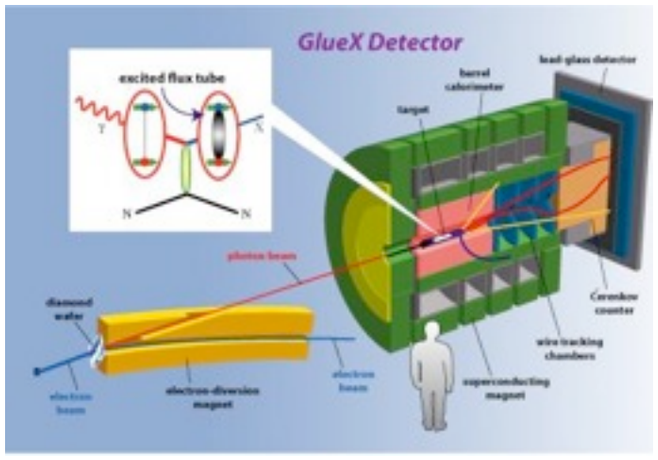
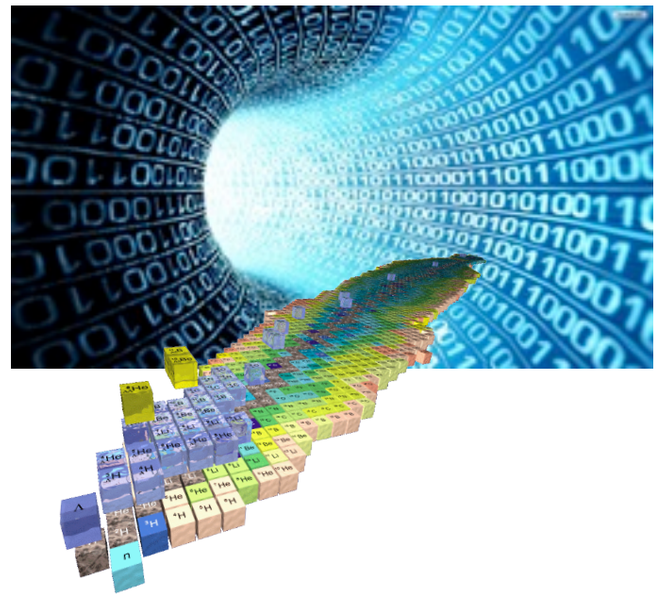


Cold QCD



Computational Nuclear Physics

Town Hall Meeting

http://www.jlab.org/conferences/cnp2014/

http://www.jlab.org/conferences/cnp2014/compnuc2014.pdf

Long-range plan Joint Town Meetings on QCD

Temple University, September 13-15 2014

Martin J Savage

INSTITUTE for NUCLEAR THEORY

Computational Nuclear Physics 2014

Computational Nuclear Physics Meeting

SURA Headquarters, Washington DC, July 14-15, 2014

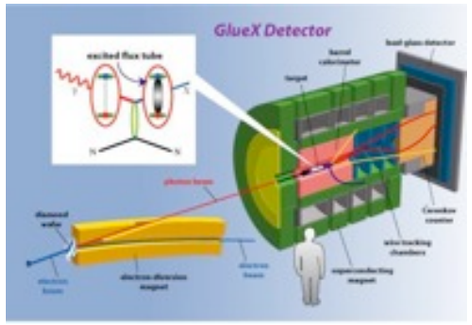
REPORT

Prepared by the Computational Nuclear Physics Meeting Writing Committee

A. Burrows, J. Carlson, W. Detmold, R. Edwards, R. Furnstahl, F. Karsch, W. Nazarewicz, P. Petreczky, D. Richards, W. Hicks, M.J. Savage.

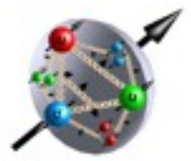
http://www.jlab.org/conferences/cnp2014/

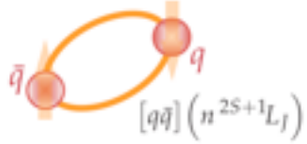
http://www.jlab.org/conferences/cnp2014/compnuc2014.pdf



