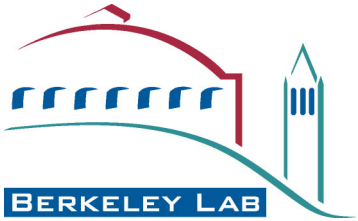
Results from ALICE

Mateusz Ploskon

ALICE Collaboration



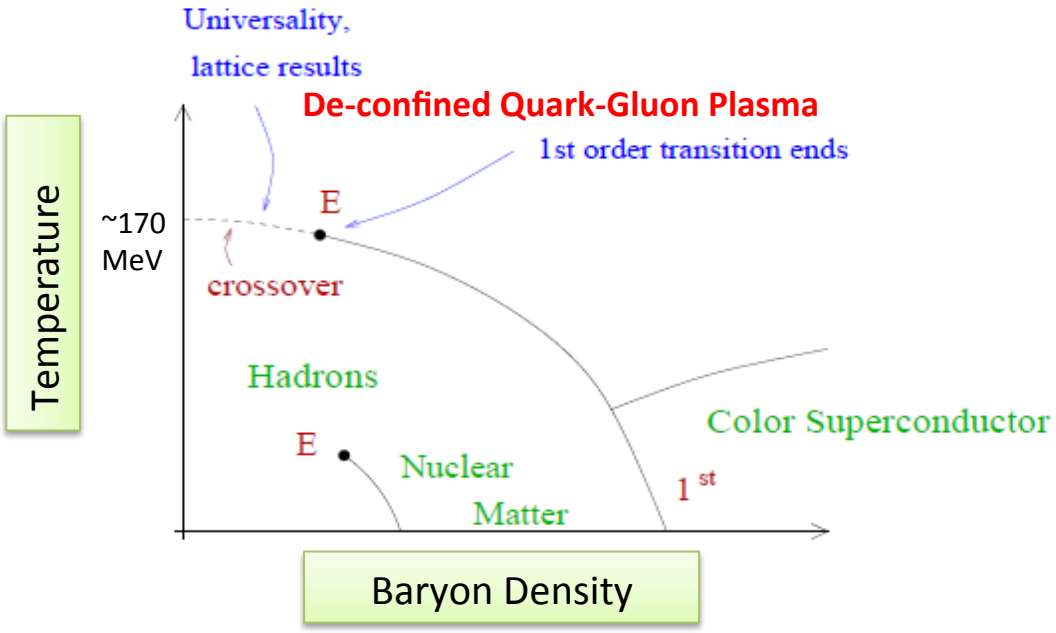
ALICE Status in 2012

- Overall very good performance throughout the year
  - Despite some issues with machine background
  - Reference p-p data sample ~doubled
- Physics harvest from the 2011 run continues
  - new details on properties of Quark Gluon Plasma (QGP) with photons, open charm, quarkonia, jets and particle correlations... (only few examples shown today)
- Very useful pilot p-Pb run from the LHC:
  - Already 3 ALICE papers submitted
  - Important findings (!)
  - Large appetite for the 2013 run – community in anticipation of the large statistics data

Hot QCD in laboratory => Heavy-ion collisions at the LHC

- QCD (lattice) predicts a phase transition from hadronic matter to a deconfined phase at high temperatures
- QGP at $\mu \sim 0$ similar to early Universe (~few first μs)
- First signals of QGP from SPS and RHIC
- LHC: detailed studies of QGP exploiting wealth and abundance of [hard] probes (heavy-quarks, jets, quarkonia…)

QCD phase diagram



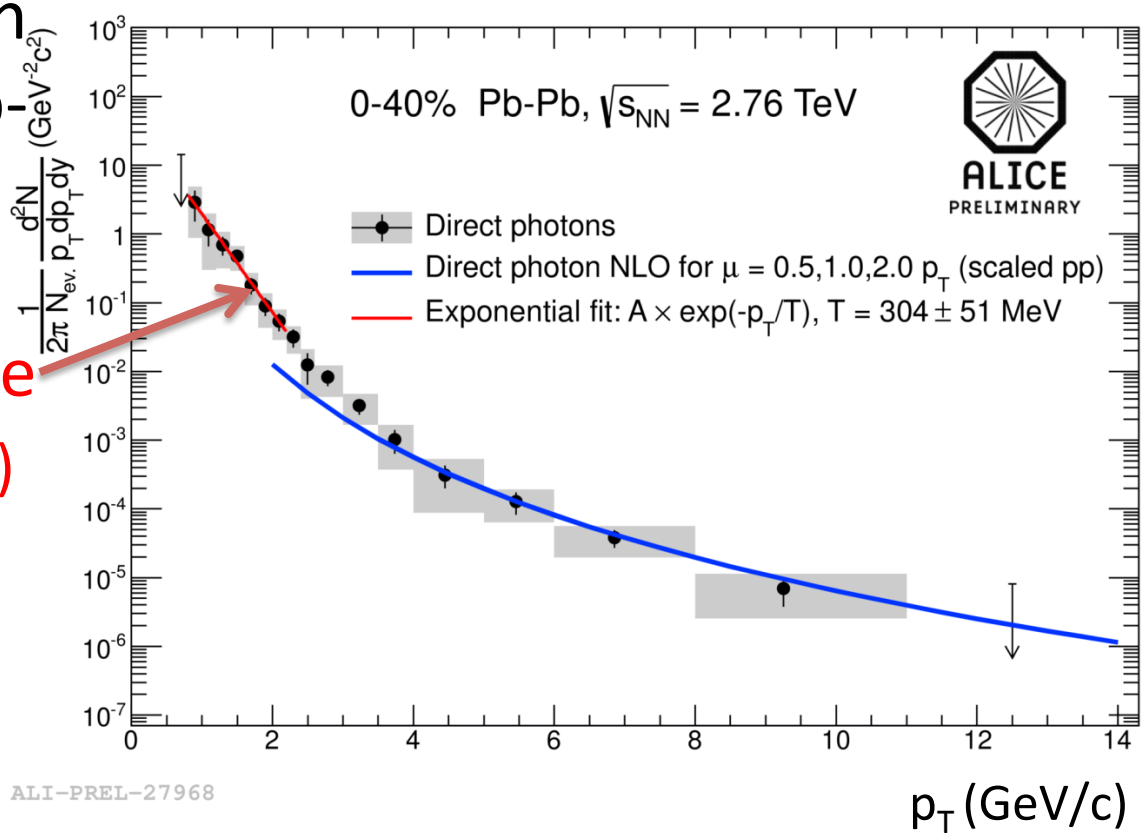
QGP Properties (Example #1)

Quantifying QGP radiation with photons – QGP glows

Production cross-section of photons in central Pb-Pb collisions

Photons shining from the plasma (thermal emission)

