Strategies and Plans in (US) Nuclear Physics

Snowmass Community Planning Meeting
October 5, 2020

Kate Scholberg* , Duke University

*A member of both HEP and NP communities,
with no current role in NP planning.

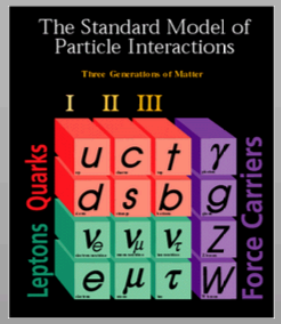
Thanks to David Hertzog, recent NSAC Chair,
and Tim Hallman, Associate Director of the Office of Science for Nuclear Physics, for input

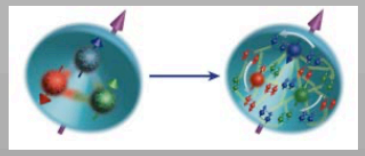
Nuclear Science Advisory Committee

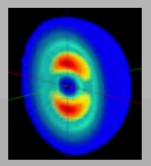
- "provides official advice to the Department of Energy
  and the National Science Foundation
  on the national program for basic nuclear science research"
- chartered under the Federal Advisory Committee Act (FACA)
- equivalent to HEPAP (High Energy Physics Advisory Panel)

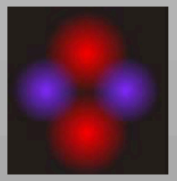
Long-range planning in NP is more directly coupled to NSAC,
unlike the two-step community (Snowmass) + P5 (HEPAP subcommittee)
process for High Energy Physics in the US

21st Century Nuclear Science: Probing nuclear matter in all Its forms & exploring their potential for applications



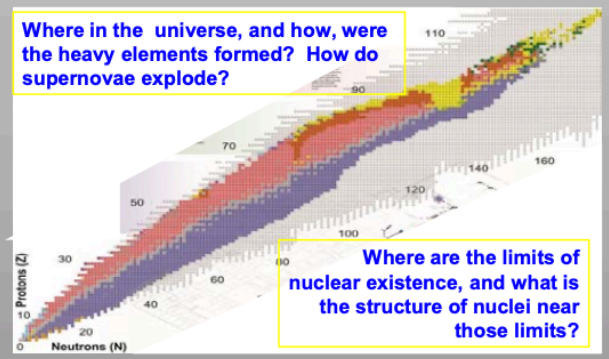






How are the properties of protons and neutrons, and the force between them, built up from quarks, antiquarks and gluons? What is the mechanism by which these fundamental particles materialize as hadrons?

Where in the universe, and how, were the heavy elements formed? How do supernovae explode?



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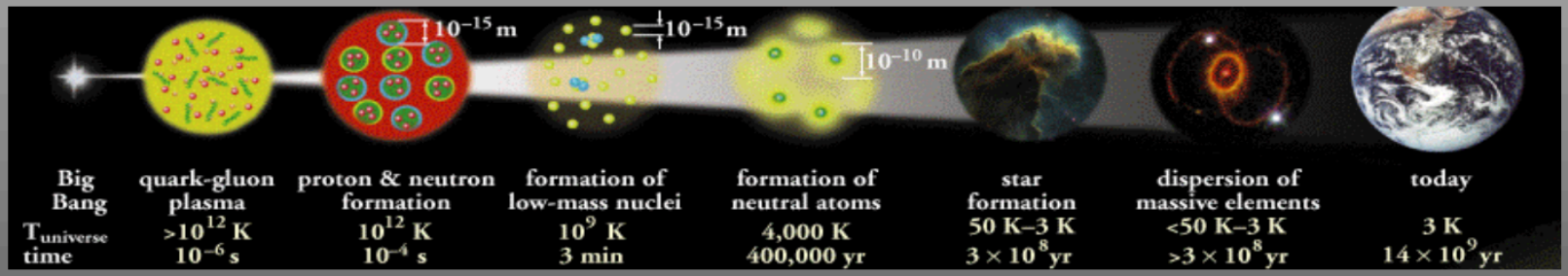
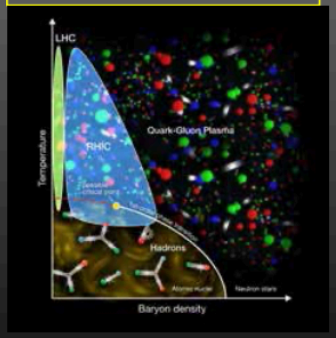
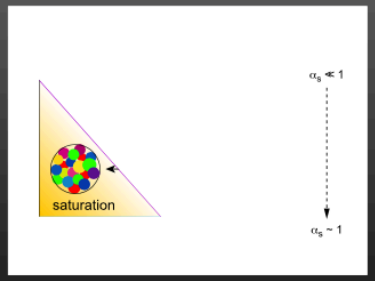


What is the nature of the different phases of nuclear matter through which the universe has evolved?



