WP1-ITS3 status report

ITS plenary meeting (12th May 2020)

A. Kalweit, A. Rossi

Outline

- Updates on physics studies: Bs and c-deuteron (dca)
- Flash on geometry implementation
- Status overview and plans for LHCC meeting in June

General info:

- Weekly meetings on Wednesday 9:30 am https://indico.cern.ch/category/11831/
- In case you are interested in a specific topic, please do not hesitate to contact Alexander and Andrea and to sign up on alice-its3-wp1

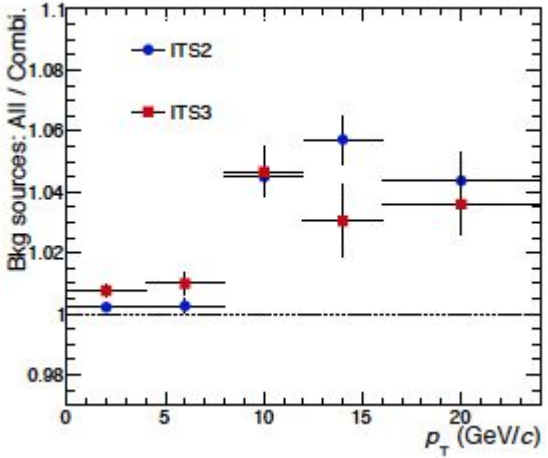
Update on B_s-> $D_s\pi$

L. Veermunt

Several news on analysis

- 2 ML model applied in sequence
- Inclusion of all background sources, including those with real D_s (prompt or from b-hadron decay)

$$B = \frac{B_{\text{SB data}}^{\text{current}}}{B_{\text{MC}}^{\text{current}}} B_{\text{MC}}^{\text{upgrade}} + \underbrace{B^{(\text{pr } D_s)+\pi}}_{\text{FONLL-TAMU}} + \sum_{\text{b hadron}} \underbrace{B^{(\text{fd } D_s)+\pi}}_{\text{FONLL-TAMU}} \cdot \frac{F_{\text{b}\to\text{b hadr.}\to D_s+X}}{F_{\text{b}\to D_s+X}}$$



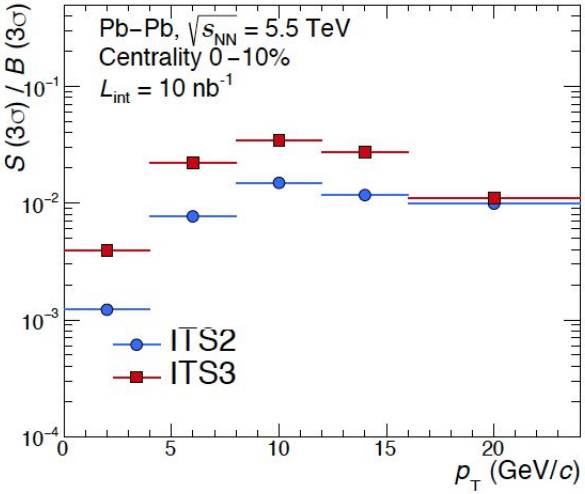
Analysis almost completed (should be in time for June LHCC)

→ more details in a dedicated presentation in future ITS meeting

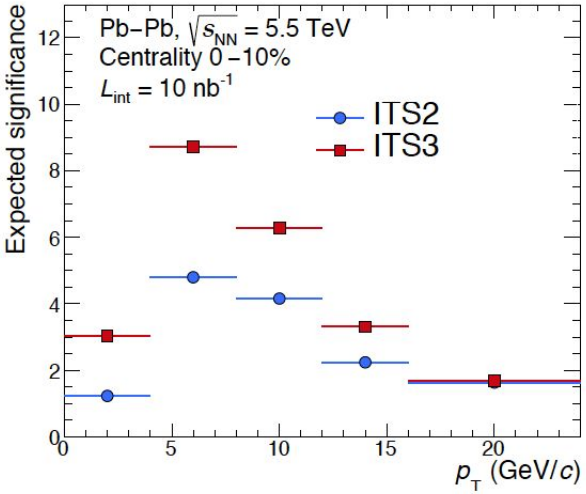
Update on B_s-> $D_s\pi$

L. Veermunt

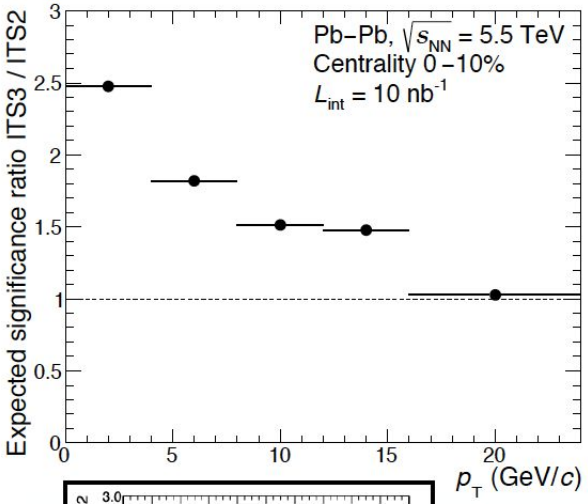
S / B



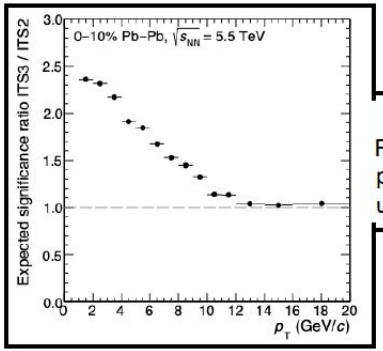
Significance



Ratio Significance



- Improvement of factor 1.5 - 2.5 for ITS3, very similar as observed in the non-prompt Ds analysis.
- With the ITS3, the low and high p_T bin would get into reach
  - NB: Quoting [0-4] GeV/c here, but with a minimum p_T of 1 GeV/c for the D_S in the MC production, there is probably not a lot below 4 GeV/c. To be checked.

