SPC perspectives

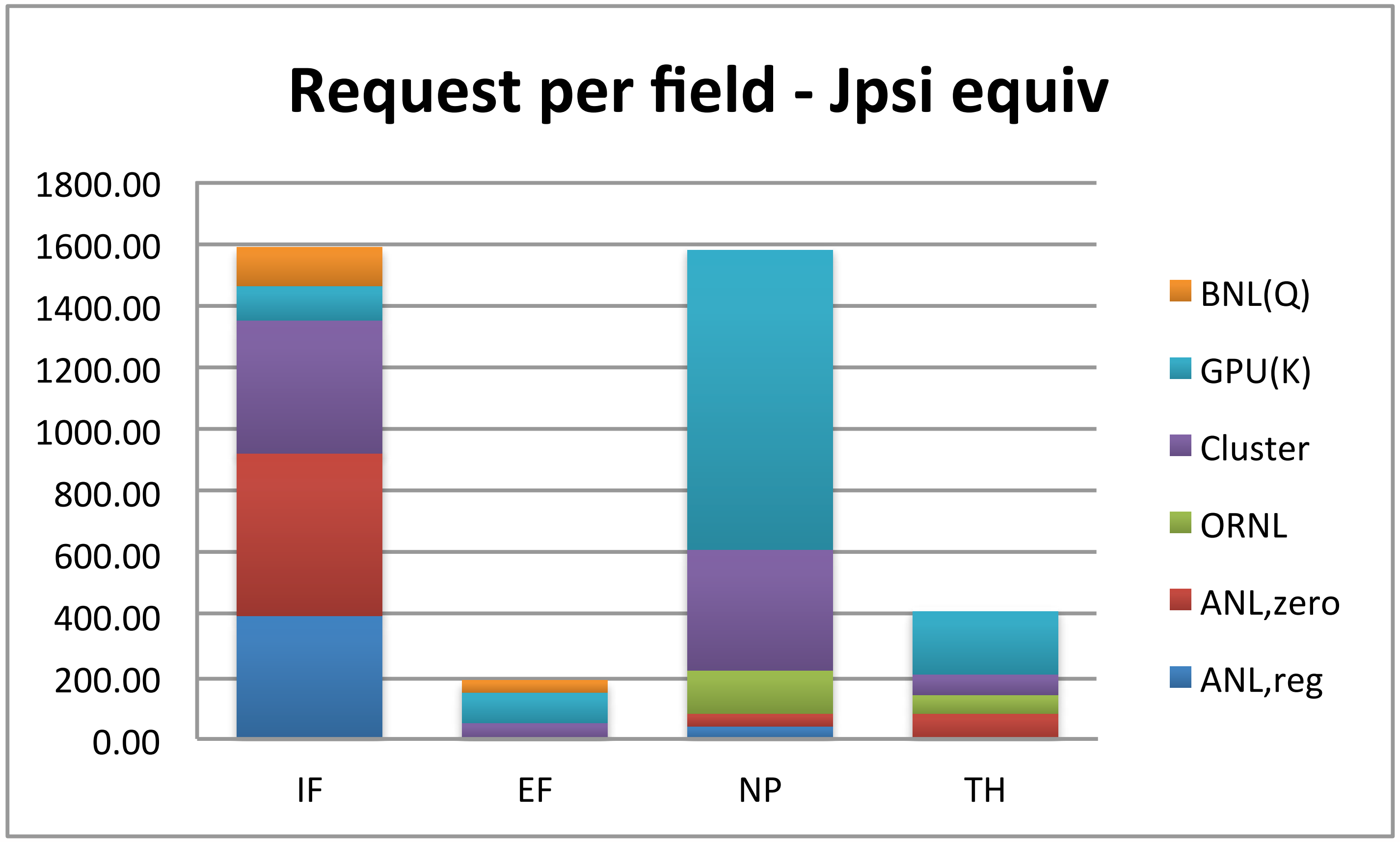
2015-16 proposals are roughly equally distributed between HEP and NP:

HEP:

- Intensity Frontier
- Energy Frontier

NP:

- Cold Nuclear Physics
- Hot Nuclear Physics



P5 Panel Report

Building for Discovery

Strategic Plan for U.S. Particle Physics in the Global Context

Executive Summary

Executive Summary

- Use the Higgs boson as a new tool for discovery
- Pursue the physics associated with neutrino mass
- Identify the new physics of dark matter
- Understand cosmic acceleration: dark energy and inflation
- Explore the unknown: new particles, interactions, and physical principles.

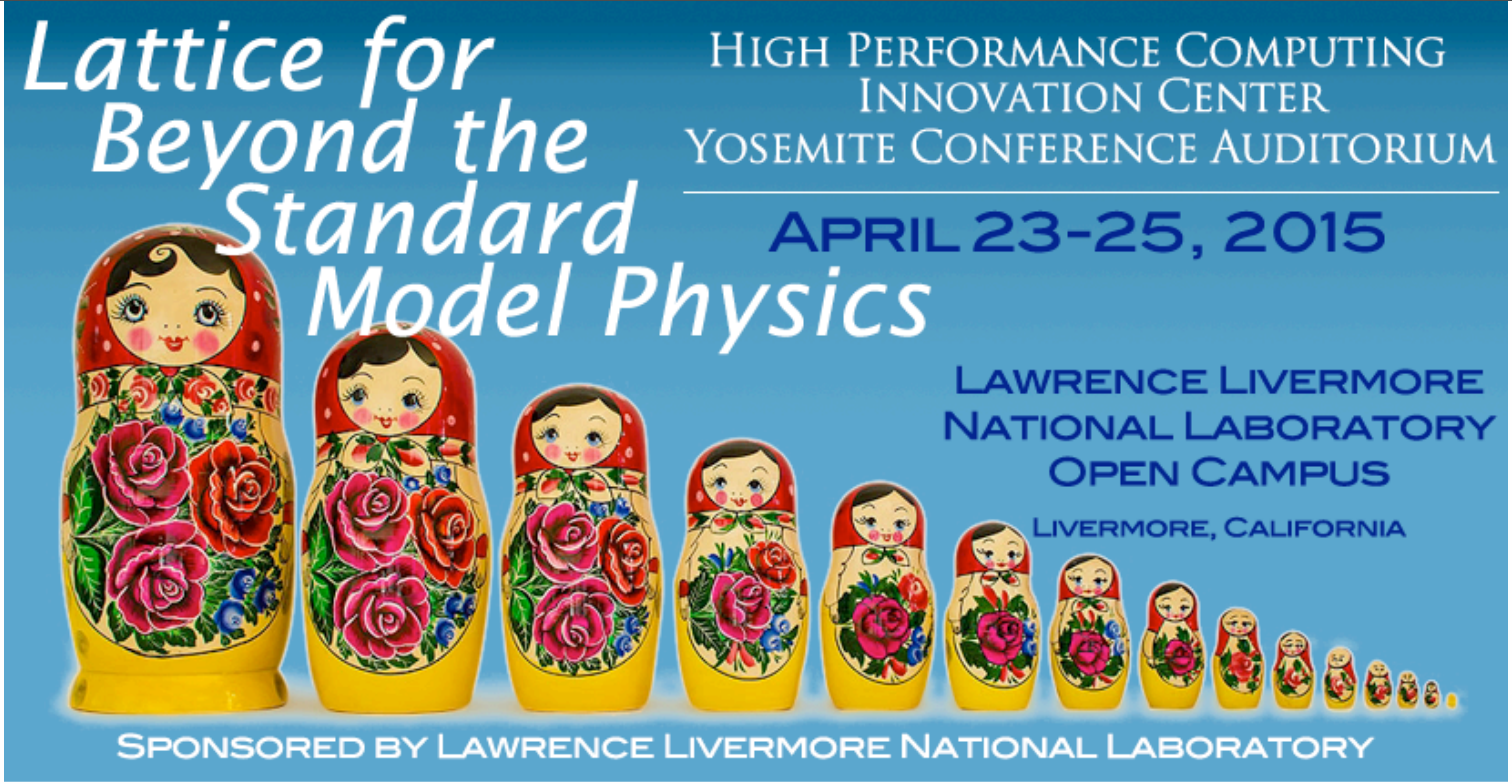
Energy Frontier on the lattice

Composite Higgs variants and lattice SUSY

- Composite Higgs, Partial composite Higgs, ETC
- Equally many dark matter candidates

- There are several viable models :
  - Study the most promising
  - OR : Study the general properties of many

- Less well defined than lattice QCD calculations
- Require new methods/techniques



