Probing technicolor theories with staggered fermions

Kieran Holland (UoP)

Lattice Higgs Collaboration
Zoltan Fodor (Wuppertal), Julius Kuti (UCSD),
Daniel Nogradi (UCSD), Chris Schroeder (UCSD)

outline

- motivation for technicolor
- near-conformal theories
- strategy
- something unexpected for fundamental?
- outlook

technicolor

replace Higgs with strong gauge theory

good:

avoid triviality, fine-tuning

duplicate QCD

what's new?

bad:

flavor-changing neutral currents

electroweak precision data

quark masses - extended technicolor

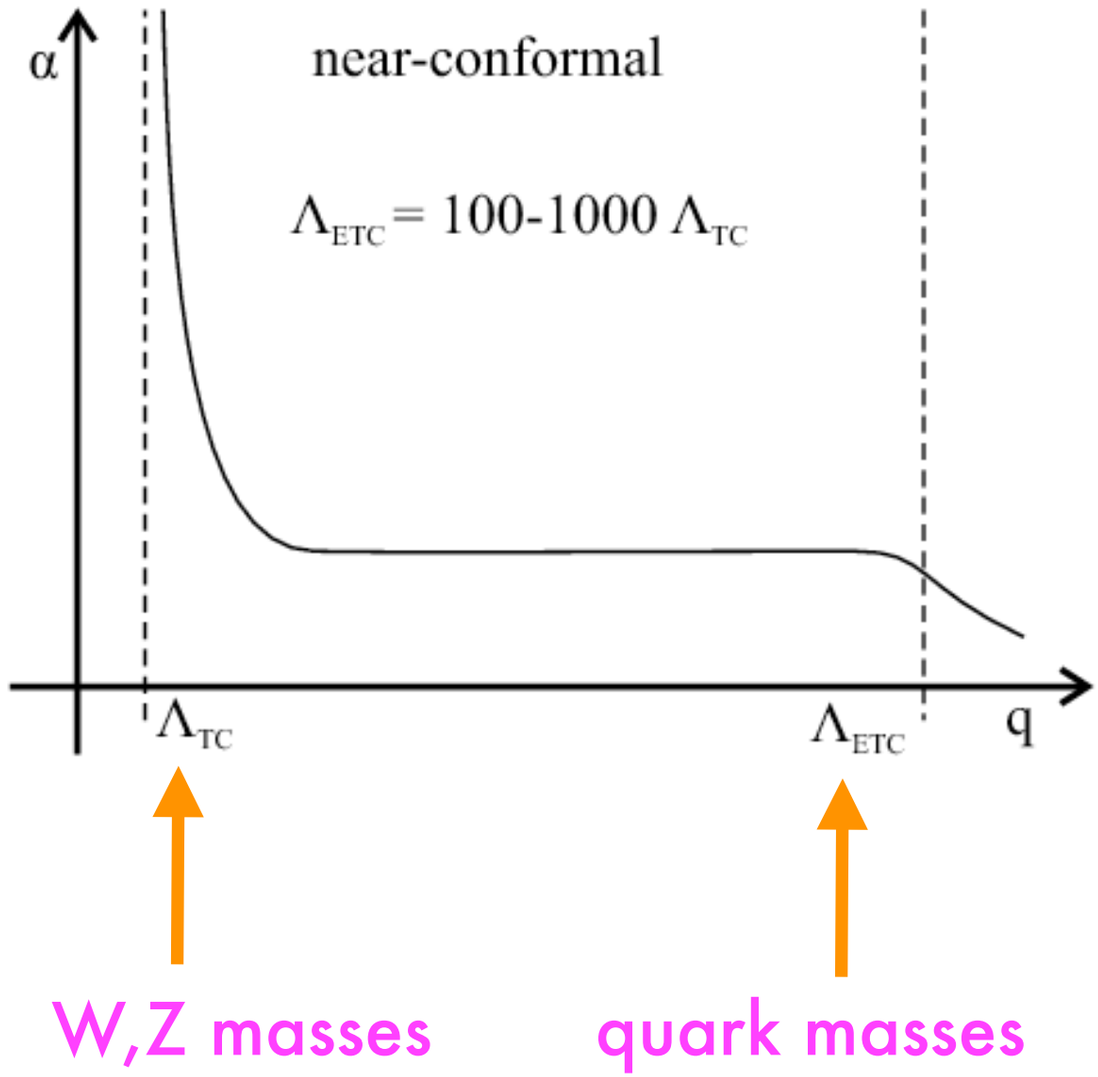
light composite Higgs?

