A critical point in HIC?

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In collaboration with:
Y. Nara, Y. Wang, V. Vovchenko, Y. Ye, A. Mukherjee, Q. Li and H. Stöcker

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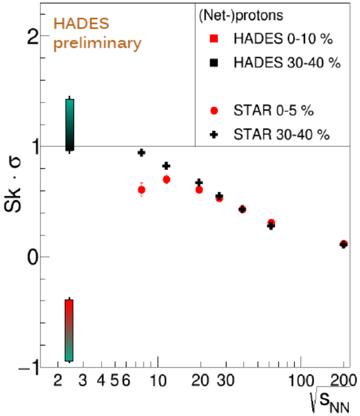
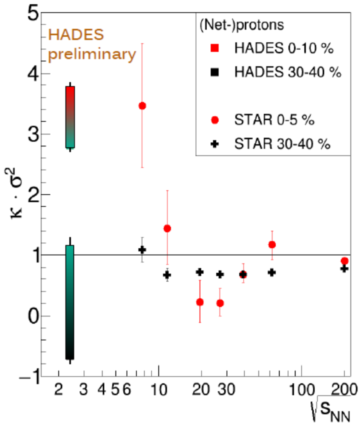
Y. Ye *et al.*, arXiv:1808.06342 [nucl-th].

Fluctuations/correlations as possible interesting signatures for a CeP or phase transition

From STAR and HADES (preliminary)





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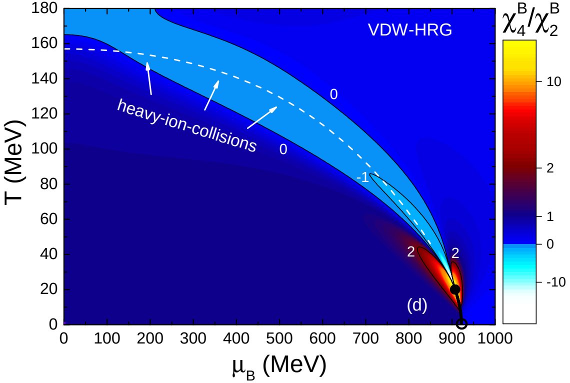
Van der Waals model for nuclear interaction.



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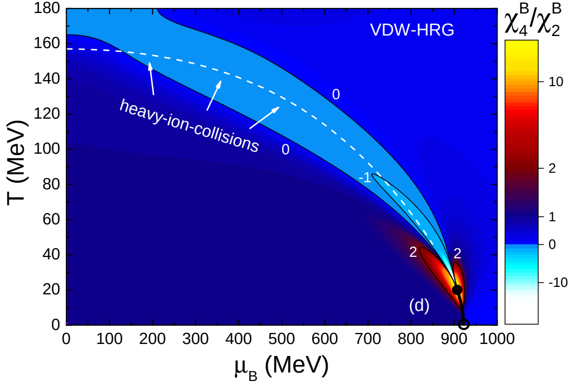

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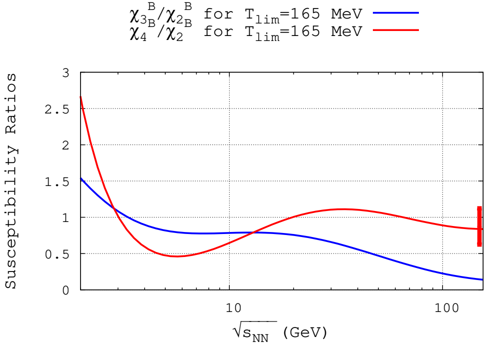
Including another sharp crossover to a deconfined phase.



A. Mukherjee, J. Steinheimer and S. Schramm, Phys. Rev. C **96**, no. 2, 025205 (2017)

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- Include nuclear potentials.

Introducing Potentials

To include nuclear interactions

Each hadron is represented by a Gaussian wave packet in phase space. The time evolution of the centroids ($\mathbf{r}_i$ and $\mathbf{p}_i$) of the Gaussians obey Hamilton's equations,

$$\dot{\mathbf{r}}_i = \frac{\partial \langle H \rangle}{\partial\ \mathbf{p}_i}, \dot{\mathbf{p}}_i = -\frac{\partial \langle H \rangle}{\partial \mathbf{r}_i}. \tag{1}$$

Here $\langle H \rangle$ is the total Hamiltonian function of the system, it consists of the kinetic energy of the particles and the effective interaction potential energy.

$$U = \alpha \left(\frac{\rho}{\rho_0} \right) + \beta \left(\frac{\rho}{\rho_0} \right)^{\gamma} + t_{md} \ln^2[1 + a_{md}(\mathbf{p}_i - \mathbf{p}_j)^2] \frac{\rho}{\rho_0}. \tag{2}$$

