Chiral restoration and deconfinement in two-color QCD with two flavors of staggered quarks

David Scheffler, Philipp Scior, Christian Schmidt, Dominik Smith, Lorenz von Smekal

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- Introduction
- Observables
- Setting the temperature scale
- Magnetic scaling
- Summary and outlook

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HIC for FAIR

Helmholtz International Center

Motivation

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- two-color QCD as QCD-like theory where finite density is accessible
- preparations for finite density

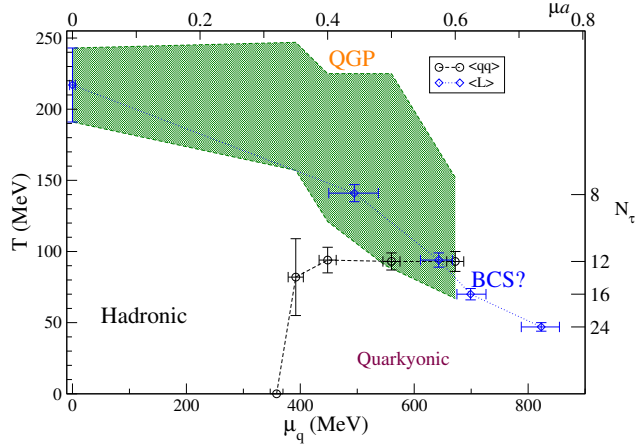
chiral properties

- scale setting
- scaling behavior

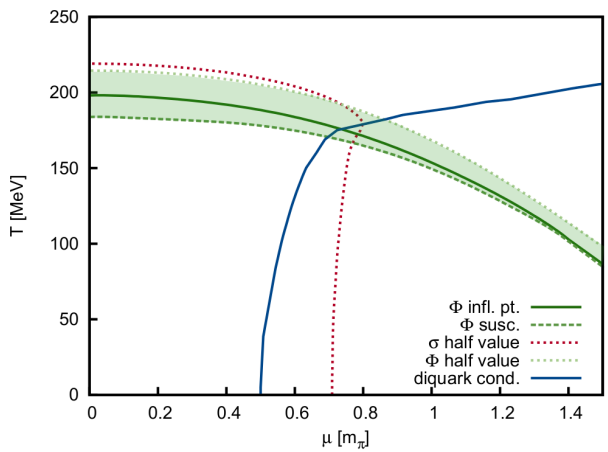
effective Polyakov loop potential

- influence of quarks
- compare to effective model descriptions

→ HK 42.6 Philipp Scior



Boz, Cotter, Fister, Mehta, Skullerud [1303.3223]



Strodthoff, von Smekal [1306.2897]

Simulation setup

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- $N_f = 2$ staggered quarks via RHMC
- $N_t = 4, 6, 8$ with aspect ratio $N_s/N_t = 4$
- finite temperature: vary coupling β
- several masses

symmetry breaking

- continuum: $SU(2N_f) \rightarrow Sp(N_f)$
- staggered: $SU(2N_f) \rightarrow O(2N_f)$, here: $SU(4) \simeq O(6) \rightarrow O(4)$

Order parameters

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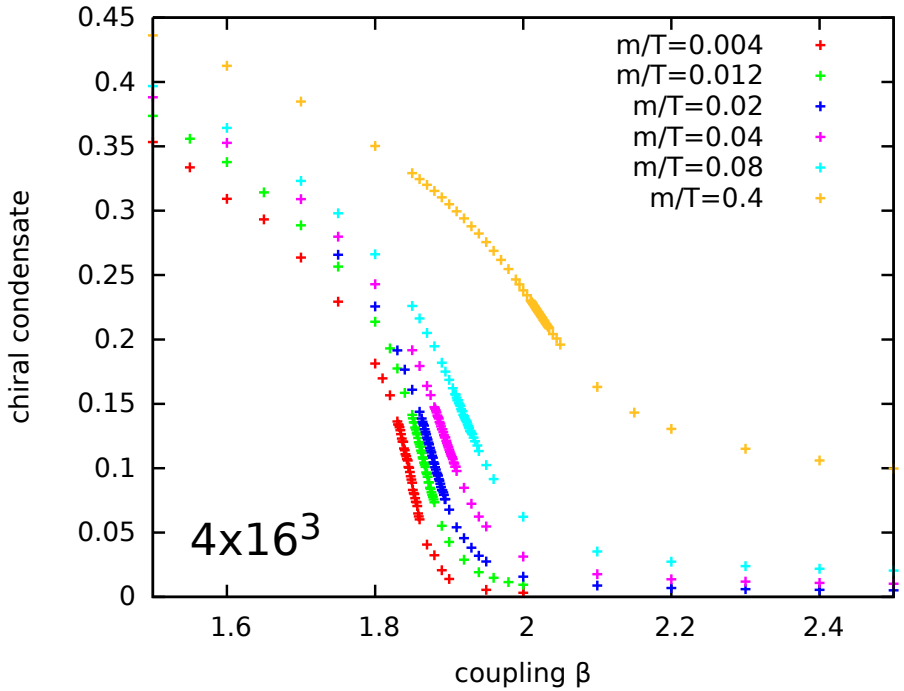

