALICE absorber test.

A secondary beam of π's produced by the SPS with a maximal energy of 100 GeV has been used with a maximal intensity of 10^4 per spill and with a spatial definition of 1 cm at the absorber target. The incident beam is defined by two scintillators S_1 and S_2 separated by 10 m. The scintillator AH covers the front area of the absorber and serves as

veto for the halo particles. After the lead absorber and the iron block, the last scintillator μ gives a veto against muons contained in the beam [6]. The trigger is defined by the set of the coincidences $S_1 \times S_2 \times \overline{AH \times \mu}$.

The absorber is a block of lead ($90 \times 50 \times \Delta$e) cm for which Δe/2 is the variable lateral thickness. The absorber lies on a block of concrete shielding in order that the beam spot fire the center of the front lead.

Two kinds of detectors have been used:

- On one hand, a multiwires proportionnal chamber is set-up parallel to the beam axis and on the side of the lead with an air gap of 6 cm. This gazeous detector is devoted both to the measurements of the lateral profile and the production rate of the punch-through particles. The data obtained with the proportionnal chamber are analysed in another note [6].
- On another hand, a CsI(Tl) scintillator [7] is set-up perpendicular to the beam axis and against the absorber at 45 cm from the beginning of the lead. This location corresponds to the maximum emission of particles according to the GEANT simulations. The CsI cristal provides charged hadrons (p, d, t, ^{3}He, ^{4}He) and γ + electron separation. It gives the particle composition of the lateral punch-through and the energy distributions of the different particles .

3 Analysis of the CsI(Tl) detector results

The CsI detector is a cylindrical cristal of 4 cm diameter and 8 cm length. An steel protection of 3 cm surround the CsI and the PMT.

The particle discrimination is achieved by the simultaneous measurement of the fast (Q_f) and slow (Q_s) response of the CsI scintillator using a charge analysis of the light signal by two different gates. The figure 2 shows the typical identification pattern of the scintillating signals (Q_s vs Q_f) observed in the test experiment. During the analysis phase of the detector data, the separation between the different particles is obtained from polynomes of the third order which are represented on figure 2. (γ + electron), proton, (d + t) and (^{3}He + ^{4}He) are clearly separated but because of the low statistic of the heavier particles, it has not been possible to separate d from t and ^{3}He from ^{4}He. Mis-identifications was estimated to remain below 5 % for all species during the identification procedure.

The energy calibration of the CsI detector was performed during the test. The energy deposition of the π's beam in 4 cm of CsI (the cristal was placed perpendicular to the beam) and in 8 cm of CsI (the cristal was placed parallel to the beam) are measured knowing the energy deposition in the CsI (8 MeV.cm^{-1} for π's at 50 GeV). Figure 3

