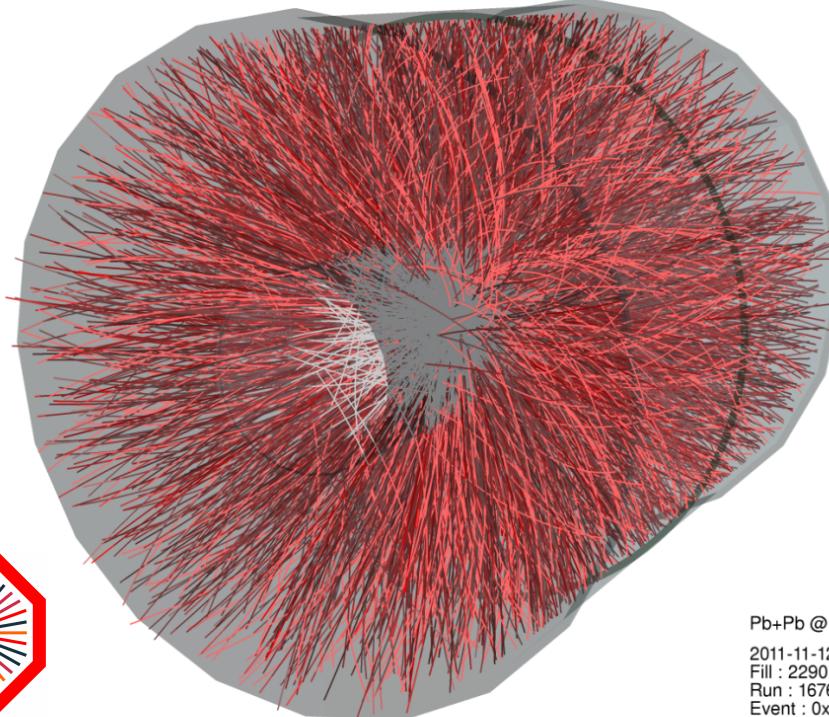




ALICE



Pb+Pb @ $\text{sqrt}(s) = 2.76 \text{ ATeV}$

2011-11-12 06:51:12

Fill : 2290

Run : 167693

Event : 0x3d94315a

ALICE Status Report

111th LHCC Meeting – Open Session
26th September 2012

David Dobrigkeit Chinellato
for the ALICE Collaboration

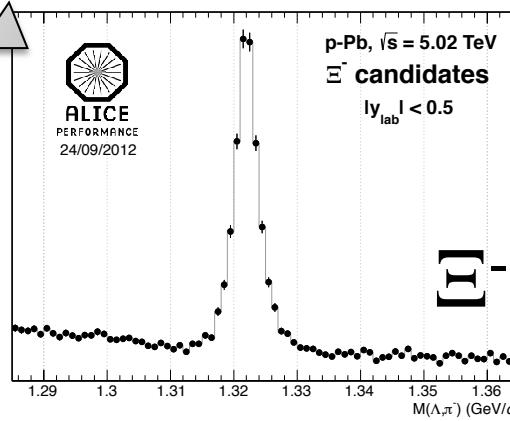
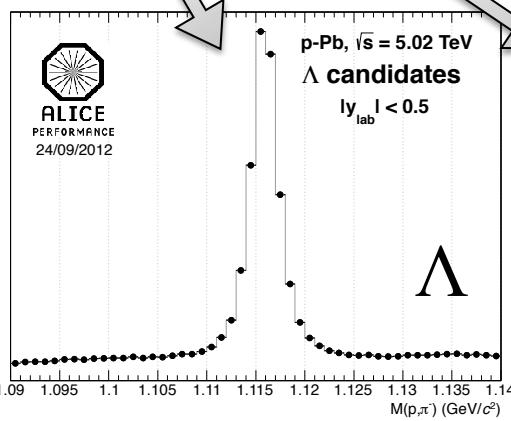
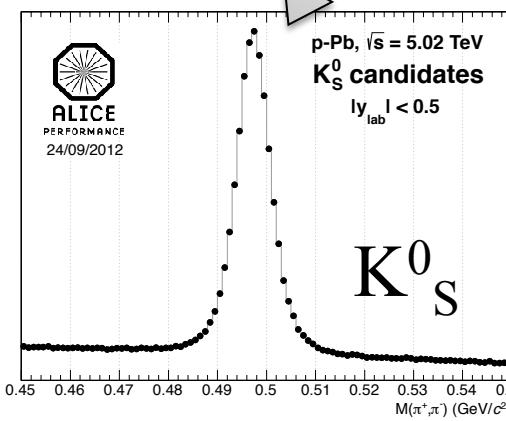
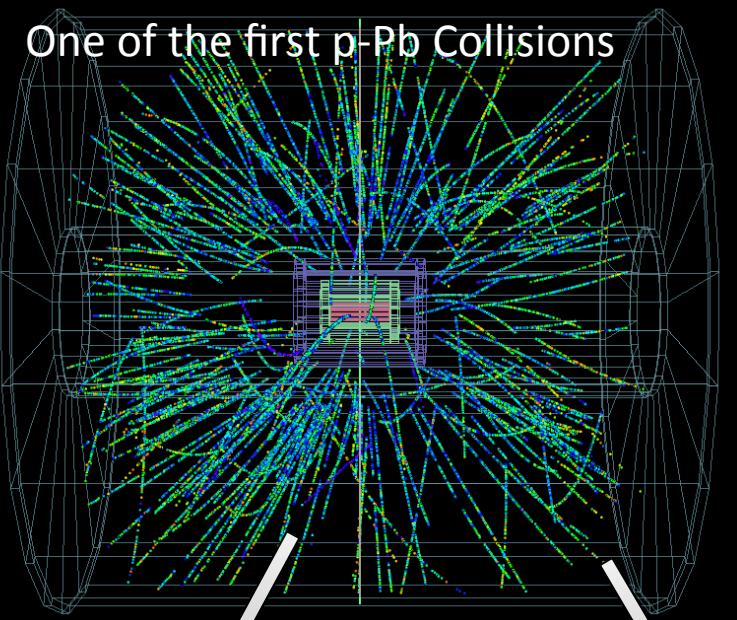
ALICE Data Taking: pp at $\sqrt{s} = 8$ TeV

- Main mode: satellite-main collisions to reduce luminosity, pileup
 - Luminosity of the order of 1 Hz/ μb (plan is $> 2\text{Hz}/\mu\text{b}$)
 - Large background
- Continuous operation: HLT with TPC clustering and data compression
- On tape:
 - 250M minimum bias data
 - ~ 0.4 /pb of EMCal (photon, jets), dimuon,
- new triggers
 - ~ 30 /nb TRD jet trigger, joined in production recently
 - TRD electron
 - high multiplicity



ALICE Data Taking: p-Pb at $\sqrt{s} = 5.02$ TeV

One of the first p-Pb Collisions



13th September: p-Pb collisions recorded

- Quite successful with higher than predicted luminosity
- Minimum Bias event rate: ~ 200 Hz
- On tape
 - 1.8M min. bias triggers
 - 260K min. bias with disp. vertex, +50 cm
 - 370K min. bias with disp. vertex, -50 cm



10 New Publications By ALICE

since last LHCC Meetings

On arXiv.org

- [1] K^0_s - \bar{K}^0_s correlations in pp collisions at $\sqrt{s} = 7$ TeV from the LHC ALICE experiment, <http://arxiv.org/abs/1206.2056>
- [2] Measurement of electrons from beauty hadron decays in pp collisions at $\sqrt{s} = 7$ TeV , <http://arxiv.org/abs/1208.1902>
- [3] D^+ meson production at central rapidity in proton--proton collisions at $\sqrt{s} = 7$ TeV , <http://arxiv.org/abs/1208.1948>
- [4] Measurement of inelastic, single- and double-diffraction cross sections in proton--proton collisions at the LHC with ALICE, <http://arxiv.org/abs/1208.4968>
- [5] Production of $K^*(892)^0$ and $\Phi(1020)$ in pp collisions at $\sqrt{s} = 7$ TeV, <http://arxiv.org/abs/1208.5717>
- [6] Charge separation relative to the reaction plane in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, <http://arxiv.org/abs/1207.0900>
- [7] Net-Charge Fluctuations in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, <http://arxiv.org/abs/1207.6068>
- [8] Pion, Kaon, and Proton Production in Central Pb--Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV, <http://arxiv.org/abs/1208.1974>
- [9] Centrality Dependence of Charged Particle Production at Large Transverse Momentum in Pb-Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV, <http://arxiv.org/abs/1208.2711>
- [10] Coherent J/ψ photoproduction in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, <http://arxiv.org/abs/1209.3715>

proton-proton

Pb-Pb





Quark Matter 2012

13th – 18th August

7 Plenaries:

- Overview of ALICE Results (*K. Šafařík*)
- Flow Overview (*S. Voloshin*)
- Jets and Structure (*A. Morsch*)
- Identified Particle Spectra (*M. Ivanov*)
- Heavy Flavour (*Z. Conesa del Valle*)
- Quarkonia Production (*E. Scomparin*)
- Correlations (*A. M. Adare*)

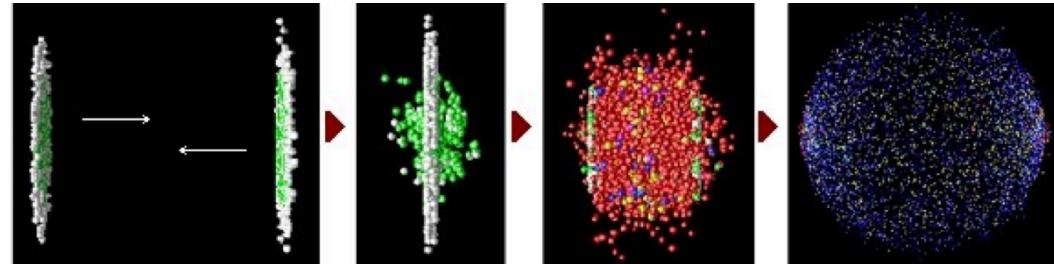
30 Parallel Talks, topics:

- Global and Collective Dynamics
- Azimuthal Flow
- Correlations and Fluctuations
- High pt identified particles
- Jets
- Heavy Flavour
- Quarkonia
- Direct Photons
- Detector Upgrade

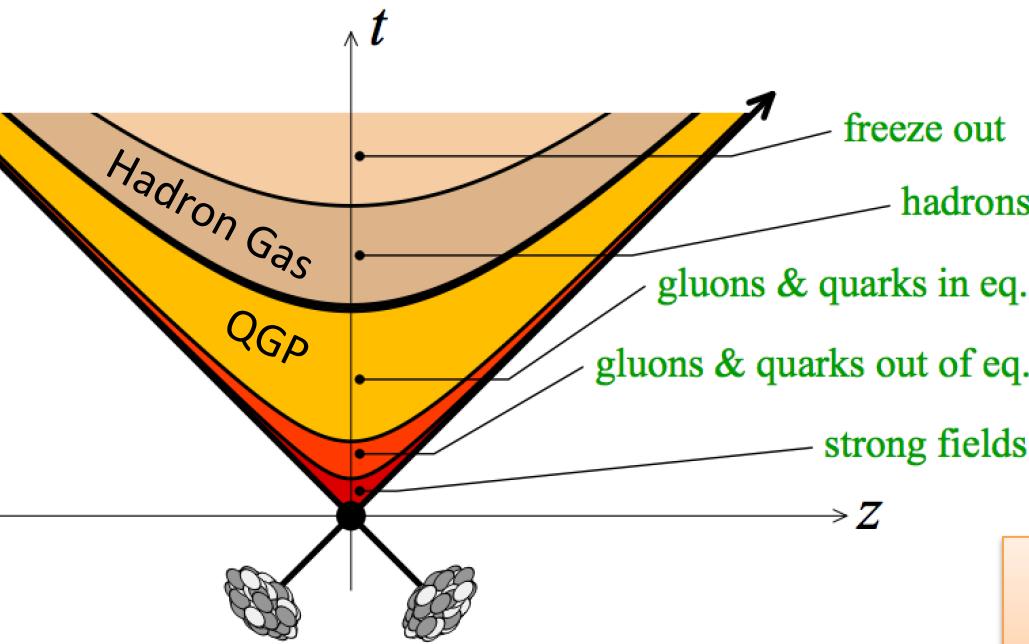
...and 45 posters



Pb-Pb Physics: A quick reminder



Formation of a deconfined state of quarks and gluons



Questions:

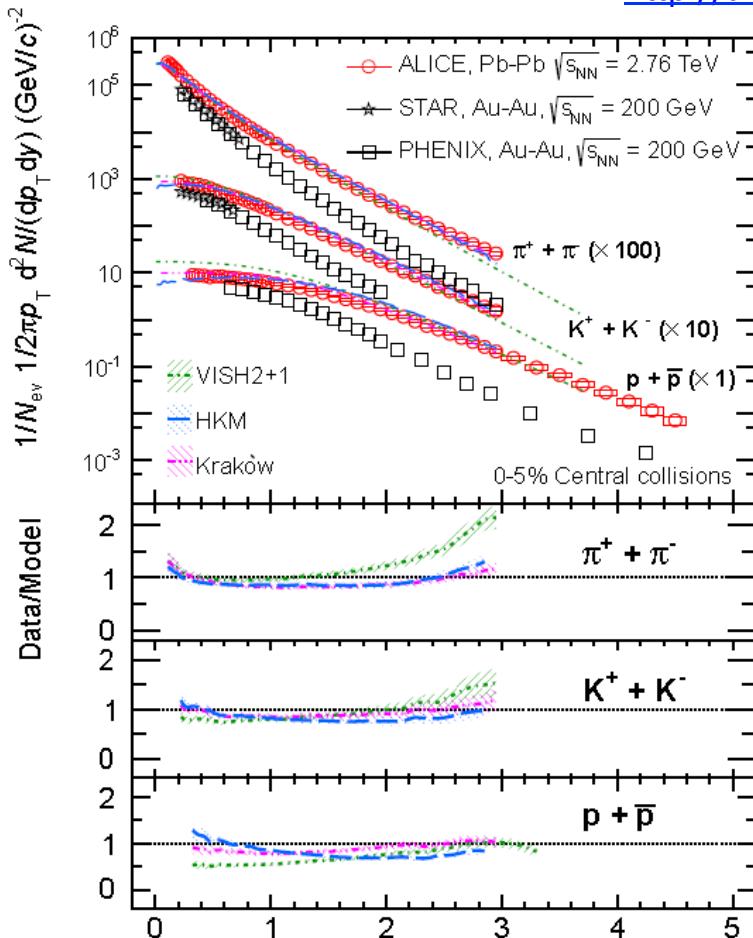
1. What governs hadrochemistry?
2. What can we learn about the collectivity of the system using identified particles?
3. Can correlations tell us more about system evolution and earlier stages?
4. How do different quark flavours interact with the QGP?

Will focus on how recent physics results contribute to these points



Low- p_T identified particle spectra

<http://arxiv.org/abs/1208.1974>



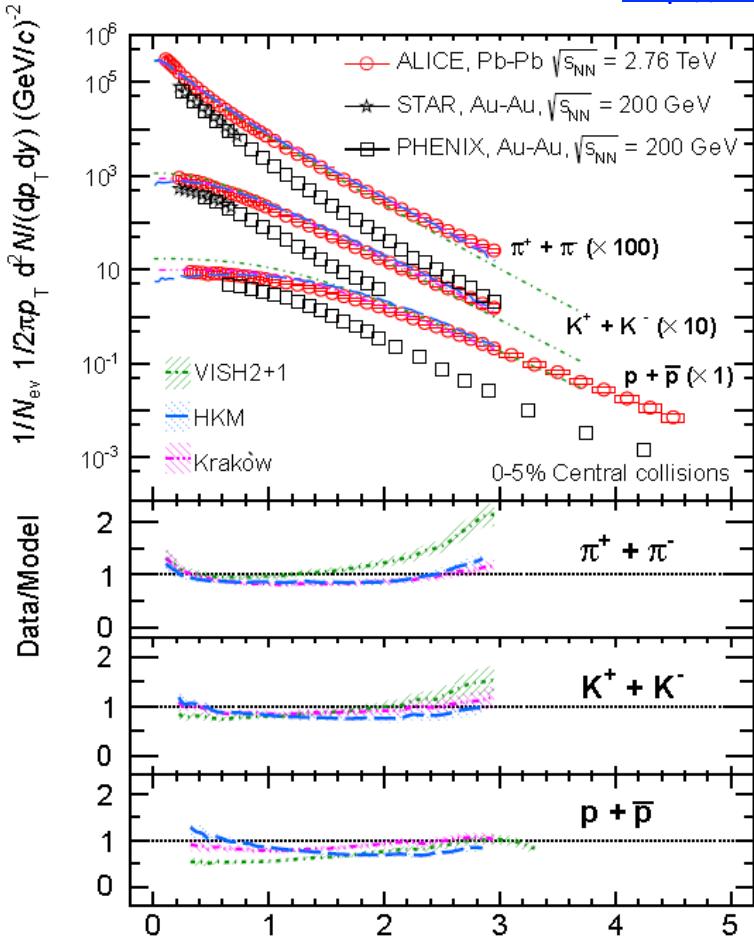
Hydrodynamics description: $p_T (\text{GeV}/c)$

More successful if final state interactions are considered in the hadronic phase (UrQMD)



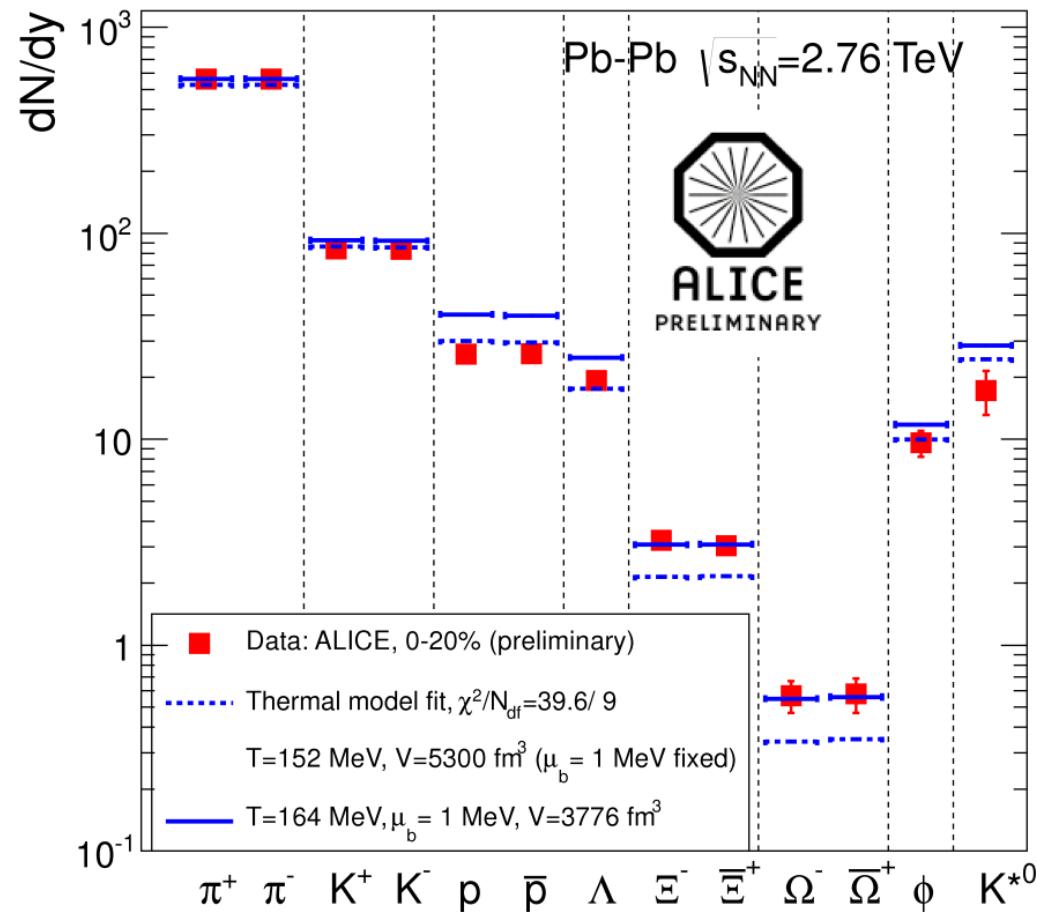
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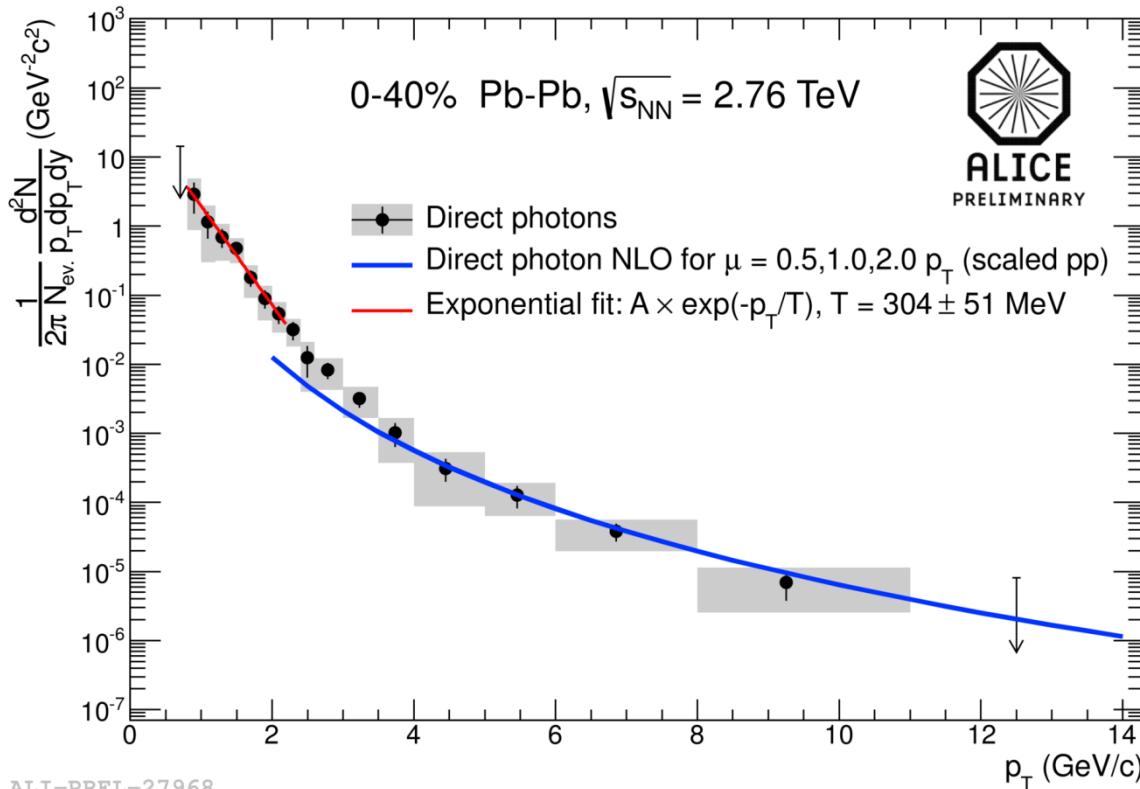
Statistical particle production model:

