Inclusive jet measurements in pp and Pb-Pb collisions with ALICE

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on behalf of the ALICE Collaboration

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Aix-Les-Bains, France

Wright Laboratory Yale

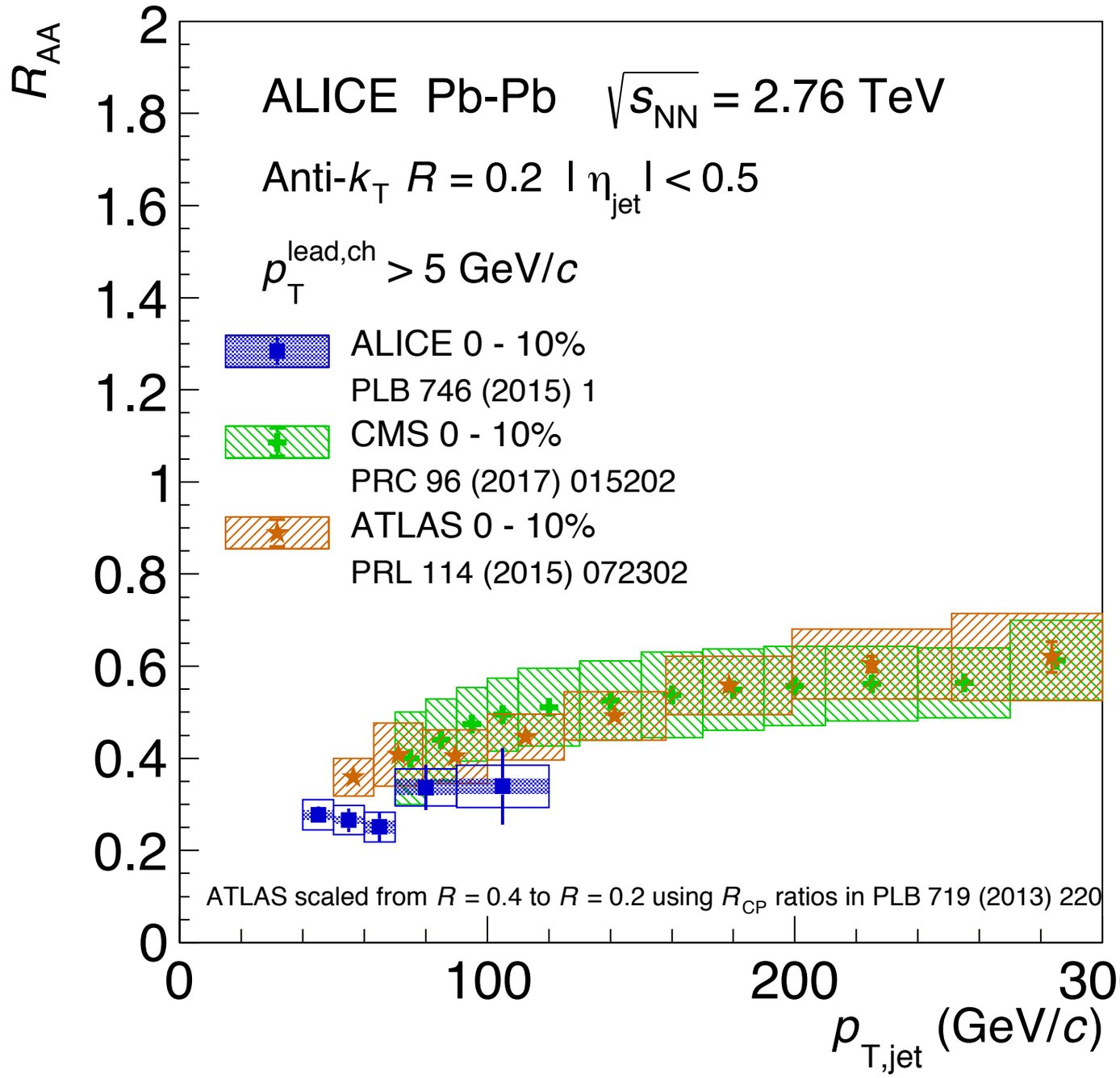
ALICE

Jet yields are suppressed in heavy-ion collisions

$$R_{AA} = \frac{\frac{1}{\langle T_{AA} \rangle} \frac{1}{N_{event}} \frac{d^2N}{dp_T d\eta}\Big|_{AA}}{\frac{d^2\sigma}{dp_T d\eta}\Big|_{pp}}$$

Inclusive jet measurements show that jets in central Pb-Pb collisions lose on average ~10-20% of their energy, depending on $p_{T,jet}$

The energy loss fraction gradually decreases as $p_{T,jet}$ increases



ALI-DER-310487

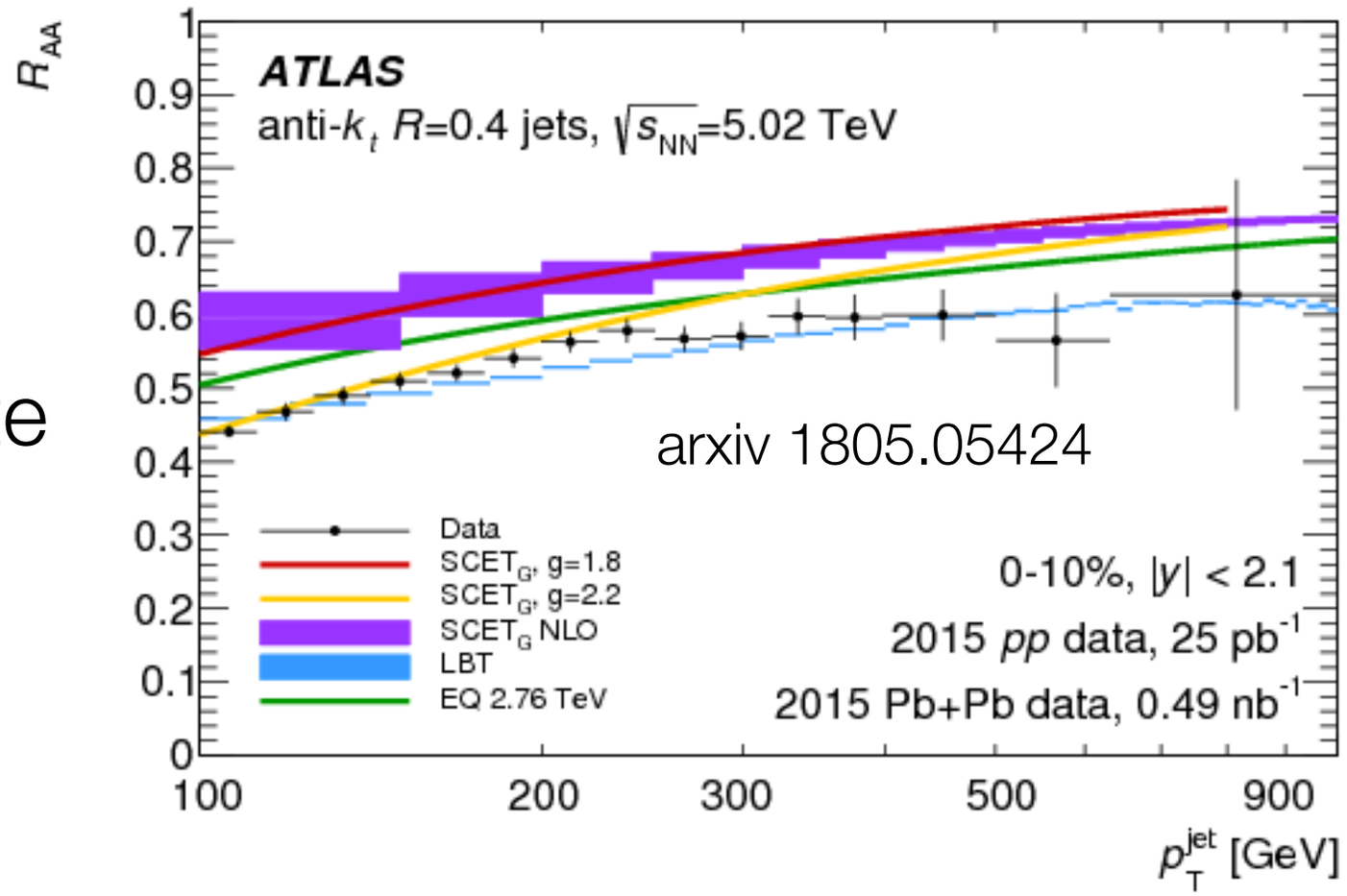
How well do we understand jet R_{AA}?

Can we distinguish jet energy loss models using jet R_{AA}?

- All models have strong quenching, decreasing with p_T
- There are slight differences in the absolute level of quenching, and the p_T-dependence of quenching

ATLAS jet R_{AA} measurement at 5.02 TeV from p_T = 100-1000 GeV

High precision!

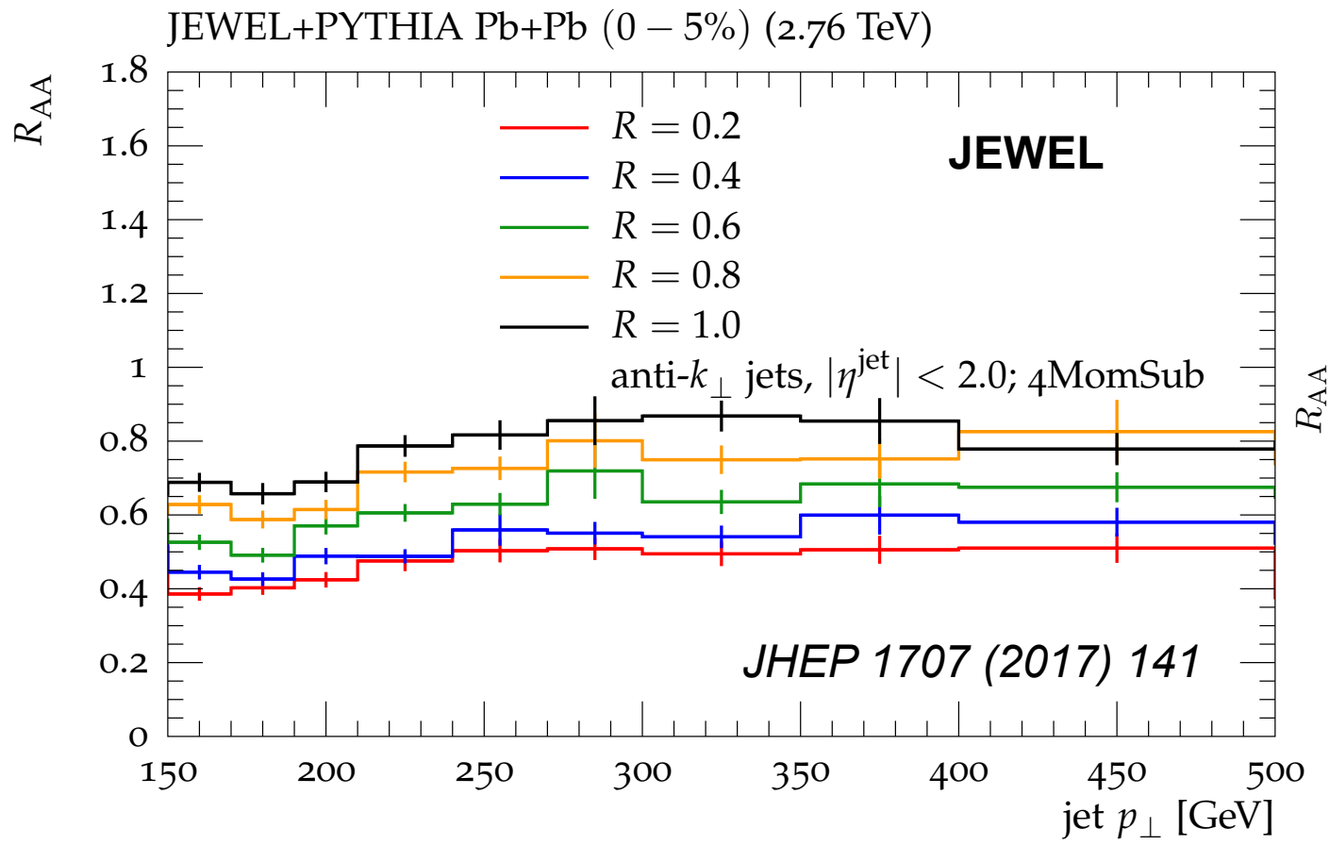


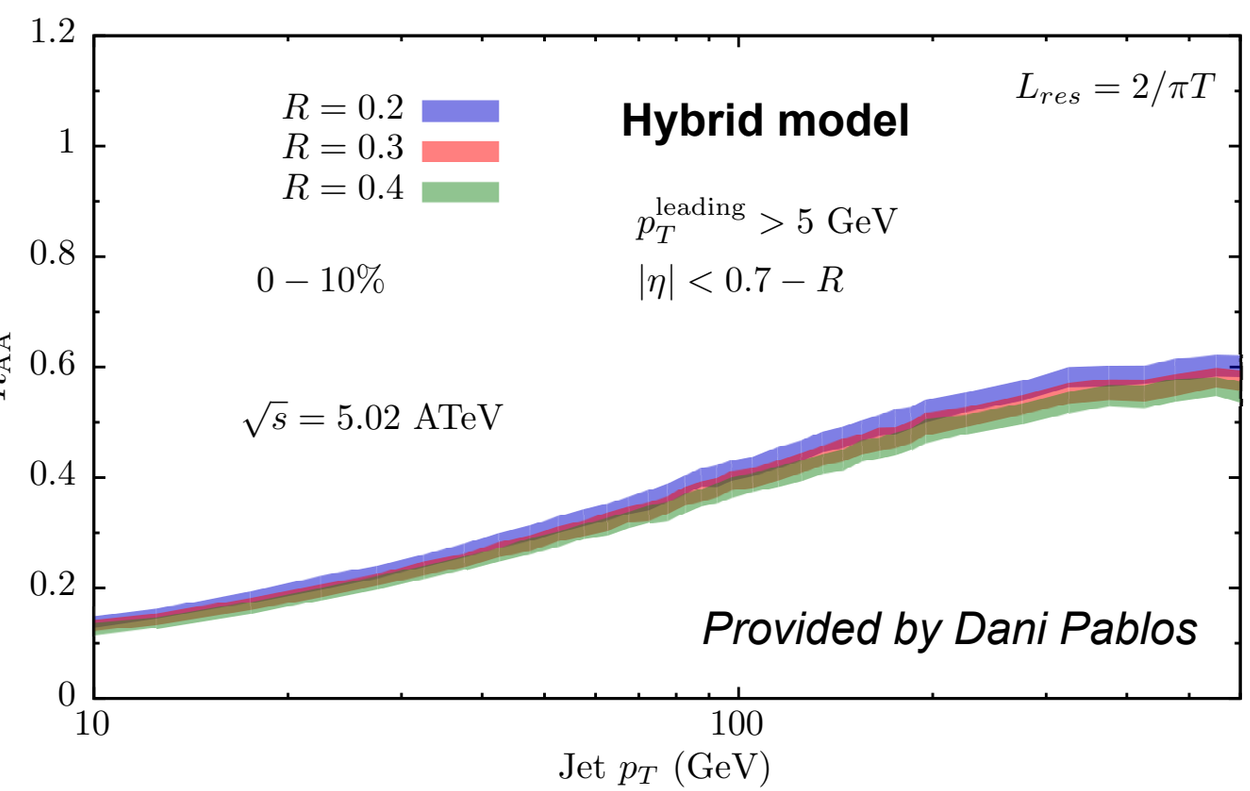
What about at low p_T? → Strongest p_T-dependence

How well do we understand jet R_{AA}?

