Measurements of charmonium production and v_2 coefficient in p-Pb collisions

C.Cheshkov
On behalf of ALICE Collaboration

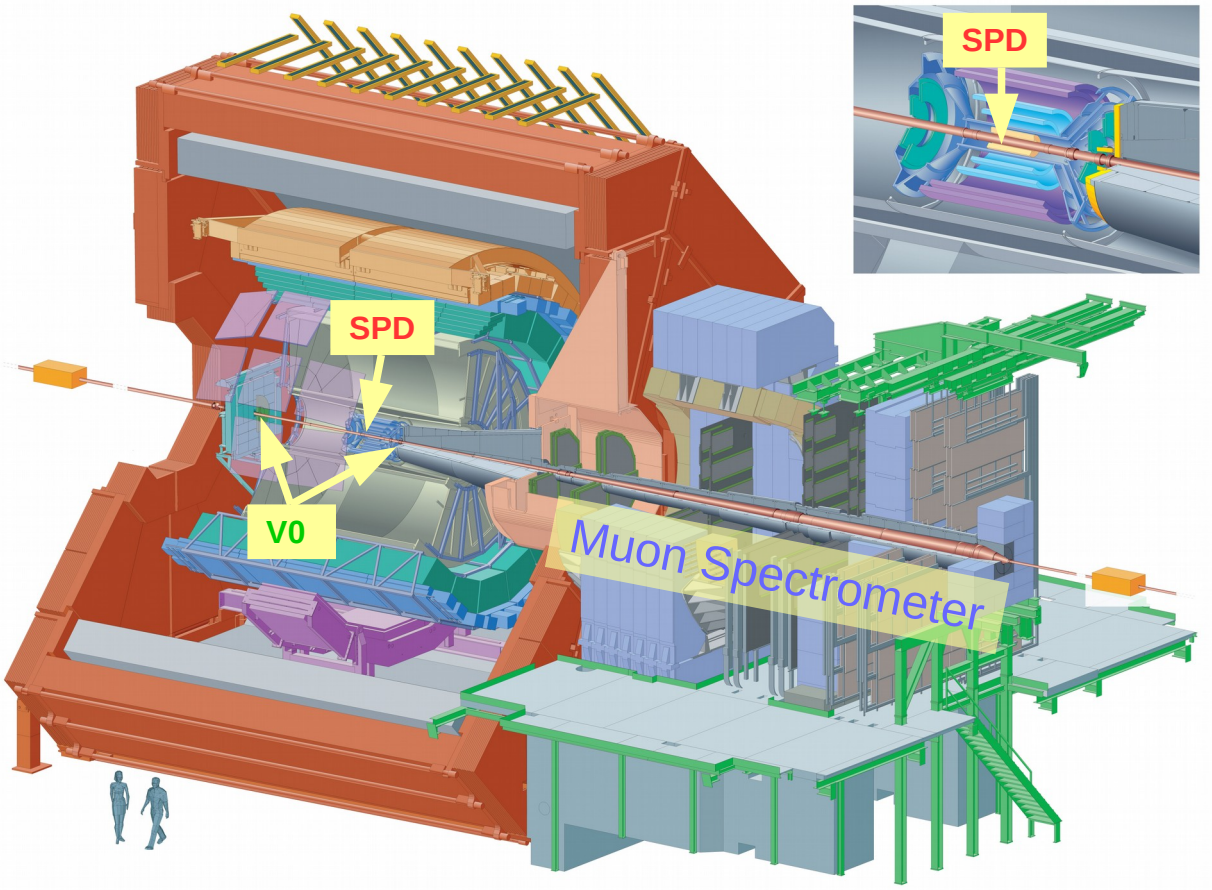
IPNL Lyon & CERN

4th International Conference on the Initial Stages in High-Energy Nuclear Collisions
20/09/2017, Cracow, Poland

Outline

- J/ψ production in p-Pb @ 8.16 TeV
- **ψ(2S) suppression in p-Pb @ 8.16 TeV (new!)**
- **J/ψ v_2 in p-Pb @ 5.02 and 8.16 TeV (new!)**

ALICE



Silicon Pixel detector (SPD)

$|\eta_{lab}|<1.4$

Primary vertex reconstruction

Primary charged particles reconstructed via SPD tracklets (vertex + 2 hits in SPD layers)

$<p_T>$ ~ 0.75 GeV/c

Forward Muon spectrometer

$\psi \rightarrow \mu^+\mu^-$

$2.5<y_{lab}<4$

Acceptance down to 0 p_T

V0 detector

$-3.7<\eta_{lab}<1.7 + 2.8<\eta_{lab}<5.1$

Minimum-bias trigger

Event-multiplicity selection with V0M (sum of signal from rings on both sides of IP)

