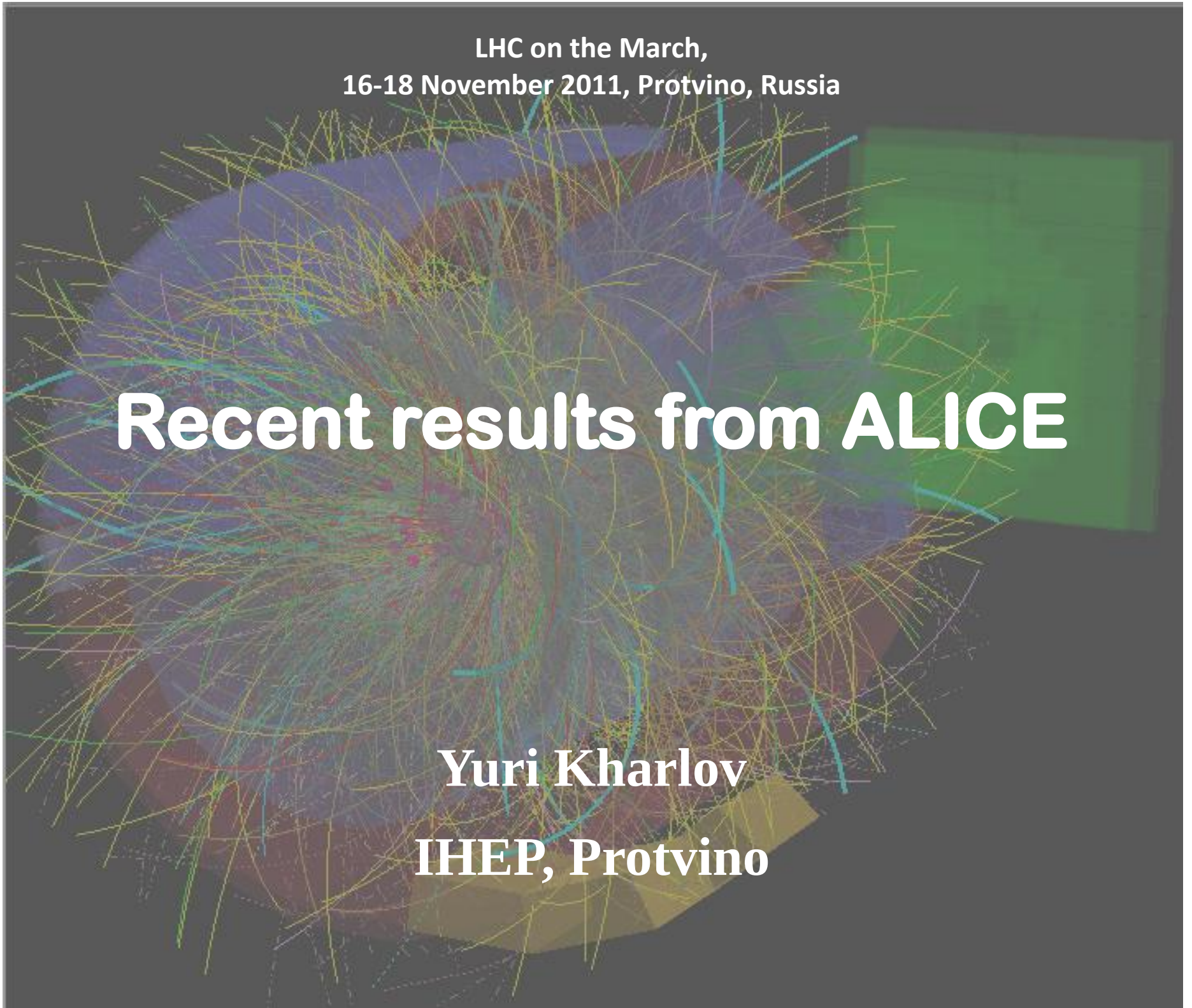
LHC on the March,
16-18 November 2011, Protvino, Russia



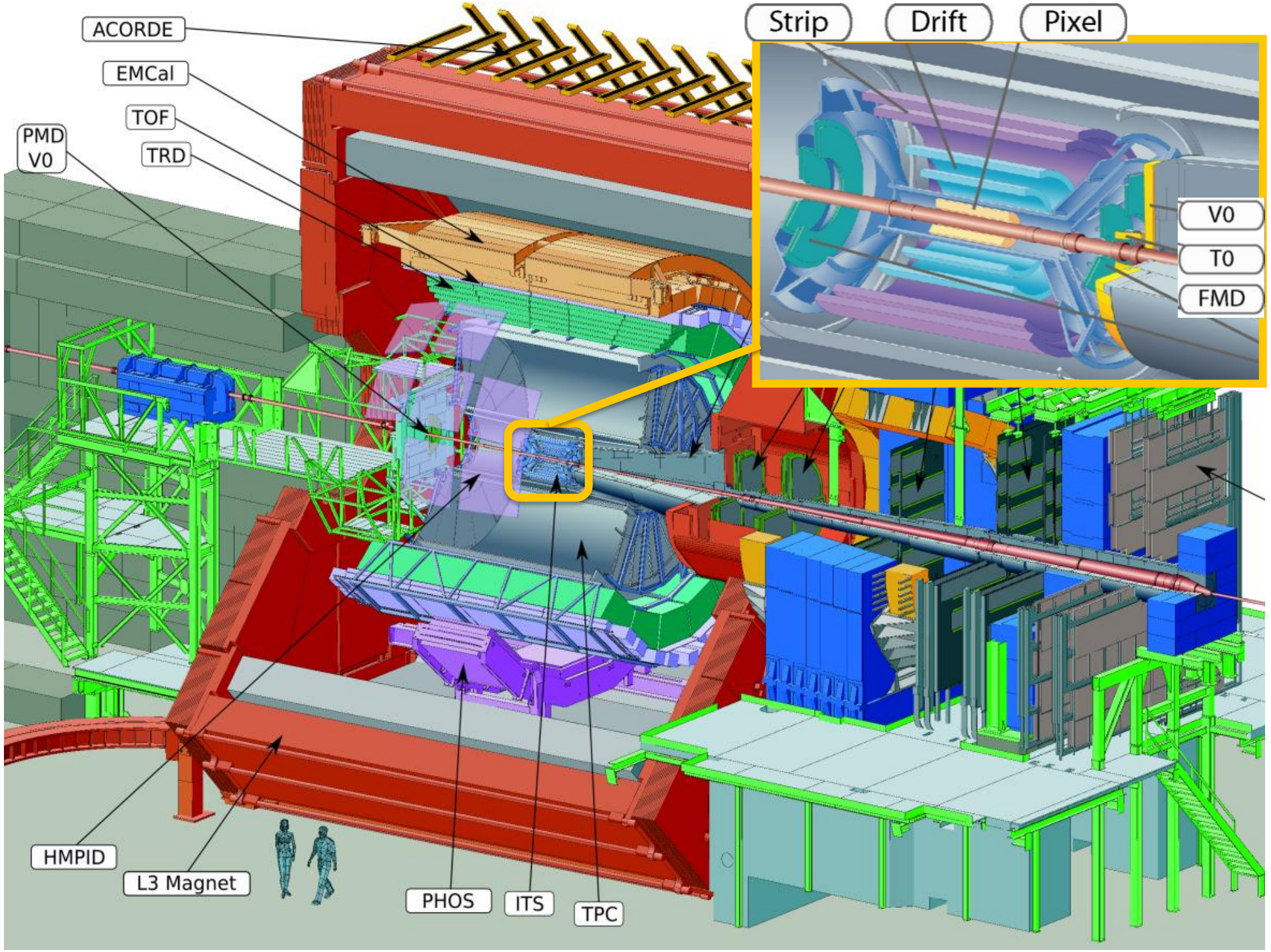
Recent results from ALICE

Yuri Kharlov

IHEP, Protvino

ALICE physics program

- ALICE is a dedicated heavy-ion detector to exploit the unique physics potential of nucleus-nucleus interactions at LHC energies.
- ALICE aim is to study the physics of strongly interacting matter at extreme energy densities, where the formation of a new phase of matter, the quark-gluon plasma, is expected.
- ALICE is carrying out a comprehensive study of the hadrons, electrons, muons and photons produced in the collision of heavy nuclei.
- ALICE is also studying proton-proton collisions both as a comparison with lead-lead collisions and in physics areas where ALICE is competitive with other LHC experiments.


ACORDE
EMCal
TOF
TRD
PMD
V0
Strip
Drift
Pixel
V0
T0
FMD
HMPID
L3 Magnet
PHOS
ITS
TPC

Detector status

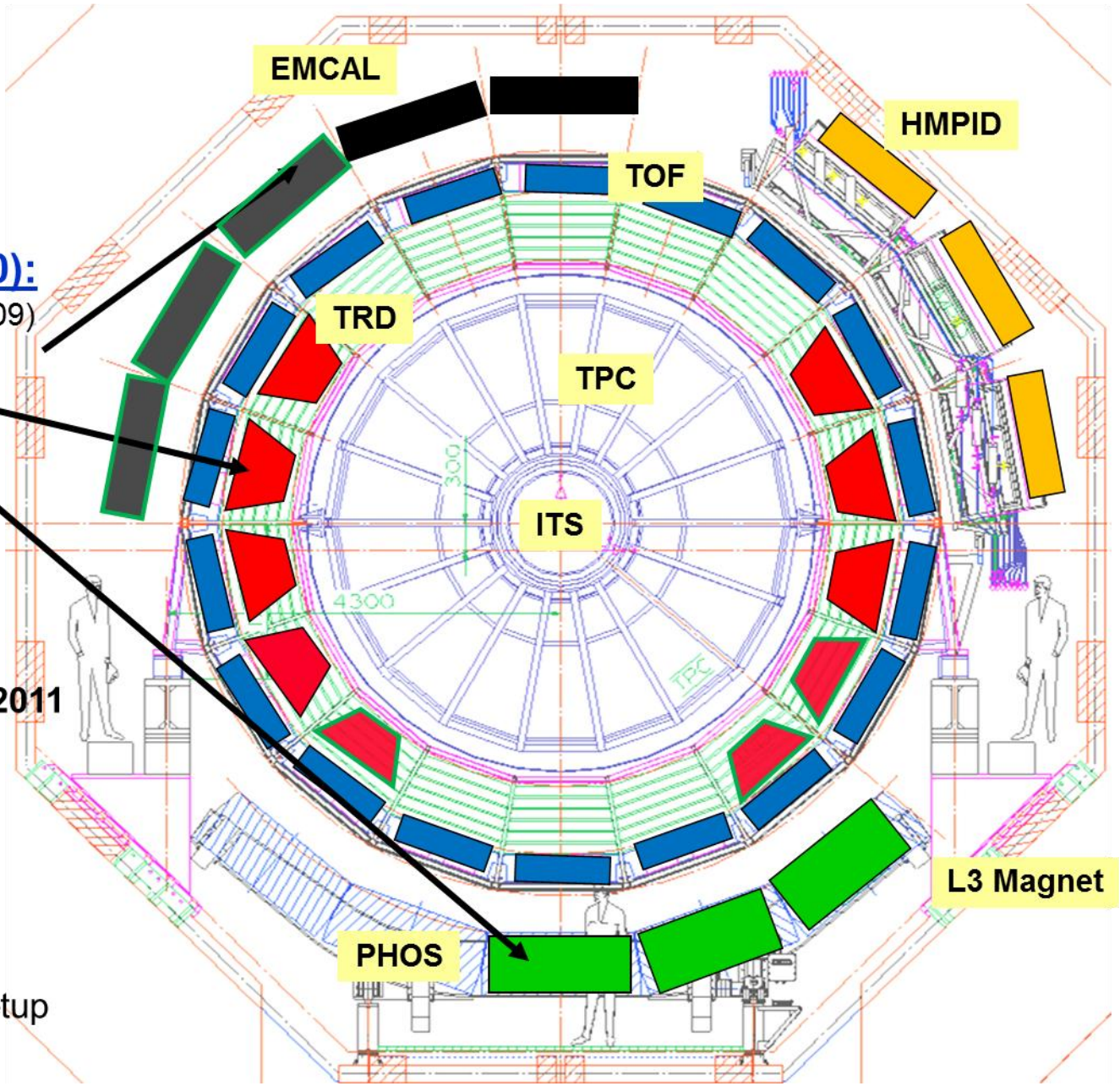
Complete since 2008:
ITS, TPC, TOF, HMPID, FMD, T0, V0, ZDC, Muon arm, Acorde PMD , DAQ

Partial installation (2010):
4/10 EMCAL* (approved 2009)
7/18 TRD* (approved 2002)
3/5 PHOS (funding)

~ 60% HLT (High Level Trigger)

2011
10/10 EMCAL
10/18 TRD

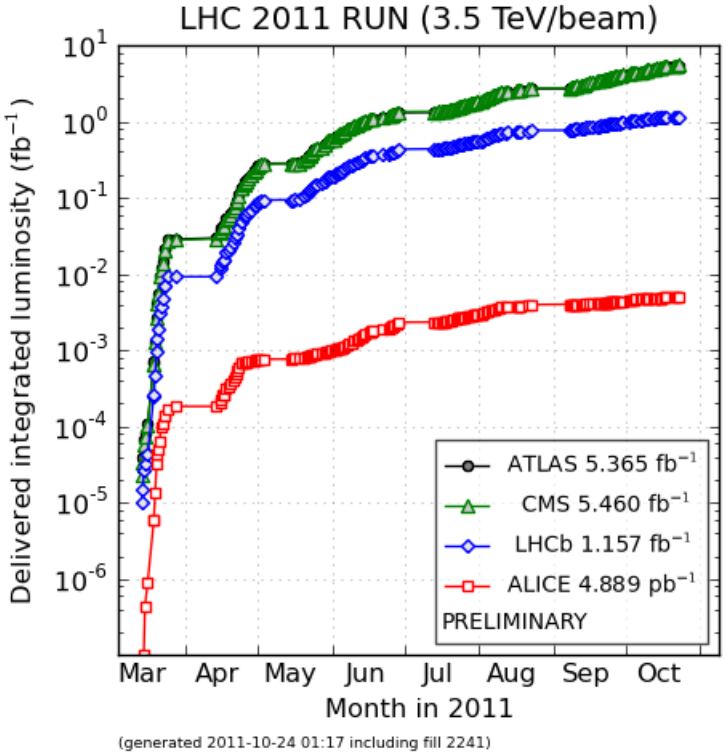
TRD to be completed end 2011

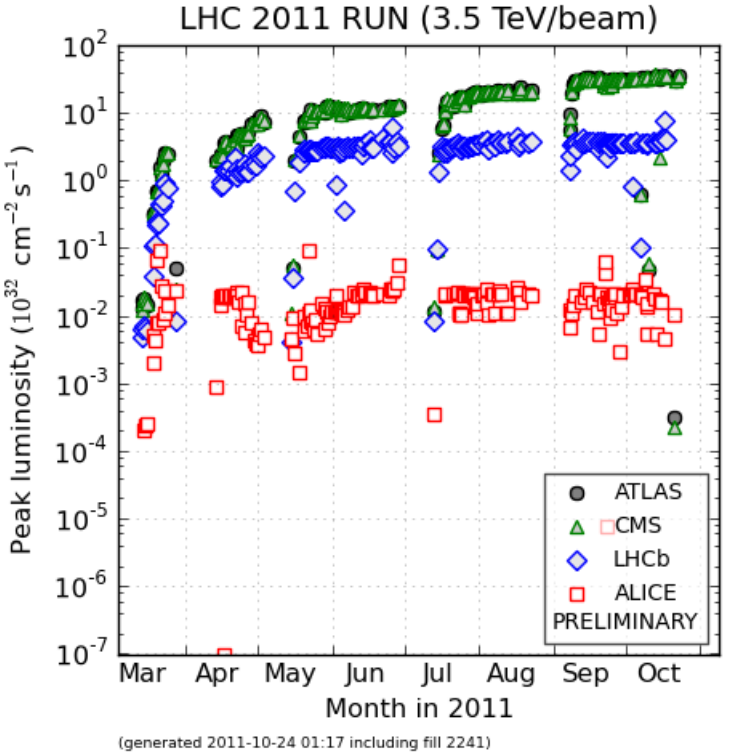


*upgrade to the original setup

Physics with pp in 2011

- 500 M events with pp at $\sqrt{s}$=7 TeV to reach the original goal of 10^9 events (double 2010 min bias statistics)
- > 10 pb^{-1} (2011+2012) rare triggers with pp at $\sqrt{s}$=7 TeV (jets, muons, photons) for comparison with PbPb
- Data with with pp at $\sqrt{s}$=2.76 TeV for direct comparison with PbPb at $\sqrt{s_{NN}}$=2.76 TeV