Do nucleons and all nuclei, viewed at near light speed, appear as walls of gluons with universal properties?



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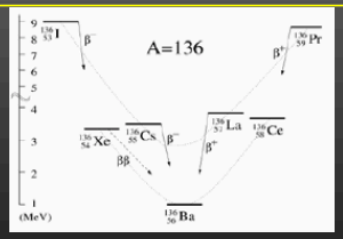

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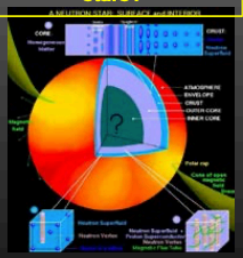

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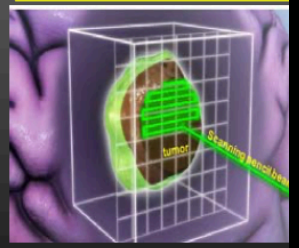

D. Geesaman, October 2015 NSAC meeting

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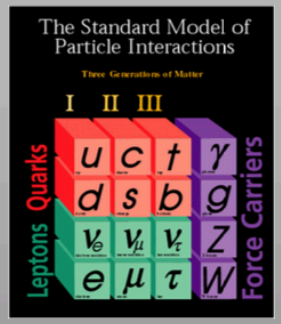

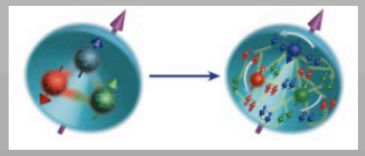

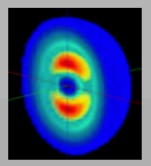

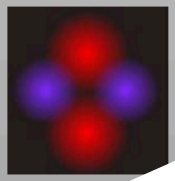

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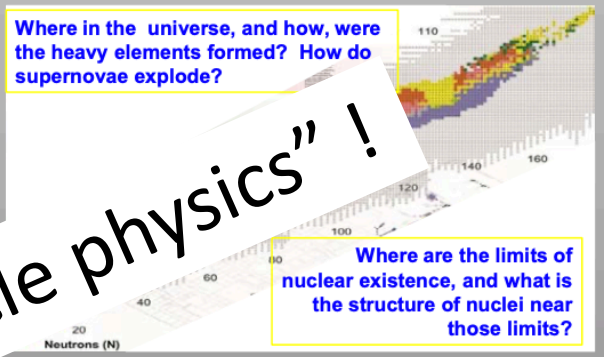

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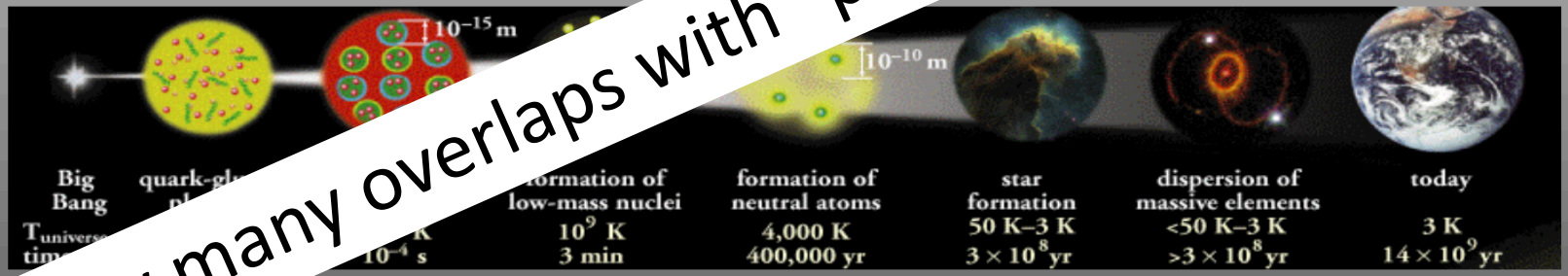
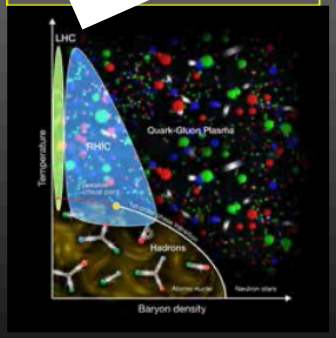
Many many overlaps with "particle physics" !



evolved?



