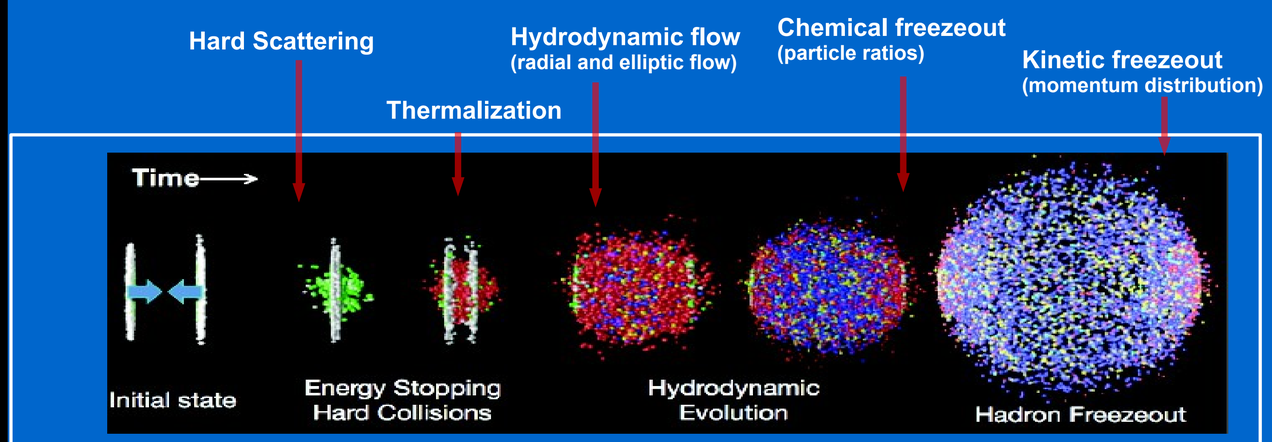
Production of light flavour hadrons in pp, p–Pb and Pb–Pb collisions at the LHC energies measured with ALICE

Francesco Barile for the ALICE Collaboration
Università degli Studi di Bari and INFN Sezione di Bari
francesco.barile@cern.ch

Abstract: In the first three years of the LHC operation, ALICE has measured identified light flavour hadrons in a wide transverse momentum range. The measurements have been performed in the three collision systems: pp at $\sqrt{s}$ = 0.9, 2.76 and 7 TeV, p–Pb at $\sqrt{s_{NN}}$ = 5.02 TeV and Pb–Pb at $\sqrt{s_{NN}}$ = 2.76 TeV. In this poster, the latest results on transverse momentum distributions, particle ratios and integrated production yields for π, K, p, Λ will be reported. The system-size dependence of particle ratios will be discussed and a detailed comparison of the yields with thermal model predictions will be made.

Physics motivation

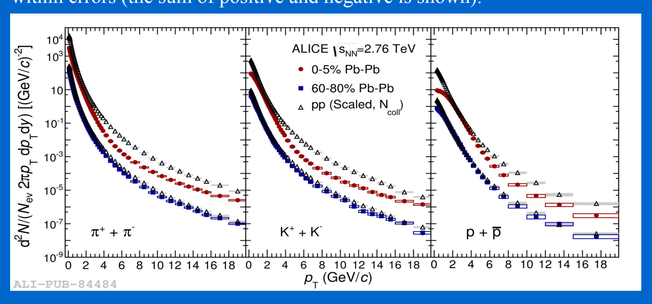
- Nuclear matter under extreme conditions can be investigated in ultra-relativistic heavy-ion collisions.
- Collective and thermal properties of the **Quark Gluon Plasma** inferred from **transverse momentum (p_T) distributions and integrated yields** of identified particles;

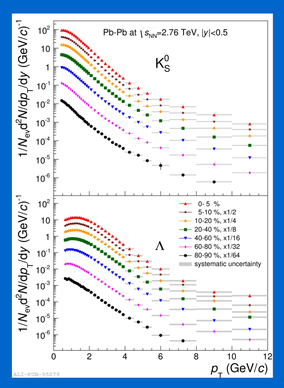


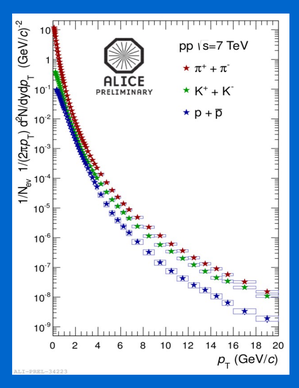
Heavy Ion collisions dynamical evolution

