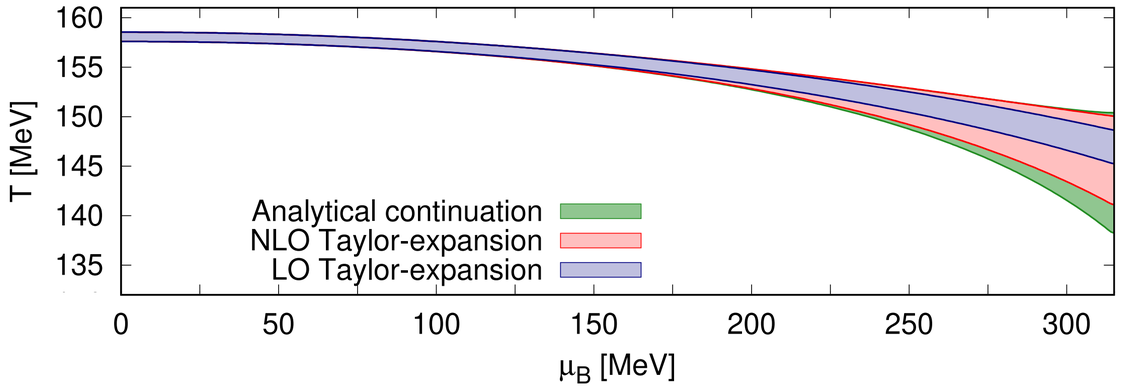
Comparison of Crossover & Freeze-out

- Precise knowledge of the QCD pseudocritical temperature and characterization of transition line at finite chemical potential

$$\frac{T_c(\mu_B)}{T_c(\mu_B = 0)} = 1 - \kappa_2 \left(\frac{\mu_B}{T_c(\mu_B)} \right)^2 - \kappa_4 \left(\frac{\mu_B}{T_c(\mu_B)} \right)^4$$



S. Borsanyi et al, PRL (2020)
See also: A. Bazavov et al, PLB (2019)
S. Borsanyi et al, arXiv:2502.10267

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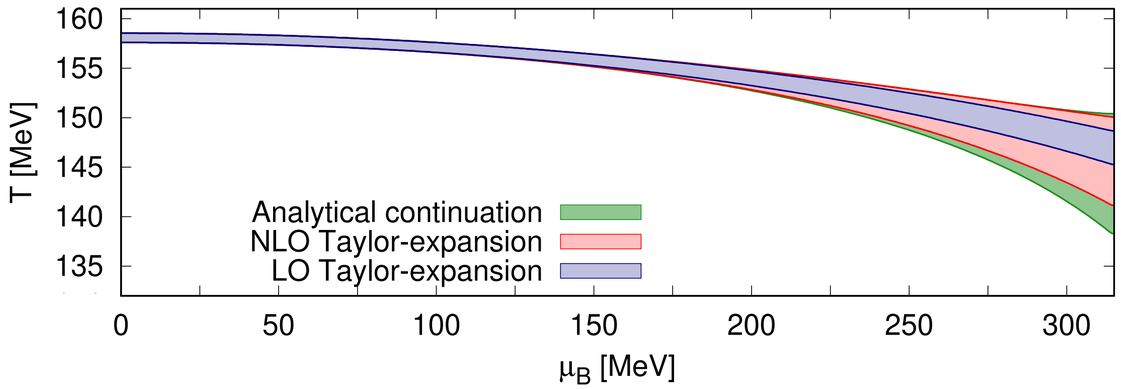