Not as successful as at RHIC



Direct Photon Production

probing the early temperature



Exponential fit for $p_T < 2.2$ GeV/c

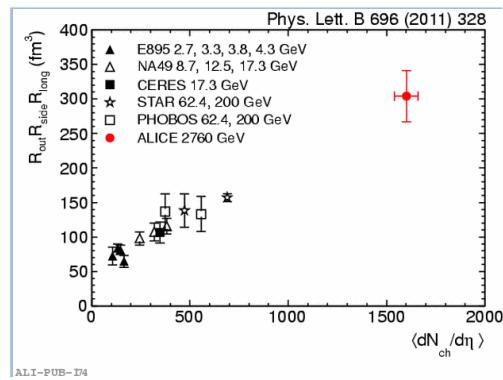
inv. slope **$T = 304 \pm 51$ MeV**

for 0–40% Pb–Pb at $\sqrt{s} = 2.76$ TeV

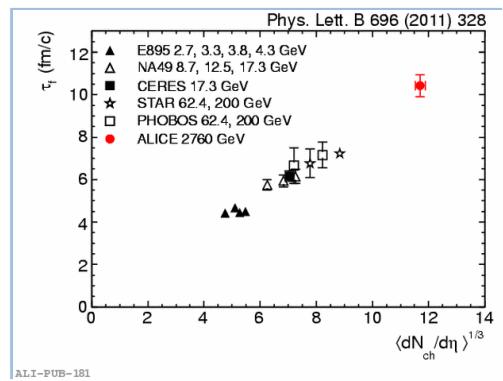
PHENIX: **$T = 221 \pm 19 \pm 19$ MeV**

for 0–20% Au–Au at $\sqrt{s} = 200$ GeV

2x Volume at RHIC



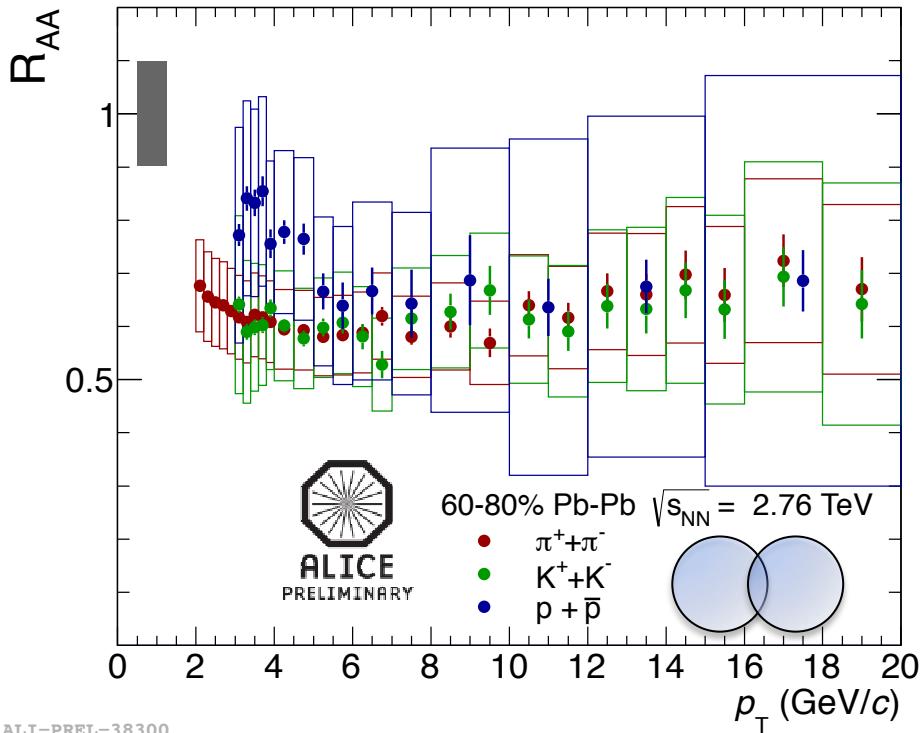
+20% Lifetime



Temperature: +40%

"Highest measured temperature"

Identified Particle R_{AA}



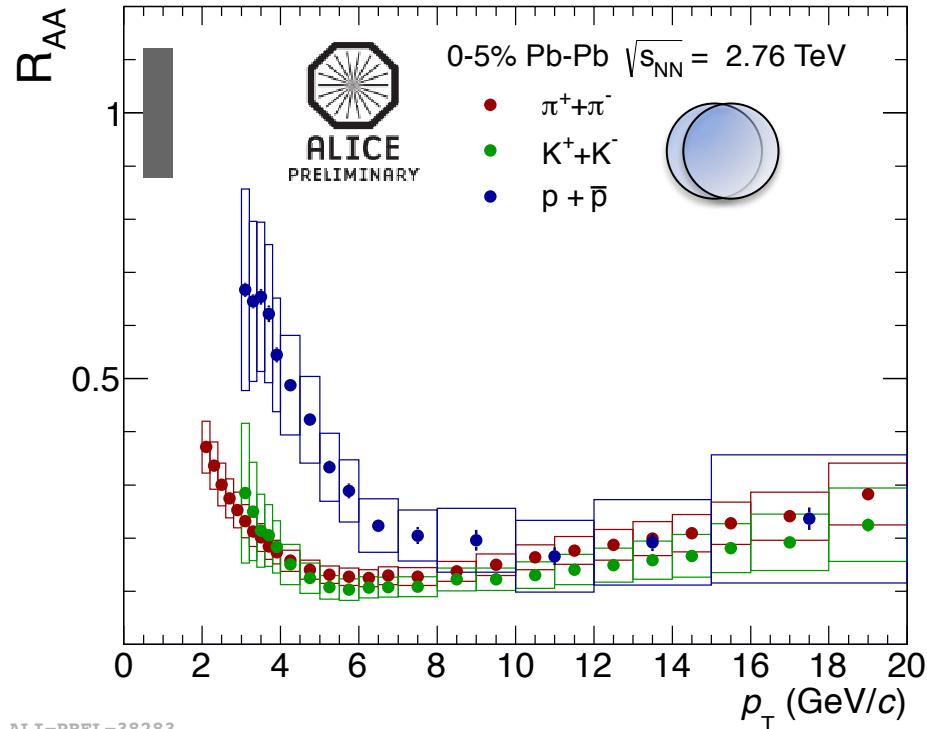
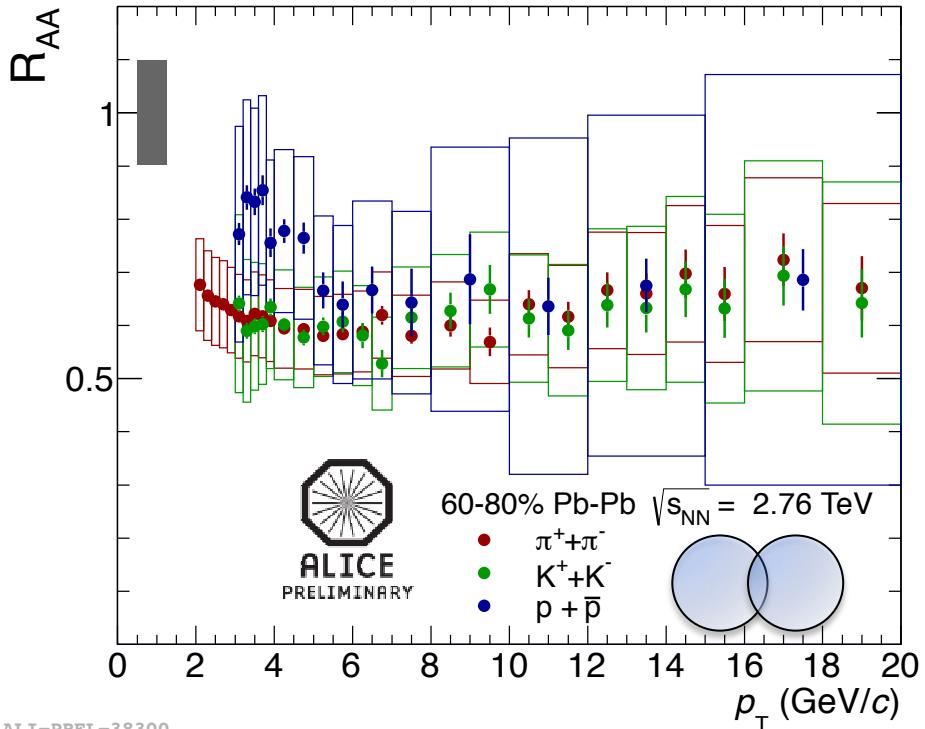
$$R_{AA}(p_T) = \frac{(1/N_{\text{evt}}^{AA}) d^2 N_{\text{ch}}^{AA} / d\eta dp_T}{\langle N_{\text{coll}} \rangle (1/N_{\text{evt}}^{pp}) d^2 N_{\text{ch}}^{pp} / d\eta dp_T}$$

Yield in Pb-Pb

Yield in pp



Identified Particle R_{AA}



$$R_{AA}(p_T) = \frac{(1/N_{\text{evt}}^{AA}) d^2 N_{\text{ch}}^{AA} / d\eta dp_T}{(N_{\text{coll}})(1/N_{\text{evt}}^{pp}) d^2 N_{\text{ch}}^{pp} / d\eta dp_T}$$

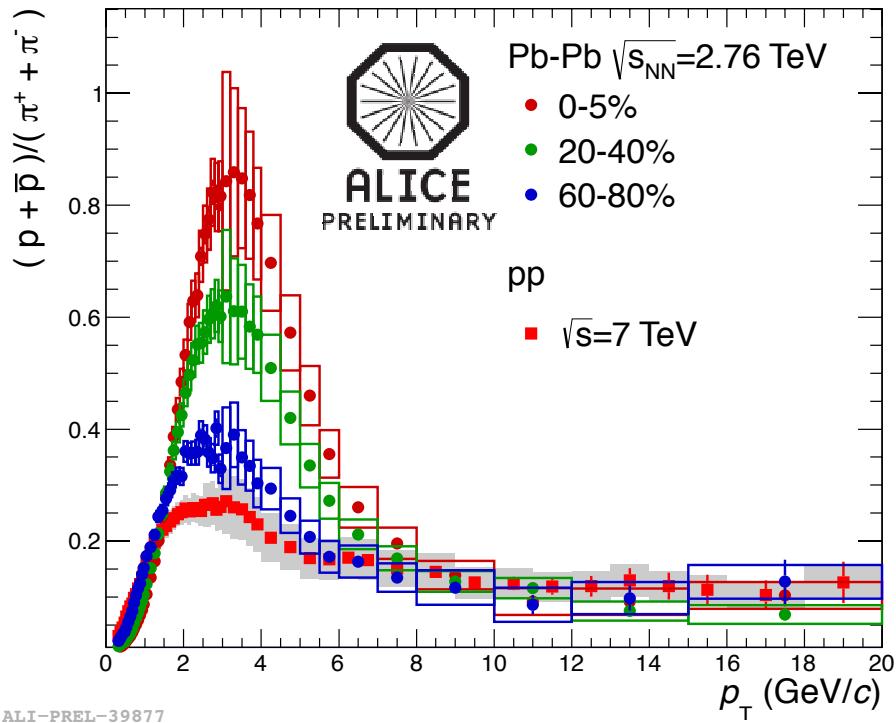
Yield in Pb-Pb

Yield in pp

Observed in central Collisions: Large suppression of higher transverse momenta;
no particle species dependence at high p_T -> energy loss does not affect hadronization?



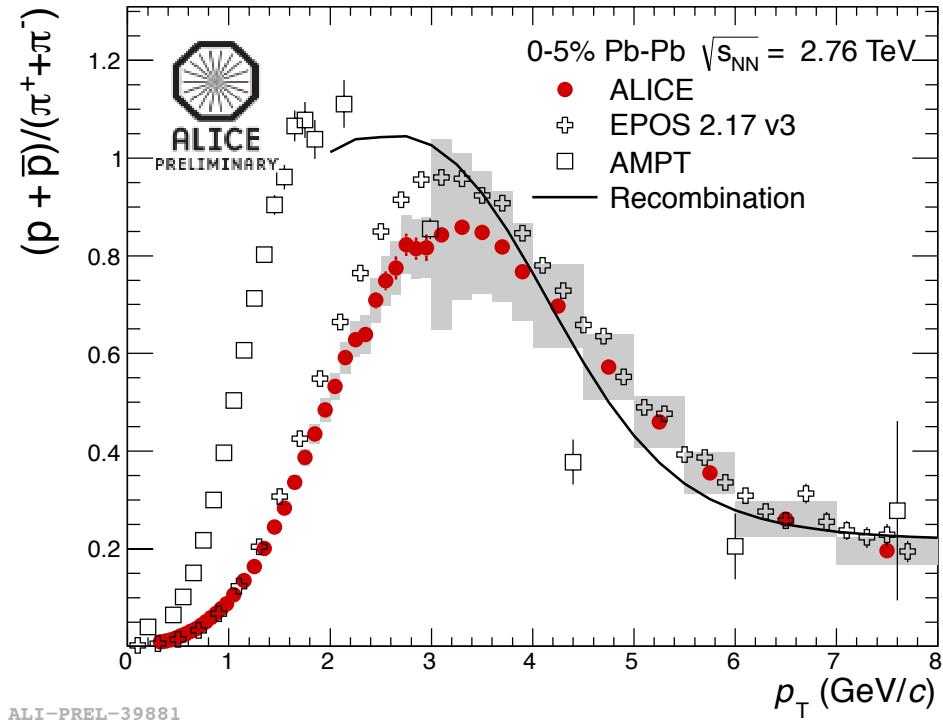
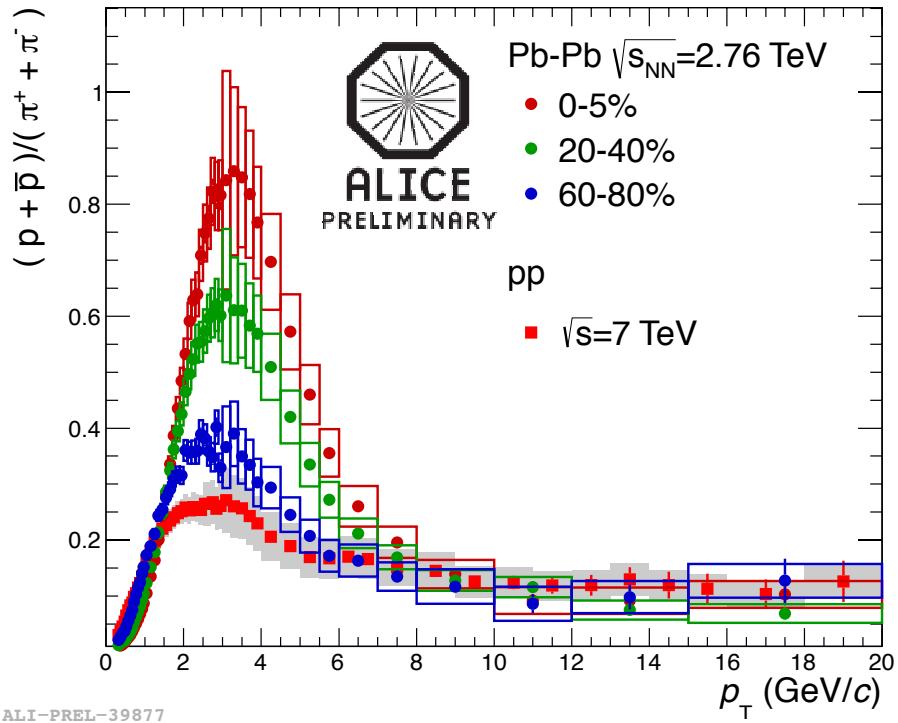
The Baryon to Meson Ratio: p/π



- Steady increase of p/π ratio at mid- p_T for more central events



The Baryon to Meson Ratio: p/π



- Steady increase of p/π ratio at mid- p_T for more central events
- Sensitive to recombination and hydrodynamics.