Identified hadrons spectra in pp, p-Pb and Pb-Pb

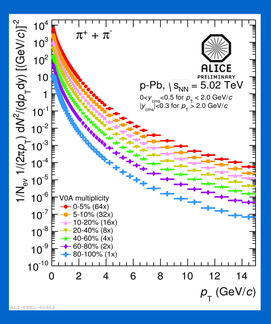
ALICE has measured the yields of produced charged pions, kaons and protons in a wide momentum range and in several colliding systems. The measurements have been performed in pp, p–Pb and Pb–Pb collisions. At the LHC energies, particle and anti-particle production are consistent within errors (the sum of positive and negative is shown).

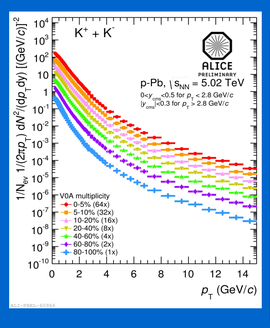


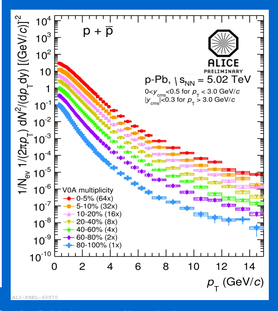




Pb–Pb and pp
- Shape of the spectrum in Pb–Pb differs from pp reference
- Difference most pronounced in central collisions







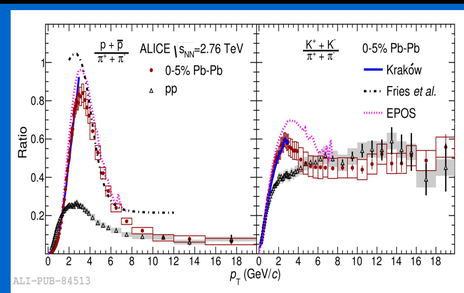
p–Pb
- Multiplicity classes* from V0A detector (correlation between impact parameter and multiplicity is not straightforward as in Pb-Pb);
- Spectra combined from low p_T and high-p_T analysis
- Harder spectra for higher multiplicities mass ordering of pions, kaons and protons
  - Indication for collective effects in p–Pb
  - Reminiscent of observed effects in Pb–Pb → attributed to radial flow

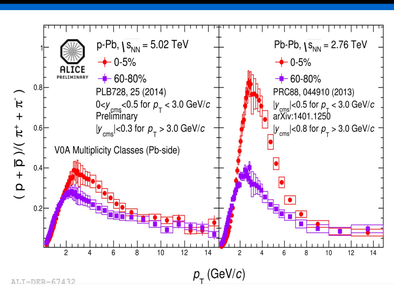
*p–Pb, definition of multiplicity classes: slices in VZERO-A (V0A amplitude).
ALICE Collaboration Physics Letters B 728 (2014) 25–38;

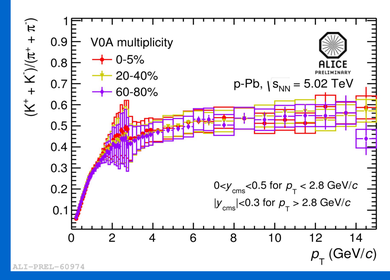
Particle ratios

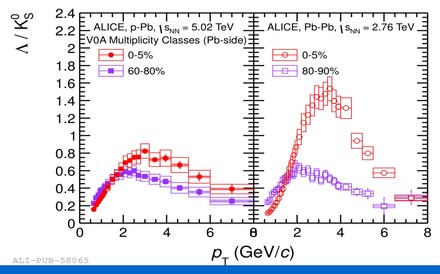
p/π vs p_T
- Similar behaviour observed in p–Pb and Pb–Pb collisions but much weaker: the maximum value reaches 0.8 in central Pb–Pb while 0.4 in highest multiplicity p–Pb
- Significant increase at intermediate p_T with increasing multiplicity → Significant depletion in the low p_T region
- Enhancement of protons in p–Pb at intermediate p_T ~ 3 GeV/c
- reminiscent of radial flow in Pb–Pb

