Search for the critical point through the rapidity dependence of cumulants

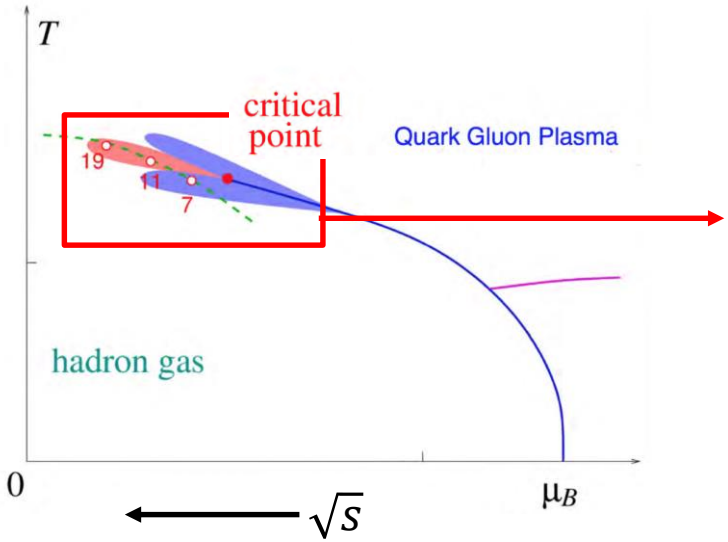
Jasmine Brewer

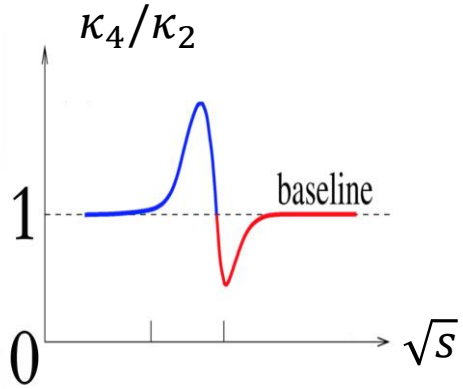
With Swagato Mukherjee, Krishna Rajagopal, and Yi Yin

arXiv: 1804.10215

Search for a critical point at the Beam Energy Scan

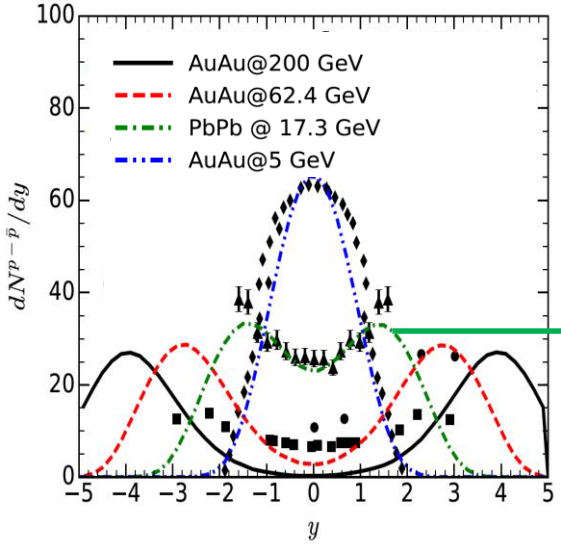
- characteristic signature: non-monotonicity and sign change of cumulants as a function of beam energy





Stephanov 0809.3450, 1104.1627

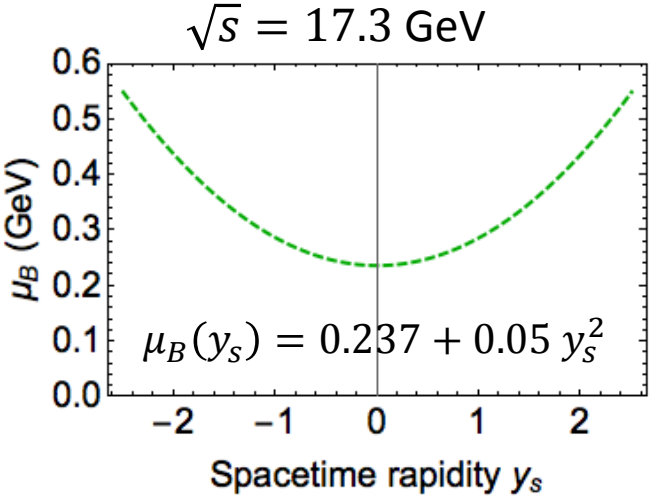
At RHIC energies, μ_B has non-trivial rapidity dependence



