Investigating the conformal behaviour of SU(2) with one adjoint Dirac flavor

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Slides: https://edbennett.github.io/lattice2021-talk

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Outline

- Introduction
  - Motivation
  - Previous work
- Results
  - Spectrum
  - Mass anomalous dimension
  - Chiral perturbation theory
- Conclusions

Introduction

Why SU(2) + 1 adjoint Dirac?

- Conformal window
- BSM strong dynamics
- Topological phase transitions

What do we know?

- 1412.5994: Single value $\beta = 2.05$
  - Scalar lightest state
  - Roughly constant mass ratios
  - Anomalous dimension $\gamma_* \approx 0.95$
- 1507.08892: Adds $\beta = 2.2$
  - Constant mass ratios persist
- 1912.11723 (Bi et al.): $\beta = 2.05, 2.2$
  - Consistent masses
  - Composite fermion $\approx$ hybrid fermion state
- Overall: hints of near-conformality

What don't we know?

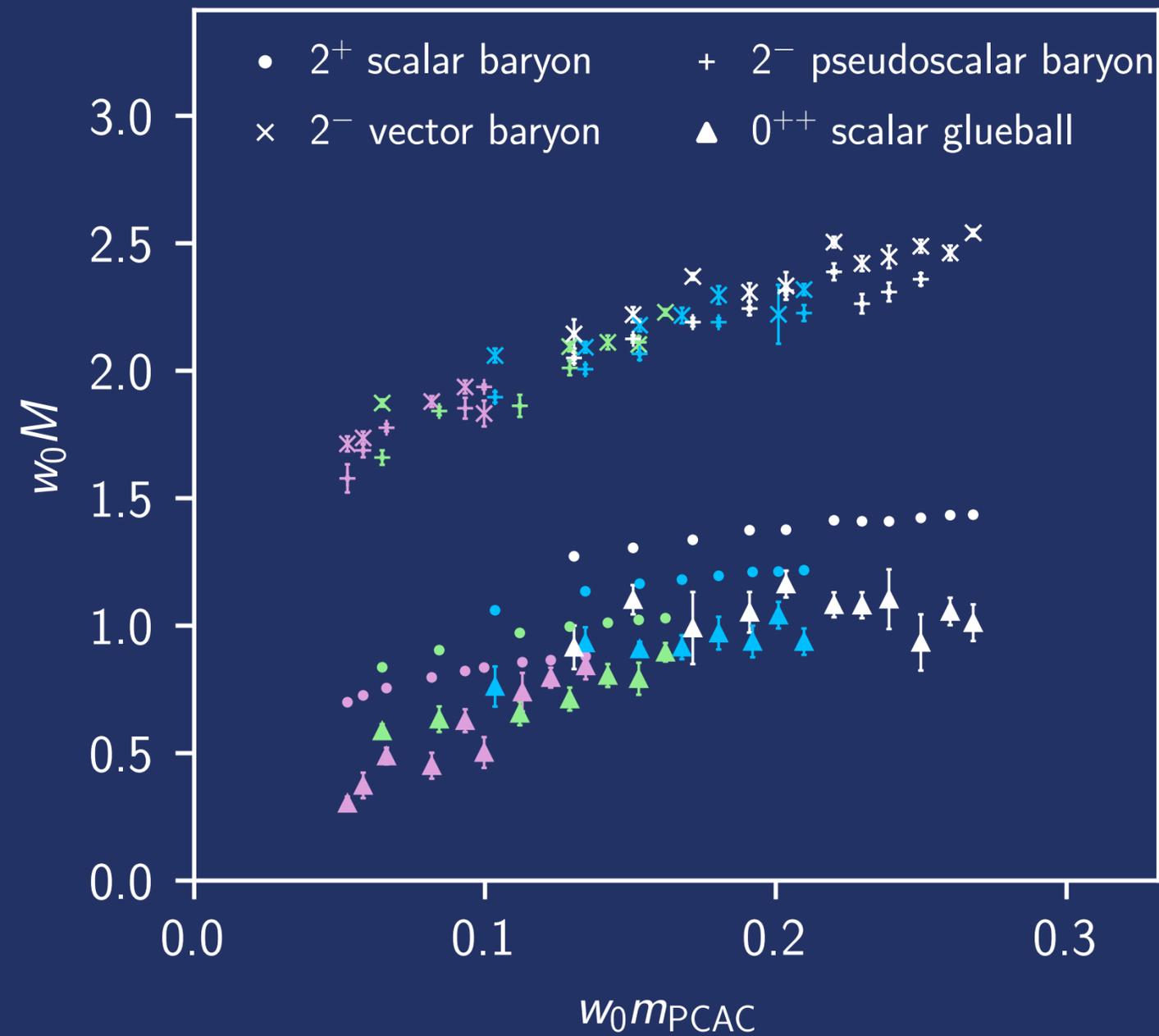- Chiral limit
- Continuum limit
  - Hadron masses
  - Mass anomalous dimension