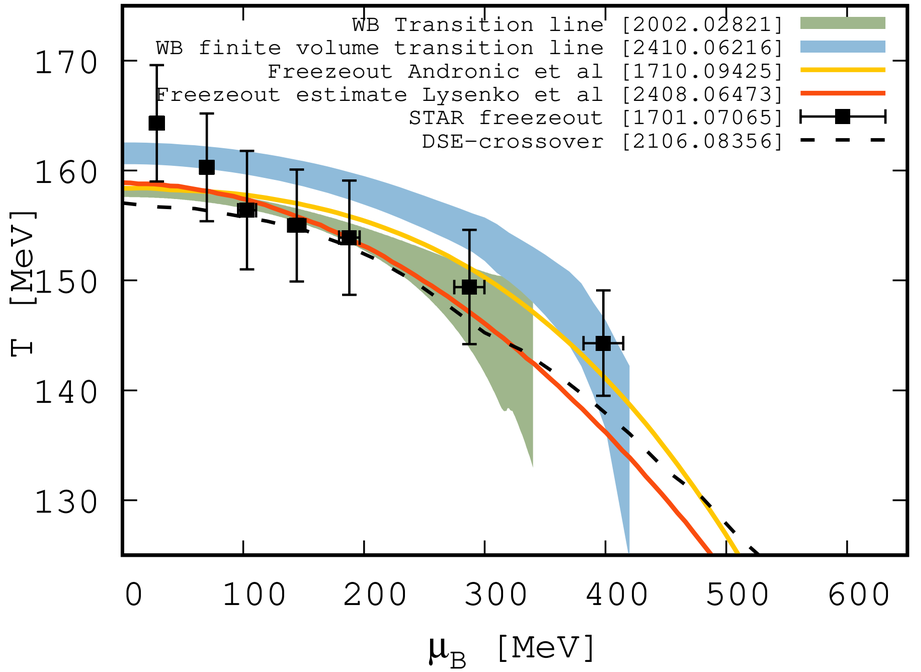

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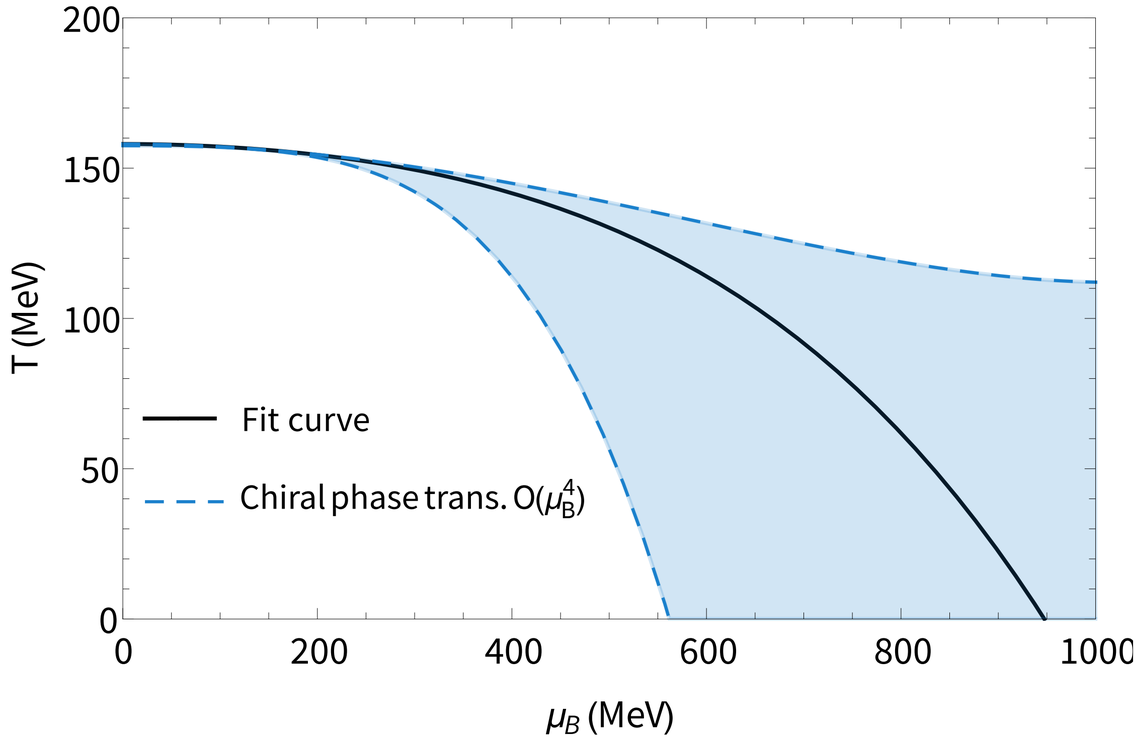
Comparison of Crossover & Freeze-out

