Topological reconstruction of D mesons with ALICE

$\mathrm{D}^+ \to \mathrm{K}^0_\mathrm{S}\ \pi^+$ reconstruction in p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV

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13 October 2015

Outline

1./ Introduction:

D-mesons reconstruction with ALICE

- usual decay channels ($\pi^{\pm}/K^{\pm}$)
- additional decay channels (K^0_S)

2./ $D^+ \longrightarrow K^0_S \pi^+$ reconstruction:

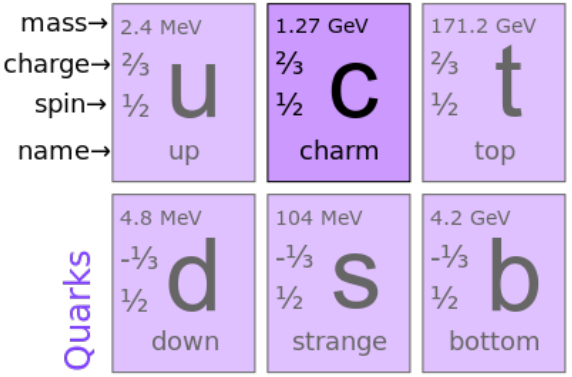
Exploratory study in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

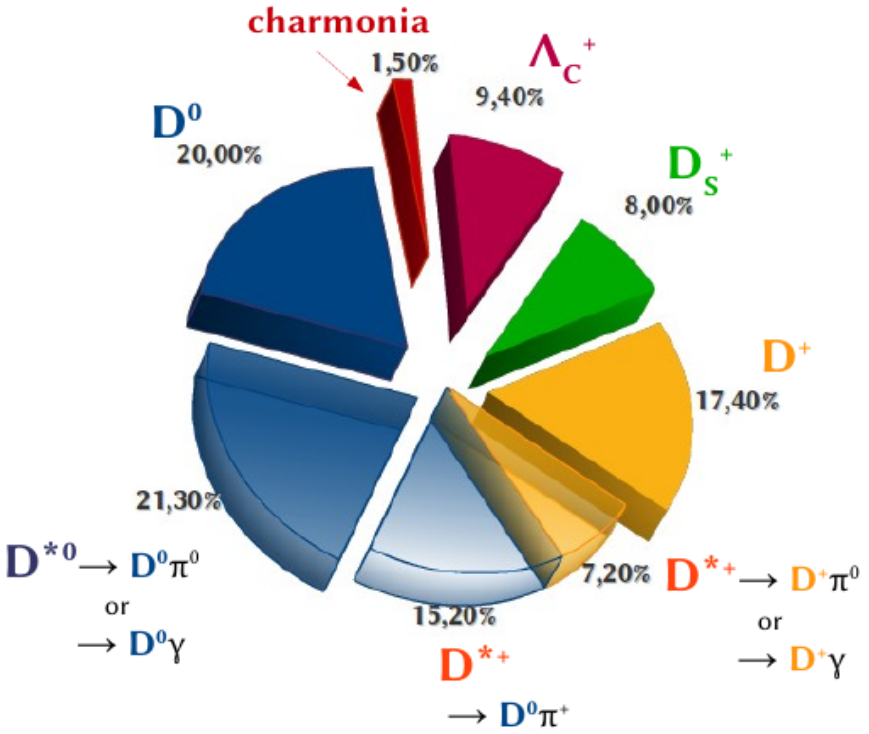
3./ Conclusion and prospect

Charm quarks as probes

Charm quarks: "tomographic" **probes** of the QGP, mainly produced at the early stage of collisions

→ experience the **full** evolution of the medium





Total charm cross section expected at the LHC in pp (Kai Schweda)

D mesons: ~ 90% of the charm-quark population

Open heavy flavour:

- key to understand parton energy losses:

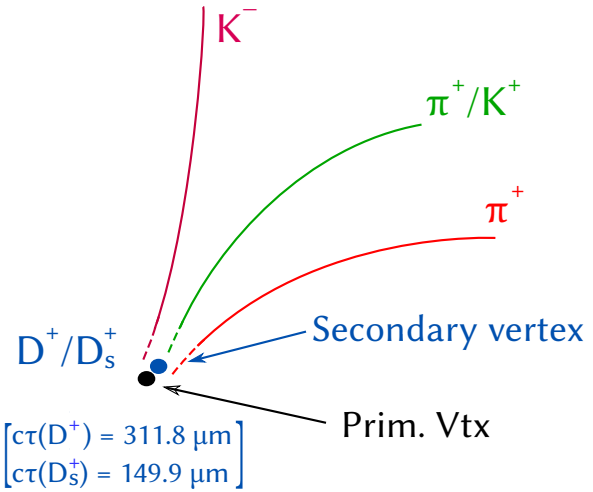
$$\Delta E_{g,u,d,s} > \Delta E_c > \Delta E_b$$

