

Outline:

- \* Phase diagram
- \* Equation of State
- \* Femtosopic correlations
- \* Preliminary results



*Dr Maria Stefaniak:*

# Femtoscscopy in EoS studies

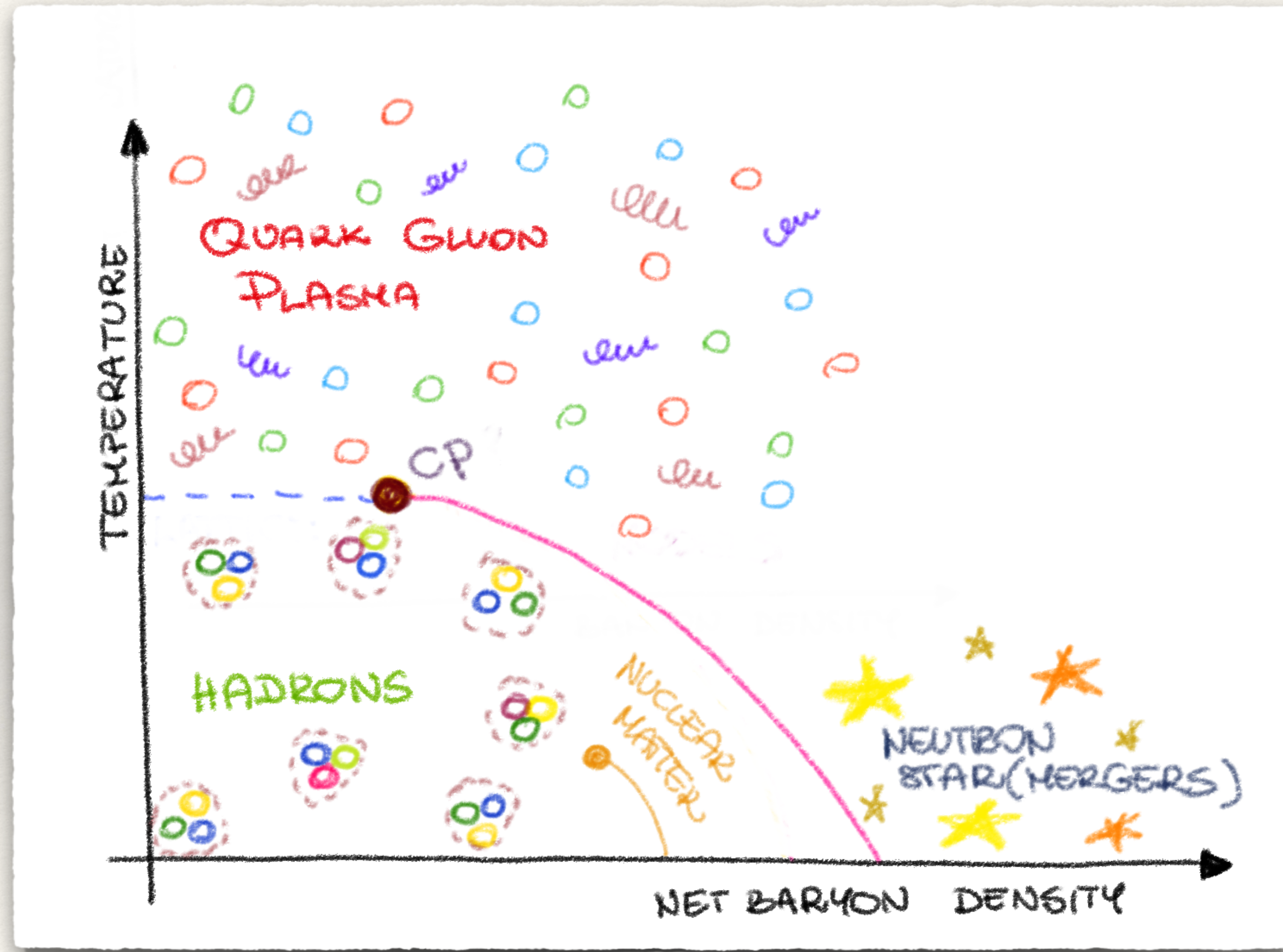


THE OHIO STATE UNIVERSITY



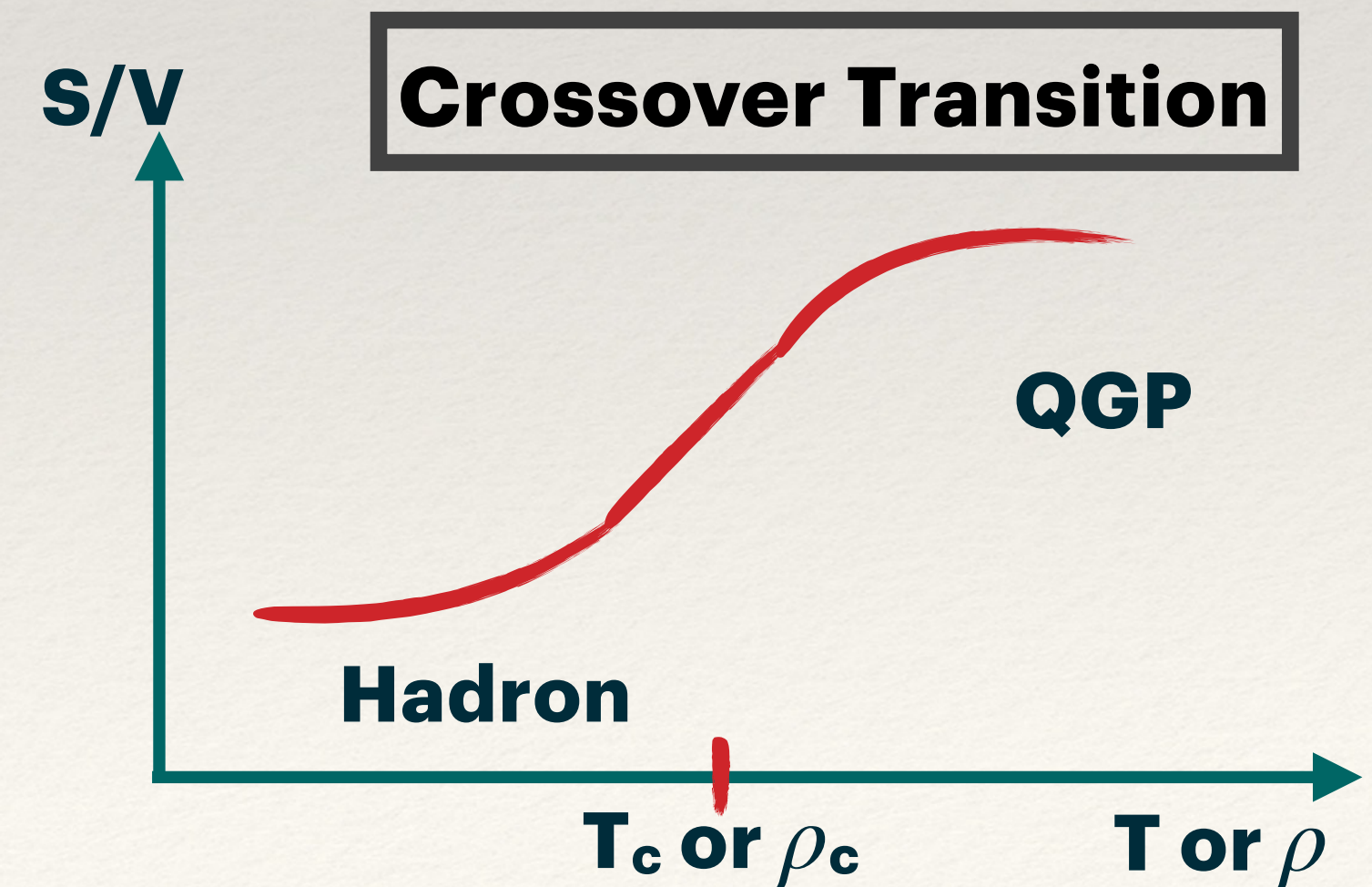
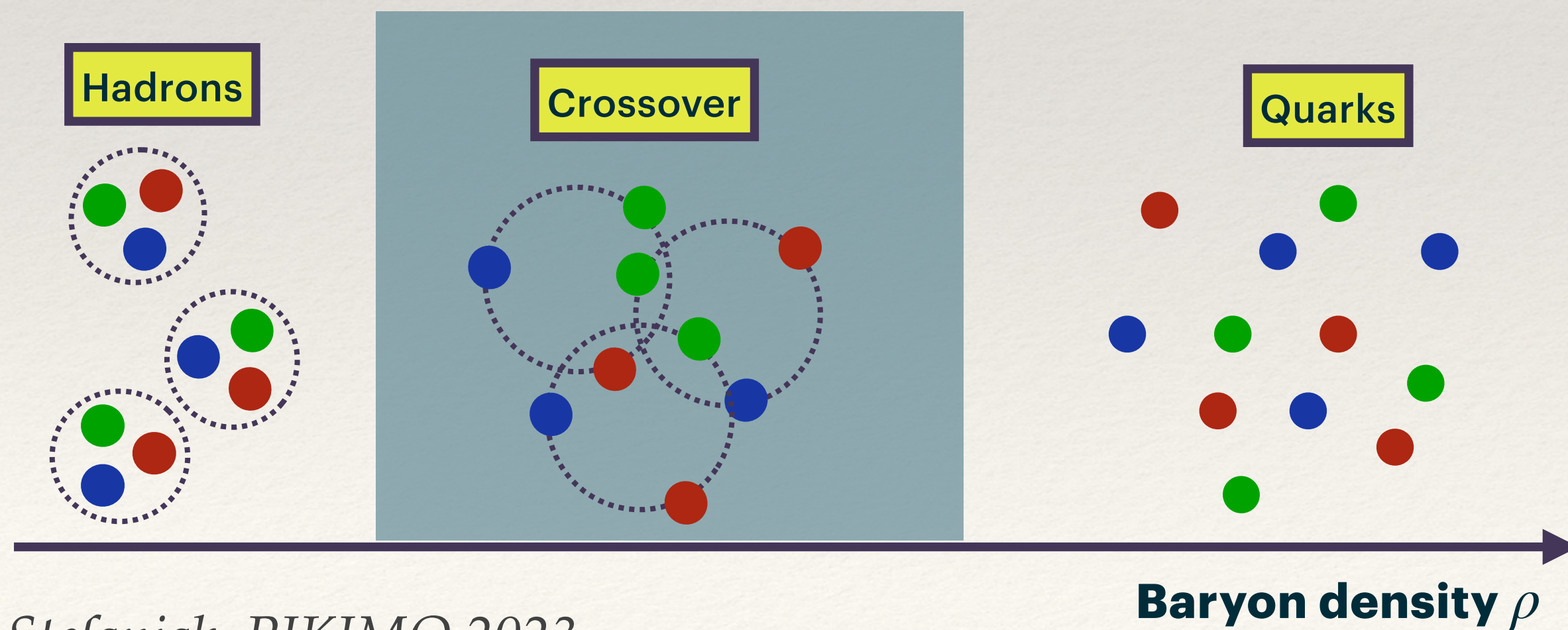
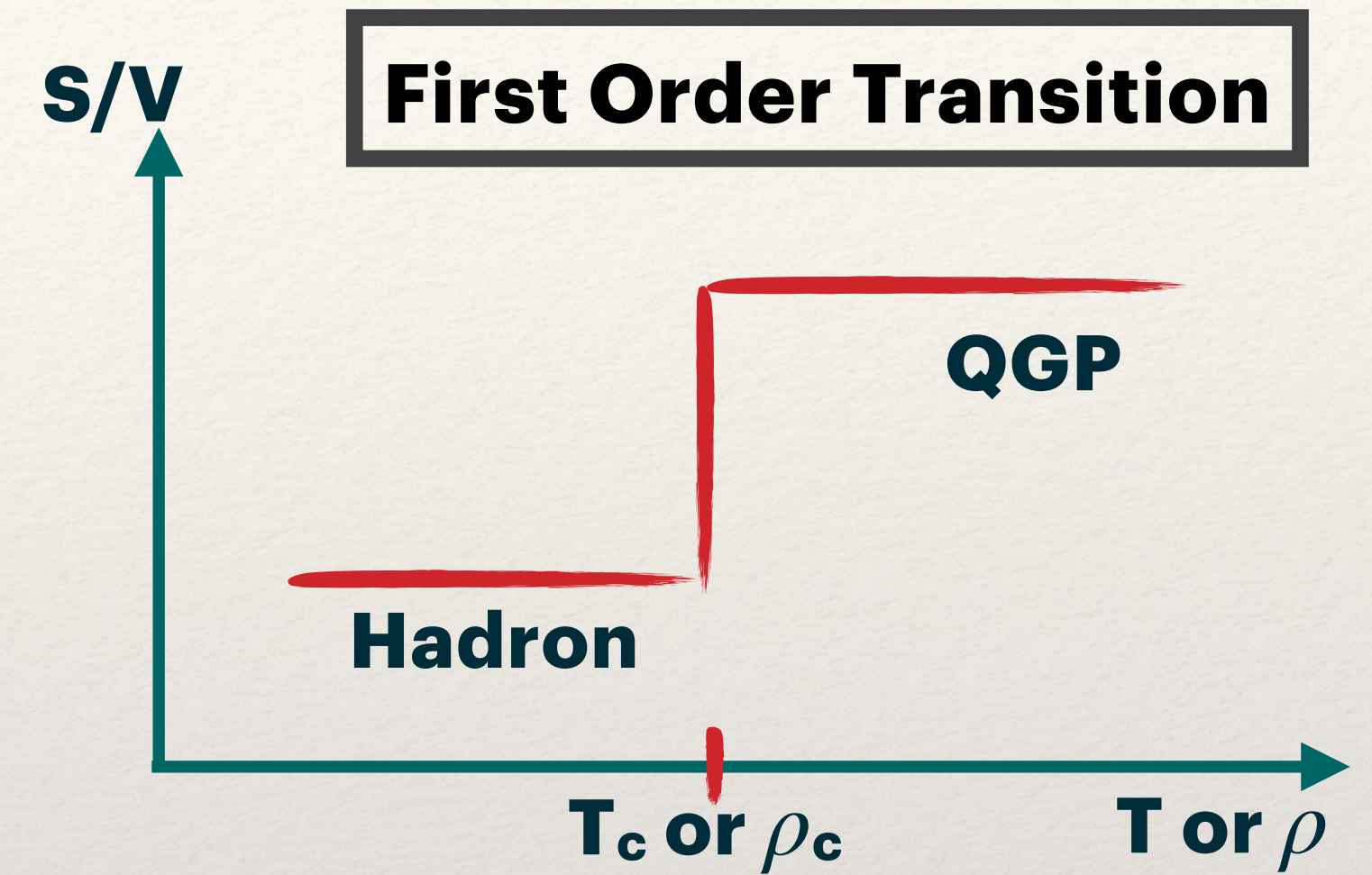
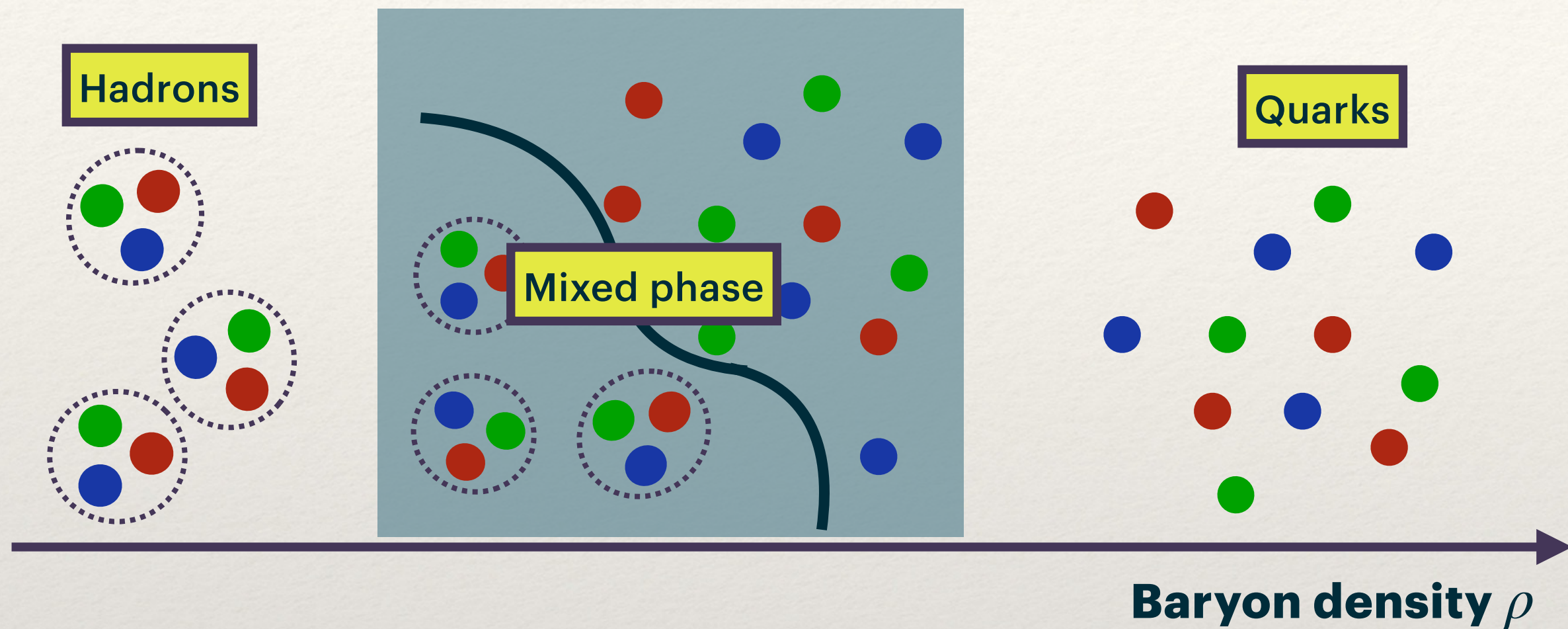