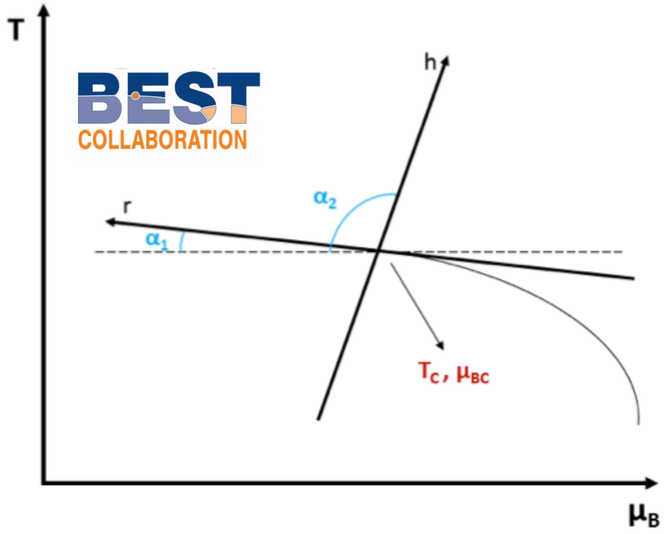
- Plot out even further and make a choice of a parabola that lies within the error band



Choose location to map Ising critical point & determine α_1:

$$(\mathbf{r},\mathbf{h}) \longleftrightarrow (\mathbf{T},\mu_\mathbf{B}): \quad \frac{T-\mathbf{T_C}}{\mathbf{T_C}} = \mathbf{w}\,(r\rho\,\sin\alpha_1 + h\,\sin\alpha_2)$$

$$\frac{\mu_B-\mu_\mathbf{BC}}{\mathbf{T_C}} = \mathbf{w}\,(-r\rho\,\cos\alpha_1 - h\,\cos\alpha_2)$$



For a given choice of μ_c, a range of α_1 allowed, larger uncertainty at large μ

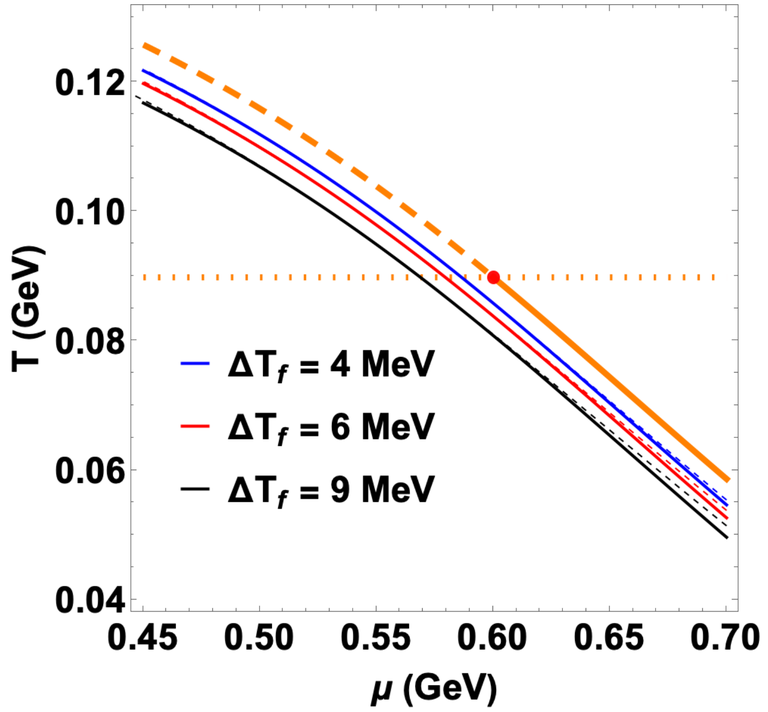
J.M. Karthein, V. Koch, C. Ratti, PRD (2025)

Quantifying Fluctuation Signatures

- Make a choice of the location informed by recent model predictions and study the uncertainty in the position of freeze-out in the fluctuation observables