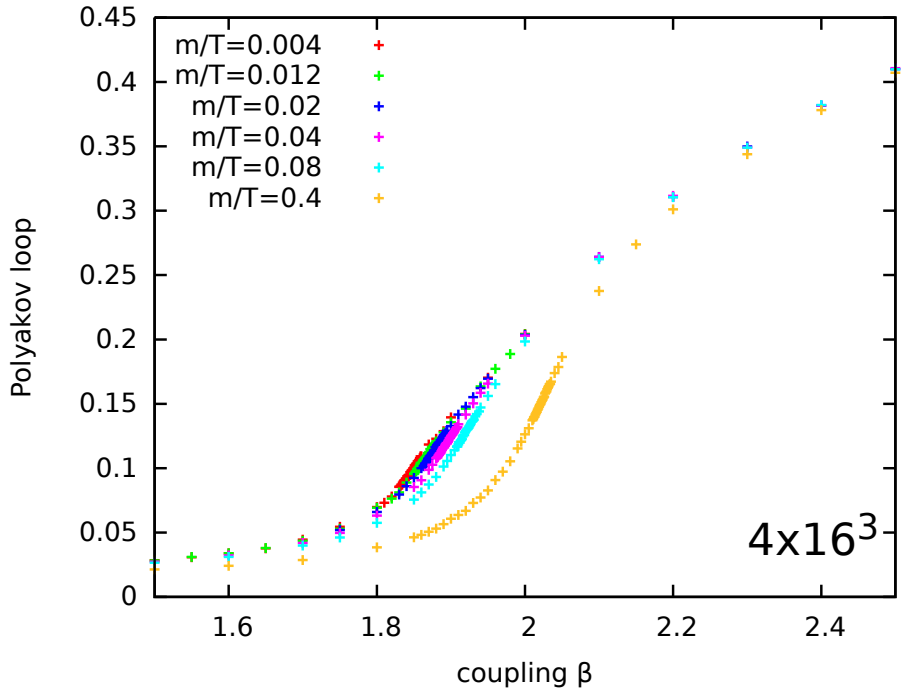

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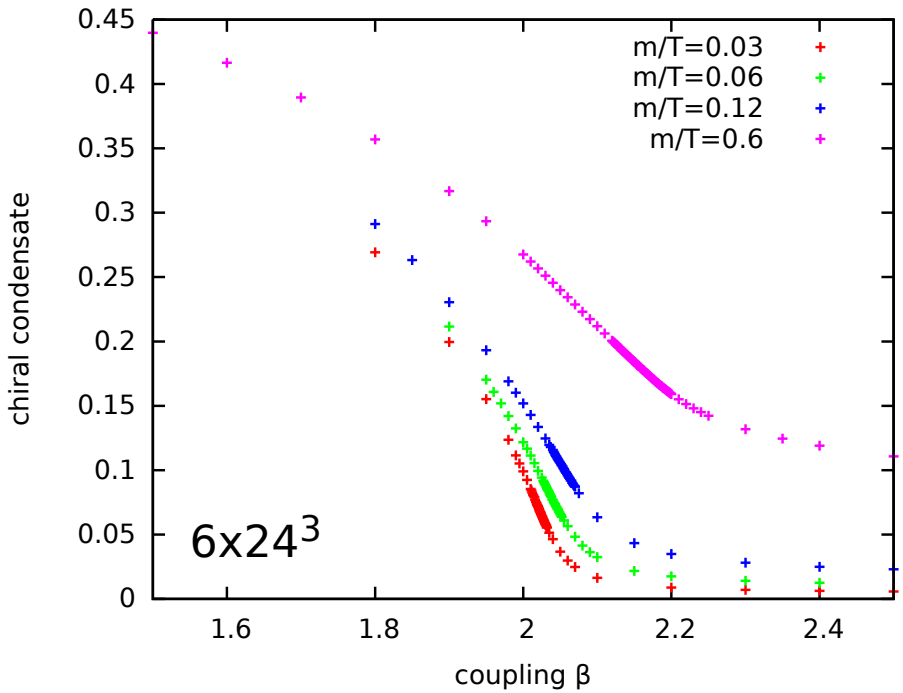

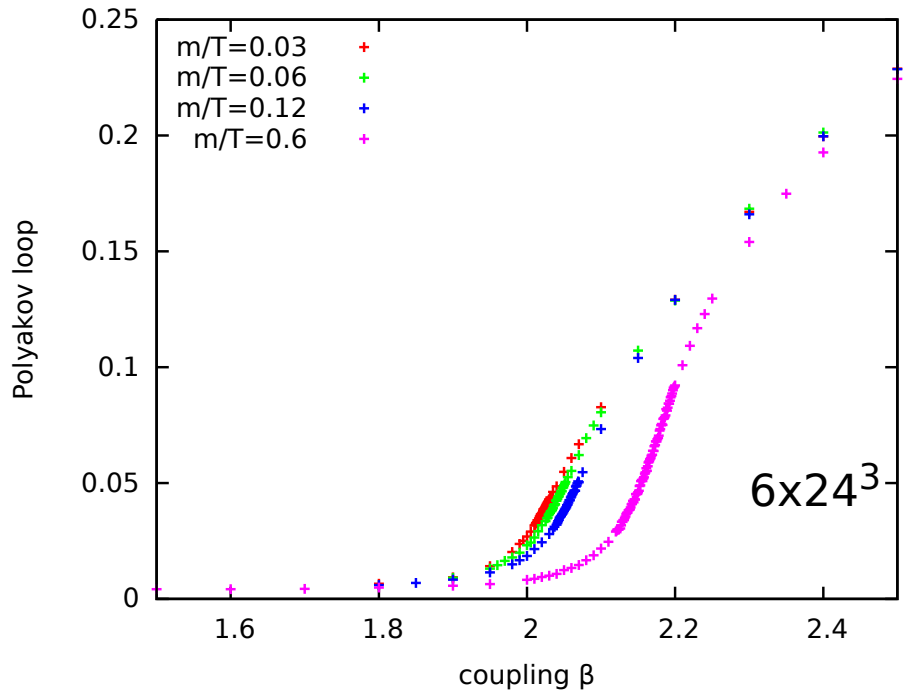

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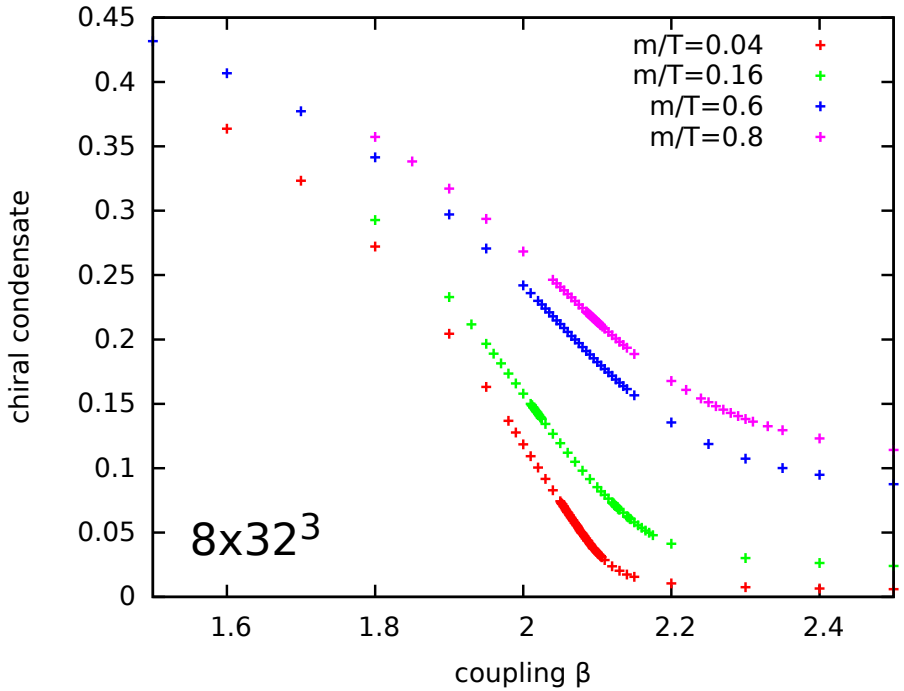

