Lattice 2004

Wolfram Schroers

Picking up the gauntlet

Meeting the challenge of light quarks
~with hybrid calculations

Alexander von Humboldt Stiftung

massachusetts institute of technology

R. Edwards, G. Fleming, Ph. Hägler,
J.W. Negele, K. Orginos, A.V. Pochinski,
D.B. Renner, and D. Richards

The challenge

- Light valence fermions are possible today
- Light sea quarks remain major issue
- Staggered quarks may be able to meet the challenge
- Still want to have chiral fermion formulation for valence quarks
- Can hybrid calculations meet the challenge?

Asqtad+NRQCD vs. Nature

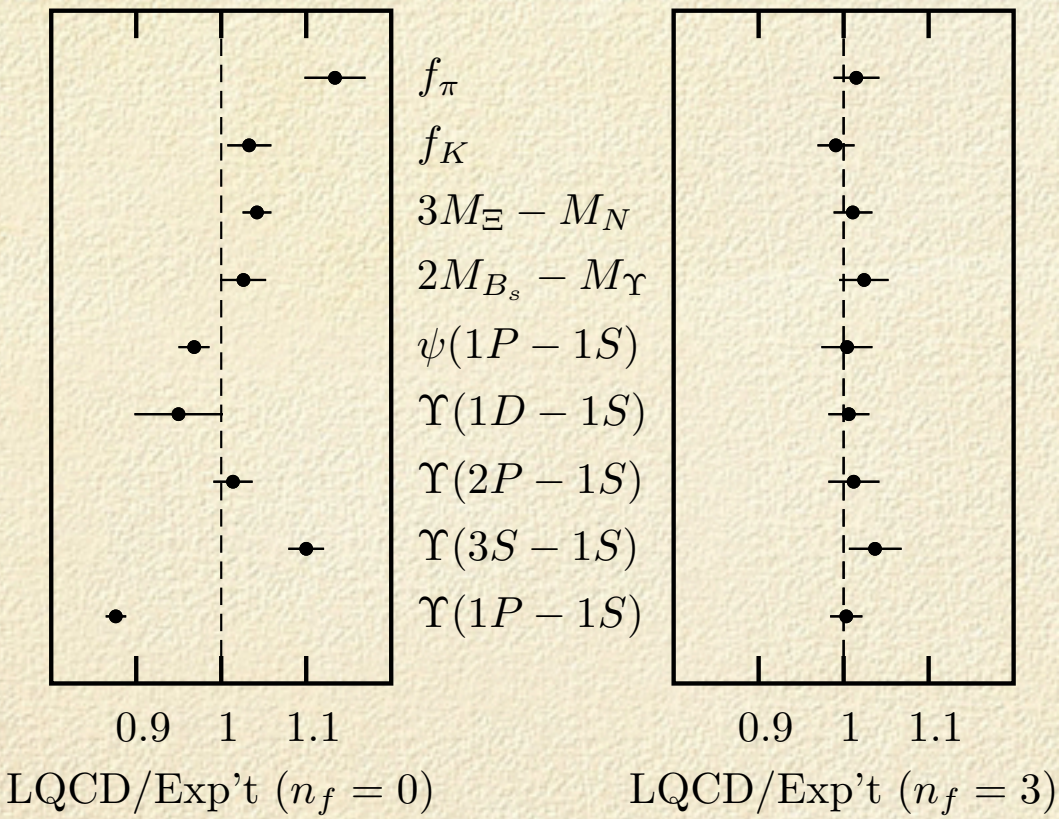


Figure from **PRL92:022001,2004**

On staggered actions see also **hep-lat/0406027**

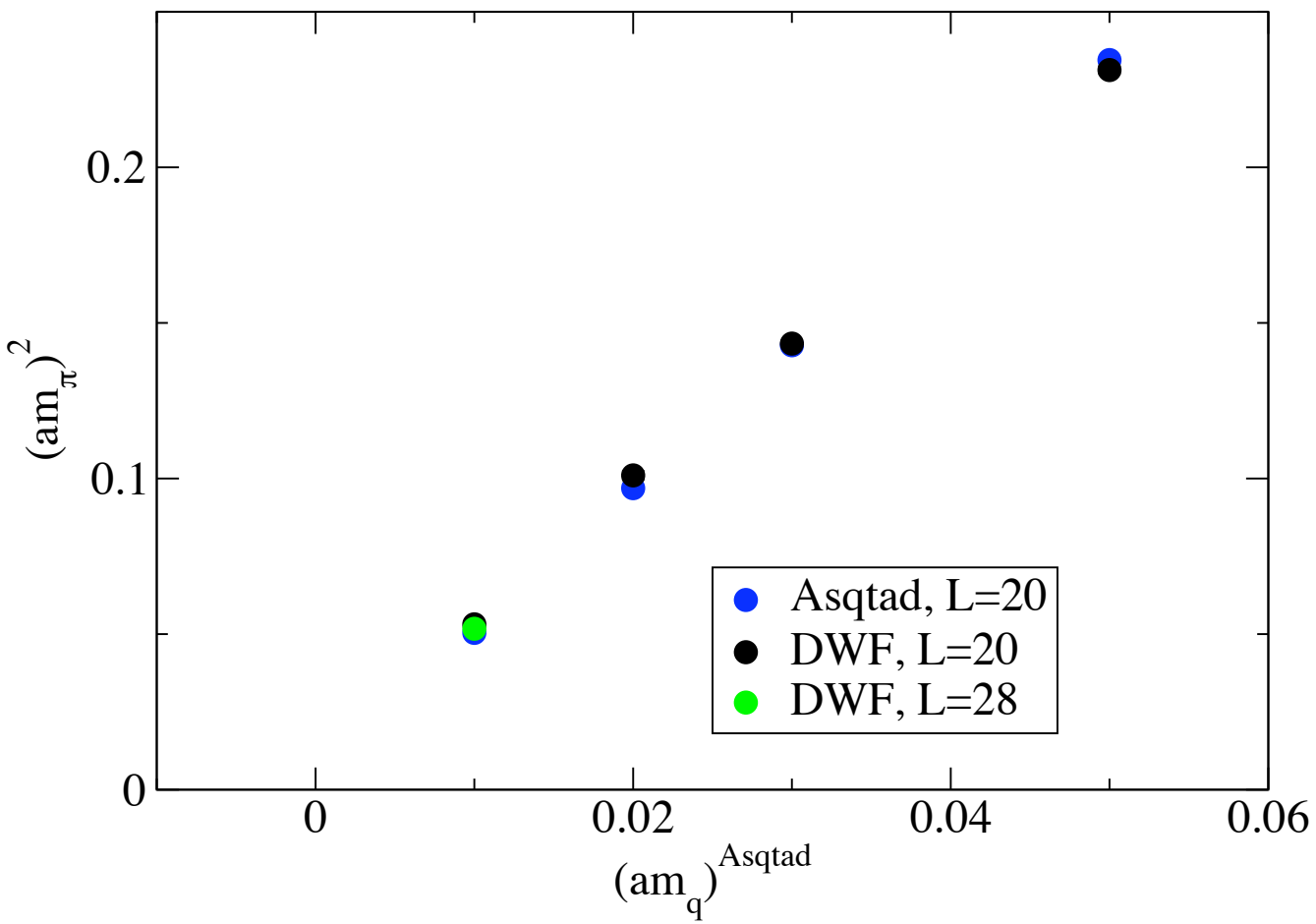
Hybrid calculation with Domain wall fermions

- Using MILC lattices with Asqtad seaquarks
- Apply hypercubic smearing, then take only the first half lattice (**PRD64:034504,2001**)
- Compute observables with valence quarks using the standard DWF action

Tuning the pion mass

Ω	#confs	m_{PS}^{Asqtad}	m_{PS}^{DWF}	m_{PS}/m_V
32×20^3	107	774.8(0.3)	775.8(2.1)	0.687(6)
	134	604.6(0.3)	605.8(2.1)	0.588(7)
	56	498.0(0.3)	502.1(3.7)	0.530(11)
	104	359.1(0.4)	368.8(3.5)	0.415(9)
32×28^3	138		363.8(1.6)	0.387(7)

Pseudoscalar mass comparison



Bare quark masses

Ω	$am_q^{\text{Asqtad, sea}}$	$am_q^{\text{Asqtad, val}}$	$am_q^{\text{DWF, val}}$
32×20^3	0.05/0.05	0.05	0.0810
	0.03/0.05	0.03	0.0478
	0.02/0.05	0.02	0.0313
	0.01/0.05	0.01	0.0138
32×28^3	0.01/0.05		0.0138

Setting L_5

- Perform a series of computations with varying L_5 and 25 configurations each
- Determine observables which we expect to be sensitive to chirality
- Jackknife the mass differences between to values of L_5

