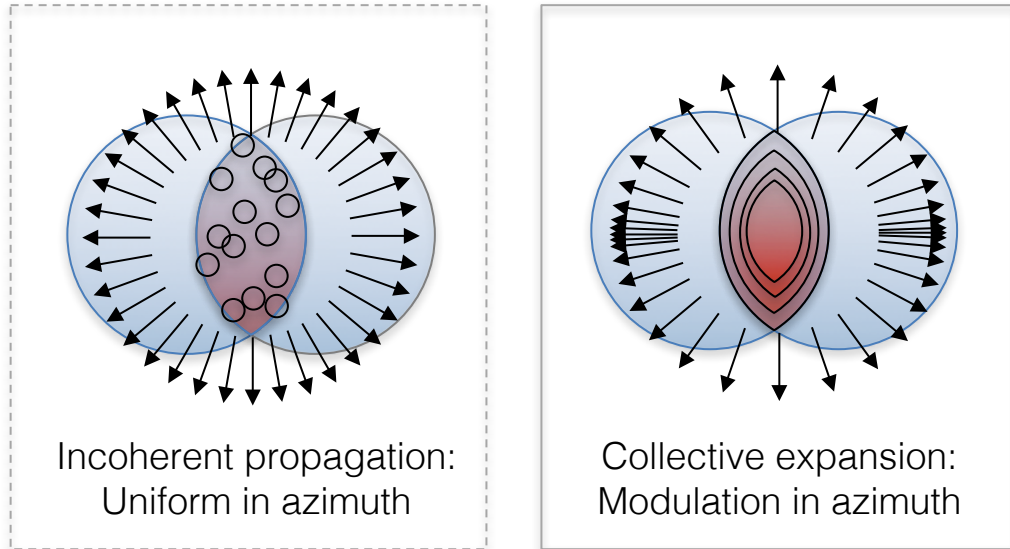


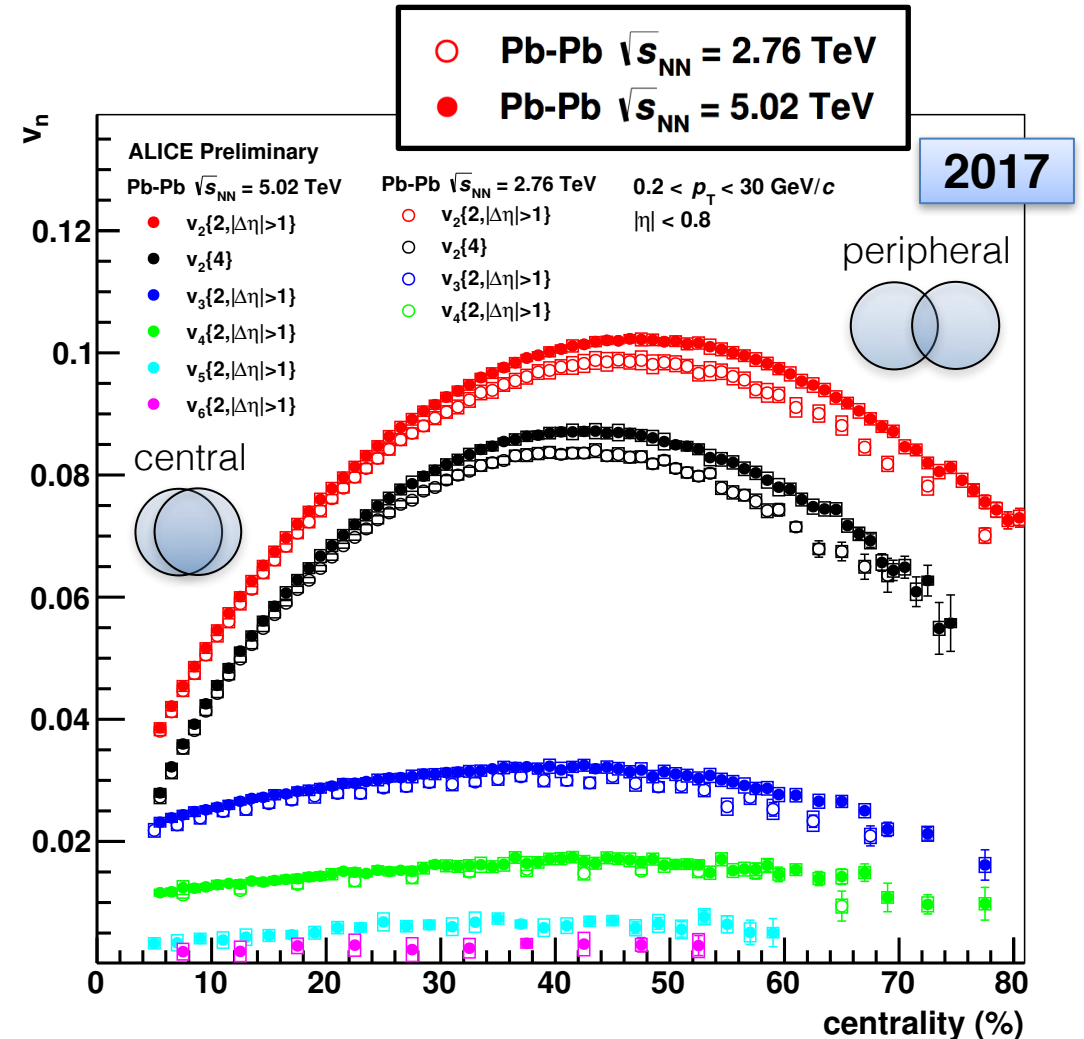
The background of the slide is a schematic diagram of the ALICE detector. It shows a central black circle representing the interaction point, with a vertical axis and a horizontal axis. The detector is composed of several concentric layers of particle detectors, represented by a dense field of thin, grey lines radiating outwards from the center. A central region, roughly circular in shape, is highlighted in a reddish-brown color. The text is overlaid on this central region.

Recent results from the  
**ALICE** Collaboration

# Characterizing the Quark-Gluon Plasma: Flow in Pb-Pb collisions



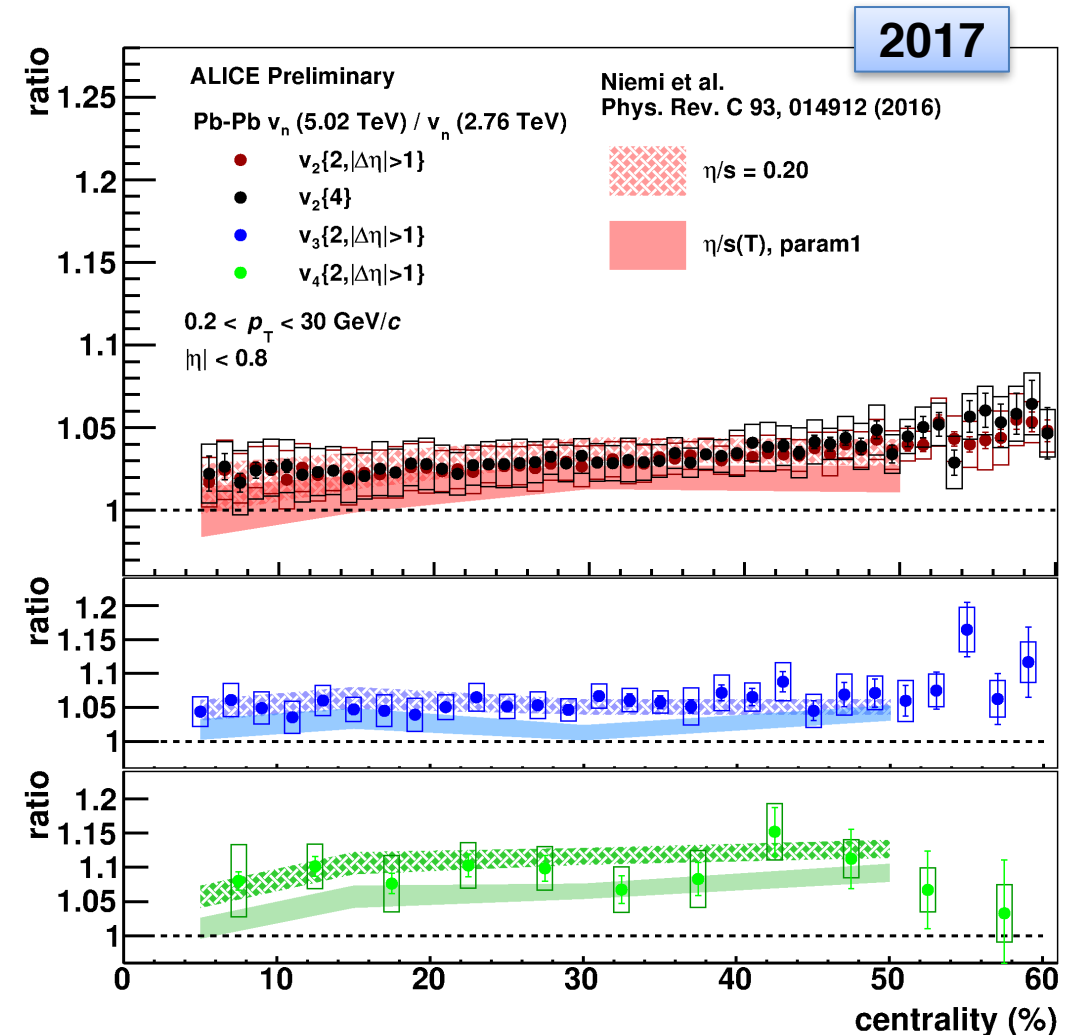
- Flow coefficients ( $v_n$ ) now measured in Pb-Pb at both 2.76 and 5.02 TeV
- **Clear hydrodynamical behaviour** as opposed to incoherent superposition of pp collisions
- Measurements encode information about **medium properties (viscosity)**



