The light baryon spectrum calculated with 2+1 flavors of domain wall fermions

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Outline of the talk

- Simulation summary
- Fitting procedure
- Sources and effective masses
- Preliminary results
- Some analysis
- Summary/Outlook

Simulation summary

2+1 flavors of domain wall fermions, Iwasaki gluons

β	m_l	size	Generator
2.13	0.005, 0.01, 0.02, 0.03	$16^3 \times 32$, $24^3 \times 64$ ($L_s = 16$)	RBC, UKQCD
2.25	0.004, 0.006, 0.008	$32^3 \times 64$ ($L_s = 16$)	LHPC, RBC, UKQCD

2.13: $a^{-1} = 1.729(28)$, $L \approx 2.74$ fm, $m_l/m_s \approx 0.217 \rightarrow 0.884$
$m_s = 0.04$, $m_{res} = 0.00315$

[arXive:0804.0473]

2.25: Target same physical volume, $m_l/m_s \approx 1/7 \rightarrow 2/7$
$m_s = 0.03$, $m_{res} \sim 0.0005$

Fitting Procedure

- Gaussian, Box, and Wall source quark propagators

- Average forward $(1+\gamma_4)$ and backward $(1-\gamma_4)$ propagating baryon states to improve signal

- Up to 4 sources on each configuration, spread over time, sometimes over space

- Measurement frequency as small as 10 monte-carlo time units, up to 40

- Measurements blocked into bins of size 40 monte-carlo time units

Propagator Summary

size	m_l	source type	correlators	source time slices	config's
24^3	0.005	Gauss ($r = 7$)	nuc	0,8,16,19,32,40,48,51	932*
24^3	0.005	Box	dec	0,32	90
24^3	0.01	Gauss ($r = 7$)	nuc	0,8,16,19,32,40,48,51	357
24^3	0.01	Box	dec	0,32	90
24^3	0.02	Gauss ($r = 7$)	nuc	0,8,16,19,32,40,48,51	99
24^3	0.02	Box	dec	0,32	43
24^3	0.03	Gauss ($r = 7$)	nuc	0,8,16,19,32,40,48,51	106
24^3	0.03	Box	dec	0,32	44
32^3	0.004	Wall	dec, nuc	0,16,32,48	74
32^3	0.006	Wall	dec, nuc	0,16,32	90
32^3	0.008	Wall	dec, nuc	0,16,32,48	100

* Doubled sources, separated by 32 time slices in a pair

LHPC has calculated Gaussian props on 32^3

Fitting procedure

- Fit function (minus sign for Anti-Periodic BC):

$$C(t) \;=\; Ae^{-m\,t} \pm Be^{-m^-\,t}$$

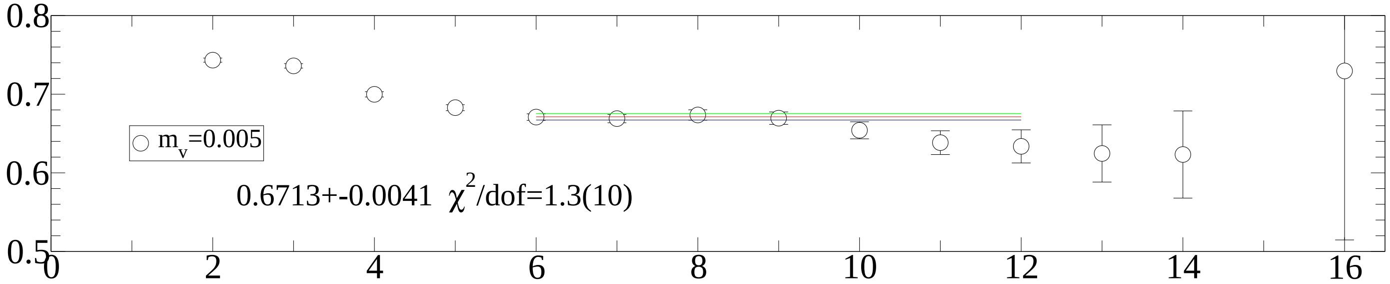
- Fully covariant fit to correlation function