Residual mass

- Effects of finite L_5 induce extra term in divergence of axial current

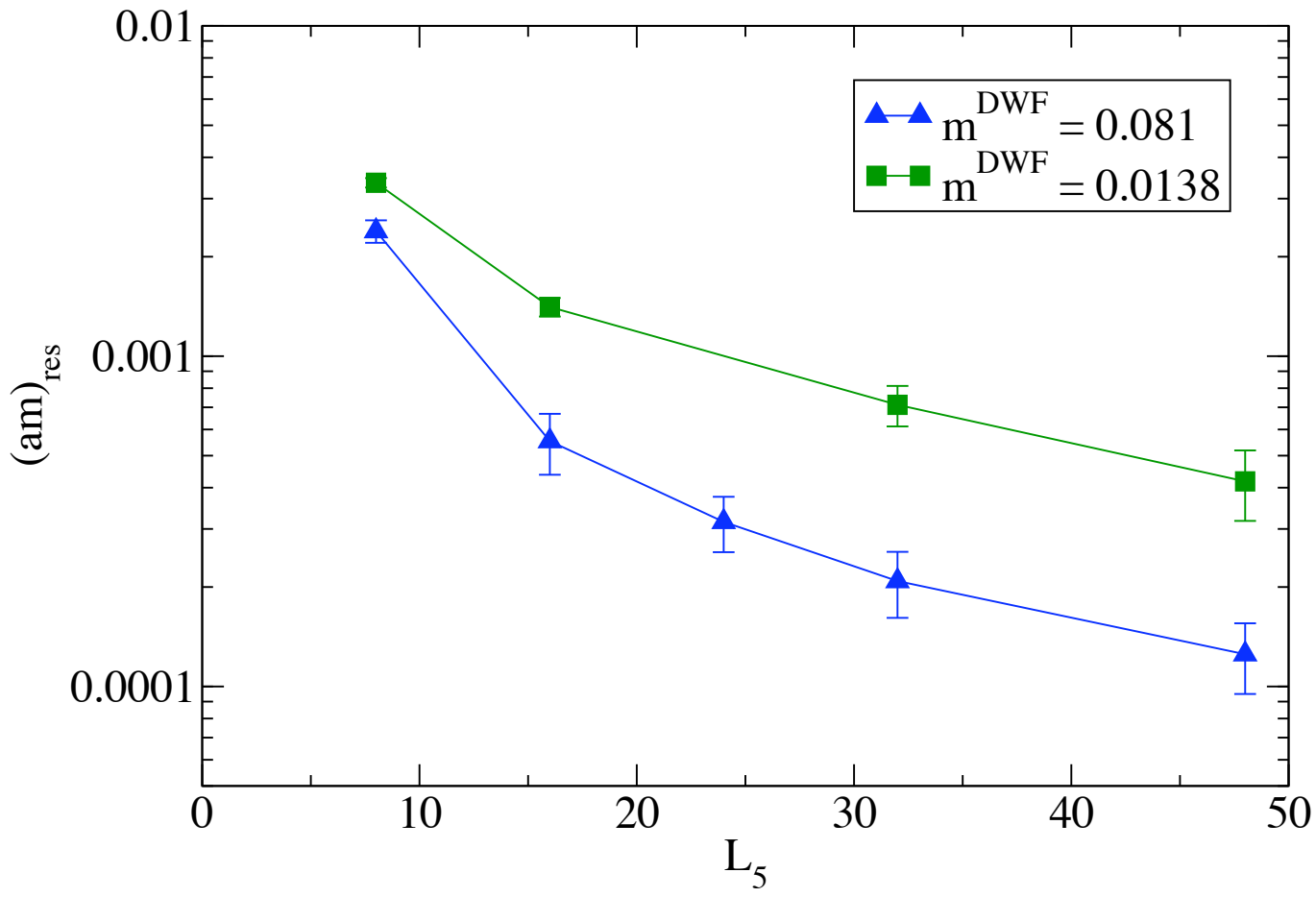
$$\Delta^\mu \mathcal{A}^a_\mu(x) = 2m_f J^a_q(x) + 2J^a_{5q}(x)$$

- Generates a "residual quark mass" m_{res} via

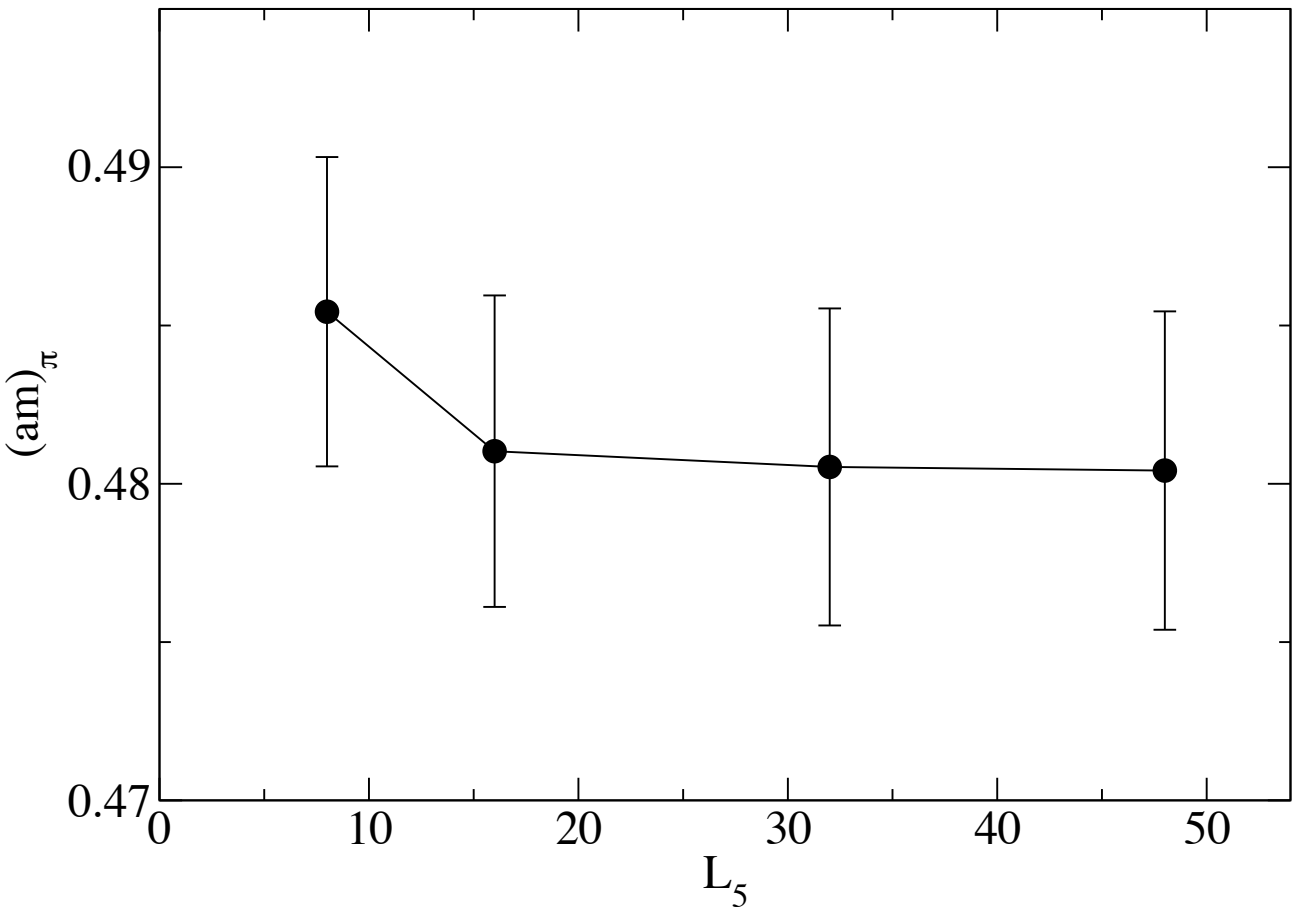
$$J^a_{5q} \approx m_{\text{res}} J^a_5$$

