

# LHC HI WG: Kickoff (!)

ATLAS perspective, wishes (!!),  
proposals, and views on the working  
group



Zvi Citron



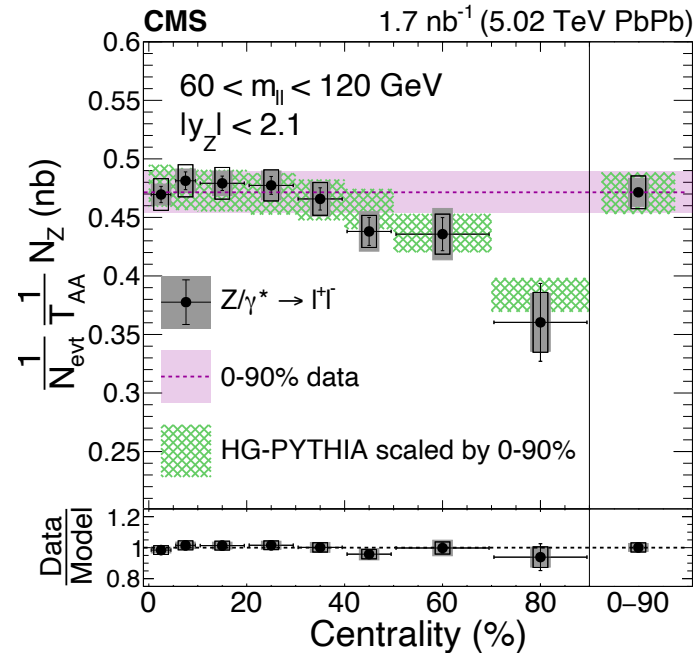
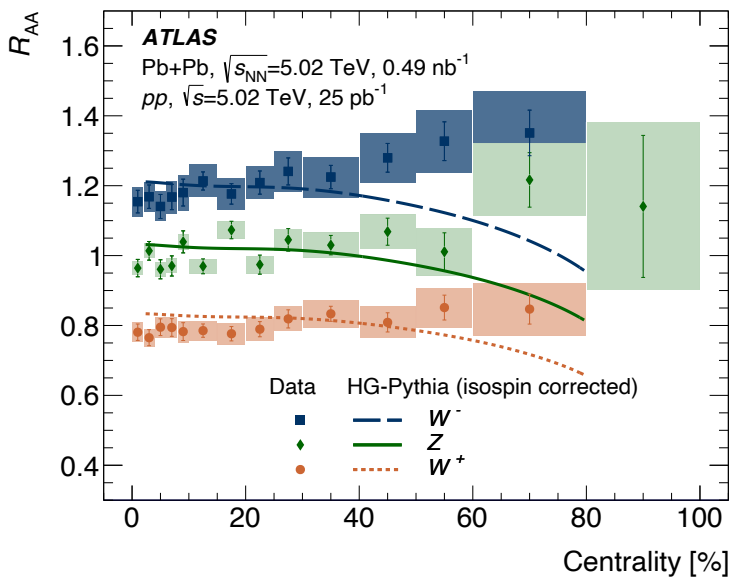
אוניברסיטת בן-גוריון בנגב  
Ben-Gurion University of the Negev

LHC HI WG: 7 July 2021

# Getting Our House in Order

- Most basic function of such a forum is resolving tensions within the community
- Place to systematically and comprehensively review
  - Tensions (or disagreements) in data/results
  - Tensions (or disagreements) in planning priorities with shared implications

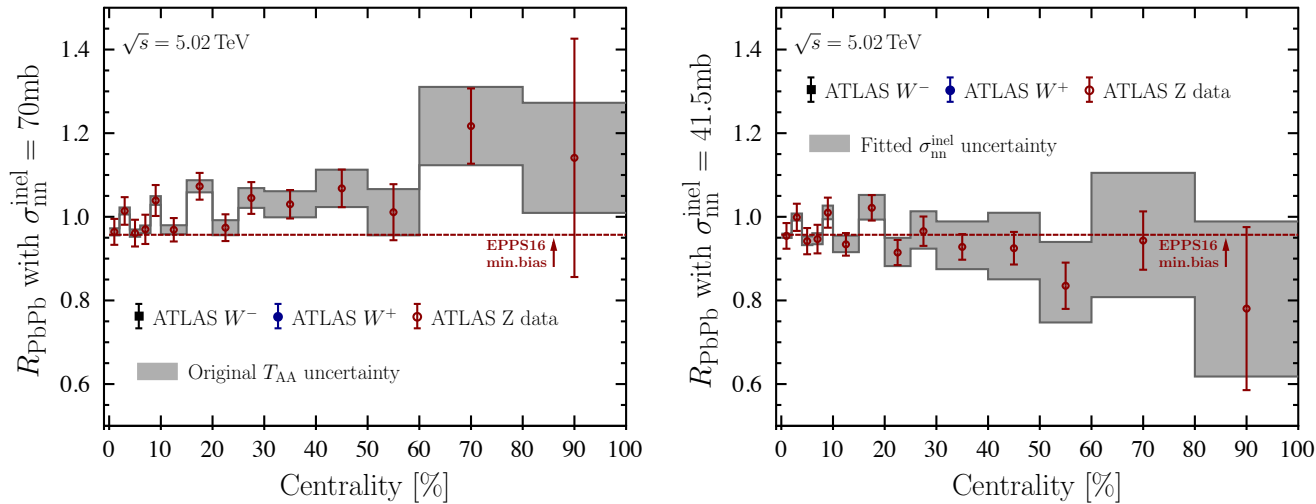
# EW Bosons as Standard Candles (Have We/They Failed?)



