Giornate di Studio
Progetti del Centro Fermi 2019-2021

Centro Fermi, Roma – December 18-19, 2018

Quark-gluon coloured world - QGCW

Roma, December 19°, 2018.

Silvia Pisano*

*Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi and Laboratori Nazionali di Frascati - INFN

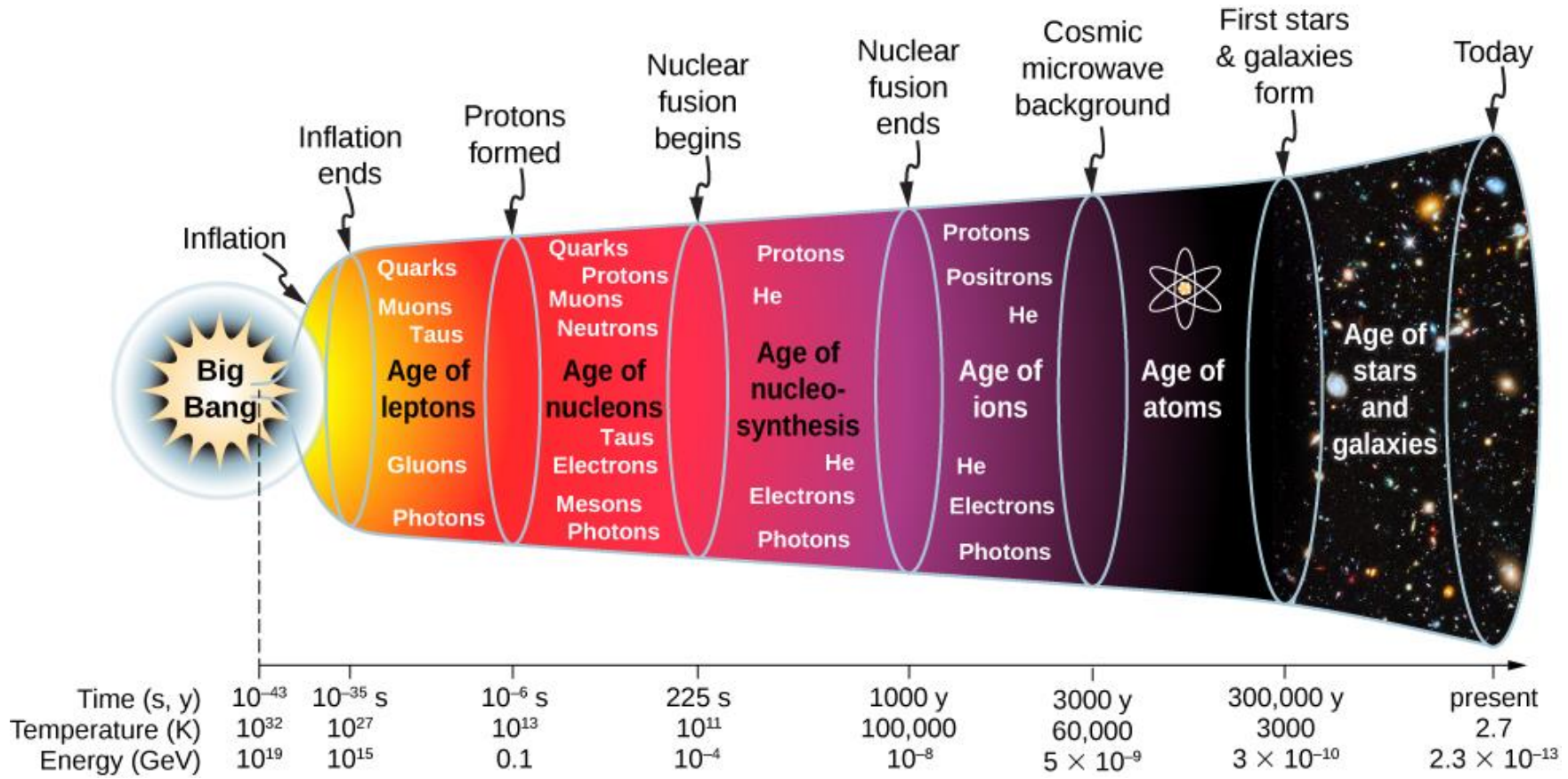
Quark-gluon colored World - ALICE

- **Project leaders**: Prof. A. Zichichi, Prof. L. Cifarelli

- **Participants**:
  1. Andrea Alici, *ITS Run Coordinator, ALICE contact person for LHC Background Study Group (LBS) and Machine Protection Panel (MMP)*
  2. Francesca Carnesecchi, *fellow (also in EEE)*
  3. Luisa Cifarelli
  4. Daniele De Gruttola, *DQM Coordinator (also in EEE)*
  5. Despina Hatzifotiadou , *outreach convener (also in EEE)*
  6. Rosario Nania
  7. Francesco Noferini, *TOF software responsible in CB, italian TIER coordinator*
  8. Silvia Pisano, *fellow (also in EEE)*

- **Collaborations**:
  1. Strong connections with other institutions involved in the TOF project, INFN Bologna and Salerno
  2. ~ 1000 authors, ≥ 140 institutes in Europe, America, Asia, Africa
  3. Affiliations of people from other institutions working in ALICE: INFN and Università of Alessandria, Bari, Bologna, Cagliari, Catania, LNF, Padova, Pavia/Brescia, Salerno, Torino, Trieste

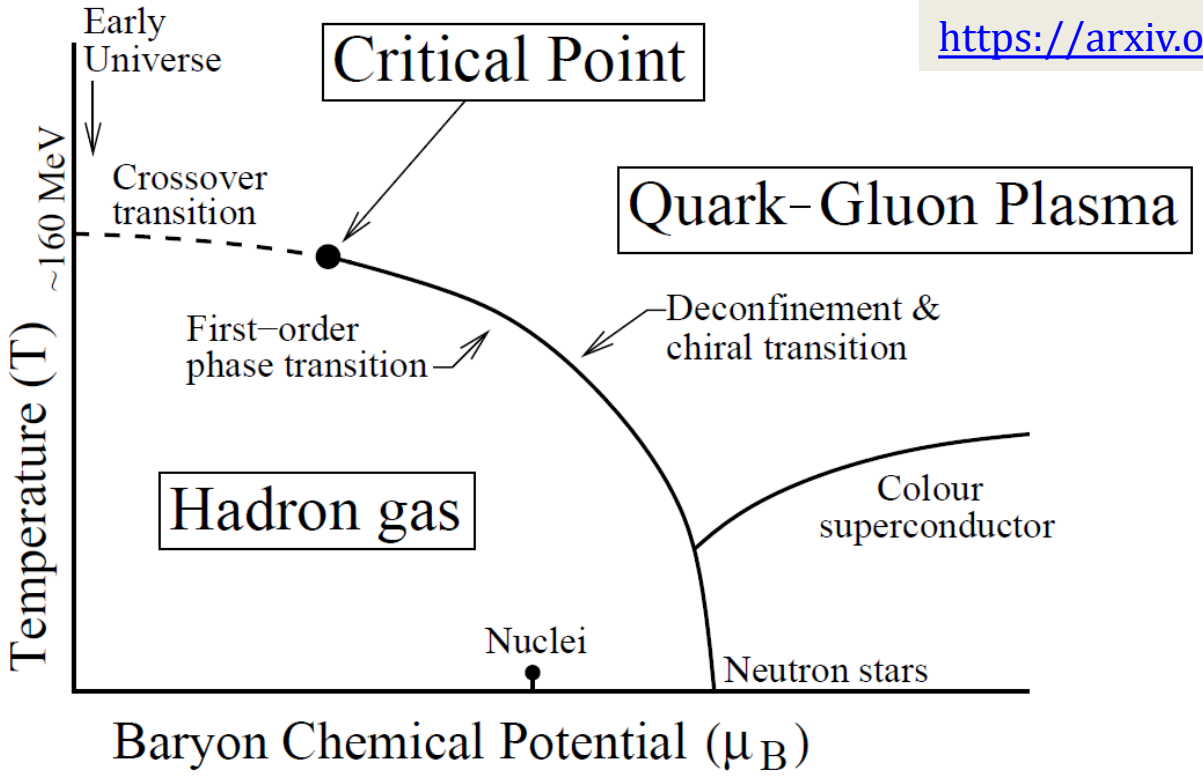
Universe «phase diagram»



Quark-gluon colored world

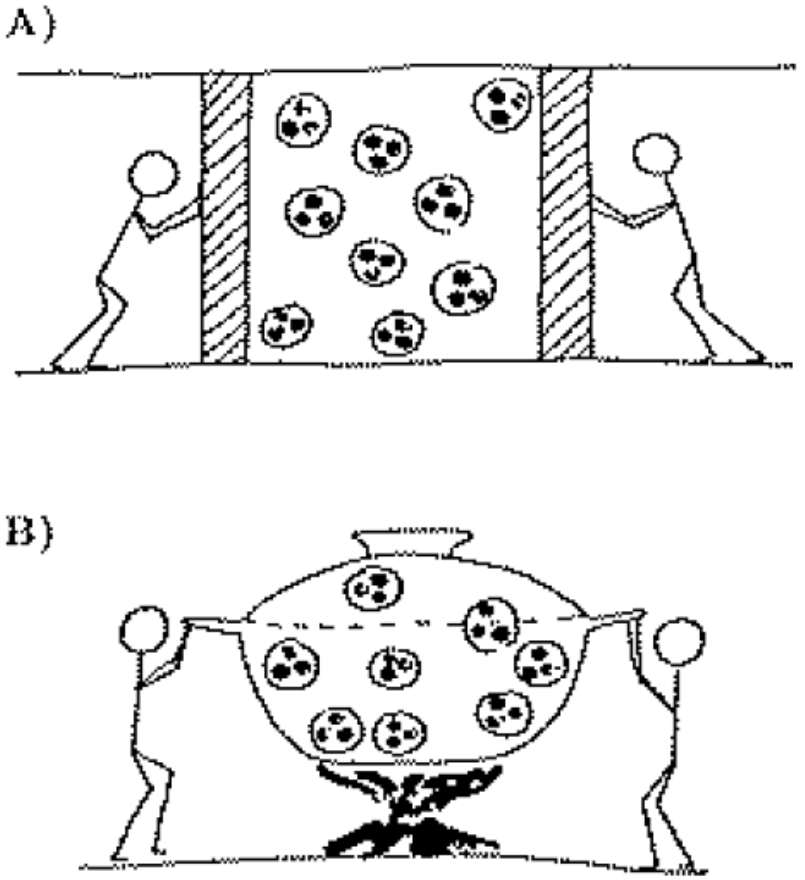
To be mapped out QUANTITATIVELY

https://arxiv.org/abs/1404.3294

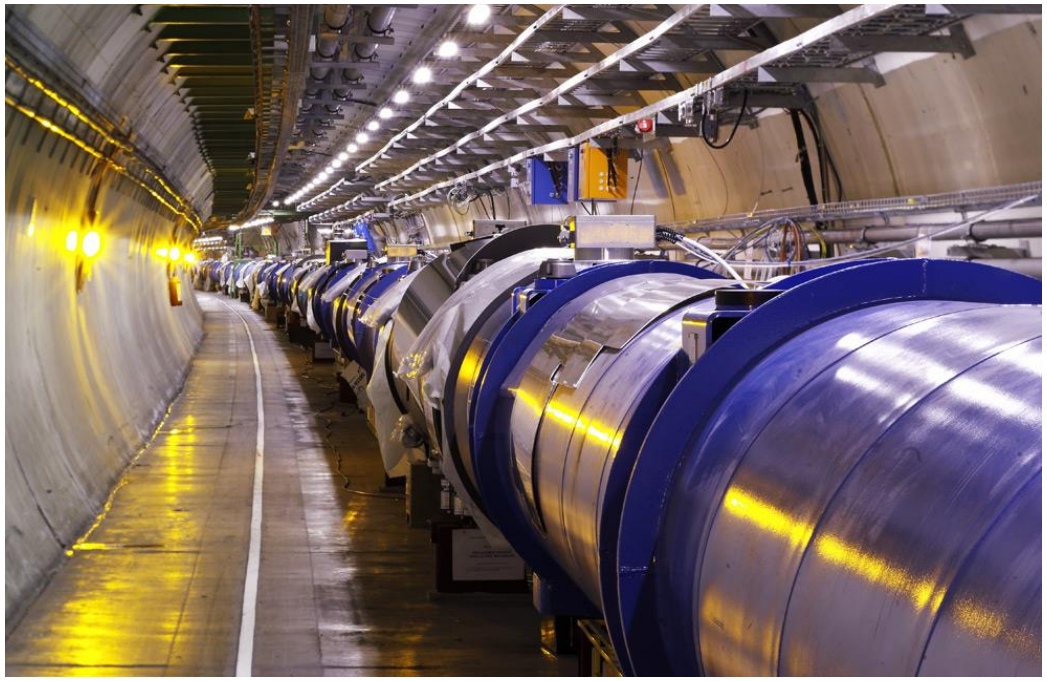


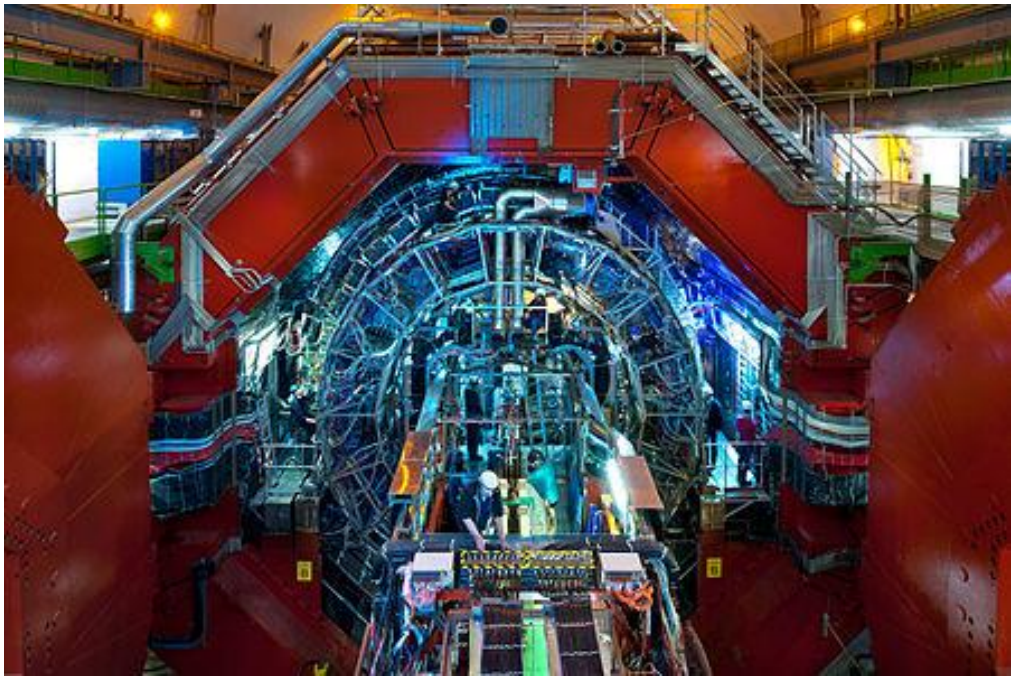
See A. Zichichi Nuclear Physics A 805 (2008) 36c–53c