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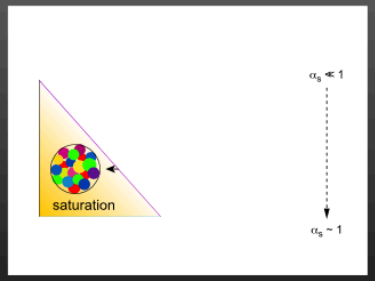

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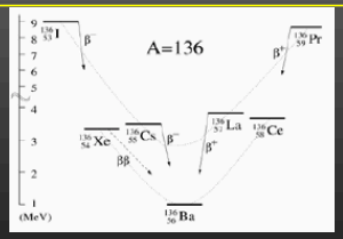

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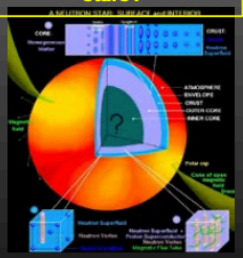

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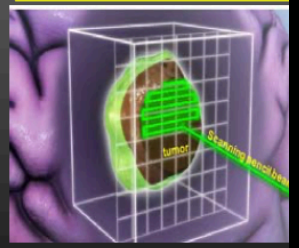
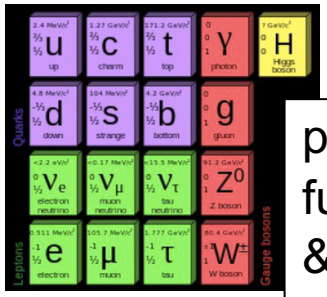


D. Geesaman, October 2015 NSAC meeting

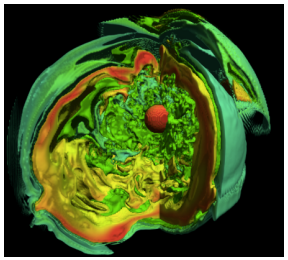
Many connections, in both science and tools...



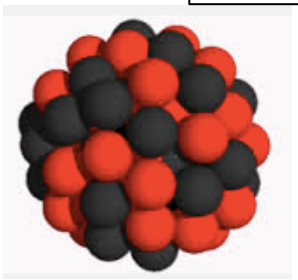
properties of fundamental particles & interactions