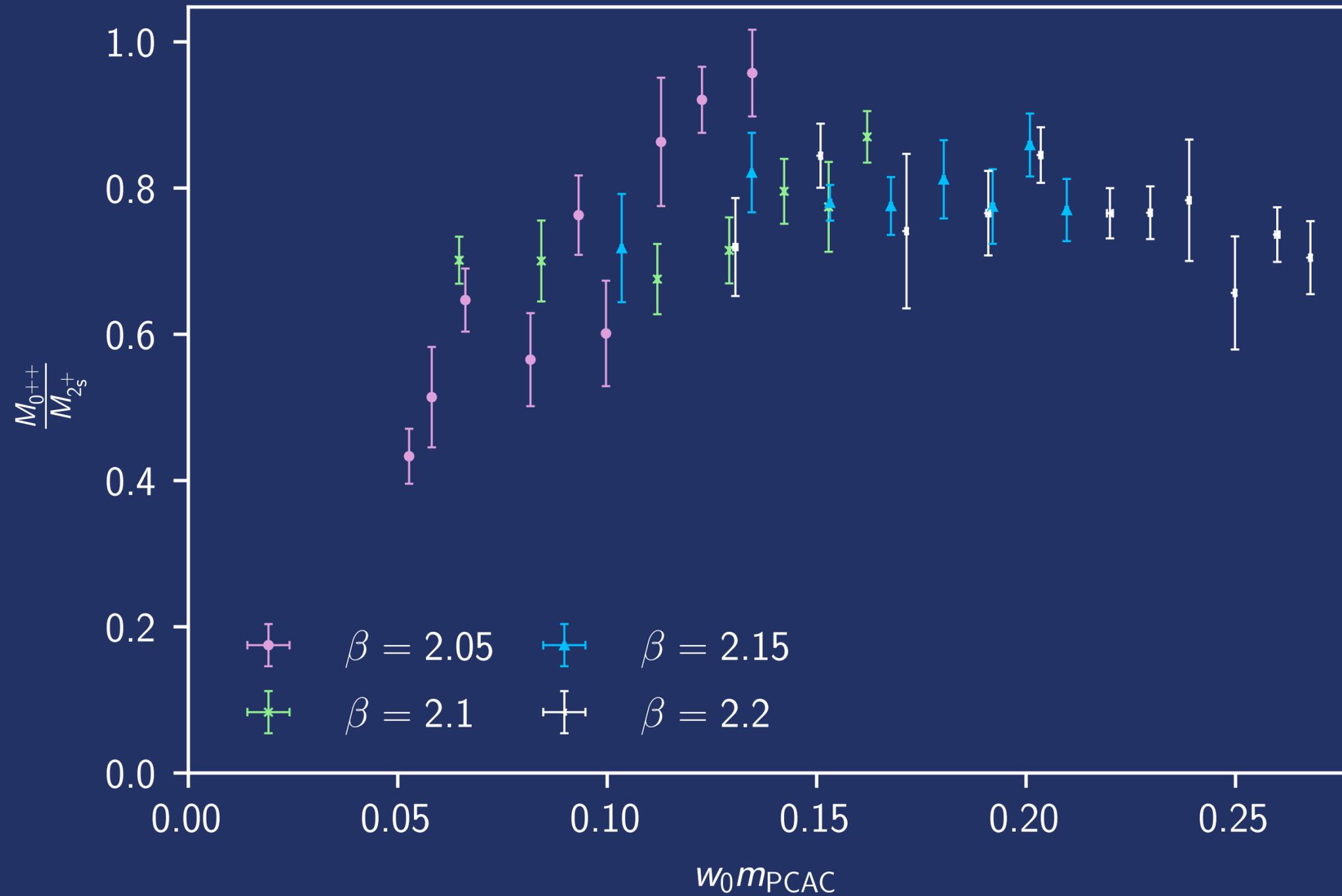# Results

What have we simulated?

- Unimproved Wilson gauge action
- Unimproved Wilson fermion action
