Exploring the large N_c limit with one quark flavour

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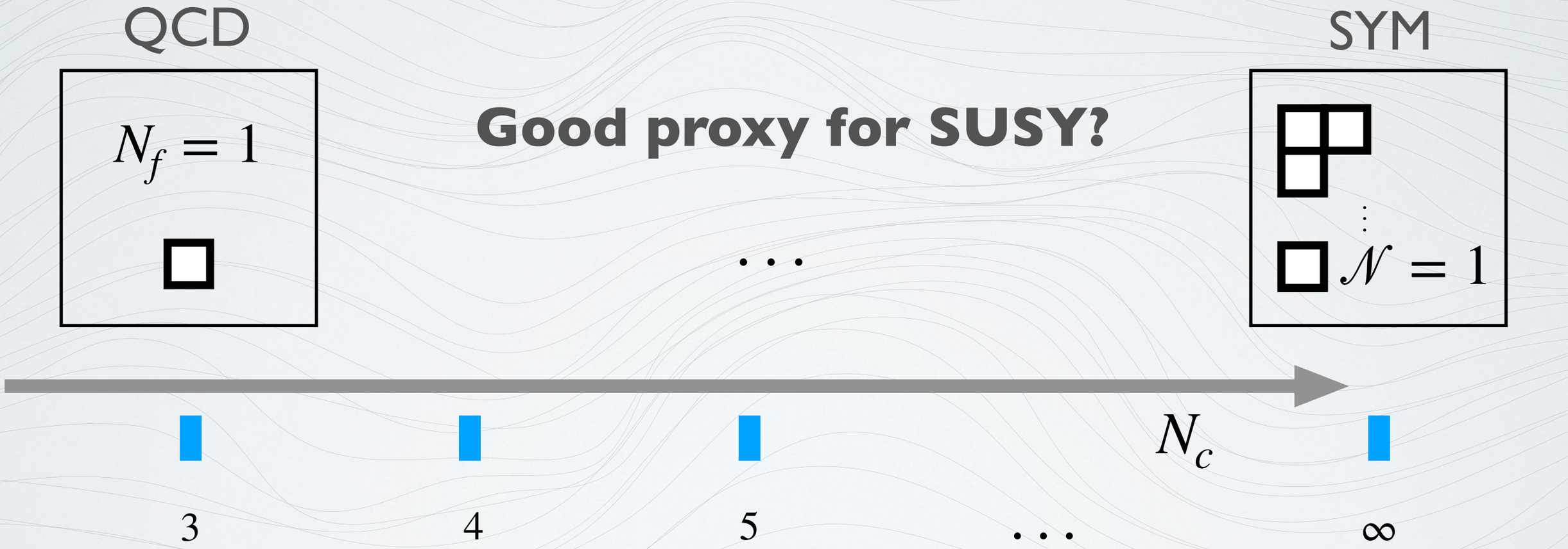
CP³ Origins
Cosmology & Particle Physics

D·IAS

Study SUSY with $N_f = 1$ QCD

- Simulate SUSY without the need to simulate SUSY



previous work
Corrigan & Ramond, 1979
hep-th/0309252 hep-th/0403071
hep-th/0603045 hep-th/0609187
hep-lat/0810.0161

Study SUSY with $N_f = 1$ QCD

- Simulate SUSY without need to simulate SUSY
  - Study spectrum and compare to EFT

$$\frac{M_{PS}}{M_S} = 1 - \frac{22}{9N_c} - \frac{4}{9}\beta + \mathcal{O}(1/N_c^2)$$

hep-th/0309252

  - Equivalence

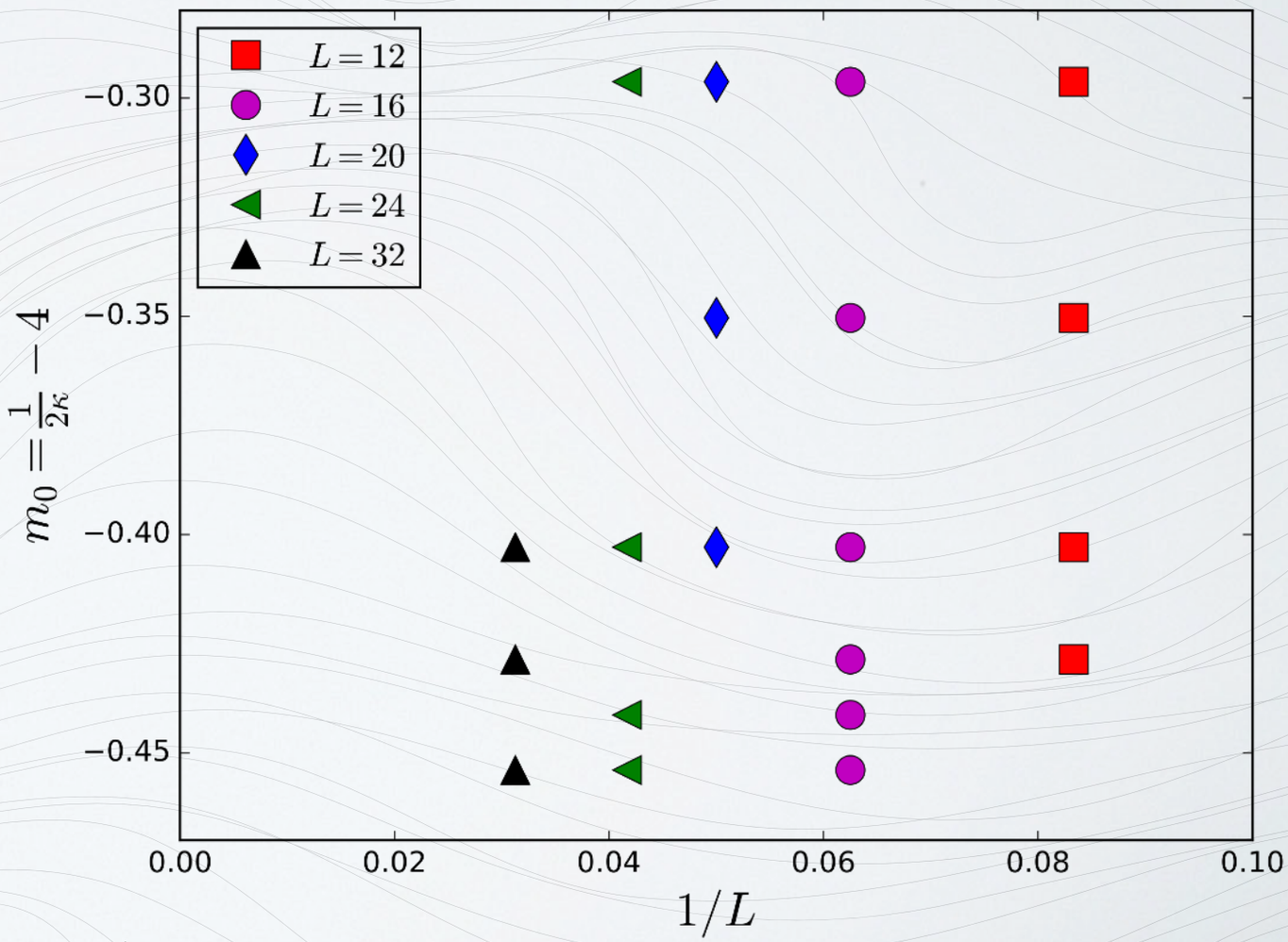
$$\frac{M_{PS}}{M_S} = 1 - \frac{2}{N_c} + \ldots$$