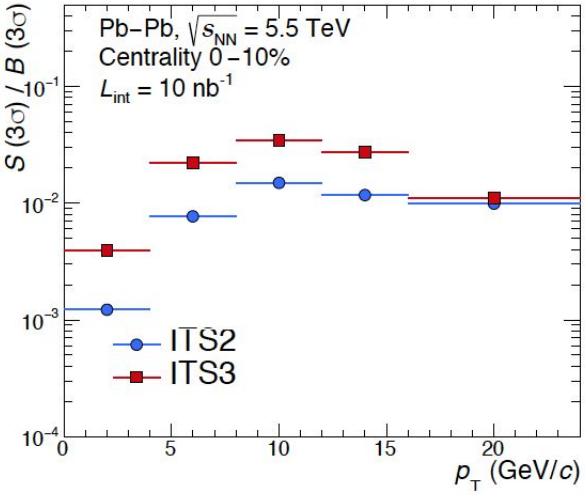


Taken from Fabrizio's non-prompt Ds ITS upgrade study

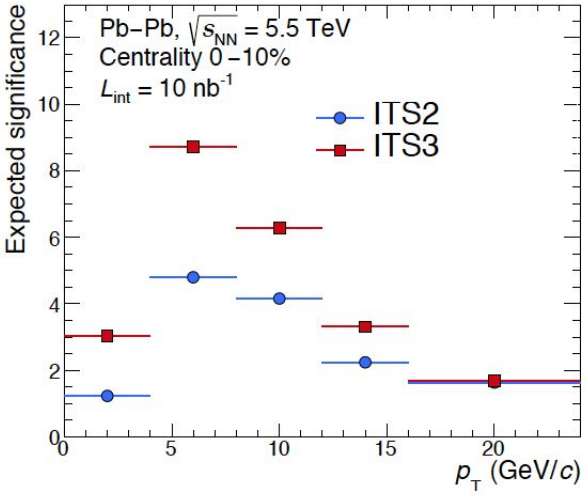
Update on B_s-> $D_s\pi$

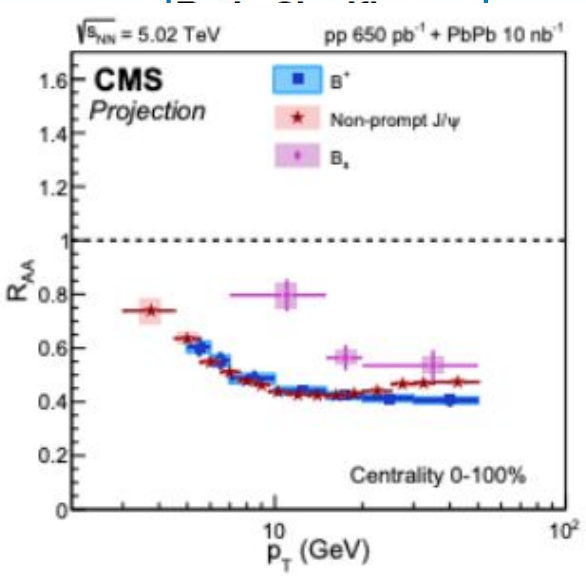
L. Veermunt

S / B



Significance

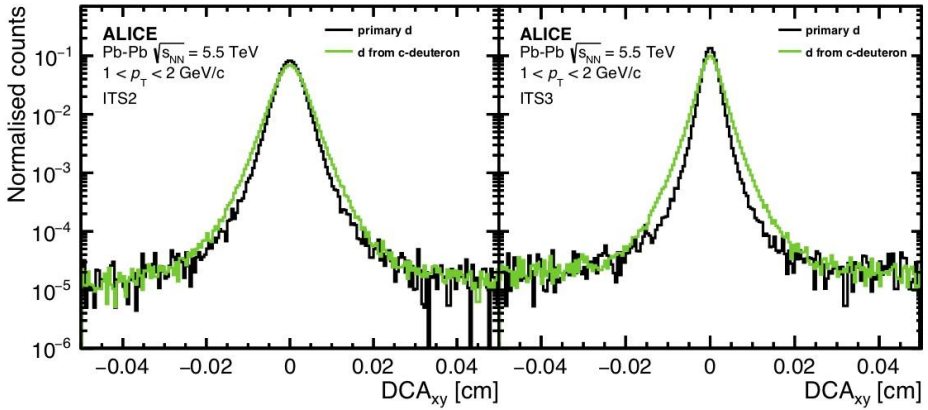




Competitive with CMS expectations reported in Yellow Report:
improved pt reach into most significant region (+ note different centralities)