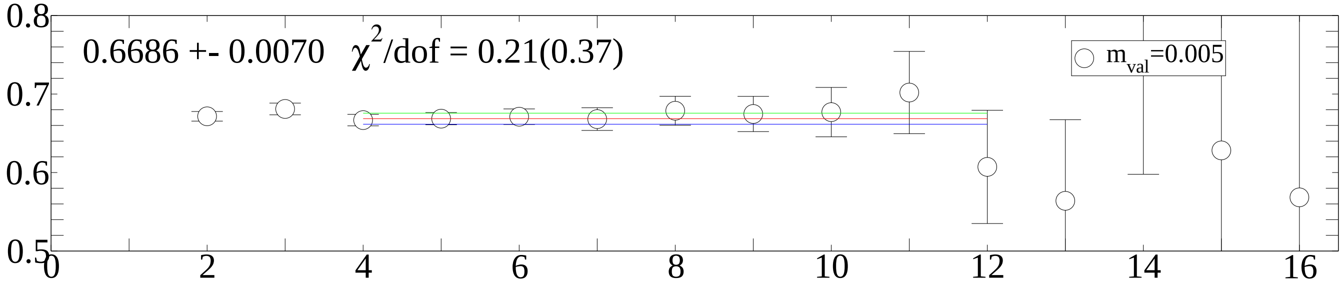
- Errors from jackknife, covariance matrix calculated for each block

- choose fit range to minimize χ^2

Effective masses

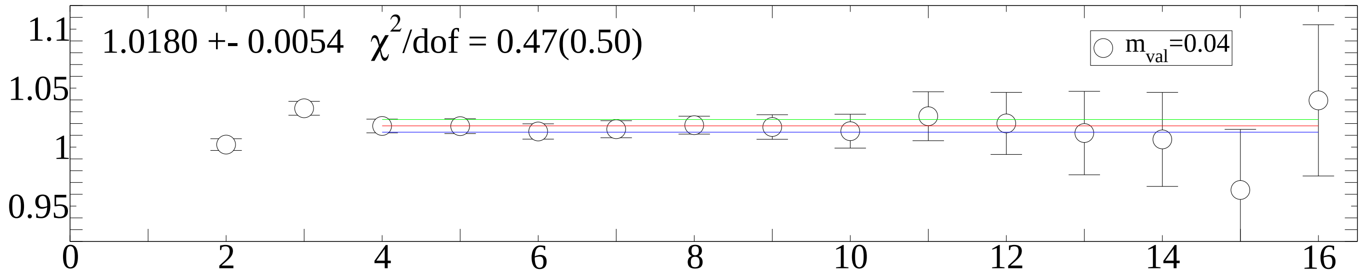
Plateaus: Gaussian vs. 16^3 Box (Nucleon (uud) 24^3)

