A Large Ion Collider Experiment

Recent Results from ALICE

- for the session : Global & Collective Dynamics

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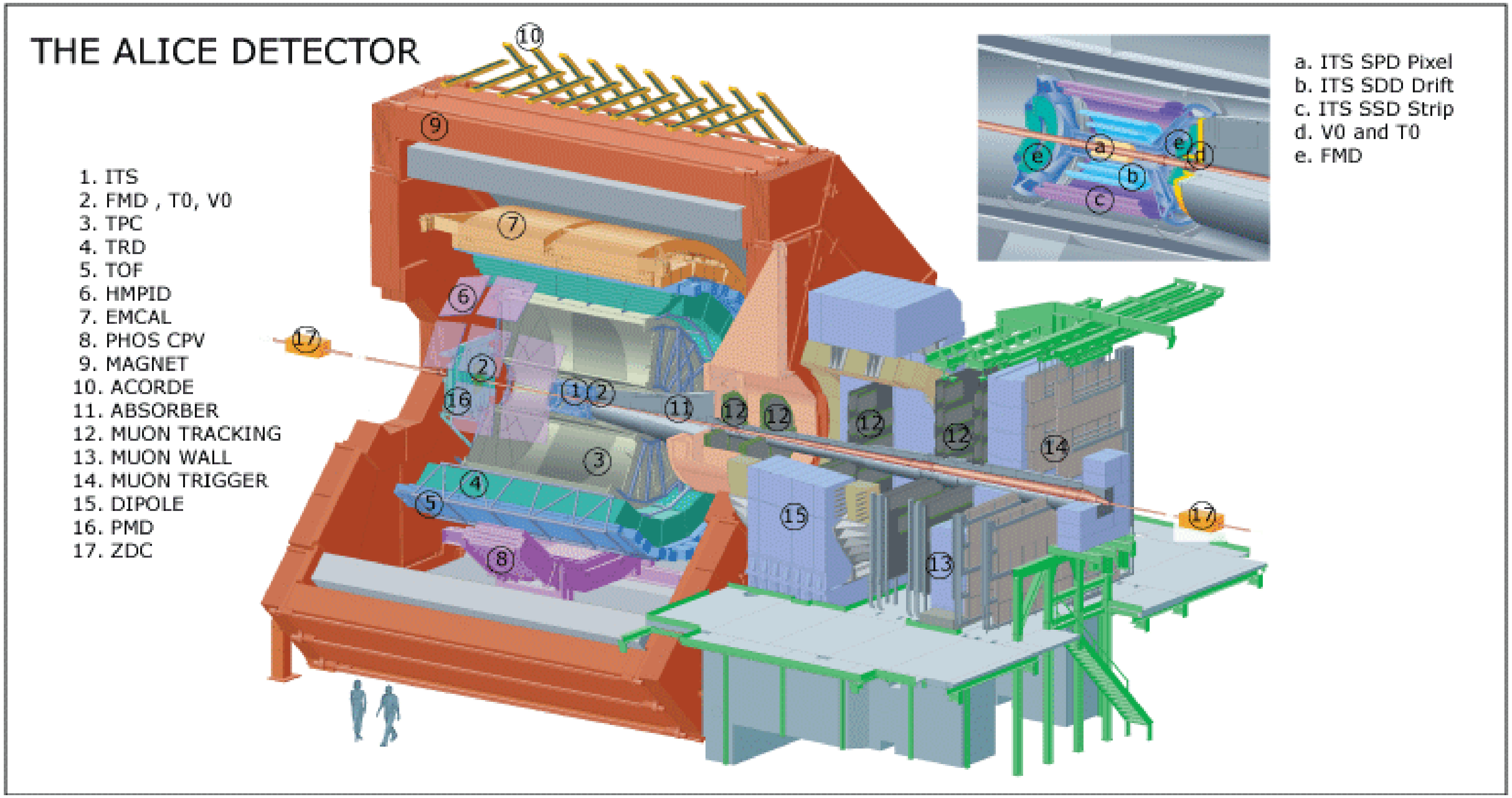
Outline

Recent Results from ALICE on Global & Collective Dynamics

- ALICE Detector and PID
- Bulk : Multiplicity
- Collective Expansion
    - Radial Flow
    - Elliptical Flow
- Miscellaneous
- Summary & Outlook

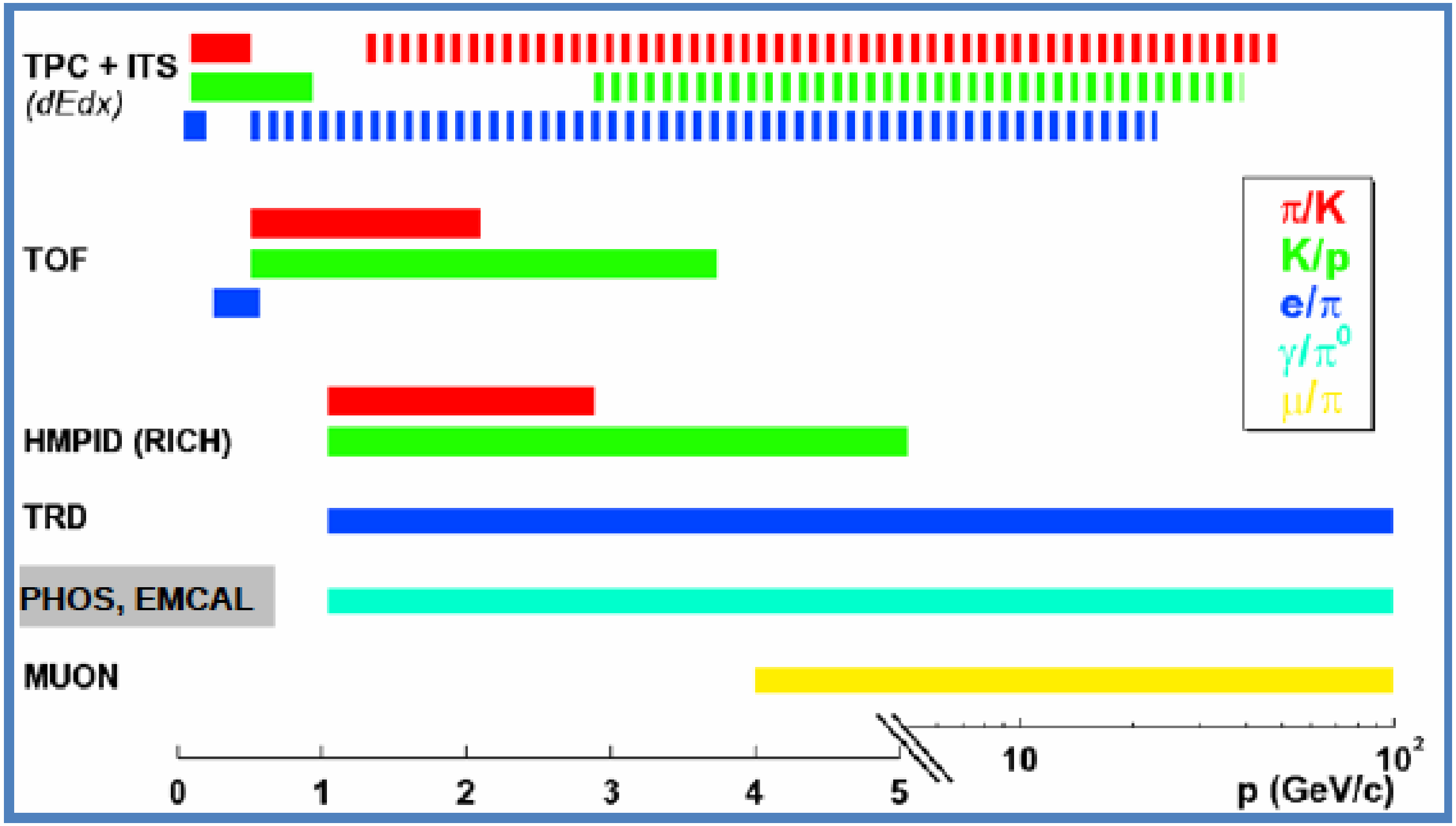
ALICE

- 1300 Members, 120 Institutes, 35 Countries
- Detector : 16 m x 26 m, 10,000 tons
- Tracking 7, PID 6, Cal. 5, Trig. 11