hep-th/0508107

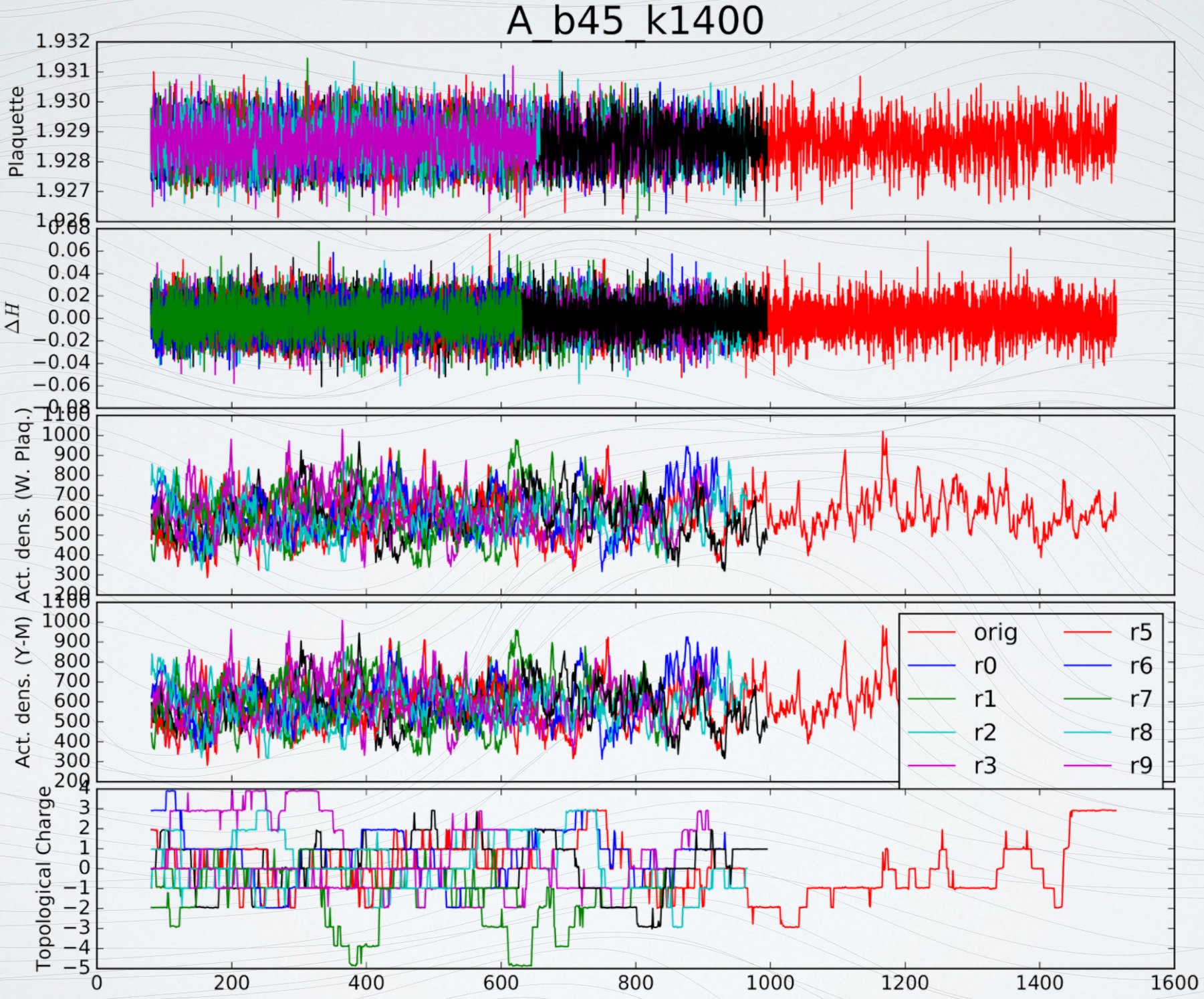
  - @ Lattice: Compute masses and check the ratio

Lattice Setup

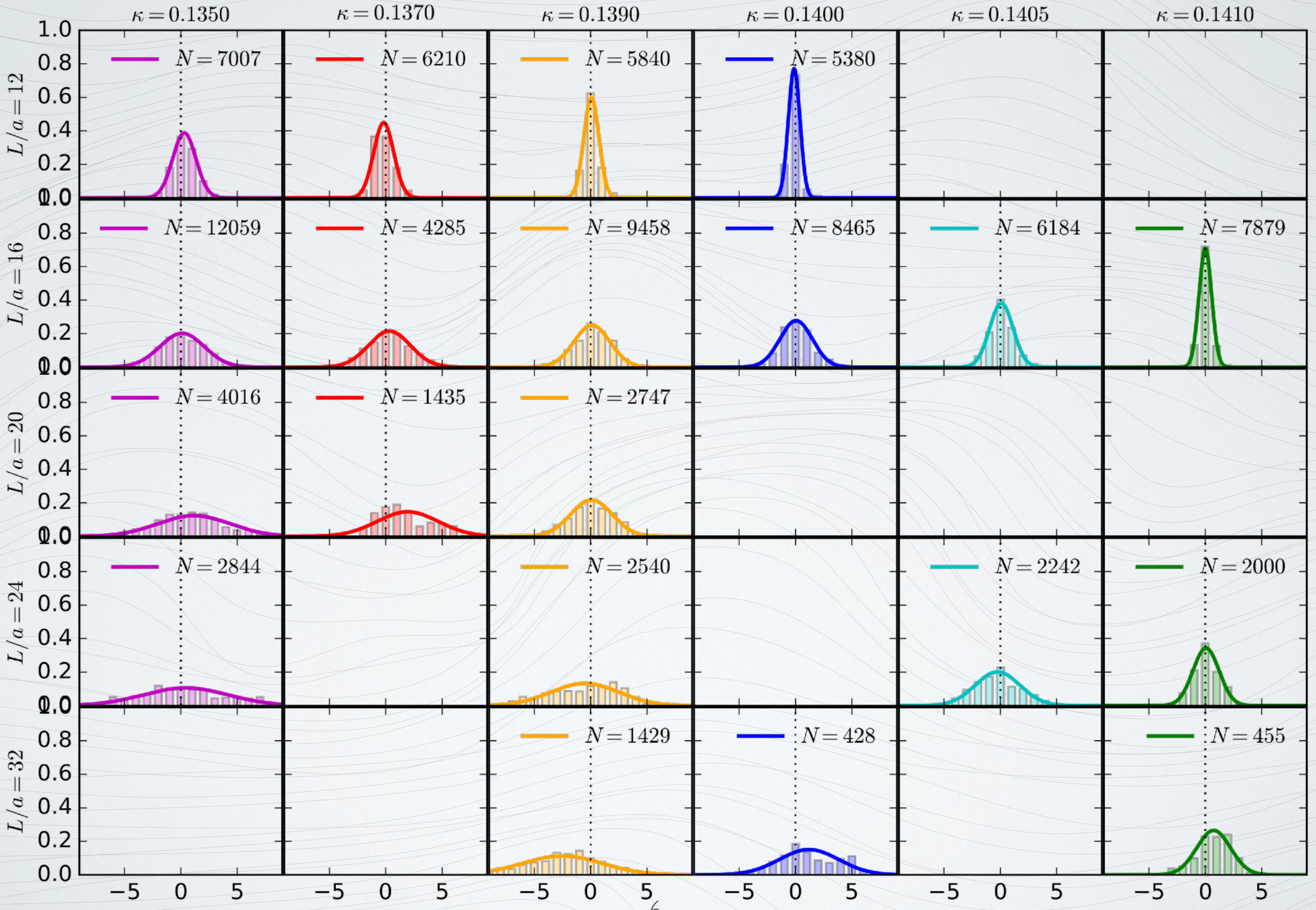
- **Our setup**
  - Gauge: Symanzik improved gauge action ($\beta = 4.5$)
  - Fermion: $\mathcal{O}(a)$ improved Wilson fermions ($c_{sw} = 1$)
  - 5 x Volumes
  - 6 x Masses
  - $a \sim 0.06$ fm
- **One Flavour**
  - Use RHMC
  - Monitor eigenvalues
  - $\det M > 0$?



