NUCLEI SciDAC Project

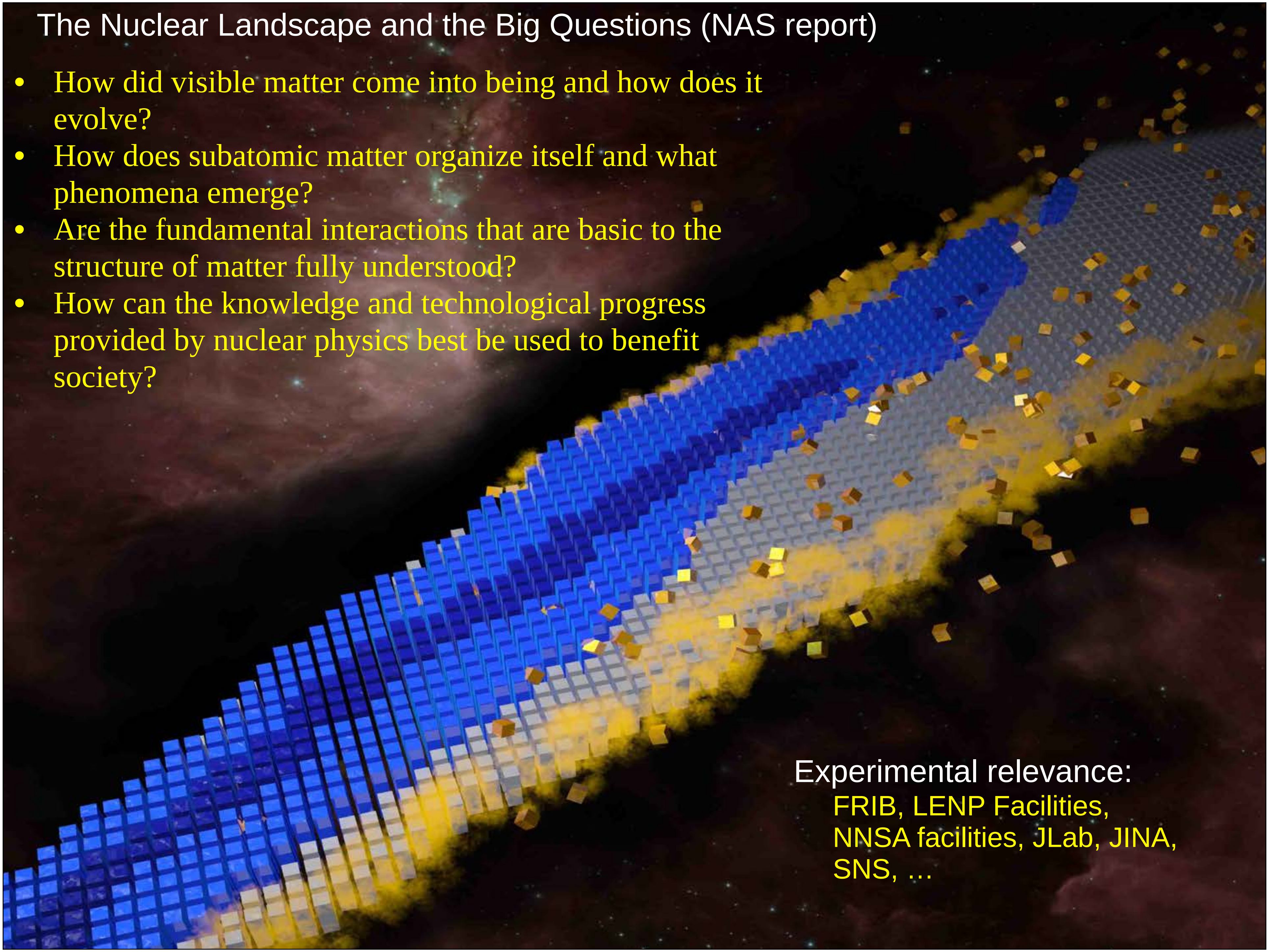
PI: Joe Carlson, LANL
Math/CS Co-Director: Rusty Lusk, ANL
Physics Co-Director: Witold Nazarewicz, UT

NUCLEI

Nuclear Computational Low-Energy Initiative

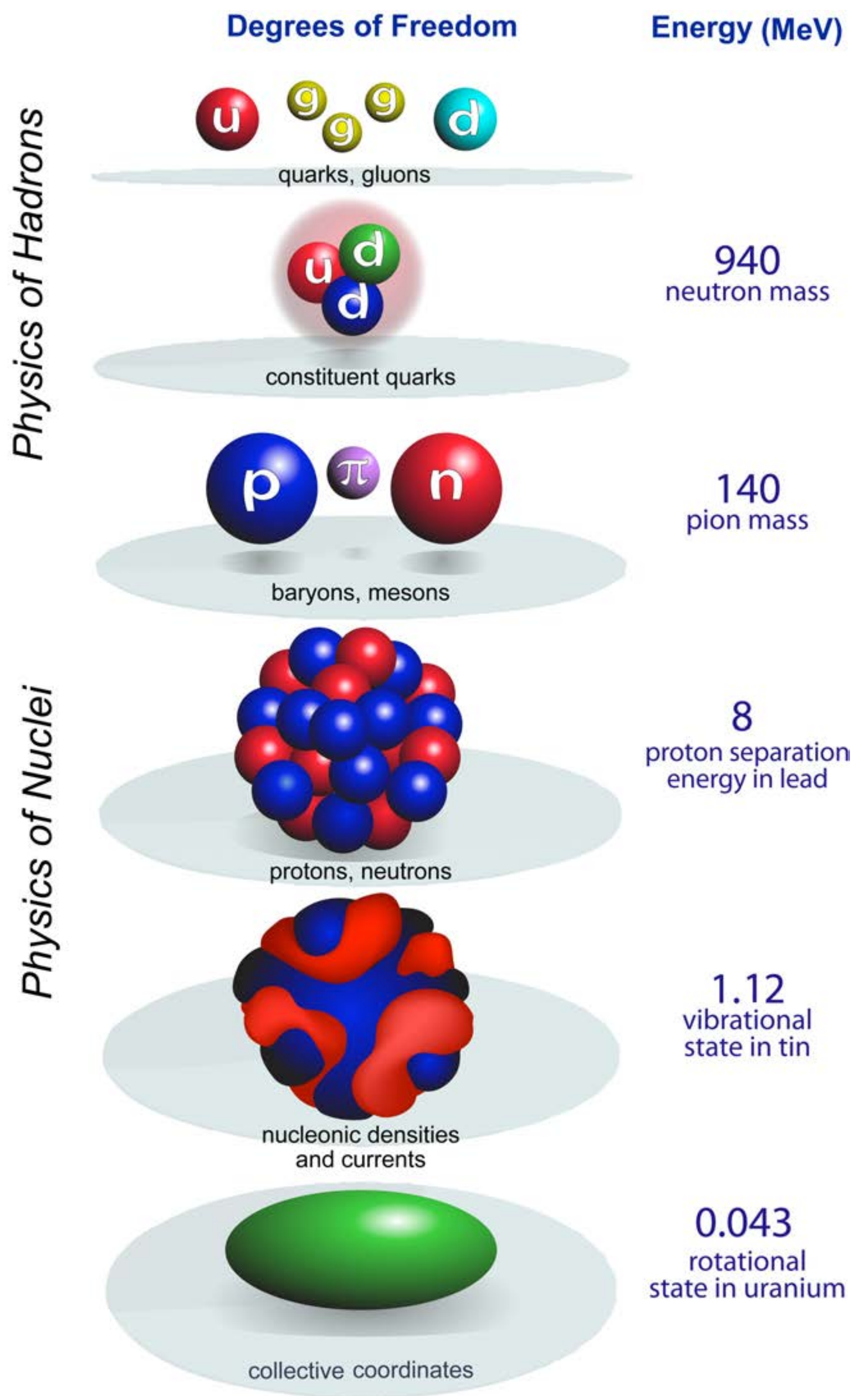
The Nuclear Landscape and the Big Questions (NAS report)

- How did visible matter come into being and how does it evolve?
- How does subatomic matter organize itself and what phenomena emerge?
- Are the fundamental interactions that are basic to the structure of matter fully understood?
- How can the knowledge and technological progress provided by nuclear physics best be used to benefit society?



Experimental relevance:

FRIB, LENP Facilities, NNSA facilities, JLab, JINA, SNS, …



Major Physics Goals

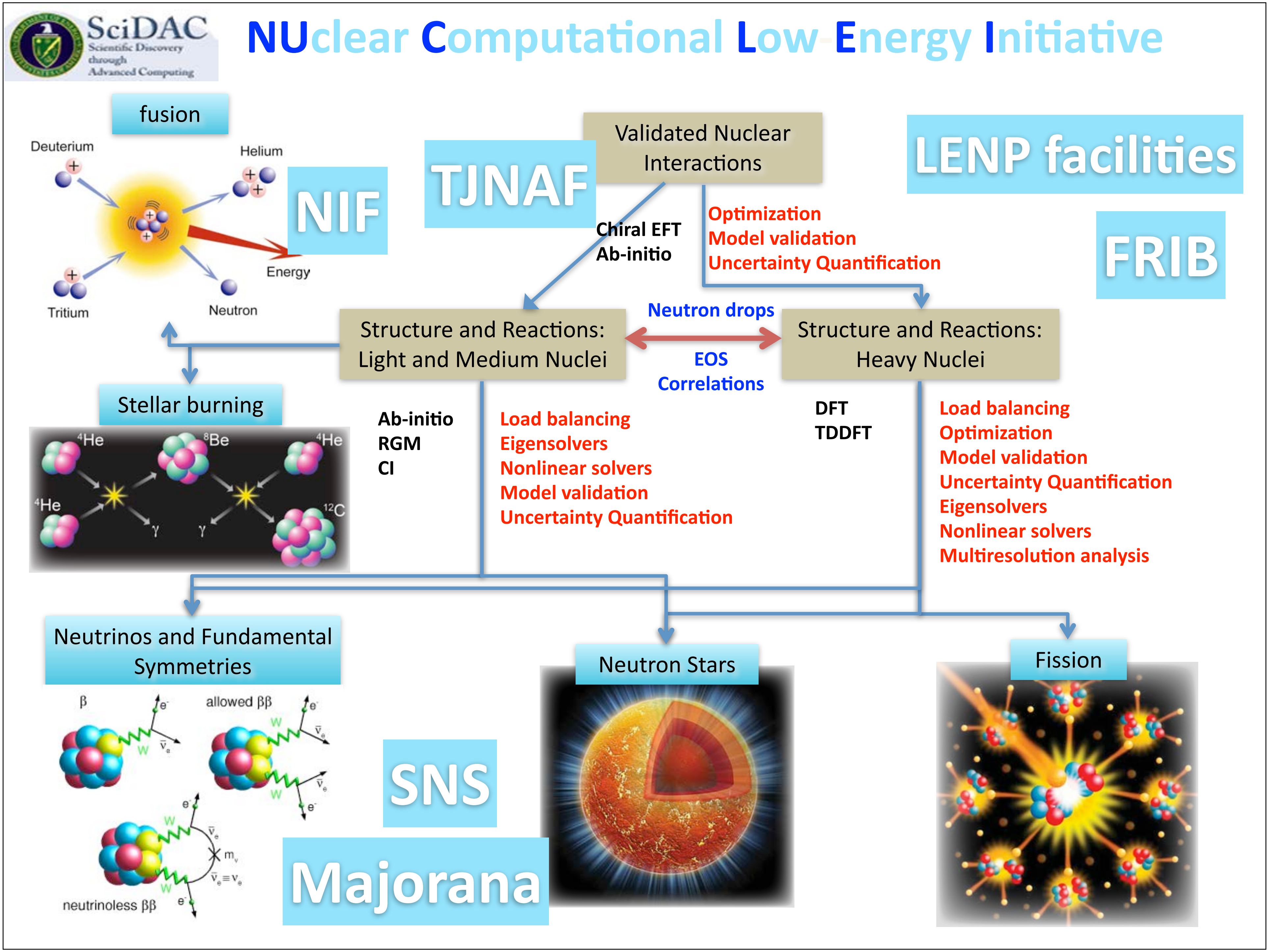
Nuclear Interactions and Structure:
chiral EFT, light nuclei,

Reactions in light nuclei:
BBN, solar neutrinos,
accelerator neutrinos, NIF, ...