ALI-PREL-118603

# Characterizing the Quark-Gluon Plasma: Flow in Pb-Pb collisions

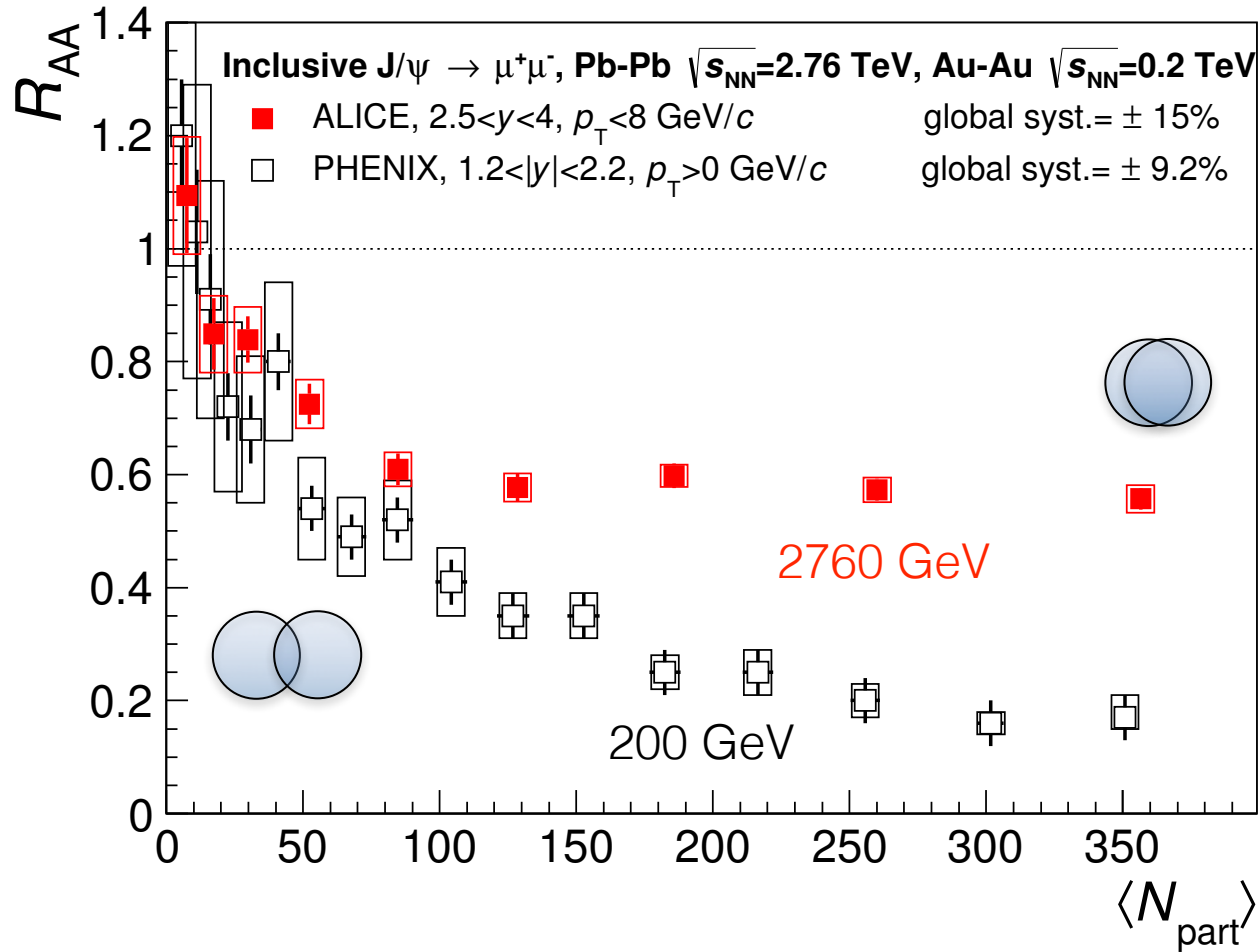
- Stronger flow at larger energy: consistent with hydrodynamical calculations
- Data favour a constant shear viscosity to entropy density ratio of  $\eta / s \sim 0.2$ 
  - Nearly perfect fluid:  $1/4\pi < \eta / s < 3/4\pi$



ALI-PREL-120937

# J/ψ production suppressed in Pb-Pb collisions

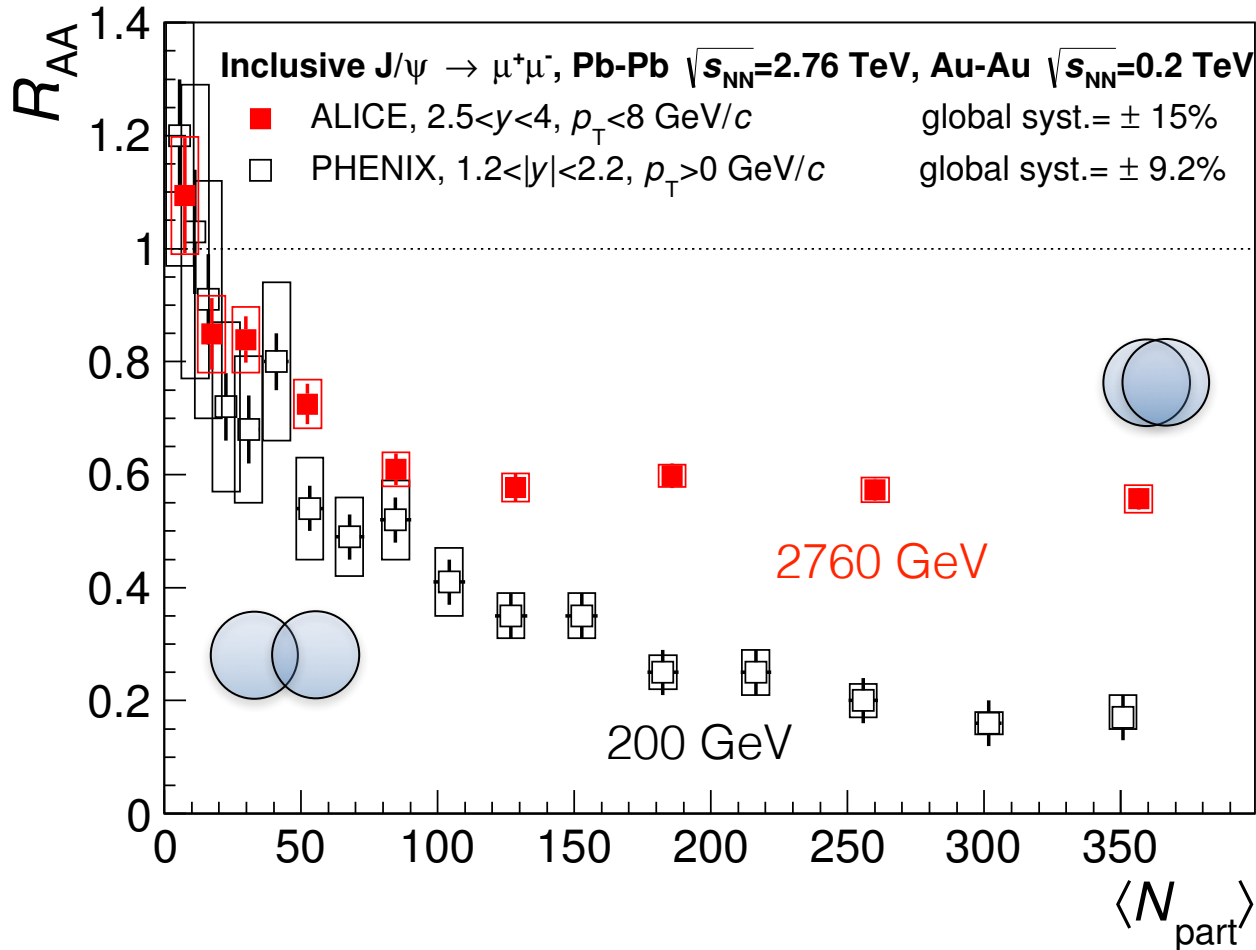
nuclear modification factor



- $R_{AA}$ : ratio of Pb-Pb spectra and scaled pp reference
  - $R_{AA}$  around unity: Pb-Pb  $\equiv$  scaled pp
- J/ψ  $R_{AA}$  below unity: energy loss, melting

