Study of D^0 signal extraction in ALICE using combinatorial background subtraction techniques

Chitrasen Jena[1] and Christian Möhler[2] for the ALICE Collaboration
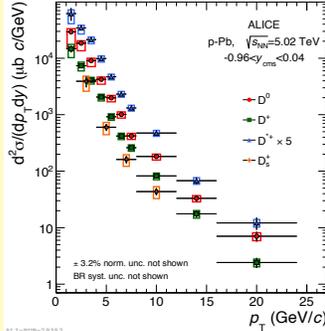[1]**Università degli Studi di Padova, INFN Sezione di Padova**
[2]**Ruprecht-Karls-Universität Heidelberg**

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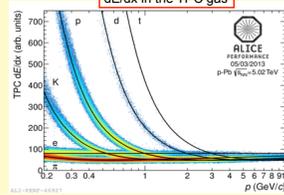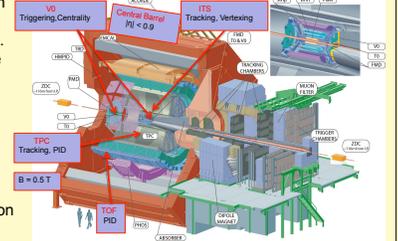
ALICE

1. Introduction

- Heavy-flavour production offers a unique probe to study the properties of the Quark-Gluon Plasma (QGP) formed in heavy-ion collisions.
- Due to the large mass, charm (~1.5 GeV/c^2) and beauty (~5 GeV/c^2) quarks are produced in the early stages of the collision and they experience the full evolution of the system.

> **HF in pp collisions:**
> ✓ Reference for p-Pb and Pb-Pb measurements
> ✓ Test of perturbative QCD calculations

> **HF in p-Pb collisions:**
> ✓ Understand initial-state effects:
>   • Shadowing and parton saturation
>   • k_T-broadening

- Inclusive p_T-differential production cross section of D^0 meson has been measured in the p_T range 1 to 16 GeV/c in pp collisions and 1 to 24 GeV/c in p-Pb collisions.
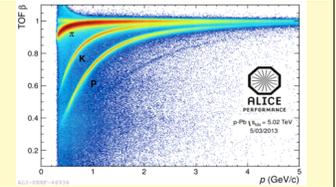- This analysis aims at extending the measurement down to $p_T = 0$.
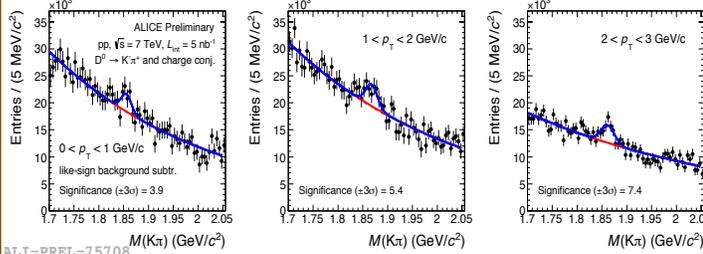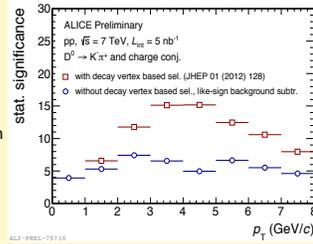

ALICE Collaboration, arXiv:1405.3452

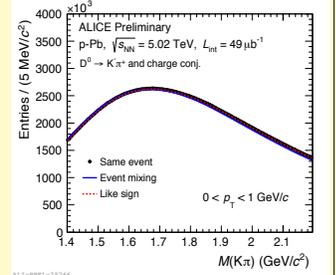## 4. Signal in pp collisions at $\sqrt{s}$ = 7 TeV

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Example: Like sign background subtraction method
- Invariant mass spectra after like sign background subtraction fitted with a Gaussian term for signal and an exponential term for residual background.
- Sigma of the Gaussian fixed to the MC value.

$$\text{significance} = \frac{S}{\sqrt{S+B}}, \text{ where B is before like sign background subtraction}$$

- Significance of the D^0 signal in pp collisions for $0 < p_T < 1$ GeV/c is 3.9.
- For $p_T > 2$ GeV/c, the method based on topological selections provides a better statistical significance.