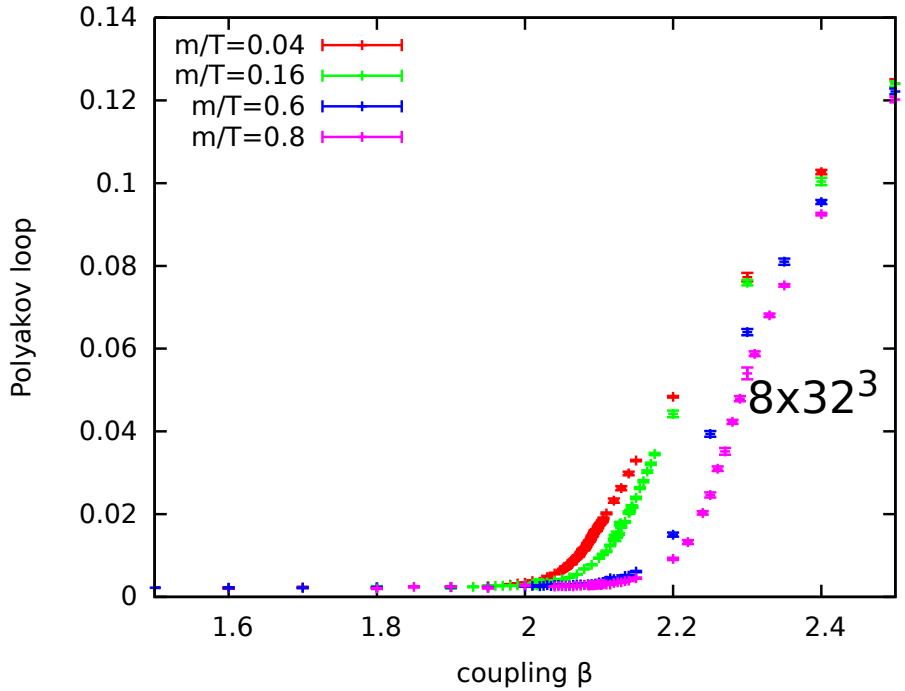

Chiral susceptibilities

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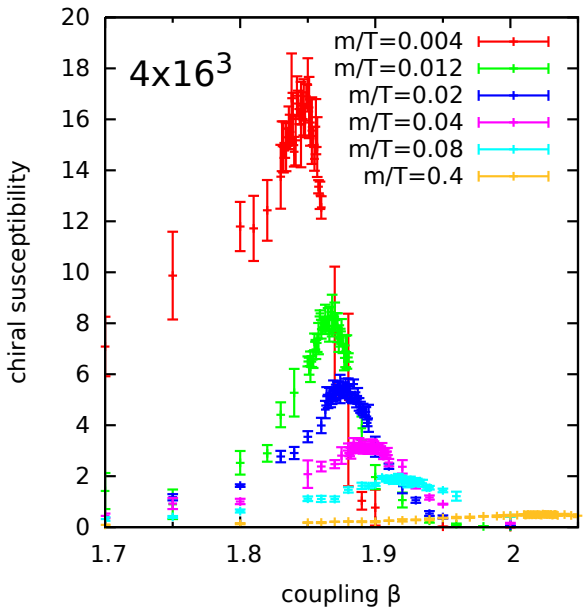

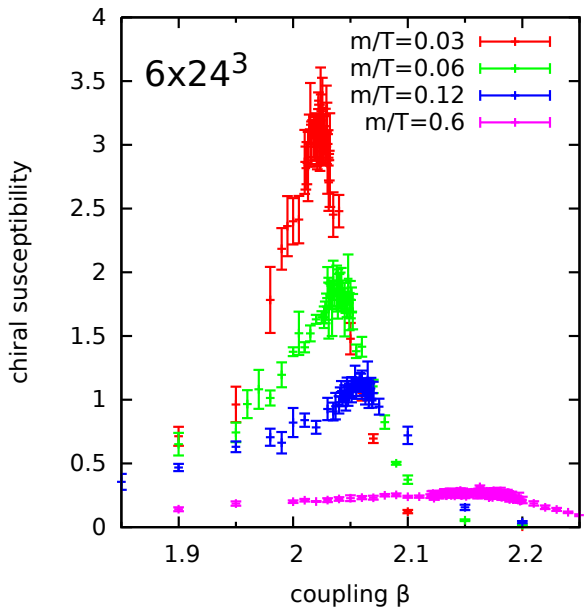

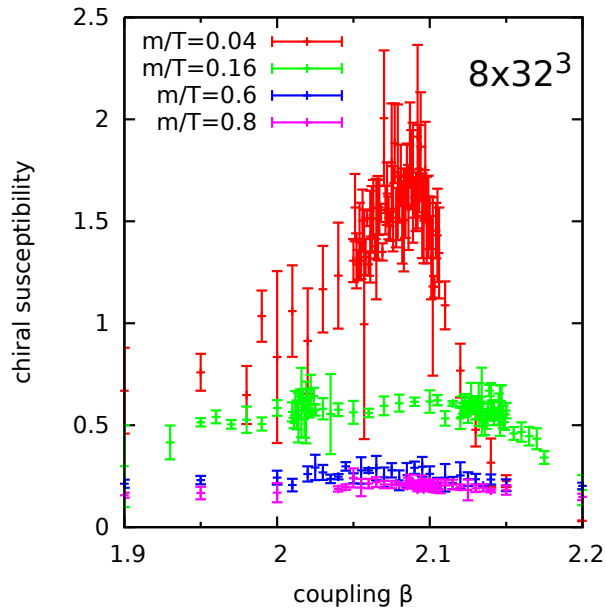

Runtime

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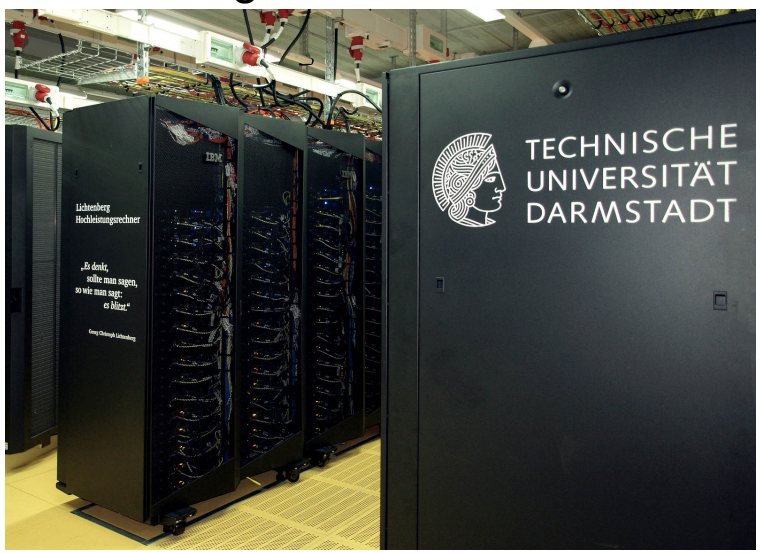
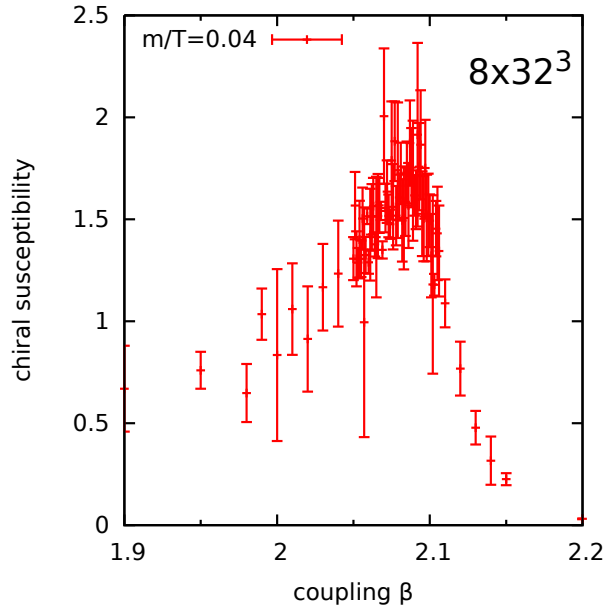
$N_t = 8, N_s = 32, m/T = 0.04$ data:

- approx. runtime: 80 GPU months
- using NVIDIA® Tesla™ K20X
- Lichtenberg-Cluster @ TU Darmstadt