up to $\mathcal{O}(a^2)$ in low momentum amplitudes

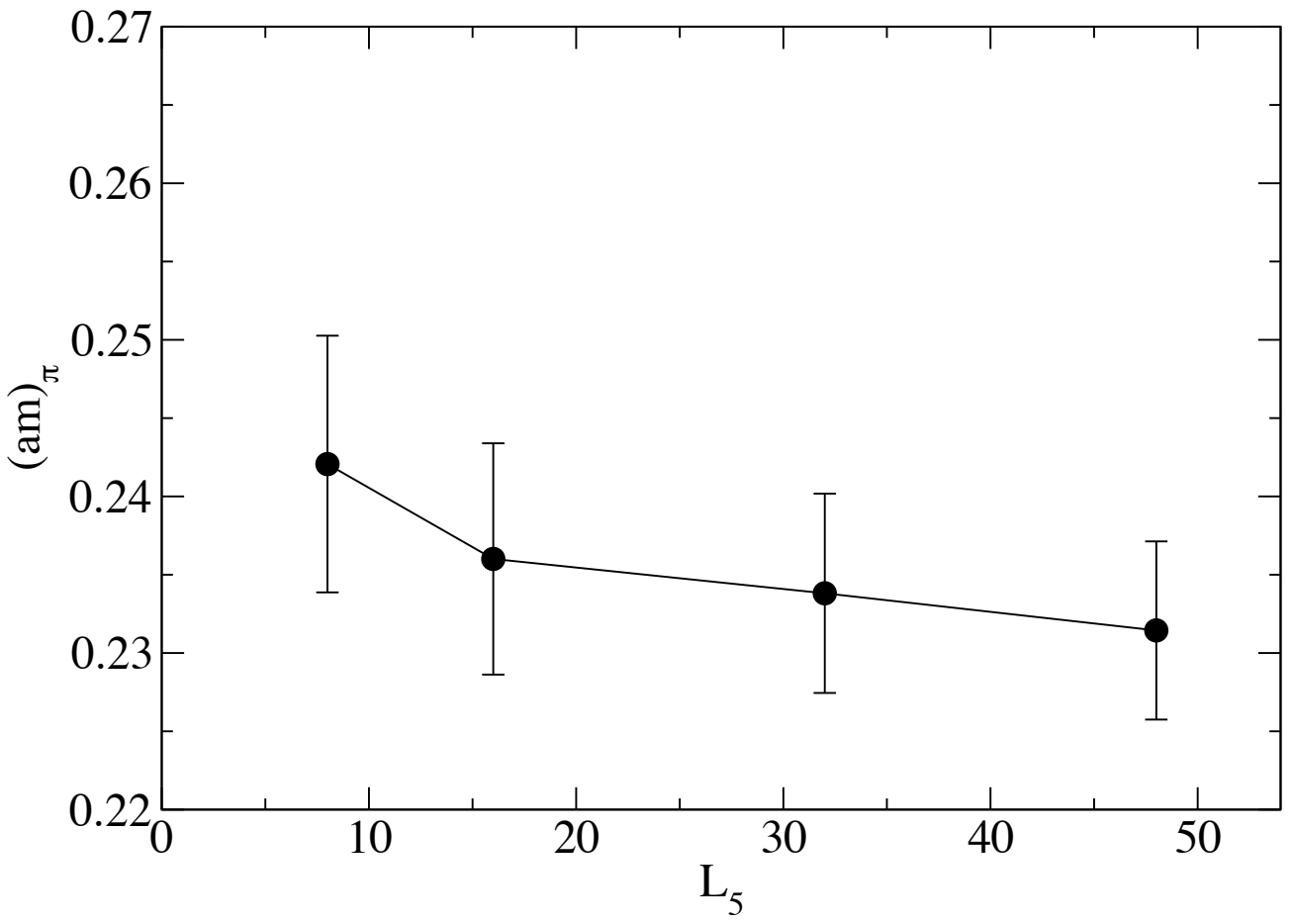
Residual mass



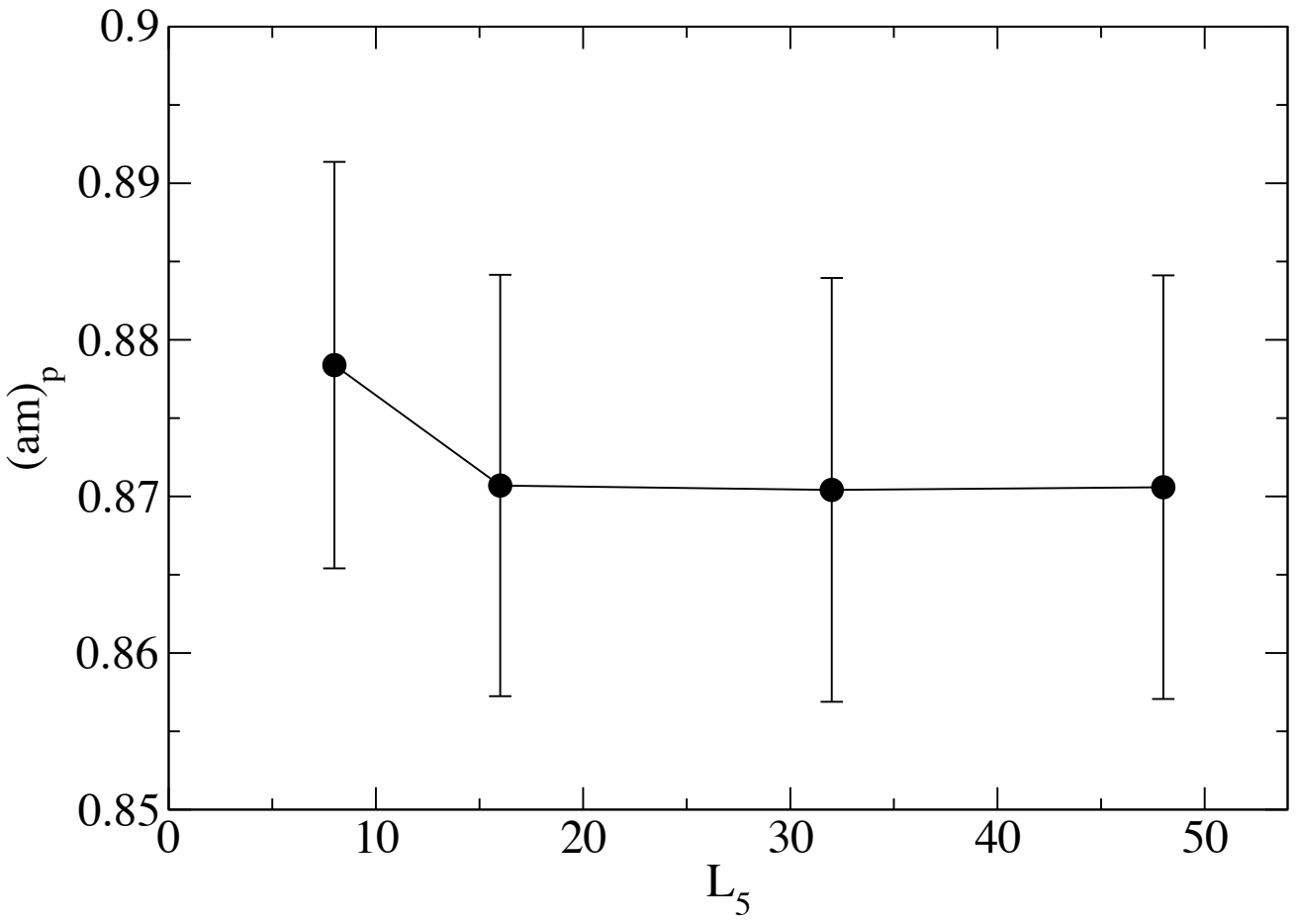
Pion mass (heavy)



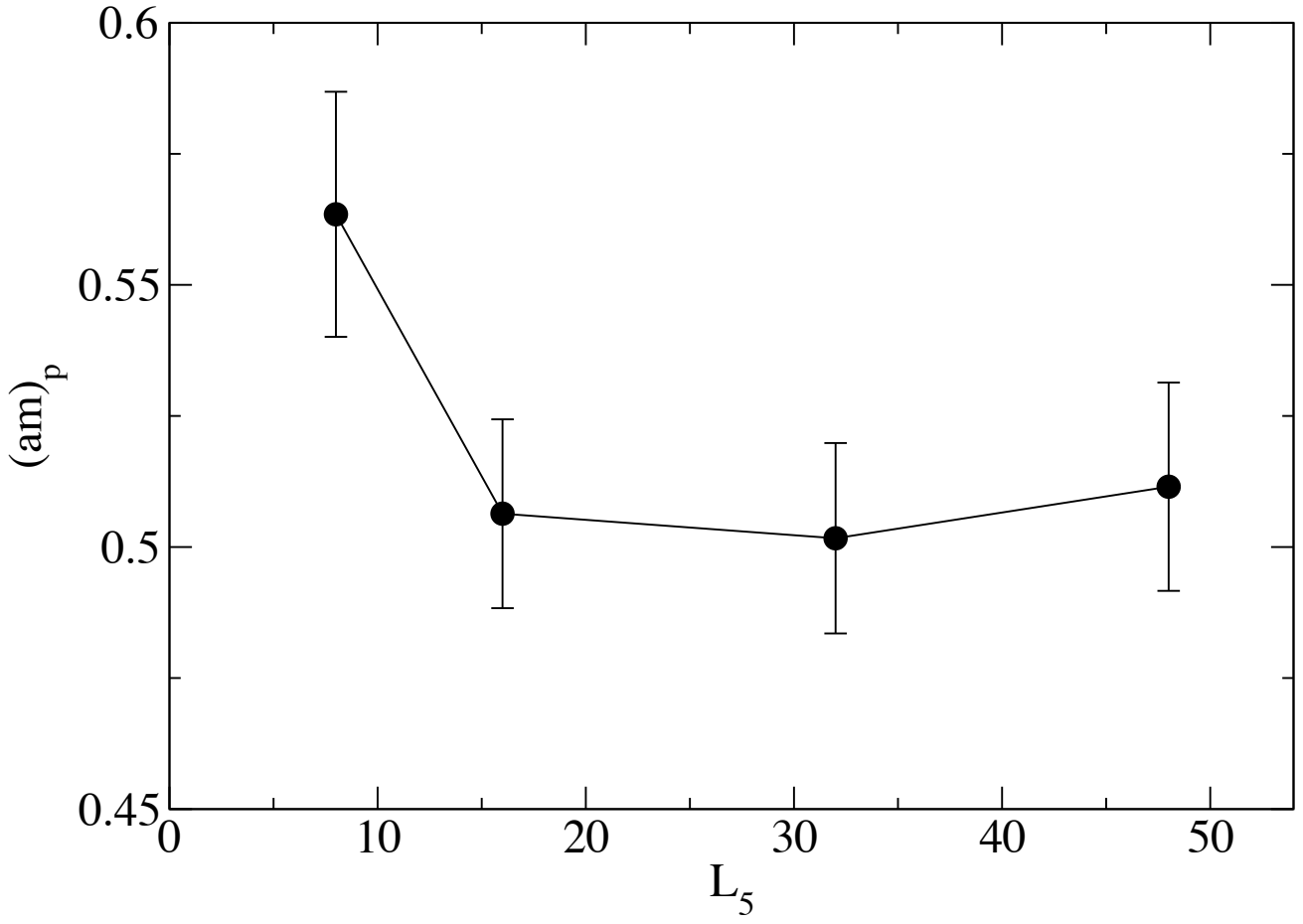
Pion mass (light)



