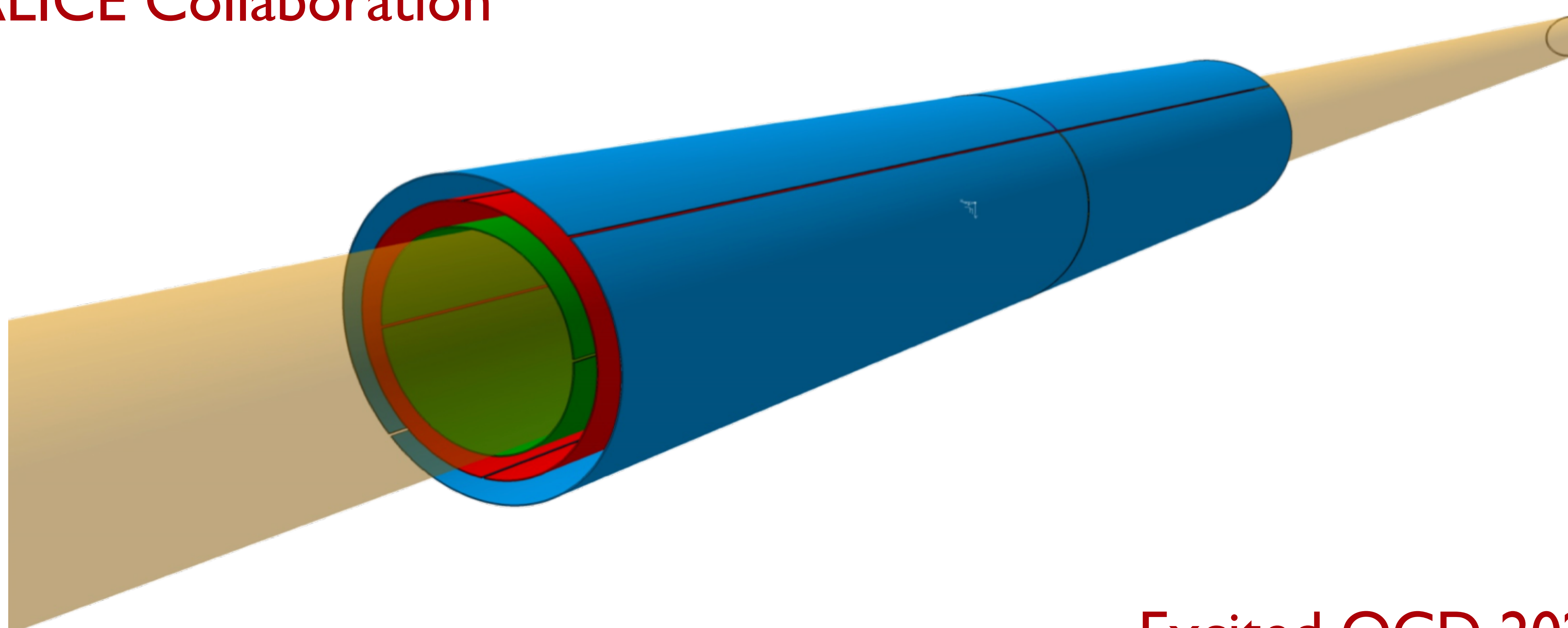
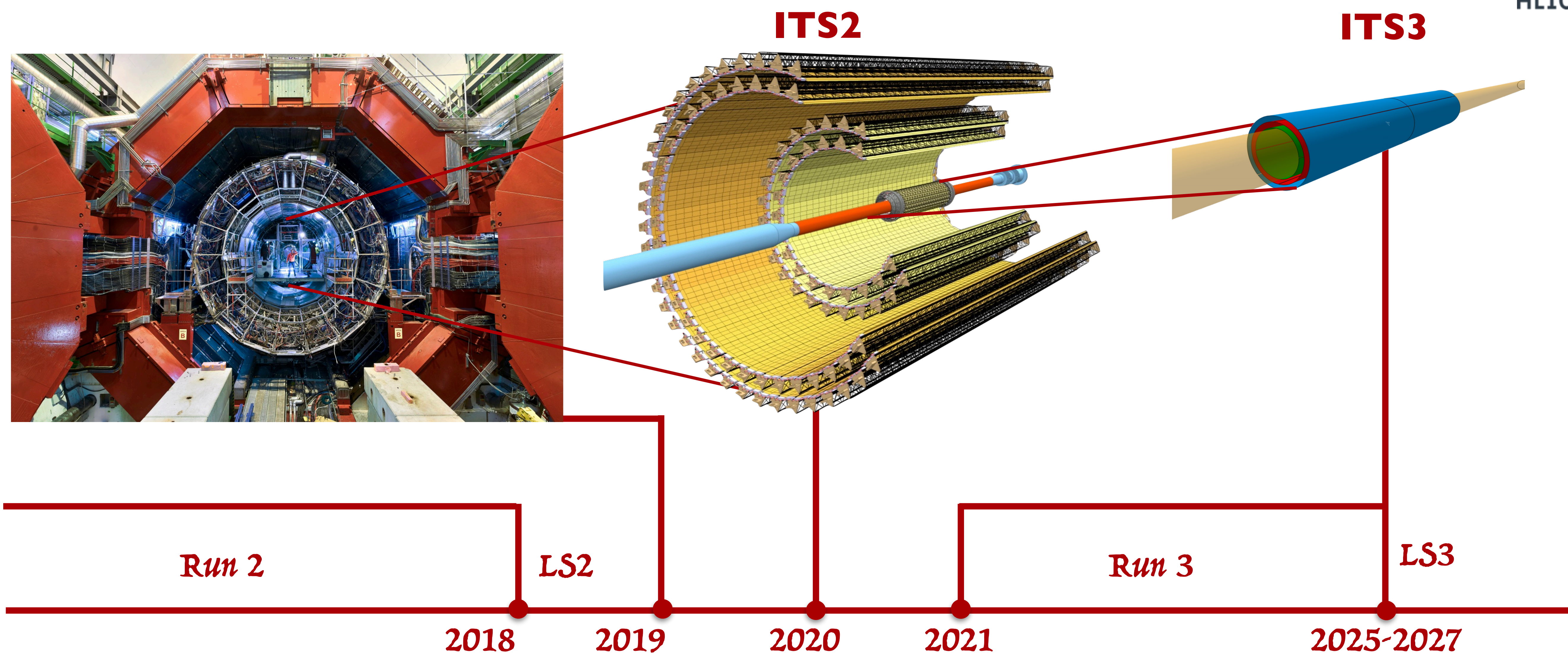
Heavy Flavour measurements in Pb–Pb collisions with the upgraded ALICE Inner Tracking System

Dimitra Andreou
for the ALICE Collaboration



Excited QCD 2020
2-8 February
Krynica Zdrój, Poland

Introduction



Physics motivation for Inner Tracking System 3 (ITS3)
High-density QCD future opportunities after LS2

Current status
Talk by L. van Doremalen

Physics motivation

- Physics motivation for Inner Tracking System 3 (ITS3)
- High-density QCD future opportunities after LS2

arXiv:1812.06772

- Characterisation of the macroscopic long wavelength Quark-Gluon Plasma (QGP) properties
  - Temperature

Thermal radiation at all collision stages
- Real γ
-Virtual γ (dileptons)

Physics motivation

- Physics motivation for Inner Tracking System 3 (ITS3)
- High-density QCD future opportunities after LS2

arXiv:1812.06772

- Characterisation of the macroscopic long wavelength Quark-Gluon Plasma (QGP) properties
  - Temperature
  - Transport coefficients

Heavy quark (c, b) diffusion coefficient Ds

Thermalization of heavy quarks in medium $\tau_q = \frac{m_q}{T} D_s$

Physics motivation

- Physics motivation for Inner Tracking System 3 (ITS3)
- High-density QCD future opportunities after LS2

arXiv:1812.06772

- Characterisation of the macroscopic long wavelength Quark-Gluon Plasma (QGP) properties
  - Temperature
  - Transport coefficients

Hadronization through recombination with QGP quarks

↓

Enhanced production of HF baryons (Λ_c , Λ_b)
HF strange mesons (D_s , B_s)

- Investigation of the microscopic parton dynamics underlying QGP properties
  - Heavy Flavour recombination

Physics motivation

- Physics motivation for Inner Tracking System 3 (ITS3) arXiv:1812.06772
- High-density QCD future opportunities after LS2

- Characterisation of the macroscopic long wavelength Quark-Gluon Plasma (QGP) properties
  - Temperature
  - Transport coefficients
- Investigation of the microscopic parton dynamics underlying QGP properties
  - Heavy Flavour recombination

- Development of a unified picture of particle production and QCD dynamics from small to large systems
- Exploration of parton densities in nuclei in a broad kinematic range and search for saturation

Physics motivation

- Physics motivation for Inner Tracking System 3 (ITS3)
- High-density QCD future opportunities after LS2

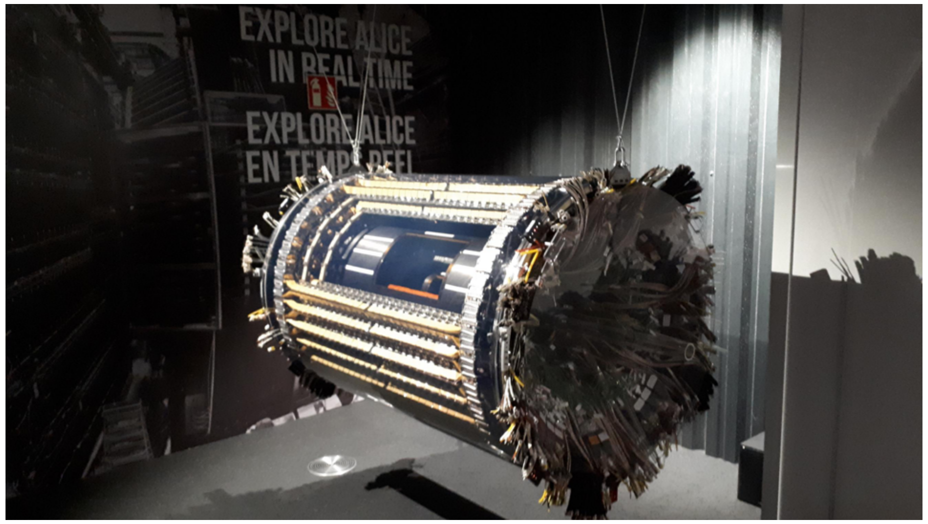
arXiv:1812.06772

- Characterisation of the macroscopic long wavelength Quark-Gluon Plasma (QGP) properties
  - Temperature
  - Transport coefficients
- Investigation of the microscopic parton dynamics underlying QGP properties
  - Heavy Flavour recombination
- Development of a unified picture of particle production and QCD dynamics from small to large systems
- Exploration of parton densities in nuclei in a broad kinematic range and search for saturation