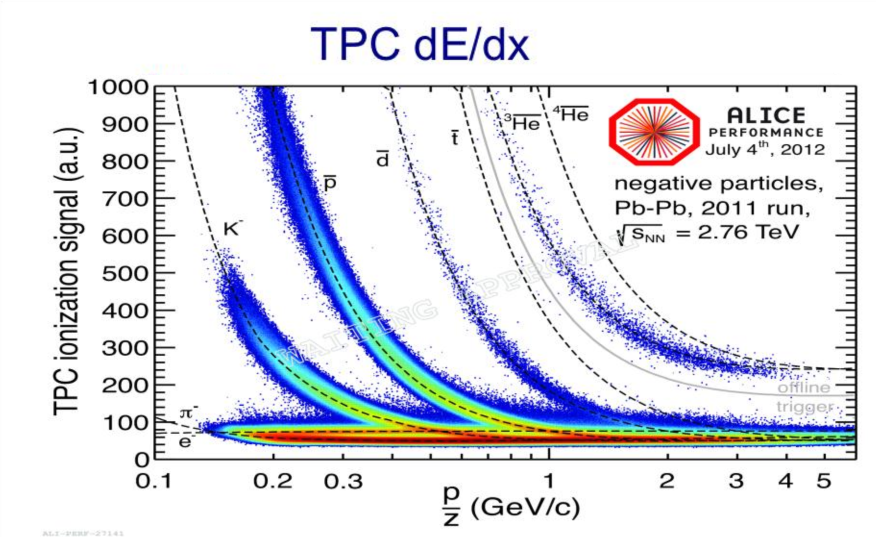


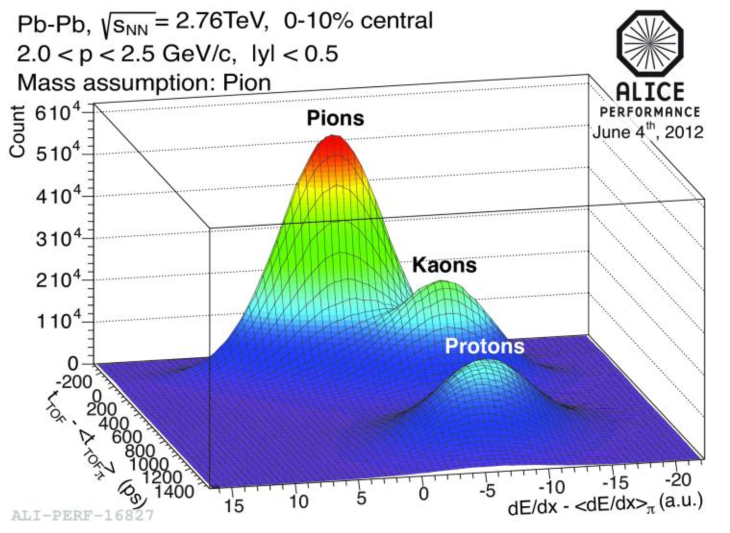
ALICE PID

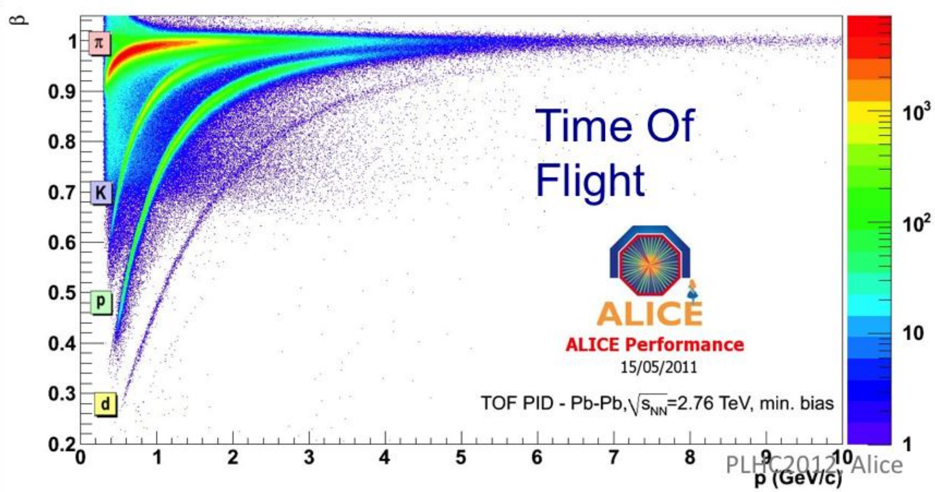
- optimized hadron PID at low p
- low material budget / magnetic field
- high granularity $dN_{ch}/d\eta \sim 8000$

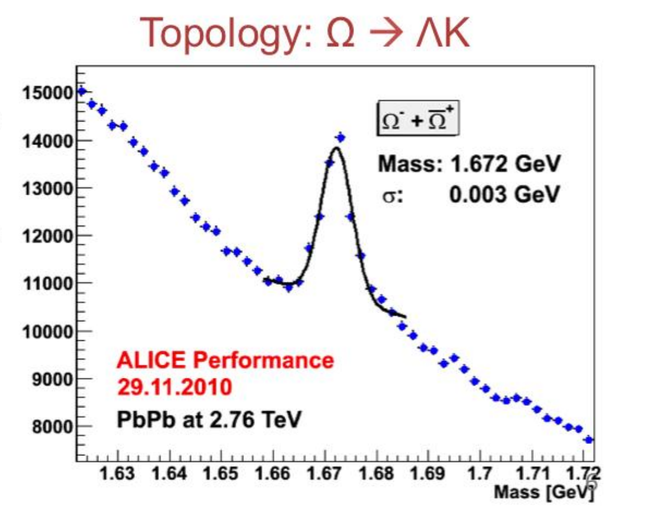


PID Performance

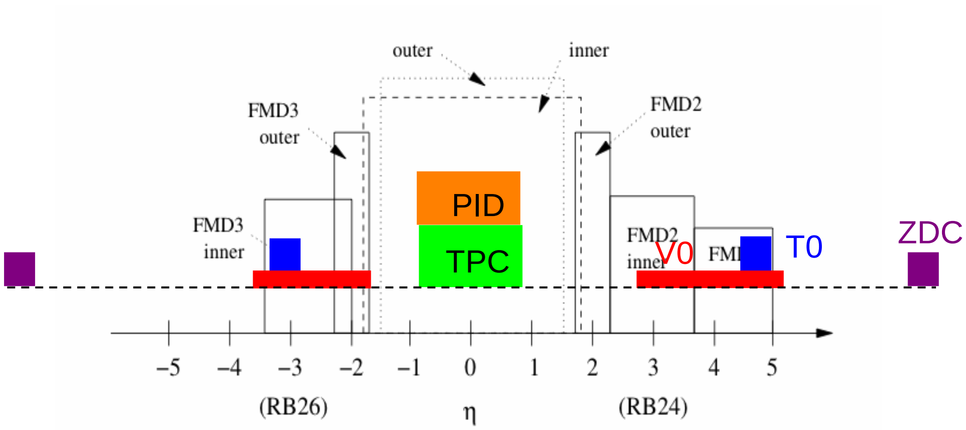




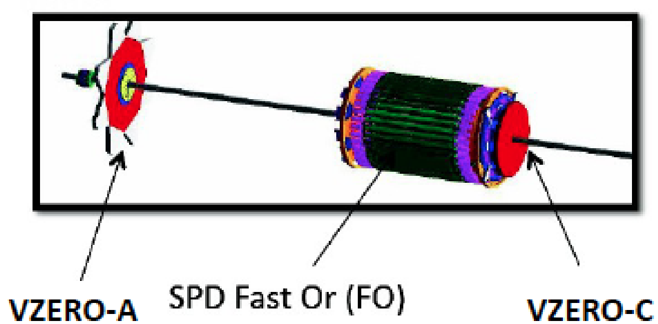




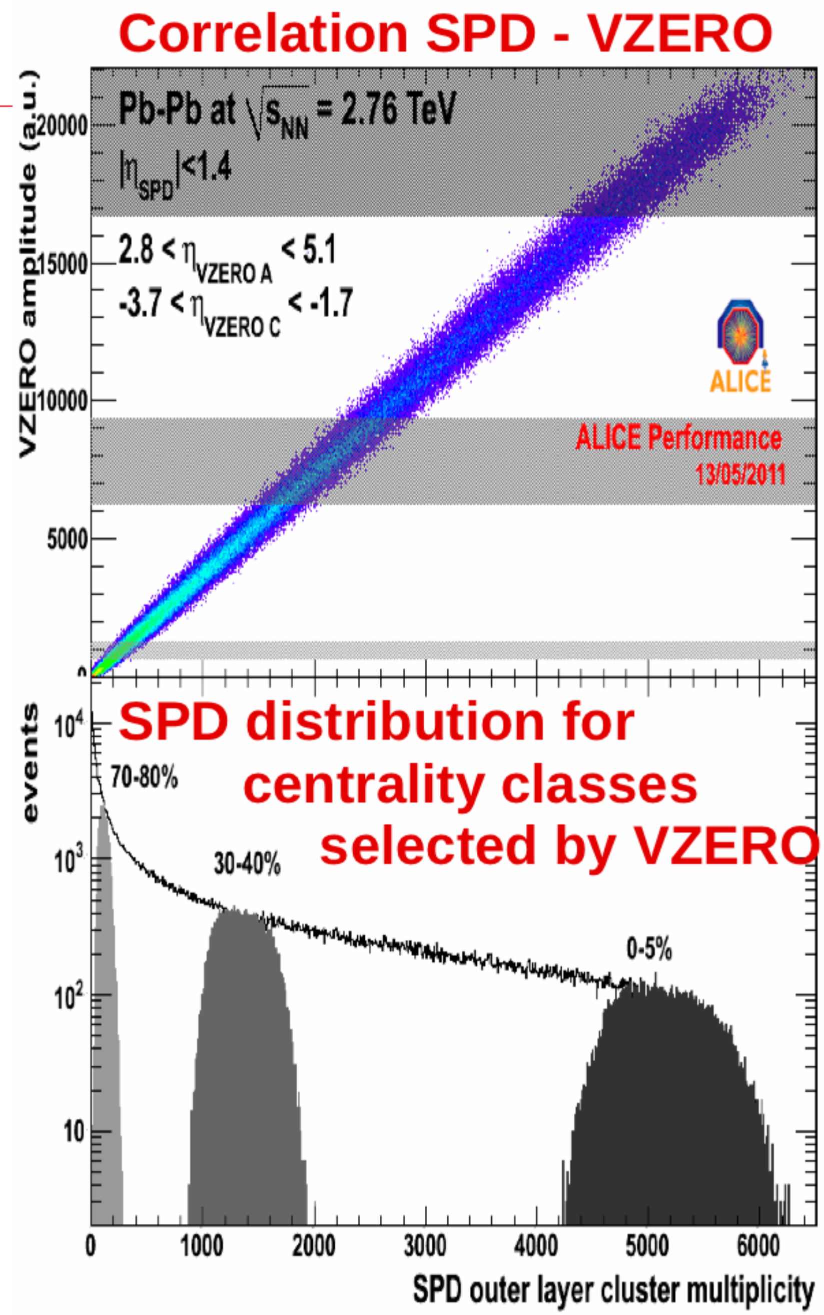
ALICE Coverage & Trig.



