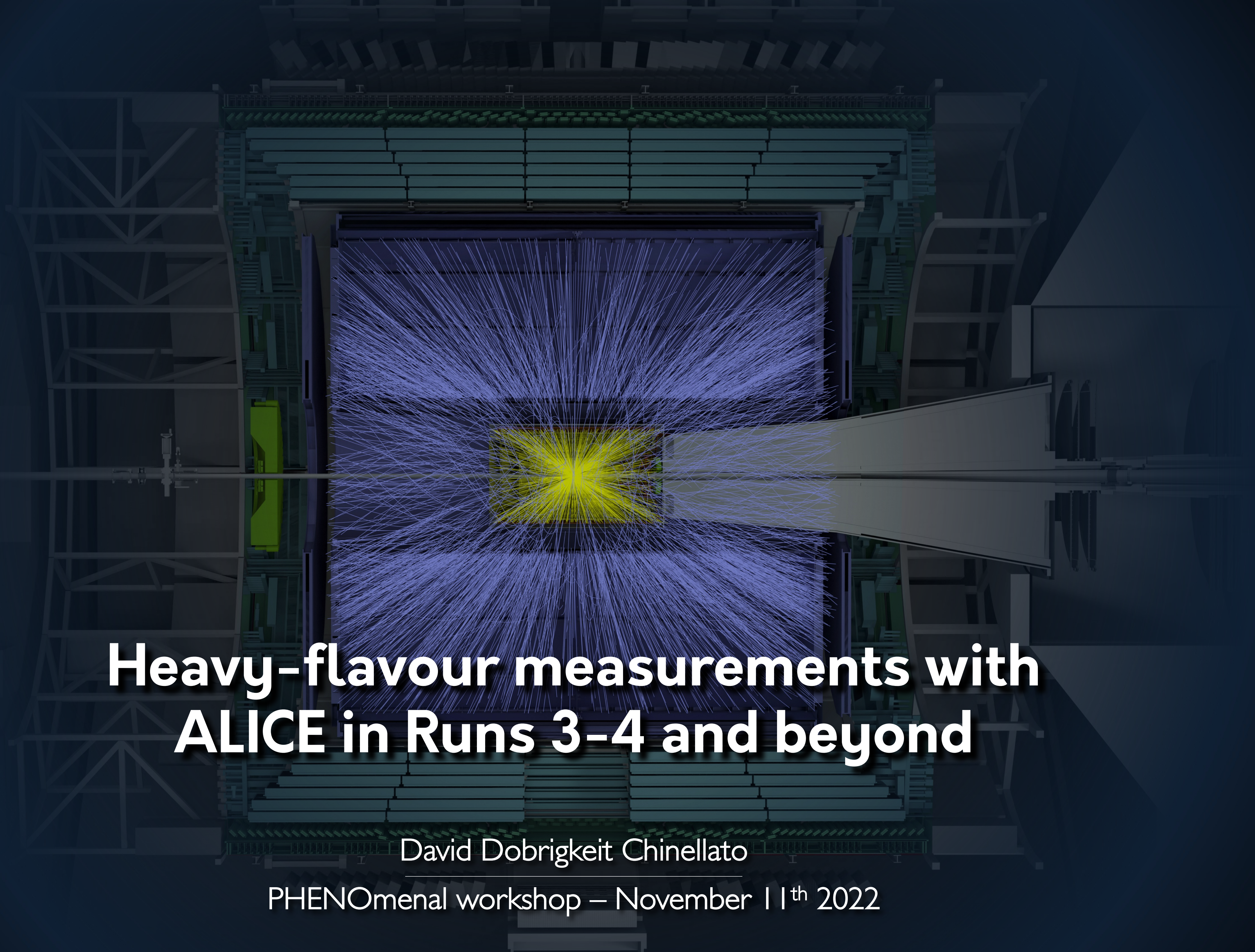
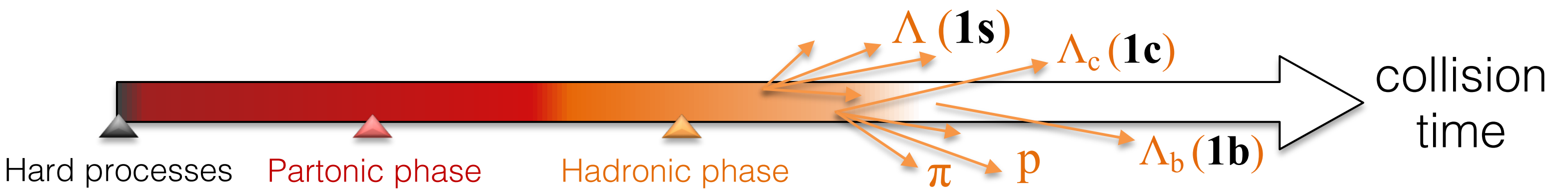


Heavy-flavour measurements with ALICE in Runs 3-4 and beyond

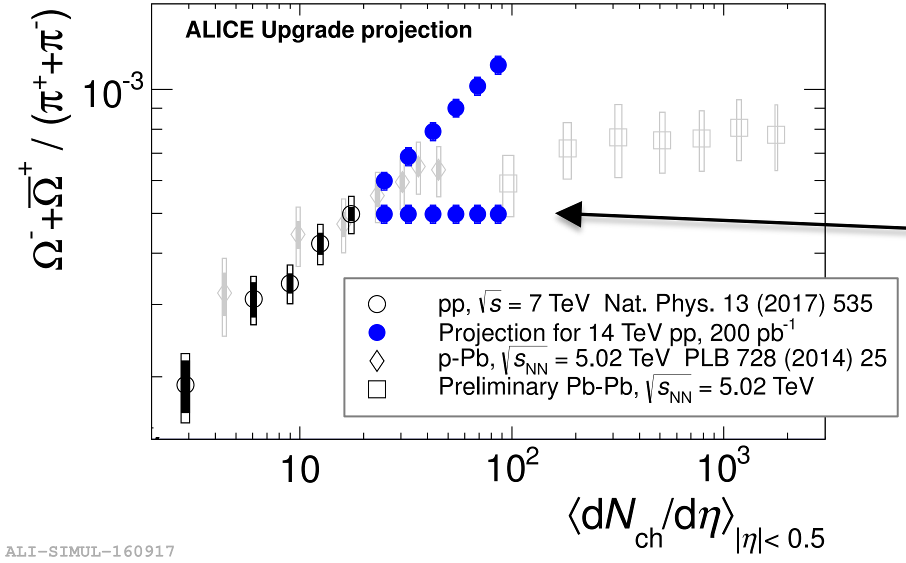
David Dobrigkeit Chinellato

PHENOmenal workshop – November 11th 2022

Understanding flavour hadronization



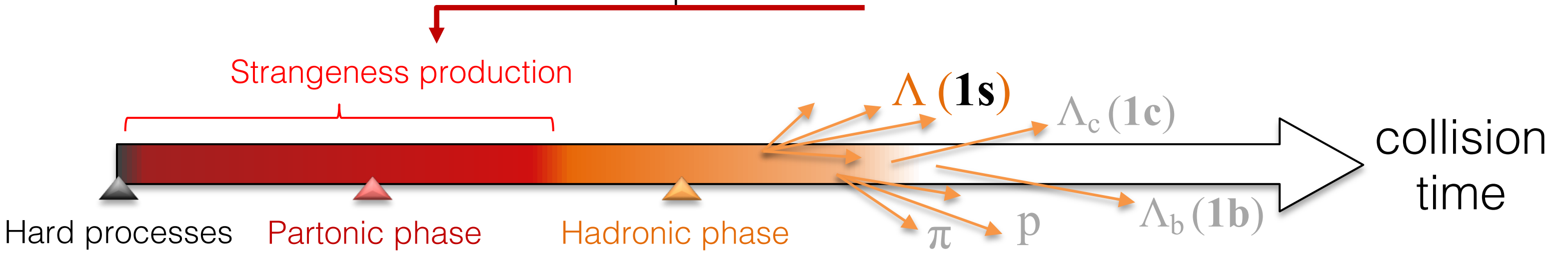
Yellow report (https://arxiv.org/abs/1812.06772, adapted)



Understanding flavour hadronization

Does strangeness production saturate in pp?

- Would mean universal "equilibration" limit exists



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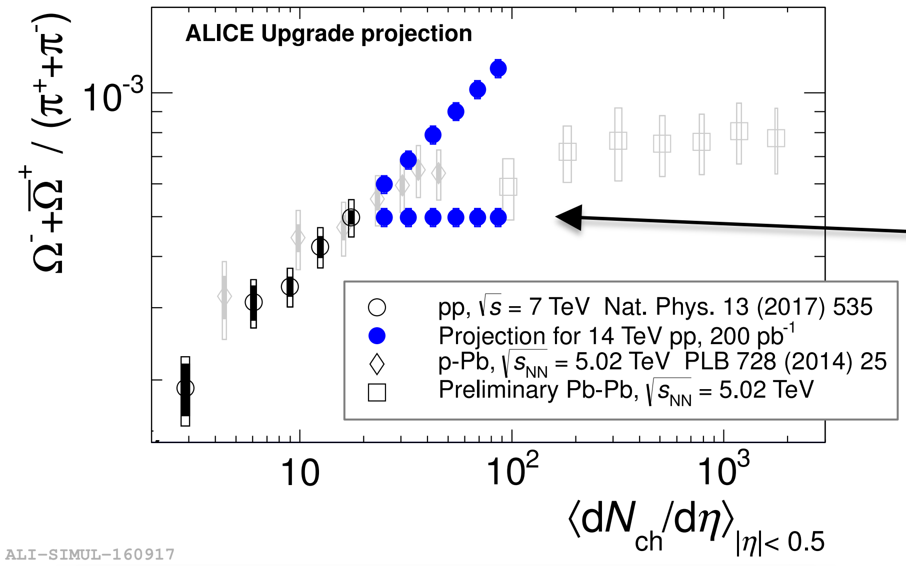

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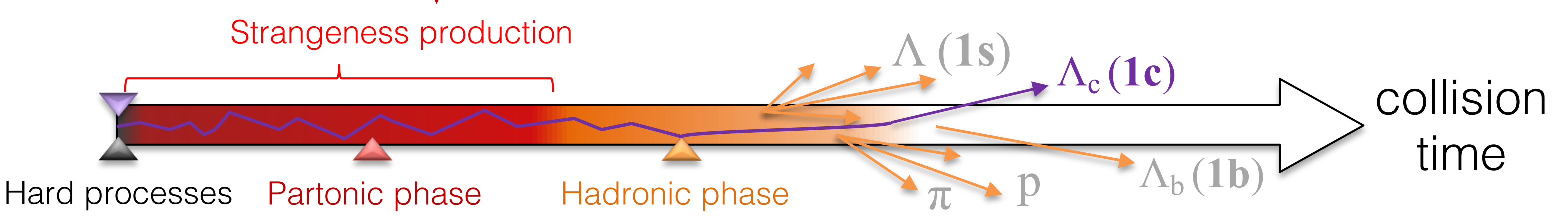
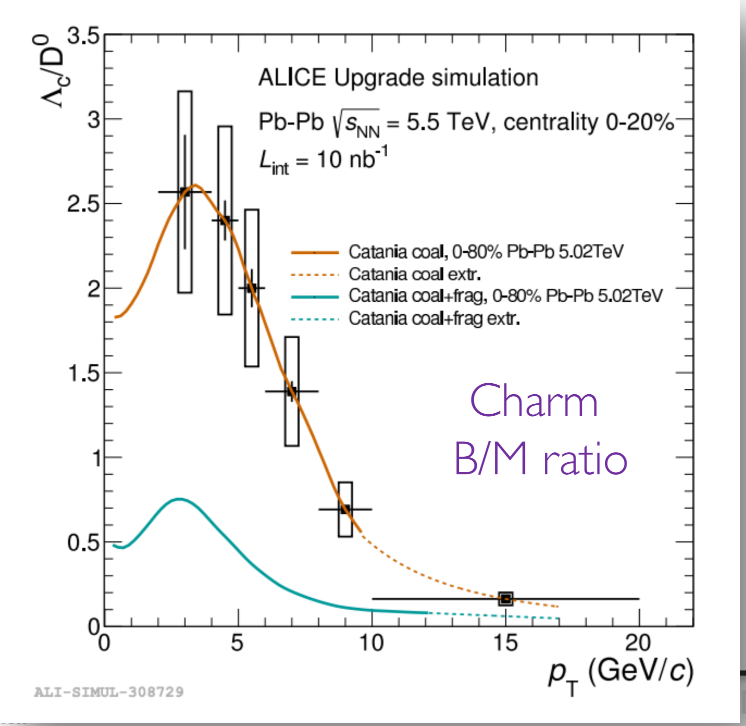
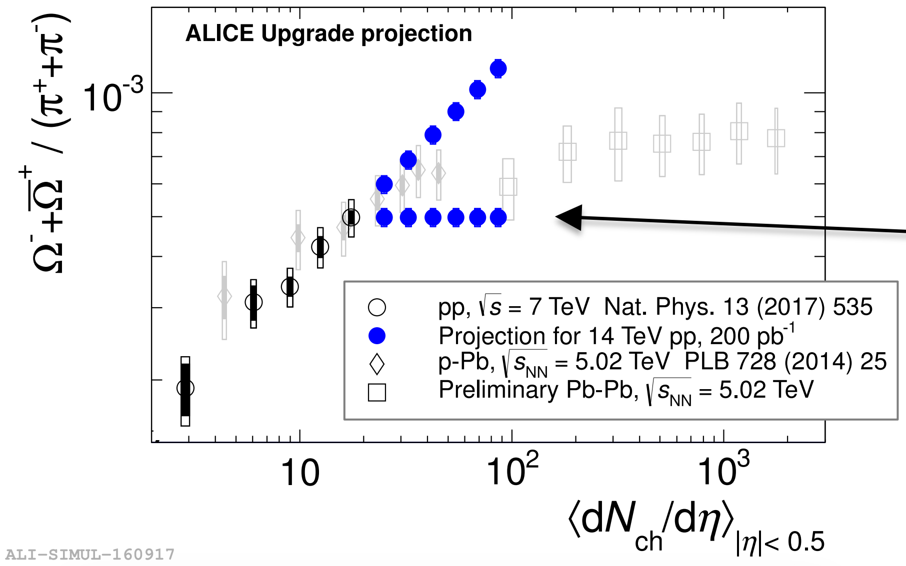