Trigger

V0 Minimum-bias

Unlike-sign muon pair

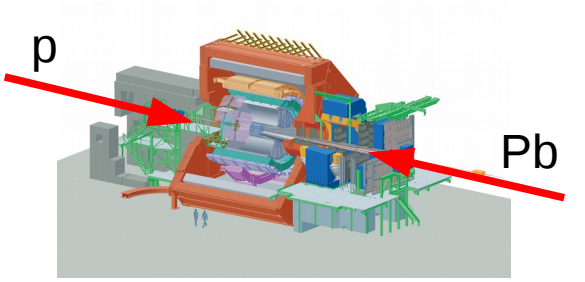
μ efficiency ~50 % at p_T=0.5 GeV/c

Data sets

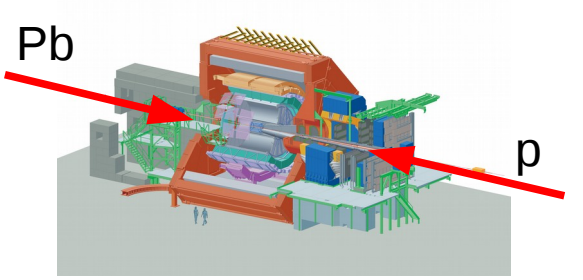
- Run1 : 5.02 TeV
- Run2 : 8.16 TeV (part taken at 5.02 TeV)

- Asymmetric beam energies
  → c.m.s. shifted by 0.465 in direction of proton beam

- Both beam configurations
  - p-Pb : proton towards the MUON spectrometer
    $2.03 < y < 3.53$
  - Pb-p : Pb towards the MUON spectrometer
    $-4.46 < y < -2.96$



Forward



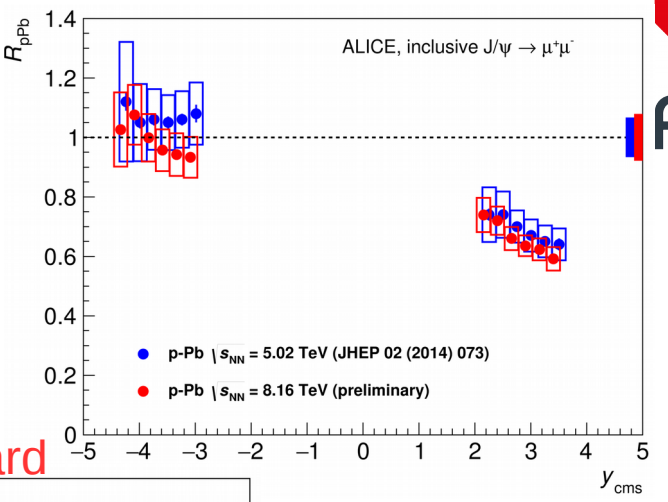
Backward

- Integrated luminosities :

	p-Pb	Pb-p
5.02 TeV	~8.0 nb^{-1}	~5.8 nb^{-1}
8.16 TeV	~8.7 nb^{-1}	~12.9 nb^{-1}

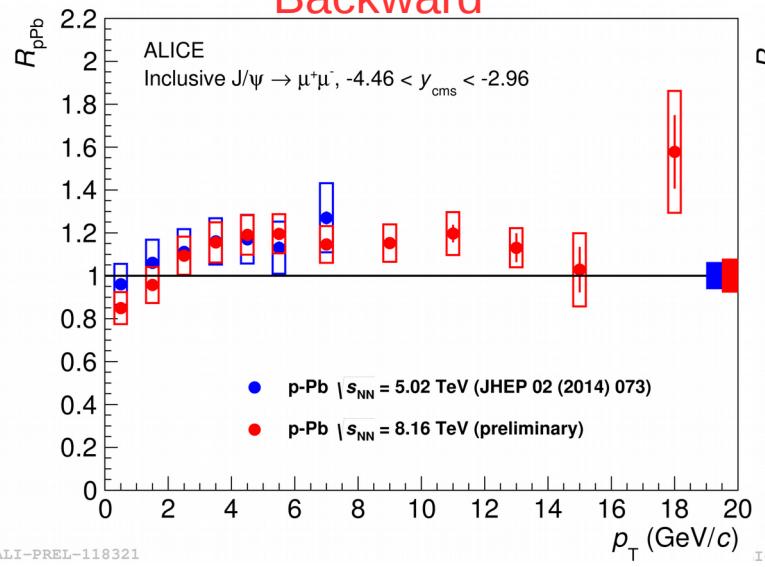
J/ψ production in p-Pb@8.16 TeV

- **Both forward and backward R_{pPb} compatible with 5.02 TeV within uncertainties, in y and p_T**
- Suppression @ forward rapidity, R_{pPb}~1 @ backward rapidity

