MCRG Study of SU(3) Gauge Theories with 8 and 12 Fundamental Fermions

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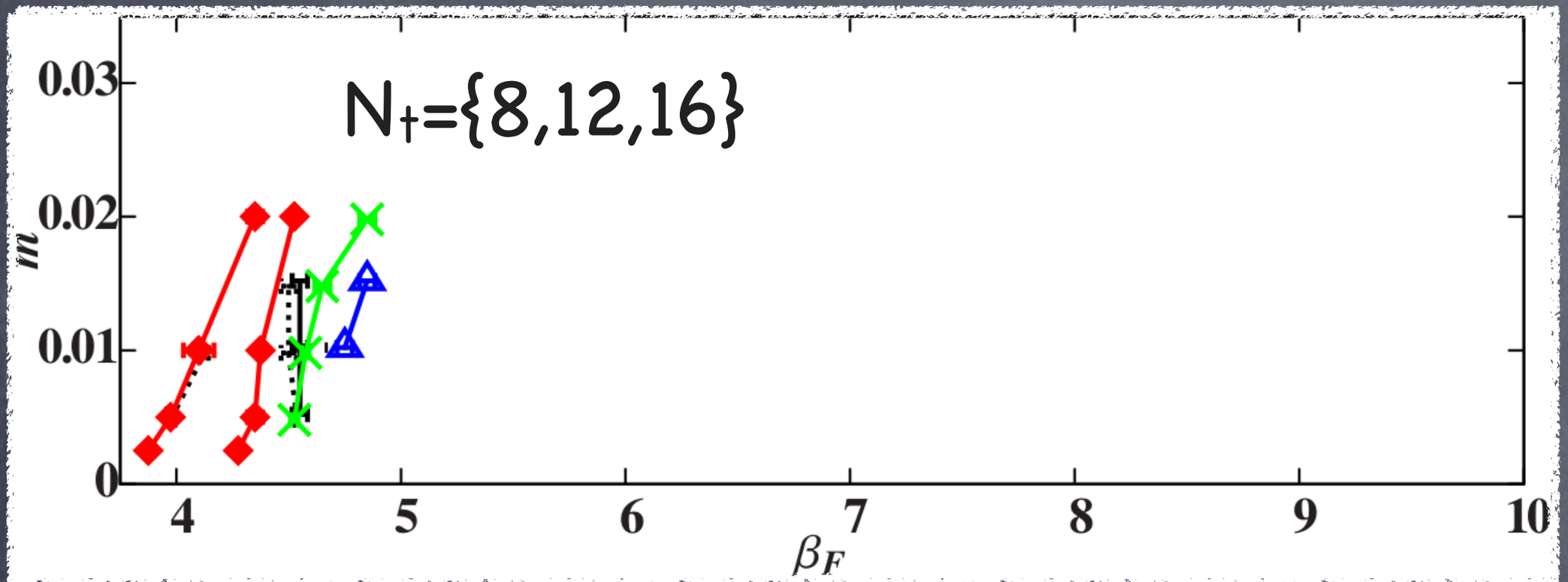
Motivation

Colorado NHYP BSM

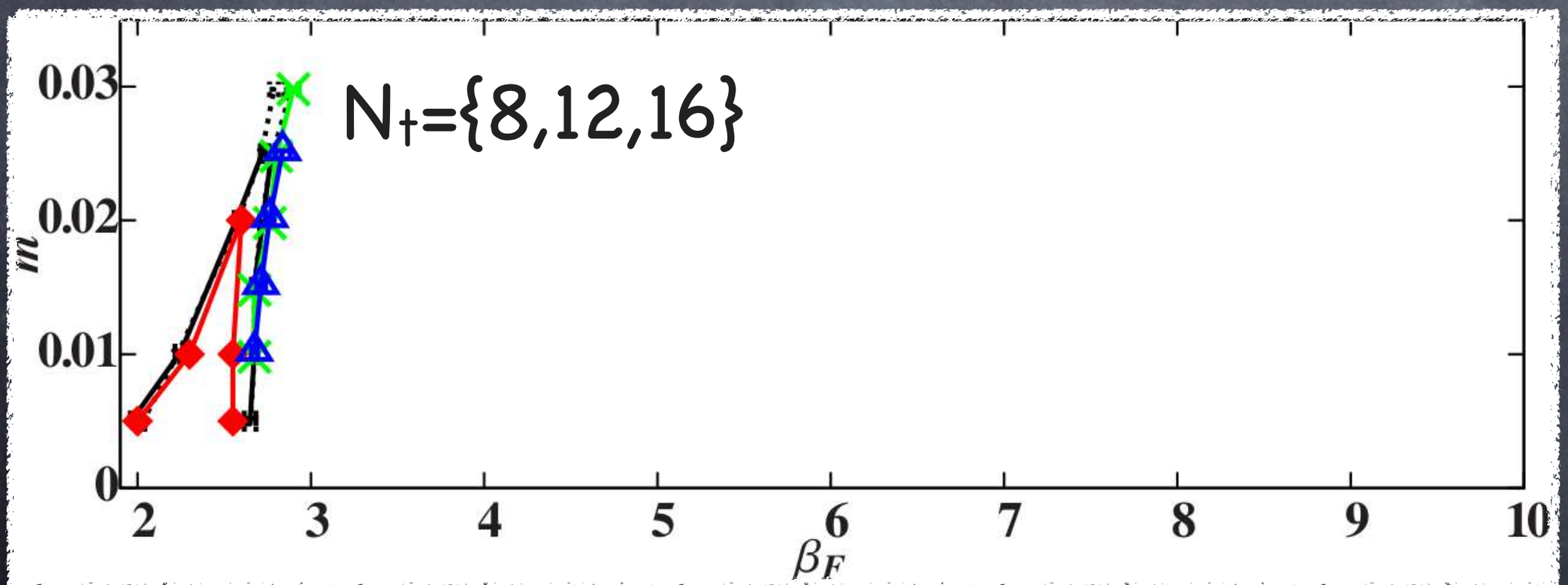
- Anna Hasenfratz
- David Schaich
- Gregory Petropoulos
- Anqi Cheng

- SU(3) Gauge Group
- Fundamental Fermions
- NHYP smeared staggered action
- Fundamental & Adjoint gauge action

