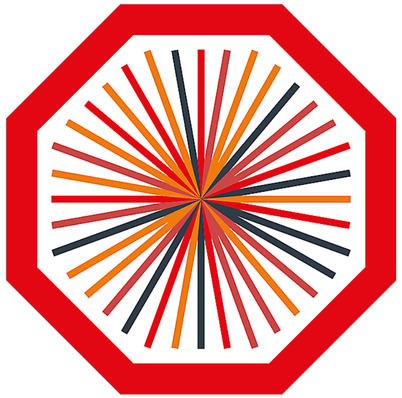


ALICE

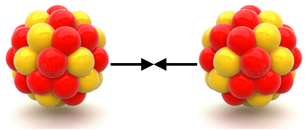
Status report

Mohamad Tarhini
On behalf of the ALICE Collaboration
139th meeting of the LHCC, 12/09/2019

Subatech

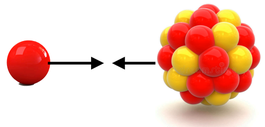
New ALICE results since last LHCC

New publications:



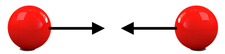
Pb-Pb collisions

- Global polarization of Λ and $\overline{\Lambda}$ hyperons in Pb-Pb collisions at the LHC, submitted to PRC, arXiv:1909.01281
- (anti-)hypertriton lifetime measurement in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV via two-body decay, accepted by PLB arXiv:1907.06906
- Measurement of Y(1S) elliptic flow at forward rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$ =5.02 TeV, submitted to PRL, arXiv:1907.03169
- Differential study of inclusive J/ψ production at forward rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV, submitted to JHEP, arXiv:1909.03158



p-Pb collisions

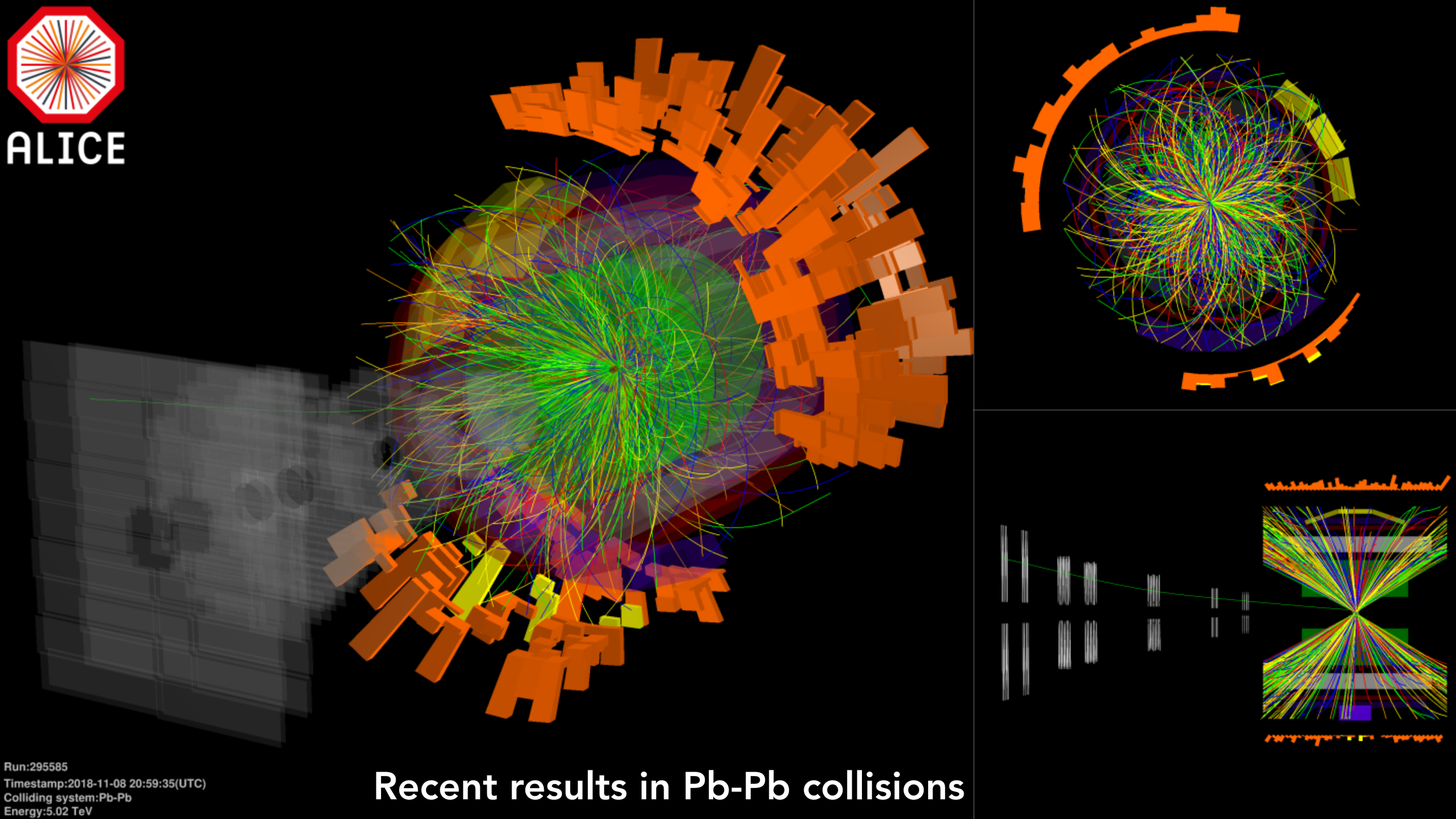
- Measurement of prompt D^0, D^+, D^{*+}, and D_s^+ production in p–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV, submitted to JHEP, arXiv:1906.03425
- Multiplicity dependence of light (anti-)nuclei production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV, submitted to PLB, arXiv:1906.03136
- Measurement of Λ(1520) production in pp collisions at $\sqrt{s}$ = 7 TeV and p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV, submitted to EPJC, arXiv:1909.00486



pp collisions

- Multiplicity dependence of (multi-)strange hadron production in proton-proton collisions at $\sqrt{s}$ = 13 TeV, submitted to EPJC, arXiv:1908.01861

+ set of new preliminary results presented in the summer conferences



Recent results in Pb-Pb collisions

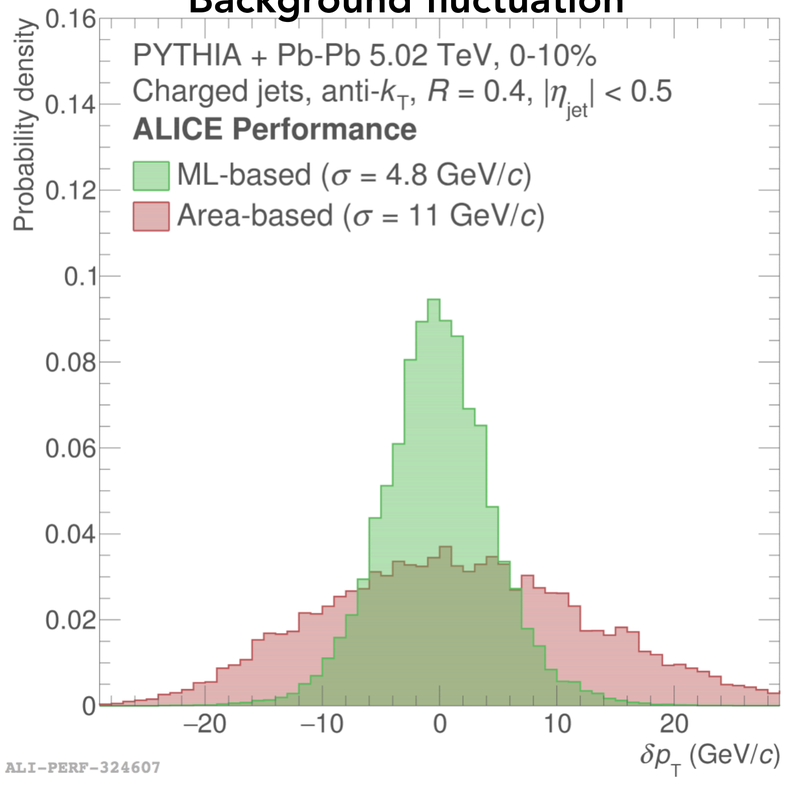
Machine learning for jet reconstruction

NEW Preliminary

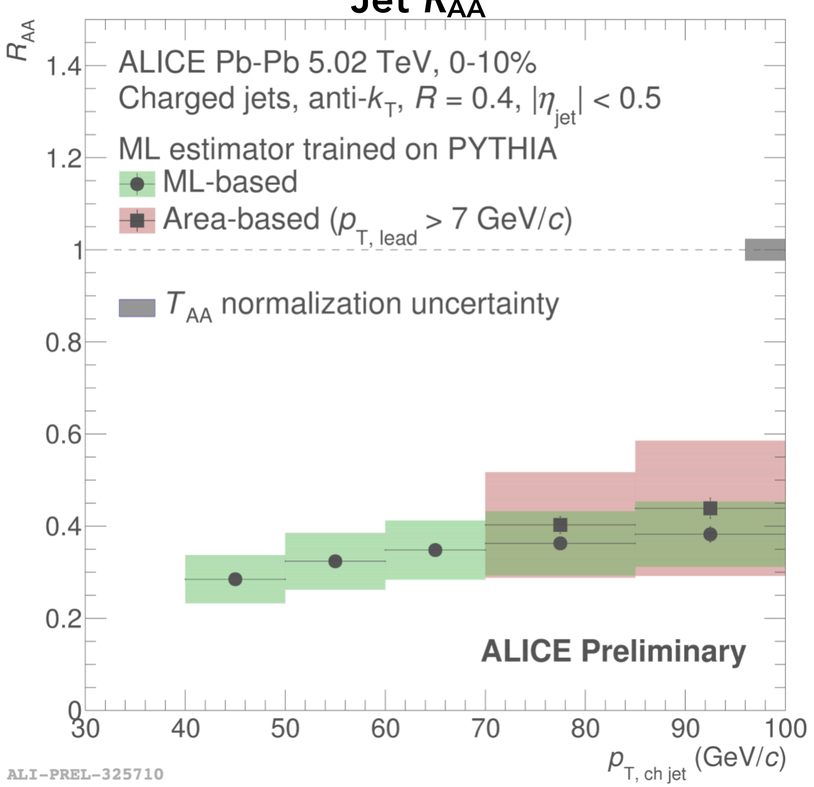
- Jet reconstruction in central Pb-Pb collisions suffers from large amount of background
- Development of new technique based on Machine-Learning
  - Reduces background fluctuations

$$R_{\mathrm{AA}} = \frac{dN/dp_{\mathrm{T}}}{N_{\mathrm{event}} \cdot \langle T_{\mathrm{AA}} \rangle \cdot d^2\sigma_{\mathrm{pp}}/dp_{\mathrm{T}}}$$

Background fluctuation



Jet R_{AA}



- **Allows the measurement down to much lower jet p_T**
  - **Jet R_{AA} < 1: parton energy loss**

Machine learning for jet reconstruction

NEW Preliminary

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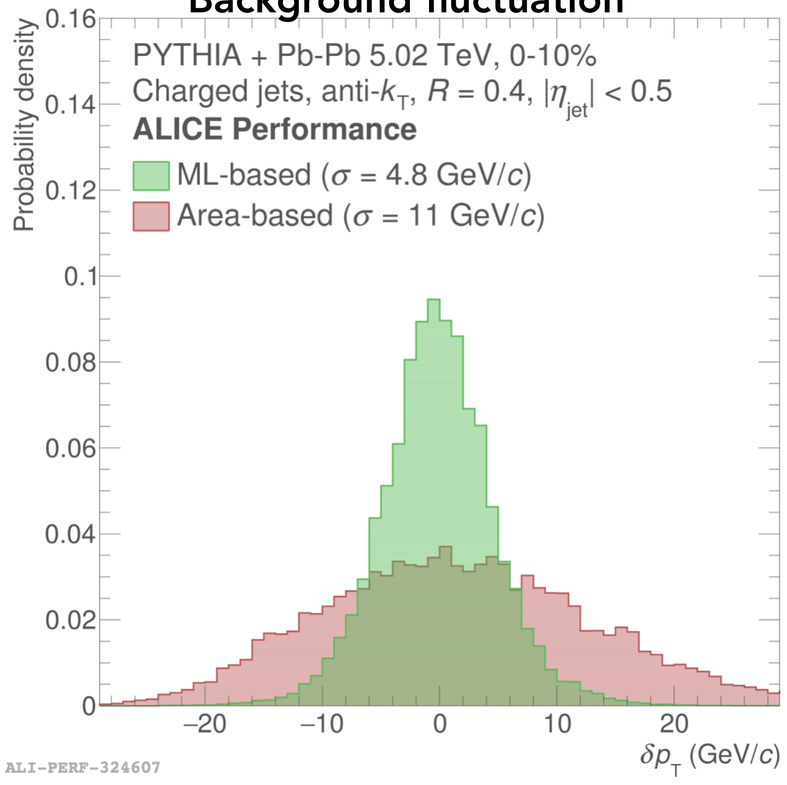
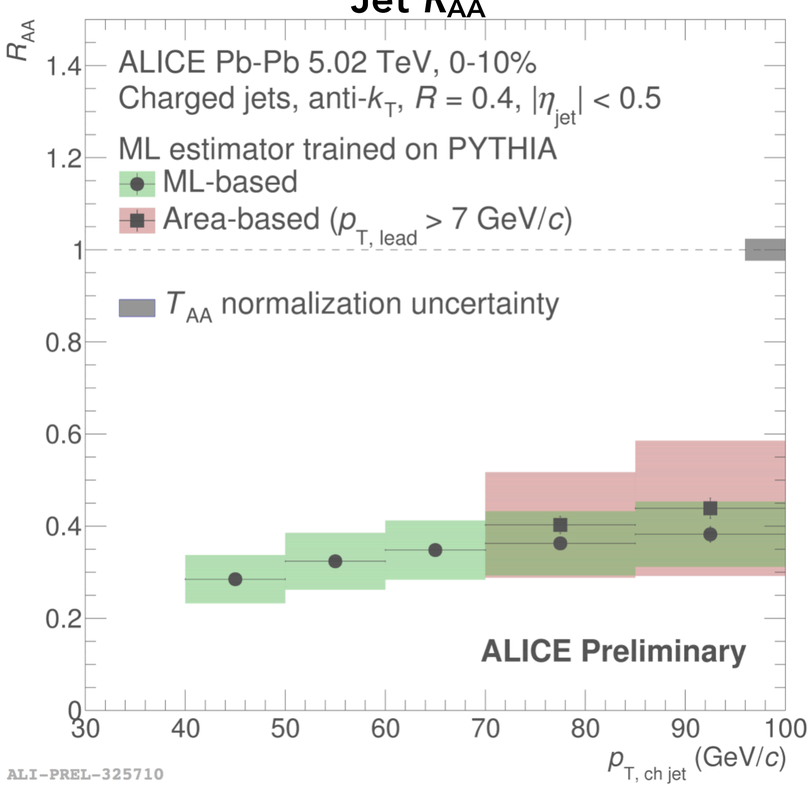
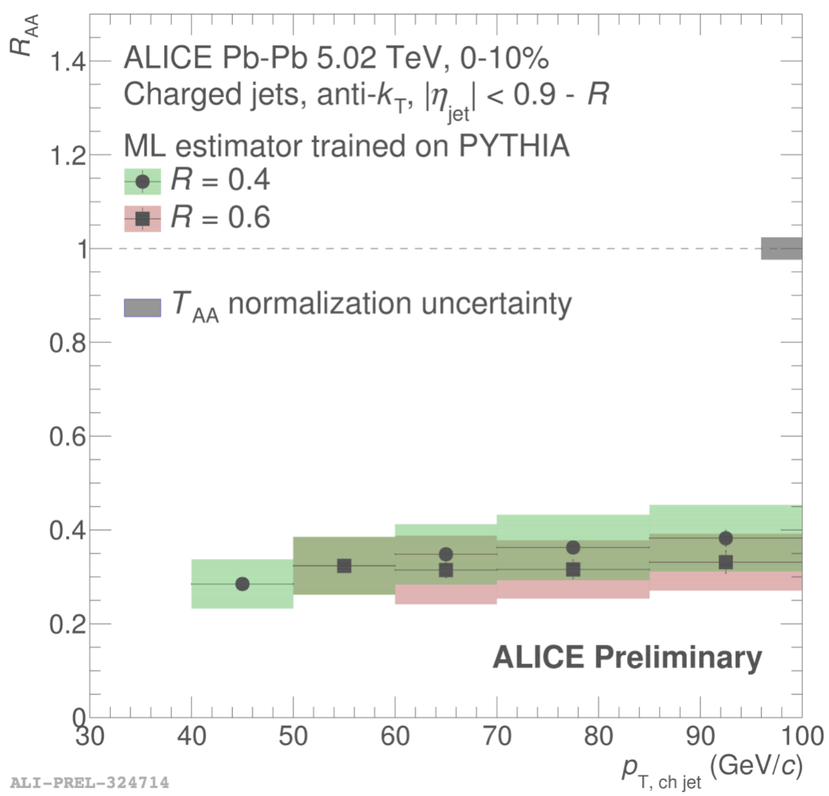
Background fluctuation



Jet R_{AA}



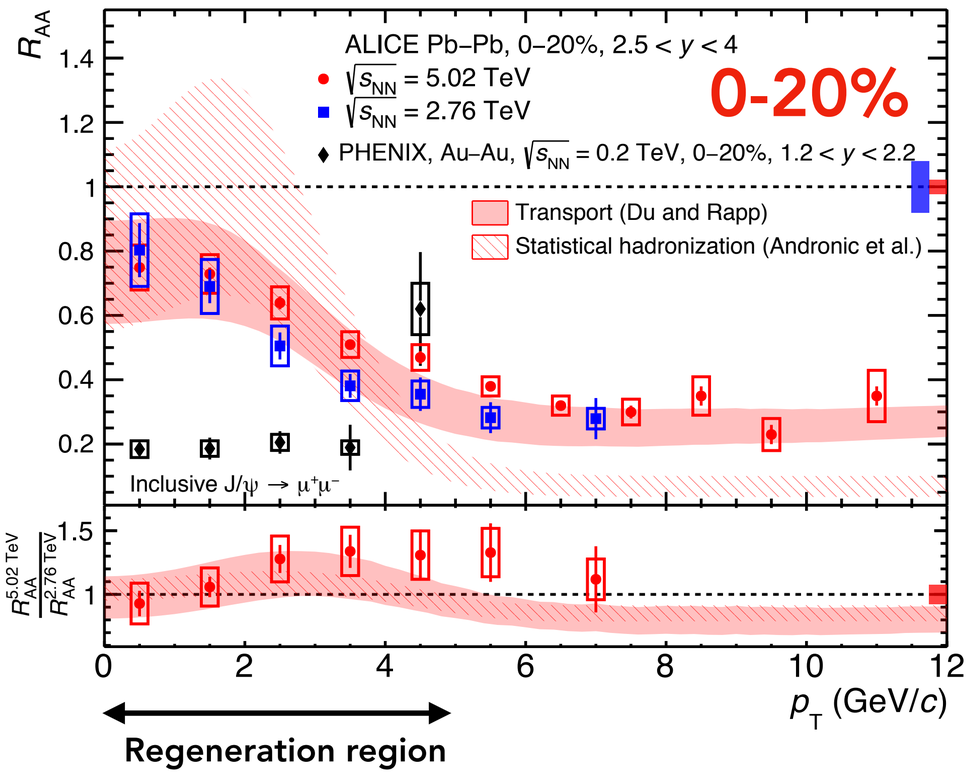


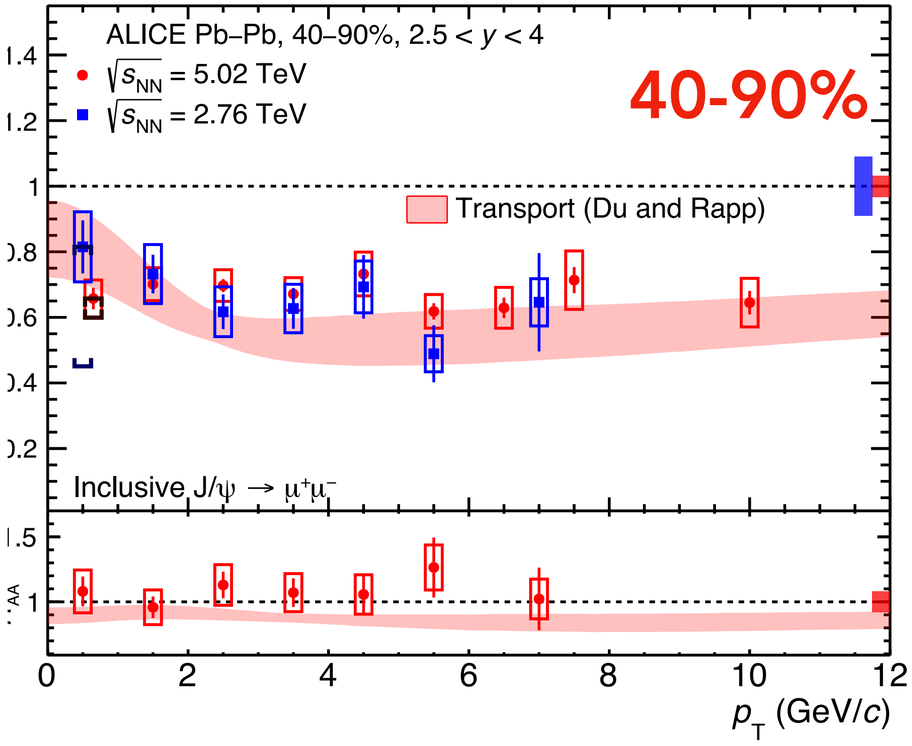
- **Allows the measurement down to much lower jet p_T**
  - **Jet R_{AA} < 1: parton energy loss**
- New measurement with larger jet resolution at R=0.6
- Outlook: training ML estimator with fragmentation models other than PYTHIA

