Introduction
PID in ITS
SDD calibration
SDD effect correction
PID2 algorithm
The Bayesian approach
PID results
Conclusion

Particle Identification in the Inner Tracking System of ALICE

Emanuele Biolcati
for the ALICE Collaboration

Università e INFN di Torino

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Trieste - September, 14 2009

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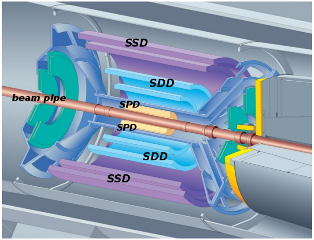
ITS role in ALICE

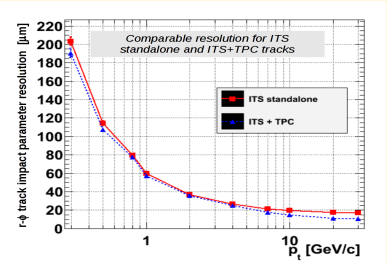


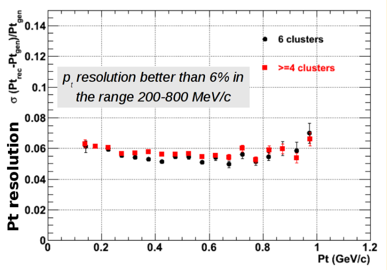
- Reconstruction of primary vertex with resolution below 100 μm
- Prolong TPC tracks to the primary vertex. ITS crucial for p_{t} and impact parameter resolution
- Track and identify particles missed by the TPC (p_{t} cutoff, decays, acceptance)
- Detection of secondary vertices from hyperons, K^0_{s} and heavy flavor decays

Features of ITS as standalone tracker

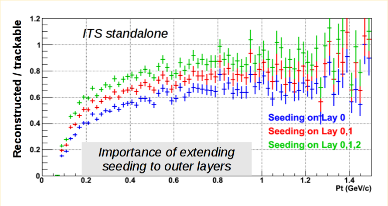
(thanks to Francesco Prino and Andrea Dainese)

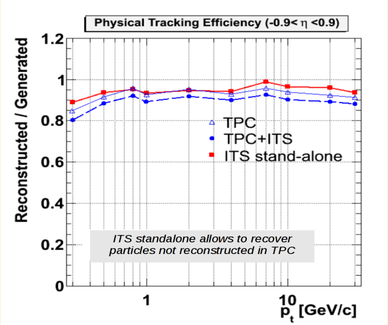
Resolution





Efficiency





The PID in the ITS

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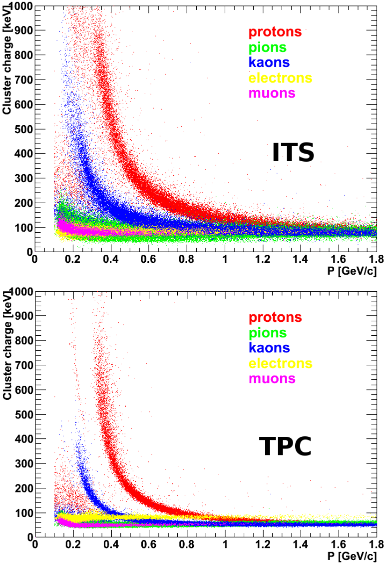

Simulation of *p*-*p* events

Possible to distinguish p, K and π only

PID in ITS will be important for all tracks missed by TPC ($\approx$10%)

PID in ITS is crucial when ITS is used as a standalone tracker

PID algorithm in ITS

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AliITSpidESD1.h

- dE/dx obtained as truncated mean of the cluster charge read by the 4 ITS outer layers (tails cut $\longrightarrow$ distributions fitted by a Gaussian)
- conditional probabilities calculated from a sigma cut of dE/dx value obtained with the Bethe-Bloch formula for a given particle with a given momentum

AliITSpidESD2.h

- based[1] on the convoluted Landau-Gaussian fits to the dE/dx
- signal from each SDD and SSD layer individually treated

[1] E.Bruna, *Response functions for Particle Identification in the Inner Tracking System*, ALICE Internal Note (October 2006)

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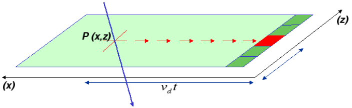
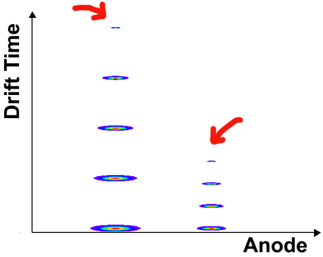
SDD: drift time dependence

