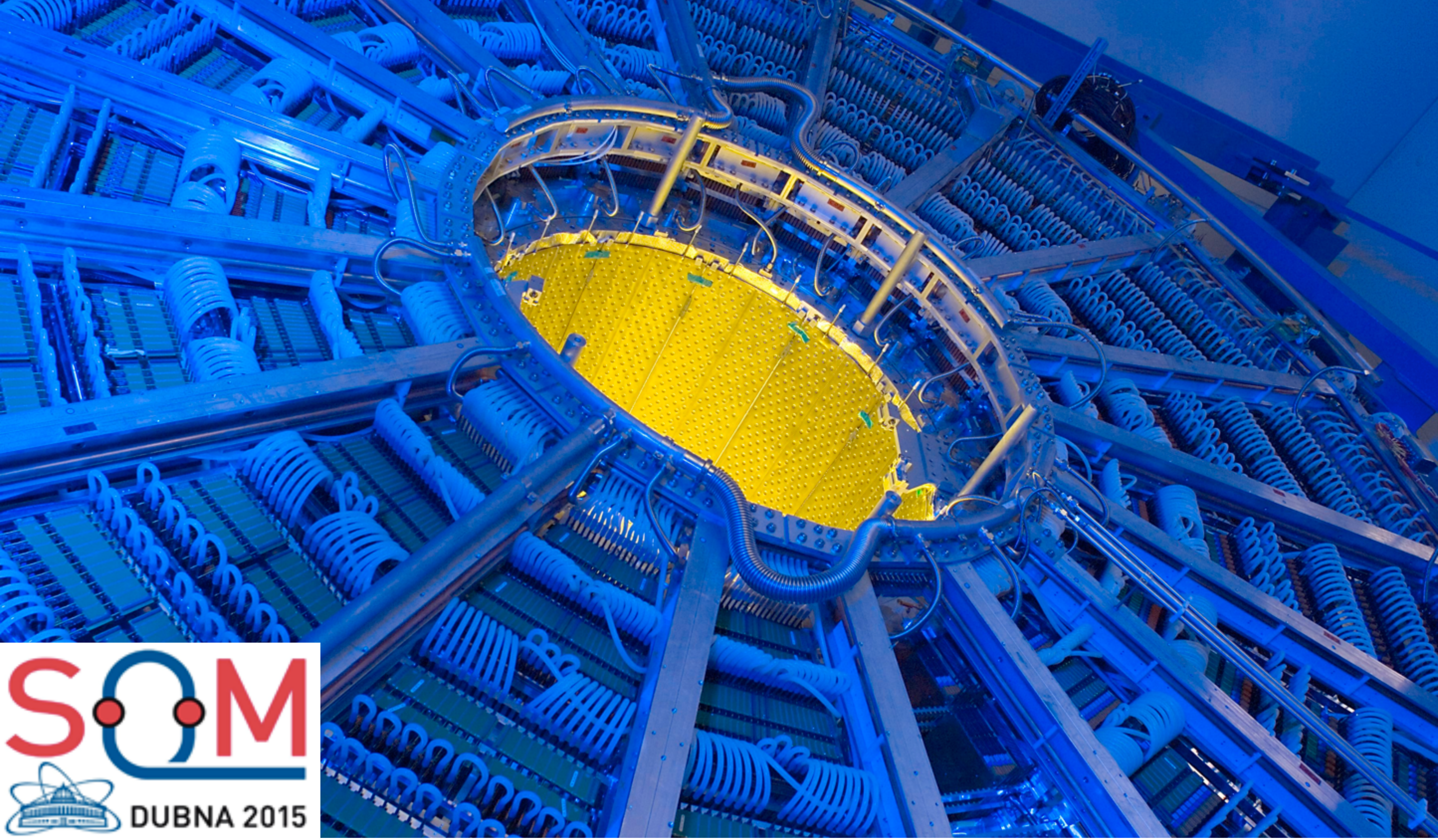

ALICE Overview

Michele Floris (CERN)
on behalf of the ALICE Collaboration
SQM, July 6 2015, Dubna

Why are we here?

- Study the **QGP**
  - Transport and bulk properties
  - Microscopic structure
  - How it hadronizes
  - How “the medium” emerges from strong interaction
- **Flavor** plays a key role!
- Studying largest system @ highest energy not enough
  - $\sqrt{s}$ dependence
  - System size dependence
    - Control for CNM effects

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- Flow, Spectra & Correlations
- “Calibrated” probes
  - Jets
  - Heavy Flavor
- Particle yields & ratios
- p-Pb and pp Collisions

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Ref to talk or arXiv NEW

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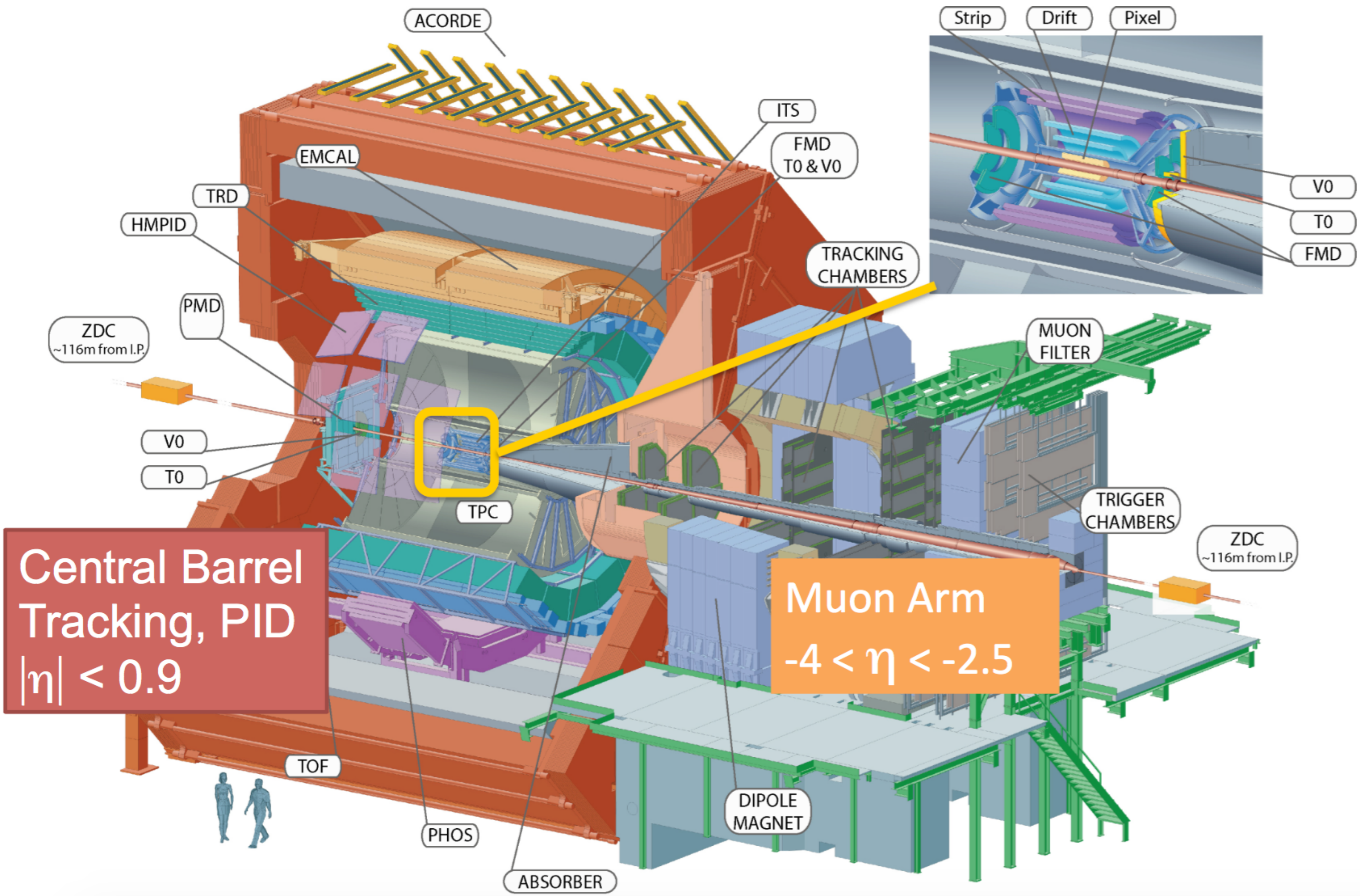
The ALICE Detector



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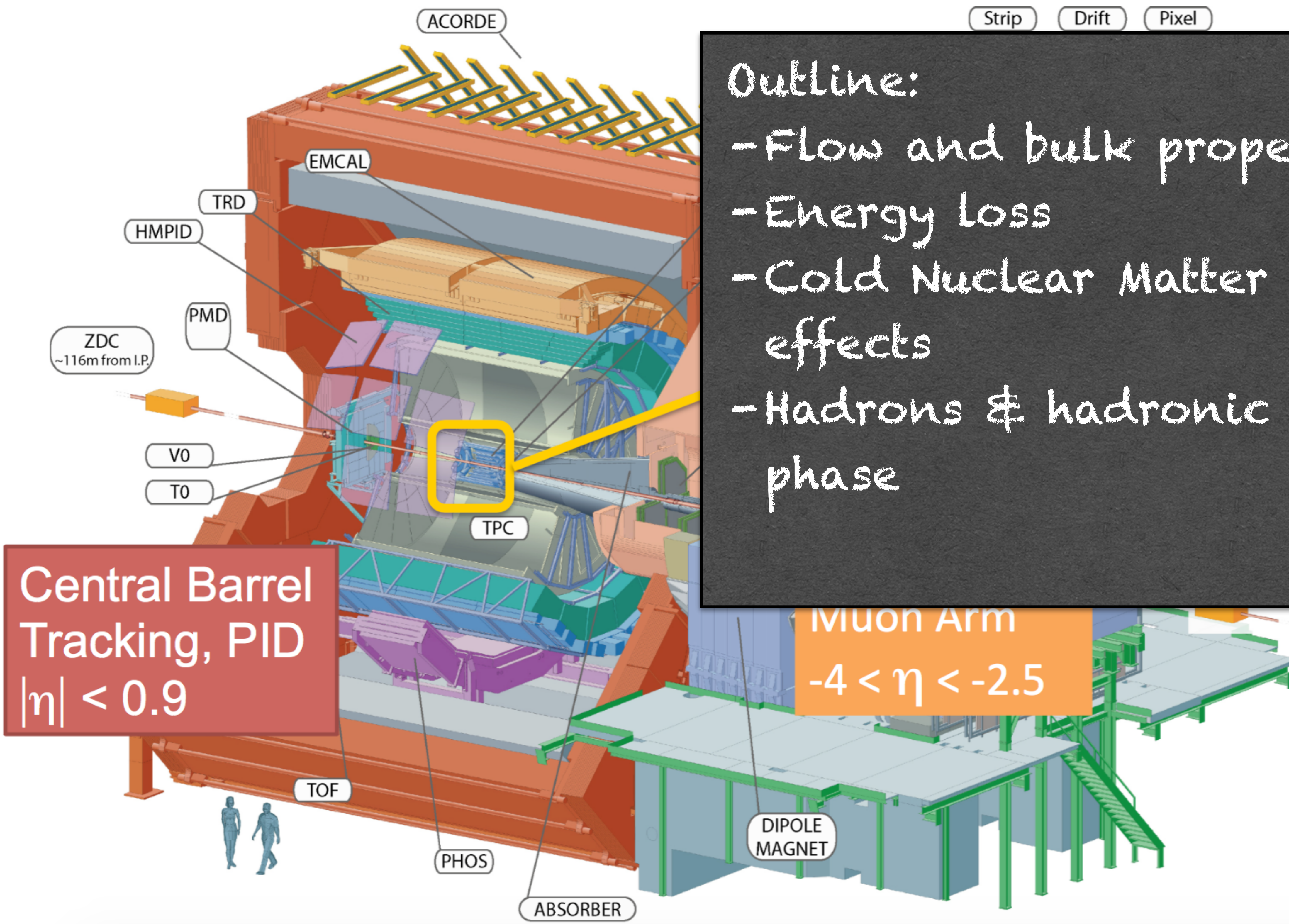


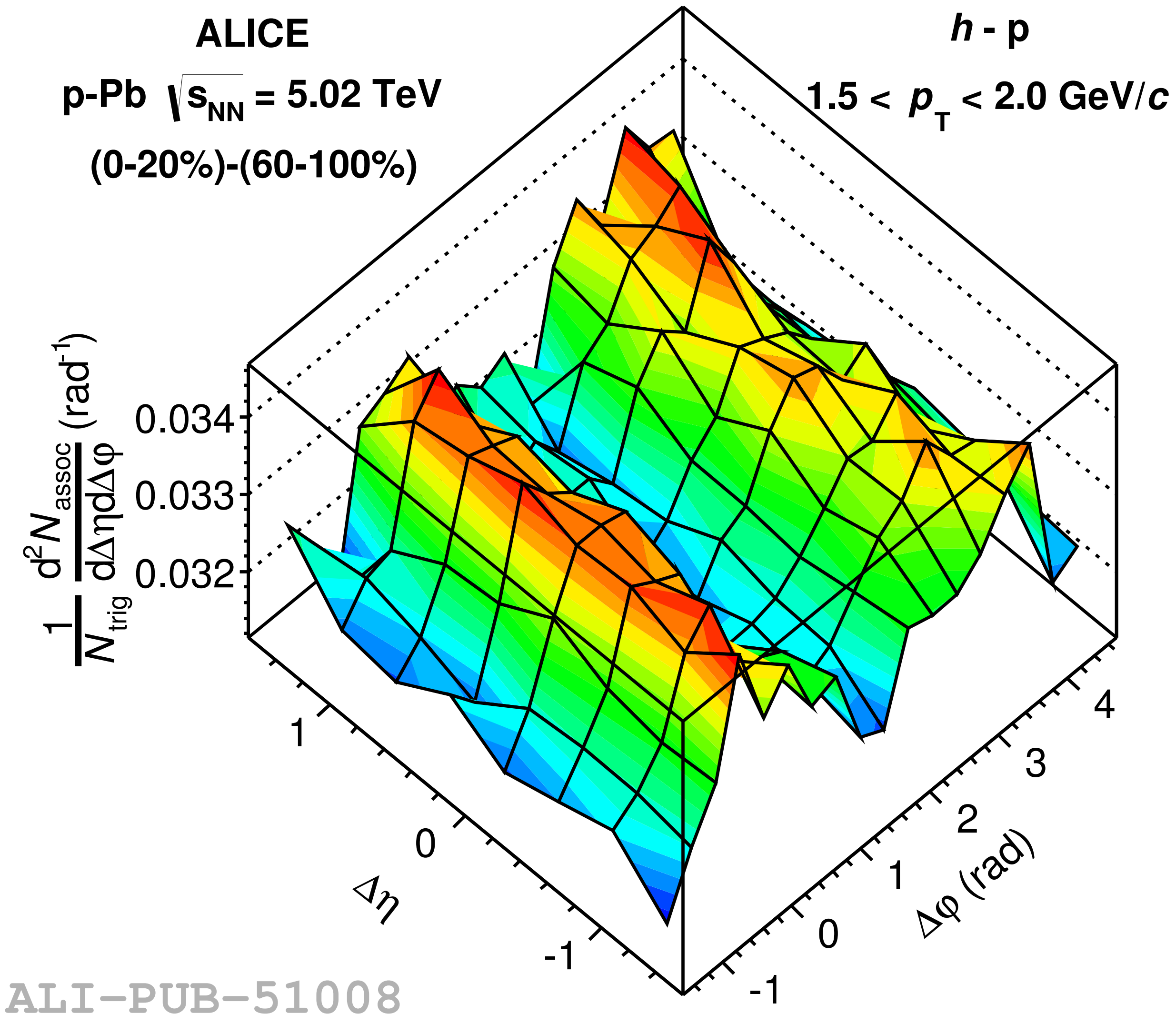
Outline:
- Flow and bulk properties
- Energy loss
- Cold Nuclear Matter effects
- Hadrons & hadronic phase

Flow and Bulk Properties

A. Ohlson, Thu 17:20
arXiv:1506.08032

NEW

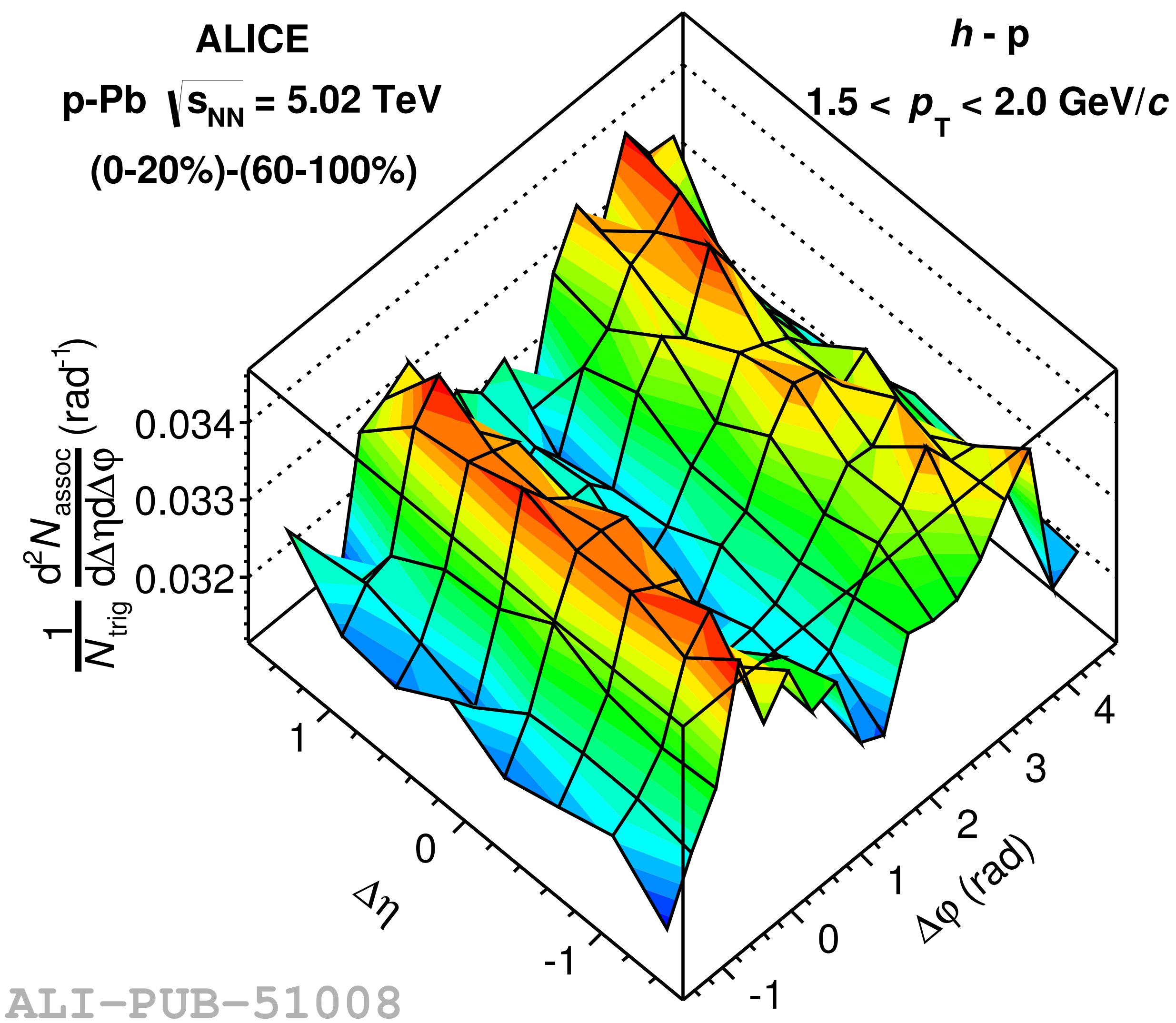
h-h correlations (the "ridge")



Flow signals also measured in p-Pb

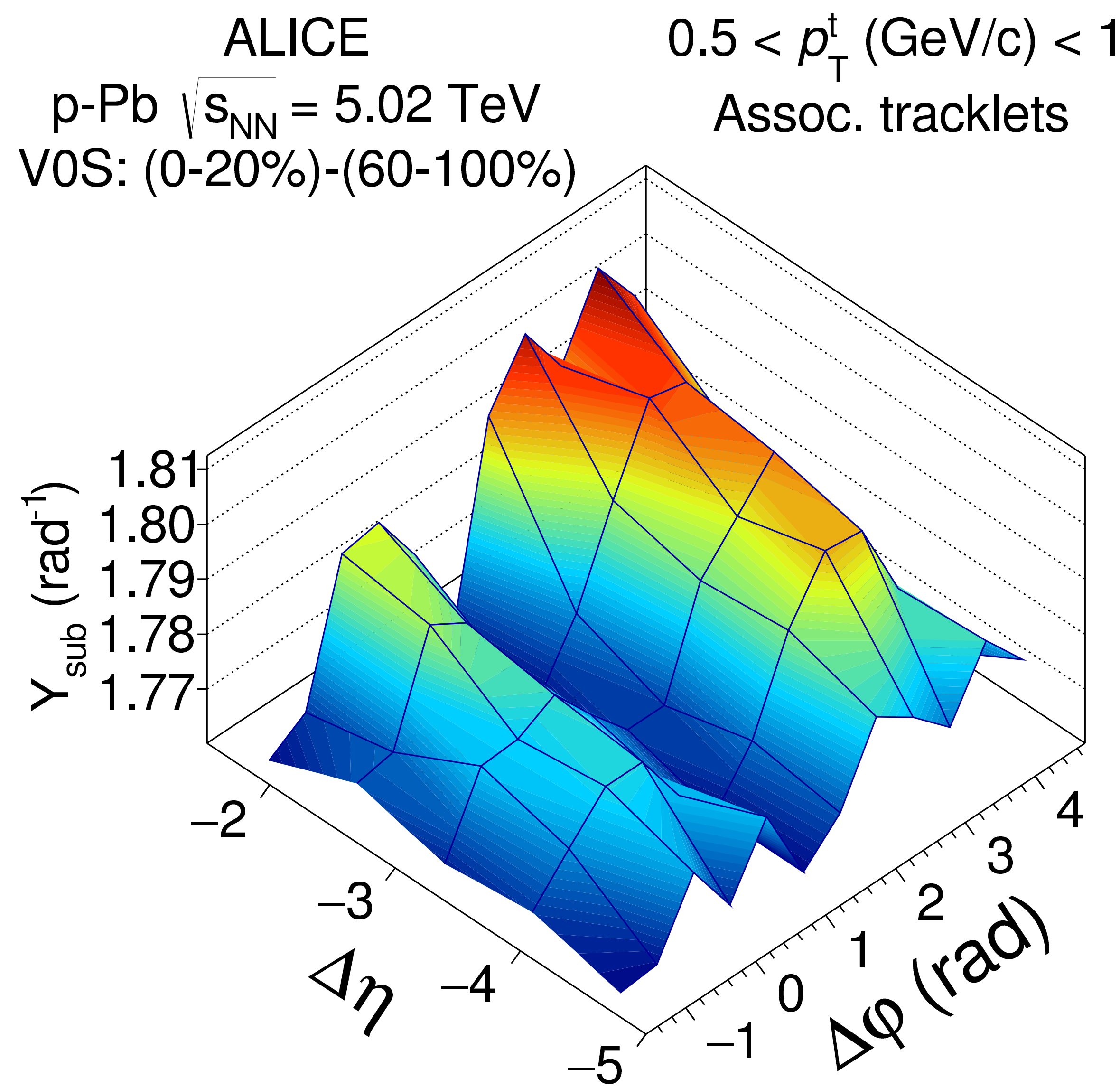
Small systems ridges

h-h correlations (the "ridge")



Flow signals also measured in p-Pb

Forward-μ - h correlations



Measurement covers 10 units of Δη ($1.5<|\Delta\eta_{lab}|<5$)!

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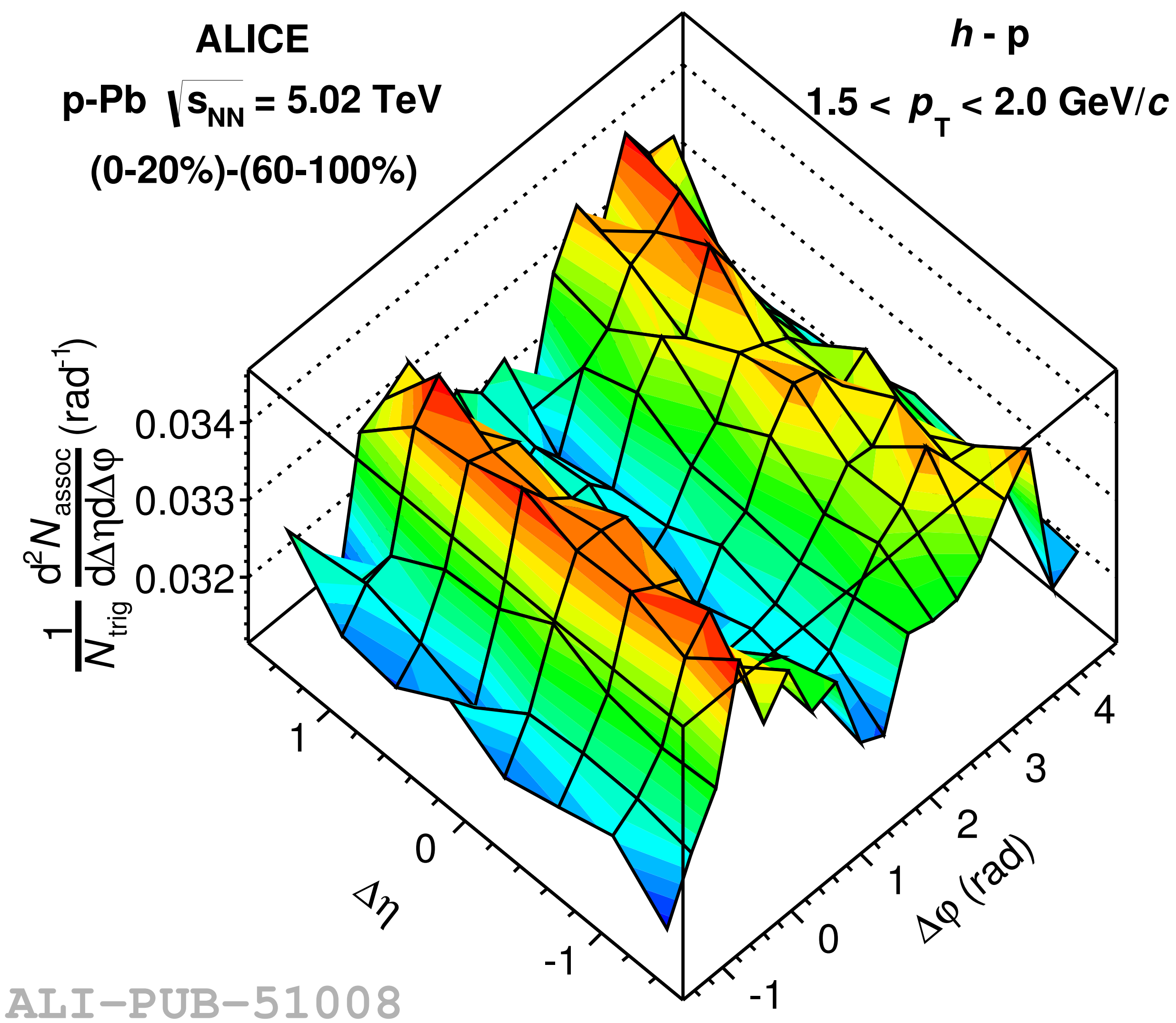

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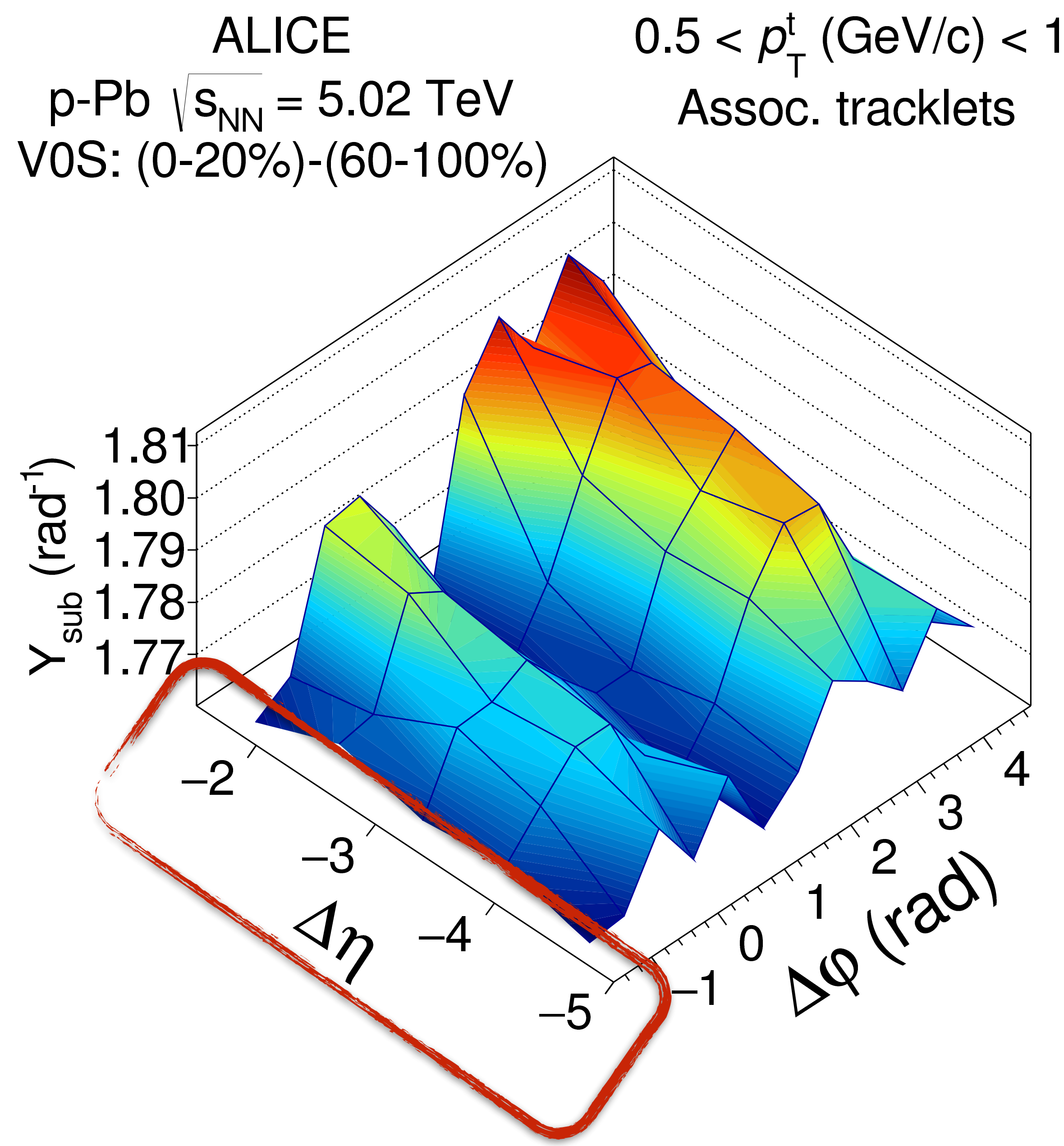

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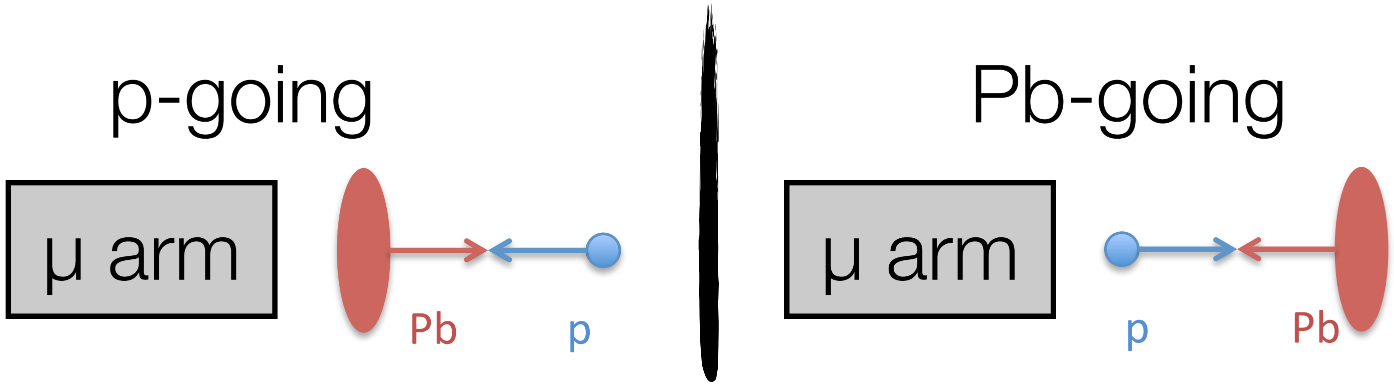
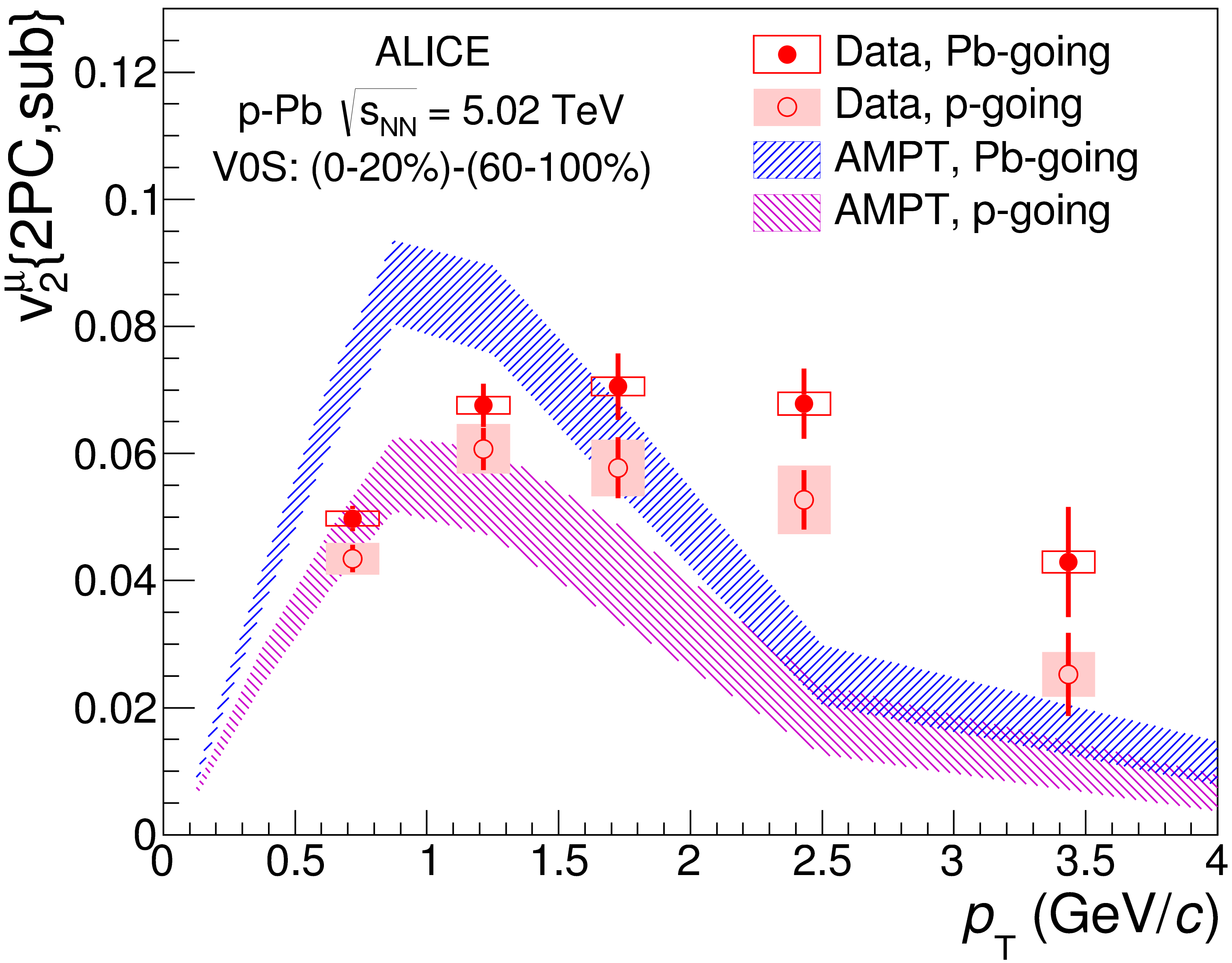
Forward-μ – hadron correlations



Similar p_T dependence in p-going and Pb-going directions



~(16±6)% higher in the Pb-going direction

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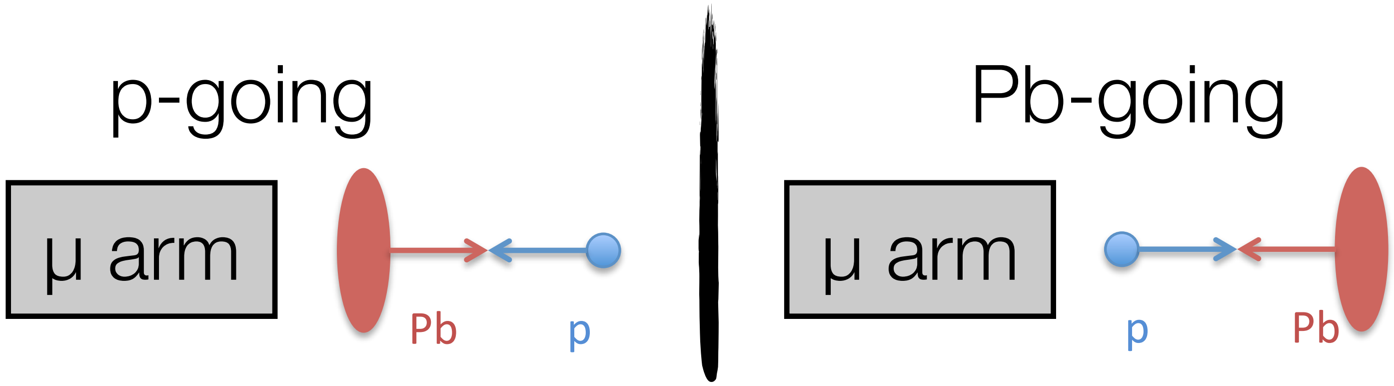

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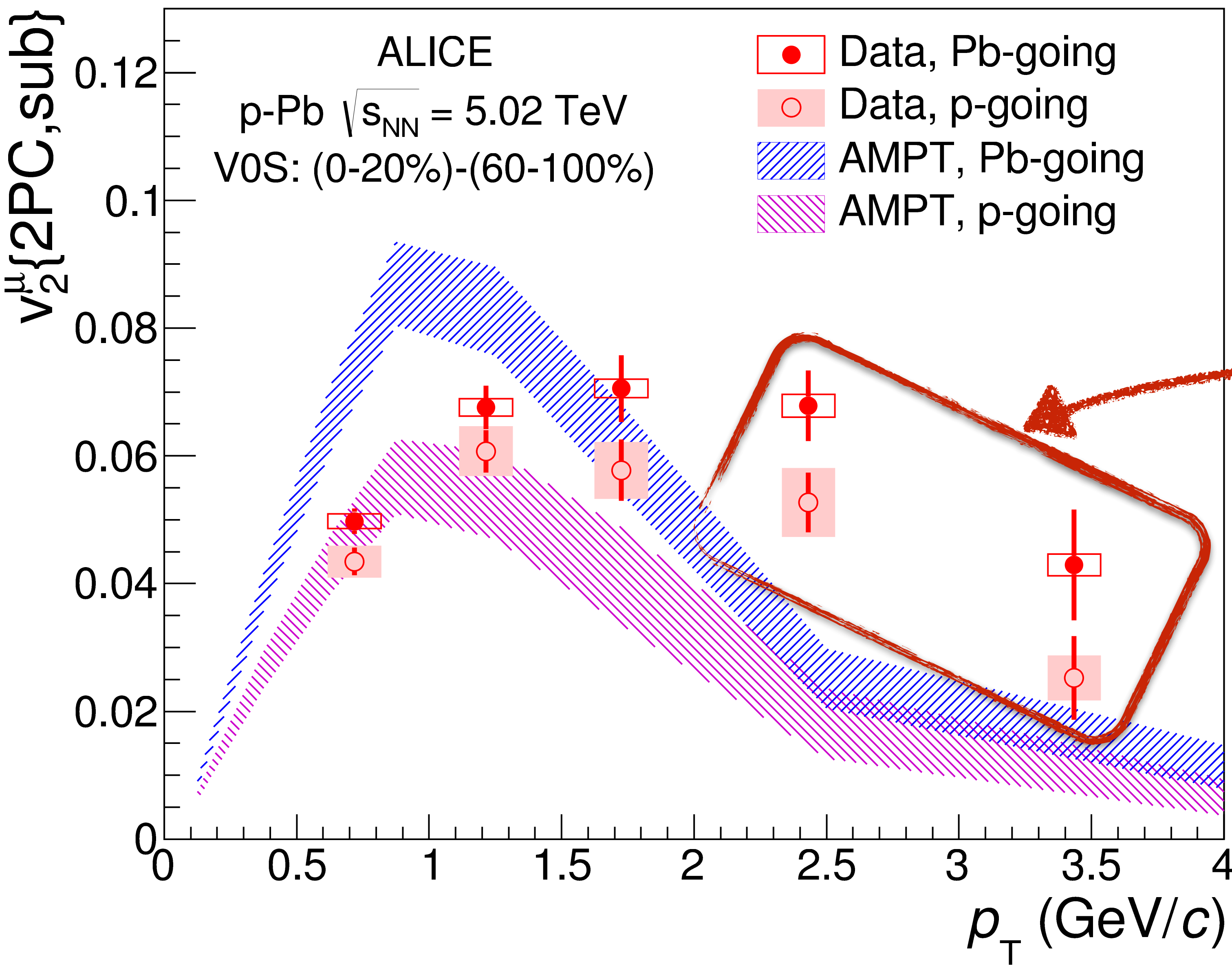

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μ ← HF dominate!

