Search for the critical point through the rapidity dependence of cumulants

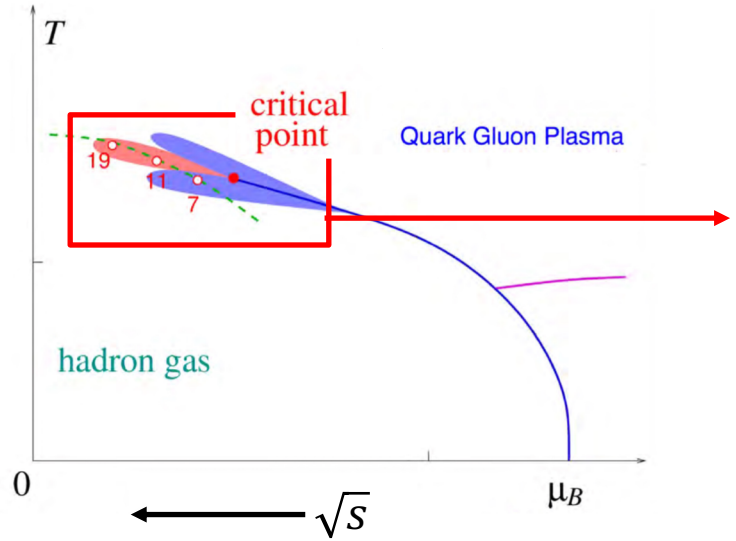
Jasmine Brewer

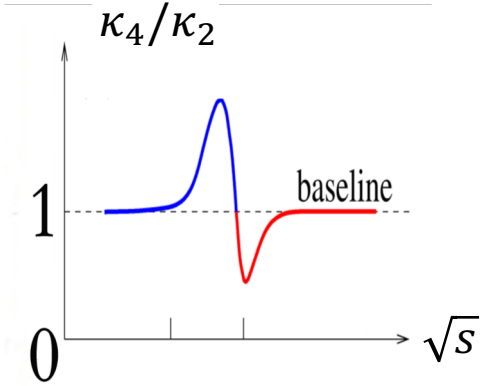
With Swagato Mukherjee, Krishna Rajagopal, and Yi Yin

arXiv: 1804.10215

Search for a critical point at the Beam Energy Scan

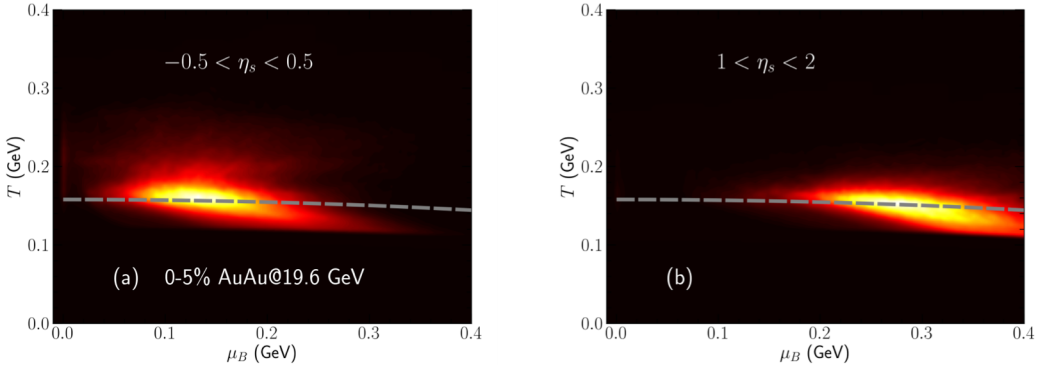
- characteristic signature: non-monotonicity and sign change of cumulants as a function of beam energy





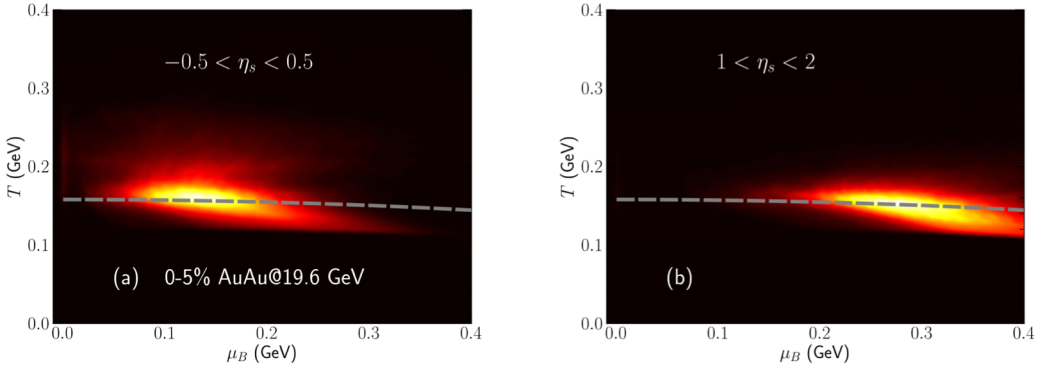
Stephanov 0809.3450, 1104.1627

At RHIC energies, μ_B has non-trivial rapidity dependence

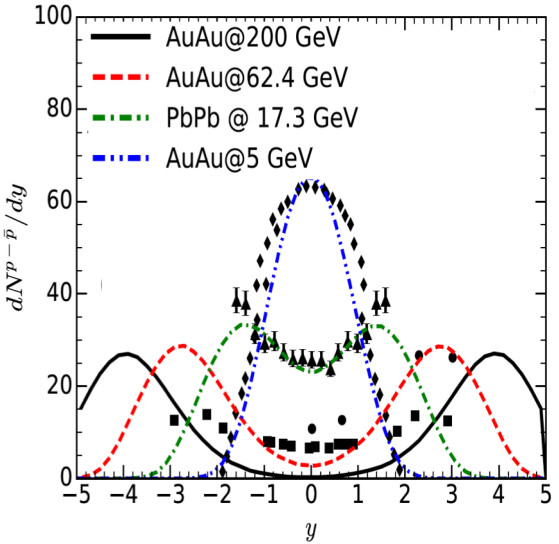


Shen and Schenke, 1807.05141

At RHIC energies, μ_B has non-trivial rapidity dependence

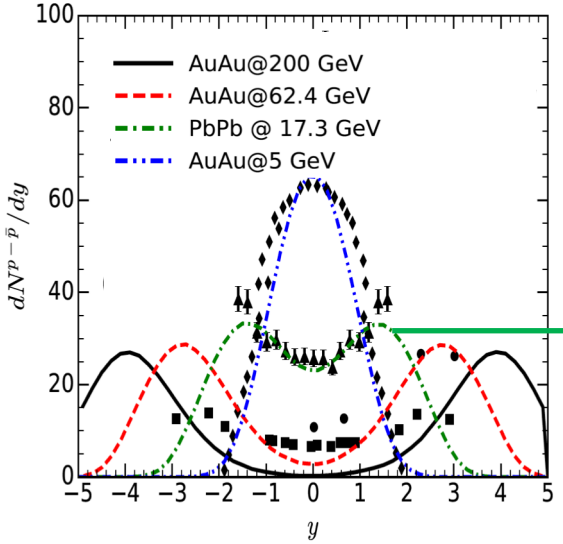


Shen and Schenke, 1807.05141



Shen and Schenke, 1710.00881

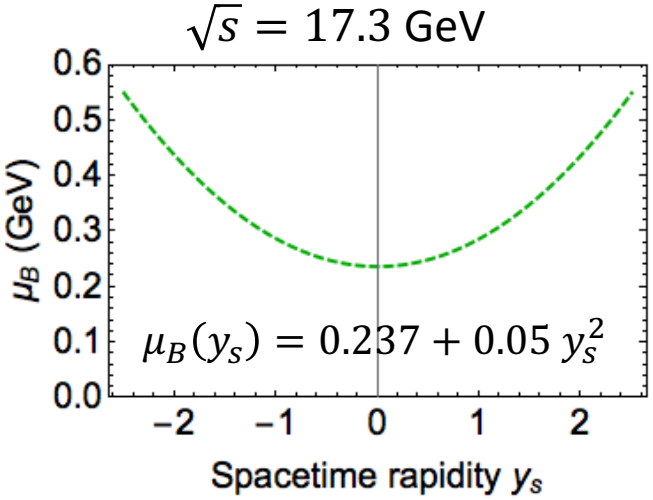
At RHIC energies, μ_B has non-trivial rapidity dependence