K/π vs p_T
- Weak evolution with multiplicity in p–Pb → small increase at intermediate p_T with increasing VZERO-A multiplicity → corresponding small depletion in the low p_T region
- Similar behaviour as observed in Pb-Pb collisions









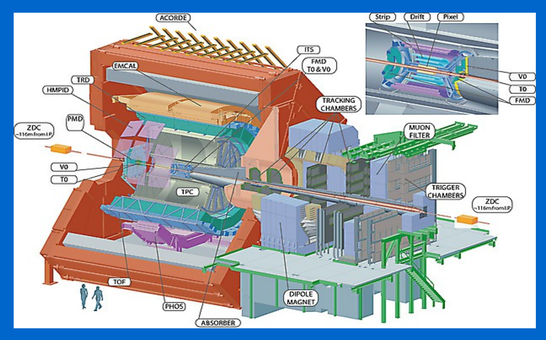
Λ/K^0_S vs p_T
- Similar behaviour observed in p–Pb and Pb–Pb collisions (but much weaker)
- Significant increase at intermediate p_T with increasing multiplicity → Significant depletion in the low p_T region
- Stronger enhancement at p_T ~ 3 GeV/c than K/π
- In Pb-Pb: collective flow and/or quark recombination?

- ALICE Collaboration, Nuclear Physics A 904–905 (2013) 763c–766c
- P. Bozek, Phys. Rev. C 85, 034901 (2012).
- R. Fries, B. Muller, C. Nonaka, S. Bass, Hadronization in heavy ion collisions: recombination and fragmentation of partons, Phys. Rev. Lett. 90 (2003) 202303.
- ALICE Collaboration http://arxiv.org/abs/1401.1250
- ALICE Collaboration Physics Letters B 728 (2014) 25–38 Phys. Rev. C 88, 044910 (2013)

ALICE detector

ALICE Collaboration, http://arxiv.org/abs/1402.4476

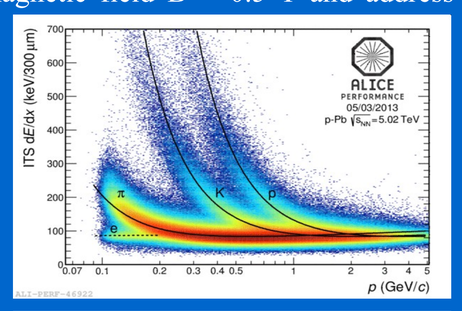
ALICE is a heavy-ion experiment at the CERN Large Hadron Collider. The experiment continuously took data during the first physics campaign of the machine from fall 2009 until early 2013, using proton and lead-ion beams. The central-barrel detectors (ITS, TPC, TRD, TOF, PHOS, EMCal, and HMPID) are embedded in a solenoid with magnetic field B = 0.5 T and address particle production at mid-rapidity.

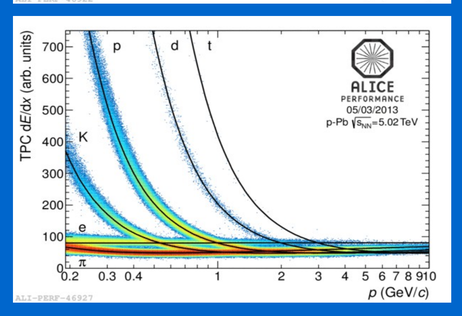


**VZERO trigger, beam-Bkg rejection, multiplicity/centrality classes

pp, p–Pb and Pb–Pb details

- $\sqrt{s_{pp}}$ = 0.9, 7, 2.76 TeV (2010, 2011)
- $\sqrt{s_{Pb\text{-}Pb}}$ = 2.76 TeV (2010, 2011)
- $\sqrt{s_{p\text{-}Pb}}$ = 5.02 TeV (2012, 2013)
- Asymmetric energy/nucleon in the beams (CMS moves with rapidity y_{cms} = 0.465)





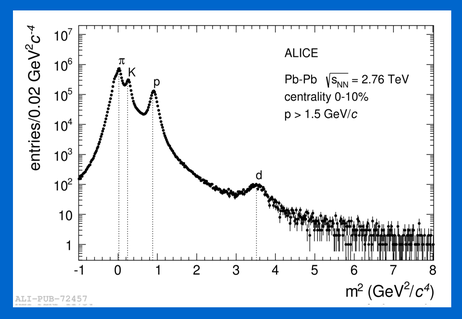
Particle Identification in Central Barrel