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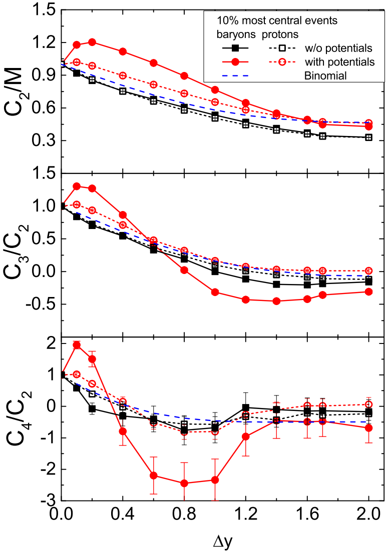

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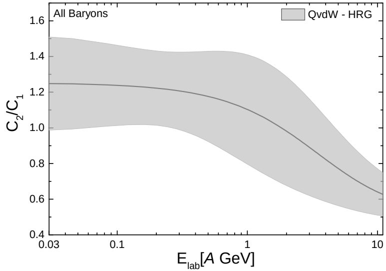
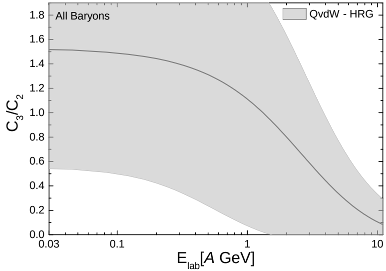
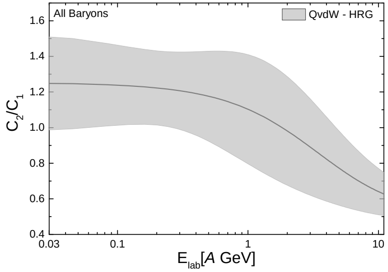
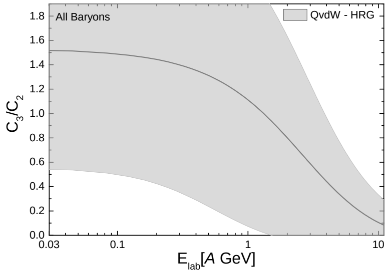




What to expect as function of beam energy?

- Just follow the chemical FO curve ±.
- These are GC values. Not directly comparable with finite acceptance.
- Large spread of possible values from the VdW-HRG model.
- Caveat: How reliable is the freeze out curve at such low beam energies?





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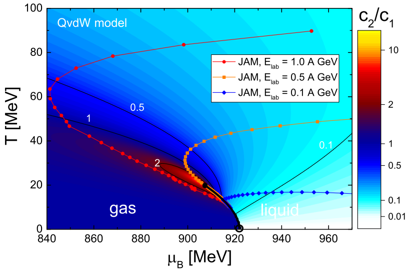

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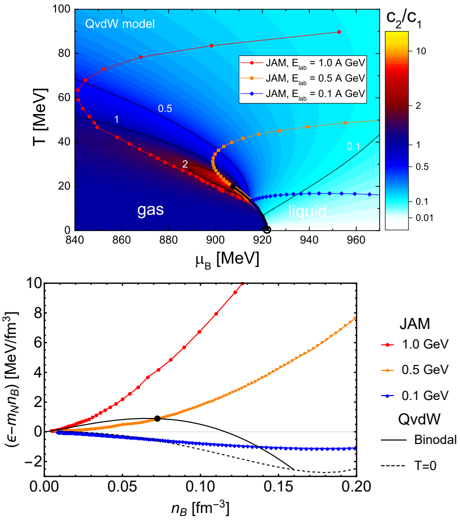

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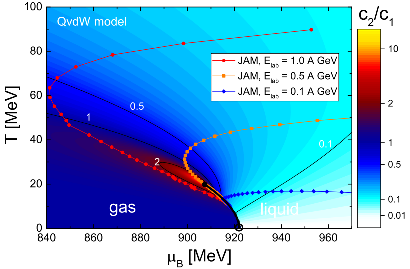
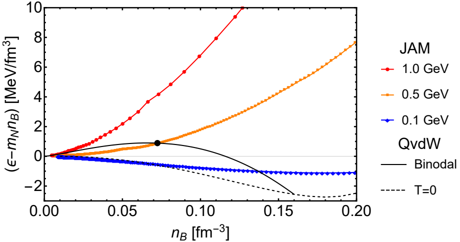
Trajectories estimates

- Use the transport models to estimate the trajectories in the VdW-HRG (Nuclear) phase diagram.
- First in T and μ_B.
- Then in energy density and density
- 500 MeV hits the critical point.