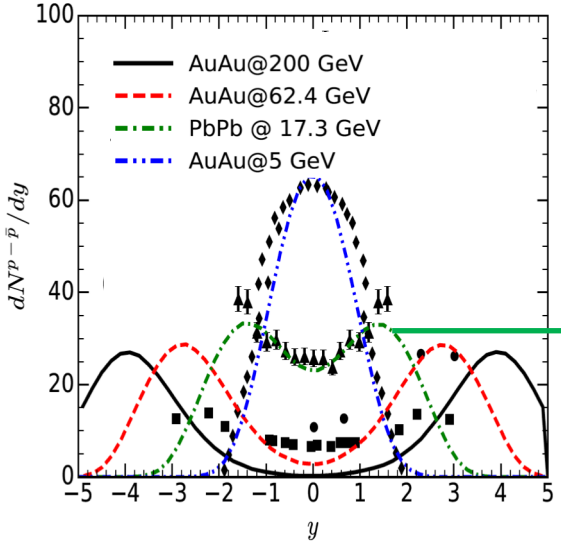
Shen and Schenke, 1710.00881

Thermal model fit

Beccatini et. al. 0709.2599



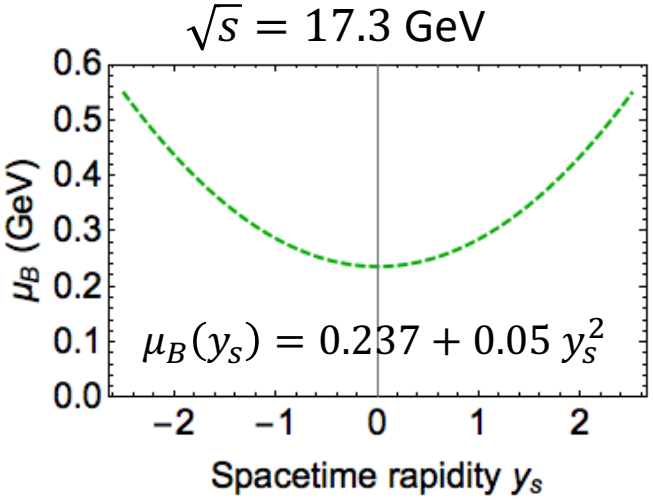
At RHIC energies, μ_B has non-trivial rapidity dependence



Shen and Schenke, 1710.00881

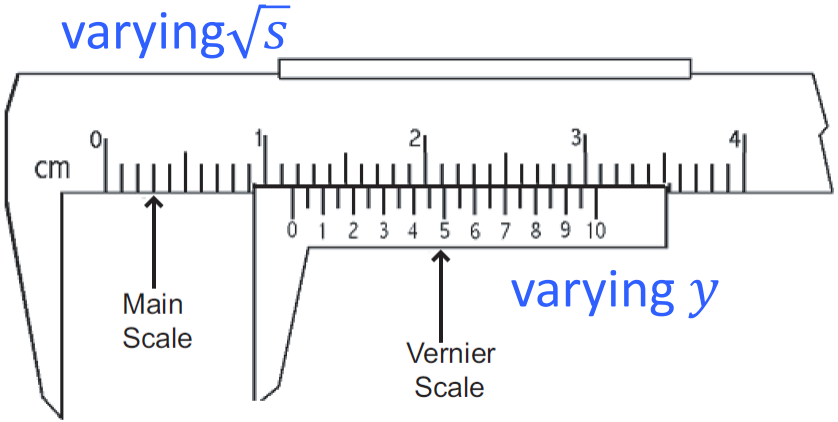
Thermal model fit

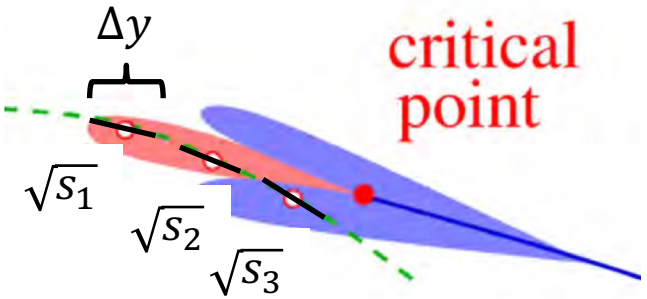
Beccatini et. al. 0709.2599



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

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

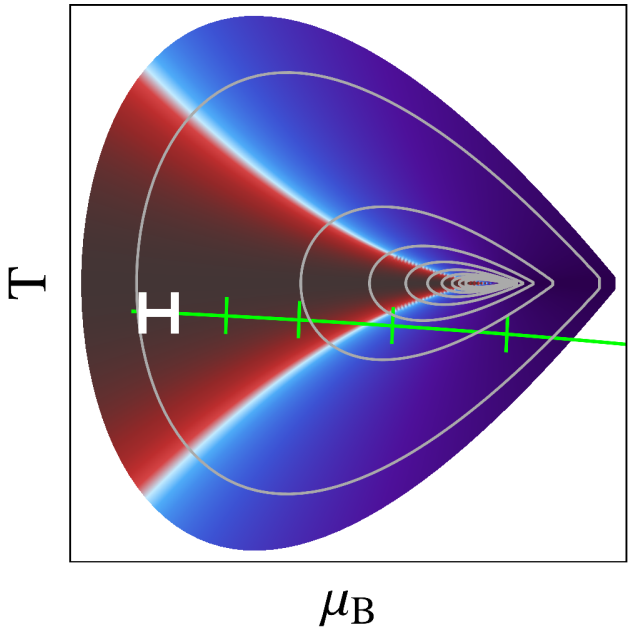




"mini-scan" in y can be used to give additional signatures of a CP

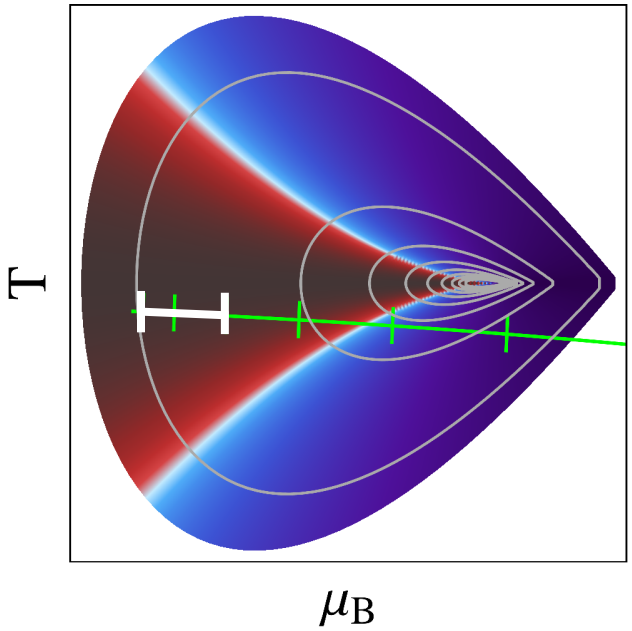
There are several different ways to look at the rapidity dependence