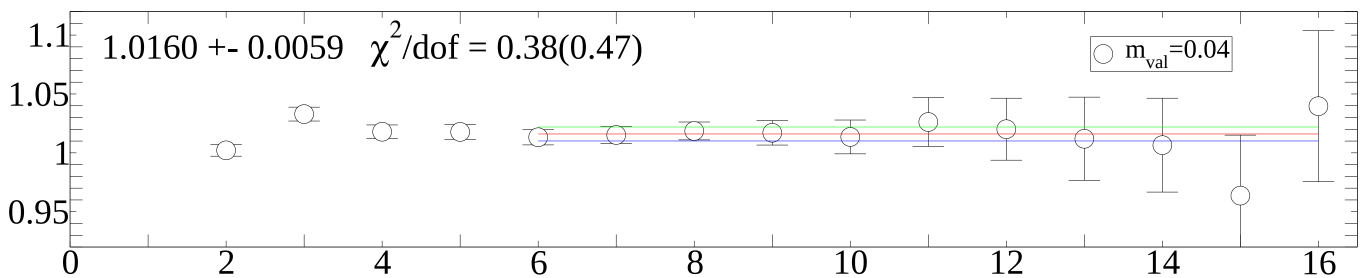




Effective masses

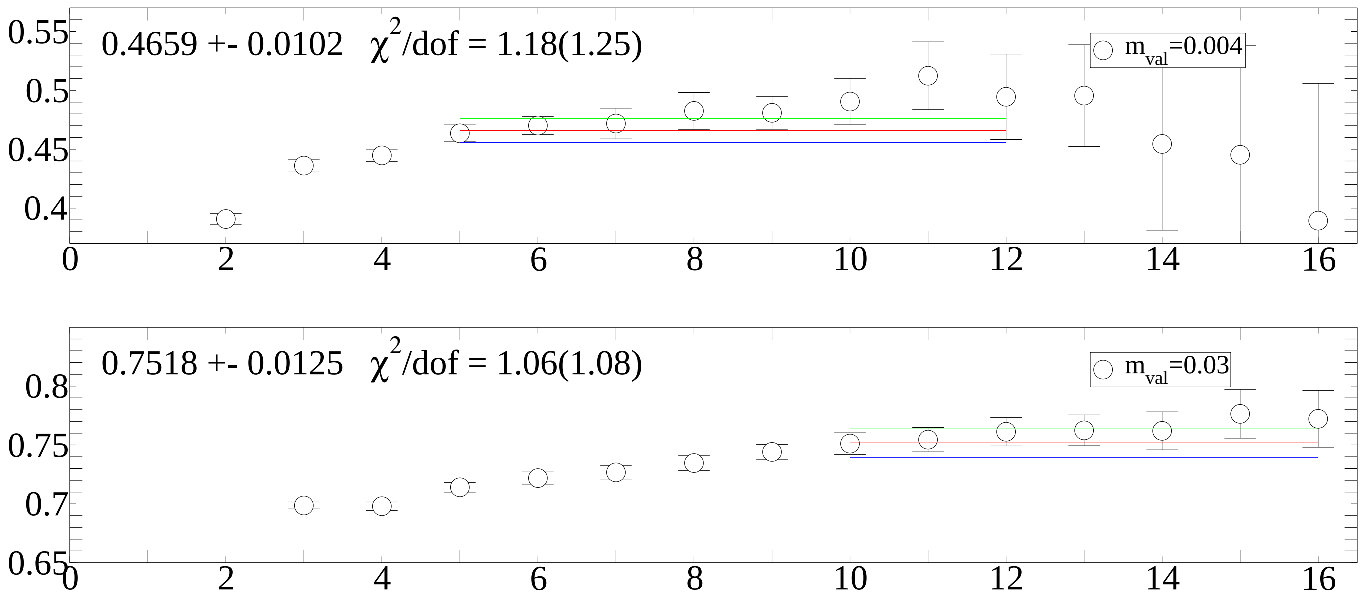
Plateaus: Wall (Ω (sss) 24^3)