cosmology

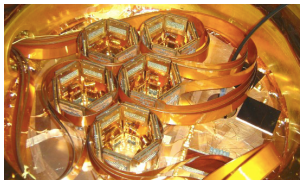
understanding of astrophysical objects

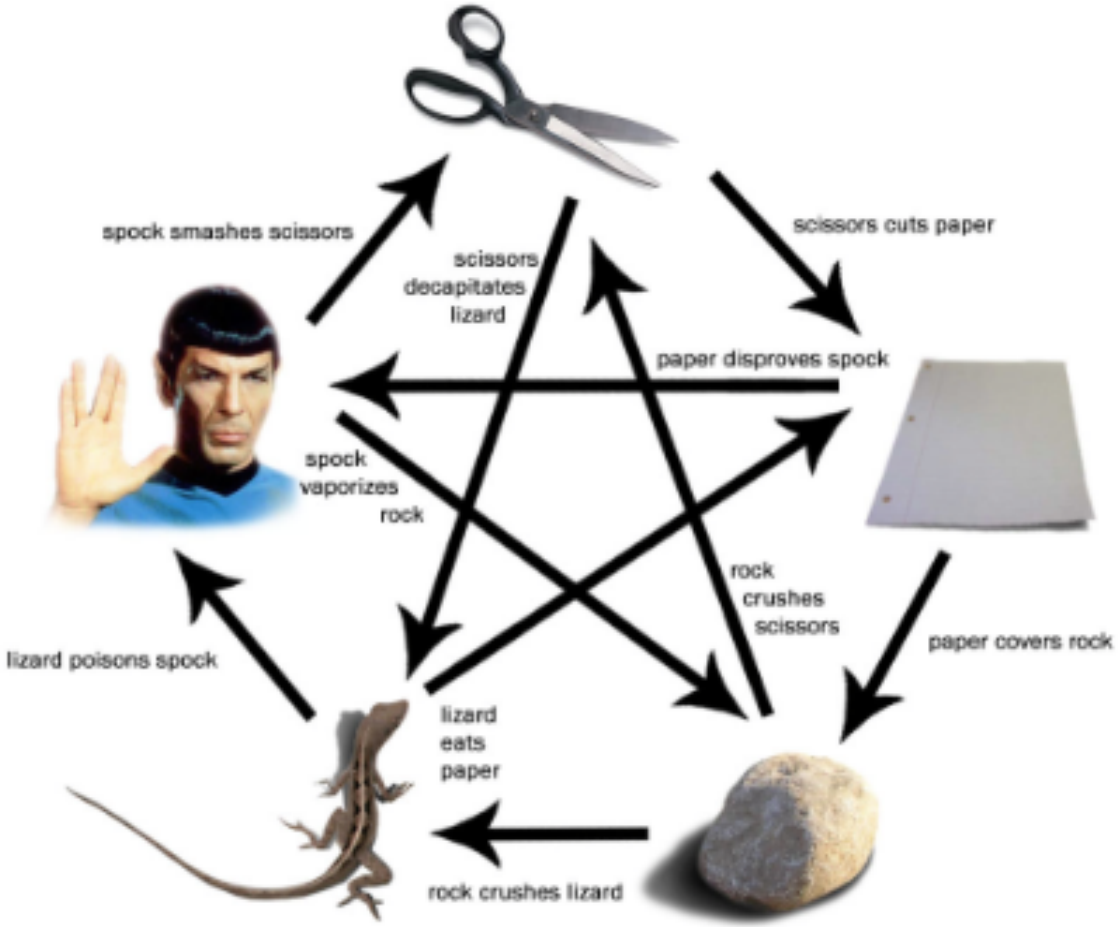


properties of nuclei



technology

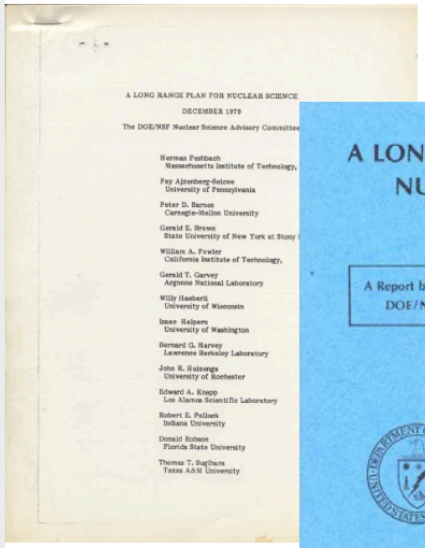




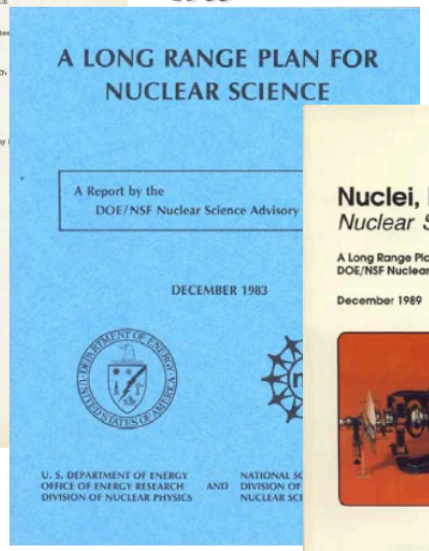
Note: relationships are two-way, *not* like rock-paper-scissors-lizard-spock

