Isospin symmetry breaking effects in the pion and nucleon masses

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Outline

- √ Motivation
- √ Theory Background
- √ Current run on QCDOC
- √ Preliminary Result on the LECs
- √ Plan for the future work

Reference

- √ A. Duncan et al, PRL(V76), 3894, (1996)
- √ T. Blum et al, PRD, 114508, (2007)
- √ J. Bijnens et al, PRD. 014505(2007)
- √ also Subhasish Basak's talk at Thursday

Motivation

- ✓ What is $SU(3)$ isospin symmetry breaking?
  $m_u \neq m_d \neq m_s, \;\; q_u \neq q_d = q_s$
- ✓ It's effect: mass splitting
  $m_{\pi^+} \neq m_{\pi^0}, m_p \neq m_n ...$
- ✓ mass splitting
  => the UNKNOWN parameters in PQχPT
  => make prediction

Theory Background

m^2_{meson}	related quantity	LECs
$(QCD)_{LO}$	m	B
$(QCD)_{NLO}$	$m^2, m^2 \log m$	L_i
$(QED)_{LO}$	$e^2(q_u - q_d)^2$	C
$(QED)_{NLO}$	$e^2 m, e^2 m \log m$	Y_i
DWF effect	$e^2(q_u + q_d)^2$	C_2

Table 1: Mass in PQχPT, From J.Bijnens and N.Danielsson PRD. 014505(2007)

Theory Background

$(QCD)_{LO}$ result$(m_u = m_d)$:

$m_{\pi^+}^2 = 2B_0 m_u$

For DWF $m_{\pi^+}^2 = 2B_0(m_u + m_{res})$

- ✓ $m_{\pi^+}^2(e \neq 0) = 2B_0(m_u + m_{res}^{e\neq 0}) + ...$
- ✓ $m_{\pi^+}^2(e = 0) = 2B_0(m_u + m_{res}^{e=0}) + ...$
- ✓ $m_{res}^{e\neq 0} - m_{res}^{e=0} = C_1 e^2 (q_u - q_d)^2 + C_2 e^2 (q_u + q_d)^2$

✓ $\delta m^2 = m_{\alpha\neq 0}^2 - m_{\alpha=0}^2 \sim C, Y_i, C_2$

Lattice Simulation

QCD effect + QED effect=>Mass

- √ QCD conf: 2+1f 16^3 and 24^3 lattice conf(RBC)
- √ QED conf: Quenched non-compact QED conf
- √ turn off QED => $m^2(e = 0)$
- √ turn on QED => $m^2(e \neq 0)$
- √ $\delta m^2 = m^2_{\alpha \neq 0} - m^2_{\alpha = 0}$ ==> C, Y_i, C_2

Our current run

lat	msea	mval	qcd-range	Δ	qed-range	Δ
16^3	0.01	0.01-0.03	500-4000	20	0-351	1
16^3	0.02	0.01-0.03	500-4000	20	0-351	1
16^3	0.03	0.01-0.03	500-4000	20	0-175	1
24^3	0.005	0.005-0.03	900-8660	40	0-194	1
24^3	0.01	0.01-0.03	1500-5040	20	0-179	1
24^3	0.02	0.02	1800-3580	20	0-359	1
24^3	0.03	0.03	1260-3040	20	0-359	1