Total rapidity acceptance



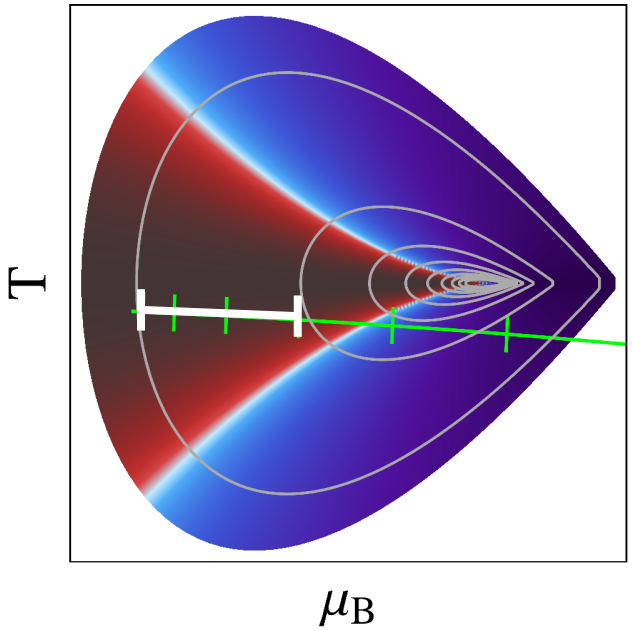
There are several different ways to look at the rapidity dependence

Total rapidity acceptance



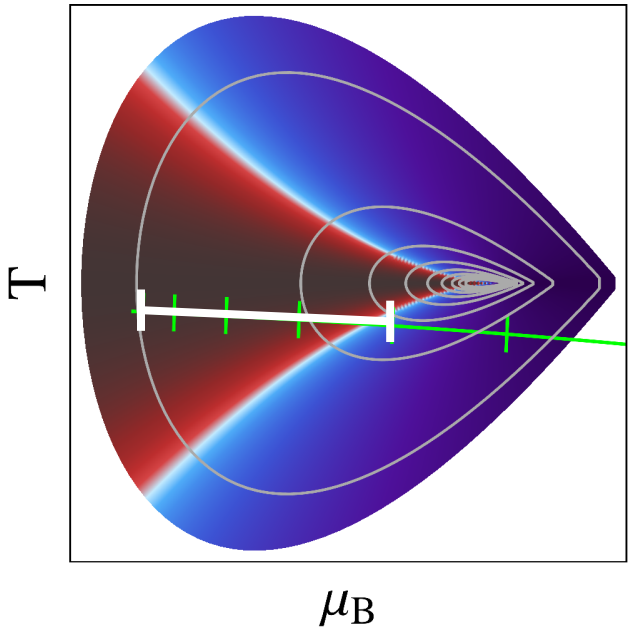
There are several different ways to look at the rapidity dependence

Total rapidity acceptance



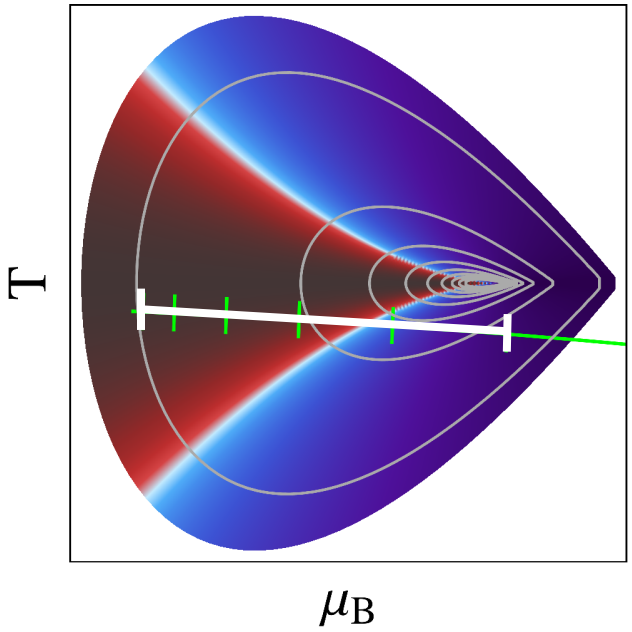
There are several different ways to look at the rapidity dependence

Total rapidity acceptance



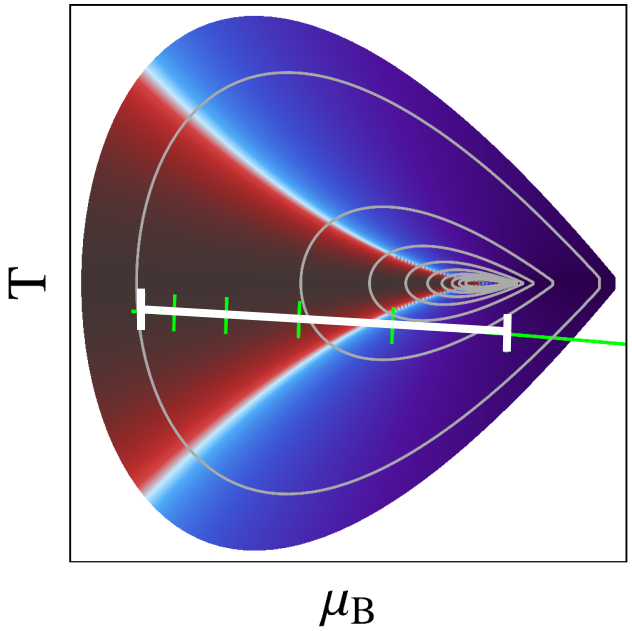
There are several different ways to look at the rapidity dependence