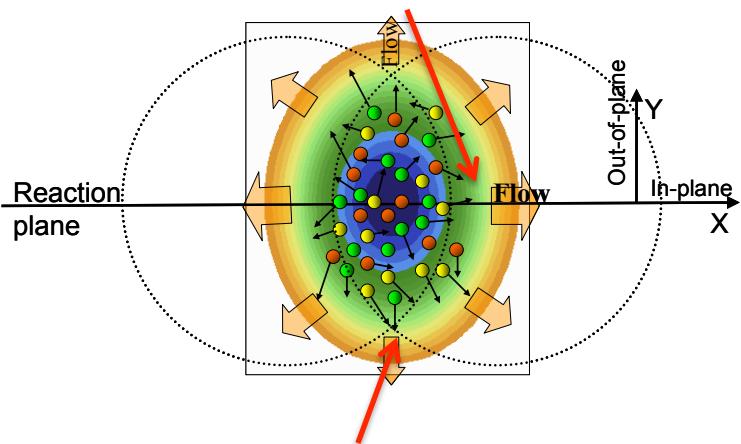


Azimuthal Momentum Anisotropy: v_2

Higher energy gradient:

Higher pressure

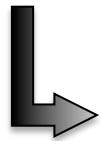
Larger momenta



Lower Energy Gradient:

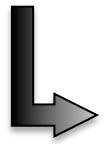
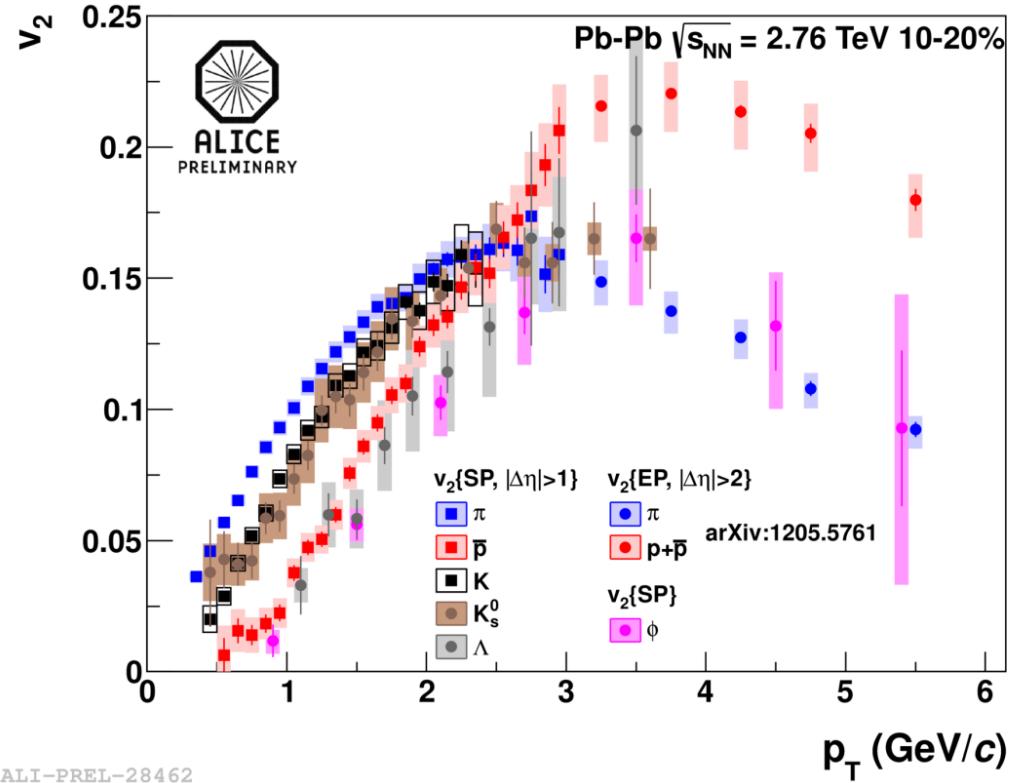
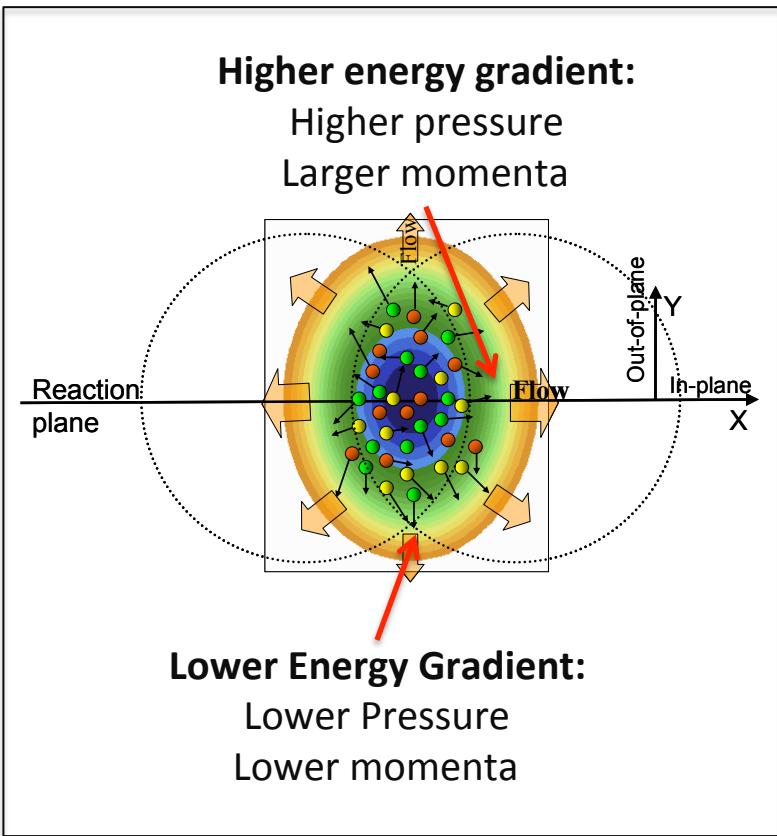
Lower Pressure

Lower momenta



$$E \frac{d^3N}{d^3p} = \frac{1}{2\pi} \frac{d^2N}{p_t dp_t dy} \left(1 + \sum_{n=1}^{\infty} 2v_n \cos[n(\phi - \Psi_r)] \right)$$

Azimuthal Momentum Anisotropy: v_2

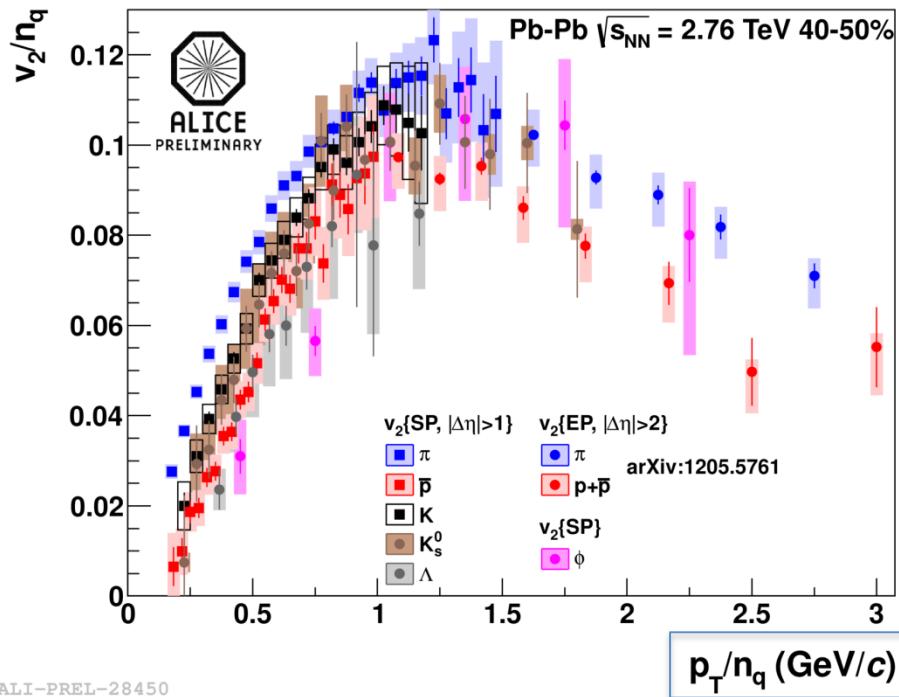


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Elliptic Flow (v_2): $n = 2$



v_2 and scaling

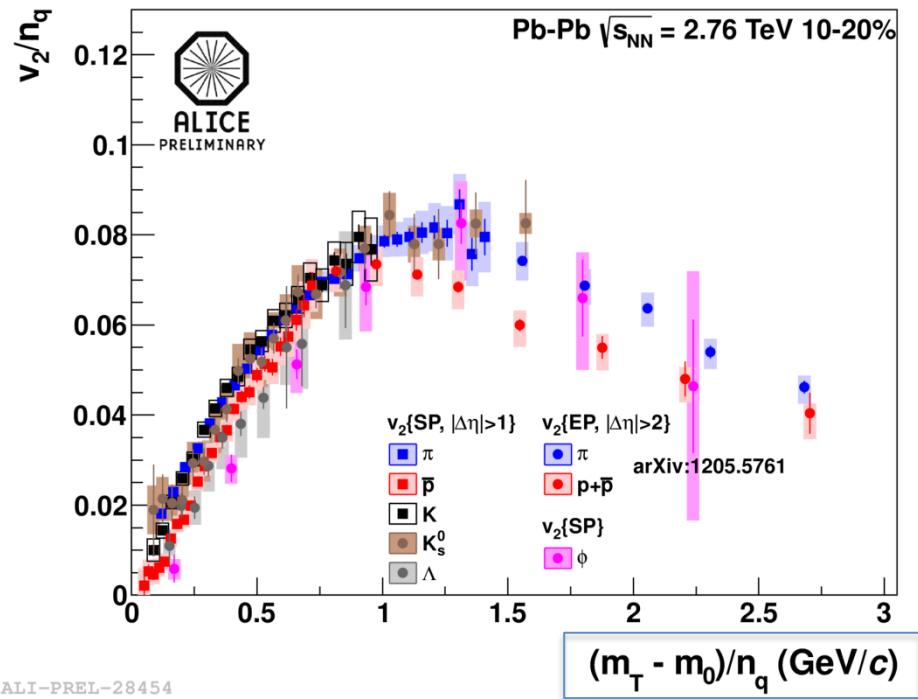
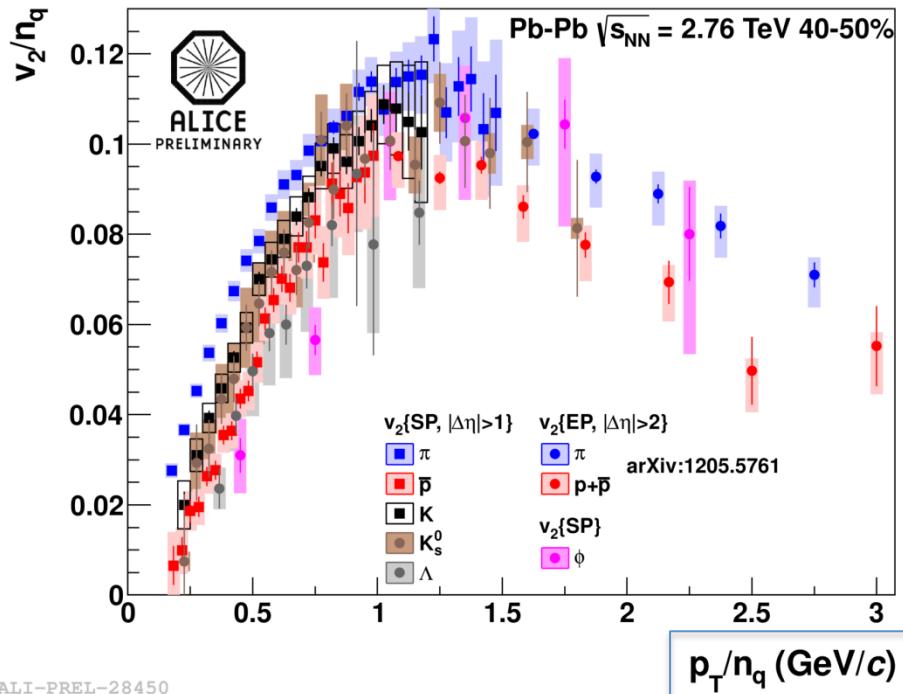


ALI-PREL-28450

$N_q(p_T)$ scaling off by 10-20% at high p_t (where mass is negligible)



v_2 and scaling



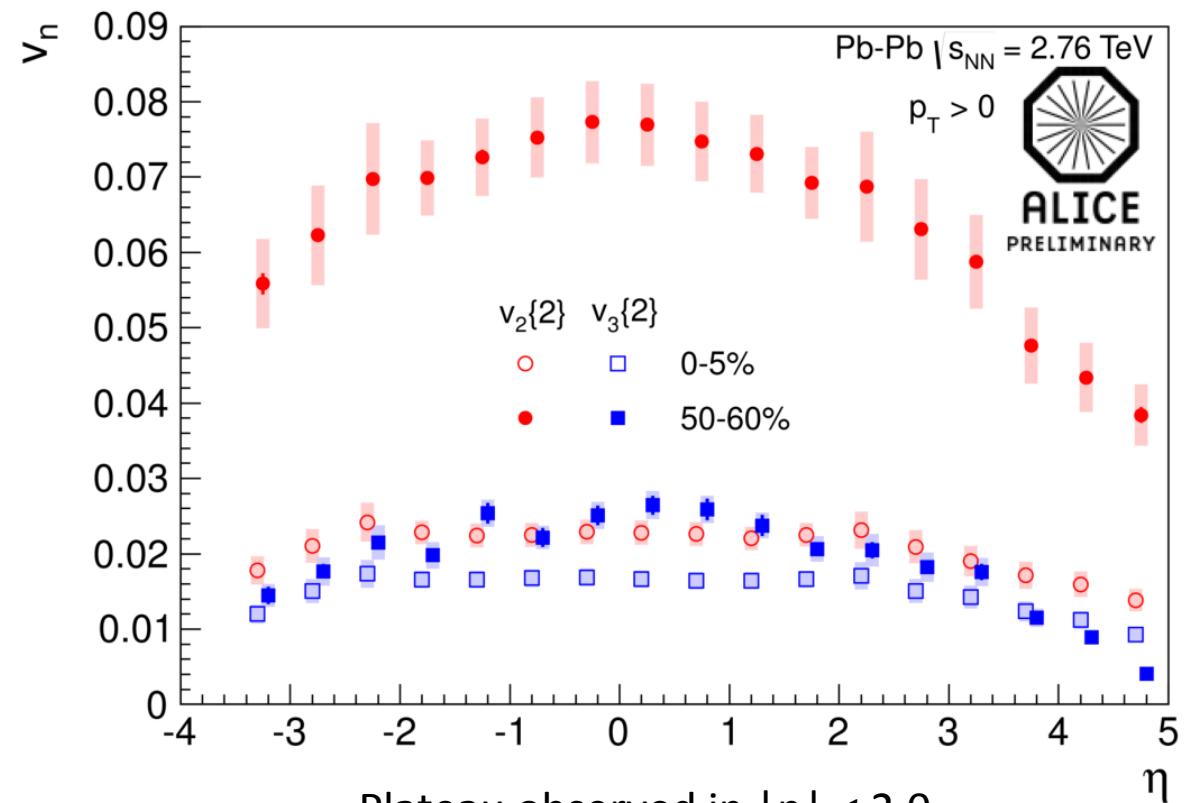
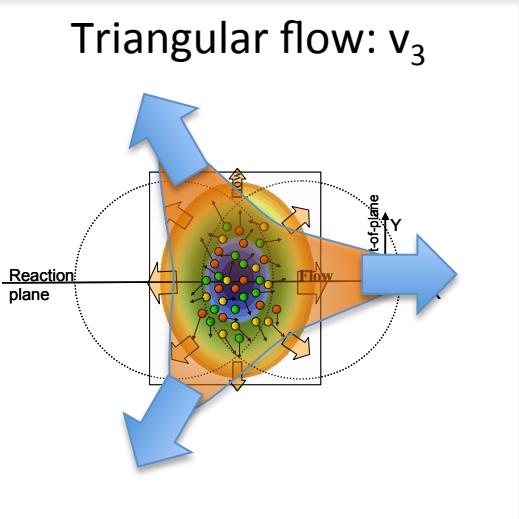
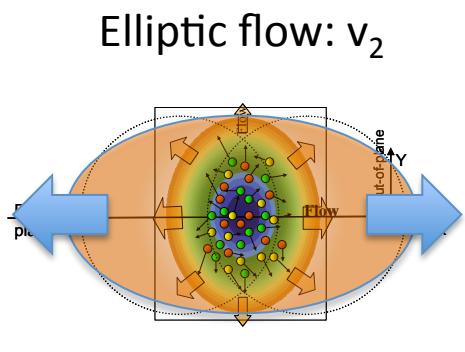
$N_q(p_T)$ scaling off by 10-20% at high p_t (where mass is negligible)

$N_q(m_T)$ scaling (hydro approximation)

- Works better
- ...but worse than at RHIC
- Needs full hydro comparison



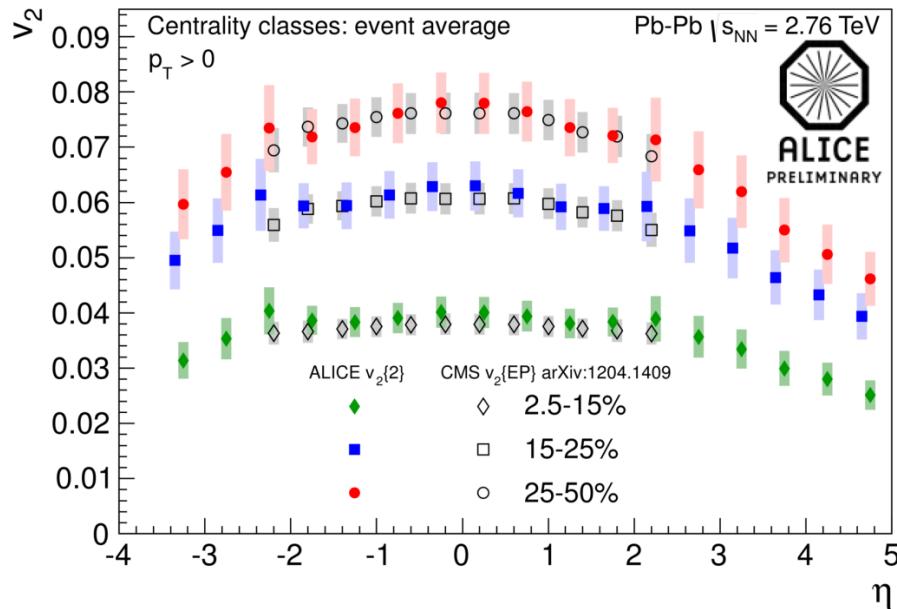
Anisotropy as a function of η



Plateau observed in $|\eta| < 2.0$
Small but non-zero triangular flow
 v_3 : information regarding initial state



v_2 compared to other measurements

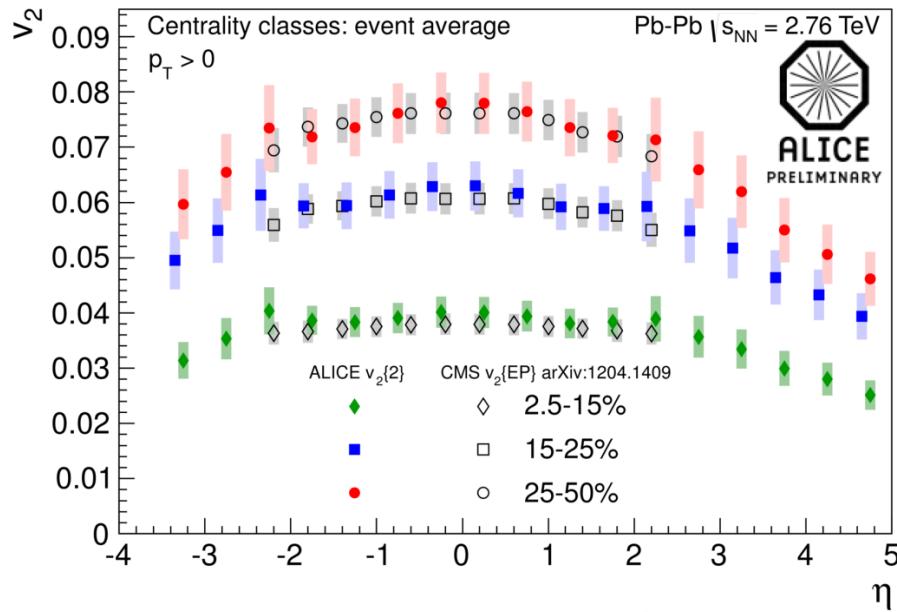


ALI-PREL-27803

Very good agreement with CMS in $|\eta| < 2.4$

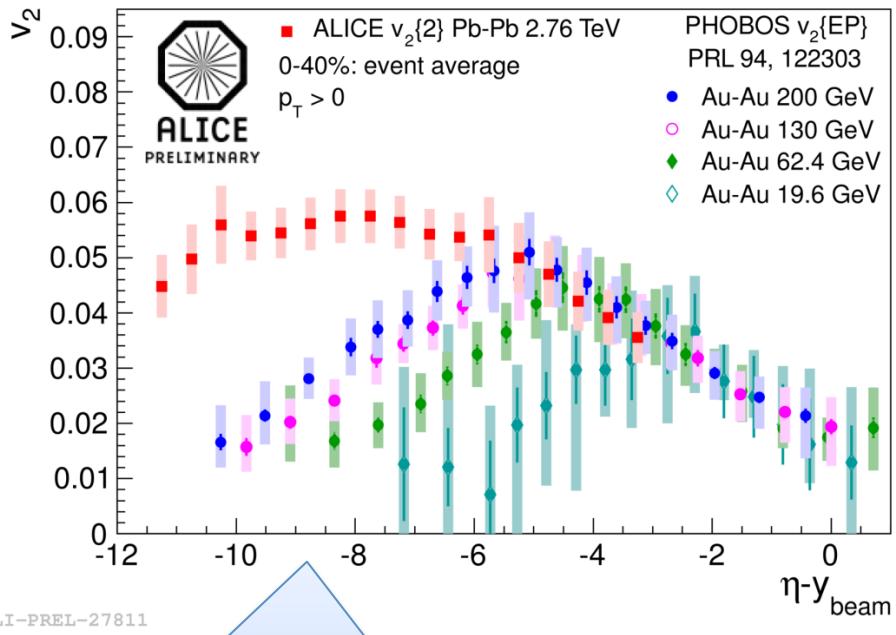


v_2 compared to other measurements



ALI-PREL-27803

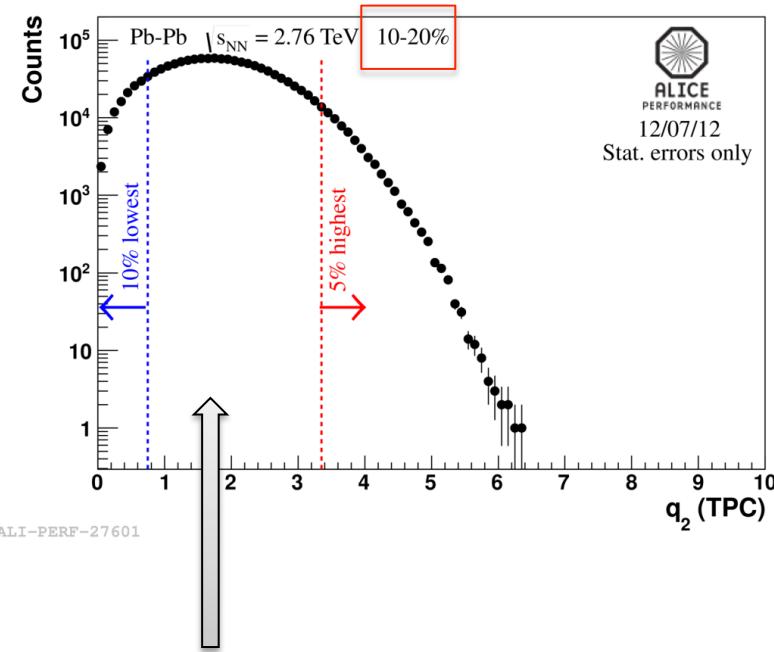
Very good agreement with CMS in $|\eta| < 2.4$