ITS3 figures of merit for c-deuteron identification

M. Buckland
J. Norman

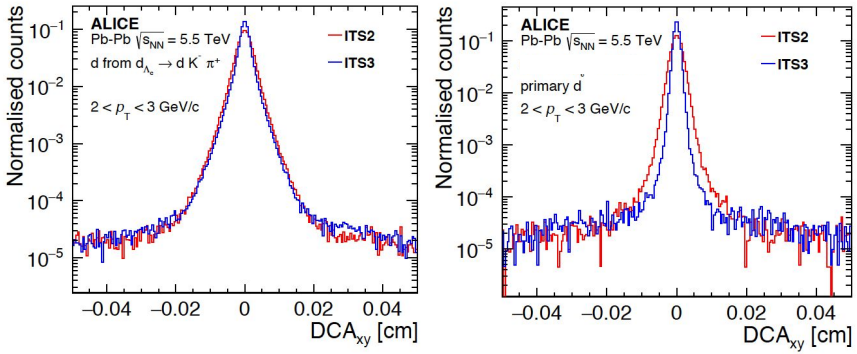


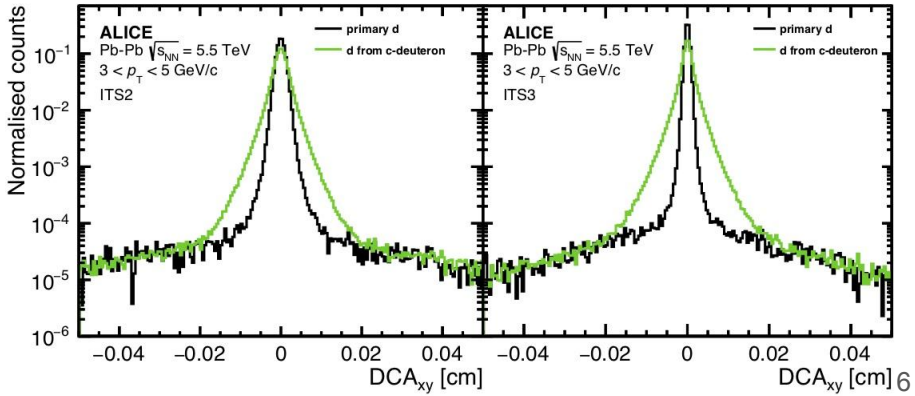
Assuming Λ_c lifetime ($c\tau$~60 μm), deuterons from c-deuteron very close to primary vertex

Higher ITS3 resolution fundamental to discriminate signal deuterons from primary deuterons

Especially at low pt, where most of the signal sits

N.B. Distributions normalised to their integral



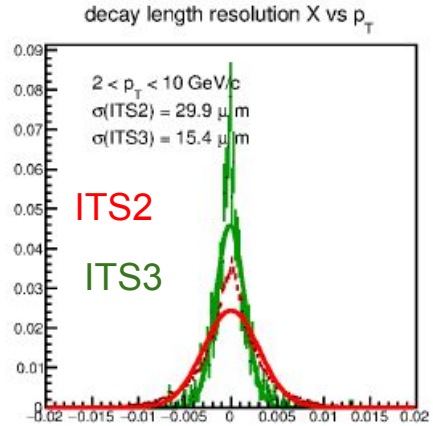


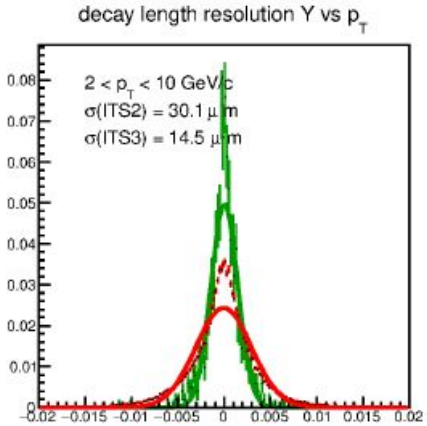
c-deuteron studies with new MC simulation

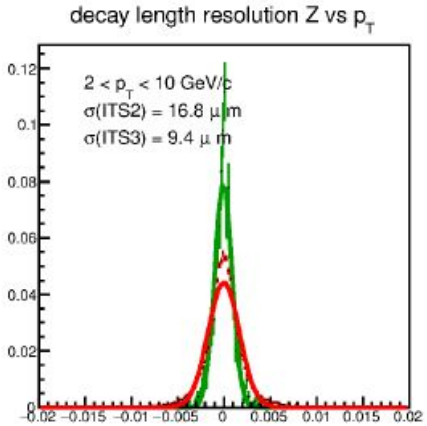
M. Buckland
J. Norman

First (ever, though MC) reconstruction of a c-deuteron vertex :)

Clear benefit from ITS3: improved decay length resolution + better identification of real vertices

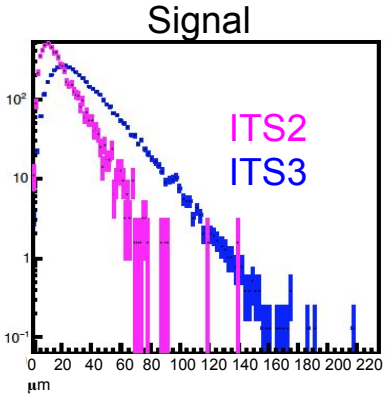


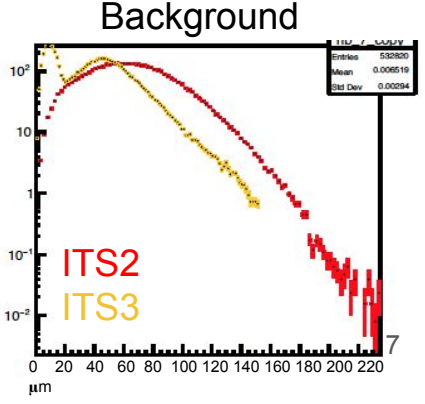




Track dispersion around reco vtx:

$$\sigma_{\text{vertex}} = \sqrt{d_1^2 + d_2^2 + d_3^2}$$





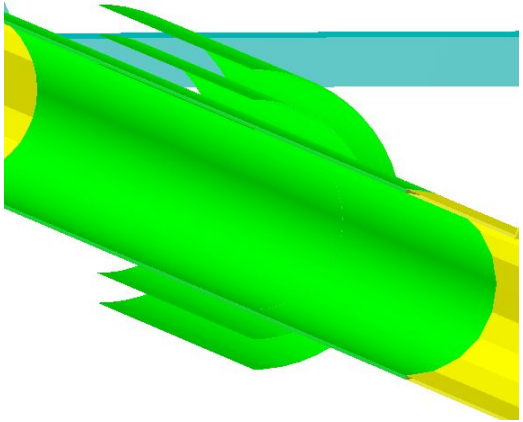
Boost to signal-background separation power