Recipes for preparing dense hadronic matter



Recipes for preparing dense hadronic matter: ingredients



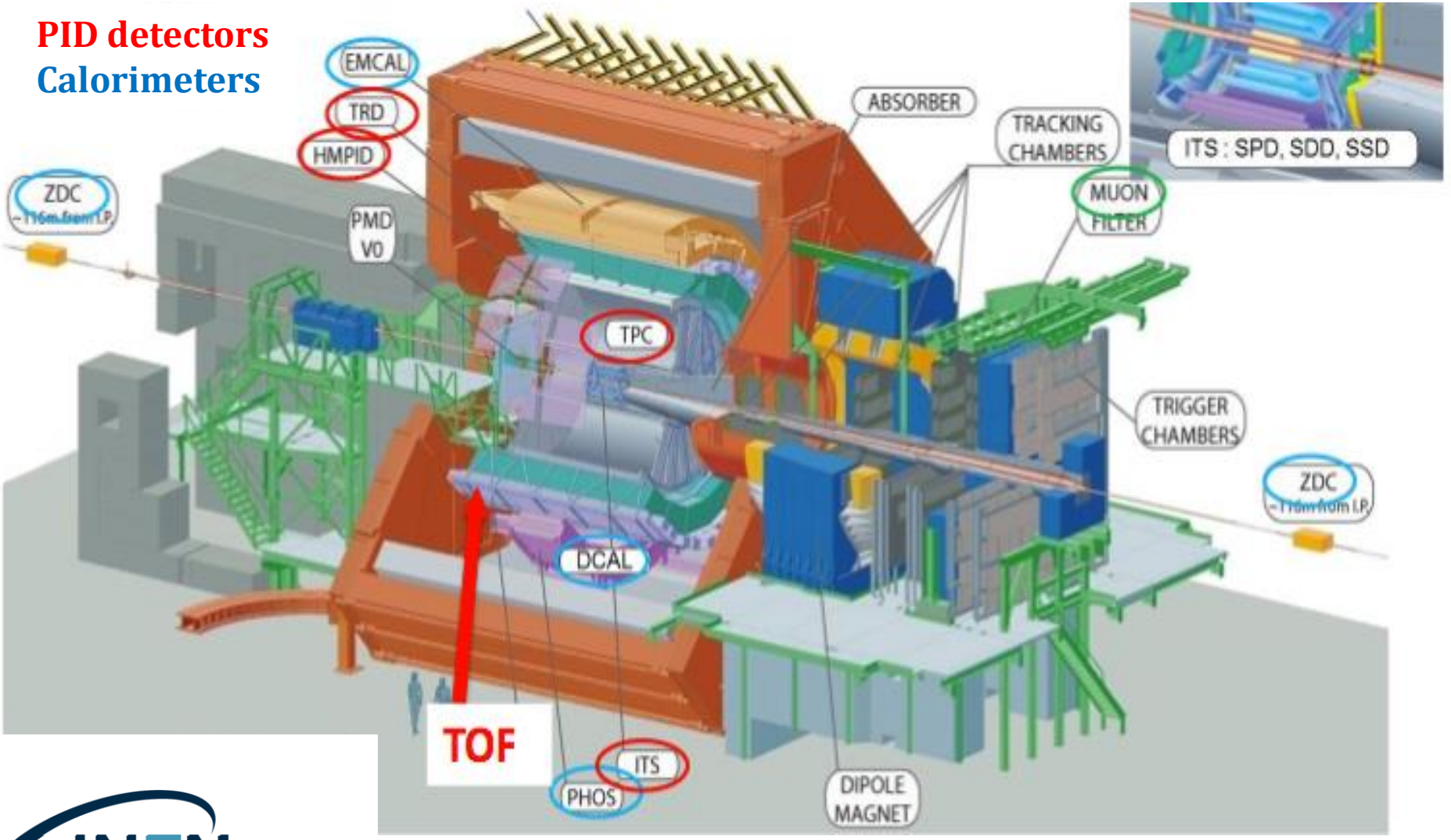


1) A Large-Hadron Collider (preferably with a $\sqrt{s_{NN}}$~TeV)

2) A detector with great PID capabilities to reconstruct high-multiplicity final states

The ALICE experiment

PID detectors
Calorimeters



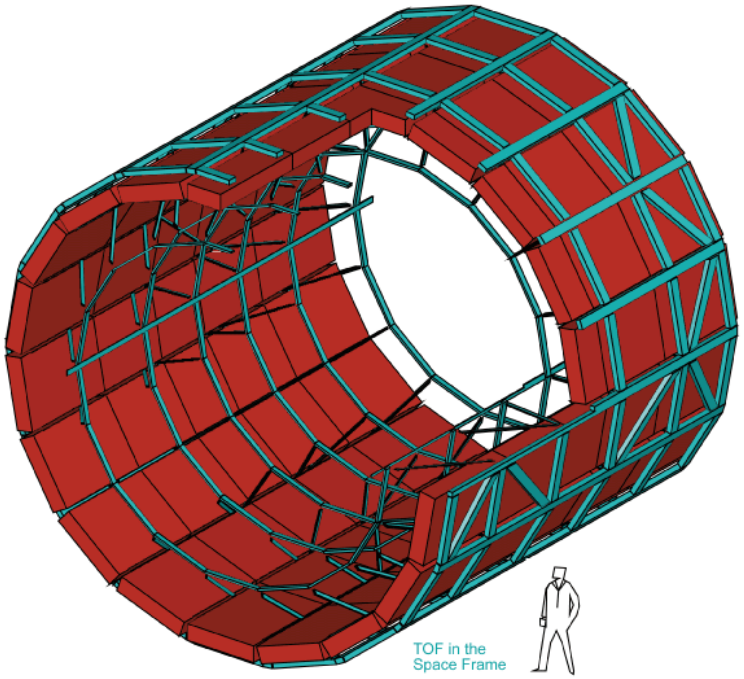
The Time-Of-Flight detector

Requirements:

- Large coverage (~144 m^2)
- High efficiency (> 95%)
- High granularity (~10^5 channels)

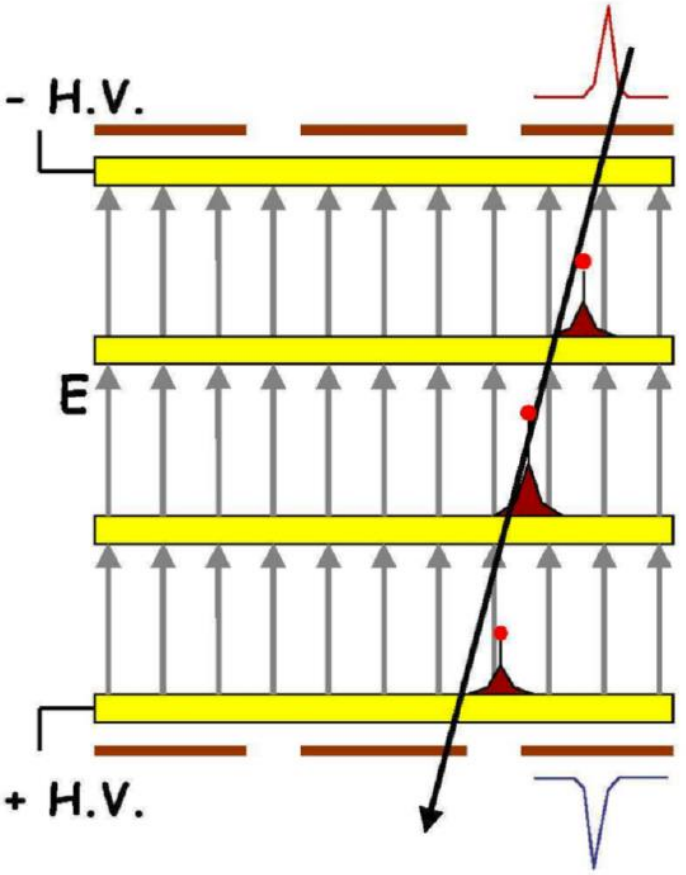
⇒ Gaseus detector composed of 1638 MRPC on a 144 m^2 surface, read pad 1.5 x 10^5 pads

The Time-Of-Flight detector

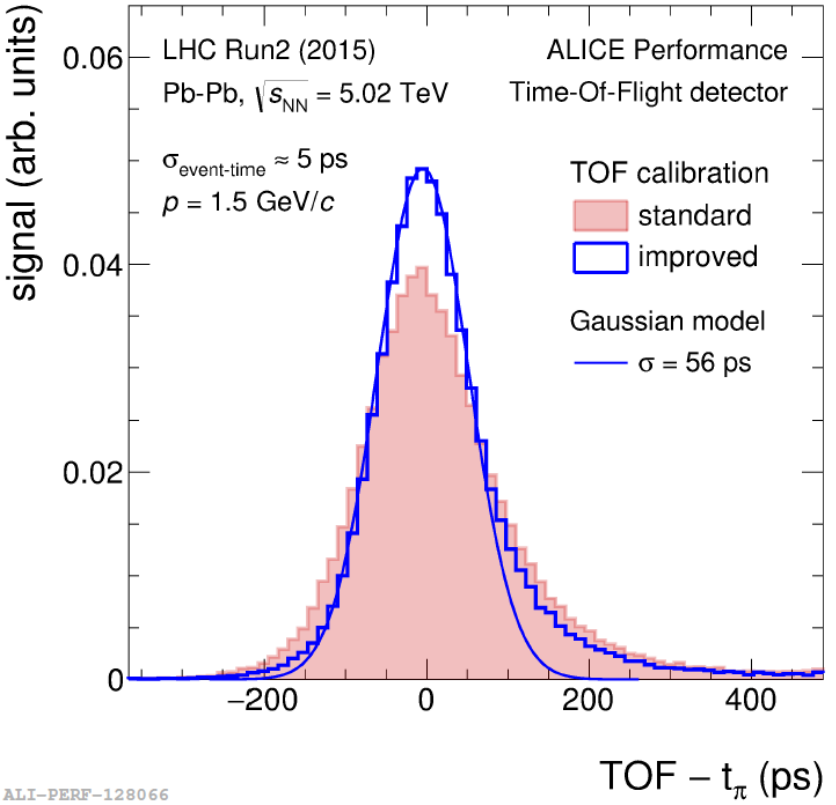


1500 MRPC on a 144 m^2 surface
1.5 x 10^5 redout pads

The Time-Of-Flight detector



The Time-Of-Flight detector



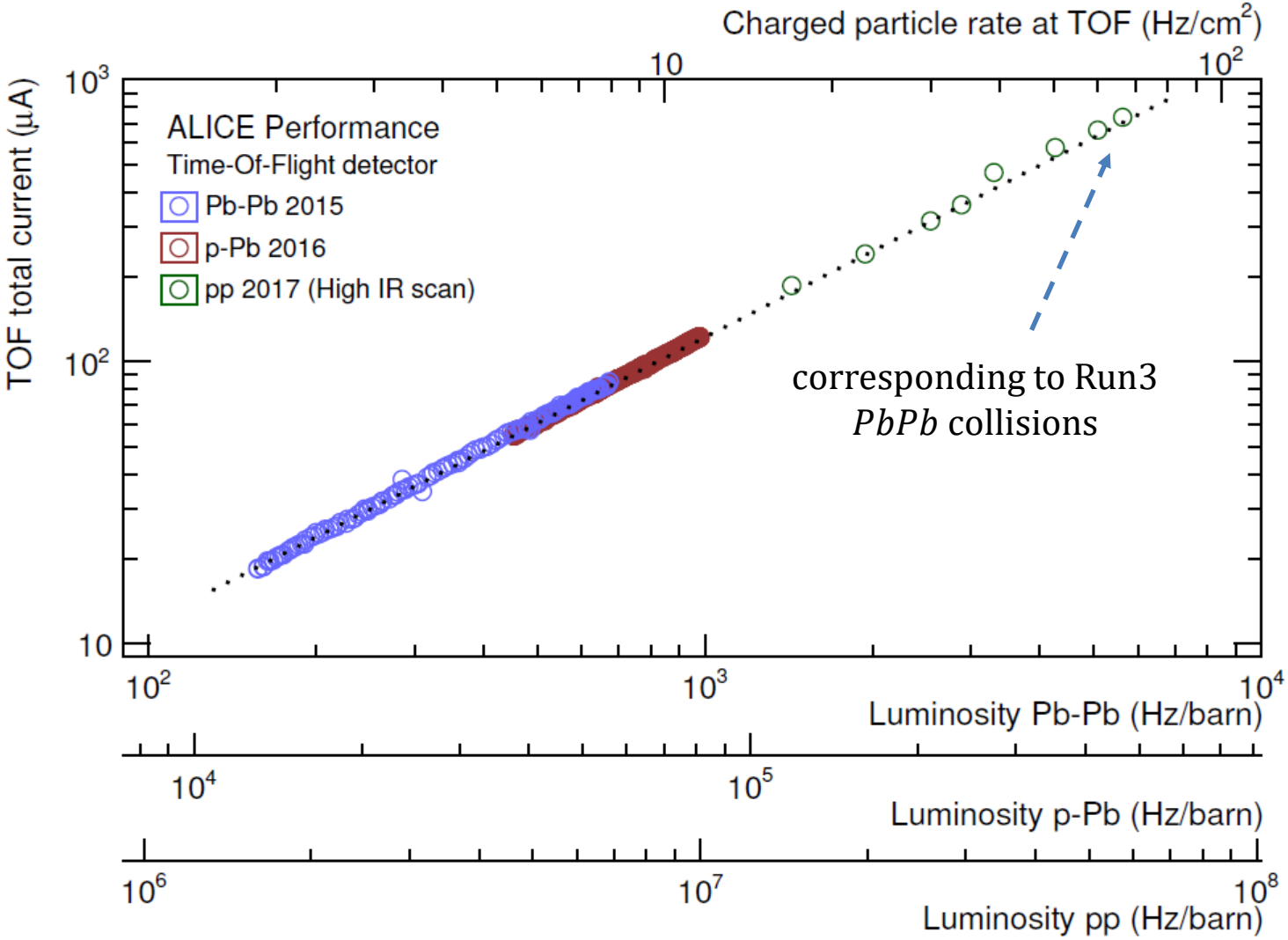
RPC2018 proceedings: https://arxiv.org/abs/1806.03825