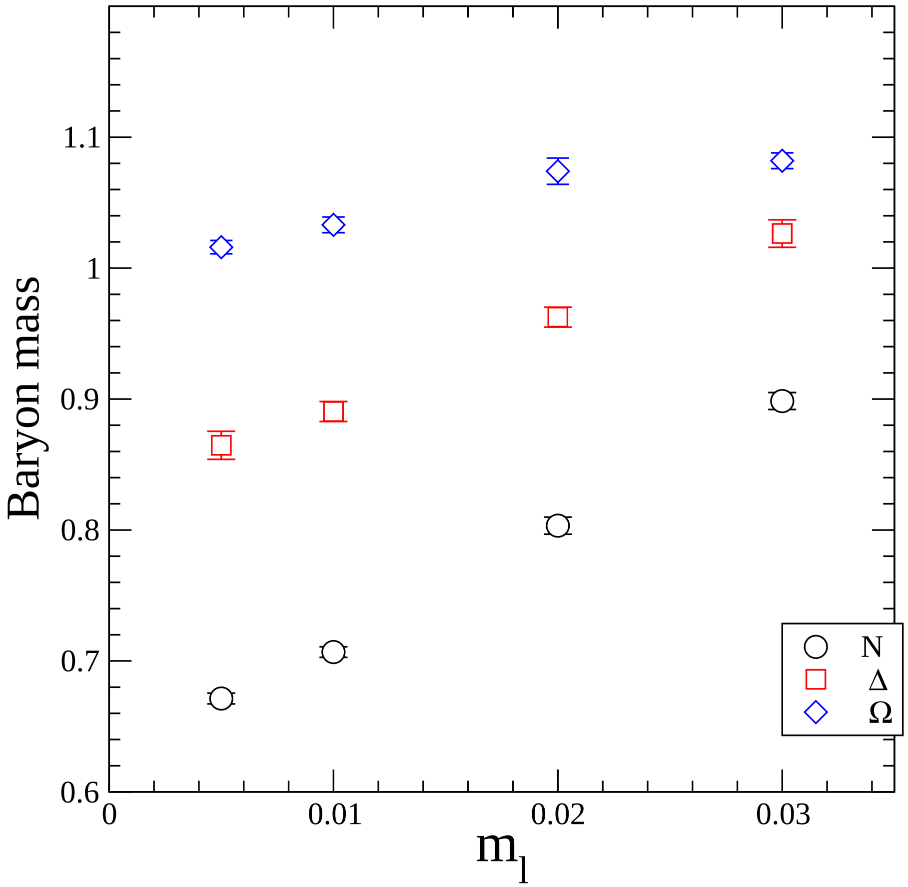
Effective masses

Plateaus: Wall (N and Ω 32^3)