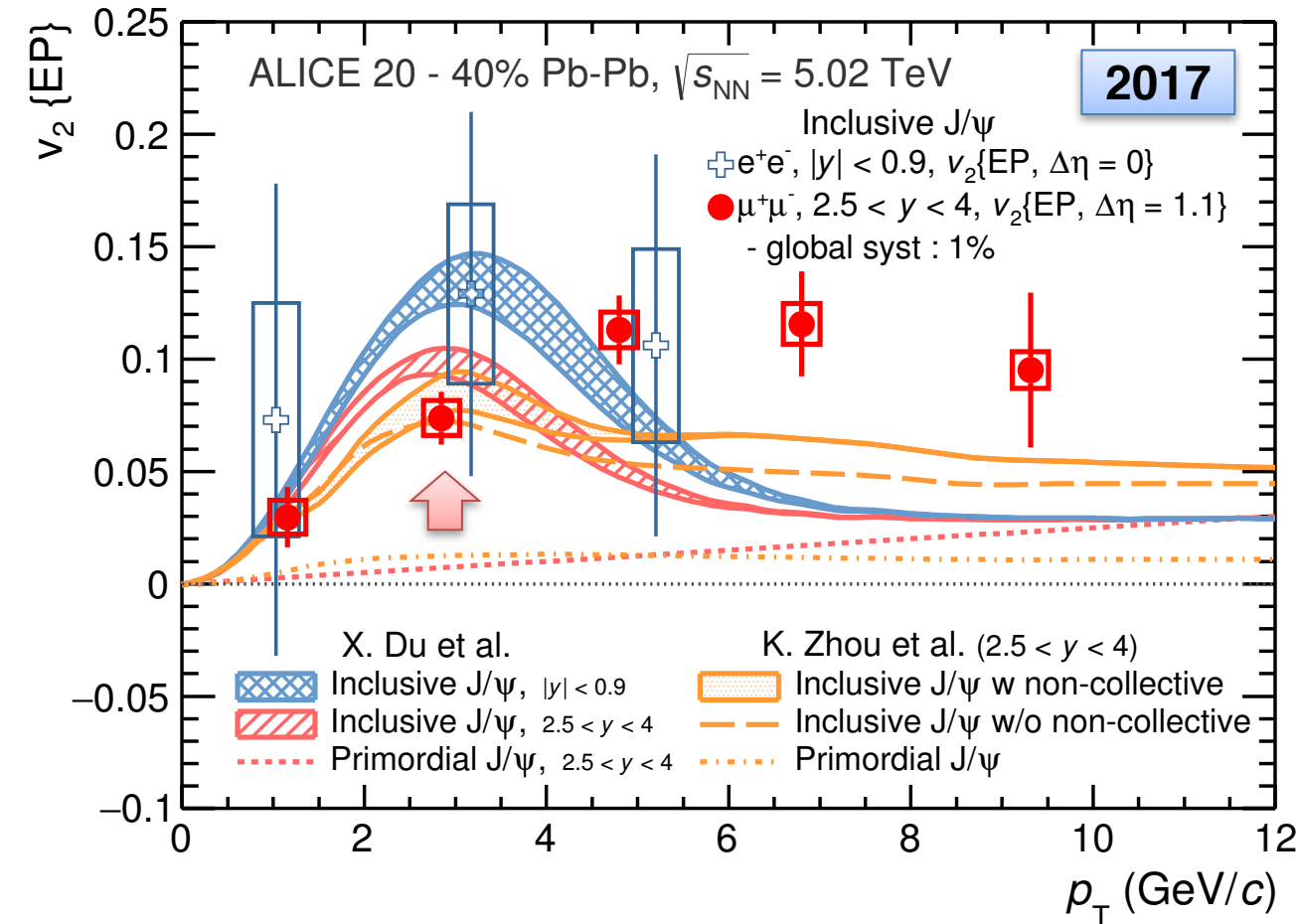
# $J/\psi$ production suppressed in Pb-Pb collisions

nuclear modification factor



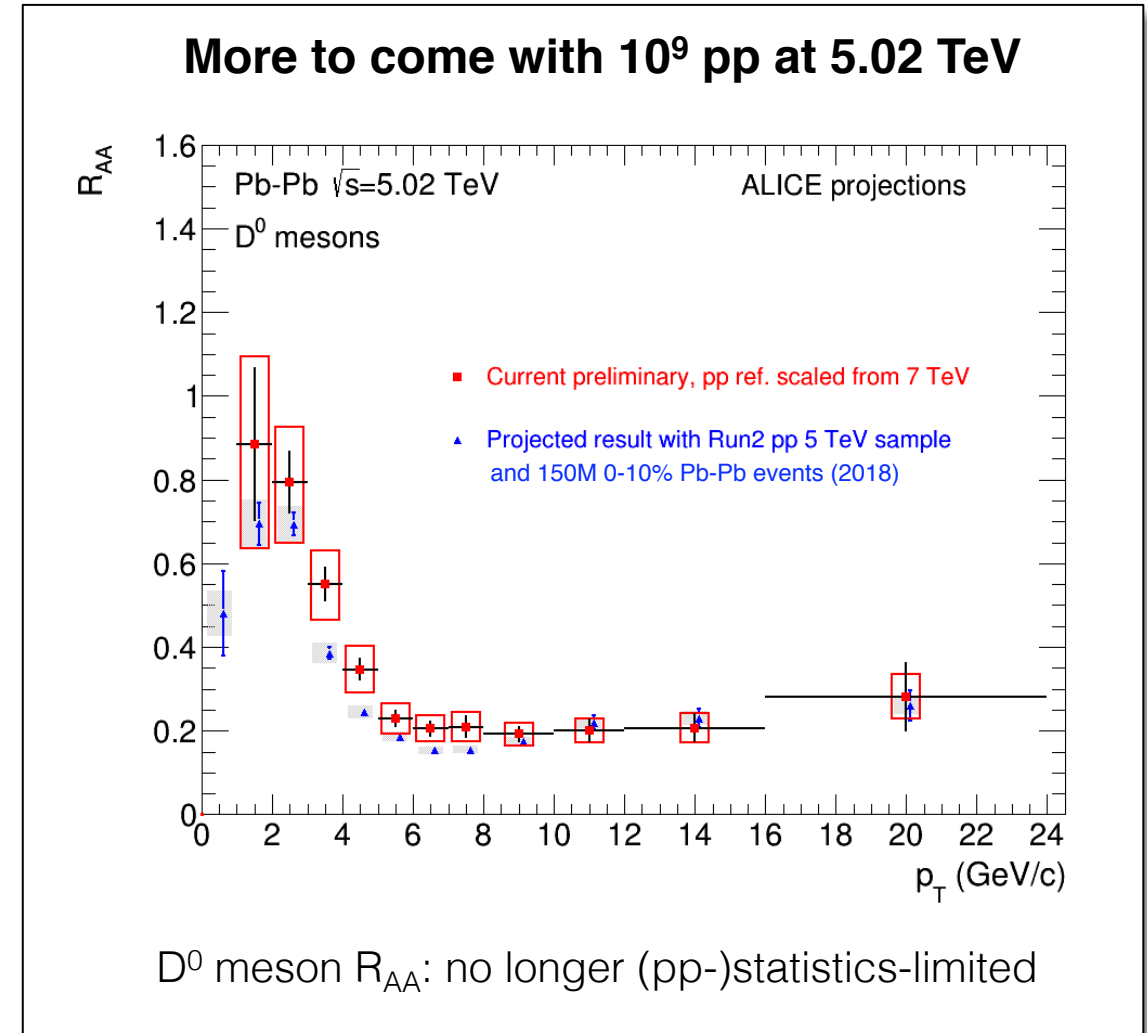
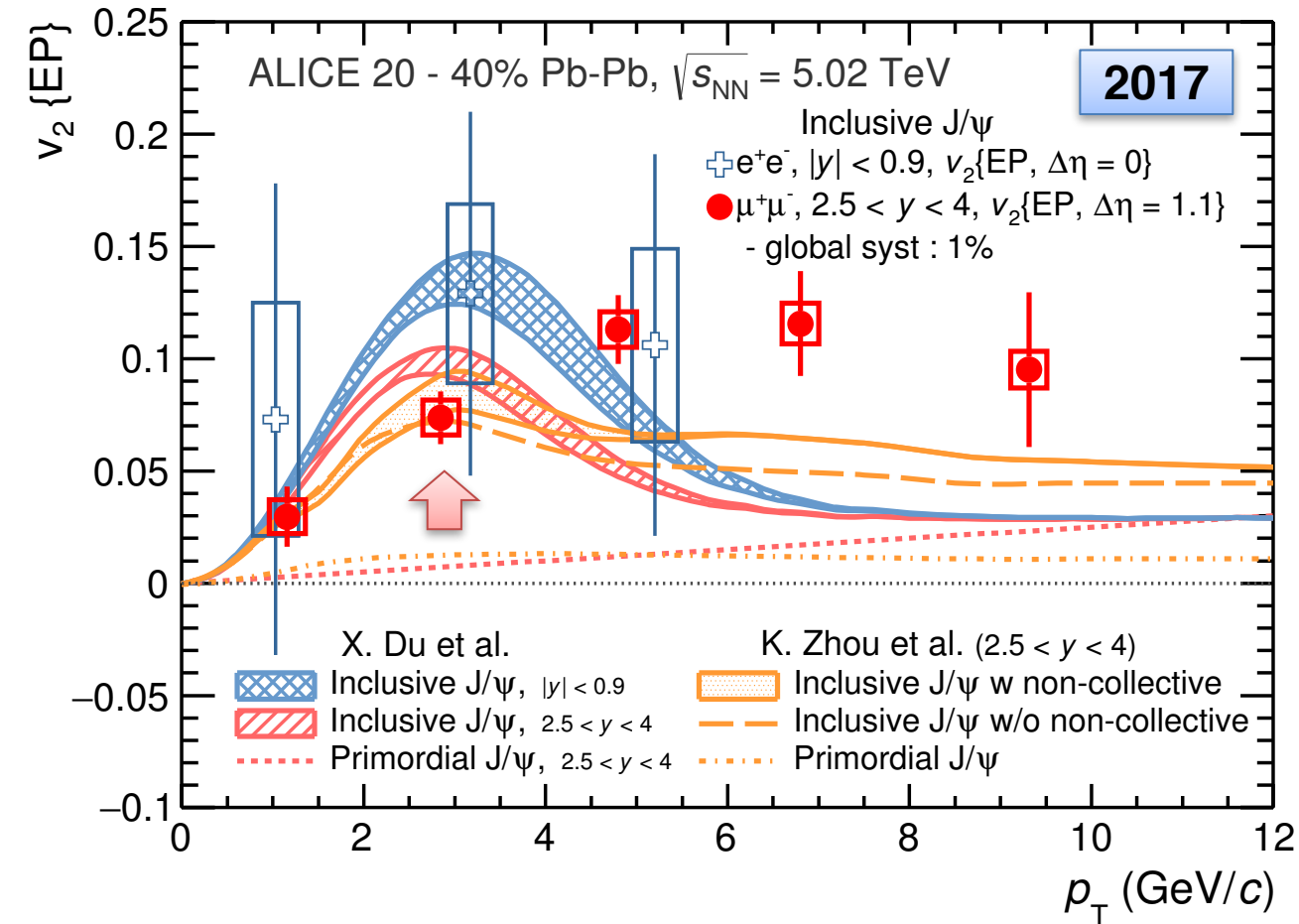
- $R_{AA}$ : ratio of Pb-Pb spectra and scaled pp reference
  - $R_{AA}$  around unity: Pb-Pb  $\equiv$  scaled pp
- $J/\psi$   $R_{AA}$  below unity: energy loss, melting
- Consistent with models that include a  $J/\psi$  regeneration component:
  - significant recombination of thermalized  $c$  quarks at play