Motivation

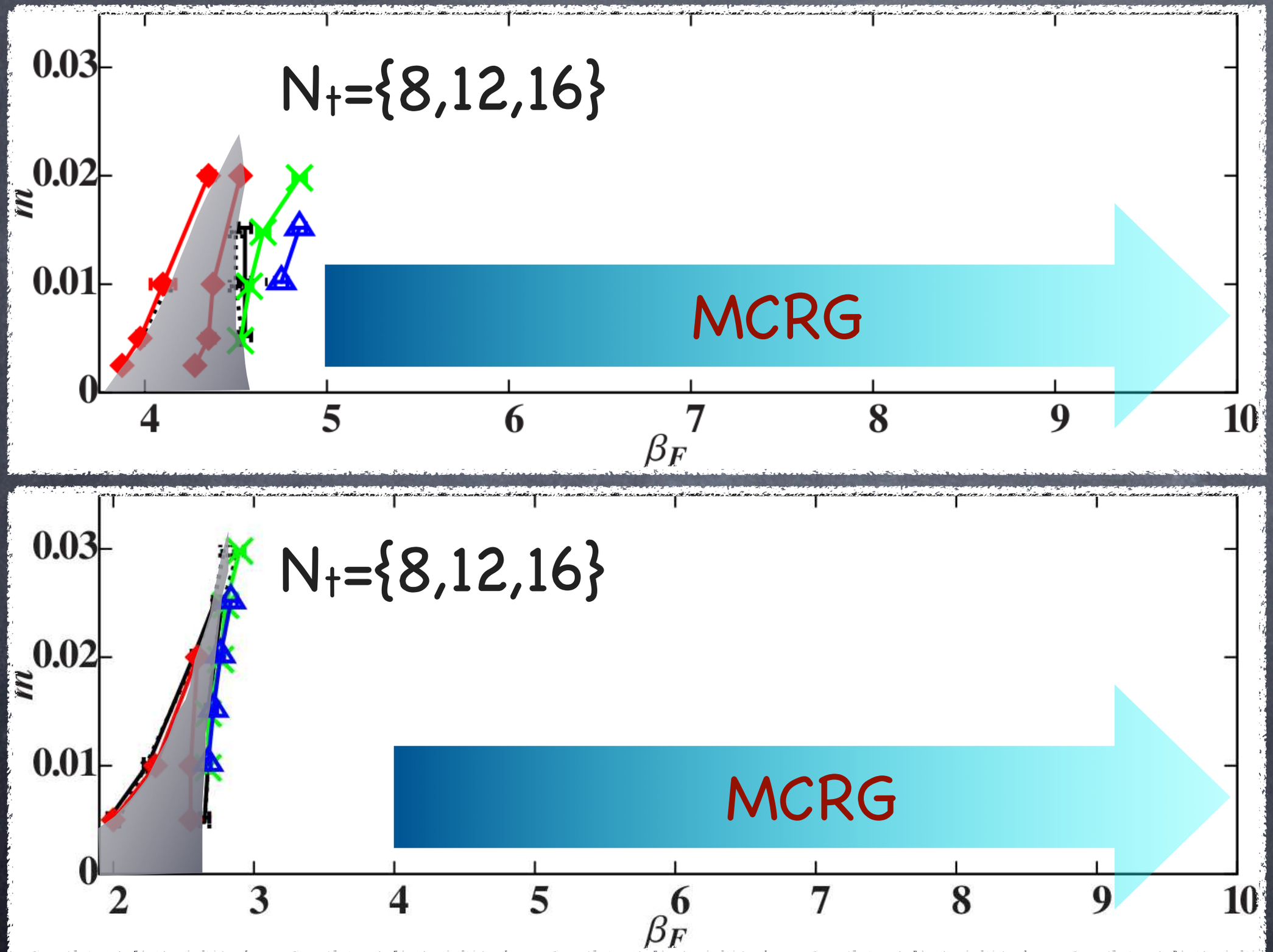


8 flavor finite temperature phase diagram



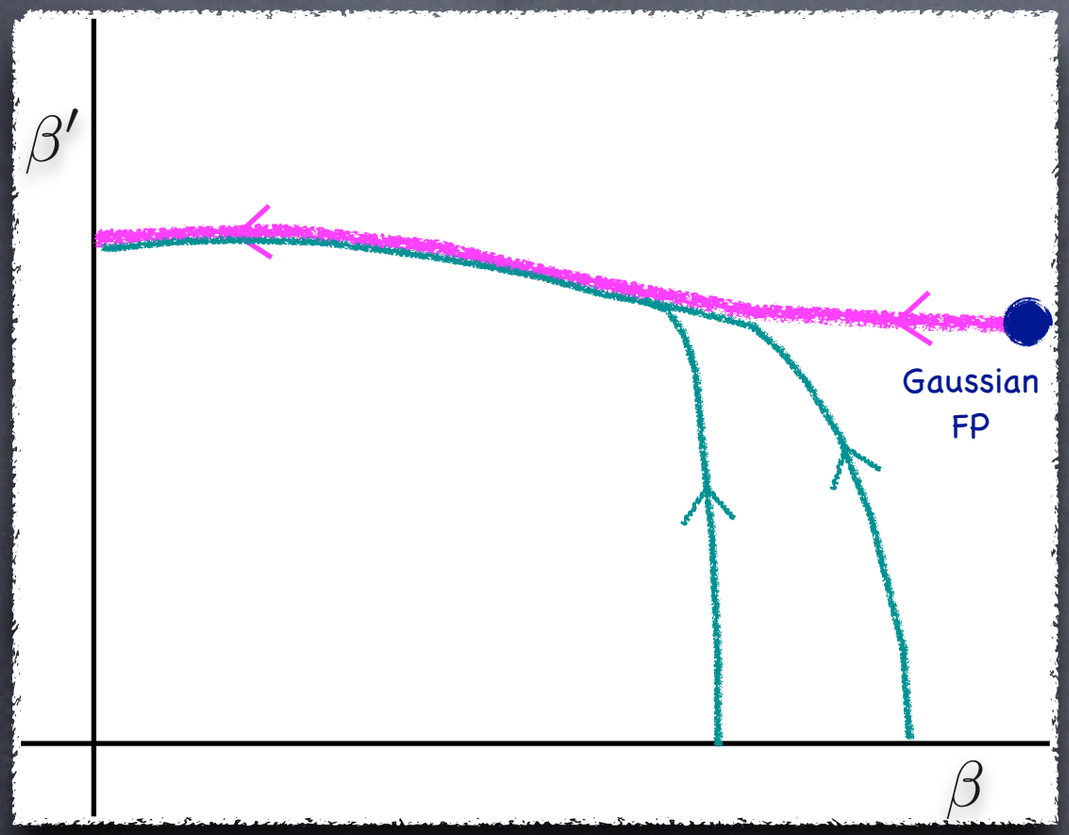
12 flavor finite temperature phase diagram