- cold nuclear matter effects (low x_B)
- complementary to hidden charm

D mesons with ALICE

Strategy: D mesons are reconstructed from their decays into $\pi^{\pm}$ and $K^{\pm}$

- take advantage of the secondary vertex displacement
- topological selections



	Usual channels		cτ (μm)
D^+	$K^- 2\pi^+$	(9.13 ± 0.19) %	311.8
D_s^+	$\phi(1020)\,\pi^+$	(2.28 ± 0.12) %	149.9
D^0	$K^- \pi^+$	(3.88 ± 0.05) %	122.9
D^{*+}	$D^0 \pi+$	(67.7 ± 0.5) %	~ 0

A challenging measurement: substantial uncertainties

- close to the primary vertex
- $\pi^{\pm}$ and $K^{\pm}$ are abundant

→ large combinatorial background

- low cross section (~ μb)
- low branching ratios (~ %)

→ low statistics

Q: *How can one reduce uncertainties?*

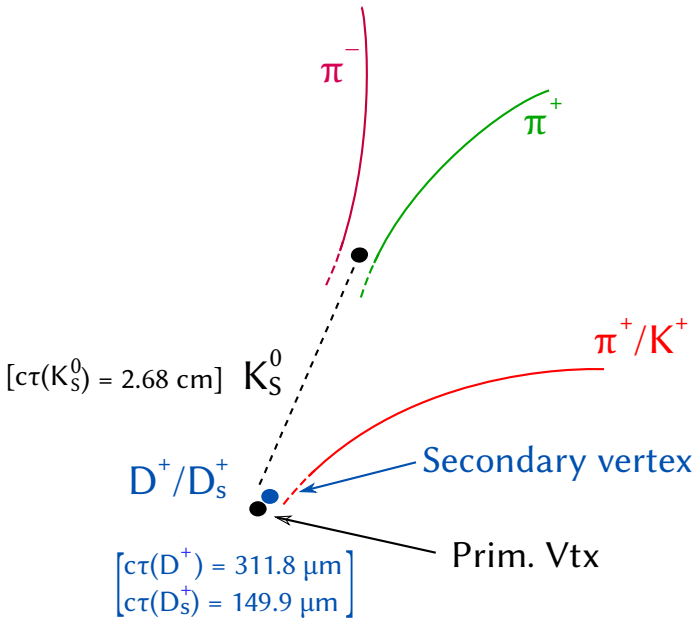
Additional D-meson decay channels

New approach: extend the D-meson studies to **other** decay channels, involving $\mathbf{K^0_S}$

- initiated by the ALICE group at IPHC (Strasbourg)

✓ additional source of statistics for D-meson studies

✓ cross-check for usual D-meson decay channels



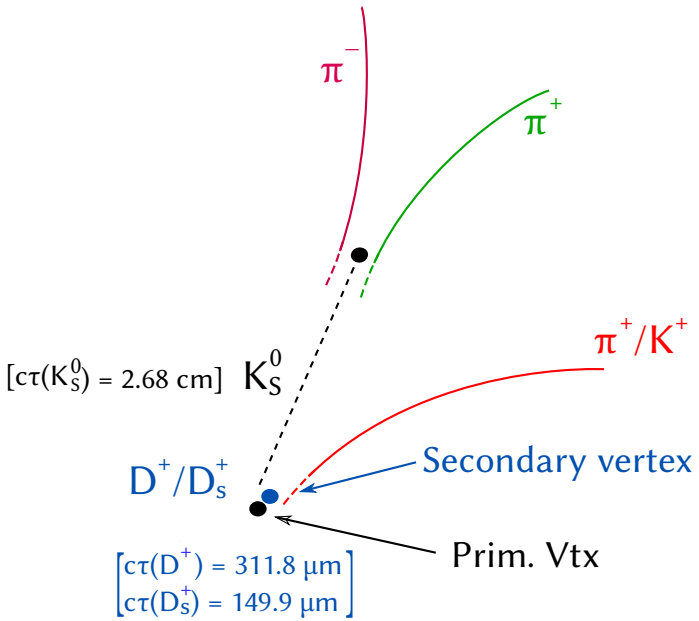
	Usual channels		Alternatives	
$\mathbf{D^+}$	$K^- 2\pi^+$	(9.13 ± 0.19) %	$\mathbf{K^0_S \pi^+}$	(1.47 ± 0.07) %
D^+_s	$\phi(1020)\,\pi^+$	(2.28 ± 0.12) %	$K^0_S K^+$	(1.48 ± 0.08) %
D^0	$K^- \pi^+$	(3.88 ± 0.05) %	$K^0_S \pi^+\pi^-$	(2.83 ± 0.20) %
D^{*+}	$D^0 \pi+$	(67.7 ± 0.5) %	———	

