Walking technicolor on the lattice

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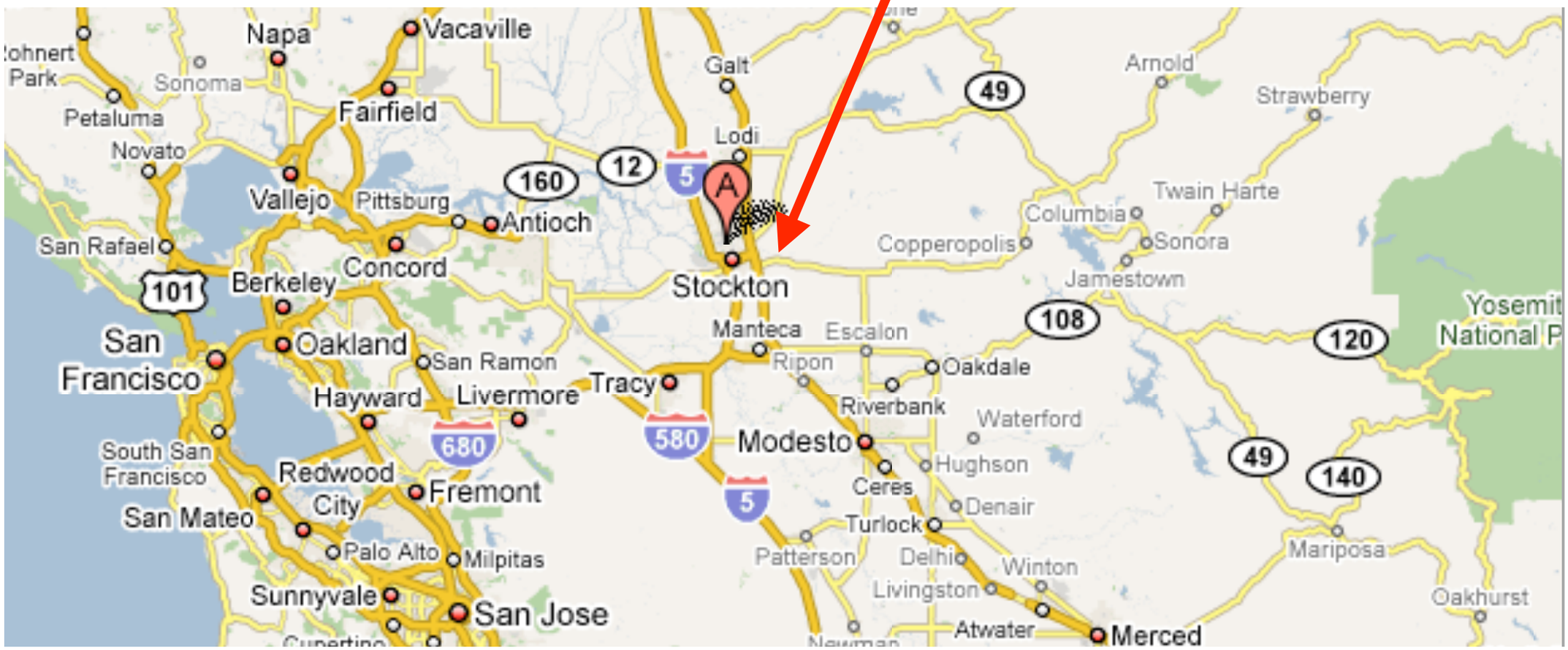
where is UoP?



3 lattice faculty: Jim Hetrick, Jimmy Juge, KH

oldest university in California (1851)

Stockton “foreclosure capital” of the USA

outline

- motivation for technicolor
- walking technicolor
- strategy
- something unexpected for fundamental?
- outlook

technicolor

replace Higgs with strong gauge theory

good:

avoid triviality, fine-tuning

QCD disguised as Electroweak

bad:

quark masses - extended technicolor

flavor-changing neutral currents

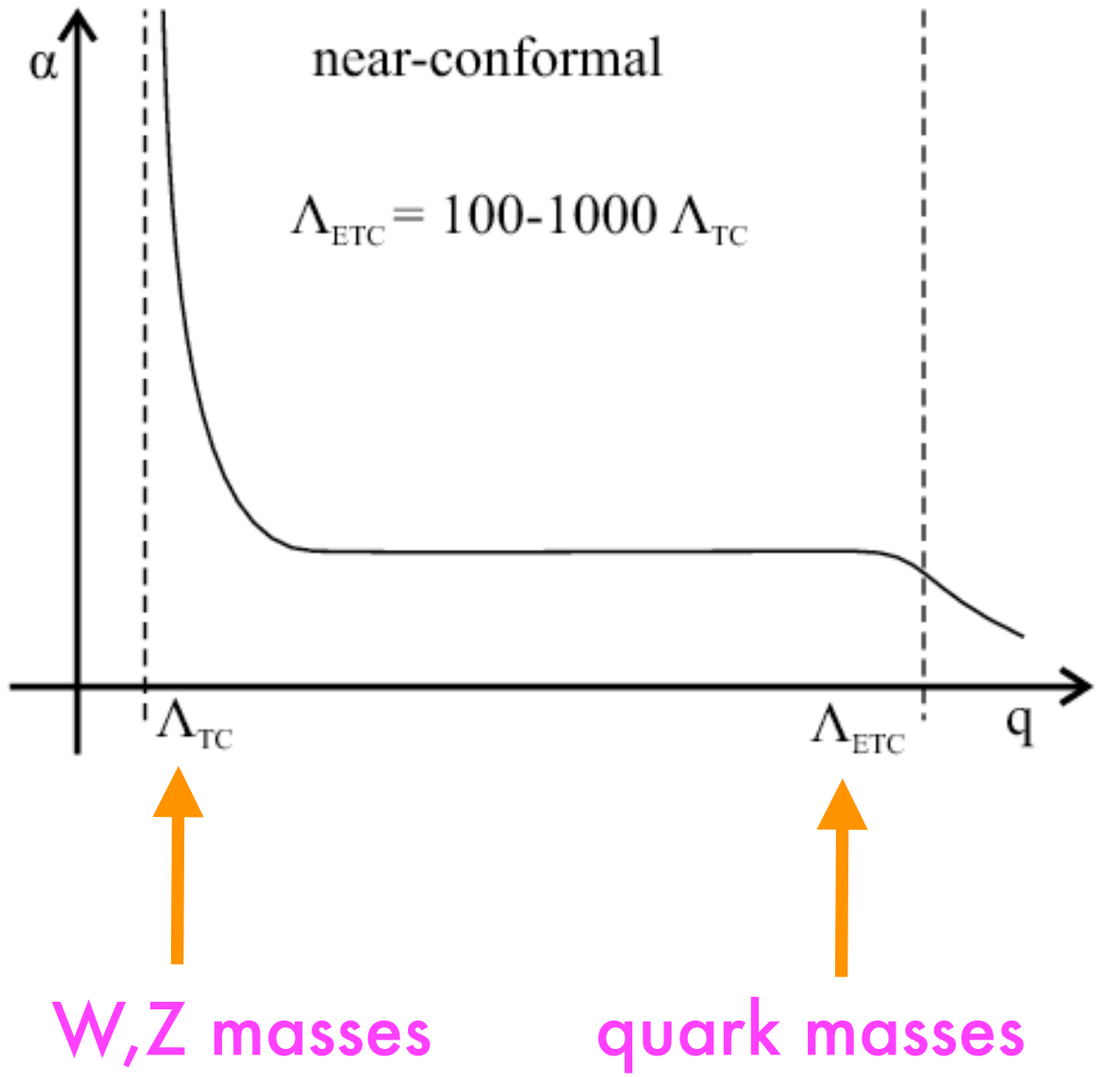
electroweak precision data

light composite Higgs?

what's new?

walking technicolor

if coupling walks, separate scales
fix FCNC's?
light composite Higgs?

