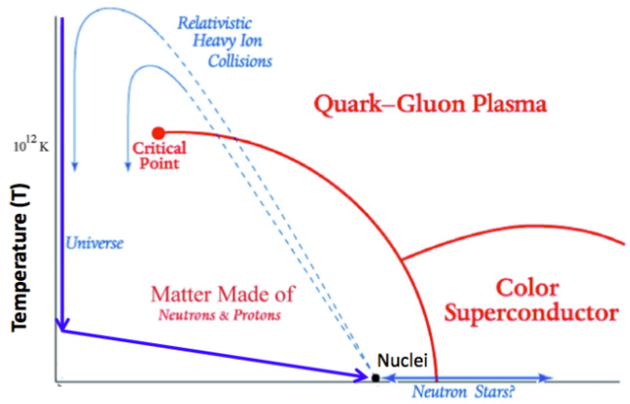
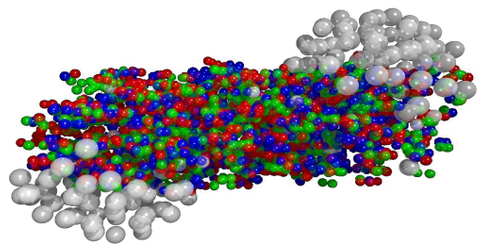
ALICE Overview

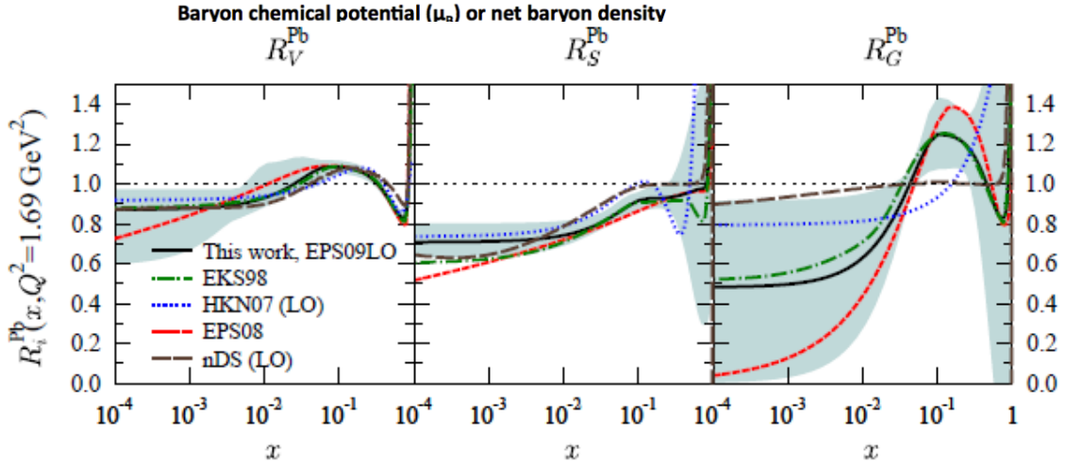
Davide Caffarri (Nikhef) on behalf of the ALICE Collaboration

The “pre-LHC” paradigm

- Study of A-A collisions to probe the properties of **high density and temperature nuclear matter**.
  - Hot Nuclear Matter effects (Quark Gluon Plasma)
- Study of p-A collisions to investigate **Cold Nuclear Matter** (CNM) effects
  - nPDF modifications, Saturation, Color Glass Condensate
- Study of pp collisions important as **reference** to compare other systems (no CNM, no QGP effects expected)

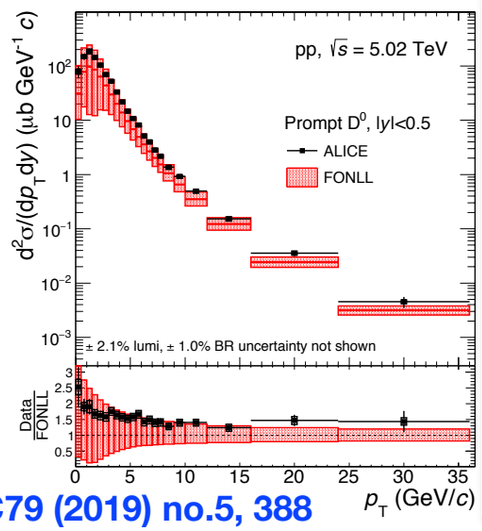


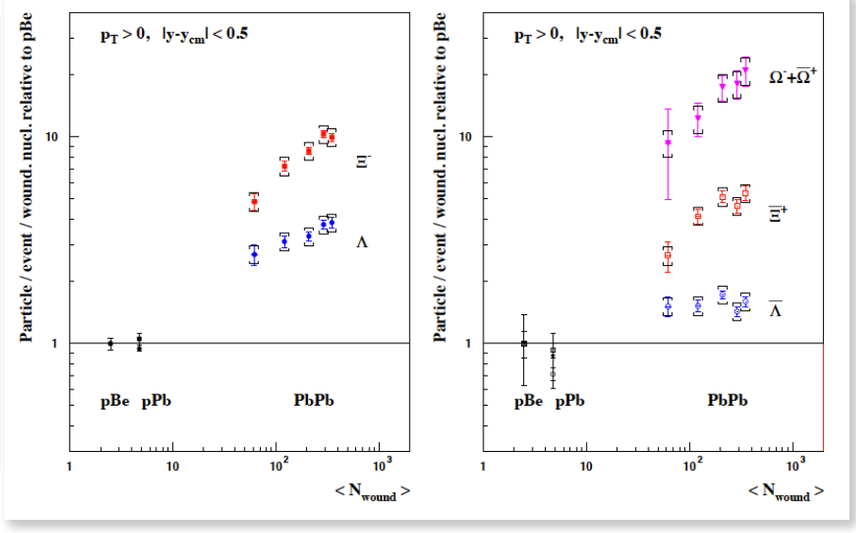




see e.g. Eskola et al. JHEP0904(2009)065

NA57 JPG32, 427 (2006)





ALICE Collab. Eur.Phys.J. C79 (2019) no.5, 388

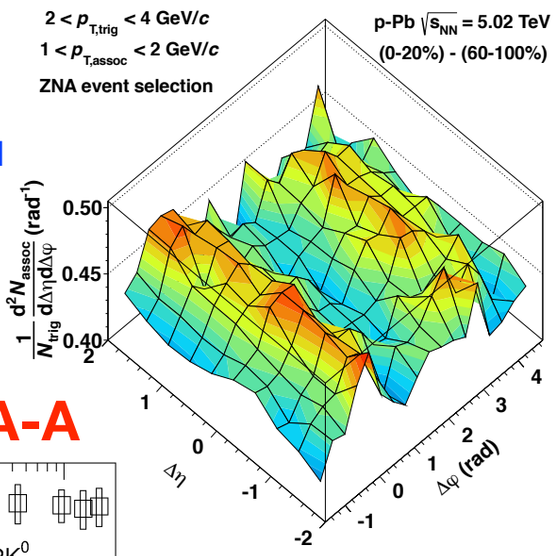
The “pandora box”

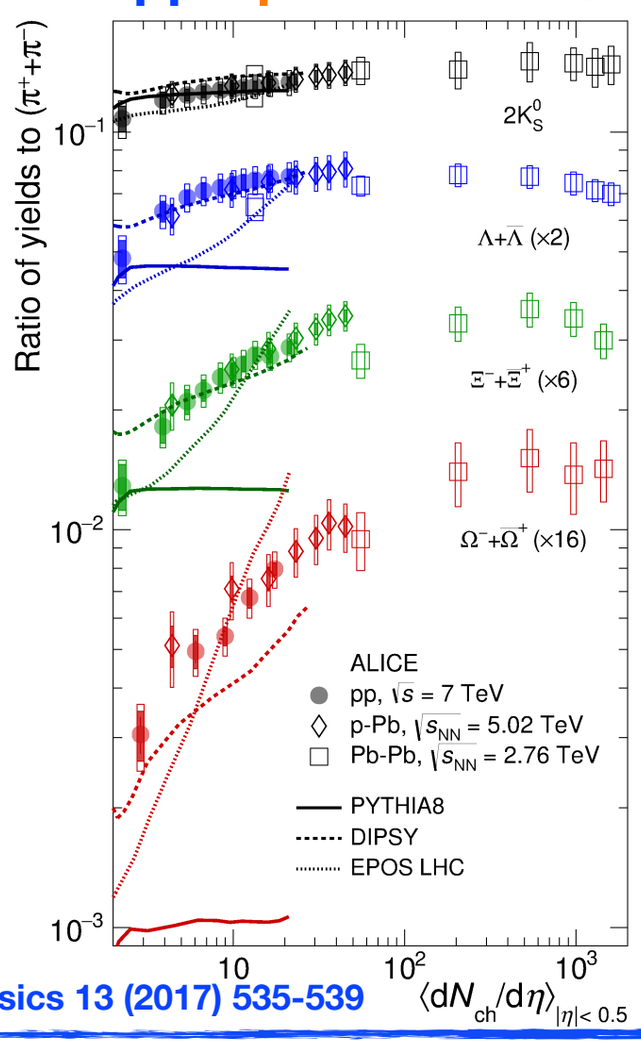
- **Double ridge structures** observed also in small collisions systems for high-multiplicity events.

- **Smooth evolution** of particle production from small to large systems vs charge multiplicity

- **Where all this comes from?**
  - Initial stages effects?
  - Better understanding of the observables we use in A-A for small systems?
  - Common mechanism of particle production?
  - Final state effects?

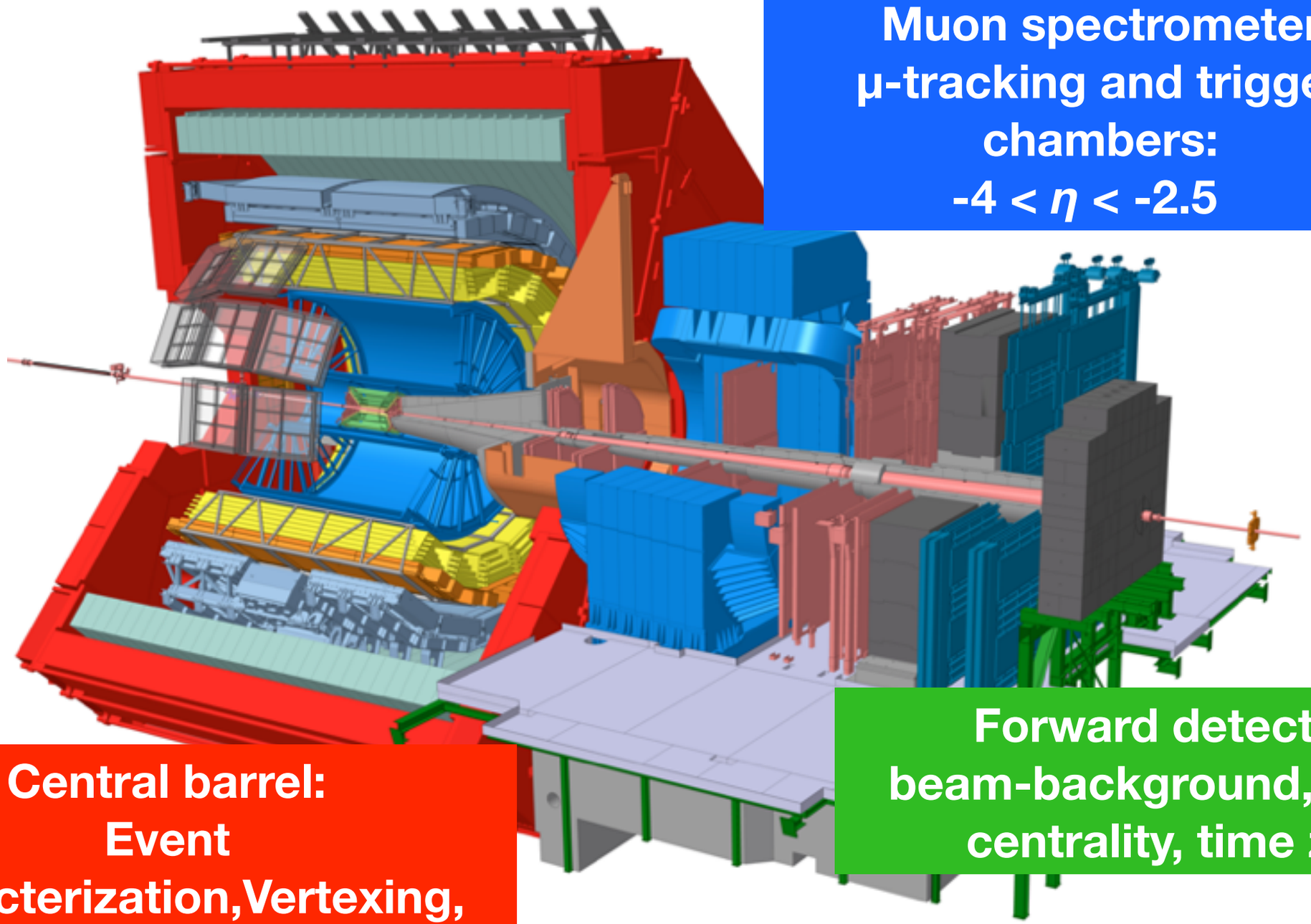
ALICE, Phys. Lett. B 719 (2013) 29-41
ATLAS, PRL 110 (2013) 182302
CMS, PLB 718 (2013) 795





ALICE Coll. Nature Physics 13 (2017) 535-539

A Large Ion Collider Experiment (ALICE)



Muon spectrometer μ-tracking and trigger chambers: $-4 < \eta < -2.5$

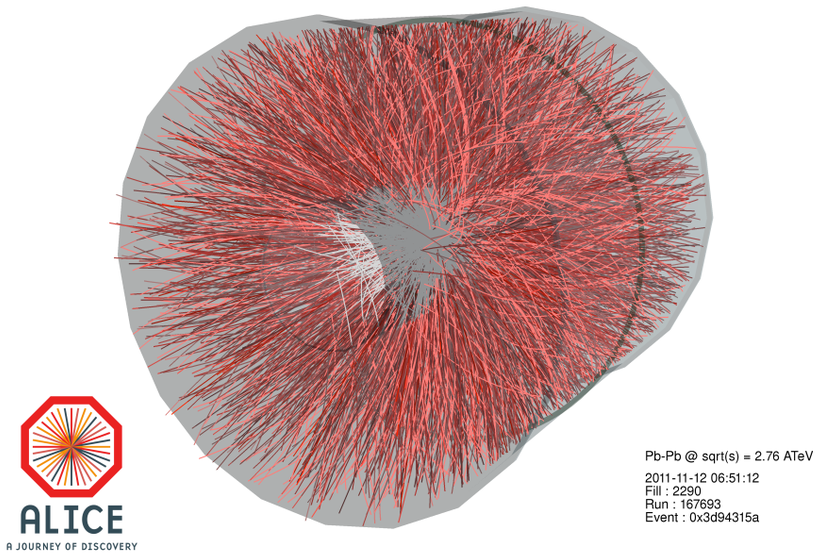
Central barrel: Event characterization,Vertexing, Tracking, PID, EM Calos $|\eta| < 0.9$

Forward detectors: beam-background, trigger, centrality, time zero

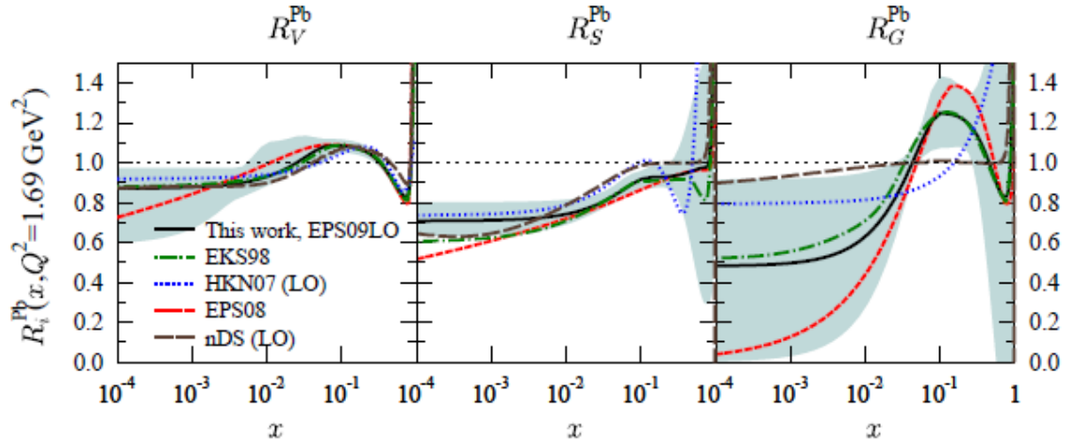
JINST, 3 (2008), S08002
Phys Rev Lett, 106 (2011), 032301
Int. J. Mod. Phys. A 29 (2014) 1430044

ALICE Data samples

System	Year	$\sqrt{s_{NN}}$ (TeV)	L_{int}
Pb-Pb	2010-2011 2015 2018	2.76 5.02 5.02	~75 μb^{-1} ~250 μb^{-1} ~0.9 nb^{-1}
Xe-Xe	2017	5.44	~0.3 μb^{-1}
p-Pb	2013 2016	5.02 5.02, 8.16	~15 nb^{-1} ~3 nb^{-1}, ~25 nb^{-1}
pp	2009-2013 2015-2018	0.9, 2.76, 7, 8 5.02, 13	~200 μb^{-1}, ~100 μb^{-1}, ~1.5 pb^{-1}, ~2.5 pb^{-1} ~1.3 pb^{-1} , ~59 pb^{-1}



- Significant increase in integrated luminosity in pp, p-Pb and Pb-Pb collisions
  → more precise measurements also for rare probes.
- Energy and system dependence studies of particle production are possible
- New results on latest Pb-Pb 2018 sample



see e.g. Eskola et al. JHEP0904(2009)065

Initial stages and CNM effects

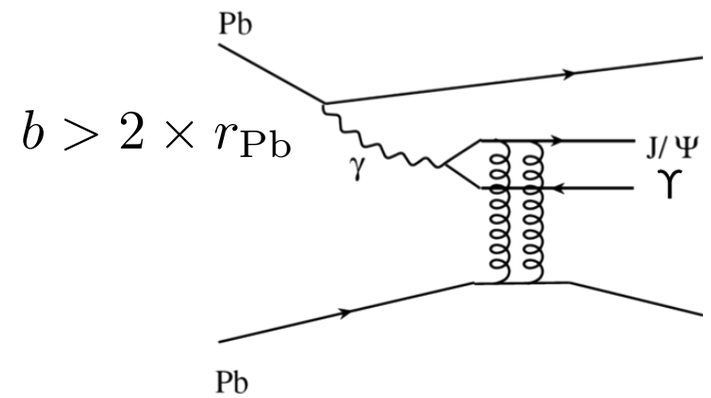
- Provide data to constrain nPDF
- Saturation / Color Glass Condensate regimes
- Understand possible effects on hadron productions

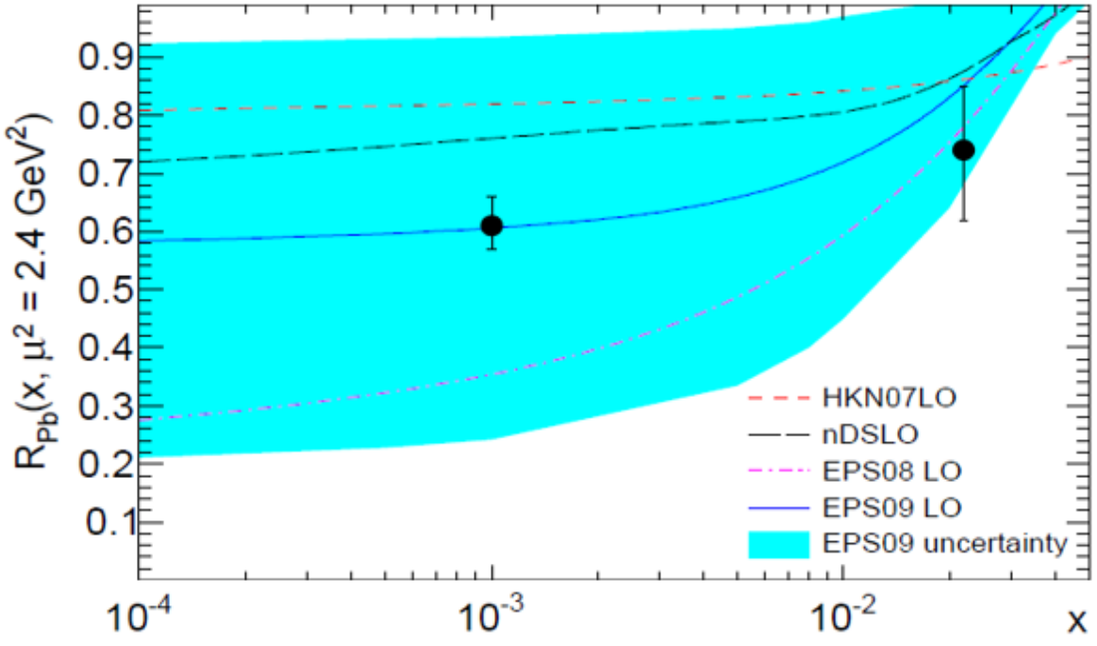
Coherent J/ψ photoproduction in UPC

- Coherent J/ψ photoproduction cross section proportional to the square of the gluon density in the target

$$\left.\frac{\mathrm{d}\sigma_{\gamma A\to J/\psi A}}{\mathrm{d}t}\right|_{t=0} = \frac{M_{J/\psi}^3\Gamma_{ee}\pi^3\alpha_s^2(Q^2)}{48\alpha_{\mathrm{em}}Q^8}\left[xg_A(x,Q^2)\right]^2$$

- J/ψ photoproduction in Pb-Pb Ultra-Peripheral collisions allow to access gluon shadowing in nuclei at low *x*





Guzey et al Phys Lett B726 (2013) 290
Guzey, Zhalov JHEP 1310 (2013) 207

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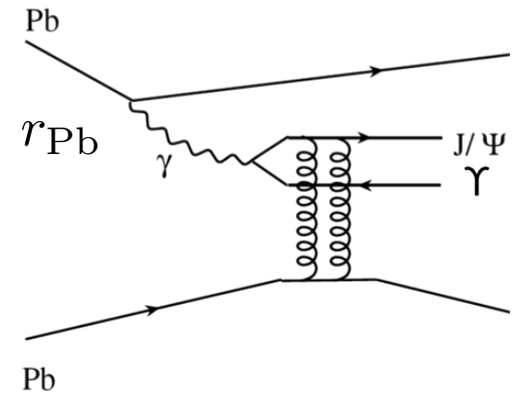
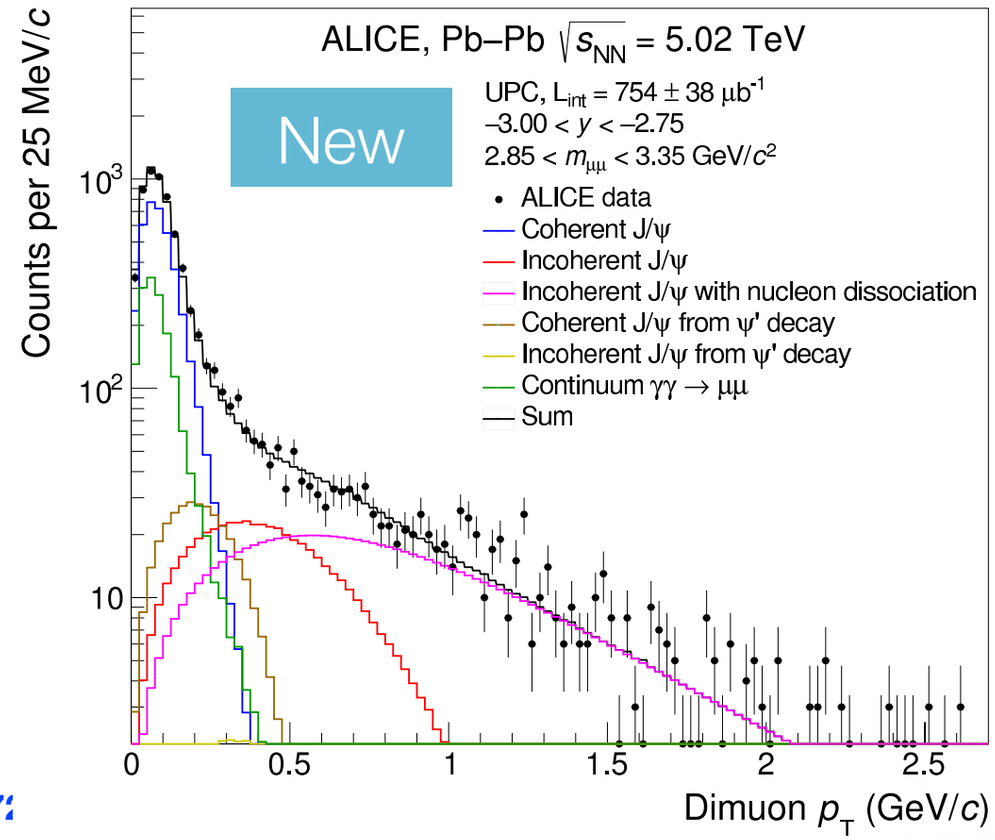
$b > 2 \times r_{\mathrm{Pb}}$



- Extract coherent J/ψ fraction using di-muons p_T spectrum for 6 *y* bins
  - Photon couples coherently to all nucleons
  - $< p_T >$ ~ 60 MeV/*c*



ALICE Collab. Submitted to PLB arXiv:1904.0627

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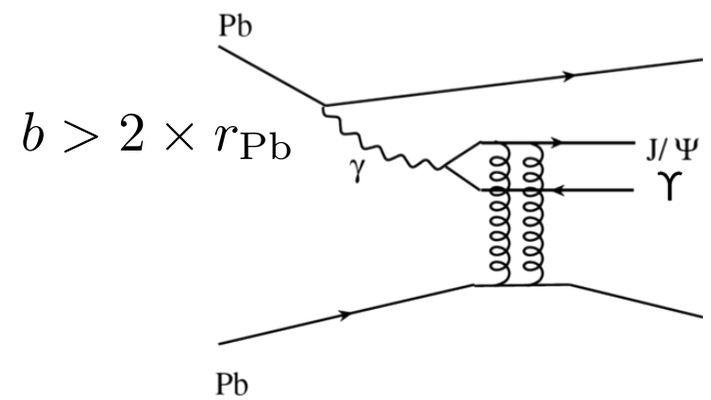
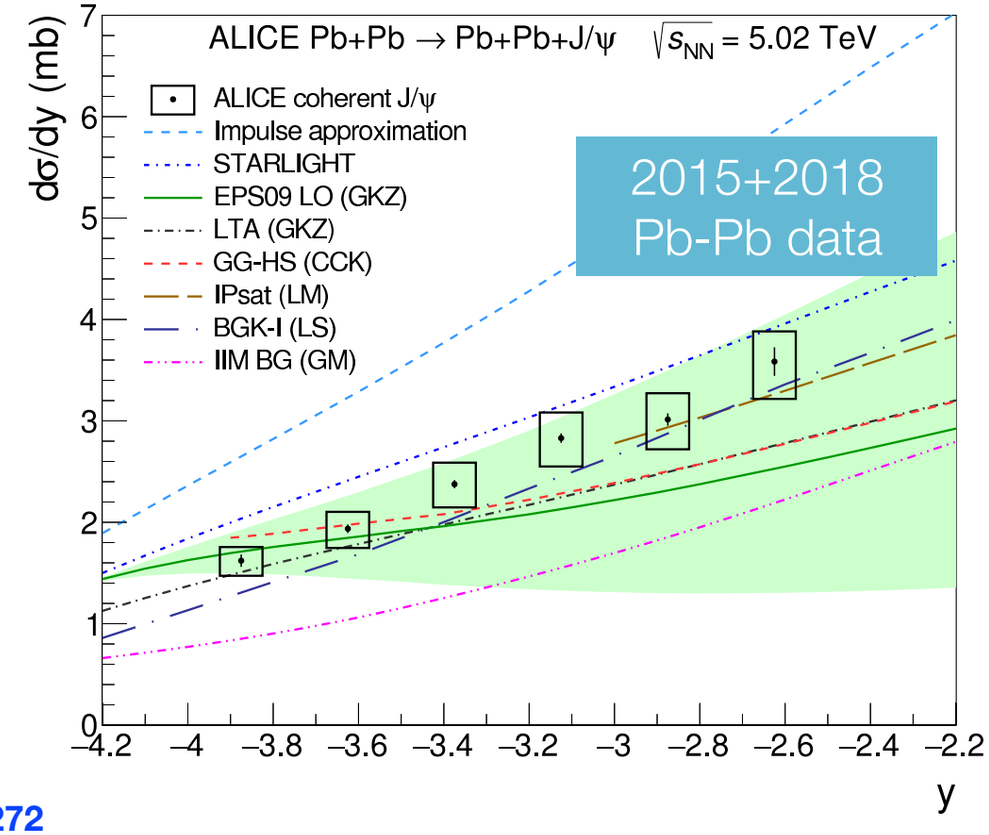


- Extract coherent J/ψ fraction using di-muons p_{T} spectrum for 6 *y* bins
  - Photon couples coherently to all nucleons
  - $< p_{\mathrm{T}} >$ ~ 60 MeV/*c*

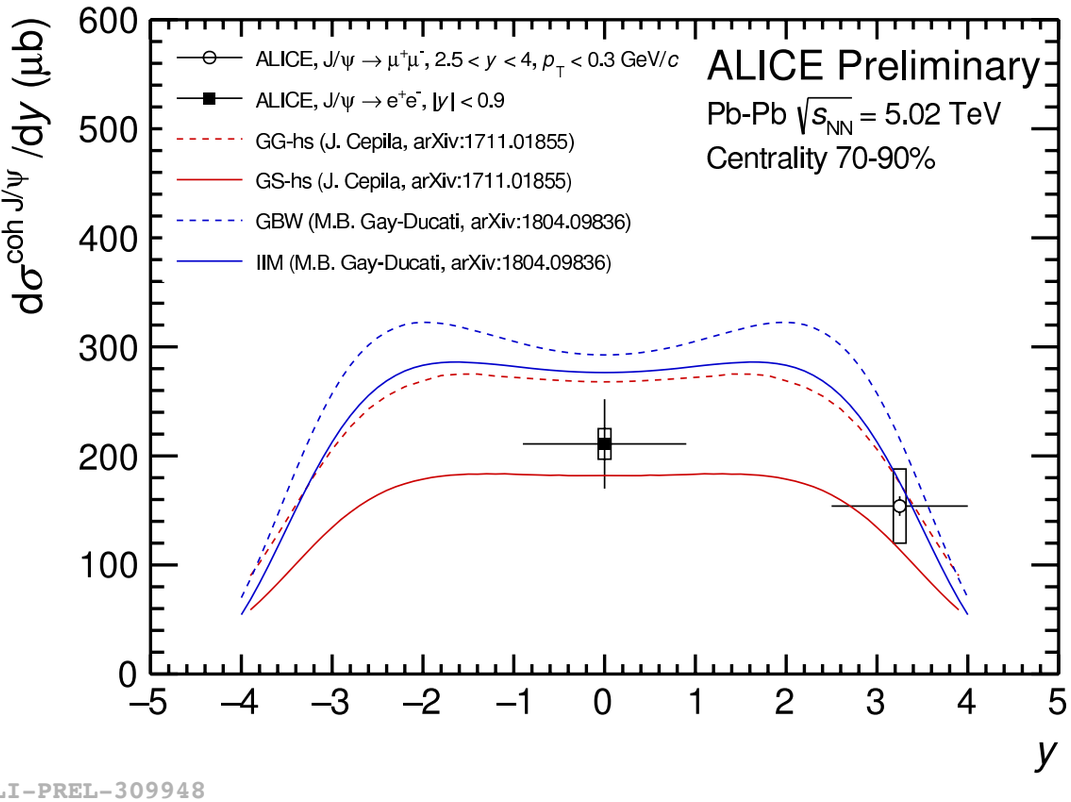
- Results of coherent J/ψ photoproduction:
  - Moderate nuclear gluon shadowing
  - Potentially constrain the gluon distributions in global nPDF fits



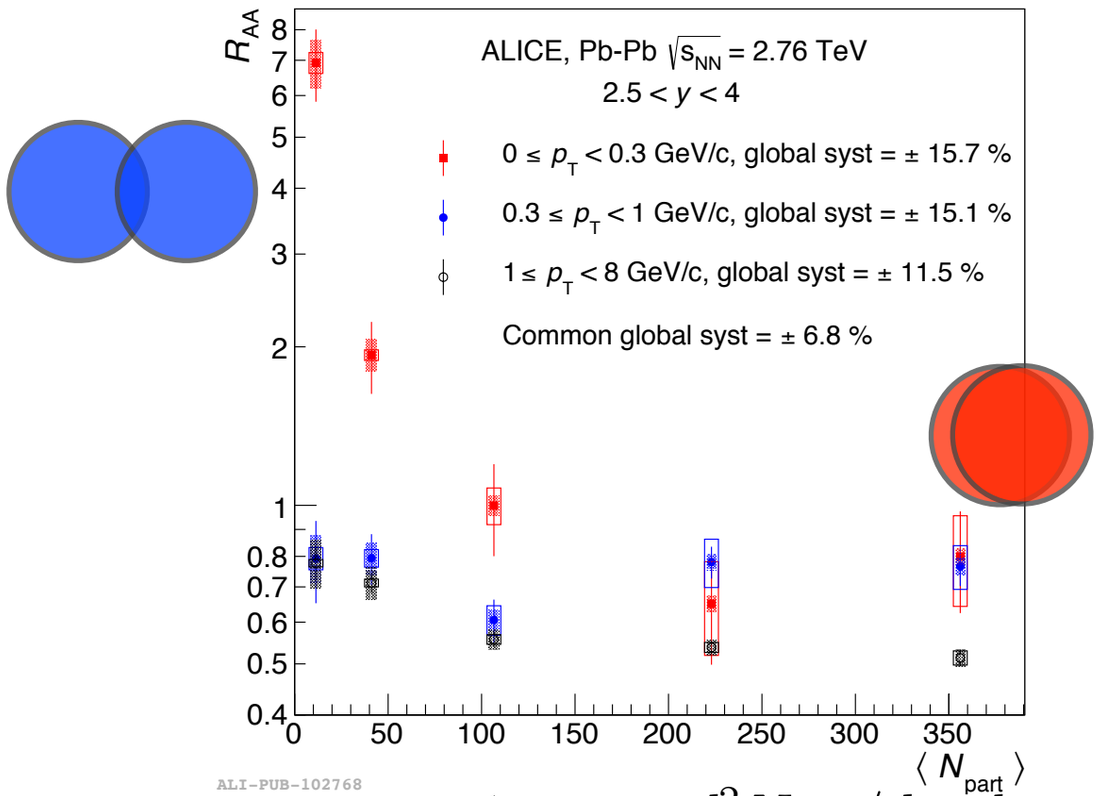
ALICE Collab. Submitted to PLB arXiv:1904.06272

Coherent J/ψ photoproduction in Pb-Pb hadronic collisions

- Excess of J/ψ for $p_T < 200$ MeV/c in peripheral Pb-Pb collisions (70-90%) $R_{AA} \sim 7$
- New ALICE results at $\sqrt{s_{NN}} = 5.02$ TeV for both central and forward rapidity



ALICE Coll. PRL 116 (2016) 222301

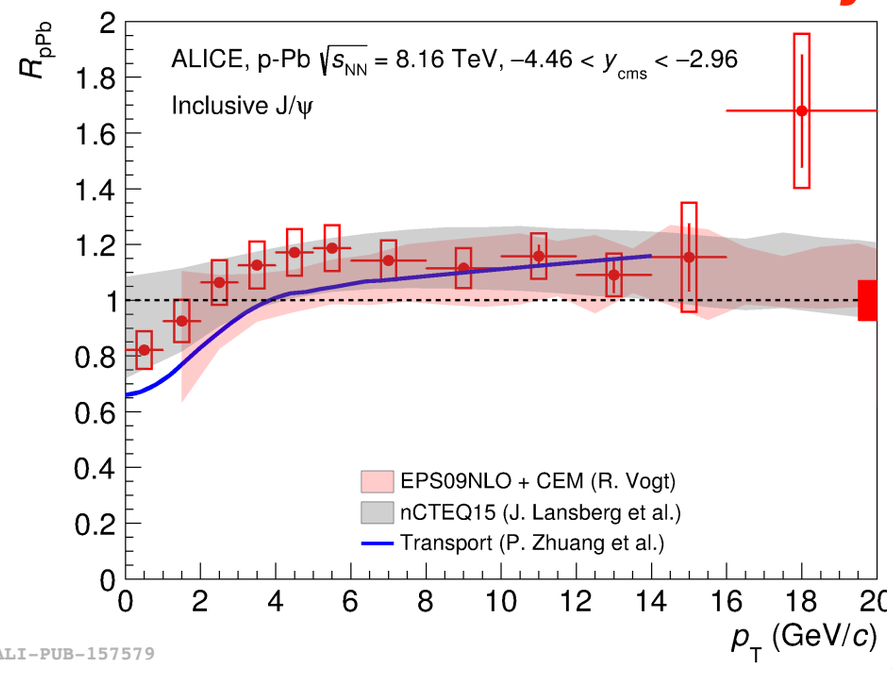


$$R_{\mathrm{AA}}(p_{\mathrm{T}}) = \frac{1}{< N_{coll} >} \times \frac{d^2 N_{AA}/dp_T d\eta}{d^2 N_{pp}/dp_T d\eta}$$

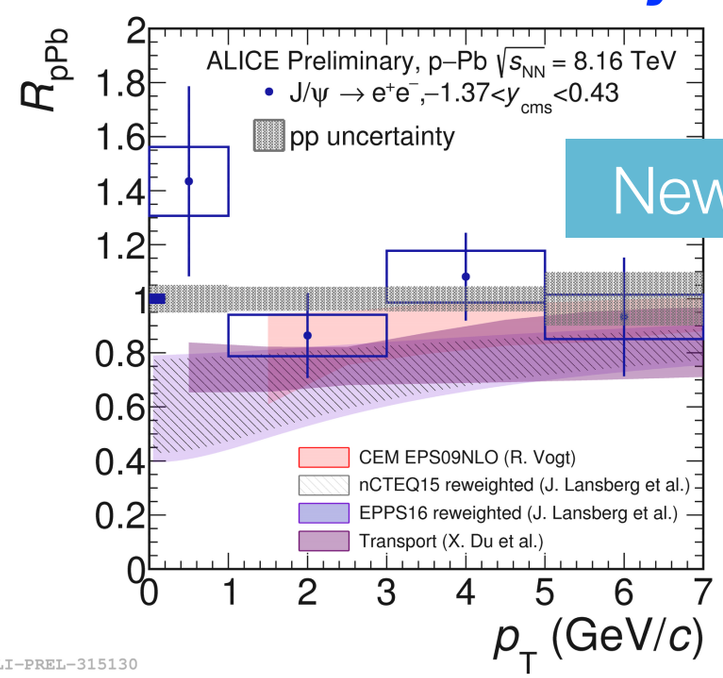
- How can the coherence condition survive when both nuclei are broken by the hadronic interaction?
- Coherent photoproduction on nuclear fragments? Spectators participate in the coherence?