- Triggers: minimum bias in pp and Pb-Pb.
  - Trigger detectors: **SPD | VZERO-A | VZERO-C**

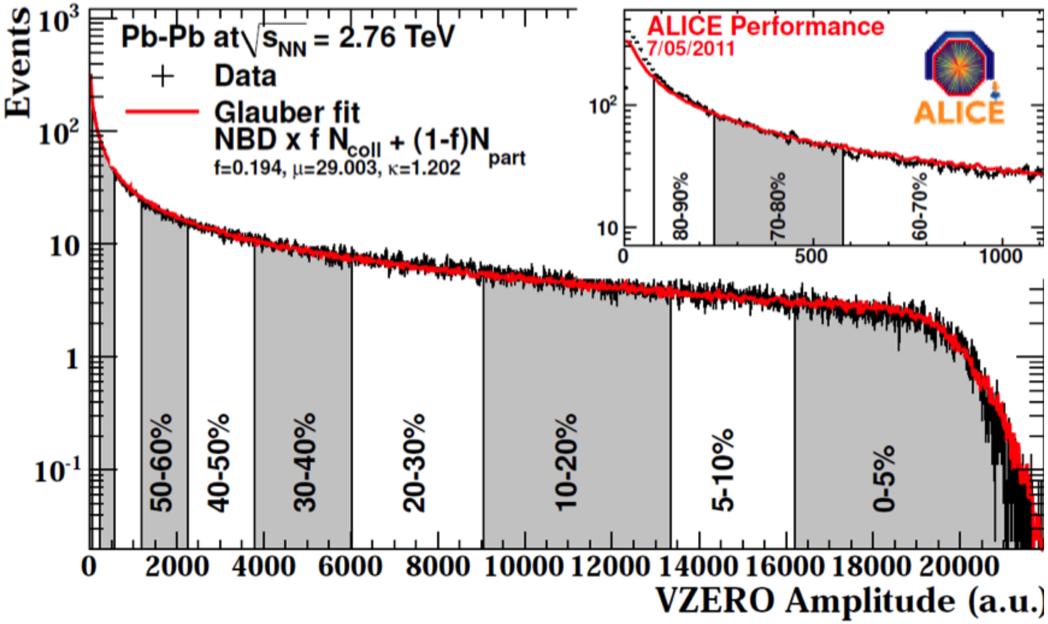


- **From MB to selective triggers** : Centrality classes (central and semi-central), Muons, EMCAL, PHOS and special triggers for Ultra Peripheral Collisions (UPC)



ALICE Data & Events

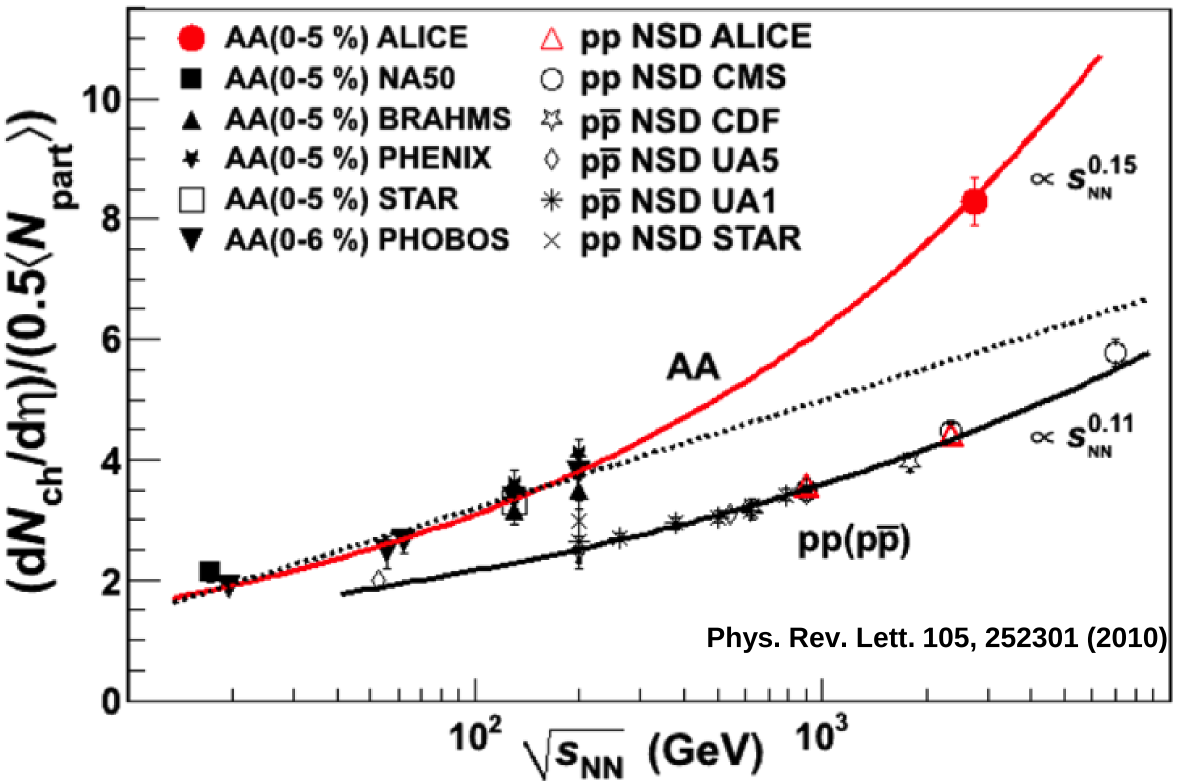
System	pp*	pp *	PbPb	PbPb
Energy (TeV)	7	2.76	2.76	2.76
Year	2010	2011	2010	2011
L_{int} MB/cent	5-6/nb	1.5/nb	2.5/μb	6.5/μb
L_{int} μ (μμ)	15-17/nb	19-20/nb	2.5/μb	(70/μb)



The Bulk : Multiplicity

Energy Dependence

- $dN_{ch}/d\eta$ = 1584+-4+-76 for most central ev.
- Nuclear Modification ~ 1.9 @ 2.76TeV

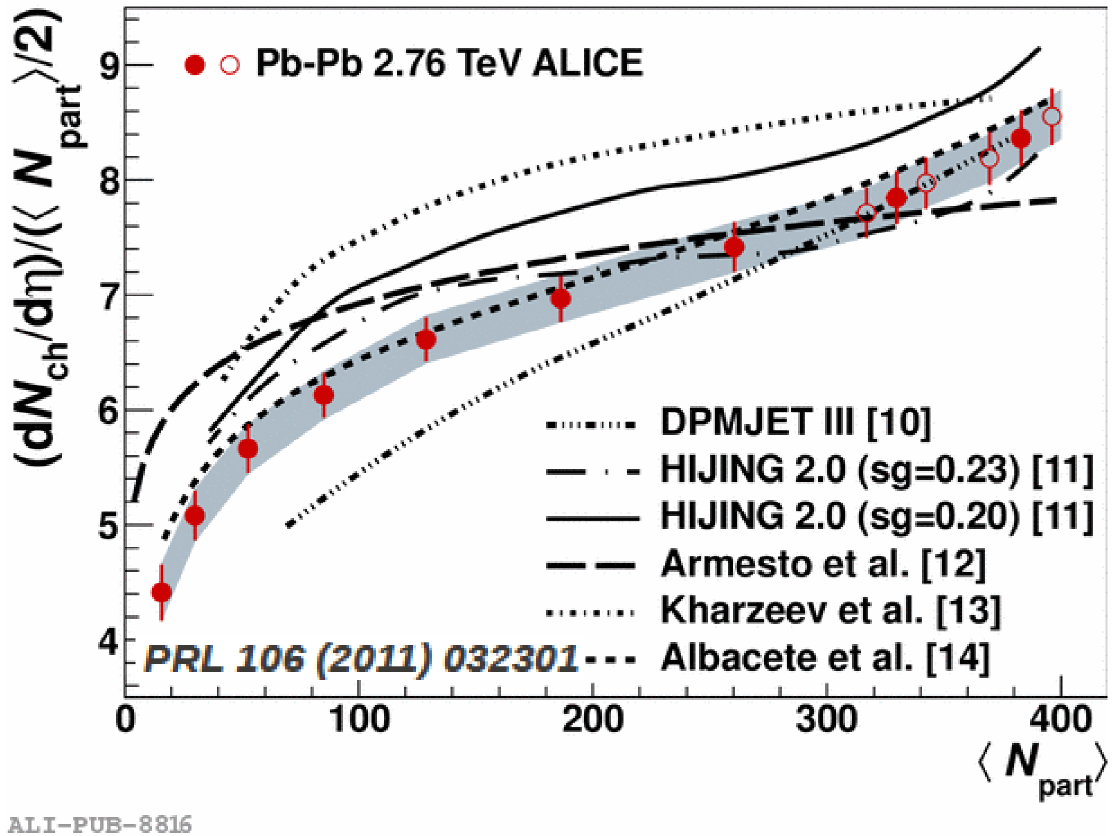


Phys. Rev. Lett. 105, 252301 (2010)