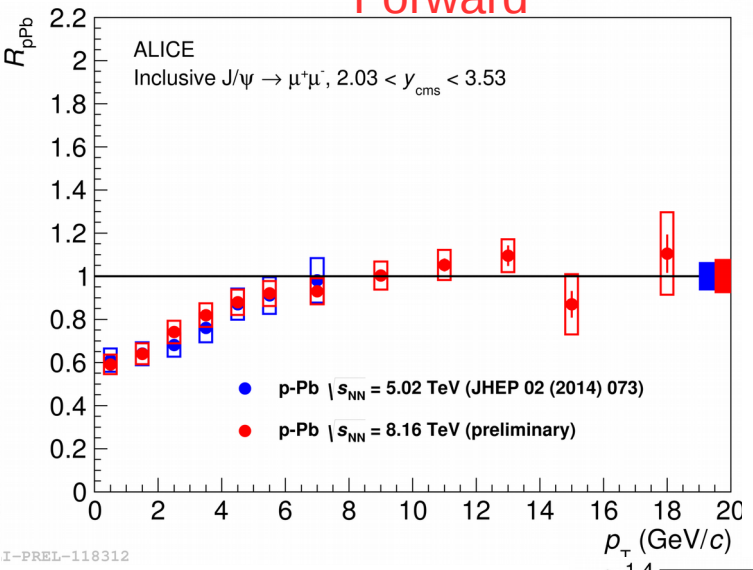


ALICE-PUBLIC-2017-001

Backward

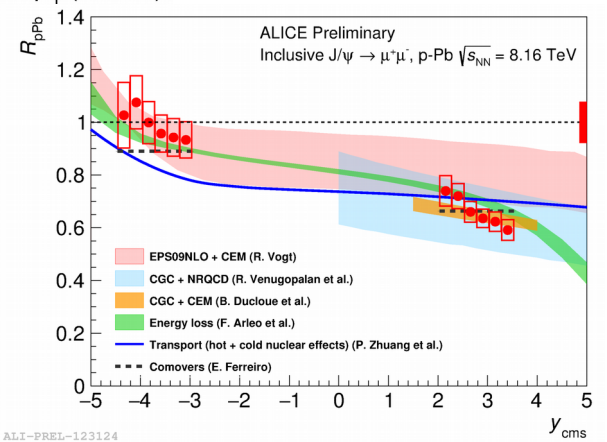


Forward



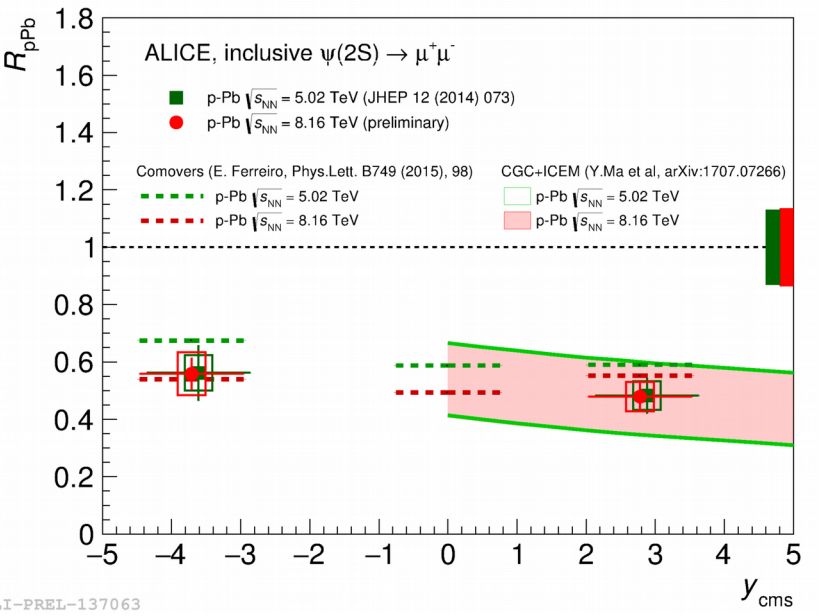
p_T coverage extended
8 → 20 GeV/c wrt Run1

- J/ψ production can be described quite satisfactory by models implementing Cold Nuclear Matter (CNM) effects
  - nPDF and/or energy loss sufficient to describe data