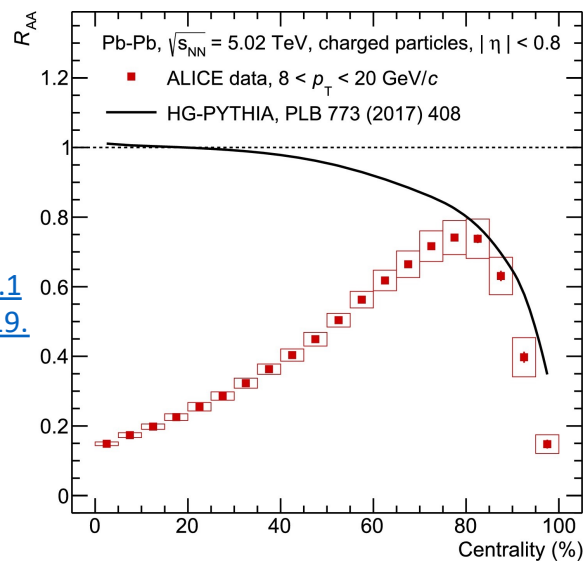
- Tension in results is clear
- Probably not some 'trivial' Z boson measurement issue
- Origin not yet understood

# Broad Implications

K.Eskola et al [PRL 125, 212301 (2020)]



- ATLAS results mean HG-Pythia model is incomplete/wrong
  - May suggest modification of  $\sigma_{NN}$
- CMS results mean strong confirmation of HG-Pythia model
- → This is not a Z boson issue, this is a baseline for HI interpretation issue



ALICE

<https://doi.org/10.1016/j.physletb.2019.04.047>



# Centrality – Cart or Horse?

- My best guess (for the moment) is that disagreement stems from centrality treatments, in particular EM background contribution to MB definitions

**ATLAS** [Phys. Lett. B 802 \(2020\) 135262](#)

25]. The mapping is based on specific studies of an event sample without additional Pb+Pb collisions within the same or neighbouring bunch crossings (pile-up) collected with minimum-bias (MB) triggers. A special treatment is employed for events in the 20% most peripheral interval, where diffractive and photonuclear processes contribute significantly to the MB event sample. This requires extrapolating from the total number of MB events in this region and employing a special requirement on the  $Z$  boson event topology, as described in Section 4.2. Table 1 summarises the re-

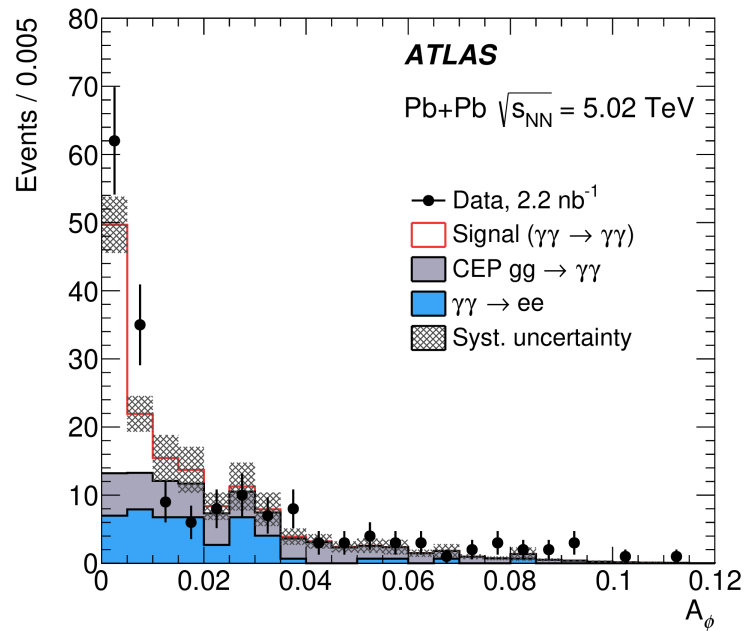
**CMS** <https://arxiv.org/abs/2103.14089>

