LHC HI WG: Kickoff (!)

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

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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
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

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

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-
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 ...

- 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, \textit{e.g.} \texttt{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 2nd case, total charm was 1st ]
• 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 aco-planarity
Inclusive Jet $v_2$ in central PbPb

Tension observed between ALICE results and the other experiments, as those results are used to constrain data, it will be great to clarify with ALICE and 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, 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

<table>
<thead>
<tr>
<th>Year</th>
<th>System</th>
<th>Energy</th>
<th>Data (pb⁻¹)</th>
<th>Experimental Collaborations</th>
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</thead>
<tbody>
<tr>
<td>2027</td>
<td>Pb–Pb 5.5 TeV</td>
<td>5 weeks</td>
<td>3.8</td>
<td>ALICE, 300 (ATLAS, CMS), 25 (LHCb)</td>
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<tr>
<td></td>
<td>pp 5.5 TeV</td>
<td>1 week</td>
<td>3</td>
<td>ALICE, 300 (ATLAS, CMS), 25 (LHCb)</td>
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<tr>
<td>2028</td>
<td>p–Pb 8.8 TeV</td>
<td>3 weeks</td>
<td>0.6</td>
<td>ATLAS, CMS, 0.3 (ALICE, LHCb)</td>
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<tr>
<td></td>
<td>pp 8.8 TeV</td>
<td>few days</td>
<td>1.5</td>
<td>ALICE, 100 (ATLAS, CMS, LHCb)</td>
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<tr>
<td>2029</td>
<td>Pb–Pb 5.5 TeV</td>
<td>4 weeks</td>
<td>3</td>
<td>ALICE, 300 (ATLAS, CMS), 25 (LHCb)</td>
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<td>Run-5</td>
<td>Intermediate AA</td>
<td>11 weeks</td>
<td>e.g. Ar–Ar 3–9</td>
<td>(optimal species to be defined)</td>
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<tr>
<td></td>
<td>pp reference</td>
<td>1 week</td>
<td></td>
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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.