SU(2) Adjoint MWT in the chirally rotated Schrödinger functional scheme

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in coll. with: R. Arthur, L. Del Debbio, B. Lucini, A. Patella, A. Rago, S. Sint, P. Vilaseca

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Outline

- Chirally rotated SF scheme
- Preliminary results for the coupling
- Outlook

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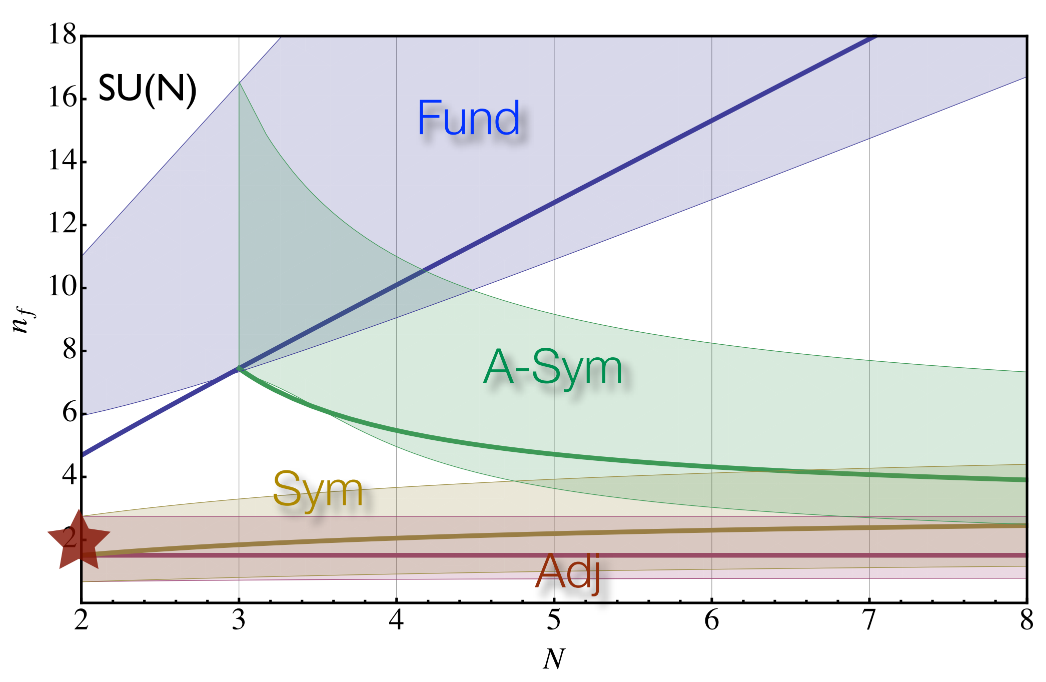
SU(2) Adj Minimal Walking Technicolor

$SU(2)_{TC}$ + 2 Dirac Adjoint fermions

- close/inside the conformal window by analytic estimates



- minimum value of the naïve S-parameter: $S = \frac{N_D d_R}{6\pi}$
- expected SB pattern: $SU(4) \to SO(4)$ $\Rightarrow$ 3+6 GBs
- glue-fermion composite states

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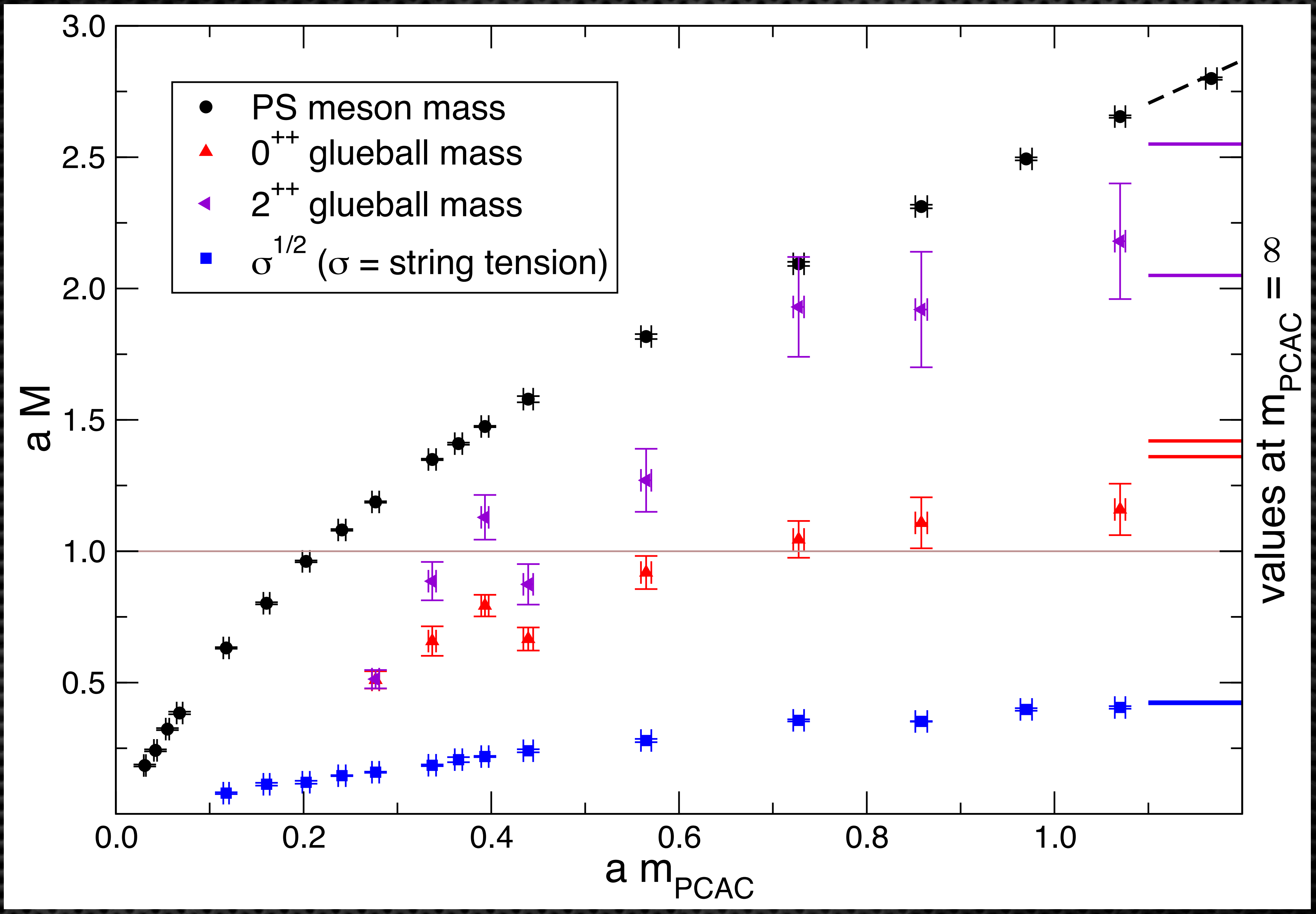
MWT Spectrum



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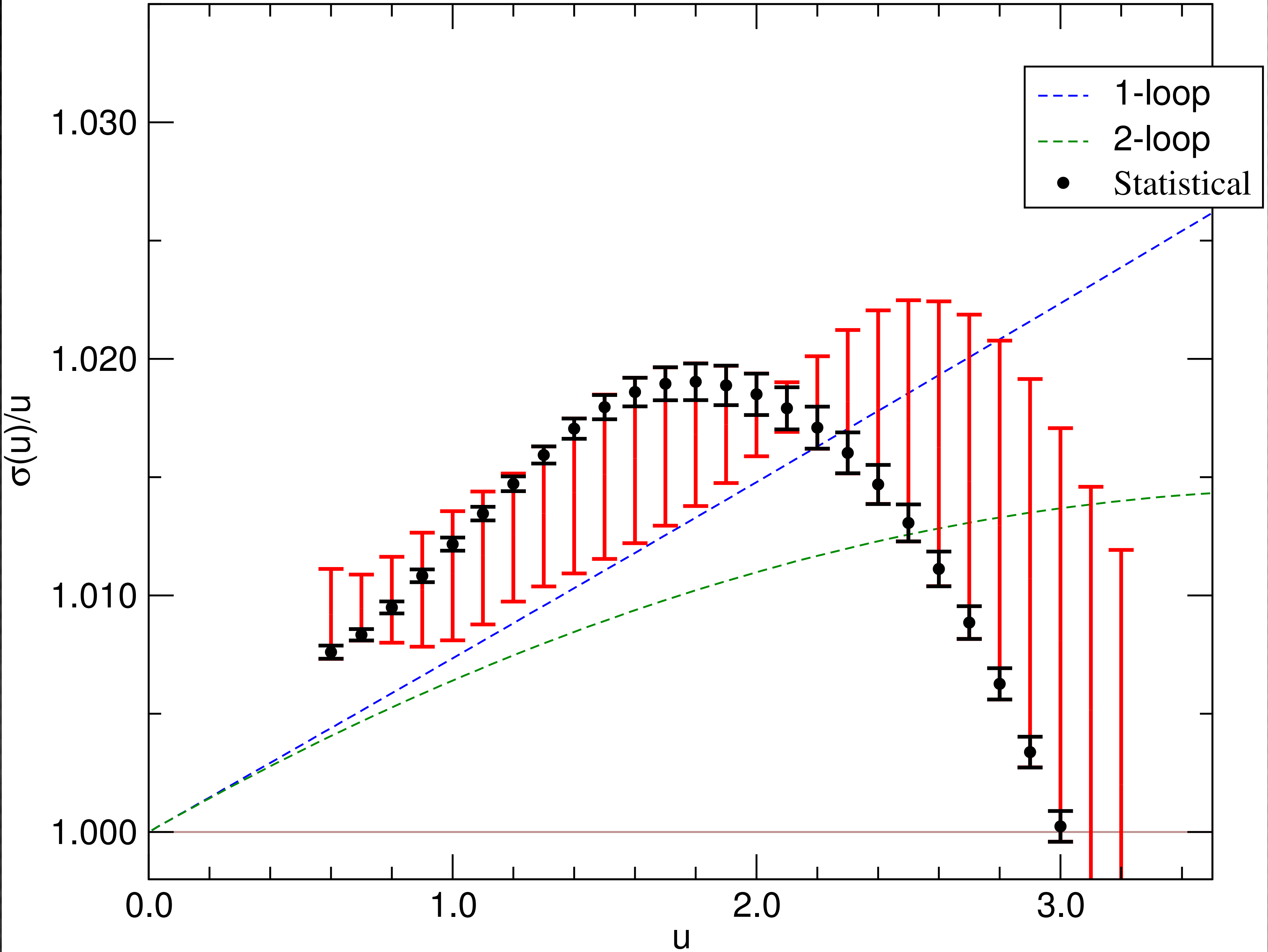
Schrödinger Functional coupling