The centrality calibration is affected by the MB event selection efficiency of the HF calorimeters, which is  $97.5^{+1.0}_{-0.5}\%$  for the 0–100% centrality range. The uncertainty in this efficiency is propagated to the final observables, resulting in a final uncertainty of 0.1 (8.4)% in central (peripheral) events. Uncertainties in the single-lepton trigger, reconstruction, and selection

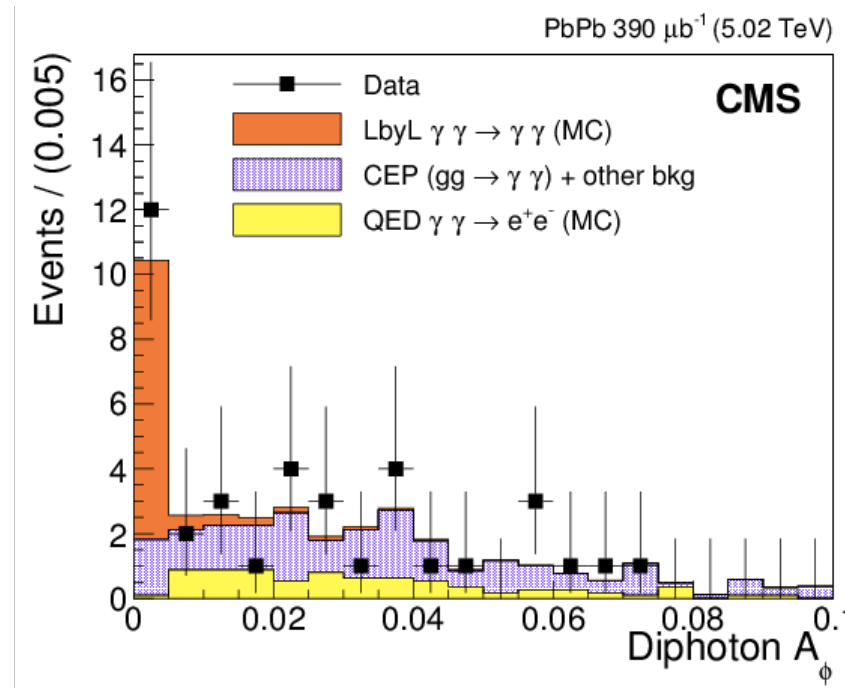
# Compatible (Unified?) Centrality Treatment

- Whether or not my guess is correct, points to a need for a compatible or even unified centrality treatment
- Clear definitions *and goals* for centrality classification
  - (I don't claim this will be trivial)
- Once 'vocabulary' is shared well positioned for more possibilities:
  - pA collisions
  - Light ion collisions
  - EW boson *based* centrality (?)

# Go Out for a Stroll ...



[JHEP 03 (2021) 243]



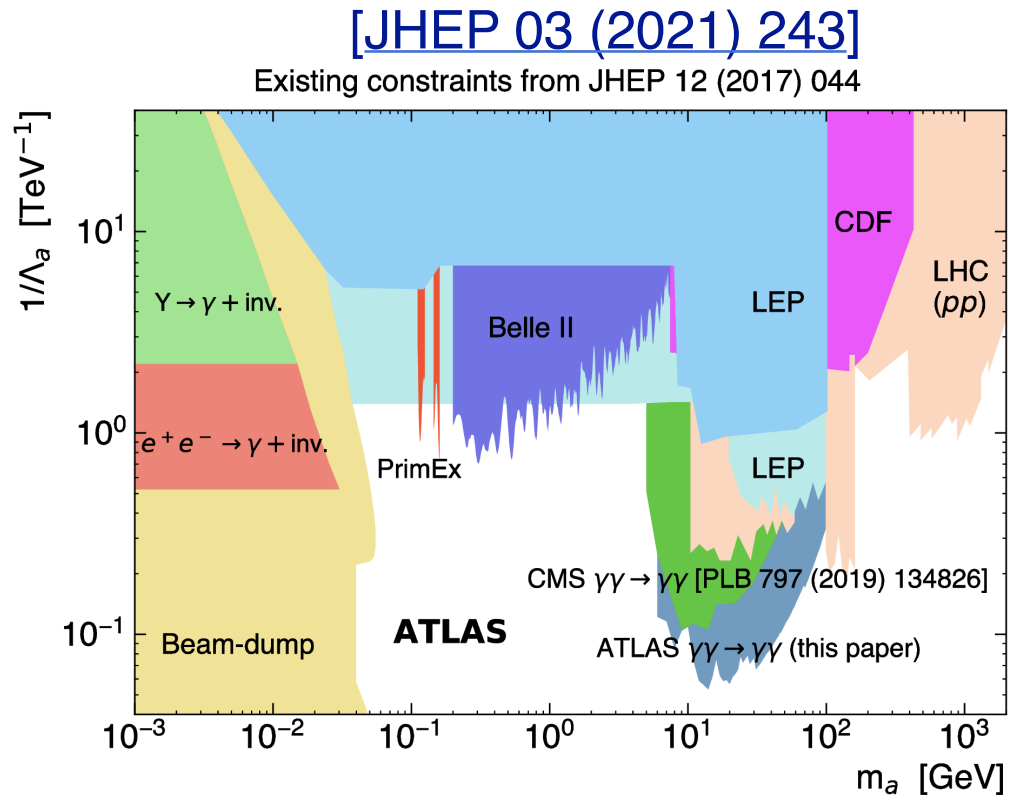
[Phys. Lett. B 797 (2019) 134826]