Charm production



- $c\bar{c}$ yields: fixed at the beginning, much larger masses than strangeness
- First step: precise Λ_c/D^0 and v_2: coalescence / collectivity
- Run 3+4 special: unprecedented focus on low-p_T
- Follow-up: charmed baryon yields and hadrochemistry

Yellow report (https://arxiv.org/abs/1812.06772, adapted)



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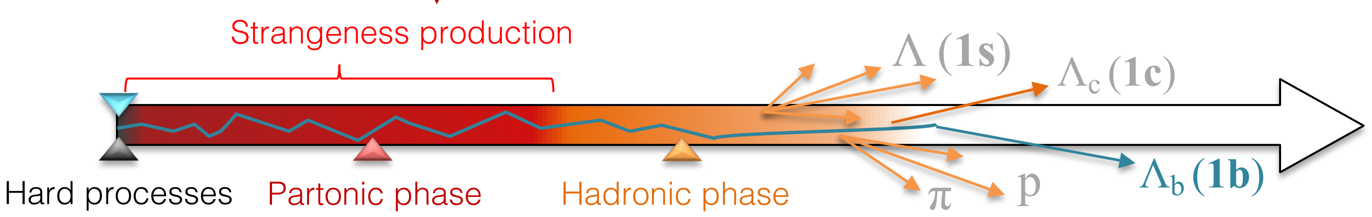
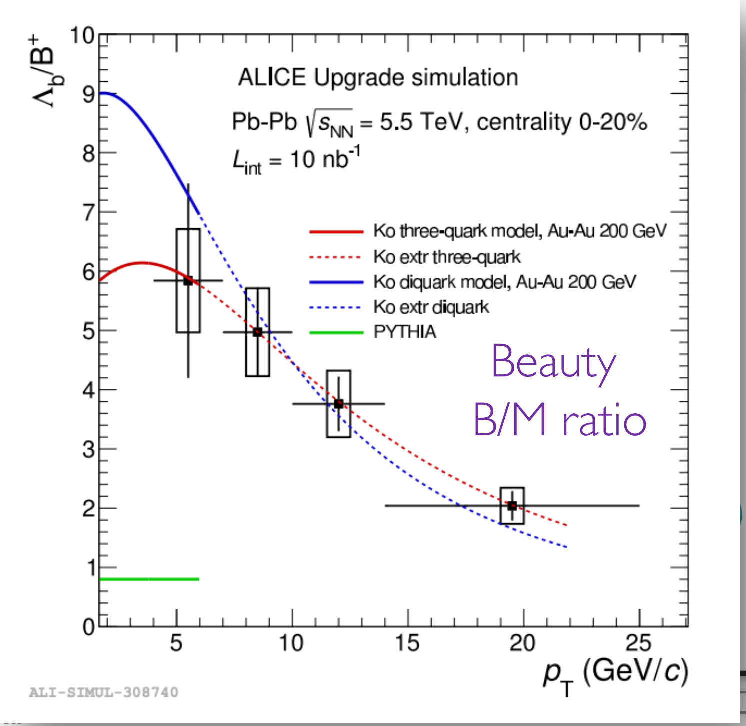


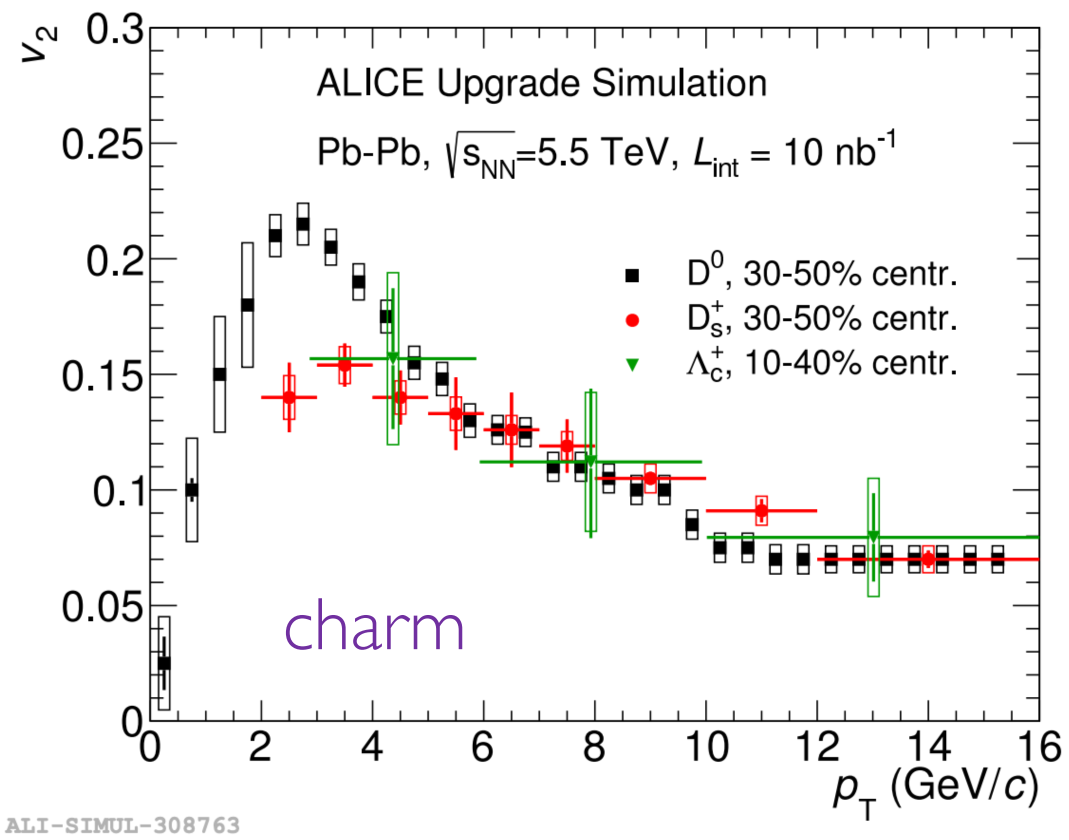
Beauty production

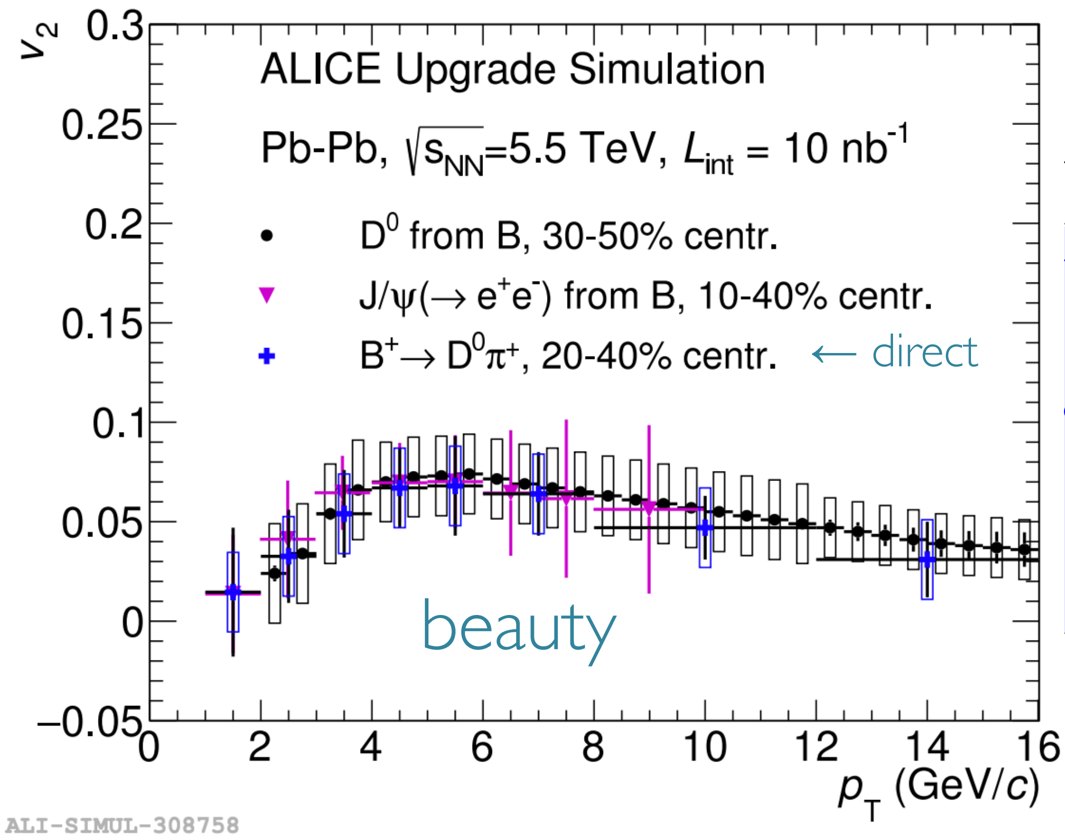
- $b\bar{b}$ yields: significantly larger mass still
- Kinematic and chemical equilibration not a given
- Unique opportunity to learn about the evolution of the QGP!
- Expect direct access to single-beauty hadrons B, Λ_b in Runs 3 and 4