Shen and Schenke, 1710.00881

Thermal model fit

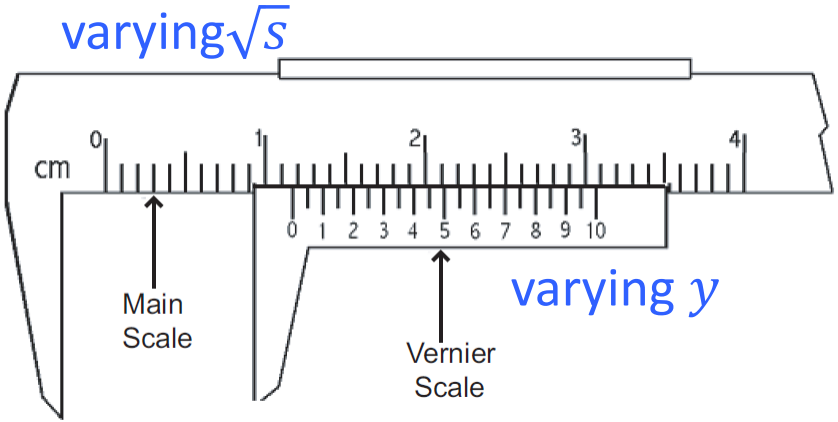
Beccatini et. al. 0709.2599

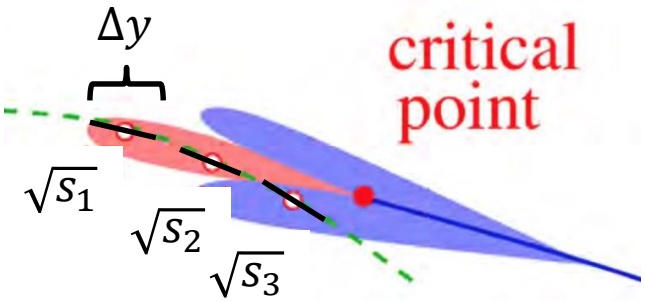


Near mid-rapidity: $\mu_B(y_s) \approx \mu_{B,0} + \alpha\, y_s^2$

(see Chun Shen's talk at 11:30 today for a more complete picture!)

Rapidity is a finer-resolution probe of the critical regime than $\sqrt{s}$

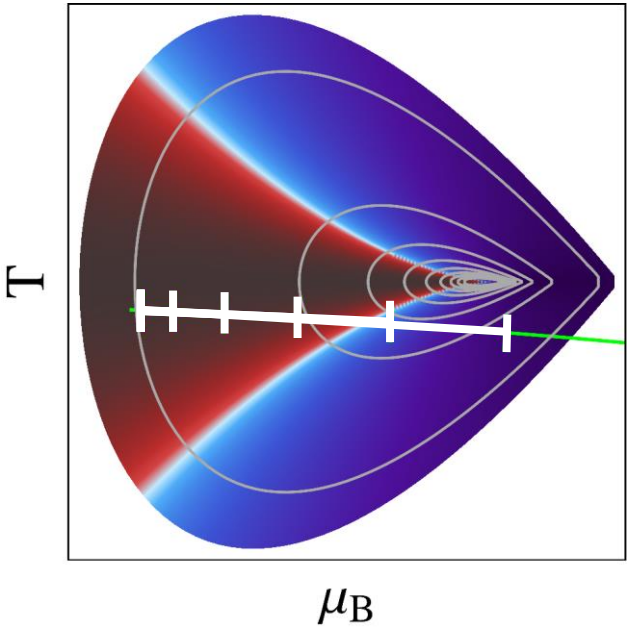




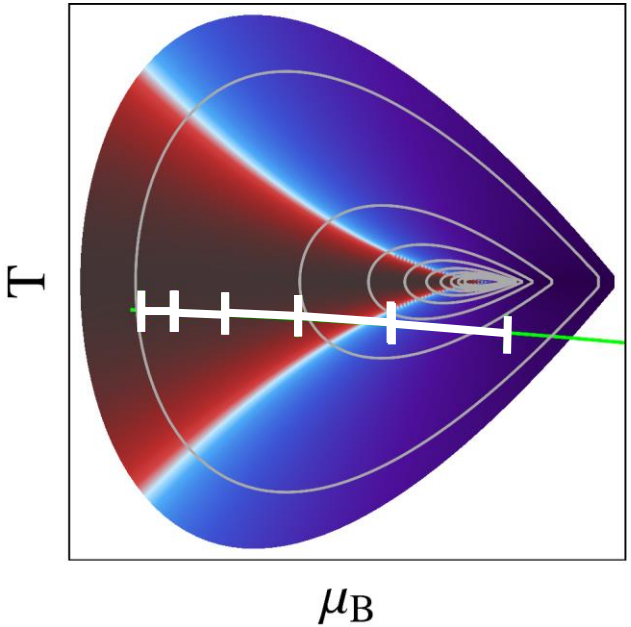
"mini-scan" in y can be used to give additional signatures of a CP