TOF upgrade: high rate and continuous readout

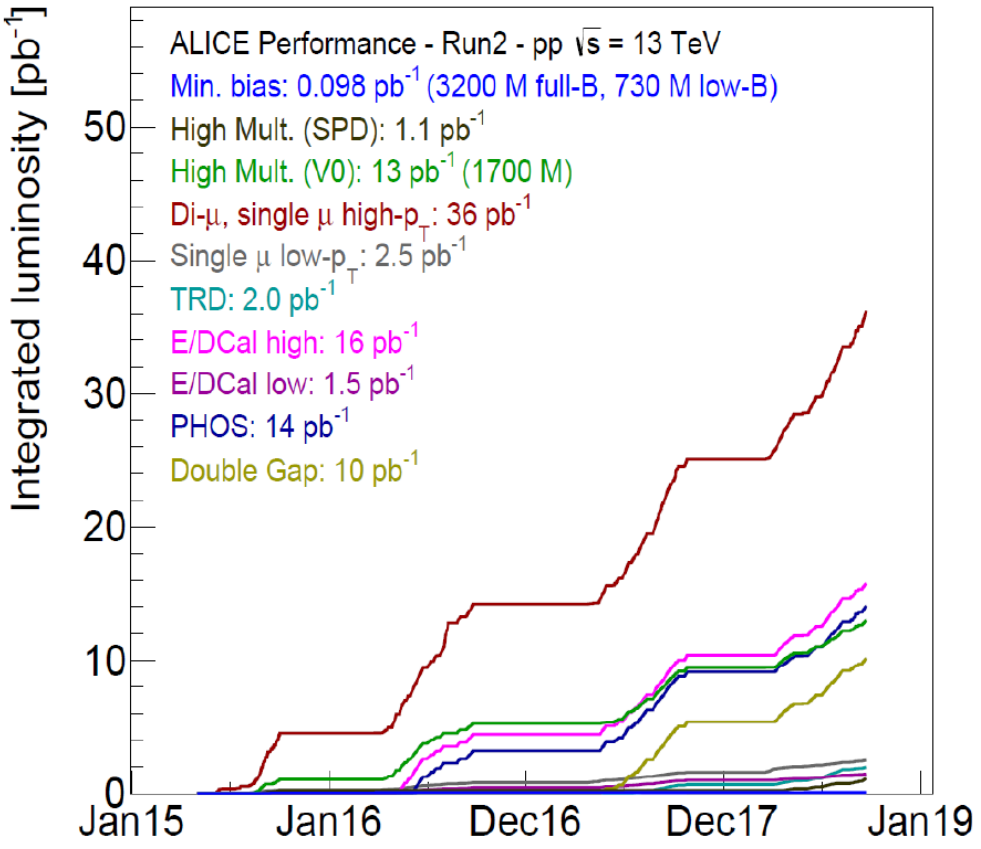
Current measurement as a function of the **charged particle flux**

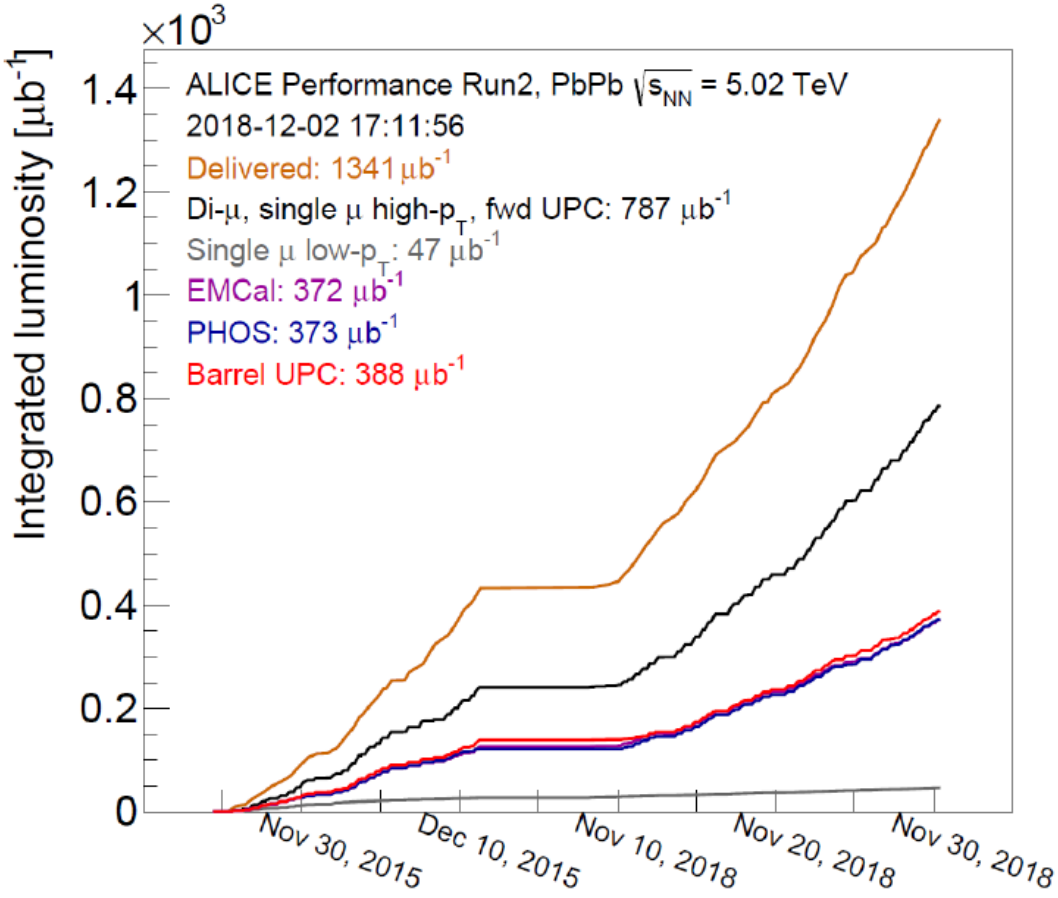
No sign of deviation up to **very high fluxes**

Suitable for operations at the expected **50 kHz of Run3 *PbPb*** data recording



Run 2 statistics at the end of 2018: $pp\&PbPb$





Alice highlights: charmed heavy-flavors

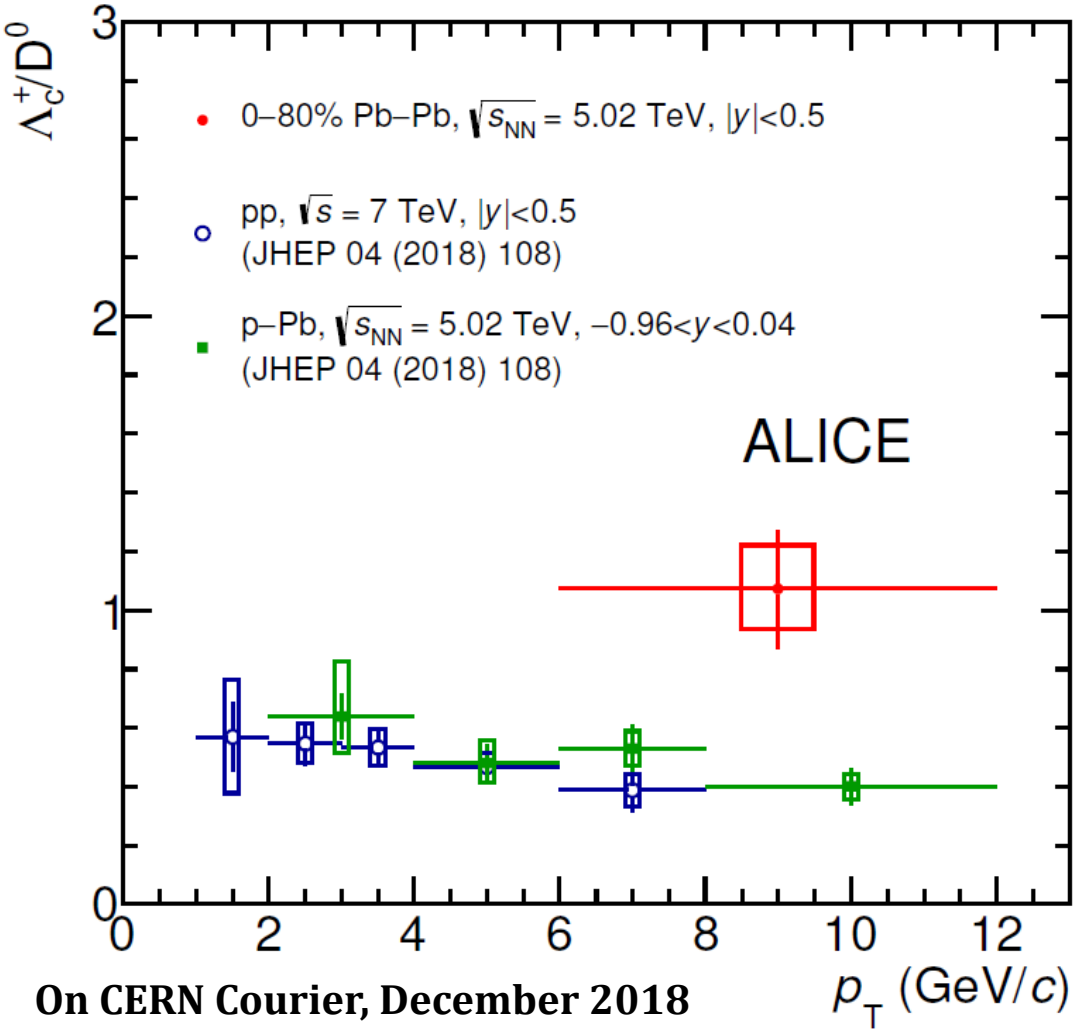
NEW@PbPb:https://arxiv.org/abs/1809.10922

Insights on the fragmentation mechanisms for both light and heavy quarks crucial for QCD understanding

