Status of the chiral fits for $N_f = 2+1+1$

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Overview

- General strategy of fits
- Pion mass & decay constant
- Nucleon mass
- Kaon mass & decay constant
- Conclusions

General strategy

SU(3) χPT?

theoretically elegant

many free parameters

not a very good expansion

NNLO is an option (MILC)

General strategy

Extended SU(2) χPT

SU(2) + flavour expansion in m_s

minimalistic parameter set

better convergence for heavy m_s

solid track record
(RBC/UKQCD, PACS-CS)

parameters are not LEC's

General strategy

Few points available

- ✗ Lattice spacing artifacts
- ✗ NNLO contributions
- ✗ Renormalization factors
- ✗ Correlated bootstrap (for now)

General strategy

✔ Parameter free FV (GL)

CDH an option as data set increases

✔ Scale set through m_π/f_π

✔ Consistent first order approximation

Pion mass

$$m_{\pi,\infty}^2 = 2B_0\mu_l + \frac{4B_0^2\mu_l^2}{16\pi^2 f_0^2}\ln\left(\frac{2B_0\mu_l}{\Lambda_3^2}\right)$$

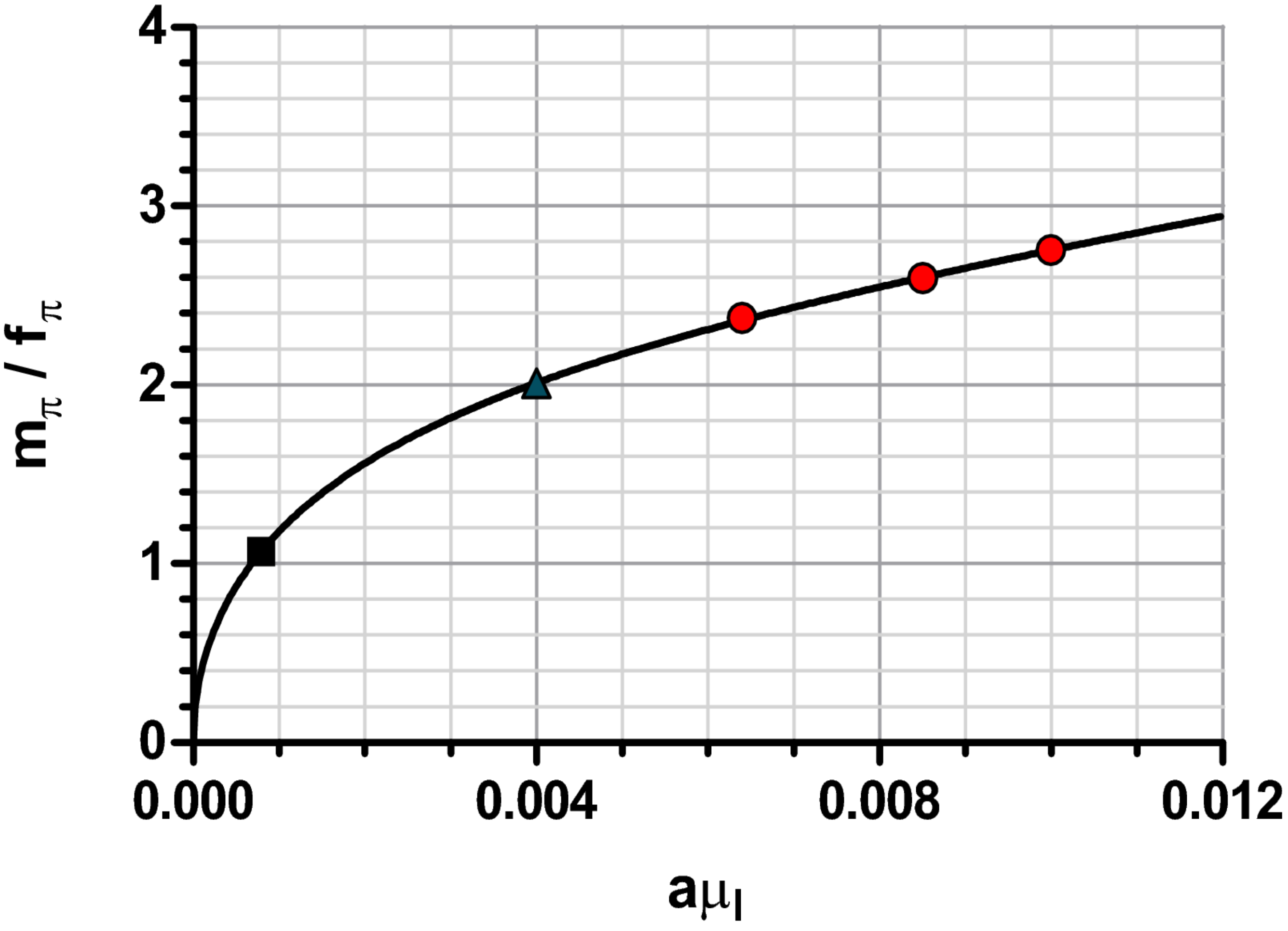
$$m_{\pi,L}^2 = m_{\pi,\infty}^2 + \frac{2B_0\mu_l}{16\pi^2 f_0^2}\delta_1\left(\sqrt{2B_0\mu_l}L\right)$$

Pion decay constant

$$f_{\pi,\infty} = f_0 - 2\frac{2B_0\mu_l}{16\pi^2 f_0}\ln\left(\frac{\text{۲}\,B_0\mu_l}{\Lambda_4^2}\right)$$

$$f_{\pi,L} = f_{\pi,\infty} - 2\frac{2B_0\mu_l}{16\pi^2 f_0^2}\delta_1\left(\sqrt{2B_{.}\mu_l}\,L\right)$$

Benchmark $N_f = 2$



Benchmark $N_f = 2$

Our code	Published result
$a = 0.086(1)$	$a = 0.087(1)$
$l_3 = 3.72(15)$	$l_3 = 3.65(12)$
$l_4 = 4.65(7)$	$l_4 = 4.52(6)$
$f_0 = 121.0(2)$	$f_0 = 121.3(7)$

From hep-lat/0701012v2 (Dynamical Twisted Mass Fermions...)