Additional D-meson decay channels

Strong points: exploit the K^0_S reconstruction (well displaced decay vertex)

- reconstruction limited to secondary tracks
- K^0_S are well identified, even without PID

→ *a **cleaner** signal is expected wrt usual decay channels*



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(Weak point): lower branching ratio than usual channels

Compromise: efficiency (x B.R.) VS purity

Purpose of this work: *investigate the **possibility** to extend the D-meson studies in ALICE*

$D^+ \longrightarrow K^0_S\pi^+$

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p-Pb data analysis

As an exploratory study:

Try to extract a signal of $\mathrm{D}^+ \to \mathrm{K}^0_\mathrm{S}\,\pi^+$ in **p-Pb** collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV

- most favourable collision system for an exploratory study

Event selections:

- LHC run I data (2013): 130×10^6 minimum bias events
- $|z_{\text{Prim. vtx.}}| < 10$ cm
- pile-up rejection

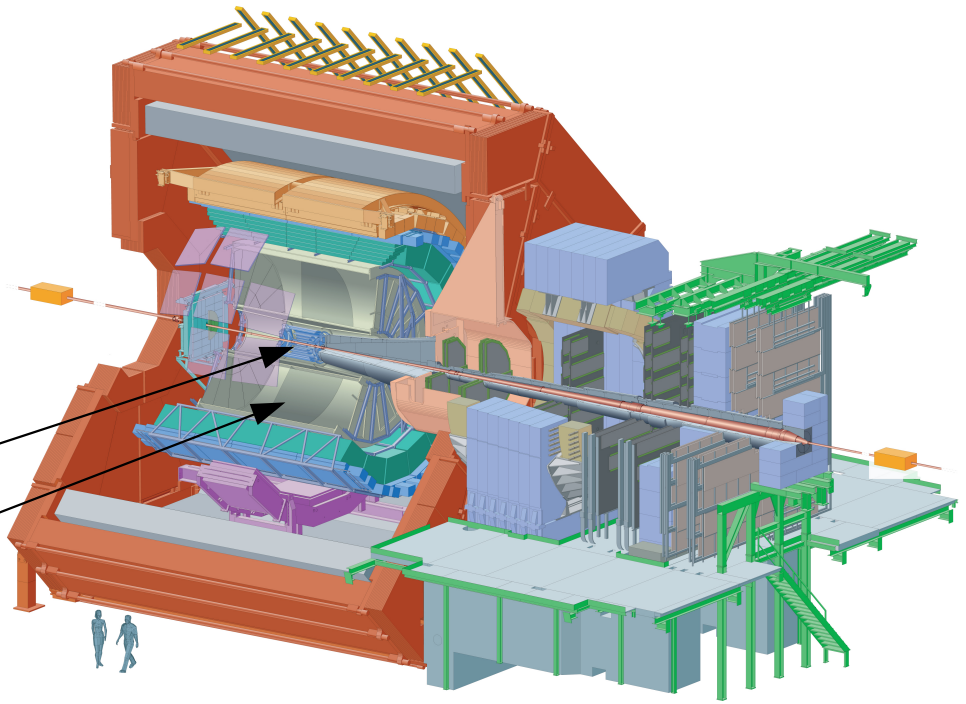
D^+ analysis:

- Mid-rapidity region: $|\eta| < 0.8$
- Only tracking and vertexing (no PID for a start)

→ Tracking of charged particles ($\pi^\pm$):