# Phase diagram of nuclear matter





# Equation of State



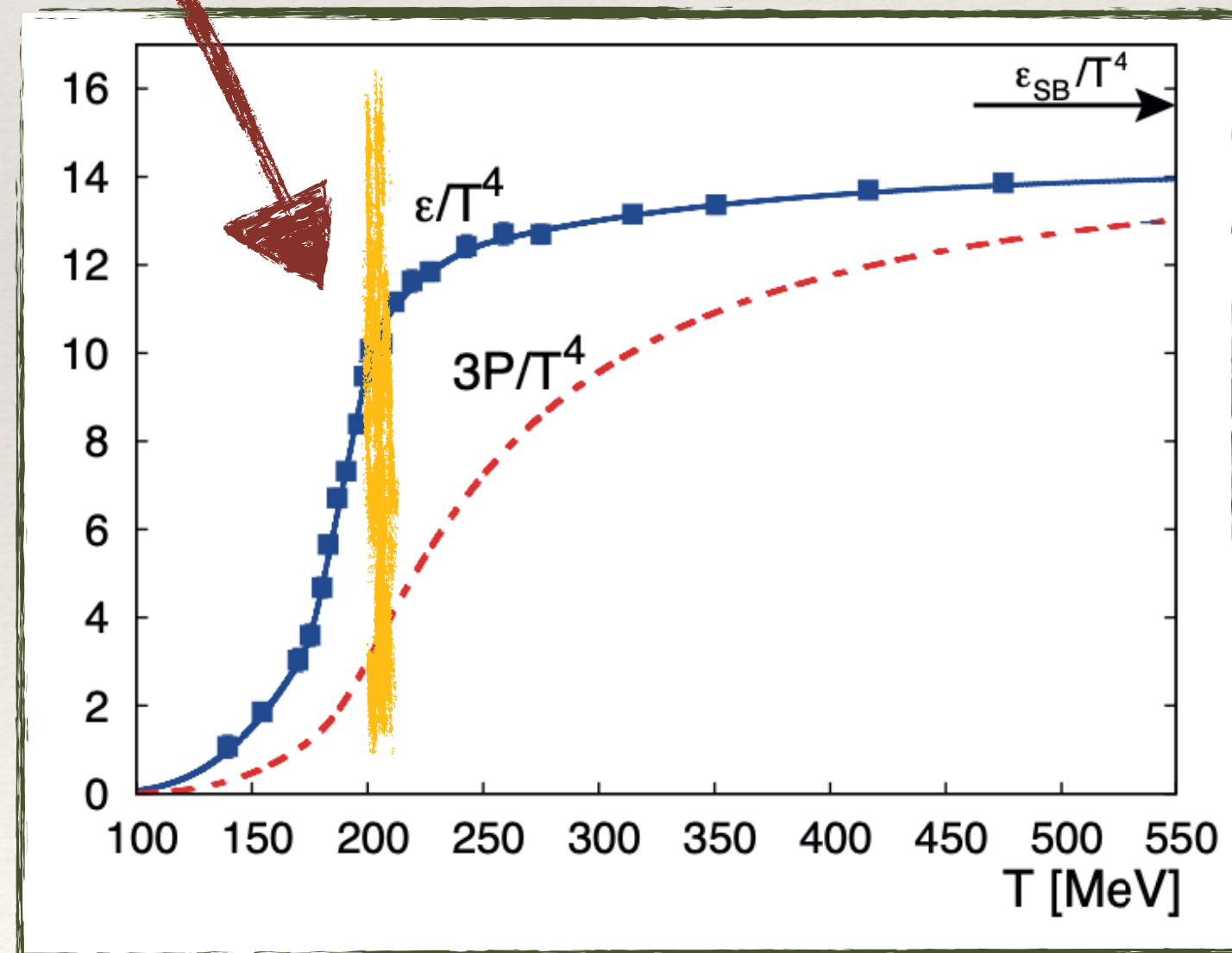


# Equation of State

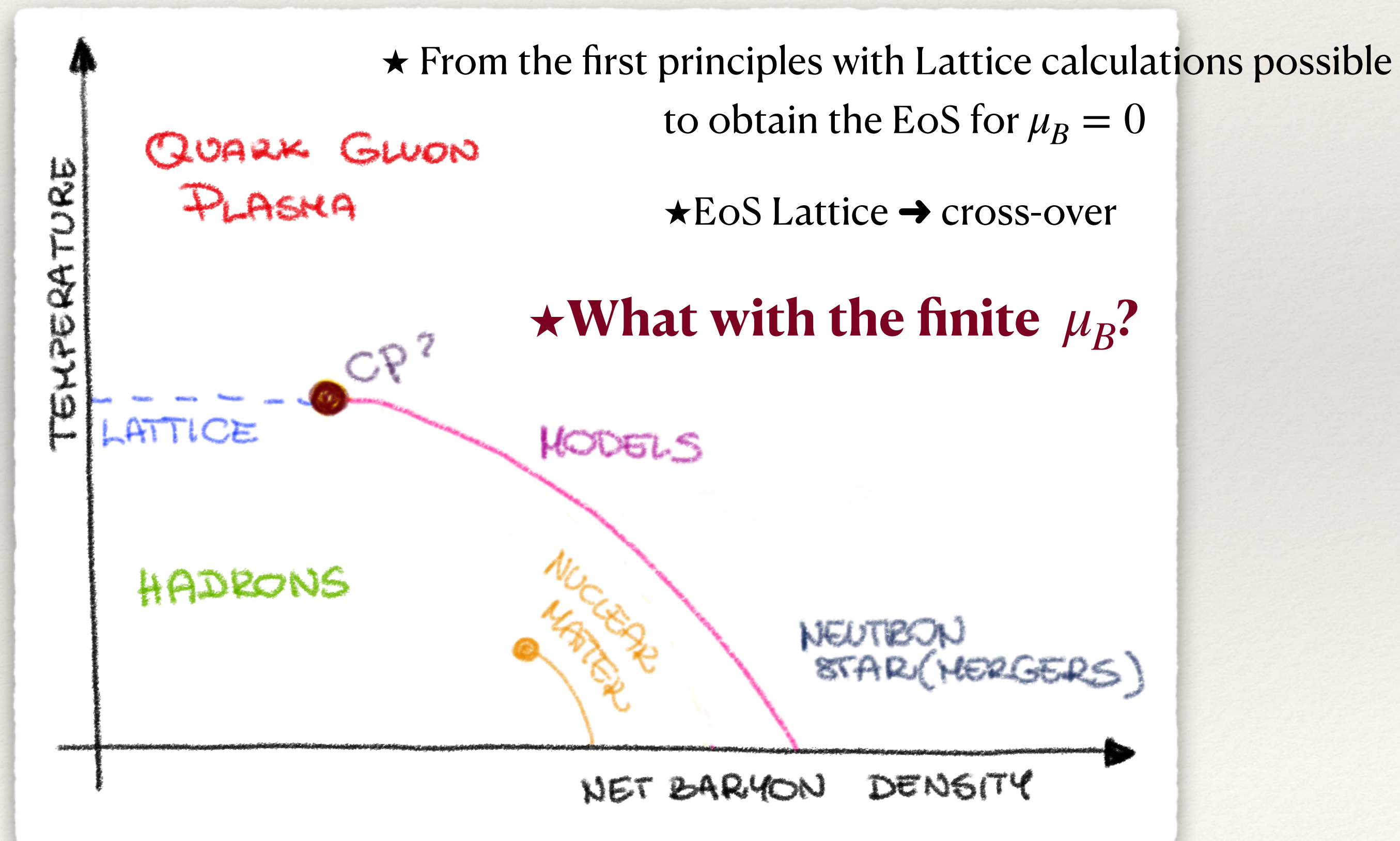
Recommend to take a look on:  
M. Stephanov: PoS LAT2006 (2006) 024

## Description of the equilibrium properties of QCD matter

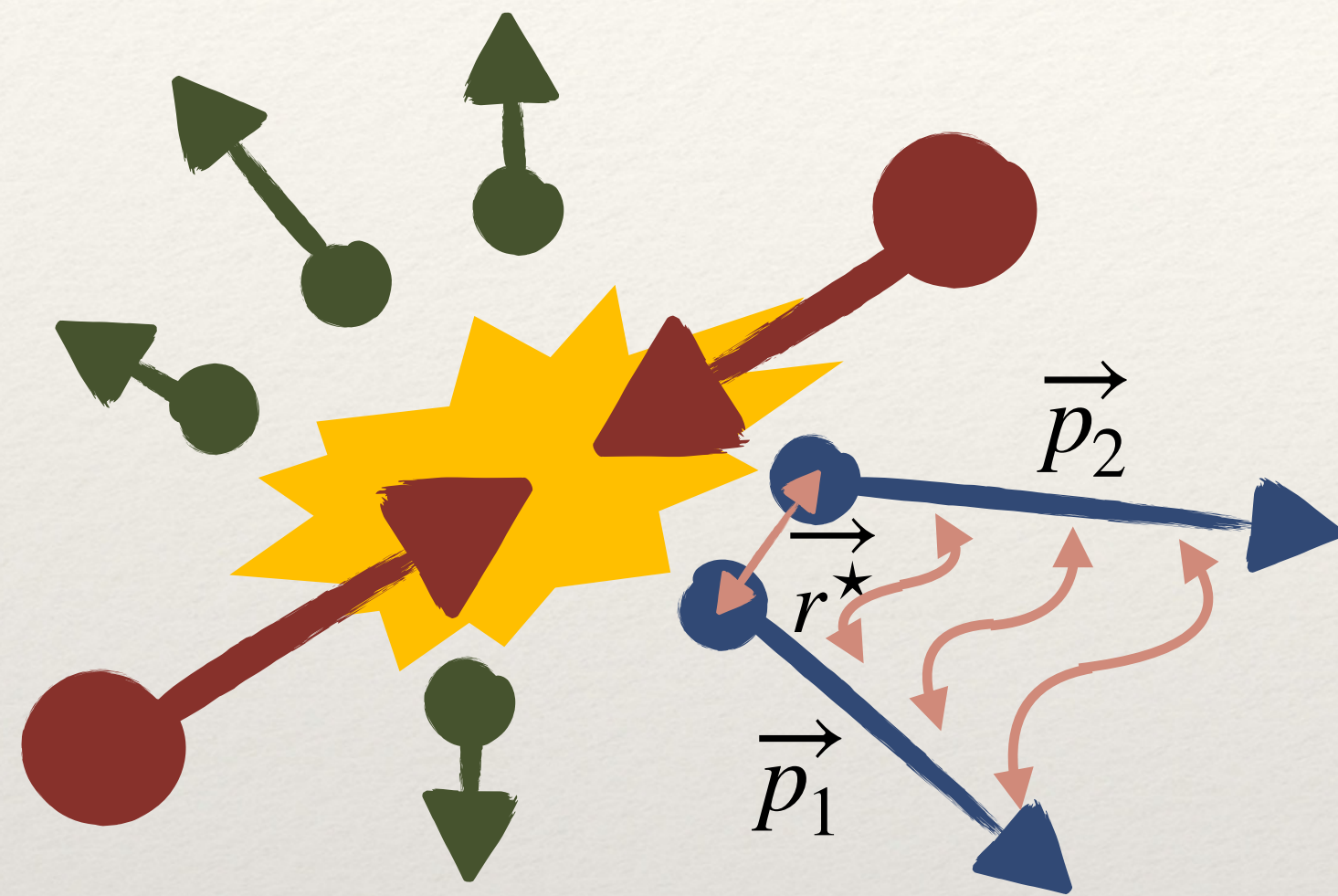
increase of the degrees of freedom  
→ phase transition