Typical run

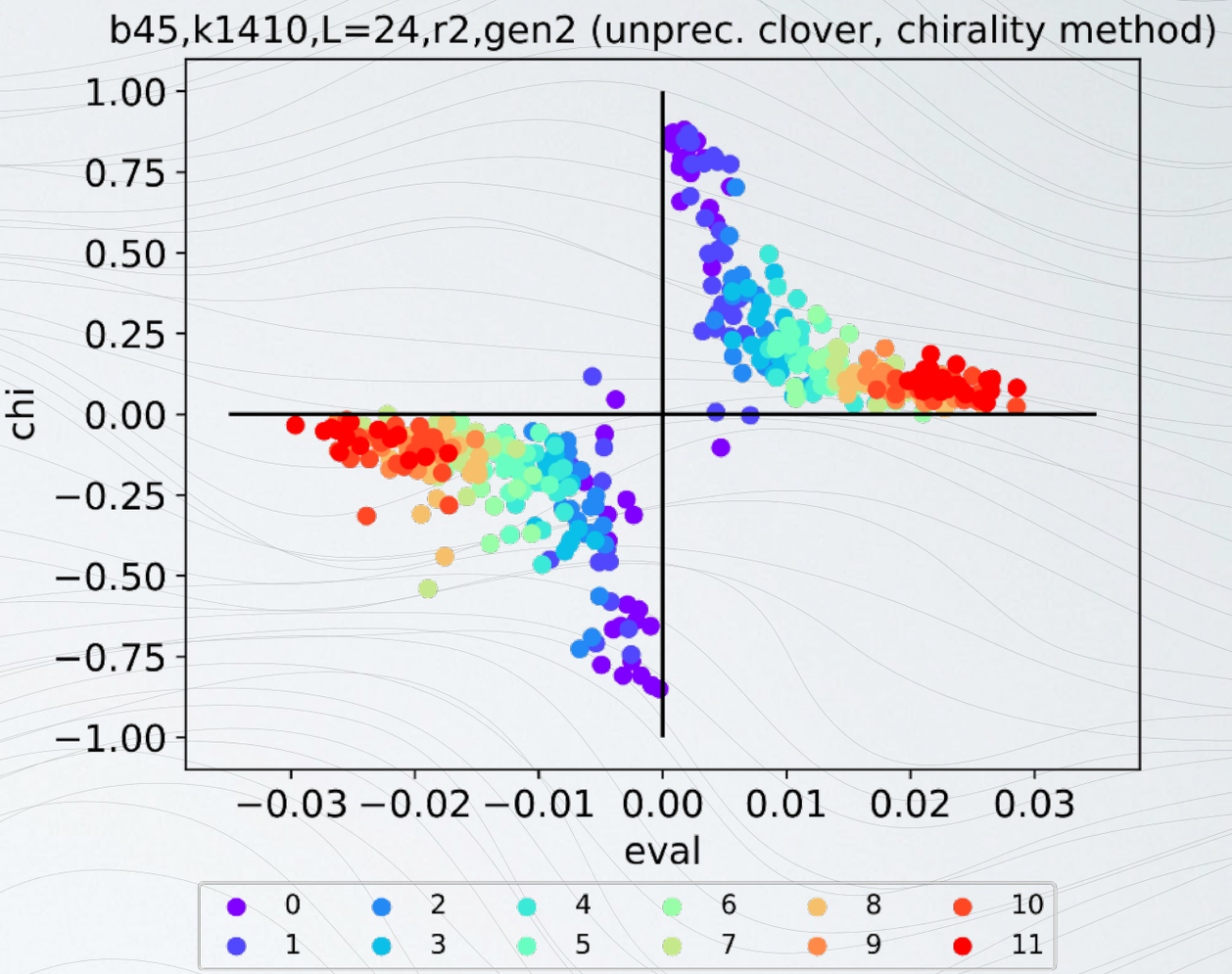

A_b45_k1400
Plaquette
ΔH
Act. dens. (W. Plaq.)
Act. dens. (Y-M)
Topological Charge
orig
r0
r1
r2
r3
r5
r6
r7
r8
r9

Topological Charge



Comment on Eigenvalues

- One Flavour simulation
  - Wilson fermions
  - $\det(M) < 0$ possible
  - Monitor eigenvalues
  - Tracking method 2003.13359



- Check eigenvalues
  - $L/a = 16$: $\det(M) > 0$ for all config
  - $L/a = 24$: $\det(M) < 0$ for about $\lesssim 1\,\%$ config

Spectrum

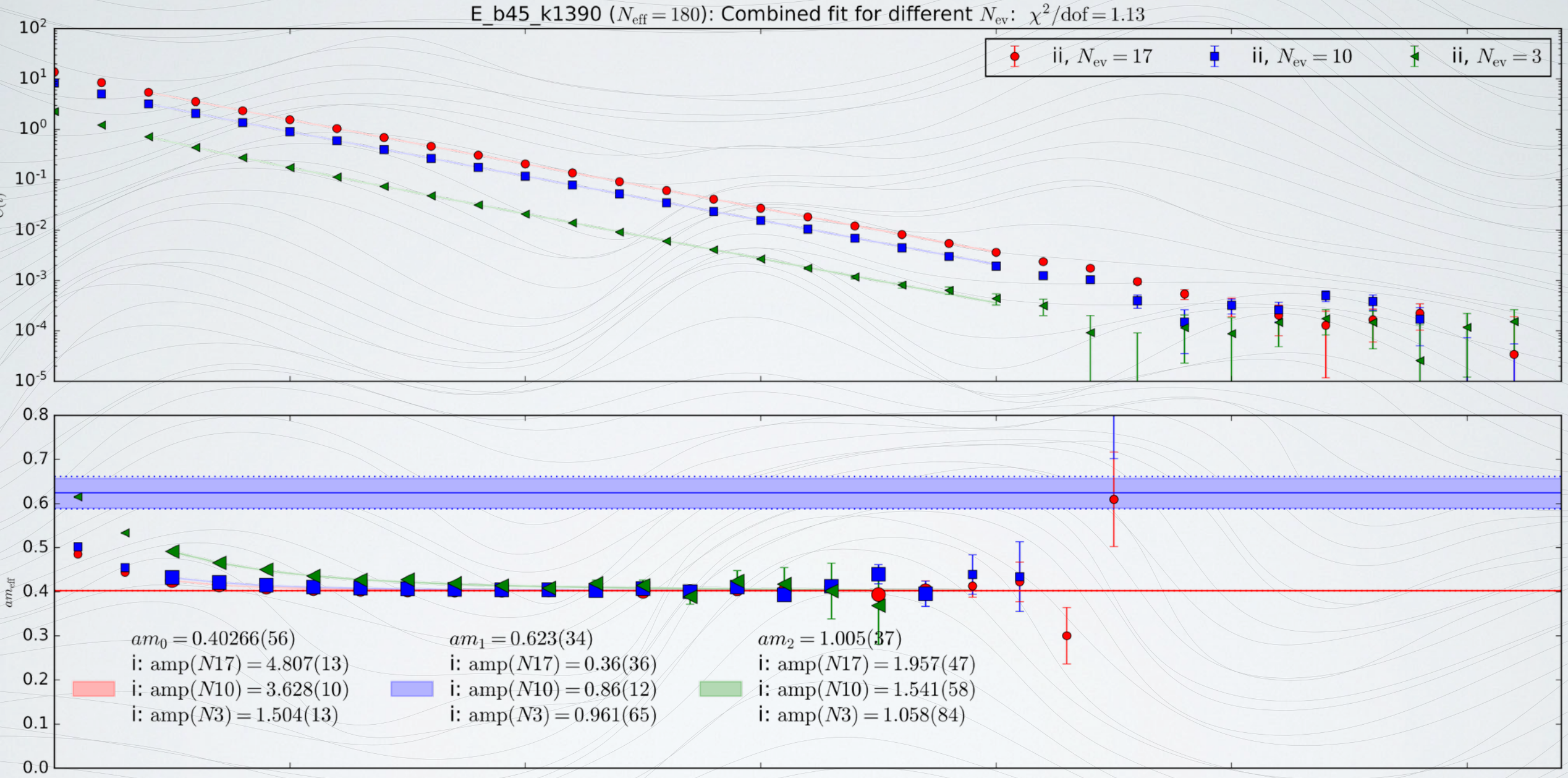
- **Compute the spectrum**
  - Ground state + exited states

$$C_{ij}(t) = \sum_n \langle 0|\widehat{O}_i|n\rangle\langle n|\widehat{O}_j^\dagger|0\rangle e^{-t\, m_n}$$

