New ALICE results on identified particle production in Pb-Pb collisions at 5.02 TeV

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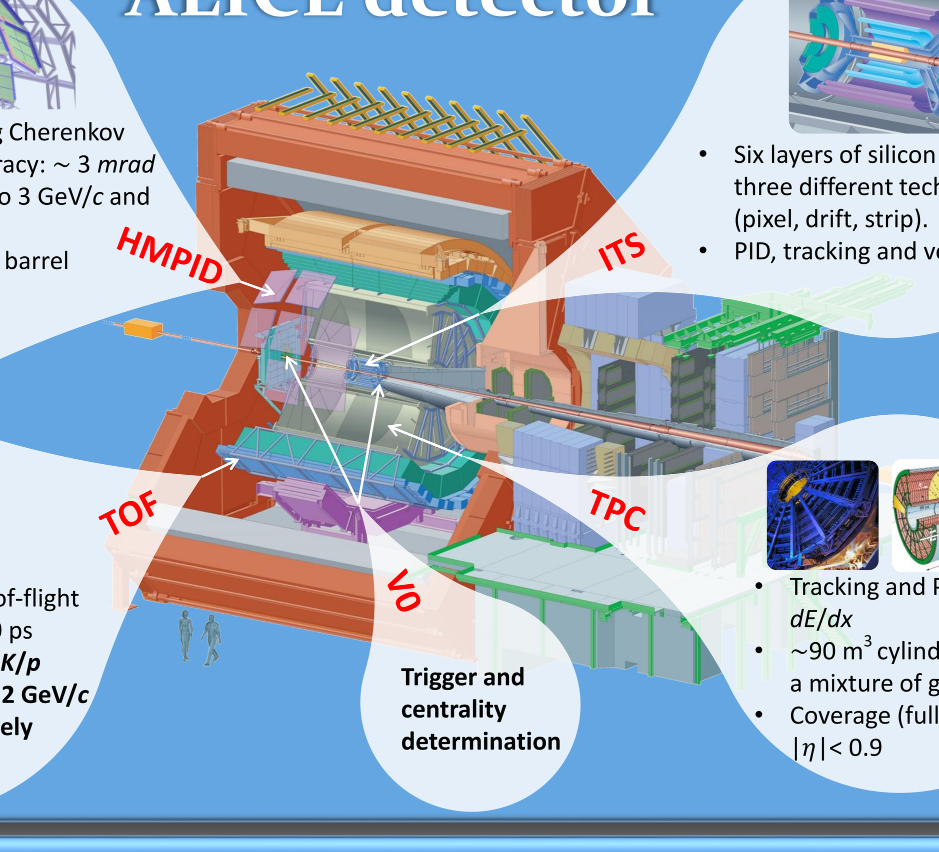
ALICE detector



- Based on Ring Imaging Cherenkov
- Cherenkov angle accuracy: ~ 3 *mrad*
- Separation of π/K up to 3 GeV/*c* and of K/p up to 5 GeV/*c*
- Covers ~5% of central barrel acceptance

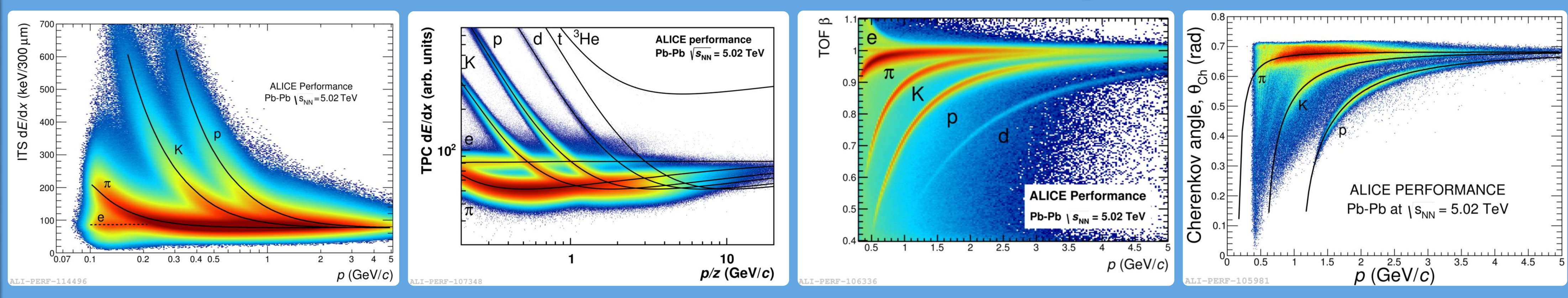
- Six layers of silicon detectors of three different technologies (pixel, drift, strip).
- PID, tracking and vertexing