US Computational Program in Cold QCD

- Nucleon Structure
- Hadron Spectroscopy
- Nuclear Forces and Nuclei

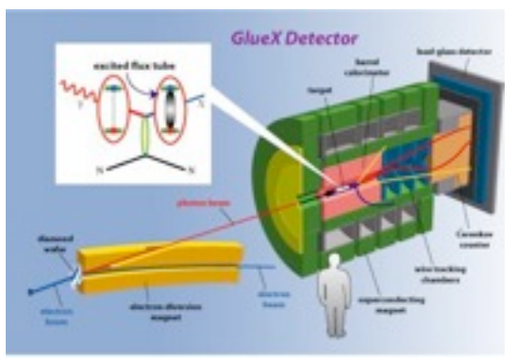


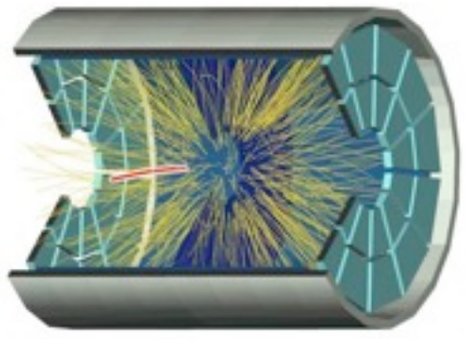


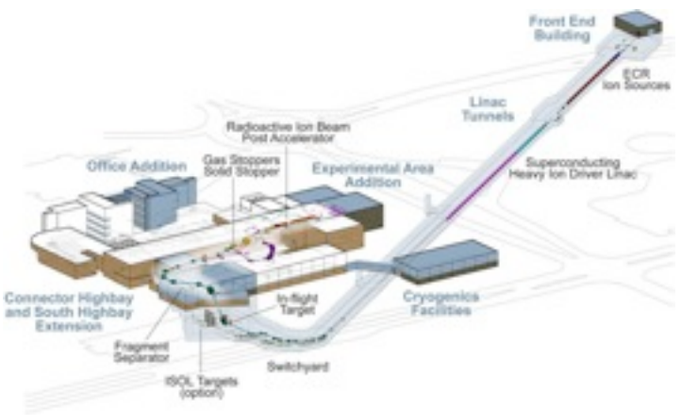
Capability Computing

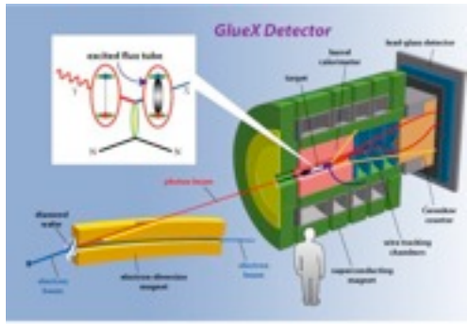
Capacity Computing

- Aligned with NP experimental program

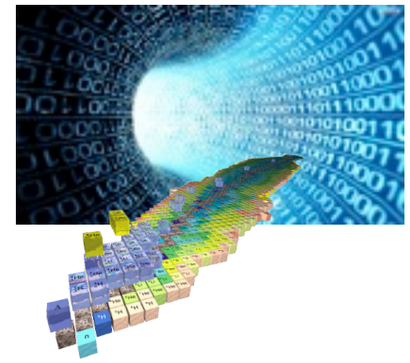








Nucleon Structure

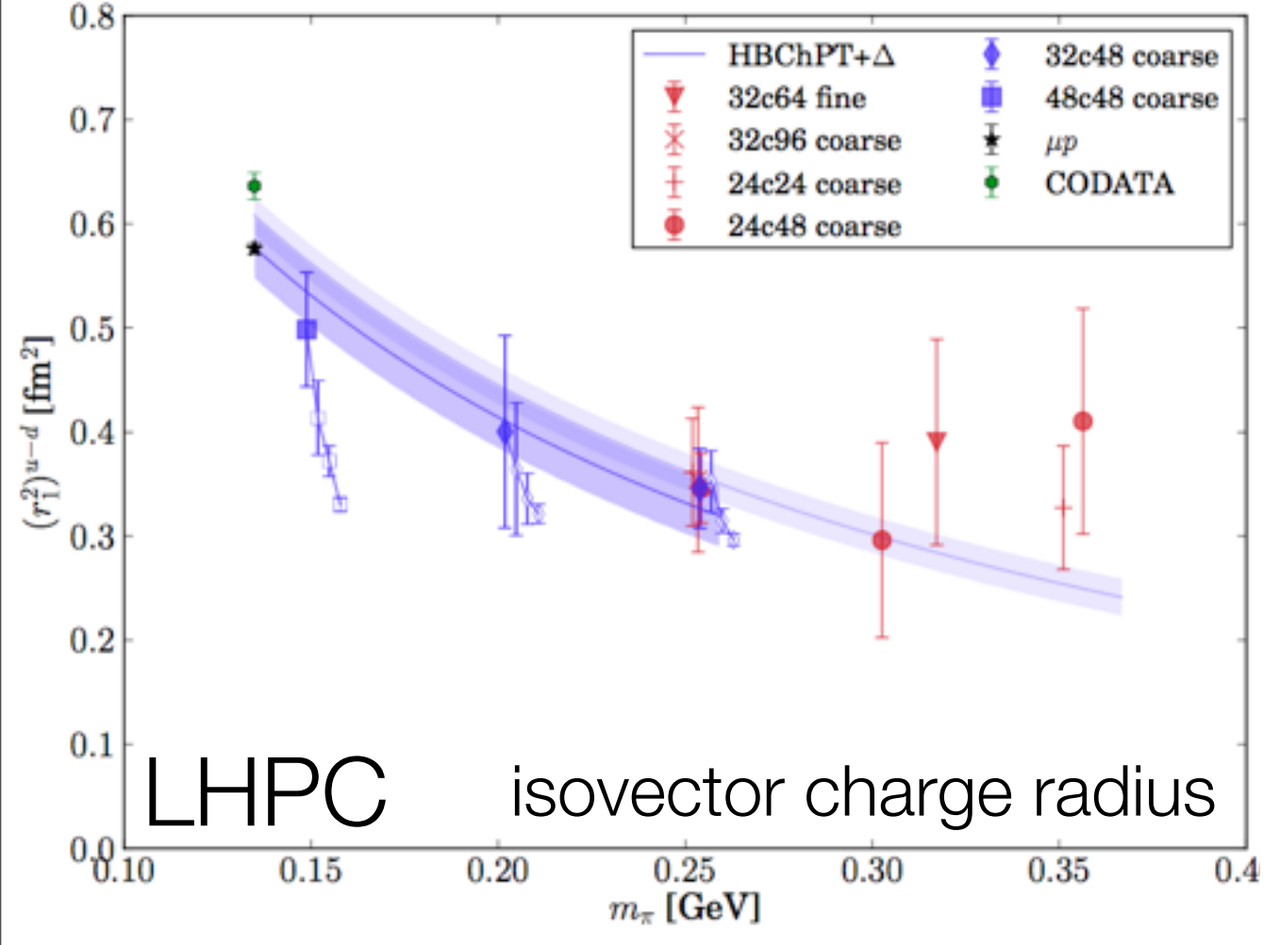


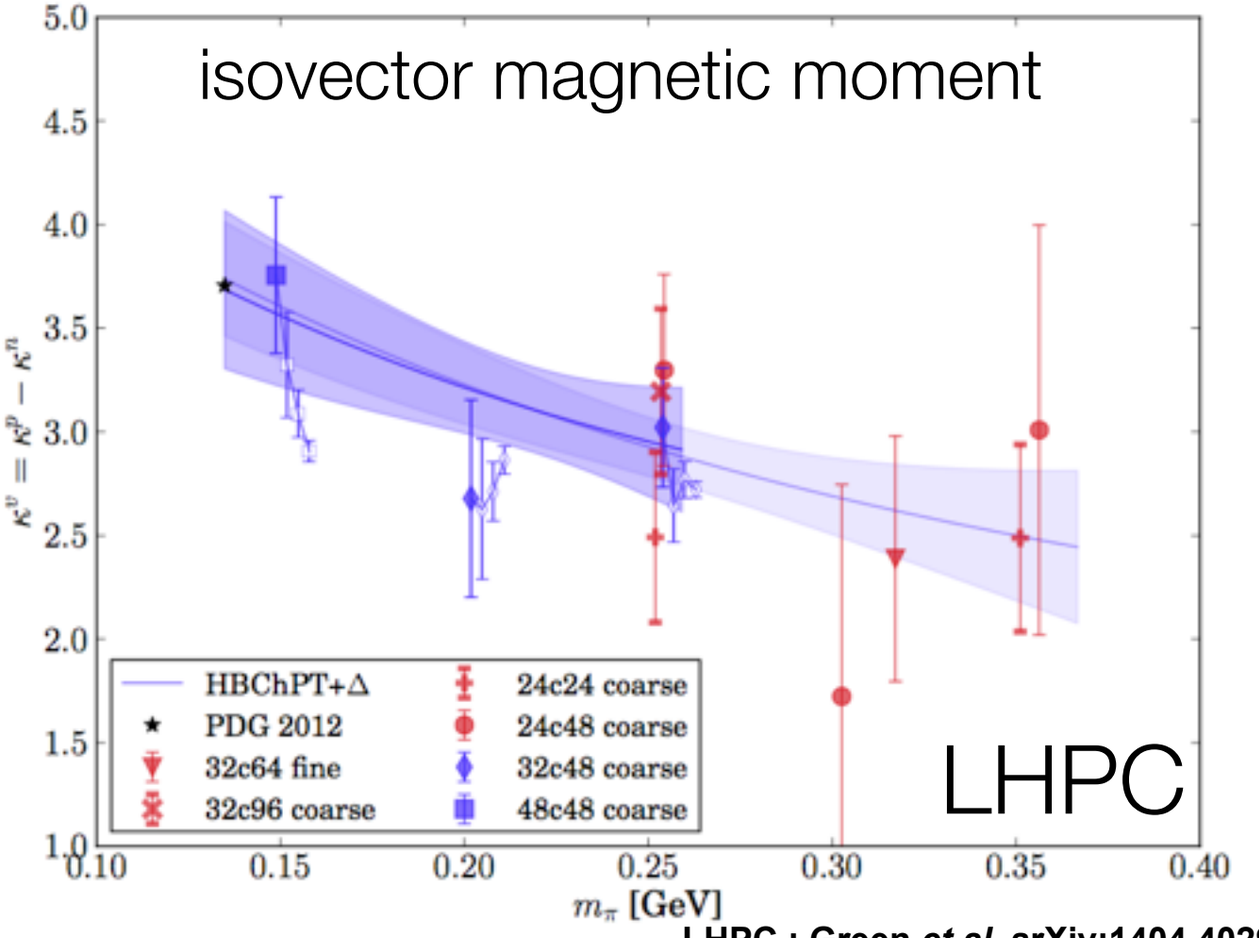
- g_A and other $q^2=0$ matrix elements
- $\langle x^n \rangle$
- charge and magnetic radii, etc
- associated form factors

First LQCD calculations at physical pion mass during 2012

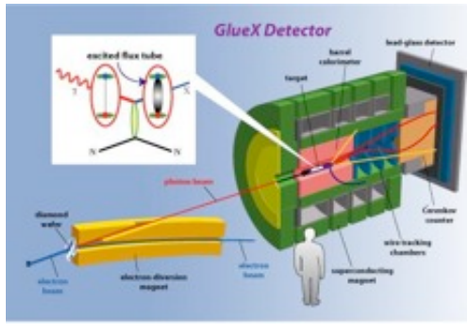
Precision is needed
(complete uncertainty quantification)

