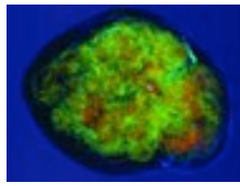
Computational Nuclear Physics 2007-2014

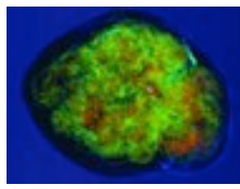
SURA Headquarters
Washington D.C.
July 14-15, 2014

Martin J Savage

INSTITUTE for
NUCLEAR THEORY

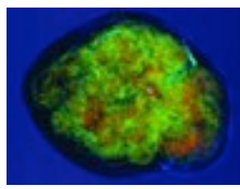


1. Community Organization
2. Resources
3. Training
4. Scientific Highlights

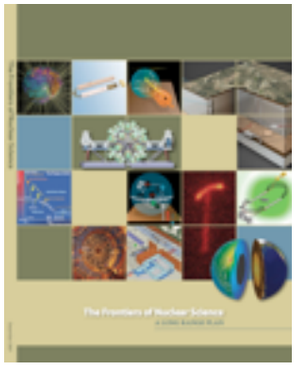


Community Organization

LRP/Workshops/Reports



2007 Long Range Plan Recommendations



RECOMMENDATION I — JLab

We recommend completion of the 12 GeV CEBAF Upgrade at Jefferson Lab. The Upgrade will enable new insights into the structure of the nucleon, the transition between the hadronic and quark/gluon descriptions of nuclei, and the nature of confinement.

RECOMMENDATION II — FRIB

We recommend construction of the Facility for Rare Isotope Beams, FRIB, a world-leading facility for the study of nuclear structure, reactions, and astrophysics. Experiments with the new isotopes produced at FRIB will lead to a comprehensive description of nuclei, elucidate the origin of the elements in the cosmos, provide an understanding of matter in the crust of neutron stars, and establish the scientific foundation for innovative applications of nuclear science to society.

RECOMMENDATION III — DUSEL

We recommend a targeted program of experiments to investigate neutrino properties and fundamental symmetries. These experiments aim to discover the nature of the neutrino, yet-unseen violations of time-reversal symmetry, and other key ingredients of the New Standard Model of fundamental interactions. Construction of a Deep Underground Science and Engineering Laboratory is vital to U.S. leadership in core aspects of this initiative.

RECOMMENDATION IV — RHIC

The experiments at the Relativistic Heavy Ion Collider have discovered a new state of matter at extreme temperature and density—a quark-gluon plasma that exhibits unexpected, almost perfect liquid dynamical behavior. We recommend implementation of the RHIC II luminosity upgrade, together with detector improvements, to determine the properties of this new state of matter.

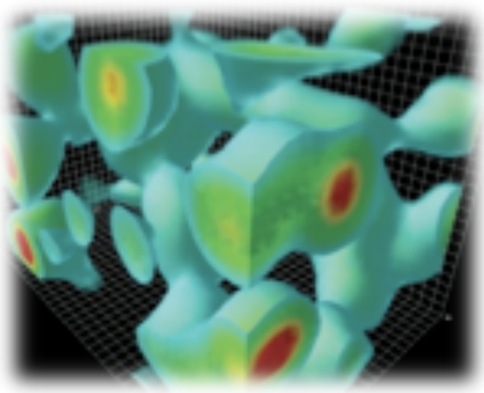
Computational Nuclear Physics 2014

2009 NP HPC Status and Projected Needs

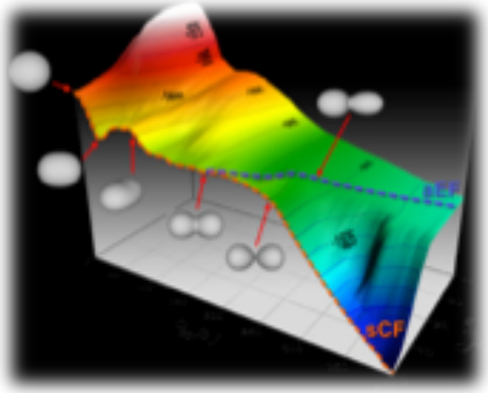
Fred Bertrand (Facilitator)

Meeting in Washington DC
Jan 26 , 27, 28 (2009)

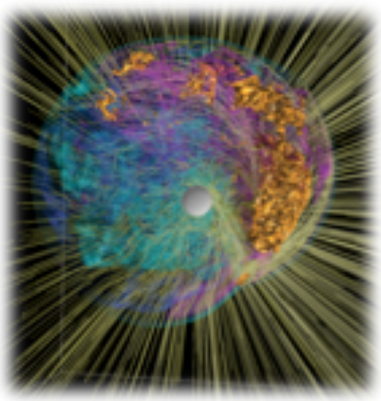
Glenn Young (Chair) , David Dean (co-Chair) , Martin Savage (co-Chair)



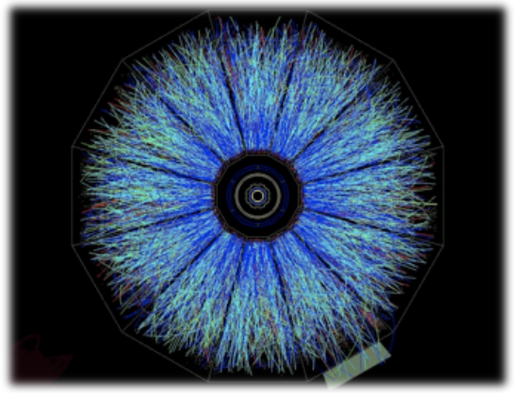
Tom Luu (LLNL)
David Richards (TJNAF)



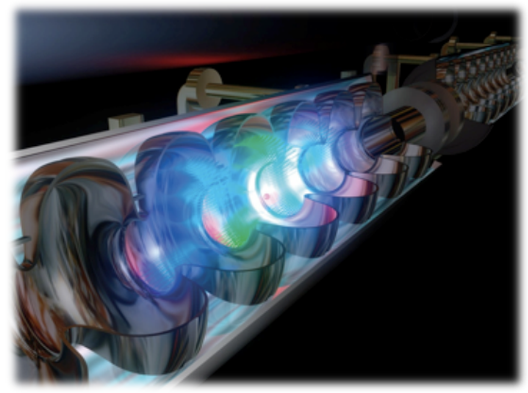
Steven Pieper (ANL)
James Vary (Iowa)



George Fuller (UCSD)
Tony Mezzacappa (ORNL)

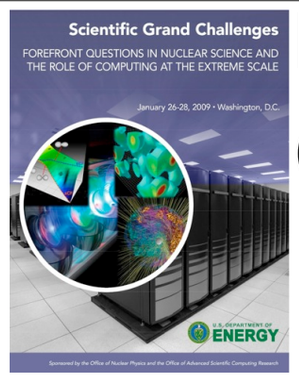


Steffen Bass (Duke U.)
Frithjof Karsch (BNL)

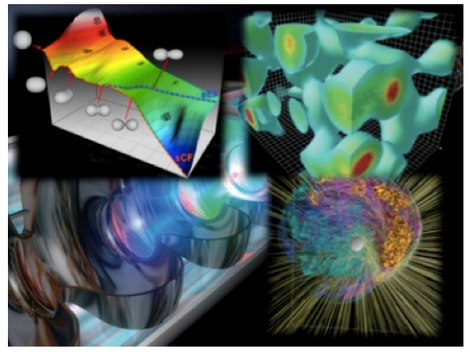


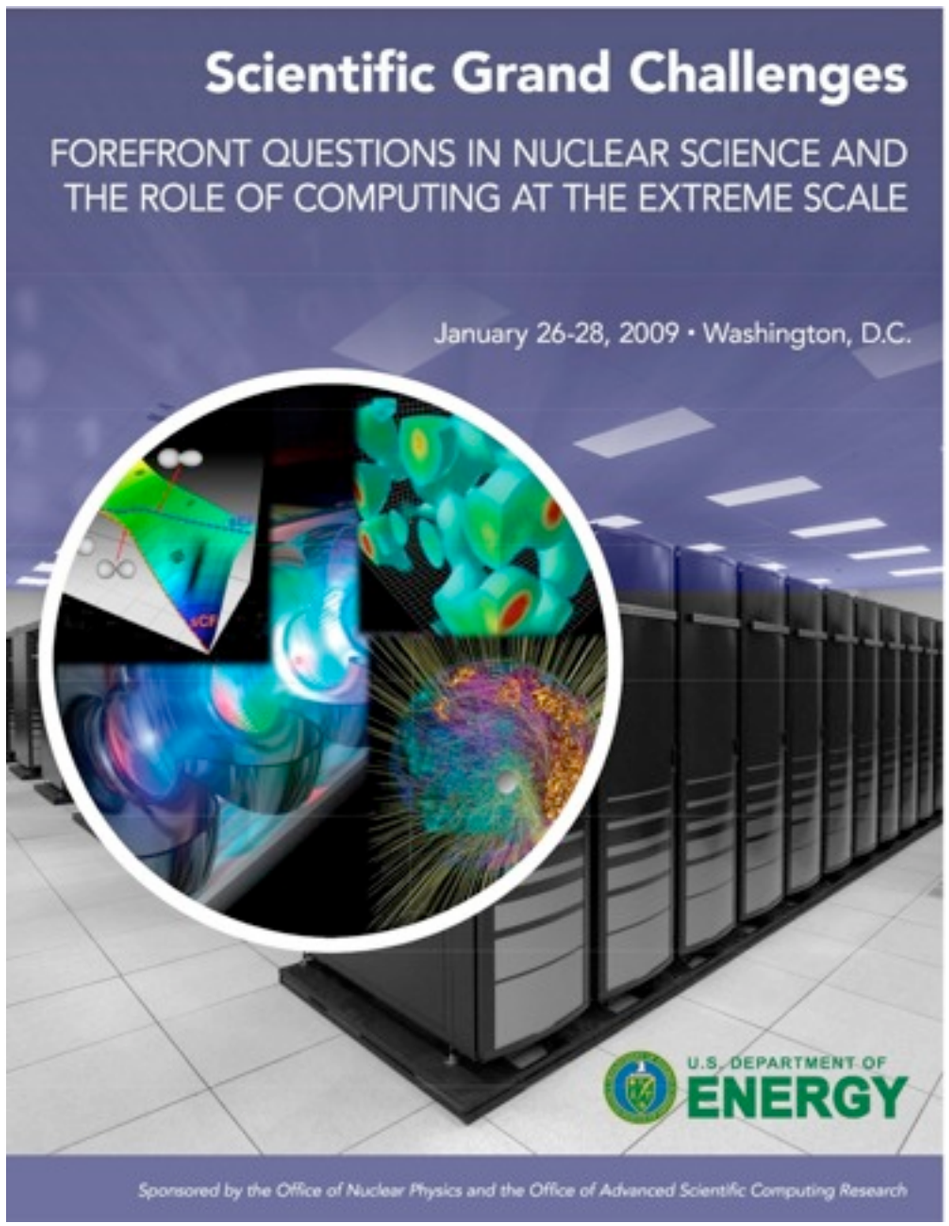
Robert Ryne (LBNL)

- 109 Attendees
- Physics, Computer Science, Mathematics and Applied Mathematics
- 27 Universities (US and foreign), 7 Labs, 6 Corporations (US and foreign), 2 Federal Agencies
- PNNL administered/document production (Moe Khaleel, Hope Mathews (technical writer))



Paraphrase of Concluding Remarks Trivelpiece Comm. 2009

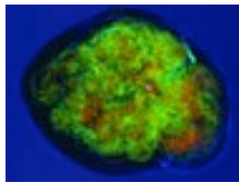




Capability Resources

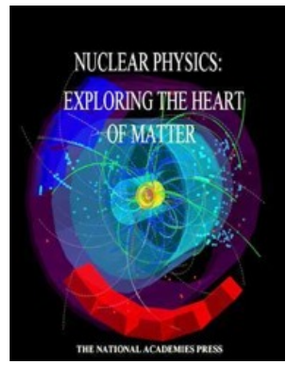
Capacity Resources

Collaborating Scientists



Computational Nuclear Physics 2014

2012 National Academy Report Recommendations



Finding: By capitalizing on strategic investments, including the ongoing upgrade of the continuous electron beam accelerator facility (CEBAF) at the Thomas Jefferson Accelerator Facility and the recently completed upgrade of the relativistic heavy ion collider (RHIC) at Brookhaven National Laboratory, as well as other upgrades to the research infrastructure, nuclear physicists will confront new opportunities to make fundamental discoveries and lay the groundwork for new applications.

RHIC JLab

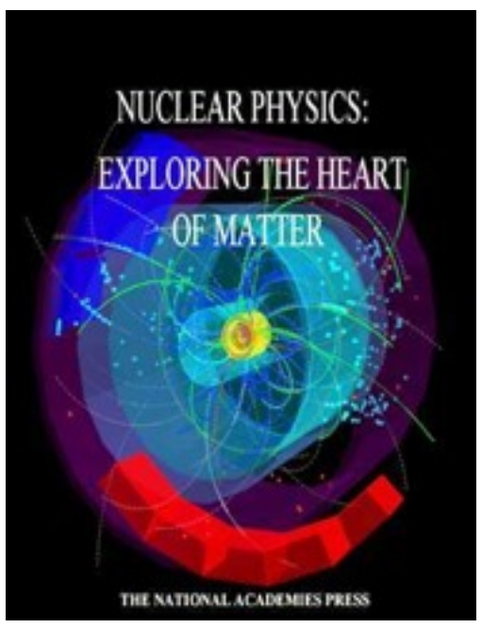
Recommendation: The Department of Energy, the National Science Foundation, and, where appropriate, other funding agencies should develop and implement a targeted program of underground science, including important experiments on whether neutrinos differ from antineutrinos, on the nature of dark matter, and on nuclear reactions of astrophysical importance. Such a program would be substantially enabled by the realization of a deep underground laboratory in the United States.

DUSEL

Finding: The Facility for Rare Isotope Beams is a major new strategic investment in nuclear science. It will have unique capabilities and offers opportunities to answer fundamental questions about the inner workings of the atomic nucleus, the formation of the elements in our universe, and the evolution of the cosmos.

Recommendation: The Department of Energy's Office of Science, in conjunction with the State of Michigan and Michigan State University, should work toward the timely completion of the Facility for Rare Isotope Beams and the initiation of its physics program.

FRIB



Recommendation: A plan should be developed within the theoretical community and enabled by the appropriate sponsors that permits forefront-computing resources to be deployed by nuclear science researchers and establishes the infrastructure and collaborations needed to take advantage of exascale capabilities as they become available.

Computational Nuclear Physics

2012

Strongly endorsed NAS Report HPC statements and Recommendation

TOWN MEETING RECOMMENDATIONS

RECOMMENDATION 1

The nuclear physics community should work with DOE and NSF to increase funding for the NP SciDAC programs and other cyber-related initiatives, and to foster partnerships with ASCR, NNSA, OCI, and other agencies to strengthen the impact of these programs. In addition to enabling new physics, these partnerships also open new avenues in the areas of computer science and applied mathematics.

RECOMMENDATION 2

Collaboration amongst the fields of computational nuclear physics, experimental nuclear physics and analytic theory is critical. In particular, new experimental initiatives should be integrated with large-scale theoretical computations to maximize the combined science output.

RECOMMENDATION 3

Concrete steps should be taken to educate and train the next generation of computational nuclear physicists, and to increase the cross-fertilization between the various efforts, exploiting synergies in physics, computer science and applied mathematics. The options include, but are not limited to: computational nuclear physics meetings, workshops, and schools; enhanced connections between SciDAC projects; and student exchanges.

Computational Nuclear Physics Town Meeting
SURA Headquarters, Washington DC, July 23-24, 2012

REPORT

Prepared by the Computational Nuclear Physics Town Meeting Organizing Committee
A. Burrows, J. Carlson, R. Edwards, W. Nazarewicz, P. Petreczky, D. Richards, M. J. Savage

→ Strengthen SciDAC and related

→ Computing integrated with new expt initiatives

→ Education, training, intra, AM, CS

Computational Nuclear Physics 2014

2013

The Tribble Committee Report

Report to the
Nuclear Science Advisory Committee

Implementing the 2007 Long Range Plan

January 31, 2013

Texas A&M Physicist's Committee Weighs in on Future of U.S. Nuclear Science

January 29, 2013

"If you look at history, all of our technology now came from discovery science. It was not science funded by anyone to make a product. It was just, 'why is this happening?'"
— Robert Tribble, Director of the Cyclotron Institute

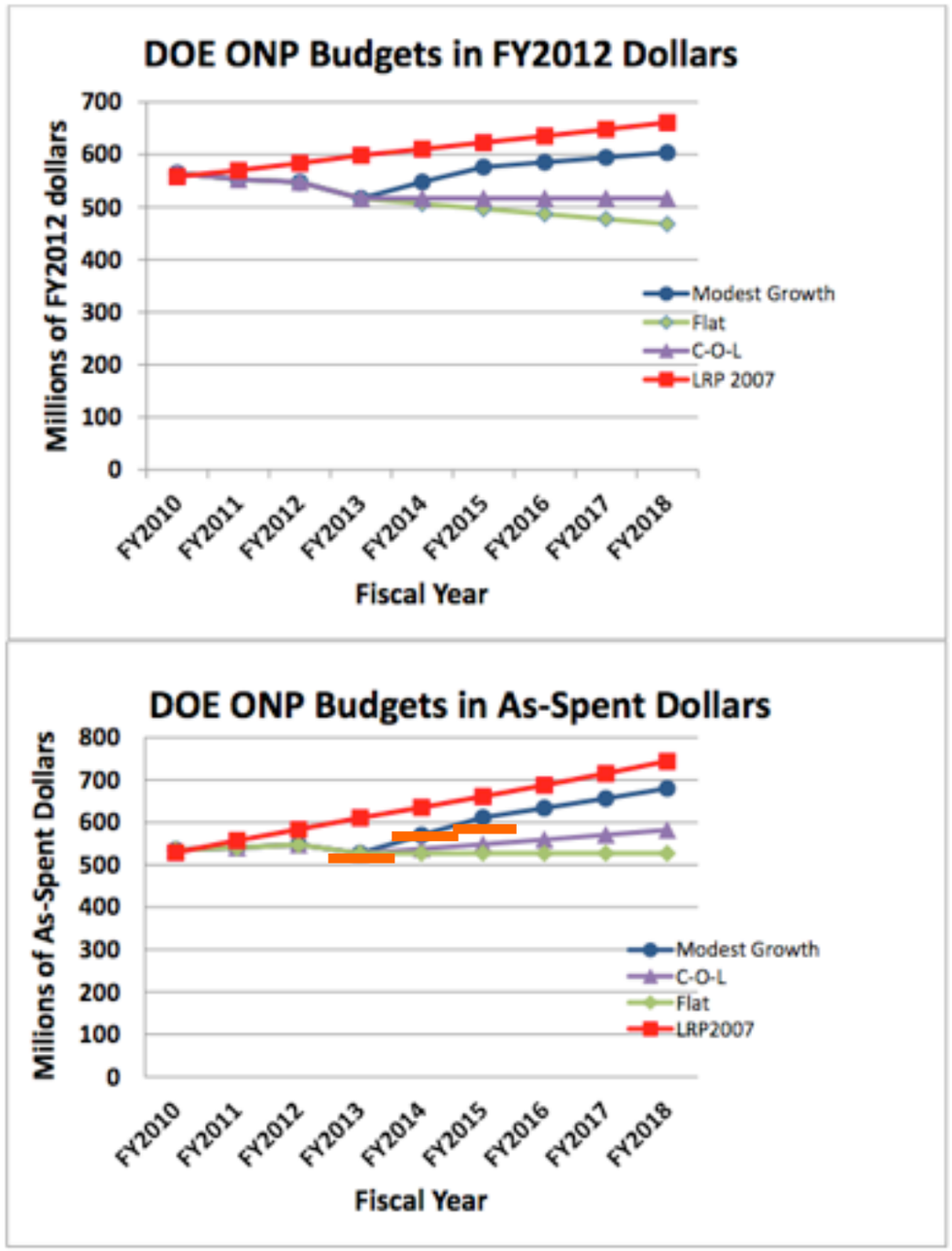
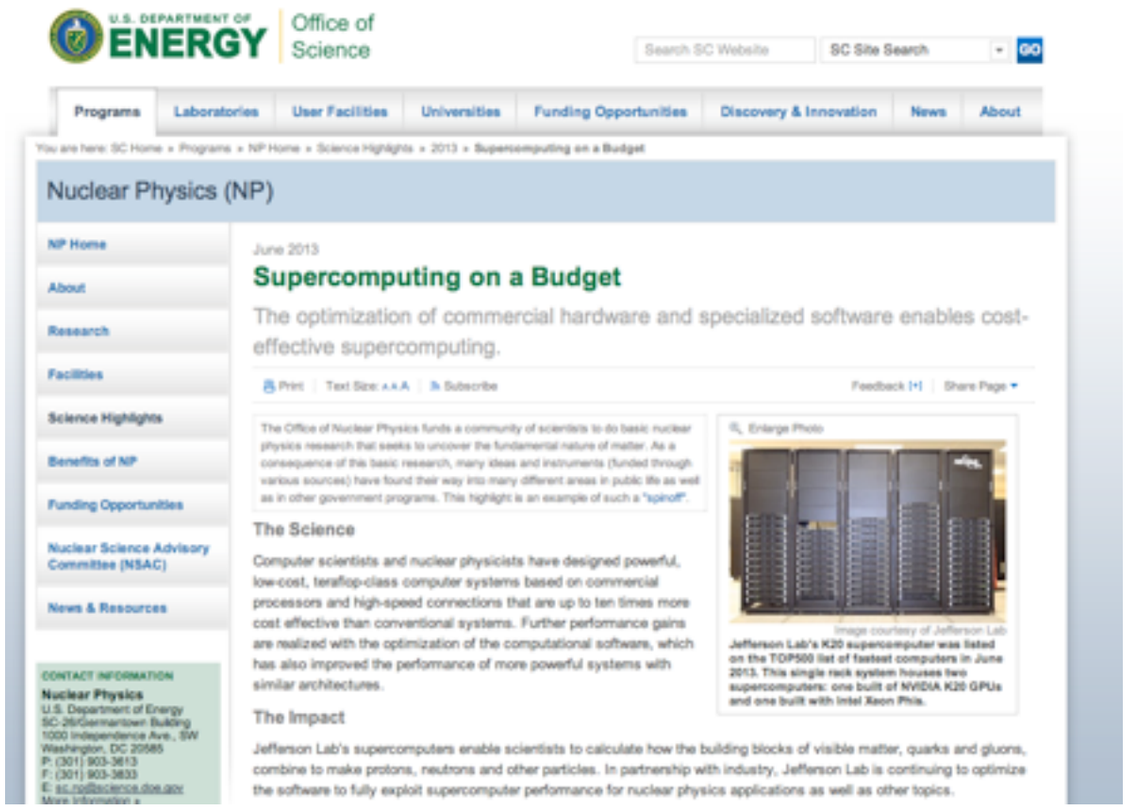


Figure VI-1: Budget scenarios considered by the subcommittee. The top panel gives the numbers in FY2012 dollars for modest growth, flat funding, and cost of living. For comparison, the 2007 LRP line is shown corrected for inflation and the isotopes program. The bottom panel shows them in as spent dollars with an inflation rate of 2% for FY2014-FY2018. The modest growth budget corresponds in FY2014 to a return to the cost-of-living-adjusted (COLA) FY2012 budget, with an additional increase in FY2015 to the level corresponding to steady growth at 1.6% per year since FY2012. Subsequent years then grow annually at 1.6% above COLA.