  - as 1412.5994
  - Real action
- $\beta = 2.05, 2.1, 2.15, 2.2$
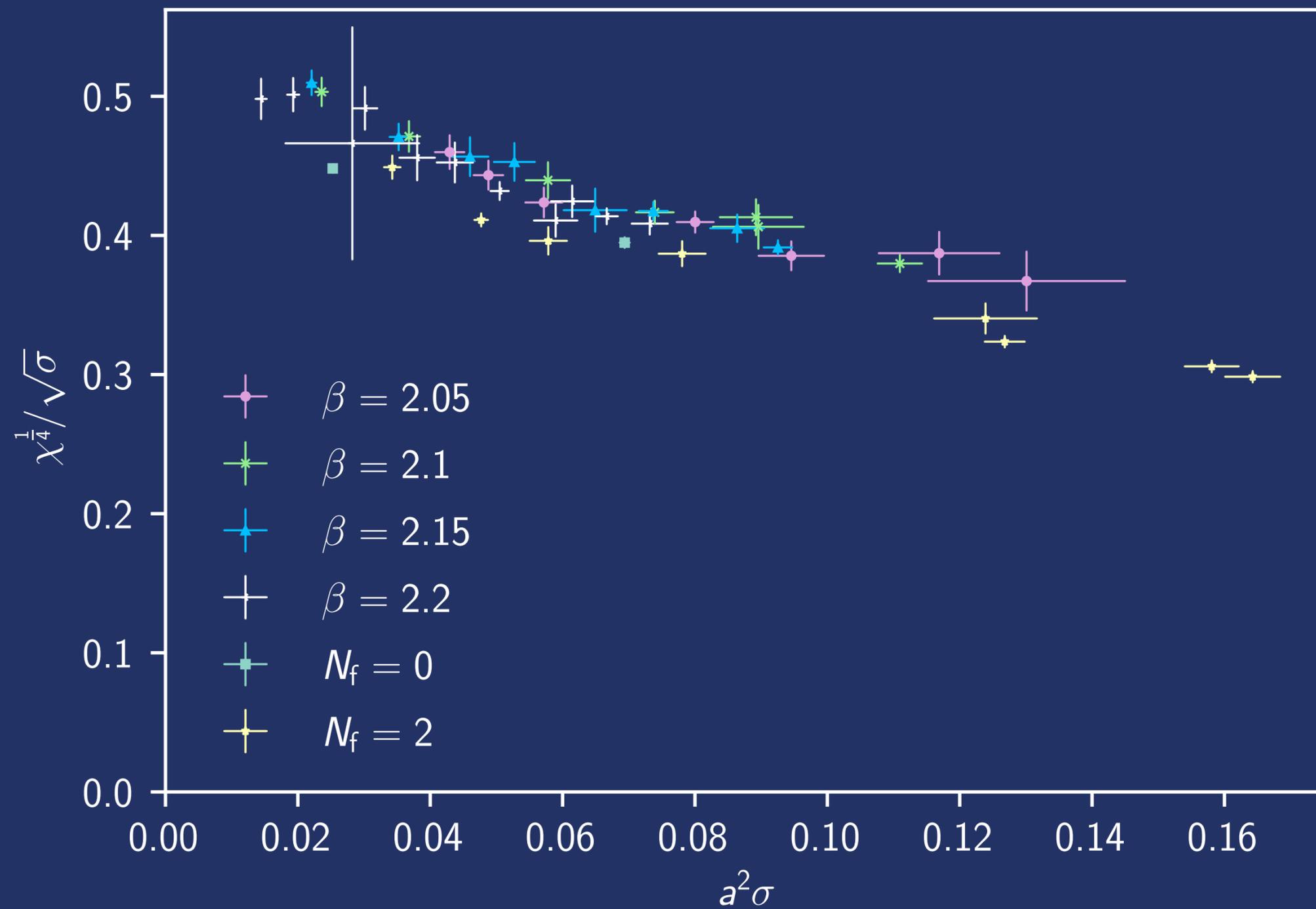- $am_{2_s^+} \in (0.42, 1.08)$