PDG value of neutron properties

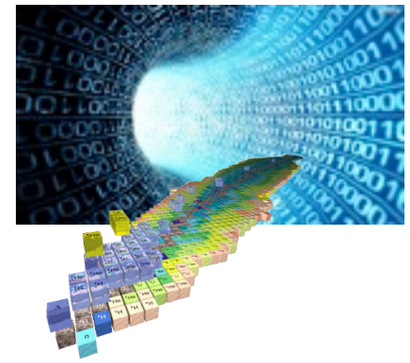




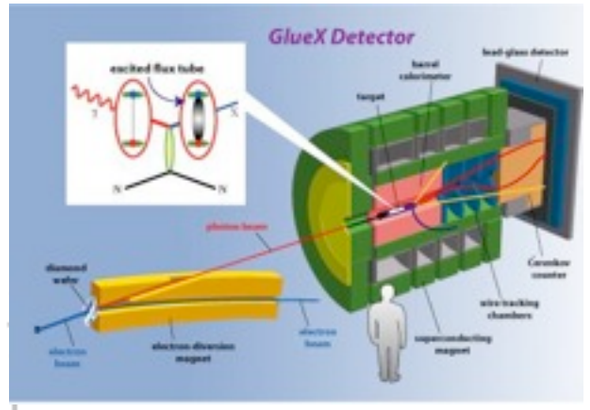
LHPC : Green *et al*, arXiv:1404.4029



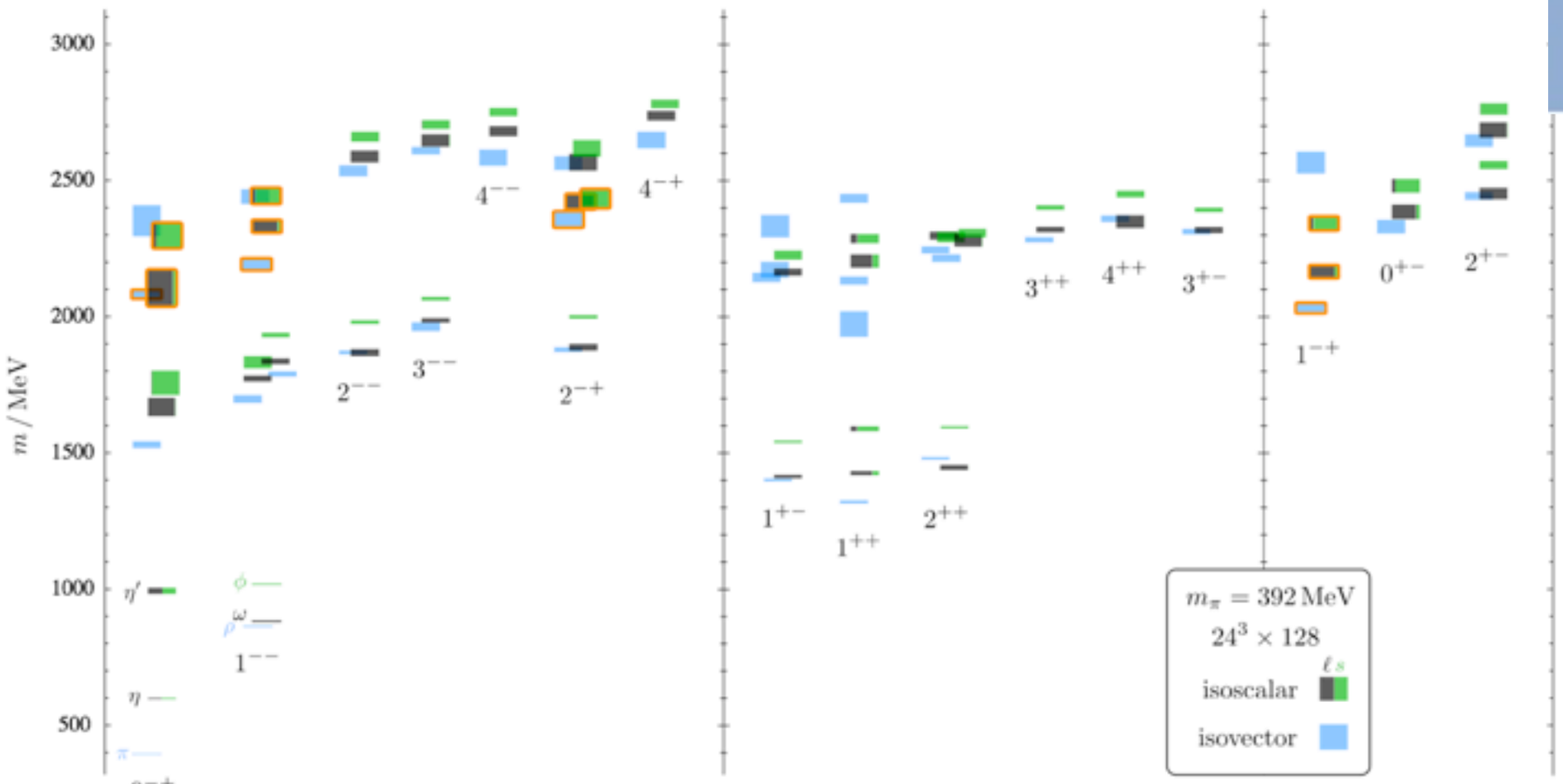
Spectrum of Hadrons



- exotics, molecules
- coupled channels, etc
- provided motivation for 12 GeV upgrade



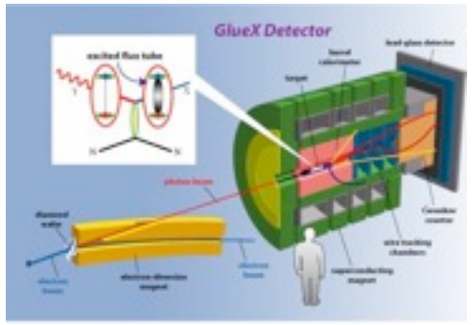
Jefferson Lab
EXPLORING THE NATURE OF MATTER



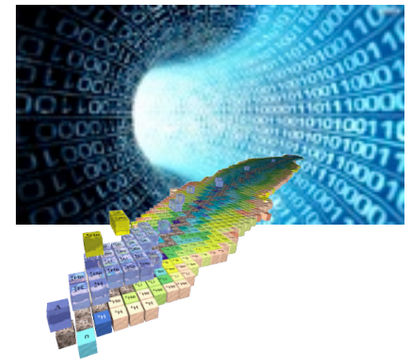
Dudek *et al*, Phys.Rev. D88 (2013) 094505

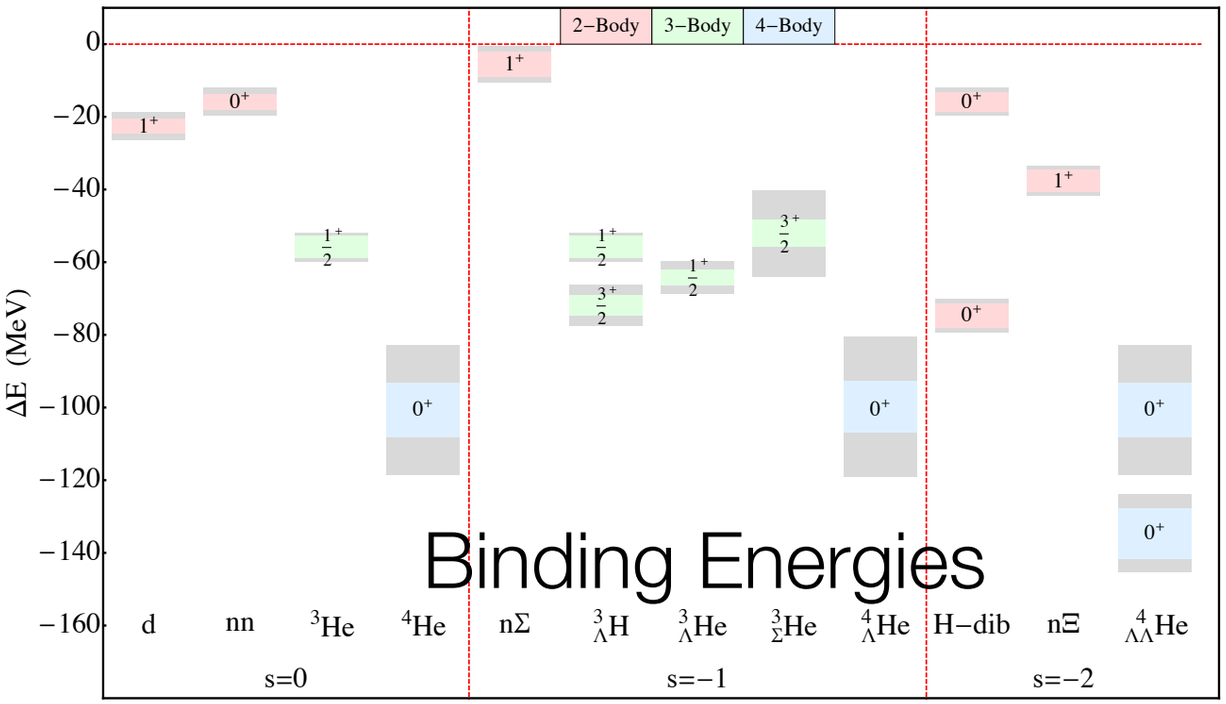
Lattice QCD can predict the exotic spectrum before or during the GlueX experiment