Resources

Compute Cycles/Software/Humans

GPU's Arrive ARRA @ JLab 2009

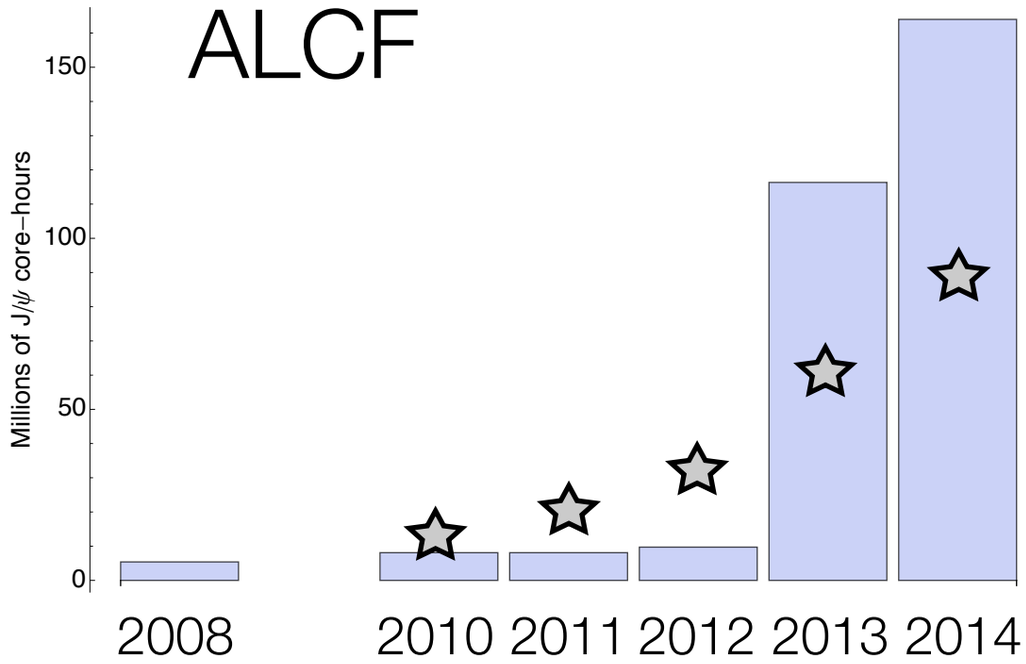


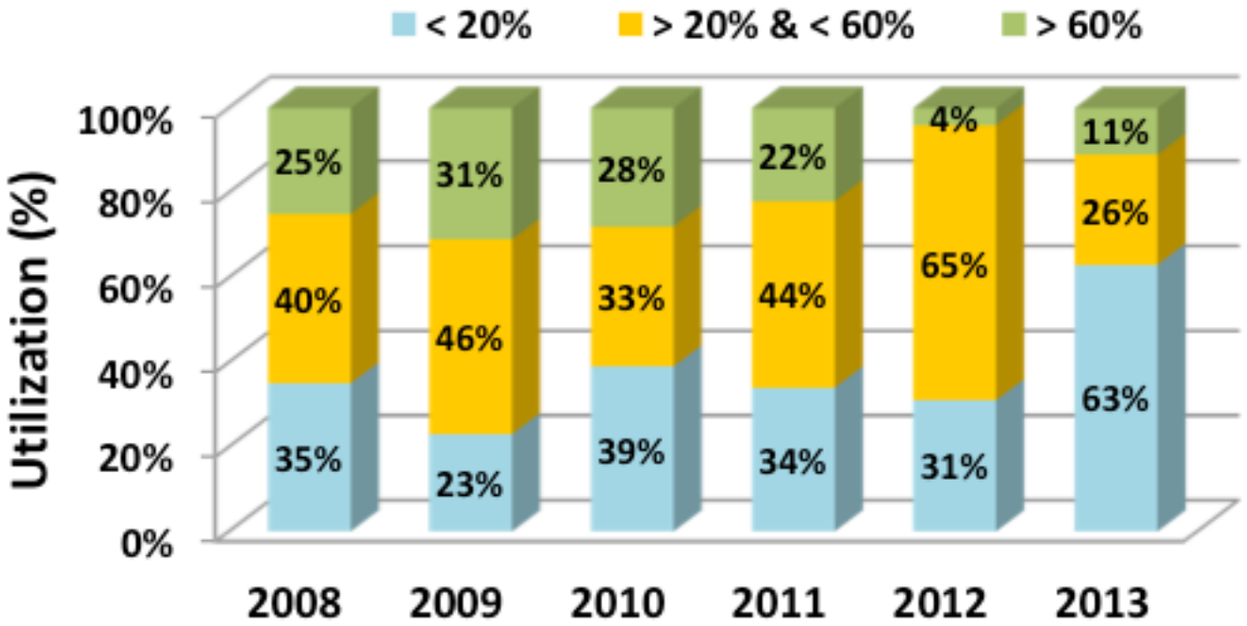
Next NERSC Procurement - Xeon Phis

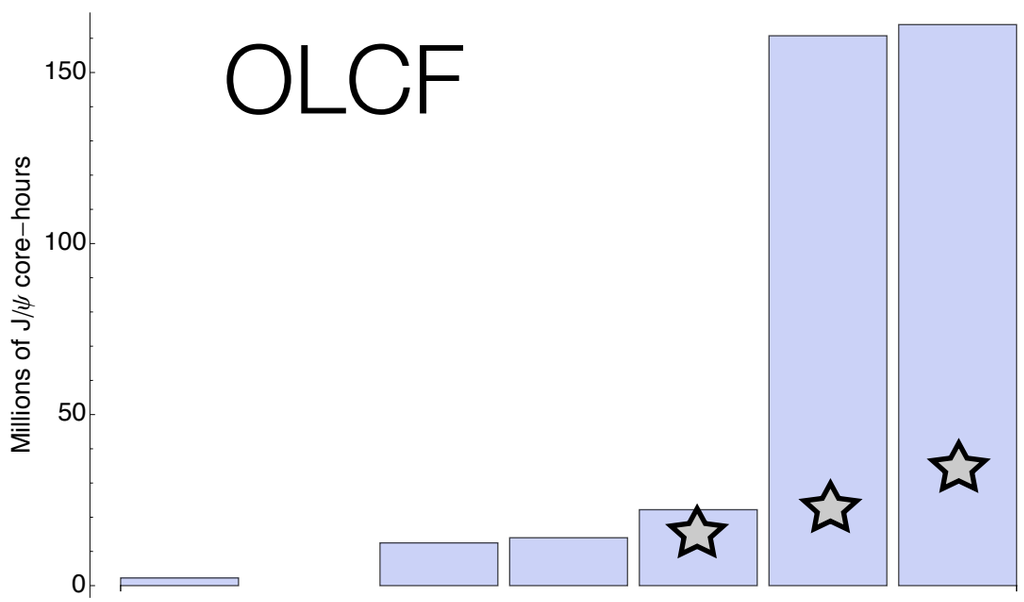
Life will never be the same !

Computational Nuclear Physics 2014

Nuclei Collaboration





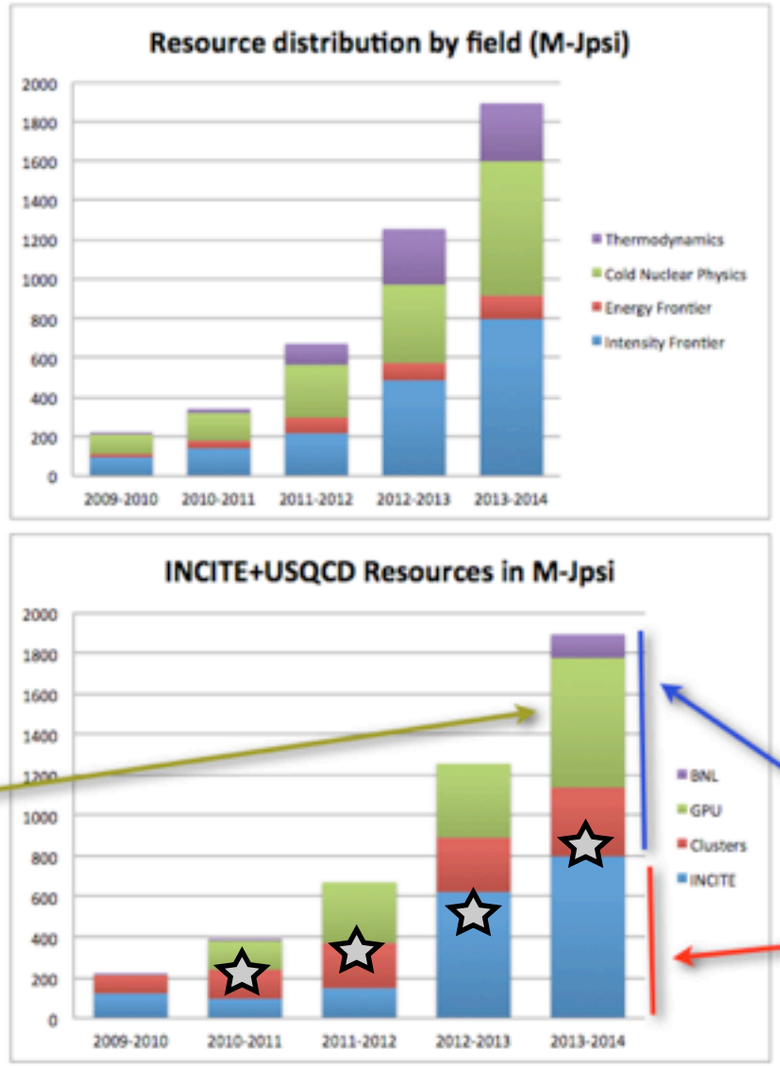


Computational Nuclear Physics 2014

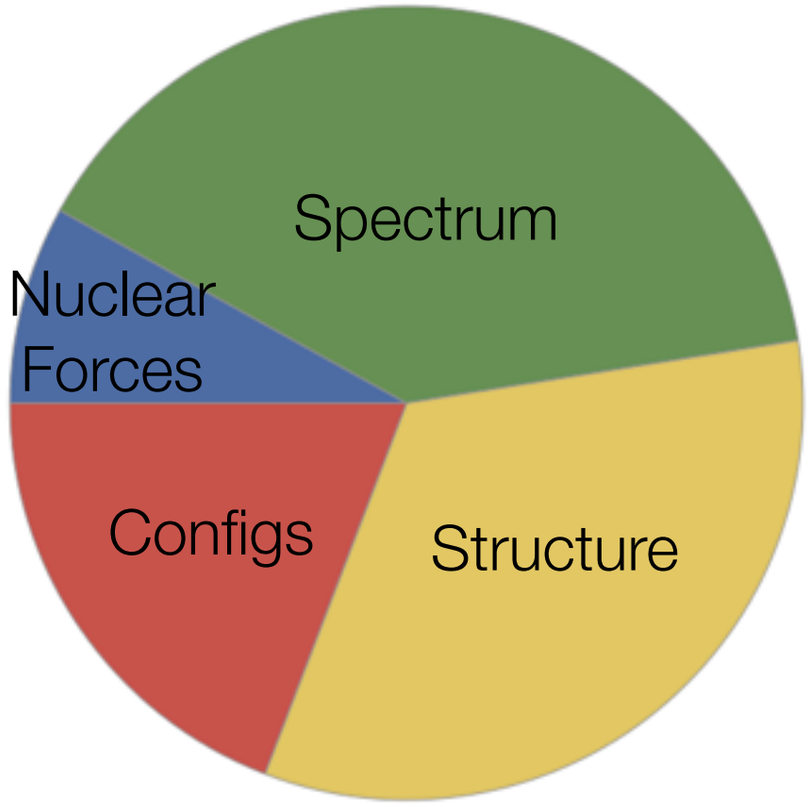
Cold and Hot QCD
USQCD

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.

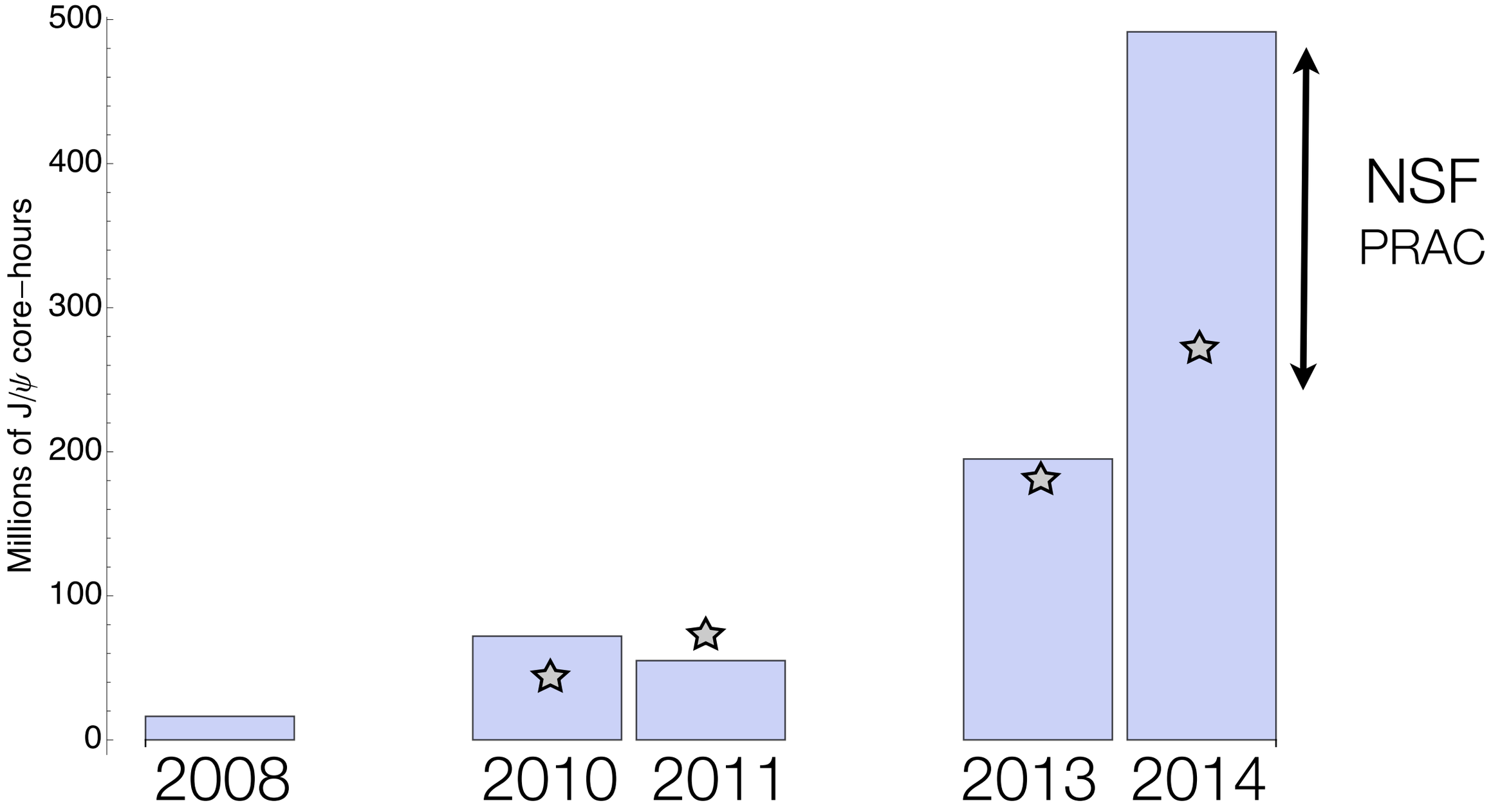
LQCD Project resources

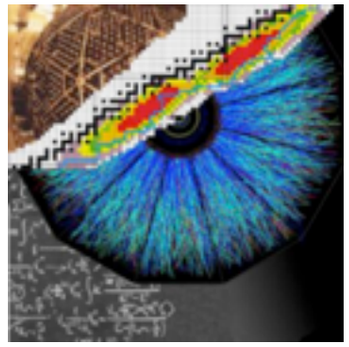
INCITE resources

Capacity hardware project significantly underfunded > 2014

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

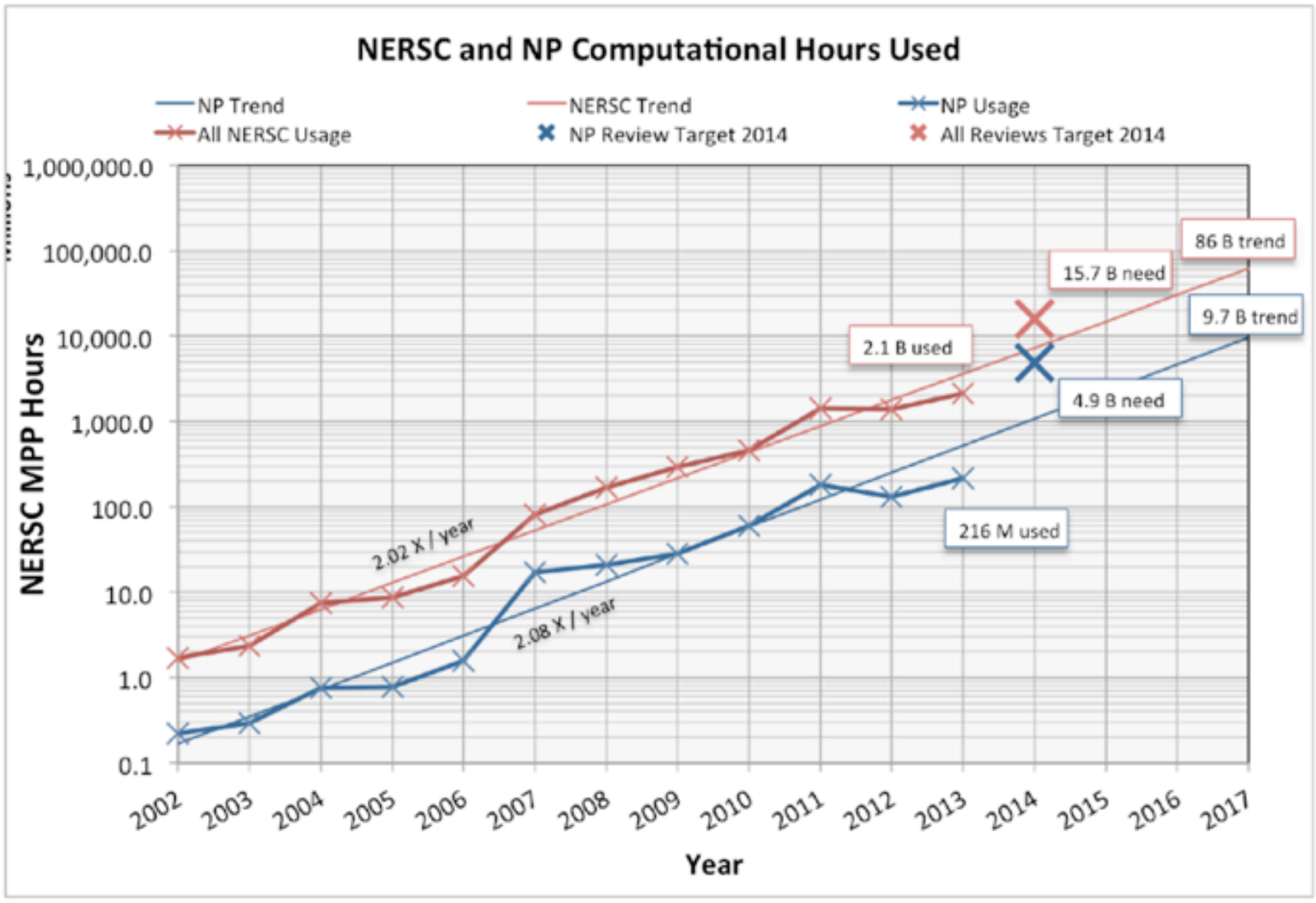
Nuclear Astrophysics





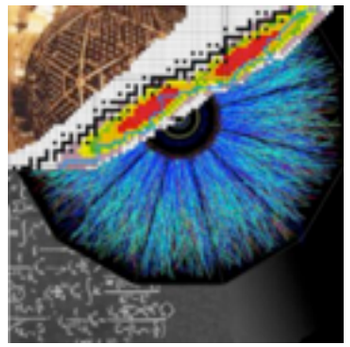
Computational Hours

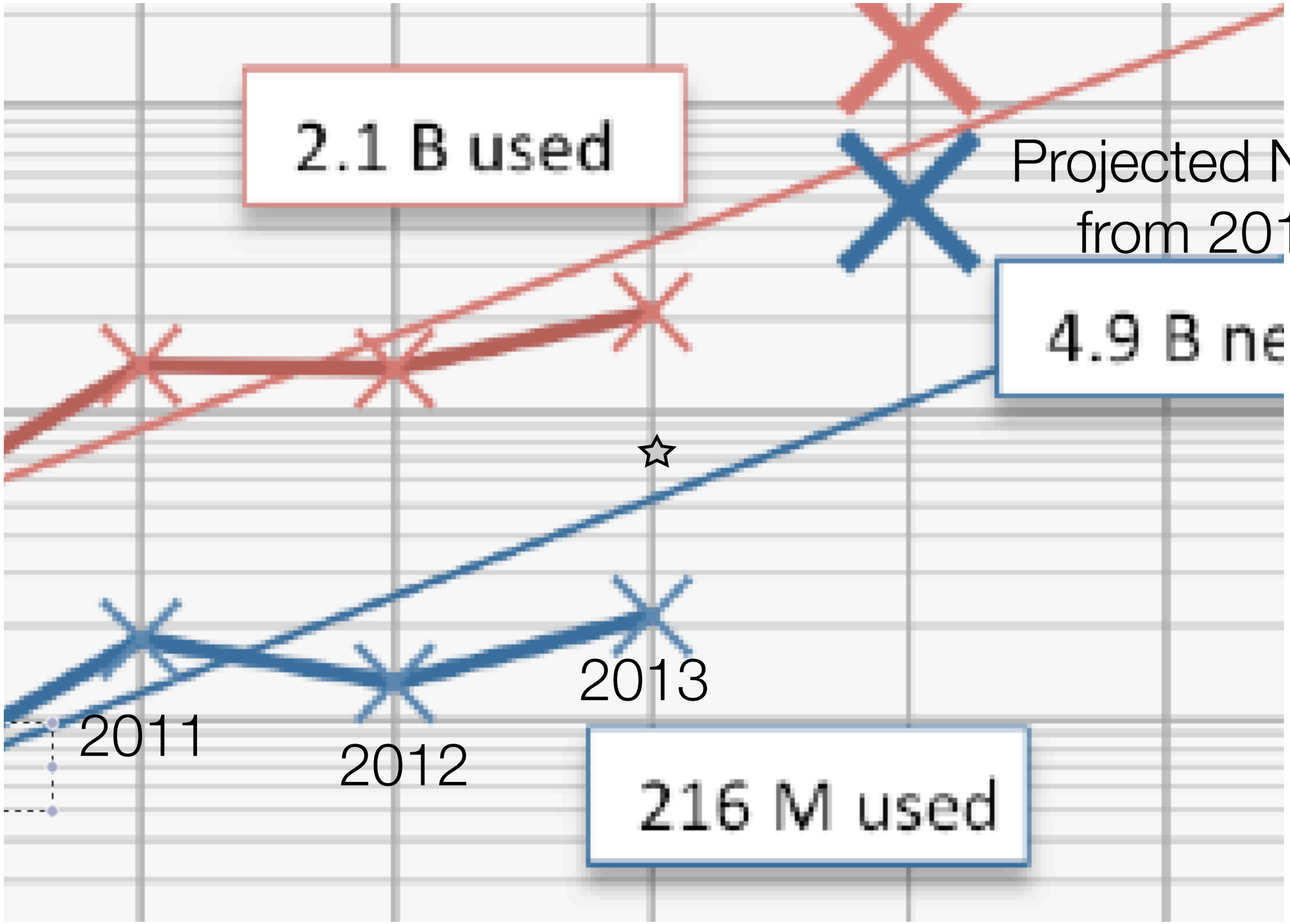
NERSC 40 YEARS at the FOREFRONT



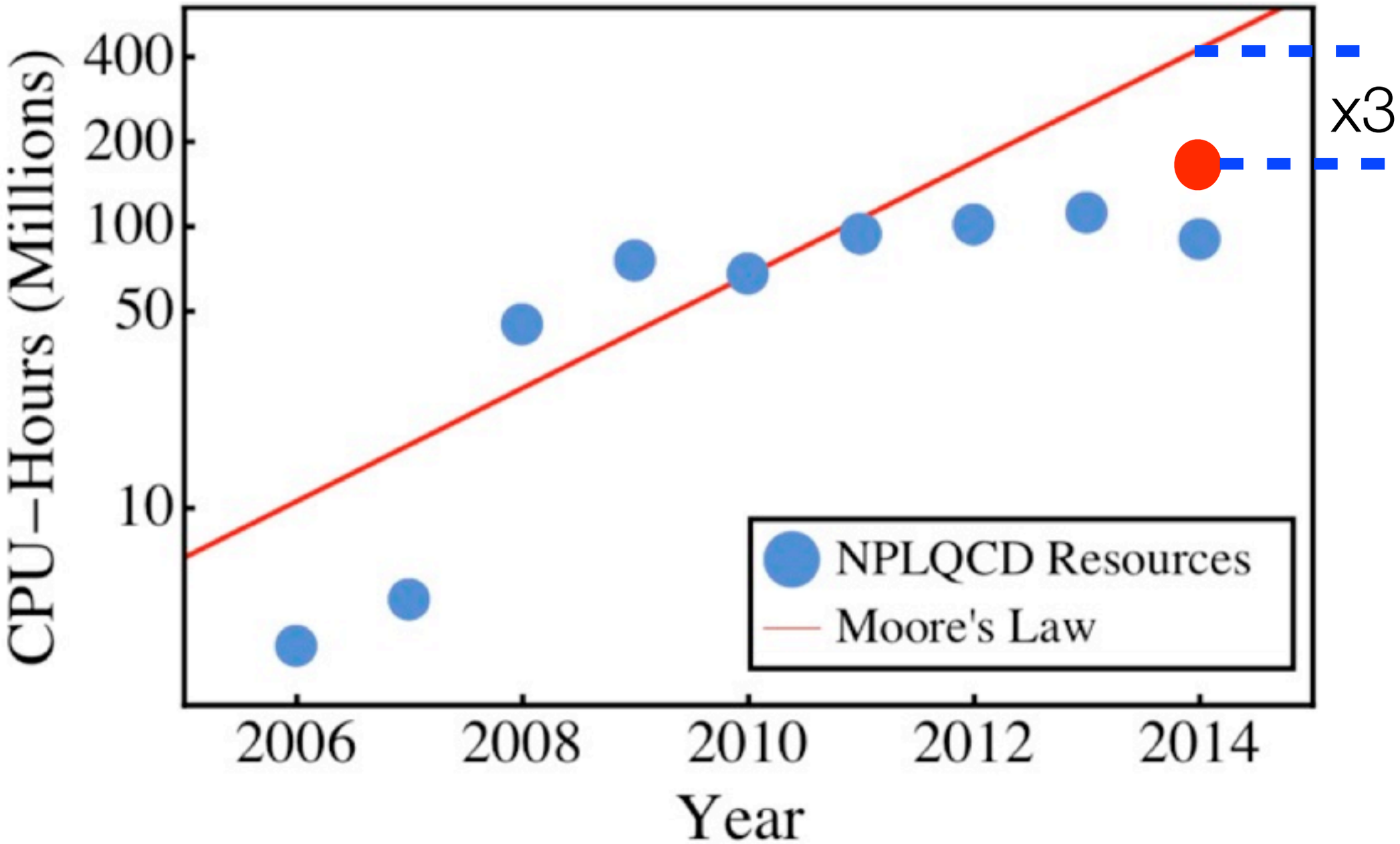
Computational Nuclear Physics 2014

ALL NERSC



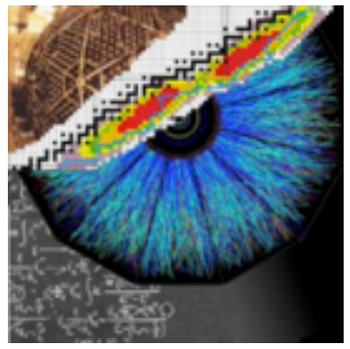


Capacity Computing
e.g. Nuclear Forces



i.e. a 1 year project now takes 3 years!