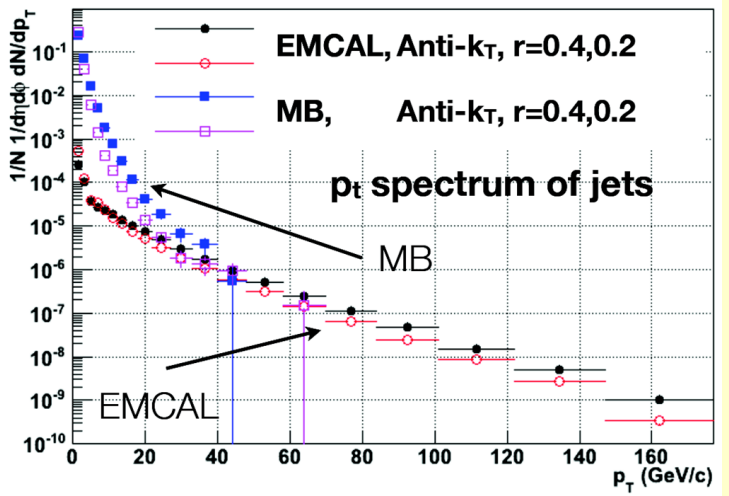


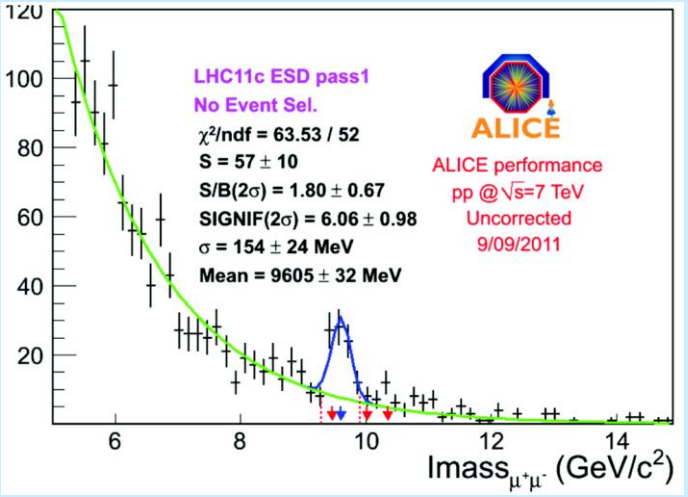


Rare event triggers at a glance

EMCAL: L_{INT} >2 pb^{-1}

- Jet spectrum till p_T=160 GeV



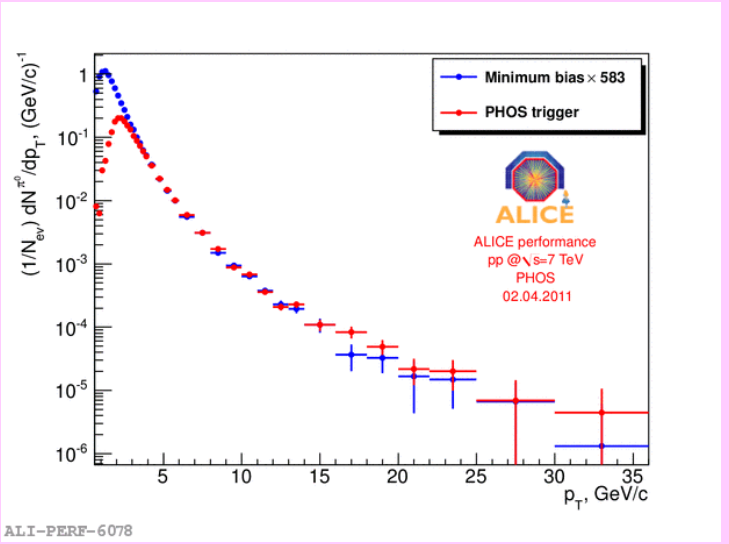


MUON: L_{INT} ~ 2 pb^{-1}

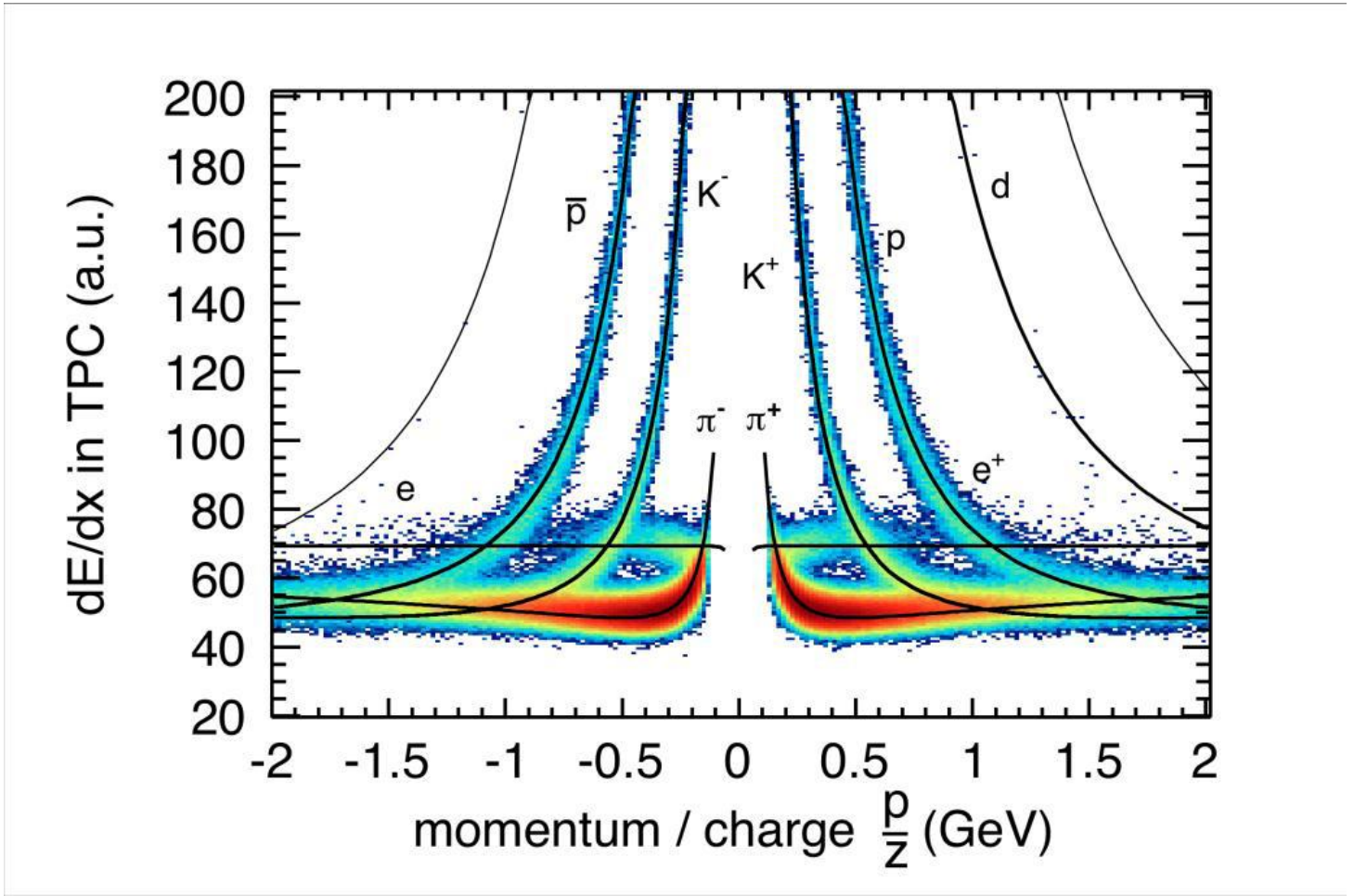
- High statistics J/ψ and Υ signal in pp collisions at √s = 7 TeV

PHOS: L_{INT} ~ 75 nb^{-1}

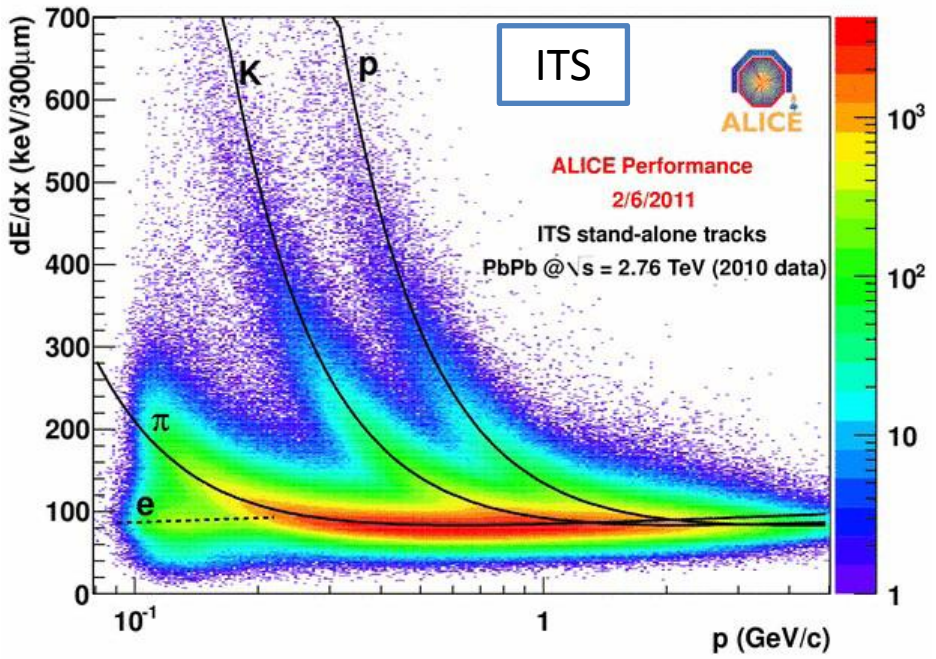
- Photon and neutral meson spectra measurements at p_T up to 40 GeV/c

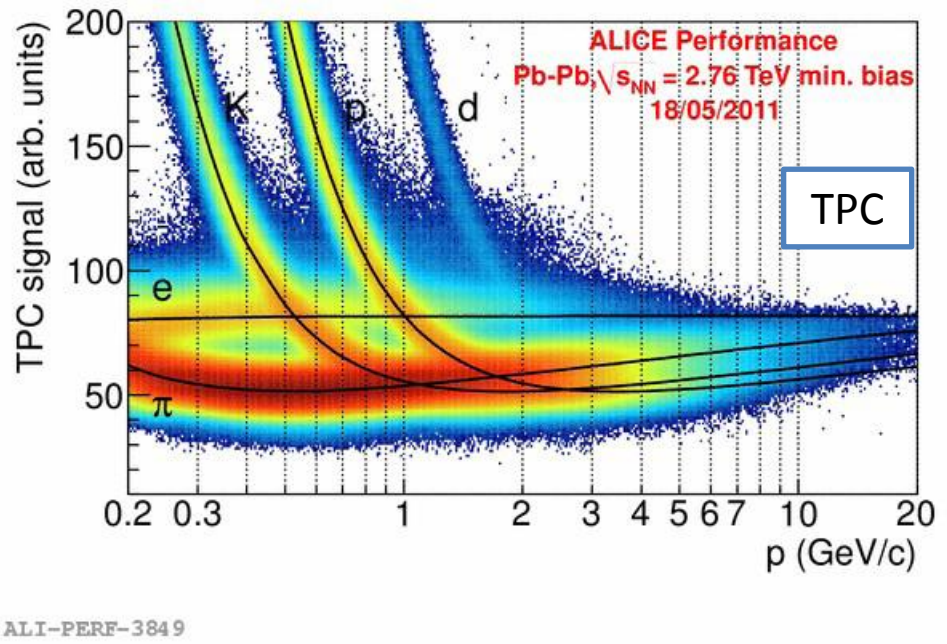


Hadron production in pp

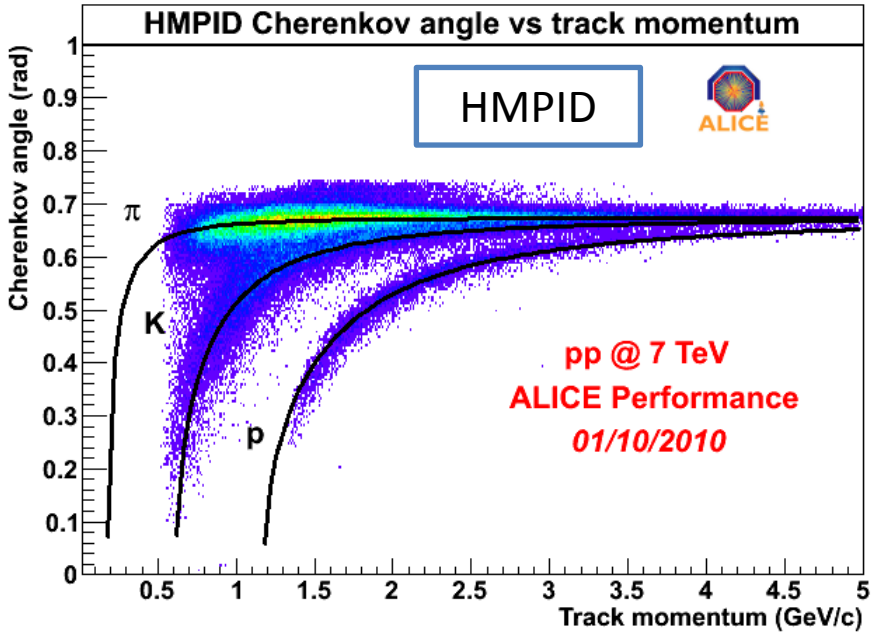


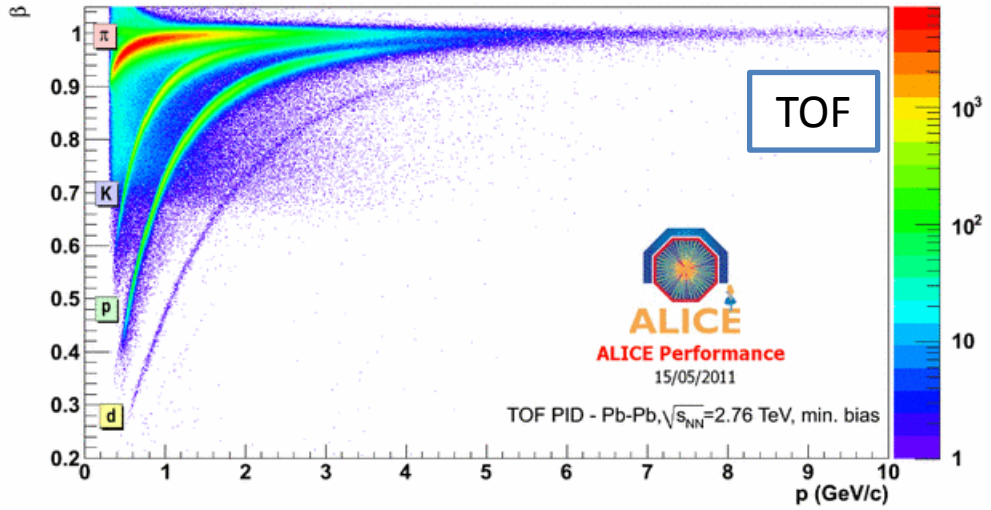
Particle identification with ALICE





ALI-PERF-3849

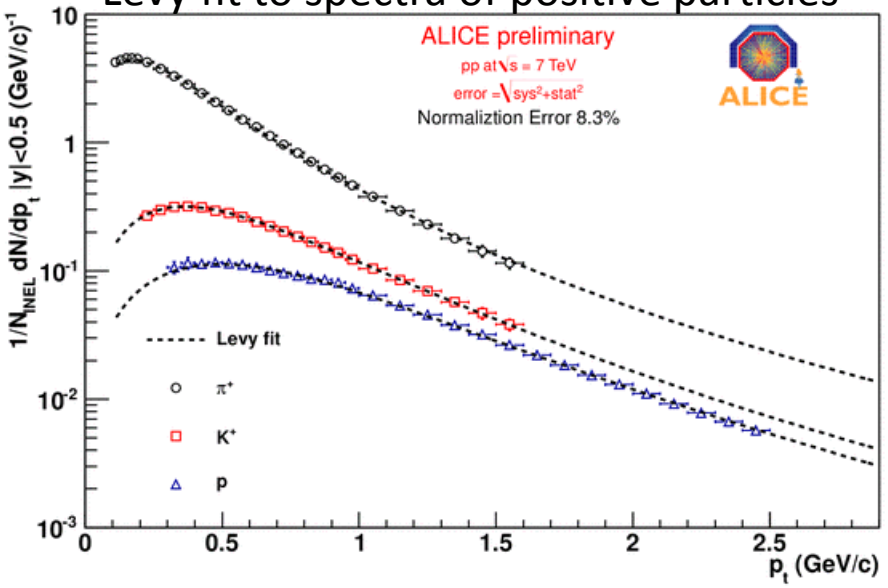




ALI-PERF-3478

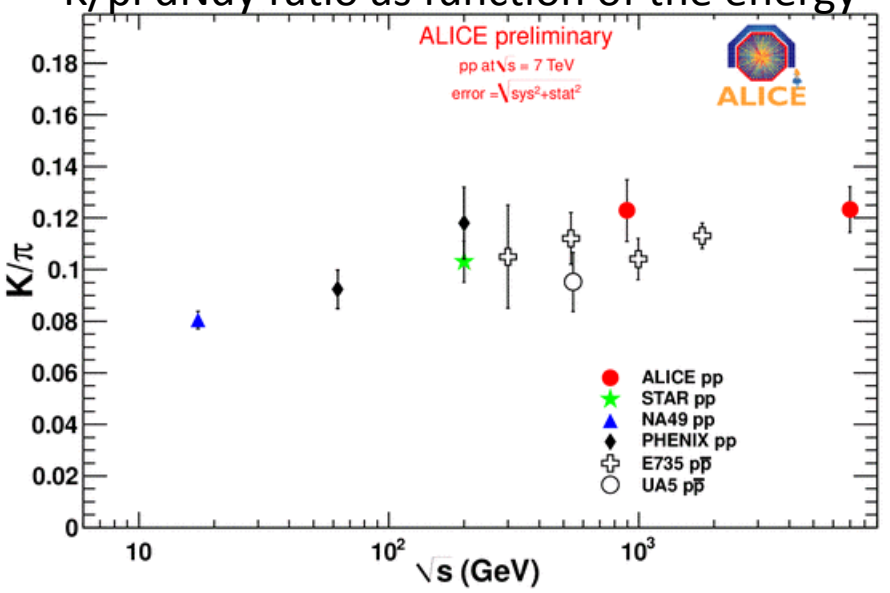
Identified hadron spectra in pp @ 7 TeV

Levy fit to spectra of positive particles

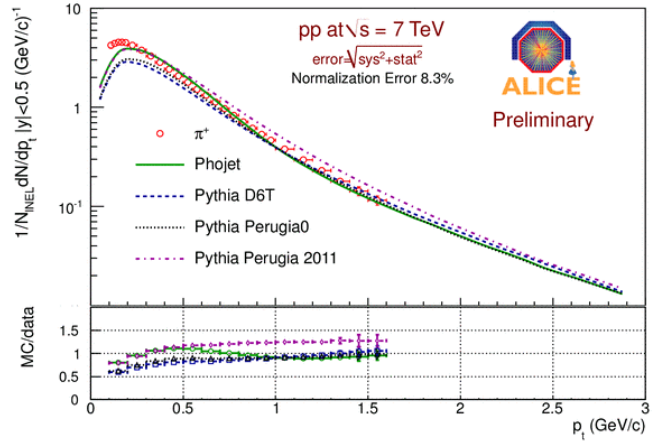


ALI-PREL-2124

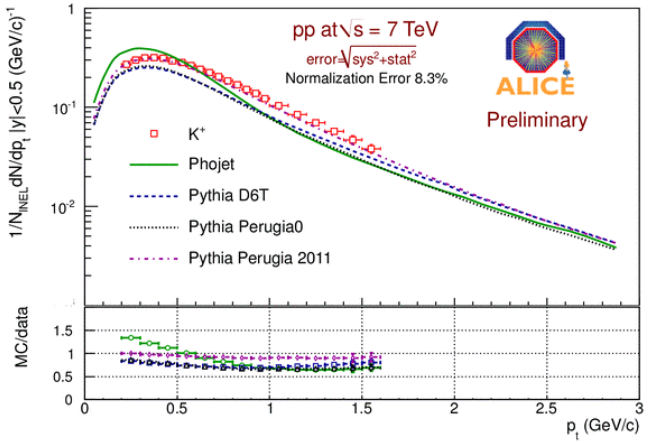
K/pi dNdy ratio as function of the energy