ALI-PREL-27811

When compared to PHOBOS lower energy data and considering $\eta - y_{\text{beam}}$: longitudinal scaling observed

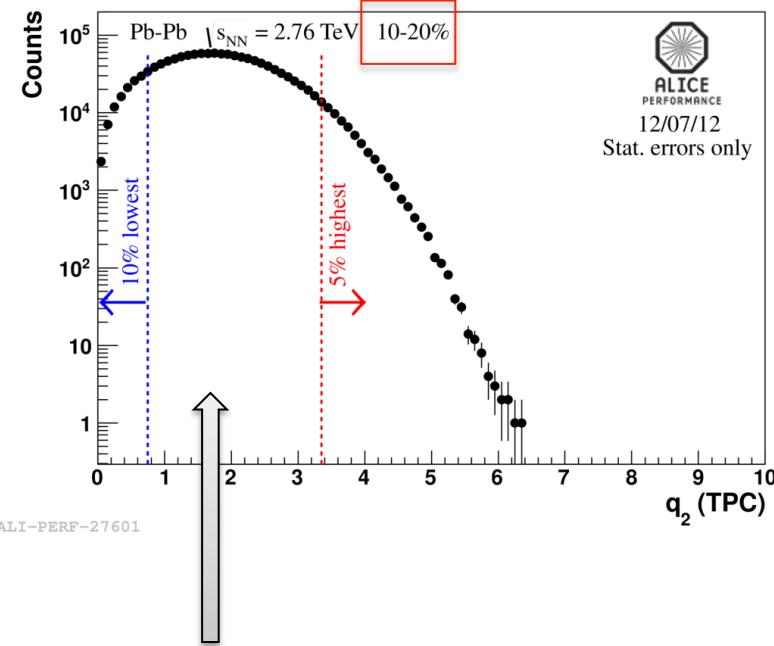
Event Shape Engineering



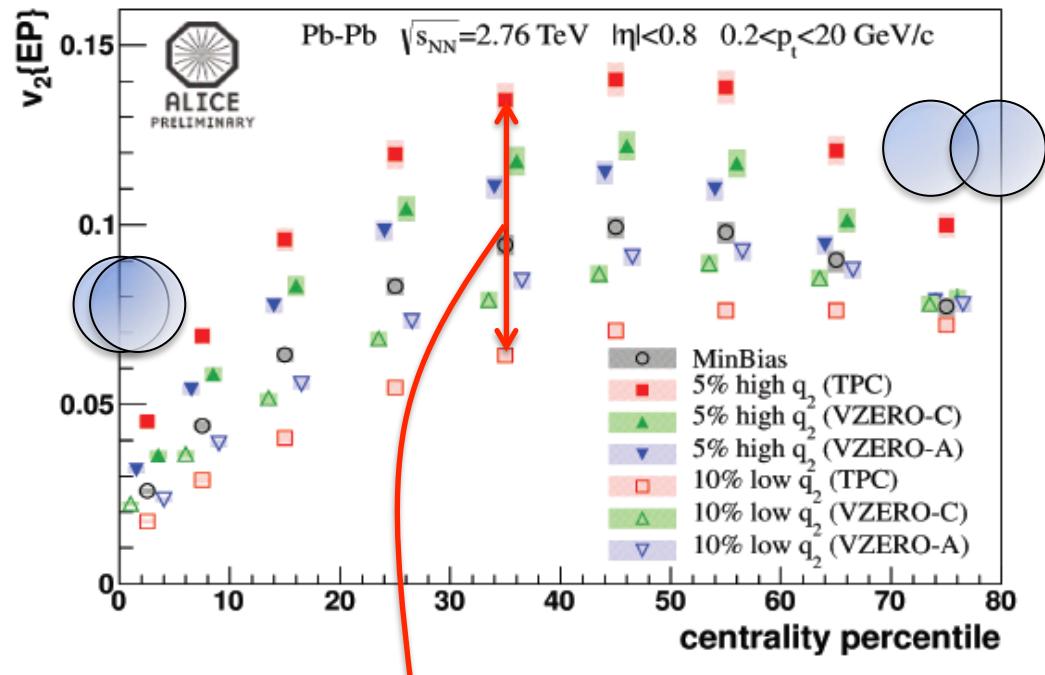
Large event-by-event anisotropy
differences observed



Event Shape Engineering



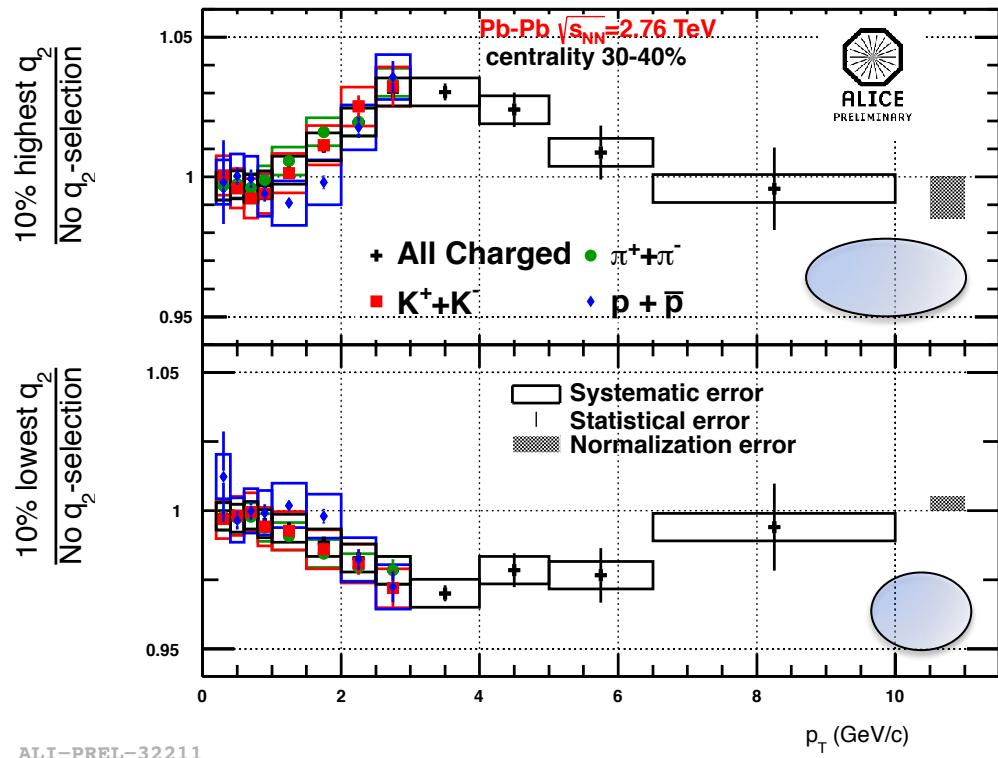
Large event-by-event anisotropy differences observed



Up to a factor 2 difference in v_2 for semi-central events

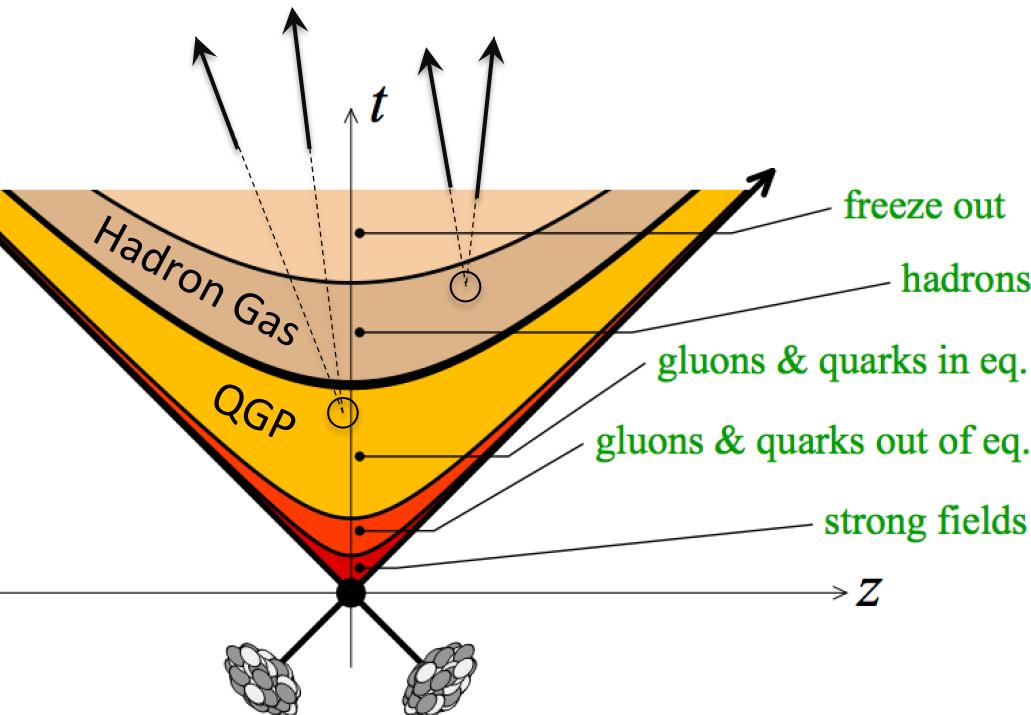
A new tool towards a better understanding of elliptic flow

Event Shape Engineering: Example



- Modification of the p_T spectrum:
Large $q_2 \rightarrow$ harder spectrum
- Hint of mass ordering?
- Are v_2 and radial flow correlated?

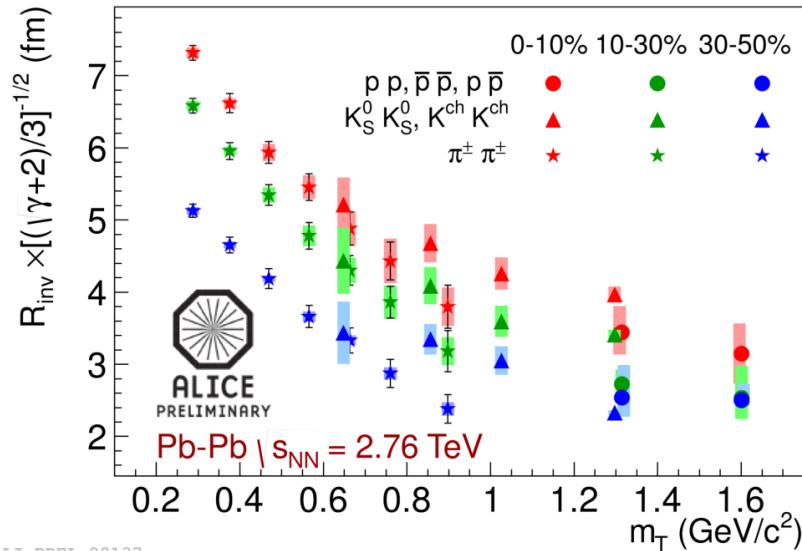
Pb-Pb Physics: Correlations and Fluctuations



Questions:

1. What governs hydrochemistry?
2. What can we learn about the collectivity of the system using identified particles?
3. Can correlations tell us more about system evolution and earlier stages?
4. How do different quark flavours interact with the QGP?

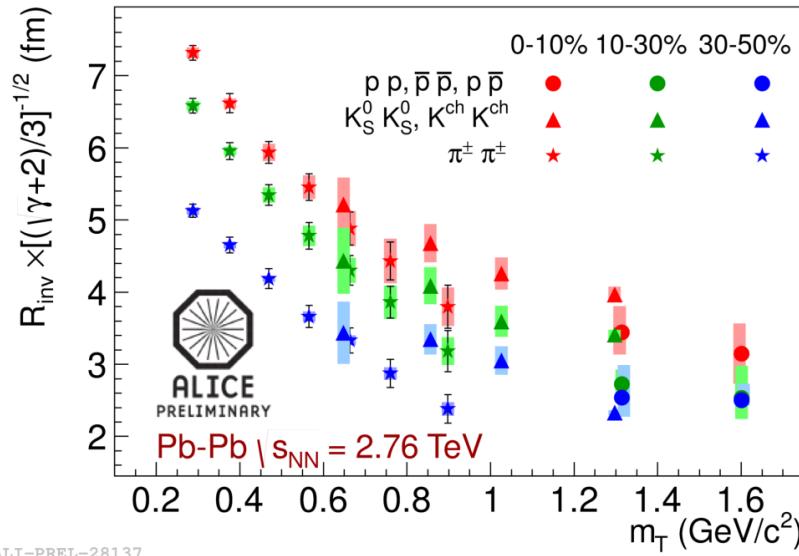
Baryon Femtoscopy



for the first time m_T -scaling of homogeneity length for all particle species
– consistent with hydro



Baryon Femtoscopy



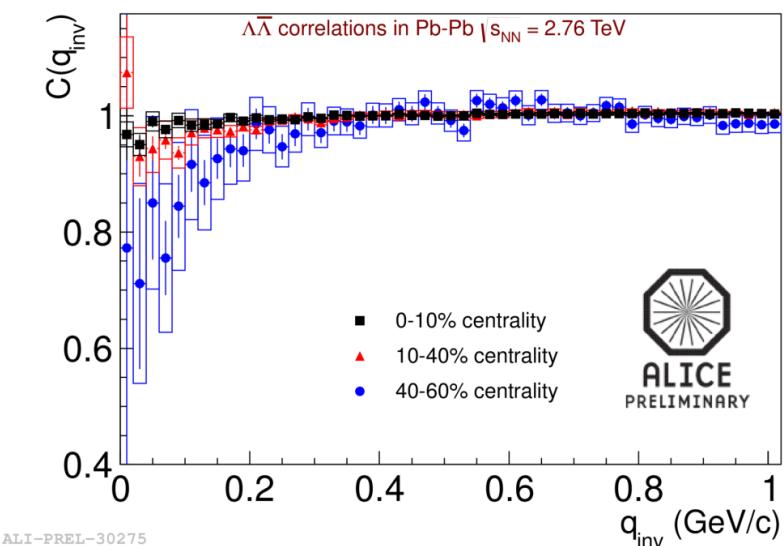
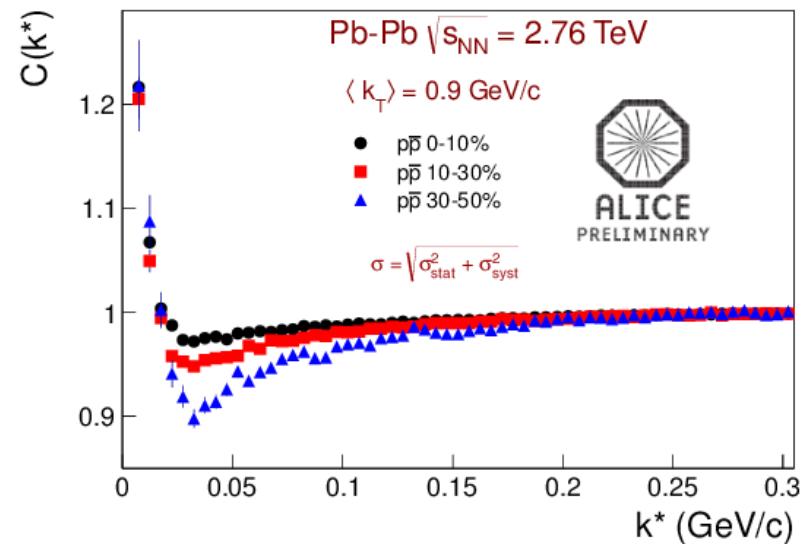
ALI-PREL-28137

for the first time m_T -scaling of homogeneity length for all particle species

– consistent with hydro

baryon–antibaryon correlation function has large contribution from final state interaction
– measurement of **annihilation cross section**

because of a large density, p and Λ may be suppressed due to annihilation ?



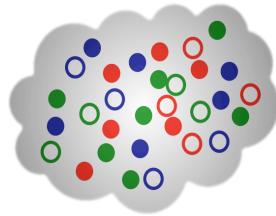
Net Charge Fluctuations

<http://arxiv.org/abs/1207.6068>

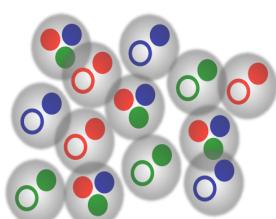
Relevant charge carriers:

Jeon, Koch, PRL 85, 2072 (2000).

Asakawa et al., PRL 85, 2076 (2000).