Can we distinguish the *R*-dependence of jet energy loss?

- *Do we recover induced gluon radiation and/or medium recoil? (Less suppression as R increases)*
- *Or do smaller R jets tend to be more collimated, and therefore less quenched? (More suppression as R increases)*

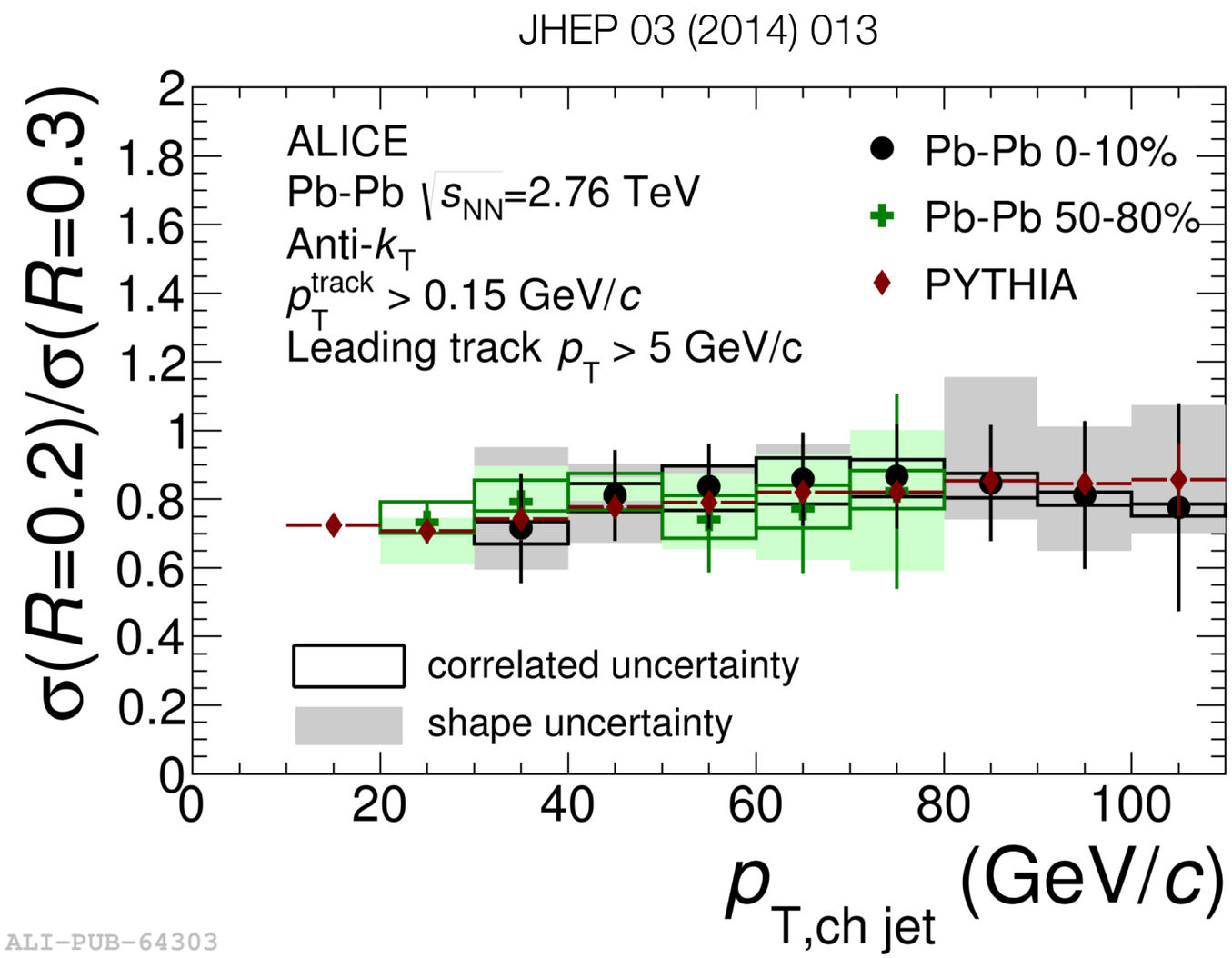




→ Can we achieve sufficient experimental precision to distinguish whether jet R_{AA} increases or decreases with jet *R*?

Do measurements show an *R*-dependence?

- **ALICE charged jets**
  - **No modification in ratio *R*=0.2/*R*=0.3**
- CMS jet R_{AA}
  - No significant modification *R*=0.2-0.4
- ATLAS R_{CP}
  - Significant modification for *R*=0.2-0.5
- Jet shapes (ALICE, CMS) show modification, hadron-jet coincidence measurement (ALICE) shows no significant intra-jet broadening from *R*=0.2-0.5, …



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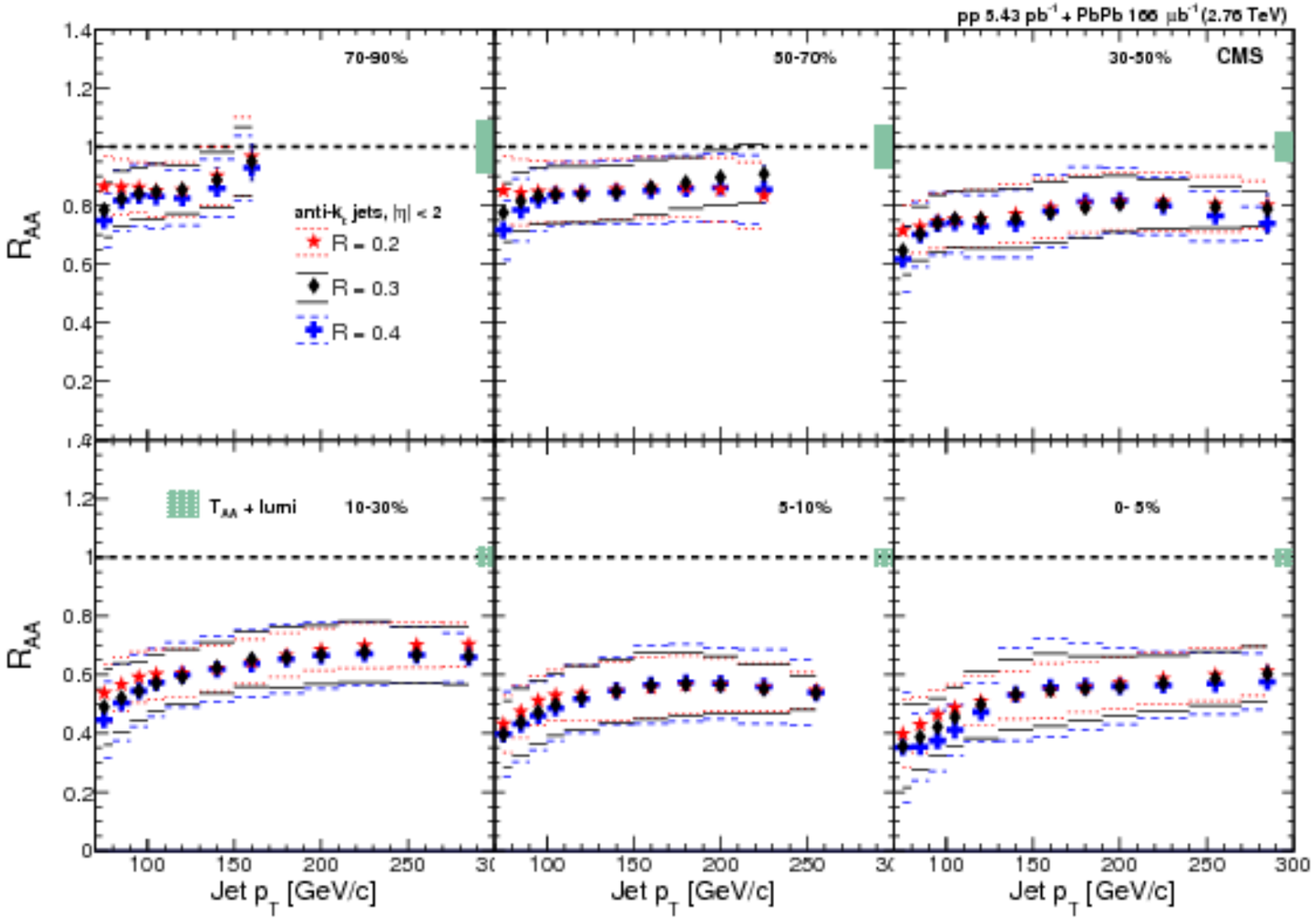
Phys. Rev. C 96 (2017) 015202



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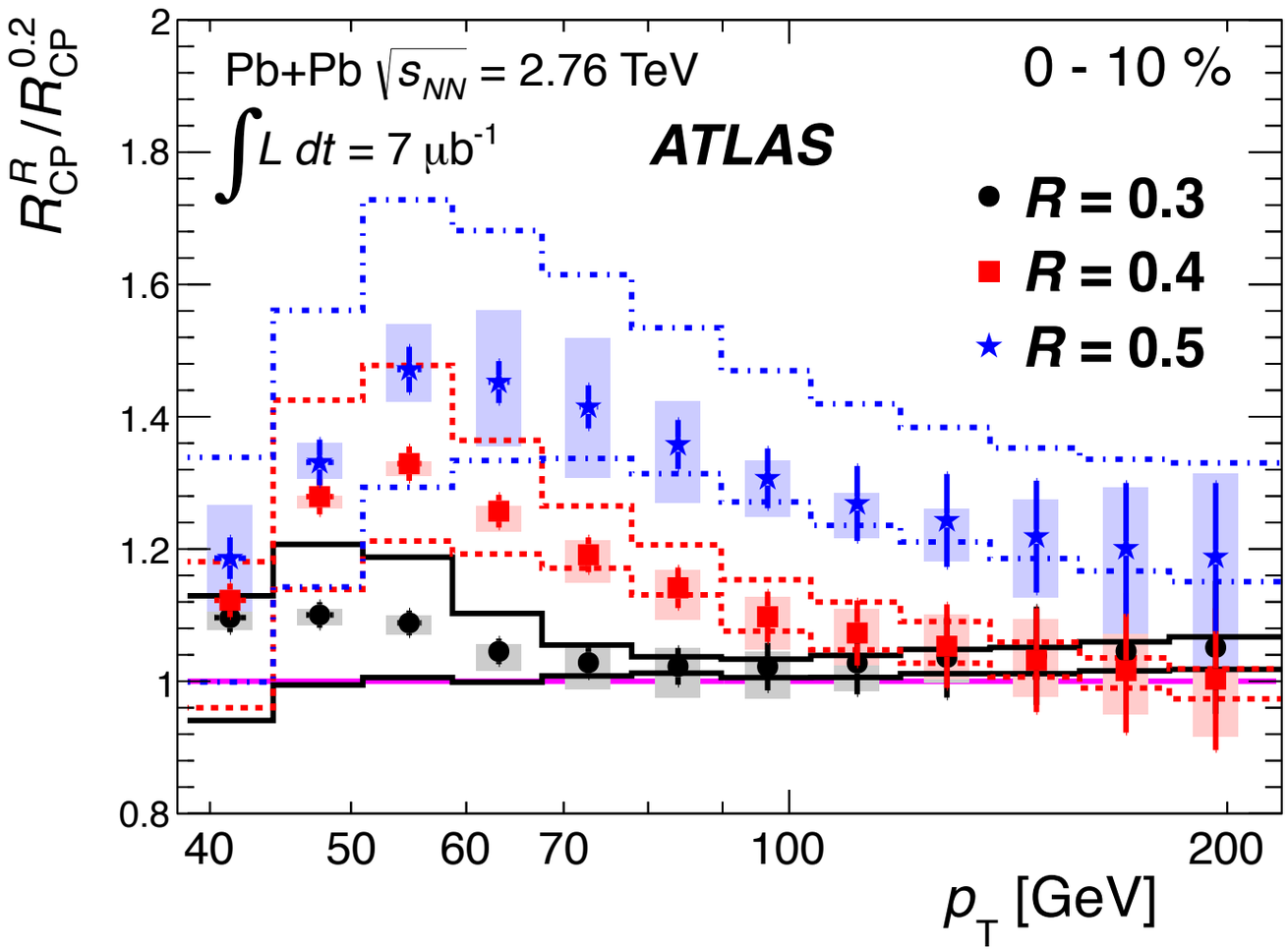
Phys. Lett. B 719 (2013) 220-241



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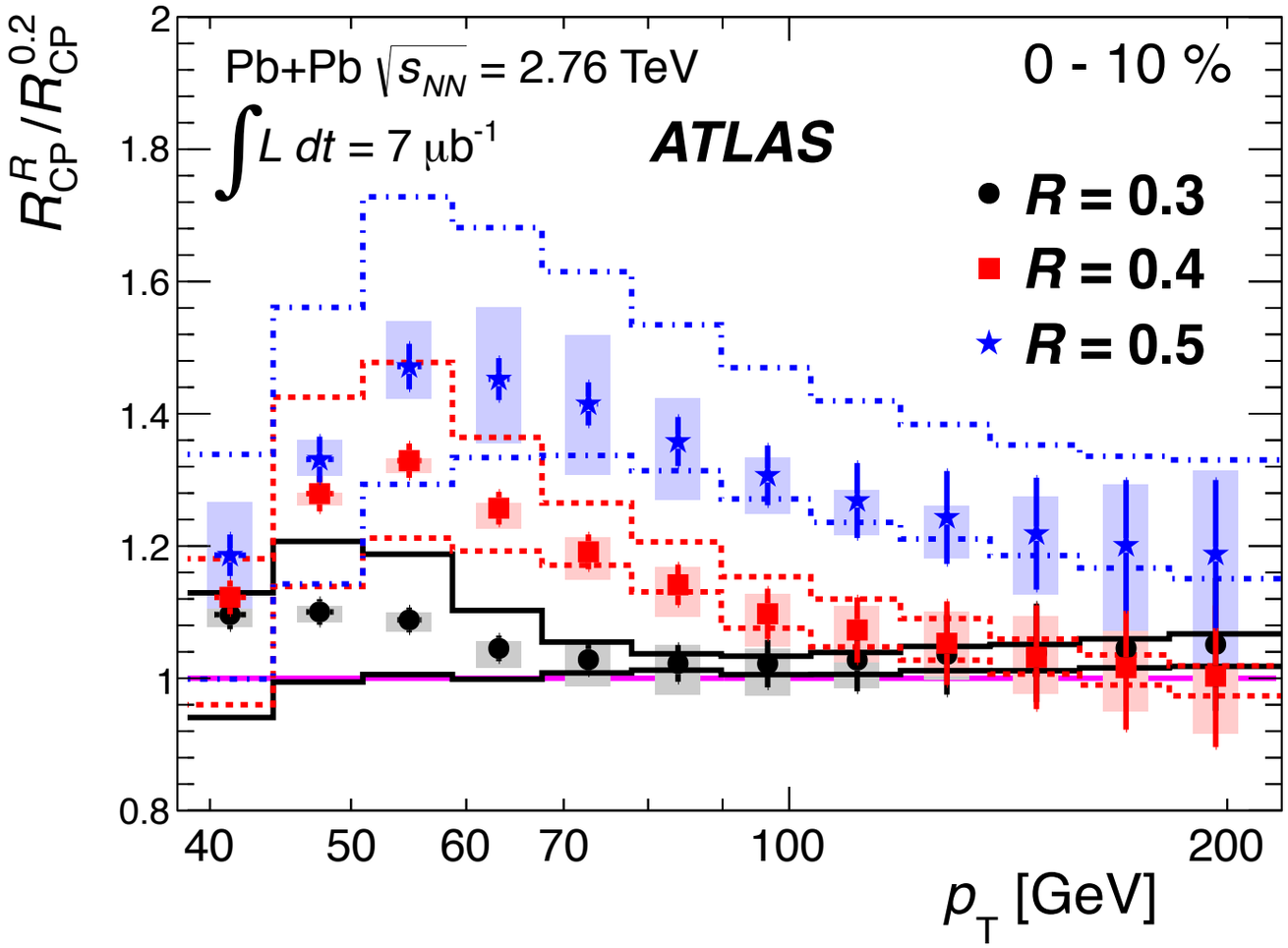
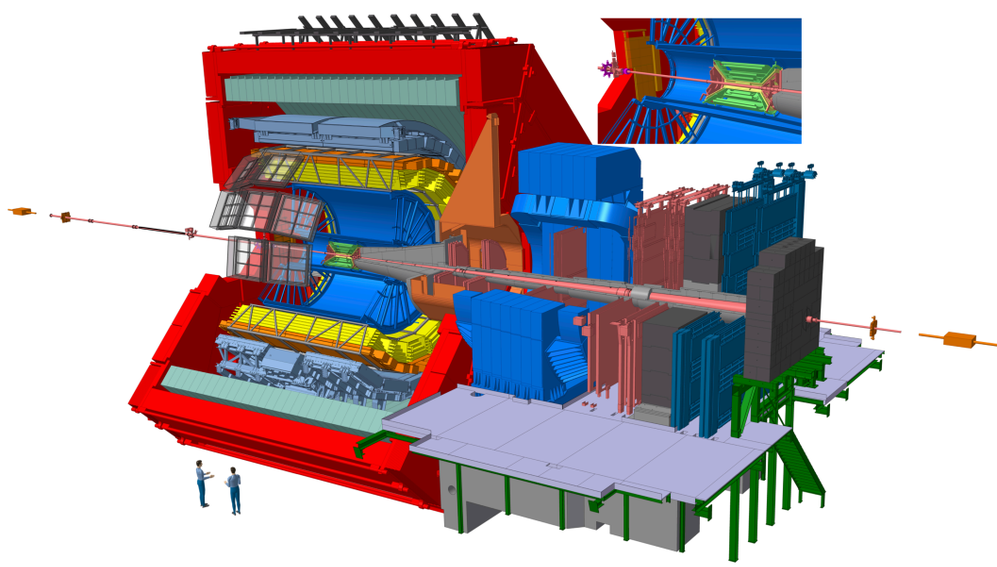