NSF



- 2013 : Bluewaters
  - not available for XSEDE allocation
  - LQCD, Astro have projects

- XSEDE -> notXSEDE ?
  - should not be considered a stable source of computing for NP

- MRIs
  - Have provided important compute resources to universities for NP
    - valuable for code development for larger facilities
    - none recently (that I am aware of)

Computational Nuclear Physics 2014

US Human Resources

SciDAC
Scientific Discovery through Advanced Computing

- SciDAC has been transforming the field since inception
  - Very successful
- Crucial for new and emerging machine architectures
  - System is already highly stressed with CPUs and GPUs, now Xeon Phis

Computational Nuclear Physics 2014

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

Computational Nuclear Physics 2014

SciDAC - Algorithms
Nuclei examples

Scalable Eigensolver for Many-Fermion Dynamics - nuclear (MFDn)

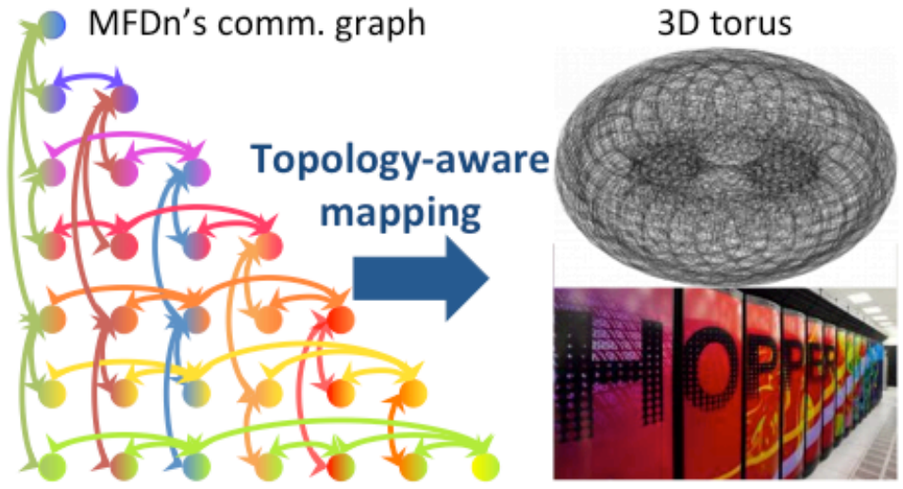
ASCR/NP – Applied Math/Computer Science Highlight

Objective

- Efficient and scalable iterative solvers for extreme-scale eigenvalue problems arising in nuclear physics (MFDn code)

Impact

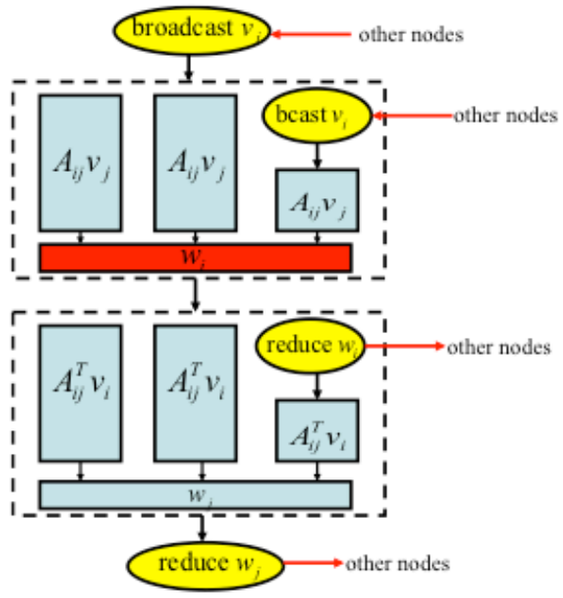
- Drastically reduced communication overheads
- Significant speed-ups over earlier version of MFDn (up to 6x on 18,000 cores)
- Almost perfect strong scaling on up to 260,000 cores on Jaguar



Topology-aware mapping of processes to the physical processors becomes more important as the gap between computational power and bandwidth widens. Communication groups are optimized through a column-major ordering of processes on the triangular grid [1].

Communication Hiding

Flow-chart for multi-threaded SpMV computations during the eigensolve phase of MFDn. Expensive communications are overlapped with computations. Explicit communications are carried out over topology-optimized groups [2].



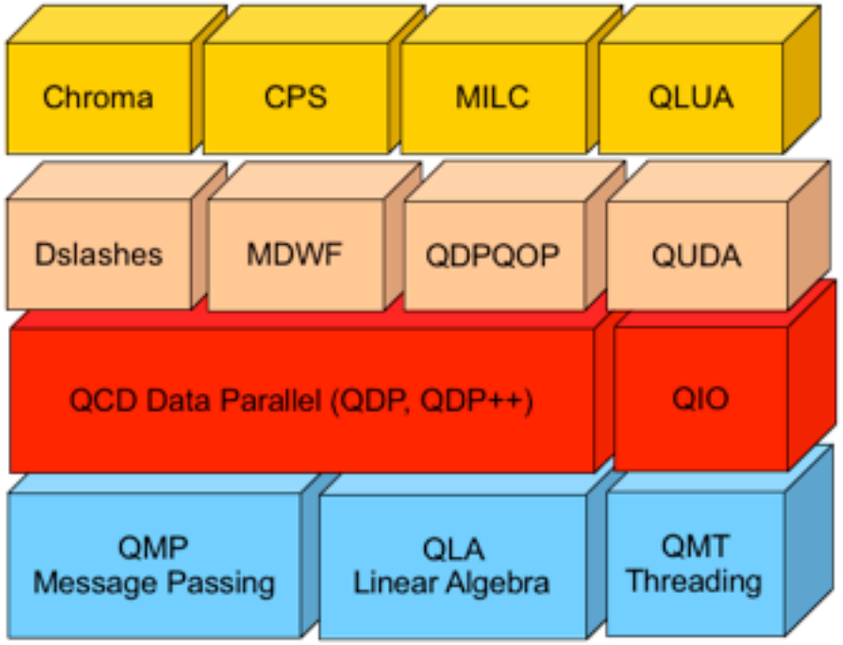
Contacts: E. Ng, egng@lbl.gov; J. Vary, jvary@iastate.edu

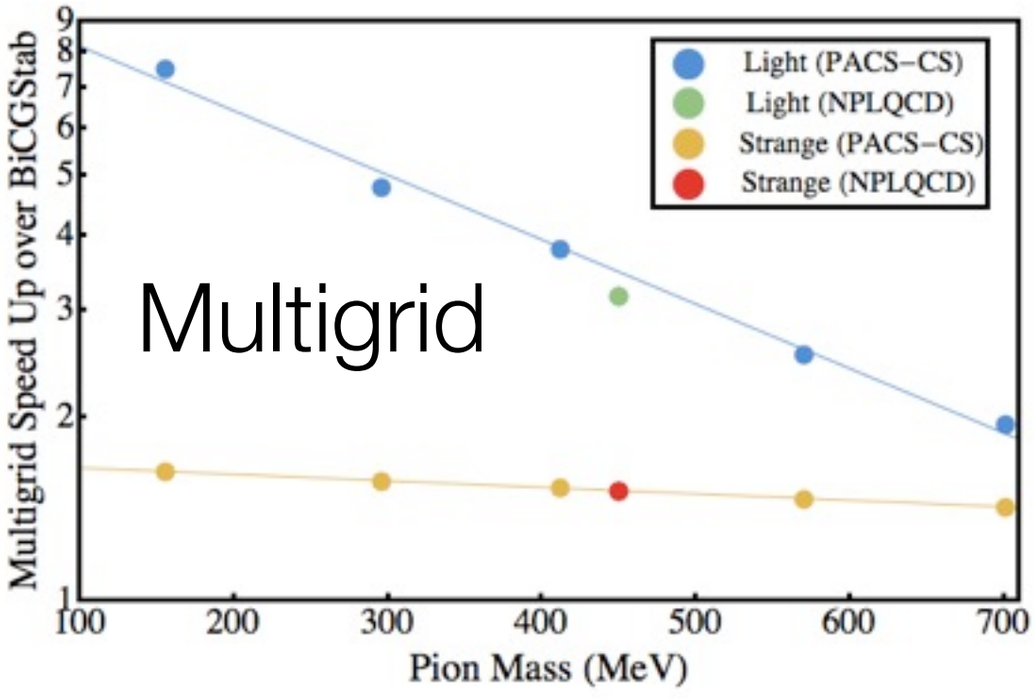
[1] H.M. Aktulga,C. Yang,P. Maris,J.P. Vary,E.G. Ng, "Topology-Aware Mappings for Large-Scale Eigenvalue Problems", Euro-Par 2012 Conference
[2] H.M. Aktulga,C. Yang,E.G. Ng,P. Maris,J.P. Vary, "Improving the Scalability of a Symmetric Iterative Eigensolver for Multi-core Platforms", CCP&E, in review

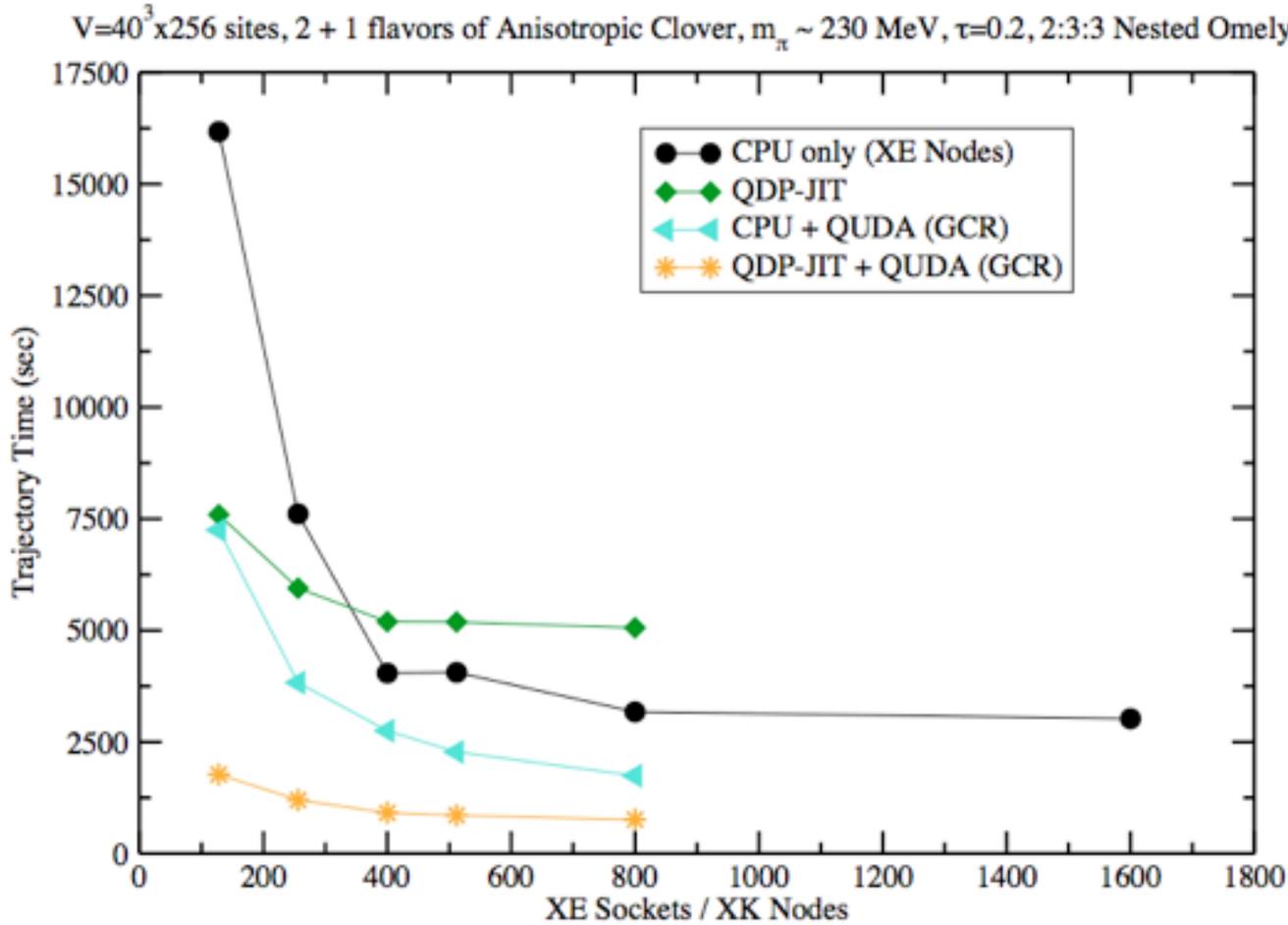
U.S. DEPARTMENT OF ENERGY | Office of Science
INCITE Advancing America's Science and Industrial Competitiveness
NUCLEI Nuclear Computational Low-Energy Initiative
FASTMATH

Computational Nuclear Physics 2014

SciDAC - Algorithms
USQCD examples



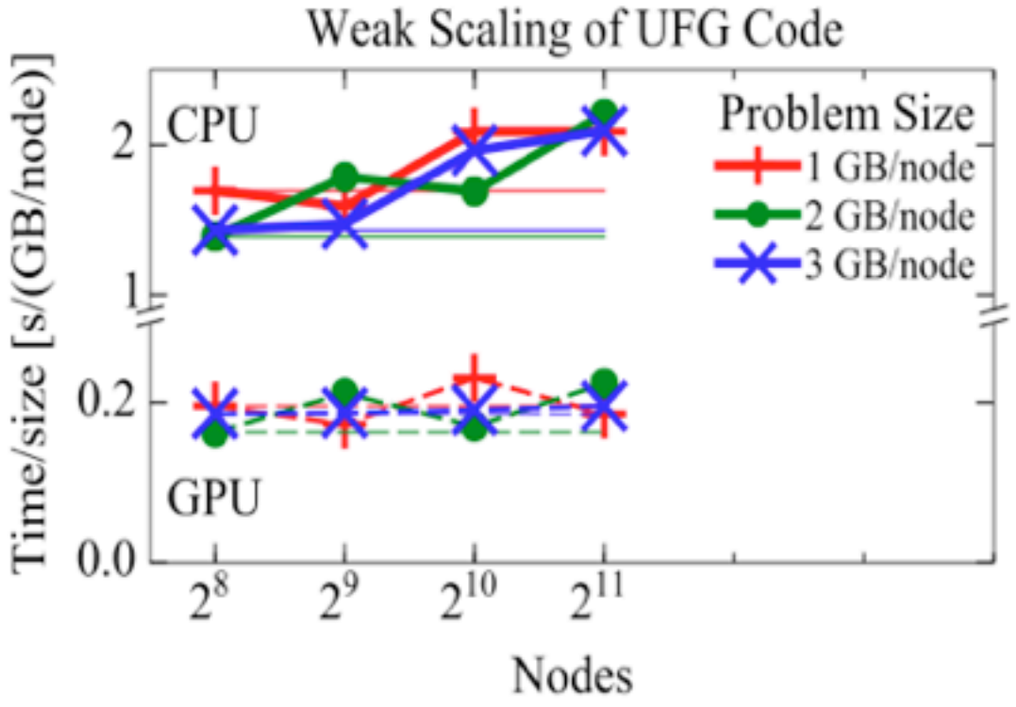


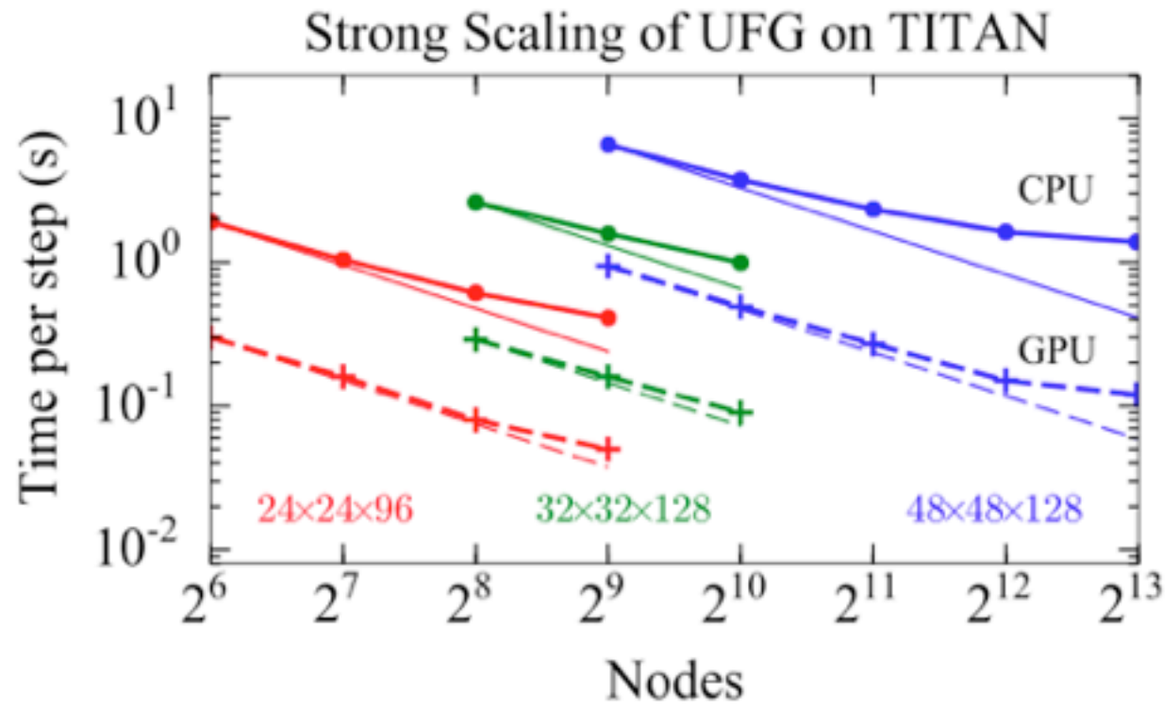


Computational Nuclear Physics 2014

Non-SciDAC Algorithms
Large GPU Partitions

Bulgac, Roche,
Stetcu, Wlazowski





$N_xN_yN_z$	N_{wf}	memory	CPU comp. + comm.	CPU comp.	GPU comp. + comm.	GPU comp.	# of GPUs	speedup
48^3	110592	10 TB	3.9s	2.4s	0.39s	0.023s	6912	10
64^3	262144	56 TB	20s	9.1s	0.80s	0.48s	16384	25

Over 1 million time-dependent 3D nonlinear complex coupled PDEs

SciDAC - Support - Nuclei

NUCLEI Year 2

Graduate Students

- Murat Bakirci, Ames and ODU
- Bridget Bertoni, UW / INT
- Noah Birge, UT (20%)
- Sushant More, OSU
- Titus Morris, MSU (50%)
- Erik Olsen, UT (30%)
- Kemper Talley, UT (50%)
- Dossay Oryspayev, Ames and ODU (100%)
- Nathan Parzuchowski, MSU (40%)
- Hugh Potter, ISU (50%)
- Ermal Rrapaj, UW / INT (100%)
- Shiplu Sarker, CMU
- Andre Schneider, IU
- Thomas Shafer, UNC
- Fei Yuan, MSU (15%)
- Chunli Zhang, UT (100%)

Postdocs

- Andreas Ekstrom, MSU
- Heiko Hergert, OSU (FRIB Fellow at MSU from 8/2014)
- Sebastian Koenig, OSU (50%)
- Nobuo Hinohara, UNC (80%), UT (20%)
- Jeremy Holt, UW
- Guillaume Hupin, LLNL
- Gustav Jansen, UT/ORNL (10%)
- Michael Kruse, LLNL
- Diego Lonardoni, ANL (100%)
- Joel Lynn, LANL (100%)
- Allesandro Lovato, ANL
- Justin Lietz, MSU (15%)
- Jordan McDonnell, LLNL (100%)
- Mika Mustonen, UNC (100%)
- George Papadimitriou, ISU (100%)
- Sergey Postnikov, IU (50%)
- Jhilam Sadhukhan, UT
- Irinia Sagert, IU (50%)
- Andre Schneider, IU (50% through 8/14)
- Roman Senkov, CMU (100%)
- Yue Shi, UT (50%)
- Angelo Signoracci, UT/ORNL (100%)
- Andrew Steiner, UW / INT
- Vaibhav Sundriyal, Ames (100%)
- Kyle Wendt, UT/ORNL (100%)

Impacting
25 postdocs
16 postdocs

Computational Nuclear Physics 2014

SciDAC - Support - USQCD-NP
~2/3 request

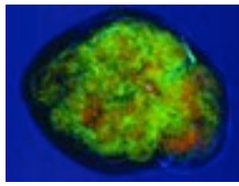
Nuclear USQCD

Labs

- JLab 1.5 FTE
- BNL 0.62 FTE
- LLNL 0.17 FTE

Universities

- MIT 0.67 FTE
- WM 0.5 FTE
- UNC 0.5 FTE
- UW 0.67 FTE

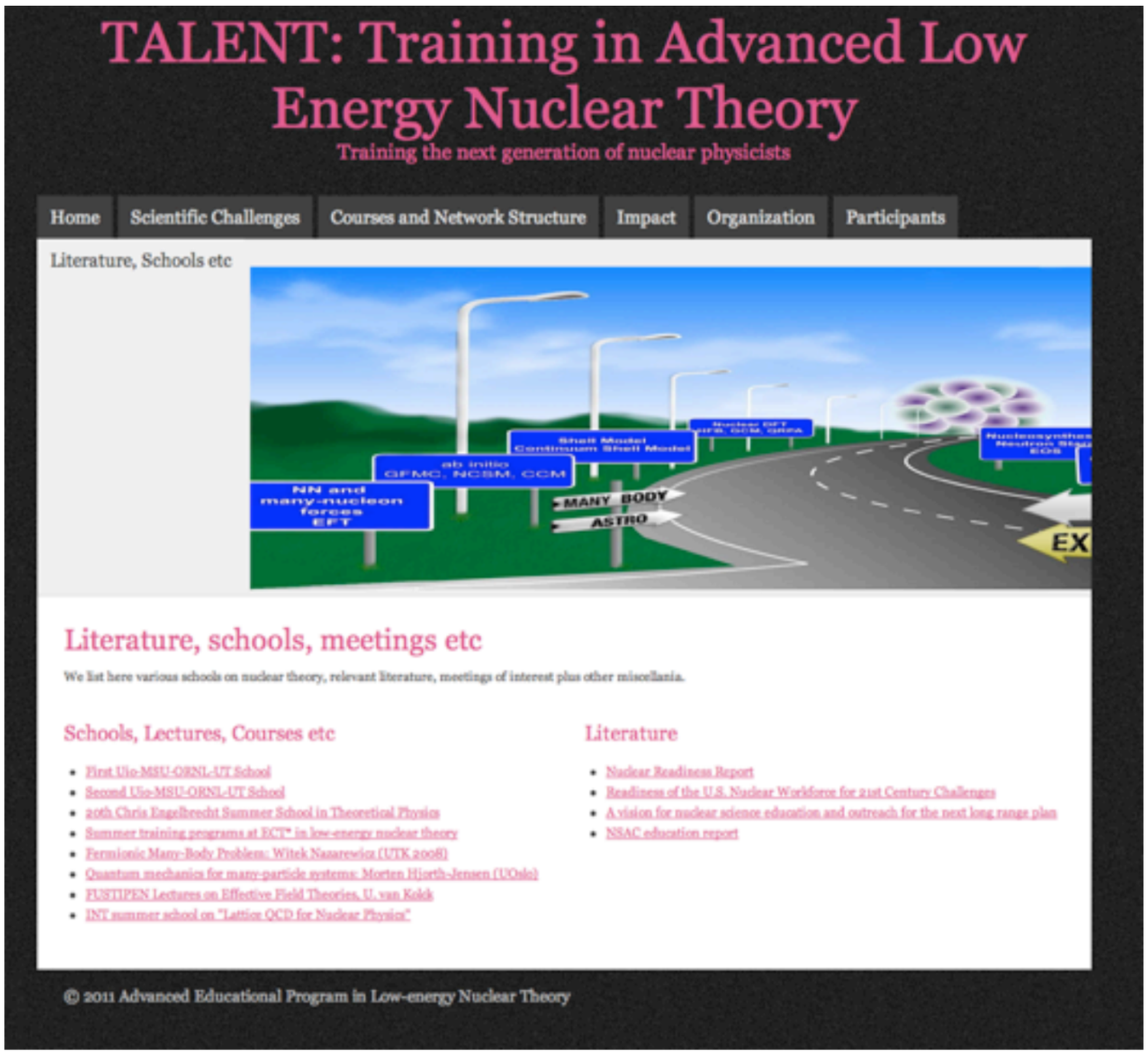


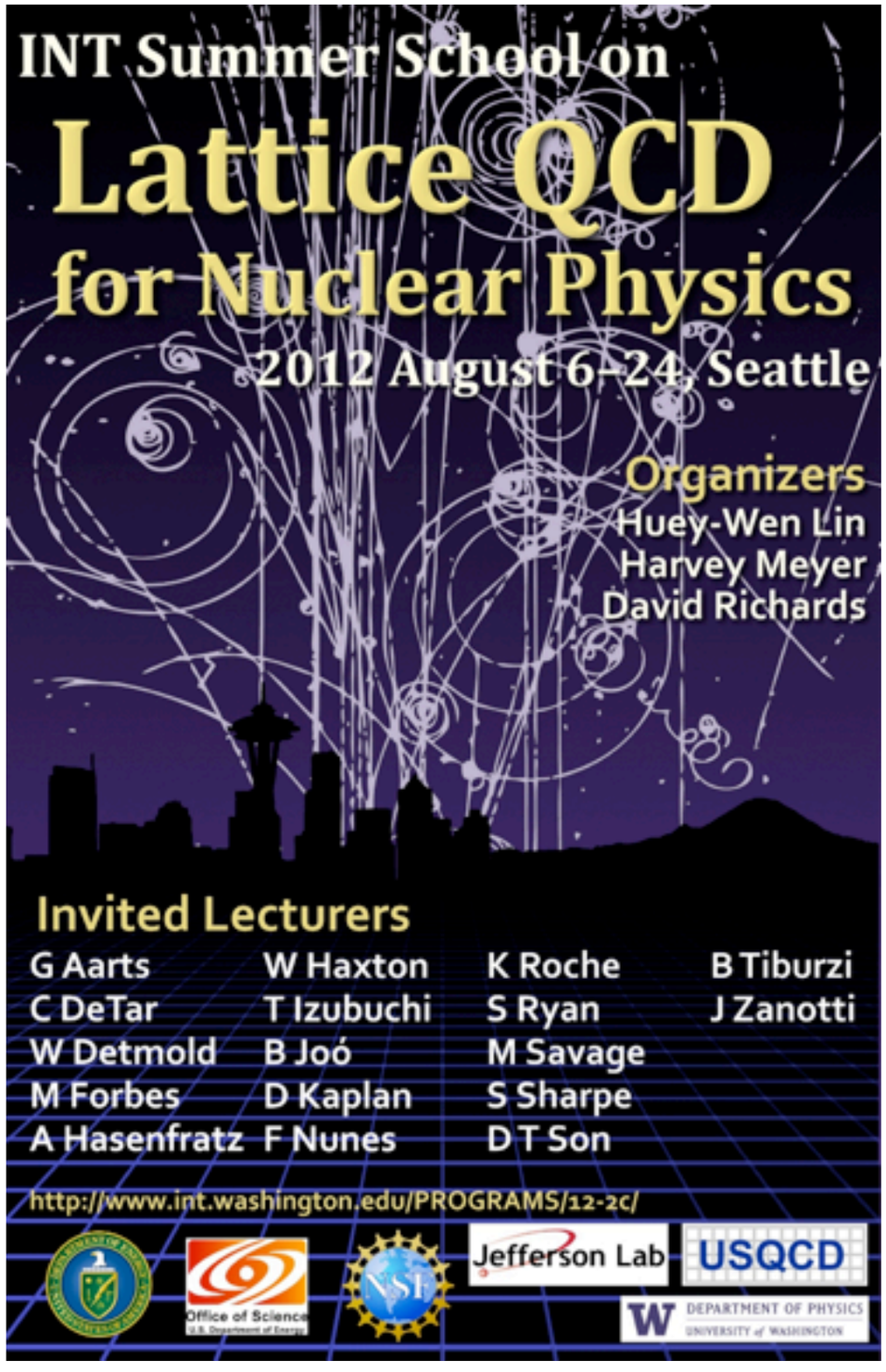
Training

Young Scientists/Workshops/Computing/Schools

Computational Nuclear Physics 2014

Training Young Physicists





https://www.facebook.com/INTLatticeSchool2012

Computational Nuclear Physics 2014

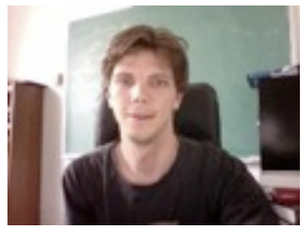
Training Young Physicists Lattice QCD

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

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

Computational Nuclear Physics 2014

Training Young Physicists Nuclei

Person	Institution
Joaquin Drut	UNC, Chapel Hill
Michael Forbes	Washington State
Jason Holt	TRIUMF
Heiko Hergert	FRIB
Stefano Gandolfi	LANL
Alexandro Gezerlis	U. Guelph
Gaute Hagen	ORNL
Nobuo Hinohara	U. Tsukuba
Eric Jurgenson	LLNL
Markus Kortelainen	U. Jyvaskyla
Plamen Krastev	Harvard
Alexandro Lovato	ANL
Pieter Maris	Iowa State
Eric McDonald	Michigan State
Gustavi Nobre	BNL (NNDC)
Junchen Pei	Pekin U.
Lucas Platter	U. Tennesses/ORNL
Sofia Quaglioni	LLNL
Nicolas Schunck	LLNL
Andrew Steiner	U. Tennessee/ORNL
Ionel Stetcu	LANL
Jun Terasaki	U. Tsukuba
Stefan Wild	ANL