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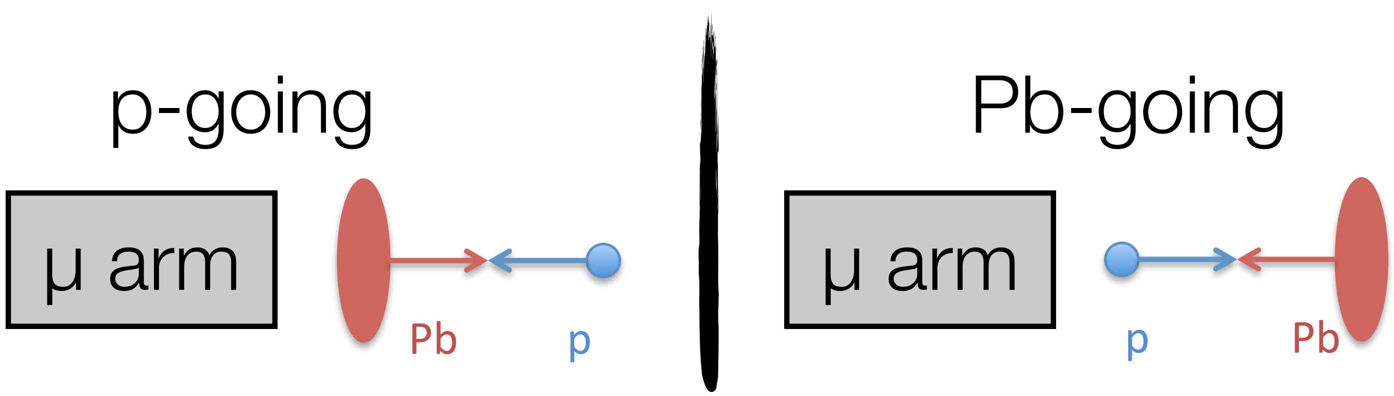

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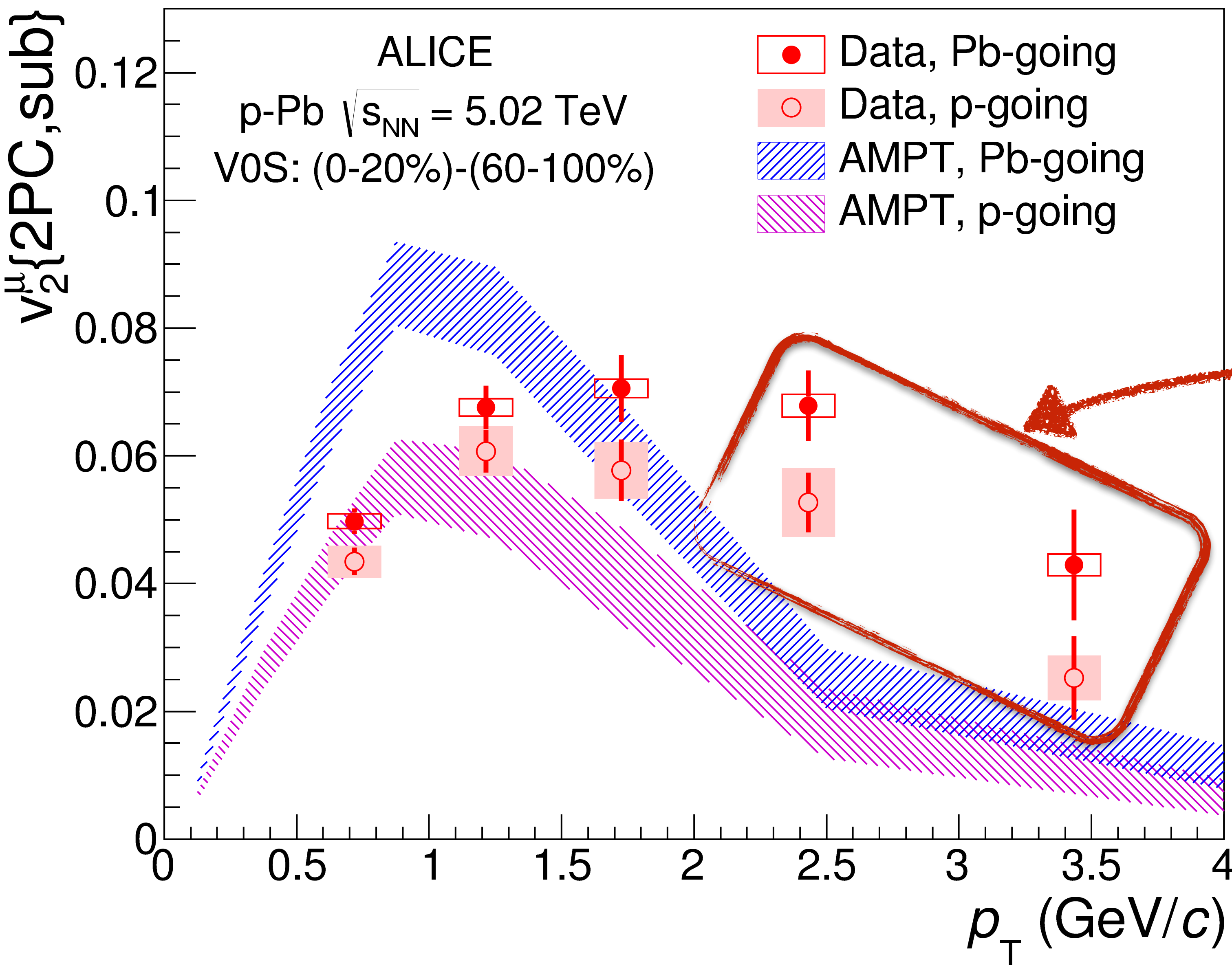


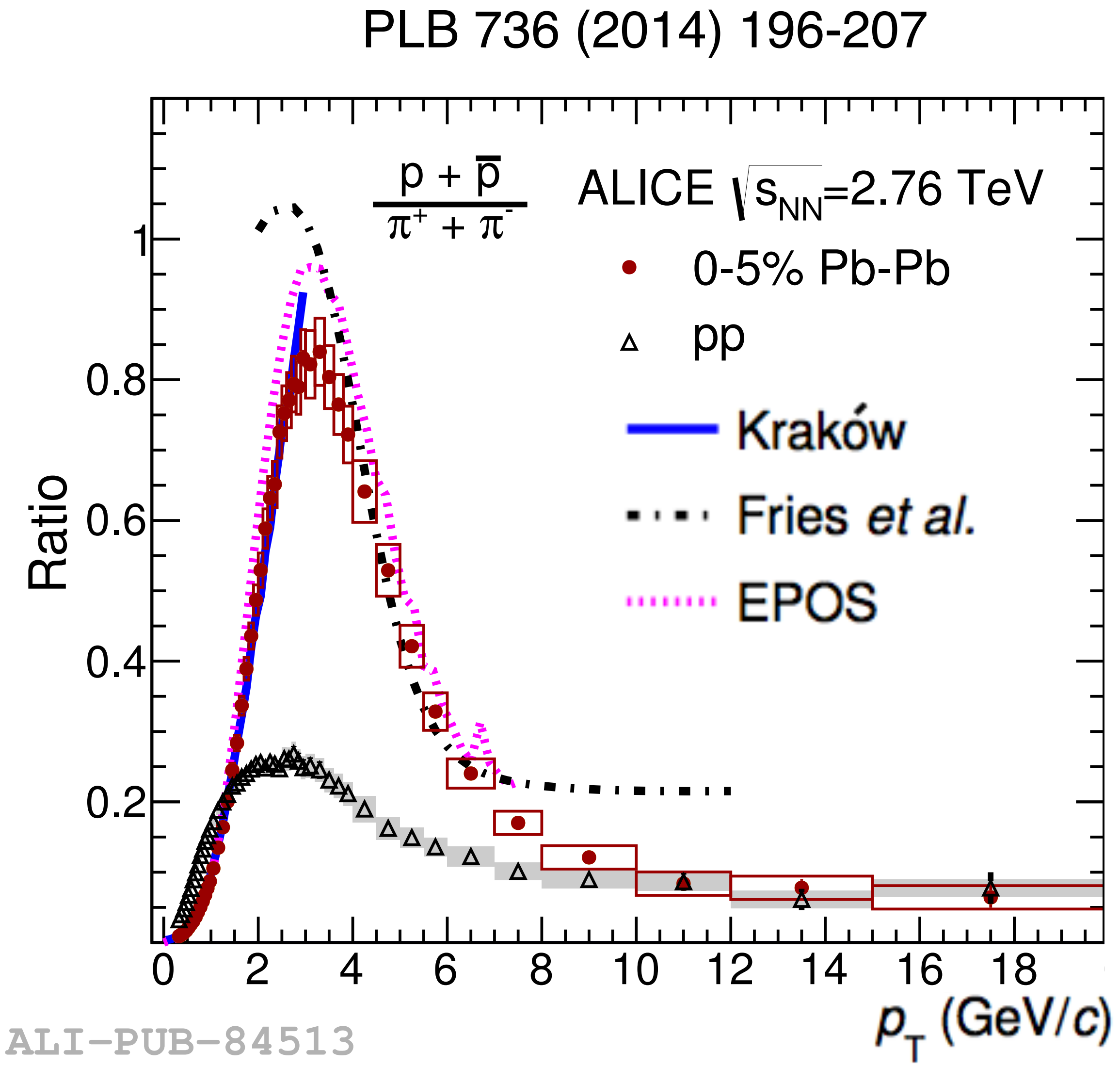
~(16±6)% higher in the Pb-going direction

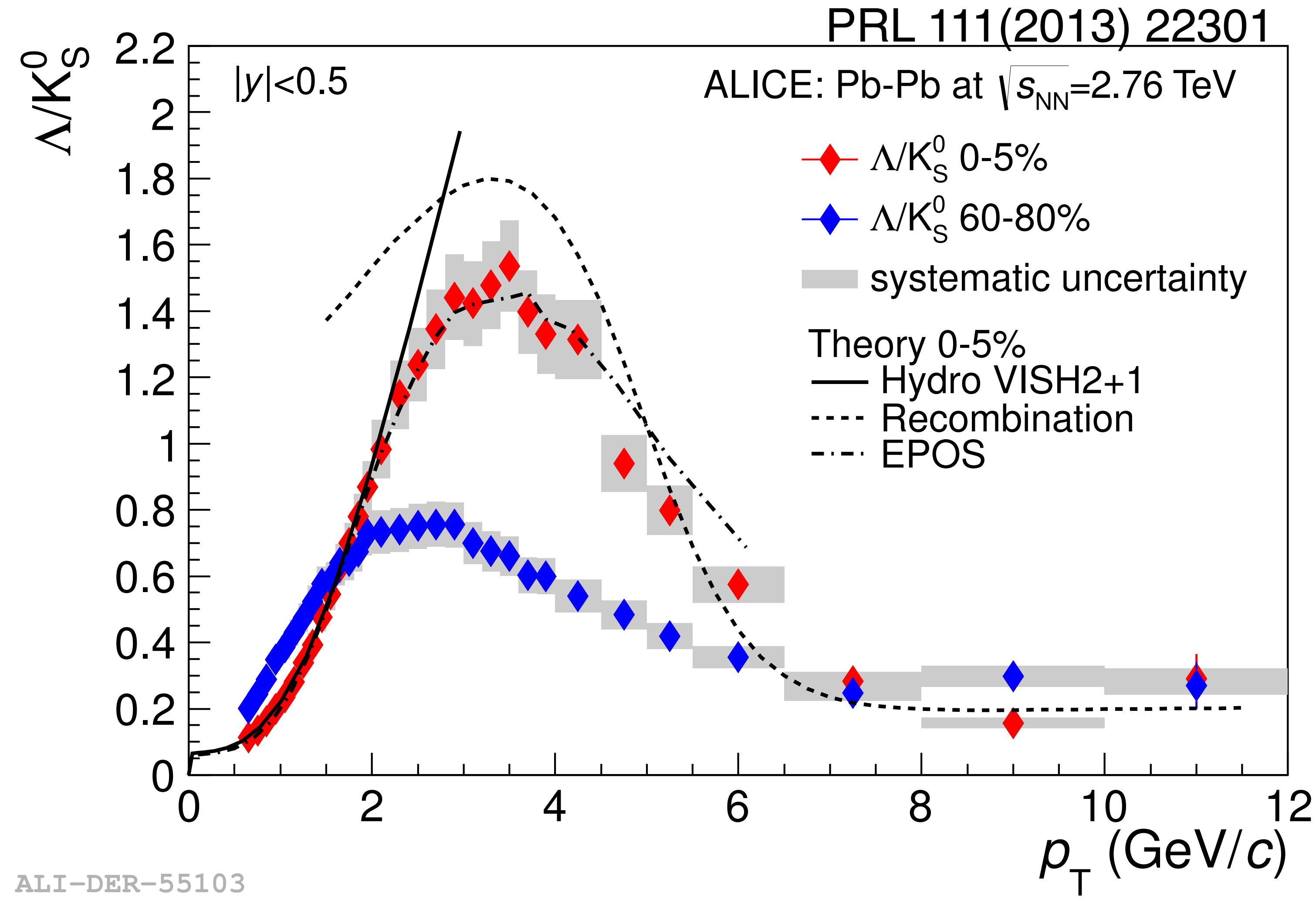
μ ← HF dominate!

Possible scenarios:

$v_2 > 0$ for HF decay muons? *See also F. Bossù, Thu 17:40*

Different parent particle composition?





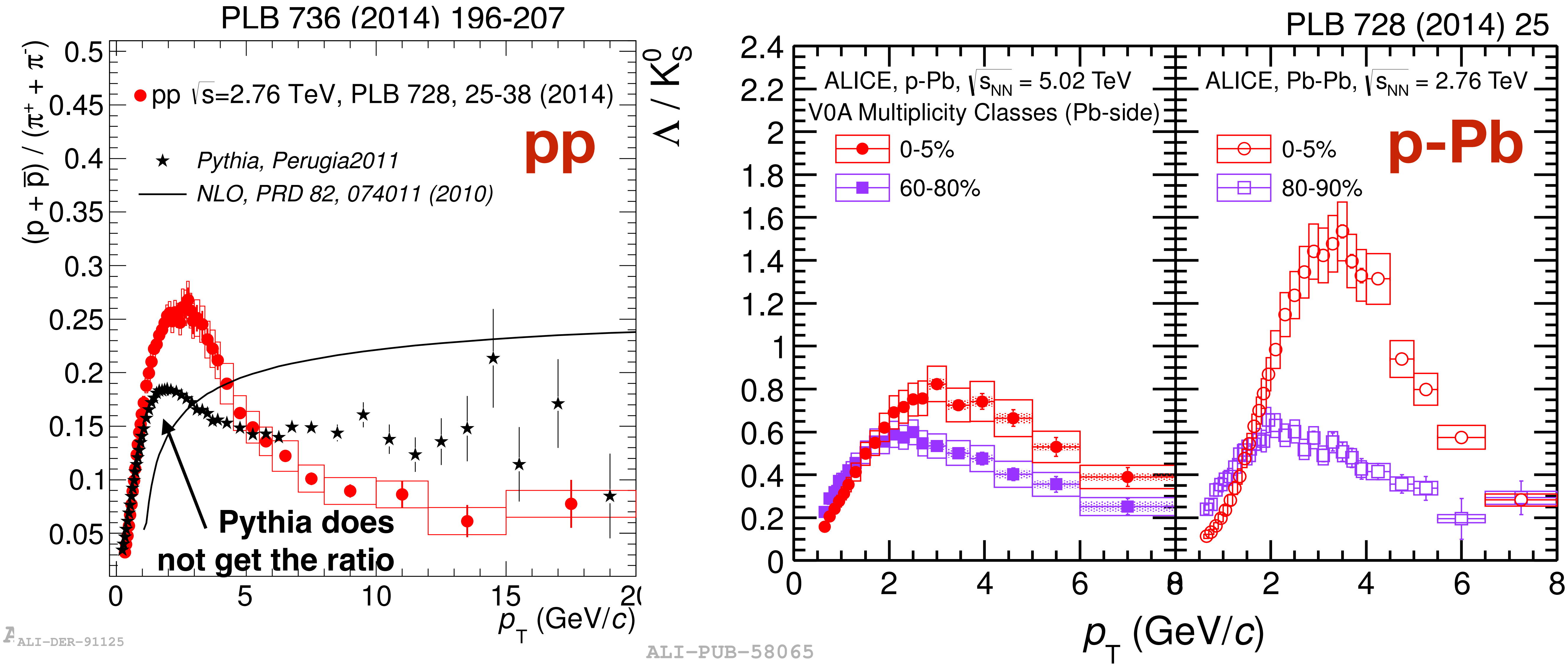
B/M enhanced at intermediate p_T in central collisions

Hydro? → describes only rise

Recombination? → describes qualitatively shape (w/ flow)

Baryon/Meson ratios

D. Chinellato, Tue 9:30
G. Volpe, Thu 15:40, B. Guerzoni, Thu 16:00



B/M enhanced at intermediate p_T in central collisions

Hydro? → describes only rise

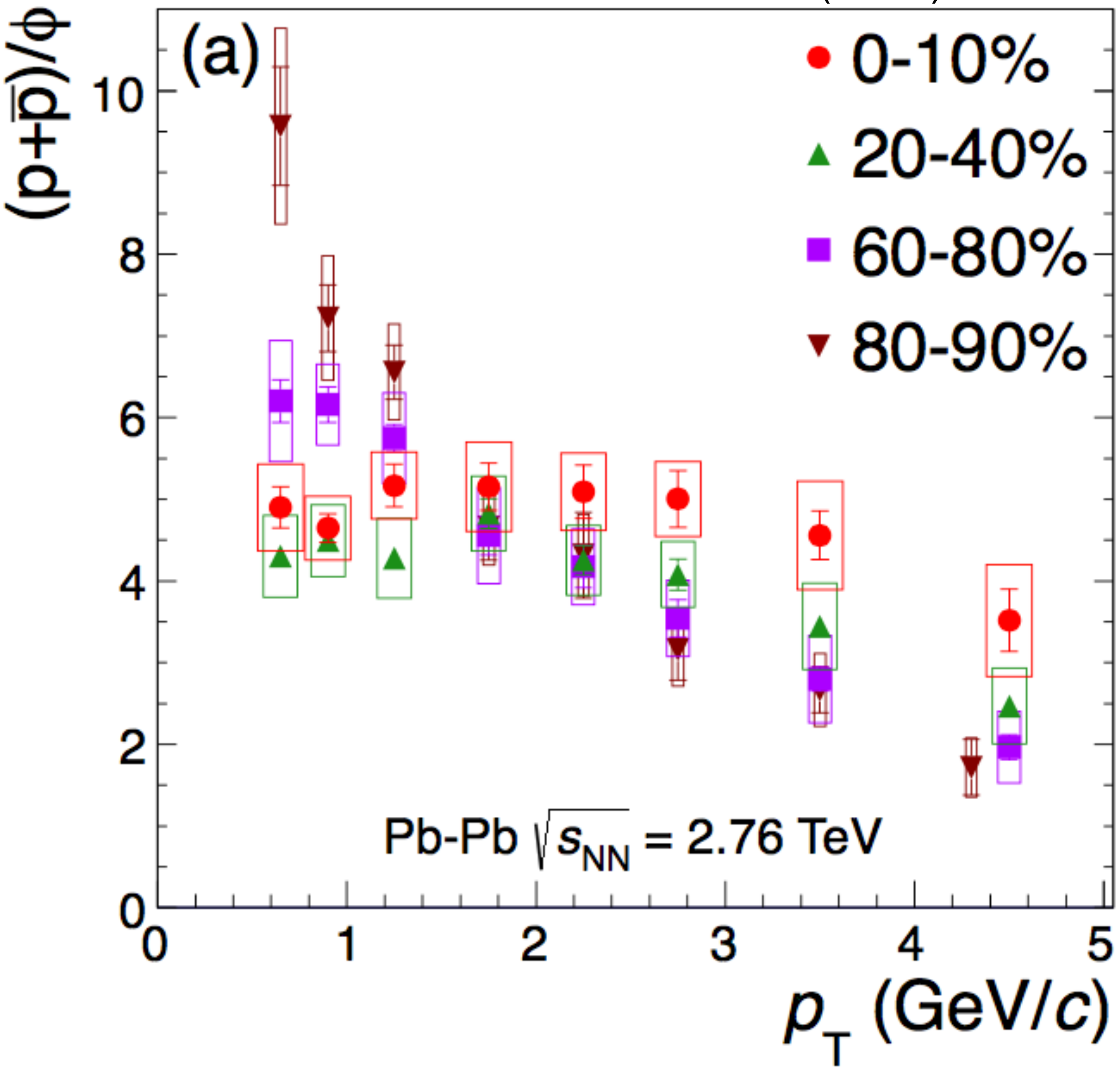
Recombination? → describes qualitatively shape (w/ flow)

"Mini" enhancement in pp & p-Pb,
not (yet?) reproduced in QCD models

Origin of the B/M enhancement?

F. Krizek, Fri 12:00
V. Riabov, Tue 18:00

PRC91 (2015) 024609



It's a mass effect!
(in the most central collisions…)

Origin of the B/M enhancement?

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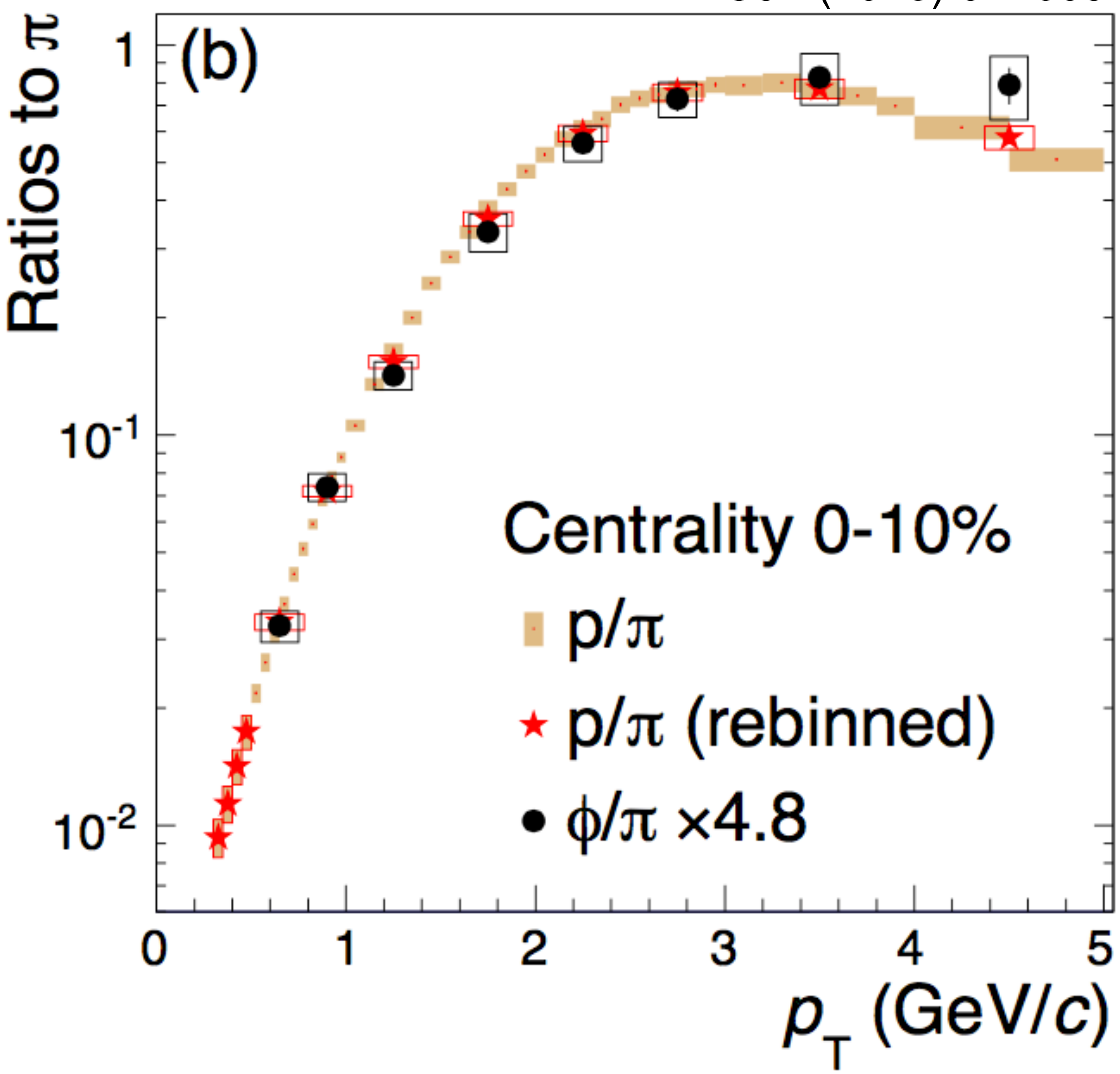

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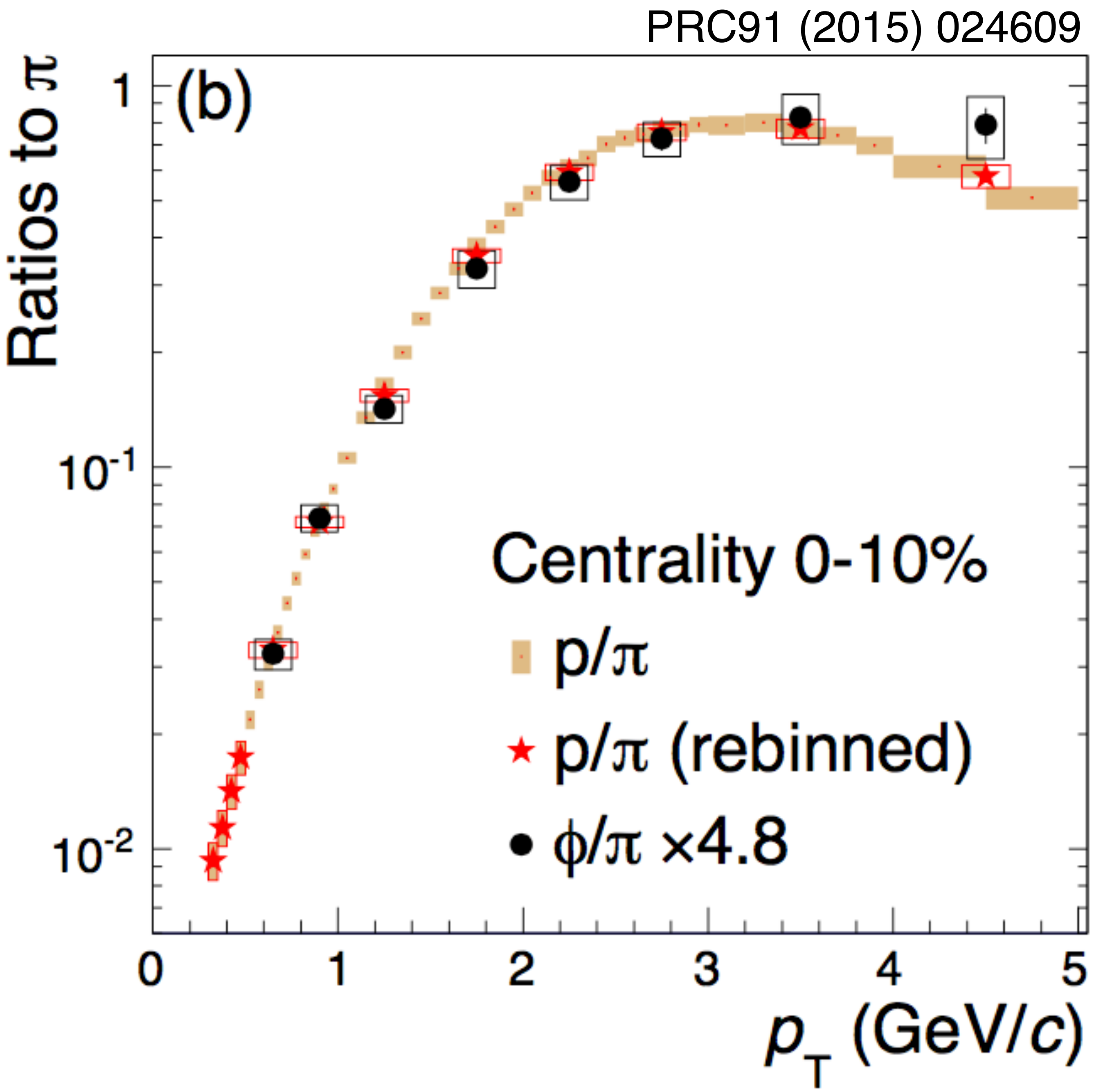
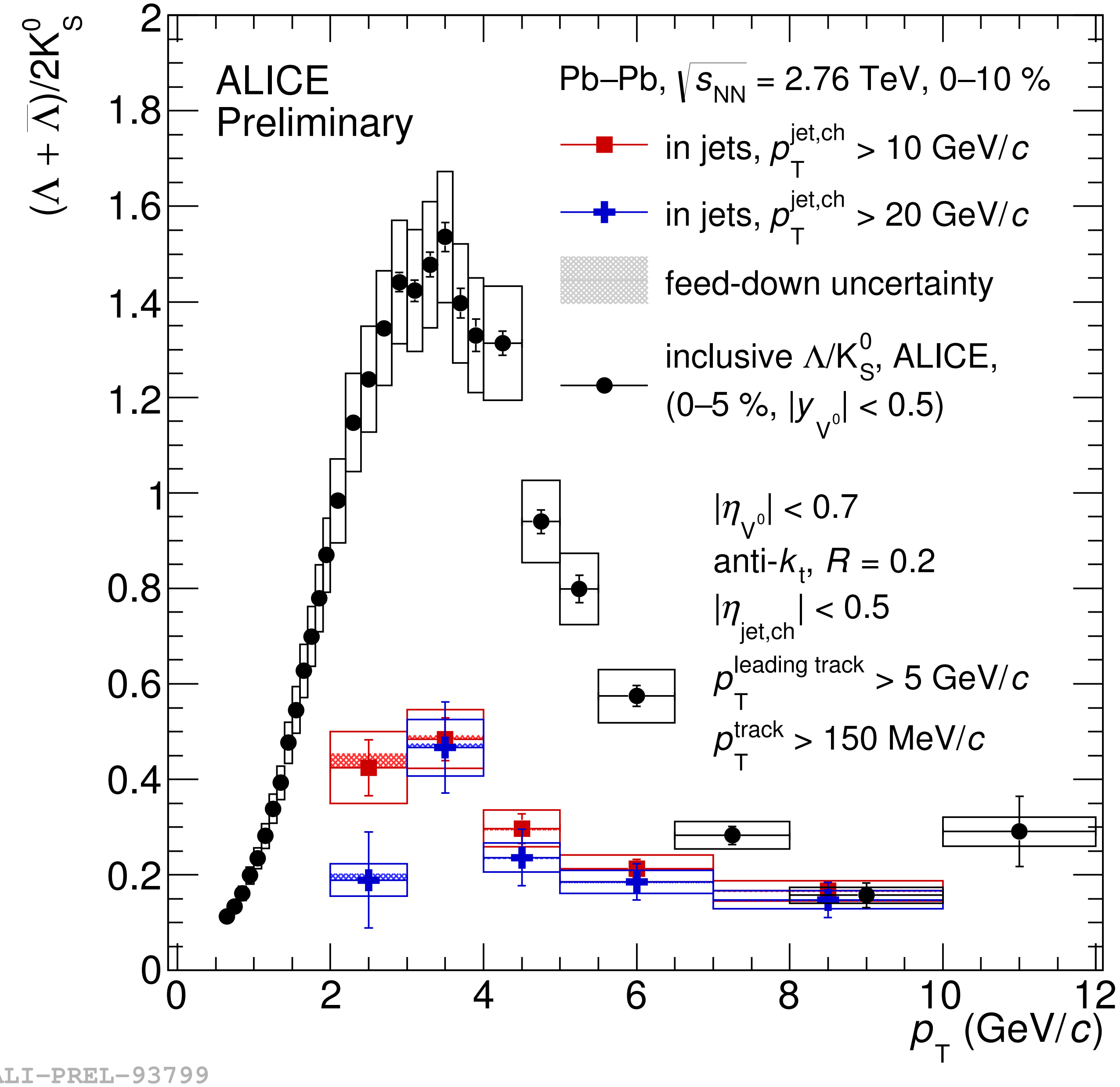




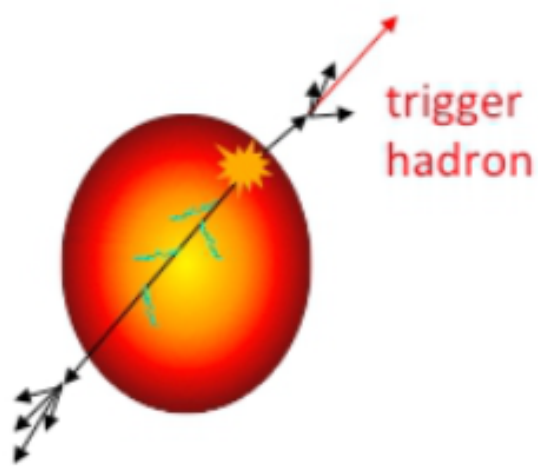
It's a mass effect!
(in the most central collisions…)

It's not a jet effect!