Density functional theory
FRIB, fission, astrophysics

Nucleonic matter:
neutron stars, ν opacities

NUclear Computational Low Energy Initiative



NUCLEI council:
Richard Furnstahl, OSU
Mihai Horoi, CMU
Hai Ah Nam, ORNL ←
Esmond Ng, LBNL ←
Sanjay Reddy, UW
James Vary, ISU ←

NUCLEI team:
Scott Bogner, MSU
Jon Engel, UNC
George Fann, ORNL
Stefano Gandolfi, LANL
Robert Harrison, ORNL
Gaute Hagen, ORNL
Dave Higdon, LANL ←
Chuck Horowitz, IU
Pieter Maris, ISU
Erich Ormand, LLNL
Thomas Papenbrock, UT
Lucas Platter, ANL
Steven Pieper, ANL
Sofia Quaglioni, LLNL
Nicolas Schunck, LLNL
Masha Sosonkina, Ames,ODU
Stefan Wild, ANL ←
Robert Wiringa, ANL
Chao Yang, LBNL ←

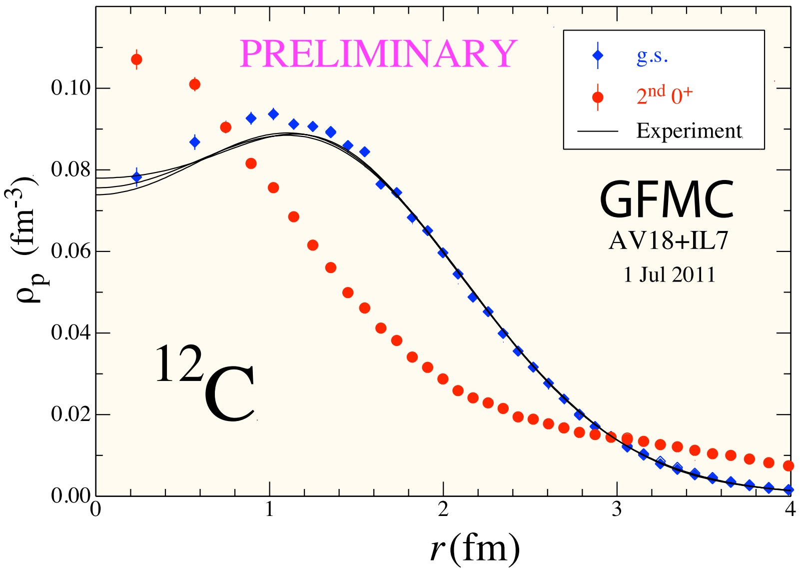
NUCLEI team

9 Universities
6 National Labs

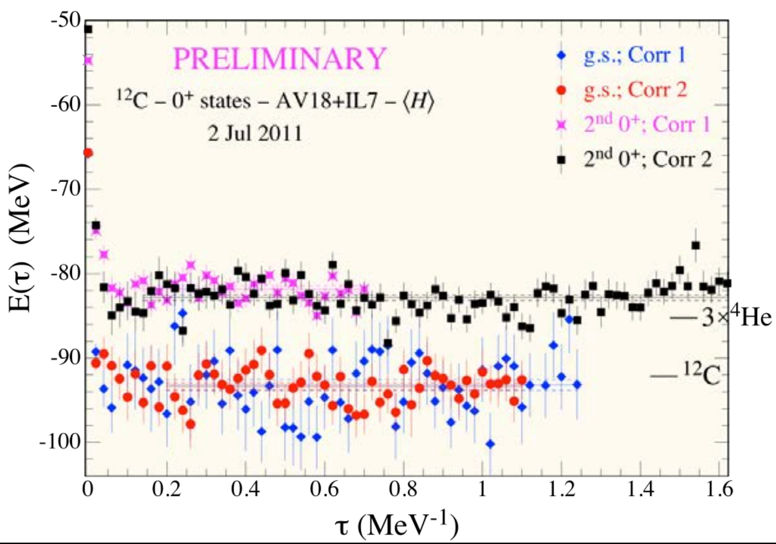
Strong collaboration between physicists and applied mathematicians computer scientists

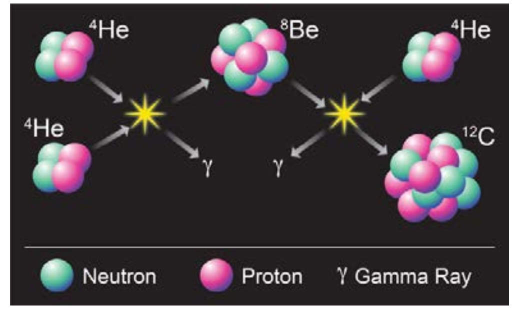
Ab initio description of ^{12}C

GFMS (Pieper et al.)

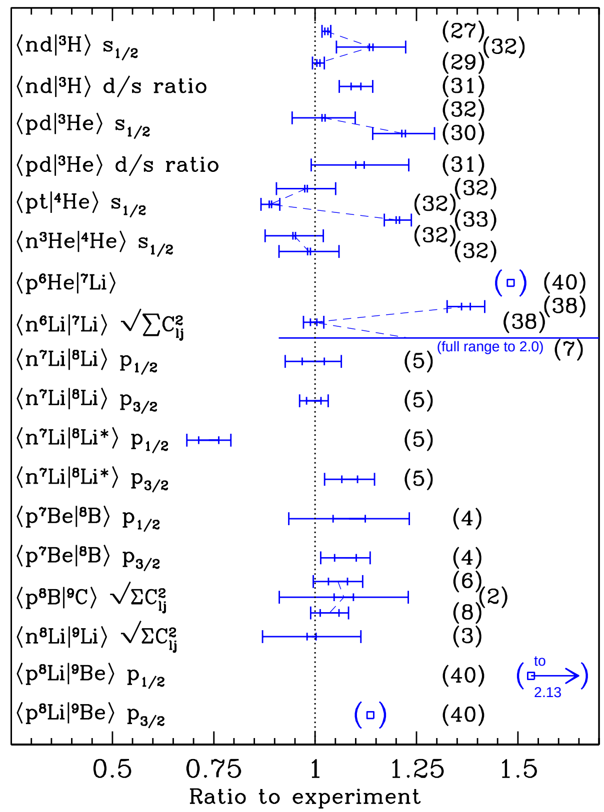


The ADLB (Asynchronous Dynamic Load-Balancing) library & GFMC. GFMC energy 93.5(6) MeV; expt. 92.16 MeV. GFMC pp radius 2.35 fm; expt. 2.33 fm.





Asymptotic Normalizations



Nollett and Wiringa, 2012

Making a simple programming model scalable:
The Asynchronous Dynamic Load Balancing Library

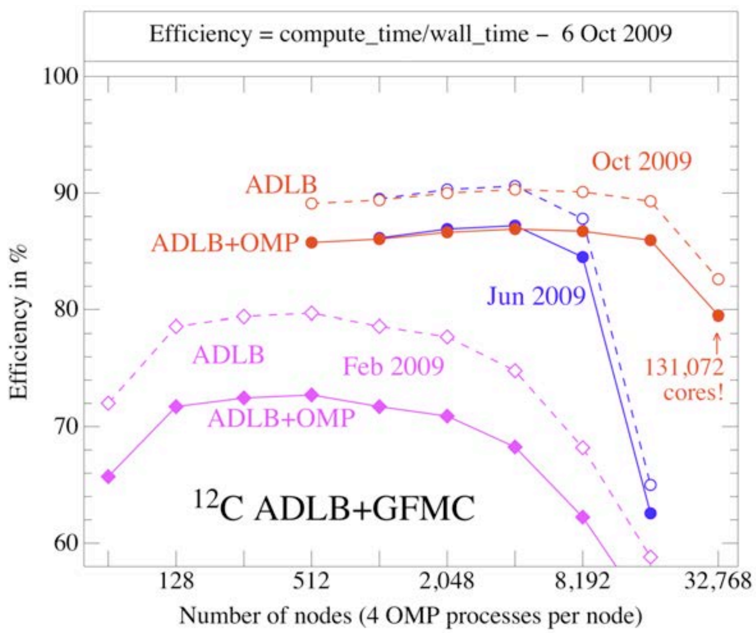
Objectives

- Enable large-scale computations at high efficiency
- Simplify programming model
- Scale to leadership class machines

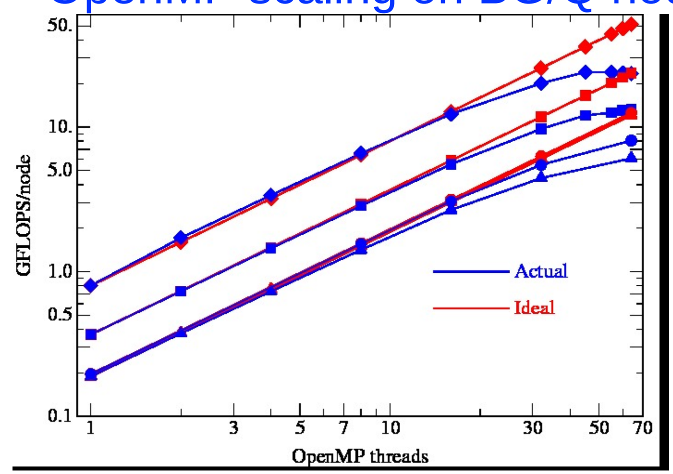
Impact

- Demonstrate capabilities of simple programming models at petascale and beyond
- Show path forward with hybrid programming models in library implementation

Improved Efficiency (compute time/wall time) with more nodes



OpenMP scaling on BG/Q nodes

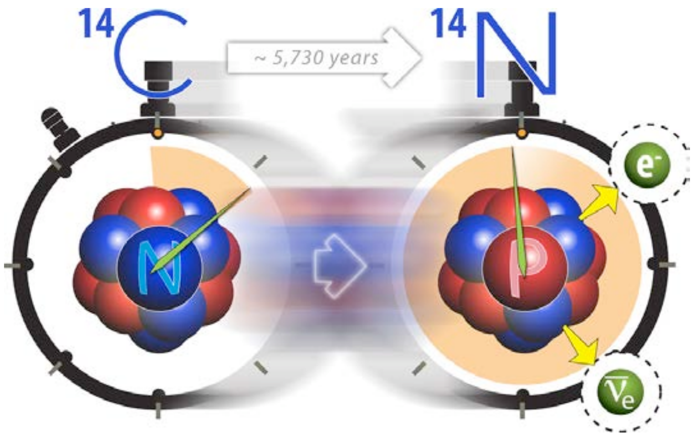


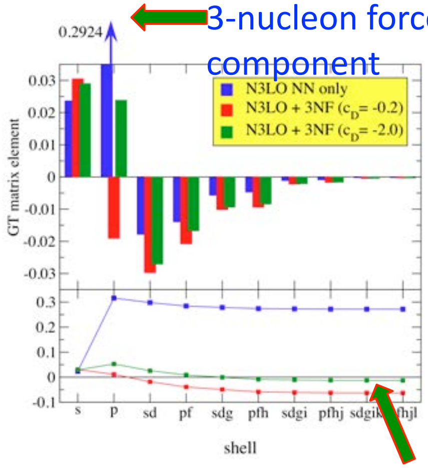
See poster by Hai Ah Nam

SCIDAC-3 NUCLEI Project
Larger Computers (BG/Q)
Fault Tolerance
Performance Analysis
MPI-3 features

Anomalous Long Lifetime of Carbon-14

Anomalous long lifetime of Carbon-14 (used in carbon dating) explained by ab-initio calculations using NN and NNN forces. Phys. Rev. Lett. 106, 202502 (2011)

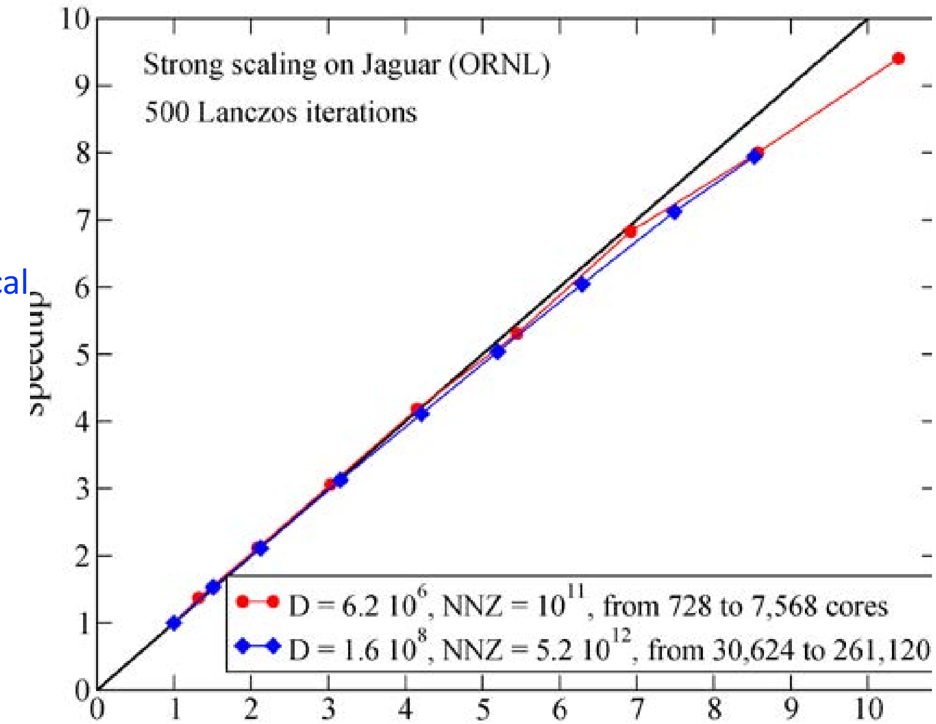




3-nucleon forces suppress critical component

net decay rate
Is very small

Strong Scaling of MFDn on Jaguar



http://www.newscientist.com/article/mg21128214.400-quantum-quirk-makes-carbon-dating-possible.html
http://phys.org/news/2011-05-physicists-lifetime-carbon-.html

NUCLEI project: large-scale diagonalization (Chao Yang poster)

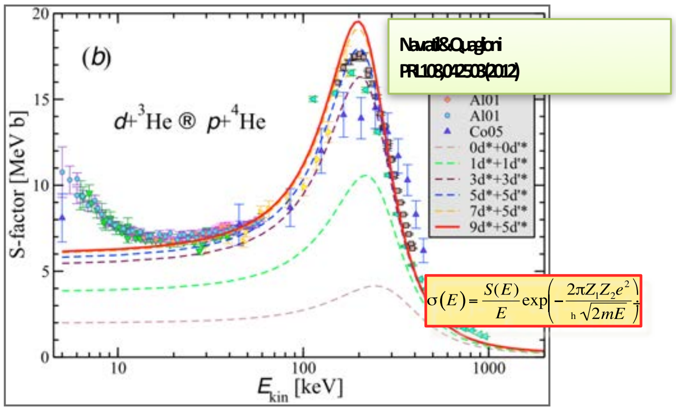
- Physics Requirement: Larger Model Spaces

- Reduce memory requirements: regenerating Hamiltonian
  flash-memory non-volatile disk

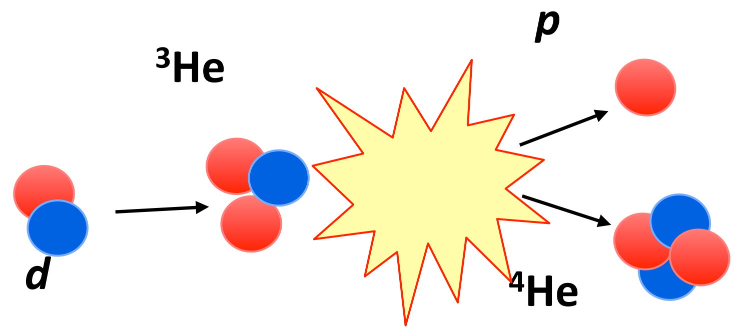
- Will also leverage work with FASTMath Institute to improve numerical quality of solvers.

