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Upgrade of the ALICE Inner Tracking System

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ALICE (A Large Ion Collider Experiment) is a general purpose experiment optimized for the study of heavy-ion collisions at the CERN LHC. The physics programme includes proton-proton collisions for reference data and also for genuine physics topics for which ALICE is complementary to the other LHC experiments [1].

The ALICE Inner Tracking System (ITS) is the innermost tracking detector of ALICE and therefore it plays a key role in tracking and vertexing capabilities. The ITS consists of three coaxial subsystems, surrounding the beam pipe, each one comprising two layers based on different silicon technologies: the Silicon Pixel Detector (SPD), the Silicon Drift Detector (SDD) and the double-sided Silicon Strip Detector (SSD), innermost to outermost respectively. The number, position, granularity and technologies of the layers were optimized for efficient track finding and high impact-parameter resolution in the severe high-multiplicity environment expected for the central Pb-Pb collisions at LHC energy [2].

After two years of operation with p-p and Pb-Pb collisions, the ITS has demonstrated its tracking and vertexing capabilities, which are in excellent agreement with the design values. Since the ITS project was frozen, almost 10 years ago, the frontier silicon detector technologies have made a substantial progress and therefore nowadays a detector upgrade based on the currently ongoing developments may allow a substantial enhancement of the ALICE physics capabilities. In particular, the ITS upgrade will improve the tracking performance for heavy-flavour detection, where the impact parameter resolution to the primary vertex position plays a crucial role.

After a brief introduction on the performance of the present ITS, this contribution will focus on the ongoing studies for an upgrade of the ITS.

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1.Current ITS performance

The present ALICE Inner Tracking System (ITS) consists of six cylindrical layers of silicon detectors coaxial with the beam pipe. They are located at radii between 39 mm and 430 mm and cover the pseudo-rapidity range $|\eta| < 0.9$ for vertices located within ±60 mm with respect to the nominal interaction point (i.e. $\pm1\sigma$ of the luminous region). Within the boundaries set by technological limitations and available funds, the number, position and segmentation of the layers were optimized to achieve a high precision in the determination of the distance of closest approach of the charged particles to the primary vertex and efficient track finding in combination with the large volume Time Projection Chamber surrounding the ITS [2]. The radius of the innermost ITS layer is the minimum allowed by the radius of the beam pipe, while the outer radius is determined by the necessity to match tracks with those from the TPC. The first layer has a more extended pseudo-rapidity coverage ($|\eta| < 1.98$) to provide, together with the Forward Multiplicity Detectors (FMD), continuous coverage for the measurement of charged particle multiplicity.

The current ITS is designed to handle the expected high particle density, up to 100 particles per cm^2 for Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV, and in order to achieve the required distance of closest approach resolution, the first two layers are made of Silicon Pixel Detectors (SPD), the two middle ones are made of Silicon Drift Detectors (SDD) and the two outer layers, where the track density falls to about one particle per cm^2 of double-sided Silicon micro-Strip Detectors (SSD). The four outer layers are equipped with analogue readout and therefore can be used for particle identification via dE⁄dx measurement in the non-relativistic ($1/\beta^2$) region. All detector elements were carefully optimized to minimize the material budget, achieving a radiation length of at most 1.1% X_0 per layer, which is the lowest value for a silicon tracker among all the current LHC experiments. The commissioning and performance with cosmic rays and beams of the ITS are described in [3].

The performance of the present ITS for tracking and identifying charged particles in pp and Pb-Pb collisions and in particular, for the determination of the track distance of closest approach is well adequate to study the production of charm mesons in exclusive decay channels (e.g. $D^0 \rightarrow K\pi \; and \; D^+ \rightarrow K\pi\pi$) at values of transverse momentum above 2 GeV/c [4]. At lower transverse momenta, however, the statistical significance of the measurement is insufficient and the situation is even worse for charm baryons, as it will be discussed in the next section.