- PID by means of time-of-flight
- A time resolution of 80 ps provides a 3σ π/K and K/p **separation up to p = 2.2 GeV/*c*** and 4 GeV/*c*, respectively

Trigger and centrality determination

- Tracking and PID through dE/dx
- ~90 m^3 cylinder filled with a mixture of gases
- Coverage (full tracks): $|\eta|<0.9$

Particle Identification (Pb-Pb@5.02 TeV)



ITS
Average energy loss in the ITS four outermost layers vs momentum

Lines: parametrization of the detector response based on a polynomial function at $\beta\gamma \leq 0.7$ and the PHOBOS Bethe-Bloch formula [1] at $\beta\gamma > 0.7$.

TPC
Average energy loss in TPC gas (Ar-CO_2) vs momentum

$\sigma_{dE/dx} \sim 5$ %

Lines: Bethe-Bloch parametrization for various particle species.

TOF
Time-of-flight measurement: beta vs momentum

$\sigma_{TOF} \sim 80$ ps

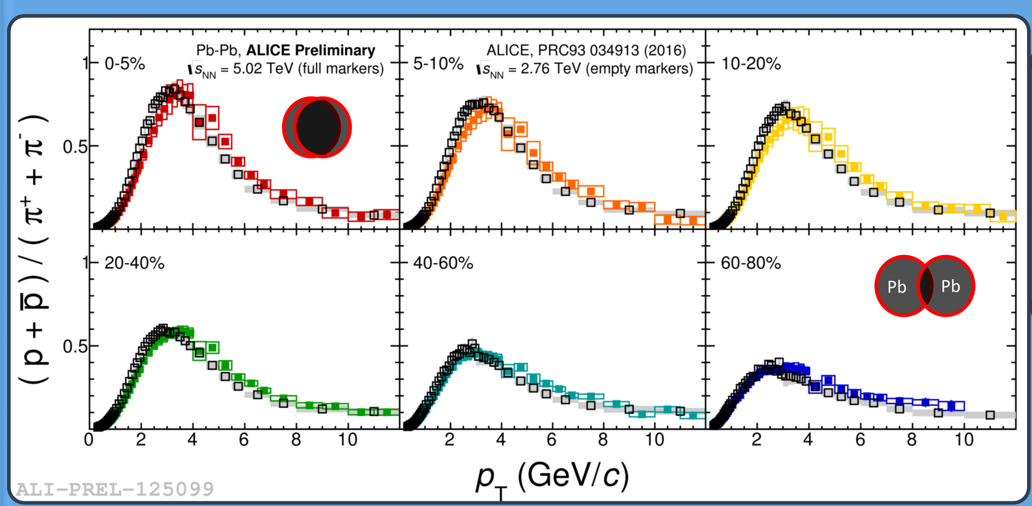
Visible bands for *e*, π, *K*, *p*, *d*

HMPID
Cherenkov angle vs momentum

$\theta_{ch} = \arccos\left(\frac{\sqrt{p^2+m^2}}{np}\right), n = 1.29\ (C_6F_{14})$