c-production importal tool to test *p*QCD predictions

***Baryons-to-mesons* ratio highly sensitive to fragmentation process**

baryon-to-meson ratio



On CERN Courier, December 2018

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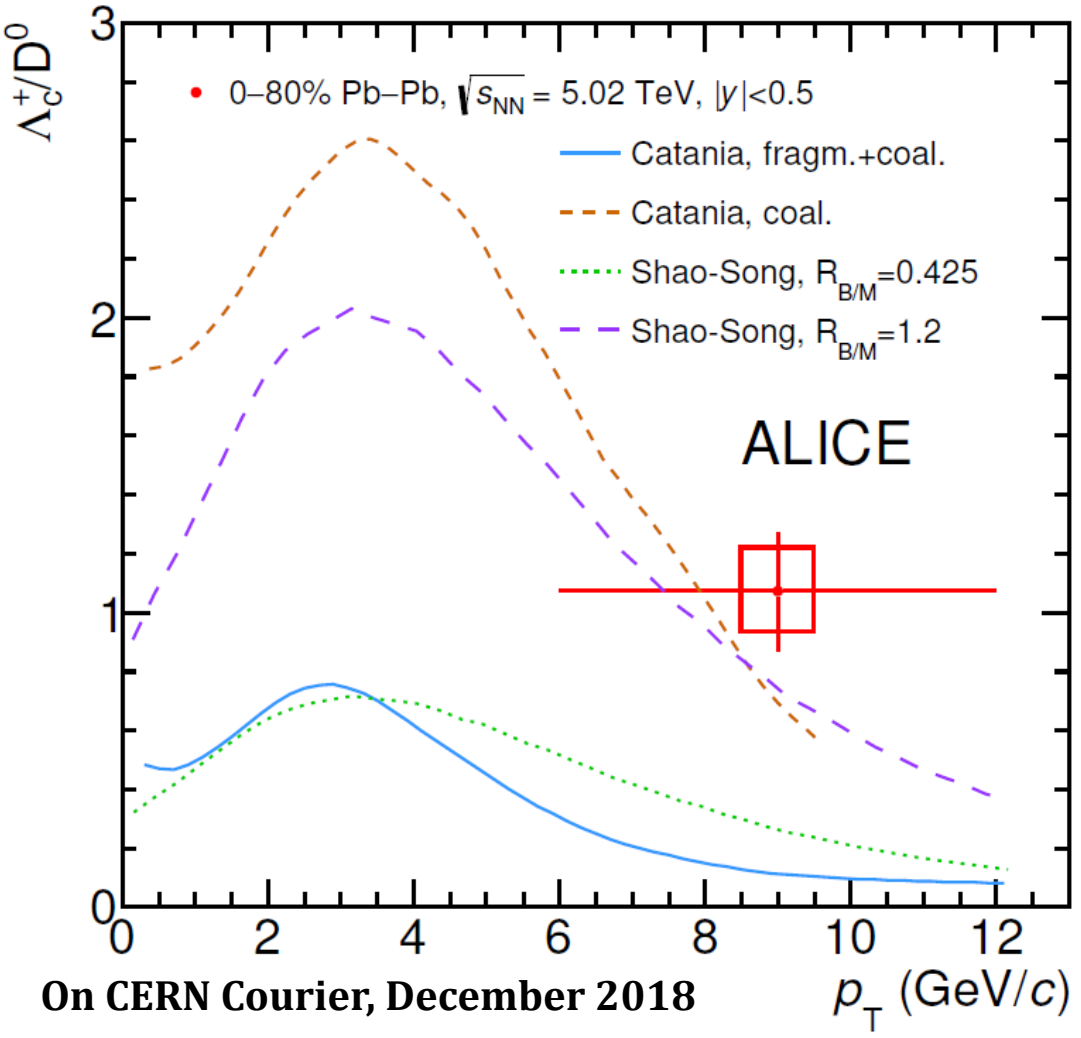
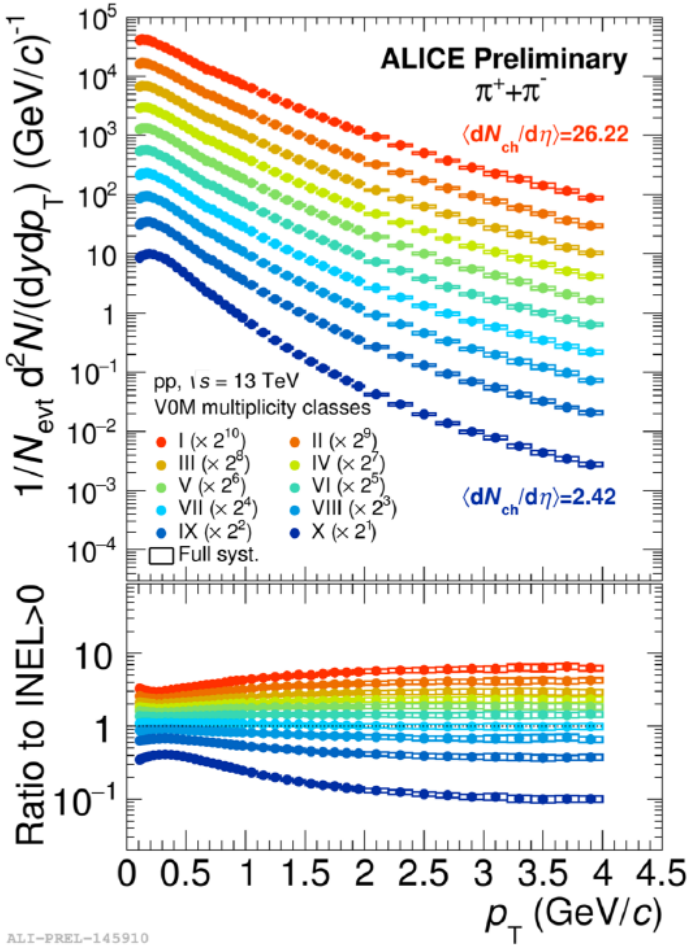
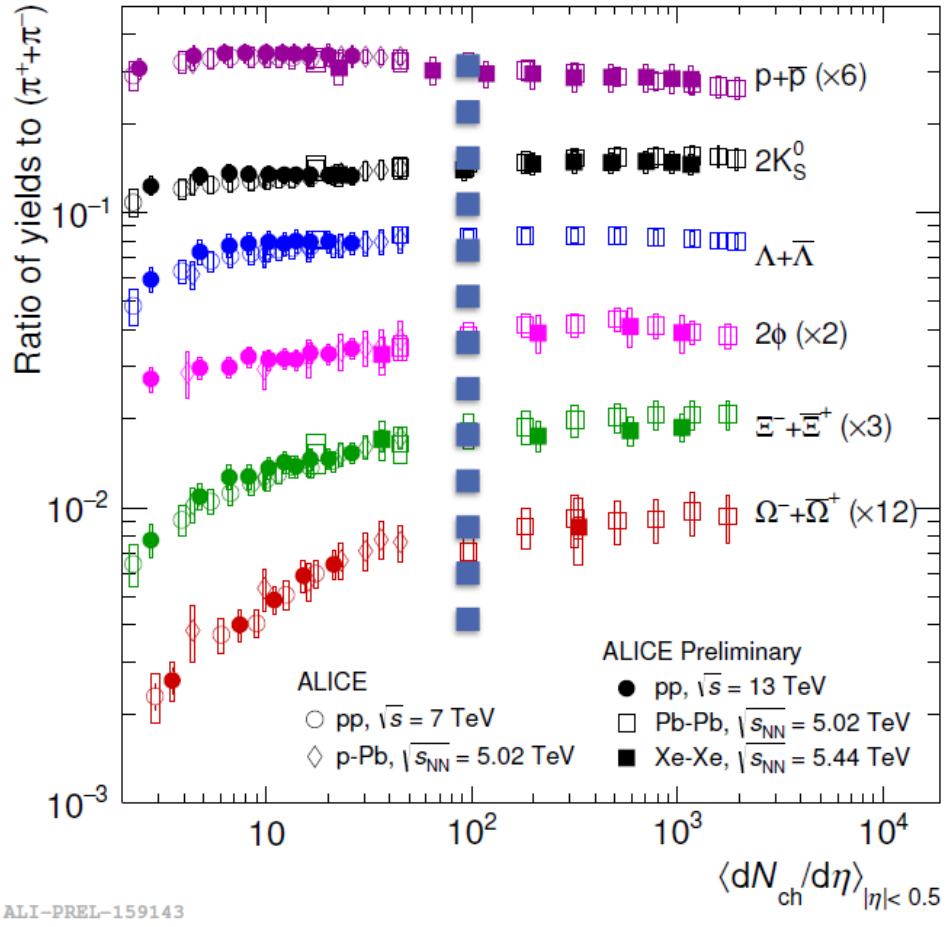


On CERN Courier, December 2018

Alice highlights: particle chemistry





$\pi/K/p$ in pp@13 TeV vs. multiplicity

⇢ Essential input to check energy independence of evolution of particle chemistry with system size

Coalescence

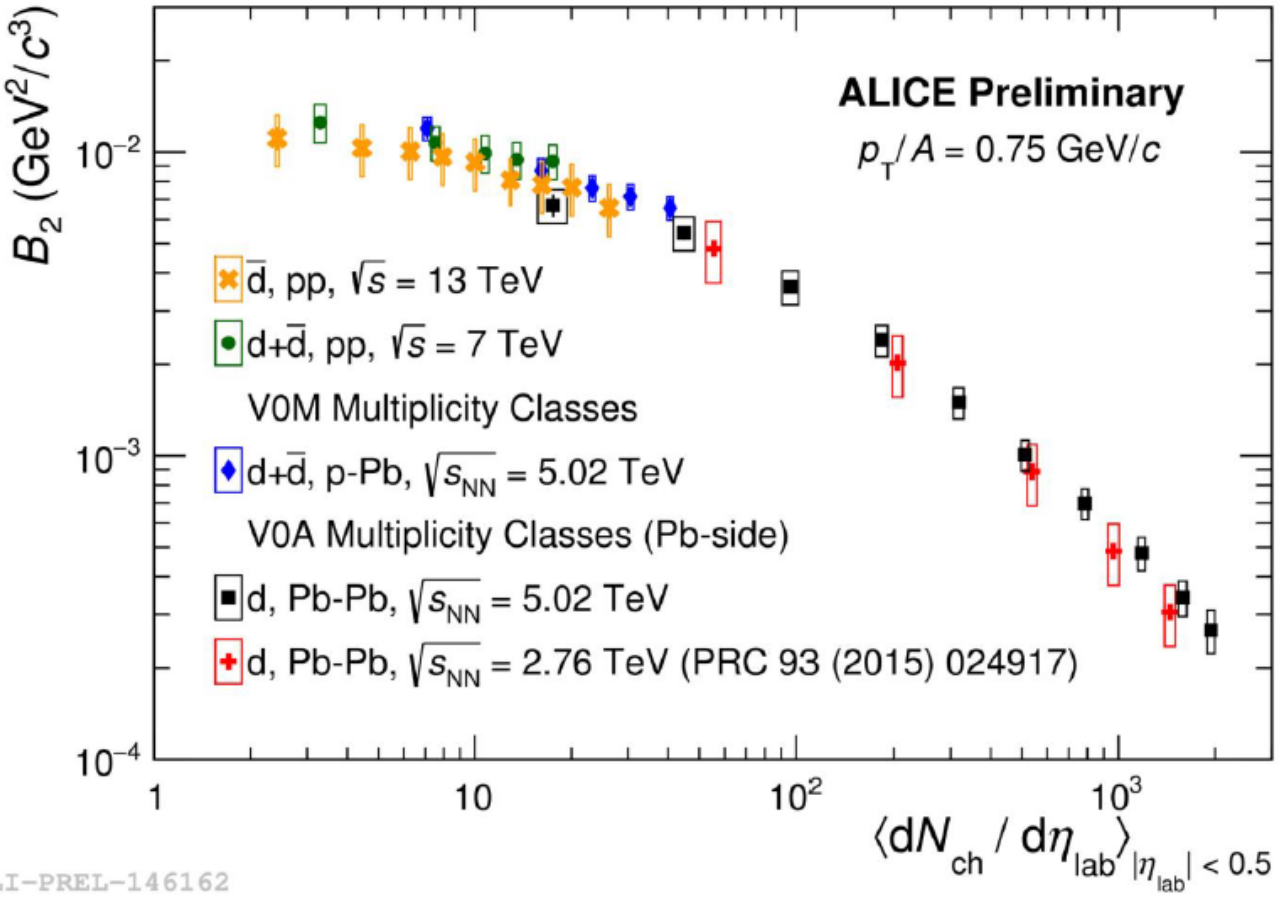
B_A: relates the formation of composite nuclei to the ones of primordial protons and neutrons through

$$E_A \frac{d^3N_A}{dp_A^3} = B_A \left(E_p \frac{d^3N_p}{dp_p^3} \right)^A$$

$p_p = p_A/A$.

Coalescence suppression with multiplicity ⇢ increasing size of the hadronic emission region

Effect predicted in more elaborated coalescence models.



ALI-PREL-146162

Coalescence

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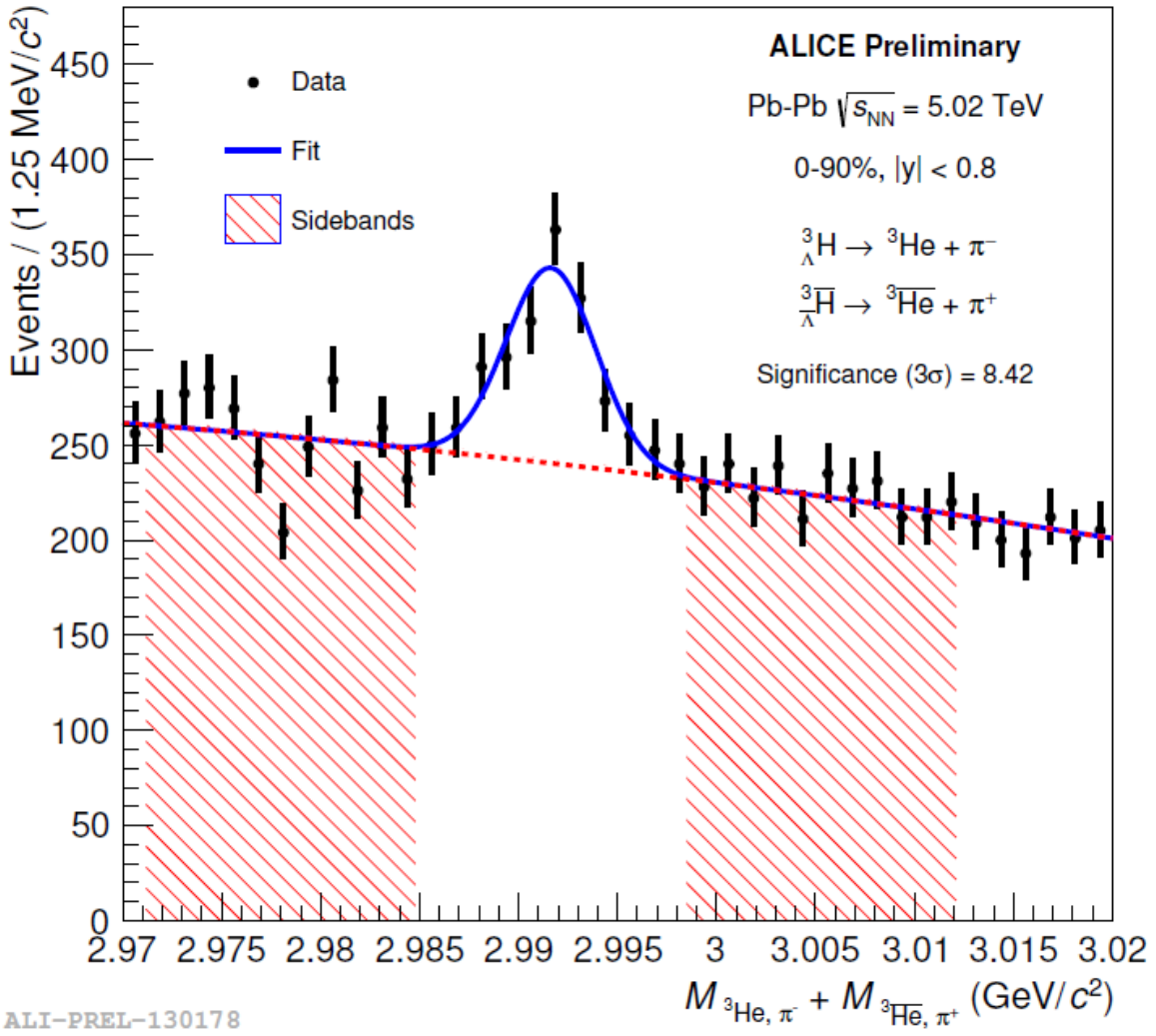
$p_p = p_A/A$.

