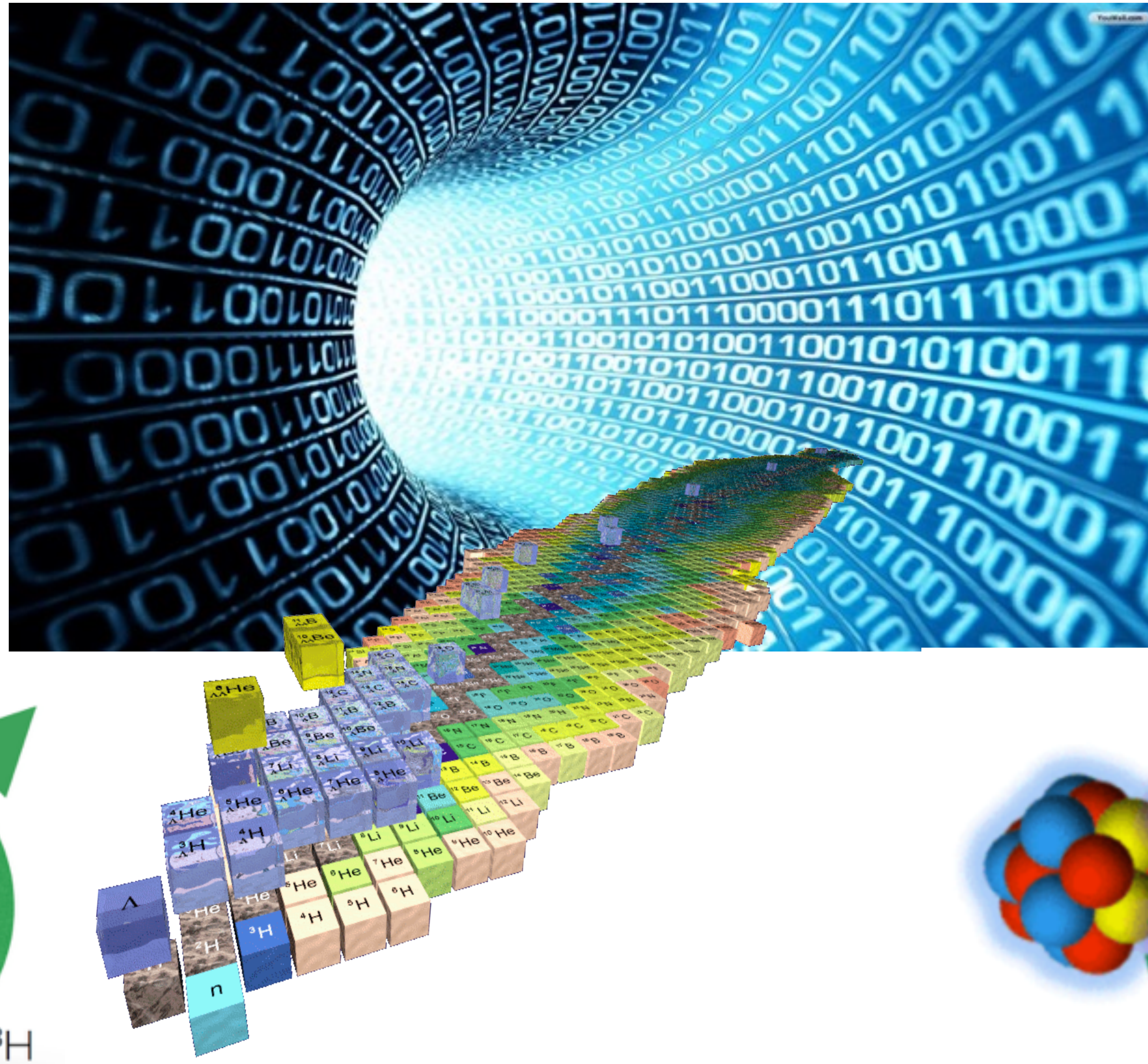
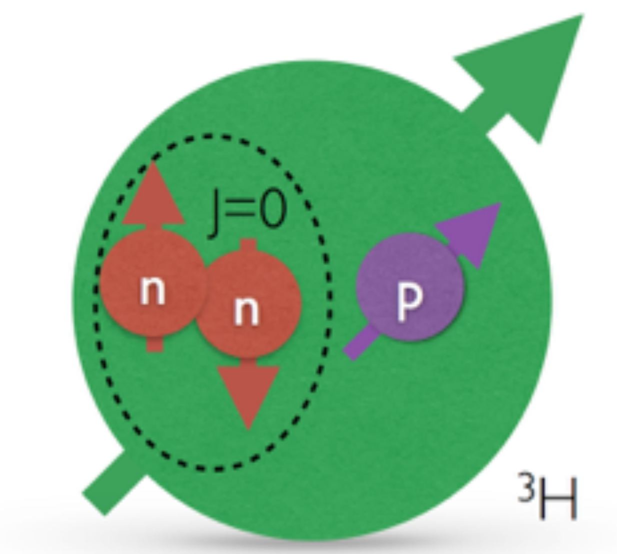
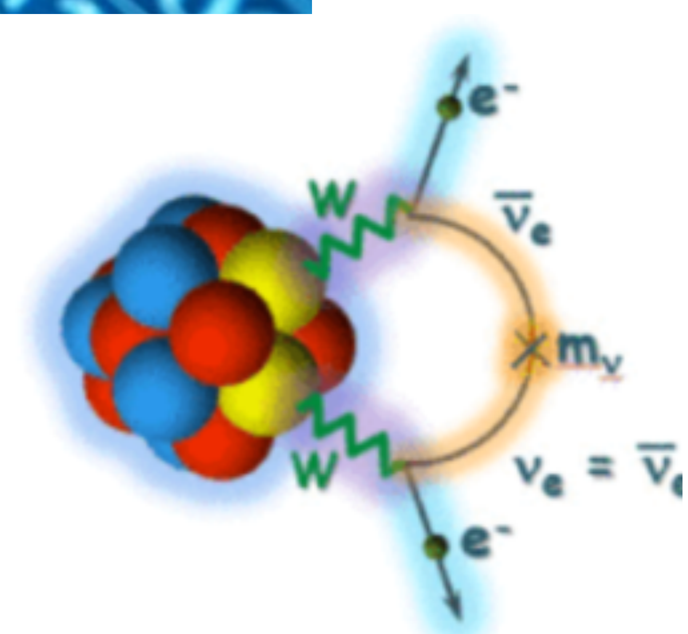






The Weak Structure of Light Nuclei

USQCD Proposal (2016-2017)