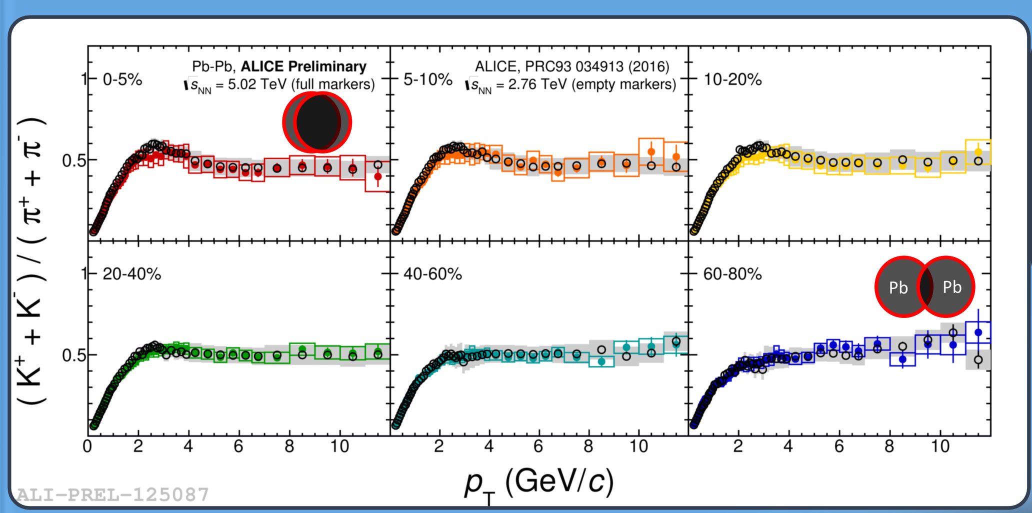
Lines: expected Cherenkov angle values vs track momentum

Particle ratios



Proton to Pion ratio vs p_T

- Comparison with results in Pb-Pb collisions at 2.76 TeV (empty markers) [2]
- **Indication of a slightly higher radial flow in central collisions compared to lower energies.**



Kaon to Pion ratio vs p_T

- Comparison with results in Pb-Pb collisions at 2.76 TeV (empty markers) [2]
- **No significant changes between the two energies**

Boxes: systematic uncertainties
Bars: statistical errors

Blast-wave fits to spectra

- **Boltzmann-Gibbs blast-wave fit** [3] → A three parameters simplified hydrodynamical model

The **resulting spectrum is a superposition of the individual thermal sources**, each boosted with the boost angle ρ [3].

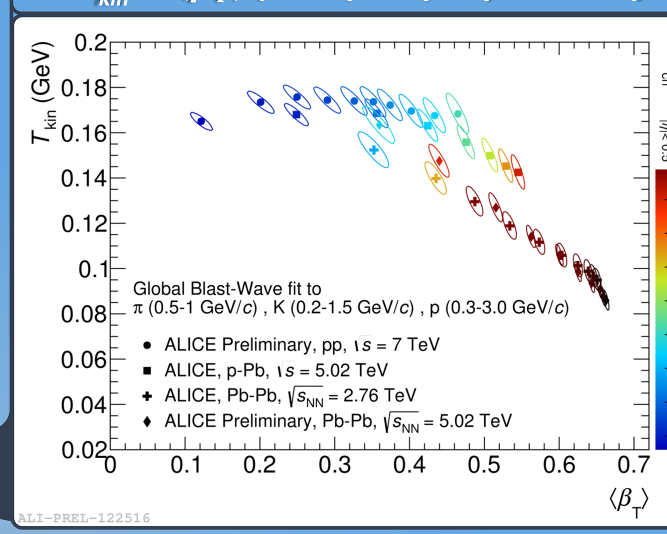
$$E\frac{d^3N}{dp^3} \propto \int_0^R m_T I_0\left(\frac{p_T \sinh(\rho)}{T_{kin}}\right) K_1\left(\frac{m_T \cosh(\rho)}{\beta_T}\right) r\, dr$$