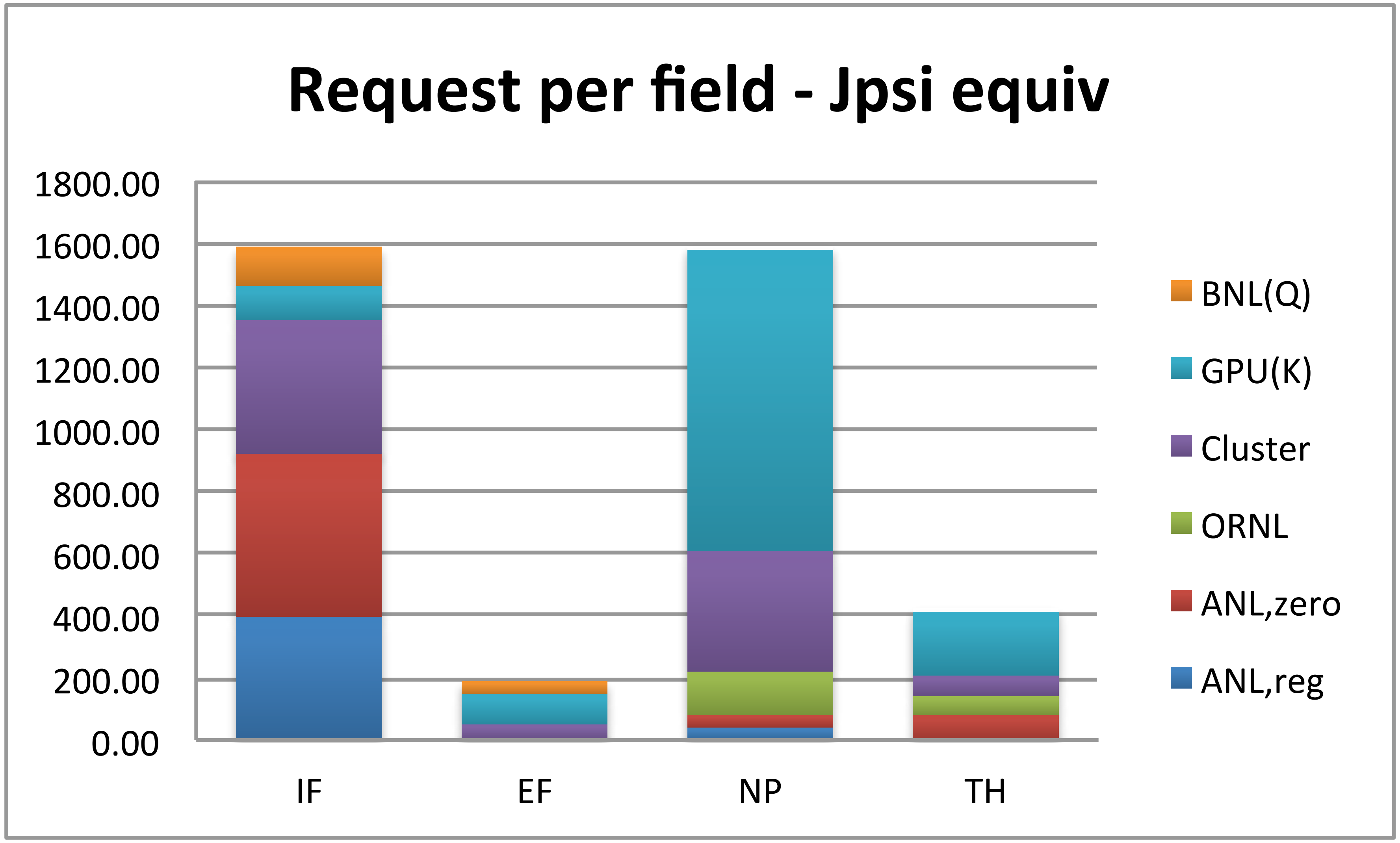
Focus:

The focus will be on the **role that Lattice numerical simulations can play** in the study of possible strong interactions in **Beyond the Standard Model (BSM) physics**, and in particular within the following topic areas:

- **Composite dark matter**
- **Composite Higgs models and EWSB**
- **Theoretical applications in conformal field theory, string theory, and holography**
- **Strongly coupled models, including many-fermion gauge theories and SUSY**

Type- A Proposals:

2015-16 proposals are roughly equally distributed between HEP and NP:



Total:(J-psi hrs)
IF: 78%
EF: 9%

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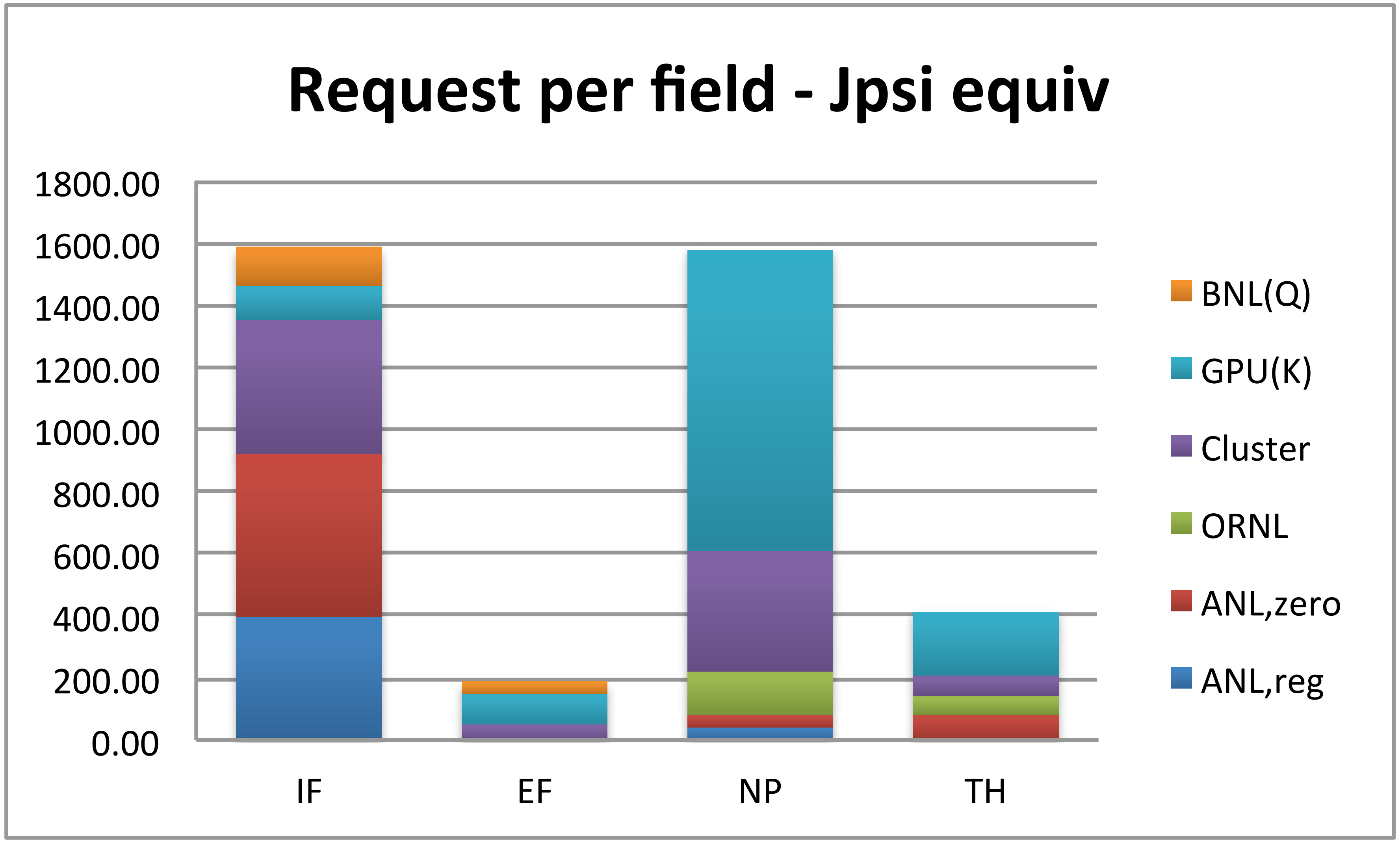