J/ψ production in p-Pb collisions $\sqrt{s_{NN}}$ = 8.16 TeV

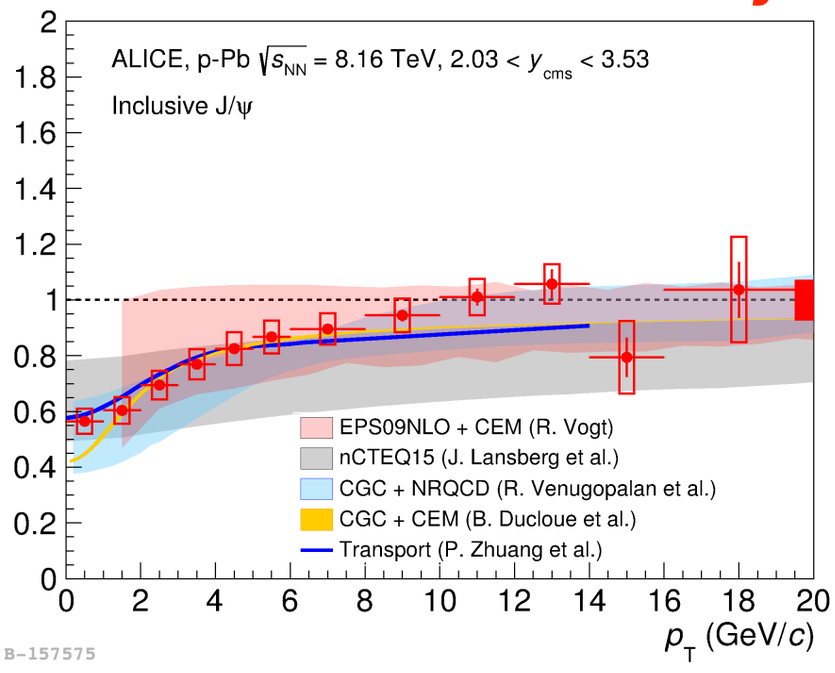
Backward-*y*



Central-*y*



Forward-*y*



ALICE Collab. JHEP 07 (2018) 160

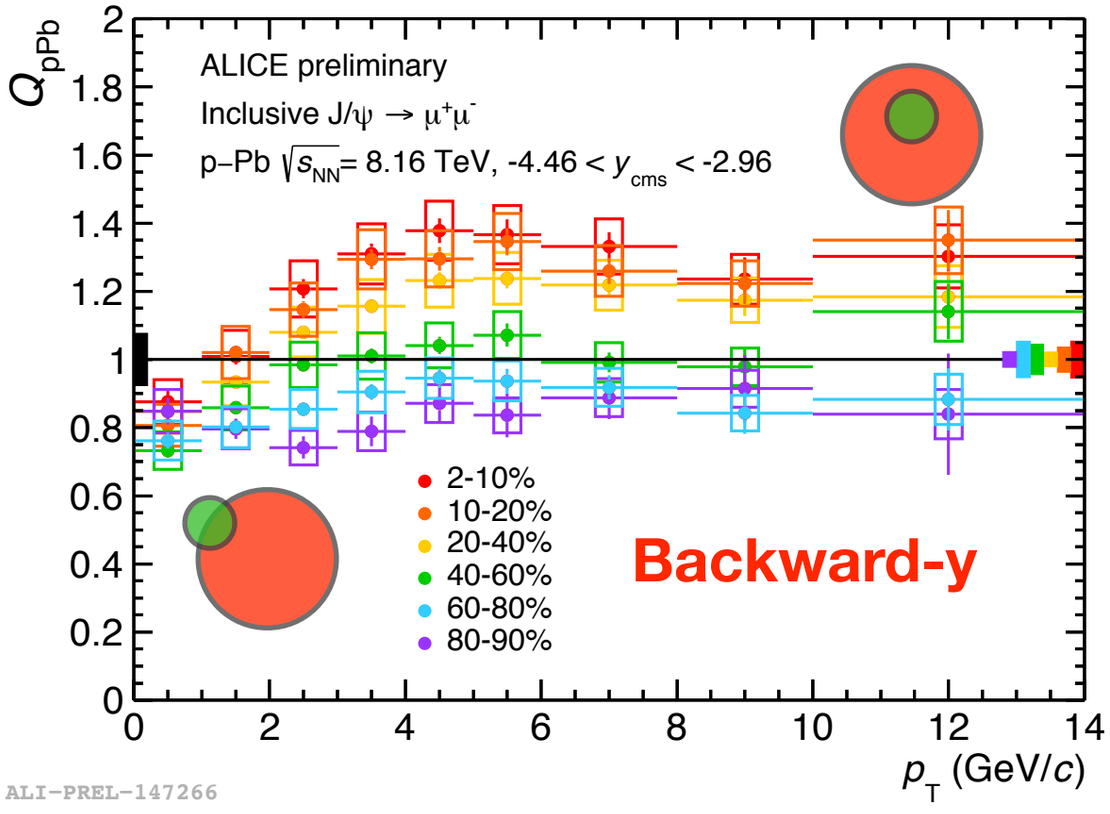
- At backward and forward-y, R_{pPb} shows a p_T dependence, increase from low to high p_T
- At central-y R_{pPb} is compatible with unity with almost no (or mild) p_T dependence.

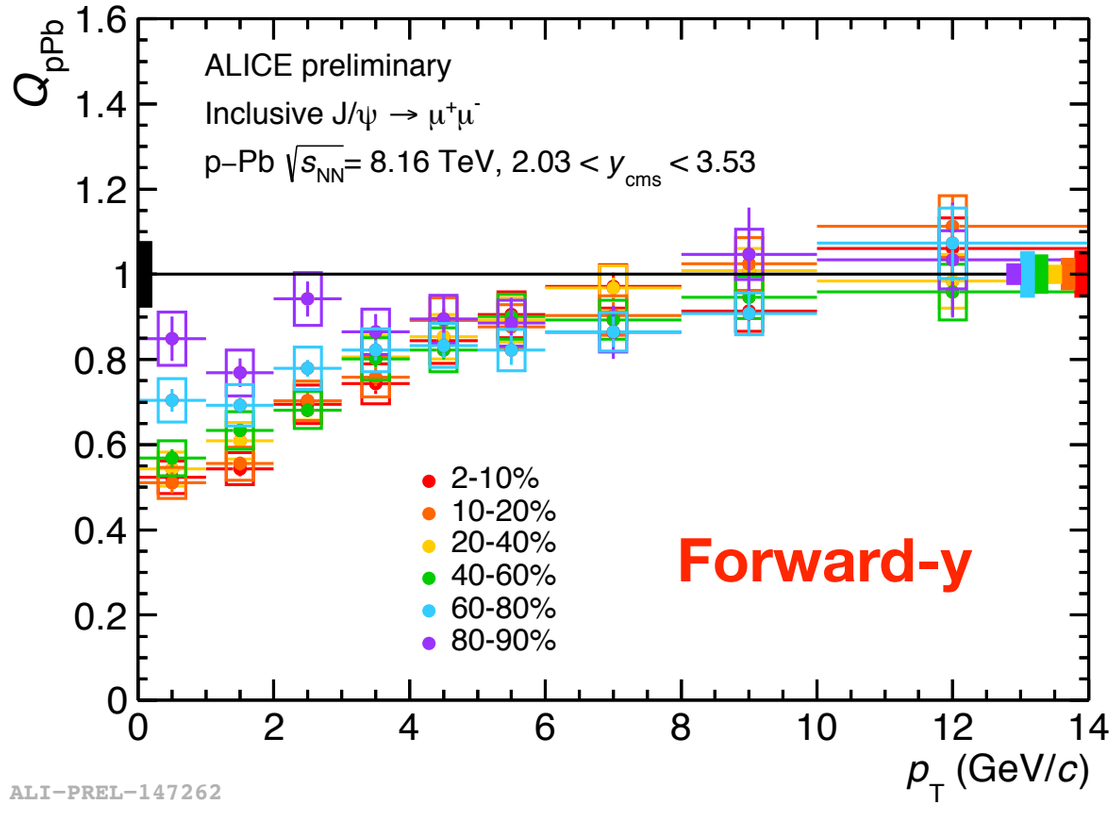
- Suppression seen at forward rapidity, low p_T multiple explanations possible
- Size of theory uncertainties (mainly shadowing) still limits a more quantitative comparison

J/ψ production in p-Pb collisions $\sqrt{s_{NN}}$ = 8.16 TeV

- Multi-differential studies of J/ψ production in p-Pb collisions at backward and forward rapidity

ZN centrality estimator

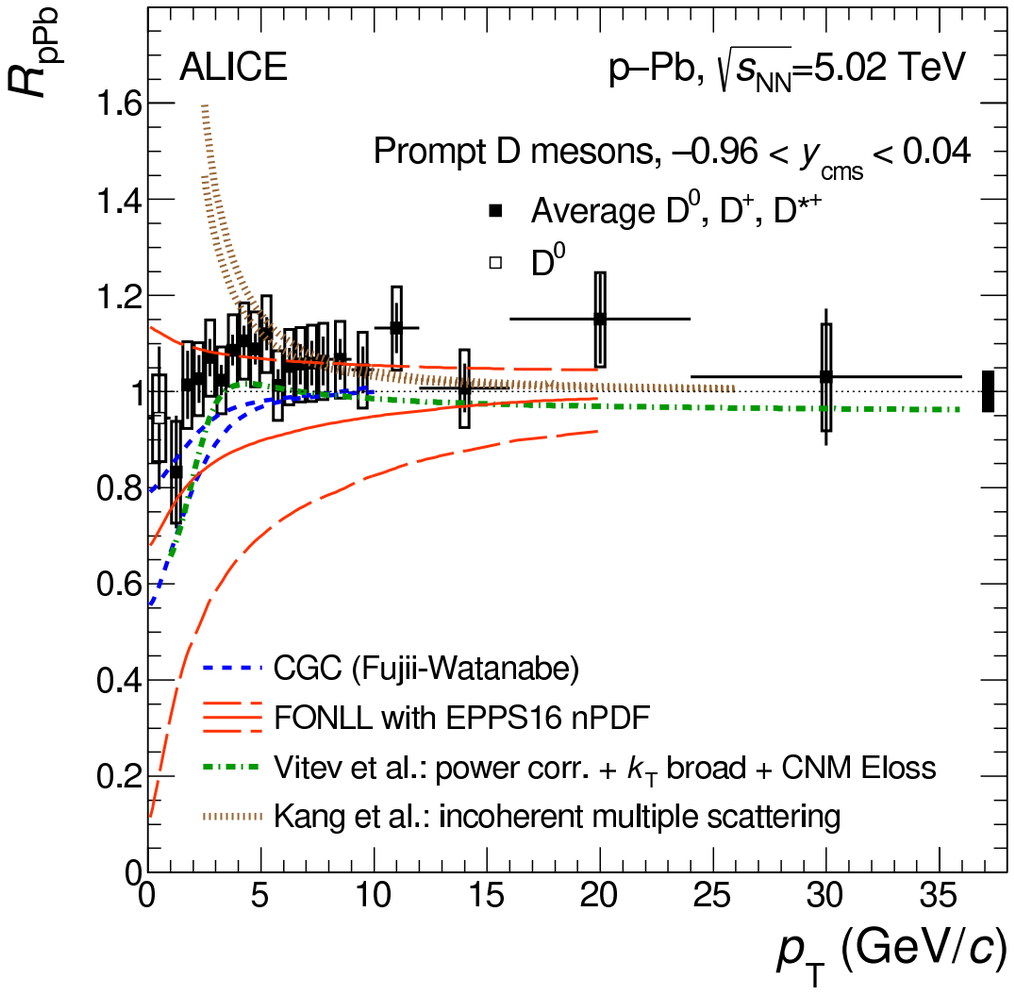


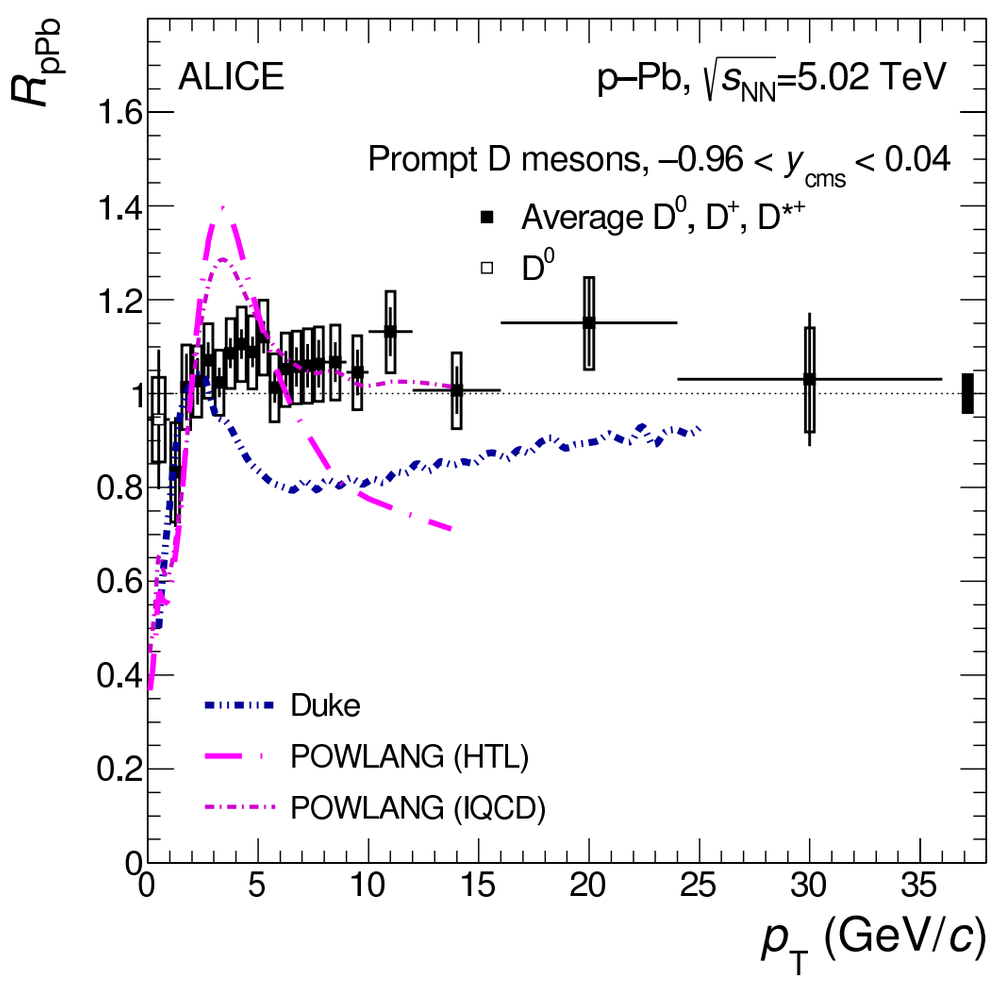


- Q_{pPb} shows a clear evolution vs p_T in different centrality classes
  - Backward-y clear enhancement in most central collisions for $p_T > 3$ GeV/c
    - Clear difference between central and peripheral p-Pb collisions
  - Forward-y stronger suppression for most central collisions?
  - Larger CNM for most central collisions? Final state effects ?

D meson production in p-Pb collisions

ALICE Coll. submitted to JHEP arXiv 1906.03425





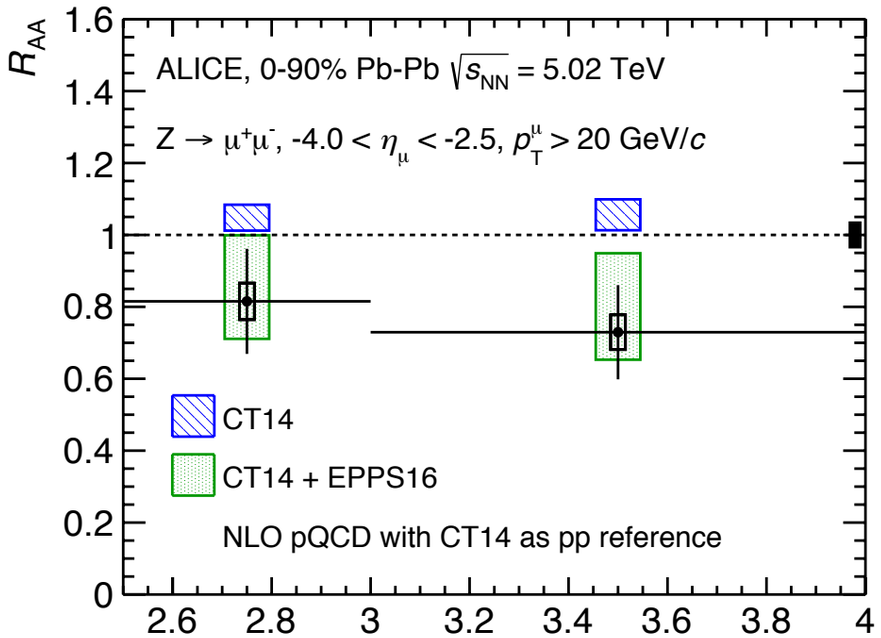
- D-meson R_{pPb} compatible with unity in 0< p_T < 36 GeV/c
  - Described fairly well by models including CNM effects
  - No evidence of energy loss suppression for intermediate p_T

Z production in p-Pb and Pb-Pb collisions

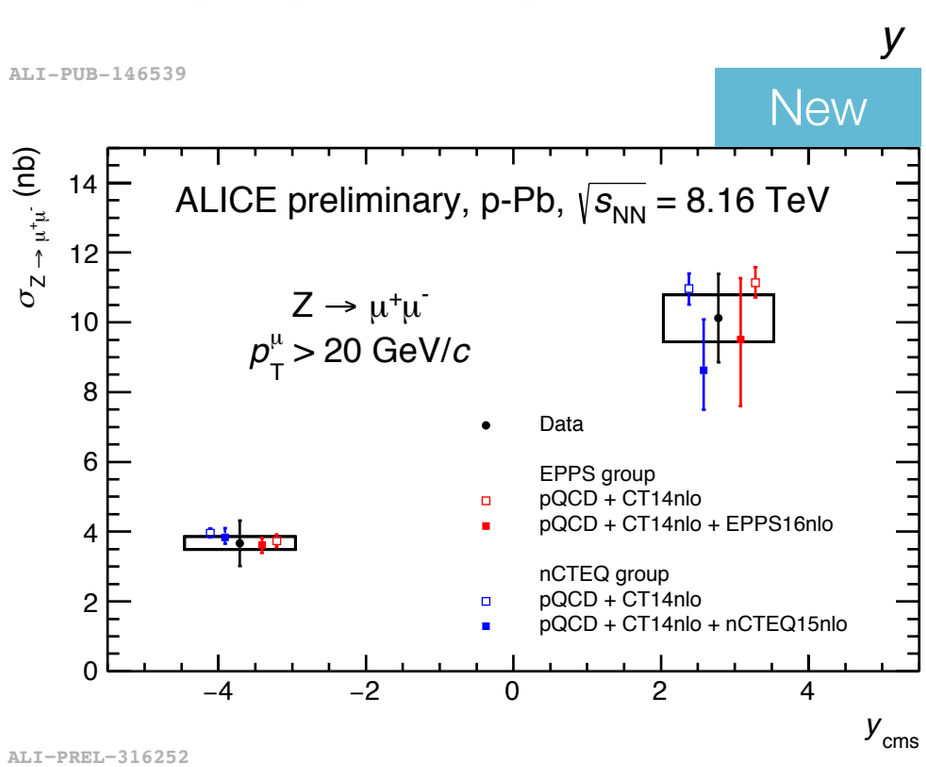
- Electroweak bosons production in p-Pb and Pb-Pb collisions at forward rapidity constrain nPDF at large Bjorken-*x*

- Z-boson R_{AA} measured in Pb-Pb collisions
  - CT14 w/o nPDFs deviates from experimental data by 2.3σ

ALICE Collab. Phys.Lett. B780 (2018) 372-383



- Z-boson cross section measured in p-Pb collisions at $\sqrt{s_{NN}}$ = 8.16 TeV.
- Nuclear shadowing effect smaller than in Pb-Pb
- Data comparable with expectations w/o nPDFs (CT14) and with nPDFs (EPPS16 and nCTEQ groups)



Particle production vs multiplicity

- Study of particle production mechanisms across different collisions systems
  - Event activity is the main variable?
  - Which mechanisms enter in the game?

- Possible connection between hard and soft processes
  - Production at QGP freeze-out.
  - Role of hadronic re-scattering phase
  - Hadronization at high-p_T

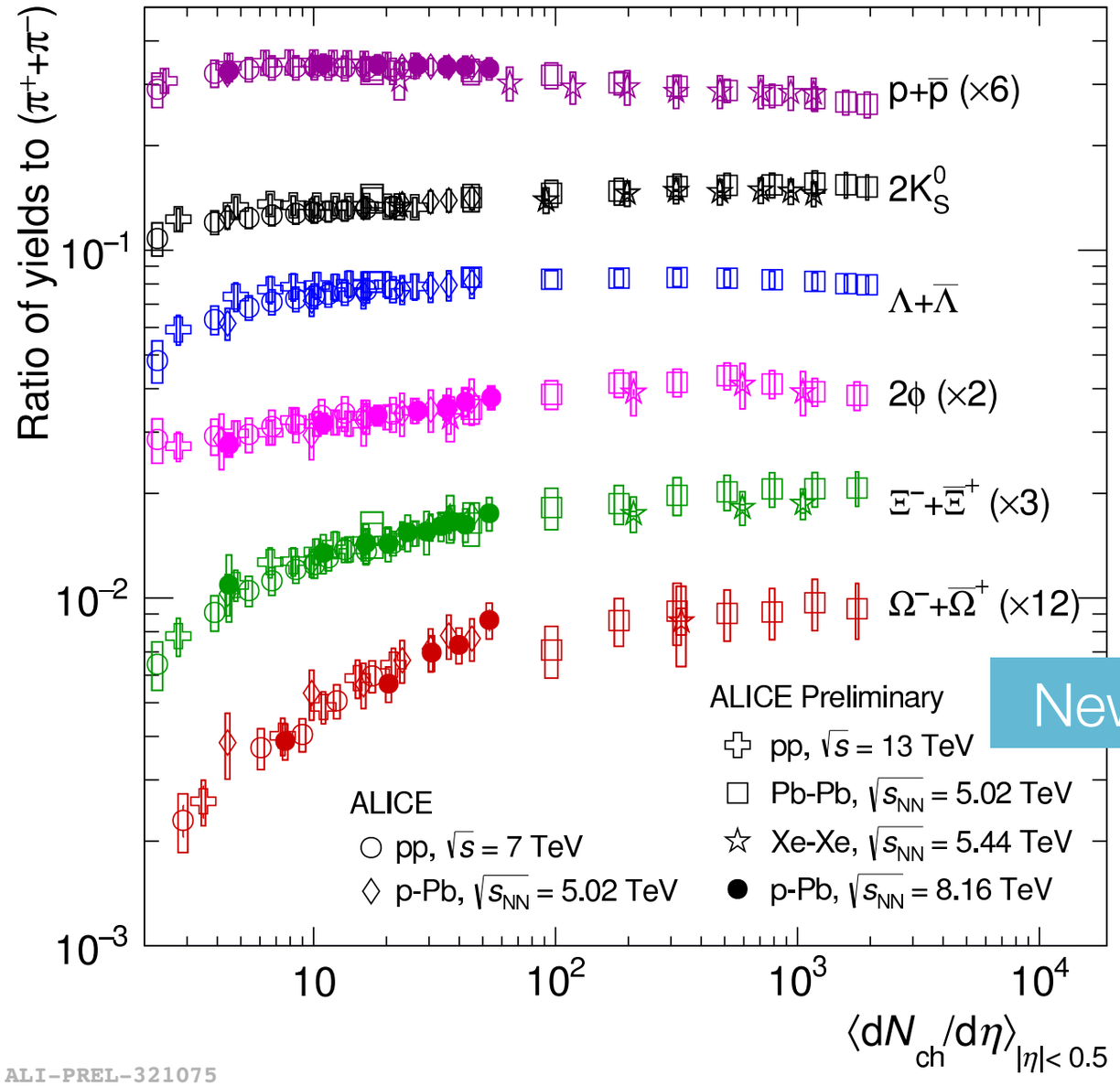
Relative strangeness production in pp, p-Pb, Pb-Pb and Xe-Xe

- Historically a signature of the QGP formation

- No energy dependence observed
  - New preliminary results for pp at $\sqrt{s}$ = 13 TeV and p-Pb at $\sqrt{s_{NN}}$ = 8.16 TeV

- Smooth evolution vs multiplicity from pp to Pb-Pb collisions
  - Including new results in Xe-Xe collisions

- Strangeness production driven by multiplicity also for different collisions systems
- Role of Multi Parton Interactions in small systems?



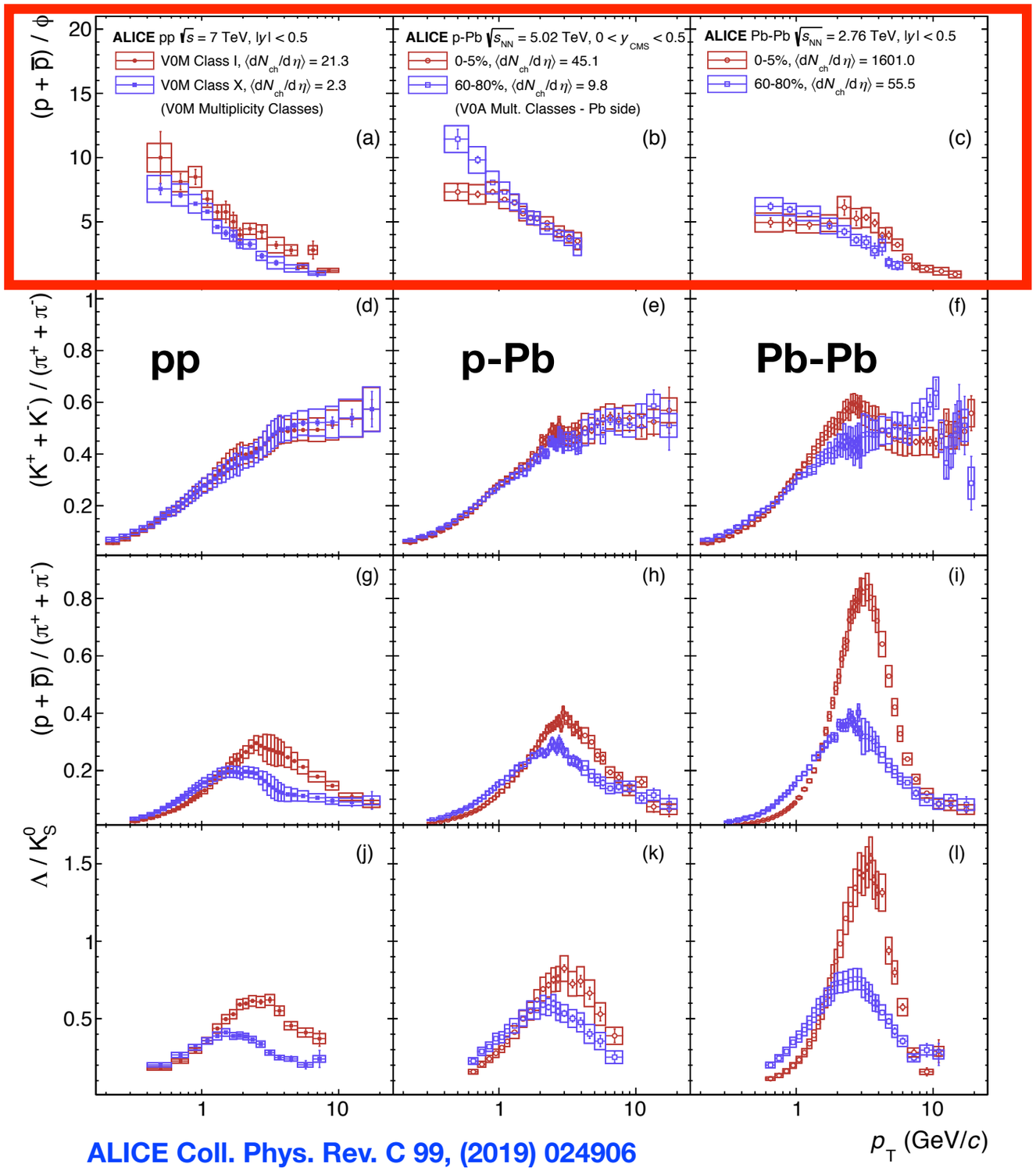
New

ALICE Coll. Nature Physics 13 (2017) 535-539
Phys. Lett. B 758 (2016) 389-401

Particles ratios vs p_T

Highest multiplicity
Lowest multiplicity

- Similar evolution pattern of particle ratios from pp to Pb-Pb collisions
  - p/ϕ decreasing with p_T in the three systems



ALICE Coll. Phys. Rev. C 99, (2019) 024906

Particles ratios vs p_T

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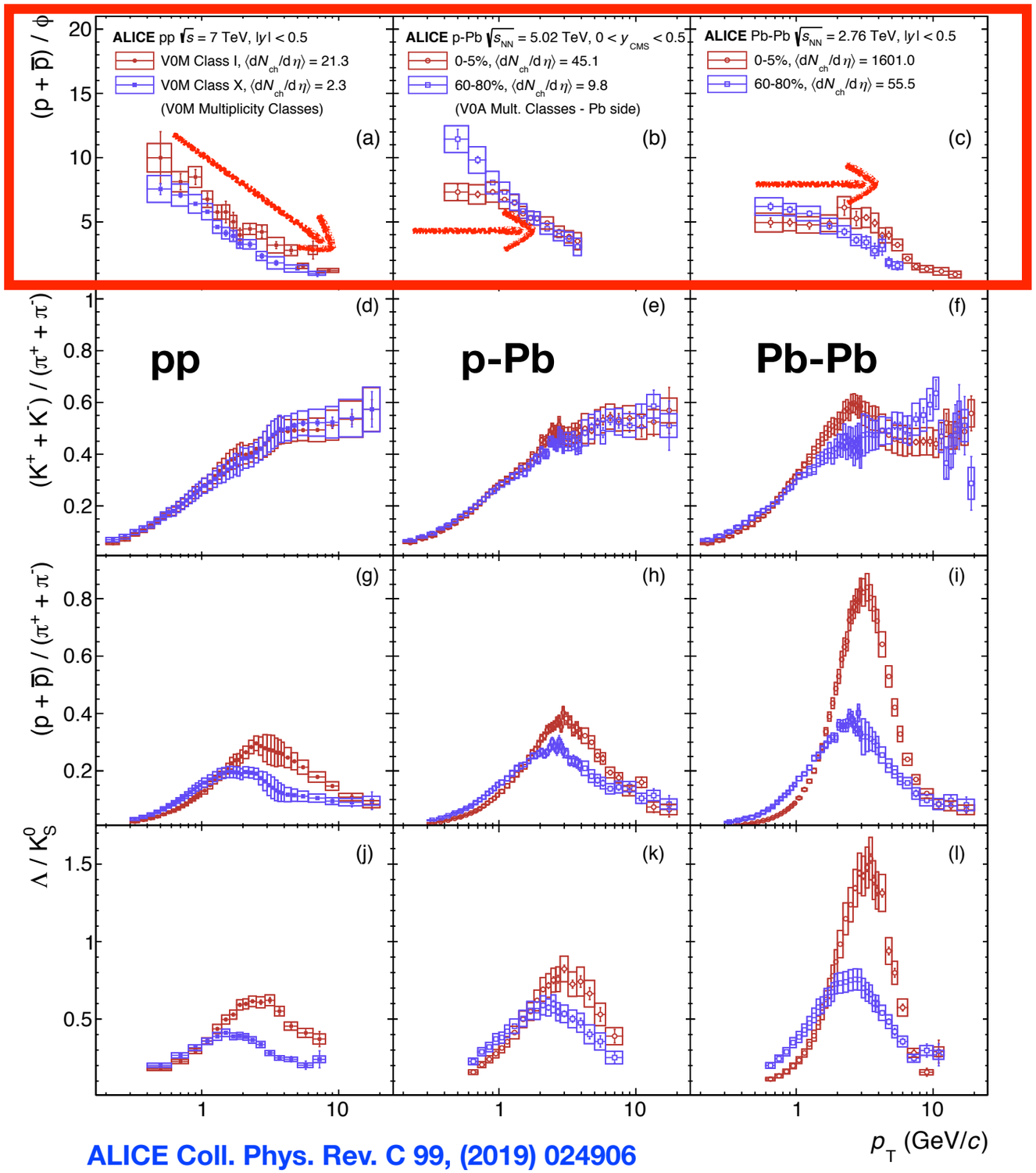
Lowest multiplicity

- Similar evolution pattern of particle ratios from pp to Pb-Pb collisions
  - p/ϕ decreasing with p_T in the three systems → **flattening in large systems from radial flow?**



ALICE Coll. Phys. Rev. C 99, (2019) 024906

Particles ratios vs p_T

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- Similar evolution pattern of particle ratios from pp to Pb-Pb collisions
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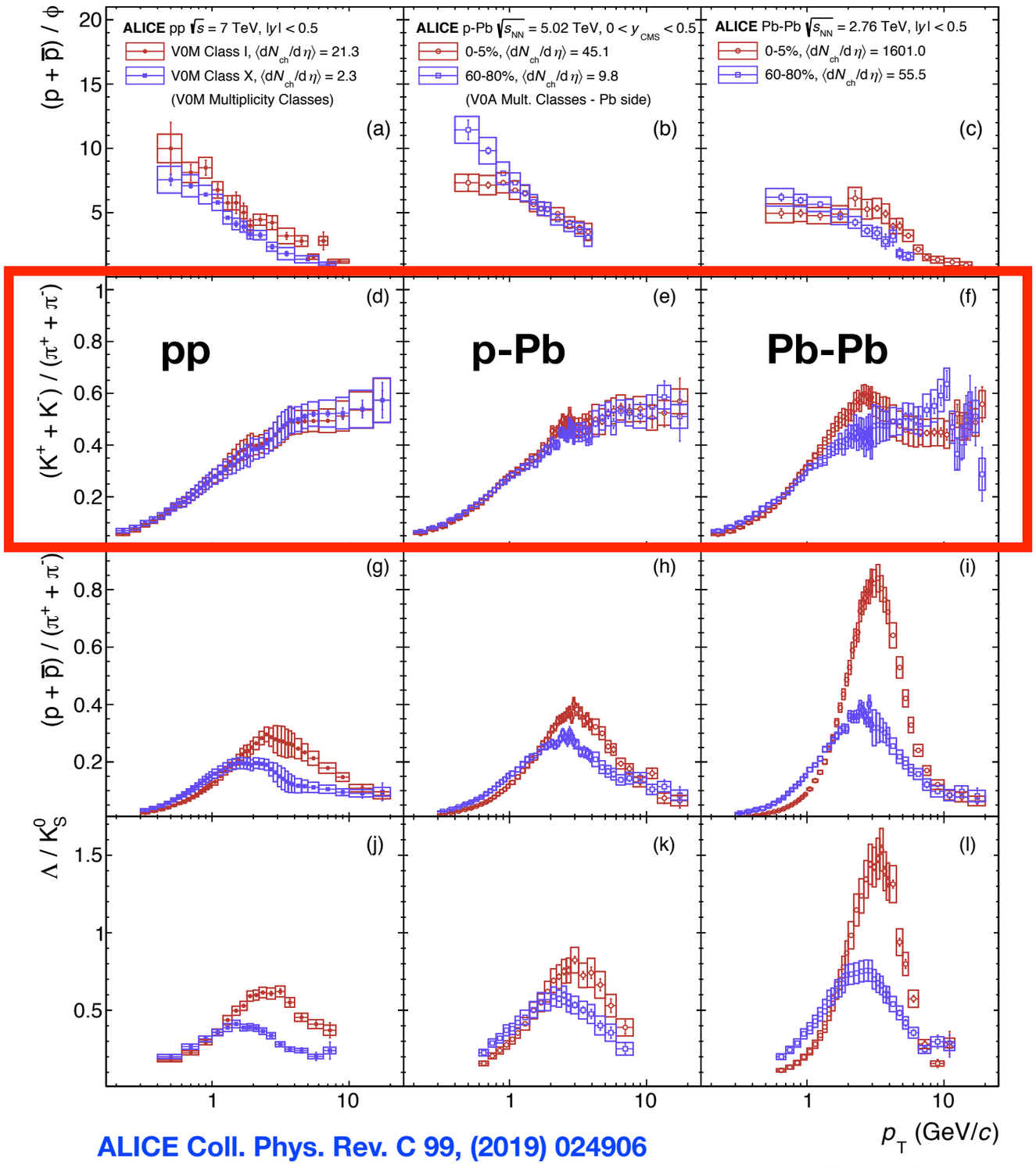
  - **K/π multiplicity independent** except for central Pb-Pb collisions



