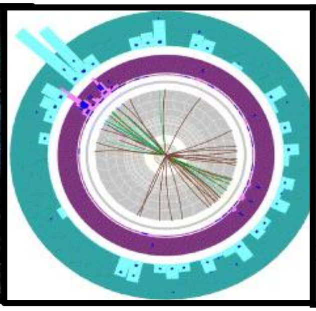
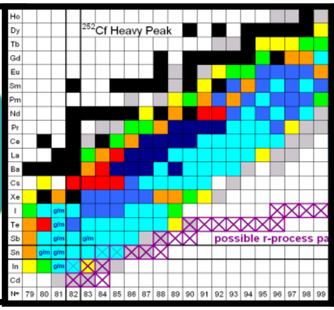
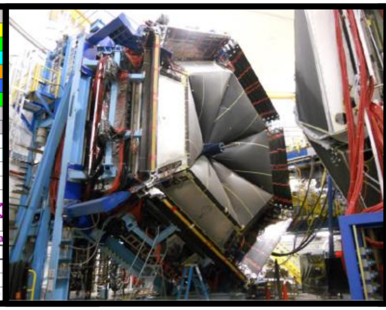
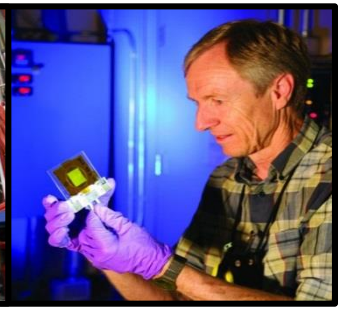
U.S. DEPARTMENT OF ENERGY | Office of Science

Perspectives from DOE Nuclear Physics

March 18, 2021

Dr. Timothy J. Hallman
Associate Director of the Office of Science
for Nuclear Physics

Budget Matters

Summary of 2021 Enacted Relative to FY 2020

Total, NP	**651,500**	**635,000**	**-16,500**
Total, NP Appropriation	**713,000**	**713,000**	**-**

FY 2020 Enacted	FY 2021 Enacted
Core Research reduced 5.5% from FY19 Enacted (including COL, this is a 7.4% cut from constant effort in FY19). New ECA awards were made.	**Core research** reduced 3.75% from FY20 Enacted. This reduction also includes a reduced number of new ECA awards in FY21.
LHC M&O commitments were met.	**LHC M&O** commitments met but subject to the research cut.
FRIB Research was supported as planned.	**FRIB Research** is reduced by 3.75% from FY20; planned ramp-up is not supported.
nEDM supported modestly below planned profile.	**nEDM** supported below planned profile, possibly impacting schedule.
SciDAC maintained relative to FY 2019	**SciDAC** supported but subject to the research cut.
Nuclear Data held flat with FY19 Enacted	**Nuclear Data** research funds subject to the research cut. Experimental commitments met, but limited funding is available for new awards.
NP QIS at $6.8M (NP QIS flat with FY2019)	**NP QIS** at $9.5M, an increase of $2.7M from FY2020
Accelerator R&D was increased	**Accelerator R&D** is reduced by $1M beyond 3.75% cut.
Machine Learning/Artificial Intelligence awards were initiated through the SC ML/AI FOA.	**The new ML/AI Initiative** is supported with $4M of dedicated funds.

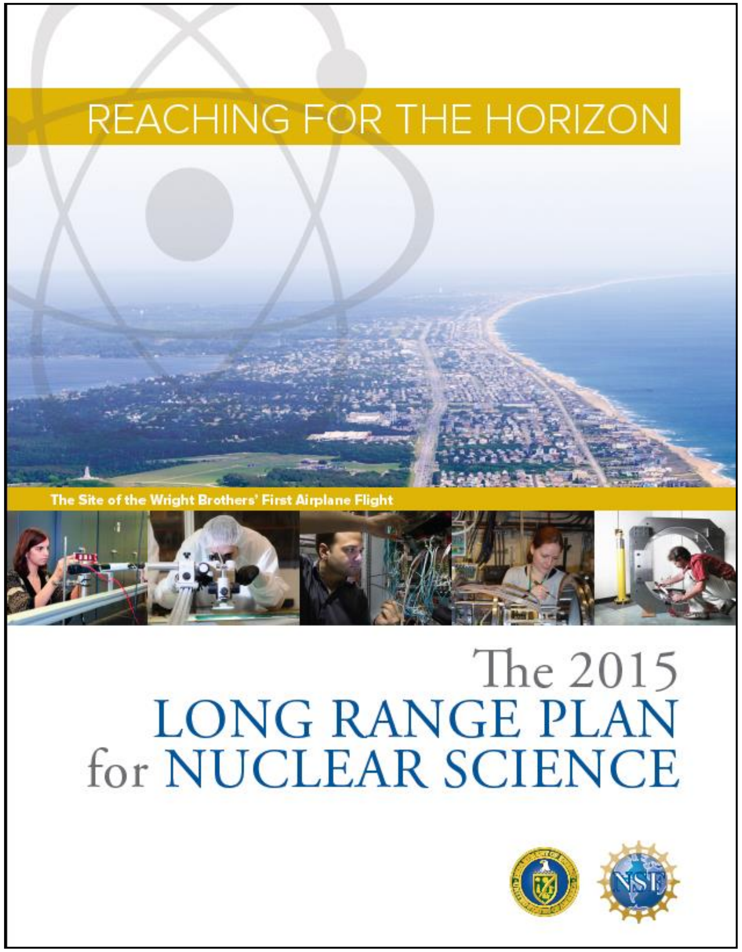
Summary of 2021 Enacted Relative to FY 2020

<table>
<tr><th>FY 2020 Enacted</th><th>FY 2021 Enacted</th></tr>
<tr><td>Facility operations at constant effort
- RHIC operates 28 weeks (100 % optimal)
- CEBAF operates 22.5 weeks (100 % maximum)
- ATLAS operates 41 weeks (90 % optimal)</td><td>Facilities operations funding is reduced by 3.75%. Estimated run times are:
- RHIC operates 24 weeks (100 % maximum)
- CEBAF operates 7 weeks (41 % maximum)
- ATLAS operates 39 weeks (92.6 % optimal)</td></tr>
<tr><td>FRIB operations supported at planned level $28.5M</td><td>FRIB ops supported slightly below planned levels ($50M vs $59.8M)</td></tr>
<tr><td>FRIB construction at baselined $40M</td><td>FRIB construction at baselined $5.3M</td></tr>
<tr><td>EIC construction at TEC of $1M and OPC of $10M</td><td>EIC construction at TEC of $5M and OPC of $24.65M</td></tr>
<tr><td>Ongoing Major Item of Equipment:
- GRETA reduced below planned levels ($6.6M)
- sPHENIX at planned baseline level ($9.52M)
- SIPF at planned baseline level ($1.5M)</td><td>Ongoing Major Item of Equipment:
- GRETA flat with FY2020, below baselined level ($6.6M)
- sPHENIX at baseline level ($5.53M)</td></tr>
<tr><td>New Major Items of Equipment initiated
- MOLLER at $2M TEC
- TSNLDBD at $1M TEC
- HRS at $1M TEC</td><td>Major Items of Equipment initiated in FY 2020
- MOLLER increased to $5M, but below planned level
- TSNLDBD at $1.4M TEC
- HRS at $3M TEC</td></tr>
<tr><td>Isotope Program at $60.5M</td><td>Isotope Program at $78M</td></tr>
</table>

The 2015 Long Range Plan for Nuclear Science

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. ✓



NP continues to execute on the 2015 LRP Vision

Upcoming Decisions

Three Front-Runner Technologies

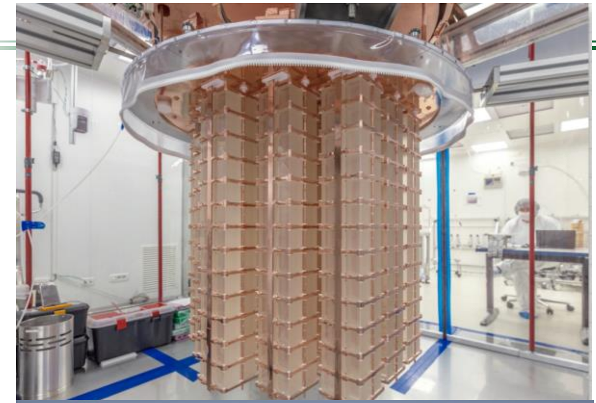
- Scintillating bolometry (**CUPID**, ^{100}Mo enriched Li_2Mo_4 crystals)
- Enriched ^{76}Ge crystals (**LEGEND-1000**, drifted charge, point contact detectors)
- Liquid Xenon TPC (**nEXO**, light via APD, drifted ionization)

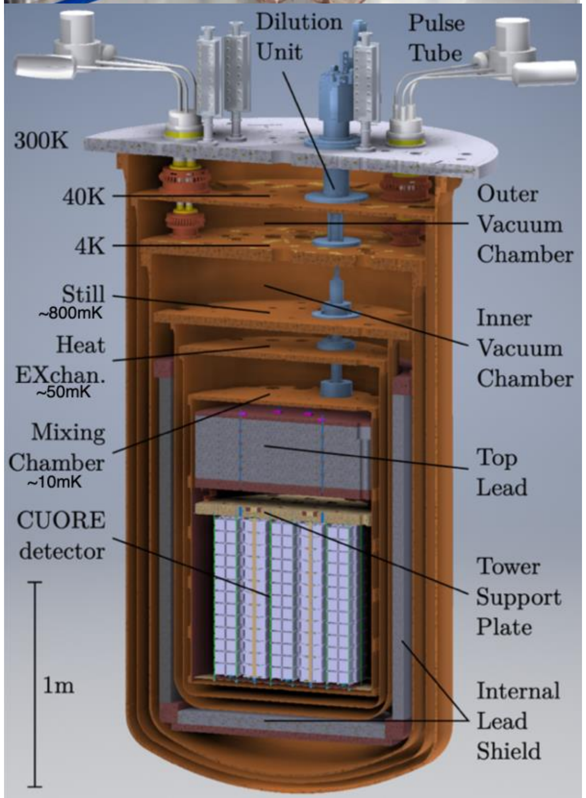
Background constraints are exceptionally challenging < 1 count/ton of material/year

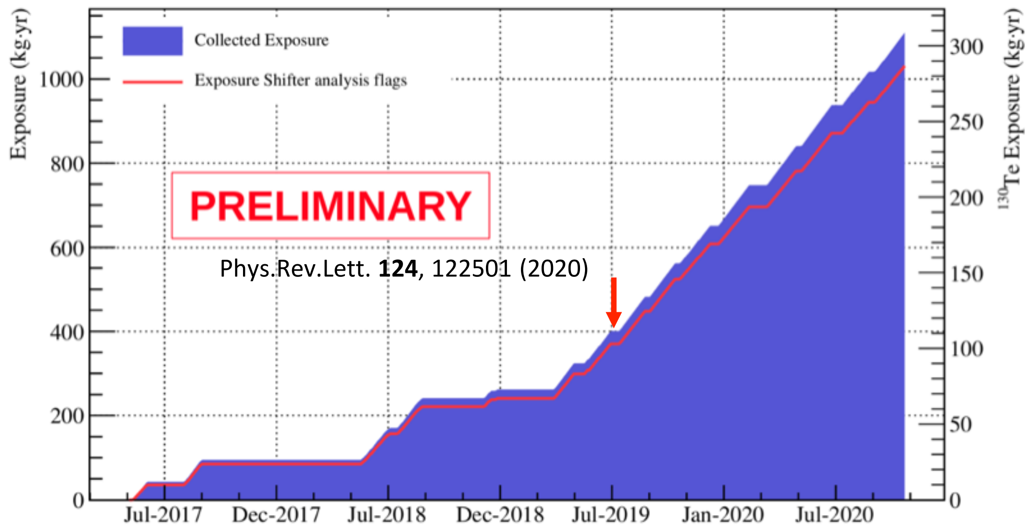
Also, must choose between possible sites

- SURF (SD)
- SnoLab (Canada)
- Gran Sasso (Italy)