Sofia Quaglioni

DOE Career Award 2011

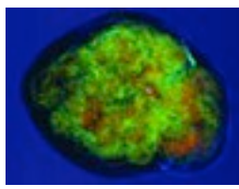
Gaute Hagen

DOE Career Award 2013

Laboratory

IUPAP Prize, 2013

DOE OJI or Career, NSF Career



Computational Nuclear Physics 2014

Training Young Physicists Nuclear Astro

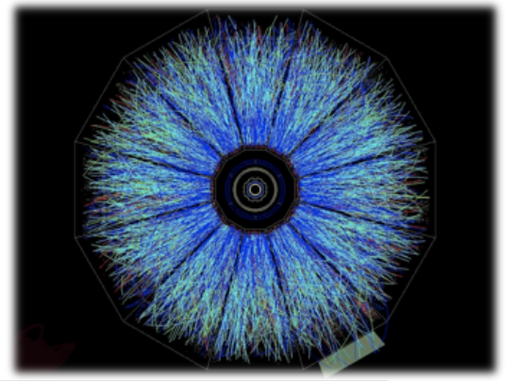
Person	Institution
Dan Kasen	LBL
Carla Frohlich	North Carolina State
James Kneeler	North Carolina State
Huaiyu Duan	New Mexico State
Andrew Steiner	U. Tennessee/ORNL
Aimee Hunderford	LANL
Candace Joggerst	LANL
Vincenzo Cirigliano	LANL
Rebecca Surman	Union College
Falk Herwig	U. Victoria
C. Ott	Caltech
T. Thompson	Ohio State
J. Murphy	Florida State
Kev Abazajian	UC Irvine
Ken Nollett	U South Carolina
Richard Cyburt	MSU

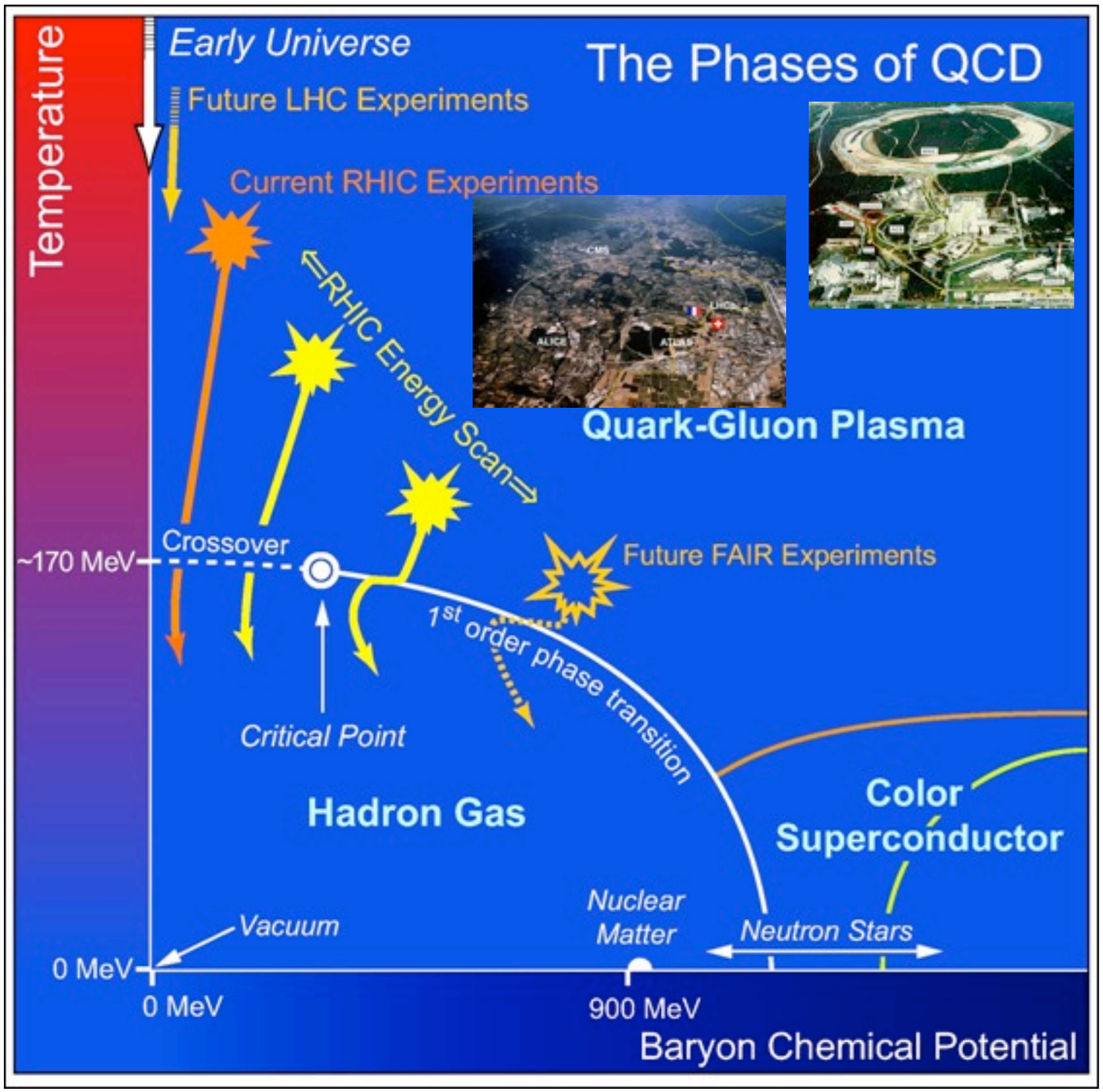
Laboratory

Scientific Highlights

Computational Nuclear Physics 2014

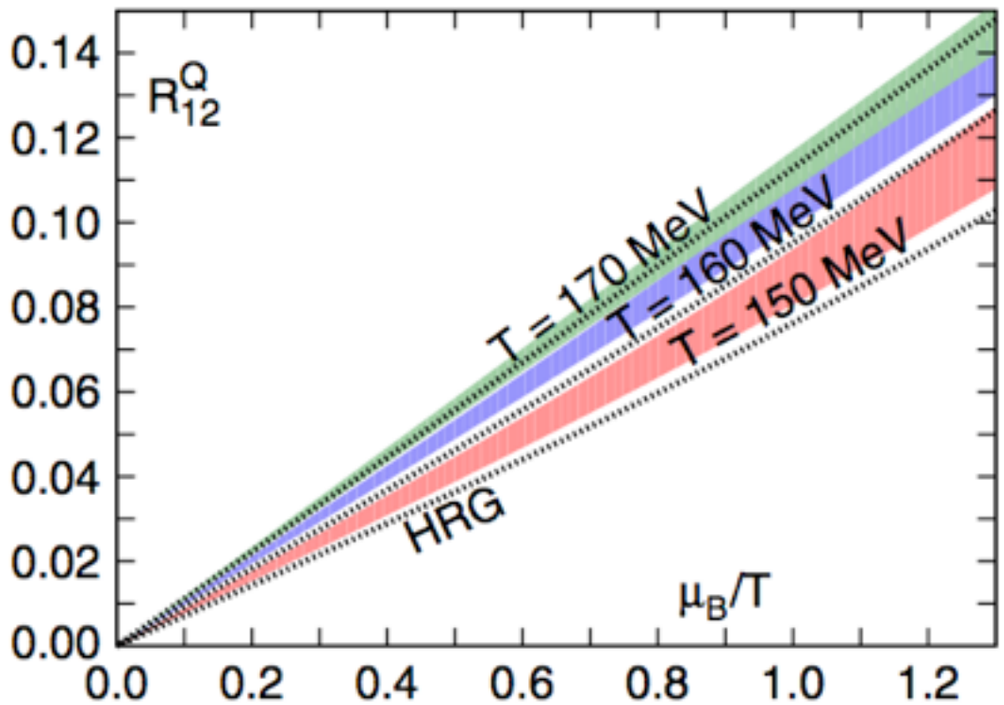
Hot QCD (I)





$T_c = 154 +- 9$ MeV

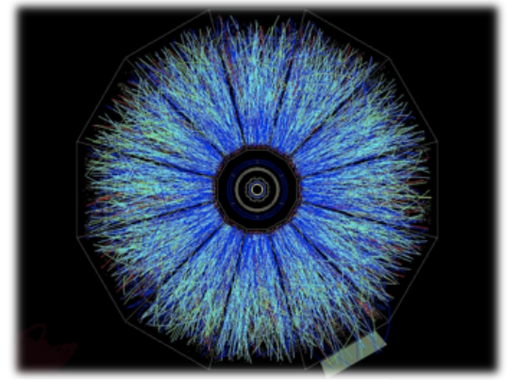
(Bazavov *et al*, 2012)

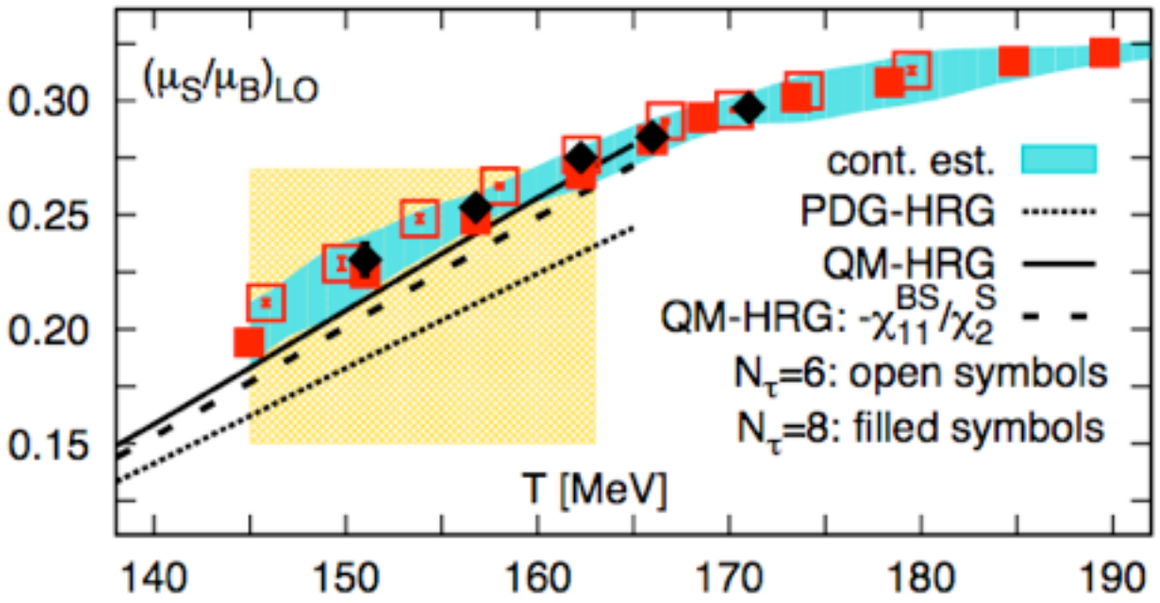


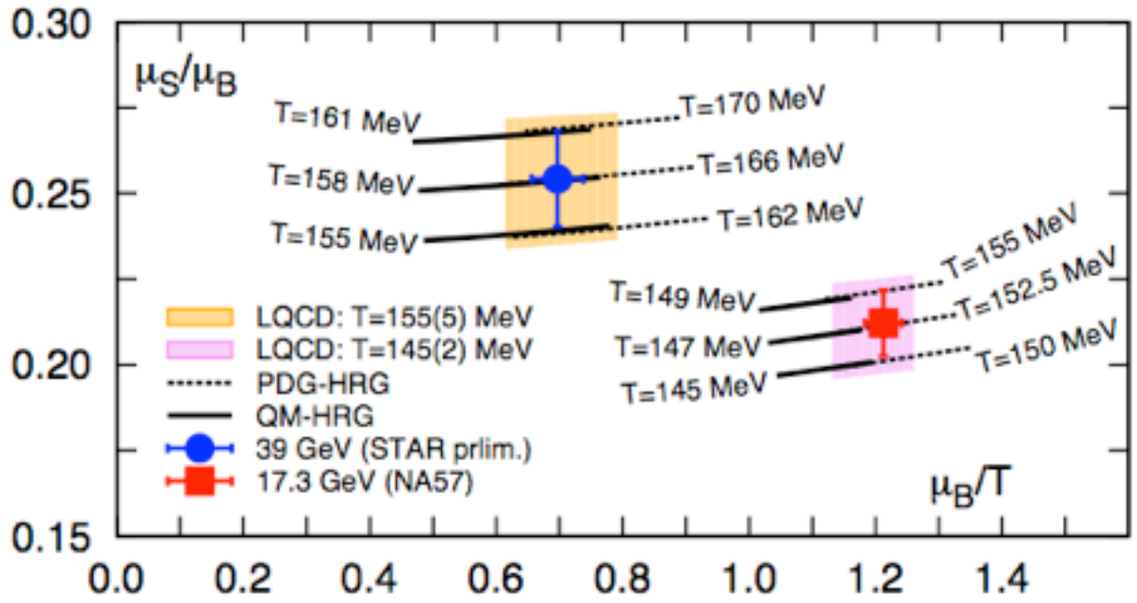
(Cheng *et al*, Bazavov *et al*.)

Computational Nuclear Physics 2014

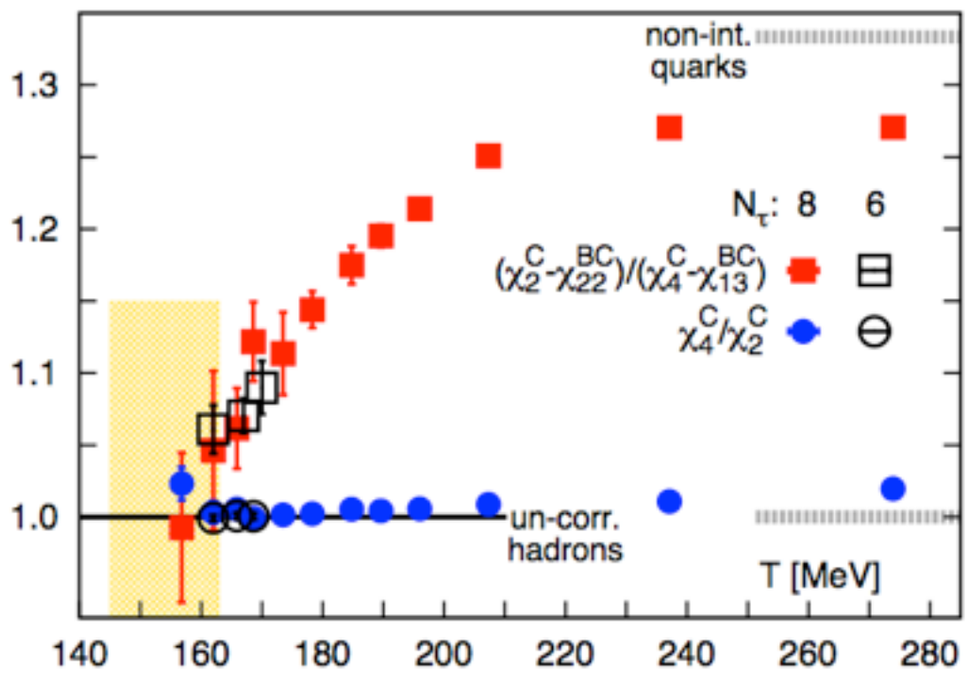
Hot QCD (II)







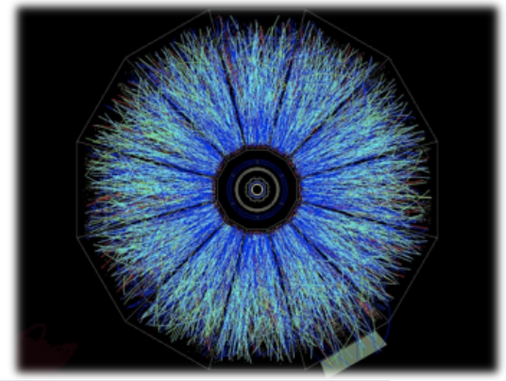
Fluctuations diagnostic of HI collisions - c/w LQCD

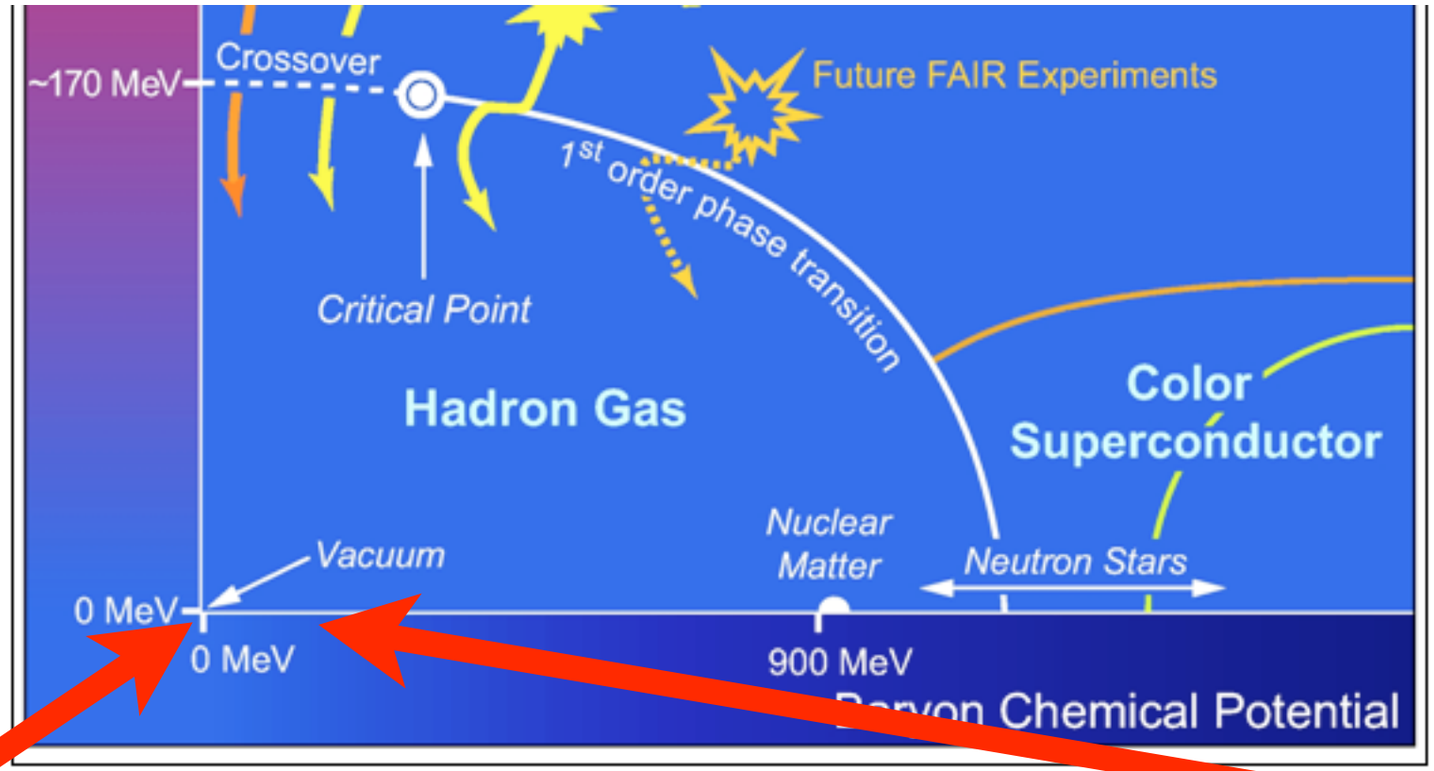


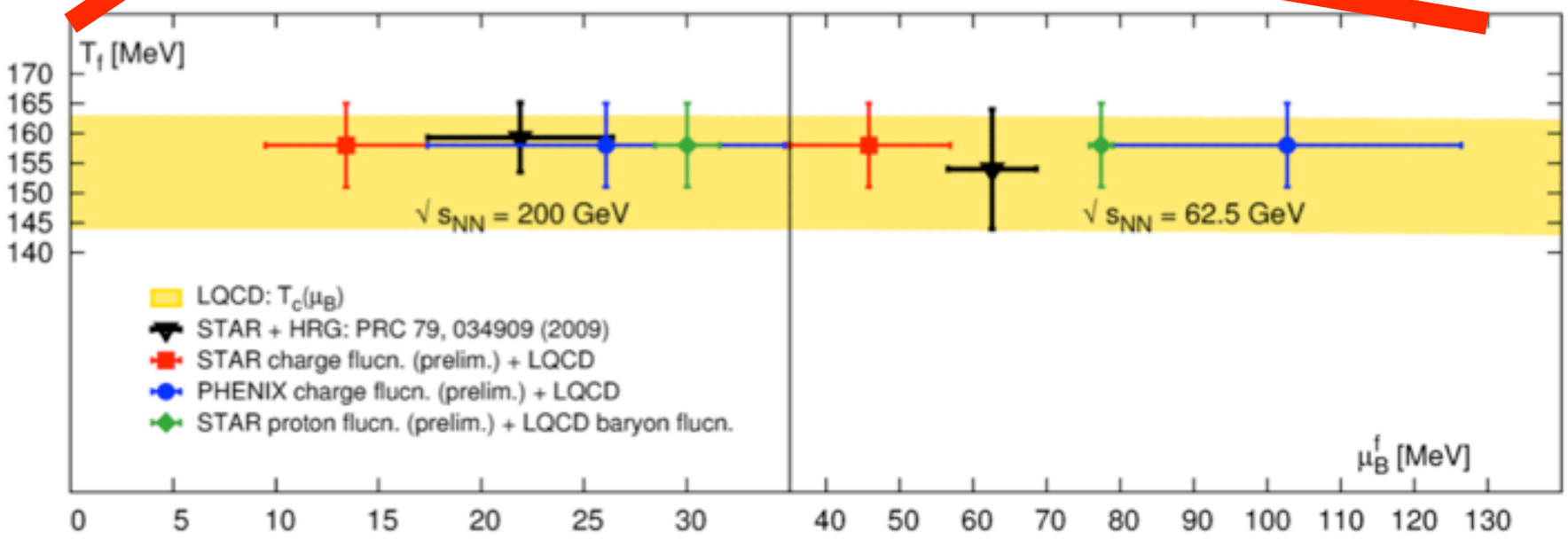
Melting of charmed hadrons

(Bazavov *et al*, 2014)

Hot QCD (III)