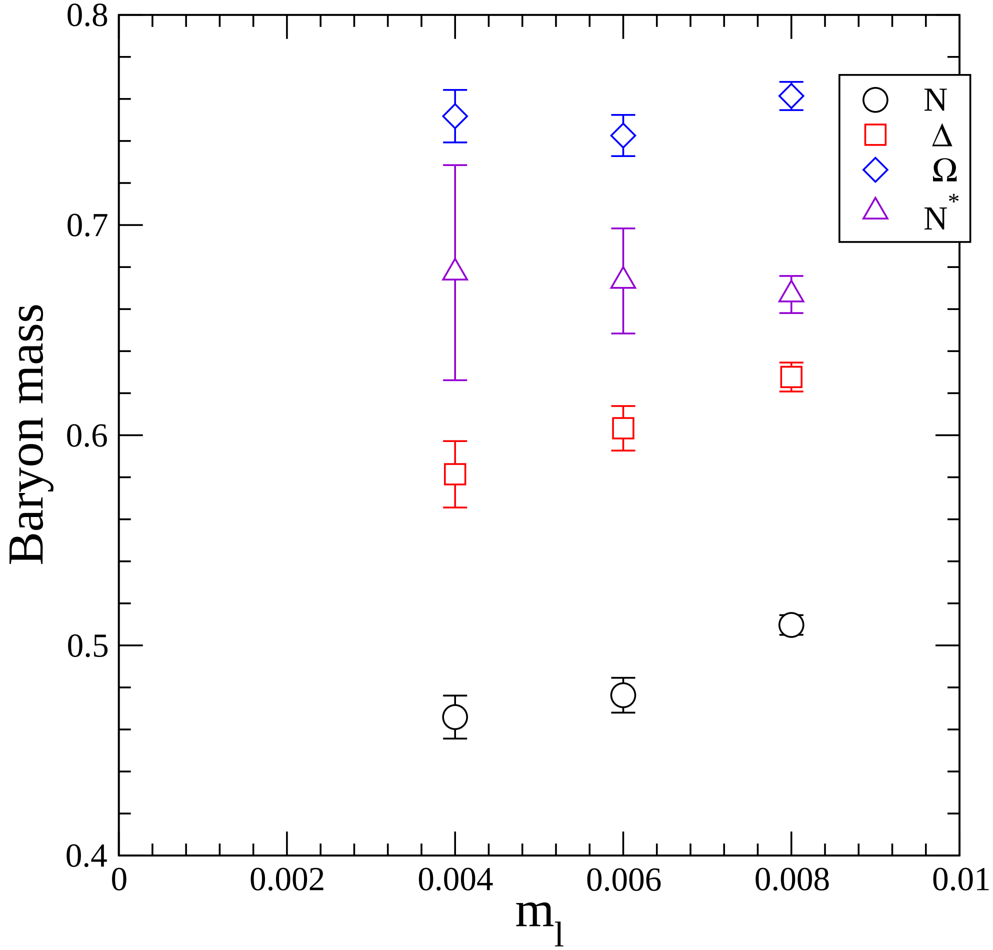


Wall not quite as good as box. Still need to compare to Gaussian

Spectrum: 24^3



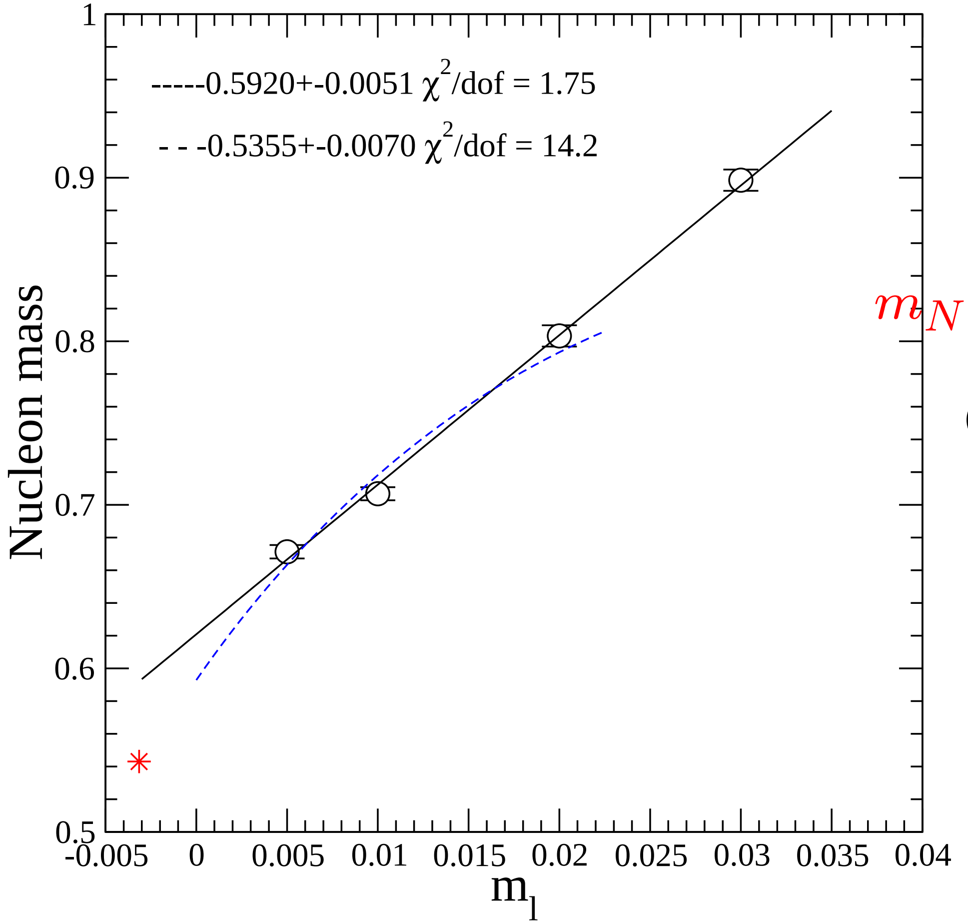
Spectrum: 32^3



N^* is first excited state
much more noisy

Ω not monotonic in m_l
Need more statistics

Chiral Extrapolation of the nucleon mass (24^3 only)



Heavy Baryon χPT

$$m_N = M_0 - 2\alpha m_\pi^2 - \frac{3g_A^2}{(4\pi f)^2} m_\pi^3 + \text{logs}$$

(Jenkins & Manohar, 1991)

