The QCD Equation of State in Small Systems

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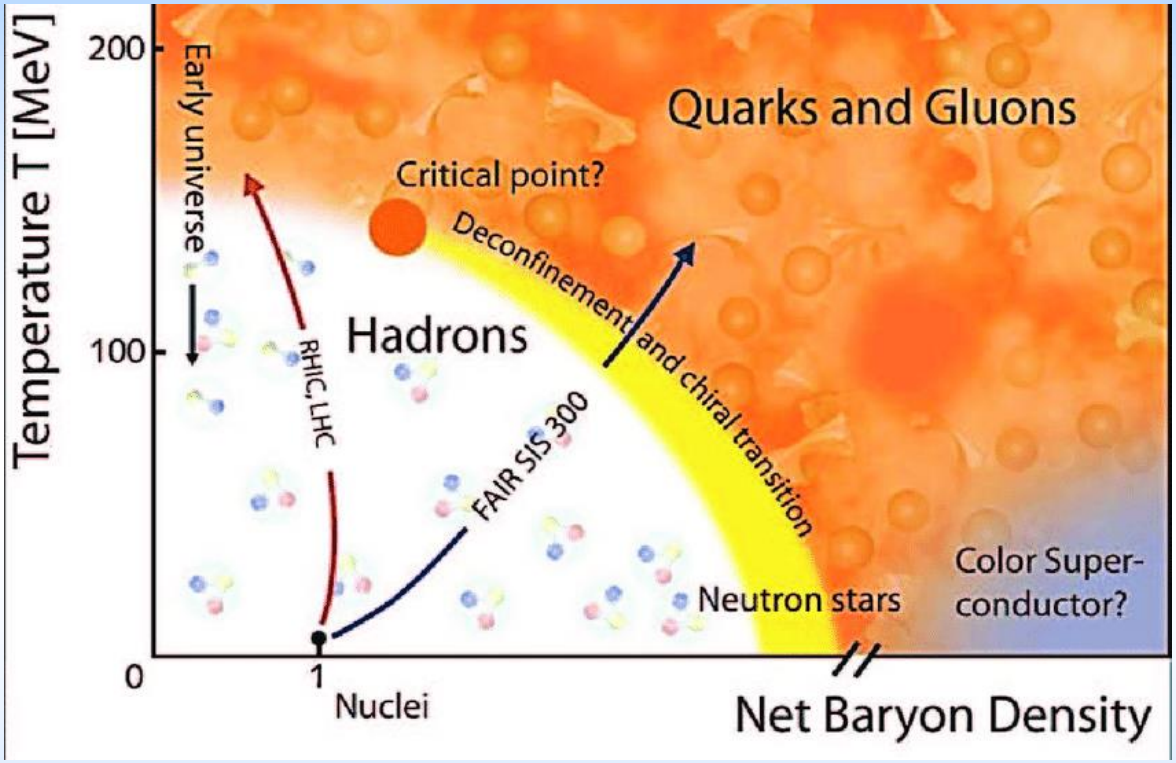
Mogliacci, Kolbé, WAH, PRD102 (2020) [1807.07871]
Kitazawa, Mogliacci, Kolbé, WAH, PRD99 (2019) [1904.00241]
WAH and Rothkopf, *in progress*

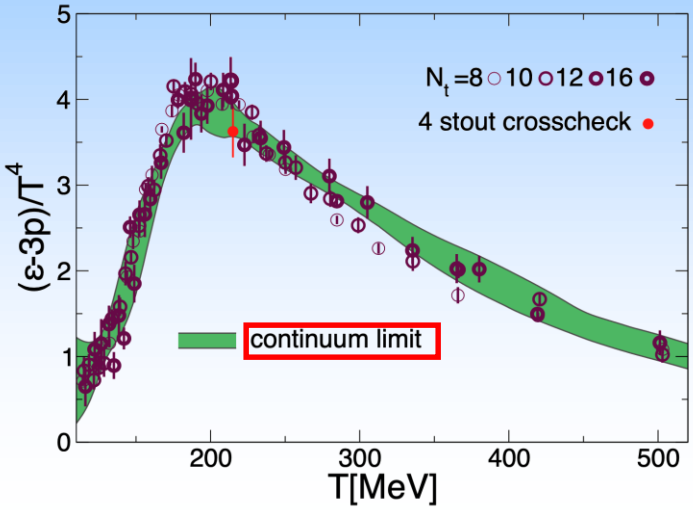
Why HI Collisions?



