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

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

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Helmholtz International Center

Motivation

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

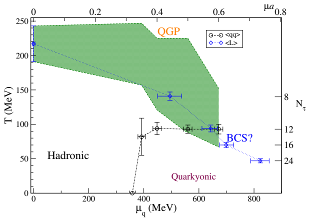
chiral properties

- scale setting
- scaling behavior

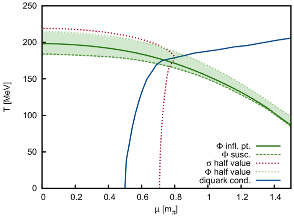
effective Polyakov loop potential

- influence of quarks
- compare to effective model descriptions

→ next talk by Philipp Scior



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



Strodthoff, von Smekal [1306.2897]

Simulation setup

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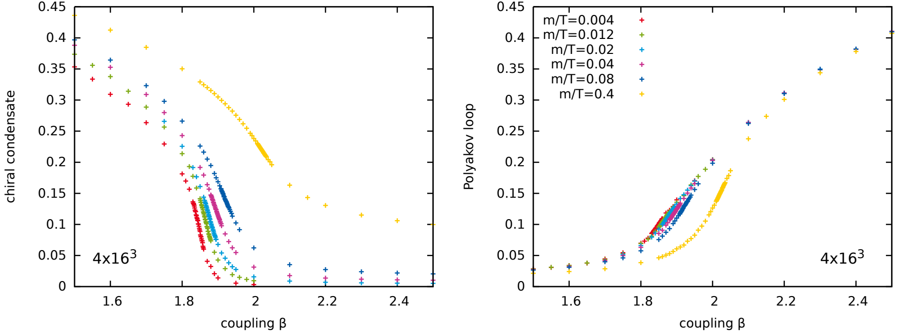
- $N_c = 2$ Wilson gauge action
- $N_f = 2$ staggered quarks via RHMC
- $N_t = 4, 6, 8$ with aspect ratio $N_s/N_t = 4$
- finite temperature: vary coupling β
- several masses

symmetry breaking

- continuum: $\mathrm{SU}(2N_f) \to \mathrm{Sp}(N_f)$
- staggered: $\mathrm{SU}(2N_f) \to \mathrm{O}(2N_f)$, here: $\mathrm{SU}(4) \simeq \mathrm{O}(6) \to \mathrm{O}(4)$

Order parameters



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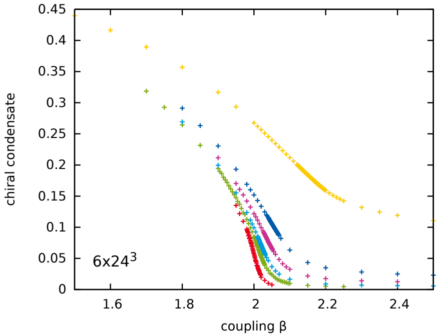

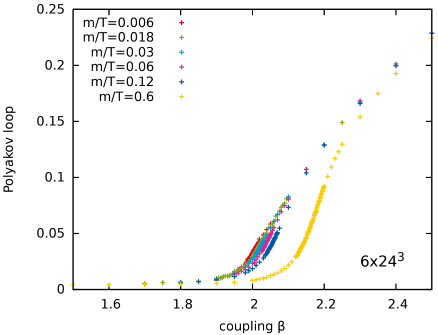

Order parameters

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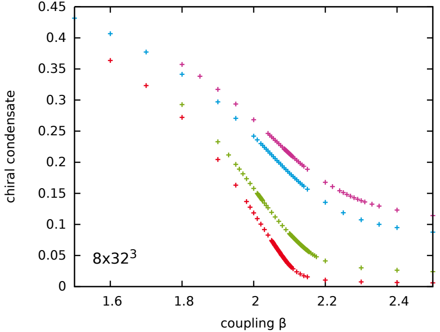
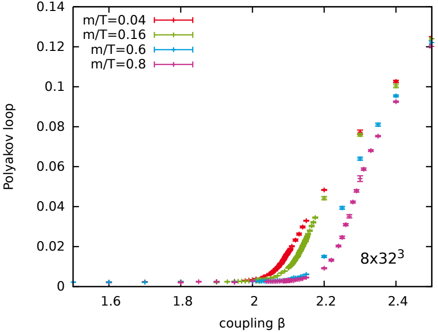
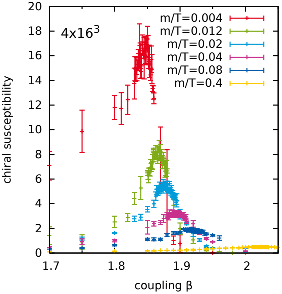
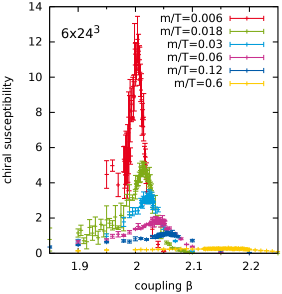
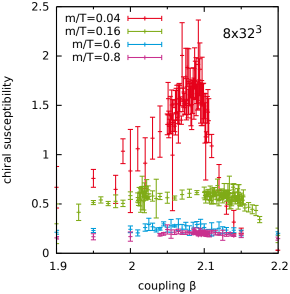