The ITS capability in terms of heavy flavor decay vertex reconstruction is given by the impact parameter resolution d_0, which is the convolution of the vertex resolution and the track pointing resolution. Figure 1 (left panel) shows the impact parameter resolution in the bending plane ($r\varphi$) as function of transverse momentum for tracks reconstructed with the ITS stand-alone in Pb-Pb collisions.

The particle identification capability provided by the four outermost layers can be inferred from Figure 1 (right panel). The energy loss measurement in each of the four outermost layers is corrected for the track length in the sensitive volume using the tracking information and then the dE/dx value associated to each track is calculated using a truncated mean method [5]. Figure 1 (right panel) shows the truncated mean dE/dx value for a sample of ITS stand-alone reconstructed tracks along with a parametrization of the most probable value [6] based on the Bethe-Bloch formula.

The readout rate capability of the ITS depends only marginally on the detector occupancy and, therefore, it is very similar for pp and Pb-Pb events. Assuming a 100% dead time, the maximum readout rate is defined by the SDD, the slowest ITS sub-detector, which can record date at about 1 kHz, while the other two sub-detectors can run more than a factor 3 faster.

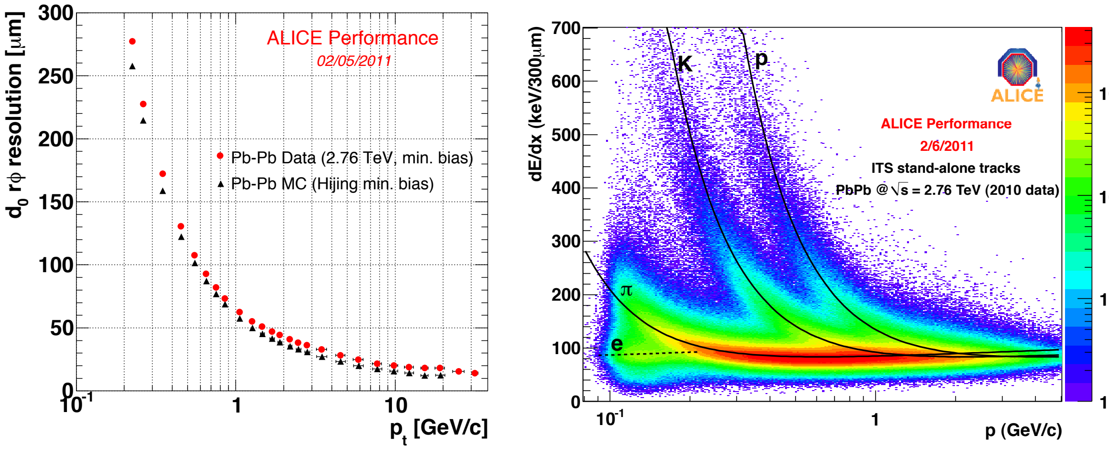

Figure 1: Left panel shows the impact parameter resolution of the current ITS as function of p_t in the bending plane (rφ) for Pb-Pb and MonteCarlo data. Right panel shows the the specific energy loss dE/dx as function of the momentum measured by the ITS for Pb-Pb collisions; the solid lines are derived from a parametrization of the detector response based on the Bethe-Bloch formula.

2.Upgrade physics motivation

The longterm goal of the ALICE experiment is to provide a precise characterization of the Quark-Gluon Plasma (QGP) state. A precise determination of its properties including initial temperature, degrees of freedom, speed of sound, and in general, transport coefficients would be a major achievement. This would go a long way towards a better understanding of QCD as a genuine multi-particle theory. To achieve this goal, high statistics measurements are required, which will give access also to the very rare physics channels needed to understand the dynamics of this condensed phase of QCD. Within such a physics program the upgrade of the ITS to improve its resolution and readout rate capabilities is a fundamental cornerstone.

The present ITS setup is well suited for studying yields and spectra of charm mesons at transverse momentum above 2 GeV/c, however it is not optimized to perform measurements on charm and beauty production in heavy-ion collisions to address the following two important questions:

- Study of the quark mass dependence of in-medium energy loss, by measuring the nuclear modification factors R_{AA} of the p_t distributions of D and B mesons separately.
- Study of the thermalization of heavy quarks in the medium, in particular by measuring the baryon/meson ratio for charm (Λ_c/D) and for beauty (Λ_b/B), and the elliptic flow for charm mesons and baryons.

