Open forum meeting: Future of RHIC Upgrades

Brian A. Cole
Columbia University
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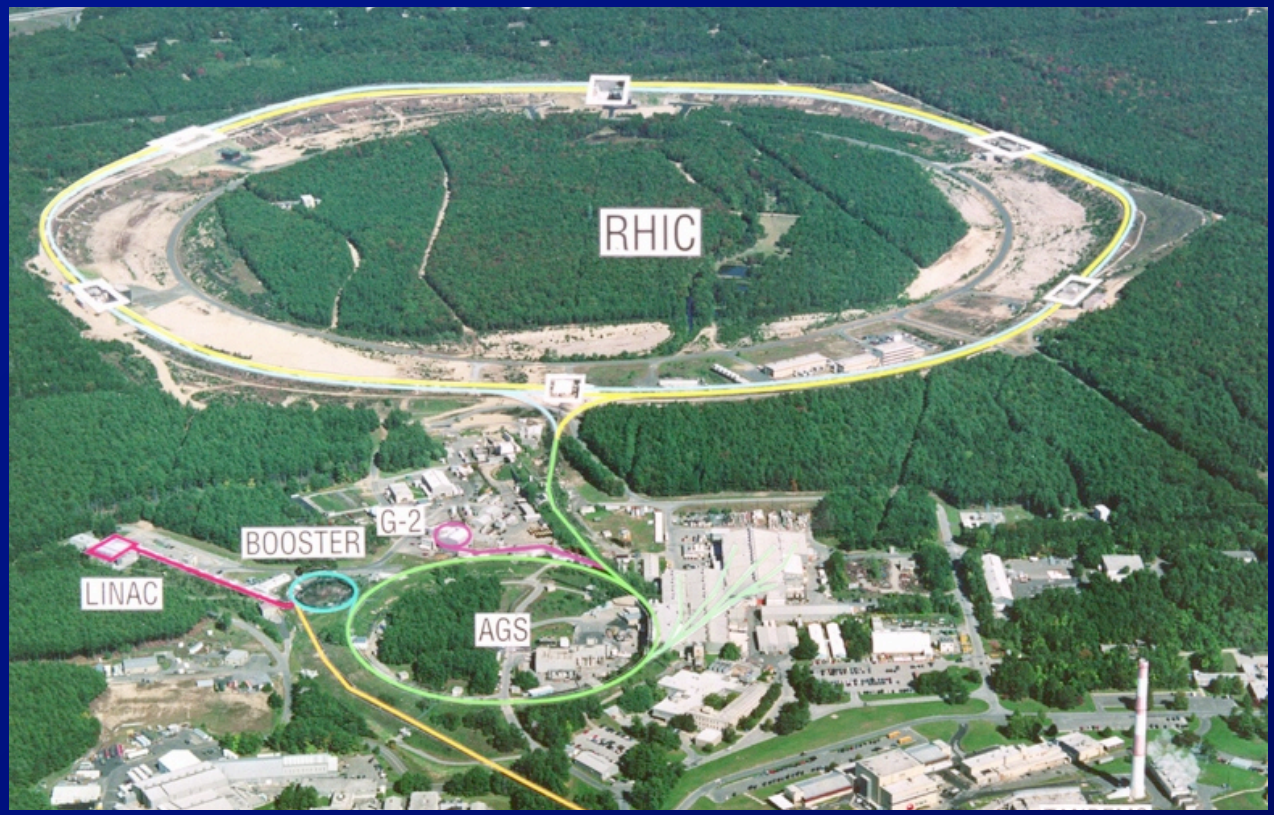


The Big Picture

- We know that strong interactions are well described by the QCD Lagrangian:

$$L_{QCD} = -\frac{1}{4} F^a_{\mu\nu} F^{\mu\nu}_a - \sum_n \bar{\psi}_n \left(\not{\partial} - ig\gamma^\mu A^a_\mu t_a - m_n \right) \psi_n$$

  ⇒Perturbative limit well studied

- Nuclear collisions provide a laboratory for studying QCD outside the large Q^2 regime:
  - Deconfined matter (quark gluon plasma)

    ⇒"Emergent" physics not manifest in L_{QCD}

    ⇒ Strong coupling ⇒ AdS/QCD (?)