F. Bursa, L. Del Debbio, L. Keegan, CP, T. Pickup, Phys.Rev. D81 (2010) 014505

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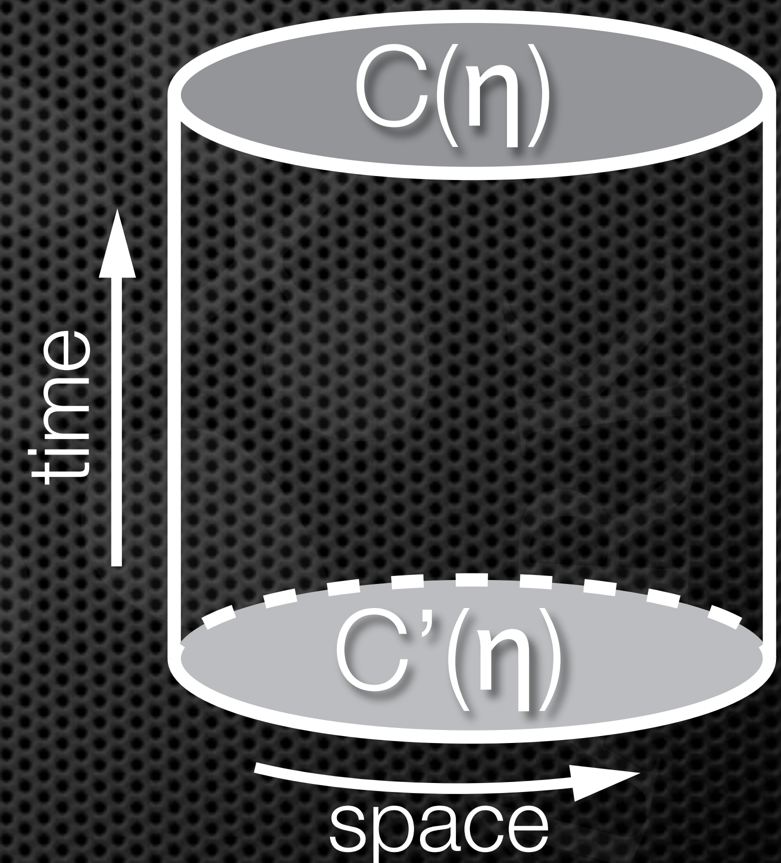
Chirally rotated Schrödinger Functional

S. Sint, PoS LAT2005 (2006) 235
S. Sint,   Nucl. Phys. B847 (2011) 491-531
S. Sint & P. Vilaseca, PoS LATTICE2011 (2011) 091
S. Sint & P. Vilaseca, PoS LATTICE2012 (2012) 031

χSF

We consider the functional integral on a hypercylinder with periodic spacial B.B. and Dirichlet B.C. in time with boundary fields C(η) and C'(η):

$$Z[\eta] = e^{-\Gamma[\eta]} = \int_{\eta} DU D\psi D\bar{\psi} e^{-S[U,\psi,\bar{\psi}]}$$



For SU(2) we use:

$$C: \quad U_k(t=0) = \exp[-i\phi\tau^3/L]$$

$$C': \quad U'_k(t=0) = \exp[-i\phi'\tau^3/L]$$

with

$$\phi = \eta \quad ; \quad \phi' = \pi - \eta$$

We use HALF background field configurations with:

$$\phi_{HB} = \phi/2 \quad ; \quad \phi'_{HB} = \phi'/2$$

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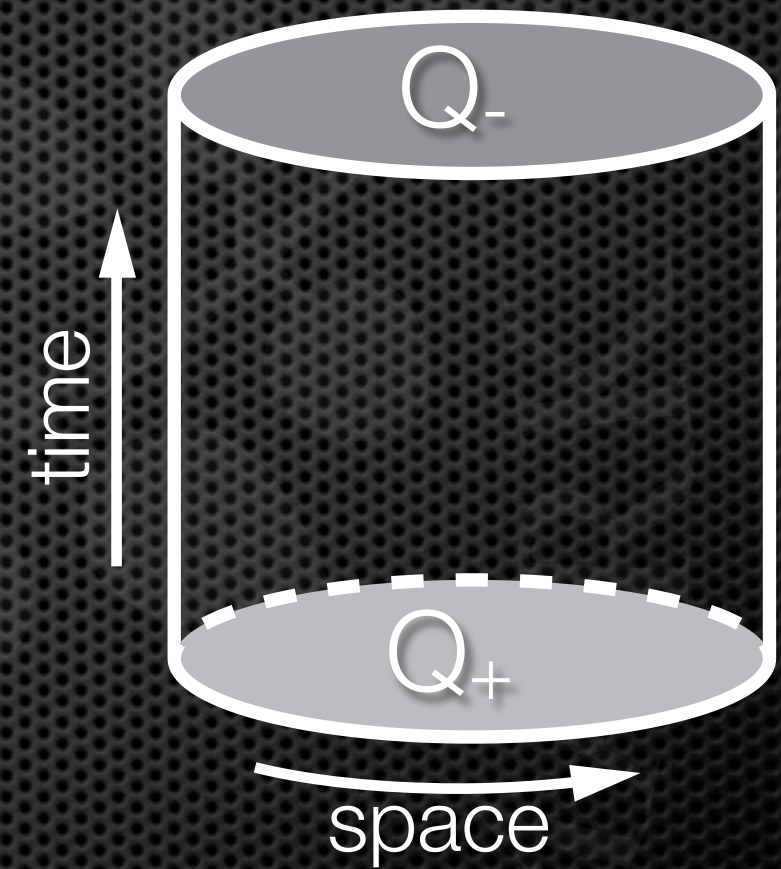
For the fermions B.C. we have for Nf=2:

$$\tilde{Q}_+ \Psi(t=0) = 0 = \tilde{Q}_- \Psi(t=L)$$

$$\overline{\Psi}(t=0)\tilde{Q}_+ = 0 = \overline{\Psi}(t=L)\tilde{Q}_-$$

with:

$$\tilde{Q}_\pm = \frac{1}{2}(1 \pm i\gamma_0\gamma_5\tau^3)$$



This is related to the standard SF via a chiral rotation:

$$\Psi \to R(\alpha)\Psi \quad , \quad R(\alpha) = \exp(i\alpha\gamma_5\tau^3/2)$$

and the projections are:

$$P_\pm(\alpha) = \frac{1}{2}[1 \pm \gamma_0 \exp(i\alpha\gamma_5\tau^3)]$$

χ S F

O(a) improving requires 3 boundary counterterms: c_t, d_s, z_f

In perturbation theory: $c_t = 1 + c_t^{(1)} g_0^2 + \mathcal{O}(g_0^4)$

$$d_s = 1/2 + d_s^{(1)} g_0^2 + \mathcal{O}(g_0^4)$$

We use d_s=1/2 and the 1-loop expression for c_t.

We remain with one parameter z_f we tuned non-perturbatively.

This is done tuning to zero a $\gamma_5\tau^1$-odd operator.