walking technicolor

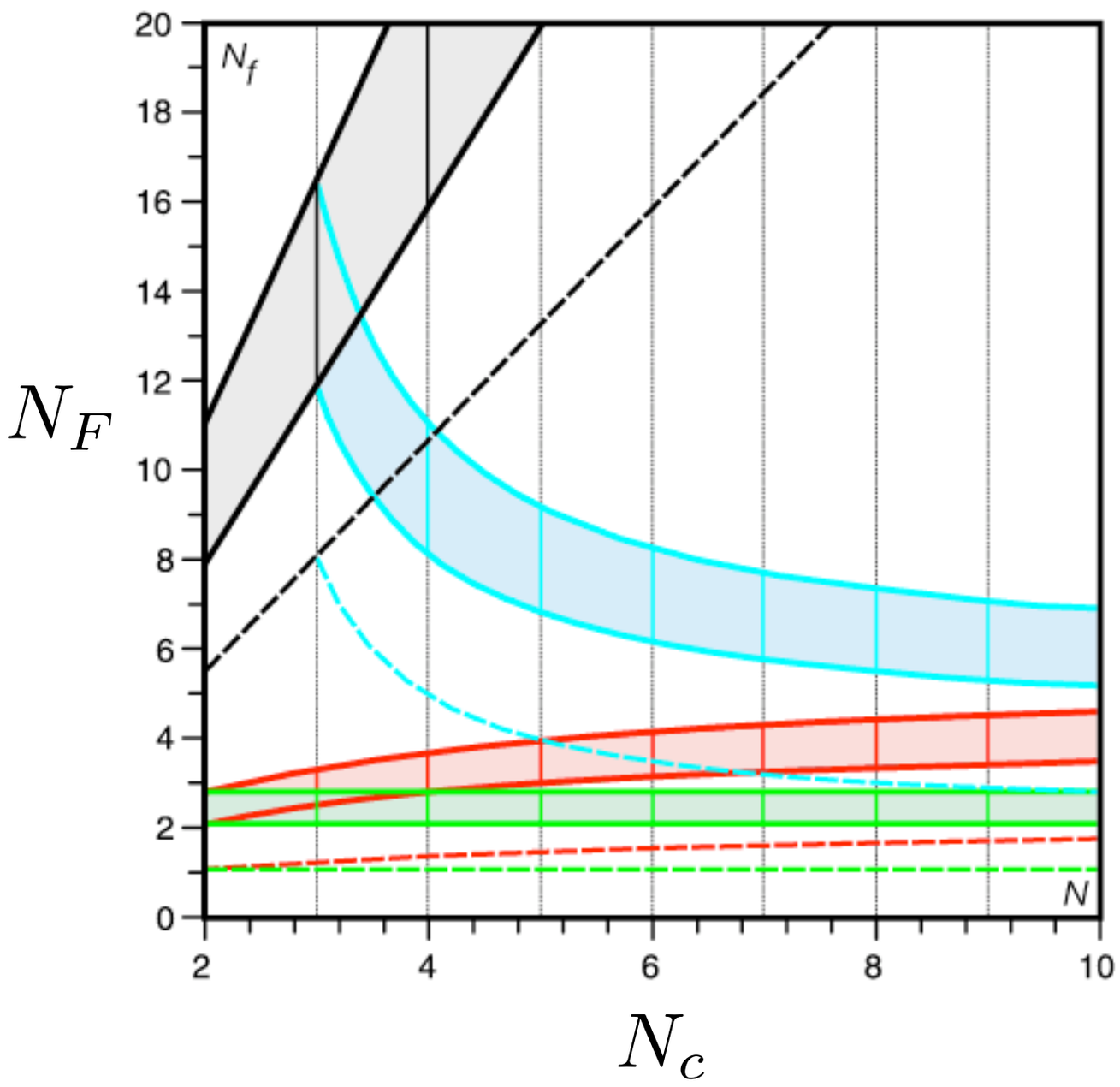
if coupling walks, separate scales
fix FCNC's
light composite Higgs?