(details in the Davide Falchieri's talk)



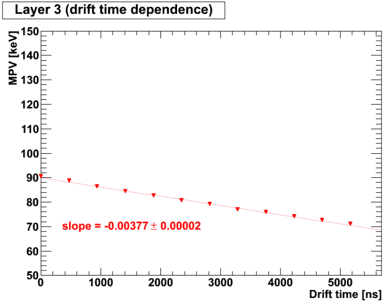


- Electron cloud, generated in the Si, spreads during the drift
- Signal tails could be cut by the zero-suppression algorithm
- For each SDD layer, charge distributions plotted in drift time bins and fitted by Landau+Gaussian convolution
- Fit parameter plotted versus drift time (next slide)

SDD: drift time dependence, results for layer 3

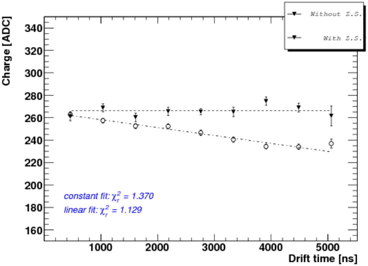
p-p events simulation

Dependence on drift time (data are zero-suppressed)



Cosmic data in Turin, single module

No dependence on drift time for non zero-suppressed data



SDD: correction for zero suppression

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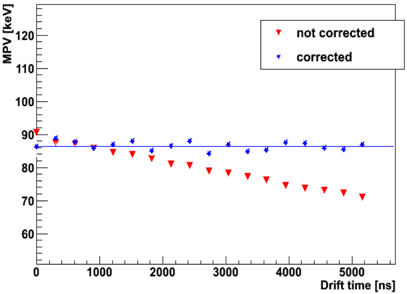
Correction in the code:

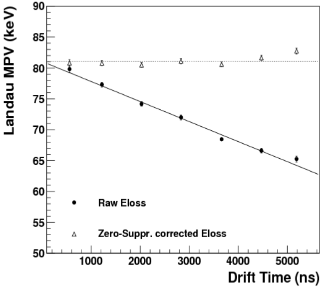
AliITSClusterFinderV2SDD.cxx

```
q/=rsdd->GetADC2keV();
q+=(driftTime*rsdd->GetChargevsTime());
```

simulation



data



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PID2 status

Done:

- $Pb - Pb$ events (by Elena Bruna) but...
  - response functions $R(S)$ obtained with old ADC charge scale and old detector description
  - possible differences with respect to p-p events
- correction for detector systematics (i.e. SDD drift time)

On going:

- $R(S)$ with new keV charge scale
- p-p events

To do:

- cosmics: comparison between simulation and reconstruction to validate the $R(S)$
- $Pb - Pb$ events

PID2 algorithm I

Evaluation of the response functions:

- Event generation (PYTHIA or HIJING)
- Tracking in ITS (tracks with 4 clusters in SDD and SSD)
- For each reconstructed track, all the 4 charge signals coming from the 4 different layers (SDD+SSD) retrieved
- dE/dx histograms in momentum slices 0.032 GeV/c wide
- For each momentum bin, dE/dx distribution for p, K, π (*i.e.* $R(S)$) fitted by Landau-Gaussian convolution
- Four fit parameters:
  - Width Landau (WL)
  - Most Probable Value (MP)
  - Total Area (neglected)
  - Width Gaussian (WG)
- $R(S)$ normalized to its total area

PID2 algorithm II

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- Fit parameters plotted versus momentum bins and fitted by *ad hoc* functions: f_{WL}, f_{MP}, f_{WG}:

Pions

$$\begin{cases} f_{WL} = A + \frac{B}{p^2} + \frac{C}{p^2}\log p^2 \\ f_{MP} = A + \frac{B}{p^2} + \frac{C}{p^2}\log p^2 \\ f_{WG} = A + \frac{B}{p^2} + \frac{C}{p^2}\log p^2 \end{cases}$$

Kaons, Protons

$$\begin{cases} f_{WL} = A + \frac{B}{p^2} \\ f_{MP} = A + \frac{B}{p^2} + \frac{C}{p^2}\log p^2 \\ f_{WG} = A + \frac{B}{p^2} + \frac{C}{p^2}\log p^2 \end{cases}$$