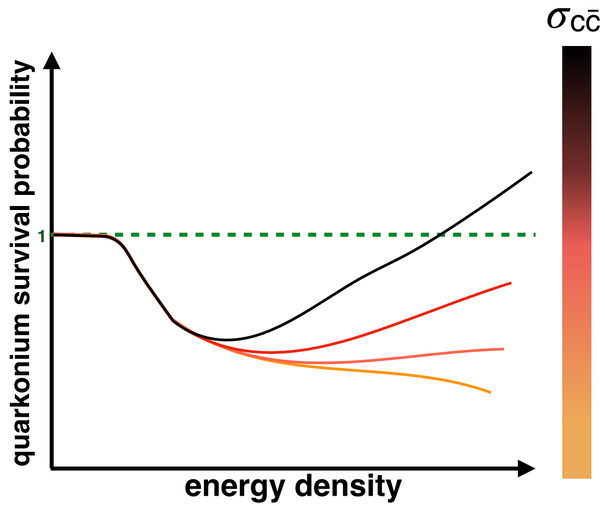
J/ψ suppression in Pb-Pb collisions at 5.02 TeV

arXiv: 1909.03158

- Quarkonium suppression: probe of de-confinement in the QGP
- Quarkonium production can be enhanced via regeneration







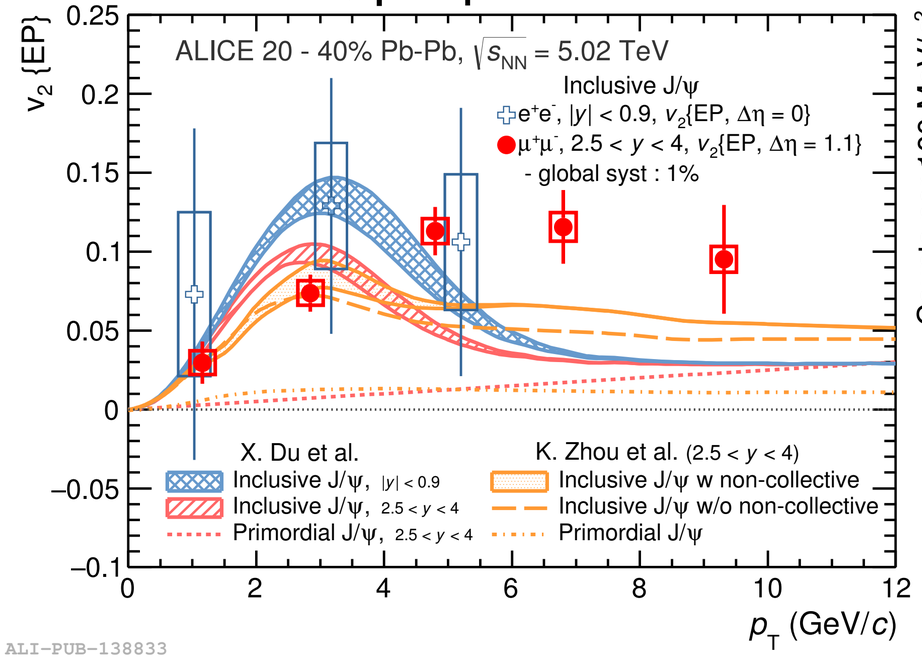
- New double differential results: compatible the two LHC energies in the different centrality, p_T, y regions.
- Models are able to reproduce the results with some tensions at intermediate/high p_T.
- **R_{AA} at low p_T + J/ψ elliptic flow: clear evidence for regeneration**

Upsilon elliptic flow in Pb-Pb at 5 TeV

arXiv: 1907.03169

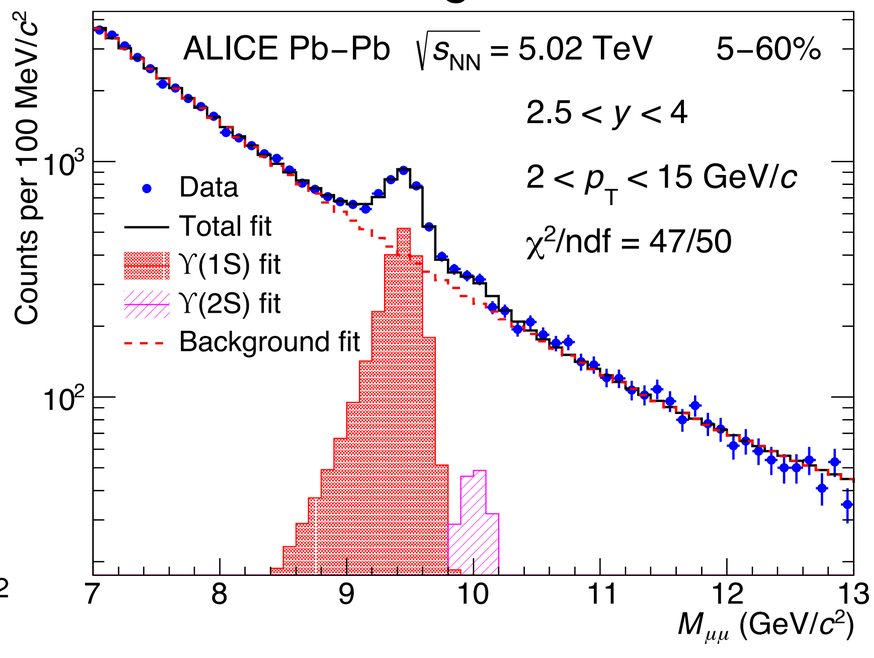
- Regenerated Quarkonia inherit elliptic flow from deconfined heavy quarks

J/ψ elliptic flow

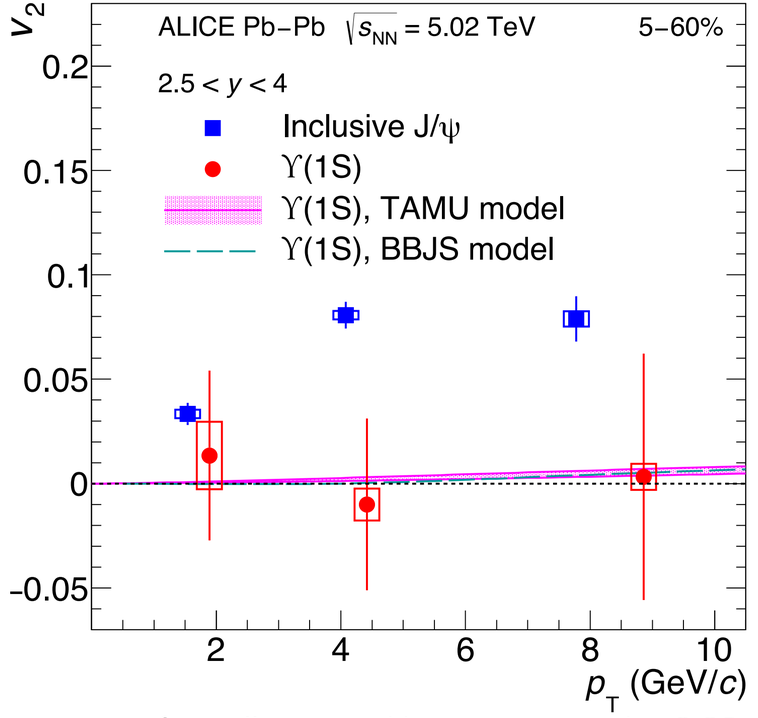


ALI-PUB-138833

ϒ signal



ϒ elliptic flow



V_2 acquired from path-length dependent dissociation of initially-created bottomonia in the QGP

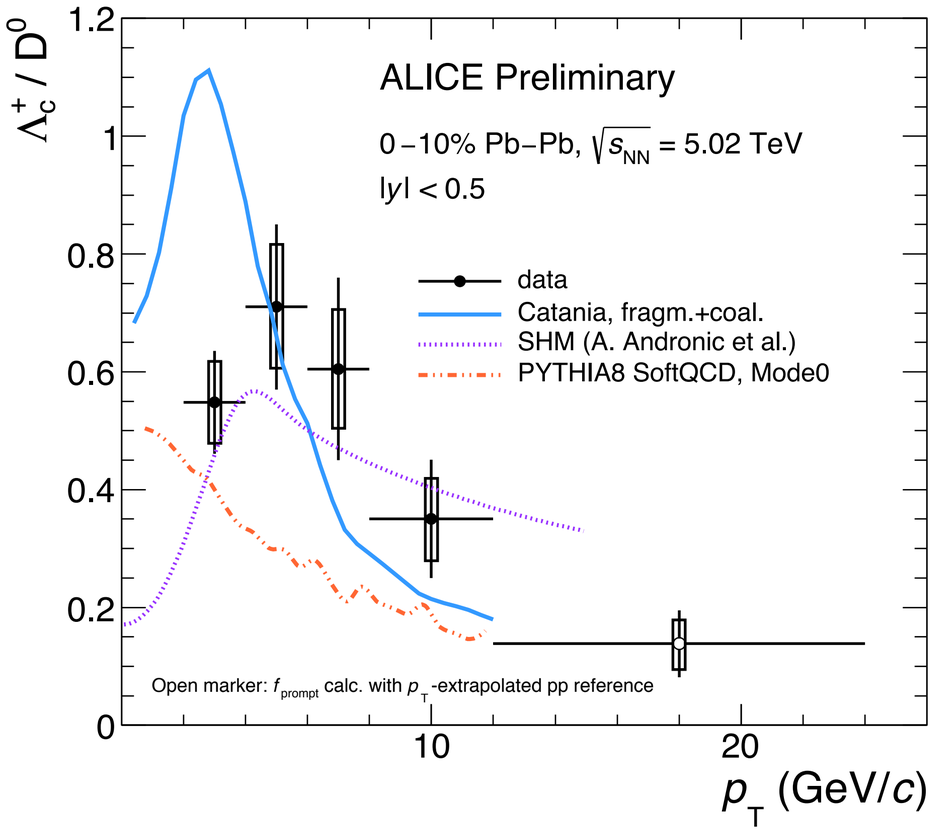
+ (re)generation

- First measurement of the upsilon flow in Pb-Pb collisions
  - **$v_2(\Upsilon) < v_2(J/\psi)$ at 2.6σ**
  - Compatible with zero and with models having negligible regeneration

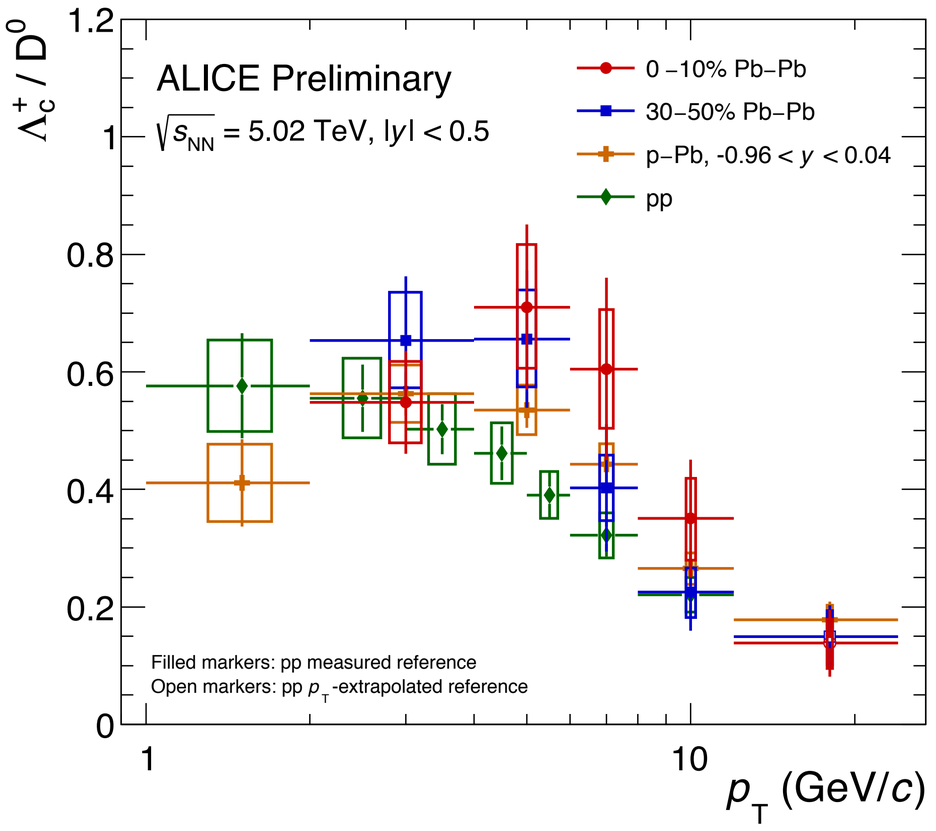
Λ_c production in Pb-Pb at 5.02 TeV

NEW Preliminary

- Λ_c/D^0 ratio is sensitive to the charm quark hadronisation mechanism in the medium
- Larger statistics and higher p_T reach using the 2018 data sample



ALI-PREL-325749



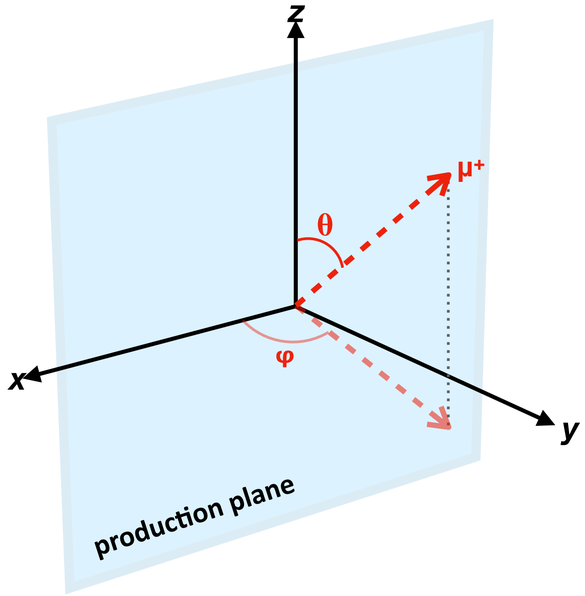
ALI-PREL-321712

- Results are qualitatively reproduced by coalescence/thermal models, and underestimated by PYTHIA8 ‘string fragmentation’ model
- Need more data to look for possible differences in pp, pPb, and PbPb collisions

J/ψ polarisation in Pb-Pb collisions at 5.02 TeV

NEW Preliminary

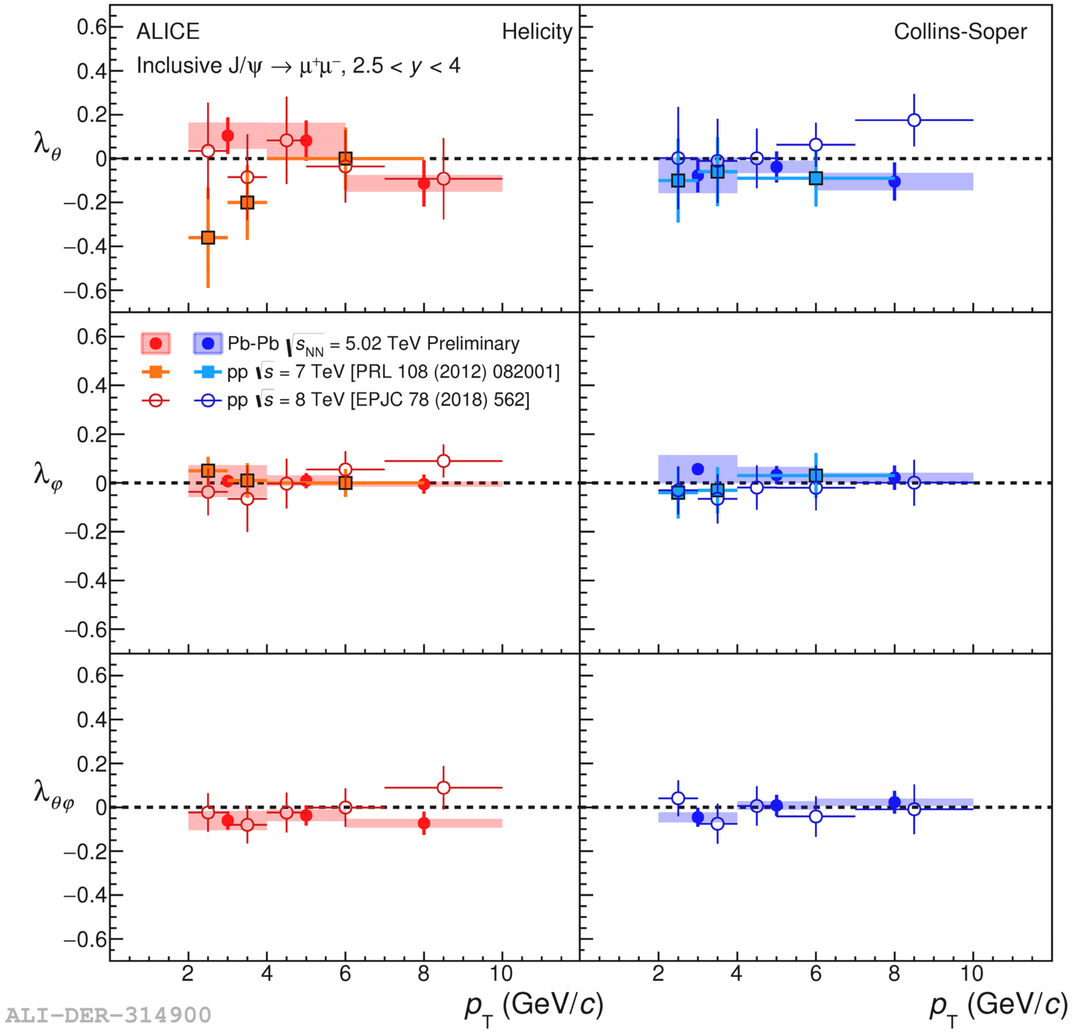
- At the LHC, all the measurements in pp collisions lead to zero polarisation
  - Different models predict non-zero J/ψ polarisation
- Usually studied using the di-lepton decay angular distributions



$$W(\cos\theta,\varphi)$$

$$\frac{1}{3+\lambda_\theta}\left[1+\lambda_\theta\cos^2\theta+\lambda_\phi\sin^2\theta\cos(2\varphi)+\lambda_{\theta\phi}\sin(2\varphi)\right]$$