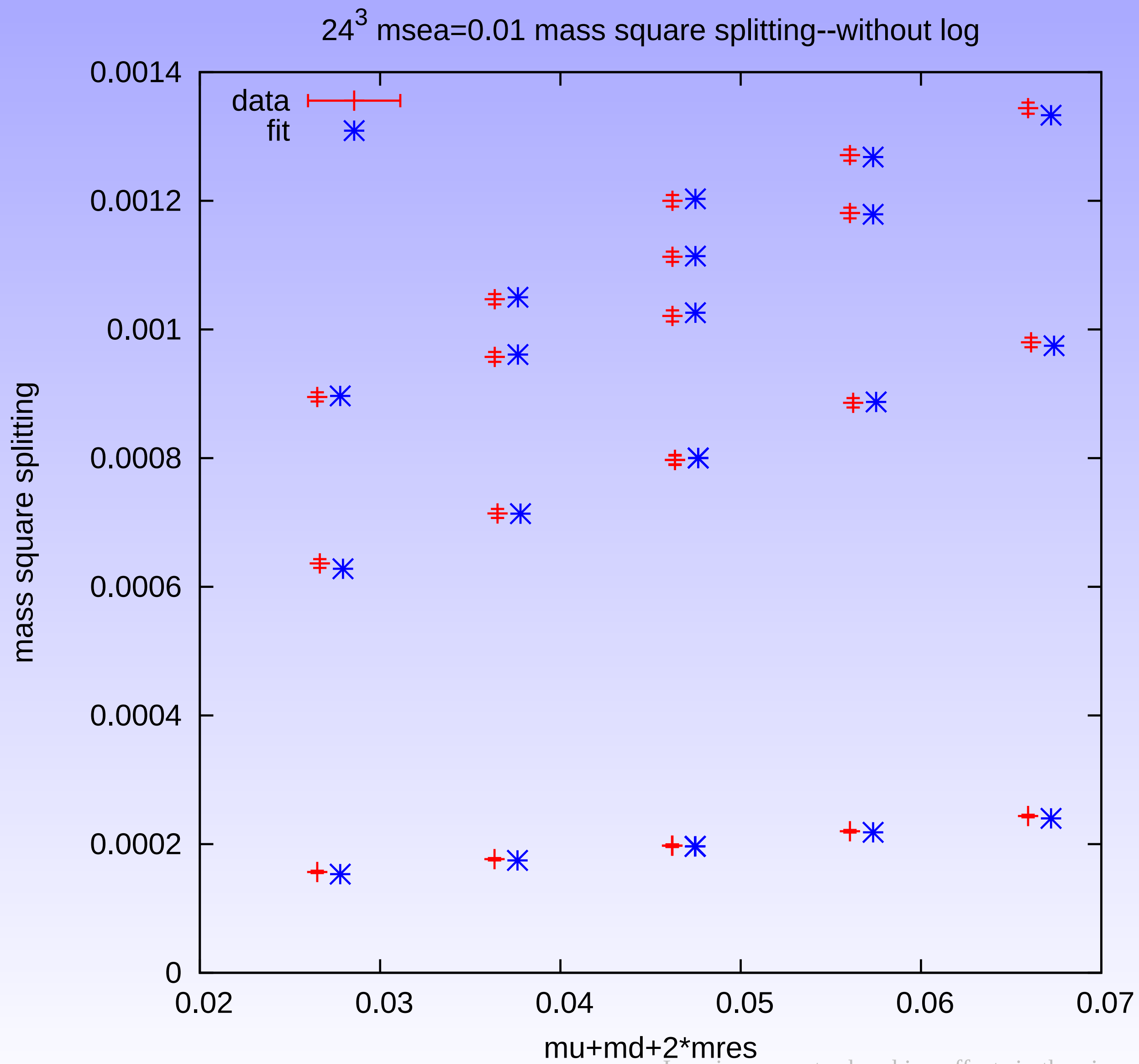
Table 2: Measure parameter for $16^3, 24^3$ lattice, Δ is the separation between the different measurements