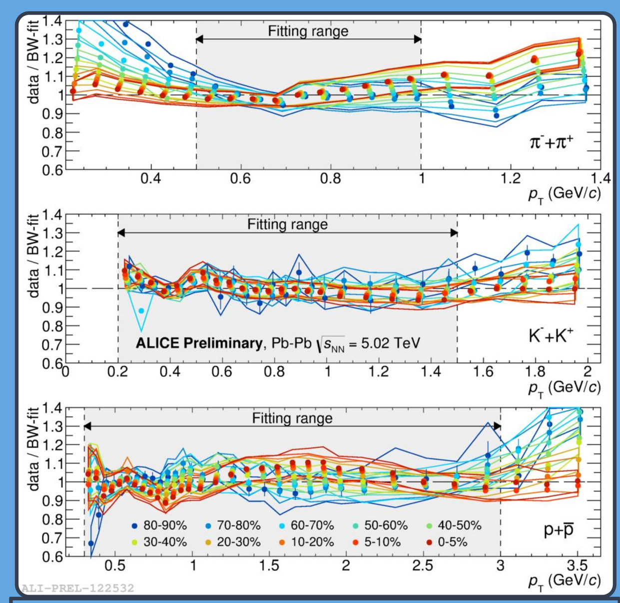
$$\rightarrow m_T = \sqrt{m^2+p_T^2} \quad \rho = \tanh^{-1}(\beta_T) \quad \beta_T(r) = \beta_s\left(\frac{r}{R}\right)^n$$

n: velocity profile ↔ profile form
T_{kin}: kinetic freeze-out temperature
$\beta_T(r)$: transverse velocity distribution
m_T: transverse mass
β_s: surface velocity
ρ: boost angle
I_0, K_1: Bessel functions

- T_{kin} and $\langle\beta_T\rangle$ evolve with multiplicity
- Larger $\langle\beta_T\rangle$ for central Pb-Pb collisions
- **Measured Pb-Pb@5.02TeV points follow the same trend as lower energy ones (qualitative comparison)**
- Contours correspond to 1σ uncertainties (stat + syst quadratically added).

T_{kin} vs $\langle\beta_T\rangle$ (multiplicity dependence)