the LHC Quark-Gluon Plasma is the hottest man-made matter

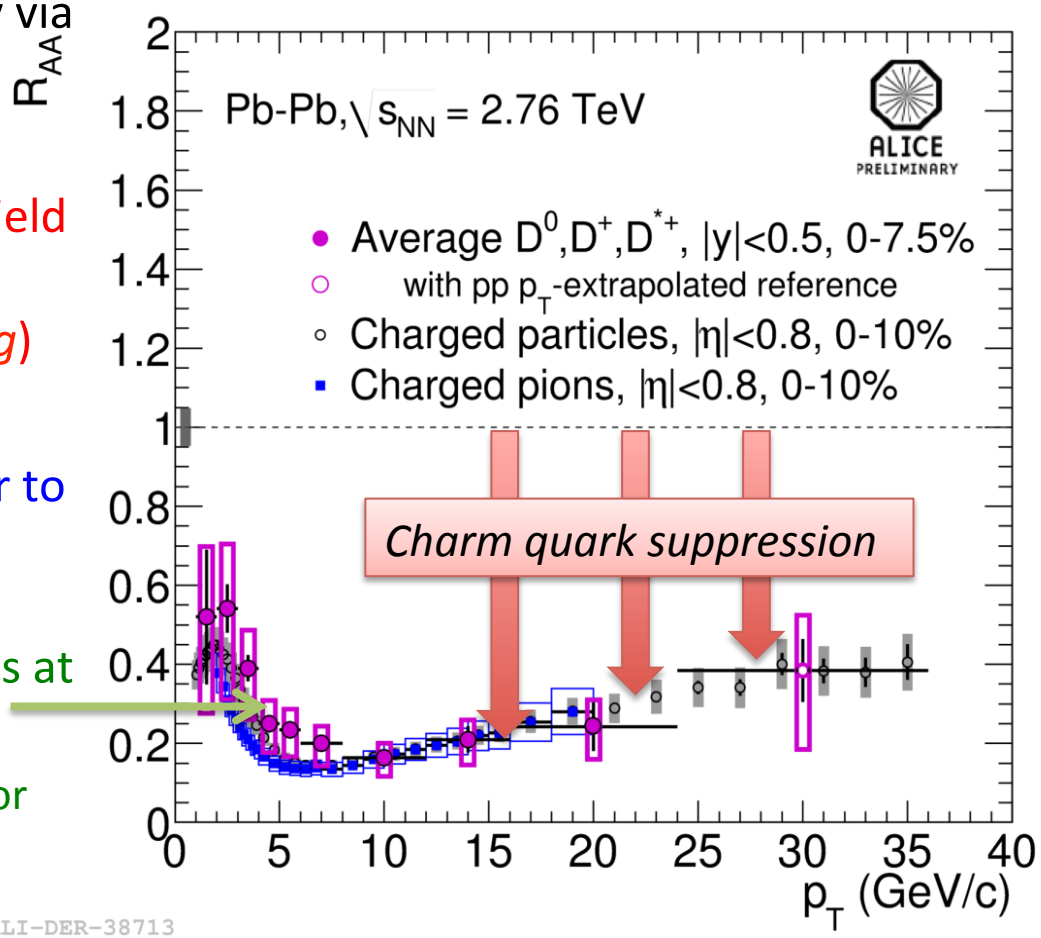


Inverse slope of the exponential fit (p_T<2 GeV/c): 304 +/- 51 MeV

QGP properties (Example #2): Charm suppression ⇔ Jet quenching

Studies for colour charge and mass dependence of parton energy loss

- D-mesons measured at mid-rapidity via hadronic decays
- R_{AA} - suppression pattern (ratio of yield in Pb-Pb to yield in proton-proton) shows a strong deficit (*jet quenching*)
- Quenching: charm at high-pT similar to light flavor
- Possible hint of colour charge effects at low-p_T (below 10 GeV/c)
  - => need better precision (outlook for next years and upgraded detector)

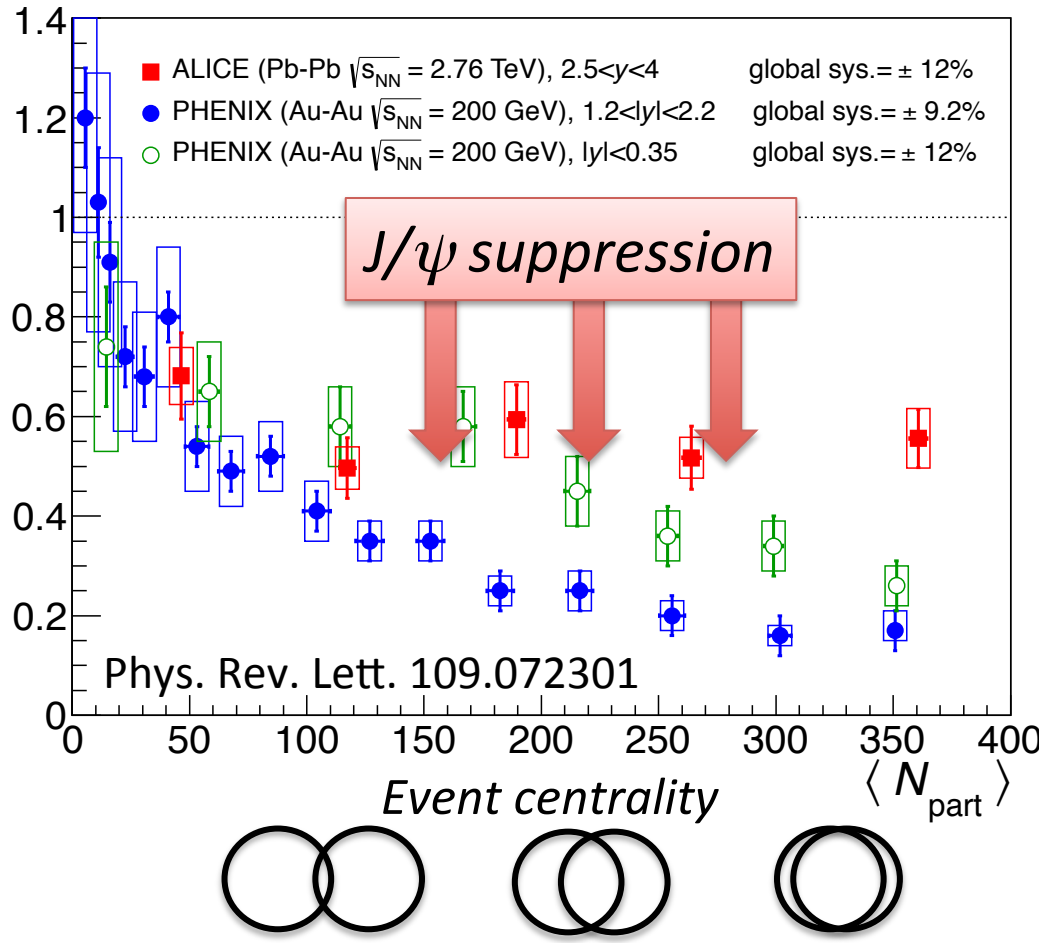


QGP Properties (Example #3): J/ψ

- Inclusive J/ψ yield lost in central Pb-Pb collisions as compared to equivalent number of p-p collisions
  - Quarkonia "melts" within QGP
- LHC: Less suppression than at RHIC and flat centrality dependence
- => in-medium ccbar recombination?
- Important: better knowledge of initial state effects crucial – cold nuclear matter / shadowing / saturation

J/ψ measured with forward muon arm

J/ψ—>$\mu^+\mu^-$



QGP Properties (3/3): J/ψ

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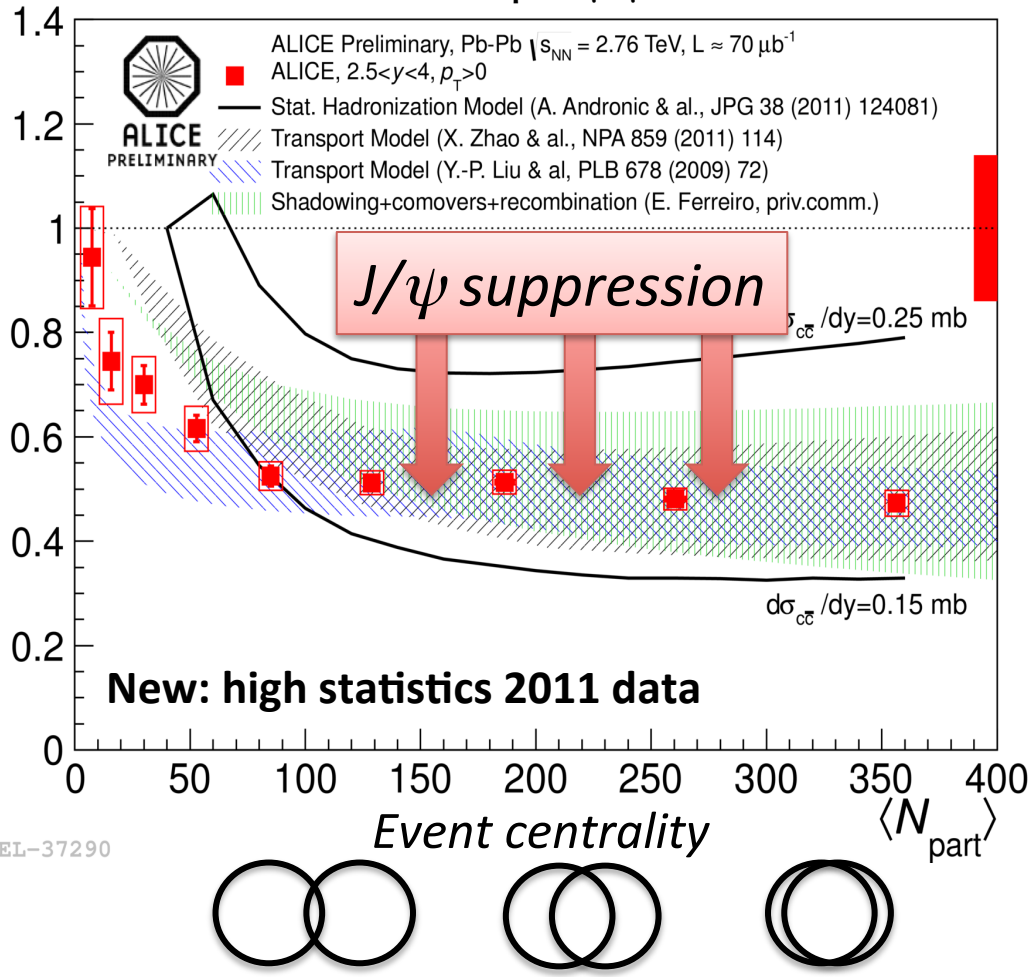