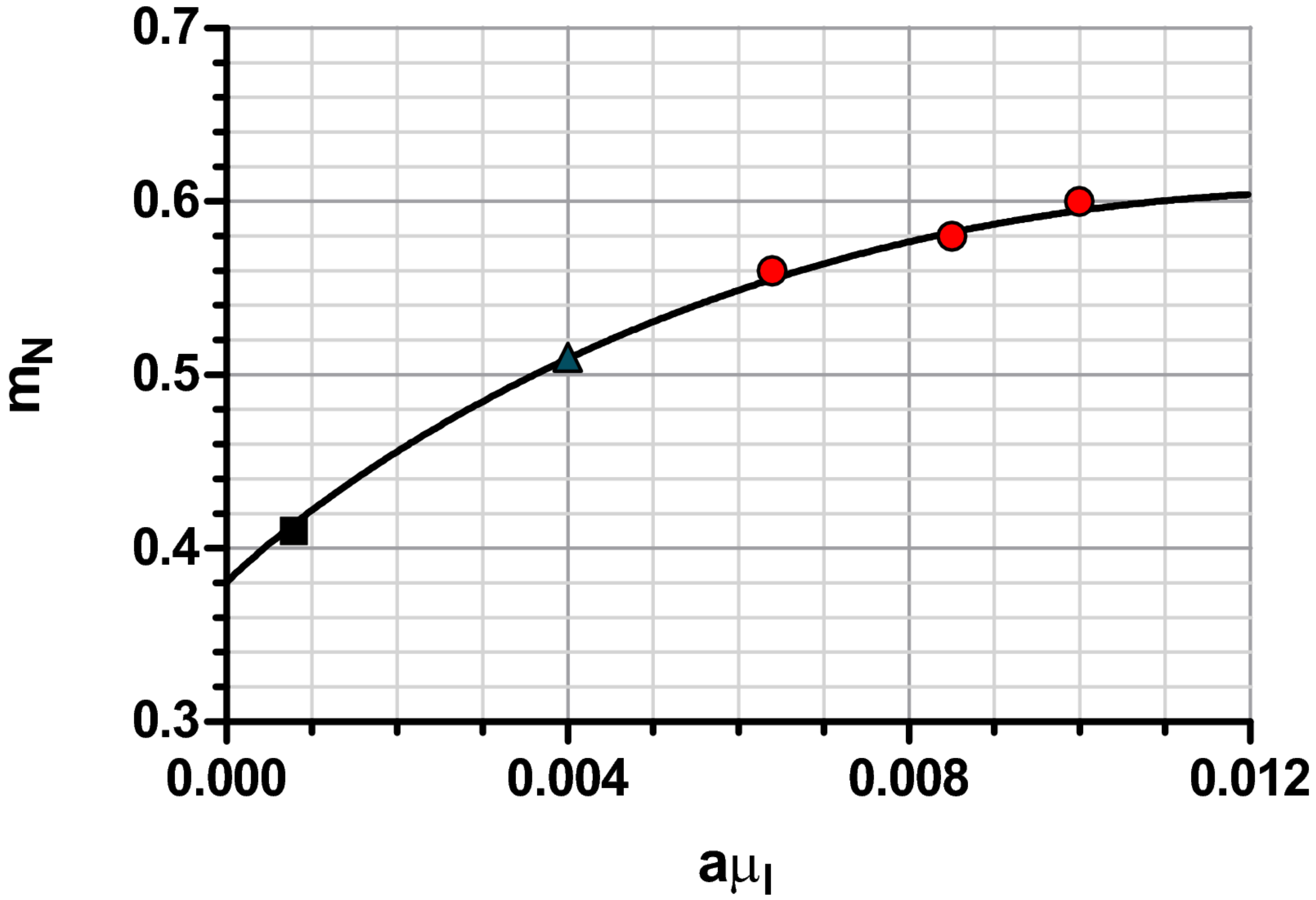
Nucleon mass

$$m_{N,\infty} = m_N^0 - 4c_1(2B_0\mu_l) - \frac{3g_A^2}{16\pi^2 f_0^2}(2B_0\mu_l)^{\frac{3}{2}}$$

$$m_{N,L} = m_{N,\infty} - 2m_N^0 \frac{3g_A^2}{16\pi^2 f_0^2}(2B_0\mu_l) \times$$

$$S\left(m_N^0, \sqrt{2B_0\mu_l}, L\right)$$

Benchmark $N_f = 2$



Benchmark $N_f = 2$

Our code	Published result
$m_N^{\ 0} = 893(92)$	$m_N^{\ 0} = 889(13)$
$g^0_{\ A} = 1.07(15)$	$g_A = 1.27$
$m_N = 965(70)$	$m_N = 963(12)$

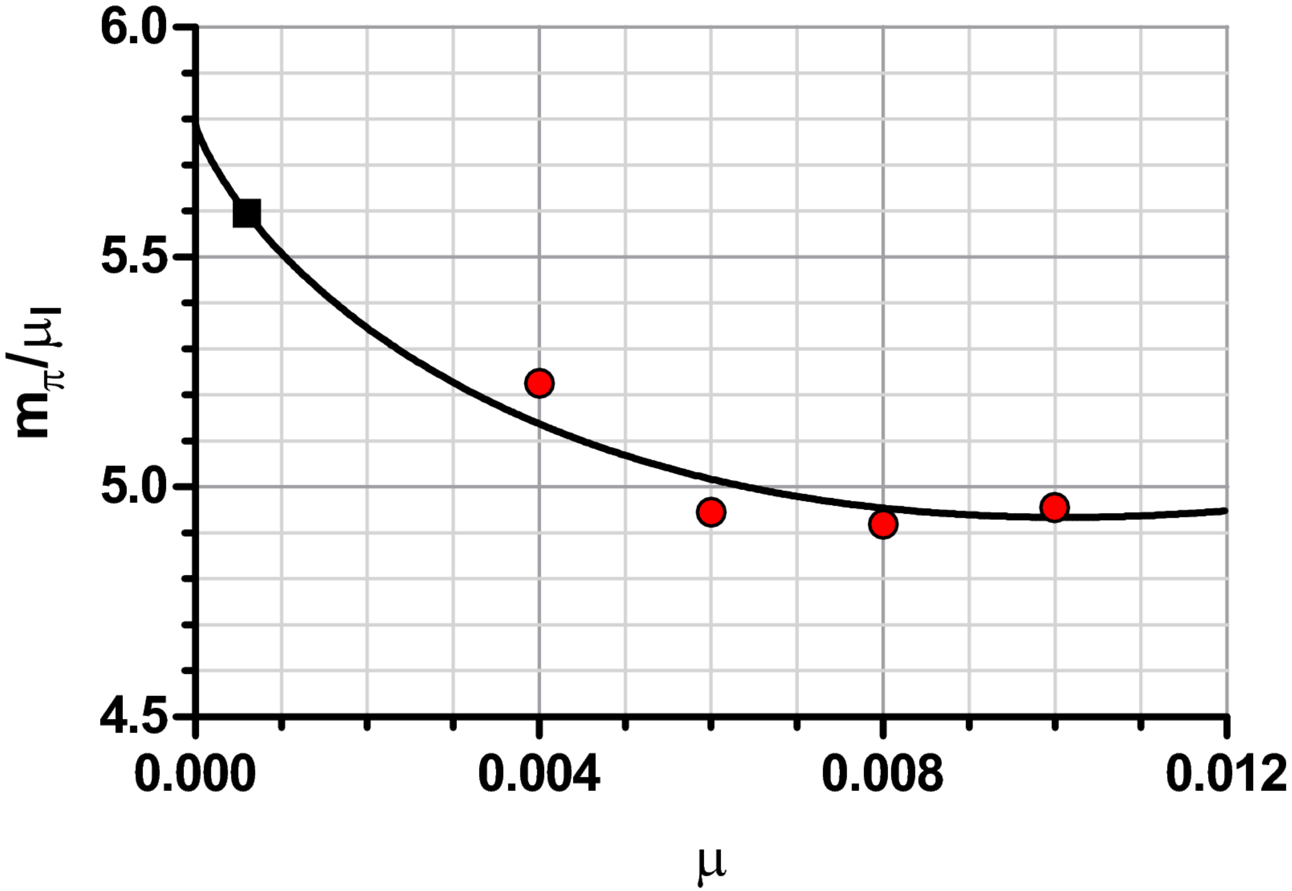
From hep-lat/0803.3190v2 (Light Baryon Masses...)