In all cases: systematic studies ranging from Pb-Pb to pp

Heavy-flavour collectivity in runs 2 and 3

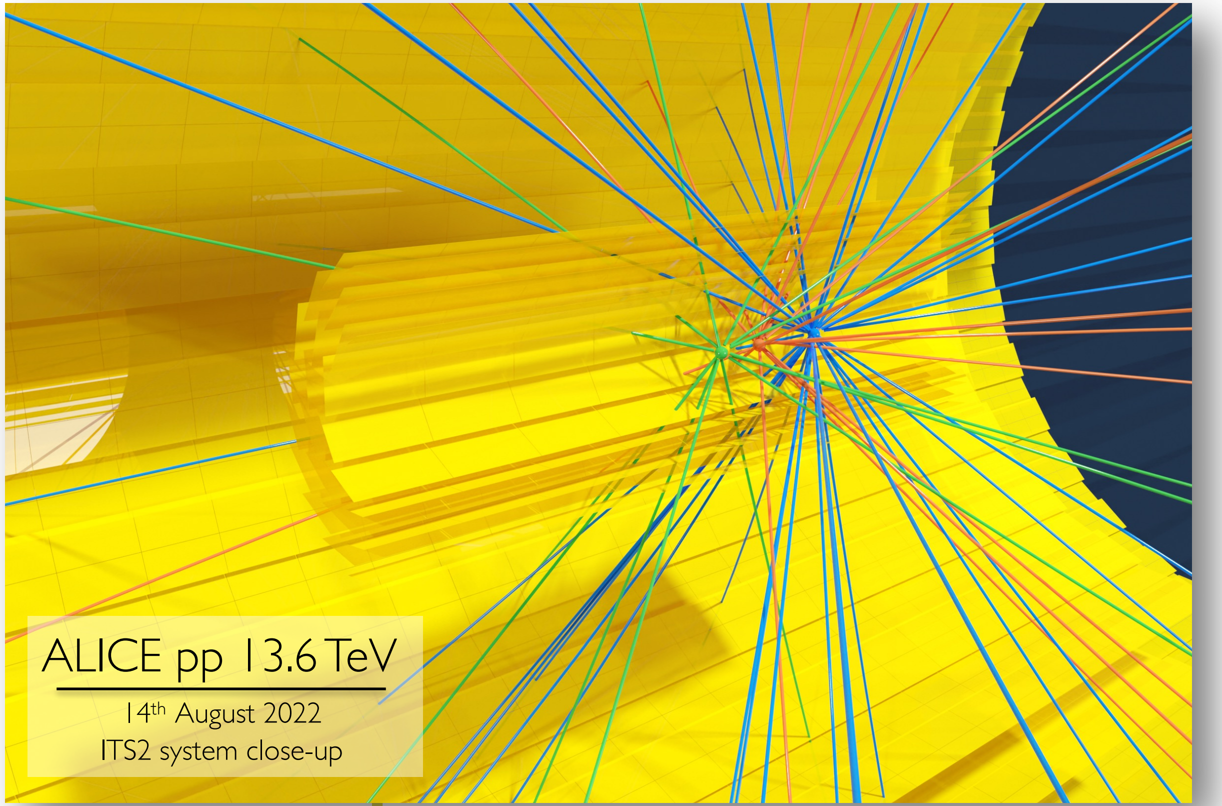


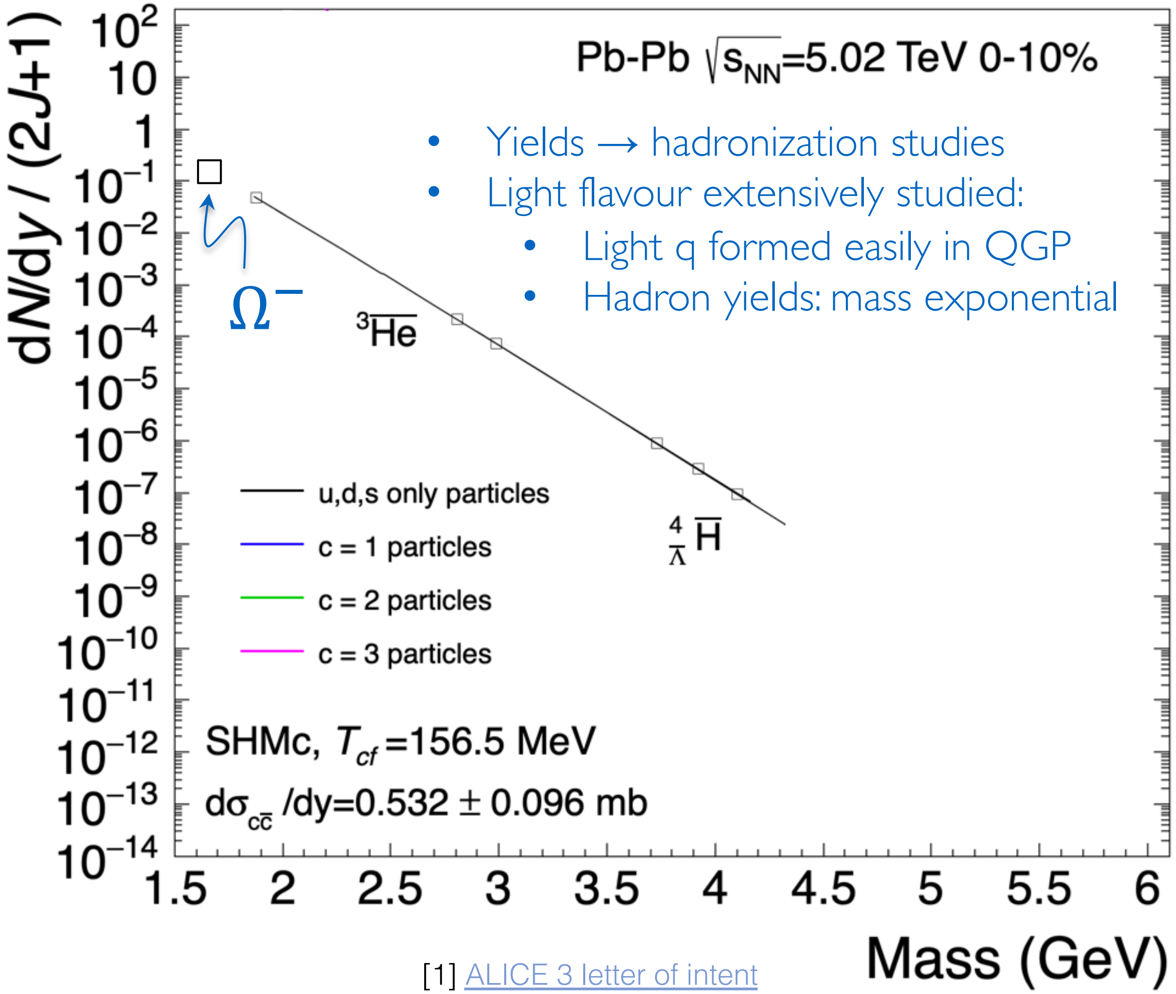


Yellow report (https://arxiv.org/abs/1812.06772)

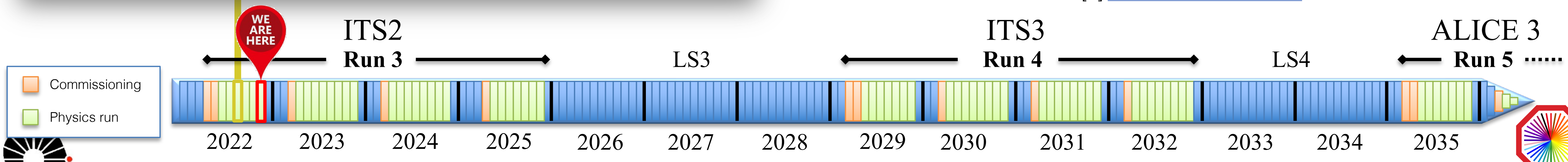
- Collectivity: a cornerstone of heavy-ion physics
- Heavy-flavour collectivity: unveil properties of the medium via stable probes
- Direct access to beauty hadrons in Run 3+4

A charming future ahead at the LHC





[1] ALICE 3 letter of intent
[2] JHEP **07** (2021) 035
[3] Andronic et al, QM2022



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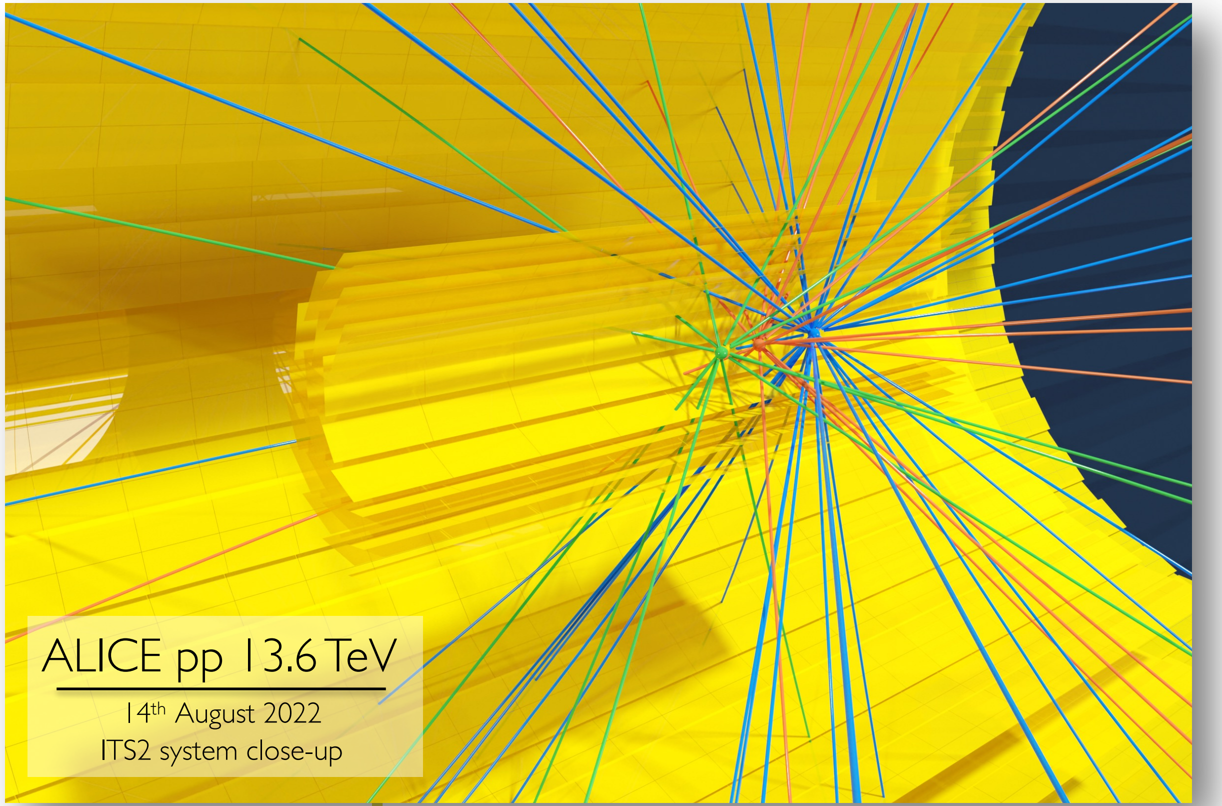