- $(\lambda_\theta,\lambda_\varphi,\lambda_{\theta\varphi}) = (0,0,0)$ → no polarisation
- $(\lambda_\theta,\lambda_\varphi,\lambda_{\theta\varphi}) = (-1,0,0)$ → total longitudinal polarisation
- $(\lambda_\theta,\lambda_\varphi,\lambda_{\theta\varphi}) = (+1,0,0)$ → total transversal polarisation

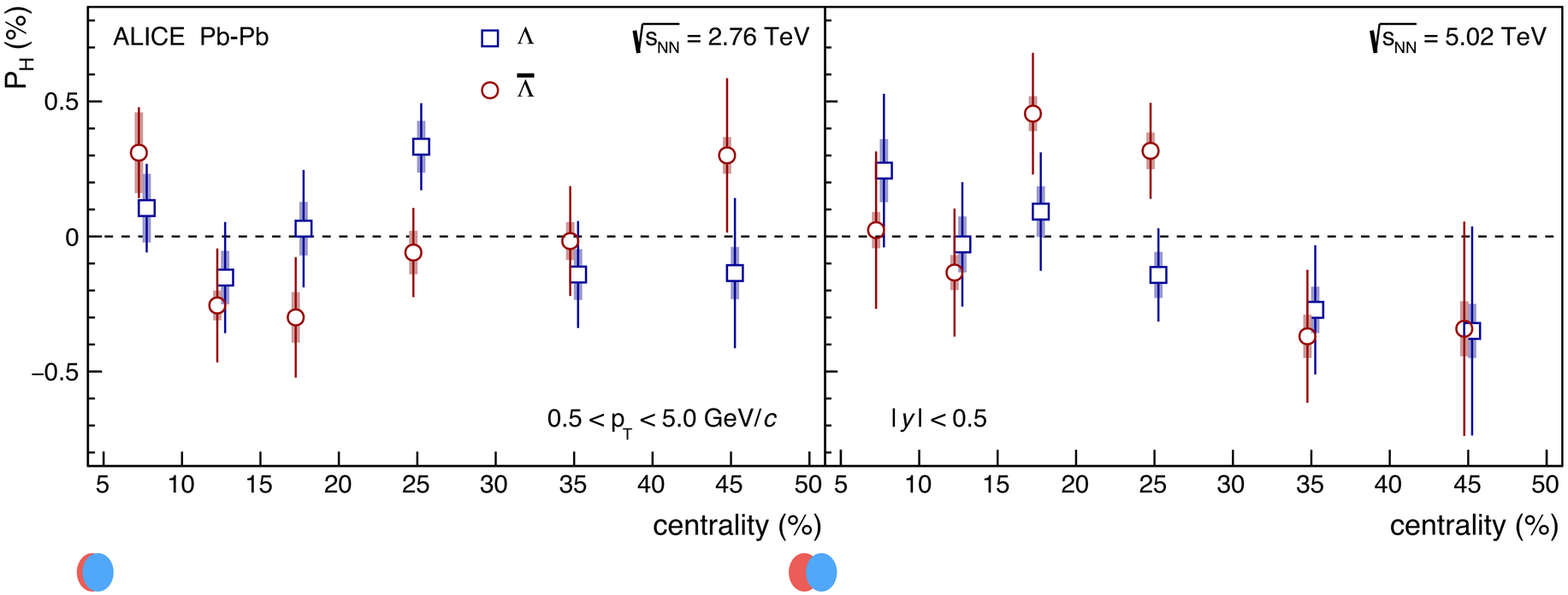


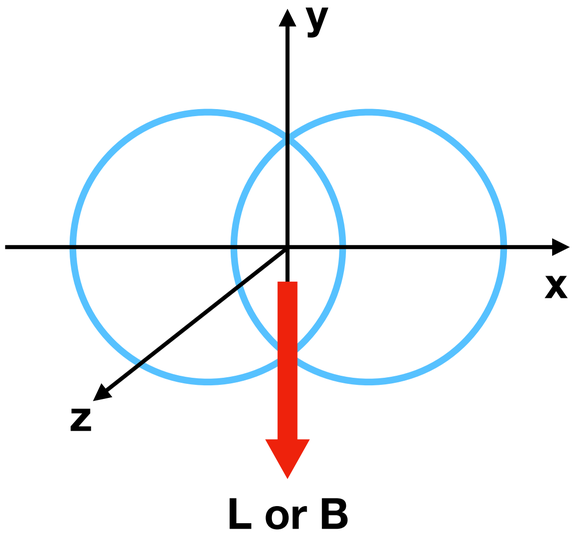
- First measurement in Pb-Pb collisions at the LHC
- Within uncertainties, **compatible with *zero*** and the pp results
- Run-3 and 4: Polarisation measurement for the photo-production excess in peripheral collisions

Λ global polarisation in Pb-Pb at 2.76 and 5.02 TeV

arXiv: 1909.01281

- Angular momentum + spin-orbit coupling → global polarisation
- +, splitting between polarisation of (anti-)particles to study the present magnetic fields





$$\zeta = (s+1)\omega/(3T)$$

$$\omega = 1/2(\Delta \times v)$$

- **Polarisation compatible with zero**

Λ global polarisation in Pb-Pb at 2.76 and 5.02 TeV

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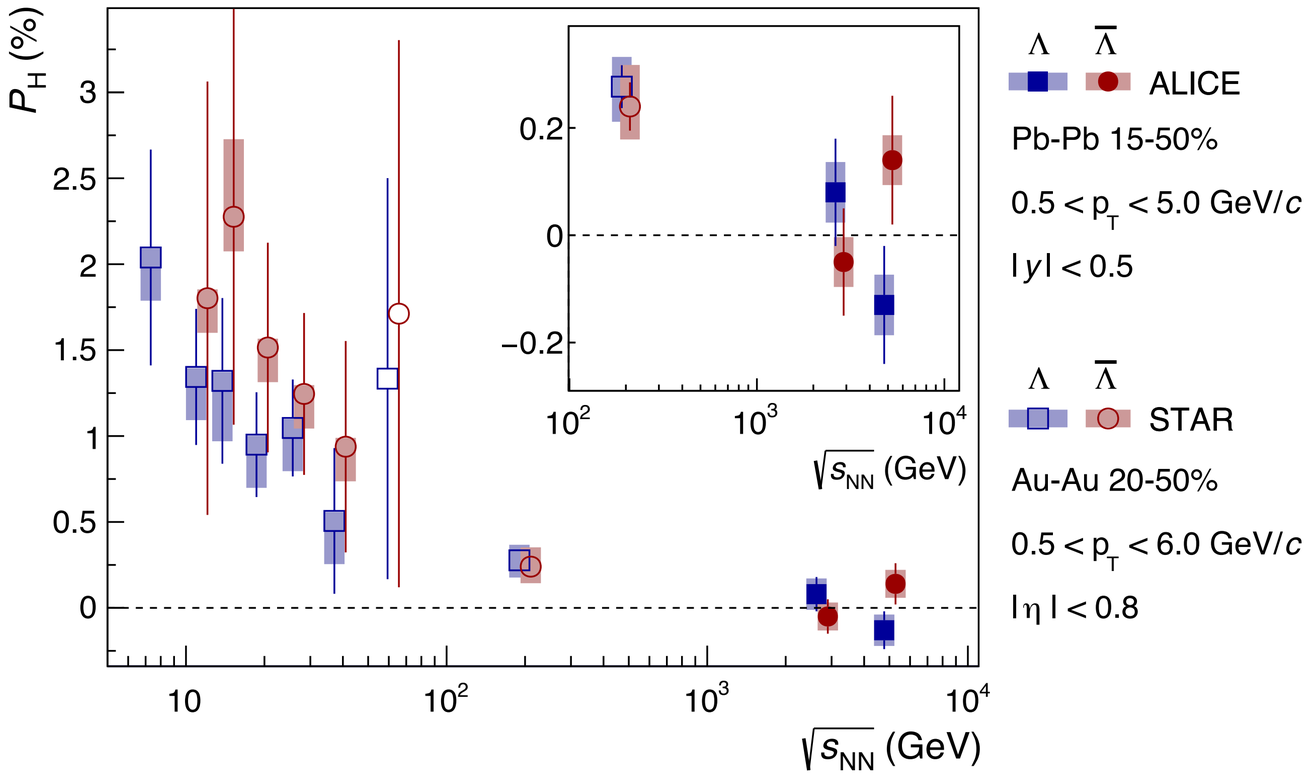
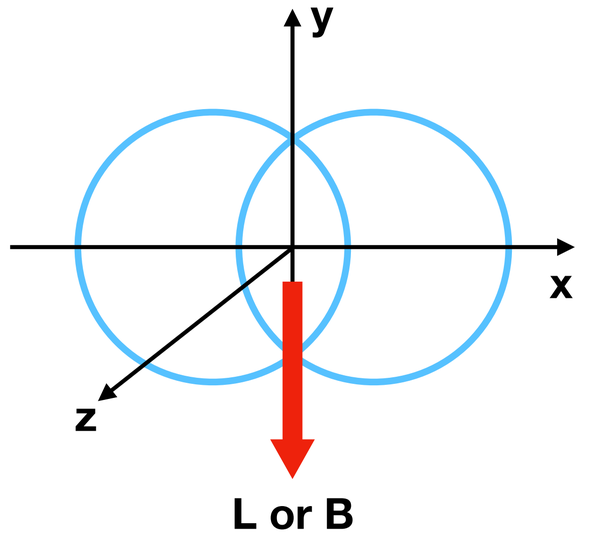




$$\zeta = (s+1)\omega/(3T)$$

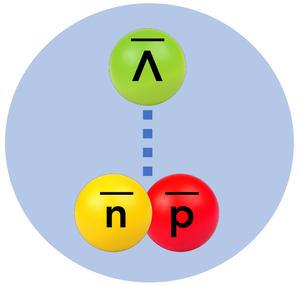
$$\omega = 1/2(\Delta \times v)$$

- **Polarisation compatible with zero**
- Results compatible with empirical extrapolation relating the global polarisation to the system vorticity

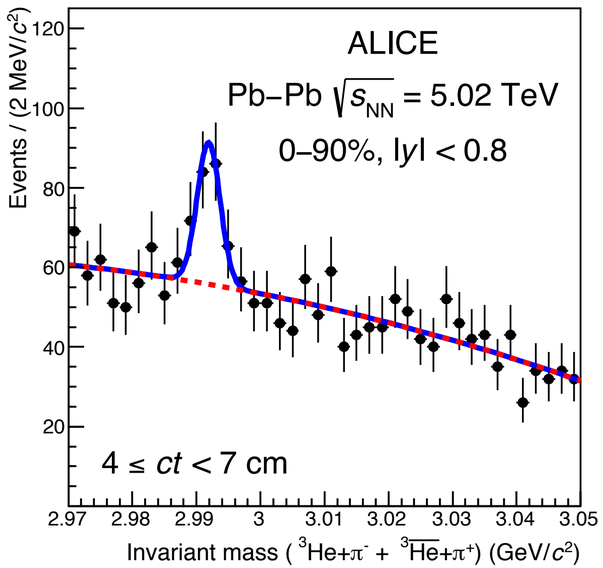
(anti-)hypertriton lifetime measurement in Pb-Pb at 5 TeV

arXiv: 1907.06906

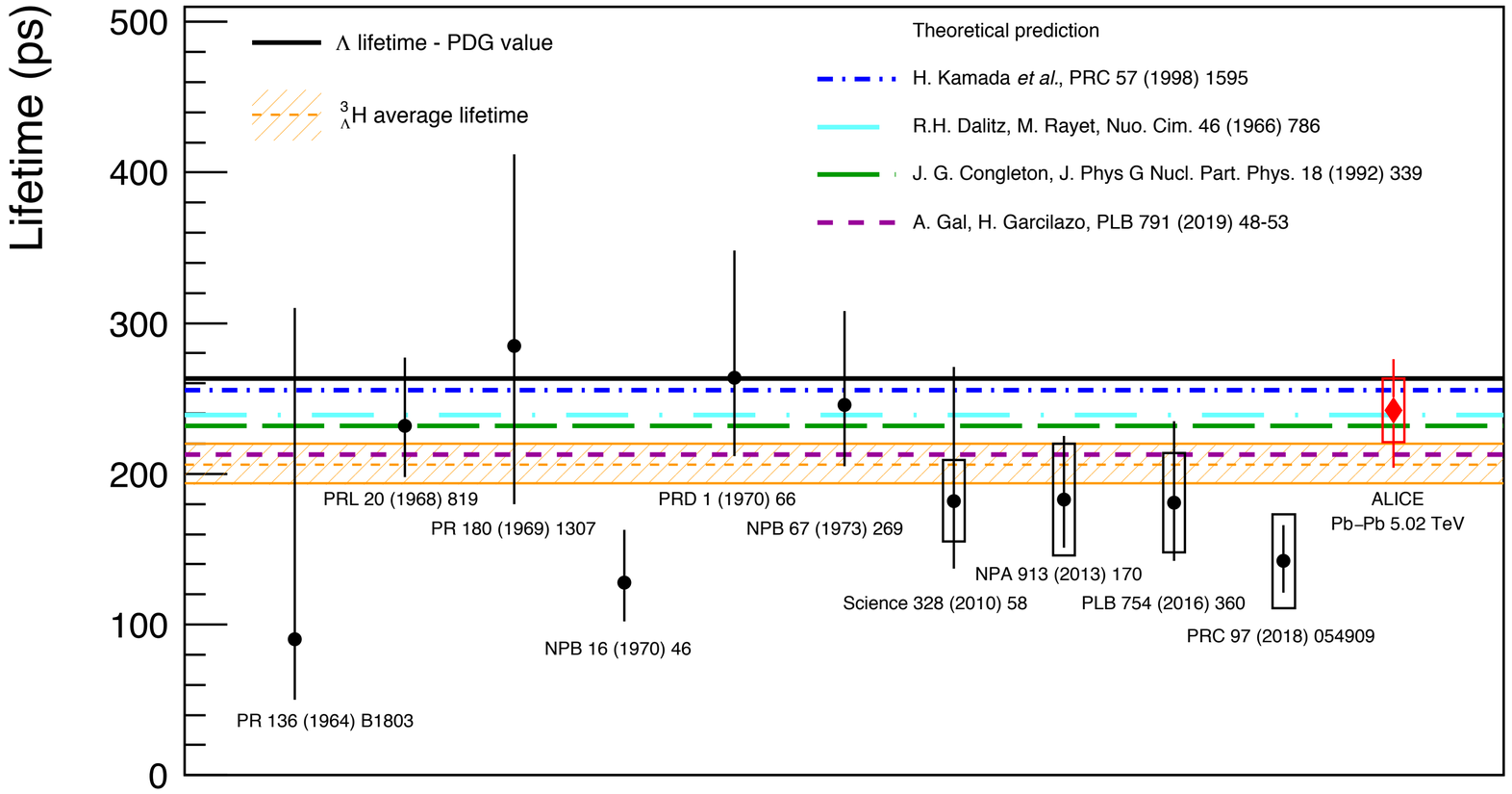
- Properties of exotic nuclei sensitive to hyperon-nucleon interaction potentials: relevant to astrophysics



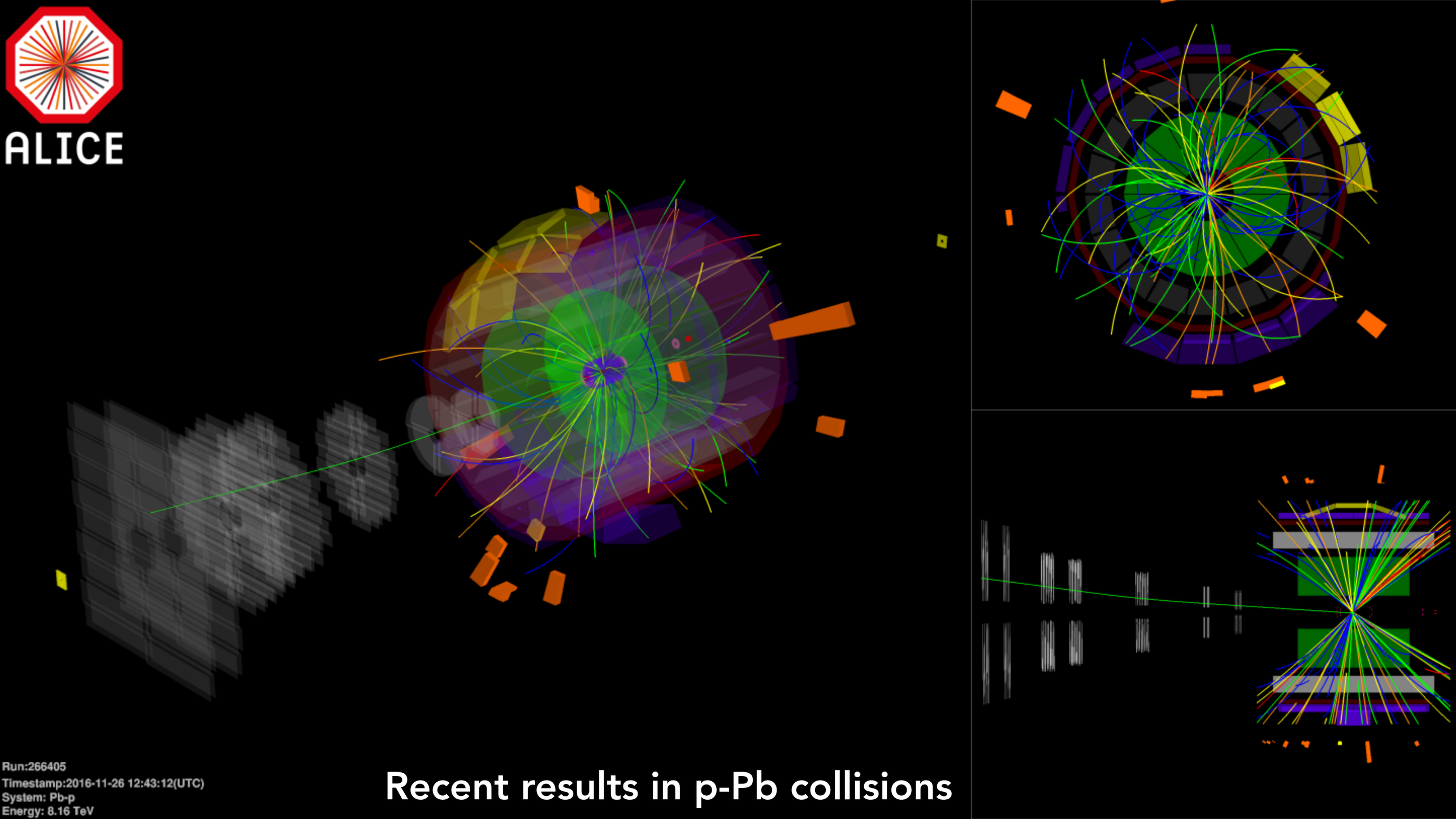
anti-hypertriton



$$^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-}$$



- **ALICE measurement agrees with the different theoretical predictions and with the Λ lifetime**
- With Runs-3 and 4 data: expected ALICE precision ~1% and measurement of higher states