ITS3 geometry in O2 simulation

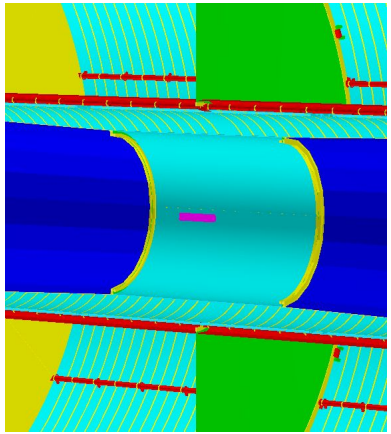
→ ITS3 geometry is now available in the O2 software: many thanks to M. Sitta!

→ Layout is configurable (e.g. four instead of three layers) for more involved studies.

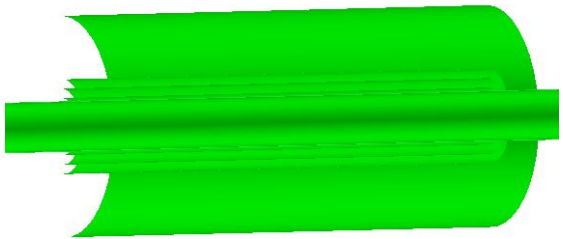
→ First simulation of events is currently ongoing (M. Concas).



3 layers layout

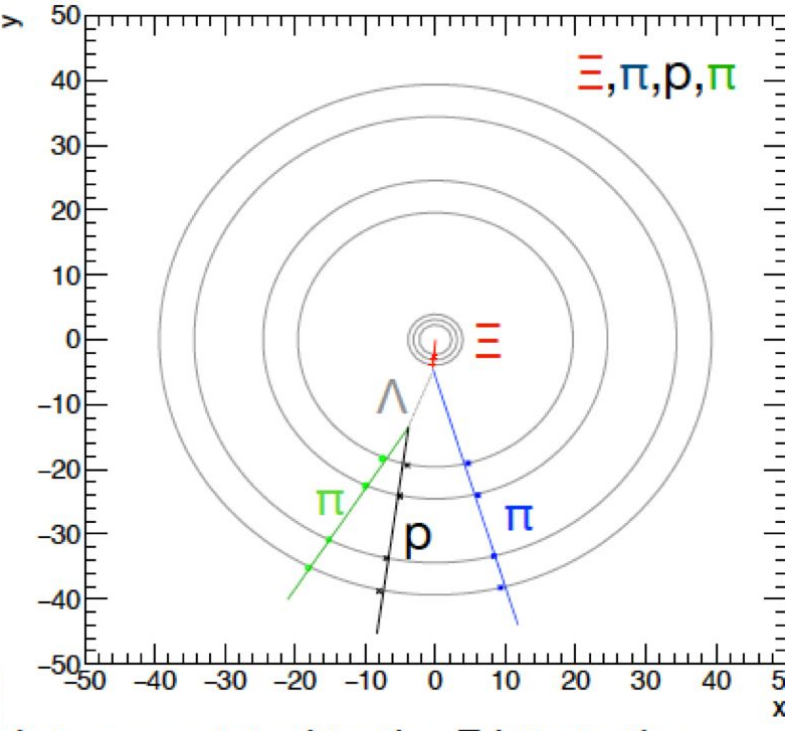


ITS3 inside TPC



4 layer layout

Strangeness tracking



[Link to dedicated meeting on the topic]

- Several charged strange particles have lifetimes similar to the inner barrel radius → we can aim at tracking them turning ITS3 into a "MHz bubble chamber"

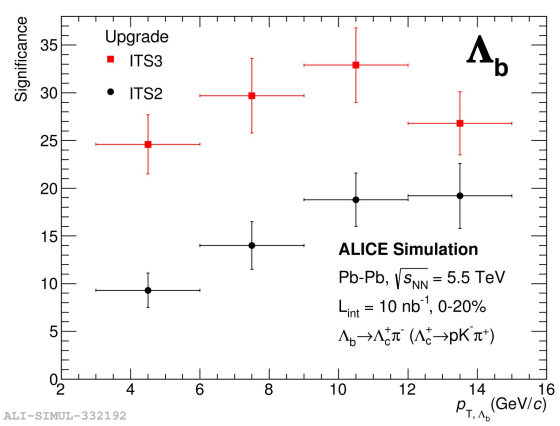
- These mini tracks might help to improve the identification of secondary vertices from strange-charm baryons in some decay channels:
  - Ξ_c^+ (cτ~132μm)→ pKπ, $\Xi^- \mathbf{2\pi^+}$
  - Ξ_c^0 (cτ~34μm)→ $\Xi^- \boldsymbol{\pi^+}$ → $\Lambda\pi^+ \boldsymbol{\pi^+}$ → $p\pi^+ \ \pi^+ \pi^+$
  - Ω_c^0 (cτ~80μm)→ $\Omega^- \boldsymbol{\pi^+}$ **(most promising candidate)**