# J/ψ flowing with the QGP expansion

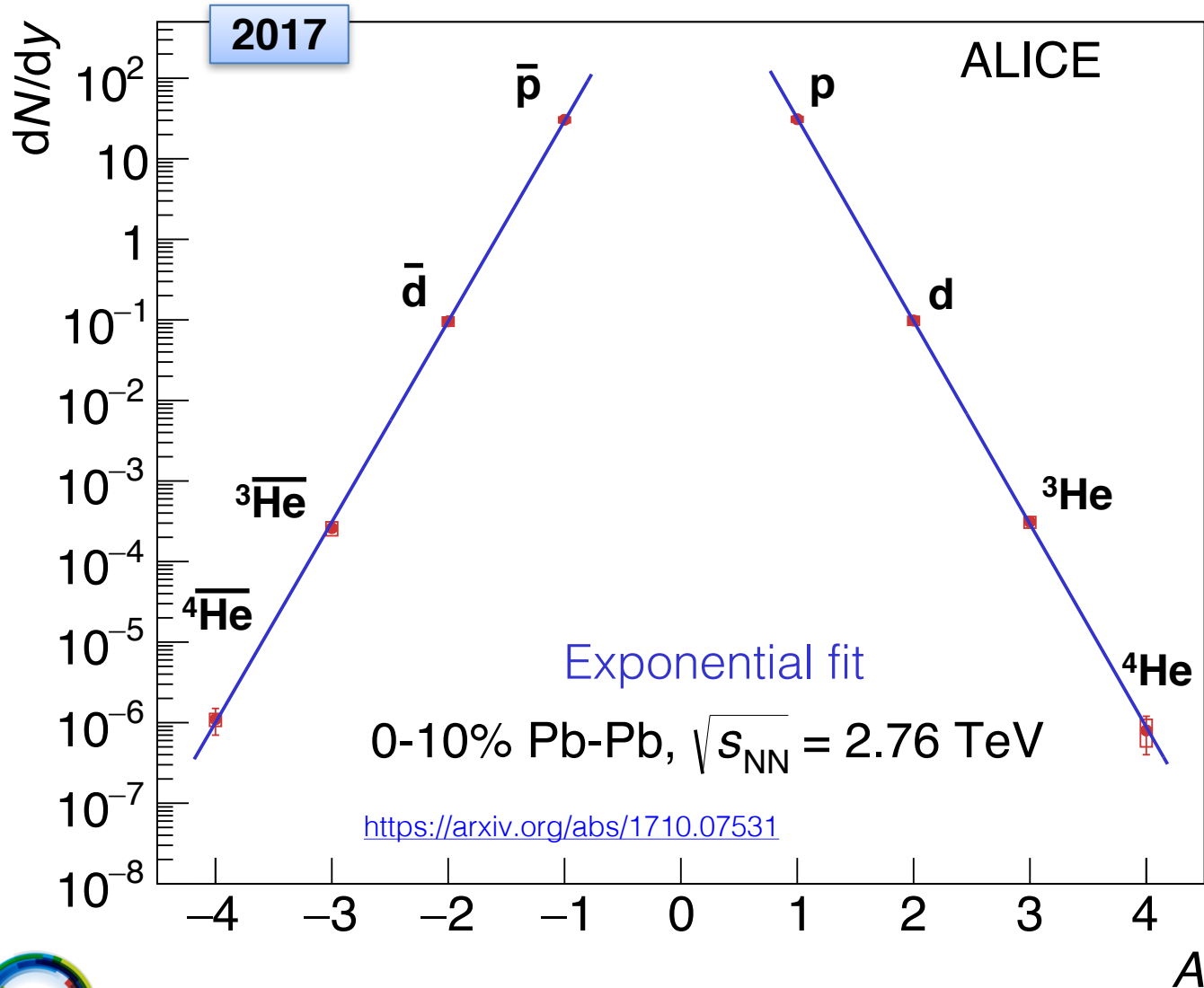


- J/ψ elliptic flow measured in Pb-Pb at 5.02 TeV
  - Explained with [parton recombination](#)
- No model explains large  $v_2$  values at high  $p_T$ 
  - [New J/ψ production mechanism](#) at play?