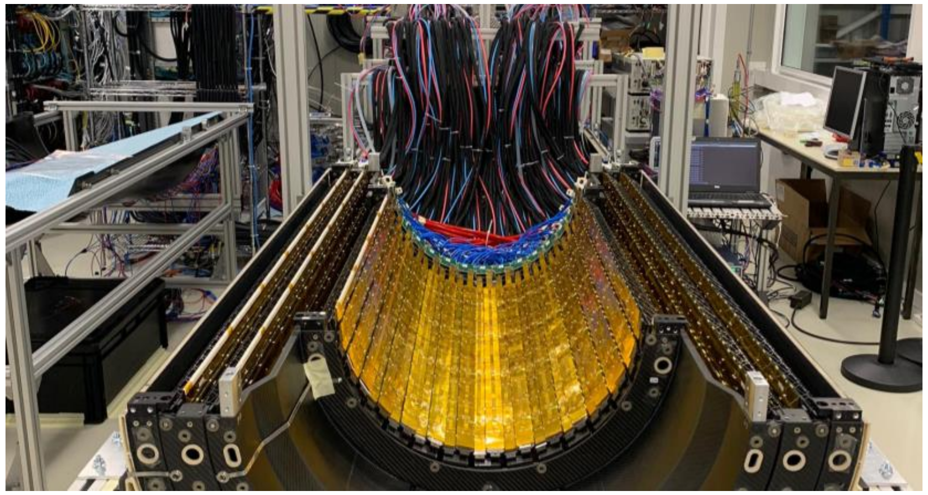
Heavy Flavour measurements

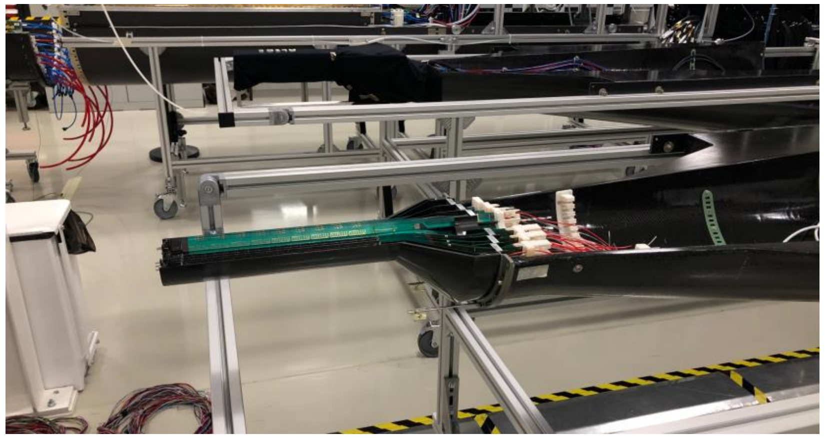
ITS3 Upgrade concept

ITS1



ITS2



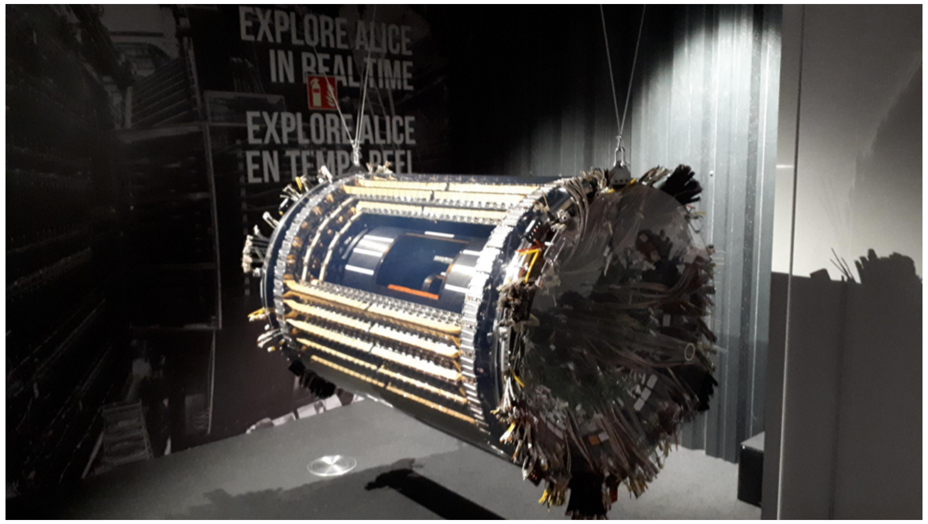


Higher Tracking Resolution & Efficiency

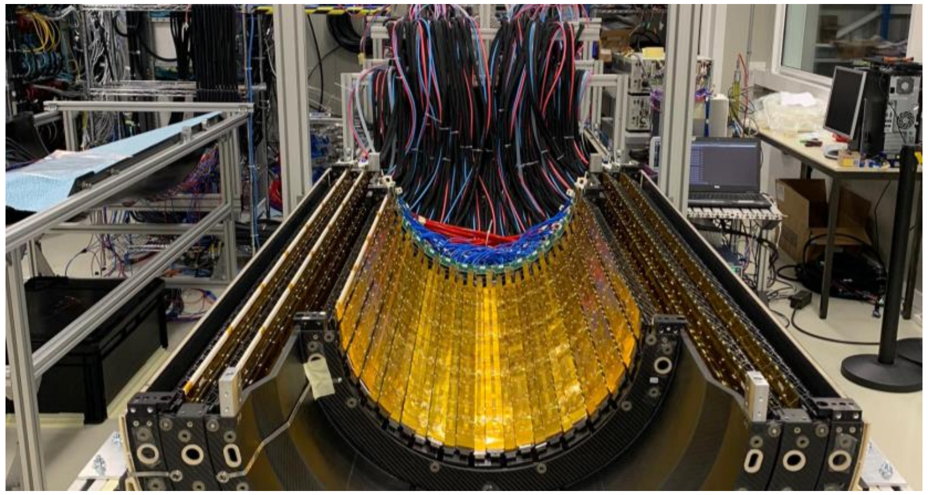
ITS1	ITS2
• 6 Layers SPD, SDD, SSD	• 7 Layers of MAPS
• Material Budget X/X_0 1.14% (inner layers)	• Material Budget X/X_0 0.35% (inner layers)
• Readout rate 1kHz (Pb-Pb)	• Readout rate 100kHz (Pb-Pb)
• Pixel size (SPD) 50 x 425 μm^2	• Pixel size 27 x 29 μm^2
• Inner Radius 33mm	• Inner Radius 22mm