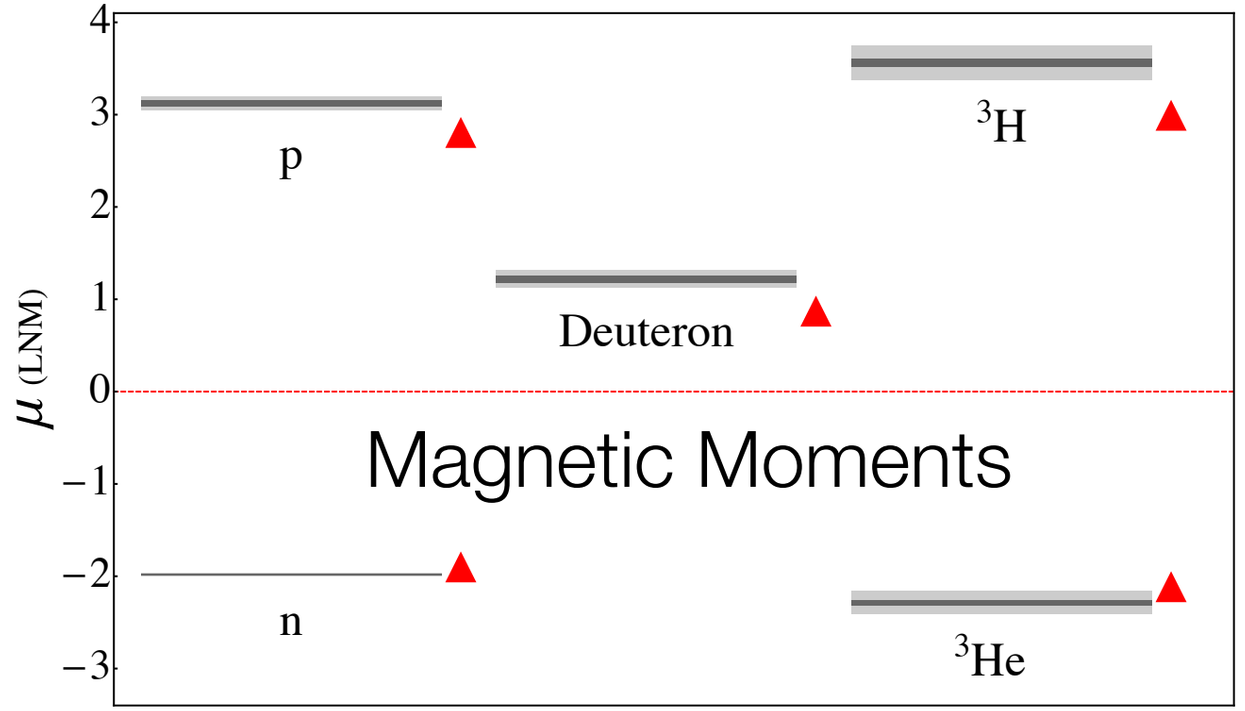
(with sufficient compute resources)

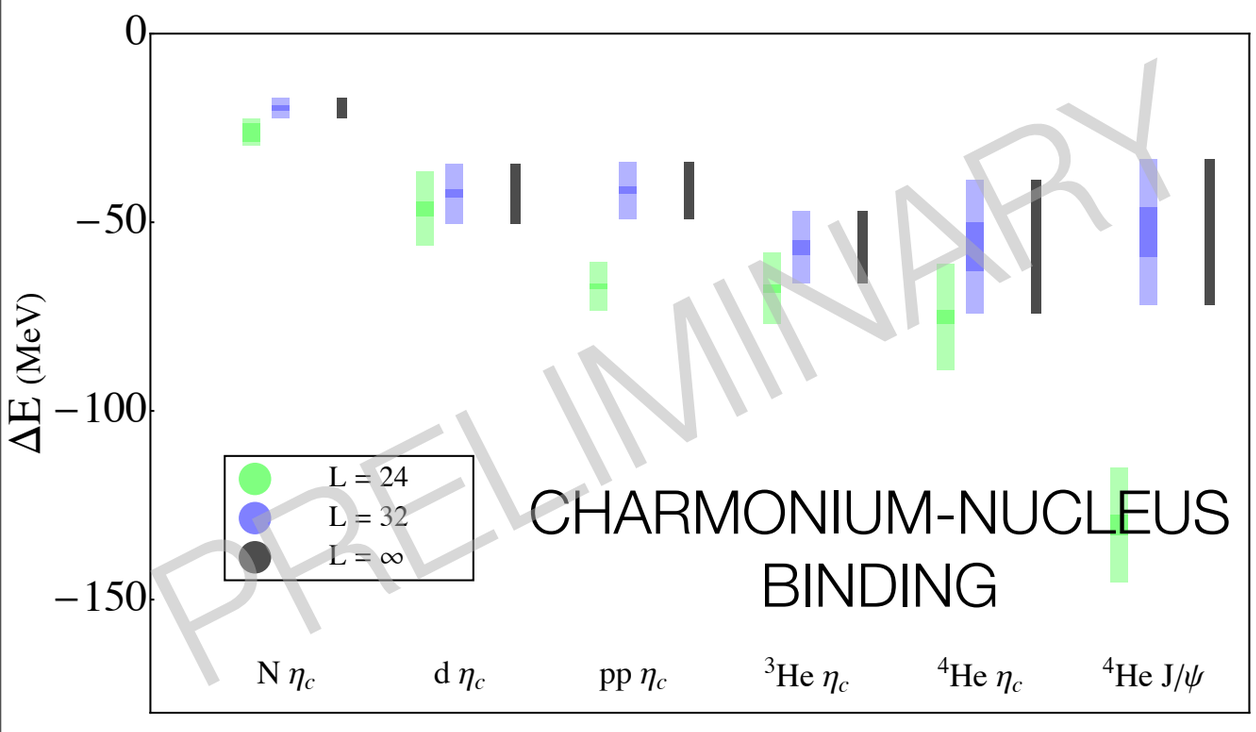


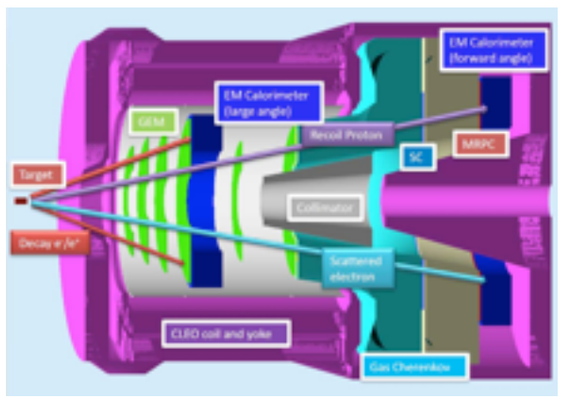
Nuclei and Exotic Nuclei









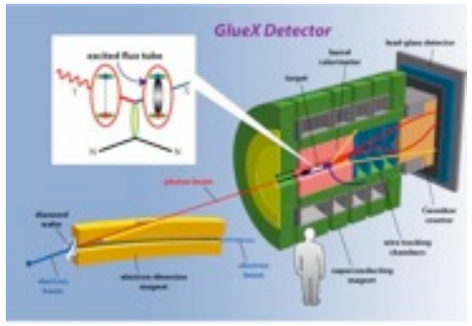


Athenna

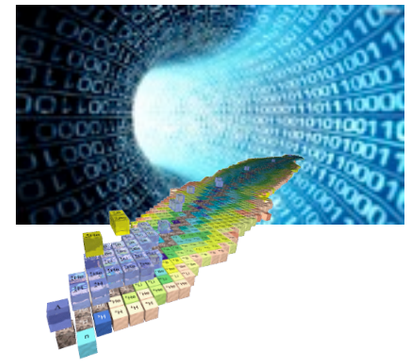
m_π ~ 800 MeV

Jefferson Lab
EXPLORING THE NATURE OF MATTER

Beane *et al*,
Phys.Rev. D87 (2013) 3, 034506,
Phys.Rev. C88 (2013) 2, 024003,
arXiv:1409.3556 (2014)