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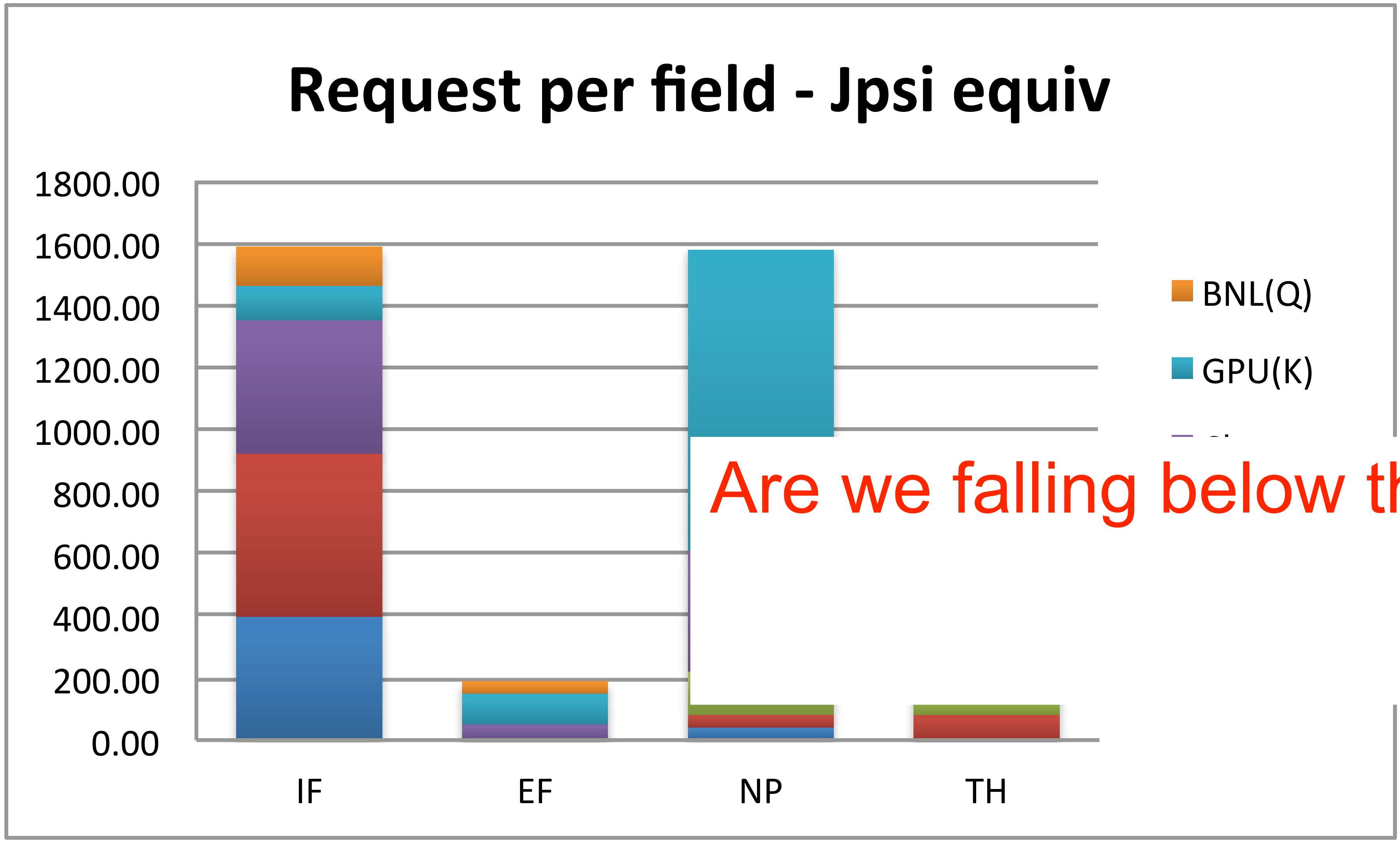

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Are we falling below the critical mass?

2014-15 proposals:

From AHM 2014

5 type-A proposals - same as last year. Do we have a critical size??

Anna Hasenfratz

Investigations near the conformal window with nHYP-smeared fermions

15.7M clus

Julius Kuti

Three Milestones of the Minimal Composite Higgs Mechanism

18.2M BNL, 980K GPU

Ethan Neil

Electromagnetic Polarizability of Bosonic Composite Dark Matter

26.4M FNAL

Claudio Rebbi

A handle on near conformal BSM dynamics: SU(3) gauge system with four plus eight flavors

9.45M FNAL

David Schaich

Lattice N = 4 supersymmetric Yang–Mills with 2, 3 and 4 colors

2015-16 EF proposals:

5 Type-A proposals - same as last year.

Anna Hasenfratz

Models near the conformal window - study of universality 13.1M Jpsi

Julius Kuti

Toward the minimal realization of the light composite Higgs

21.1M BNL, 1200K GPU (138M Jpsi)

Ethan Neil

Non-Perturbative Collider Phenomenology of Stealth Dark Matter 12.5M Jpsi

Claudio Rebbi

A handle on near conformal BSM dynamics: SU(3) gauge system with four plus eight flavors

11.7M Jpsi

David Schaich

Anomalous dimension from lattice SUSY

14M Jpsi

Lattice SUSY:

Anomalous dimensions from lattice N = 4 super Yang–Mills with an improved action

Simon Catterall,[1] Poul H. Damgaard,[2] Thomas DeGrand,[3]
Joel Giedt,[4] David Schaich (PI),[1,*] and Aarti Veernala[1]

- Significantly improved the lattice action (theory)
- New code is publicly available
- Several interesting new results:
  - Static potential might show non-perturbative effects:
    U(2) appears to follow perturbative
    U(3) might be consistent with ADS/CFT
  - They plan to measure the anomalous dimension of the Konishi operator:
    anomalous dimension expected ~1 - could be resolved on the lattice
- This group does everything to encourage others to join
  are there any takers?

Composite Higgs inspired:

Ethan Neil

Non-Perturbative Collider Phenomenology of Stealth Dark Matter

Julius Kuti

Toward the minimal realization of the light composite Higgs

Anna Hasenfratz

Models near the conformal window - study of universality

Claudio Rebbi

A handle on near conformal BSM dynamics: SU(3) gauge system with 4+8 flavors

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2-flavor sextet

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Models near the conformal window - study of universality

2-flavor sextet

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A handle on near conformal BSM dynamics: SU(3) gauge system with 4+8 flavors

What are the general properties of near-conformal systems?

Universality - is it a problem?

From AHM 2014

Systems

- with identical field content
- identical symmetries
- at criticality (basin of attraction of the FP)

are expected to show universal critical behavior.

Lattice symmetries:

- SU(N_c) gauge preserved ✔
- SU(N_f) x SU(N_f) chiral symmetry is not:
  - staggered fermions : only U(N_f/4) x U(N_f/4) flavor symm.
  - Wilson fermions : no chiral symmetry
  - Domain Wall fermions : approximate chiral symm.

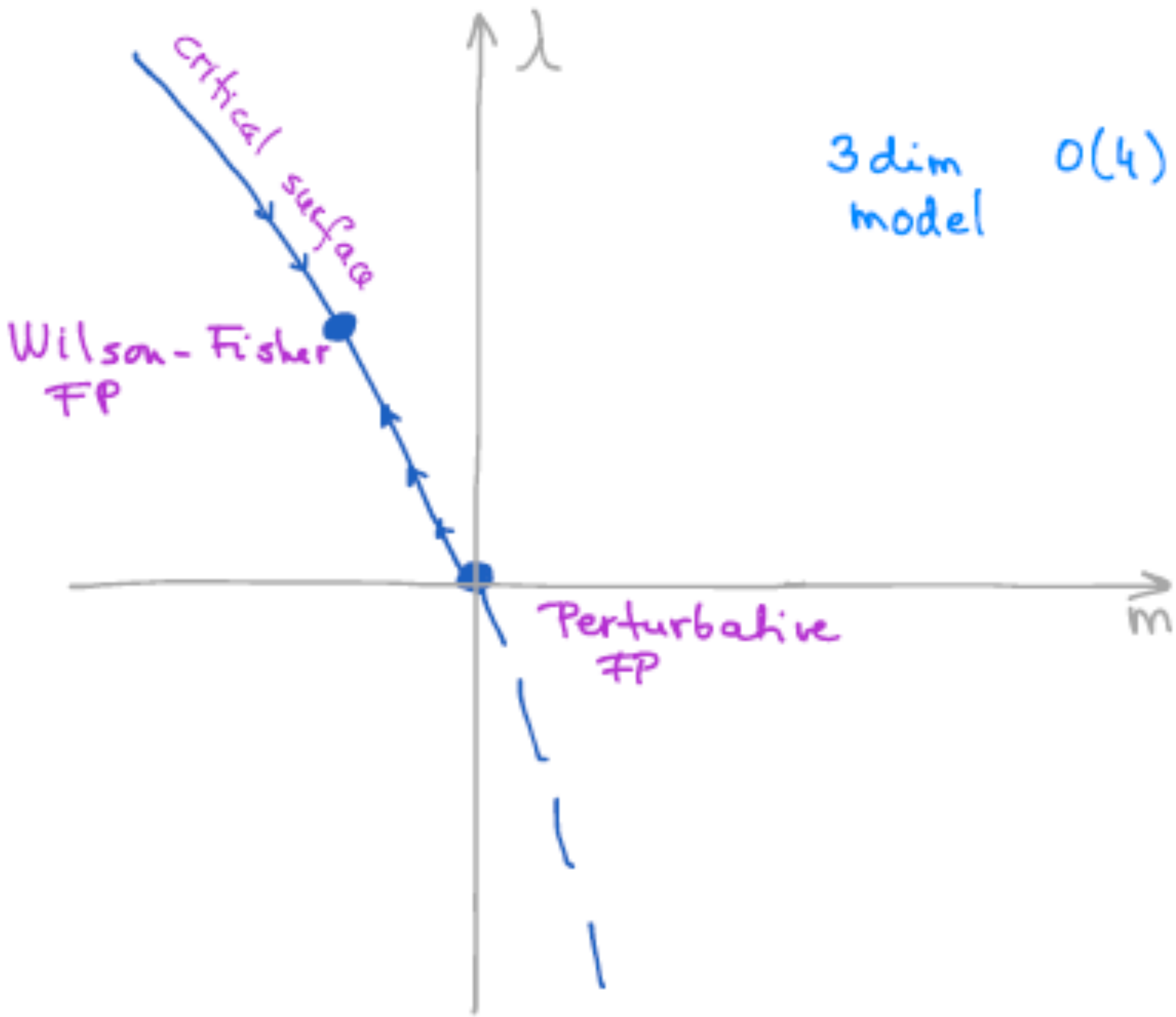
At the $g^2 = 0$ UVFP all formulations approach continuum fermions ✔