QGP: Charge unit = fractional

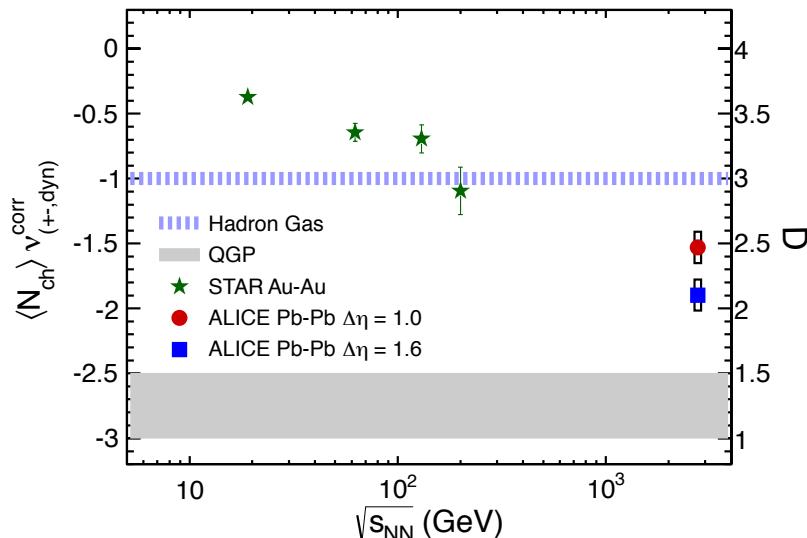
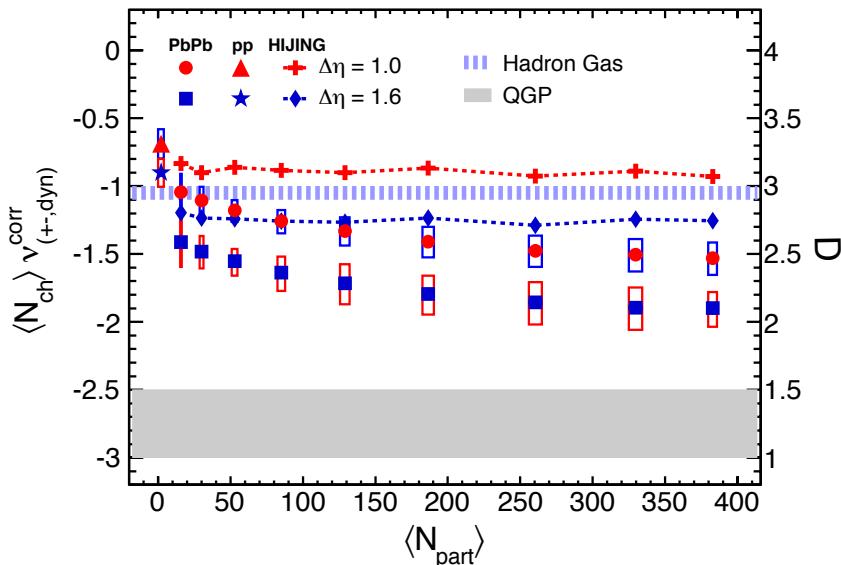


Hadron Gas: Charge unit = 1

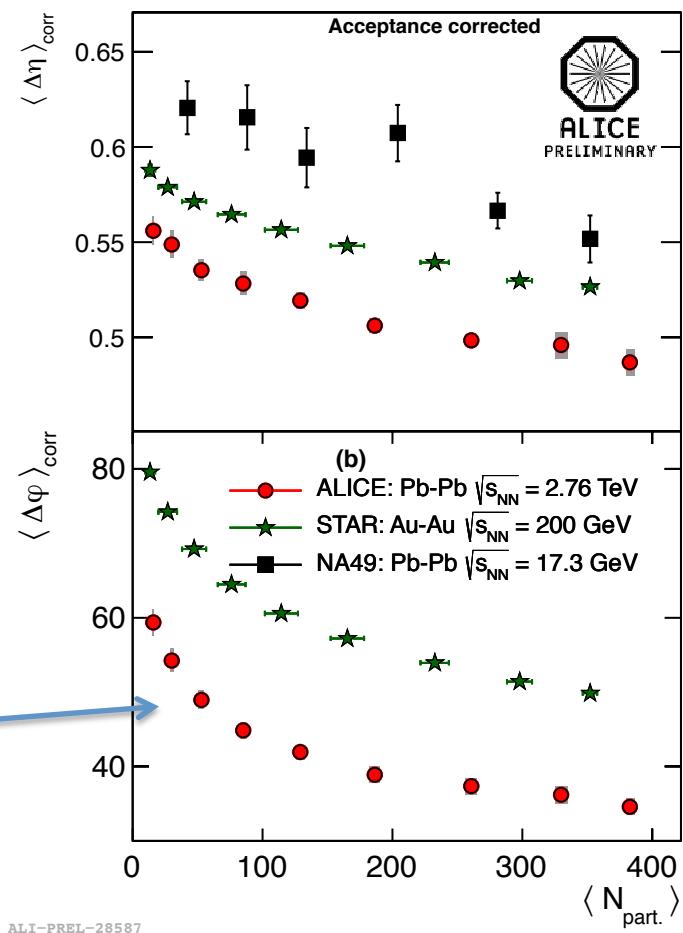
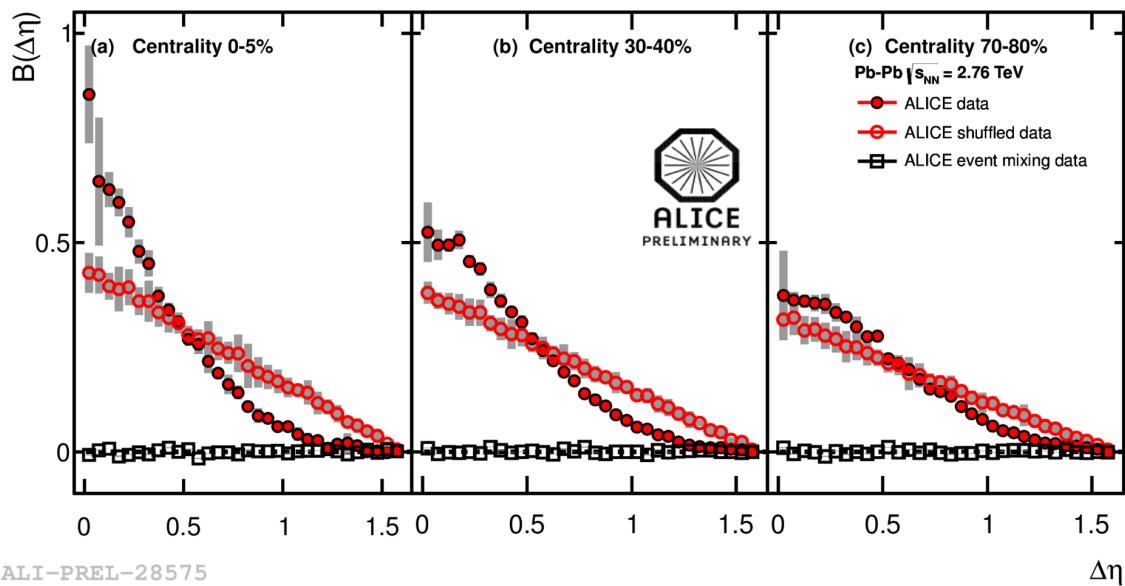
- Depends strongly on the originating phase
- Event-by-event net-charge fluctuations:

$$\nu_{(+,-,\text{dyn})} = \frac{\langle N_+(N_+ - 1) \rangle}{\langle N_+ \rangle^2} + \frac{\langle N_-(N_- - 1) \rangle}{\langle N_- \rangle^2} - 2 \frac{\langle N_+ N_- \rangle}{\langle N_+ \rangle \langle N_- \rangle}$$

Fluctuations remain closer to partonic expectations even after system evolution



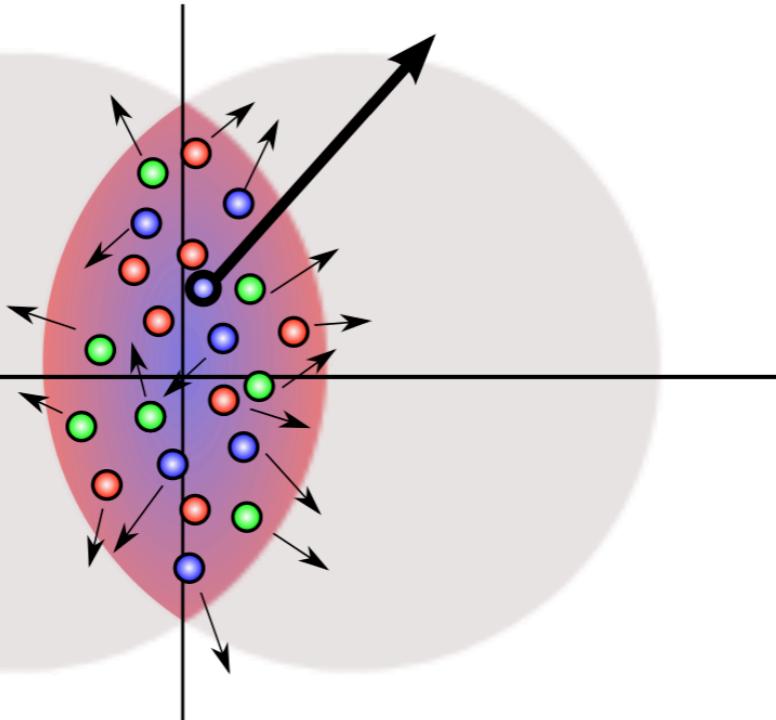
Balance Functions



Balance functions:

- Measure of correlation of balancing charges
- Narrowing** with increasing centrality
- Consistent with system exhibiting
 - Late stage creation of balancing charges*
 - Larger Radial Flow** in central collisions
- Constraint to hadronization models*

Heavy Flavour Measurements



Questions:

1. What governs hadrochemistry?
2. What can we learn about the collectivity of the system using identified particles?
3. Can correlations tell us more about system evolution and earlier stages?
4. How do different quark flavours interact with the QGP?

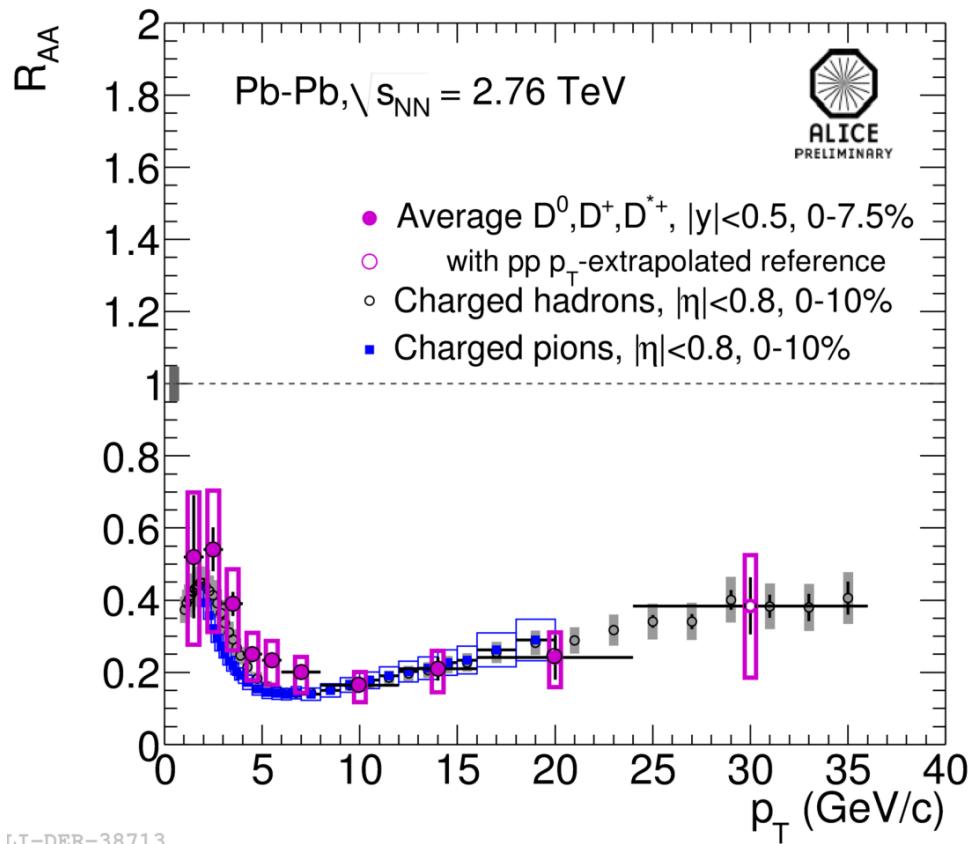
$$\Delta E_{hf} < \Delta E_q < \Delta E_g$$

Less suppression?

Less susceptible to collective effects?

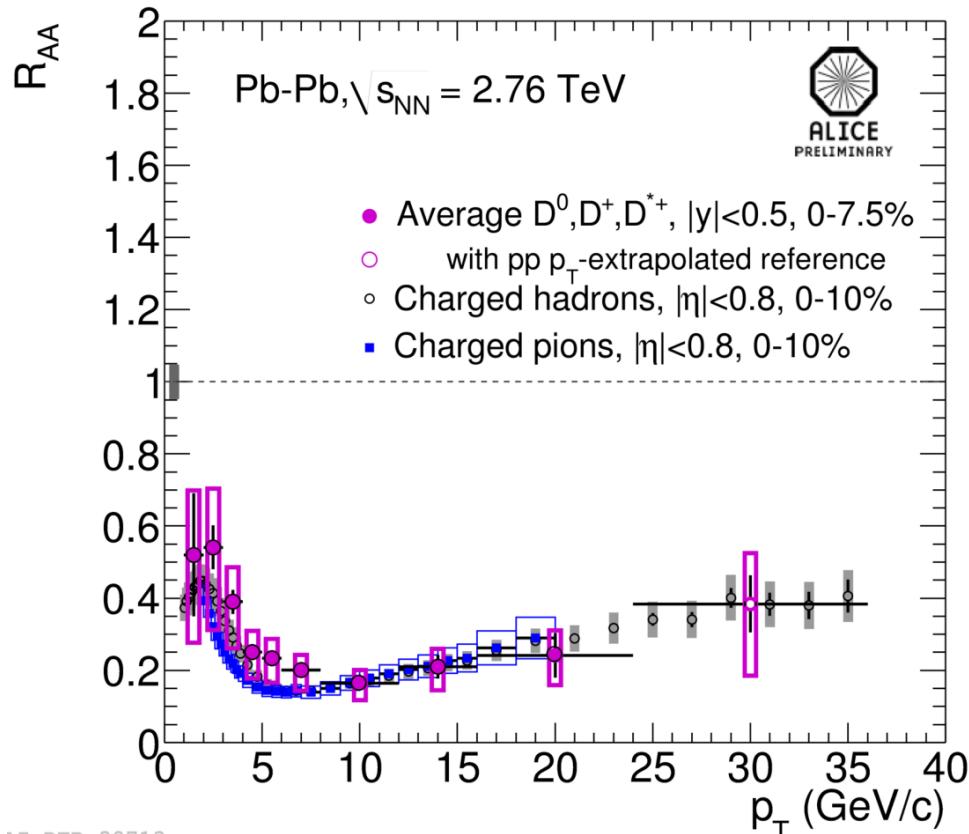
Assess heavy quark transport parameters of the medium

D Meson R_{AA} and v_2



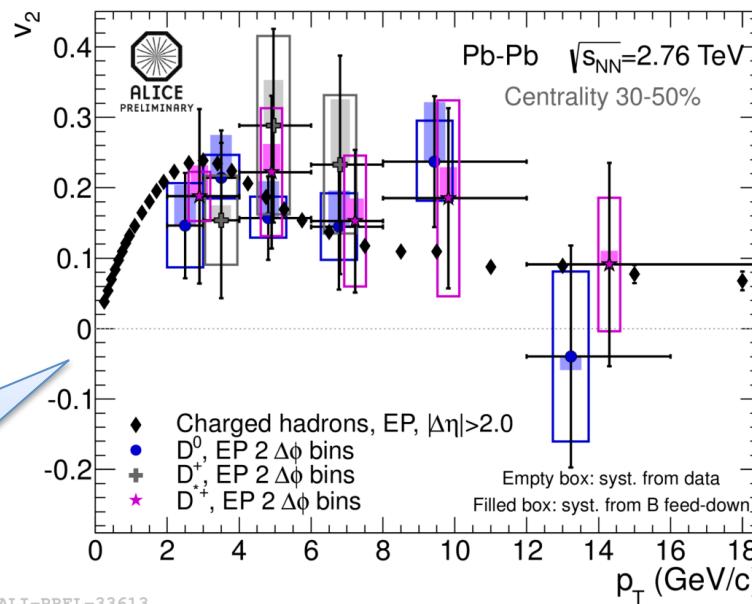
- D R_{AA} extended from 15 to 30 GeV with 2011 data
- Expectation based on colour-charge dependence of E loss: D less suppressed than pions
- Observation is not yet conclusive

D Meson R_{AA} and v_2

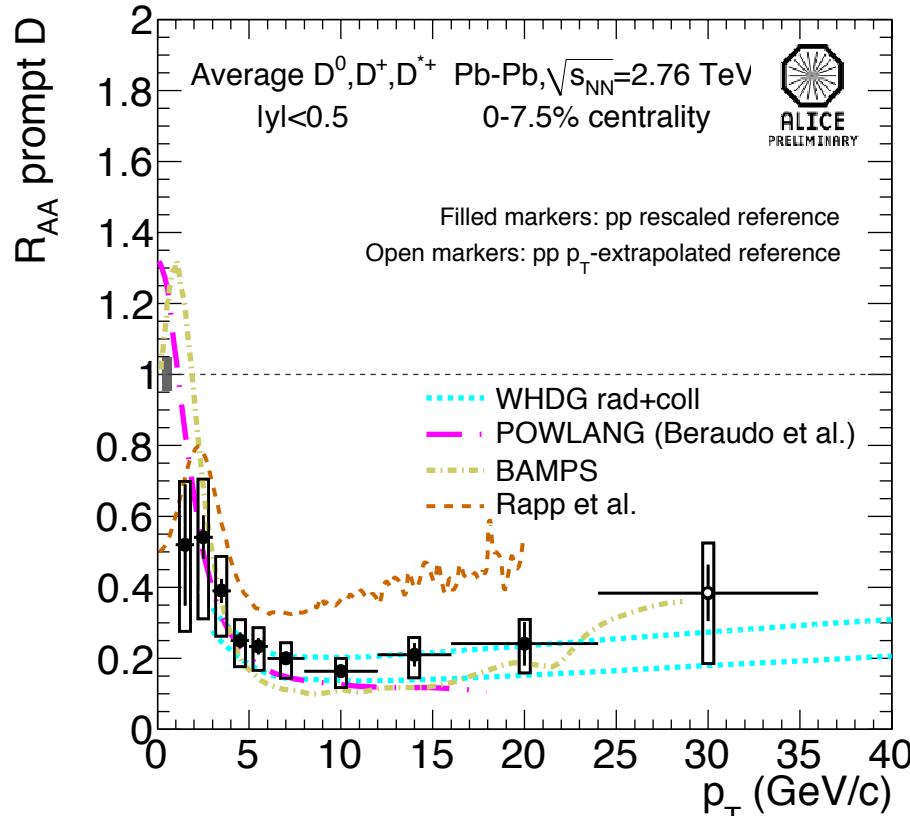


Also: Non-zero v_2
Simultaneous observation: R_{AA} and v_2
Strong constraint to transport models

- D R_{AA} extended from 15 to 30 GeV with 2011 data
- Expectation based on colour-charge dependence of E loss: D less suppressed than pions
- Observation is not yet conclusive



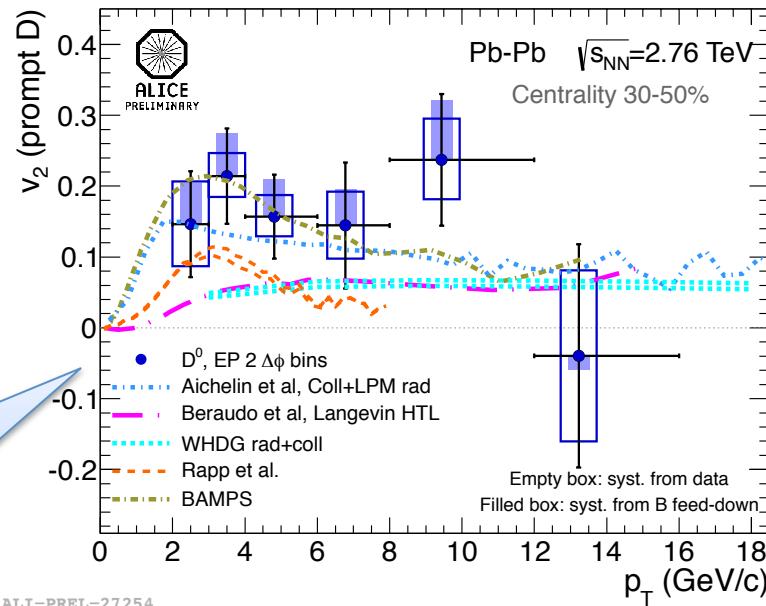
D Meson R_{AA} and v_2



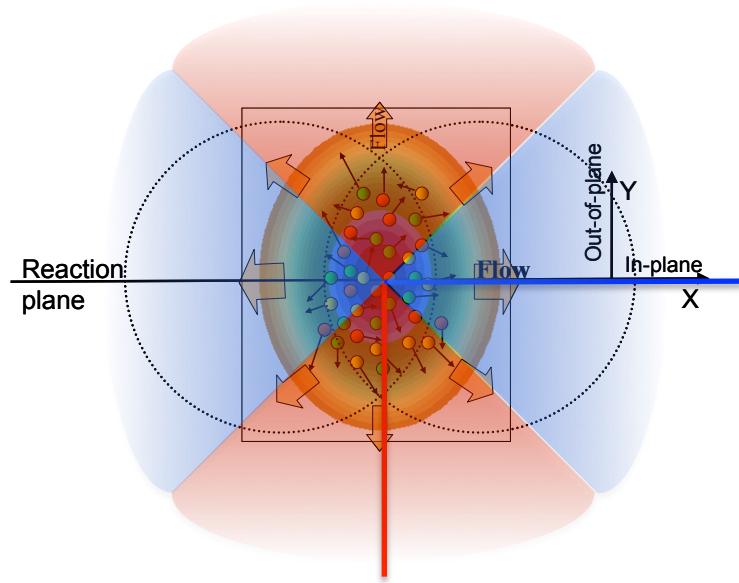
ALI-PREL-35484

Also: Non-zero v_2
Simultaneous observation: R_{AA} and v_2
Strong constraint to transport models