- The MADNESS team will export a prototyped scalable dense eigensolvers from MADNESS with an open interface for other applications in the NUCLEI project.

Nuclear reactions



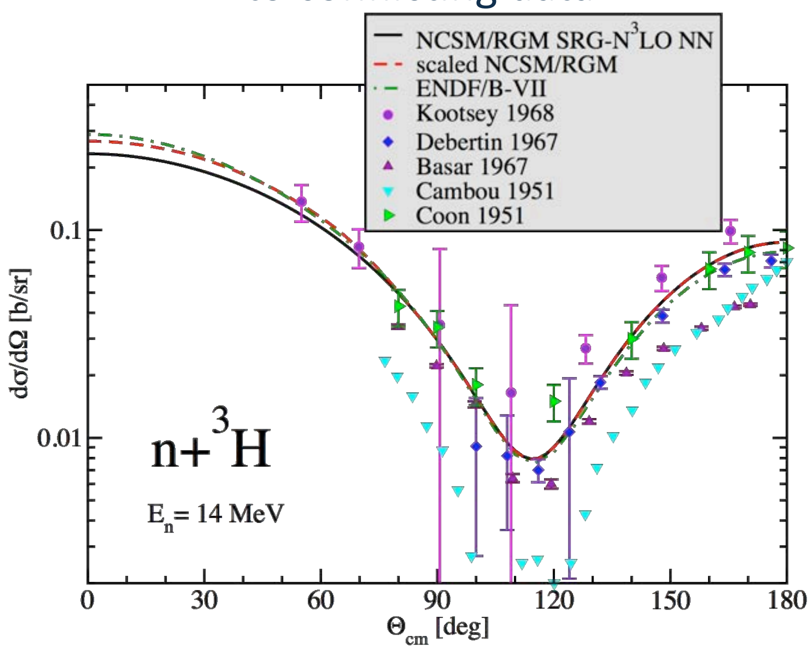
Data deviate from NCSM/RGM results at low energy due to lab. electron-screening



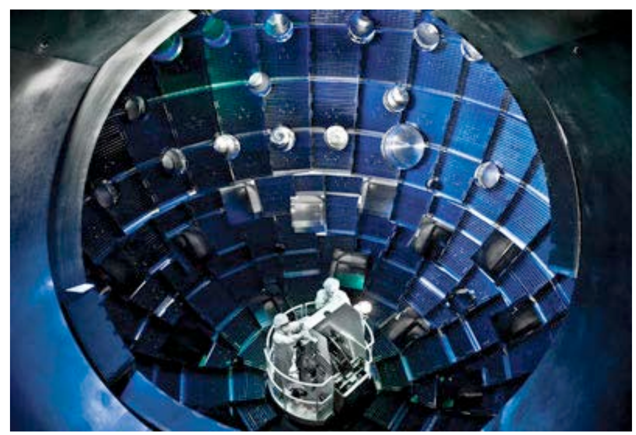
NCSM/RGM is pioneering *ab initio* calculations of light-nuclei fusion reaction with NN interaction. Here, $^3He(d,p)^4He$ S-factor.

PRC 84, 034607(2011), PRC 85, 054621 (2012)

Ab initio theory reduces uncertainty due to conflicting data



- ``First measurements of the differential cross sections for the elastic n-^{2}H and n-^{3}H scattering at 14.1 MeV using an Inertial Confinement Facility", by J.A. Frenje *et al.,* Phys. Rev. Lett. **107,** 122502 (2011)



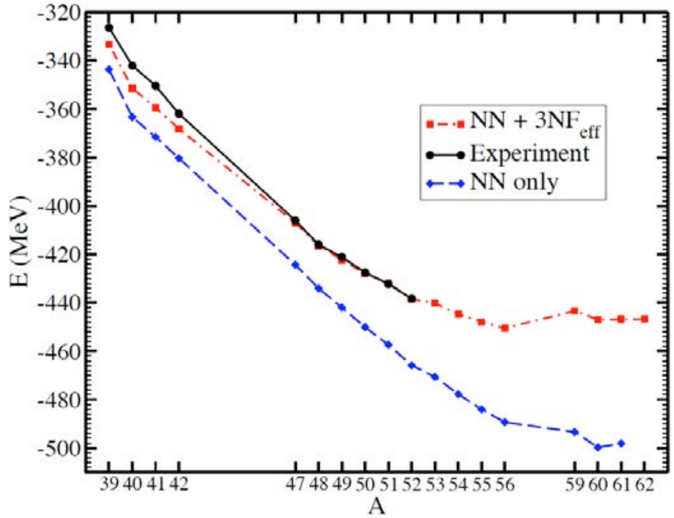
NIF

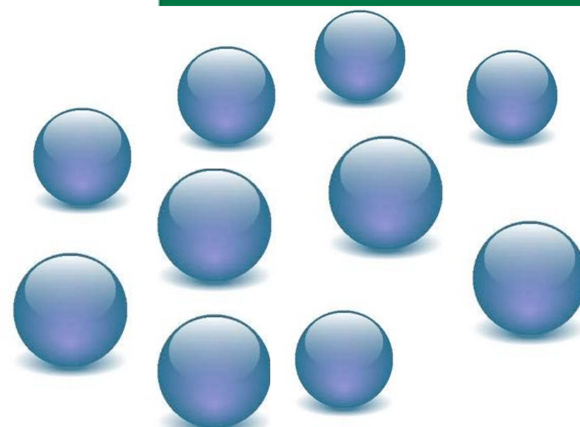
http://physics.aps.org/synopsis-for/10.1103/PhysRevLett.107.122502

Larger Nuclei: Coupled-cluster method

G. Hagen et al., Phys. Rev. Lett. 109, 032502 (2012)

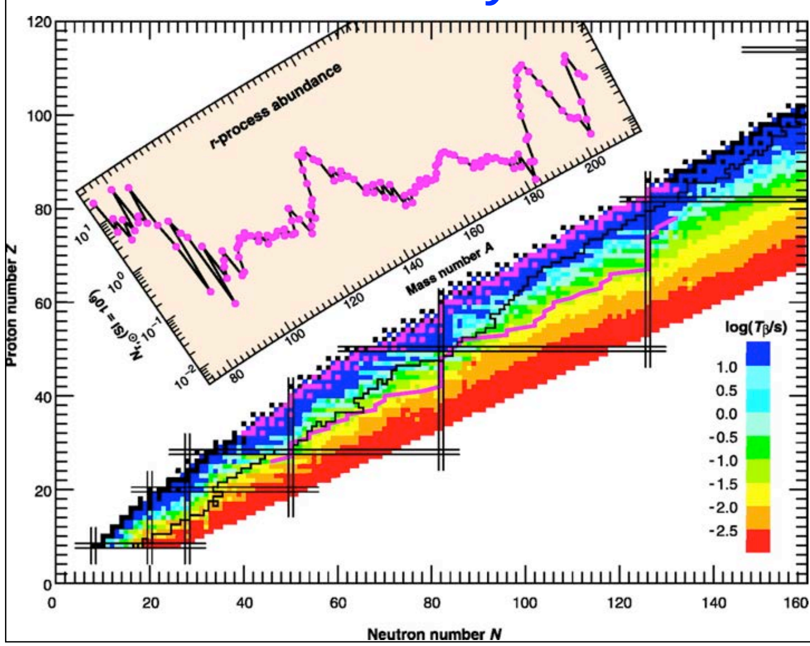
FACILITY FOR RARE ISOTOPE BEAMS

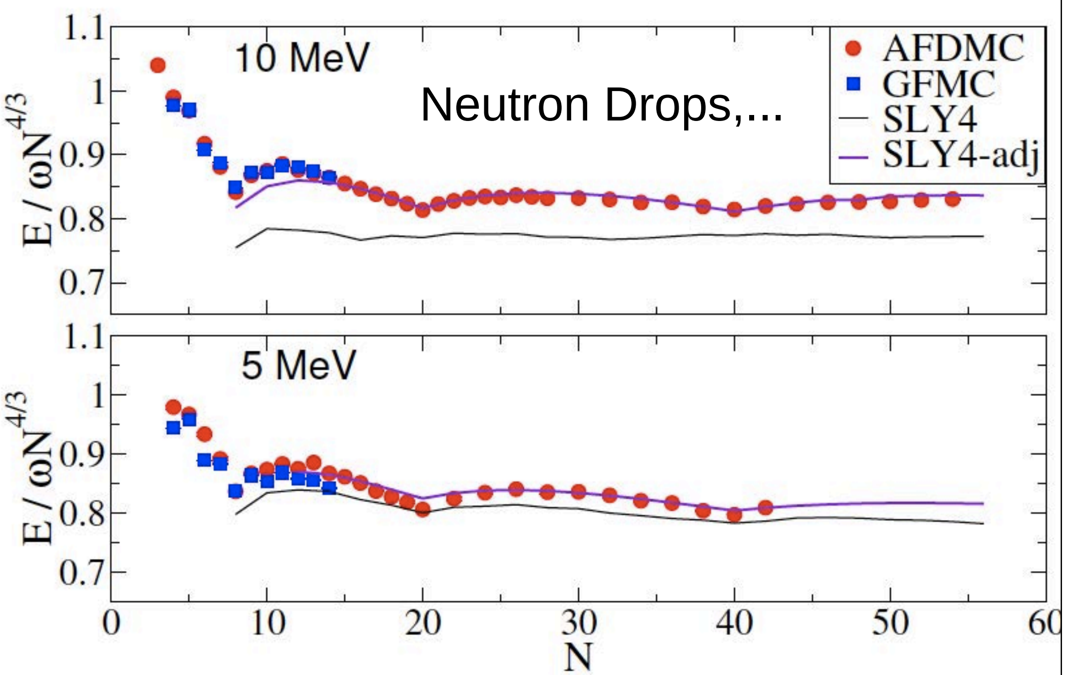




Coupling Ab-Initio Approaches to Density Functional Theory

Neutron drip line and R-process nucleosynthesis





Optimization Plans in NUCLEI
Stefan Wild / SUPER

New Optimization Capabilities

- State-of-the art mathematical/numerical optimizations of next-generation EDFs *(with LLNL, ORNL, Tennessee)*
- Optimization of basis states and non-perturbative coupling constants arising in chiral Hamiltonians *(with ISU)*
- Enable nucleus lifetime computations with collective action minimizations *(with LLNL, others)*

- Exploit additional parallelism at the simulation-optimization interface
- Extend POUNDERS to address missing states and available sensitivity information
- Incorporate uncertainties and QUEST technologies