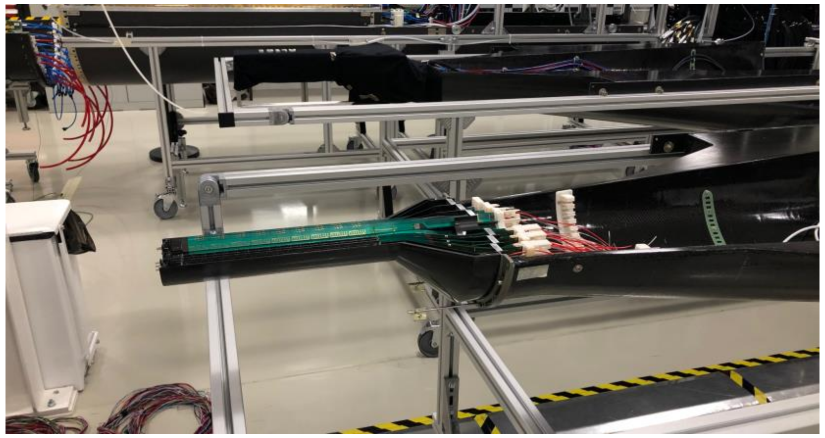
ITS3 Upgrade concept

ITS1

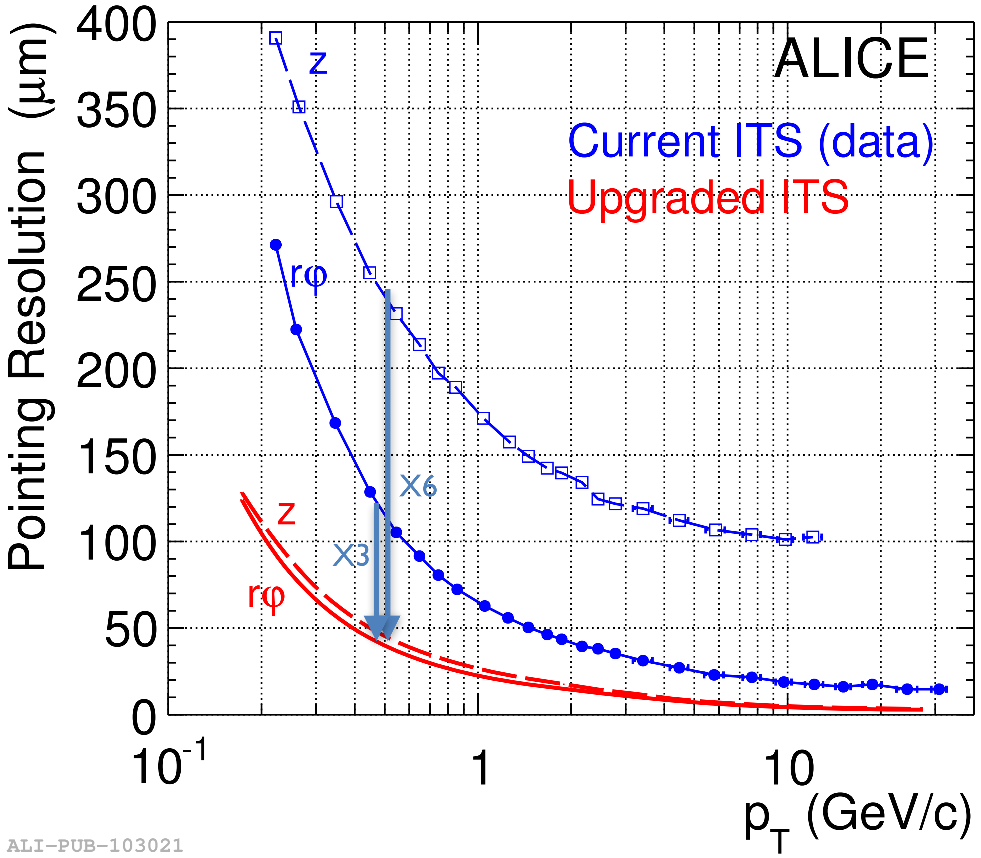


ITS2

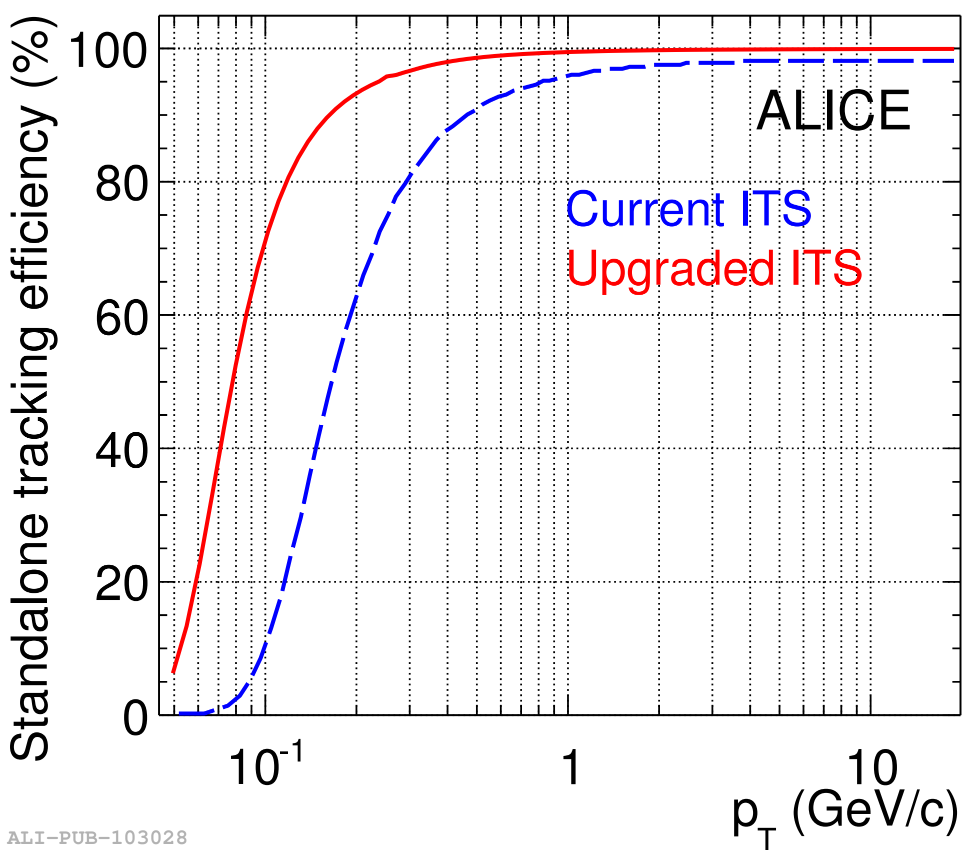




Impact Parameter Resolution



Tracking Efficiency



ITS3 Upgrade concept

ITS2 → ITS3

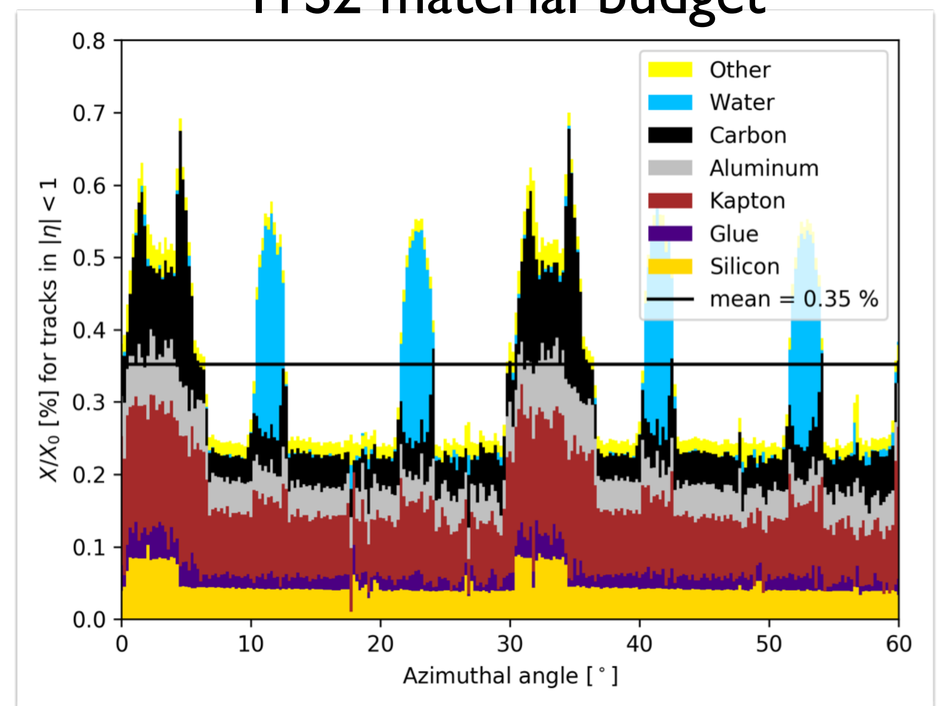
Can we get lighter? Can we get closer?

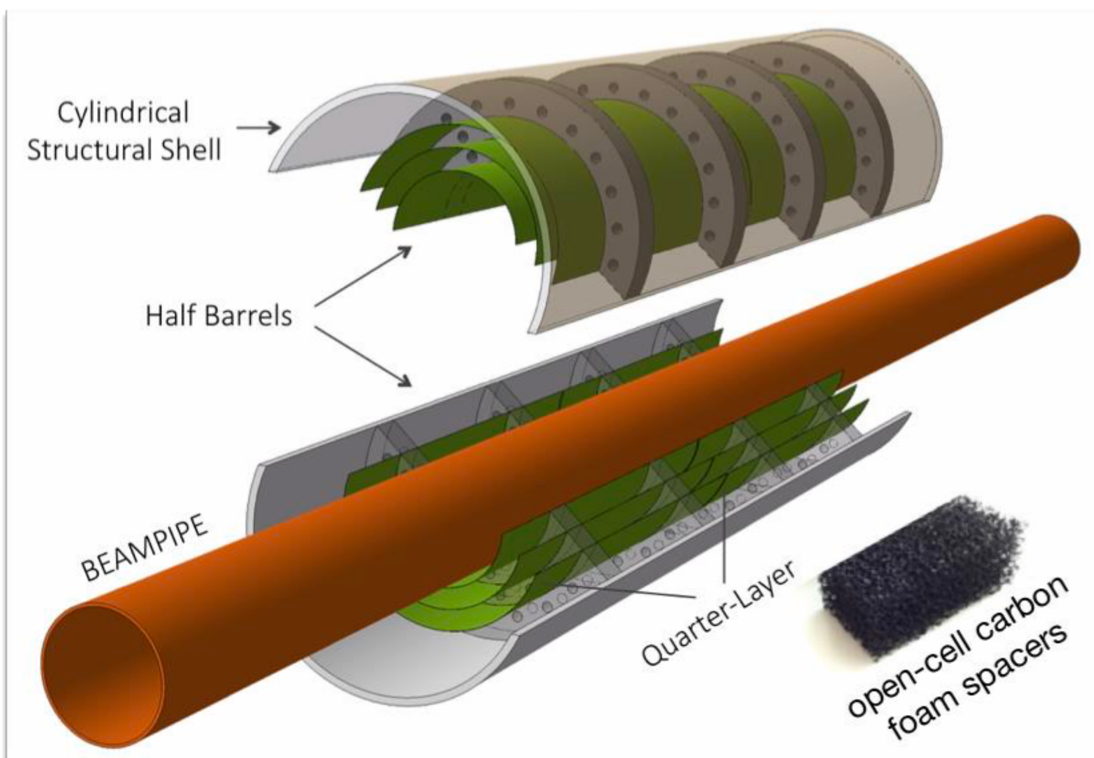
ITS3 Upgrade concept

Improvements for ITS3

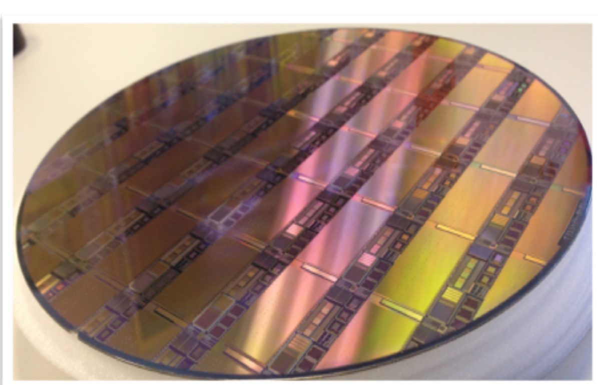
- 3 Cylindrical layers of "massless" wafer-scale sensors
- Thinning to 20 - 40 um and bending of the silicon
- Air Cooling, 20 mW/cm^2
- Removal of support structures
- Reduction of material budget 0.35% → 0.05%
- Beam pipe radius 22mm → 18mm
- Approach the interaction point