Measurements do not provide a clear picture

Measuring jets in ALICE

ALICE reconstructs jets at mid-rapidity ($\eta < 0.7$) in pp, p-Pb, Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76 - 13$ TeV

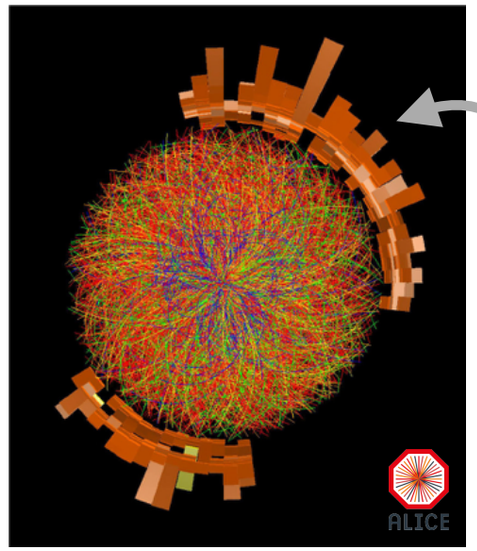


Charged particle jets (*charged jets*)

- High-precision tracking down to $p_{\mathrm{T,track}} = 150$ MeV/c

Jets (*full jets*)

- Addition of particle information from the EM calorimeter down to $p_{\mathrm{T,cluster}} = 300$ MeV/c



EMCal φ acceptance: 108°

Measuring jets in ALICE

Most ALICE jet measurements use charged particle jets

Today, I will focus on ***full jets*** (charged + neutral)

- **Full jets allow a direct comparison to theory**
- But significant experimental complication!
  - And reduced statistics due to limited coverage

Measuring jets in ALICE

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Inclusive jet measurement in pp, Pb-Pb at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV

1. Measure jet R_{AA} for R=0.2-0.4
2. Measure Pb-Pb jet cross-section ratio

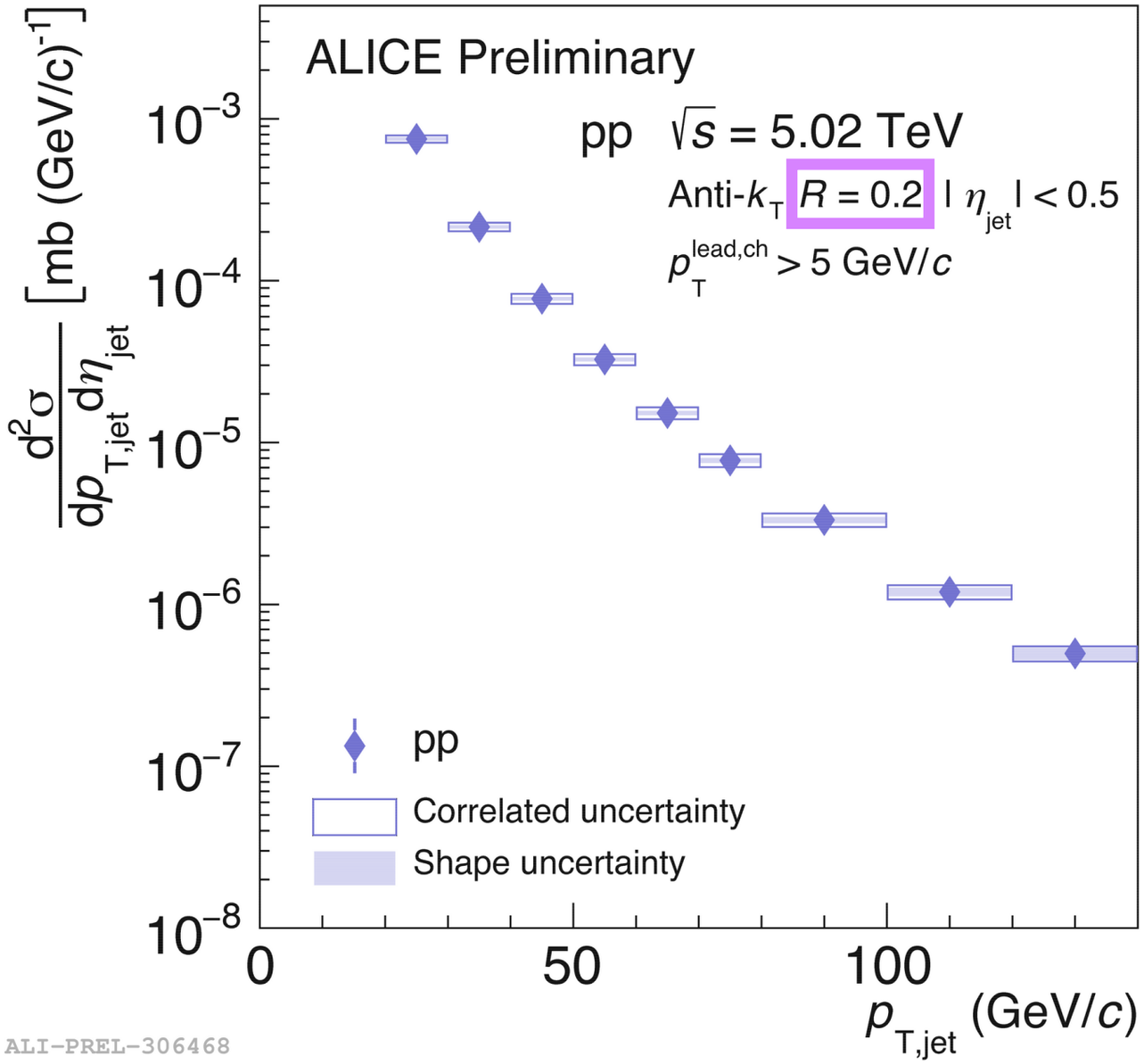
Analysis strategy

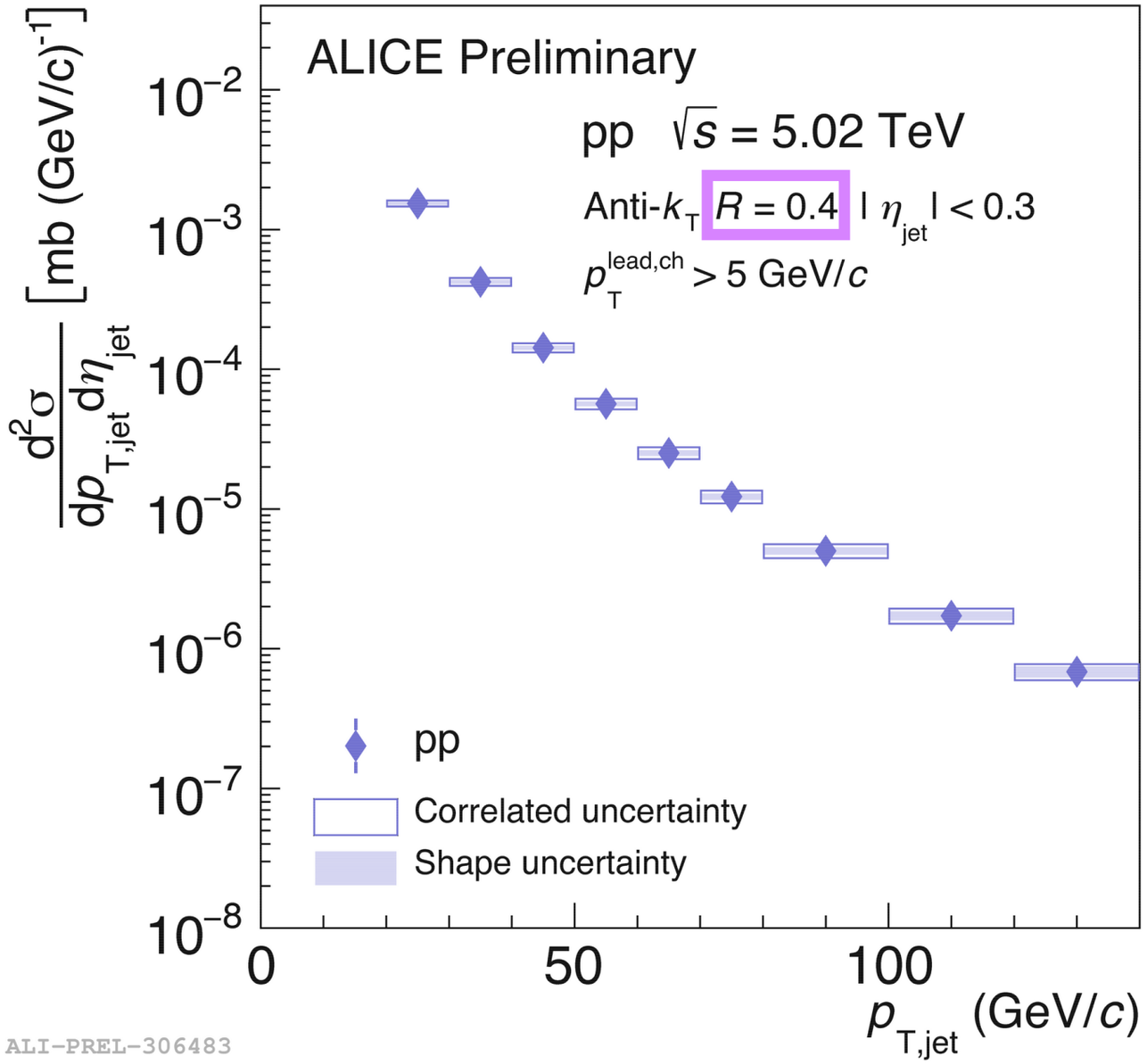
- **Three main pieces to the analysis:**
  - Measure the jet p_T — combine track p_T and EMCal p_T
  - Subtract the combinatorial background event-by-event
  - Correct the jet p_T for detector and resolution effects

- **Improvements relative to the 2.76 TeV ALICE analysis**
  - Extend to R=0.4
    - Allows examination of modification to jet shape
  - Refine analysis technique
    - Better understanding of our tracking and calorimetry
    - Utilization of embedding-based jet p_T correction

Results — pp jet cross-section

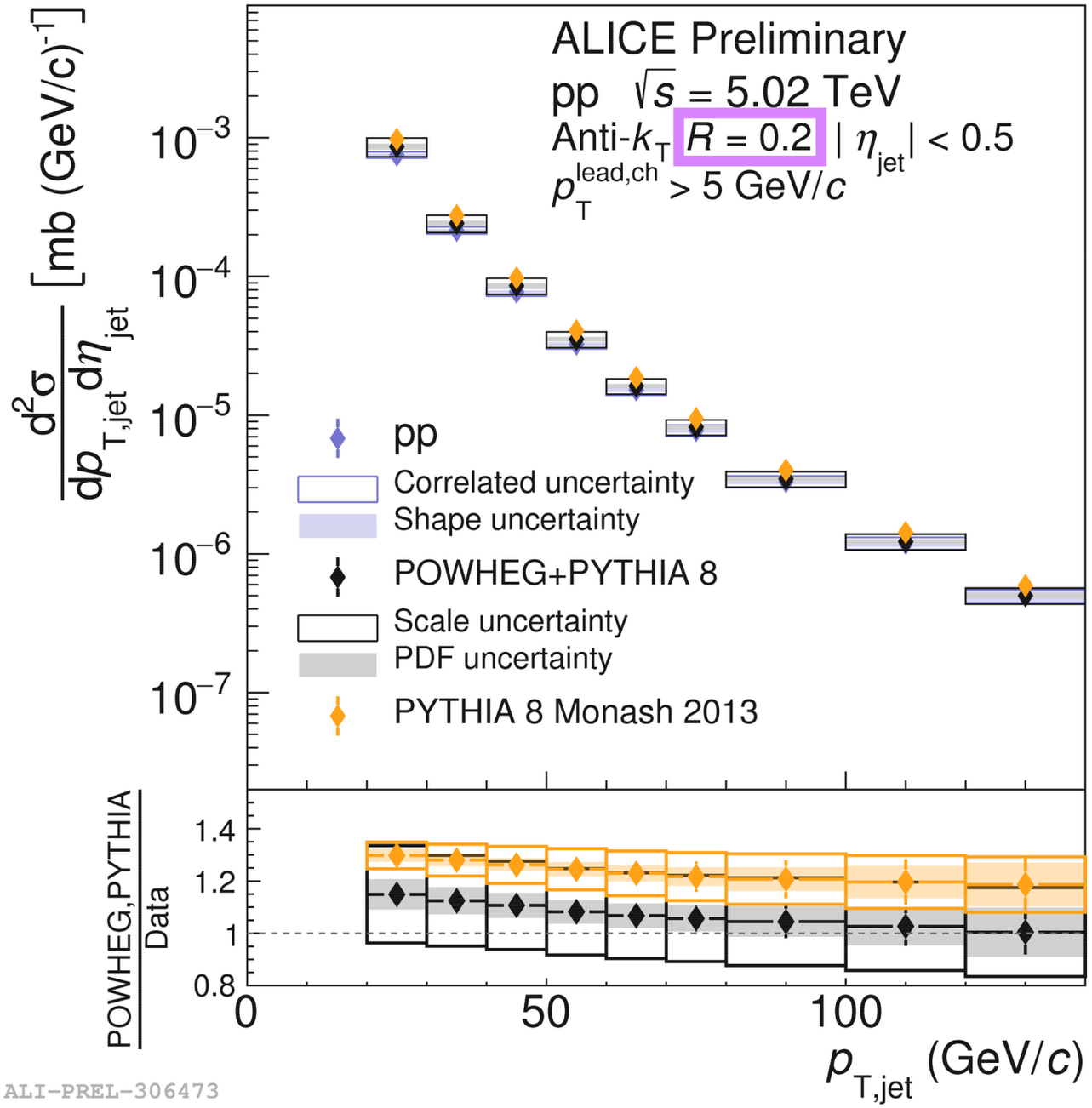
We measure the inclusive pp jet cross-section for $p_{T,jet}$ = 20-140 GeV/c at 5.02 TeV as a reference for jet R_{AA}





