Open Questions: Heavy Ion Physics in HL-LHC and Beyond

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Workshop on the physics of HL-LHC, and perspectives at HE-LHC

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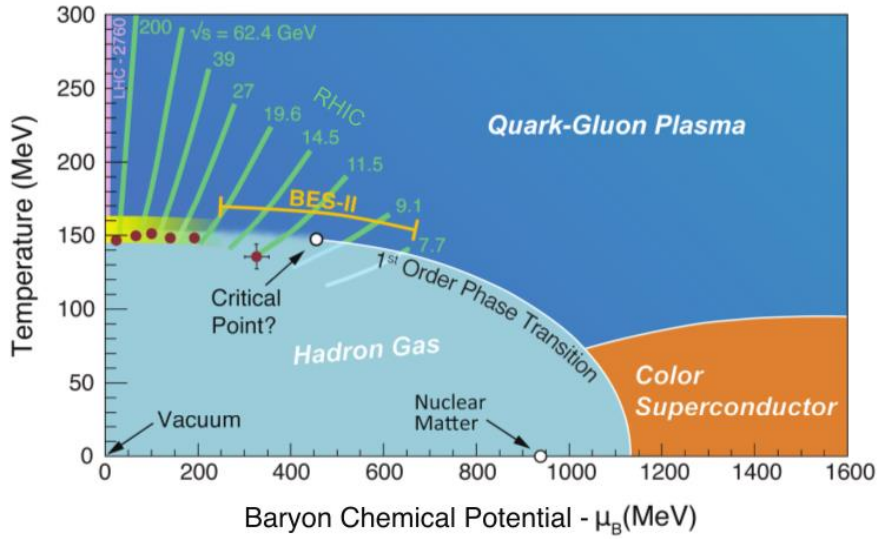
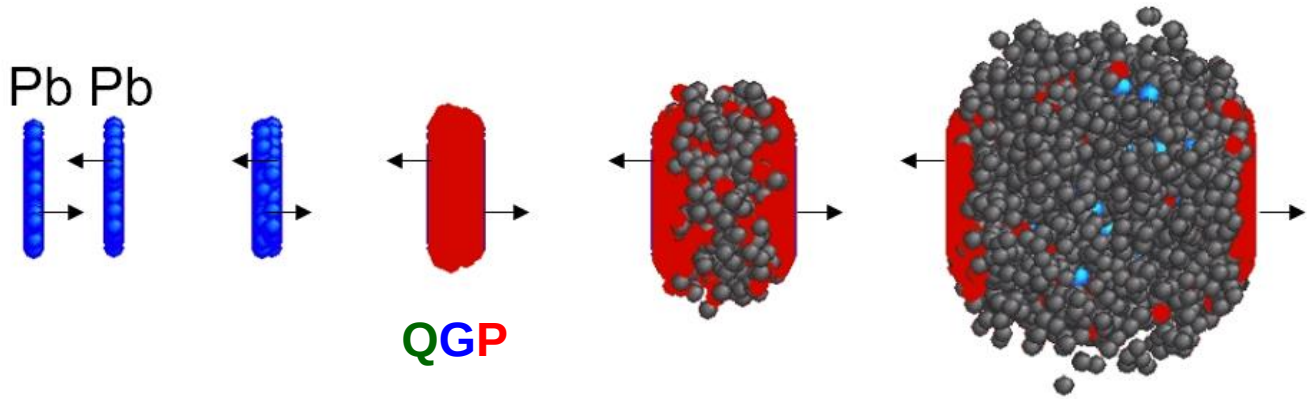
QCD Phase Diagram

- Is there evidence for a chiral phase transition?
- What is the evidence of an increase in the number of degrees of freedom as the QGP is formed? It should be about a factor 10.
- Is it possible to see a first order phase transition when we have high baryon density?



Early Stages of the Collisions



- What is the state of matter ***before*** the collisions happen?
- What happened ***between*** the collision and the production of the **QGP**?
- How does the strongly interacting medium emerge from an asymptotic free theory (QCD)?
- Is the produced system in equilibrium *at "birth"* or does it thermalize and equilibrate as a result of interactions, after the initial collision (or both)? How can we show it experimentally?

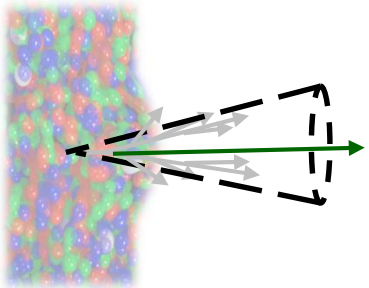
The Strongly Interacting Medium

- What is the evidence that the strongly interacting medium we see is really a deconfined liquid?