An upgrade of the ITS can dramatically improve or make accessible for the first time the measurements in Pb-Pb collisions of charm and beauty baryons with full coverage in transverse momentum and in particular, down to very low momenta. In addition, it will be extremely important for a detailed measurement of thermal electromagnetic radiation from the hot QGP, which is just in its infancy at the LHC. The design of the new ITS will allow the identification of secondary vertices from decaying charm or beauty (D^0, J/Ψ, Λ_c, Λ_b) and to achieve high stand-alone tracking efficiency, which is fundamental to implement trigger capabilities based on topological triggers and are not possible in the current setup. For instance, the most abundantly produced charm baryon Λ_c has a mean proper decay length cτ of only 60 μm, which is lower than the impact parameter resolution of the present ITS in the transverse momentum range of the majority of its daughter particles. Therefore, charm baryons are presently not accessible by ALICE in central Pb-Pb collisions. For the same reason, the study of beauty mesons and baryons, or indeed of hadrons with more than one heavy quark, are also beyond the capability of the current detector.

Another important limitation of the present ITS detector is given by its poor readout rate capability. The ITS can run up to a maximum of 1 kHz, which allows to exploit only a small fraction of the full 8 kHz Pb-Pb collision rate that LHC can deliver and will prevent collecting the required reference data in pp collisions.

Finally, the impossibility to access the present ITS detector for maintenance and repair interventions during the yearly LHC shutdowns represents also a major limitation in accomplishing a high data quality. In the context of an upgrade, the accessibility to the detector will be set as a priority.

3.Upgrade scenario

In order to achieve the physics goals described above, the ITS upgrade should feature with respect to the present performance:

- A better resolution of the track impact parameter d_0 by a factor 3 or better for the reconstruction of the secondary vertices from decaying charm and beauty
- An higher standalone tracking efficiency and transverse momentum resolution, which would also allow to extend the trigger capabilities for selecting events on the base of their topology and study rare charm and beauty hadron production at mid rapidity with higher statistics; in the present ALICE setup these studies are limited by the combined readout rate capabilities of the central barrel detectors.

The key elements to achieve these goals are a reduced radial distance of the first detection layer, a lighter material budget, a smaller pixel size, the capability of measuring the energy loss and a faster readout time. In this context, it should be mentioned that optimizing the detector geometry in order to achieve the highest standalone tracking efficiency and transverse momentum resolution leads to a different configuration: e.g. a larger number of layers and different radii.

The basic concept for the layout of the ITS upgrade is a detector consisting of seven concentric cylindrical layers covering a radial extension from 22 mm to 430 mm with respect to the beam line. The baseline option is to replace the existing ITS detector in its entirety with four inner layers of pixel detectors followed by three outer layers of pixel detectors, in case of lower granularity, or double-sided silicon strips. For comparison, an alternative layout envisages the replacement of the two existing innermost ITS layers (SPD) with three layers of newer pixel detectors, while drift (SDD) and strip (SSD) layers are left unchanged. In the following, this latter configuration is called “New SPD”, while the baseline is called “All New”. The new detector geometry in terms of number of layers, radial position, segmentation and the technology choice for each layer will be evaluated with respect to their performance in terms of standalone tracking efficiency, momentum resolution and particle identification. Further considerations related to space and integration issues as well as cost will also be taken into account. For the purpose of the simulation studies, both in the “ALL New” and “New SPD” options all new layers have been assumed to have the same features in terms of radiation length and intrinsic space accuracy.

The outer radius of the beryllium beam pipe, which is at present 29.8 mm, defines the radial distance of the innermost ITS layer from the colliding beams: in the present layout, the first layer has an average radius of 39 mm in order to have a minimum clearance with respect to the bema pipe of about 5 mm. On the basis of the very first considerations, the installation of a new beam pipe with an outer radius of 19 mm is considered a realistic possibility. This would enable the first detection layer to be located at a radius of about 22 mm. Concerning the beam pipe wall thickness, which is at present 0.8 mm, the possibility of a thinner wall (e.g. 0.5 mm) is also being evaluated.