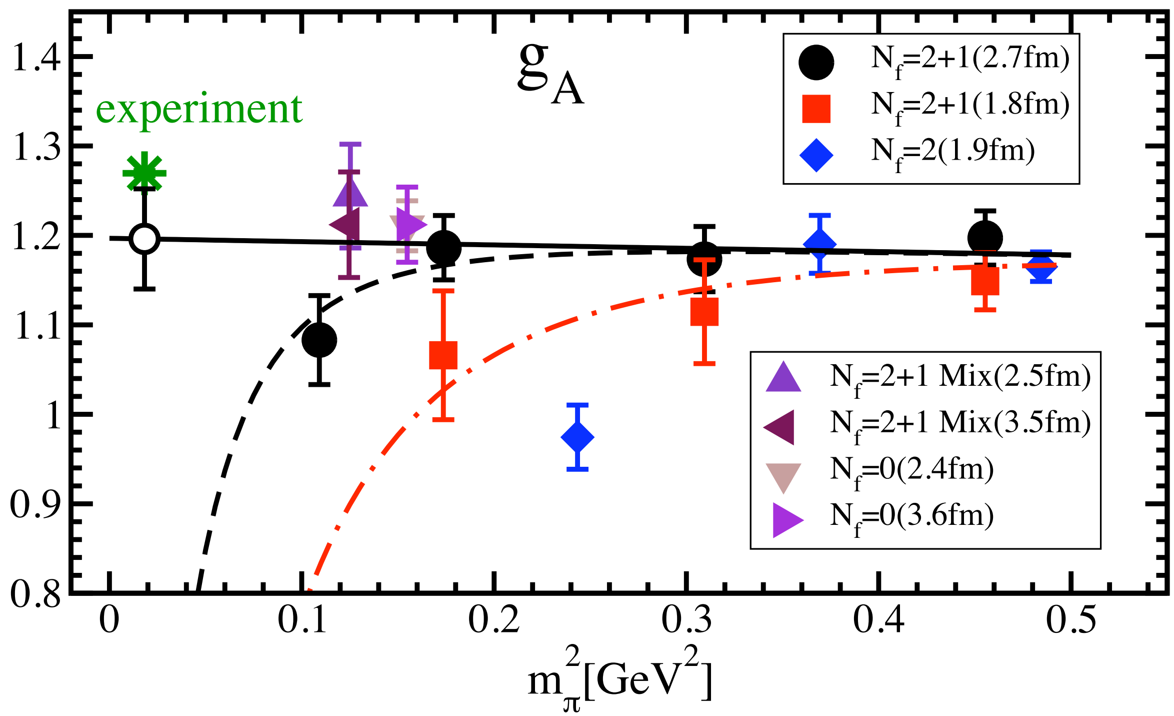
omit logs in fit

Take $g_A = 1.27$ and

$f = 115$ MeV [arXive:0804.0473]

$\chi^2 >> 1$ for HBχPT

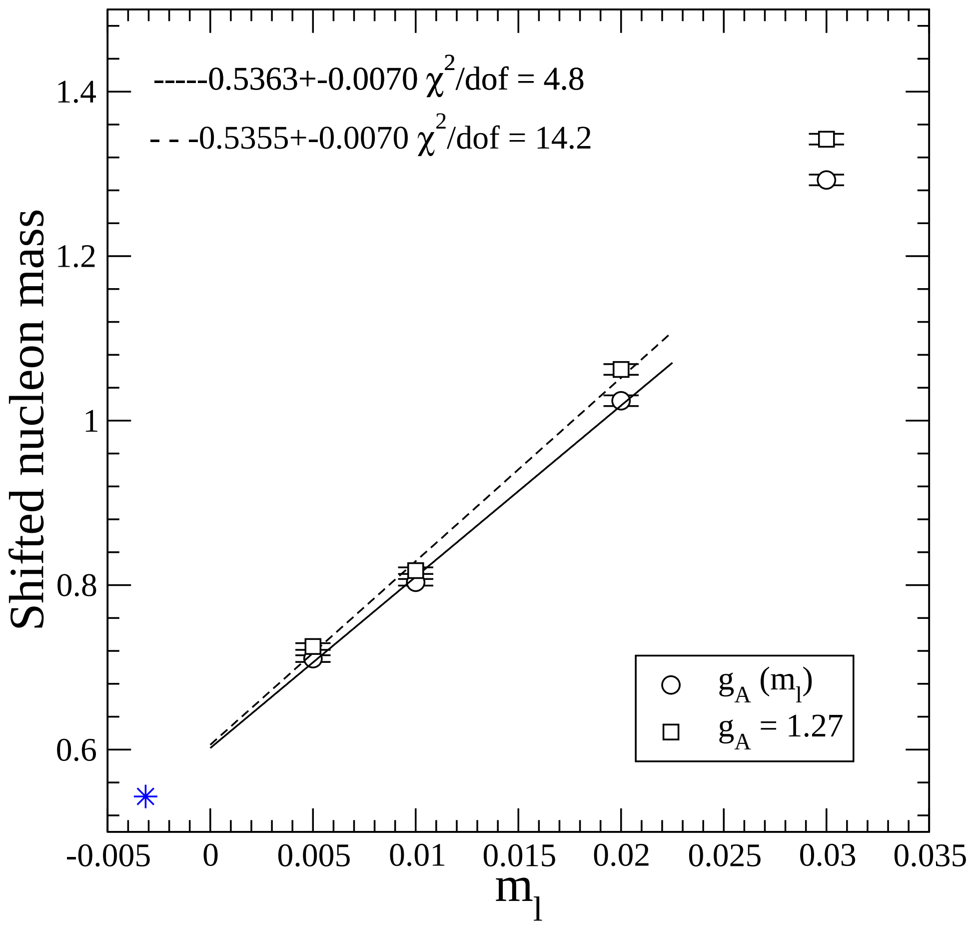
Finite volume effect in g_A (24^3 only)