- Quantify non-trivial, emergent many-body phenomena of non-Abelian QFT

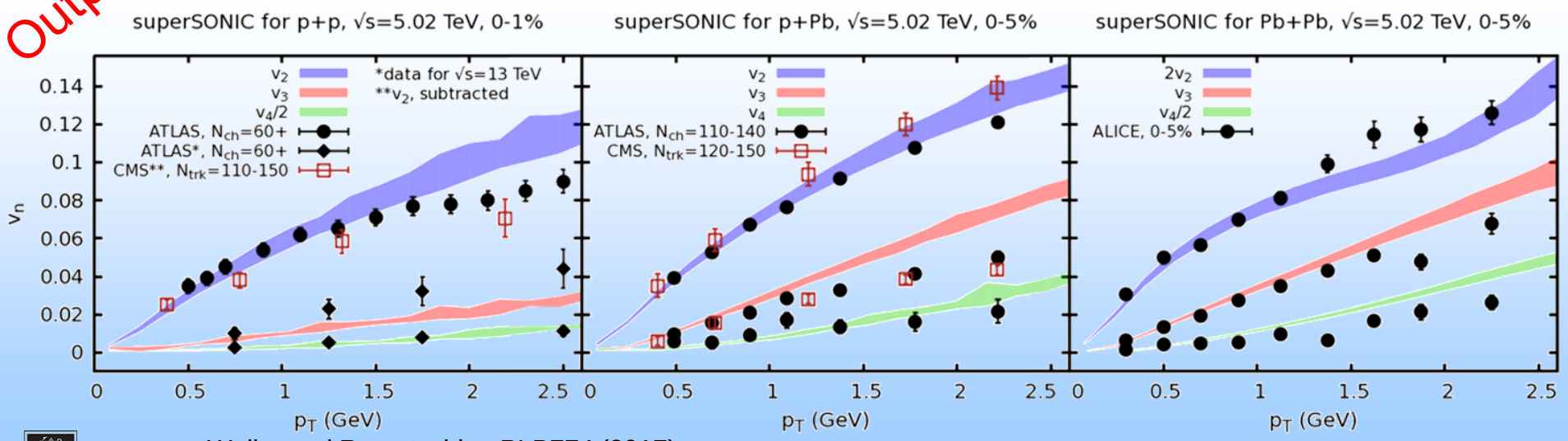
Hydro + HI Probes QCD/QGP

Input



Borsanyi et al., PLB730 (2014)