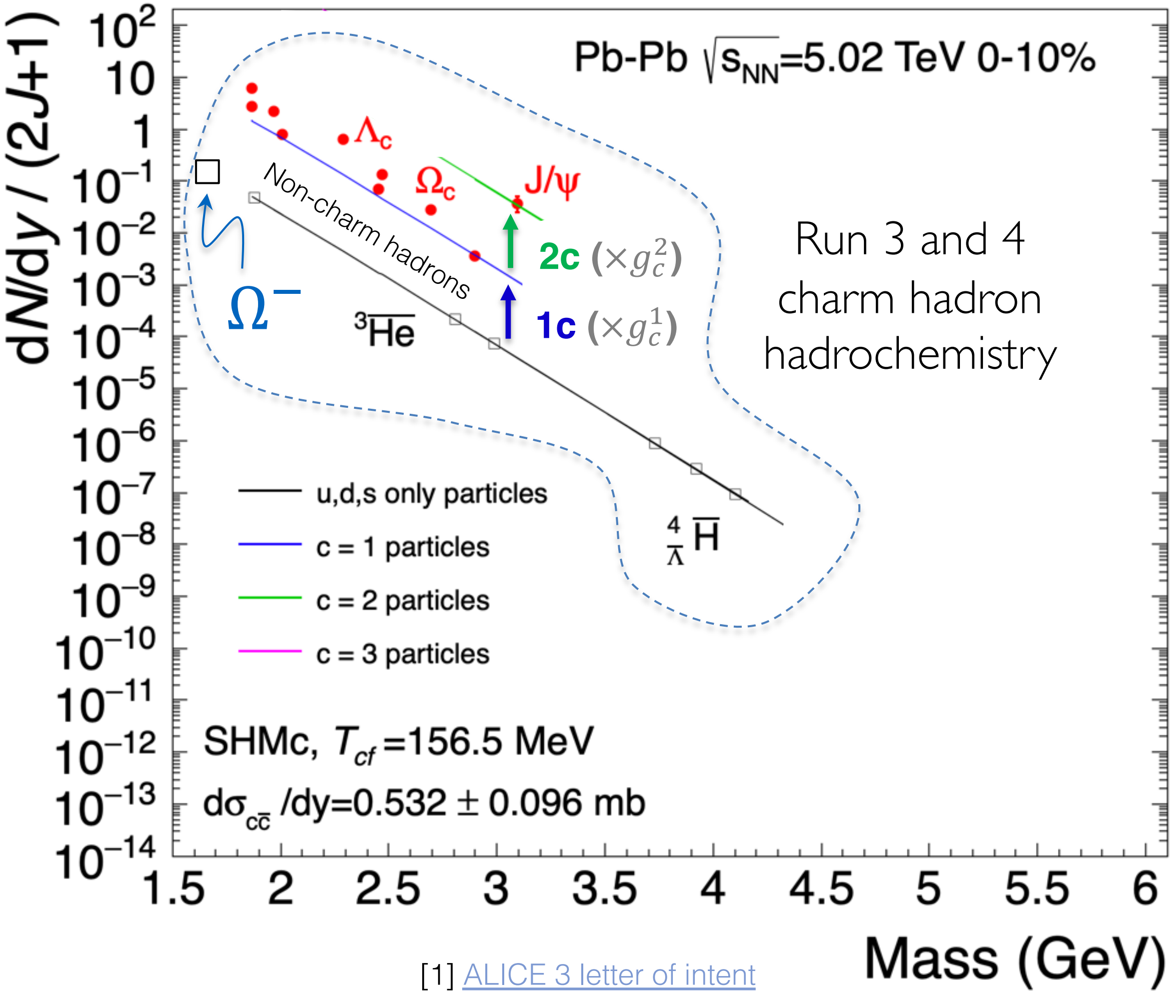

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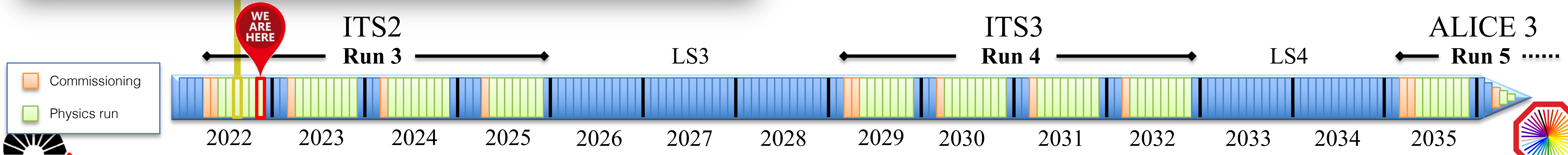

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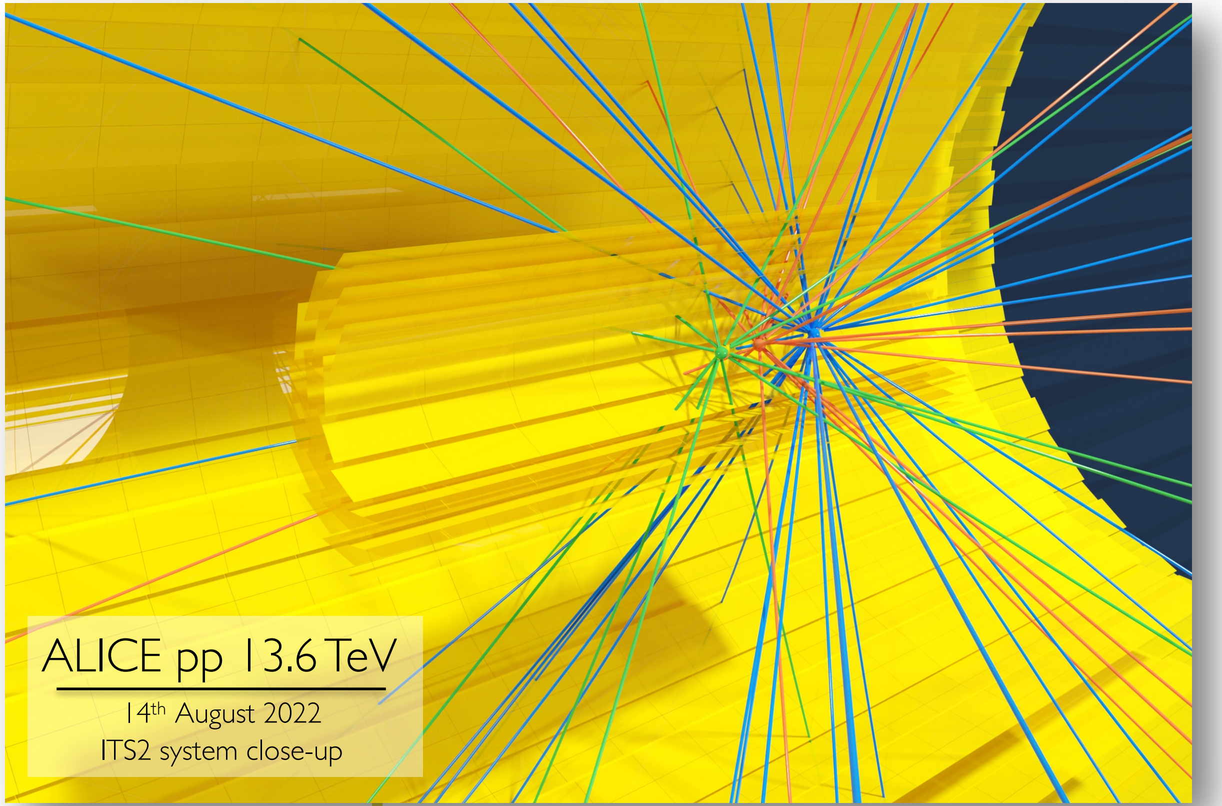

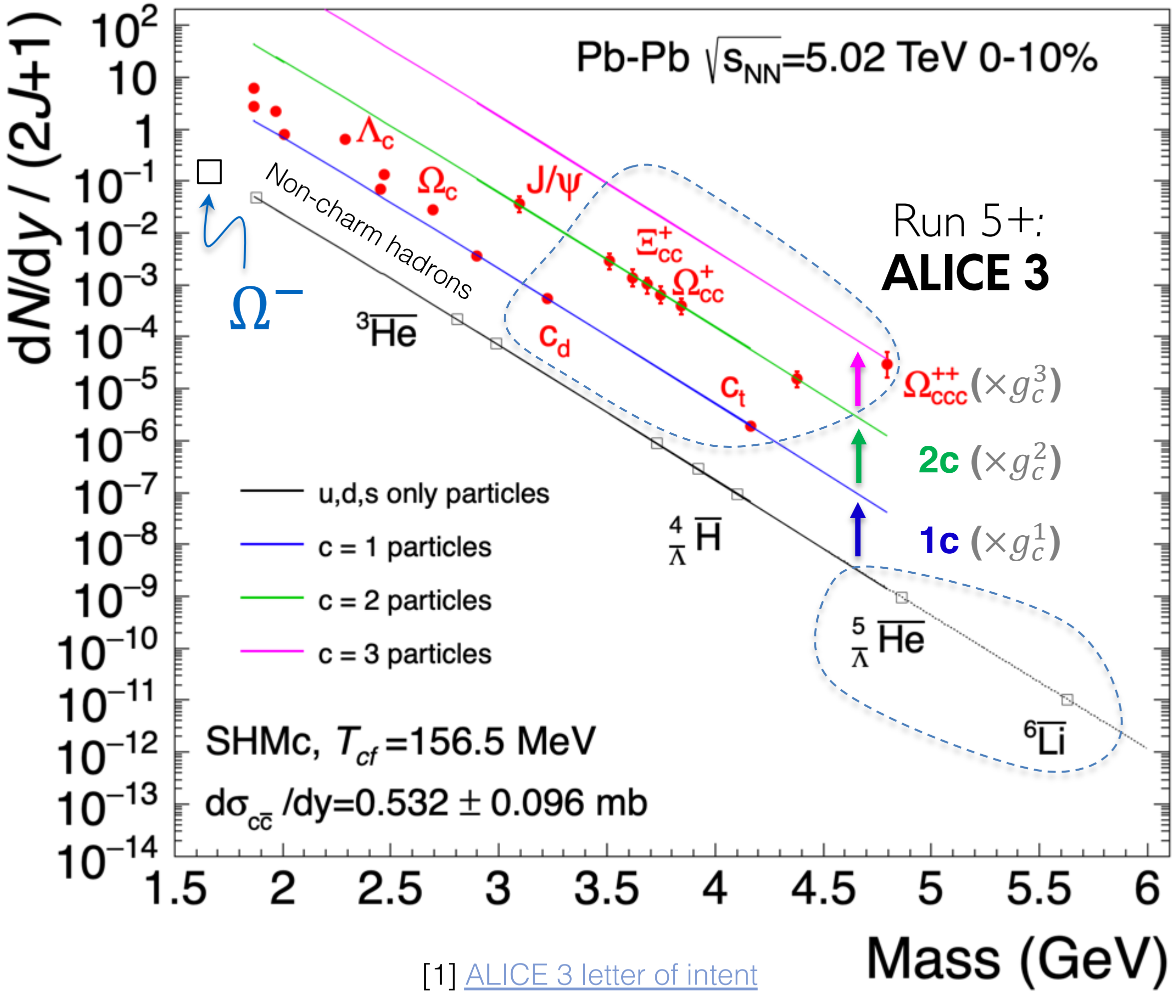

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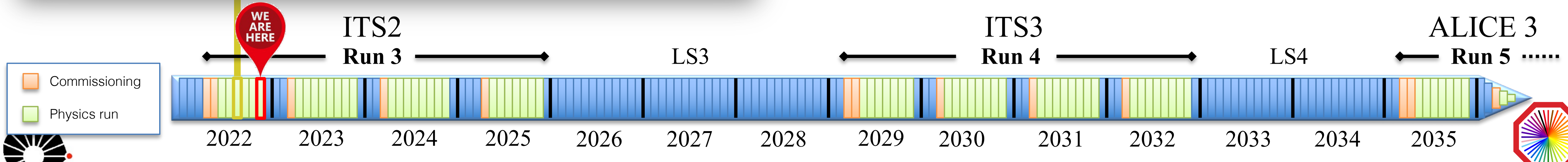
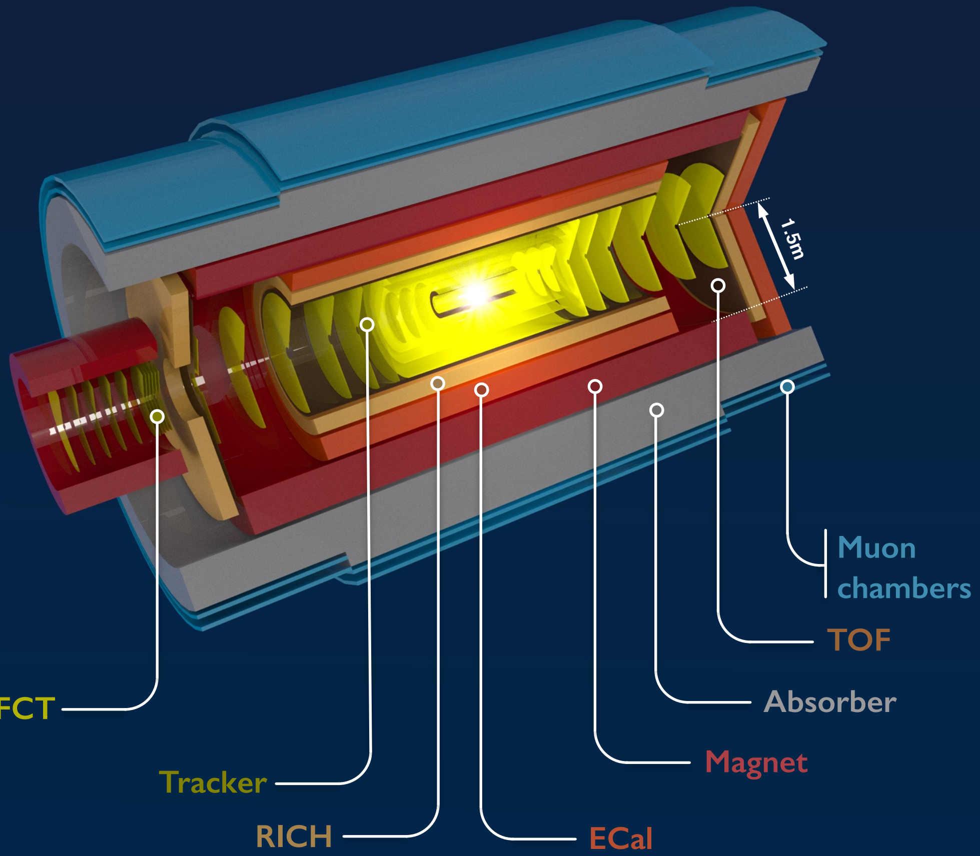