- Once our house is in order we can go out for a walk

→ Clear target is data combination, **e.g. LbyL**

Combination analysis is ongoing as part of the HonexComb project

# Go Out for a Stroll ...



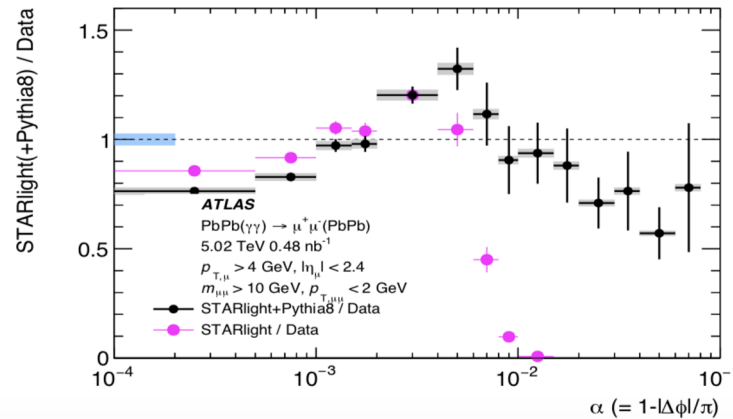
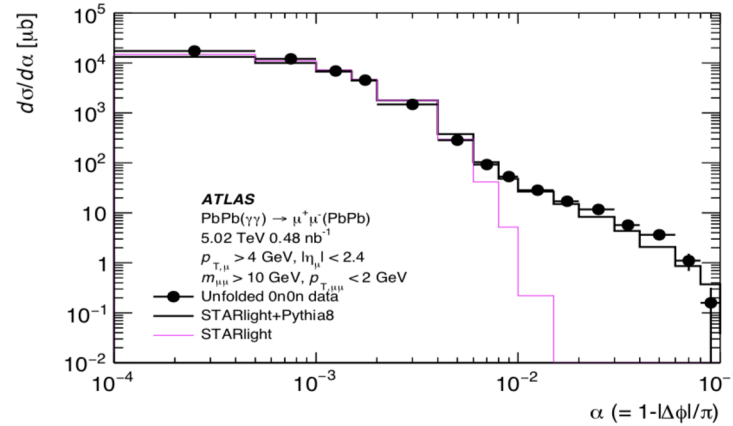
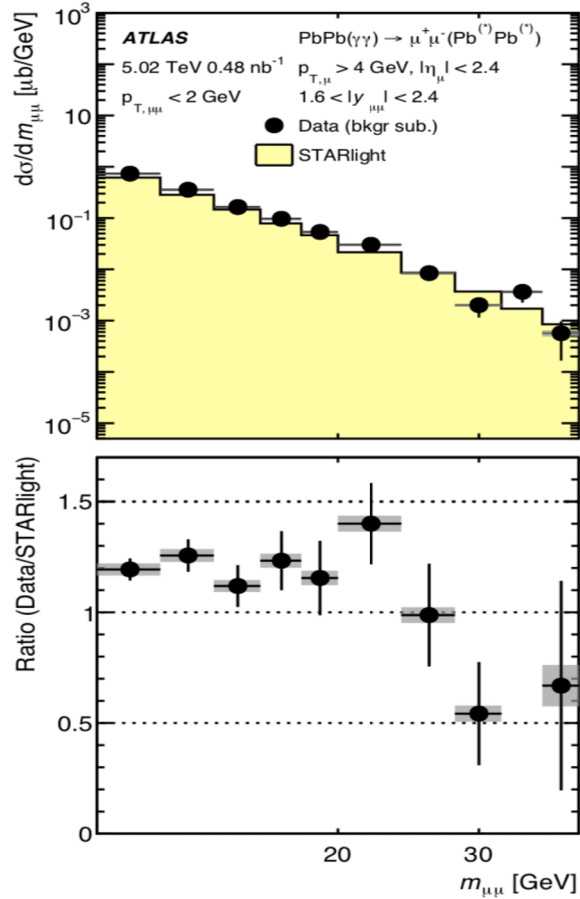
- Once our house is in order we can go out for a walk  
→ Clear target is data combination, e.g. **LbyL**  
Also set limits on ALP