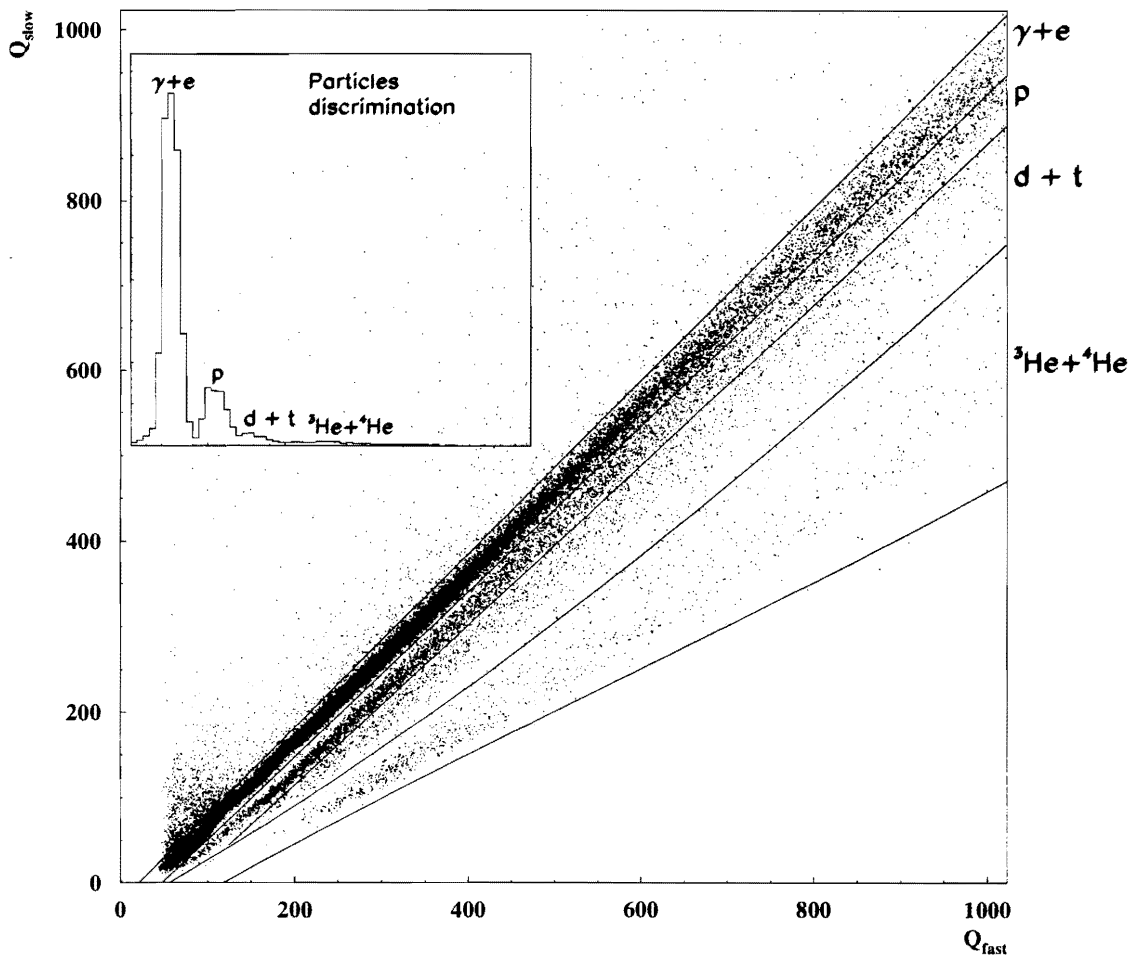

Figure 2: Particles identification.

shows the results of the calibration runs. The channel 264.5 corresponds to a deposited energy of 32 MeV and the channel 656.4 corresponds to a deposited energy of 64 MeV in the cristal.

The low energy calibrations were obtained using γ and electron sources. Extrapolation of the calibration curves over the whole dynamic was performed using the results of previous studies on these scintillator cristals [8] [9]. The overall energy calibration of the scintillator accurates within 10 %. Hard energy thresholds were set below 0.5 MeV during the data taking. During the analysis, soft energy thresholds of 2 MeV for ($\gamma's$ + electrons) and of 5 MeV for the heavier particles were introduced.

At the final step of the analysis, corrections due to the inefficiency of the $\overline{\mu}$ veto were

taken into account. 5 % (resp. 20 %) of the incident particles were tagged as muons at the beam energy of 50 GeV (resp. 70 GeV).

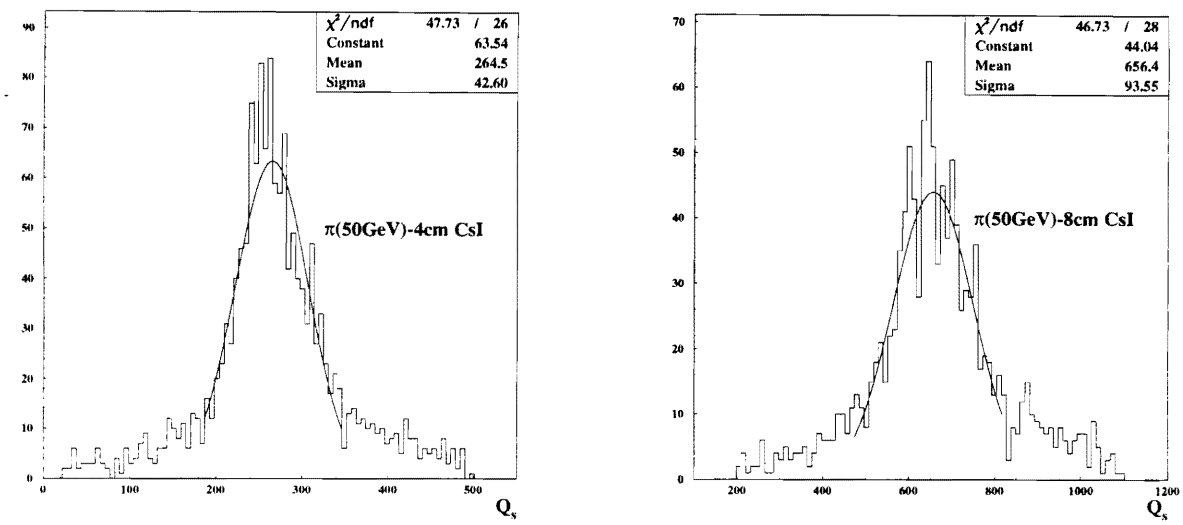

figure 3: Q_s obtained for π of 50 GeV in 4 cm and 8 cm of CsI.