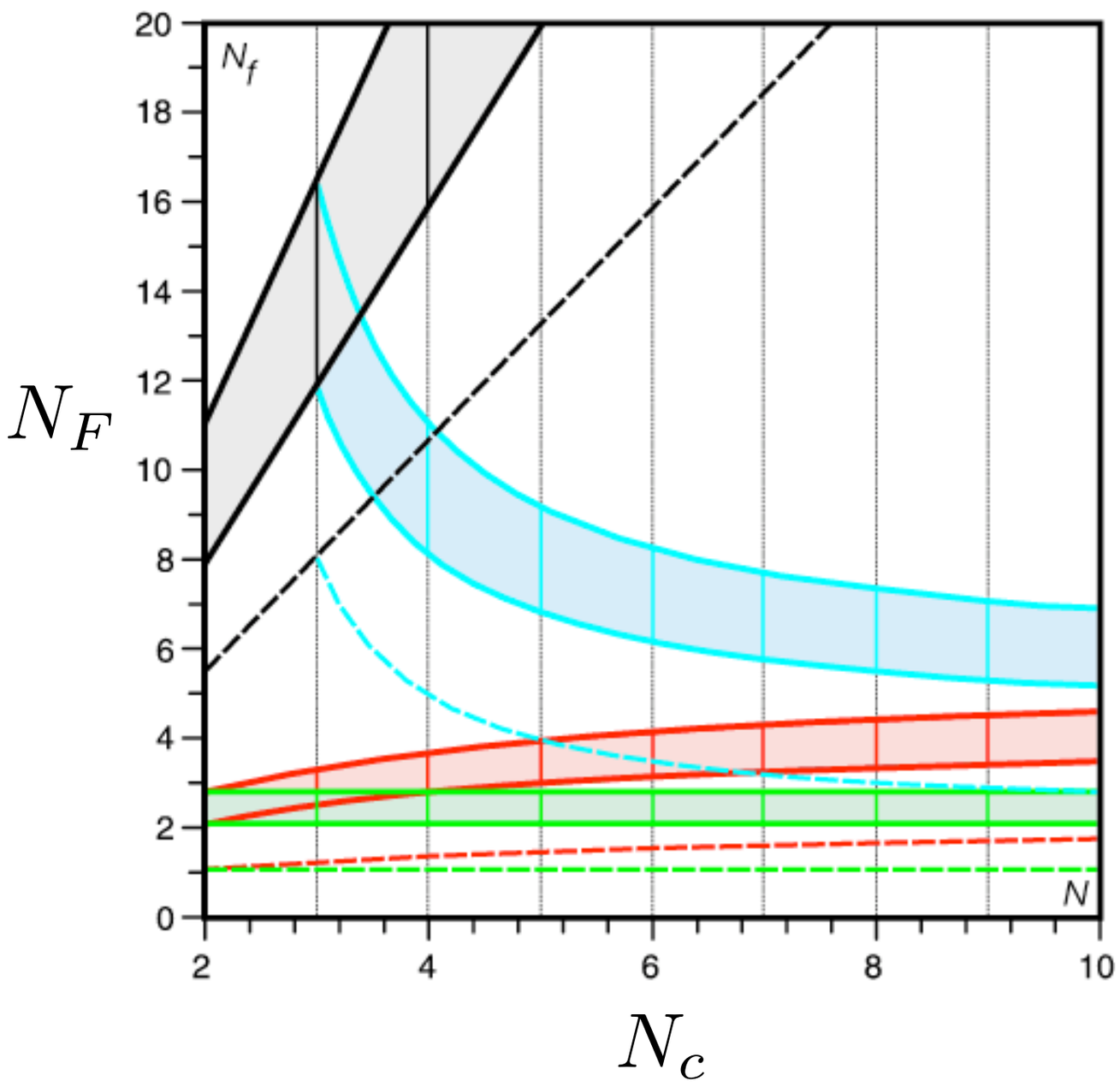


techniquark fundamental rep.
need large N_F

bad for EW precision

extended technicolor difficult

possible theories

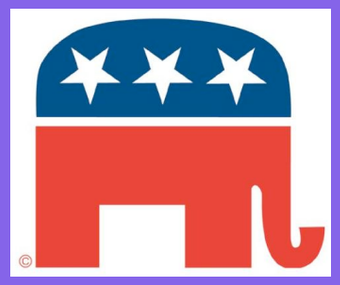


conformal window
upper curve: AF lost
lower curve: chiral SB

gray: fundamental
blue: 2-index antisymmetric
red: 2-index symmetric
green: adjoint

perturbative

want to be below window
(except Georgi,Luty)



candidates

EW precision prefers small N_F S parameter

$N_c = 3$

2-index Symmetric $N_F(\chi SB) = 2.5$

fundamental $N_F(\chi SB) = 11.91$

$N_F = 2$ 2-index Symm. 3 Goldstone bosons for W's, Z

best candidate?

$N_F = 12$ fundamental borderline, test case

less likely for new physics

lattice problems

- large bare coupling: QCD-like for all N_F
- small bare coupling: femto-world, free theory
- Wilson: explicit chiral SB
- Staggered: taste-breaking, what N_F?
- Overlap: expensive

strategy

examine eigenvalues of the Dirac operator λ

if chiral SB and $\frac{1}{F_\pi} \ll L \ll \frac{1}{m_\pi}$ ϵ-regime

chiral Lagrangian dominated by zero modes

eigenvalue distributions known Random Matrix Theory

$p_k(z,\mu)$ $z = \lambda\Sigma V, \mu = m\Sigma V$ Σ quark condensate

if conformal $\rho(\lambda) \sim \lambda^{3+\gamma}$ anomalous dimension

staggered simulations

2 and 3 flavors staggered fermions, fundamental rep.