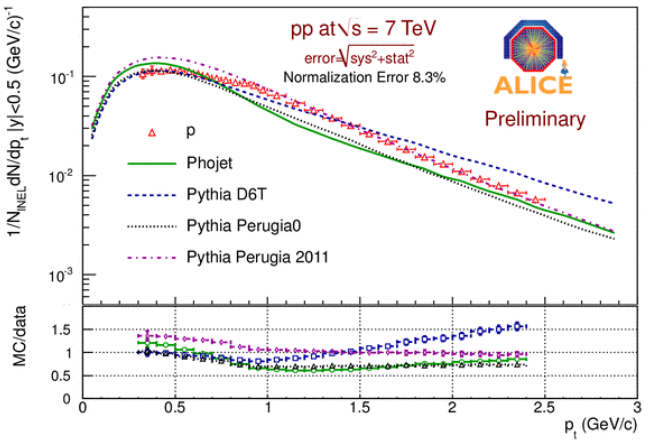
ALI-PREL-2136



ALI-PREL-10373



ALI-PREL-10385

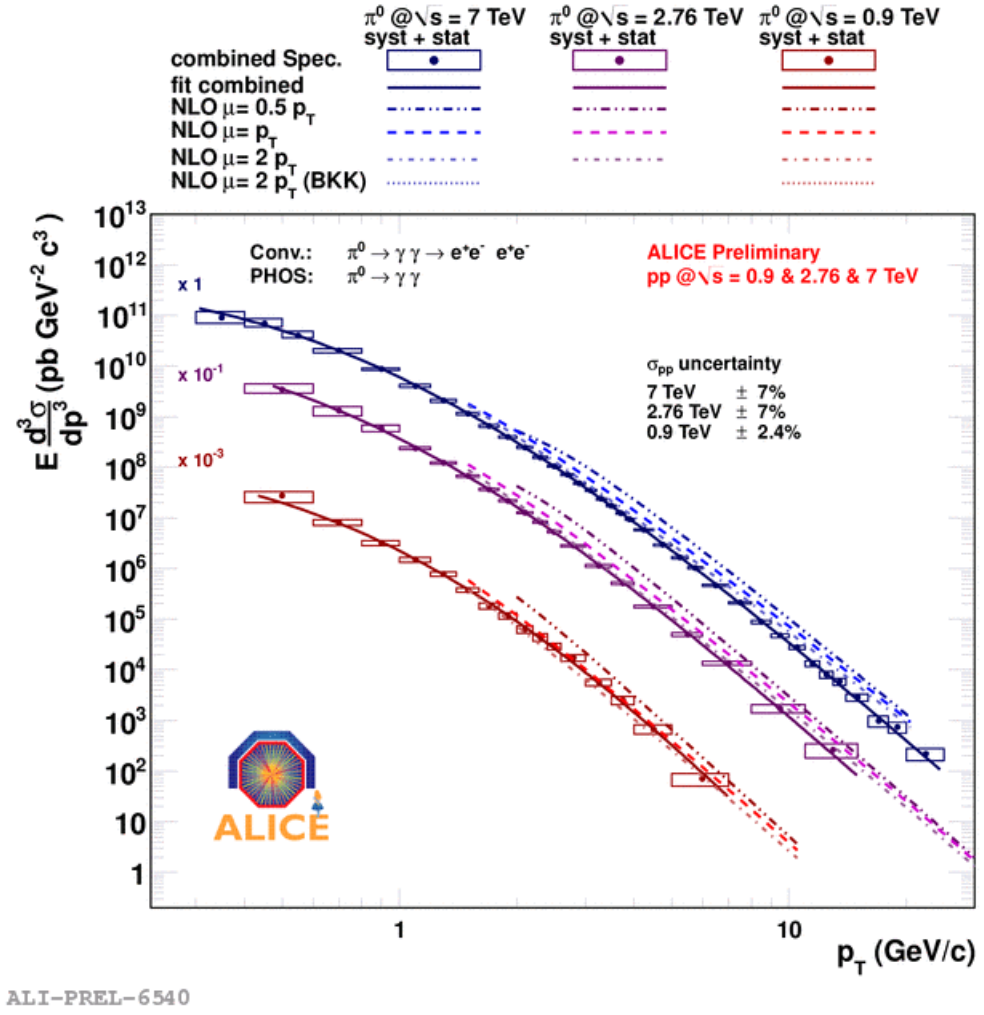


ALI-PREL-10393

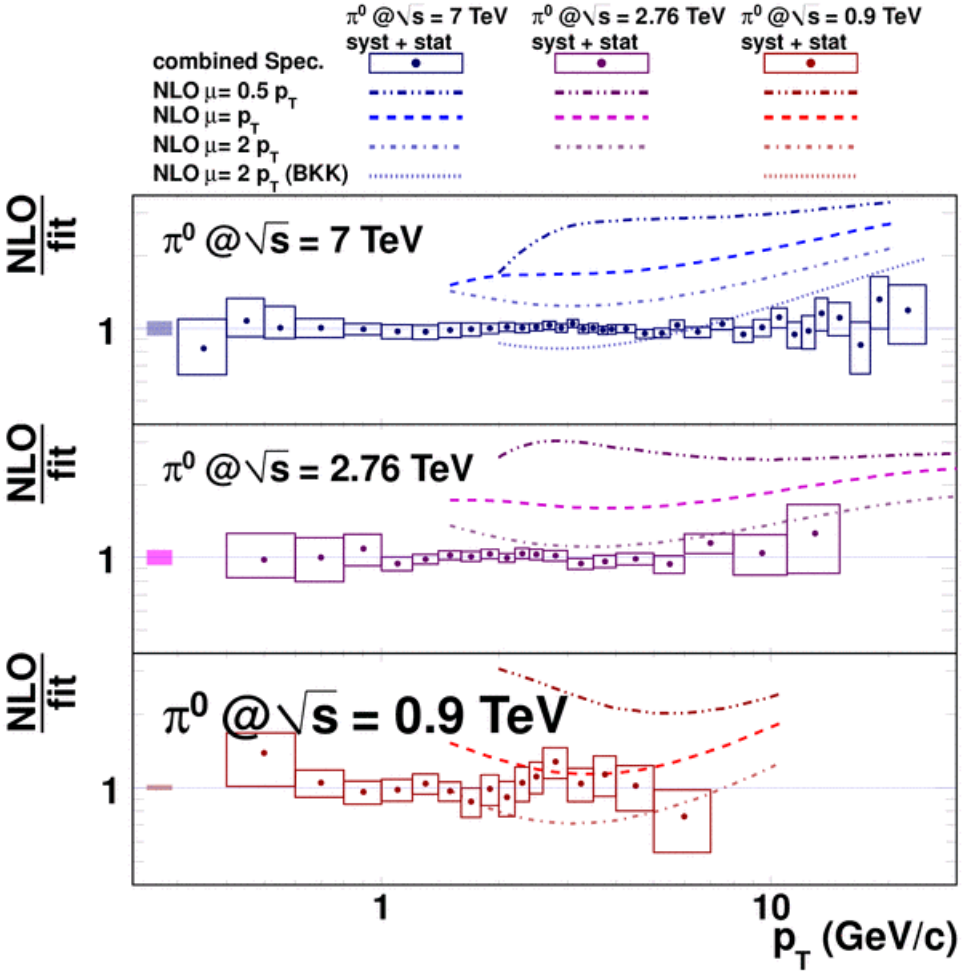
MC models do not describe particle spectra at low p_T.

B. Guerzoni, 16.11.2011

π^0 spectrum in pp @ 0.9, 2.76, 7 TeV



ALI-PREL-6540

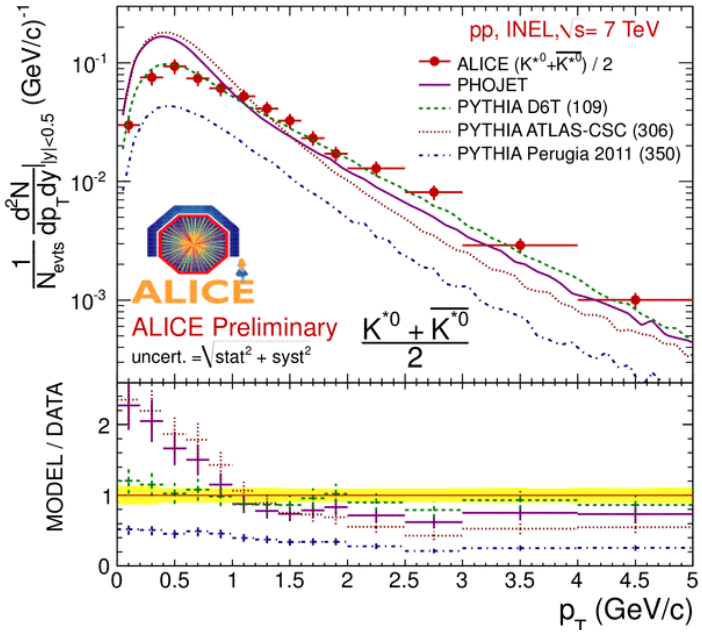


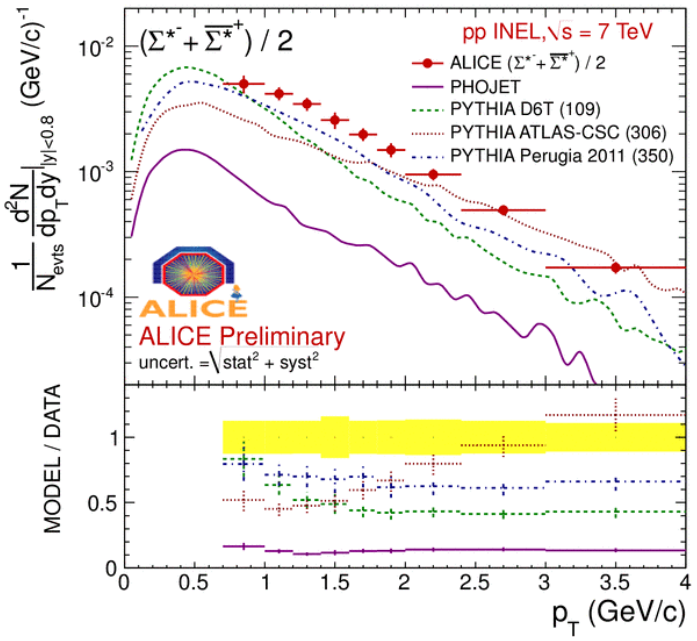
ALI-PREL-6543

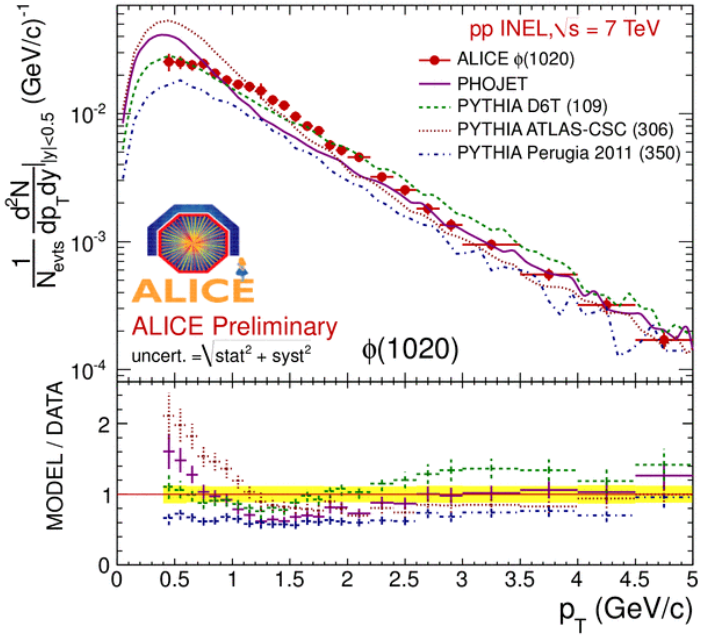
pQCD NLO does not describe particle spectra at high p_T.

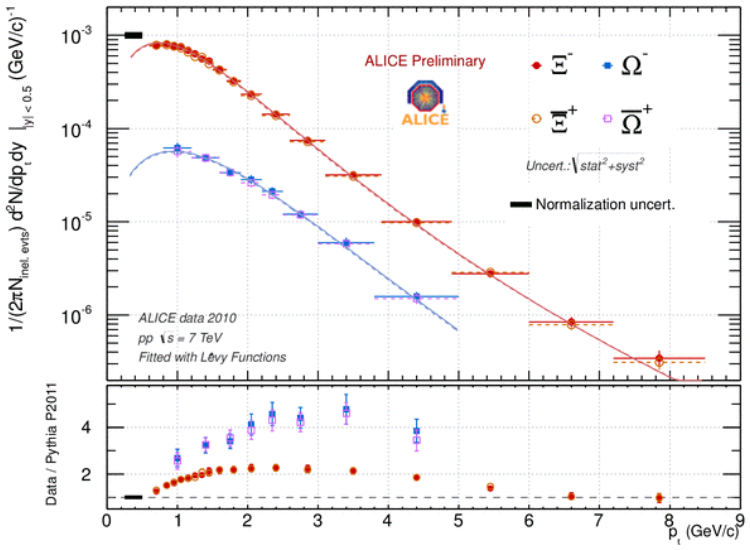
B. Polishchuk, 16.11.2011

Resonance spectra in pp @ 7 TeV









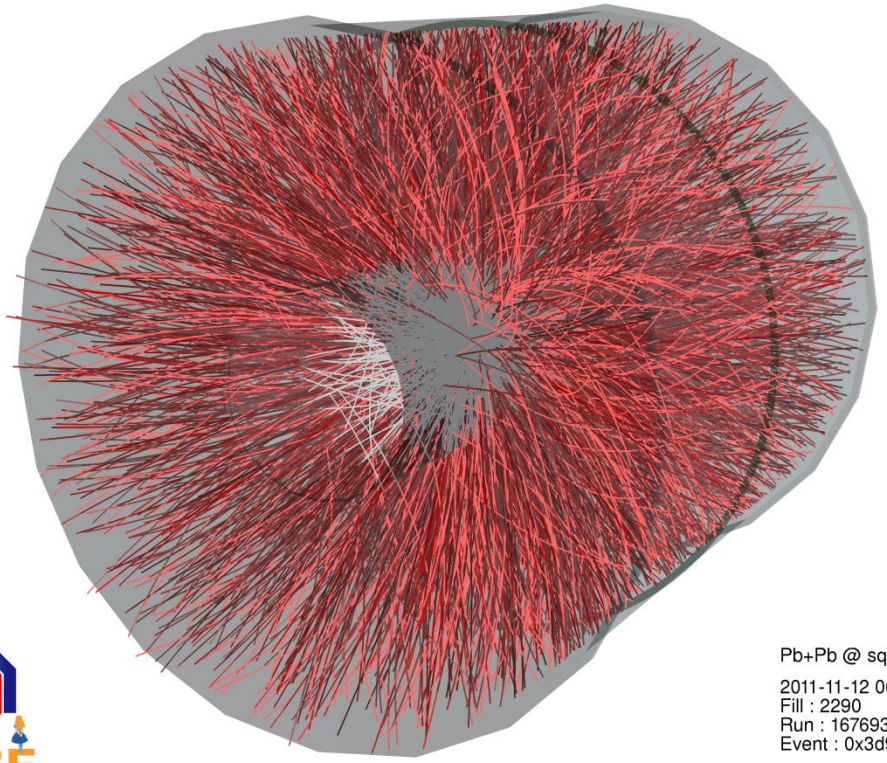
ALI-PREL-11057

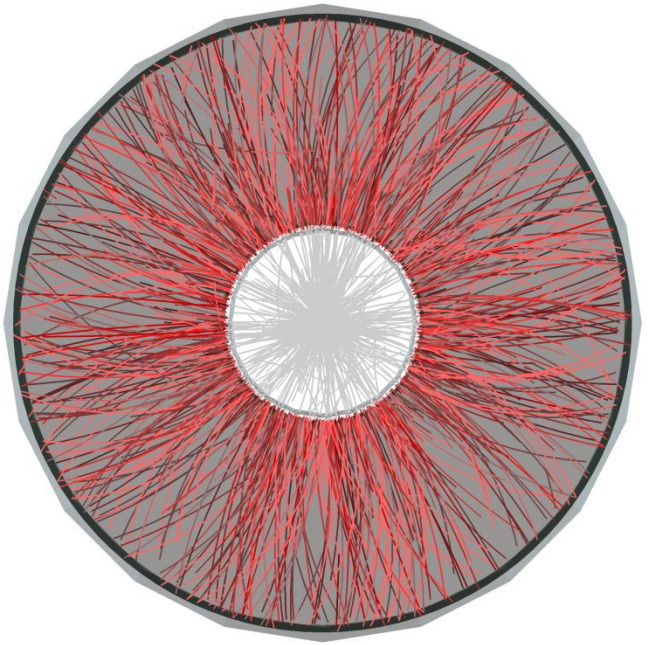
ALI-PREL-10736

Important constraint on Monte Carlo generators:

MC models yield a poor description of the data (some exceptions)

Global event features

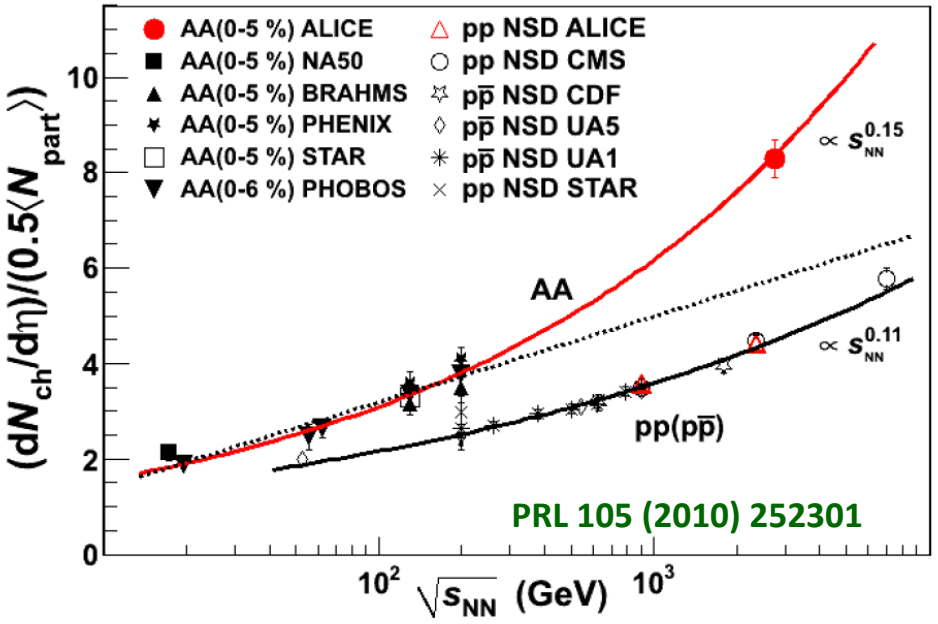


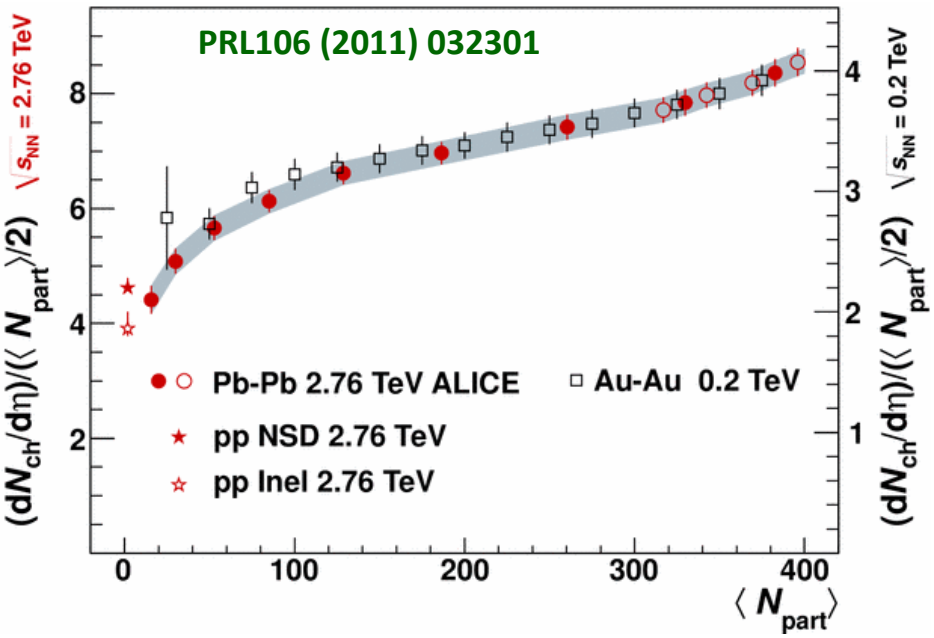


Pb+Pb @ sqrt(s) = 2.76 ATeV

2011-11-12 06:51:12
Fill : 2290
Run : 167693
Event : 0x3d94315a

Charged particle multiplicity



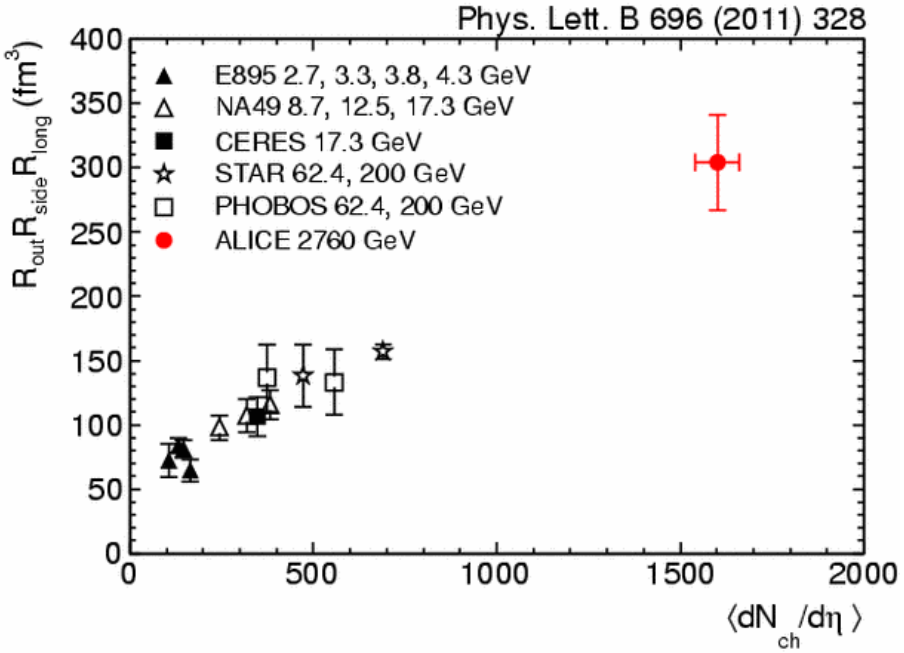


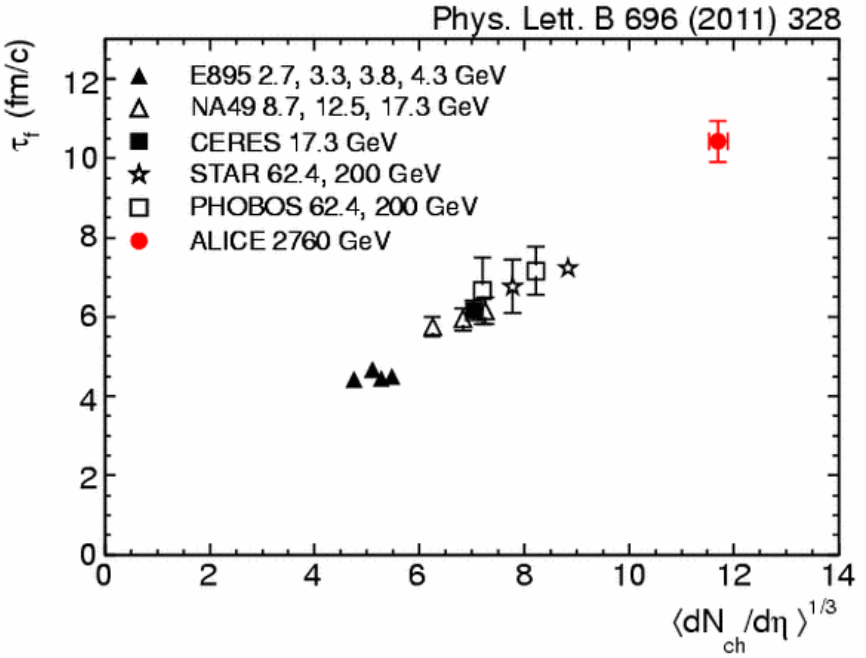
- $dN_{ch}/d\eta = 1584 \pm 76$
- $(dN_{ch}/d\eta)/(N_{part}/2) = 8.3 \pm 0.4$
  - ≈ 2.1 x central AuAu at $\sqrt{s_{NN}}$=0.2 TeV
  - ≈ 1 .9 x pp (NSD) at $\sqrt{s}$=2.36 TeV
- Stronger rise with $\sqrt{s}$ in AA w.r.t. pp
- Stronger rise with $\sqrt{s}$ in AA w.r.t. log extrapolation from lower energies

- Very similar centrality dependence at LHC & RHIC (RHIC results are scaled x2.1 to the multiplicity of central collisions at the LHC)

System size

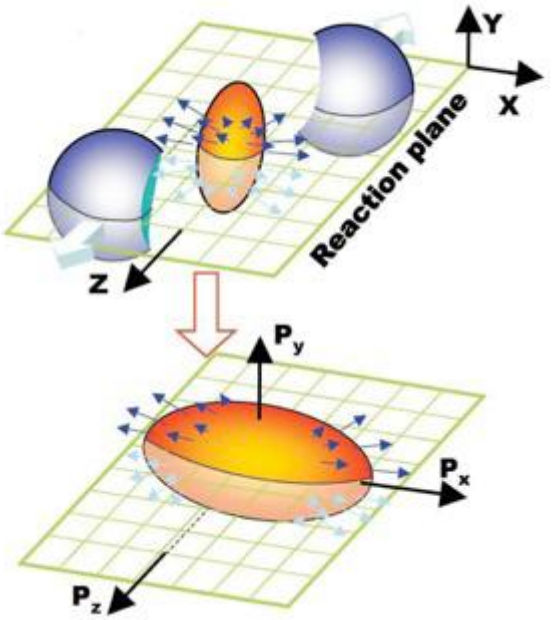
- Spatial extent of the particle emitting source extracted from interferometry of identical bosons
  - Two-particle momentum correlations in 3 orthogonal directions -> HBT radii (R_{long}, R_{side}, R_{out})
  - Size: twice w.r.t. RHIC
  - Lifetime: 40% higher w.r.t. RHIC





L. Malinina, 16.11.2011

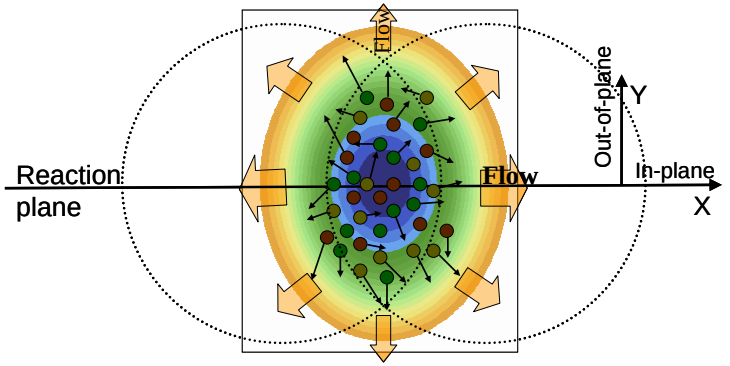
Collective expansion

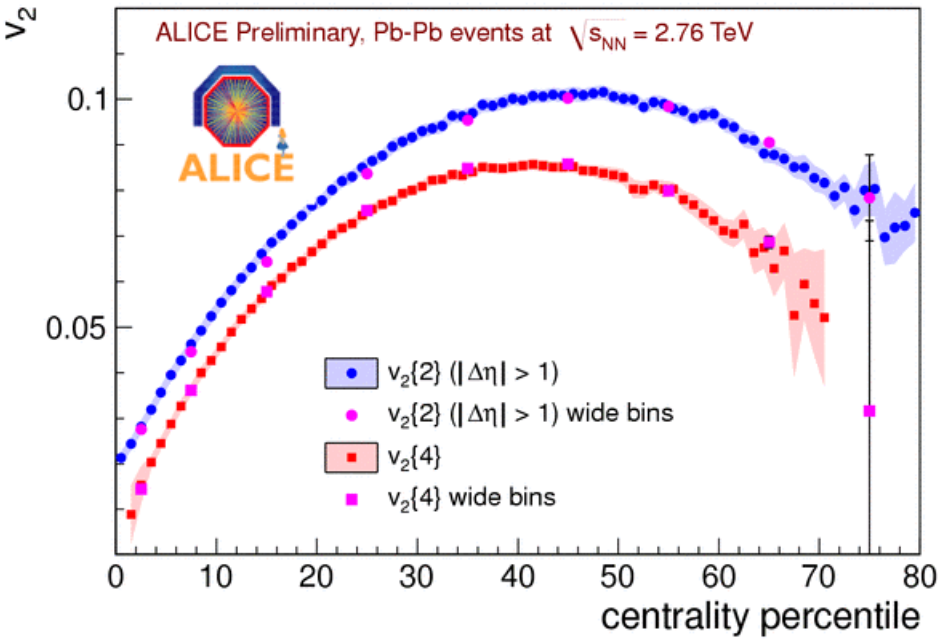


Elliptic flow

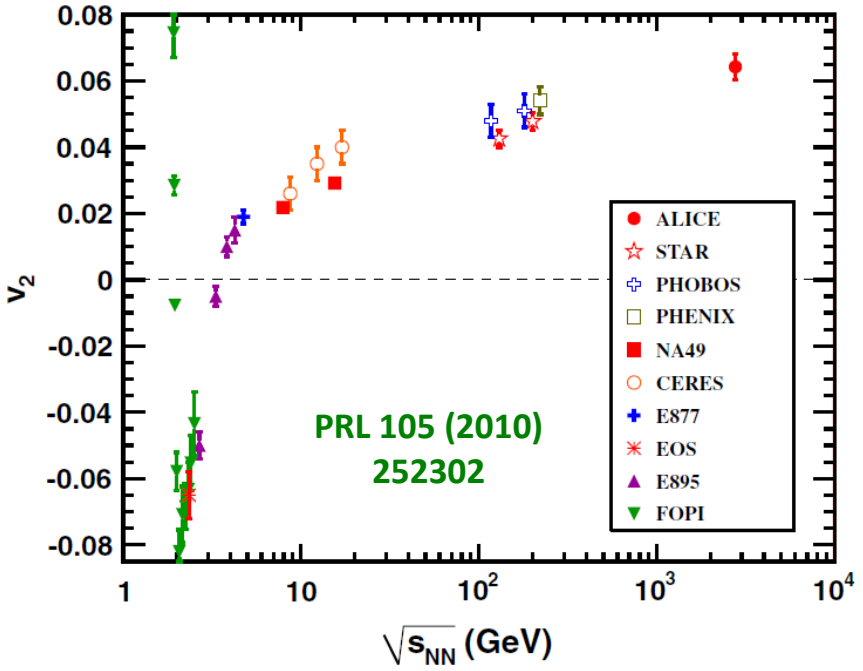
$$\frac{dN}{d(\varphi-\psi_{RP})} \propto 1+2\sum_{n=1} v_n \cos(n[\varphi-\psi_{RP}])$$

$$v_2 = \langle \cos[2(\varphi-\Psi_{RP})] \rangle$$



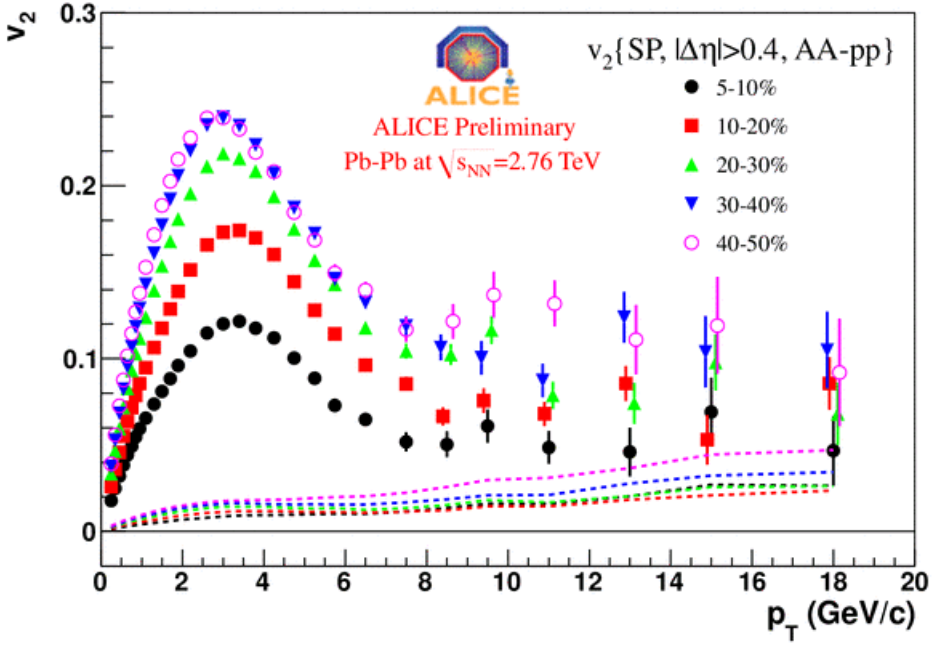


ALI-PREL-2424

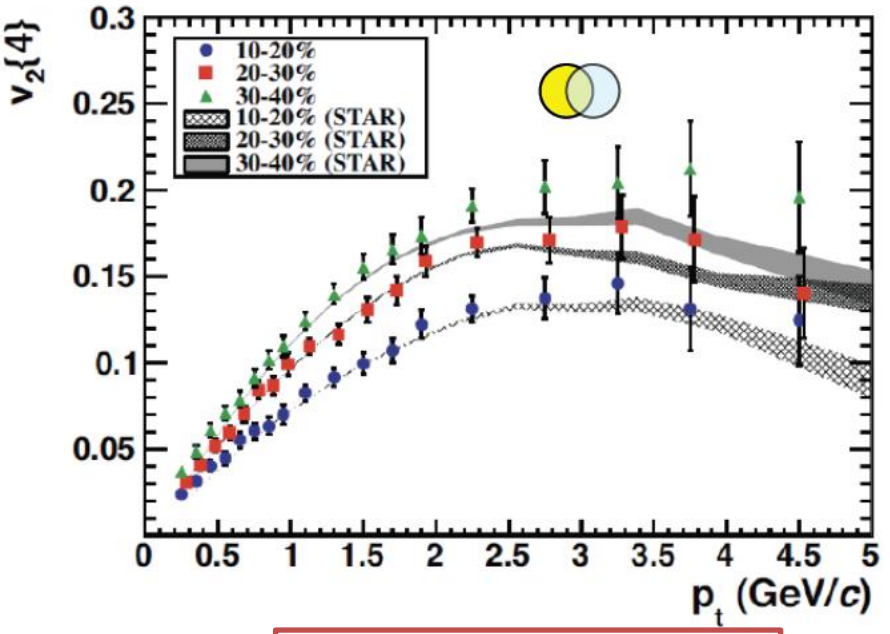


At LHC, p_T-integrated v_2 increases by 30% w.r.t RHIC data at $\sqrt{s_{NN}}$=200 GeV