Total rapidity acceptance

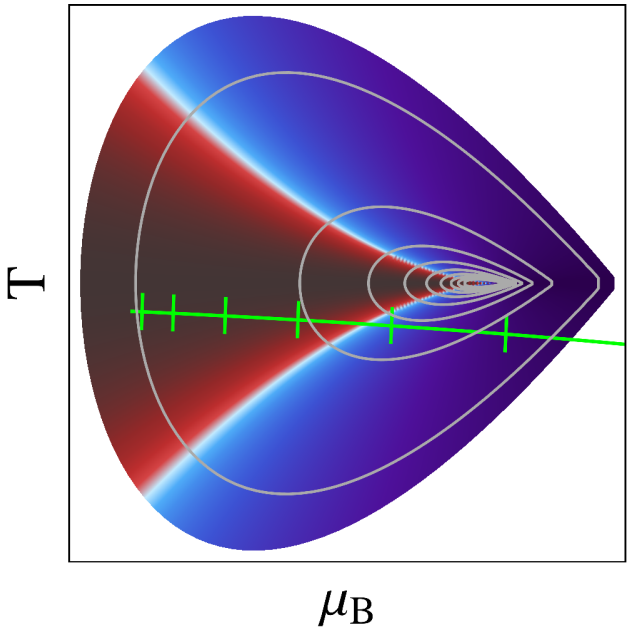


There are several different ways to look at the rapidity dependence

Total rapidity acceptance

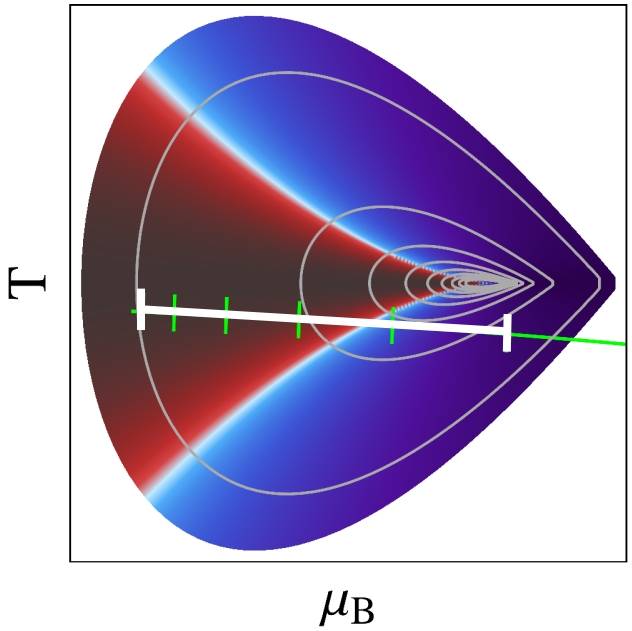


Binning in rapidity

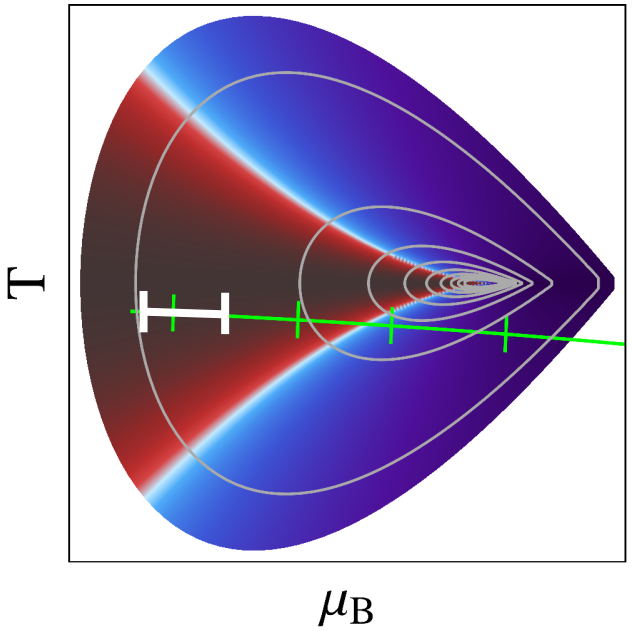


There are several different ways to look at the rapidity dependence

Total rapidity acceptance

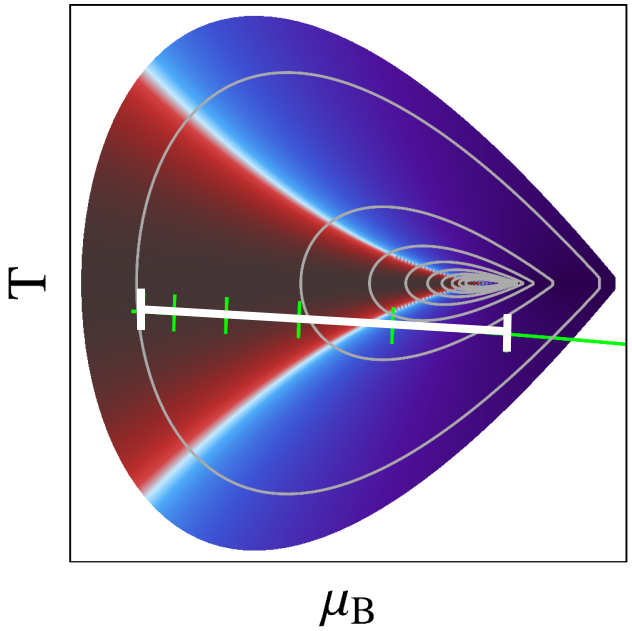


Binning in rapidity

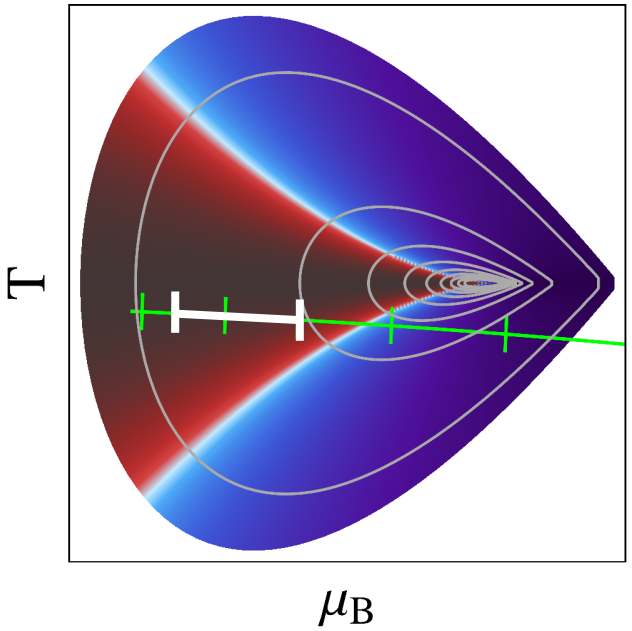


There are several different ways to look at the rapidity dependence

Total rapidity acceptance

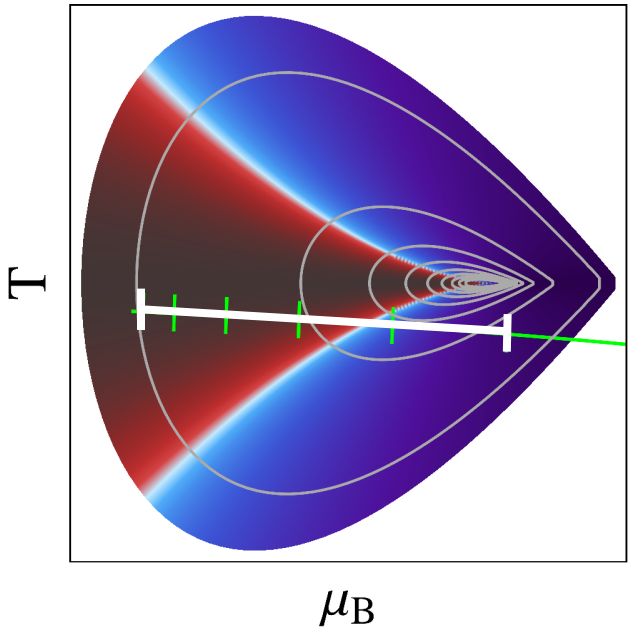


Binning in rapidity

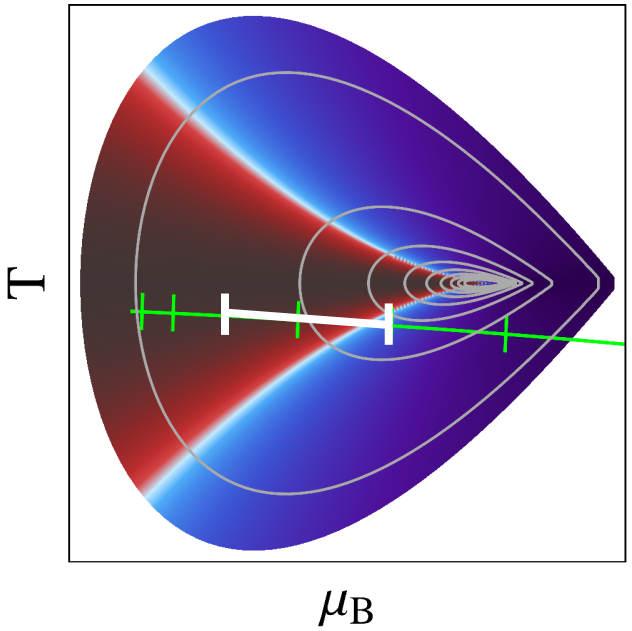


There are several different ways to look at the rapidity dependence

Total rapidity acceptance