The Bulk : Multiplicity

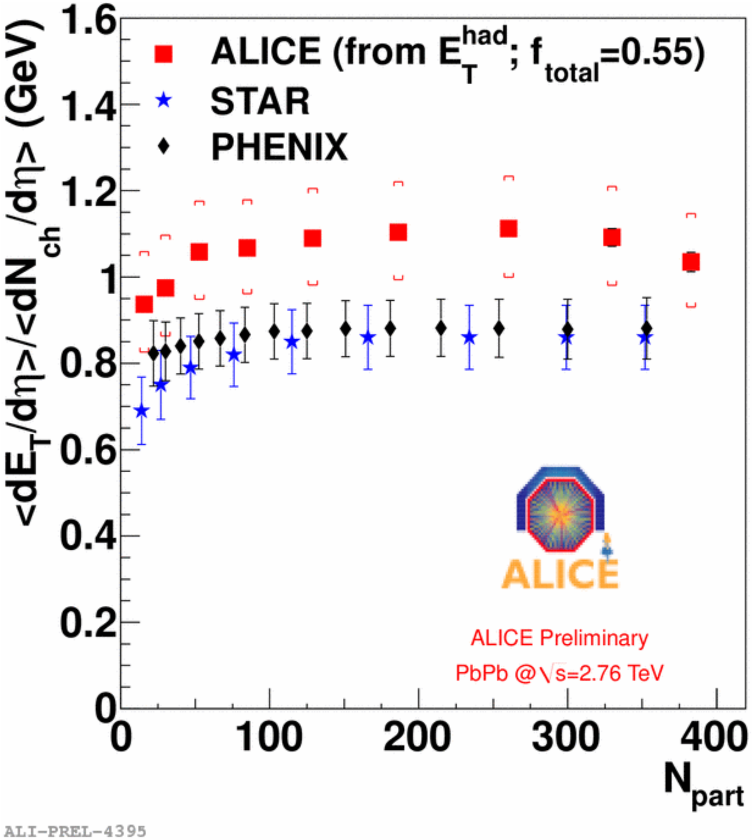
System size dependence @ 2.76 TeV

- Comparison data with Theories



The Bulk : Transverse Energy

Collision Geometry



$$\varepsilon_{Bj} = \frac{1}{\tau \pi R^2} \frac{dE_T}{d\eta}$$

$\varepsilon_{Bj}\tau$ ~ 16 GeV/fm^2

formation time τ unknown,

but τ < 1fm/c

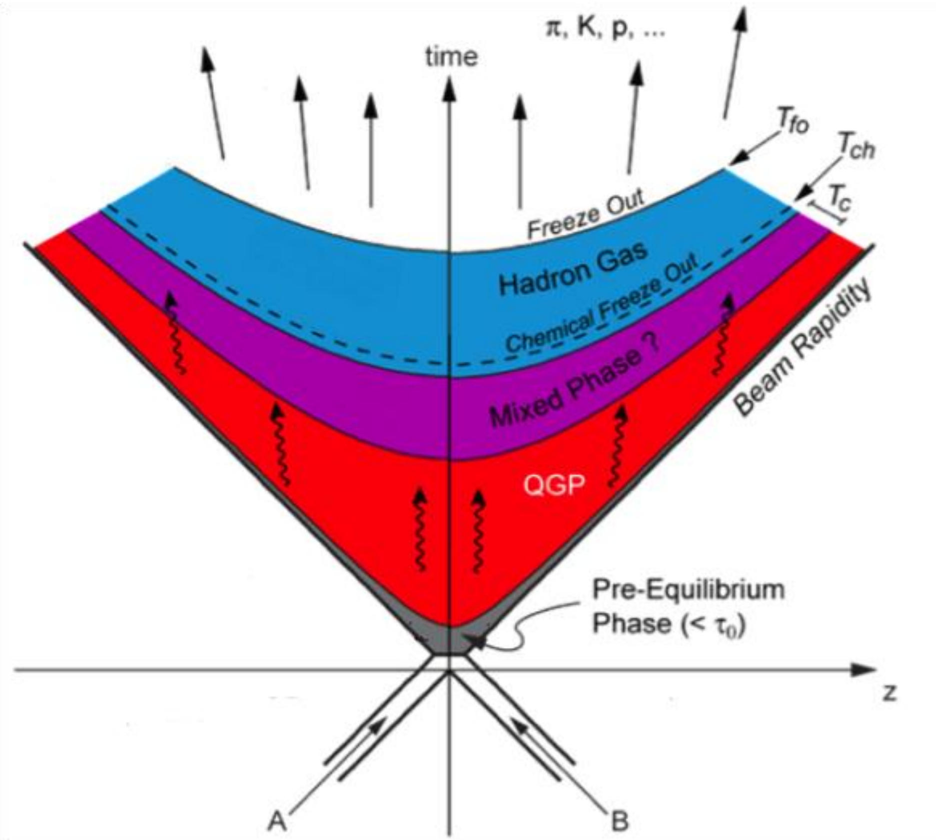
→ ε_{Bj} > 15 GeV/fm^3

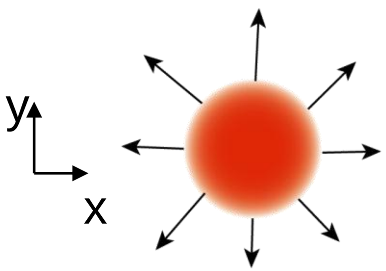
→ well above lattice critical

density (ε_c ~ 0.7 GeV/fm^3)

Collective Expansion

Motivation

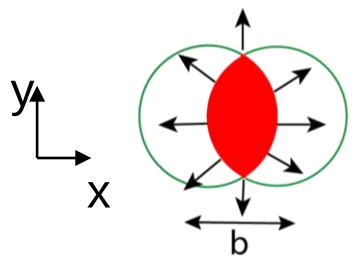




pressure gradient in-/out-side

→ radial expansion

→ boosted pT spectrum



spatially asymmetric system

→ anisotropy in momentum space

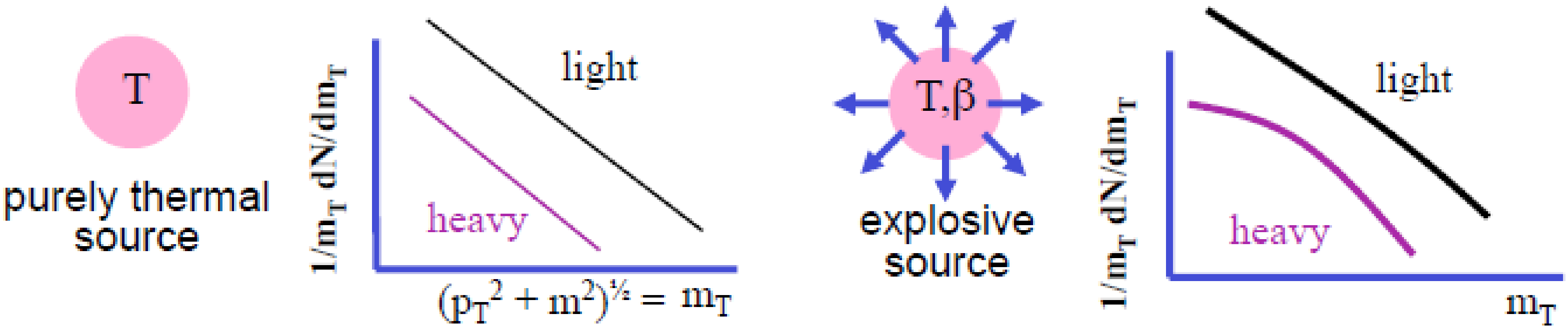
→ comparison results to hydro-calculation with inputs of initial condition (*e*, V, ε,…)

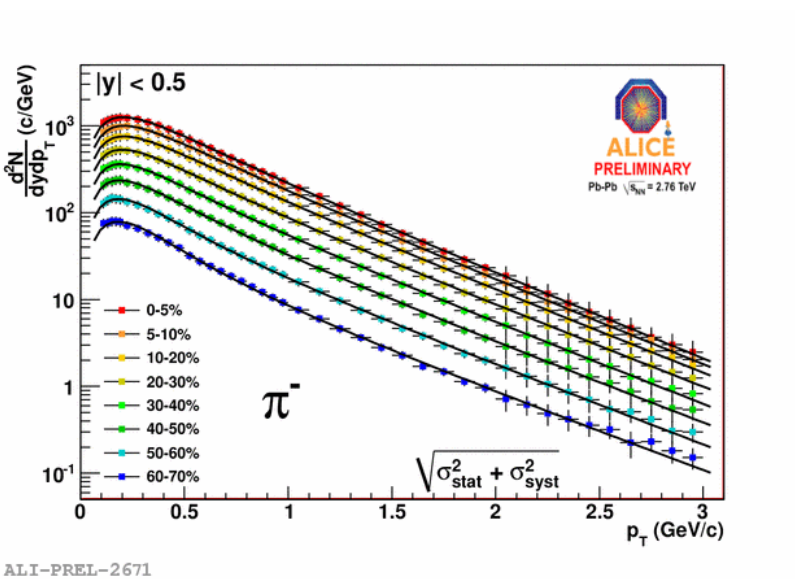
→ properties of produced matter (η …)

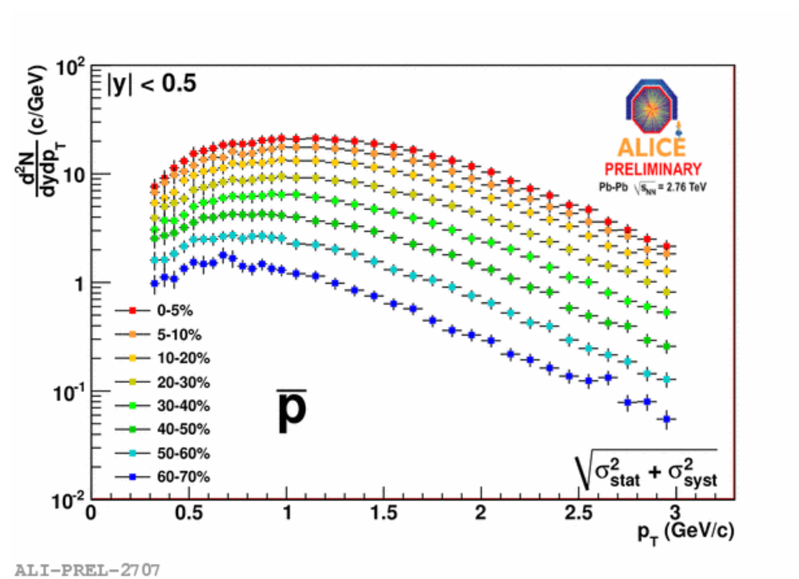
Radial Flow

Collective Transverse Expansion

- different shape in p_T ← different mass





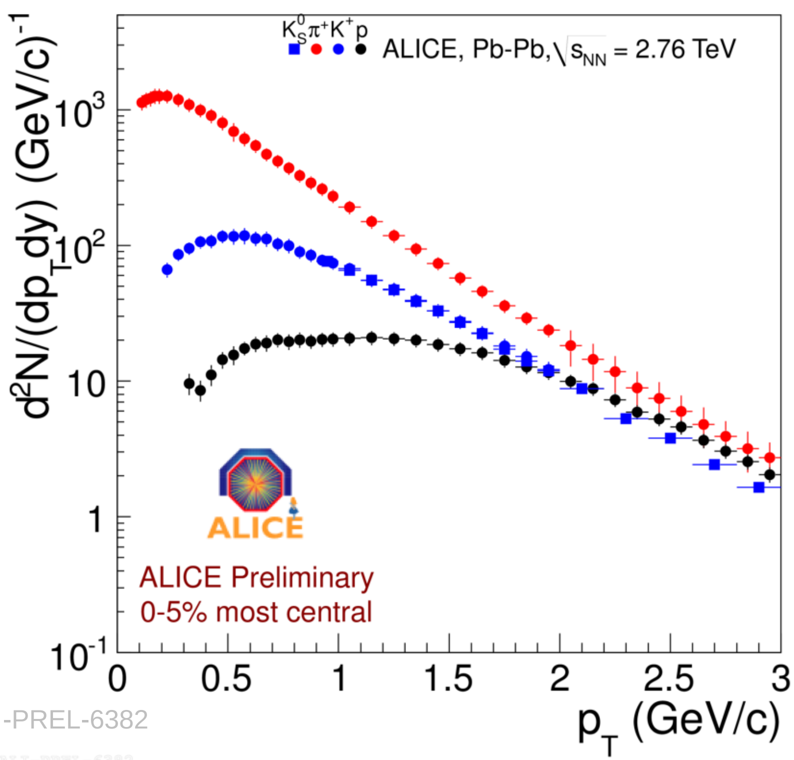


Radial Flow

Collective Transverse expansion

$$\frac{d^2N_j}{m_T dy dm_T} = \int_0^{R_0} A_j m_T \cdot K_1\left(\frac{m_T \cosh\rho}{T}\right) \cdot I_0\left(\frac{p_T \sinh\rho}{T}\right) r dr$$