- Can we see quasi particles (quarks and gluons) in the QGP?
  Is the medium smooth like a clam chowder, smoothie, or much smoother like water?



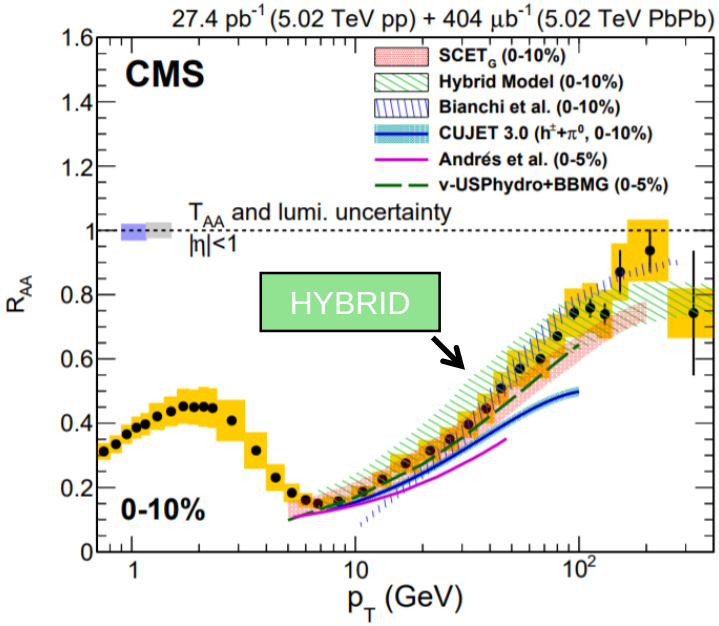
- Could we see medium response (recoil, Mach cone and wake) in the Quark Gluon Plasma?

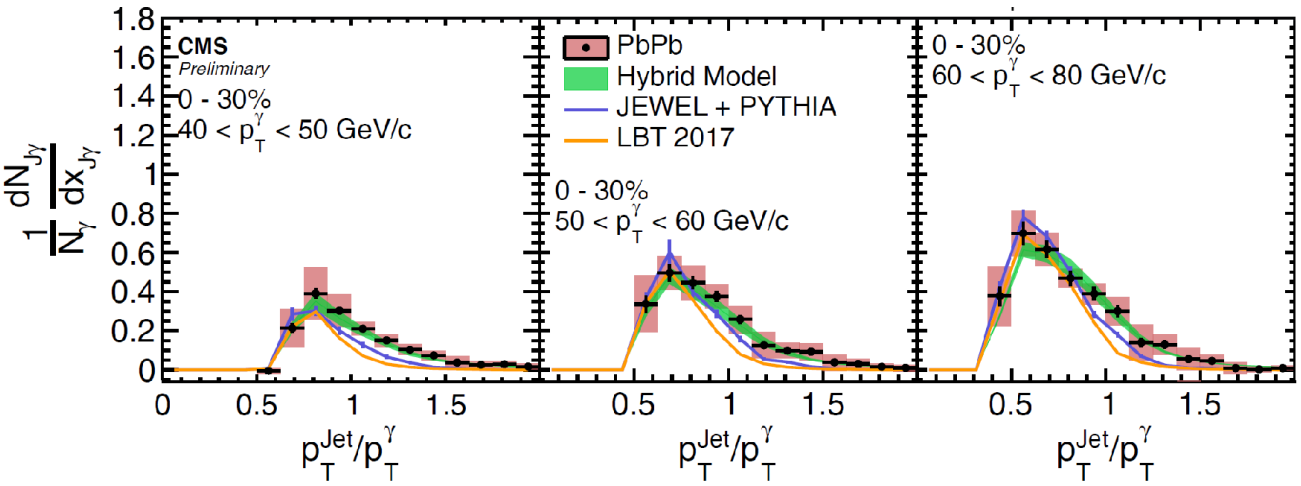


- How are hadrons produced in AA, pA and dA collisions? Are they the same or different from pp collisions?

Detailed Understanding of Jet Quenching

- What, in reality, is the mechanism of jet and hadron quenching?