ALICE 3: a next-generation experiment for the 2030s



- All-silicon, large-acceptance tracker
  - High rate: 5x bigger luminosity, exploit LHC
  - Momentum precision of $\sigma_p/p \sim 1\%$
  - $\sim 10\%\ X_0$ overall material budget
- State-of-the-art particle identification
  - Silicon-based TOF and RICH
  - Muon identification
- Very high vertexing precision
  - First layer at 5 mm from interaction point
  - Impact parameter resolution:
    - ~10 µm at p_T ~200 MeV/c
    - ~3 µm at p_T > 1 GeV/c

https://arxiv.org/abs/2211.02491

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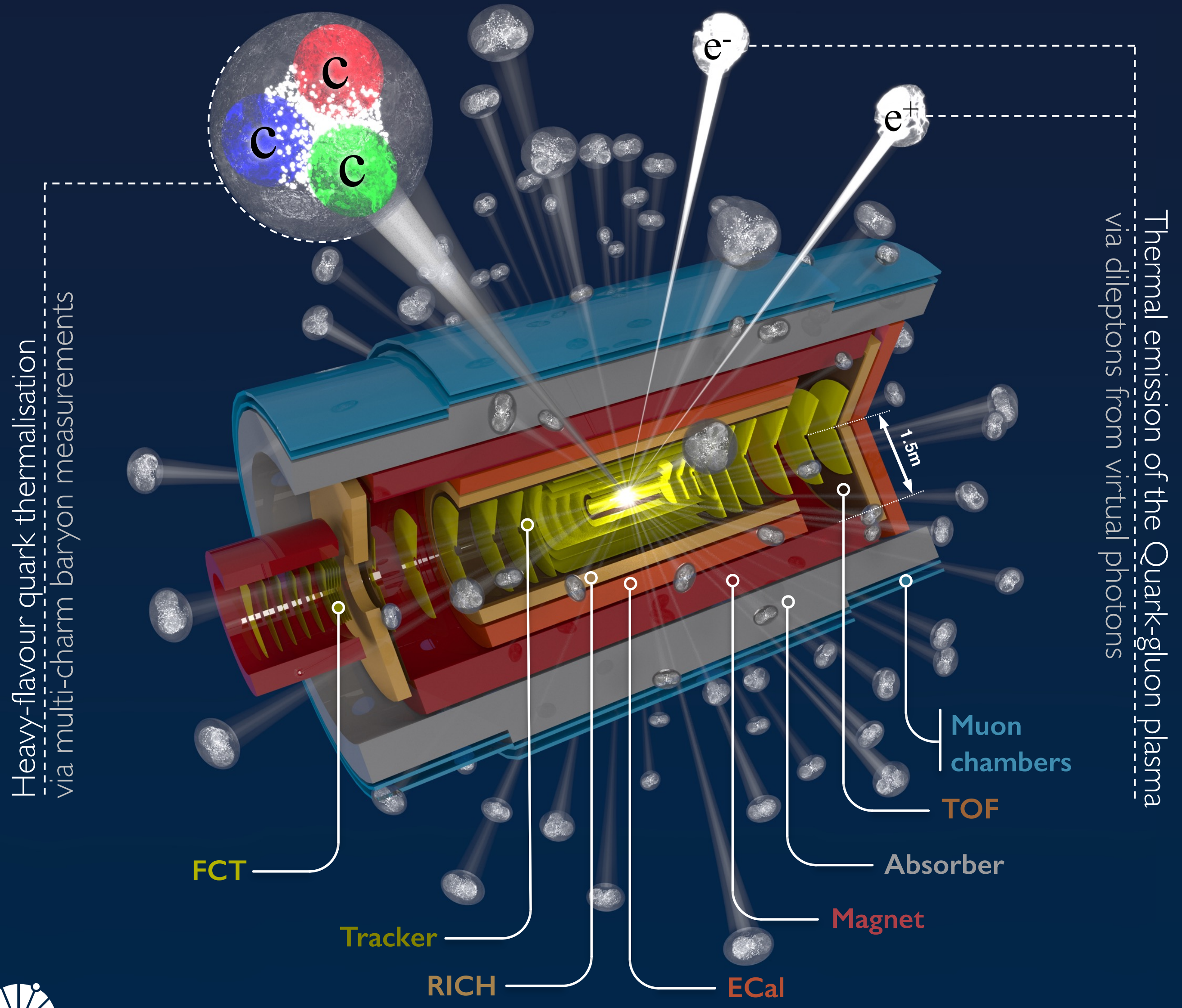

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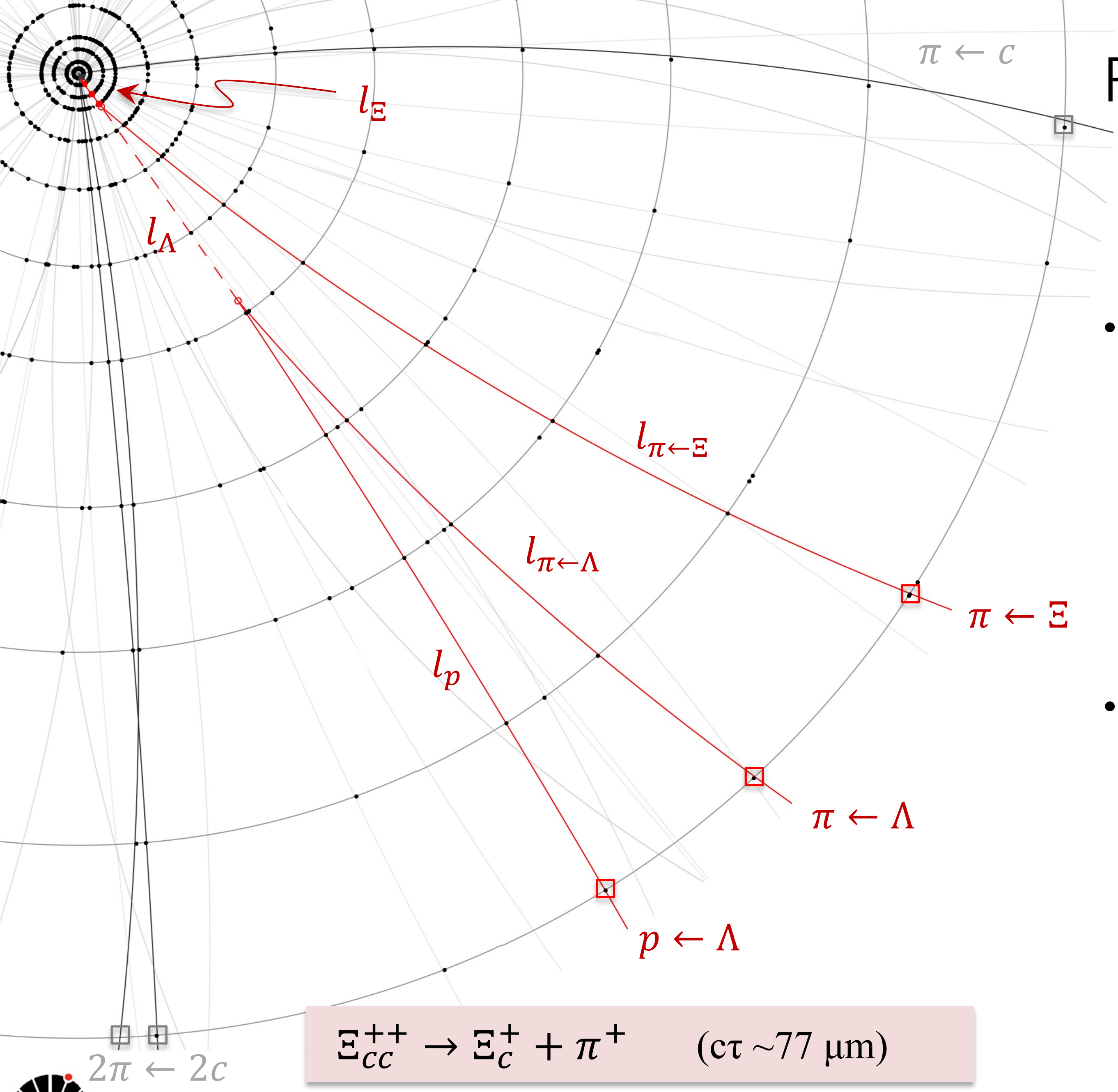
The heavy flavour angle: new frontier beyond simple thermalization

Required: **new detector, new techniques**

https://arxiv.org/abs/2211.02491

Reconstructing strange baryons in ALICE 3: Ξ^- and Ω^-



- TOF identification for Ξ decay products
  - Expected time of arrival should be calculated candidate-by-candidate
  - $t = l/v$ calculated for each of the Ξ products
  - Primary pions and protons arrive earlier than those from Ξ: heavy particles travel slower
- Don't just select π and p…
  - ….select π and p which arrived late!

$\Xi_{cc}^{++} \rightarrow \Xi_c^{+} + \pi^{+}$ (cτ ~77 μm)

$\Xi_c^{+} \rightarrow \Xi^{-} + 2\pi^{+}$

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ALICE

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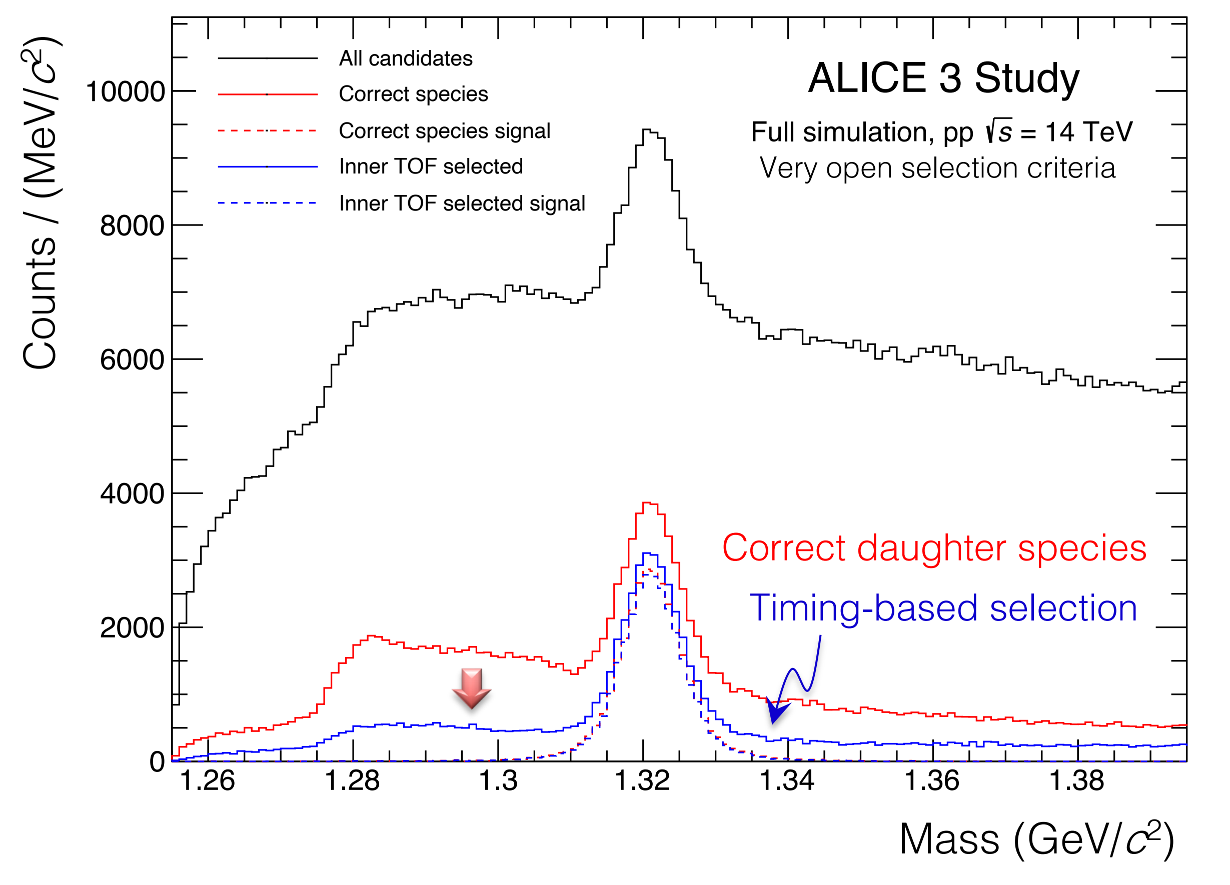