There are several different ways to look at the rapidity dependence

Total rapidity acceptance

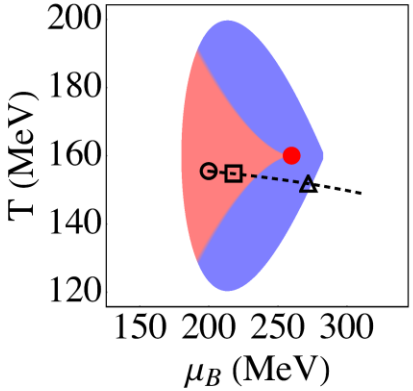


Binning in rapidity



More crisp picture of the critical region

Consider a hypothetical heavy ion collision which freezes out near a hypothetical critical point:



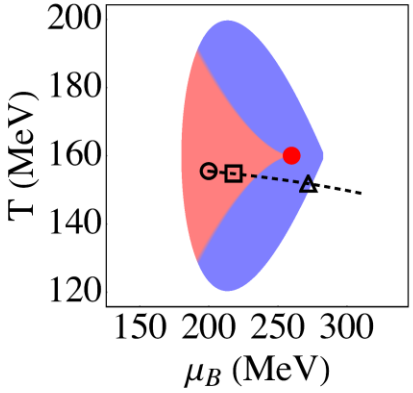
freezeout curve is extended in the critical regime due to

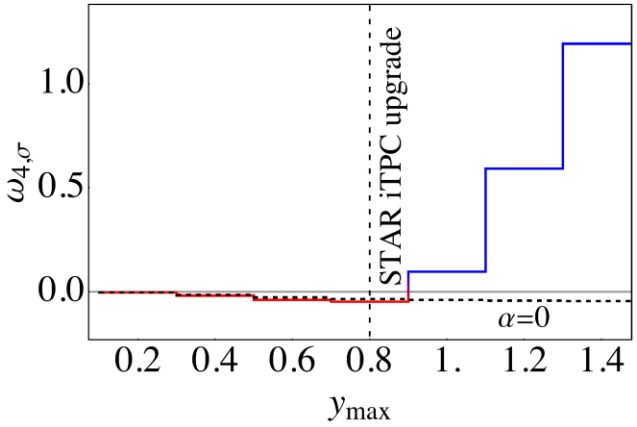
$$\mu_B = \mu_B(y_s) = \mu_{B,0} + \alpha\, y_s^2$$

○ □ △ $\rightarrow y_s = 0, 0.6, 1.2$

$\alpha = 50\ MeV$

Distinctive signatures of criticality arise in the dependence of the kurtosis on the total rapidity acceptance