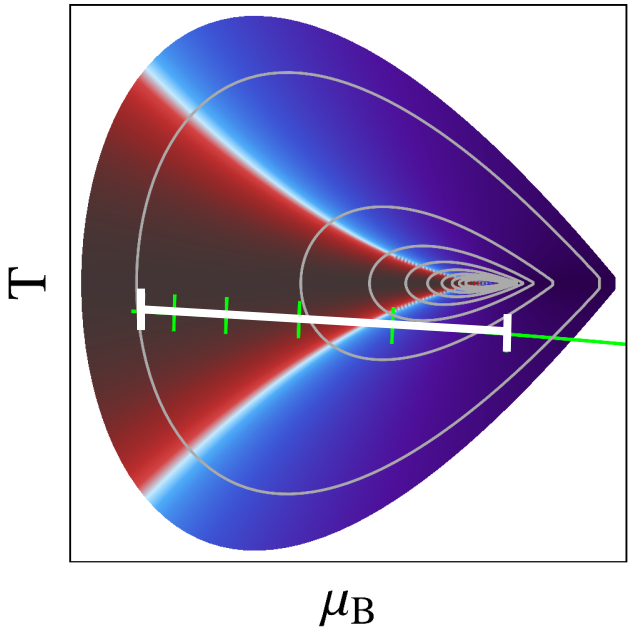


Binning in rapidity

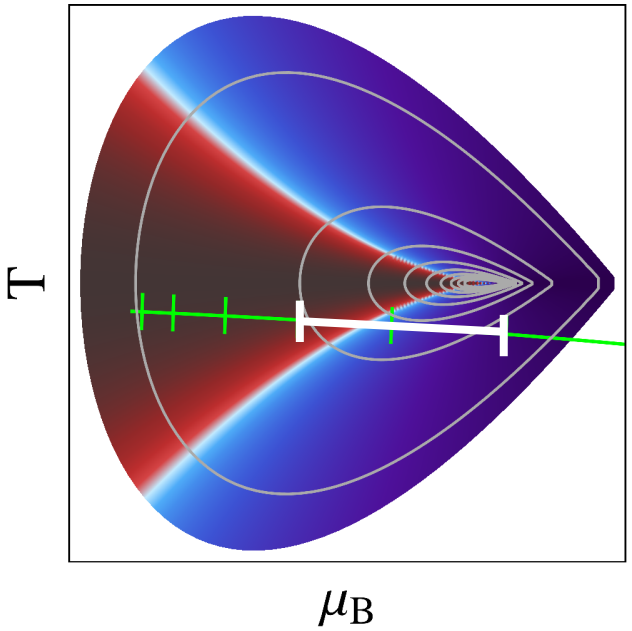


There are several different ways to look at the rapidity dependence

Total rapidity acceptance

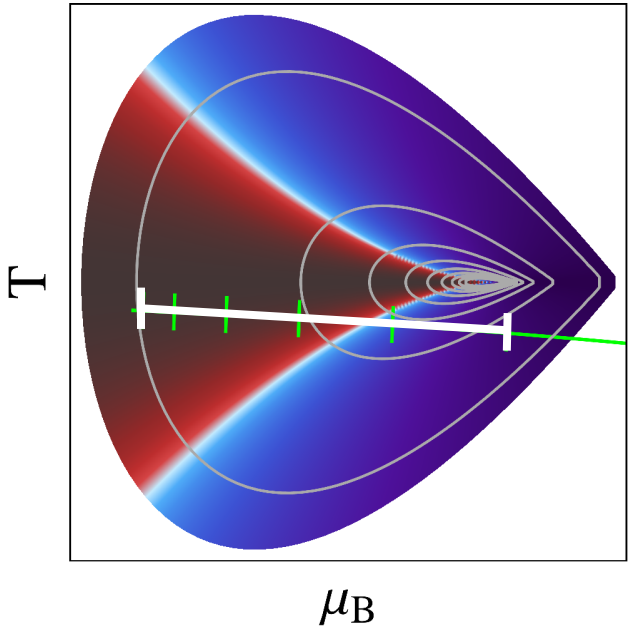


Binning in rapidity

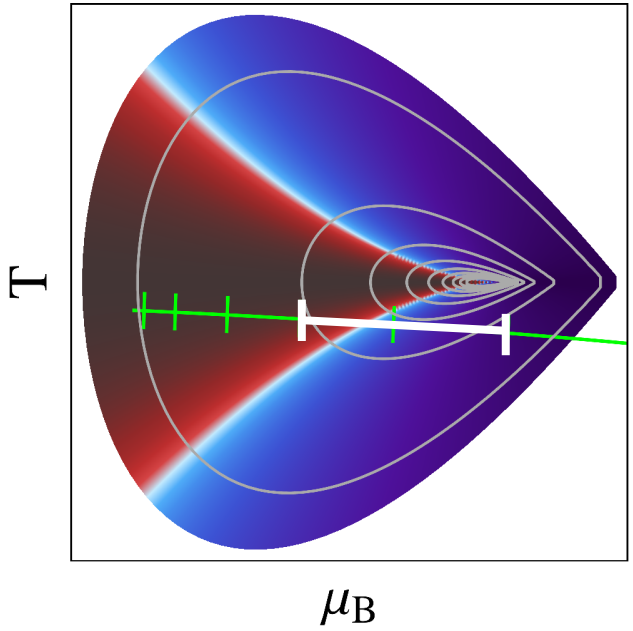


There are several different ways to look at the rapidity dependence

Total rapidity acceptance

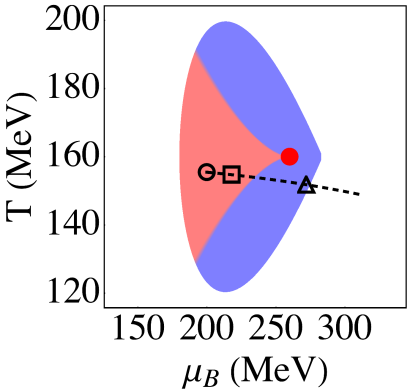


Binning in rapidity



More crisp picture of the critical region

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



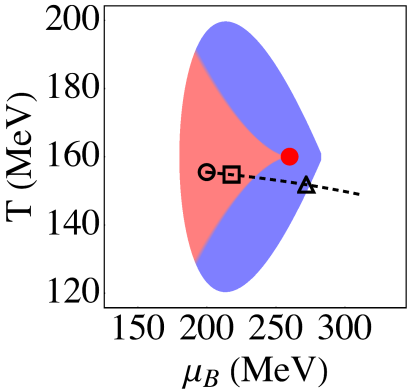
freezeout curve is extended in the critical regime due to

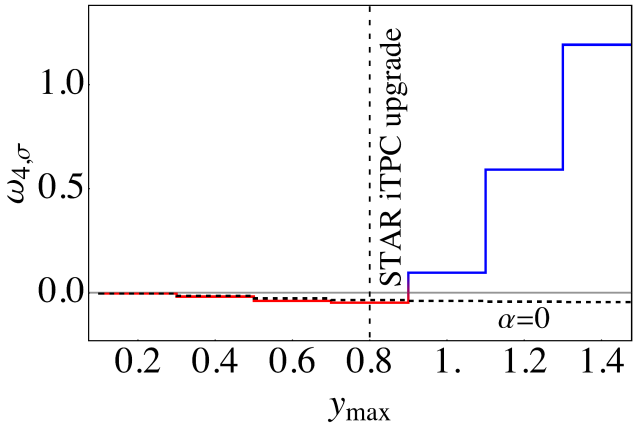
$$\mu_B = \mu_B(y_s) = \mu_{B,0} + \alpha\, y_s^2$$