Fresh off the press: Results from p-Pb

p-A: Address cold nuclear effects and calibrate findings related to hot QGP

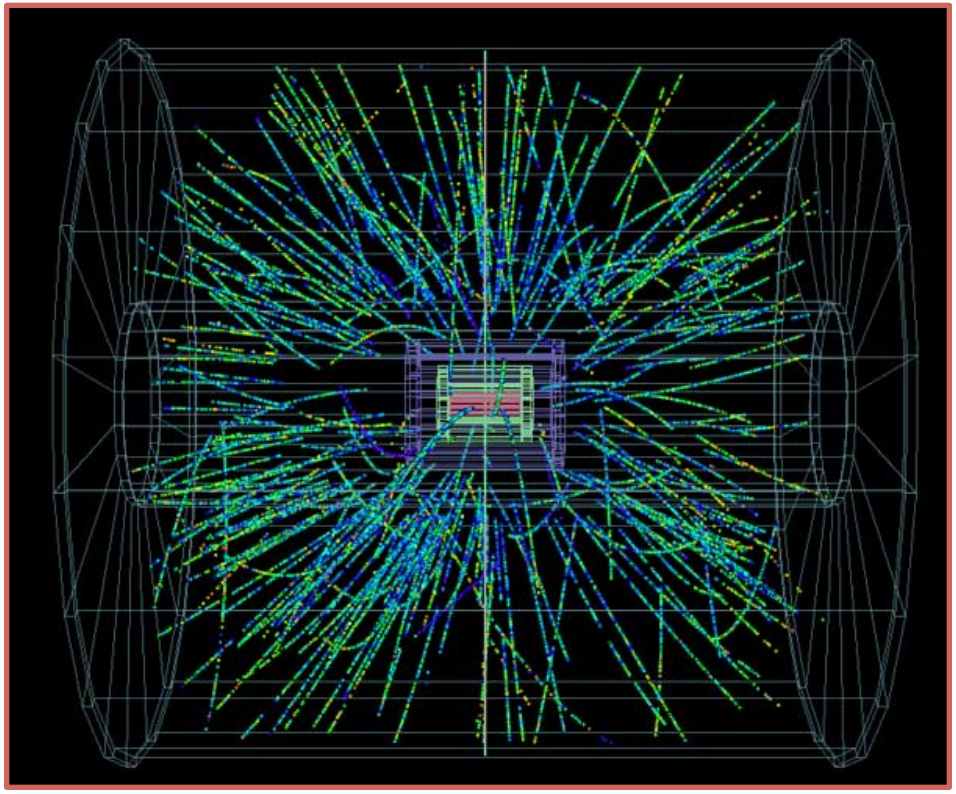
Few hours of stable beams at low luminosity

$\sqrt{s_{NN}}$=5.02 TeV

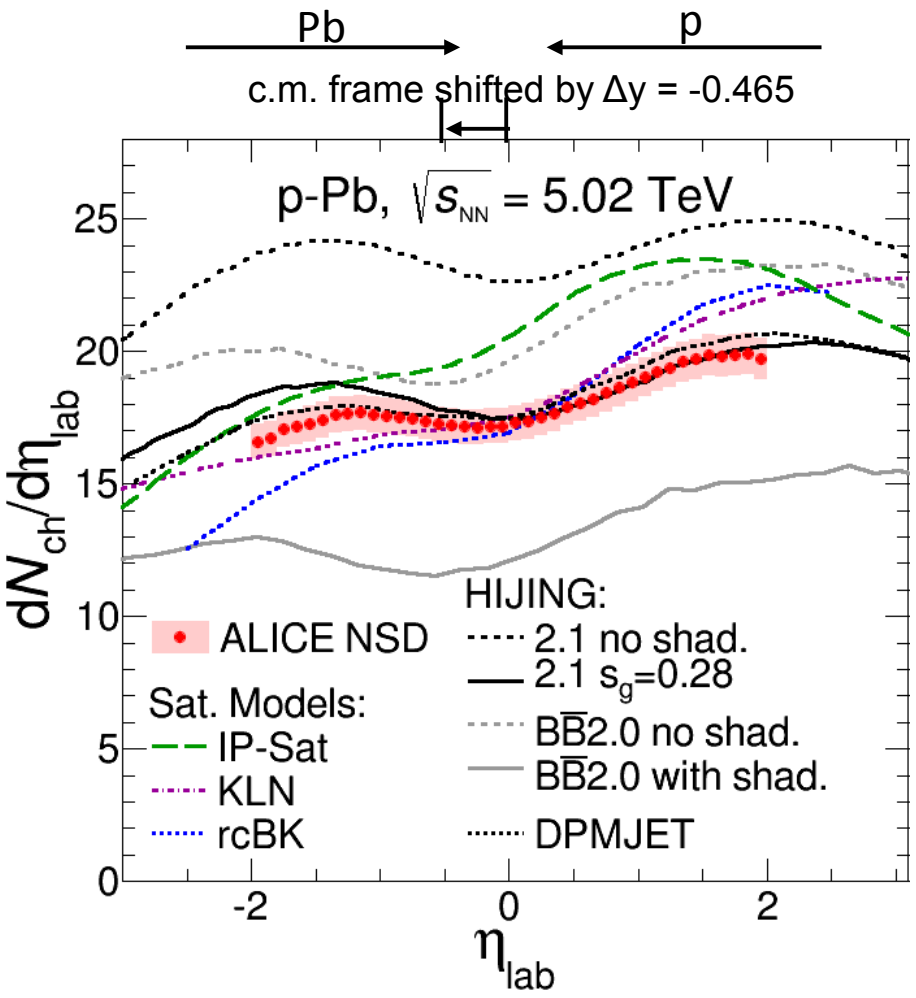
Recorded ~2M min-bias events (after event selection)

THANK YOU LHC CREW!