At the $g^2 \neq 0$ conformal IRFP that is not the case ✕

Universality should be investigated more carefully

(but only staggered fermions in this talk)

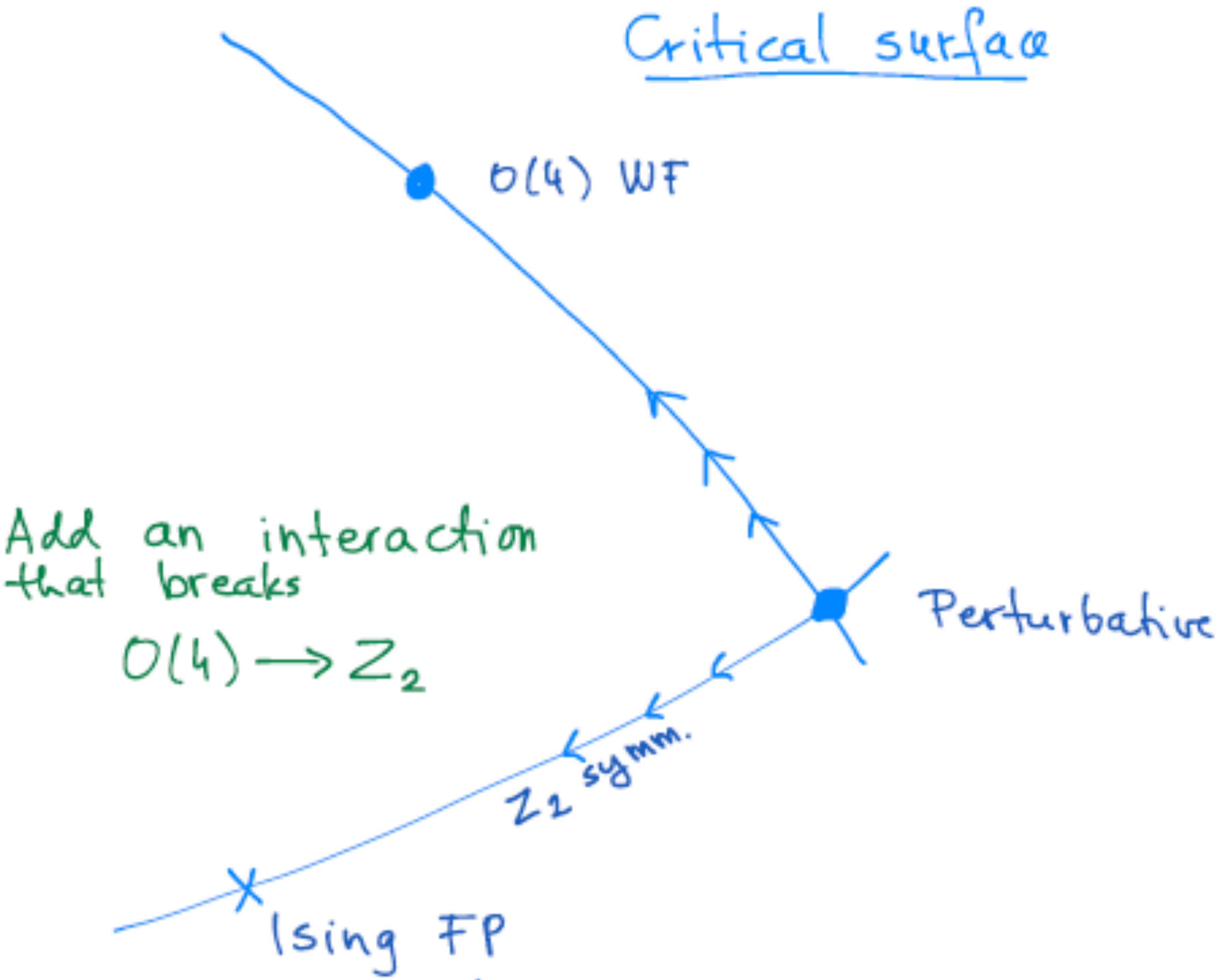
Example: 3dim O(N) scalar model



Perturbative FP is mean-field with 2 relevant directions

Wilson-Fisher FP has only one relevant direction (mass)

Example: 3dim O(N) scalar model



An interaction that breaks O(N) --> O(M) has a different WF FP but it is still connected to the perturbative FP

Universality of conformal systems

Staggered, Wilson, Domain Wall fermions have different chiral symmetry away from the perturbative FP

they might have different conformal FP, worth investigating

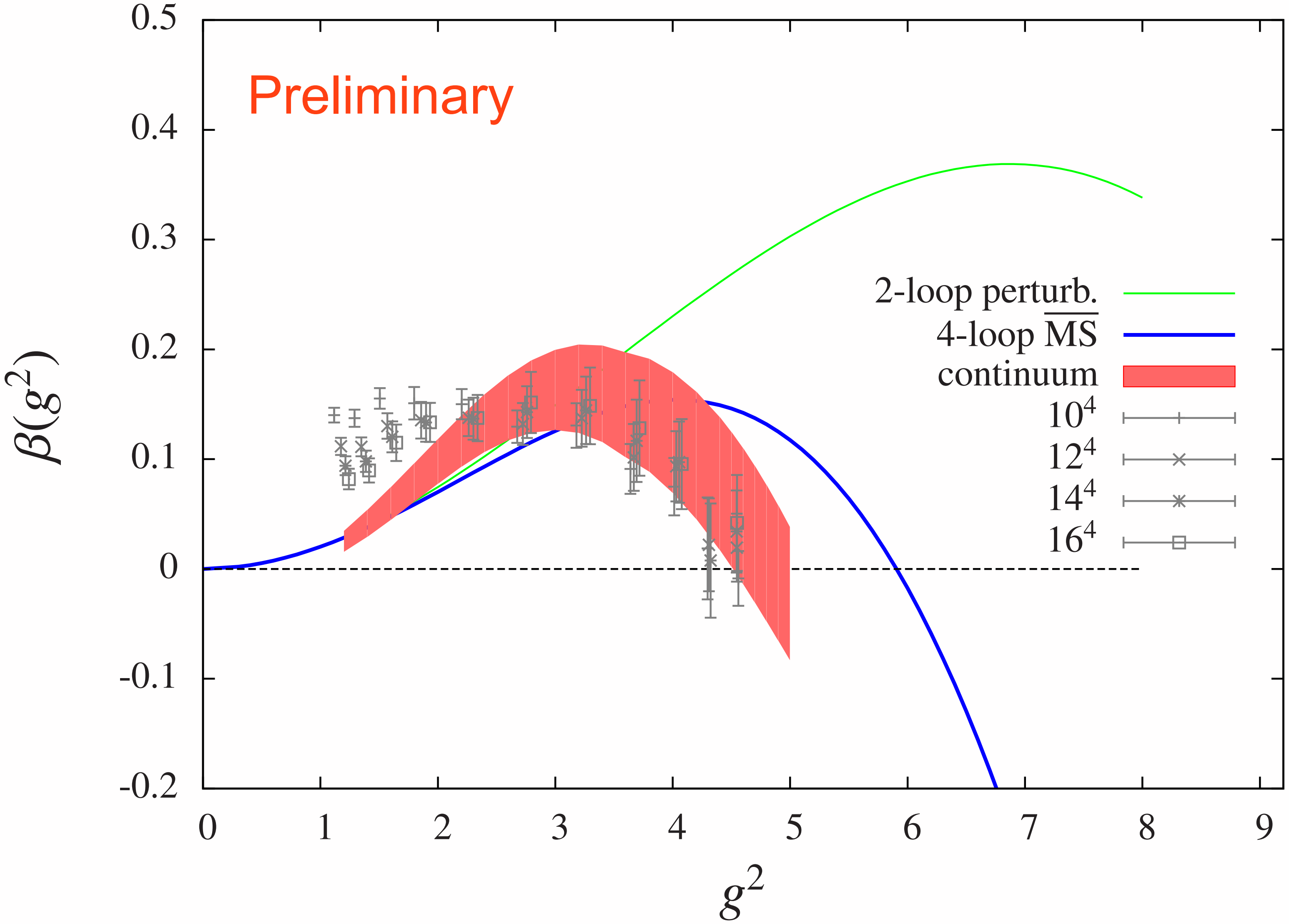
(Does not matter for chirally broken composite models)