In this work we use $g_{A+}^{ud}(x_0)$

χSF

The **χ**SF coupling is defined as usual: $\bar{g}^2 = \left.\frac{\Gamma_0'(\eta)}{\Gamma'(\eta)}\right|_{\eta=\pi/4}$

From the step scaling function:

$$\Sigma(u,s,a/L) = \left.\bar{g}^2(g_0, sL/a)\right|_{\bar{g}^2(g_0,L/a)=u}$$

we can obtain the beta function:

$$\sigma(u,s) = \lim_{a/L\to 0} \Sigma(u,s,a/L) \qquad -2\log s = \int_u^{\sigma(u,s)} \frac{dx}{\sqrt{x}\beta(\sqrt{x})}$$

$$\beta(u) = 0 \quad \Rightarrow \quad \sigma(u,s) = u$$

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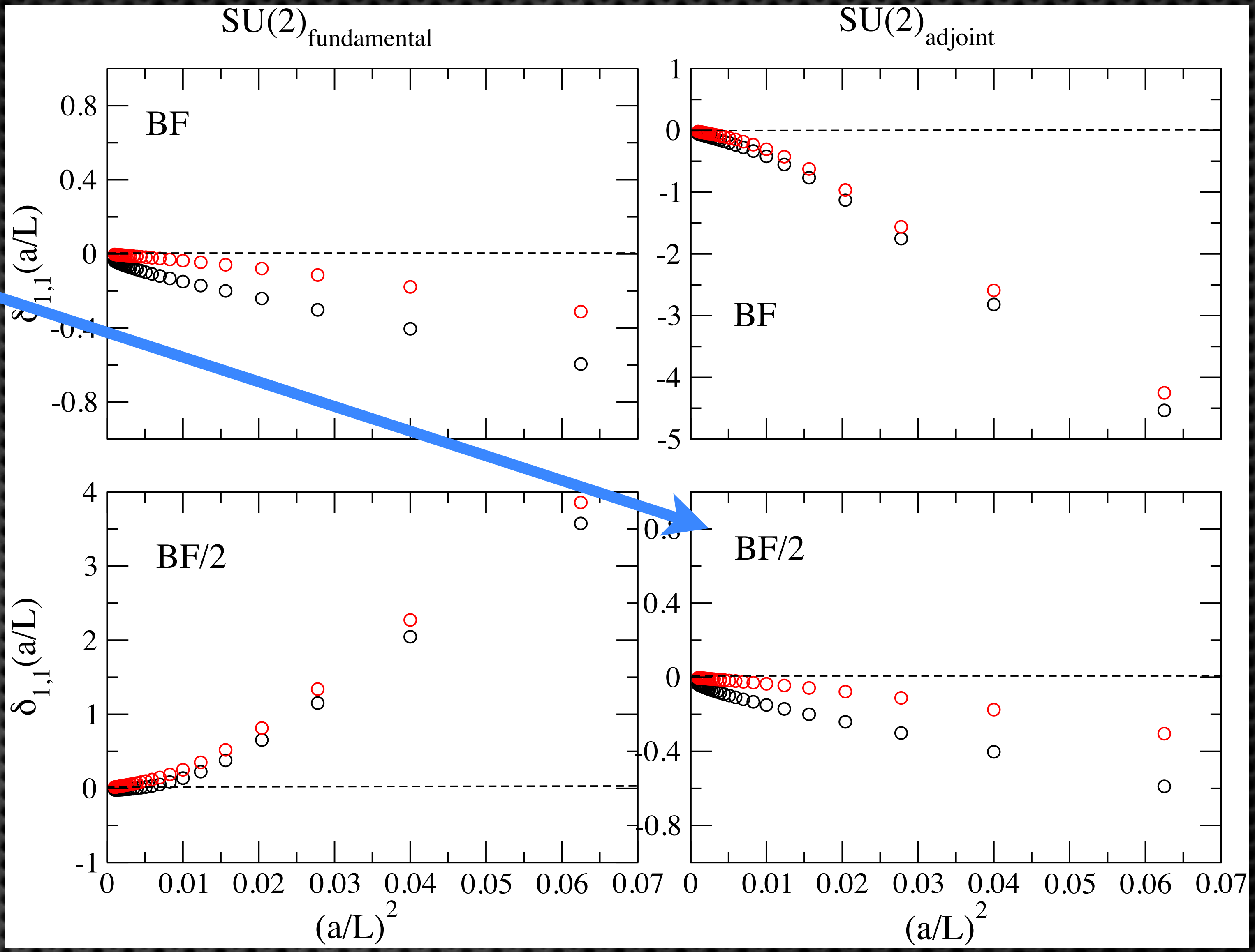
Preliminary numerical results

R. Arthur, L. Del Debbio, B. Lucini, A. Patella, CP, A.Rago, S. Sint, P. Vilaseca *in preparation*

Simulation details

We use half background field strength



$$\Sigma(u,2,a/L) = u + \Sigma_1(a/L)u^2 + \mathcal{O}(u^3)$$

$$\sigma(u,2) = u + \sigma_1 u^2 + \mathcal{O}(u^3)$$

$$\delta_1(a/L) = \frac{\Sigma_1(a/L) - \sigma_1}{\sigma_1}$$

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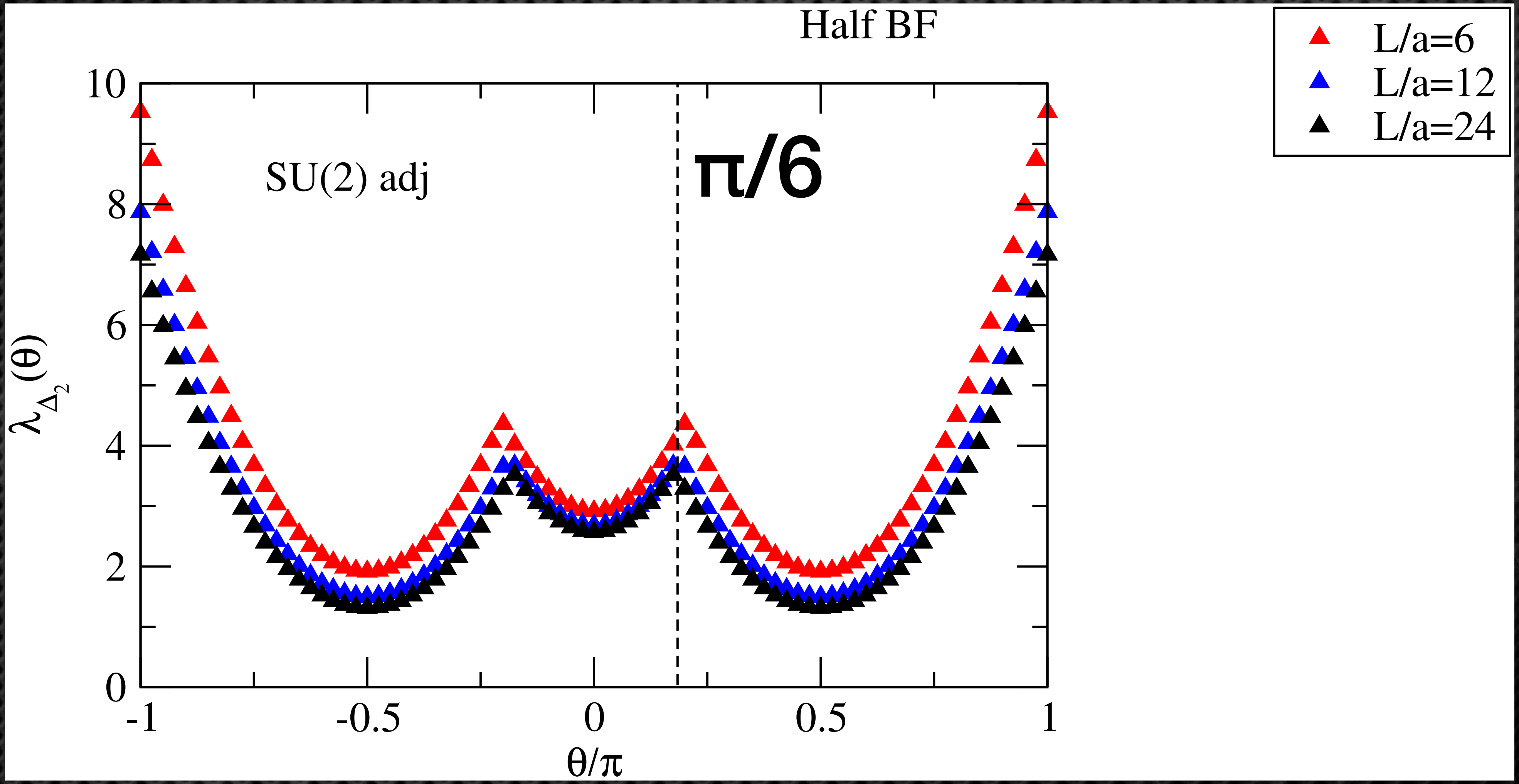
Simulation details

For fermion fields we use spatial B.C. periodic up to a phase:

$$\Psi(x+L\hat{k}) = e^{i\theta}\Psi(x) \quad ; \quad \overline{\Psi}(x+L\hat{k}) = e^{-i\theta}\overline{\Psi}(x)$$

to maximise the lowest eigenvalue of the Dirac operator.