Results — pp jet cross-section

The measurement is consistent with POWHEG + Pythia8



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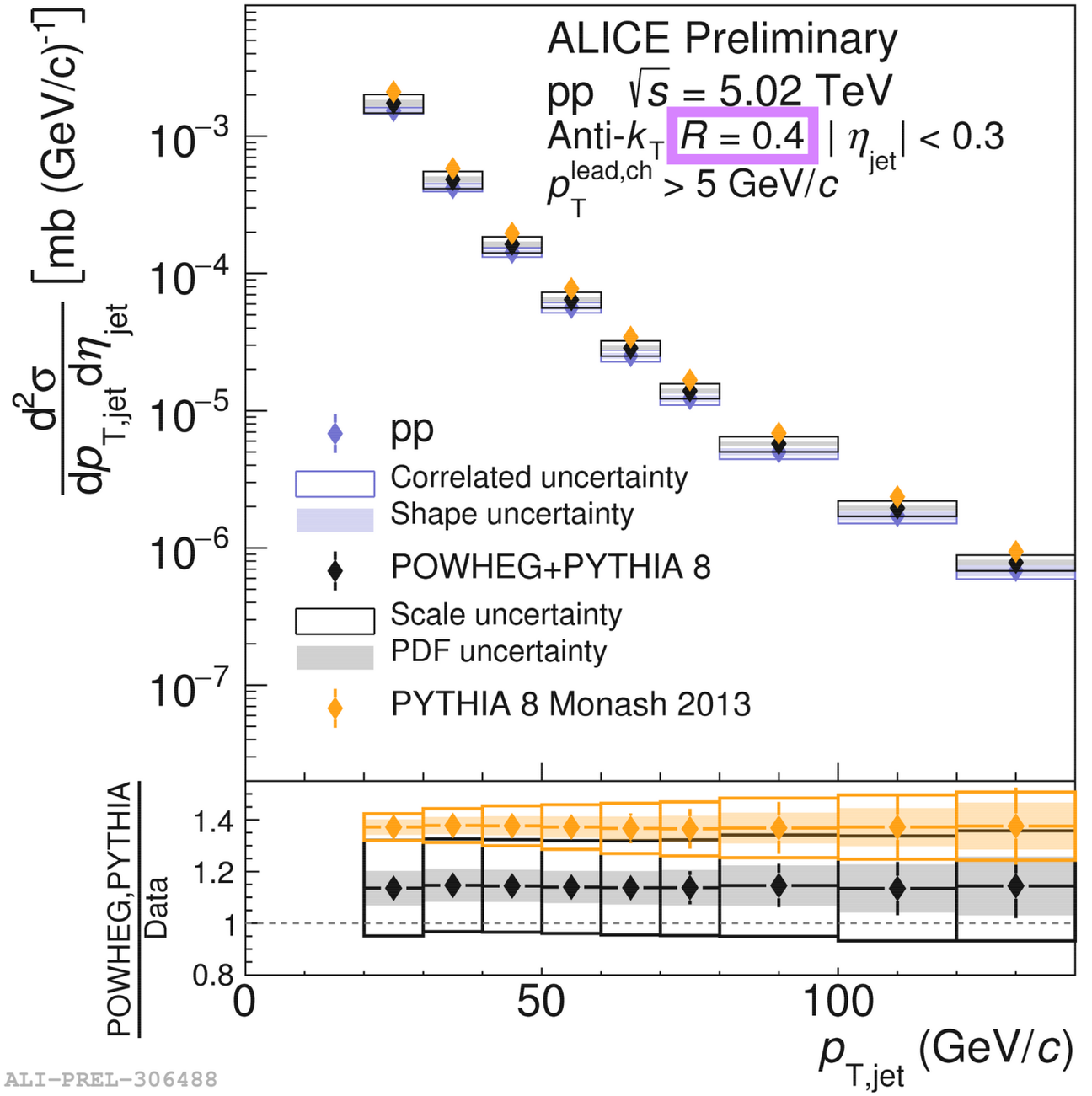

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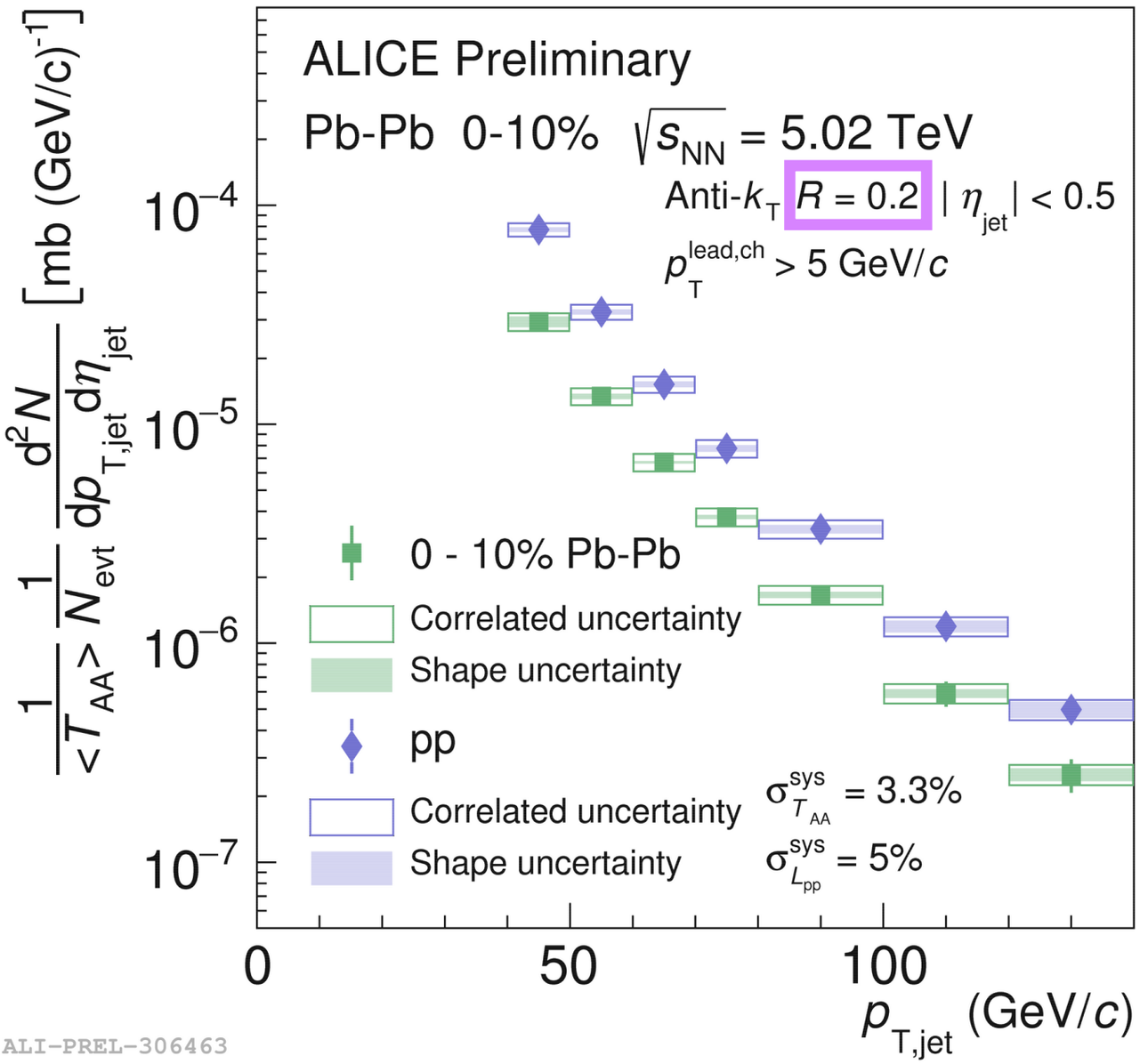
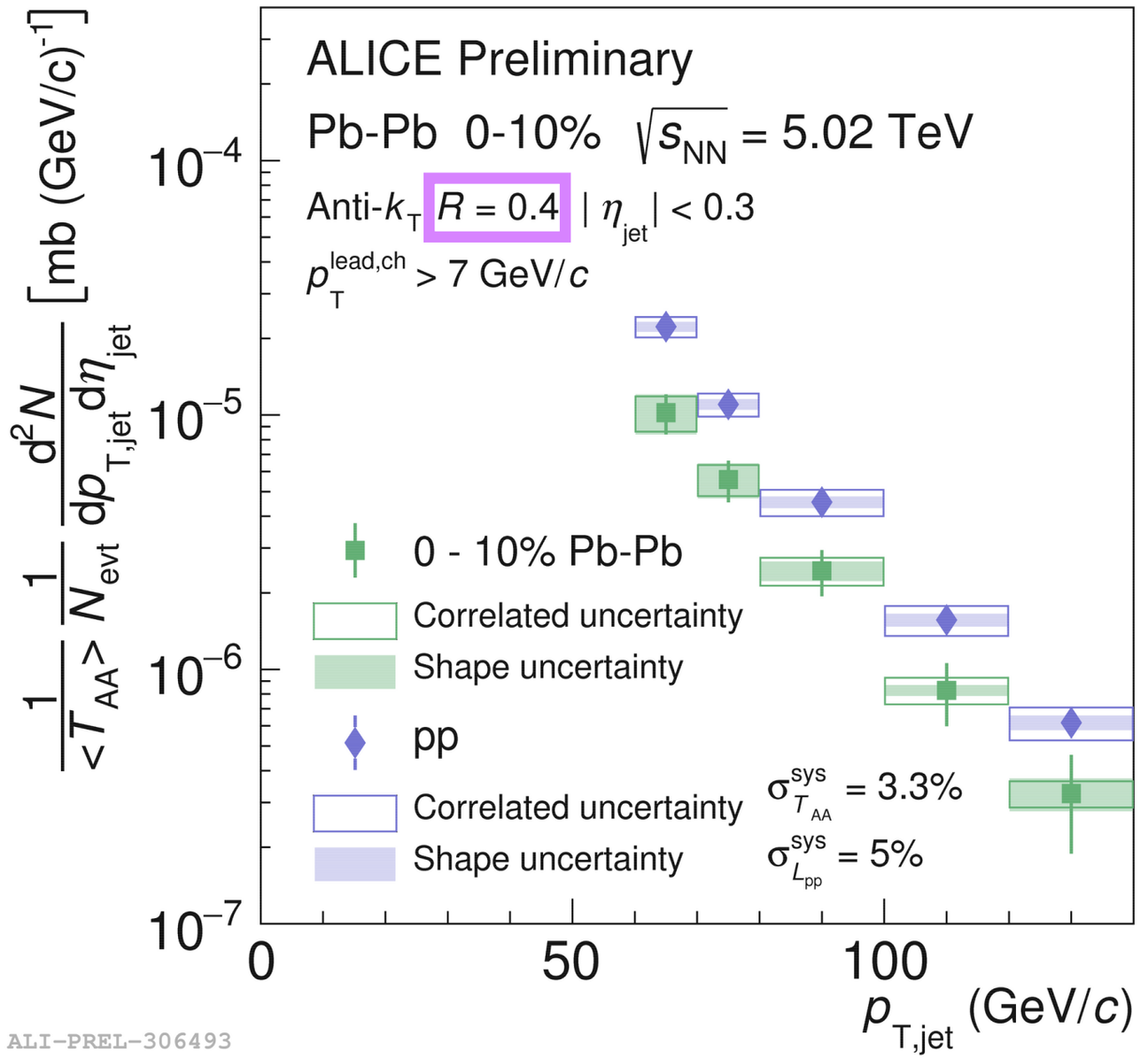
Results — Pb-Pb jet spectra

We measure the Pb-Pb jet spectrum in 0-10% centrality for $p_{\mathrm{T,jet}} = 40\text{-}140$ GeV/c