Coupling NUCLEI Subgroups

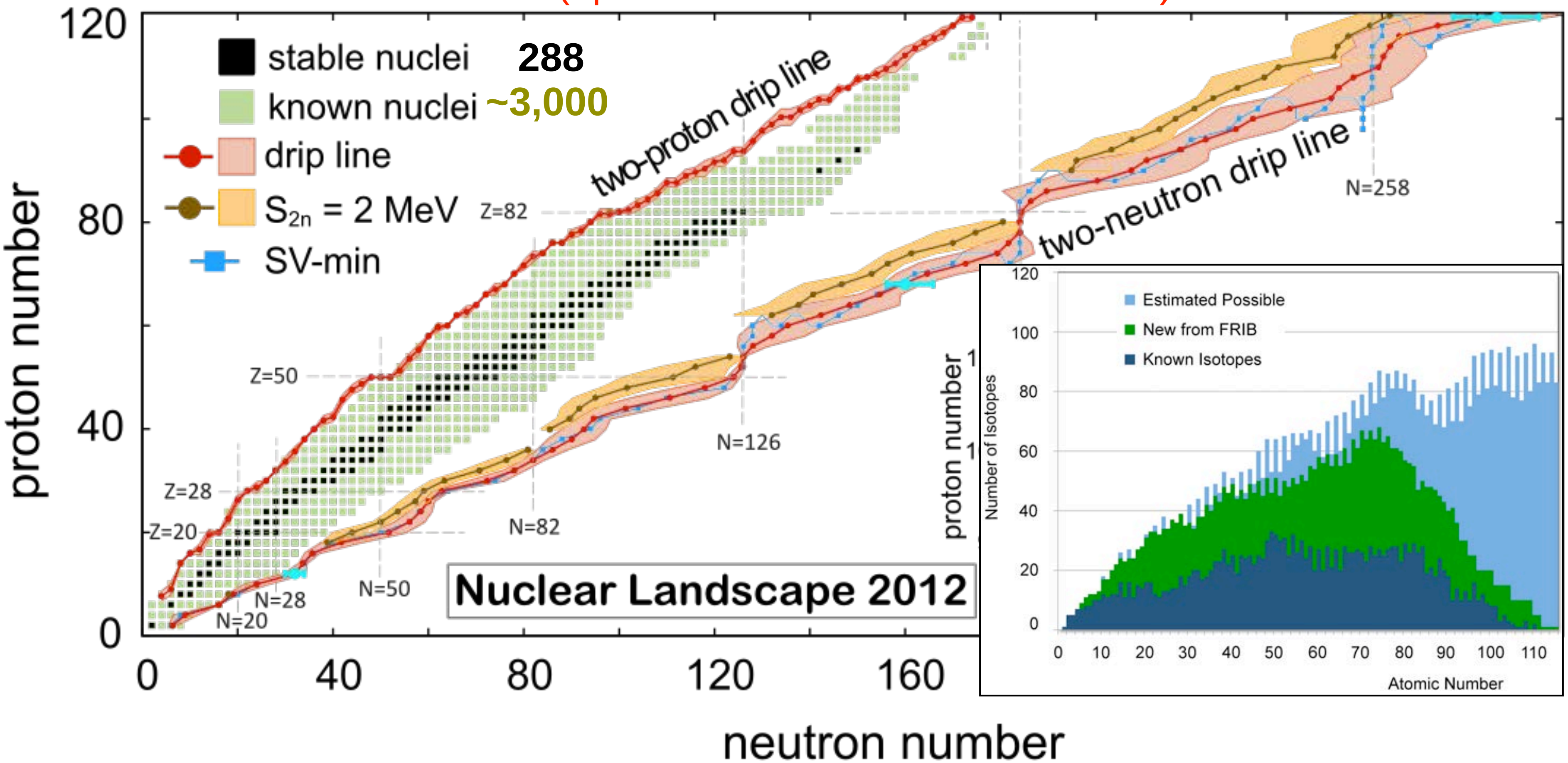
- Incorporate new observables from various NUCLEI subgroups
  - giant resonance data,
  - binding energy of neutron droplets in a trap,
  - …

Deploy code optimization tools

- Introduce performance, energy, and resilience tools developed by the SUPER SciDAC Institute for use in NUCLEI codes
- Deliver representative NUCLEI computational kernels to SUPER

The limits: Skyrme-DFT Benchmark 2012

- Systematic errors (due to incorrect assumptions/poor modeling)
- Statistical errors (optimization and numerical errors)



How many protons and neutrons can be bound in a nucleus?

Skyrme-DFT: 6,900±500$_{syst}$

Erler et al.,
Nature 486, 509 (2012)

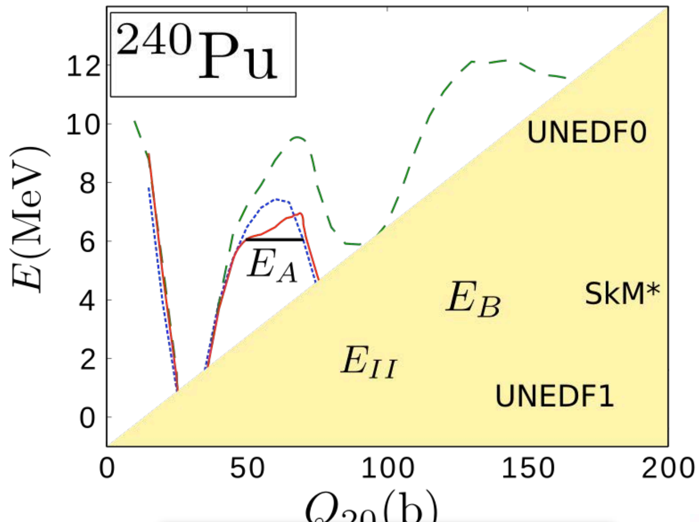
http://www.livescience.com/21214-atomic-nuclei-variations-estimate.html
http://www.sciencedaily.com/releases/2012/06/120627142518.htm

LACM, Fission: the ultimate challenge

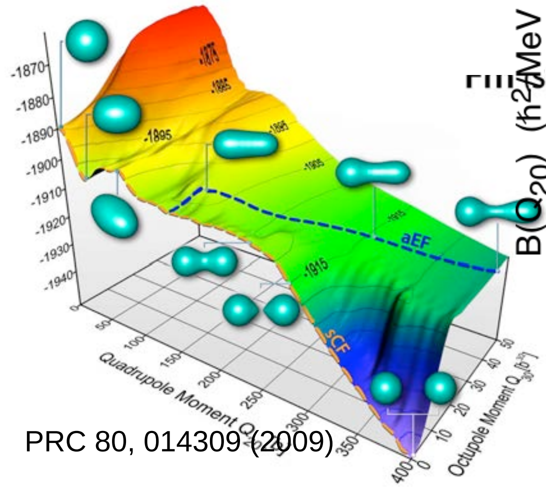
(see Jordan McDonnell poster)

Optimized Functionals

PRC 85, 024304 (2012)

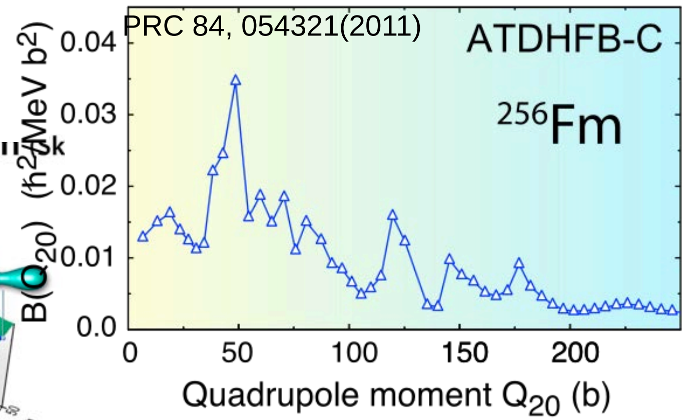


Large-scale DFT

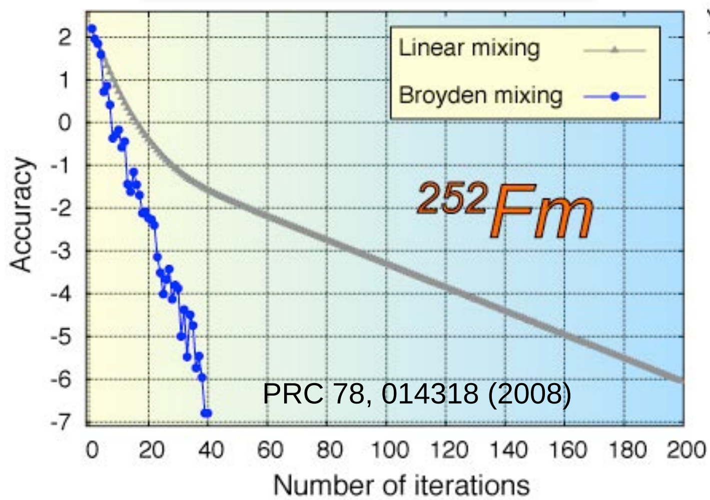


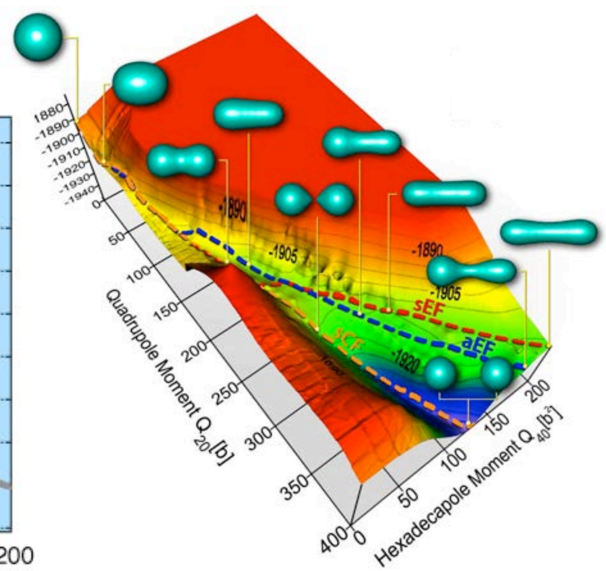
PRC 80, 014309 (2009)

Collective dynamics



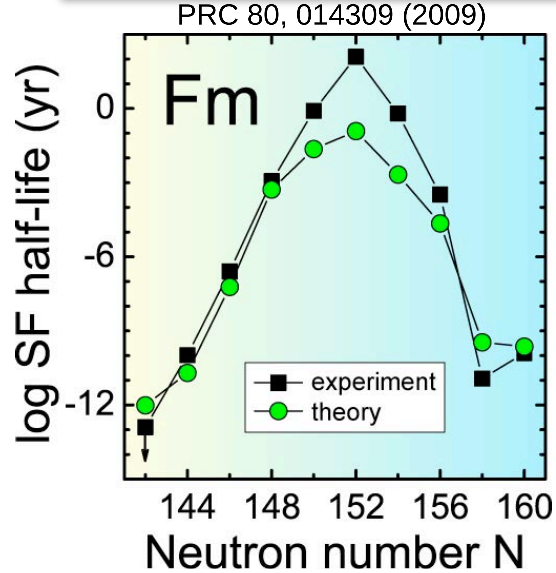
Numerical Techniques



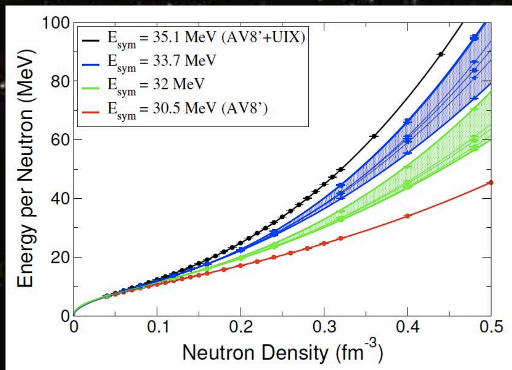


Confrontation with experiment; predictions

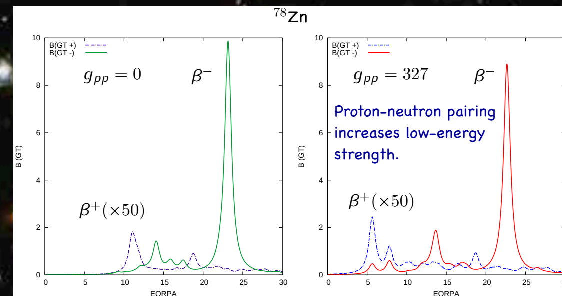
PRC 80, 014309 (2009)



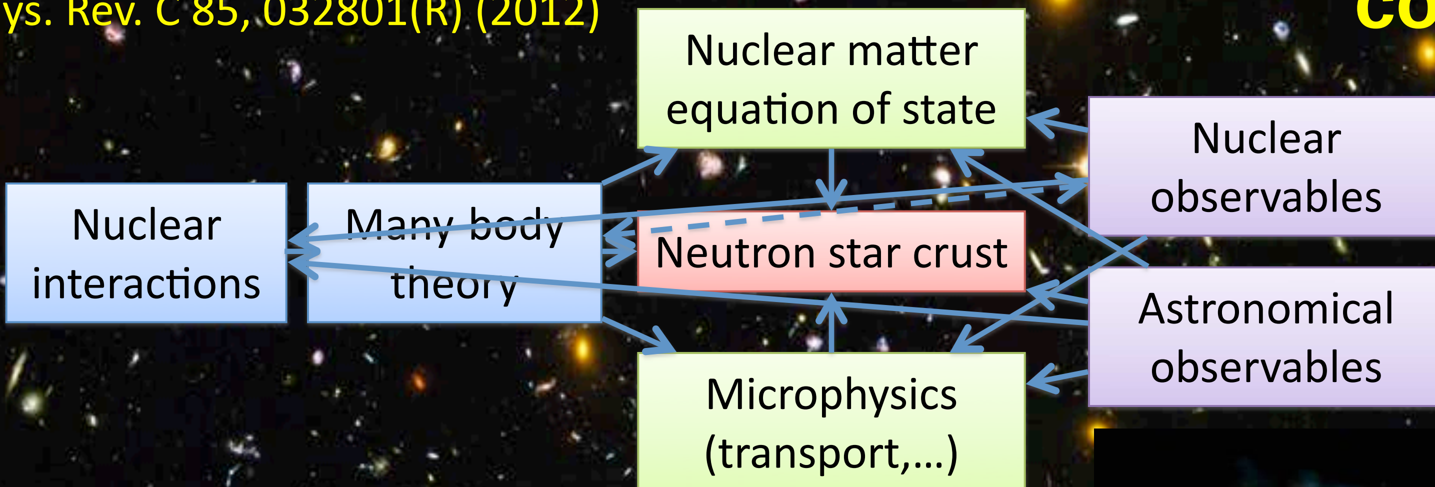
Quest for understanding the neutron-rich matter on Earth and in the Cosmos