Motivation

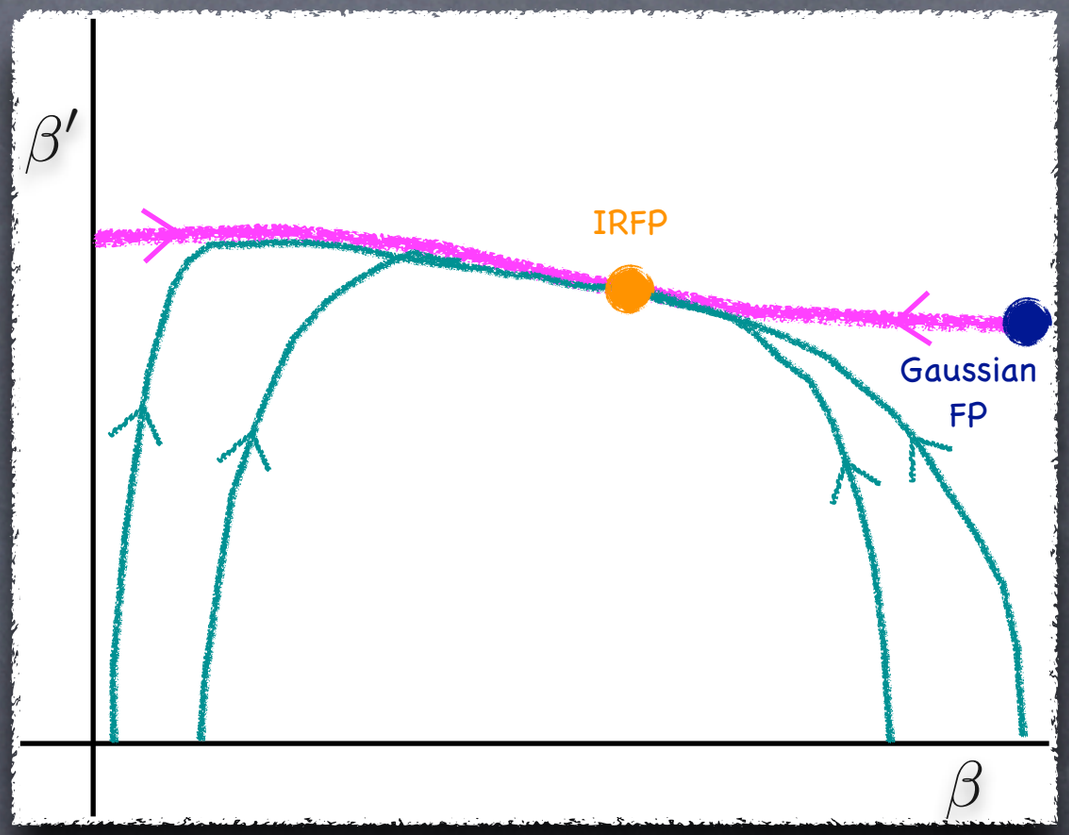


8 flavor finite temperature phase diagram

12 flavor finite temperature phase diagram

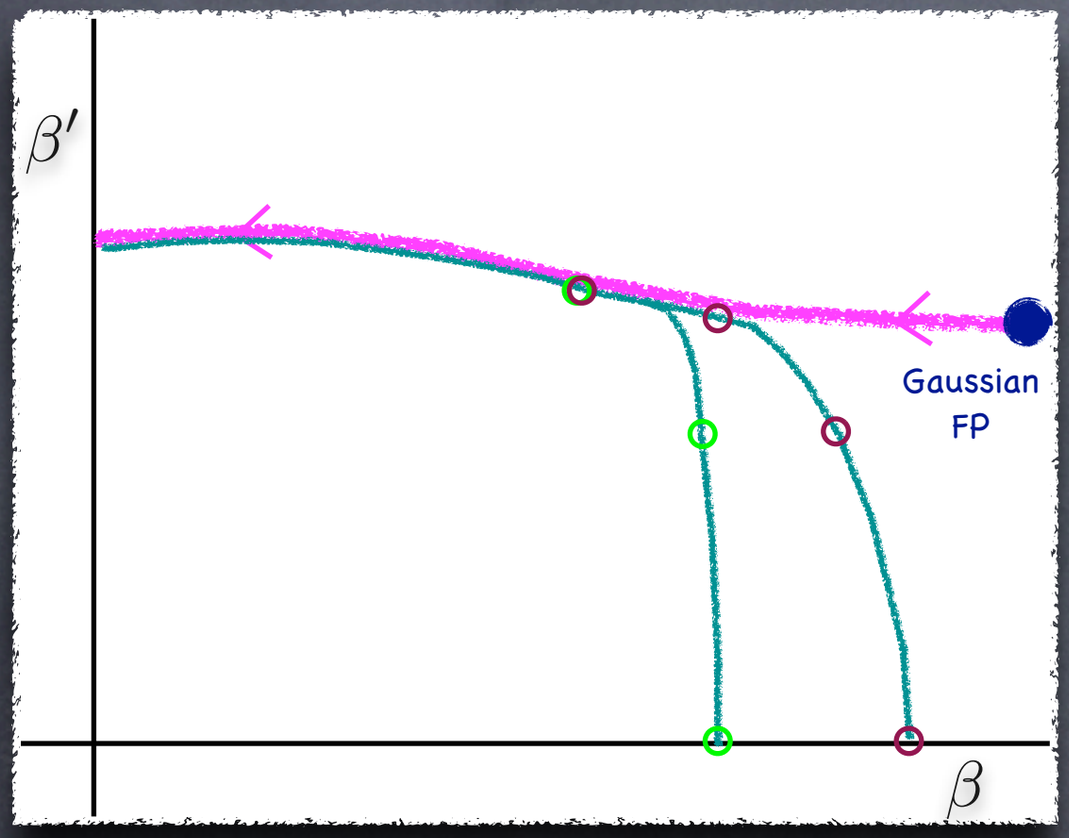


QCD-like Renormalized Trajectory

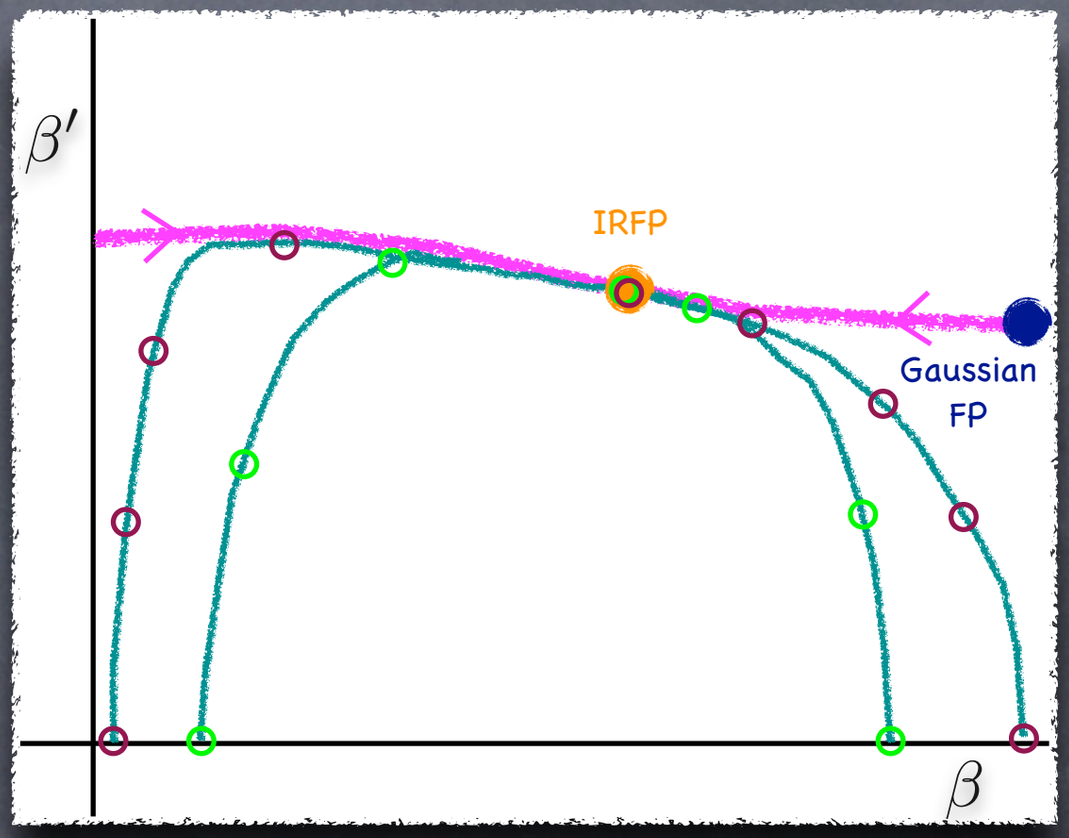


Conformal Renormalized Trajectory

Renormalized flow on the m=0 critical surface



QCD-like Renormalized Trajectory



Conformal Renormalized Trajectory

Renormalized flow on the m=0 critical surface

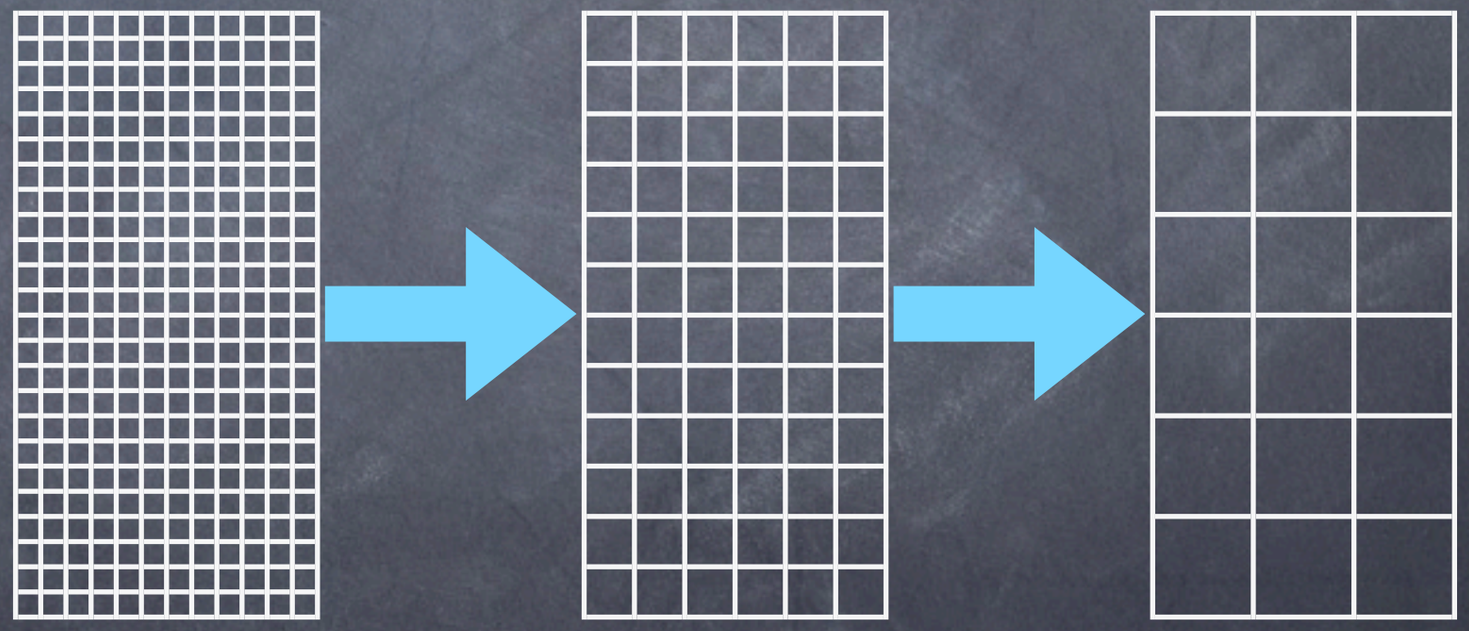
Step 1/3: Blocking

NHYP smeared block transformation

Inner Smearing: 0.2
Outer Smearing: α

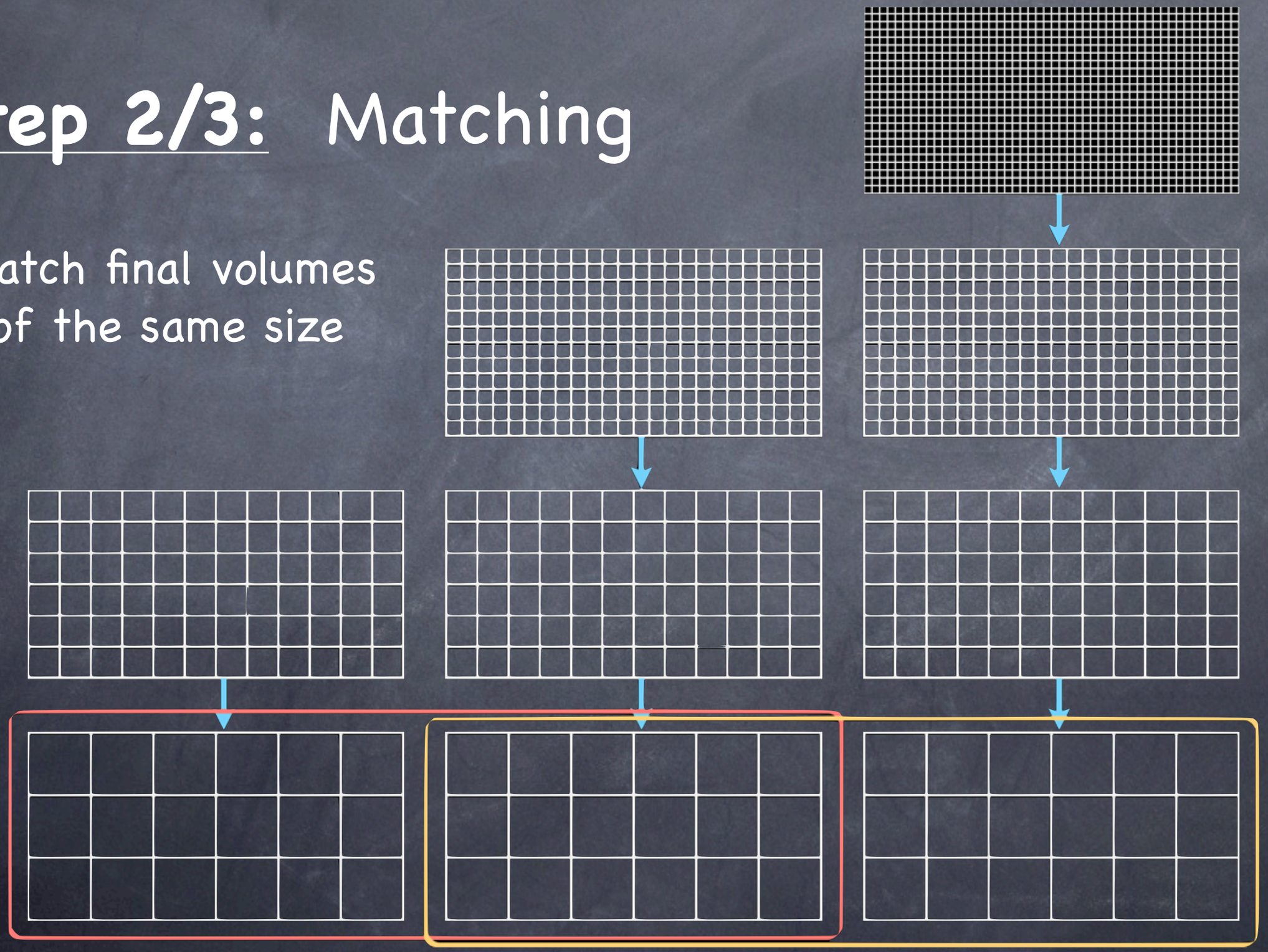
Measure:

- plaquette
- 6 link loops
- 8 link loop

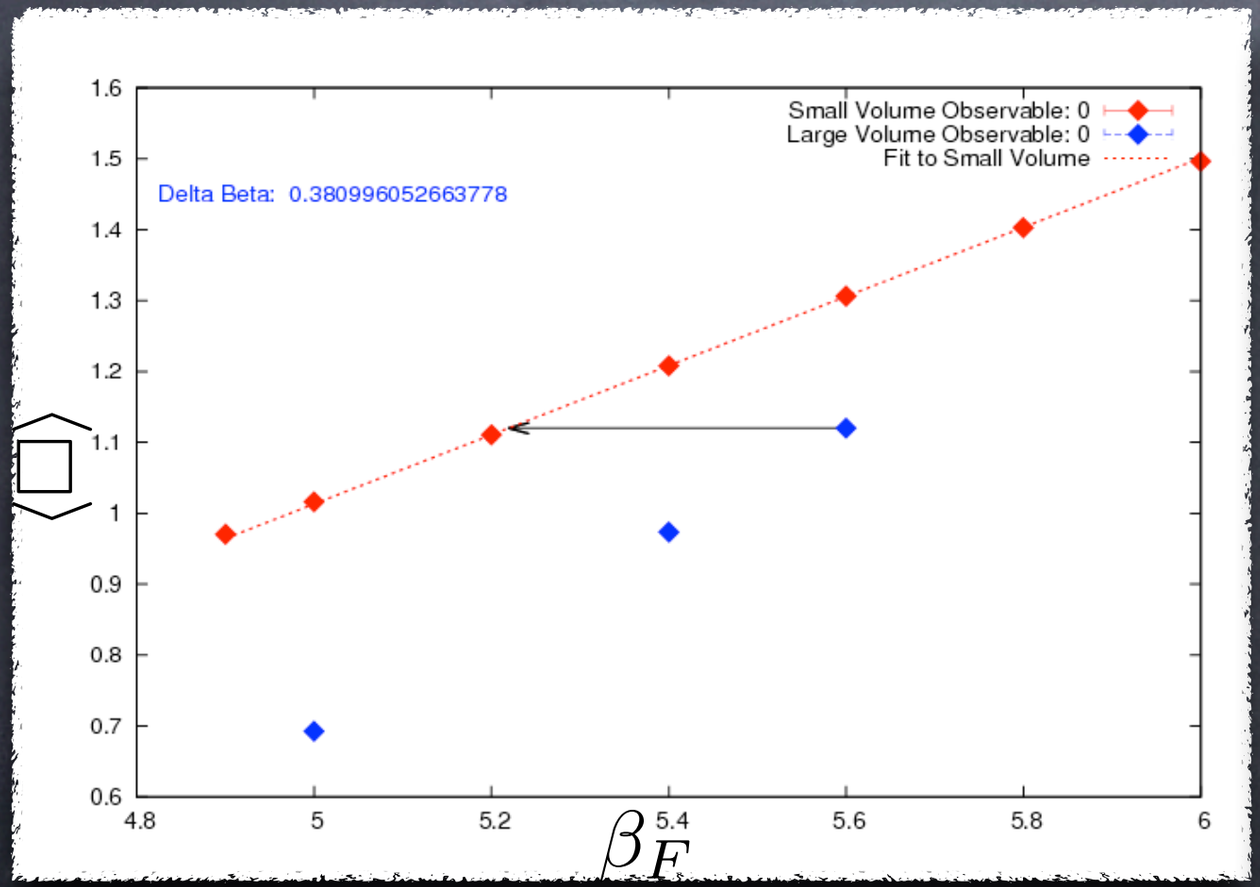


Step 2/3: Matching

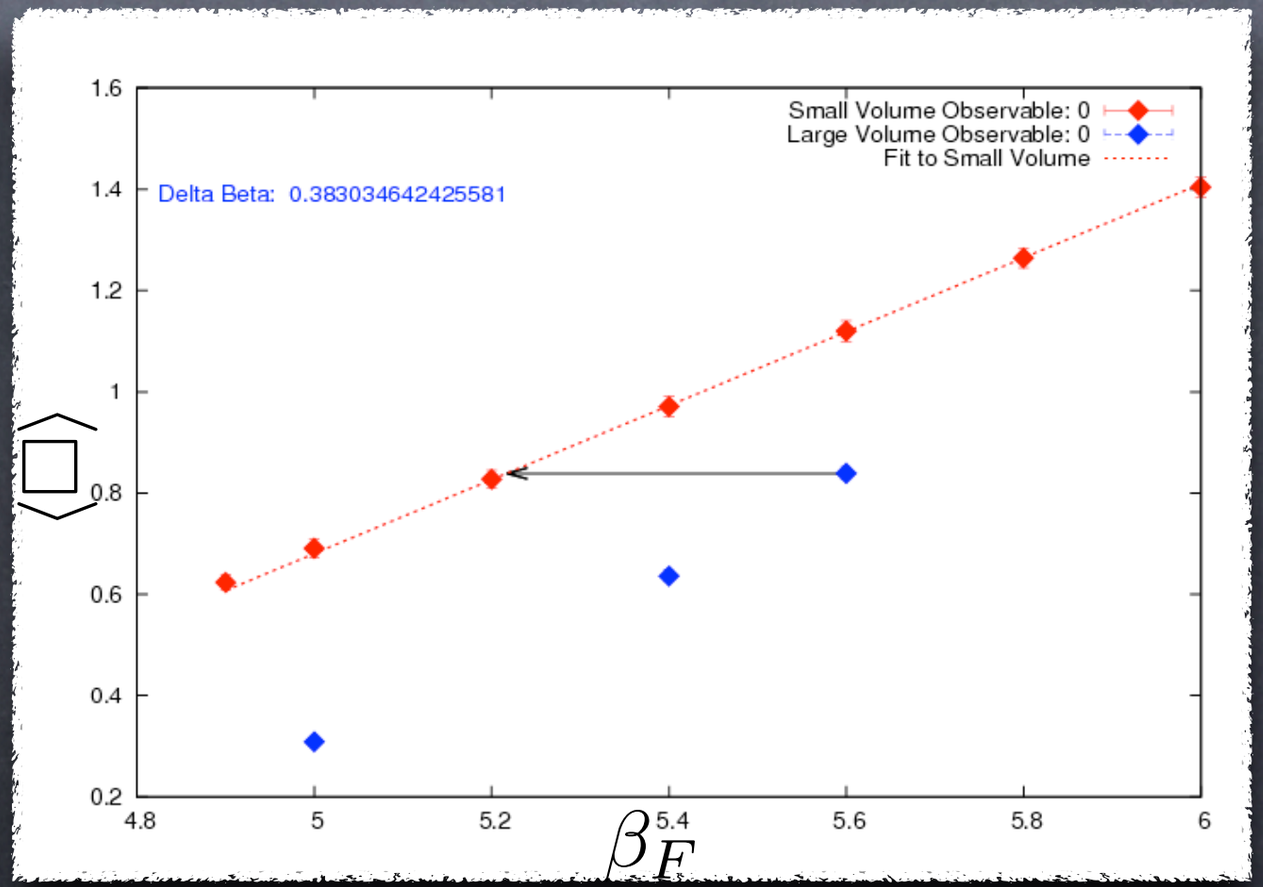
Match final volumes of the same size



Step 2/3: Matching to find Δβ

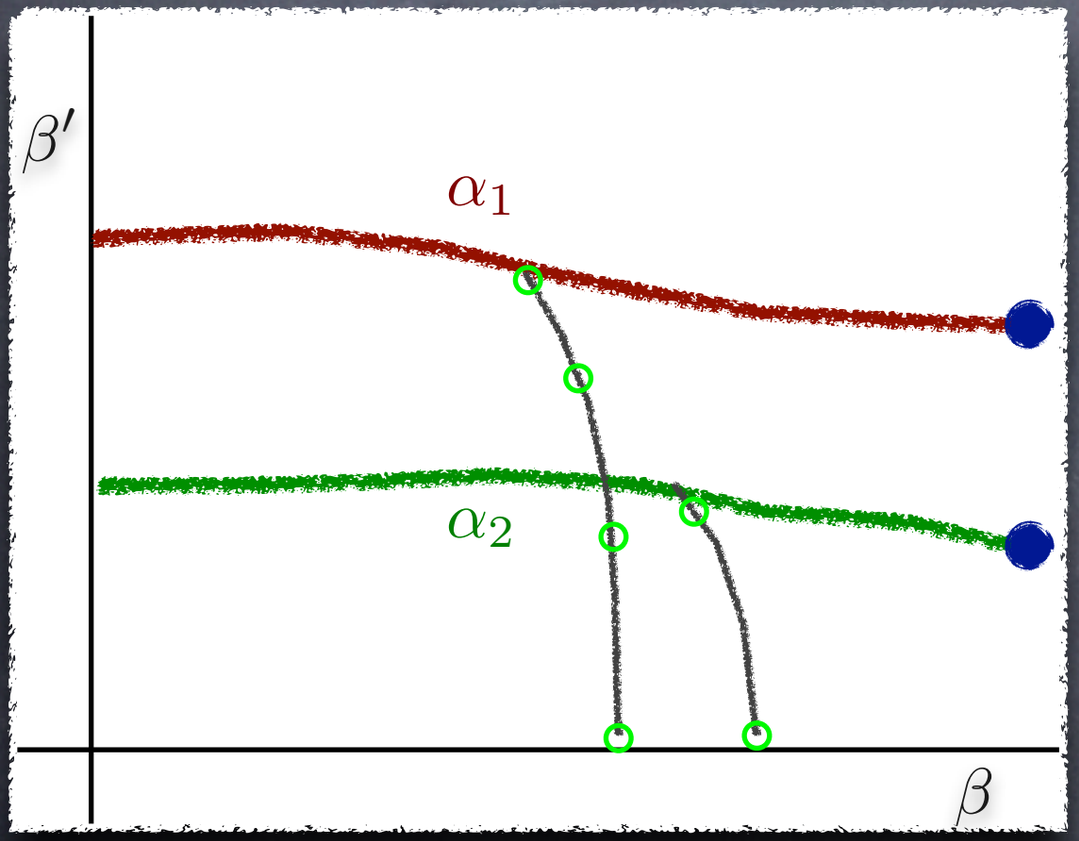


Matching between
24^3x48 blocked to 6^3x12
12^3x24 blocked to 6^3x12

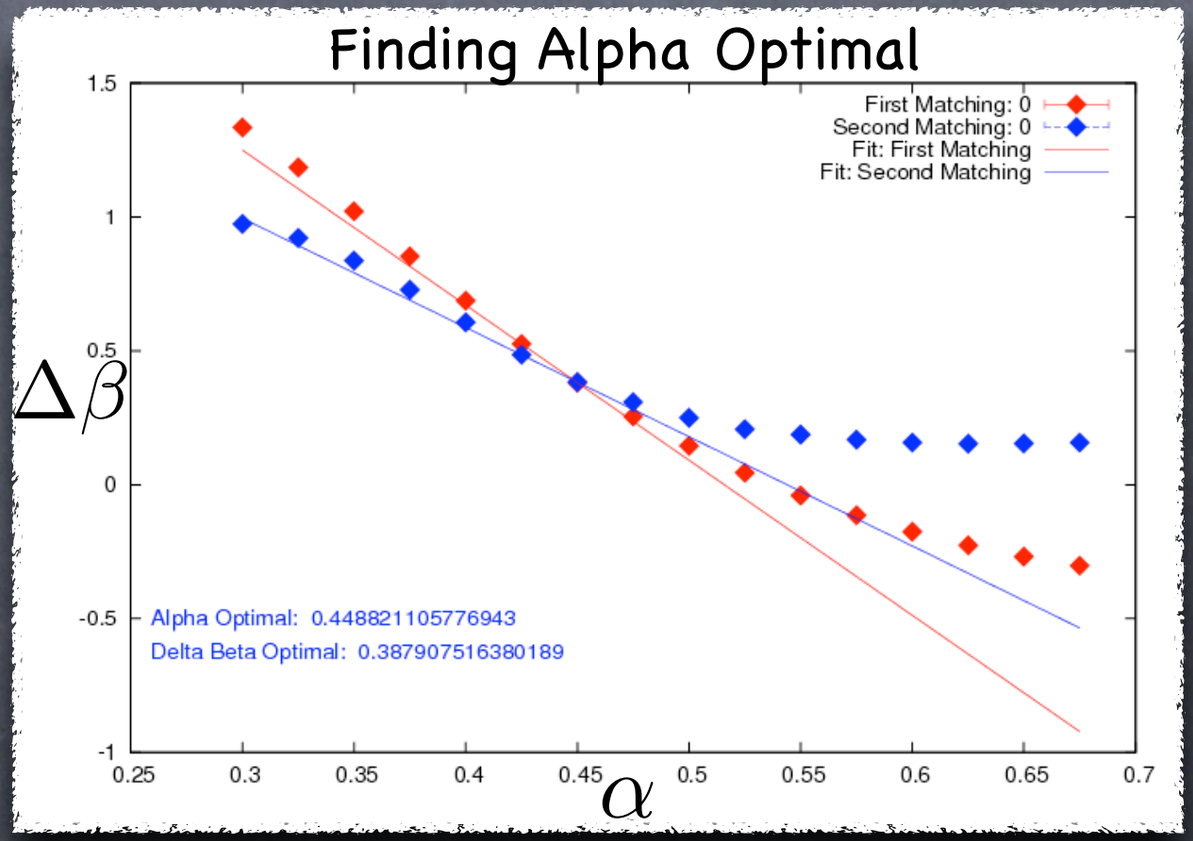