Benchmark $N_f = 2$

Code reproduces the Nf = 2 results

Cross check indicates
correct fits, correct scale setting

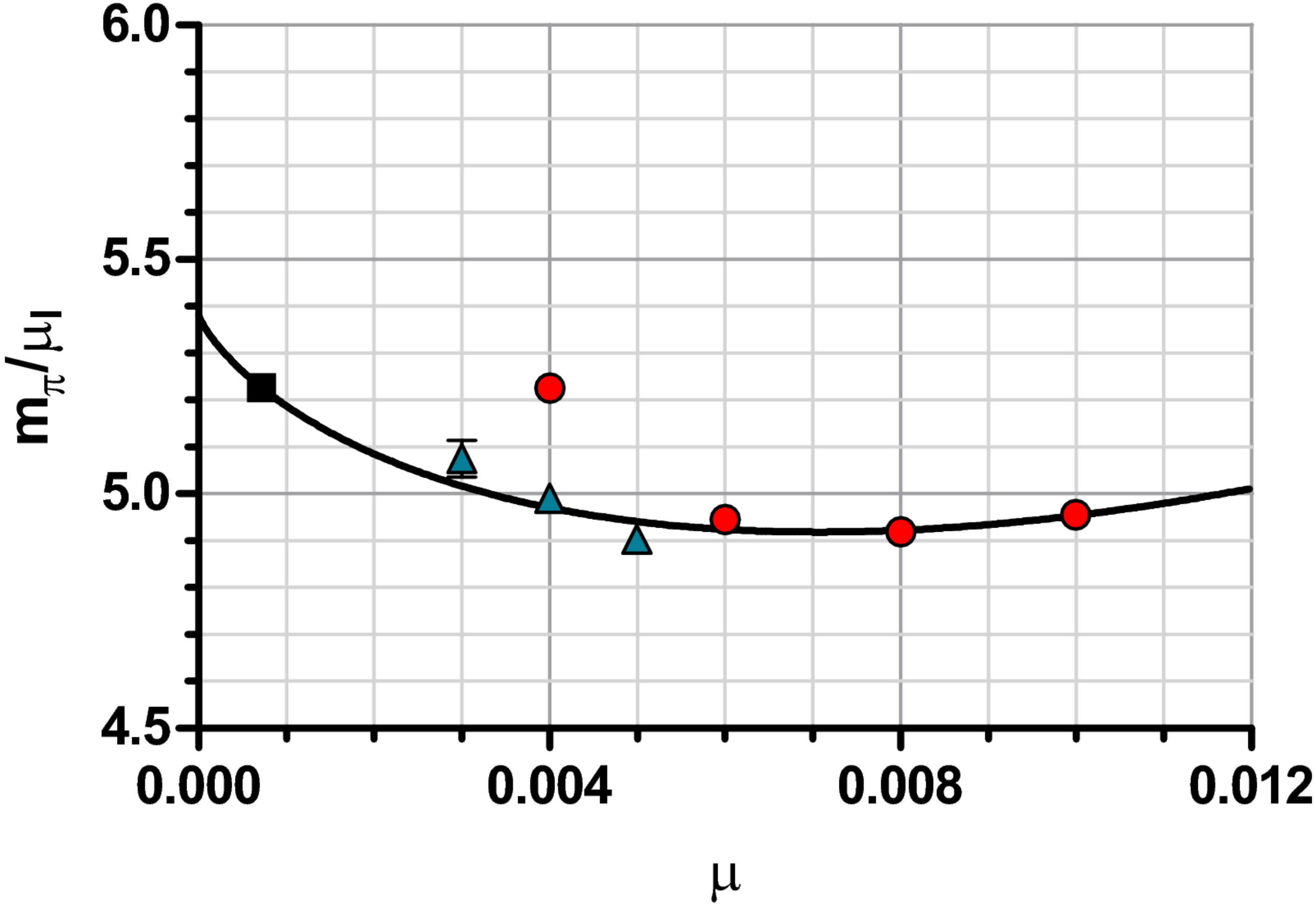
N_f = 2+1+1 – β 1.90



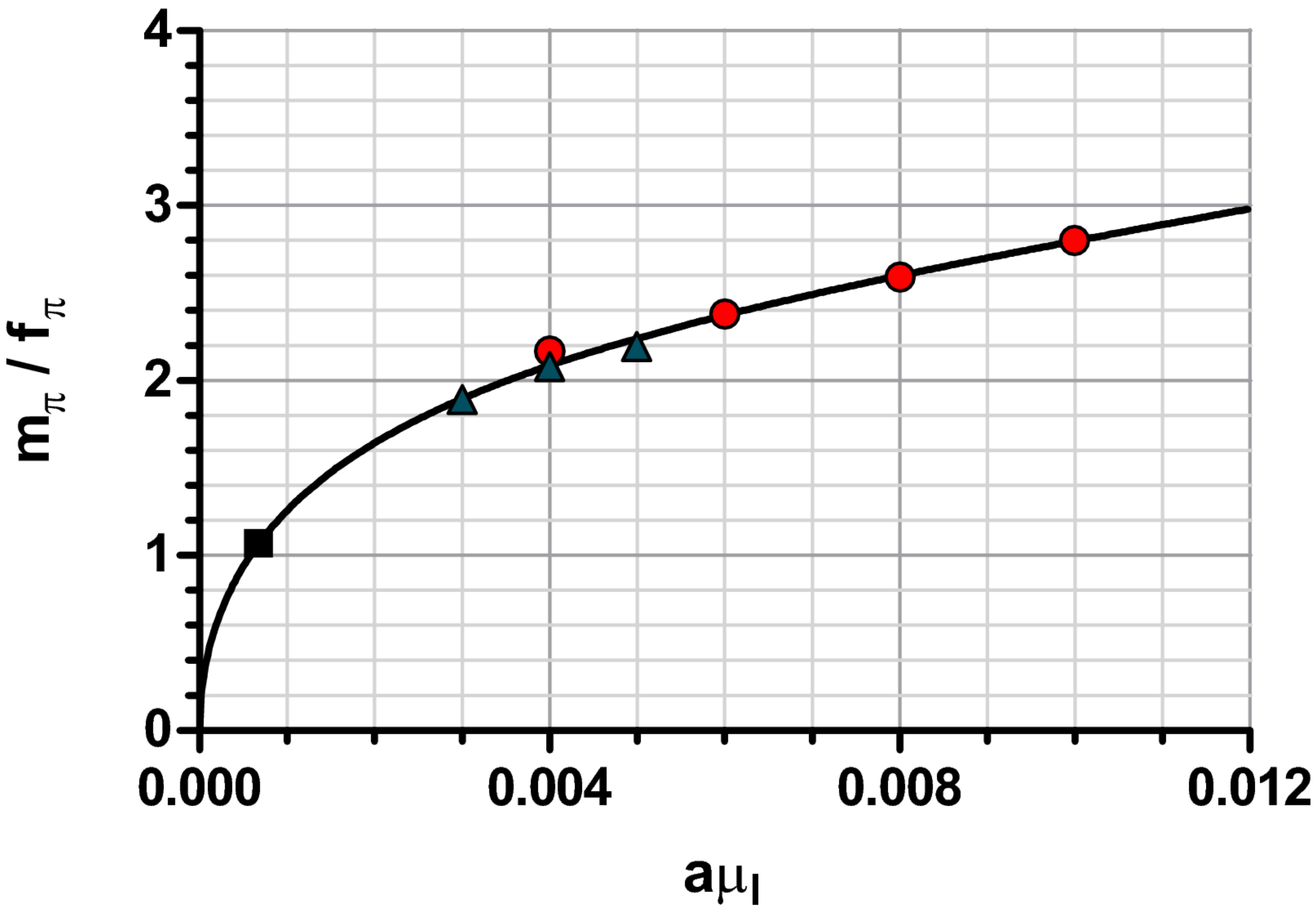