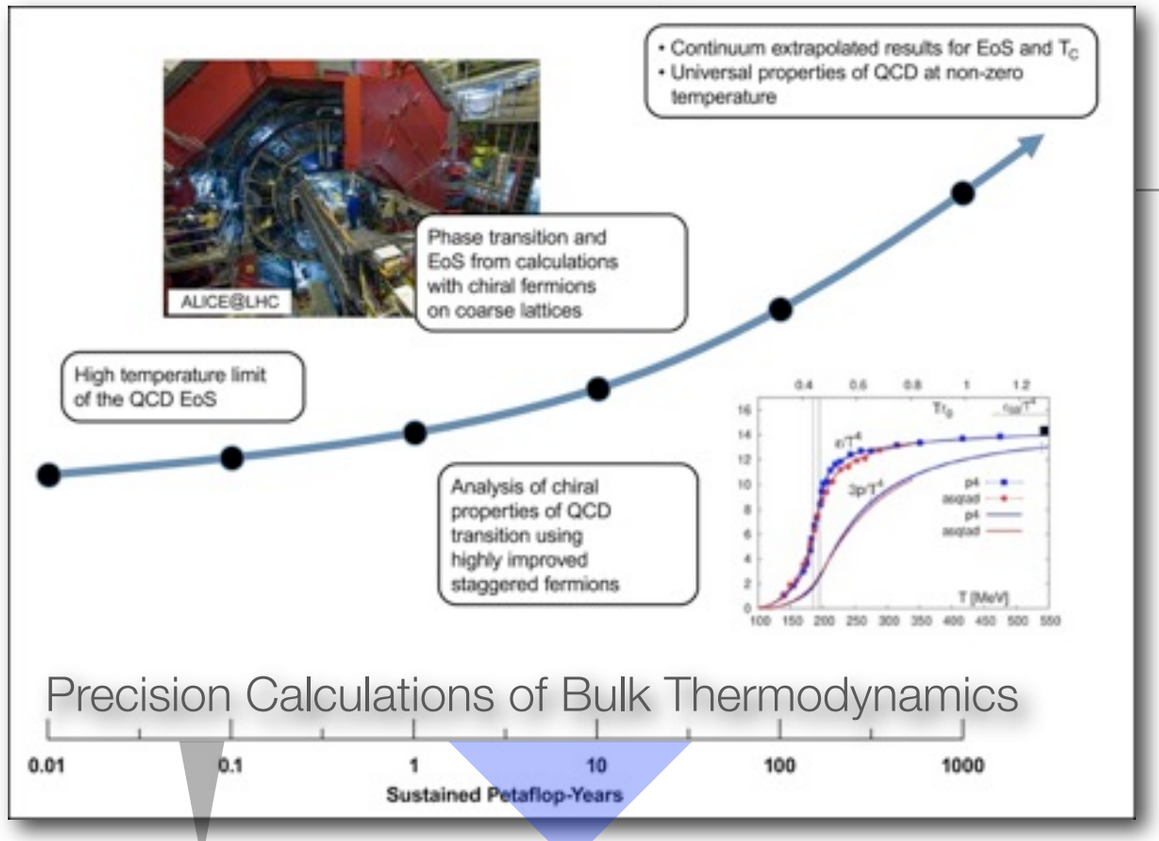


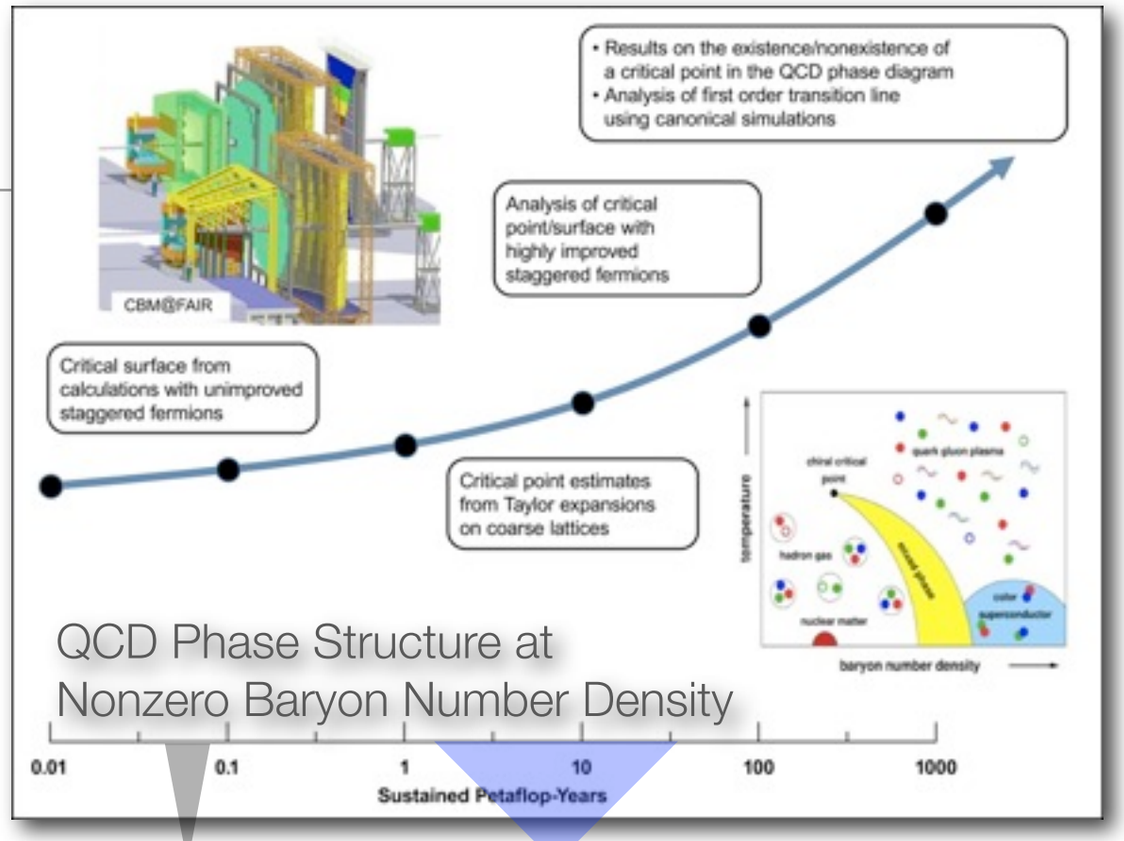


HotQCD

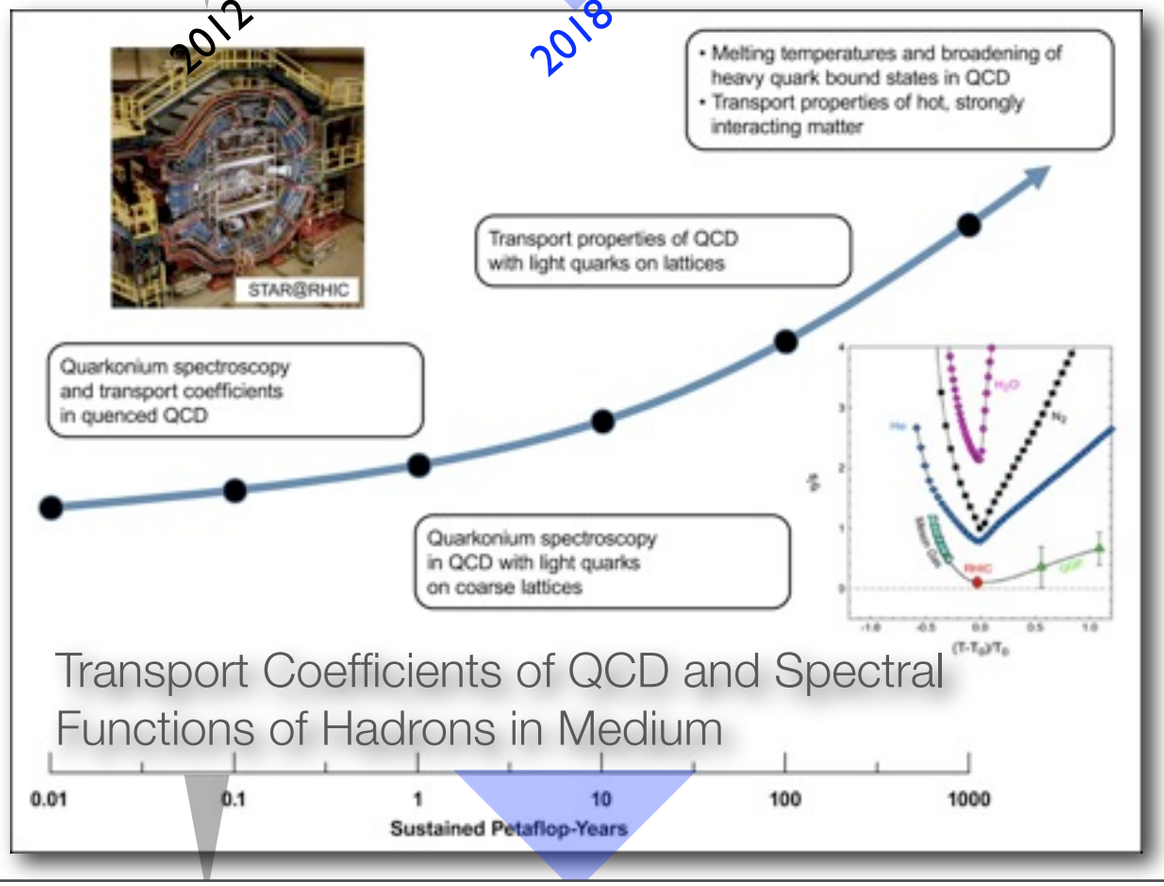
freeze-out in RHIC takes place close to the phase boundary

Flat+COLA 2013

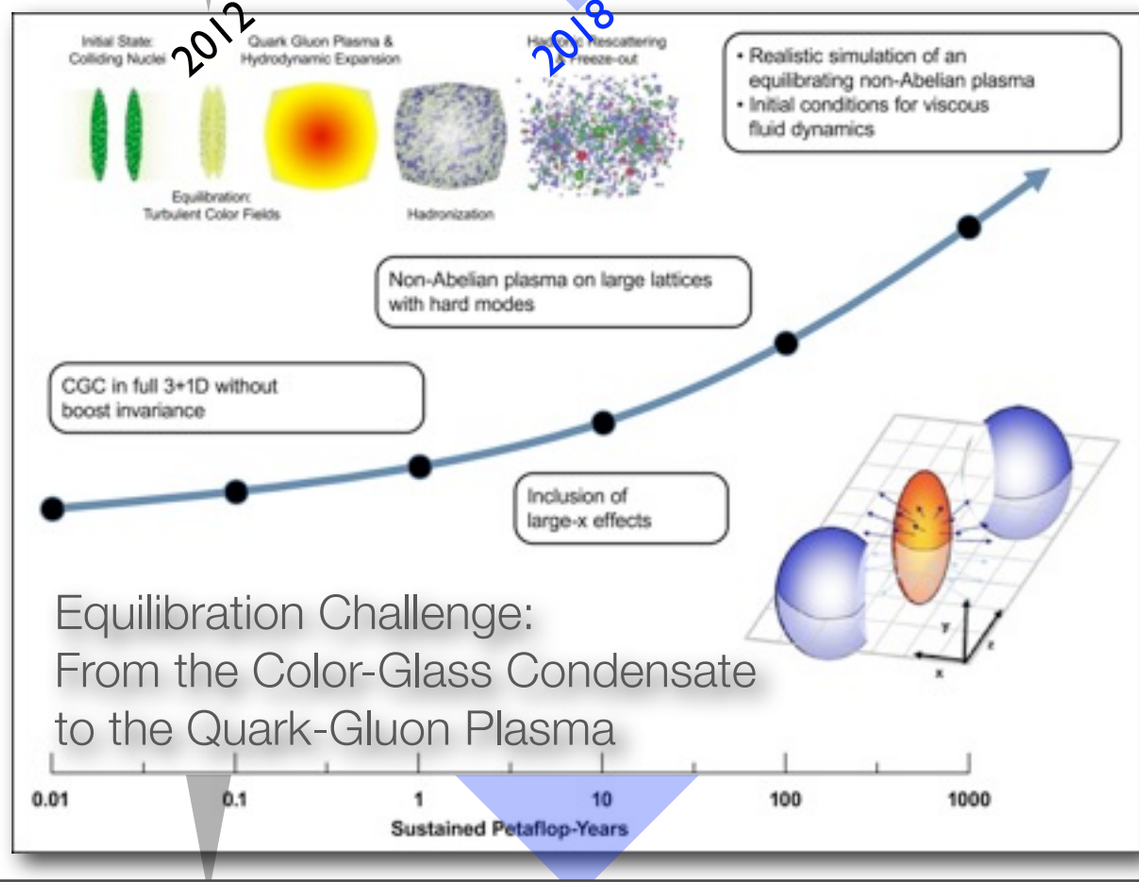




2012 2018

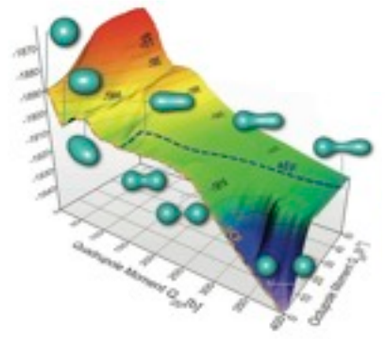


2012 2018



Computational Nuclear Physics 2014

Nuclei (I)



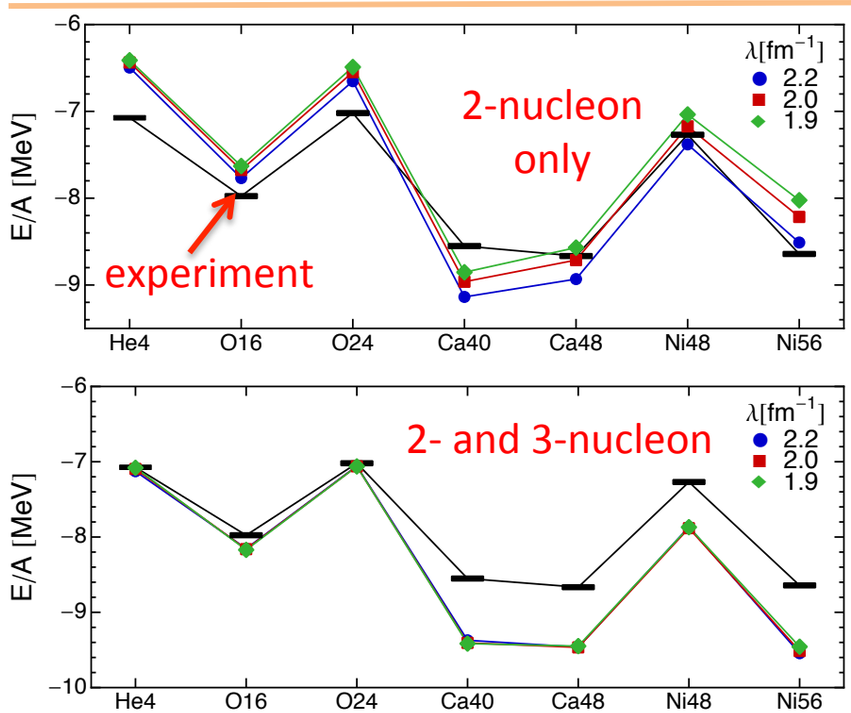
A powerful new ab-initio many-body method for nuclei: The In-Medium Similarity Renormalization Group (IM-SRG)

Objectives

- Develop the IM-SRG as an efficient, comprehensive ab initio framework
- Quantify statistical and systematic uncertainties of theoretical predictions
- Study and benchmark chiral 2- and 3-nucleon interaction effects in medium-mass nuclei

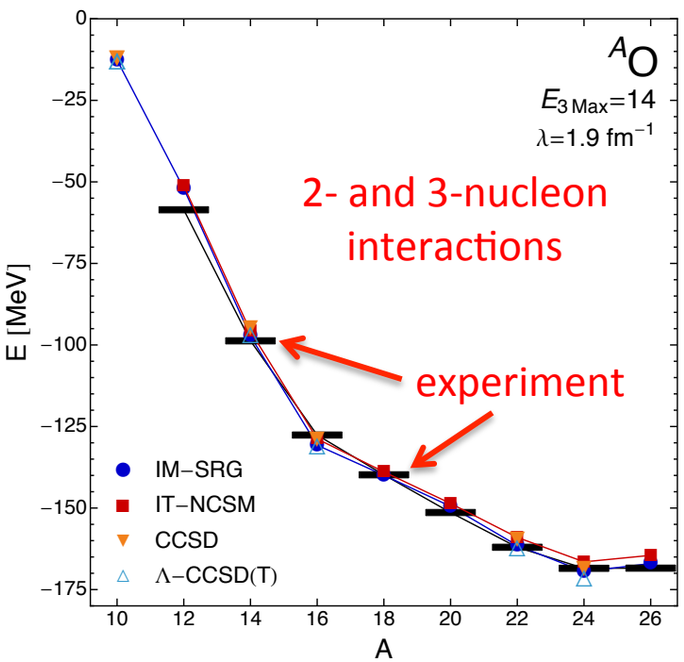
Impact

- Ab initio analysis and prediction of properties for isotopic and isotonic chains, including exotics, with quantifiable theoretical uncertainties
- Microscopic origin of Gamow-Teller quenching, effective charges, and other features
- Ab initio structure input for reaction theory and nuclear astrophysics



Accomplishments

- Complete study of closed-shell nuclei with 2- and 3-nucleon interactions
- Ab initio description of oxygen ground-state energies
- Showed 3-nucleon forces needed for correct systematics



U.S. DEPARTMENT OF ENERGY | Office of Science

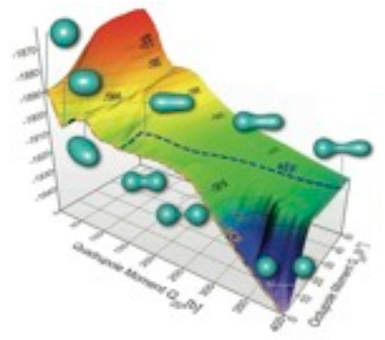
NUCLEI Nuclear Computational Low-Energy Initiative

Reference: H. Hergert, S. Bogner et al., Phys. Rev. C 87, 034307 (2013)

Contact: H. Hergert, hergert.3@osu.edu

Computational Nuclear Physics 2014

Nuclei (II)



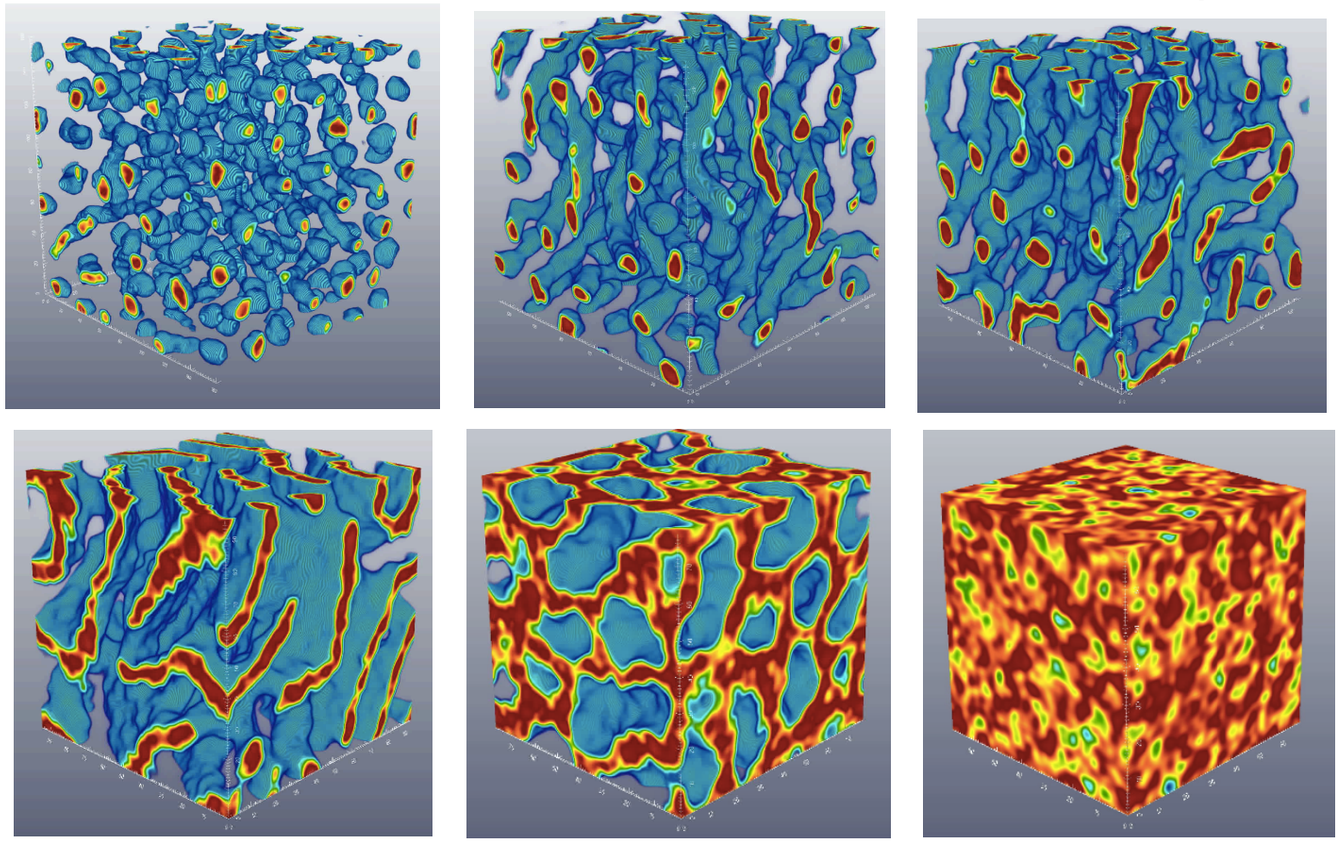
Large scale MD simulations of nuclear pasta formation: Nuclear reactions that make a neutron star

Objectives:

- Determine how core of massive star, during supernova, transforms from 10^{55} separate nuclei into a single large nucleus --- a newly formed neutron star.
- Study large-scale shape oscillations associated with formation of exotic nuclear pasta phases.

Impact:

- Determine time scales for large-scale nuclear shape changes.
- Guidance for multifragmentation and other heavy-ion reactions.
- Determine many transport properties important in astrophysics.



Accomplishments:

- Performed MD simulations with $\leqq$ 300,000 nucleons.
- Directly determined time scales for different nuclear pasta shape changes.

Reference: A. Schneider et al., to be published.

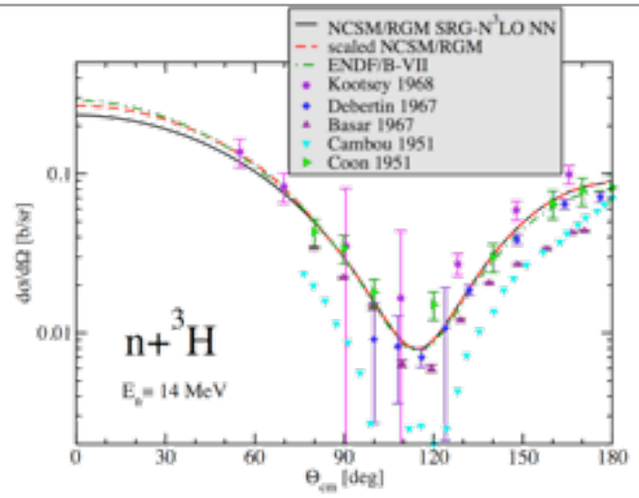
Contact: C. Horowitz horowit@indiana.edu

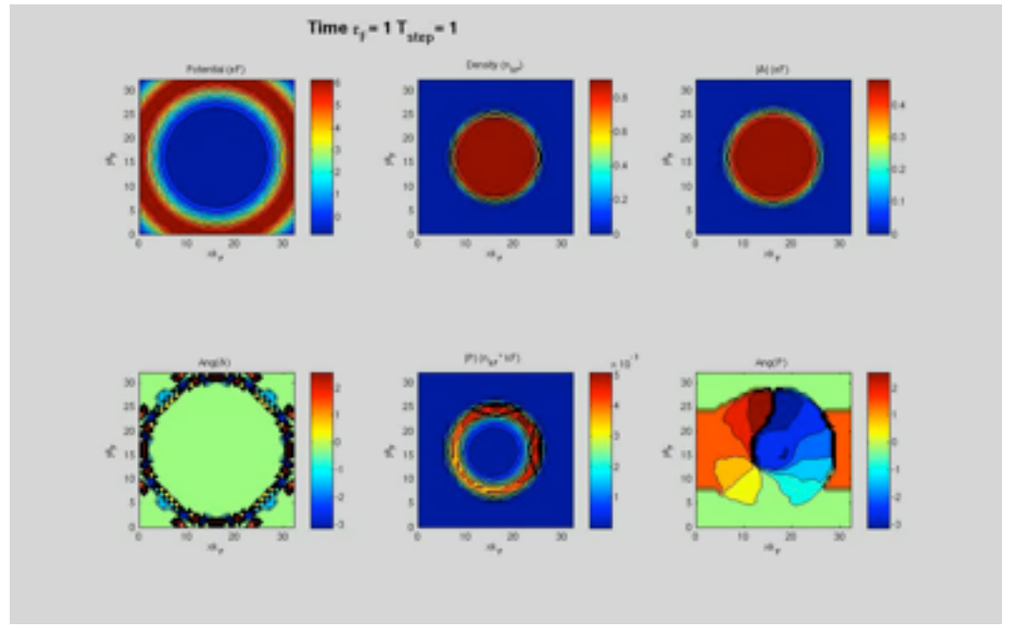
NUCLEI Nuclear Computational Low-Energy Initiative

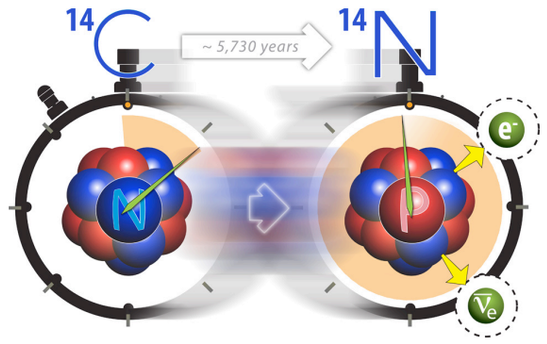
U.S. DEPARTMENT OF ENERGY | Office of Science