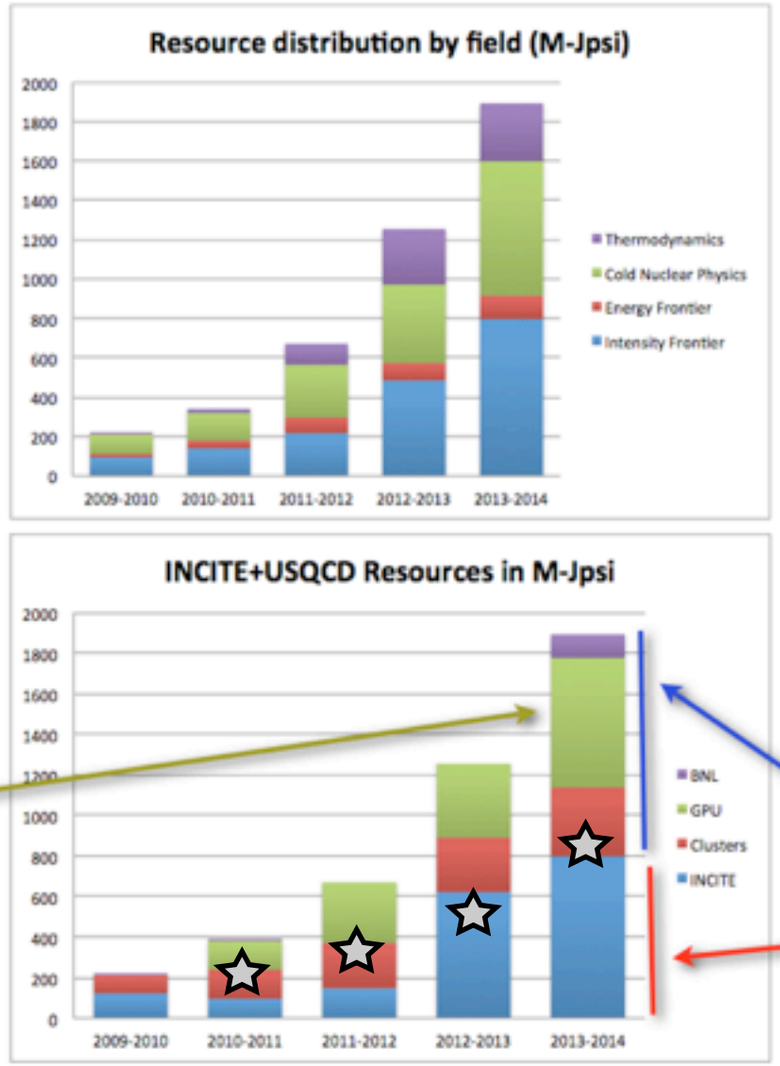


Cold and Hot QCD
USQCD

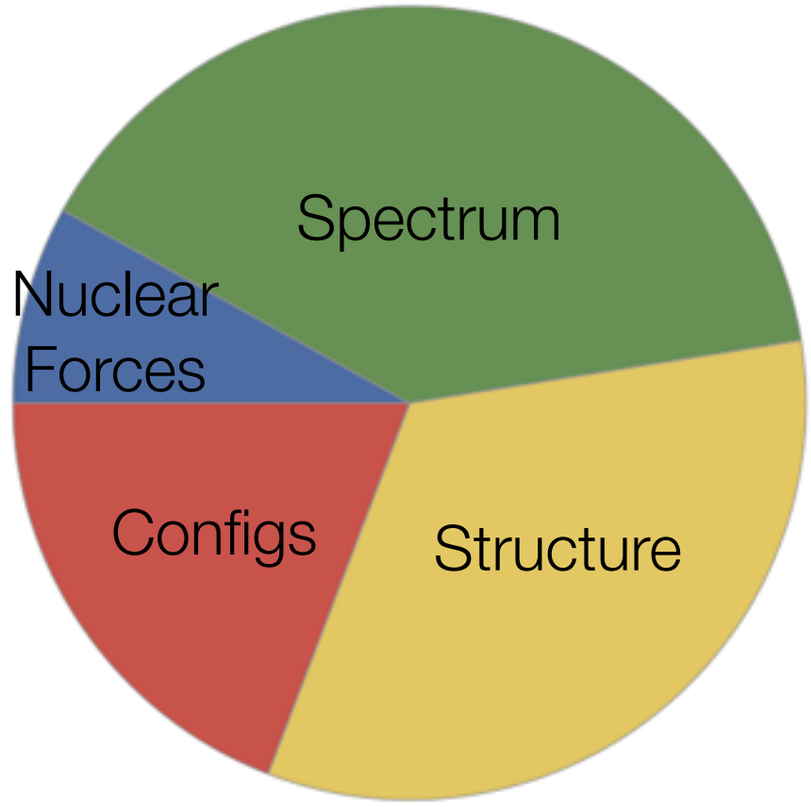


Allocations

The jpsi core-hour is USQCD's standard allocation unit.
A jpsi core ~ 1.2 GF.
1 teraflop-year ~ 6.5 M jpsi ch.



Beyond the standard model and QCD thermodynamics fractions have been rising.



Cold QCD

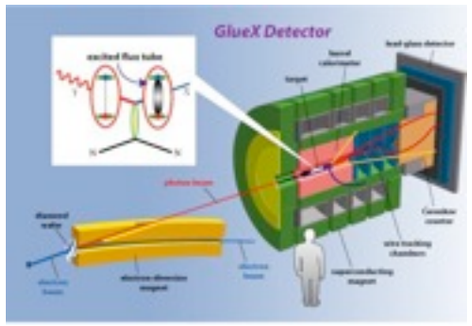
GPUs 20% of Project $, but 50% of Project cycles; but: less general-purpose cycles:
- many GPUs are not error correcting, many single GPU jobs.

LQCD Project resources

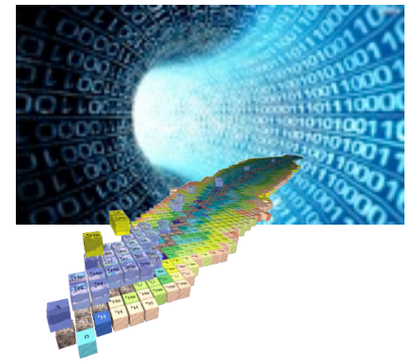
INCITE resources

Capacity hardware project significantly underfunded > 2014

will deliver ~1/3 integrated cycles c/w requested = problem



US Human Resources



SciDAC
Scientific Discovery through Advanced Computing

3 Projects Currently Supported :

Computing Properties of Hadrons, Nuclei and Nuclear Matter from Quantum Chromodynamics

Nuclear Computational Low-Energy Initiative (NUCLEI)

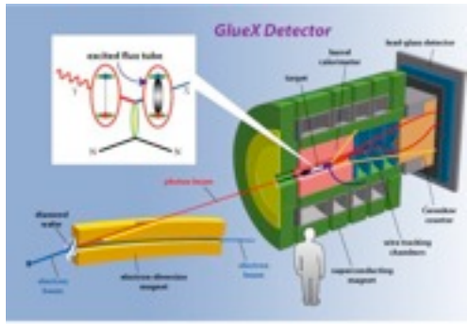
A Multi-Scale Approach to Nuclear Structure and Reactions: Forming the Computational Bridge between Lattice QCD and Nonrelativistic Many-Body Theory (CalLAT)