ON-GOING: hyper-triton on new *PbPb* data



Quark-Gluon Coloured World: 2018 milestones

ALICE Time-Of-Flight

Test on electronics completed ⇢ to be upgraded during Long-Shutdown 2

Data analysis on *PbPb* data

Spectra vs. multiplicity analyses ⇢ Cold Nuclear Matter effects under evaluation by comparison among pp, pPb and $PbPb$ data

Baryon-to-meson ratios for charmed quark: Λ_c/D^0 ⇢ measured ratio different from MC expectation

Analysis of production models (thermal *vs.* coalescence) through investigation of light-nuclei production

Quark-Gluon Coloured World: 2018 milestones

ALICE Time-Of-Flight

Test on electronics completed ⇢ 100% completed

Data analysis on *PbPb* data

Spectra vs. multiplicity analyses ⇢ Cold Nuclear Matter effects under evaluation by comparison among *pp*, *pPb* and *PbPb* data

Baryon-to-meson ratios for charmed quark: expectation

80% completed

Preliminary results presented at QM2018

Analysis of production models (thermal *vs.* coalescence) through investigation of light-nuclei production

Quark-Gluon Coloured World: 2019 milestones

ALICE Time-Of-Flight

Ugrade activities ⇢

Test and installation of new FE and LV

Data analysis on *PbPb* data

Spectra vs. multiplicity analyses ⇢ Cold Nuclear Matter effects under evaluation by comparison among *pp*, *pPb* and *PbPb* data

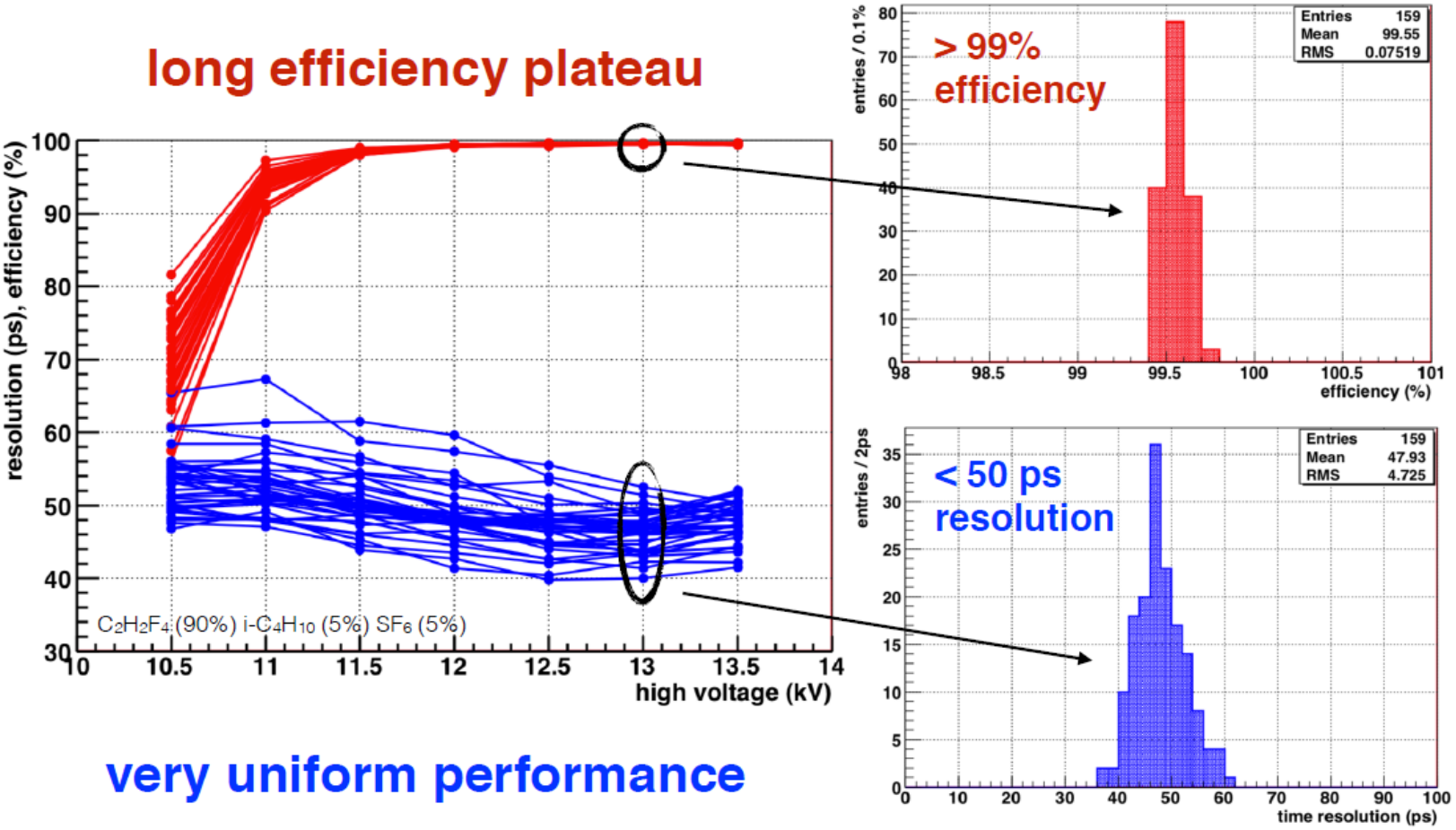
Baryon-to-meson ratios for charmed quark expectation

Analysis of production models (thermal *vs.* production

Publication of the ongoing analyses

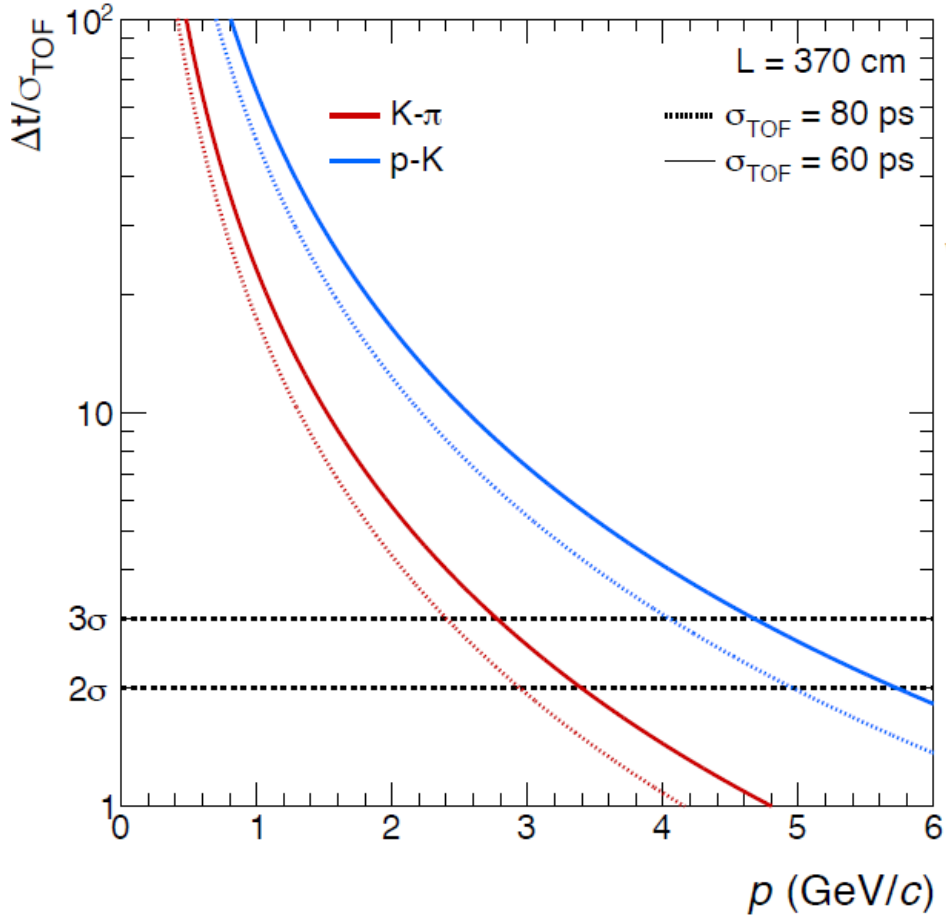
backup

TOF test-beam performances



NIM A 602 (2009) 709

Particle identification with TOF



$$\Delta t = t_1 - t_2 = \frac{L}{2c}\left(\frac{m_1^2c^2 - m_2^2c^2}{p^2}\right)$$

for a **L = 370 cm** long track

valid for $|\eta| = 0$ straight (high p_T tracks)

K/π (p/K) separation

better than 3σ up to about

(design performance) 2.5 (4.0) GeV/c

(actual performance) **3.0 (5.0)** GeV/c

better than 2σ up to about

(design performance) 3.0 (5.0) GeV/c

(actual performance) **3.5 (6.0)** GeV/c

Alice highlights: charmed heavy-flavors

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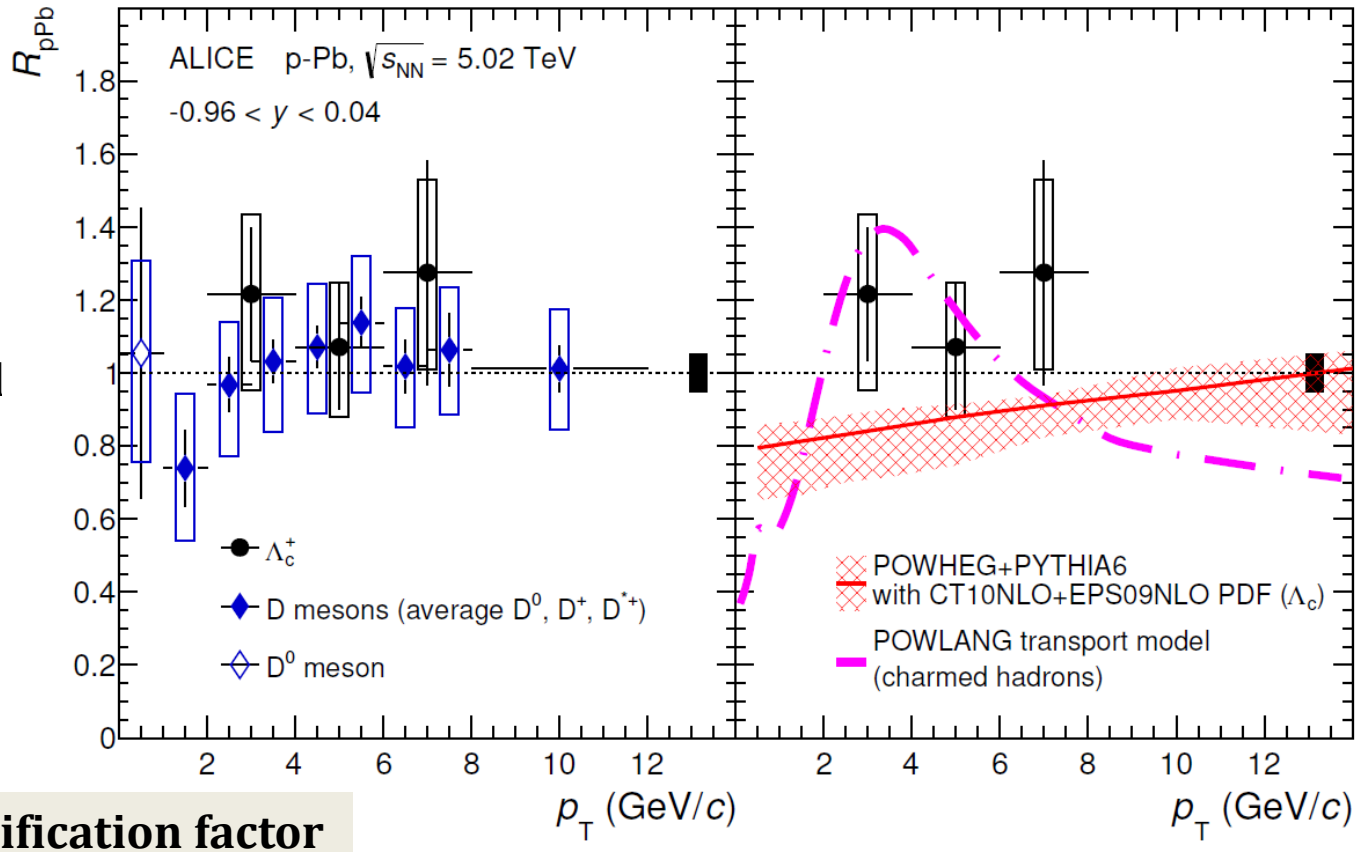
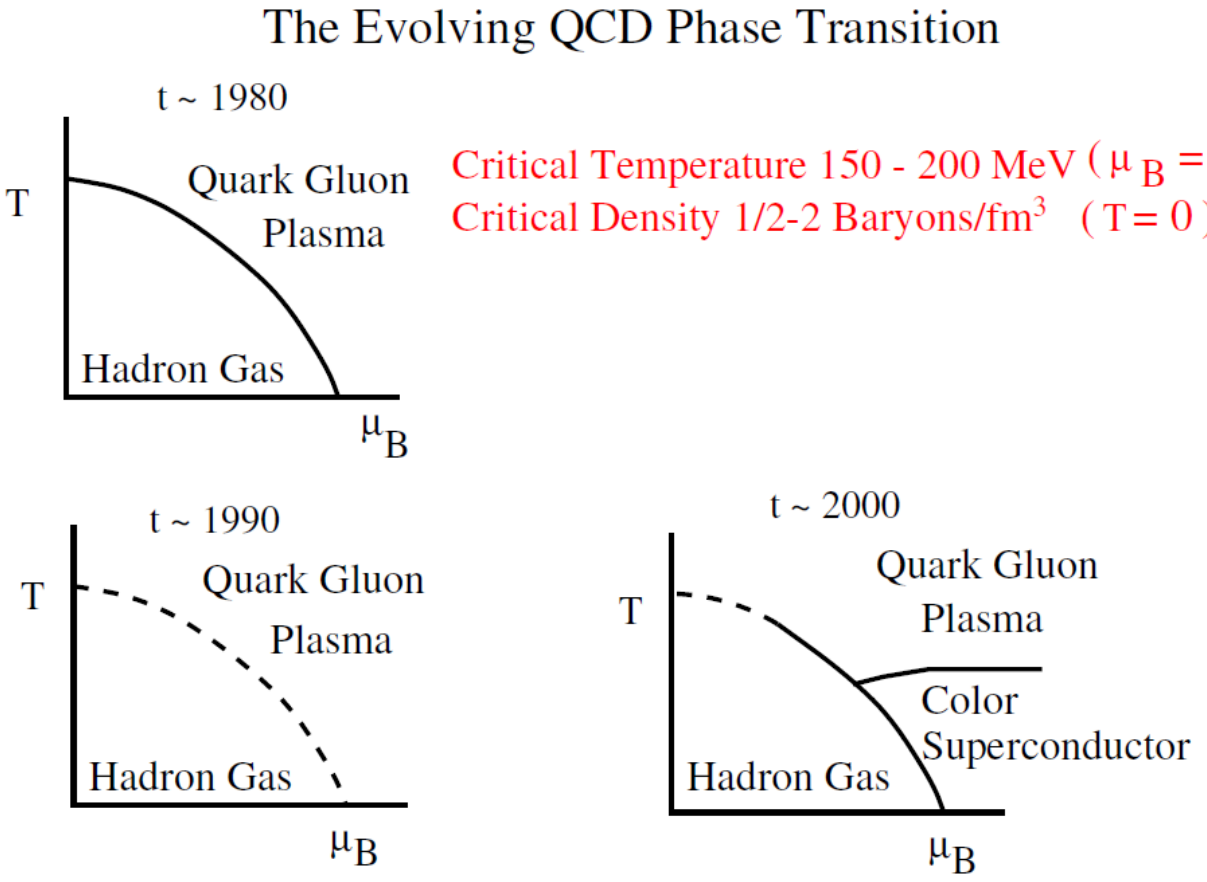
c-production important tool to test *p*QCD predictions