Energy loss

Jet Modifications: broadening?

F. Krizek, DATE
arXiv:1506.03984



[1] de Barros et al., arXiv:1208.1518

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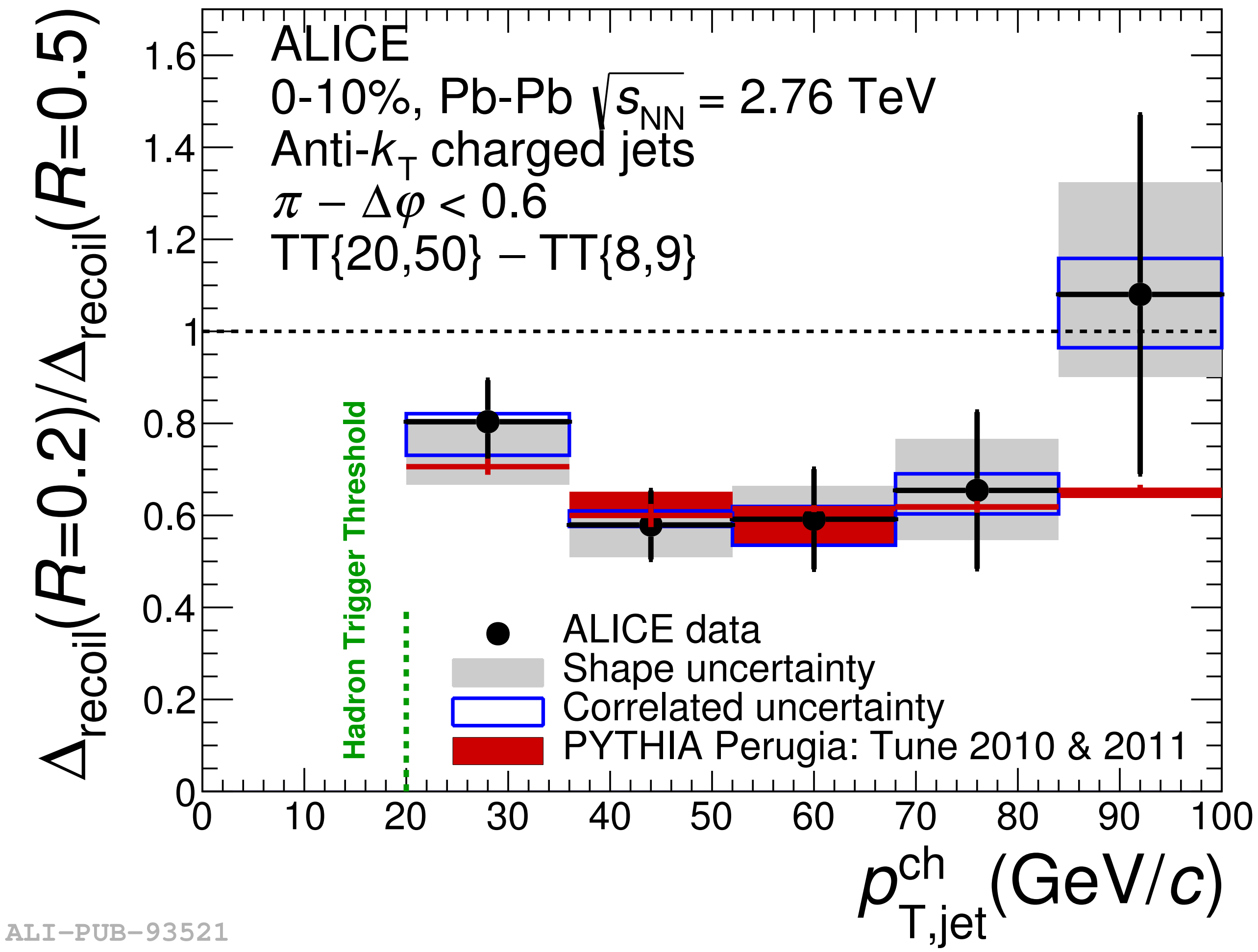

No evidence of intra-jet broadening for R<0.5

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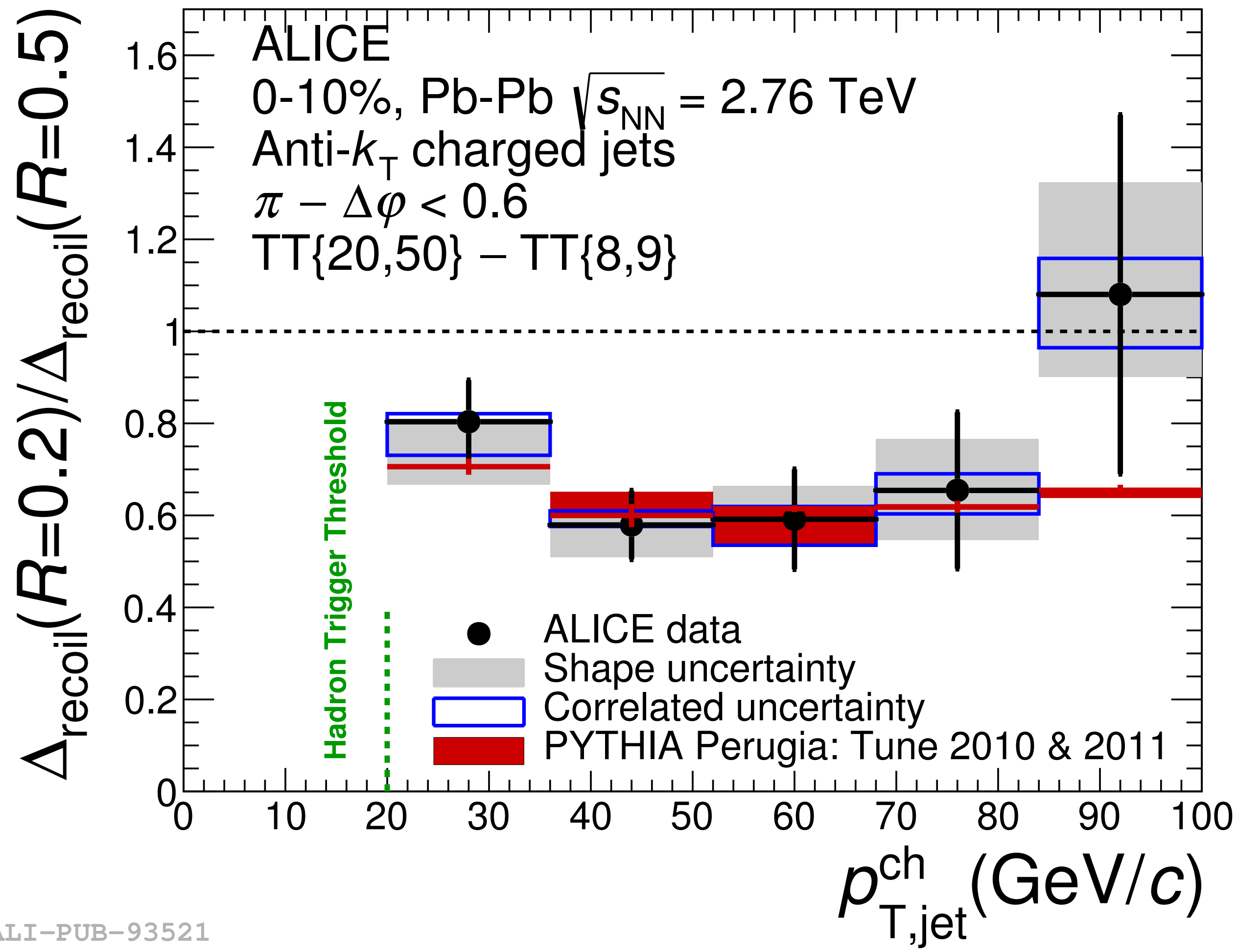
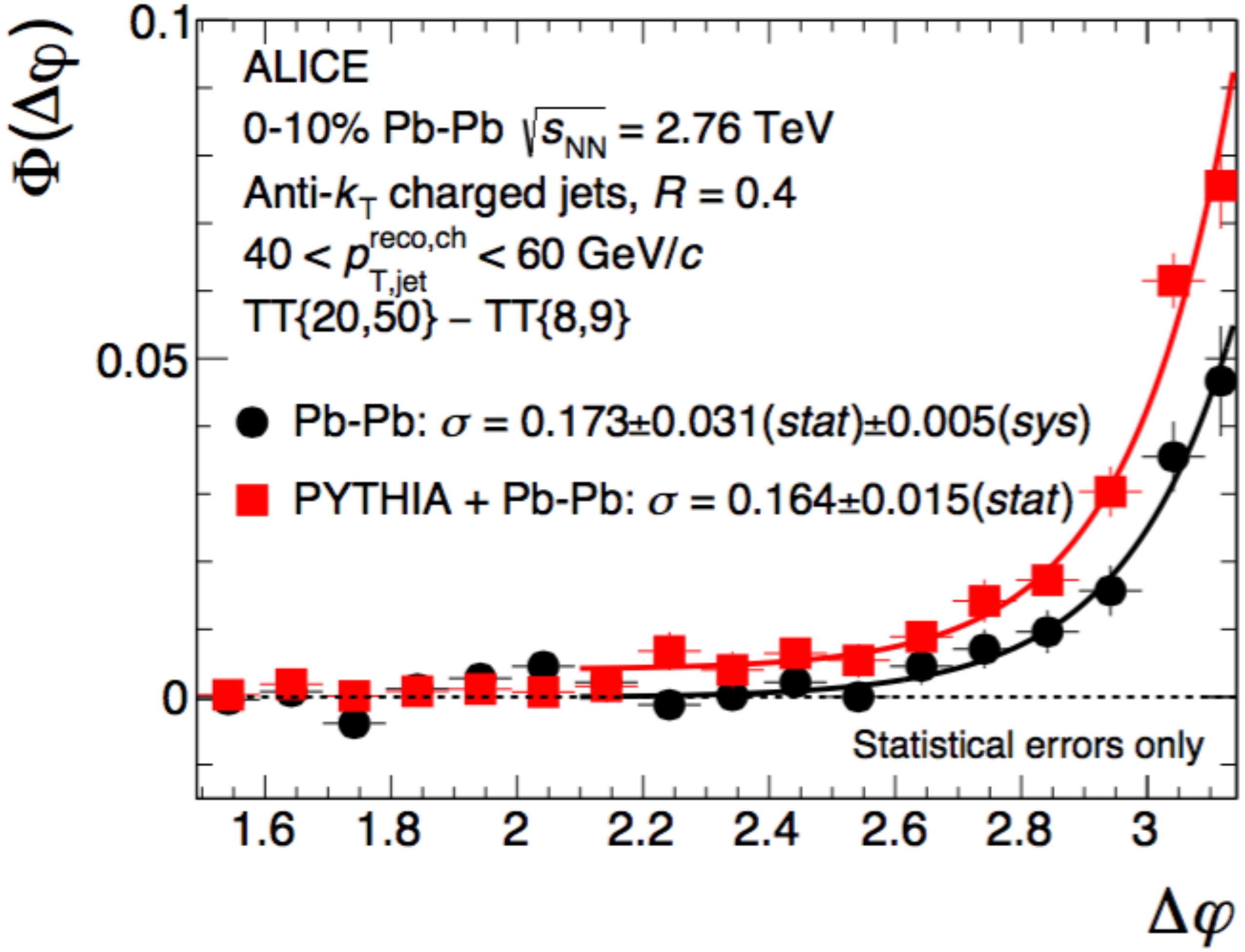




No evidence of intra-jet broadening for R<0.5

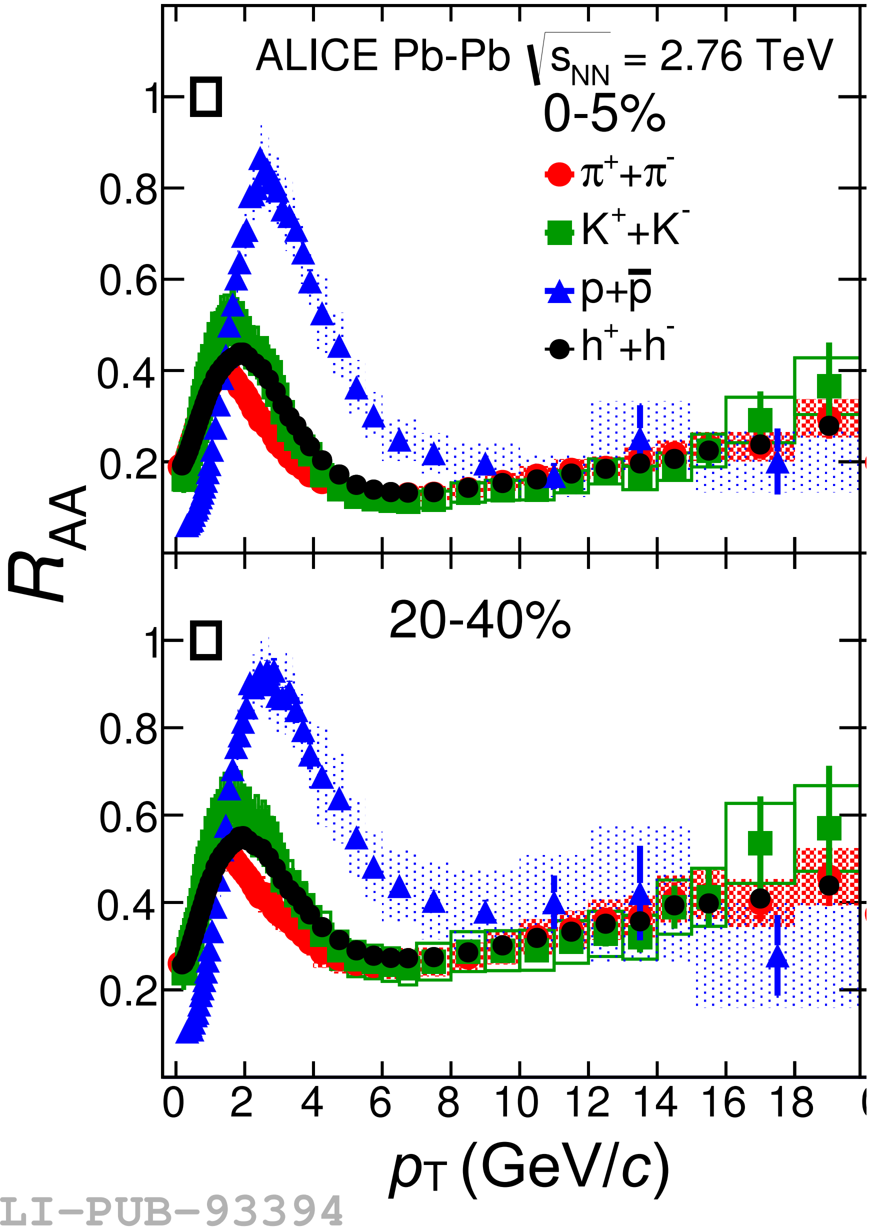
No evidence of medium-induced acoplanarity

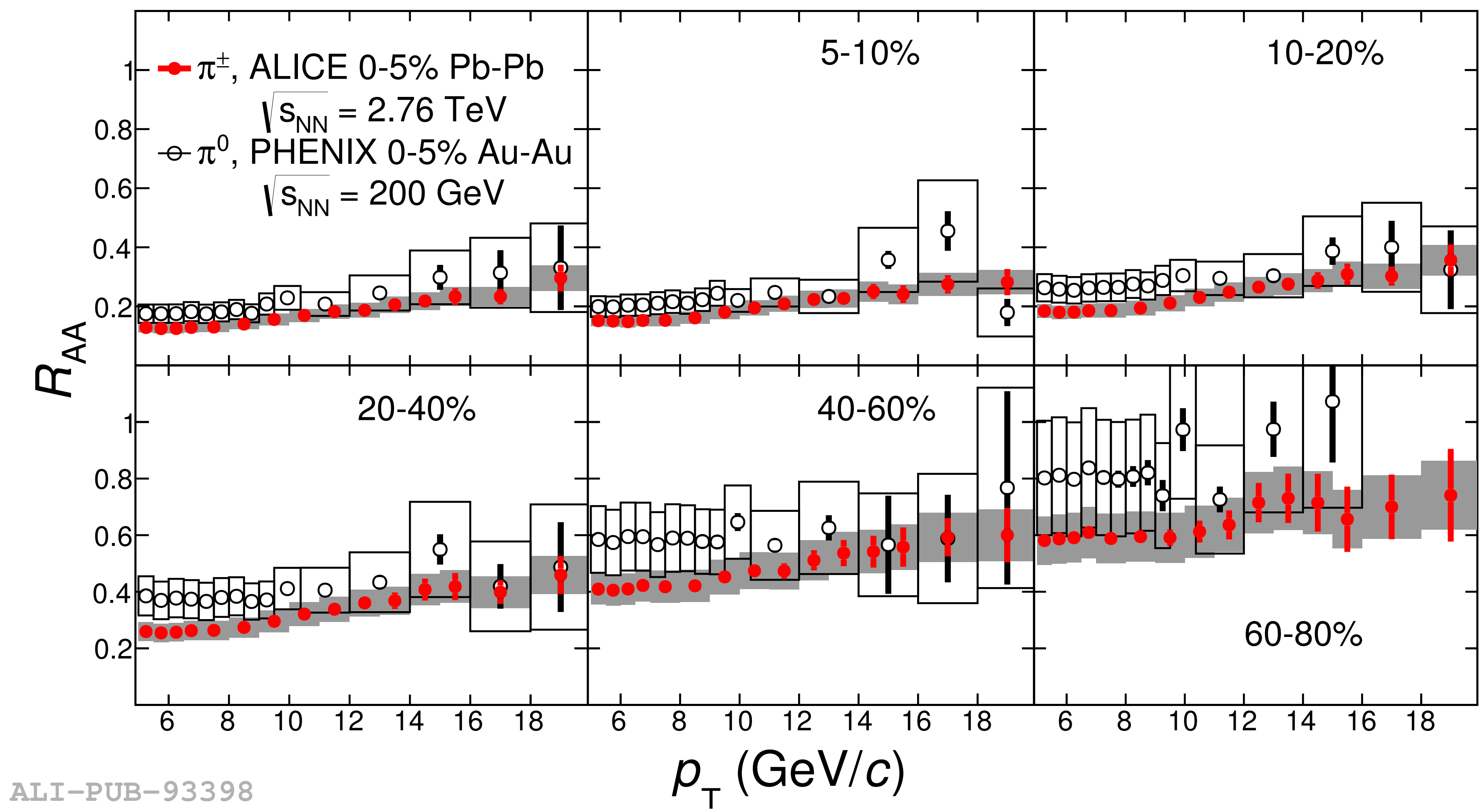
No signal for large angle (Moliere) patron-medium scattering

→ Consistent with largely homogeneous medium

Jet Modification: fragmentation?

arXiv:1506.07287





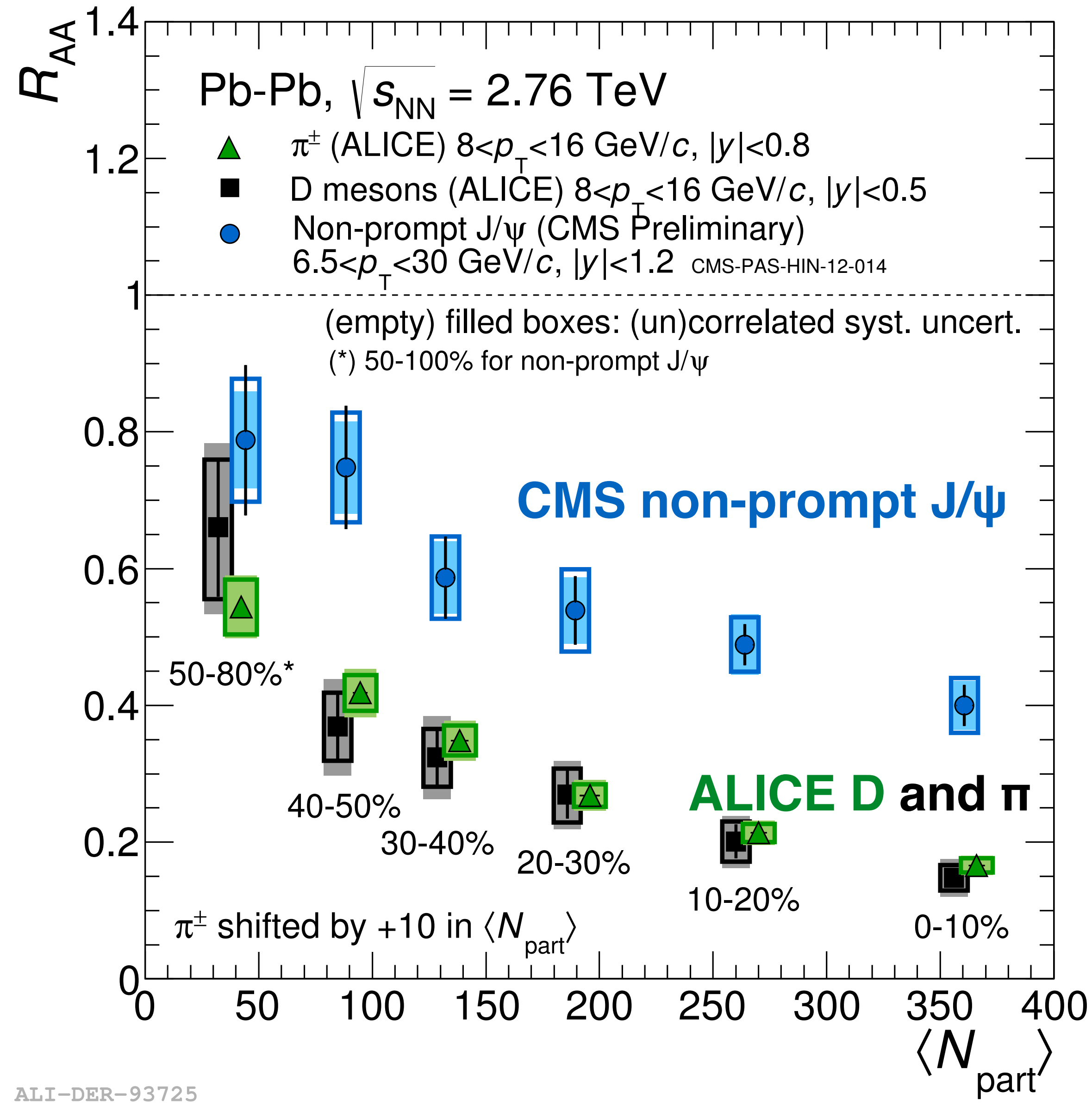
$p_T \gtrsim$ 10 GeV/c: suppression similar for all particles

⇔ jet chemistry not modified

Similar R_{AA}^{π} at RHIC/LHC, despite vastly different $d\sigma/dp_T$

R. Bailhache, Thu 10:00, A. Festanti, Thu 17:00
A. Barbano, Thu 15:40, arXiv:1506.06604

NEW



$$\Delta E_g > \Delta E_{u,d,s} > \Delta E_c > \Delta E_b?$$

$$R_{AA}^D < R_{AA}^B \text{ (via non prompt J/}\psi\text{)!}$$

First clear indication with **mass dependent energy loss**

R. Bailhache, Thu 10:00, A. Festanti, Thu 17:00
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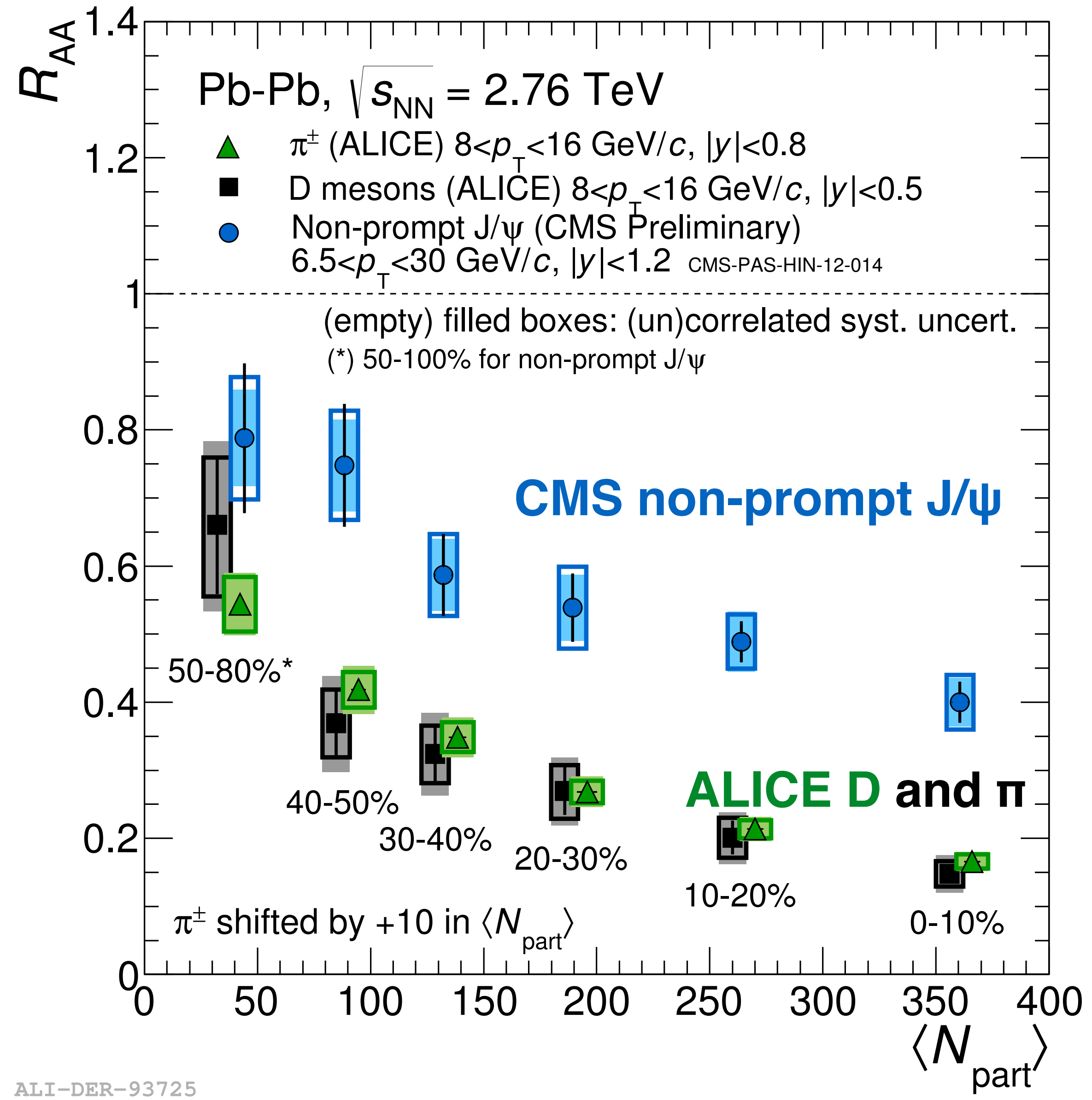

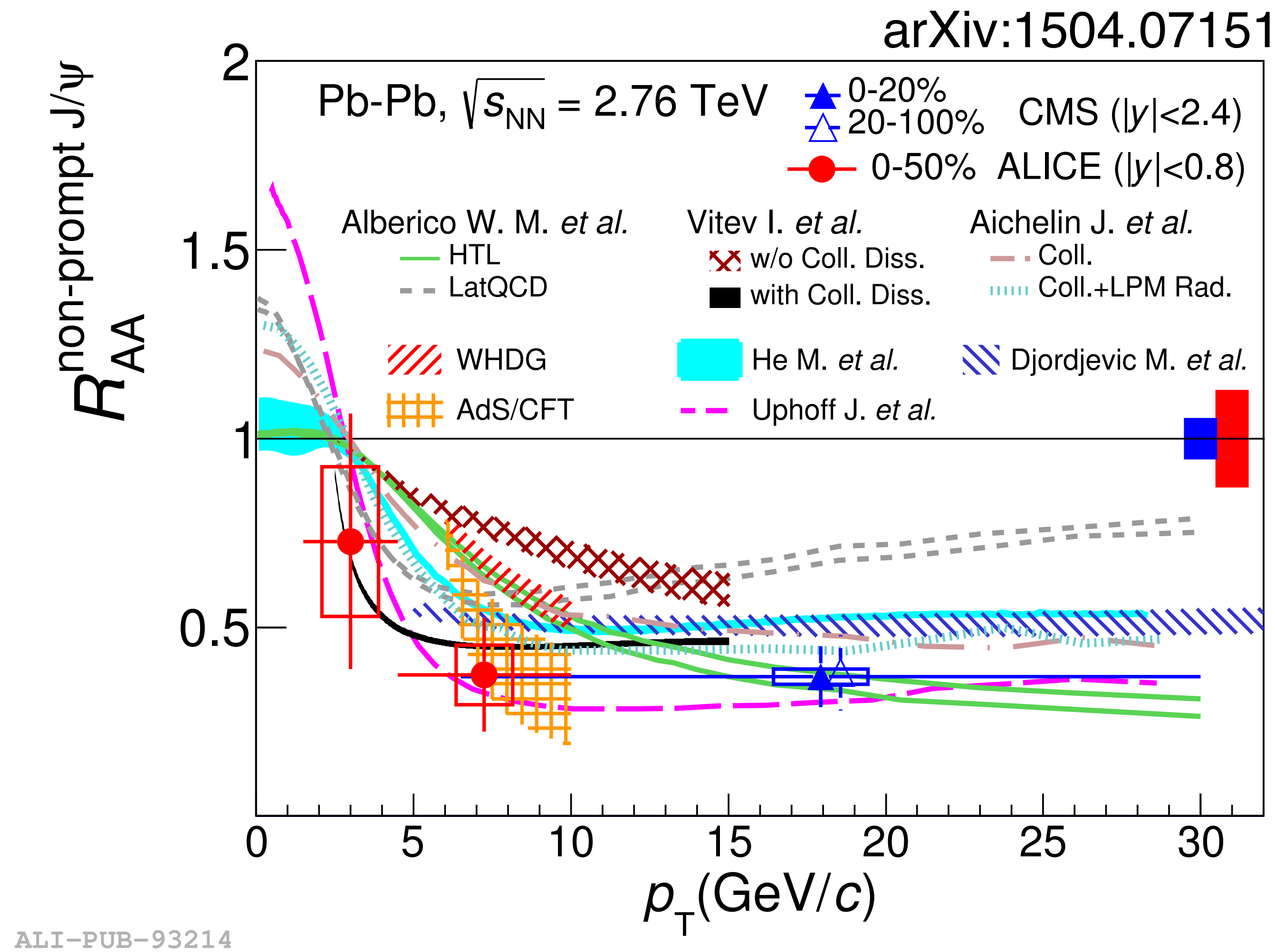

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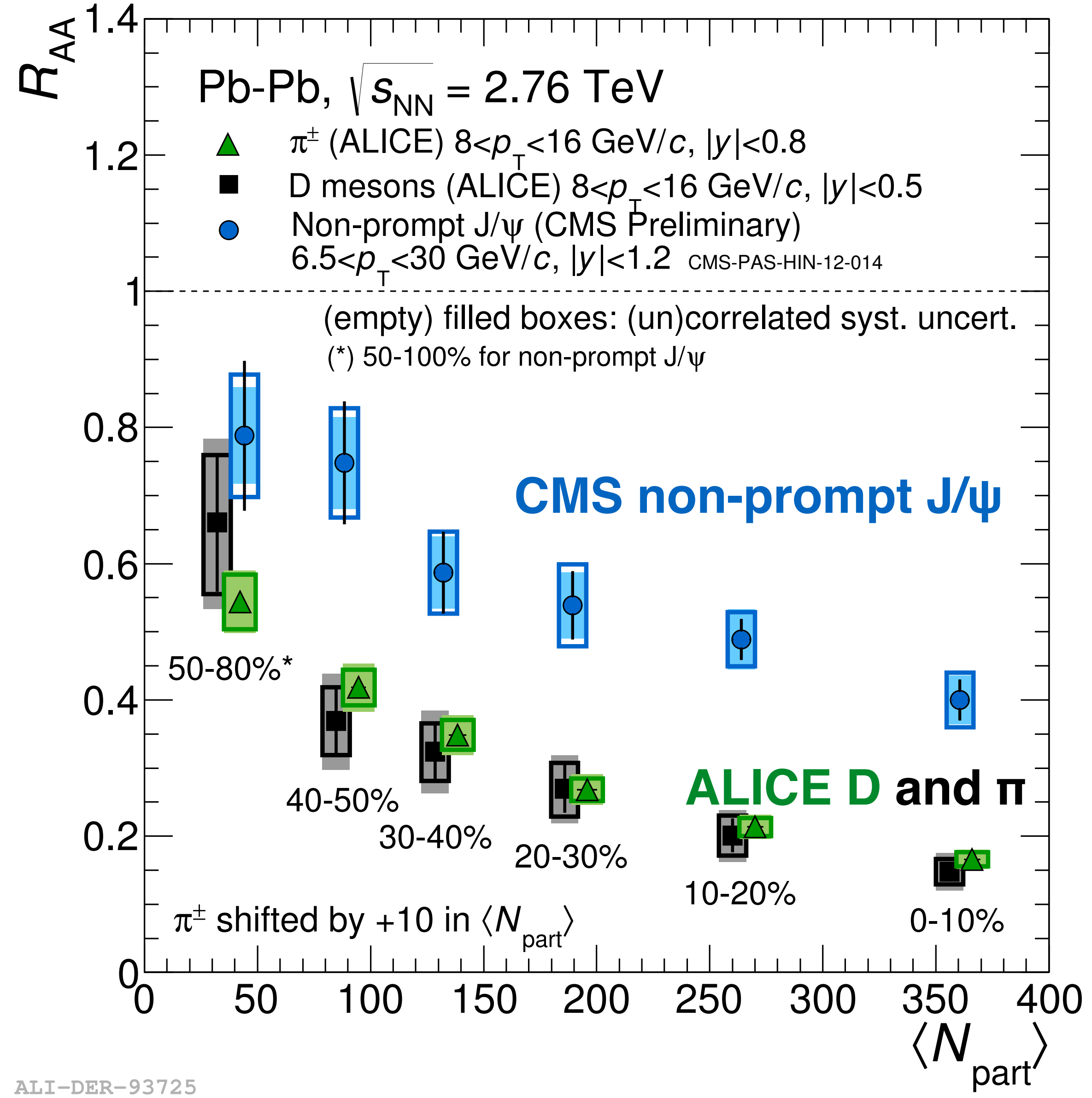
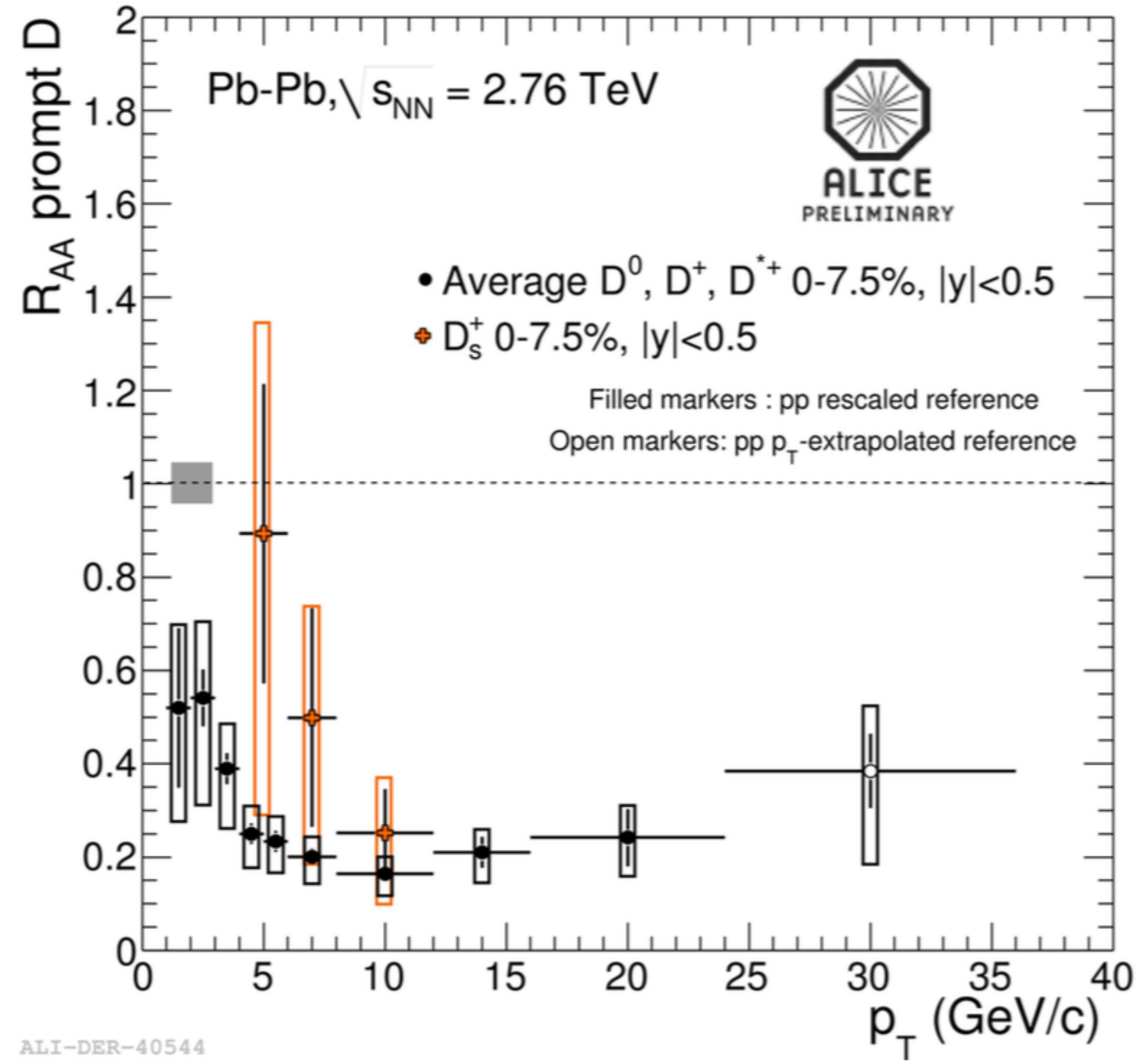
Heavy Flavor energy loss





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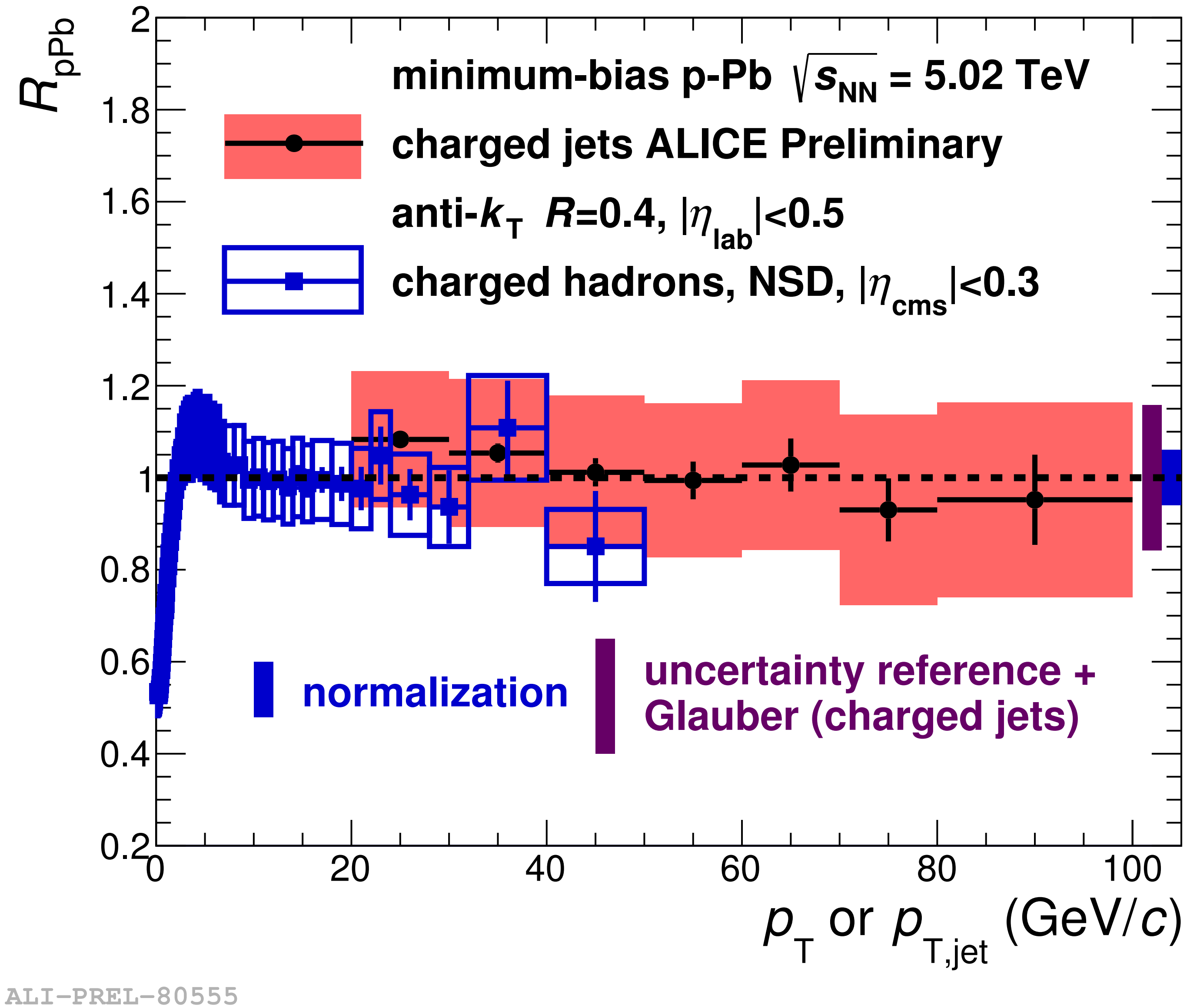
First clear indication with **mass dependent energy loss**

Hint for increase in **D_s R_{AA}**

What about high-p_T suppression in pA?

