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Charged-particle pseudorapidity density with the silicon pixels in ALICE

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Summary. — The first measurement that will be carried out with the ALICE detector, both in p-p and in Pb-Pb collisions, is the charged-particle pseudorapidity density distribution. After a brief introduction on the ALICE experiment and the relevance of the first measurements, the reconstruction algorithm, using data provided by the Silicon Pixel Detector only, is described. The analysis procedure with the main correction factors and the expected results based on Monte Carlo samples are also shown.

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1. – The ALICE experiment at LHC

ALICE is a general-purpose heavy-ion experiment designed to study the physics of strongly interacting matter and the quark-gluon plasma properties in nucleus-nucleus collisions at LHC energy. The ALICE apparatus has several features, such as very low p_T acceptance, excellent tracking and particle identification capability, high minimum bias trigger efficiency, that make it also an important contributor to proton-proton physics. A complete research program on p-p collisions is planned, aiming both to set the baseline for the understanding of the heavy-ion data and to explore the new energy domain [1].

2. – Charged particle pseudorapidity density measurement

The pseudorapidity density distribution will be the first measurement carried out with the ALICE detector, first presumably at a centre-of-mass energy $\sqrt{s} = 900\,\text{GeV}$ and then at higher energy, namely $\sqrt{s}$ from 8 to 14 TeV. The measurement at the lowest energy would allow comparisons with the existing results for p-$\bar{\text{p}}$ collisions at the same centre-of-mass energy performed at Sp$\bar{\text{p}}$S. Together with the measurements at higher energies, it will constrain the hadroproduction models allowing to correctly configure the Monte Carlo generators and determine the energy dependence of the charged-particle density.

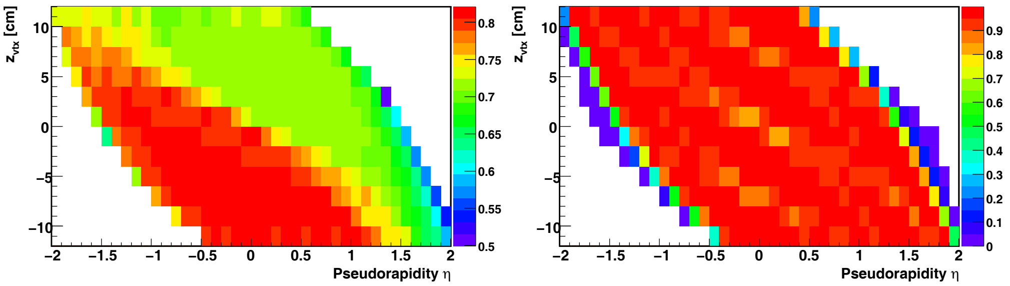

Fig. 1. – Two of the tracklet level corrections: the algorithm and detector inefficiency correction (on the left) and the detector acceptance correction (on the right).

The reconstruction of the pseudorapidity density distribution in the central η region can also be performed using only data provided by the two innermost layers of the inner tracking system, namely the Silicon Pixel Detector (SPD).

3. – The silicon pixel detector

The two SPD layers, placed at 3.9 cm (with a pseudorapidity coverage $|\eta| < 2$) and 7.6 cm ($|\eta| < 1.4$) average distances from the beam line, are equipped with hybrid pixels. The detector is composed of 120 basic modules, 40 in the inner layer and 80 in the outer layer, with a total number of pixels of about 10 M. The pixel cell size is $50 \times 425\,\mu\text{m}^2$ [2].

The SPD will allow to reconstruct the primary vertex position, to select events contributing to the Level 0 (L0) minimum bias trigger and to reconstruct the charged-particle multiplicity and pseudorapidity density distributions.