Baryons-to-mesons ratio highly sensitive to fragmentation process



$pPb \rightarrow R_{pPb}$, nuclear modification factor

QCD «phase diagram»



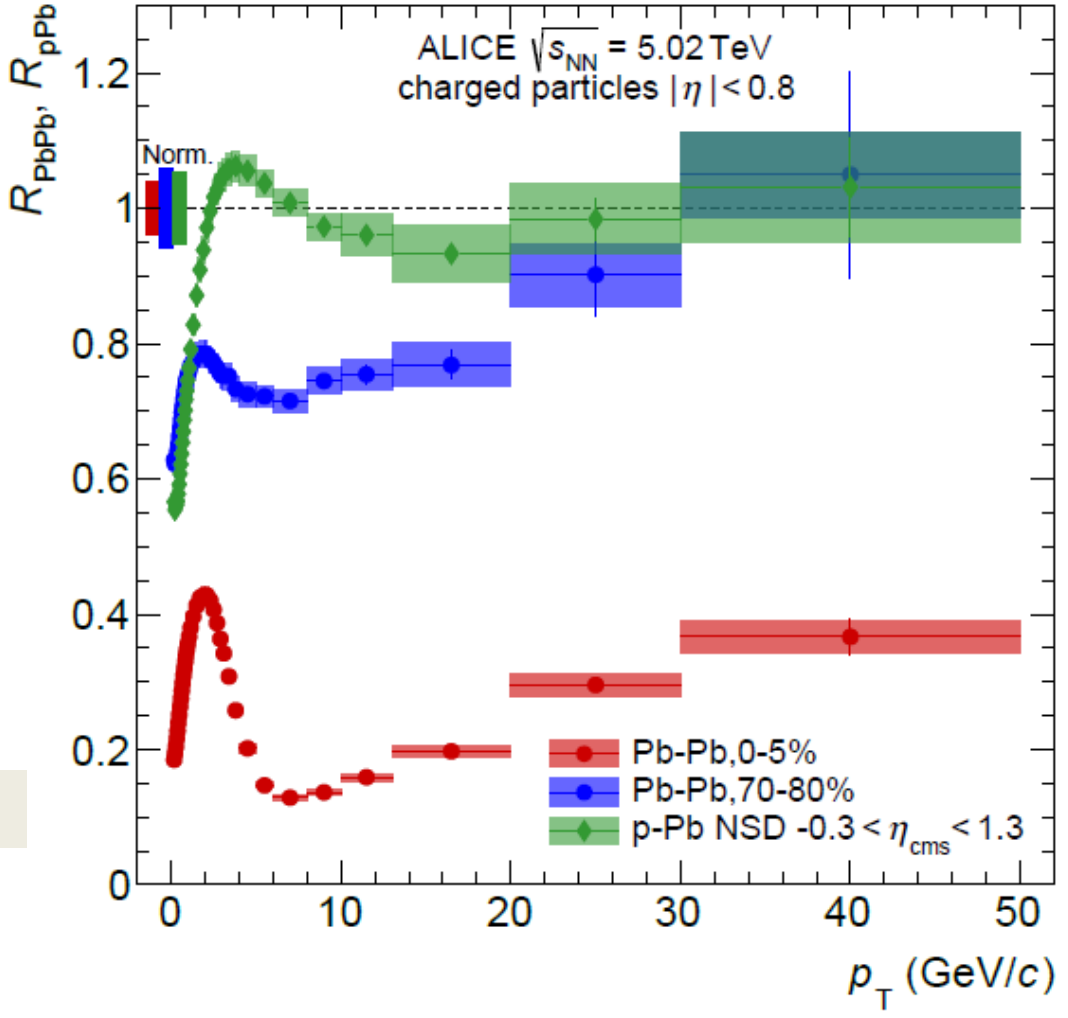
10.5170/CERN-2007-005.75

Alice hightlights: disentangling Cold Nuclear Matter effects

pPb data plays a crucial role in comparing with different collision systems

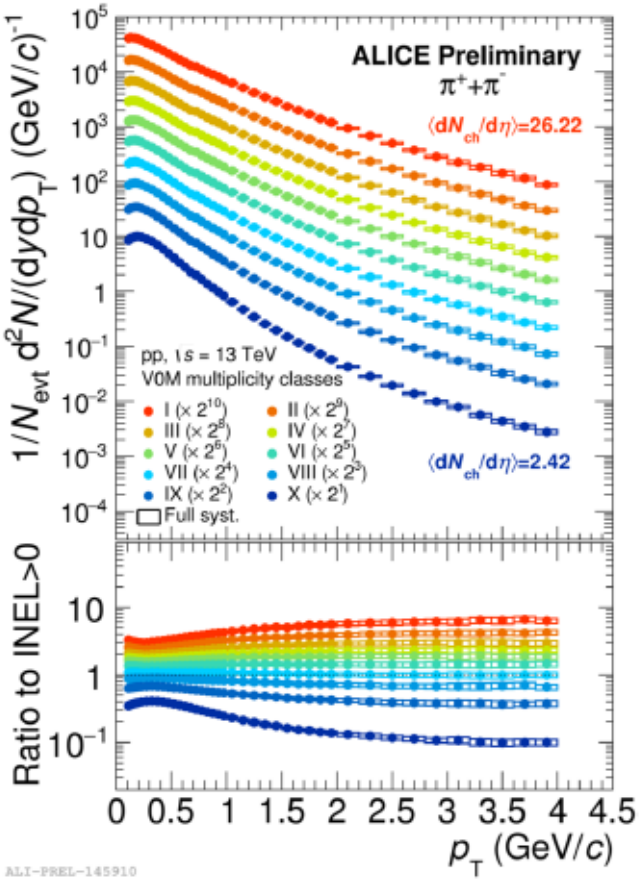
→ cold nuclear matter effects – might influence the particle production at low and high *p_T*; search for collective phenomena or final state effects