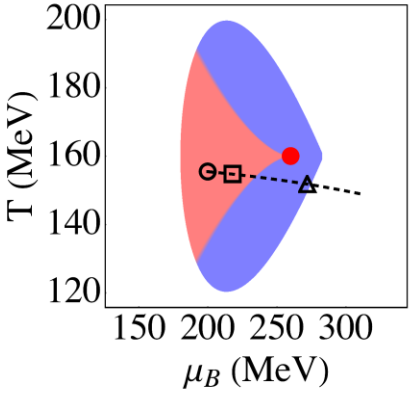


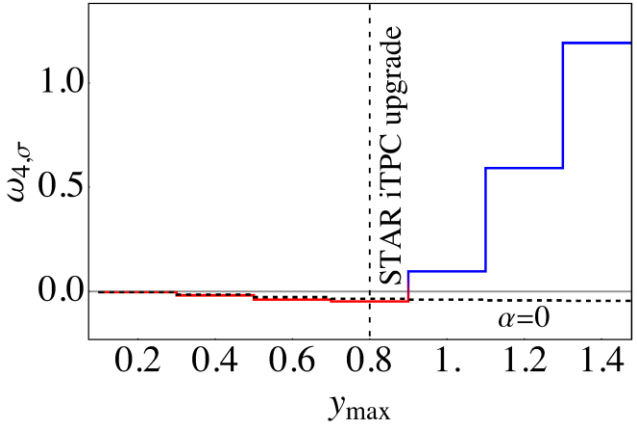


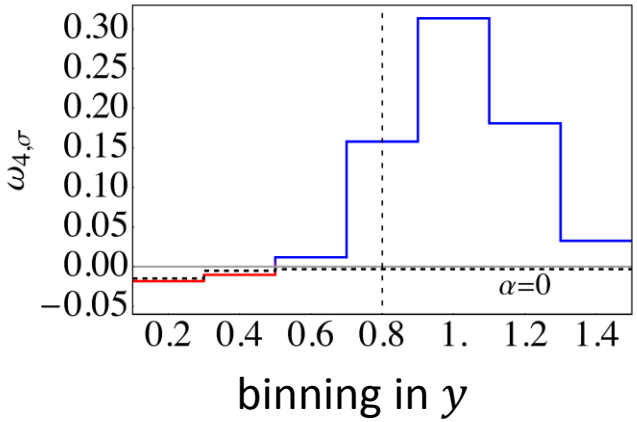
Including contributions from total rapidity acceptance $|y| < y_{max}$ averages over details of the critical regime