R_{pPb} consistent with unity for:

charged hadrons, Jets, D mesons and HF decay electrons



Other measurements consistent with pp:

- di-jet k_T
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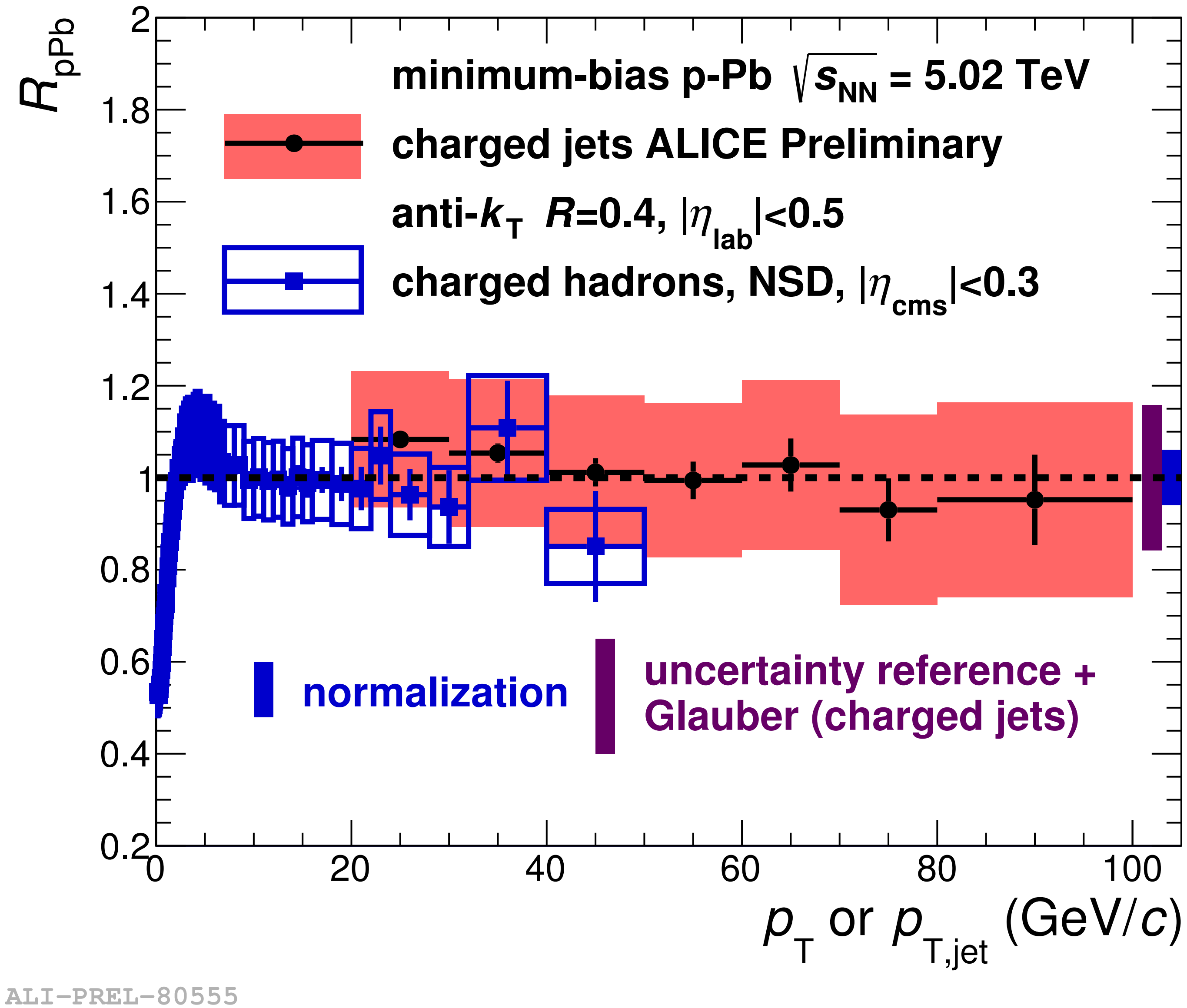

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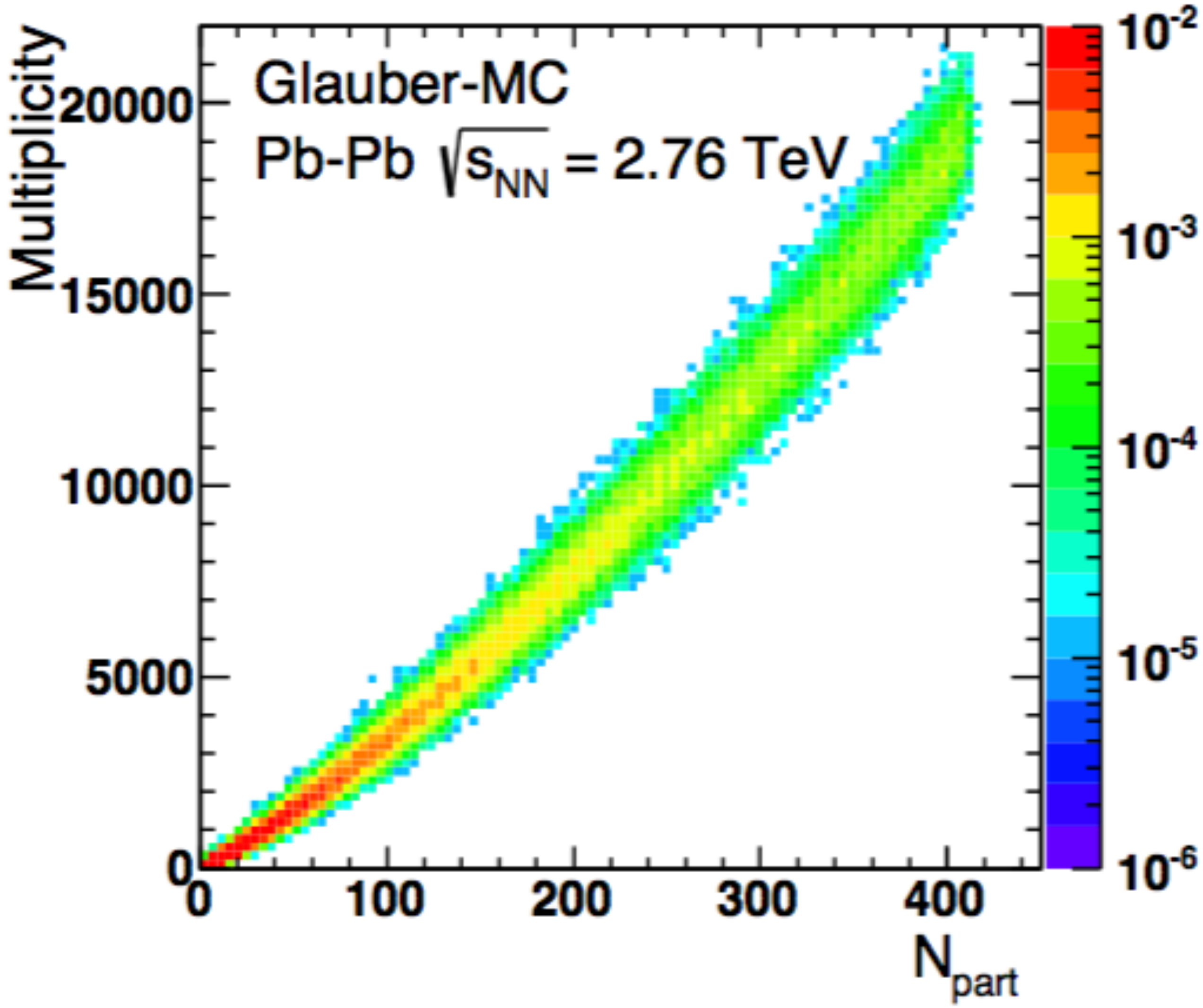
Multiplicity dependence? → understand biases!

Centrality and biases in pA

Large fluctuations in pA
⇒ large biases



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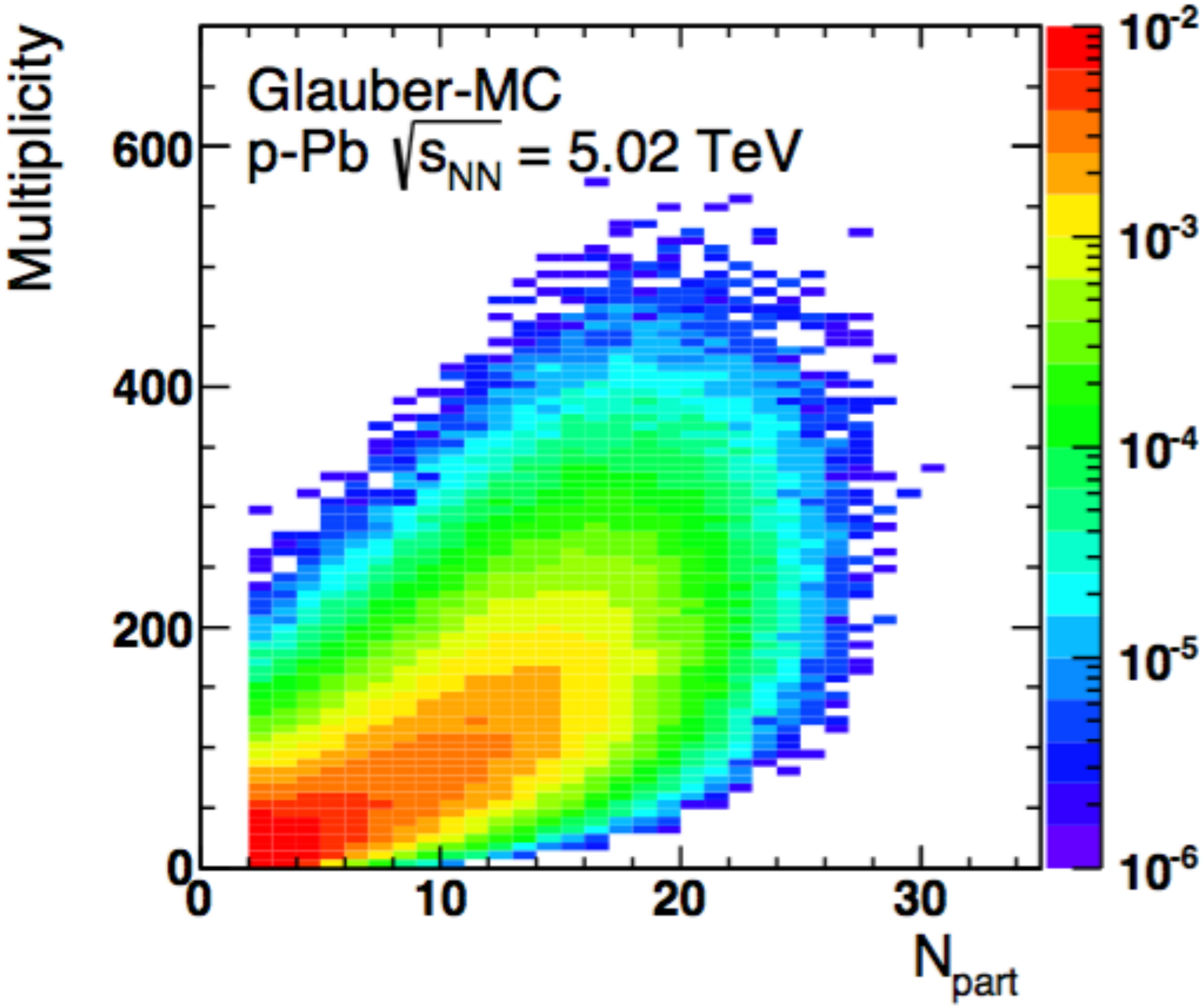

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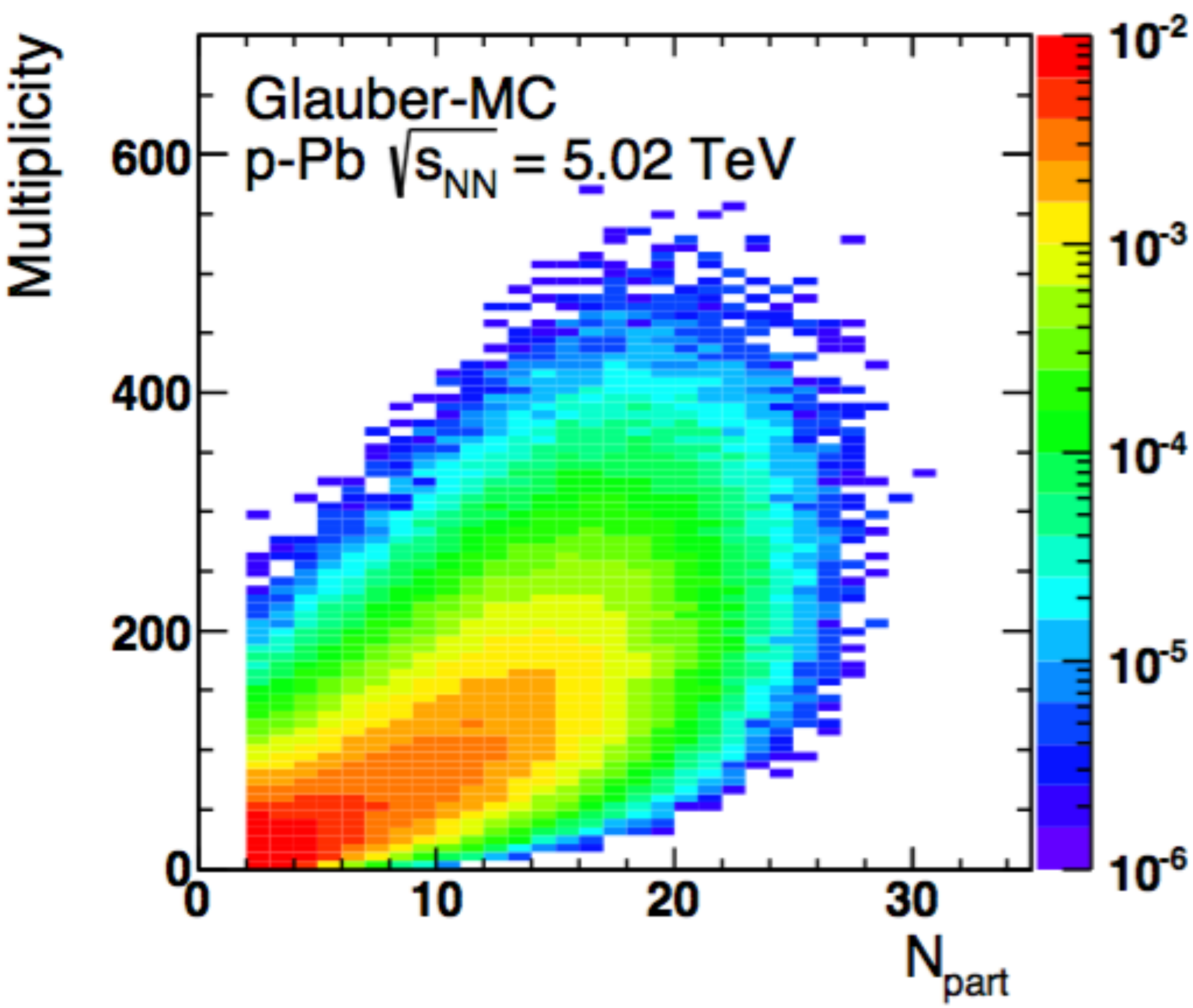
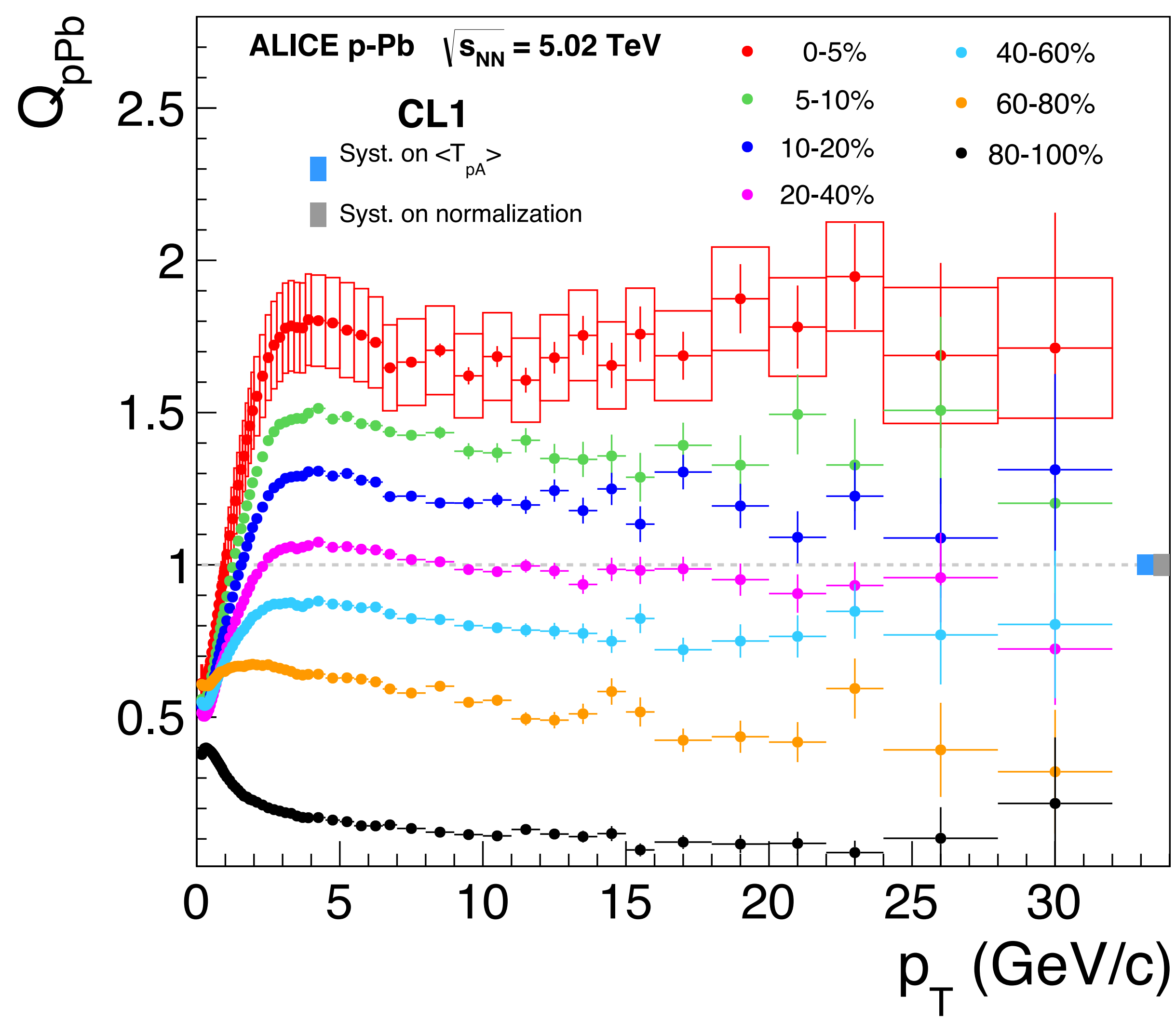


Introduce "Q_{pPb}"

$$Q^{i}_{pA} = \frac{dN_{pA}/dp_T}{\langle N_{coll}\rangle_i \, dN_{pp}/dp_T}$$



mid-rapidity estimator & mid-rapidity spectra: largest bias

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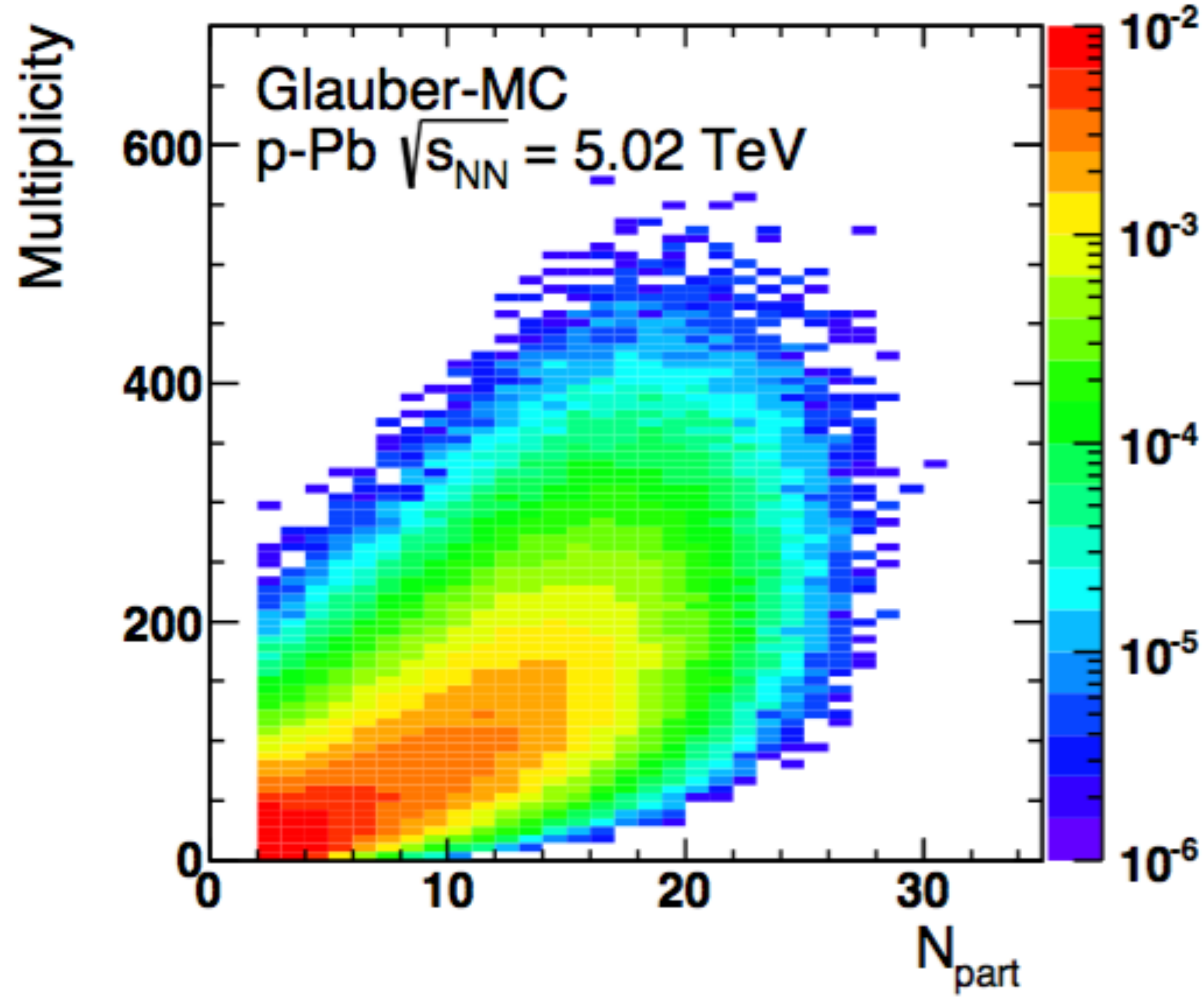

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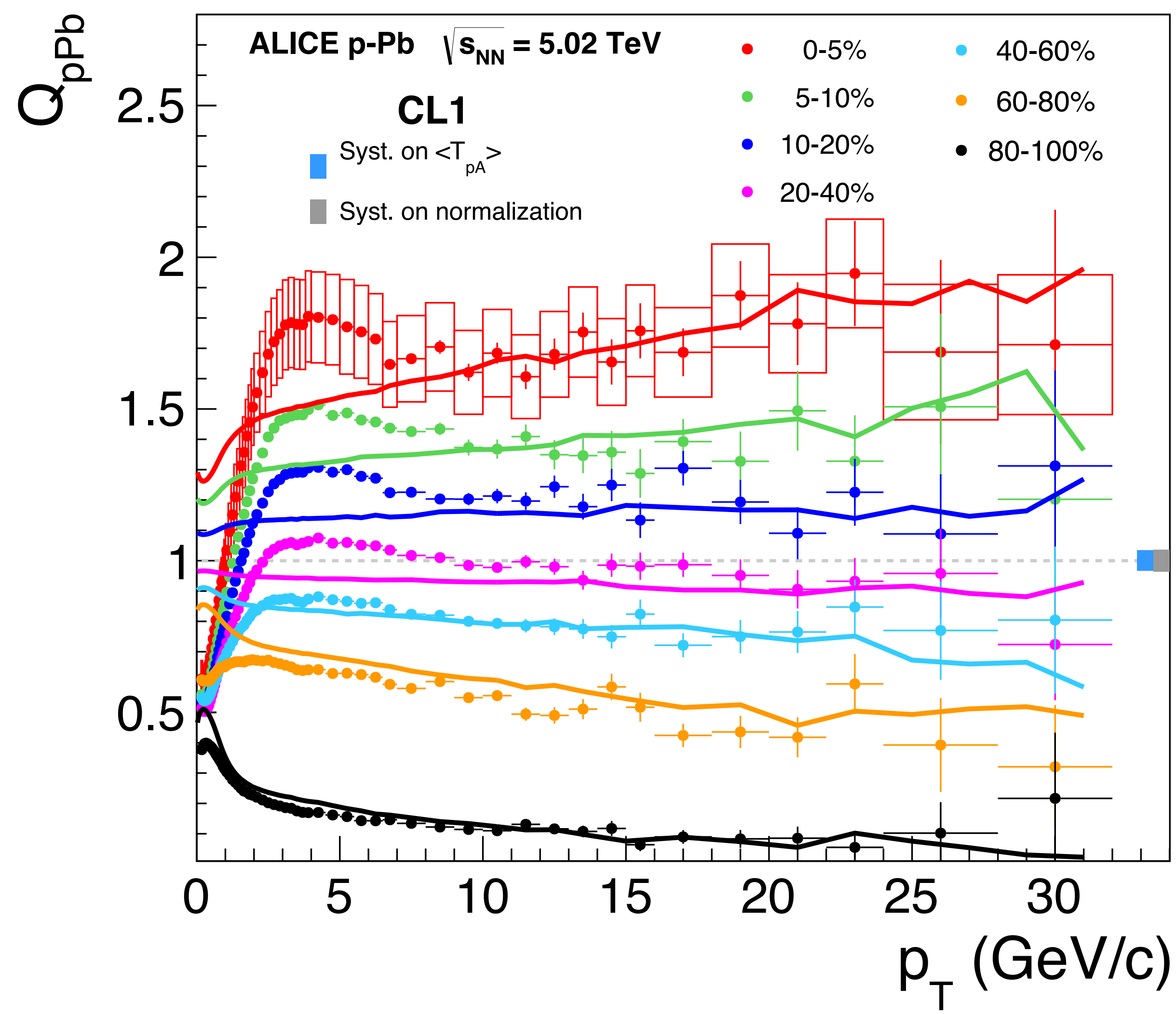
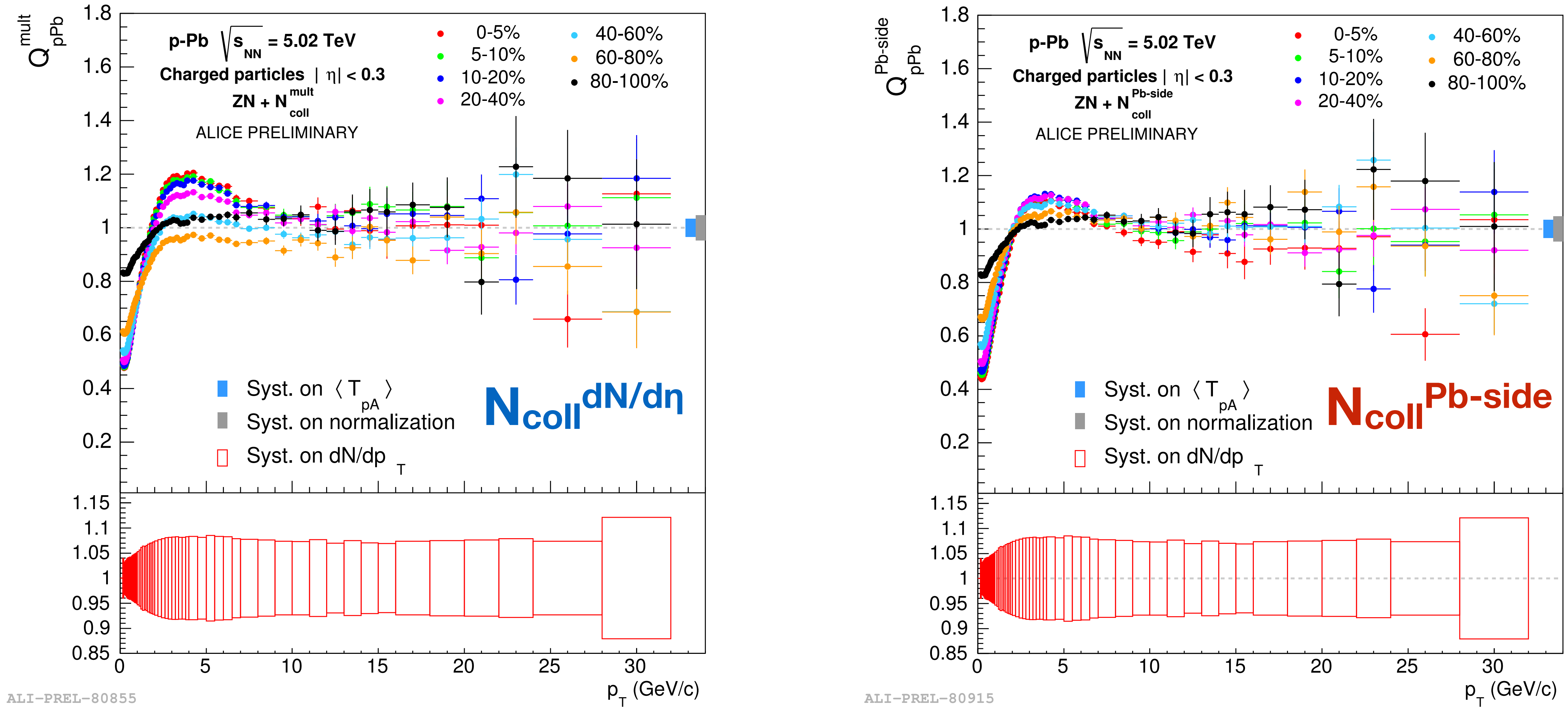


mid-rapidity estimator & mid-rapidity spectra: largest bias

Centrality biases in p-Pb

Least biased estimator:

1. Neutron Zero Degree Calorimeter (ZN)
2. ⟨N_{coll}⟩ estimated with:
   dN/dη, yield at high p_T, yield on Pb side

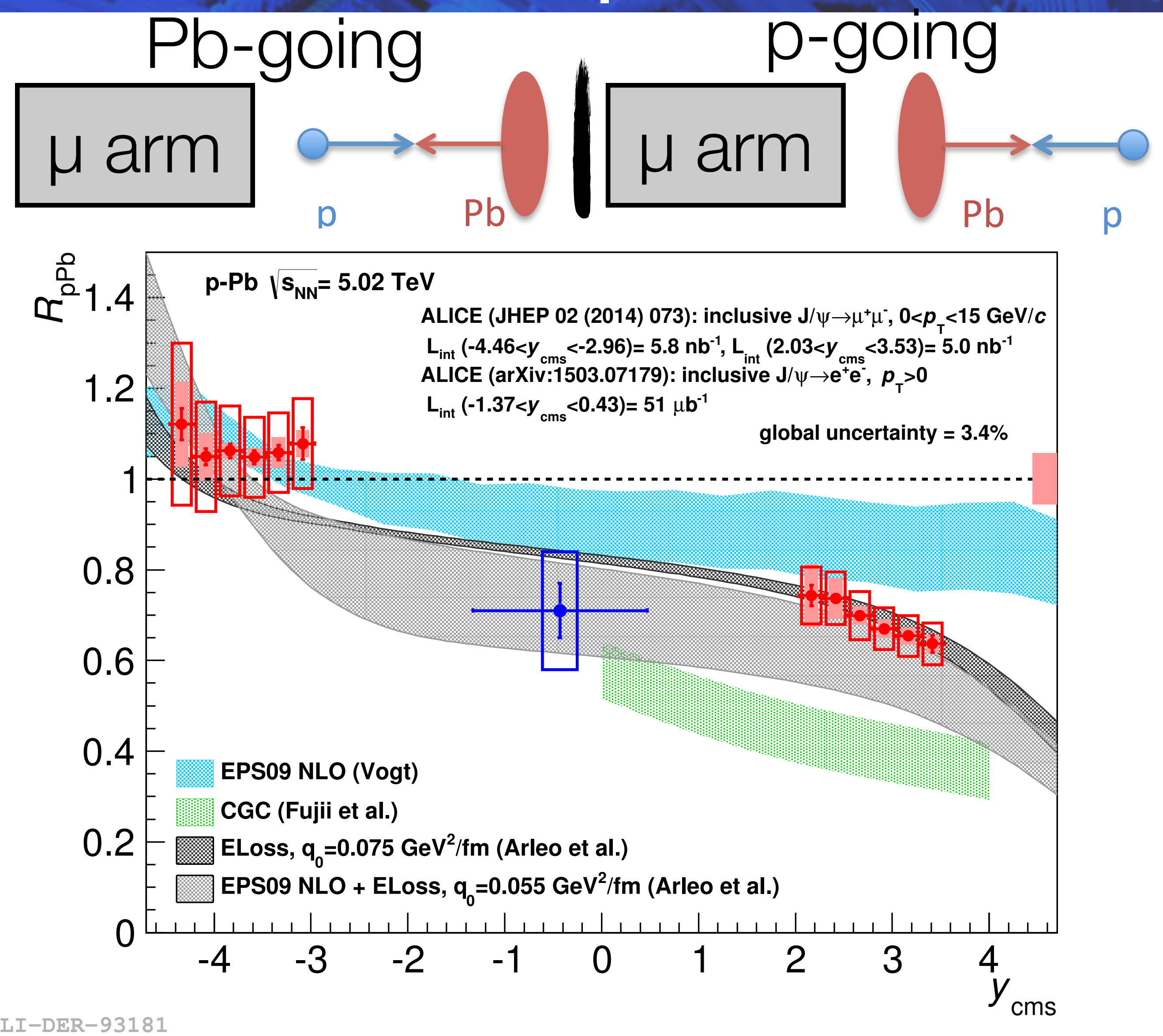


Q_{pPb} consistent with unity at high p_T for all classes!