Every ~4-7 years NSAC is charged by DOE and NSF to make a long-range plan

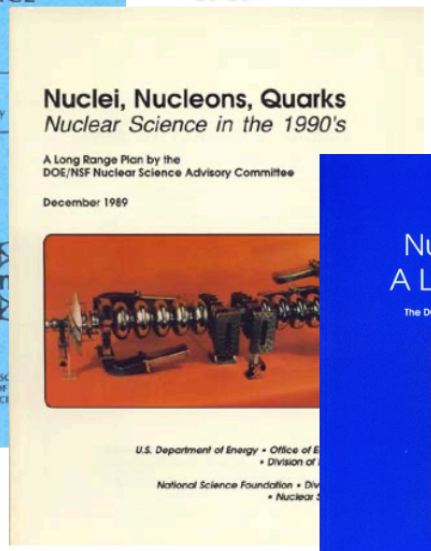
1979



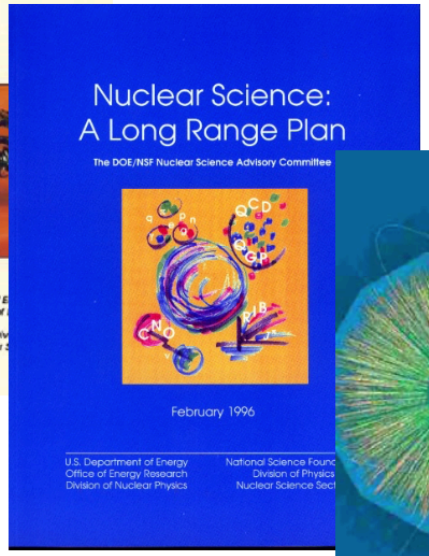
1983



1989

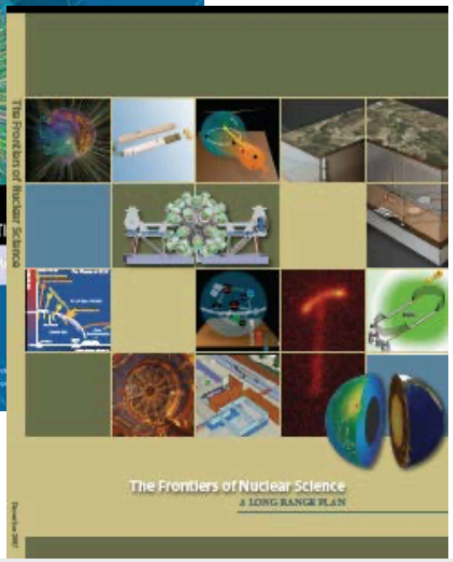


1996



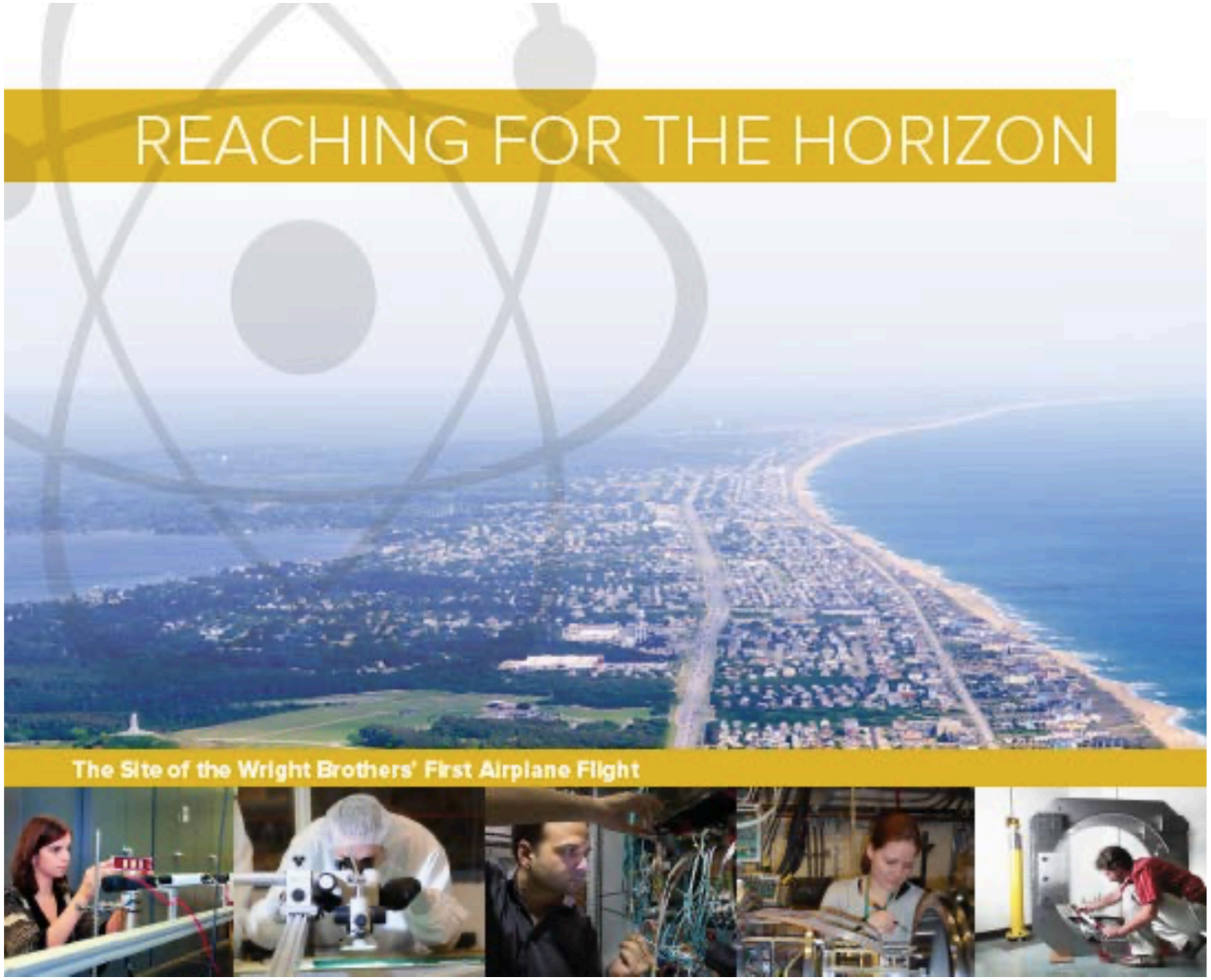
2002

2007



D. Geesaman, October 2015 NSAC meeting

Most recent instance:



The 2015
LONG RANGE PLAN
for NUCLEAR SCIENCE

Nuclear physics long-range planning process

- LRP working group: ~60 members from different sectors of the community
  + international observers from Europe and Asia

- Few months of community activities: DNP "Town Meetings" (summer 2014)
  - Education and Innovation
  - Nuclear Structure and Nuclear Astrophysics
  - Hadron and Heavy Ion QCD
  - Fundamental Symmetries, Neutrinos, Neutrons and Relevant Nuclear Astrophysics

- White papers submitted by community (January 2015)

- Text of report written

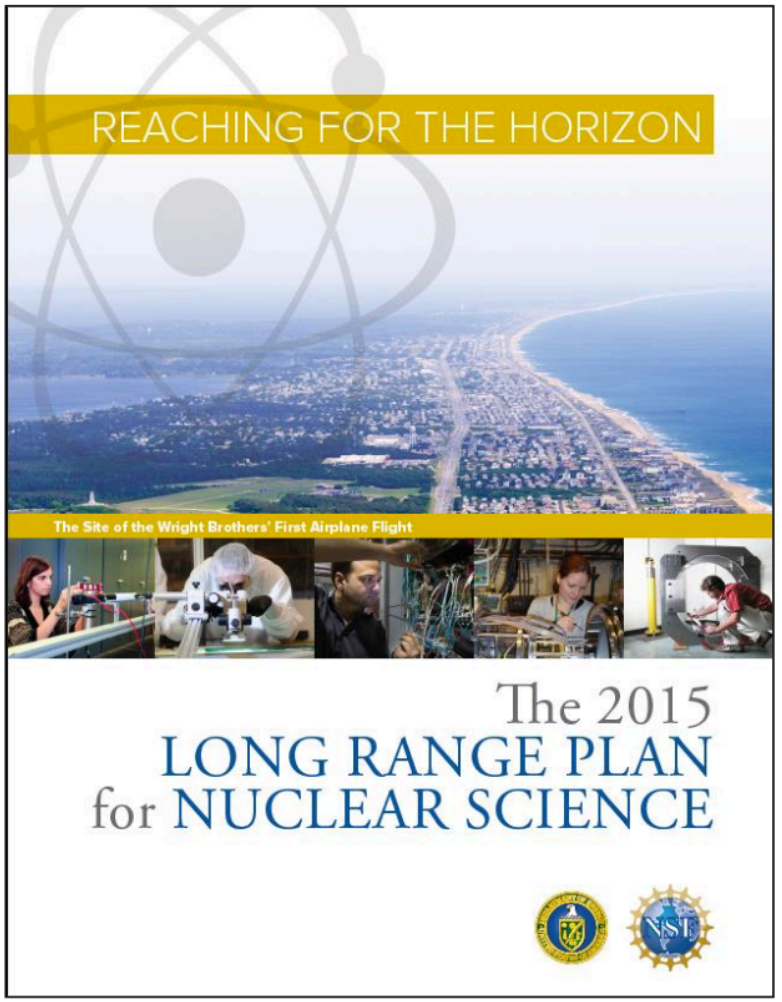
- "Resolution meeting" of entire working group, to finalize recommendations (April 2015)

- Report finalized October 2015

2015 LRP Recommendations

Recommendations:

1. Capitalize on investments made to maintain U.S. leadership in nuclear science.
2. Develop and deploy a U.S.-led ton-scale neutrino-less double beta decay experiment.
3. Construct a high-energy high-luminosity polarized electron-ion collider (EIC) as the highest priority for new construction following the completion of FRIB.
4. Increase investment in small-scale and mid-scale projects and initiatives that enable forefront research at universities and laboratories.



T. Hallman, March 2020 NSAC meeting

Recommendations 1 (capitalize on investments), and 4 (small-scale and mid-scale projects): many initiatives underway

See talks by T. Hallman (DOE) , A. Opper (NSF) @ March 2020 NSAC meeting

Recent highlights:

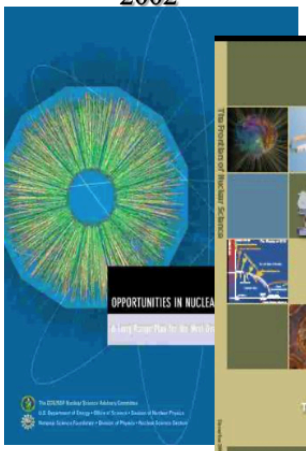
- Facility for Rare Isotopes Beams is >93% complete (NSCL → FRIB transition)
  - GRETA, HRS in progress
- ATLAS (Argonne Tandem Linac Accelerator System)
  stable beam facility for nuclear structure & nuclear astrophysics
- 12 GeV CEBAF @ JLab science program underway
  - MOLLER @ JLab
- RHIC operating 24 weeks for data-taking in FY21
  - sPHENIX upgrade continues
- Many smaller initiatives