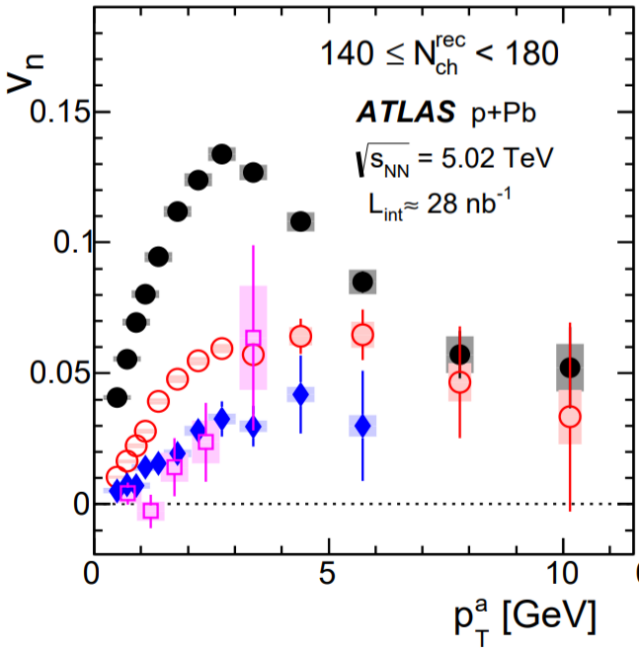




- Is the thermalization of the jets (and the heavy quarks) the same mechanism as the one responsible for hydrodynamic flow?

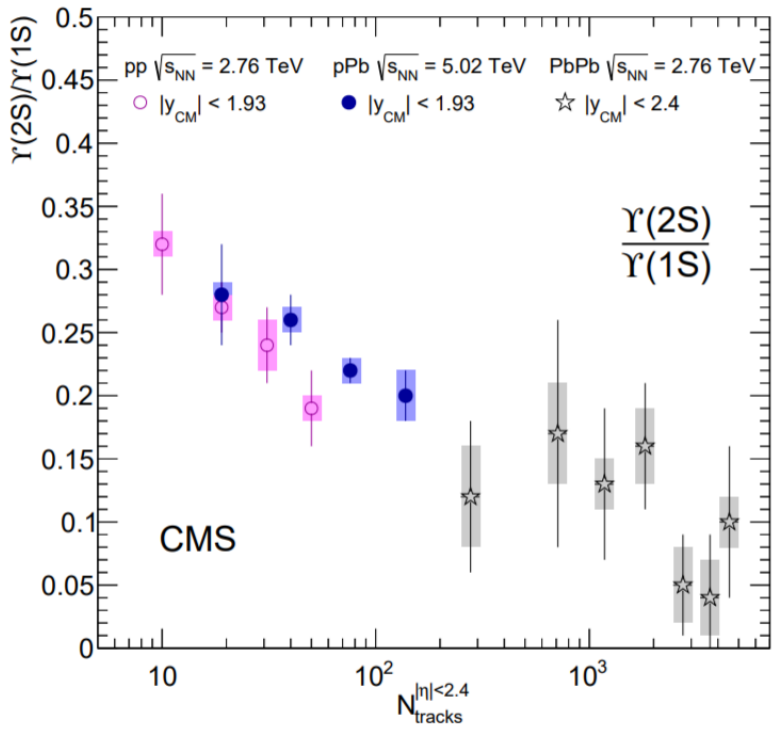
- Are jets quenched in smaller system? What is the minimum requirement?

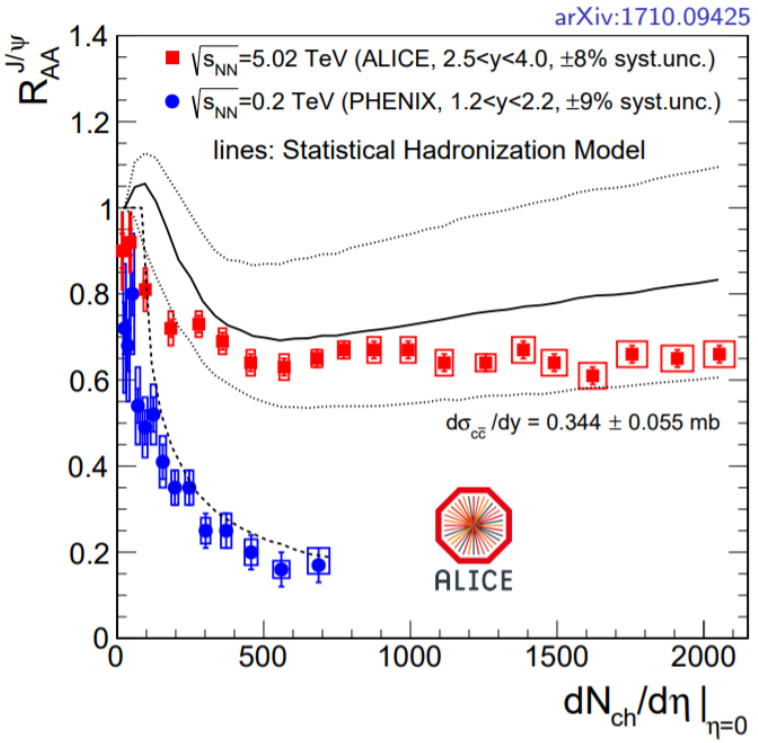
- How do we detect jet quenching in high multiplicity pp? (if any)