  - Operators: scalar **(S)**, glue **(G)**, vector **(V)**, pseudo-scalar **(P)**

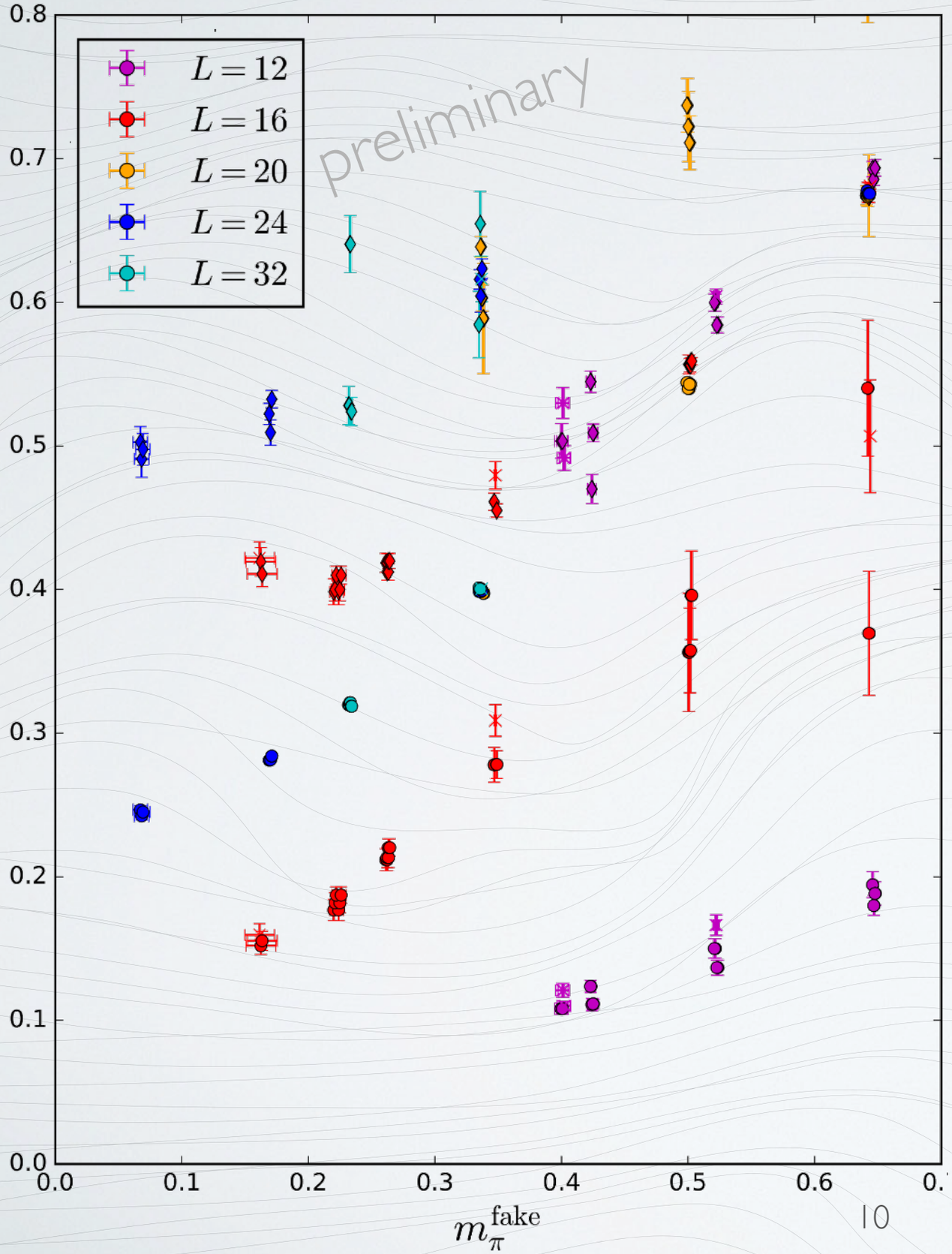
- **LapH method**
  - Disconnected diagram included :)
  - Multiple levels of smearing

Fitting the Correlators



- Simultaneous fit to different levels of smearing

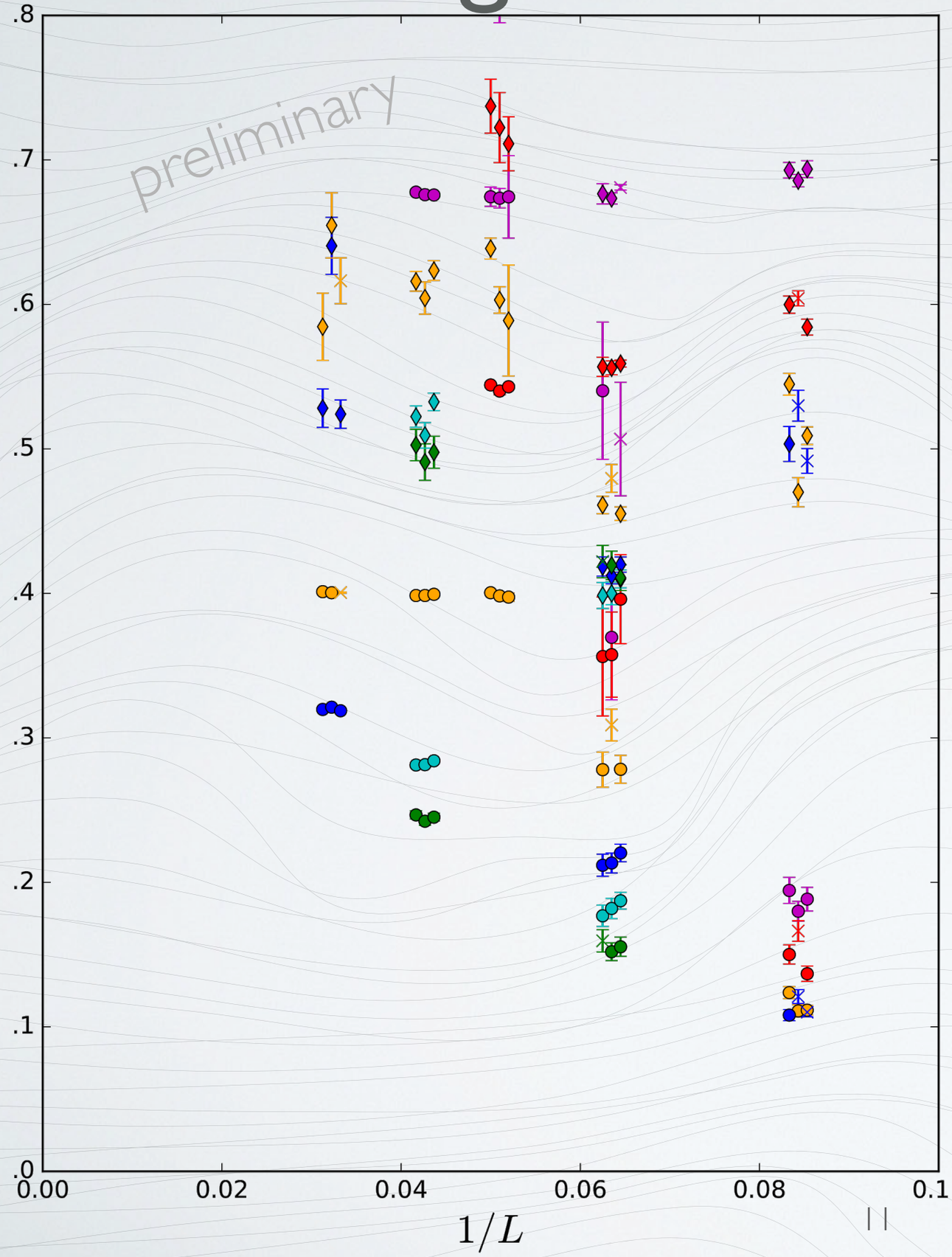
Making sense of the spectrum



- Vector mass
- Two lowest lying states
- m_π^{fake}: Connected pion corr.