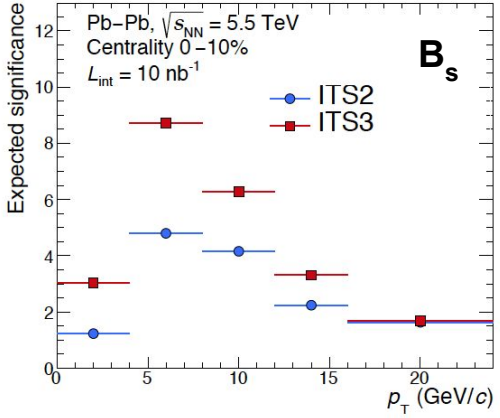
- Additional physics cases: direct reconstruction of hyper-triton mother and Sigma+

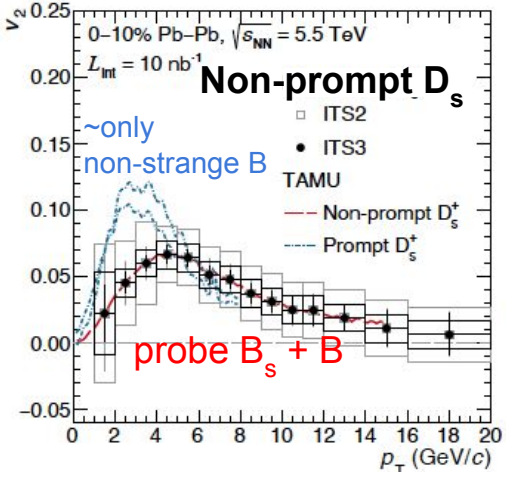
Physics topics for LHCC

1. B_s fully reconstructed (new results from new MC very likely ready in time)
2. Non-prompt D_s (new results from new MC, already approved)
3. C-deuteron (new topic: proxy studies + DCA and vertex performance from new MC)
4. Λ_b (probably only QM studies, not shown before to LHCC)
5. Ξ_c (only plot showing vertex performance but it is not granted)
6. Di-leptons (no news)
7. Strangeness tracking (we may mention the idea, maybe in connection with Ξ_c and Ω_c)
8. Charm correlations / jets (likely nothing in time, MC production in preparation)
9. ITS3 geometry in O2 (now available)

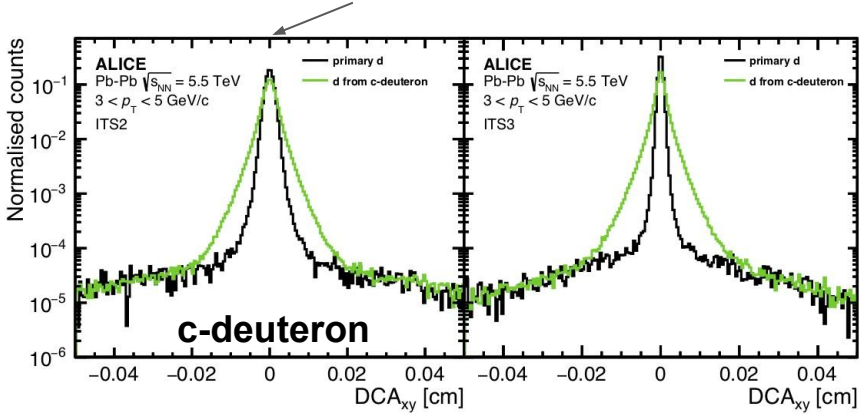
LHCC pictures

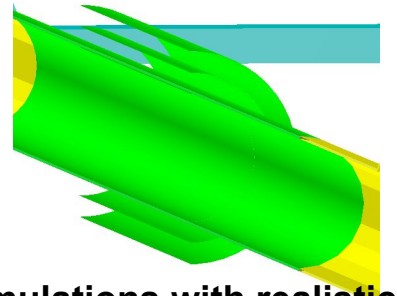




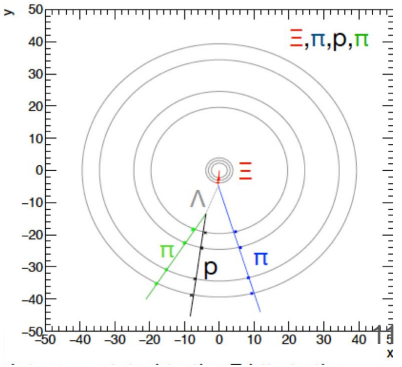


New "exotic" ideas → **Strangeness tracking**
→extend charm baryon capability?





Simulations with realistic geometry upcoming



Backup slides

c-deuteron with DCA analysis?

M. Buckland
J. Norman

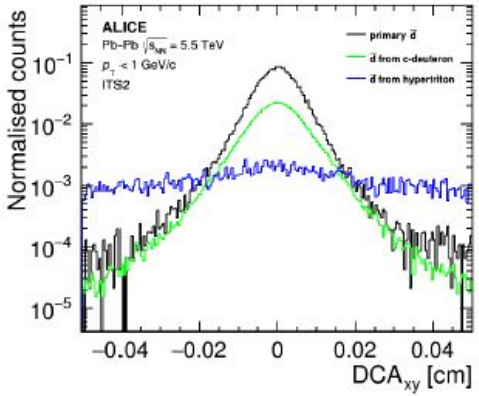
Anti-deuteron DCA distributions with more realistic normalisations (**still being finalised!**)

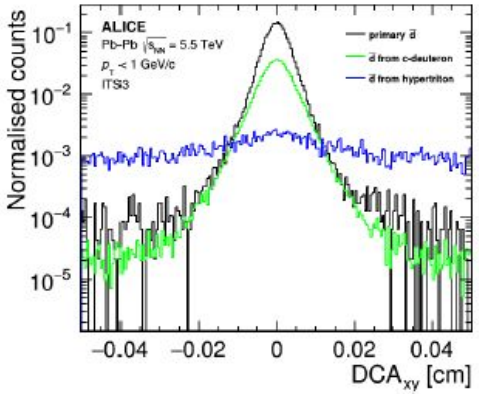
DCA-based analysis of “non-prompt” deuteron to extraction c-deuteron feed-down fraction very challenging

Hope with ITS3 for pt>3 GeV/c?