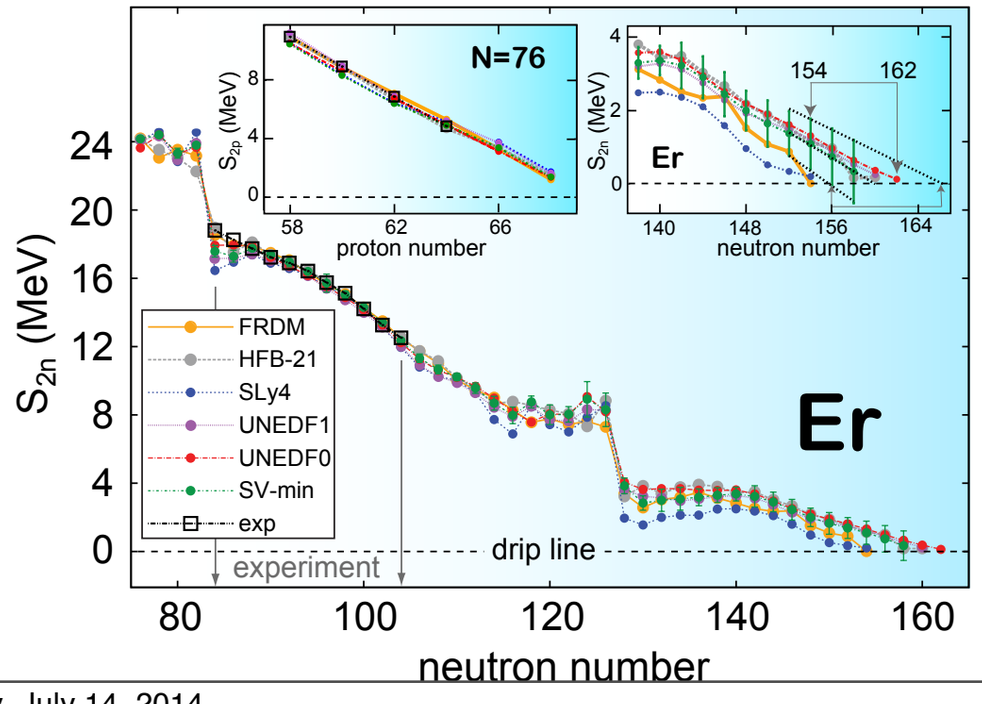
Computational Nuclear Physics 2014

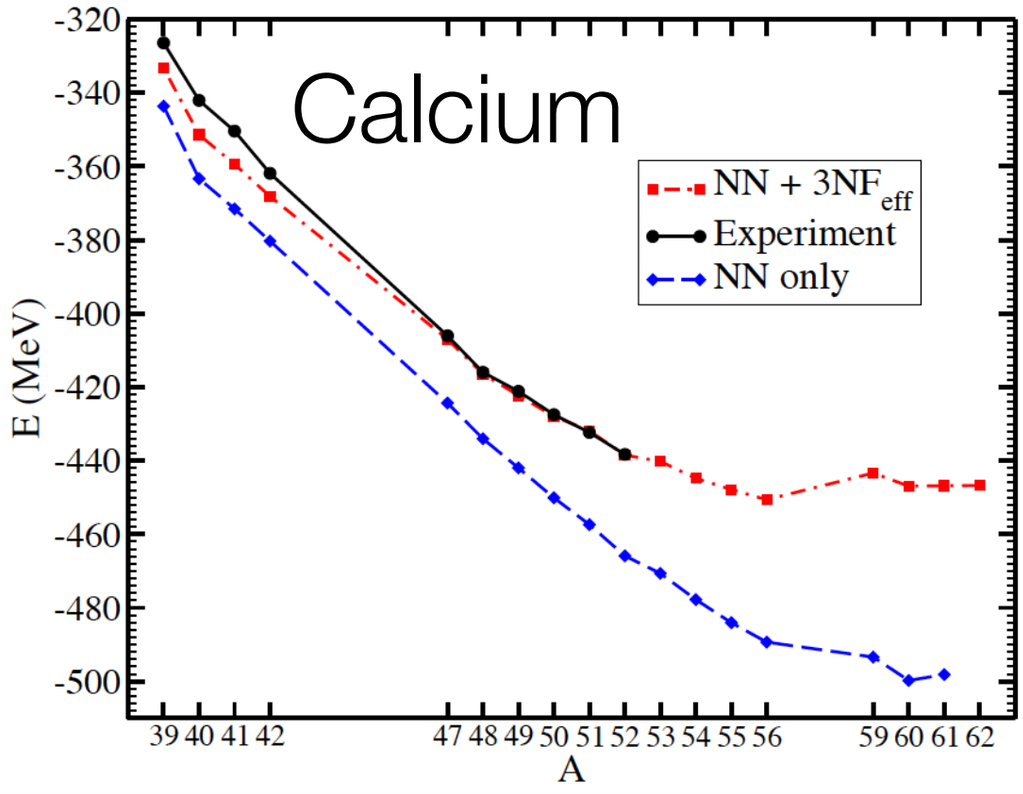
Nuclei (III)



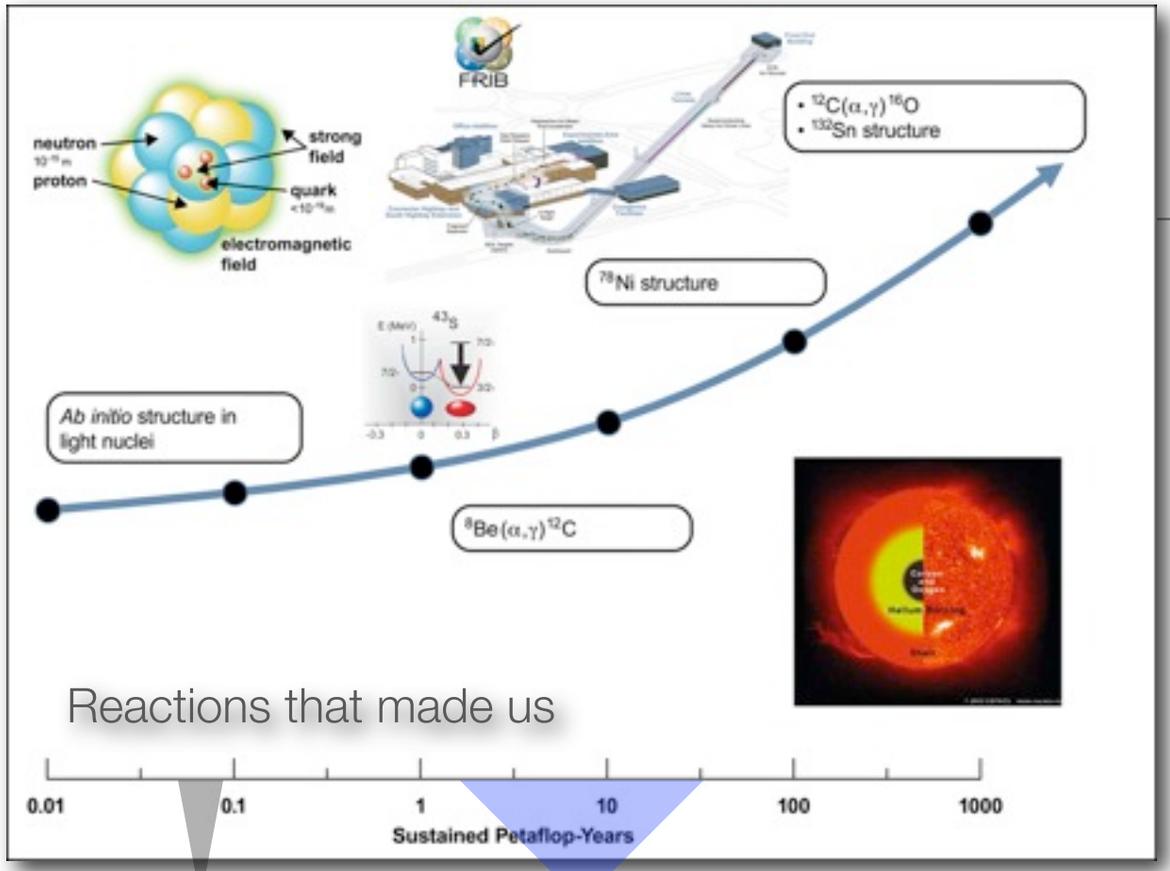


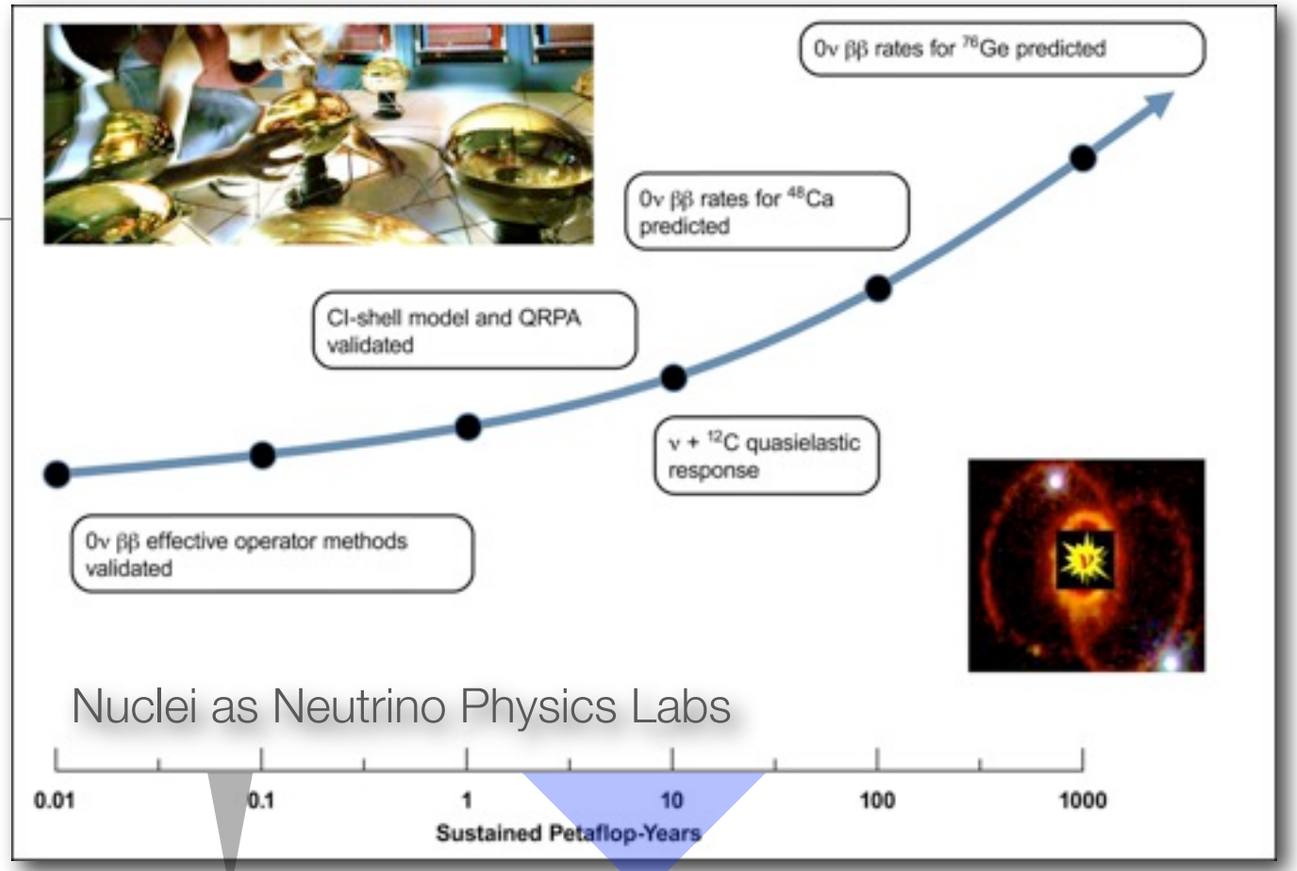


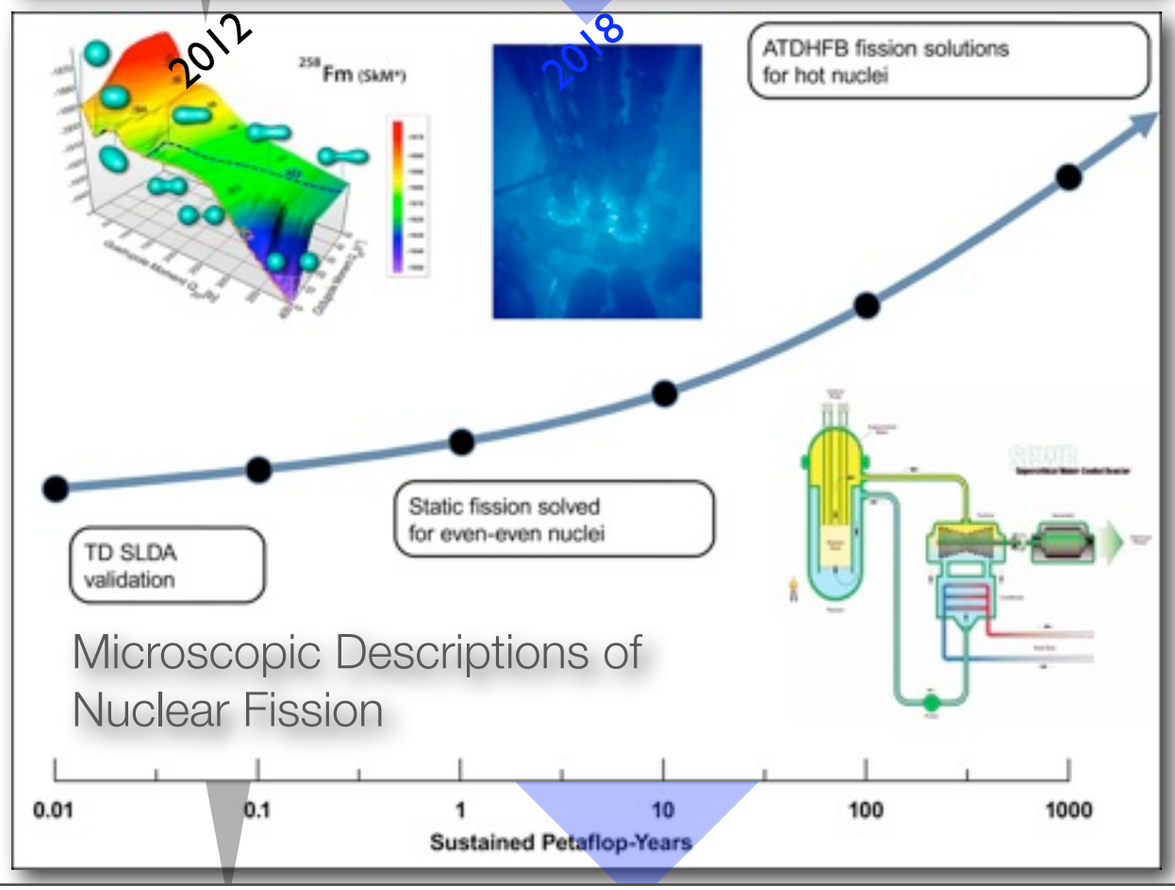


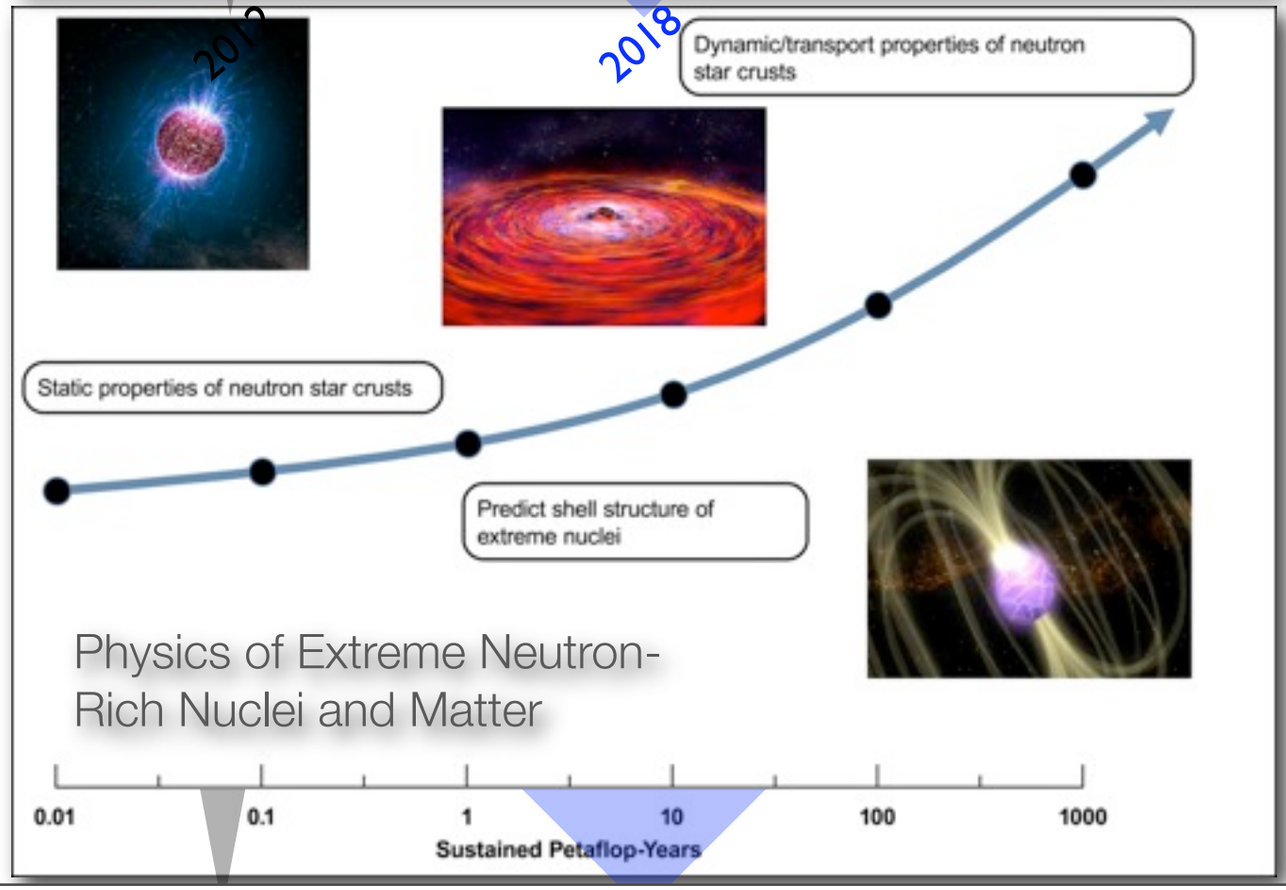


Flat+COLA 2013









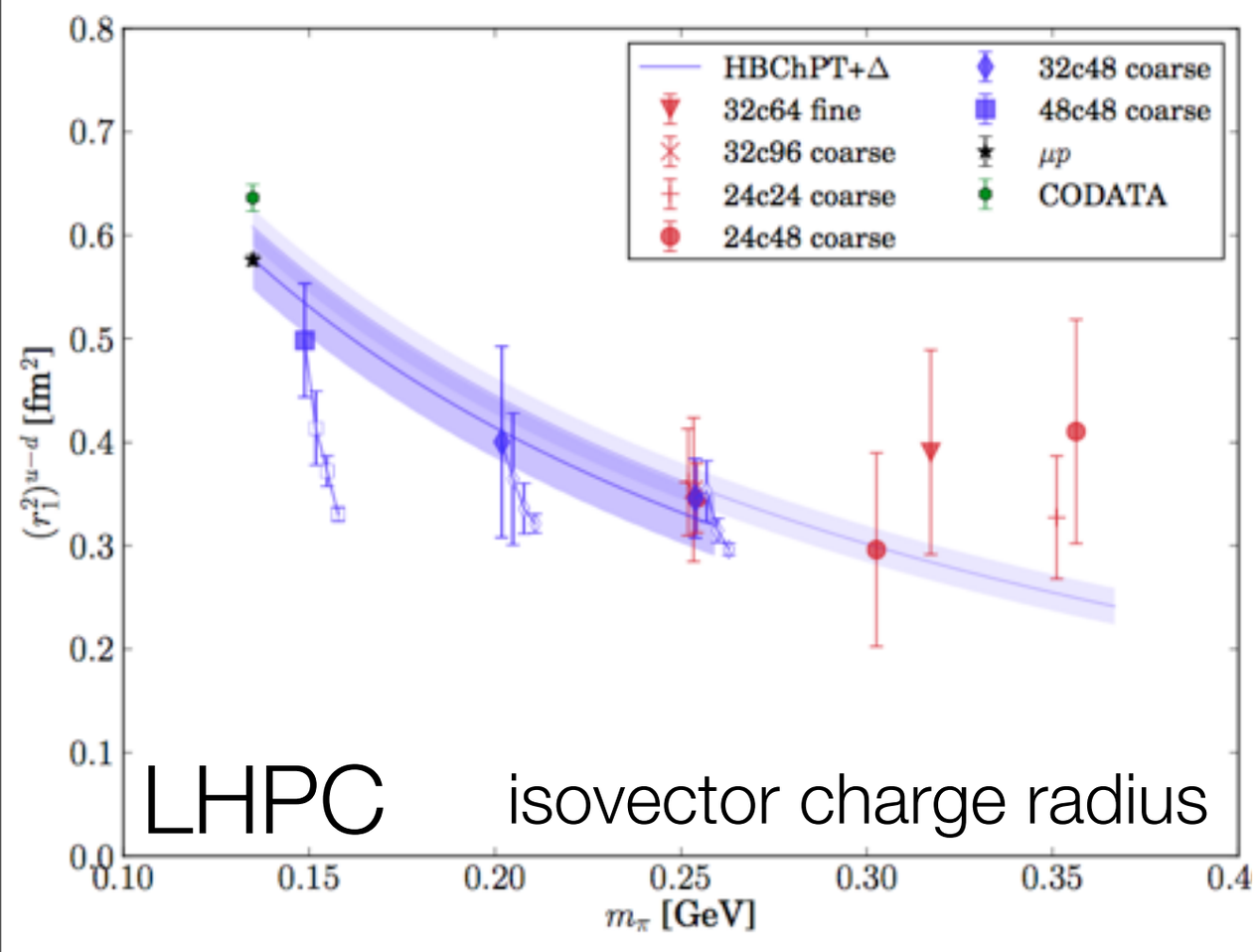
Computational Nuclear Physics 2014

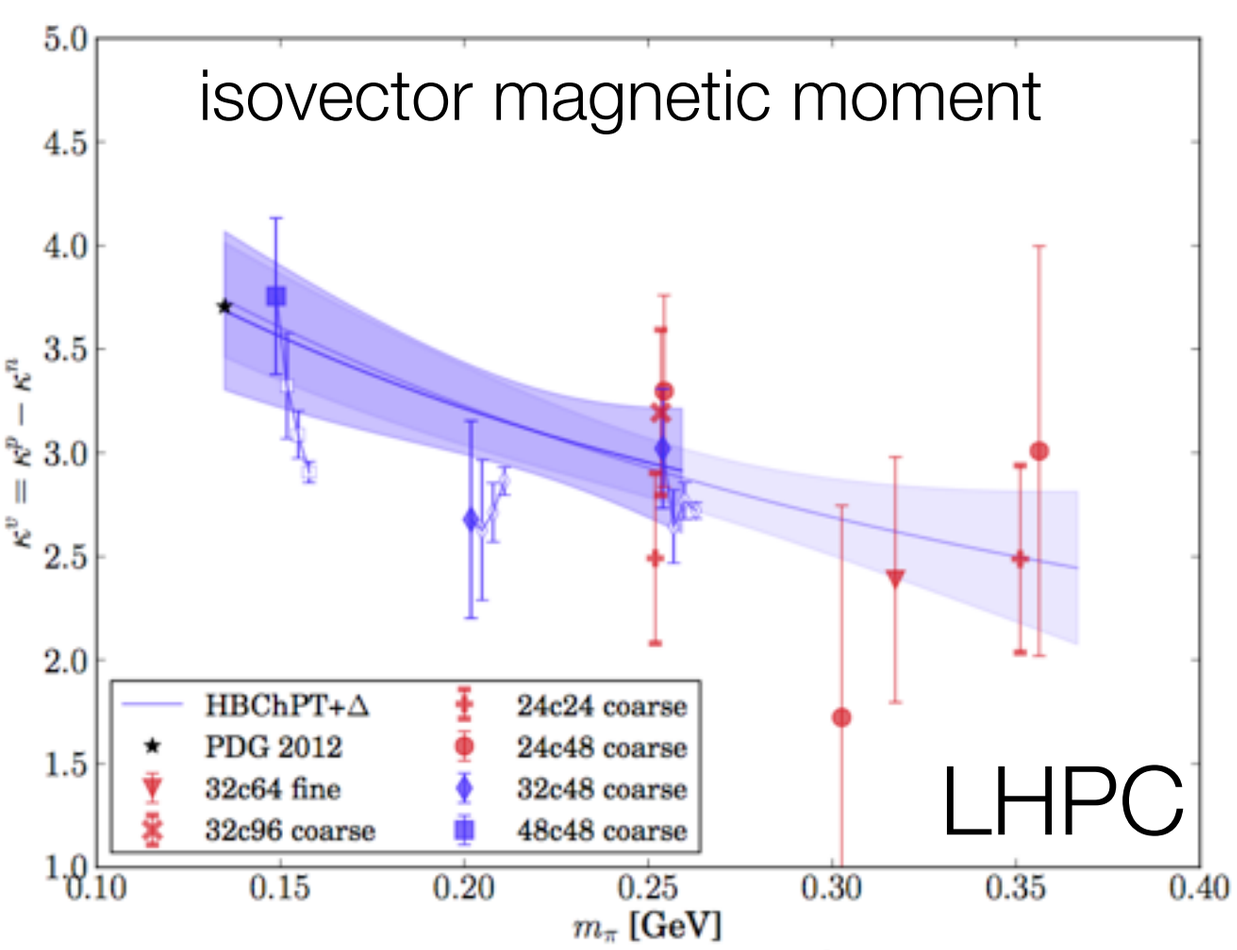
Cold QCD (I) Structure

- 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)

