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STATISTICAL MULTIDIMENSIONAL SEPARATION OF THE ELECTRON AND PION EVENTS IN THE IRON-SCINTILLATOR HADRONIC CALORIMETER

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The hadronic iron-scintillator tile calorimeter [1] of the ATLAS detector will contain 5120 cells which will be read-out by 10240 PMT's. For each cell the calibration constants, which define the relationship between the calorimeter signals expressed in picoCoulombs and the energy of the absorbed particles, must be determined with an accuracy of 1% [2]. It is important to have the events with known initial particles. But the test beams at the SPS CERN are the mixture of muons, electrons, and hadrons. Therefore, the identification of these particles on the basis of the calorimetric information is necessary.

The important characteristic of a hadronic calorimeter is the e/h ratio which determines the degree of non-compensation. In order to obtain this value with the systematic error smaller than 0.3% the electron — pion separation must be smaller than 0.2%.

We have used the data obtained at the SPS in the energy range of 10 — 300 GeV.

For the electron and pion selection we have used the C_i, E_{cut} and $\check{C}_1$ cuts. The C_i cut

$$C_i = \sum_{selected\ i} \sum_{k=1}^{2} \sum_{l=1}^{2} E_{ikl}/E_{beam}, \tag{1}$$

is the relative shower energy deposition in the first two calorimeter depths, where E_{ikl} is the energy deposition in ikl cell, i is the raw number, k is the depth number, $l = 1,\ 2$ is the PMT number. The basis for this electron-hadron separation is the different longitudinal energy depositions for electrons and hadrons. For example, if a 100 GeV particle crosses 45 cm of the Tile calorimeter from the front face it corresponds to 18 radiation lengths or 2.2 nuclear interaction lengths. The amount of the deposited energy is equal to 95% for the electromagnetic shower and 50% for the hadronic shower [3]. The E_{cut} cut

$$E_{cut} = \frac{\sqrt{\sum_c (E_c^\alpha - \sum_c E_c^\alpha / N_{cell})^2}}{\sum_c E_c^\alpha}, \tag{2}$$

where $1 \leq c \leq N_{cell}$, N_{cell} is the used cells number, is related with the lateral shower spread. This spread is connected with the containment radius of shower which considerably differs for the electromagnetic and hadronic showers. For example, for the 100 GeV hadronic shower the 99% containment radius is equal to 430 mm, but for the electromagnetic shower the one is equal to 70 mm [3]. The power parameter $\alpha = 0.6$ has been tuned to achieve maximum separation efficiency.

The $\check{C}_1$ cut is connected with the Cherenkov counter amplitude and used for $E \leq 20$ GeV.

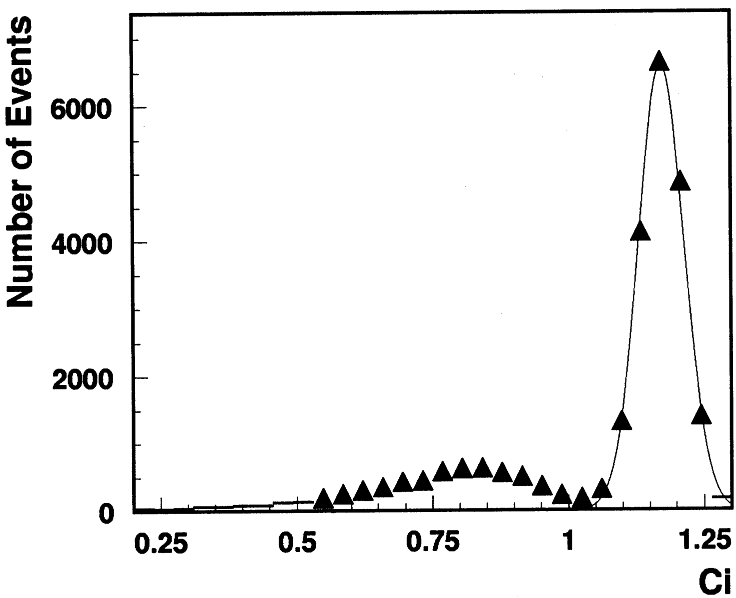

Figure 1: The C_i distribution for E = 180 GeV.

Figs. 1 and 2 show the typical C_i and E_{cut} distributions. The left peak corresponds to pion events, the right peak — the electron events. Figs. 3 and 4 show the typical scatter plots of E_{cut} vs C_i and C_i vs $\check{C}_1$. The top right regions are the electron events, the bottom left regions are the pion events. These Figures allow to determine the values of the cuts and to estimate the contaminations.

At energies ≤ 20 GeV there is a bad separation with the C_i and E_{cut} (contaminations about 10%). This situation is greatly improved by using the Cherenkov counter signal cut (Fig. 4).

We have estimated by extrapolation of the fitted pion peak curve to the region of the electron peak (Figs. 1, 2) that the contamination of the pion events in the electron events does not exceed the 0.2% level. The developed method has allowed to decide the task of obtaining of the clean

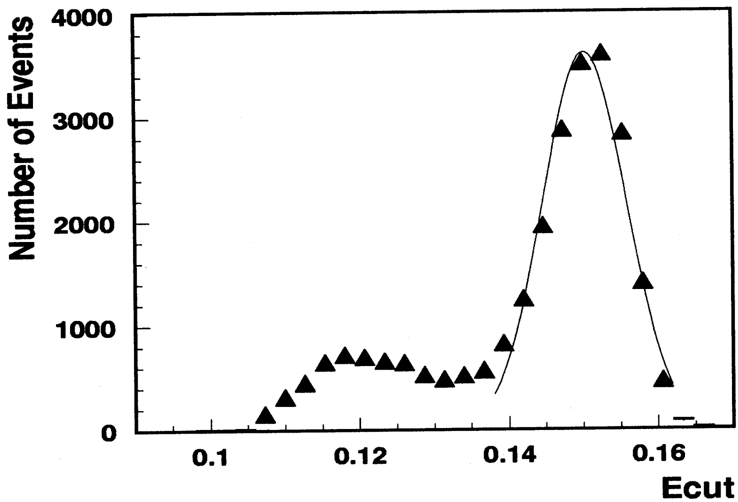

Figure 2: The E_{cut} distribution for E = 180 GeV.

