The ALICE Inner Tracking System Off-line Software

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Abstract

An overall view of the ALICE Inner Tracking System Off-line Software is presented. Besides the general scheme, some preliminary results concerning geometry, material budget, track reconstruction and particle identification are also shown.

Keywords: LHC, ALICE, ITS

1 Introduction

ALICE (A Large Ion Collider Experiment) [1] is an experiment at the Large Hadron Collider (LHC) optimized for the study of heavy-ion collisions, at a center-of-mass energy ~ 5.5 TeV per nucleon. The prime aim of the experiment is to study in detail the behaviour of nuclear matter at high densities and temperatures, in view of probing deconfinement and chiral symmetry restoration.

The detector consists of two main components: the central part, composed of detectors mainly devoted to the study of hadronic signals and dielectrons, and the forward muon spectrometer, devoted to the study of quarkonia behaviour in dense matter. The Inner Tracking System (ITS) [2] is one of the detectors of the central part, which covers the polar angle range $\pm 45^\circ$ ($|\eta| < 0.9$) with respect to the normal to the beam direction. It consists of six layers of silicon detectors. From the inside to the outside, there are two layers of silicon pixel detectors (SPD), two of silicon drift detectors (SDD) and two of silicon strip detectors (SSD). Its basic function are: i) the determination of the primary vertex and of the secondary vertices necessary for the reconstruction of charm and hyperon decays, ii) the particle identification and tracking of low-momentum particles, and iii) the improvement of the momentum and angle measurements of the Time Projection Chamber (TPC) [3].

In this short paper we present the current status of the Off-line Software of the ITS [4]. The scheme of the code is presented in the next section while a selected series of preliminary results of the simulations is shown in section 3. Summary and conclusions are drawn in section 4.

2 The code

All the code concerning the simulation of the Inner Tracking System is written in `C++` and is included into `Aliroot` [5], the standard ALICE simulation and reconstruction package, which includes, among the others, all the GEANT3 functionalities, and is based on the ROOT [6] object-oriented data analysis framework.

A (partial) view of the block diagram of the ITS Off-line Software is shown in fig. 1. The first step consists of running `Aliroot` itself which outputs the hits on a file using the ROOT I/O functionalities. Hits are then read back by the programs of the package `ITSSIM`. In the case where

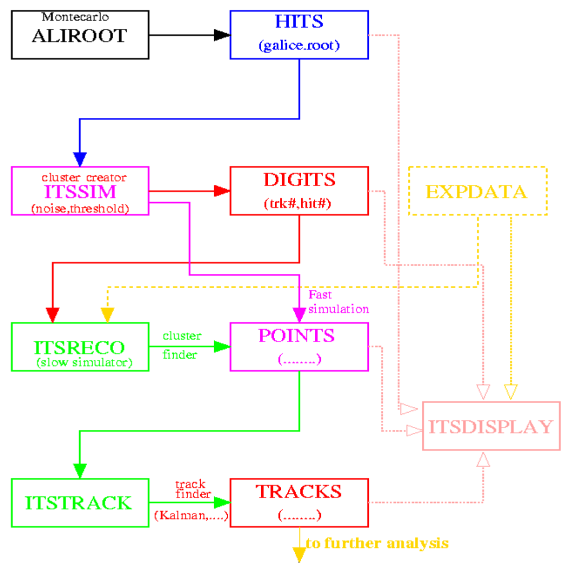

Figure 1: Scheme of the ALICE ITS Off-line Software.

a fast simulation is performed, space points are produced directly from `ITSSIM` smearing the hit coordinates. In the case of the slow simulation, `ITSSIM` performs only the digitisation (producing digits which look as close as possible to what the future experimental data are thought to be), while the cluster finding is taken in charge by the package `ITSRECO`. Space points are then treated by the track finding package `ITSTRACK` and tracks are then produced and processed by other passes of the reconstruction (particle identification, primary vertex finding, secondary vertices finding, etc.). In parallel and in conjunction with the main simulation/reconstruction/analysis stream, a graphic visualisation package, `ITSDISPLAY`, is also being developed. Any "object" created by the ITS code can be displayed both in local and global coordinates exactly in the same way as the experimental data will be when they will become available. It works as an indispensable tool to validate by the human eye all the complicated algorithms coded up in the framework.

3 Results

3.1 Geometry

One of the fundamental ingredients of a simulation program is the accuracy in the geometrical description of the detector. In this respect, the Inner Tracking System represents one of the most demanding and challenging sub-detectors in ALICE. The whole ITS (without going at the level of the single elementary detection elements) consists of about $2.5 \cdot 10^5$ volumes which have to be positioned in most cases with a precision which ranges in the micrometer scale. The build-up of the geometry, impossible to be realized in the usual `GEANT3` way without unwanted mis-placements and overlaps, is performed by a semi-automatic translation of engineering CAD files into some ASCII files which are read by `Aliroot` and converted into `GEANT3` volumes. As an example, fig. 2 shows an axonometric-cut view of the ITS as currently defined in the simulation program (more detailed views are collected in ref. [2]).