CUORE: Towards Ton-scale NLDBD Search



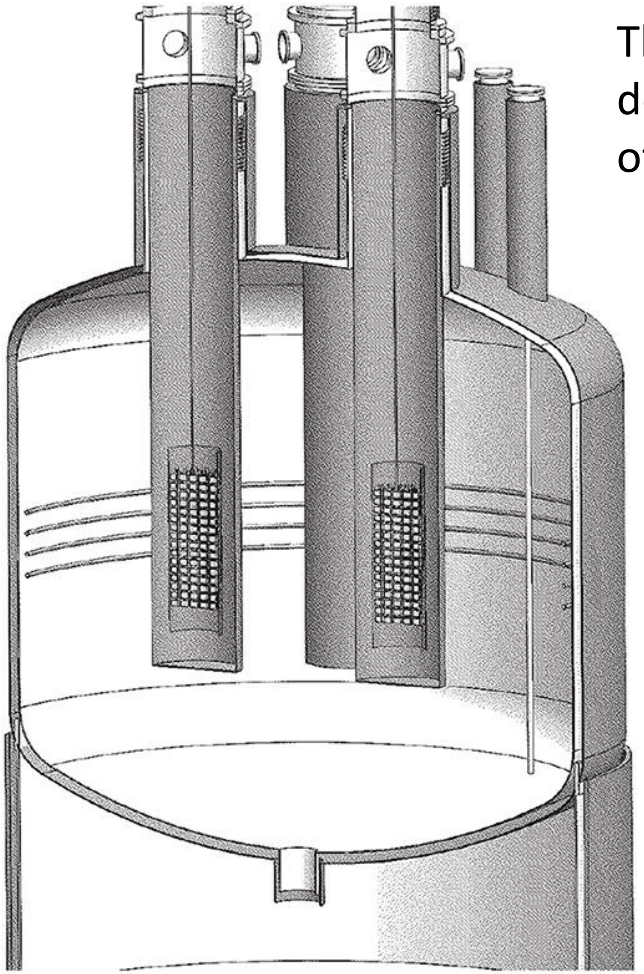




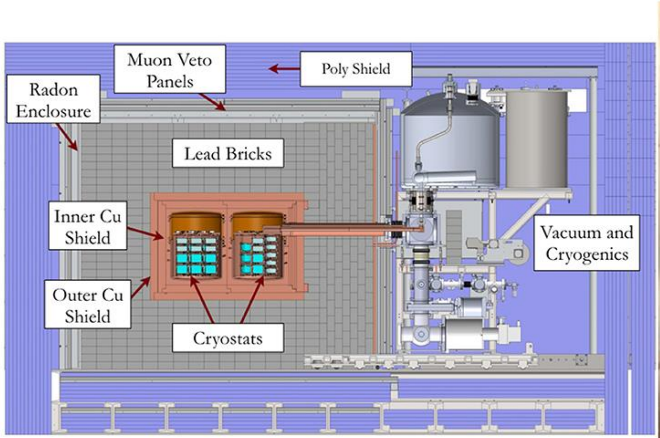
Collected TeO_2 exposure: 1110 kg*year
Analyzable exposure: 1031 kg*year (*as of Oct 26, 2020)

>1 ton*year analyzable exposure
Largest dataset ever collected by a solid-state double-beta decay experiment
Continuous operations at 11mK since March 2019
Demonstrates readiness for a ton-scale bolometric double-beta decay experiment
CUPID proceeding to technical design

LEGEND-1000



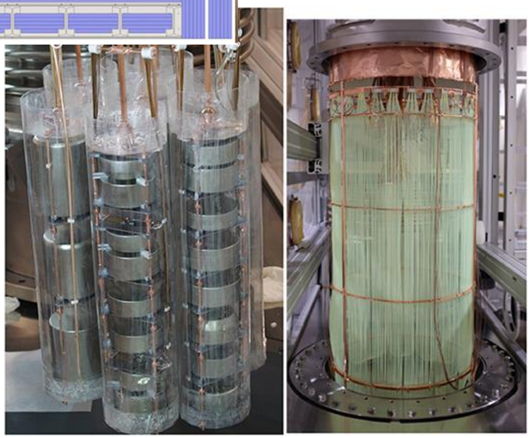
The concept for LEGEND-1000 showing a number of the deployments Ge detectors. This cut-away view shows three of five 200-kg groupings of Ge.



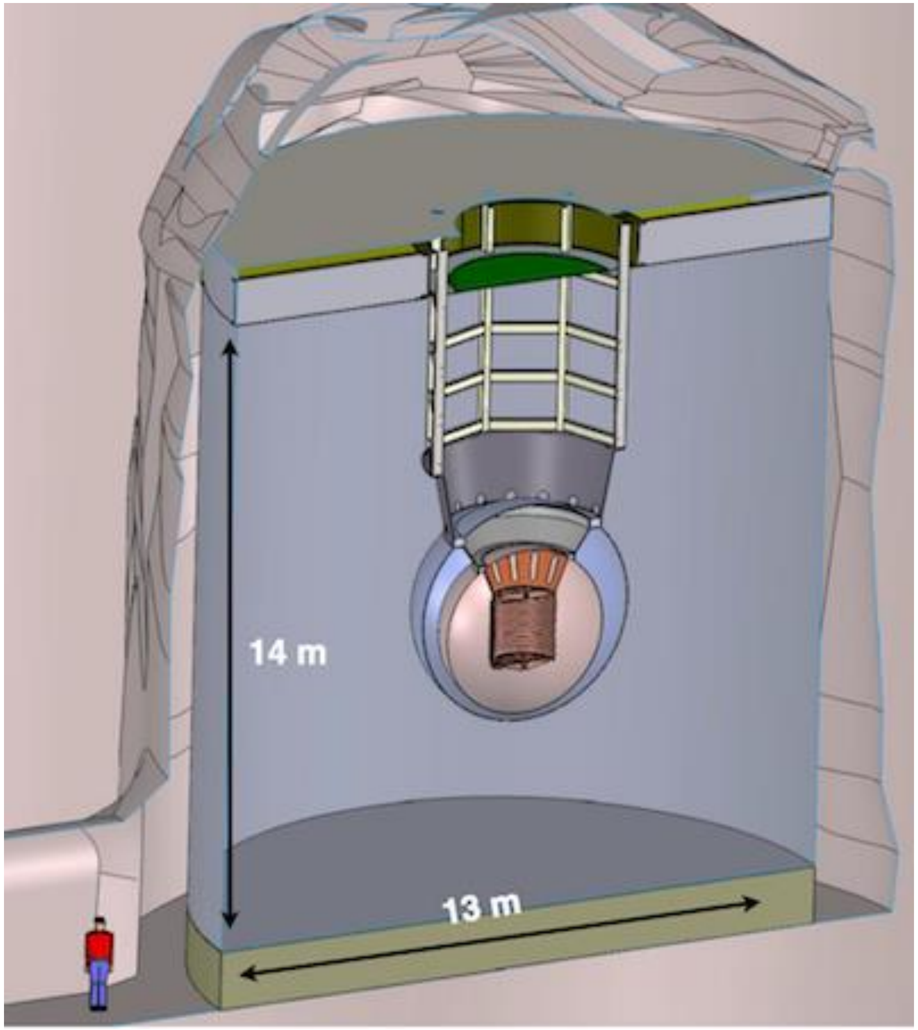
Majorana Demonstrator

+

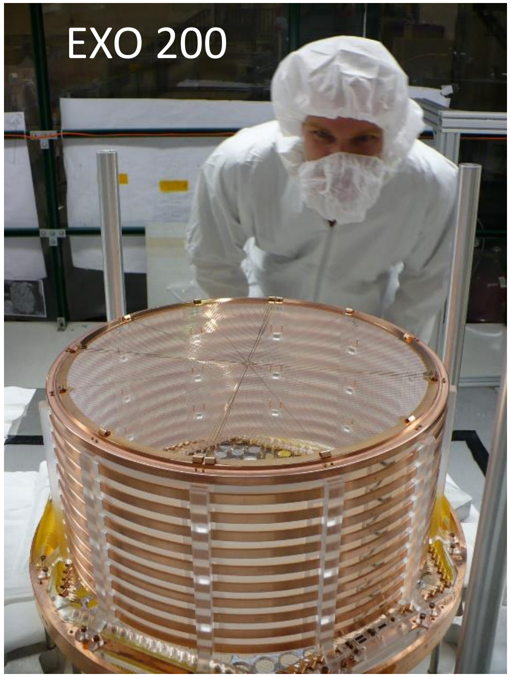
GERDA



nEXO Concept



Artist rendering of the nEXO TPC (left) and its installation at the SNOLAB cryopit (left).
The cryostat is submerged in a water tank which acts as active shielding.
SiPMs will be mounted between field shaping rings and detector wall.



$0\nu\beta\beta$ Progression

- Monthly Technical Updates with LEGEND-100, nEXO, and CUPID
- Ongoing interactions with potential international collaborators to introduce U.S. perspectives, hear European perspectives, and suggest a global approach to investment in DBD science
- DBD Portfolio Review will be held July 13-16, 2021 to inform U.S. investment strategy. Instructions published by April 15, 2021.
- North American – European Summit will be held September 27-29, 2021 to see if common ground exists for an international approach to DBD investment
- Funding for ton-scale $0\nu\beta\beta$ is going to be challenging

The Next Super High Current, Low Energy Microscope: The Facility for Rare Isotope Beams (>96% Complete)

FRIB will increase the number of known isotopes from ~2,000 to ~5,000 and will enable world-leading research on:

<u>Nuclear Structure</u>

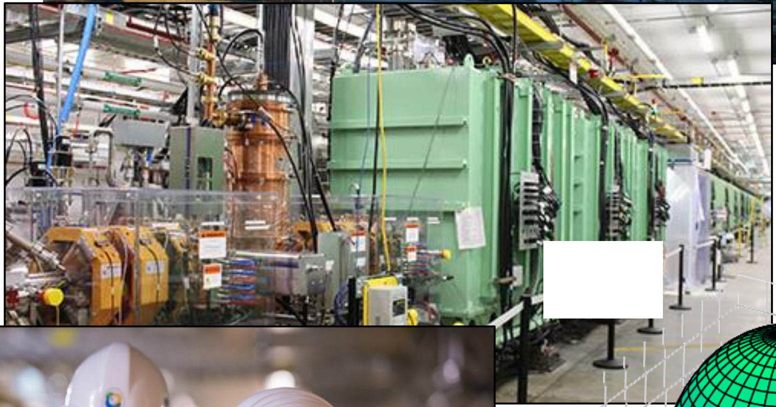
- The limits of existence for nuclei
- Nuclei that have neutron skins
- Synthesis of super heavy elements

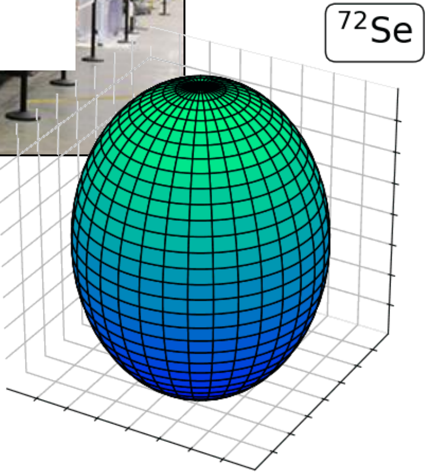
<u>Nuclear Astrophysics</u>

- The origin of the heavy elements and explosive nucleo-synthesis
- Composition of neutron star crusts

<u>Fundamental Symmetries</u>

- Tests of fundamental symmetries, Atomic EDMs, Weak Charge





	PYs	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	DOE Total	MSU	TOTAL
FUNDING PROFILE	318,000	100,000	97,200	75,000	40,000	5,300	635,500	94,500	730,000