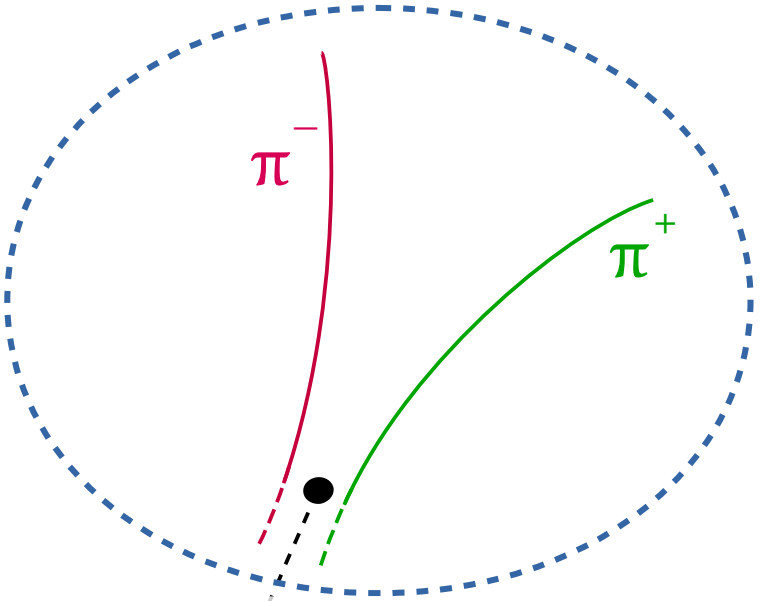
✓ Inner Tracking System

✓ Time Projection Chamber



1st step: V0 reconstruction

$K^0_S \to \pi^+\pi^-$



$[c\tau(K^0_S) = 2.68\ \text{cm}]$ K^0_S

π^+/K^+

Secondary vertex

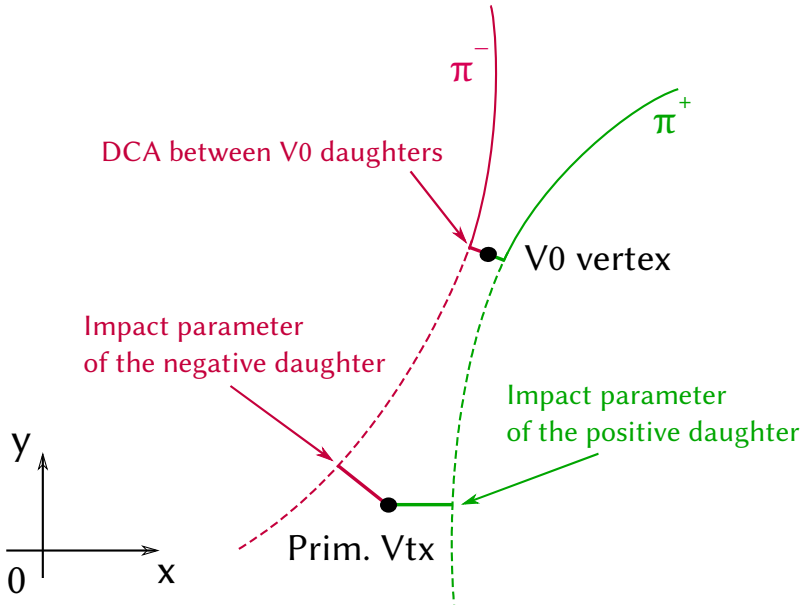
D^+/D^+_s

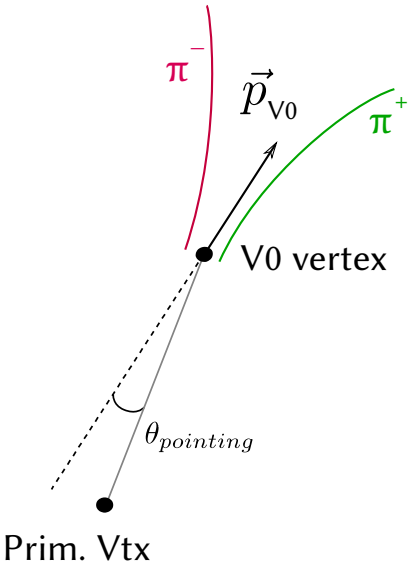
Prim. Vtx

$[c\tau(D^+) = 311.8\ \mu\text{m}$
$c\tau(D^+_s) = 149.9\ \mu\text{m}]$

1st step: V0 reconstruction

1st step: V0 reconstructed thanks to **topological** considerations (no PID)