  - High gluon field strength, saturation

    ⇒ Unitarity in fundamental field theory

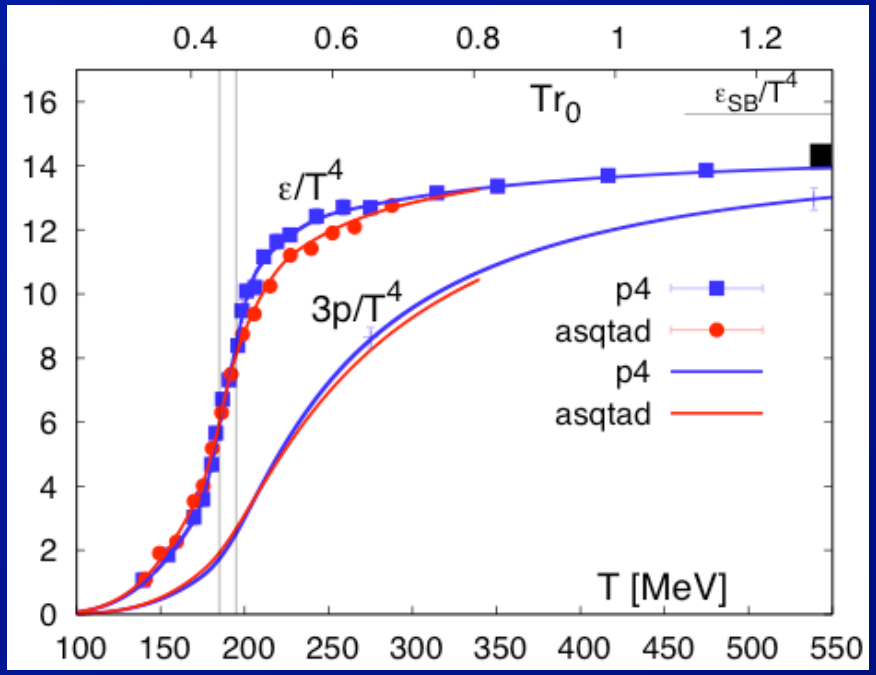
- Only non-Abelian FT whose phase transition & multi-particle behavior we can study in lab.

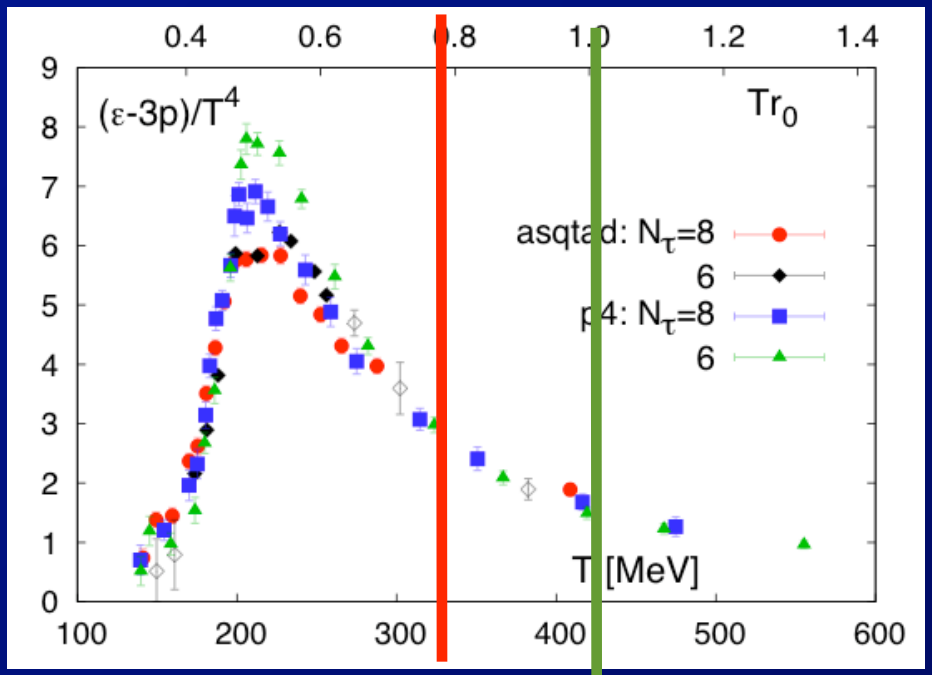
QCD Thermodynamics on Lattice

Energy Density or pressure

T_{RHIC} (τ =1fm)

T_{LHC} (τ =1fm)





- Lattice thermodynamics from hotQCD group
  - Trace anomaly $(\varepsilon-3p)/T^4$, an "interaction measure"
    - ⇒Strong coupling already evident near T_C (?)
- Can we observe any consequences of the increase of the (initial) temperature between RHIC and LHC?