Stefan-Boltzmann limit  
(ideal massless gas)







# Femtoscscopy

*is the spatio-temporal characterization of the collision region on the femtometer scale*



$$k^\star = |p_1| = |p_2|$$

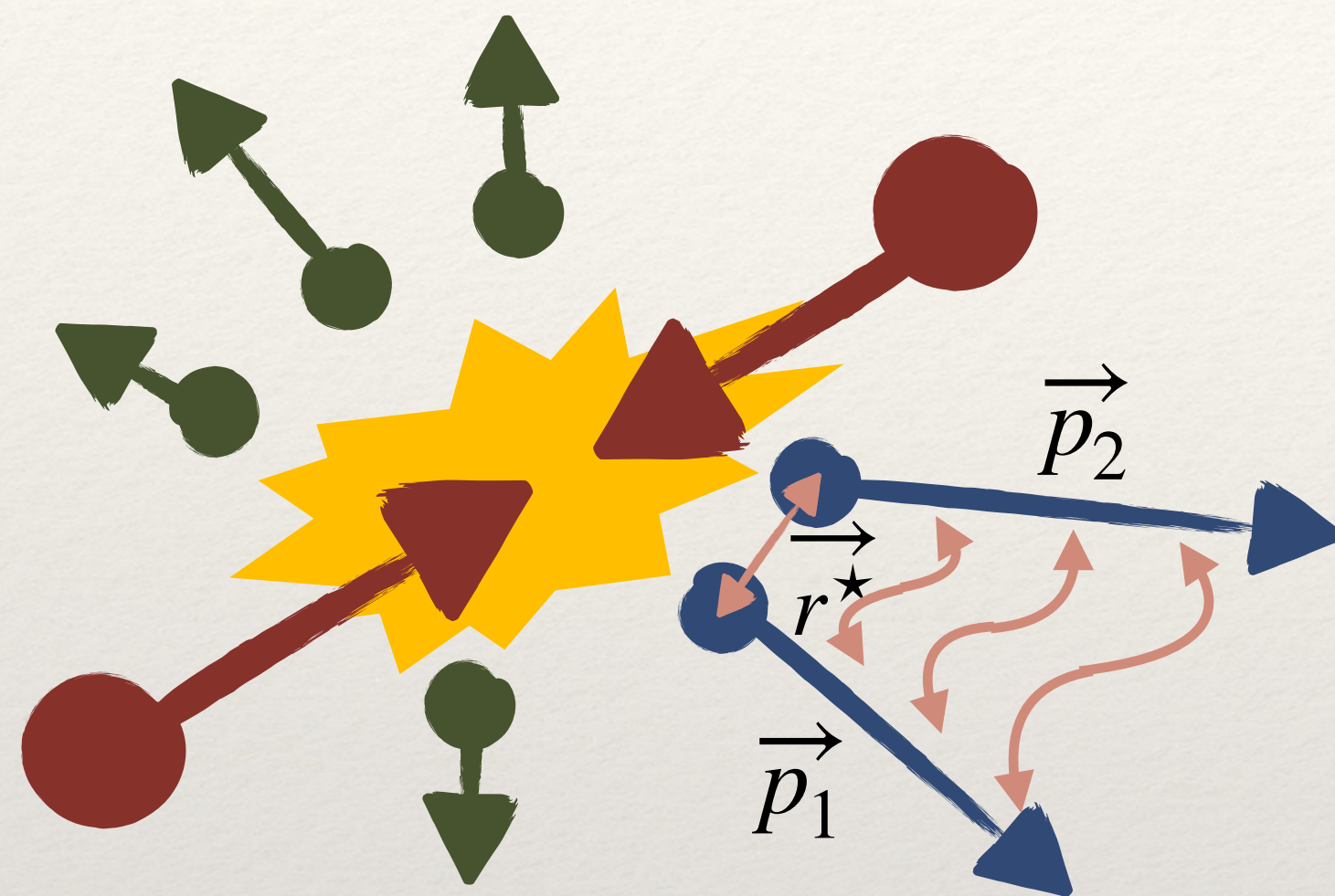
# Femtoscscopy

$$C(k^\star) = \int S(r^\star) |\Psi(k^\star, r^\star)|^2 d^3r^\star = \frac{S_{\text{gnl}}(k^\star)}{B_{\text{ckg}}(k^\star)}$$



$$k^* = |p_1| = |p_2|$$

# Femtoscscopy



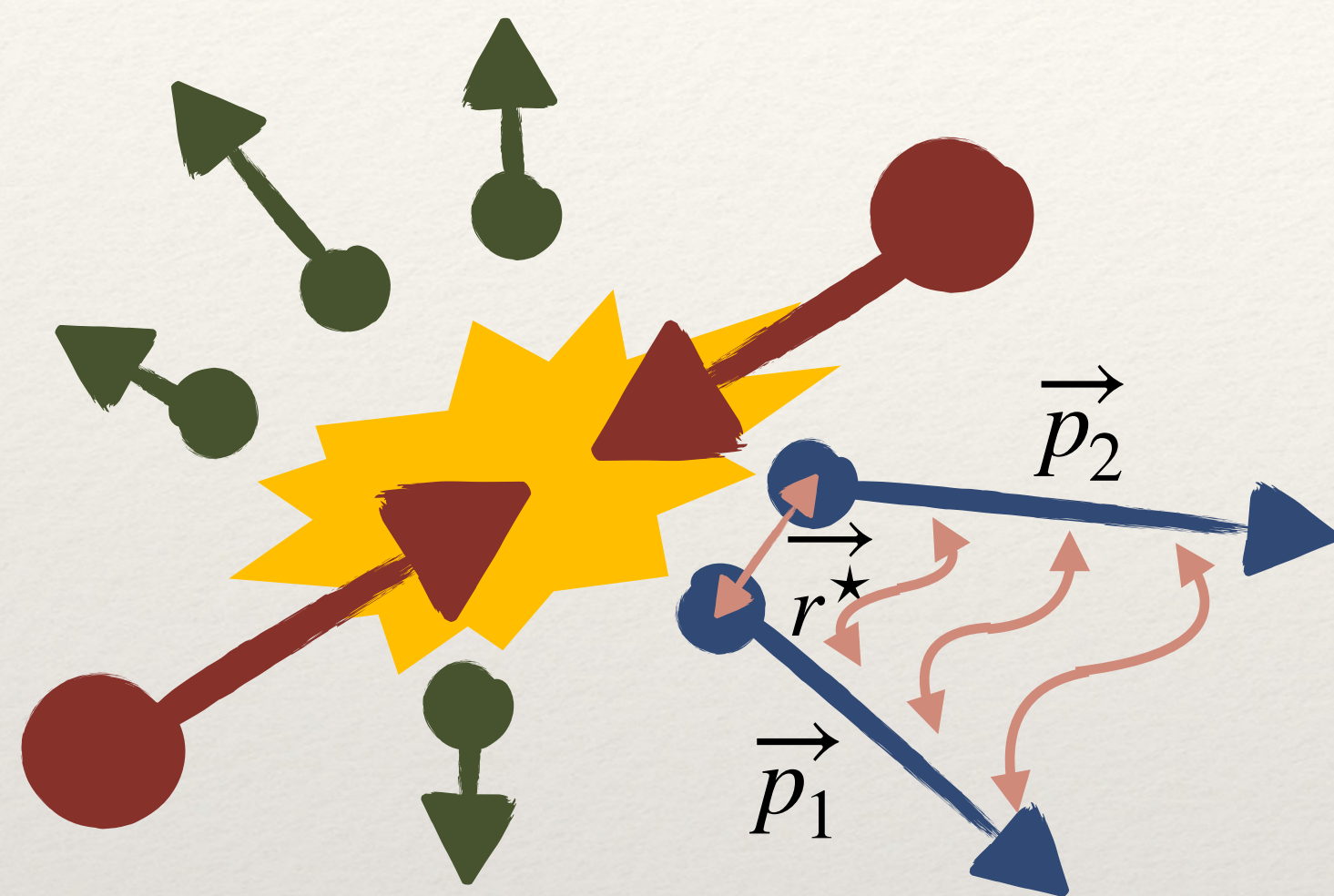
Emission source  $S(r^*)$

$$C(k^*) = \int S(r^*) |\Psi(k^*, r^*)|^2 d^3r^* = \frac{S_{\text{gnl}}(k^*)}{B_{\text{ckg}}(k^*)}$$



$$k^* = |p_1| = |p_2|$$

# Femtoscscopy

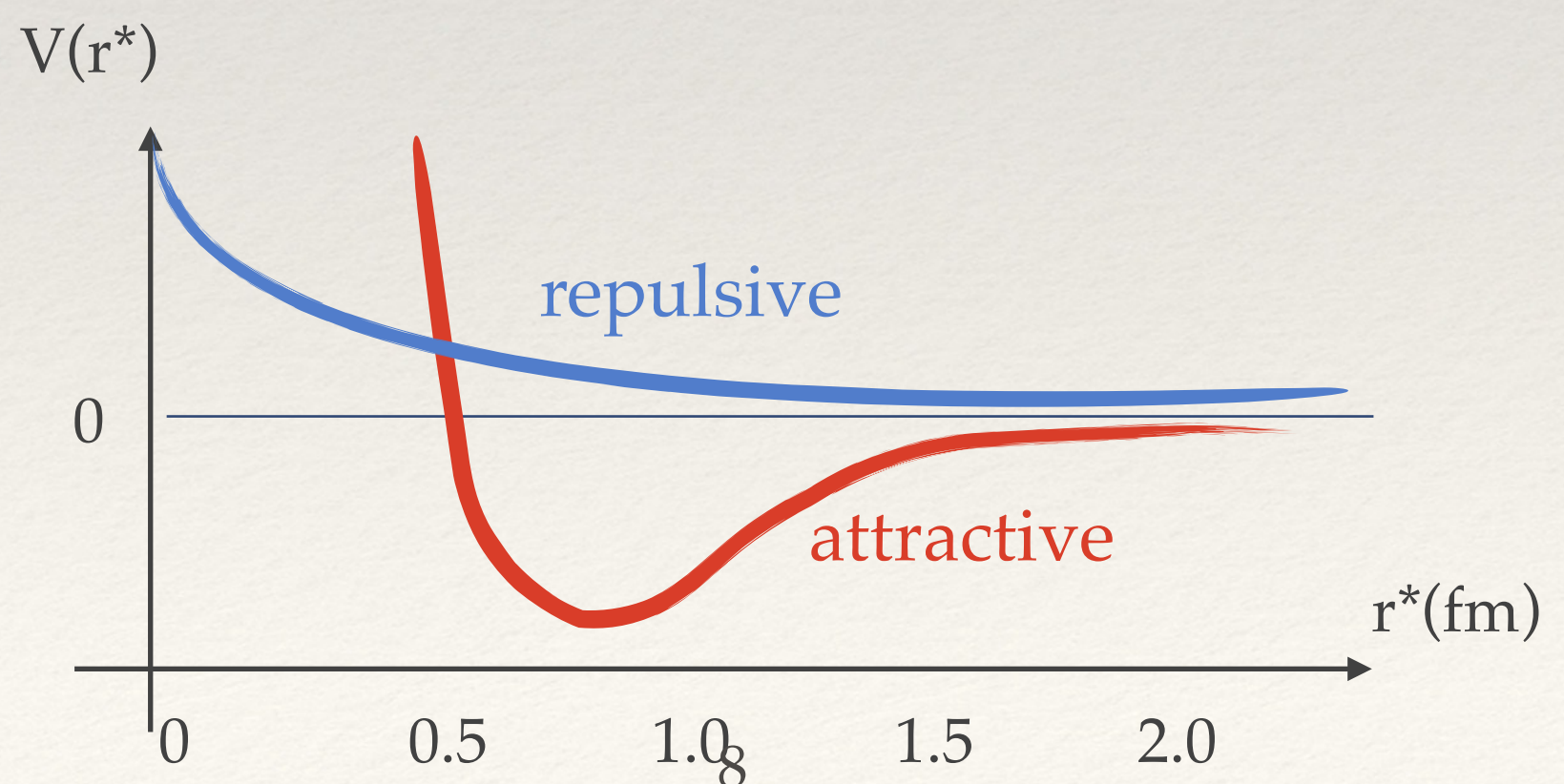


Emission source  $S(r^*)$

$$C(k^*) = \int S(r^*) |\Psi(k^*, r^*)|^2 d^3r^* = \frac{S_{\text{gnl}}(k^*)}{B_{\text{ckg}}(k^*)}$$

Schrödinger equation

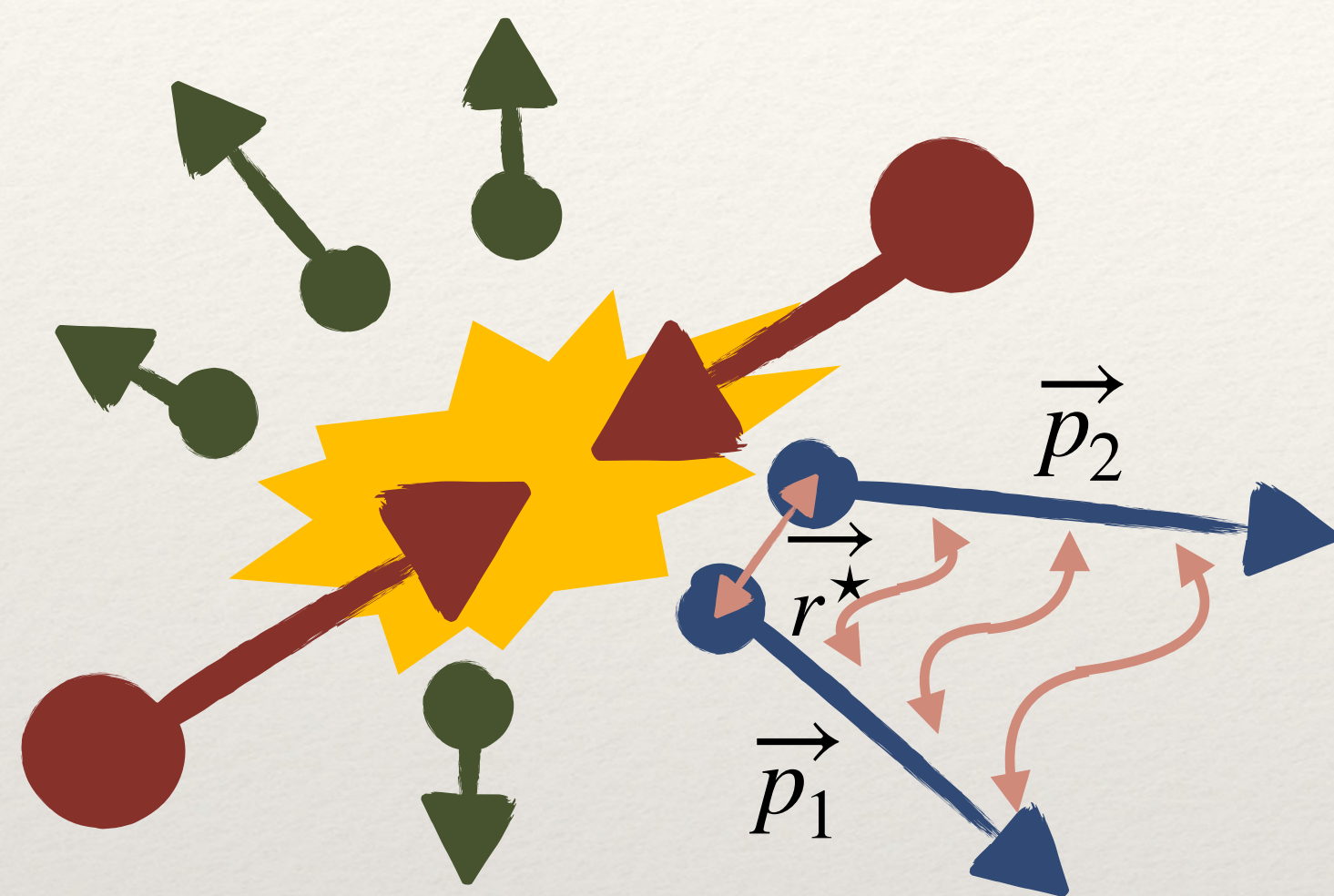
Two-particle wave function  $|\Psi(k^*, r^*)|$