Bare light quark mass: 1.572 MeV

Lattice spacing: 0.0853(5) fm

$N_f = 2+1+1$ – β 1.90



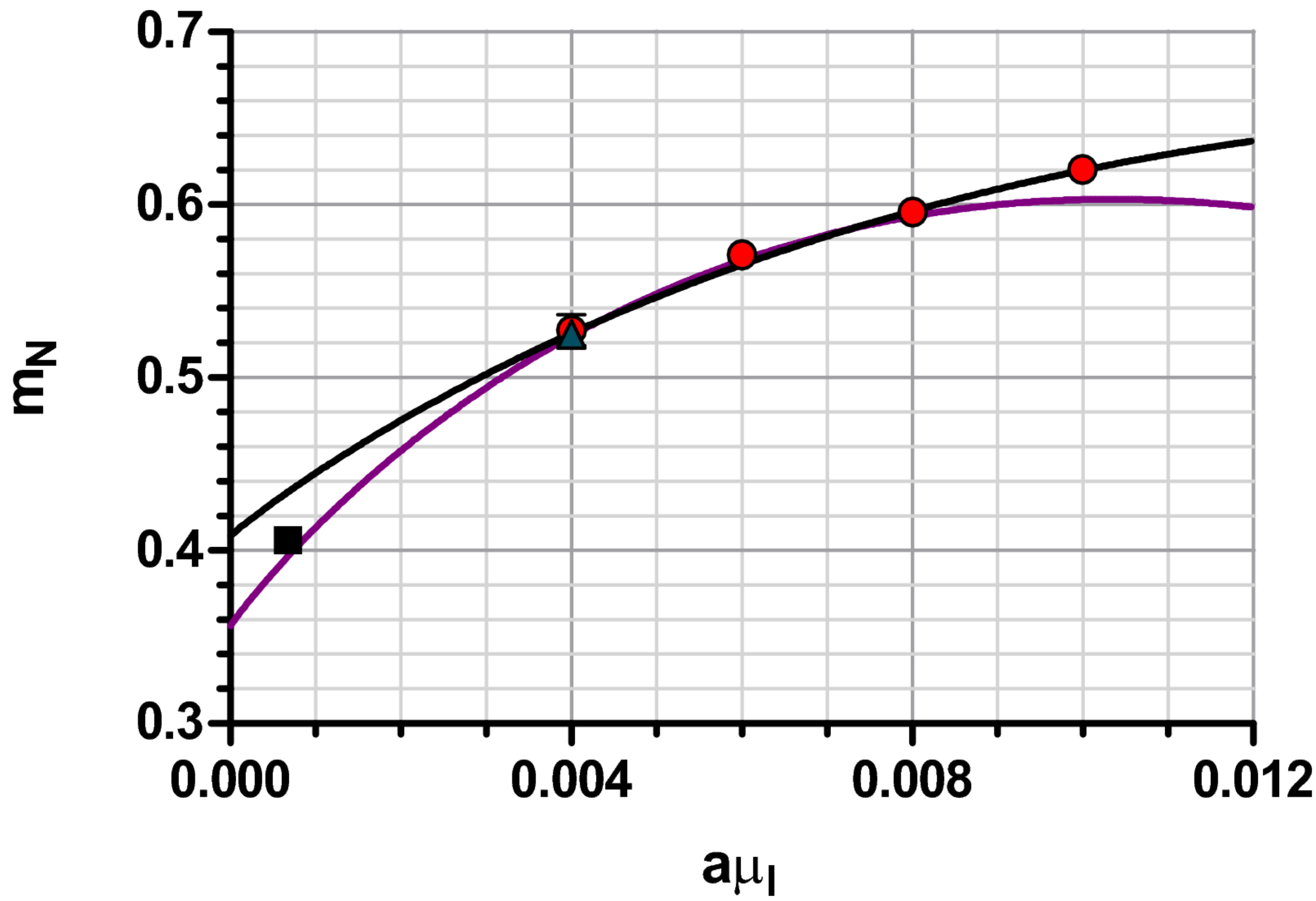
$N_f = 2+1+1 - \beta\ 1.90$



Bare light quark mass: 1.572 MeV

Lattice spacing: 0.0853(5) fm