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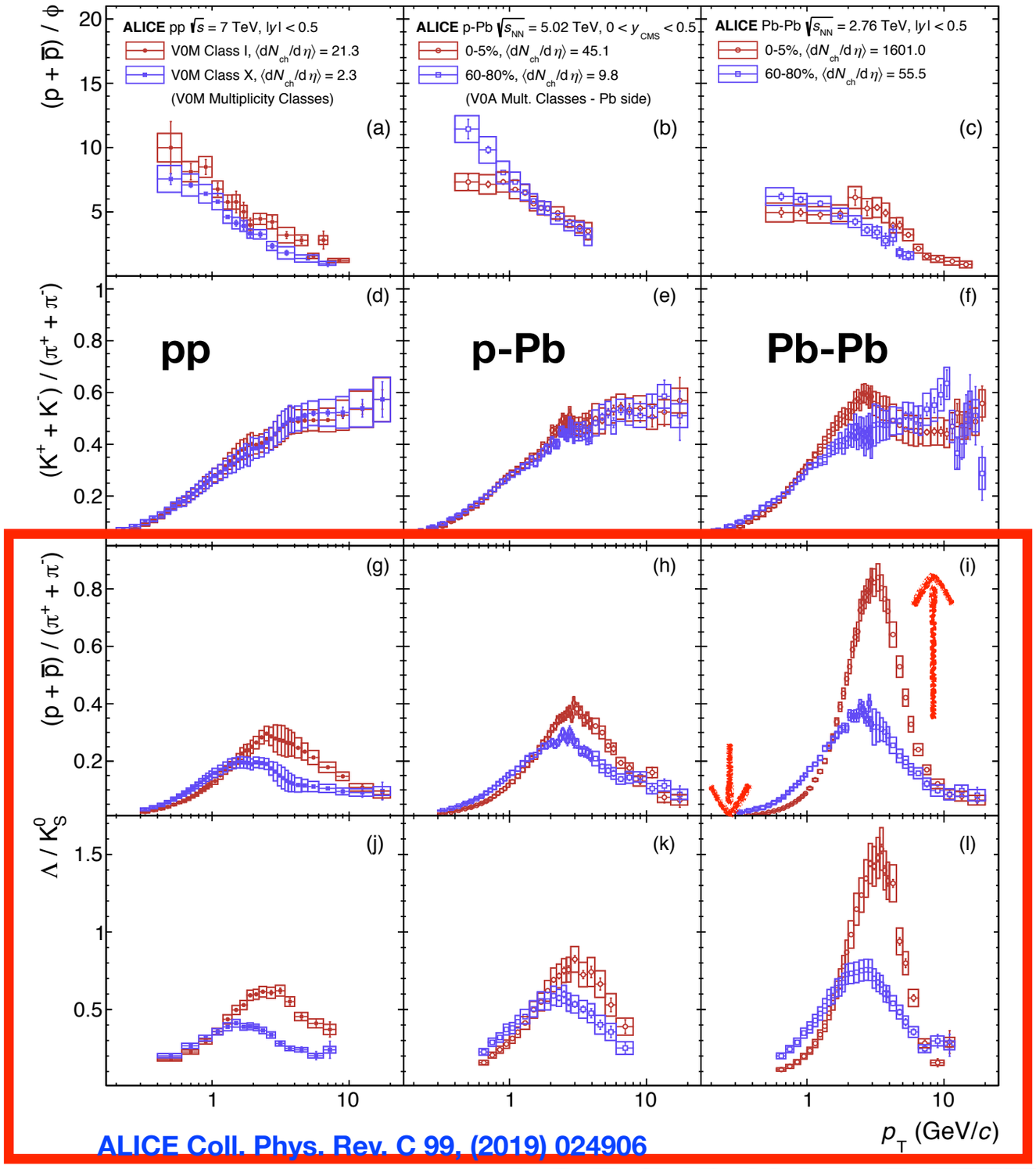
  - K/π multiplicity independent except for central Pb-Pb collisions
  - p/π, Λ/K^0_S show a depletion at p_T ~0.7 GeV/*c* and a clear enhancement at ~3 GeV/*c* in all systems → **Baryon formation effect ?**



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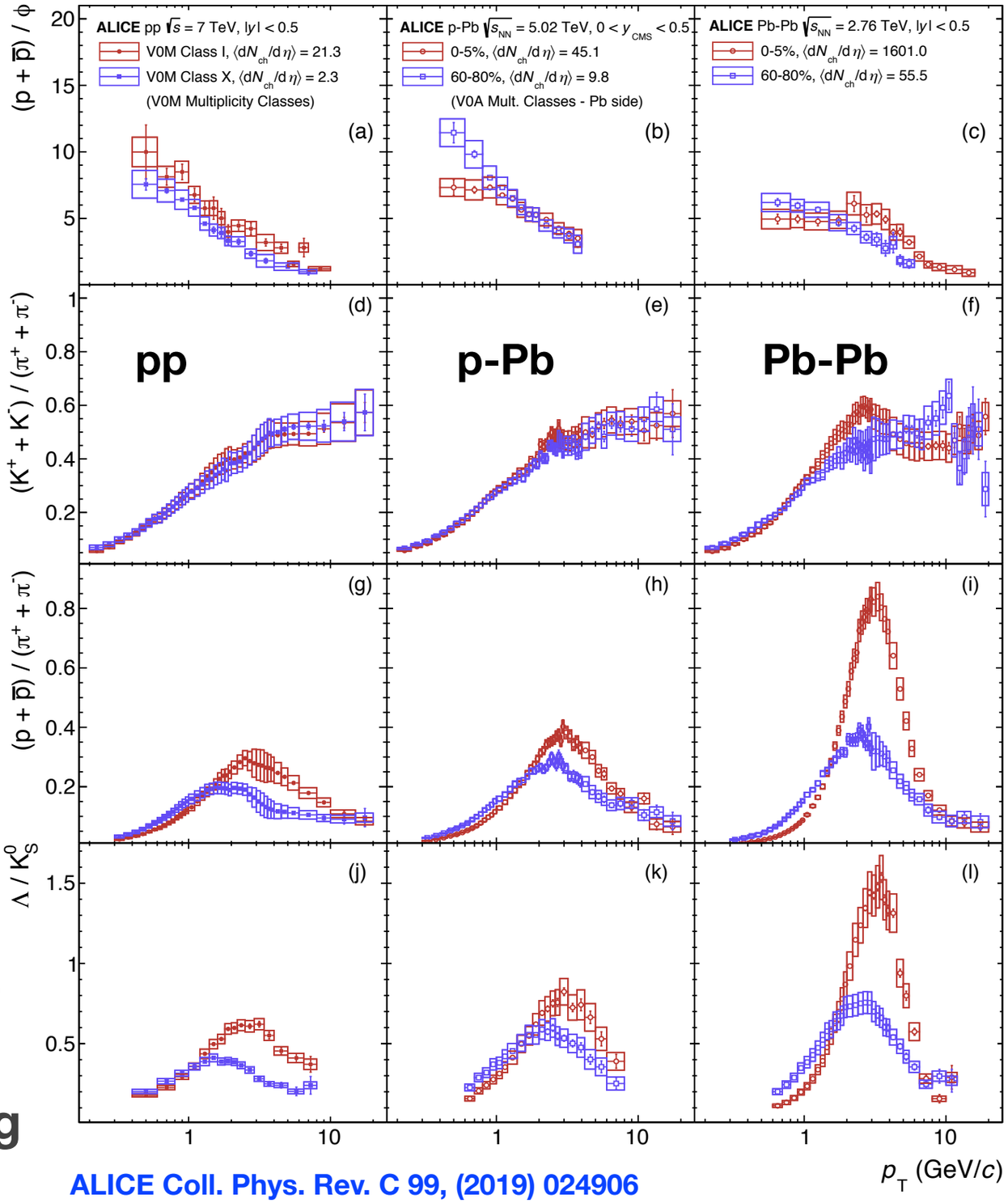
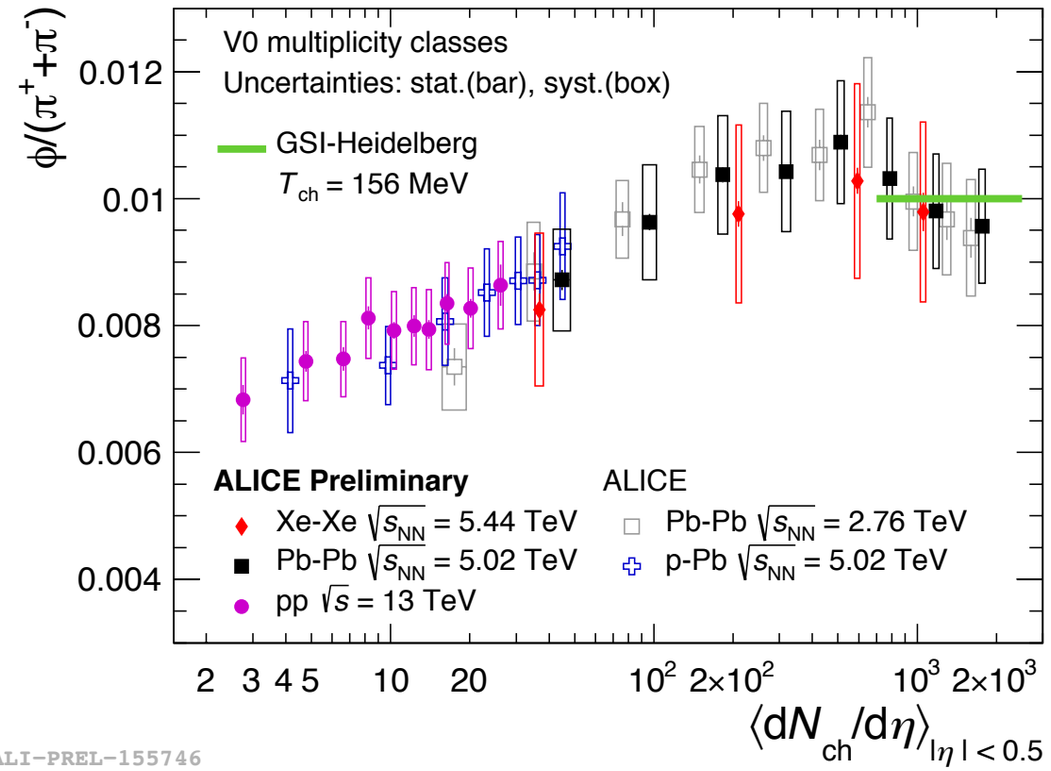
- **Particle production driven by multiplicity + flow + baryons/ recombination at intermediate p_T ?**
- **Mass ordering, baryons/mesons effect present also in the hardening of the spectra**



ALICE Coll. Phys. Rev. C 99, (2019) 024906

ϕ production and h-ϕ correlations

- ϕ/π shows an increase from pp to peripheral Pb-Pb, then a different trend for Pb-Pb (and Xe-Xe) collisions
- Use two-particle correlations to investigate the origin of the ϕ production (jet or underlying event)?



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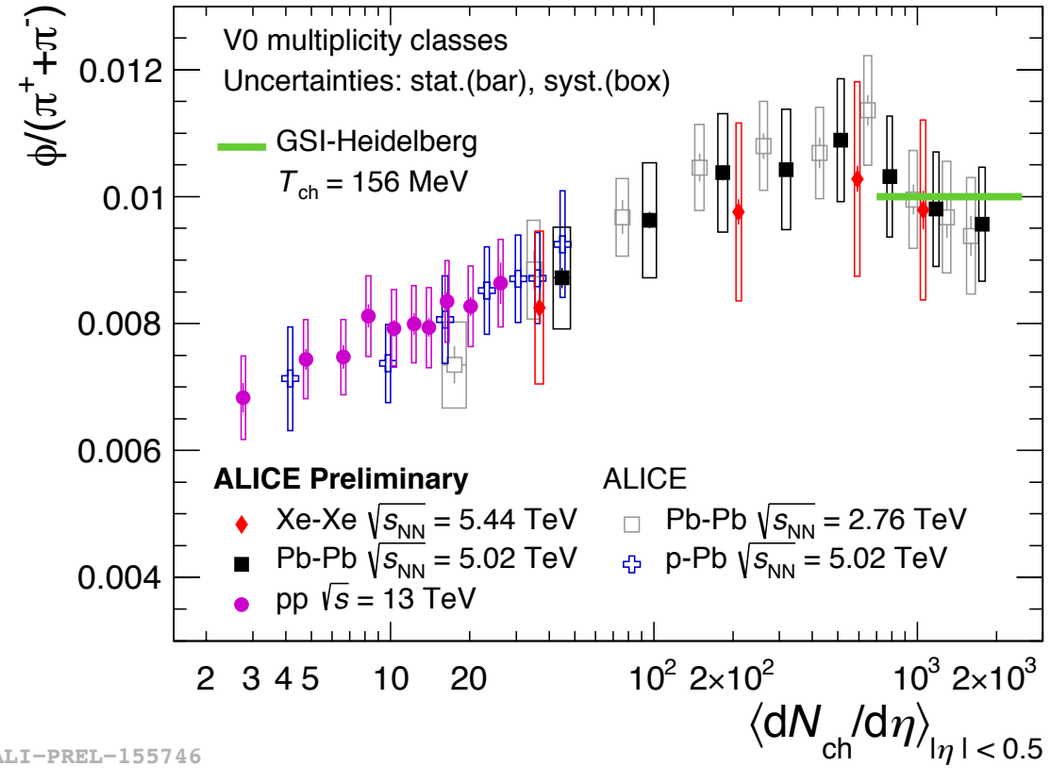
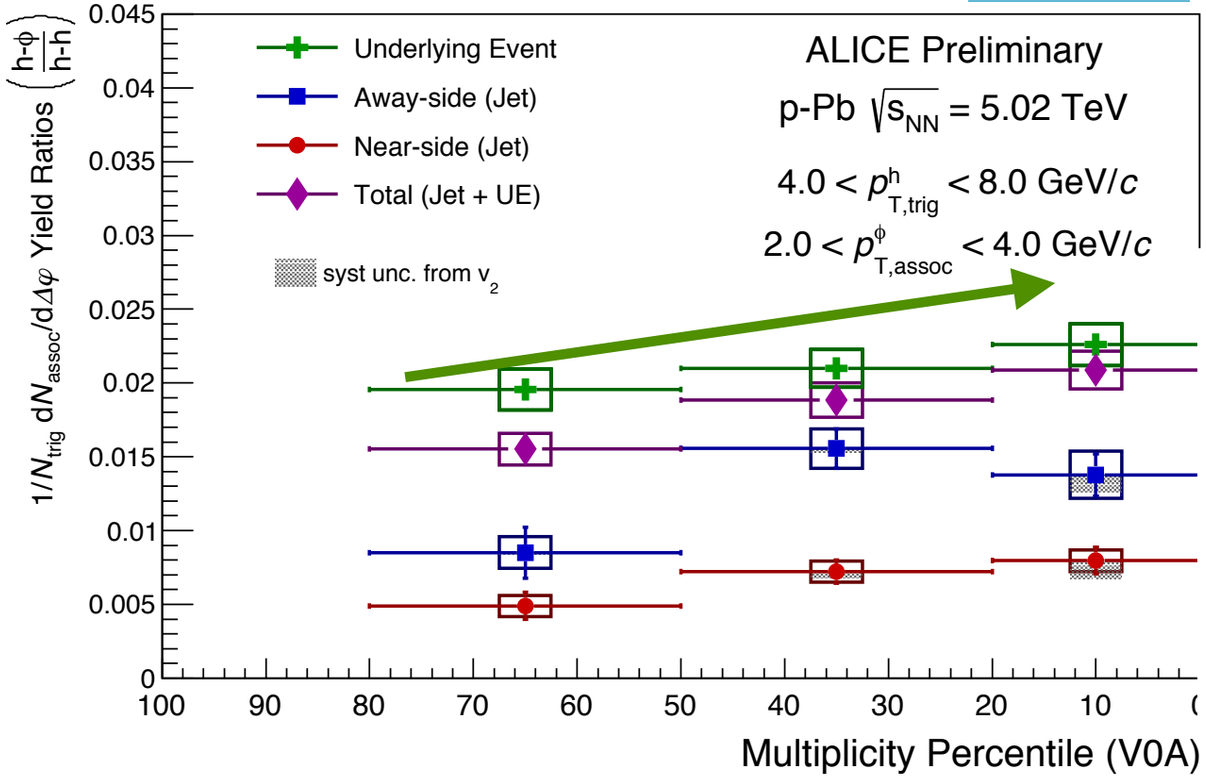
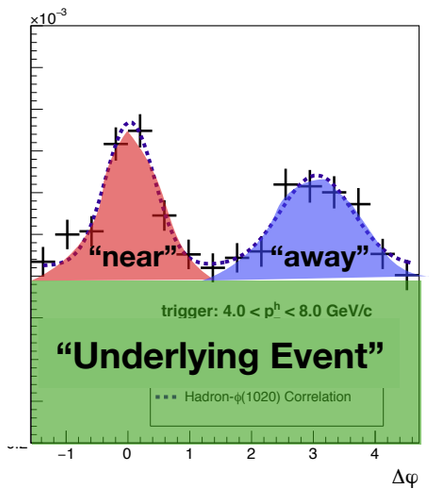


New





- Increase h-ϕ/h-h pairs vs multiplicity as ϕ/π ratio

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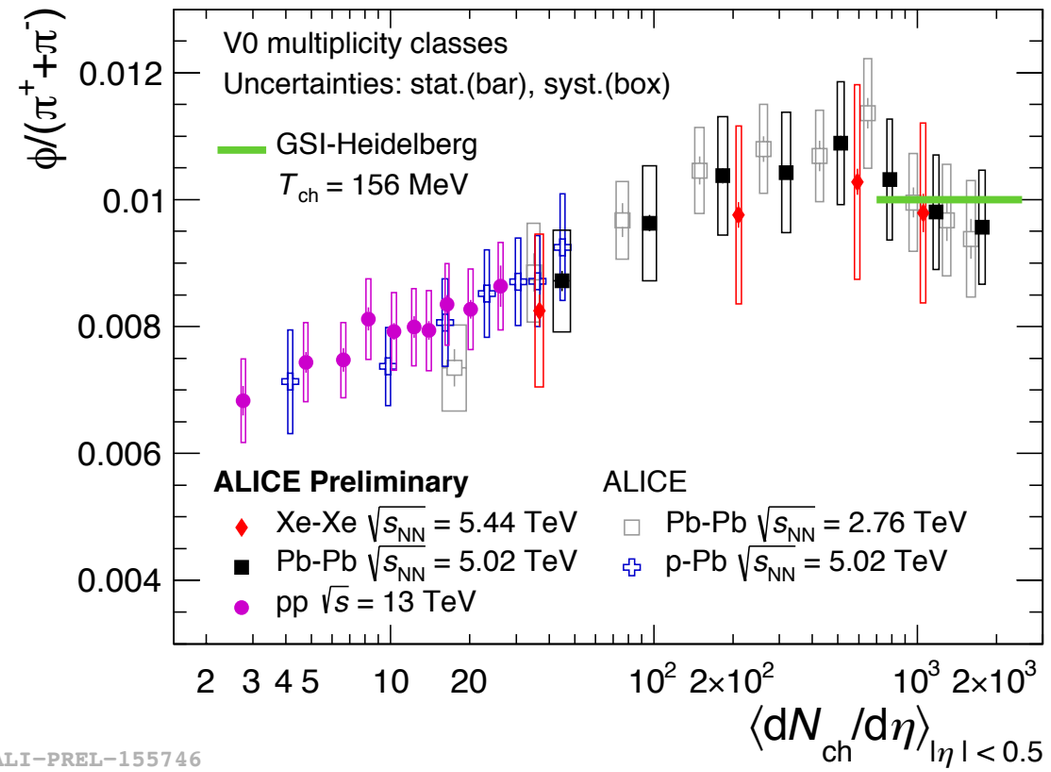
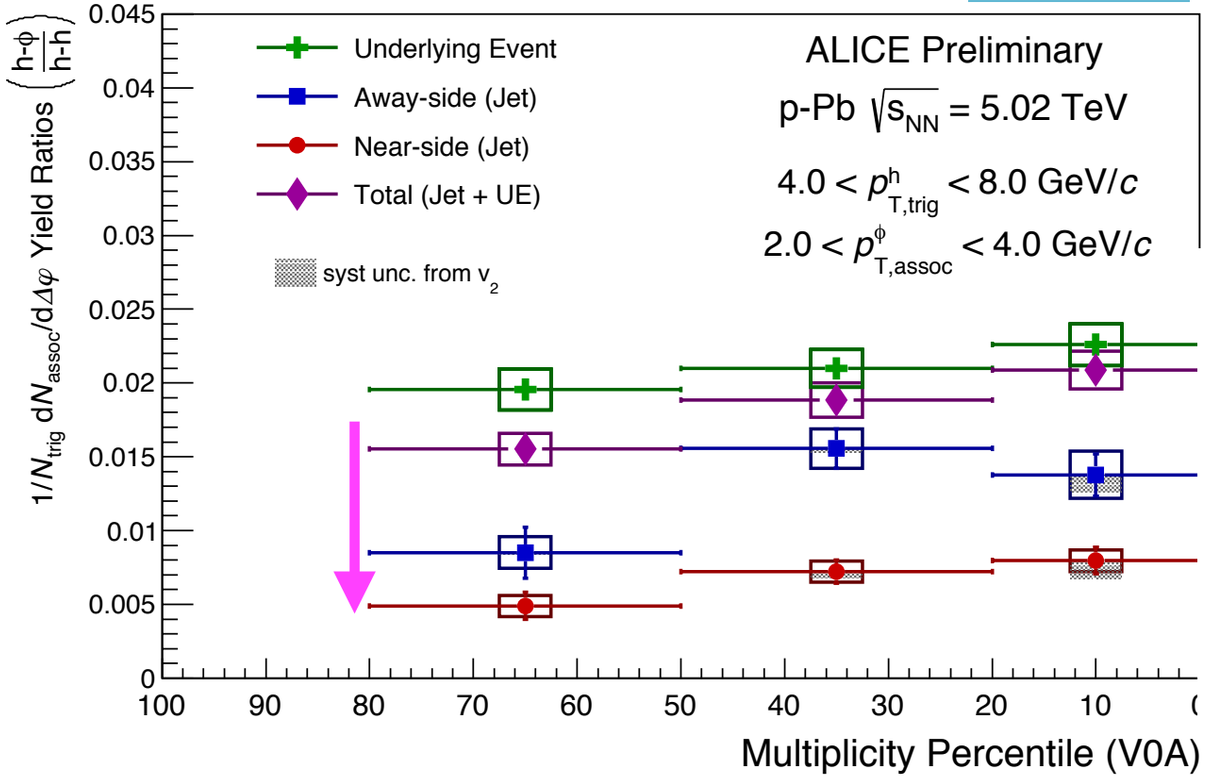
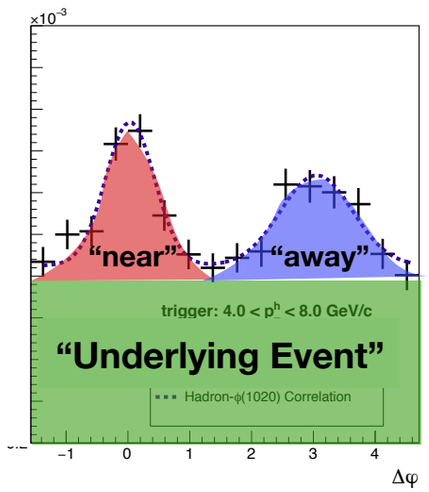
- ϕ/π shows an increase from pp to peripheral Pb-Pb, then a different trend for Pb-Pb (and Xe-Xe) collisions
- Use two-particle correlations to investigate the origin of the ϕ production (jet or underlying event)?



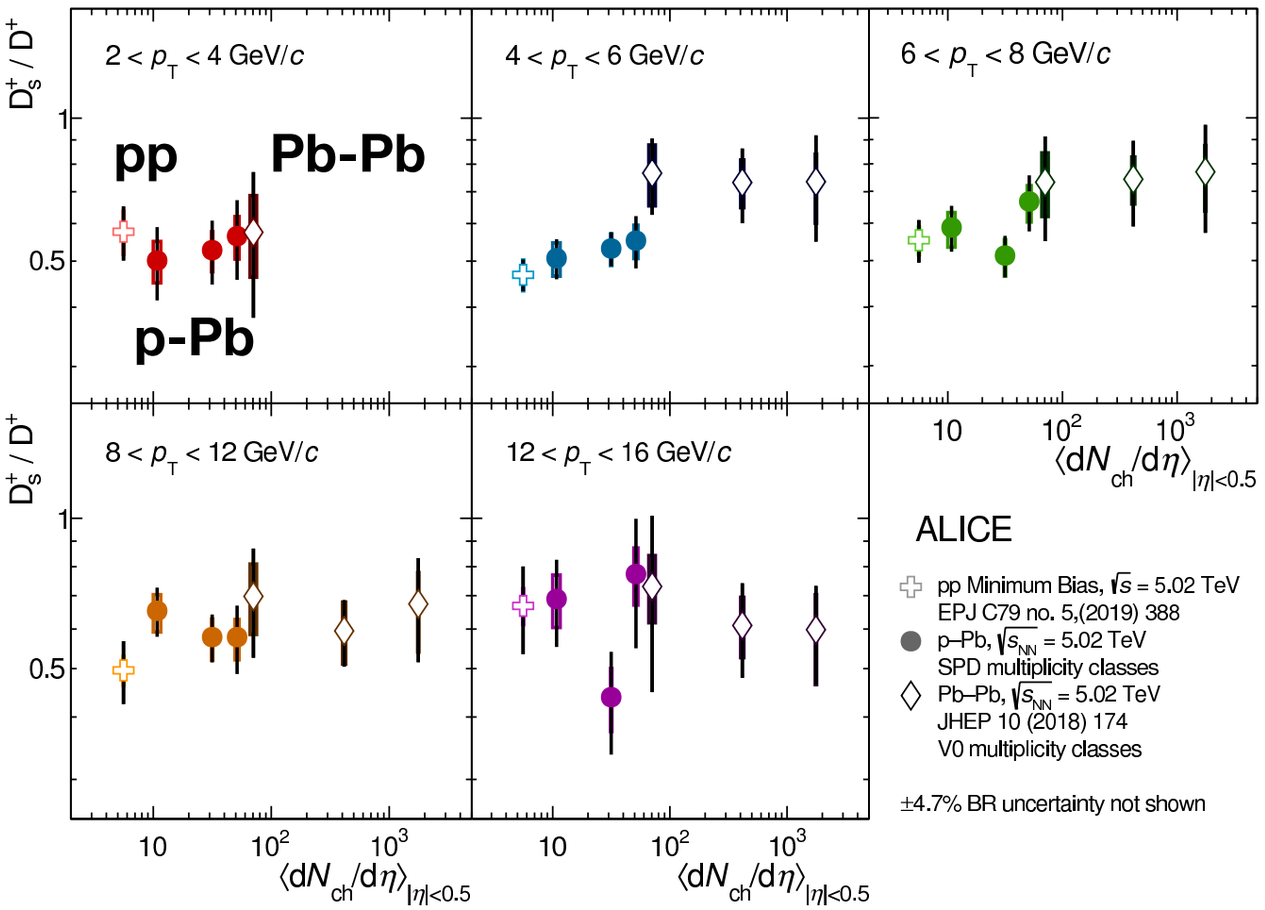
New





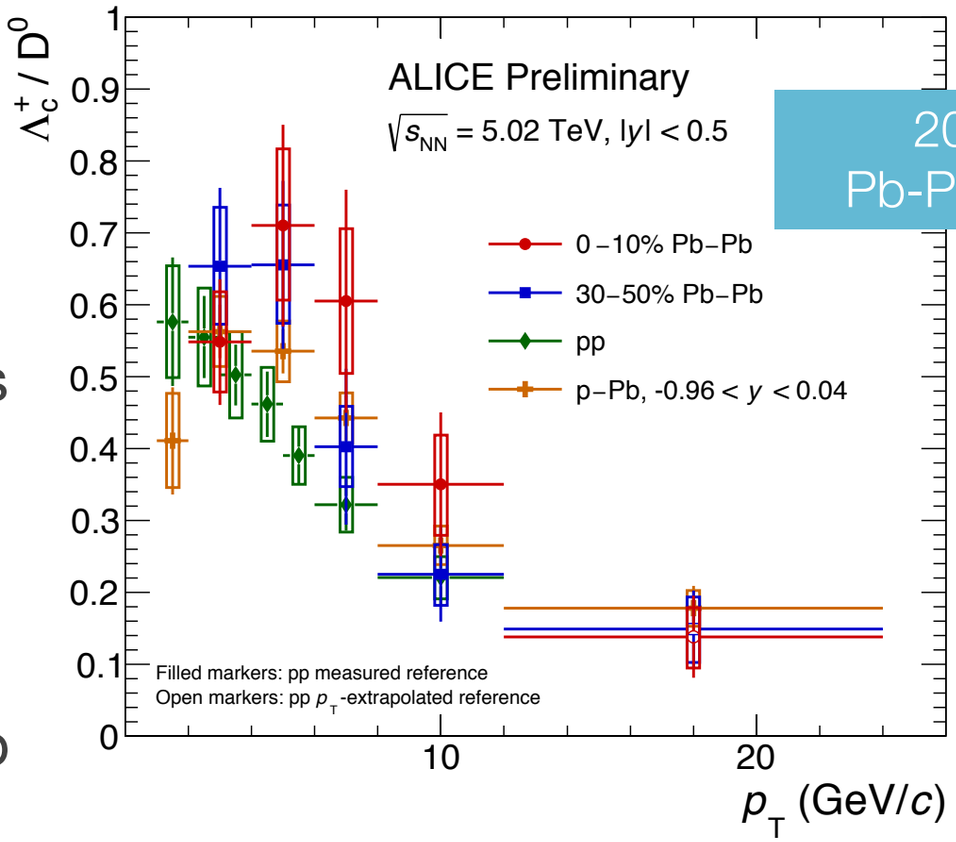
- Increase h-ϕ/h-h pairs vs multiplicity as ϕ/π ratio
- h-ϕ/h-h in jets is lower than the inclusive measurement
- Production tends to be dominated by UE

Heavy Flavour production vs multiplicity



- D^+_s/D^+ ratio vs multiplicity is flat within uncertainties across the three different systems
- A hint of increase is observed for $4 < p_T < 12$ GeV/c for most central Pb-Pb collisions

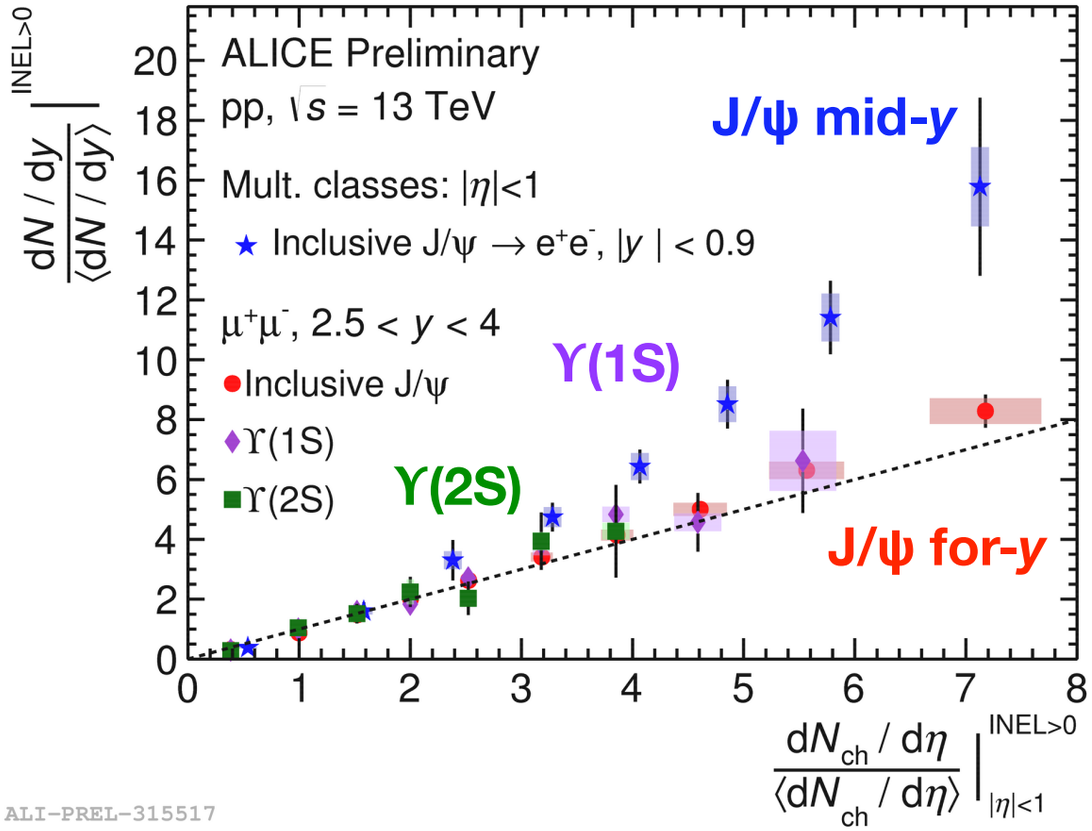
ALICE Coll. submitted to JHEP arXiv 1906.03425



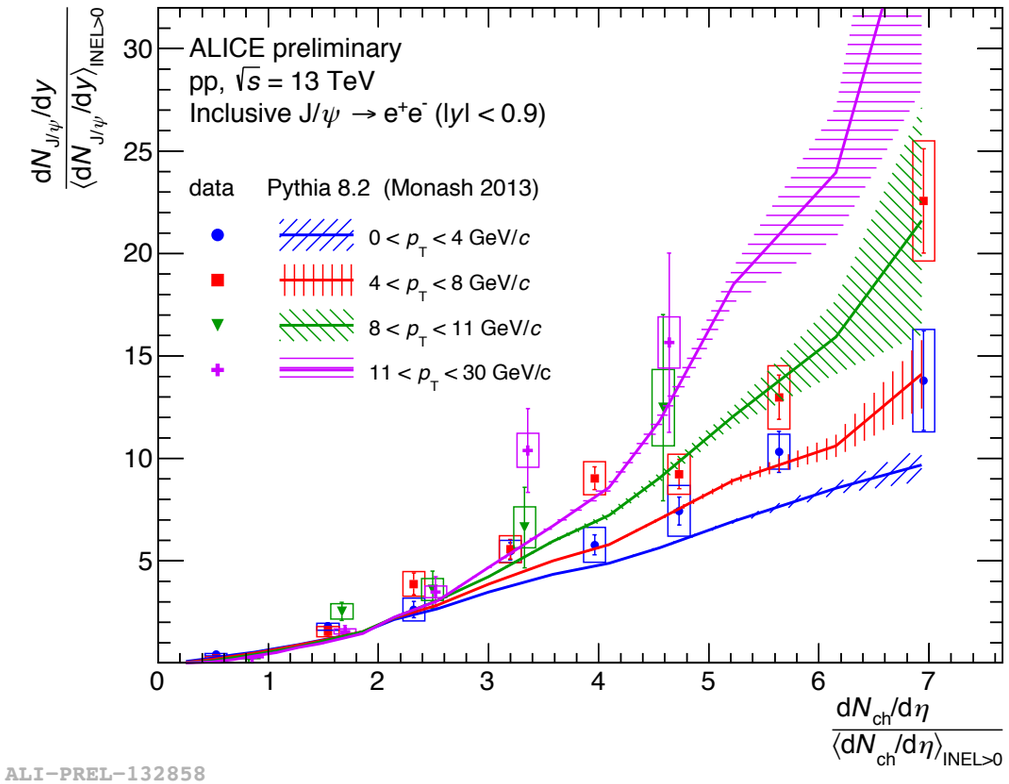
- Hint of higher Λ_c^+/D^0 ratio in Pb-Pb collisions w.r.t pp ones
- Higher Λ_c^+/D^0 ratio in pp than in e^+e^- collisions
- Baryon related effect? Models including both coalescence and fragmentation seem to reproduce better the data

-onia production in pp collisions

- HF production coming form hard scatterings (MPI?)
- -onia production increases vs multiplicity in pp collisions
  - Linear trend observed for forward-*y* production for all quarkonia state J/ψ, ϒ(1S), ϒ(2S).