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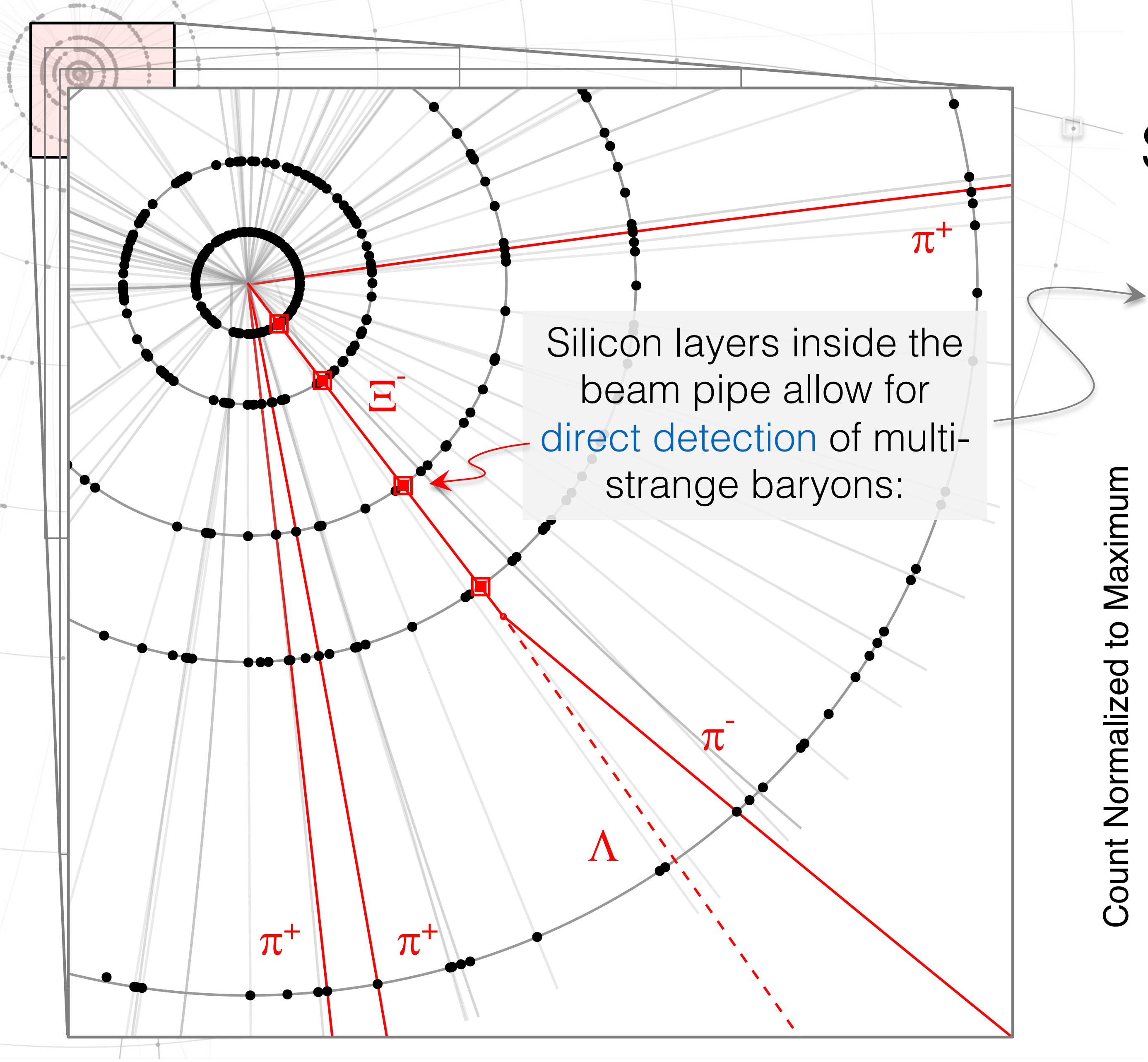
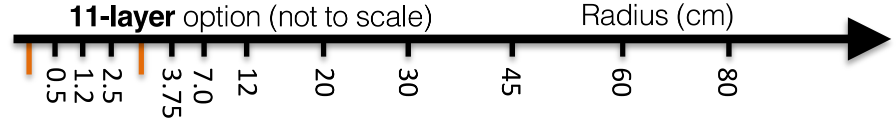
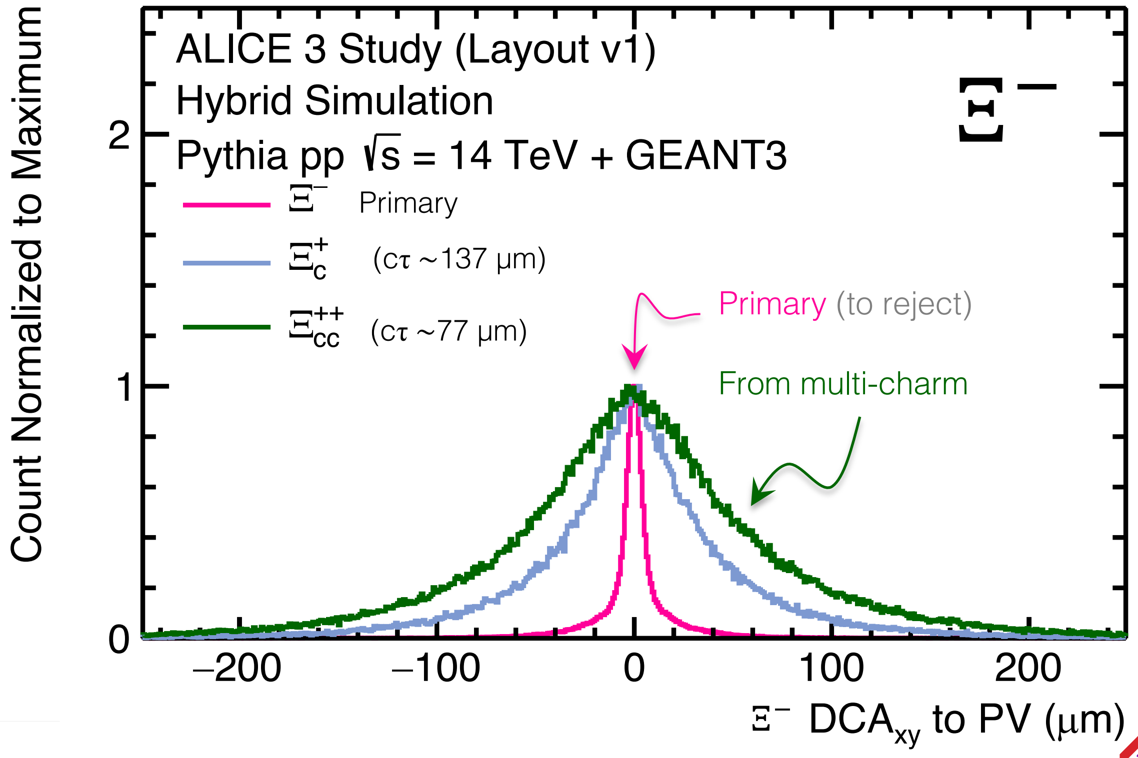
- Don't just select π and p…
  - ….select π and p which arrived late!
- Selects secondary decay daughters
  - outperforms particle identification only
- Showcases ALICE 3 tracking and TOF precision