techniquark fundamental rep.
need large N_F

bad for EW precision



possible theories

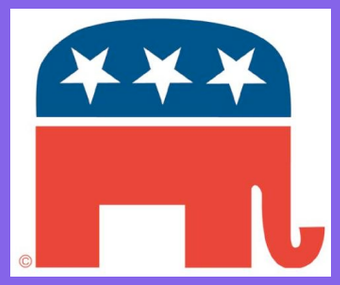


conformal window
upper curve: AF lost
lower curve: chiral SB

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? overlap simulations (talk by Nogradi)

$N_F = 12$ 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

simulations

2 and 3 flavors staggered fermions, fundamental rep.

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

Asqtad action, RHMC algorithm

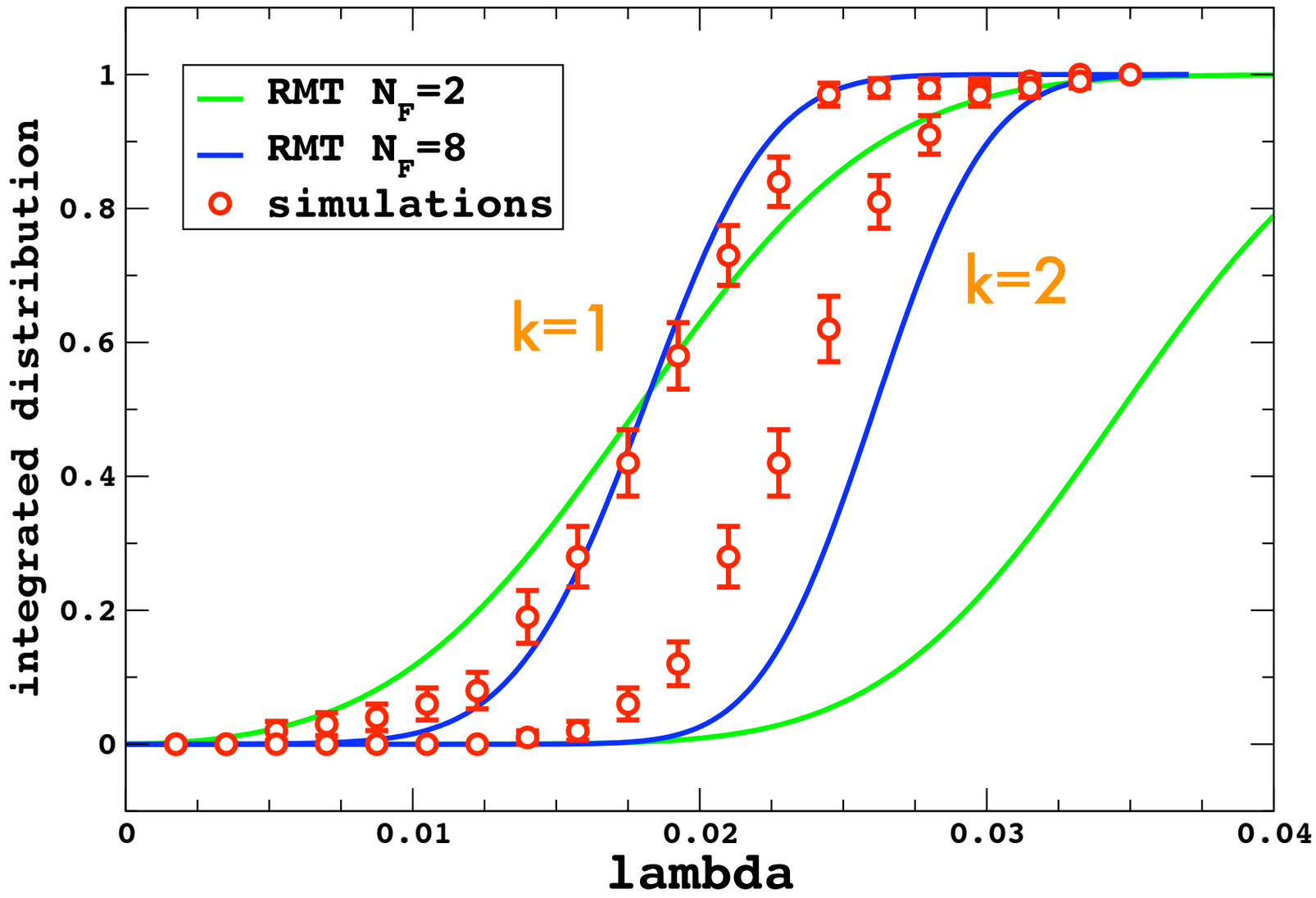
volume 10^4 quark mass $ma = 0.01$ $m < \lambda$