4 Comparison with the simulation.

The GEANT simulations of the whole set-up have been performed with energy cuts of 1 MeV for the tracking of all particles. About 10000 events per incident π's energy of 30, 50 and 70 GeV with two different lead thicknesses of 15 and 20 cm have been calculated. Estimation of the total deposited energy of each particle which impact the CsI is obtained by summing the energy losses of both the incident particle and its shower. Same energy thresholds as in the experimental data were applied after the summation of the total deposited energy. The number of particles is normalized per incident π's and per cm^2.

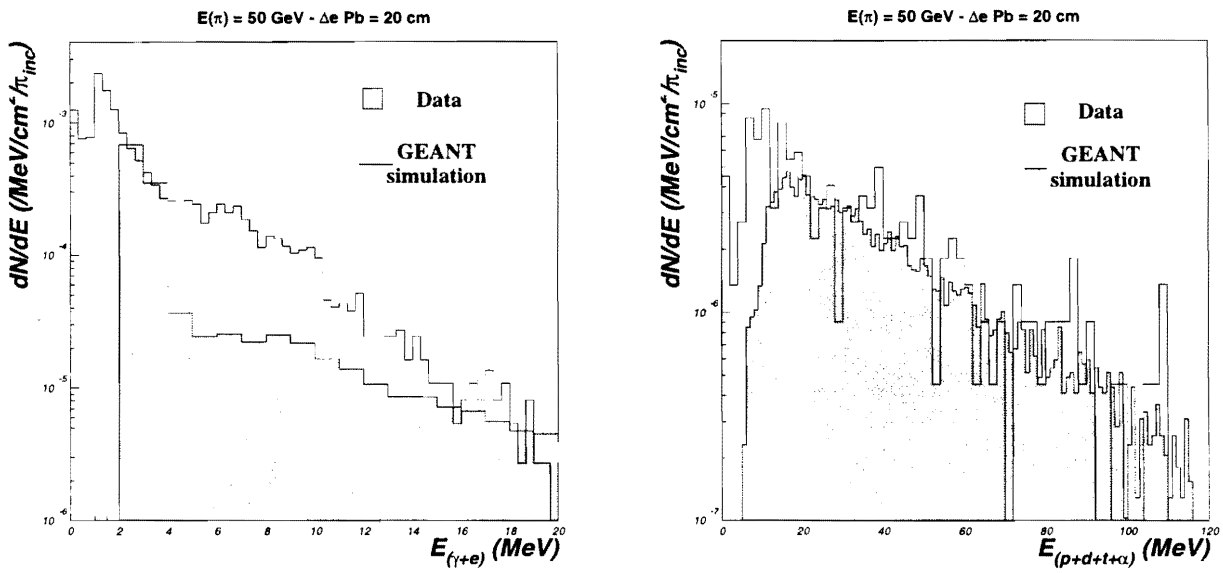

figure 4: γ + electrons and charged particles energy distribution dN/dE

Figure 4 compares the experimental and simulated energy distributions dN/dE. The shape of the distributions are the same for all incident energies and for the different thicknesses of lead. We obtain a very good agreement between experiment and simulation for charged particles. But for γ + electron's the simulation gives more of high energy particles than experiment.

thickness of lead	15 cm			20 cm		
E_π (GeV)	30	50	70	30	50	70
γ +e	5.2e-04	1.0e-03	1.5e-03	2.6e-04	4.6e-04	7.1e-04
p	2.1e-05	3.6e-05	4.3e-05	1.1e-05	1.8e-05	2.6e-05
d + t	7.4e-06	1.2e-05	1.5e-05	4.1e-06	5.7e-06	9.2e-06
^{3}He + ^{4}He	4.3e-06	7.1 e-06	8.7e-06	2.2e-06	3.2e-06	4.8e-06

Table 1: Particles detected in the CsI ($/\pi/cm^2$).

Table 1 resumes the production rates for the different kinds of particles detected in the test experiment. For all incident energy of π's and the two different thicknesses of lead, γ and electron represent 95 % of the total number of detected particles and the heavier

particles (p + d + t + ^{3}He + ^{4}He) weigh for 5 % only. The increase of the different particle rates with the incident energy of the π's looks not linear but the production rates are found two times smaller when the thickness of lead increase from 15 to 20 cm.