Recommendation 3: Electron-Ion Collider

The Science Case for An Electron-Ion Collider

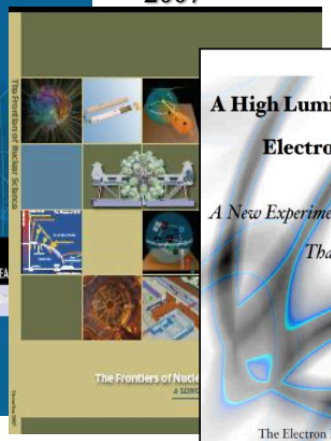
A strong community emphasis on the urgent need for a machine to illuminate the dynamical basis of hadron structure ir terms of the fundamental quark and gluon fields has been a persistent message for almost two decades

2002



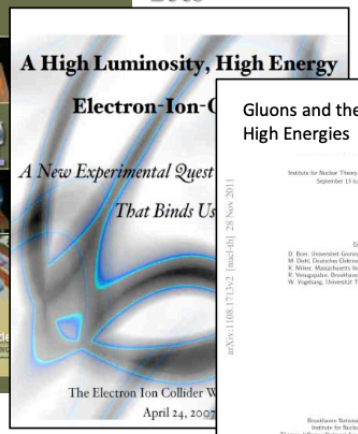
"…essential accelerator and detector R&D [for EIC] should be given very high priority in the short term."

2007



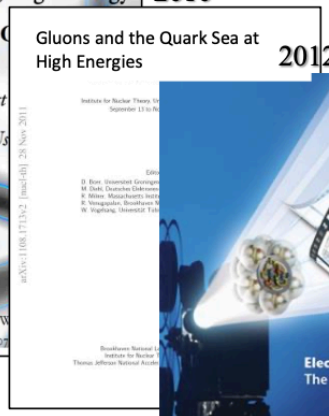
"We recommend the allocation of resources …to lay the foundation for a polarized Electron-Ion Collider…"

2009

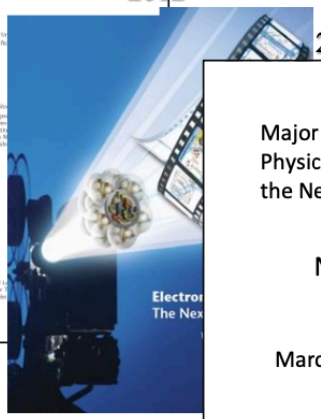


"..a new dedicated facility will be essential for answering some of the most central questions."

2010



2012



"The quantitative study of matter in this new regime [where abundant gluons dominate] requires a new experimental facility: an Electron Ion Collider.."

2013

Major Nuclear Physics Facilities for the Next Decade

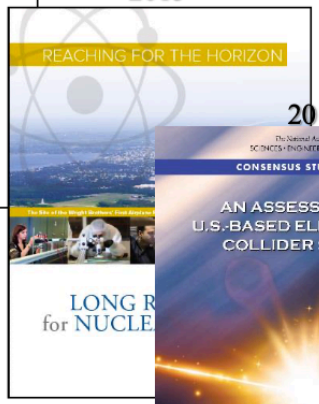
NSAC

March 14, 2013

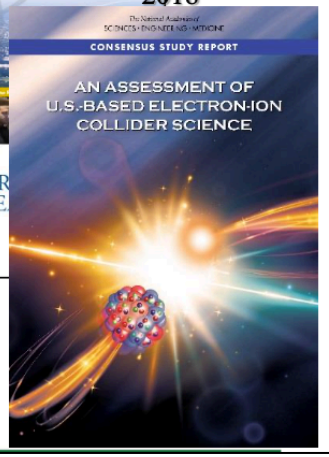
Electron-Ion Collider..*absolut ely central* to the nuclear science program of the next decade.

"a high-energy high-luminosity polarized EIC [is] the highest priority for new facility construction following the completion of FRIB."