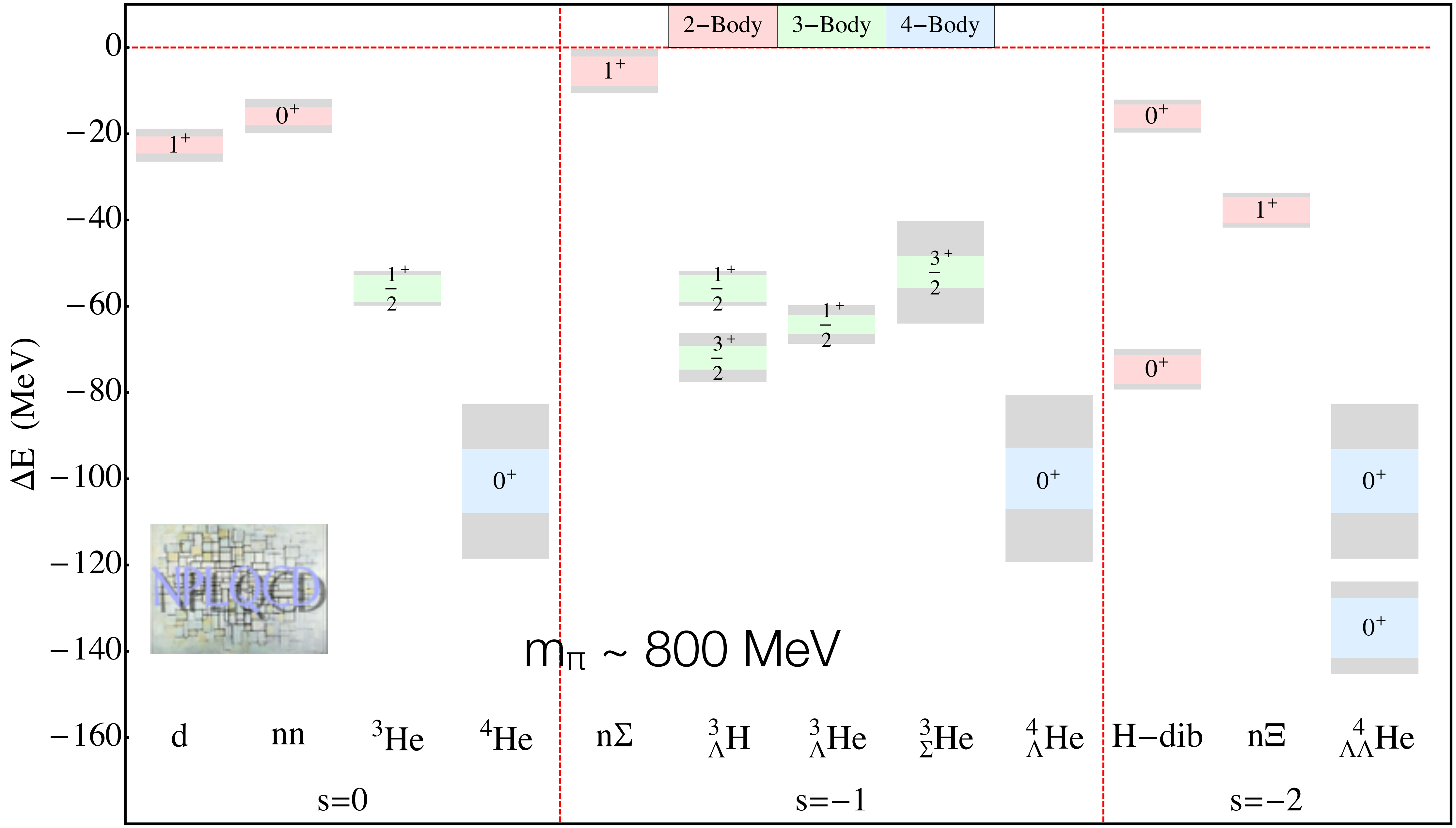
Martin J Savage

INSTITUTE for NUCLEAR THEORY

Brookhaven National Laboratory, April 29, 2016

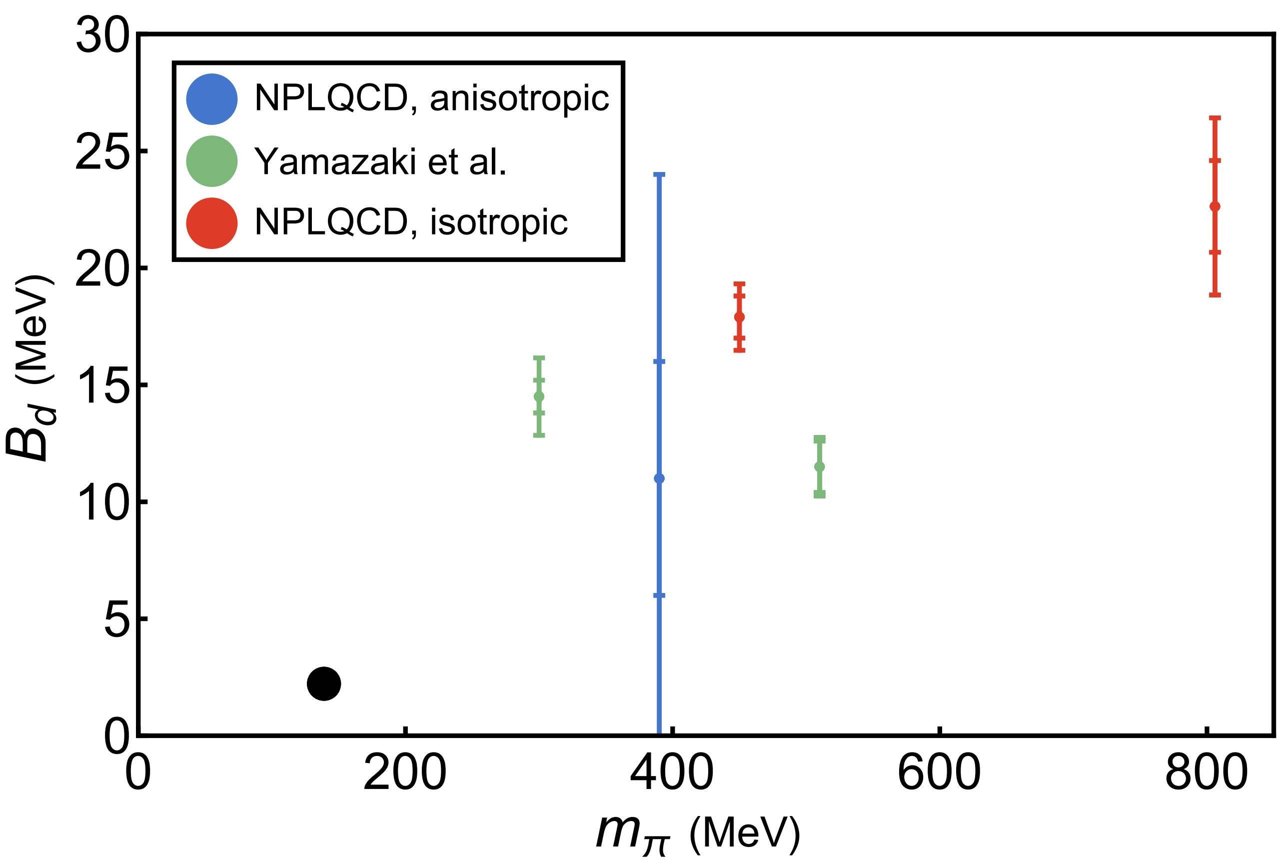
Nuclei from QCD

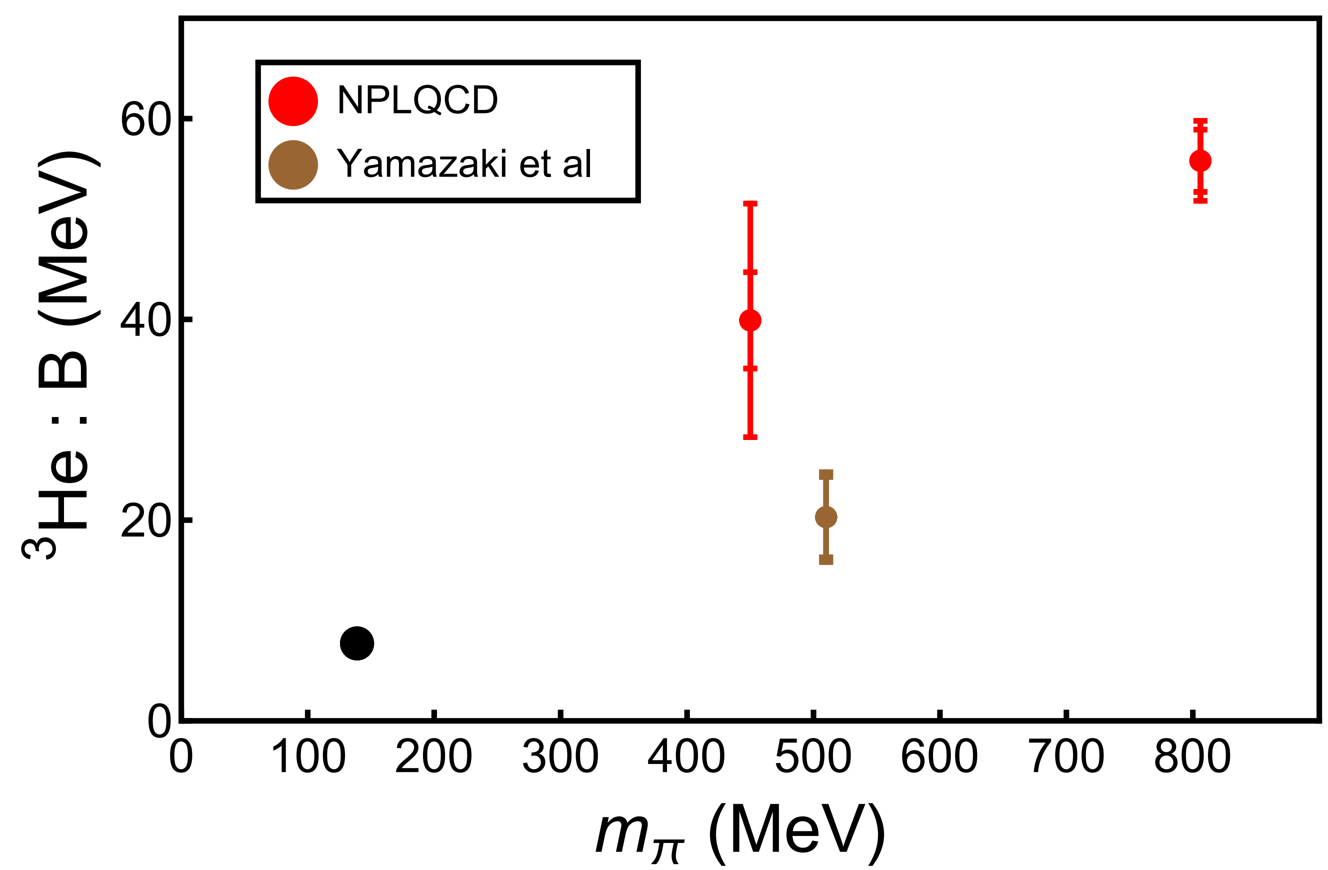
NPLQCD: Beane *et al,* Phys.Rev. D87 (2013) 3, 034506, Phys.Rev. C88 (2013) 2, 024003