# J/ψ flowing with the QGP expansion



# Nuclei and exotica measurements

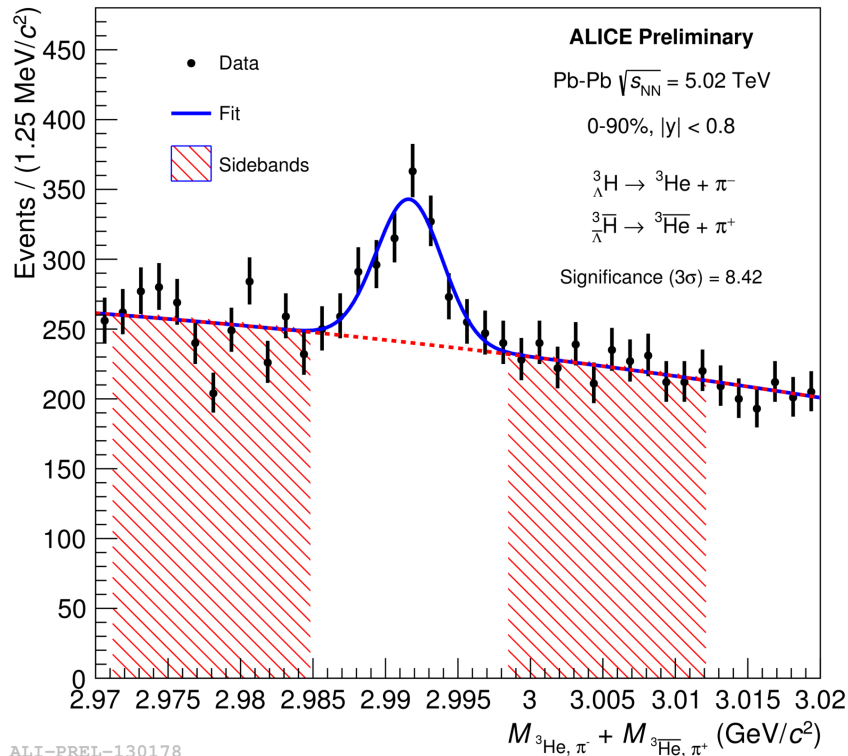
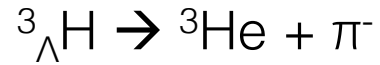


- Heavier nuclei measured all the way to  ${}^4\text{He}$ ,  ${}^4\bar{\text{He}}$
- Consistent with mass exponential



# Nuclei and exotica measurements

very good signal of:  
 ${}^3_{\Lambda}\text{H}$ : pn $\Lambda$  bound state

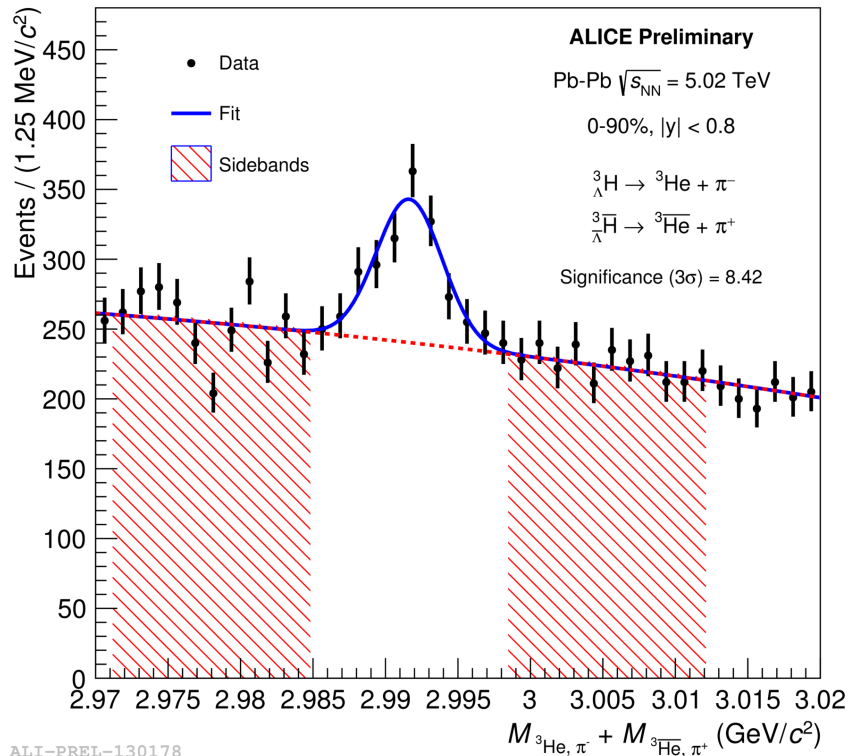
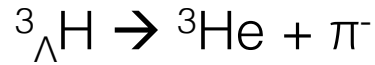