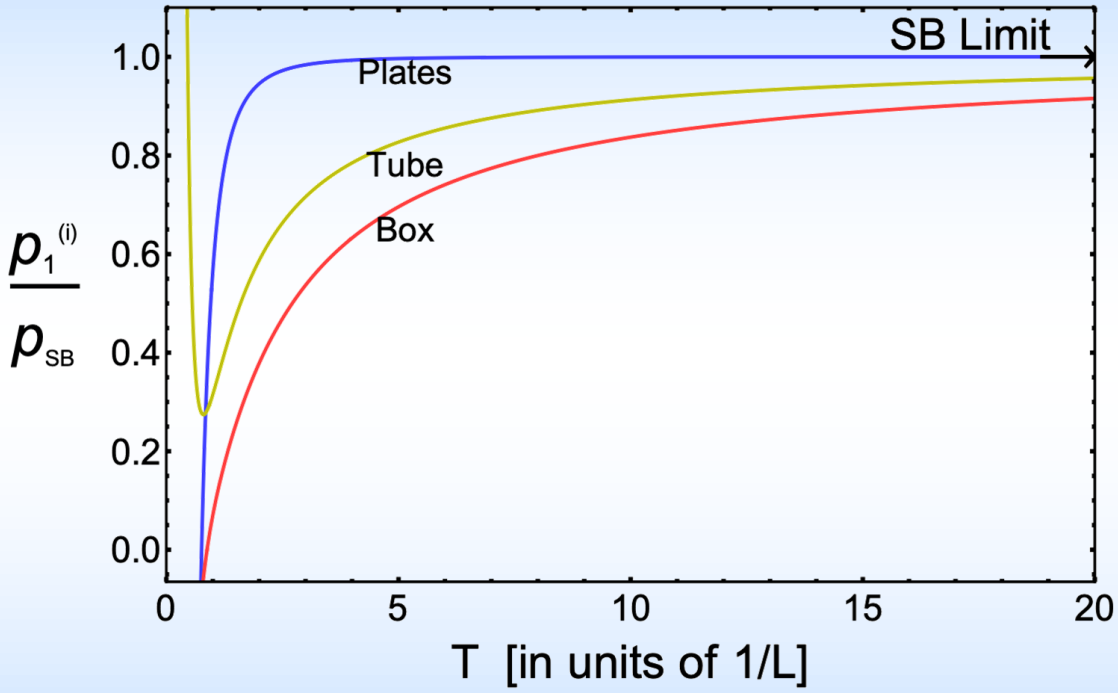
Output



Weller and Romatschke, PLB774 (2017)

Does Finite Size Affect Thermodyn.?

- Test using free scalar field theory



~10% effect at 400 MeV
for ~1 fm system

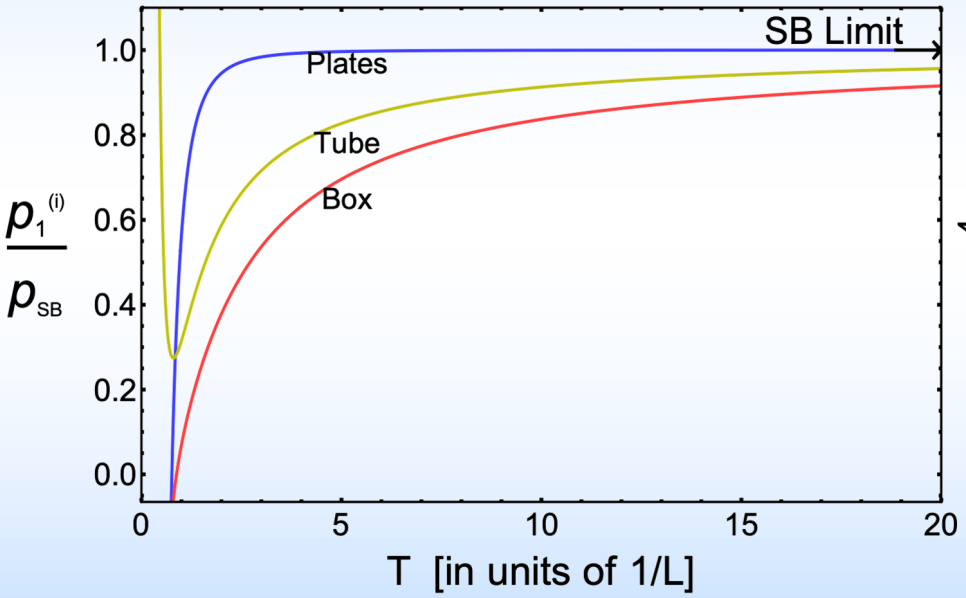
Mogliacci, Kolbé, and WAH, PRD102 (2020)

– p decreases significantly as T decreases for fixed L, converging to T = 0 Casimir effect