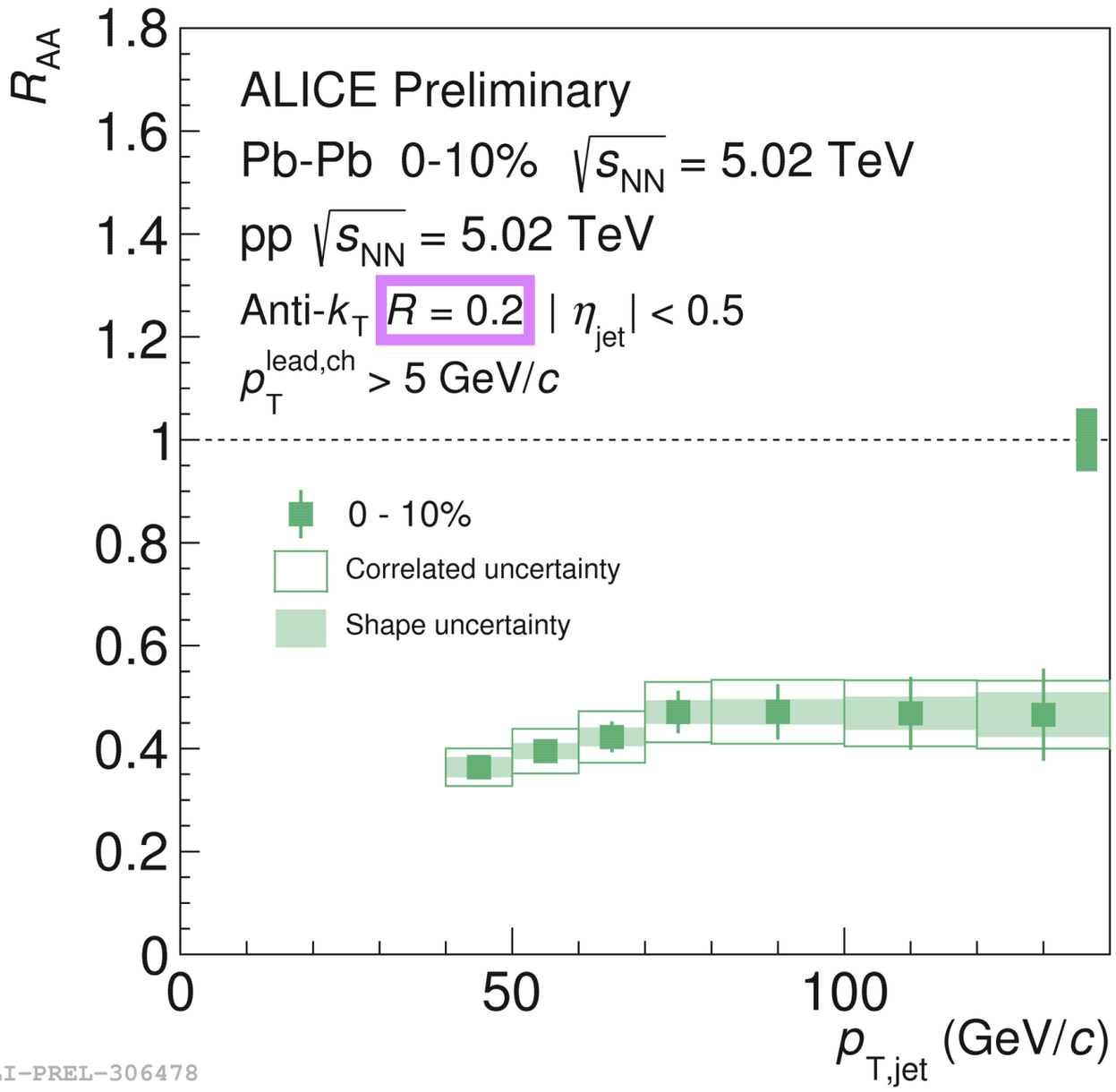


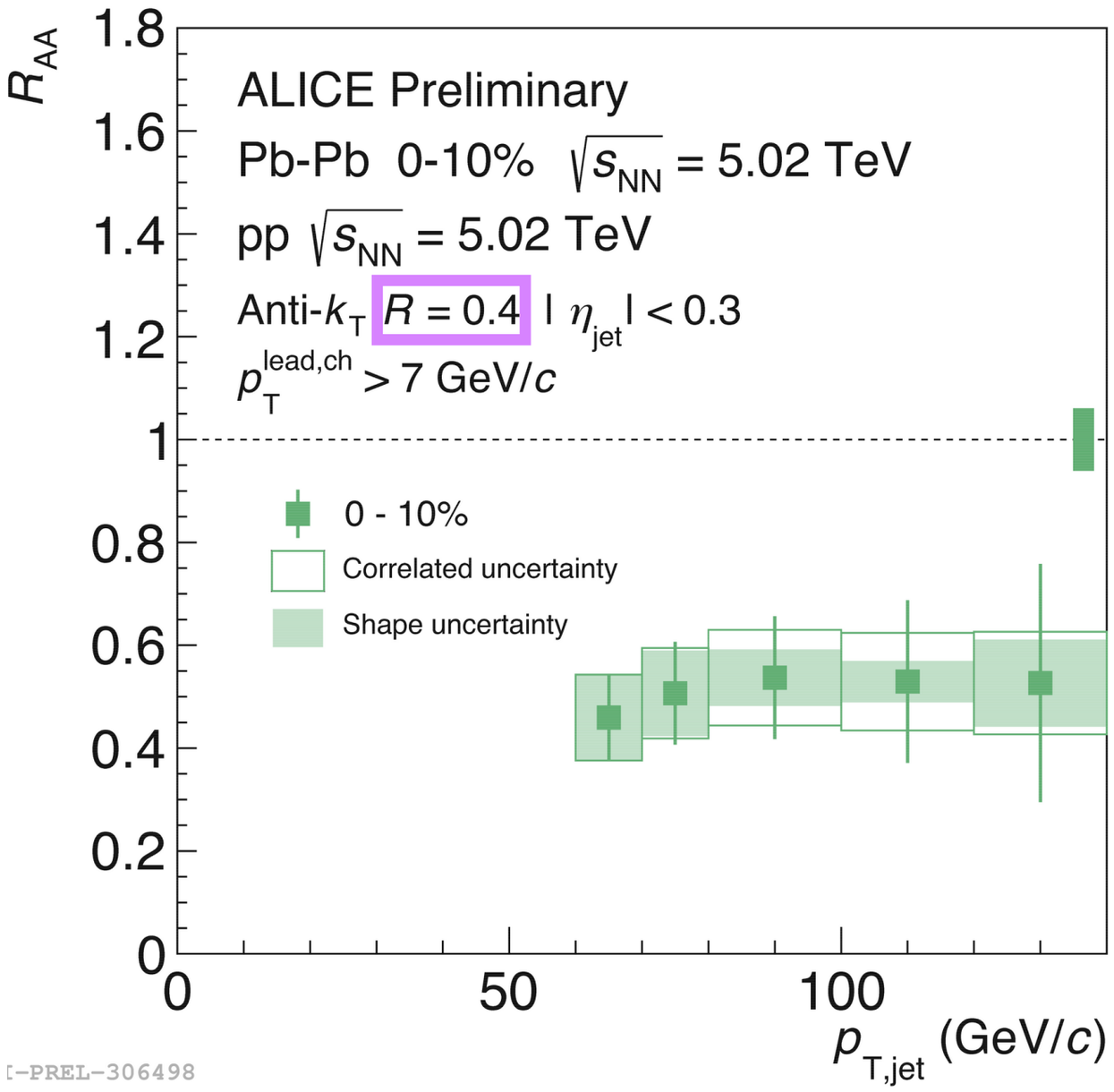


Results — Jet R_{AA}

The first full jet R_{AA} measurement at $\boldsymbol{p_{T,jet} < 100}$ **GeV/*c*** at 5.02 TeV

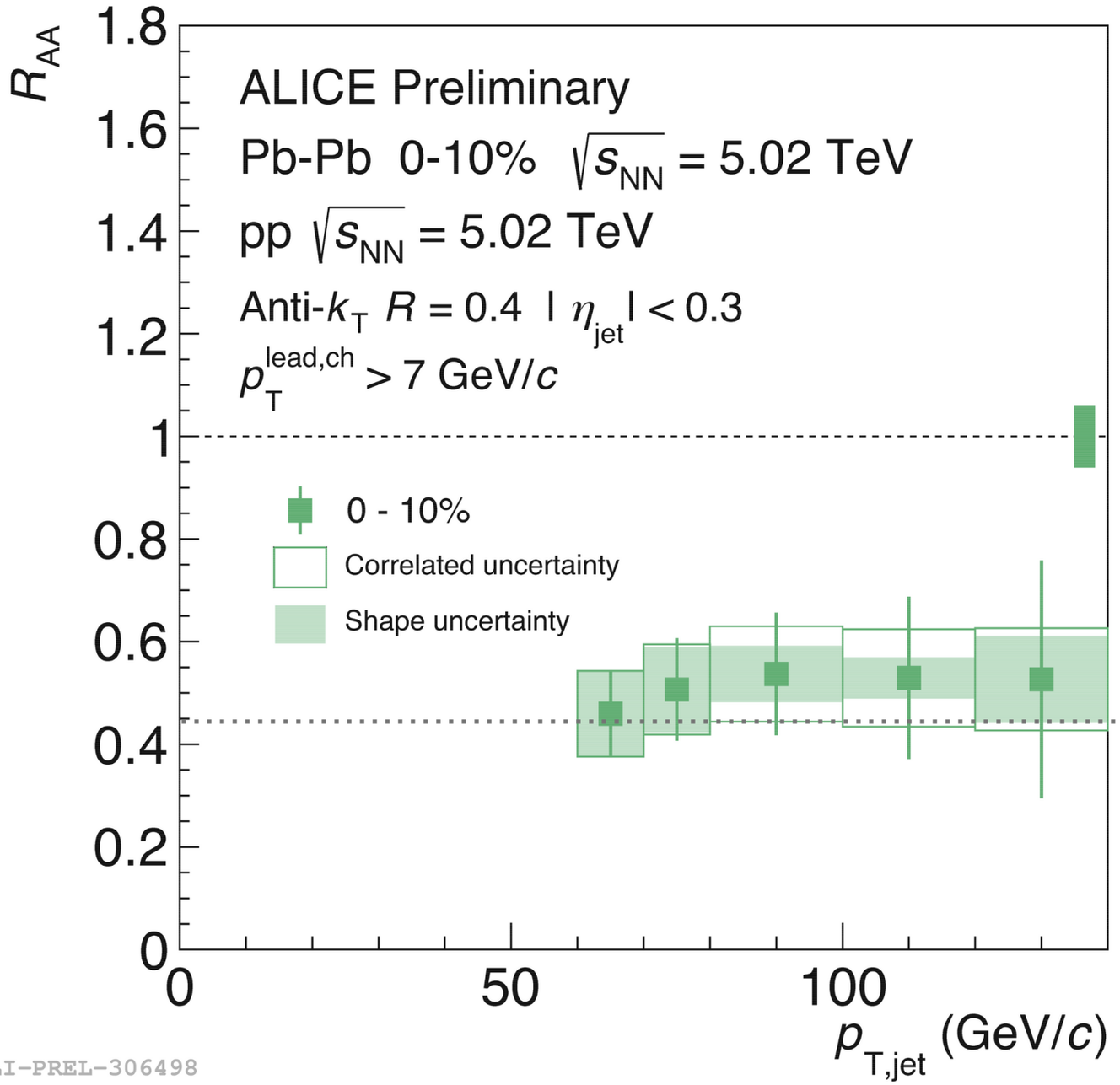
Similar suppression observed in R=0.2 and R=0.4