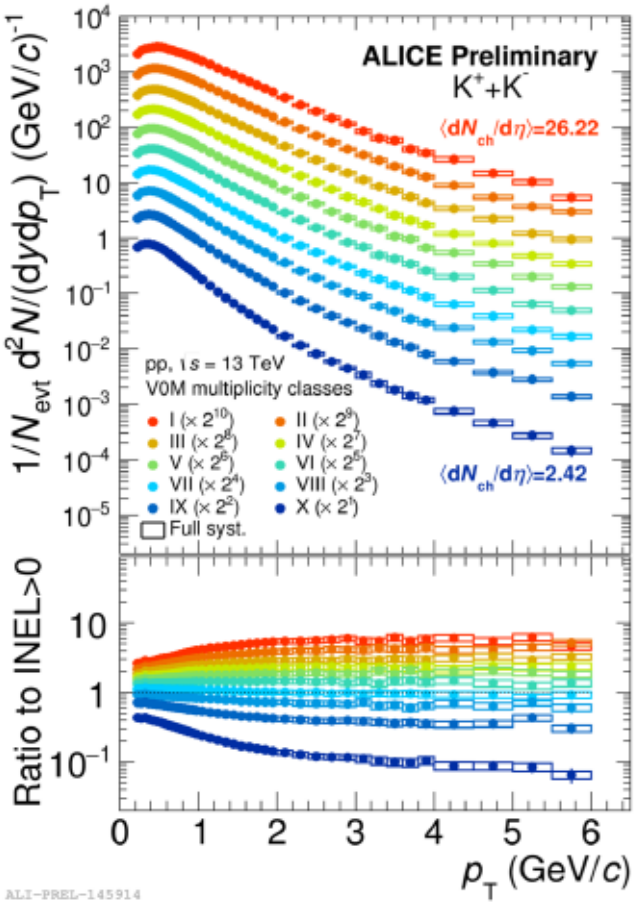
https://arxiv.org/abs/1802.09145

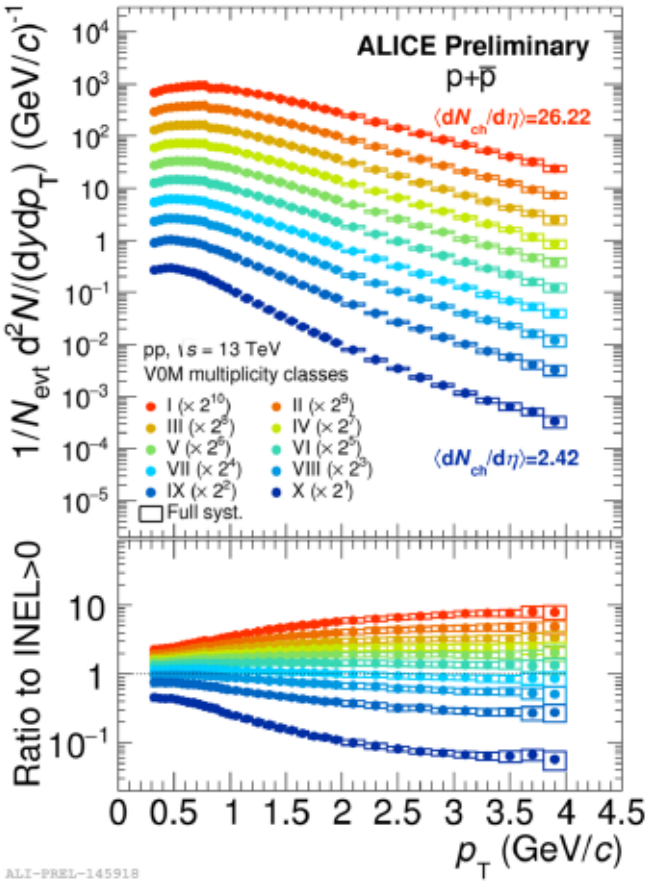


From particle spectra…

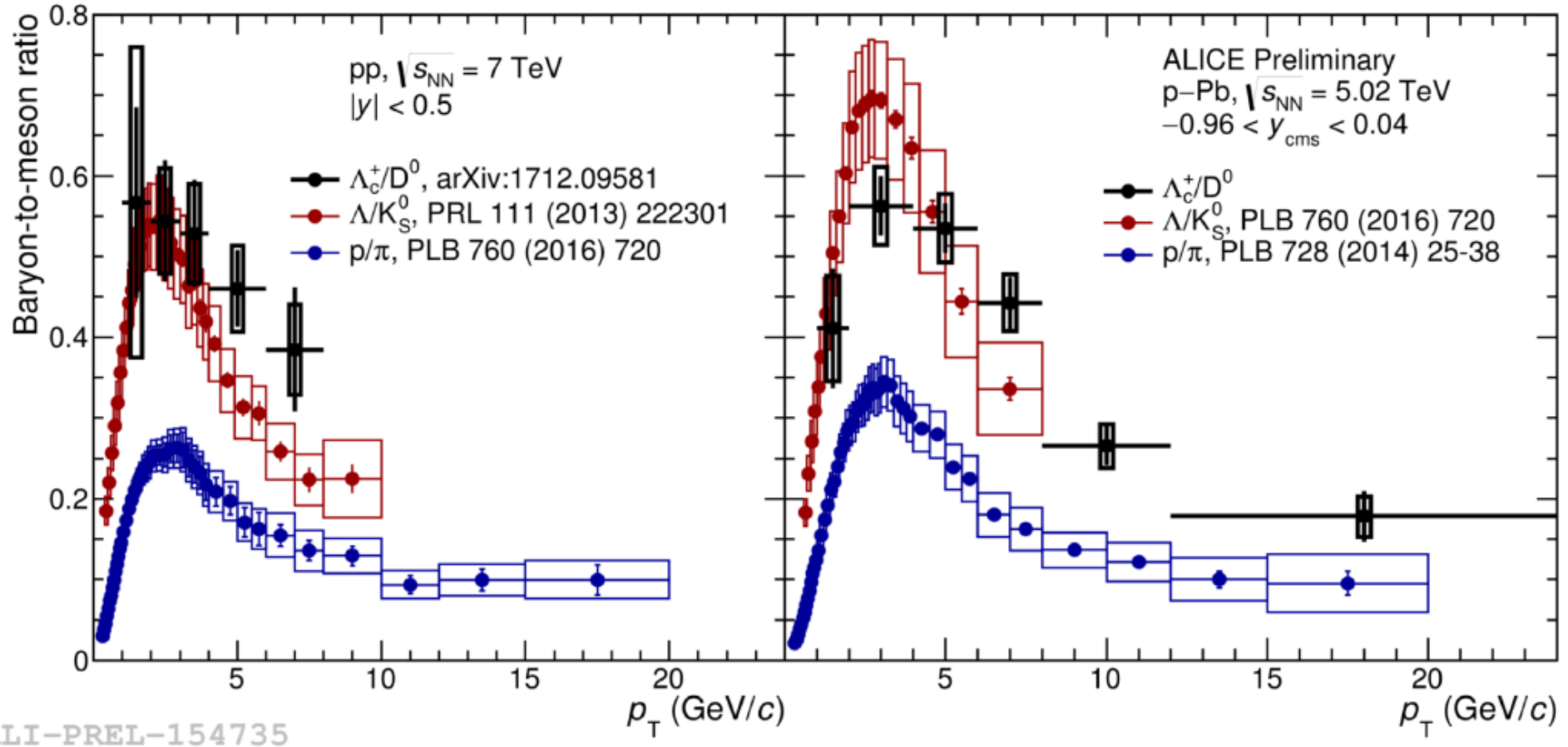
$\pi/K/p$ in pp@13 TeV vs. multiplicity







Alice highlights: baryon-to-meson ratios for different flavors



ALI-PREL-154735

⇢ **Similarities of baryon-to-meson ratios for charmed and light flavors**

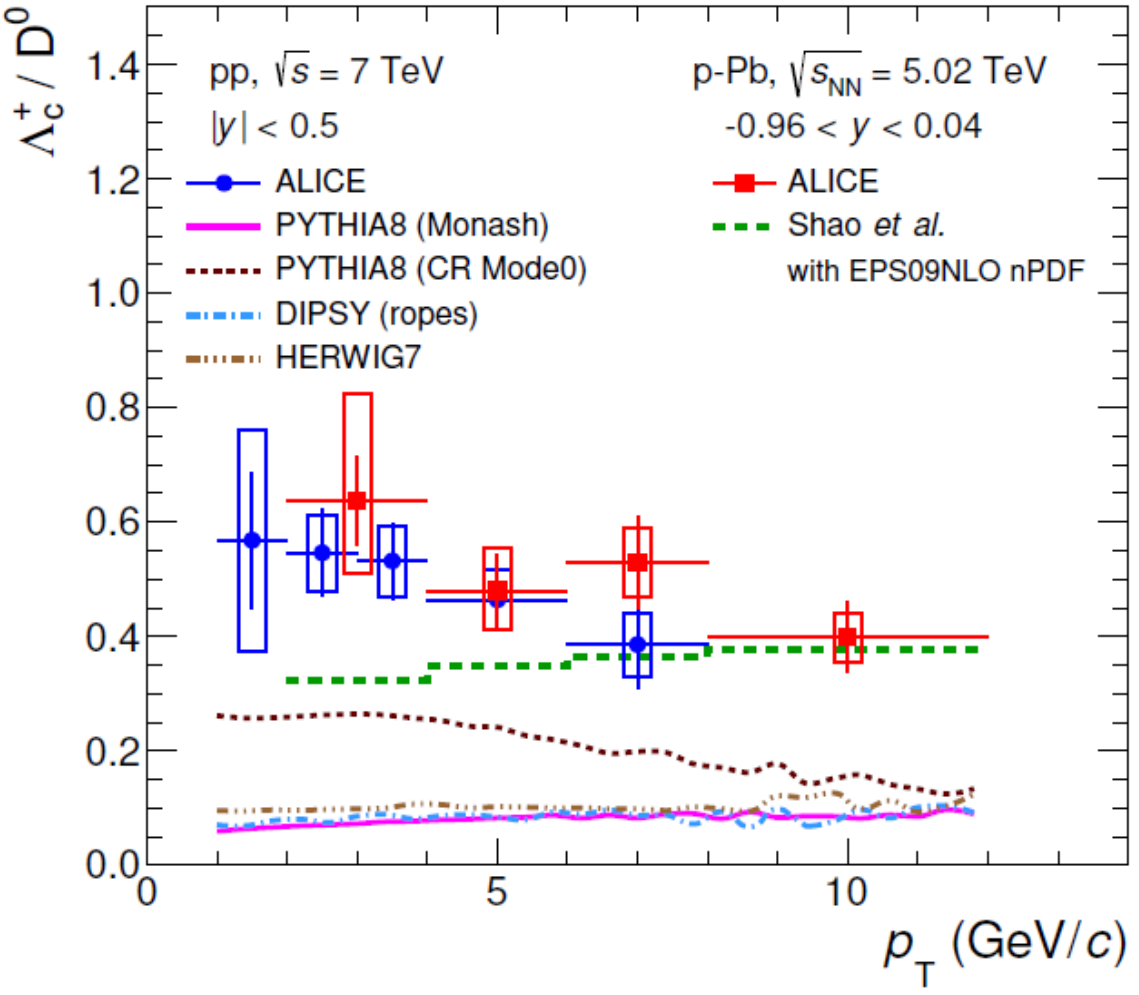
Alice highlights: charmed heavy-flavors

Insights on the fragmentation mechanisms for both light and heavy quarks crucial for QCD understanding

c-production importal tool to test *p*QCD predictions

***Baryons-to-mesons* ratio highly sensitive to fragmentation process**

***pp* → baryon-to-meson ratio**



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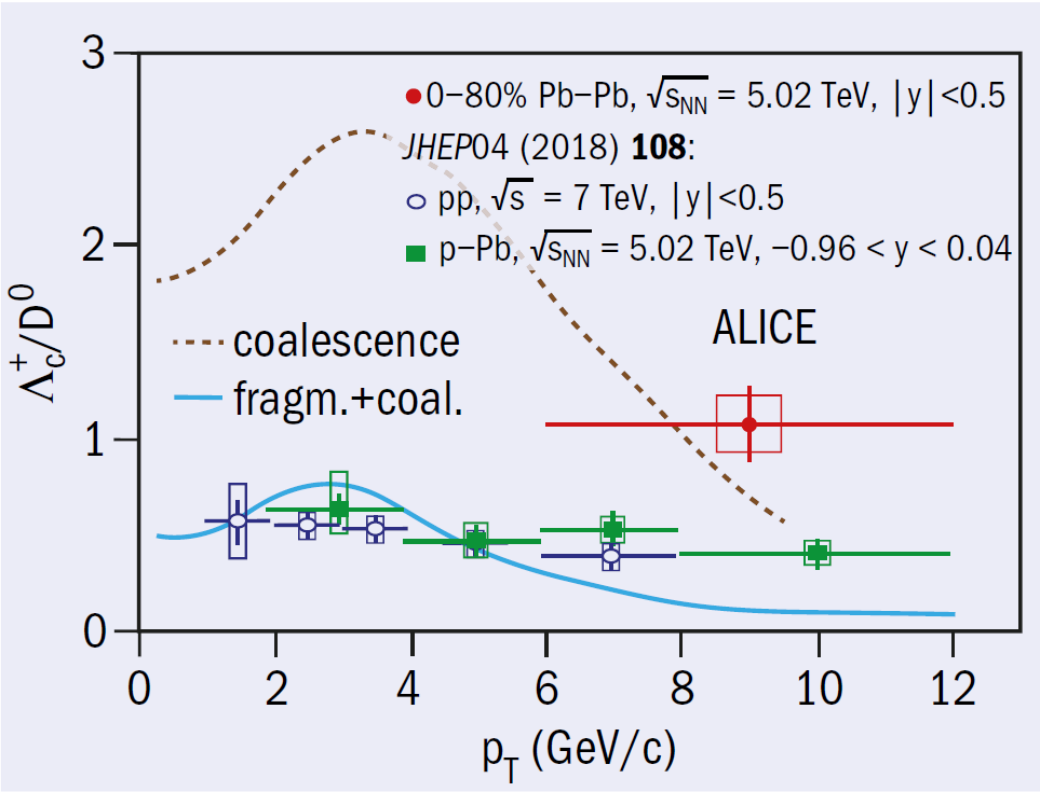
***Baryons-to-mesons* ratio highly sensitive to fragmentation process**

***PbPb* → baryon-to-meson ratio**

NEW! Analysis on PbPb data just released: https://arxiv.org/abs/1809.10922



On CERN Courier, December 2018

Coalescence

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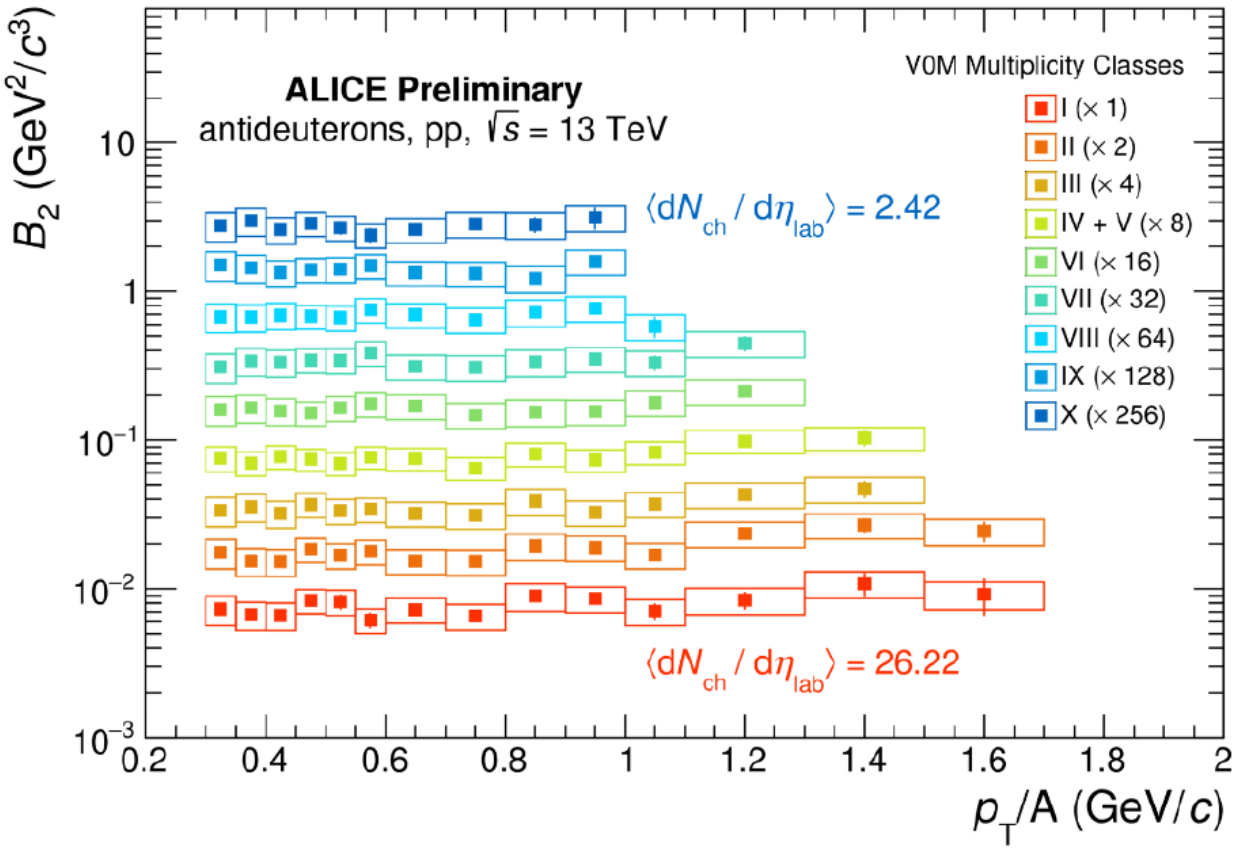
$$E_A \frac{d^3N_A}{dp_A^3} = B_A \left(E_p \frac{d^3N_p}{dp_p^3} \right)^A$$

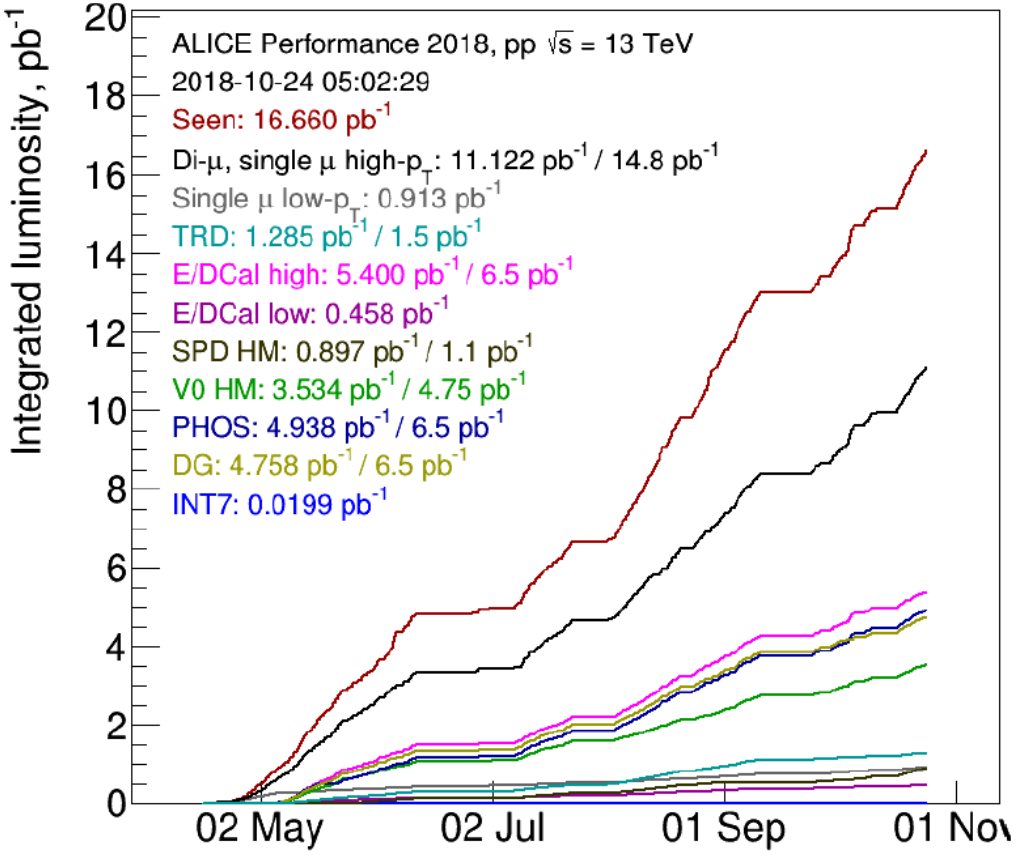
$p_p = p_A/A$.