$\mu_c = 600\,\mathrm{MeV}$

$\alpha_1 = 16.6^o, T_c = 89\,\mathrm{MeV}$



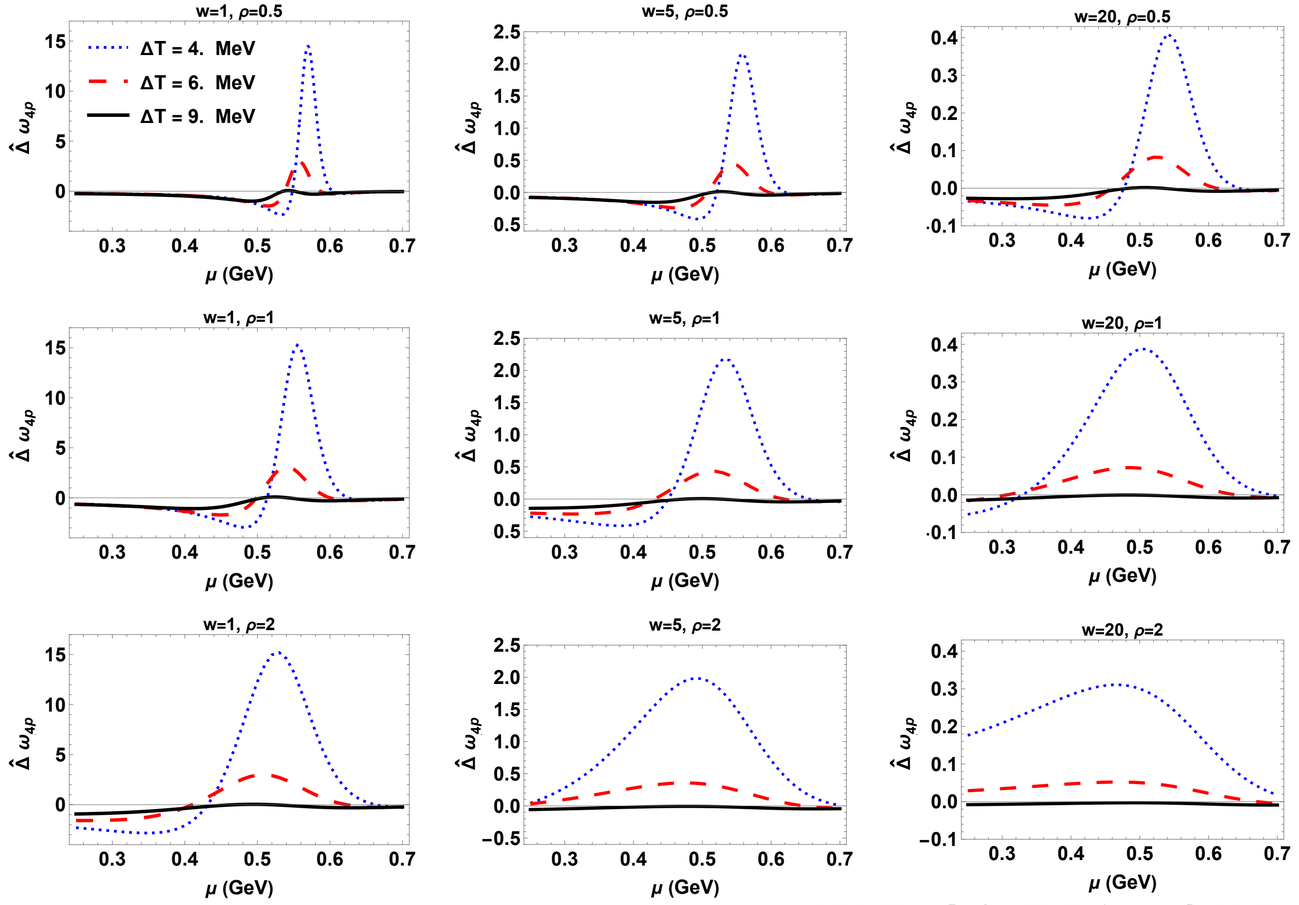
Normalized proton factorial cumulants:

$$\widehat{\Delta}\omega_{kp} = \frac{\widehat{\Delta} H_{a_1 \ldots a_k} P_p^{a_1} \ldots P_p^{a_k}}{\langle N_p \rangle} = \frac{\kappa_{4p}}{\kappa_{1p}}$$

J.M. Karthein, K. Rajagopal, M. Pradeep, M. Stephanov, Y. Yin, arXiv:2508.19237

Quantifying Fluctuation Signatures

- Utilize the maximum entropy freeze-out procedure to calculate proton fluctuations due to critical point & study the influence of the unknown EoS parameters