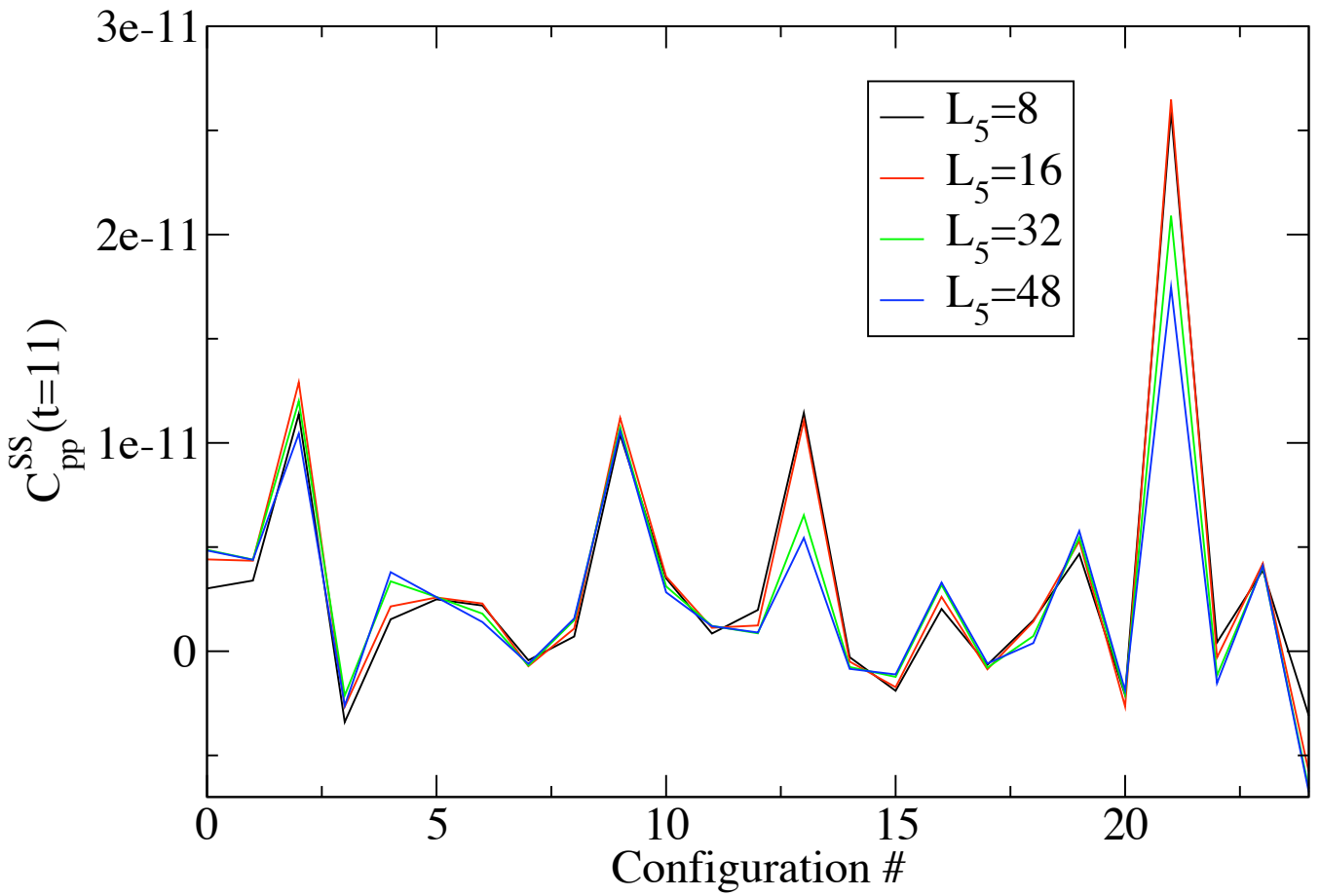
Nucleon mass (heavy)



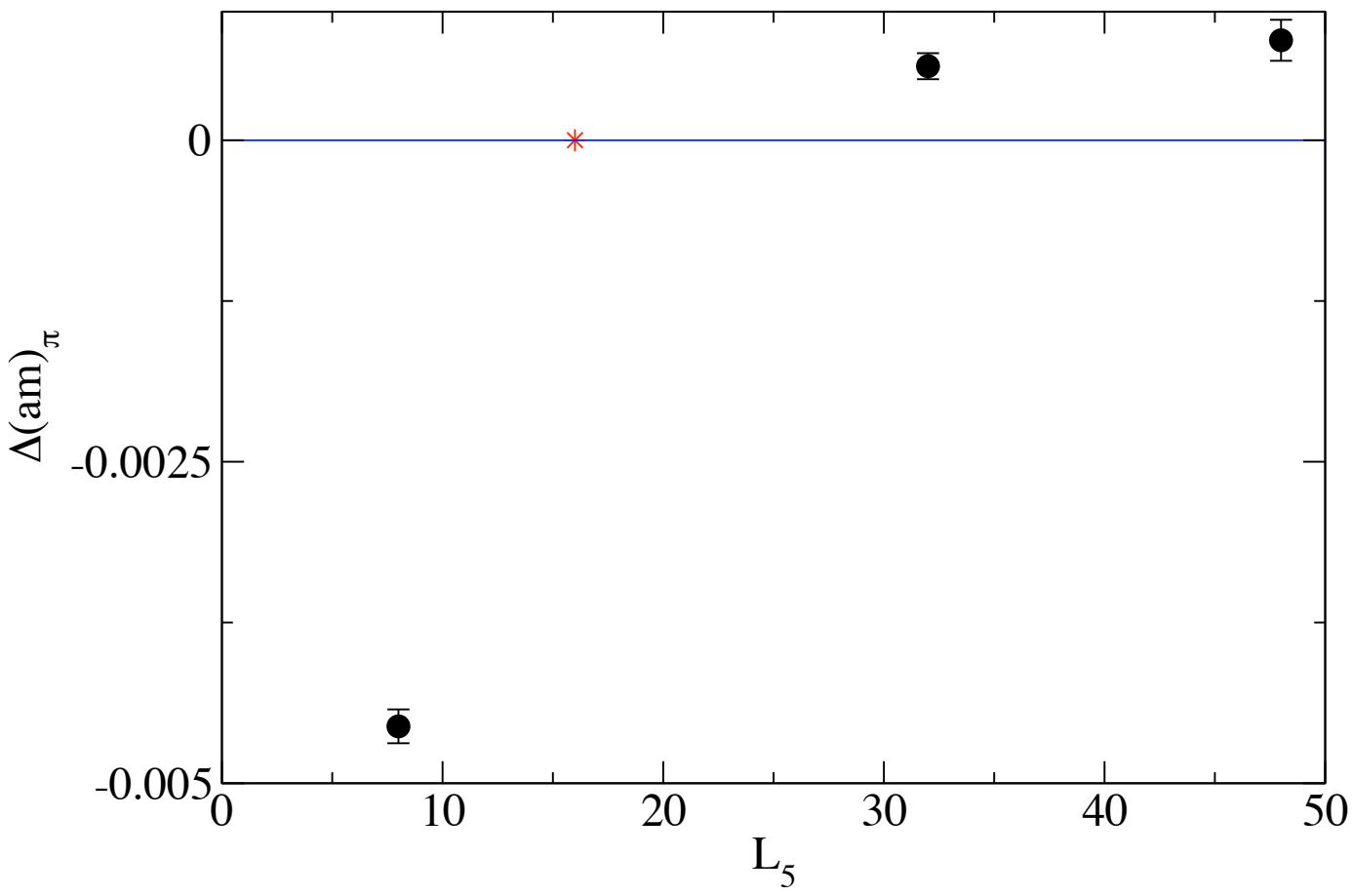
Nucleon mass (light)