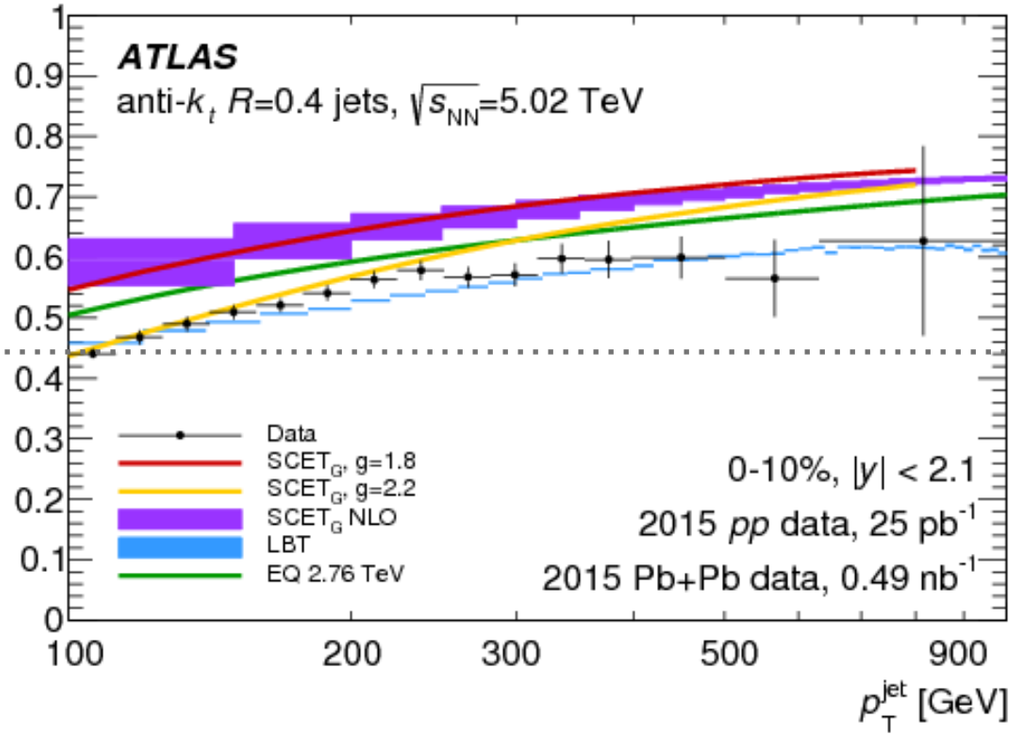


Results — Jet R_{AA}

ALICE R=0.4 jet R_{AA} is consistent with ATLAS R=0.4 jet R_{AA}

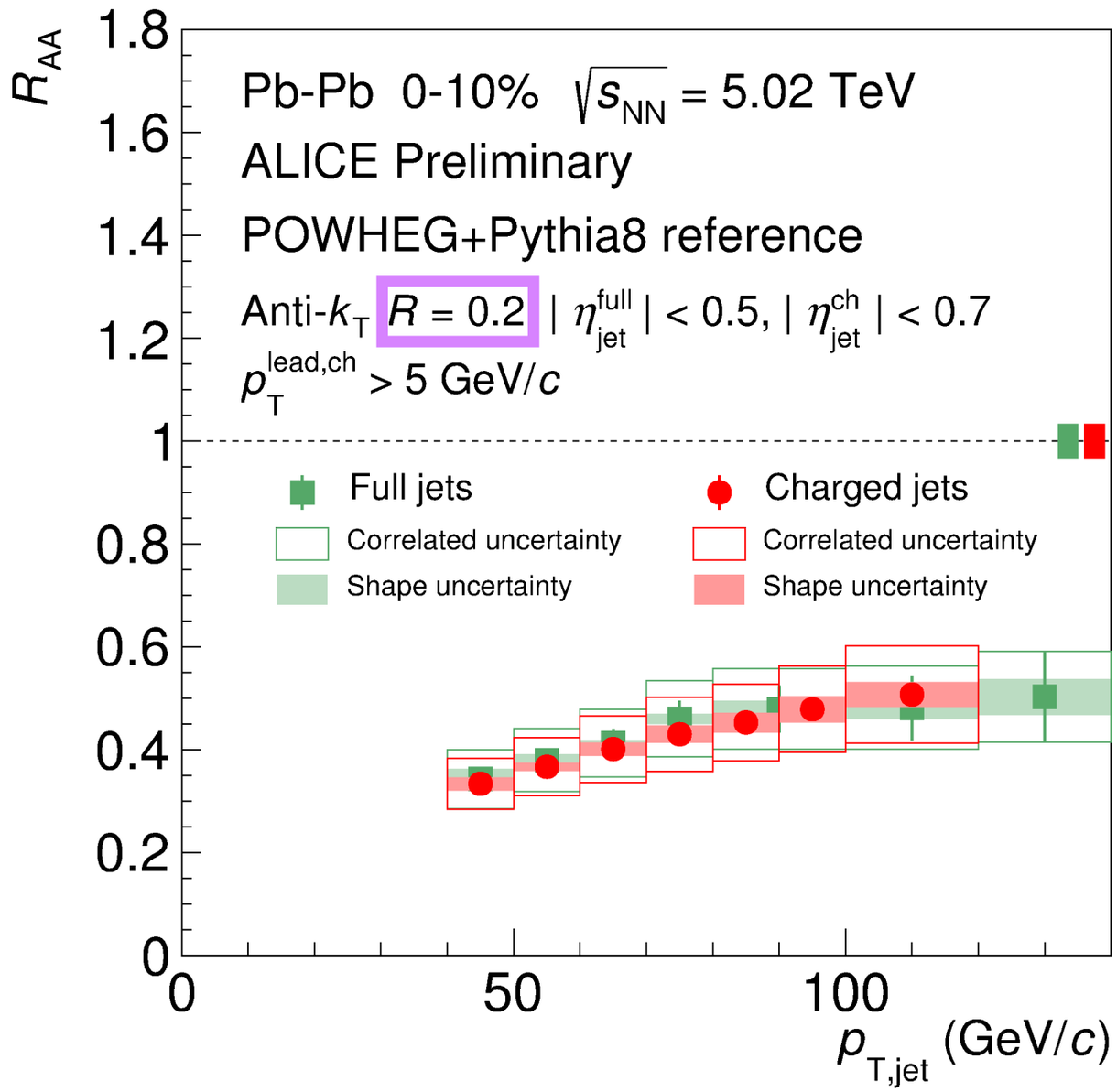


arxiv 1805.05424

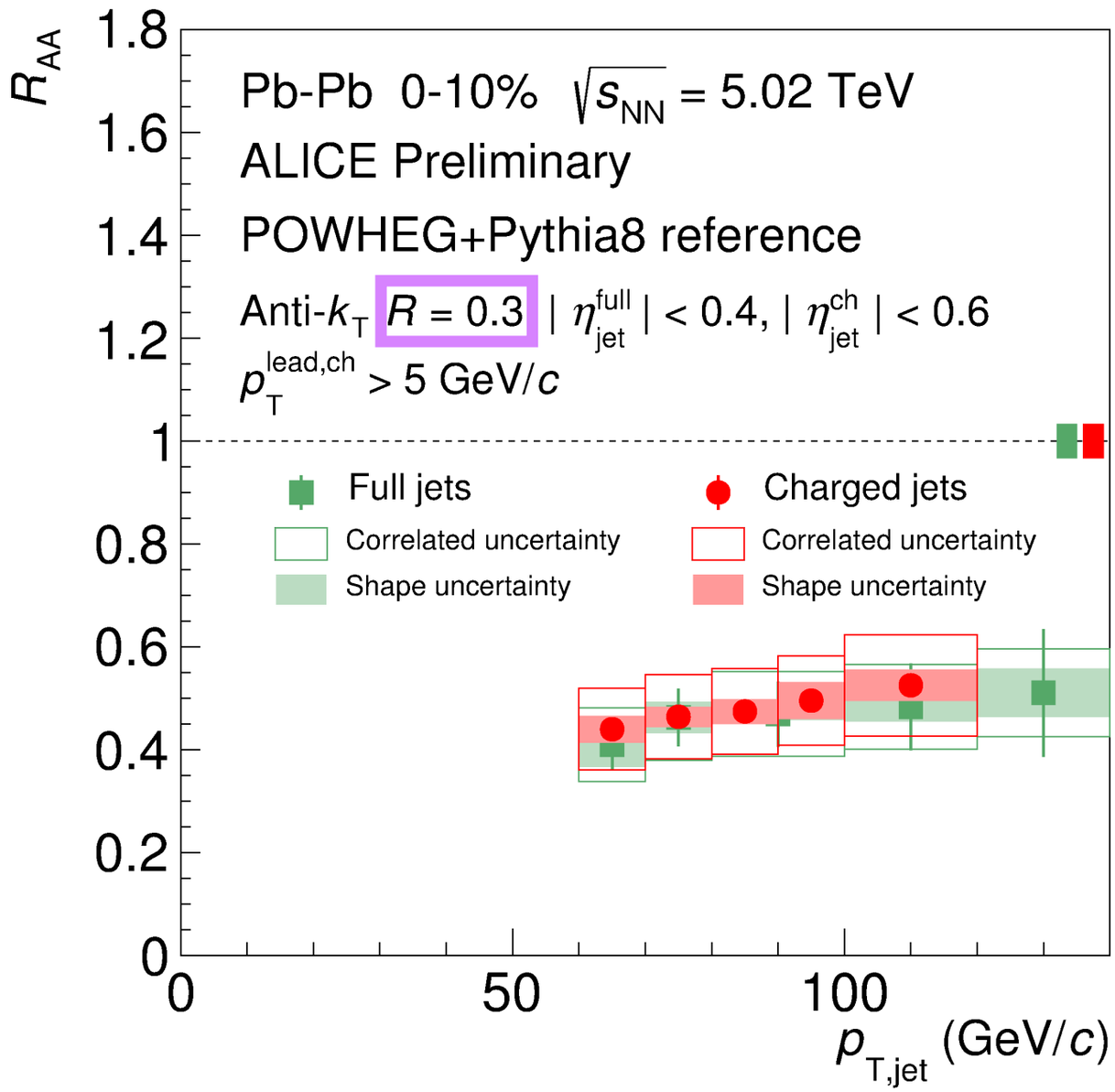


Results — Jet R_{AA}

Charged particle jets and full jets are consistent



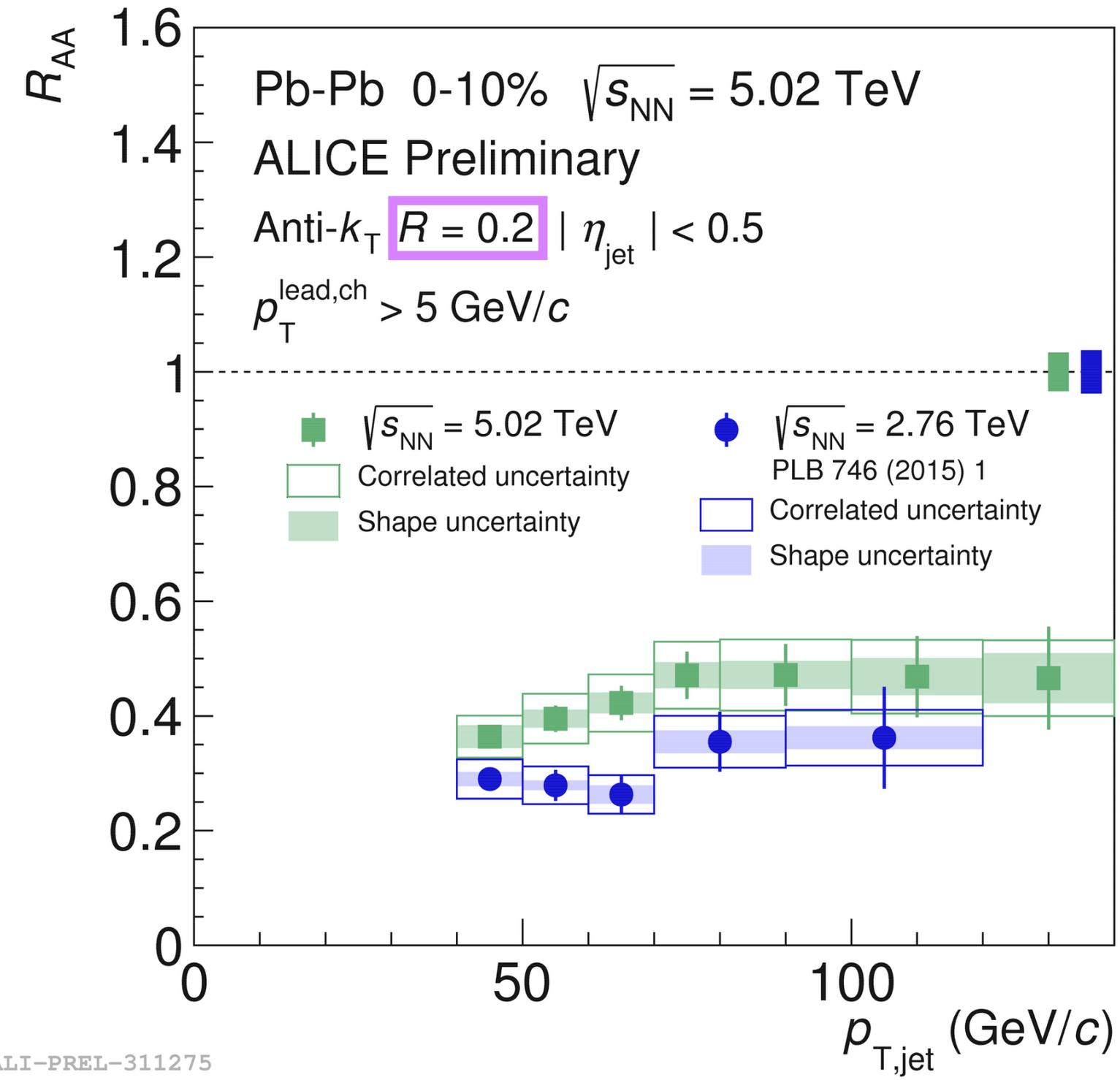
ALI-PREL-159649



ALI-PREL-159653

Results — Jet R_{AA}

ALICE full jet R_{AA} at 5.02 TeV is similar to 2.76 TeV for R=0.2, with hint of increase



Results — Jet R_{AA}

Measurements compared to theoretical predictions:

LBT provided in arxiv:1809.02525

PRC 91 (0549098)

Hybrid model provided by Daniel Pablos

JHEP 10 (2014) 19
JHEP 03 (2016) 53
JHEP 03 (2017) 135
JHEP 03 (2018) 10

SCET$_G$ provided by Haitao Li

arxiv:1801.00008
PLB 769 (242)

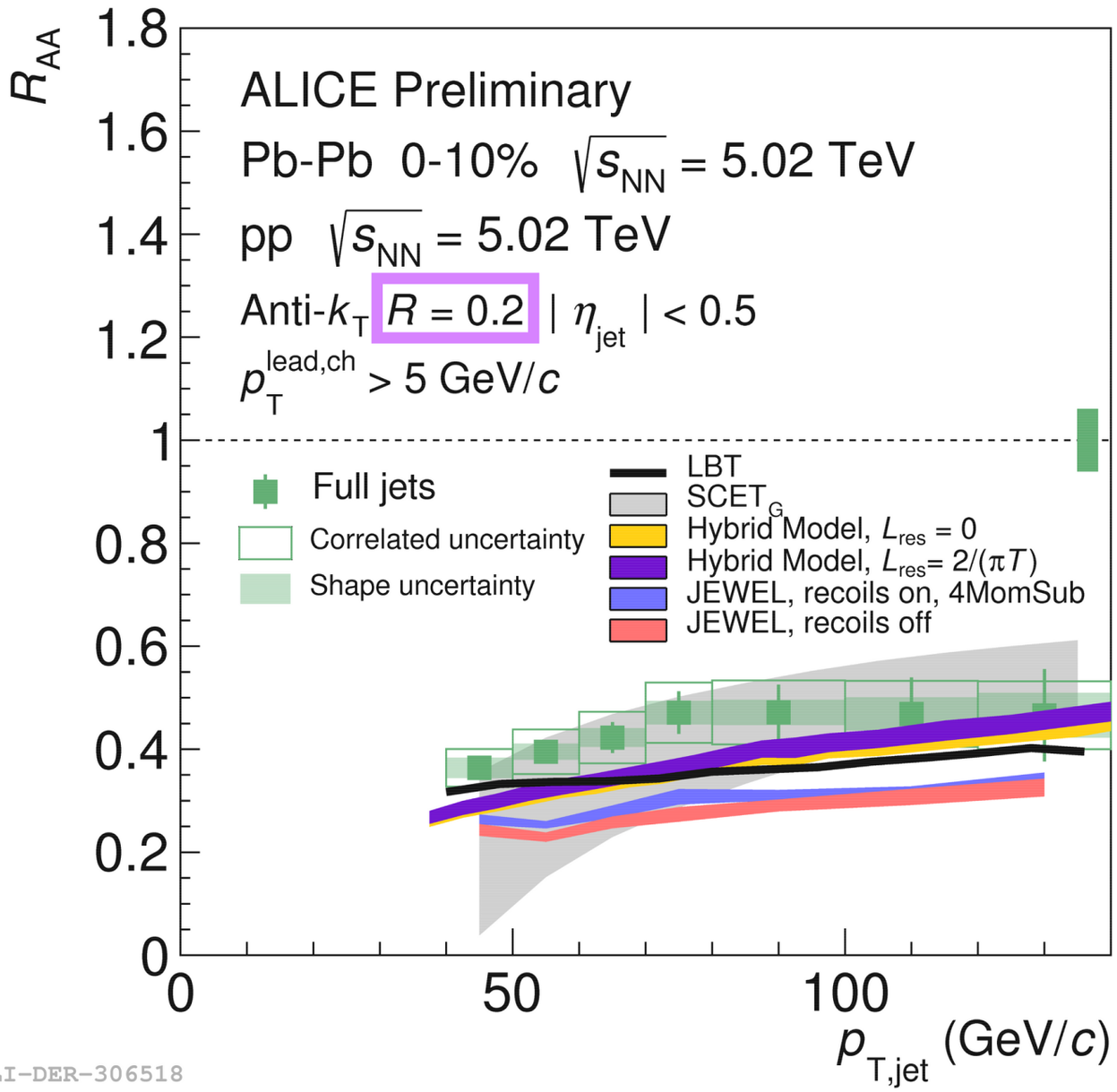
JEWEL (generated internally, Ritsuya Hosokawa)

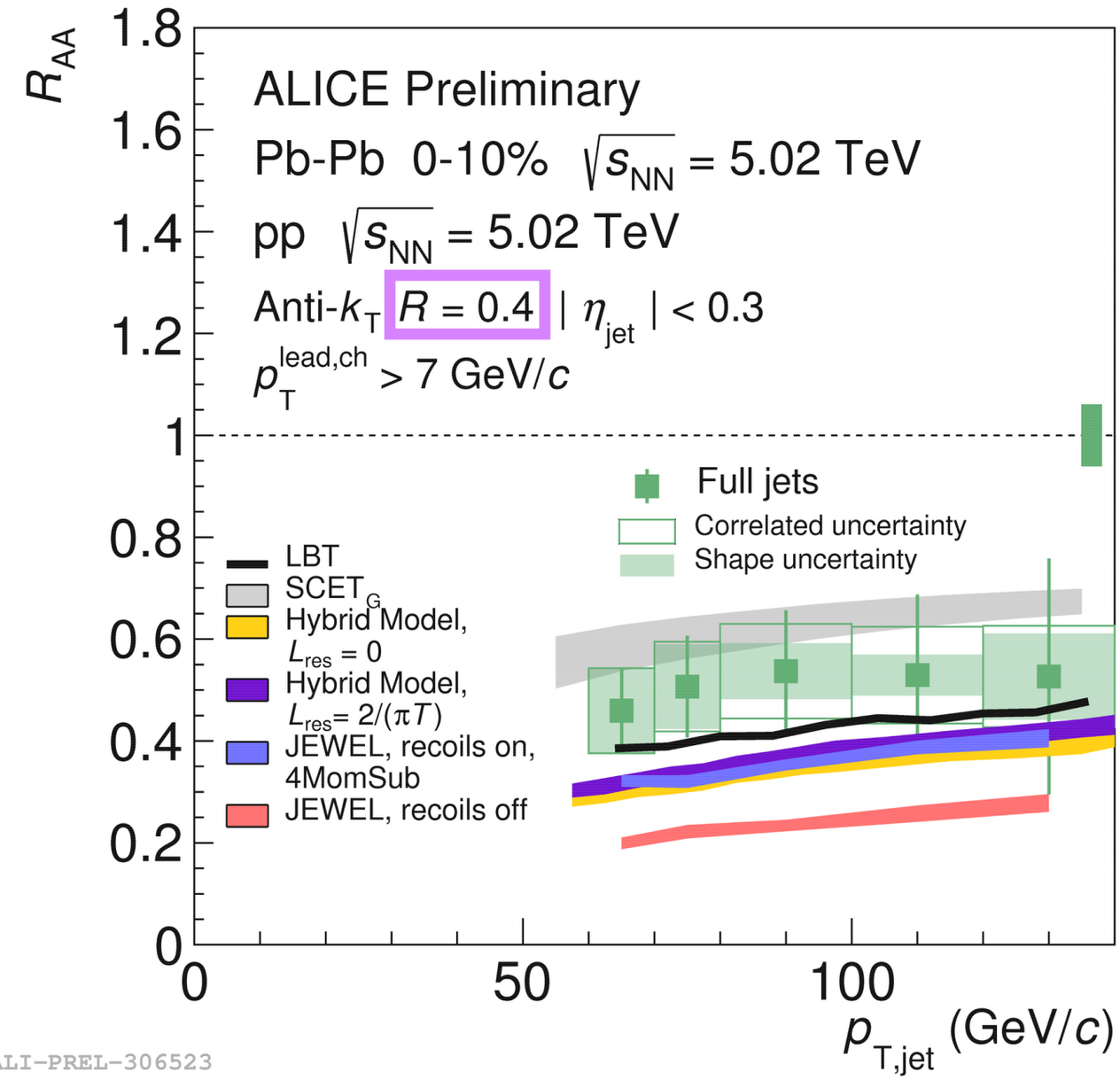
JHEP 03 (2013) 80
JHEP 07 (2017) 141
EPJ C (2016) 76:695