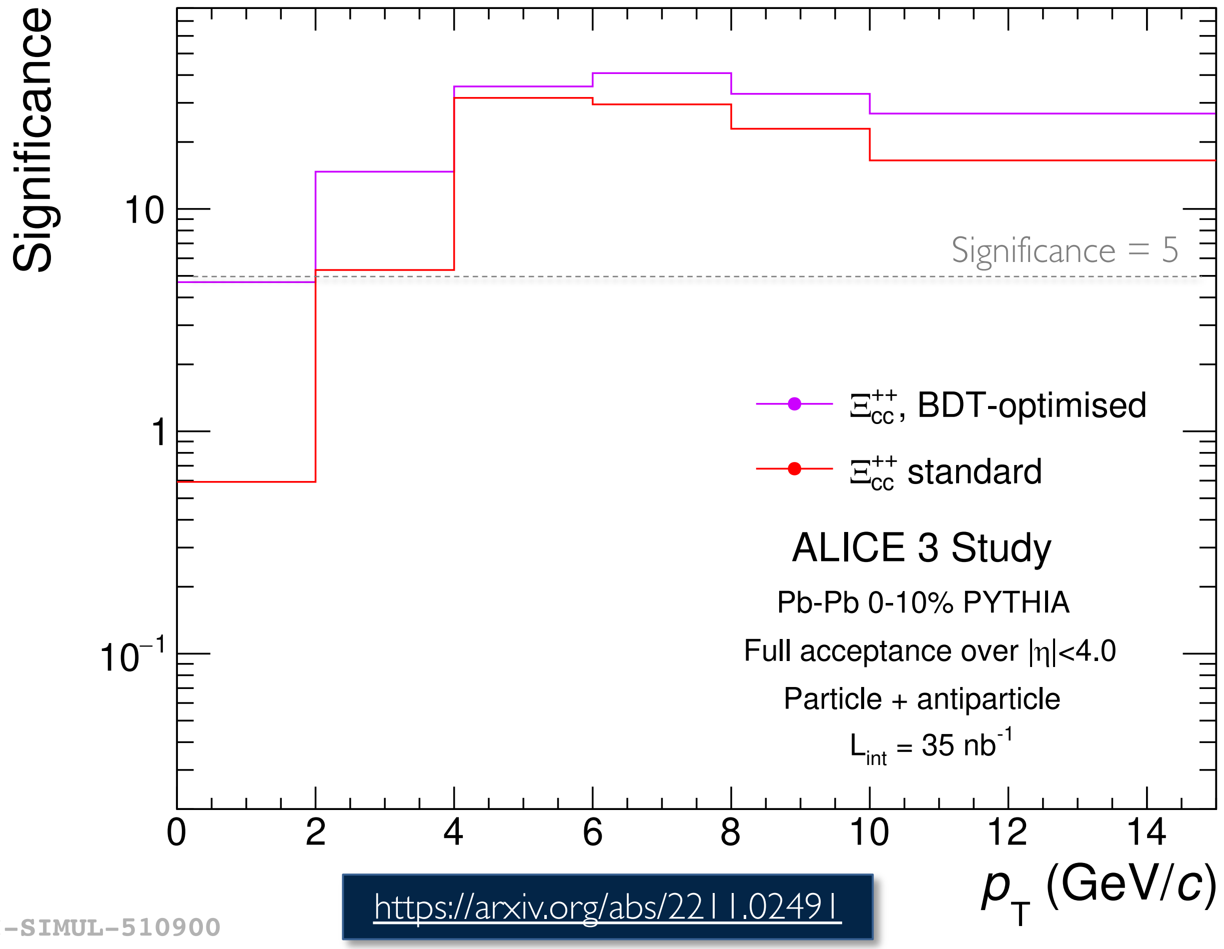
Strangeness tracking in ALICE 3







Ξ_{cc}^{++}: A taste of analysis



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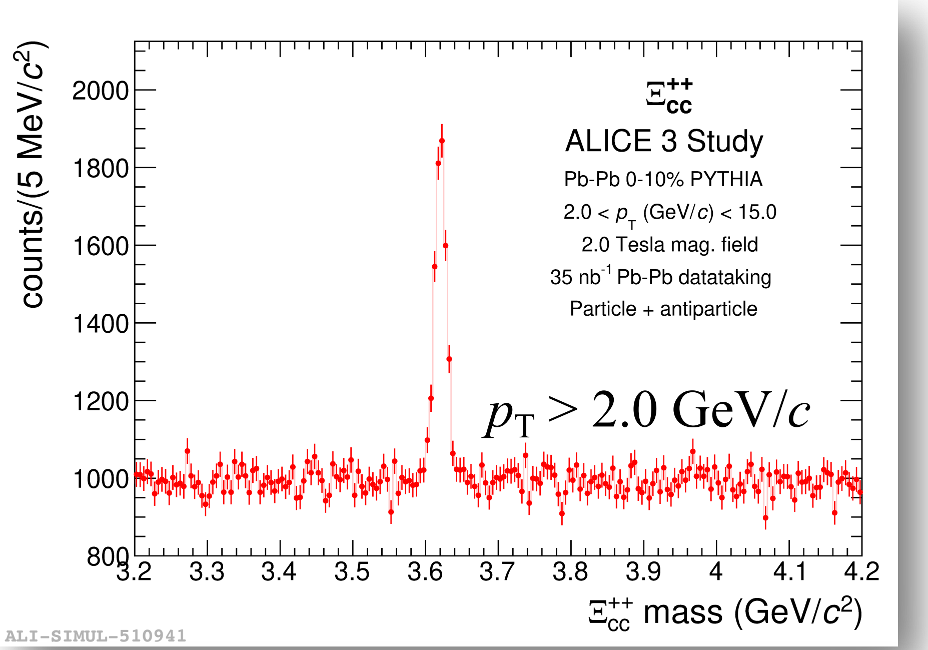
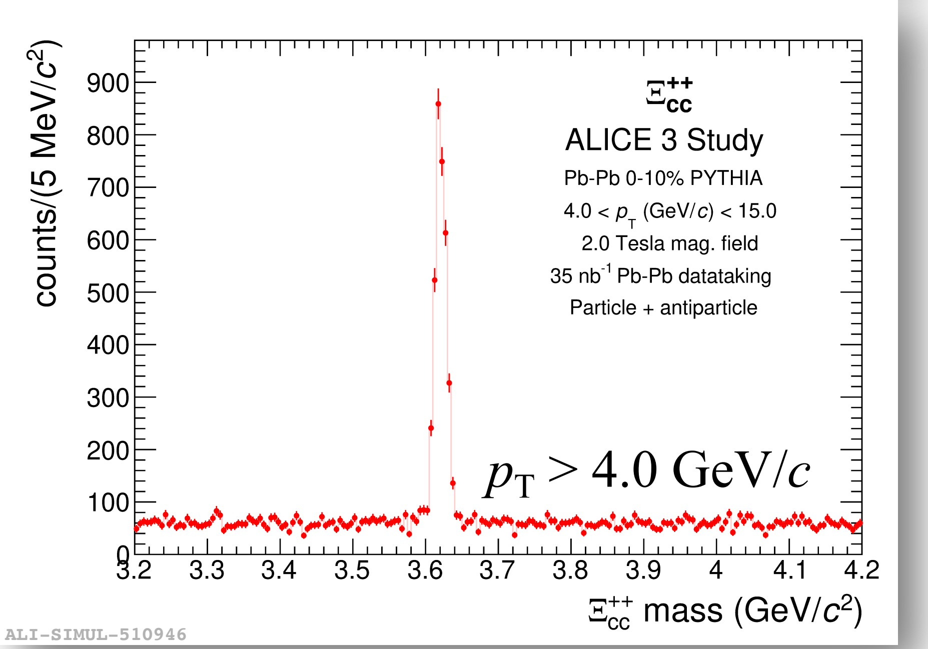




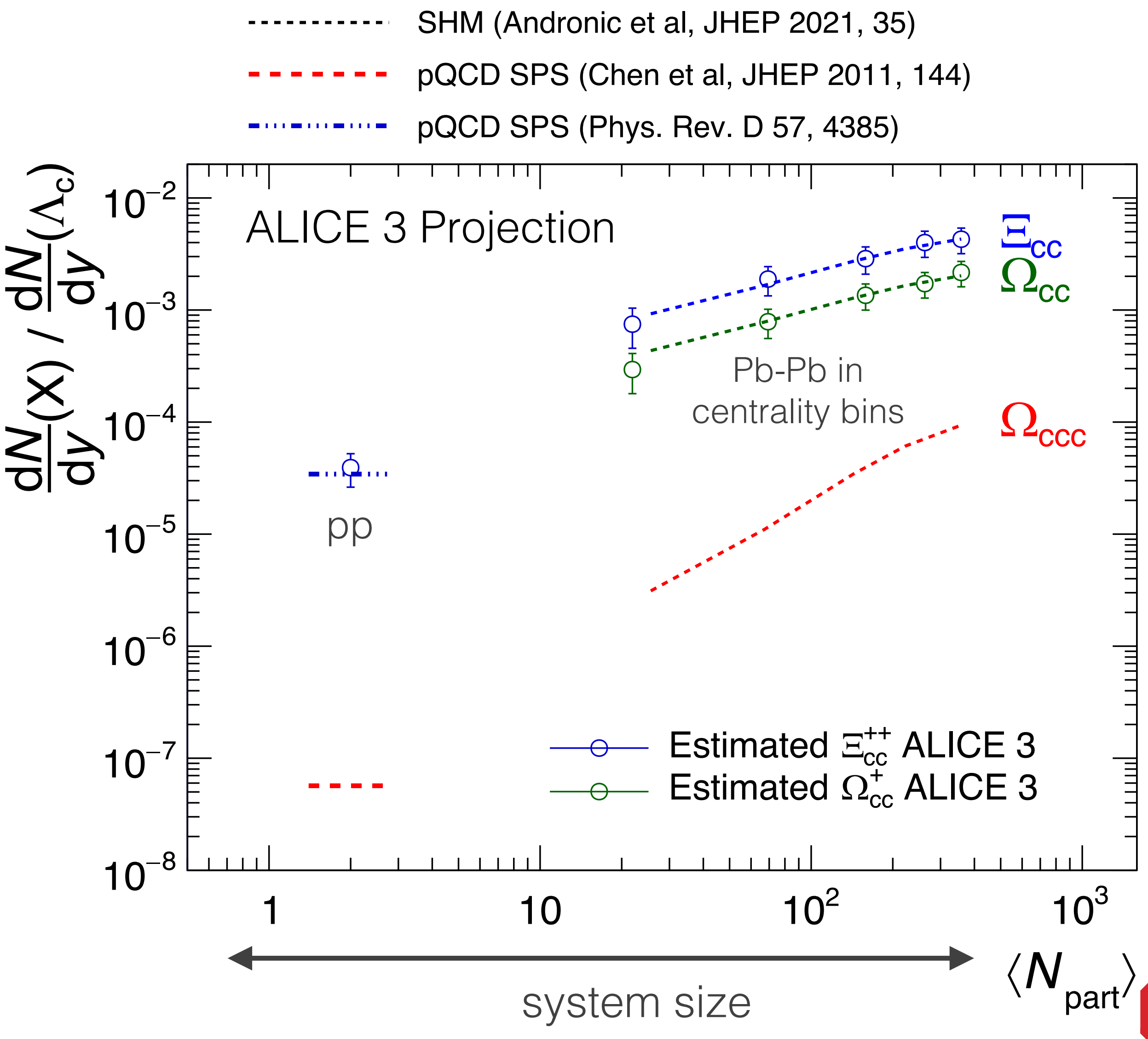
Expected Ξ_{cc}^{++} invariant mass distributions with 35 nb^{-1} of Pb-Pb data collected with ALICE 3

The future: ALICE 3 multi-charm results

- Precise multi-charm baryon measurements spanning system size: centrality selection, different collision systems: Kr-Kr, Ar-Ar, …
- Enormous dynamical effect due to charm quarks from different partonic scatterings combining!

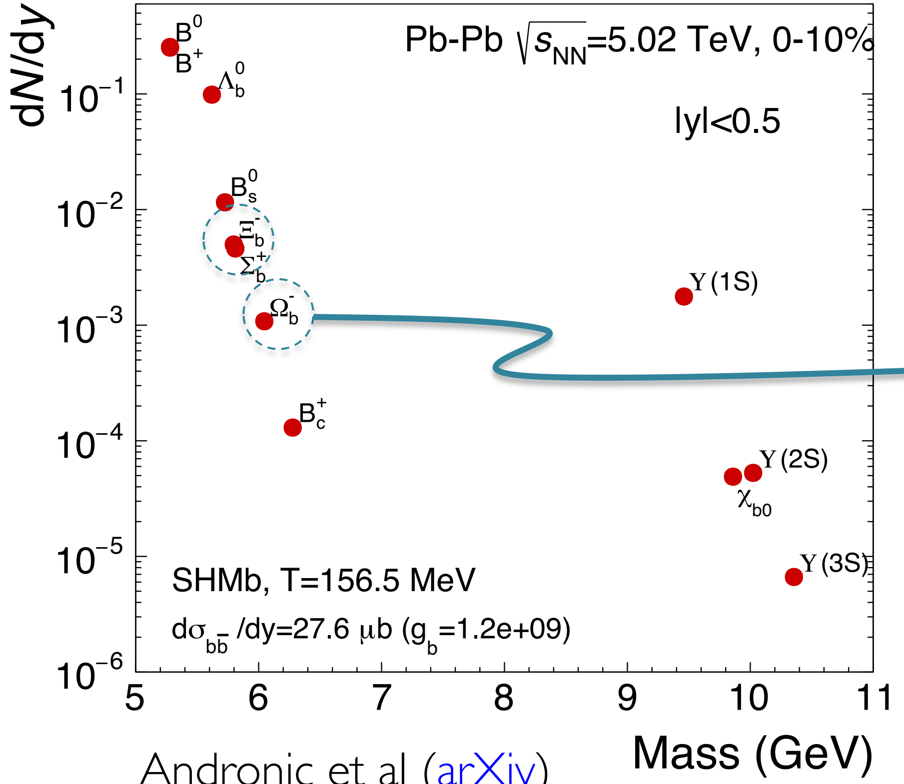
SHMc = Factor 100x for 2c, 1000x for 3c × SPS

- SHMc: thermal model values with charm, central Pb-Pb
- SPS: single partonic scattering limit
- Very high sensitivity: measurement feasible even in low (e.g. SPS in pp) yield scenarios
- The ultimate challenge: Ω_{ccc}^{++}
  - Even larger model dependence, being studied



Beauty thermalisation: beauty baryon yields

Prediction from SHMb



Andronic et al (arXiv)

Motivation for going to beauty:

- Determine the degree of beauty thermalization in nucleus-nucleus collisions
- Determine beauty quark diffusion coefficient

Extremely good channels for strangeness tracking:

$$\Xi_b^- \rightarrow \Xi_c^0 + \pi^- \rightarrow \Xi^- + \pi^+ + \pi^-$$
$$\Omega_b^- \rightarrow \Omega_c^0 + \pi^- \rightarrow \Omega^- + \pi^+ + \pi^-$$

- Masses known from LHCb (5.797 GeV/c^2, 6.046 GeV/c^2)
- Branching ratios unknown, guess 5% (up for discussion)
    - $\Xi_c^0 \rightarrow \Xi^- + \pi^+$ known to be 1.43% (smaller than Ξ_c^-)

- Competition from LHCb will exist for sure
    - Uniqueness: **low p_T, mid-rapidity, high-multiplicity**
    - Comparison to be further explored