A p-Pb collision at ALICE side-view



"Calibration" measurement – $dN_{ch}/d\eta$



ALICE: arXiv: 1210.3615

Basic measurement allows to discriminate between models

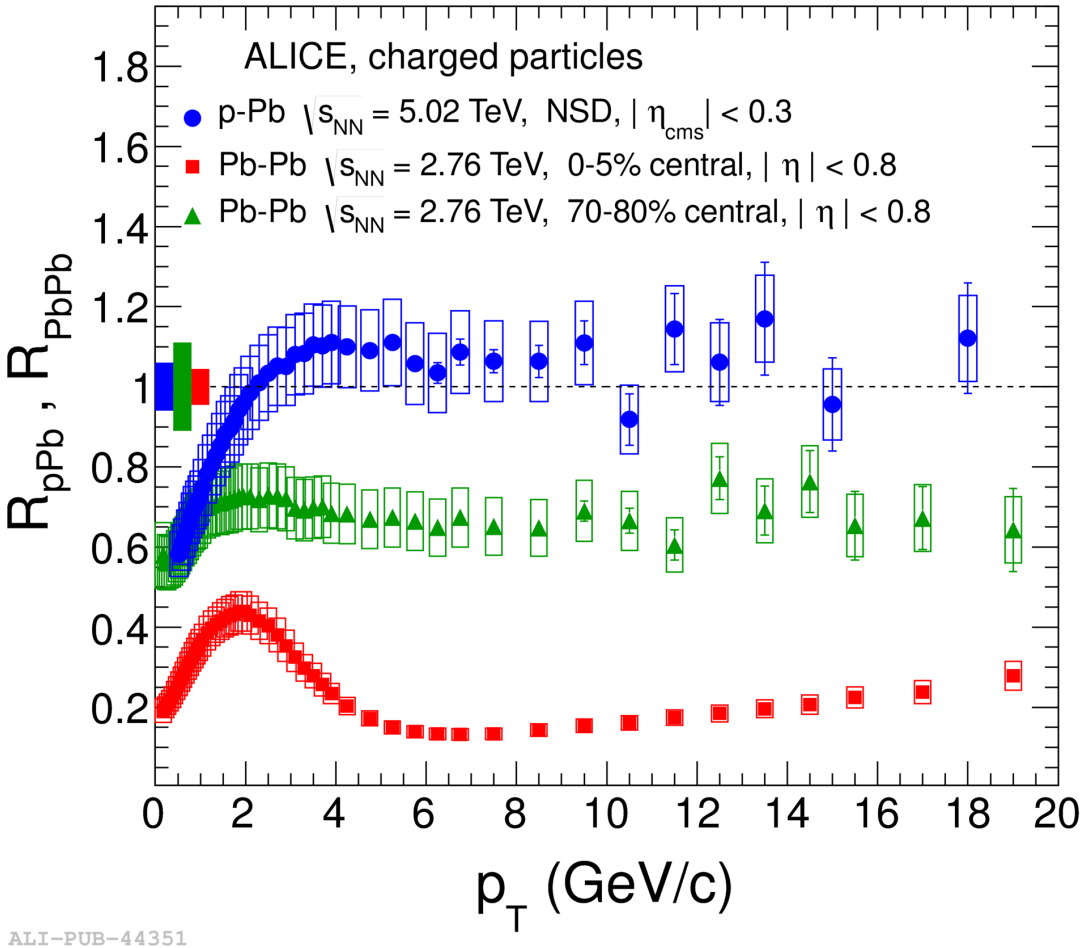
Data favors models that incorporate shadowing

Saturation models predict much steeper η-dependence not seen in the data

Cold nuclear matter effects vs. jet quenching in Pb-Pb…

Ratio = particle yield in p-Pb per single N-N collision / particle yield in proton-proton

ALICE: arXiv: 1210.4520



Compatible with unity above 2-3 GeV/c

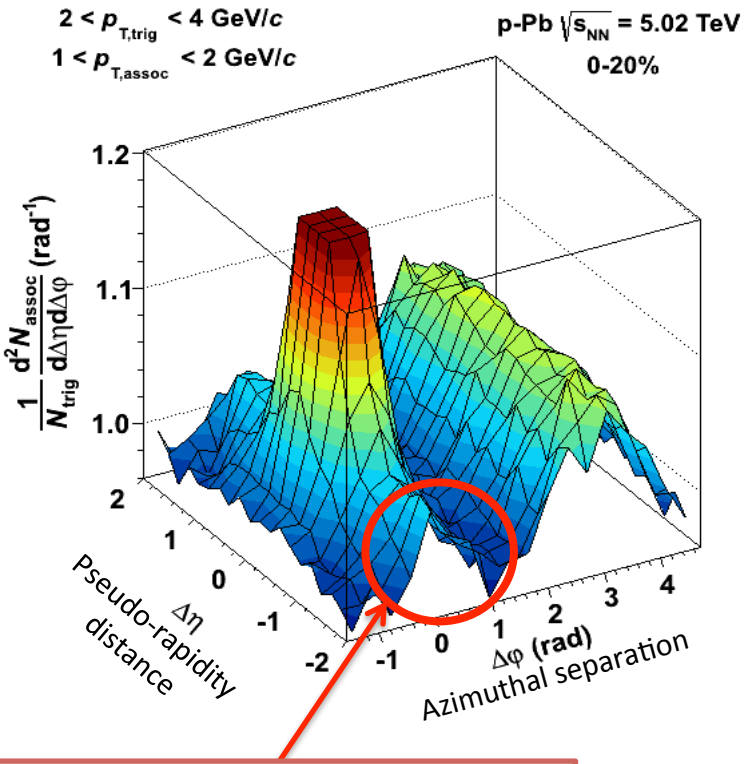
=> Binary scaling is preserved, no evidence of initial state effects

Jet quenching in Pb-Pb collisions is a final state effect (parton energy loss)

Two-particle long range correlations: The ridge in high-multiplicity events

Correlations for pairs of trigger and associated particles, $p_{T,trig}>p_{T,assoc}$, as $f(\Delta\varphi,\Delta\eta)$, defined as associated yield per trigger particle

ALICE p-Pb **arXiv:1212.2001**

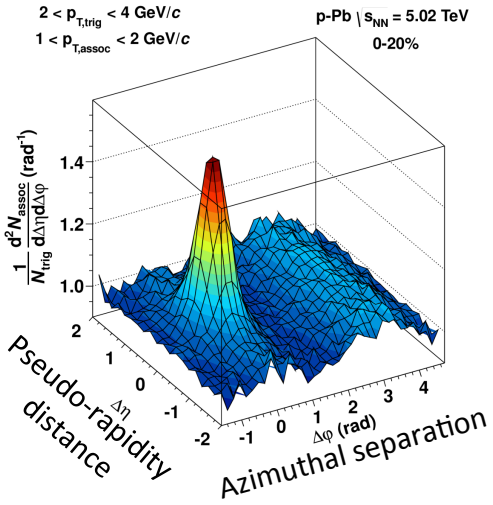


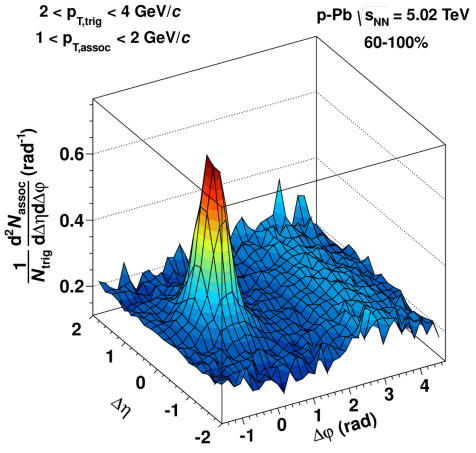
Long range correlation qualitatively similar to CMS

- **ALICE: qualitatively similar observation as compared to CMS**
  - Despite smaller rapidity coverage
  - **Elongated structure seen in high-multiplicity events**
  - Direct comparison with CMS to follow
- **Next: quantification of the finding…**

ALICE: Extraction of ridge properties

Method: from the high-multiplicity yield subtract the jet yield in low-multiplicity events (no ridge)





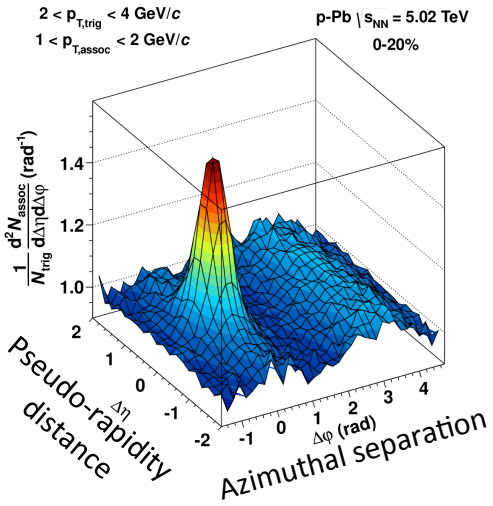
High multiplicity event class
$\langle dN_{ch}/d\eta \rangle \sim 35$

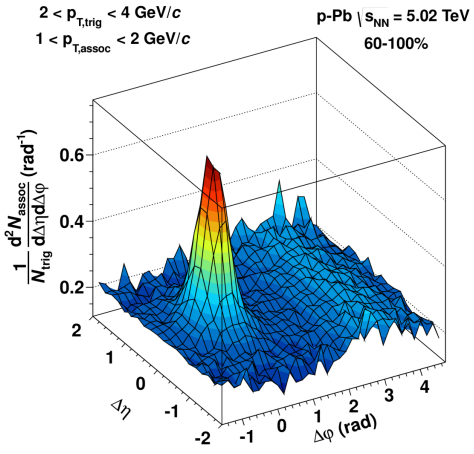
Low multiplicity event class
$\langle dN_{ch}/d\eta \rangle \sim 7$