Differential elliptic flow



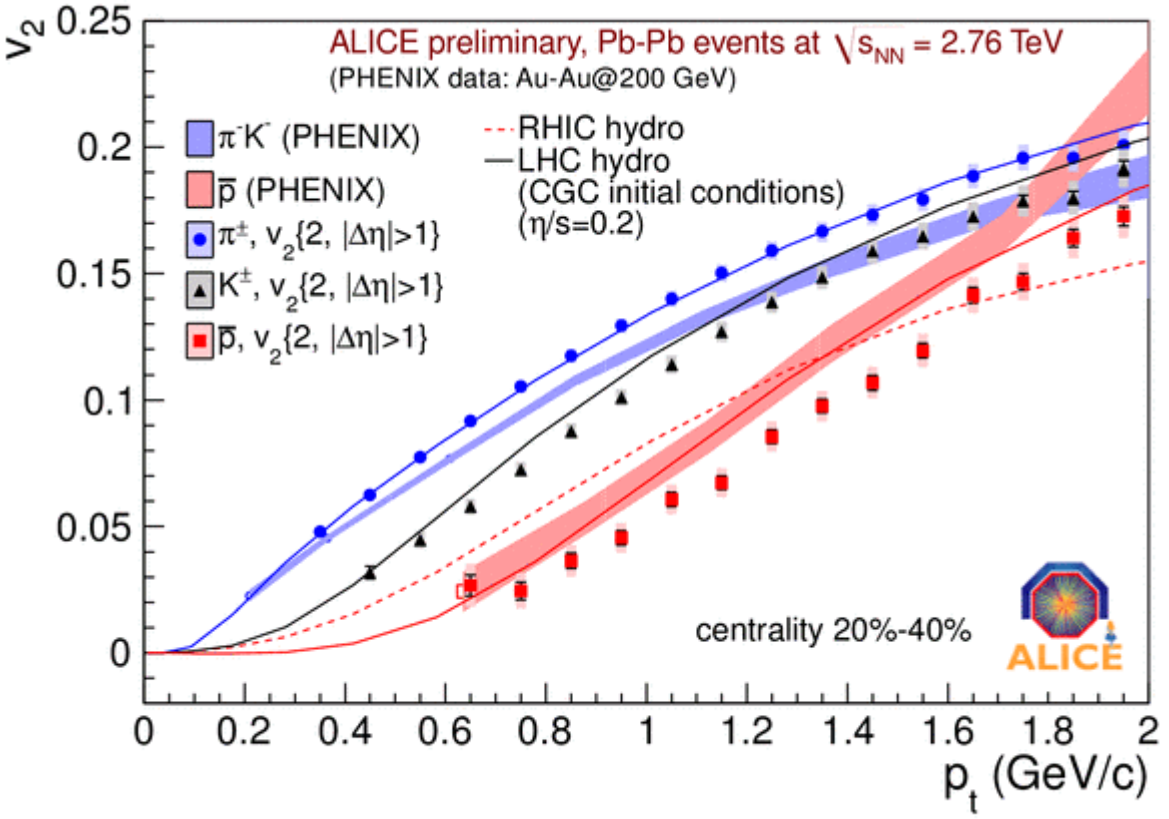
ALI-PREL-439



PRL 105, 252302 (2010)

- v_2 vs. p_T does not change within uncertainties between $\sqrt{s_{NN}}$=200 GeV and 2.76 TeV
  - 30% increase of p_T integrated flow explained by higher mean p_T due to stronger radial flow at higher energies

Elliptic flow of identified hadrons



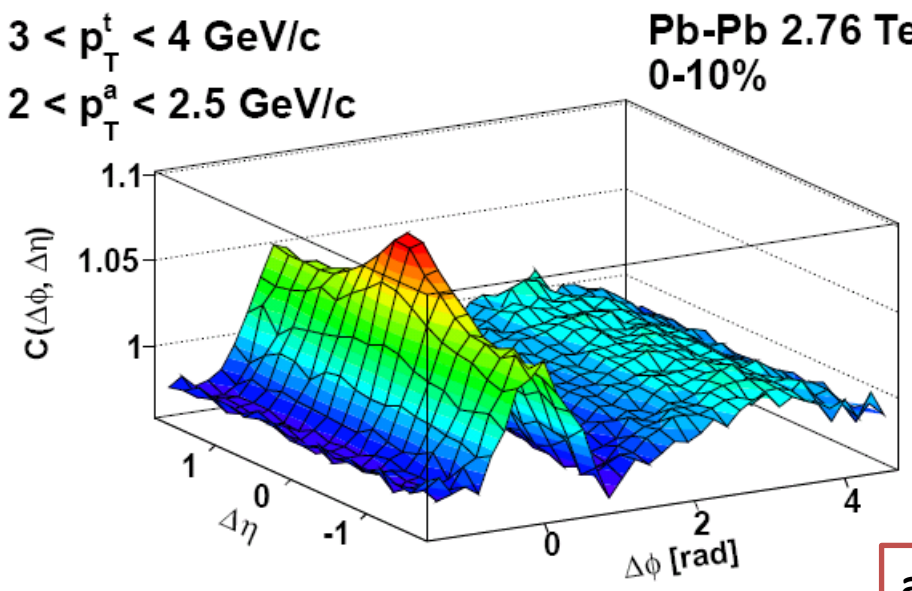
ALI-PREL-2467

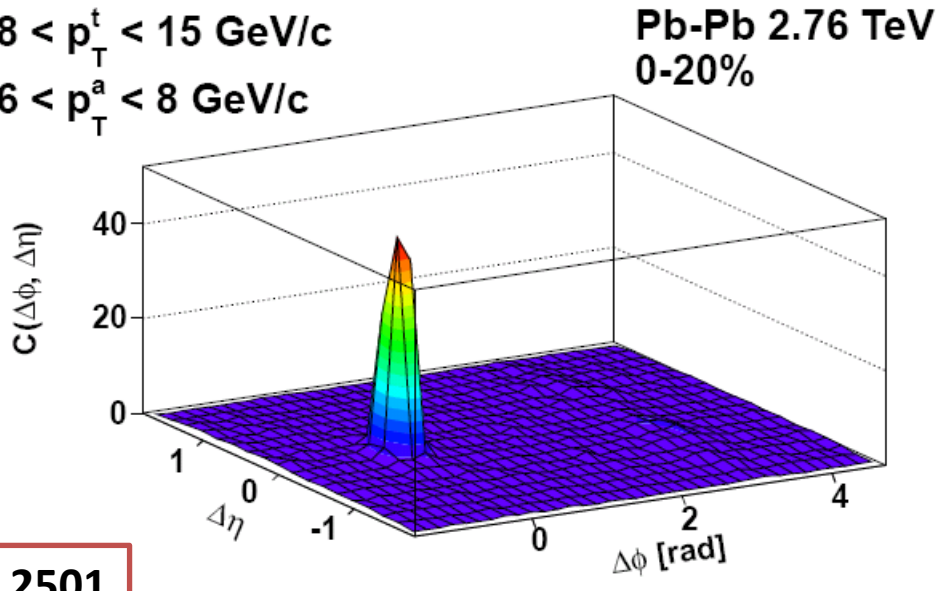
- Stronger radial flow -> more pronounced mass dependence of elliptic flow
- Hydrodynamics predictions describe well the measured $v_2(p_T)$ for π and K for semi-peripheral (40%-50%) and semi-central (10%-20%) collisions
  - Mismatch for anti-protons in the more central bin

    Larger radial flow in the data than in the Hydro model

    Rescatterings in the hadronic phase play an important role (arXiv:1108.5323)

Di-hadron correlations





arXiv:1109.2501

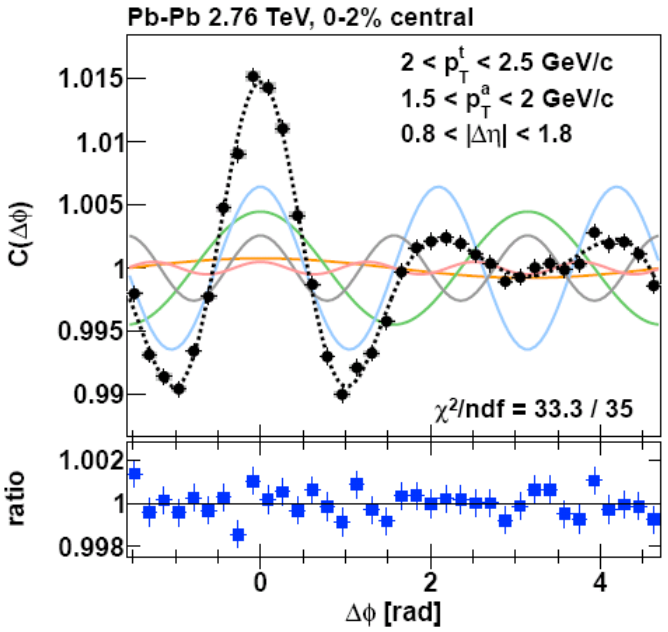
Lower p_T

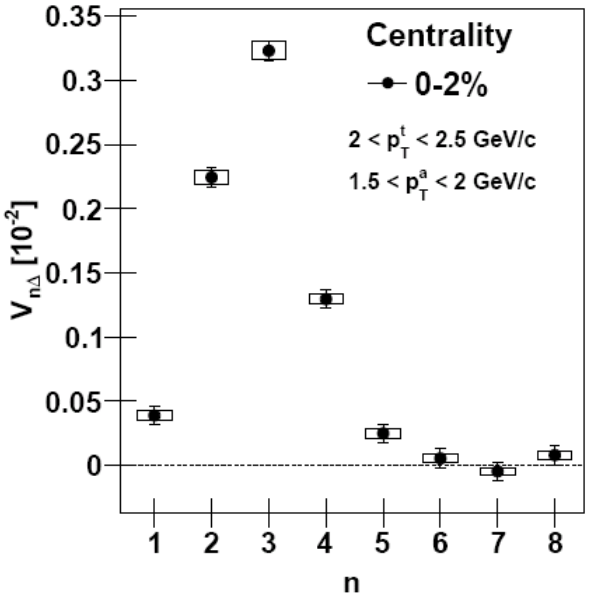
- Near-side ridge
  - First observed at RHIC
  - Observed also by CMS in high multiplicity pp collisions at √s=7 TeV
  - Broad away-side
  - Dominated by hydrodynamics and flow

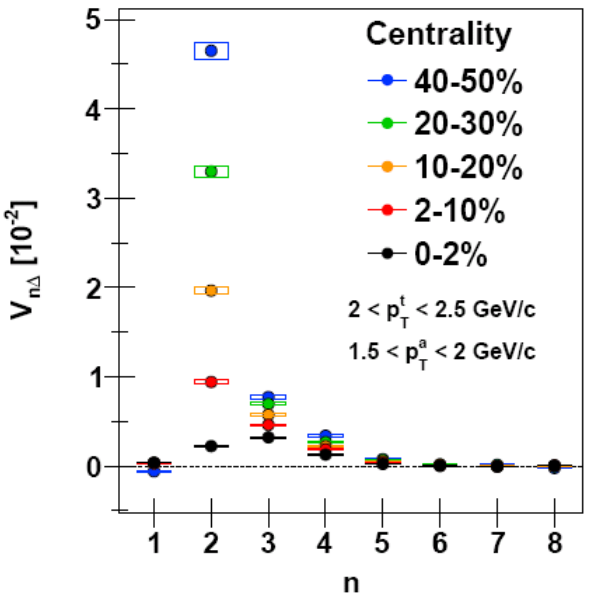
Higher p_T

- Near-side jet dominates
- Quenching/suppression and broadening of the away side jet

Di-hadron correlations: Fourier analysis





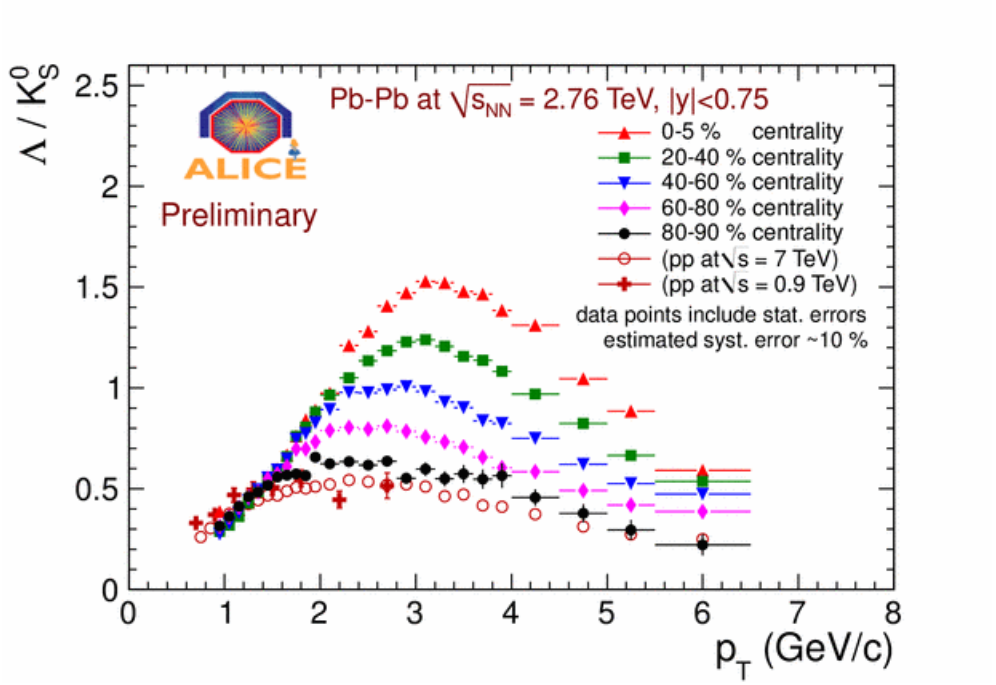


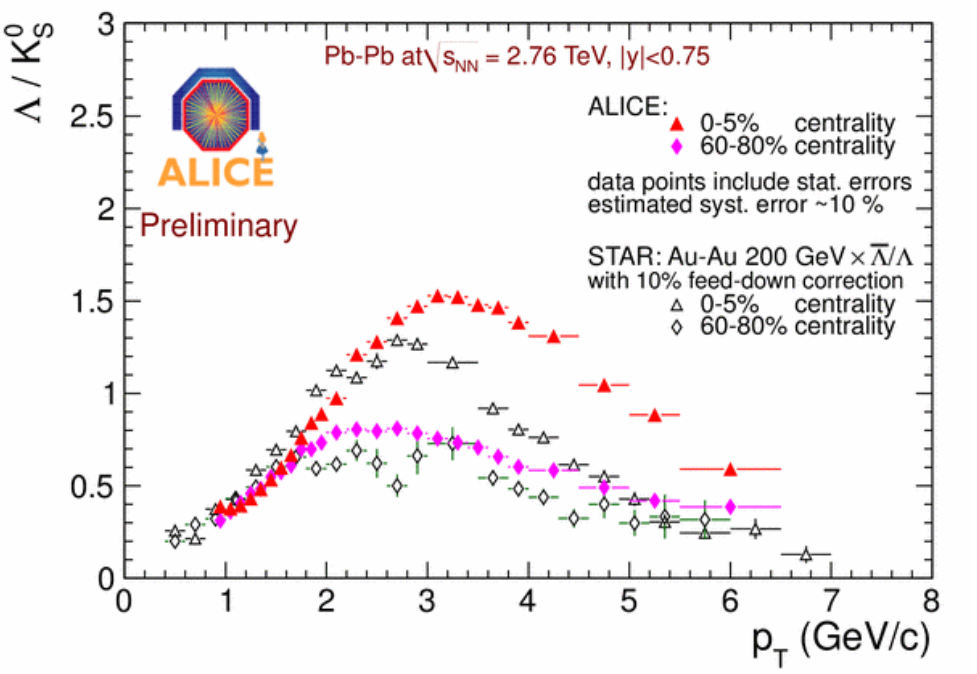
- The data also suggest that at low p_T (below approximately 3 GeV/c), any contribution from the away-side jet is constrained to be relatively small.
- In contrast, for associated p_T greater than 4–6 GeV/c, the long-range correlation appears dominated by a large peak from the recoil jet.