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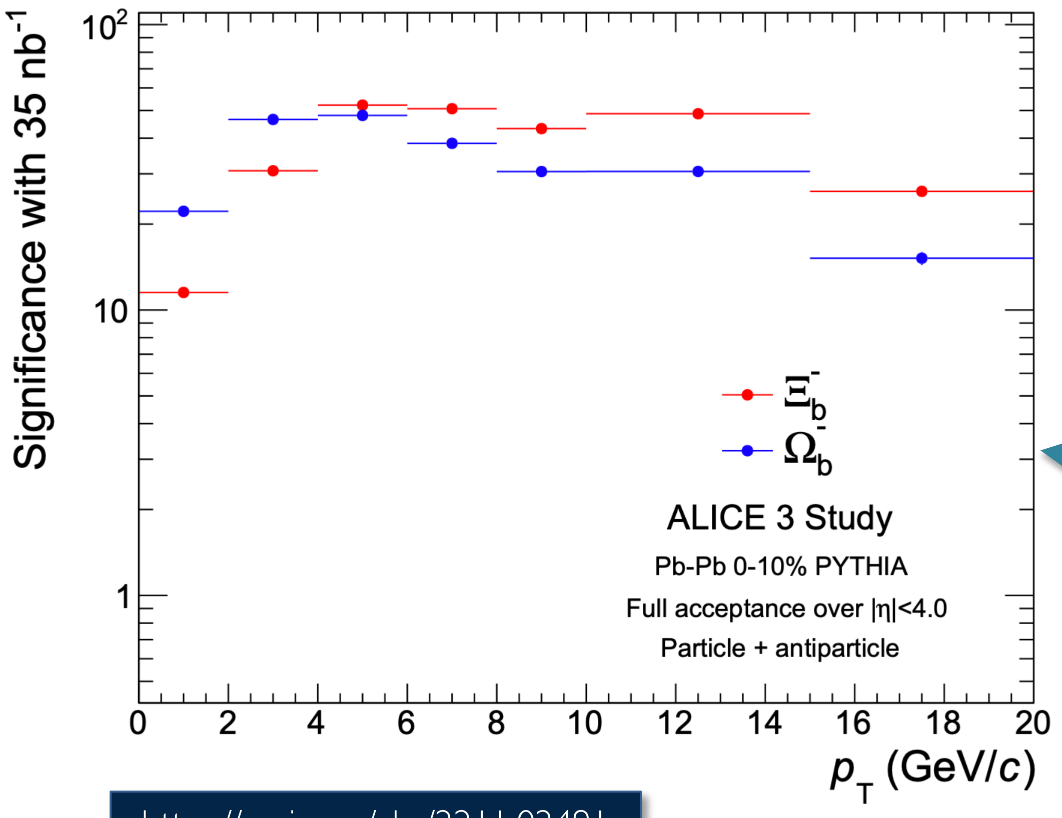

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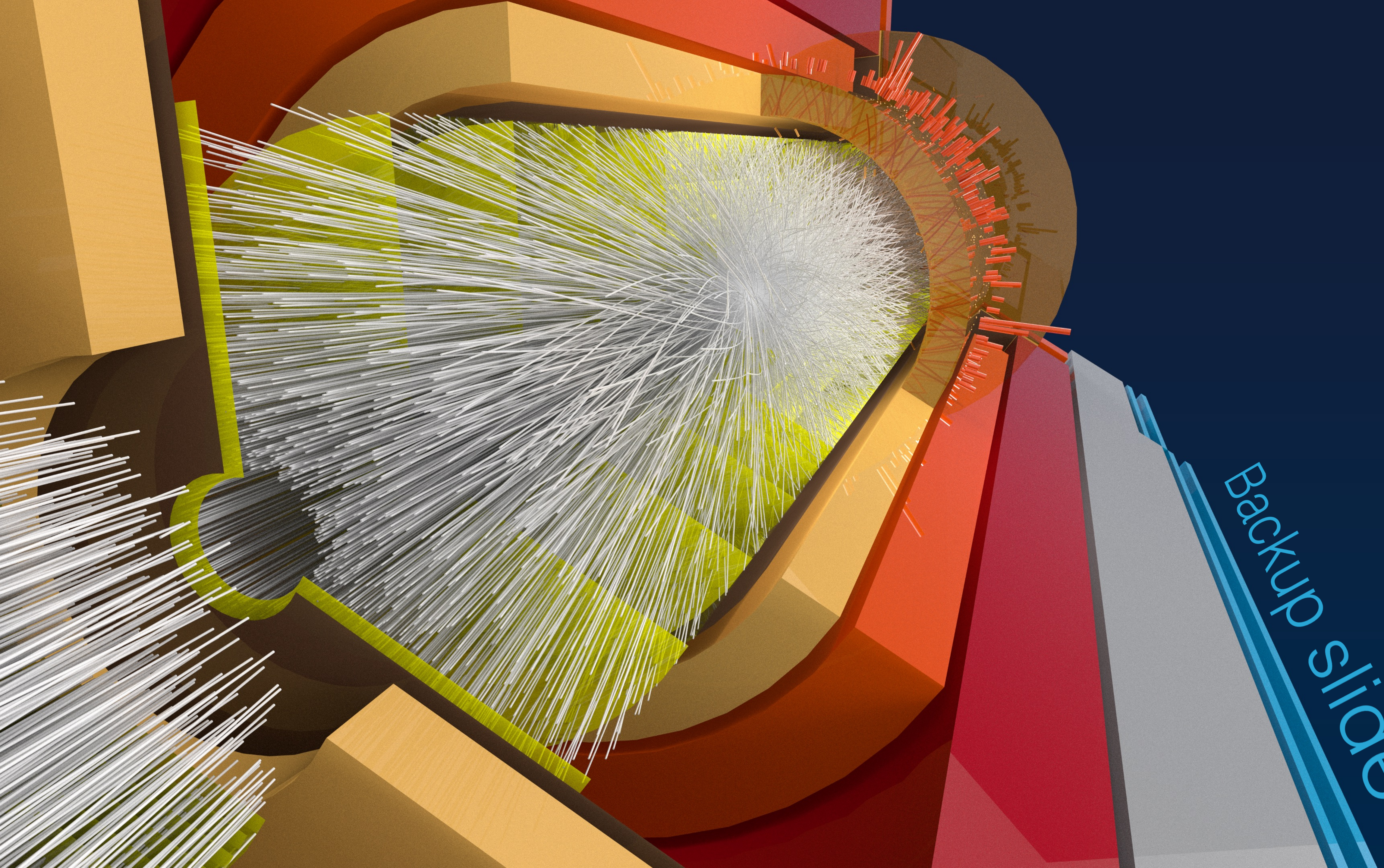
Conclusion and outlook

- **Run 3, 4 and 5** will present unique opportunities
- **Heavy flavour presents a new frontier** to be explored
- **New frontier** handled with **new hardware** and **new techniques:**

Upgraded TPC, ITS2, ITS3 and ALICE 3

- Exciting times ahead!

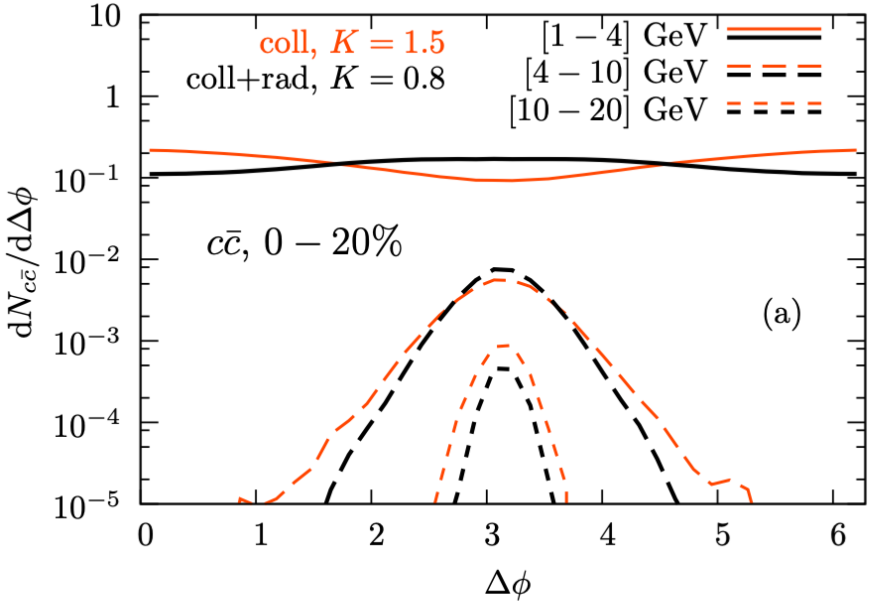
Thank you!



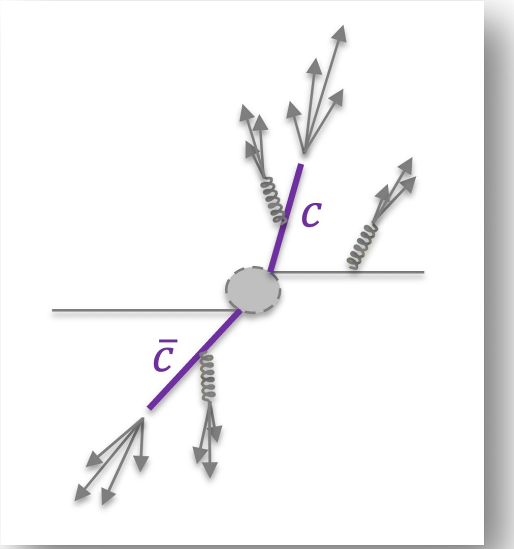
Backup slides

Further charm studies with ALICE 3

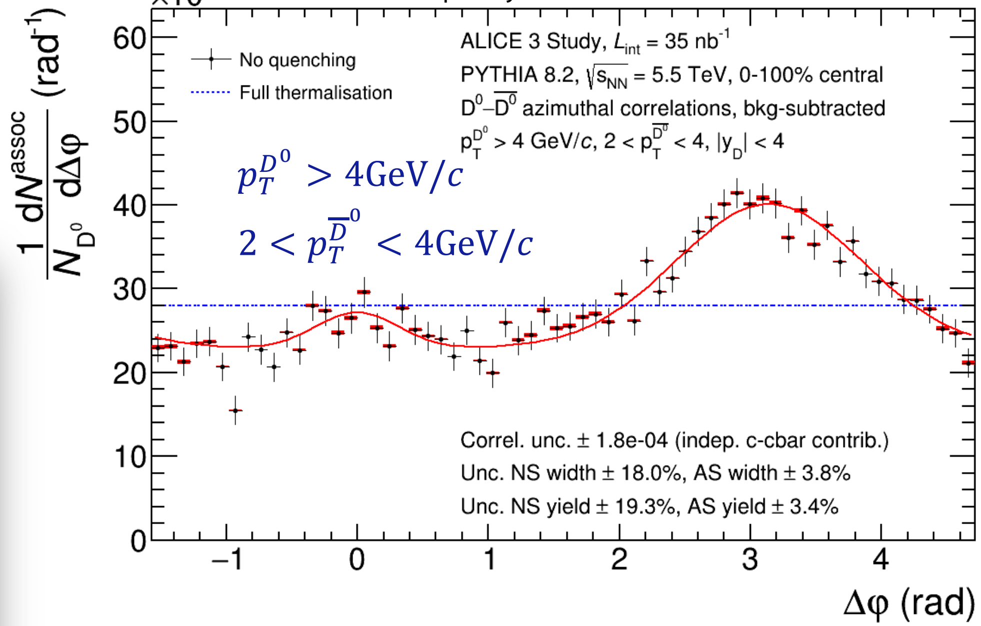
Charm azimuthal correlations



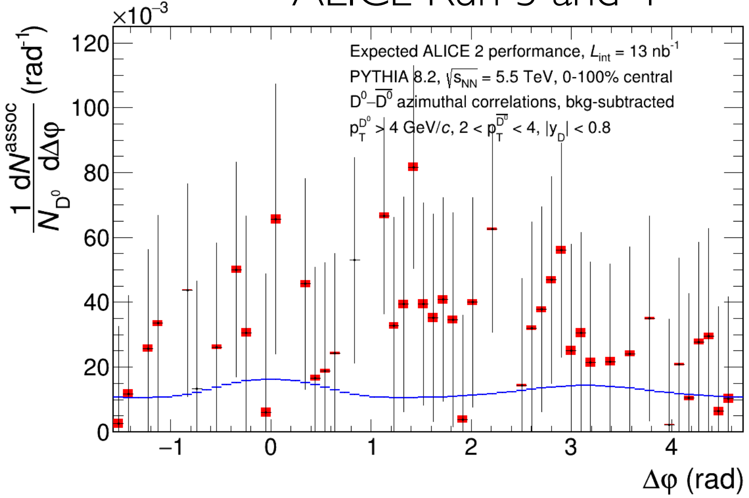
M Nahrgang et al, PRC 90, 024907



ALICE 3 projection: $\mathrm{D}\overline{\mathrm{D}}$ correlations



ALICE Run 3 and 4



- Angular decorrelation directly probes QGP scattering
- Signal strongest at low p_T
- Very challenging measurement:
  need good purity, efficiency and η coverage
  → heavy-ion measurement only possible with ALICE 3

The ITS3

- Unprecedentedly low material budget and precision
- Thin bent sheets of silicon and "nothing more"