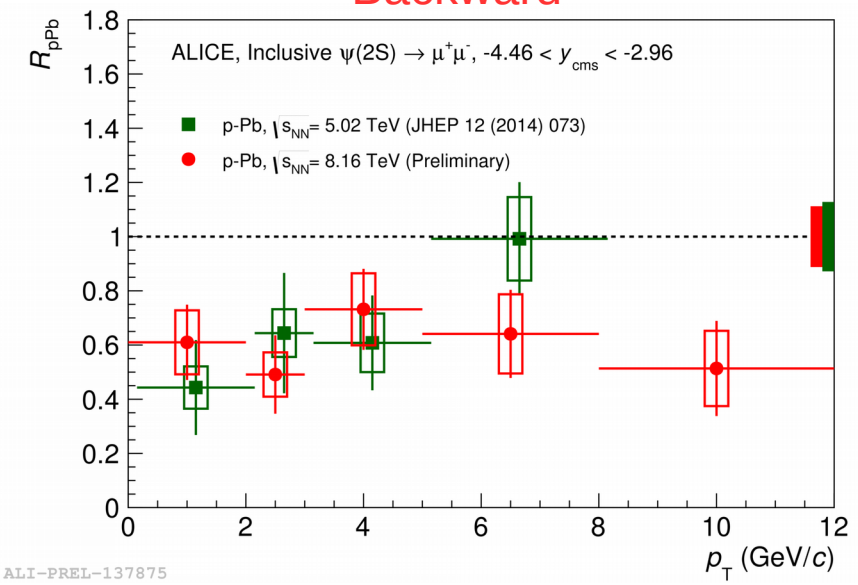


ψ(2S) suppression @ 8.16 TeV

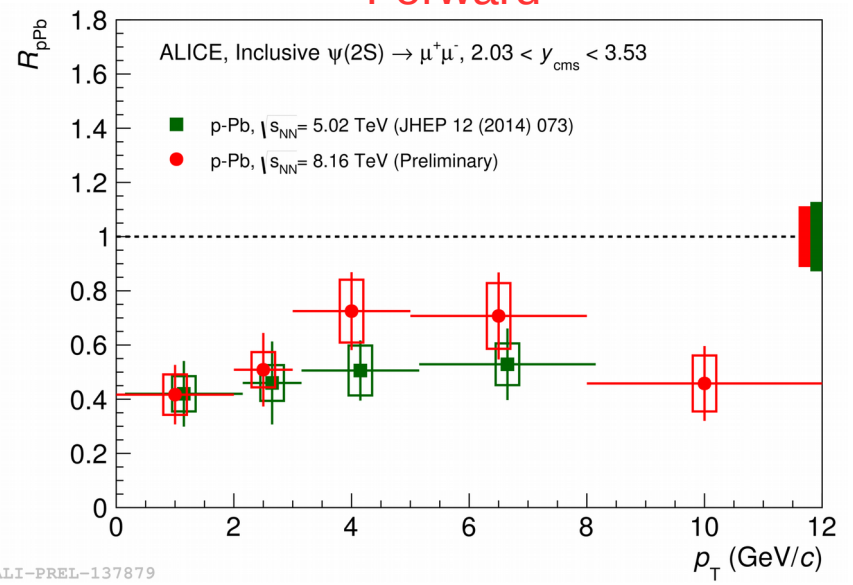
- Strong suppression of ψ(2S) wrt J/ψ, stronger in backward direction, already seen @ 5.02 TeV
  - Formation time >> crossing time → need final-state effects
    - Hadron gas (comovers model) ?
    - Hot medium effects ?
    - Comoving partons (CGC + ICEM model)
- **R_{pPb}: no sizeable $\sqrt{s_{NN}}$ dependence, both in y and p_T**
- Comovers model → a bit higher suppression @8.16 TeV wrt 5.02 TeV (due to higher hadron densities), more pronounced in backward direction
  - Data uncertainties do not allow to tell if that is the case