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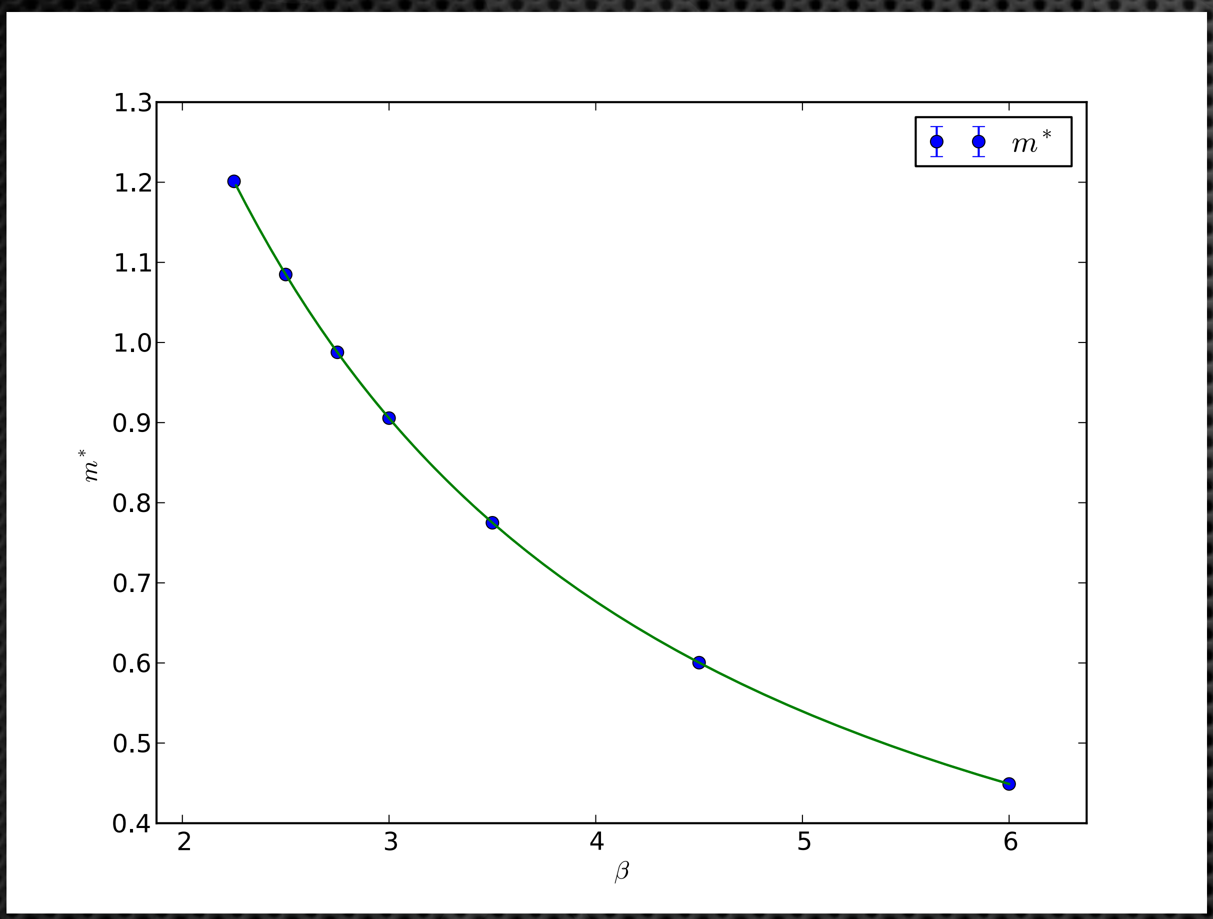
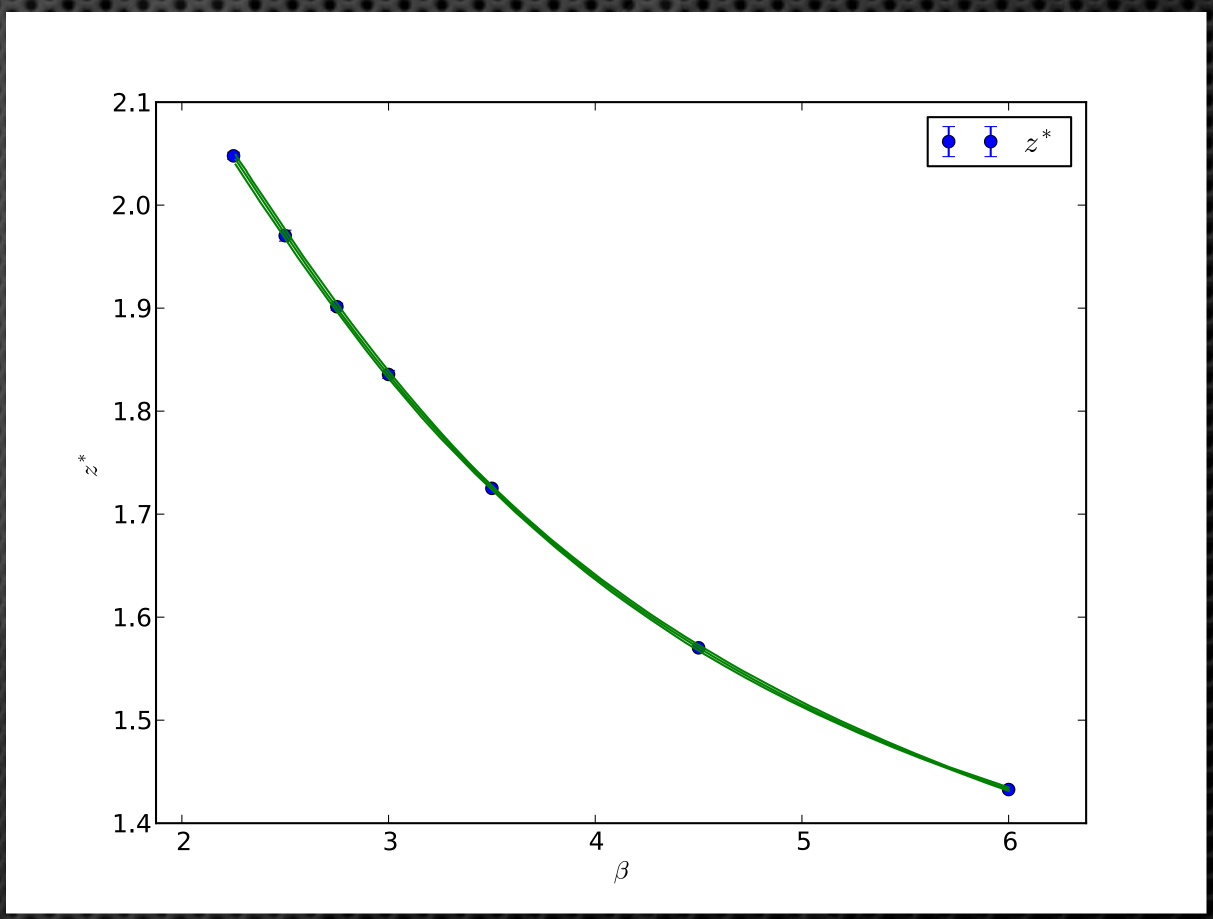
Simulation details

L = 6, 8, 12, 16 ; we plan also L = 24

β = 2.1 … 6

s = 2 (scaling factor)

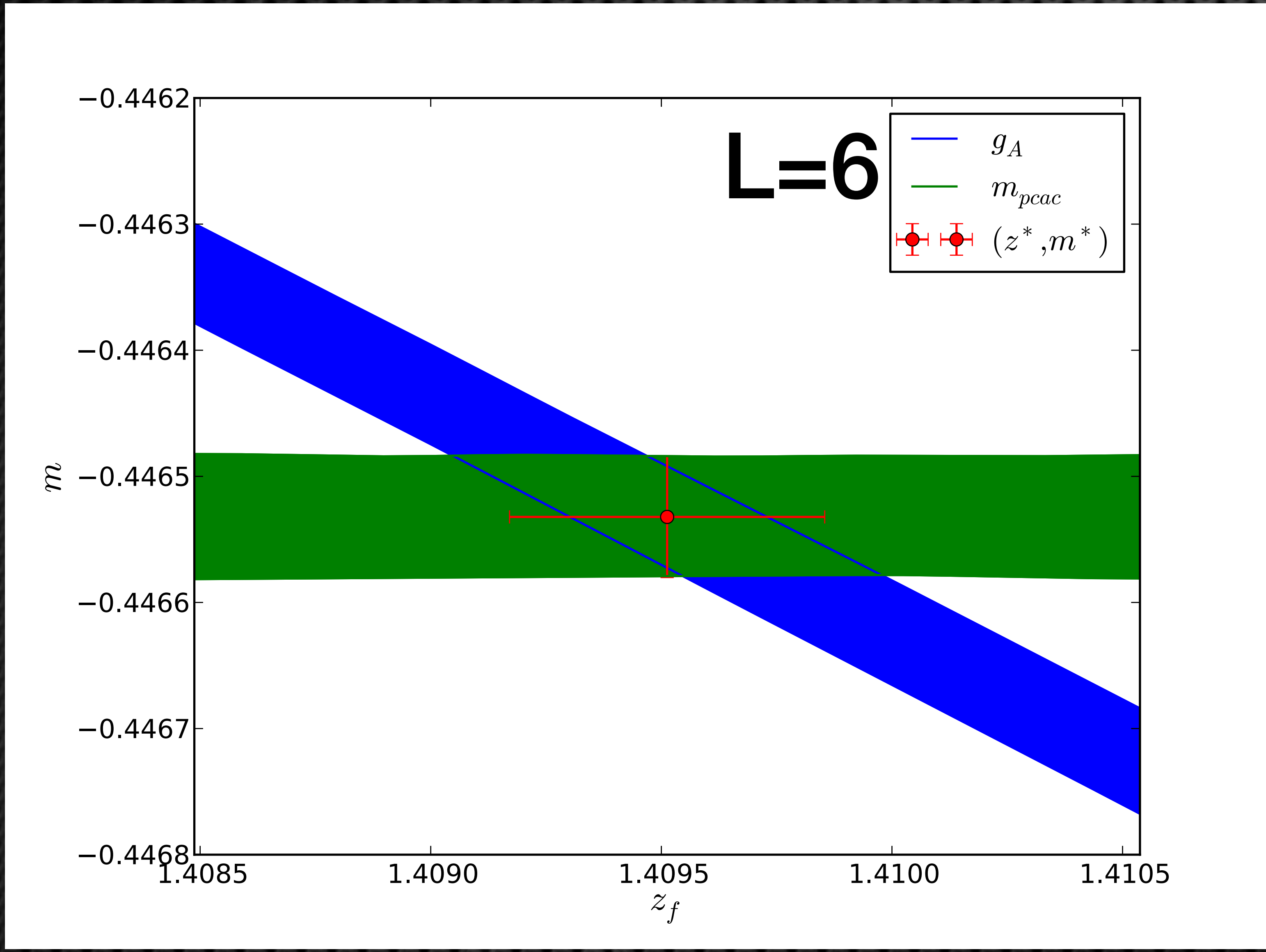




Tuning

For each volume and bare coupling, we tune 2 parameters: m_0 and z_f.