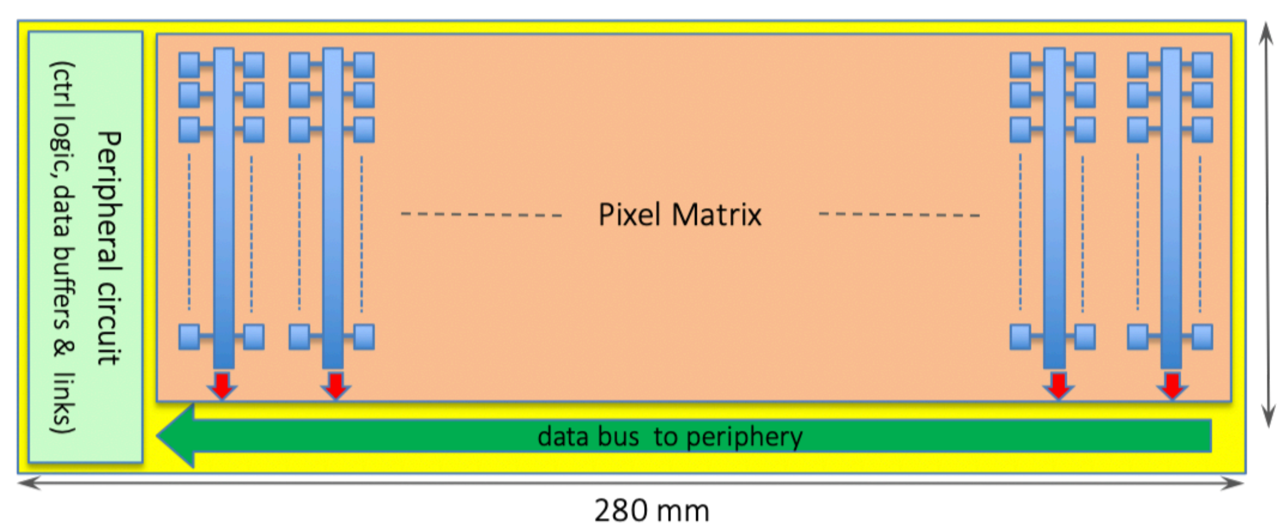
ITS2 material budget



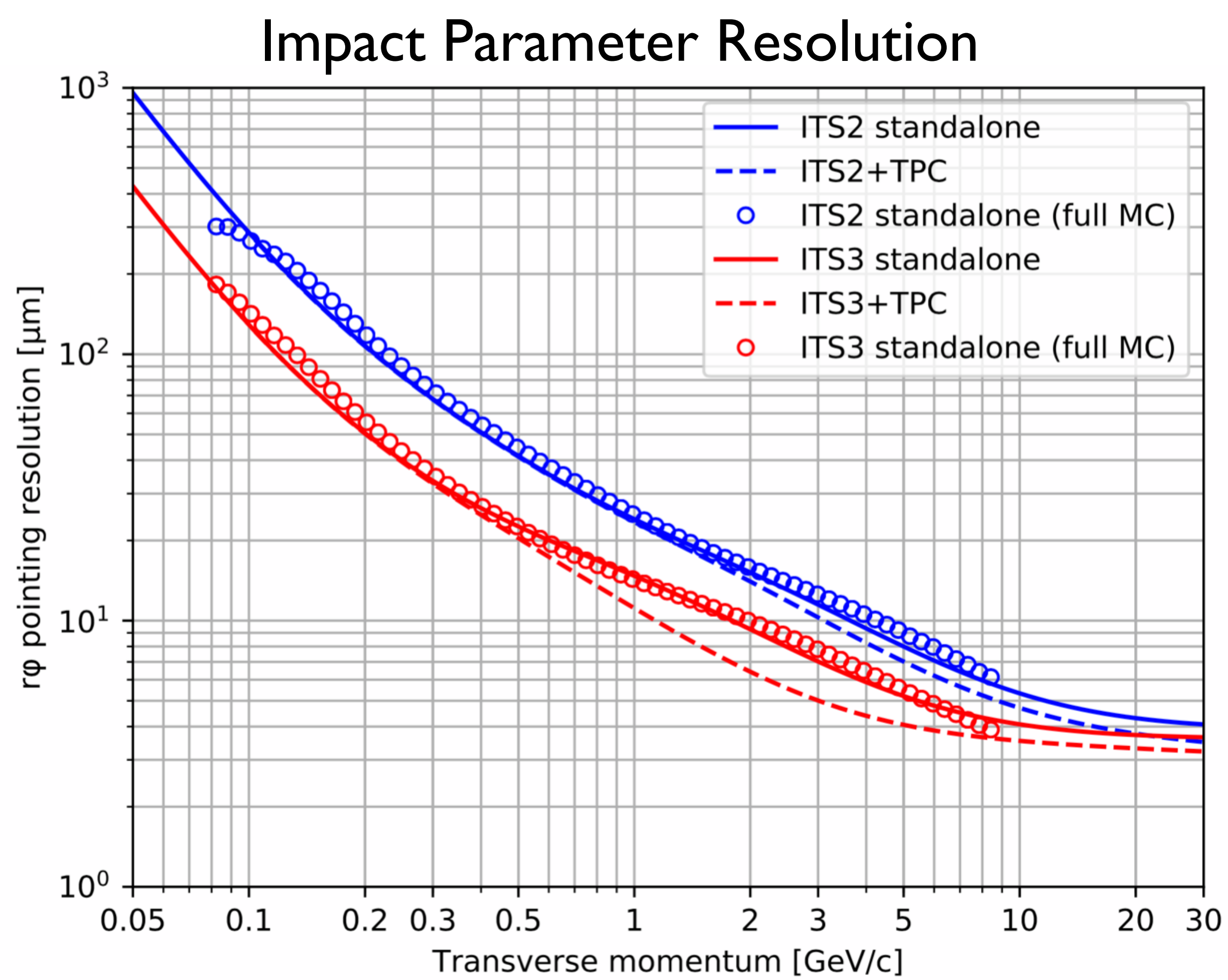


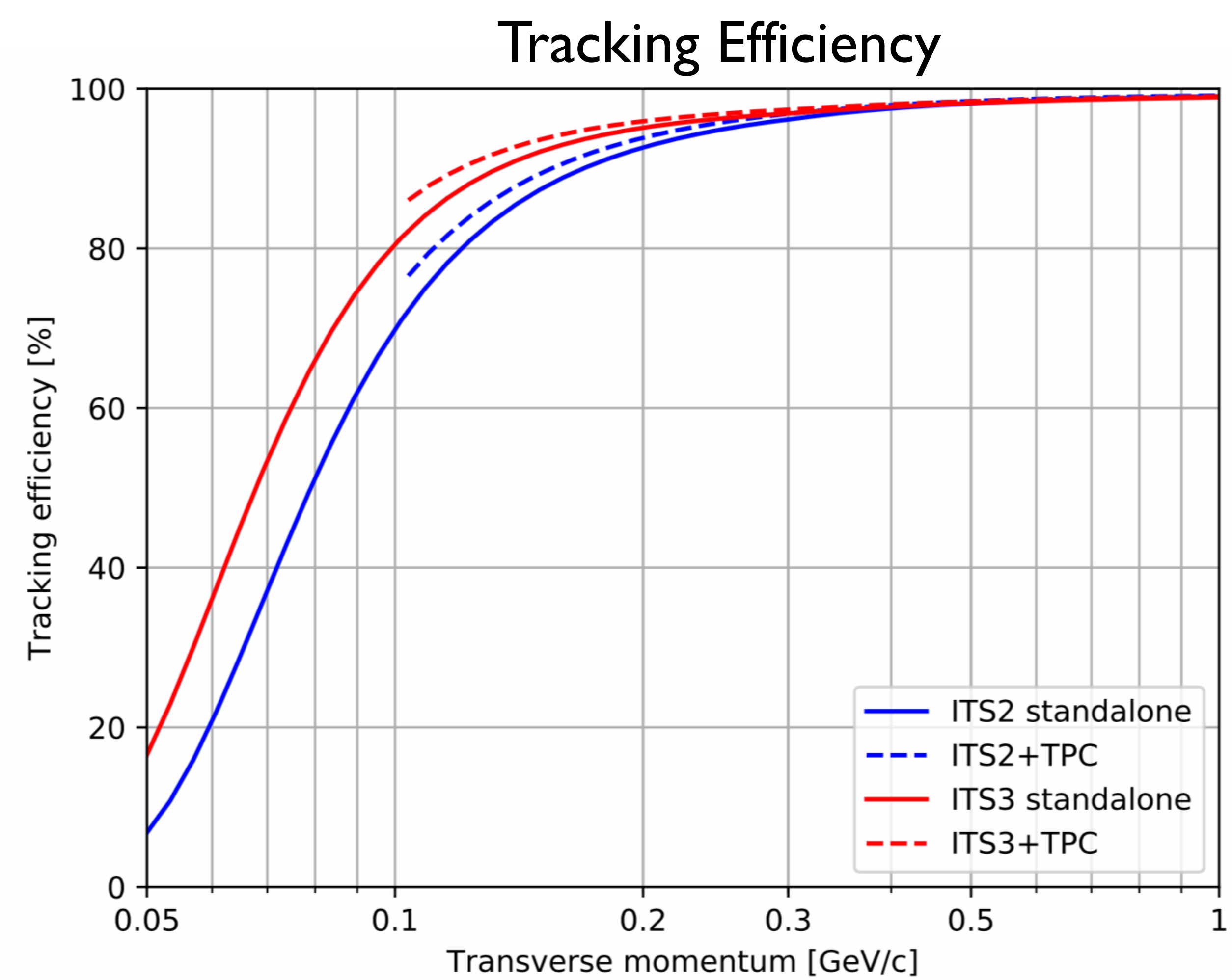
Silicon 1/7th of material budget





ITS3 expected performance





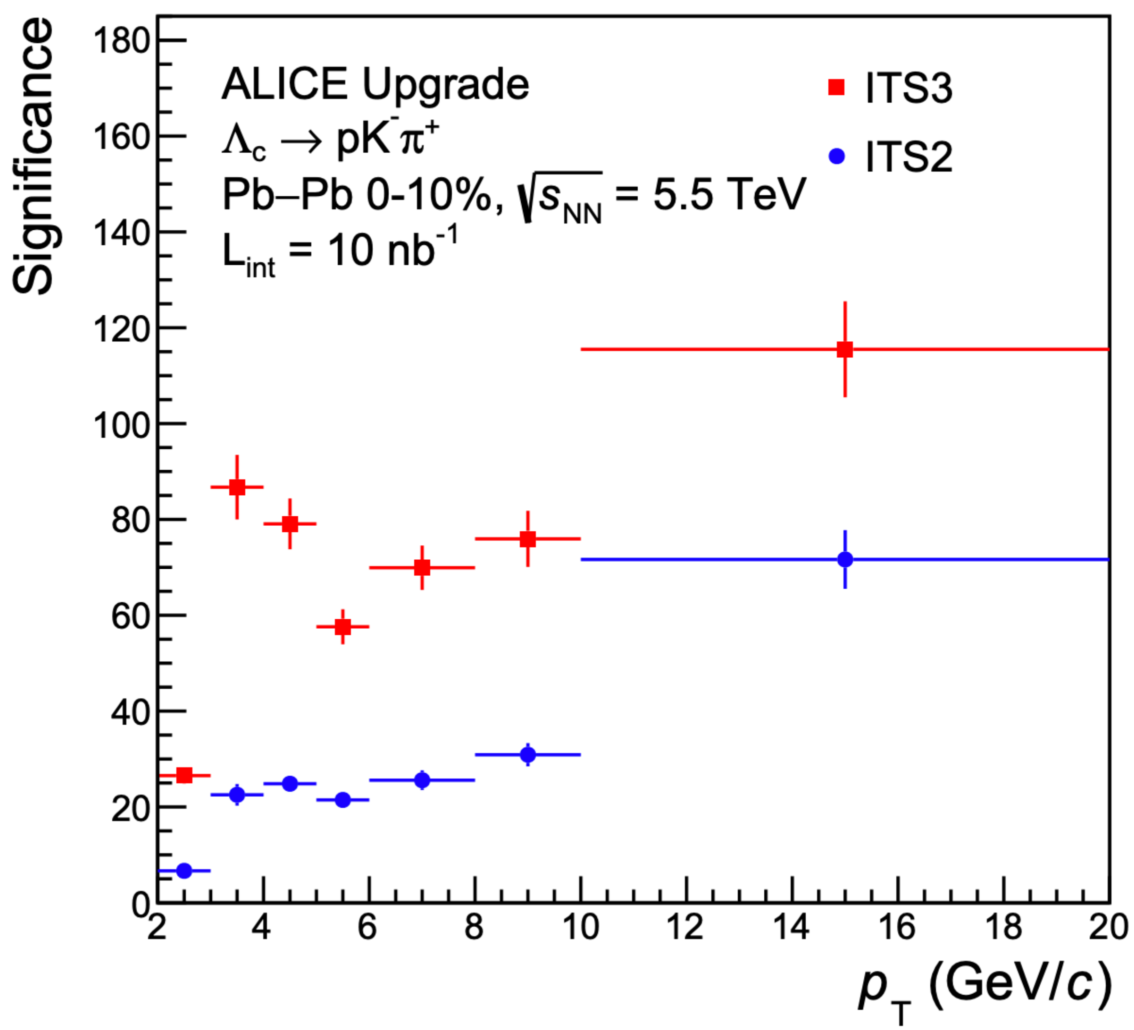
Improvement x2 at all p_T

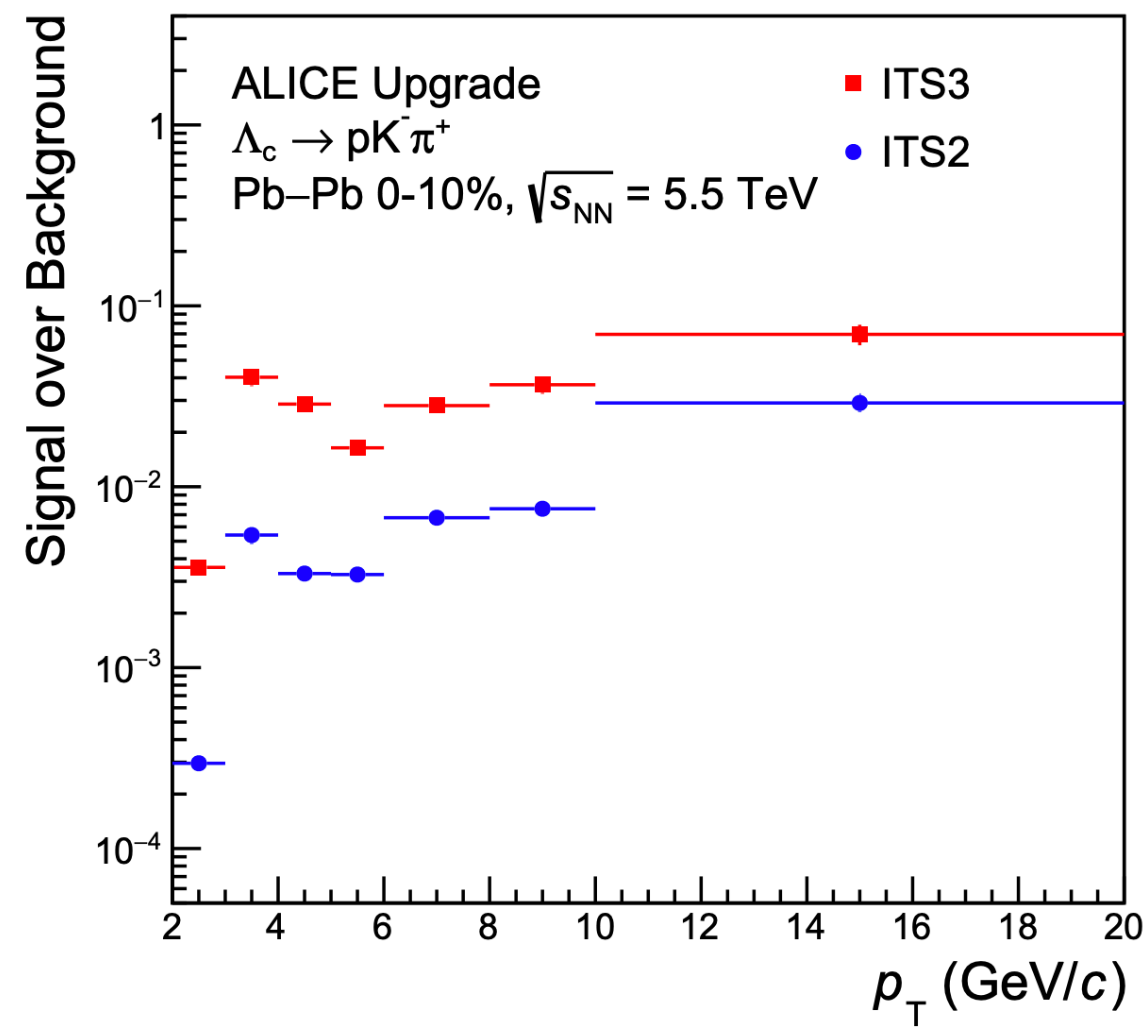
Improvement x2 at low p_T

Heavy Flavour measurements

$$\Lambda_c^+ \rightarrow \pi^+ + p + K^-$$

- PID for rejection of the large combinatorial background (p final state)
- Mean proper decay length Λ_c^+ : 59µm
- High tracking precision for the primary to secondary vertex separation
- Large improvement in Λ_c^+ signal: improved precision