Extensive study of s-shell nuclei and hypernuclei, and baryon-baryon interactions at SU(3) symmetric point

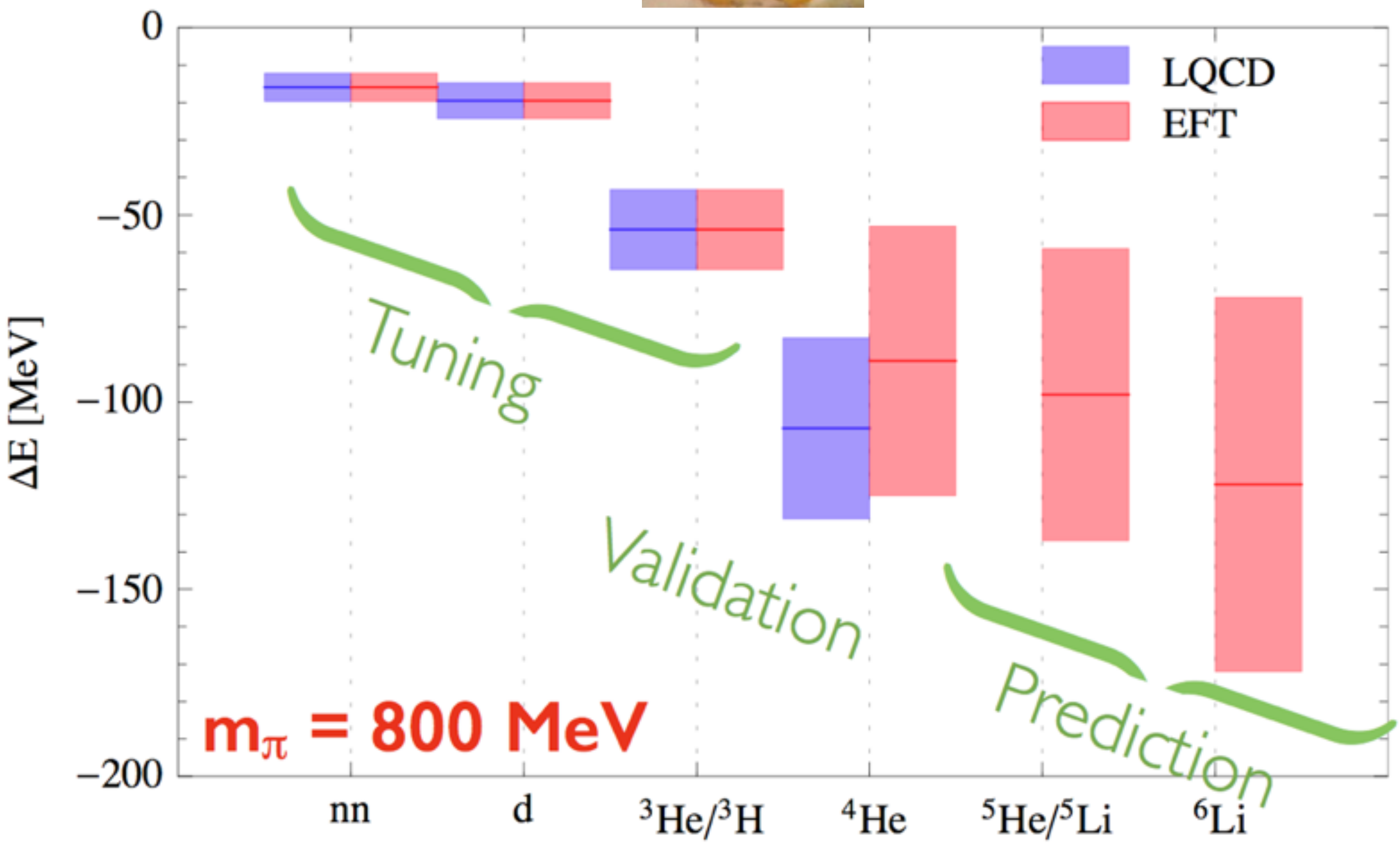
Light Nuclei :
Quark Mass Effects





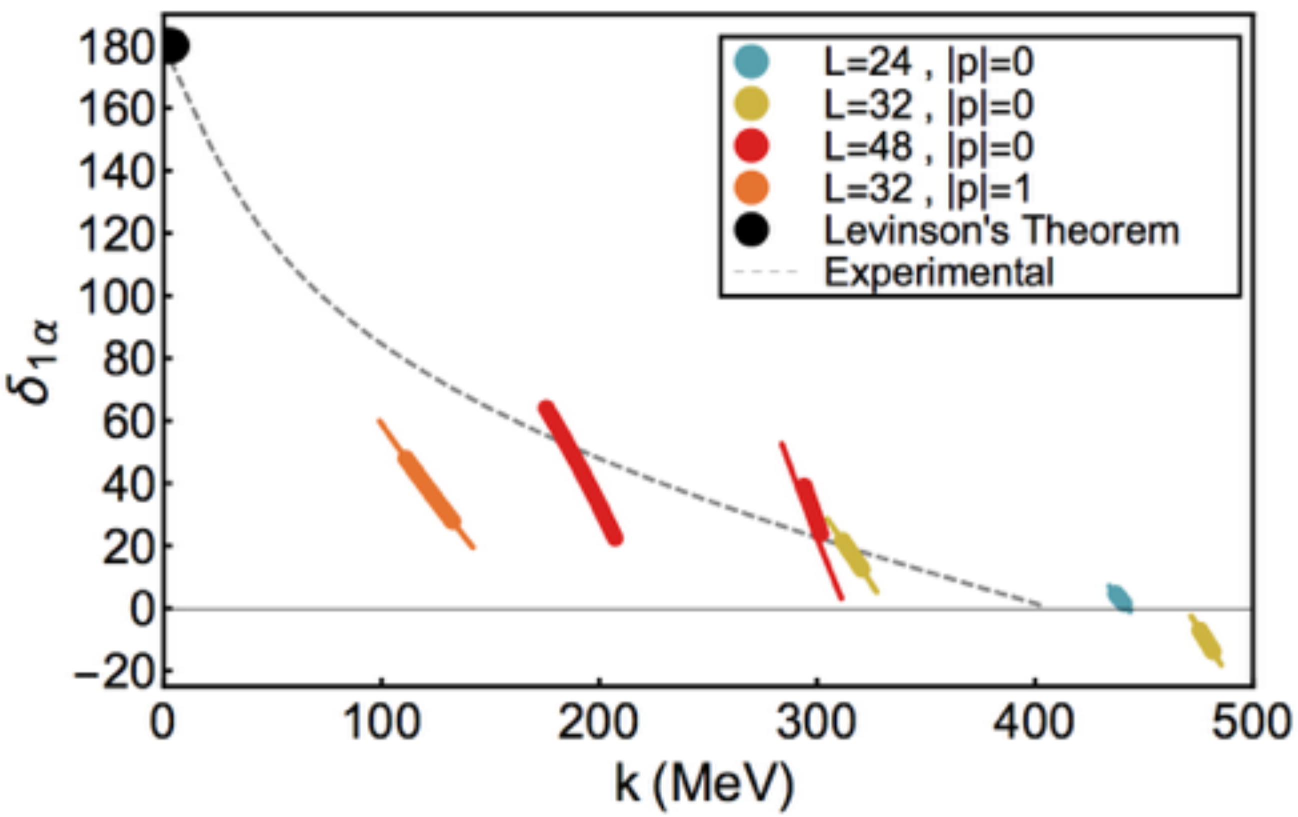
Toward The Periodic Table

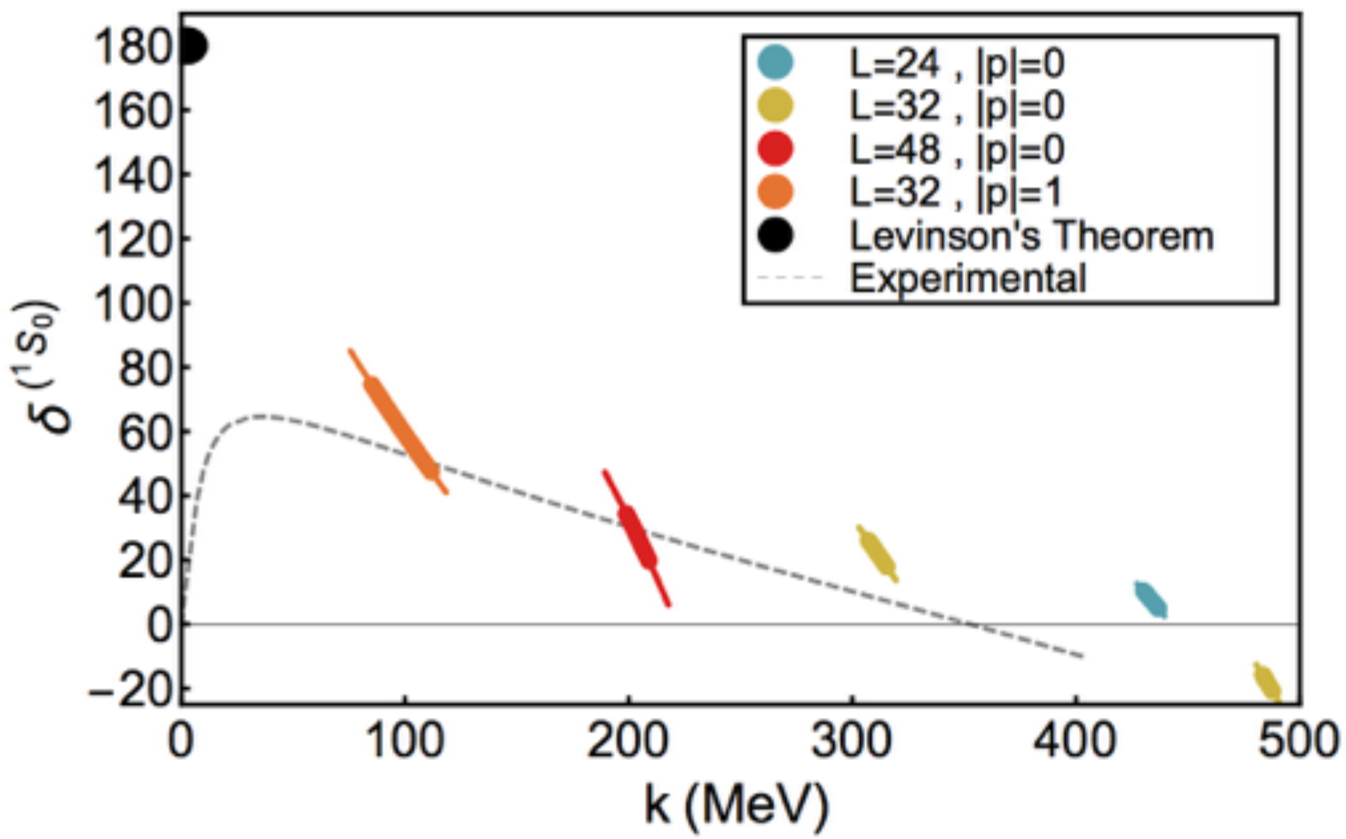
(Barnea *et al.*, Phys.Rev.Lett. 114 (2015) 5, 052501)



NN Interactions

$m_\pi \sim 450$ MeV



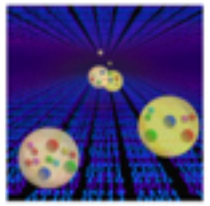


Editors' Suggestion

Two nucleon systems at $m_\pi \sim 450$ MeV from lattice QCD