A reduction of the overall material budget of the detection layer will allow the tracking performance and the momentum resolution to be significantly improved and in particular, the material budget of the first detection layer is critical for improving the impact parameter resolution. In the present ITS, the radiation length of each layer of the SPD amounts to 1.14% X_0; the goal for the upgrade is to build a detector with a radiation length of 0.3-0.5% X_0. The two main contributors to the material budget are the silicon and the aluminium/polymide interconnecting cable, which are 0.38 and 0.48% X_0, respectively. The use of Monolithic Active Pixel Sensors (MAPS) for the upgrade will allow the silicon material budget to be dramatically reduced with respect to one current SPD layer, i.e 50 μm instead of 350 μm. In addition, a careful optimization of the analogue front-end timing specifications and readout architecture will allow to limit the power density to ≈250 mW/cm^2, while at the same time increasing the pixel density. The expected power consumption and a highly optimized scheme for the distribution of the electrical power and signals will allow the material budget of the interconnecting cable to be dramatically reduced. Mechanics, cooling and other detector elements can also be slightly improved with respect to the present ITS design. Combining all these developments, it is conceivable to build a detector with a radiation length of 0.3% X_0 per layer or better. The STAR Heavy Flavour Tracker [7] represents a solid example of the feasibility of such a design. Achieving such a low material budget is particularly critical for the first detection layer, since it affects strongly the impact parameter resolution at low p_t where the resolution is mainly determined by multiple Coulomb scattering. Hybrid pixels would allow the construction of detector layers with a slightly higher radiation length (0.5% X_0) but this would still represent a significant improvement of the performance as compared to the present ITS.

The spectacular progress made in the field of imaging sensors over the last ten years allows to conceive a detector with finer pixel segmentation, e.g. 20 x 20 μm^2 or 30 x 30 μm^2 with respect to 50 x 425 μm^2 of the present pixel layers, providing an intrinsic space resolution of the order of 4 μm in both coordinates.

In Figure 2, the performance in terms of pointing resolution and standalone tracking efficiency as a function of the transverse momentum of both upgrade configuration options described above is compared to the present ITS. A great improvement is obtained with any of the two upgrade options. As an example, at p_t of about 400 MeV/c, the improvement for the pointing resolution to the vertex in the bending plane (rφ) and along the beam (z) components is a factor 3 and 5, respectively. It is worth to notice here that the material budget and the intrinsic space resolution as well as the radius of the innermost layers mainly determine the pointing resolution, while the radii of the outer layers play a key role only for the momentum resolution. In both cases, the innermost layer has been placed at 22 mm from the colliding beams and all new layers have been assumed to be 0.3% X_0 in radiation length, segmented in pixels providing 4 μm intrinsic space resolution in both coordinates and 100% of detection efficiency. The performance in terms of impact parameter resolution and standalone tracking efficiency will not change significantly if the outermost three layers would have a much lower granularity, as can be achieved for example with double-sided silicon microstrip detectors. Concerning the standalone tracking efficiency, the “All New” configuration yields a spectacular improvement that can be only partially achieved with the “New SPD” configuration.

The ITS upgrade will preserve the particle identification capability by measuring the ionization in the silicon layers, which will be equipped with an analogue readout.

In order to exploit the full Pb-Pb luminosity delivered by LHC, the ITS upgrade aims to read the data related to each individual interaction up to the nominal Pb-Pb rate of 8 kHz and a few hundreds kHz for pp collisions. The ALICE long term physics plan may require the readout architecture to be able to cope with even higher rates up to 50kHz for Pb-Pb collisions and 2MHz for pp collisions.