$$\rho(r) = \tanh^{-1}\left(\beta_\perp(r)\right)$$



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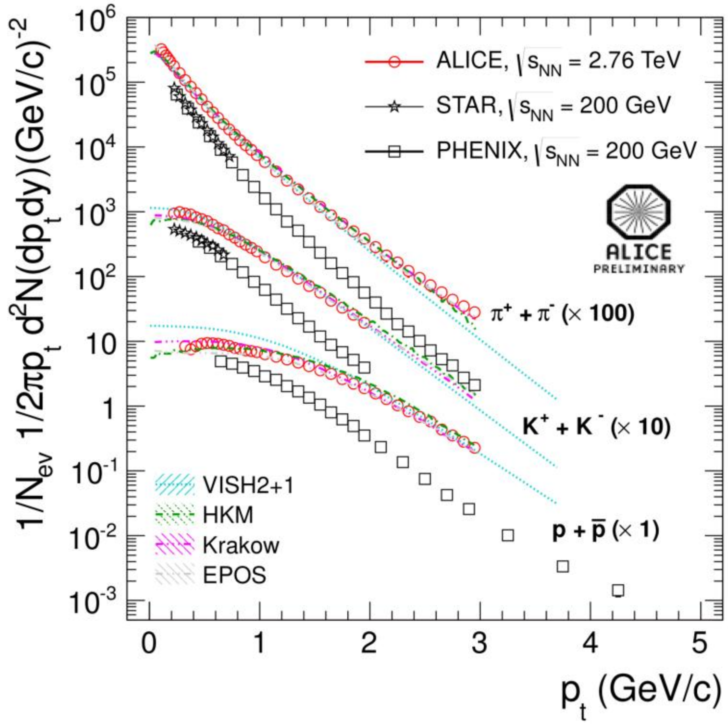
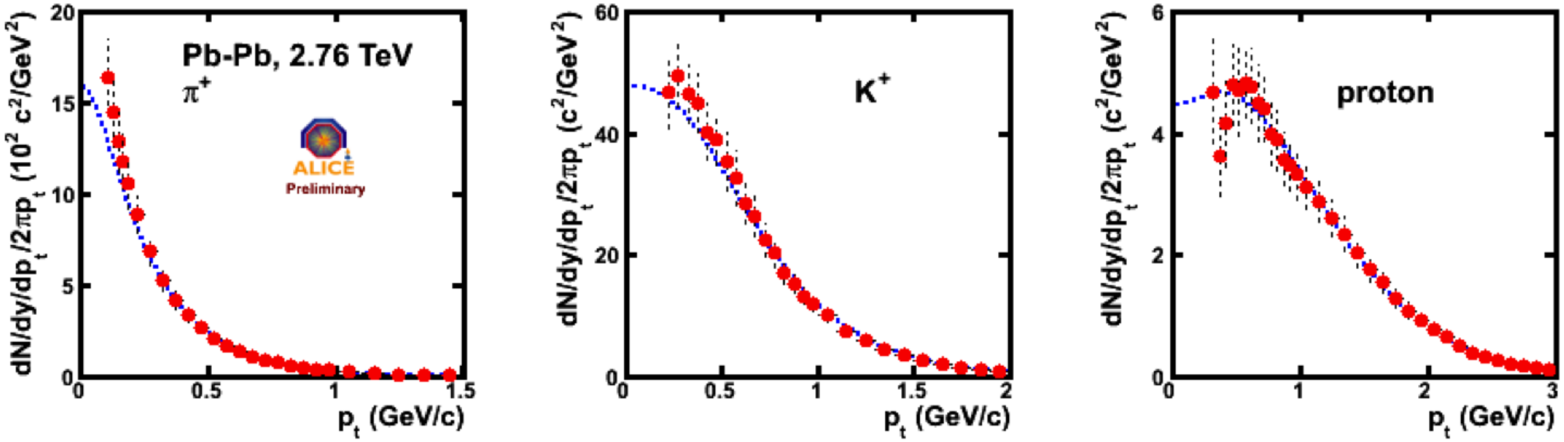
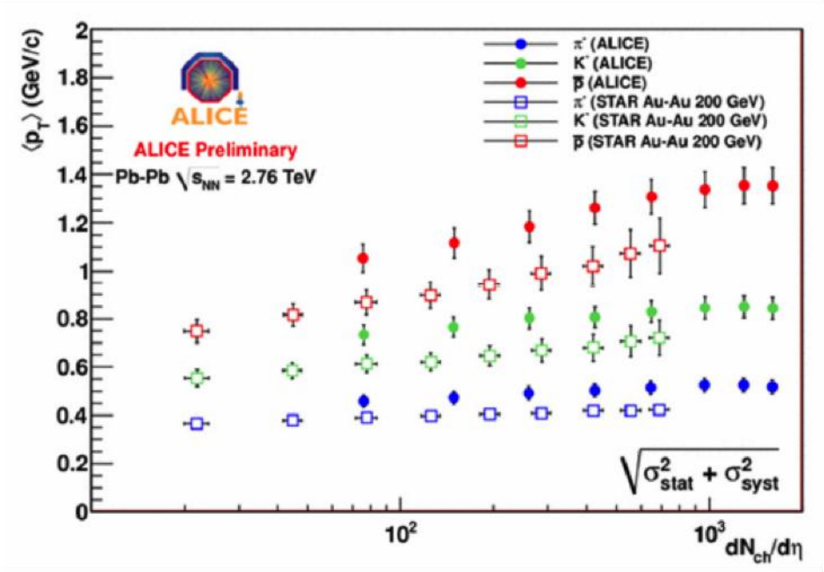