N_f = 2+1+1 – β 1.90



Physical nucleon mass: 1003(41) MeV

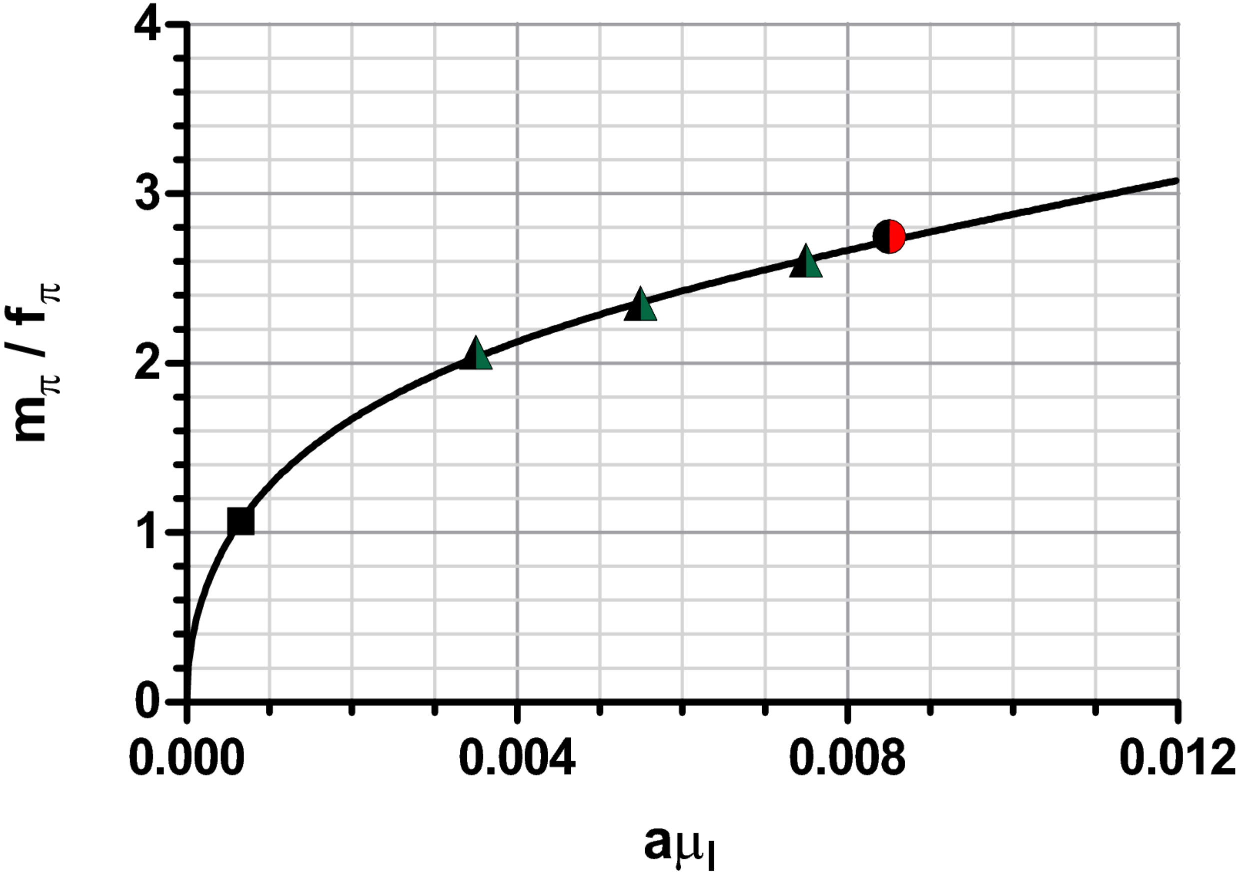
$N_f = 2+1+1$ – β 1.90

Something seems odd about
$\mu_l = 0.004$ @ $24^3 \times 48$

Nucleon mass is about 9% too high.