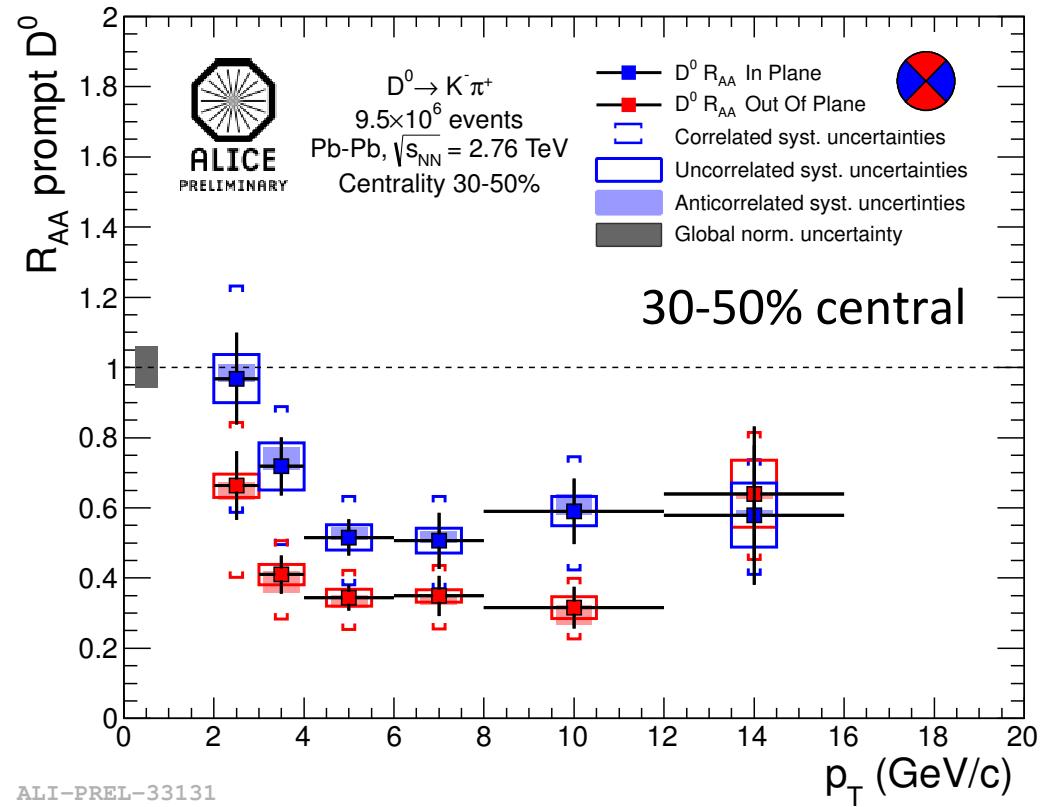
- D R_{AA} extended from 15 to 30 GeV with 2011 data
- Expectation based on colour-charge dependence of E loss: D less suppressed than pions
- Observation is not yet conclusive



D Meson R_{AA} relative to event plane

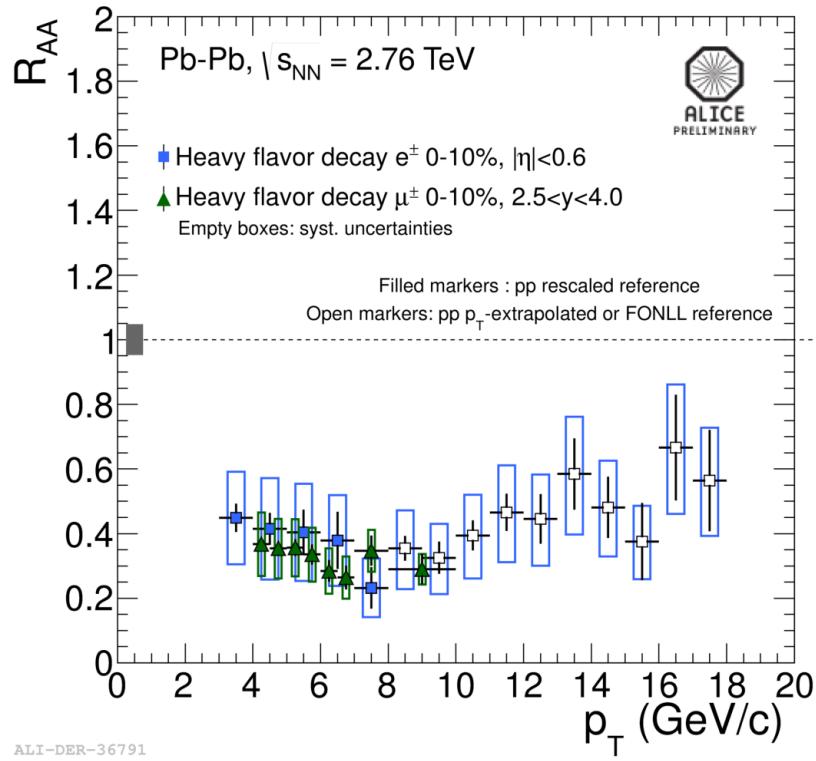


**More matter
More suppression**



Combining v_2 and R_{AA}

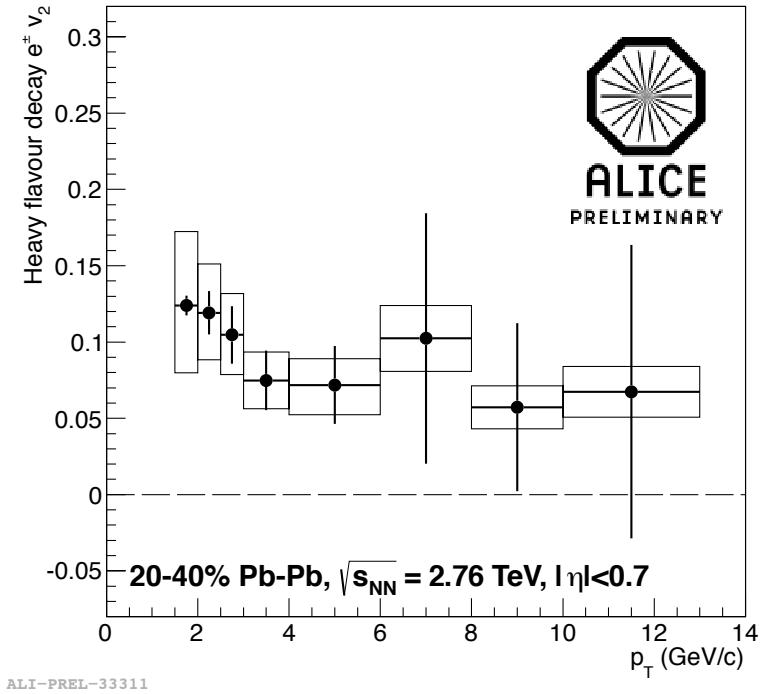
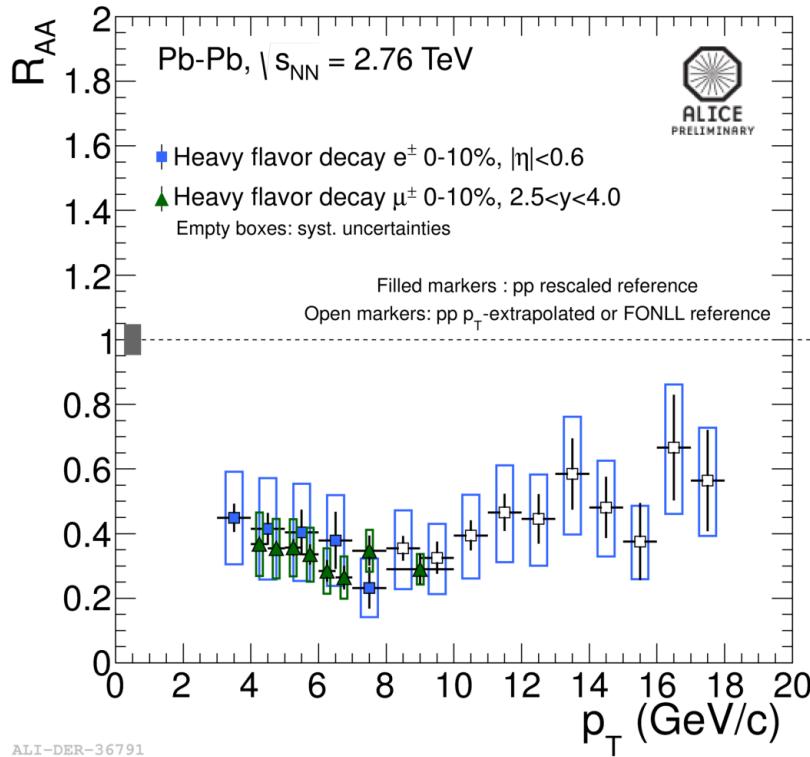
Heavy Flavour electrons, muons



- Strong Suppression throughout measured momentum
→ *Measurements at both mid- and forward rapidities show similar suppression*



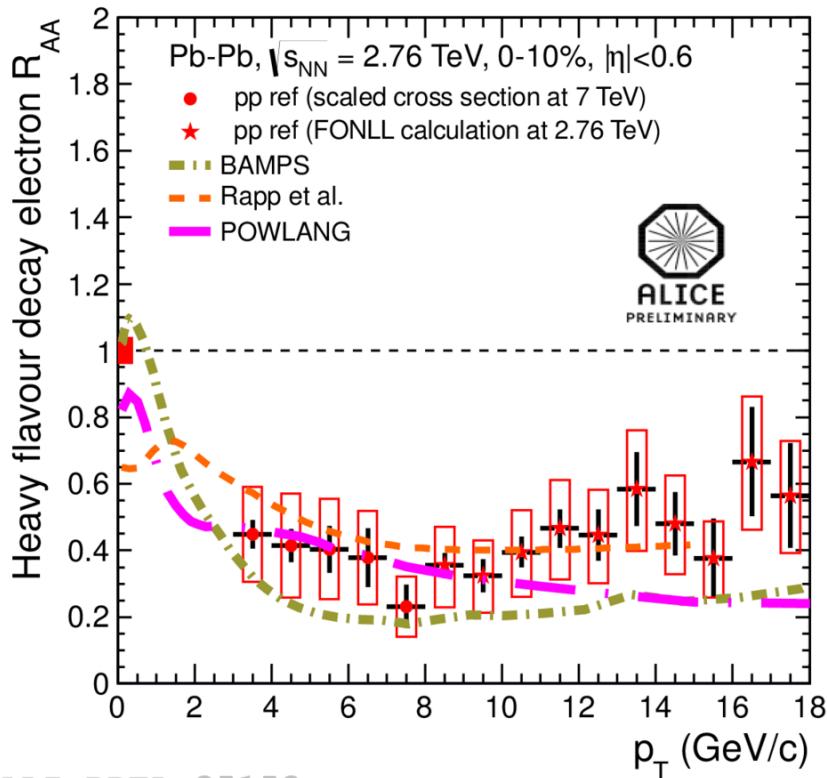
Heavy Flavour electrons, muons



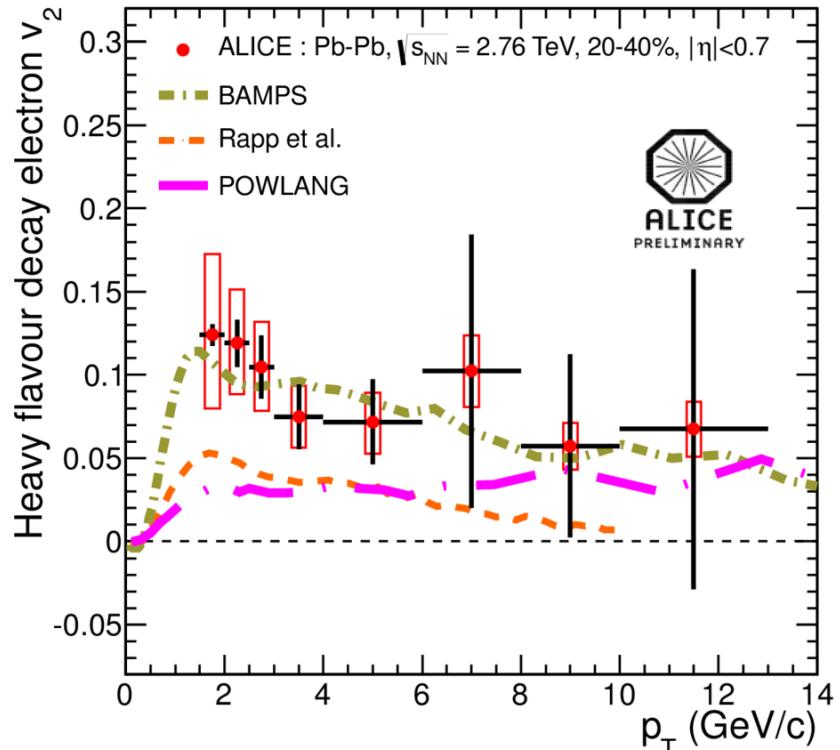
- Strong Suppression throughout measured momentum
 - Measurements at both mid- and forward rapidities show similar suppression
- v_2 measured to be non-zero in 20-40% mid-central events
 - Simultaneous measurement: R_{AA} and v_2 ; constrains transport models



Heavy Flavour electrons, muons



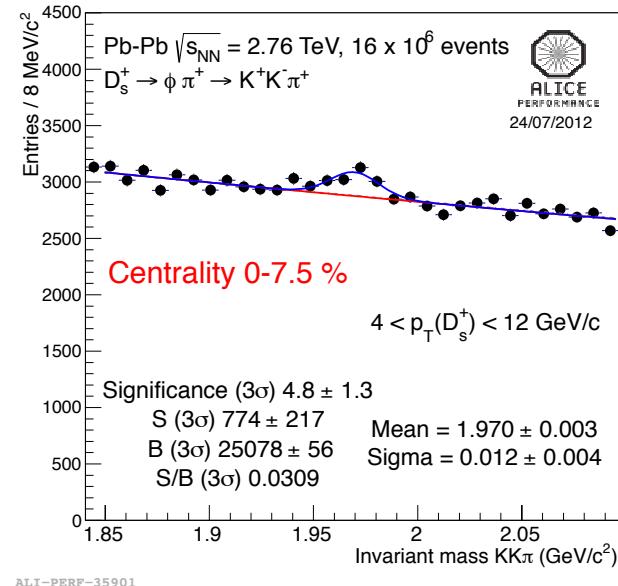
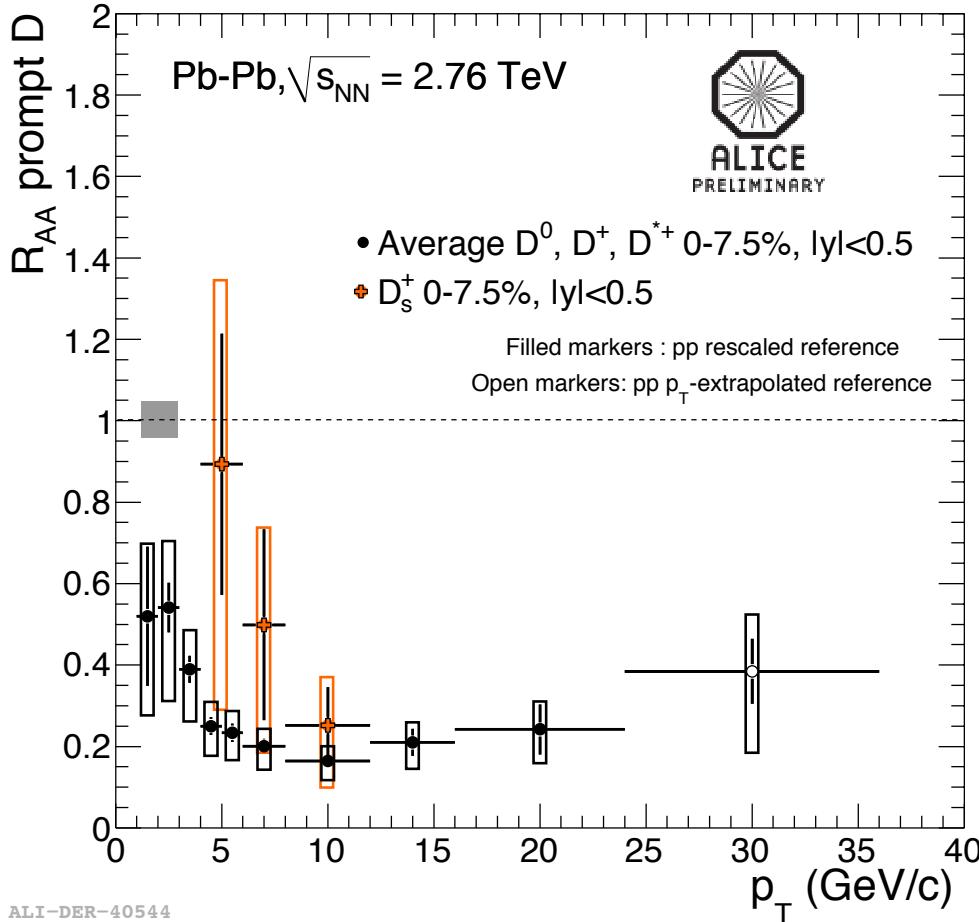
ALI-PREL-35153



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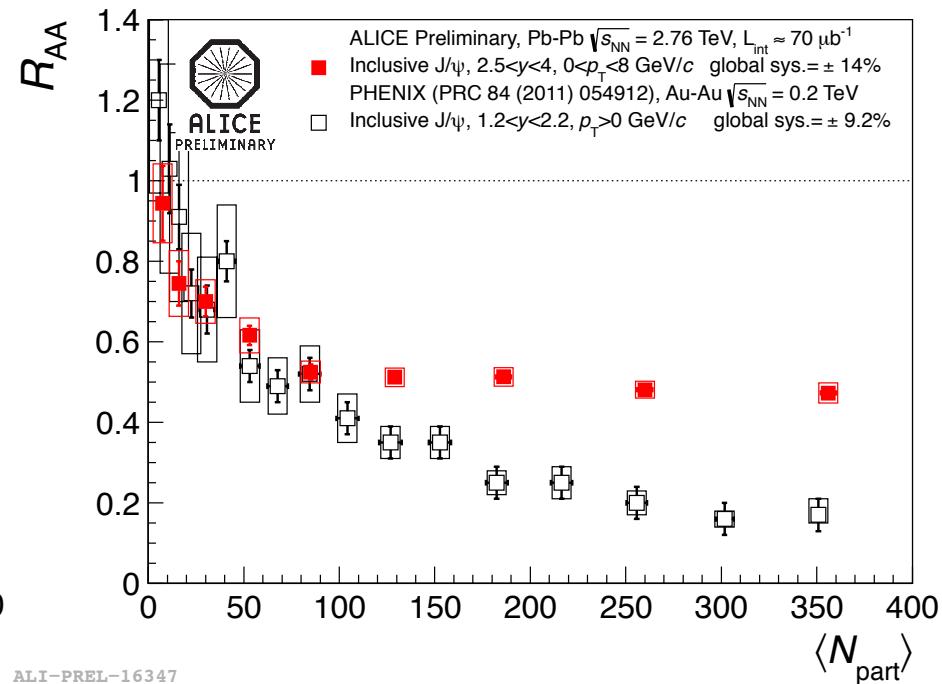
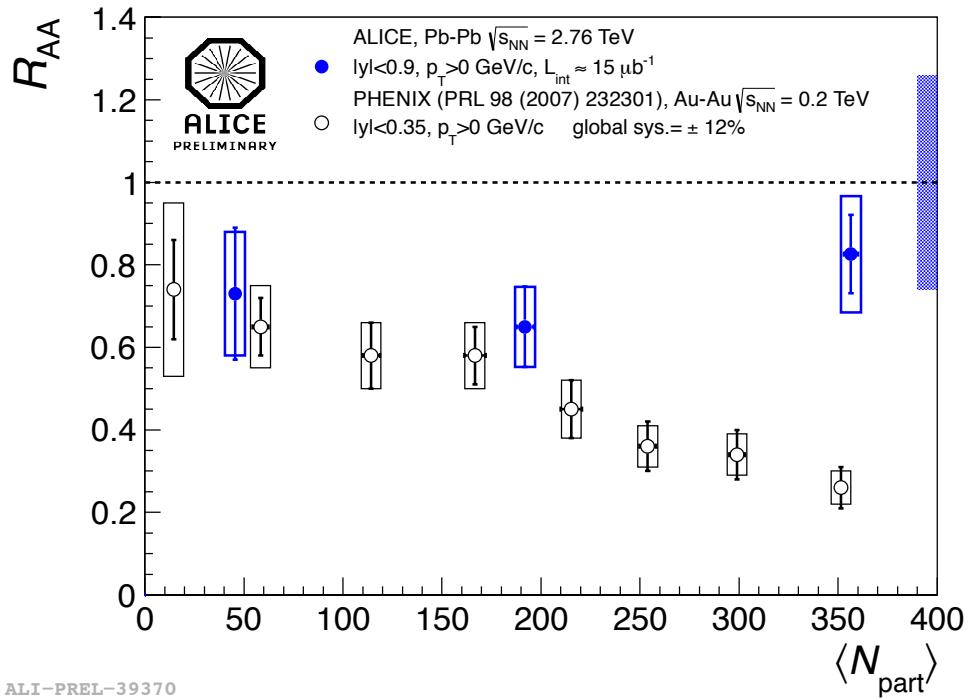