Chiral susceptibilities







Runtime

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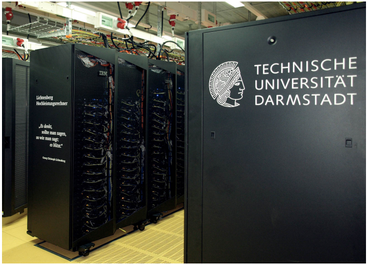
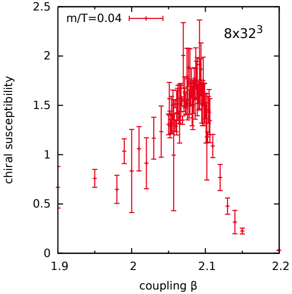
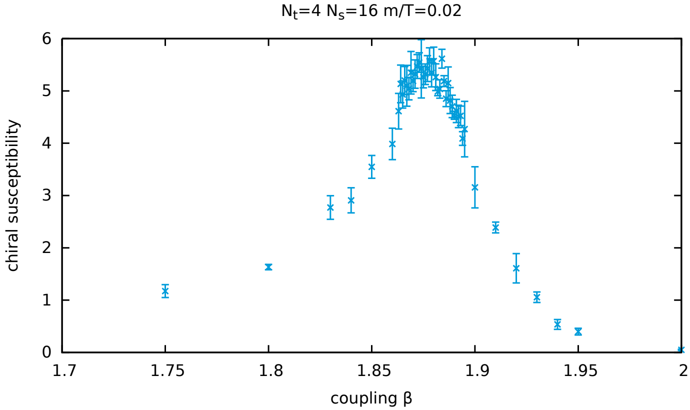
$N_t = 8, N_s = 32, m/T = 0.04$ data:

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

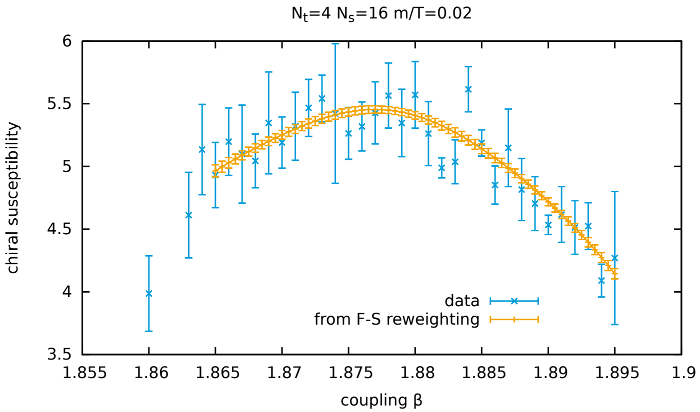




Ferrenberg-Swendsen reweighting
Example: $N_t = 4$



Ferrenberg-Swendsen reweighting
Example: $N_t = 4$



Ferrenberg-Swendsen reweighting
Example: $N_t = 6$

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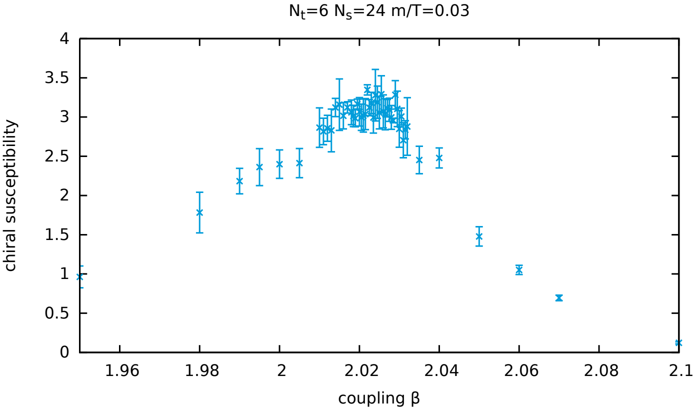