Heaviest point seems to have a very large influence – need more points

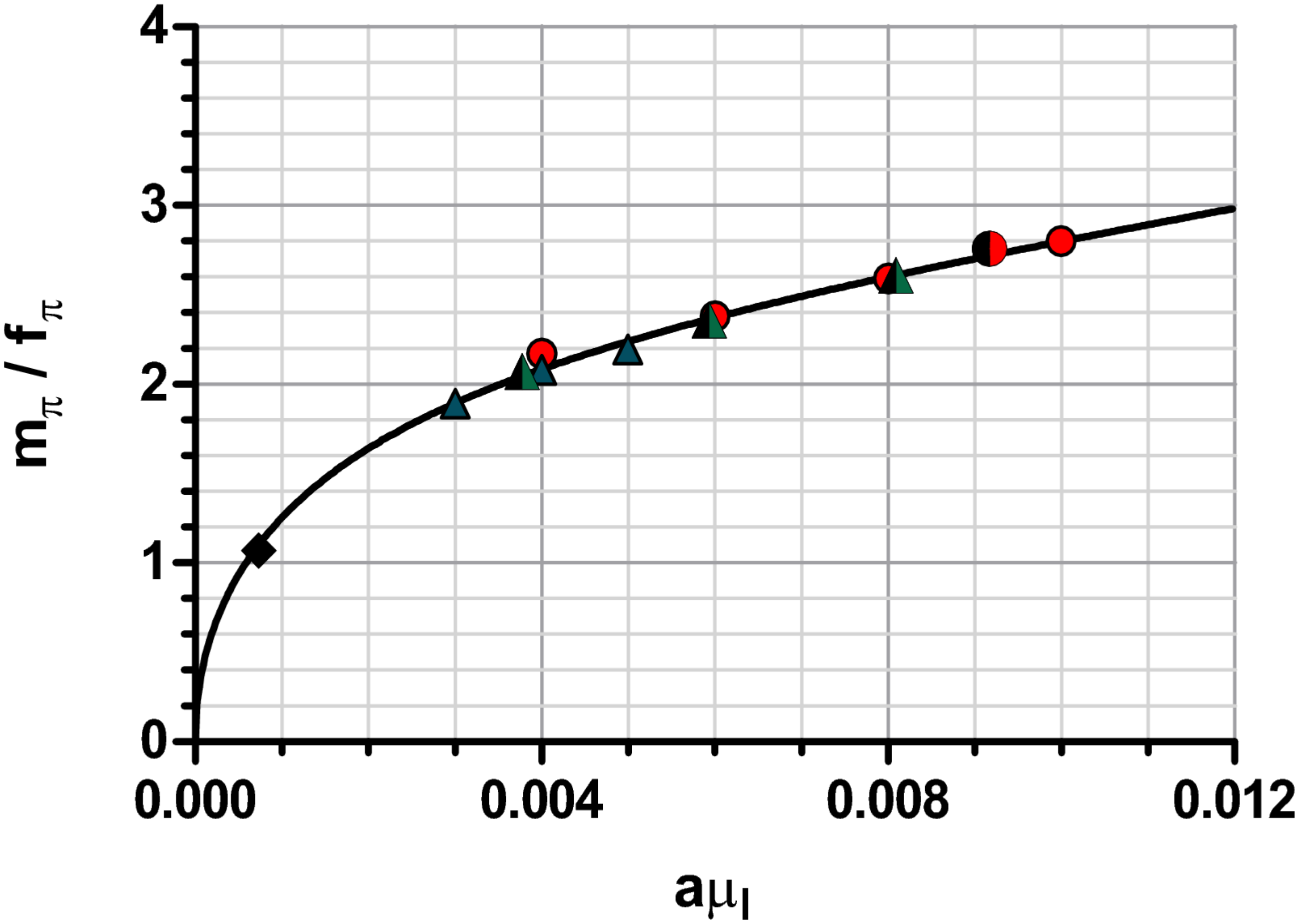
$N_f = 2+1+1 - \beta\ 1.95$



Bare light quark mass: 1.634 MeV

Lattice spacing: 0.0792(10) fm

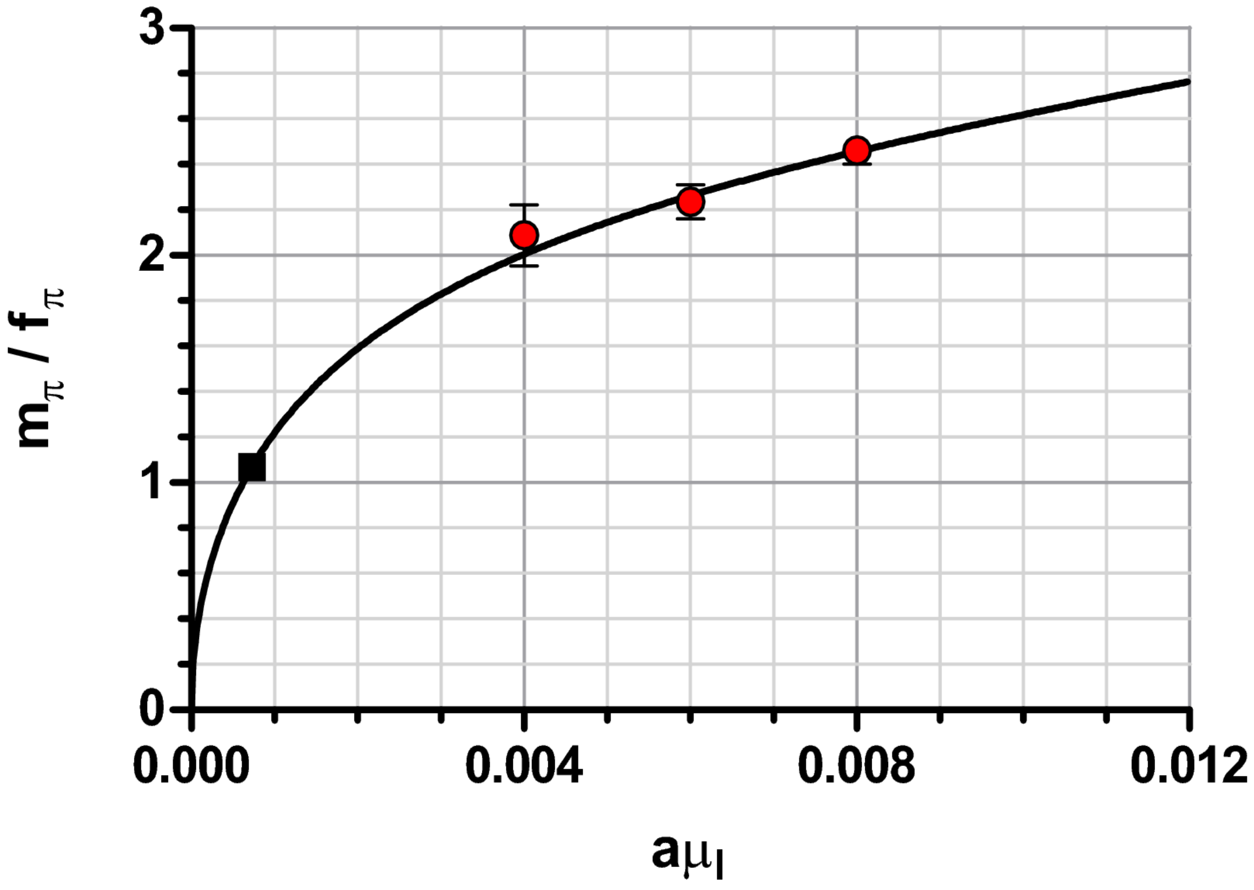
N_f = 2+1+1 – combined



New parameters: $(a_{1.9} / a_{1.95})$; $(Z_{p,1.9} / Z_{p,1.95})$

Preliminary result – numerical results upcoming

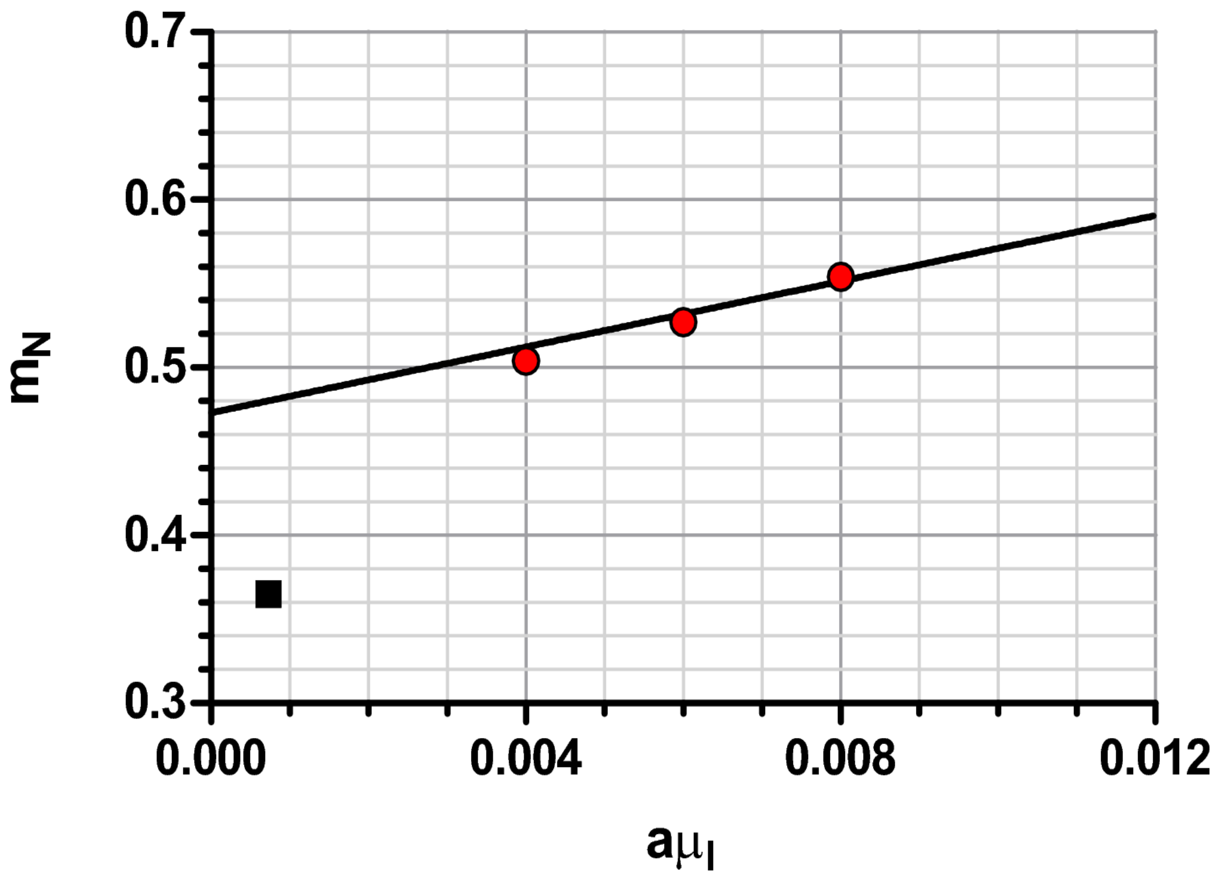
N_f = 2+1+1 – stouted



Bare light quark mass: 1.876 MeV

Lattice spacing: 0.077(2) fm

$N_f = 2+1+1$ – stouted



Physical nucleon mass: 1234(68) MeV

$N_f = 2+1+1$ – stouted

Nucleon mass a whopping 31% off

Lacking points and precision now

$m_\pi L$ low for small μ_l

No fair comparison possible!

Kaon sector

Measurement of f_K is work in progress

Only m_K needed short term

Kaon sector

$$m_{K,\infty}^2 = 2\, B_K\, \mu_s \left(1 + \lambda_1 \frac{2\, B_0\, \mu_l}{f_0^2} \right)$$

$$m_{K,L}^2 = m_{K,\infty}^2 + \frac{2\, B_0\, \mu_l}{16\, \pi^2 f_0^2}\, \delta_1 \left(\sqrt{2\, B_0\, \mu_l}\, L \right)$$