Strange D meson: D_s ($c\bar{s}$)



Potential for manifestation of strangeness enhancement: c recombination with thermally produced s quarks

J/ψ R_{AA}



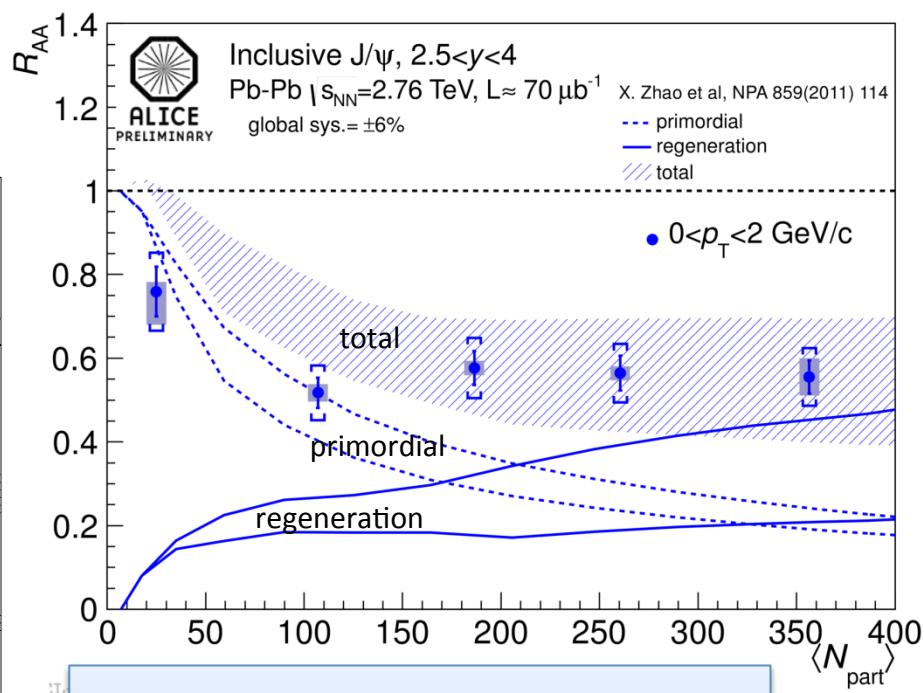
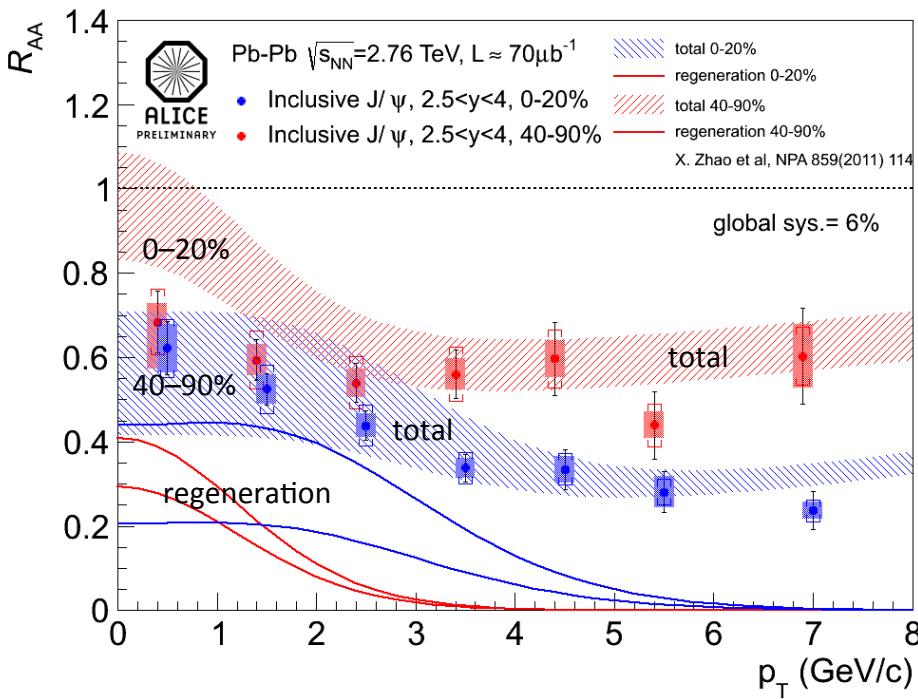
At LHC: **less suppression than at RHIC,**
Weaker centrality dependence



$J/\psi R_{AA}$

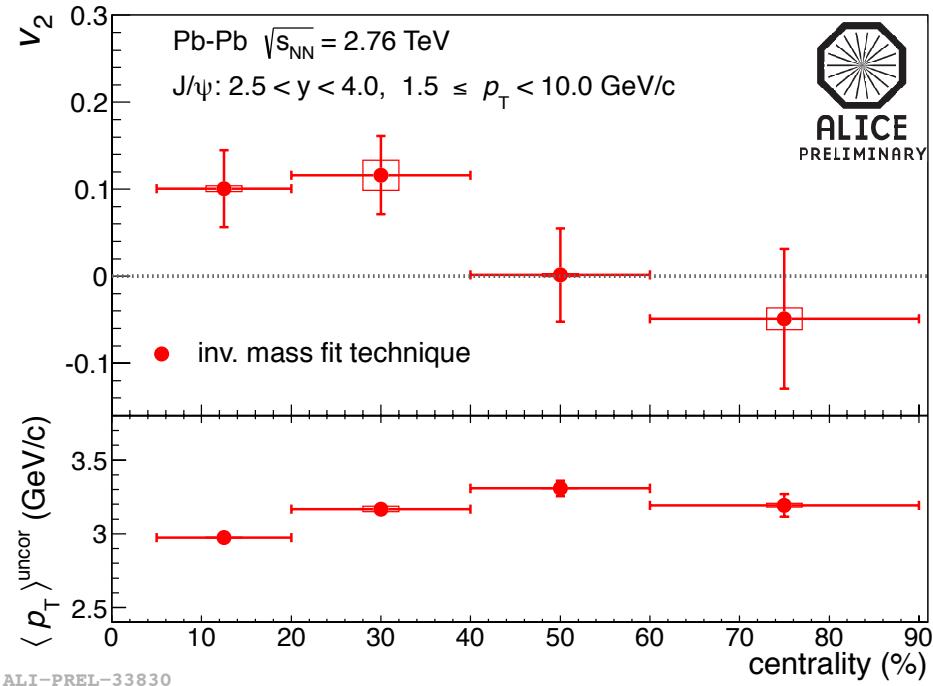
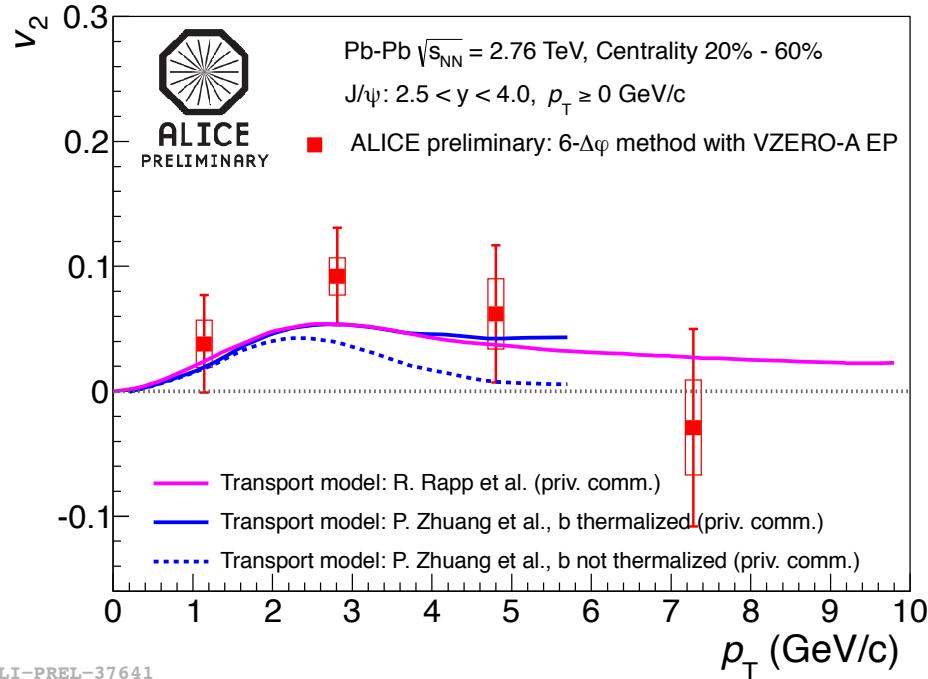
- **Primordial** production: Expected to “melt”
- **Regeneration** expected to produce low- p_T J/ψ

- Good Comparison to regeneration model: *X.Zhao, R.Rapp NPA 859 114*



- Statistical Hadronization model also describes the data (*P.Braun-Munzinger et al*)

$J/\psi v_2$

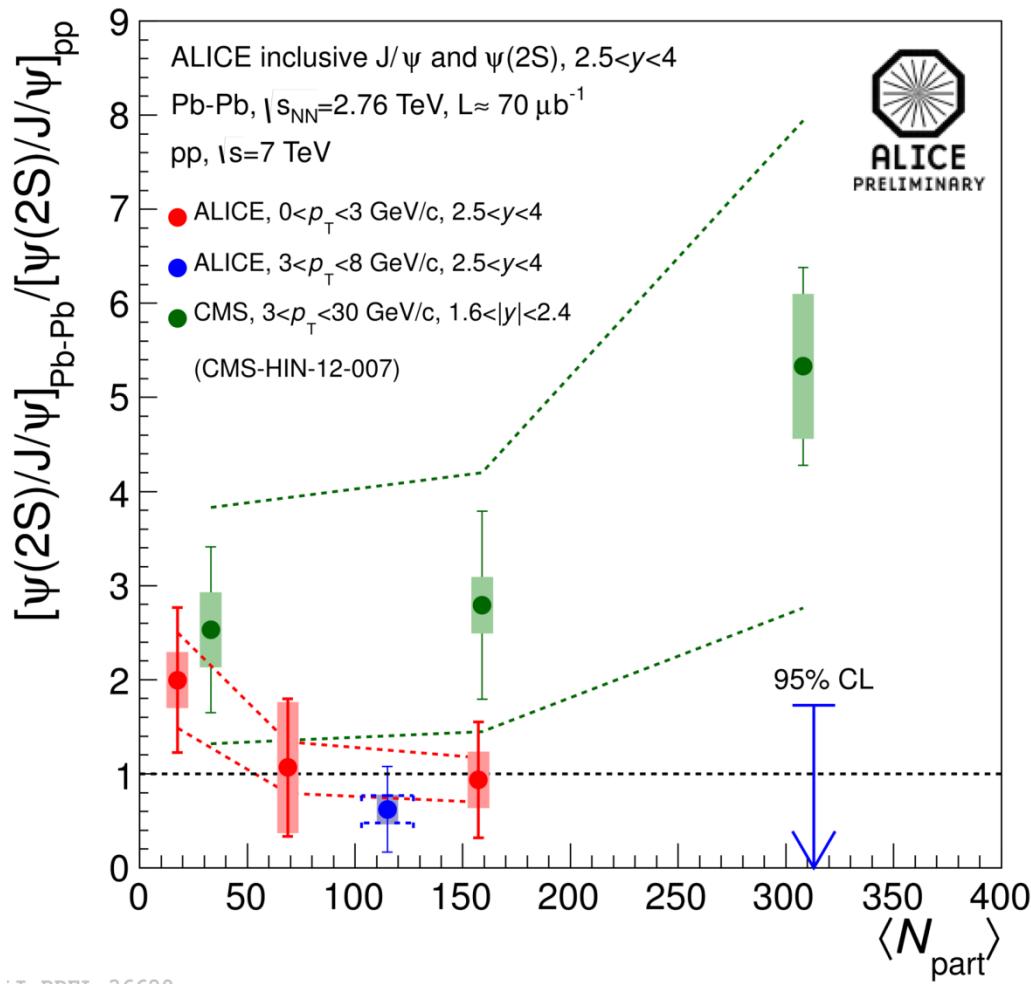


J/ψ produced with thermalized c-quarks should have non-zero v_2

- Hint for non-zero v_2 observed
- Qualitatively agrees with transport models, corroborates regeneration
- Complementary to R_{AA} measurement



ψ' and J/ ψ

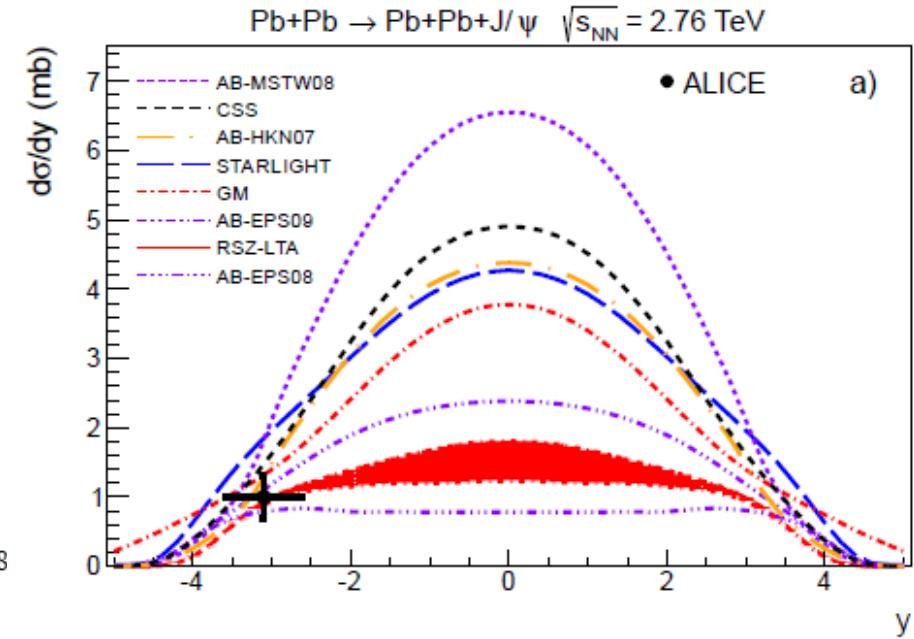
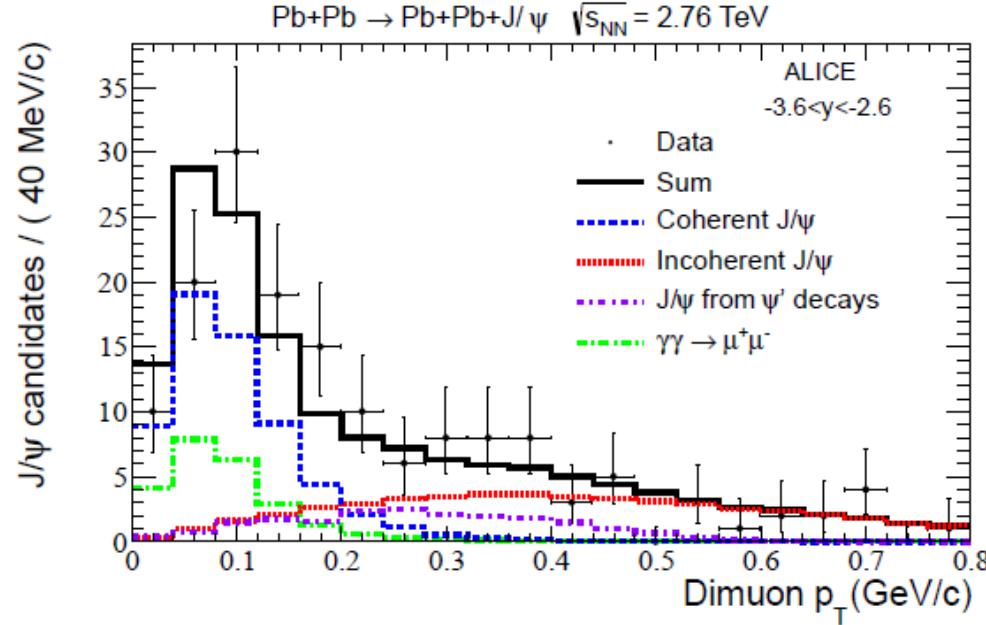


- No change of proportion between ψ' and J/ ψ when going from pp to central Pb-Pb
- Large enhancement observed by CMS at p_T above 3 GeV/c not confirmed



J/ ψ photoproduction in Ultra-Peripheral Events

Probes nuclear gluon distribution, poorly known at low Bjorken-x



<http://arxiv.org/abs/1209.3715>

Low p_T enhancement due to coherent production (photon couples to all nucleons), target nucleus does not break-up

Best agreement found with models which include **nuclear gluon shadowing** consistent with the recent EPS09 parameterization



ALICE Recent Results:

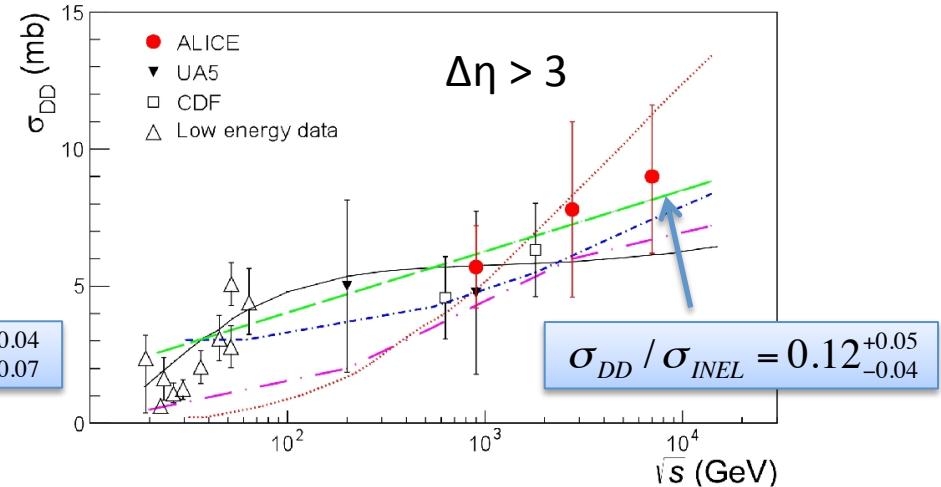
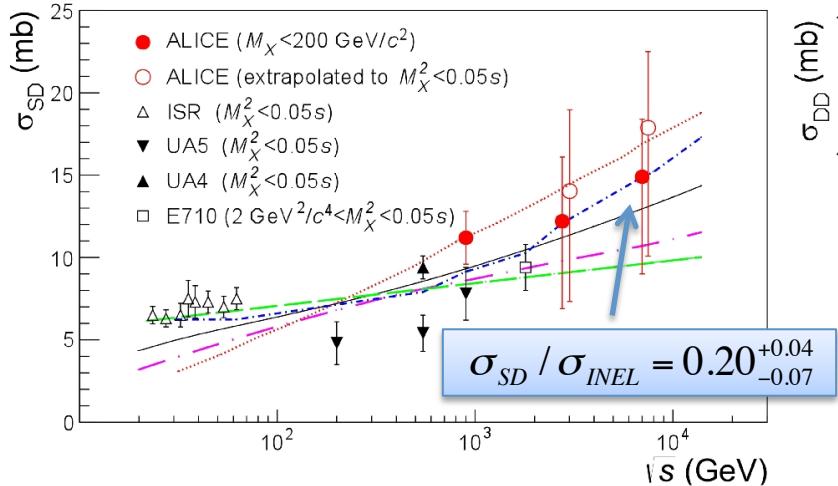
Proton-proton programme

- Proton-proton: essential reference for Pb-Pb measurements (R_{AA} , for instance)
- In addition: genuine proton-proton programme, exploiting
 - low momentum tracking
 - particle identification
- **Shown here: three recent examples of this programme**