no rooting i.e. continuum $N_F = 8, 12$

Asqtad action, RHMC algorithm

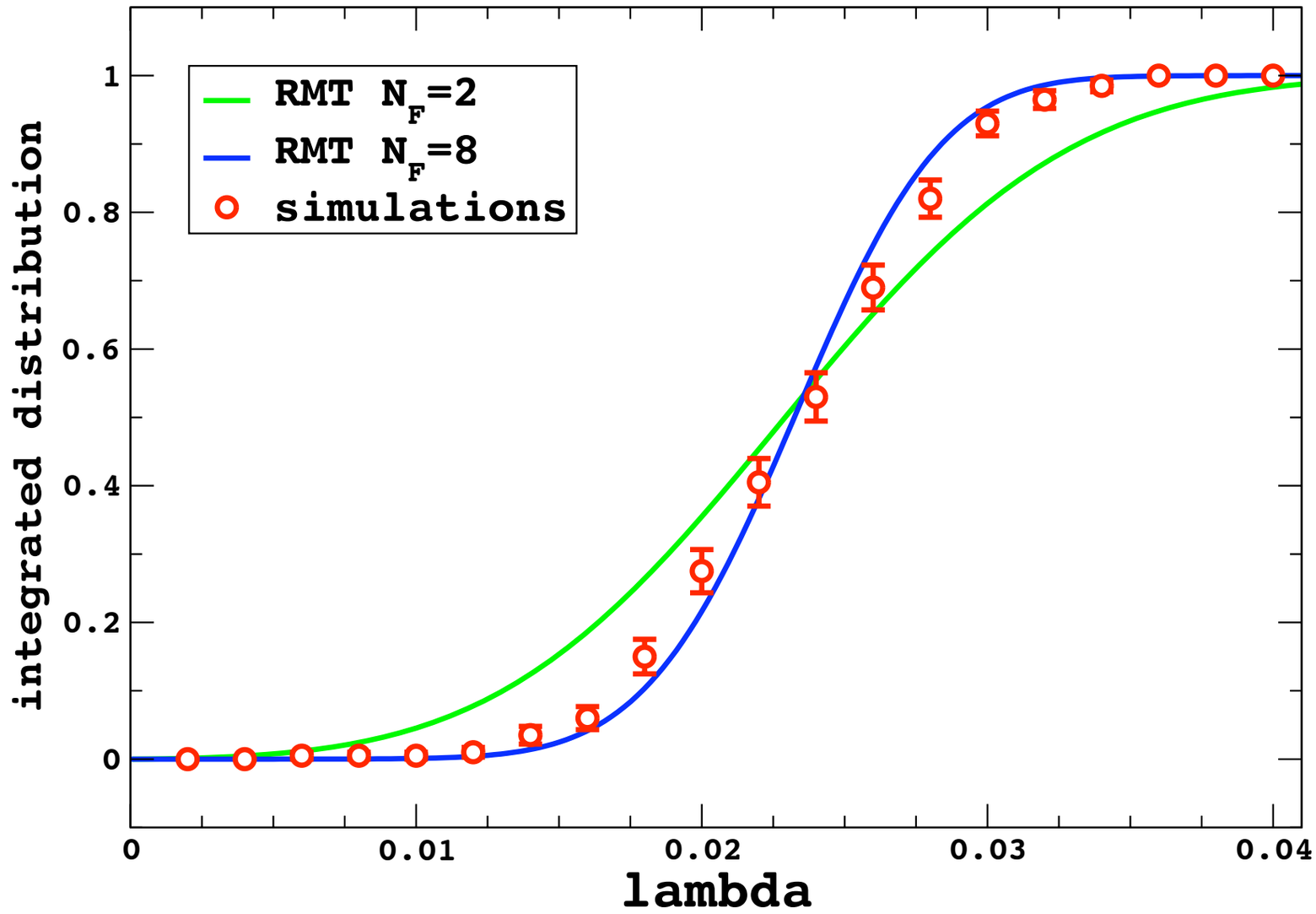
volume 10^4 quark mass $ma = 0.01$ $m < \lambda$

look at 1st eigenvalue distribution $p_1(\lambda)$

integrated distribution $\int_0^\lambda p_1(\lambda')d\lambda'$

RMT: fit Σ $\frac{\langle \lambda_1 \rangle}{m} = \frac{\langle z_1 \rangle}{\mu}$ → predict distribution