Cold Nuclear Matter Effects

Quarkonia in p-Pb

I. Arsene Thu 11:30
S. Weber, Thu 16:00 , A. Camejo, Thu 16:20



J/ψ R_{AA} vs y consistent with shadowing + E_{loss}

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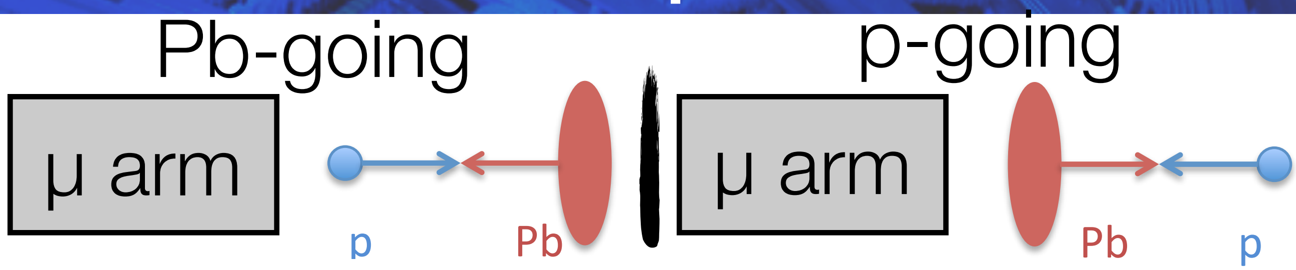

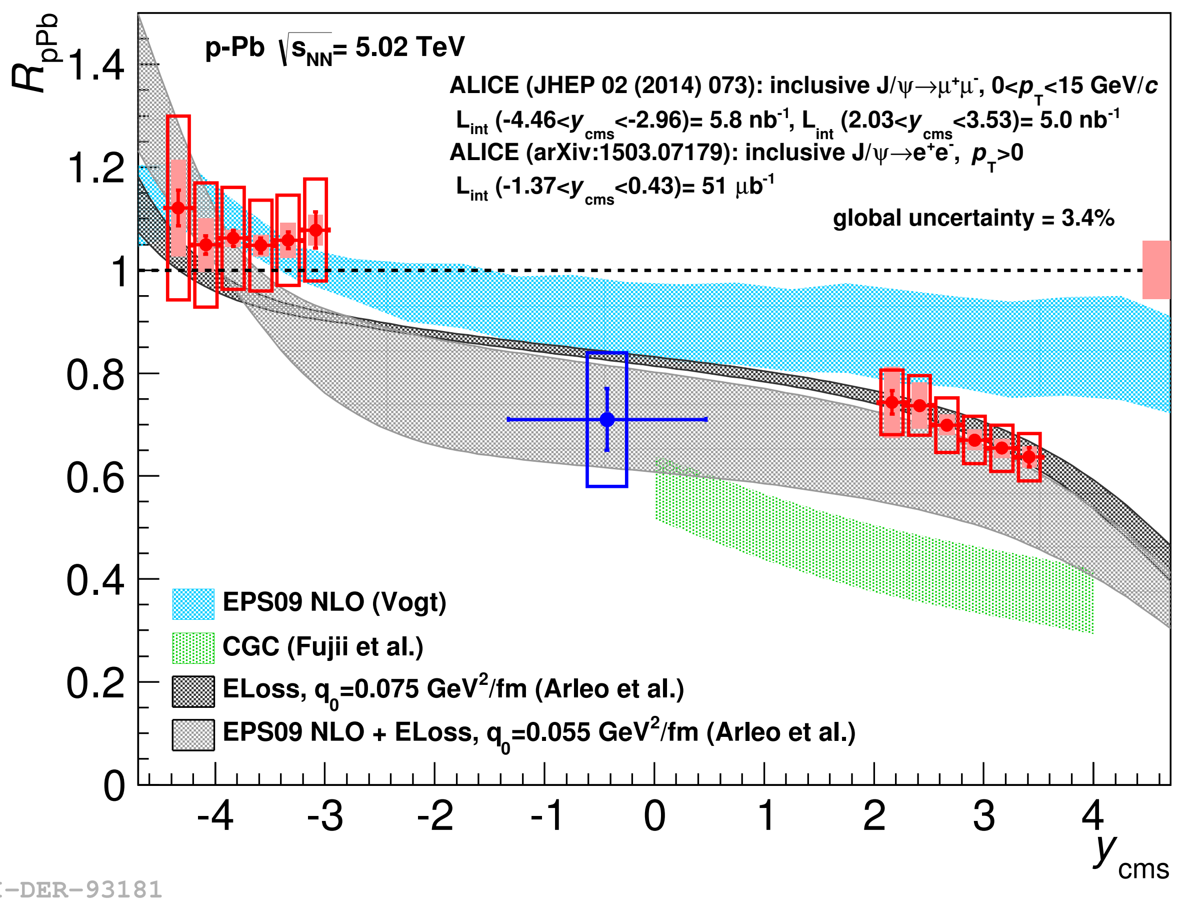

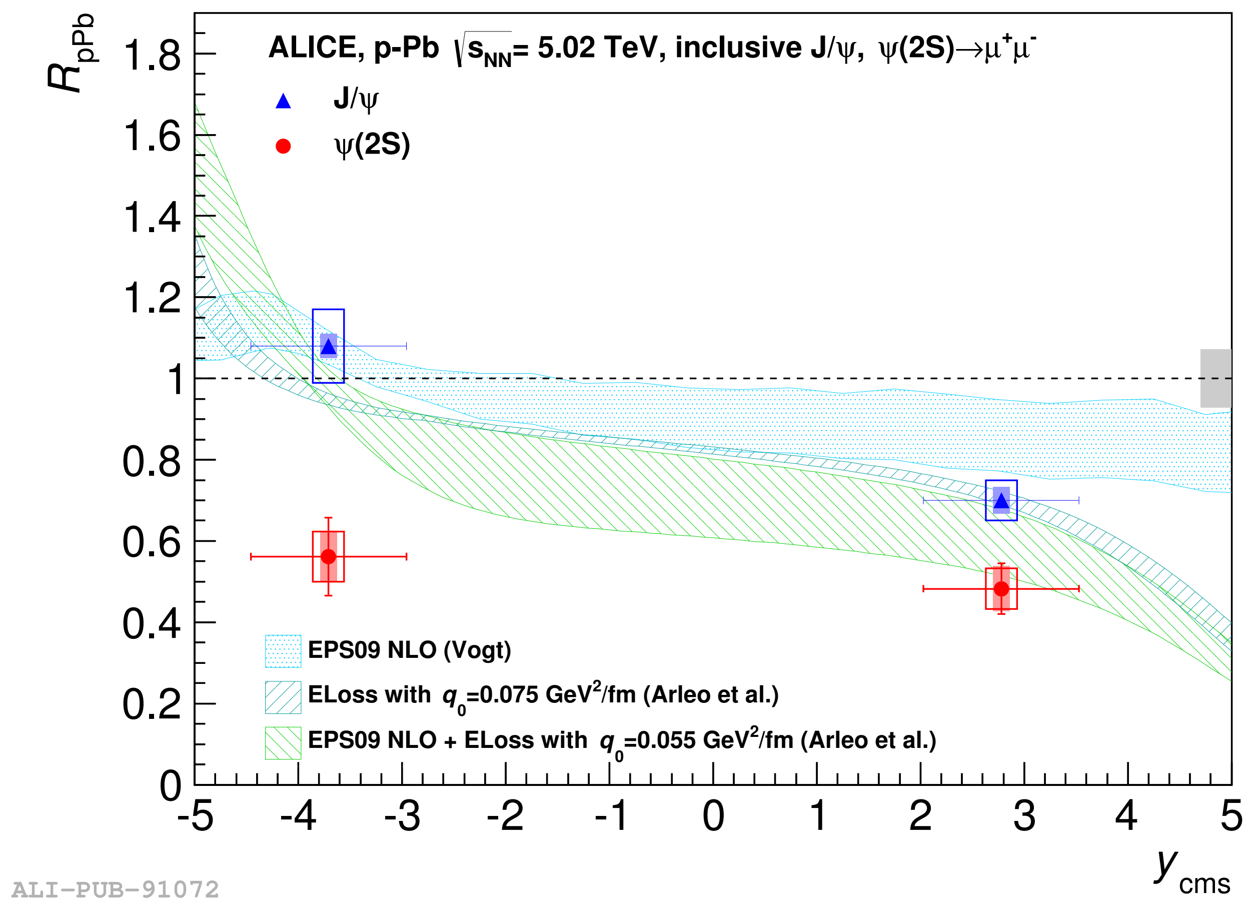

J/ψ R_{AA} vs y consistent with shadowing + E_{loss}

ψ(2S) puzzling → final state effect (co-movers?)

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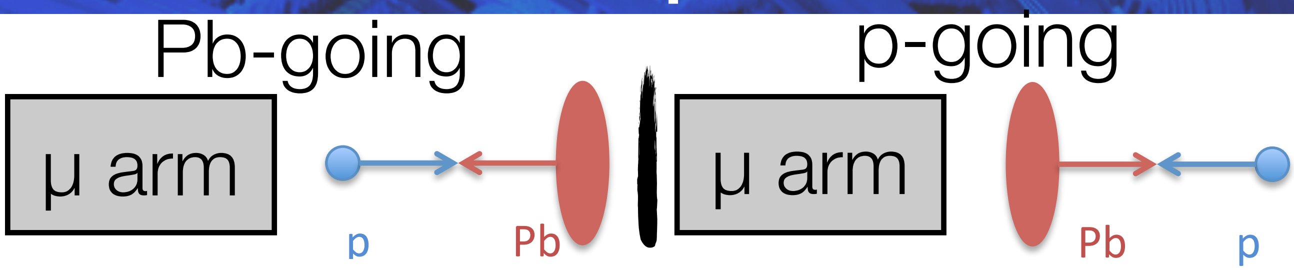

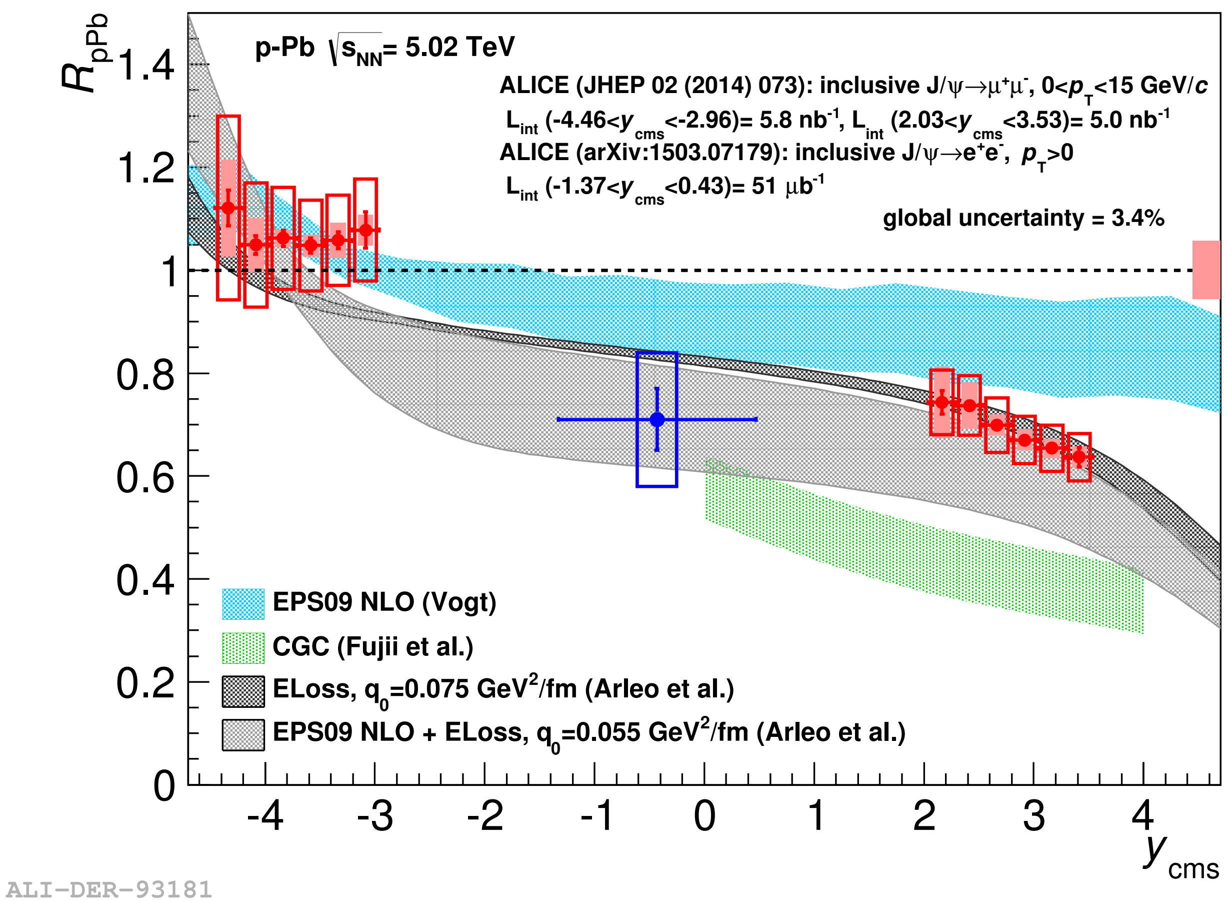

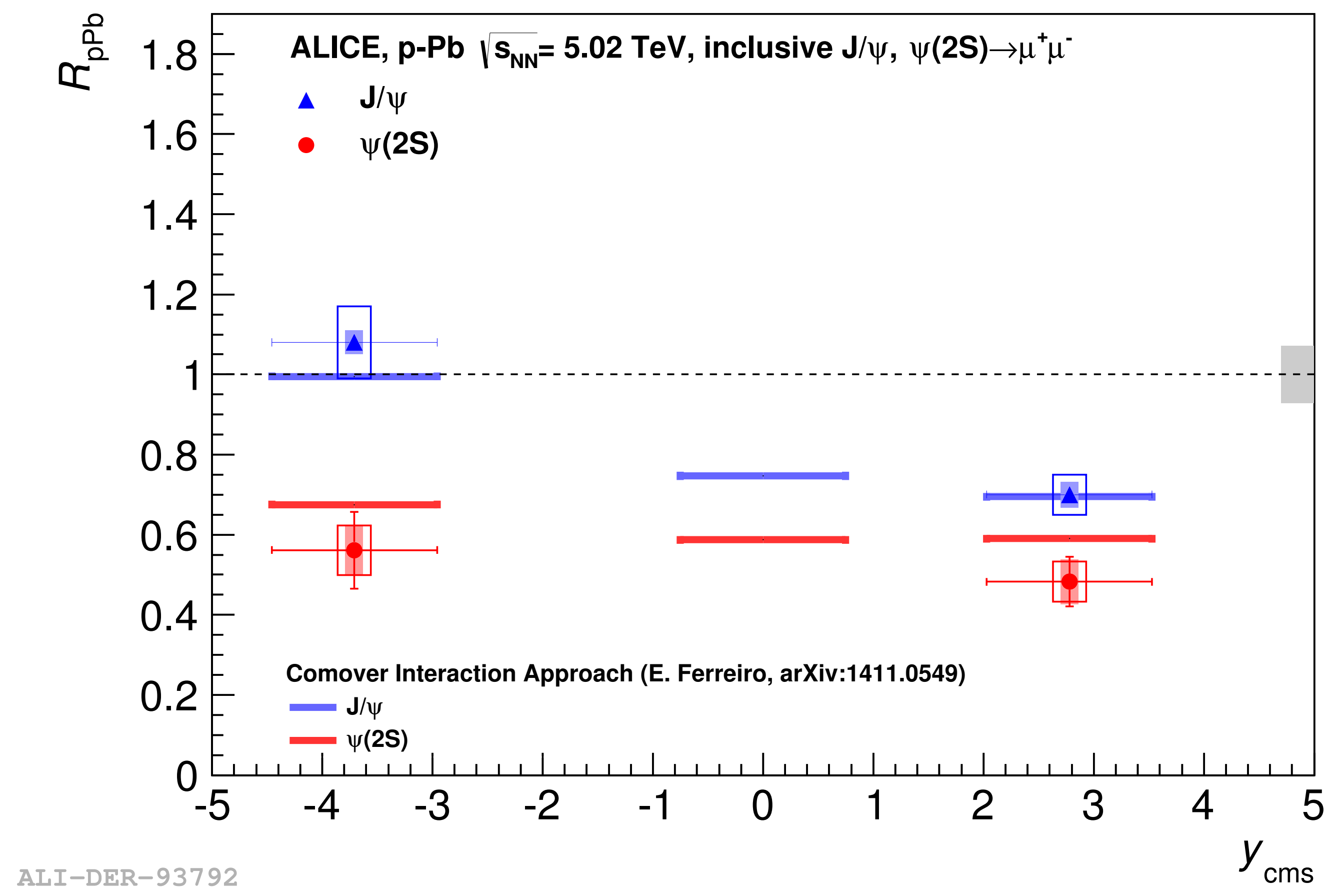

J/ψ R_{AA} vs *y* consistent with shadowing + E_{loss}

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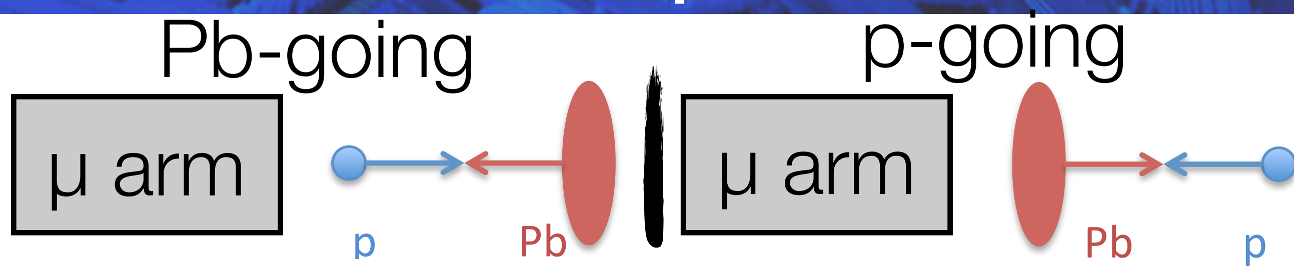
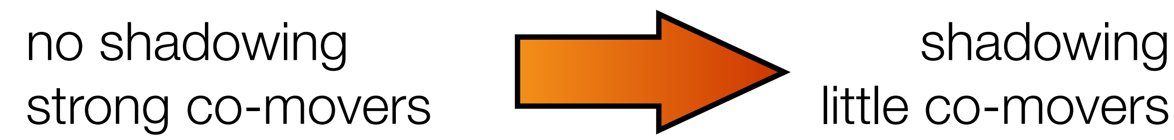
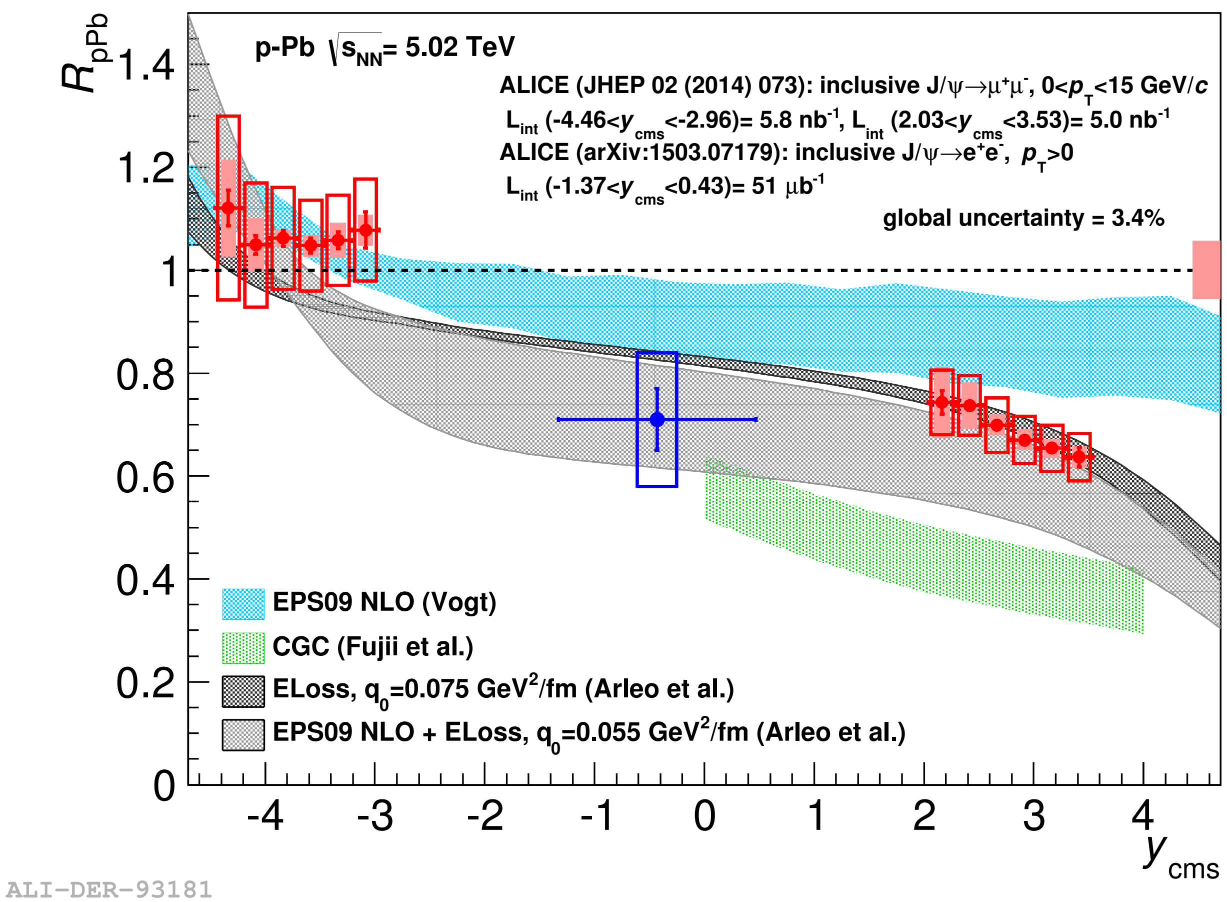
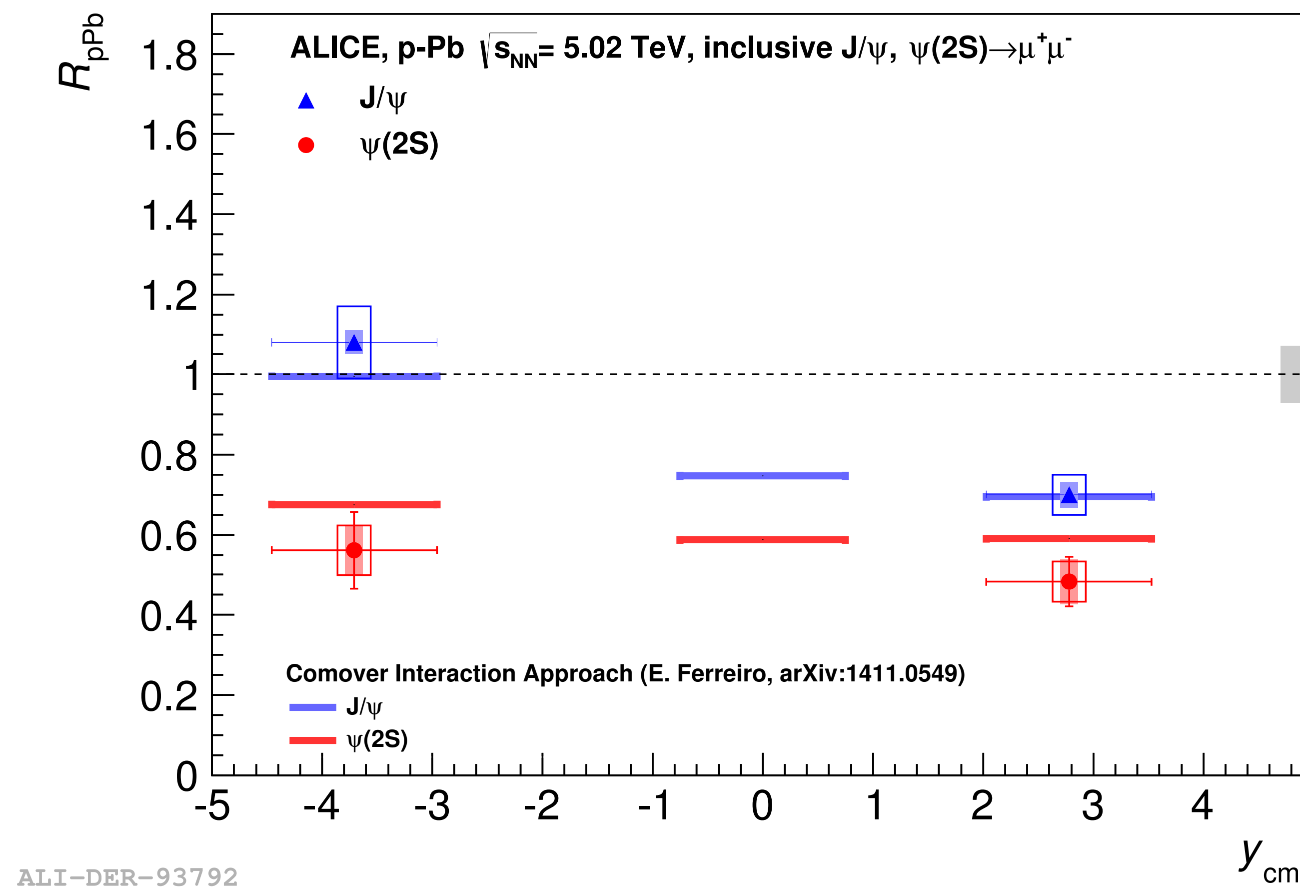








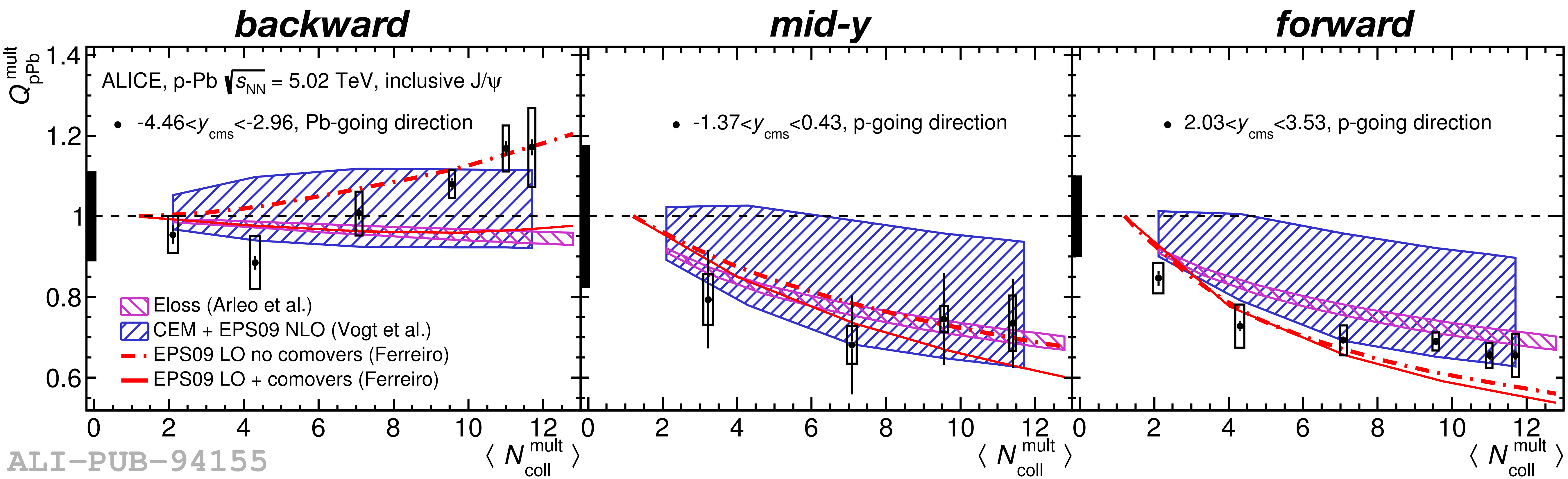
J/ψ R_{AA} vs y consistent with shadowing + E_{loss}

ψ(2S) puzzling → final state effect (co-movers?)

I. Arsene Thu 11:30, arXiv: 1506.08808
A. Camejo, Thu 16:20, S. Weber Thu 16:00

NEW

Anti-Shadowing Shadowing

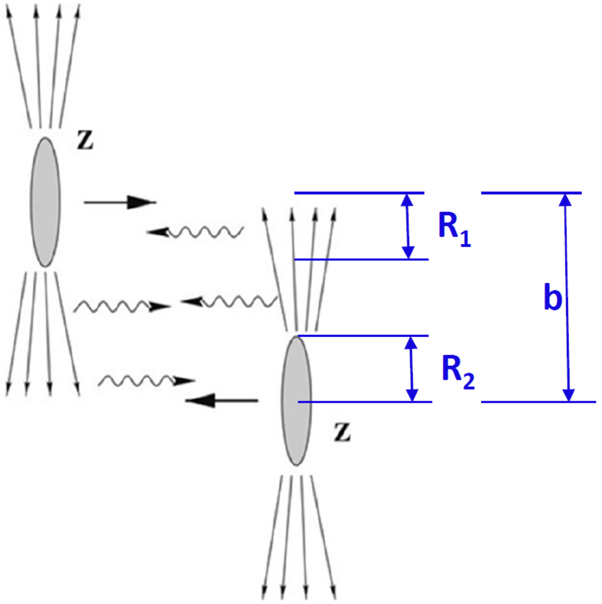


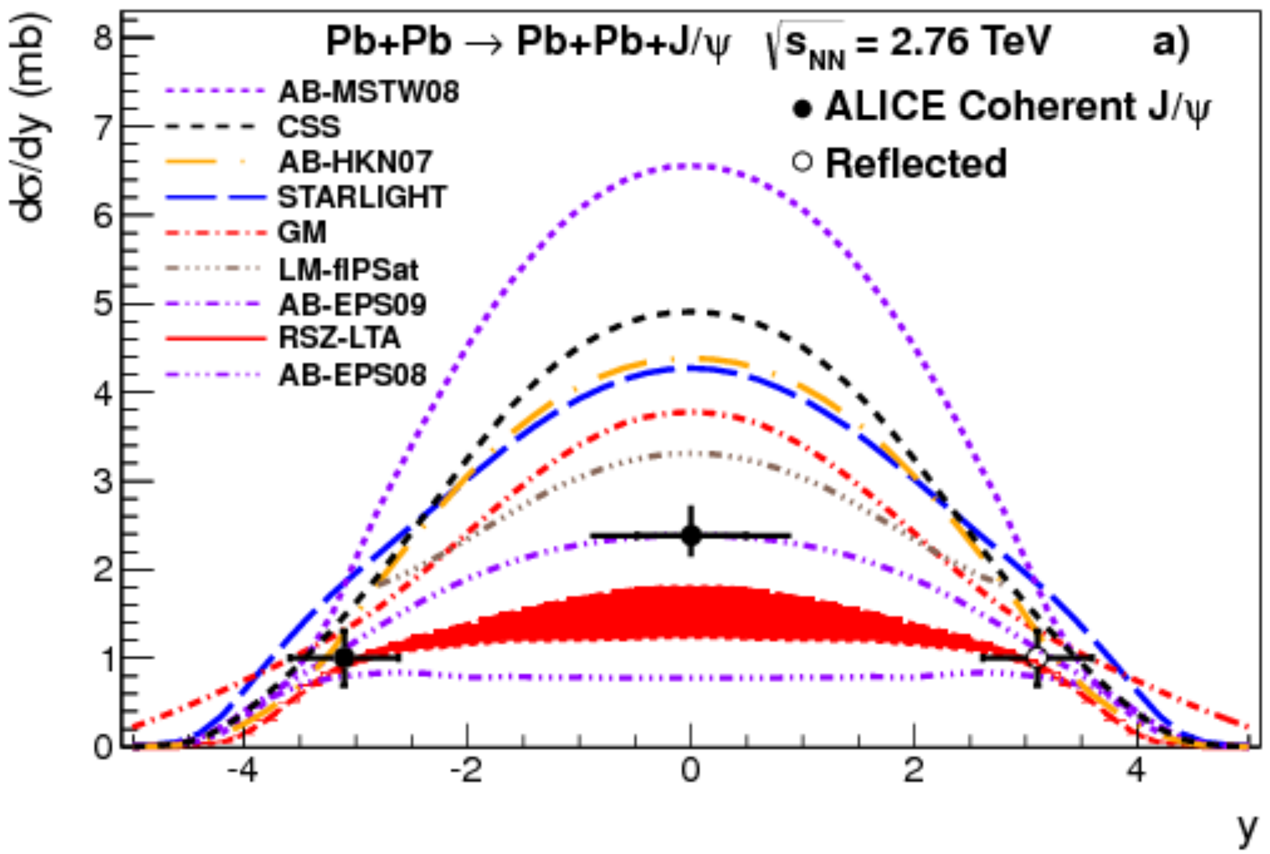
Shadowing effects reproduce the data at forward and backward rapidity

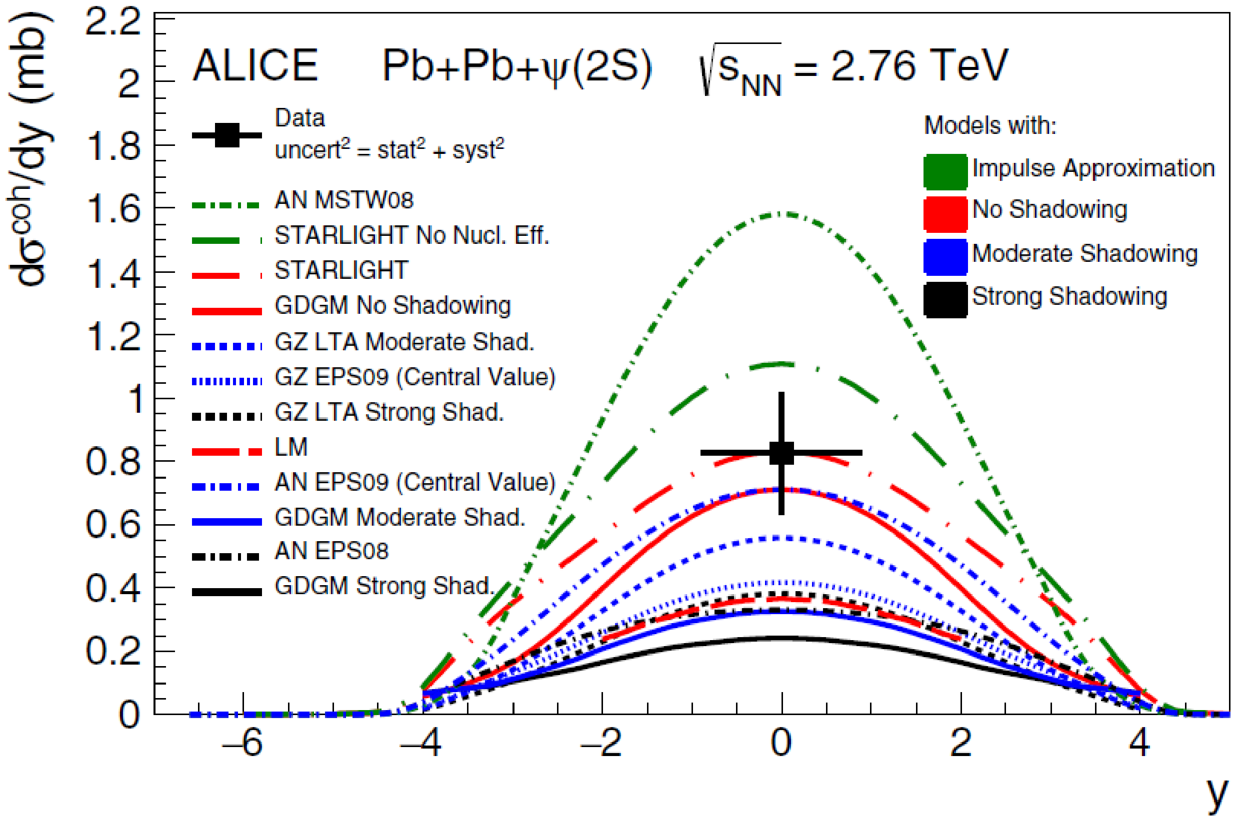
Data better described by models **w/out co-movers**