Ferrenberg-Swendsen reweighting
Example: $N_t = 6$

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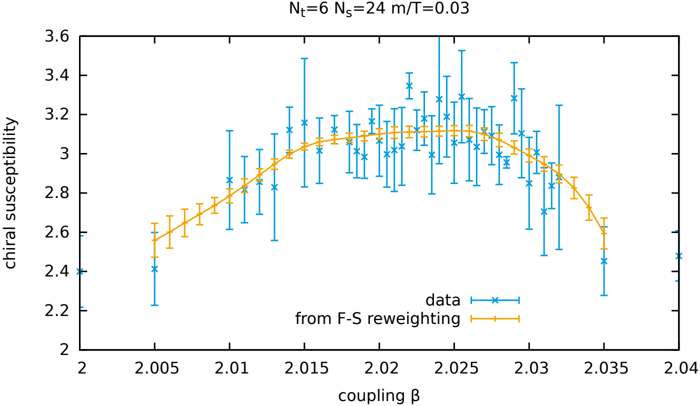
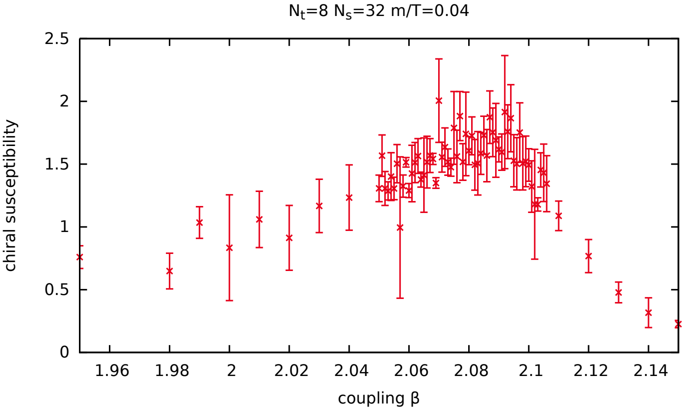
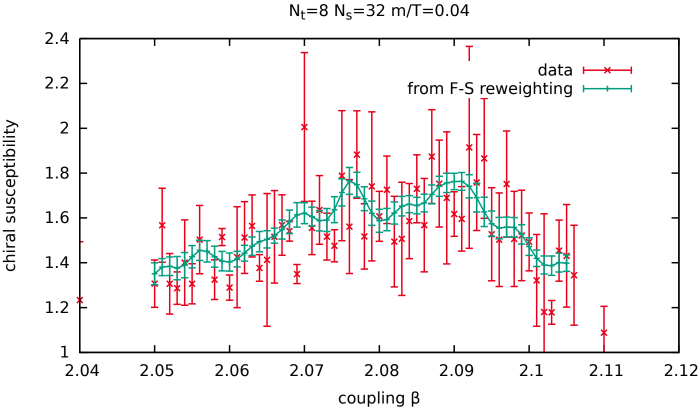


Ferrenberg-Swendsen reweighting
Example: $N_t = 8$



Ferrenberg-Swendsen reweighting
Example: $N_t = 8$



Pseudo-critical line

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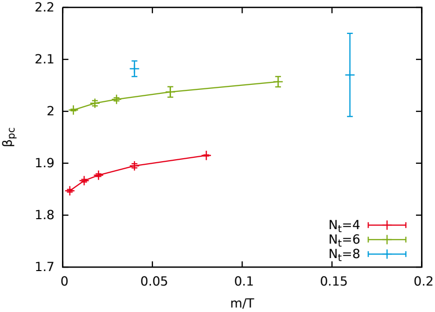