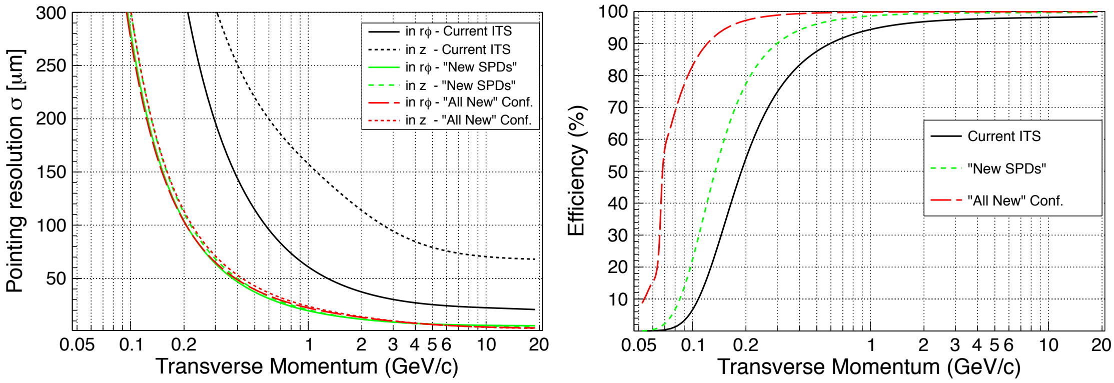

Figure 2: Pointing resolution to the vertex of charged pions (left panel) and standalone tracking efficiency (right panel) of charged pions as a function of the transverse momentum for the "New SPD" and the "All New" upgrade configurations. The performance of the current ITS is also shown for comparison.

A preliminary performance study of the impact of the upgrade on the heavy flavour detection has been carried out selecting some benchmark decay channels assuming the upgrade baseline "All New" configuration with 7 layers placed at 22, 28, 36, 200, 220, 410 and 430 mm radial distance from the colliding beams.

The decay $D^0 \rightarrow K\pi$ can be considered as a benchmark for all the D meson studies. Its measurement is fundamental for understanding the charm energy-loss mechanisms in the hot and dense medium. Moreover, the good signal extraction and the possibility to have a realistic reference of the present ITS performance based on real data, allows for a reliable study of the benefits on the performance that would come from an upgrade of the ITS. As expected, the preliminary results show that the improved impact parameter resolution provides a better separation between signal and background on several selection variables, thus the possibility to reject more background and release the cuts in order to keep more signal, which increases the selection efficiency. In addition to the increased performance in terms of pointing resolution, a further significant improvement of the measurement comes from the higher readout capabilities. Although the large uncertainty of this study, the expected performance of the upgraded detector allows for the measurement of the D^0 production down to $p_t \approx 0$ with a significance larger than 5, even considering only a Pb-Pb central event sample similar to the statistics collected during the 2011 Pb-Pb run, i.e. few 10^7 events. It should be noticed that the production of D mesons in central Pb-Pb collisions has never been measured for p_t below 2 GeV/c.

Another benchmark case is the $\Lambda_c^+ \rightarrow pK^-\pi^+$ decay. This is the most promising decay for the measurement of charm baryon production, whose physics motivation was highlighted in the previous section. In order to identify the three charged prongs decay vertex, a very high resolution is needed, owing to the short mean proper decay length $c\tau \approx 60$ μm [8]. Therefore, an improvement of the pointing resolution with respect to the current ITS, would allow a much cleaner separation of its decay point (the secondary vertex) from the interaction point (primary vertex). The decay channel $\Lambda_c^+ \rightarrow pK^-\pi^+$ can be studied by analyzing the invariant mass of fully reconstructed three-prong decays, selected by applying topological cuts and particle identification criteria. To discriminate the Λ_c signal against the background, which is made mostly of primary particles, the selection cuts on kinematical and topological variables have to be optimized to extract the signal in pp and Pb-Pb collisions.

Figure 3 shows the invariant mass distribution of $\Lambda_c^+ \rightarrow pK^-\pi^+$ candidates with $p_t > 3$ GeV/c obtained with the present ITS from a data sample of $1.9\text{x}10^8$ pp minimum bias events at $\sqrt{s}$ = 7 TeV on the left and with the upgraded ITS from the same statistics of simulated events on the right. The Λ_c signal is visible in the left-hand panel; however, the significance is low due to the limited efficiency for background rejection and increases from 5 to 12 with the upgrade. The increase of the signal statistics is of about 50% thanks to the looser cuts that can be used for the upgrade case and the corresponding increase of the signal-to-background ratio is more than a factor of 5.