○ □ △ $\rightarrow y_s = 0, 0.6, 1.2$

Binning in rapidity gives a more sensitive probe of the critical region



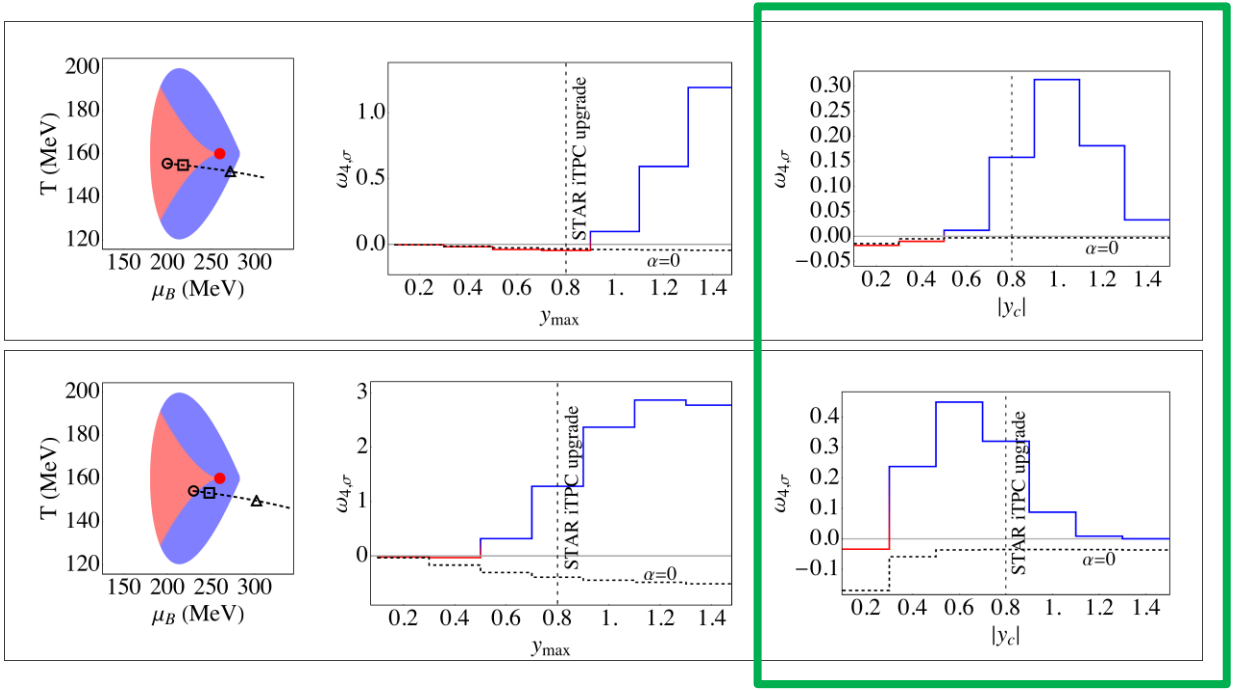




Sign change at lower rapidity

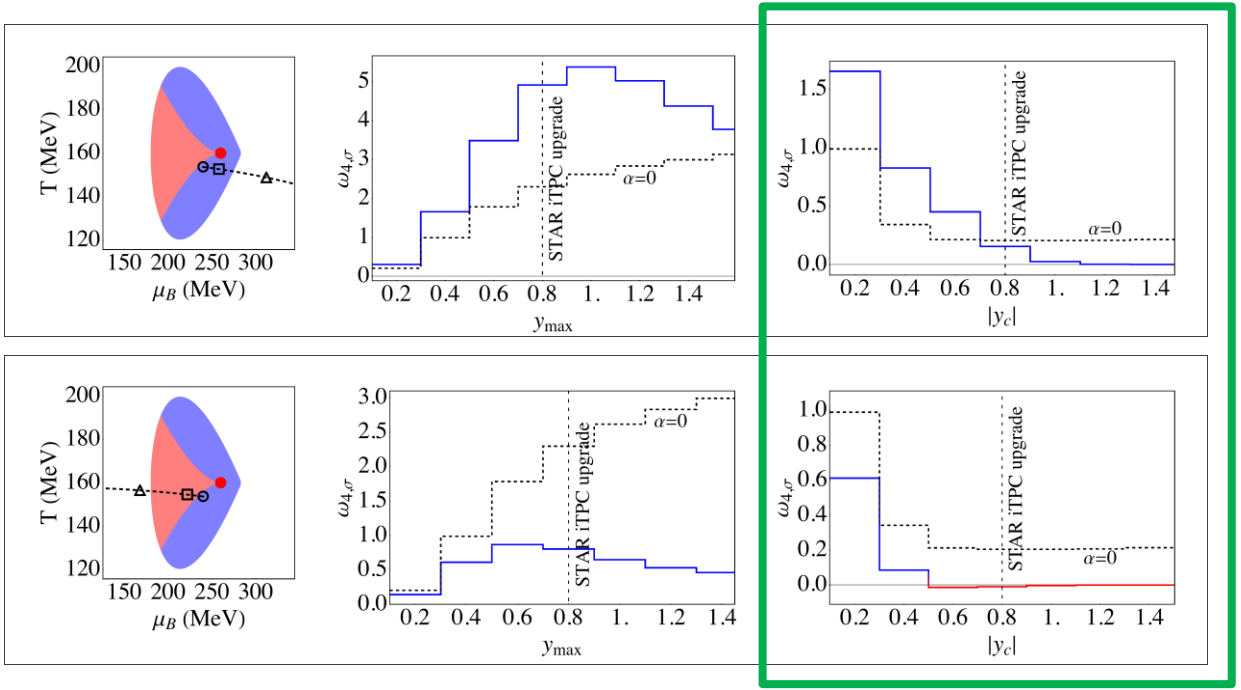
Critical signatures easier to detect at lower rapidity

Decreasing $\sqrt{s}$ to approach a critical point, binned cumulants increase with rapidity



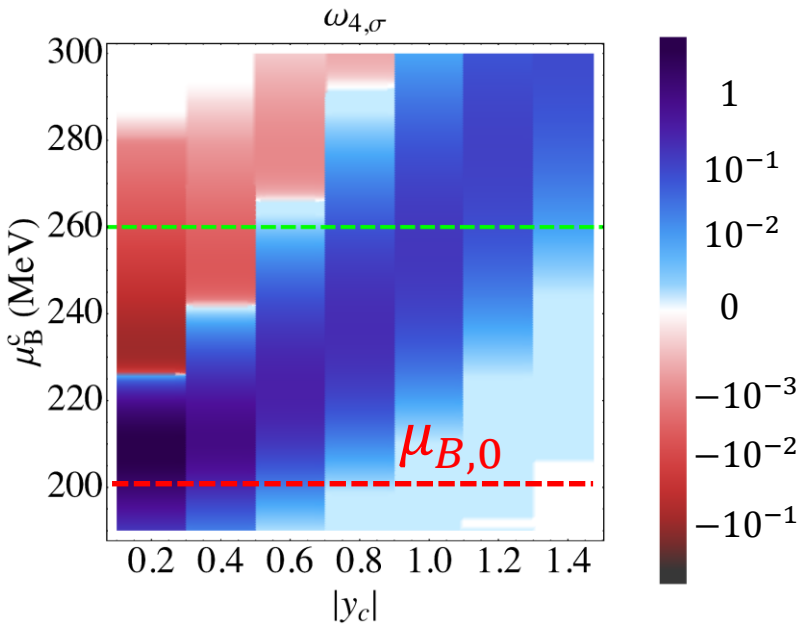
Increasing with rapidity near mid-rapidity

If a critical point is passed, binned cumulants switch to decreasing with rapidity



Decreasing with rapidity near mid-rapidity

Whether cumulants binned in rapidity increase or decrease as a function of rapidity **switches** when a critical point is passed



Independent test of critical behavior from $\sqrt{s}$-dependence of cumulants

What have we learned?

- Rapidity dependence of μ_B gives the rapidity dependence of cumulants characteristic signatures of criticality
- Binning cumulants in rapidity gives a more sensitive probe of the critical region than considering the full rapidity acceptance
- The rapidity dependence of binned cumulants changes qualitatively if the critical point is passed in the beam energy scan
  - Rapidity dependence gives independent test of location of critical point to $\sqrt{s}$ dependence