1,500 Users Engaged and Ready for Science fribusers.org

- Users organized as part of independent FRIB Users Organization (FRIBUO)
  - Chartered organization with an elected executive committee
  - 1,500 members (121 U.S. colleges and universities, 13 national laboratories, 53 countries) as of 31 August 2020
  - 19 working groups on instruments
- On track for first experiments
  - May 2020: FRIB First Experiments - Proposal Preparation workshop (1)
  - Nov 2020: FRIB First Experiments - Proposal Preparation workshop (2)
  - Dec 2020: Call for Proposals
  - May 2021: FRIB Program Advisory Committee (PAC 1)
  - Early 2022: first user experiments
- User needs and high user satisfaction are important to FRIB
  - ISO 9001 quality systems to assess user satisfaction
- Annual meetings
  - User meeting (three days with 200-300 participants)
    - » Most recent meeting August 2020 (online)

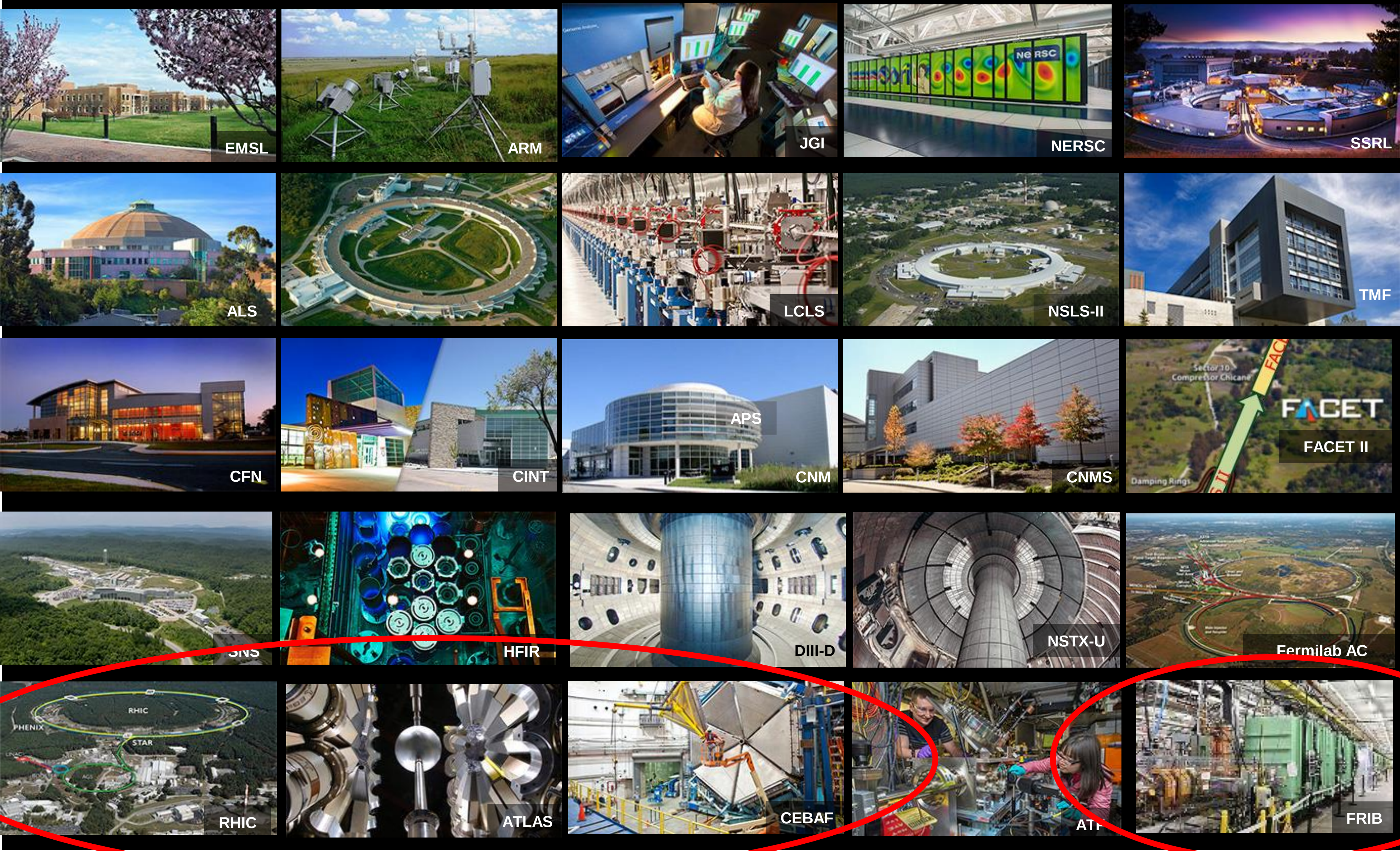
First Physics Spring of 2022

FRIB Status

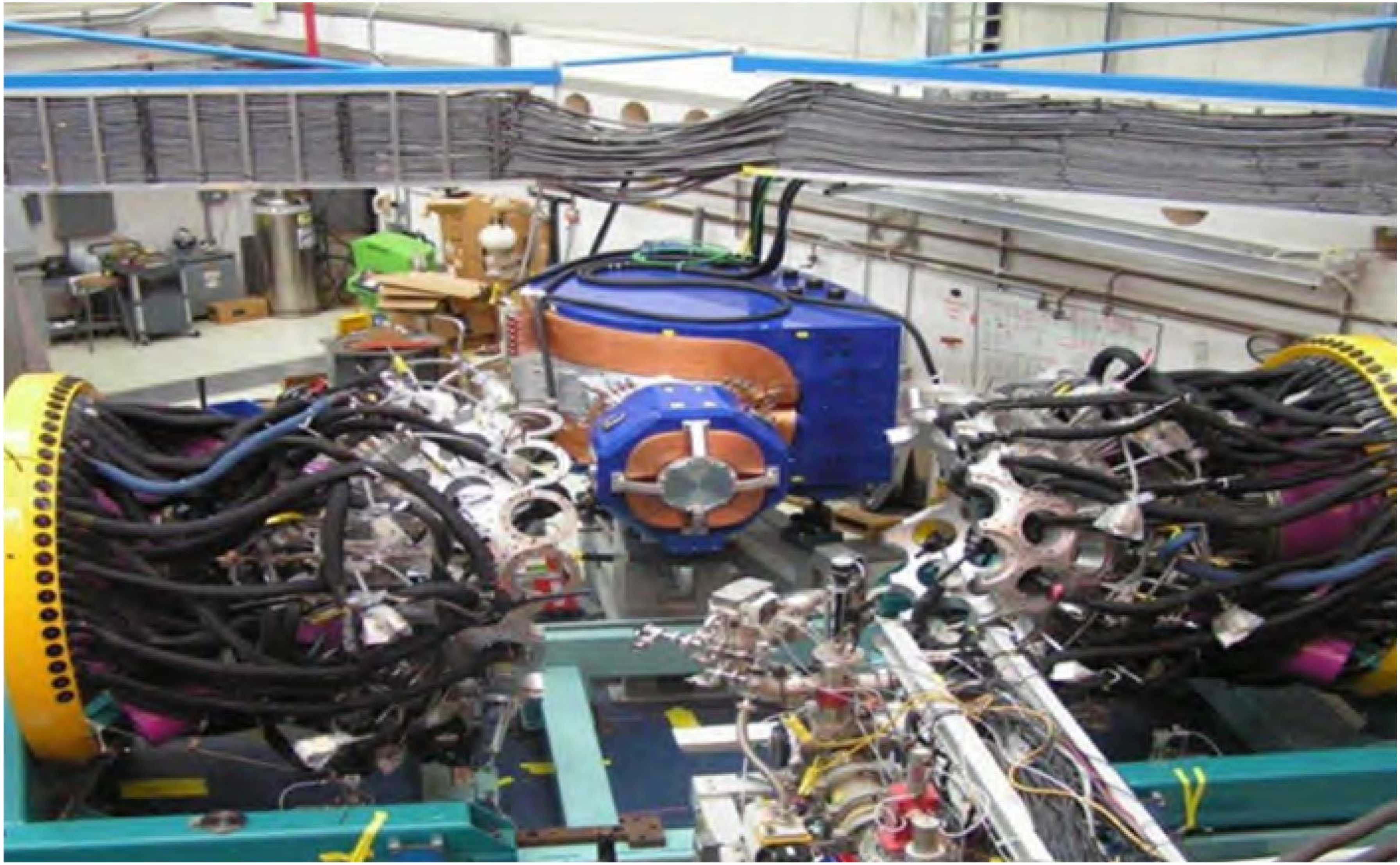
- FRIB is approximately 96% complete and continues on cost and schedule, with a target early completion of December 2021.
- FRIB will receive its final construction funding of $5.3M in FY 2021
- The Gamma Ray Energy Tracking Array (GRETA) Major Item of Equipment (MIE) and the High Rigidity Spectrometer (HRS), both are included in the FY 2021 appropriation
- The FY2021 appropriation includes $50M for FRIB operations.
- In preparation for early science, the FRIB Directorate recently issued a call for proposals to its 1500 member user group.
- In response to the call, 82 proposals were received requesting 9,784 hours of beam time
- A first FRIB Program Advisory Committee Meeting to advise on proposal selection will be held in May 2021.

Office of Science User Facilities

Number of User Facilities 28

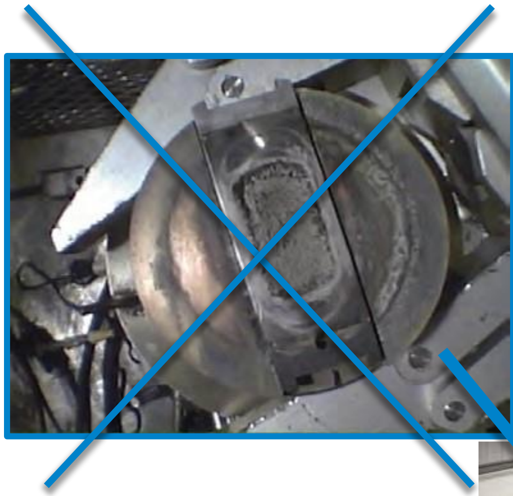


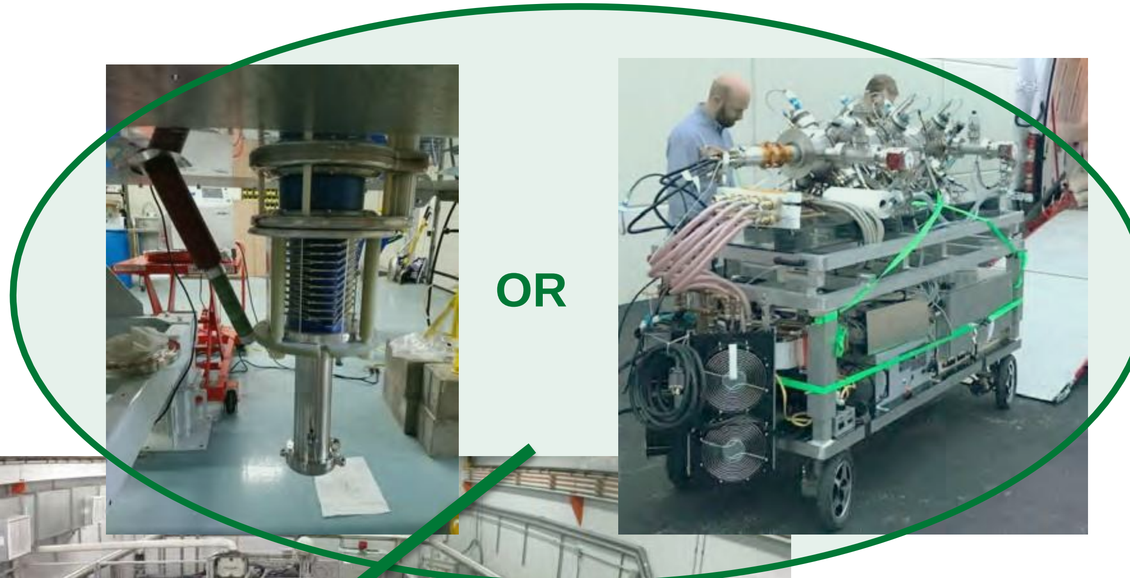
ATLAS Continues as a Premier Stable Beam Facility



NEUTRON GENERATOR UPGRADE

- Replace ^{252}Cf source by neutron-induced fission on actinide foils
  - More reliable source of fission products
  - Operationally easier to maintain and operate
  - Higher fission yield feeding in the ^{132}Sn region