Kostas Orginos, Assumpta Parreño, Martin J. Savage, Silas R. Beane, Emmanuel Chang, and William Detmold (NPLQCD Collaboration)

Phys. Rev. D **92**, 114512 (2015) – Published 23 December 2015



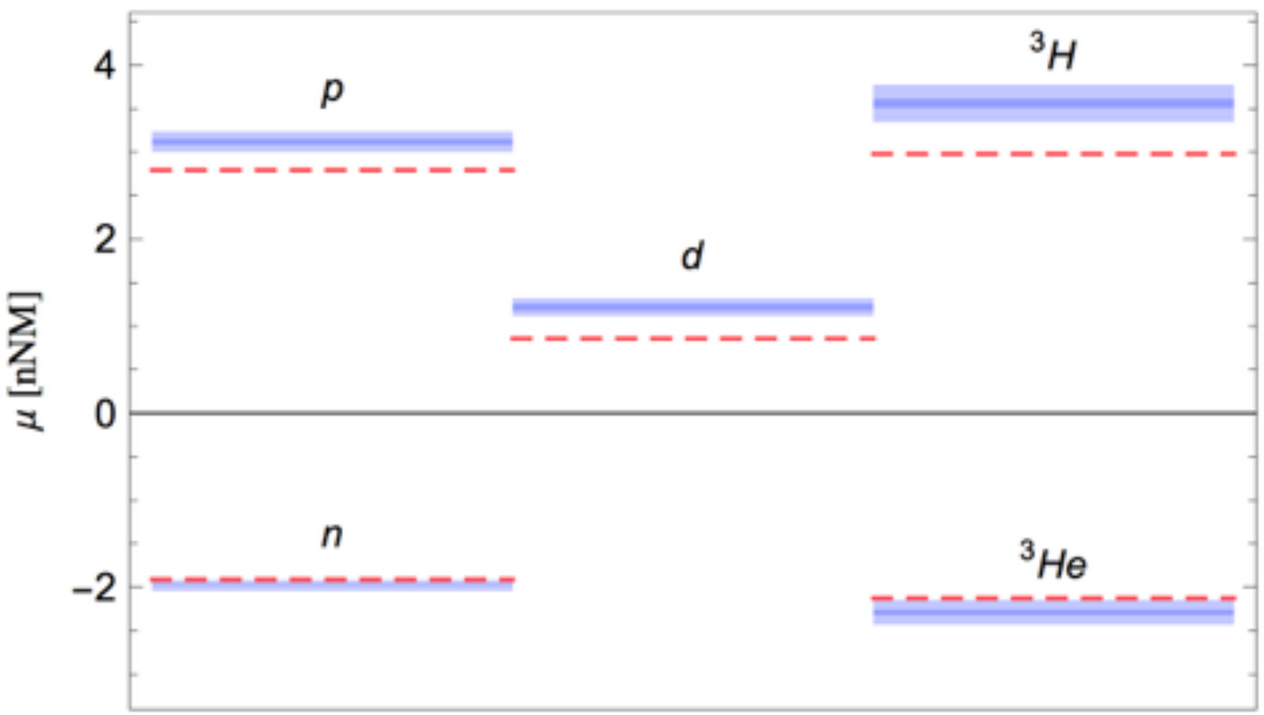
New lattice QCD results for two-nucleon systems are presented, including binding energies for the deuteron and dineutron, and S-wave scattering phase shifts. The results are then explored in the context of nucleon-nucleon effective field theory.