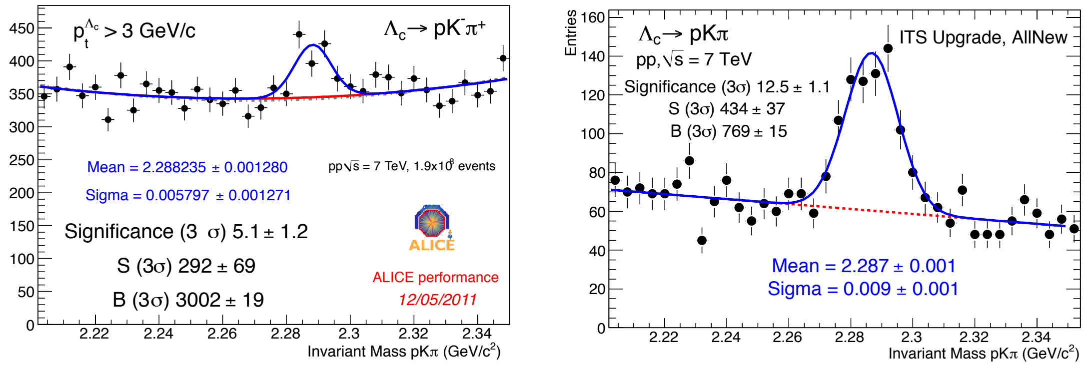

Figure 3: The invariant mass spectrum M(pKπ) in pp collisions at $\sqrt{s}$ = 7 TeV for p_t > 3 GeV/c in data with the present ITS (left) and in simulation with the ITS upgrade "All New" configuration.

Concerning Pb-Pb collisions, so far the Λ_c signal has not been observed in data with the present ITS because of the very large combinatorial background. Figure 4 shows the resulting invariant mass distribution for $\Lambda_c^+ \to pK^-\pi^+$candidates with p_t > 4 GeV/c reconstructed with the upgraded ITS, in a simulated sample of 10^8 Pb-Pb minimum bias collisions (0-100% centrality class): a clear $\Lambda_c^+ \to pK^-\pi^+$signal is visible with a significance of about 10.

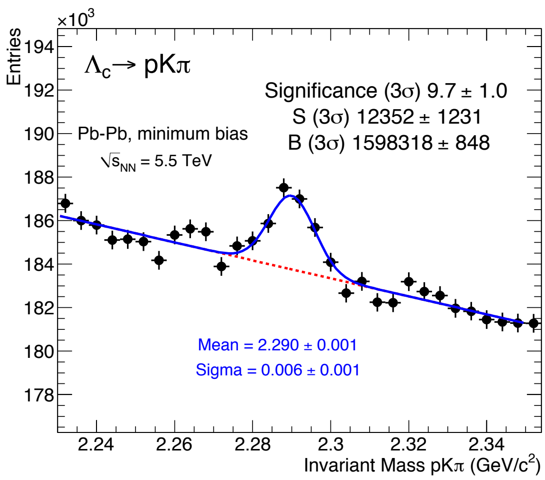

Figure 4: The invariant mass spectrum M(pKπ) with the ITS upgrade "All New" configuration in Pb-Pb minimum bias collisions at $\sqrt{s_{NN}}$ = 5.5 TeV for p_t > 4 GeV/c in the whole centrality range.

It is worthwhile to emphasize here that the significant improvement of the measurement comes not only from the increased performance in terms of resolution but also from the much higher readout capabilities of the upgraded detector.

Summarizing, this preliminary study shows that the ITS upgrade would allow to measure the D^0 production down to $p_T \approx 0$, the Λ_c signal significance improves by more than a factor of 2 in pp collisions and this signal becomes accessible in Pb-Pb collisions, where it is currently not observed in data. The heavy flavor detection capability of the ITS upgrade will be even further dramatically improved with the implementation of a dedicated trigger based on topological selections, which has not been included in the simulation yet.