This is done by imposing the vanishing of the PCAC mass and of g_{A+}^{ud}



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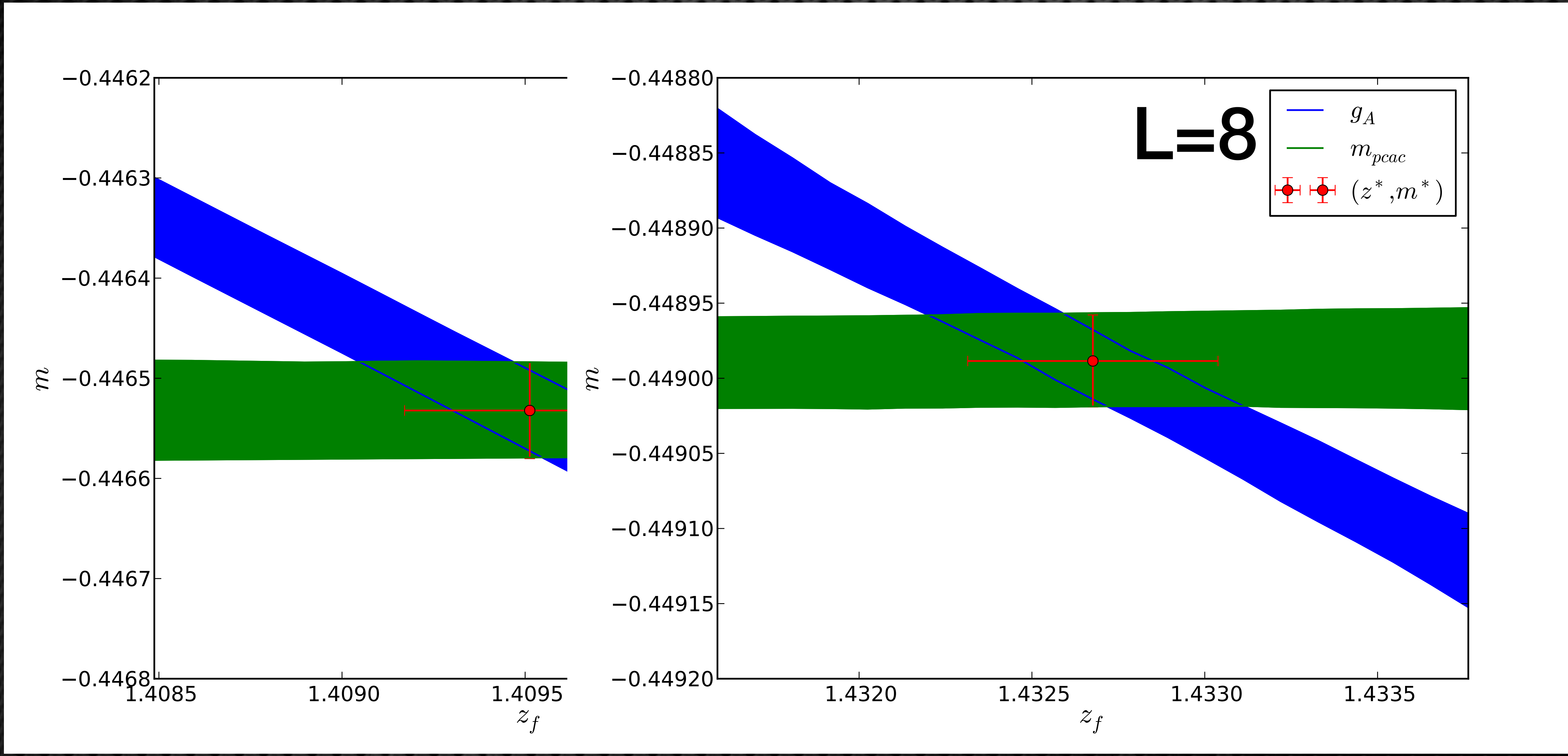

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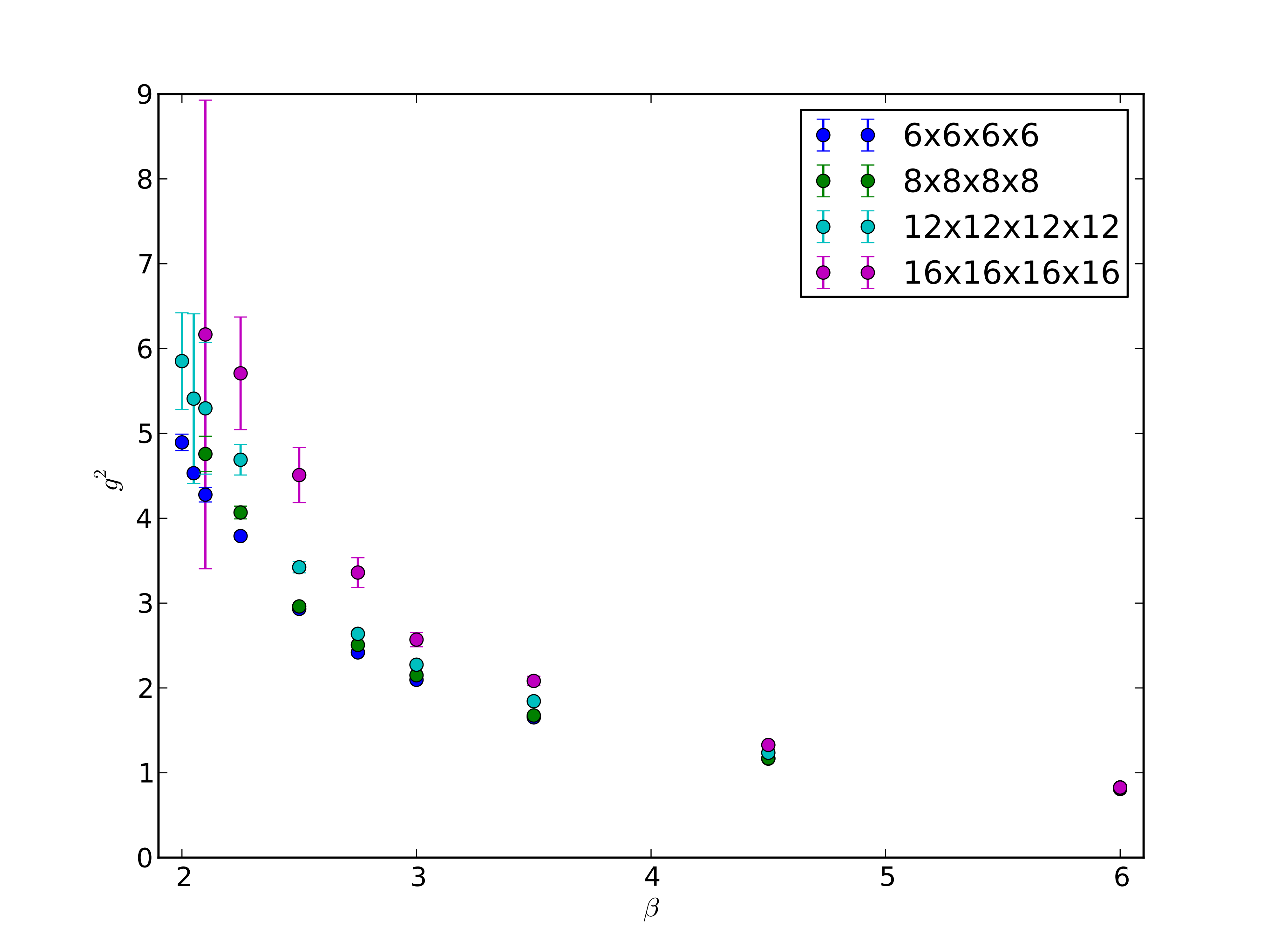
Coupling