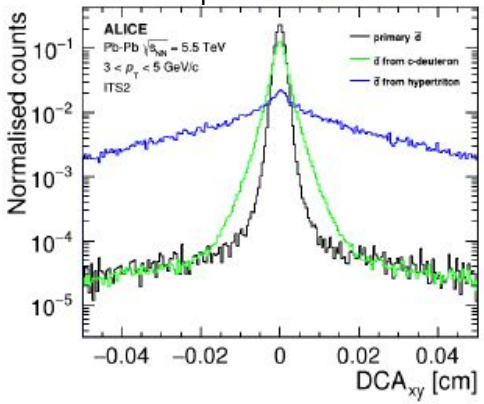
→ Need to cook a realistic cocktail of decay channels.
BR(Λ_c^+--> p X)~50%
Many 3,4 body channels
Many with smaller Q-value than pKpi

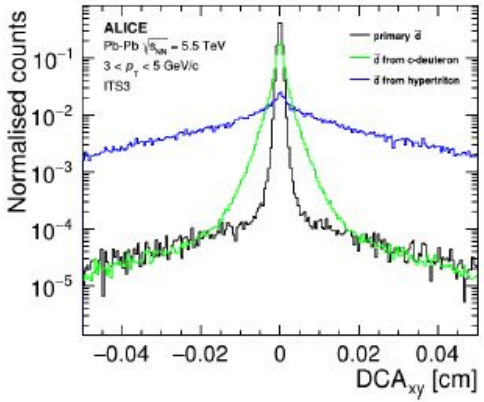
p_T<1 GeV/c





3<p_T<5 GeV/c

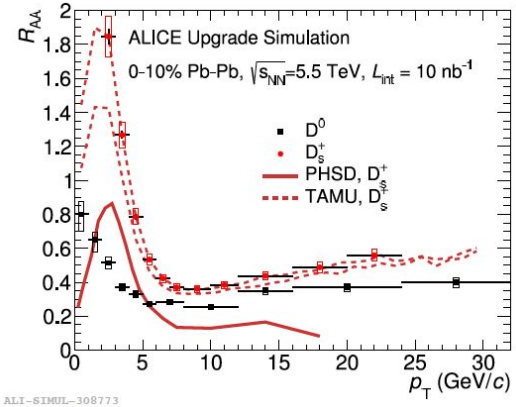




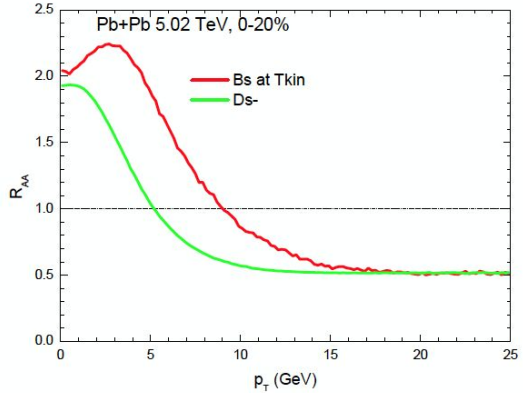
Non-prompt D_s^+ to investigate beauty hadronisation

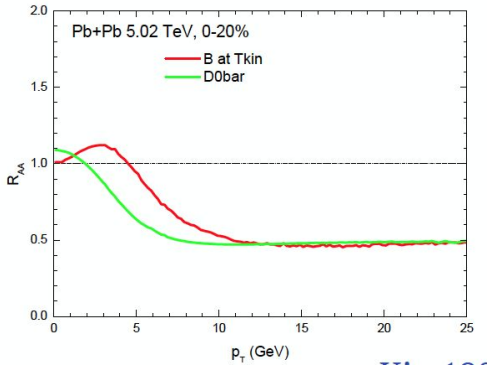
F. Grosa

Prompt D, Yellow report



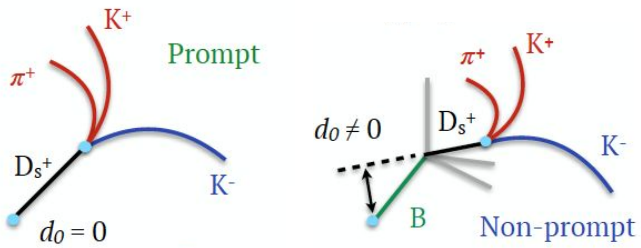
Beauty and non-prompt D: Rapp and He arxiv:1905.09216 + priv. comm.





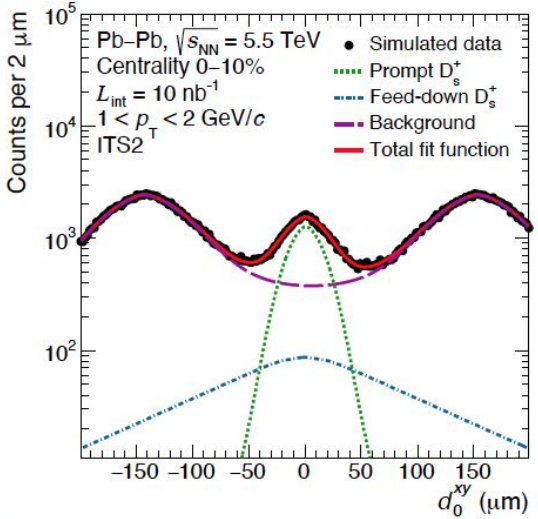
D_s and B_s RAA and v_2 → charm and beauty quark hadronisation: coalescence + strangeness enhancement