Pure energy loss scenario predicts a flatter trend at backward rapidity

Another way to get a handle on shadowing





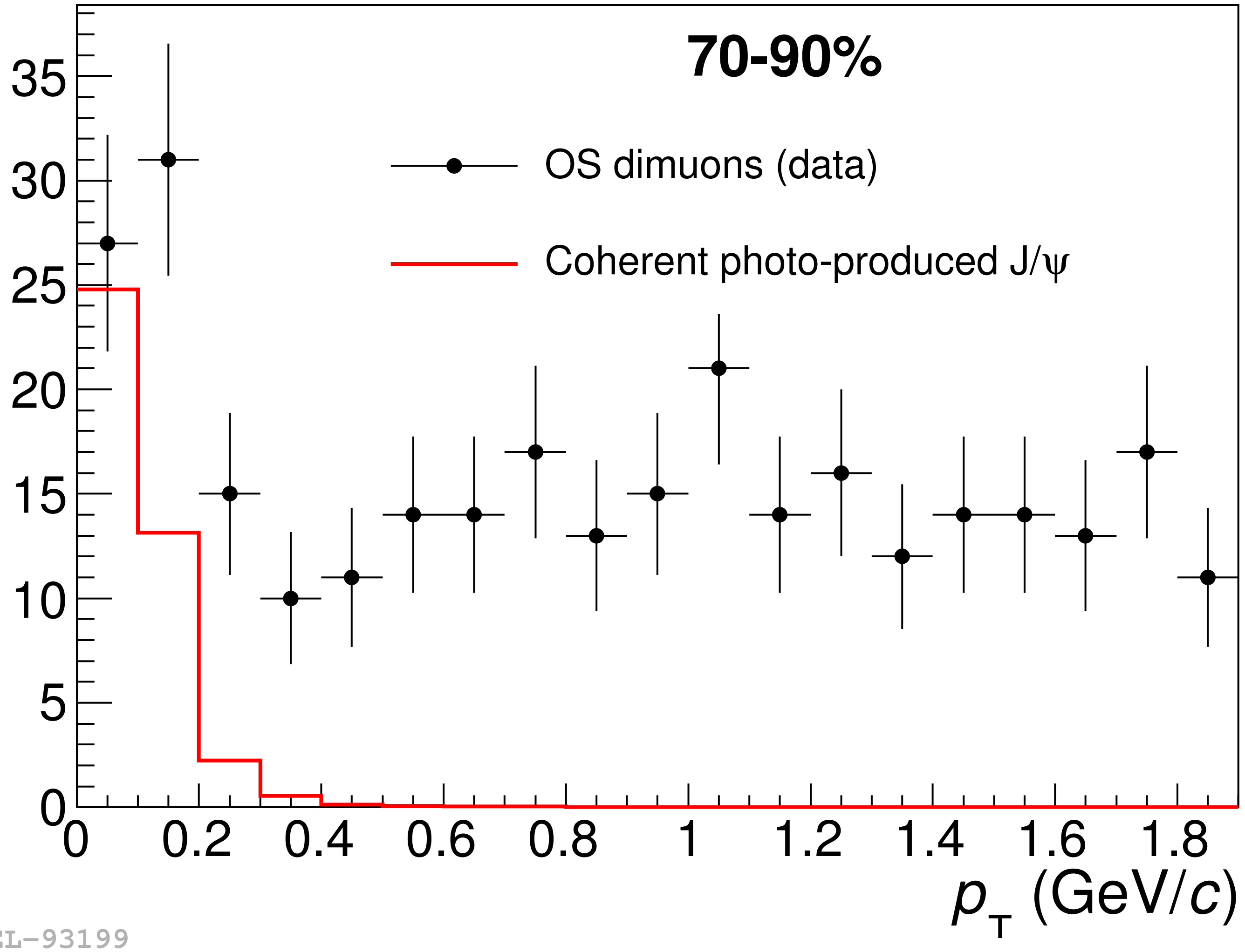


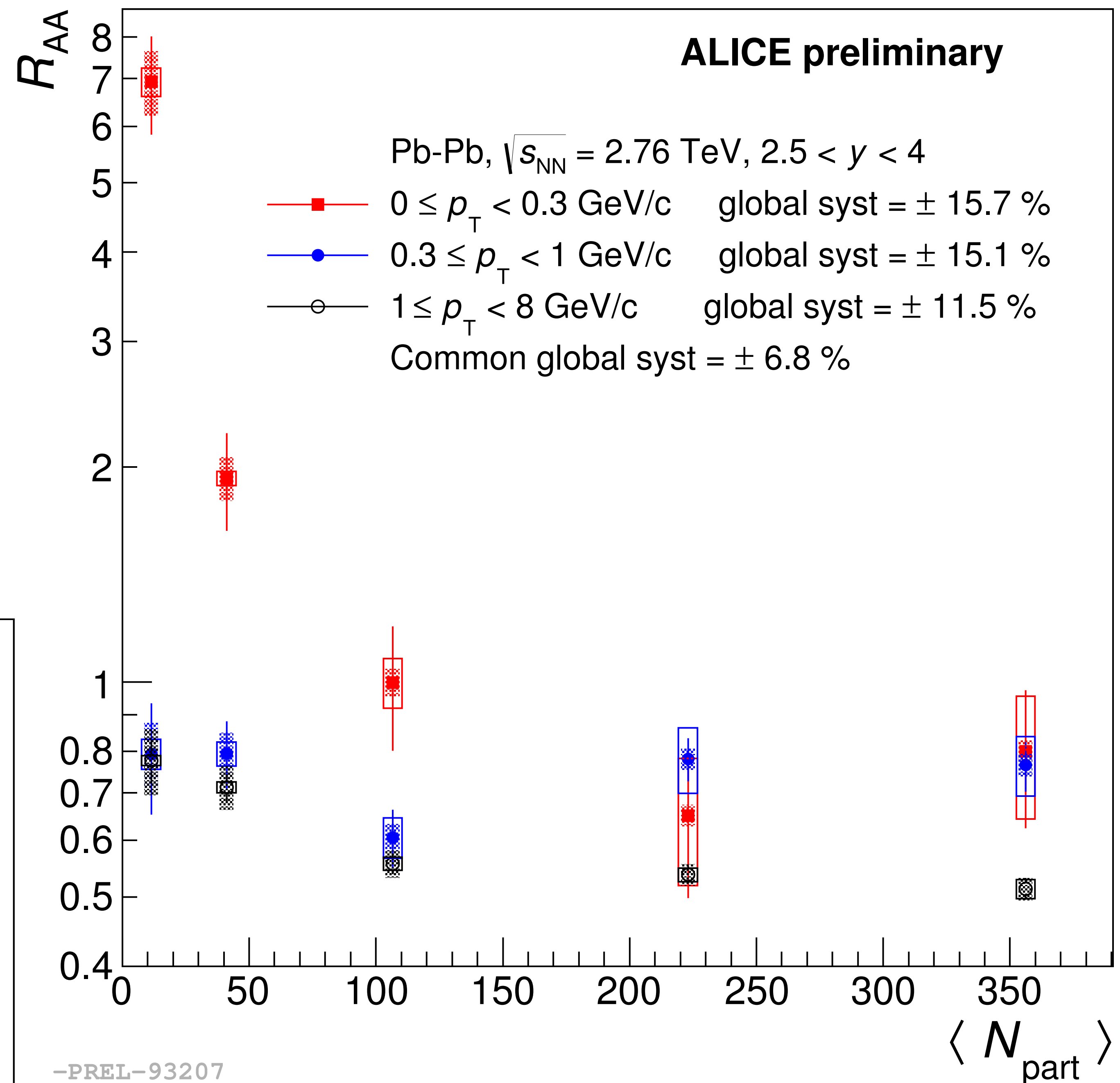
Models incorporating (moderate) shadowing give a better description of data

Photo-production at b < 2×R?

Excess of J/ψ at **low p_T** in **peripheral** events

p_T spectrum consistent with photo production

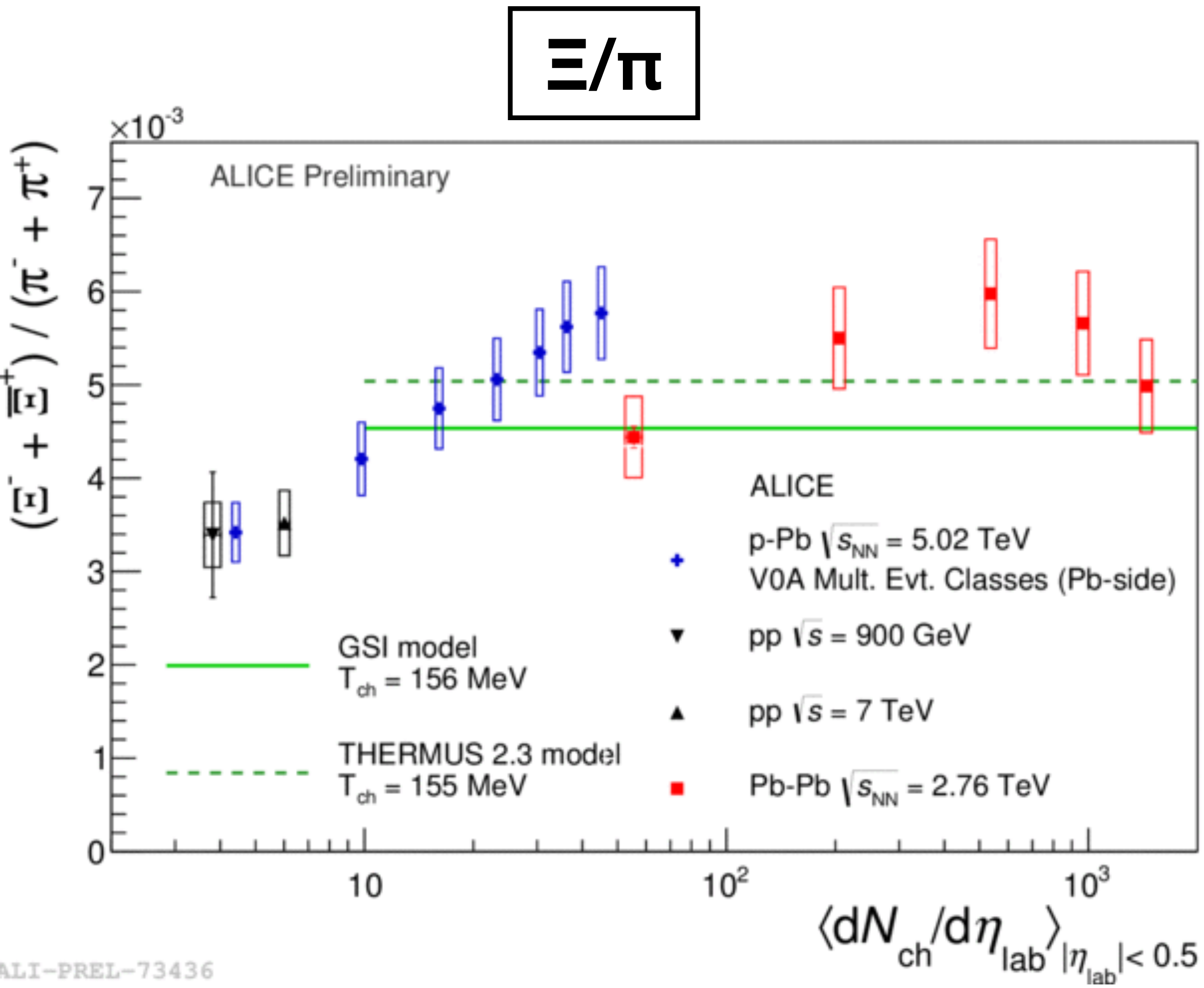


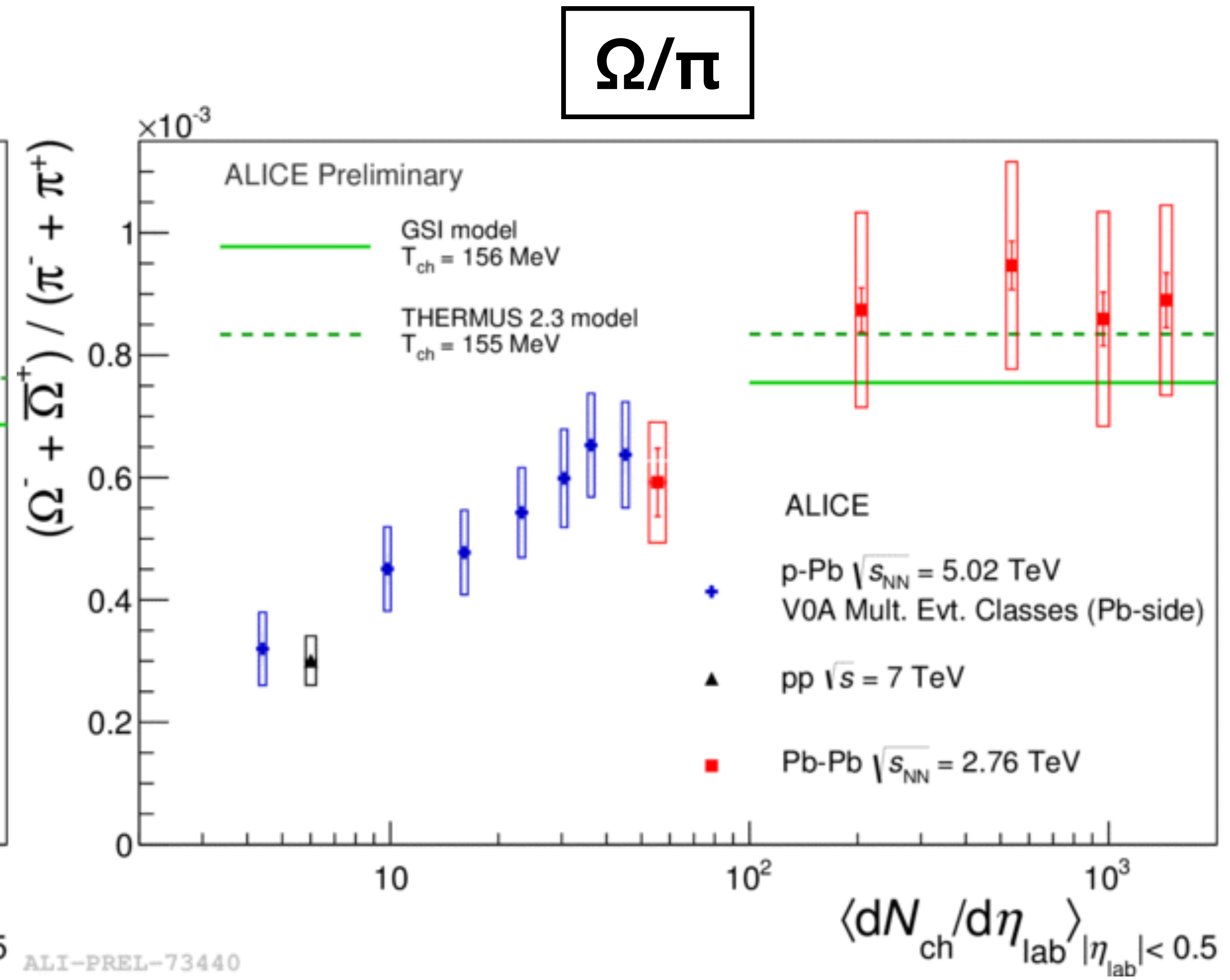


Hadrons

Strangeness in p-Pb collisions

M. Nicassio, Fri 17:20

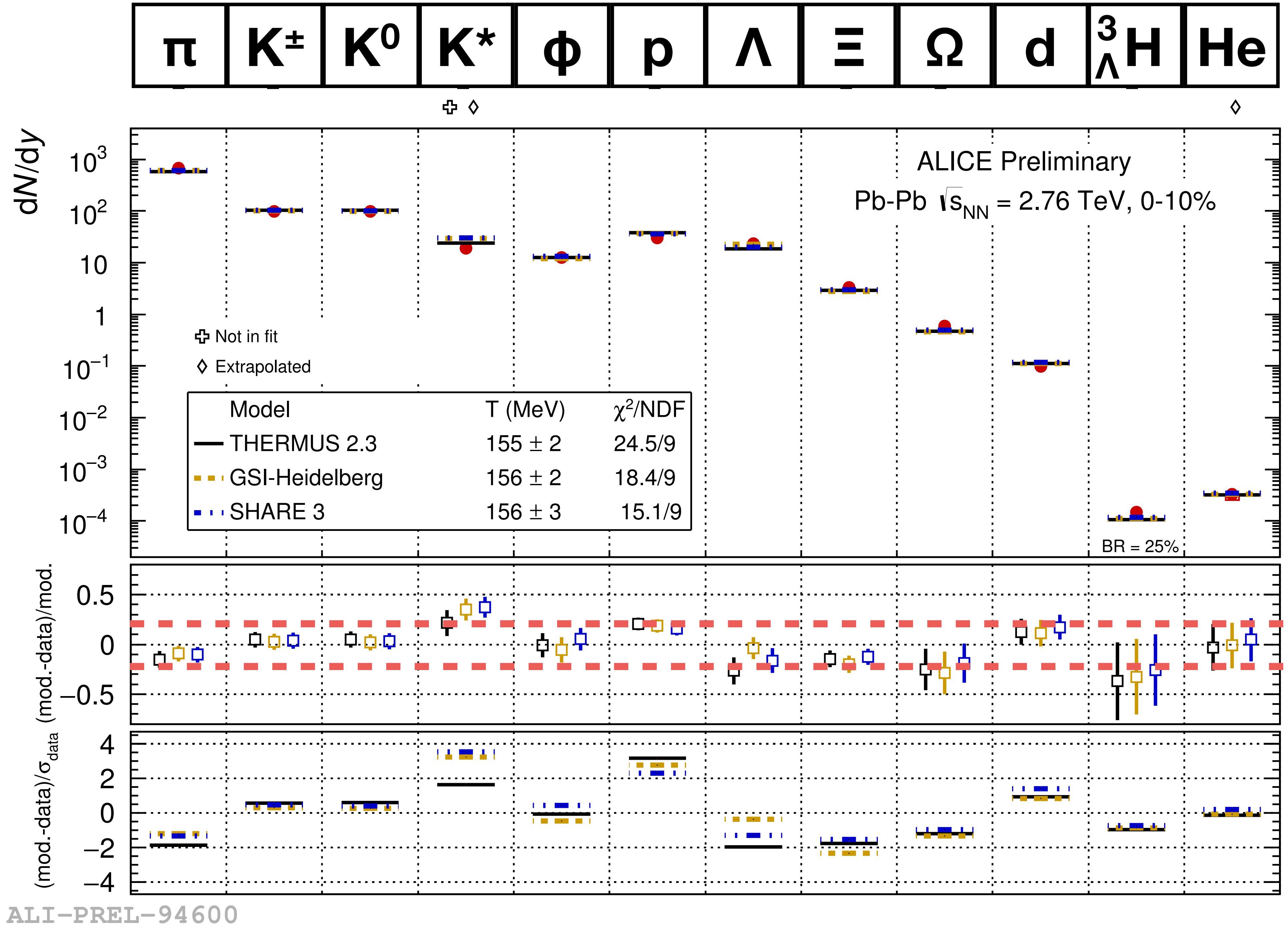




Strangeness enhancement in p-Pb collisions!

- Ξ reaches the Pb-Pb (Grand Canonical?) value
- Lift of canonical suppression? Poor GC fit in p-Pb

Equilibrium SHM Fits in Central Pb-Pb



N.B.

RHIC (STAR)

$\sqrt{s}$ = 200 GeV

χ^2/NDF~1

Better fit in 60-80%,

Petran et al, arXiv:1310.5108
Wheaton et al, Comput.Phys.Commun, 180 84
Andronic et al, PLB 673 142

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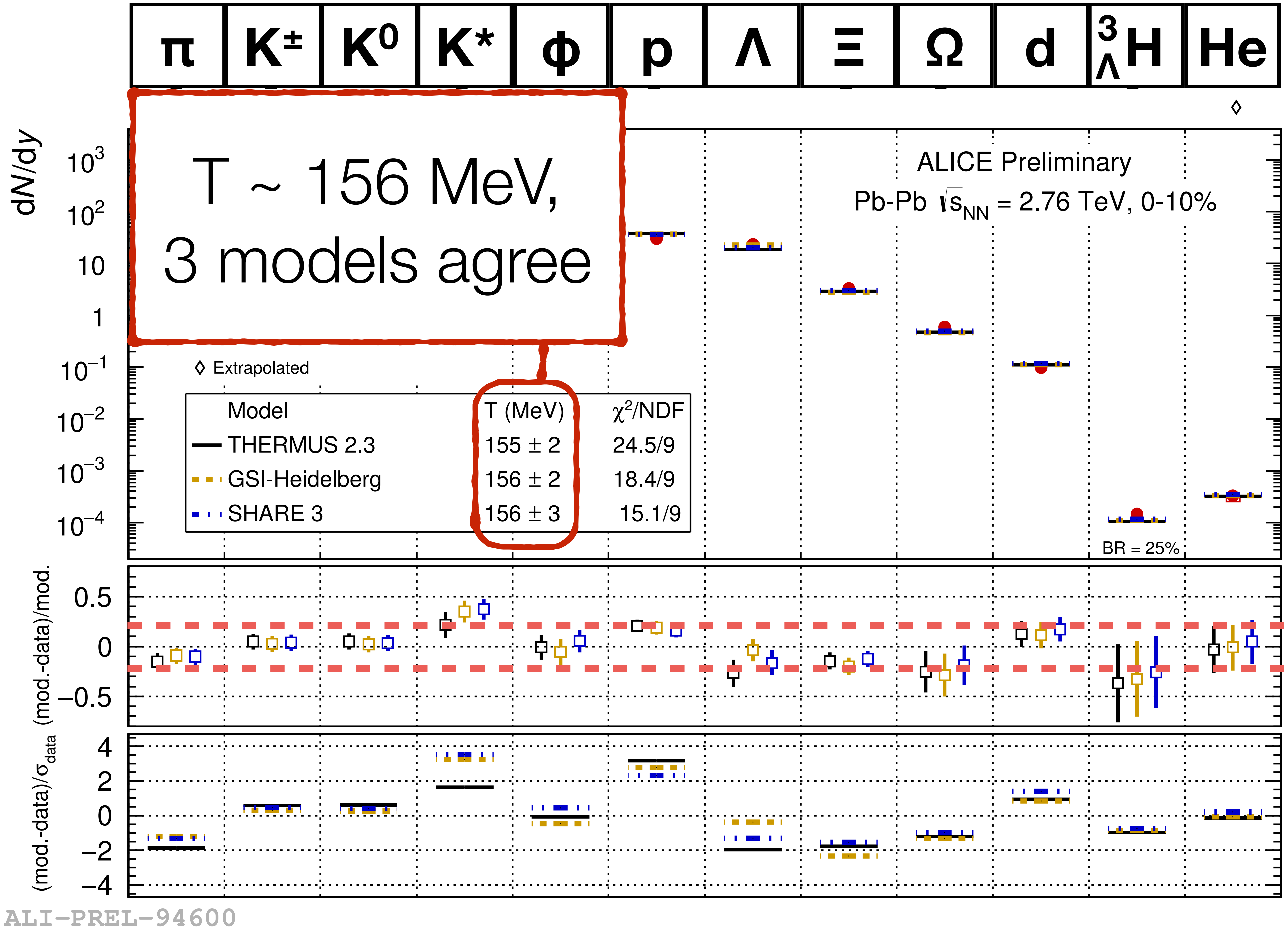

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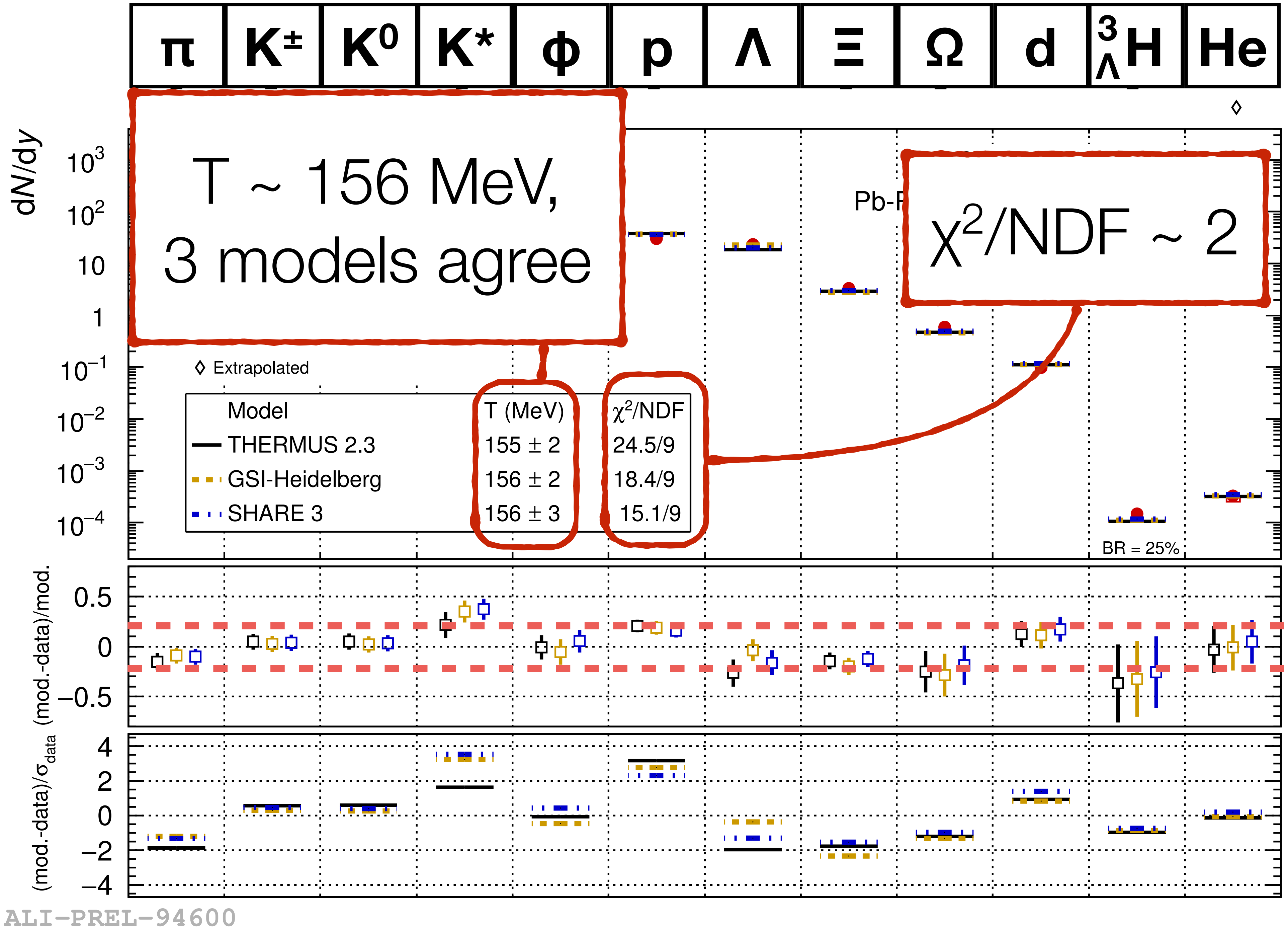

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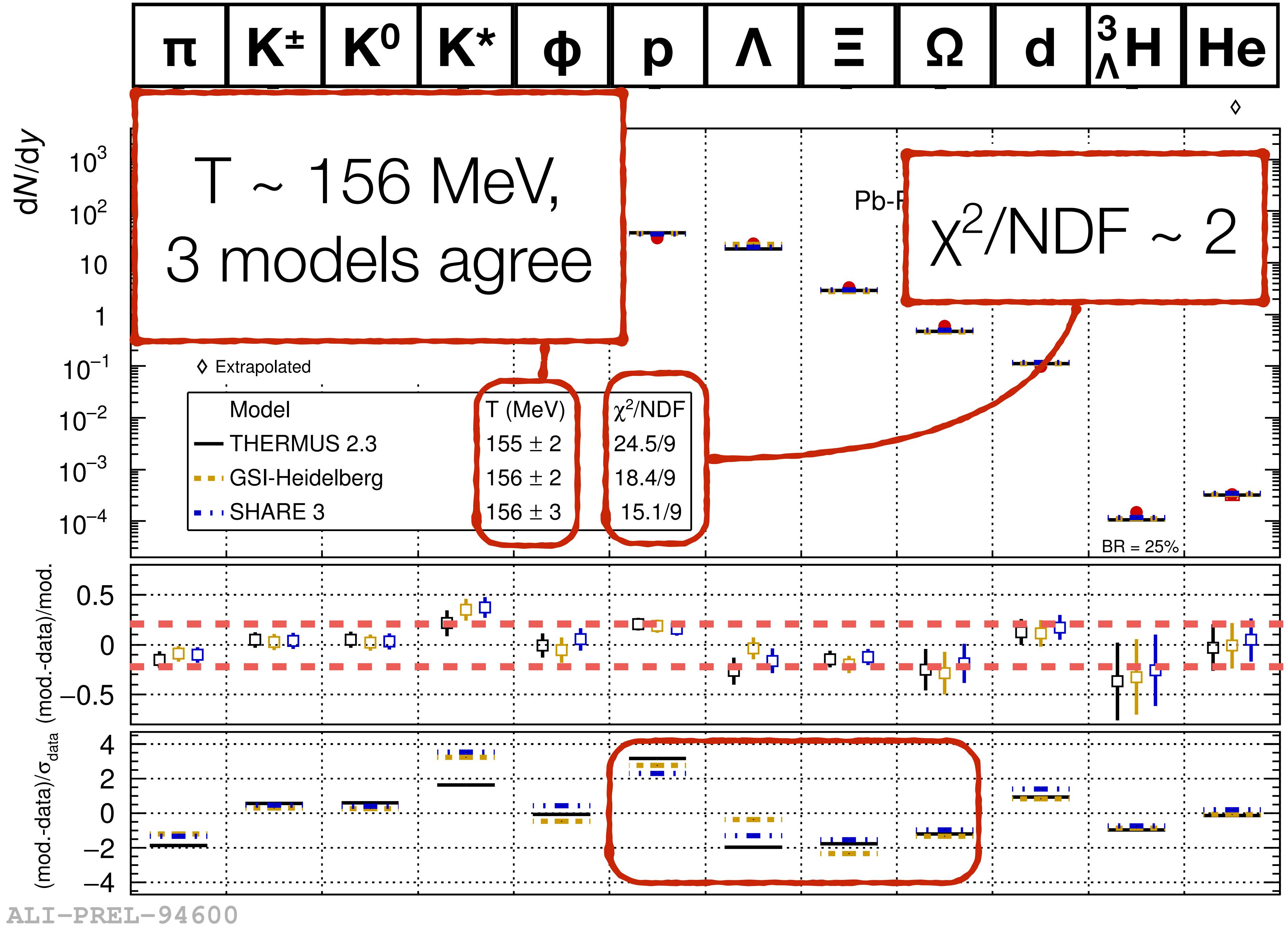

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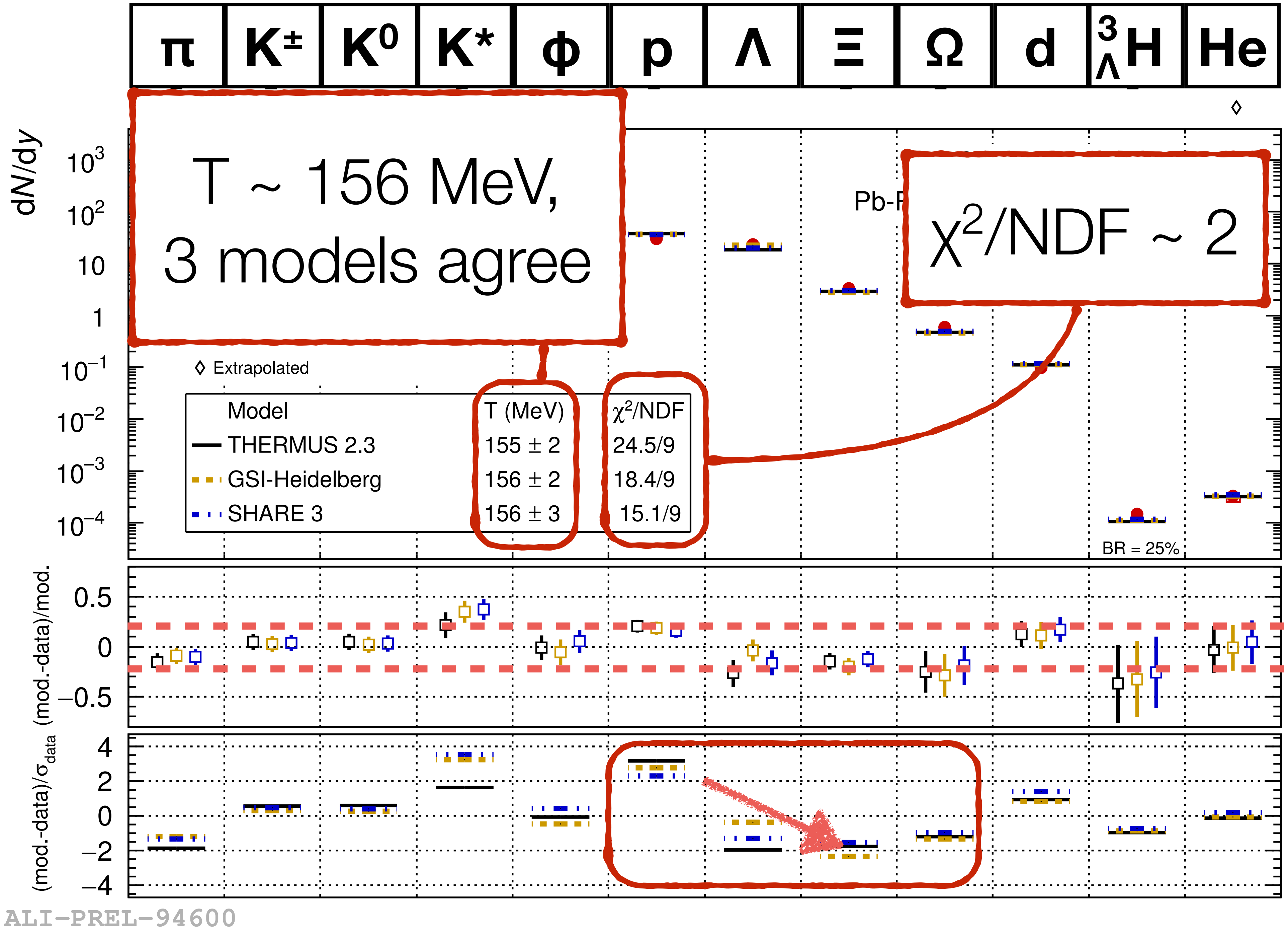

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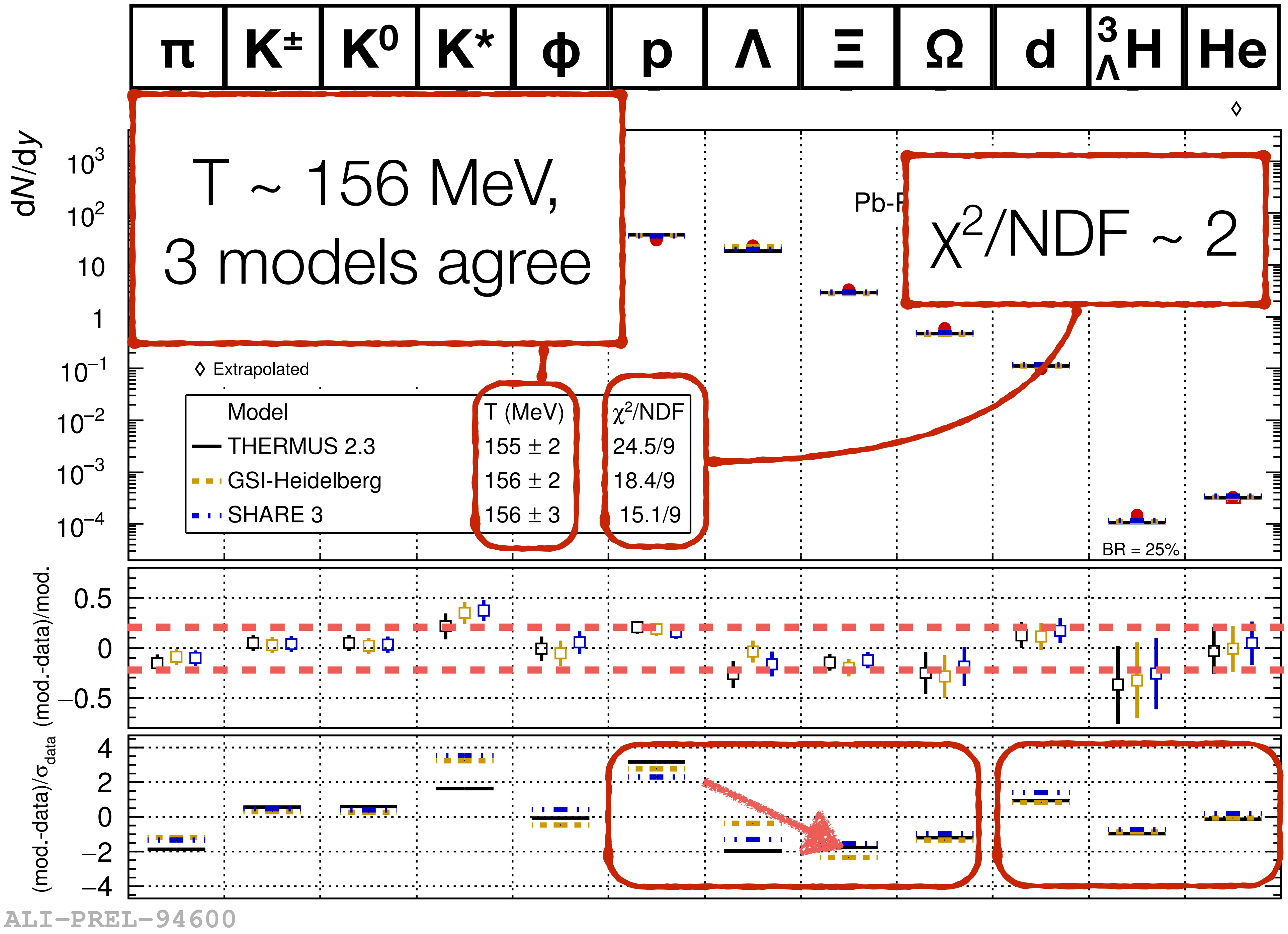

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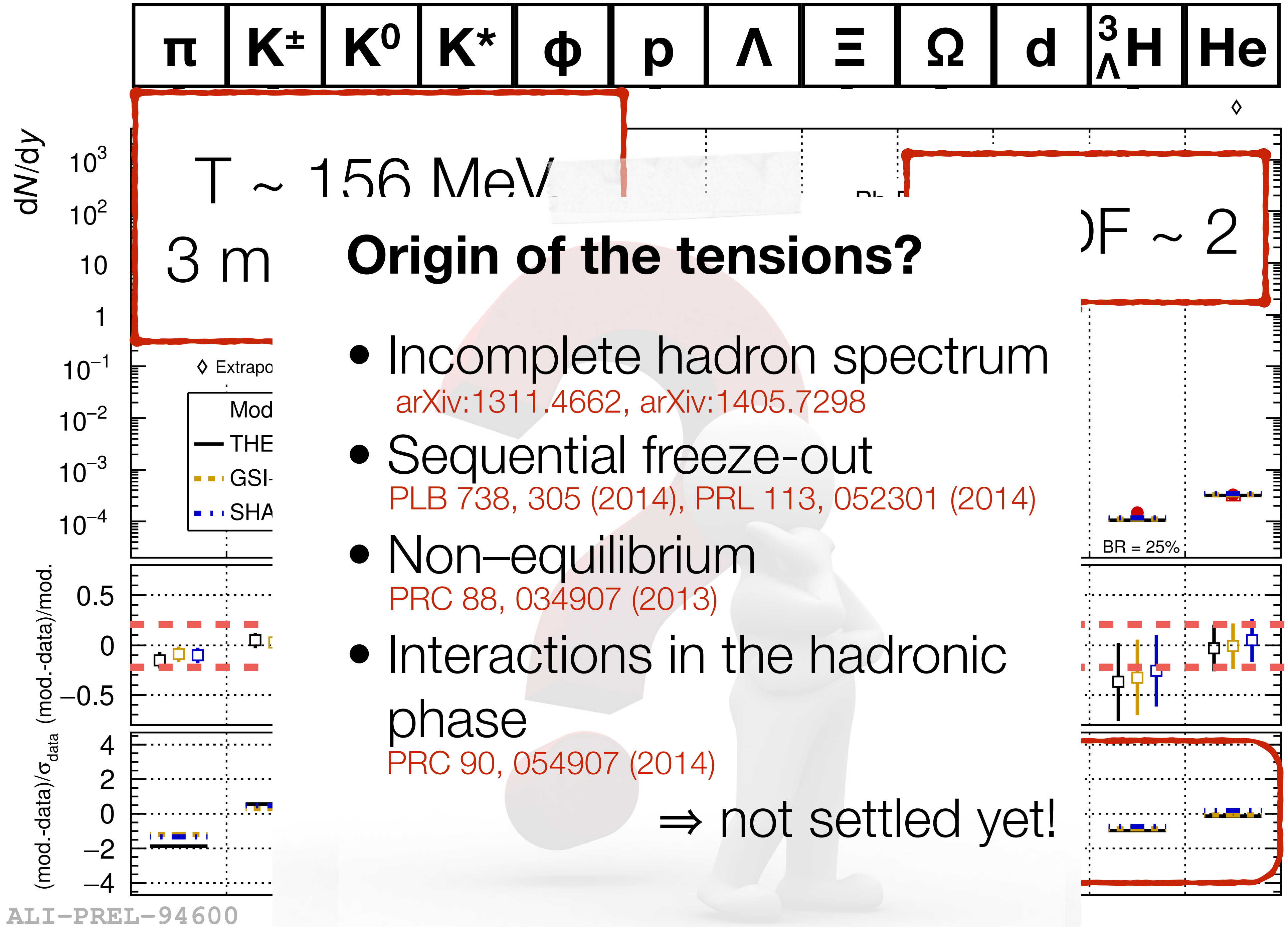

Origin of the tensions?