Matching between
24^3x48 blocked to 3^3x6
12^3x24 blocked to 3^3x6

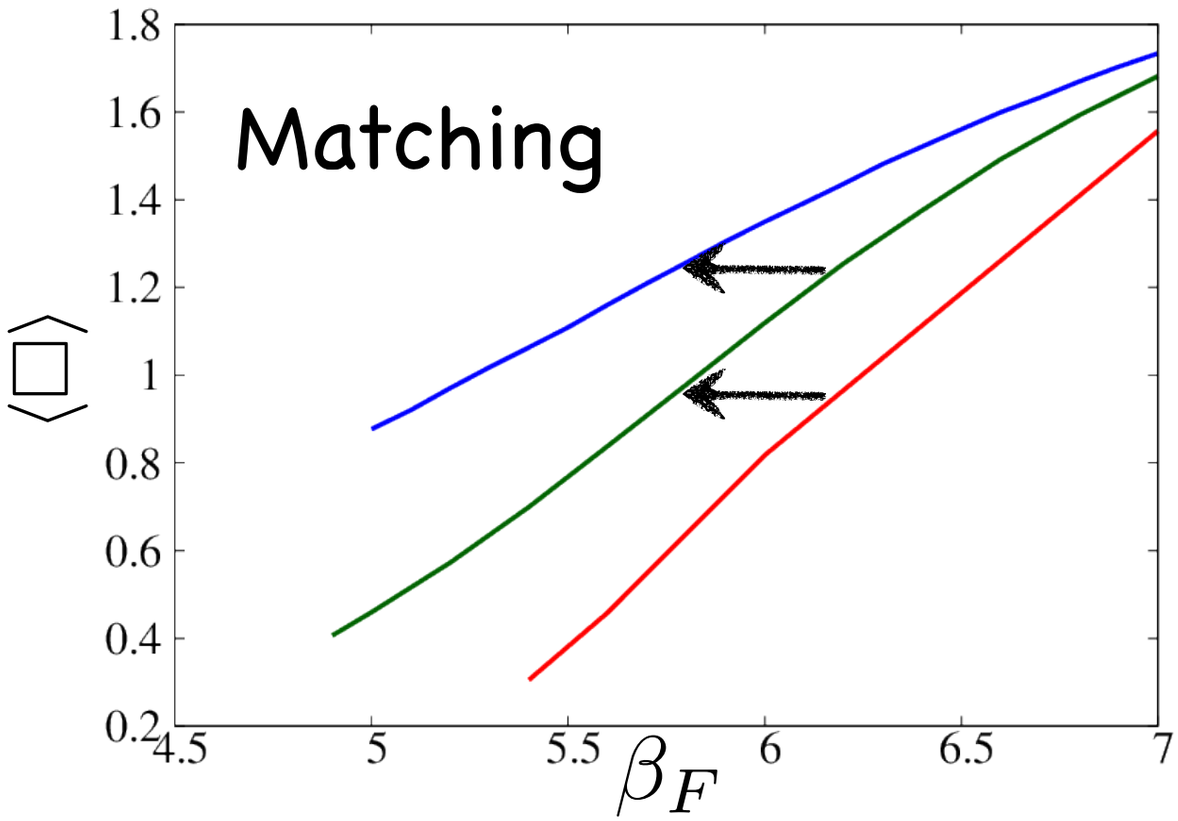
Step 3/3: Optimize α

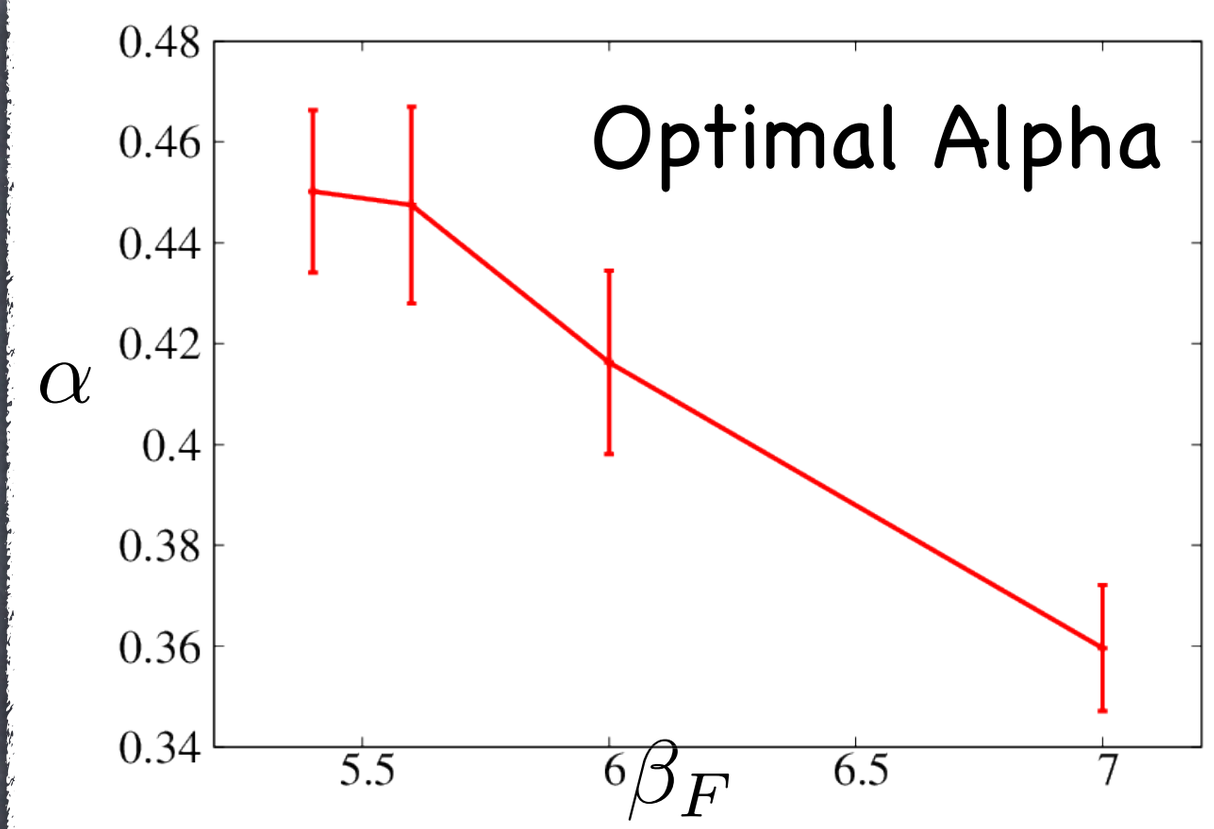


Scan over α to find the block transformation that reaches the renormalized trajectory the quickest.



Step scaling function, S_b defined where Δβ for both levels of blocking are equal.