SU(3) 2-flavor sextet with Wilson fermions

A.H, C. Huang, Y.Liu, B. Svetitsky

Step scaling function study using nHYP smeared Wilson fermions

- Improved gradient flow coupling
- volumes up to 24^4, gauge coupling β = 1.0 - 6.5 (strong coupling)
- tune $\kappa \to \kappa_{cr}$: no chiral symmetry breaking observed
-



SU(3) 2-flavor sextet with Wilson fermions

Wilson and staggered step scaling functions are not consistent □□

- Assuming both calculations are correct, this could show lack of universality

2009-10 work of DeGrand, Svetitsky, Shamir is also inconsistent with staggered result

This model is too important to allow such contradiction

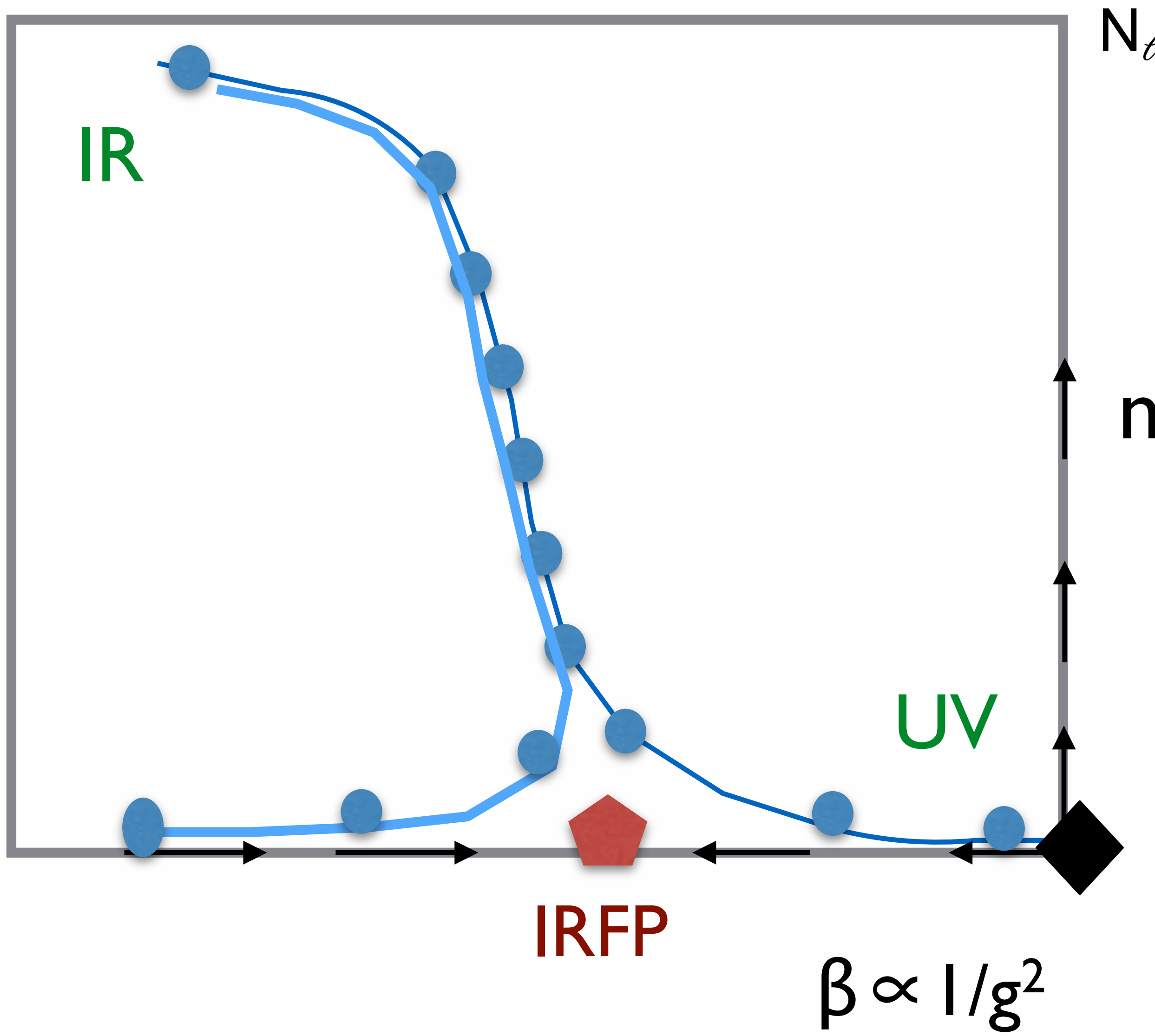
- complete the Wilson fermion calculation at stronger couplings/larger volumes
- check spectroscopy : does it show chiral breaking or consistent with finite size scaling?

C. Rebbi: SU(3) gauge theory with 4+8 flavors

R. Brower, A.H., C Rebbi, E. Weinberg, O. Witzel

SU(N_c) gauge with N_ℓ light ($m_\ell \approx 0$) and N_h heavy (m_h) fermions

$N_\ell + N_h$ = above the conformal window, N_ℓ is below



3 independent parameters:

(g^2, m_ℓ, m_h)

- g^2 does not matter once the flow reaches the RG trajectory
- sufficient to work at g^2 =const, vary m_h only ($m_\ell=0$)