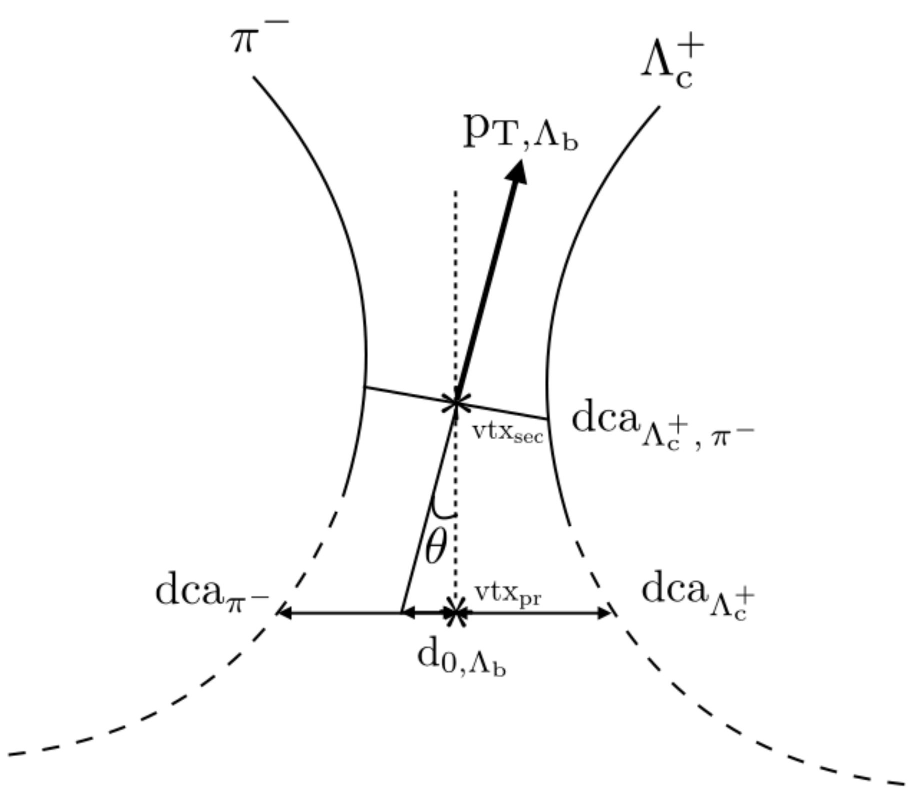




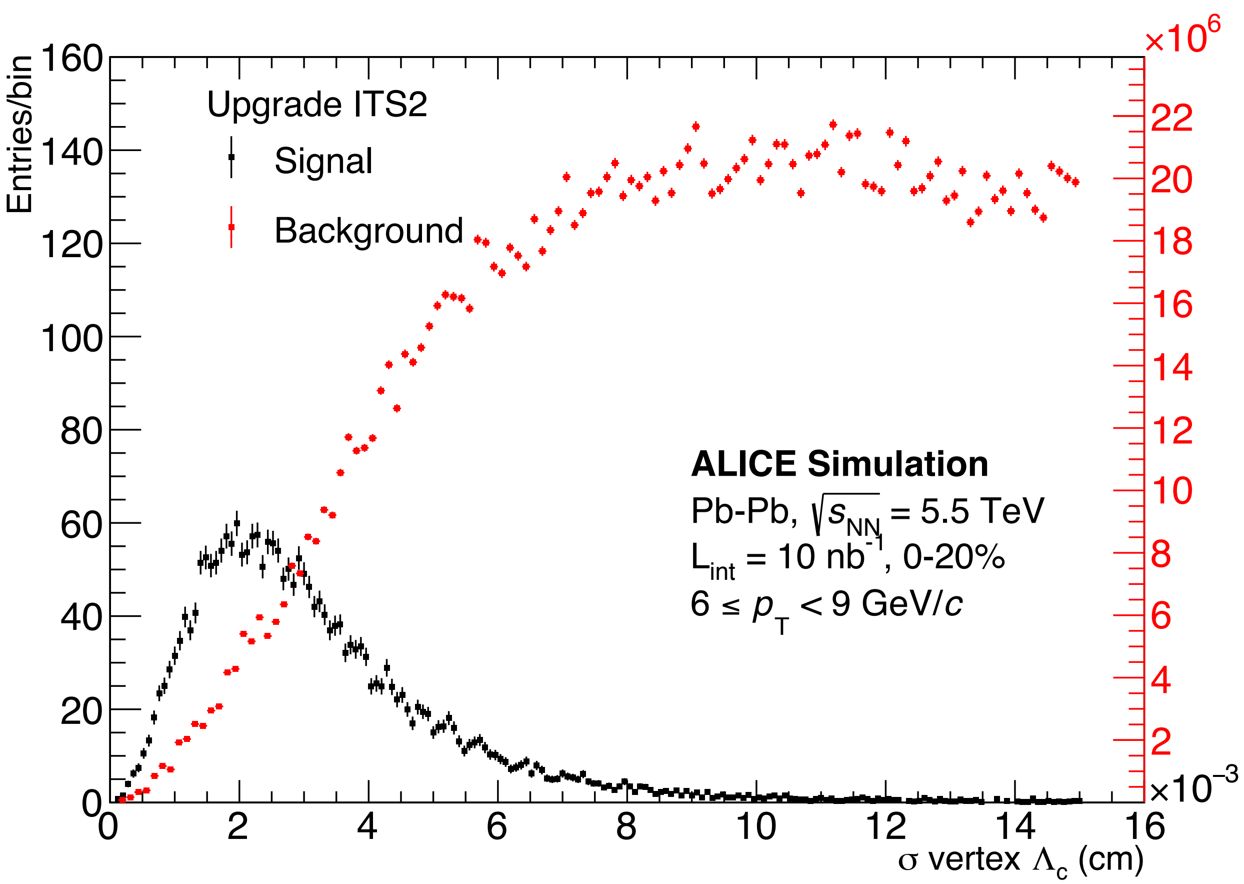
Heavy Flavour measurements

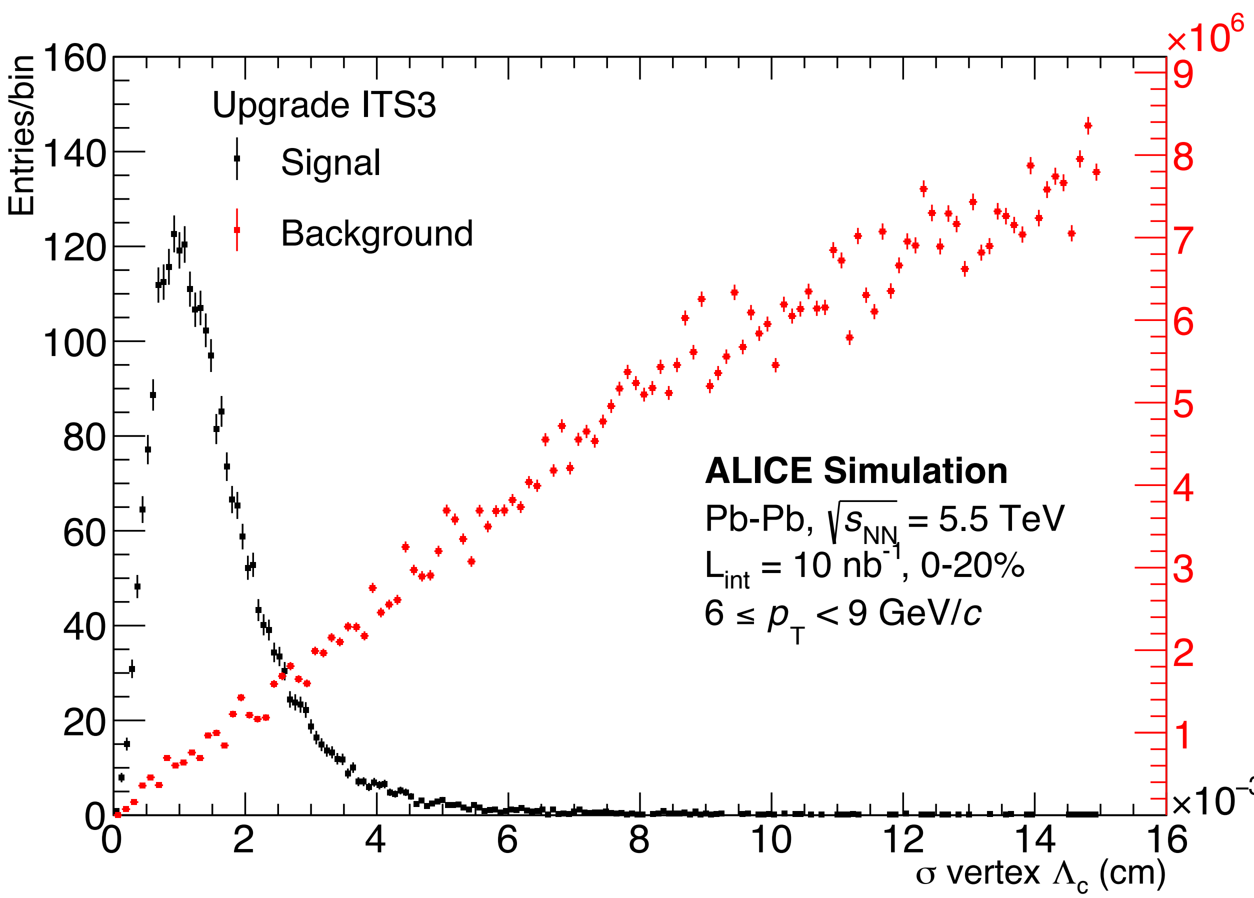
$$\Lambda_b \rightarrow \Lambda_c^+ + \pi^-, \quad \Lambda_c^+ \rightarrow \pi^+ + p + K^-$$

- Mean proper decay length Λ_b : 417μm
- Large combinatorial background
- 4 prong final state
- Small B.R.
- Tight topological selection
- Improved vertex resolution important for Λ_b signal selection