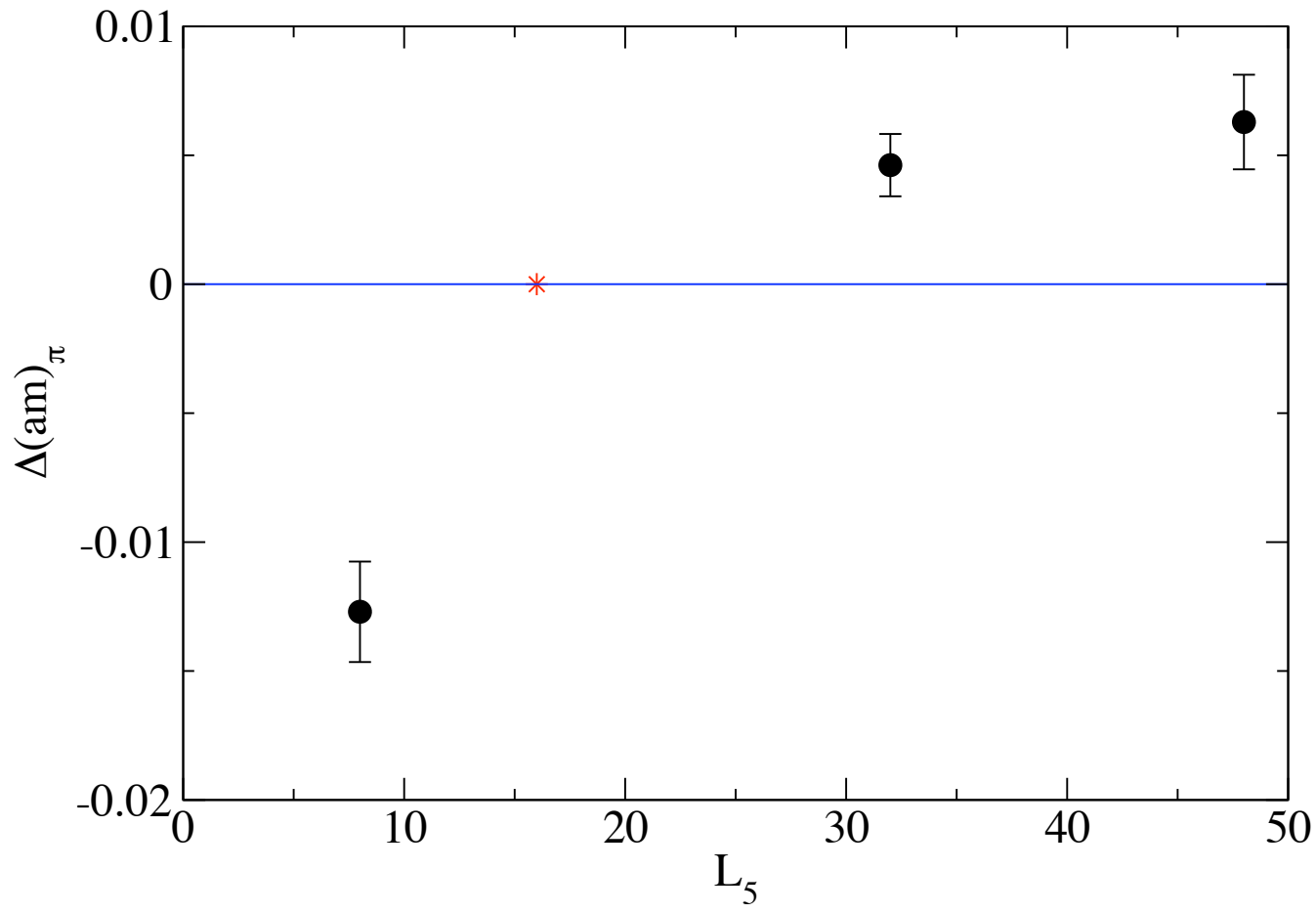
History of a single timeslice



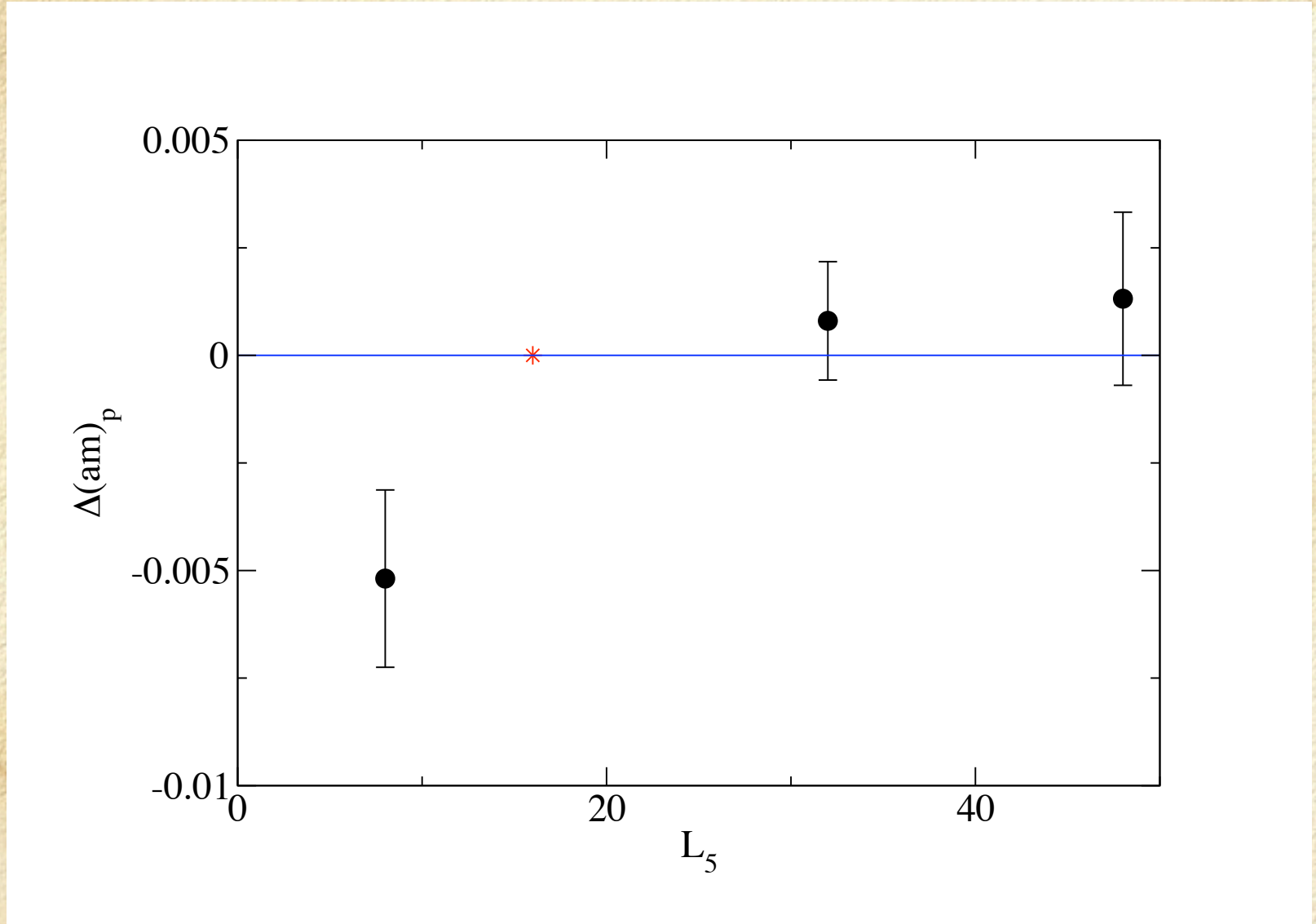
Pion mass difference (heavy)