state	$\bar{q}\,\Gamma\,q$	glue ball
vol. dep	✗	✗
mass dep.	✓	(✗)

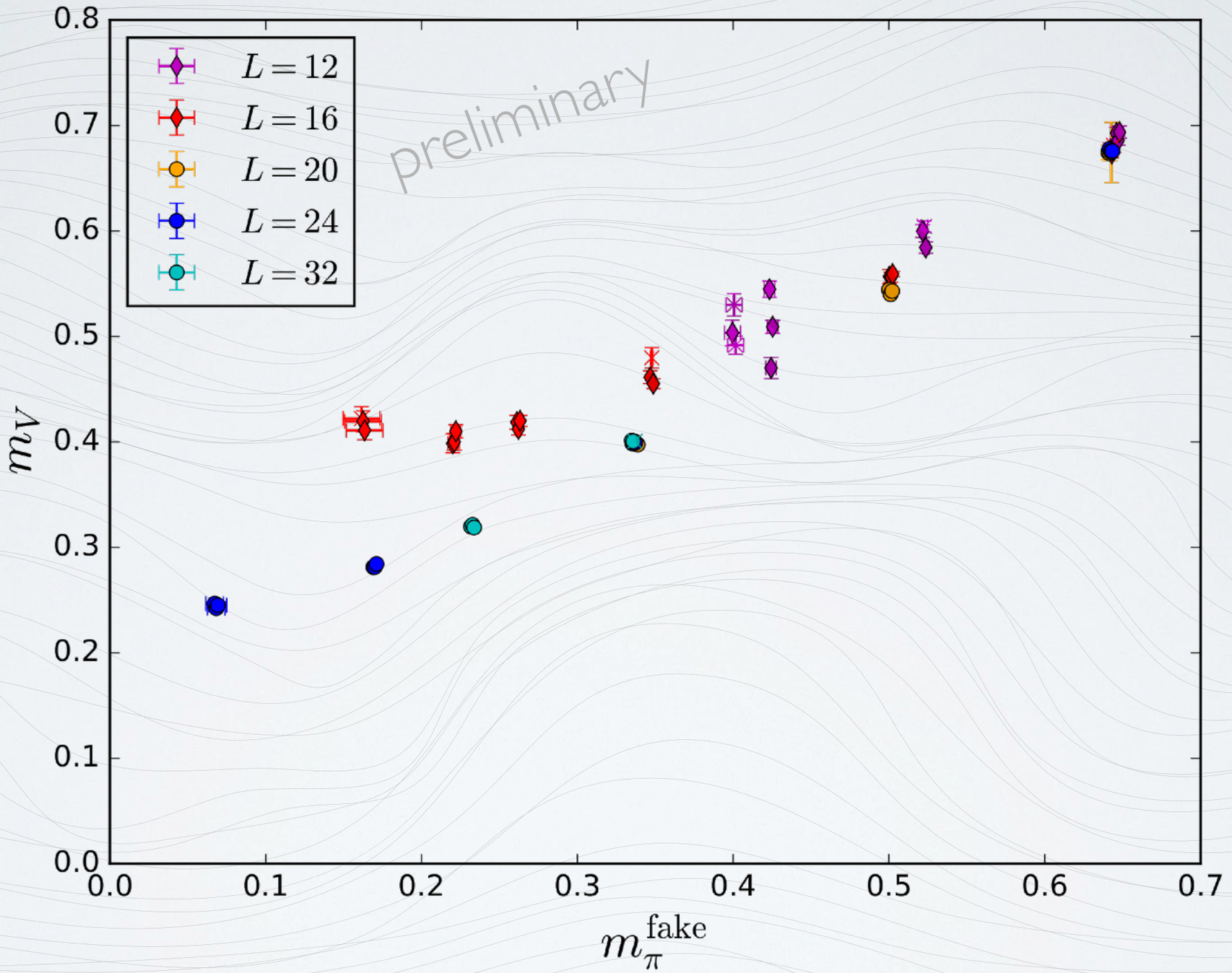
Making sense of the spectrum



- Vector mass
- Two lowest lying states
- Volume dependence
- Different colour ↔ masses

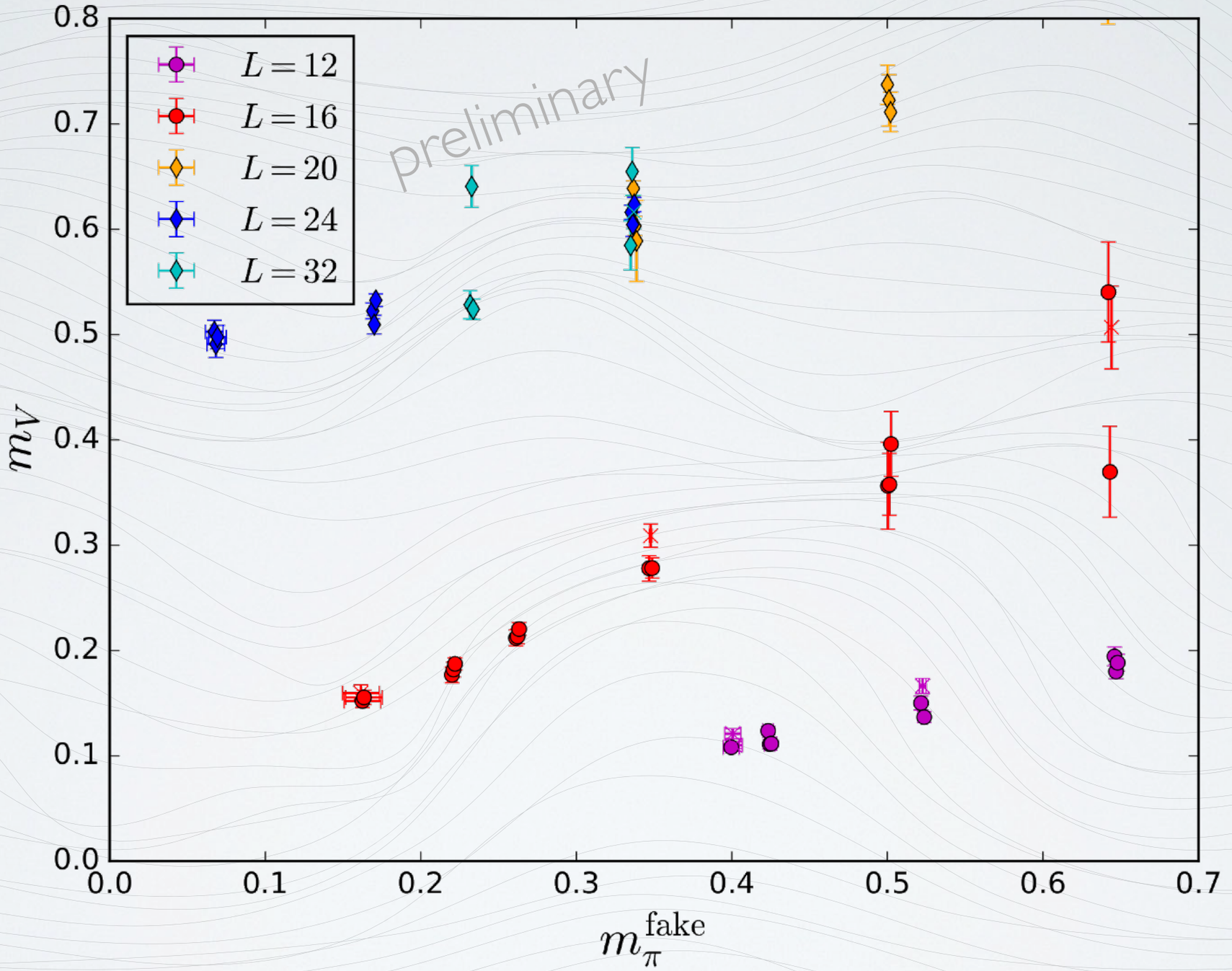
state	$\bar{q}\,\Gamma\,q$	glue ball
vol. dep	✗	✗
mass dep.	✓	(✗)