look at 1st, 2nd eigenvalues $p_k(\lambda), k = 1, 2$

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

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

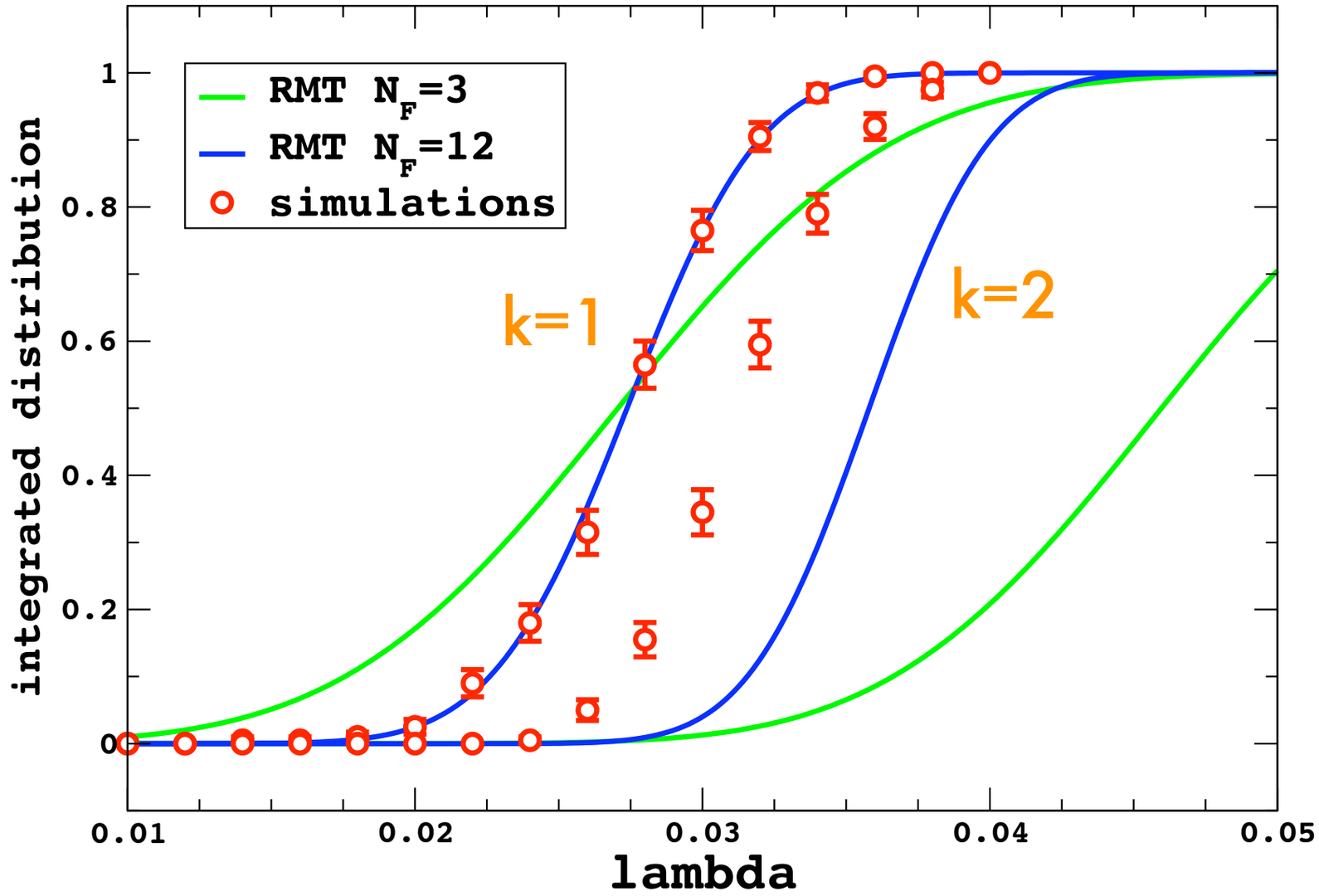
2 staggered flavors



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

consistent with Fleming & co., Pallante & co.