Backward

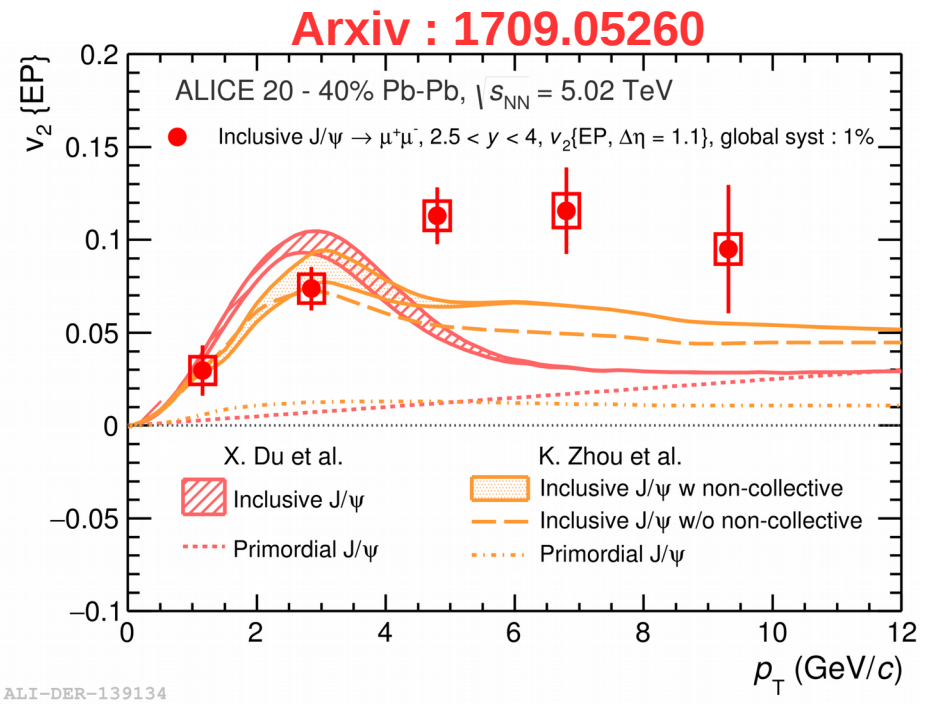


Forward



J/ψ v_2 in the small p-Pb system?

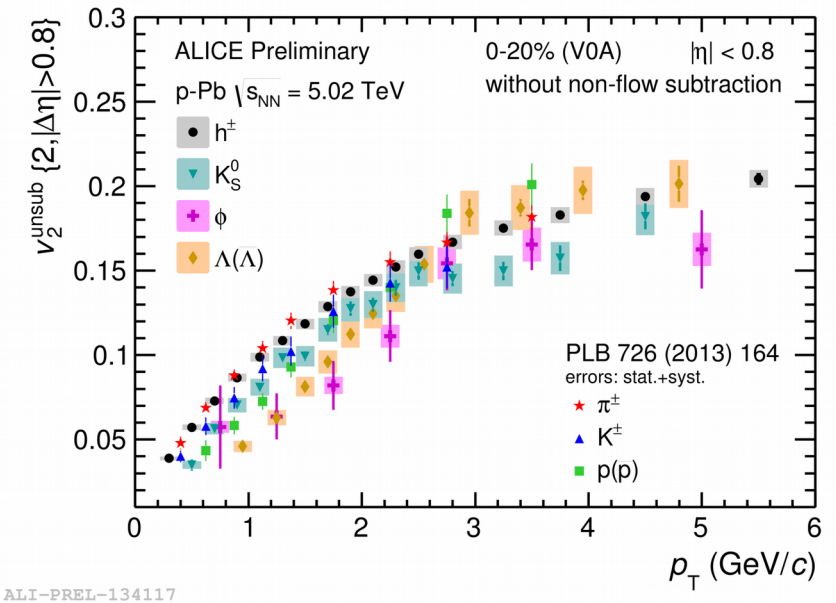
- Significant v_2 in central and semi-central Pb-Pb @ 5.02 TeV
  - At low p_T
    v_2 inherited from recombined charm quarks, described fairly well by transport model of Rapp et al.(Nucl.Phys.A943 (2015) 147–158) and Zhuang et al.(Phys.Rev.C89 (2014) 054911)
  - At high p_T
    v_2 data > predictions in which it comes from path-length dependent suppression in QGP



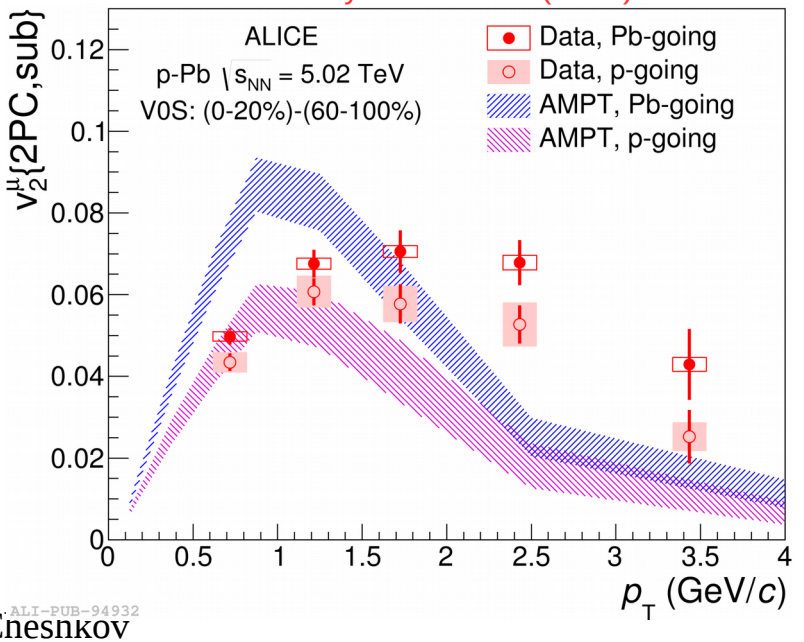
- In p-Pb
  - Much less charm quarks produced → recombination negligible
  - Small system size → negligible path-length dependence
  - Does J/ψ participate in collective behaviour of p-Pb collision system ?