Results - Vector



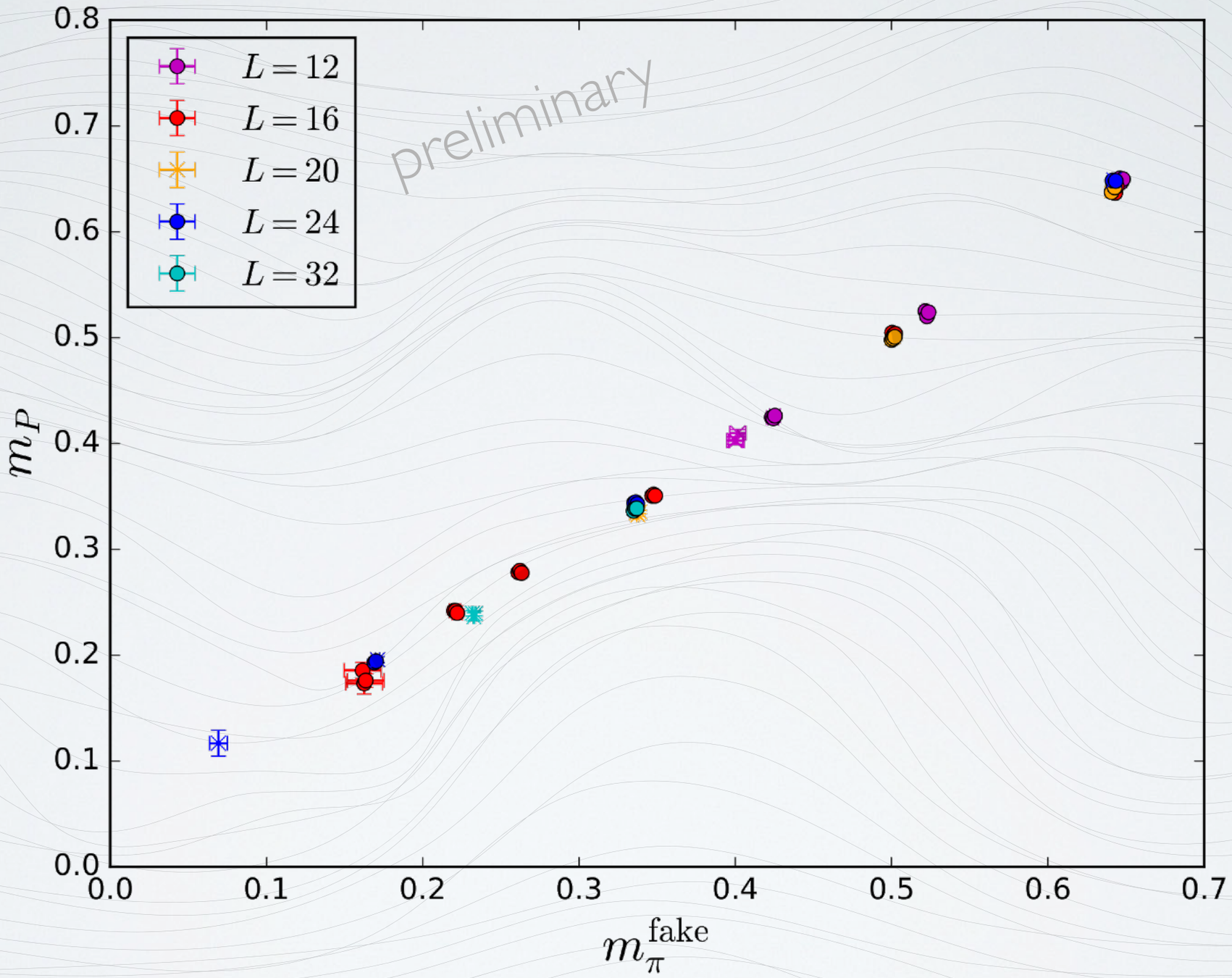
$\bar{q}\Gamma q$ state - clear mass dependence