$$k^* = |p_1| = |p_2|$$

# Femtoscscopy



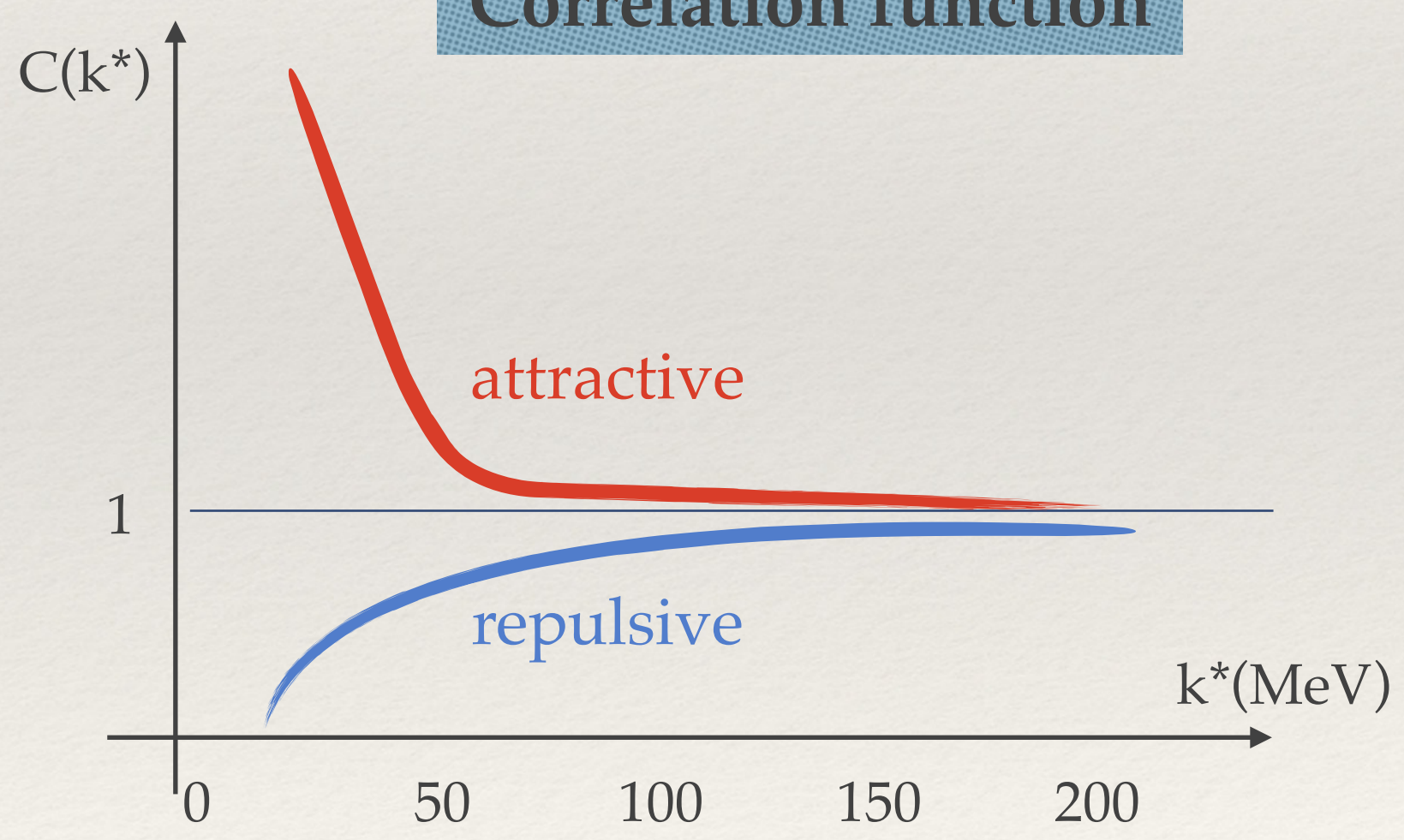
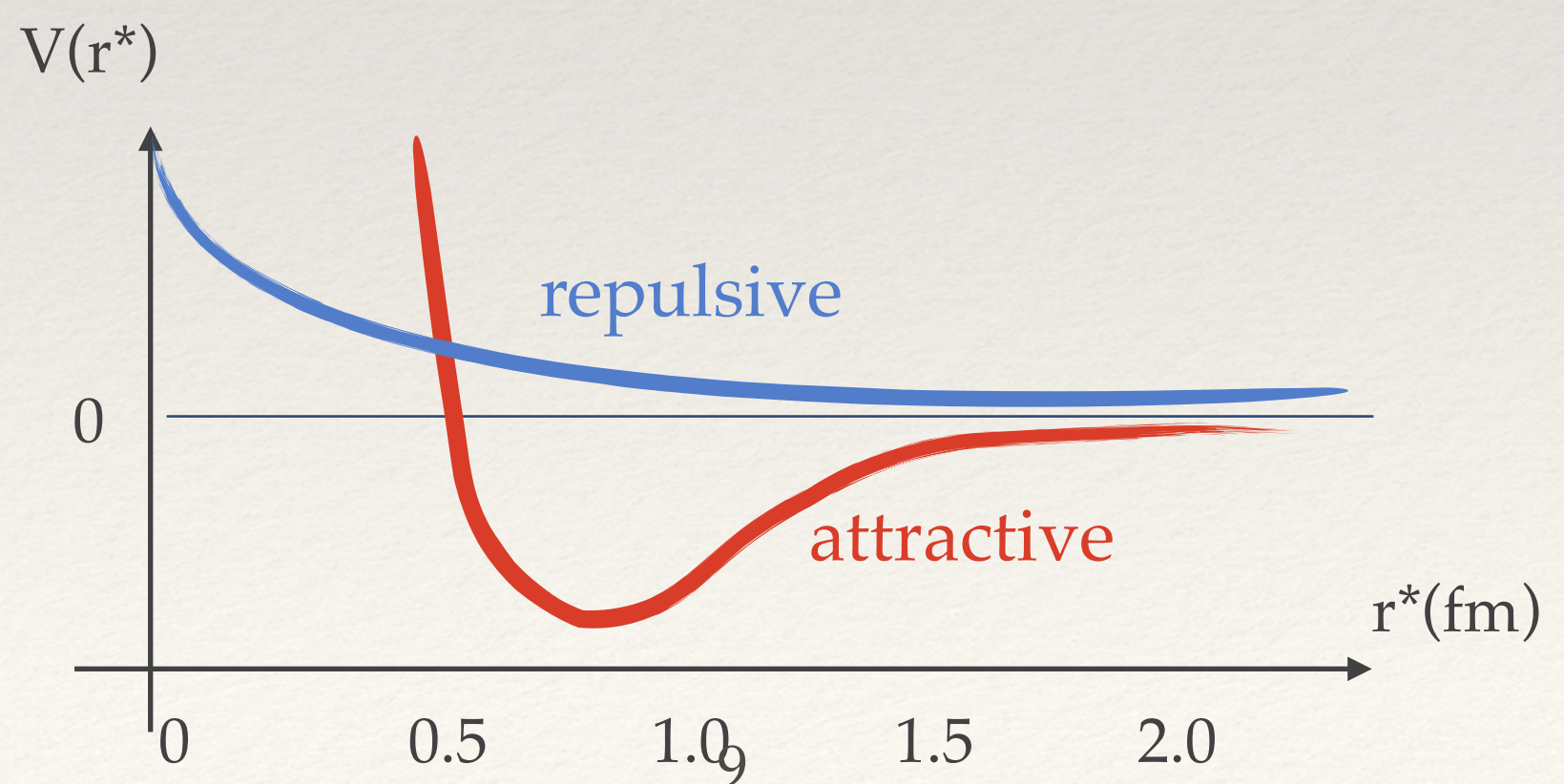
Emission source  $S(r^*)$

$$C(k^*) = \int S(r^*) |\Psi(k^*, r^*)|^2 d^3r^* = \frac{S_{\text{gnl}}(k^*)}{B_{\text{ckg}}(k^*)}$$

Schrödinger equation

Correlation function

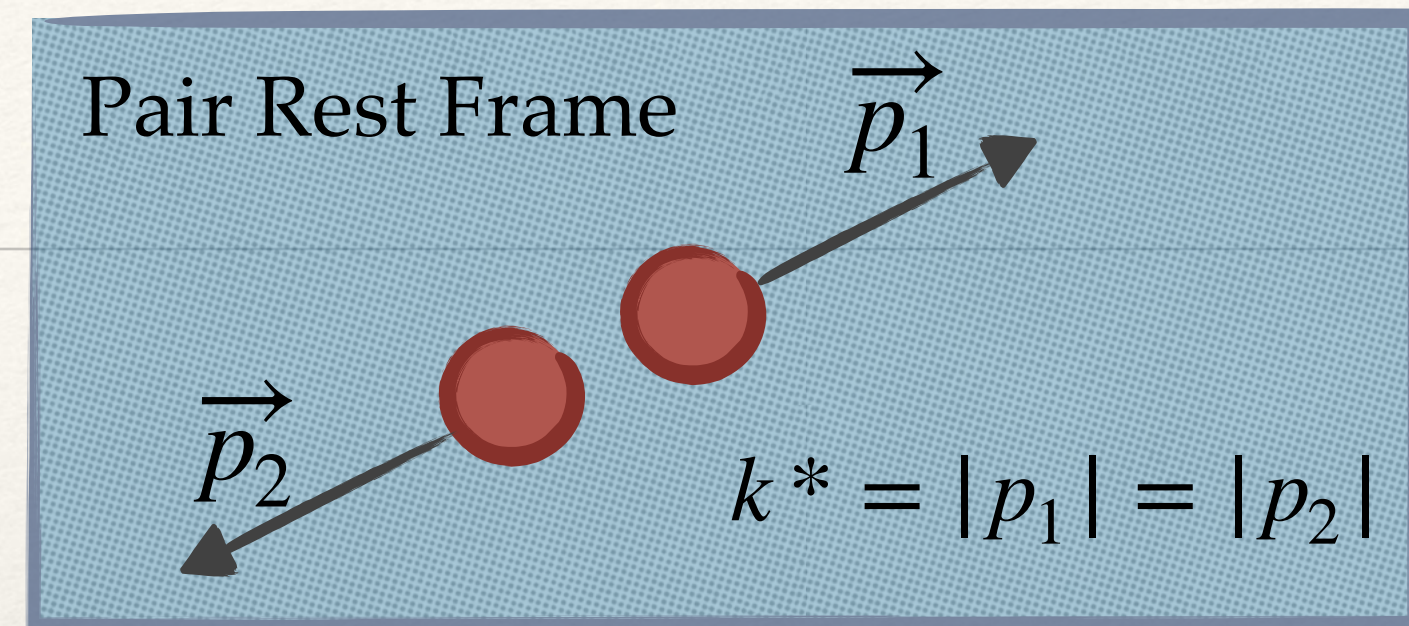
Two-particle wave function  
 $|\Psi(k^*, r^*)|$





$$k^* = |p_1| = |p_2|$$

# Femtoscscopy

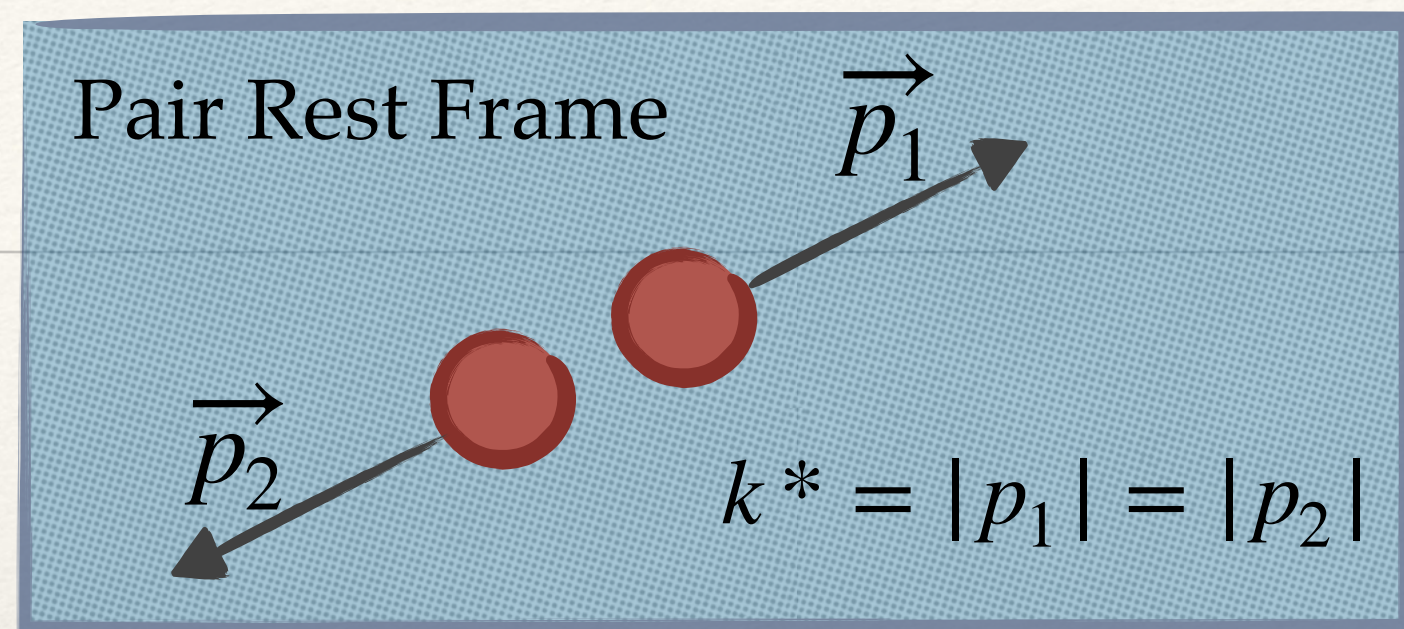


$$C(k^*) = \int S(r^*) |\Psi(k^*, r^*)|^2 d^3 r^* = \frac{S_{\text{gnl}}(k^*)}{B_{\text{ckg}}(k^*)}$$