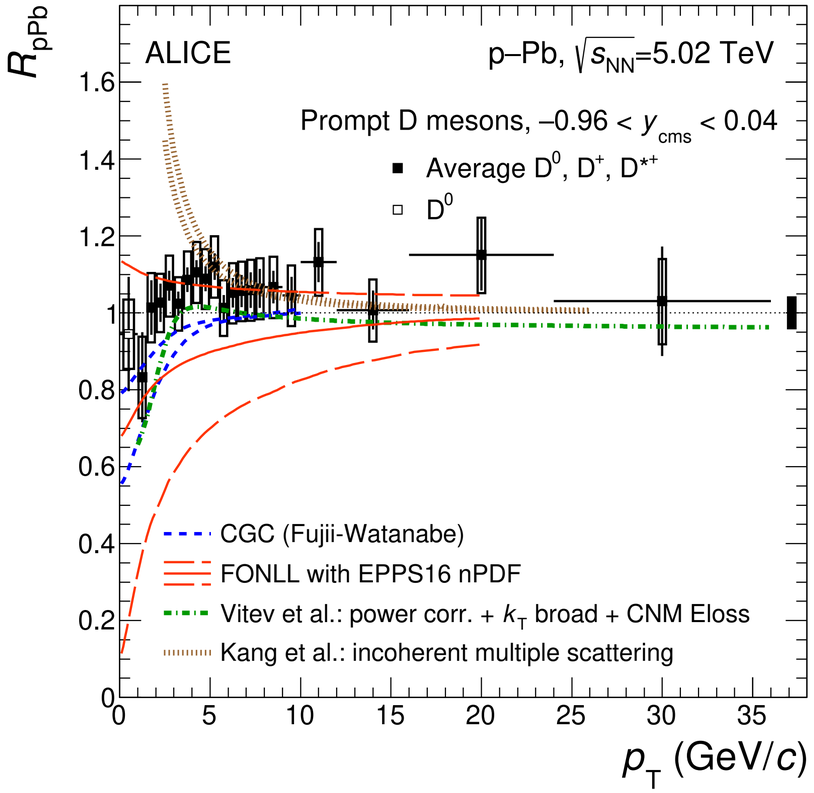
Recent results in p-Pb collisions

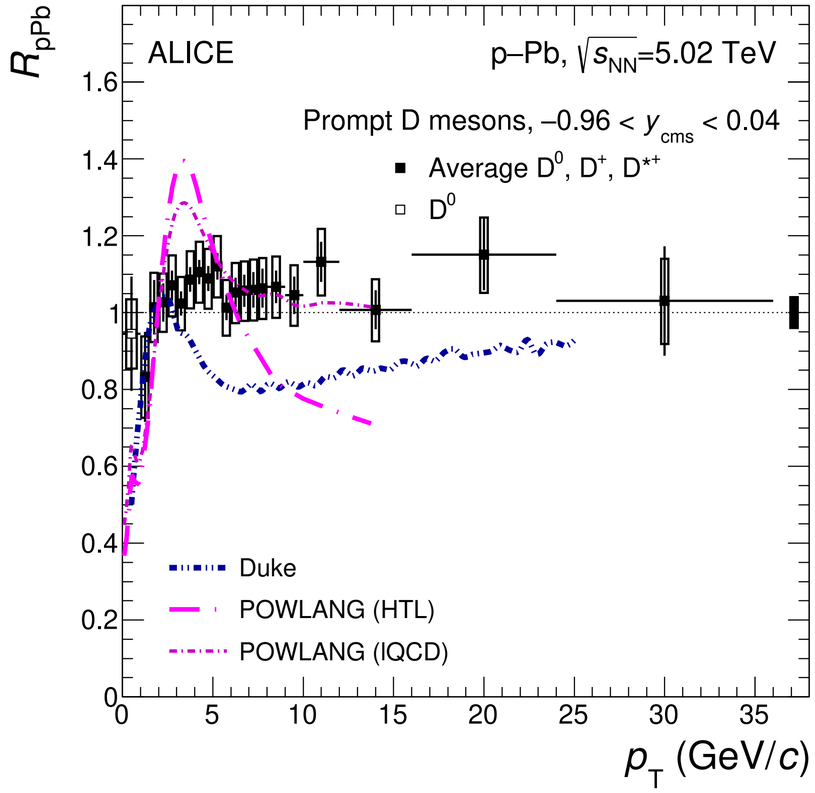
Prompt open-charm production in p-Pb at 5.02 TeV

arXiv: 1906.03425

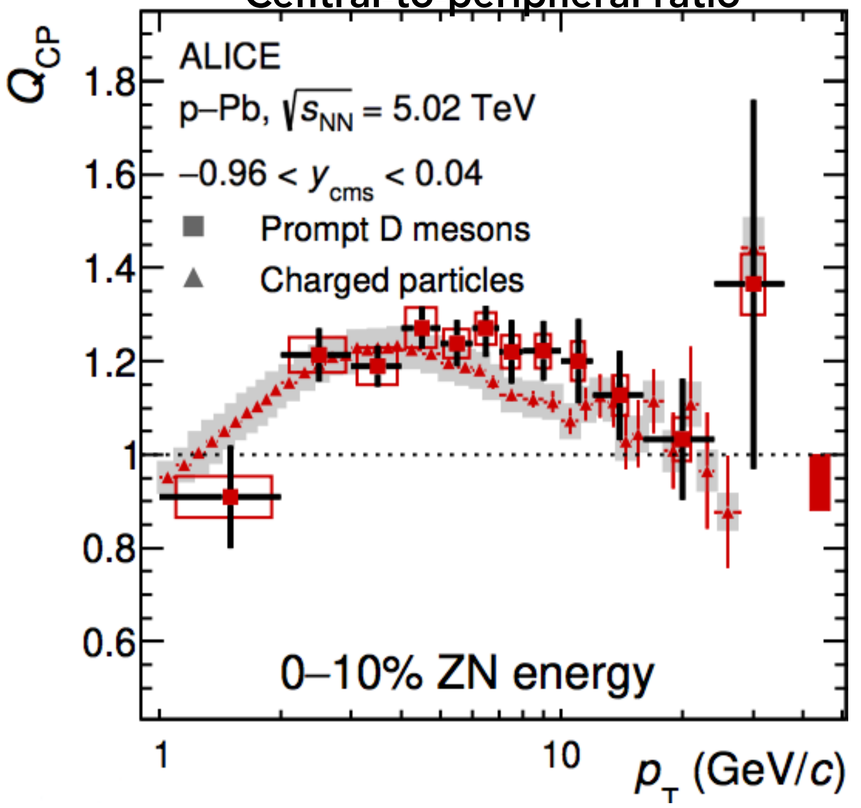
- Measurement in p-A collisions as baseline for initial state effects (e.g gluon shadowing) in A-A
- Final state effects in p-A (e.g energy loss, radial flow) ?

Nuclear modification factor





Central-to-peripheral ratio



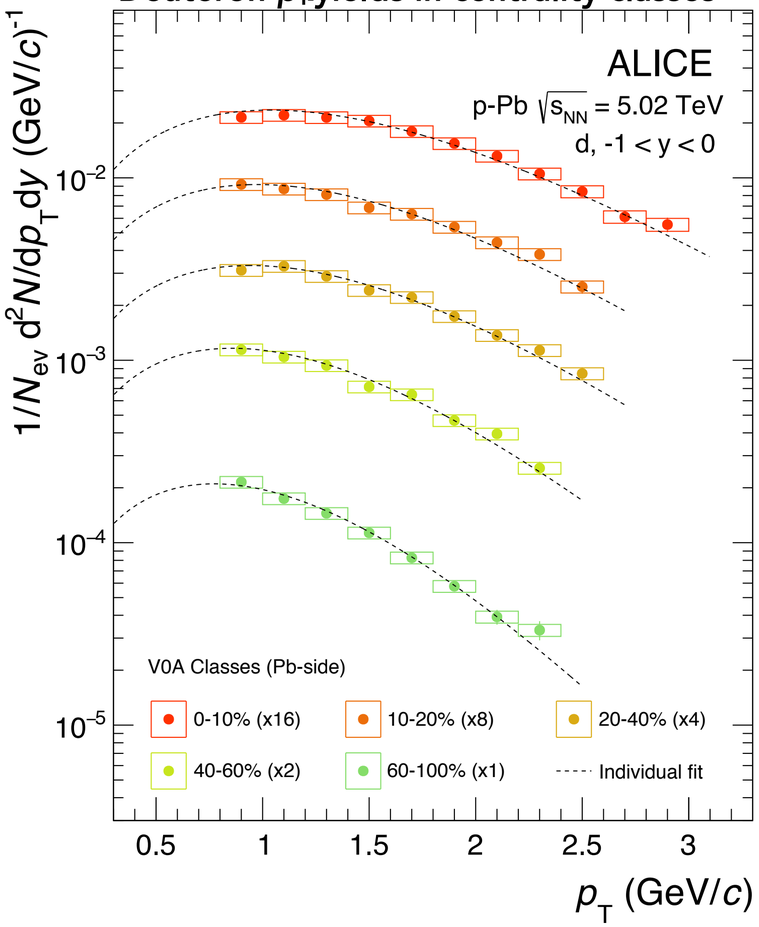
- Models with initial state effects can describe the data
- Models with large energy loss are disfavoured
- The Q_{cp} for D-mesons is compatible with that for charged particle
  - **Enhancement at intermediate p_T suggests radial flow ?**

Multiplicity dependence of light (anti-)nuclei in p-Pb at 5 TeV

arXiv: 1906.03136

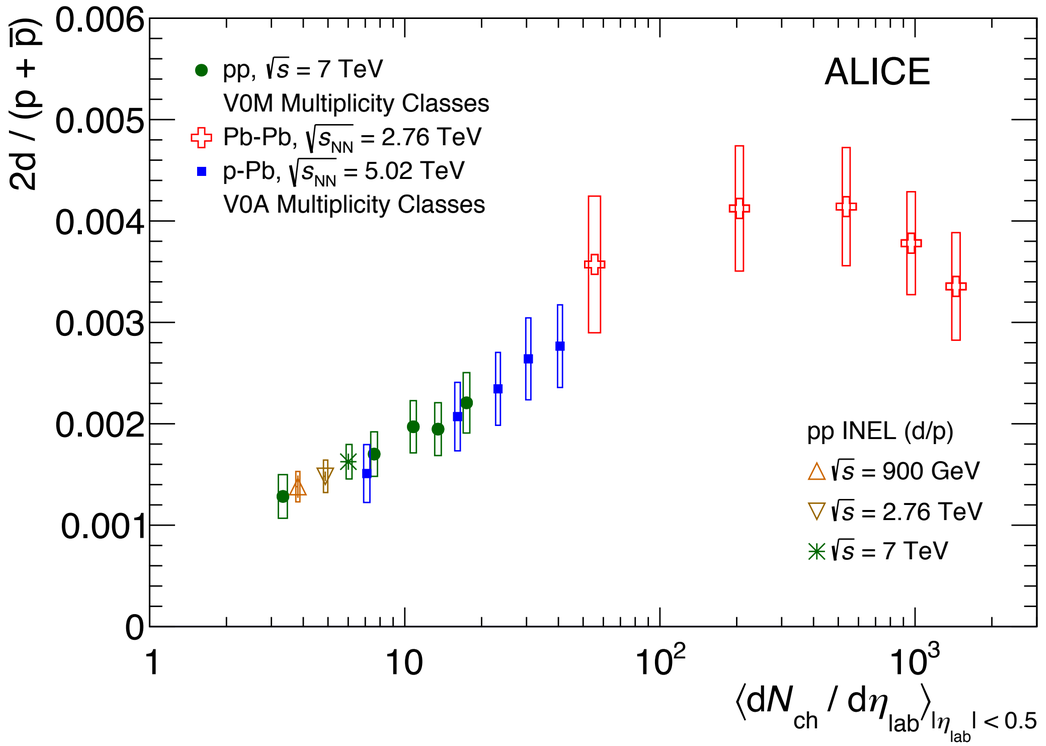
- Understanding the production mechanism provide inputs for background determination in searches for anti-nuclei in space
- Measurement in p-Pb to bridge the available results in pp and Pb-Pb

Deuteron p_T yields in centrality classes



- The spectra of d and $\bar{d}$ harden with increasing multiplicity

Deuteron/proton ratio vs multiplicity



- **p-Pb results at low (high) multiplicity compatible with the pp (Pb-Pb) ones**
  - Pb-Pb: Agreement with thermal models
  - p-Pb, pp: Qualitatively agree with expectations from coalescence models

Multiplicity dependence of light (anti-)nuclei in p-Pb at 5 TeV

arXiv: 1906.03136

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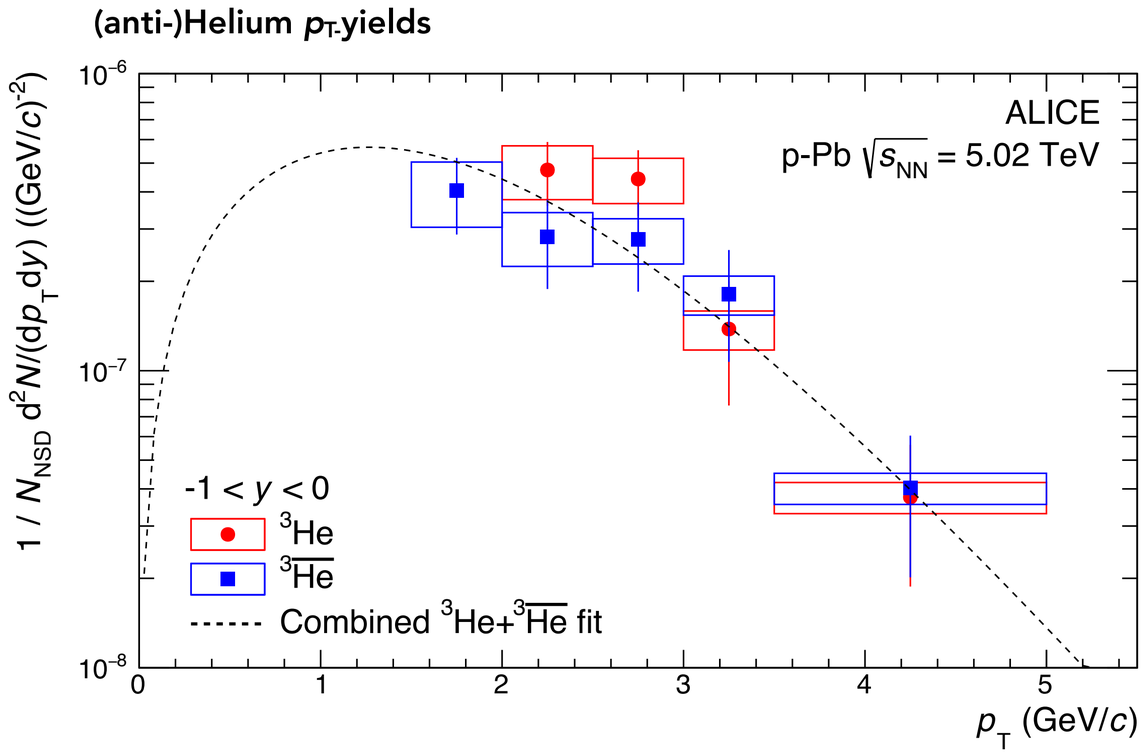
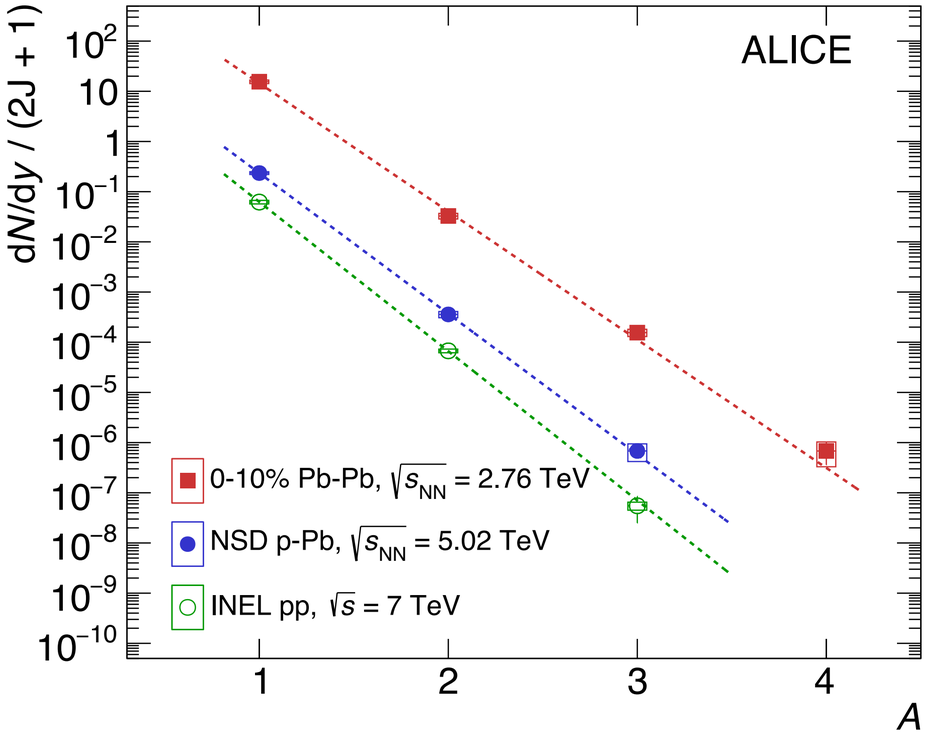
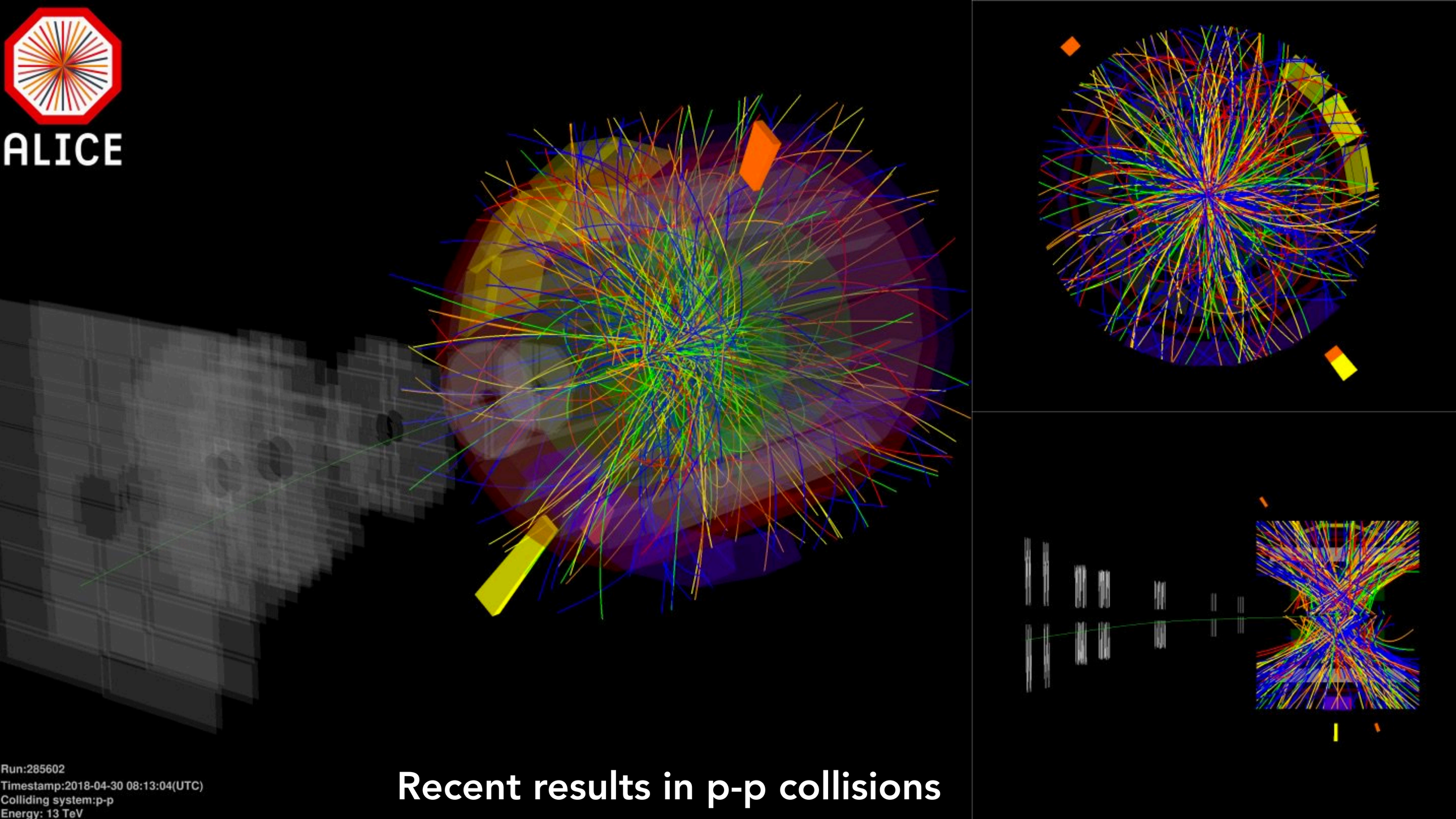