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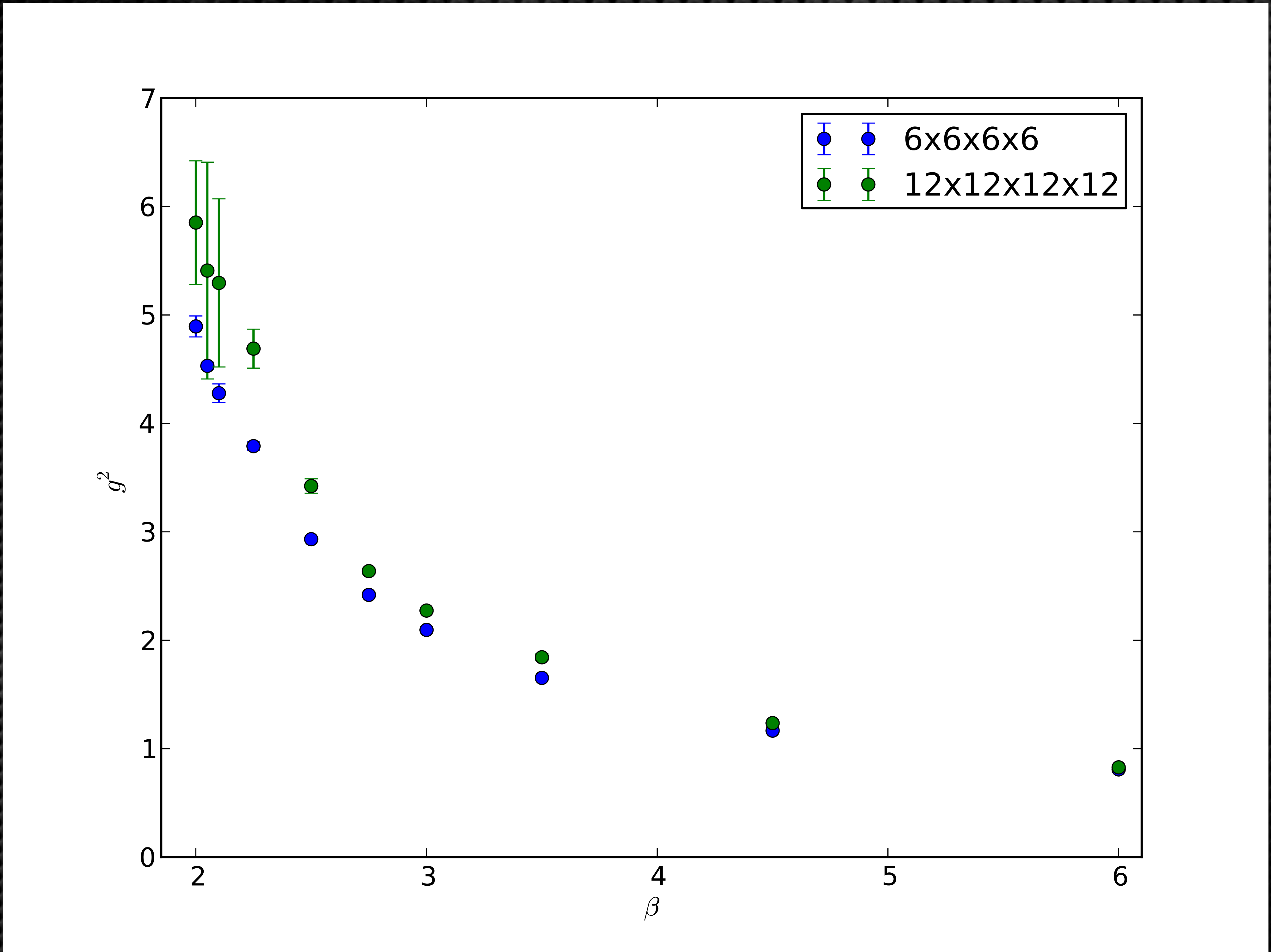
Coupling 6, 12



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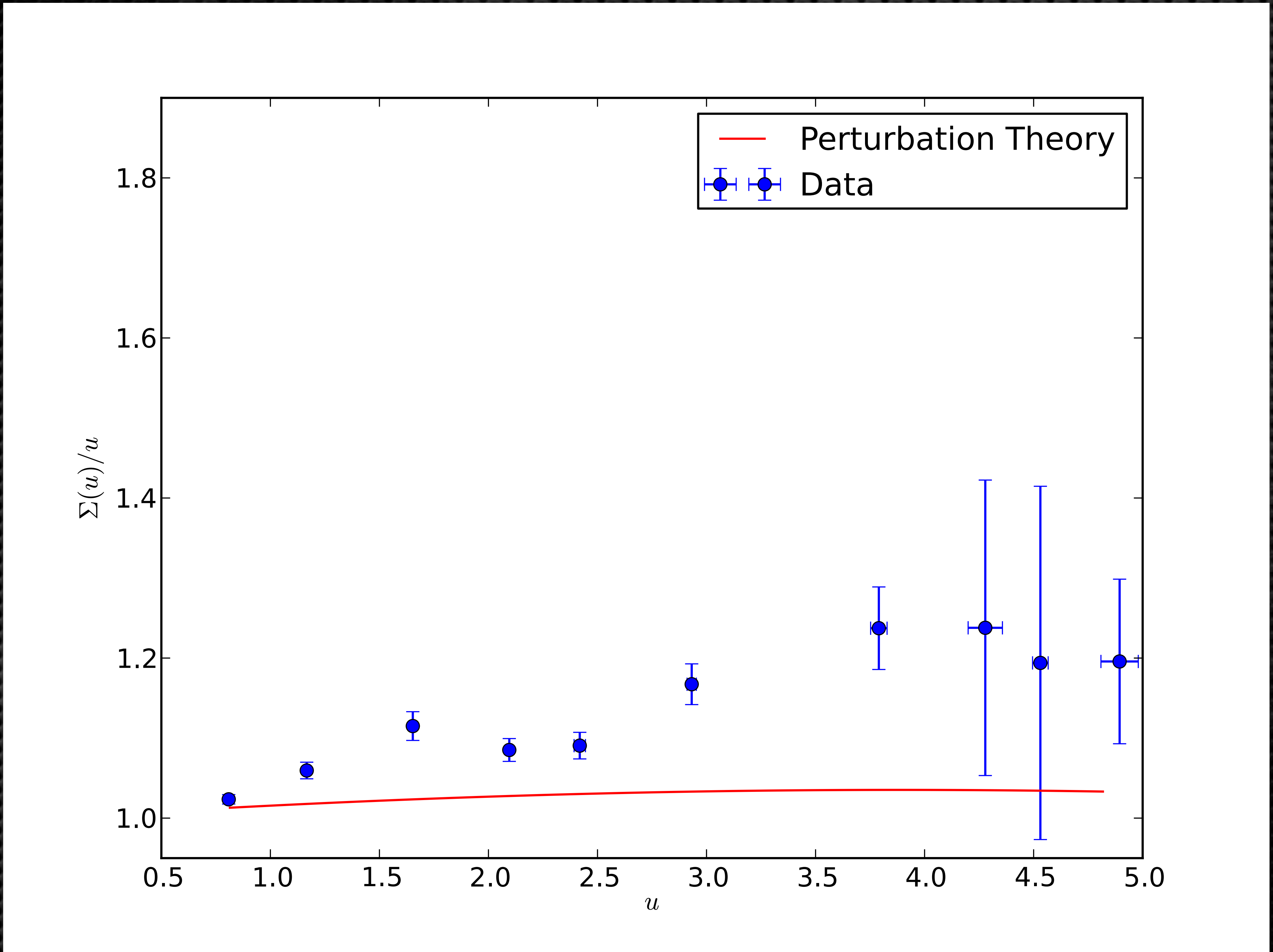
Step scaling 6 → 12



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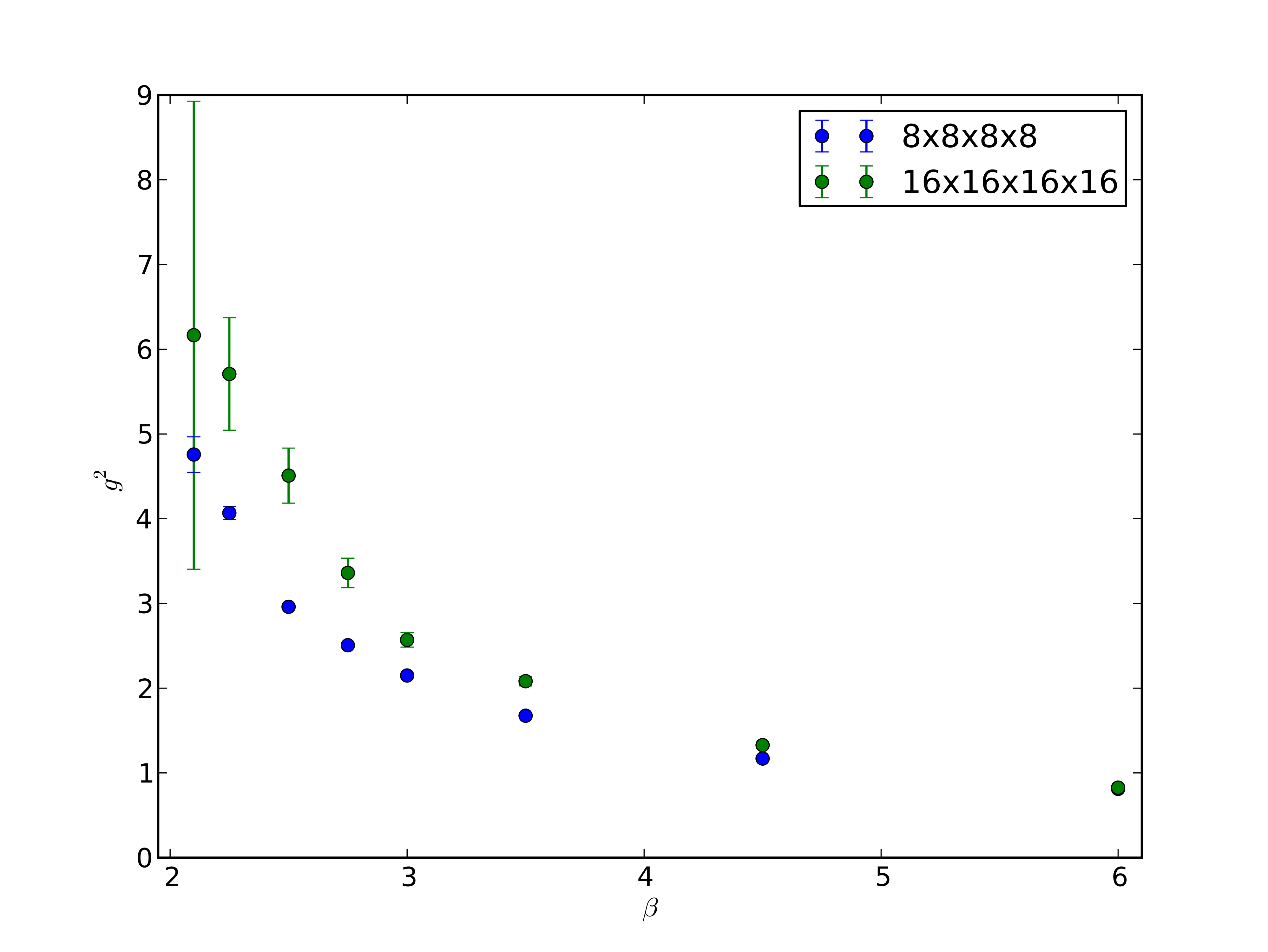
Coupling 8, 16