SciDAC support significantly reduced in 2012

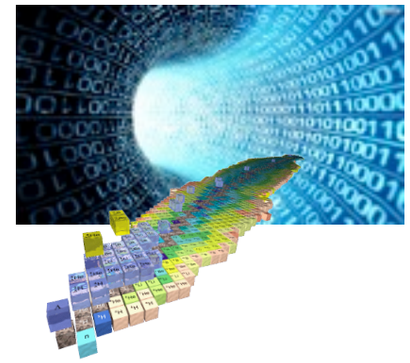
- Some projects/areas defunded, e.g. astrophysics, and all are under funded

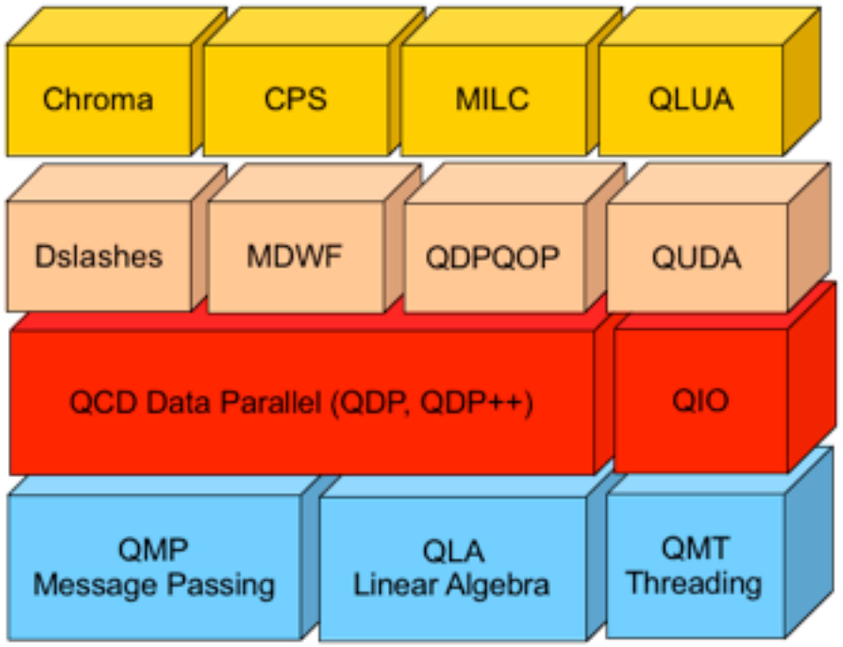
Leadership-class (and external) resources depend upon it (leveraged)

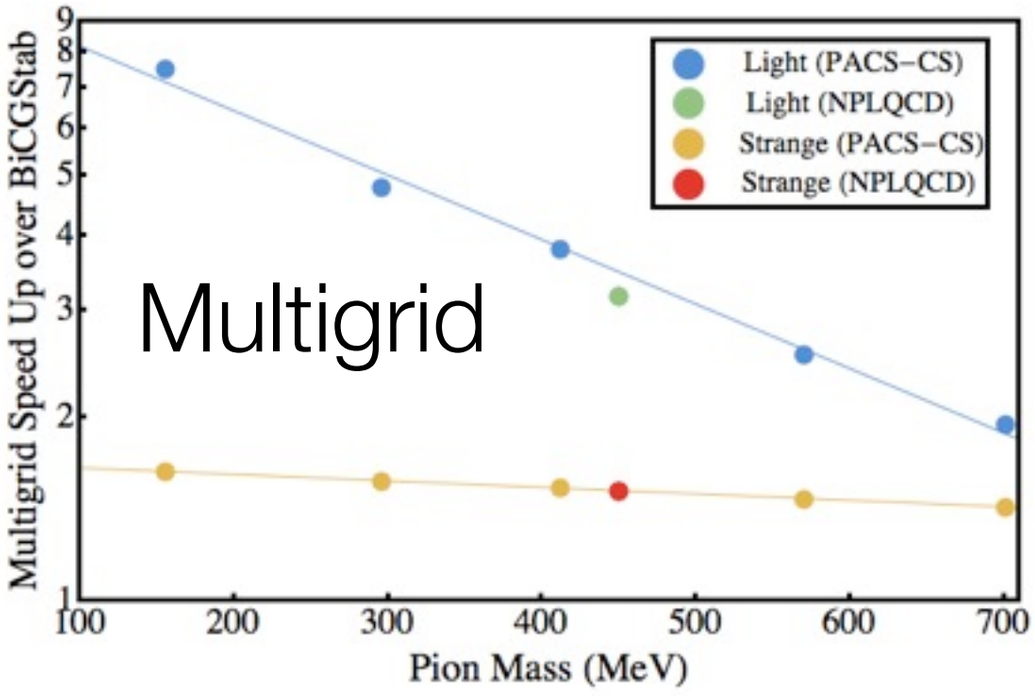
- dictates code sophistication, readiness and competitiveness