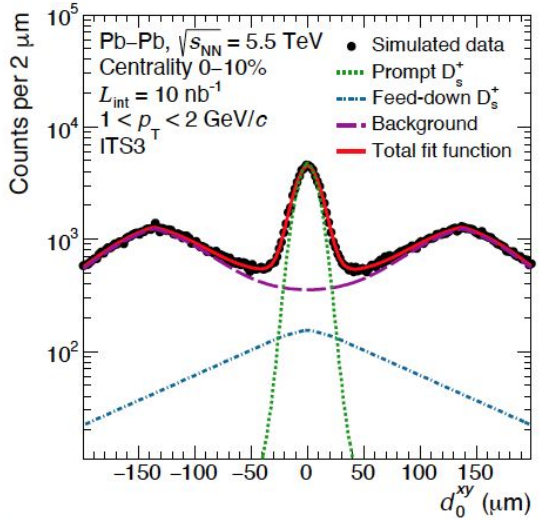
Non-prompt D_s: about 50% from B_s → sensitivity to B_s
Compared to exclusive B_s reconstruction (e.g. B_s->$D_s\pi$, BR~0.3%):
Cons: contamination from non-strange B + decay kinematics
Still a clear difference expected w.r.t. non-prompt D!
Pros: much larger statistics
Identification of non-prompt component ← displacement analysis
→ Sensitive to impact parameter resolution
→ ITS3 expected to reduce statistical and systematic uncertainties, especially at low pt

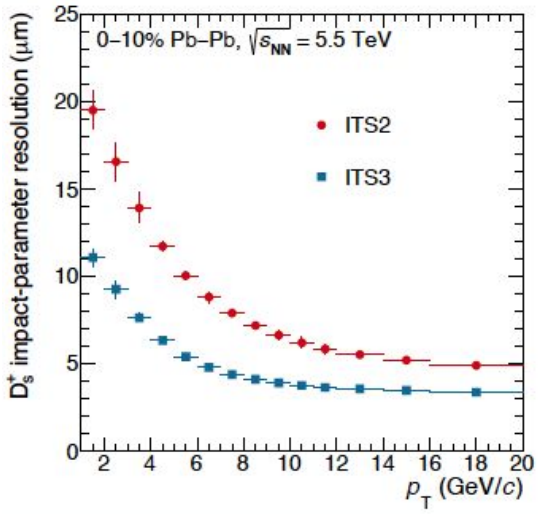


Non-prompt D_s^+: analysis (final results)

F. Grosa







3-component template fit of (selected) D_s impact parameter distribution

$$F(d_0^{xy}) = S \cdot [f_{\text{prompt}} \cdot F_{\text{prompt}}(d_0^{xy}) + (1 - f_{\text{prompt}}) \cdot F_{\text{non-prompt}}(d_0^{xy})] + B \cdot F_{\text{bkg}}(d_0^{xy})$$

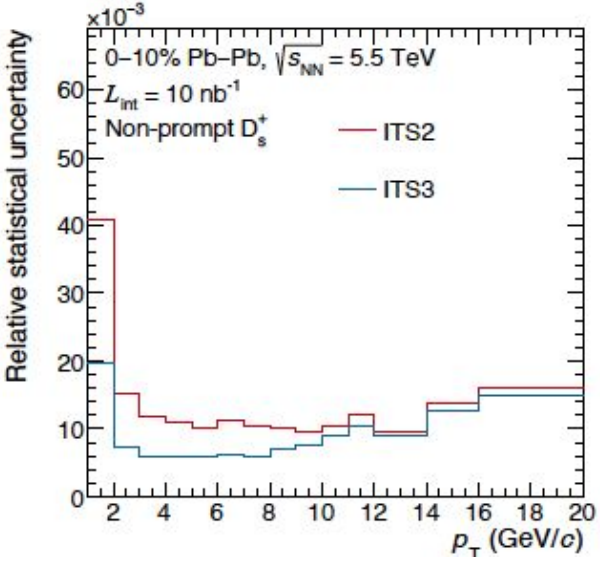
ITS3: resolution better by almost a factor 2 at low pt

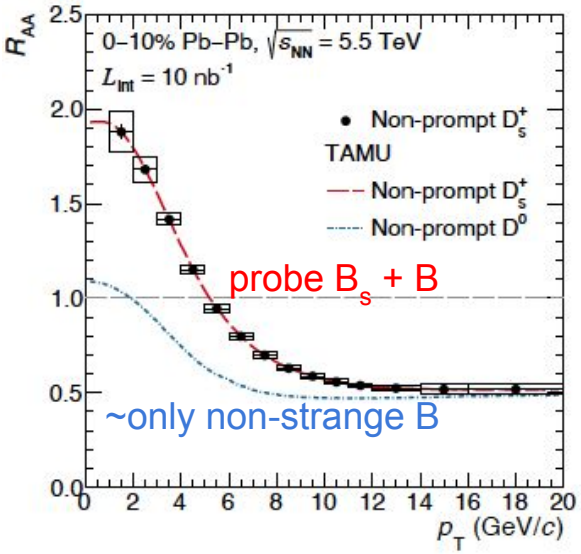
Improve background rejection before fit and impact of background determination in final fit