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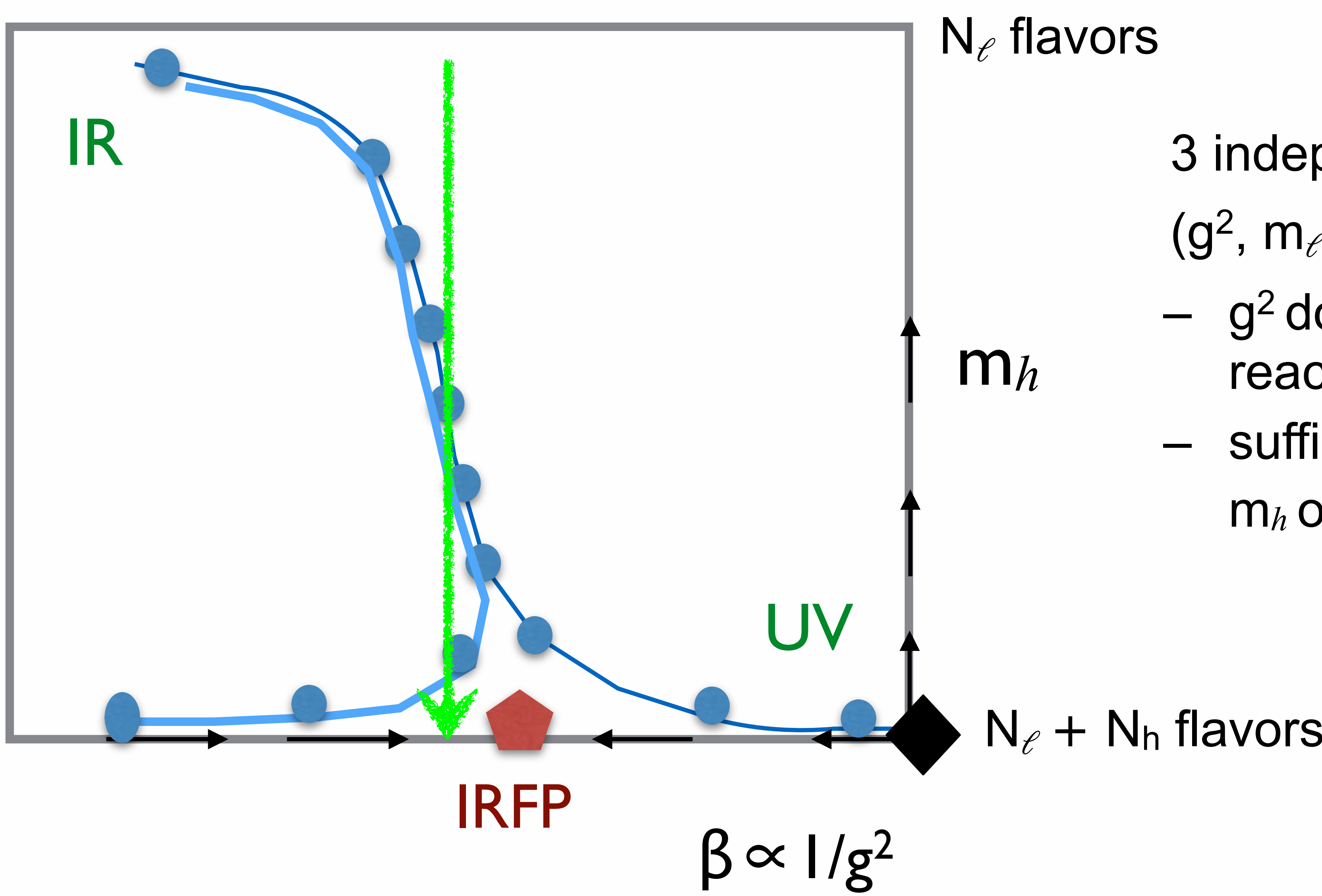

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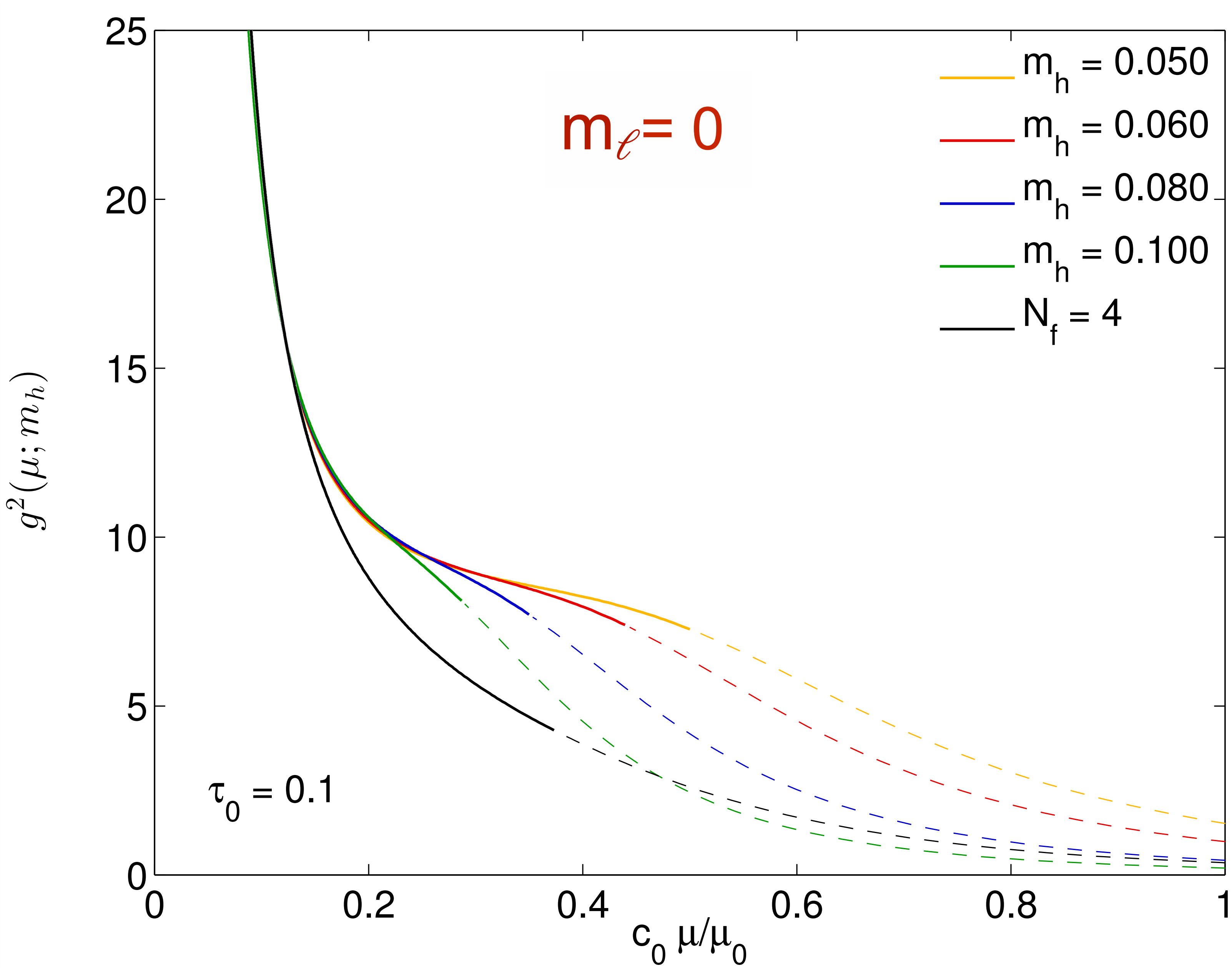
Improved running coupling : 4+8 flavors



There are error bars on this plot!

N_f=4 : running fast

$g^2_{GF}(\mu)$ develops a "shoulder" as $m_h \to 0$: this is walking !

Walking range can be tuned arbitrarily with m_h

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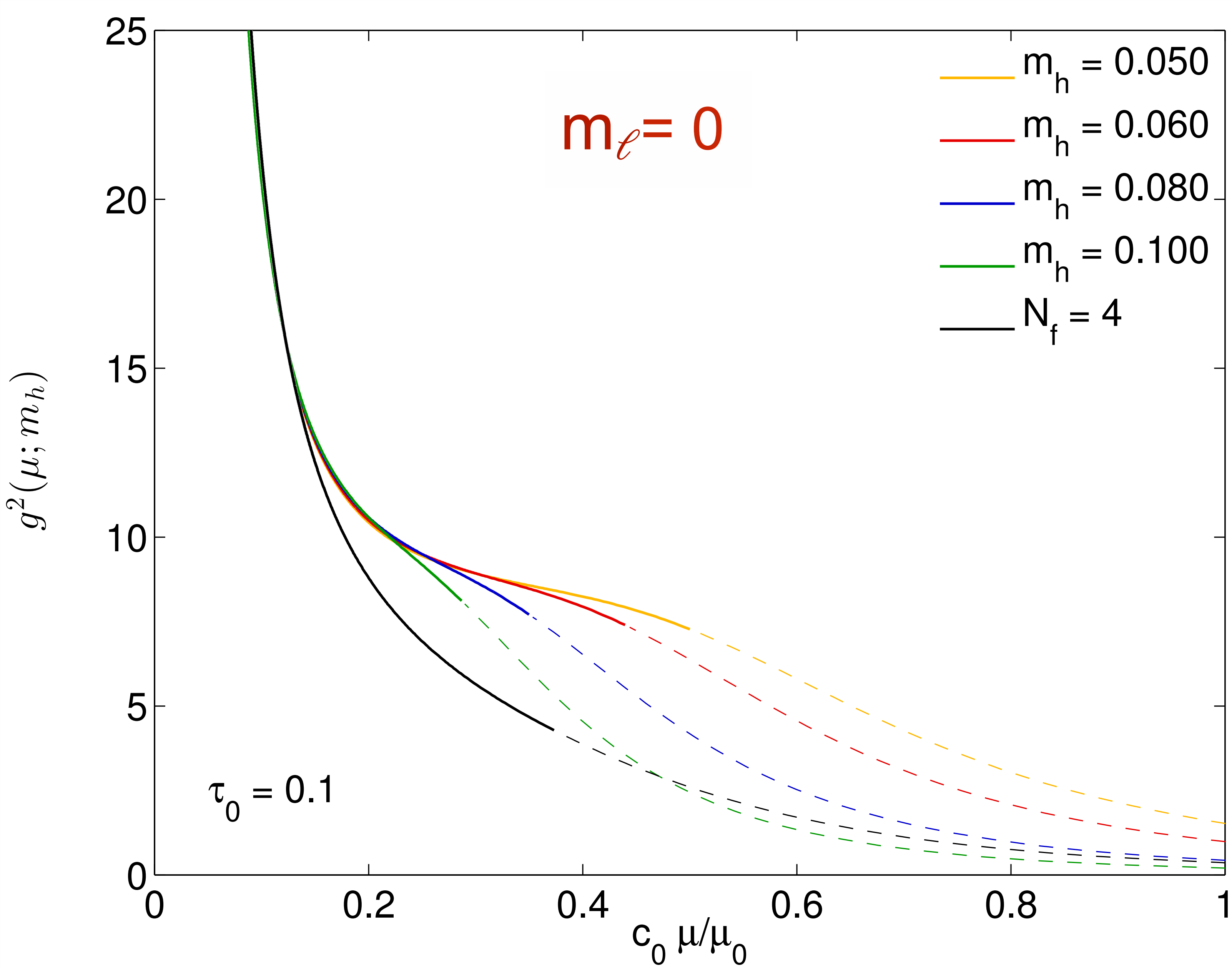