Ferrenberg-Swendsen reweighting
Example: $N_t = 4$

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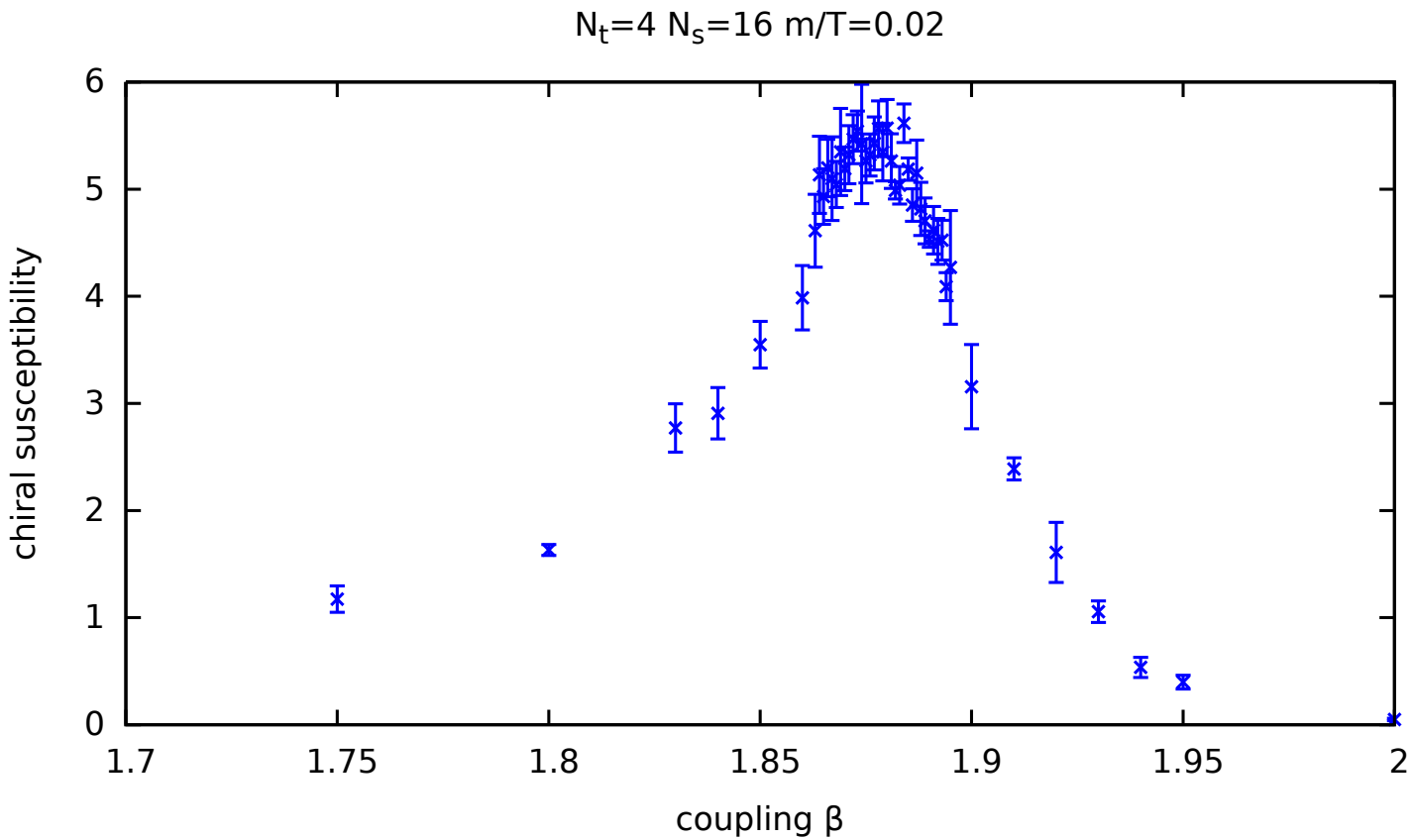

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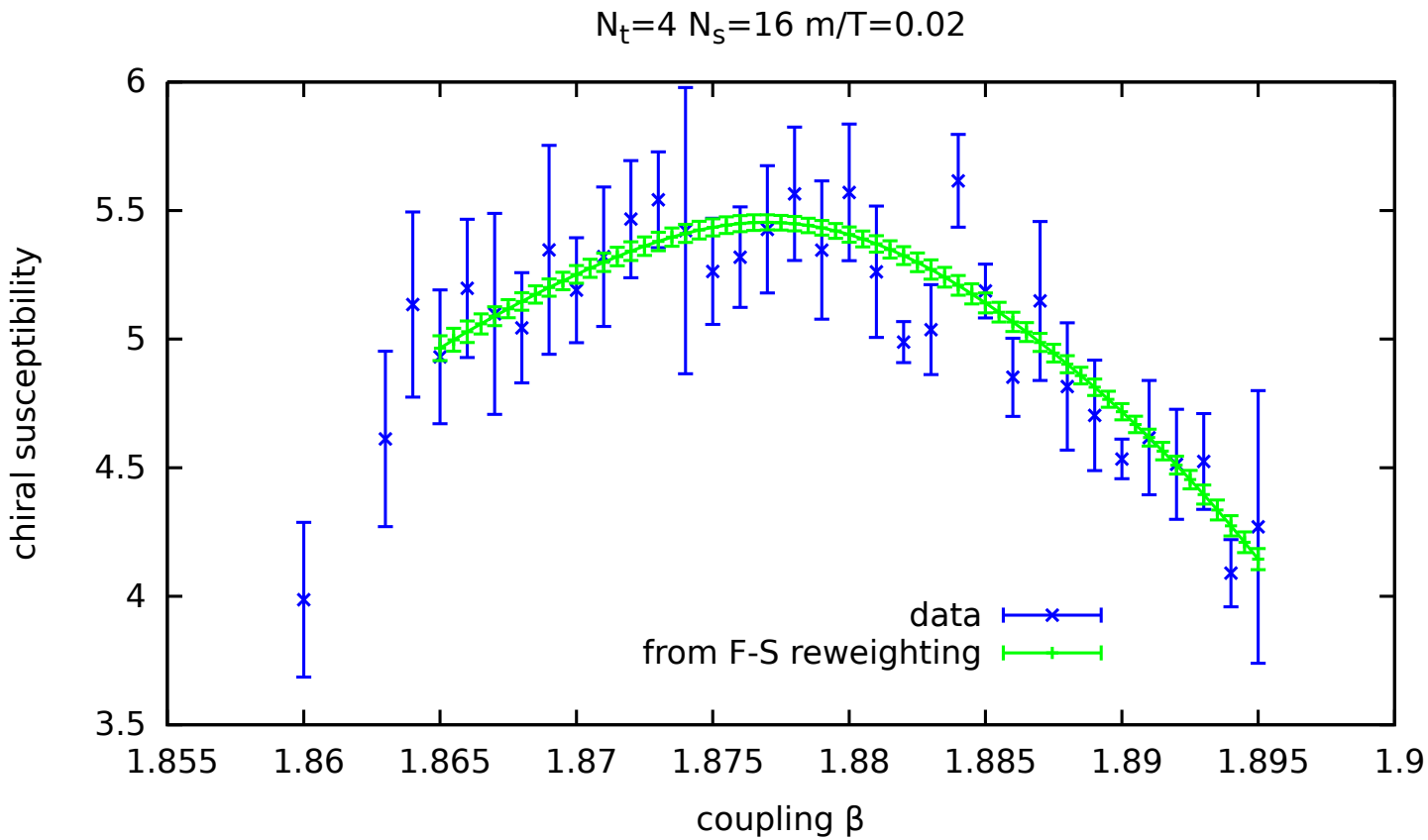