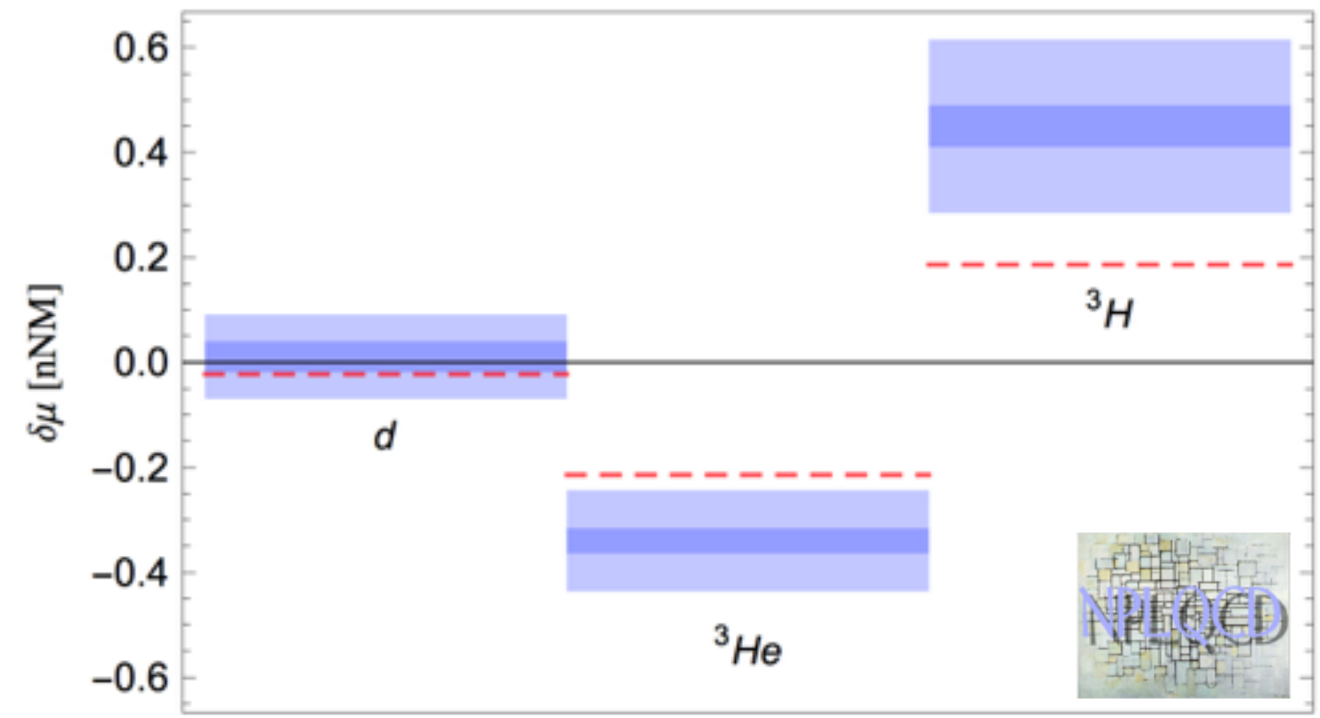
Show Abstract +

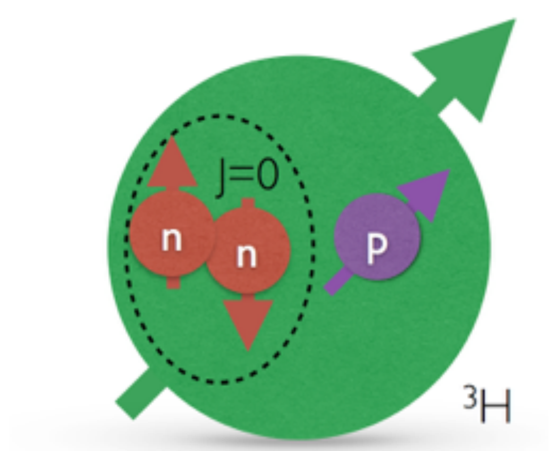
NPLQCD: Orginos et al, Phys.Rev. D92 (2015) no.11, 114512

The Magnetic Moments of Nuclei

NPLQCD: **S.R. Beane *et al.*, Phys.Rev.Lett. 113 (2014) 25, 252001, Chang et al, Phys.Rev. D92 (2015) no.11, 114502**



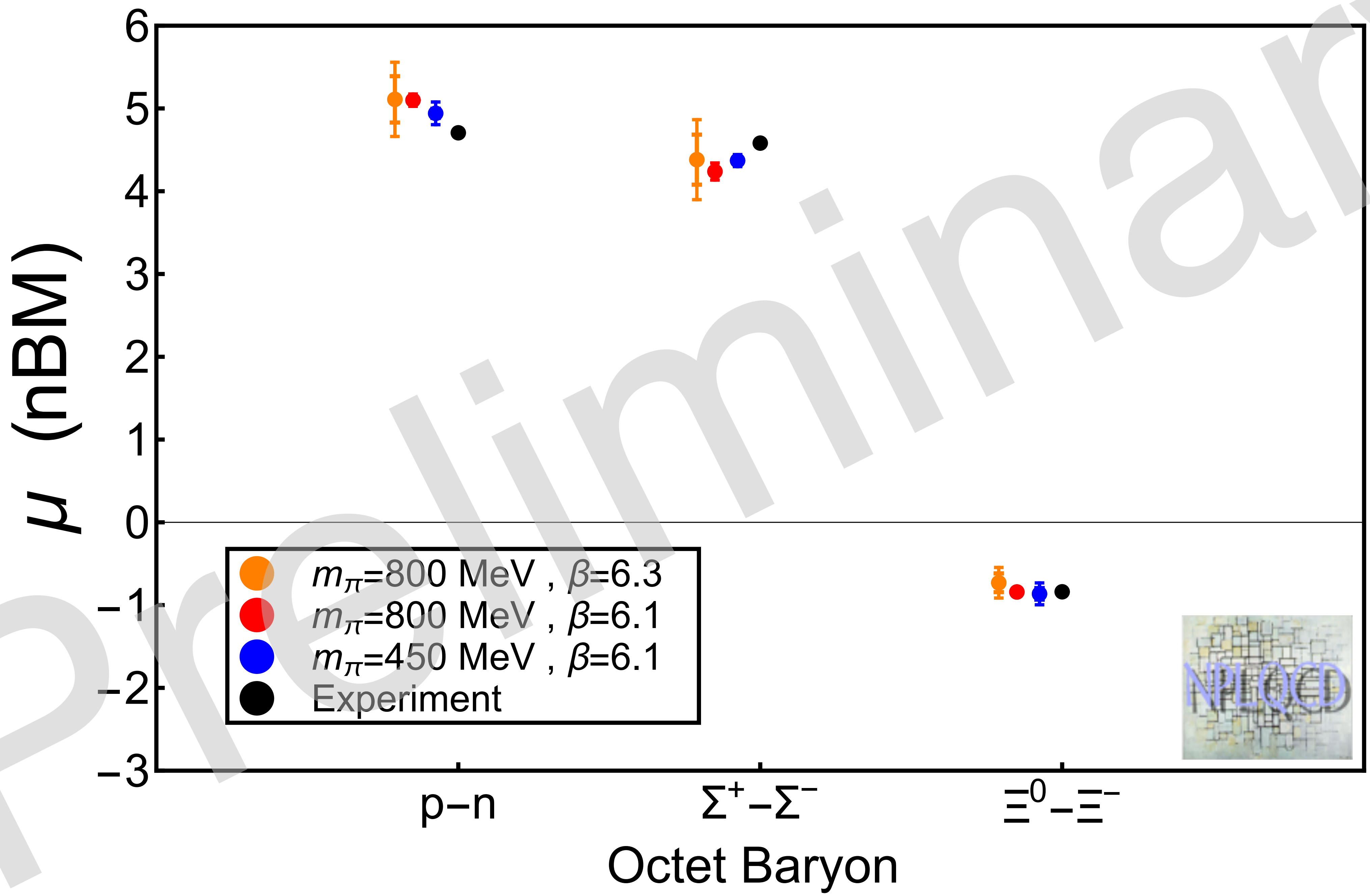




m_π ~ 800 MeV   Vs   Nature

Nuclei are (nearly) collections of nucleons
- shell model phenomenology!