ALI-PREL-315517



ALI-PREL-132858

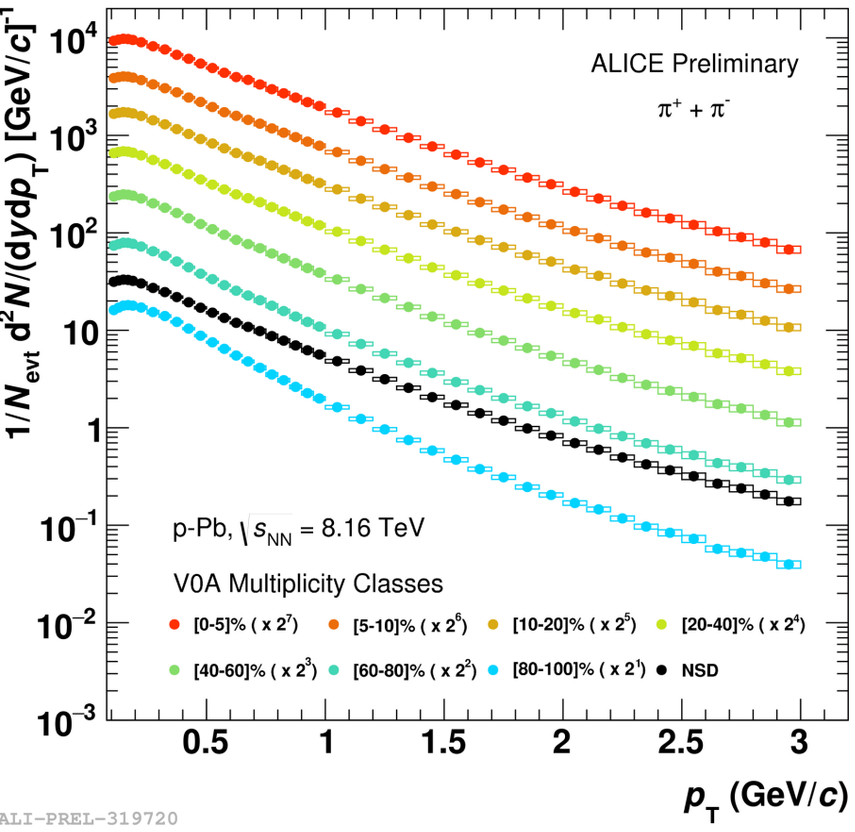
- Stronger than linear at mid-*y*, when no rapidity gap
- Steeper rise at higher p_T for mid-*y*
- Qualitative agreement with model calculations including Multi Parton Interactions (Pythia 8 Monash 2013)

Collective effects

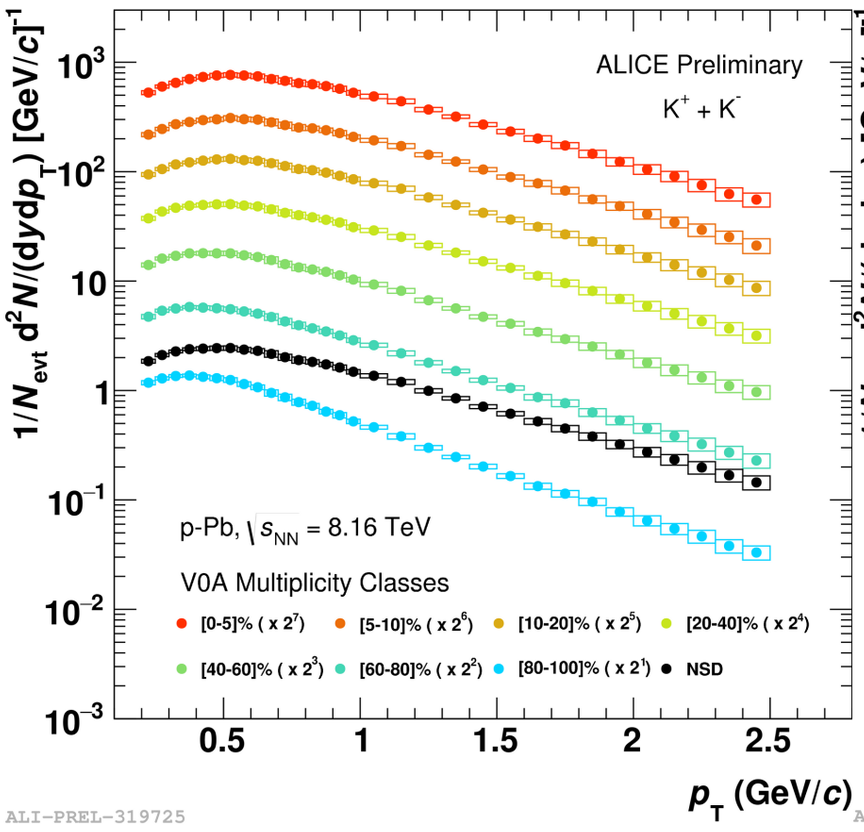
- Common velocity field for all particles induced during the expansion by the collision → Radial flow
- Azimuthal anisotropies of particles induced by collisions geometry and initial nucleon distributions fluctuations → v_2, v_3, v_4, …
- Investigation of collective like effects in p-Pb and pp collisions.

Spectra of charged π, K and p in p-Pb

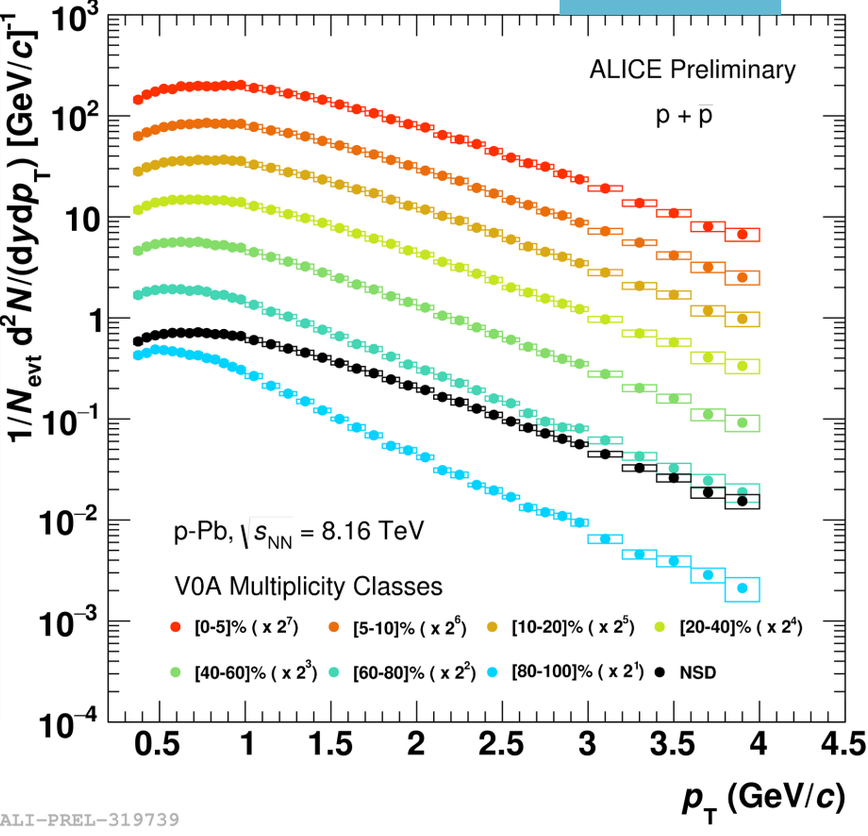
New



ALI-PREL-319720



ALI-PREL-319725



ALI-PREL-319739

- New measurement of identified particles spectra in p-Pb collisions using different techniques: ITS, TPC, TOF.
- Mass dependent hardening of the spectra with increasing multiplicity class
  - Indication of radial expansion effect in p-Pb
    - Same origin as for Pb-Pb? Hadronic re-scattering?

System size dependence of v_n coefficients

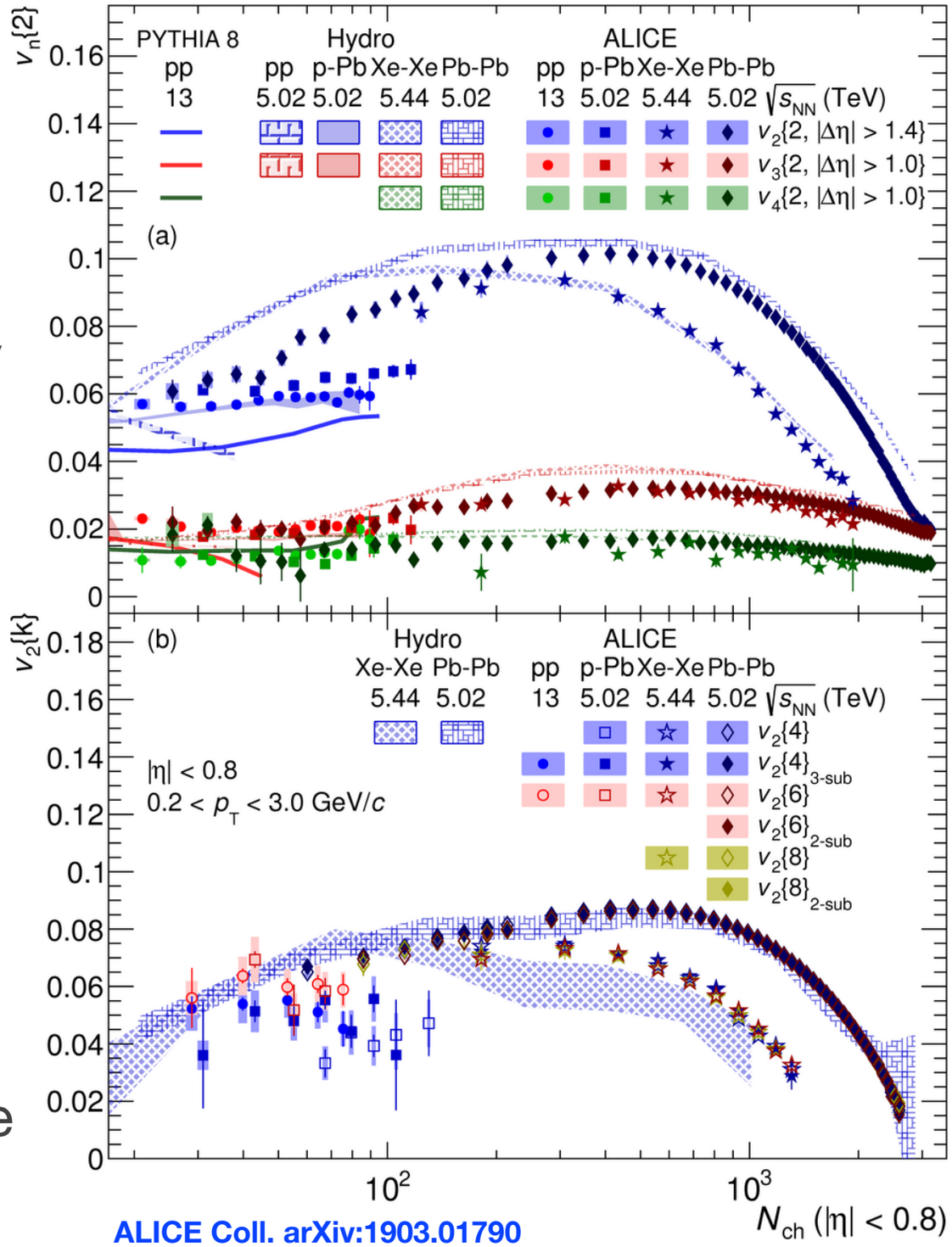
Large systems (Pb-Pb, Xe-Xe)

- Strong multiplicity dependence of vn
- $v_2 > v_3 > v_4$
- Hydro calculations describe reasonably the data at intermediate-high multiplicity
- $v_2\{4\} \sim v_2\{6\} \sim v_2\{8\}$

Small systems (pp, p-Pb)

- v_n ~ flat vs multiplicity
- $v_2 > v_3 > v_4$
- Cannot be explained by non-flow only (PYTHIA)

- Observation of long-range multi-particle correlations in small systems

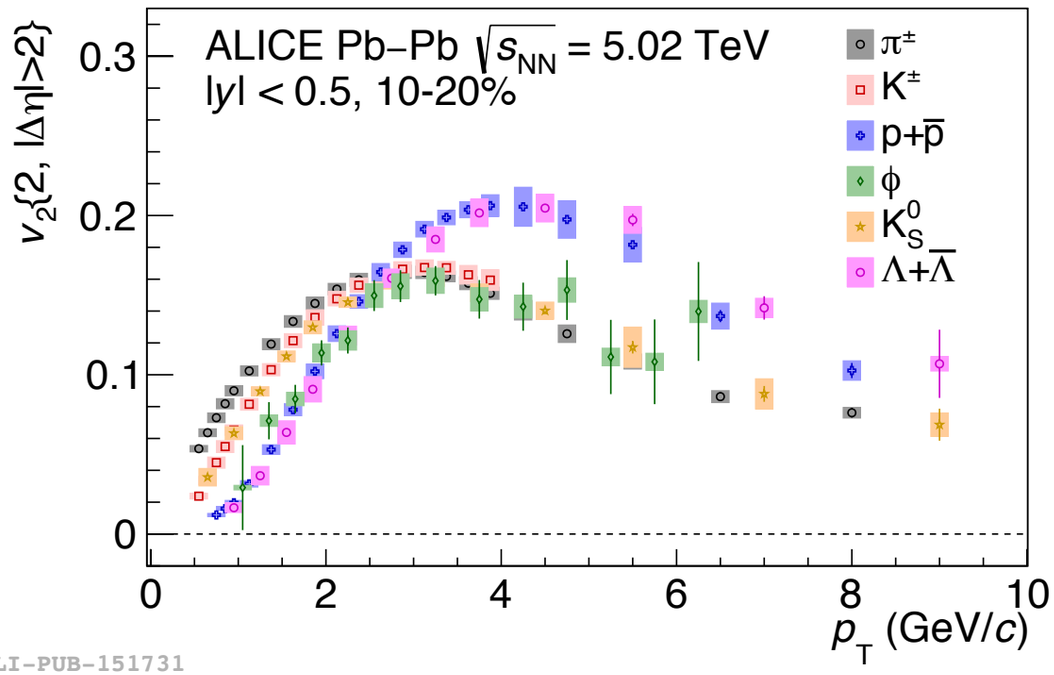


ALICE Coll. arXiv:1903.01790

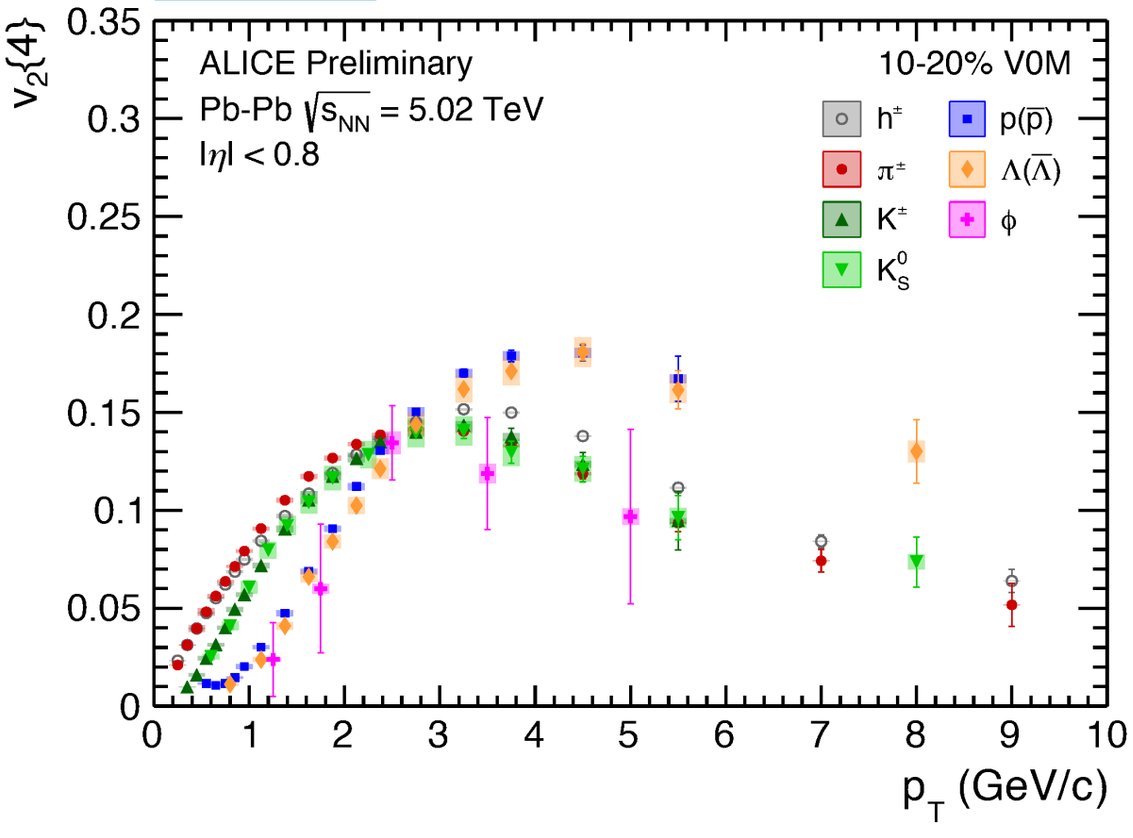
Identified particles flow coefficients

- Results of identified particles v_n in Pb-Pb collisions
  - p_T < 2 GeV/c hadron mass ordering
  - p_T ~ 2.5 GeV/c crossing between baryons and mesons
  - p_T > 2.5 GeV/c baryons v_2 > mesons v_2

ALICE Collab. JHEP 1809 (2018) 006



New



- First measurement of $v_n(p_T)$ of identified hadrons using 4-particle cumulants method
- More sensitive to initial state fluctuations, less affected by non-flow
- Similar behaviours observed as for $v_2\{2\}$ (mass ordering and baryon/meson grouping)

Identified particles flow coefficients

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  - p_T < 2 GeV/*c* hadron mass ordering
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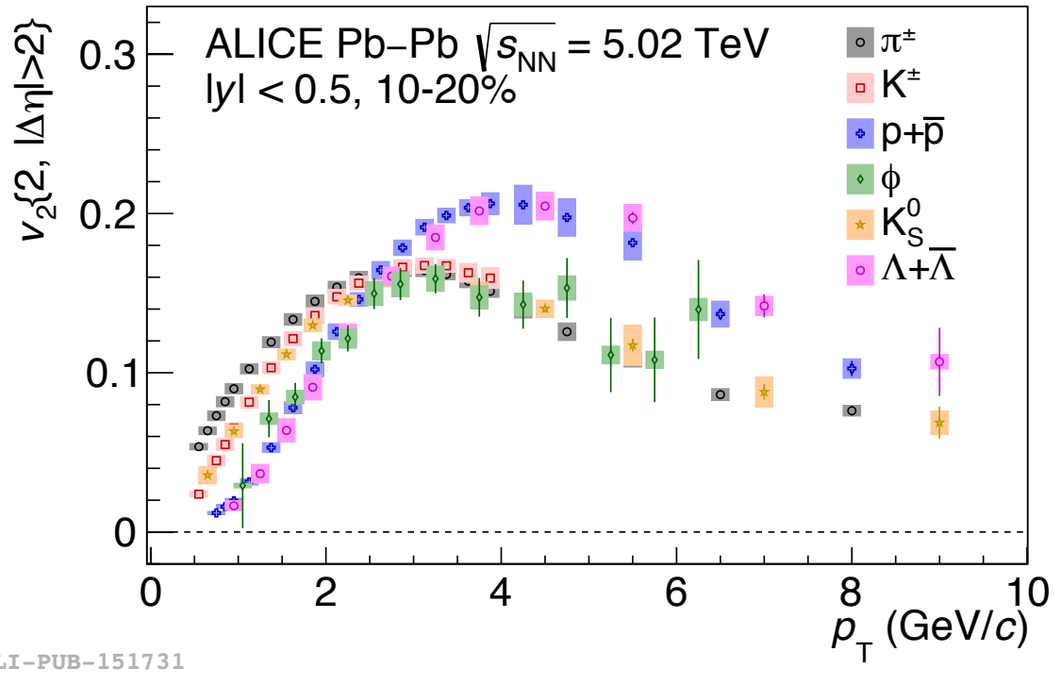
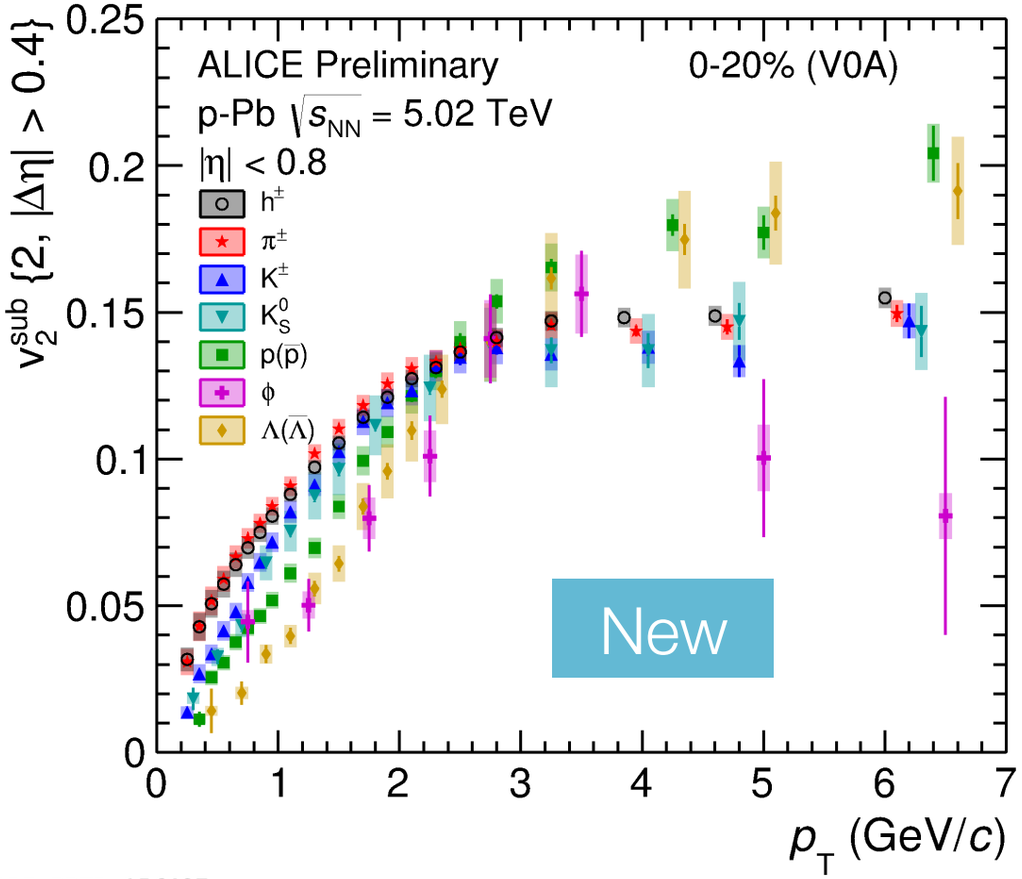


ALI-PUB-151731

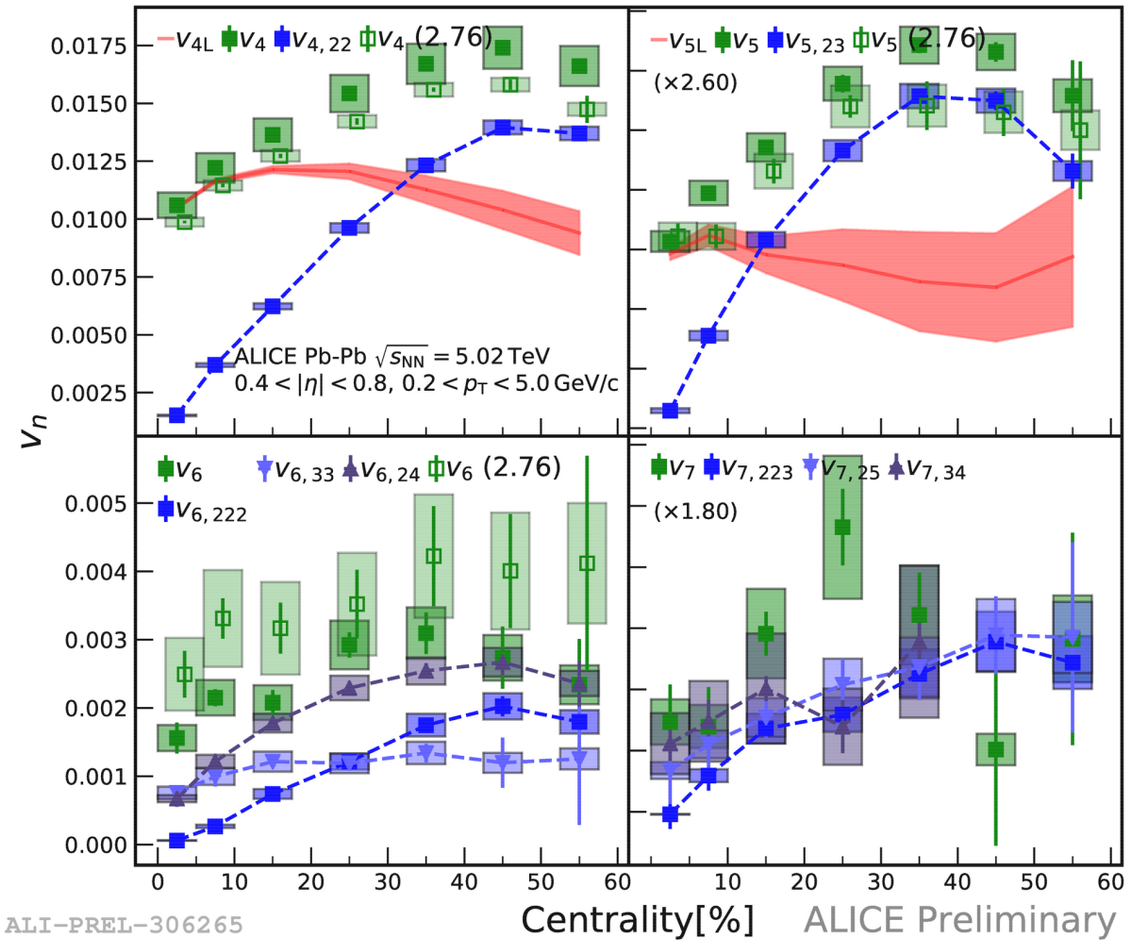


ALI-PREL-156487

- New results on $v_2\{2\}$ in p-Pb collisions for identified particles
  - Subtraction of non-flow contribution from pp collisions
  - Similar patterns as observed in Pb-Pb collisions

Poster Jasper Elias Parkkila

Non-linear flow modes in Pb-Pb collisions

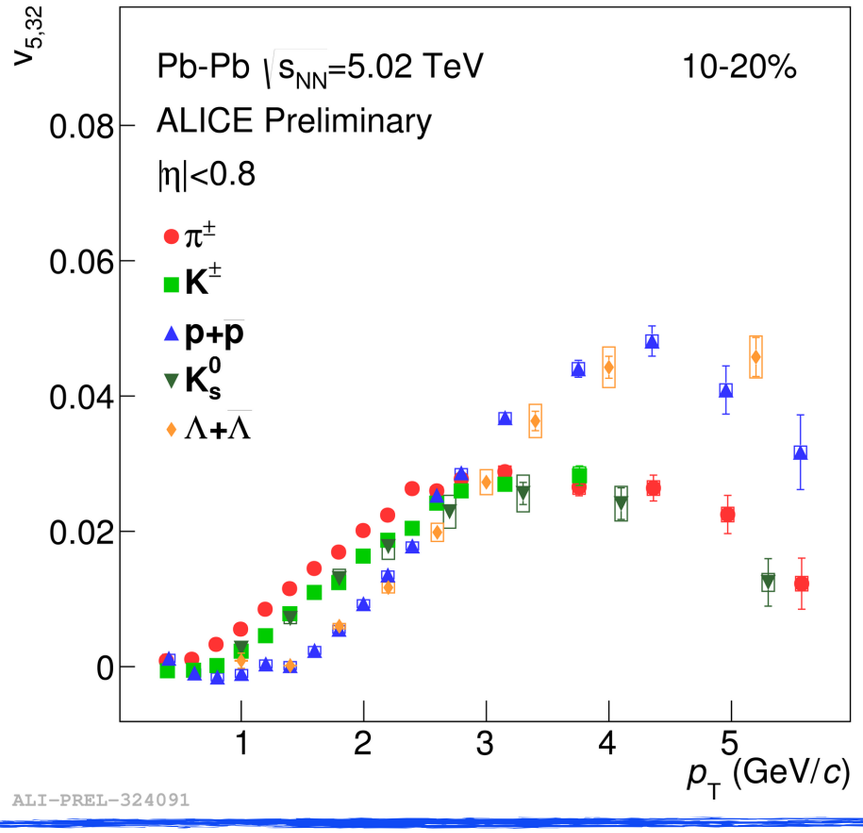


- For n>3, contributions from non-linear lower order spatial anisotropy enter in the definition of the coefficients

$$V_n = V_n^{\mathrm{L}} + V_n^{\mathrm{NL}} \quad (n > 3)$$

- Contribution of non-linear terms larger for peripheral collisions

New

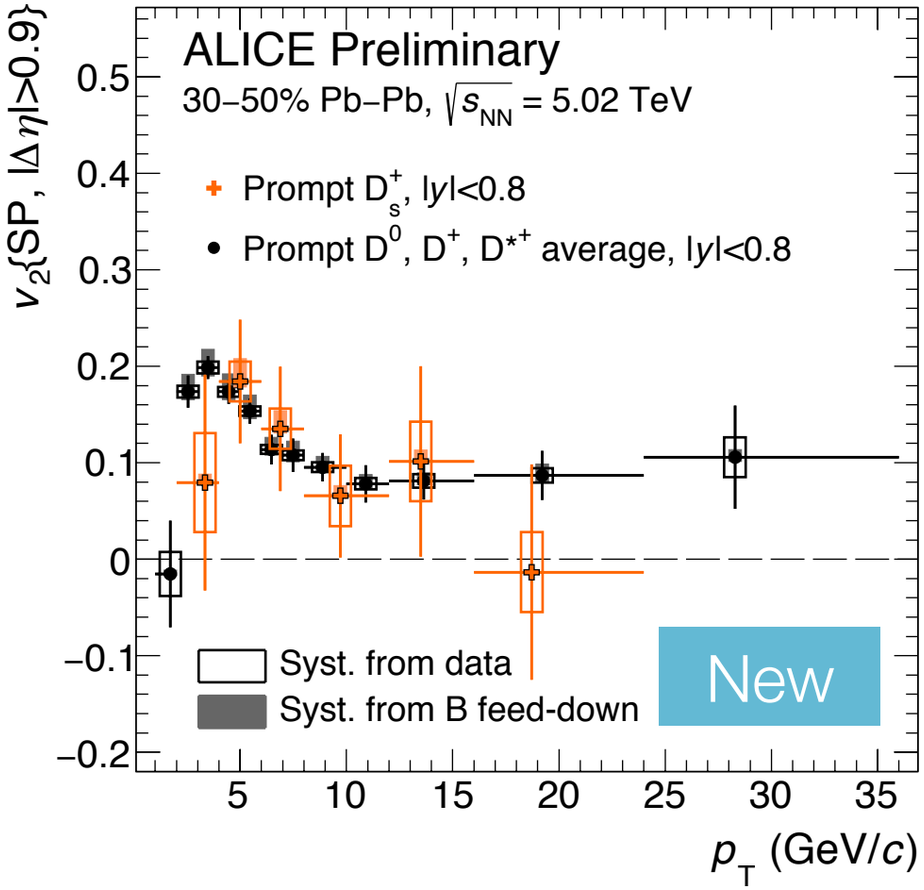


- New results of non-linear coefficients for various identified particles up to $v_{6,33}$

- Similar patterns as observed for identified particles linear terms

Heavy Flavour flow in Pb-Pb collisions

- New, more precise measurement of D meson v_2 in 30-50%
- Same v_2 for D^+_s and non-strange D mesons within uncertainties, down to 3 GeV/c



2018 Pb-Pb data

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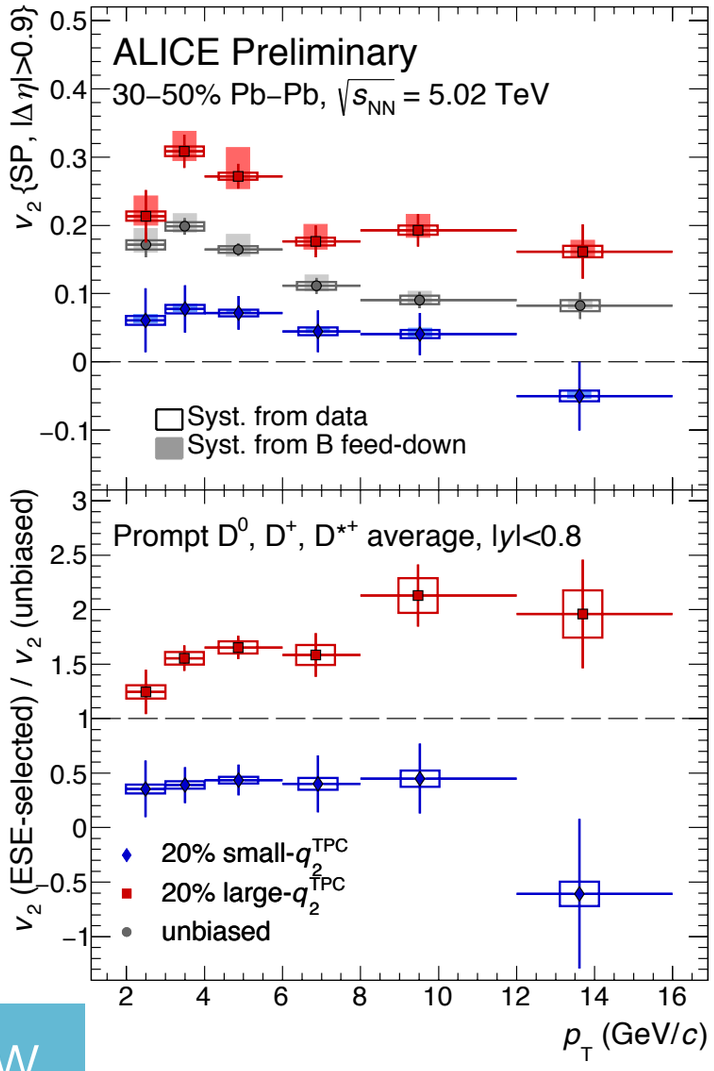
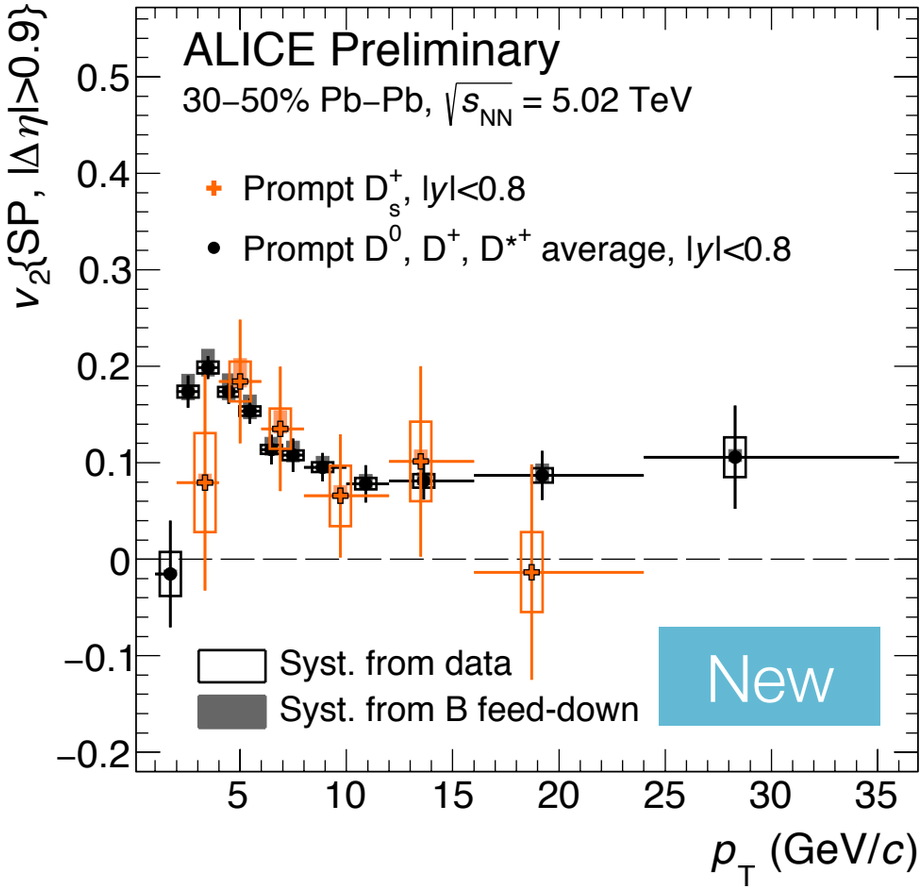


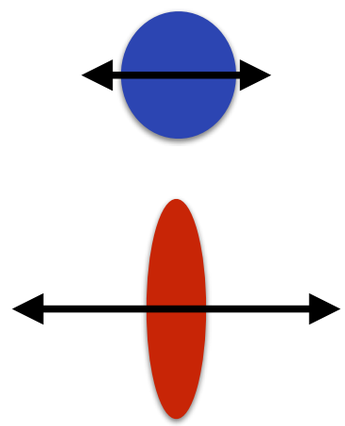
New

$$q_2 = \frac{|\vec{Q}_2|}{\sqrt{M}}, \qquad Q_{2,x} = \sum_{i=1}^{M} \cos 2\varphi_i, \quad Q_{2,y} = \sum_{i=1}^{M} \sin 2\varphi_i$$

2018 Pb-Pb data



- Event-Shape Engineering technique allows to select different eccentricity and initial conditions for a given centrality class
- Clear difference of D meson v_2 in events with small and large q_2
- Charm is sensitive to collectivity of bulk light-hadron and initial state fluctuations



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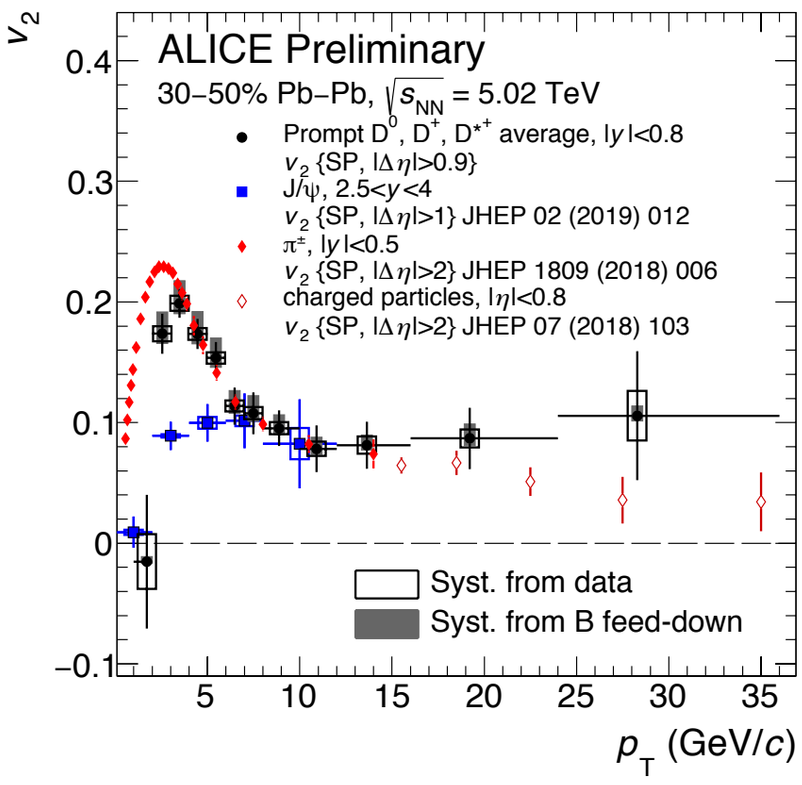
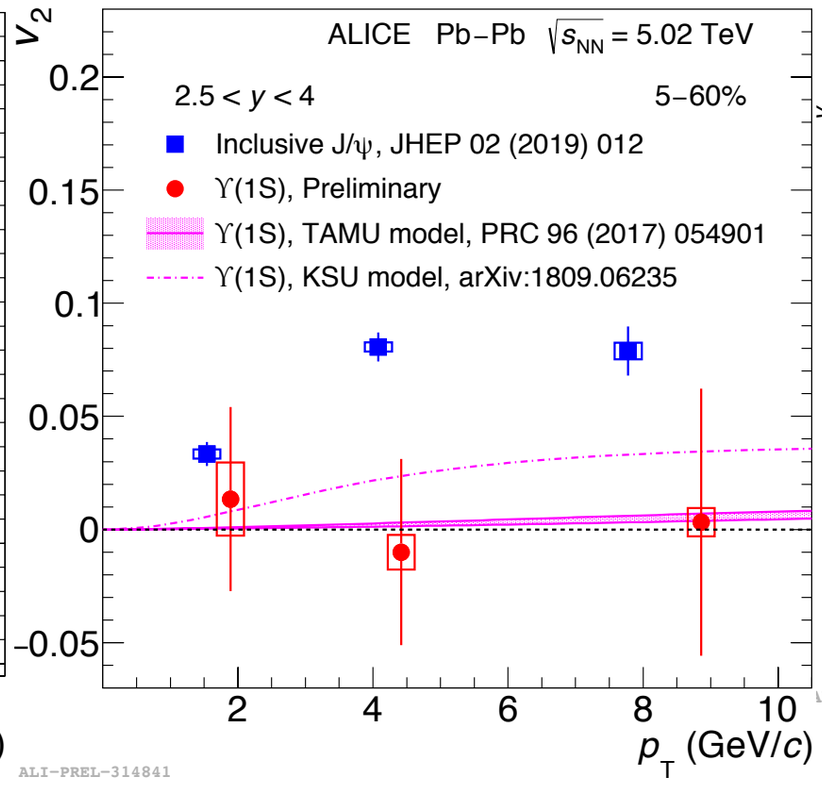
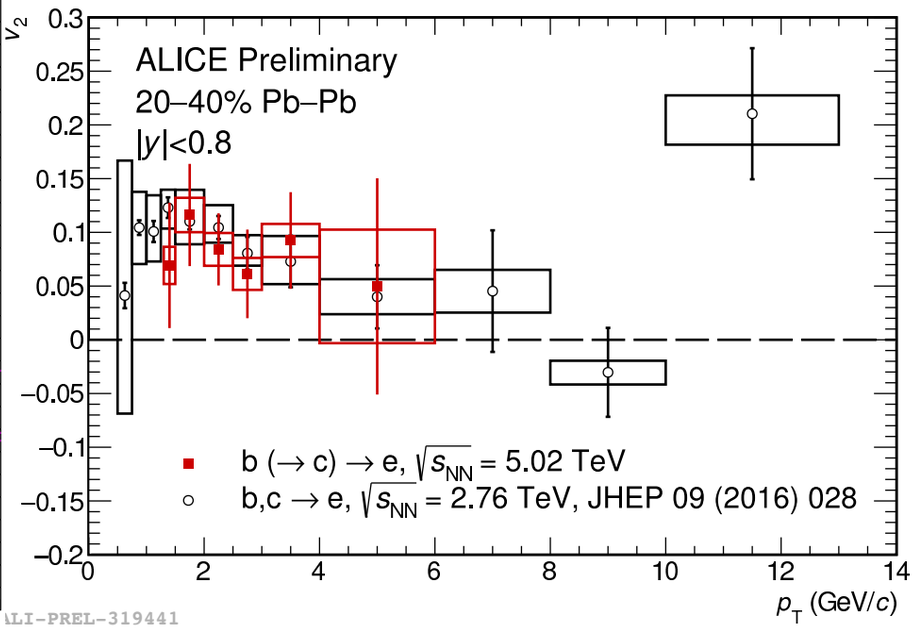
New







- At low-p_T **π v_2** > **D-meson v_2** > **J/ψ v_2** > 0
  - charm quarks seems to follow the expansion of the system
  - Recombination with flowing light-flavour quark can enhance the effect ?