- Incomplete hadron spectrum
  arXiv:1311.4662, arXiv:1405.7298
- Sequential freeze-out
  PLB 738, 305 (2014), PRL 113, 052301 (2014)
- Non–equilibrium
  PRC 88, 034907 (2013)
- Interactions in the hadronic phase
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⇒ not settled yet!

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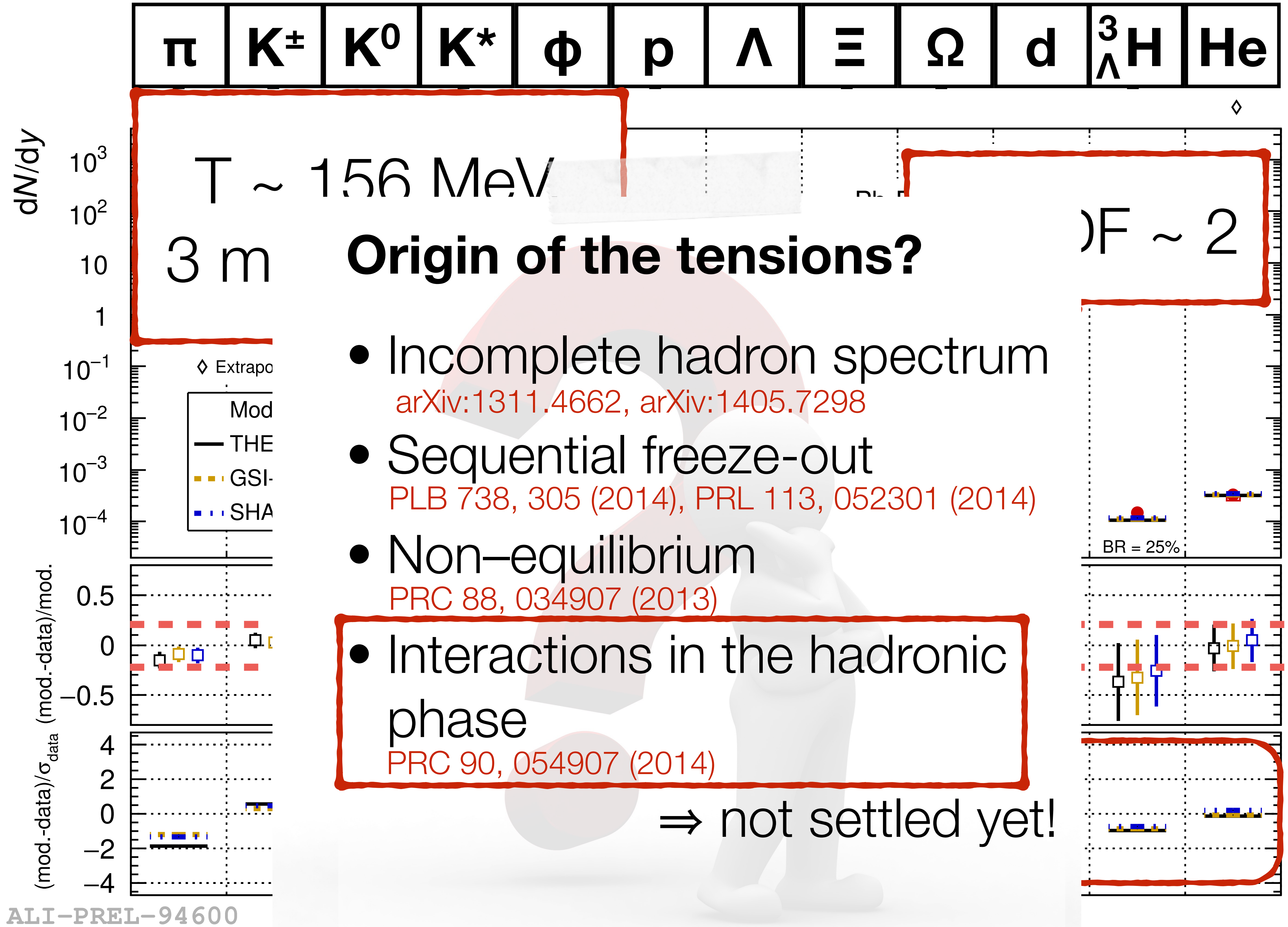

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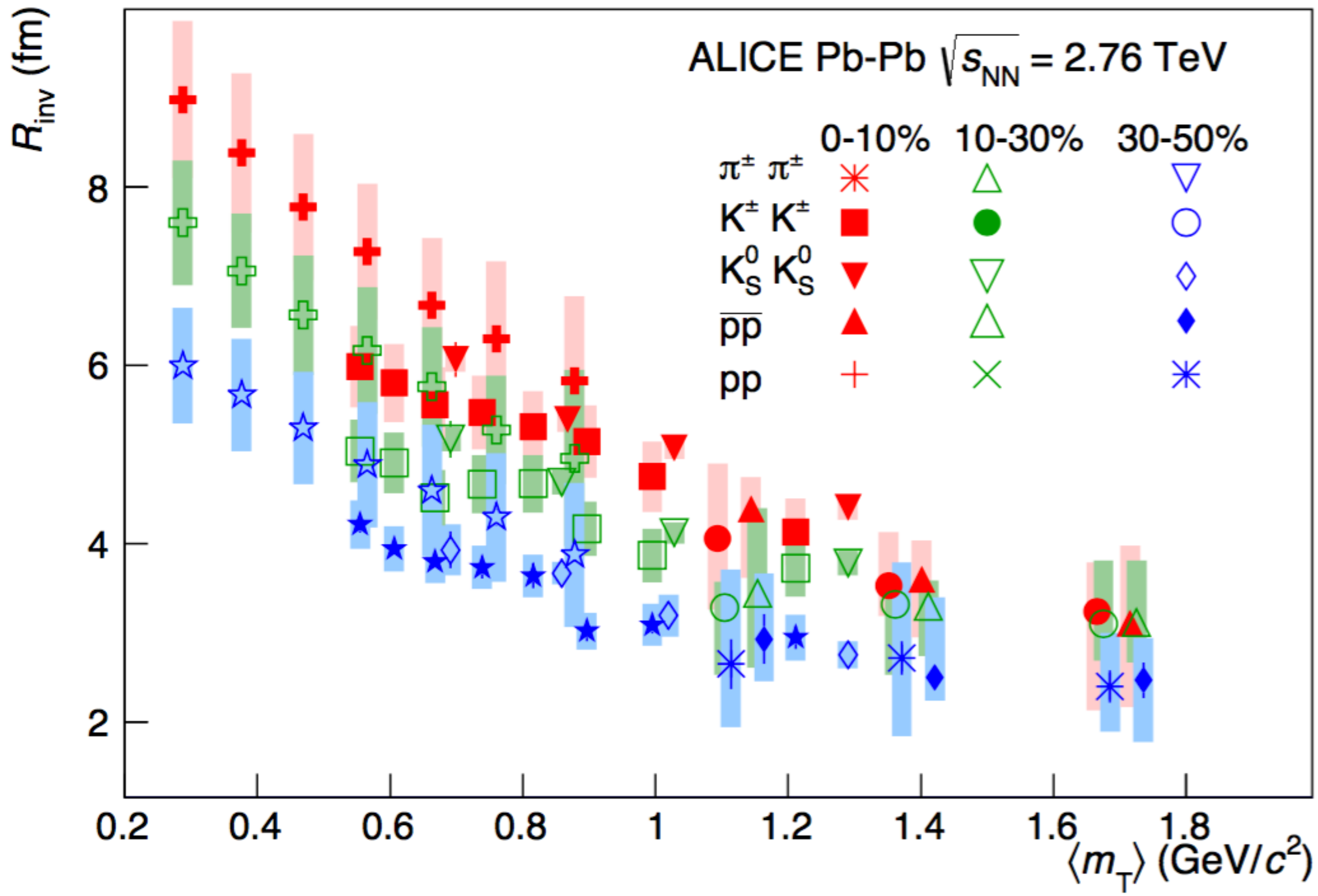
1D femto radii with PID

K. Mikhaylov, Tue 16:00
arXiv:1506.07884



R_{inv} decreases & Approximate m_T scaling

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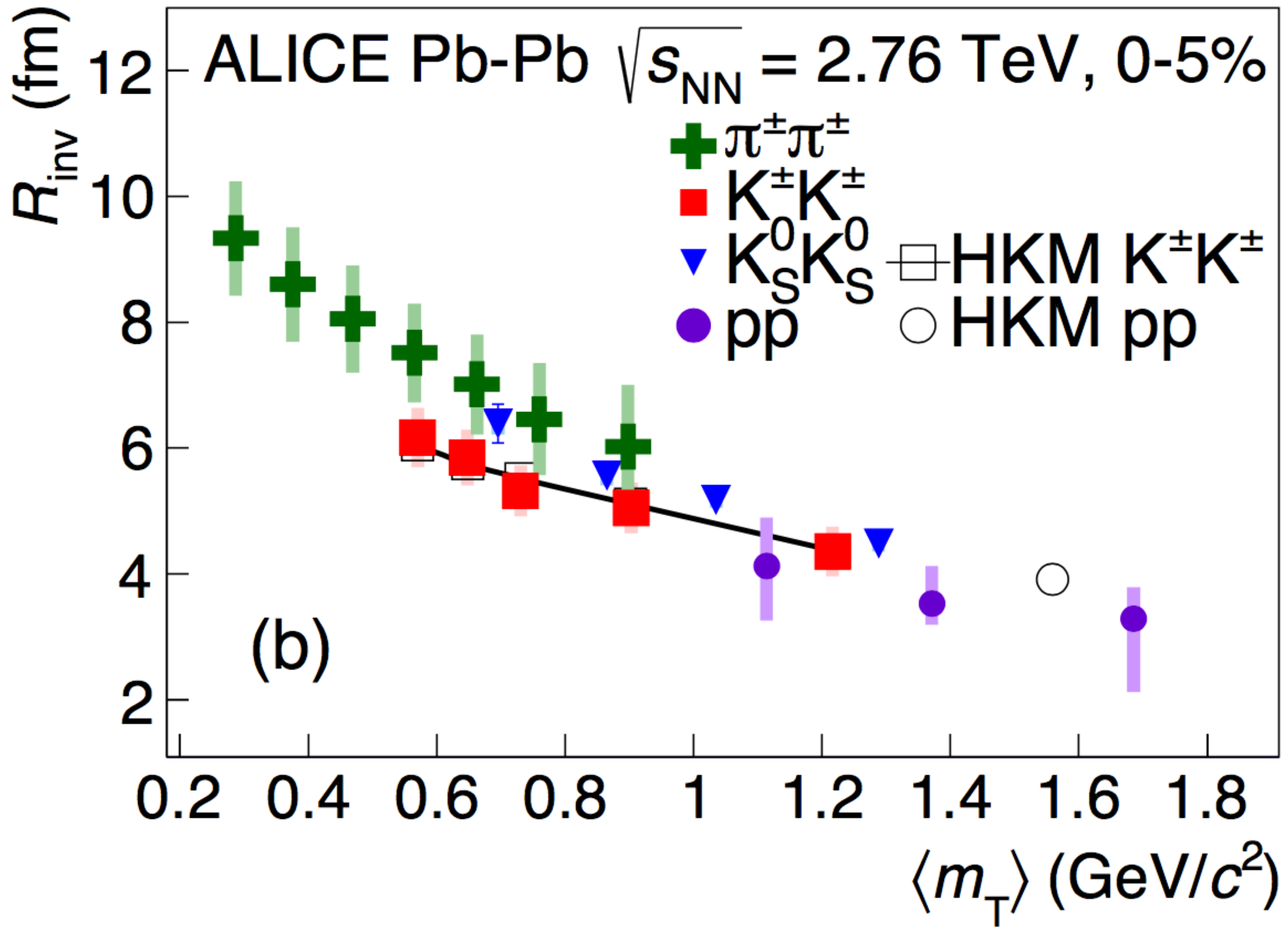
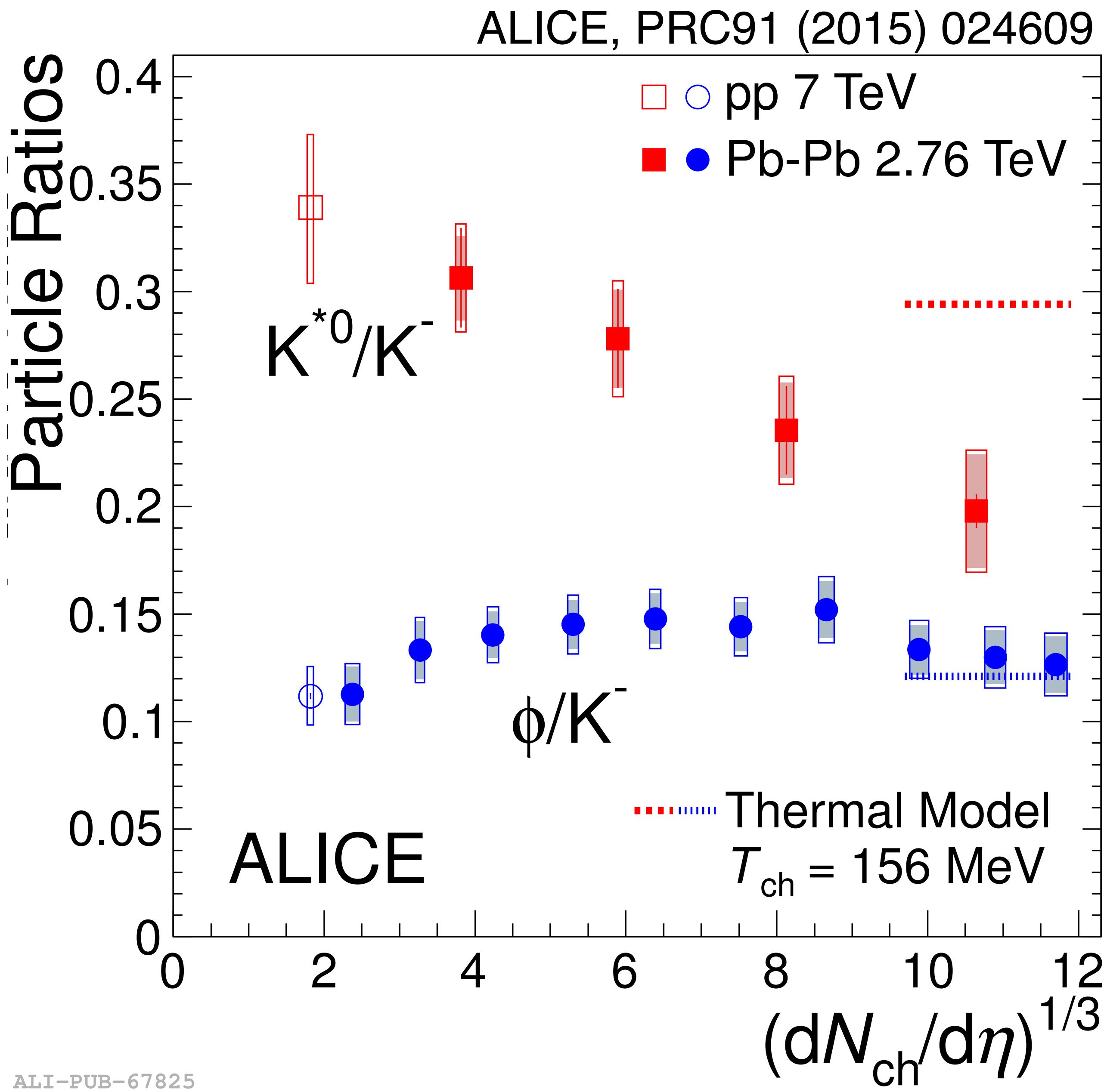


R_{inv} decreases & Approximate m_T scaling

⇒ Consistent with Hydro, hadronic phase required (HKM)?

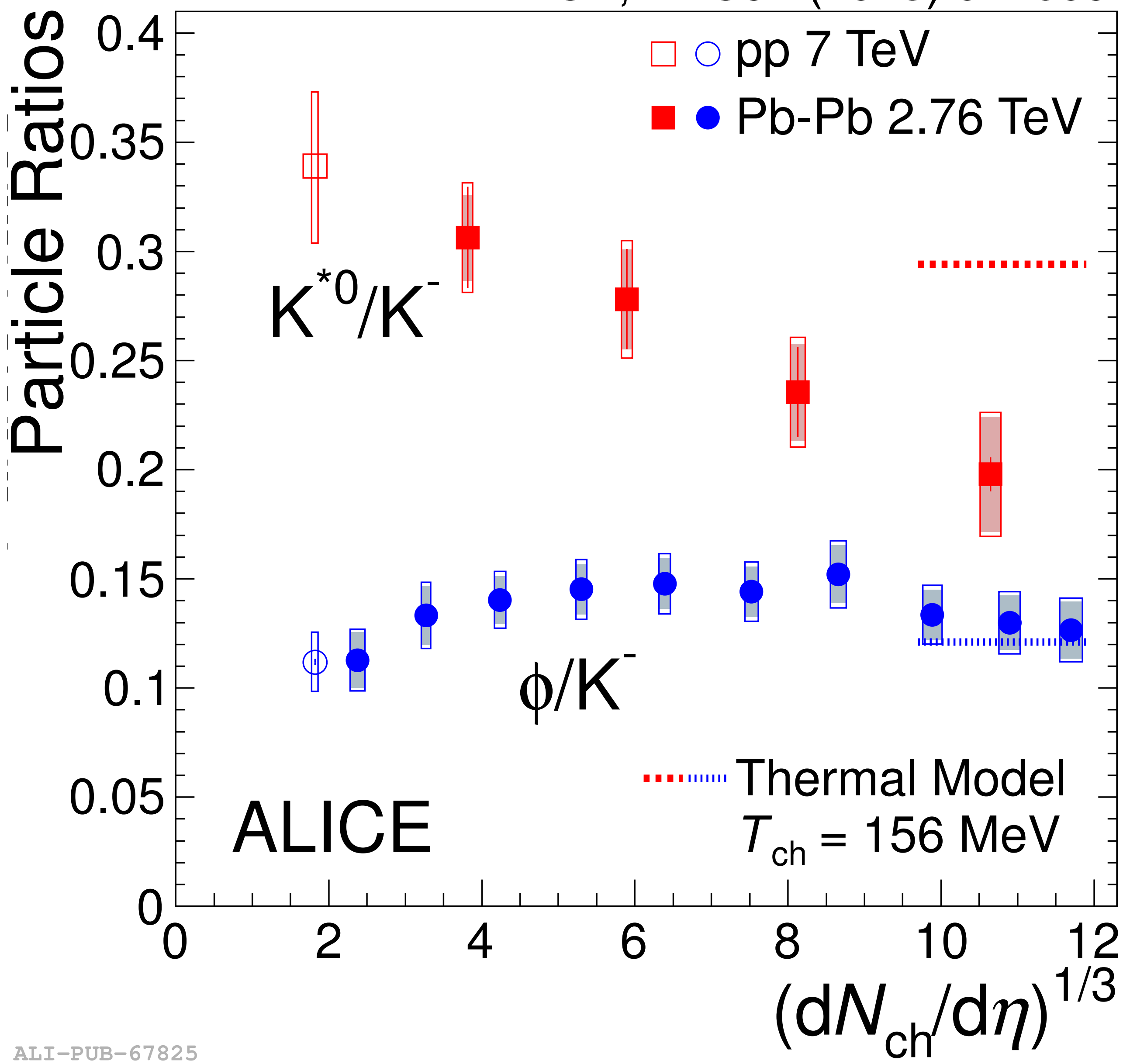
Effects in the hadronic phase?



K*/K Reduction suggests rescattering of daughters in hadronic phase

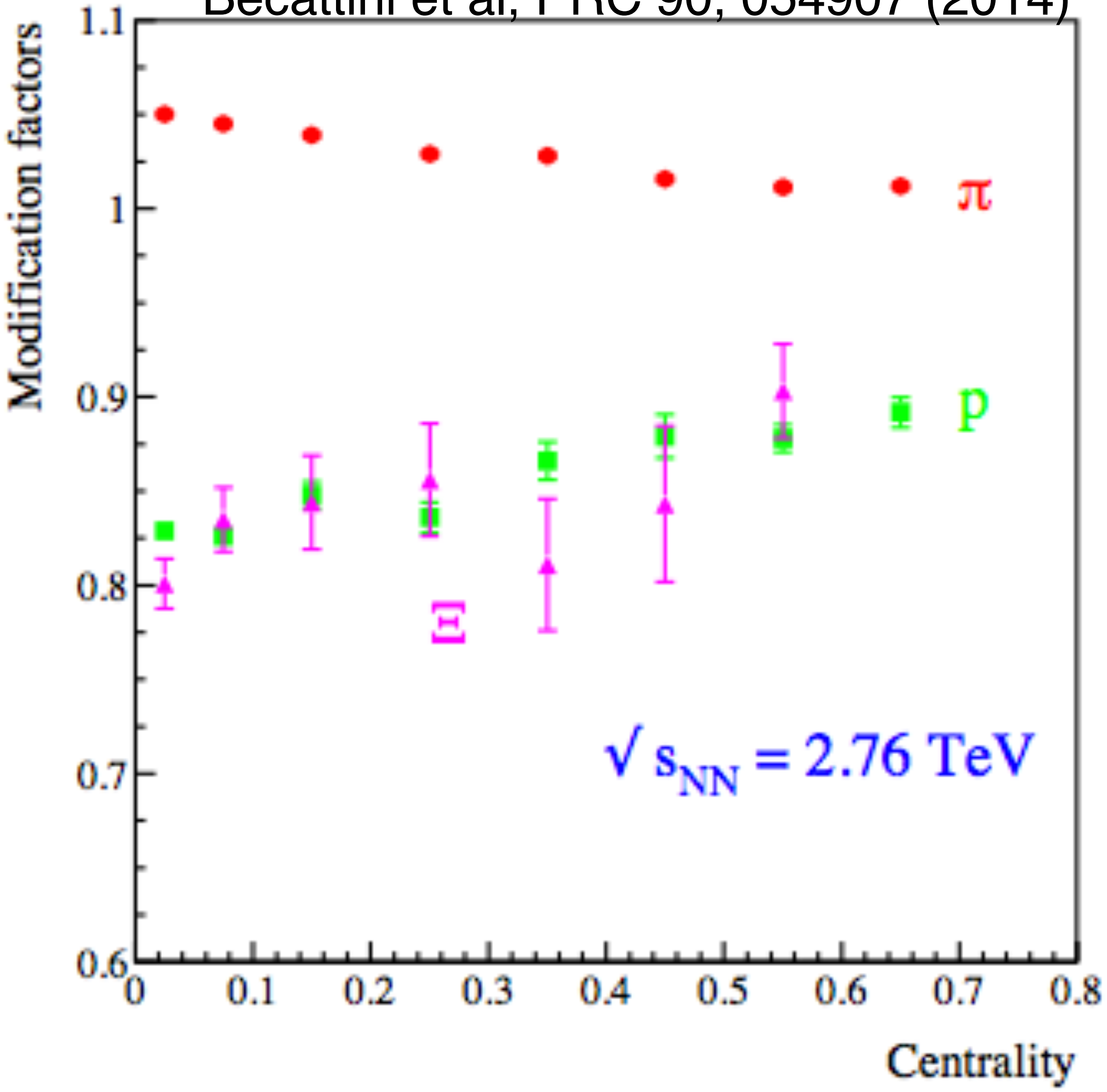
Effects in the hadronic phase?

ALICE, PRC91 (2015) 024609



Also responsible for p depletion (centrality dependence suggestive)? What about nuclei?

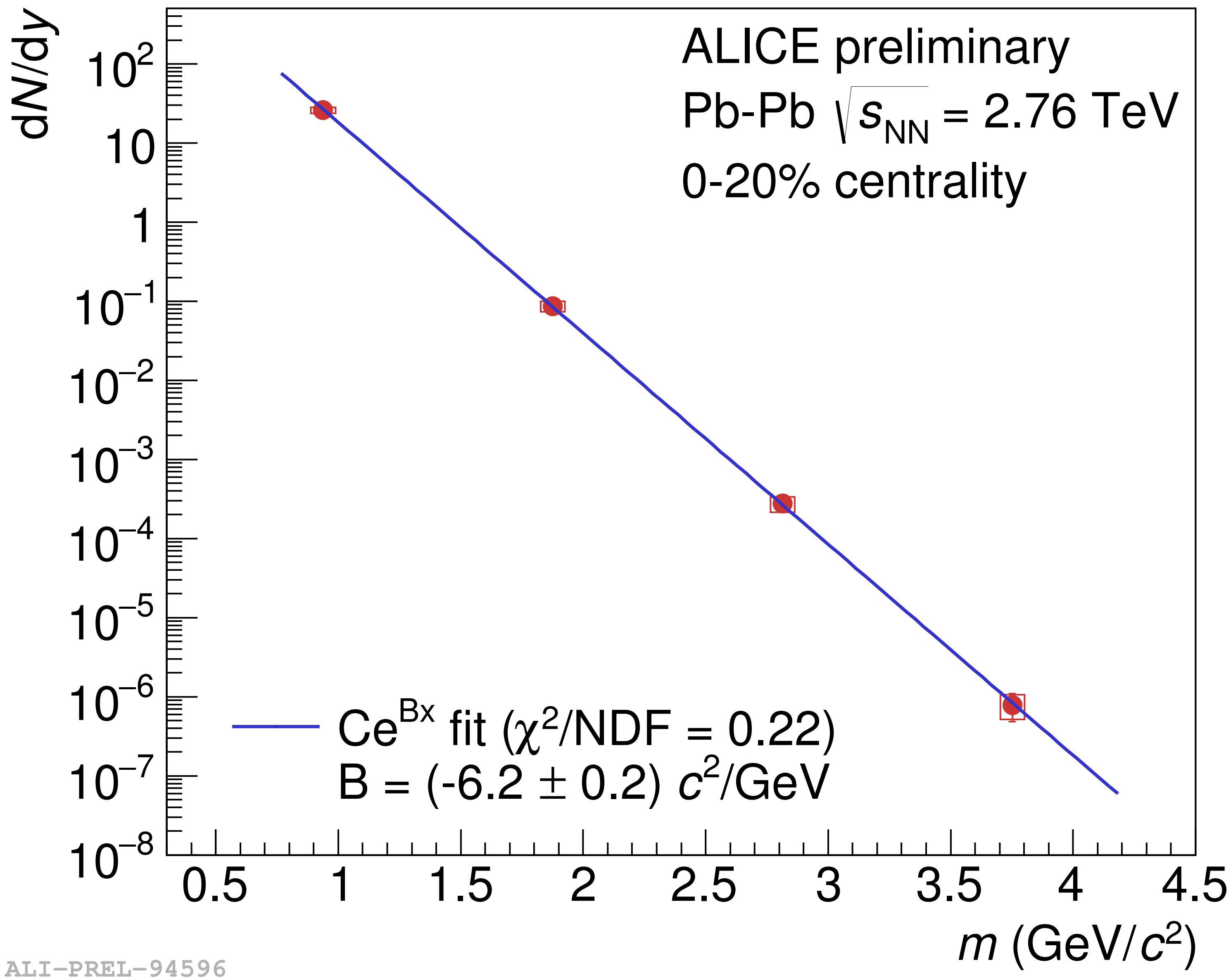
Becattini et al, PRC 90, 054907 (2014)



K*/K Reduction suggests rescattering of daughters in hadronic phase

Nuclei production

F. Barile, Thu 17:40
arXiv:1506.08951,1506.07499



dN/dy follow **expected exponential fall**

~300x penalty factor for each additional nucleon

Thermal model provides a **baseline for exotica** searches (upper limits for ΛΛ, Λn)

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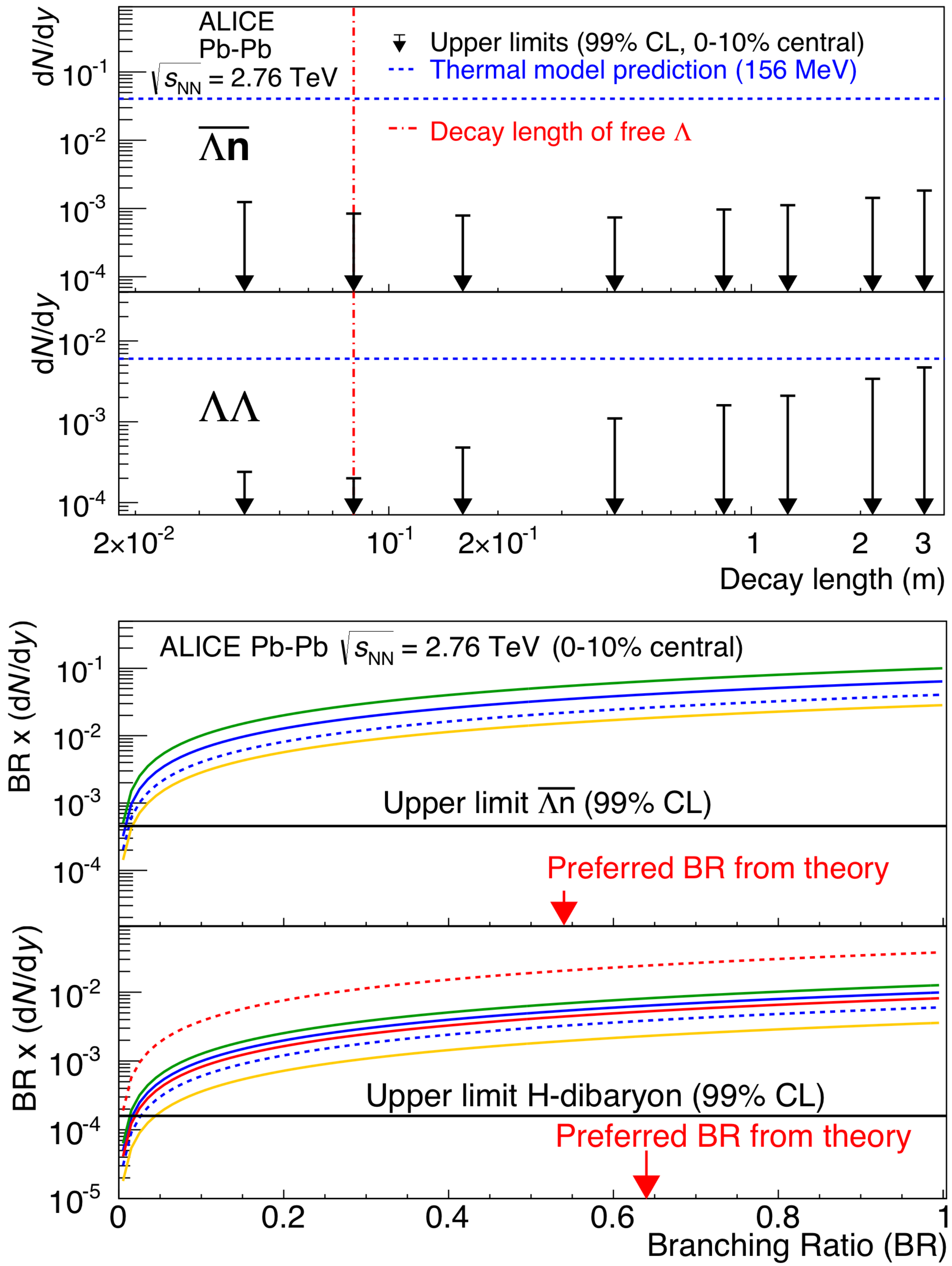