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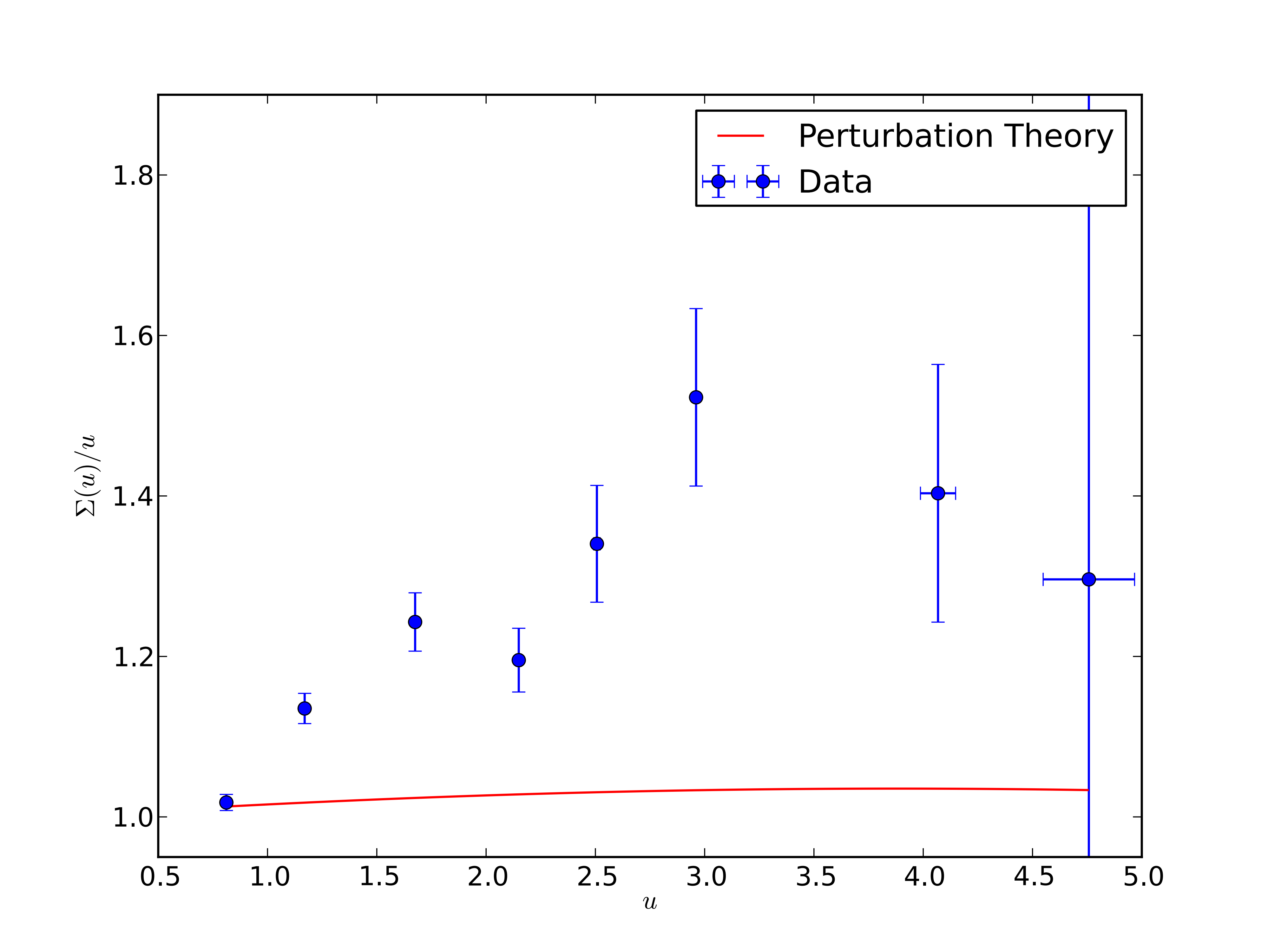
Step scaling 8 → 16



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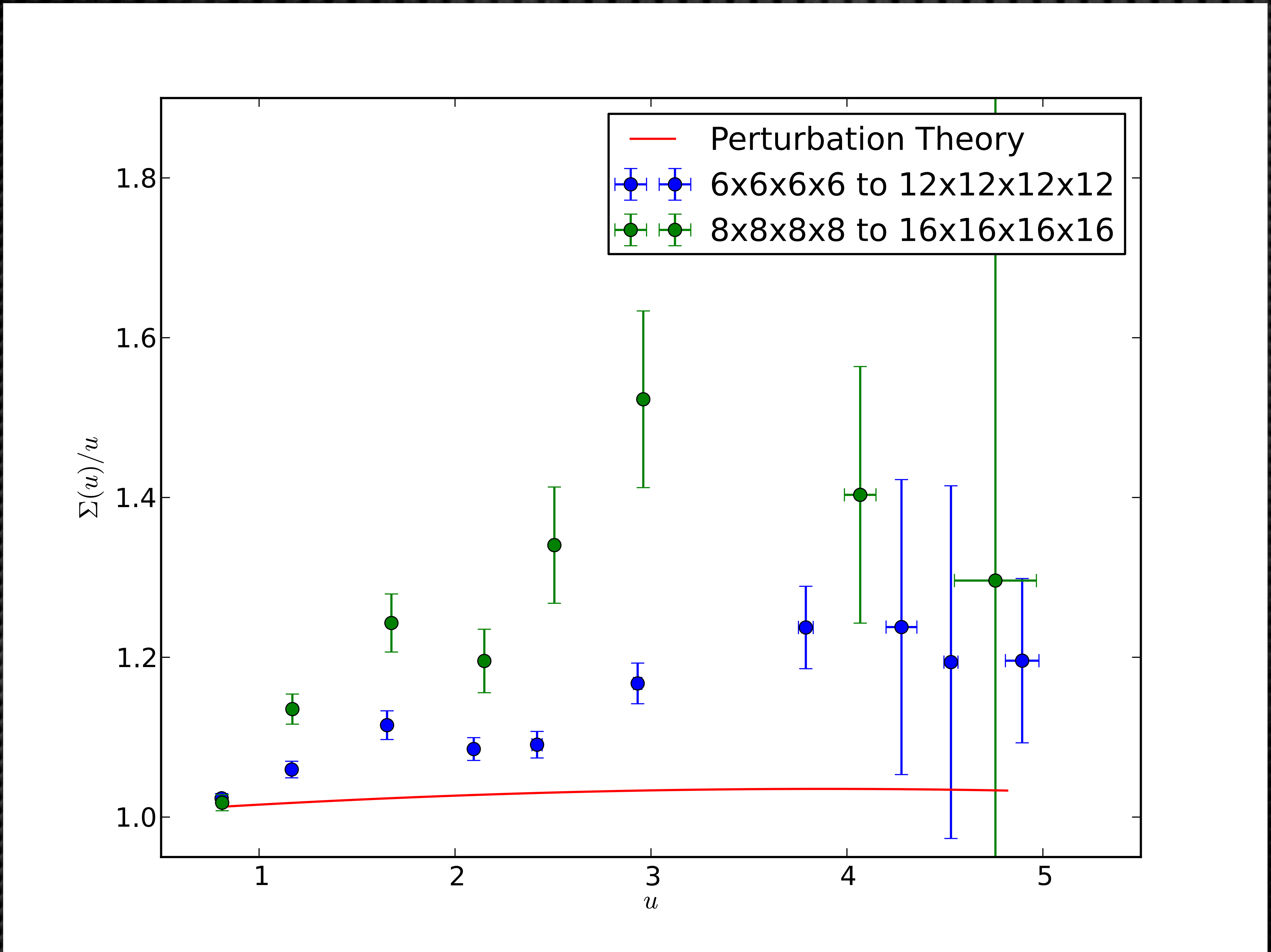
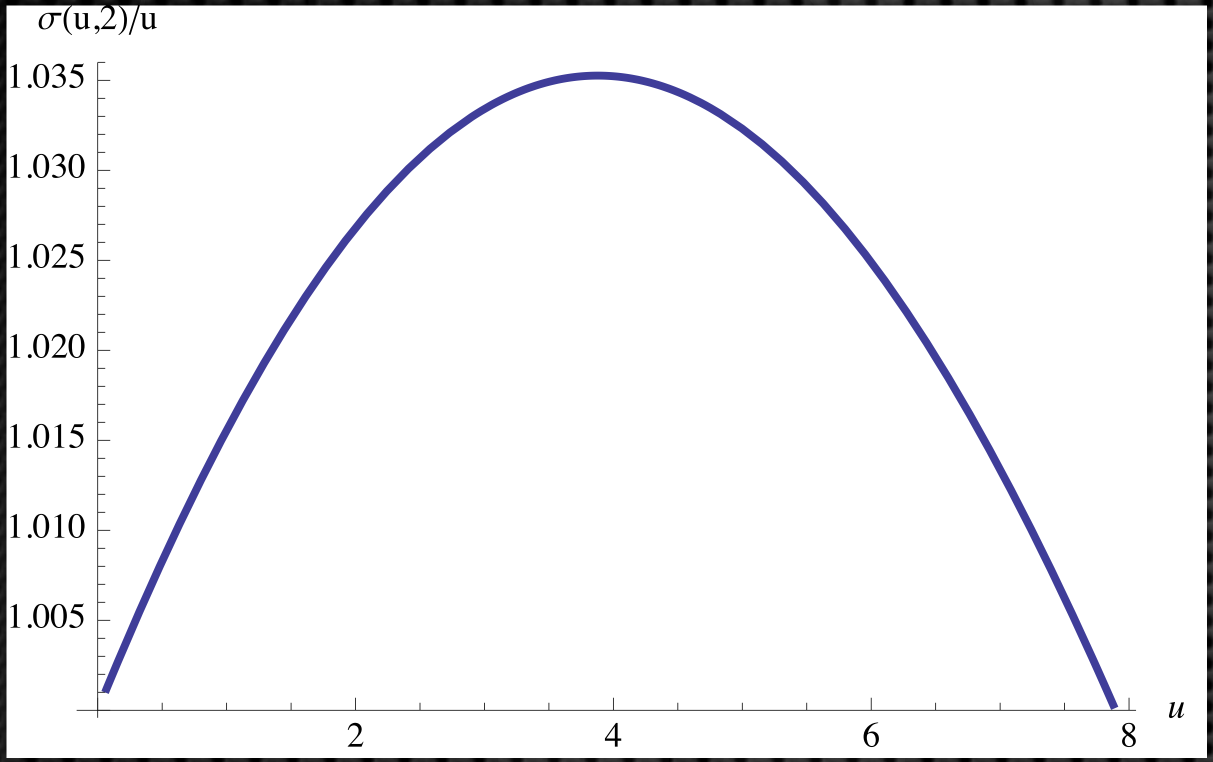
Step scaling