Results — Jet R_{AA}

All models qualitatively describe the R_{AA}

But quantitatively, most models have slight tension with the data

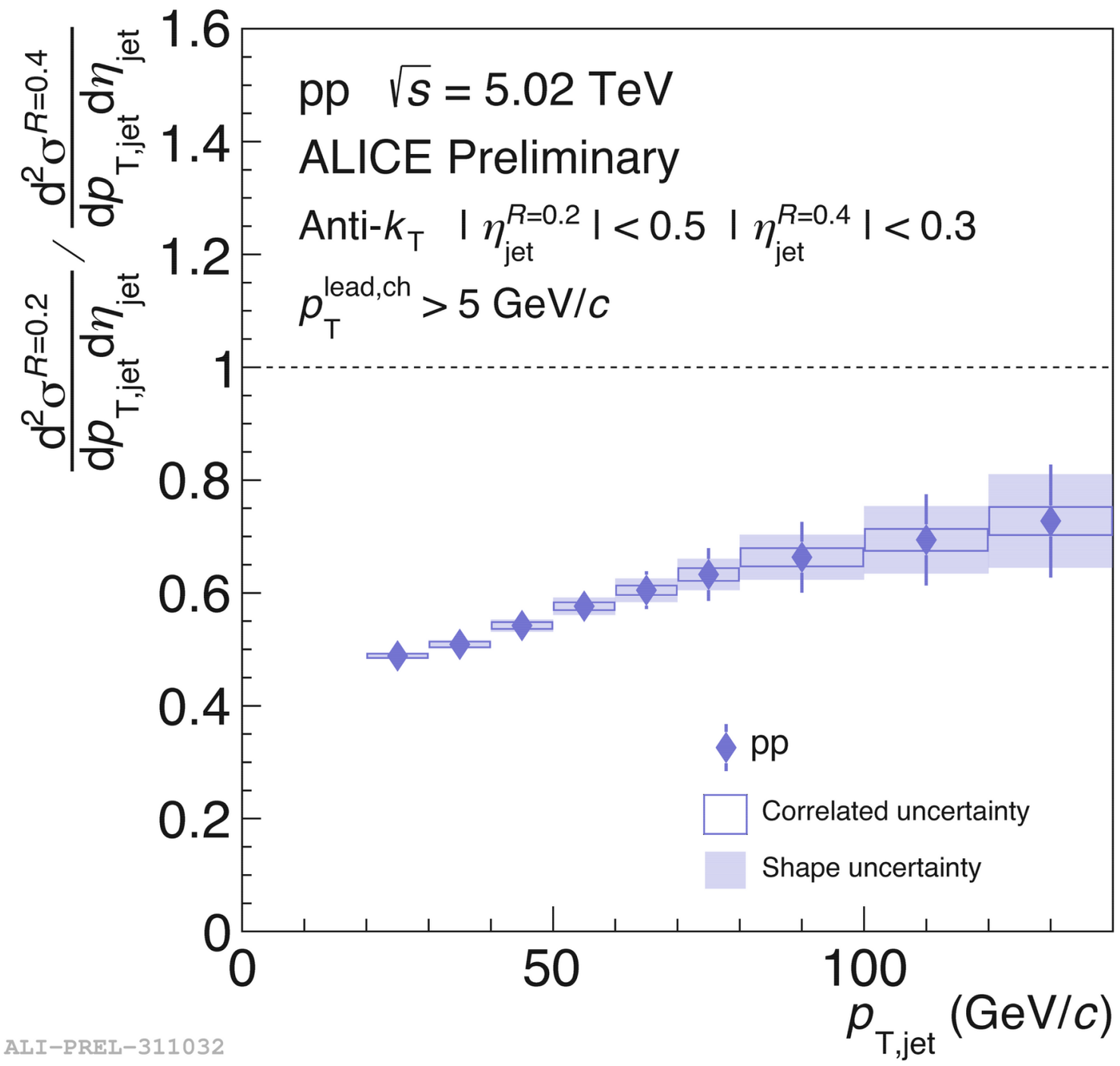




Results: Jet cross-section ratio

The ratio of jet cross-sections R=0.2 / R=0.4 in pp provides a baseline for Pb-Pb

In pp, the jet cross-section ratio is also useful to disentangle hadronization and underlying event effects

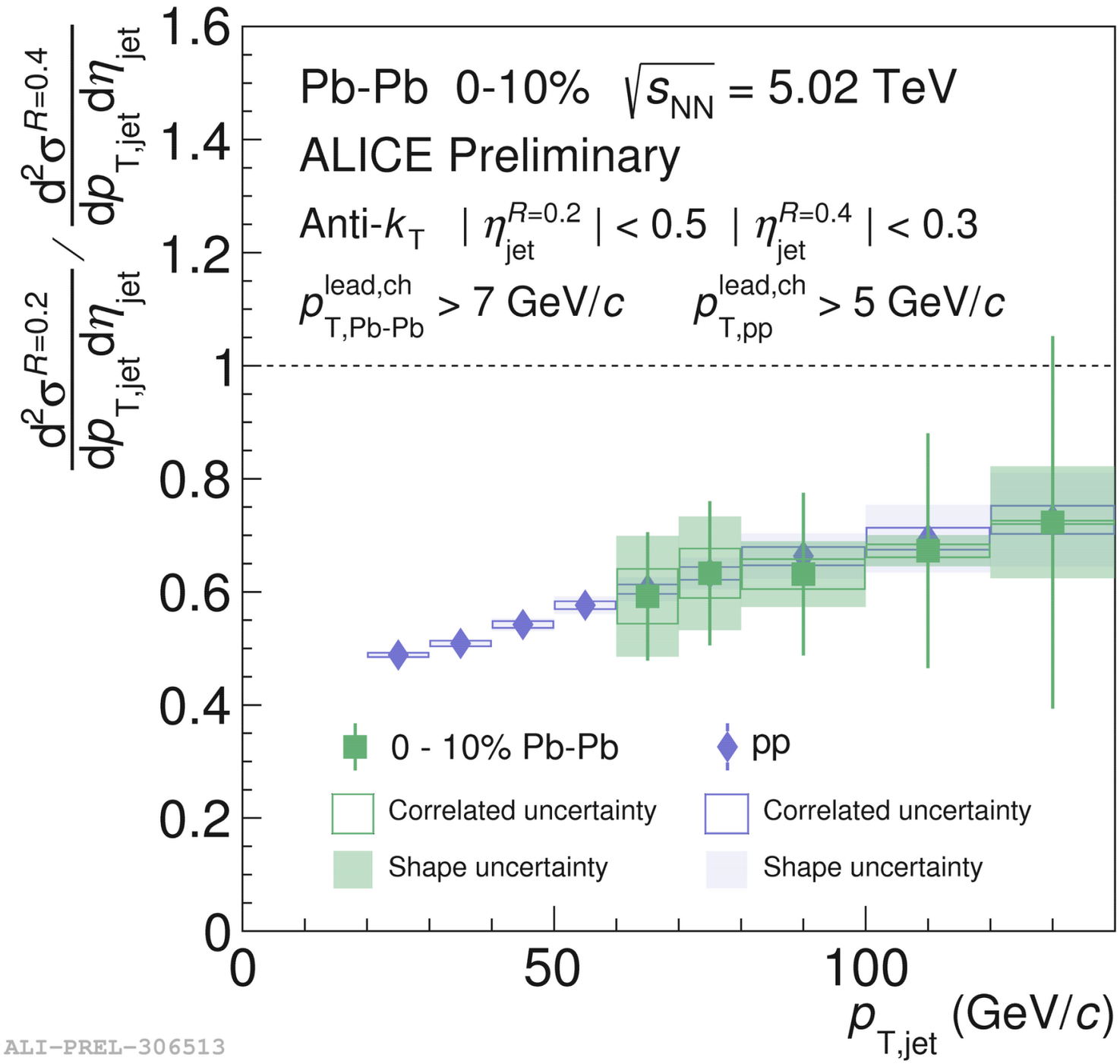


ALI-PREL-311032

Results: Jet cross-section ratio

No modification in Pb-Pb is observed compared to pp

Generally consistent with previous measurements at 2.76 TeV showing no significant modification in R~0.2-0.4

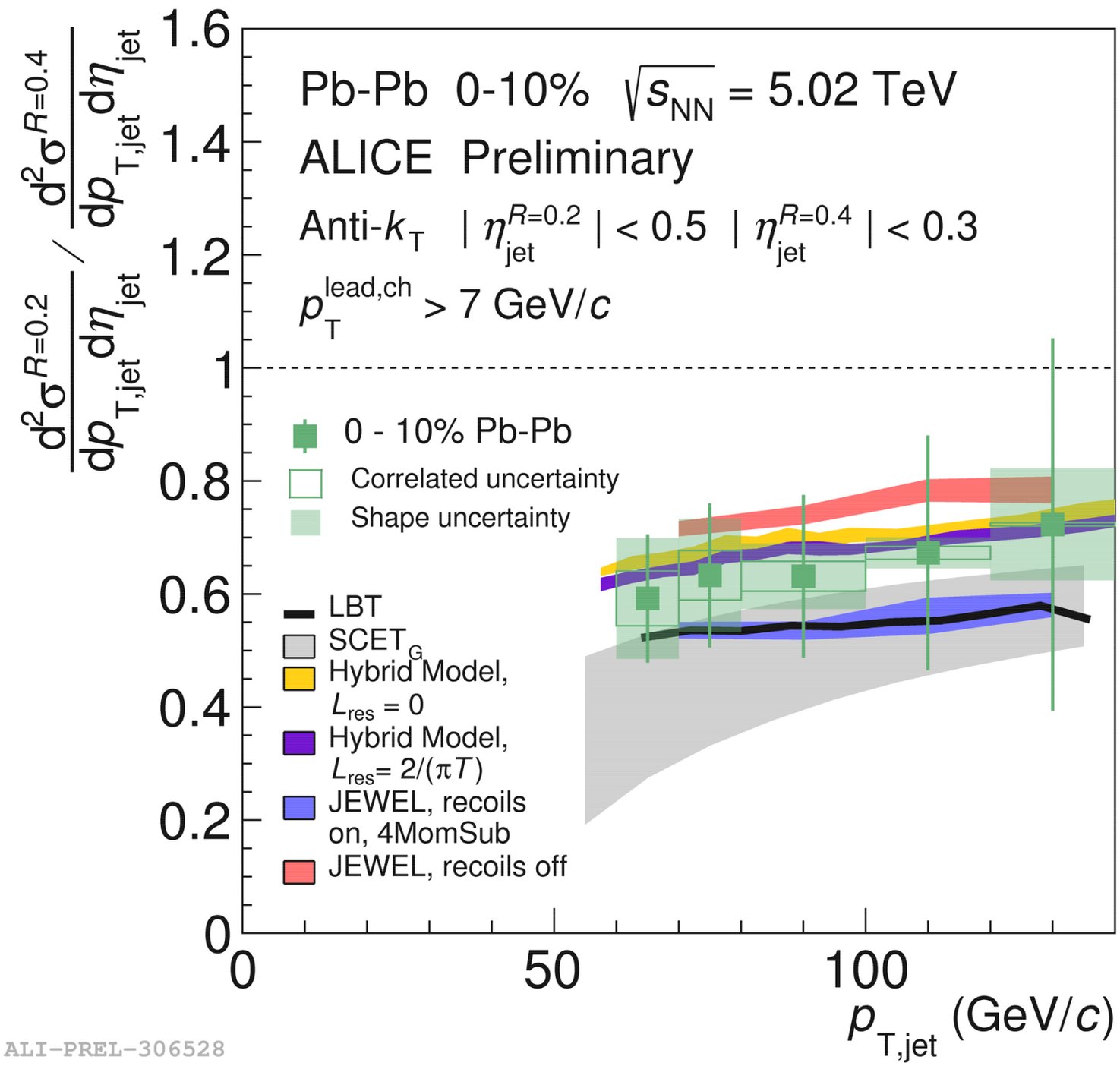


ALI-PREL-306513

Results: Jet cross-section ratio

No modification in Pb-Pb is observed compared to pp

Models predict some modification, but our resolution is not good enough to distinguish them



ALI-PREL-306528

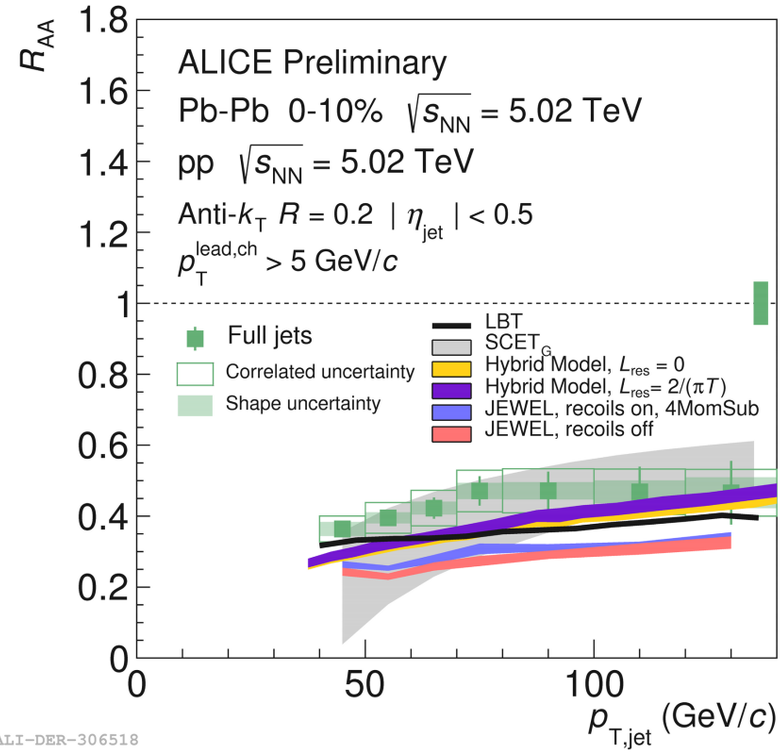
Discussion

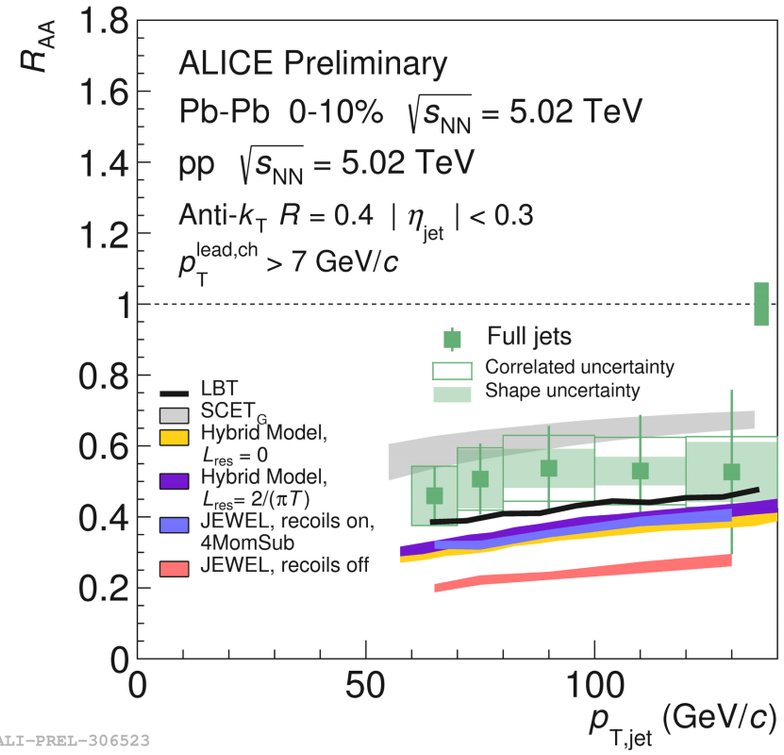
1. The measured jet R_{AA} contains sufficient precision to distinguish models at low p_T, to an extent
   - *However, the models use different input spectra, different medium evolution, different hadronization, different leading track biases, and different ways of fixing model parameters…*
   - *What does it mean for a model to be "consistent" or "inconsistent" with measured R_{AA}?*