4.Detector implementation

At the present stage of the feasibility study it is premature to select the most suitable detector technology for the ITS upgrade. There are still several open questions in terms of physics capability and detector performance requirements that require more detailed studies. The technology for the implementation of the different detector layers will be chosen, within the boundaries set by the available funds and the project time line, to best suit the detector requirements in terms of: i) distance from the interaction point in order to cope the expected level of radiation and track density, the latter defining also the necessary granularity, ii) the intrinsic space resolution, iii) the capability to measure the specific energy loss dE/dx, iv) the readut speed and the trigger capability in order to enhance the statistical significance of heavy-flavour rare probes. The preliminary results show that the required performance can be achieved either with the state of the art silicon pixel detectors or with a combination of silicon pixel and microstrip detectors. The three inner layers, where the track density is higher, must provide unambiguous 2D information to permit efficient event reconstruction. Therefore, they will be equipped with high granularity pixel detectors. Both basic technologies, i.e. hybrid silicon pixel detectors and Monolithic Active Pixel Sensors (MAPS) [see for instance 9], are under consideration. In terms of cost the use of monolithic pixel would be preferable for all layers, while the hybrid pixels may become prohibitive as the radius increases due to the cost of the bump-bonding. However, a limitation to the use of monolithic pixels for the innermost layers may arise from the level of radiation that can be tolerated by the selected technology. Moreover, if the charge signal delivered by the thin sensor layer of monolithic pixels does not provide enough resolution for particle identification, the outer layers, where the track density falls to a few per cm^2, could be equipped with more conventional silicon microstrip detector. Silicon microstrips are a proven and mature technology and they will allow to maintain the dE/dx capability that the current ITS provides.

The pixel and strip detectors employed in a future ITS upgrade will have to match the performance requirements described in this paper and therefore specific R&D activities are carried out for the key technical specifications. For reasons of space, they are only briefly summarized hereafter.

- Reduction of the pixel size in order to improve the pointing resolution and tracking efficiency in rφ and the background rejection capability in z.

- In the inner layer a maximum track density of ≈100 tracks per cm^2 is expected. Therefore, assuming a safety factor of two, the event rate per pixel is ≈50 Hz, at an interaction rate of 8-10 KHz, which is not an issue itself for pile-up. This suggests the use of long shaping times (≈μs or more) that allow to combine low series noise with small power consumption in the front-end stage and thus achieve a low power density.

- The material budget is one of the most critical parameters especially for the innermost layers, where it defines the ultimate limit of the achievable pointing resolution. The design goal is an overall material budget per layer of 0.3% and 0.5% X_0 for monolithic and hybrid pixels, respectively, which is challenging but feasible according to the most recent developments.

- Assuming a maximum interaction rate of 8-10 kHz in central Pb-Pb collisions, the minimum distance between interactions will be in the order of 100 μs. A read-out time of the ITS of <50 μs can thus be considered a safe limit and it will allow also to exploit the information of the inner layers to build a topological L2 trigger.

- The information on the signal amplitude will be preserved in a sufficient number of layers in order to perform particle identification by measuring the specific energy loss in the silicon.

- For the microstrip detectors, the main change with respect to the present detector is the reduction of the strip length, to allow their use at intermediate radii, and the analog to digital converter (ADC) functionality embedded in the on-detector electronics.

The present ITS layout is shown in the left panel of Figure 5: the SPD (1), the SDD (2) and the SSD (3) are attached together in correspondence of the cones (8 and 9), which are also used to hold the services in place on both sides. The ITS is sitting inside the TPC and fixed to its inner aperture by two hooks (11). In the same figure are shown also the forward detectors (4, 5, 6 and 7) and the front absorber placed upstream the muon arm (10). With the present layout, where the services are routed on both sides and the front absorber side is not accessible for their disconnection, the ITS cannot be extracted from inside the TPC in order to perform maintenance and repairs. In order, to get access to the ITS a series of lengthy operation is required. The time estimated to carry out this sequence of operations and restore the original configuration is about six-to-seven months plus the time needed for repairs and maintenance. Clearly this program can be accomplished only during a long shutdown lasting several months. To improve the accessibility, the ITS upgrade will be conceived so that it can be inserted and extracted from the side opposite to the front absorber, as schematically shown in the right panel of Figure 5. This concept of a pluggable detector has important implications for the services, which should be routed from one side only, as well as the beam pipe support elements.