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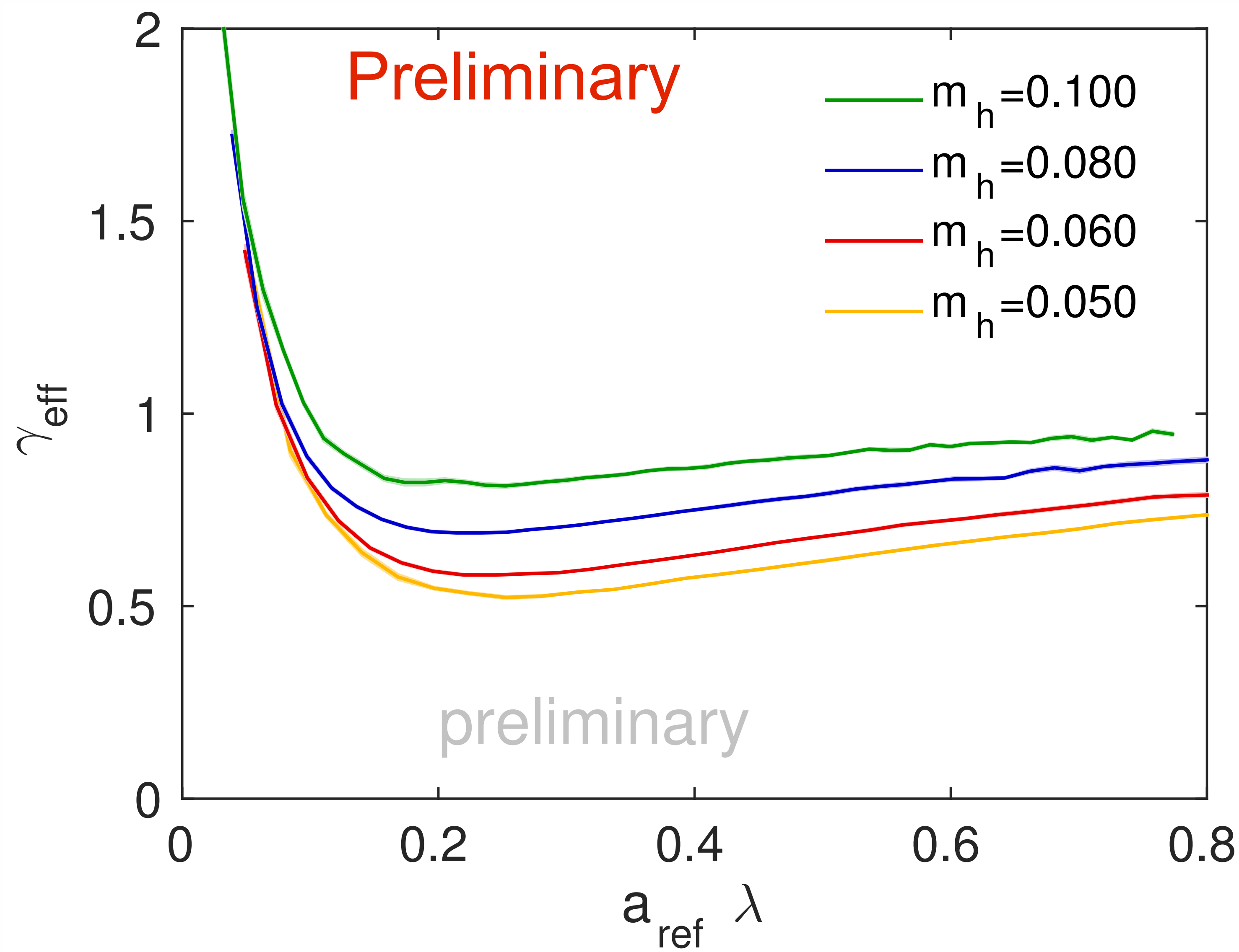
Anomalous dimension

Scale dependent anomalous dimension $\gamma_{eff}(\mu)$



In this system the anomalous dimension is not large but still O(1) and can persist

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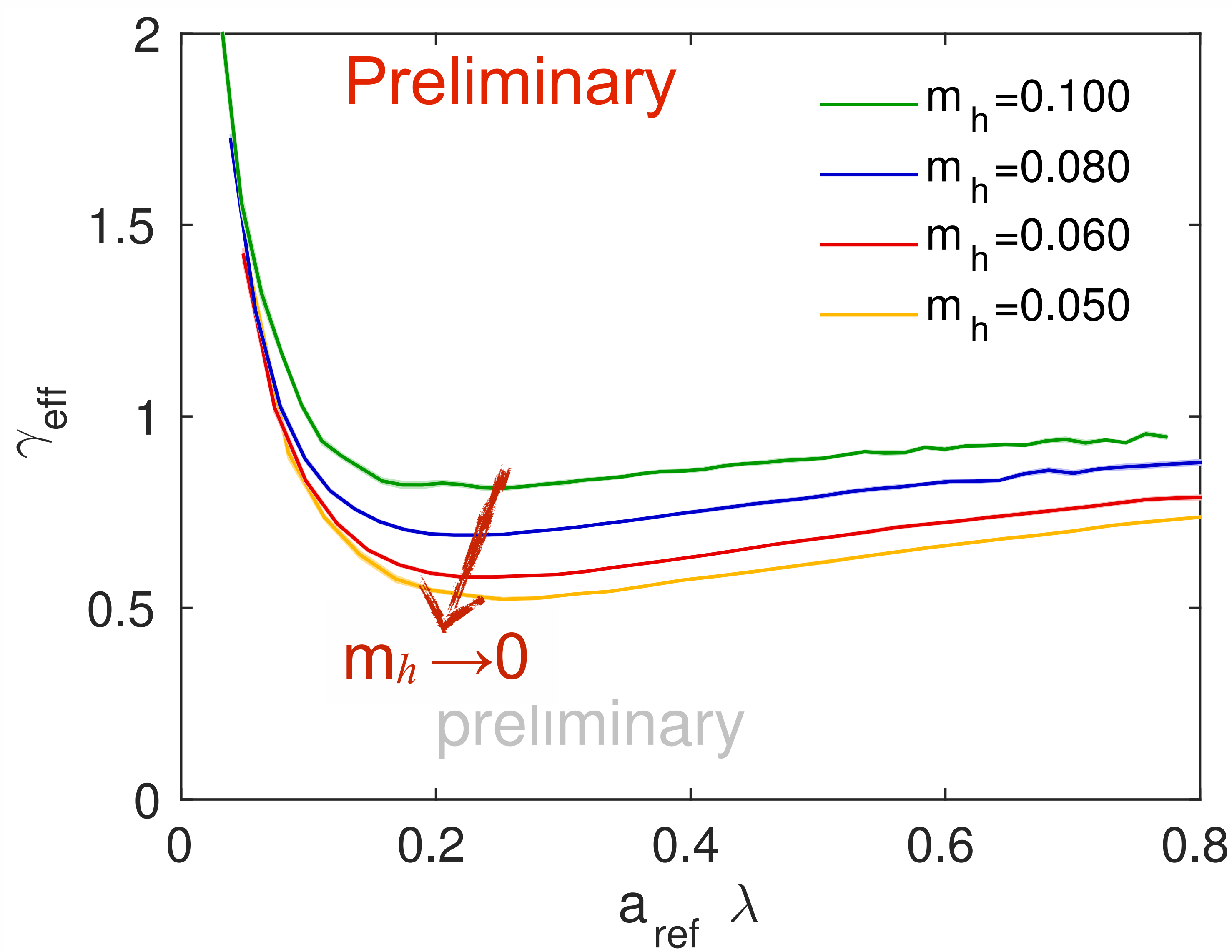