ALI-PREL-130178

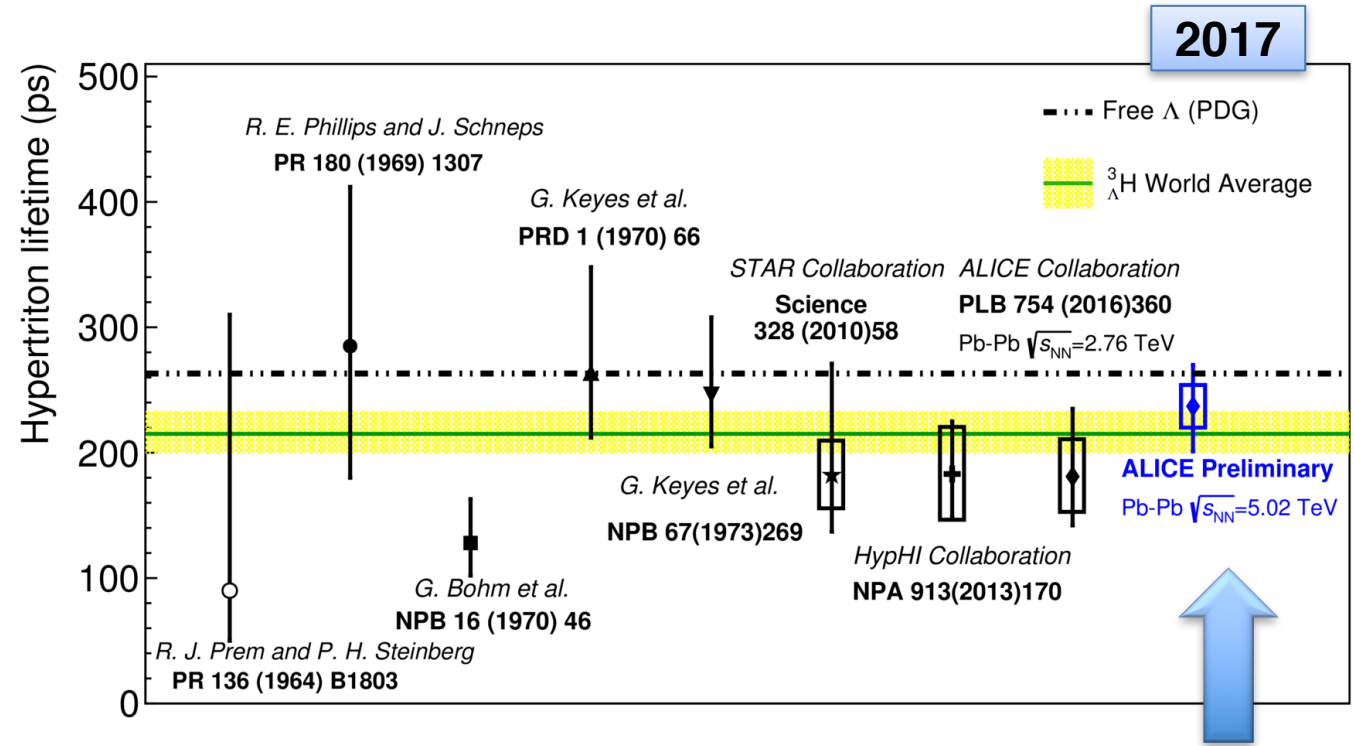


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ALI-PREL-130178



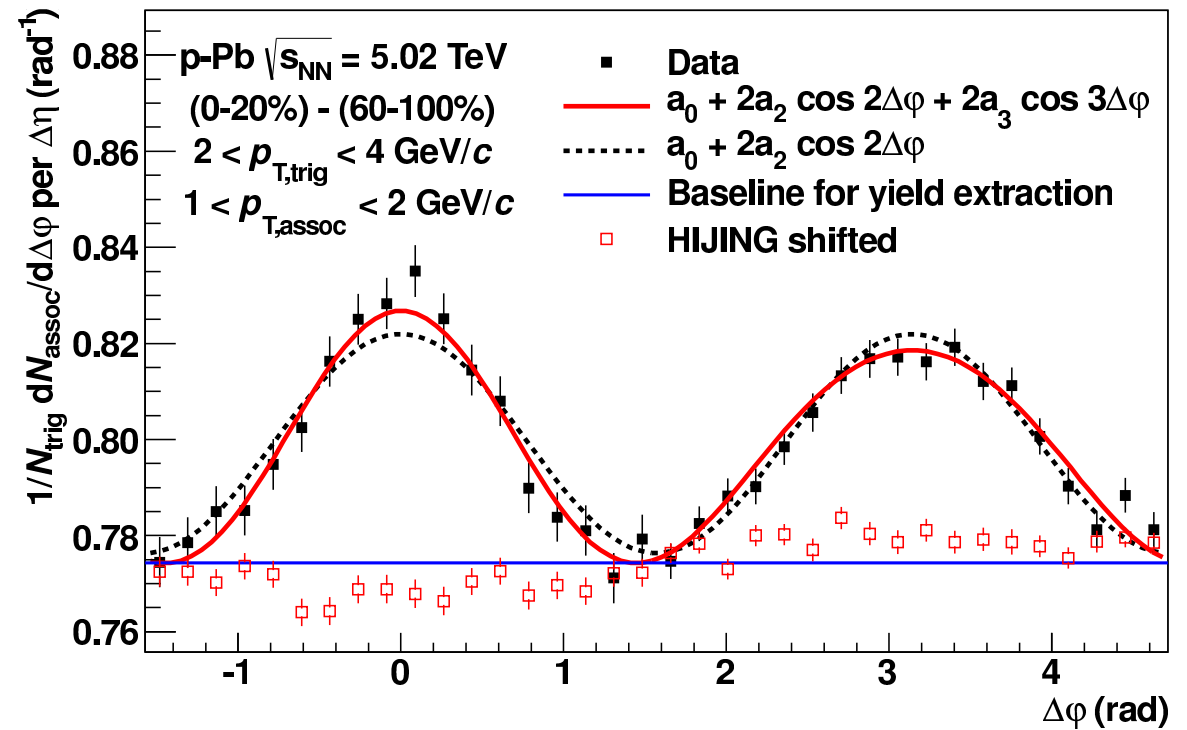
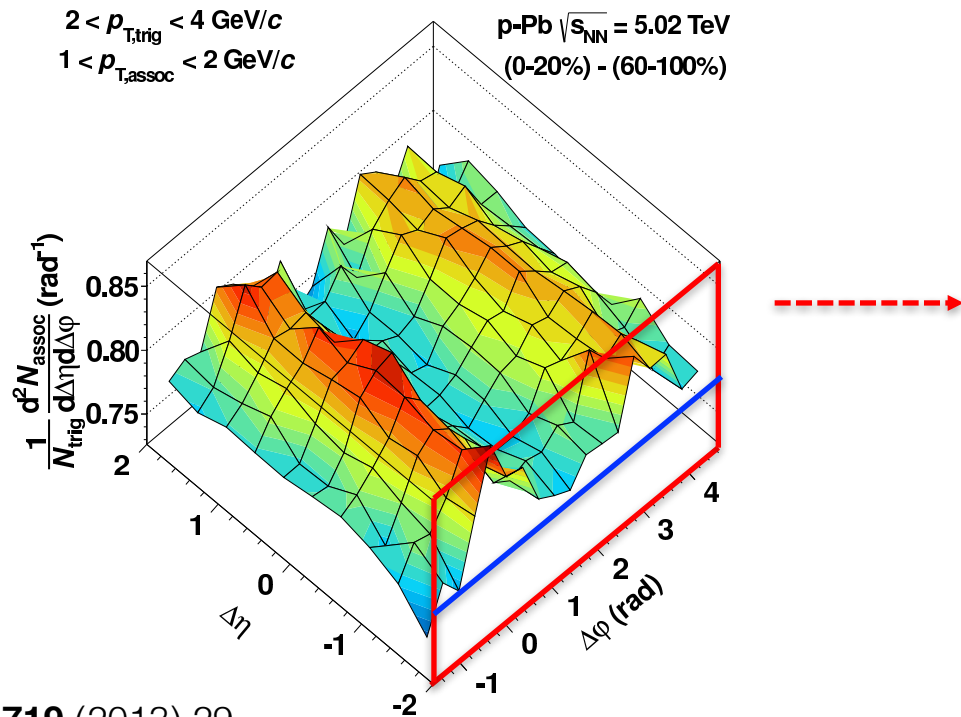
ALI-PREL-130195

Consistent with world data and  
with free  $\Lambda$  lifetime



# Elliptic flow in small systems?

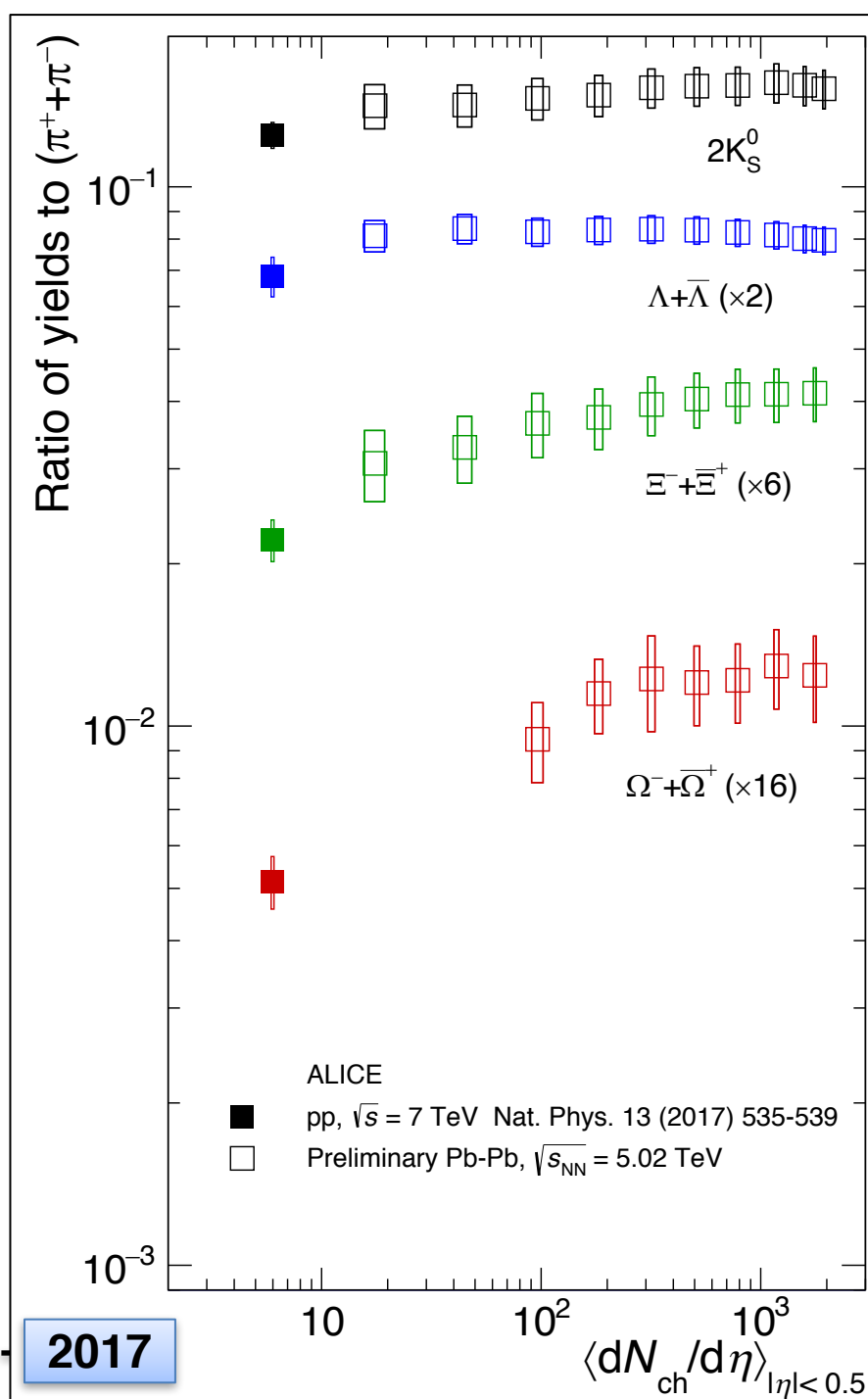
- Double-ridge structure also observed in [high-multiplicity p-Pp collisions](#)
- Collective behaviour in small systems?



- Hydrodynamics, string shoving (or a combination of both)?