The spectrum

Scalar as the lightest state

$\frac{M_{0^{++}}}{M_{2_s^+}}$

$w_0 m_{\text{PCAC}}$

$\beta = 2.05$
$\beta = 2.15$
$\beta = 2.1$
$\beta = 2.2$

Mass anomalous dimension

Chiral perturbation theory

Tensor/scalar ratio

(see also 1605.04258)

Conclusions

Summary

- Most ratios remain flat
- Scalar glueball remains lightest state
- Tensor-scalar glueball ratio falls short of gauge-gravity model predictions
- Topological susceptibility very close to quenched, $N_\mathrm{f} = 2$ data
- γ_* decreases as β increases
- Results poorly described by chiral perturbation theory

Possibile interpretations

- QCD-like, but probed with too large am
  - Inconsistent with observed mass hierarchy
- Conformal, with scaling deviations
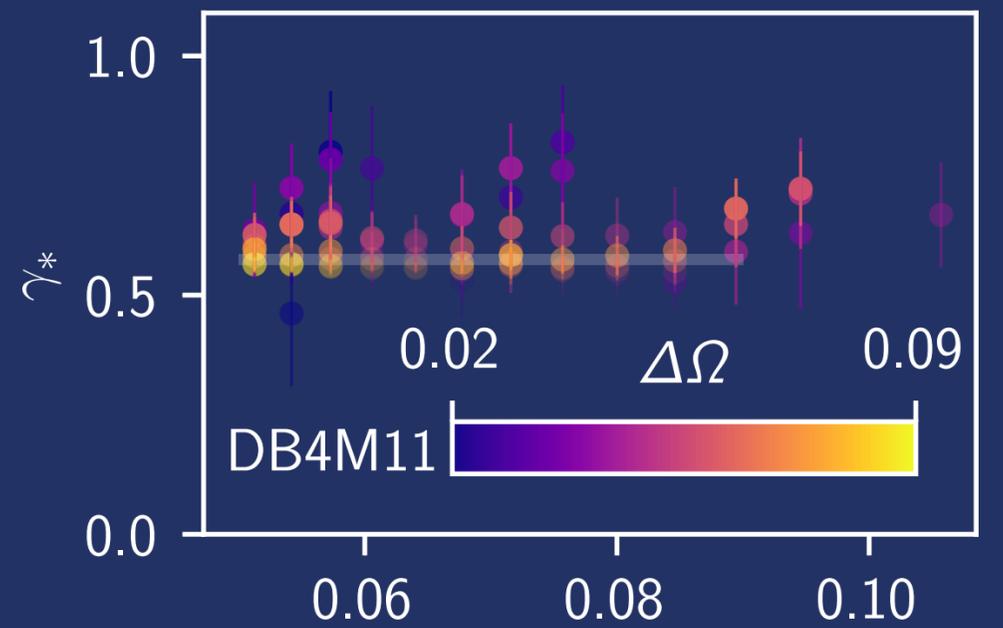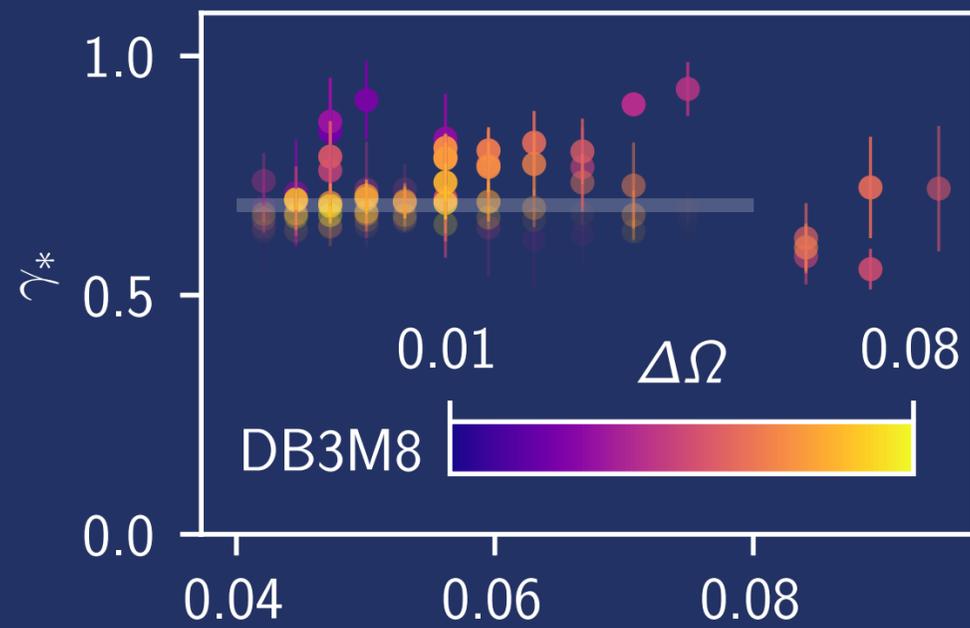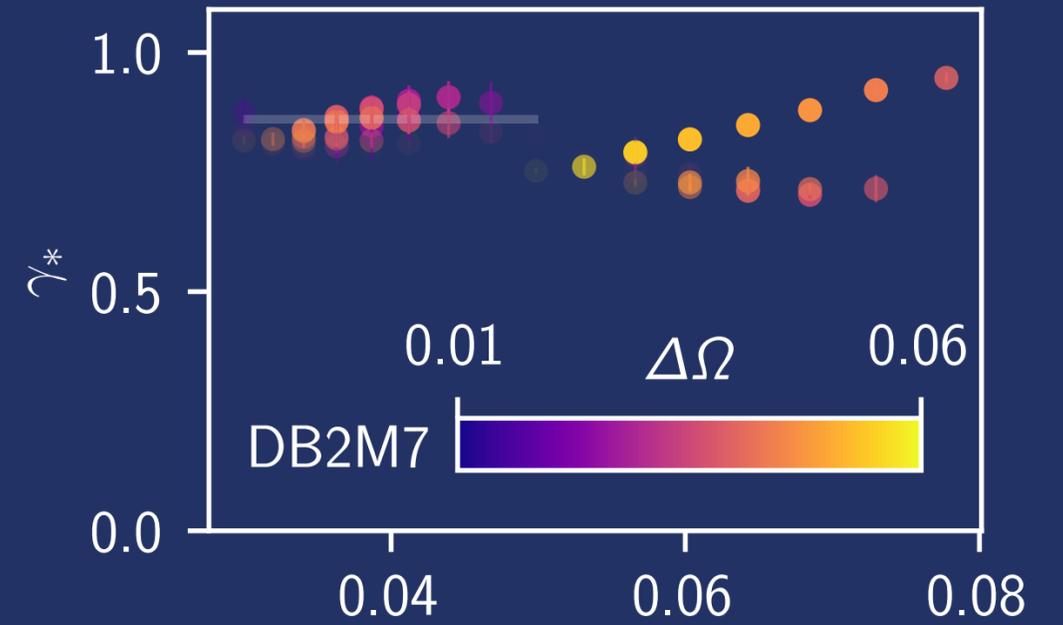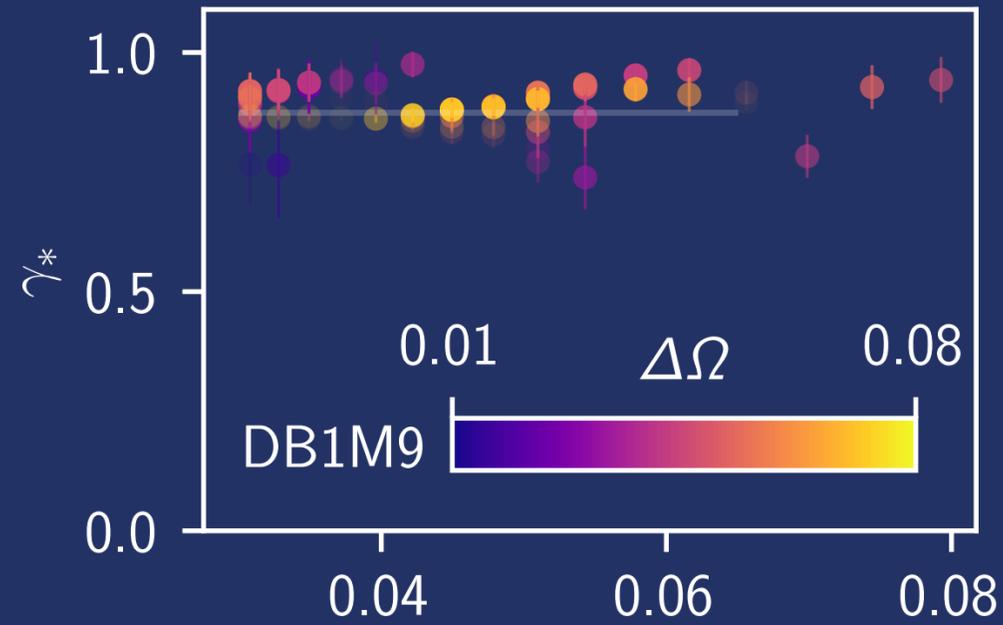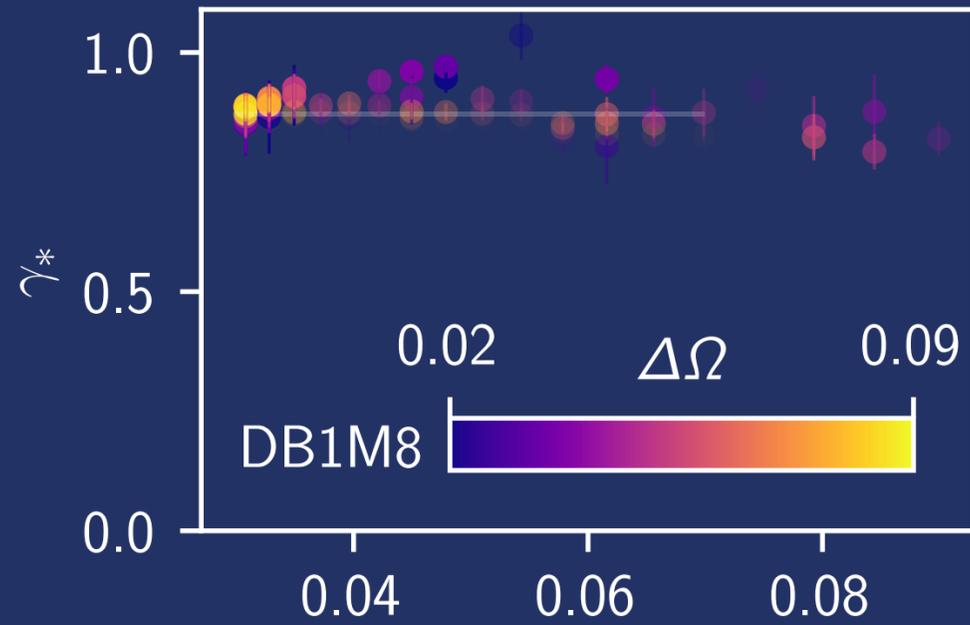- Conformal, but strongly influenced by bulk phase