Results - Vector



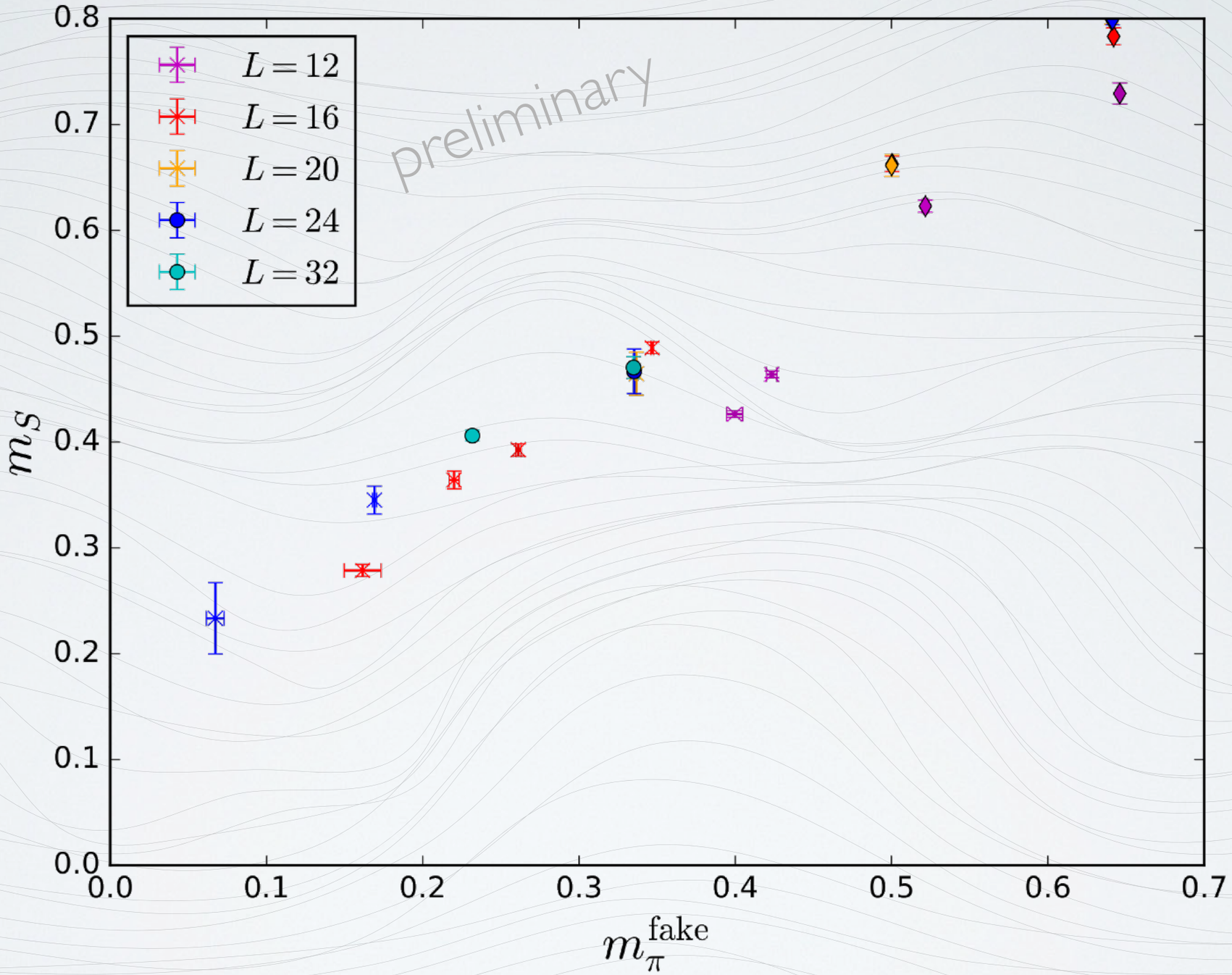
toleron state - volume dependent

Results - Pseudo-scalar



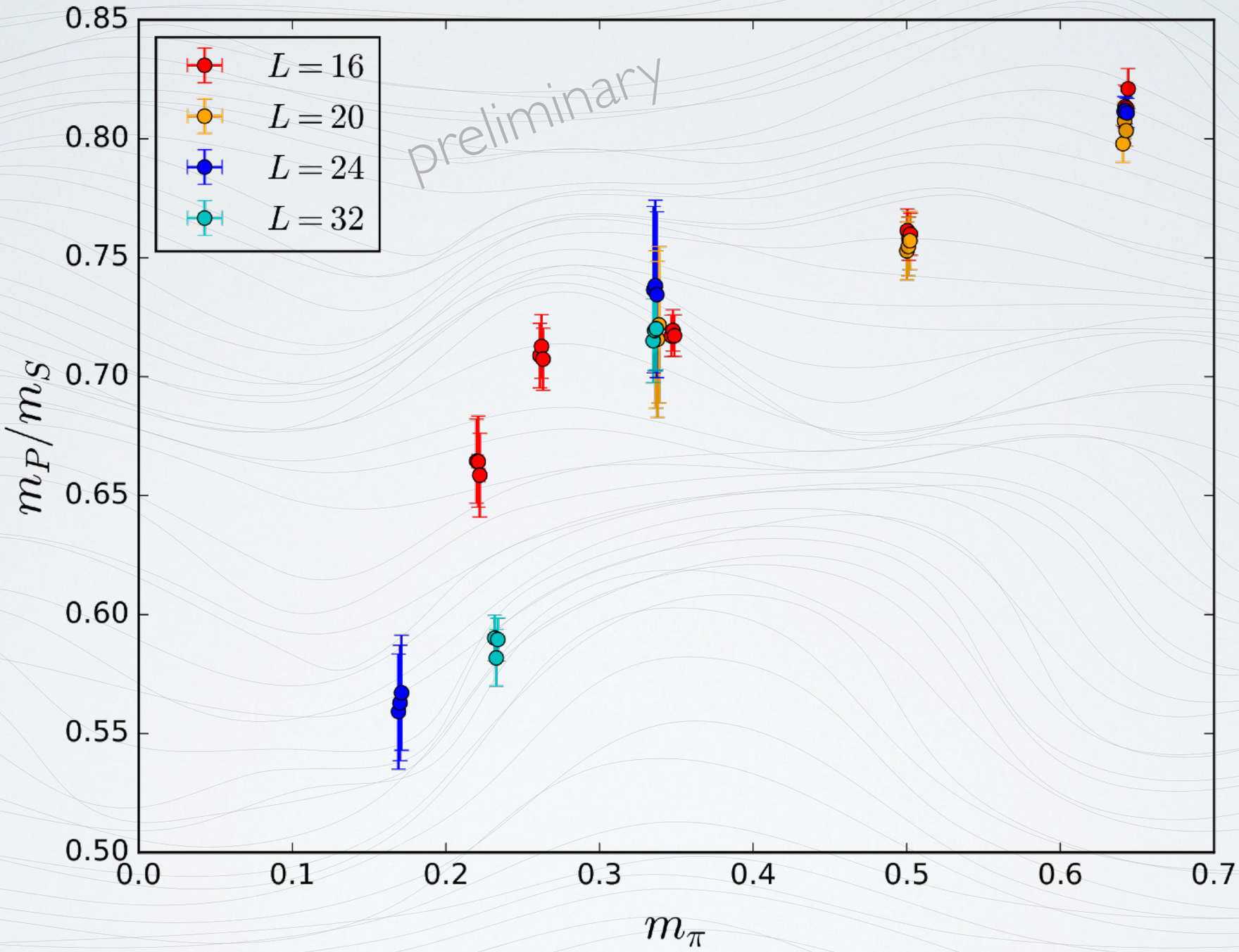
$\bar{q}\Gamma q$ state - clear mass dependence

Results - Scalar



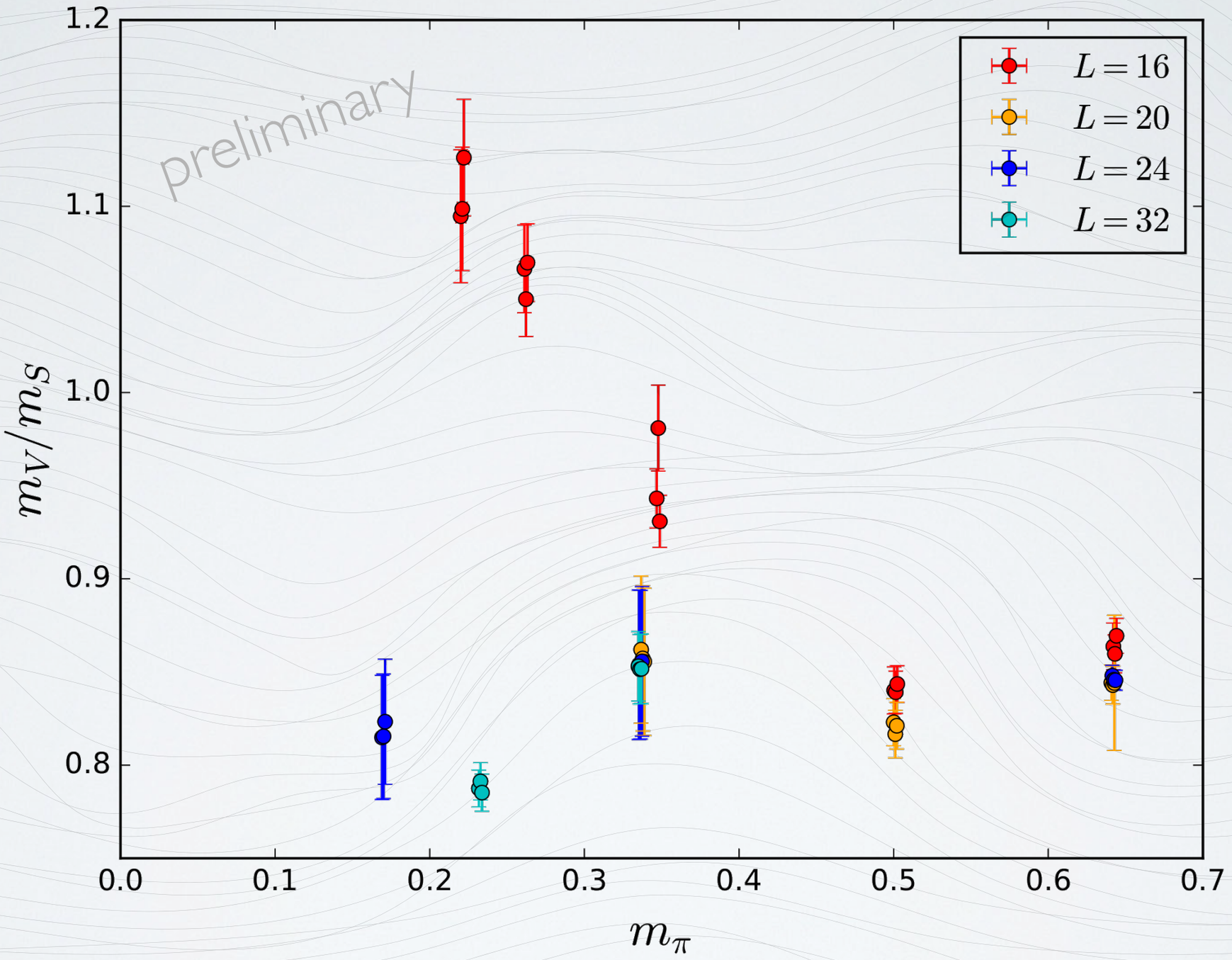
$\bar{q}\Gamma q$ state - clear mass dependence