arXiv:1109.2501

Strangeness production

Strange baryon/meson ratio

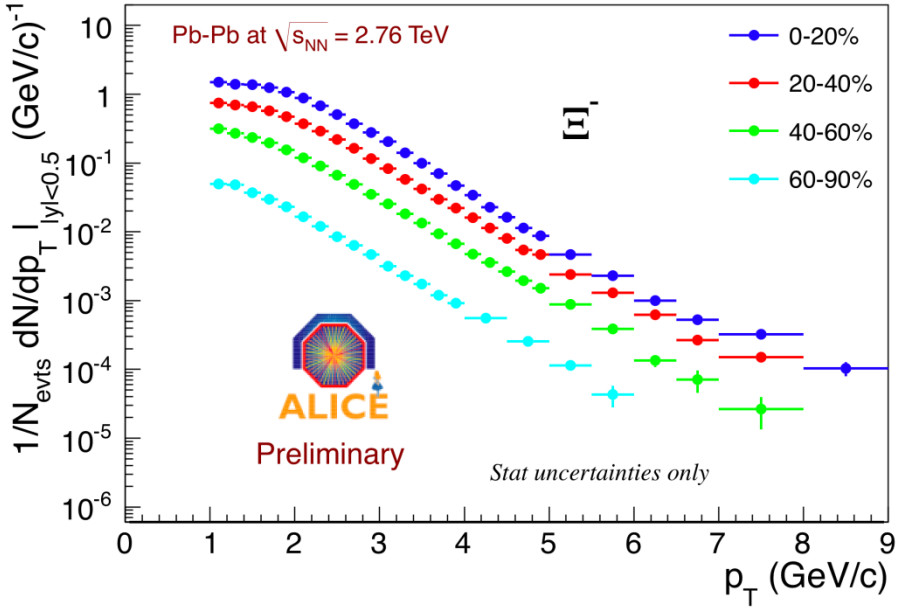


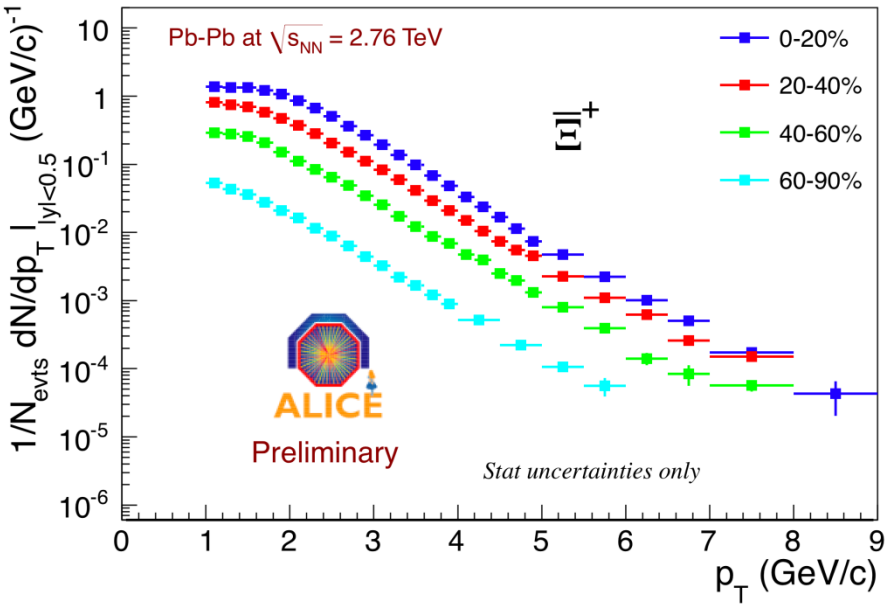


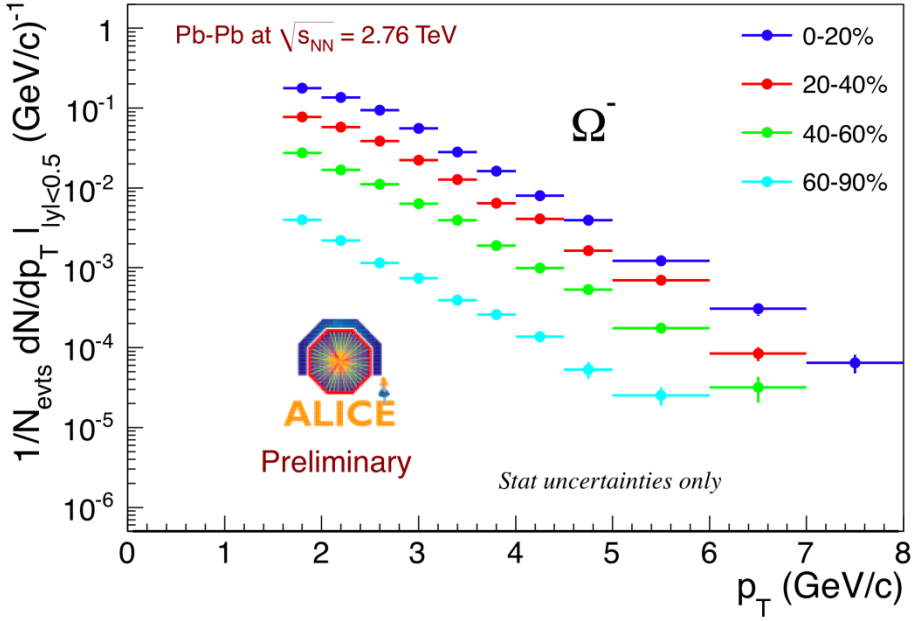
- Baryons are more abundant at intermediate p_T
- Baryon/meson ratio increases with centrality

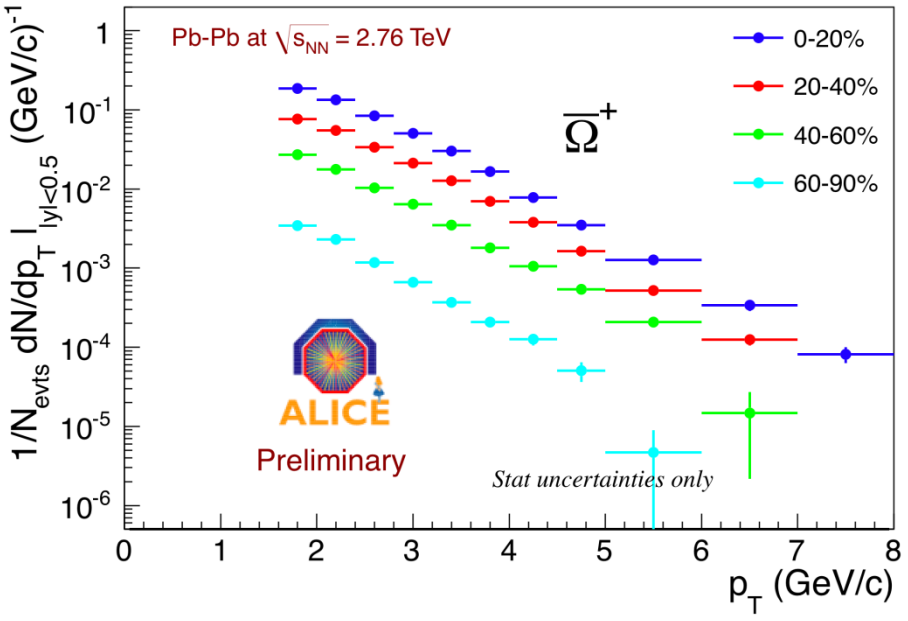
- Enhancement is stronger at LHC than at RHIC
- Maximum of Λ/K is reached at higher p_T at LHC than at RHIC

Multi-strange baryons

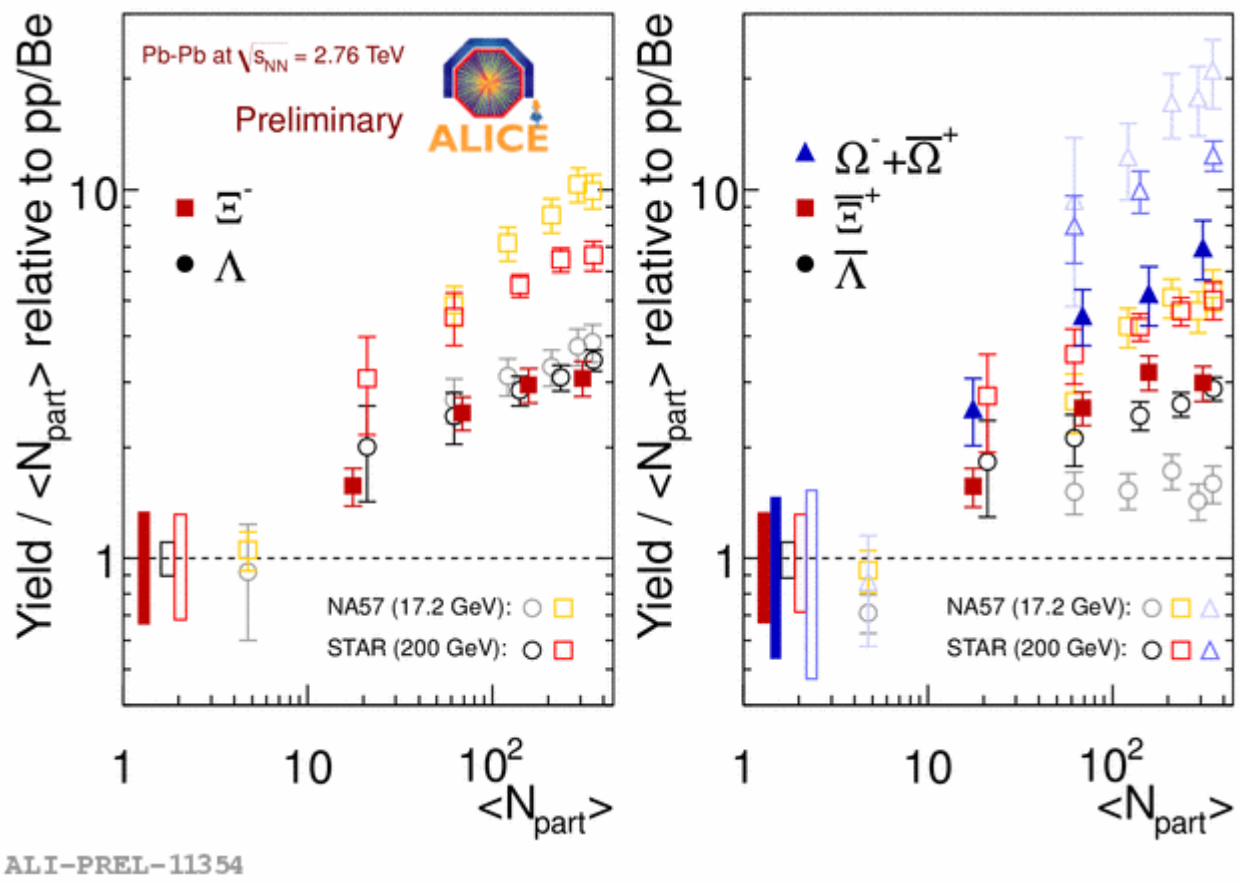






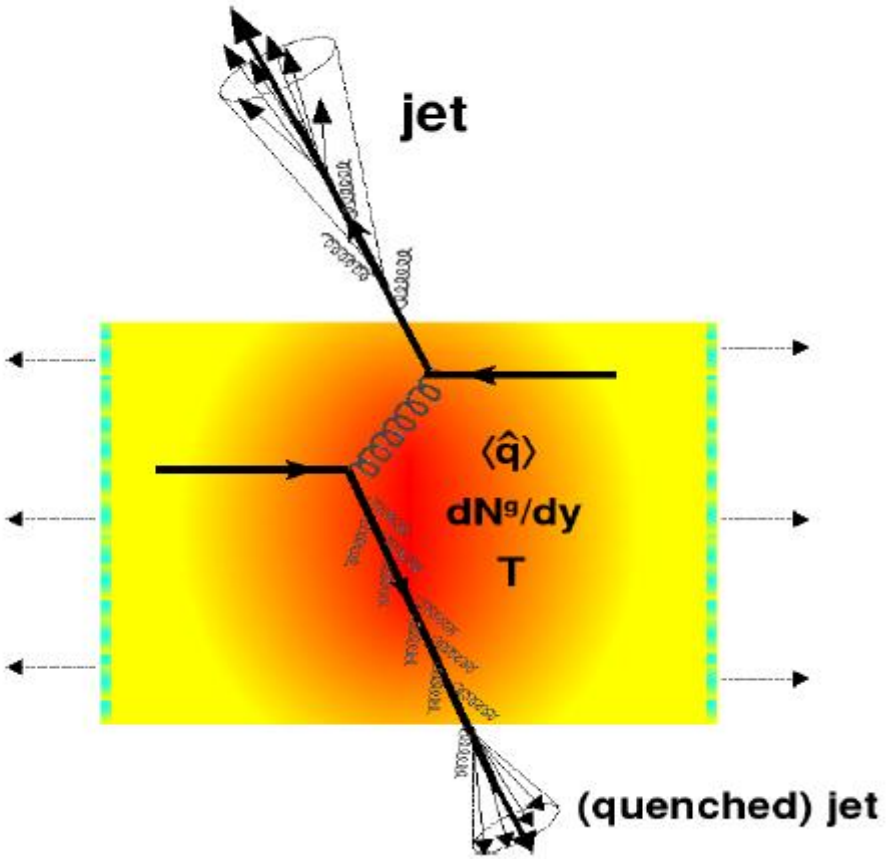


Multi-strange baryons: enhancement

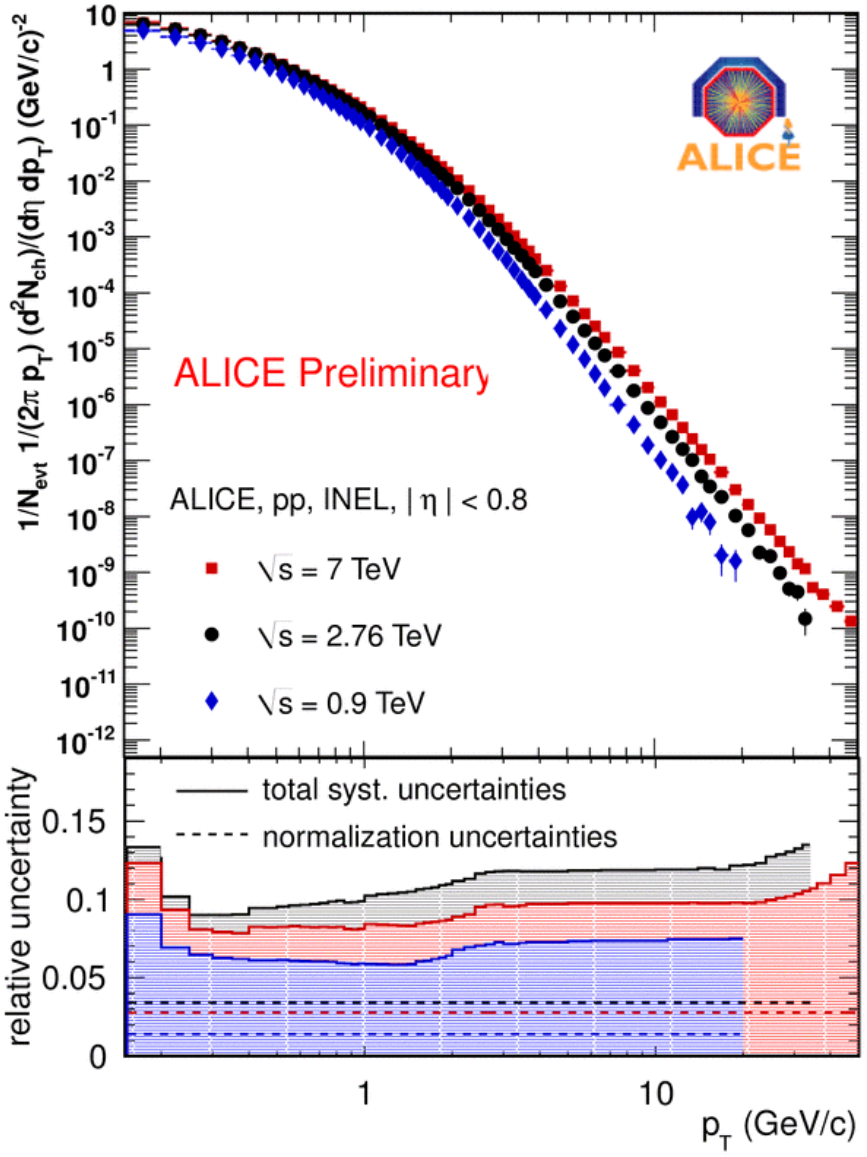


- Production of multi-strange baryons in PbPb collisions at √s=2.76 TeV are enhanced with respect to pp.
- Enhancement scaled with N_{part}.
- The enhancement of strange baryons decreases with √s