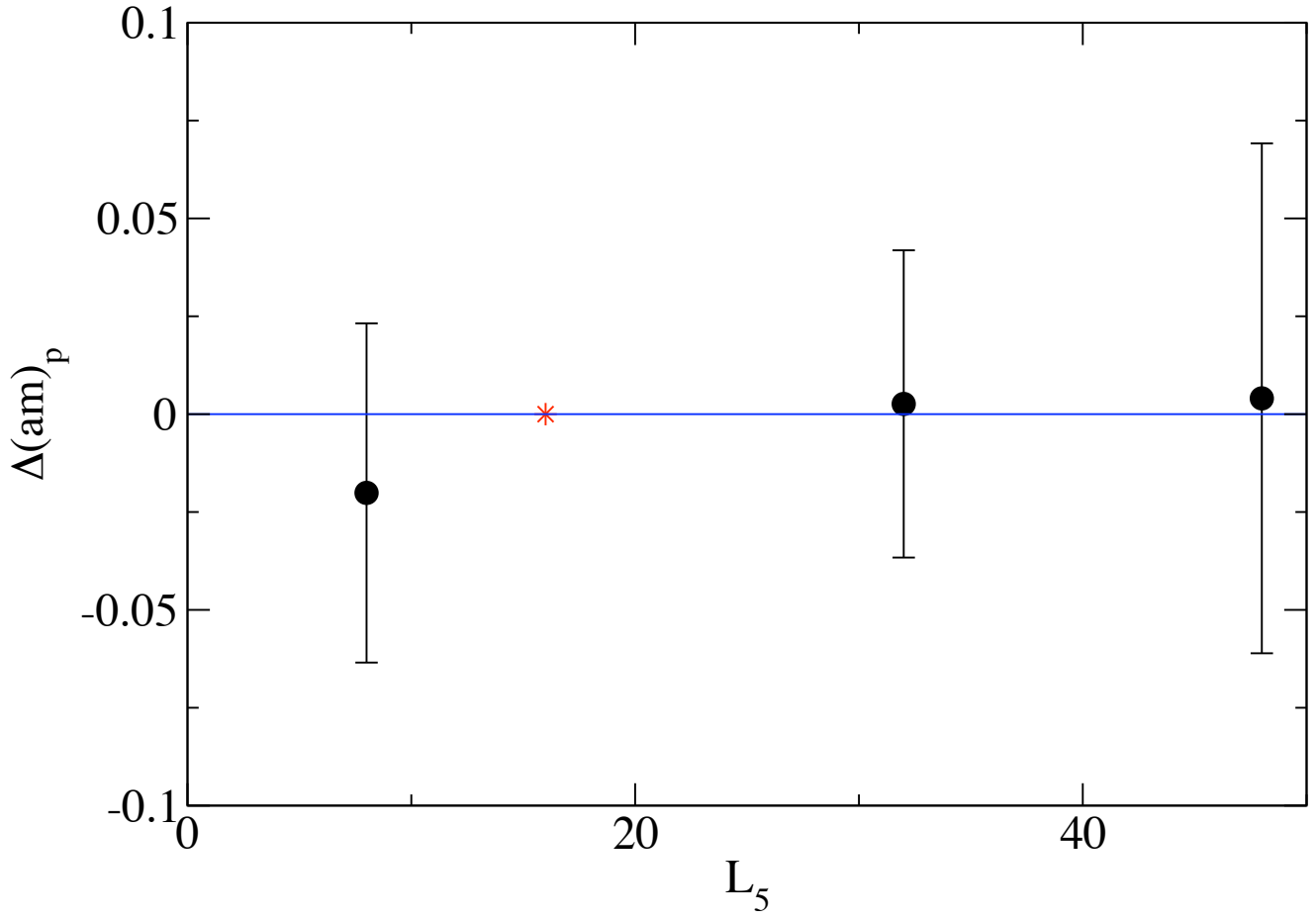
Pion mass difference (light)



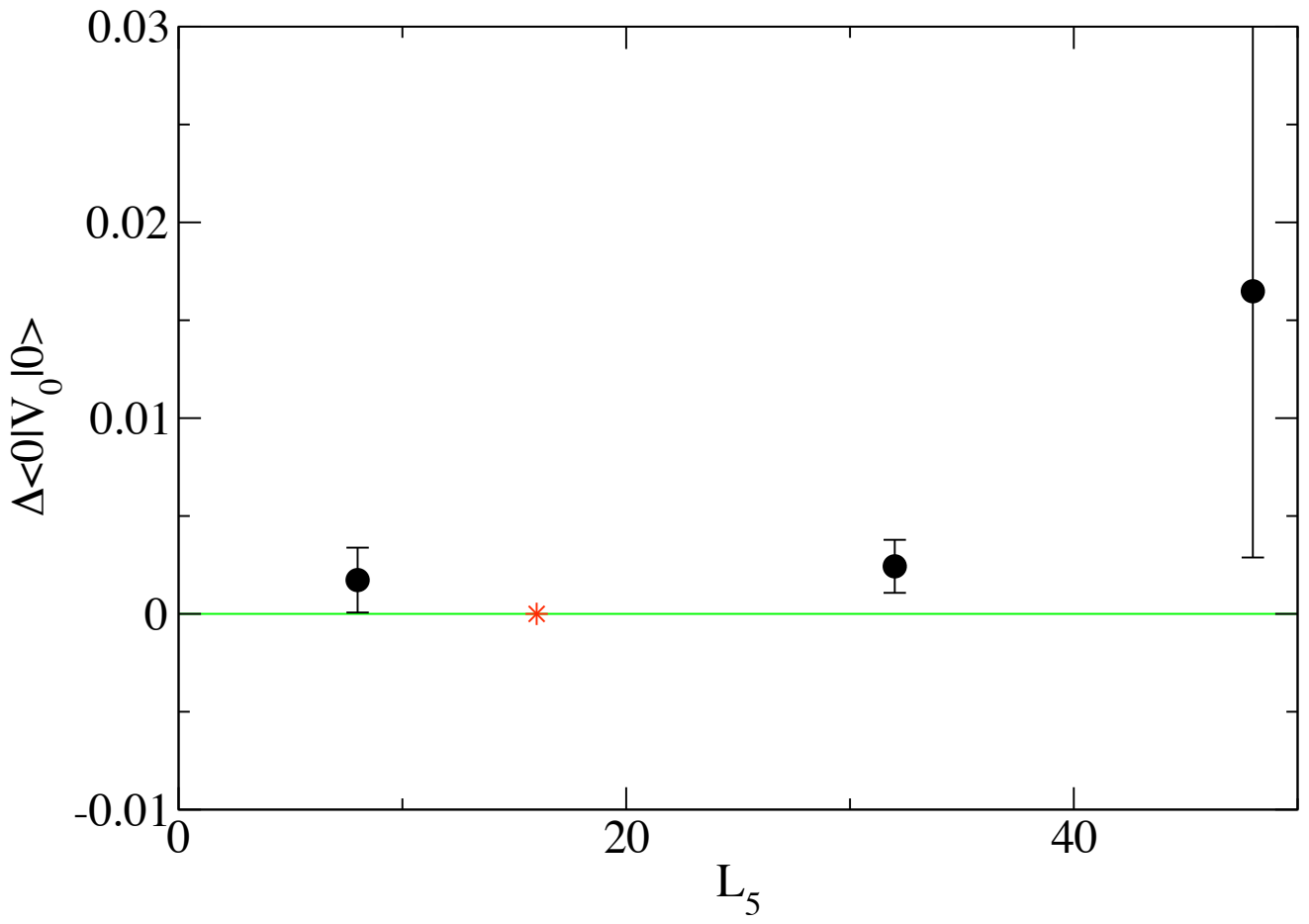
Nucleon mass difference (heavy)



Nucleon mass difference (light)



Vector current (light)