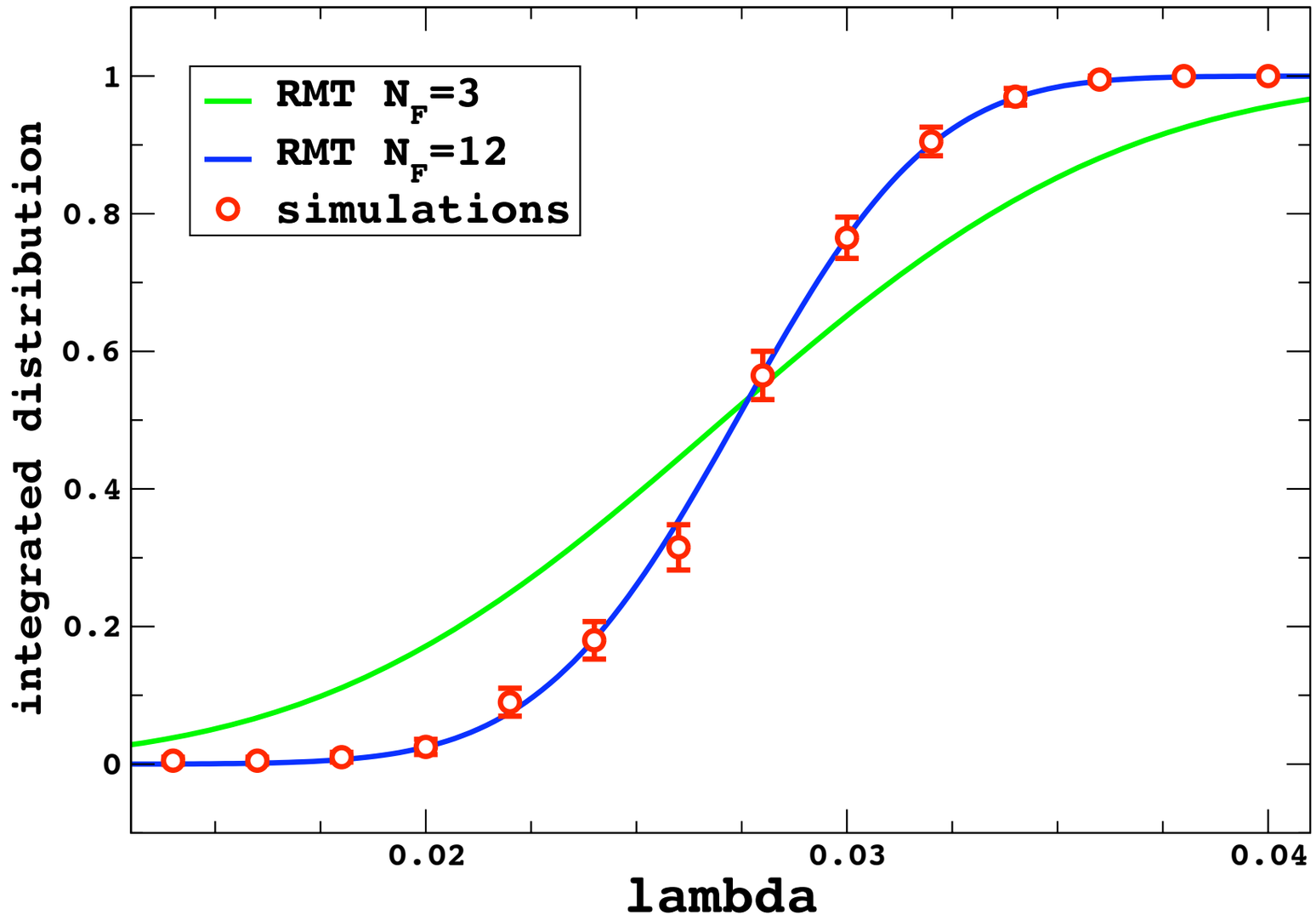
2 staggered flavors



chiral SB with continuum value $N_F = 8$? QCD-like

consistent with Fleming & co., Pallante & co.