- More ^{3}He differential results expected when exploiting the whole Run-2 data samples
- Exponential decrease vs A with different slopes
- Penalty factor = yield reduction for every extra nucleon: 942±107, 635±90, 359±41

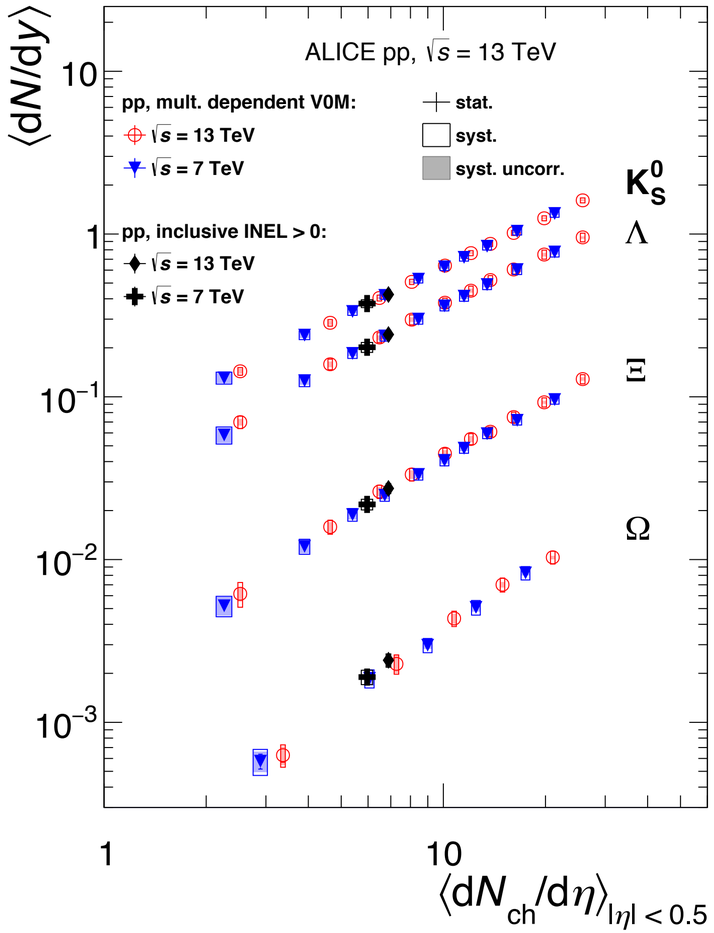


Recent results in p-p collisions

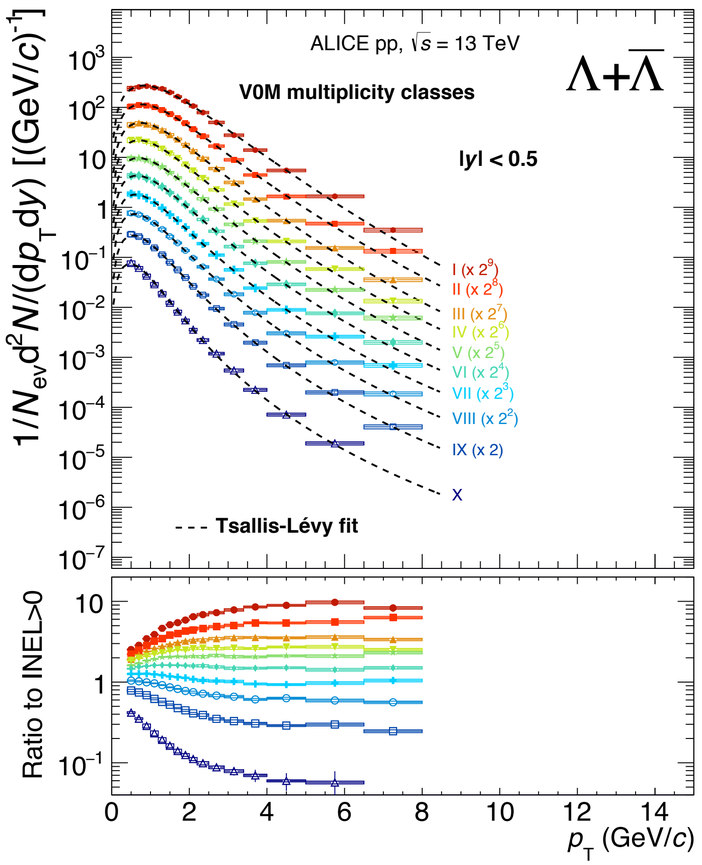
Multiplicity dependence of (multi-)strange hadron in pp at 13 TeV

arXiv: 1908.01861

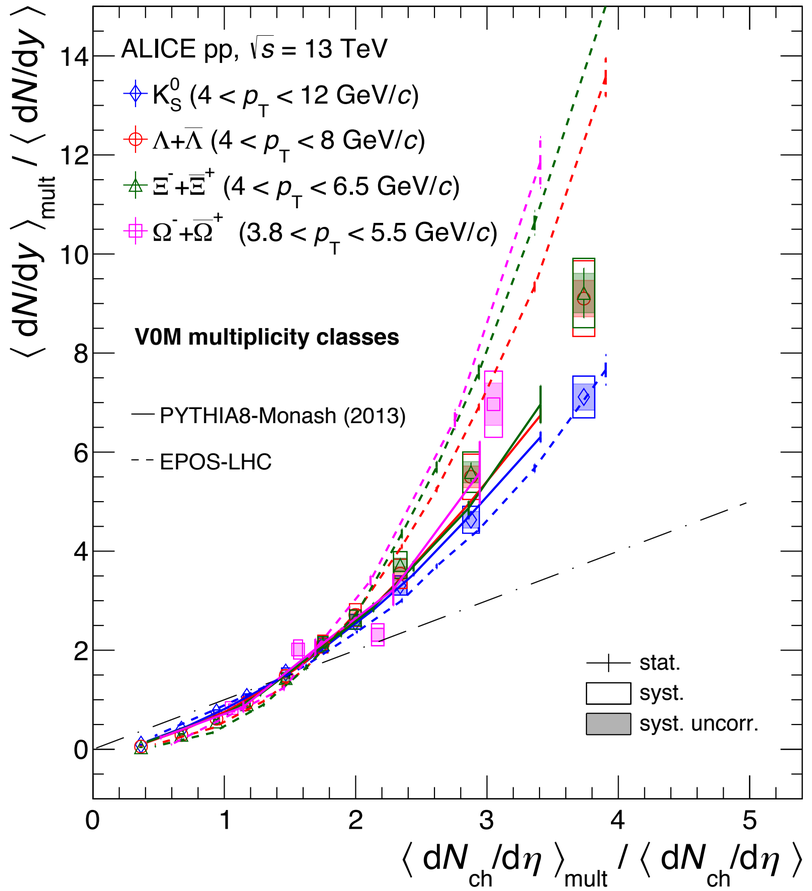
Strange-hadron total yields vs multiplicity: 7 and 13 TeV



p_T-yields for different multiplicities



Self-normalised yields: Strange-hadron vs charged particle at high p_T (> 4 GeV/c)

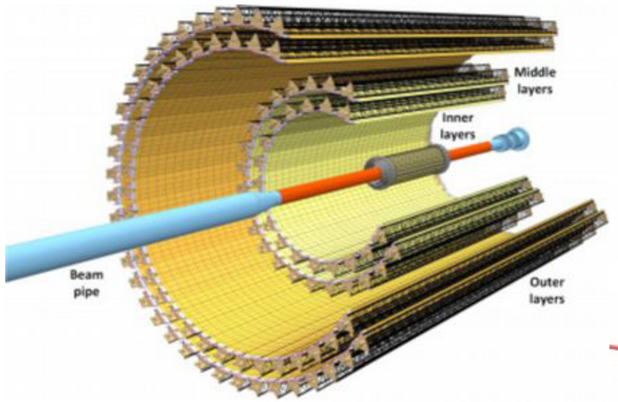


- The p_T spectra harden with increasing multiplicity
- At high-*p*T, strange hadron yields increase (non-linearly) faster than charged particle vs multiplicity
- **Strangeness-content driven by multiplicity, not collision energy**

LS2 ALICE upgrade goal

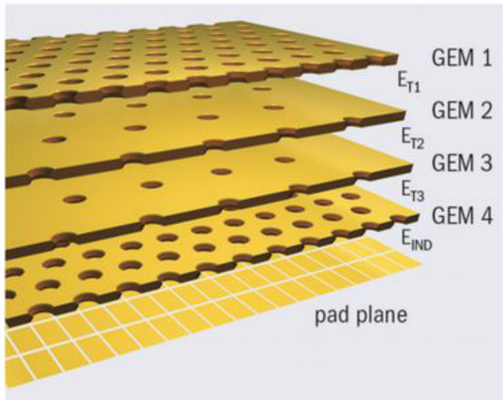
Operation at high interaction rates (50 kHz for Pb-Pb collisions, Run 2 was 8kHz) and continuous (i.e. untriggered) read-out for core detectors

Inner Tracking System

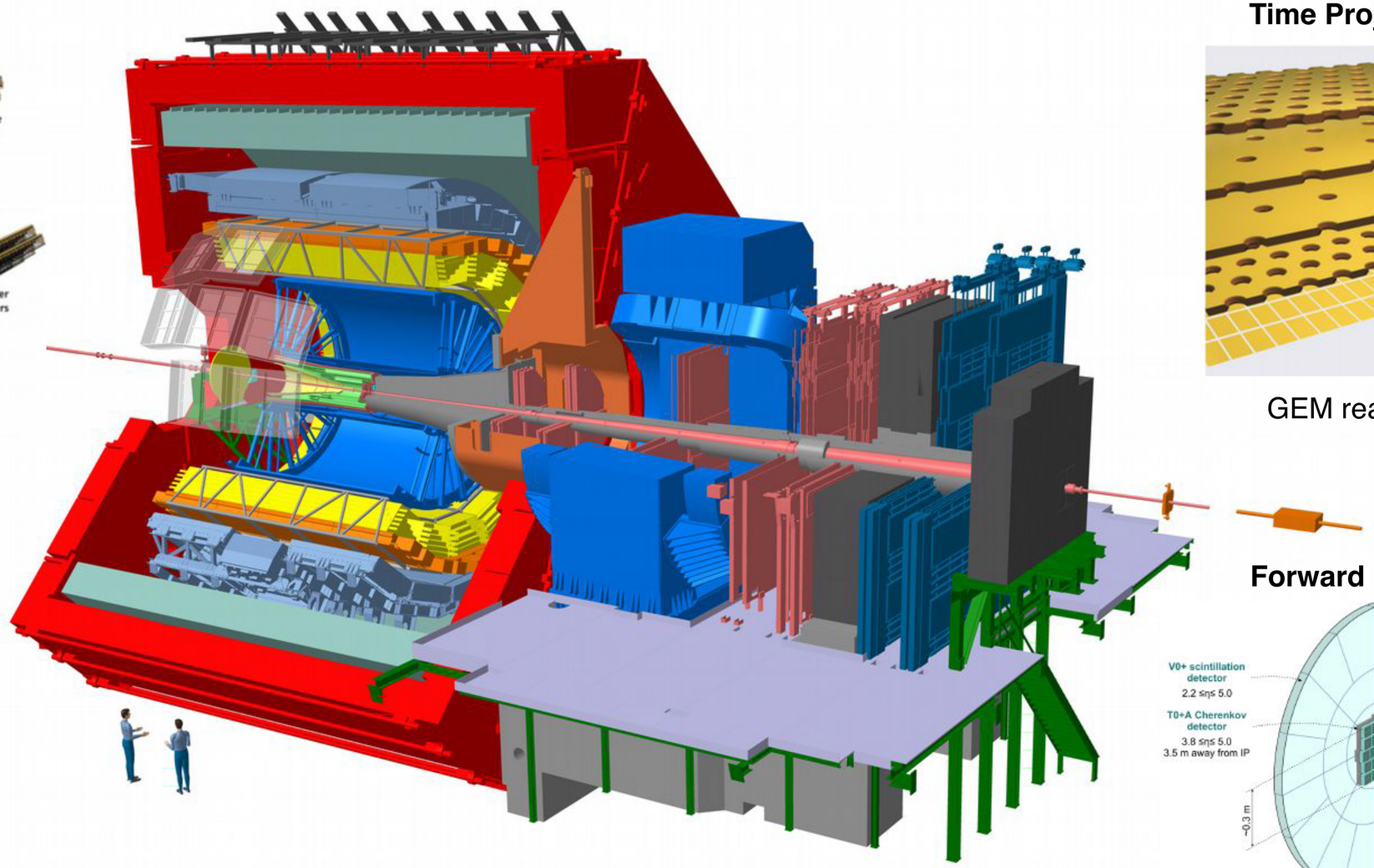


Both based on Monolithic Active Pixel Sensors

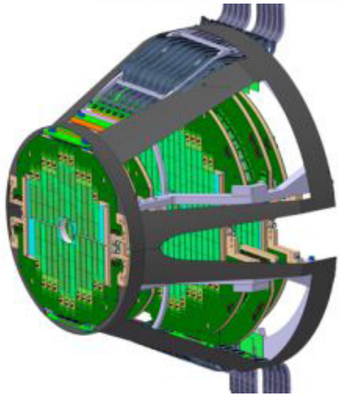
Time Projection Chamber



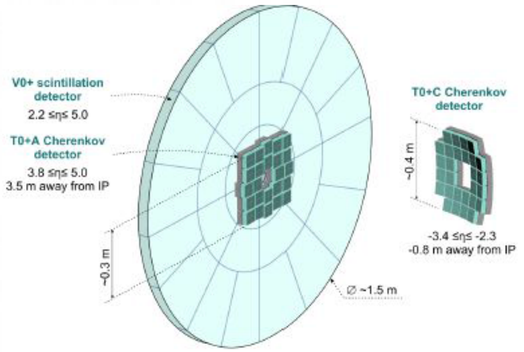
GEM readout chambers



Muon Forward Tracker

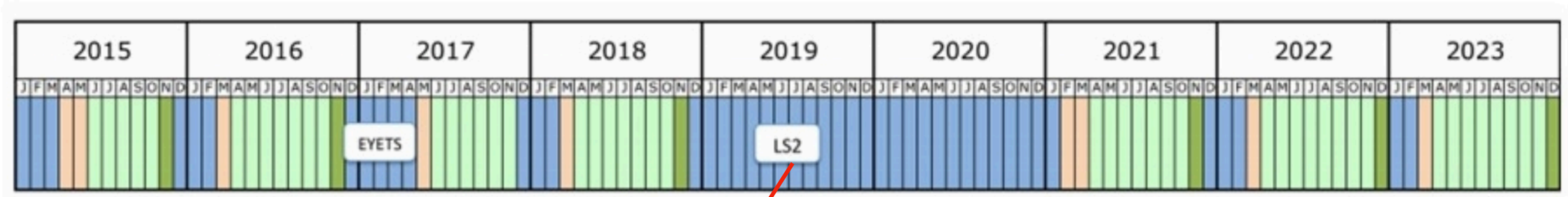


Forward Interaction Trigger



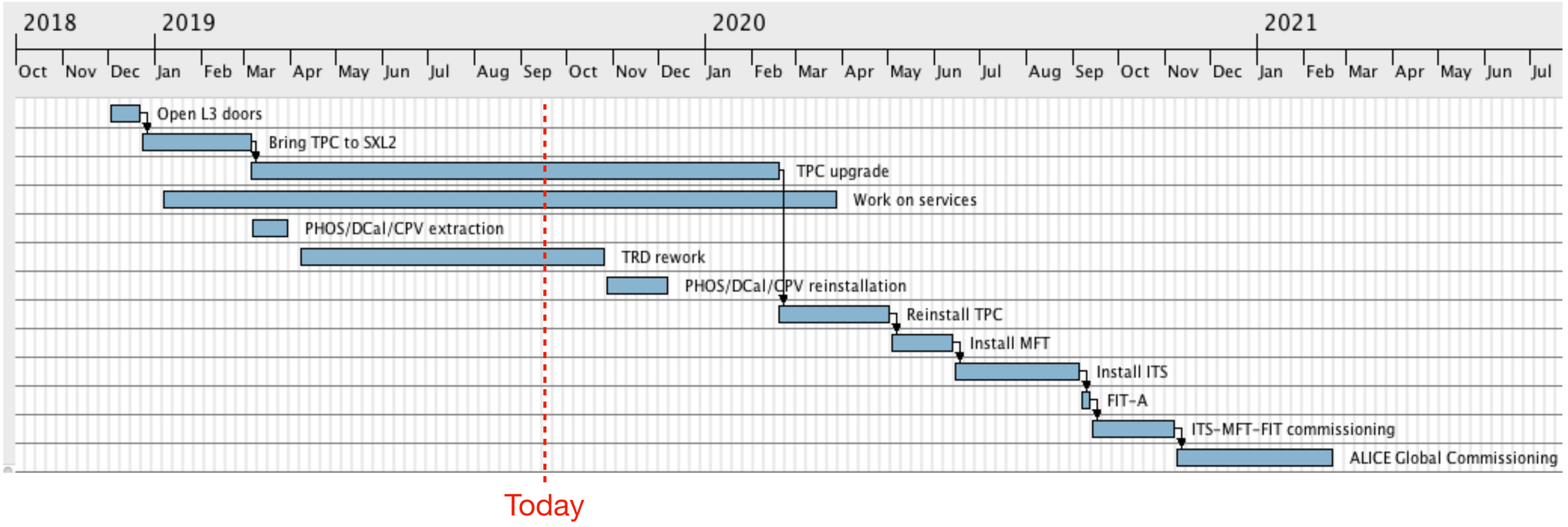
To replace the V0 and T0 detector

+ improved readout for calorimeters, TOF, TRD, Muon arm, ZDC
+ new Central trigger Processor
+ new DAQ and Online-Offline System (O^2)



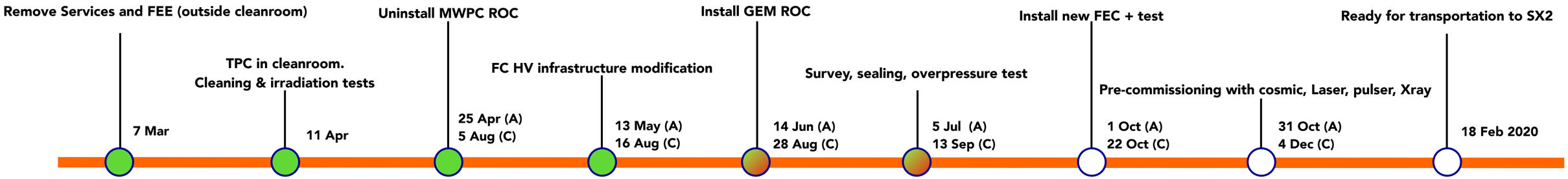
Run2 : $\mathcal{L}_{integrated}^{Pb-Pb} = 1.0\ nb^{-1}$

Run3: $\mathcal{L}_{integrated}^{Pb-Pb} = 6.0\ nb^{-1}$

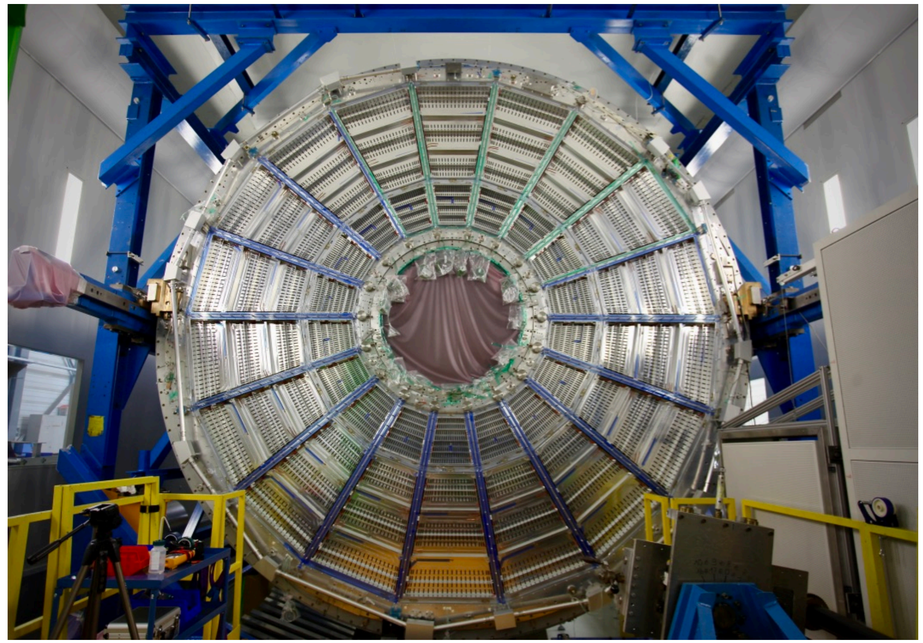


- ALICE is getting ready for the Run-3

TPC upgrade



- Chamber uninstallation on both sides completed successfully



- GEM installation on the A-side completed successfully
- C-side installation to be completed soon

ITS Upgrade: Construction Installation and Commissioning Timeline

ITS.13 May ‘19

ITS.18 Jun ‘19

ITS.14 Sep ‘19

ITS.15 Oct ‘19

ITS.28 June ‘20

Feb ‘21

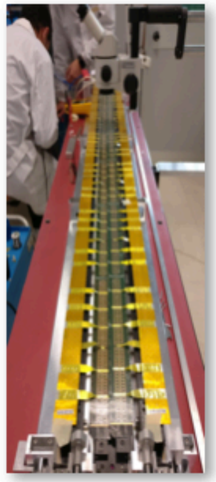
Detector Construction and Assembly

- Module production (ITS.13): completed!
- Stave production (ITS.14): 95% done
  ⇨ continues till Sep 19
- Electronics production (ITS.18): done!