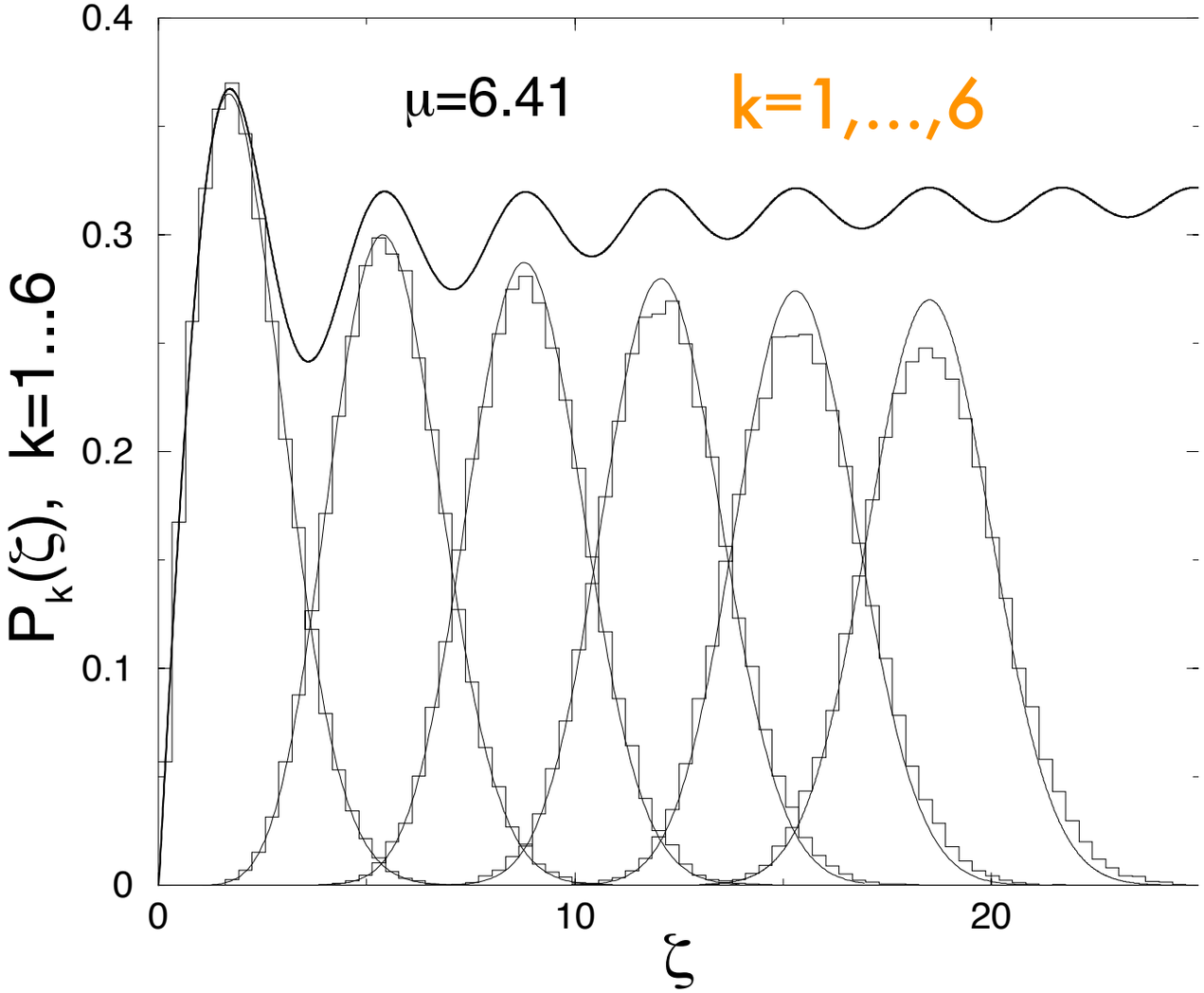
3 staggered flavors



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