Topological variables	Cut values	
Impact parameter of V0 daughters	$0.3 < d_0 < 2$ cm	← *secondary tracks*
DCA between V0 daughters	< 0.5 cm	← *tracks coming from the same vertex*
$\cos(\theta_{pointing})$	> 0.97	← *V0 originating close to the prim. vtx*
Decay length of V0	< 20 cm	← *$c\tau(K^0) = 2.68$ cm*
Fiducial transverse radius	$0.5 < r_{xy} < 20$ cm	← *reconstruction performances*

1st step: V0 reconstruction

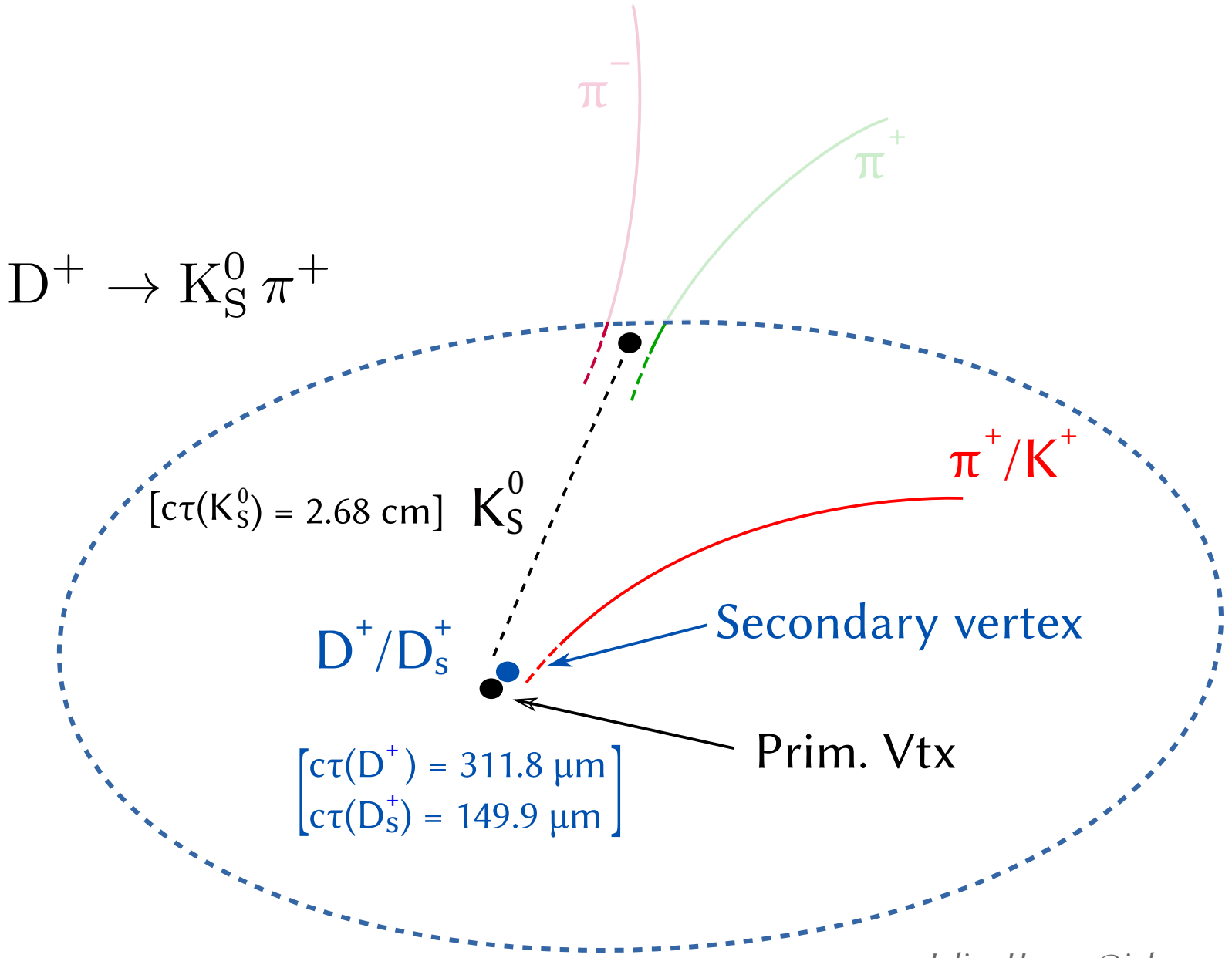
Work in progress

Signal extracted by **fitting**

- 2 asymmetric Gaussians (signal)
- 3rd order polynomial (combinatorial background)