Collectivity in p-Pb

- v_2>0 in two- and multi-particle correlations, clear signs of collectivity
- Mass ordering in $v_2(p_T)$
- Forward/backward muons v_2>0 even at high p_T dominated by heavy-flavour decays

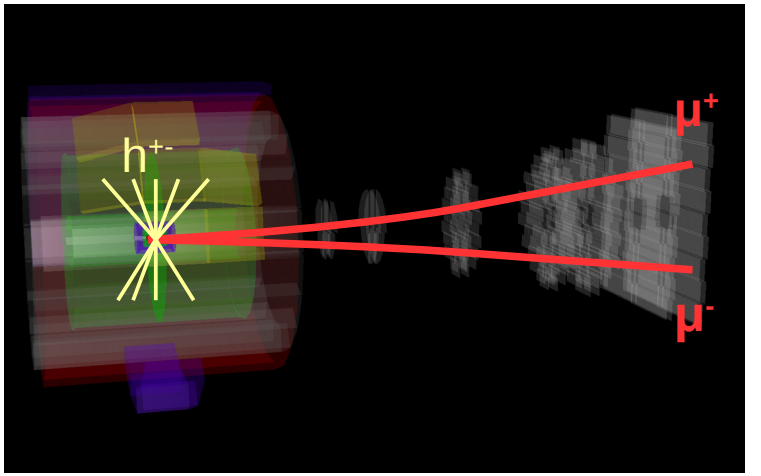


Phys.Lett.B 753 (2016) 126-139



Measurement of J/ψ v_2

- Azimuthal correlations between **forward/backward J/ψ** and **mid-rapidity charged particles**



- Correlations expressed as **associated SPD-tracklet yields per dimuon(J/ψ) trigger**

$$Y^{ij}(M_{\mu\mu}, p_{\mathrm{T}}^{\mu\mu}, \Delta\varphi, \Delta\eta) = \frac{1}{N_{\mathrm{trig}}^{ij}(M_{\mu\mu}, p_{\mathrm{T}}^{\mu\mu})} \frac{SE^{ij}(M_{\mu\mu}, p_{\mathrm{T}}^{\mu\mu}, \Delta\varphi, \Delta\eta)}{ME^{ij}(M_{\mu\mu}, p_{\mathrm{T}}^{\mu\mu}, \Delta\varphi, \Delta\eta)}$$

i – event-multiplicity class (V0M)
j – z vertex bin
N_{trig} – # of trigger dimuons

SE – # of associated tracklets from same event
ME – mixed event

- Yields projected on Δφ in **1.5<|Δη|<5.0**

- Yields per J/ψ trigger obtained from fit of yields vs $M_{\mu\mu}$

$$\frac{S}{S+B} Y_{\mathrm{J}/\psi} + \frac{B}{S+B} Y_B(M_{\mu\mu})$$

S/B – signal/background from $M_{\mu\mu}$ fit
Y_B – background v_2 (2nd order polynomial)