Detailed Understanding of Quarkonia Production

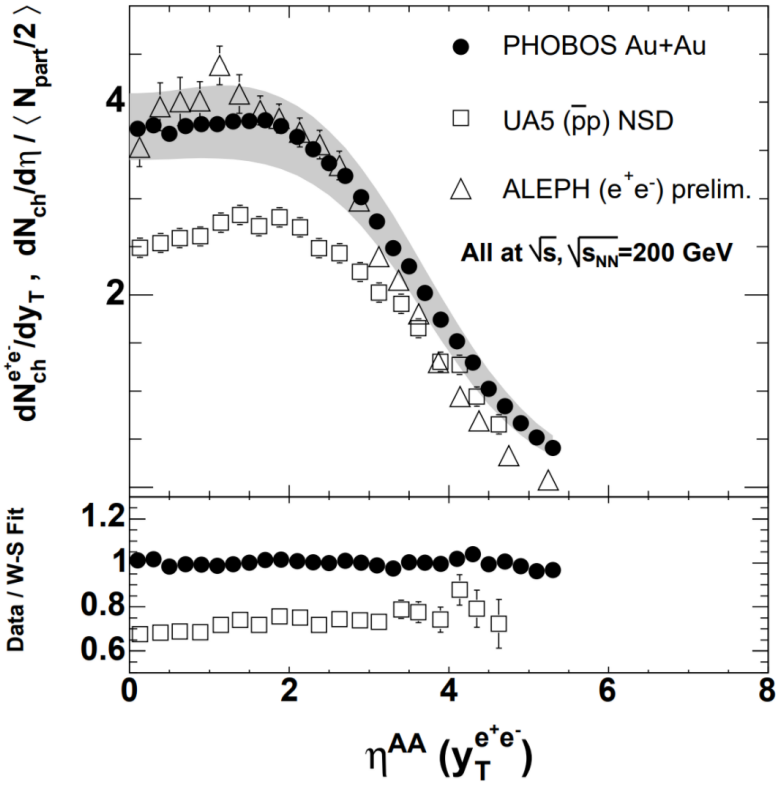
- What is the mechanism of Quarkonia suppression in pPb and PbPb collisions?
- Why are the excited states of Quarkonia more suppressed than the ground state in high multiplicity pp and pPb events?
- Have we observed low p_T J/ψ from recombination?

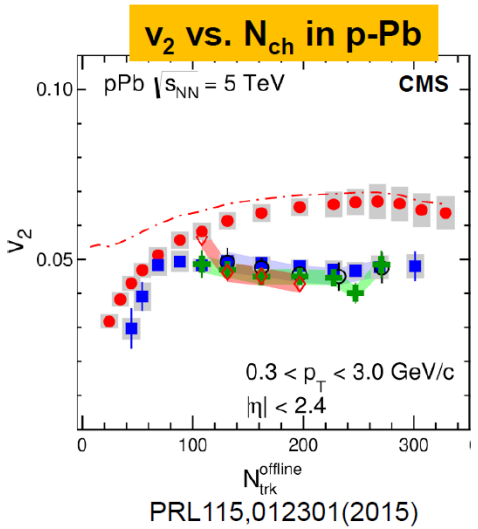




Similarity of ee, pp, pA and AA collisions

- Why are (ee), pp, pA and AA collisions so similar?
- What is the origin of the “flow like” signal in pp and dA and pA collisions?
- Does the strange hadron to pion ratio saturate at high multiplicity pp and pA collision?
- How are hadrons produced in AA, pA and dA collisions? Are they the same or different from pp collisions?