Baryon Isovector Magnetic Moments



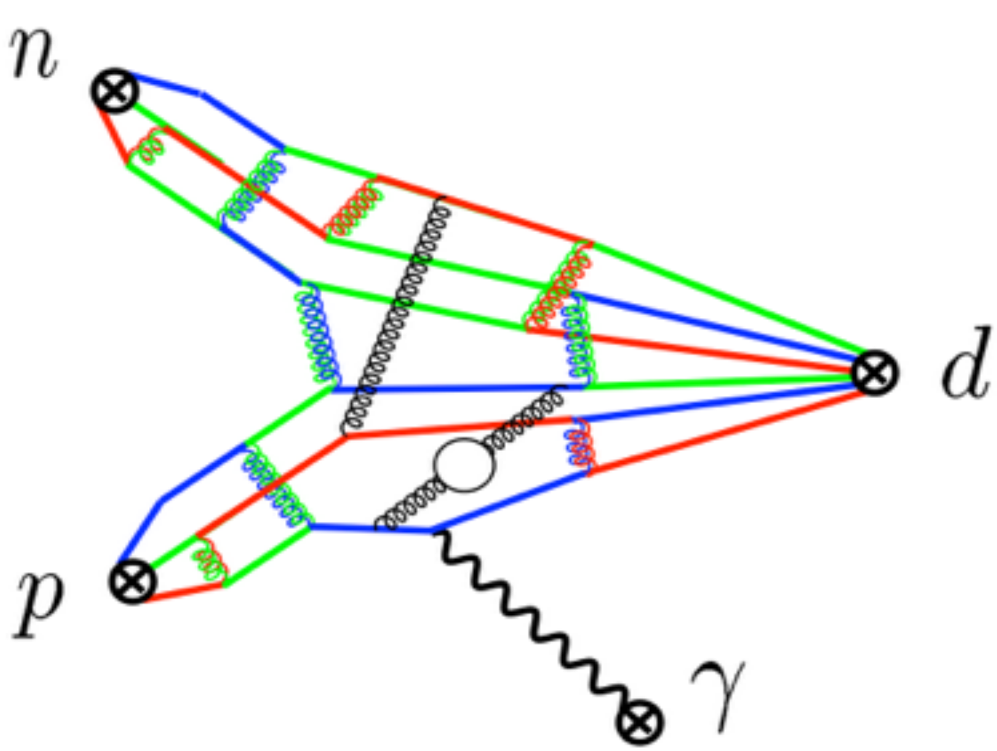
$$\frac{e}{2M(m_\pi)}$$

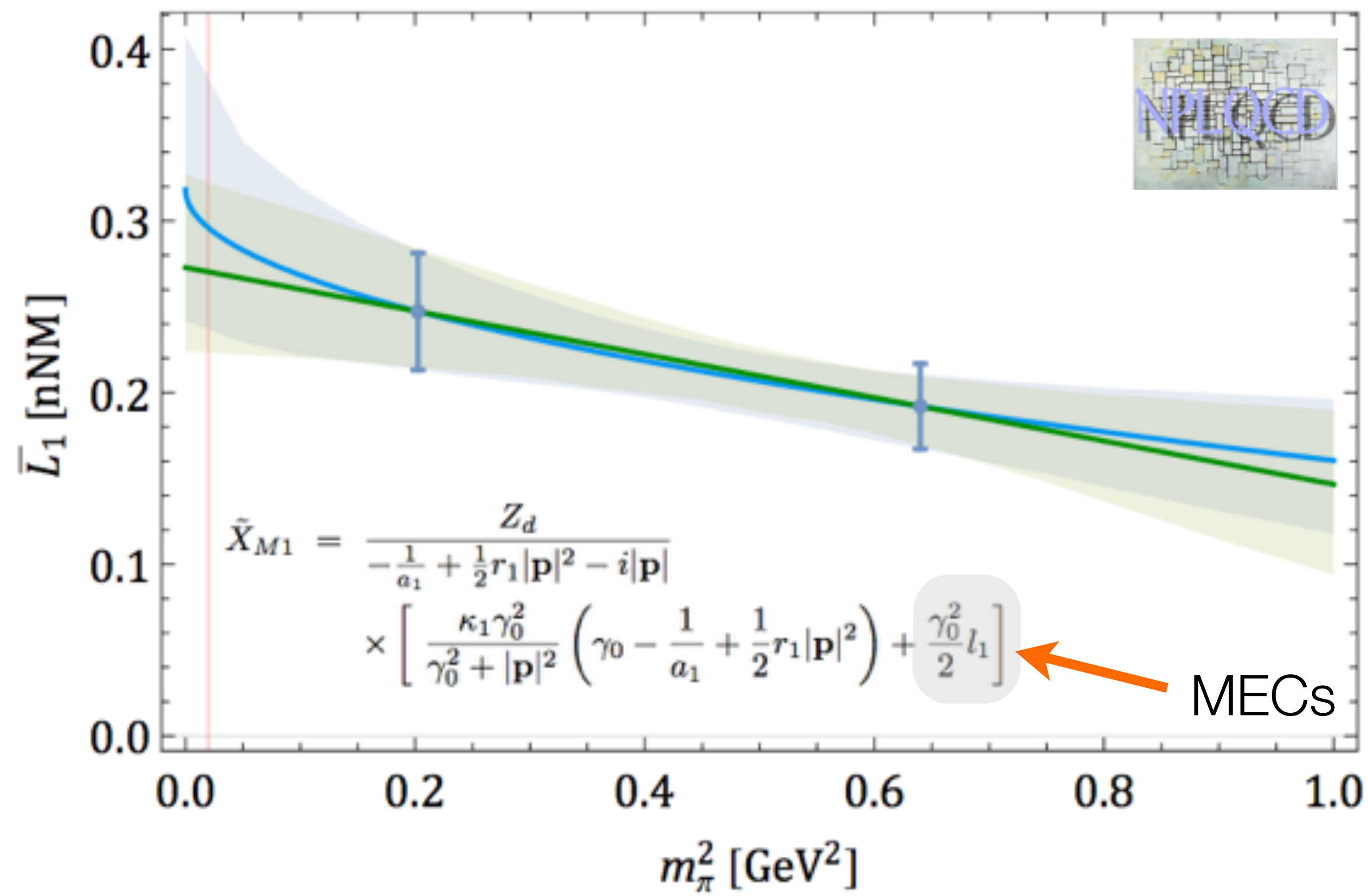
Essentially ALL quark mass dependence of nucleon magnetic moments is due to the nucleon mass