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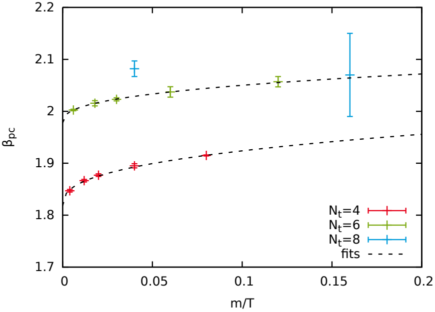
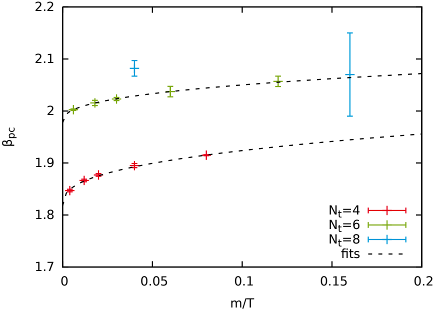


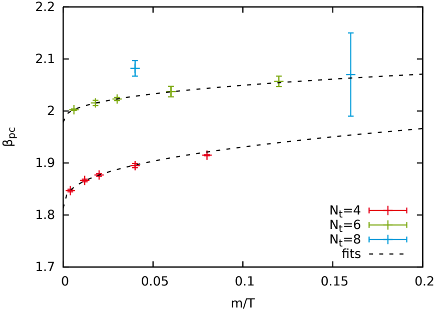
chiral extrapolation

$$\beta_{pc}(m, N_t) = \beta_c(N_t) + d \cdot \left(\frac{m}{T}\right)^c$$

with $c = \frac{1}{\beta\delta} = 0.38$ from Basile et al. JHEP02(2005)044

Pseudo-critical line





chiral extrapolation

$$\beta_{pc}(m, N_t) = \beta_c(N_t) + d \cdot \left(\frac{m}{T}\right)^c$$

N_t	β_c (all)	β_c (without largest)
4	1.818(2)	1.813(2)
6	1.9776(5)	1.9780(3)

with $c = \frac{1}{\beta\delta} = 0.38$ from Basile et al. JHEP02(2005)044

Temperature scale

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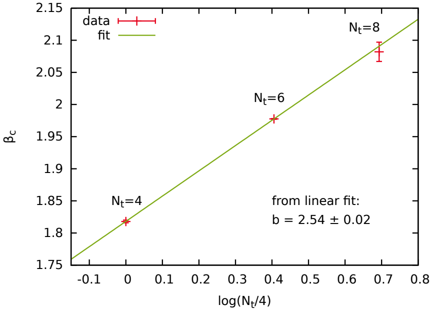
leading scaling behavior: $$\frac{T}{T_c} = \exp\{b(\beta - \beta_c)\}$$



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

Critical exponents

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$$M_{h=0,t\to 0} \sim |t|^{\beta}$$
$$\chi_{h=0,t\to 0} \sim |t|^{-\gamma}$$
$$M_{t=0,h\to 0} \sim |h|^{1/\delta}$$

with reduced temperature $t = \frac{T - T_c}{T_c}$, external symmetry breaking field $h = \frac{H}{H_0}$

pseudo-critical line:

$$t_{\text{peak}} \sim h^{1/\delta\beta}$$

$$\chi_{\text{peak}} \sim t_{\text{peak}}^{-\gamma} \sim h^{1/\delta - 1}$$

magnetic scaling

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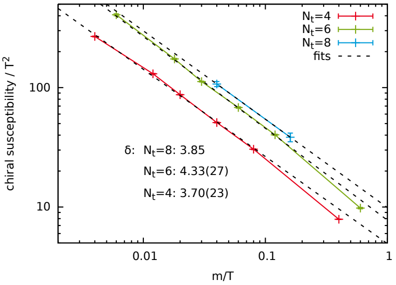
peak height: $\chi_{\text{peak}} \sim m^{1/\delta - 1}$



magnetic scaling

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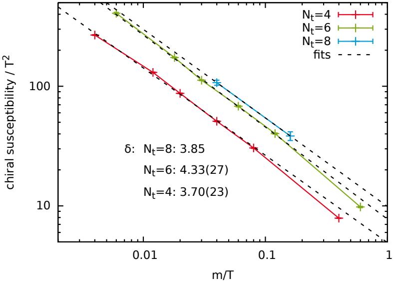

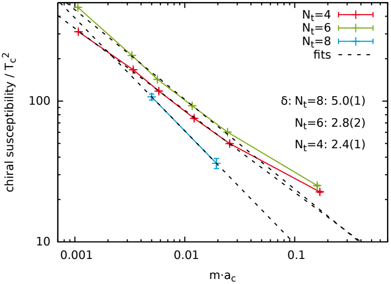

Summary and outlook

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Summary

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

Outlook

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

see next talk

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