Ongoing work

- Smaller *am*:
  - To verify observed behaviour continues
- Larger β:
  - To stabilise approach to continuum
  - To probe scaling deviations
- Domain Wall Fermion action:
  - To reduce lattice artefacts towards chiral limit
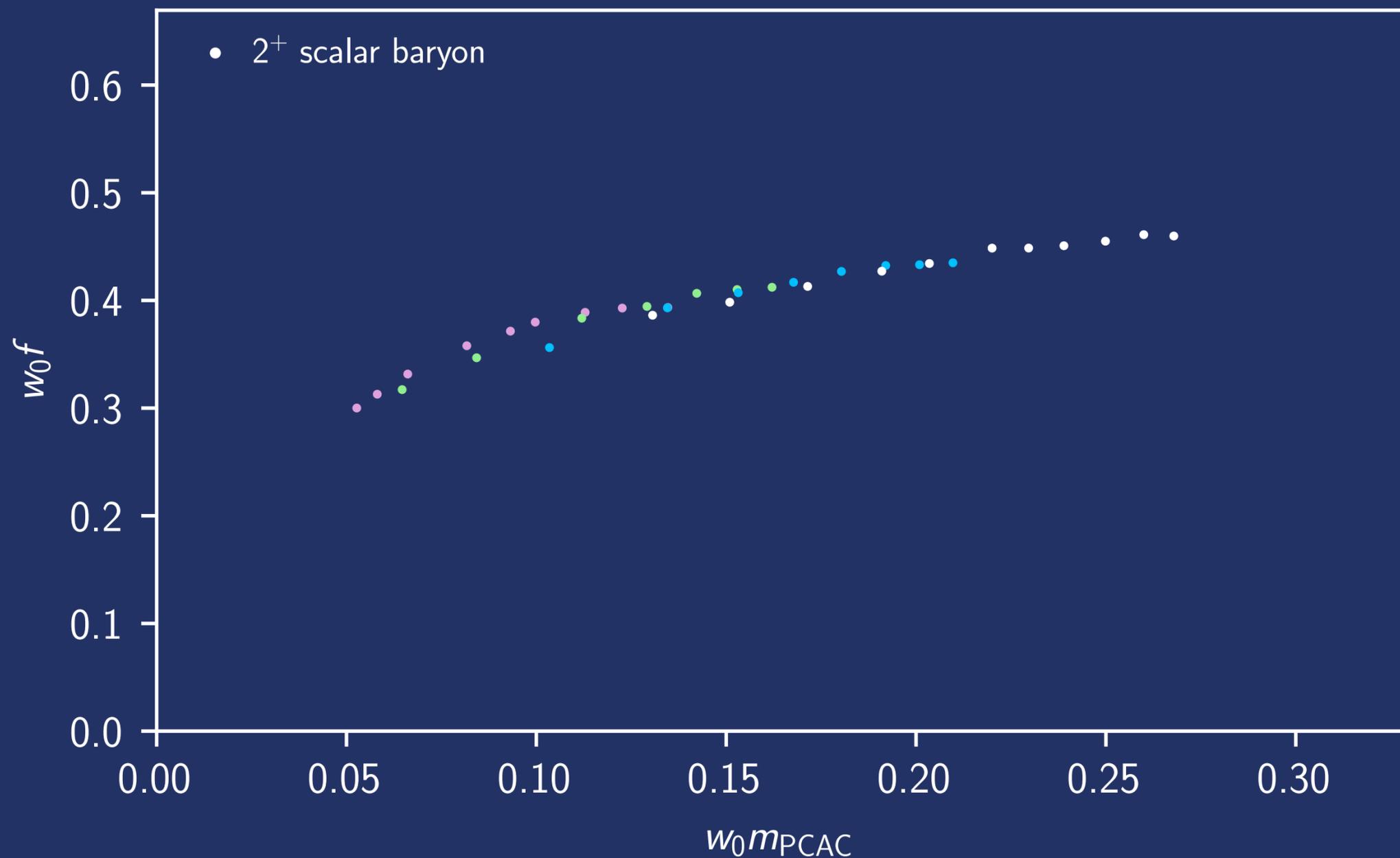