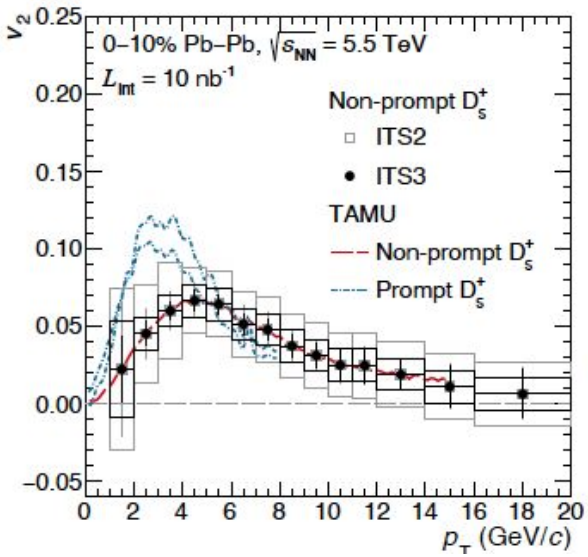
Cleaner separation of prompt and non-prompt component

F. Grosa

Non-prompt D_s^+: final results of expected performance







ITS3 can provide an improvement both in the stat. (up to a factor 2-2.5 at low p_T) and syst. unc.

→ Sensitivity to probe different R_{AA} of prompt and non-prompt D_s^+

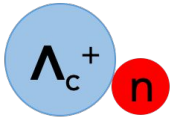
→ Sensitivity to probe different v_2 of prompt and non-prompt D_s^+

Note: results extended down to 1 GeV/c also for prompt Ds, thanks to new MC production

Dedicated study of D_s and Λ_c filtering cuts (low-pt background → CPU time at limit even with ITS2)

Next: try with different technique (cut-variation analysis with Machine Learning)

c-deuteron: “proxy studies”



- Λ_c-n bound state, m ~ 3.226 GeV/c2
  - Lightest possible hyper-nucleus with charm
  - It’s observation would provide information on hadronisation and hadron-hadron interactions
- Predictions: SHM, arxiv:1901.09200, ExHIC Coll.(first guess) - various models, arxiv:1702.00486

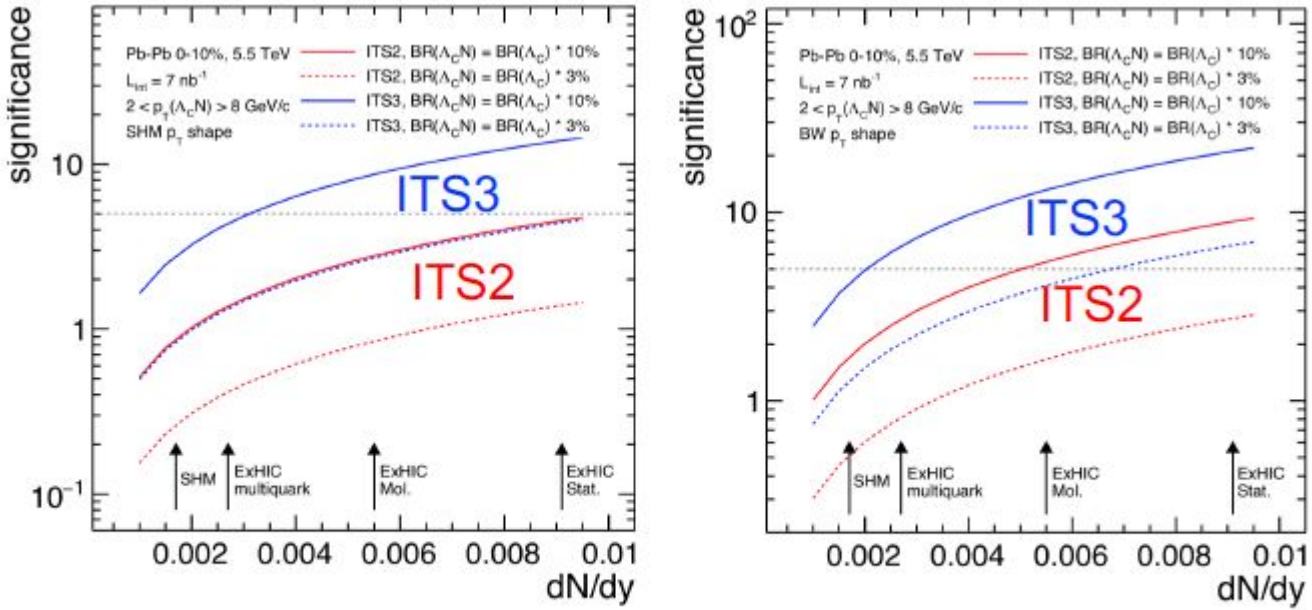
	SHM	ExHIC “multiquark”	ExHIC Molecular	ExHIC SHM
Matter dN/dy Central Pb-Pb 5 TeV	1.5e-3	2.7e-3	9.1e-3	5.5e-3

- Lowest expected rate (SHM): dN/dy ~ 10^4 with L_{int}=10 nb^{-1} Pb-Pb
- Decay:
  - $c\tau$~ $c\tau$ (Λ_c) ~ 60μmm.
  - Decay channels: no theoretical calculation. Working assumptions: consider Λ_c decay channels (e.g. $\Lambda_c \rightarrow$ pKπ, BR~6%) and multiply their BR by the probability *P* that p binds with n to form a deuteron. Not straightforward → bracket for *P*: 3-10% → overall BR ($d_{\Lambda c}$ -> dKπ): 0.18-0.6%
    → **Extremely rare signal!**

c-deuteron: “proxy studies”

M. Buckland
J. Norman

Use $\Lambda_c \rightarrow pK\pi$ with proper p/d scaling as proxy for c-deuteron ($d_{\Lambda c}$ -> $dK\pi$), BDT selection as done for Λ_c



ITS3 improves significance by x2.5 wrt ITS2