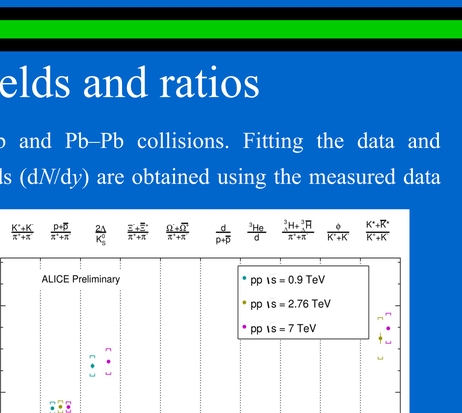
ITS: The Inner Tracking System provides a dE/dx measurement. This is mainly useful for low-p_T tracks ($p_T \leq 0.7$ GeV/c), specifically at very low- p_T, where the ITS is used for standalone tracking.

TPC: The Time Projection Chamber measures the charge deposited on up to 159 pad rows. A truncated mean dE/dx is calculated and used for a wide range of momenta. The largest separation is achieved at low-p_T ($p_T \leq 0.7$ GeV/c) but a good separation is also present in the relativistic rise region up to ~20 GeV/c.

TOF: The Time-Of-Flight detector measures the arrival time of particles with a resolution of ~80 ps. This provides a good separation of kaons and protons up to $p_T \simeq 4$ GeV/c.

HMPID: The High Momentum Particle Identification Detector is a ring-imaging Cherenkov detector that identifies pions and kaons up to $p_T \simeq 4$ GeV/c, protons up to $p_T \simeq 6$ GeV/c and deuterons (in Pb–Pb collisions) up to $p_T \simeq 8$ GeV/c.

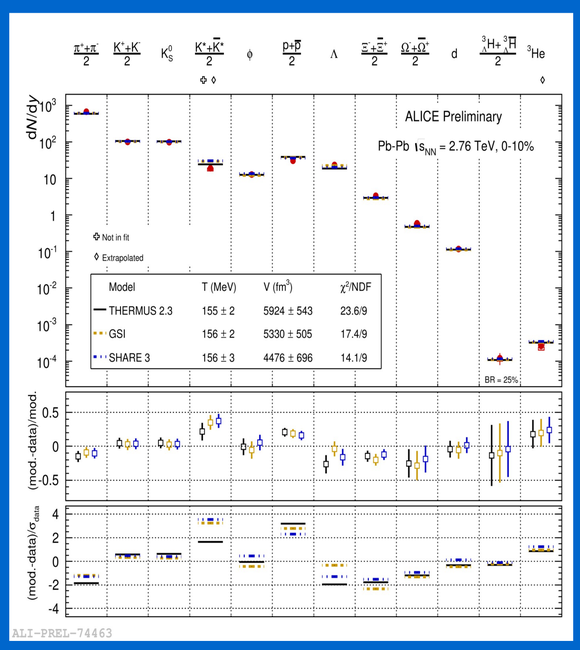


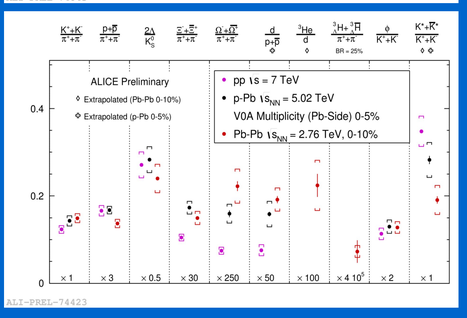


Integrated production yields and ratios

ALICE has measured the p_T-differential production yields in pp, p–Pb and Pb–Pb collisions. Fitting the data and extrapolating outside the measured p_T range, the integrated production yields (dN/dy) are obtained using the measured data points and the extrapolation;

- Particle ratios measured in pp collisions show no significant energy dependence at the LHC;
- Particle ratios evolve as a function of the system size (pp → p–Pb → Pb–Pb);
- Strangeness and deuteron enhancement is observed;
- K* and baryon suppression;





- The p_T-integrated yields and ratios can be interpreted in terms of statistical (thermal) models. The fits of the experimental data with the model provide the temperature and baryochemical potential at hadrochemical freeze-out;
- The different models yield consistent results;
- Anomalous suppression of proton yields in central Pb–Pb collisions at the LHC

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