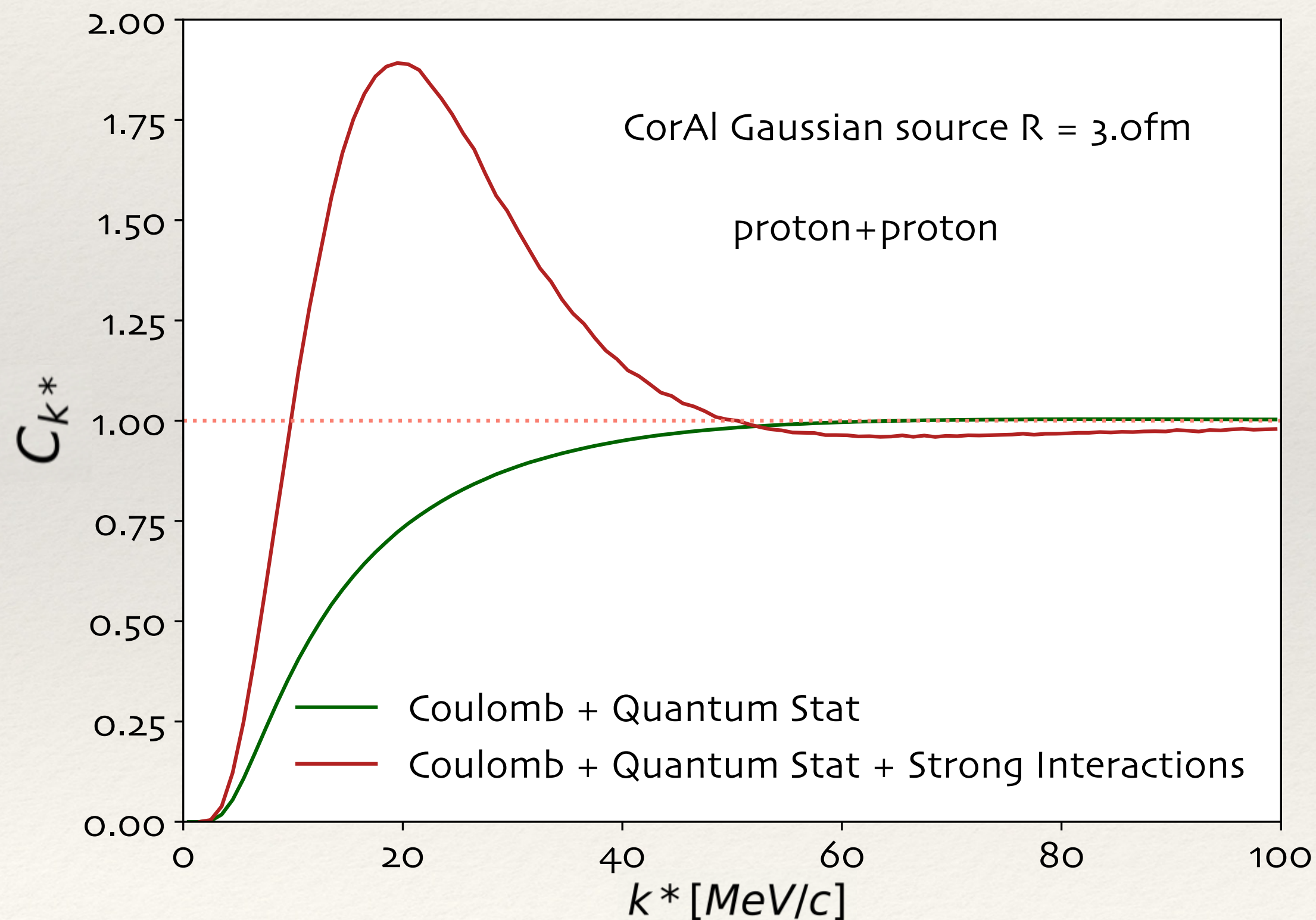


$$k^* = |p_1| = |p_2|$$

# Femtoscscopy



$$C(k^*) = \int S(r^*) |\Psi(k^*, r^*)|^2 d^3r^* = \frac{S_{\text{gnl}}(k^*)}{B_{\text{ckg}}(k^*)}$$



## 1. Coulomb:

- Attractive for opposite sign particles
- **Repulsing for same sign particles**

## 2. Quantum Statistic:

- Bosons: positive
- **Fermions: negative**

## 3. Strong Interactions:

- Can be both **positive** or negative, depending on potentials



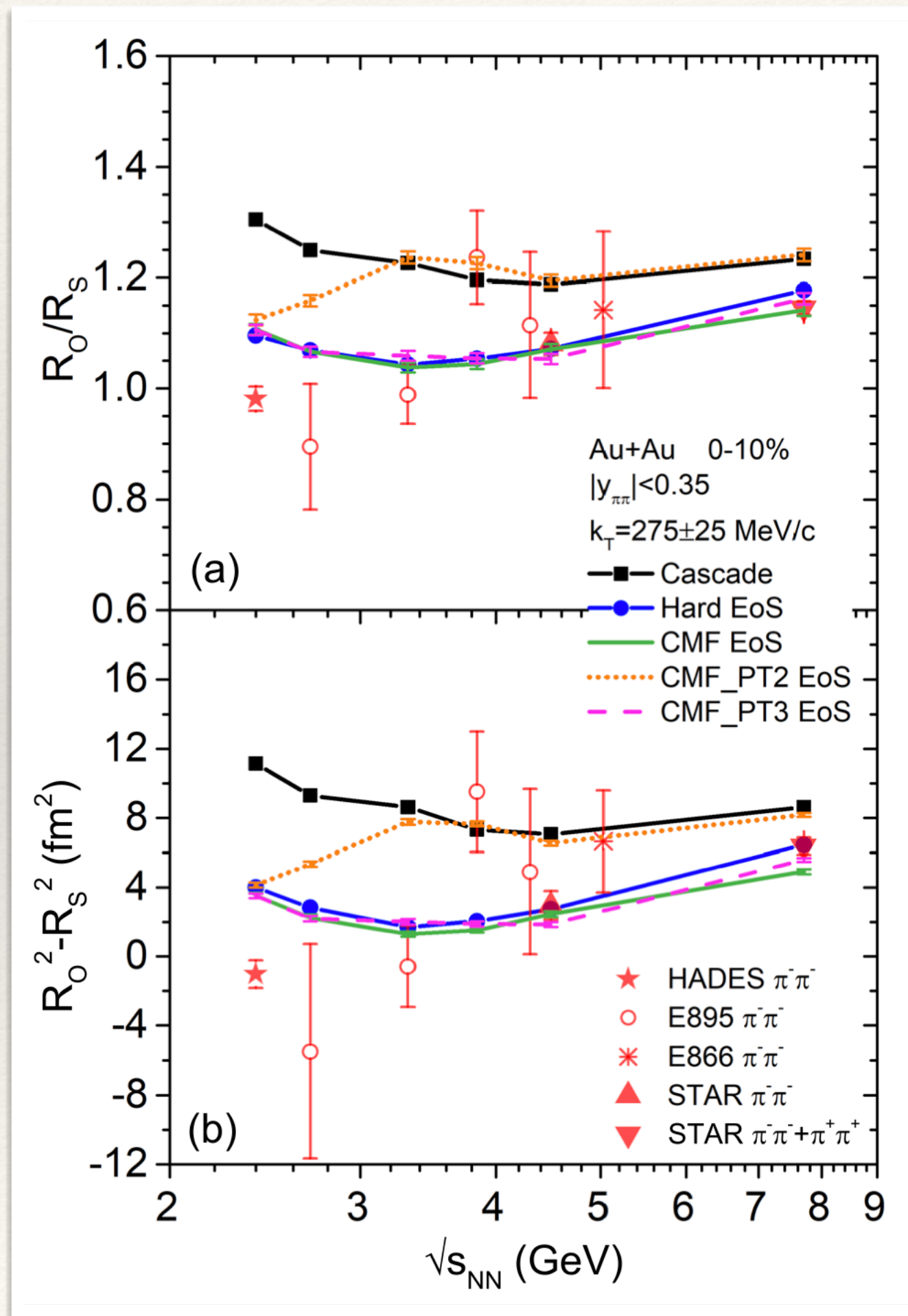
# Preliminary results



# Femtoscopy in EoS studies

Work in progress

With Scott Pratt and Jan Steinheimer



## Pion-pion correlations

Studies performed with UrQMD model + CRAB

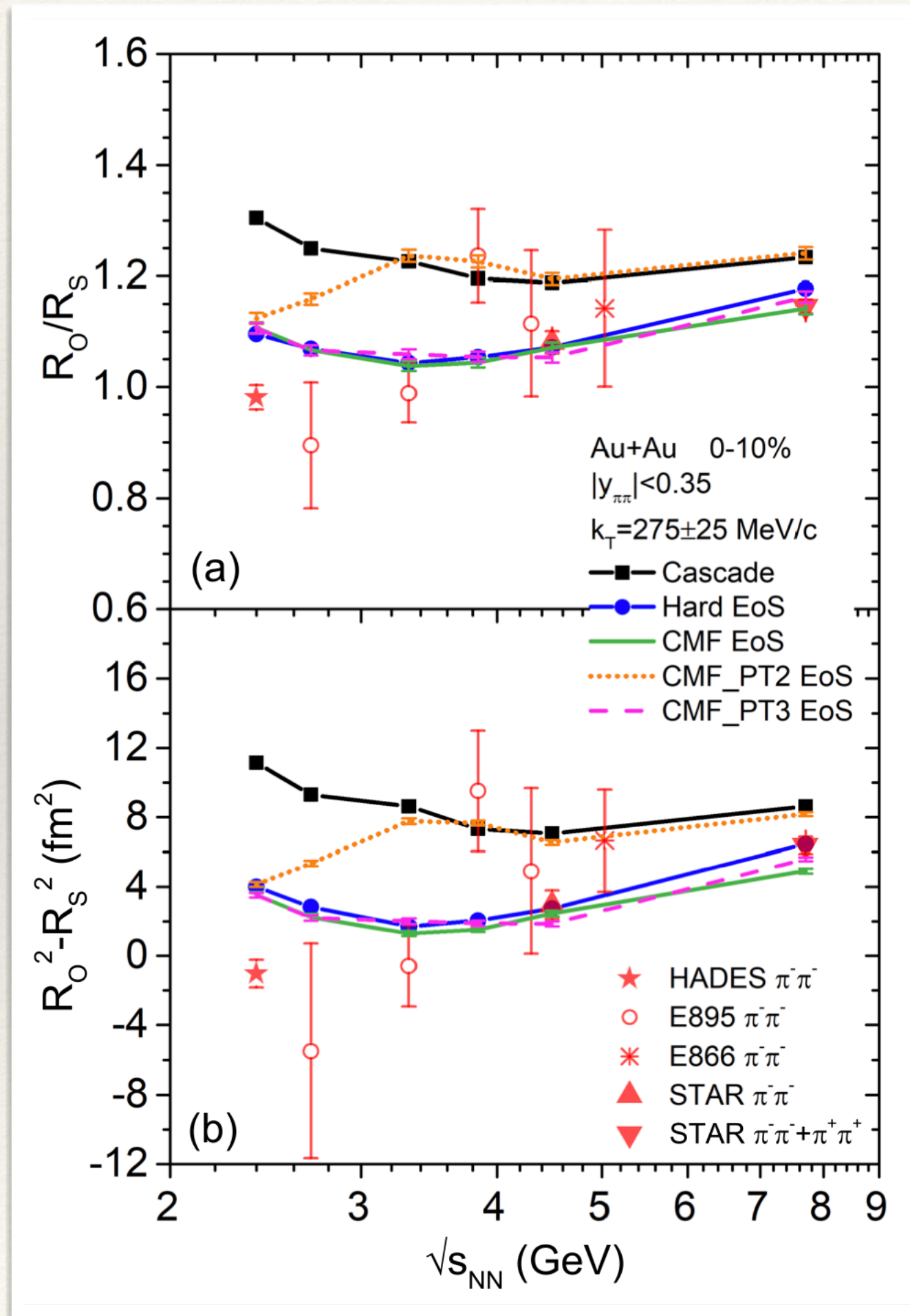
What about proton + proton correlations?



# Femtoscopy in EoS studies

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## Pion-pion correlations

Studies performed with UrQMD model + CRAB

What about proton + proton correlations?

Idea:



How the p+p correlations differ with EoS within the same model?