Ferrenberg-Swendsen reweighting
Example: $N_t = 6$

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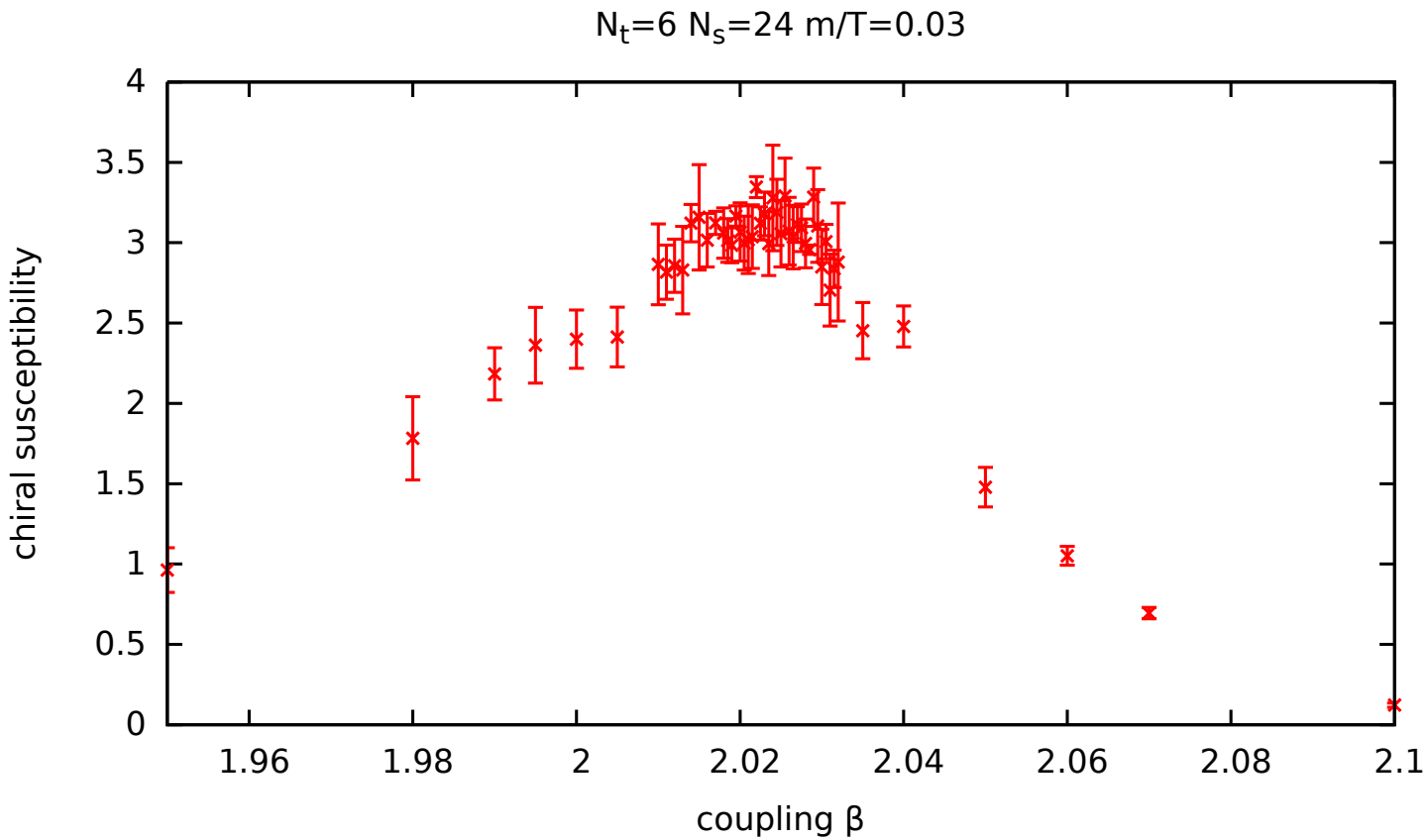

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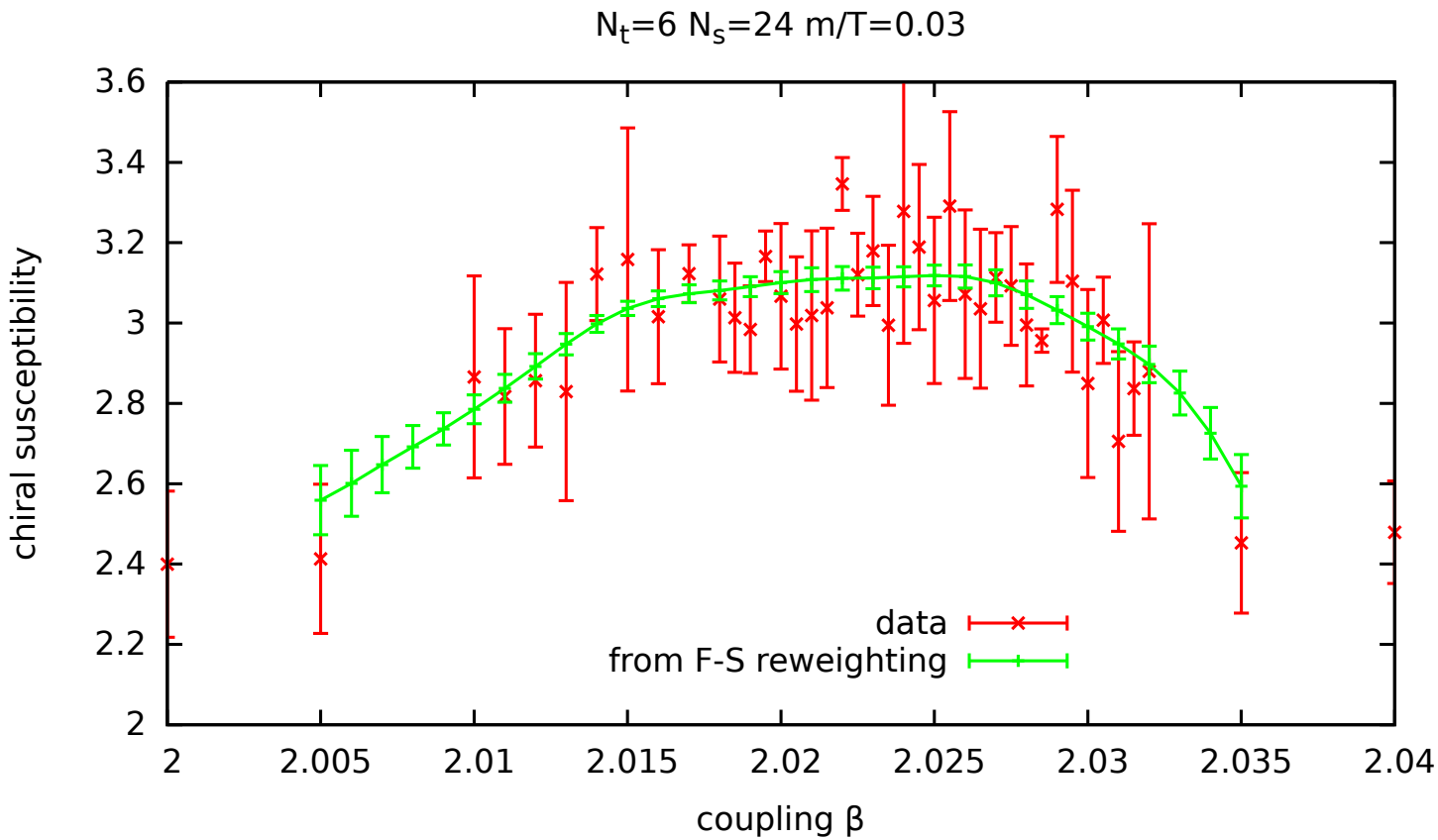