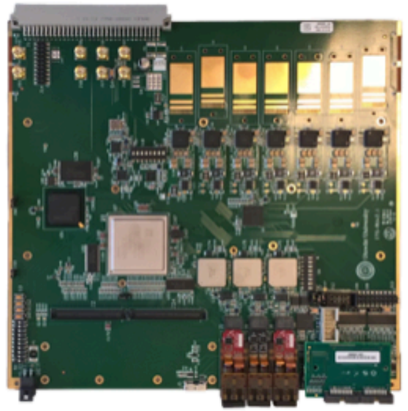
Assembly and Commissioning

Commissioning on ground with final services ongoing (operation 24/7)

OB Stave Assembly End (ITS.15): >75% done

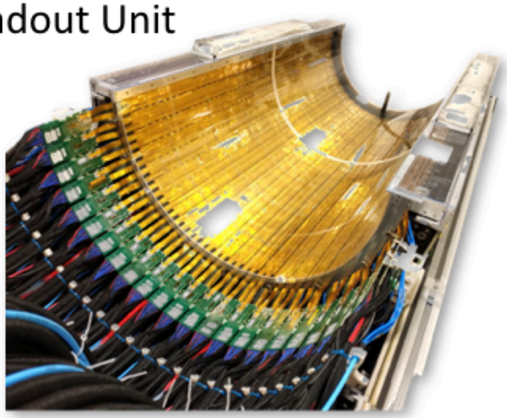


Stave



Readout Unit

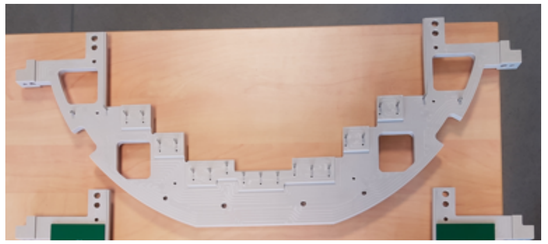
Inner Barrel Assembly



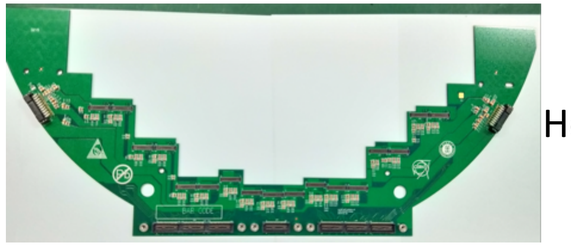
Outer Barrel Assembly

Muon Forward Trigger (MFT) and Fast Interaction Trigger (FIT)

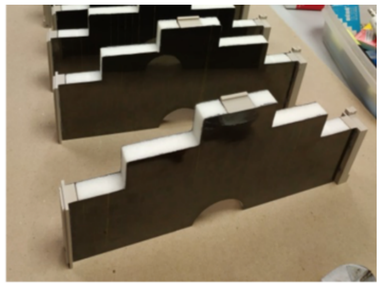
MFT disk production process:



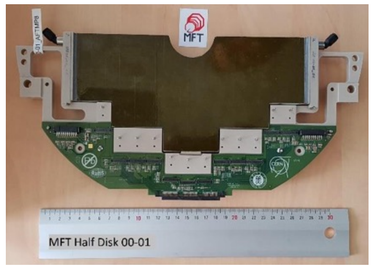
Disk support: production completed

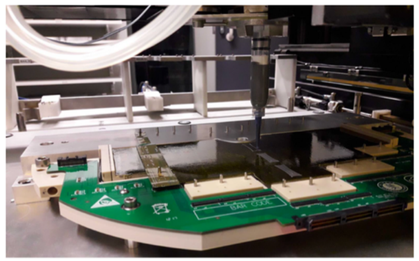


Heat exchanger: production completed



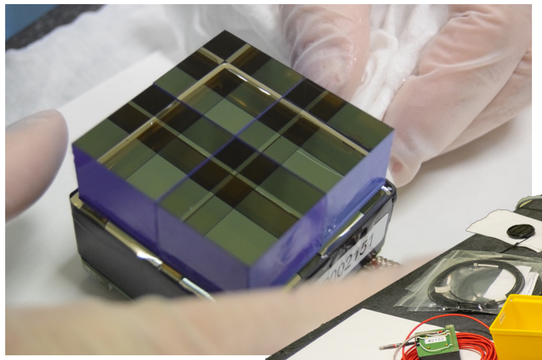
Disk PCB: production completed





Gluing ladders on disk: ongoing

FIT: New trigger setup to benefit from the LHC increasing luminosity



FT0C assembly at CERN in the Departmental Silicon Facility July 2019

- FT0C array is now fully assembled, tested, and ready for integration with MFT

ITS3 upgrade proposal for LS3

ALICE-PUBLIC-2018-013

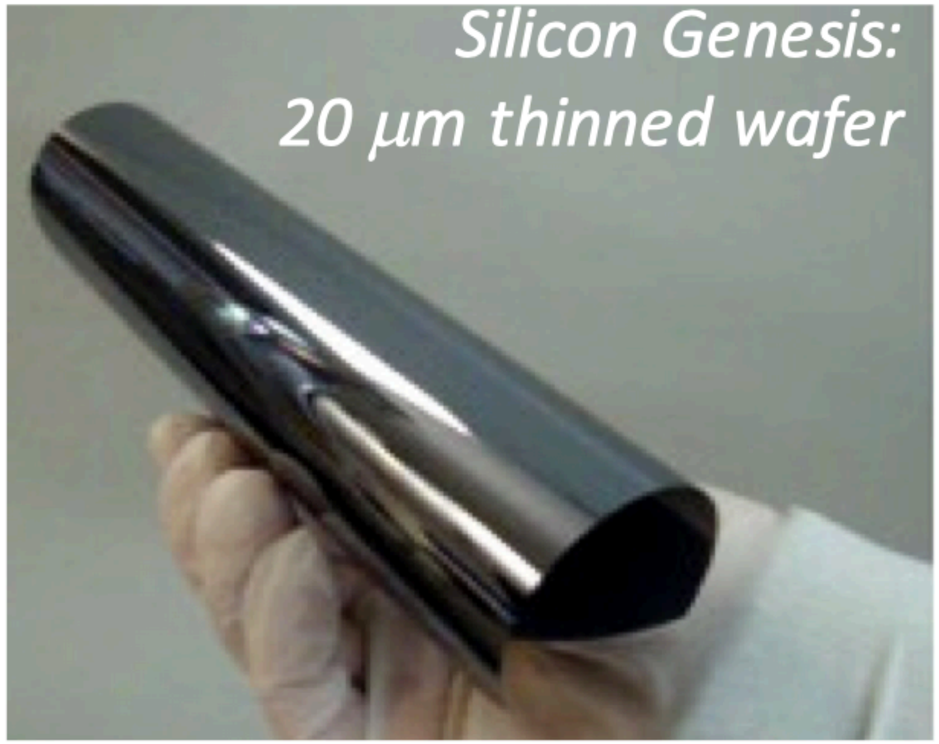
Letter of Intent for an ALICE ITS Upgrade in LS3

ALICE Collaboration, CERN, Geneva, Switzerland

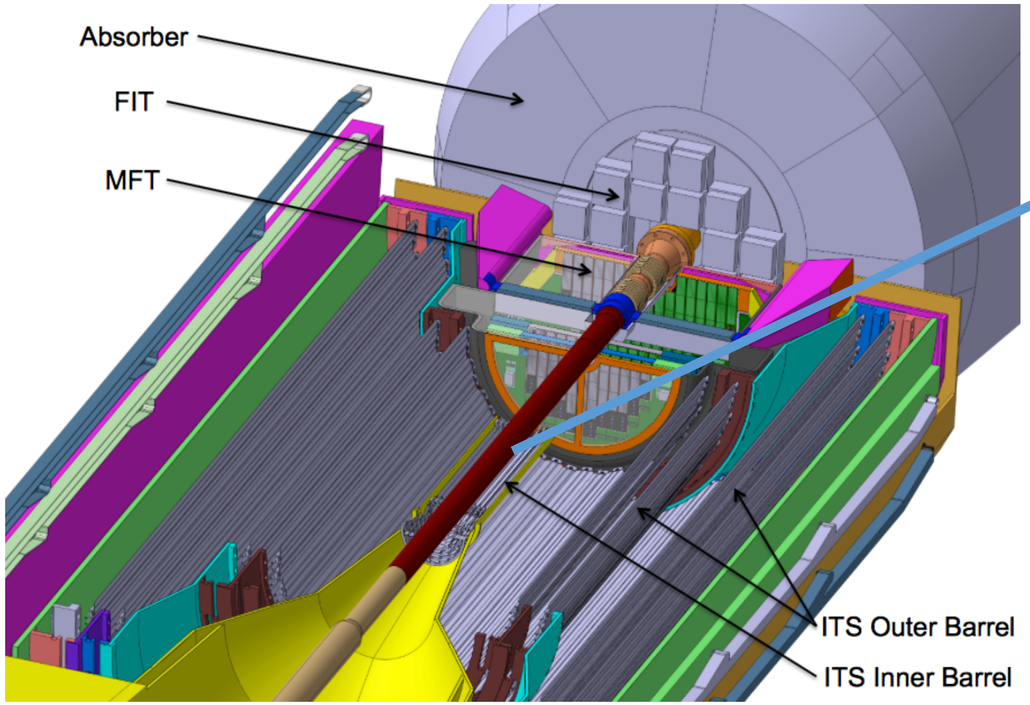
Abstract

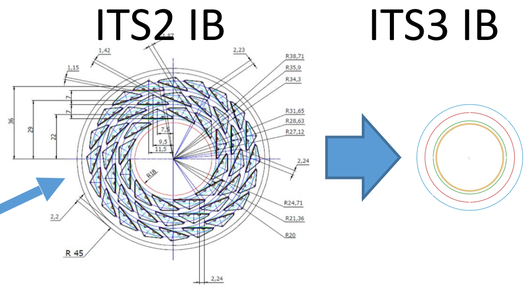
Recent innovations in the field of silicon imaging technology for consumer applications open extraordinary opportunities for new detector concepts, and hence offer strongly improved physics scope. This document presents a proposal for the construction of a novel vertex detector consisting of curved wafer-scale ultra-thin silicon sensors arranged in perfectly cylindrical layers, featuring an unprecedented low material budget of 0.05 % X_0 per layer, with the innermost layer positioned at only 18 mm radial distance from the interaction point. This new vertex detector is planned to be installed during the LHC LS3 to replace the innermost three layers of the ALICE Inner Tracking System. It will provide a large reduction of the material budget in the region close to the interaction point and a large improvement of the tracking precision and efficiency at low transverse momentum. The combination of these two improvements will lead to a significant advancement in the measurement of low momentum charm and beauty hadrons and low-mass dielectrons in heavy-ion collisions at the LHC, which are among the main objectives of the ALICE physics programme in the next decade.

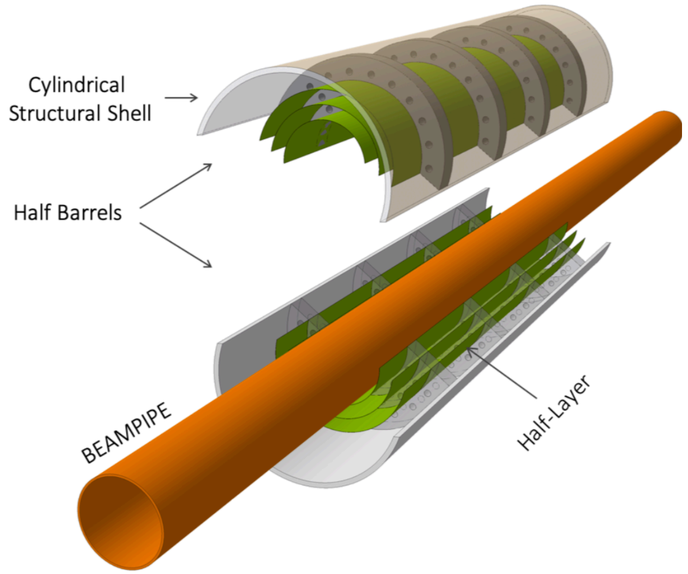
Geneva, Switzerland
September 8, 2019



ITS3 upgrade proposal for LS3



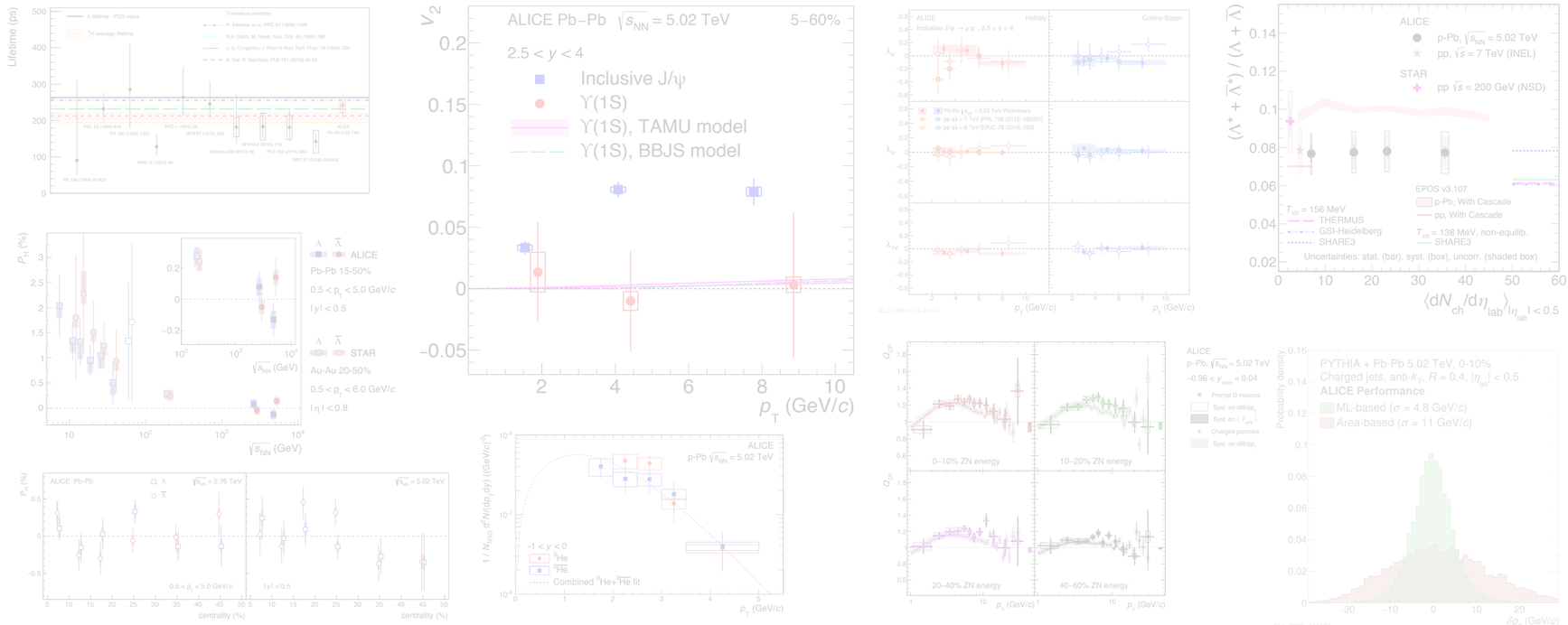




- 3 layers made of ~7x14 cm^2 sensors thinned to ~30 μm
- No water cooling, minimal support structure in acceptance
- **Total material at R < 4 cm: ~1.3% → ~0.3%**
- **Tracking precision improved by a factor ~2**

- Strong benefit for low-mass dielectron measurement (QGP radiation) and low-p_T heavy flavour (QGP transport coefficients and hadronisation dynamics)