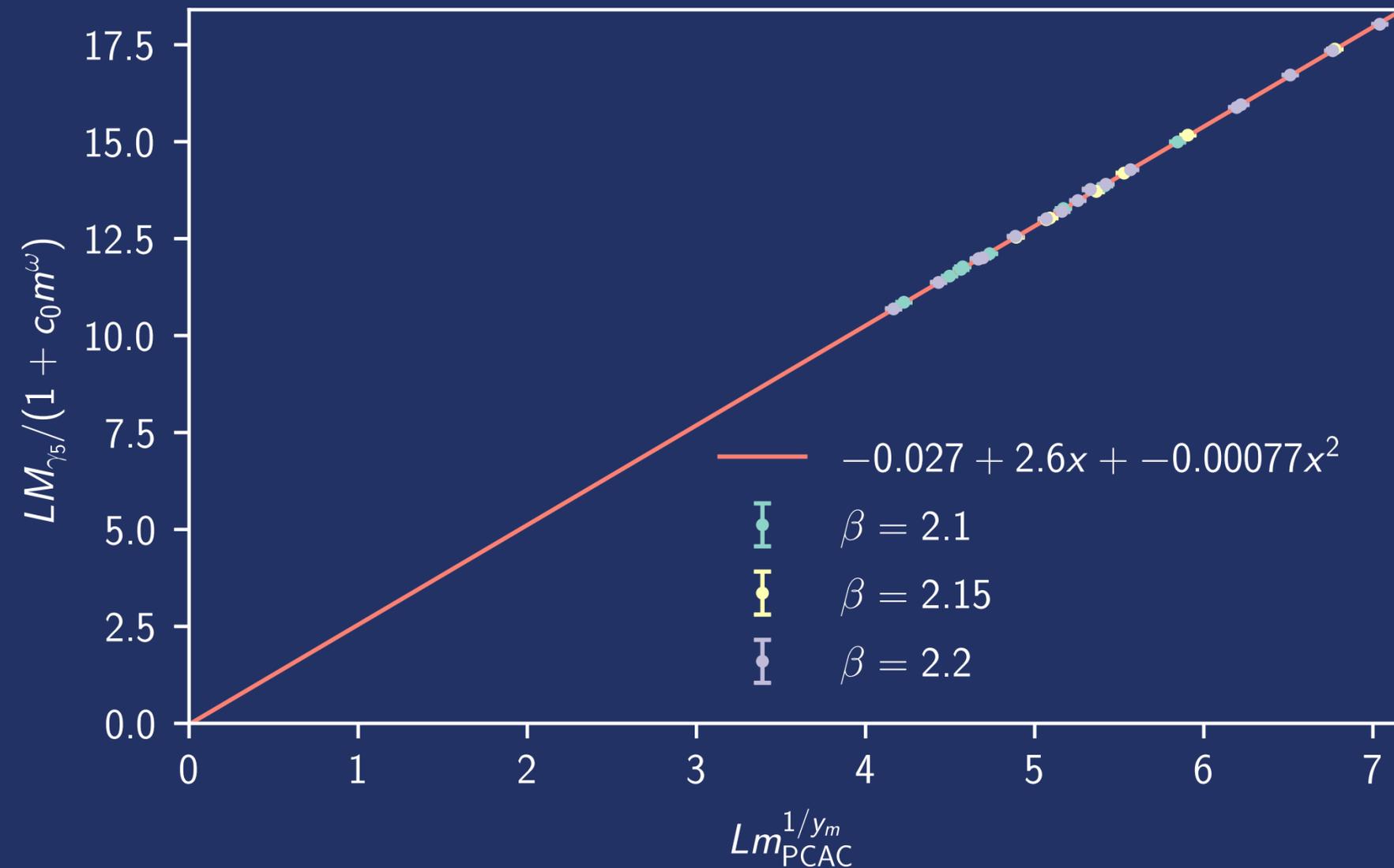# Thank you

Backup

Mode number fits

Near-marginal all-beta FSHS fits

$\gamma_* = 1.016(13),\ \omega = -0.690(23)$

$LM_{\gamma_5}/(1 + c_0 m^{\omega})$

—— $-0.027 + 2.6x + -0.00077x^2$

$\beta = 2.1$

$\beta = 2.15$

$\beta = 2.2$

Lm_{PCAC}^{1/y_m}

(Fit form as in 1401.0195)