# A Combination Paradigm?

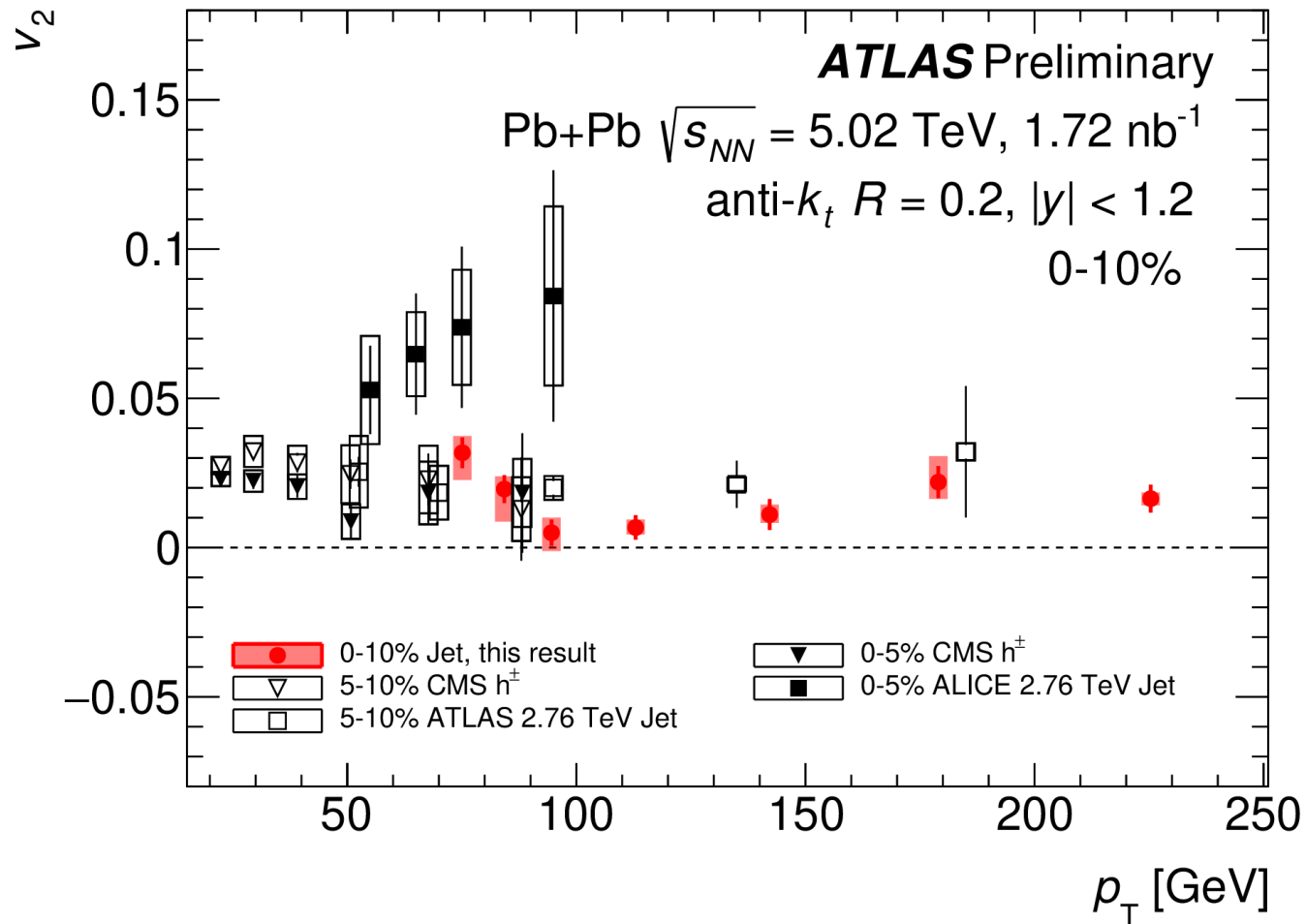
- LbyL is too good of an example!
- [HonexComb exists to focus on finding these - LbyL is 2<sup>nd</sup> case, total charm was 1<sup>st</sup> ]
- Examples ripe for combination or in tension from ATLAS measurements next slides
- Some wishlist items :
  - Top quark pairs
  - Tau pair production in UPC
- Should also consider to what extent this changes how we approach and chose the analyses that further the HI program
  - There are of course downsides to too much cooperation between independent experiments