○ □ △ $\rightarrow y_s = 0, 0.6, 1.2$

$\alpha = 50\ MeV$

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

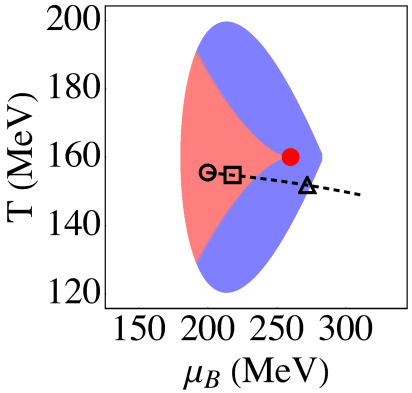


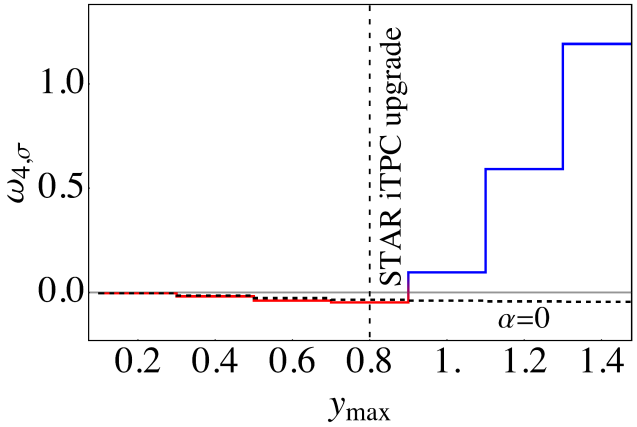


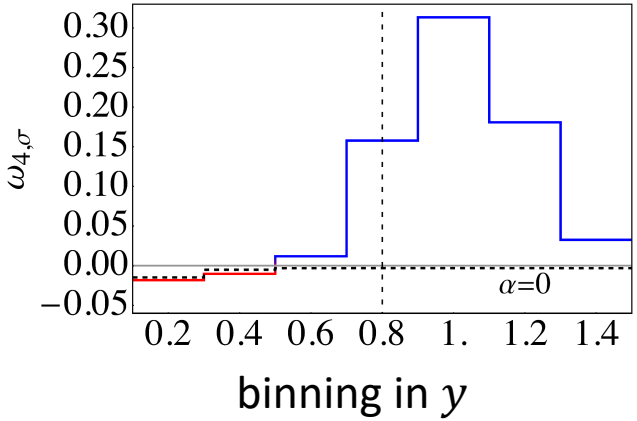
Including contributions from total rapidity acceptance $|y| < y_{max}$ averages over details of the critical regime

○ □ △ $\rightarrow y_s = 0, 0.6, 1.2$

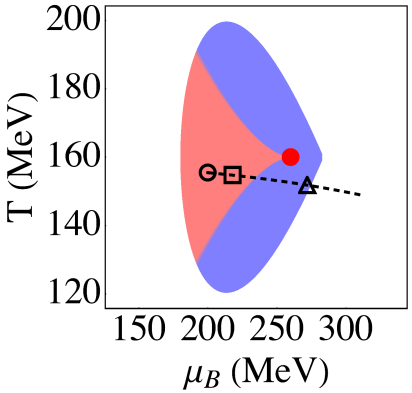
Binning in rapidity gives a more sensitive probe of the critical region