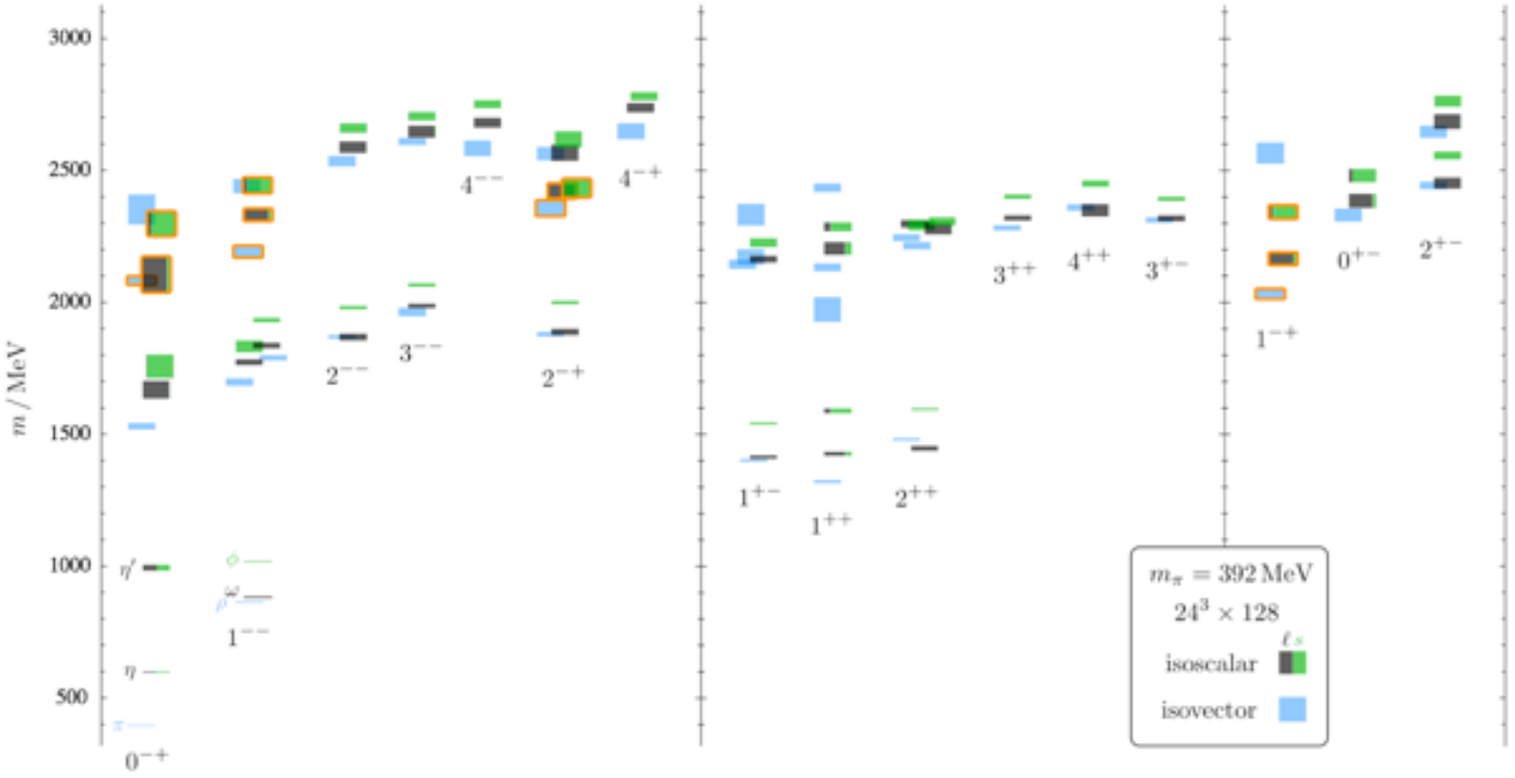




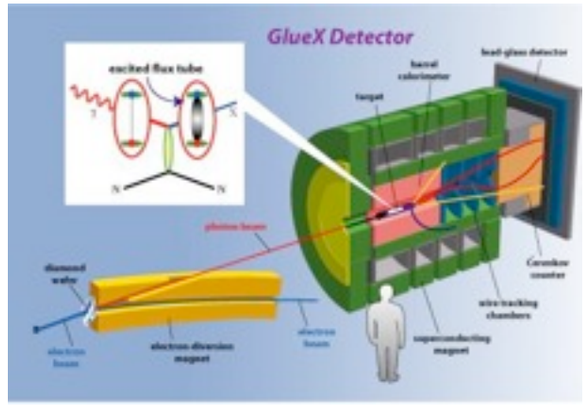
Green *et al,* arXiv:1404.4029

Cold QCD (II) Spectra

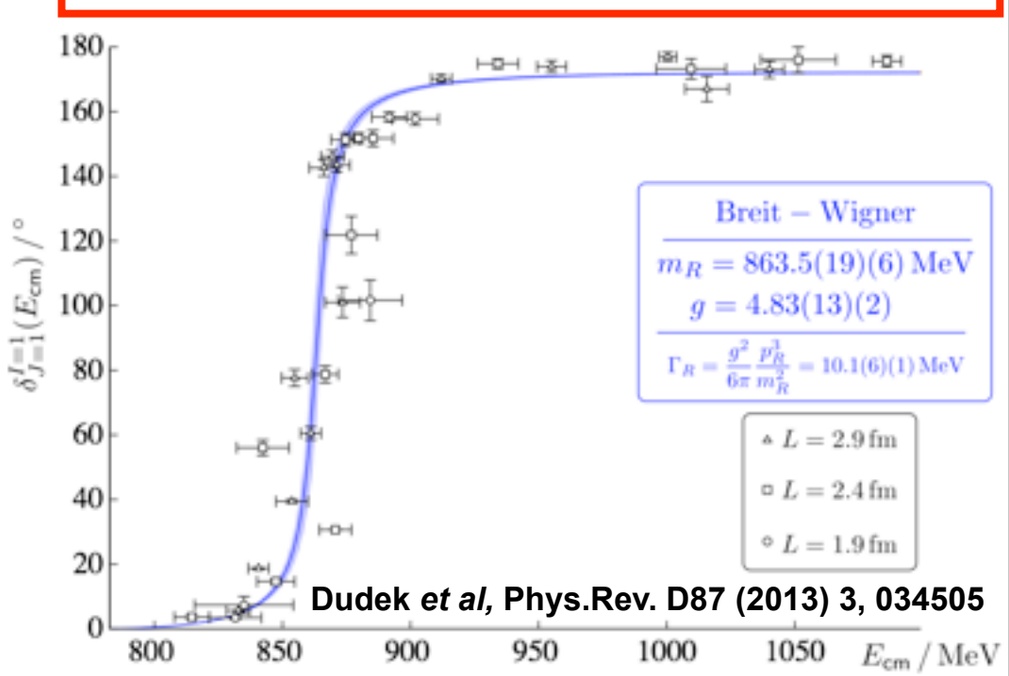
- Spectrum of mesons and baryons
  - exotics, molecules
  - coupled channels, etc
  - provided motivation for 12 GeV upgrade



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



ρ- resonance successfully determined



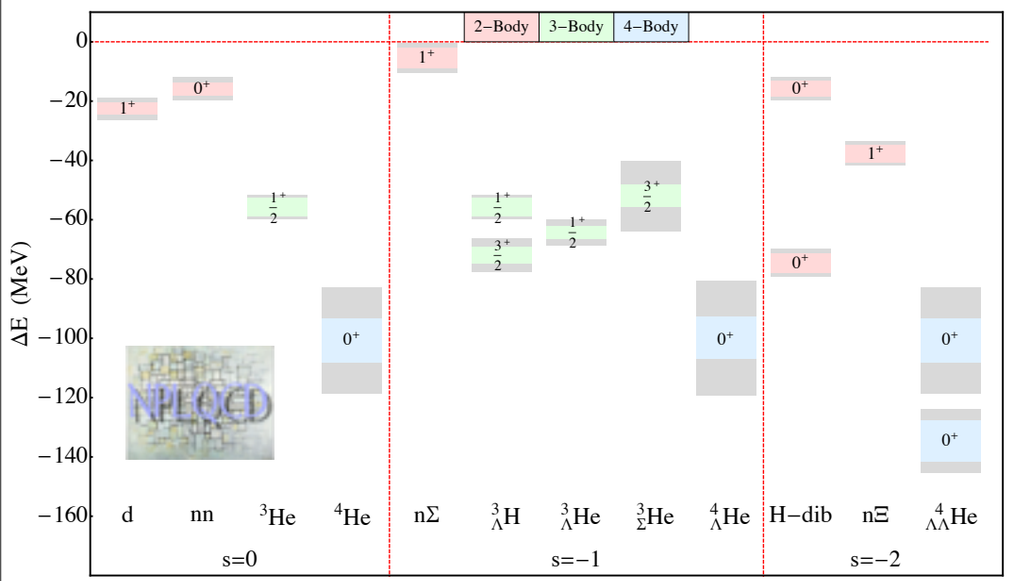
Dudek *et al*, Phys.Rev. D87 (2013) 3, 034505

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

(with sufficient compute resources)

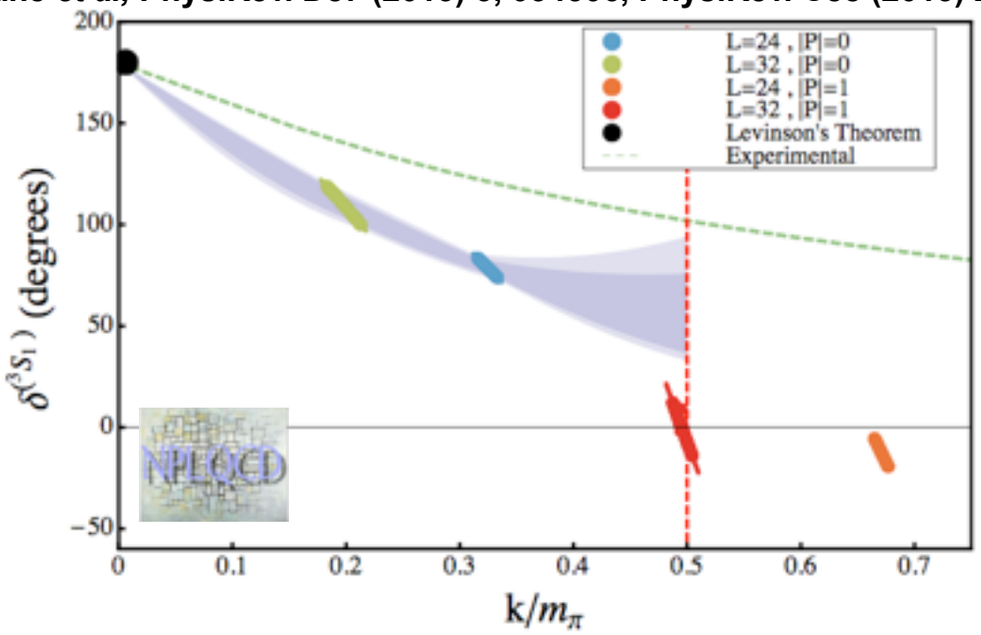
Computational Nuclear Physics 2014

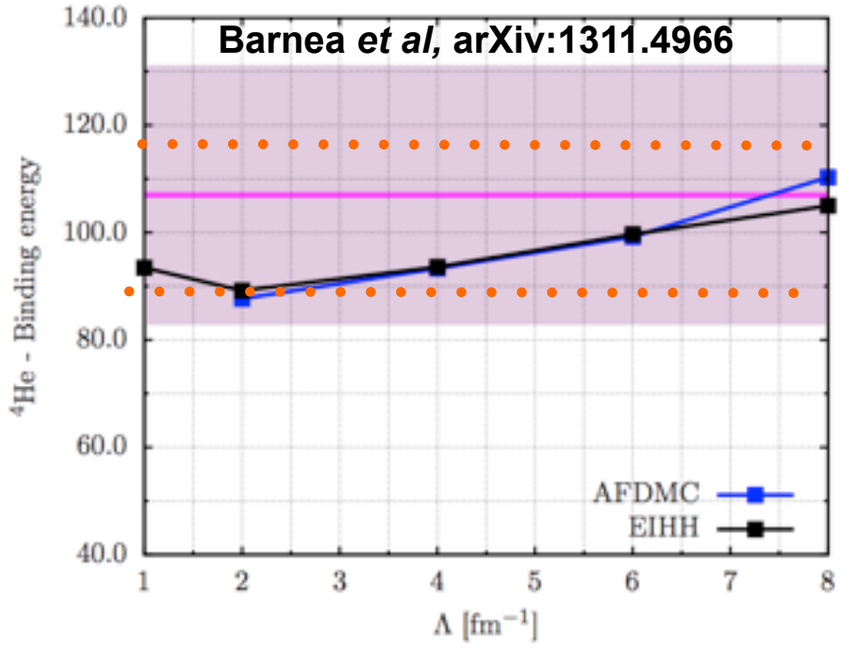
Cold QCD (III) Nuclear Forces

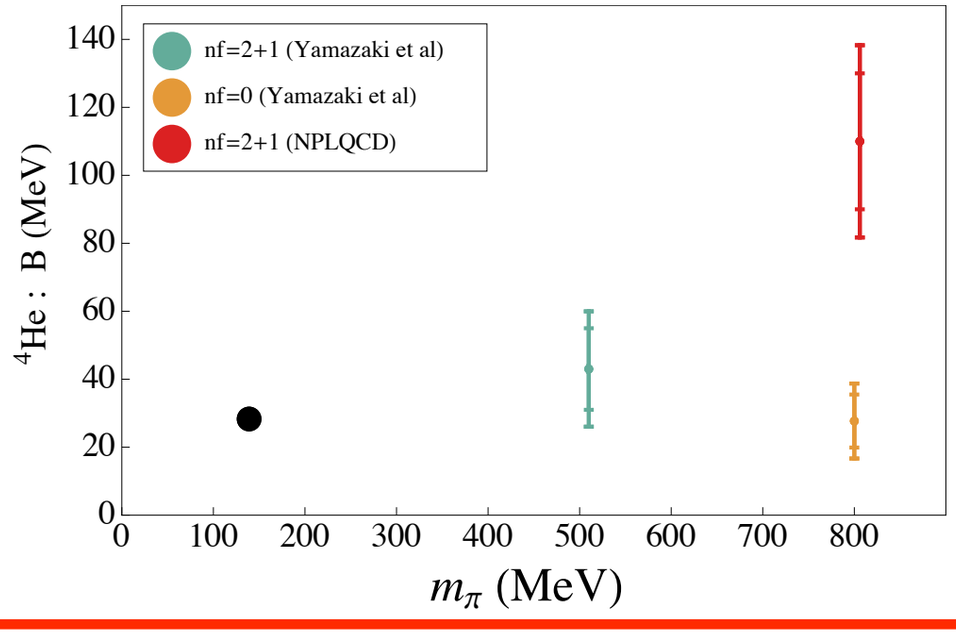


m_π ~ 800 MeV

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

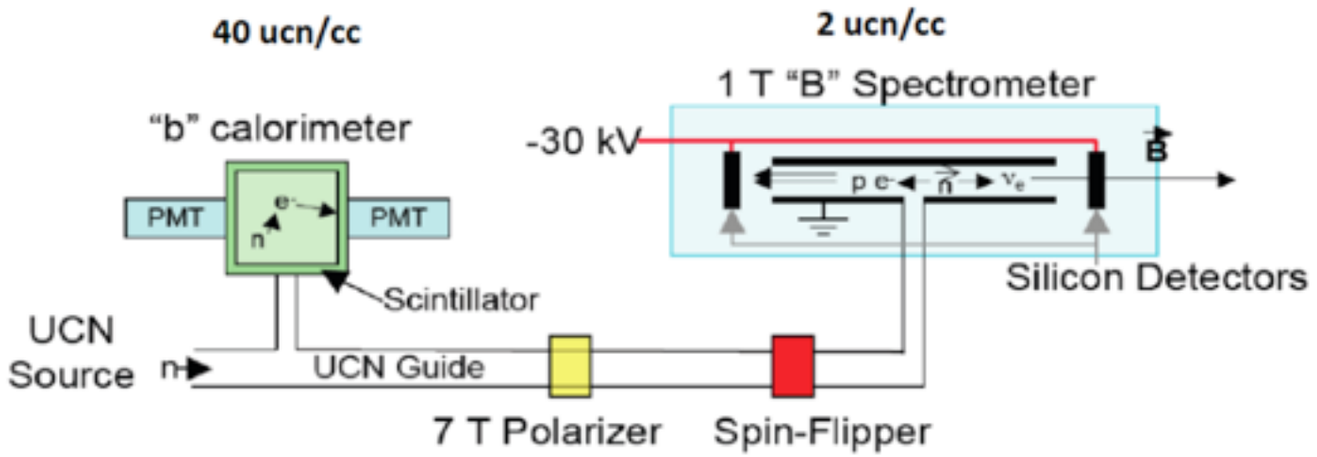






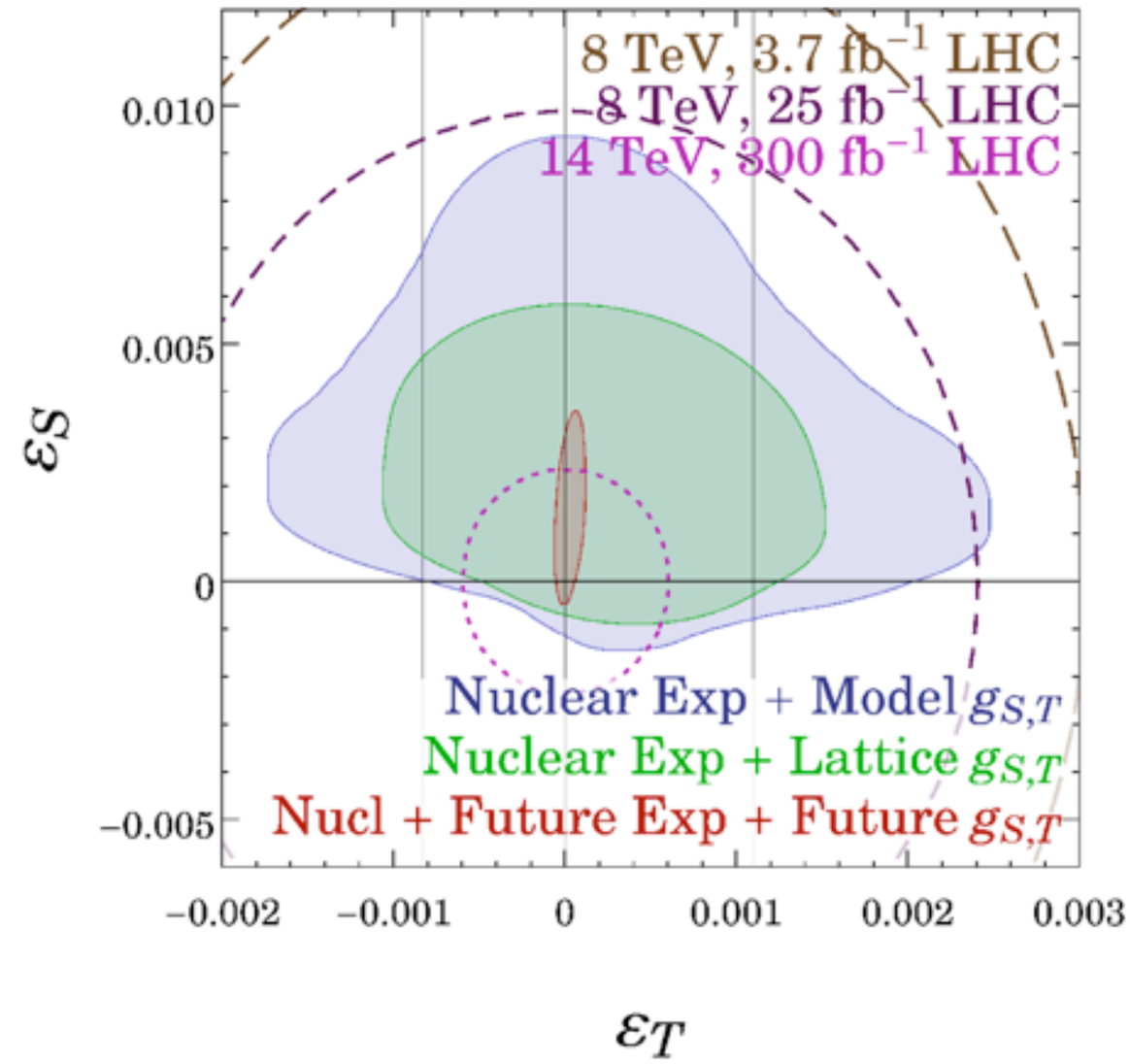
Extensive study of s-shell nuclei and hypernuclei, and baryon-baryon interactions at SU(3) symmetric point