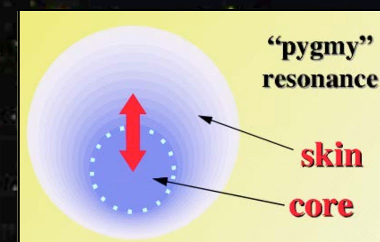


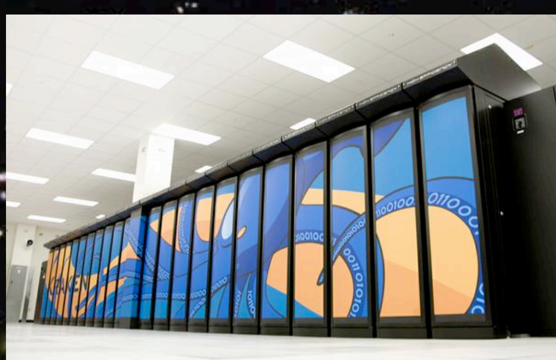
Phys. Rev. C 85, 032801(R) (2012)

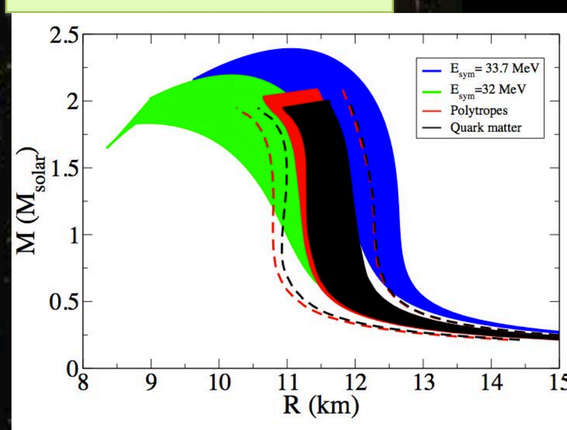


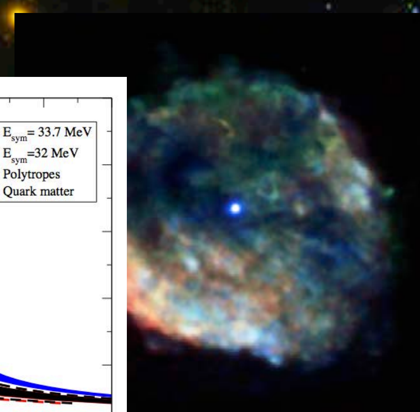
RNB Facilities/ NuN topical collaboration





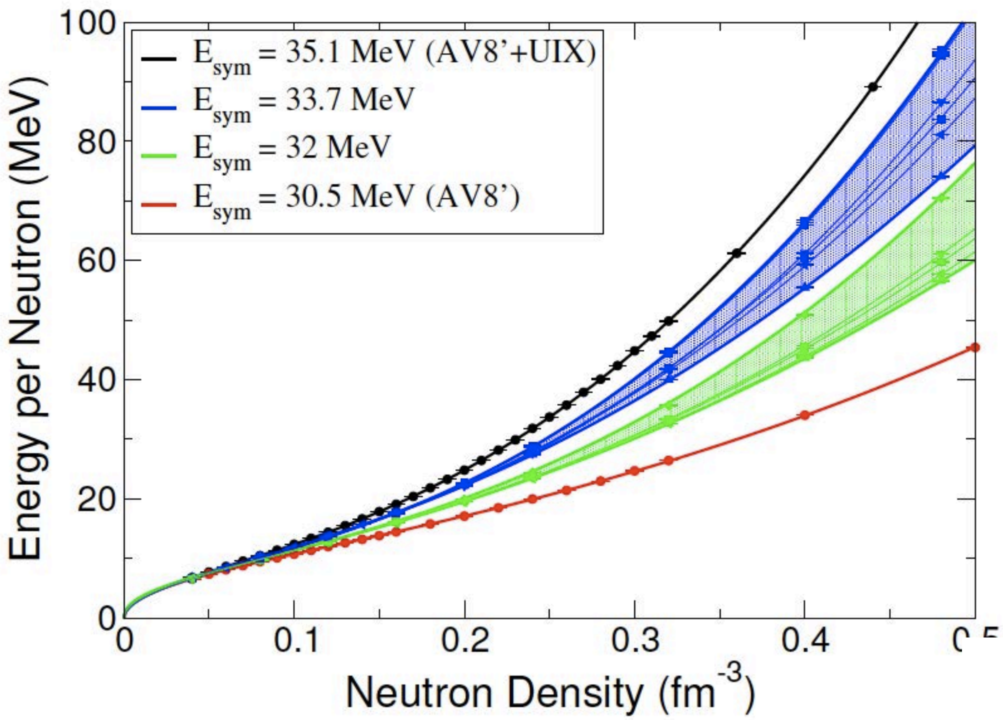




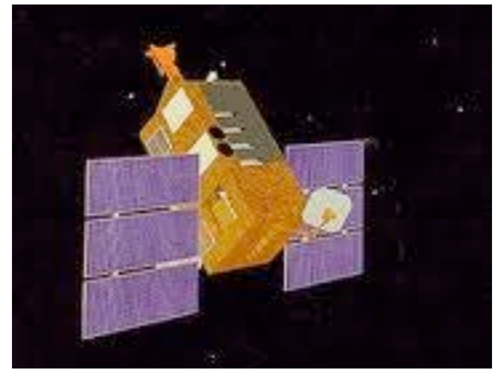


Phys. Rev. Lett. 108, 081102 (2012)

Equation of State and Neutron Stars

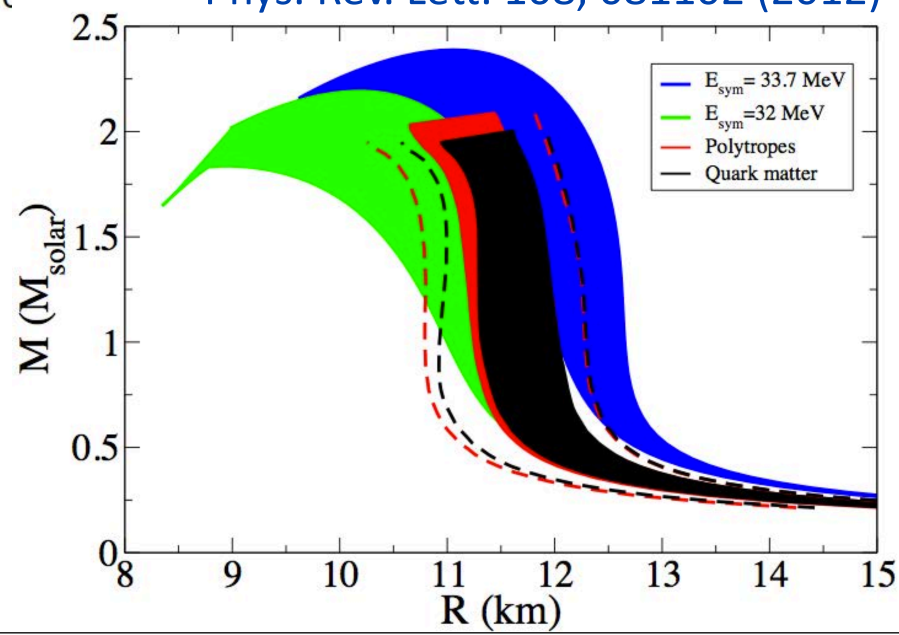


Equation of State



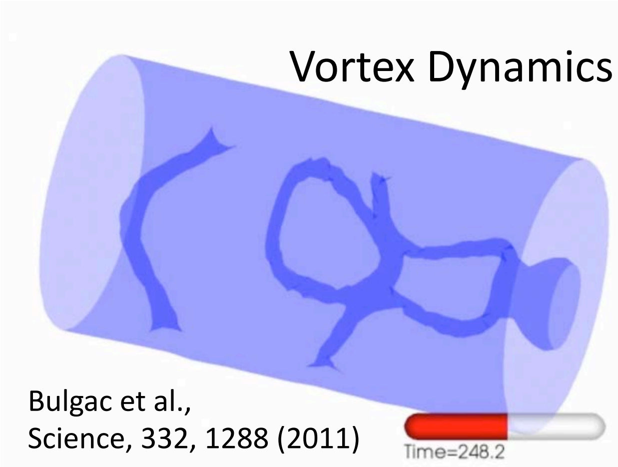
Mass/Radius

Phys. Rev. Lett. 108, 081102 (2012)



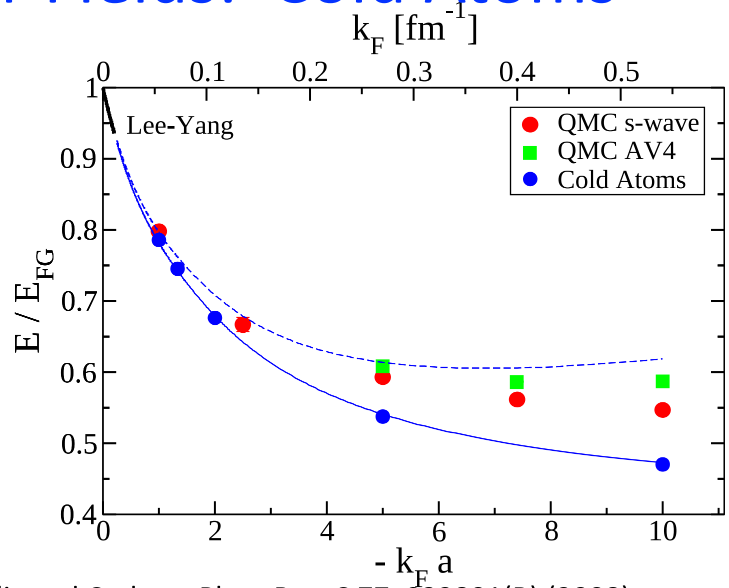
Connections to Other Fields: Cold Atoms

Vortex Dynamics



Bulgac et al.,
Science, 332, 1288 (2011)

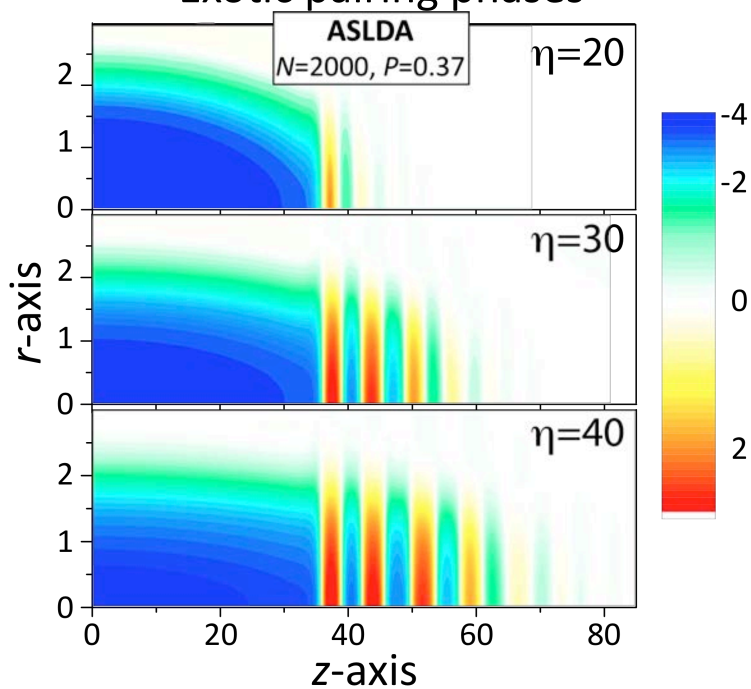
http://www.physicstoday.org/resource/1/phtoad/v64/i8/p19_s1



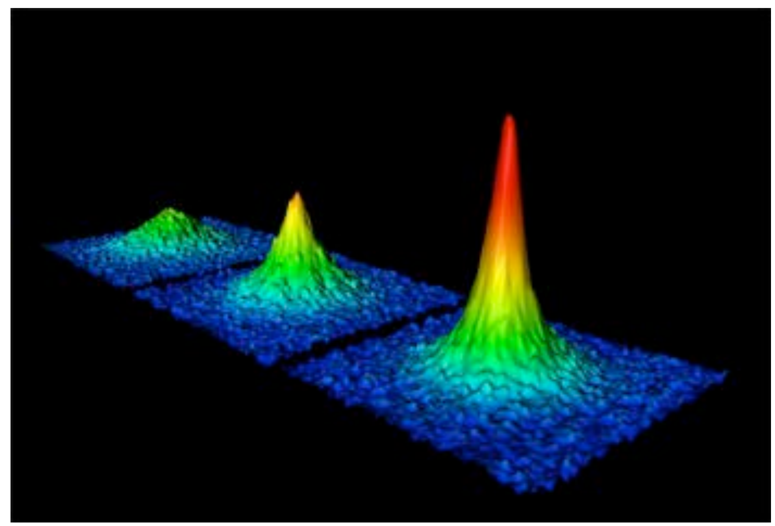
Gezerlis and Carlson, Phys. Rev. C 77, 032801(R) (2008)
Carlson, Gandolfi, Gezerlis, PTEP (2012)

Equation of State

Exotic pairing phases



J. Pei et al., Phys. Rev. A 82, 021603(R) (2010)



NUCLEI: some Computational Challenges

- Efficient usage of heterogeneous machines (GPUs)
- Reducing communications (topology awareness)
- Load Balancing at the Largest Scale Computers
- Matching Across Physical Scales (UQ)

NUCLEI

Nuclear Computational Low-Energy Initiative

Outlook:

Have developed effective collaborations between math/CS and physics. Excellent team of applied mathematicians, computer scientists, and physicists.