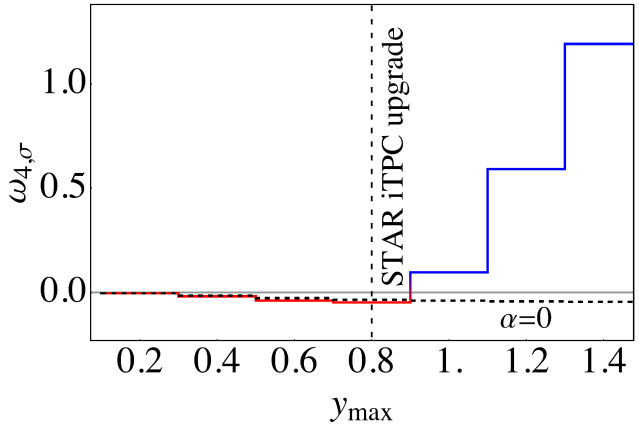


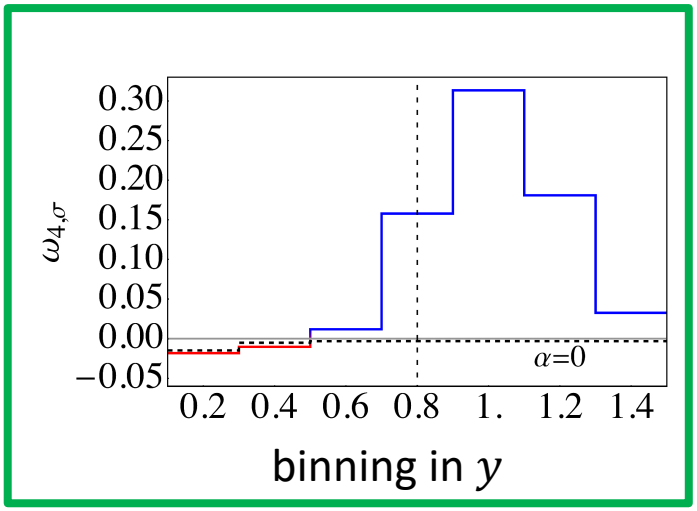




Binning in rapidity gives a more sensitive probe of the critical region

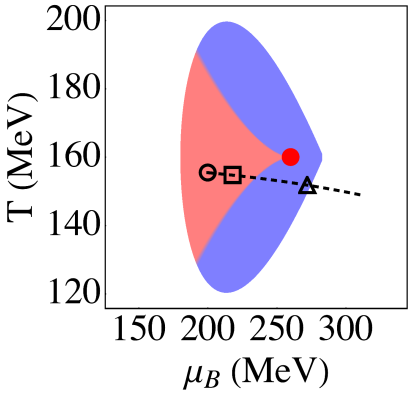


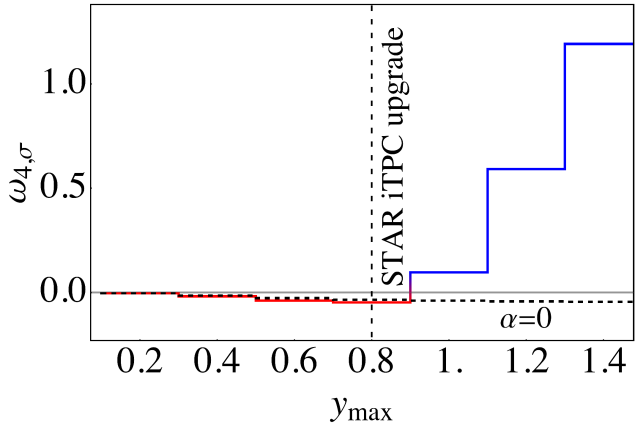


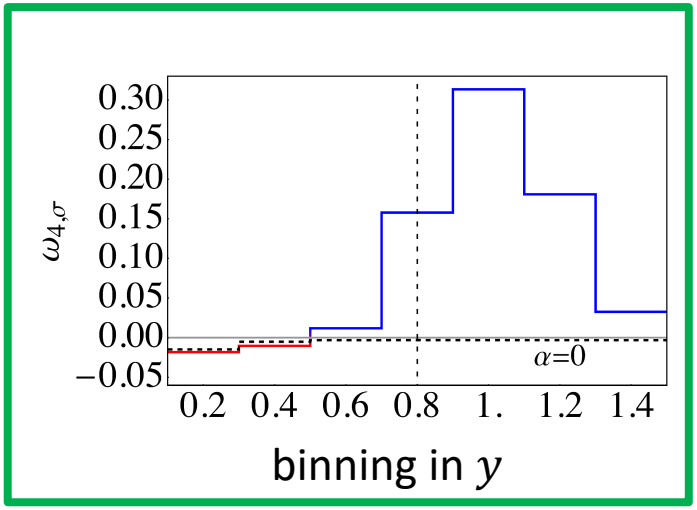


Sign change at lower rapidity

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



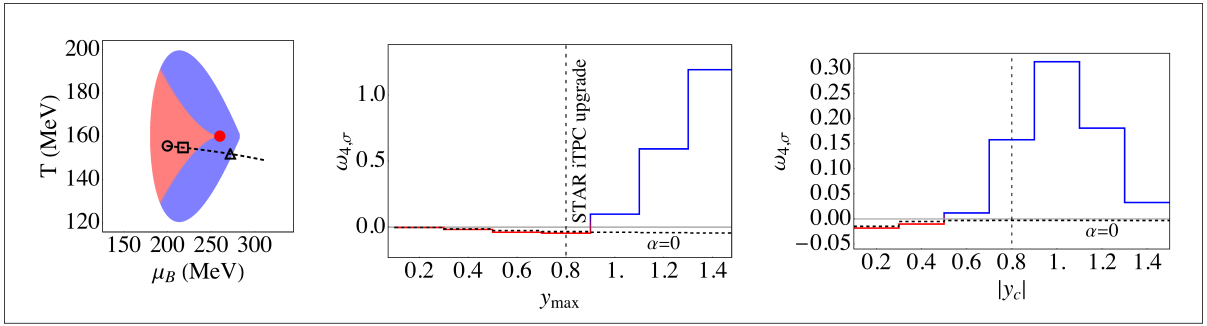




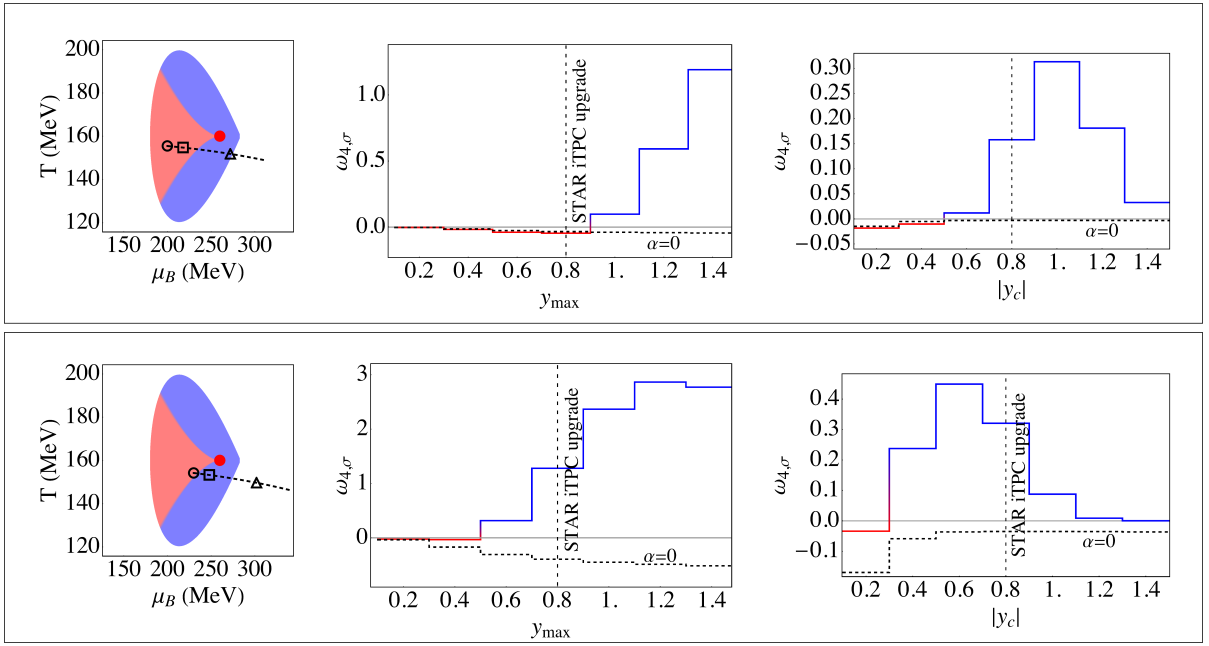
Sign change at lower rapidity

Critical signatures easier to detect at lower rapidity

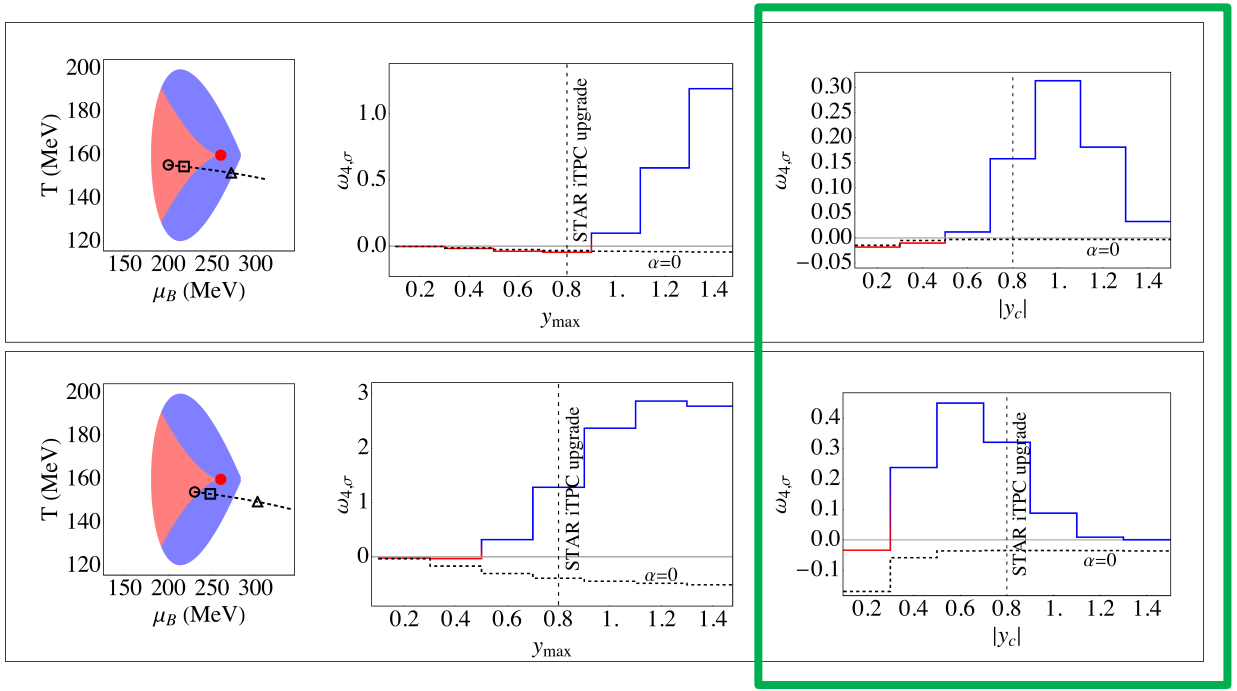
Decreasing $\sqrt{s}$ to approach a critical point, binned cumulants increase with rapidity