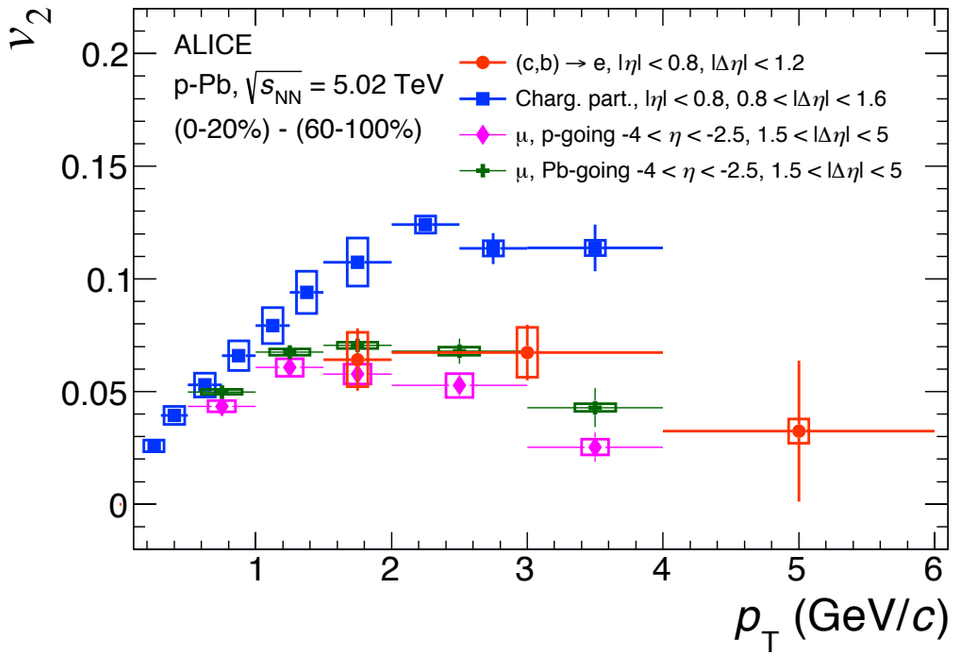
- **First measurement of ϒ(1S) elliptic flow,** compatible with zero within uncertainties

2015+2018 Pb-Pb data

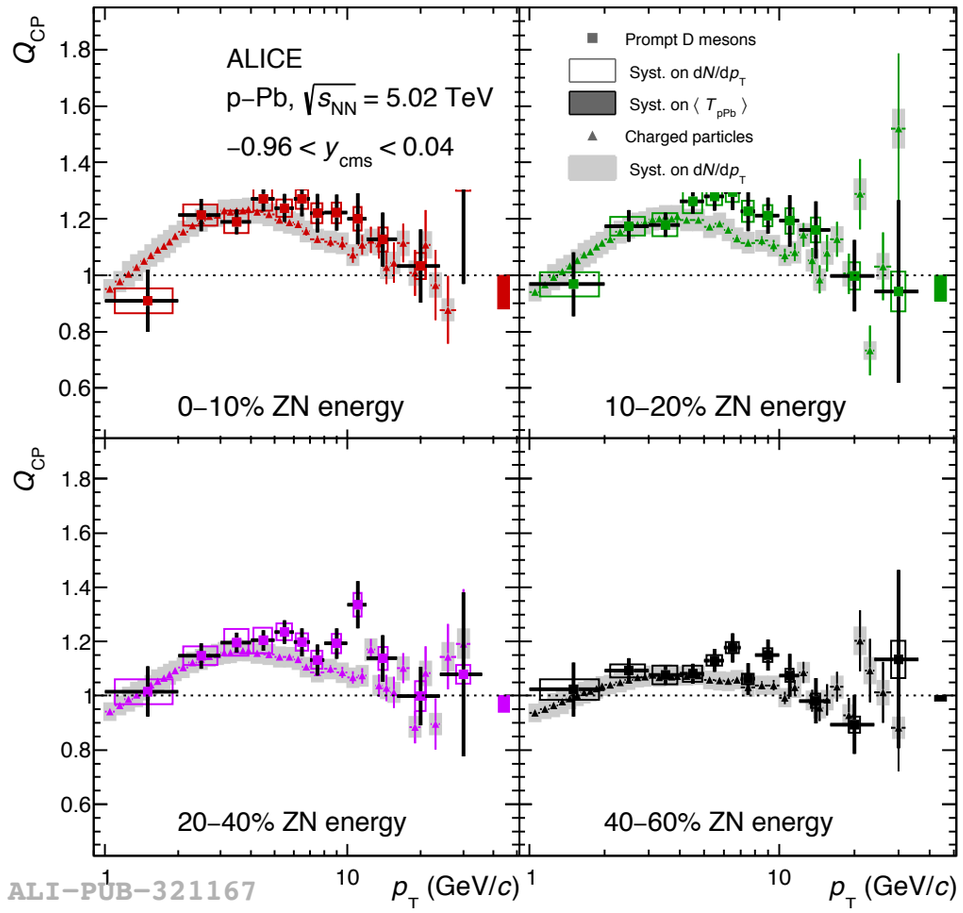
- Open beauty (b → e) v_2 > 0
  - 3.5σ effect in 1.3 < p_T < 4 GeV/c
  - Impact of collisional energy loss and coalescence for beauty?

Collective effects for HF in p-Pb collisions ?

ALICE Coll. PRL 122, 072301 (2019)



- Azimuthal correlations of heavy-flavour decay leptons used to extract Fourier coefficients in p-Pb collisions
- e,μ from heavy flavour decays show $v_2 > 0$ in high-multiplicity p-Pb collisions (5σ effects)



- D-meson central-to-peripheral ratio around 1.2 at intermediate p_T
  - Q_{cp} >1 at 3σ in 3< p_T <7 GeV/c in 20-40%
  - Similar trend as measured for charged particles

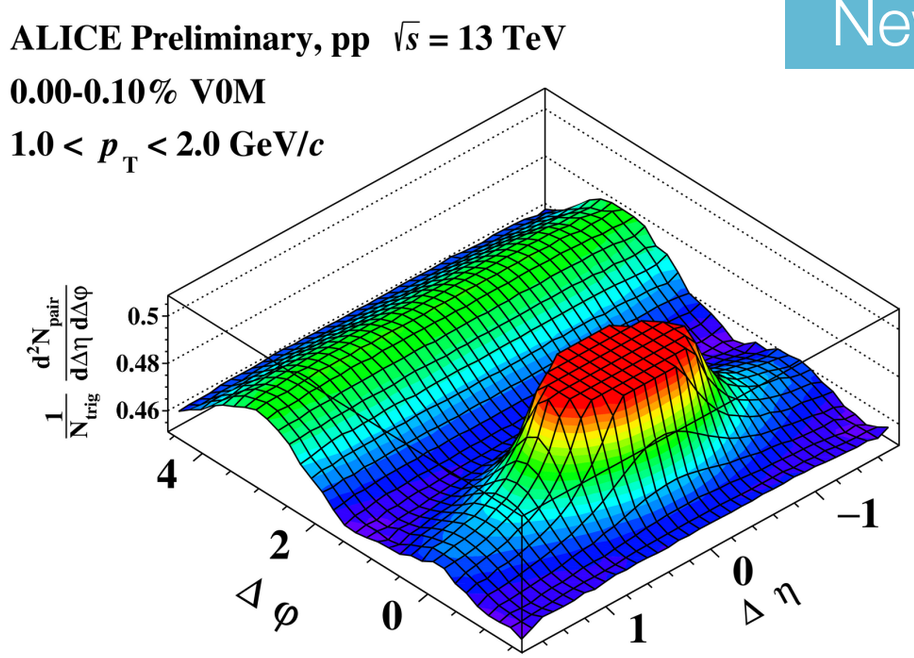
ALICE Coll. submitted to JHEP arXiv 1906.03425

Poster JunLee Kim

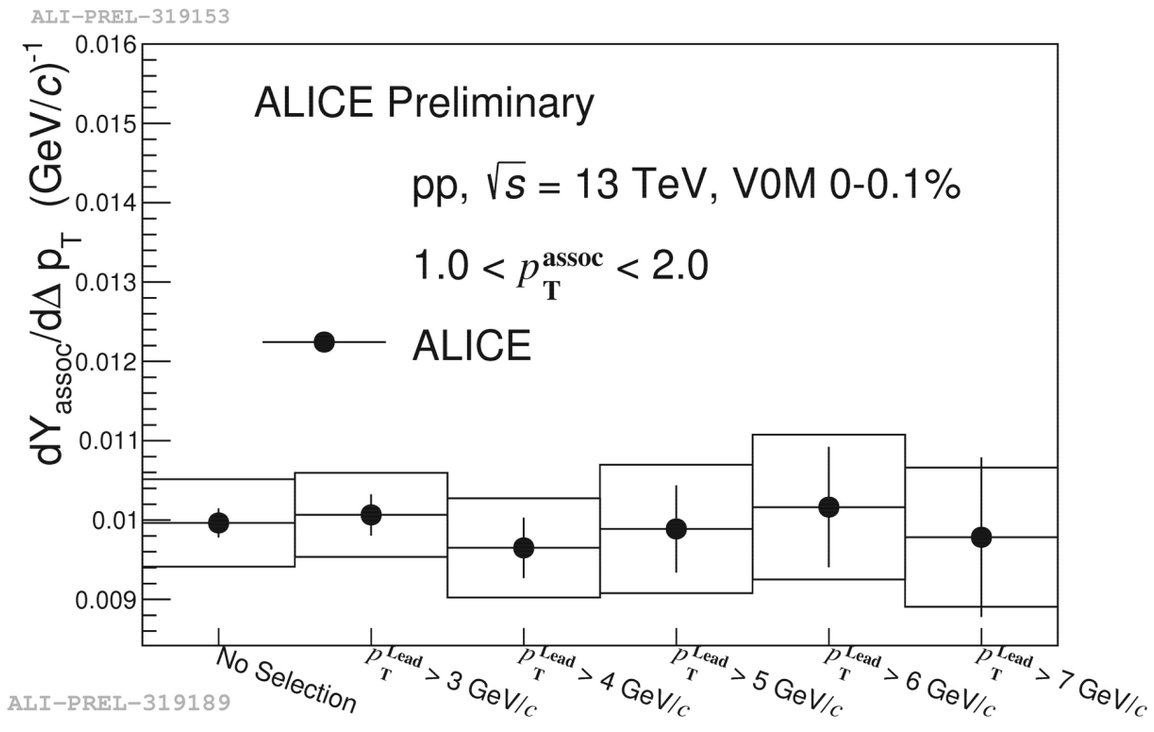
Near side ridge in pp collisions at $\sqrt{s}$=13 TeV

New

- Long range correlations in high-multiplicity pp collisions at $\sqrt{s}$=13 TeV
- Near-side ridge effect observed within ALICE acceptance $1.5 < |\Delta\eta| < 1.8$

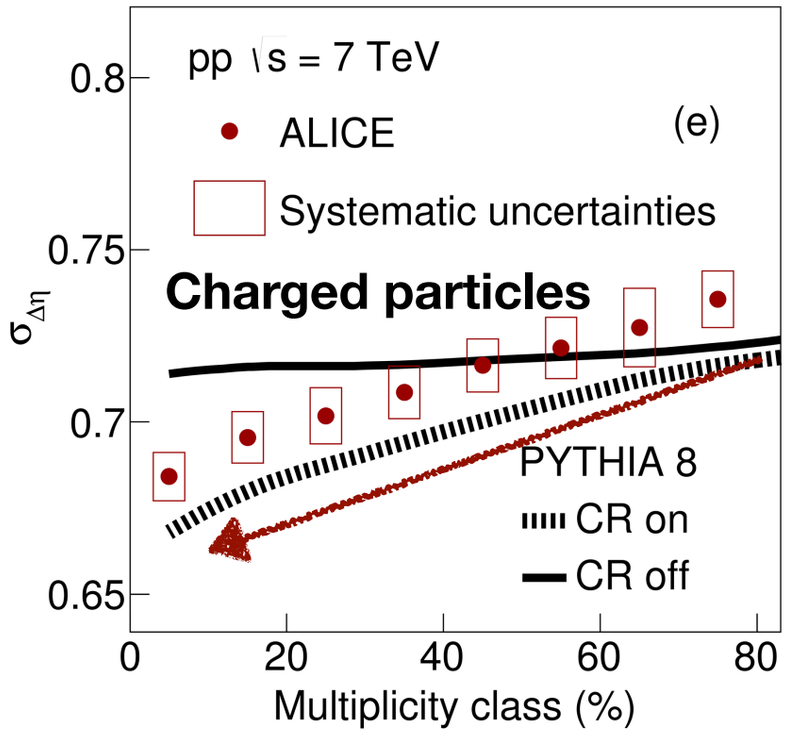


- Per-trigger associated particle yields measured for the 0.1% highest multiplicity
- Yields do not change with different p_T requirements for leading particle in the event



Balance Function in pp collisions at $\sqrt{s}$ = 5 TeV

- Access pair-particle production and collective effects
  - Narrowing of balance functions in Pb-Pb collisions → radial flow effects
  - Narrowing in pp collisions described by PYTHIA with CR ALICE Coll. Eur. Phys. J. C 76 (2016) 86



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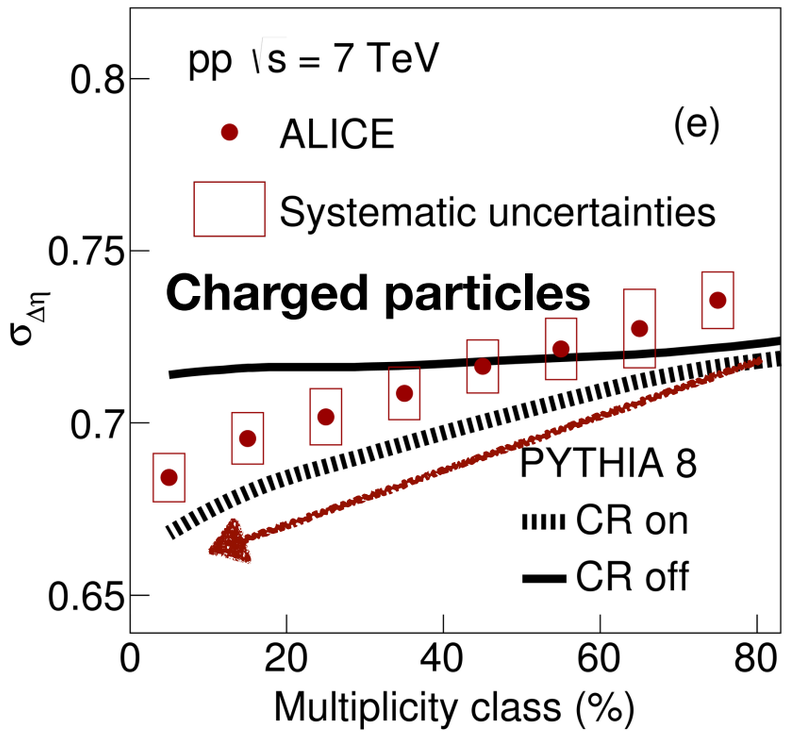
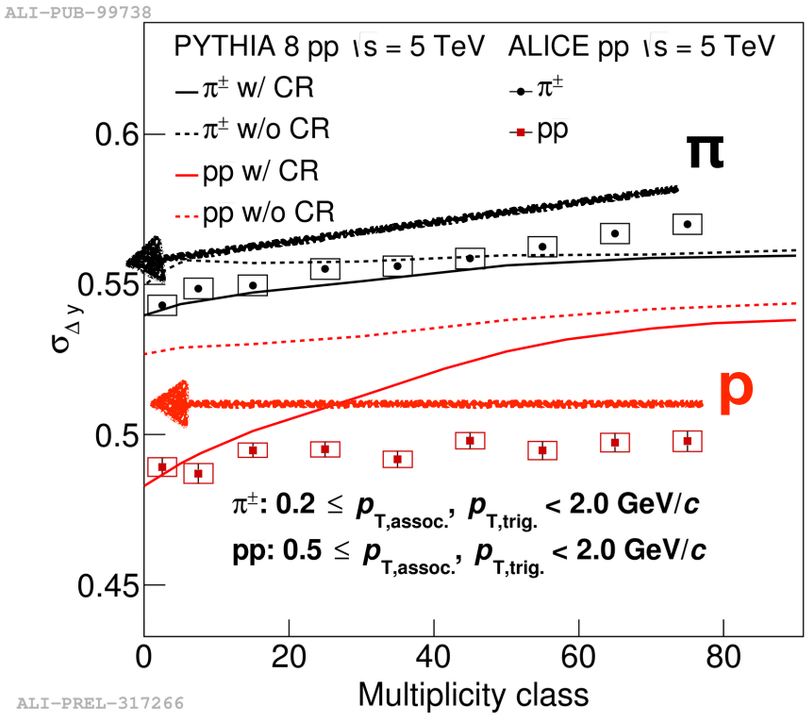


- New results of Identified Balance Functions:
  - show a **narrowing** for **π**
  - **flat behaviour** for **p**
  - Radial flow-like effects would show a larger effect for higher masses particles

- PYTHIA with CR seem to follow qualitatively the trend for **pions** but not for **protons**

New



Conclusions and outlook

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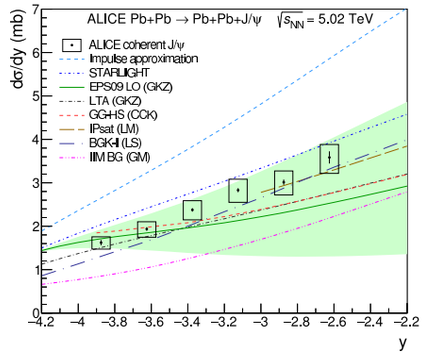

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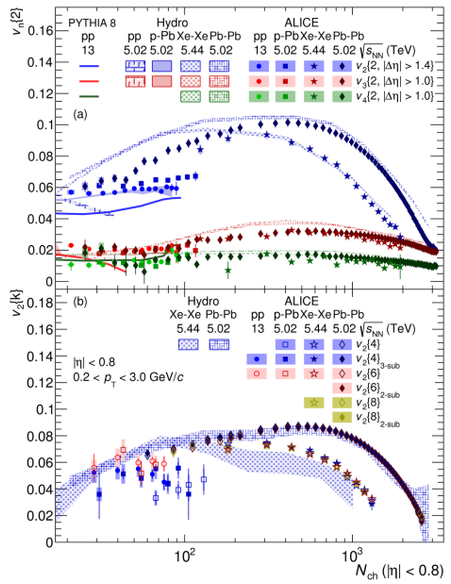

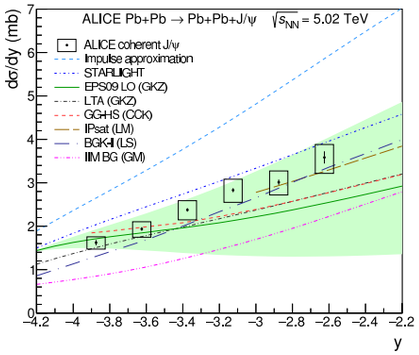

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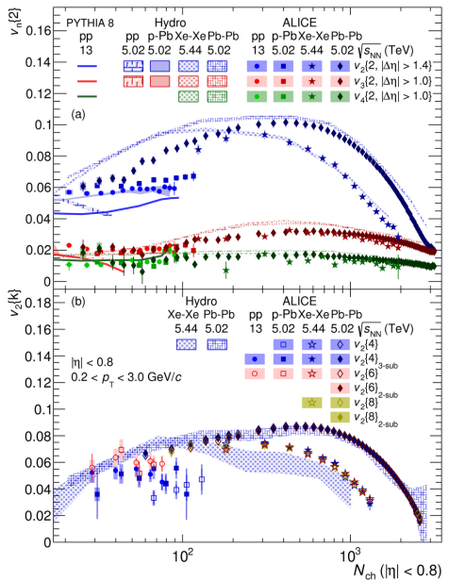

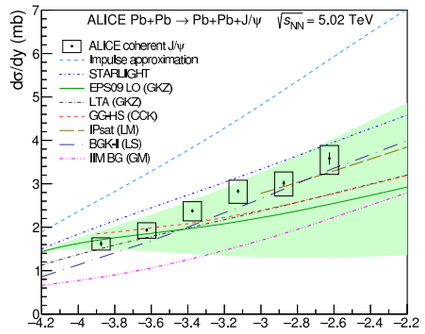

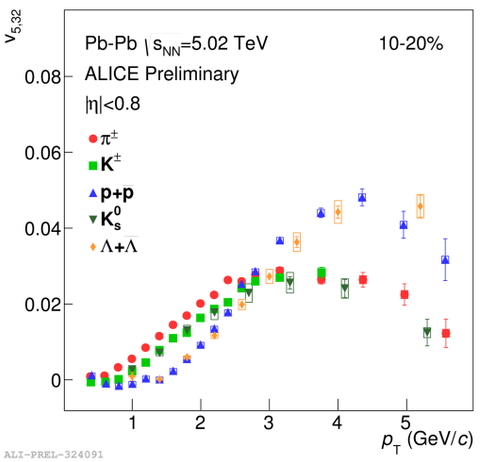

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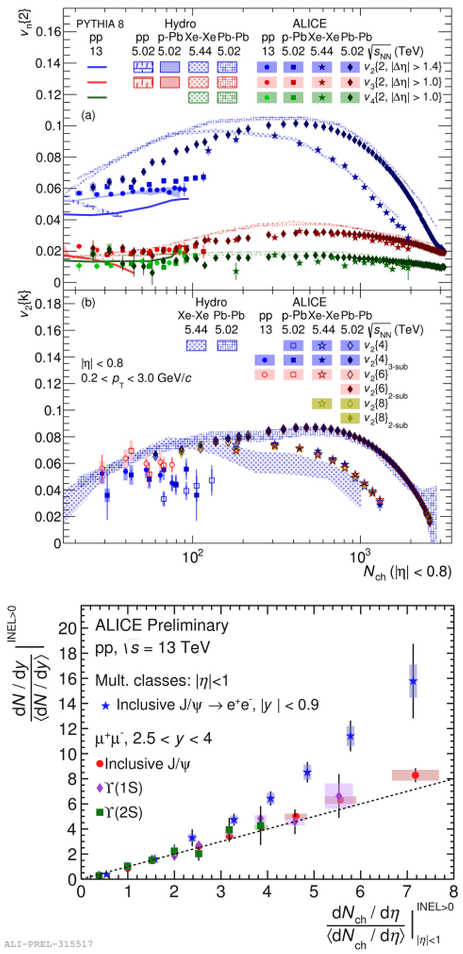

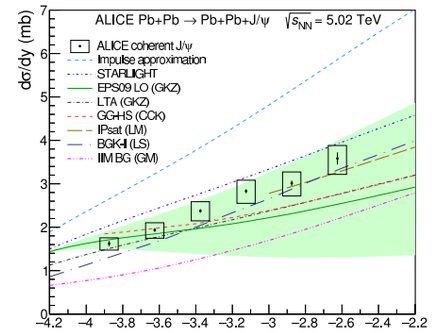

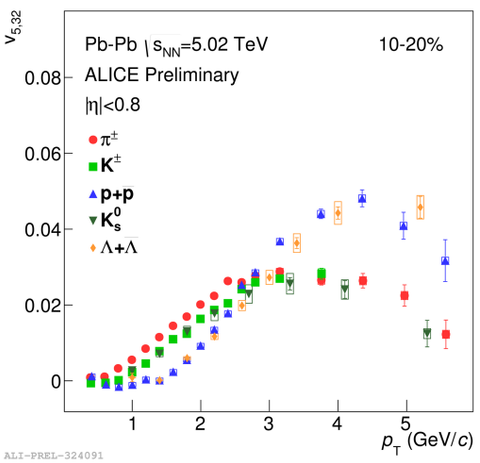

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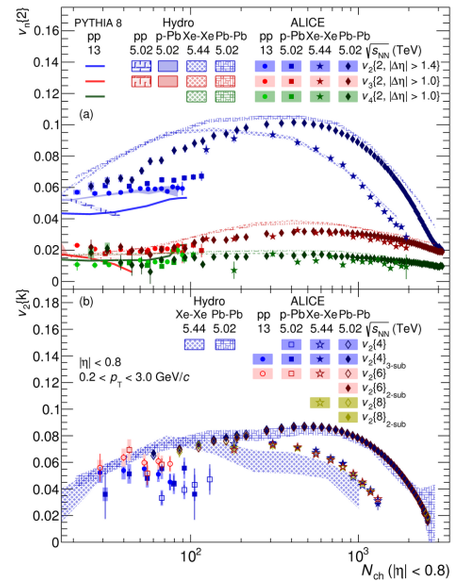
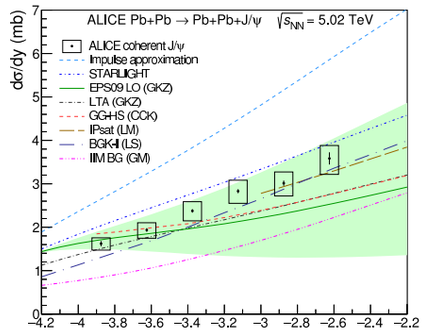
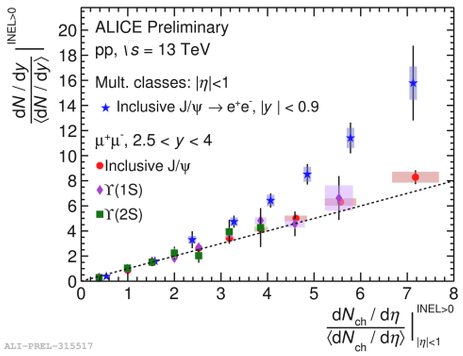
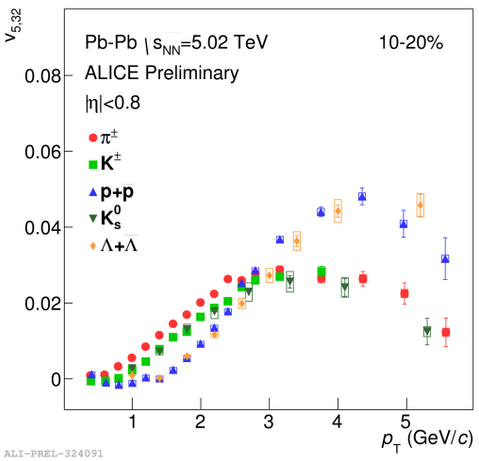
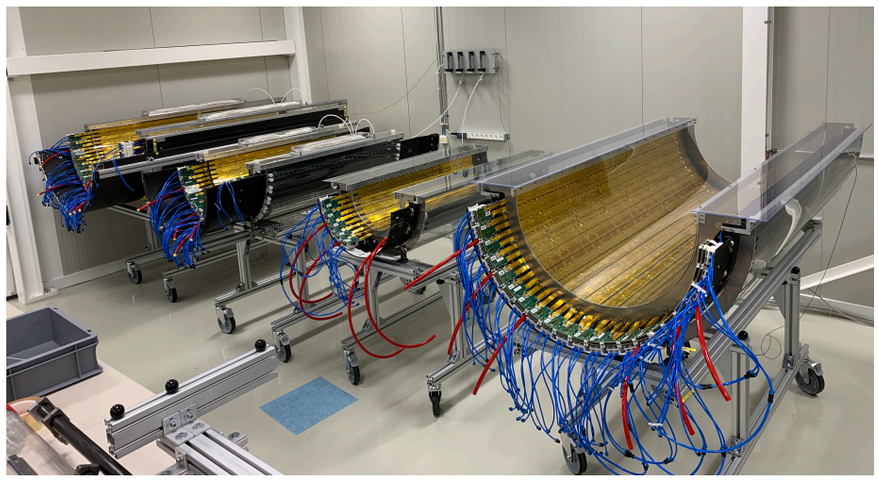
- **Upgrade program progressing well in order to be ready for the higher luminosity expected in Run3 and 4.**







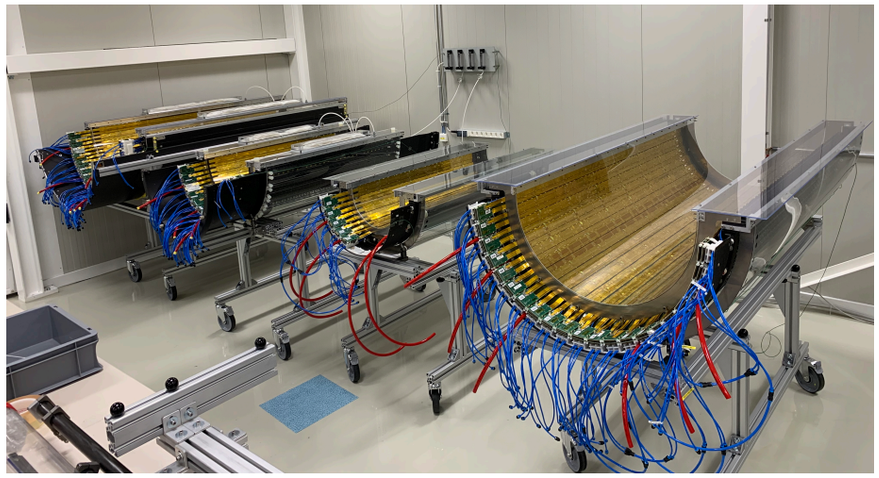




Conclusions and outlook

- Quarkonia production in pp and p-Pb collisions with ALICE at the LHC - Shinichi Hayashi
- Measurement of electroweak-boson production in p_Pb and Pb-Pb collisions at the LHC with ALICE - Nicolò Valle
- Measurement of open heavy flavour hadron production in pp, p-Pb and Pb-Pb collisions - Mattia Faggin
- Measurement of heavy-flavour jets and correlations and elliptic flow in small systems with ALICE - Fabio Colamaria
- Investigation of collectivity in small collisions system with ALICE Vojtech Pacik
- **POSTER: Higher order flow correlations and their non-linear modes in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV - Jasper Elias Parkilla**
- **POSTER: Measurement of long range correlations in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE at the LHC - Jun Lee Kim**

Thank you!



Back up

Study baryon-(anti)baryon interactions

- Femtoscopy technique used to measure the final state interaction between particles in small systems

- Standard: Use two identical bosons momentum correlations tc estimate the system size at kinematical freeze-out

$$C(\vec{p}_1,\vec{p}_2) = \frac{P(\vec{p}_1,\vec{p}_2)}{P(\vec{p}_1)P(\vec{p}_2)}$$

$$C(\vec{q}) = \int S(\vec{r})|\Psi(\vec{q},\vec{r})|^2 d^3r$$

Measured correlation

Source size/shape unknown

Two-particle wave functions Interaction known

q: relative momentum

r: relative distance between the points of emission of the two bosons

Study baryon-(anti)baryon interactions

- Femtoscopy technique used to measure the final state interaction between particles in small systems

- New idea: Use two-particle correlations to measure strong interaction (mainly among strange hadrons)

$$C(\vec{p}_1,\vec{p}_2) = \frac{P(\vec{p}_1,\vec{p}_2)}{P(\vec{p}_1)P(\vec{p}_2)}$$

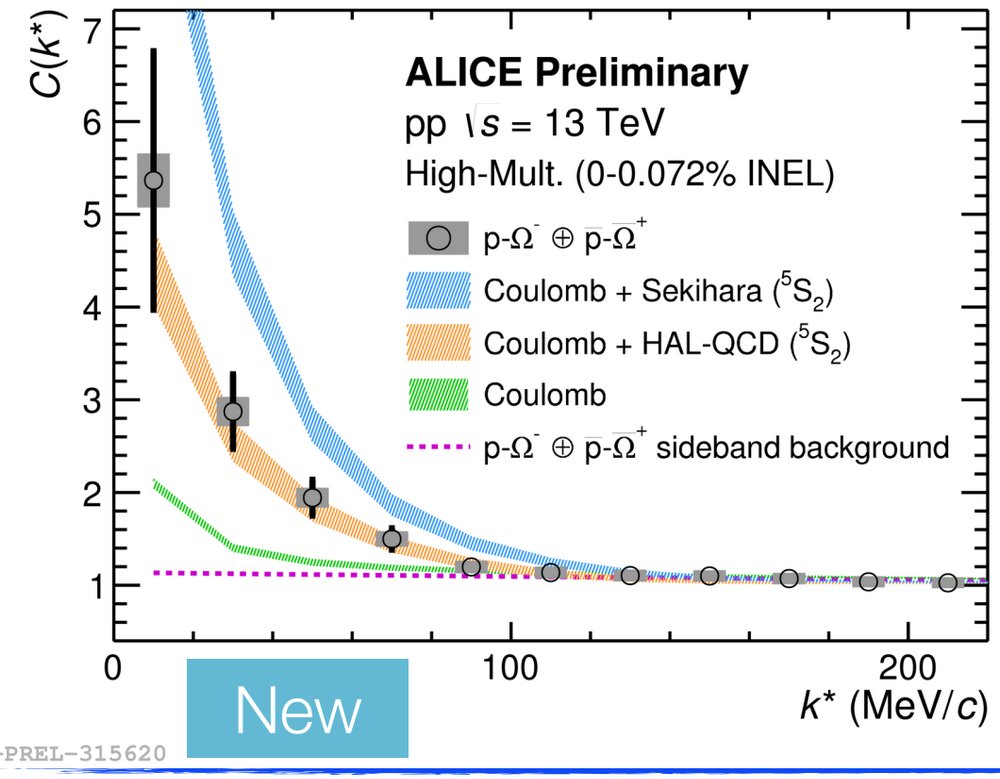
$$C(\vec{q}) = \int S(\vec{r})|\Psi(\vec{q},\vec{r})|^2 d^3r$$

Measured correlation

Source size/shape known from pp

Two-particle wave functions Interaction unknown

q: relative momentum
r: relative distance between the points of emission of the two kaons



- High-multiplicity pp collisions at $\sqrt{s}$ = 13 TeV.
- Data shows evidence of an attractive strong interaction between p and Ω.
- Strongly bound states ?