4. – The algorithm for track reconstruction with the SPD

Besides its key vertexing role in the ALICE apparatus, the SPD allows to estimate the number of primary charged particles in the central pseudorapidity region. The reconstruction algorithm uses the clusters in the SPD and the reconstructed primary vertex. Using the vertex as origin, for each cluster in the inner layer the algorithm calculates the differences in the azimuthal and polar angles ($\Delta\varphi$ and $\Delta\theta$, respectively) between this cluster and each cluster in the outer layer. Then an elliptical cut is applied and the pair which satisfies the window requirement is labeled as "tracklet" [3]. The pseudorapidity η is evaluated by considering a straight line from the main vertex to the position of the cluster in the inner layer. The multiplicity of charged particles is estimated counting the number of reconstructed tracklets.

Compared to the same measurement based on the fully reconstructed tracks, the charged multiplicity reconstructed with only the pixels has some basic advantages such as a larger acceptance coverage both in pseudorapidity and transverse momentum (down to 30 MeV/c) and the much smaller reliance on alignment and calibration procedures: this, in particular, would allow to extract results from the very first available data.

5. – Corrections and final results

Several effects have to be taken into accout in order to reconstruct the physical distribution from the measured one, both at tracklet and event level. They correspond

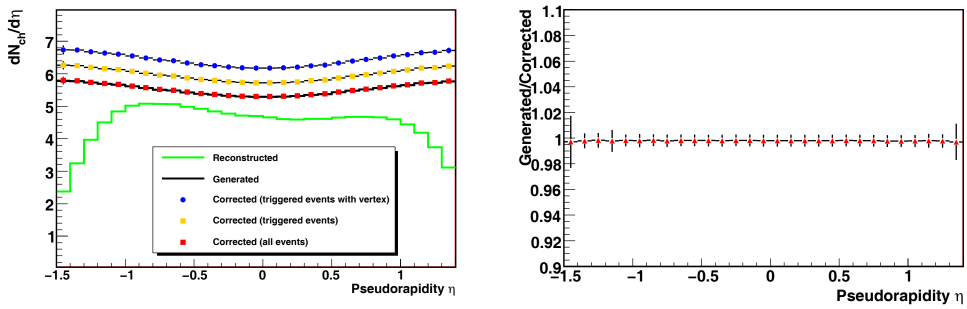

Fig. 2. – Pseudorapidity density distributions at different correction stages (on the left) and final ratio between the fully corrected and the Monte Carlo distributions.

to the following contributions: background from secondary particles, algorithm and detector inefficiency, detector acceptance, particles that do not reach the sensitive layers, vertex reconstruction inefficiency, minimum bias trigger inefficiency. These effects and the corresponding corrections have been studied and computed using dedicated Monte Carlo productions, as a function of both the pseudorapidity η and the z-coordinate of the vertex at tracklet level and as a function of both the reconstructed multiplicity and the z-coordinate of the vertex at event level. To calculate them, information from reconstruction and Monte Carlo is needed.

As an example, the correction for the algorithm and detector inefficiency and the correction for the detector acceptance are shown in fig. 1. In this analysis the SPD inefficiency has been assumed much larger than expected for the purpose of checking the correction tools and procedure only (13%, corresponding to 15 dead modules). The distribution of the SPD dead channels is not symmetric along the z direction. The effect of the asymmetry can be observed both in the efficiency correction and in the raw reconstructed distribution shown in fig. 2.

Applying each correction and taking into account the η range covered by the SPD as a function of the z-coordinate of the vertex to calculate the correct normalization factor, the results shown in fig. 2 are obtained. The ratio between the generated and the reconstructed distributions indicates that the fully corrected distribution reproduces very well the generated Monte Carlo one. Similar results have been obtained using two different generators as inputs for the correction calculation and the reconstruction algorithm, respectively. Here only the statistical error is shown, while the overall systematic uncertainty has been estimated to be at a few per cent level [4].

In conclusion, ALICE will be able to measure the charged-particle pseudorapidity density within few days of data-taking. A measurement of the $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ can be carried out using the pixel detector information in the range $|\eta| < 1.4$ with a few percent systematic error.

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