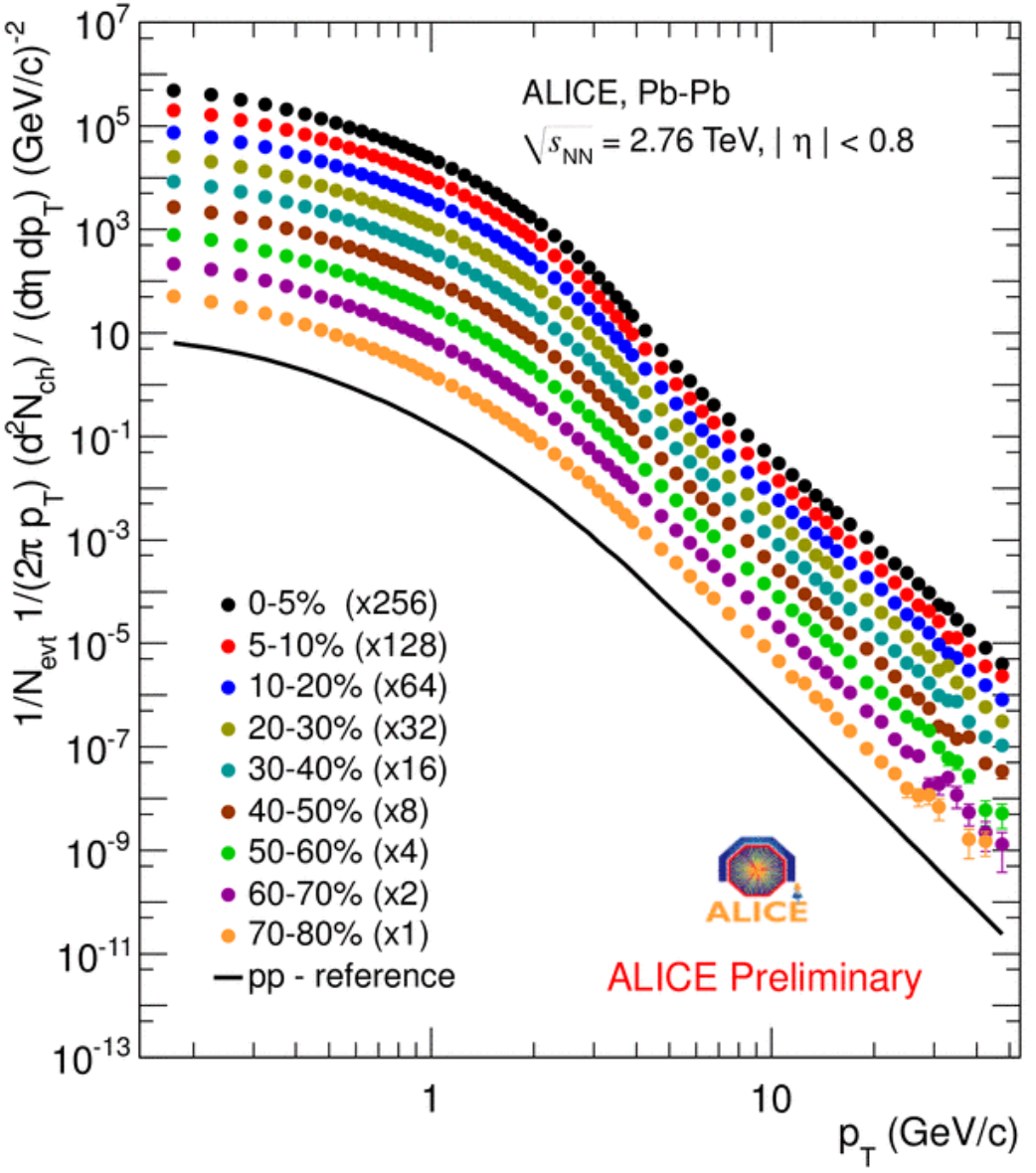
Parton energy loss in medium



Charged particle spectrum: pp vs PbPb



ALI-PREL-11366

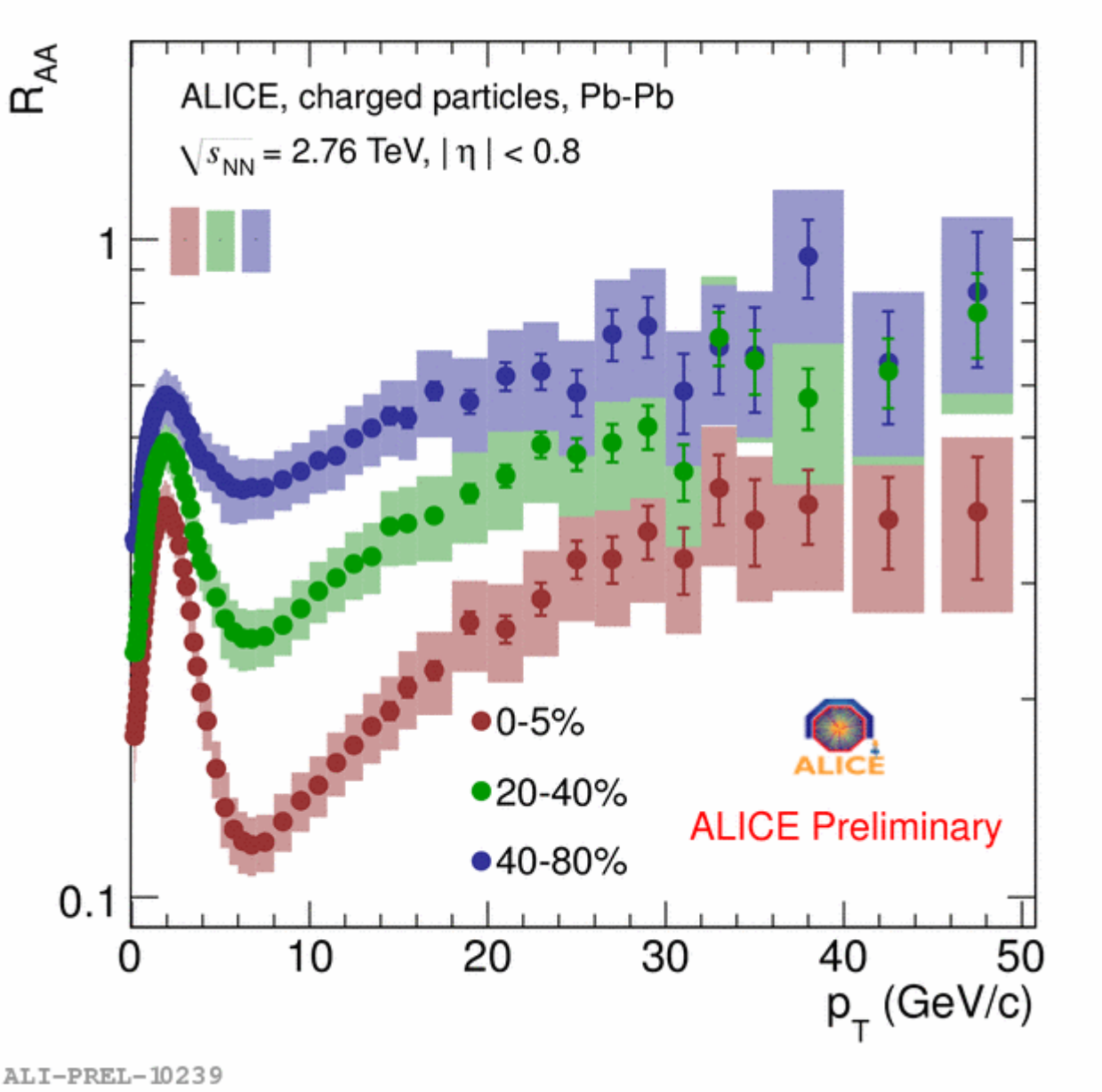


ALI-PREL-10231

Charged particle suppression

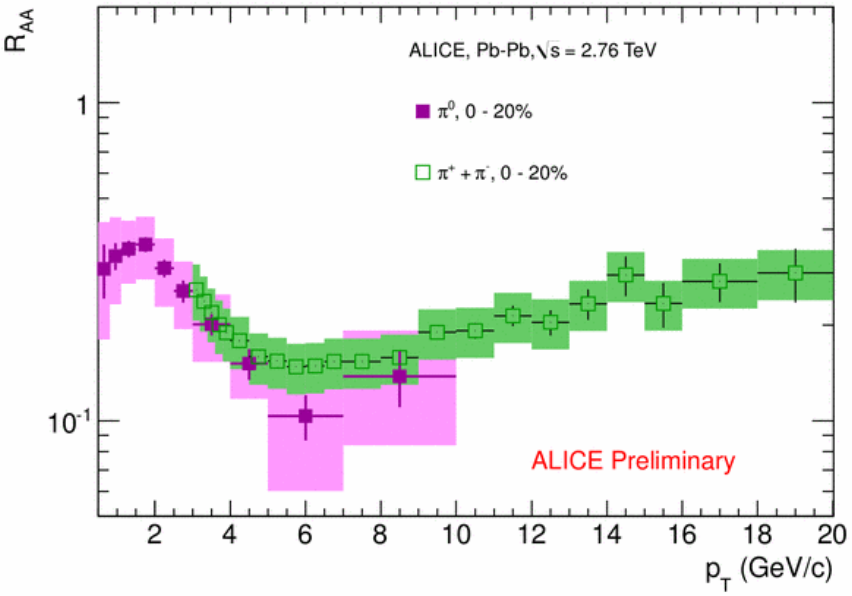
$$R_{AA}(p_T) = \frac{1}{\langle T_{AA} \rangle} \frac{dN_{AA}/dp_T}{d\sigma_{pp}/dp_T}$$

- Suppression increases with increasing centrality
- Minimum for p_T ~ 6-7 GeV/c in all centrality classes
- R_{AA} increases in the region p_T>10 GeV/c
- Hint of flattening above 30 GeV/c

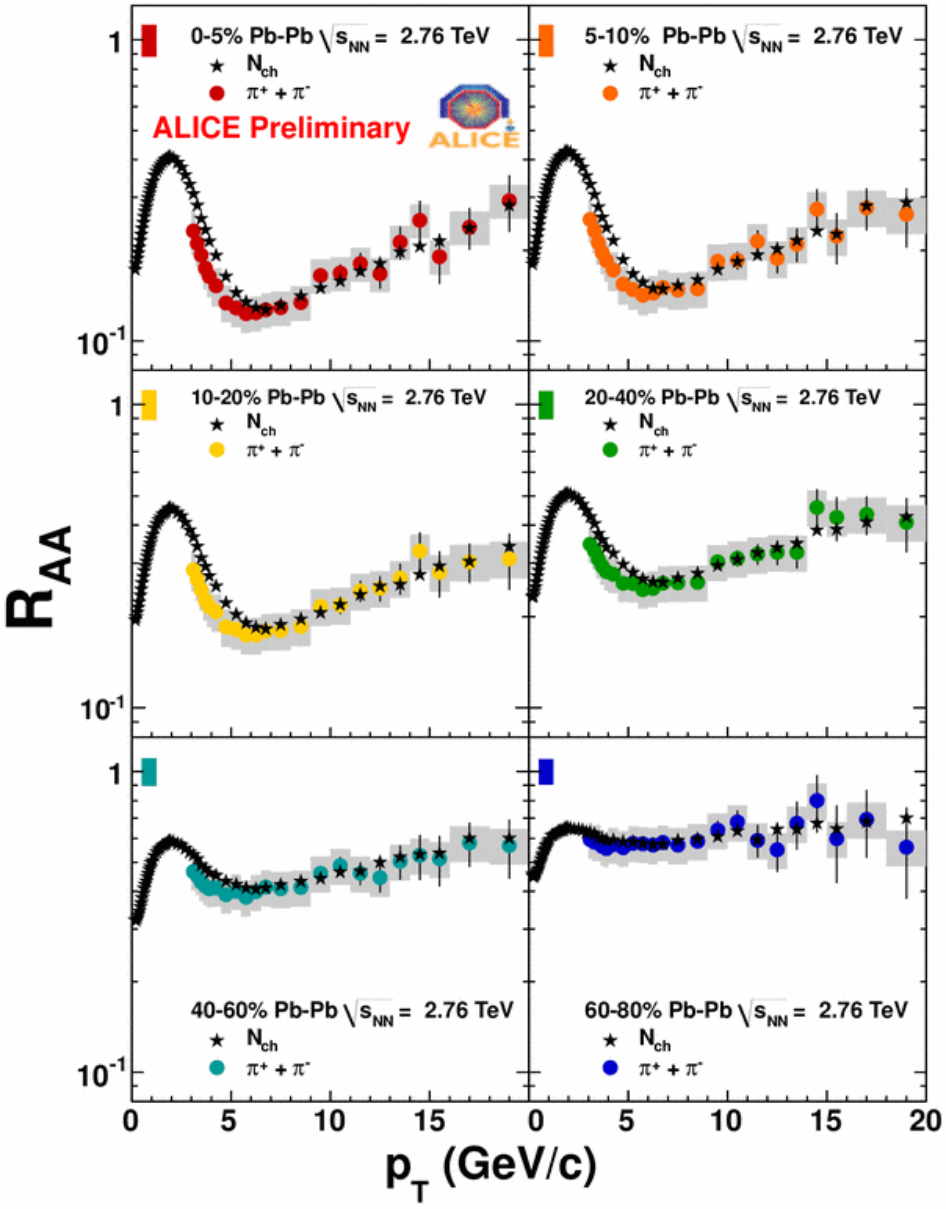


R_{AA} of light identified mesons

- $\pi^{\pm}$, $K^{\pm}$, p, anti-p are identified in TPC by ionization loss dE/dx
- π^0 are identified by γ conversions and by calorimeters.
- Same suppression for π^0 and $\pi^{\pm}$
- $\pi^{\pm}$ are stronger suppressed than charged particles:
  - Possible baryon enhancement in AA

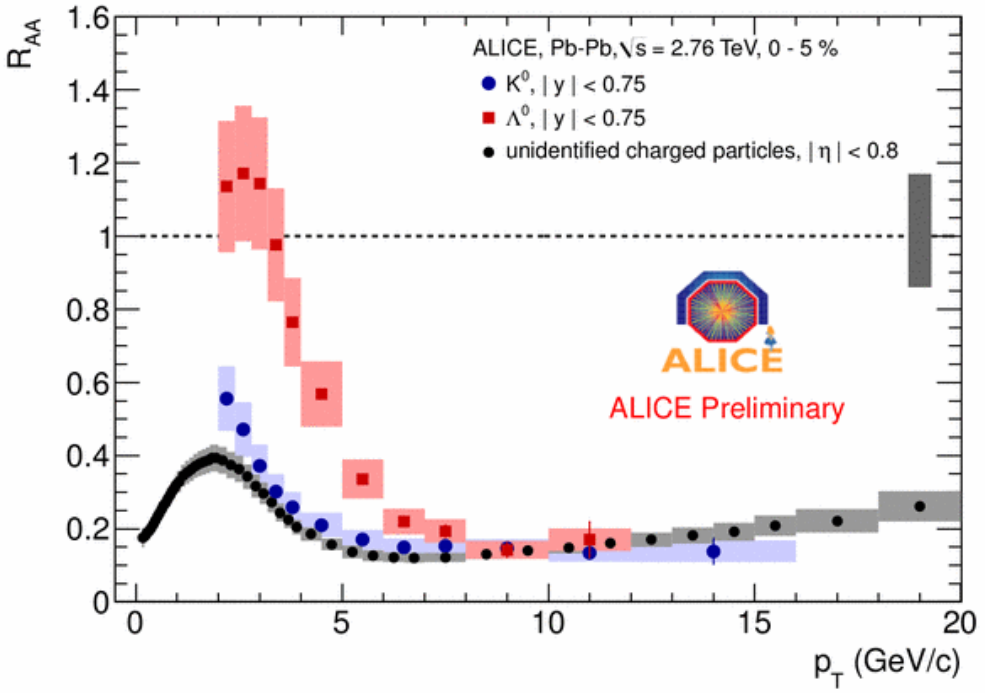


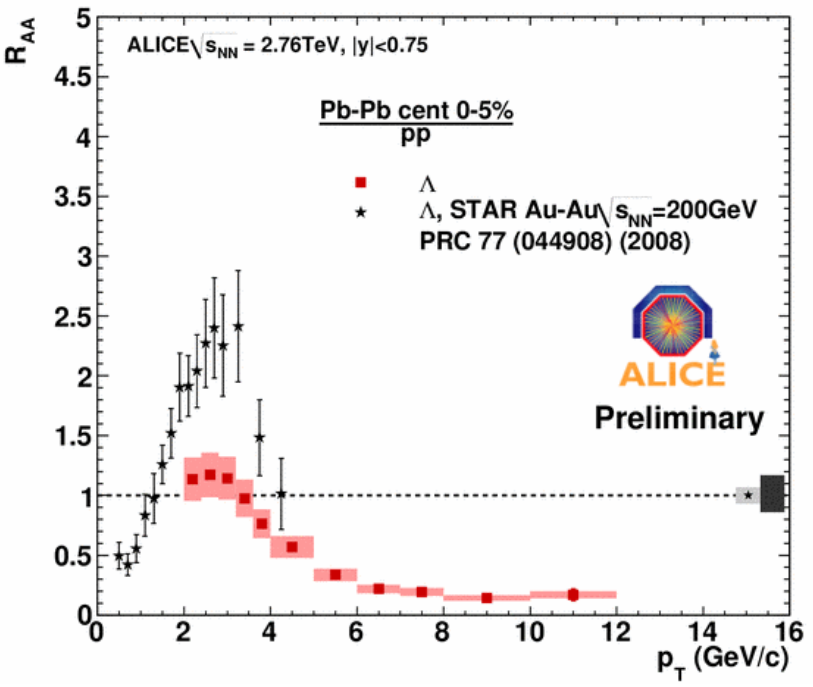
ALI-PREL-10514



ALI-PREL-8896

R_{AA} of strange hadrons



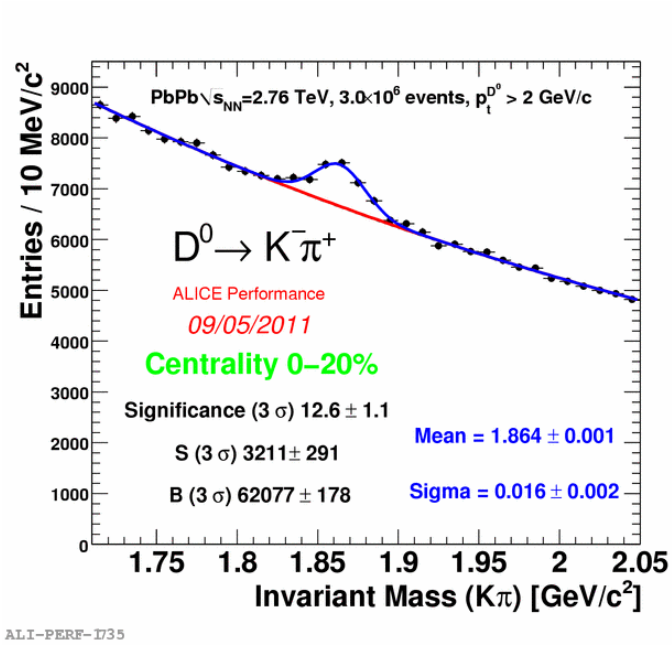


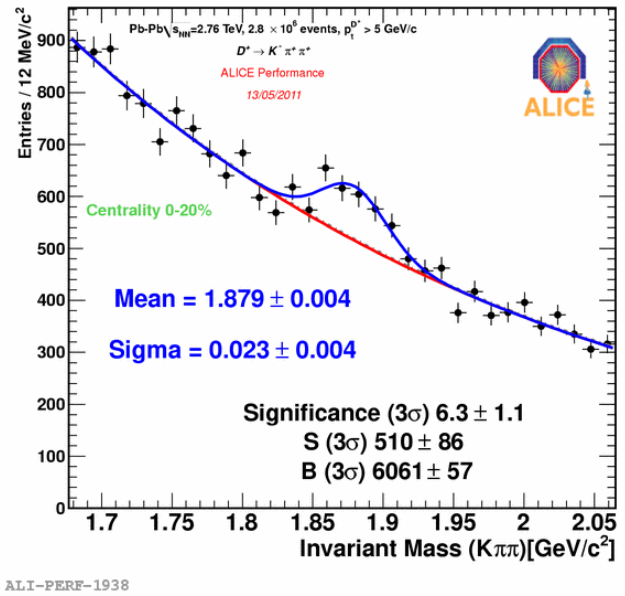
ALI-PREL-10945

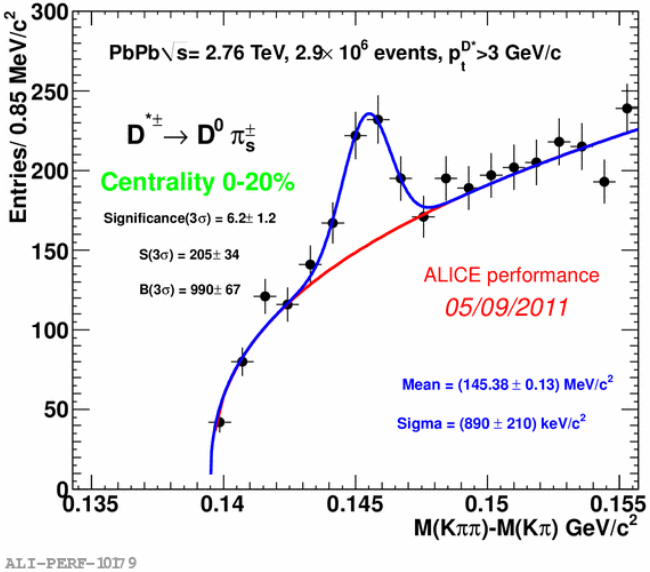
- K_s^0 is suppressed similarly to charged particles
- Suppression of Λ:
  - At high p_T similar to charged particles
  - At low p_T is less suppressed due to baryon enhancement
  - Different at RHIC and LHC