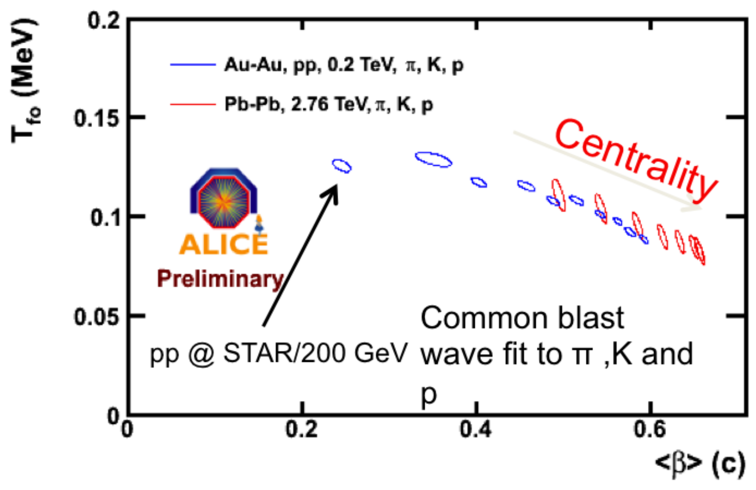
Radial Flow

Simultaneous BW Fit

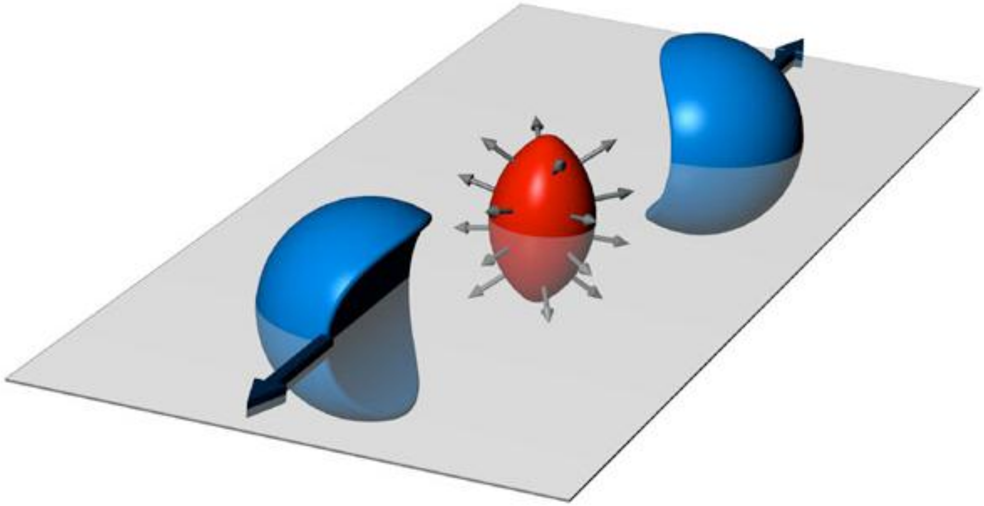
- $\beta \sim 0.66$
- $T \sim 80$ MeV

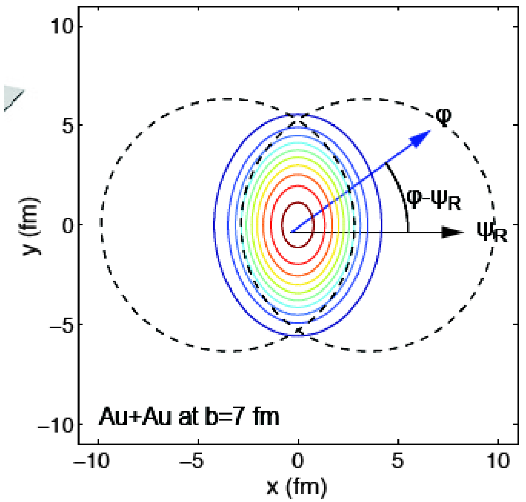






Elliptical Flow : Early Thermalization



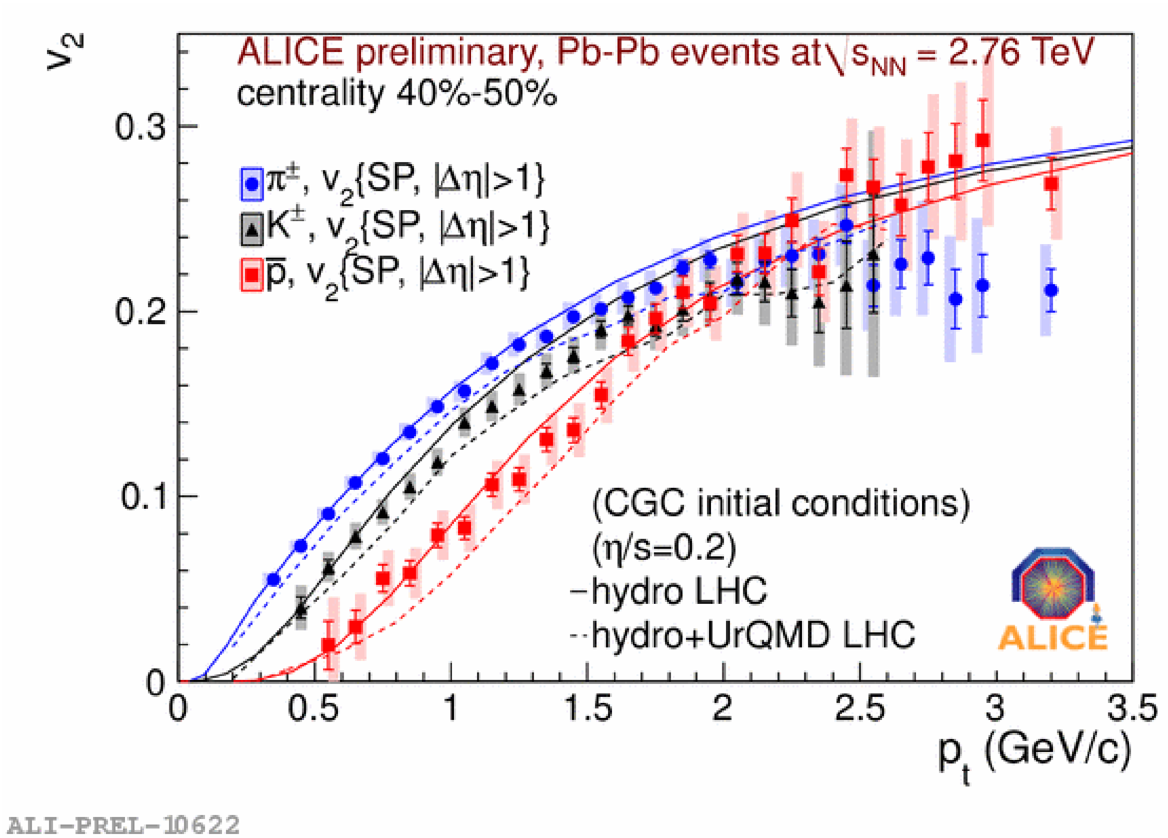


almond in space → interactions → pressure gradients → anisotropy in momentum ($\Delta p_x > \Delta p_y$)

$$\frac{dN}{d\varphi} \propto 1 + 2v_2 \cos[2(\varphi - \psi_R)] + \ldots$$

$$v_2 = \langle \cos[2(\varphi - \psi_R)] \rangle$$

Elliptical Flow : Perfect Liquid

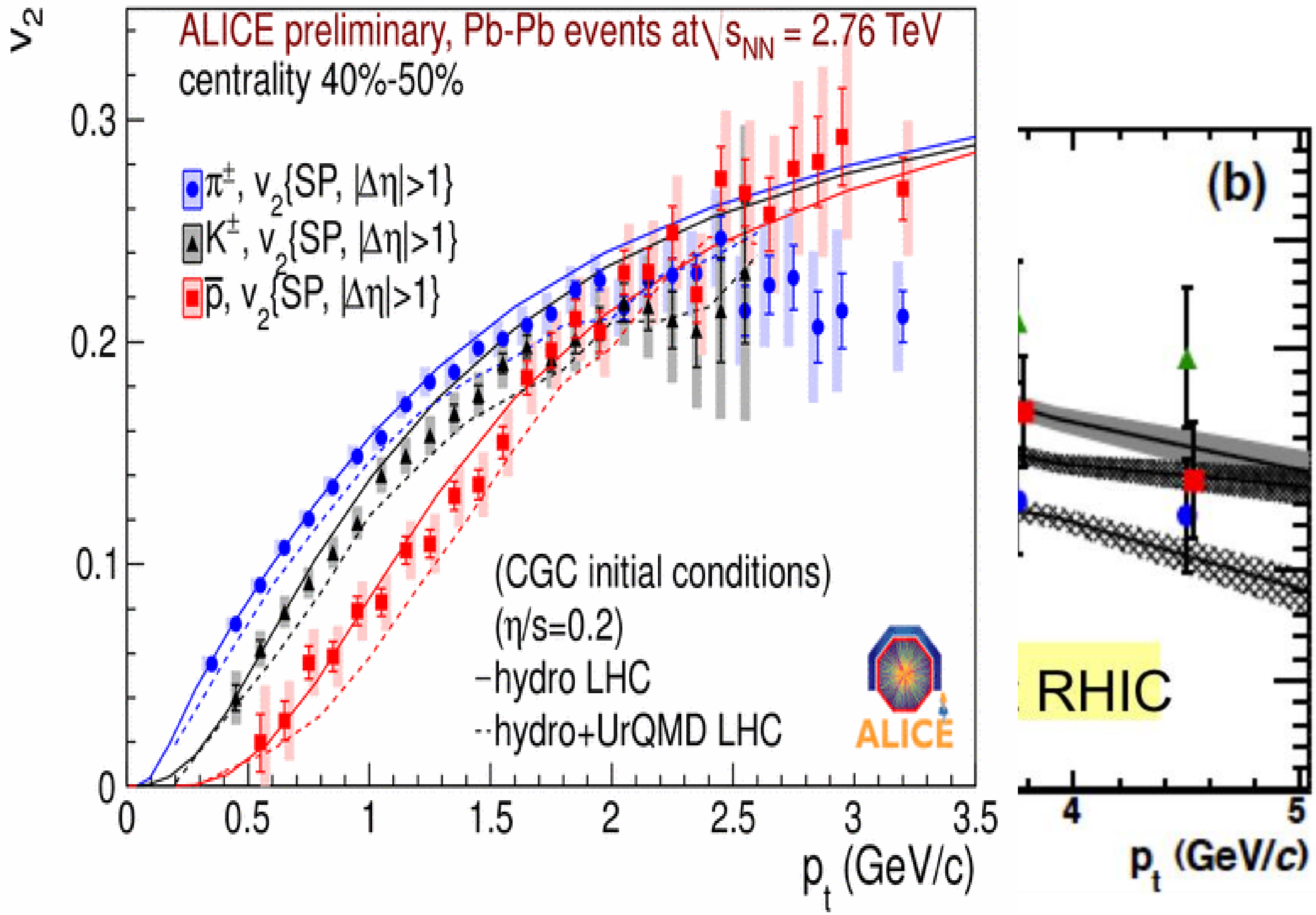


mass ordering at low p_T ← radial flow

Well described with hydro-calculation using η/s >=0.08 (AdS/CFT)

→ (almost) a perfect liquid

Elliptical Flow : RHIC vs. LHC



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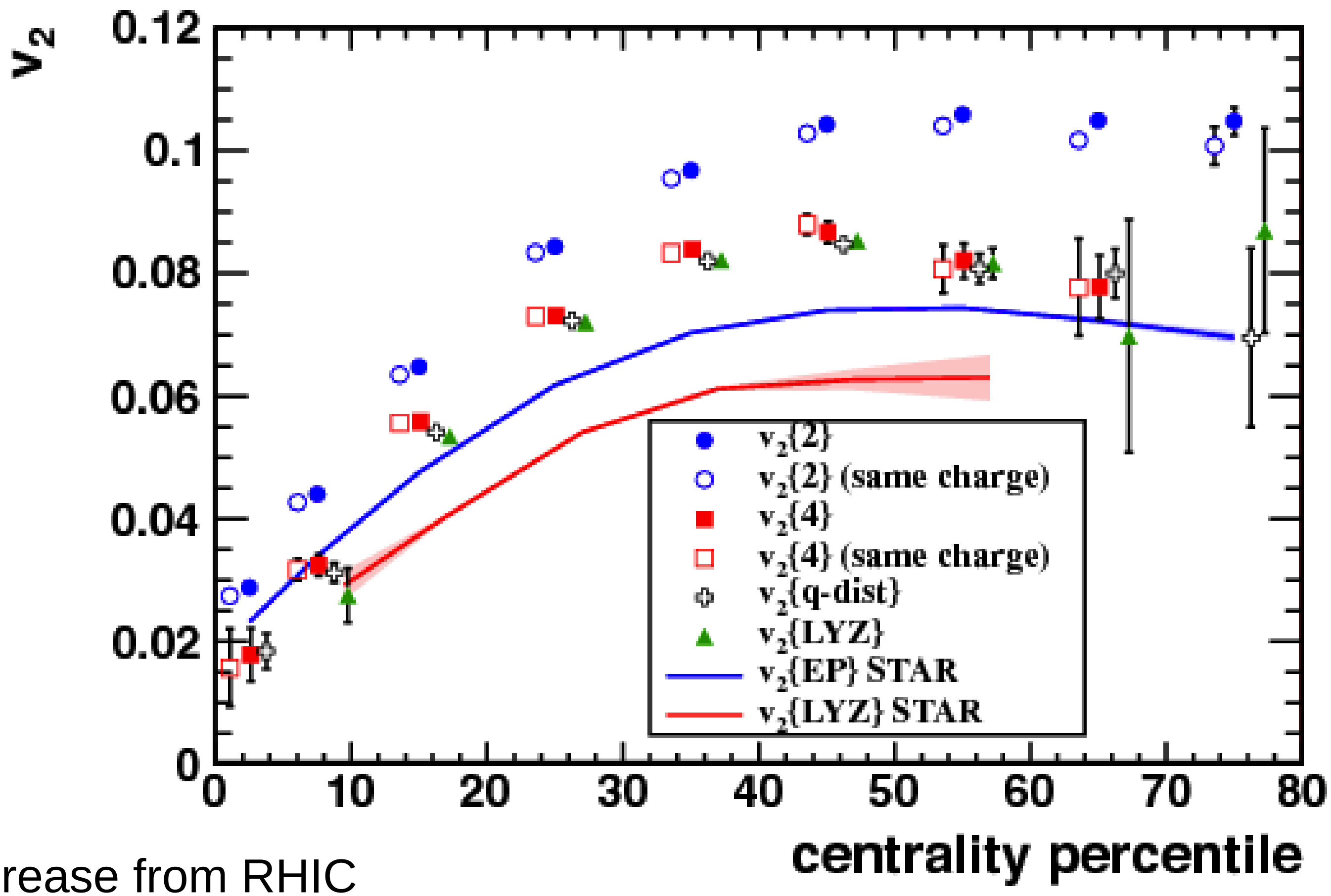
Elliptical Flow : RHIC vs. LHC