Radiative Capture

$$np \to d\gamma$$

NPLQCD: Beane et al, Phys.Rev.Lett. 115 (2015) no.13, 132001



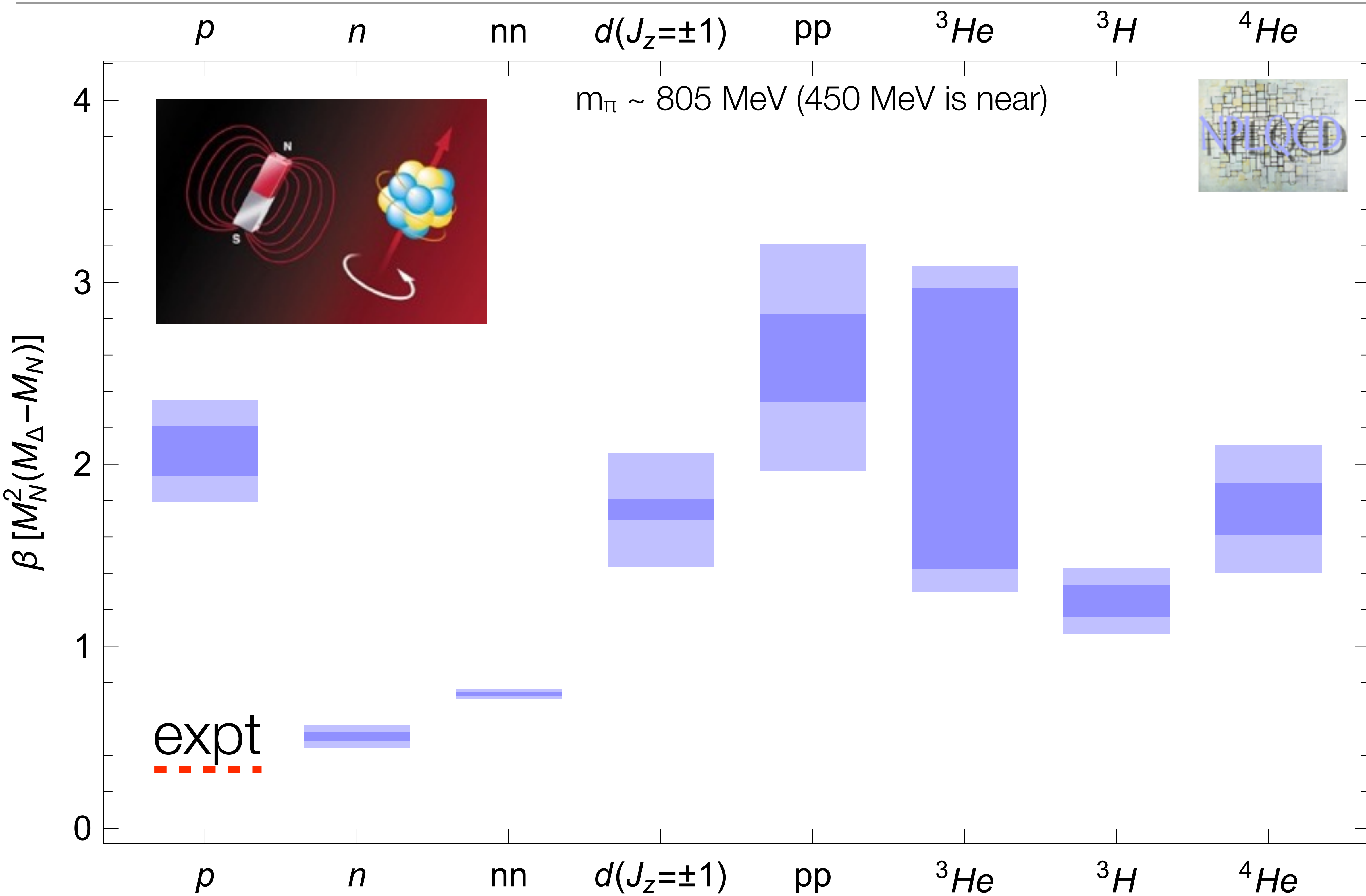


postdiction at the physical point (verification) :

$$\sigma^{\rm lqcd} = 334.9\left(\,^{+5.4}_{-4.7}\,\right)\ {\rm mb} \qquad v = 2,200\ {\rm m/s}$$

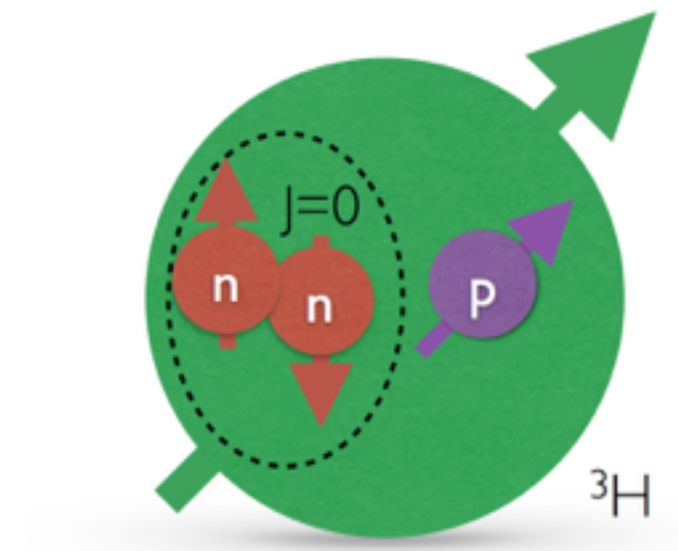
$$\sigma^{\rm expt}(np \to d\gamma) = 334.2(0.5)\ {\rm mb}$$

The Magnetic Polarizabilities of Nuclei



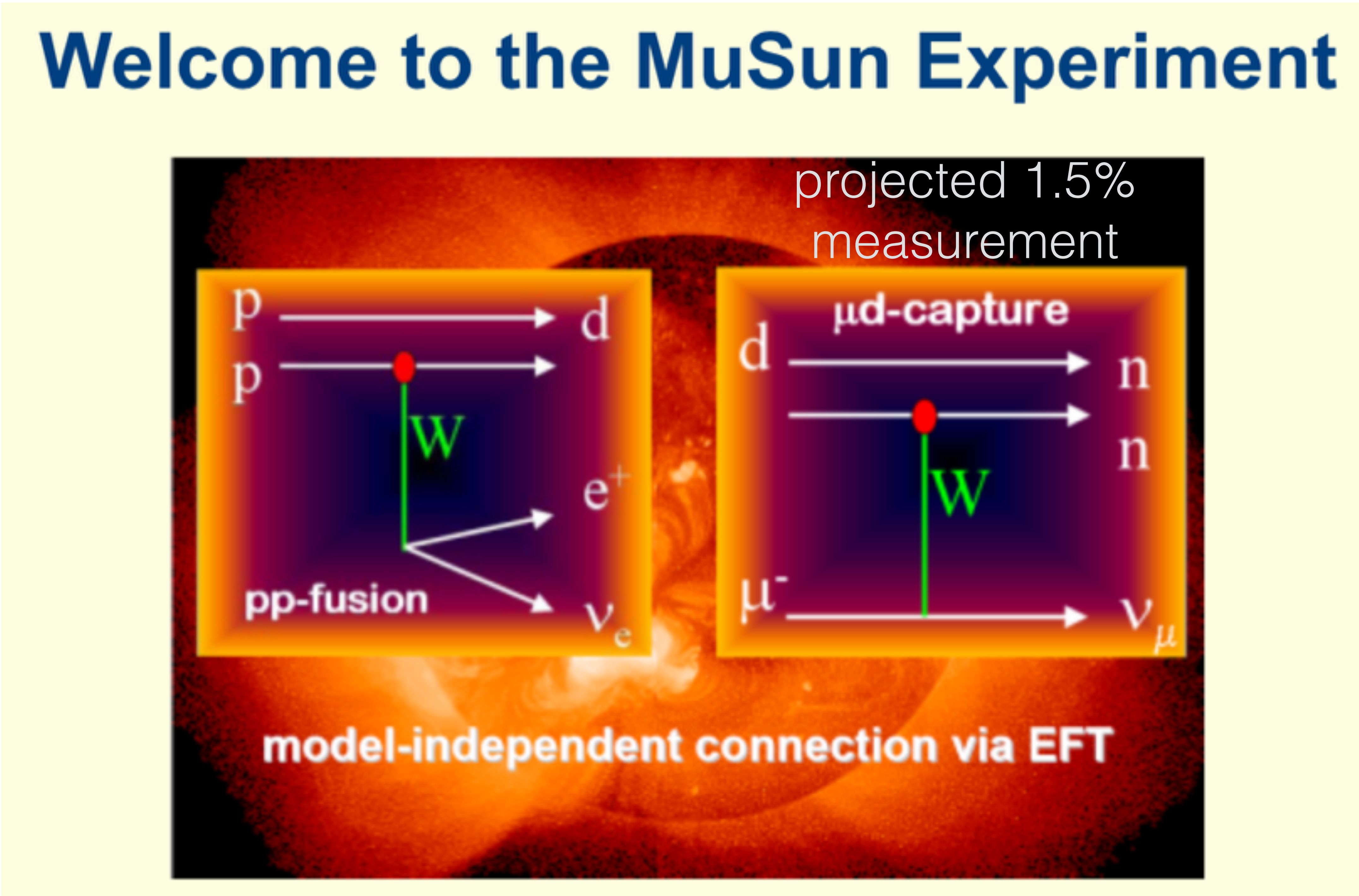
NPLQCD: Chang *et al.* Phys.Rev. D92 (2015) no.11, 114502