The future of RHIC

- **Some basic assumptions:**
  - Planning for the future of RHIC (including upgrades) should be driven by science opportunities
  - For RHIC to have a future that science must be compelling and unique***
    - ⇒Convince DNP colleagues re: science
    - ⇒Convince funding agencies, congress, OMB, re: science
    - ⇒Convince next generation re: science
  - Any plan must be realistic
    - ⇒Respect budget constraints
    - ⇒Respect manpower constraints (RHIC, LHC, EIC)
    - ⇒Can be accomplished within reasonable time
    - ⇒Compatible with a future EIC

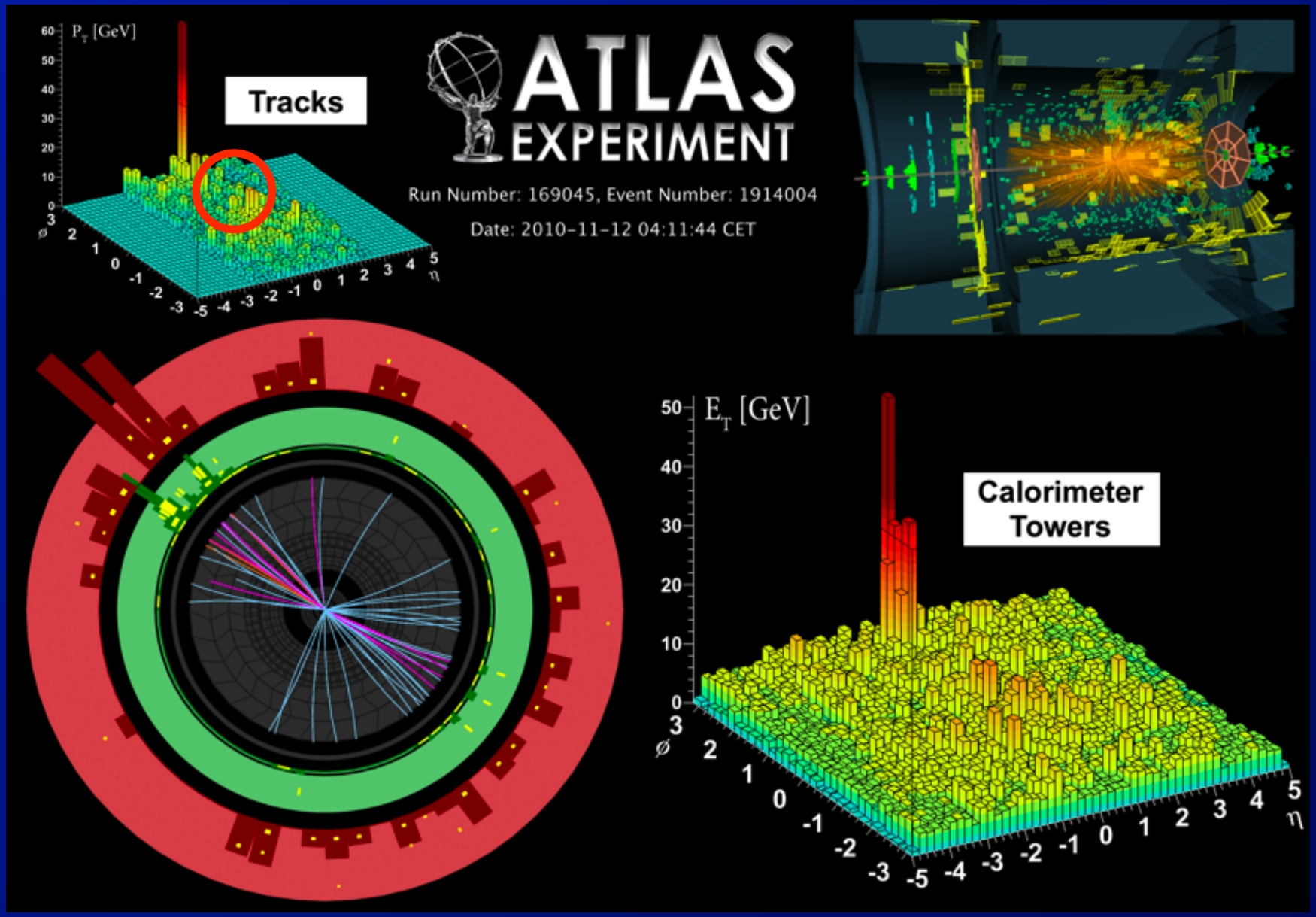
The future of RHIC

- ***What constitutes unique science @ RHIC
  - Science accessible via unique capabilities of machine
    - ⇒e.g. critical point search via lower energies
    - ⇒e.g. Cu+Au, U+U. One shot only? (precision)
  - Science accessible via unique experiment capabilities
  - Science that is unique because of physics
    - ⇒e.g. thermal direct photons @ RHIC(?)
    - ⇒e.g. quark-dominated jets @ high p_T
- Thoughts
  - Just because LHC can do a measurement (e.g. Υ), doesn't mean that a similar measurement @ RHIC isn't compelling or unique
    - ⇒Following above example, testing Υ "melting" at two different initial temperatures is compelling.