Ferrenberg-Swendsen reweighting
Example: $N_t = 8$

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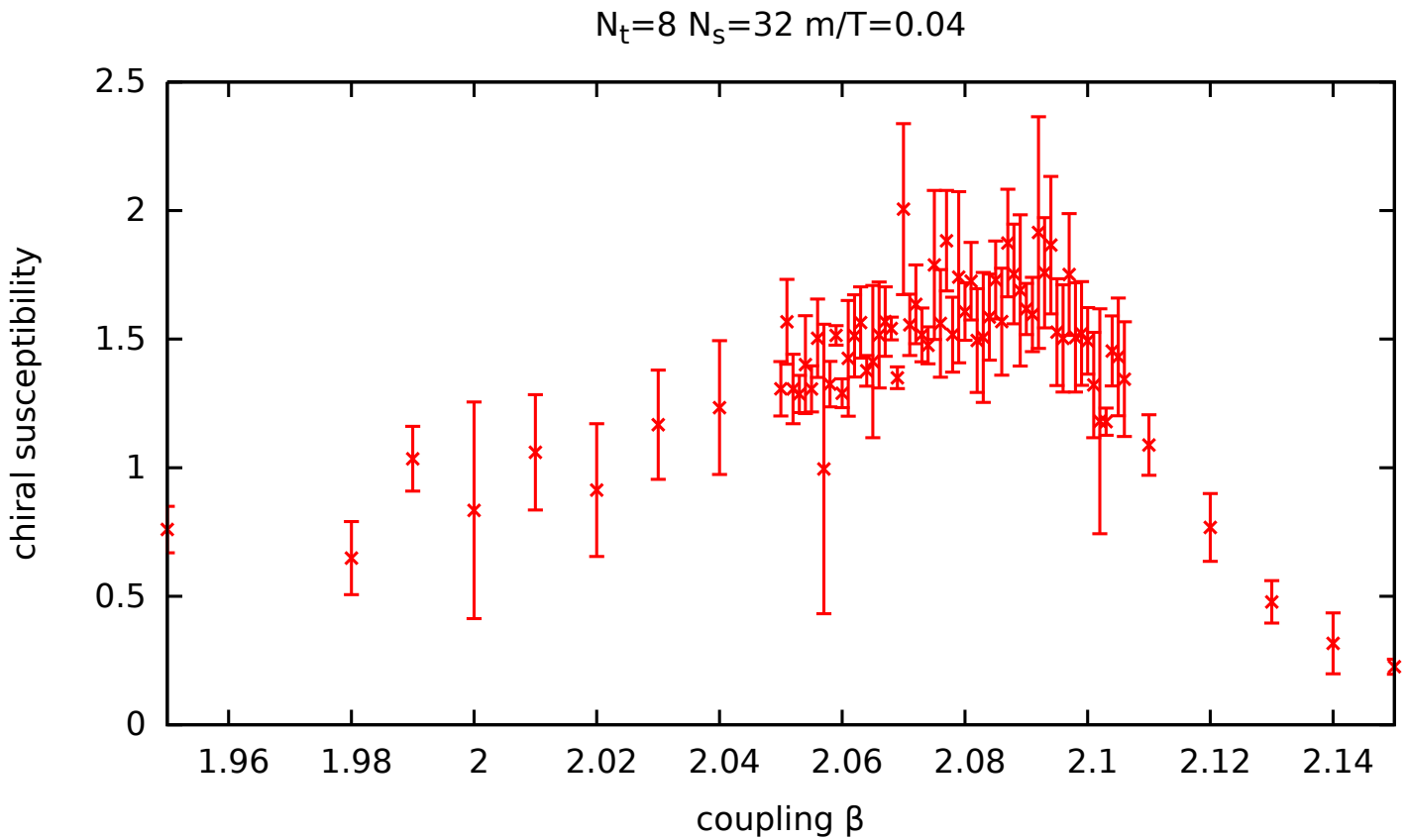

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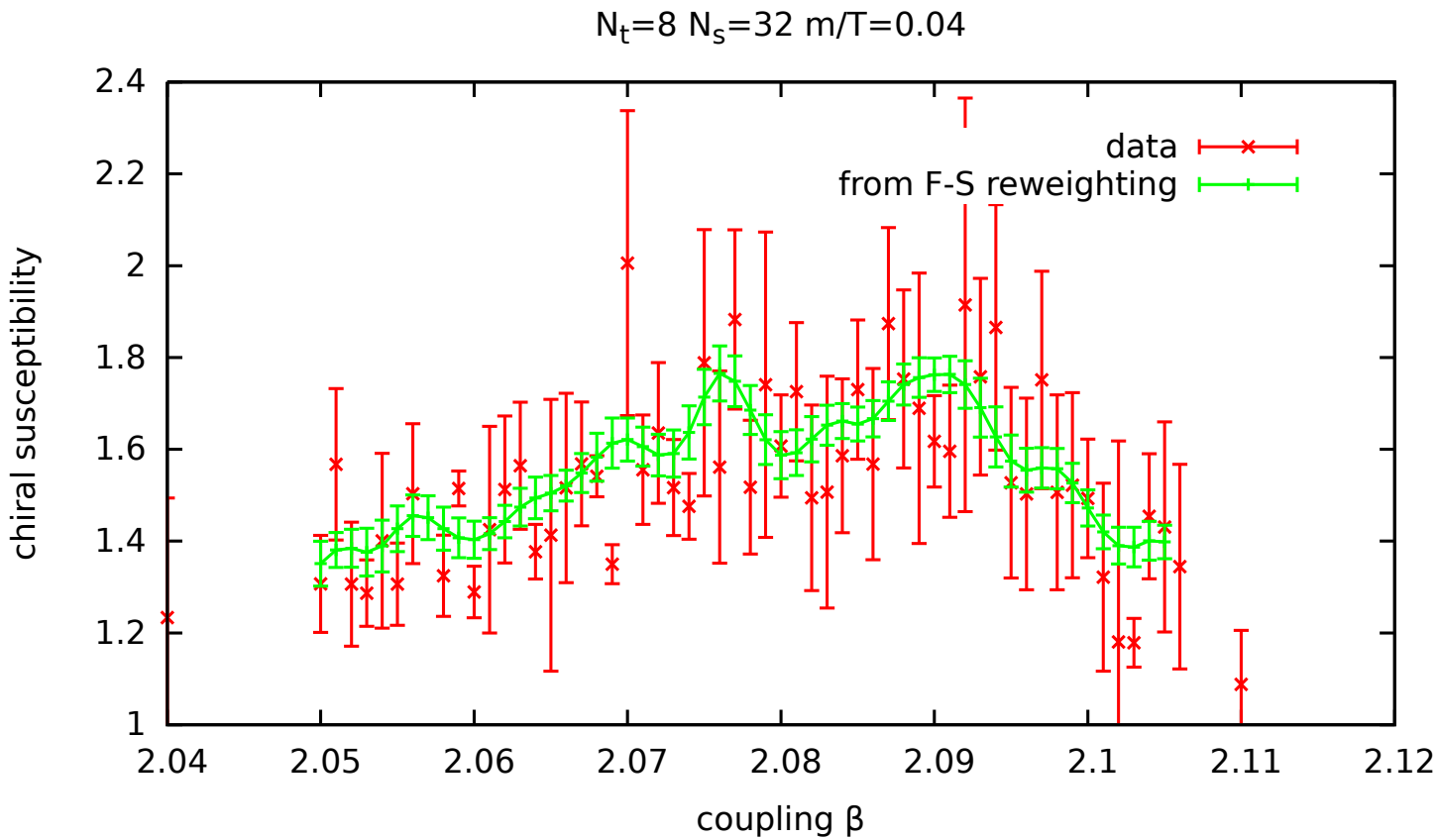