Proposal: Weak analogues of these Magnetic Quantities

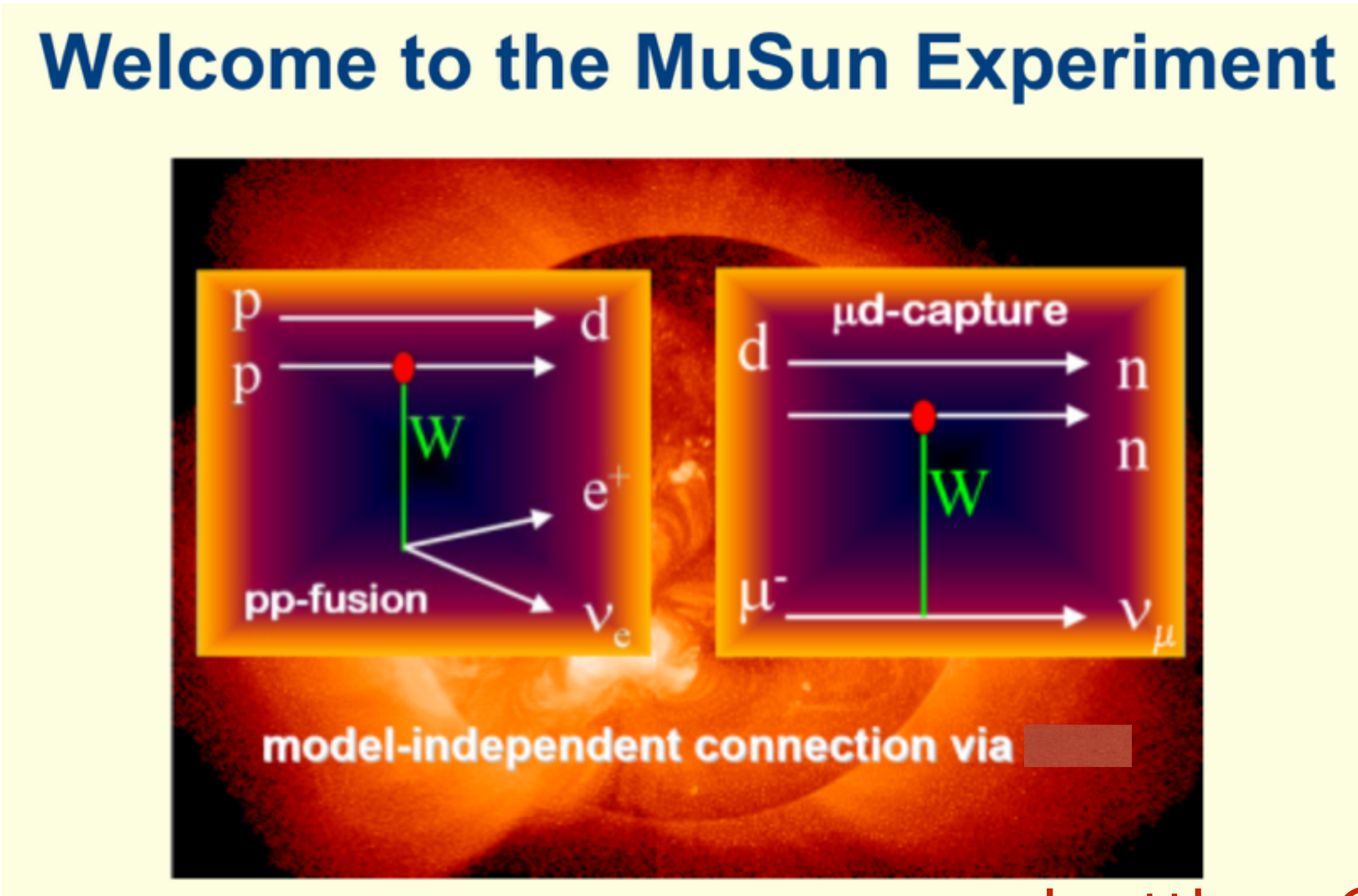


- Axial Current Matrix Elements in Nuclei
  - gA in nuclei and single-particle suppressions in nuclear phenomenology
  - Essential role in correctly predicting $0\nu\beta\beta$-decay nuclear rates
- Axial Polarizabilities
  - Also essential role in correctly predicting $0\nu\beta\beta$-decay nuclear rates
  - interesting in their own right

Proposal: Weak analogues of these Magnetic Quantities



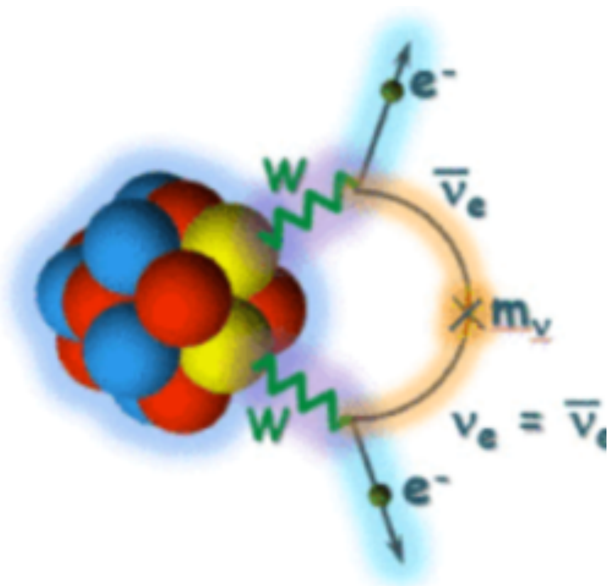
Proposal: Weak analogues of these Magnetic Quantities



Experimentalists very happy about our proposal !!

Lattice QCD

Proposal: Weak analogues of these Magnetic Quantities



RECOMMENDATION II

The excess of matter over antimatter in the universe is one of the most compelling mysteries in all of science. The observation of neutrinoless double beta decay in nuclei would immediately demonstrate that neutrinos are their own antiparticles and would have profound implications for our understanding of the matter-antimatter mystery.

We recommend the timely development and deployment of a U.S.-led ton-scale neutrinoless double beta decay experiment.

A ton-scale instrument designed to search for this as-yet unseen nuclear decay will provide the most powerful test of the particle-antiparticle nature of neutrinos ever performed. With recent experimental breakthroughs pioneered by U.S. physicists and the availability of deep underground laboratories, we are poised to make a major discovery.

Proposal: Weak analogues of these Magnetic Quantities

The Proposal and Request :

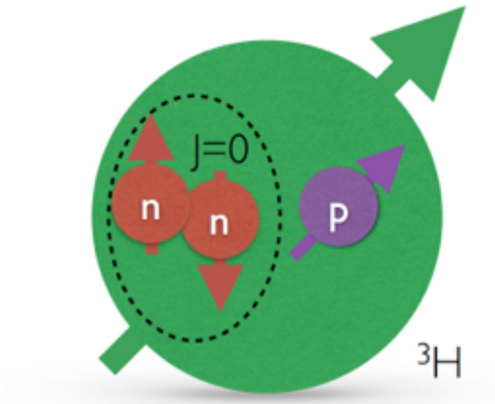
TASK	Lattice Dimensions	β	m_π (MeV)	# of sources	GPU Time [GPU-Hrs]	CPU Time [J/ψ core-Hrs]
A: Inversions	$32^3 \times 96$	6.1	450	1.28×10^5	4.48×10^5	-
A: Block Production	$32^3 \times 96$	6.1	450	1.28×10^5	1.29×10^5	-
A: Contractions	$32^3 \times 96$	6.1	450	1.28×10^5	-	18.4×10^6
A: Total					5.77×10^5	18.4×10^6
B: Inversions	$32^3 \times 96$	6.1	300	1.28×10^5	6.27×10^5	-
B: Block Production	$32^3 \times 96$	6.1	300	1.28×10^5	1.29×10^5	-
B: Contractions	$32^3 \times 96$	6.1	300	1.28×10^5	-	18.4×10^6
B: Total					7.56×10^5	18.4×10^6
Total Request:					$\mathbf{1.33 \times 10^6}$	$\mathbf{36.8 \times 10^6}$

- L_{1A} at the 20% level
  - direct comparison with muSun experiment

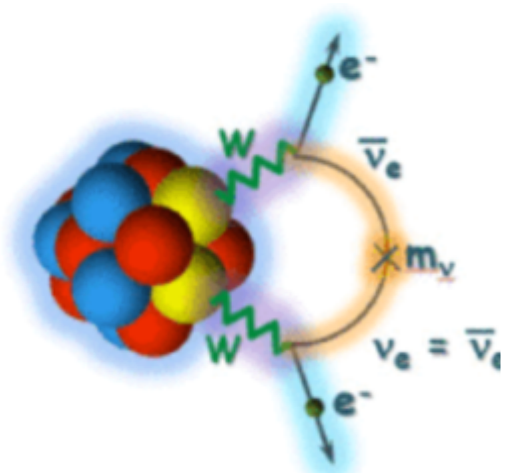
1.33 M GPU-hrs and 36.8 M CPU core-hrs

The Weak Structure of Light Nuclei

USQCD Proposal (2016-2017)



Axial Current Matrix Elements in Nuclei



Axial Polarizabilities

450 MeV and 300 MeV pion masses

Request: 1.33 M GPU-hrs and 36.8 M CPU core-hrs
20 TB disk and 20 TB tape

FIN