New results:
Λ-Λ, p-Ξ, p-Σ … interactions

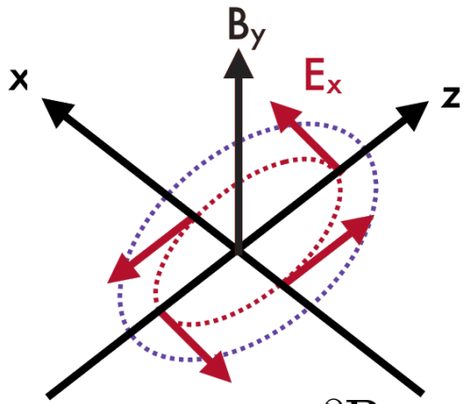
ALICE Coll. arXiv:1903.06149, arXiv:1904.12198

Direct flow in Pb-Pb collisions

U. Gursoy, D. Kharzeev and K. Rajagopal Phys. Rev. C 89, 054905 (2014)

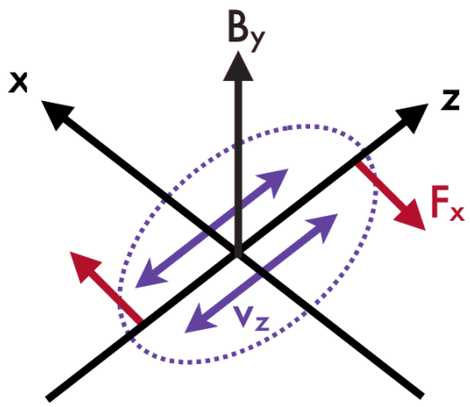
- Study the properties of high magnetic field in heavy-ions collisions.
  - Faraday effect - Electric field induced on decreasing magnetic field vs time (spectators)
  - Hall effect - Lorentz force induced by moving charges (QGP expansion)

Faraday effect



$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

Hall effect



$$\mathbf{F} = q\,\mathbf{v} \times \mathbf{B}$$

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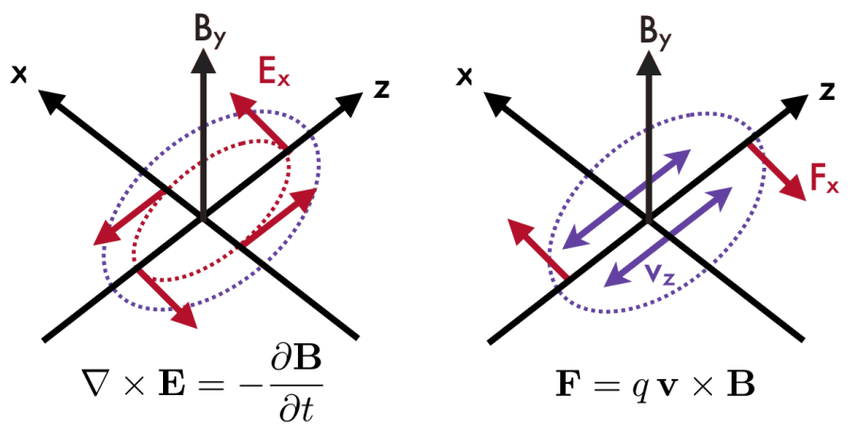
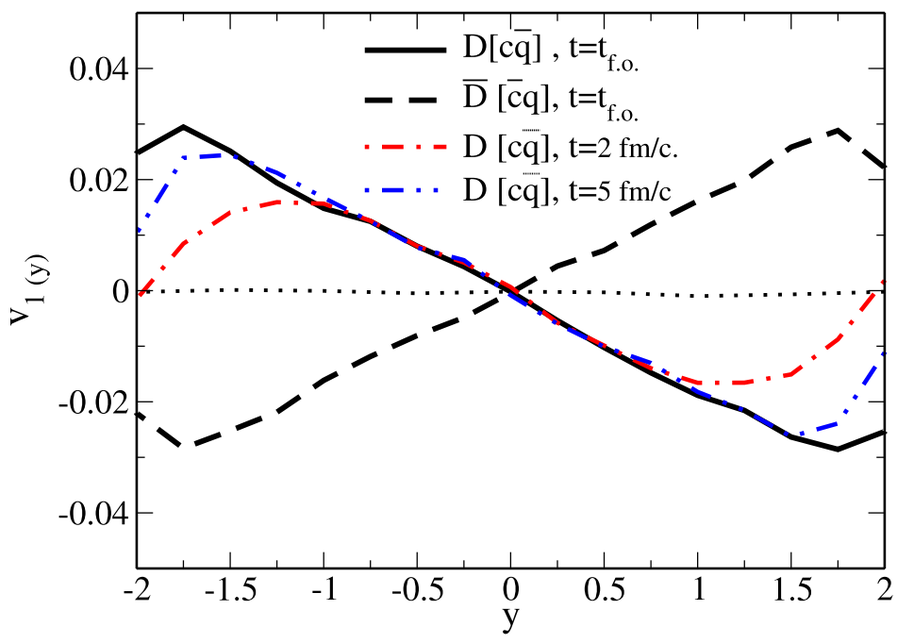
Faraday effect **Hall effect**



$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \qquad \mathbf{F} = q\,\mathbf{v} \times \mathbf{B}$$

- D-meson charge-dependent v_1 more sensitive to early stage E-M field
  - Charm formation time is comparable to maximum B
  - Relaxation time similar to QGP life time
  - Expected larger effect than light hadrons

K. Das et al, PLB 768 (2017) 260-264



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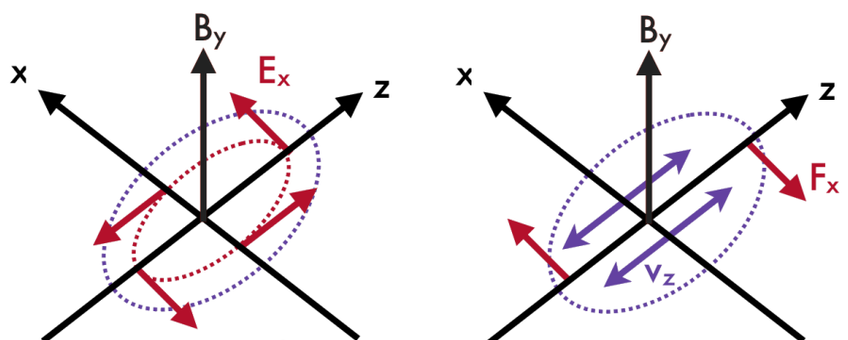
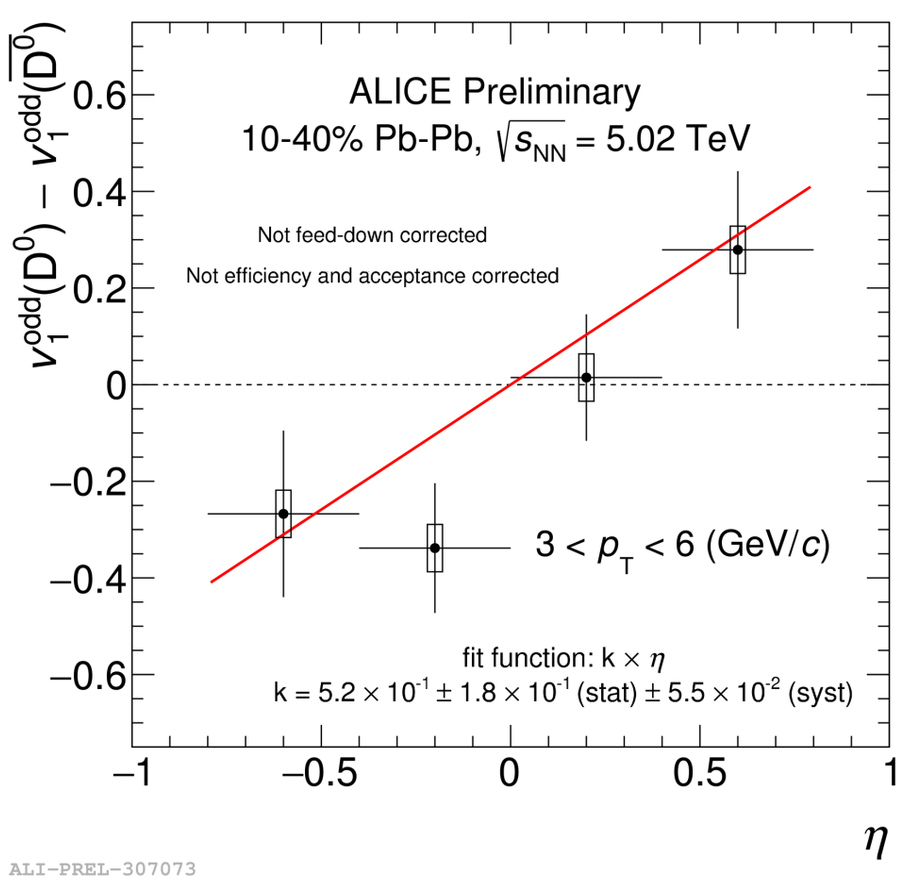
Faraday effect **Hall effect**



- D-meson charge-dependent v_1 more sensitive to early stage E-M field
  - Charm formation time is comparable to maximum B
  - Relaxation time similar to QGP life time
  - Expected larger effect than light hadrons

- Hint of positive slope (2.7σ) for $\Delta v_1^{\text{odd.}}$ in $3 < p_T < 6$ GeV/c
- Similar effects observed for v_1^{odd} (had), smaller effect expected



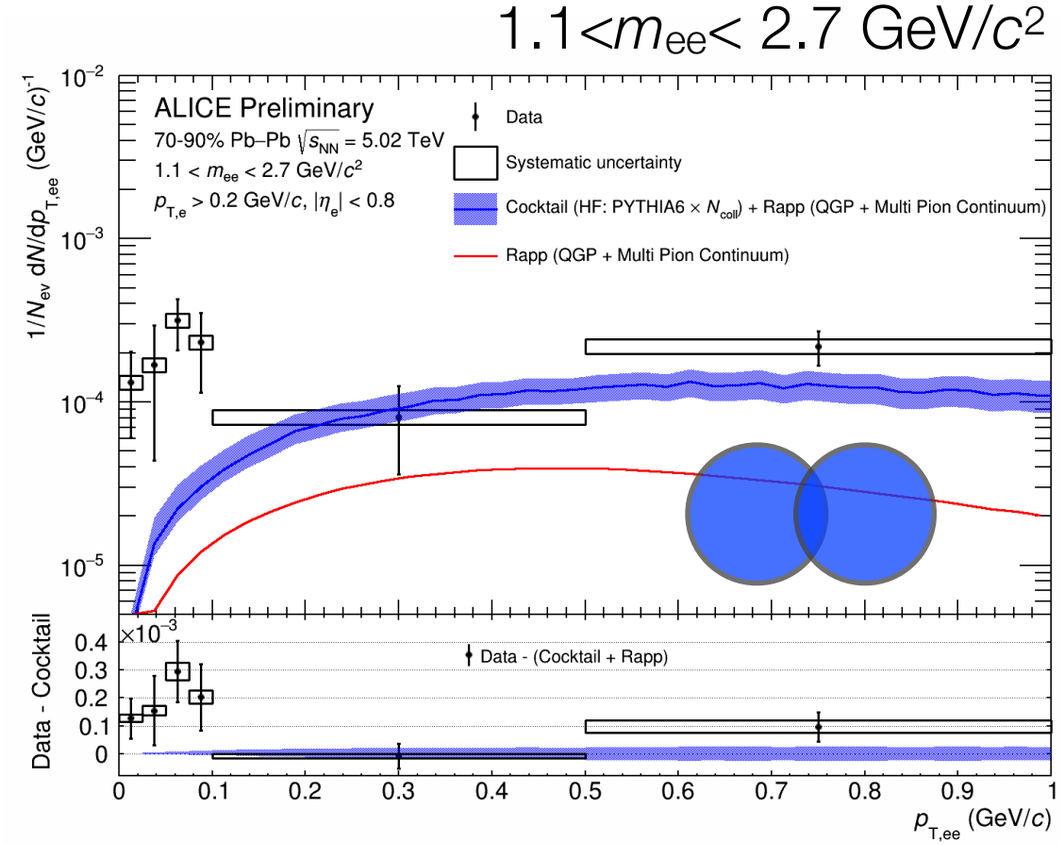
ALI-PREL-307073

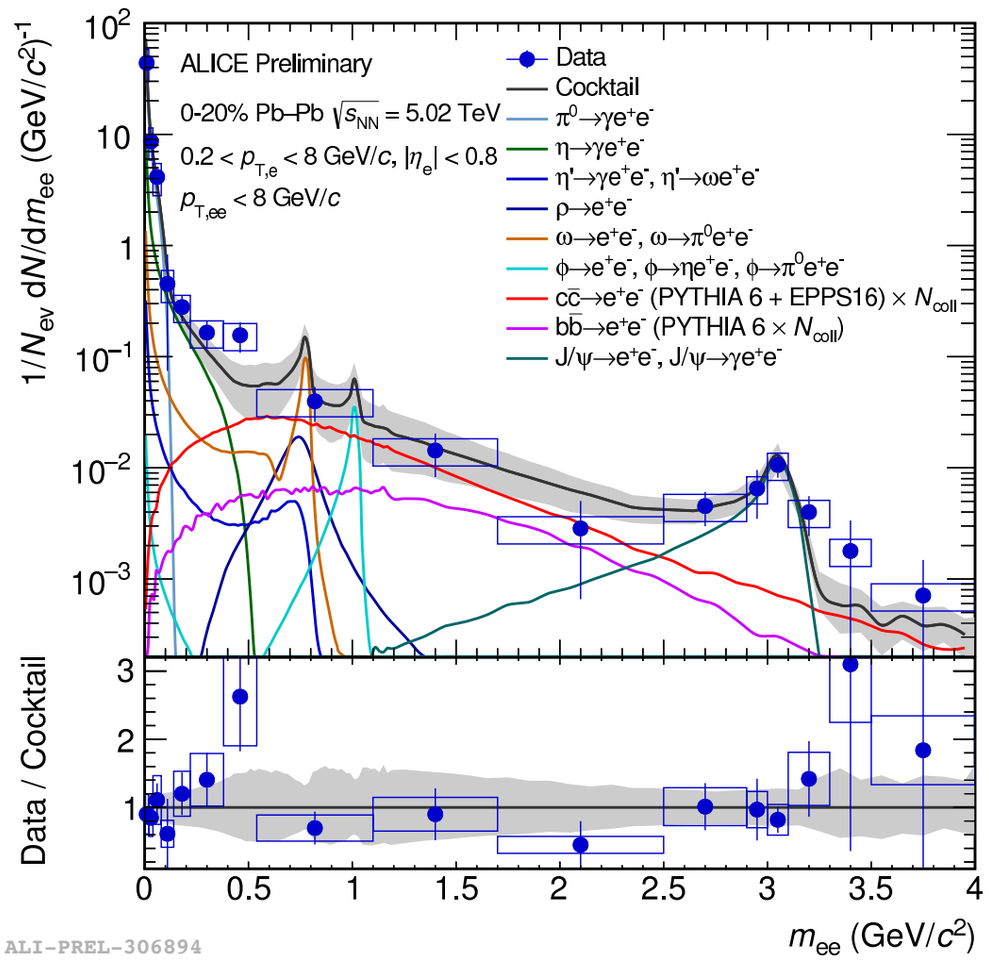
Dielectron production in Pb-Pb collisions

- Di-electron invariant mass includes production of various sources:
  - LF/HF mesons
  - Thermal radiation
  - Photoproduction

- Hadronic cocktail describes m_{ee} spectrum when accounting for CNM effects

$1.1 < m_{ee} < 2.7$ GeV/c^2

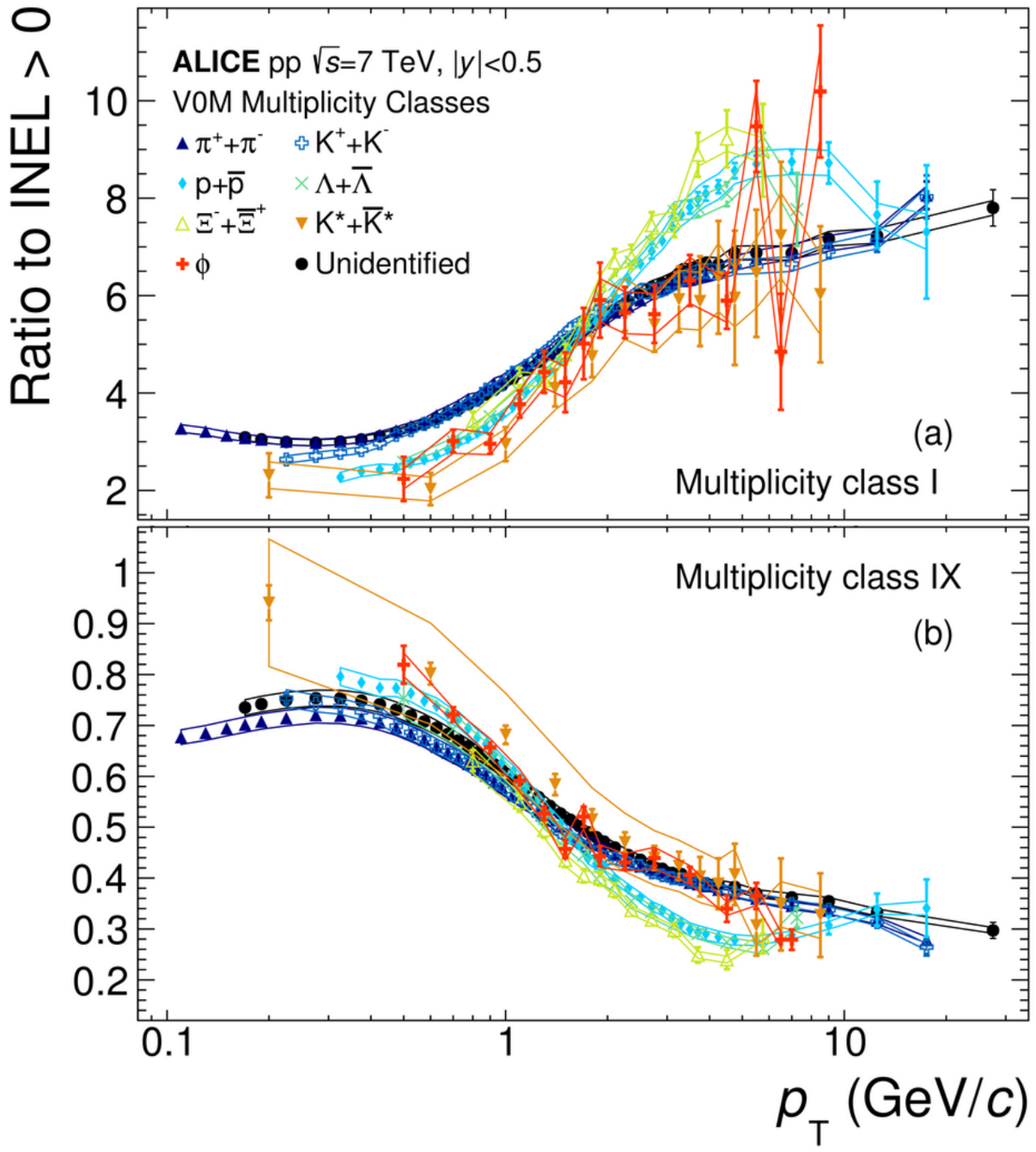




- Low-p_T range most sensitive to photoproduction
  - No-excess found for 0-40%
  - 3.7σ excess in 70-90%

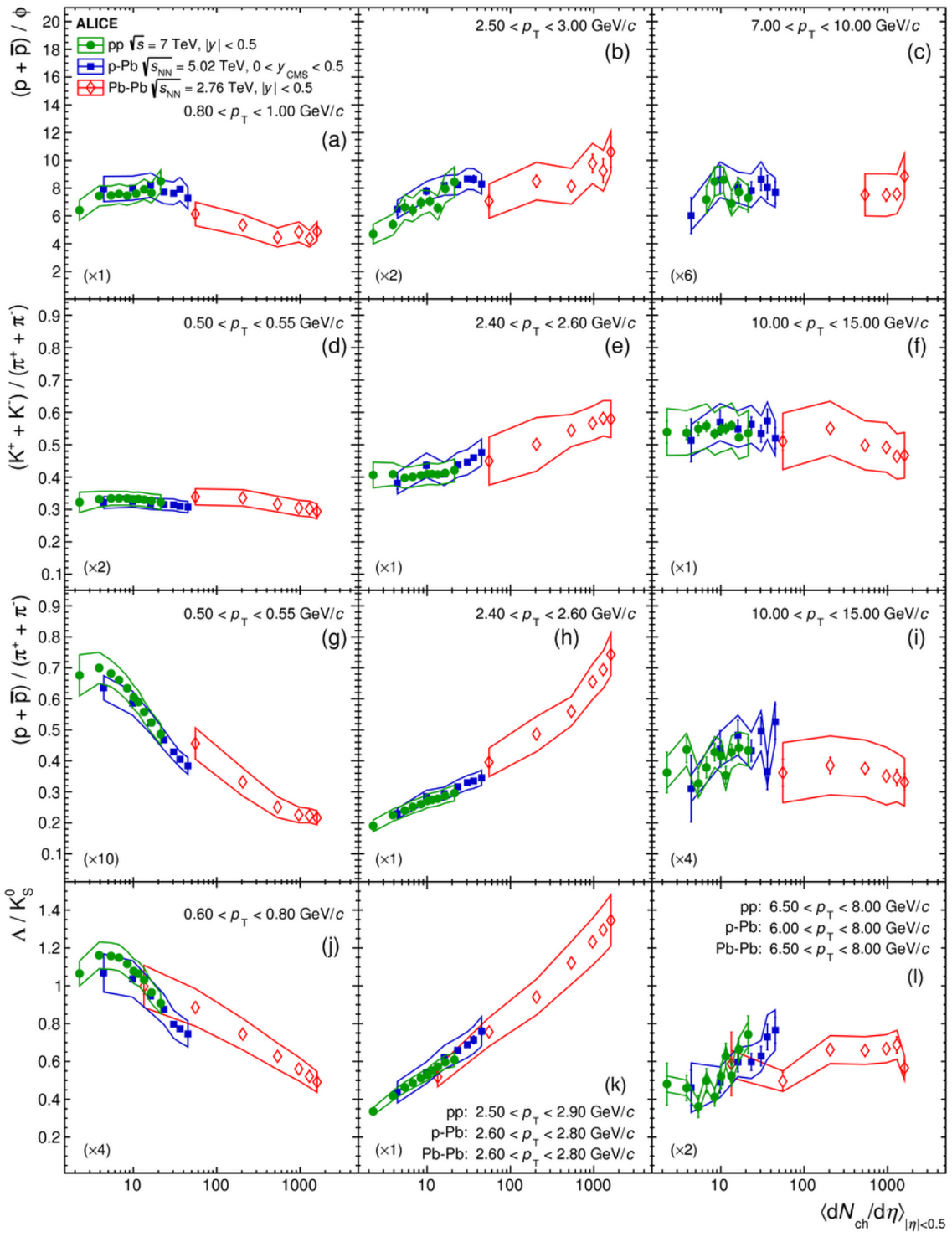
p_T spectra compared to Minimum Bias

- Hardening of the spectra different for different particle species.
- Mass hierarchy observed at low momentum
- Baryons/mesons grouping observed at intermediate-high p_T
- Resonances follow mass ordering at low p_T, mesons at high p_T

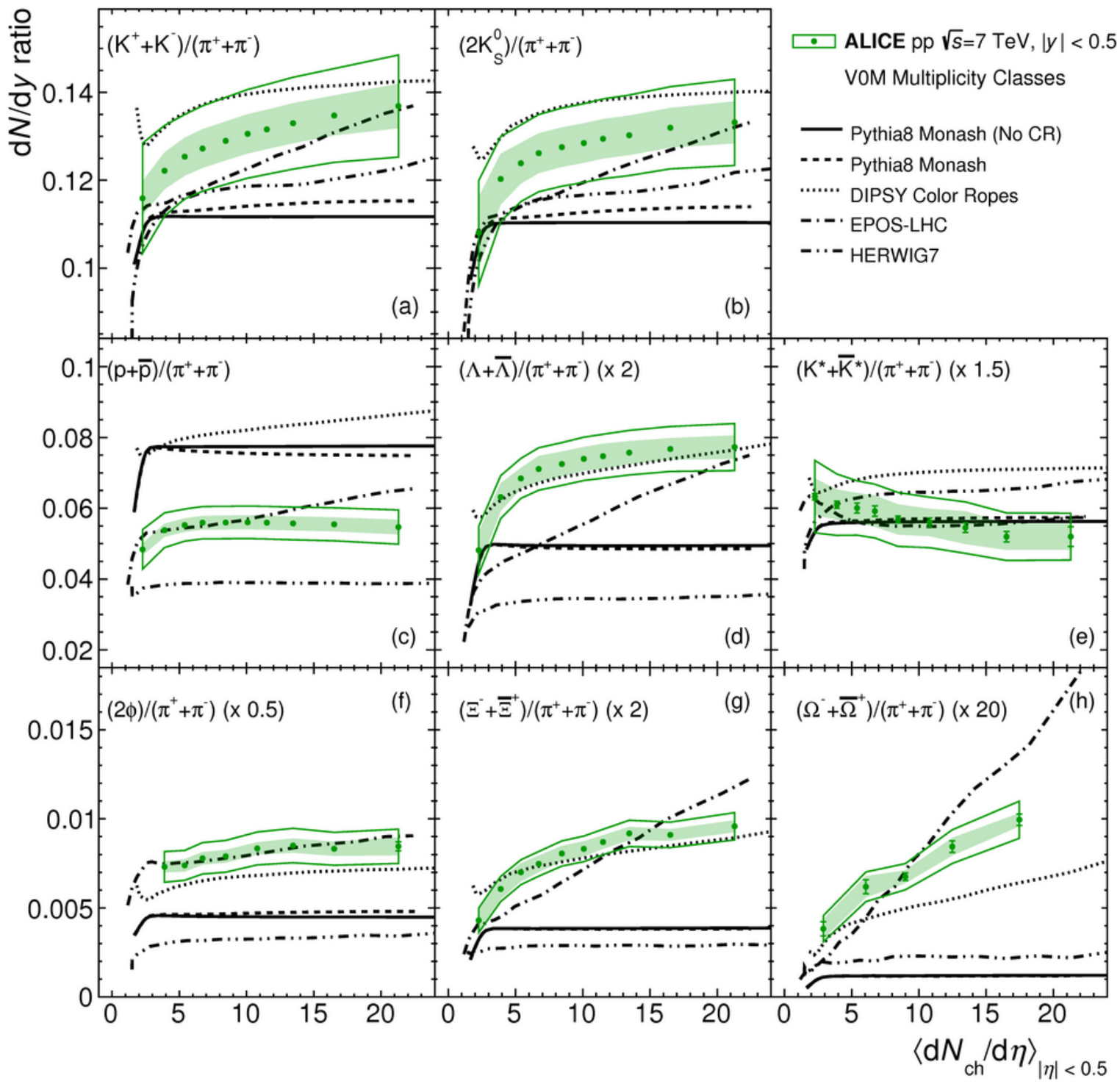


p_T spectra vs multiplicity

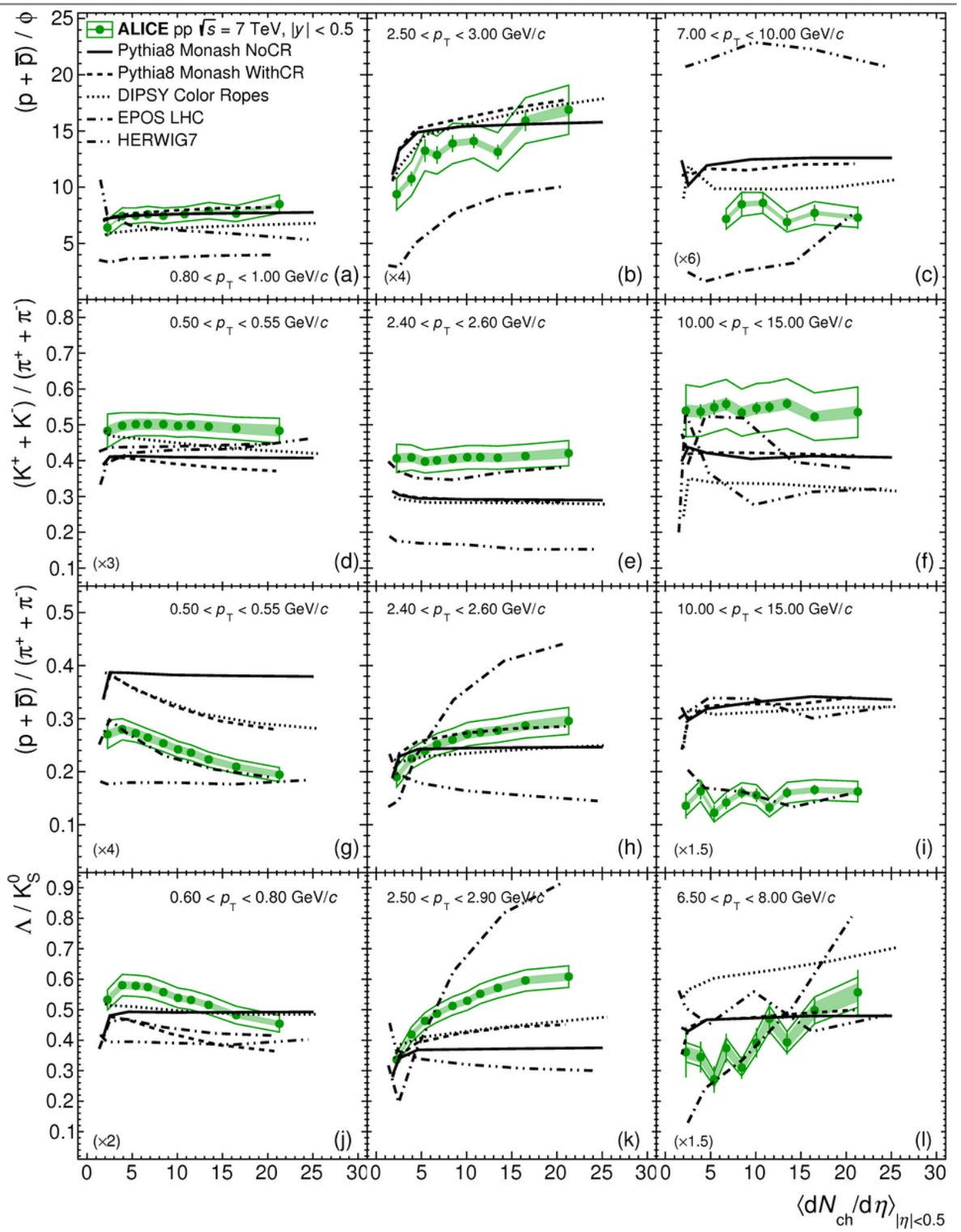
- Particles ratios studied for a given p_T bin as a function of multiplicity for the three collisions systems
- Very similar trend vs multiplicity for all collisions systems



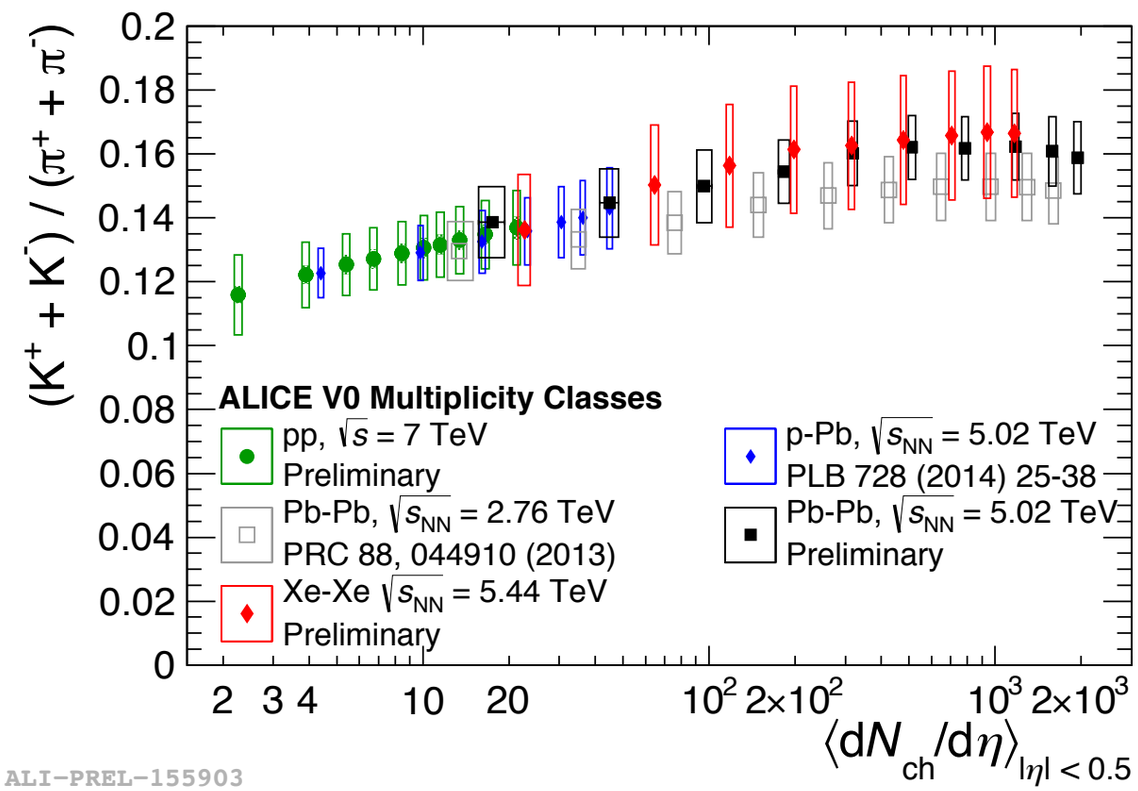
p_T yield vs multiplicity MC comparison

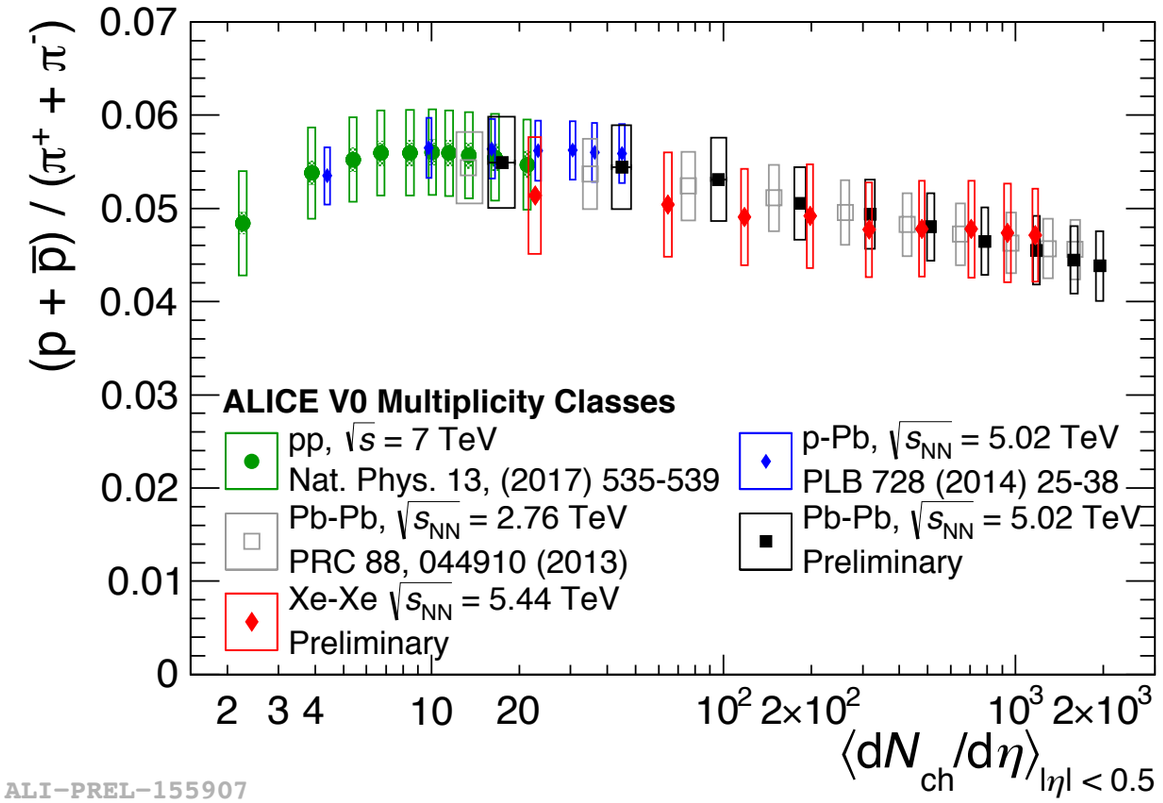


p_T spectra vs multiplicity MC comparison



p/π, K/π



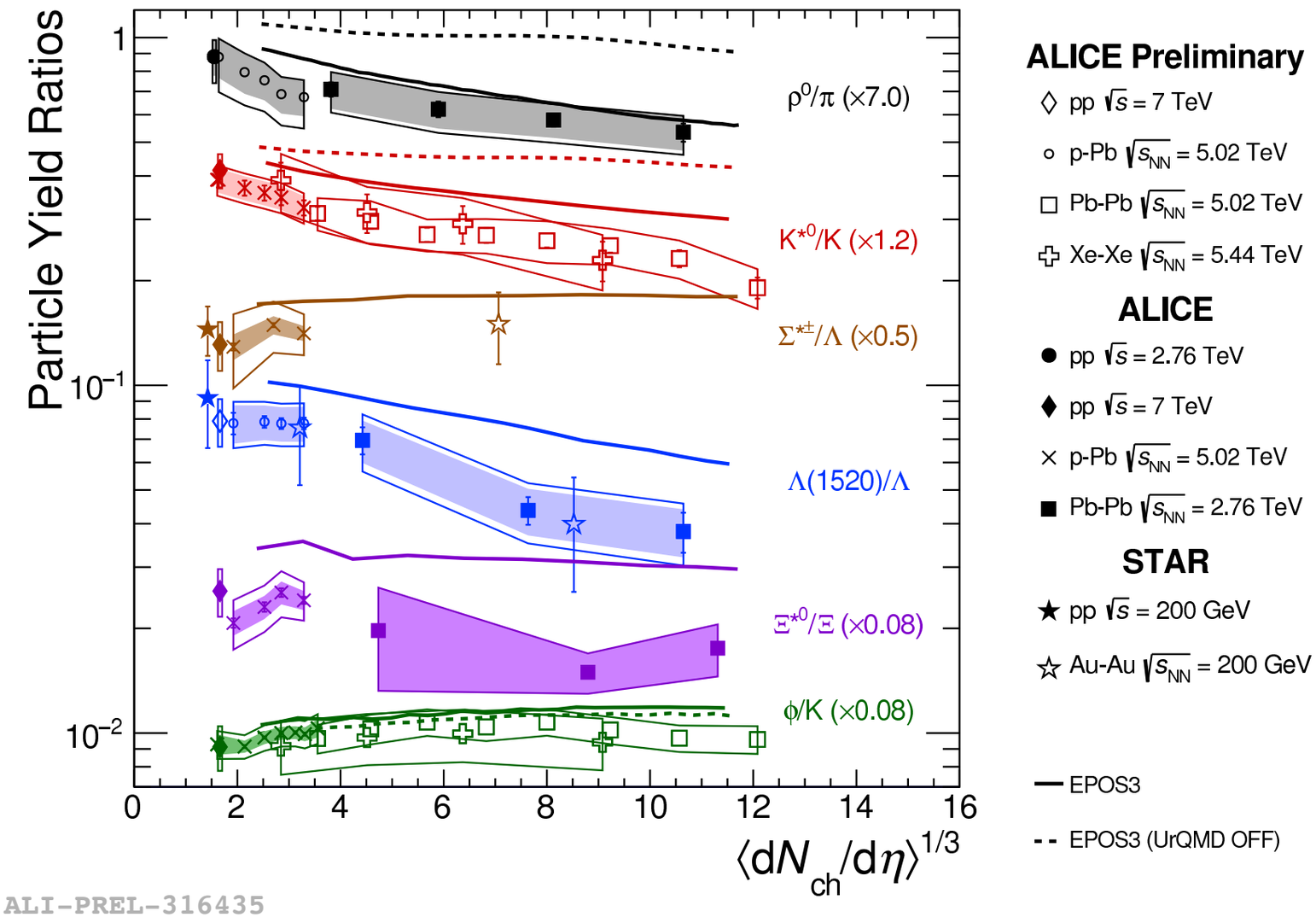


- New Pb-Pb and Xe-Xe results
- No significant energy dependence is observed
- K/π and p/π are consistent for all collision systems at the same average multiplicity.