Look forward to working with Institutes:
FASTMath, SUPER, QUEST

Exciting science: nuclear science and applications
astrophysics
neutrino physics

BACKUP SLIDES

Science on NBCNEWS.com

How many neutrons, protons can get along? Maybe 7,000

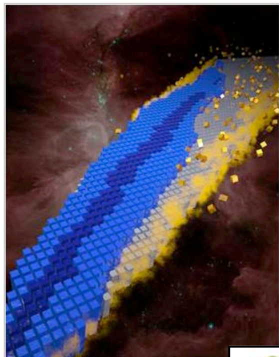
New study comes closer than ever to finding answer by estimating number of variations that can exist in an atom

Jump to discuss
Loading comments...

Recommend 29 | Tweet 1 | +1 0 | Share 13

Below: Discuss | Related

By Clara Moskowitz
LiveScience
updated 6/27/2012 3:47:54 PM ET
Print | Font: A A + −



Andy Sproles / Oak Ridge Nationa

Scientists have long wondered whether there is a limit to the number of protons and neutrons that can be clustered together to form the nucleus of an atom. A new study comes closer than ever to finding the answer by estimating the total number of nucleus variations that can exist.

The periodic table of elements includes 118 known species of atoms, and each of these exists (either naturally or synthetically) in several versions with differing numbers of neutrons, giving rise to a total of about 3,000 different atomic nuclei. As technology has

---

DEIXIS Computational Science at the National Laboratories

home | about us | contact us | article index | subscribe

Argonne | Brookhaven | Lawrence Berkeley | Lawrence Livermore | Los Alamos | Oak Ridge | Pacific

Pounding out atomic nuclei

Mike May | March 7th, 2011 | Updated: March 16th, 2011

Email This Post | Print | Share This

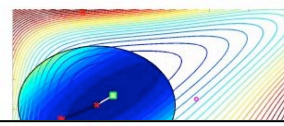
FILED UNDER Argonne,

Thousands of tiny systems called atomic nuclei – specific combinations of protons and neutrons – prove extremely difficult to study but have big implications for nuclear stockpile stewardship. To describe all of the nuclei and the reactions between them, a nationwide collaboration is devising powerful algorithms that run on high-performance computers.

Nuclear reactions, from fission in reactors to fusion in stars, depend on interactions between protons and neutrons that are building blocks of atomic nuclei.

Describing all of the nuclei and the reactions between them, however, demands powerful algorithms running on high-performance computers.

The Universal Nuclear Energy Density Functional (UNEDF) collaboration, which was created by the Department of Energy's Scientific Discovery through Advanced Computing (SciDAC) program, focuses on developing such descriptions.



The UNEDF collaboration includes researchers from seven national laboratories – Ames, Argonne, Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, and Pacific Northwest – and nine universities: Central Michigan, Iowa State, Michigan State, Ohio State, San Diego State, North Carolina at Chapel Hill, Tennessee-Knoxville, Texas A&M in Commerce and University of Washington. Recently, researchers in this collaboration made a significant advance through the use of density functional theory (DFT).

ScienceDaily®

Your source for the latest research news

News | Articles | Videos

Health & Medicine | Mind & Brain | Plants & Animals

Science News

Physicists Pin Down Proton-Halo State

ScienceDaily (May 27, 2010) — A halo may be difficult to acquire in terms of virtue, but it can also be tough to calculate in terms of physics. Thomas Papenbrock, associate professor of physics and astronomy at the University of Tennessee, Knoxville, and his colleagues Gaute Hagen from Oak Ridge National Laboratory and Morten Hjorth-Jensen from the University of Oslo have managed to do just that, however, and report their findings in *Physical Review Letters*.

---

physicstoday.org Physics Update

The latest in research

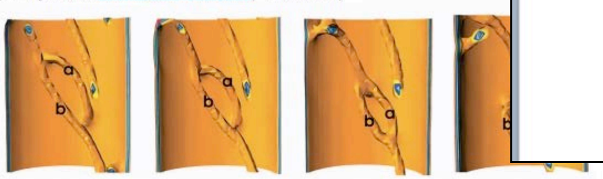
Home | Print edition | Advertising | Buyers Guide | Jobs | Events calendar |

« Fluorescing diamonds inside living cells | Physics Update

Stirring superfluids

By Physics Today on June 13, 2011 10:52 AM | No TrackBacks

If you chill fermions enough, they can pair up to form bosons and settle into a single co ground state, a Bose–Einstein condensate. In the case of helium-3 atoms, the resulting superfluid that flows without dissipation—provided the flow is not so energetic that it br apart or destroys the ground state's coherence. Until now, theorists could characterize in fermionic superfluids, but not the vigorous turbulence that results from shaking or sti Bulgac of the University of Washington in Seattle and his colleagues have adapted de functional theory—a computational approach originally devised to calculate molecular —and applied its time-dependent extension to model turbulent fermionic superfluids. A underlying quantum mechanical equations are straightforward, solving them required of the world's most powerful supercomputers, Jaguar at Oak Ridge National Laborator Tennessee. In their simulations, Bulgac and his colleagues agitated a fermionic super shooting spherical projectiles through it or by stirring it with a laser beam. Turbulent su known to harbor tubes of quantized vorticity. As the figure below shows, the simulation how two vortex tubes (marked a and b) joined to form a ring, which then opens in a ma reminiscent of the unzipping of a DNA molecule during transcription. Bulgac's model c astronomers understand another agitated superfluid: the interior of a rapidly spinning (A. Bulgac et al., *Science* **332**, 1288, 2011.)—Charles Day



U.S. DEPARTMENT OF ENERGY | Office of Science

Search SC Website | SC Site Search | GO

Programs | Laboratories | User Facilities | Universities | Funding Opportunities | Discoveries / Innovation | News | About

You are here: SC Home » News » Science Highlights Series » 2011 » Universities and DOE National Laboratories Join Forces to Understand the Nucleus of an Atom

News

Science Highlights Series

Press Releases
In the News
Science Highlights Series
2011
2010
2009
In Focus
Presentations & Testimony
Recovery Act

CONTACT US
Office of Science
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585
P: (202) 586-5430
More Information »

03.28.11

Universities and DOE National Laboratories Join Forces to Understand the Nucleus of an Atom

Find out about this collaboration's efforts and accomplishments toward completing a portrait of the nuclear landscape.

Print | SC RSS Feeds | Text Size: A A A | Share / Bookmark

Nuclear physics is the study of the tiny, massive core of an atom, a complex micro-world of particles and forces. Nearly all the mass in the visible universe is locked away in atomic nuclei, as is nearly all the energy. The physics of the nucleus lies at the heart of element formation in exploding stars, as well as sources of energy for public use and national defense. Scientists strive for a comprehensive, unified description of all nuclei, a portrait of the nuclear landscape which incorporates all nuclear properties and forces in one framework. Such a model would allow for more accurate predictions of the nuclear reactions involved in all sorts of processes, from the creation of new elements to the improvement of nuclear reactors.

Around 50 researchers — theoretical physicists, computer scientists, and applied mathematicians — from nine U.S. universities, seven national laboratories, and research institutes across Europe and Japan, have come together in an effort to develop a more complete description of the atomic nucleus and its interactions. Their computational nuclear physics project, known as Universal Energy Density Functional (UNEDF), is led by Ewing Lusk (Argonne National Laboratory) and Witold Nazarewicz (University of Tennessee/Oak Ridge National Laboratory). The project is part of the U.S. Department of Energy's Scientific Discovery through Advanced Computing (SciDAC) program, funded by the Office of Science.

A nucleus is one of the most complicated environments in nature because all fundamental forces come into play. The four fundamental forces are called the strong force, electromagnetic force, weak force, and gravity. The constituents of a nucleus are protons and neutrons (collectively referred to as nucleons), which are themselves made of fundamental particles known as quarks and gluons. Each

NewScientist Physics & Math

Home | News | In-Depth Articles | Blogs | Opinion | TV | Galleries | Topic Gui

SPACE | TECH | ENVIRONMENT | HEALTH | LIFE | PHYSICS&MAT

Home | Physics & Math | News

Quantum quirk makes carbon dating possible

› 15 July 2011 by David Shiga
› Magazine issue 2821. **Subscribe and save**

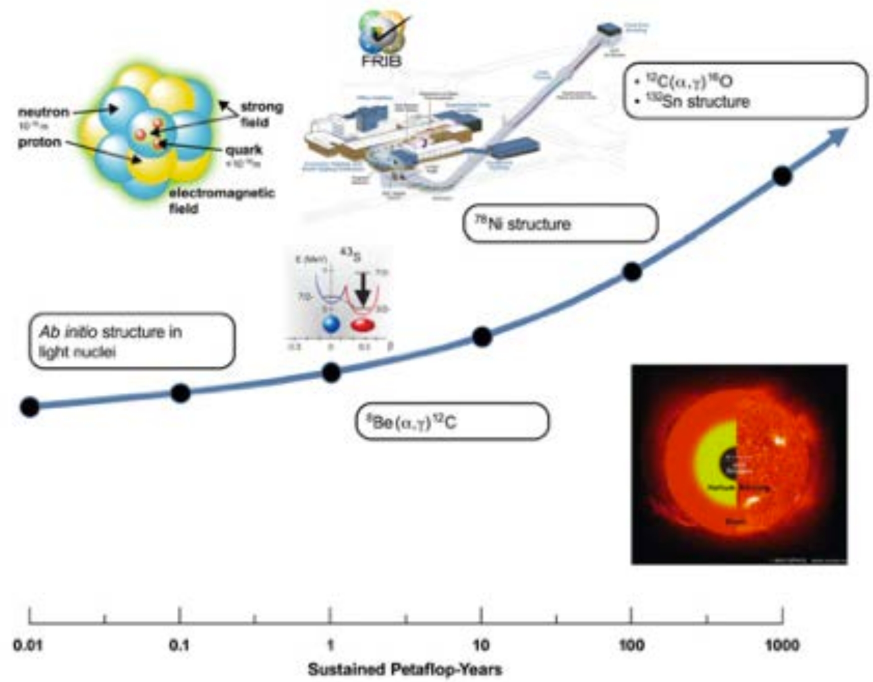
RADIOCARBON dating relies on carbon-14 to decode an object's age, but the isotope has steadfastly refused to divulge the key to its own unusual longevity. The answer, it seems, lies in the bizarre rules of quantum physics.

Carbon-14 decays with a half-life of 5730 years, so it is often used to date objects up to about 50,000 years old (anything older would have negligible amounts of the stuff).

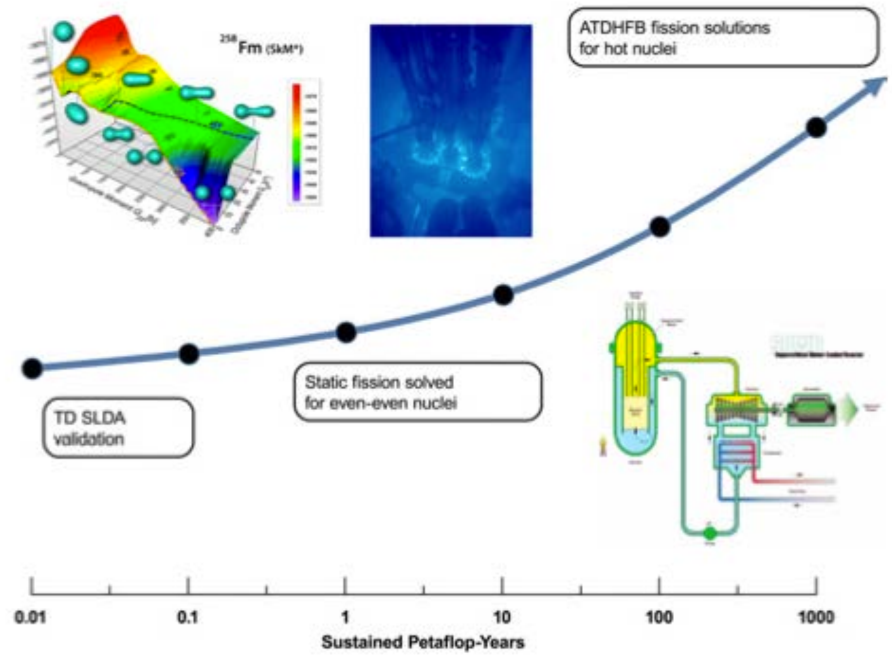
But most other atoms that decay in the same way - by converting one of their neutrons into a proton - disappear in less than a day. So what's different about carbon-14?

The nucleus of the carbon-14 isotope has six protons and eight neutrons. When it decays, one of the neutrons turns into a proton, and also releases an electron and a neutrino. The result is a nitrogen-14 nucleus with seven protons and seven neutrons.