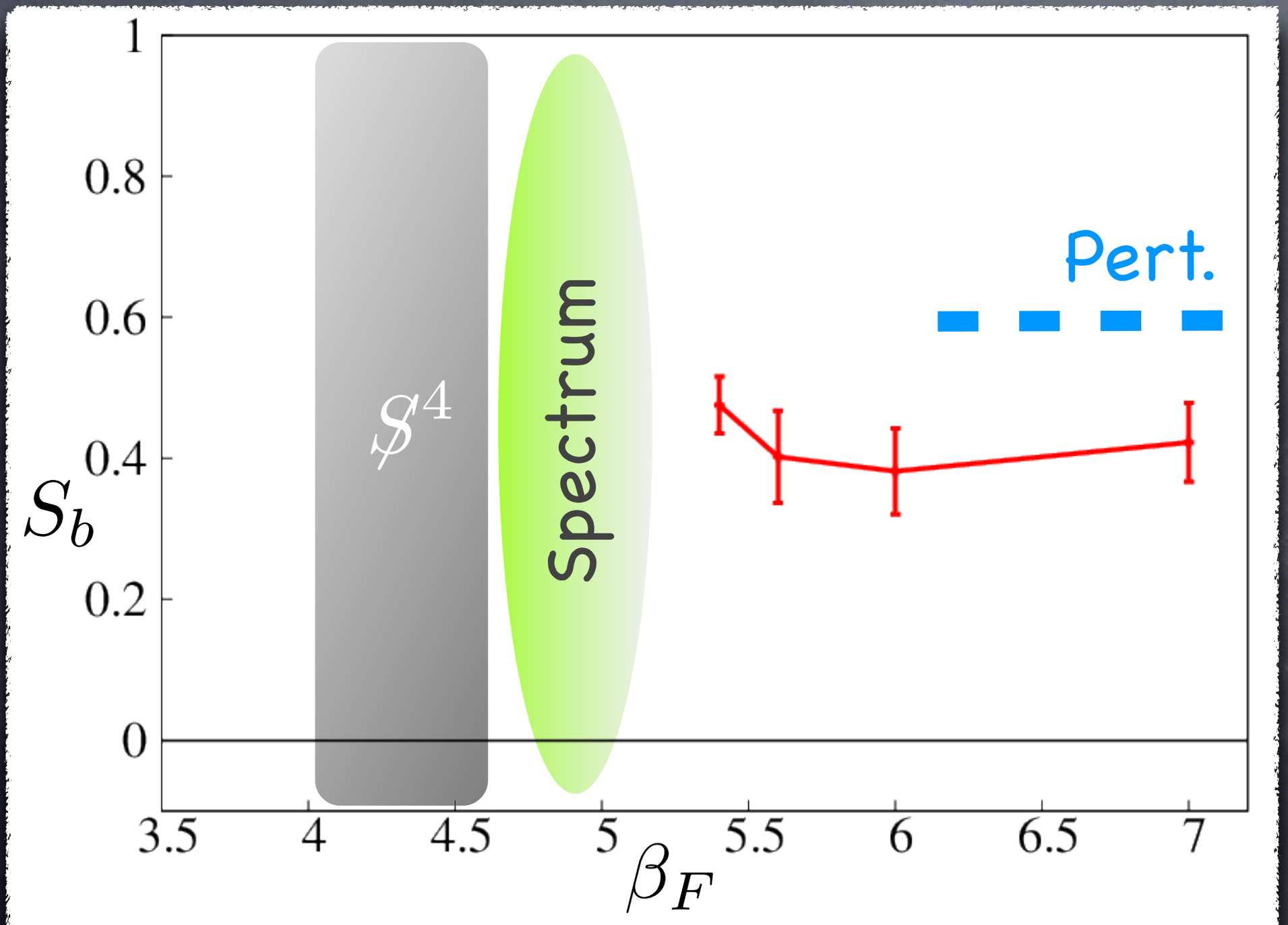




Matching between
24^3x48 blocked to 3^3x6
12^3x24 blocked to 3^3x6
6^3x12 blocked to 3^3x6

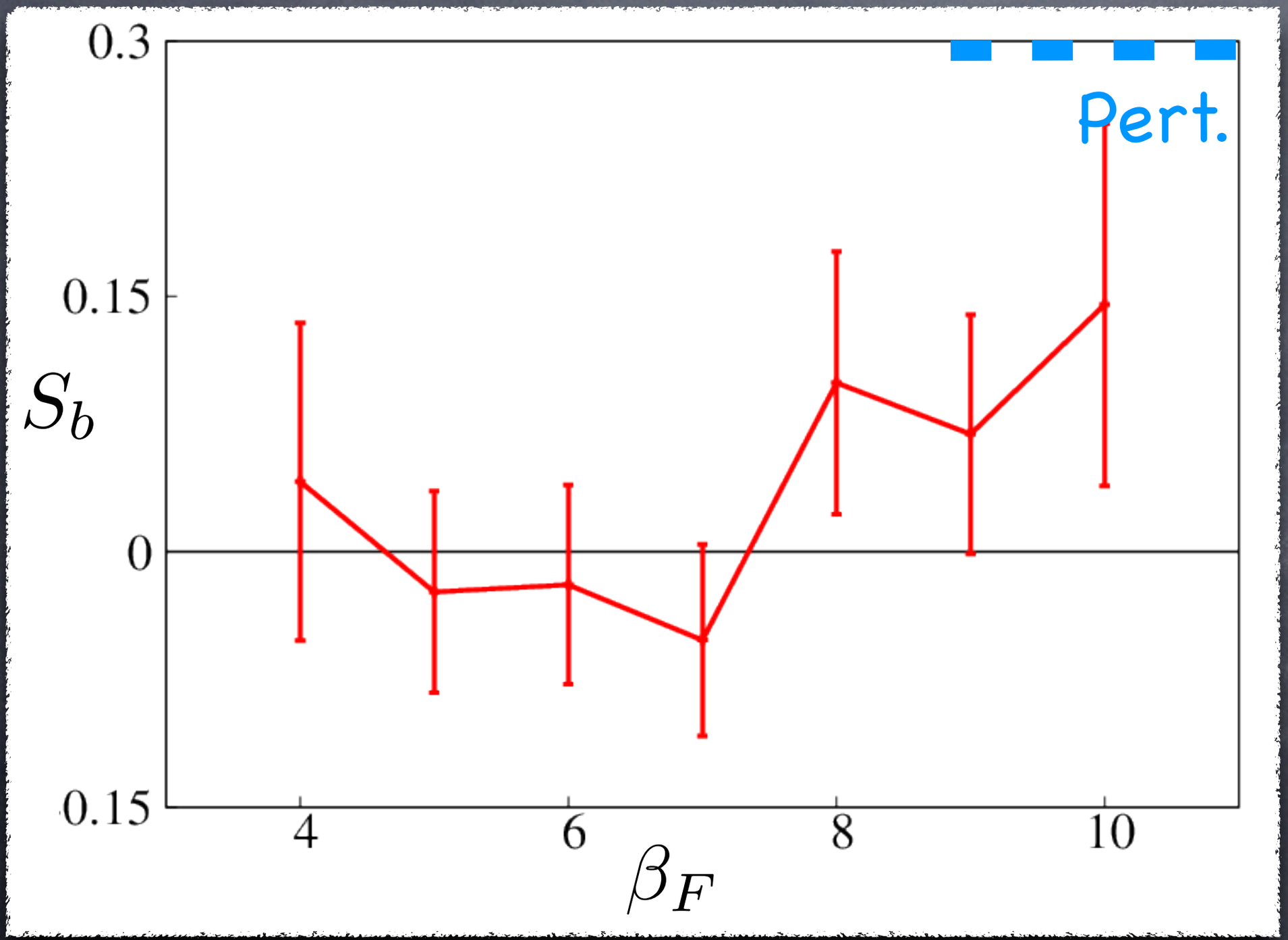
The optimal smearing parameter decreases with β.

8 Flavor Result



The step scaling function is comparable to the 2 loop value and connects perturbative and confining regions

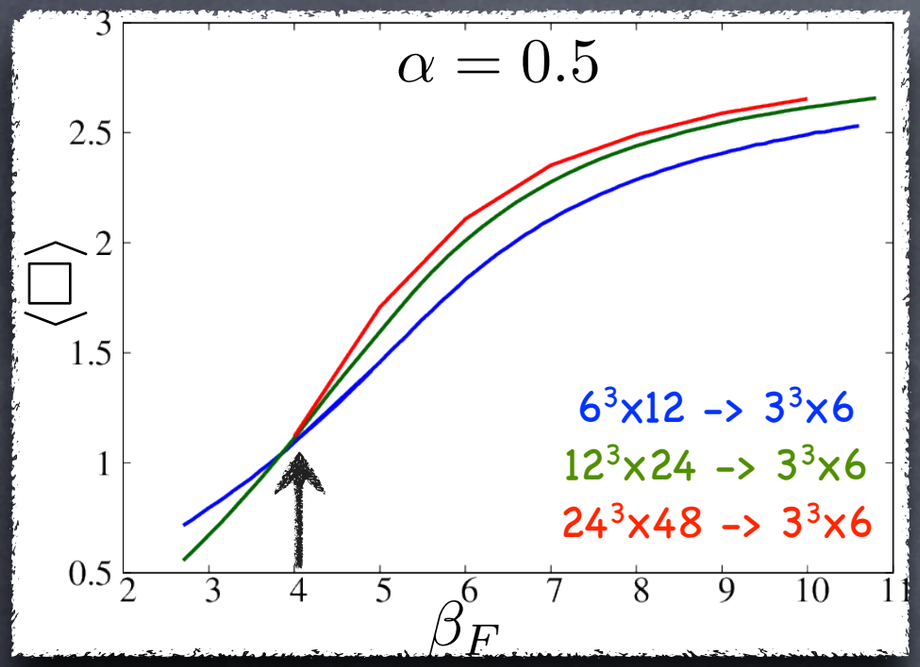
Errors determined by looking at different observables