Extraction of J/ψ v_2

Low-multiplicity

Clear away-side correlation presumably due to recoil jet

High-multiplicity

Additional enhancement at both near and away sides

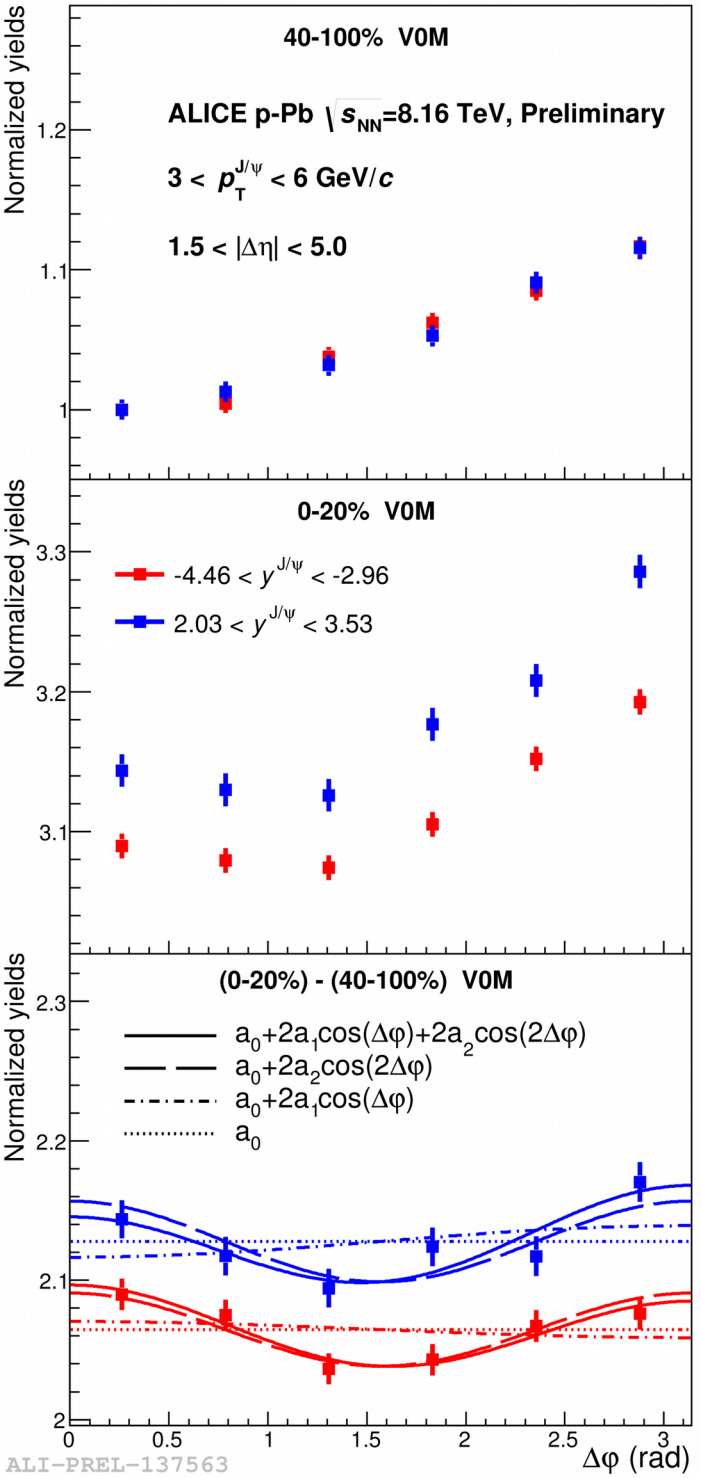
Jet correlations eliminated via subtraction