5. Signal in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

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Example: Event mixing background subtraction method
- Invariant mass spectra after event mixing background subtraction fitted with a Gaussian term for signal and a 2nd order polynomial term for residual background.
- Sigma of the Gaussian fixed to the MC value.
- Significance of the D^0 signal in p-Pb collisions for $0 < p_T < 1$ GeV/c is 5.4.
- For $p_T > 1$ GeV/c, the method based on topological selections provides a better statistical significance.
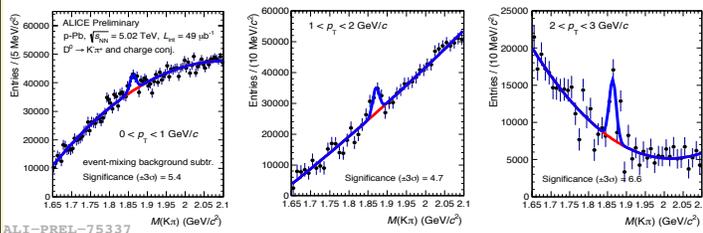

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2. Experiment & Data sets

$D^0 \rightarrow K^-\pi^+$ and charge conjugates
BR = (3.88 ± 0.05)%; $c\tau \approx 123$ μm

- Standard procedure for the reconstruction of D^0 mesons in ALICE is based on the selection of displaced secondary vertices.
- At low p_T, the topological selection on the decay vertex is less effective for the background rejection and gives low efficiency for the signal.
- A different approach has been adopted to extract the signal at low p_T using the combinatorial background subtraction techniques.
- Both methods use the particle identification capabilities of TPC and TOF in ALICE.

Data sets:
pp, $\sqrt{s}$ = 7 TeV, L_{int} = 5 nb^{-1}
p-Pb, $\sqrt{s_{NN}}$ = 5.02 TeV, L_{int} = 49 μb^{-1}

dE/dx in the TPC gas

Particle velocity from time-of-flight measured with the TOF

3. Analysis method

$D^0 \rightarrow K^-\pi^+$ and $\overline{D^0} \rightarrow K^-\pi^+$ candidates are defined from pairs of oppositely signed tracks passing the PID selections. The combinatorial background is subtracted using various techniques:

Event mixing method:
- Mix tracks from different events to break track to track correlation and increase the statistics
  ✓ Each event mixed with 5 other events
- Mix events with similar characteristics
  ✓ 20 bins in z-vertex (Δz = 1 cm)
  ✓ 10 bins in multiplicity
- Normalize outside the D^0 mass peak region e.g. for p_T: 0-1 GeV/c the mass interval for normalization is 1.5 to 1.65 GeV/c^2.

Like sign method:
- Combine two positive or two negative tracks (like-sign pairs) instead of a negative and positive track in the same event.
- Normalization: $2\sqrt{(N^{++}) \times (N^{--})}$

Side band fit method:
- Invariant mass distribution outside the D^0 mass peak (>4σ) is fitted with a 2nd order polynomial function.
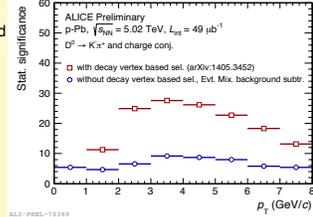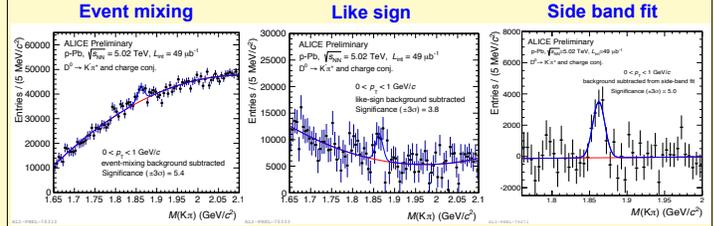- Fit function is used to subtract the background.

After background subtraction:

| Event mixing | Like sign | Side band fit |

6. Summary & Outlook

- D^0 signal has been extracted at low p_T using only PID (based on TPC and TOF signals) to select the $D^0 \rightarrow K^-\pi^+$ candidates and different combinatorial background subtraction techniques in pp and p-Pb collisions.
- For the first time, D^0 signal has been extracted for $0 < p_T < 1$ GeV/c with good significance in pp and p-Pb collisions with ALICE.
- Efforts are ongoing to extend the measurement of D^0 production cross section down to $p_T = 0$.