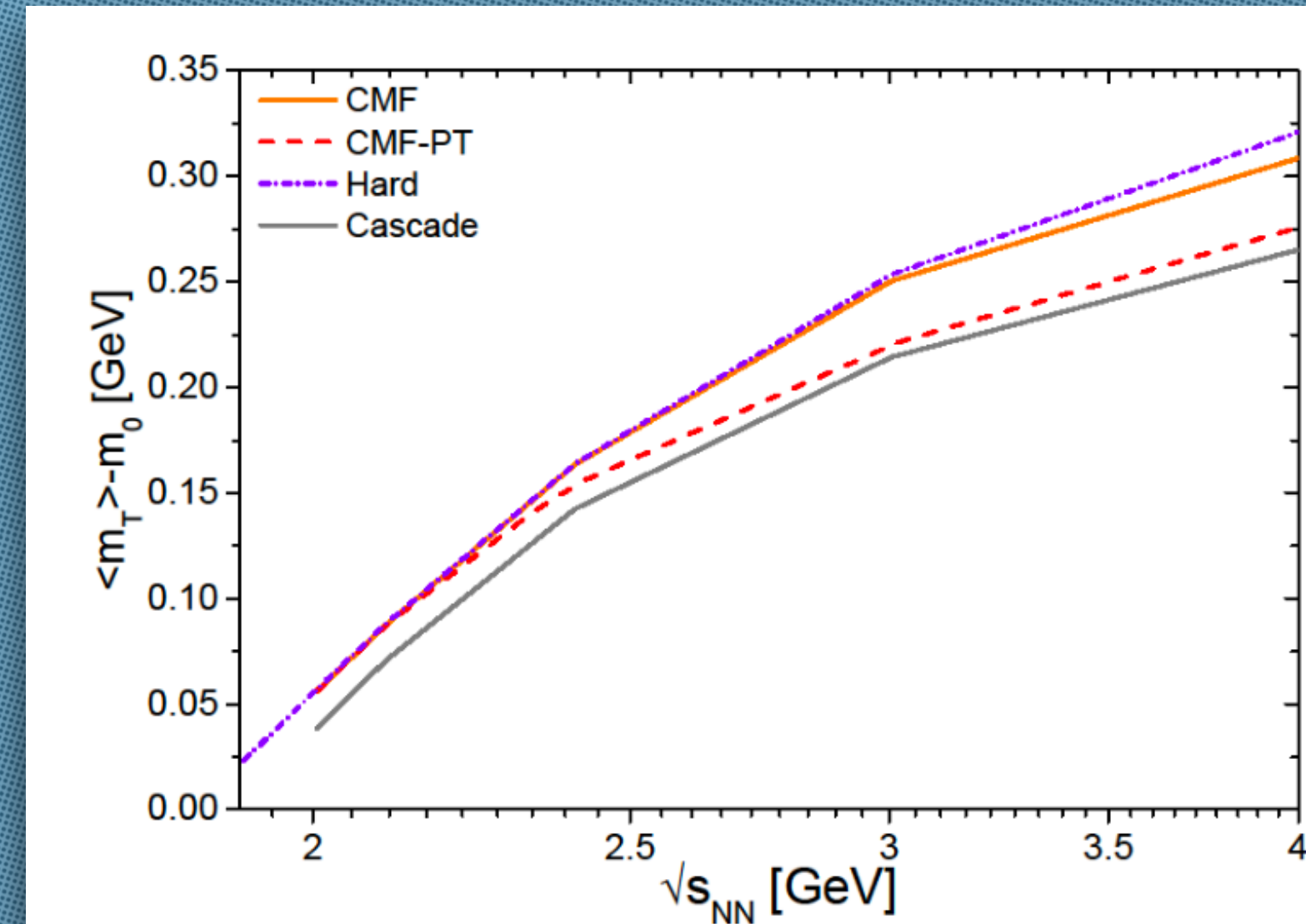
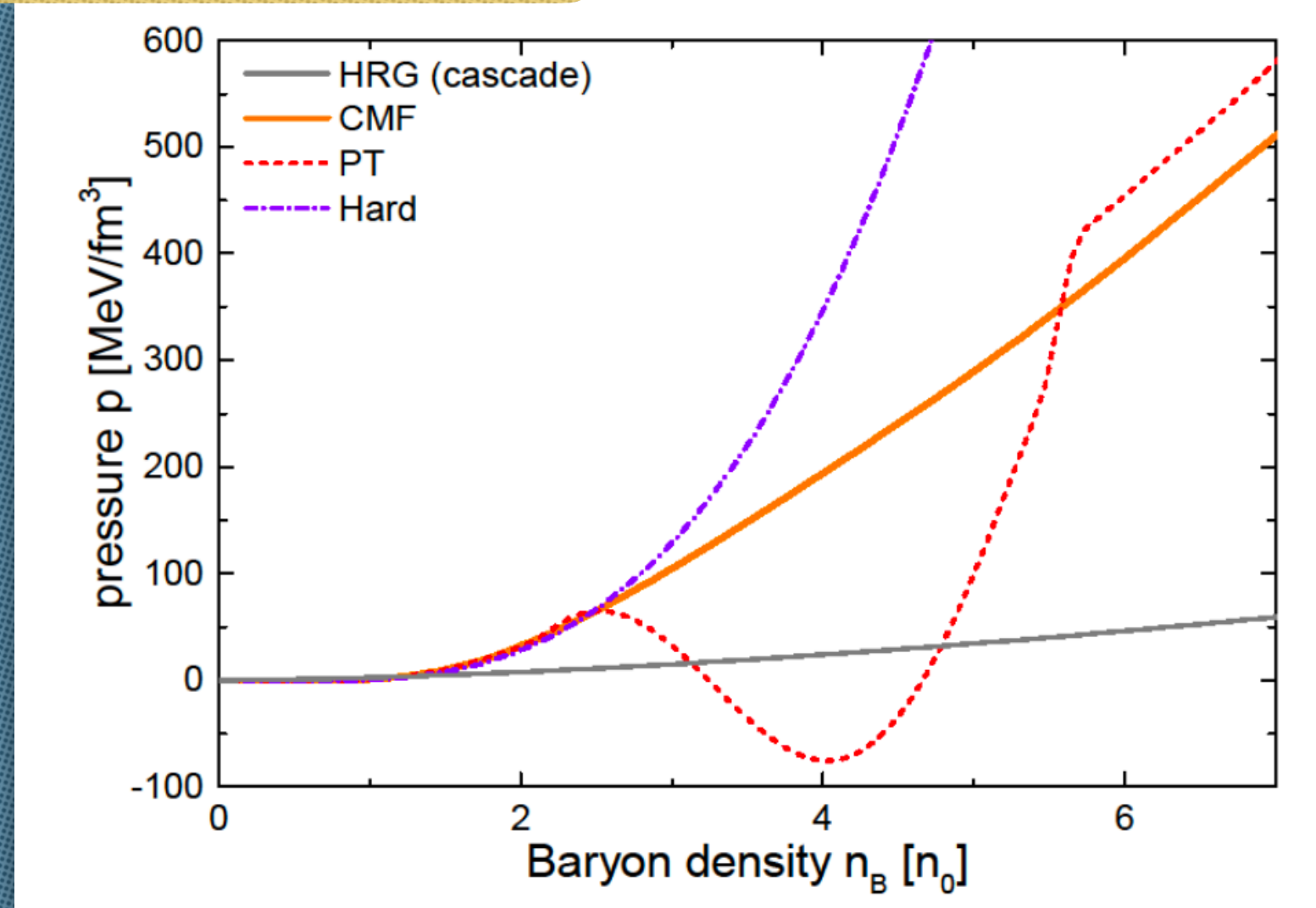


# Femtoscopy in EoS studies

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## Various EoS



## CorAl

## Correlation Analysis

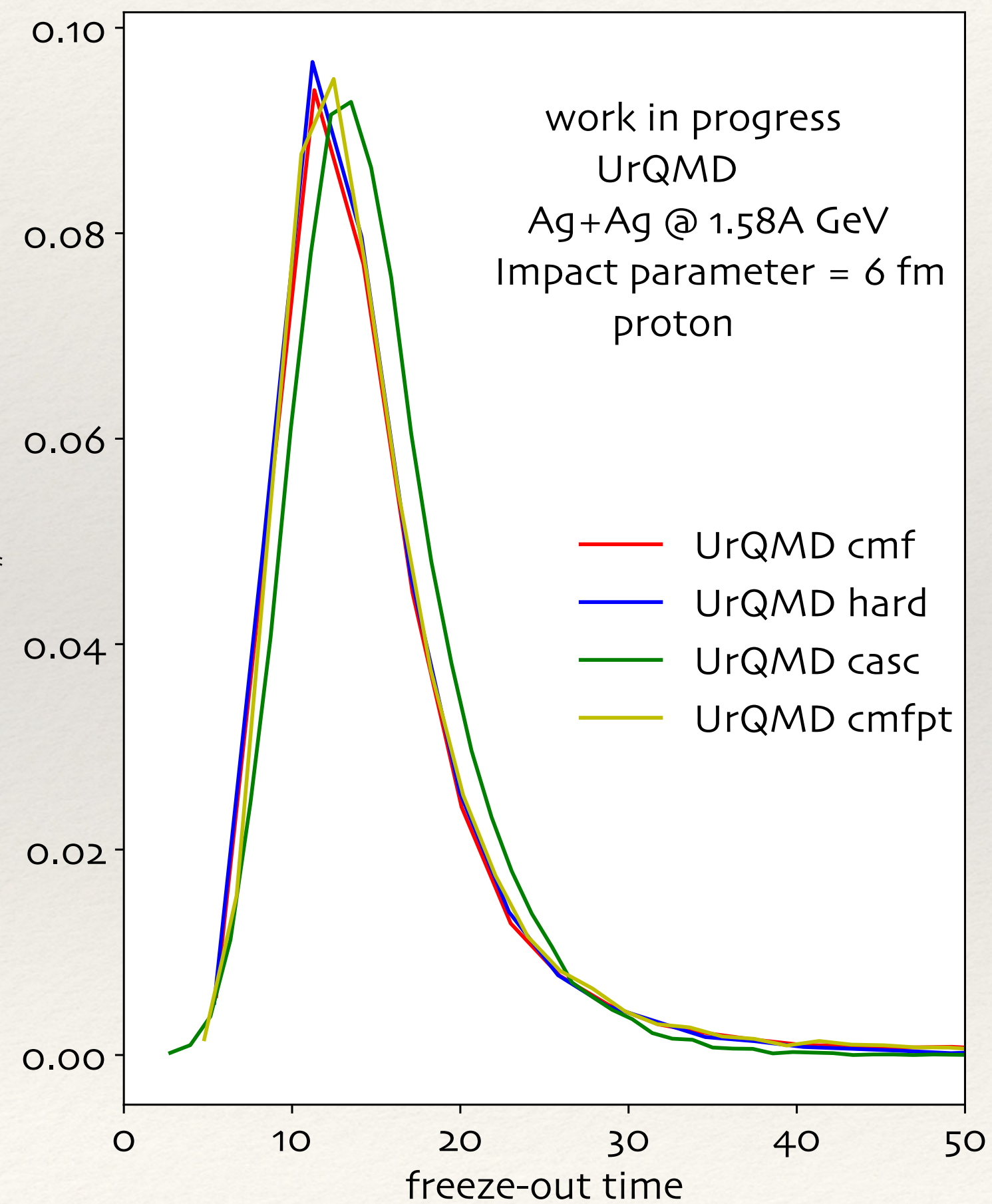
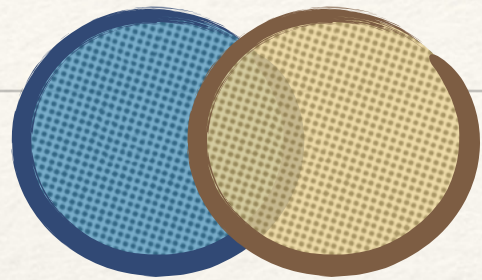
Uses Koening formula to calculate the wave functions for space-points taken from UrQMD



# Proton - proton in EoS studies

*Work in progress*

*With Scott Pratt and Jan Steinheimer*

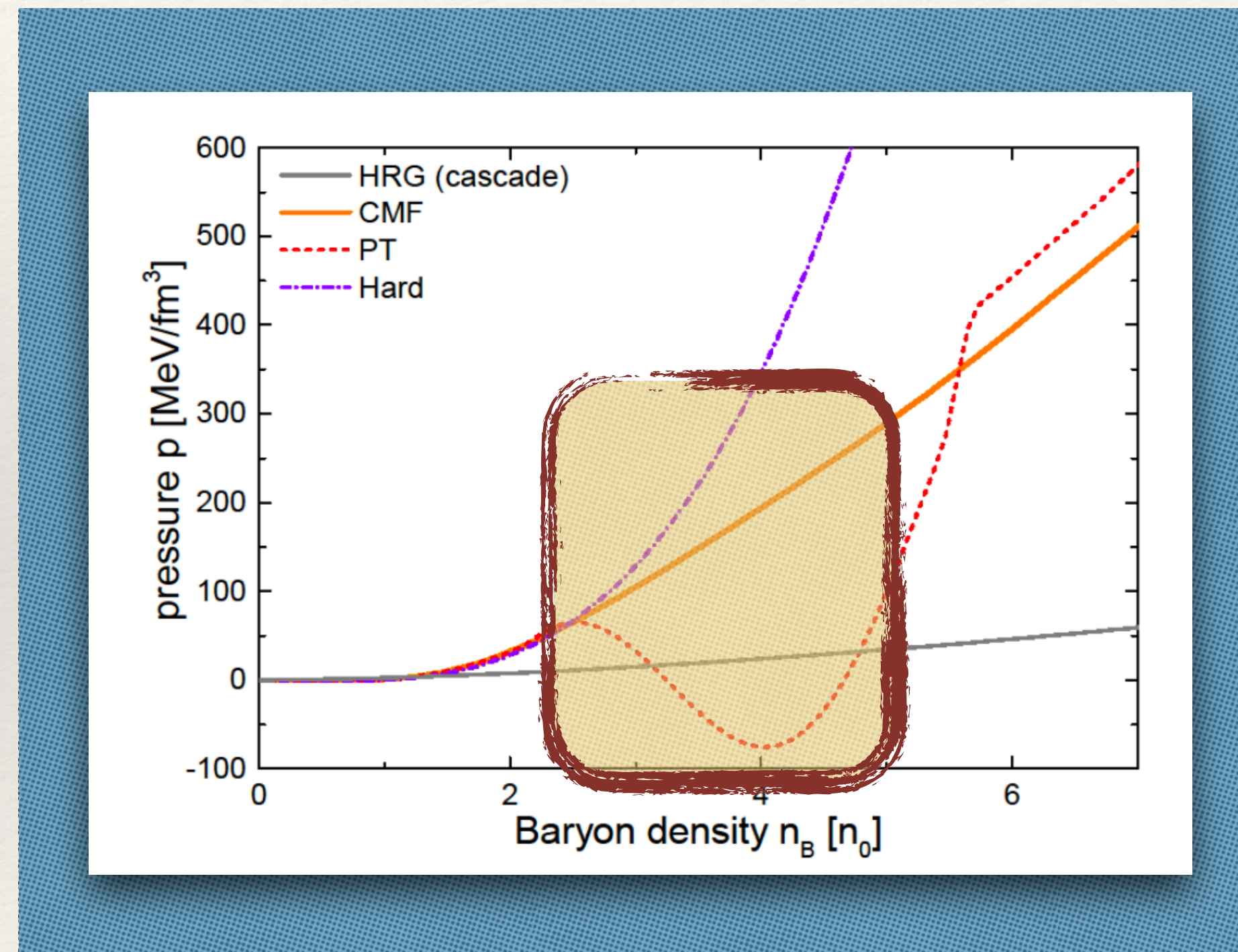
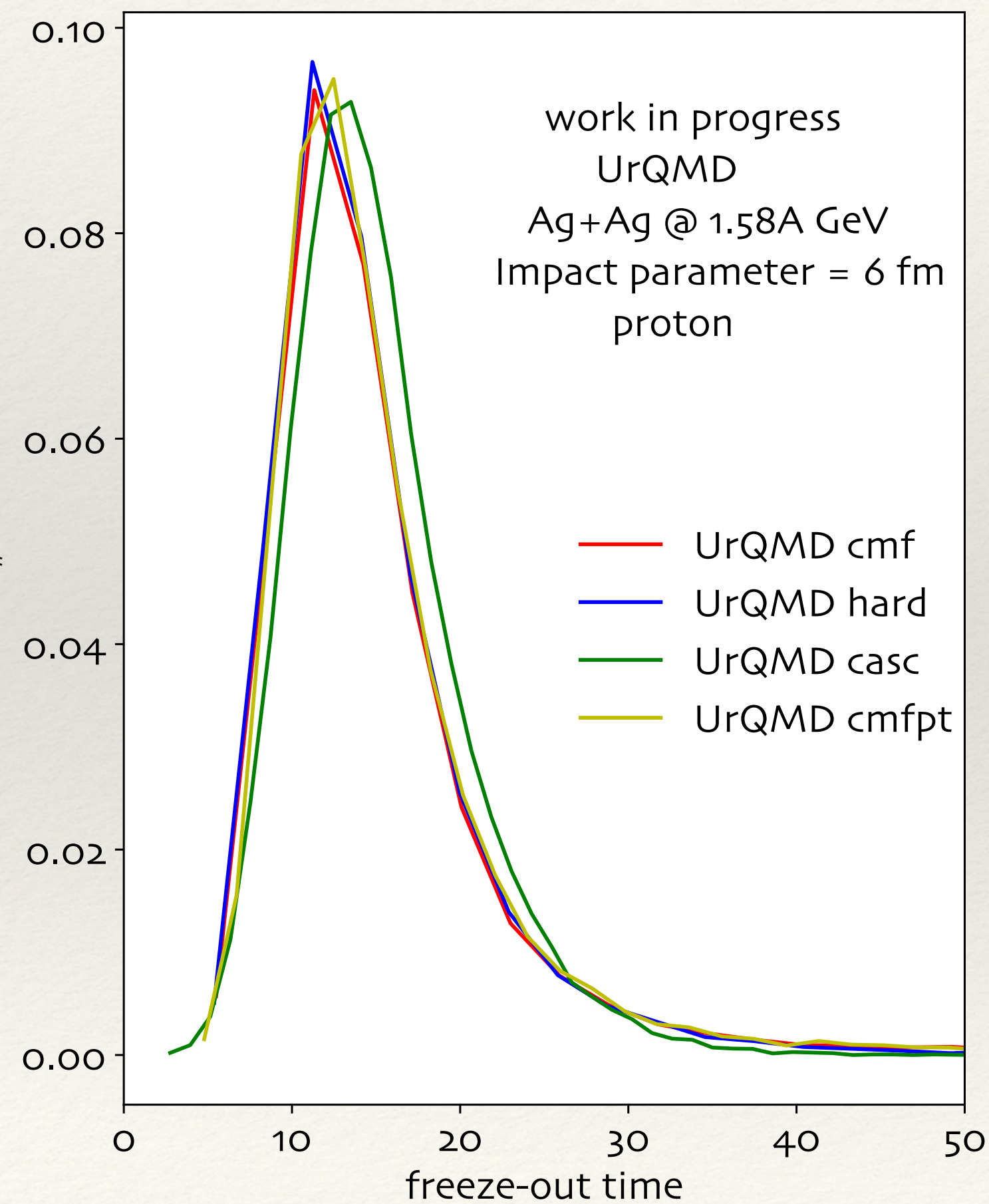
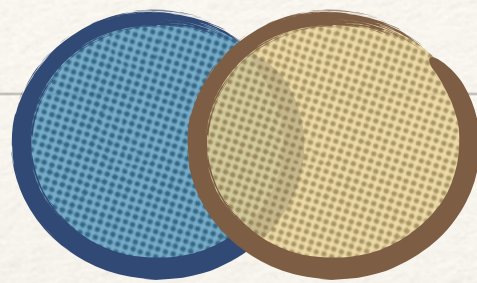