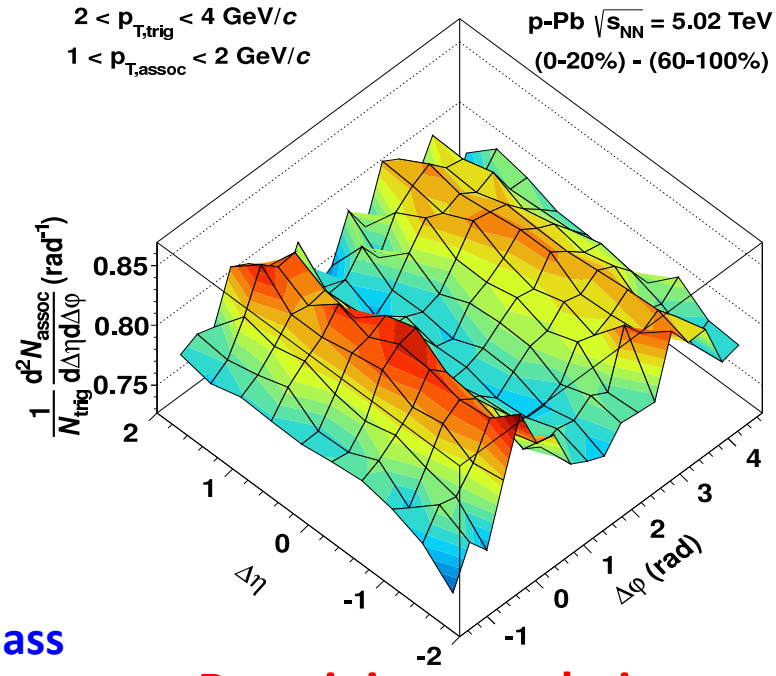
Analysis in multiplicity classes defined by the total charge in VZERO detector (away from the central region)

Extraction of ridge properties

The method: from the high-multiplicity yield subtract the jet yield in low-multiplicity events (no ridge)







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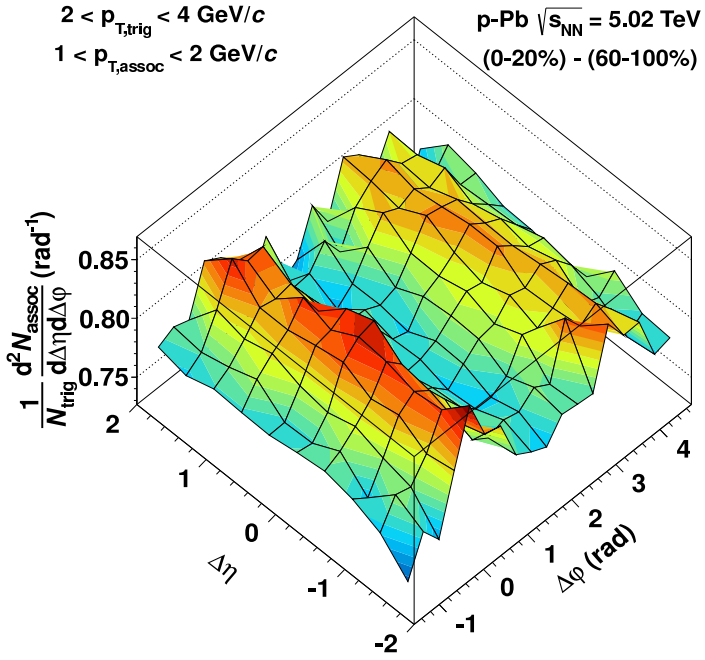
Remaining correlation: two twin long range structures

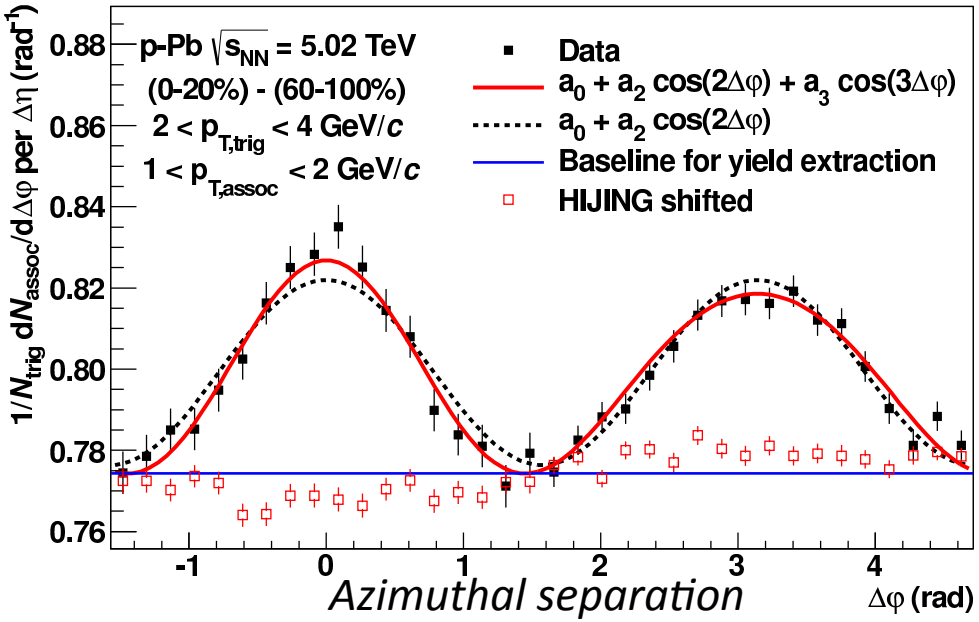
Analysis in multiplicity classes defined by the total charge in VZERO detector (away from the central region)

Twin ridge structure uncovered

ALICE: arXiv:1212.2001



Remaining correlation described by finite amplitudes of Fourier terms



Further investigations reveal:

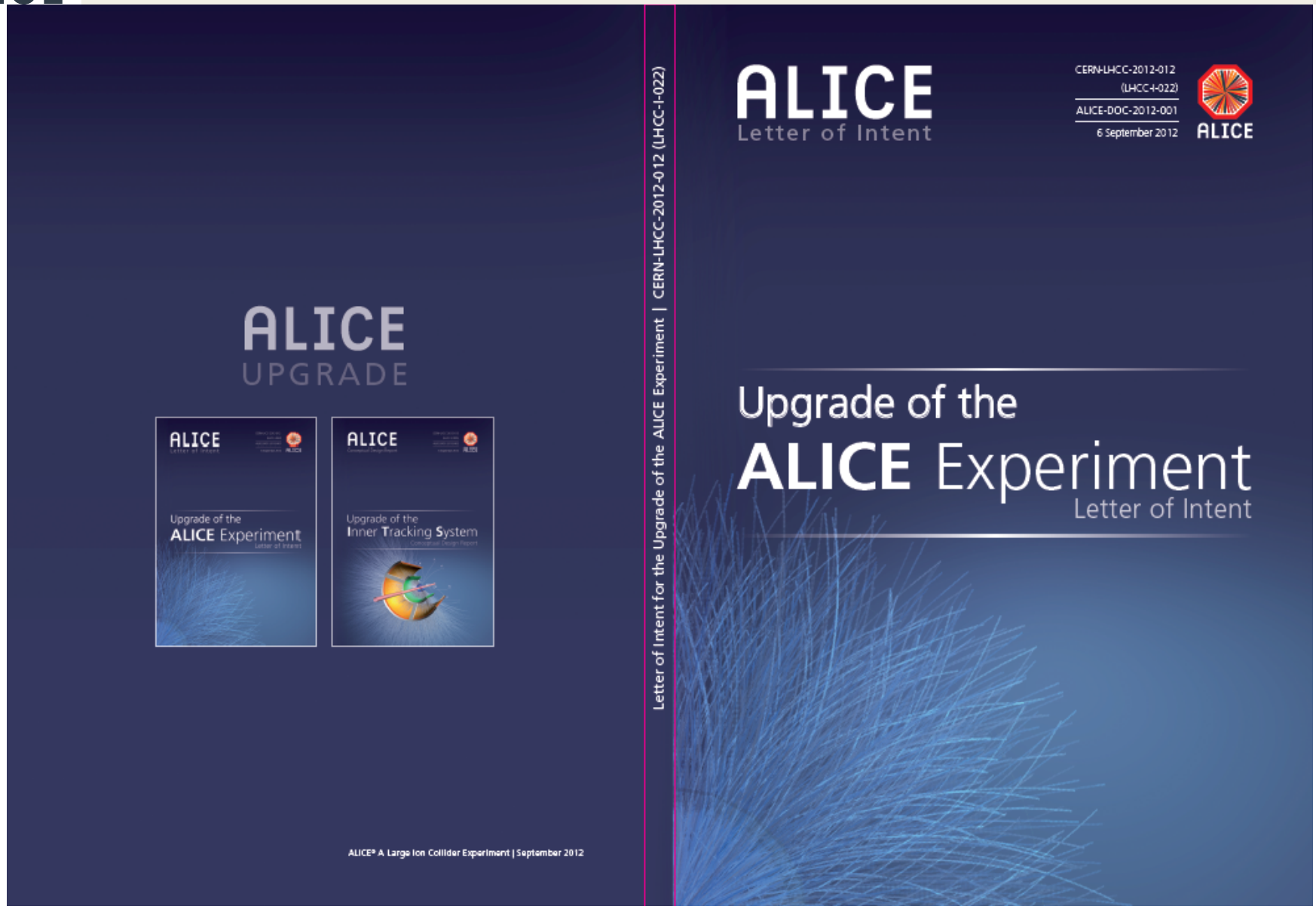
- **the full modulation is (1) di-jets and (2) the double-ridge structure – nothing more**
- **Same yield near and away side for all classes of p_T and multiplicity suggest a common underlying process**