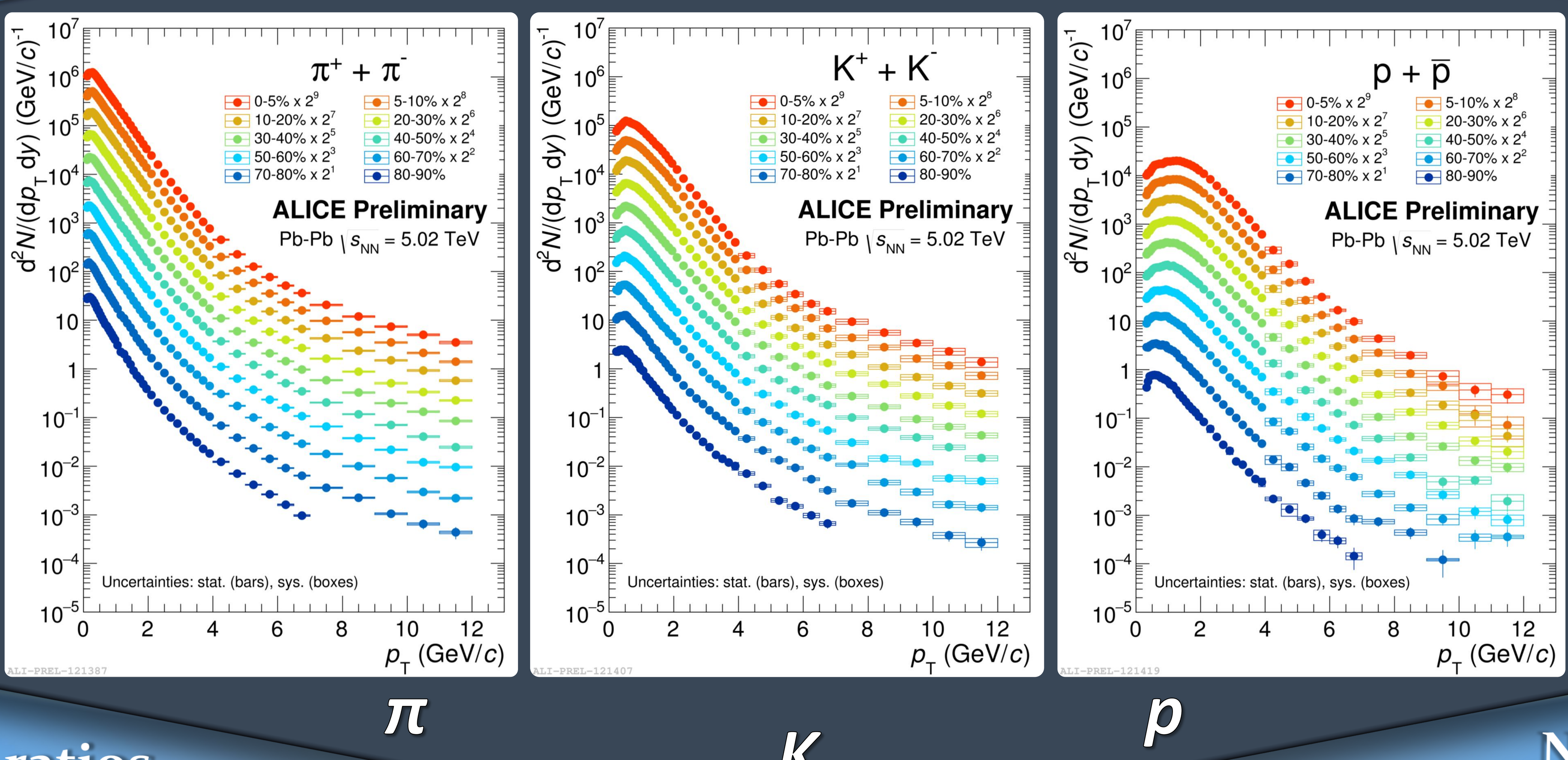
DATA/Blast-Wave fit vs p_T

- Simultaneous Boltzmann-Gibbs fit to π, *K* and *p* using Pb-Pb@2.76TeV fit ranges [4].
- **Bars**: stat. error. **Bands**: syst. uncertainties.

Identified particle spectra

Event selection

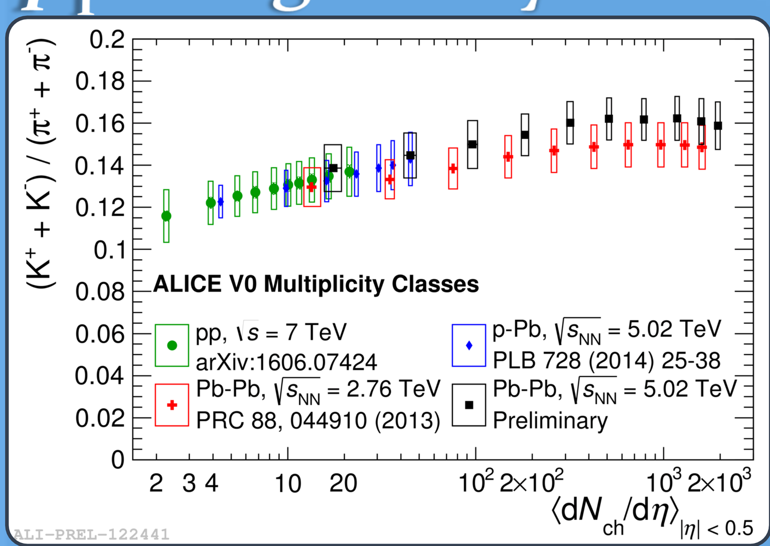
- Trigger: V0 detector
  ↔ Events triggered with inputs from V0A and V0C detectors.
  ↔ Based on V0 timing signal and the correlation between the number of hits and tracklets in the SPD.
- Centrality estimation with V0 amplitudes
  ↔ Centrality defined as the percentile of the hadronic cross section corresponding to a particle multiplicity above a given threshold [7]
  ↔ Distribution of V0 amplitude (sum of V0A and V0C) divided in percentile classes.
- Primary vertex position projected on the collision axis (*z*): $|V_z| < 10$ cm
- Pile-up rejection
  ↔ Events rejected if more than one primary vertex is reconstructed with the SPD.