Personal Prejudices

- We are closing in on a major goal of field
  - Determination of <η/s>
  - Next step: T dependence of <η/s>
- The next major quantitative goal (IMHO):
  - $\hat{q}$, $\left.\frac{dN_g}{dy}\right|_{t_0}$, i.e. jet-sQGP interactions
  - light quark vs gluon vs c, b
- Quantitative precision requires
  - Controlling initial-state effects
    - ⇒Shadowing, energy loss
  - Testing theoretical approximations
    - ⇒e.g. path length dependence
  - Clear that jets are a "game changer"

ATLAS: asymmetric dijet in Pb+Pb



Central collision, highly asymmetric dijet

RHIC Upgrades

- The (future) upgrades perspectives are very different for STAR, PHENIX
  - For long-term precision measurement program, to pursue quenching measurements with jets

    ⇒PHENIX needs major upgrade (sPHENIX)

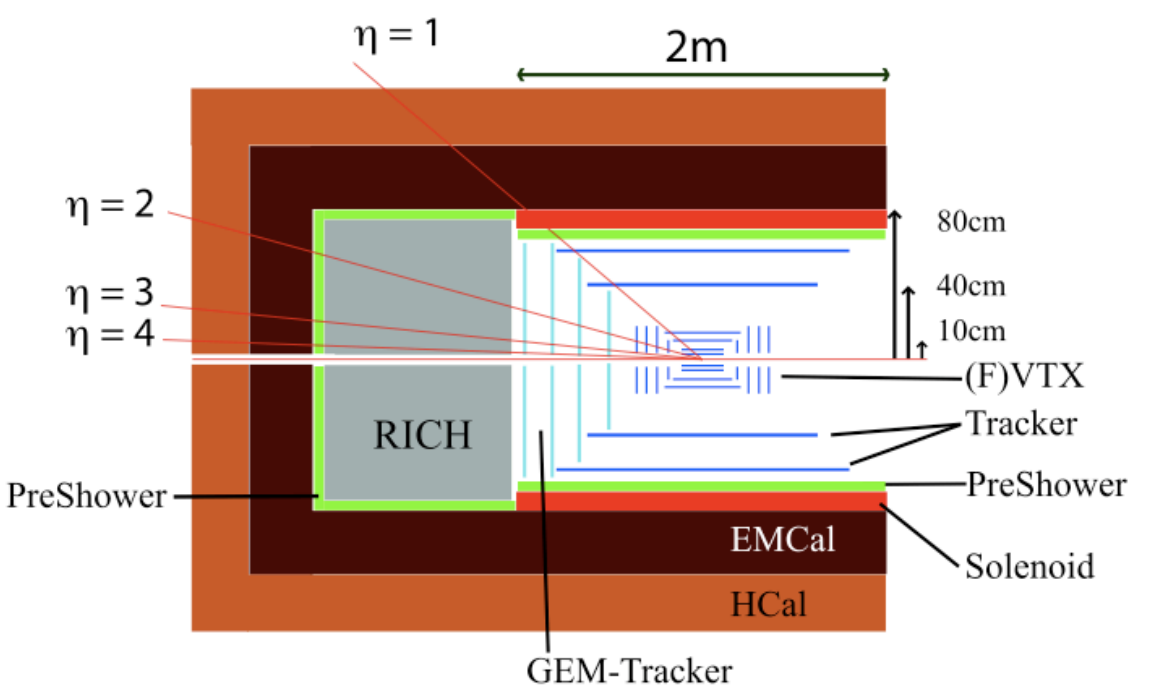


Figure 1. A strawman sketch of the sPHENIX detector. Some features of the detector are discussed in the text.

Ruminations

- I think a compelling case can be made for RHIC science for ~ another decade
  - My nightmare scenario is that RHIC, LHC programs end without quantitative follow-up to discoveries

    ⇒We cannot let that happen
- RHIC community must work together to accomplish that science

    ⇒Success of program depends on all the parts
- The η/s story shows necessity of good theory
- Strategy for RHIC into EIC beyond my pay grade
  - But Steve has articulated viable strategy IMHO
- IMNSHO EIC is essential part of program
  - Initial state, evolution to sQGP still a mystery