Summary



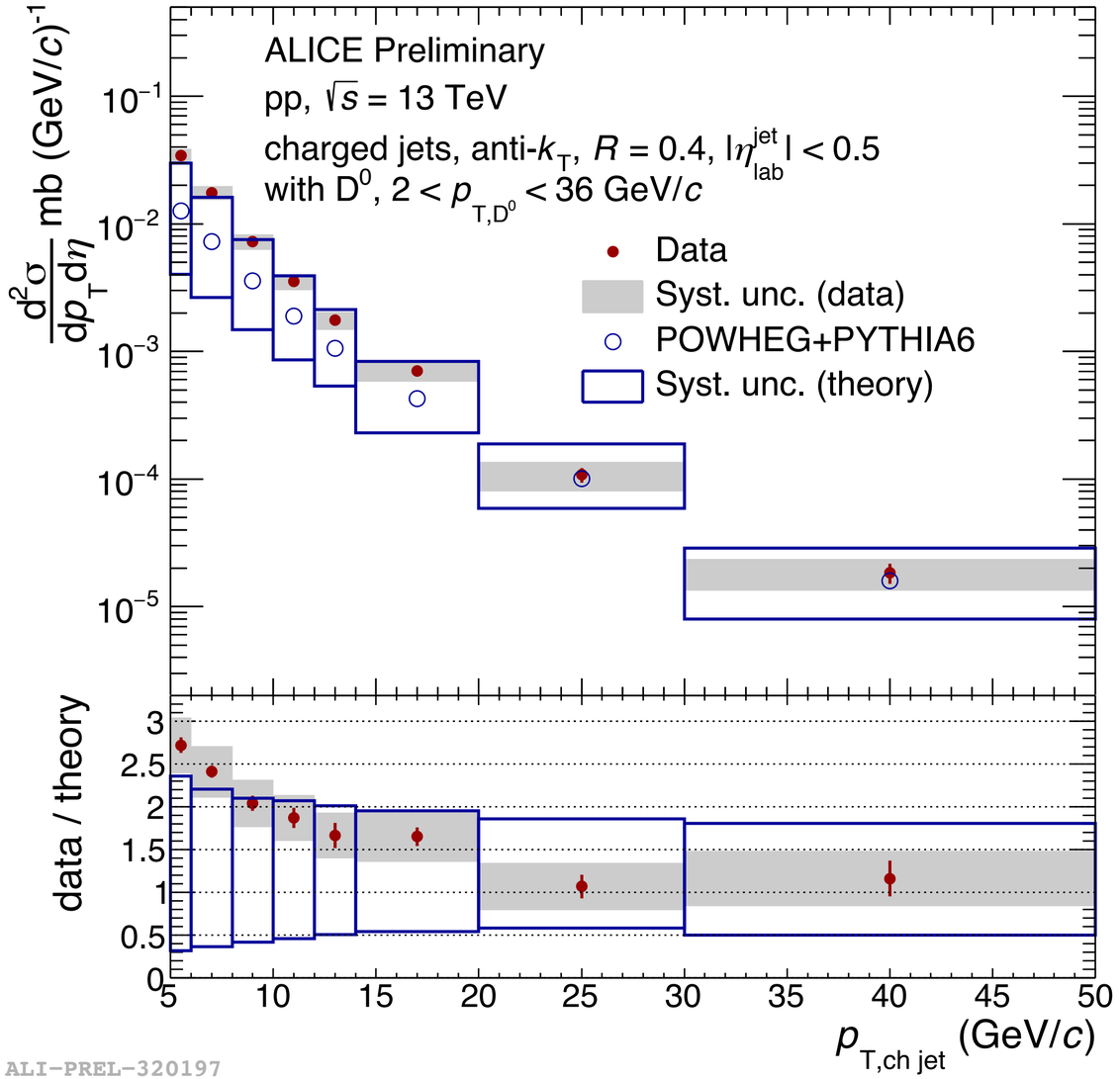
- New results for different observables in different collision systems
  - 2018 Pb-Pb being analysed: new results on charmed baryons and upsilon flow
  - More results in preparation for the next Quark-Matter conference
- ALICE LS2 activities are progressing on track
- Plan for a new detector (ITS3) to improve the tracking precision

Extra slides

D-tagged jet in pp at 13 TeV

NEW Preliminary

- Measurement of D-tagged jet (containing fully reconstructed D-hadron) is powerful tool to study charm fragmentation



- w.r.t 1905.02510 at 7 TeV
  - D^0 p_T down to 2 GeV/c (3 GeV/c)
  - Jet p_T up to 50 GeV/c (30 GeV/c)

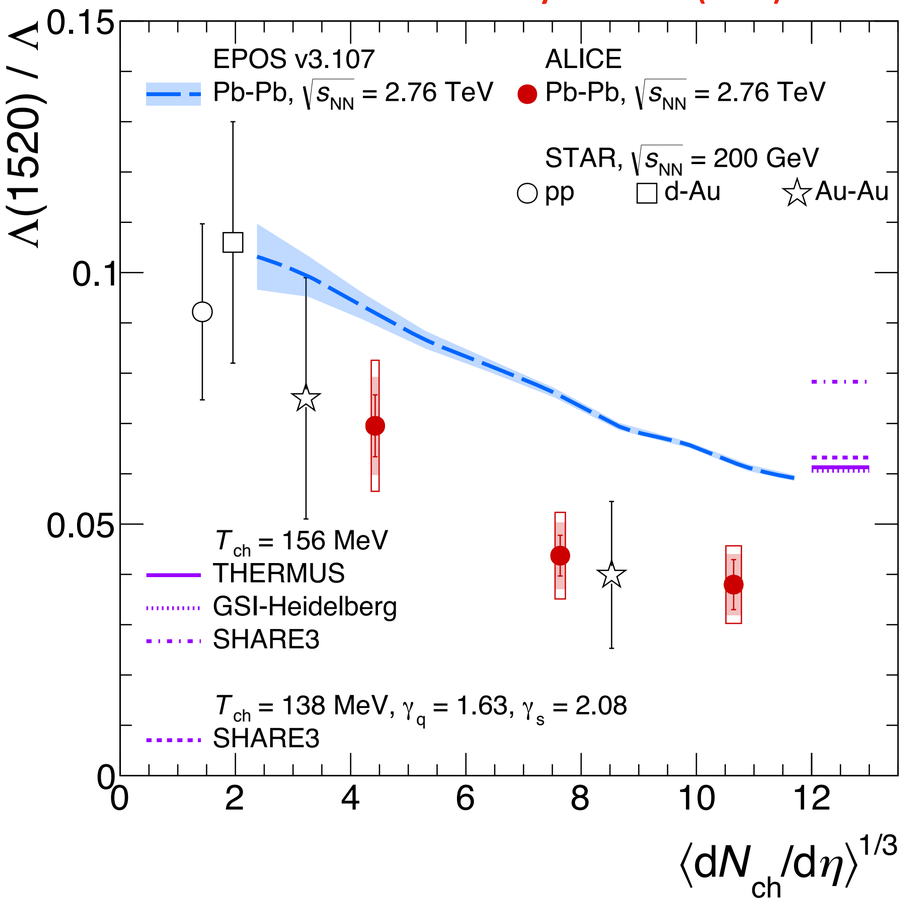
- POWHEG+PYTHIA6 describes reasonably well the differential cross section
  - Better agreement at higher p_T
  - Ongoing work on the momentum fraction carried by the D-hadrons.

Λ* measurement in pp and p-Pb at 5.02 TeV

arXiv: 1909.00486

- Λ*/Λ is suppressed in central Pb-Pb collisions with respect to peripheral ones
  - The suppression is larger than the predictions
  - Measurement in pp and p-Pb serving as baseline for Pb-Pb measurements

Phys.Rev. C99 (2019) 024905



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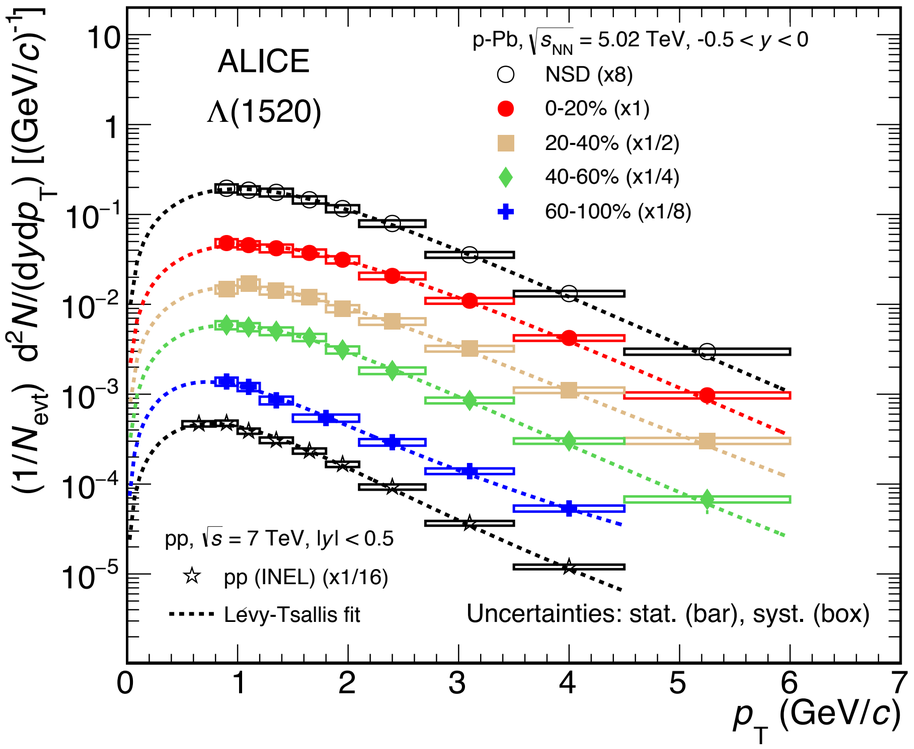

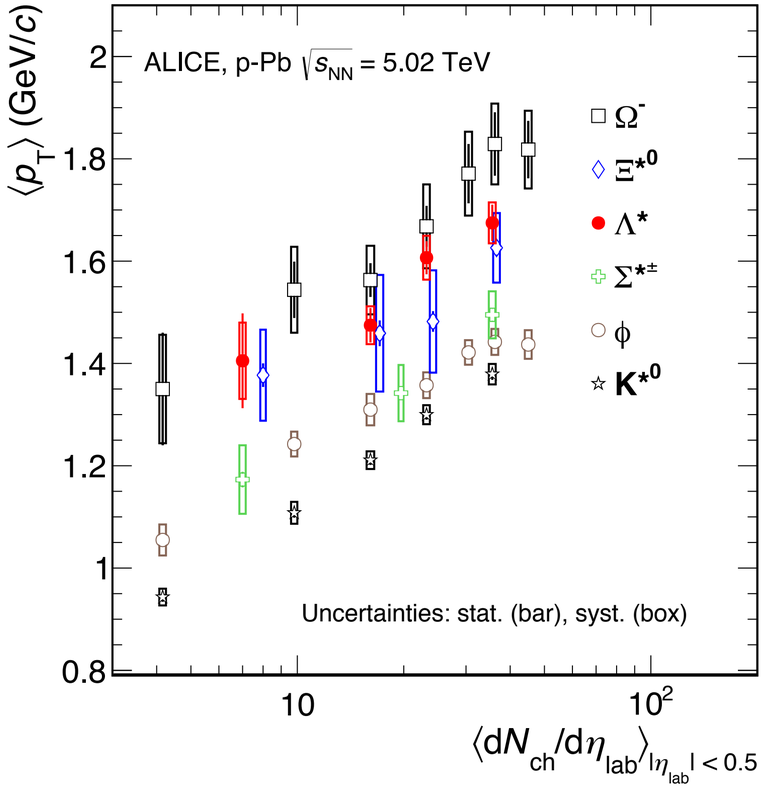

- In p-Pb, the increase of <p_T> with multiplicity is similar to the ones of other light hadrons

Λ* measurement in pp and p-Pb at 5.02 TeV

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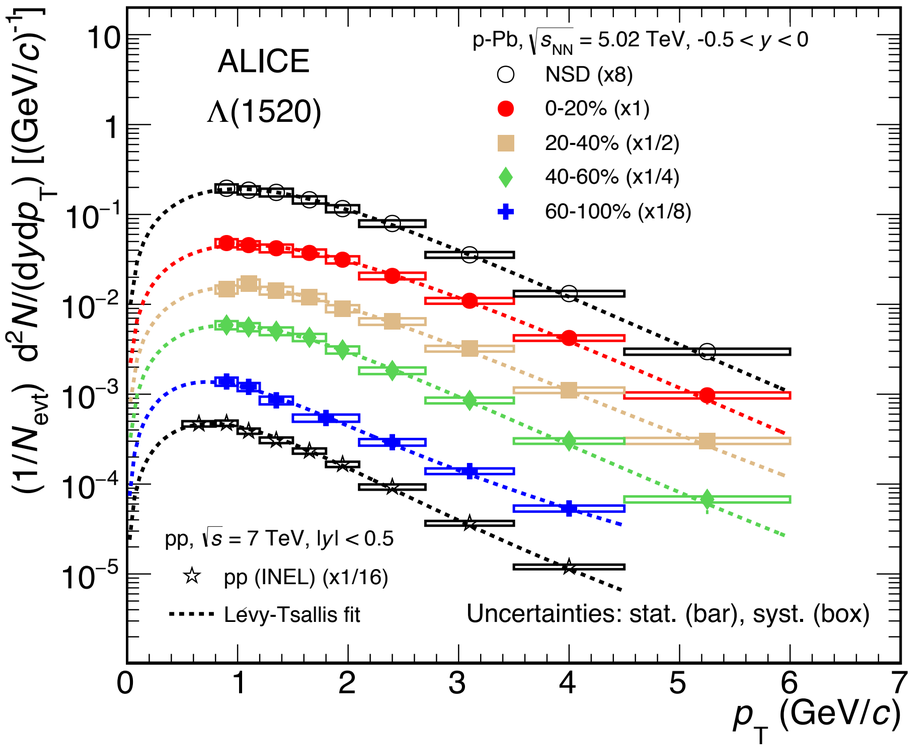

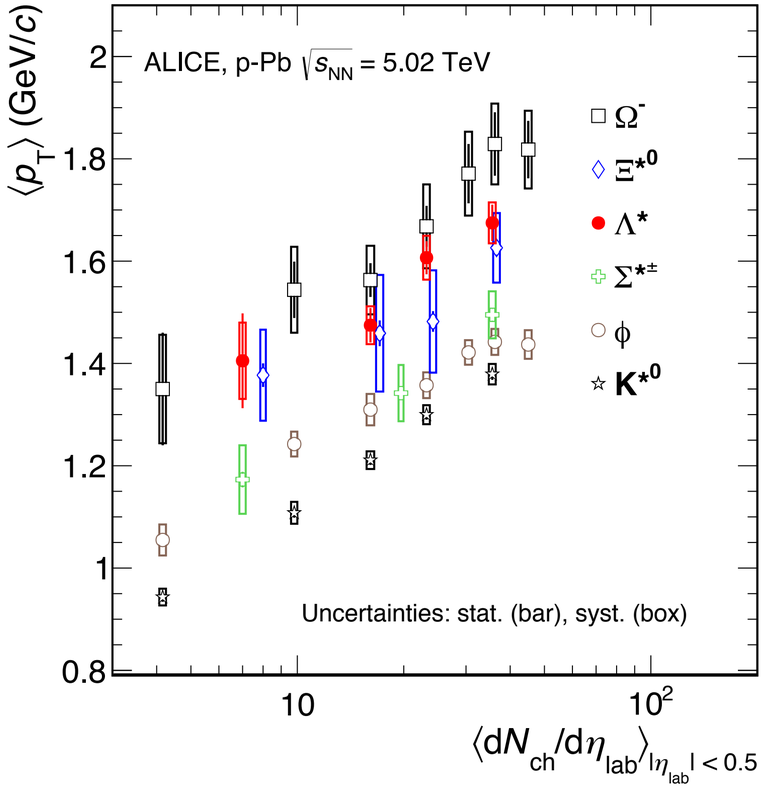

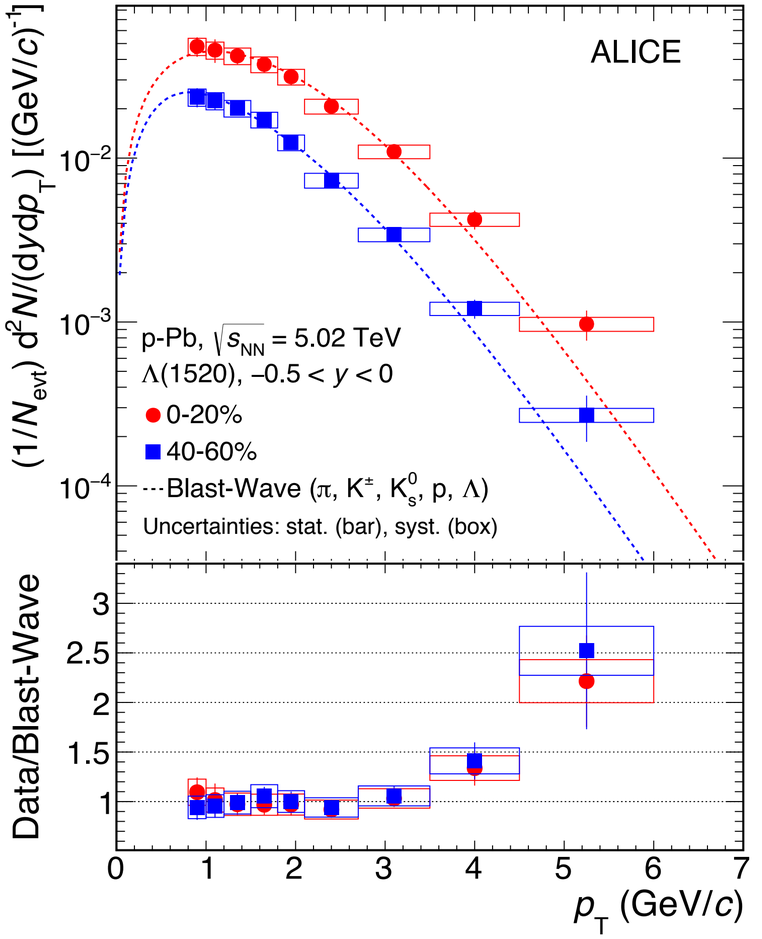

- In p-Pb, the increase of $\langle p_T \rangle$ with multiplicity is similar to the ones of other light hadrons

- Blast-wave model constrained with data of other hadrons can describe the Λ* yield for p_T < 3.5 GeV/c
  - Λ*participates in the same collective radial flow expansion as the other particles

Λ* measurement in pp and p-Pb at 5.02 TeV

arXiv: 1909.00486

- Λ*/Λ is suppressed in central Pb-Pb collisions with respect to peripheral ones
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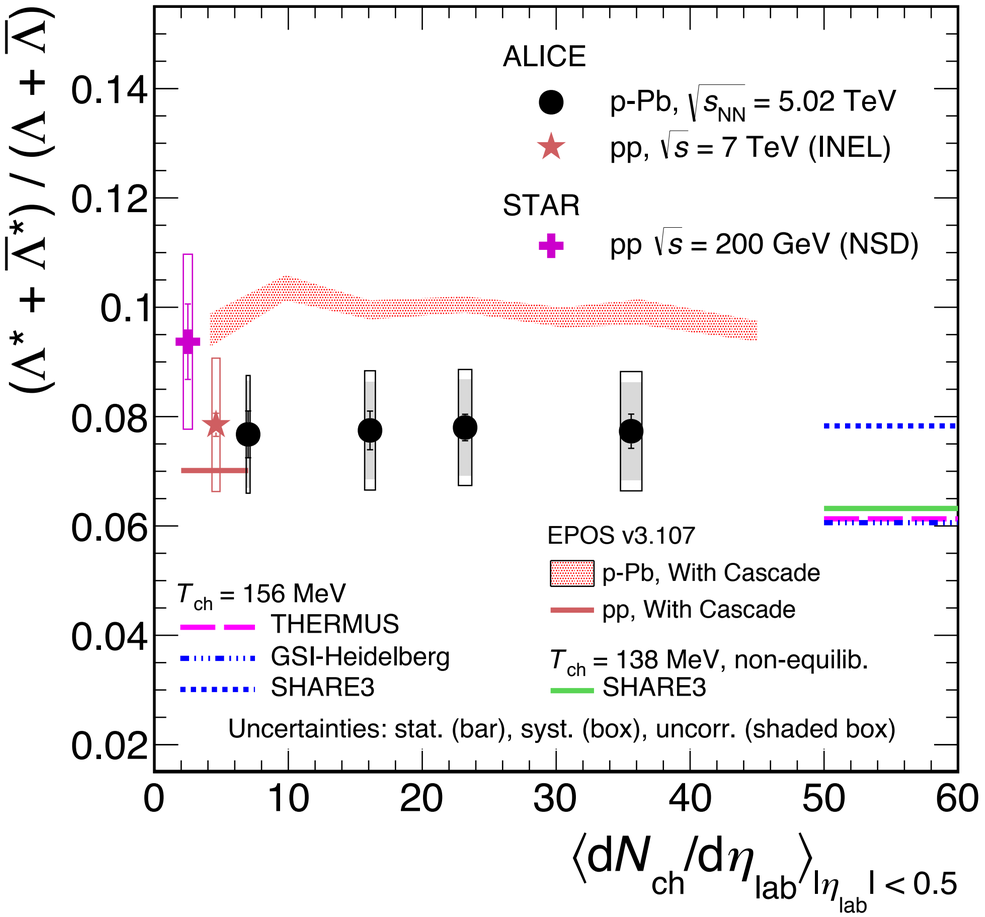