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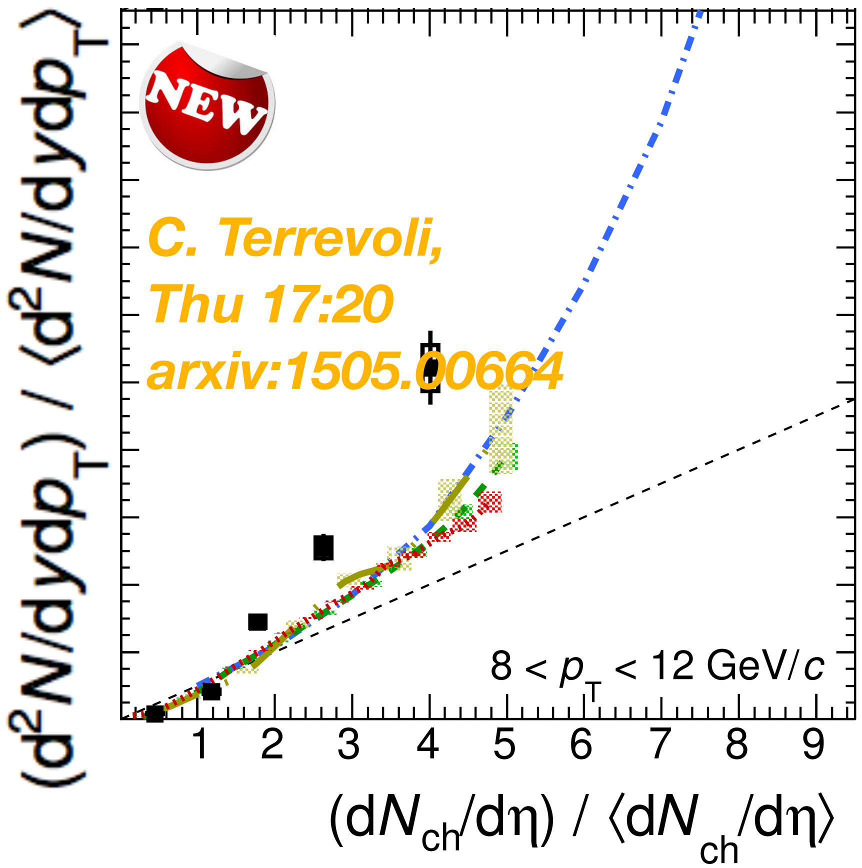
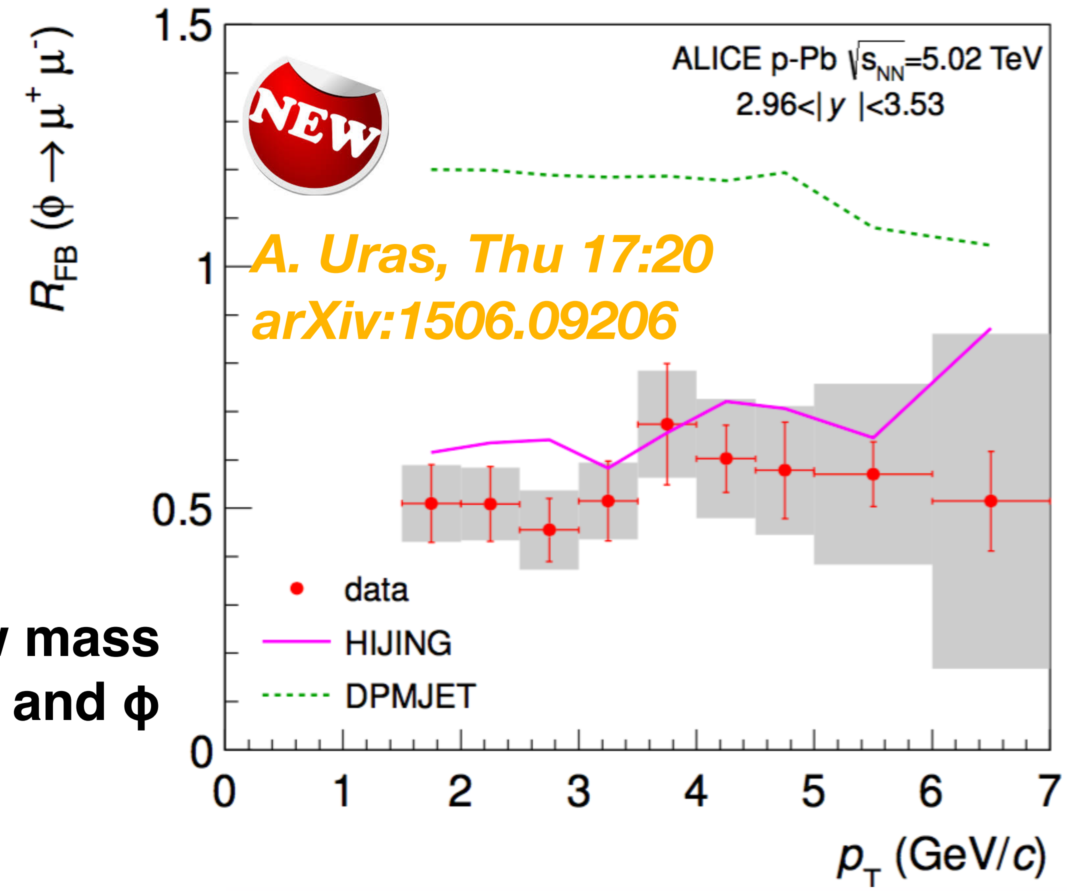
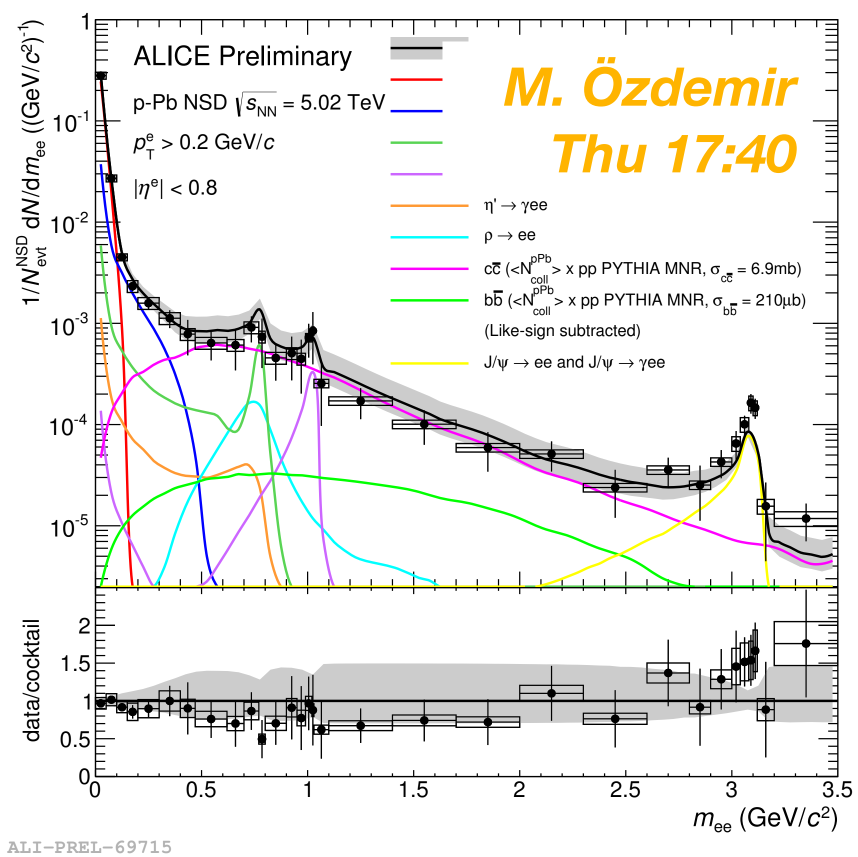
More SQM15 Results



D mesons vs multiplicity in pp & p-Pb

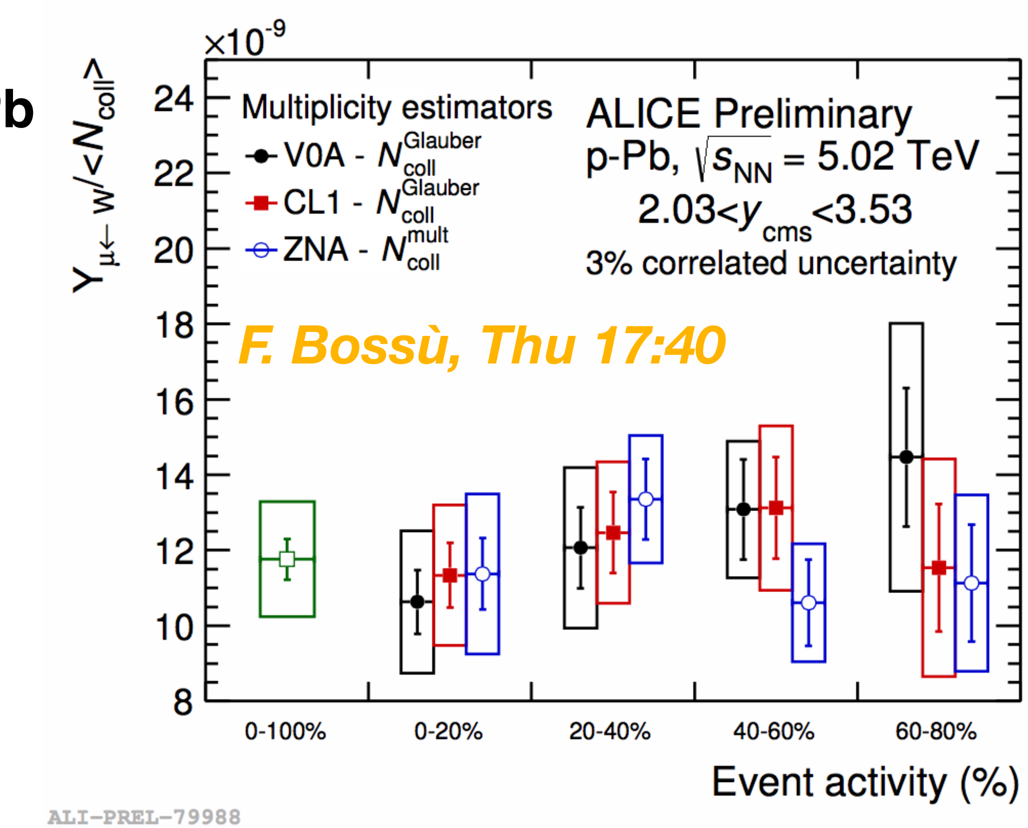


Low mass dielptons and φ



Low mass dielectrons

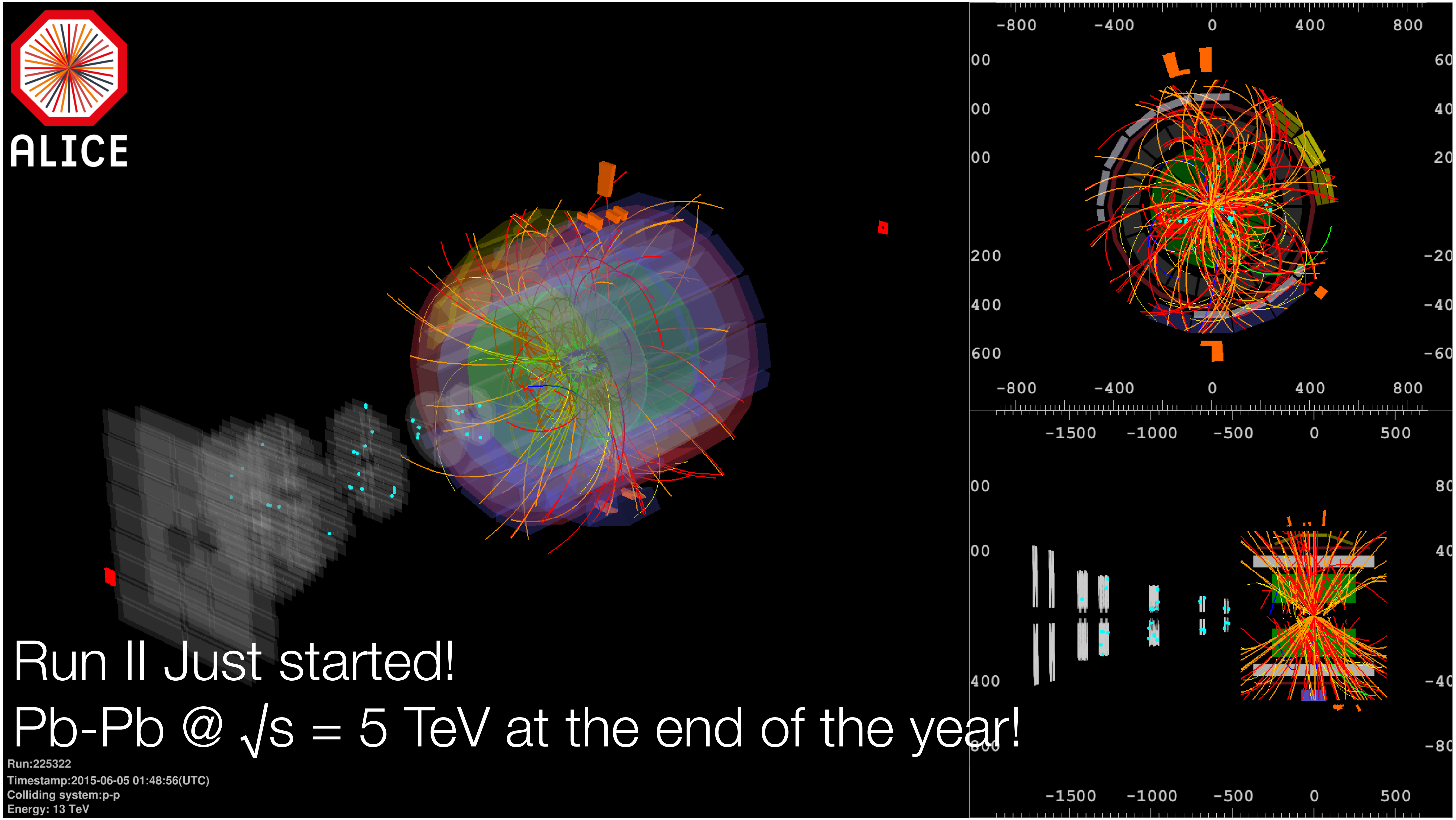
W in p-Pb



Where are we?

- **Flow & collectivity**
  - Long range correlations in p-Pb extend to large rapidities
    - Hydro and role of initial state?
  - Origin of the baryon/meson enhancement?
    - Driven by mass, not seen in jets
- **Small systems and initial state**
  - CNM effects
  - Ultra-peripheral collisions
  - Control of biases is crucial
- **High p_T suppression**
  - R_{AA}^{π} LHC ≃ R_{AA}^{π} RHIC
  - h-jet results: no modification of jet structure (R < 0.5) and no evidence for Moliere scattering
    - Despite jet $R_{AA} < 1$
  - Indication of mass dependent E_{loss}: $R_{AA}^{D\text{-meson}} < R_{AA}^{\text{non-prompt } J/\psi}$
- **Bulk particle production**
  - Strangeness enhancement in small systems
  - Constraints on the role of hadronic phase
  - Extended study of LF zoo (nuclei and searches for exotica)

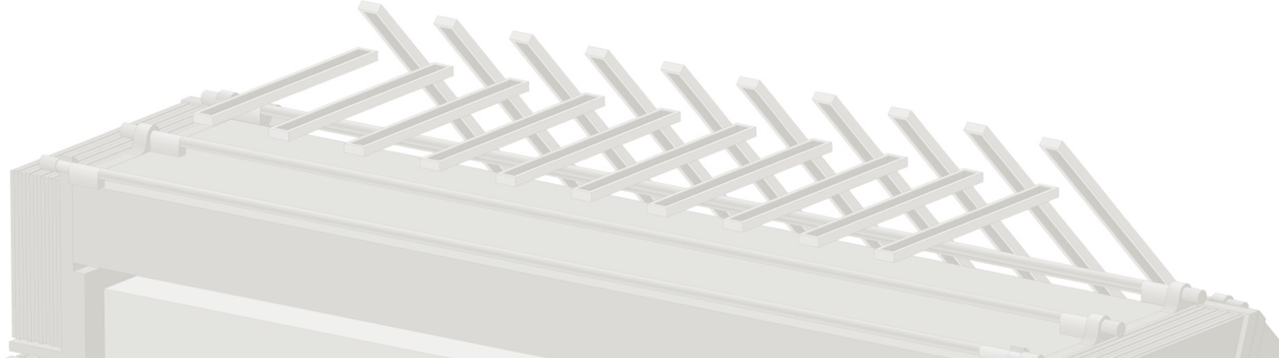
Where are we going?



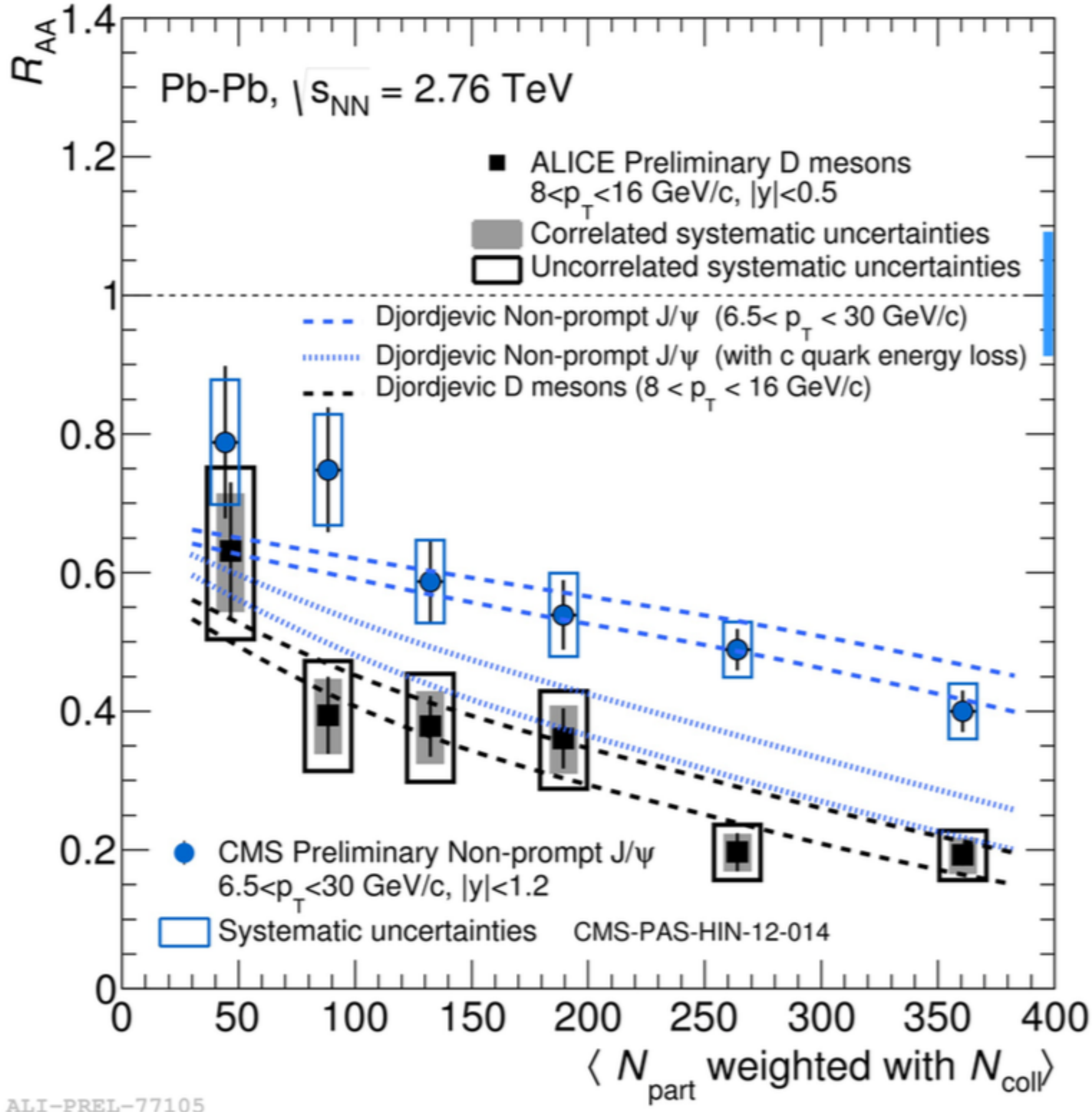
Run II Just started!

Pb-Pb @ $\sqrt{s}$ = 5 TeV at the end of the year!

Run III: See ALICE upgrade talks *A. Dainese, Sat 10:00, F. Fionda, Thu 18:00*

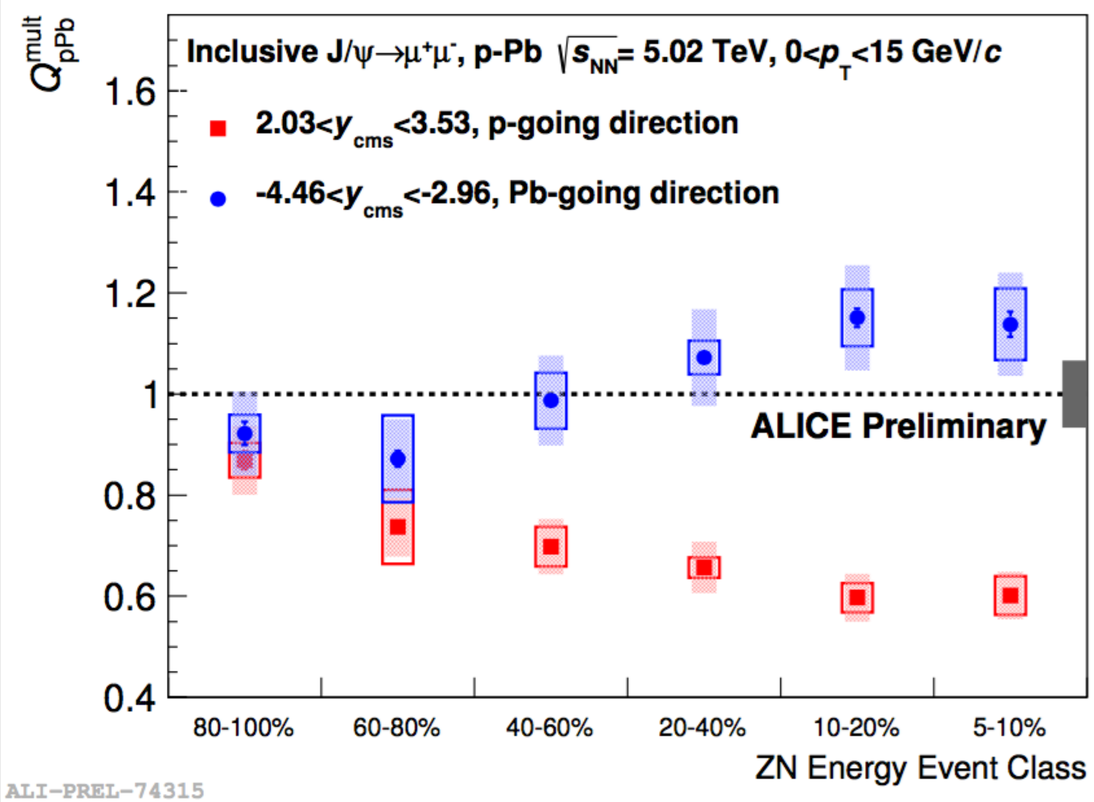


Spare Slides

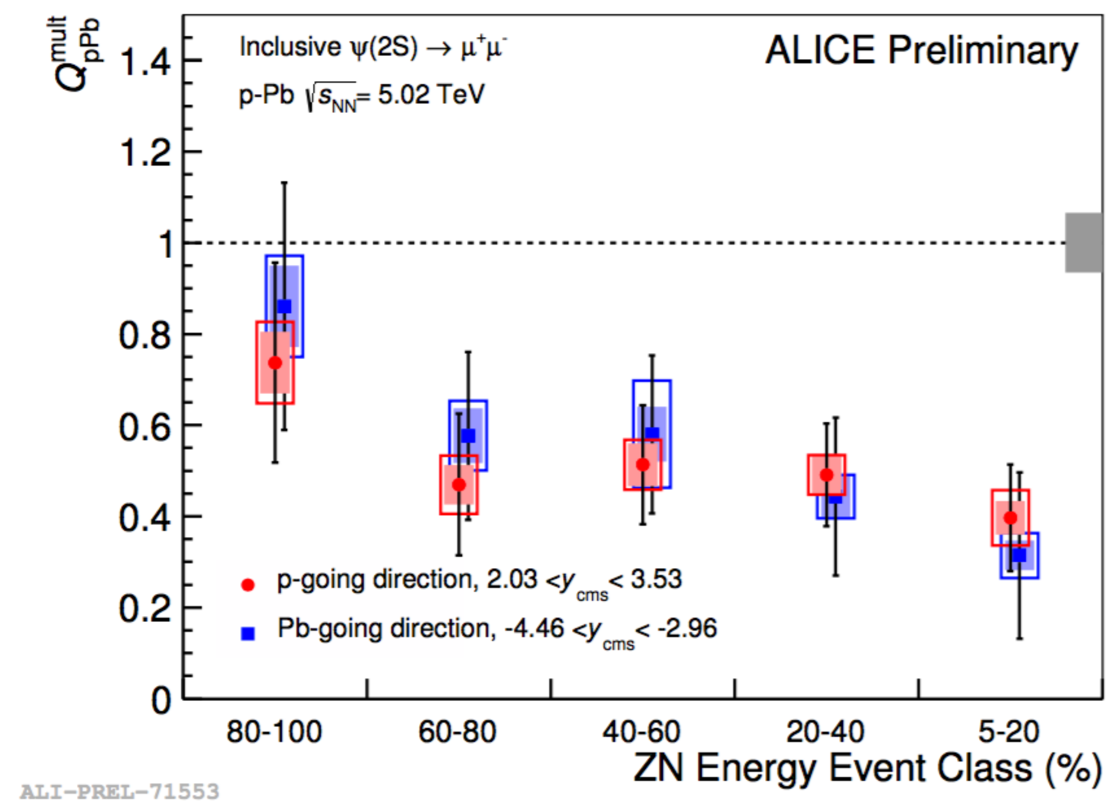


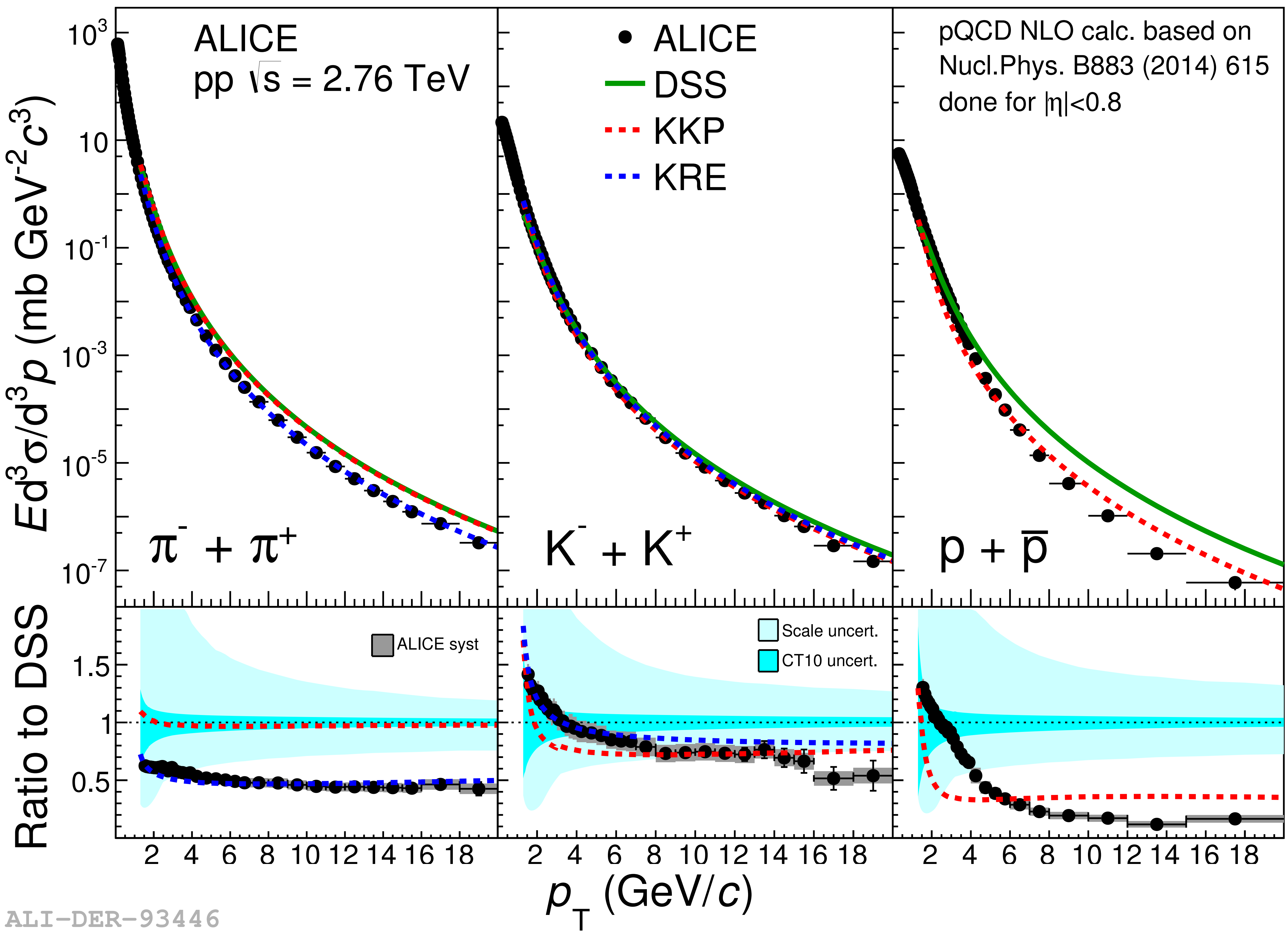
R_{AA}
Pb-Pb, $\sqrt{s_{NN}}$ = 2.76 TeV
ALICE Preliminary D mesons
8<p_T<16 GeV/c, |y|<0.5
Correlated systematic uncertainties
Uncorrelated systematic uncertainties
Djordjevic Non-prompt J/ψ (6.5< p_T < 30 GeV/c)
Djordjevic Non-prompt J/ψ (with c quark energy loss)
Djordjevic D mesons (8 < p_T < 16 GeV/c)
CMS Preliminary Non-prompt J/ψ
6.5<p_T<30 GeV/c, |y|<1.2
Systematic uncertainties
CMS-PAS-HIN-12-014
⟨ N_{part} weighted with N_{coll}⟩
ALI-PREL-77105

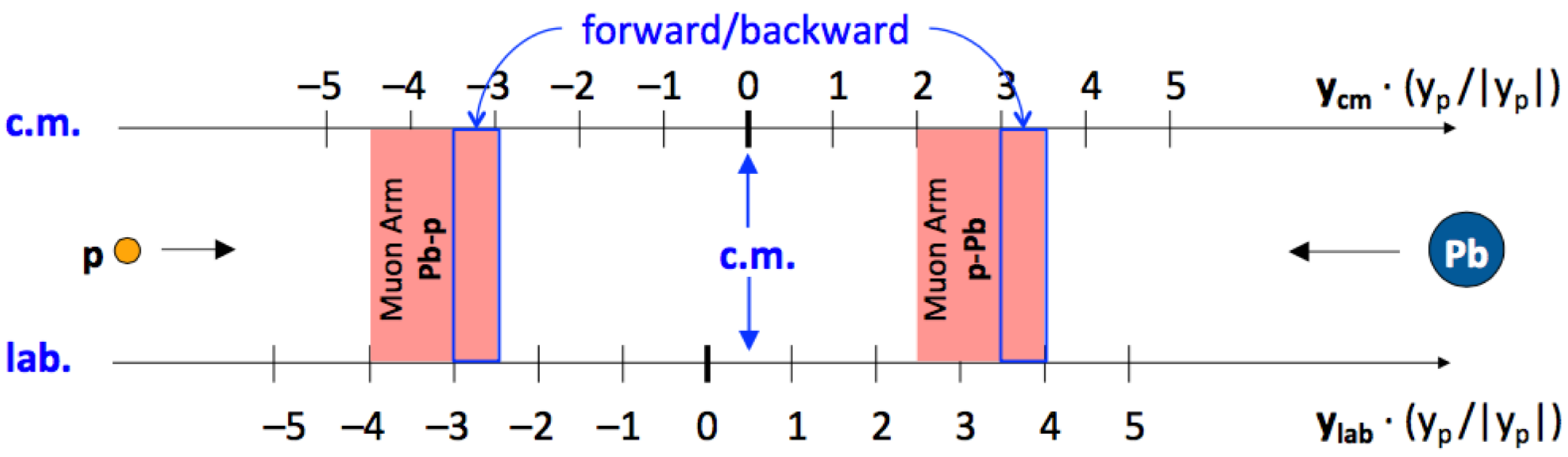
I. Lakomov QM2014



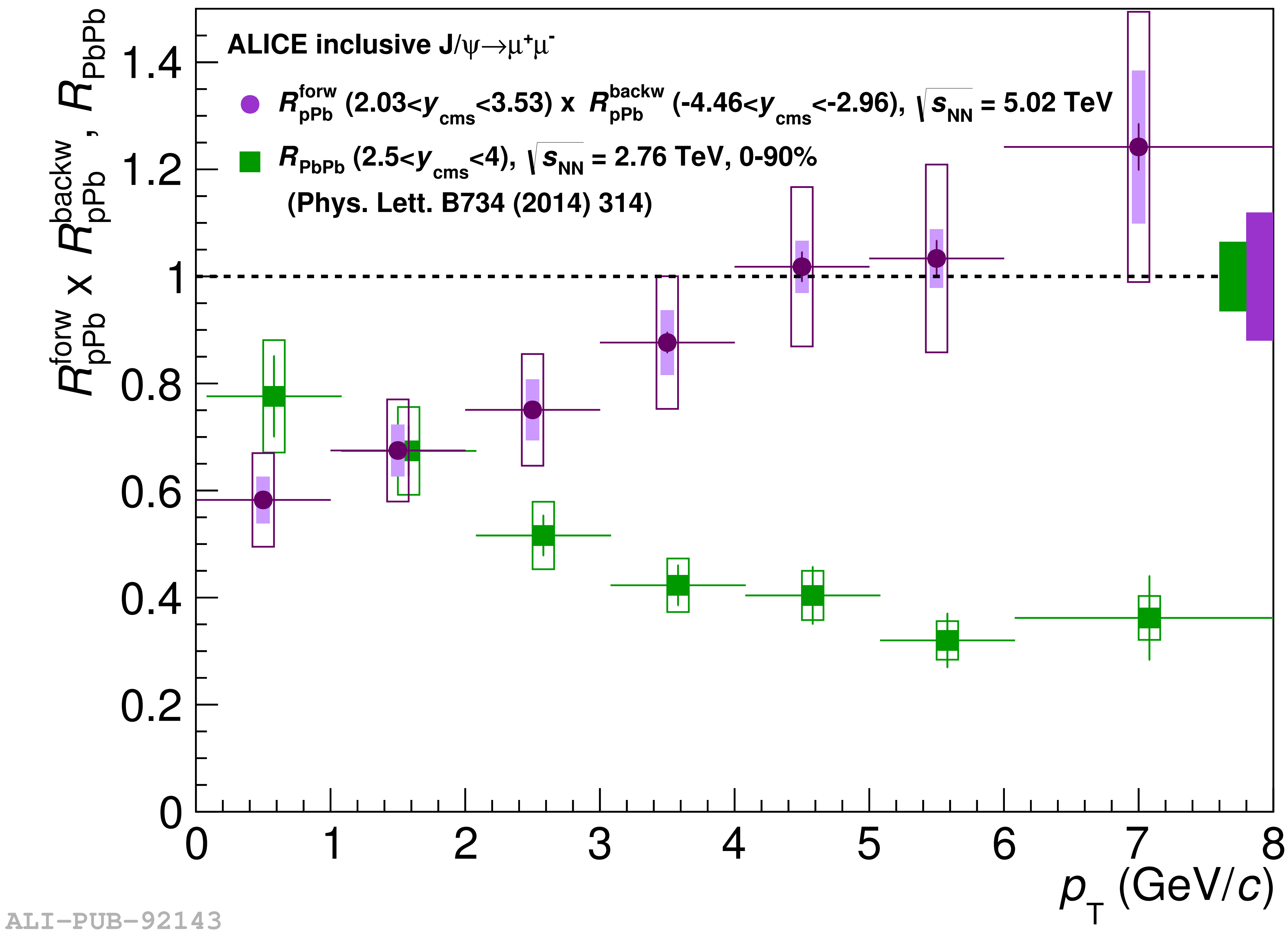
R. Arnaldi QM2014




ALICE
pp √s = 2.76 TeV
ALICE
DSS
KKP
KRE
pQCD NLO calc. based on
Nucl.Phys. B883 (2014) 615
done for |η|<0.8
π⁻ + π⁺
K⁻ + K⁺
p + p̄
ALICE syst
Scale uncert.
CT10 uncert.
Ed³σ/d³p (mb GeV⁻²c³)
Ratio to DSS
p_T (GeV/c)
ALI-DER-93446


forward/backward
c.m.
−5 −4 −3 −2 −1 0 1 2 3 4 5
$y_{cm} \cdot (y_p/|y_p|)$
Muon Arm
Pb-p
Muon Arm
p-Pb
p
c.m.
Pb
lab.
−5 −4 −3 −2 −1 0 1 2 3 4 5
$y_{lab} \cdot (y_p/|y_p|)$

CNM and J/psi


ALICE inclusive J/ψ→μ⁺μ⁻
R^{forw}_{pPb} (2.03<y_{cms}<3.53) x R^{backw}_{pPb} (-4.46<y_{cms}<-2.96), $\sqrt{s_{NN}}$ = 5.02 TeV
R_{PbPb} (2.5<y_{cms}<4), $\sqrt{s_{NN}}$ = 2.76 TeV, 0-90%
(Phys. Lett. B734 (2014) 314)
R^{forw}_{pPb} x R^{backw}_{pPb} , R_{PbPb}
p_T (GeV/c)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
1
2
3
4
5
6
7
8
ALI-PUB-92143