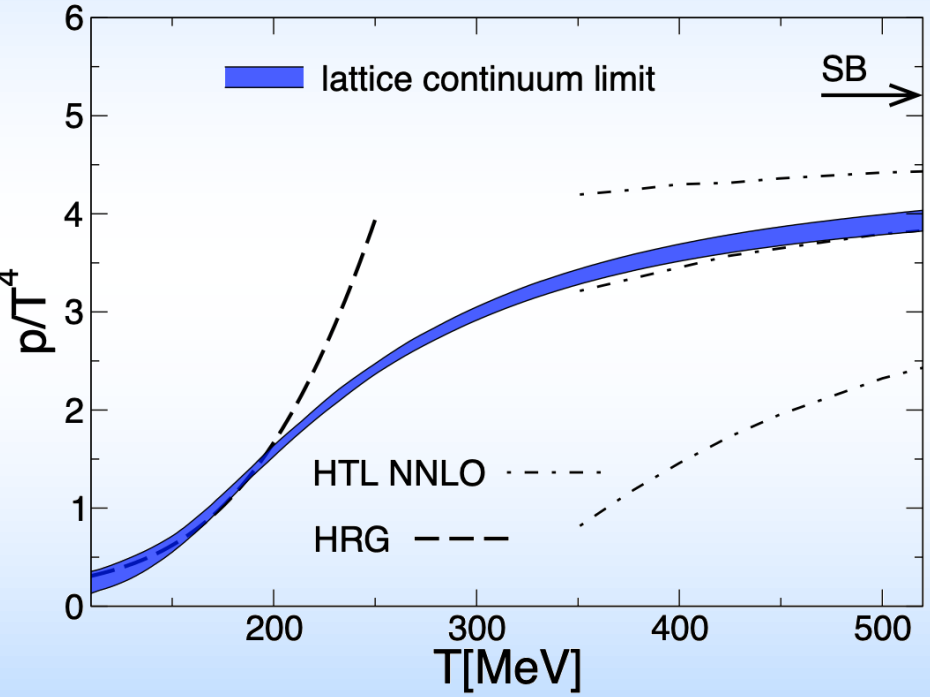
See also I Ghisoiu MSc thesis

Does Finite Size Affect Thermodyn.?

- Provocative qualitative T dependence:

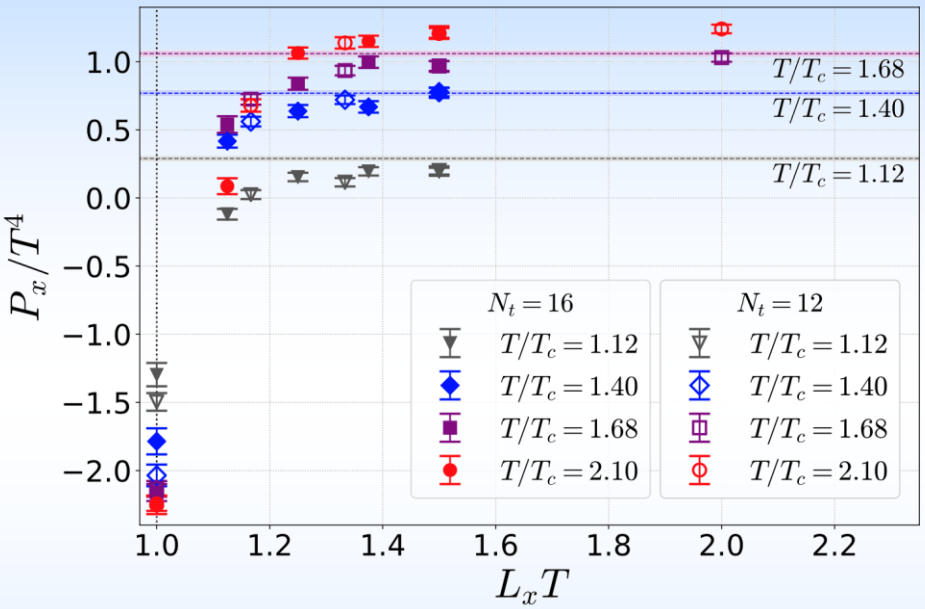


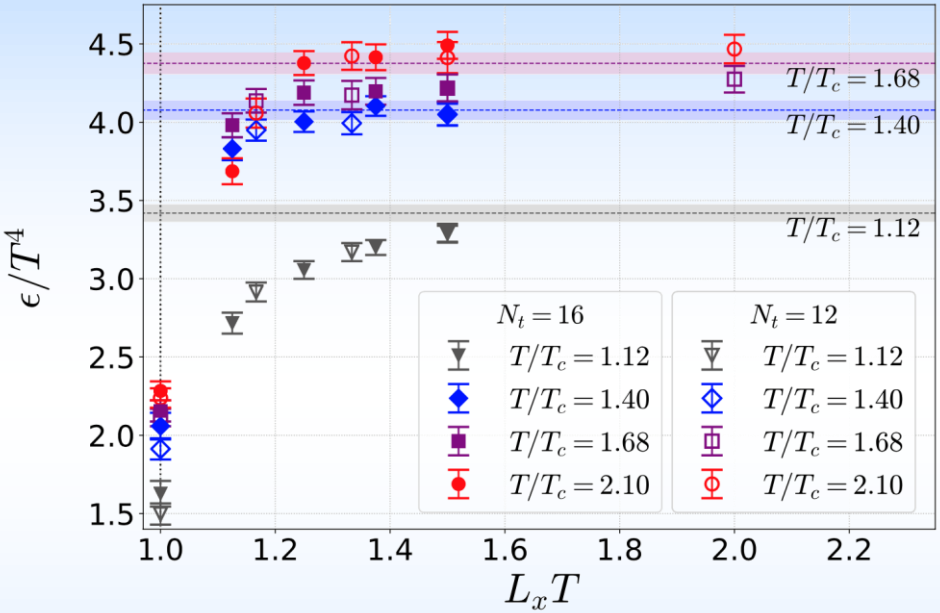
Mogliacci, Kolbé, and WAH, PRD102 (2020)



Borsanyi et al., PLB730 (2014)