High-multiplicity – Low-multiplicity

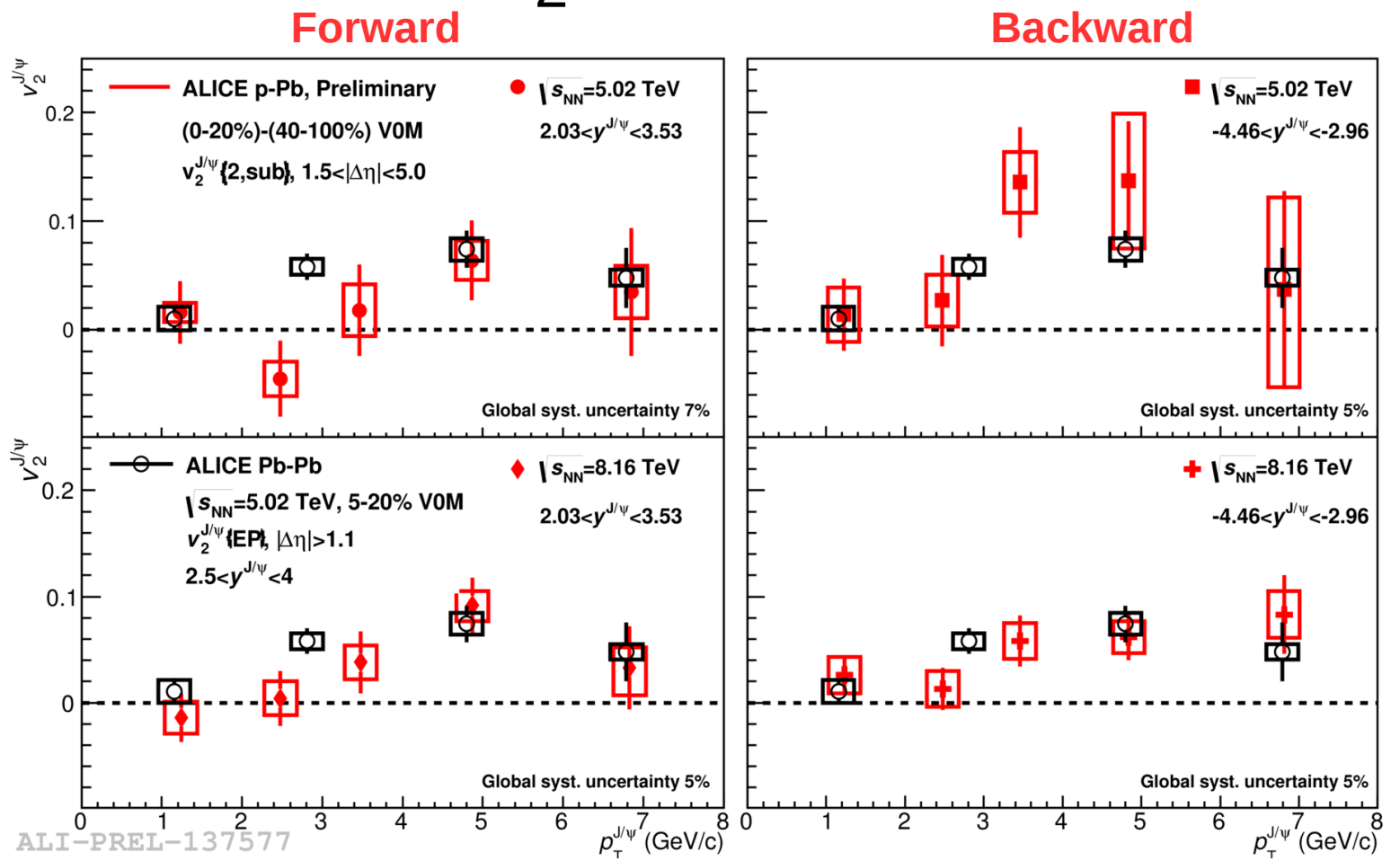
Fit with : $a_0 + 2a_1 \cos\Delta\varphi + 2a_2 \cos 2\Delta\varphi$

J/ψ v_2 extracted assuming

factorization of J/ψ and tracklet v_2



v_2 results



p_T<3 GeV/c → v_2 compatible with 0

In line with expectation of no recombination

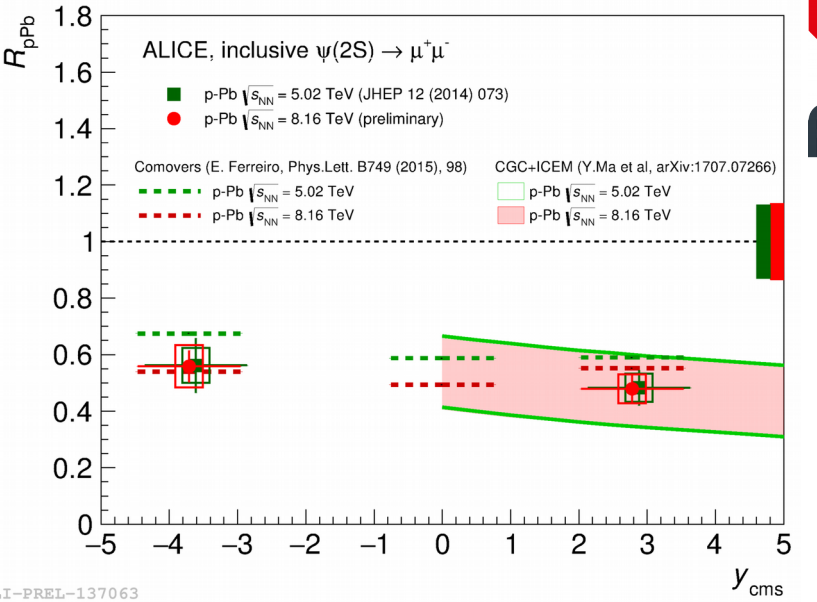
3<p_T<6 GeV/c → v_2>0

Total (forward+backward,5.02+8.16 TeV) significance about 5σ

Values comparable to the measurements in central Pb-Pb collisions

Conclusions

- **J/ψ and ψ(2S) R_{pPb} @ 8.16 TeV quite compatible with 5.02 TeV, both in y and p_T**
- **ψ(2S) strongly suppressed wrt J/ψ, more pronounced in backward direction**
  - Implies final-state interactions, hadronic gas or mini-QGP?



- **J/ψ v_2>0 observed in 3<p_T<6 GeV/c**
  - 5σ significance
  - Forward and backward data compatible within (relatively large) uncertainties
  - Intriguing similarity to Pb-Pb
  - Origin not yet understood