# Proton - proton in EoS studies

Work in progress

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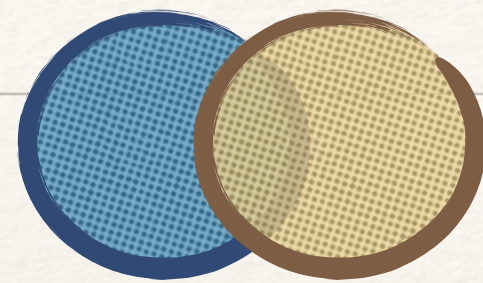




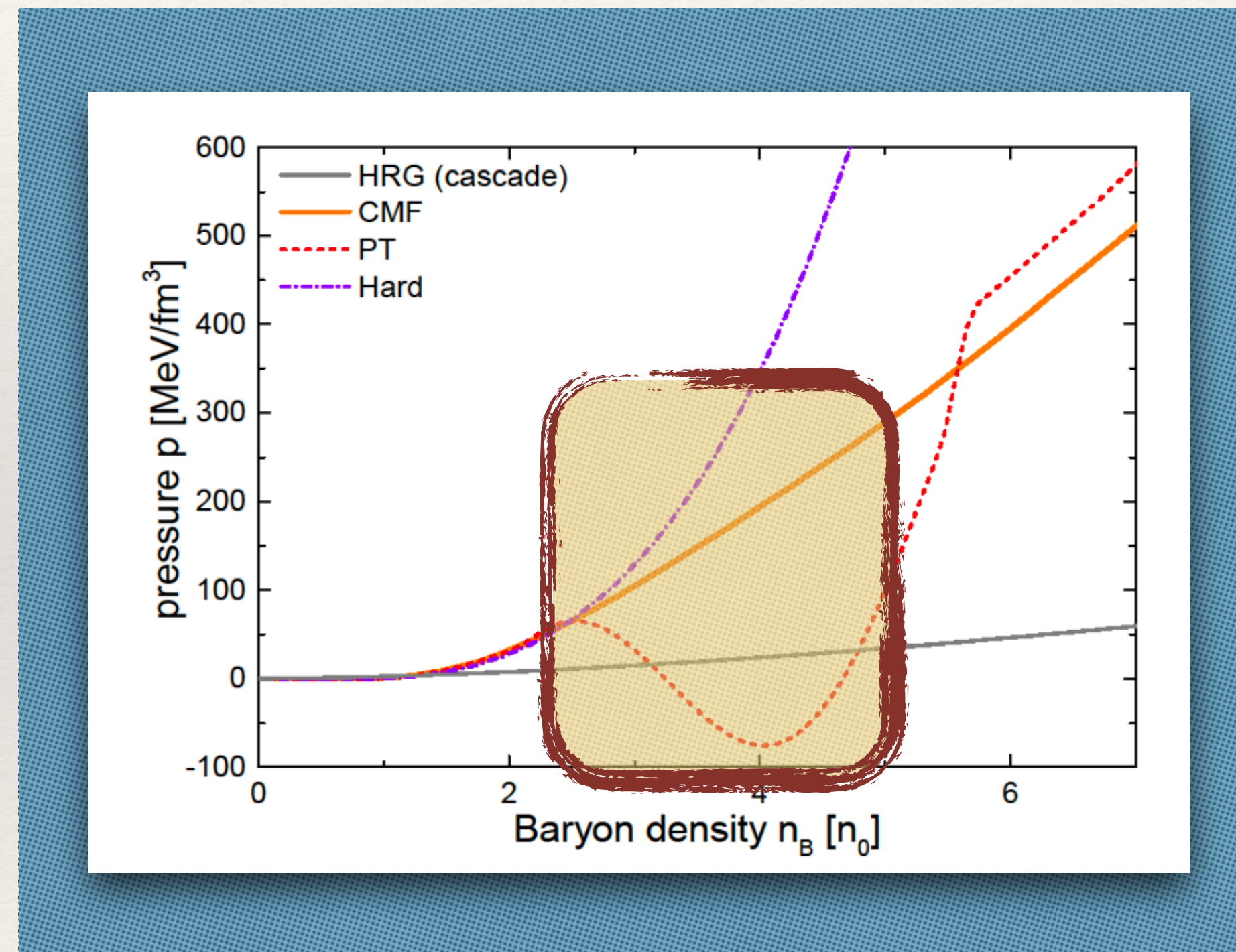
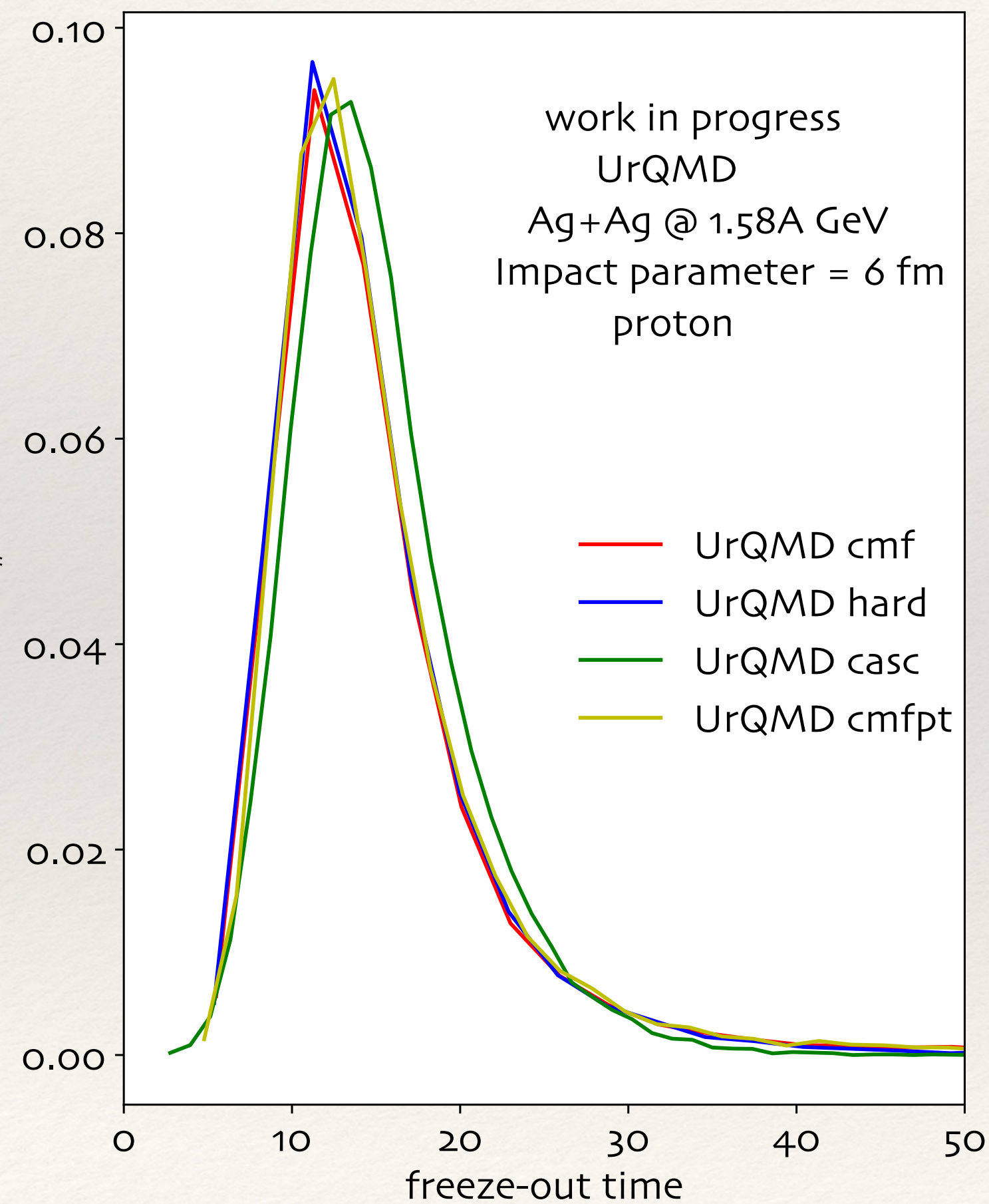
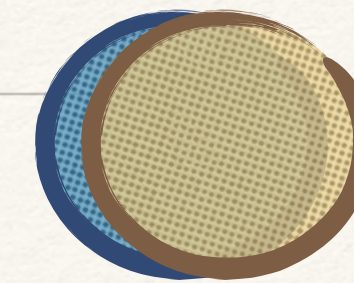
# Proton - proton in EoS studies