2. With the current statistical precision and systematics, we cannot experimentally distinguish *R*-dependence of models
   - *Increased statistics will improve the statistical and unfolding uncertainties — not clear to what extent*
   - *ATLAS/CMS can measure jet R_{AA} for R=0.2-0.4 at high-p_T with high precision at 5.02 TeV — this may distinguish the R-dependence of models (e.g. pQCD vs. Hybrid model)*

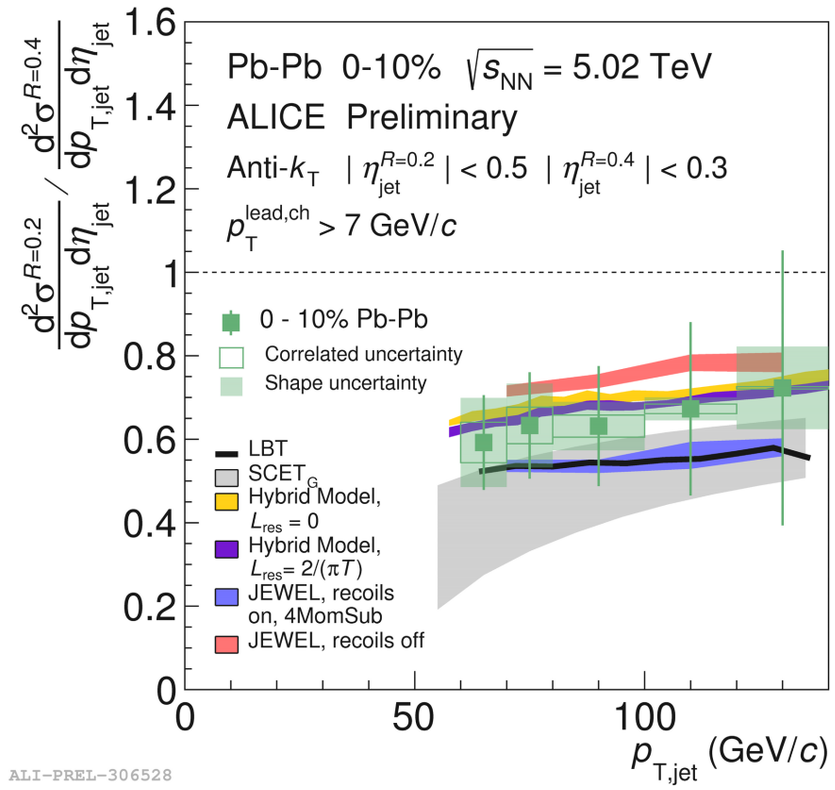
Summary

New pp and Pb-Pb inclusive full jet measurements from ALICE at 5.02 TeV





Jet R_{AA} with measured pp reference for R = 0.2, 0.4



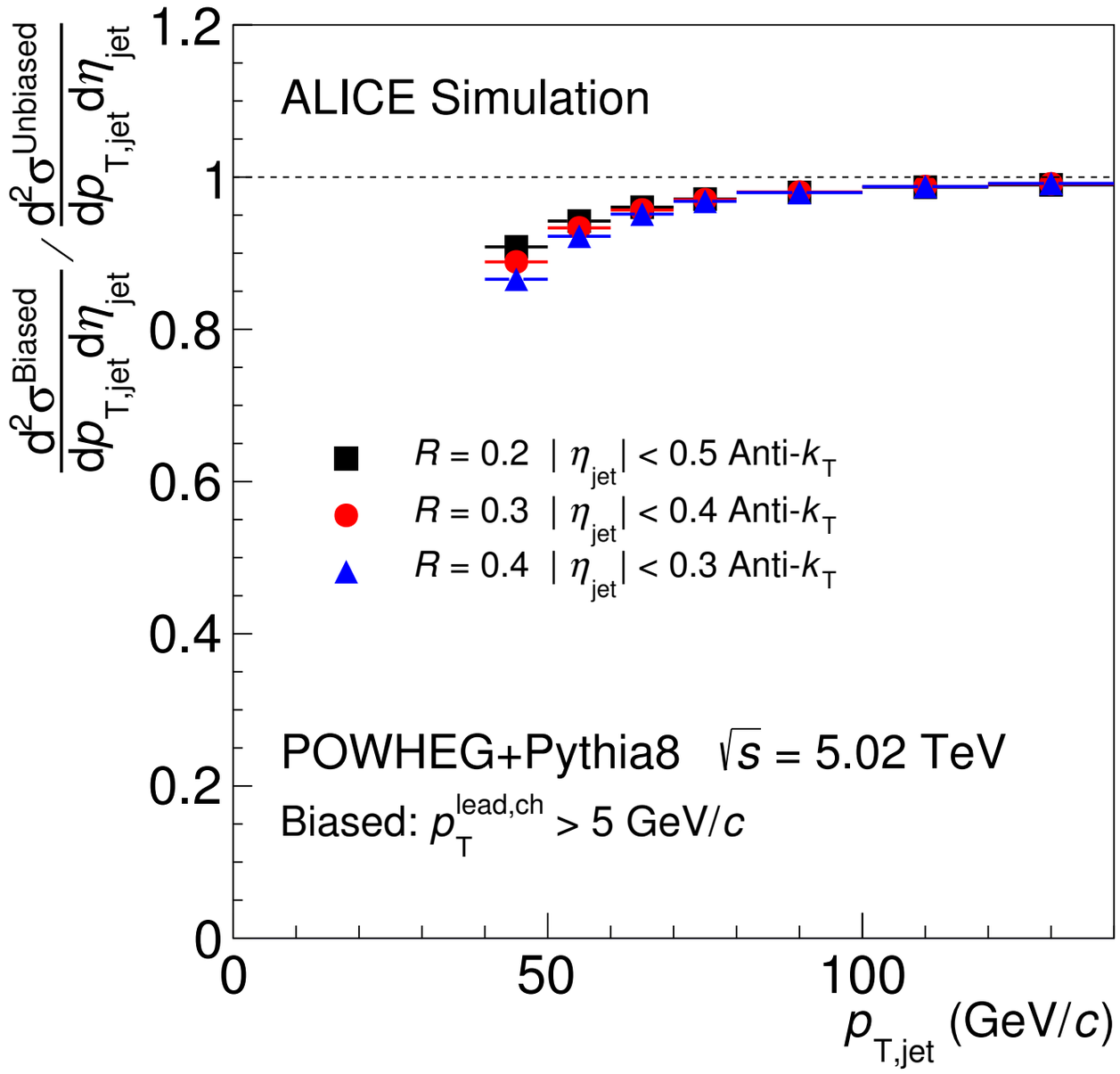
Jet cross-section ratio R = 0.2 / R = 0.4

Thank you!

Backup

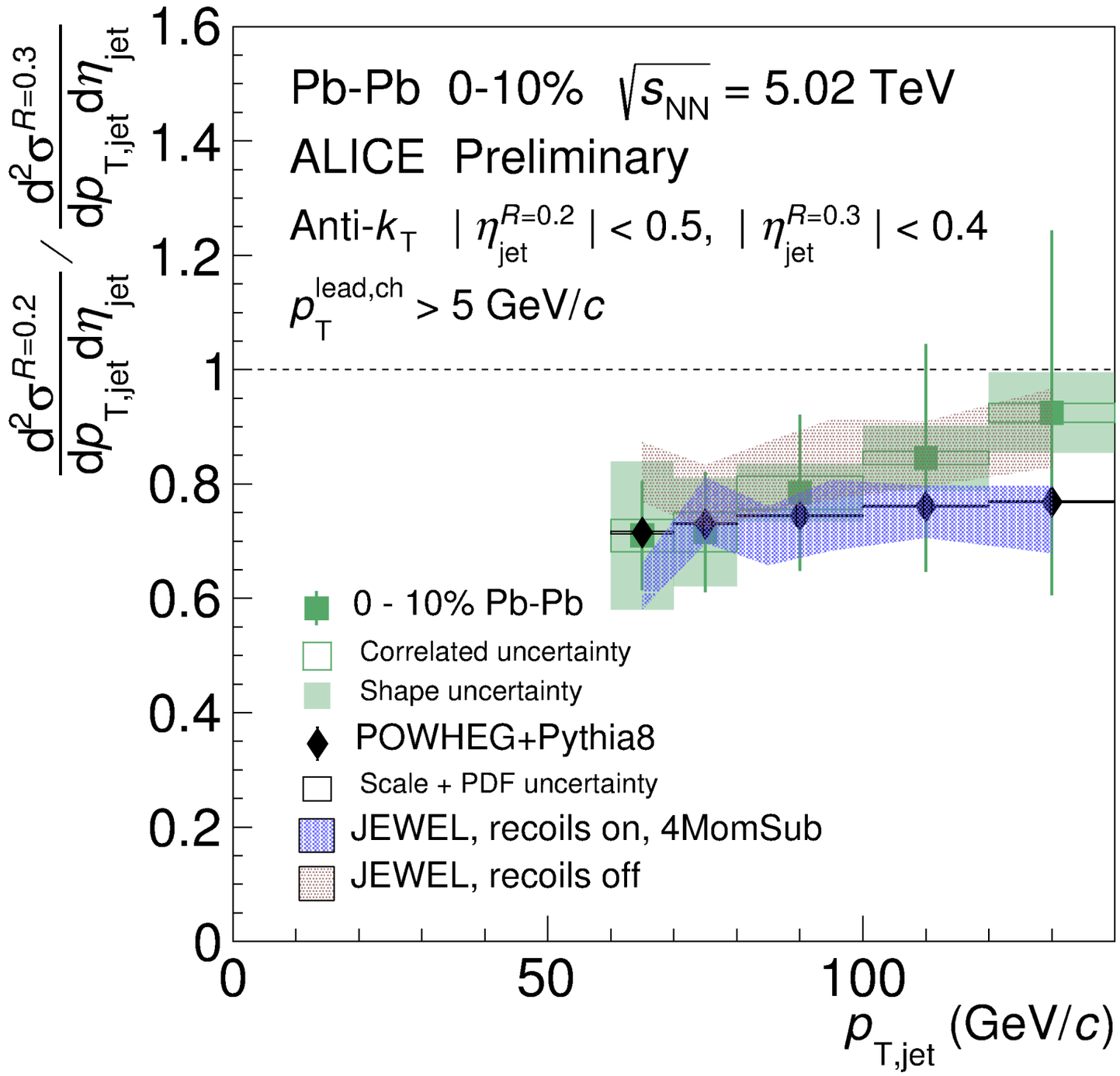
Leading track requirement

Suppress combinatorial jets by requiring jets to contain a 5 GeV/c charged track



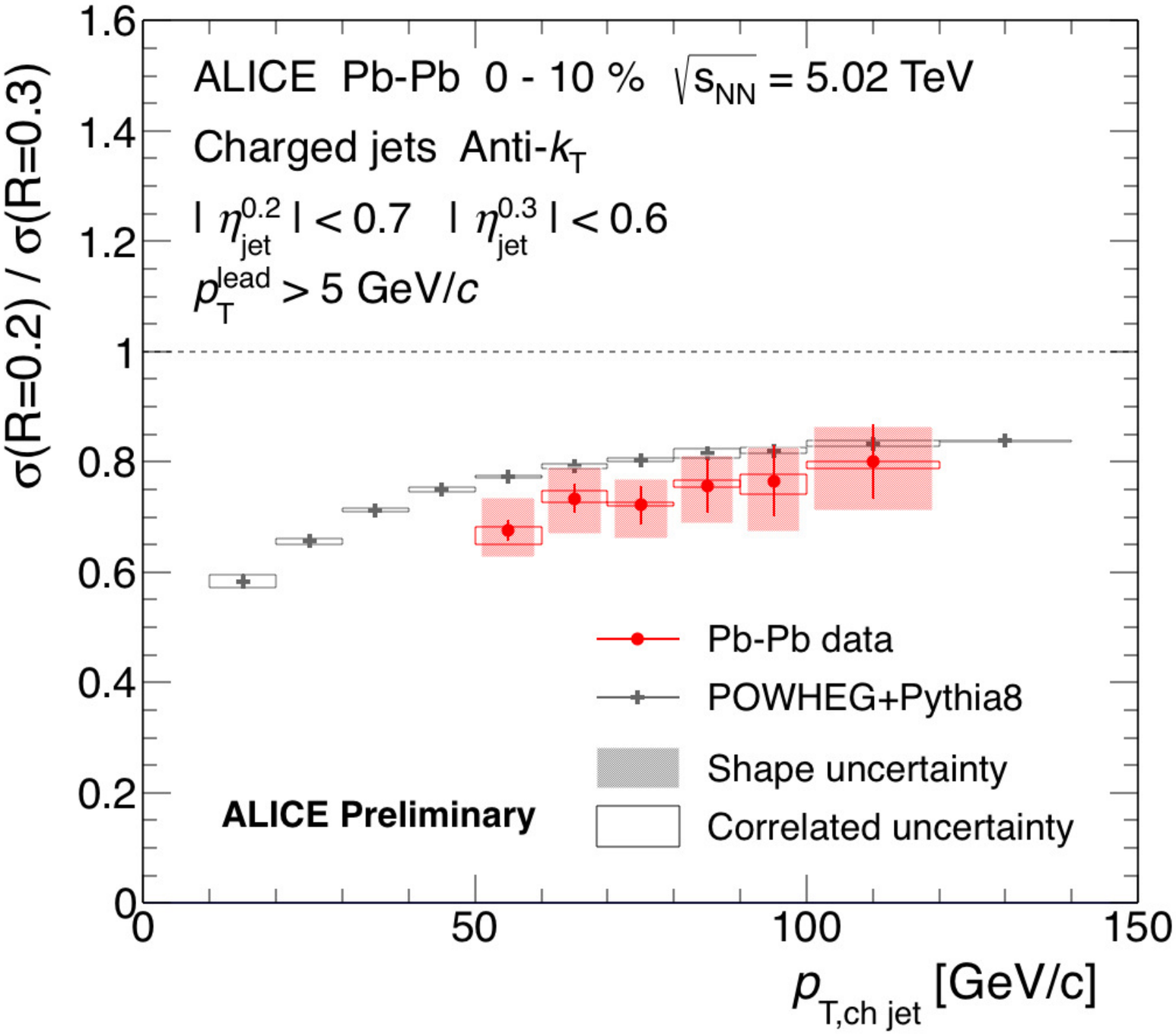
ALI-SIMUL-148684

R=0.2 / R=0.3 jet cross-section ratio



ALI-PREL-159657

Jet cross-section ratio, charged jets



ALI-PREL-156187