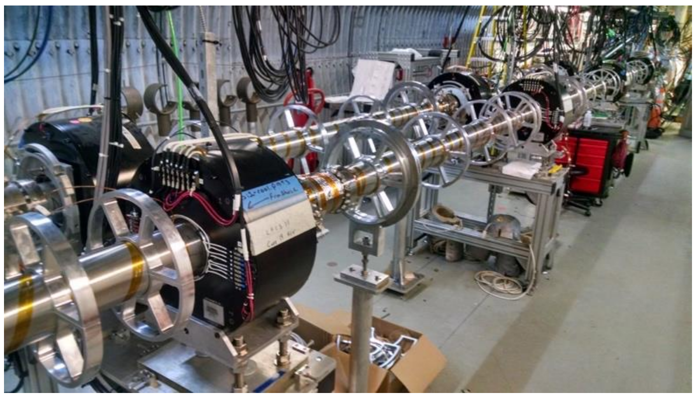




RHIC Machine Performance Continues to Set New Records

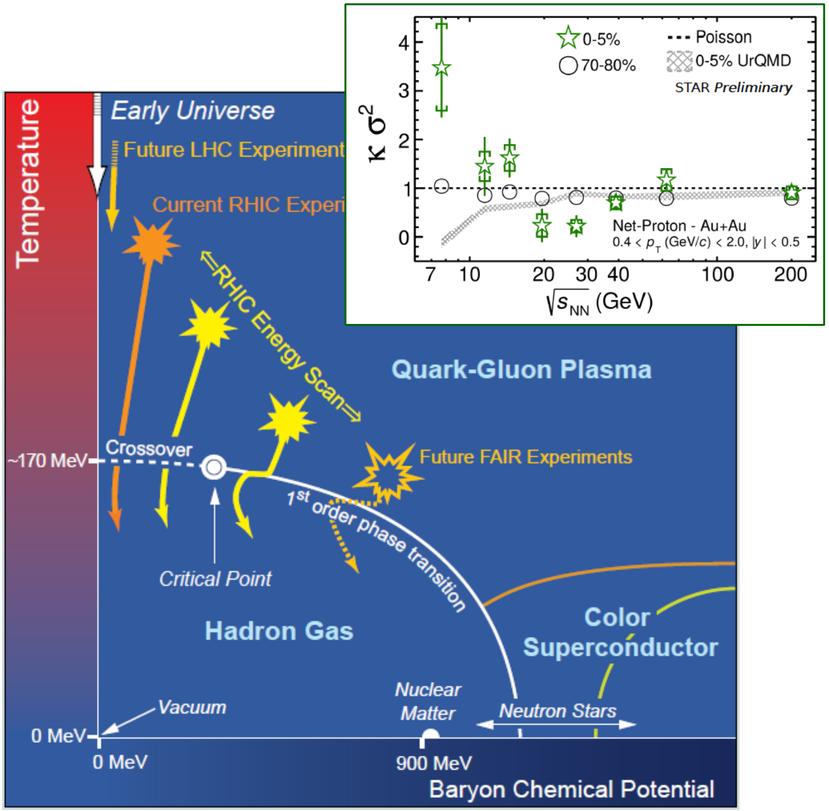
- The continued focus at RHIC: search for a critical point between the phases of nuclear matter

LEReC



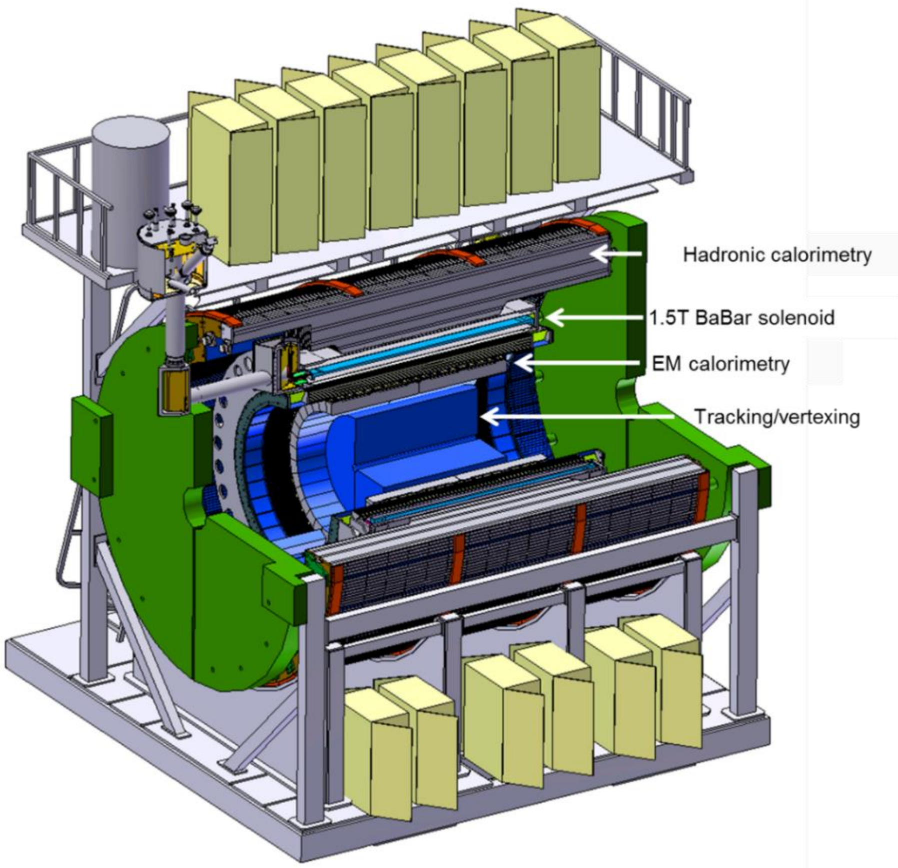
Cooling of low energy, bunched heavy ion beams (3.85–5.75 GeV/n) to increase luminosity

Project on track for use in low-energy RHIC runs



- Consistently high facility availability (~85%)
- No other facility worldwide, existing or planned, rivals RHIC in science reach and versatility as a heavy ion collider. It is the only polarized proton collider in the world.

The sPHENIX Upgrade is Continued



- mapping the character of the hadronic matter under extreme conditions by varying the temperature of the medium, the virtuality of the probe, and the length scale within the medium.
- understanding the parton–medium interactions by studying heavy-flavor jets.
- probing the effect of the quark–gluon plasma on the Upsilon states by comparing the p-p (proton-proton), p-A (proton-nucleus), and A-A (nucleus-nucleus) collisions.

August 16, 2018: CD-1 and CD-3a for long lead procurements

$6M Proposed from within the RHIC base for FY 2020 Request

implemented from within RHIC base by limiting operations to one detector and periodically not operating facility.

CMS MTD ScienceReview is Upcoming

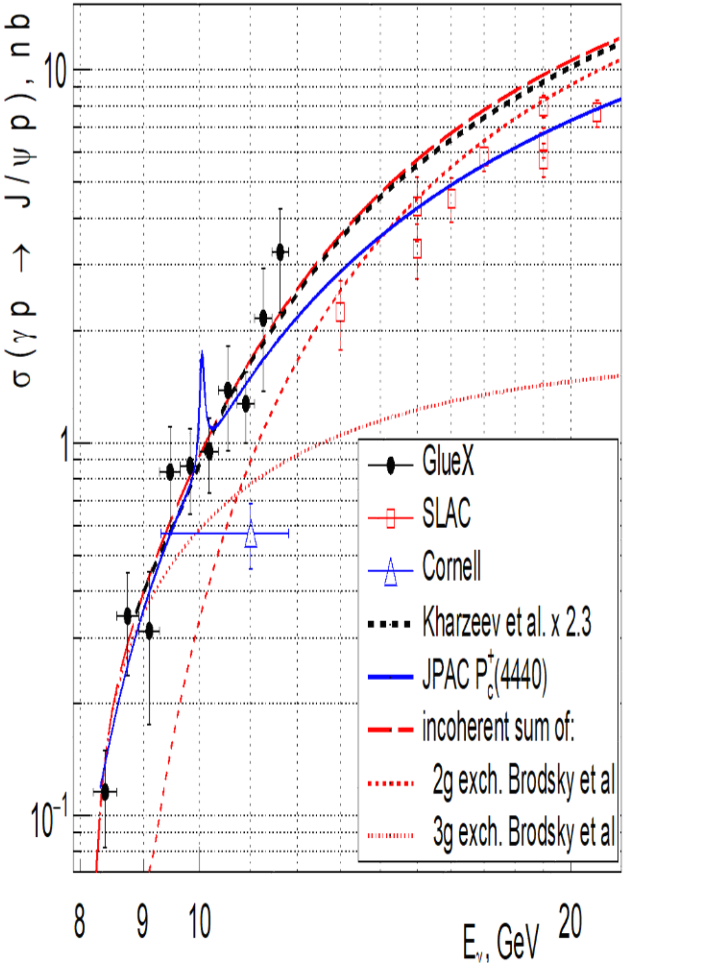
12 GeV CEBAF Science Program Continues

CEBAF Weeks Capped by CHL Install in FY21

New results from GlueX illuminate the mechanism of threshold J/Psi production and the upper limit on the pentaquark. The latter provides constraints on the structure of the LHCb pentaquark, favoring a molecular description.

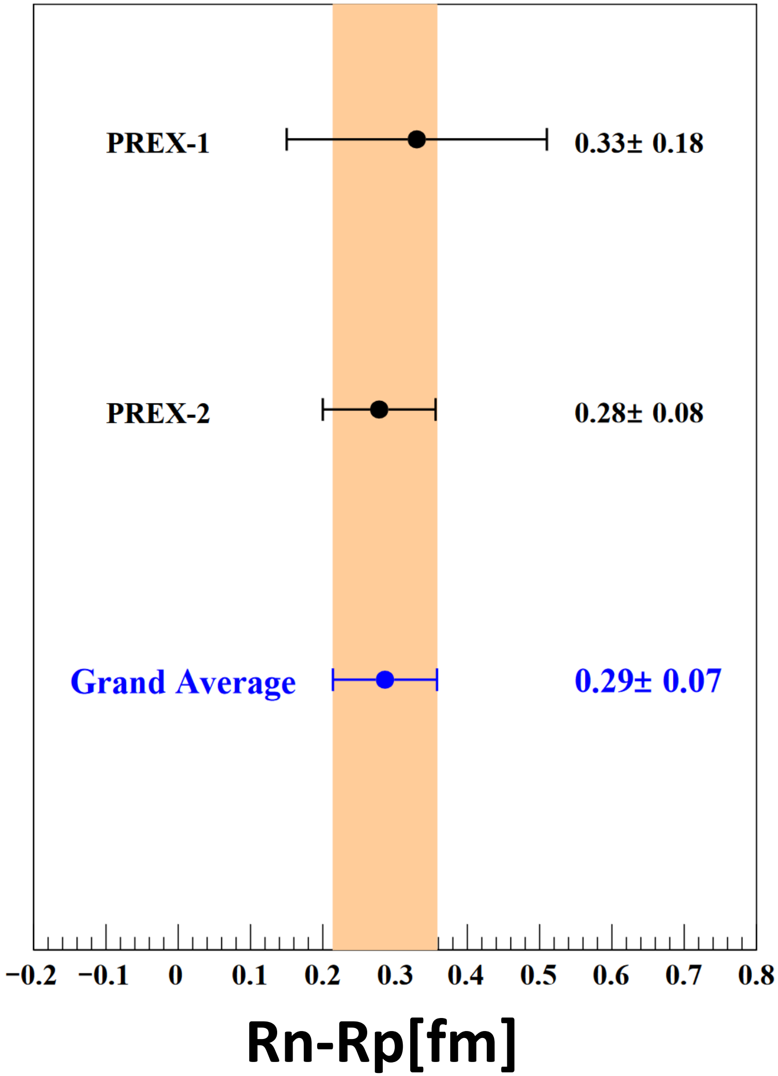
Phys. Rev. Lett. 123, 072001(2019)

$$\gamma p \to pJ/\psi \to pe^+e^-$$



(Based on ~25% of collected data.)