In order to give an idea of the material budget of the Inner Tracking System, the pseudorapidity distribution of the material traversed by straight (infinite momentum) particles, in radiation

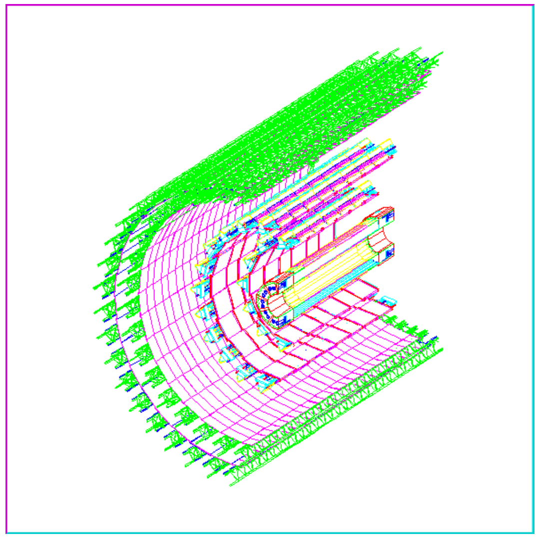

Figure 2: Axonometric-cut view of the “sensitive” part of the ITS as described in the simulation program.

length, for the whole ITS (all layers, shields and air) is shown in fig. 3. The total thickness of the ITS as seen by a straight particle, averaged over pseudorapidity and azimuthal angle, amounts to 6.5% of the radiation length.

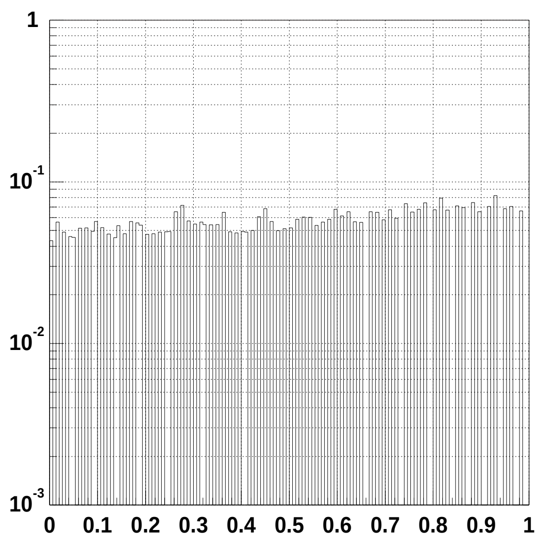

Figure 3: Pseudorapidity distribution of the material thickness in radiation length traversed by a straight track for the whole ITS, averaged over azimuthal angle. Units are fractions of X_0.

3.2 Track reconstruction

For the predicted particle densities, up to eight thousands charged particles per unit of rapidity at mid-rapidity, the track finding is one of the most challenging tasks in the ALICE experiment. At present, the track-finding method that was developed for the TPC and ITS is based on the Kalman filter algorithm, widely used in high-energy physics experiments (see refs. [2, 3] for all details). The tracking program consists of two parts: the first one for the TPC and the second one for the prolongation into the ITS. The track-finding efficiency ranges between 85% and 95% depending on the track transverse momentum. The fake-track probability is for all p_T below 5% except for very low p_T in the region 100-200 MeV/c where multiple scattering and energy-loss fluctuations start to play a role.

The high tracking efficiency is accompanied by very good track parameter resolutions as functions of the transverse momentum. As examples, the relative momentum resolution for pions and the impact parameter resolution for identified particles (see nect section) are shown in figs. 4 and 5.

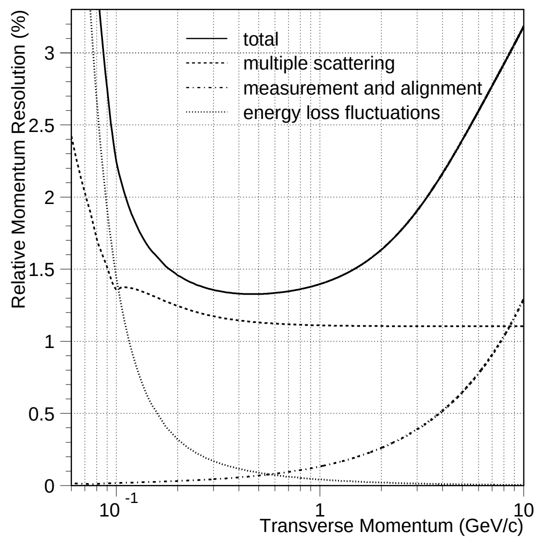

Figure 4: Relative momentum resolution for pions as a function of transverse momentum. The contributions due to multiple scattering, measurement and alignment error, and ionization energy-loss fluctuations are shown separately.