Similar observations in Pb-Pb are ascribed to collective effects!

First explanations are being put forward:

- Hydrodynamics – arXiv: 1112.0915
- Colour Glass Condensate – arXiv:1211.3701

ALICE Upgrades Plans



ALICE Upgrades Plans

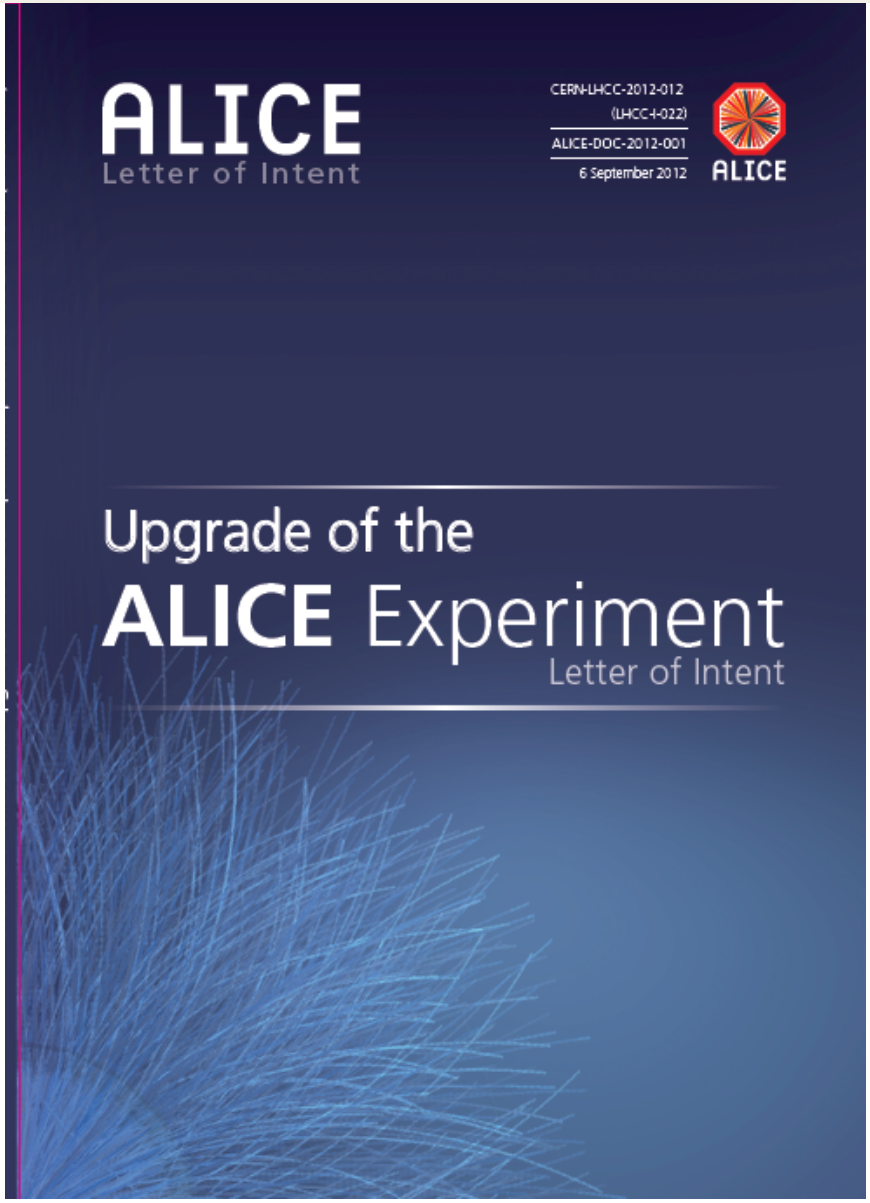
High-energy heavy-ion physics :

- Transition from exploratory phase to high-precision measurements of QGP

=> charm and beauty era

ALICE Upgrade Letter of Intent presents long-term plan for high-luminosity LHC, based on:

- Ambitious physics programme
- Improvements for heavy-flavor, low-pT and high rate capabilities



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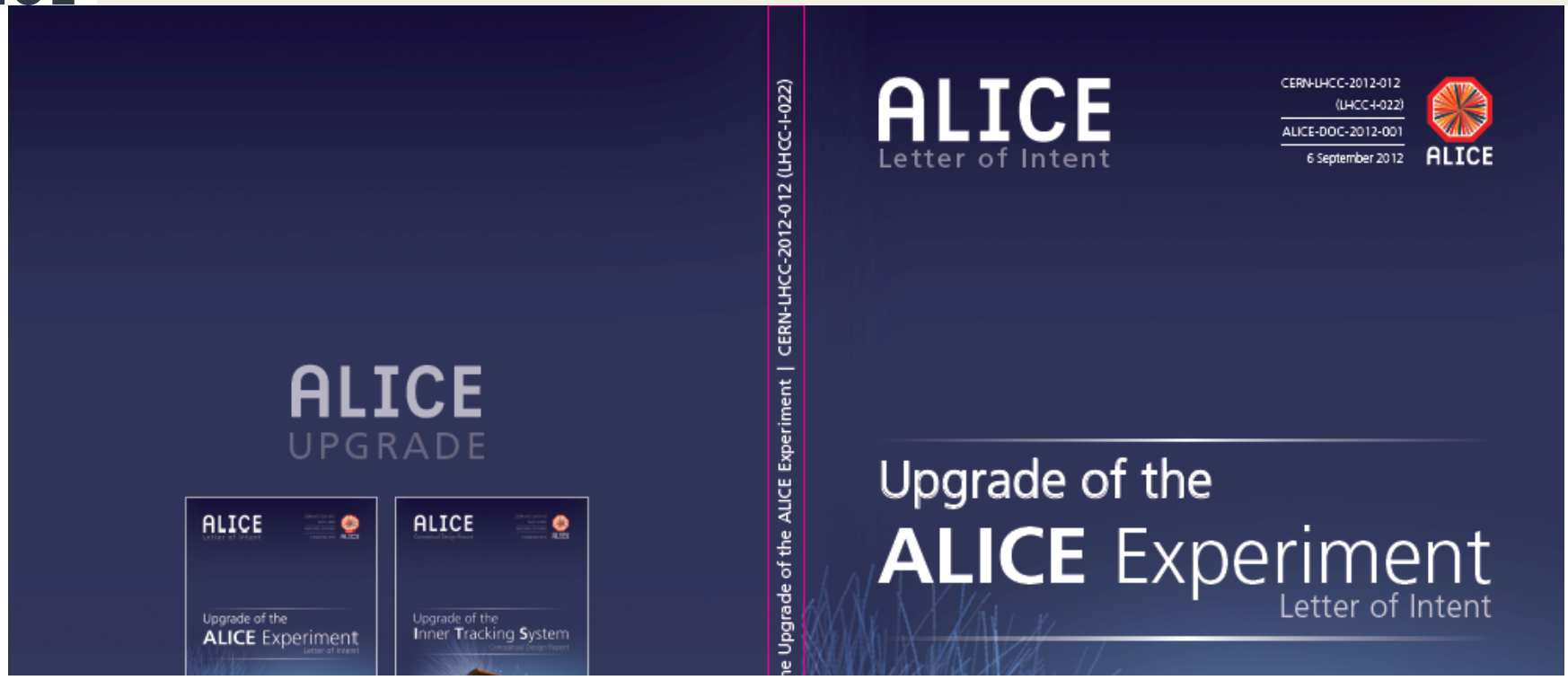