Fundamental Interactions



LANL experiment

- LQCD calcs at pion mass of 220 MeV
- Looking toward 140 MeV

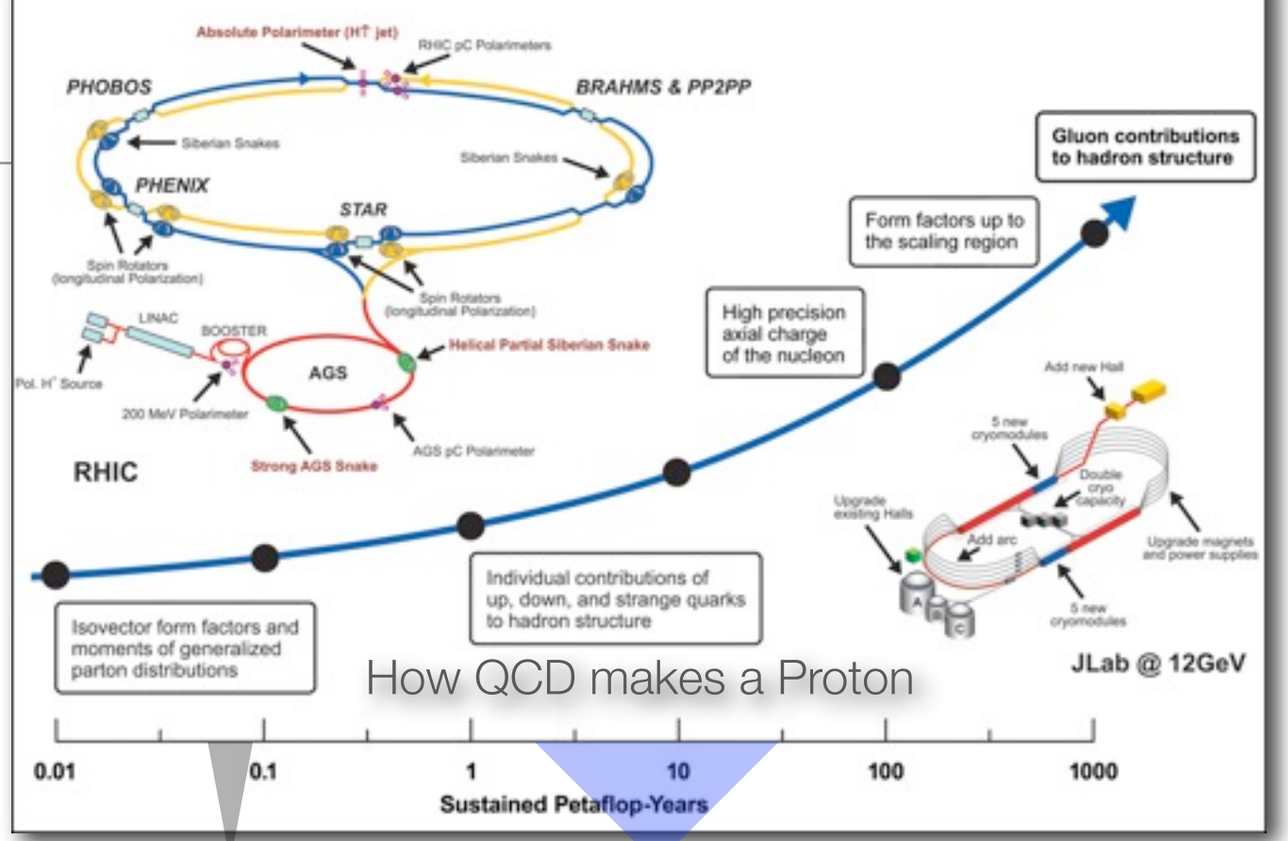


PNDME collab

Bhattacharya et al, Phys.Rev. D89 (2014) 9, Phys.Rev. D85 (2012) 054512

Flat+COLA 2013

Spectrum of QCD

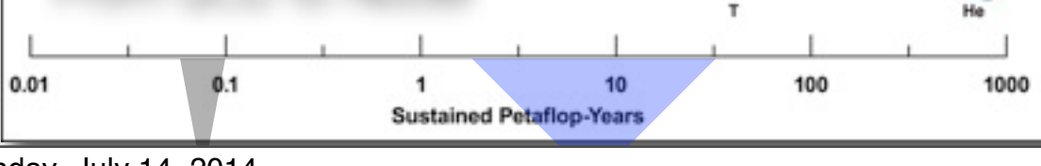


How QCD makes a Proton

2012

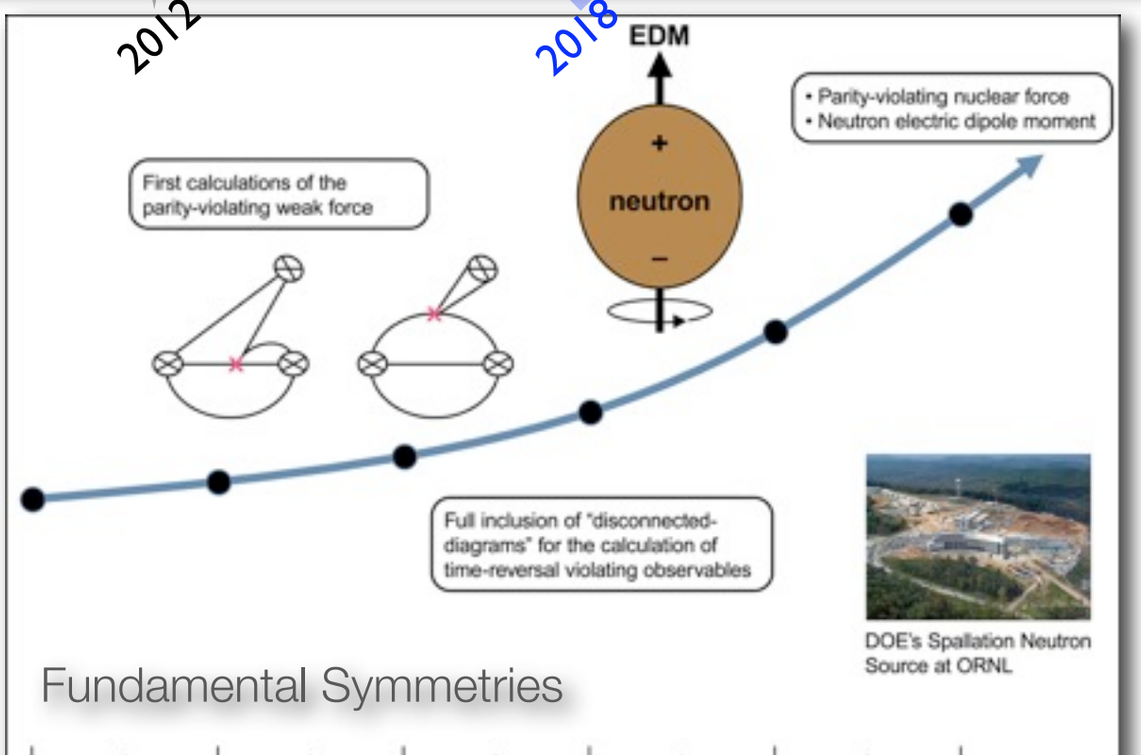
2018

From QCD to Nuclei



2012

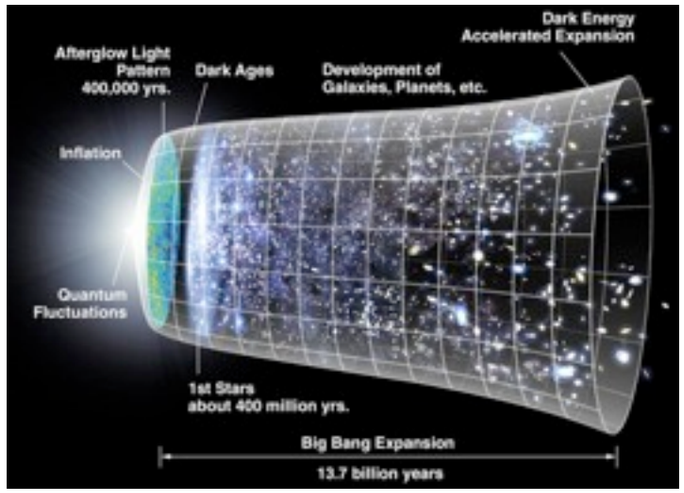
2018



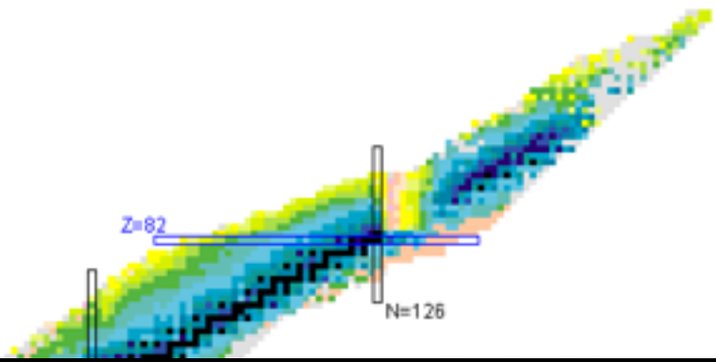
Fundamental Symmetries

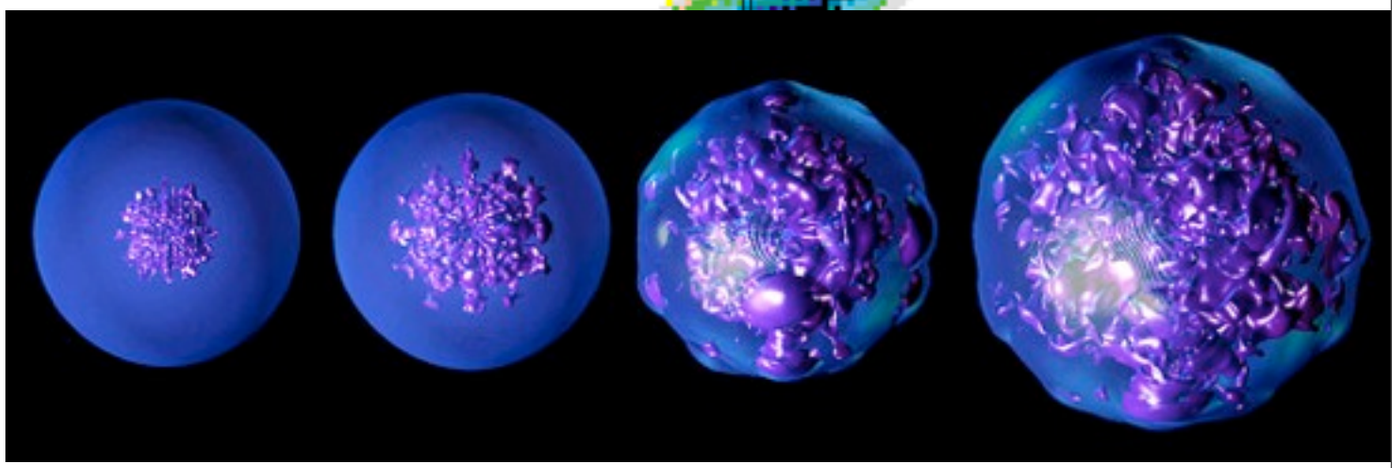
Computational Nuclear Physics 2014

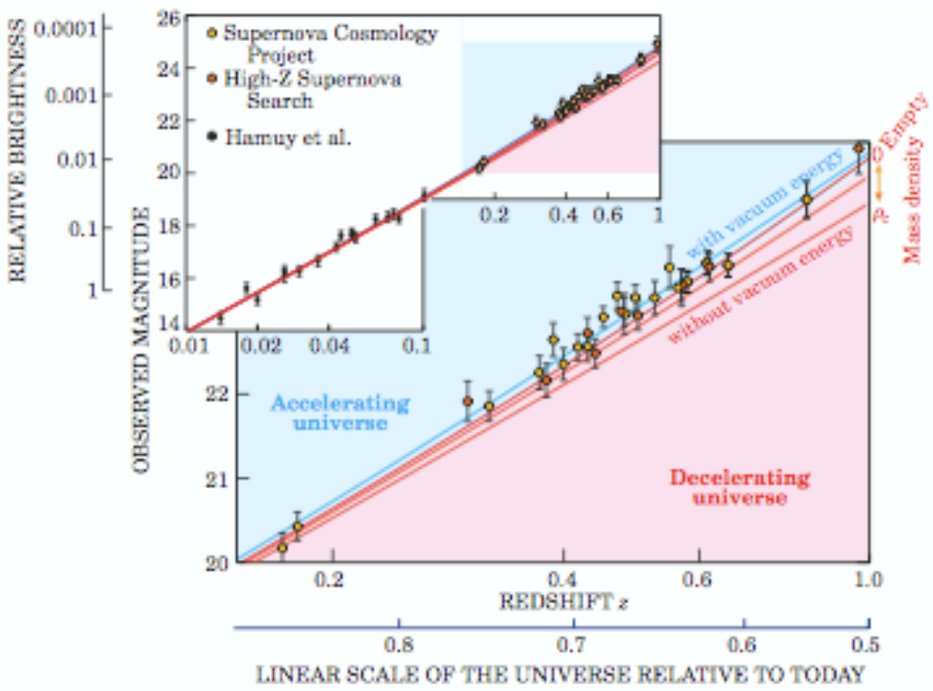
Nuclear Astrophysics (I)

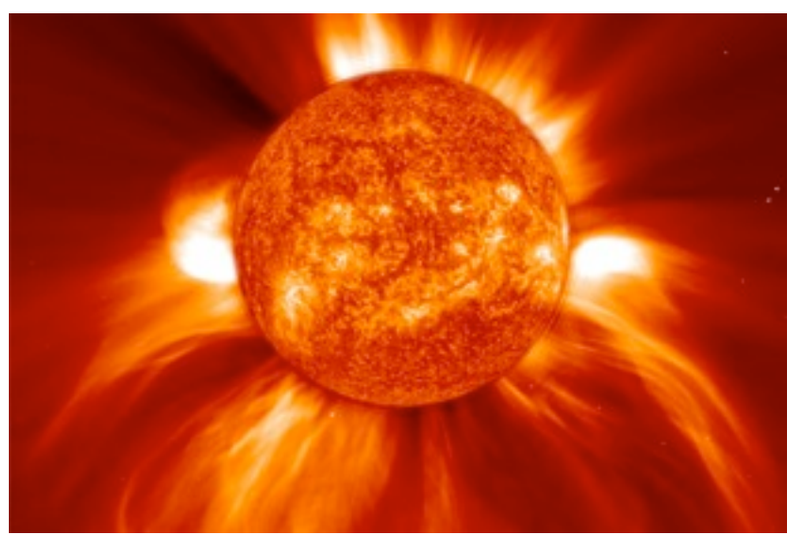




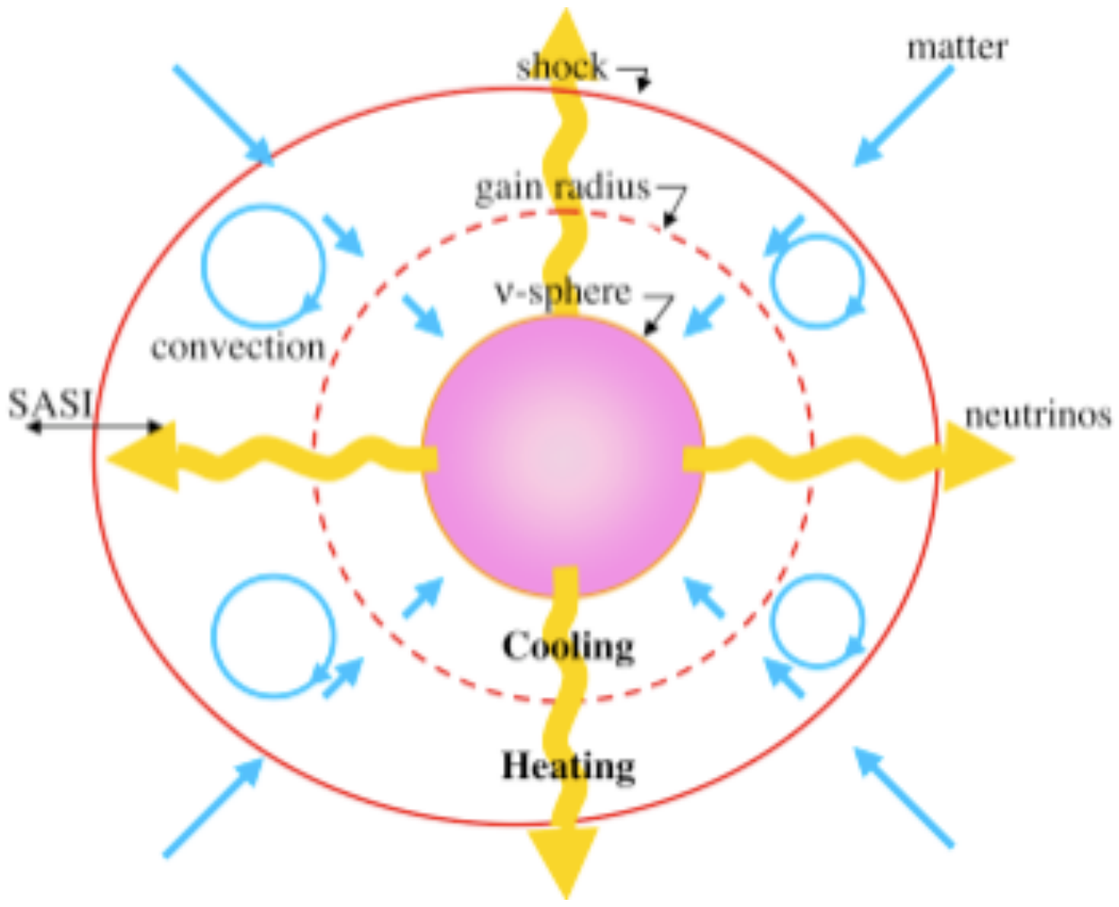


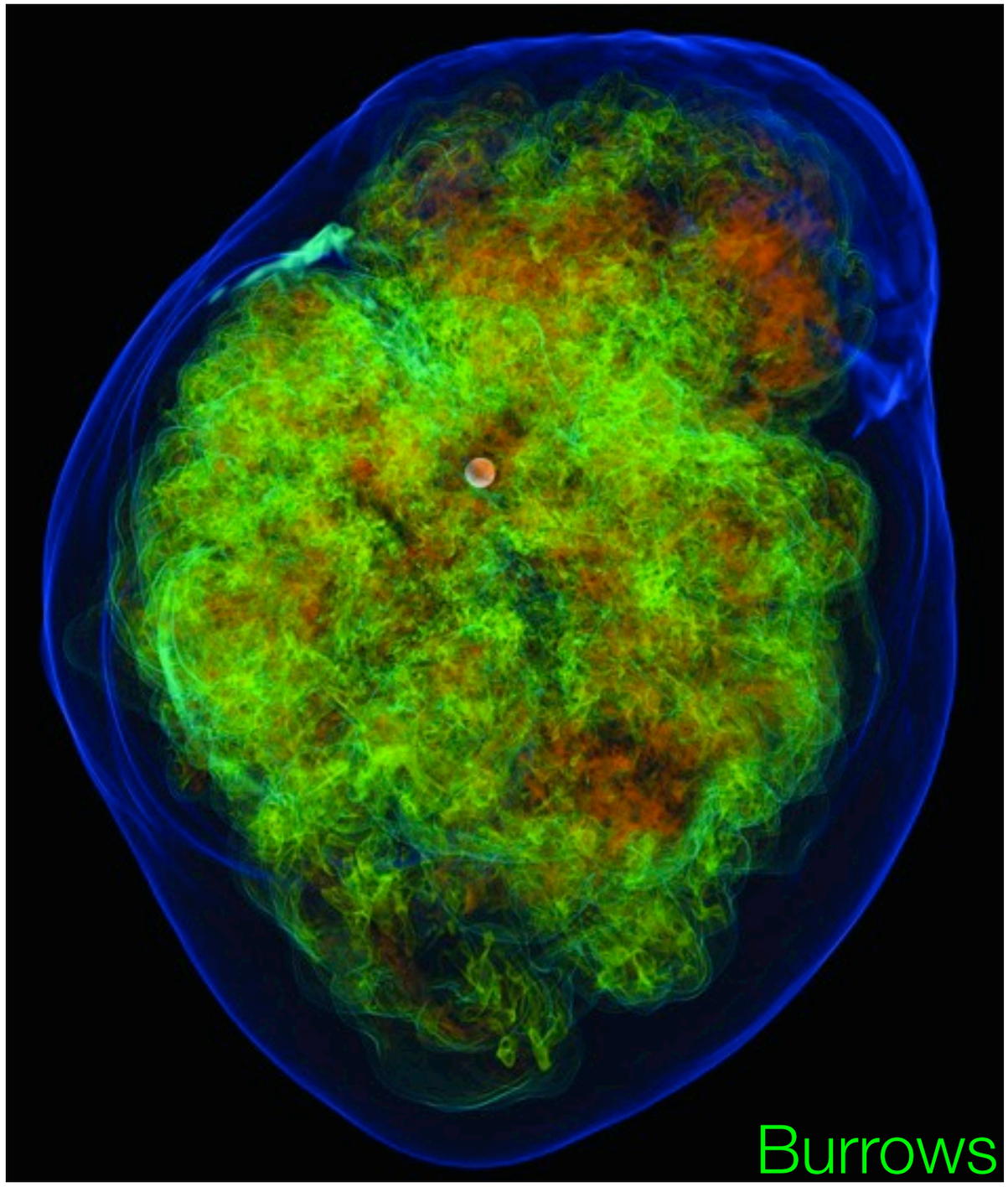






Nuclear Astrophysics (II)





Computational Nuclear Physics 2014

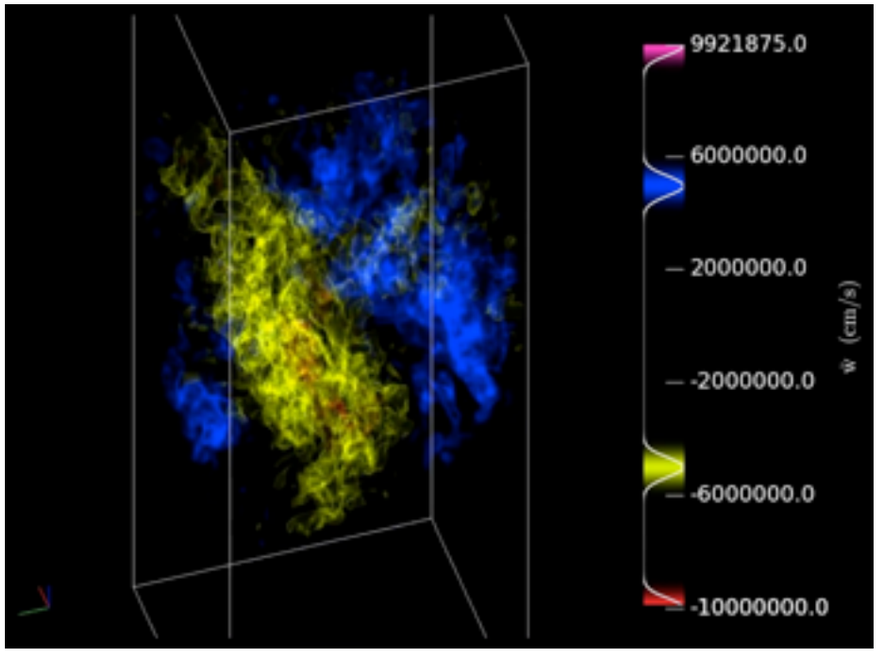
Nuclear Astrophysics (III)

- Development of 3D codes for the study of core-collapse supernovae
  - superceding the previous 2D capability

- The emergence of realistic whole-star 3D models for thermonuclear supernova explosions (Type Ias) with the deflagation to detonation transition

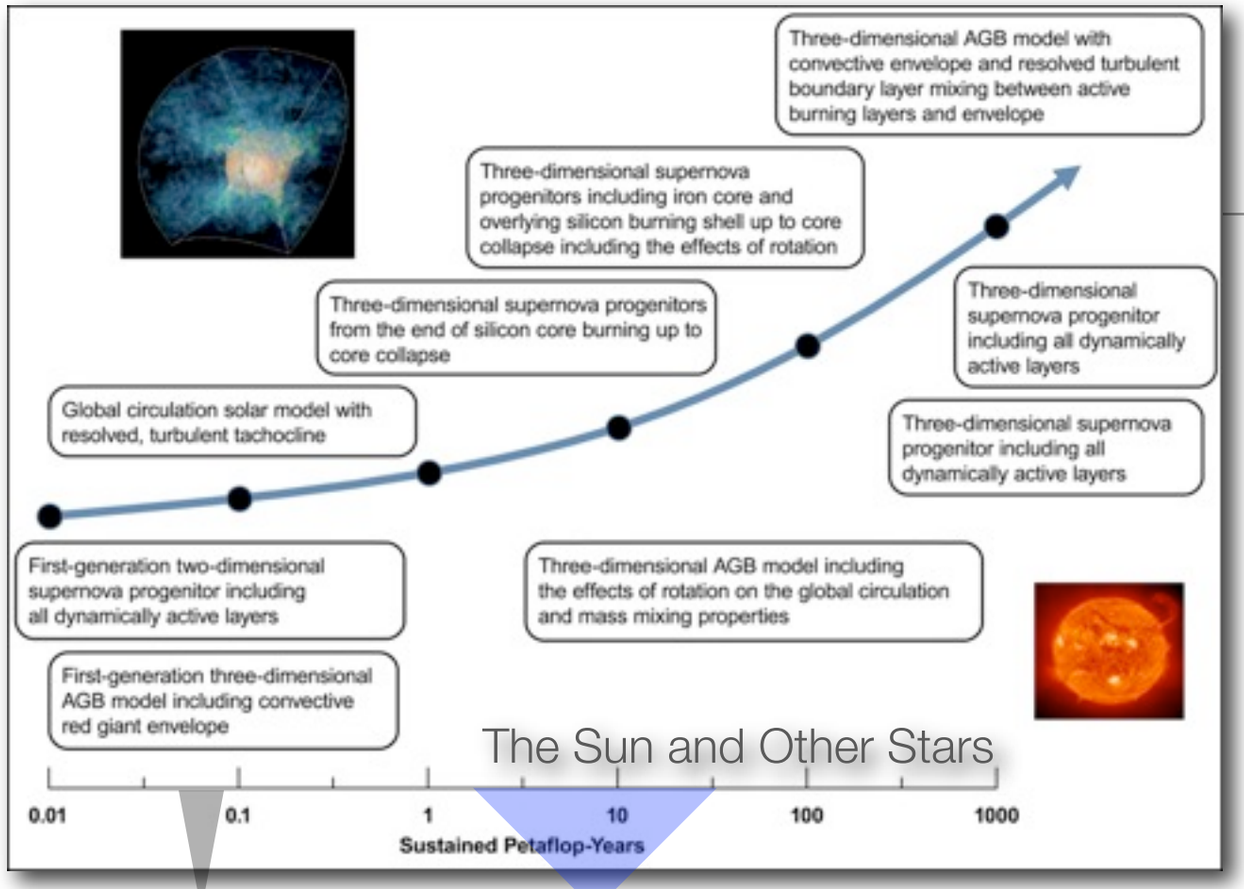
- Publication of the first detailed 2D snd 3D stellar evolution calculations, going beyond the traditional 1D models with ad hoc mixing-length convection theory

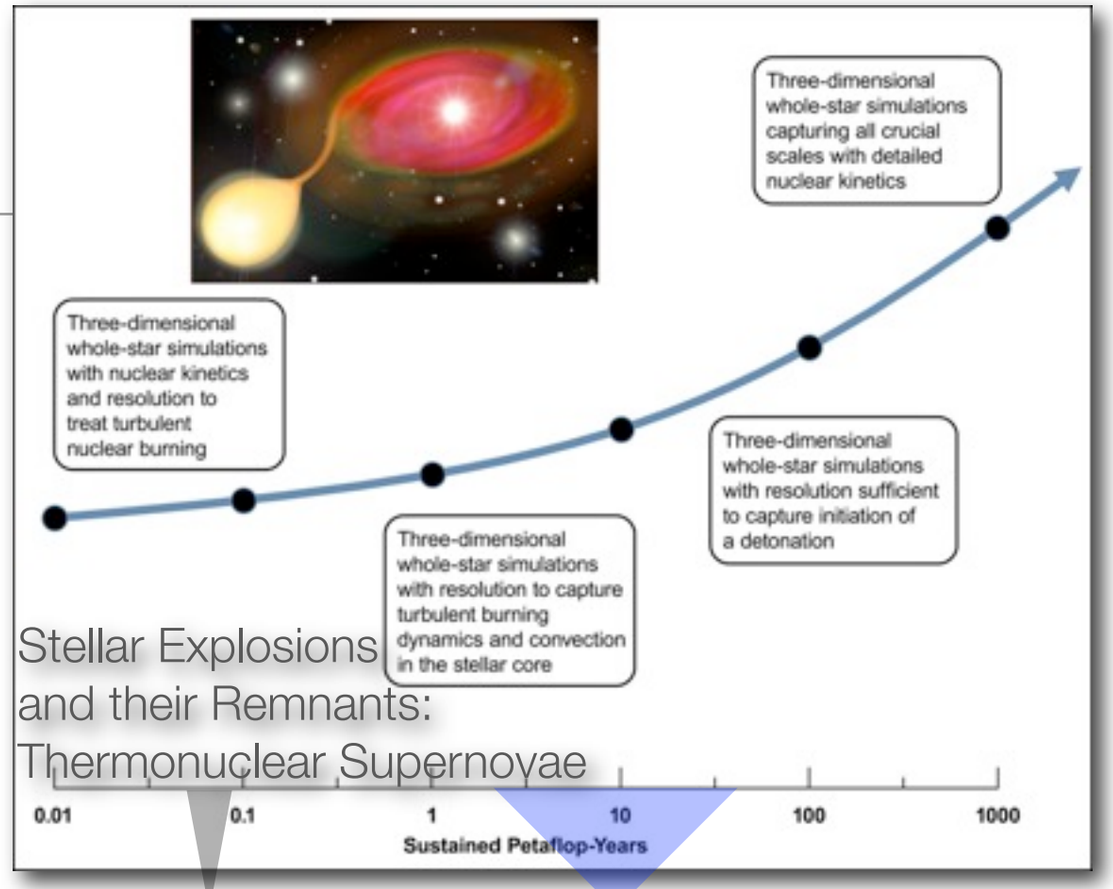
- The first neutron-star/neutron-star merger simulations in full general relativity with magnetic fields.

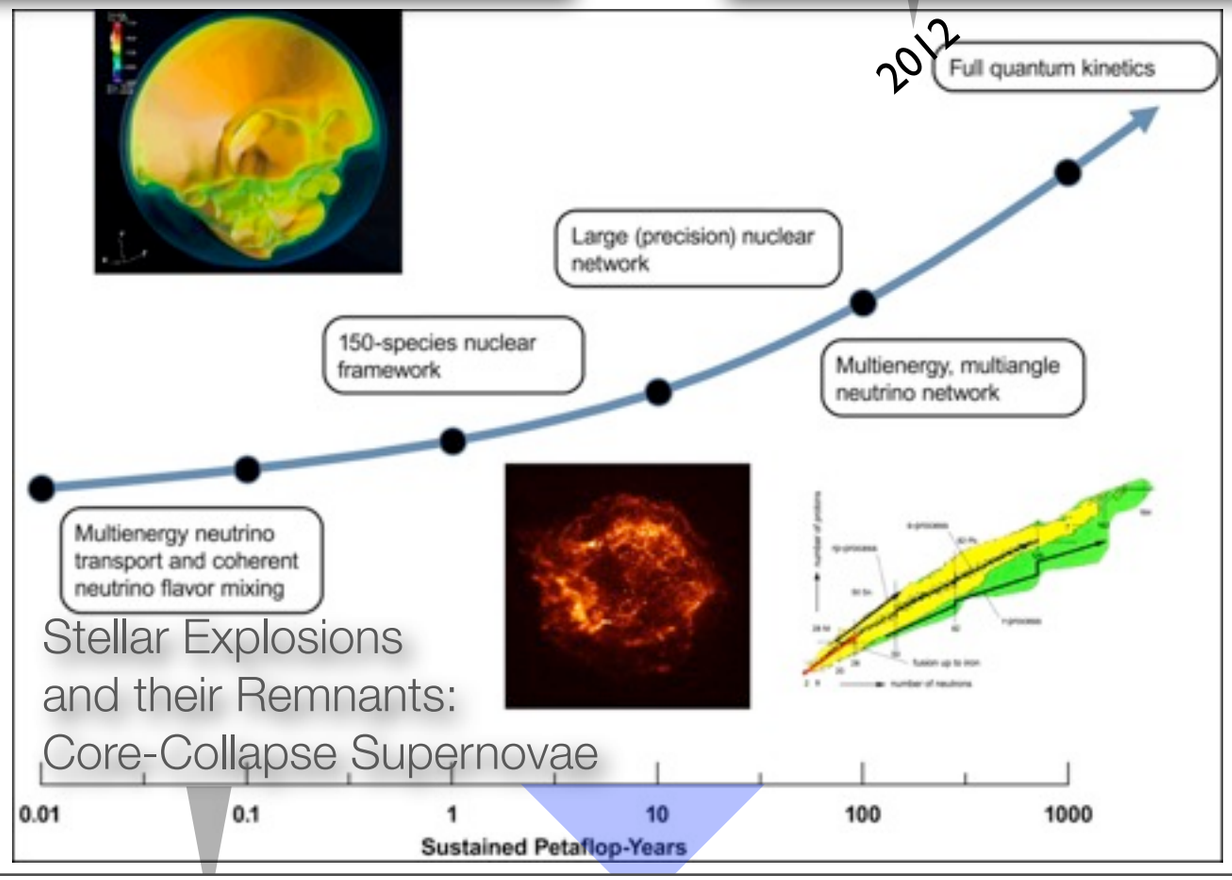


Convection in X-ray Bursts (Zingale)

Flat+COLA 2013







(* Significantly slowed due to SciDAC de-funding)

Summary (I)

- We have witnessed truly remarkable progress between 2007 and 2014
  - Nuclear Physics community is organized
  - scientific goals are well-defined
  - resource requirements identified and clearly articulated
  - junior scientists are being hired into Labs and Universities
    - visible in larger community

- HPC is essential to the success of NP experimental program and overall mission of Nuclear Physics

Summary (II)

- Our needed compute resources are significantly larger than those currently available
  - expected compute resources from traditional sources are less than Moore's Law

- Clear need for more support for people with HPC orientation, either within NP or collaborative
  - particularly true with expected machines architectures

END