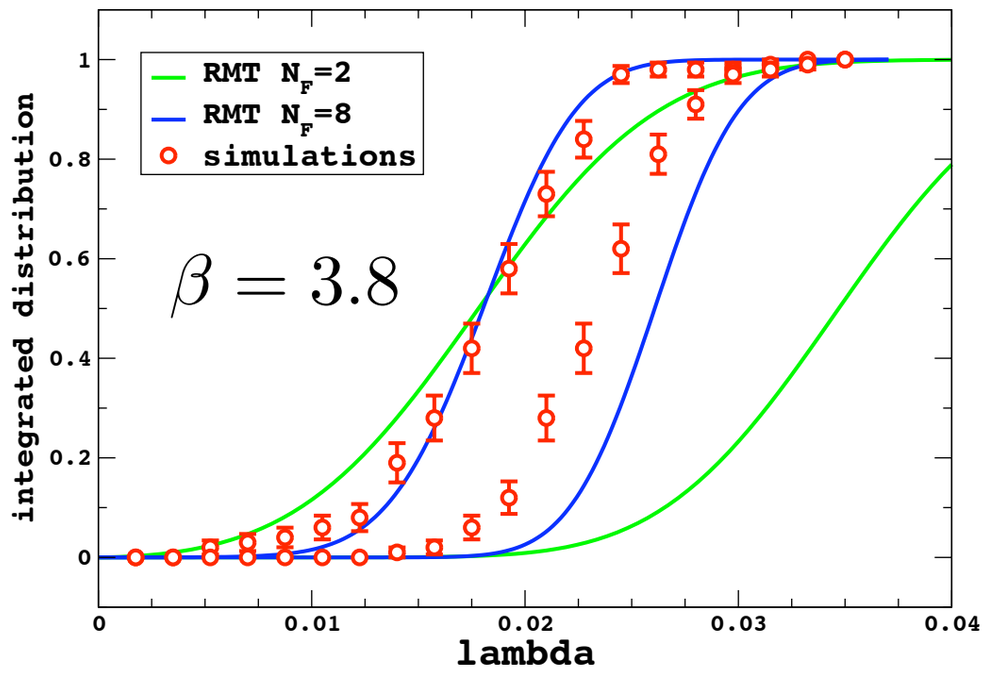
have not measured taste-breaking
what is the effective # of light pions?