# Exclusive Di-Leptons: $\gamma\gamma \rightarrow \mu^+\mu^-$



- Baseline measurement for UPC
- Statistical uncertainties dominate at high  $m_{\mu\mu}$  and high acoplanarity

# Inclusive Jet $v_2$ in central PbPb

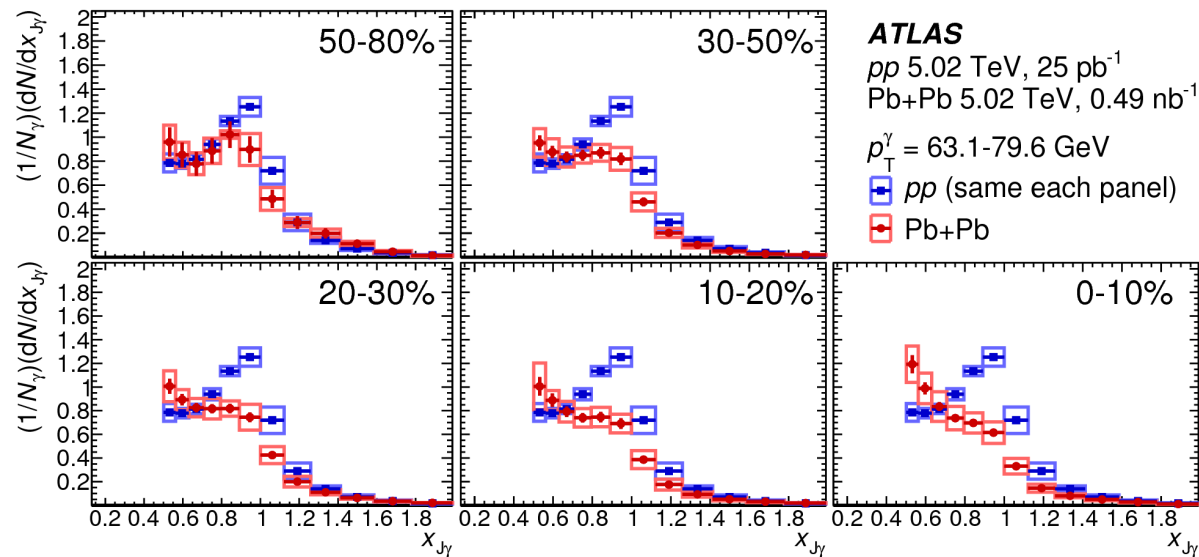
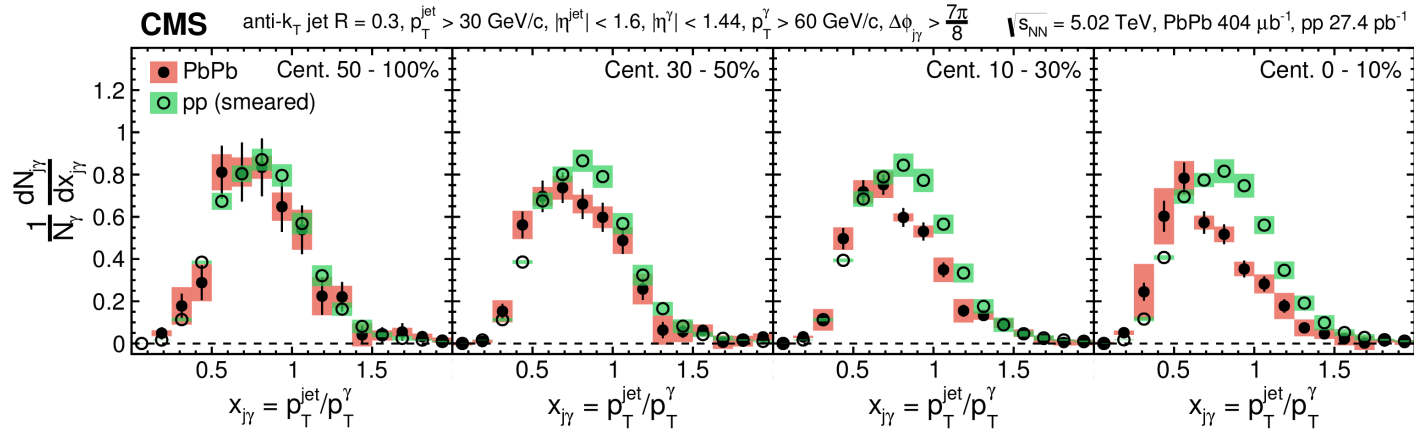