May also indicate f.v. effect in m_N

T. Yamazaki, *et al.* Phys. Rev. Lett. (2008)

Chiral Extrapolation of the **shifted** nucleon mass (24^3 only)



$m_N + \frac{3g_A^2}{(4\pi f)^2} m_\pi^3$

g_A from lattice at each m_l

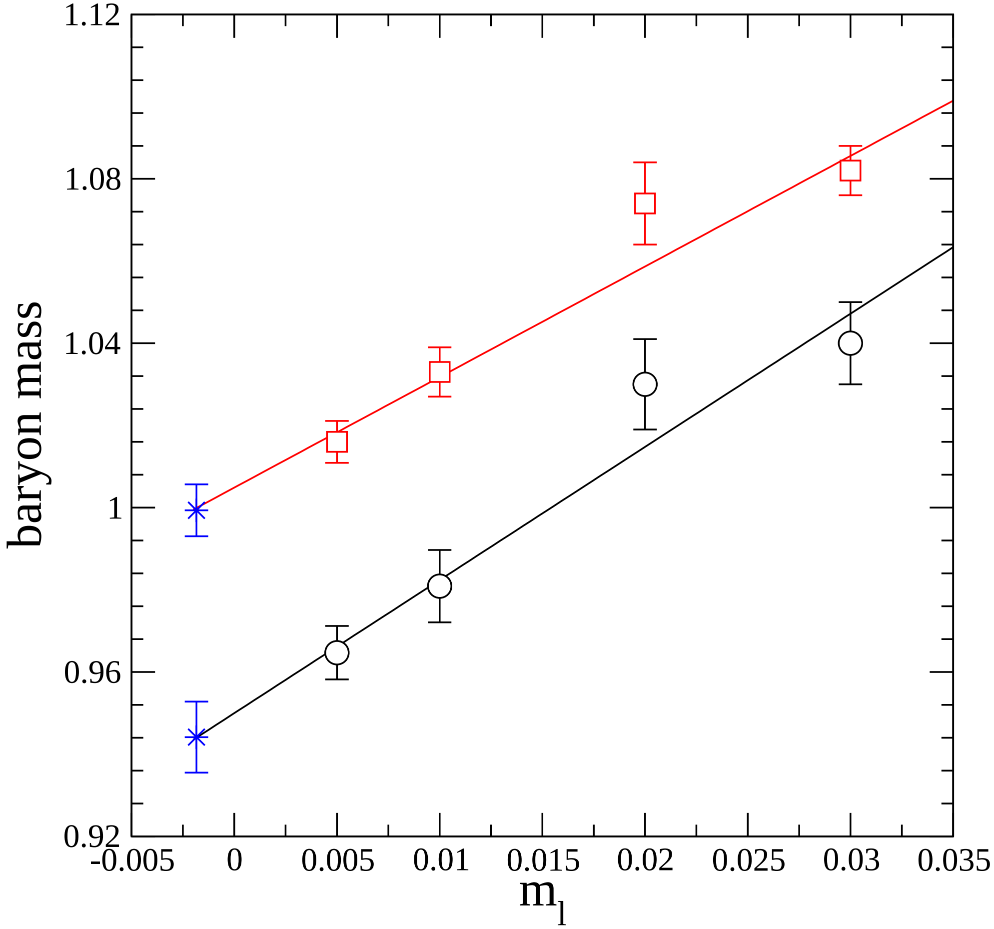
$\chi^2 >> 1$

χ^2 reduced by $\sim \times 3$

At heavier 3 masses,

f.v. effect is $\lesssim 2 \pm 2\%$

Using the Ω mass to set the scale (24^3)