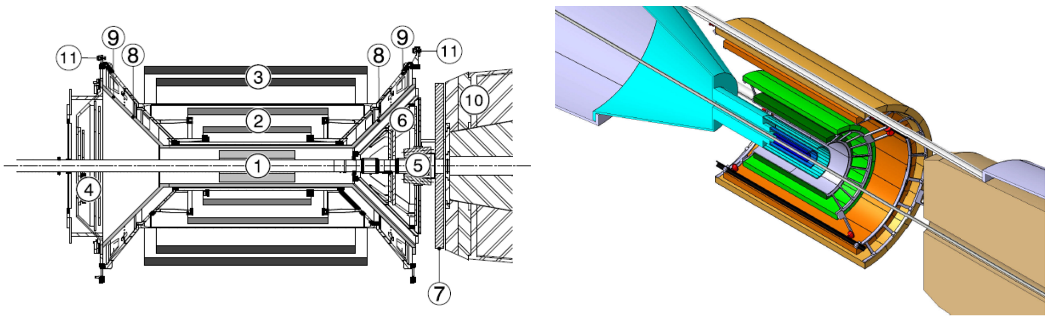

Figure 5: Left panel: Side view of the present ITS: (1) SPD, (2) SDD, (3) SSD, (4, 5, 6 and 7) forward detectors, (8 and 9) cones housing the ITS services, (10) front muon absorber and (11) hinges for the connection to the TPC. Right panel: Schematic view of the ITS upgrade showing the concept of an insertable detector with services routed on the side opposite to the front absorber only.

5.Conclusions

The performance of the present ITS is well in agreement with the design requirements and expectations; in particular, the precision in the determination of the distance of closest approach of the tracks is certainly adequate to study the production of charm mesons in exclusive decay channels (e.g. $D^0 \rightarrow K\pi \; and \; D^+ \rightarrow K\pi\pi$) at values of transverse momentum above 2 GeV/c. At lower transverse momenta, however, the statistical significance of the measurement is quite poor and the situation is even worse for charm baryons. Another important limitation of the present ITS detector is represented by the poor readout rate capabilities. Eventually, the impossibility to access the present ITS detector for maintenance and repair interventions during the yearly LHC shutdowns represents also a major limitation in achieving a high data quality.

Owing to the possibility to install a smaller radius beam pipe and taking full advantage of the spectacular progress made in the field of imaging sensors over the last ten years, it is possible to build an upgraded ITS with greatly improved features in terms of determination of the track distance of closest approach to the primary vertex, standalone tracking efficiency, momentum resolution and readout rate capabilities. Moreover, a tracker with the above features will open the possibility to develop a topological trigger that can be used for the selection of events containing rare probes, combining the particle identification information. The ITS upgrade will allow to extend the ALICE physics programme to measure charm and beauty production in Pb-Pb collisions with sufficient statistical accuracy down to very low transverse momentum values, measure charm baryons and perform exclusive measurements of beauty, which are essential measurements in order to understand the energy loss mechanism and thermalization of heavy quarks.

The ITS upgrade will require a long shutdown and, therefore, will naturally have to be in phase with the installation of upgrades for the other LHC experiments. The ITS upgrade targets the long LHC shutdown period planned in 2017/2018.

This proceeding describes the results of the very preliminary feasibility studies available at the time of the Conference; since then, much more detailed and in depth investigations have been carried out, whose results on the improvements achievable with the proposed upgrade are even more exciting. For an up-to-date document the reader is invited to consult the *Conceptual Design Report for an Upgrade of the ALICE ITS* that is currently in preparation and will be published beginning of 2012.

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