Tension observed between ALICE results and the other experiments  
 Would be great to clarify ...

# A Shared Interpretation-Oriented Paradigm?

- Besides the cases of direct comparison there is room for improvement in how we go from measurement , and specifically multiple measurements, to interpretation
- Centrality as discussed
- Bulk property measurements typically have plenty of statistics, no *large* blatant tensions between experiments, “ahead of theory”, where do we go forward? Can we develop common interpretation-oriented approach
  - Important example: Template method for 2PC used only by ATLAS
- Similar measurements are sometimes still difficult/impossible to directly compare

# Photon-Jet Asymmetry in PbPb, pp



- CMS compares reco-level PbPb w/smeared pp
- ATLAS compares fully unfolded
- Similar story elsewhere (e.g. di-jets)
- It would be great if the philosophy behind the analysis could be discussed,  $\rightarrow$  find common ground to make the comparison possible/easier.

# Light Ions (sooner)

- Many of these concerns/opportunities converge for upcoming Oxygen running
- [See [Anne's nice talk](#) at OO workshop for review of ATLAS perspective]
- Small system flow and related physics questions, require good handle on geometry description, inter-experiment clarity on centrality and related crucial
- Similar issues for understanding onset of jet quenching + need for compatibility in places where we haven't always had it

# Light Ions (later)

- It's distant but post Run 4 running (and any changes of course before then) will need some level of common buy in from the community
- Requires common physics case/questions and forum to express them

2027	Pb–Pb 5.5 TeV	5 weeks	$3.8 \text{ nb}^{-1}$
	pp 5.5 TeV	1 week	$3 \text{ pb}^{-1}$ (ALICE), $300 \text{ pb}^{-1}$ (ATLAS, CMS), $25 \text{ pb}^{-1}$ (LHCb)
2028	p–Pb 8.8 TeV	3 weeks	$0.6 \text{ pb}^{-1}$ (ATLAS, CMS), $0.3 \text{ pb}^{-1}$ (ALICE, LHCb)
	pp 8.8 TeV	few days	$1.5 \text{ pb}^{-1}$ (ALICE), $100 \text{ pb}^{-1}$ (ATLAS, CMS, LHCb)
2029	Pb–Pb 5.5 TeV	4 weeks	$3 \text{ nb}^{-1}$
Run-5	Intermediate AA	11 weeks	e.g. Ar–Ar $3\text{--}9 \text{ pb}^{-1}$ (optimal species to be defined)
	pp reference	1 week	