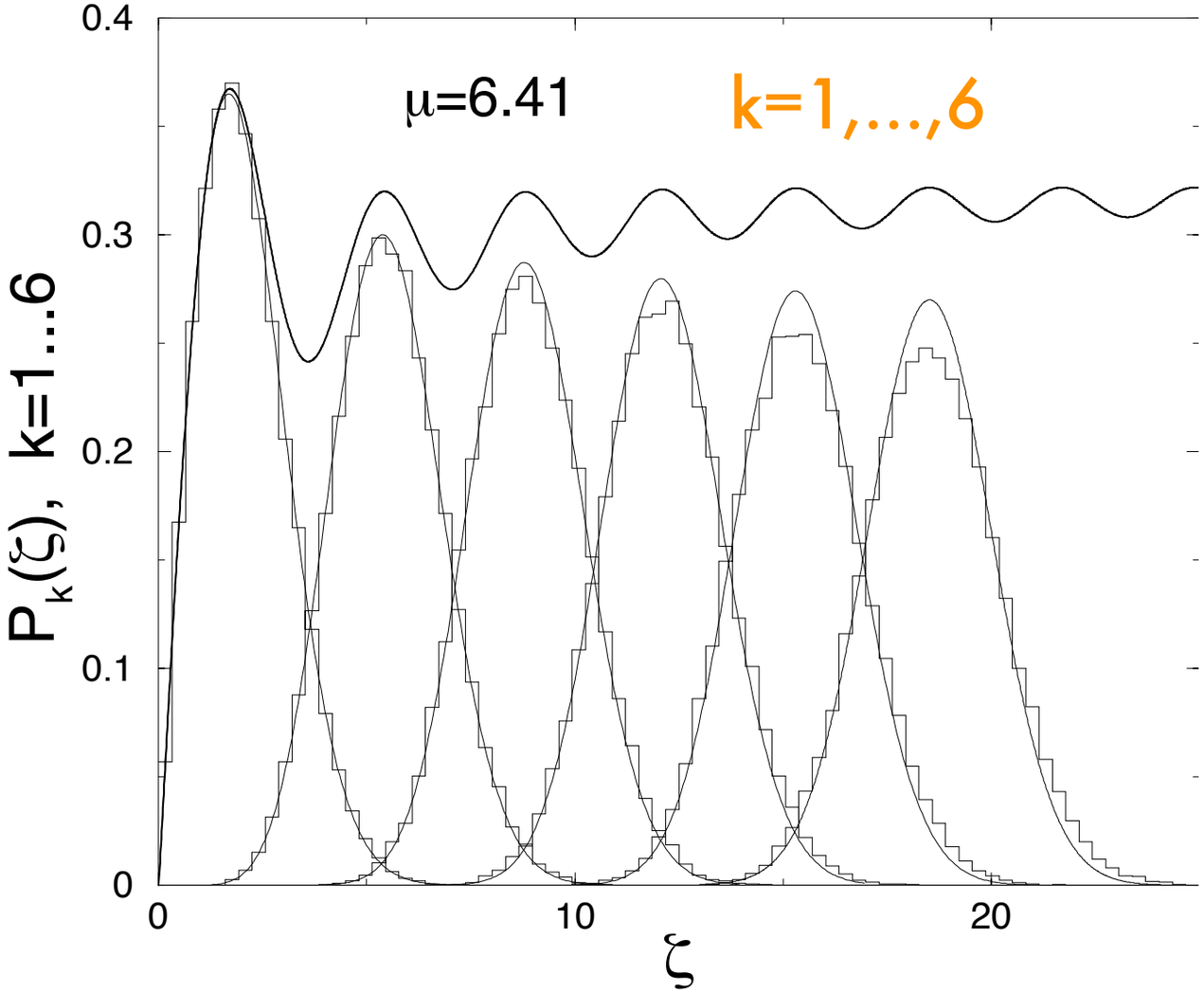
3 staggered flavors



surprise: is $N_F = 12$ outside conformal window?

not consistent with Fleming & co.

taste-breaking & effective N_F



Damgaard et al.
PLB 495, 263 (2000)

staggered 1 flavor eigenvalue distributions

superb agreement with $N_F = 1$ RMT

NOT $N_F = 4$

taste-breaking reduces effective N_F

crucial when hunting conformal window

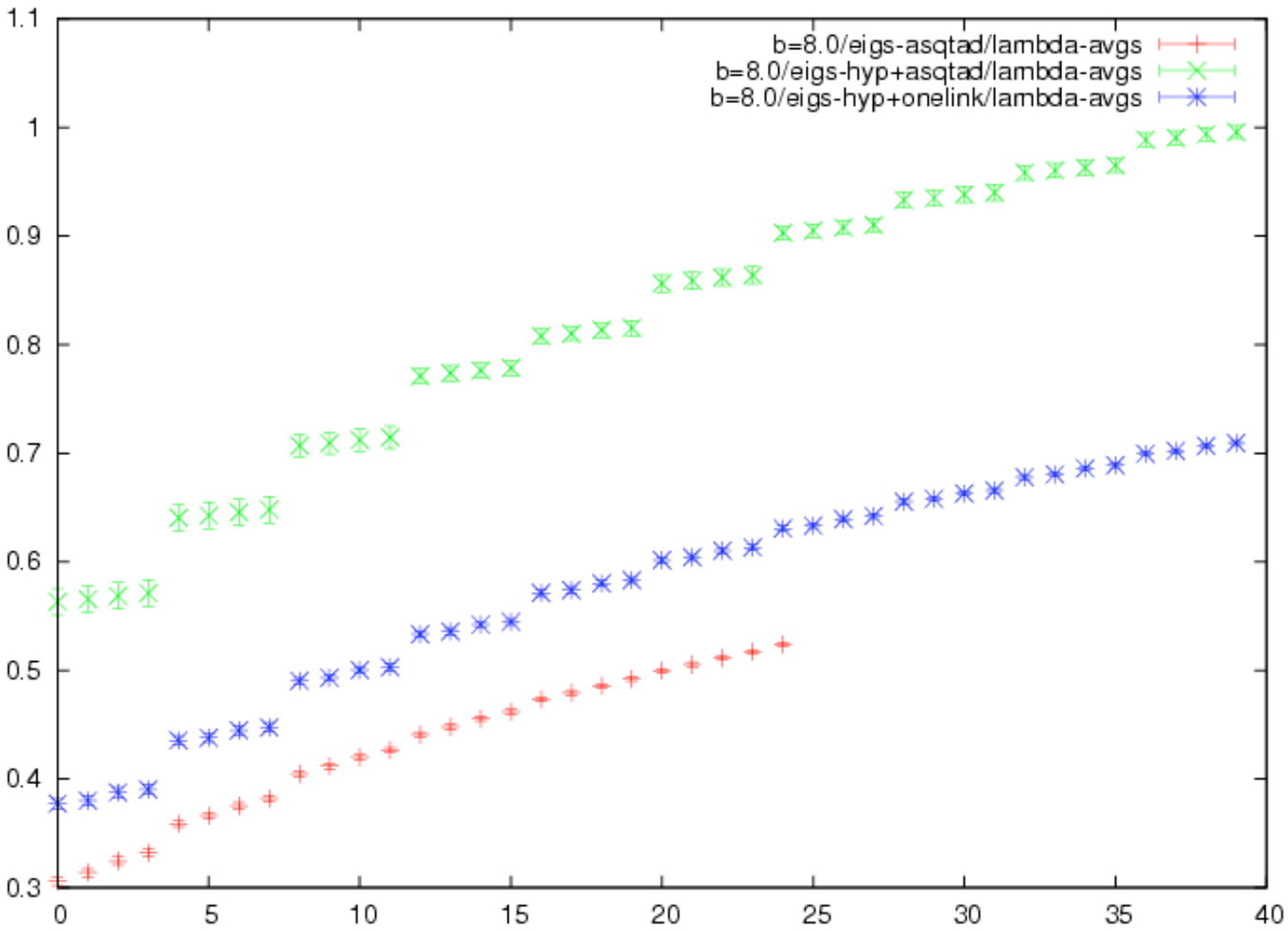
criticism

have not measured F_π, m_π
do not know if ϵ-regime conditions met

have not measured taste-breaking
what is the effective # of light pions?