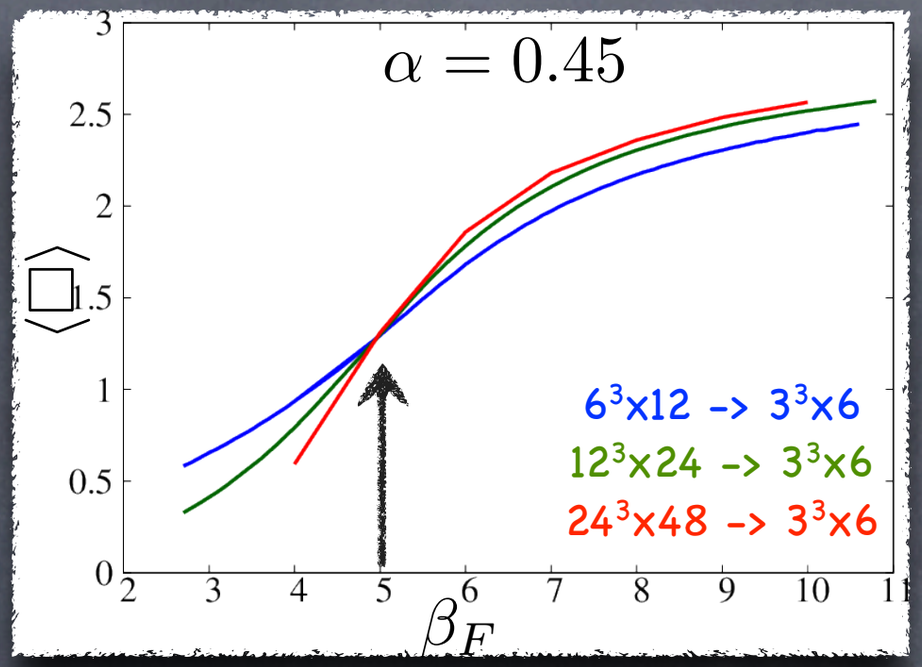


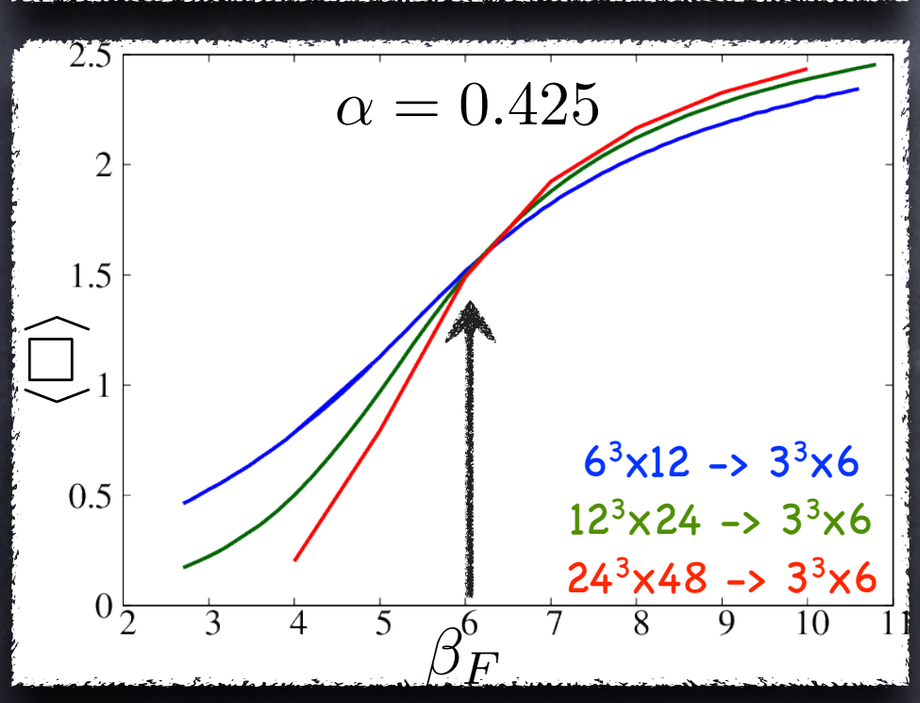
The step scaling function is consistent with zero for β={4-8}.

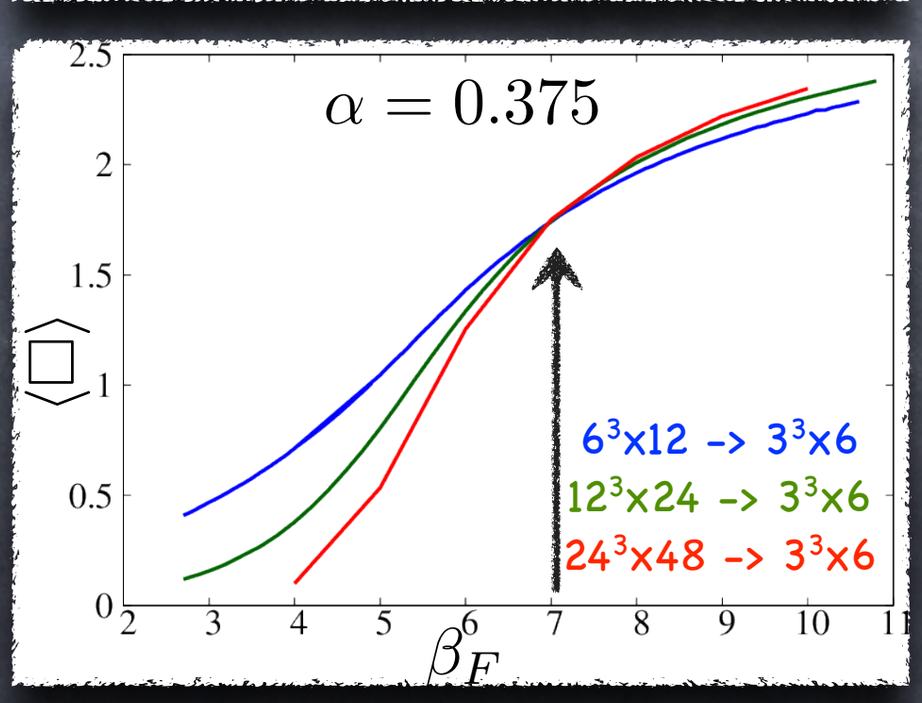
Errors determined by looking at different observables

12 Flavor Result





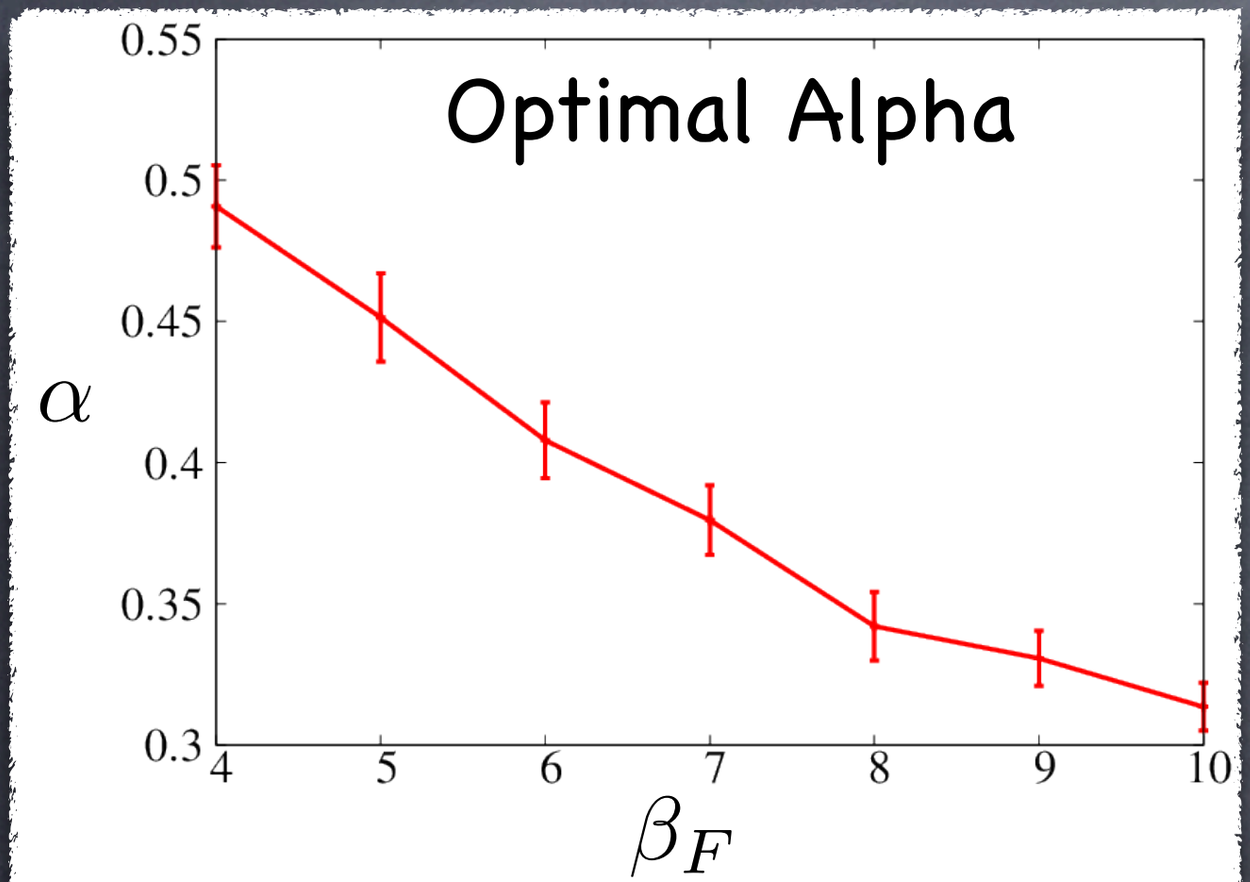


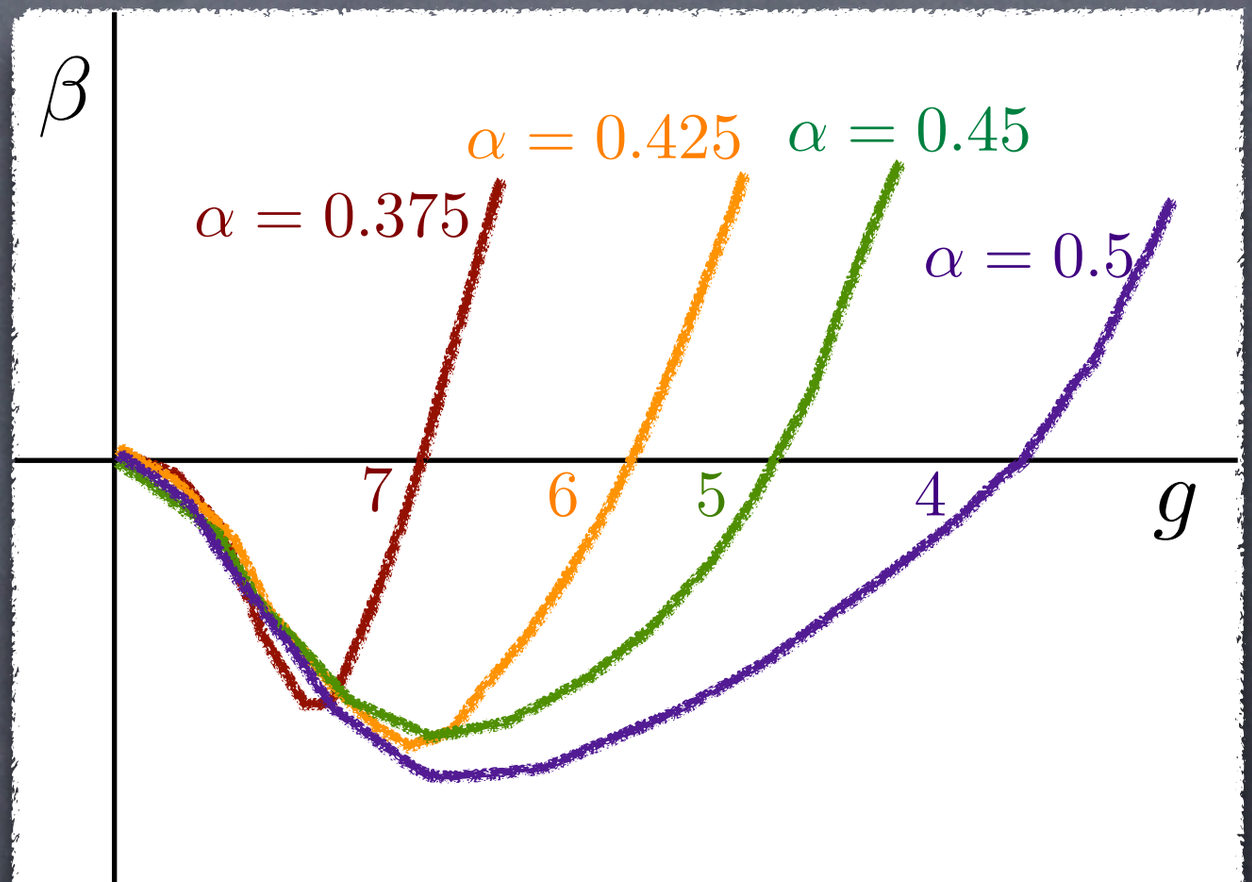


For different β values, the optimal α predicts S_b=0, shown here as the intersection of the three blocking levels.