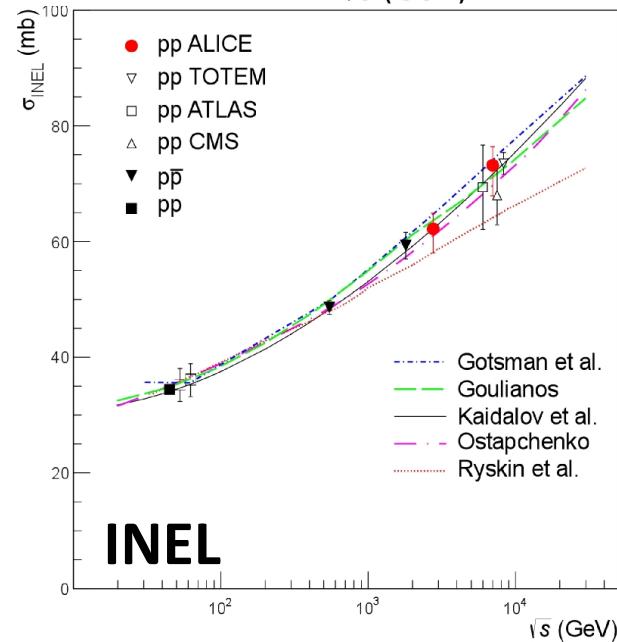


Diffractive, Inelastic Cross-sections

<http://arxiv.org/abs/1208.4968>

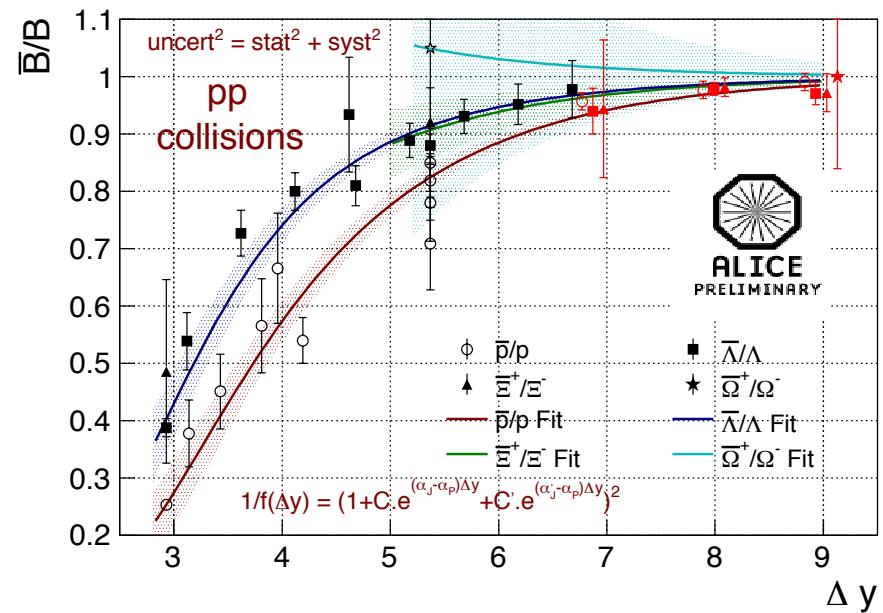
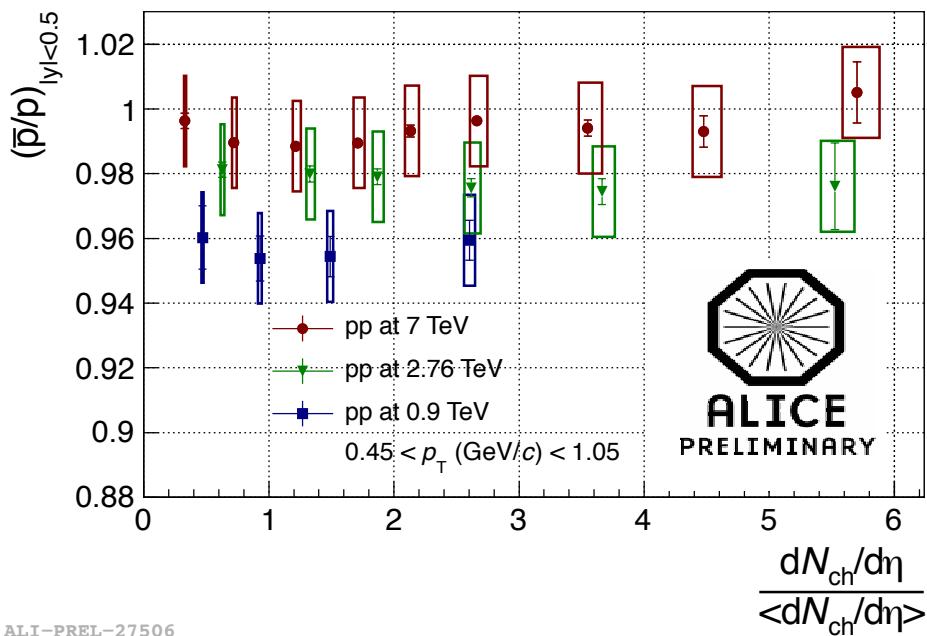


Experiment	σ_{INEL} (mb)	$\sigma_{INEL}^{\xi > 5 \times 10^{-6}}$ (mb)
ALICE	$73.2^{+2.0}_{-4.6}$ (model) ± 2.6 (lumi)	$62.1^{+1.0}_{-0.9}$ (model) ± 2.2 (lumi)
ATLAS	69.4 ± 6.9 (model) ± 2.4 (exp)	60.3 ± 0.5 (syst) ± 2.1 (lumi)
CMS	68.0 ± 4.0 (model) ± 2.0 (syst) ± 2.4 (lumi)	
TOTEM	$73.5^{+1.8}_{-1.3}$ (syst) ± 0.6 (stat)	



Antibaryon to Baryon Ratio

Protons, Λ , Ξ

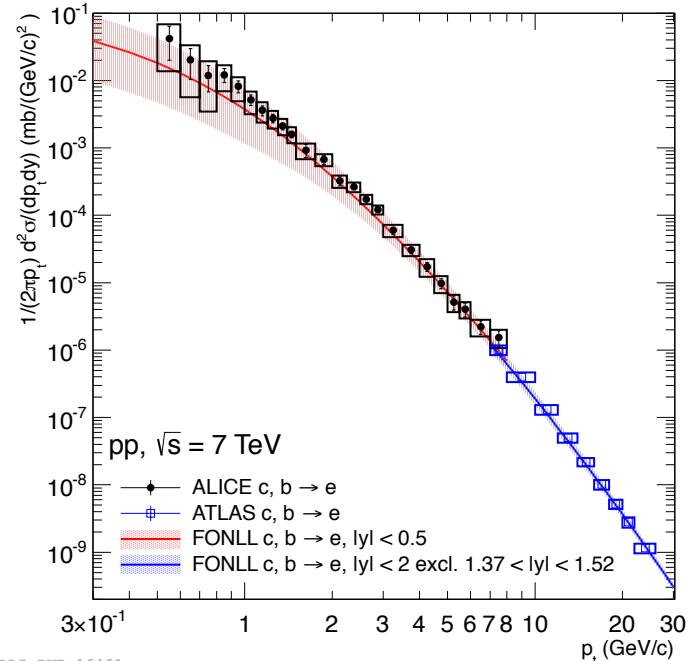
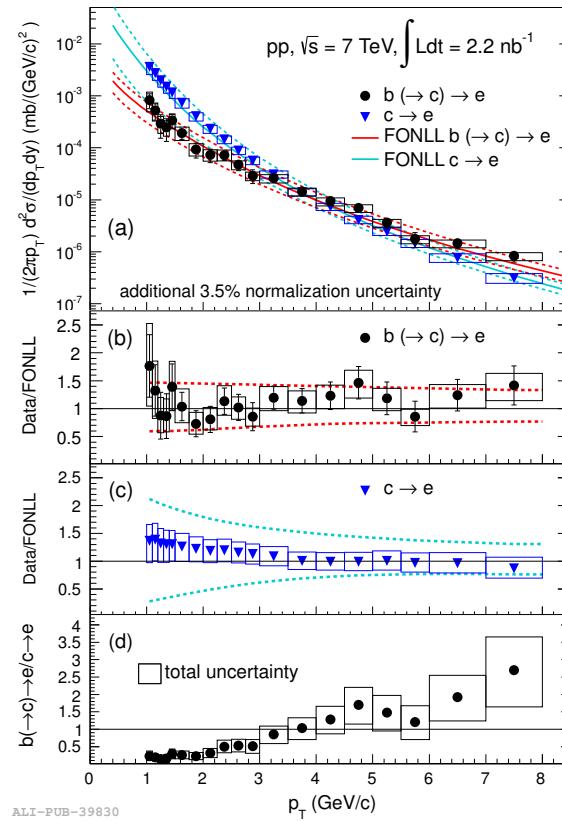
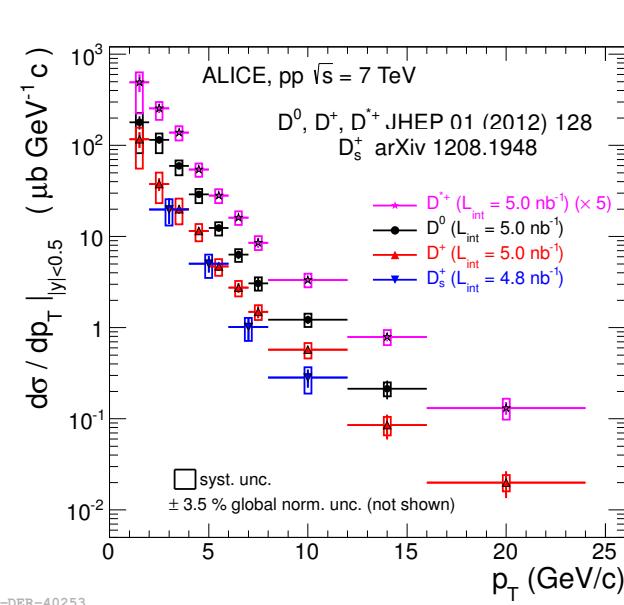


- \bar{p}/p , $\bar{\Lambda}/\Lambda$, $\bar{\Xi}^+/\Xi^-$ studied for pp and PbPb: compatible
- Studied also in **multiplicity bins**: no dependence found
- Antibaryon to Baryon ratio versus energy: shown to be consistent with baryon number transfer models with $\Delta y = y_{\text{beam}} - y_{\text{baryon}}$ parametrizations.

G.C. Rossi and G. Veneziano, Nucl. Phys. B123, (1977) 507.

Heavy Flavour in pp

- Latest new results on HF in pp:
 - D_s production for $p_T > 2 \text{ GeV}/c$ (arXiv:1208.1948)
 - B-decay electron production for $p_T > 1 \text{ GeV}/c$ (arXiv:1208.1902)
- ✓ Complementary coverages



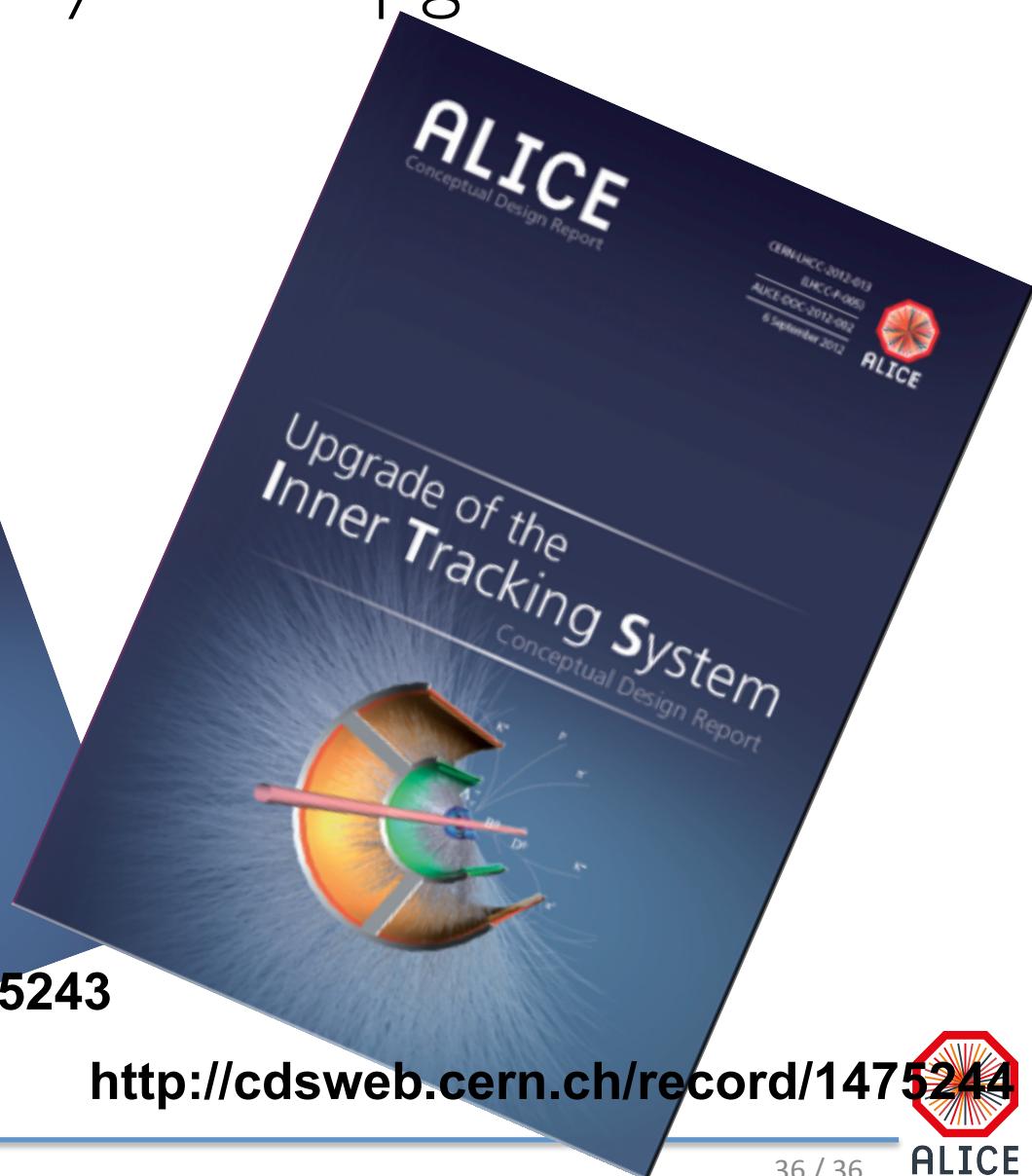
ATLAS data from
 Phys. Let., B707:438–458, 2012.

Conclusions

- PbPb: Improved understanding using two first Heavy Ion runs
 - Soft probes: spectra, direct photon measurements
 - Collective effects: $v_2 + R_{AA}$ and study of transport
 - Correlations and fluctuations
 - Heavy Flavour: Suppression and flow of D mesons, leptons, J/ ψ
- Much more to come
 - Many more Pb-Pb, pp analyses ongoing
 - p-Pb coming up! (crucial control experiment)
 - ALICE Upgrade ->



ALICE Upgrade Letter of Intent & Inner Tracking System Upgrade CDR



<http://cdsweb.cern.ch/record/1475243>

<http://cdsweb.cern.ch/record/1475244>

Backup



ALICE Upgrade Physics Motivation

Three main physics topics that are unique of the upgraded ALICE detector:

1. Heavy-flavour transport parameters in the QGP

- Heavy-quark diffusion coefficient (\rightarrow QGP equation of state, viscosity of the QGP fluid)
- Heavy-quark thermalization and hadronization in the QGP
- Mass dependence of parton energy loss in QGP medium

2. Low-mass dielectrons: thermal photons and vector mesons from the QGP

- Photons from the QGP ($\gamma \rightarrow e^+e^-$) \rightarrow map temperature during system evolution
- Modification of ρ spectral function ($\rho \rightarrow e^+e^-$) \rightarrow chiral symmetry restoration

3. Charmonia (J/ψ and ψ') down to zero p_T

- Only the comparison of the two states can shed light on the suppression/regeneration mechanism
- Study QGP-density dependence with measurements at central and forward rapidity



ALICE detector upgrade

- improved vertexing and tracking at low p_T
- preserve particle-identification capability
- high-luminosity operation without dead-time

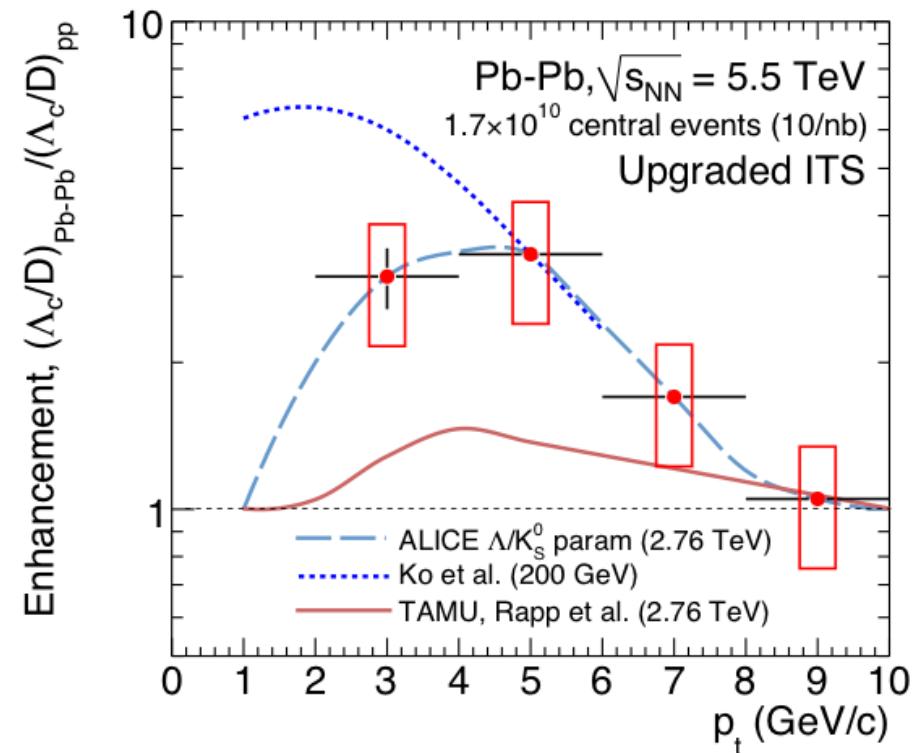
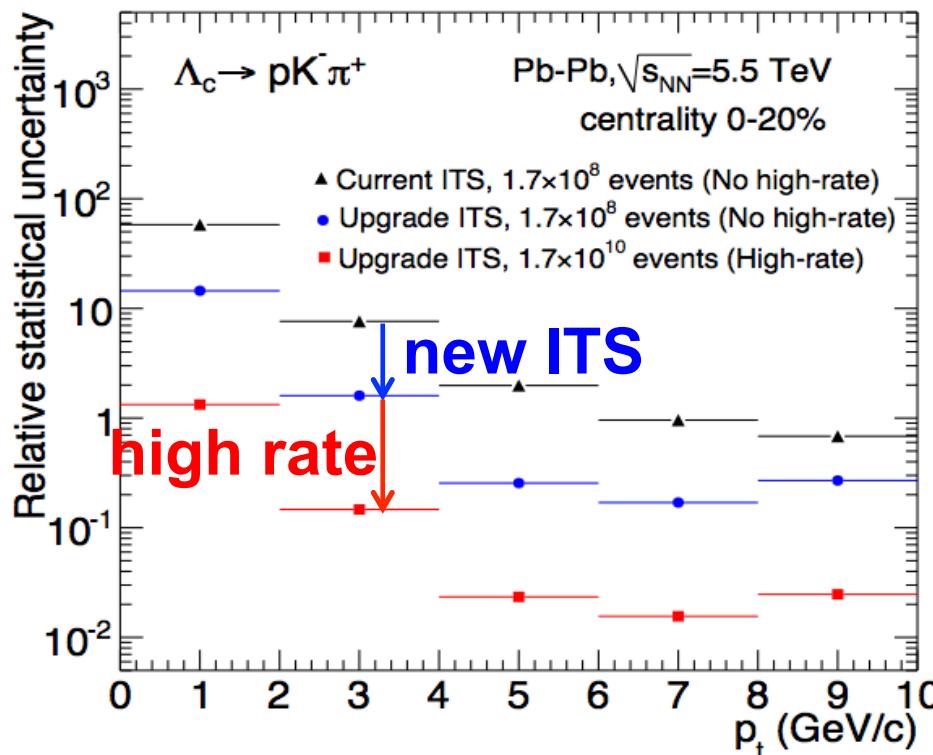
- new, smaller radius, beam pipe
- new inner tracker (ITS) (performance and rate upgrade)
- upgrade of the TPC with GEM readout chambers
- high-rate upgrade for the readout of the TPC, TRD, TOF, CALs, DAQ-HLT, Muon-Arm and Trigger detectors

- luminosity upgrade – target 50 kHz minimum-bias rate for Pb–Pb
- run ALICE at this high rate, inspecting all events
- collect more than 10 nb^{-1} of integrated luminosity
- target for installation and commissioning LS2 (2018)
 - implies running with heavy ions a few years after LS3



Performance example: Λ_c

- $\Lambda_c \tau=60 \mu\text{m}$, to be compared with $D^+ \tau=300 \mu\text{m}$
 → Measurement not possible in Pb-Pb with current ITS



With new ITS and high-rate, measure charm baryon/meson enhancement from 2 GeV/c