Preliminary Result

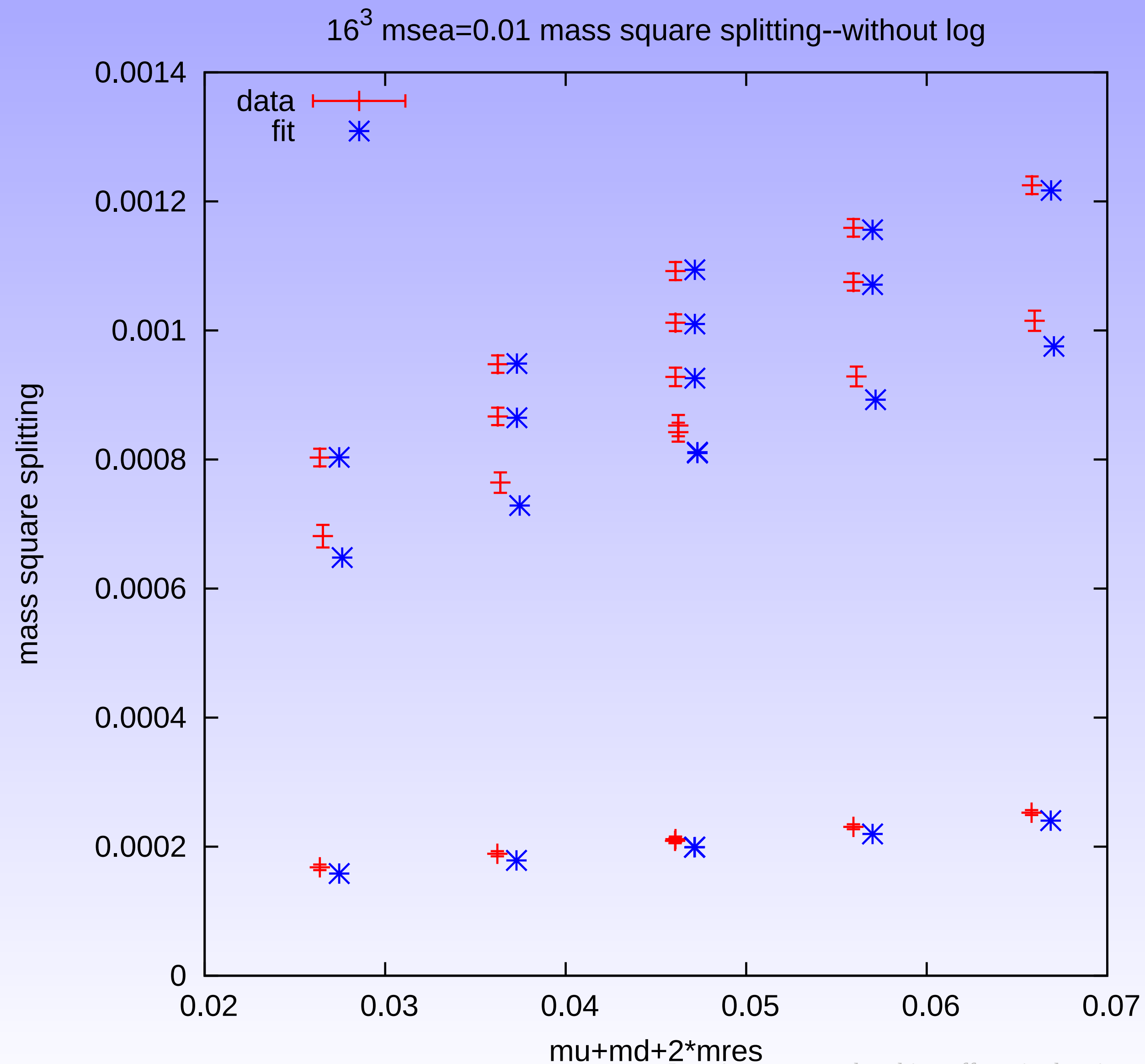
My current result is based on the:

- ✓ 16^3 data + PQχPT without chiral log
- ✓ 24^3 data + PQχPT without chiral log

Preliminary Result



Preliminary Result



Mass Splitting at Chiral Point(Preliminary)

- √ $\delta m^2 = m^2_{e\neq 0} - m^2_{e=0} = \frac{2Ce^2}{F_0^2}(q_u - q_d)^2 \ldots\ldots \pi^+$
- √ $\delta m^2 = m^2_{e\neq 0} - m^2_{e=0} = \frac{2Ce^2}{F_0^2}(q_u - q_s)^2 \ldots\ldots K^+$
- √ $\delta m = \delta m^2/(280MeV)$

Lat	$\delta m(MeV)$
16^3	3.54(8)
24^3	3.10(10)