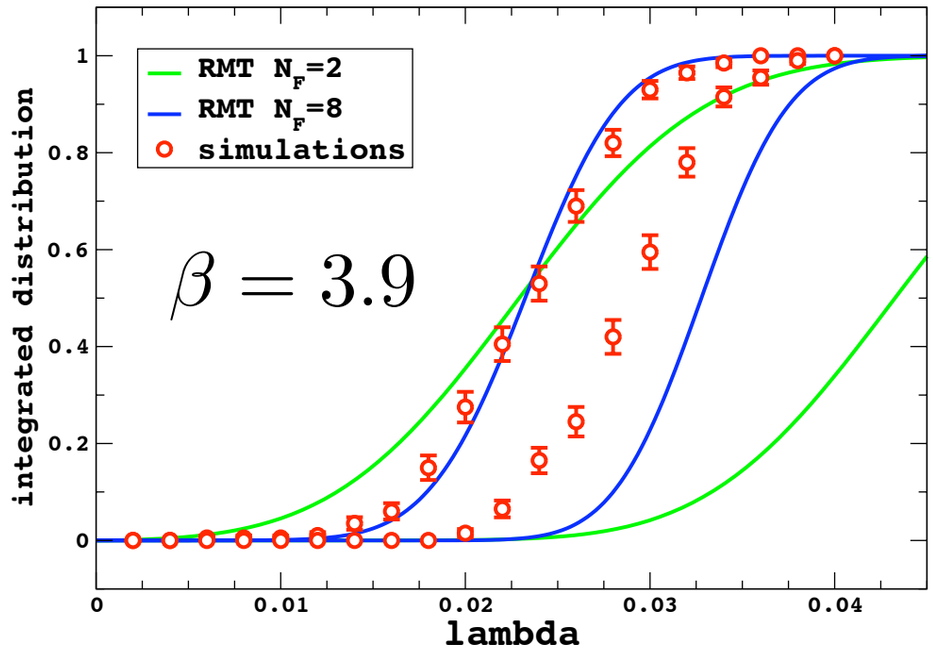
can conformal theory with finite quark mass
fake RMT with chiral SB?

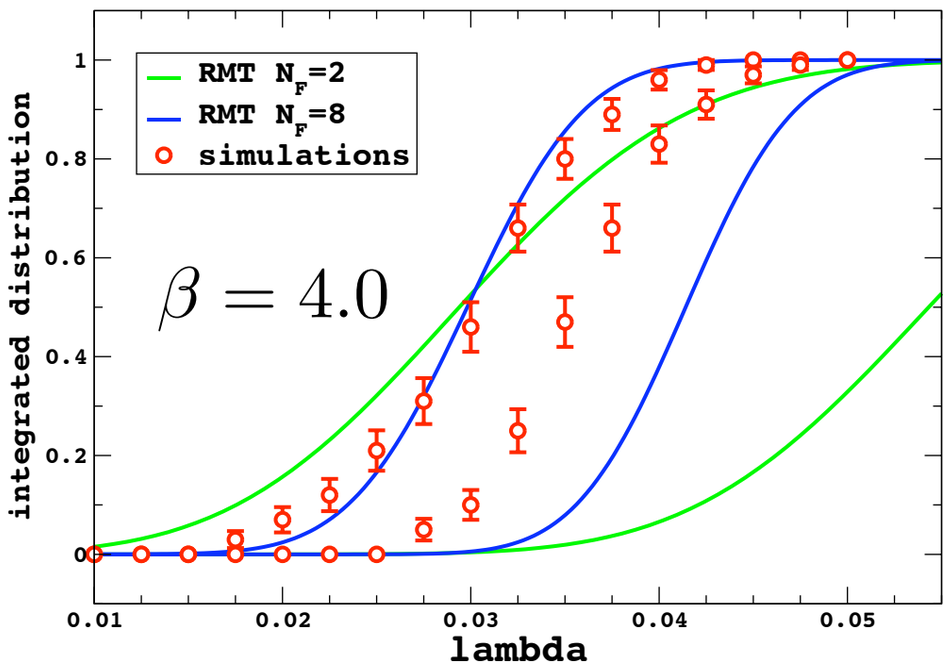
outlook

- fundamental $N_F = 12$ might not be settled
- first runs - only beginning
- taste-breaking crucial in RMT
- Asqtad, stout staggered, HISQ, HYP, ... ?
- 2-index symmetric theory more attractive, fundamental theory is the testing ground

2 staggered flavors







3 staggered flavors