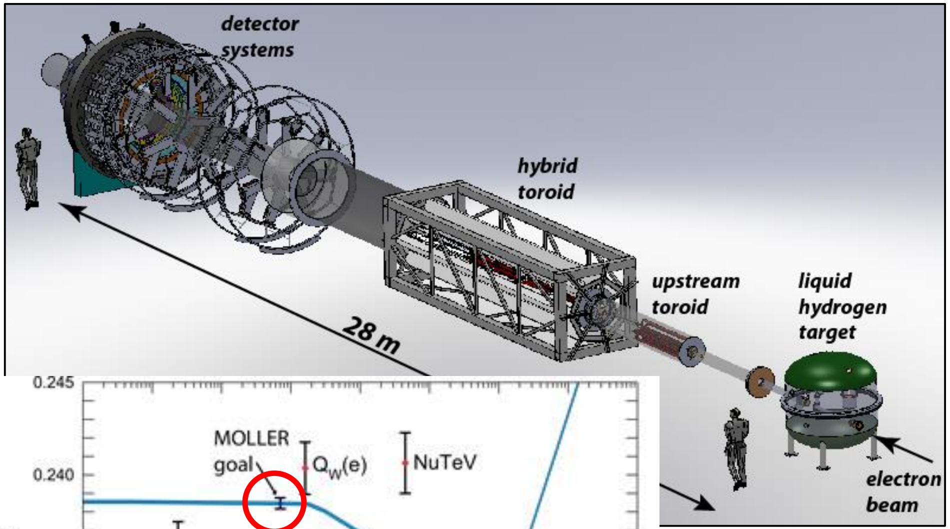
New P-REX Results Unblinded !

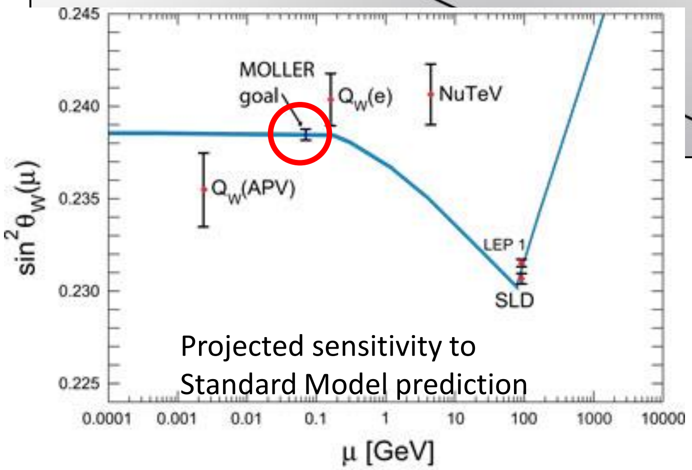


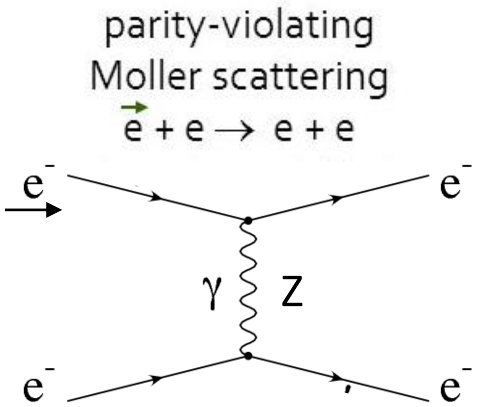
- The weak radius can be combined with the well-known charge density to obtain the baryon density of 208Pb
- This is the first clean determination of the central baryon density of a heavy nucleus and is accurate to 2%
- Provides an important benchmark to chiral EFT calculations that is closely related to nuclear saturation density
- Result has direct relevance for bounding the radius of neutron stars in concert with neutron star merger data from LIGO

MOLLER: a "Must Do" Experiment To Point the Way to New Science

The scientific world rather desperately needs additional markers due to the consistency thus far of LHC data with Standard Model Predictions. Due to the technical challenge of constructing a next generation accelerator with very high accelerating gradients, those markers will have to come from "indirect" discovery experiments like MOLLER.







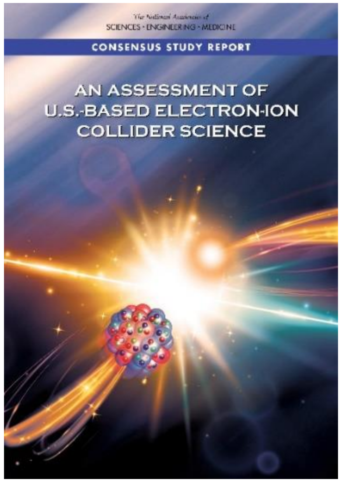
In MOLLER, polarized electrons are scattered of unpolarized electrons. The amount of parity violation due to interference of the two possible exchange mechanisms (γ or Z) is precisely predictable in QED. (No messy quarks or color charge, or QCD to worry about, only quantum electrodynamics). The theory is so "clean" that like the g-2 approach, If the level of parity violation is greater than expected, a new particle must be the source of the discrepancy.

Project at CD-1, FY 2021 Enacted: $5M

SolID Science Review is Underway

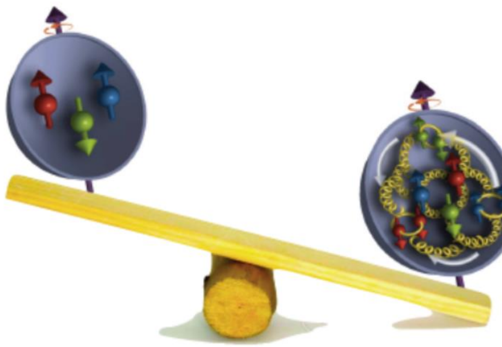
The Next Super High Power, High Energy Microscope: The Electron-Ion Collider

National Academy of Science Report: AN ASSESSMENT OF U.S.-BASED ELECTRON-ION COLLIDER SCIENCE



“An EIC can uniquely address three profound questions About nucleons—neutrons and protons—and how they are assembled to form the nuclei of atoms:

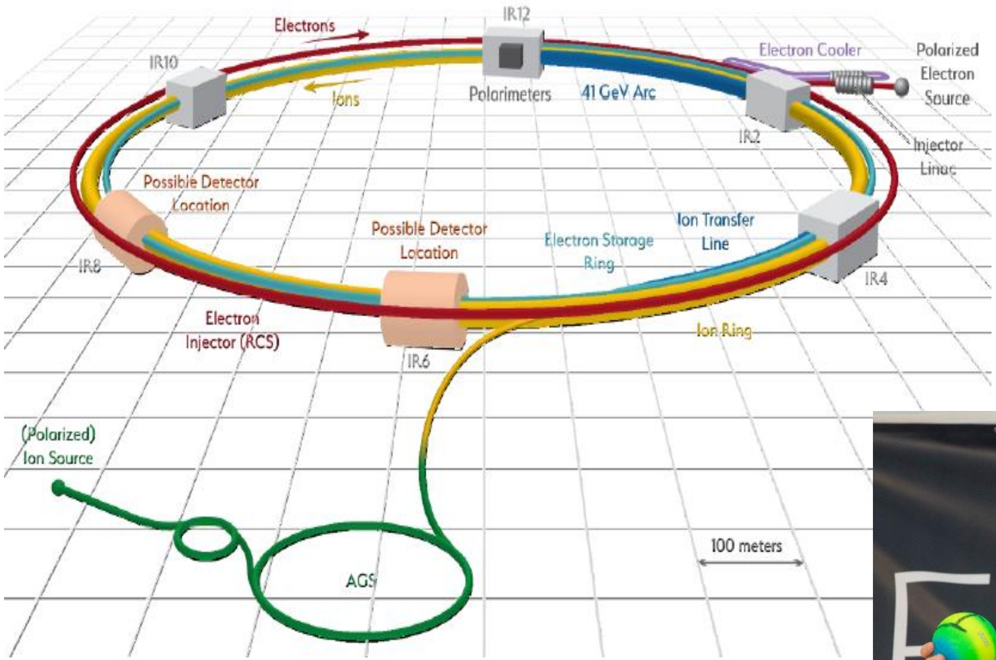
- **How does the mass of the nucleon arise?**
- **How does the spin of the nucleon arise?**
- **What are the emergent properties of dense systems of gluons?”**



The EIC would be a unique facility & maintain leadership in nuclear science

The EIC would maintain leadership in the accelerator science and technology of colliders

EIC CD-0, Site Selection, Project Start & Dedication in FY20



The EIC will be located at BNL and with TJNAF as a major partner. The realization of the EIC will be accomplished over the next decade at an estimated cost between $1.7 and $2.8 billion.

Utilize existing operational hadron collider; add electron storage ring, cooling in existing RHIC tunnel and electron injector.

EIC scope includes the machine upgrade to RHIC asset and two interactions regions with one of the interaction regions outfitted with a major detector. Working towards CD-1 in Q3 FY 2021

EIC Dedication September 18, 2020

<u>**The EIC will be a game-changing resource for the international nuclear physics community.**</u> *DOE looks forward to engaging with the international community and the international funding agencies about potential collaborations and contributions to the EIC effort, in nuclear, accelerator and computer science.*

CD-1 Reviews

- CD-1 Preparation Reviews

  Independent Design Review – November 2020

  Director's Review – December 2020

- DOE CD-1 Reviews

  DOE Office of Science, Office of Project Assessment

  CD-1 Readiness Review – January 26-29, 2021

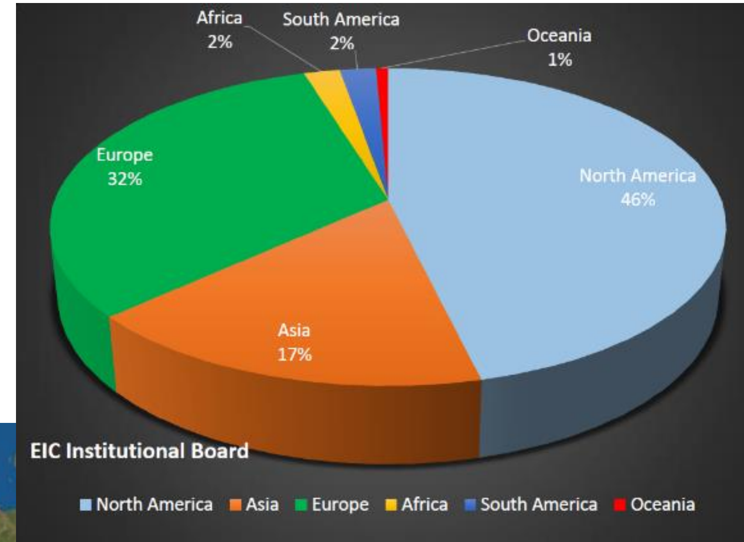
  DOE Office of Project Management Independent Cost Review – January/February 2020

DOE reviews recommend proceeding with CD-1!