- K, p production driven by multiplicity in the event.

Relative resonance production in pp, p-Pb, Pb-Pb and Xe-Xe

- Relative suppression of ρ^0, **K^{*0}**, **Λ** with increasing multiplicity
- **Σ^*/Λ**, **Ξ^*/Ξ**, **ϕ/K** are instead independent of multiplicity
- Similar trend observed in all collision systems
- EPOS3 + UrQMD describes qualitatively the trend of the data



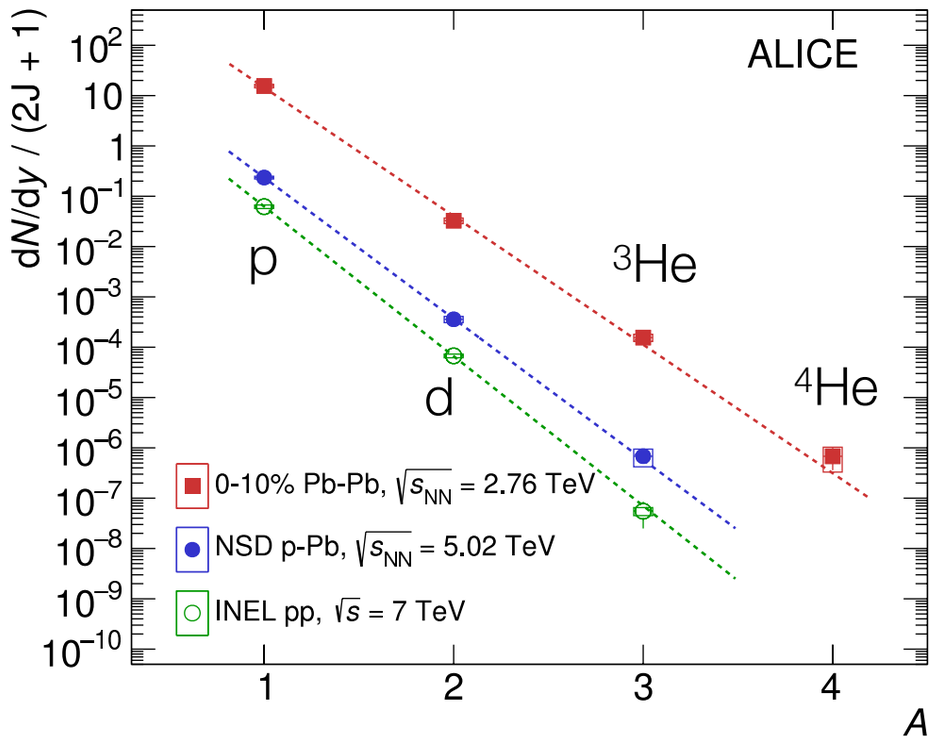
ALI-PREL-316435

- Re-scattering effects seem to dominate with respect to (re)combination in hadronic phase.

Nuclei production in pp, p-Pb and Pb-Pb

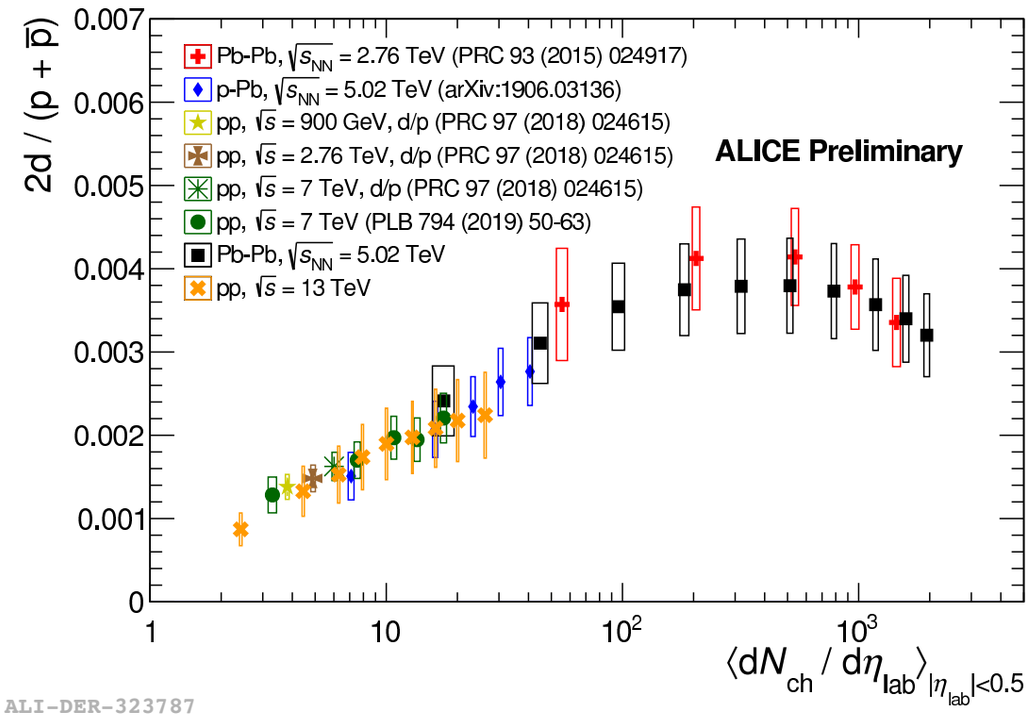
- Exponential decrease in nuclei rate in agreement with thermal model predictions.
  - Factor ~ 300 (Pb-Pb), ~600 (p-Pb) and ~1000 (pp) per each additional nucleon

ALICE Collaboration.
p-Pb Submitted to PLB arXiv:1906.03136
pp Phys. Rev. C97 (2018) 024615
Pb-Pb Nucl. Phys. A 971 (2018) 1

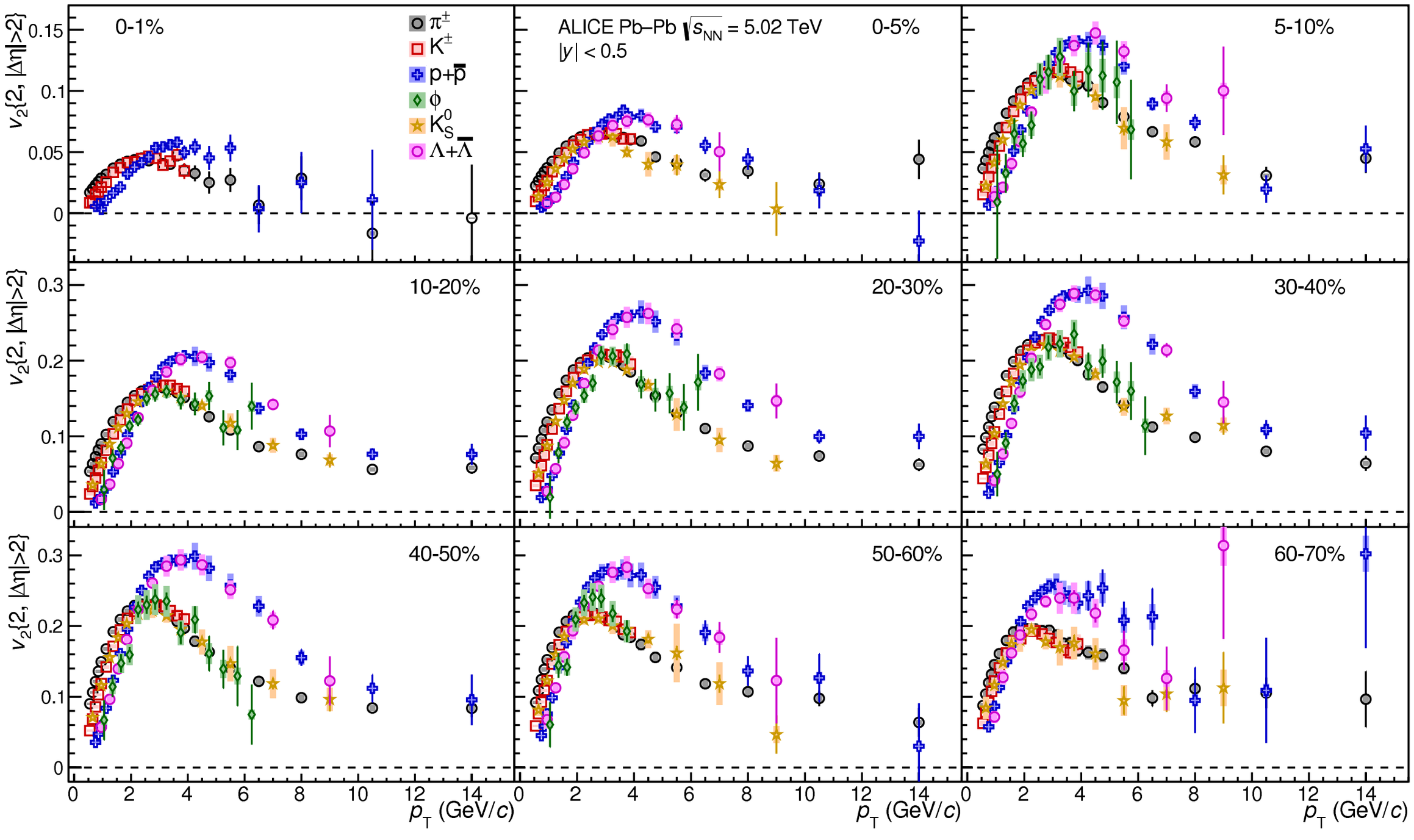


- d/p vs multiplicity
  - Increase from pp to peripheral Pb-Pb consistent with coalescence model
  - Different trend for Pb-Pb collisions (yields consistent with thermal model)
  - No energy dependence observed.

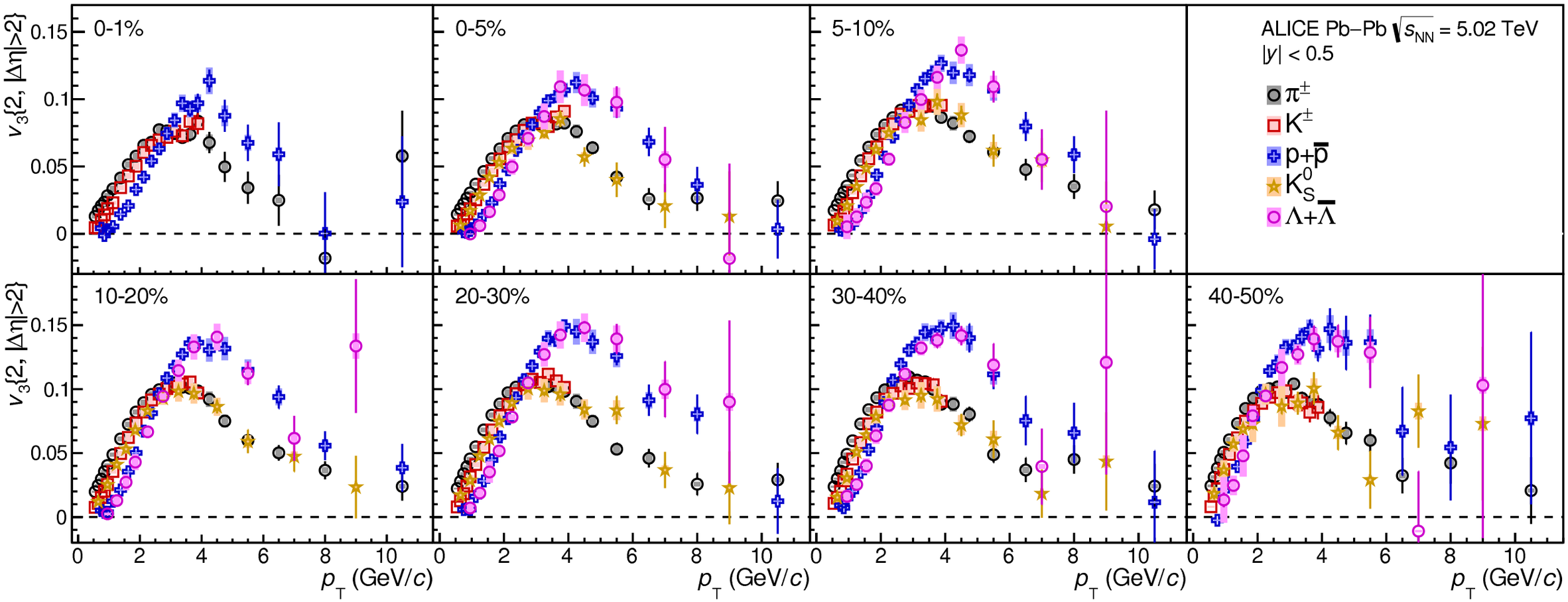
- Production mechanism (Thermal vs coalescence)? Same or different in small and large systems ?



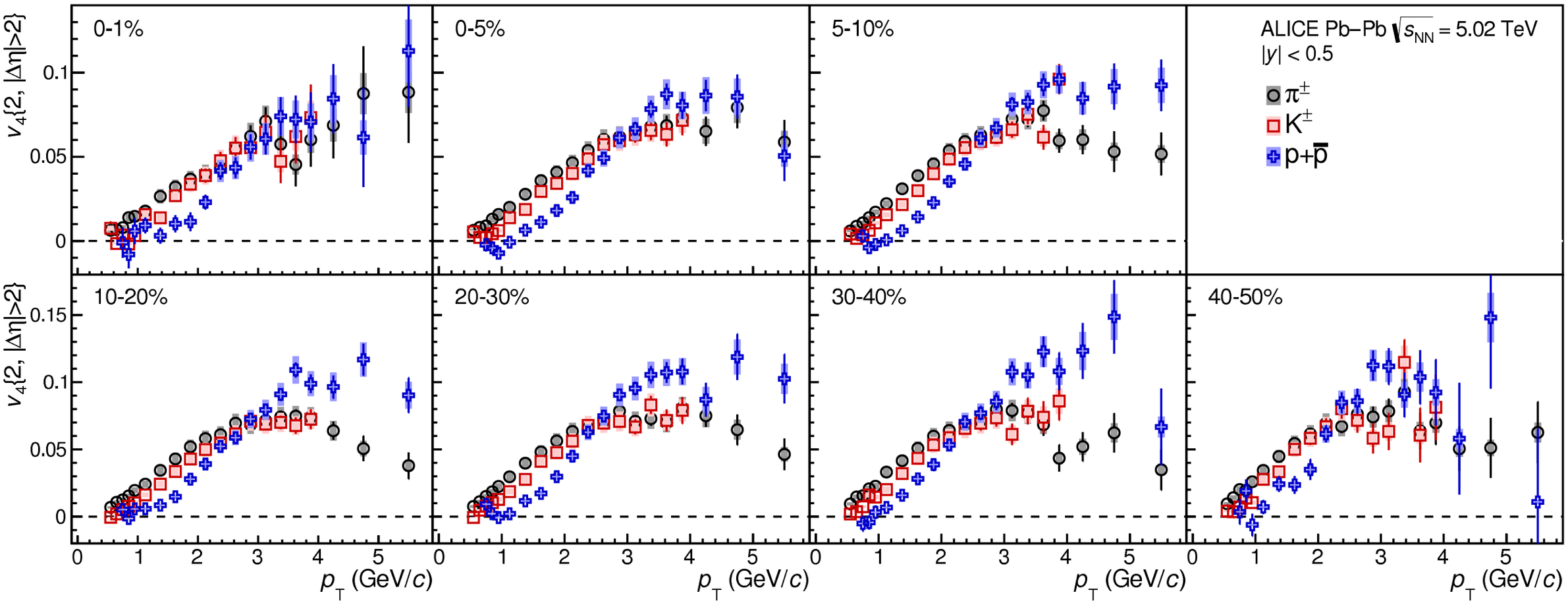
PID v_2 in Pb-Pb



PID v_3 in Pb-Pb

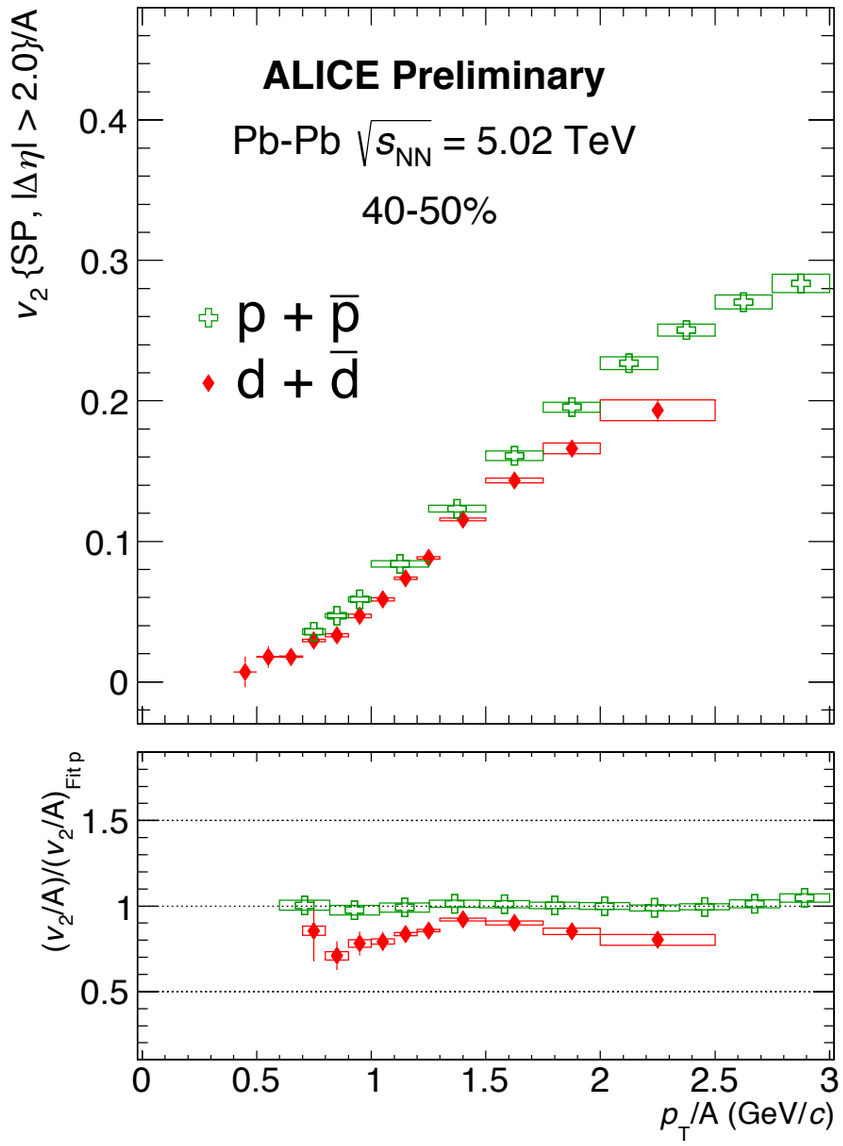


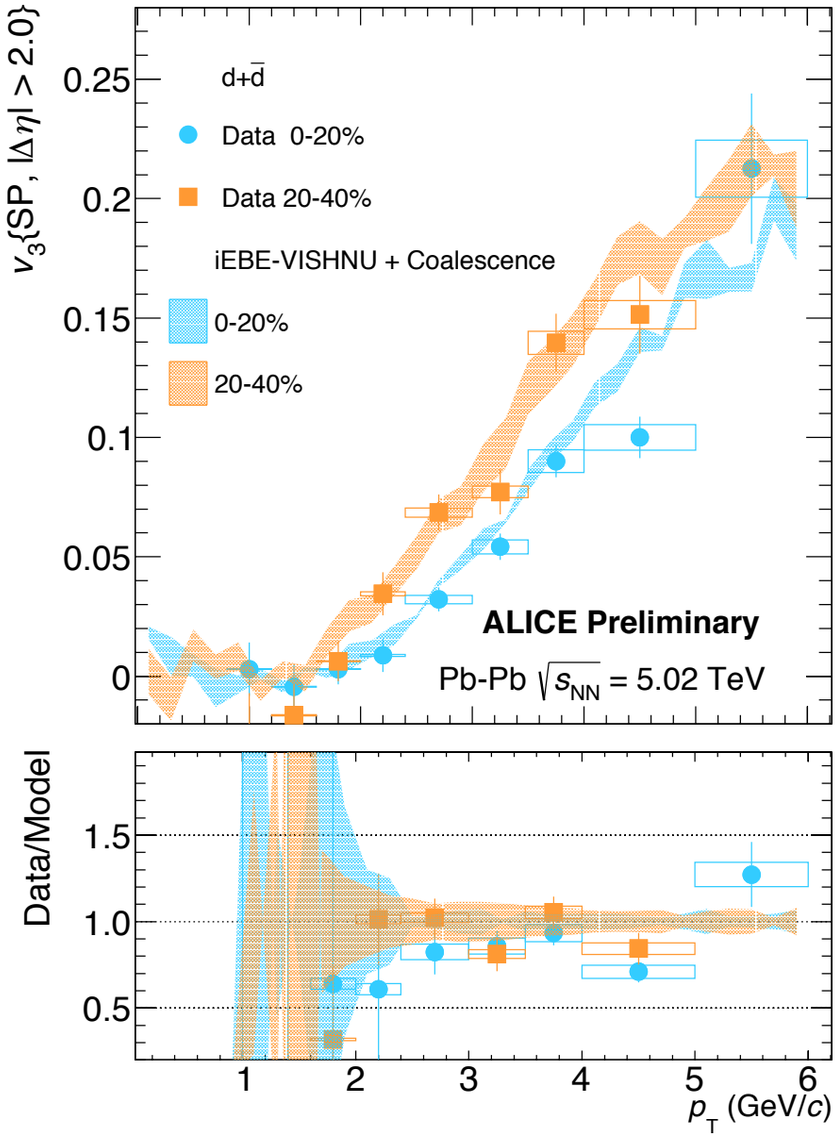
PID v_4 in Pb-Pb



Anti-d v_2,v_3 in Pb-Pb

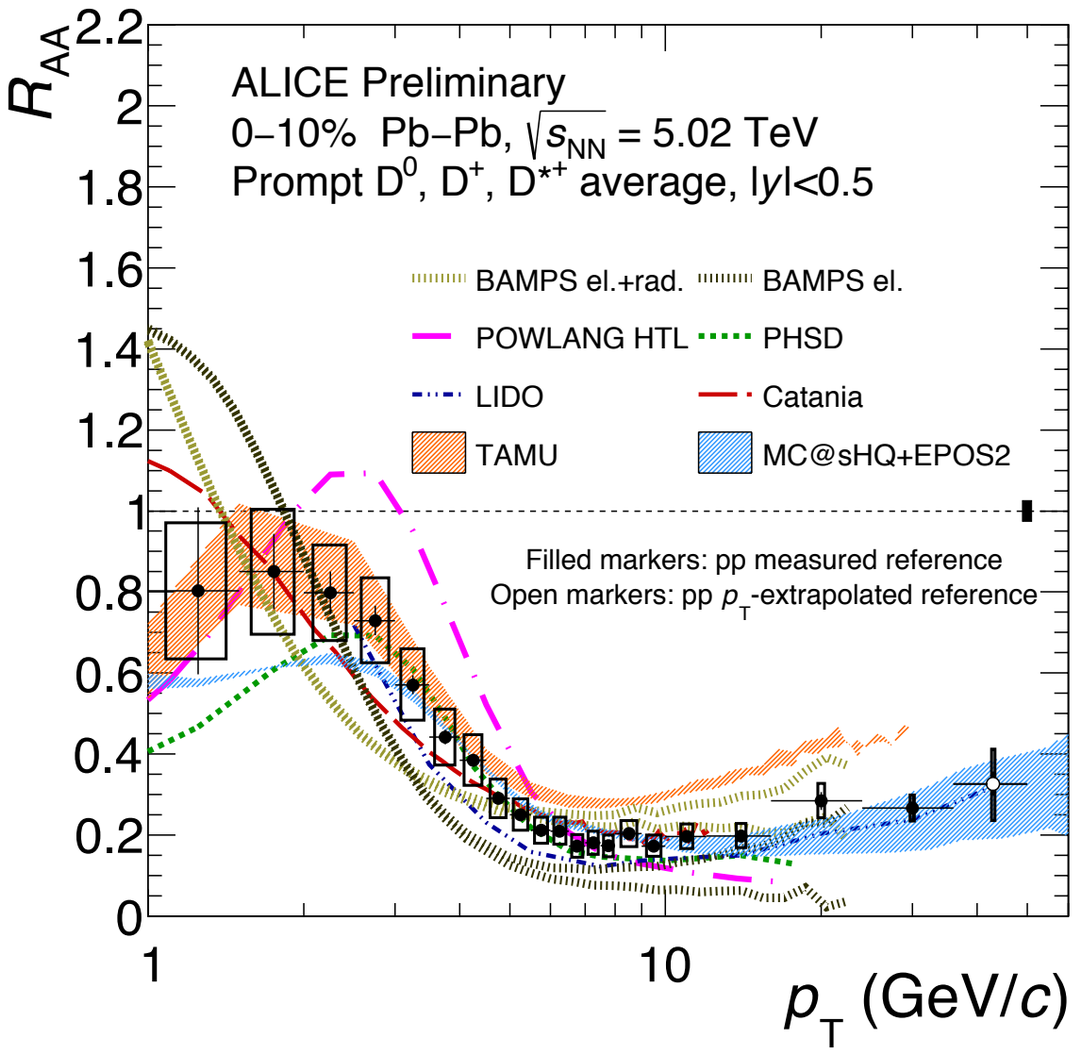
New

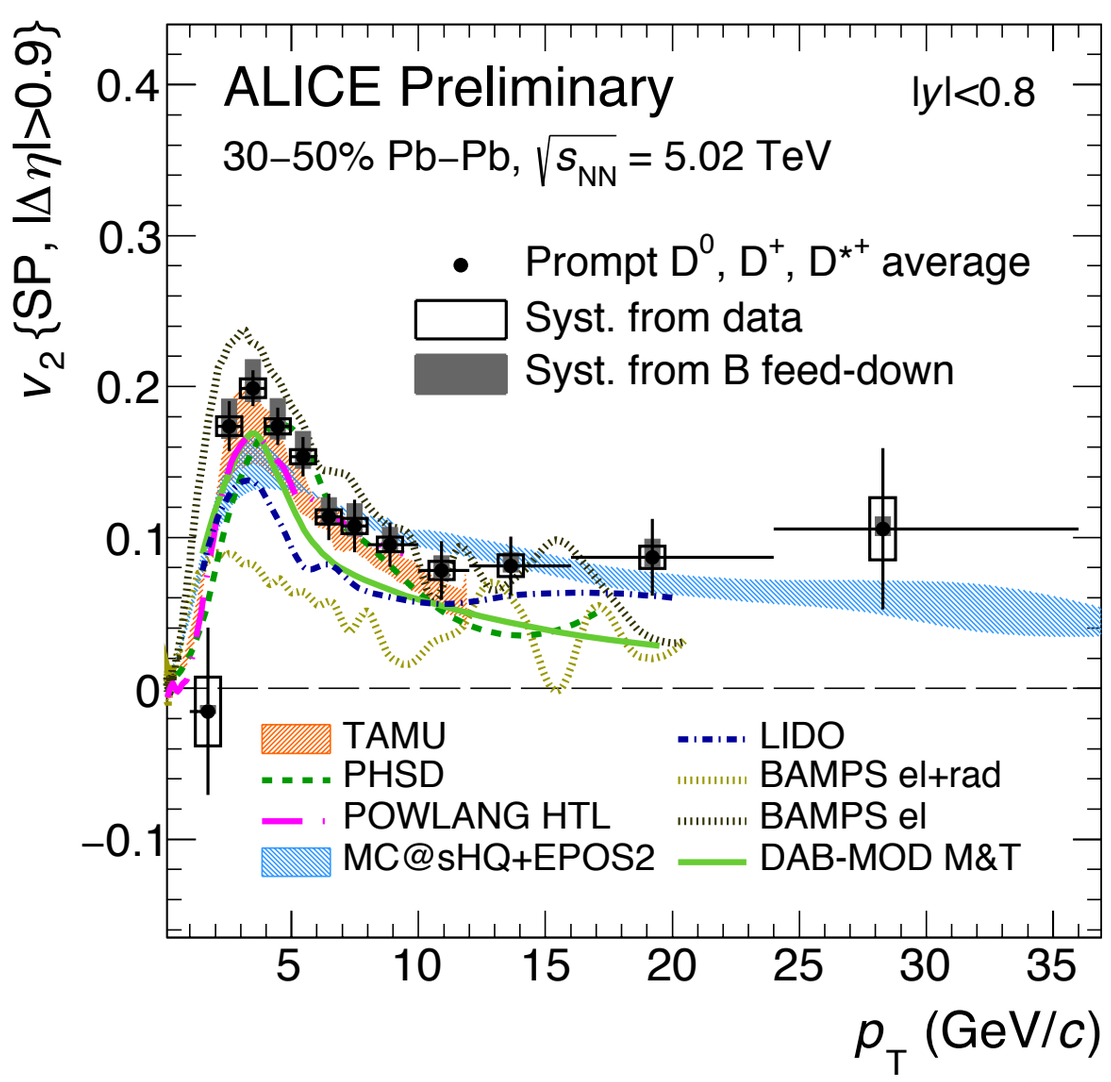




- (Anti)deuteron v_2 and v_3 comparable with proton ones
- Coalescence model with phase-space distribution of p and n from iEBE-VISHNU in agreement with data

Heavy Flavour energy loss in Pb-Pb collisions





New

2018 Pb-Pb data

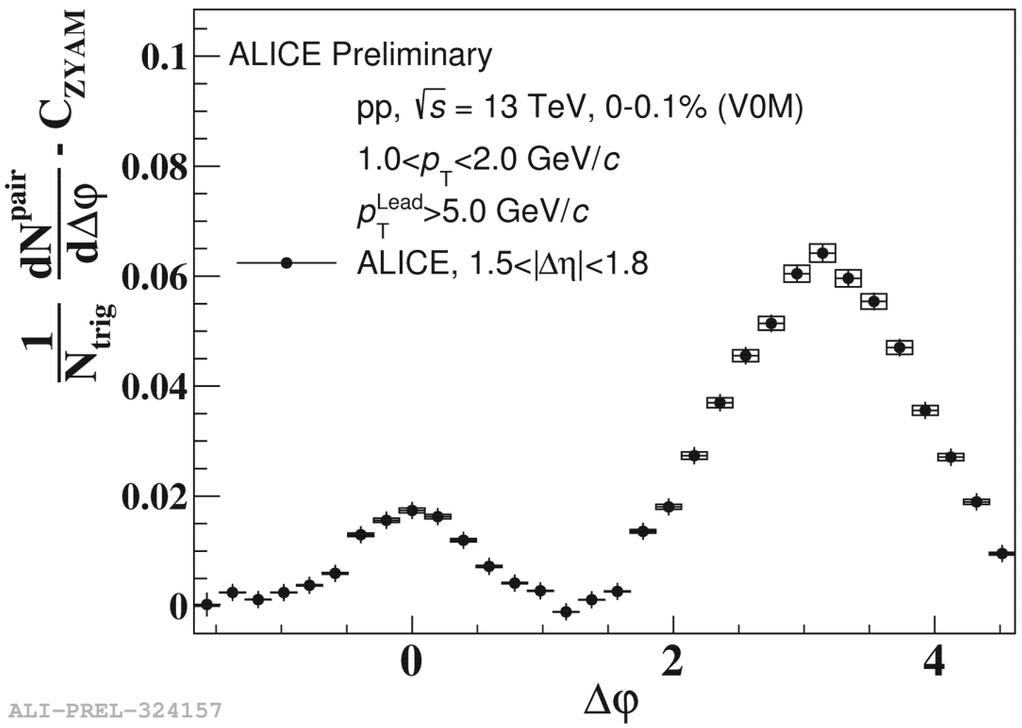
BAMPS: JPG 42, 115106 (2016); **Catania**: EPJC (2018) 78: 348; **DAB-MOD**: PRC 96 064903 (2017); **LBT**: PLB 777 (2018) 255-259; **MC@sHQ+EPOS2**: PRC 89 014905 (2014); **TAMU**: PLB 735,445-450(2014); arXiv:1905.09216; **PHSD**: PRC 92, 014910 (2015); **POWLANG**: EPJC 75,121(2015);

Poster JunLee Kim

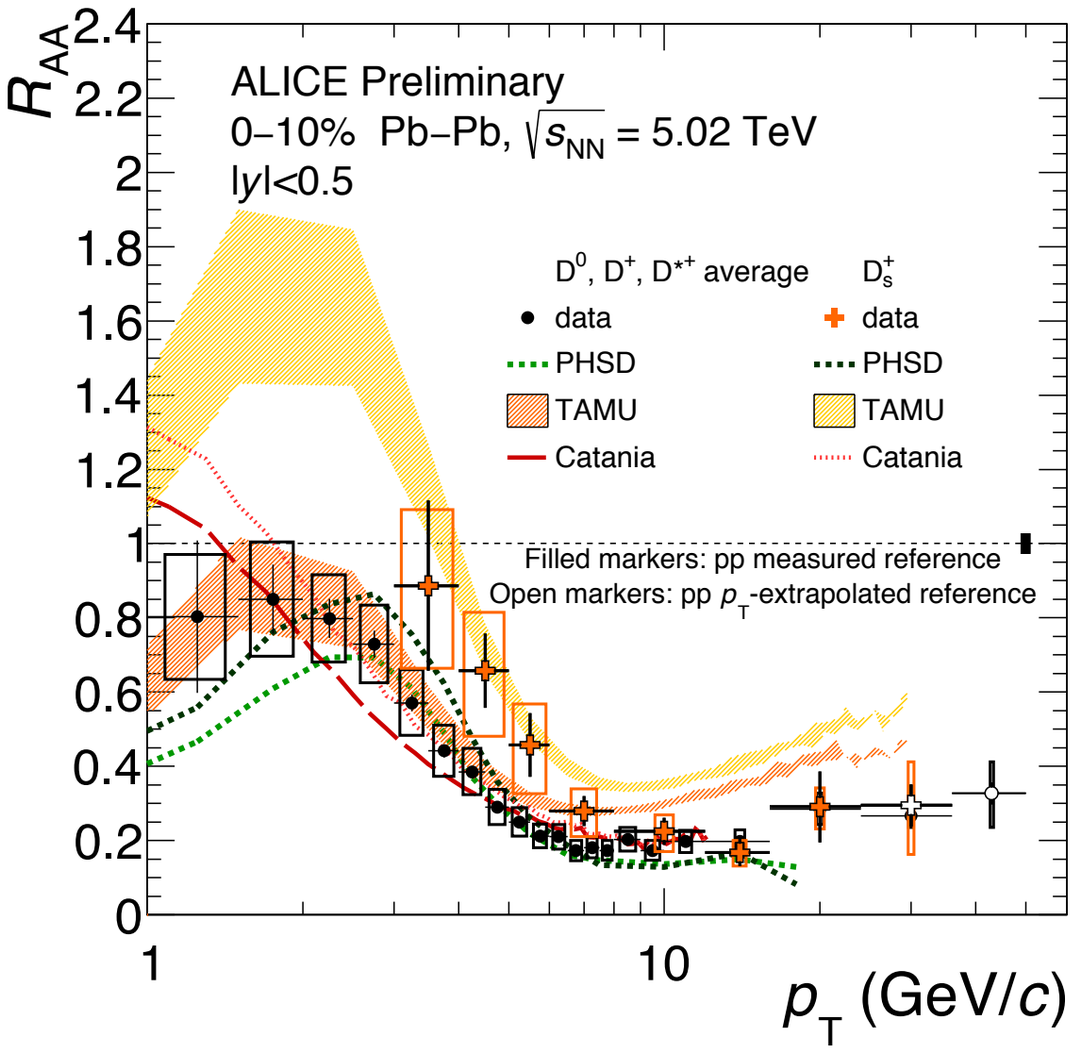
Near side ridge in pp collisions at $\sqrt{s}$=13 TeV