- Bayesian approach: probability for a track of momentum p, with measured dE/dx, to be of type i:

$$P(i|S) = \frac{R(S|i)P(i)}{\sum_{t=p,K,\pi} R(S|t)P(t)}$$

where $S{=}dE/dx$, $P(i)$ are the priors

- Recursive method:
  - first step: $P(i) = \frac{1}{3}$ for π, K, p
  - next steps: $P'(i) = \frac{N_i}{N_{tot}}$, where N_i particles with $P(i|S) > threshold$

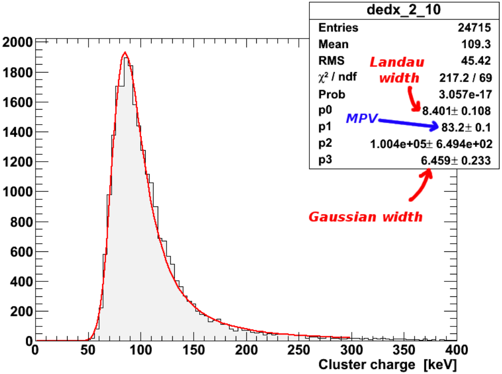
Binning in momentum

- For each particle specie, for each layer (SDD and SSD), binning in momentum is performed
- 50 bins 32 MeV/c wide, from 0 to 1.6 GeV
- Fit parameters are stored to be plotted versus momentum

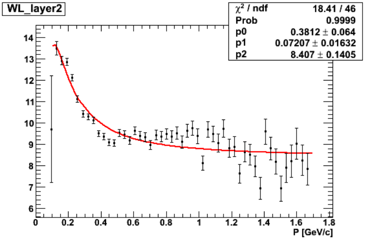
Example

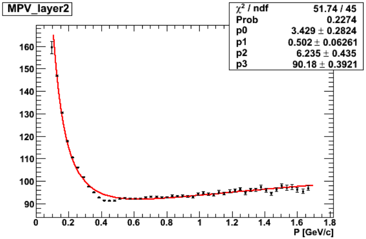
layer 4
particle π
$P \in [320\text{ MeV}, 352\text{ MeV}]$

estimation of resolution
$\sqrt{WL^2 + WG^2} \simeq 10keV$

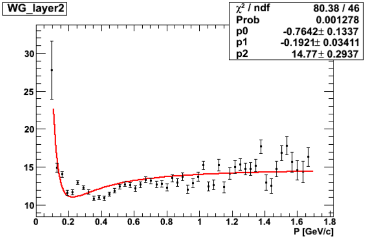


Fit parameters: p-p events, layer 3 SDD, **pions**

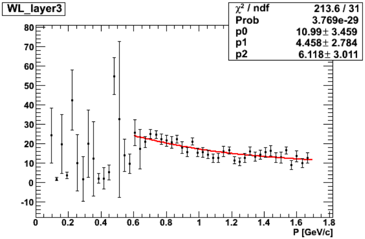


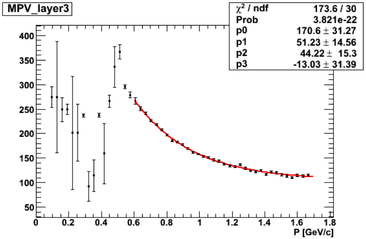


simulation
p-p events
layer: 3
particle code: 211

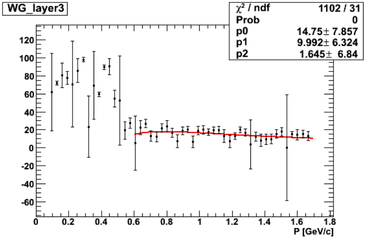


Fit parameters: p-p events, layer 4 SDD, **protons**

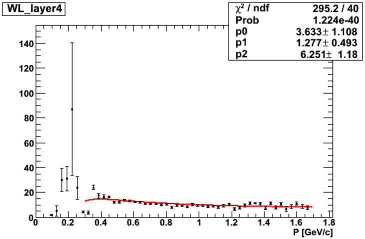


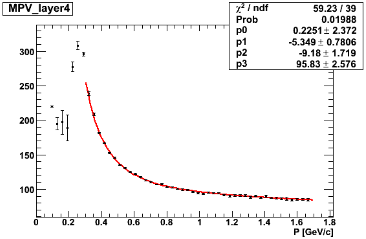


simulation
p-p events
layer: 4
particle code: 2212

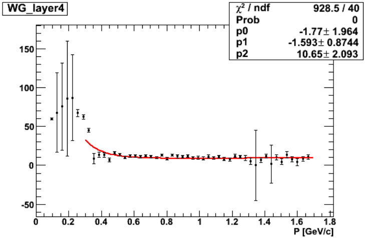


Fit parameters: p-p events, layer 5 SSD, **kaons**





simulation
p-p events
layer: 5
particle code: 321



Contamination and efficiency: definition

- Test and improve of pidESD2:
  - check the $R(S)$ calculated by the recursive method
  - fine tuning of the *ad hoc* fit functions