FS Effects in Quenched QCD



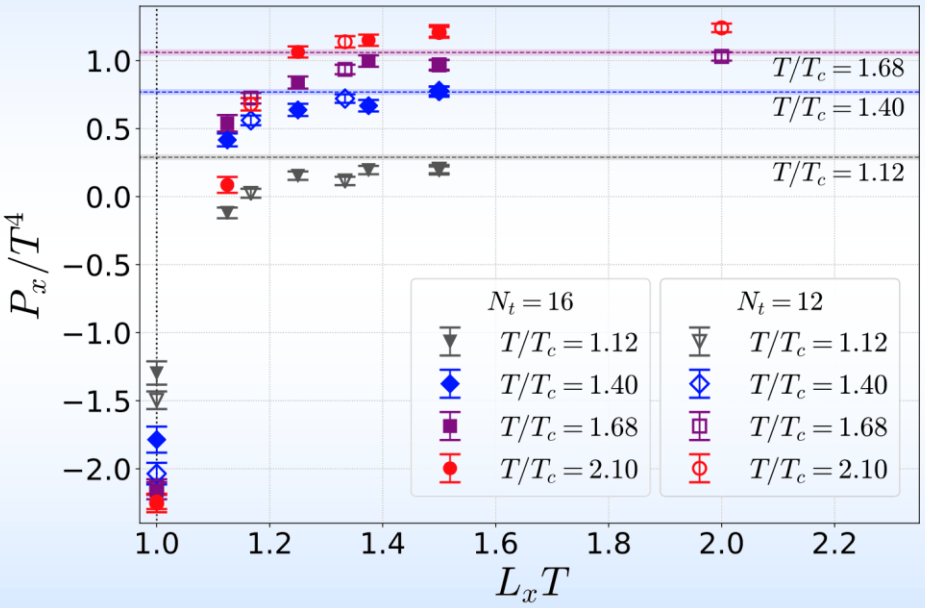


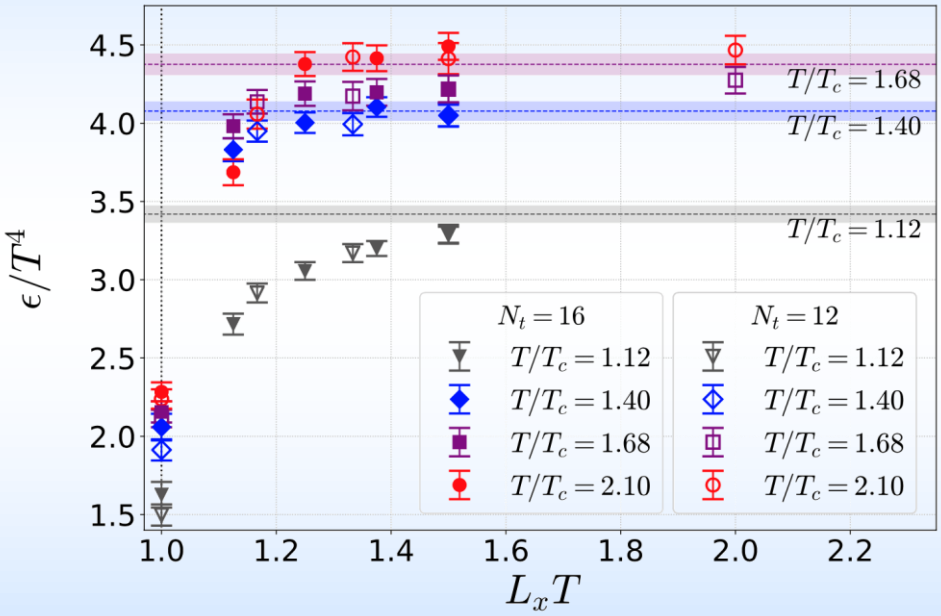
Kitazawa, Mogliacci, Kolbé, and WAH, PRD99 (2019)

- Full lattice simulations of p, e follow analytic scalar/Casimir expectations

FS Effects in Quenched QCD

- Thermodynamic quantities on anisotropic lattice with periodic boundary conditions



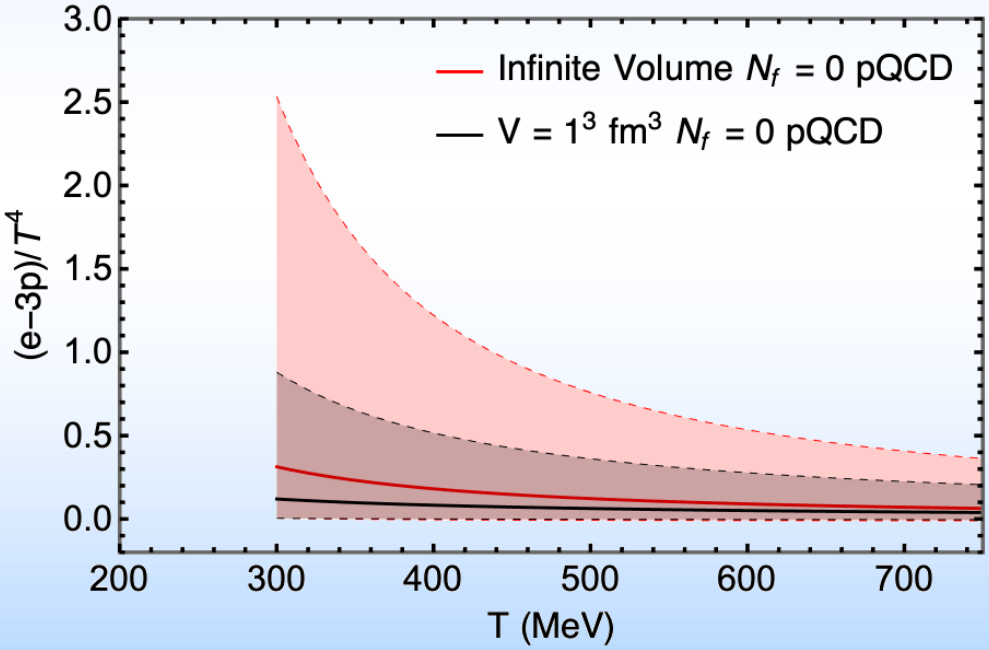


Kitazawa, Mogliacci, Kolbé, and WAH, PRD99 (2019)

  - Reduction of p, e with T*L qualitatively similar to free, massless scalar theory