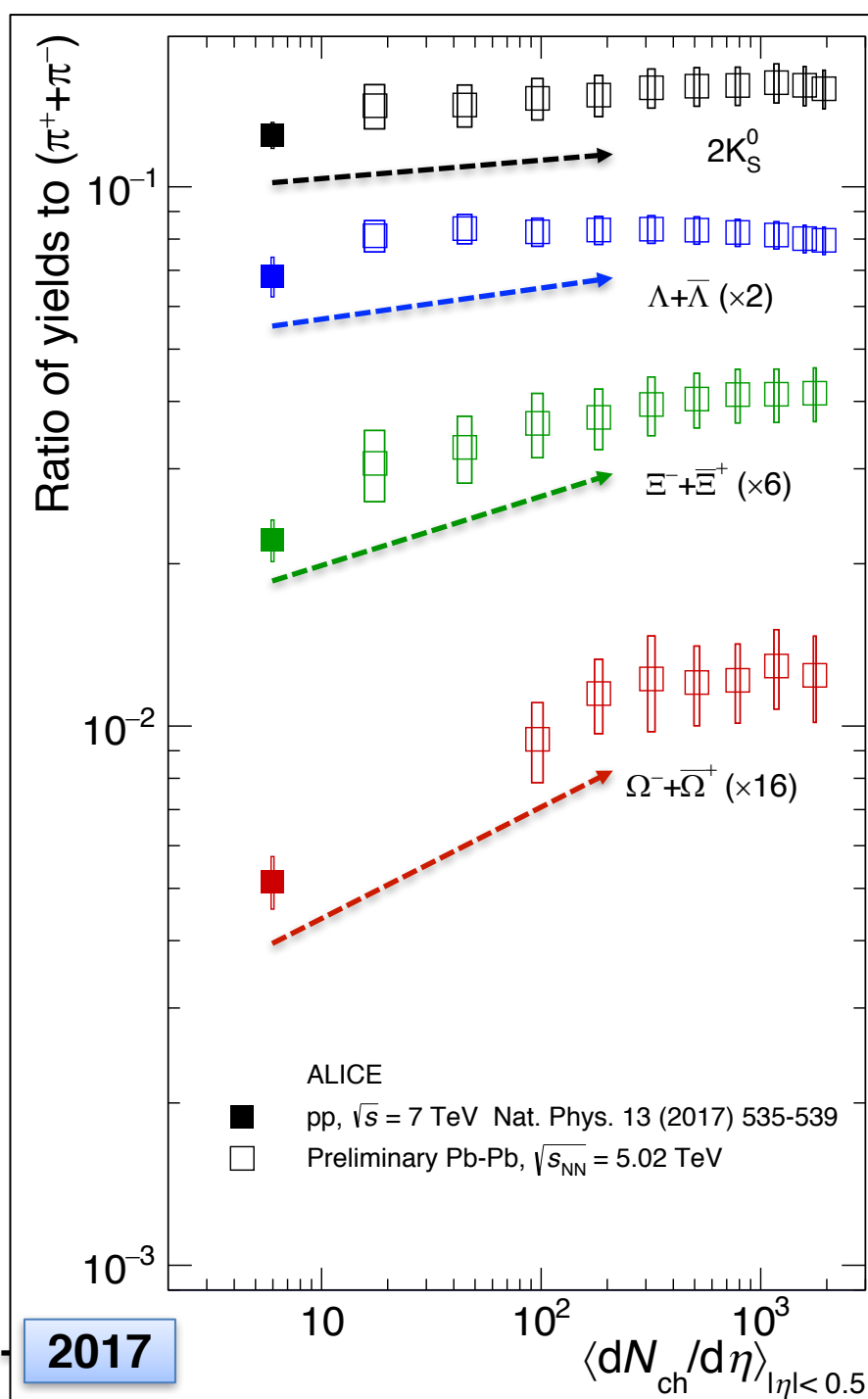
# Strangeness production

- One of the original signatures of the Quark-Gluon Plasma
  - Thermal **production via gluon fusion** in a QGP scenario
- $K_S^0$ ,  $\Lambda$  ( $uds$ ),  $\Xi$  ( $dss$ ) and  $\Omega$  ( $sss$ ) in Pb-Pb at 5.02 TeV
  - **Production enhanced compared to pions**



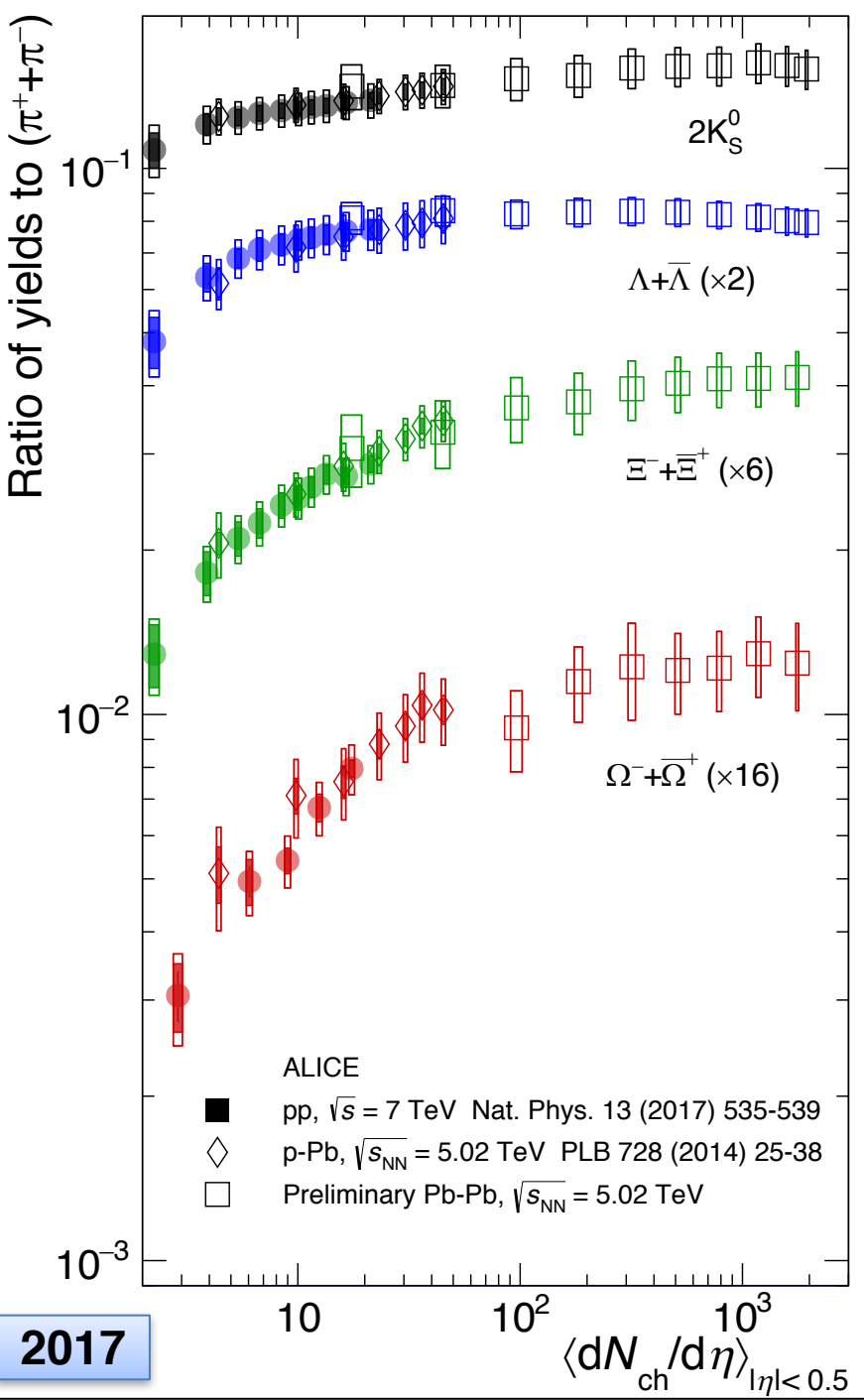
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2017

# Strangeness production



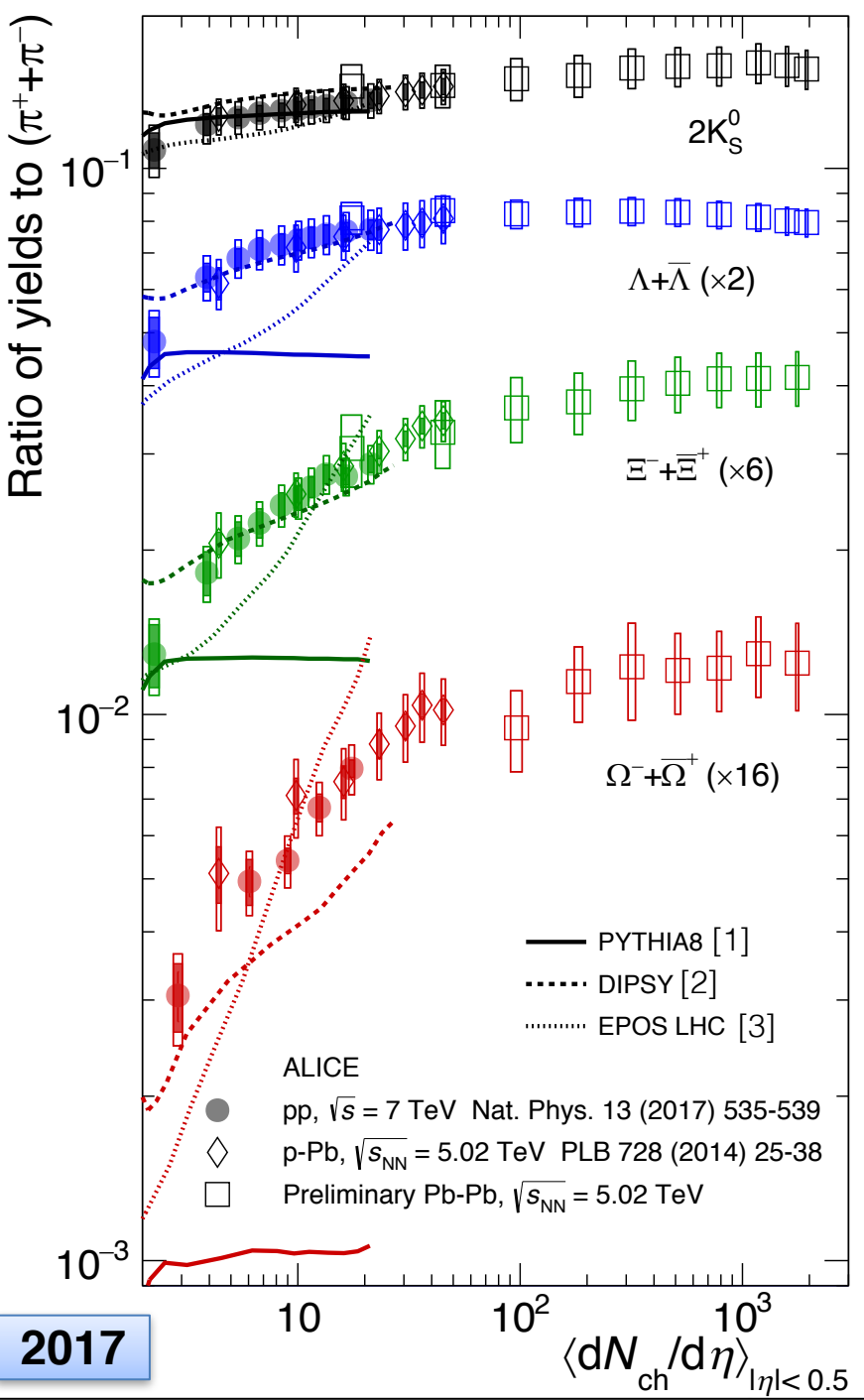
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  - universal trend for strangeness increase with multiplicity
  - Mini-droplets of QGP?