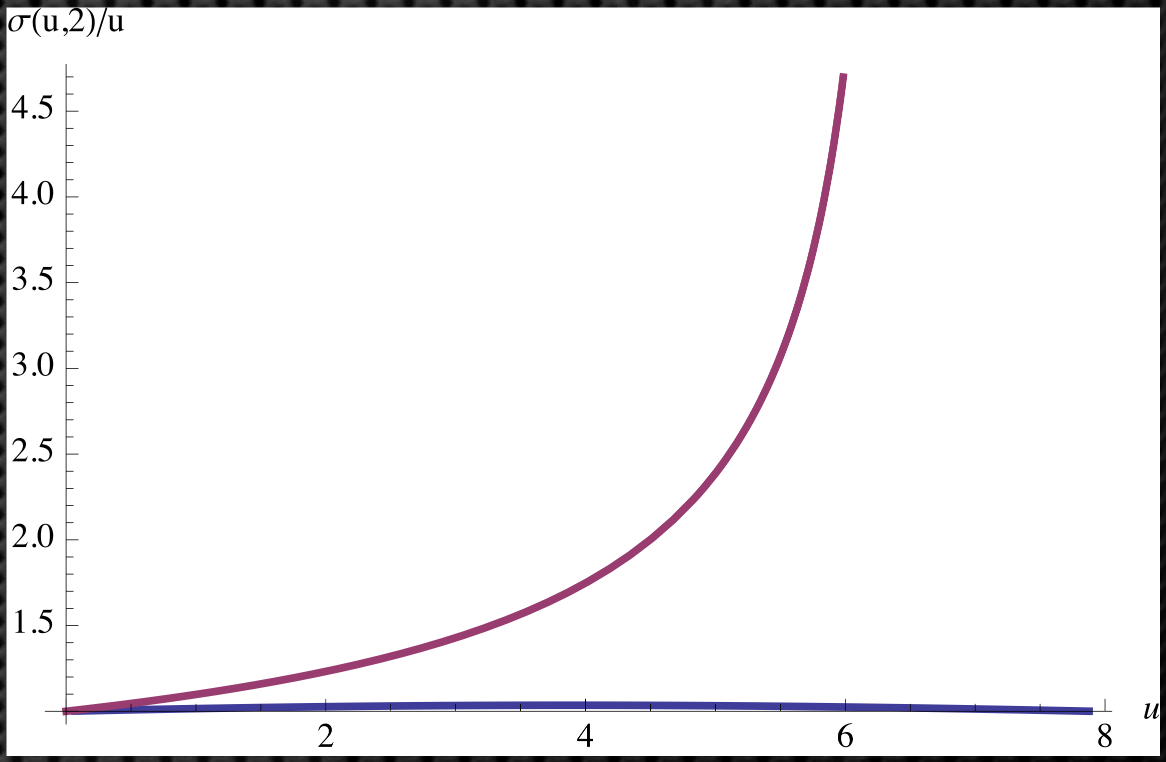


2-loop beta function

SU(2) Adj MWT



QCD nf=2



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Conclusions

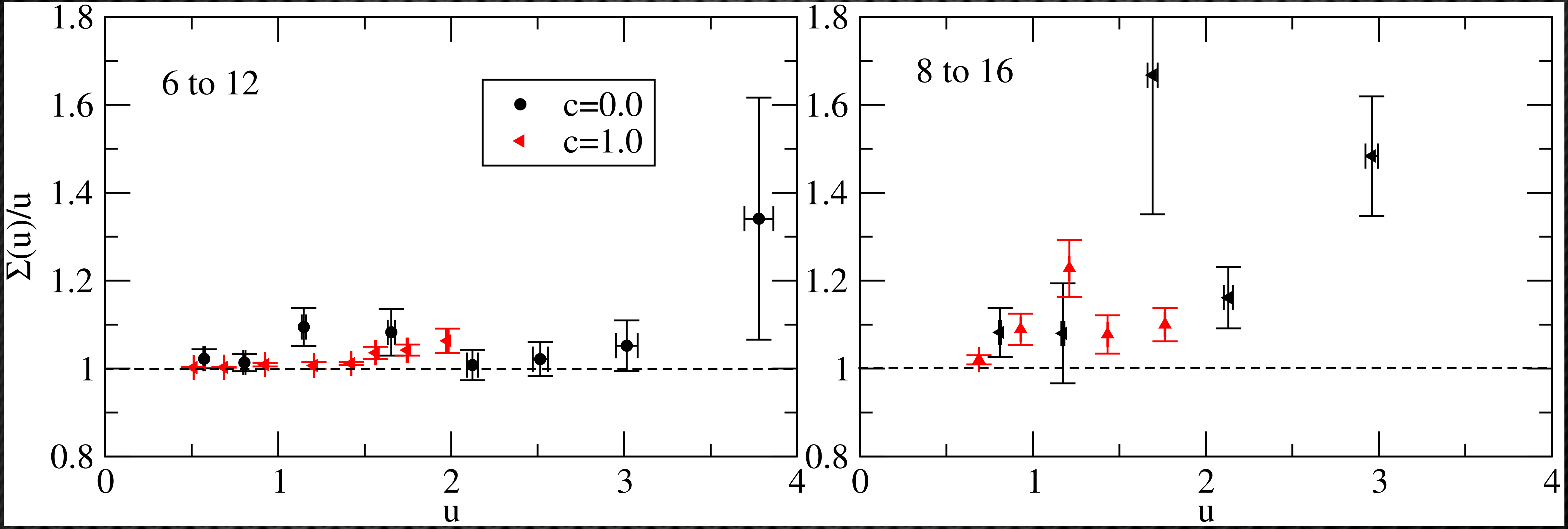
- χSF tuning work well at weak coupling, but expensive at stronger couplings
- fixed point still not reached, hints at stronger coupling
- cutoff effects seems to large at interesting values of the coupling

Ongoing:

- need more statistics to reduce errors on the step scaling functions
- continuum extrapolation

Conclusions

- explore use Wilson Flow to increase signal/noise ratio



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