Nuclear Reactions



Microscopic Theory of Fission



2012 2020 2020 2030 2028 2020

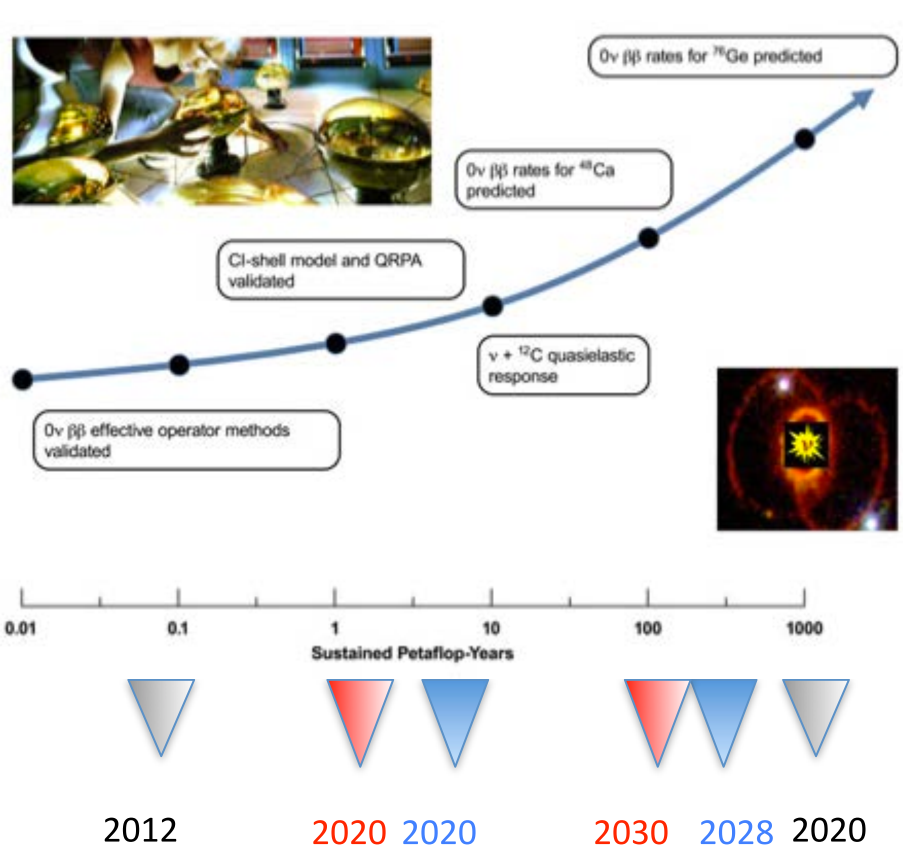
2012 2020 2020 2030 2028 2020

Desired Trajectory

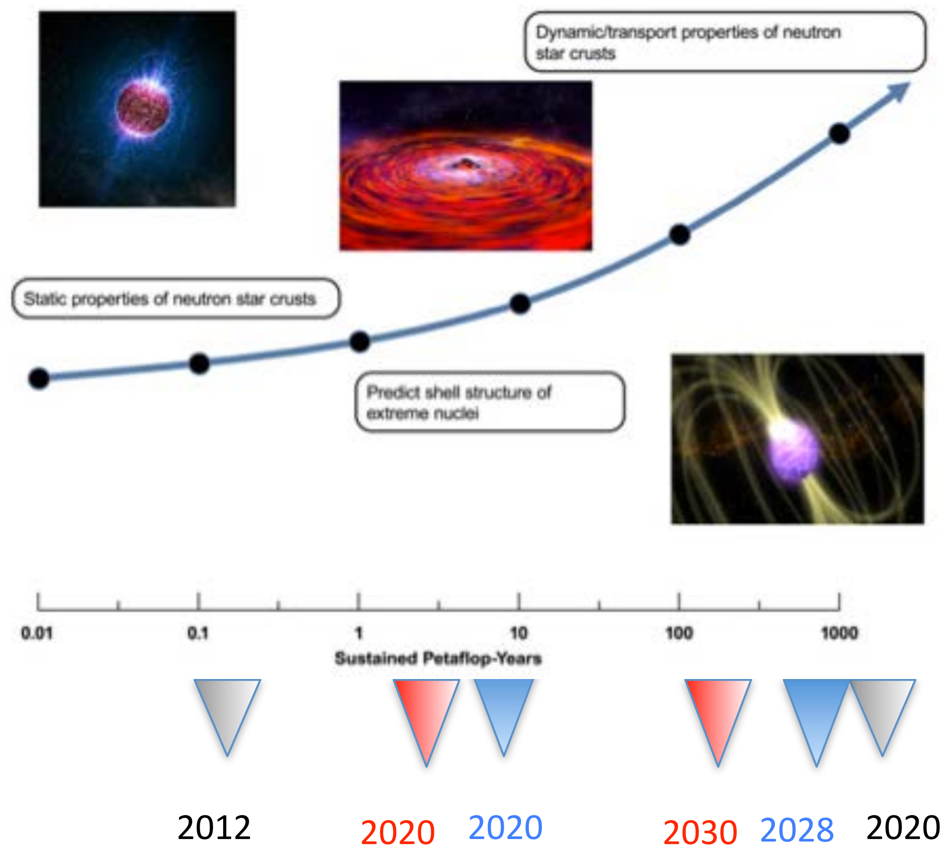
Flat Trajectory

Flat-Flat Trajectory

Neutrinos as Nuclear Physics Laboratories



Physics of Extreme Neutron-Rich Nuclei and Neutron Stars



Desired Trajectory

Flat Trajectory

Flat-Flat Trajectory

Junior Scientists in UNEDF

POST-DOCTORAL ASSOCIATES (2010)

Christopher Calderon, LBNL (staff, Numerica co.)
Joaquin Drut (Professor, UNC)
Stefano Gandolfi, LANL (staff, LANL)
Kai Hebeler, OSU (TRIUMF)
Heiko Hergert, MSU (OSU)
Jason Holt, UTK/ORNL
Eric Jurgenson, LLNL (staff, LLNL)
Markus Kortelainen, UTK (U. Jyväskylä)
Plamen Krastev, UCSD (research, Harvard)
Pieter Maris, ISU (Research Prof. ISU)
Eric McDonald, MSU (staff scientist, MSU)
Gustavo Nobre, LLNL (BNL, NNDC)
Junchen Pei, UTK (Prof., Pekin U.)
Nicolas Schunck UTK (staff, LLNL)
Roman Senkov, CMU
Ionel Stetcu, UW (staff, LANL)
Jun Terasaki, UNC (staff, U. Tsukuba)
Stefan Wild, ANL (staff, ANL)

Relevant instruction (workshops, courses) is crucial for the future of the field

Effect of UNEDF on workforce

Year-1: 9 students, 17 postdocs;
Year-2: 12 and 12;
Year-3: 10 and 18;
Year-4: 11 and 19

2010: Early Career Award

2010: Math/CS Staff ANL

2011: Faculty UNC/Chapel Hill

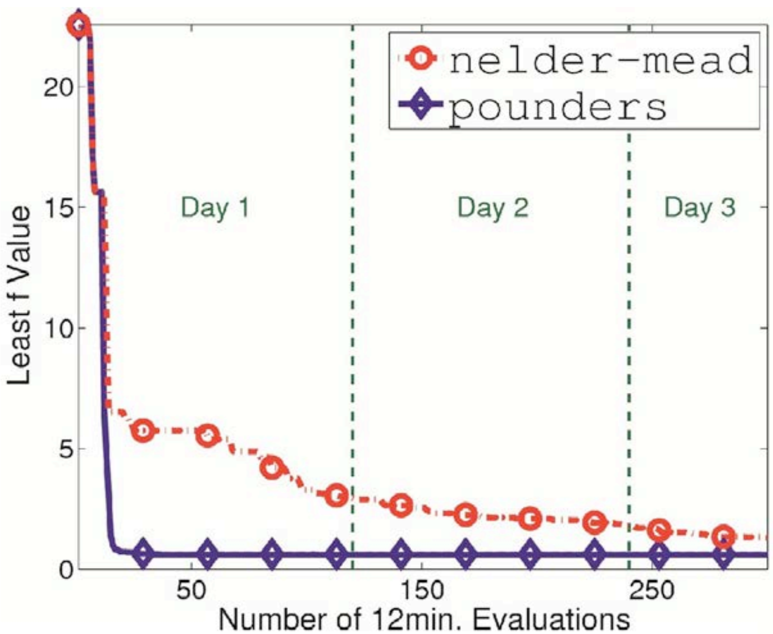
2010:Staff LLNL

2012: Faculty Guelph

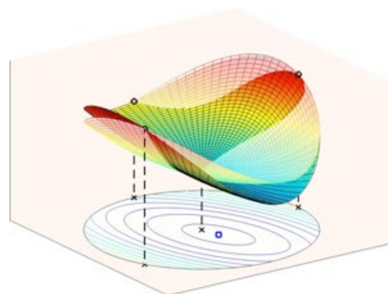
2012: Harvard Research Computing

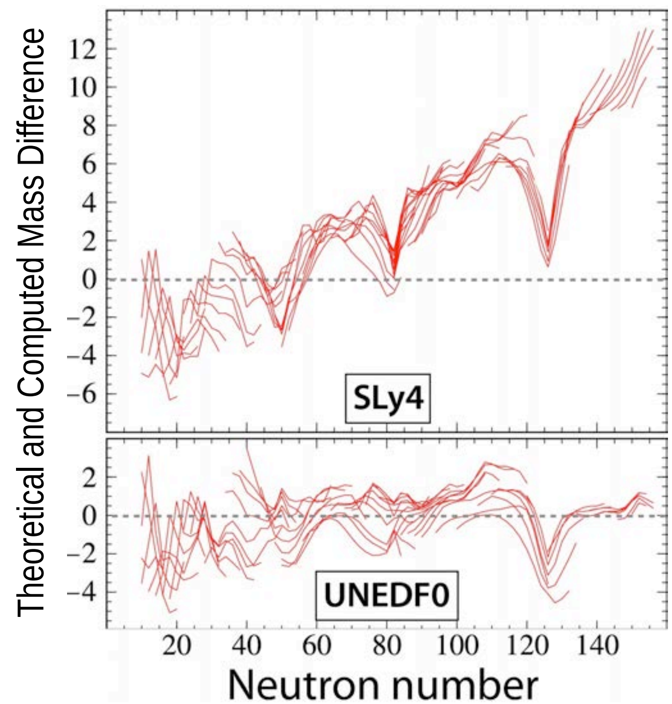
Derivative-free Optimization for Energy Density Functional Calibration

New algorithm for tuning large-scale nuclear structure simulations turns days into hours



- Energy density functional (EDF) predictions rely on large-scale computer simulations that must be calibrated to experimental data
- TAO 2.0's **POUNDERS** developed for UNEDF to exploit the mathematical structure of this calibration problem
- Substantial computational savings over alternative algorithms enables fitting of complex EDFs





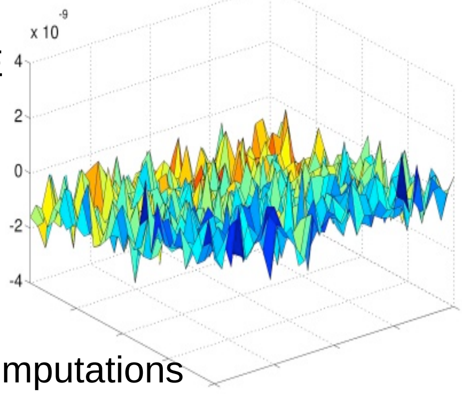
- Previous optimizations required too many evaluations to obtain desirable features exhibited by *UNEDF0, UNEDF1, …*
- Derivative-free sensitivity analysis procedure developed for UNEDF exposes correlations and constraining data in 1 minute using 20k cores
  - *"Nuclear Energy Density Optimization" Kortelainen et al., PhysRevC '10.*
  - *"N.E.D.O.: Large Deformations" Kortelainen et al., PhysRevC '12.*
  - *"Occupation Number-based Energy Functional for Nuclear Masses" Bertolli et al., PhysRevC '12.*

Optimal Derivatives of Noisy Numerical Simulations

Computational Noise

In all computations of DOE interest containing

- adaptivity,
- discretizations
- iterative methods
- petaflops,
- roundoff errors

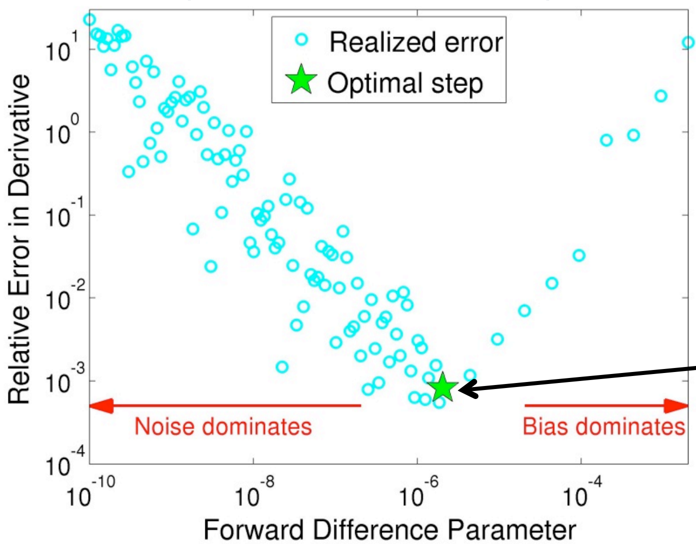


❖Includes *deterministic* computations

Noise Impacts in UNEDF & Beyond

- Uncertainty in computed outputs
- Unstable derivative estimates for sensitivity analysis
- Can be unrelated to/overwhelm truncation error
- Blurs relationship between tolerance values and stability

Our optimal forward difference parameter



Tools & Techniques

- *ECNoise* provides reliable estimates of stochastic and deterministic noise in few simulations
- Nonintrusive **stability bounds for extreme scale simulations**, can instruct precision levels/tolerances for subroutines
- Optimal difference parameters calculated without computationally expensive parameter sweeps

Optimal step was obtained with only two simulation evaluations. *Classical approach (circles): result of a sweep across 100 difference parameters, each point requiring a new simulation.*

"Estimating Computational Noise," Moré & Wild, SIAM Sci. Comp., '11

"Estimating Derivatives of Noisy Simulations," Moré & Wild, ACM TOMS'12

Making a simple programming model scalable: The Asynchronous Dynamic Load Balancing Library