Increasing ρ increases peak width

J.M. Karthein, K. Rajagopal, M. Pradeep, M. Stephanov, Y. Yin, arXiv:2508.19237

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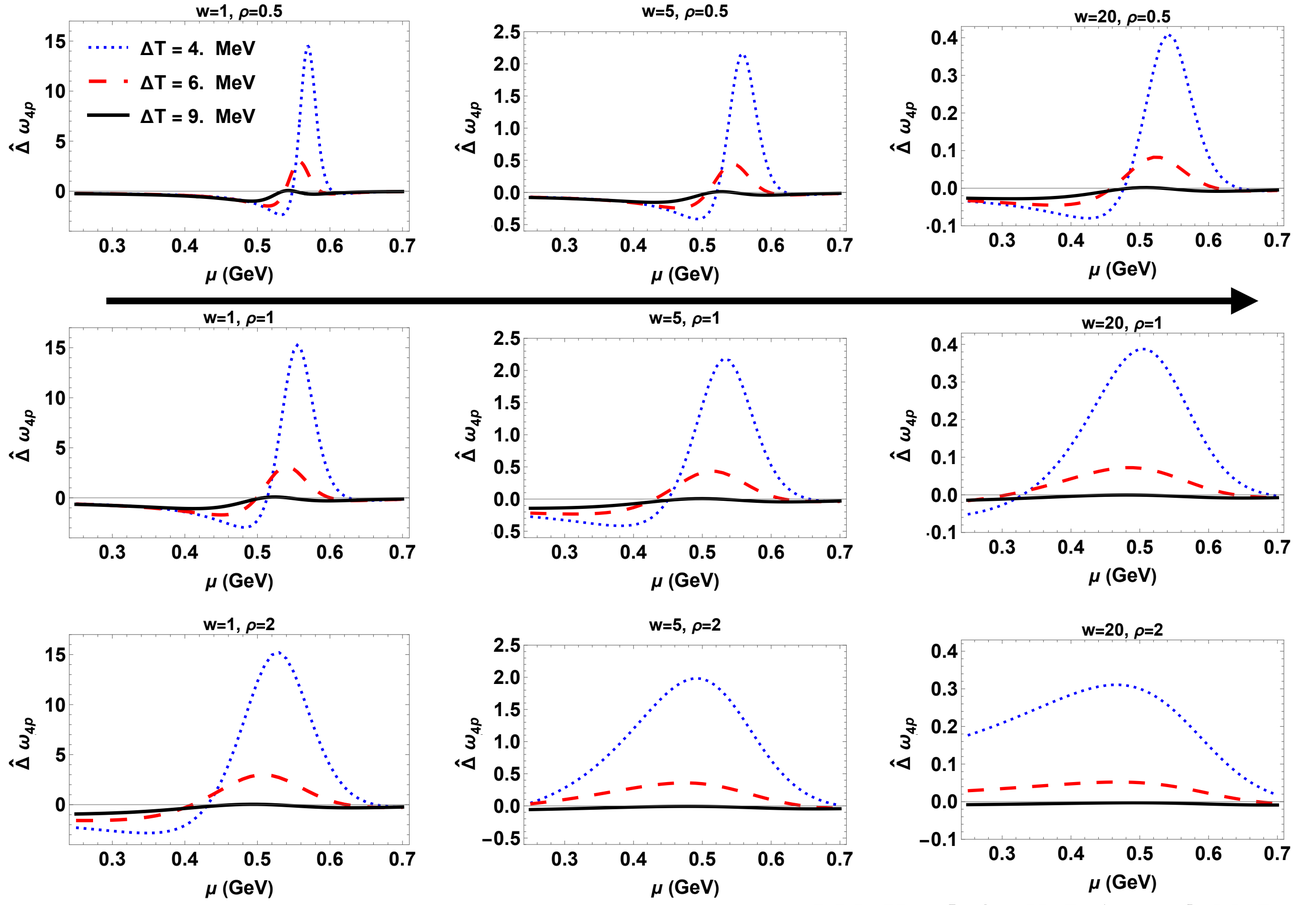

Increasing w reduces peak height

J.M. Karthein, K. Rajagopal, M. Pradeep, M. Stephanov, Y. Yin, arXiv:2508.19237