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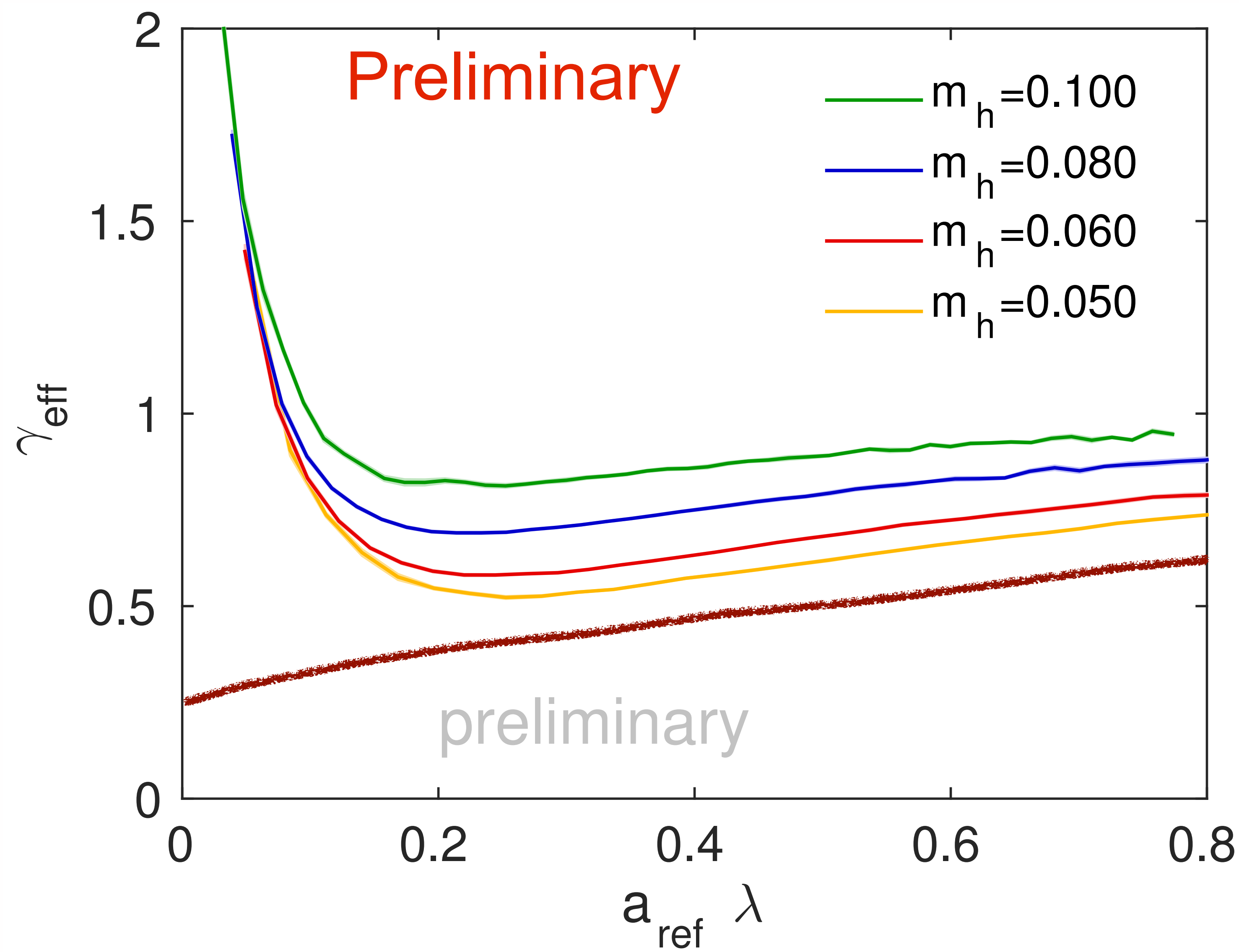
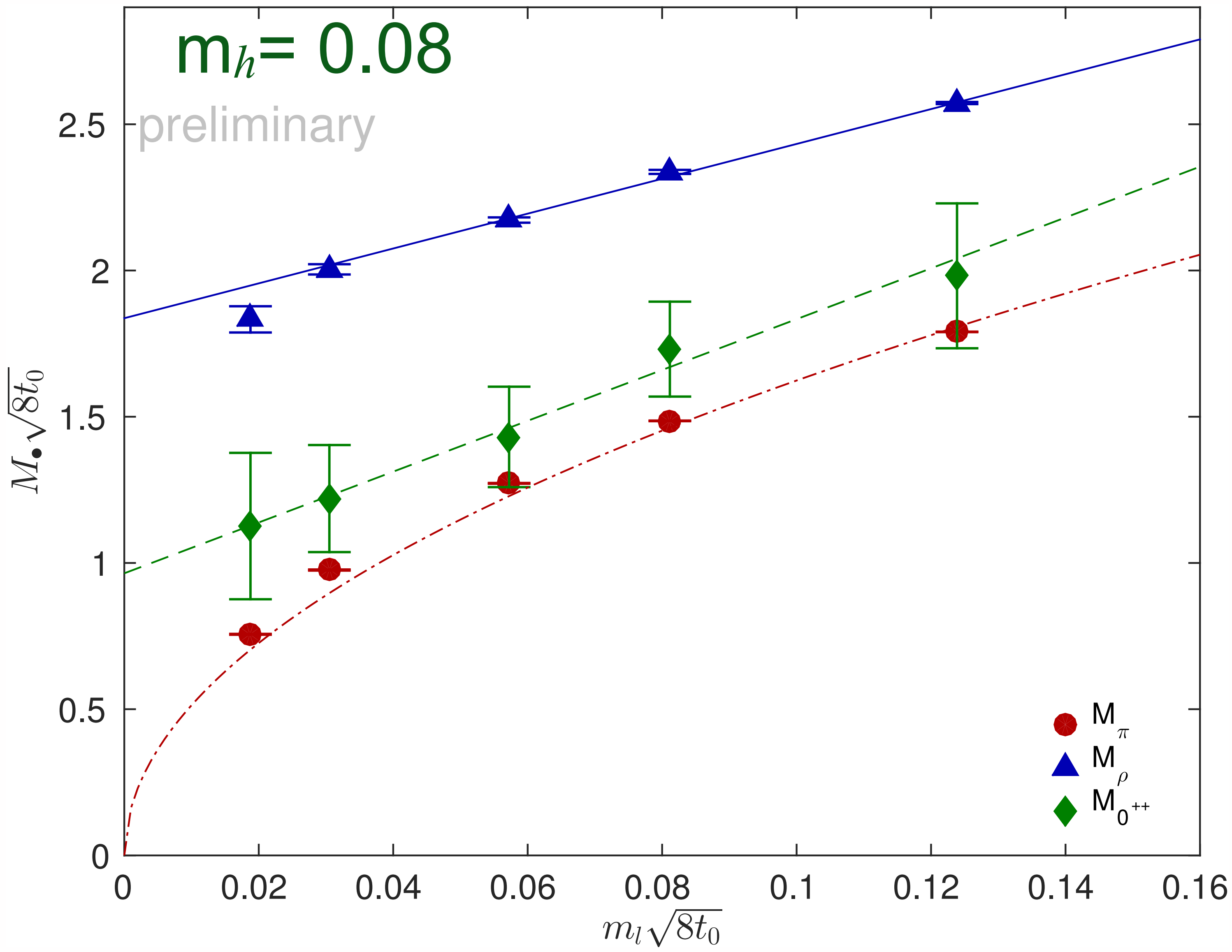


N_f=12 : γ_{IRFP}=0.235(15)

In this system the anomalous dimension is not large but still O(1) and can persist

Spectrum

Compare the pion, rho and 0^{++} masses (preliminary):



m_h = 0.08: the 0++

- is just above the pion,
- not Goldstone
- well below the rho
- very different from QCD

The results so far are promising.

- better the 0^{++} measurement : larger volumes, smaller masses
- repeat at 2 - 3 different heavy mass values

SPC summary:

There are a lot of interesting questions in BSM /Energy frontier that require lattice methods

This is well aligned with the P5 recommendations

I hope that more groups will enter/return to this field

- specific models promising for EWSB :
  - dilaton as Higgs
  - PGB Higgs, little Higgs, partial composite Higgs, etc

- general predictions from composite systems (dark matter)
- general field theoretical properties of composite systems (light 0^{++})
-