PRL105, 252302

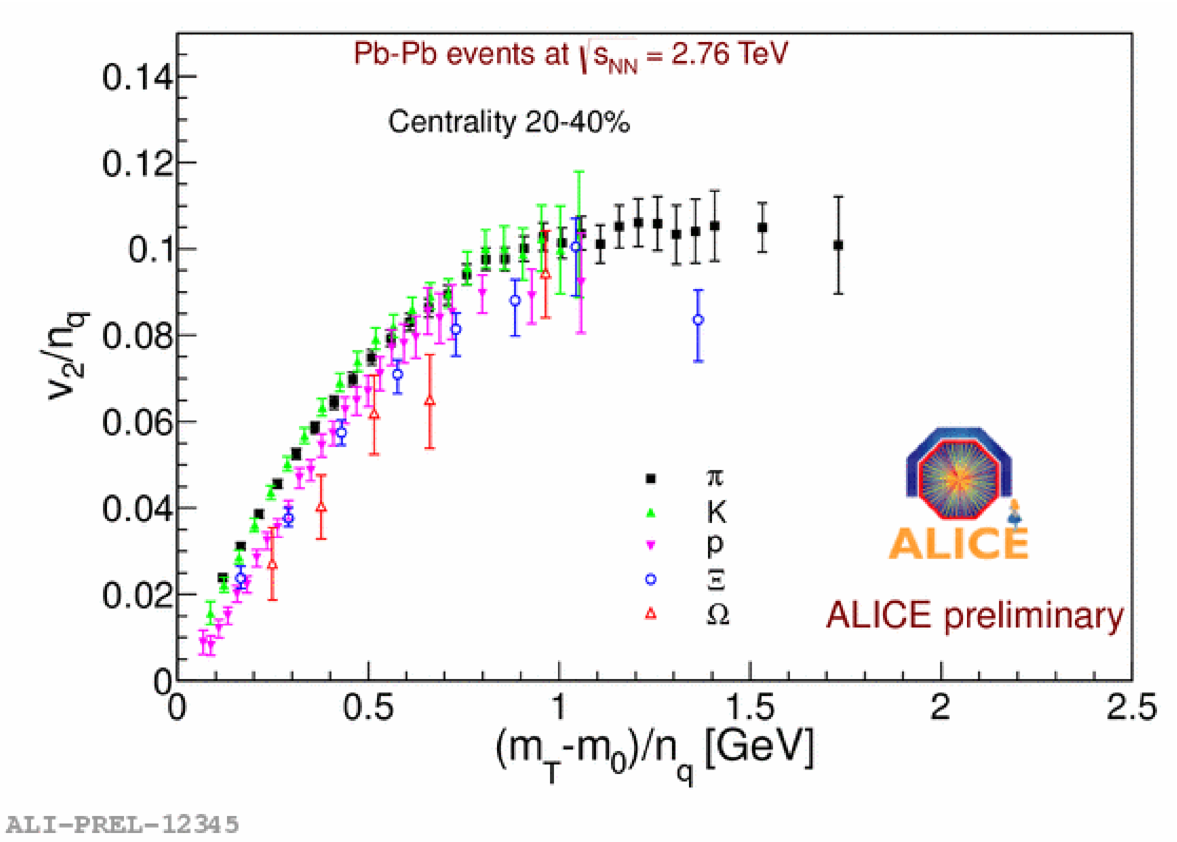


30% increase from RHIC

at the upper edge within hydro-prediction

Elliptic Flow : What and How?

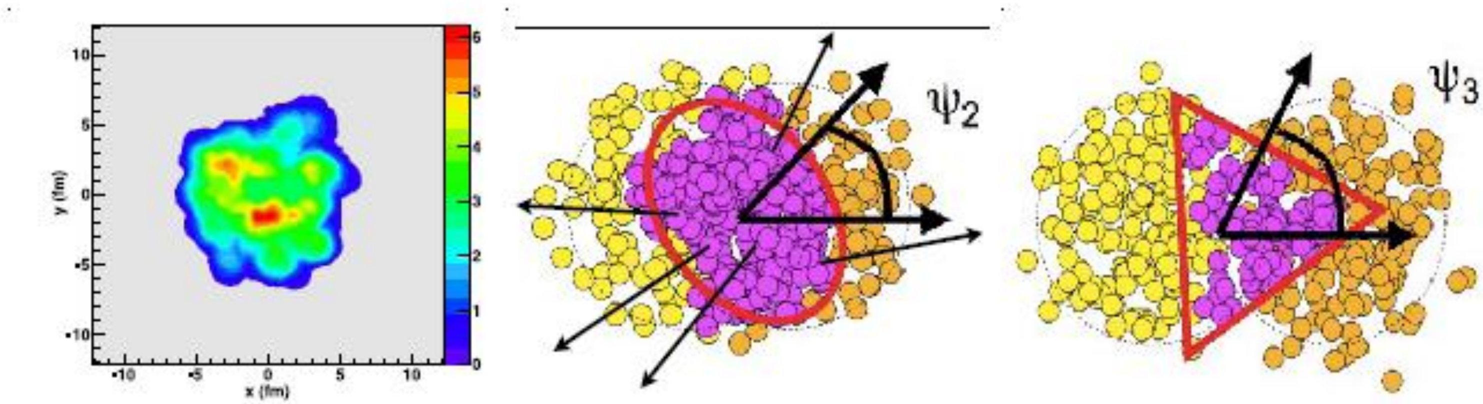
Quark Constituent Scaling



Partonic Collectivity

Initial Conditions

E-by-E fluctuations



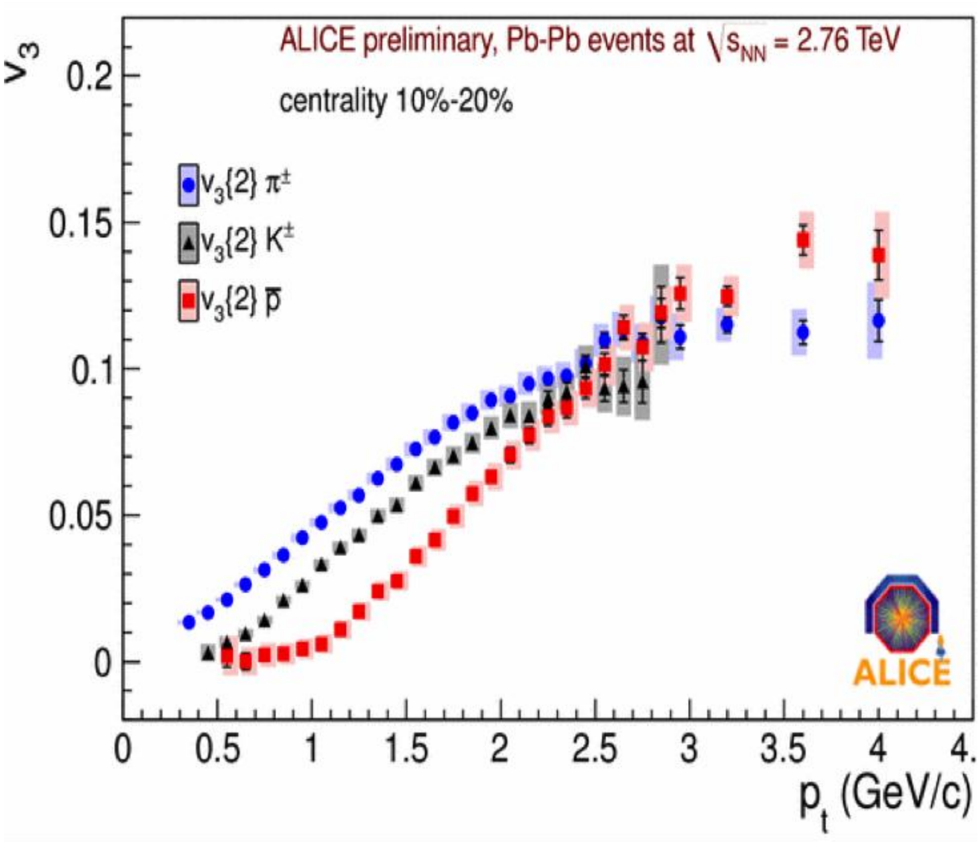
- v_2 is NOT enough for describing the angular dependence of particle density
- different initial shape and density in each event

→ different symmetry planes

→ higher order coefficient v_n

Higher Harmonics

Really from Flows?



- more mass splitting !

← predicted by hydro

- v_3 magnitude (also p_T dep.)