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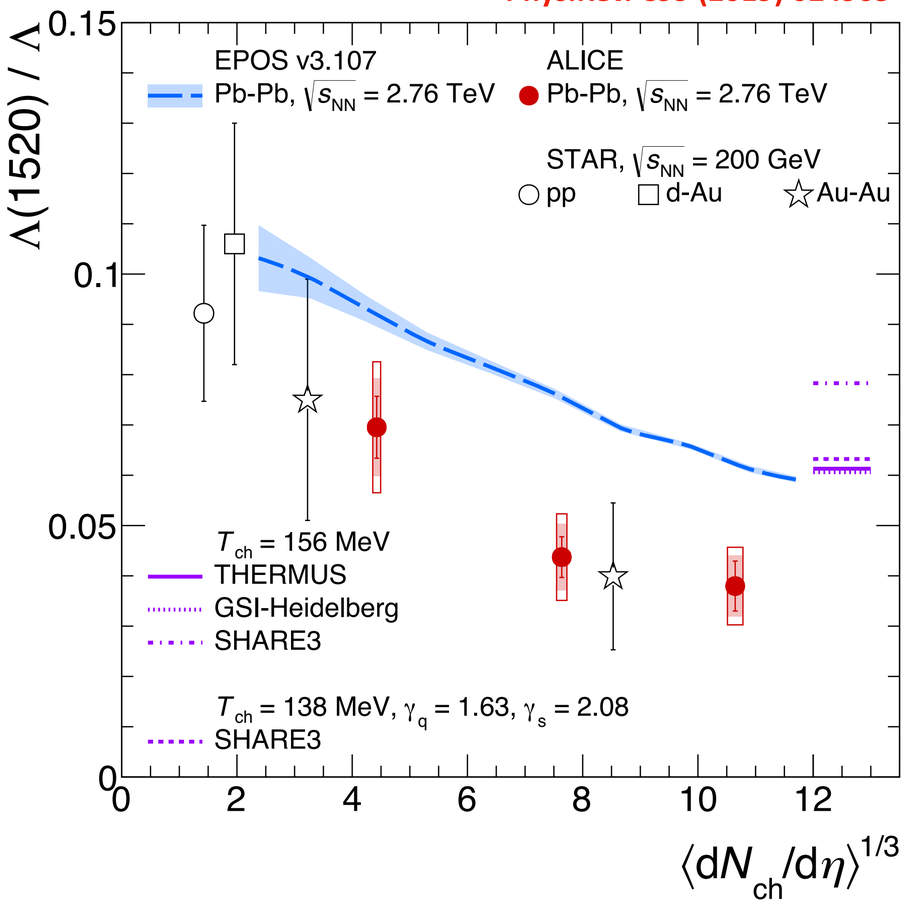
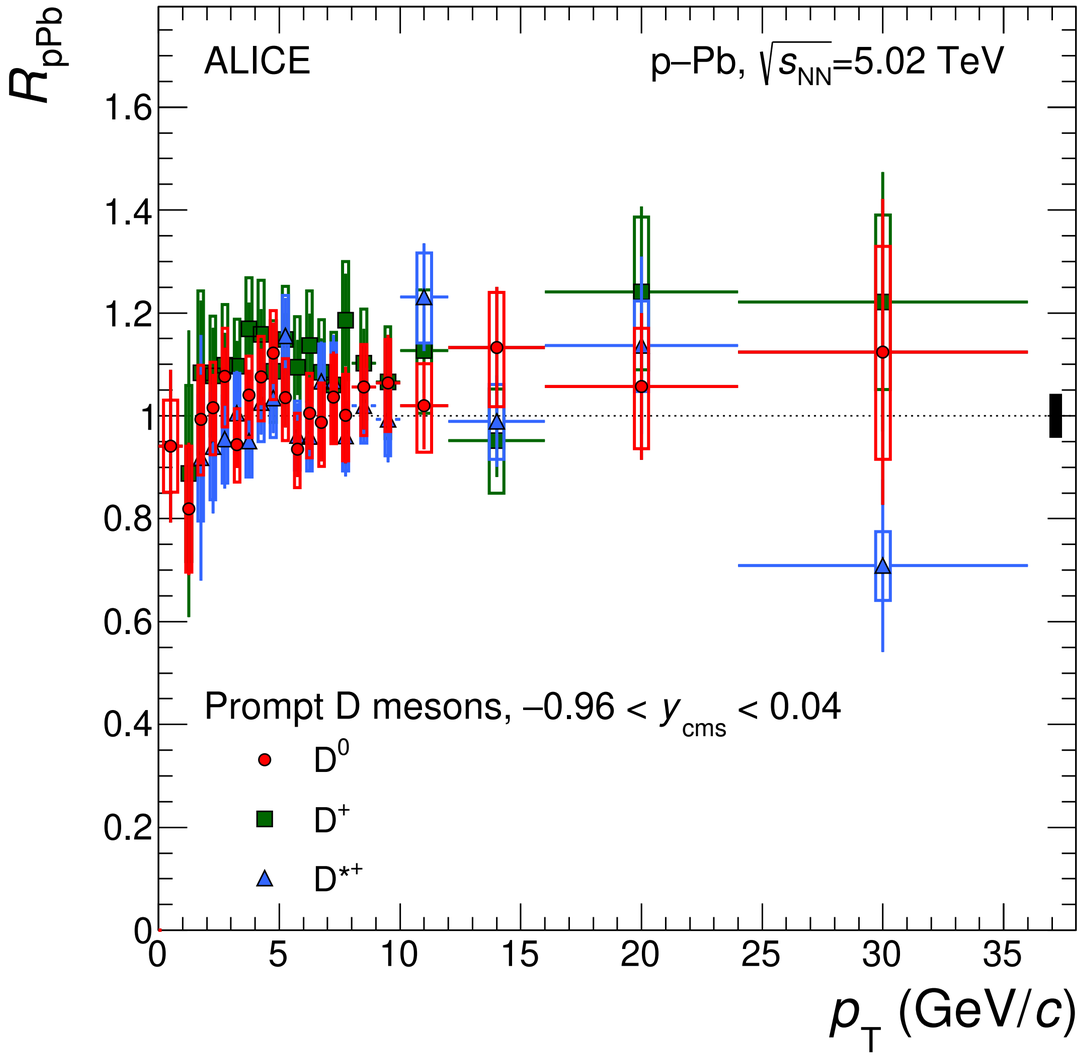
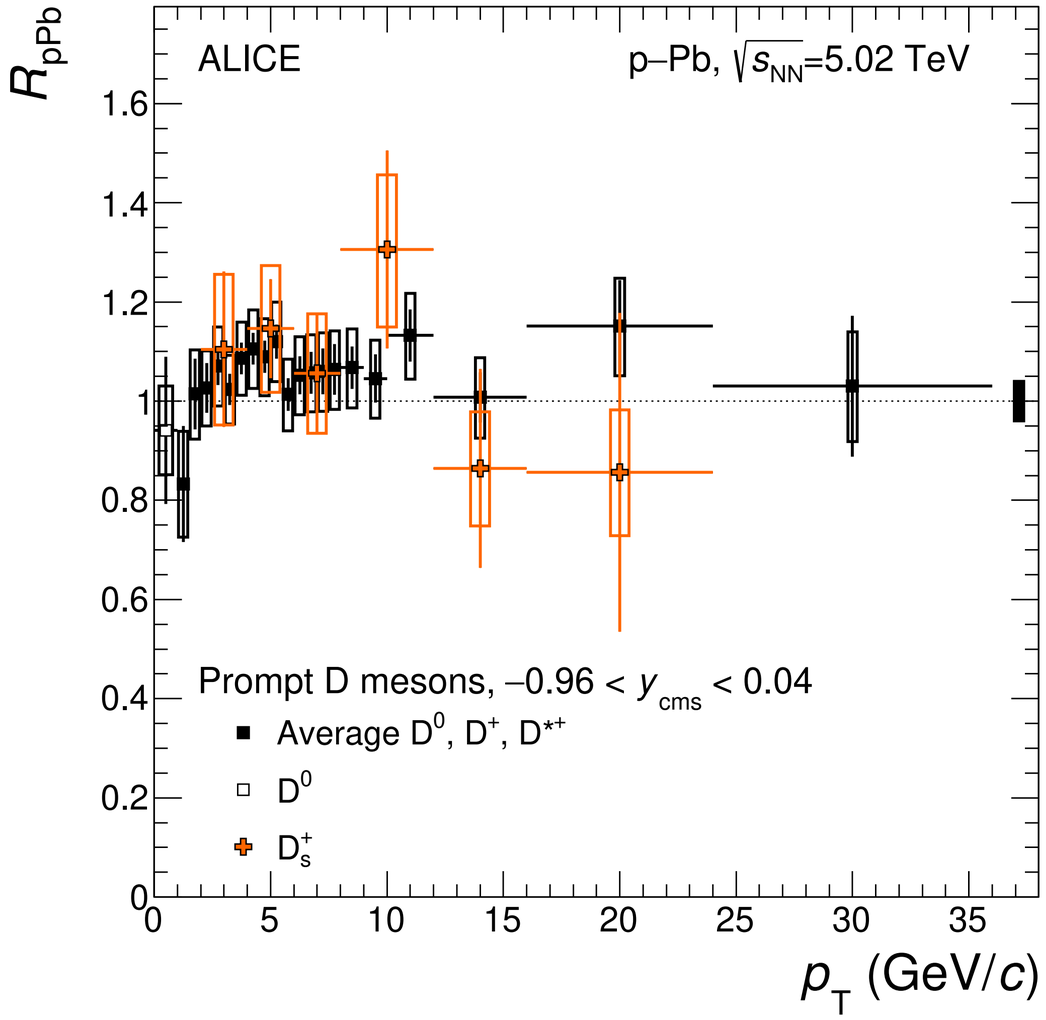


- Λ*/Λ is independent of centrality ≈ Pb-Pb
  - The enhancement in p-Pb depends on the strangeness content and not the mass

Prompt open-charm production in p-Pb at 5 TeV

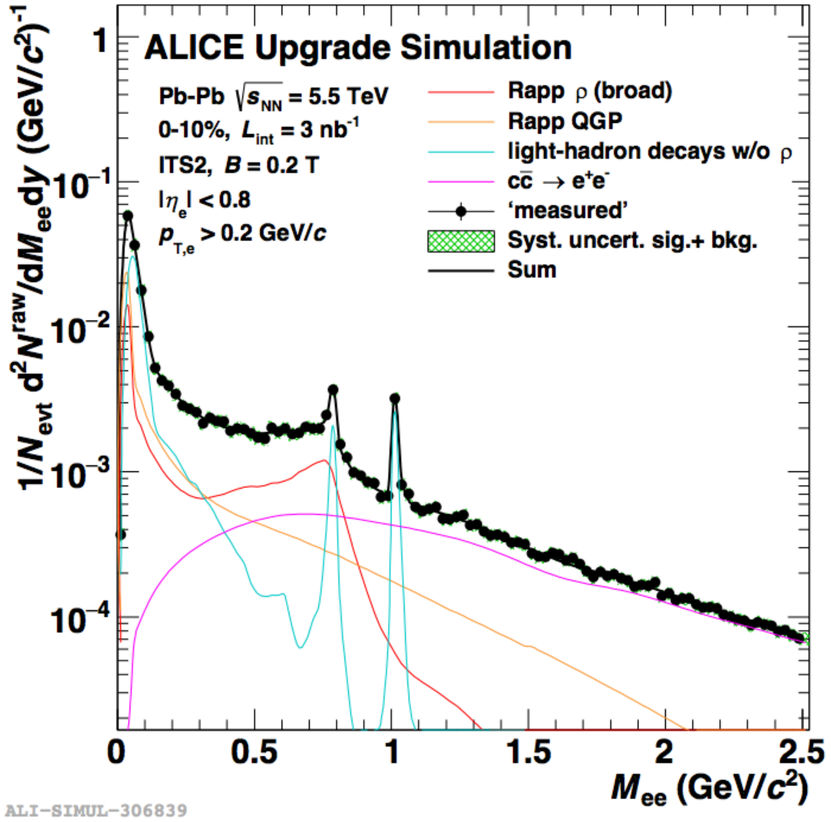
arXiv: 1906.03425



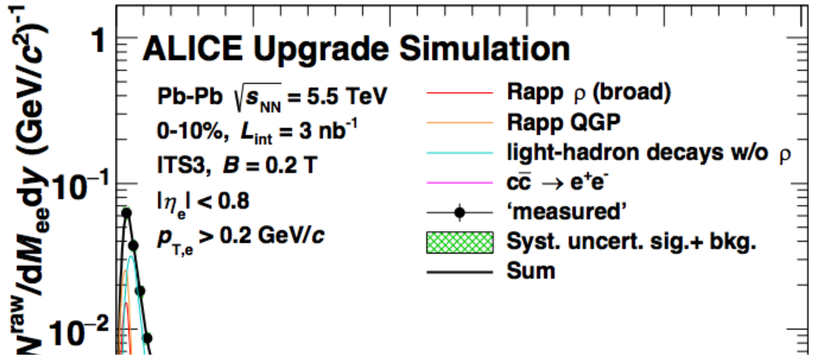


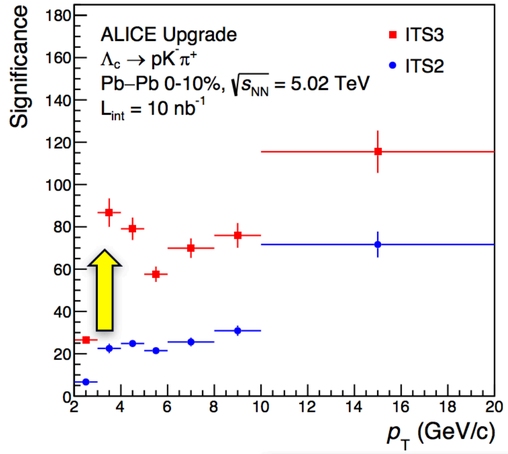
ITS3: Improvement for low mass dielectron

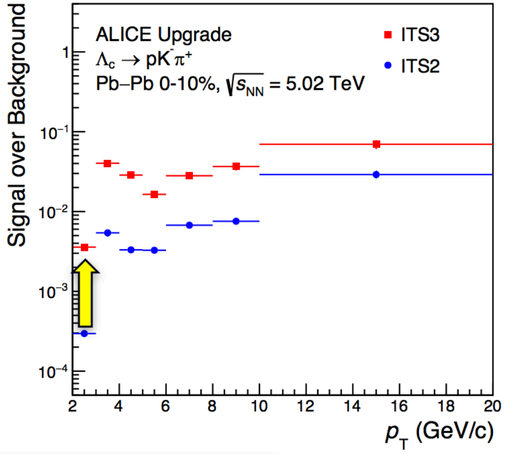
ITS2



ITS3

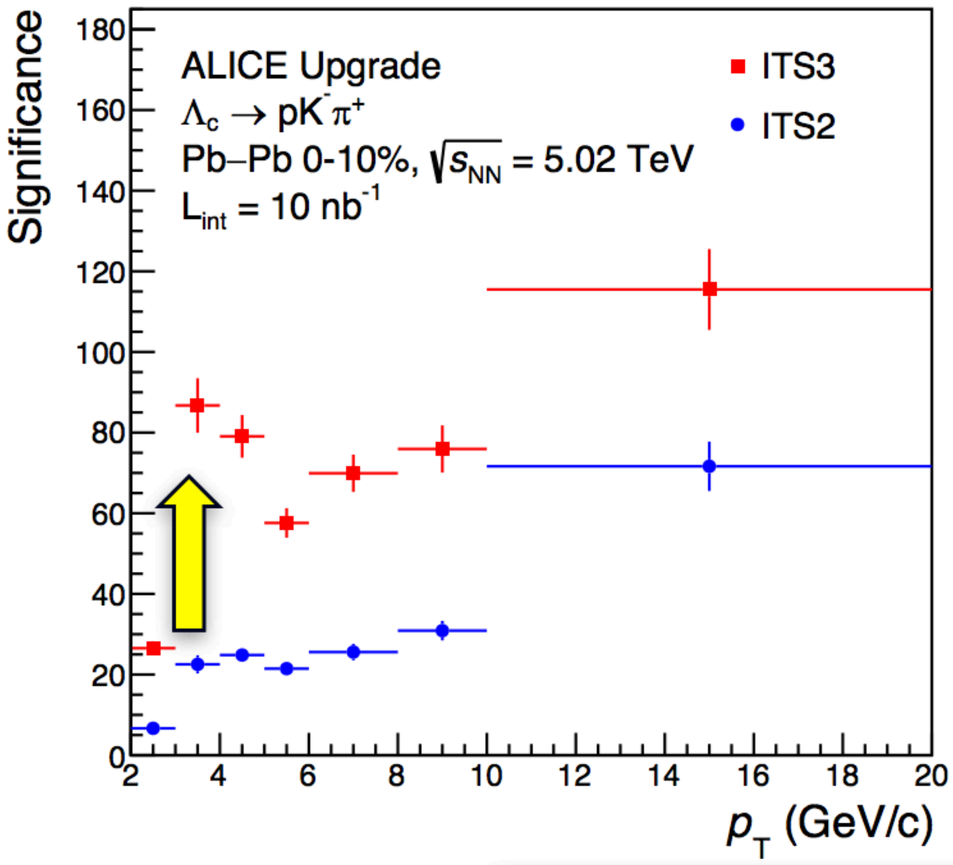


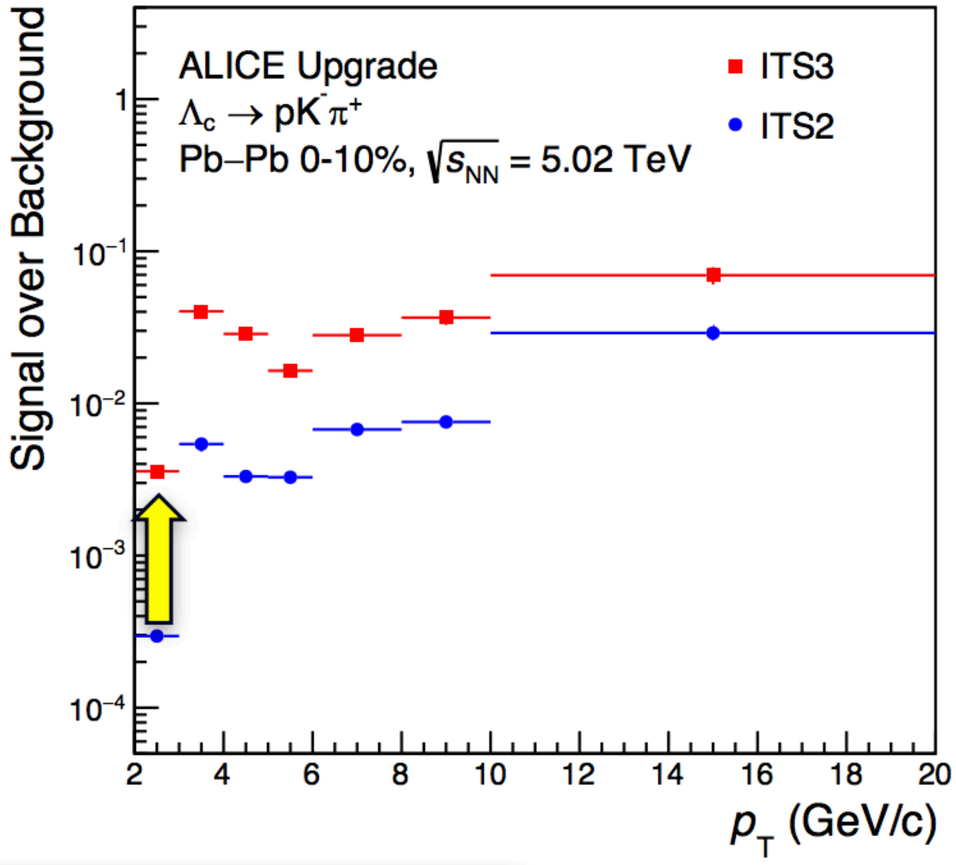




	Significance	S/B
ITS3 / ITS2	4	10

ITS3: Improvement for Λ_c





	Significance	S/B
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