Temperature scale

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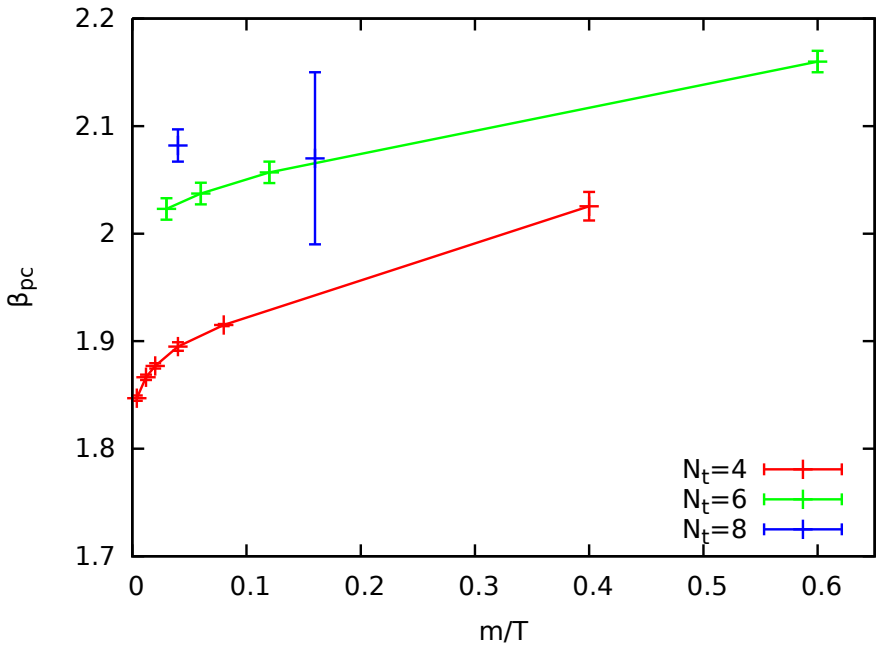

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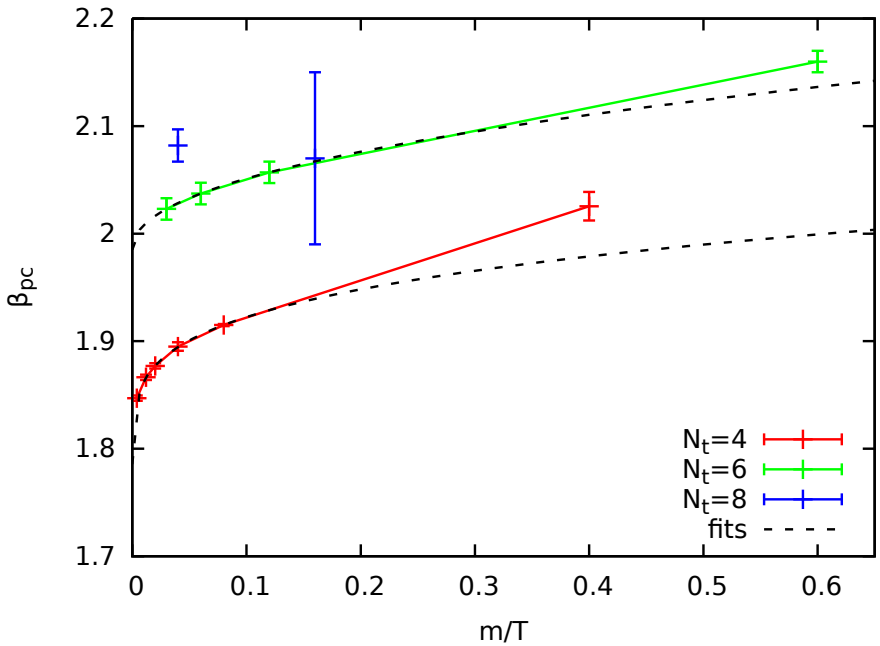

chiral extrapolation

$$\beta_{pc}(m, N_t) = \beta_c(N_t) + b \cdot am^c$$

Temperature scale

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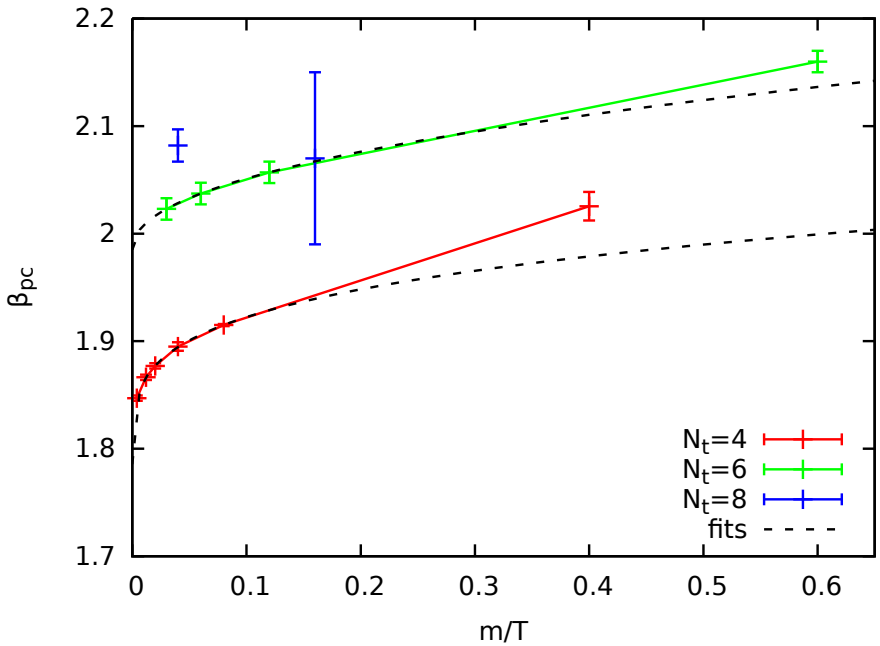