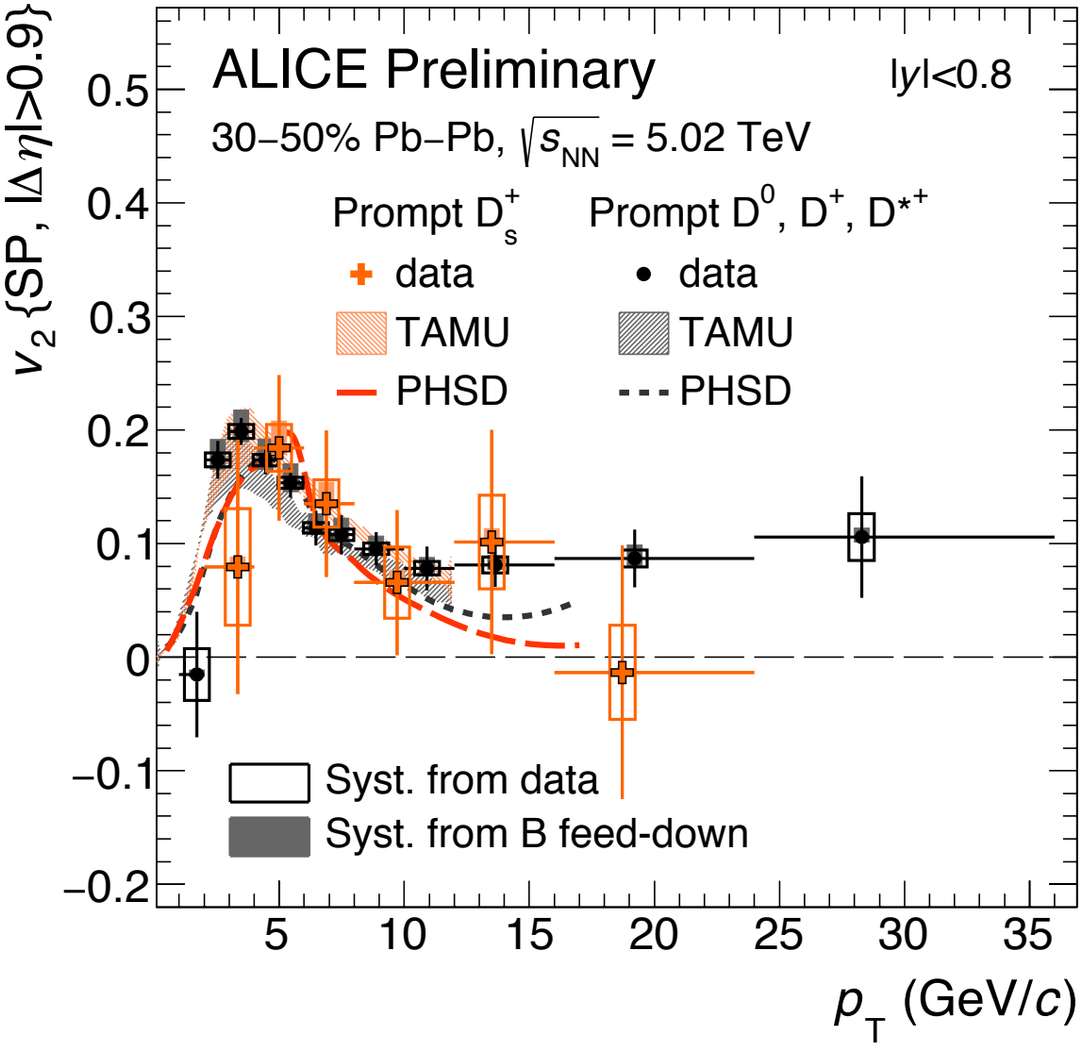
New

- Long range correlations in high-multiplicity pp collisions at $\sqrt{s}$=13 TeV
- Near-side ridge effect observed within ALICE acceptance $1.5 < |\Delta\eta| < 1.8$
- Per-trigger associated particle yields measured for the 0.1% highest multiplicity
- Yields do not change with different p_T requirements for leading particle in the event



Heavy Flavour energy loss in Pb-Pb collisions



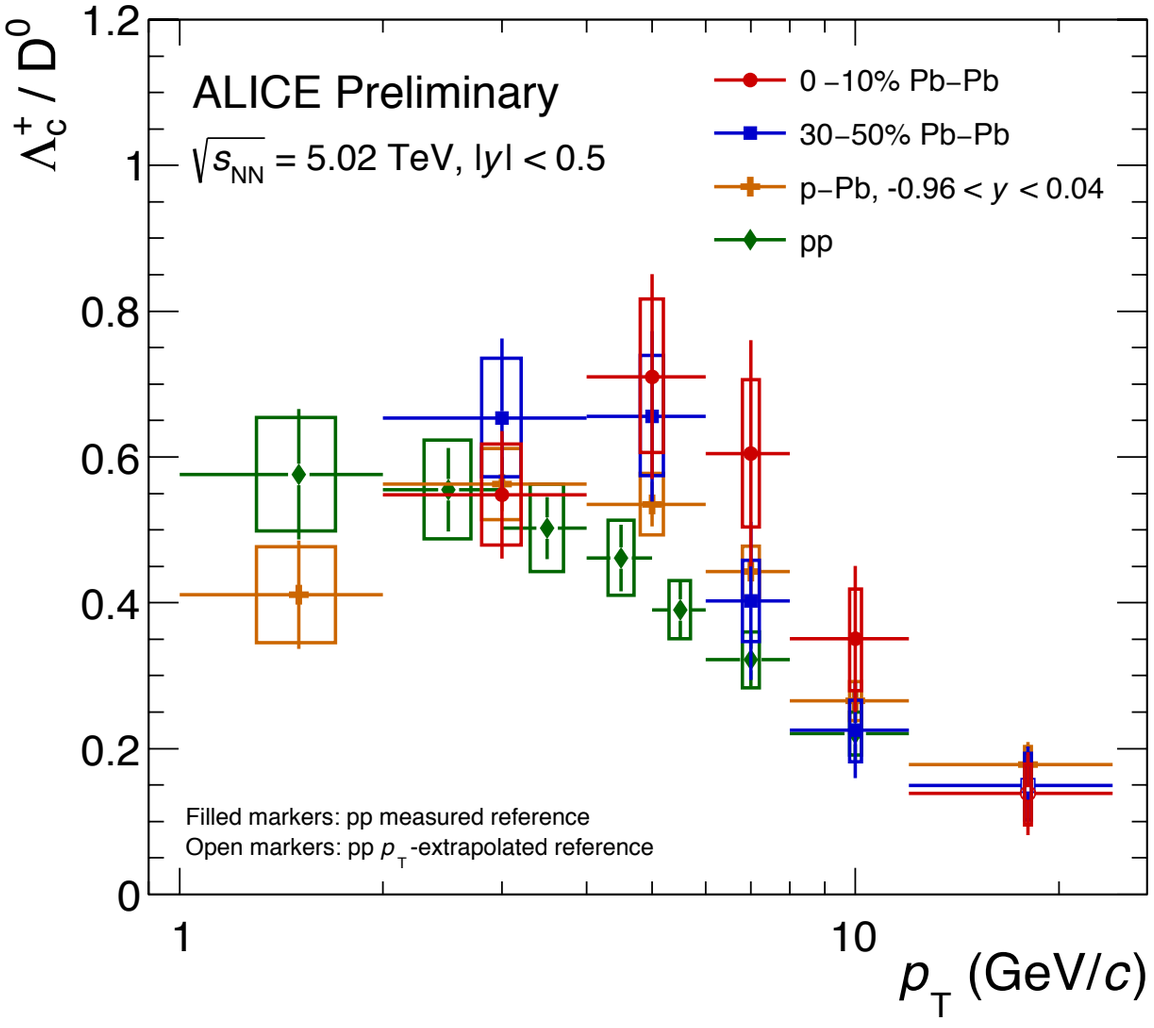


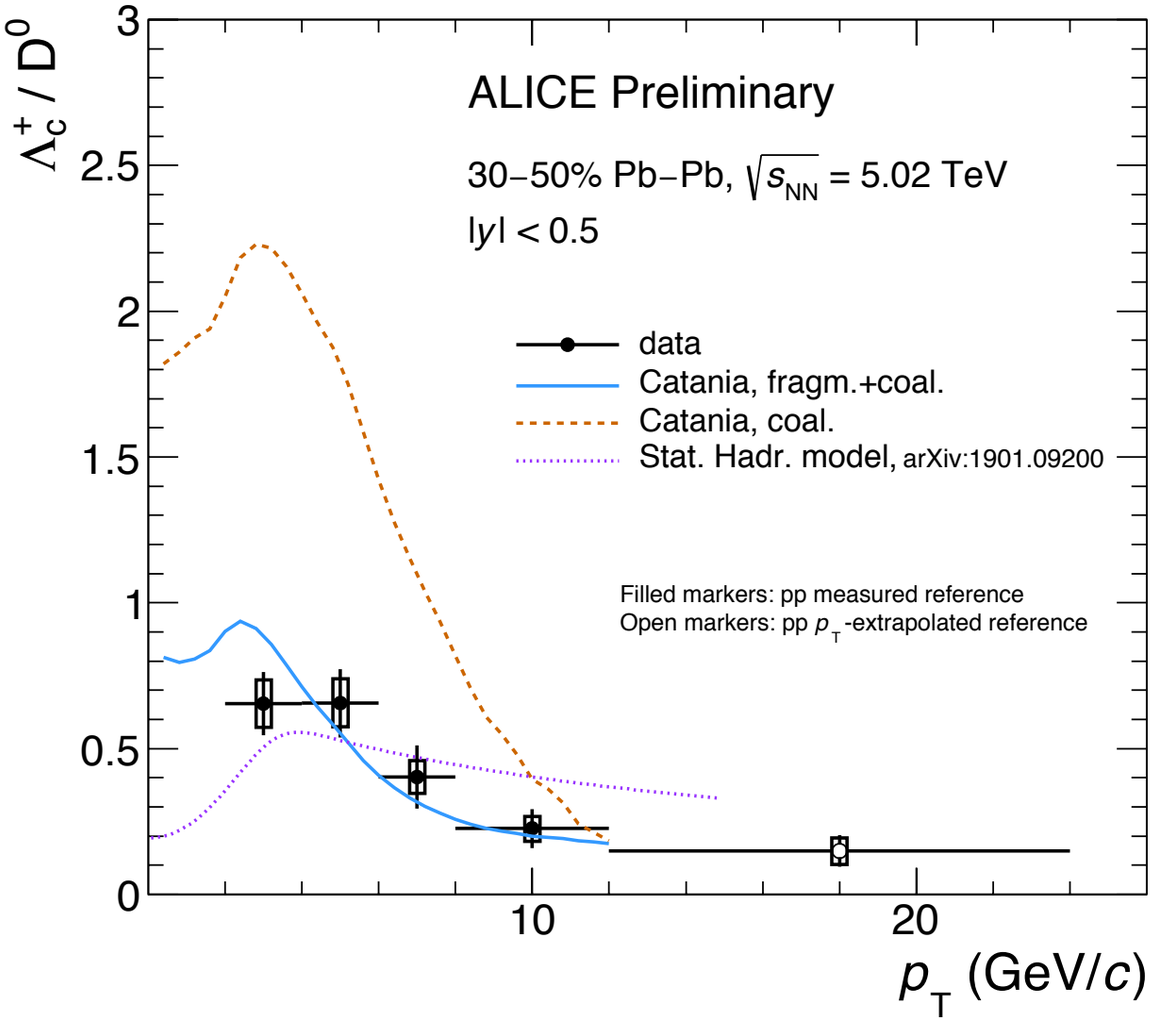
New

2018 Pb-Pb data

TAMU: PLB 735,445-450(2014); arXiv:1905.09216; **PHSD**: PRC 92, 014910 (2015); **Catania**: EPJC (2018) 78: 348

Λ_c^+ in Pb-Pb collisions

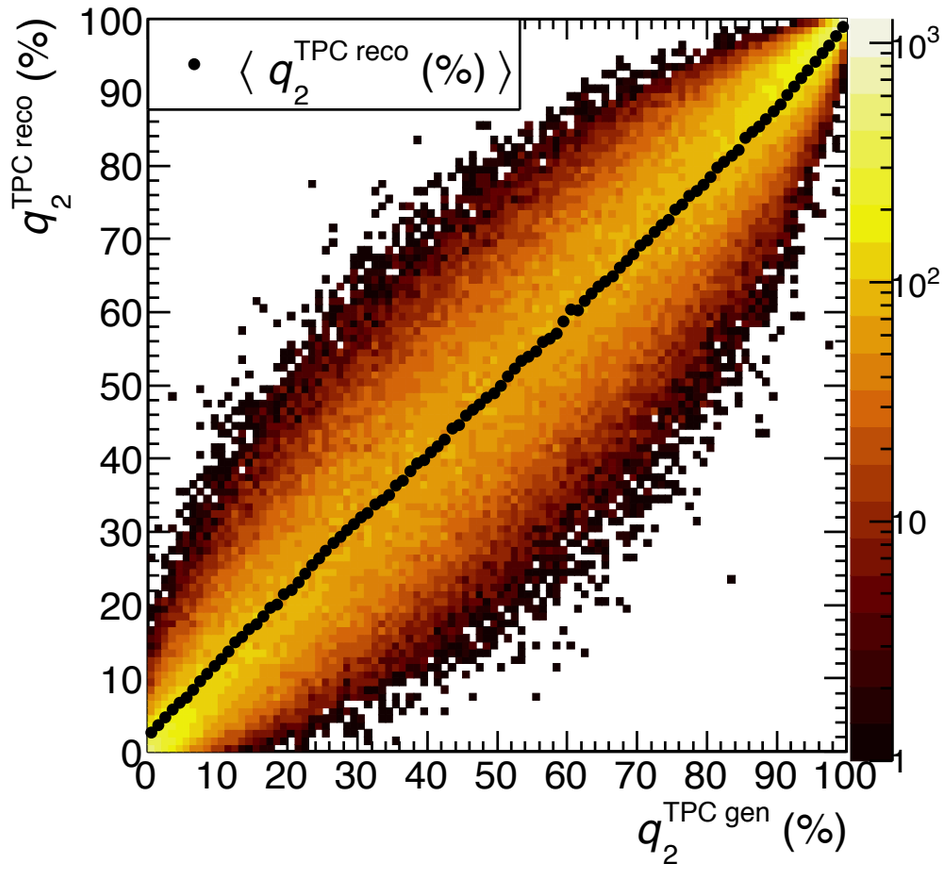


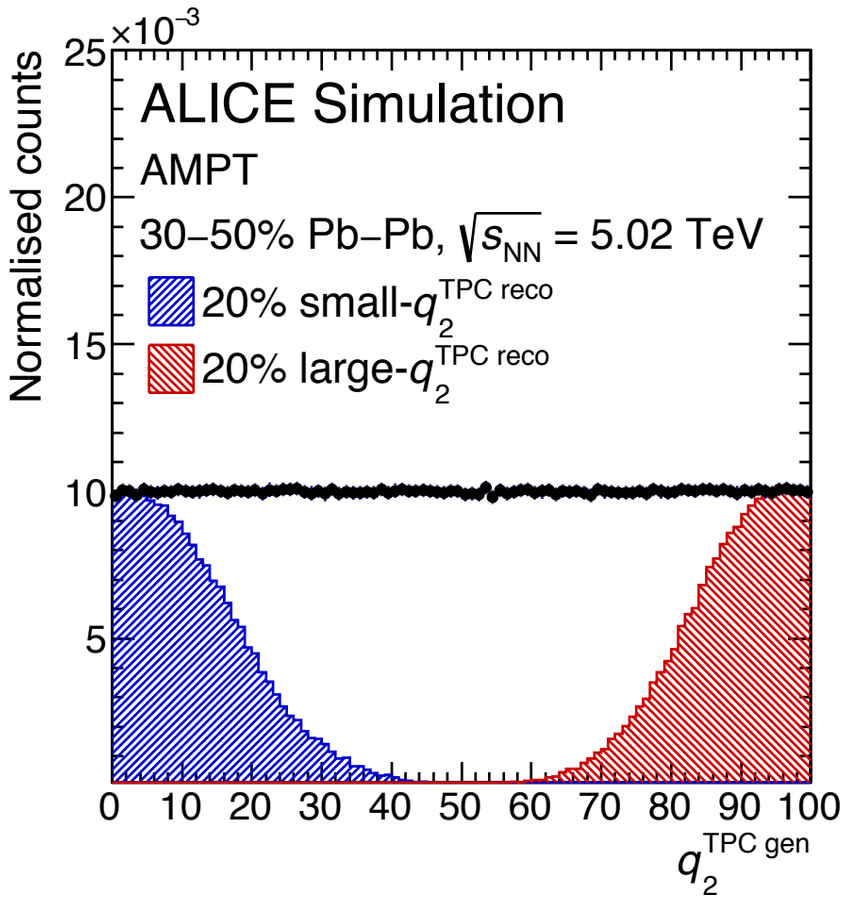


New

2018 Pb-Pb data

HF Event Shape Engineering





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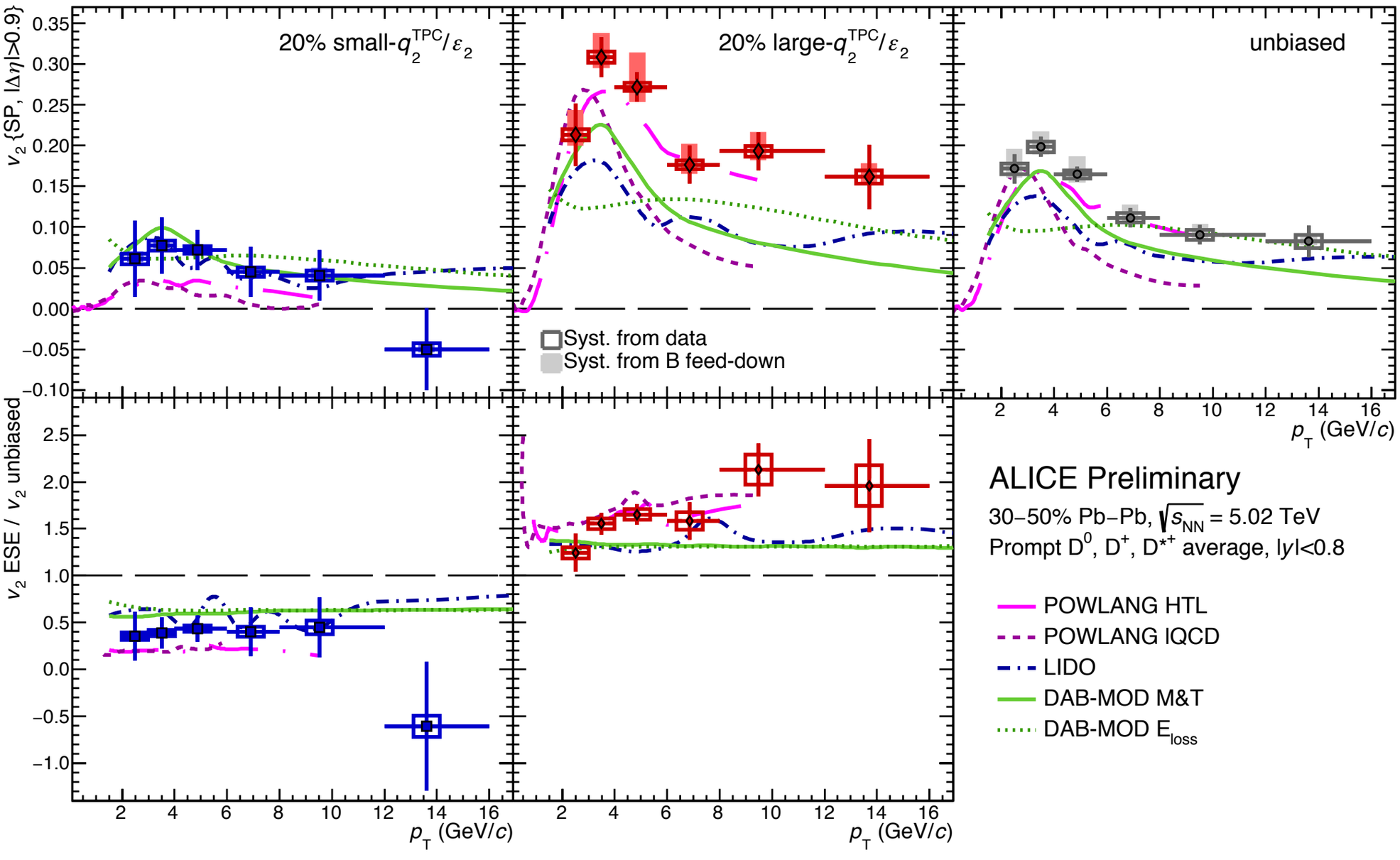


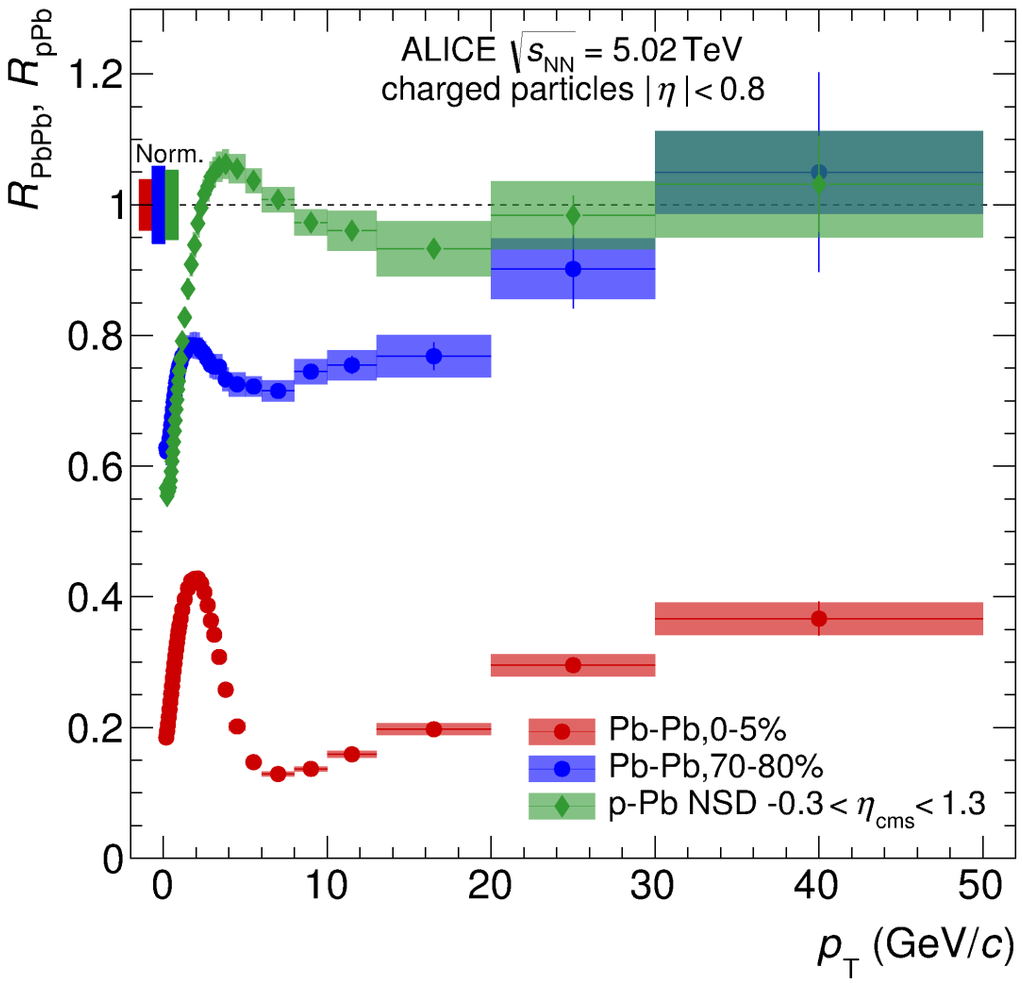
POWLANG: EPJC 75,121(2015); **LIDO**: arxiv 1810.08177; **DAB-MOD**: PRC 96 064903 (2017)

New

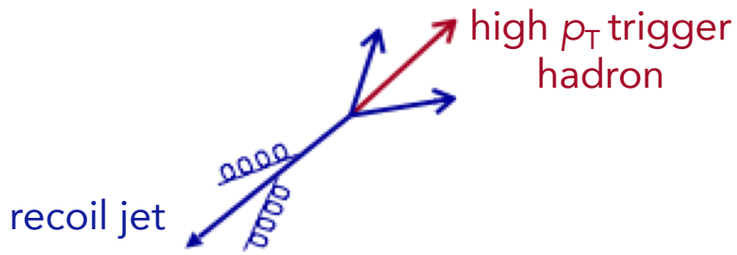
2018 Pb-Pb data

What about energy loss in small systems?

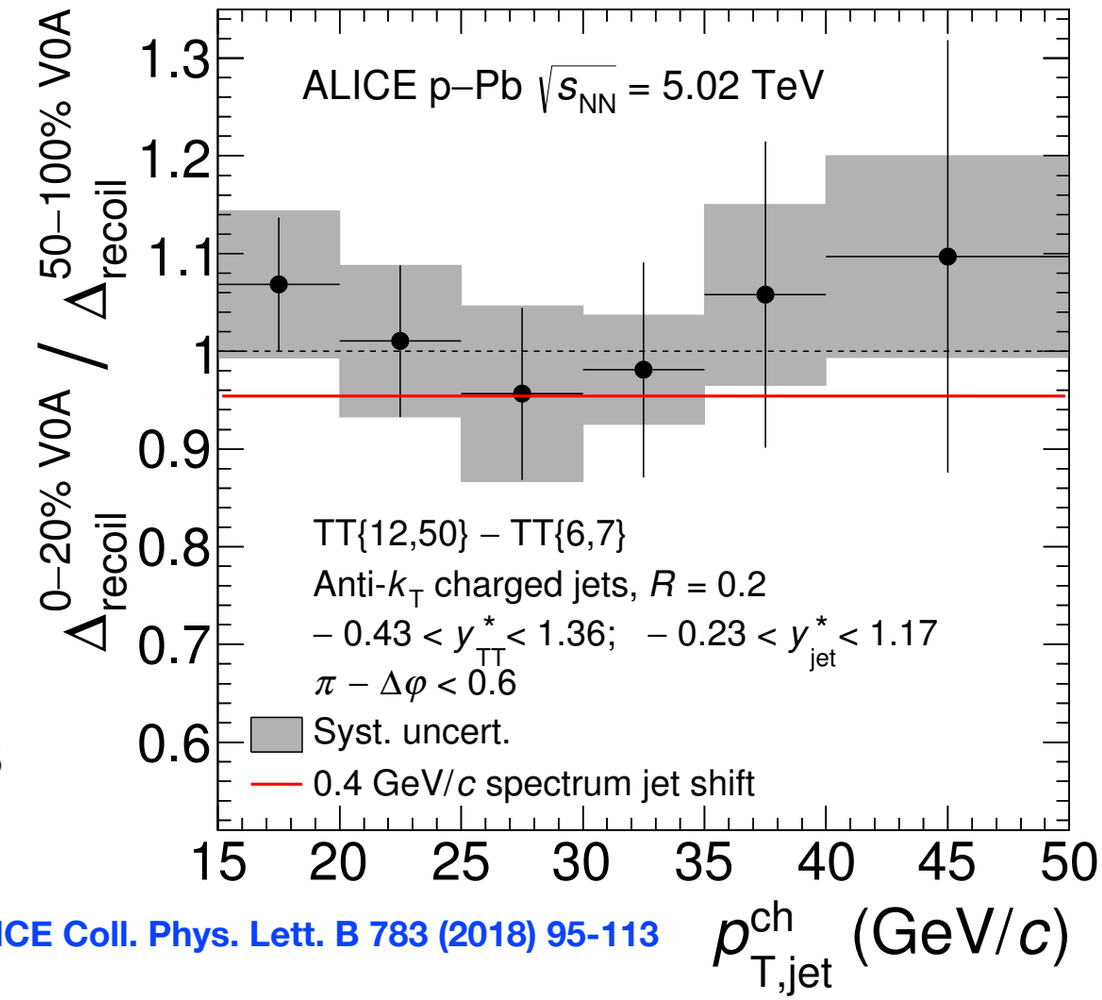
ALICE Coll. arXiv:1802.09145



- R_{pPb} =1 ⇒ no evidence of energy loss



- hadron-recoil jet coincidence measurements
- semi-inclusive recoil jet distribution for different p-Pb multiplicity classes

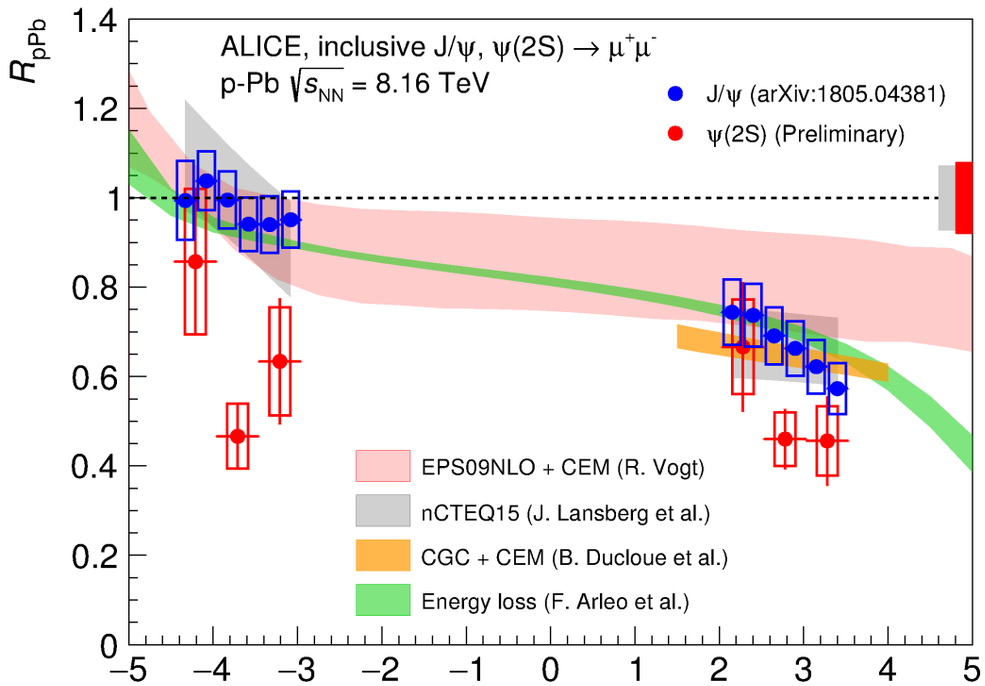


ALICE Coll. Phys. Lett. B 783 (2018) 95-113

- No significance modifications (ΔE<0.4 GeV)

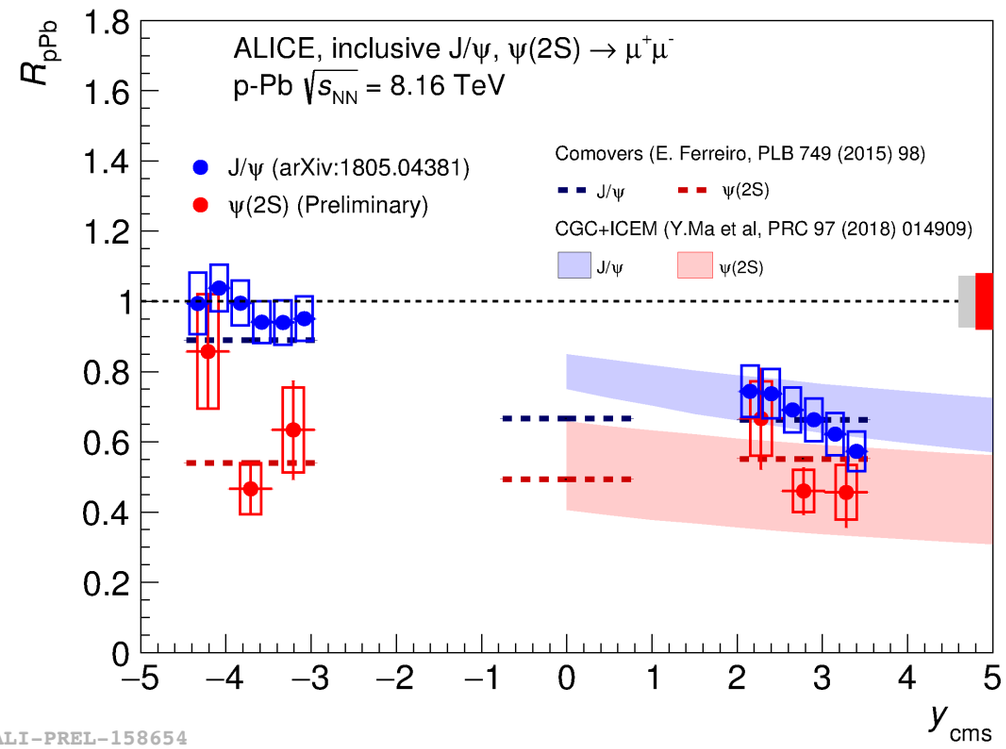
ψ(2S) production in p-Pb collisions

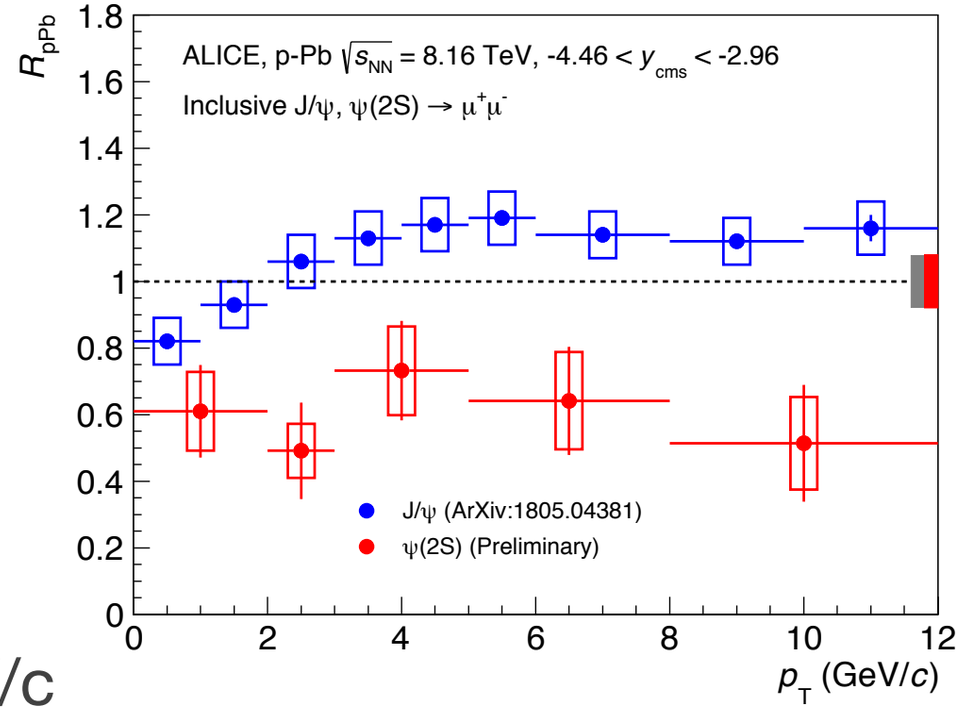
- ψ(2S) suppression in p-Pb collisions is stronger than the J/ψ one in particular at backward-y
  - Not expected different behaviour for the two states
  - Shadowing/energy loss not enough to describe the suppression at backward-y



ψ(2S) production in p-Pb collisions

- ψ(2S) suppression in p-Pb collisions is stronger than the J/ψ one in particular at backward-y
  - Not expected different behaviour for the two states
  - Shadowing/energy loss not enough to describe the suppression at backward-y
  - Additional final state effects needed:
    - Soft colour exchanges between cc and coming partons
    - “classical” commoner model, with break up σ tuned on low energy data
    - Regeneration and dissociation in the QGP and hadronic phase
- More differential studies to clarify the mechanisms behind the observed difference
  - ψ(2S) RpPb ~ flat at 0.6 up to pT ~ 10 GeV/c





Title