LHCC On September 27, the LHCC has endorsed the ALICE Upgrade LoI and ITS CDR.:

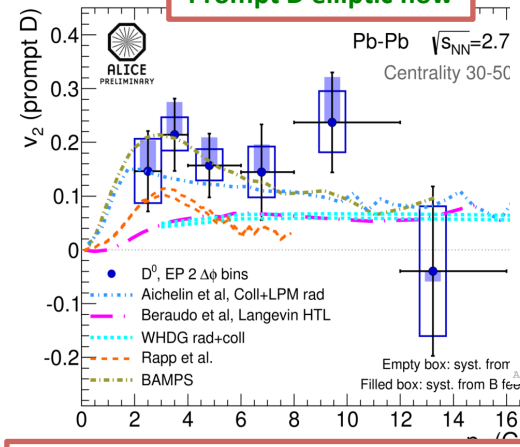
"The LHCC commends this joint approach to heavy ion physics and endorses the upgrade plans of the ALICE collaboration. The committee is looking forward to the seeing the detailed technical solutions presented in the respective TDRs."

ALICE looking forward to an exciting long-term future!

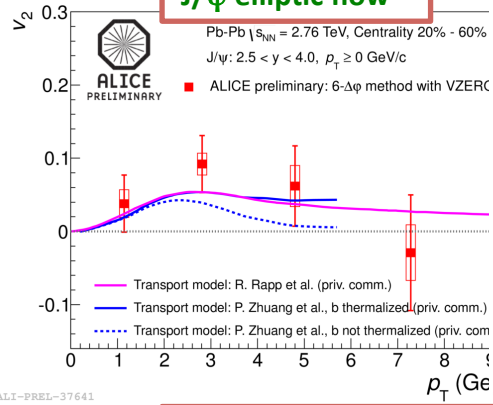
Instead of summary… many more results!

By far not all shown here!

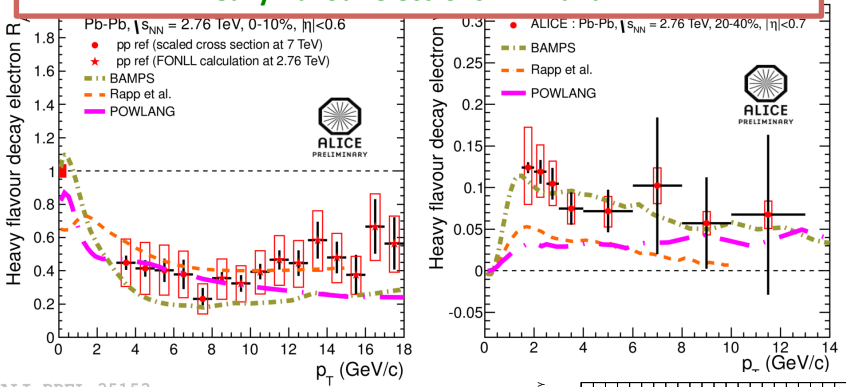
Prompt D elliptic flow



J/ψ elliptic flow

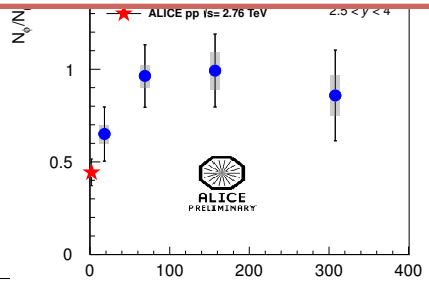


heavy-flavour electrons: RAA and v2

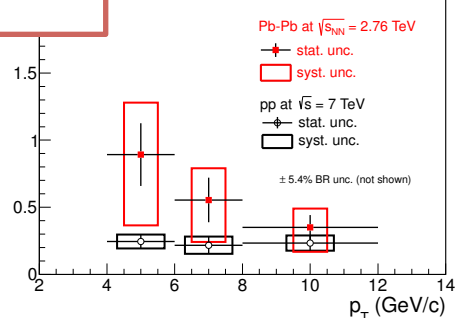


Low-mass di-muon spectra in Pb-Pb

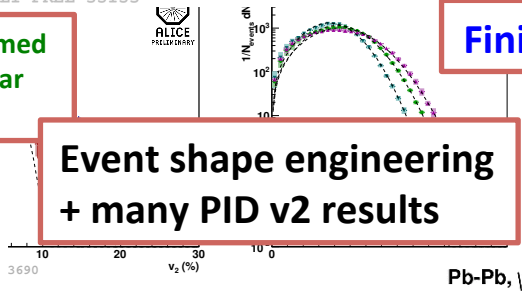
⇒ Ratio of yields: ϕ / ω+ρ



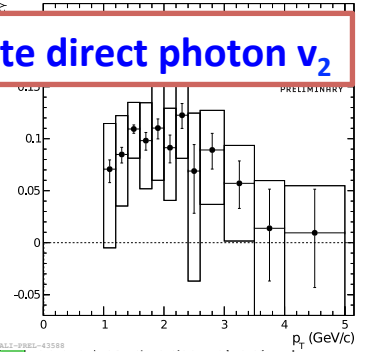
s-enhancement with charmed mesons: D_s^+/D^0 ratio (similar effect for D_s^+/D^+)



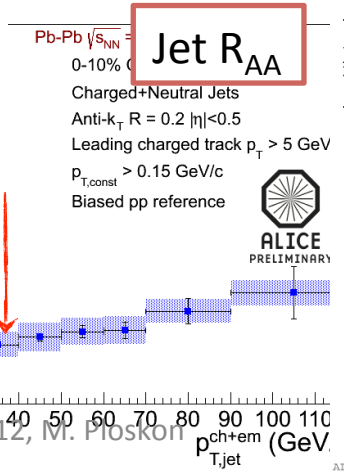
Event shape engineering + many PID v2 results

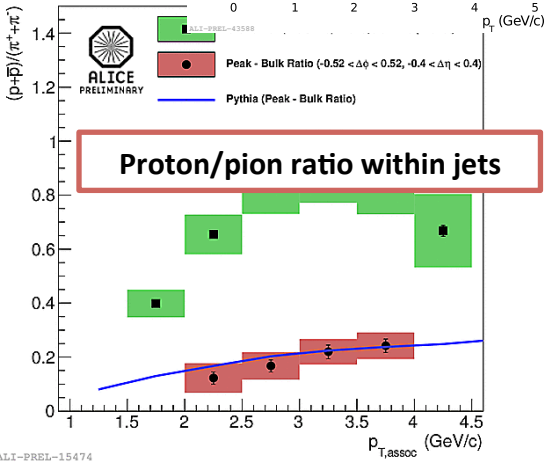


Finite direct photon v_2



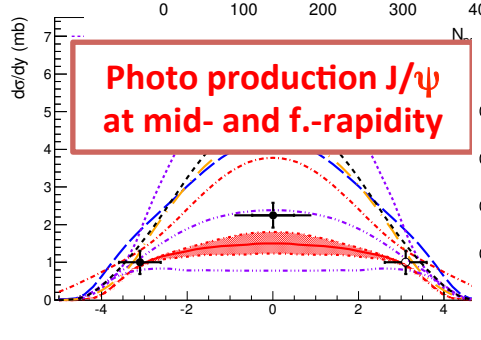
Jet R_{AA}

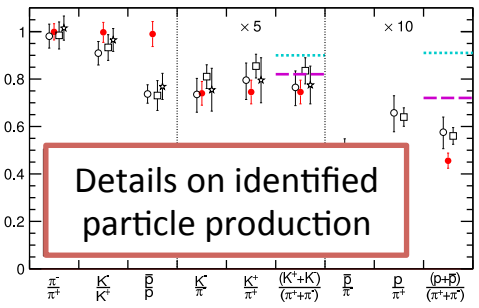




Proton/pion ratio within jets

Photo production J/ψ at mid- and f.-rapidity





Details on identified particle production

Instead of summary… Happy Holidays!