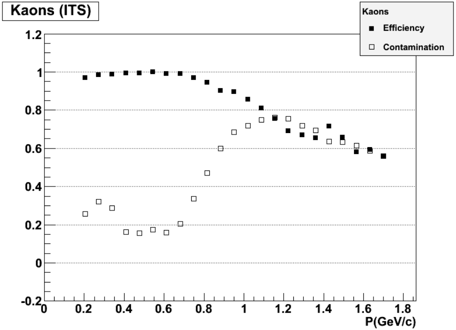
- Using contamination/efficiency:

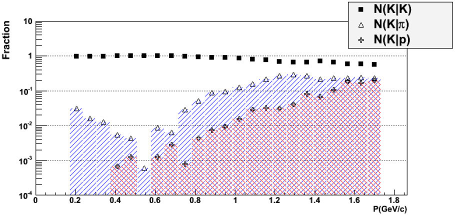
$$\begin{cases} efficiency = \frac{N_{good}}{N_{true}} \\ \\ contamination = \frac{N_{fake}}{N_{identified}} \end{cases}$$

- Using fractions (for example for π:

$$\begin{cases} N(\pi|\pi) = \frac{true\ \pi\ identified\ as\ \pi}{true\ \pi} \\ \\ N(\pi|K) = \frac{true\ \pi\ identified\ as\ K}{true\ \pi} \\ \\ N(\pi|p) = \frac{true\ \pi\ identified\ as\ p}{true\ \pi} \end{cases}$$

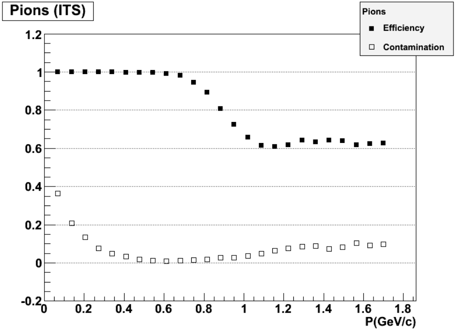
Contamination and efficiency: **kaons**

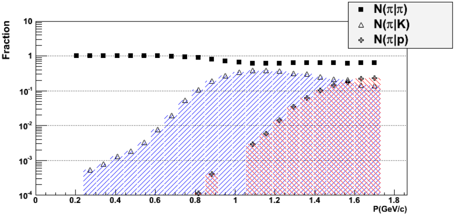




kaons
300 k entries
p-p events
ITS standalone

Contamination and efficiency: **pions**





pions
300 k entries
p-p events
ITS standalone

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Conclusions

Landau+Gaussian PID in ITS

Work in progress to tune the response functions taking into account:

- new keV charge scale
- correction for detector systematics (i.e. SDD drift time)
- *p*-*p* events (simulation)

Results and future. . .

- Contamination and efficiency values good for low momentum particles
- To do: cross check using cosmic data
- Algorithm will be ready for first *p*-*p* collisions (data)
- It will be possible to perform dN/dp_t and dN/dy distributions using ITS in standalone mode $\rightarrow$ particles at lower p_t reach with respect to TPC based analysis

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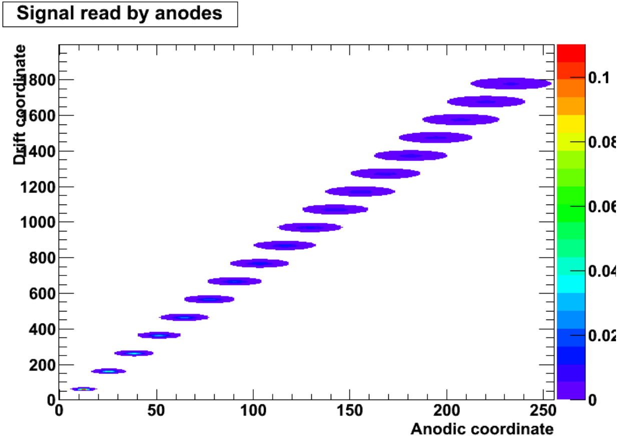
That's all, thanks.

Part I

Backup slides

Zero-suppression effect simulation (I)



Zero-suppression effect simulation (II)