3.3 Particle identification

In thin silicon detectors it is possible to measure the energy loss and use this information for particle identification in the non-relativistic $(1/\beta^2)$ region. The energy deposited in the ITS is measured in the four outer drift and strip layers by collecting the charge from the ionization process. The raw pulse-height information from the silicon detectors is corrected for geometrical effects and loss of signal due to signal spread and threshold cut. Charge distribution are then refined using the method of truncated mean from more measurements. As an example, momentum spectra of generated and identified hadrons are shown separately in fig. 6 for pions, kaons and protons.
Dotted histograms show a typical residual contamination which amounts to about 2% for kaons and 6% for protons. Efficiency and contamination always depend on the values chosen for the cut in the deposited energy and have to be tuned with respect to the specific physics requirements.

4 Summary and conclusions

The ALICE detector is being designed at the leading edge of the technology both for the actual realization and simulation point of view. Along this line, the ITS Off-line Software has been conceived and realized following the criteria of the object-oriented software engineering. Preliminary results obtained with this code are greatly satisfying, confirming the capabilities foreseen for this detector which is crucial for the physics to be done with ALICE.

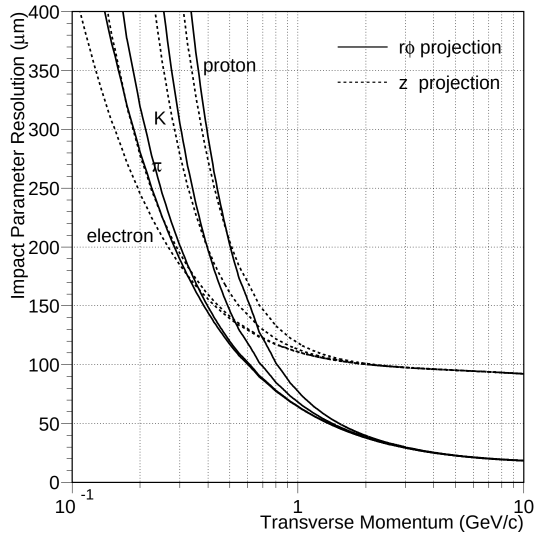

Figure 5: Impact parameter resolution for electrons, pions, kaons and protons, as a function of transverse momentum. The bending and non-bending projections are shown separately.

References

1 ALICE Collaboration, Technical Proposal, CERN/LHCC 95-71.

2 ALICE Collaboration, Inner Tracking System, Technical Design Report, CERN/LHCC 99-12.

3 ALICE Collaboration, Time Projection Chamber, Technical Design Report, CERN/LHCC 2000-001.

4 Every continuously updated detail about the ITS Off-line Software can be found in the official WWW pages located at the URL: `http://www.physics.ohio-state.edu/~nilsen/ALICE_ITS/ITSofflineWebPage.html`.

5 All details about `Aliroot` can be found in the official ALICE Off-line Project WWW pages located at the URL: `http://AliSoft.cern.ch/offline/`.

6 R. Brun and F. Rademakers, Proceedings of the *AIHENP '96 Workshop*, Lausanne, (1996); Nucl. Instrum. Methods Phys. Res. A 389 (1997) 81. See also `http://root.cern.ch`.

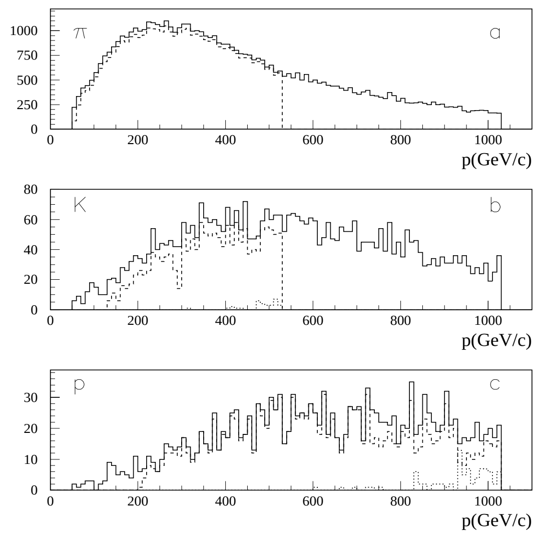

Figure 6: Momentum spectra of generated (solid histogram) and identified (dashed histogram) hadrons, separately, for pions (a), kaons (b) and protons (c). Dotted histograms refer to the contamination.