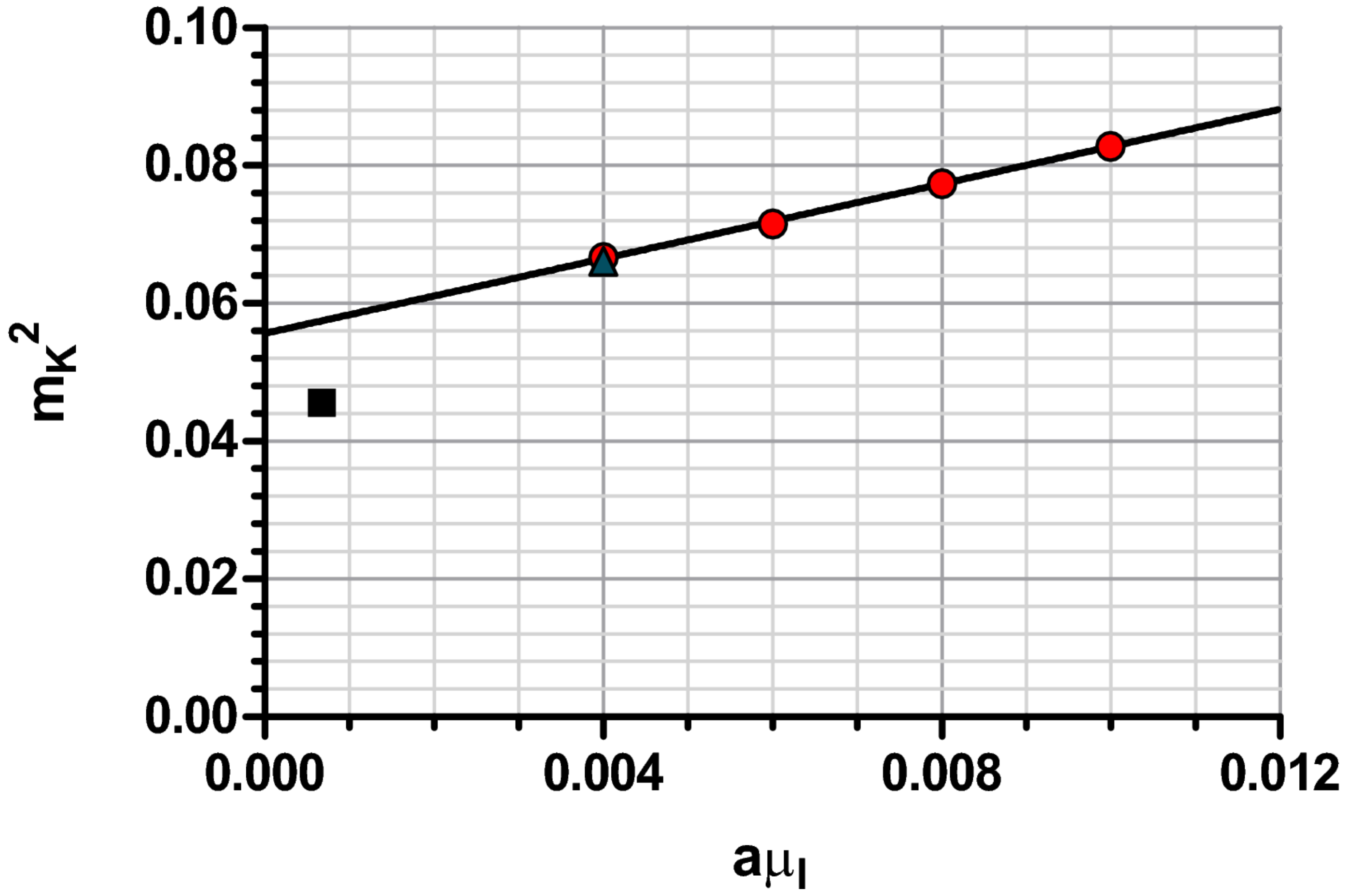
Kaon sector

$$f_{K,\infty}=f_K^0\left(1-c\frac{2B_0\mu_l}{f_{\cdot}^2}\right)-\frac{3}{4}\frac{2B_0\mu_l}{16\pi^2 f_0^2}\ln(2B_0\mu_l)$$

$$f_{K,L}=f_{K,\infty}-\frac{1}{\text{۶۴}\,\pi^2 f_0^2}\times$$

$$3(2B_0\mu_l)\delta_1(\sqrt{2B_0\mu_l}L)+$$
$$2\Big((2B_0\mu_l)+(2B_K\mu_s)\Big)\delta_1(\sqrt{2B_0\mu_l+2B_K\mu_s}L)+$$
$$\Big((2B_0\mu_l)-(2B_K\mu_s)\Big)\delta_3(\sqrt{2B_K\mu_s}L)$$

$N_f = 2+1+1 - \beta\ 1.90$



Kaon mass: 552(6) MeV

Kaon decay constant: 175(1) MeV

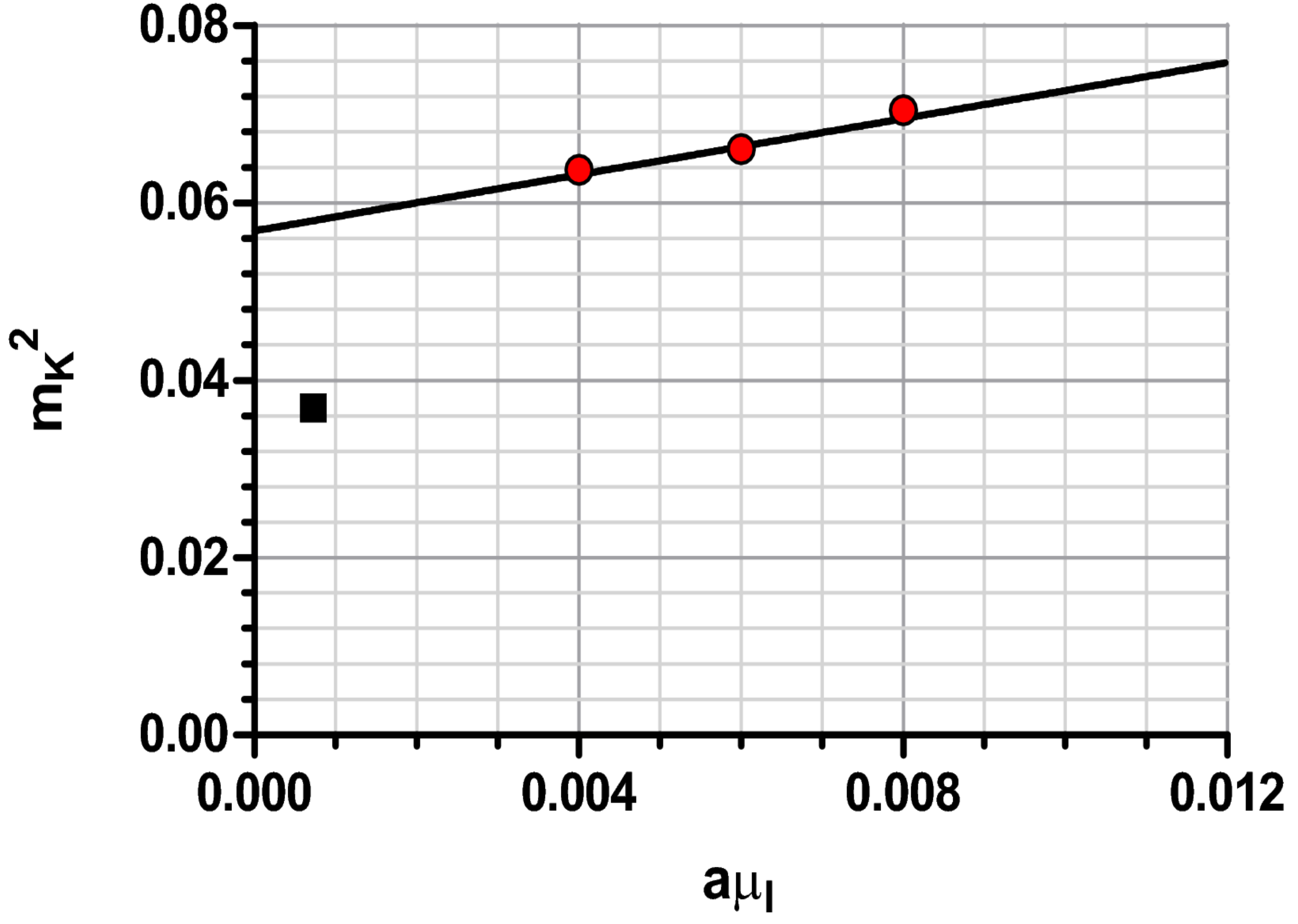
$N_f = 2+1+1$ – β 1.90

Both mass and decay constant
about 10% too high

f_K values still very preliminary

m_K effectively a linear fit,
little room for changes

N_f = 2+1+1 – stouted



Kaon mass: 619(18) MeV

Kaon decay constant: 264(11) MeV

Conclusions

- ✔ Careful choice of fitting points seems necessary ($m_\pi L$, m_π)
- ✔ Lighter points needed for nucleon
- ✔ m_K systematically high
- ✔ Stout data insufficient for chiral fitting