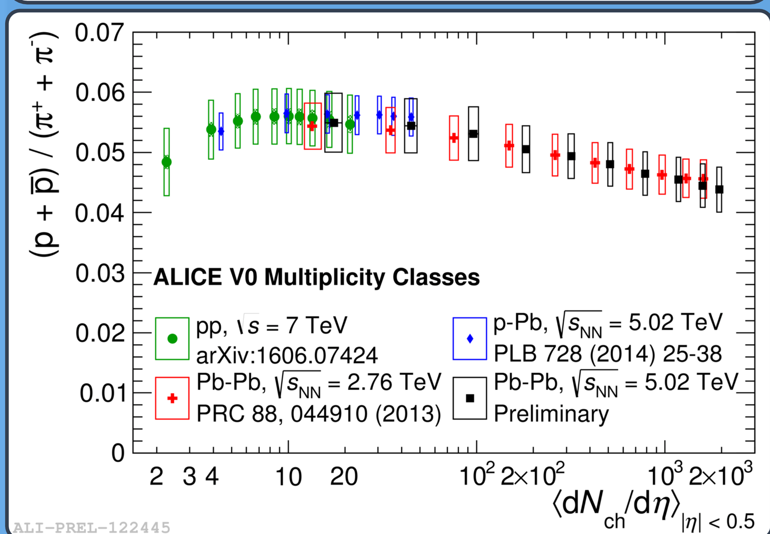


Analysis details

- Individual spectra obtained in different p_T intervals based on particle identification with **ITS, TPC, TOF, HMPID** and **kink topology** (only kaons).
- Pb-Pb dataset
  ↔ Data collected in November-December 2015
- Systematic uncertainties
  ↔ Main sources: tracking, PID technique, material budget
- Combined spectra are calculated using the uncorrelated systematic uncertainties as weights.

p_T-integrated yield ratios





dN/dy ratio of K/π and p/π vs $dN_{ch}/d\eta$ for different colliding systems and energies

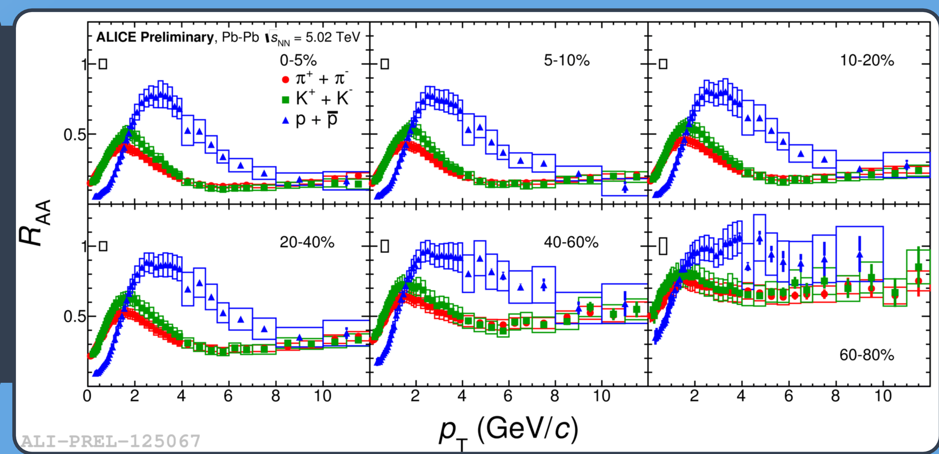
- **No significant evolution is observed with respect to lower energy data**
- **Yield ratios for K/π and p/π measured in Pb-Pb peripheral collisions are compatible with the ones in pp and p-Pb collisions.**

