New software for ITS upgrade studies

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presentation based on the work of Cristina Terrevoli,
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Outline

• motivations
• how-to
• status
  • simulation
  • reconstruction
• conclusions
Motivations

• We need a tool to simulate possible upgrades of the ITS detectors, in order to
  • evaluate their physics performances, depending on the layout
  • to guide the design of the new detector

• Optimization of the configuration can be done with respect to:
  • number of layers
  • thickness of sensitive detector & material budget of each layer
  • radii of layers
  • spatial resolutions of detector (layer by layer)
How to

• introduce the software to simulate the new detector into the AliRoot package
  • replace the actual ITS with ITSupgrade (with an option to be set in the Config.C)

• In such a way, we would have the final analysis tools available to make performance studies on a few benchmark channels (e.g. $D^0 \rightarrow K\pi$, $\Lambda_c \rightarrow pK\pi$)
How to

ideal situation

PWGs software

Simulation
ITS

Simulation
ITSupgrade

Reconstruction

ESD

AOD

actual situation

not yet verified

Simulation
ITS
done

Simulation
ITSupgrade

Reconstruction
 ITS

70% done

Reconstruction
ITSupgrade

PWGs software

D^0 \rightarrow K^- \pi^+

pp \rightarrow 7 \text{ TeV}, 1.4 \times 10^7 \text{ events, } p_T^{D_0} > 2 \text{ GeV/c}

Mean = 1.867 \pm 0.001

Sigma = 0.014 \pm 0.001

Significance (2 \sigma): 21.3 \pm 1.2

S (2 \sigma): 1486 \pm 82

B (2 \sigma): 3380 \pm 32
Status of simulation

• The detector geometry should be as flexible as possible
  • same code for different n. of layers, sensor thicknesses, material budgets, cell segmentations

• Implementation:
  • **Detector Parameters** (i.e. number, thicknesses and radii of layers, parameters of beam pipe) set in the Config.C
  • **layer** = silicon cylinder (sensitive volume) + copper coaxial cylinder (overall material budget)
  • **cell segmentation**: virtual and adjustable to simulate the space resolution of each layer
  • **Response model** (i.e. from Hits → SDigits → Digit): fast simulation
Status of simulation

- Example of a geometry implementation for a seven layer configuration
Status of reconstruction

1. Clusterization  \hspace{1cm} \textit{done}

2. Tracking
   \begin{itemize}
   \item ITUpgrade standalone
      \begin{itemize}
      \item track finding  \hspace{1cm} \textit{done}
      \item track fitting
         \begin{itemize}
         \item global fitting (Rieman)  \hspace{1cm} \textit{done}
         \item Kalman  \hspace{1cm} \textit{working on}
         \end{itemize}
      \end{itemize}
   \item Combined barrel tracking  \hspace{1cm} \textit{not considered}
   \end{itemize}
Status of reconstruction

• Clusterization (Digits → RecPoints) steered by standard AliReconstruction class
  ➢ build TreeR filled with RecPoints in the standard format and container of AliRecPoint

RecPoints of ITSUpgrade:
• global coordinates
• energy loss
• number of electrons
• cluster type

![Old ROOT Object Browser](image)
Status of reconstruction

Projection in XY plane of RecPoints (global coordinates)

Cluster type

1 2 3 4
**Strategy:** adapt the tracking method of ITSStandAlone

**STEP 1:** Track Finding → re-write **FindTrack** method for ITSUpgrade

**STEP 2:** Fitting Methods for the ITSUpgrade

- Global Fitting: (e.g. AliRieman)
  - Test of the clusterization and track finding procedure
- Write a Kalman method for the upgrade
Validation of the simulation tools

Preliminary tracking with a global fit

• Perfect Track Finding using the MC truth:
  • The selection of the clusters belonging to a given track is done by a selection on the trackID (track info from the MC kinematics)

• Global Fitting with AliRieman
  • Rieman fit: Spatial Points projected on the “Rieman sphere” → linearization of equations of the $\chi^2$ minimization

• Analysis of the reconstructed tracks
  • Each “AliRieman”-track is converted into an “AliExternalTrackParam”. The latter provides the relevant track information, e.g. the impact parameter.
Validation of the simulation tools

First performance study: Config.C with AliITSupgrade set with the design parameters of the present ITS
✓ virtual segmentation set so as to obtain the actual resolution of SPD, SDD, SSD
✓ same radii of the actual ITS
✓ same material budget of the actual ITS \( (X/X_0 = 8\% \text{ in tot}) \)

<table>
<thead>
<tr>
<th></th>
<th>SPD</th>
<th>SDD</th>
<th>SSD</th>
</tr>
</thead>
<tbody>
<tr>
<td># of layers</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>radius (cm)</td>
<td>3.9 &amp; 7.6</td>
<td>15 &amp; 24</td>
<td>38 &amp; 43</td>
</tr>
<tr>
<td>spatial precision (µm)</td>
<td>( r\phi =12\mu m ) ( z = 100\mu m )</td>
<td>( r\phi =35\mu m ) ( z = 25\mu m )</td>
<td>( r\phi =20\mu m ) ( z = 830\mu m )</td>
</tr>
</tbody>
</table>
Factor of merit
Impact parameter resolution

Official ITS and Kalman Filter StandAlone reconstruction

Simulation and reconstruction with ITSUpgrade (Rieman)

- \( p_t = 1 \text{ GeV/c} \)
  - \( \sigma_{d_0} = 60 \mu \text{m} \)

- \( p_t = 30 \text{ GeV/c} \)
  - \( \sigma_{d_0} = 20 \mu \text{m} \)

- \( p_t = 1 \text{ GeV/c} \)
  - \( \sigma_{d_0} = 86 \mu \text{m} \)

- \( p_t = 30 \text{ GeV/c} \)
  - \( \sigma_{d_0} = 23 \mu \text{m} \)
Validation of the simulation tools

In the previous slide:
Discrepancy at low momentum due to the usage of the Rieman fit (verified by using AliRieman instead of AliITStrackerMI also in the actual simulation)

• Global fitting (i.e. Rieman) provides the best description of a track as a whole
• Kalman fitting provides by definition a much better local description of a track (hence better description of the impact parameter)

next: use the Kalman Filter
ITS upgrade: example of a new configuration

• 7 equidistant layers: first layer at 2.5 cm (beam pipe radius at 2.0 cm)
  • SPD0 - SPD1 - SPD2 - SDD1 - SDD2 - SSD1 - SSD2
  • Present ITS: 6 layers, 1st layer at 3.9 cm
• same segmentation, resolution and thickness of the actual SPD, SDD, SSD

![Impact Parameter Distribution](image1.png)

Biased at low $p_t$ due to the Riemann Fit

$p_t = 1$ GeV/c
$\sigma_{d_0} = 66$ µm (86 µm)

$p_t = 30$ GeV/c
$\sigma_{d_0} = 16$ µm (23 µm)
Conclusion

• A flexible tool to simulate prototypes of an upgraded ITS detector is being developed within AliRoot:

  ✓ from Hits to RecPoints $\rightarrow$ OK
  ✓ the development of the track reconstruction is ongoing

• Results shown at previous ITS meetings
  ✓ general agreement to commit the code to the svn AliRoot repository