ALICE

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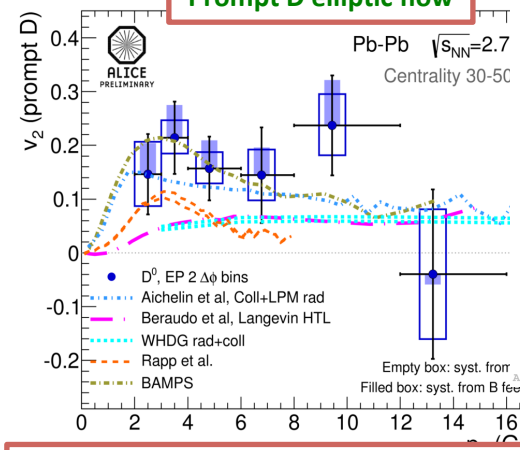

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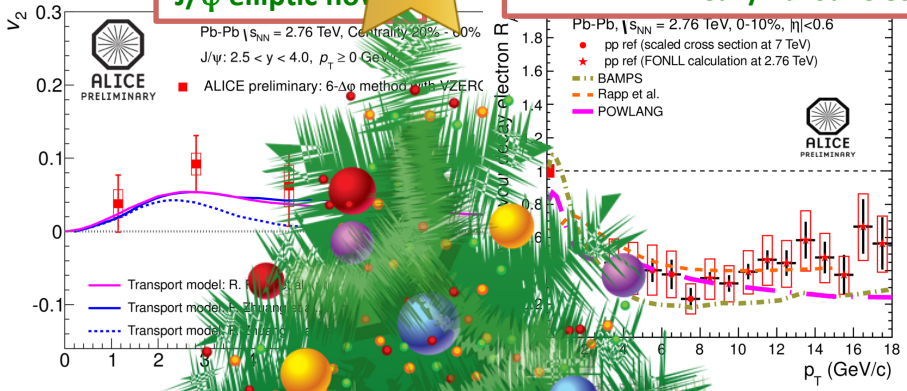

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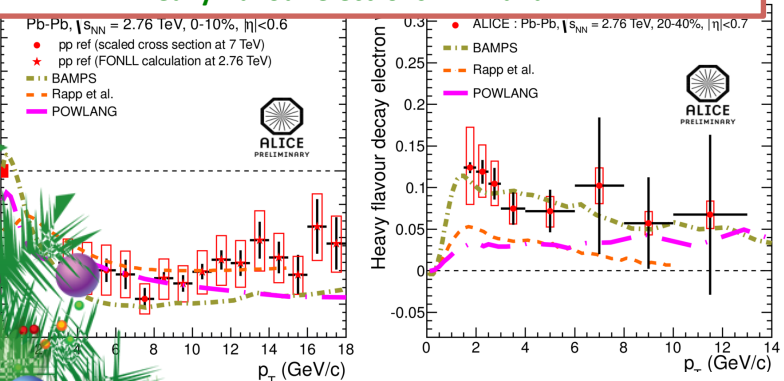

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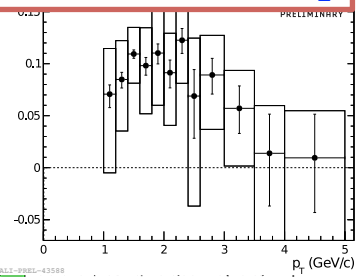

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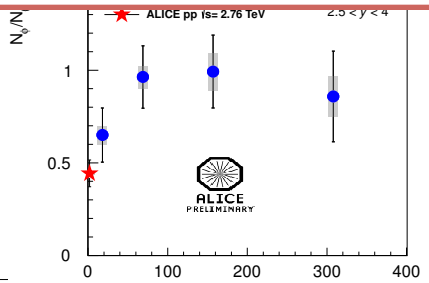
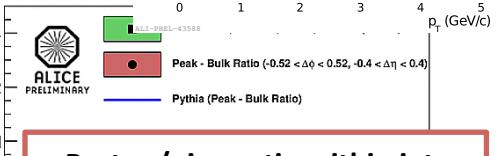


ape engineering

z results



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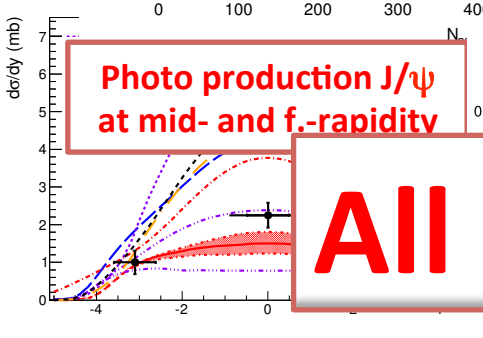

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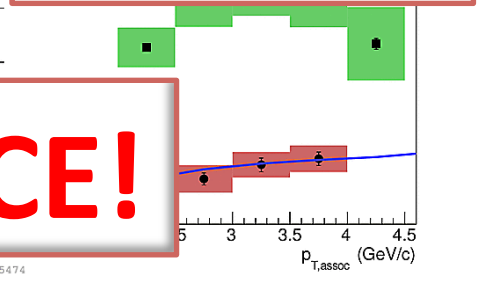
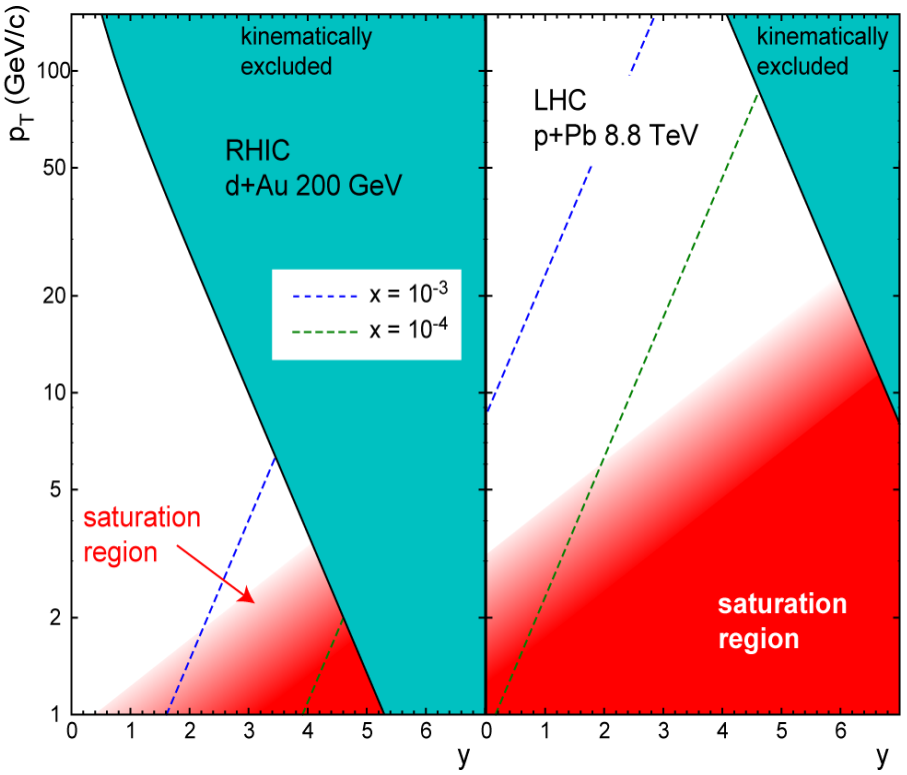


All the best from ALICE!

Extra Slides

p-Pb at the LHC vs RHIC



- Q_{sat} larger: saturation in perturbative (few GeV) regime?
- Larger energy: lower x at same rapidity
- Larger energy: kinematic limit is farther away

(Note: kinematic limit p_T=5 GeV @ η = 3.5 for RHIC)