B_2 ⇢ no p_T dependence, in agreement with *simple coalescence*:

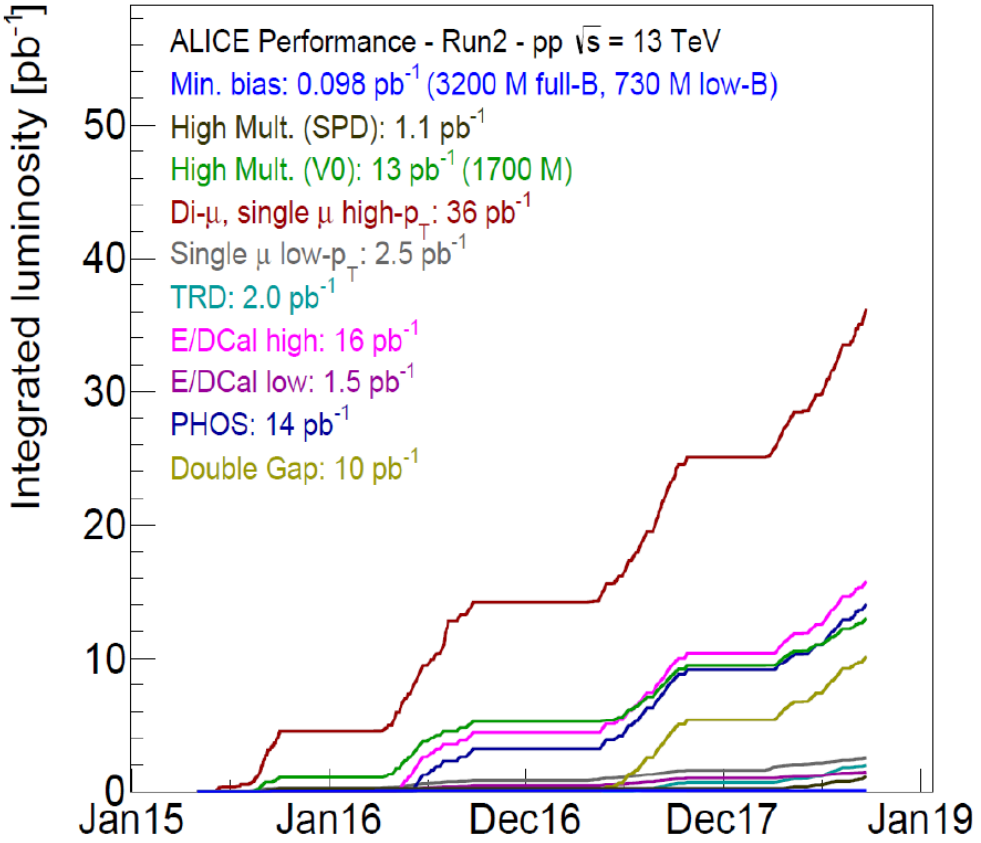
$$B_2 = \left(\frac{4}{3}\pi p_c \right) \frac{m_d}{m_p^2}$$



Data recorded in 2018: pp

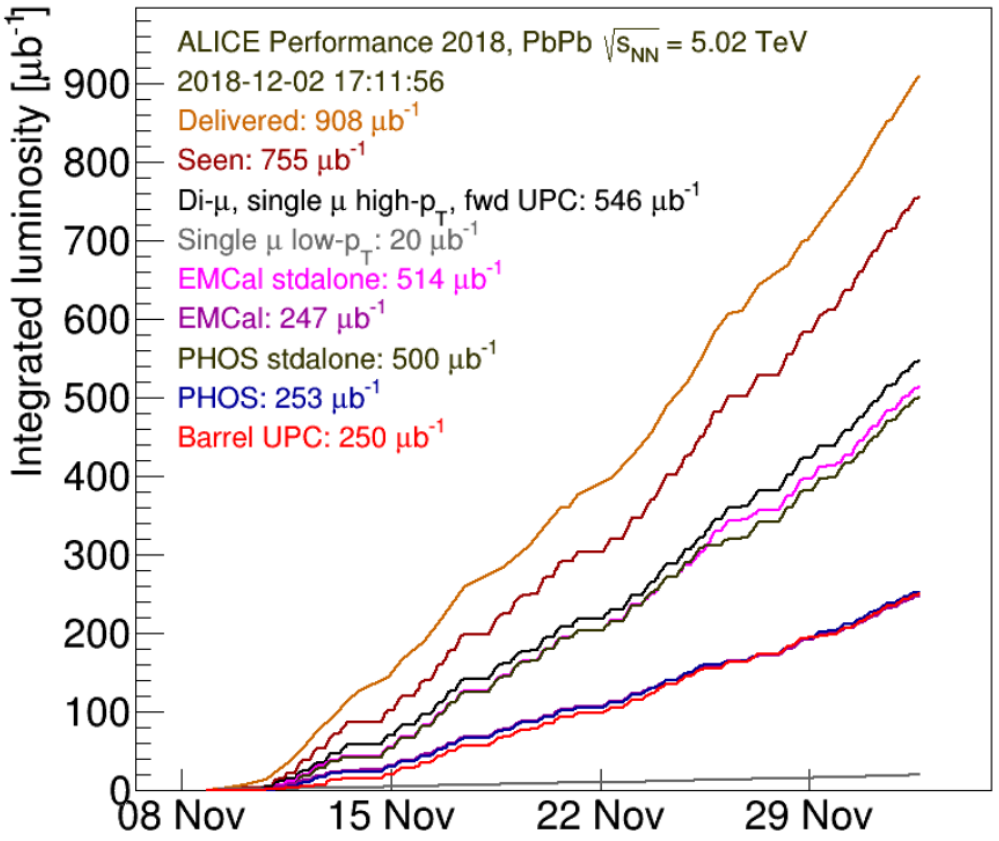


2018 data

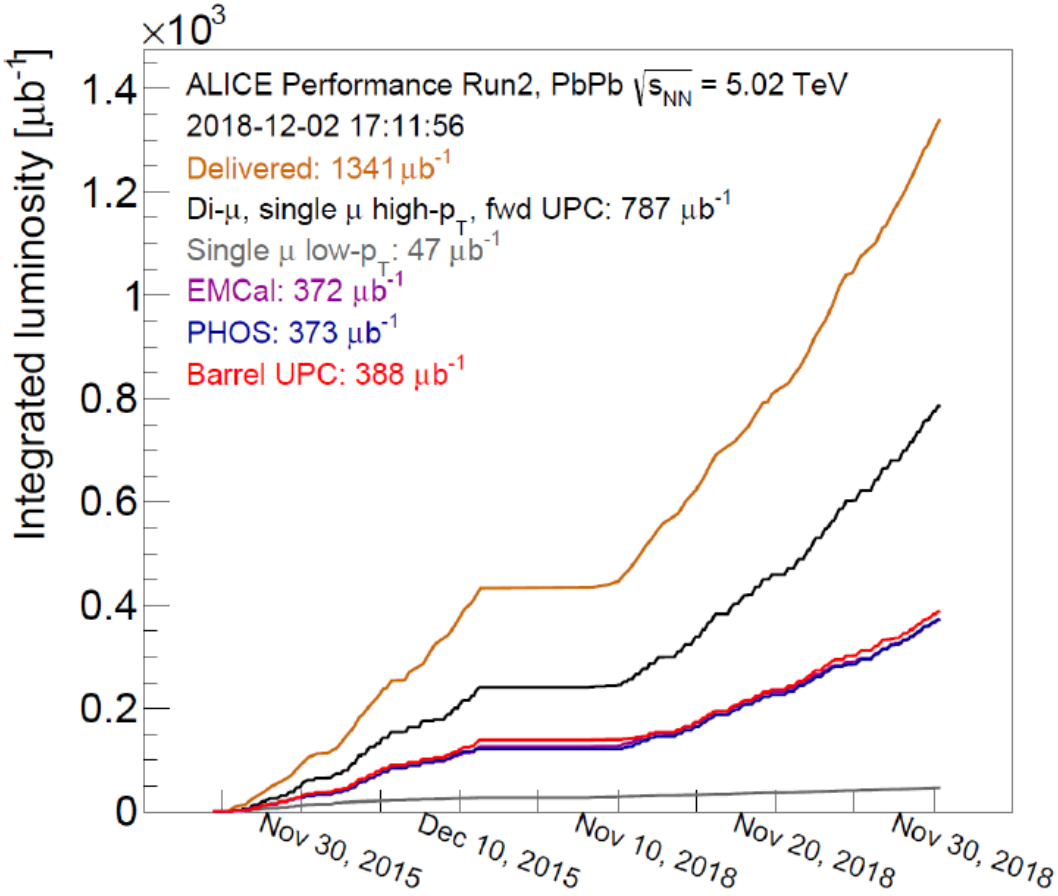


Full stat cumulated in Run2 for pp with $\sqrt{s_{NN}}$= 13 TeV

Data recorded in 2018: $PbPb$



2018 data



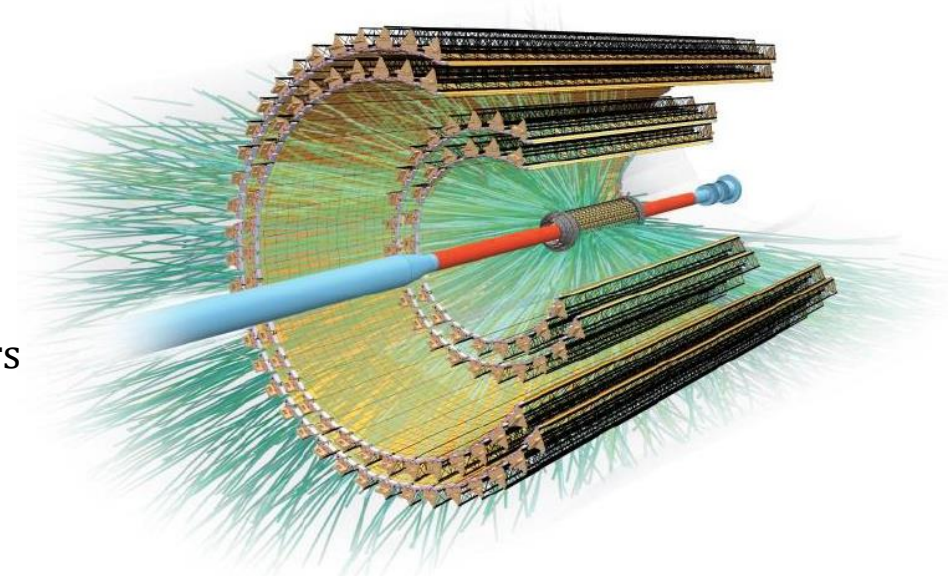
Full stat cumulated in Run2 for $PbPb$ with $\sqrt{s_{NN}}$= 5.02 TeV

ALICE upgrade for Run-3

LHC schedule for *PbPb*:

Run-3 (2021-2023) ⇢ L_{int}^{PbPb}=6.0 nb^{-1}
Run-4 (2026-2029) ⇢ L_{int}^{PbPb}=7.0 nb^{-1}

Long shutdown 2 just started
⇢ major upgrade of detector systems: faster detectors
+ continuous readout (TPC)



Main physics challenges:

1. Parton thermalization in QGP, especially for *c* and *b* (**ITS upgrade** crucial for reconstructing secondary vertices)

2. Low-*p* charmonia dissociation/regeneration to study deconfinement and medium *T*

3. Initial T estimation through thermal photon and low-mass dileptons from QGP

4. Precision study of light nuclei and hyper-nuclei ⇢ higher statistics, faster DAQ rate (**TPC upgrade**)

Quark-Gluon Coloured World ALICE

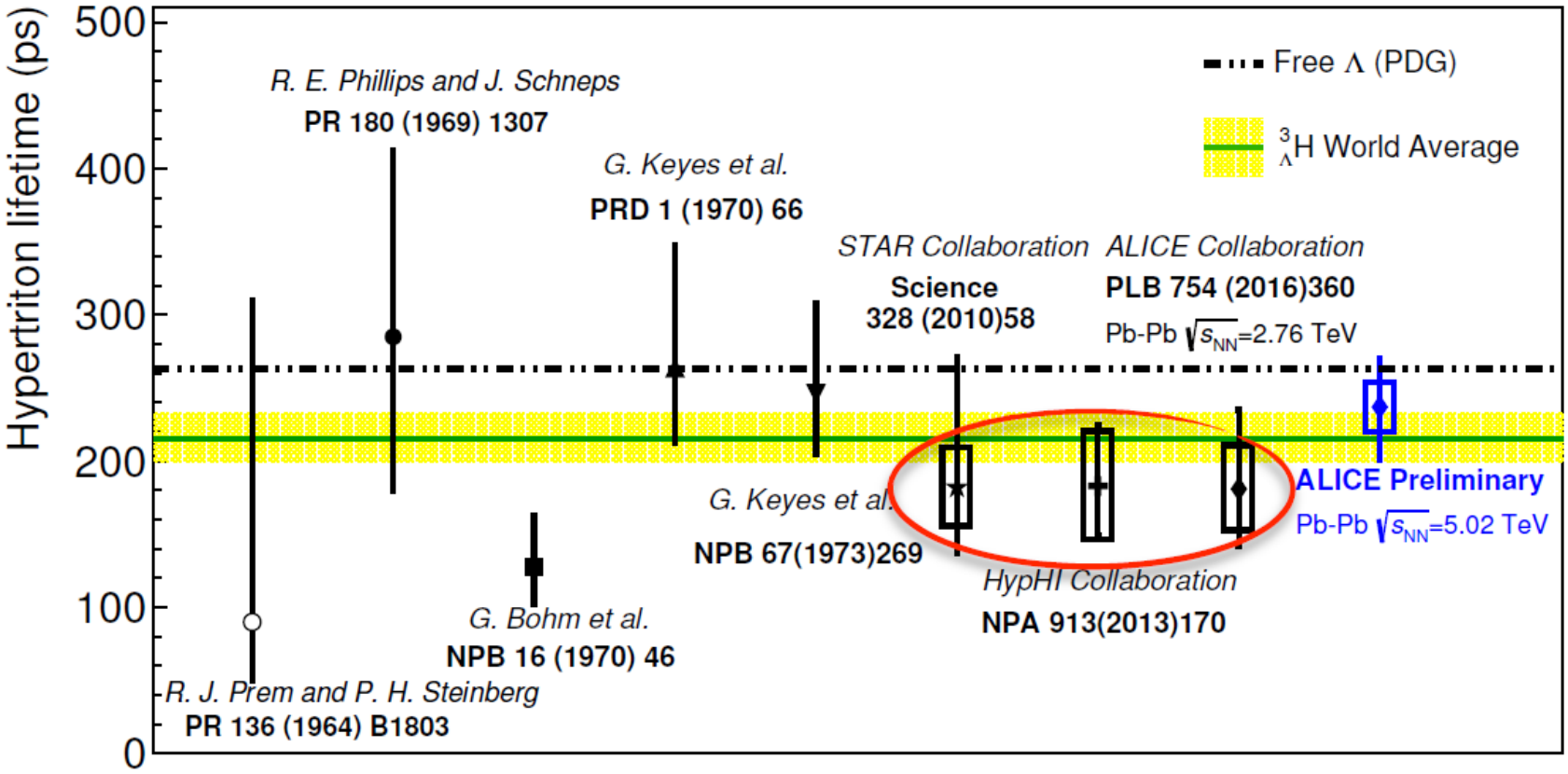
Expected products:

- Several publications in scientific journals
- Statistica sulle pubblicazioni

Impact on research and outreach activities:

- Seminar/visits with schools (~4000 schools per year)
- ALICE dedicated Masterclasses
- Activities with high-schools and local communities
- Newsletters and outreach material (brochures, posters, videos…)
- Social media
- New exhibition at Point2 (experiment site)

Hyper-triton lifetime



ALI-PREL-130195