Results from UrQMD and JAM -All baryons

What do the transport models say

- Only calculate C_2/C_1 and C_3/C_2 due to limited statistics.
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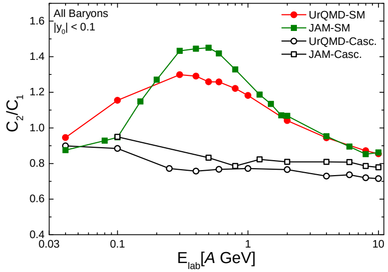

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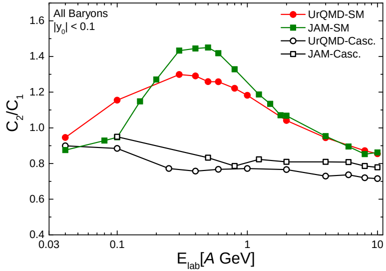
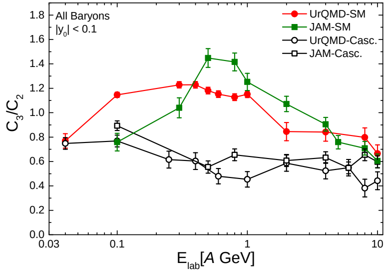
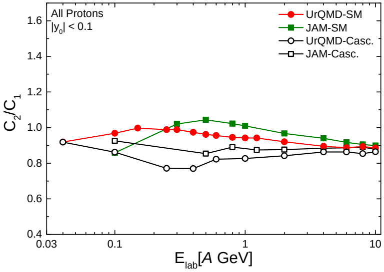
- Small rapidity window to avoid effects from conservation.
- A clear peak shows up in 'All Baryons' at 500 MeV.
- Small model dependence in peak position
- Also visible in skewness.

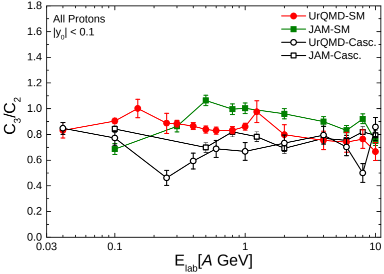




Results from UrQMD and JAM -Protons

Measuring only protons decreases the signal, but still visible.





Discussion

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- Since it is a finite size system it is not really the critical point, but maybe a remnant.
- Cancellation of attractive and repulsive forces.

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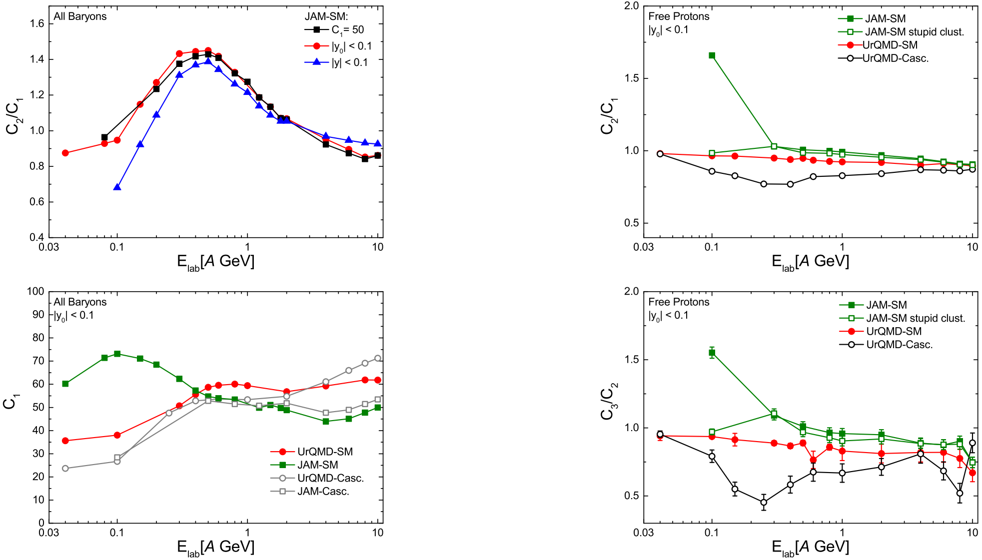
- Since it is a finite size system it is not really the critical point, but maybe a remnant.
- Cancellation of attractive and repulsive forces.
- Same energy as maximum of squeeze-out $\rightarrow$ soft EoS?
- Food for thought.

Backup


All Baryons
JAM-SM:
C_1= 50
$|y_0|$ < 0.1
$|y|$ < 0.1
C_2/C_1
E_{lab}[A GeV]
Free Protons
$|y_0|$ < 0.1
JAM-SM
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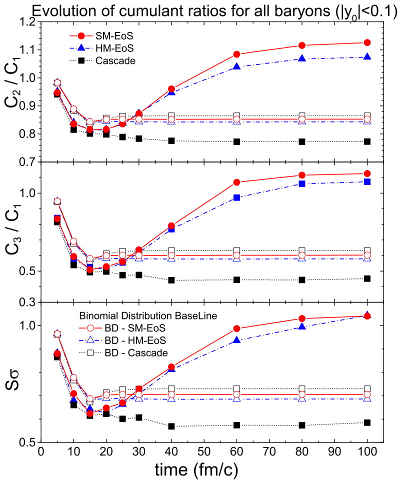

Evolution of cumulant ratios for all baryons (|y_0|<0.1)
SM-EoS
HM-EoS
Cascade
C_2 / C_1
C_3 / C_1
Sσ
Binomial Distribution BaseLine
BD - SM-EoS
BD - HM-EoS
BD - Cascade
time (fm/c)
1.2
1.1
1.0
0.9
0.8
0.7
0.5
0.3
0
10
20
30
40
50
60
70
80
90
100