2015



2018



T. Hallman, March 2020 NSAC meeting

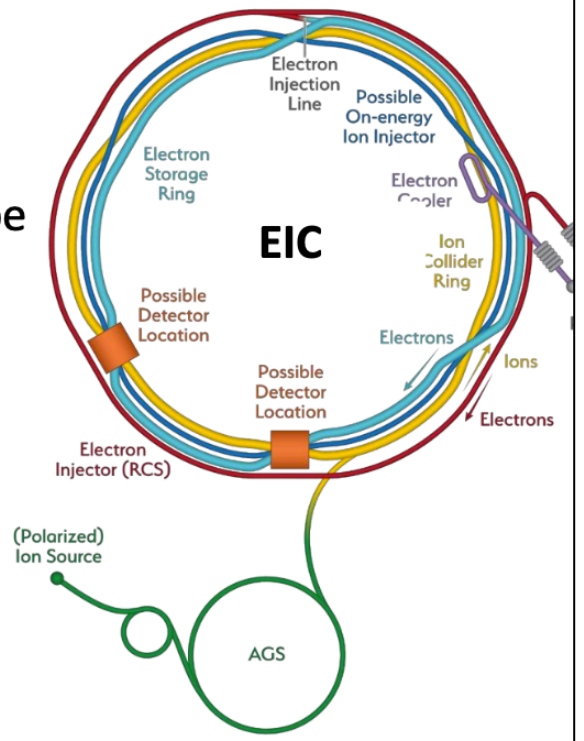
Important Milestones for the EIC

- Mission Need Statement Approved: January 22, 2019
  - Total Project Cost (TPC) range: $1.1 - $2.5 Billion
- Independent Cost Review (ICR) as required by DOE Order 413.3b completed July 31, 2019
- Independent Electron Ion Collider Site Assessment: October 8-9th
- FY 2020 Enacted Budget includes both TEC and OPC for EIC
- CD-0 was approved by DOE in December 2019
- Site Selection at Brookhaven National Laboratory was announced by DOE in January 2020

EIC Receives CD0 and Will be Sited at BNL

An SC Prime Directive: The Project will be carried out as a full intellectual partnership between the BNL and JLAB teams (and other collaborators) with major participation by all

- TPC range of EIC is $1.6B – $2.6B; complete early next decade
- TPC and completion of project dependent upon congressional appropriation and final agreed upon scope when baselined
- Magnitude of reprioritized funds ranges from ~$0.6B – $1.2B over the lifetime of the project.
- Reprioritization of activities towards the EIC also decreases the amount of new funding required
- The EIC could be implemented with caps on amount of new funds needed on an annual basis and still be implemented successfully and in a timely manner. I



EIC Project team is working towards being prepared for a CD-1 review early in calendar 2021

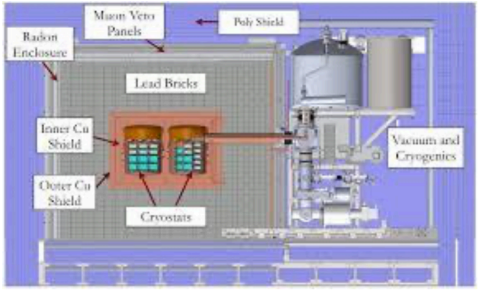
T. Hallman, March 2020 NSAC meeting

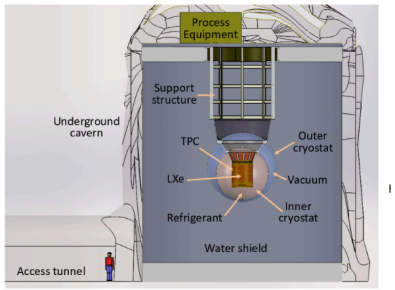
Recommendation 2: ton-scale neutrinoless double beta decay experiment

NLDBD of great interest to particle physics community (NF05);
stewarded by NP within DOE and supported by NSF in the US

Current Status of Ton-Scale 0νββ

- Within DOE, Office of Science, NP is the steward of neutrinoless double beta decay and the ton-scale experiment
- Critical Decision – 0, Mission Need, approved in November 2018
- TEC construction start for a ton-scale 0νββ experiment requested in the FY2020 President's Budget Request. TEC Funding of $1.44M Requested. R&D funding is continuing
- Met on the margins of IUPAP WG9 Meeting in London (8/2019) to discuss possible international collaboration
- Processes for technology down-select and site selection for a 1 ton experiment are under discussion:
  - Three front runner candidate experiments, LEGEND-1000 (Ge-76), CUPID (Mo-100), nEXO (Xe-136).
  - Three current candidate site locations: Gran Sasso (Italy), SNOLAB (Canada) and SURF (U.S)





T. Hallman, October 2019 NSAC meeting

- progress by ongoing experiments and R&D for next-generation
- progress in theory
- anticipated "down-select" still under discussion (site, technology)

Summary and Future for US Nuclear Physics Strategies and Plans

- Plans from NSAC 2015 LRP in advanced stage of fulfillment, coming to the end of the cycle
- Schedule and specifics for NLDBD down-select process not yet determined
- Schedule for next NSAC Long Range Planning process not yet determined

Final note from me:

Many, many overlaps,
in both core
and ancillary interests,
between NP and HEP
(and beyond)

... we need to
pay careful attention
to exploit these overlaps
and make sure that
science does not get lost
at the interfaces