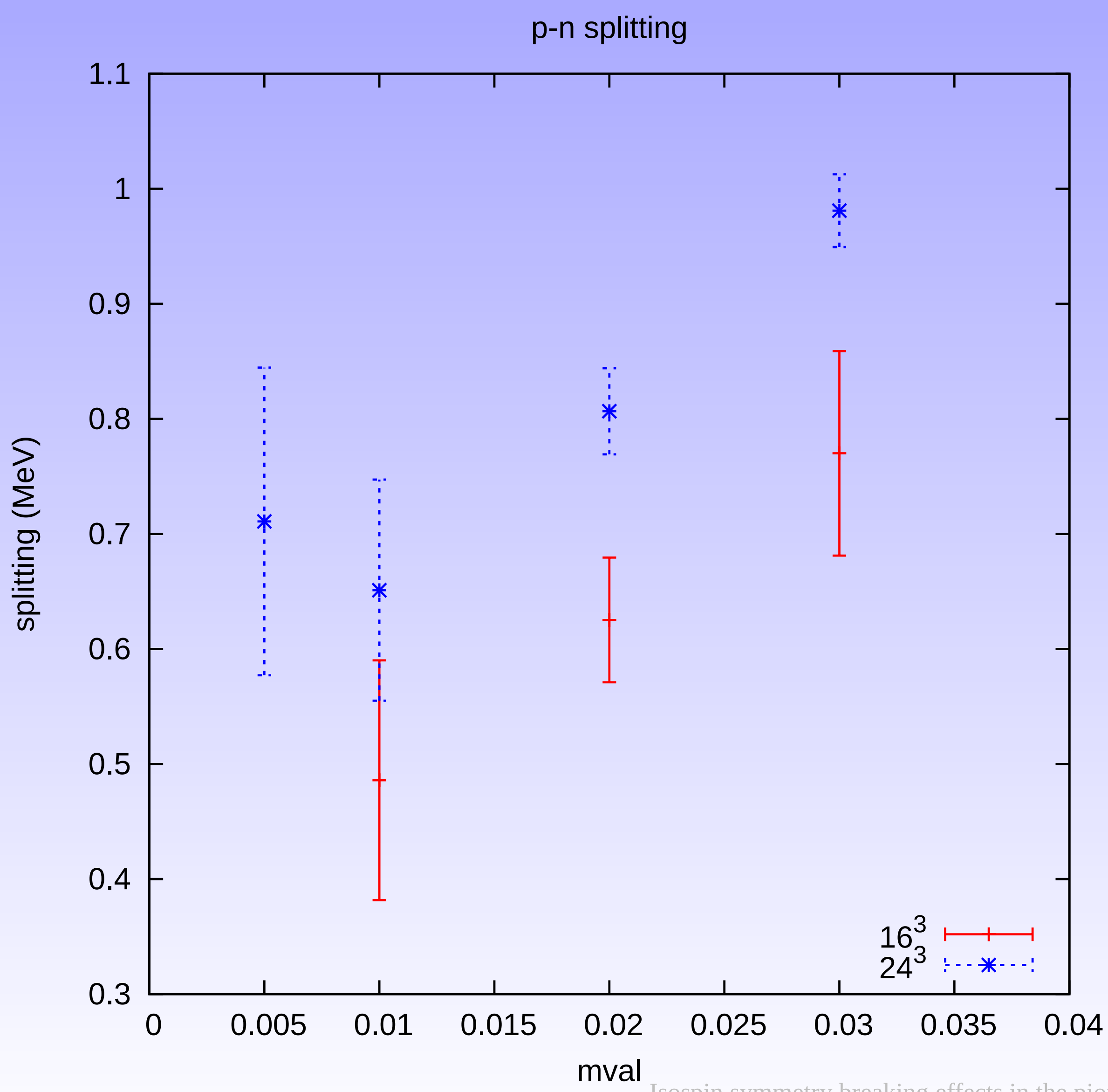
- √ No chiral log,
- √ No finite volume correction

Mass Splitting in the p-n system

$$m_p \neq m_n$$

- √ QCD: $m_u \neq m_d$
- √ QED: $q_u \neq q_d$
- √ Parameterize the QED effect($m_u = m_d$):
  $\delta m = m_n - m_p \propto e^2 m_u + const$

Mass Splitting in the p-n system



future work

- √ conform the LECs result and INCLUDE the chiral log
- √ study the physicical $m_{\pi^+} - m_{\pi^0}$ using the LECse
- √ $m_u \neq m_d, e = 0$ effect on the proton, neutron mass splitting