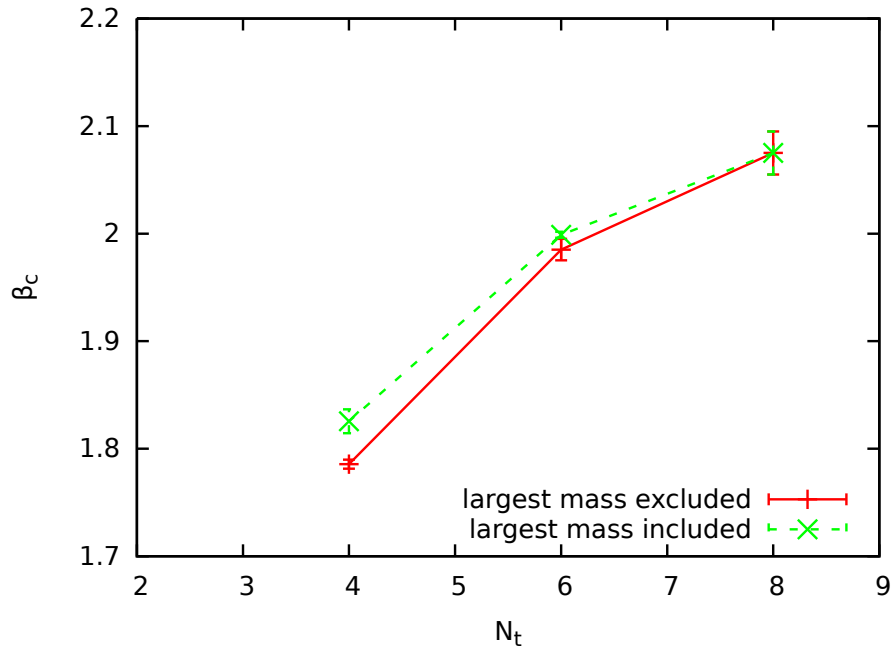

chiral extrapolation

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Temperature scale

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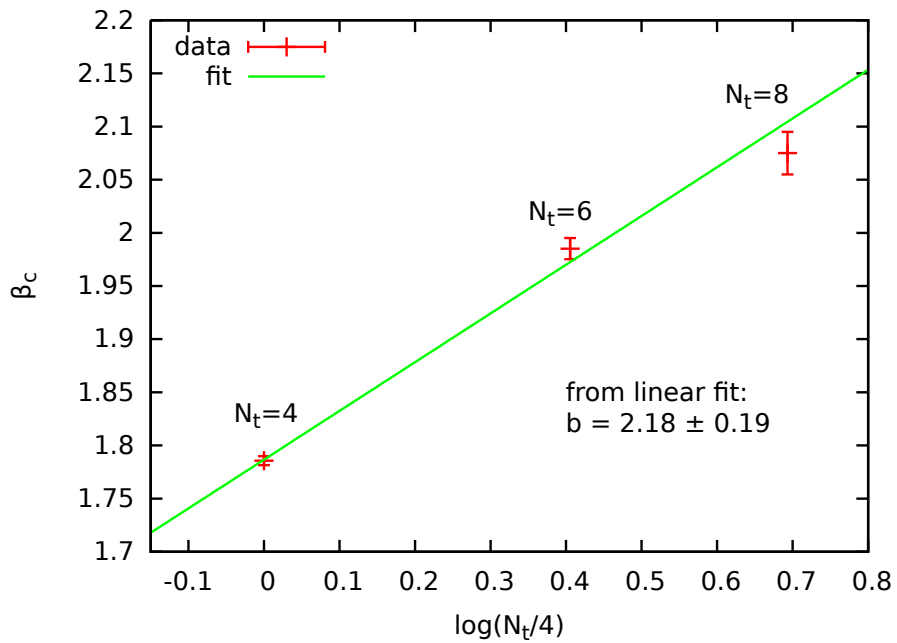
leading scaling behavior: $$\frac{T}{T_c} = \exp\{b(\beta - \beta_c)\}$$



- similar analysis using deconfinement transition in pure SU(2)(Smith et al. [1307.6339])

magnetic scaling

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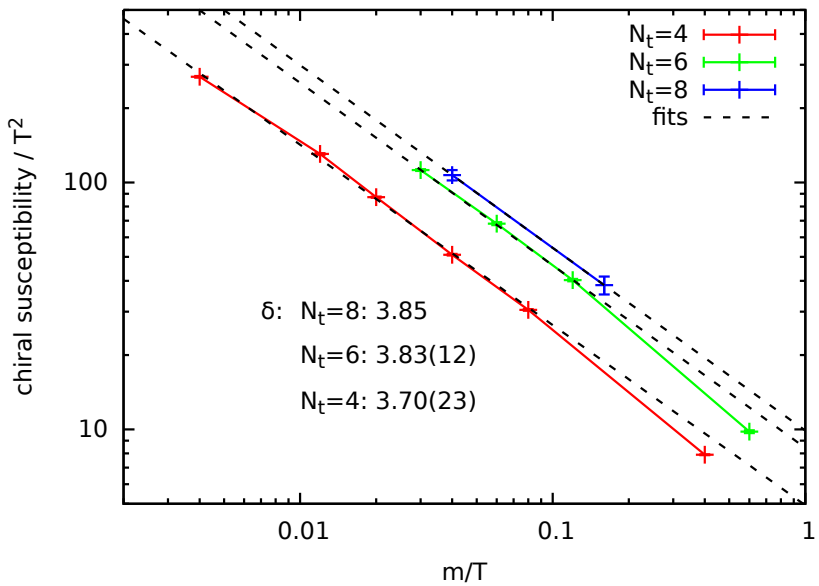
peak height: $\chi_{max} \sim m^{1/\delta - 1}$



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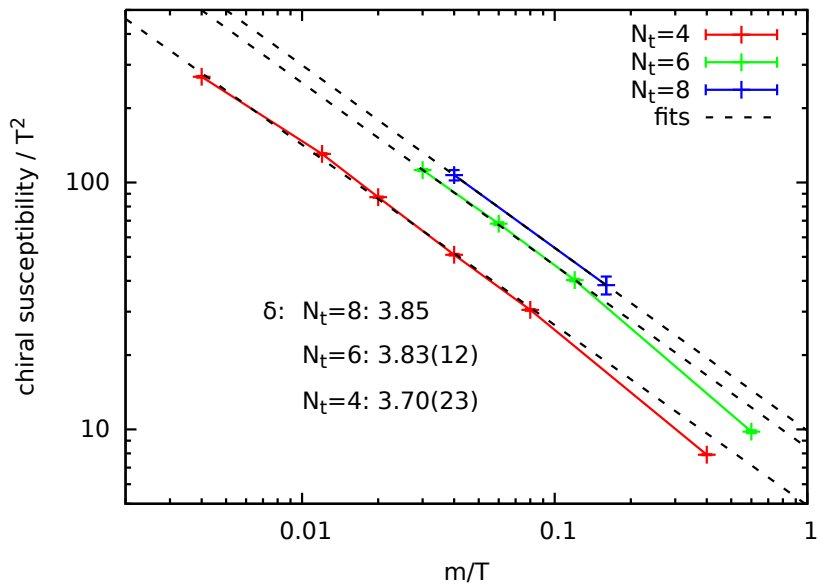

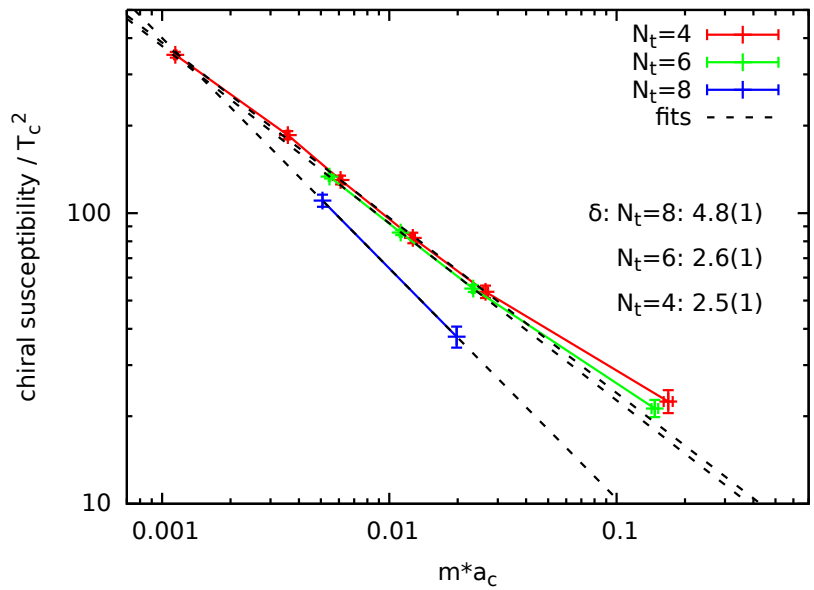

Summary and outlook

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Summary

- first steps towards scale setting and determination of critical exponents
- successful use of Ferrenberg-Swendsen reweighting for $N_f = 4$ and $N_f = 6$

Outlook

- chiral properties need more work, especially at $N_t = 8$
- lines of constant physics
- finite density

see HK 42.6

- effective Polyakov loop potentials, Polyakov loop correlators, ...
- in comparison to pure gauge simulations and effective theories