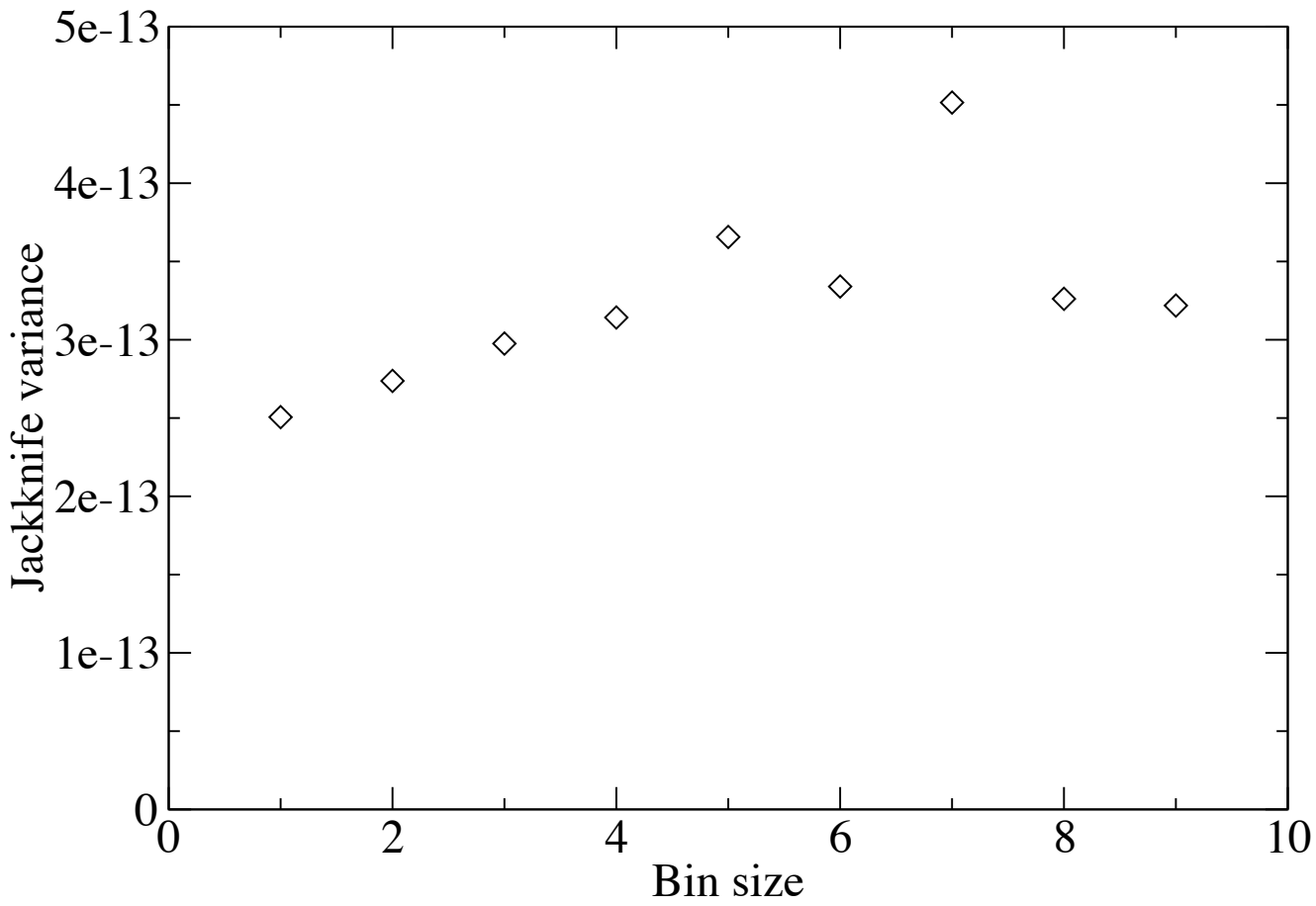
Autocorrelation time

- Every 12 MILC trajectories one measurement has been taken
- Estimate τ_{int} using Jackknife with varying bin-sizes:

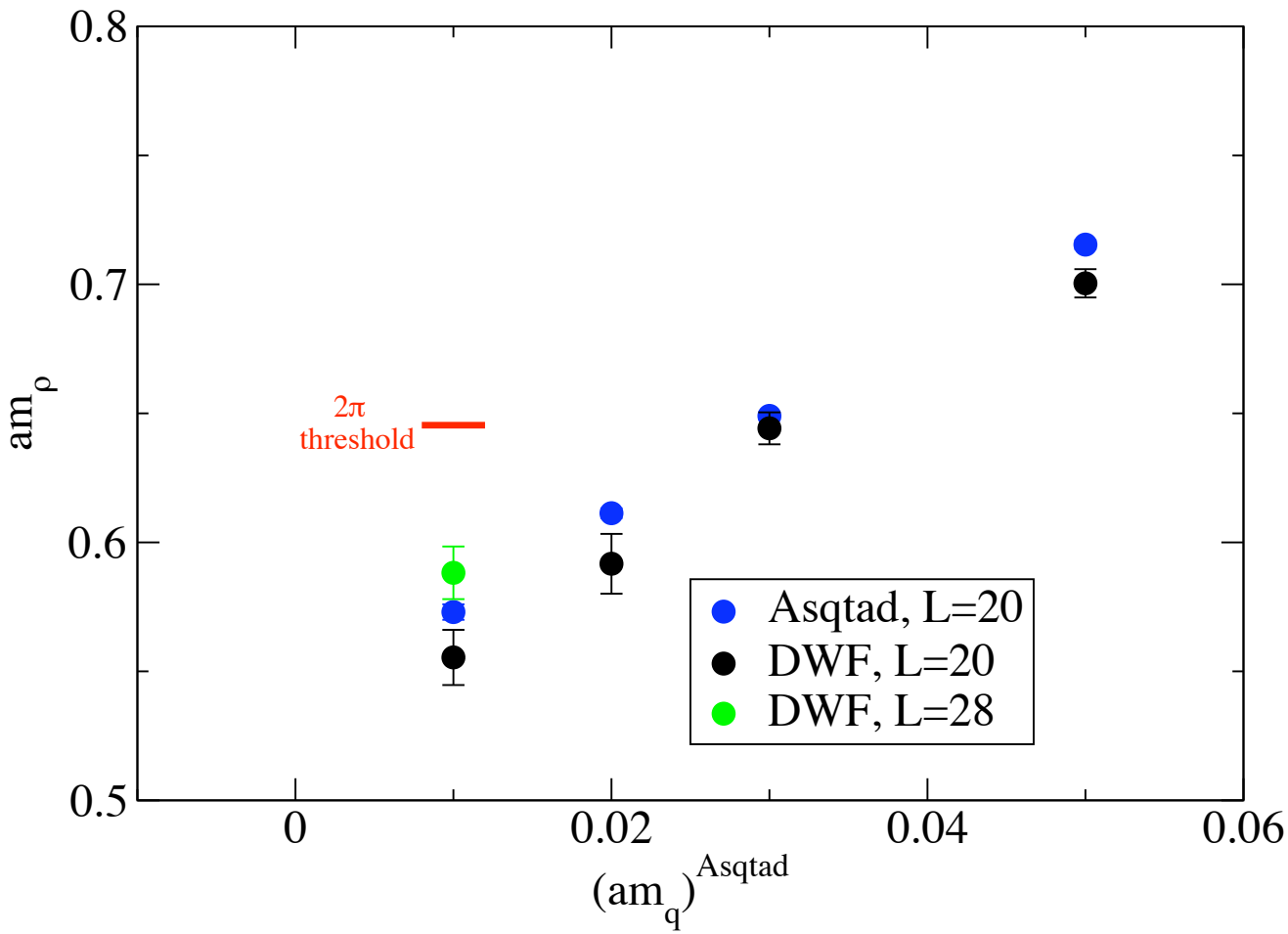
$$\tau_{\text{int}} = \frac{1}{2}\frac{\sigma(B \to \infty)}{\sigma(B = 1)}$$