FS Effects on Trace Anomaly

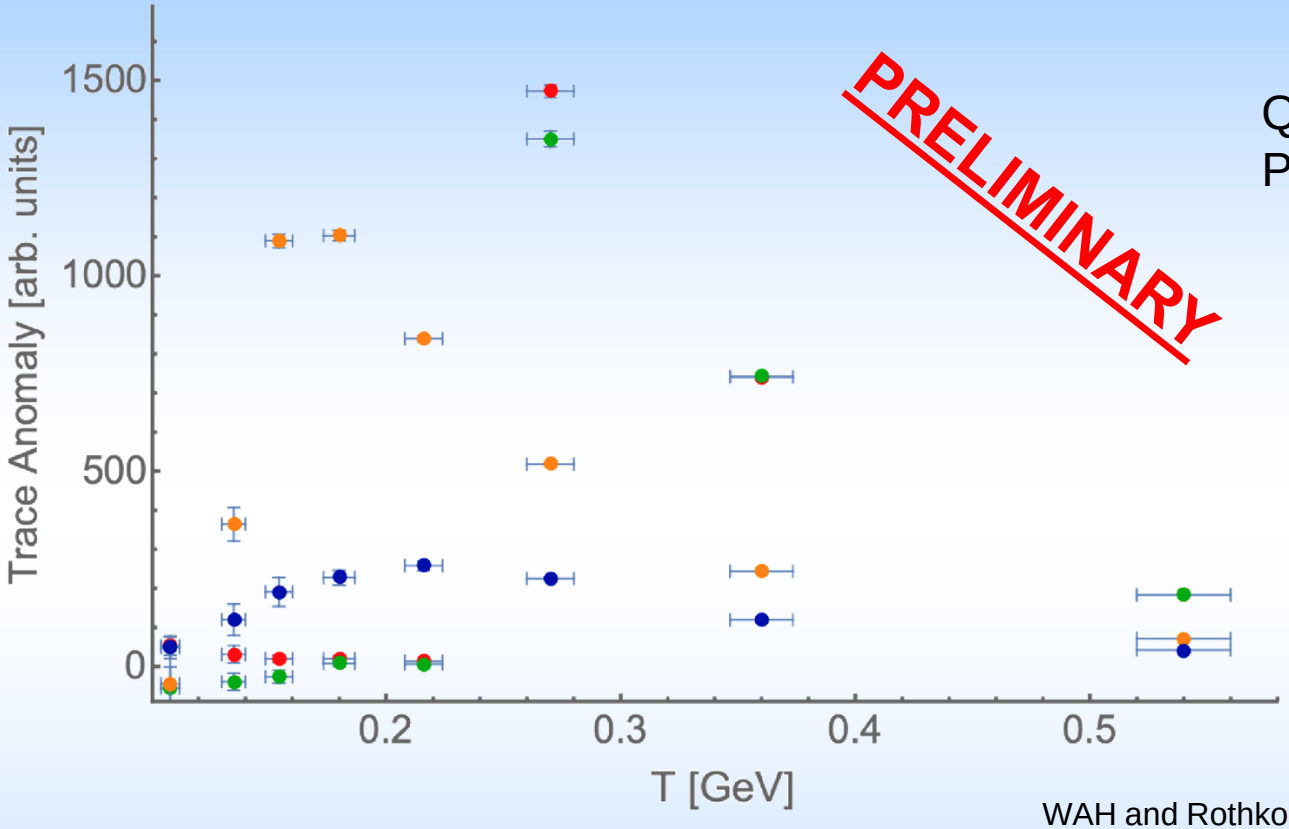
- Analytic expectations
  - Scalar running coupling decreased by FS
  - Use form of scalar FS correction in SU(3)



WAH and Rothkopf, *in progress*

  - Δ decreases with decreased system size

FS Effects on Δ in Lattice



Quenched QCD
Periodic BCs

WAH and Rothkopf, in progress

- Decreasing system size:
  - decreases Δ
  - washes out phase transition

Conclusions

- Finite size effects can be large for thermodynamics in QFT's
  - Appear to be phenomenologically relevant for pp collisions up to peripheral AA
  - Likely impact extraction of QCD EoS from data
- Future work:
  - Explicitly compute finite size effects in running QCD coupling
  - Refine current lattice calculations with periodic BCs
  - Implement more realistic Dirichlet BCs on lattice
  - Maintaining gauge invariance a challenge