EIC User Community

EIC Users Group Formed in 2016
EICUG.ORG

Status February 2021:
- Collaborators 1259
- Institutions 252
- Countries 34



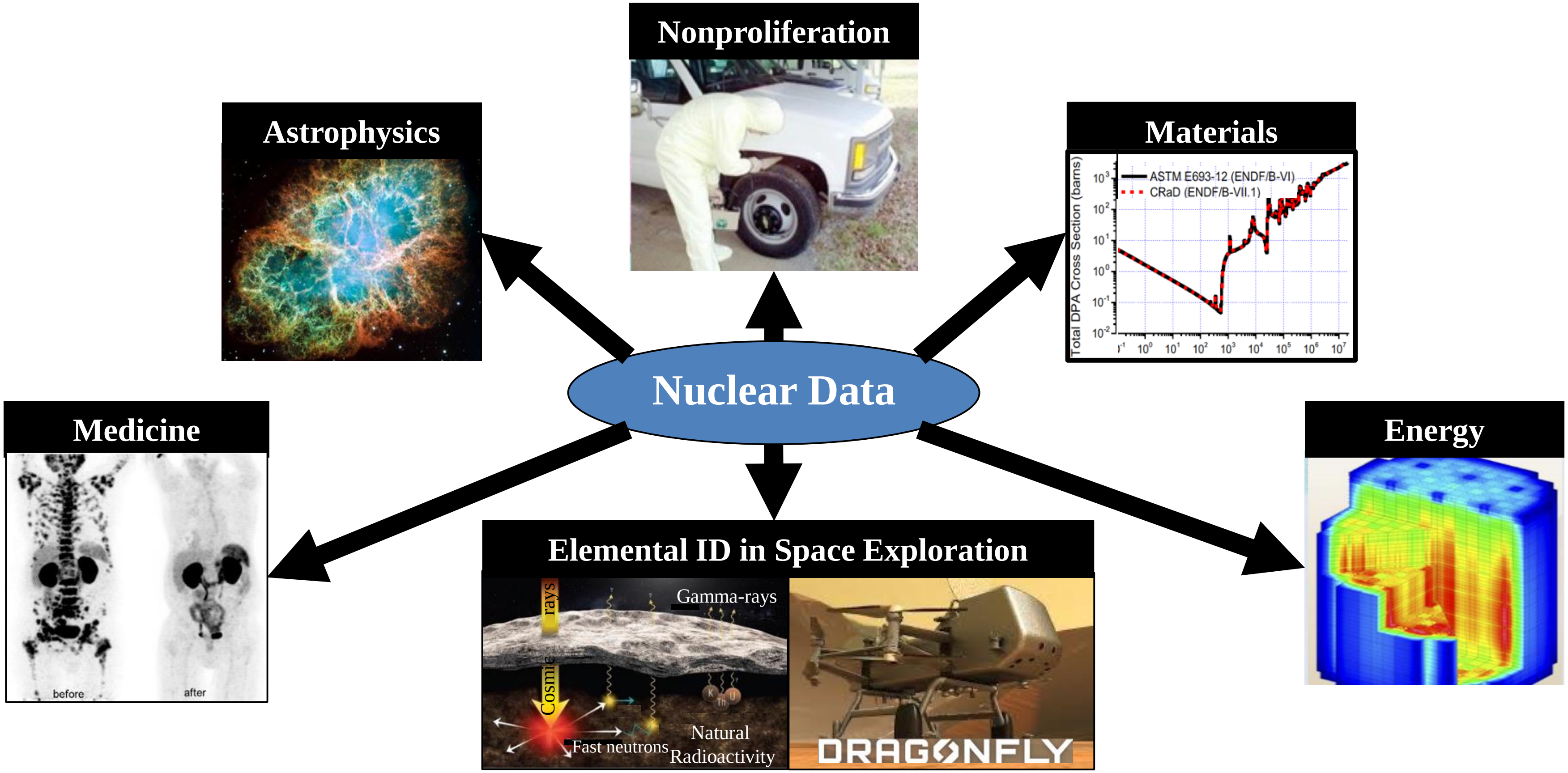
Annual EICUG meeting
2016 UC Berkeley, CA
2016 Argonne, IL
2017 Trieste, Italy
2018 Washington, DC
2019 Paris, France
2020 Miami, FL
2021 Warsaw, Poland

The convergence of the Electron Ion Collider "Microscope" and the prospect of error corrected Quantum Computing is exceptionally exciting.

NP is contributing to the development of both

New & Traditional Frontiers Requiring Accurate Nuclear Data

Many types of nuclear data are “crosscutting” to numerous applications



NP Leads a Nuclear Data Interagency Working Group (NDIAWG) that has published 4 FOAs

Active Participants in WANDA and/or NDIAWG

NNSA
National Nuclear Security Administration

NASA

NATIONAL NUCLEAR LABORATORY

NEA
Nuclear Energy Agency

In Support of Clean Energy Goals

Next generation reactors use faster neutrons, different fuels, and coolants to achieve greater safety and modularity

$$k = \eta f p \varepsilon P_{FNL} P_{TNL}$$

neutron multiplication factor — k

Thermal fission factor — η

Thermal utilization factor — f

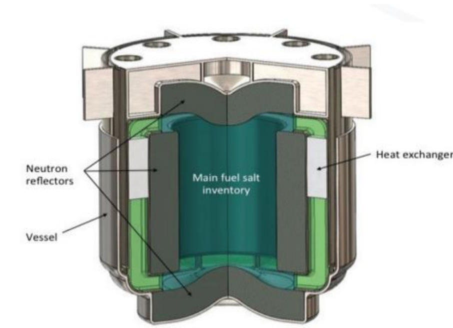
Resonance escape factor — p

Fast fission factor — ε

Fast Non − leakage factor — P_{FNL}

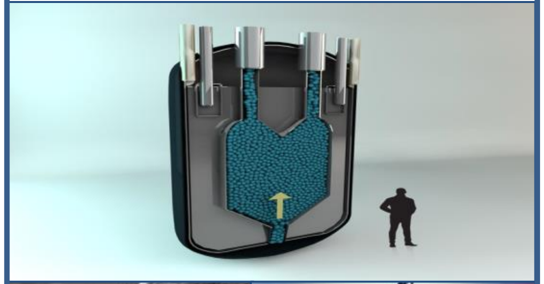
Thermal Non − leakage factor — P_{TNL}

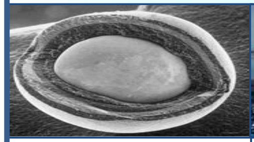
Terrapower



MCFR (Cl)

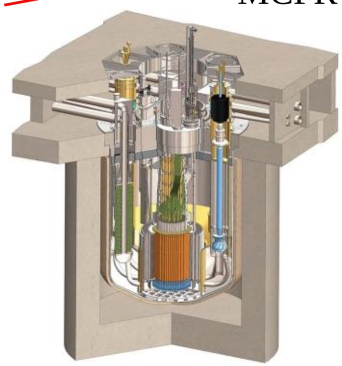
Kairos FHR





TRISO Pebble Fuel (U,C,Si)	Molten Salt Coolant (Flibe)

Non-existent or uncertain Nuclear Data needs to be redressed for new materials and fuels in order to correctly understand/model the neutronics in new designs at a high level of confidence



SMR (Na)

https://nucleardata.berkeley.edu

Nuclear Data & Space Nuclear Propulsion

Presented to: Workshop on Applied Nuclear Data Activities (WANDA) 2021

Space Technology Mission Directorate
Technology Demonstration Mission Program
Space Nuclear Propulsion Project

Kelsa Palomares, AMA Inc. | January 25, 2020

Progress is Ongoing in Quantum Information Science

A Landmark Study Published in Journal Nature

Article

Impact of ionizing radiation on superconducting qubit coherence

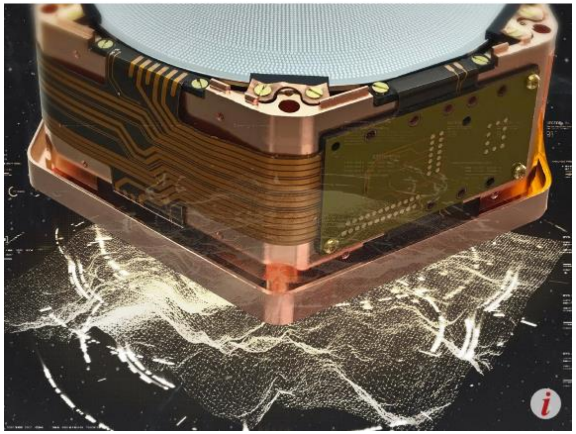
https://doi.org/10.1038/s41586-020-2619-8

Received: 25 January 2020

Accepted: 5 June 2020

Published online: 26 August 2020

Antti P. Vepsäläinen[1]✉, Amir H. Karamlou[1], John L. Orrell[2]✉, Akshunna S. Dogra[1,4], Ben Loer[2], Francisca Vasconcelos[1], David K. Kim[3], Alexander J. Melville[3], Bethany M. Niedzielski[3], Jonilyn L. Yoder[3], Simon Gustavsson[1], Joseph A. Formaggio[1], Brent A. VanDevender[2] & William D. Oliver[1,3]



Naturally occurring radiation produced by environmental radioactive materials and cosmic rays is enough to limit the useful lifetime of superconducting qubit state to just a few milliseconds… Identifying ionizing radiation as a dominant source of excess quasiparticles… is a first step towards developing to mitigate its impact on superconducting circuits, including those used for quantum computation and quantum sensing.

Popular press coverage: ***PNNL “Natural Radiation Can Interfere with Quantum Computers “and MIT Technology Review “Cosmic rays could pose a problem for future quantum computers “*** https://www.pnnl.gov/news-media/natural-radiation-can-interfere-quantum-computers https://www.technologyreview.com/2020/08/26/1007688/cosmic-rays-could-pose-a-problem-for-future-quantum-computers/

***Independent*, Future of Quantum Computing Could Be Disrupted by Space**
https://www.independent.co.uk/life-style/gadgets-and-tech/news/quantum-computer-cosmic-rays-radiation-space-a9689946.html

***The Vice*, Particles From Space Are Messing With Our Quantum Computers, Scientists Discover**
https://www.vice.com/en_us/article/wxqy5x/particles-from-space-are-messing-with-our-quantum-computers-scientists-discover

New Scientist, Quantum computers may be destroyed by high-energy particles from space
https://www.newscientist.com/article/2252933-quantum-computers-may-be-destroyed-by-high-energy-particles-from-space/

“Natural Radiation Can Interfere with Quantum Computers”

NP Pilot: Research Traineeships to Broaden and Diversify the NP Workforce

In 2019, 88 NP-supported students received their Ph.D.'s. Only 5% were Black or Hispanic, nearly a factor of 7 below representation in the US population. The goal of the pilot is to increase minority community's access to existing research infrastructure and expertise and thereby increase participation.

Research groups from National Labs and Universities, leveraging existing infrastructure, will work with MSIs to provide training and mentorship for undergraduates.

Extended duration traineeships will provide financial and mentoring support during the summer and academic year and may extend after graduation for up to one "gap" year.

Designed to remove barriers to graduate school and to fulfill several key recommendations of the recent AIP TEAM-UP Report:

- Increasing a sense of belonging
- Facilitating the development of a physics identity, and
- Providing support to help students advance academically while earning money

NP Pilot FOA on Diversity: Varied Expertise and Backgrounds

Mentoring, Diversity & Inclusion, MSI/HBCU, Undergrad Research, Nuclear Physics

Tan Ahn *(Notre Dame, Nuclear Experiment, Experienced Undergrad Mentor)*
Stephon Alexander *(Brown, Cosmology Theory, Author, National Society of Black Physicists)*
Ketevi Assamagan *(BNL ATLAS Experiment, NSBP, Outstanding Mentor Award, co-founder of African School of Physics)*
Brian Beckford *(DOE, HEP Intensity Frontier Program Manager, AIP Team-up Task Force)*
Tommy Boykin II *(UMD, Condensed Matter Exp., APS Bridge Program Grad, Inclusive Grad. Ed. Network Advisory Board)*
Jason Detwiler *(UW Nuclear Experiment, Early Career Award, Physics Dept. Mentoring Award, Breakthrough Prize)*
Paul DeYoung *(Hope College, APS Outstanding Research and Mentoring at an Undergrad Inst.)*
Evangeline Downie *(GWU, Nuclear Experiment, Muse, Committee on the Status of Women in Physics)*
Renee Fatemi *(UK, Nuclear Experiment, STAR, g-2, Excellent Undergraduate Research Mentor Award)*
Roy Lacey *(Stony Brook, Chemistry Dept., Nuclear Experiment, STAR, AAPT, NSTA)*
Dina Myers-Stroud *(Executive Director Fisk-Vanderbilt Bridge Program)*
Jesus Pando *(DePaul U, Nuclear Experiment, National Society of Hispanic Physicists, SACNAS)*
Diana Parno *(Carnegie Mellon, Nuclear Experiment, Organizer LGBT+ Physicists advocacy group, Best Practices Guide)*
Carol Scarlett *(Florida A&M, Nuclear Theory, Axion Tech LLC.)*
Yolanda Small *(York College/CUNY, Theoretical Chemist, Chair Undergraduate Research Symposium)*
Daniel Tapia Takaki *(Kansas, Nuclear Experiment, ALICE and CMS Collaborations)*