θ : pointing angle

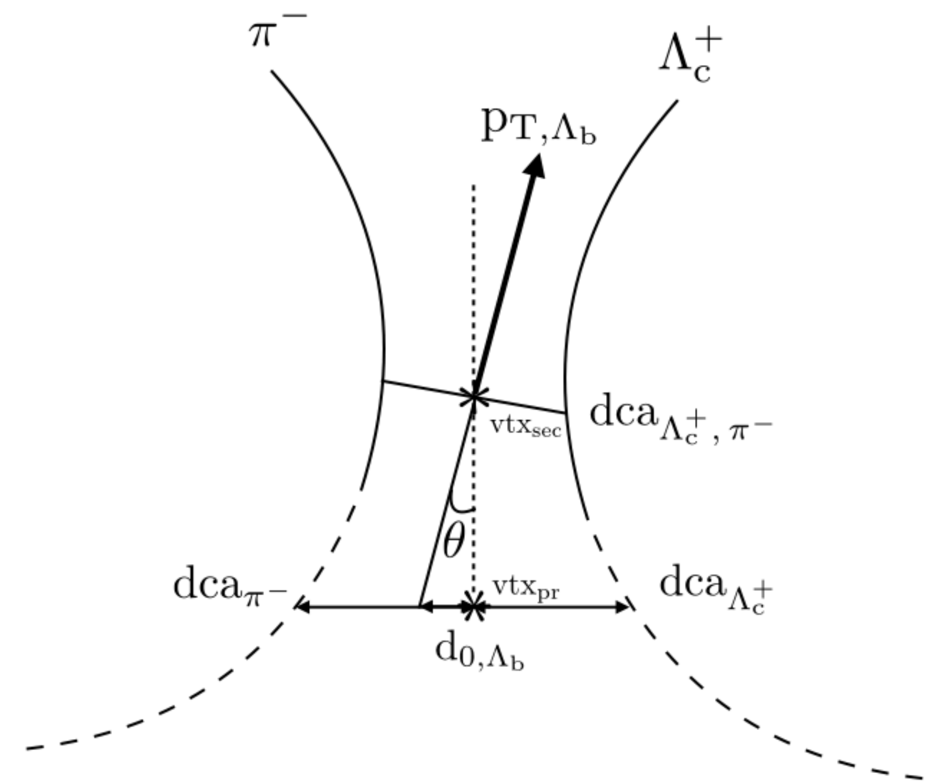




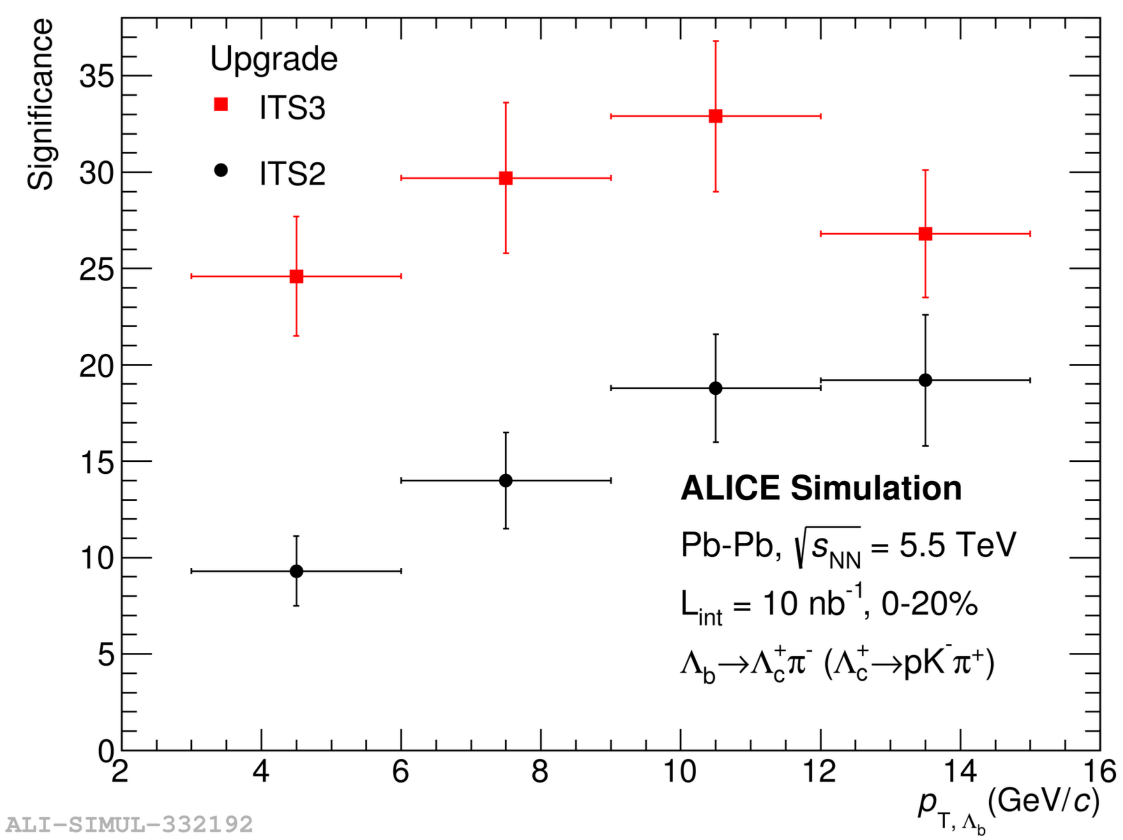
Heavy Flavour measurements

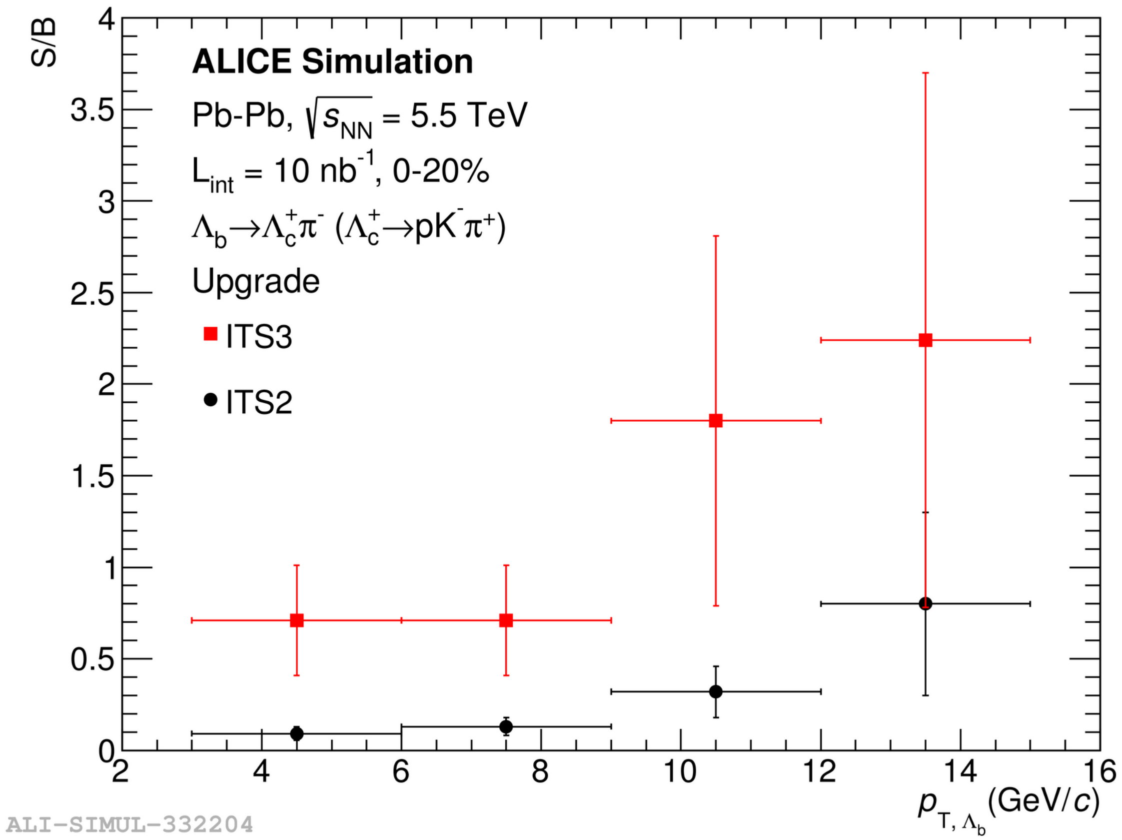
$$\Lambda_b \rightarrow \Lambda_c^+ + \pi^-, \quad \Lambda_c^+ \rightarrow \pi^+ + p + K^-$$

- Mean proper decay length Λ_b : 417µm
- Large combinatorial background
- 4 prong final state
- Small B.R.
- Tight topological selection
- Improved vertex resolution important for Λ_b signal selection



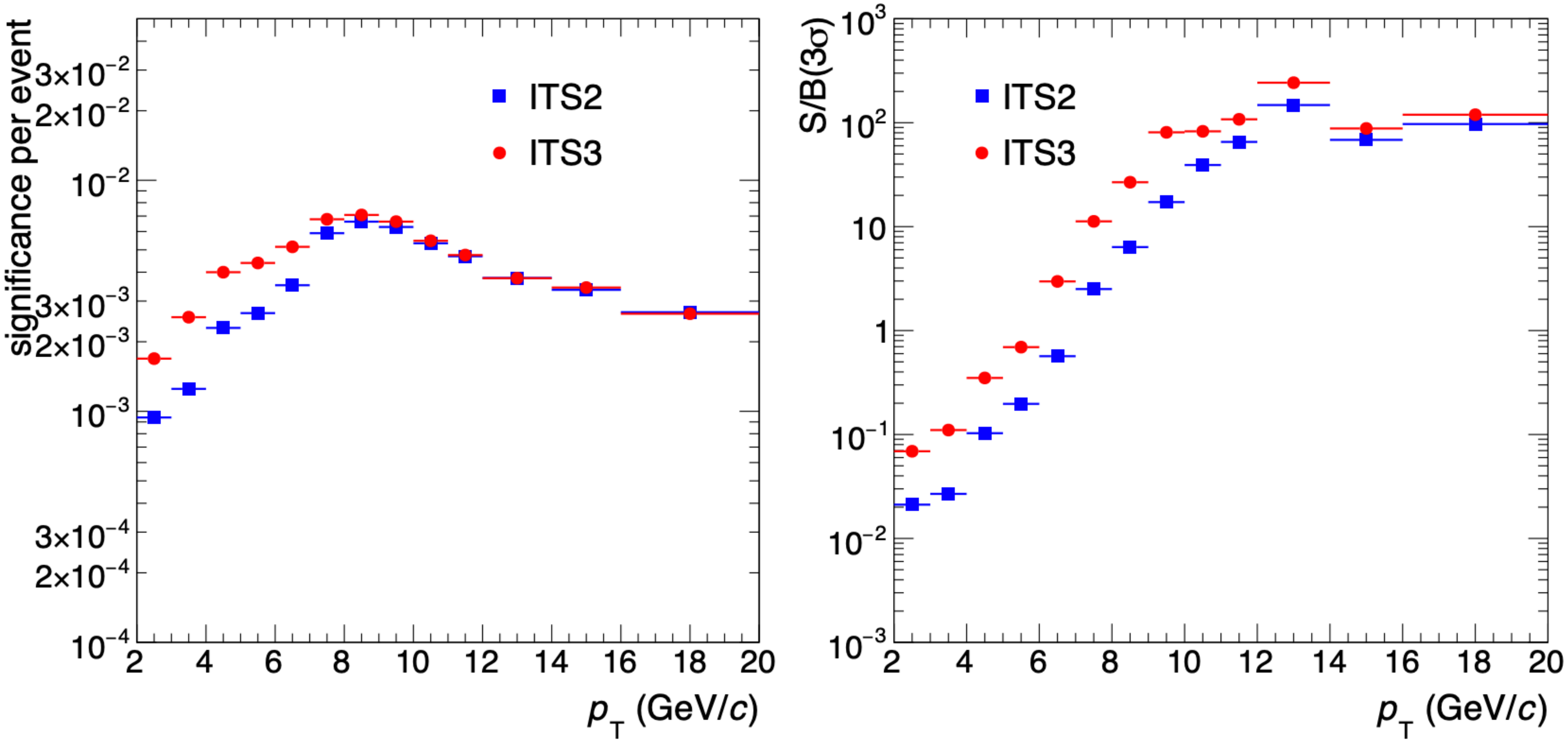
θ : pointing angle





Heavy Flavour measurements

$D_s \rightarrow \Phi + \pi \rightarrow K + K + \pi$ (non-prompt)