- Choose pion correlator at timeslice 5 on largest lattice with lightest mass

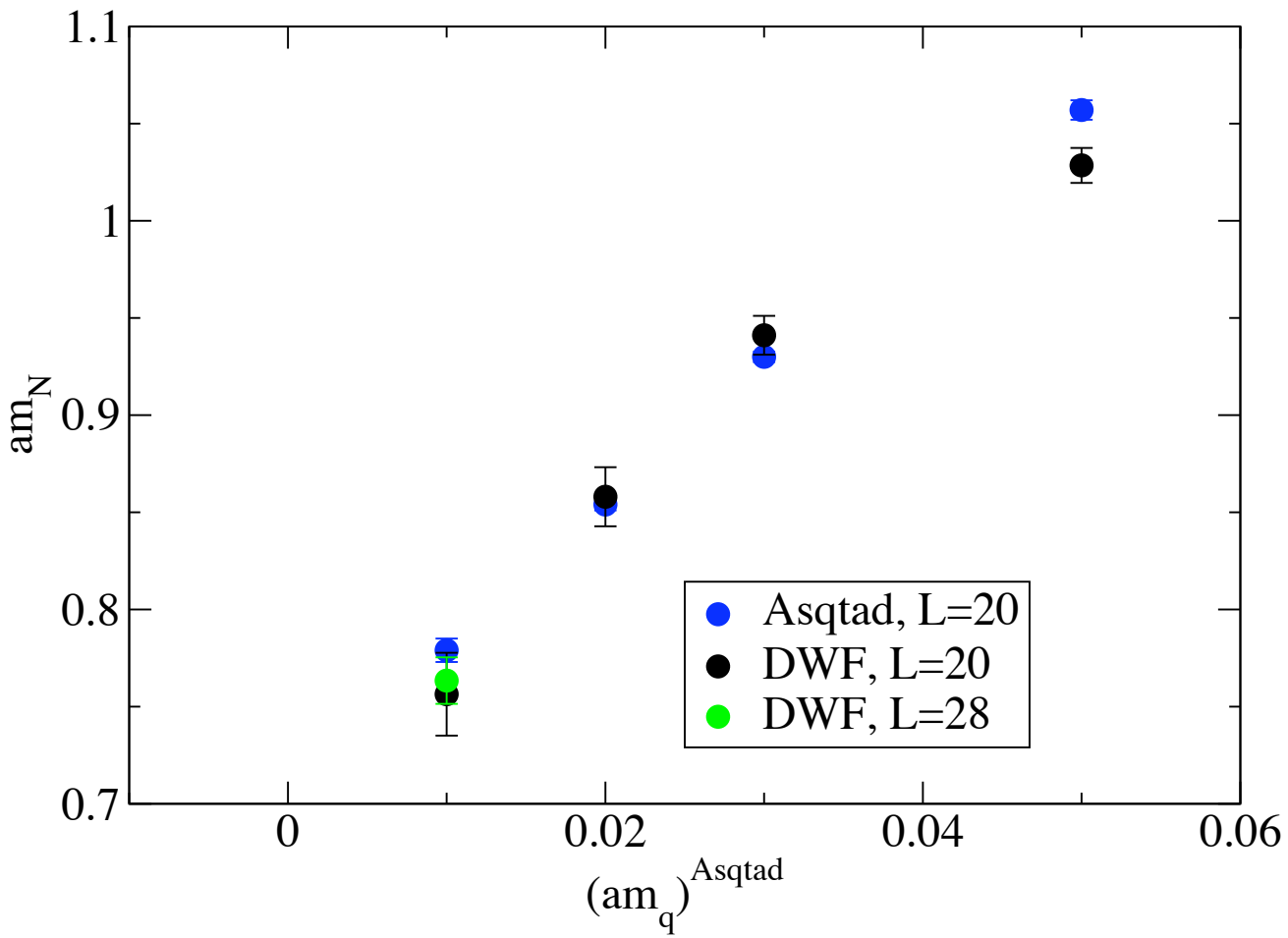
Residual autocorrelation



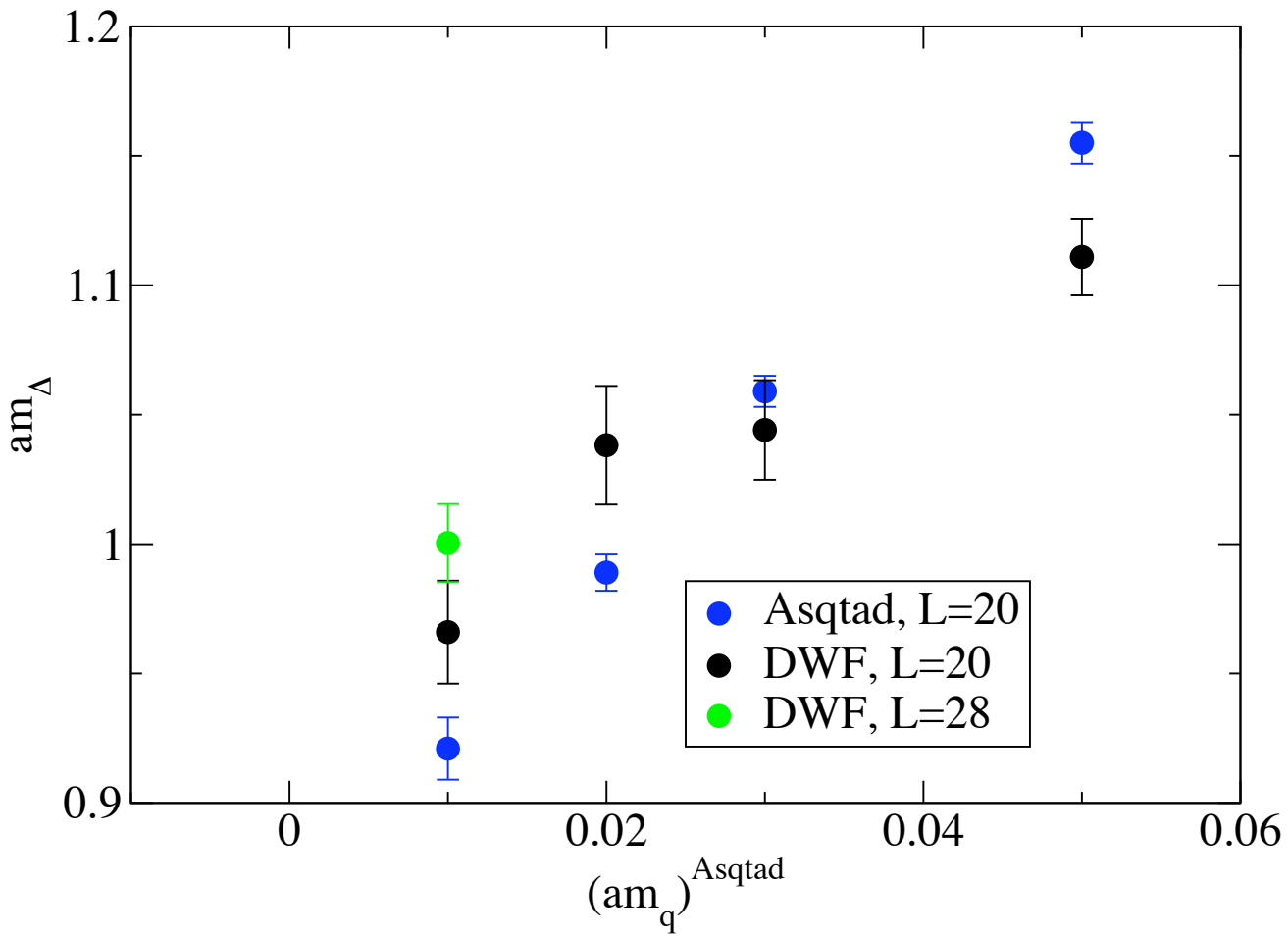
Light mesons (vector)



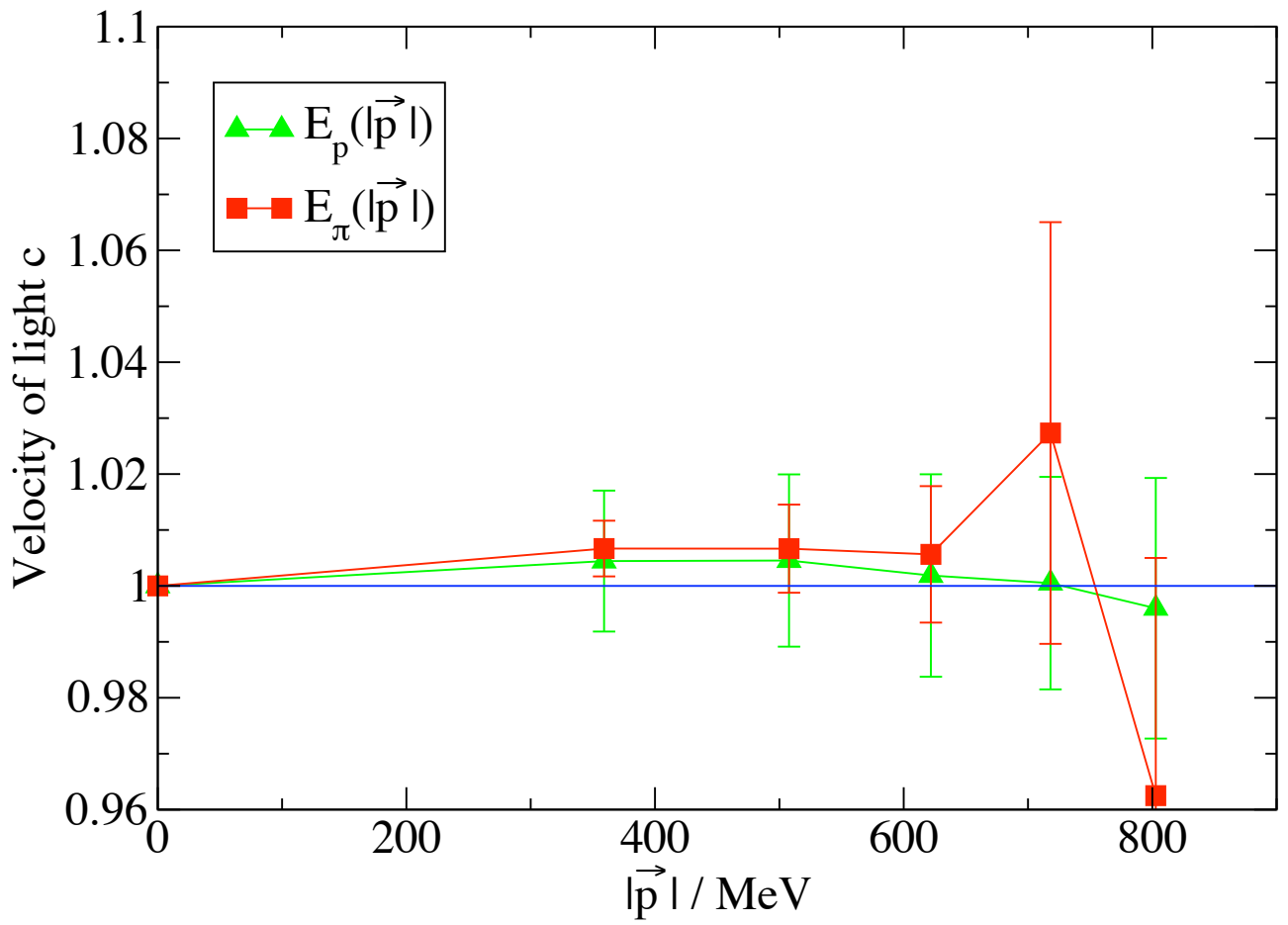
Nucleon


1.1
1
0.9
0.8
0.7
am_N
0
0.02
0.04
0.06
$(am_q)^{Asqtad}$
Asqtad, L=20
DWF, L=20
DWF, L=28

Delta


1.2
1.1
1
0.9
am_Δ
0
0.02
0.04
0.06
$(am_q)^{Asqtad}$
Asqtad, L=20
DWF, L=20
DWF, L=28

Dispersion relation



Summary

- Tuned quark masses to full QCD limit
- Examined L_5 dependence of observables to determine optimal value
- Compared mass spectrum for Asqtad and DWF

Outlook

- Hadronic matrix elements will be presented by D. B. Renner at this conference
- Current results encouraging - we will continue calculations with hybrid actions