Work in progress

With Scott Pratt and Jan Steinheimer



Increase of the baryon density

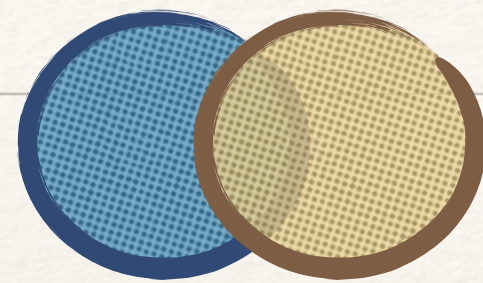




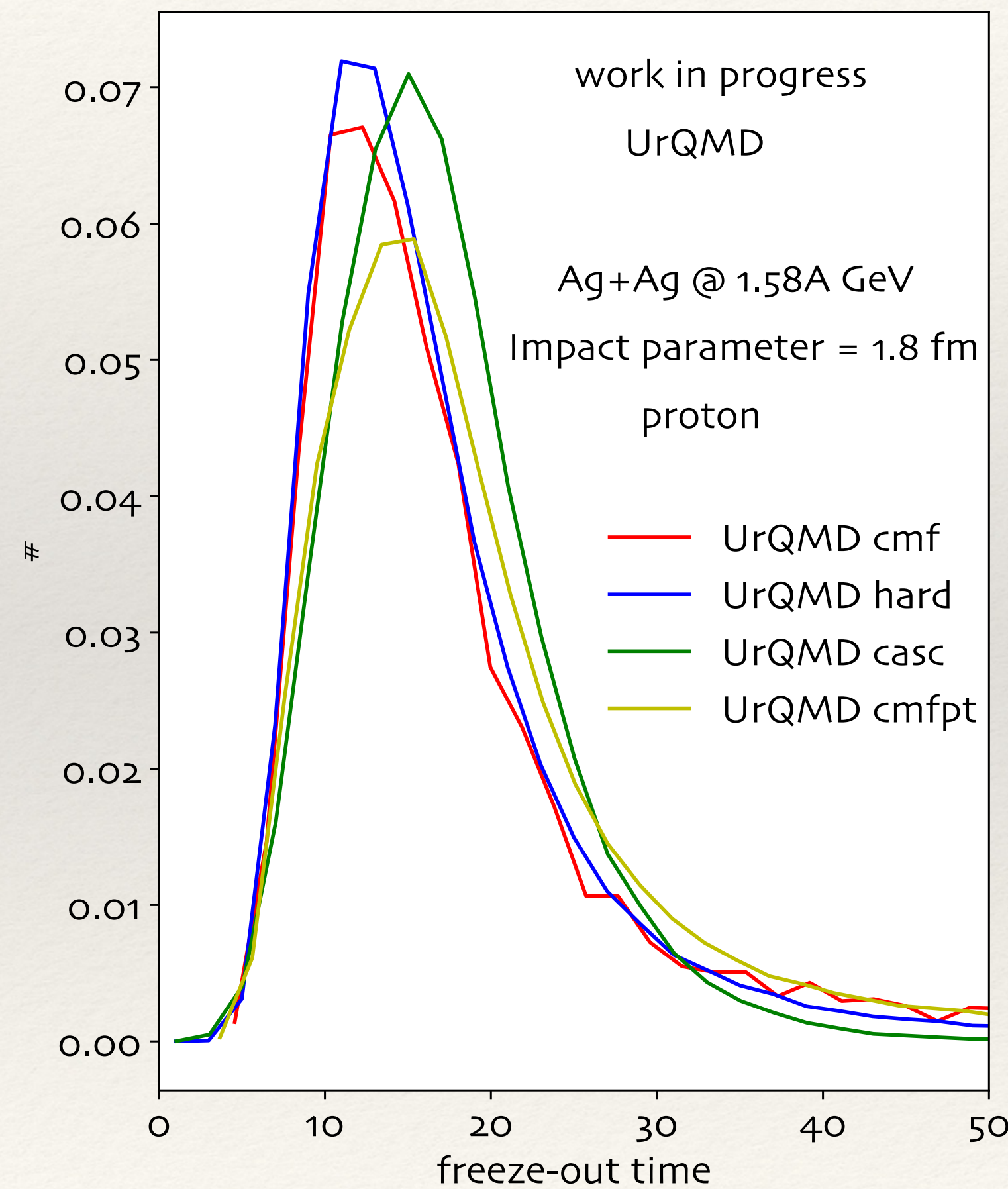
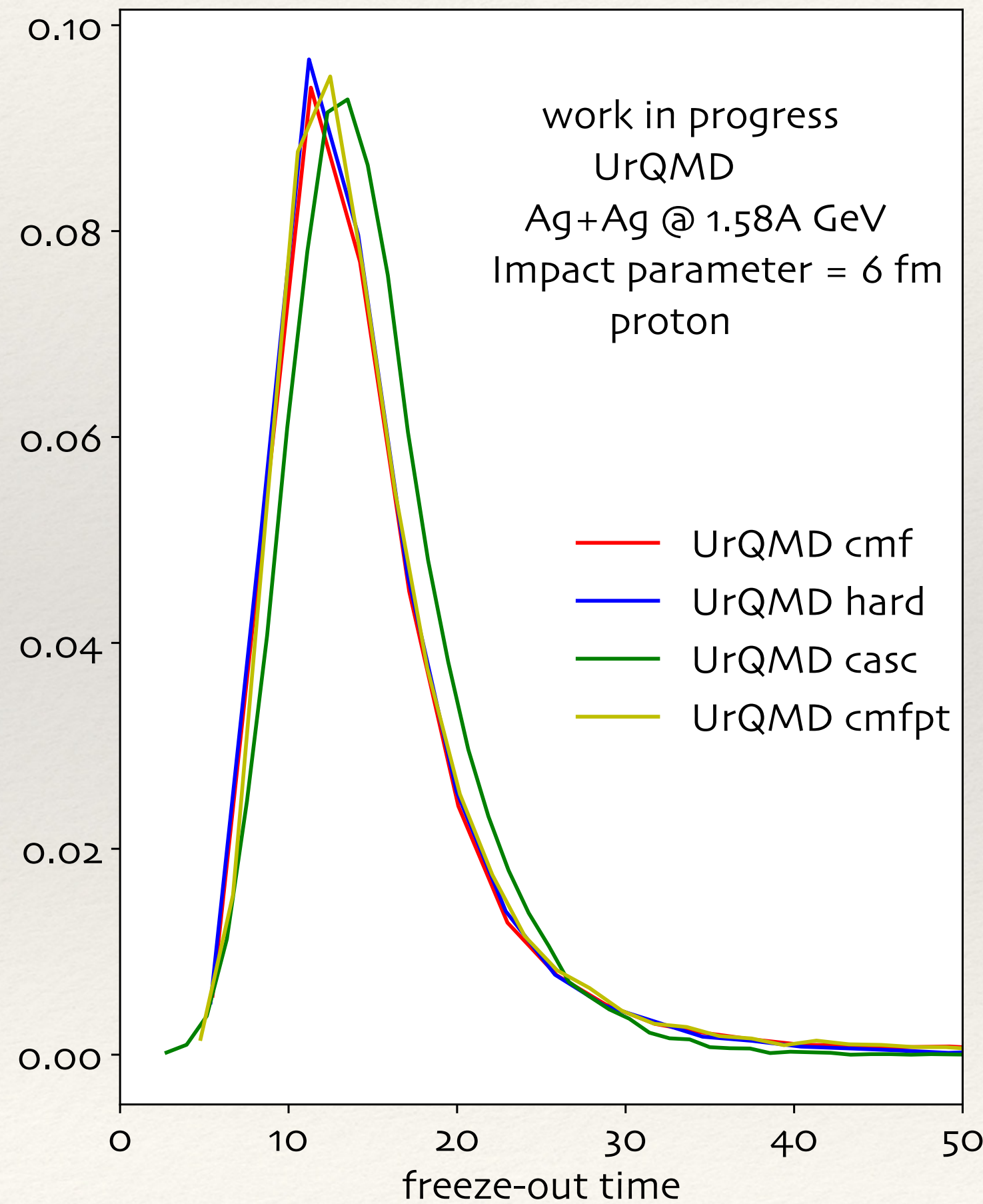
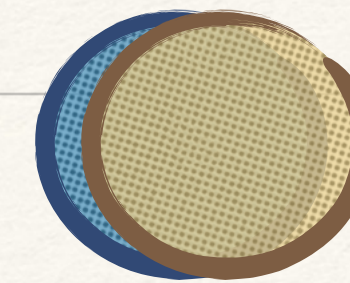
# Proton - proton in EoS studies

*Work in progress*

*With Scott Pratt and Jan Steinheimer*



Increase of the baryon density



**SOFTER**

**EoS:**

vs

**STIFFER**

**Longer emission duration**

**Shorter emission duration**

**Visible changes of EoS in emission time**

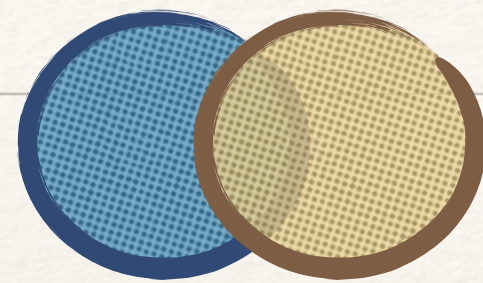
The higher baryon density the more vital differences



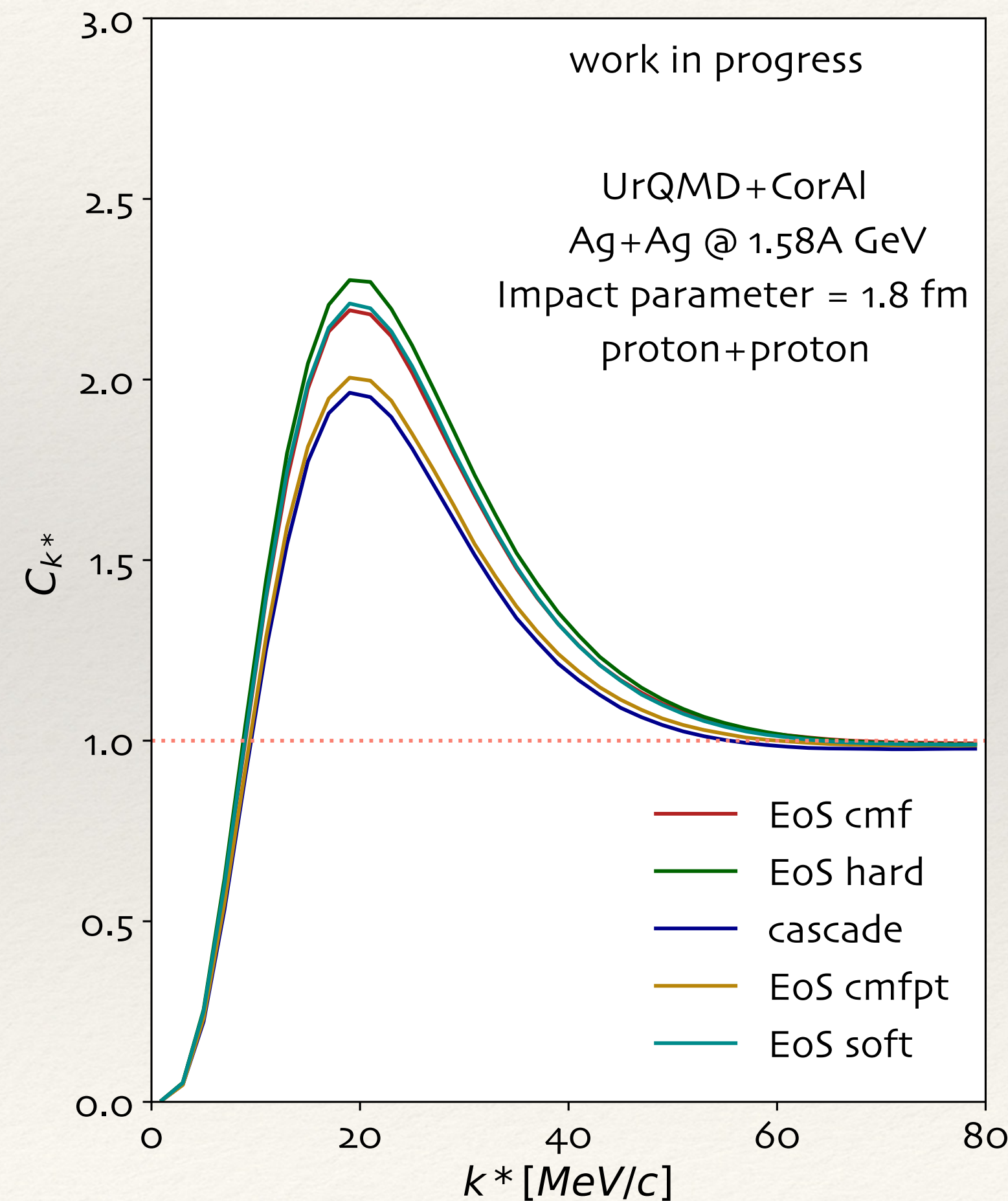
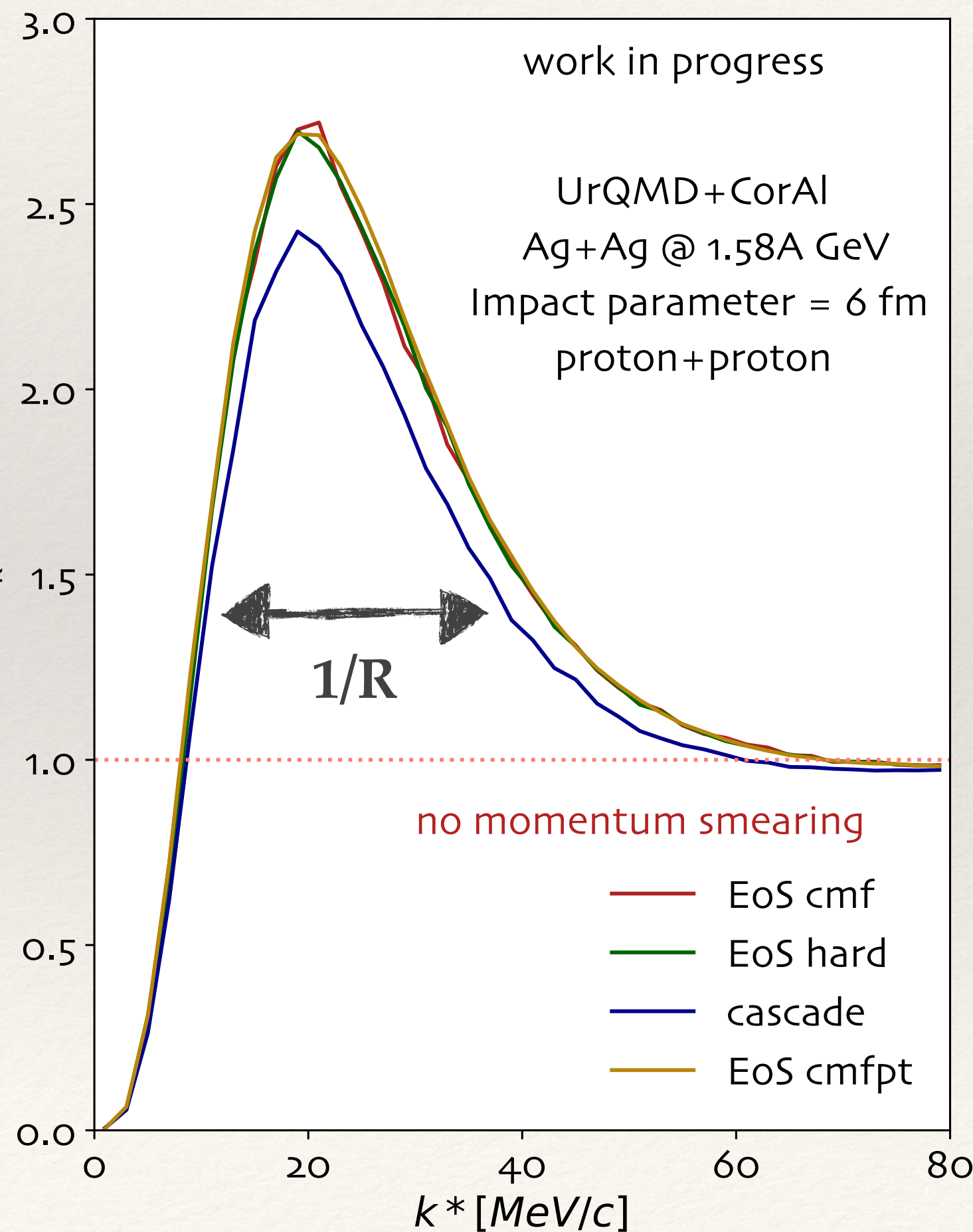
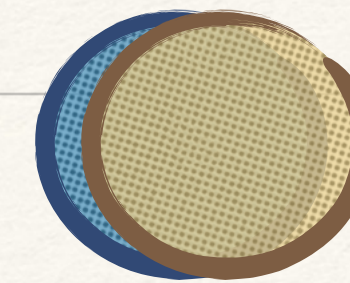
# Proton - proton in EoS studies

Work in progress

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Increase of the baryon density



**EoS:**

**SOFTER**

vs

**STIFFER**

Longer emission duration

Shorter emission duration

Higher flow

Smaller flow

**Visible changes of EoS in pp CF**

The higher baryon density the more vital differences



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# Summary and Outlook

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First studies of UrQMD+Coral femtoscopic correlations shows **great sensitivity** to proposed EoS within the same model!

Extraction of proton source parameters and increase of studies precision using 3D femtoscropy

Thank you