✓ Pure set of 1.1×10^7 K^0_S

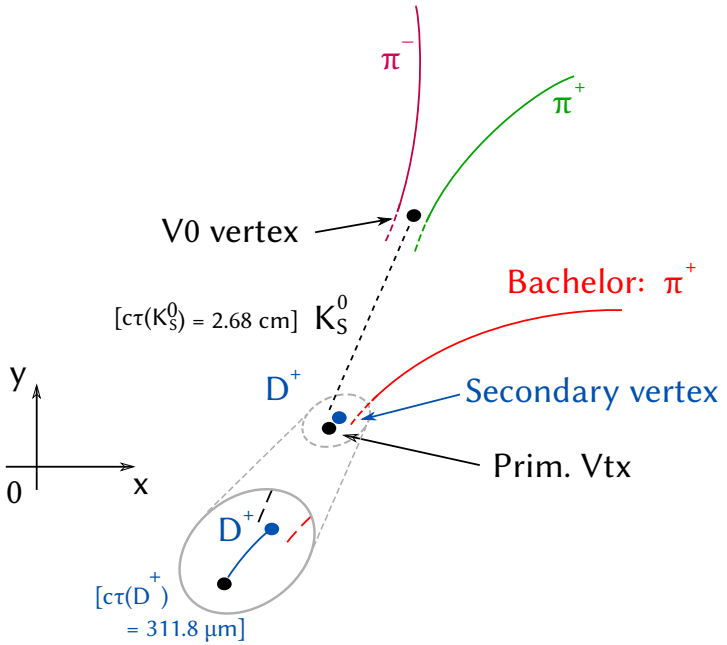
2nd step: D+ reconstruction



D^+ topological reconstruction

The analysis is limited to: $3 < p_T(D^+) < 4$ GeV/c

Topological selections: take advantage of the secondary vertex **displacement**



	Topological variables	Cut values
D^+ daughters	$\lvert M(V0) - M(K^0_S) \rvert$	< 18 MeV/c^2
	$d_0(\pi^+)$	> 0.02 cm
	$\lvert \cos(\theta^*) \rvert$	< 0.7
D^+ candidate	$\cos(\theta_{pointing})$	> 0.99
	Decay length of D^+	$500 < L_{3D} < 3000$ μm
	L_{xy}/σ_{xy}	> 2
	χ^2/ndf	< 20

"Blind optimisation": no MC simulations were available to optimise these cuts

- based on other D-meson analysis ($D^0 \longrightarrow K^- \pi^+$)
- by playing with multi-dimensional trees to enhanced S/B ratio

$D^+ \longrightarrow K^0_S \pi^+$ signal

The analysis is limited to: $3 < p_T(D^+) < 4$ GeV/c

Work in progress

A signal of $D^+ \longrightarrow K^0_S \pi^+$ is observed: for the **first time** with ALICE

- low statistics measurement can be improved by founding an other set of cuts

→ encouraging results for further studies

In the meantime at INFN

Similar measurements: carried out by Riccardo Russo (ALICE group at INFN-Torino)

- $D^+ \longrightarrow K^0_S \pi^+$ in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV
- Particle identification is used

Work in progress

Work in progress

Close collaboration is started: to cross-check analysis

- comparison between analysis framework (reconstruction package)
- reconstruction of V0

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Conclusion and prospect

Purpose of this work: *investigate the **possibility** to extend the D-meson studies in ALICE*

✓ **IPHC team approach:** evidence a $D^+ \to K^0_S \pi^+$ **signal** in **p-Pb** collisions at $\sqrt{s_{NN}}$ = 5.02 TeV
for $3 < p_T(D^+) < 4$ GeV/c, at mid-rapidity

Similar (higher) signal was observed simultaneously for $p_T(D^+)$ in [2, 3] and [3, 4] GeV/c,
by Riccardo Russo (INFN)

✓ **Analysis tasks:** the **framework adaptation** is already implemented, for tracking+reconstruction only

✘ - particle **identification** (TPC+TOF) will help to reduce the background

✘ - topological selections has to be **optimised**:
dedicated Monte Carlo sample to be studied

✘ - extend the K^0_S channels to other D mesons

During my PhD

→ study of $D \to K^0_S + X$ planned for the **LHC Run II**
(where statistics will increase!)