The results obtained with the CsI differ in some points with the results of the chamber [6] which show higher production rates both in the experiment and the simulation. Our experimental results for charged particles are about a factor of 10 lower than the results of the chamber. This discrepancy can be explained by our threshold settings which are of some keV for the chamber and of 2 MeV (for γ + electron) and 5 MeV (for charged particles) for the CsI.

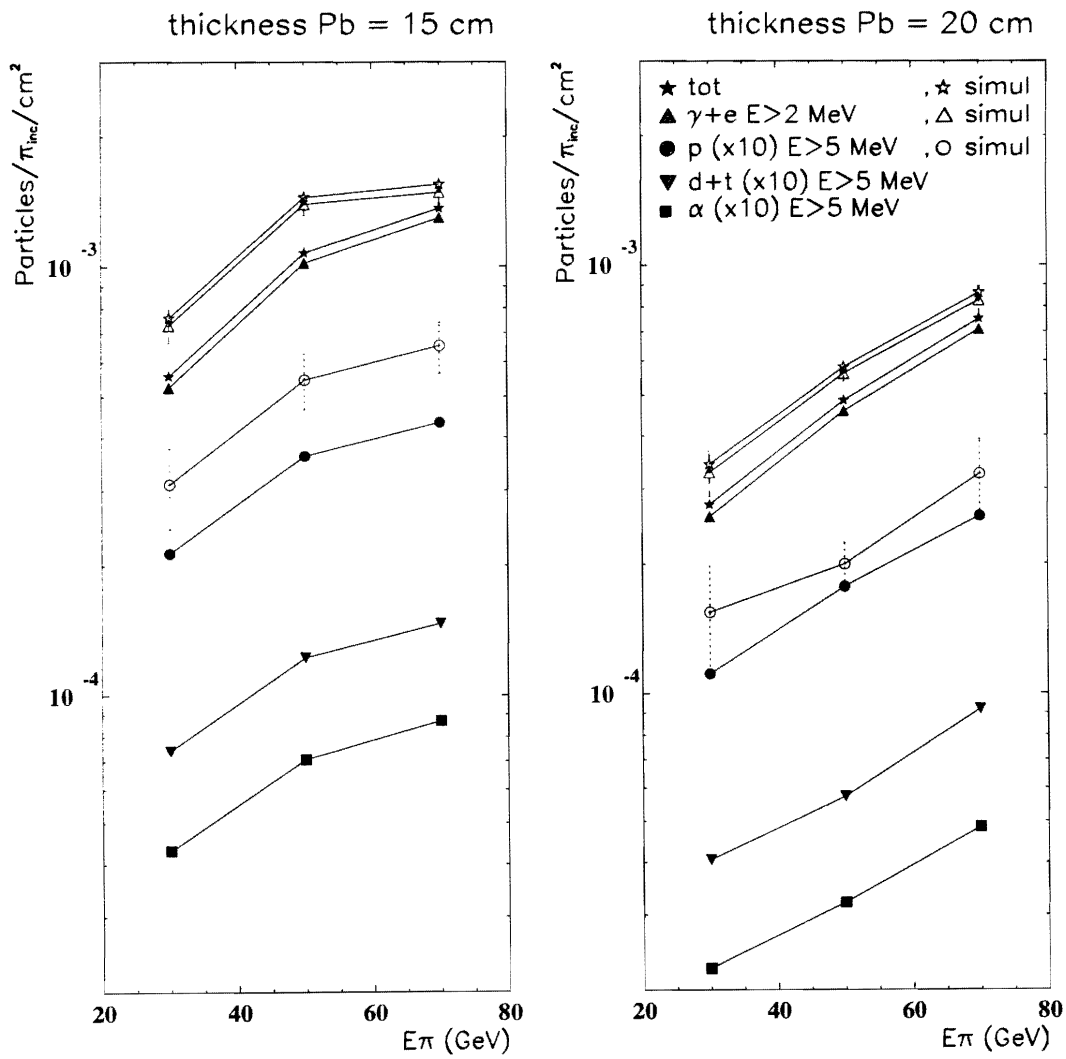

figure 5: Number of particles per incident π and per cm^2 as a fonction of the incident energy.

The comparison of CsI results with the results of the GEANT simulation is presented on figure 5. One obtain a good agreement with the simulation for γ + electron and p which were produced in the GEANT code. The heavy fragments d, t, ^{3}He and ^{4}He are not found in the simulation, but these components , which correspond to a very marginal part of the total charged particle flux, would not change drastically the integral rate.

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(This report is also published in the ALICE collaboration under the reference ALICE Note 96-33)