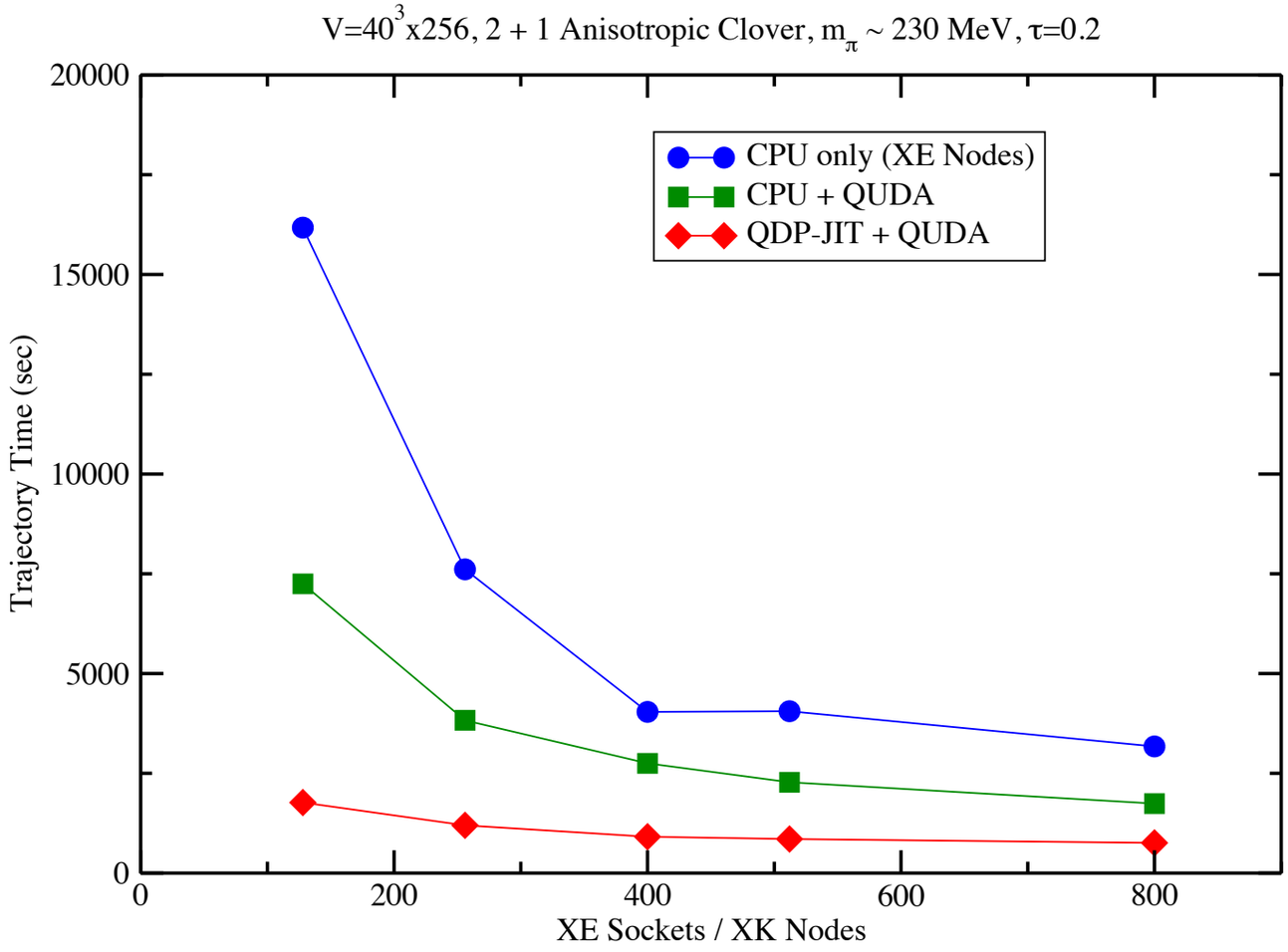


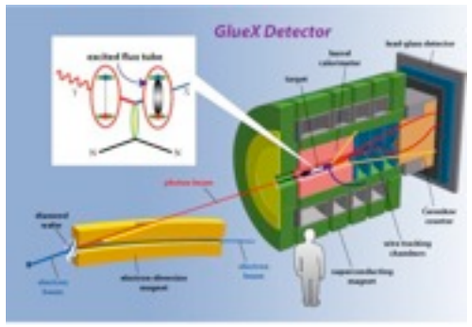
SciDAC - Algorithms
USQCD examples



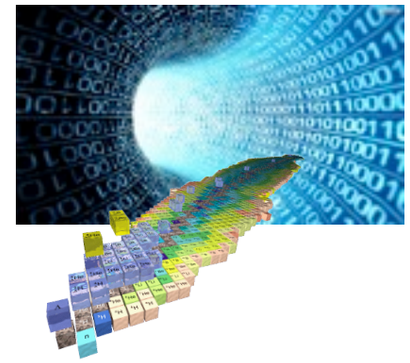








Training Young Physicists
Lattice QCD

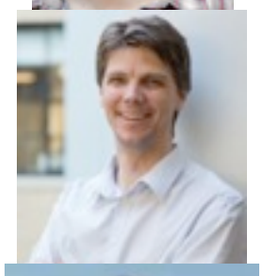


Person	Institution
Silas Beane	University of Washington
Kostas Orginos	C. of William and Mary/JLab
Jozef Dudek	Old Dominion U./JLab
Jimmy Juge	University of the Pacific
Peter Petreczky	BNL [former RIKEN Fellow]
Balint Joo	JLab
Nilmani Mathur	Tata Institute
William Detmold	MIT
Harvey Meyer	Mainz
Brian Tiburzi	City College, NY/BNL [RIKEN]
Andrei Alexandru	George Washington Univ.
Swagato Mukherjee	BNL
Saumen Datta	Tata Institute
Shinji Ejiri	Niagata Univ.
Takashi Umeda	Hiroshima Univ.
Christopher Thomas	Cambridge
Andre Walker-Loud	C. of William and Mary/JLab

Silas Beane
NSF Career Award
2007

Kostas Orginos
DOE Career Award
2008

Jozef Dudek
DOE Career Award
2011

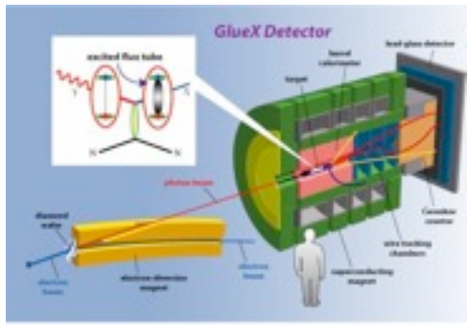


William Detmold
DOE Career Award
2010, 2013

Andrei Alexandru
NSF Career Award
2012

Andre Walker-Loud
DOE Career Award
2014

Laboratory Top-5 University, OJI DOE OJI or Career, NSF Career



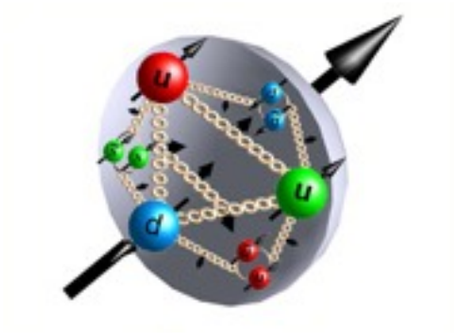
Future Computational Needs

Physics Objectives

2007-2014 ...

Structure of the Nucleon

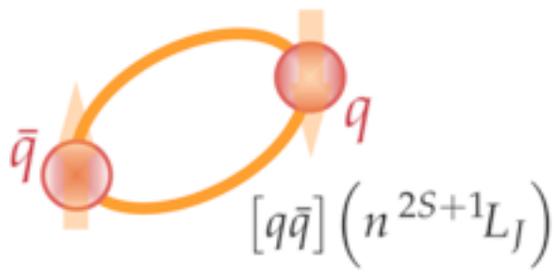
multiple L, T, lattice spacings
multiple discretizations
N predictions for mq(phys)



140 MeV

Meson and Baryon Spectroscopy

multiple L, T
one lattice spacing
resolved spectrum
mapped out resonances



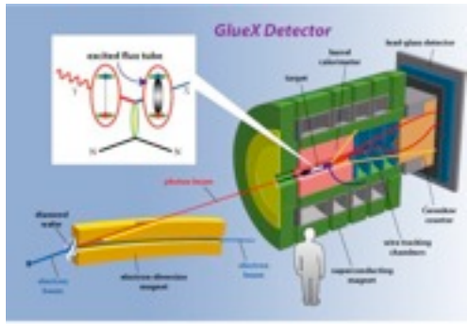
300 MeV

Nuclei and Nuclear Forces

multiple L, T
one lattice spacing
light (hyper-)nuclei, scattering
simple properties of nuclei

800 MeV

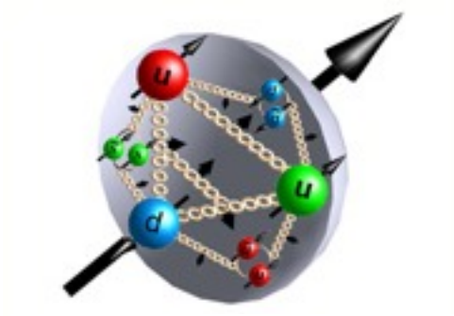
Pion Mass

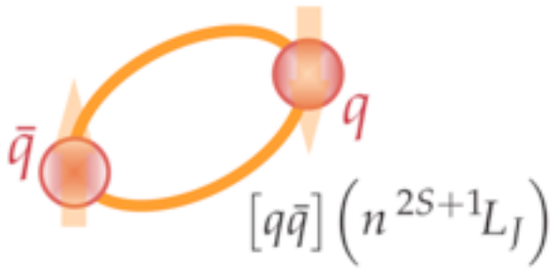


Future Computational Needs

Physics Objectives

Before 2022 ...

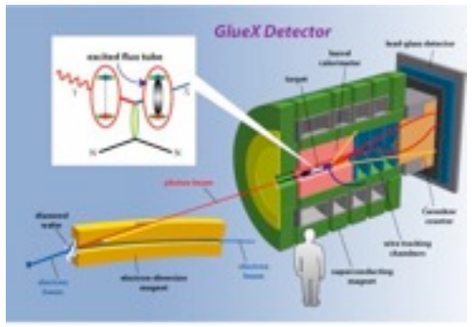




- physical pion mass with $n_f = 1+1+1+1$
- electromagnetism
- precision calculations
- multiple lattices volumes with large T
- multiple lattice spacings
- multiple discretizations
- fully quantified uncertainties
- complement experimental program
- guide future experimental program
- provide critical inputs for theory