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

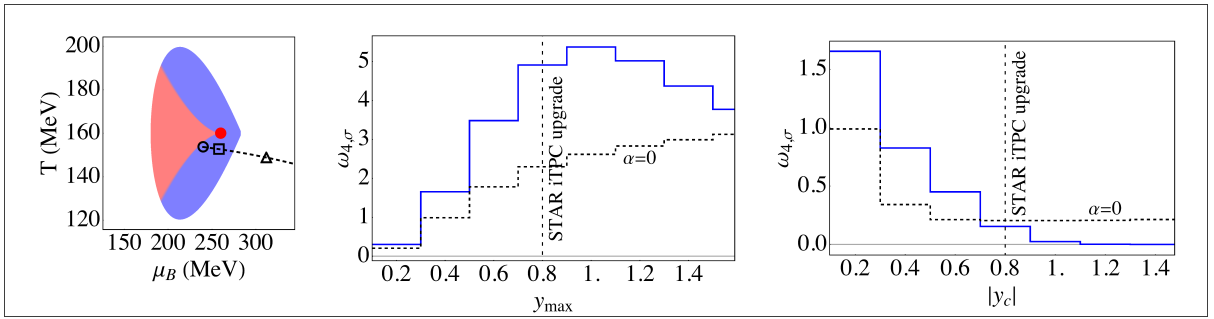


Decreasing $\sqrt{s}$ to approach a critical point, binned cumulants increase with rapidity

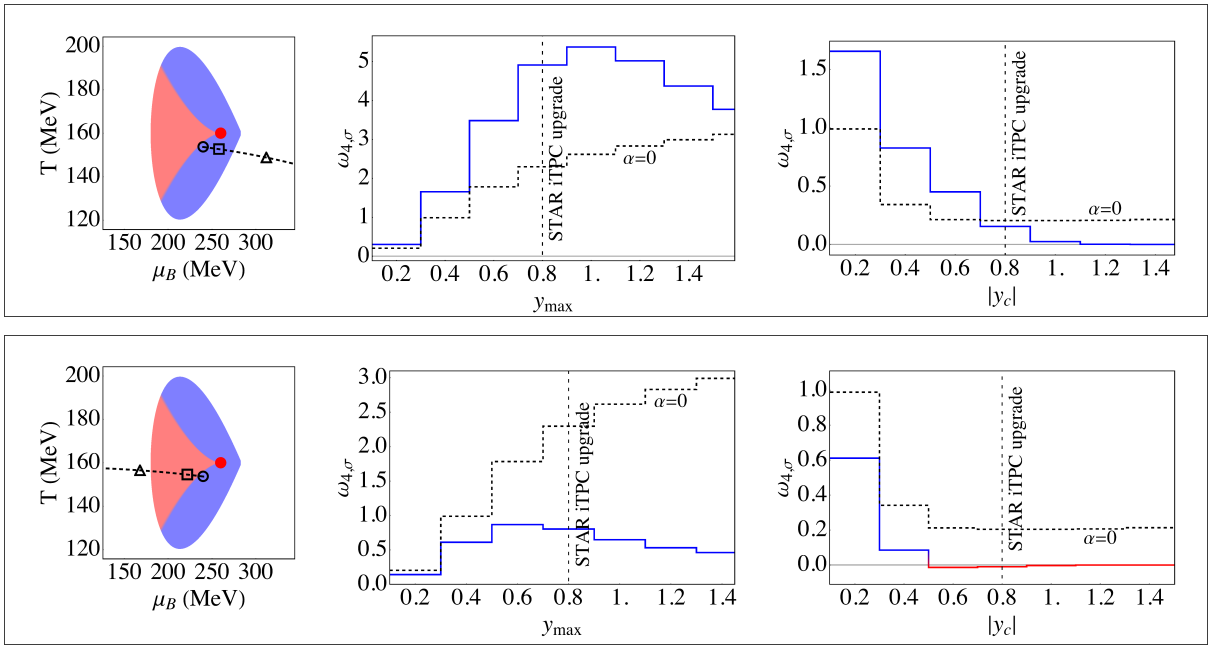


Increasing with rapidity near mid-rapidity

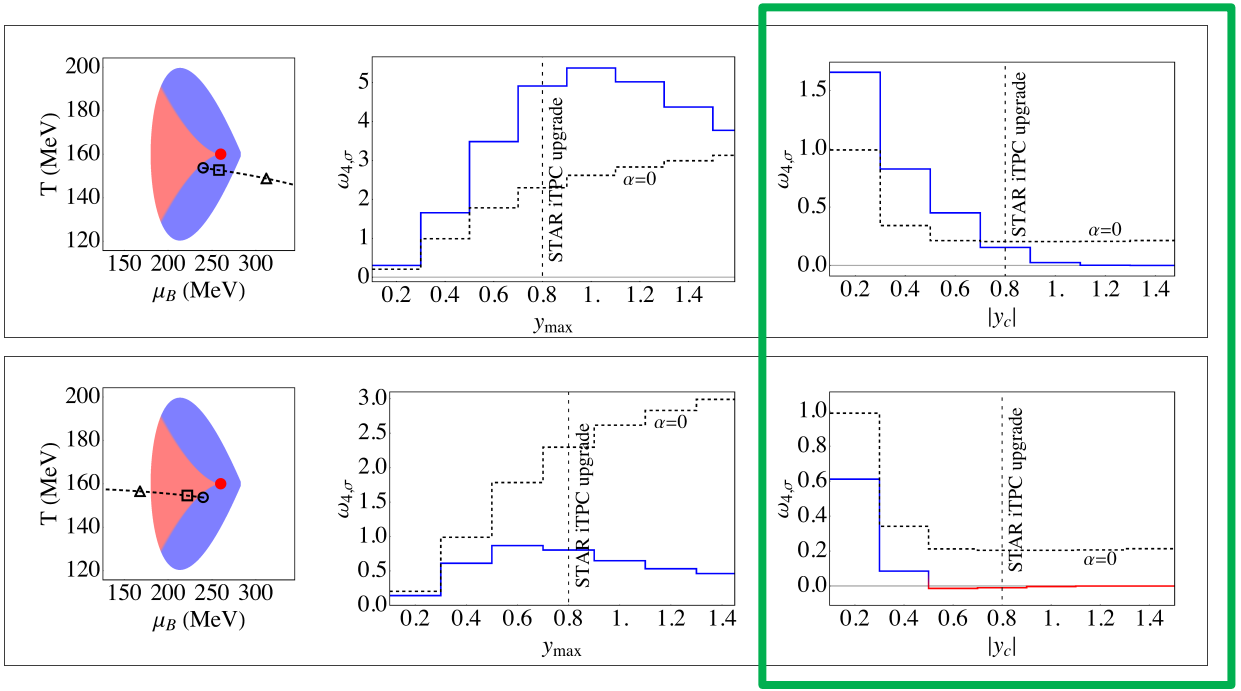
If a critical point is passed, binned cumulants switch to decreasing with rapidity



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



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



Decreasing with rapidity near mid-rapidity

What have we learned?

What have we learned?

- Rapidity dependence of μ_B gives the rapidity dependence of cumulants characteristic signatures of criticality

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

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

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