can conformal theory with finite quark mass
fake RMT with chiral SB?

improve taste-breaking

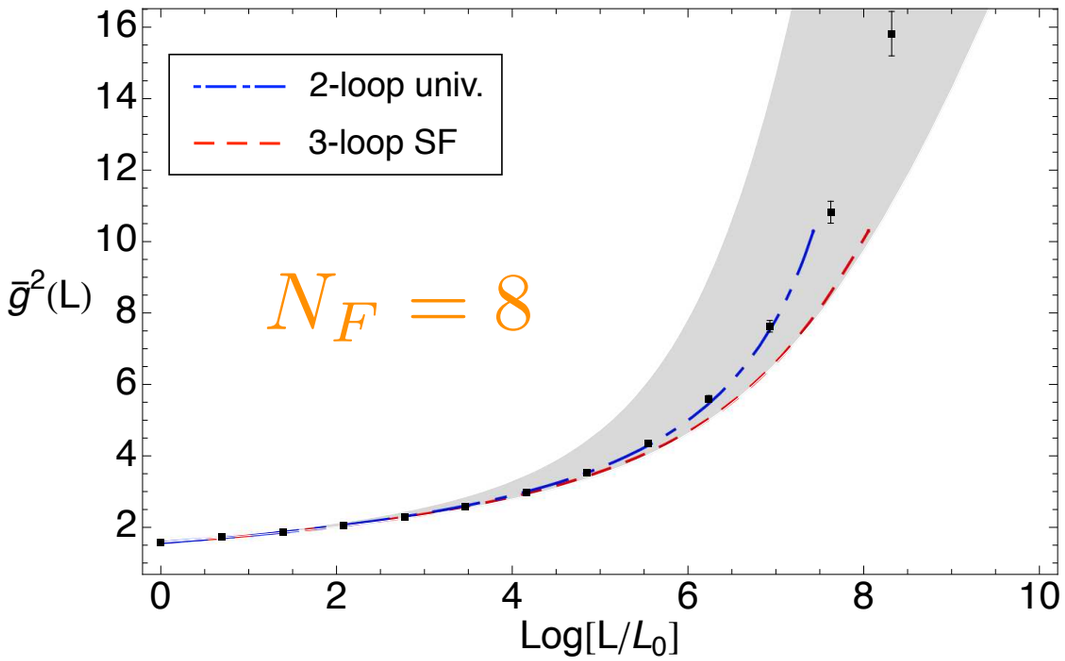


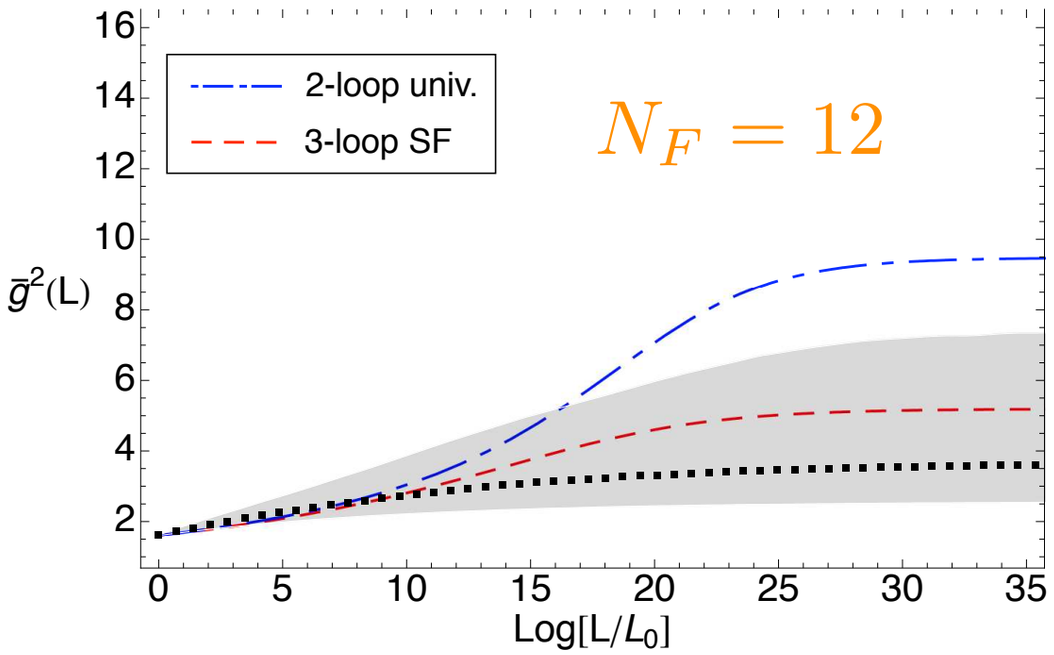
1 staggered flavor

eigenvalue quartets taste-symmetry restored

improved Dirac operator essential

running coupling





Appelquist, Fleming, Neil,
PRL 100 (2008),171607

2,3 staggered flavors, fundamental

Schrodinger functional, box-size L

large L correspond to low energy

8 flavors: coupling large at low energy - - QCD-like

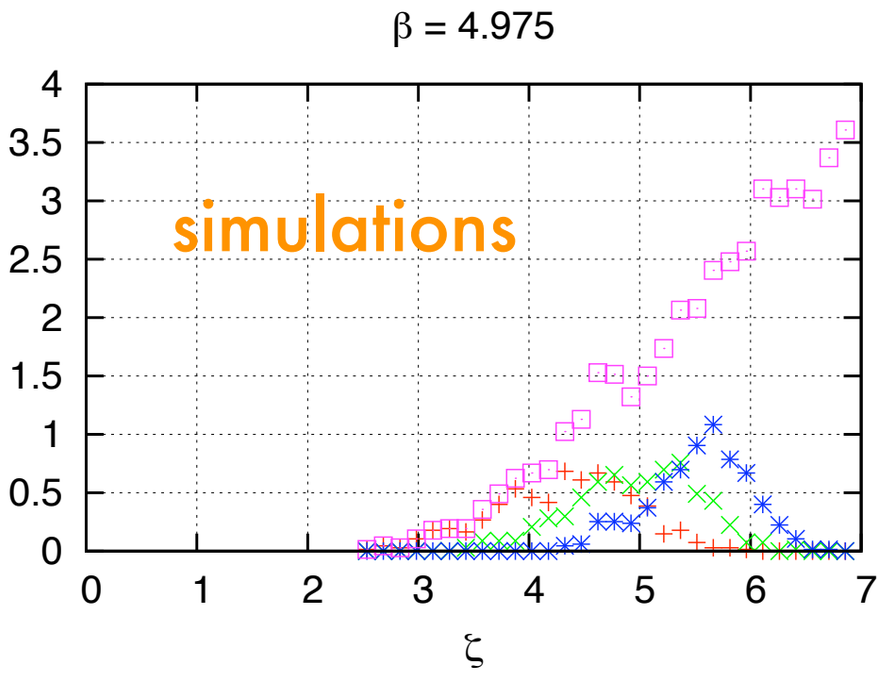
12 flavors: coupling freezes at low energy - - conformal