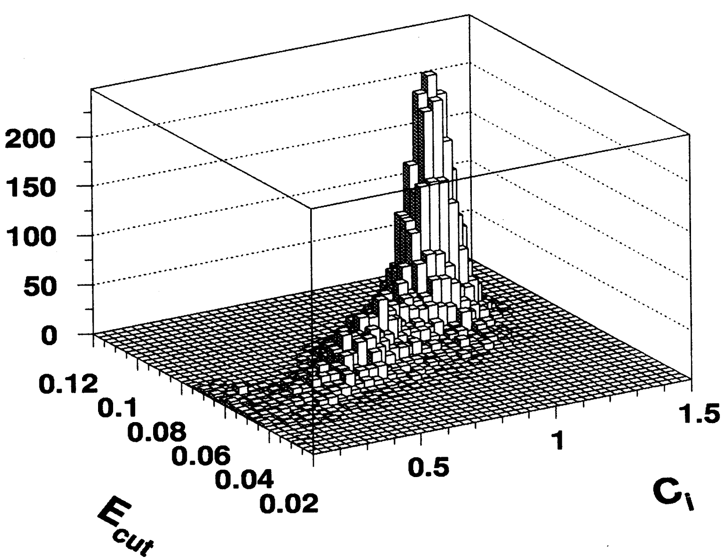

Figure 3: The plot of E_{cut} vs C_i for E = 20 GeV.

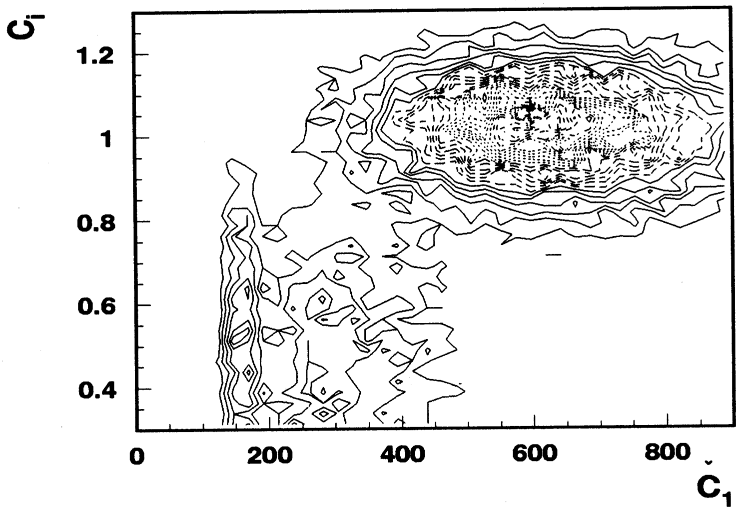

Figure 4: The plot of C_i vs $\check{C}_1$ for E = 20 GeV.

samples of the electron and pion events for the calibration of modules of the tile calorimeter, for the determination of the electron and pion energy resolutions and the e/h ratio values [1]-[5].

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References

[1] ATLAS Collaboration, CERN/LHCC/96-42.

[2] ATLAS Collaboration, CERN/LHCC/99-14.

[3] P. Amaral et al., NIM A443 (2000) 51.

[4] S. Akhmadaliev et al., NIM A480 (2002) 508.

[5] S. Akhmadaliev et al., NIM A449 (2000) 461.

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Кульчицкий Ю. А., Виноградов В. Б. E1-2003-4
Статистическое многоразмерное разделение
электронных и пионных событий
в железосцинтилляционном адронном калориметре

Разработан новый статистический многоразмерный алгоритм для выделения электронных и пионных событий в адронном калориметре. Алгоритм основан на различном пространственном развитии электромагнитного и адронного ливней. Метод был апробирован при анализе экспериментальных данных, полученных в пучках заряженных электронов и пионов с энергиями 10–300 ГэВ на ускорителе SPS (ЦЕРН) с помощью железосцинтилляционного адронного калориметра эксперимента ATLAS. Результаты проведенного исследования показали высокую (на уровне 99,8 %) эффективность распознавания событий.

Предложенный алгоритм может быть использован для анализа данных, полученных на современных калориметрических комплексах, применяемых в таких экспериментах, как ATLAS, CMS на LHC и CDF, D0 на TEVATRON.

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Kulchitsky Y. A., Vinogradov V. B. E1-2003-4
Statistical Multidimensional Separation of the Electron
and Pion Events in the Iron-Scintillator Hadronic Calorimeter

We have developed and studied the statistical multidimensional combined algorithm for the selecting of the electron and pion events. The algorithm is based on the different spatial electromagnetic and hadronic shower developments. The method has been tested on the basis of the experimental data of the ATLAS tile iron-scintillator hadronic calorimeter exposed to the electron and pion beams of energies from 10 to 300 GeV of the CERN SPS. The results of the investigation have shown the high efficiency (at the level of 99.8 %) of the event separation.

This algorithm can be used for the data analysis from the modern combined calorimeters like the ATLAS, CMS detectors at the LHC and the CDF, D0 at the TEVATRON.

The investigation has been performed at the Dzhelepov Laboratory of Nuclear Problems, JINR.

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