Build ratio - P / S



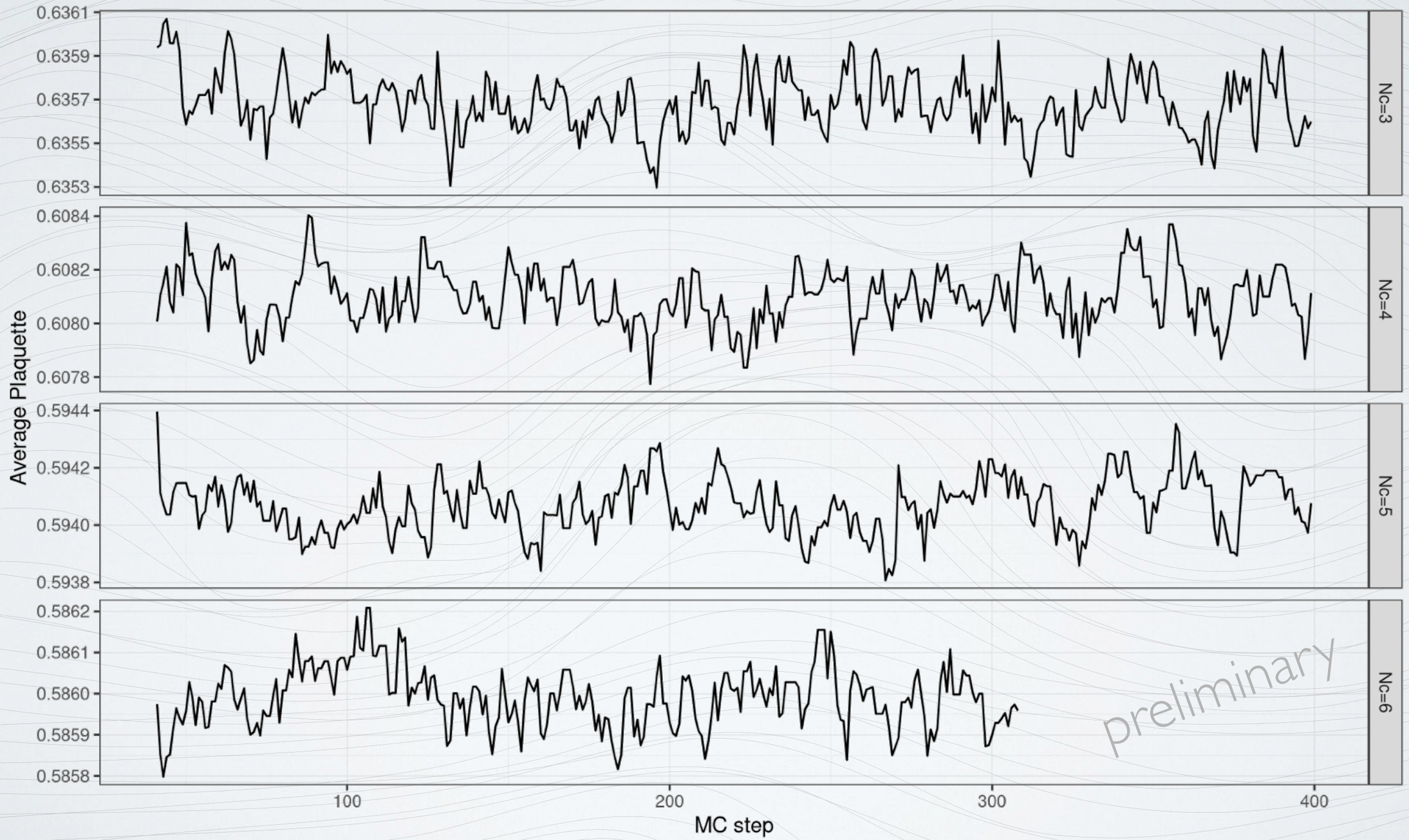
Comparison with prediction: $\frac{M_{PS}}{M_S} = 0.410(32)(15)$ hep-lat/0810.0161

Build ratio - V / S



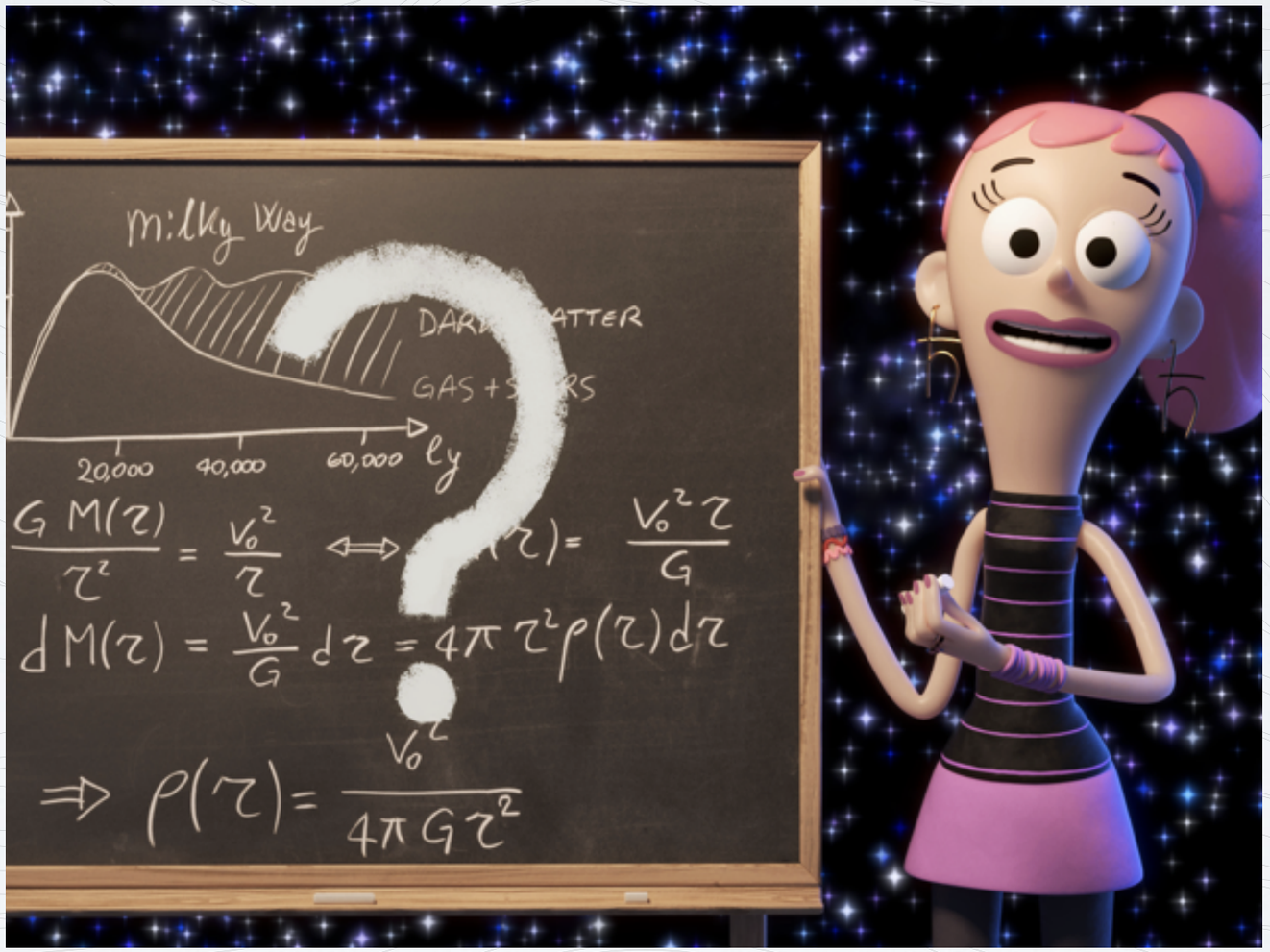
Future

- Increase N_c - first for Pure Gauge - Using GRID hep-lat/1512.03487



Questions?

Thank you for your attention!



Quantum Kate (orig. Kvante Karina): CP3 Outreach http://www.kvantebanditter.dk/en