Heavy flavors

Open charm: D mesons



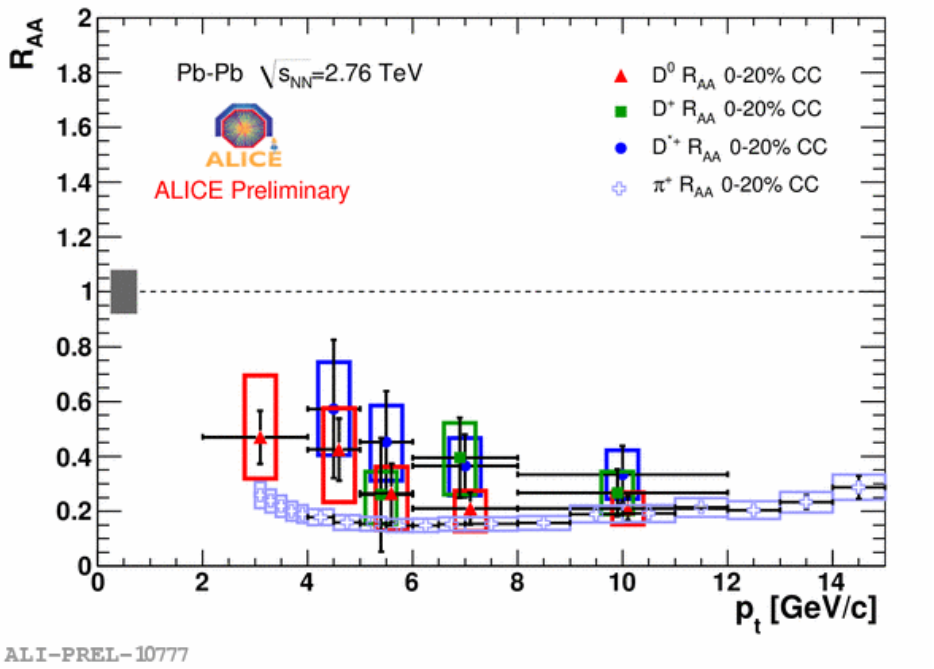


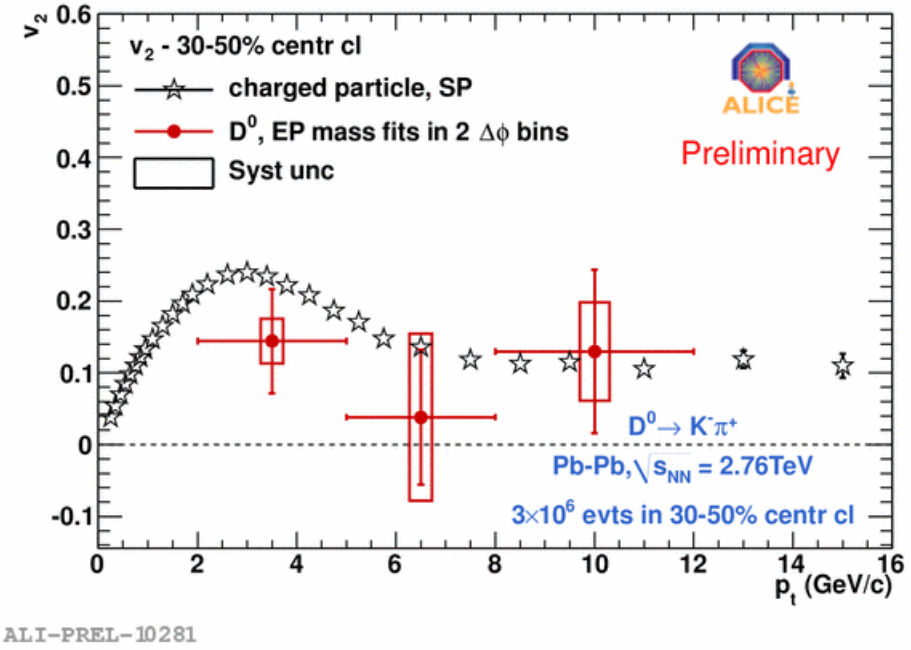


- Invariant mass analysis of fully reconstructed decay topologies displaced from the primary vertex
- Reconstructed D-meson spectra are corrected for B decays (10-15%, FONLL).

R. Averbeck, 18.11.2011

D mesons in PbPb





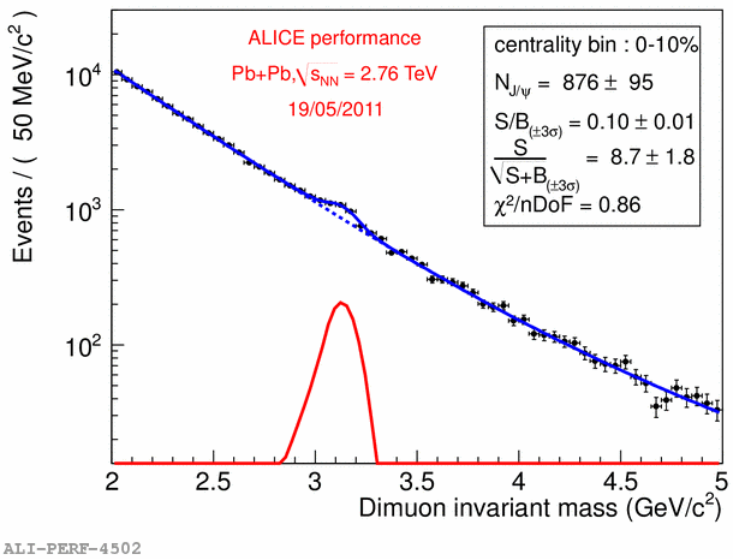
Suppression of prompt D mesons in central (0-20%) PbPb collisions by a factor 4-5 for p_T>5 GeV/c

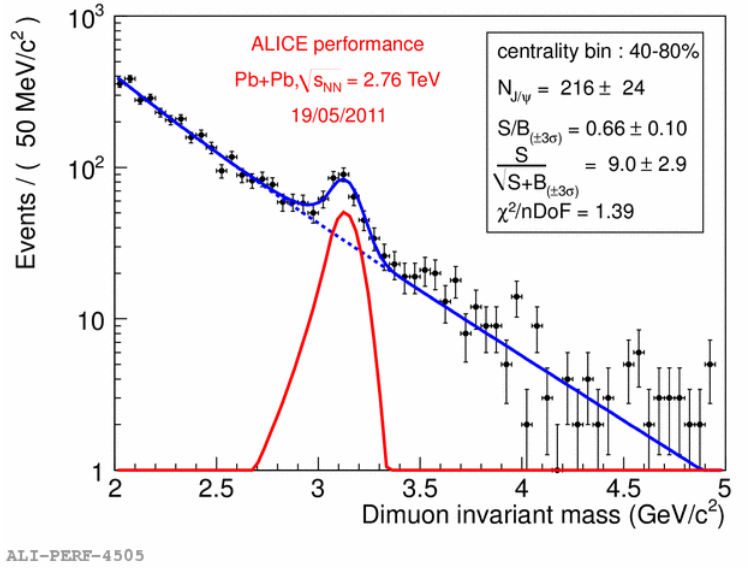
- Little shadowing at high p_T → suppression is a hot matter effect
- Similar suppression for D mesons and pions
- Maybe a hint of $R_{AA}^{D} > R_{AA}^{\pi}$ at low p_T

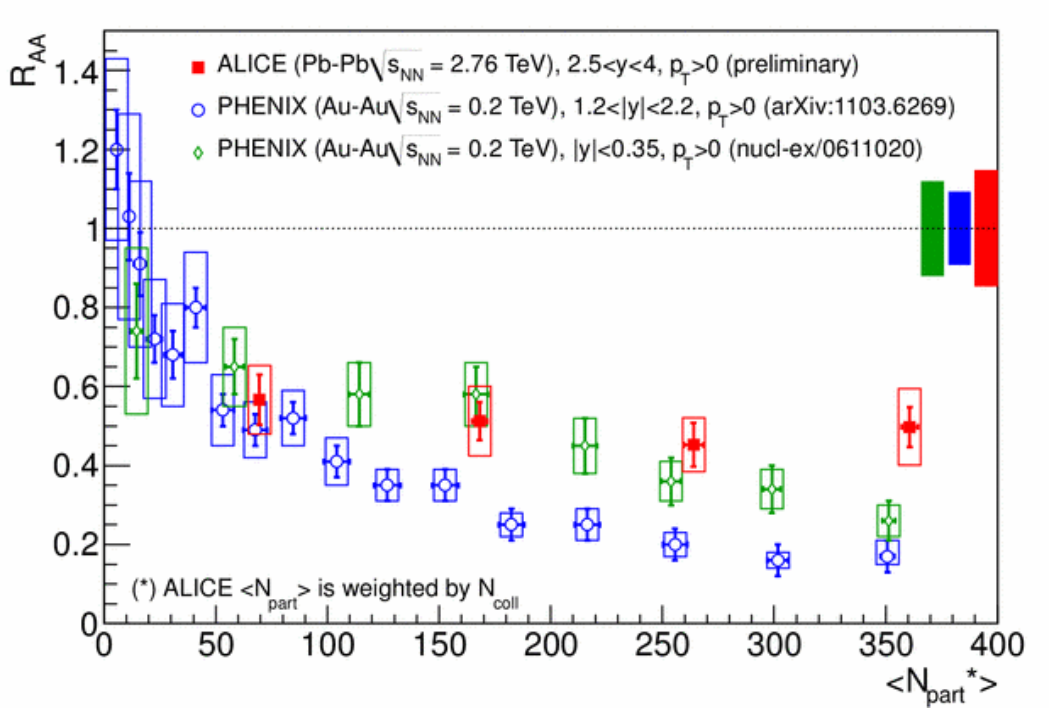
First direct measurement of D flow in heavy-ion collisions

Yield extracted from invariant mass spectra of Kπ candidates in 2 bins of azimuthal angle relative to the event plane

Charmonium in PbPb





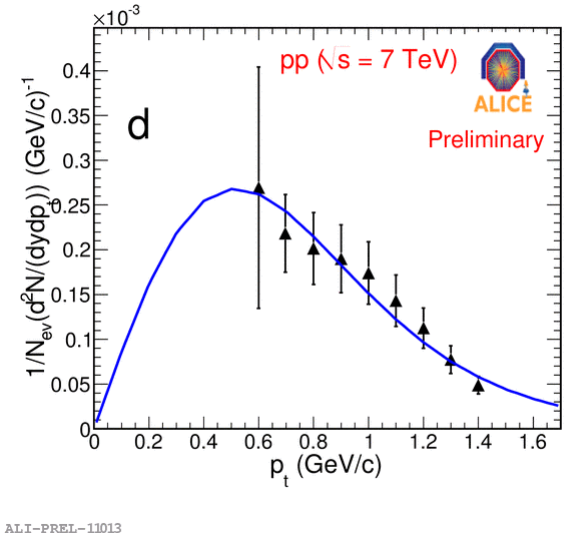


Less suppression at LHC than at RHIC at forward rapidity:

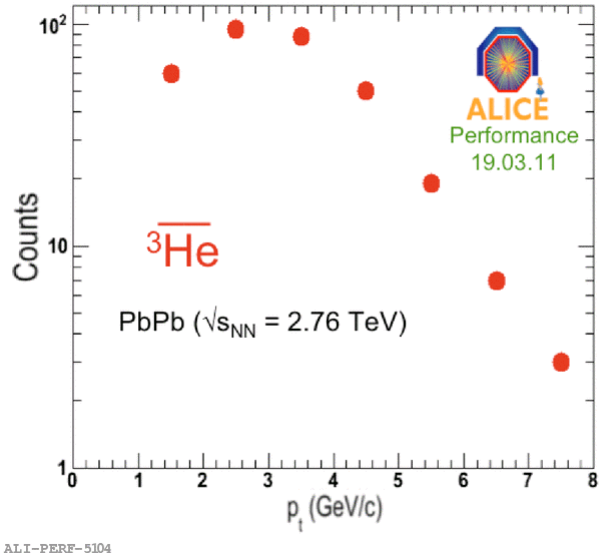
R_{AA}(ALICE) > R_{AA}(PHENIX, 1.2<y<2.2)

F. Bossu, 18.11.2011

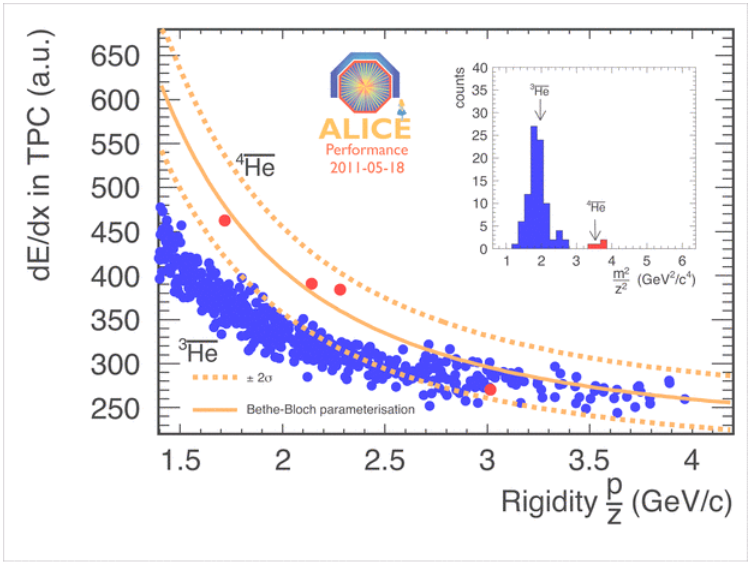
Light nuclei in pp and PbPb



ALI-PREL-11013



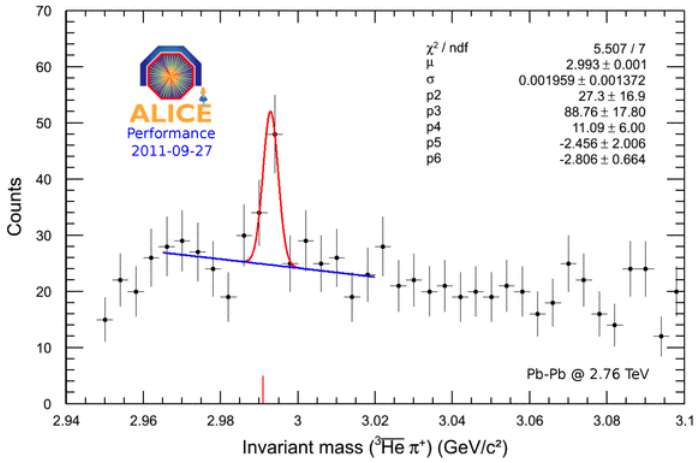
ALI-PERF-5104



ALI-PERF-4884

Raw Anti-Helium3 spectra for PbPb collisions at √s=2.76 ATeV

Light nuclei in pp and PbPbThe figure shows the observation of four anti-alpha candidates in the ALICE experiment. The plot shows the measured dE/dx signal in the ALICE TPC versus rigidity together with the expected curve for anti-alpha. The dotted lines show a 2sigma-band around this expected curve. Below R = 2.3 GeV/c a clean identification with only the TPC is possible. Above this, the bands from He-3 and He-4 are overlapping so that information from the TOF for tracks inside the 2sigma-band must be included.



ALI-PERF-11629

The plot shows the invariant mass distribution of v0 candidates whose negative daughter was identified as a anti-He3 nucleus based on TPC dEdx.

Summary

- ALICE is exploring hadron production in pp collisions at $\sqrt{s}$=0.9, 2.76, 7 TeV:
  - Tests of various models, constraints on the model parameters
- ALICE is exploring quark matter with PbPb at $\sqrt{s_{NN}}$=2.76 TeV
  - Medium with 3 times higher energy density than at RHIC
  - Abundance of hard probes
- Smooth evolution of global (bulk) event characteristics from RHIC to LHC energies
  - Precision measurements in 2011 with x10 times more statistics
    - Better constraints for existing models
- Hard probes: novelties, surprises, challenges for theory
  - High p_T hadrons
    - Strong suppression (factor 7 at p_T~7 GeV/c)
    - Heavy quark R_{AA} similar to that of pions at high p_T
  - Quarkonia:
    - J/ψ less suppressed than at RHIC at forward rapidity