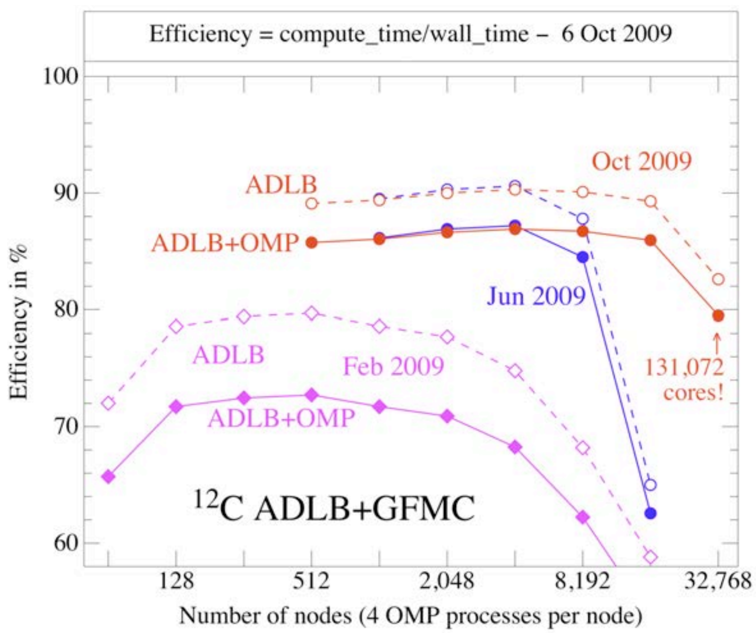
Objectives

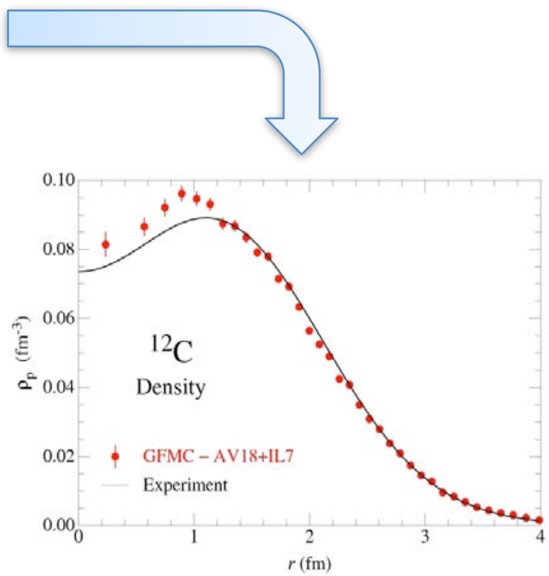
- Enable Green's Function Monte Carlo calculations for ^{12}C on full BG/P as part of UNEDF project
- Simplify programming model
- Scale to leadership class machines

Impact

- Demonstrate capabilities of simple programming models at petascale and beyond
- Show path forward with hybrid programming models in library implementation

Improved Efficiency (compute time/wall time) with more nodes





Progress

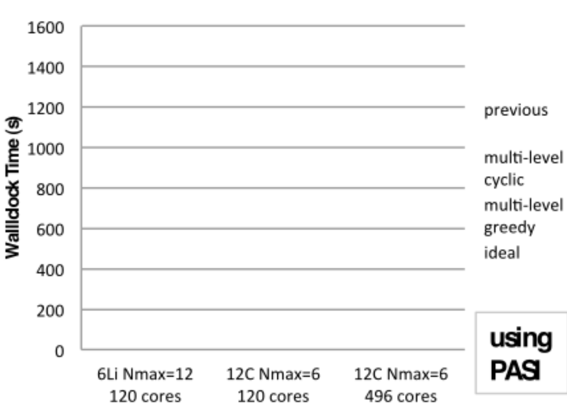
- Initial load balancing was of CPU cycles
- Next it became necessary to balance memory utilization as well
- Finally ADLB acquired the capability to balance message flow
- "More Scalability, Less Pain" by E. Lusk, S.C. Pieper and R. Butler published in SciDAC Review 17, 30 (2010)

MFDn: Total-J Progress

- **M-scheme approach:** works directly on the Hamiltonian, extracts all low energy states
- **J-scheme approach:** alternative to find a large number of low energy states for a prescribed total angular momentum (J) value
- **Targeted applications:** investigation of nuclear level densities, evaluation of scattering amplitudes
- **Total-J code:** implementation of the J-scheme approach in Fortran, MPI
- **CS Challenges in Total-J:** Three distinct phases, each with very different computing and storage characteristics

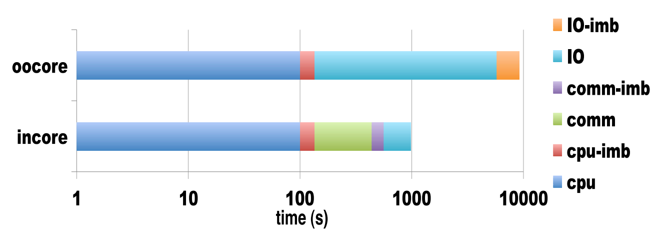
Phase 1: Construction of the J-basis

Implemented a multi-level greedy load balancing algorithm



Phase 2: Invariant Subspace Projection

In-core implementation to reduce I/O overheads in the out-of-core version



^{6}Li, N_{max}=14, J=3

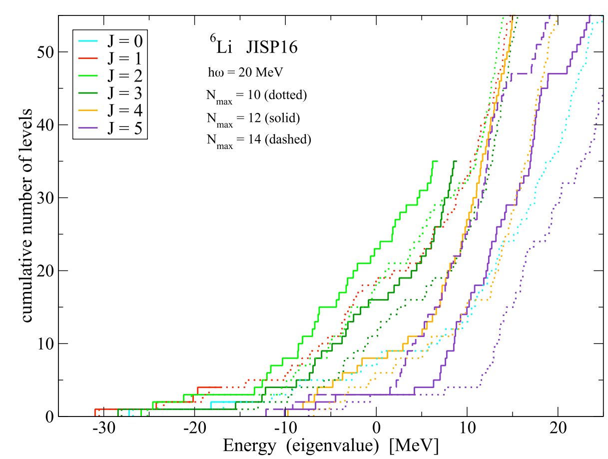
dimension of H ~ 1.7×10^{8}

10x speed-up, default striping

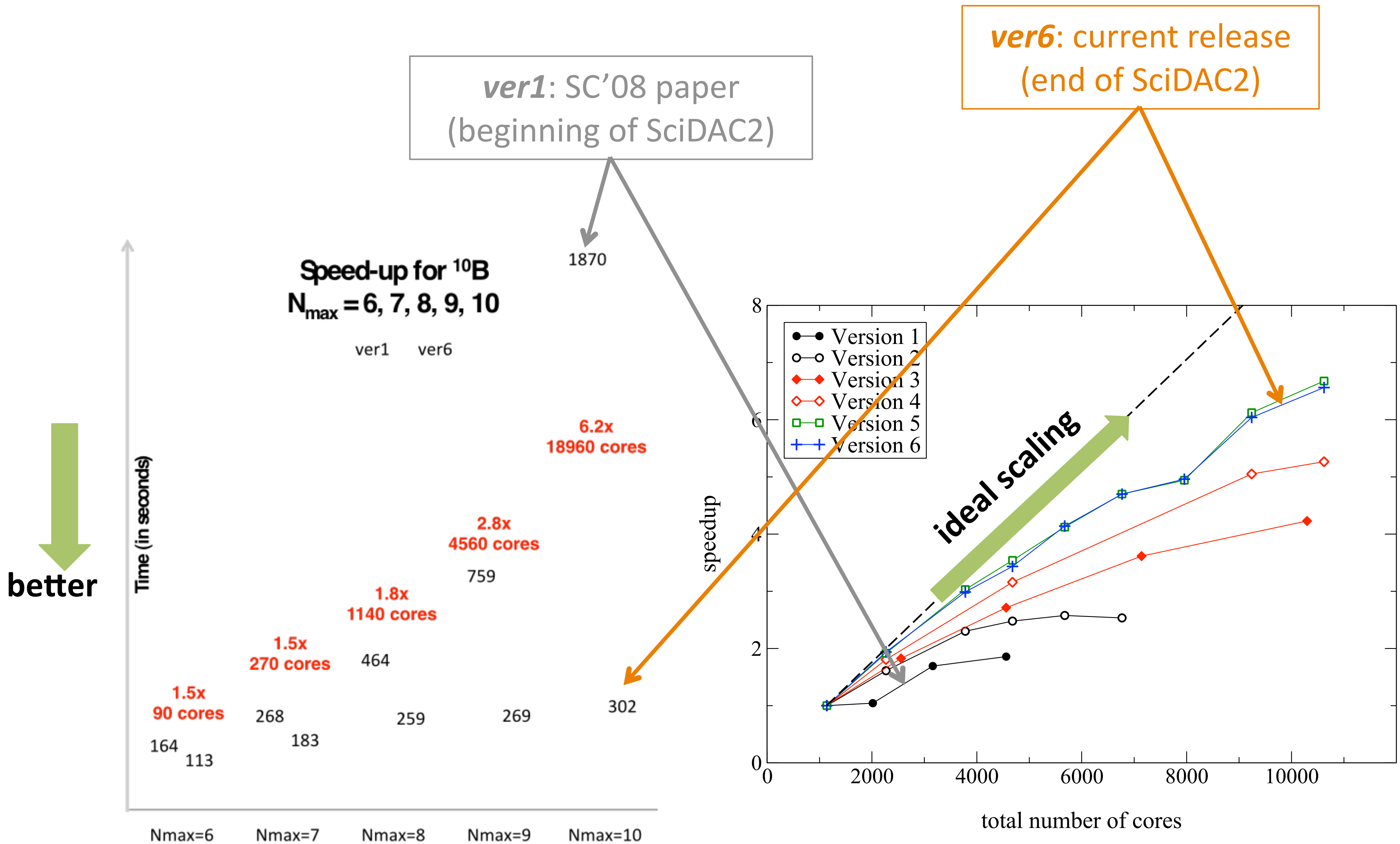
4x speed-up, optimal striping

Application:

Predicting the Nuclear Level Density of ^{6}Li (PRELIMINARY)



M-scheme: Performance Improvements



Weak Scaling

Strong Scaling for ^{10}B, N_{max} = 8

One Demonstration of NP – ASCR Coupling: Over 20 joint publications resulting from UNEDF

- "Real-Time Dynamics of Quantized Vortices in a Unitary Fermi Superfluid," A. Bulgac, Y.-L. Luo, P. Magierski, K.J. Roche, and Y. Yu, Science 332, 1288 (2011).
- "Origin of the anomalous long lifetime of ^{14}C," P. Maris, J. P. Vary, P. Navratil, W. E. Ormand, H. Nam, and D. J. Dean, Phys. Rev. Lett. 106, 202502 (2011).
- "More Scalability, Less Pain," E. Lusk, S.C. Pieper and R. Butler, SciDAC Review 17, 30 (2010).
- "Nuclear Energy Density Optimization," M. Kortelainen, T. Lesinski, J. More, W. Nazarewicz, J. Sarich, N. Schunck, M. V. Stoitsov, and S. Wild, Phys. Rev. C 82, 024313 (2010).
- "One-quasiparticle States in the Nuclear Energy Density Functional Theory," N. Schunck, J. Dobaczewski, J. McDonnell, J. More,, W. Nazarewicz, J. Sarich, and M.V. Stoitsov, Phys. Rev. C 81, 024316 (2010).
- "Scaling of ab-initio nuclear physics calculations on multicore computer architectures," P. Maris, M. Sosonkina, J. P. Vary, E. G. Ng and C. Yang, International Conference on Computer Science, ICCS 2010, Procedia Computer Science 1, 97 (2010).
- "Hamiltonian light-front field theory in a basis function approach," J. P. Vary, H. Honkanen, Jun Li, P. Maris, S. J. Brodsky, A. Harindranath, G. F. de Teramond, P. Sternberg, E. G. Ng, C. Yang, Phys. Rev. C 81, 035205 (2010).
- "Ab initio nuclear structure: The Large sparse matrix eigenvalue problem," J.P. Vary, P. Maris, E. Ng, C. Yang, and M. Sosonkina, J. Phys. Conf. Ser. 180, 012083 (2009).
- "Fast Multiresolution Methods for Density Functional Theory in Nuclear Physics," G. I. Fann, J. Pei, R. J. Harrison, J. Jia, J. Hill, M. Ou, W. Nazarewicz, W. A. Shelton, and N. Schunck, Journal of Physics: Conference Series 180, 012080 (2009).
- "Solution of the Skyrme-Hartree-Fock-Bogolyubov equations in the Cartesian deformed harmonic-oscillator basis. (VI) HFODD (v2.38j): a new version of the program," J. Dobaczewski, W. Satula, B.G. Carlsson, J. Engel, P. Olbratowski, P. Powalowski, M. Sadziak, J. Sarich, N. Schunck, A. Staszczak, M. Stoitsov, M. Zalewski, H. Zdunczuk, Comp. Phys. Comm. 180, 2361 (2009).
- "Towards The Universal Nuclear Energy Density Functional," M. Stoitsov, J. More, W. Nazarewicz, J. C. Pei, J. Sarich, N. Schunck, A. Staszczak, and S. Wild, Journal of Physics: Conference Series 180, 012082 (2009).
- "Deformed Coordinate-Space Hartree-Fock-Bogoliubov Approach to Weakly Bound Nuclei and Large Deformations," J.C. Pei, M.V. Stoitsov, G.I. Fann, W. Nazarewicz, N. Schunck and F.R. Xu, Phys. Rev. C 78, 064306 (2008).
- "Time-Dependent Density Functional Theory Applied to Superfluid Nuclei," A. Bulgac and K.J. Roche, J. Phys.: Conf. Ser. 125, 012064 (2008).
- ...