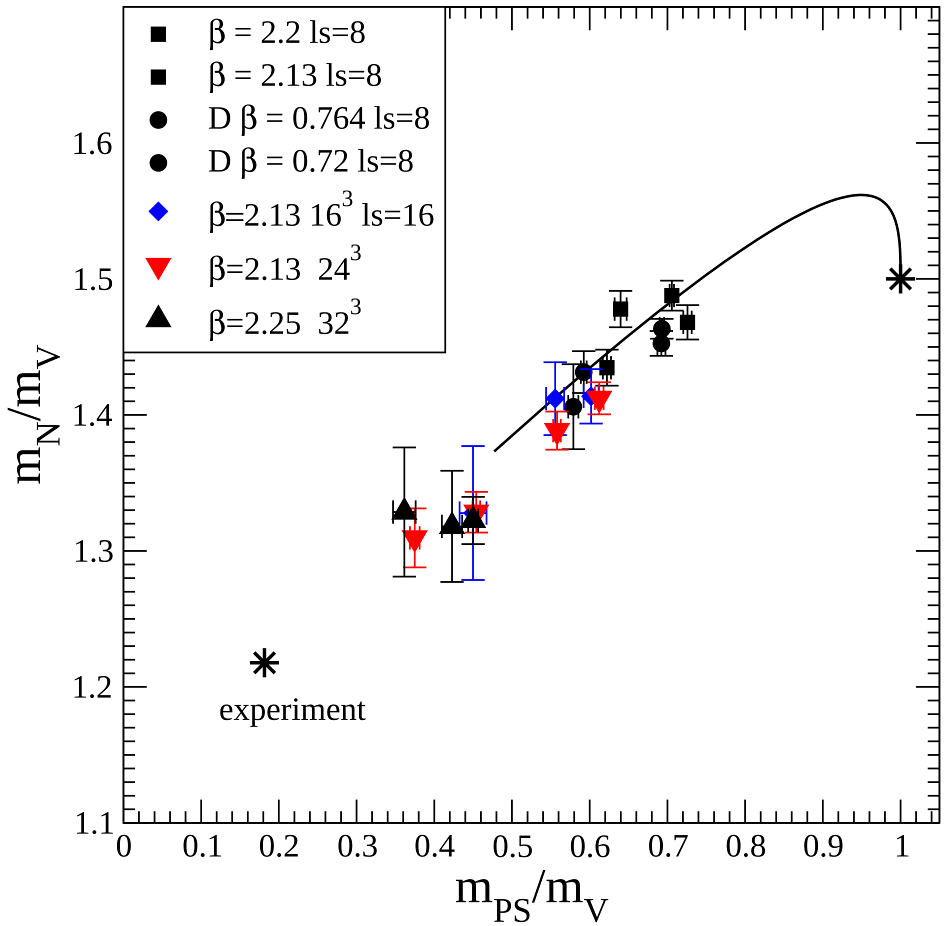
m_Ω analytic in m_l, robust chiral extrap

[Toussaint and Davies, Lattice 2004; Tiburzi and Walker-Loud (2005)]

$a^{-1} = 1.729(28)$GeV

[RBC/UKQCD arXive:0804.0473]

Edinburgh Plot



Lattice spacing errors mild

Statistical errors (only) relatively large

Vector is less robust

Summary/Outlook

- Baryon spectrum in reasonably good shape
- Need more critical analysis of chiral exptrapolation
- Important to handle finite volume systematics as $m_l \to 0$
- Continue to improve statistics at 32^3
- Thanks to Chris Dawson and Chris Maynard

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