36 proposals to create collaborations with ~40 MSIs and HBCU's submitted

Additional NP DOE FOAs

FOA/Lab Call	**Nuclear Data Interagency Working Group Research Program**
FOA/Lab Call	Quantum Horizons: QIS Research and Innovation for Nuclear Science
FOA/Lab Call	Pilot Program for Traineeships to Broaden and Diversify the NP Workforce
FOA/Lab Call	Data Analytic for Autonomous Optimization and Control of Accelerators and Detectors

Other News Items

- New Staff in DOE NP

• Xiaofeng Guo	Nuclear Physics Computing
• Ivan Graff	Nuclear Physics Major Initiatives
• Kenneth Hicks (IPA)	Heavy Ion
• Paul Mantica (IPA)	Technical Advisor/Facilities & Project Management Division
• Melissa Emerson (CONTR)	Administrative Specialist
• Saryna Cameron (CONTR)	Program Support Specialist

- George Fai has retired
- Richard Witt has returned to USNA (Hicks HI, Farkhondeh ECA)
- New FOAs contemplated in QIS, Nuclear Data, Accelerator R&D, Traineeships to Broaden and Diversify

Office of Nuclear Physics

Timothy J. Hallman, Associate Director

Melissa Emerson, Administrative Specialist (CONTR)

Associate Director's Office Staff

Brian Knesel, Financial Management Specialist
VACANT, Financial Management Analyst
Linnette Quick, Program Assistant (CONTR)
Brenda May, Program Analyst
VACANT, International Cooperation and Outreach

Physics Research Division

VACANT, Director

Christine Izzo, Program Support Specialist

- **Medium Energy & Quantum Information Science** – Gulshan Rai, Technical Advisor
- **Heavy Ion Nuclear Physics** – VACANT; Kenneth Hicks (IPA)
- **Nuclear Structure and Astrophysics** – Sharon Stephenson
- **Nuclear Theory** – VACANT
- **Nuclear Data** – Keith Jankowski
- **Fundamental Symmetries** – Paul Sorensen
- **Nuclear Physics Computing** – Xiaofeng Guo

Facilities & Project Management Division

Jehanne Gillo, Director

Saryna Cameron, Program Support Specialist (CONTR)
Paul Mantica (IPA), Technical Advisor
Latifa Elouadrhiri (Detailee)

- **Advanced Technology R&D** – Manouchehr Farkhondeh, Deputy
- **Nuclear Physics Facilities** – James Sowinski
- **Nuclear Physics Major Initiatives** – Ivan Graff
- **Nuclear Physics Instrumentation** – Elizabeth Bartosz
- **Industrial Concepts** – Michelle Shinn

(IPA) – Intergovernmental Personnel Act

DOE National Laboratories are Invited to Submit Nominations: FY21 Distinguished Scientist Fellows Program

- **Program Objectives:**

  Develop, sustain, and promote scientific and academic excellence in SC research through collaborations between institutions of higher education and national laboratories.

  Strengthen support for the National Laboratory system and to provide National Laboratory scientists with access to an opportunity and honor similar to some that are available to scientists outside the National Laboratory structure.

- One or more awards may be conferred among the six SC research programs: ASCR, BES, BER, FES, HEP, NP
- Fellows receive $1 million in funding over three years to advance program objectives.
- All 17 DOE Laboratories are eligible to submit up to two (2) nominations.
- Selections will be made by senior SC leadership, based on peer review.
- Visit the program website for nomination guidelines, eligibility requirements, review criteria, and FAQs. Program Website: https://science.osti.gov/fellows
- **Submissions:** Deadline: 5:00 pm Eastern, Friday, May 7th, 2021
- Questions and URL requests can be sent to: SC.Fellows@science.doe.gov

Distinguished Scientist Award

Eligibility Requirements
•Nominees must be full time employees of any DOE National Laboratory at the time of nomination.
•Nominees must have been permanent employees for a minimum of 10 (cumulative) years within the DOE National Laboratory system.
•Nominees must be either Citizens of the United States or Lawful Permanent Residents of the United States.
•Nominees must show sustained scientific excellence in research that is supported by DOE and is relevant to SC programs.

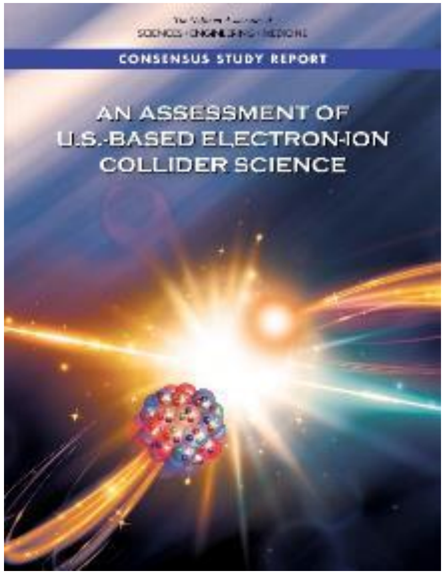
Prizes:
One time total award of $1,000,000 in funding, intended to be spent over three years, contingent upon the awardee's continued employment at the National Laboratory at which they received the award. Awards are intended to support activities that develop, sustain, and promote scientific and academic excellence in SC research through collaborations between institutions of higher education and national laboratories. They cannot be used to augment current sponsored research projects.

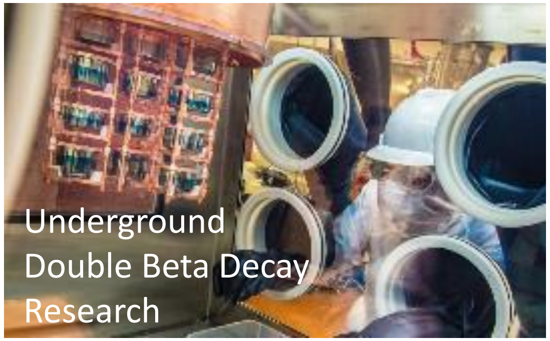
Selection Criteria:
•Evidence of scientific leadership and engagement with academic and university research community.
•Evidence of sustained scientific excellence and significant scientific achievement.
•Honors and awards.
•Quality of high impact peer-reviewed publications.
•Research relevance to programmatic goals in ASCR, BES, BER, FES, HEP, or NP.
•Service to the research community through agency, professional society, or advisory work.
•Significant mentoring of early career scientists or engineers.
•Evidence of a commitment to diversity, equity, and inclusion.

Overall, Progress in Implementing the LRP Has Been Good

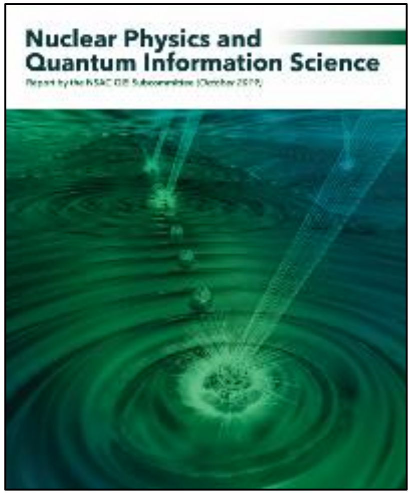
World leading research supported at state-of-the-art NP National User Facilities

The vision to maintain U.S. leadership continues to be implemented: EIC construction; FRIB construction





Pioneering experiments and research tools (MIEs) are created



Groundbreaking contributions to national cross-cutting priorities continue

General Outlook

- The experience with FY18 and FY19 budgets maybe similar in the next budget cycle.
- We need to stay focused and continue to deliver important outcomes for the nation.
- Delivering exciting discoveries, important scientific knowledge, technological advances, and workforce training is what we do.
- We need to keep up the good work!

A Long Tradition of Partnership and Stewardship

There has been a long tradition in Nuclear Science of effective partnership between the community and the agencies in charting compelling scientific visions for the future of nuclear science.

Key factors:

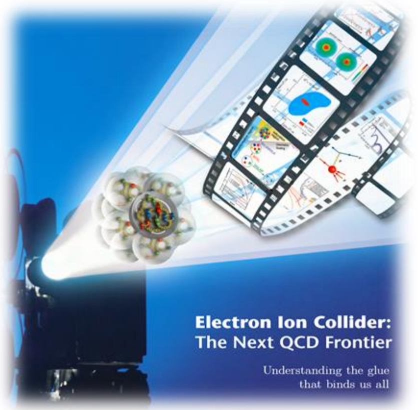
1) Informed scientific knowledge as the basis for recommendations and next steps
2) Mutual respect among scientific sub-disciplines
3) Commitment to the greater good of nuclear science as a discipline
4) Meticulously level playing field leading to respect for process and outcomes
5) Deep appreciation for the wisdom of Ben Franklin

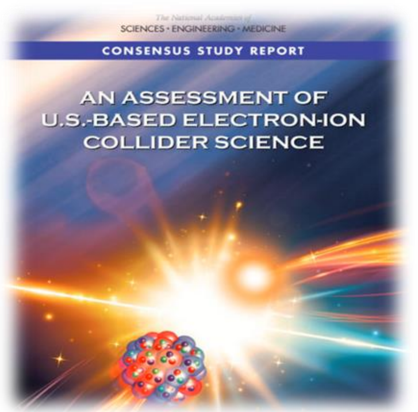
The last thing needed right now…

Noun
(*plural* circular firing squads)
1.(idiomatic) A political party or other group experiencing considerable disarray because the members are engaging in internal disputes and mutual recrimination

Additional Information

Science-Driven Project Requirements





<u>Project Design Goals</u>

- High Luminosity: $L = 10^{33} – 10^{34} cm^{-2} sec^{-1}$, 10 – 100 fb^{-1}/year
- Highly Polarized Beams: 70%
- Large Center of Mass Energy Range: E_{cm} = 20 – 140 GeV
- Large Ion Species Range: protons – Uranium
- Large Detector Acceptance and Good Background Conditions
- Accommodate a Second Interaction Region (IR)

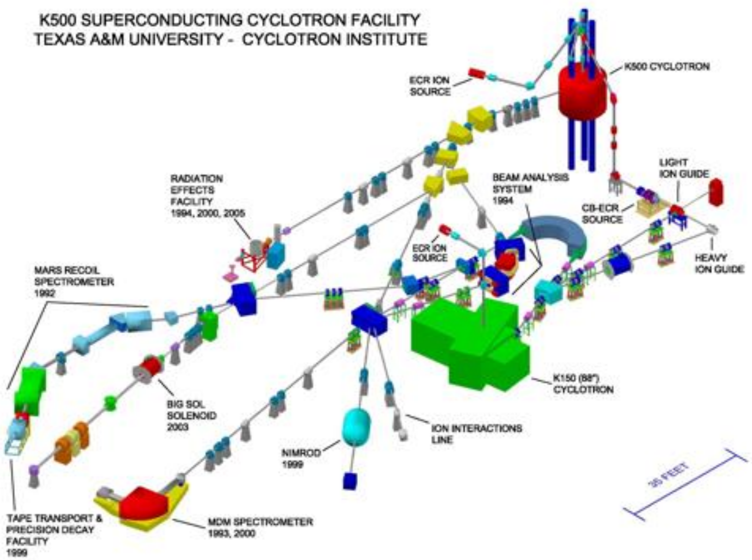
Conceptual design scope and expected performance meets or exceed NSAC Long Range Plan (2015) and the EIC White Paper requirements endorsed by NAS (2018)

These challenging performance goals require a machine that is state-of-the-art

Two NP Centers of Excellence at TUNL and Texas A&M

1967 - 2017 50 YEARS OF BEAM *exploring the nuclear frontier*

CYCLOTRON INSTITUTE
TEXAS A&M UNIVERSITY

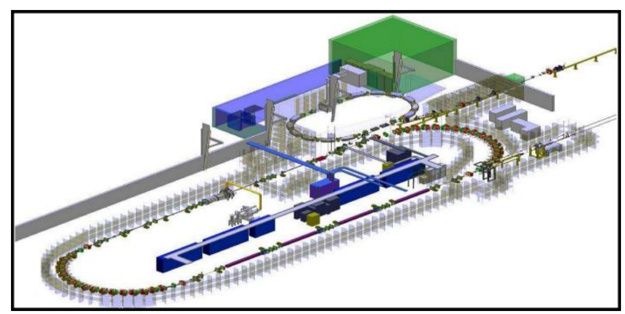


The Texas A&M University Cyclotron Institute jointly supported by DOE and the State of Texas focuses on conducting basic research, educating students in accelerator-based science and technology, and providing technical capabilities for a wide variety of applications in space science, materials science, analytical procedures and nuclear medicine.