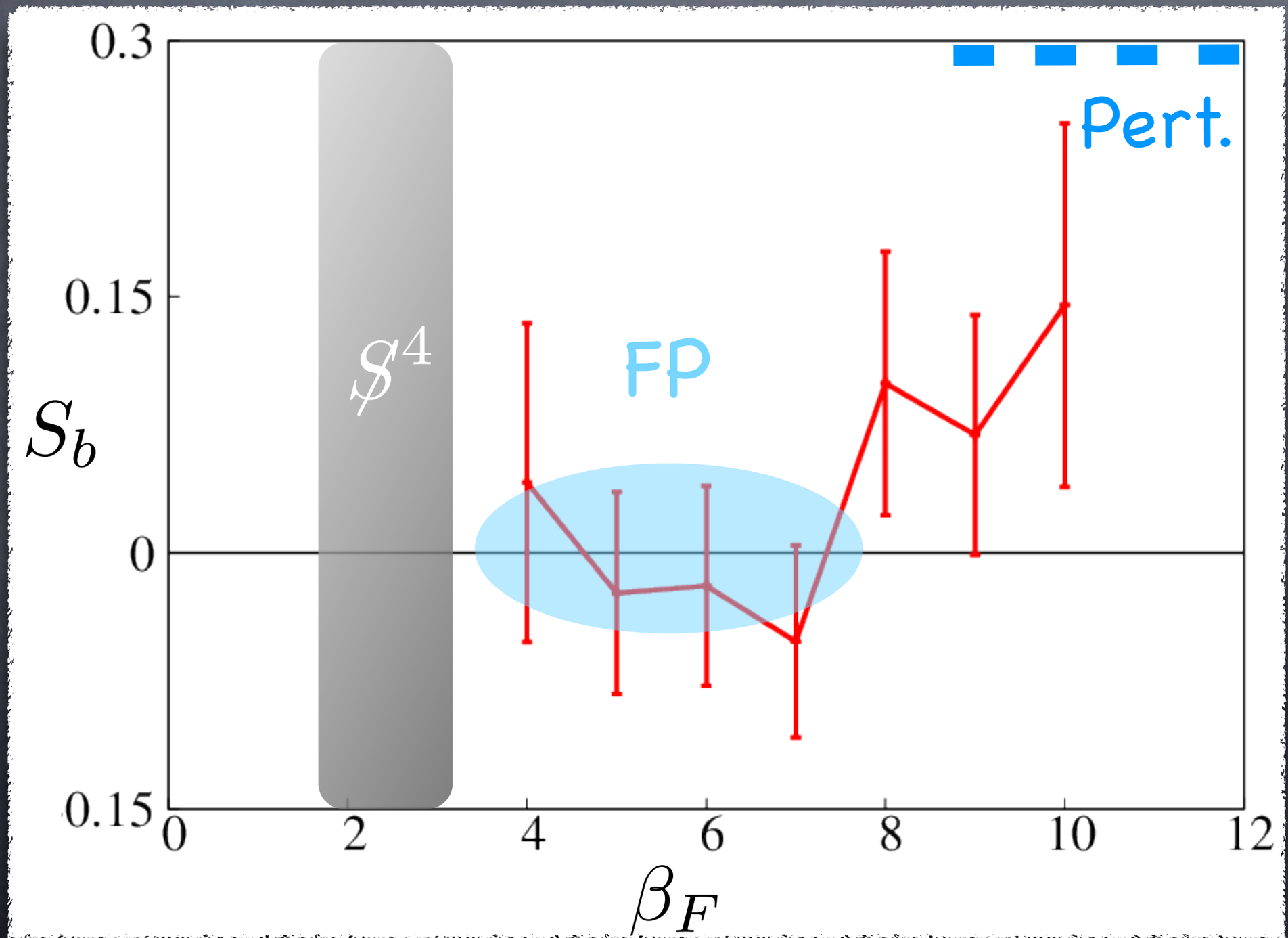
The Infrared Fixed point is moving!

12 Flavor Result

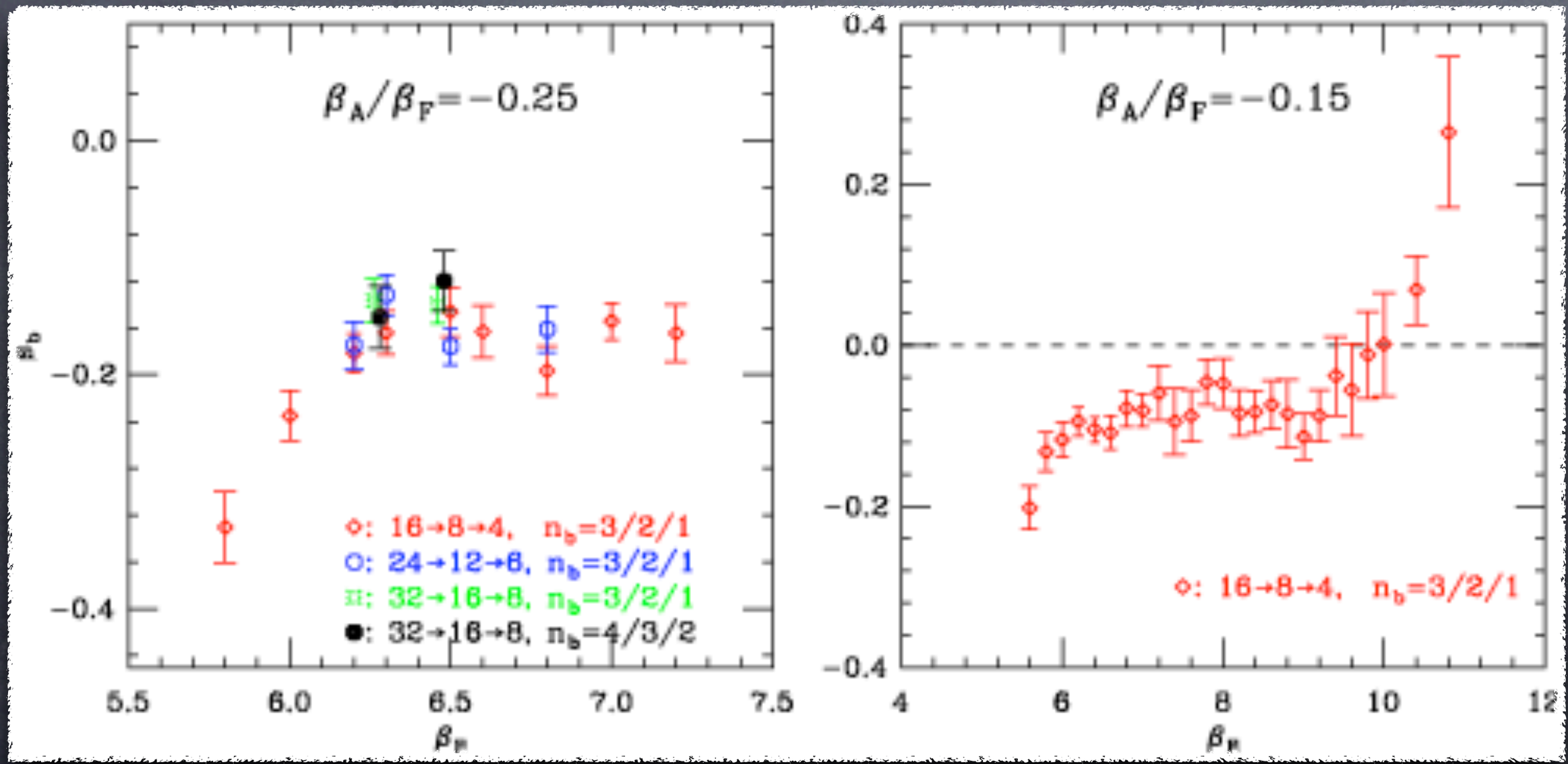




The optimization is choosing a fixed point at the simulation β_F, making the interpretation of MCRG subtle.


0.3
0.15
0
0.15
S_b
$\mathcal{S}^4$
FP
Pert.
0
2
4
6
8
10
12
β_F

12 Flavor Result



Hasenfratz SU(3) Nf=12 results from last year using a different action showing similar plateau behavior in strong coupling.

Conclusion

- We studied the MCRG behavior at couplings weaker than the S^4 broken phase at small fermion mass
- MCRG predicted bare step scaling function for 8 flavors is positive (Confining)
- MCRG predicted bare step scaling function for 12 flavors is consistent with an IR fixed point
- Complements Eigenvalues and Finite T studies (previous talks by A. Hasenfratz and D. Schaich)

Acknowledgments

- Anna, David, Anqi
- DOE Office of Science Graduate Fellowship
- USQCD
- University of Colorado Research Computing (Janus)
- NSF XSEDE
- Thank you and have a G'Day

Simulation

	8 Flavor	12 Flavor
Volumes	6^3x12 12^3x24 24^3x48	6^3x12 12^3x24 24^3x48
Couplings	5.0-7.0 4.9-7.0 5.4, 5.6, 6.0	2.6-9.0 2.7-8.8 4.0, 5.0, 6.0, 7.0
Masses	0.02 0.01 0.0025	0.02 0.01 0.0025

24^3x48 -> 12^3x24 -> 6^3x12 -> 3^3x6

12^3x24 -> 6^3x12 -> 3^3x6

6^3x12 -> 3^3x6

Blocked observables:

- Plaquette
- 6 Link Loops
- 8 Link Loop

NHYP smeared block transformation:

0.2

0.2

α