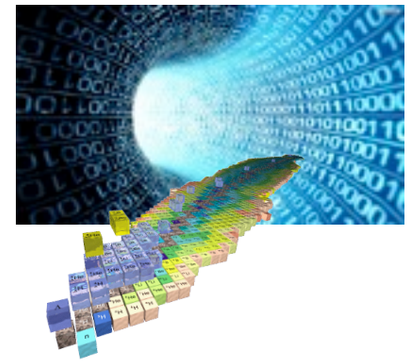
140 MeV 300 MeV 800 MeV

Pion Mass



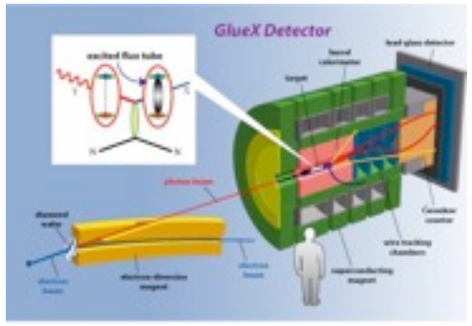
Future Computational Needs

Human Resources



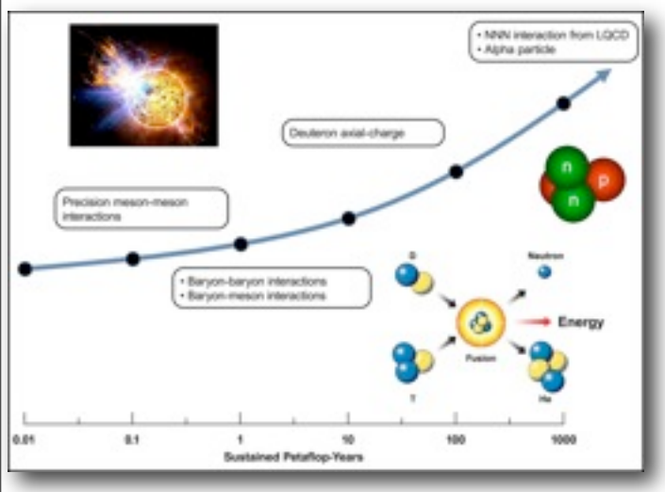
- Enhanced HPC-trained workforce is required to execute the NP mission
  - Provide guidance for, and physics extraction from, experiment
  - QCD theory objectives cannot be accomplished without this workforce.

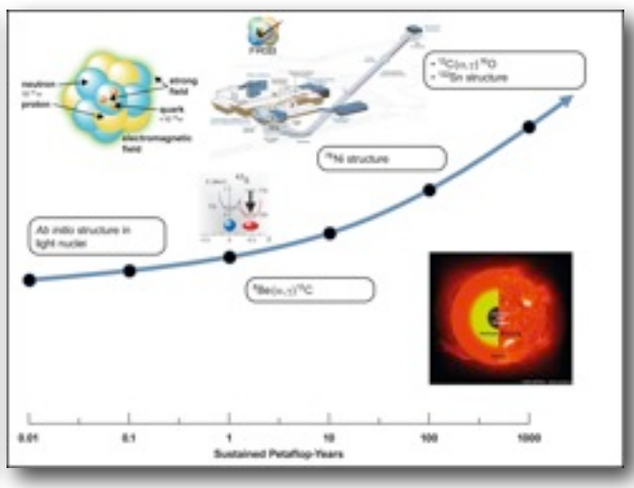
- Enhanced collaborations with Computer Scientists, Applied Mathematicians, and between Nuclear Physicists, are critical, e.g. SciDAC projects

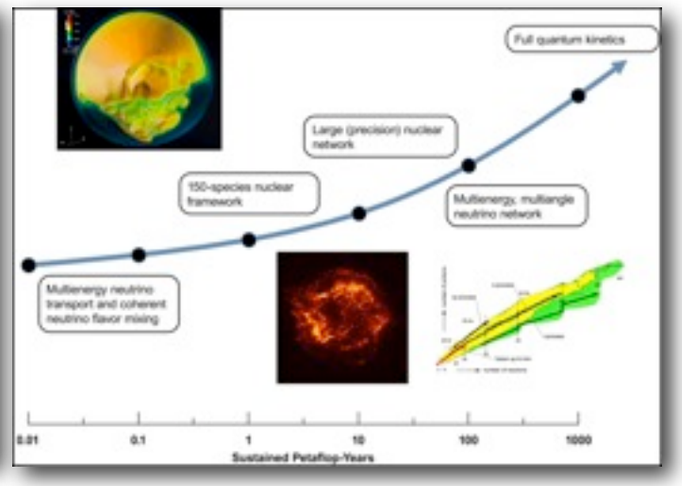


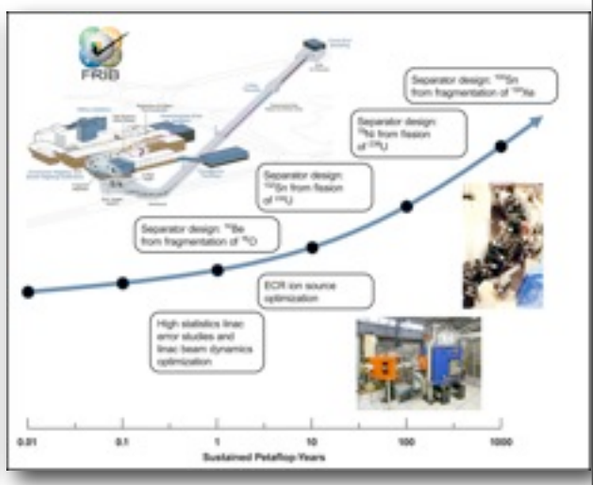
Future Computational Needs

Computational Resources



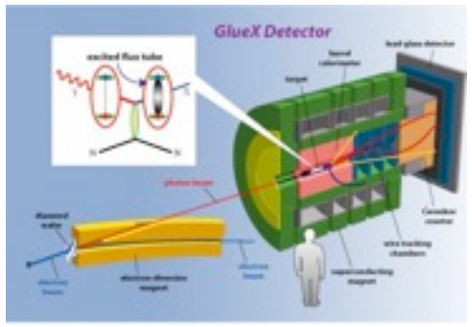






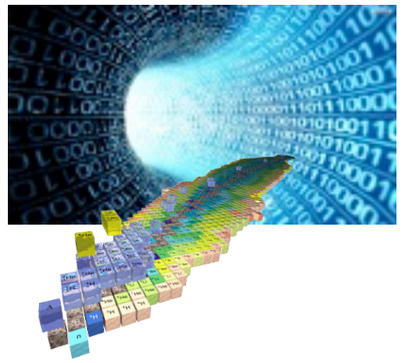
Requirements for accomplishing DOE QCD mission:

- Continued access to *Leadership-Class* computing
  - ASCR , INCITE and ALCC awards
  - ~constant fraction of US facilities (with Moore's Law growth)
- Significantly increased *Capacity* computing resources
  - not ASCR
  - in addition to NERSC awards



Future Computational Needs

Computing for Nuclear Physics



Computational Nuclear Physics 2014

Recommendation

Realizing the scientific potential of current and future experiments demands large-scale computations in nuclear theory that exploit the US leadership in high-performance computing. Capitalizing on the pre-exascale systems of 2017 and beyond requires significant new investments in people, advanced software, and complementary capacity computing directed toward nuclear theory.

Computational Nuclear Physics 2014

Request

To this end, we ask the Long-Range Plan to endorse the creation of an NSAC subcommittee to develop a strategic plan for a diverse program of new investments in computational nuclear theory. We expect this program to include:

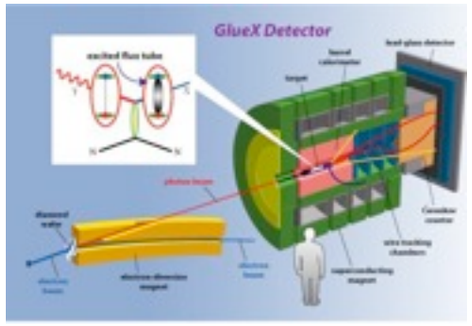
- new investments in SciDAC and complementary efforts needed to maximize the impact of the experimental program;

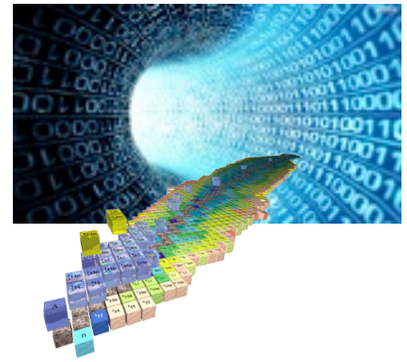
- development of a multi-disciplinary workforce in computational nuclear theory;

- deployment of the necessary capacity computing to fully exploit the nations leadership-class computers;

with support ramping up over five years towards a level of around $10M per annum.

- Resources for entire field - not just for this community
- Endorsed by Low-Energy Town Hall (3rd Bullet)
- QCD Town Hall Endorsement ??





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