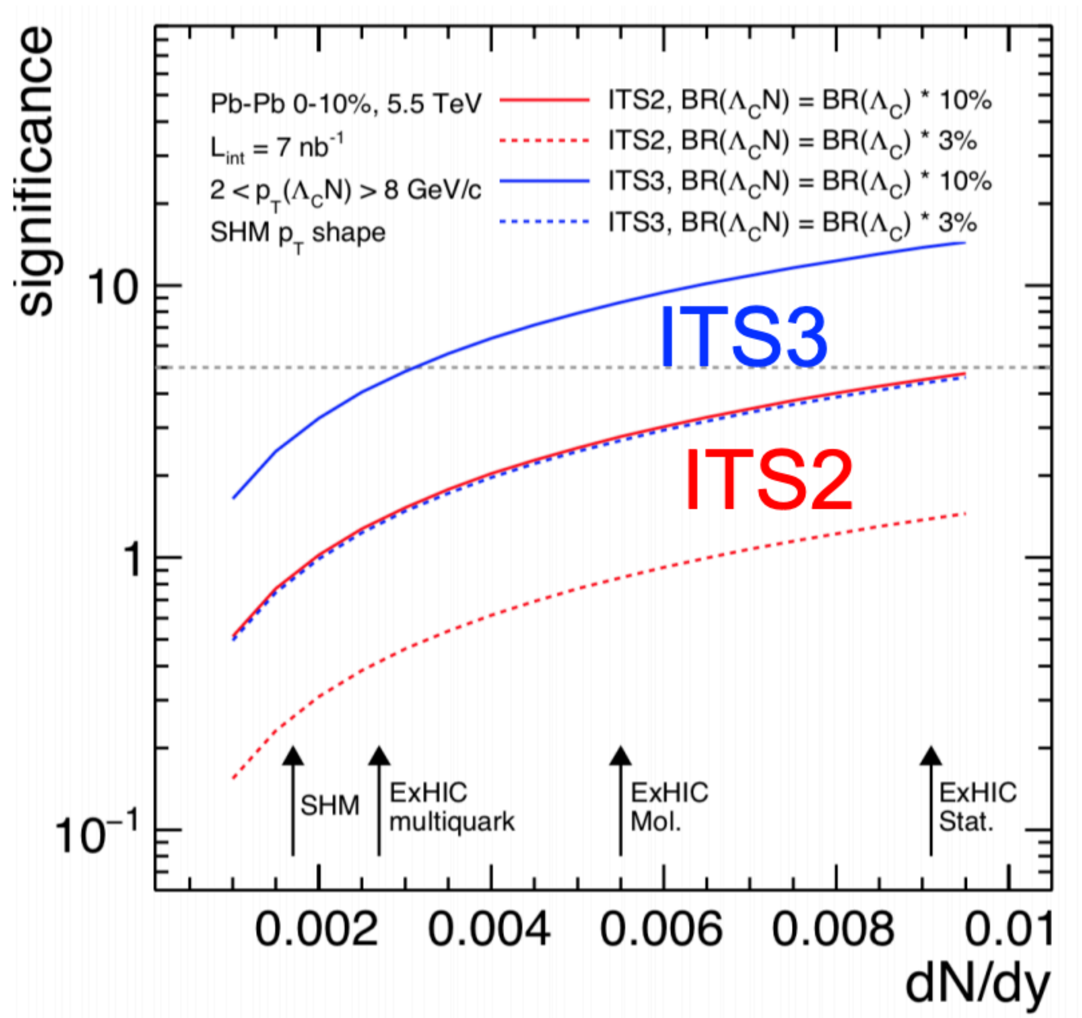


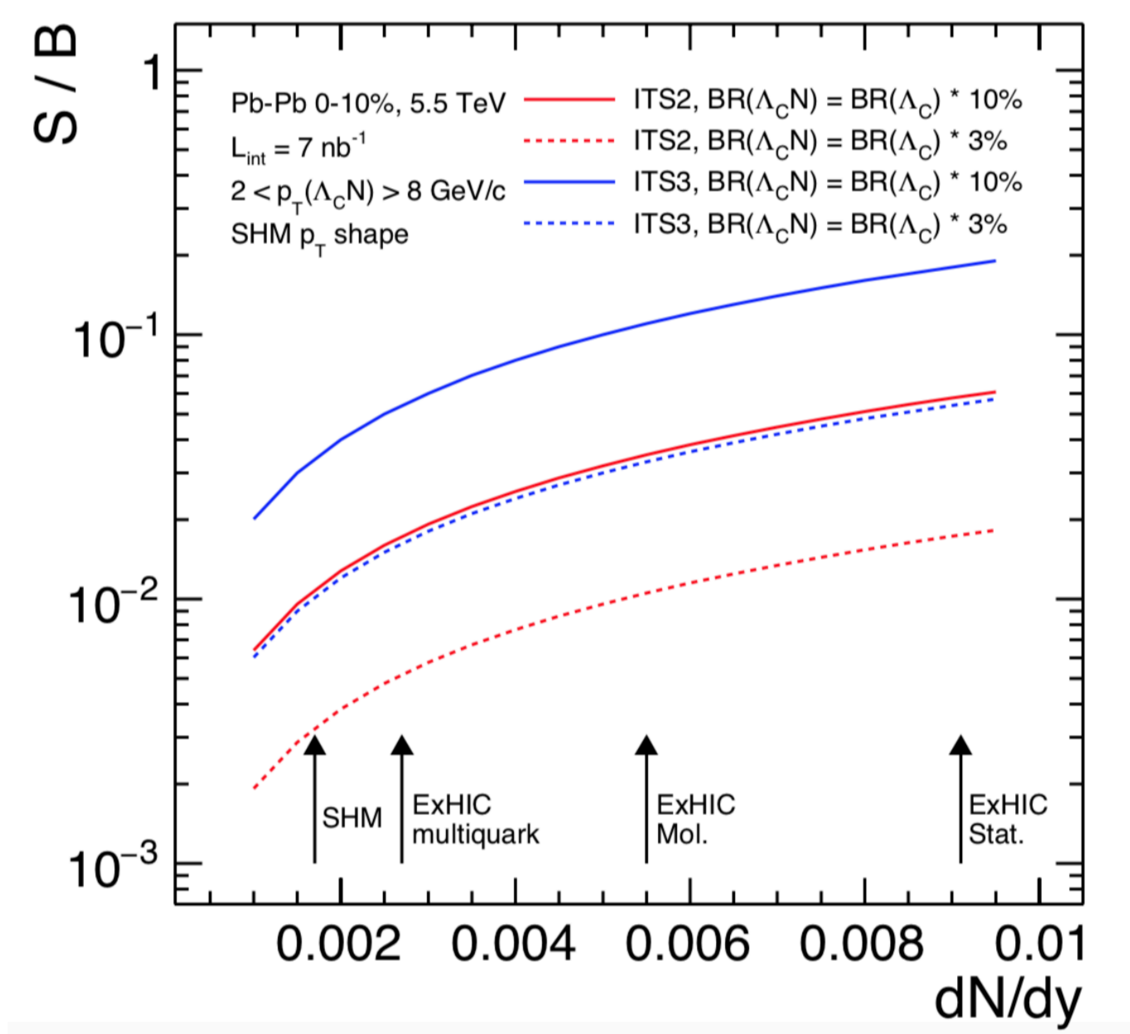
- Small $c\tau \sim 150\mu m$
- Improvement of significance by a factor of 2 at low p_T
- S/B improvement up to 20 GeV/c

Heavy Flavour measurements

c-deuteron

- $\Lambda_c n$ bound state
- Decay $d + K^- + \pi^+$ $(\Lambda_c \rightarrow p + K^- + \pi^+)$
- c-deuteron B.R.= B.R. Λ_c x P(p combines with n)
- Significance of ITS3 improved by a factor of 2.5
- Signal / Background of ITS3 improved by a factor of 3.3





Conclusions

- Improvement on measurements of small $c\tau$ hadrons
- Improvement on multi-prong final states
- Heavy Flavour Baryon / Meson
    - Λ_b / B enhanced if b recombines
    - Λ_c / D
    - D_s / D
- New prospects
    - B_s through the (non-prompt D_s)
    - Ξ_c^+ , Ξ_c^0 , Ω_c^0 *with ct* 130, 30, 20μm (c, s *quarks*)

Conclusions

- Improvement on measurements of small $c\tau$ hadrons
- Improvement on multi-prong final states
- Heavy Flavour Baryon / Meson
    - Λ_b / B enhanced if b recombines
    - Λ_c / D
    - D_s / D
- New prospects
    - B_s through the (non-prompt D_s)
    - Ξ_c^+ , Ξ_c^0 , Ω_c^0 *with ct* 130, 30, 20μm (c, s *quarks*)

ITS3 - Heavy Flavour

Improvements on challenging channels

Exploration of new channels in Pb-Pb

Thank you!