- Individual Blast-Wave fit to spectra used for **low-p_T extrapolation**
- **Open boxes**: systematic uncertainties

Nuclear modification factor (R_{AA})

R_{AA} for π, *K*, *p* vs p_T (centrality dependence)

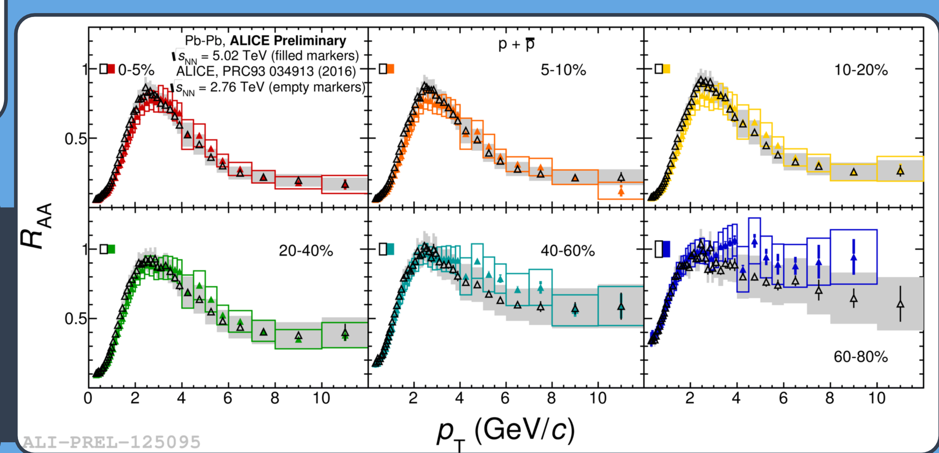
- R_{AA} computed using
  - pp reference which was interpolated using the data of pp collisions at 7 and at 2.76 TeV
  - $\sigma_{pp}^{INEL}/\langle N_{coll}\rangle$ from [6]
- ***π, K, p* equally suppressed for all centralities at high p_T (> 8 GeV/*c*)**
- **Errors**: bars = stat, boxes = syst.



$$R_{AA} = \frac{\sigma_{pp}^{INEL}}{\langle N_{collisions}\rangle}\frac{d^2N_{PbPb}/dydp_T}{d^2\sigma_{pp}^{INEL}/dydp_T}\begin{cases} >1 & \text{(enhancement)} \\ =1 & \text{(no medium effects)} \\ <1 & \text{(suppression)}\end{cases}$$

R_{AA} for $p+\bar{p}$ vs p_T (energy dependence)

- Comparison with Pb-Pb@2.76 TeV data [2].
- **No significant evolution with the collision energy**
- Similar conclusion for π and *K*



References

[1] PHOBOS Collaboration, *Phys. Rev. C75 (2007) 024910*
[2] ALICE Collaboration, *Phys. Rev. C93 (2016) no.3, 034913*
[3] E. Schnedermann, J. Sollfrank, U. Heinz, *Phys. Rev. C 48 (1993) 2462*
[4] ALICE Collaboration, *Phys. Rev. C88, (2013) 044910*
[5] ALICE Collaboration, *Phys. Lett. B 760 (2016) 720*
[6] ALICE Collaboration, *CERN-PH-EP-2015-324*
[7] Alice Collaboration, *Phys. Rev. C88 (2013) 044909*