2017



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  - Mini-droplets of QGP?
  - Color ropes?
  - Statistical hadronization?

[1] Comput. Phys. Commun. 178 (2008) 852–867  
 [2] JHEP 08 (2011) 103  
 [3] Phys. Rev. C 92, 034906 (2015)

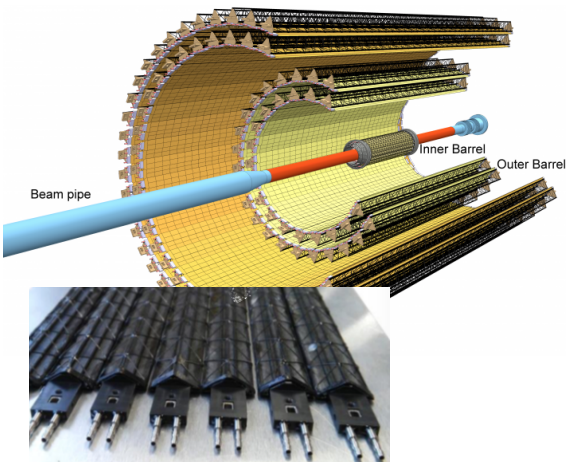


2017

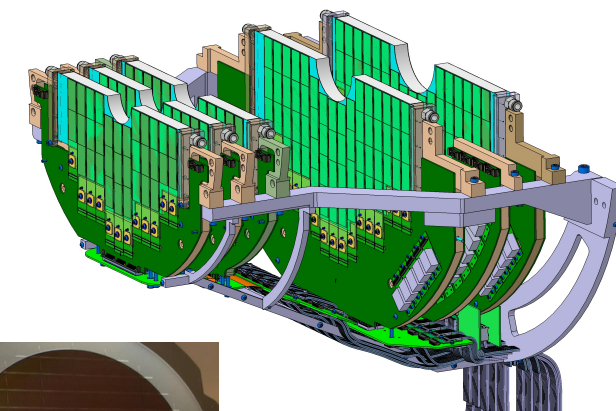


# ALICE upgrades in Long Shutdown 2

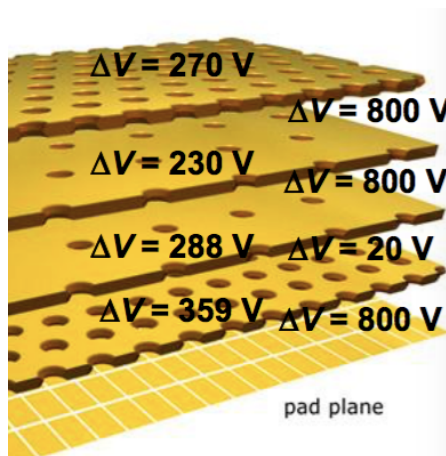
Monolithic-pixel Inner Tracking System



Pixel Muon Forward Tracker



GEM-based TPC readout



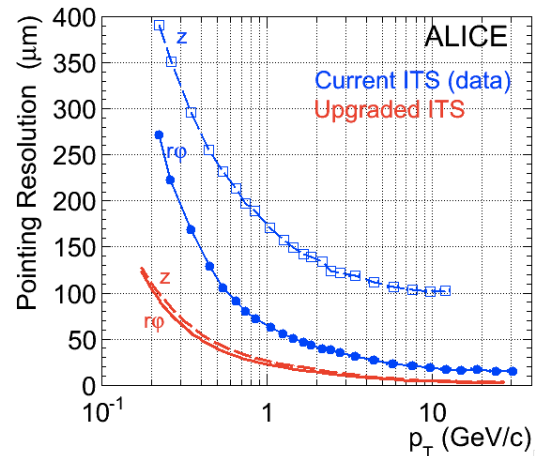
Key physics improvements requiring high readout rate:

- Low- $p_T$  heavy-flavour mesons and baryons
- Low- $p_T$  charmonia
- Low-mass di-electrons

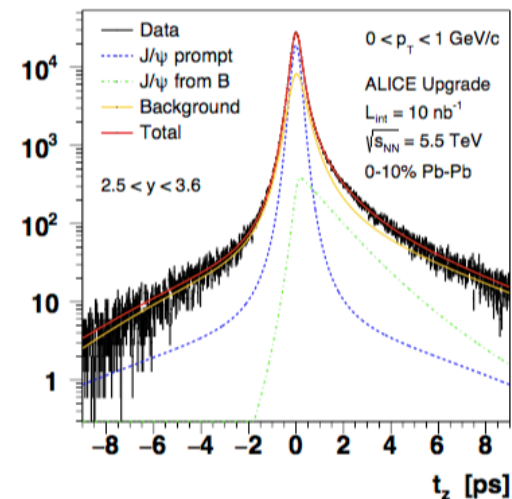


# ALICE upgrades in Long Shutdown 2

All-pixel Inner Tracking System  
 → x3-5 better tracking precision



Pixel Muon Forward Tracker  
 → non-prompt muons from B decays



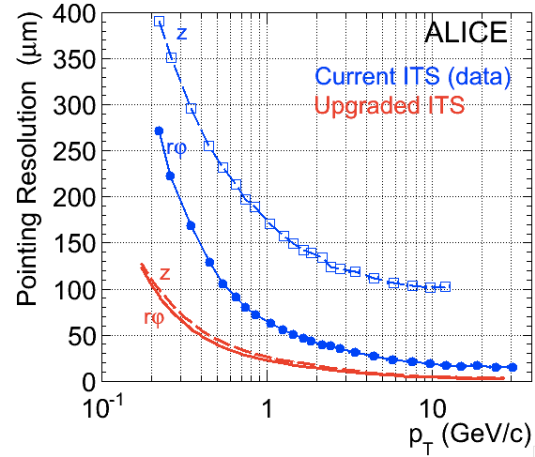
GEM-based  
 TPC readout  
 → x100 readout  
 rate in Pb-Pb

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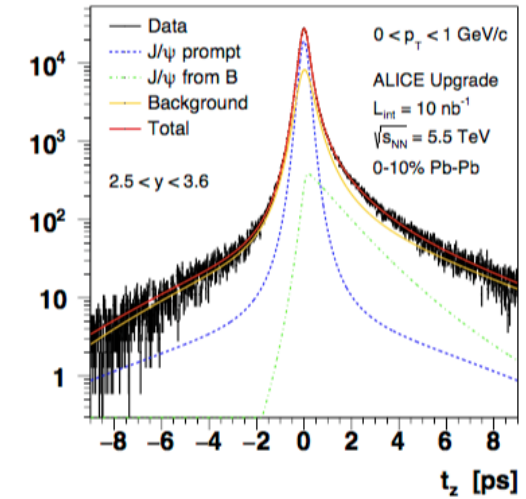
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GEM-based  
 TPC readout  
 → x100 readout  
 rate in Pb-Pb

... and much more:

- Fast Interaction Trigger
- New Online-Offline system
- Readout upgrade of several detectors

# Conclusion

- Precision measurements of the Quark-Gluon plasma
  - Very successful 7 years and a particularly fruitful 2017
- New opportunities emerging: proton-proton, proton-lead
  - Bridge understanding from few-particle interactions to thermalized parton systems
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