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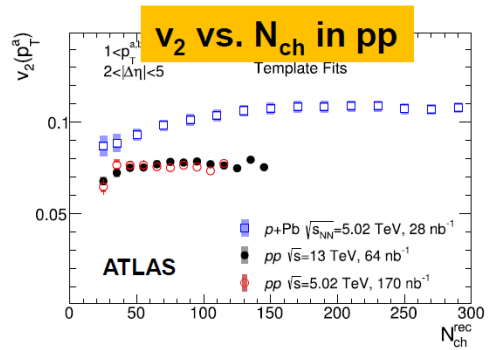

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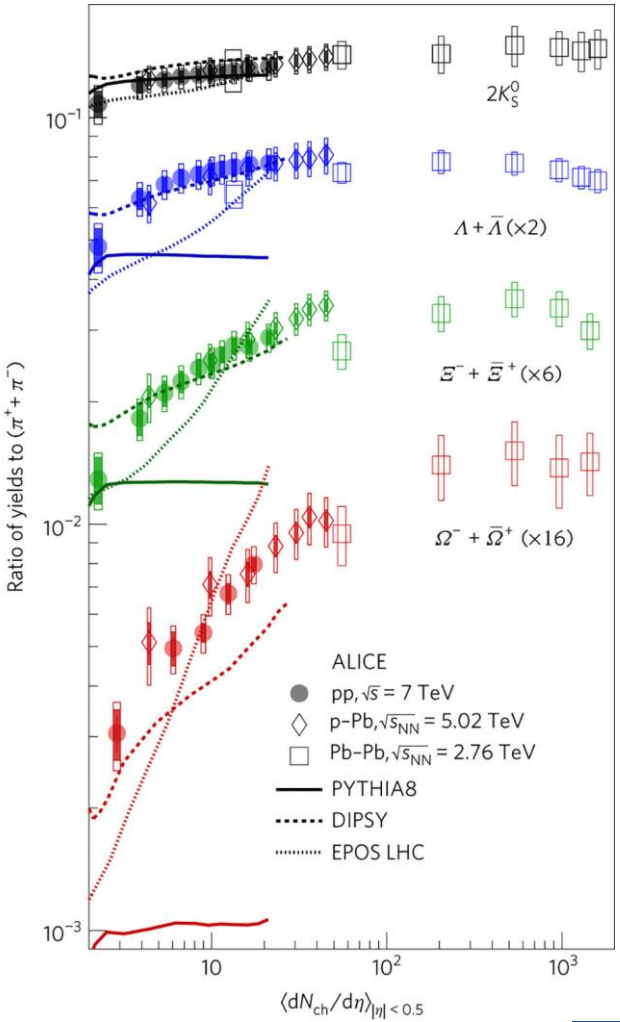
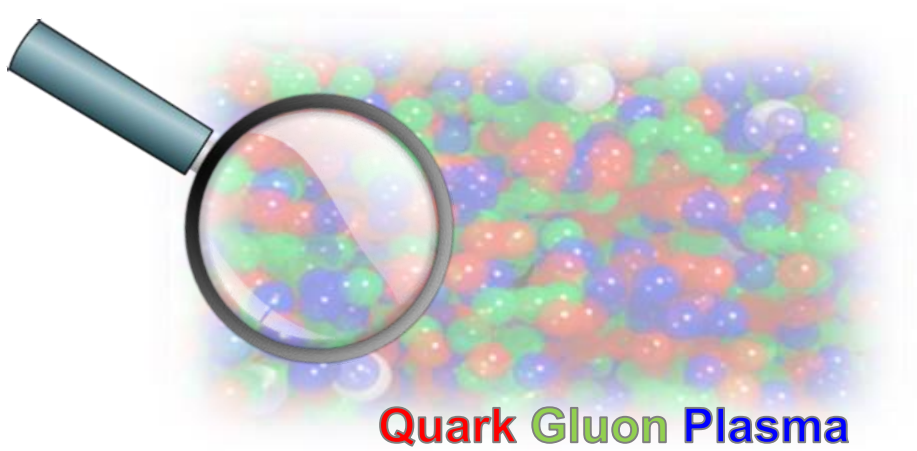


“New Physics” in QGP

- Chiral Magnetic Effect?
- Vortices?
- Production of jets with exotic structure?
- (.. new particle which could only be produced in the bath of color field?)



One day, in my dream…

LHC

HL-LHC