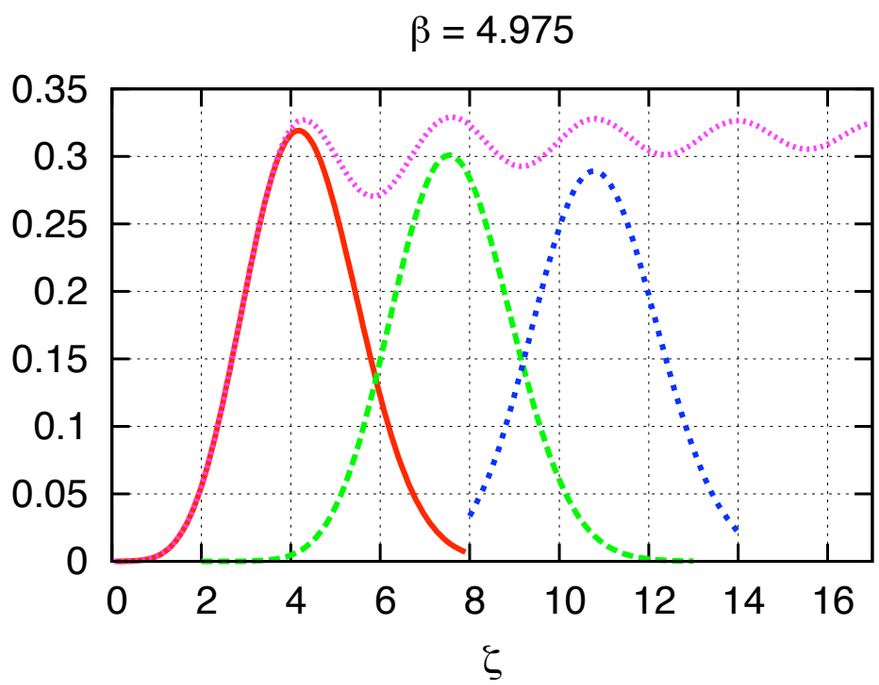
overlap simulations

overlap fermions, 2 flavors, 2-index symmetric rep.

topology-conserving algorithm, volume $6^4, ma = 0.05$

fit condensate, predict $\rho(z) = \sum_{k=1}^{\infty} p_k(z)$





theory not QCD-like?

consistent with DeGrand, Svetitsky, Shamir

outlook

- fundamental $N_F = 12$ might not be settled
- 2-index symmetric maybe conformal

- first runs - only beginning project
- taste-breaking crucial in RMT
- Asqtad, stout staggered, HISQ, HYP, ... ?
- 2-index symmetric theory more attractive, fundamental theory is the testing ground