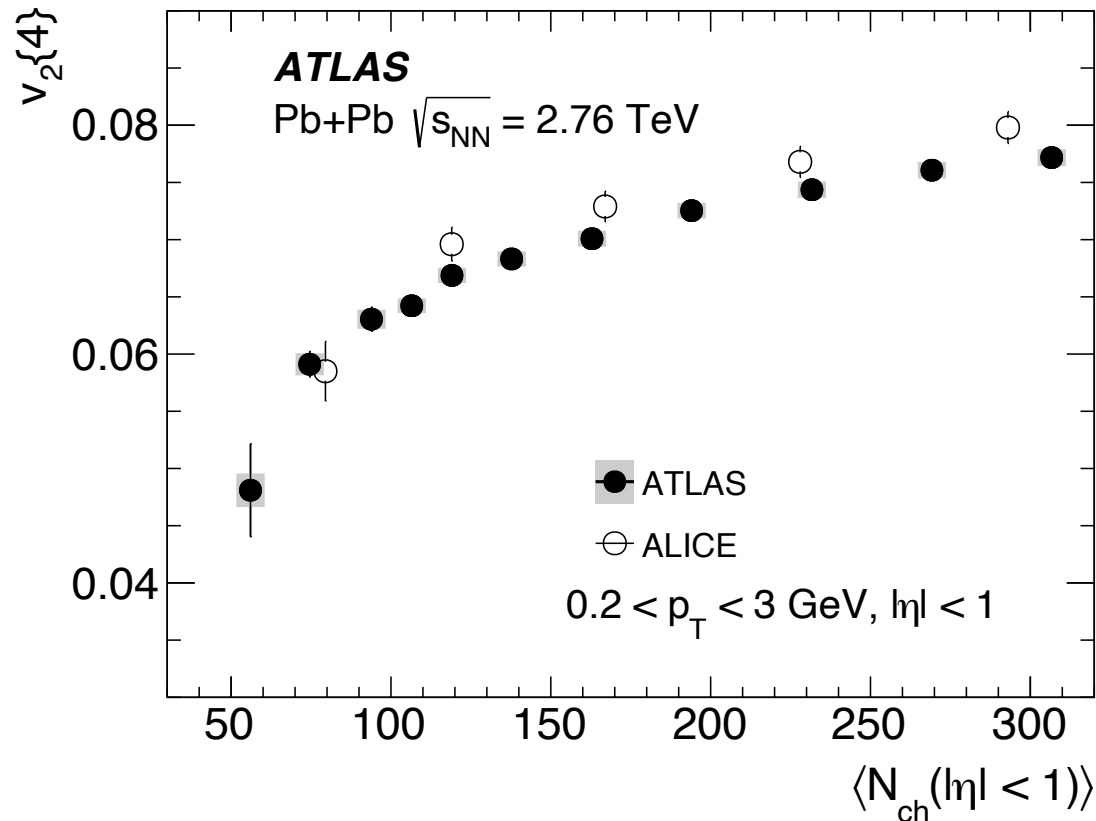
# Summary

- Some existing tensions linger and understanding them matters!
- Data combination can help us with important measurements
- We should consider where coordinating in general approach (i.e. beyond one particular measurement) can help us, especially for reaching meaningful interpretations
- Upcoming (and future) light ion running at the LHC is an especially good opportunity to implement these ideas and make use of this forum



# Backups

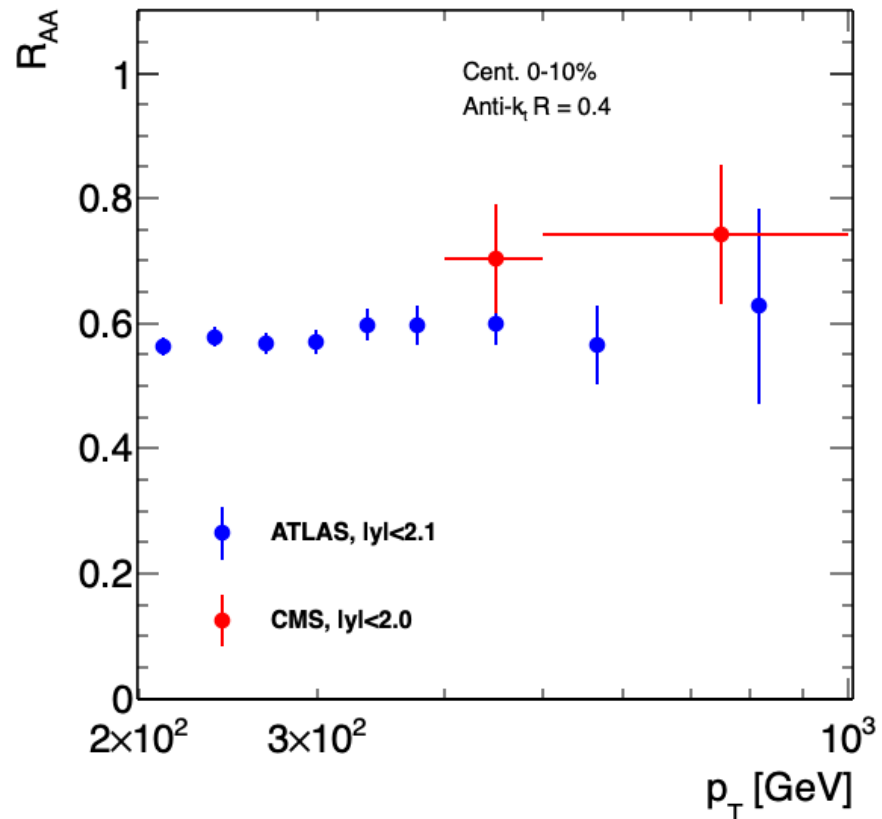
# ATLAS-ALICE Tension in PbPb $v_2$ from 4-cumulants



# Inclusive Jet $R_{AA}$

CMS arXiv:2102.13080

ATLAS arXiv:1805.05635



Hint of a tension, but still consistent within uncertainties.