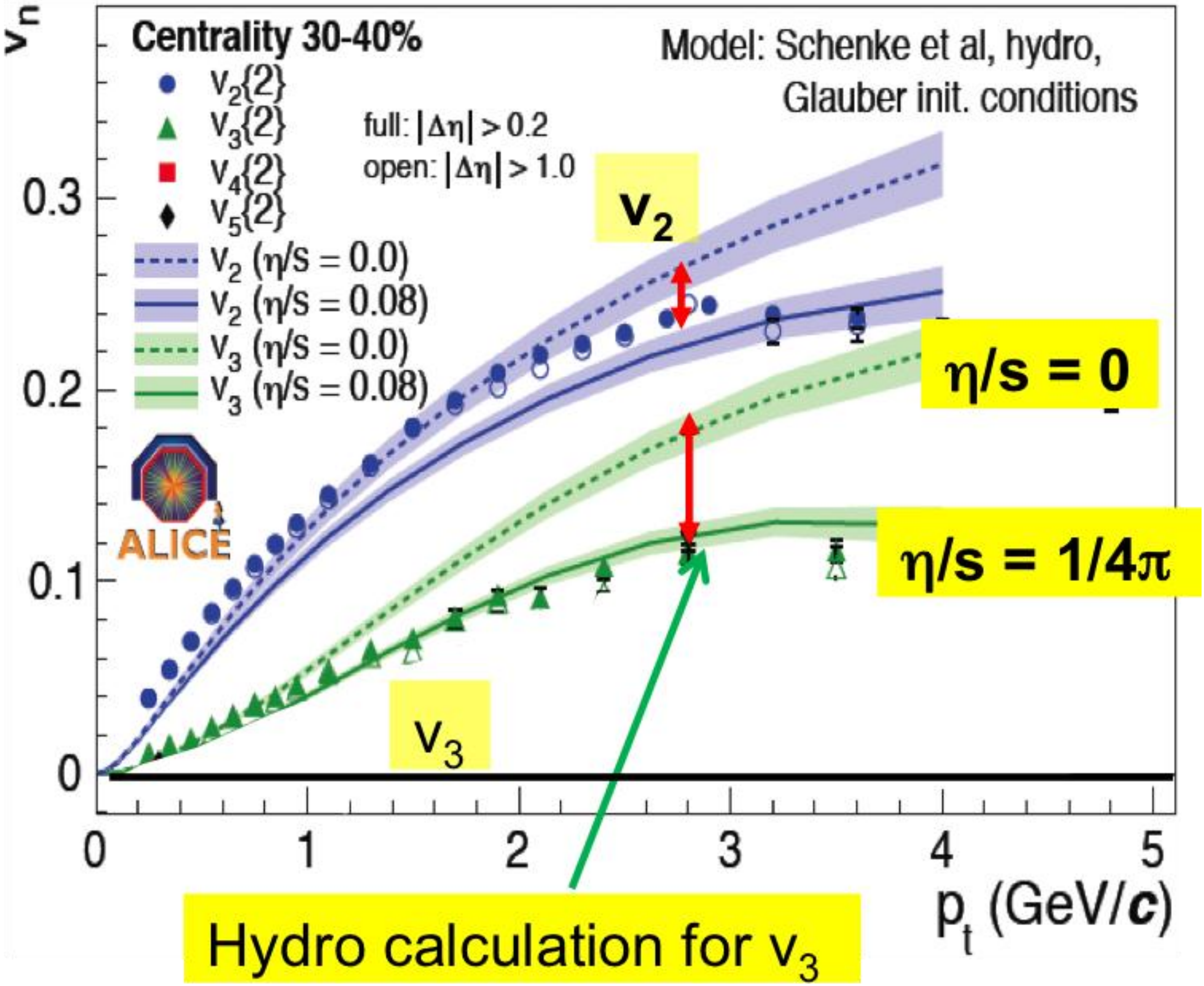
← expected by geometric fluctuations

- further study with v_n in angular correlation

Higher Harmonics

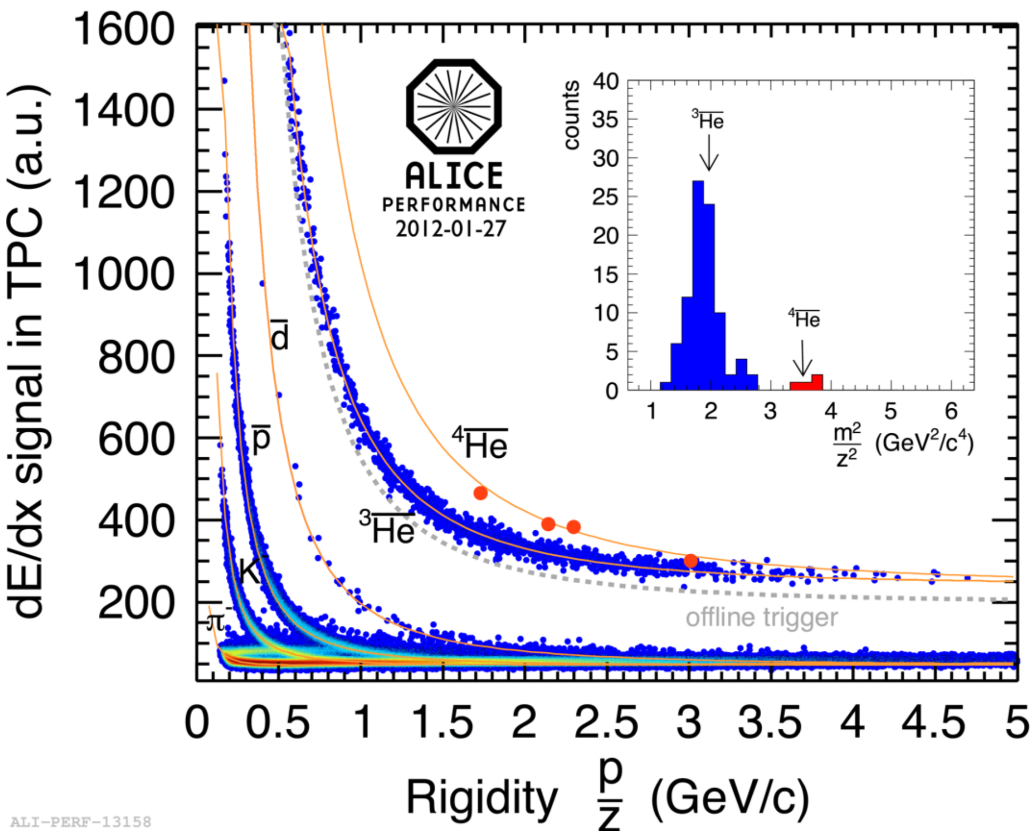
Sensitivity to η/s

PRL 107, 032301 (2011)



Miscellaneous

Anti-He4

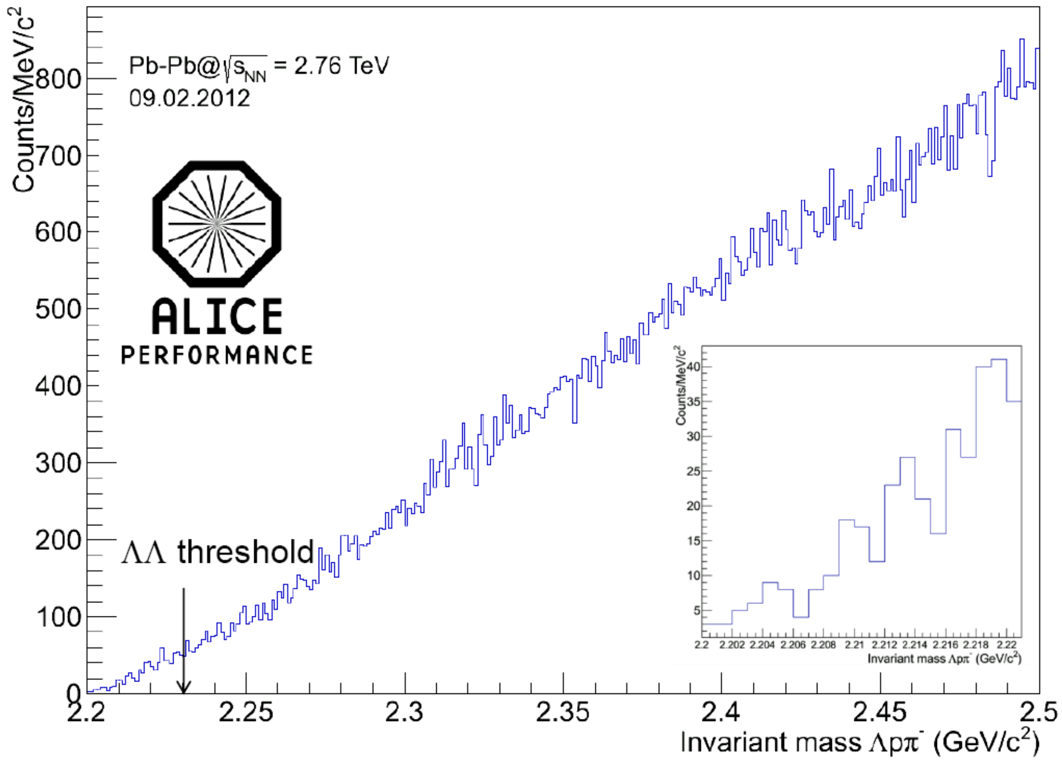


An improved version expected at QM2013

Miscellaneous

H-dibaryon

NO significant enhancement



ALICE

Summary & Outlook

- Multiplicity : $dN_{ch}/d\eta$ ~ 1600 (larger than most model predictions)
- ε > 15 GeV/fm^3 assuming τ < 1fm
- Radial Flow : transverse expansion with β ~ 0.66, T ~ 80 MeV
- Elliptical Flow : hydro with η/s >=0.08 – still a (almost) perfect liquid
- Initial conditions, Fluctuations : Sensitivity to η/s
- Miscellaneous : Antimatter particles confirmed, No H-dibaryon so far!

- ALICE upgrades : for 50kHz PbPb, 2MHz pp
    - ITS – B/D separation
    - MFT – b-tagging for Jpsi, dimuons at forward
    - VHMPID – PID (track-by-track) at higher pT up to 30 GeV/c
    - FOCAL – low x physics with γ/π^0