The 88 inch cyclotron also plays a crucial role in space radiation effects chip testing for the Air Force

TUNL TRIANGLE UNIVERSITIES NUCLEAR LABORATORY
Durham, North Carolina
A US Department of Energy Center of Excellence in Nuclear Physics

The Triangle Universities Nuclear Laboratory (TUNL) is Center of Excellence that focuses on low-energy nuclear physics research. TUNL is a consortium Duke University, North Carolina State University, and the University of North Carolina at Chapel Hill comprising about 30 faculty members, 20 postdocs and research scientists, and 50 graduate students.

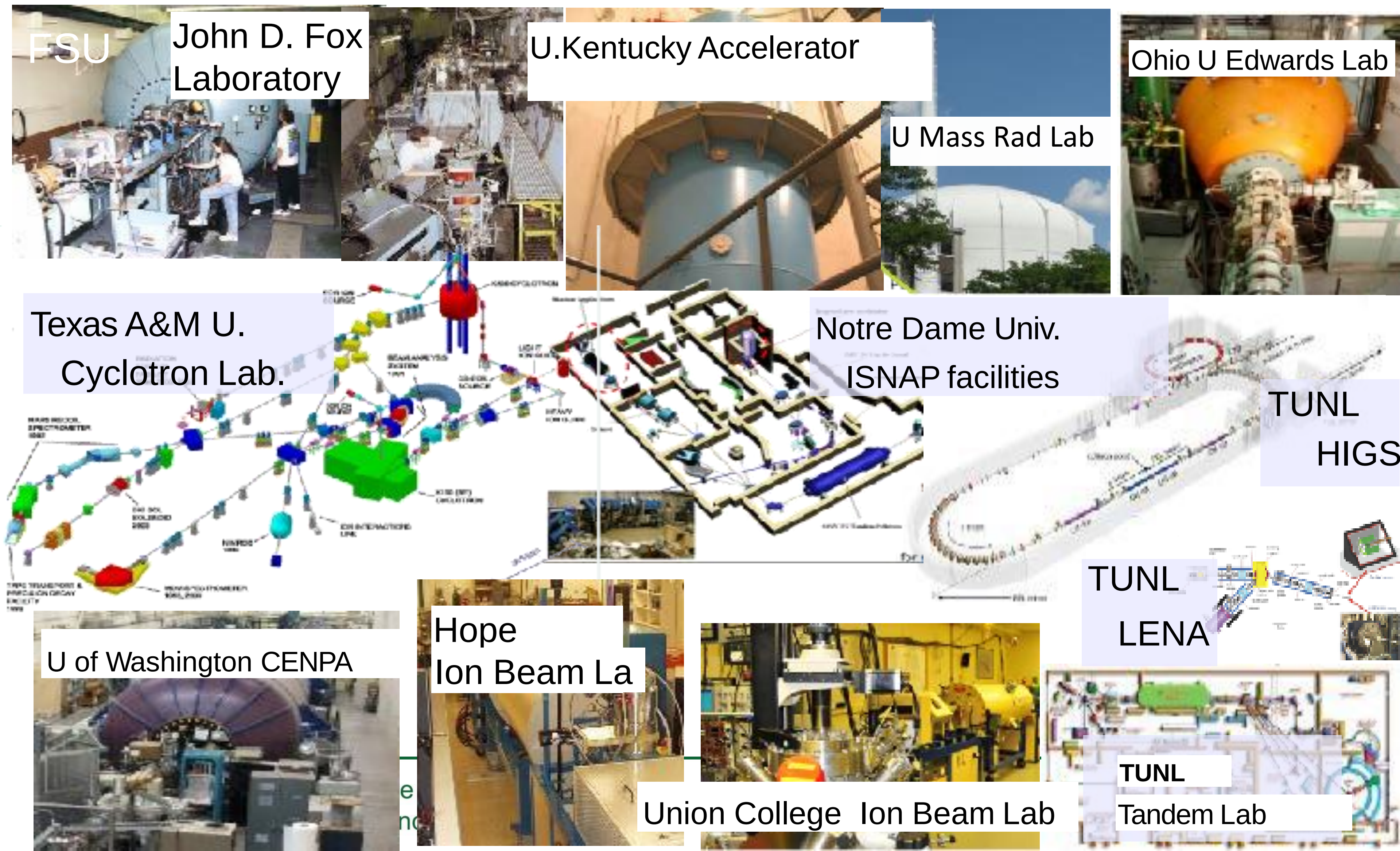


http://aruna.physics.fsu.edu

10 members

~200 users

ARUNA- Association for Research at University Nuclear Accelerators



Mo-99 Charge Letter

This letter is to request that, in accordance with direction given to the DOE in the National Defense Authorization Act (NDAA) for FY2013, the Nuclear Science Advisory Committee (NSAC) standing Subcommittee on Mo-99 conduct its annual assessment of the effectiveness of the National Nuclear Security Administration, Office of Material Management and Minimization (NNSA-MMM) Domestic Molybdenum-99 (Mo-99) Program (formerly known as the Global Threat Reduction Initiative).

The American Medical Isotopes Production Act of 2012 (Act), formerly known as S. 99 and H.R. 3276, was incorporated into the National Defense Authorization Act (NDAA) for FY2013. On January 2, 2013, President Obama signed the NDAA into law, enacting this legislation. A stipulation of the NDAA under section 3173 – *IMPROVING THE RELIABILITY OF DOMESTIC MEDICAL ISOTOPE SUPPLY* is that:

"…the Secretary [of Energy] shall…use the Nuclear Science Advisory Committee to conduct annual reviews of the progress made in achieving the [NNSA MMM] program goals and make recommendations to improve effectiveness."

The Department of Energy (DOE) and National Science Foundation (NSF) very much appreciate NSAC's six previous assessments as described in reports transmitted to the agencies on May 8, 2014, July 30, 2015, November 3, 2016, March 19, 2018, April 17, 2019, and March 16, 2020.

Mo-99 Charge Letter

We request that NSAC provide a seventh annual assessment addressing the following charge elements:

- What is the current status of implementing the goals of the NNSA-MMM Mo-99 Program? What progress has been made since the 6th NSAC assessment?
- Is the strategy for continuing to implement the NNSA goals complete and feasible, within an international context?
- Are the risks identified in implementing those goals being appropriately managed?
- Has the NNSA-MMM Program addressed concerns and/or recommendations articulated in the 2019/2020 NSAC assessment of the Mo-99 Program appropriately and adequately?
- What steps should be taken to further improve NNSA program effectiveness in establishing a domestic supply of Mo-99?

It is requested that this assessment be submitted spring of 2021.

Mo-99 Charge Letter

We are aware that this charge represents an additional burden on your time. However, the involvement of NSAC is essential to inform the Agency regarding the effectiveness of efforts to steward Mo-99, and isotope essential for the health and well-being of the Nation.

Sincerely,

J. Stephen Binkley
Acting Director
Office of Science

Sean Jones
Assistant Director
Directorate for Mathematical
and Physical Sciences
National Science Foundation

Thank You!

DOE/NSF
Nuclear Science Advisory Committee

Certificate of Appreciation to Departing Members

The Department of Energy and the National Science Foundation express their appreciation to you for the significant contributions you have made while serving on the Nuclear Science Advisory Committee during your term.

Jozek Dudek, Olga Evdokimov, Tori Forbes,
Krishna Kumar, Suzanne Lapi, Artemis Spyrou

Benefits of Training in Nuclear Science

- Highly Specialized Technical skills
- Creative problem analysis/solving ability
- Scientific communication skills
- Resilience despite frustration / perseverance
- Self confidence
- Time management ability
- Project planning skills
- Ability to team and working within a large collaboration
- Leadership development

The result is an essential national core competency useful not only for “things nuclear”, but for a variety of other challenge pursuits as well

Space Nuclear Propulsion: NTP Nuclear Data Needs

1. **HALEU Fuel Enrichment**
   - *Use of HALEU may drive the desire to thermalize the neutron spectrum compared to historic fast and epithermal designs*

2. **Unique Operating Regime –** NTP operating temperatures vary from cryogenic to ultrahigh temperature (> 2750 K)
   - *Cross section temperature dependence*

3. **High Temperature Moderators and Materials** – space reactors may benefit from high temperature moderator candidates (metallic hydrides and beryllium compounds) and refractory metals / ceramics
   - *Previous benchmarks and historic testing do exist for reference but spectrum may differ (possible need resolution of unresolved resonances over energy range)*

4. **Unique Working Fluids** – Scattering in hydrogen can play a role in reactor control and reactivity
   - *Scattering in hydrogen non-negligible contribution to overall reactivity*

5. **Prototypic Environment** - The use of a nuclear reactor in space must consider background radiation and probabilities for interaction with the reactor
   - *High energy photonuclear reactions and photon sources should be characterized to understand any impact to the reactor during idle, start up, or nominal operation*
   - *Different backgrounds expected for in-space or surface operation*

6. **Testing Infrastructure** – Space reactor technologies could benefit from pre-existing or new infrastructure for experimental testing and evaluation of nuclear data

7. **Uncertainty data** – updated covariance data will allow for more accurate characterization of reactor uncertainty / sensitivities

Safe nuclear energy is almost certainly part of a U.S. clean energy future. Accurate, reliable nuclear data is central to realizing that vision, terrestrially or "out of this world".

In Support of Clean Energy Goals

Next generation reactors use faster neutrons, different fuels, and coolants to achieve greater safety and modularity

$$k = \eta f p \varepsilon P_{FNL} P_{TNL}$$

neutron multiplication factor

Thermal fision factor

Thermal utilization factor

Resonance escape factor

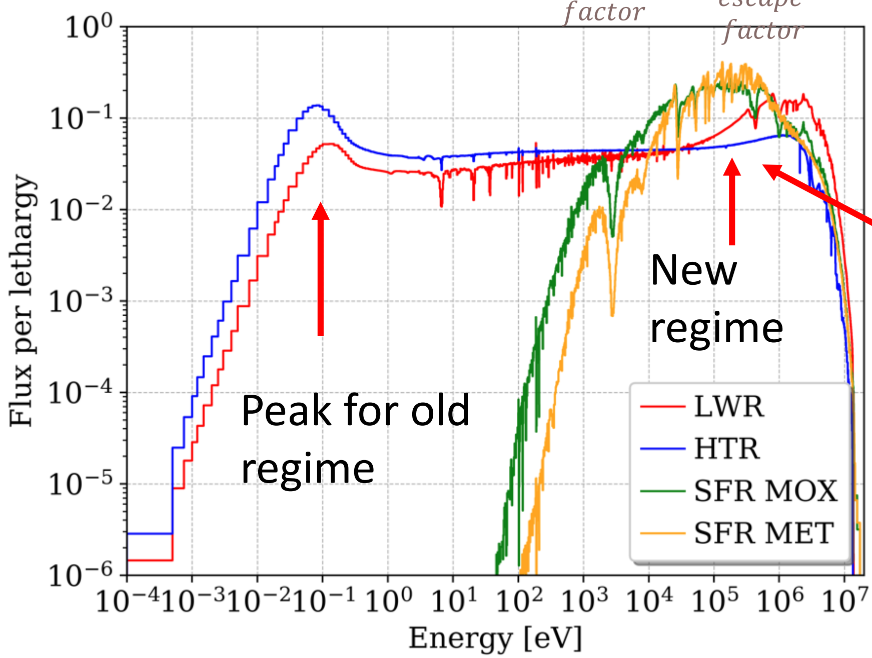
Fast fission factor

Fast Non – leakage factor

Thermal Non – leakage factor

The harder neutron spectrum and different fuel introduce a dependence on types of nuclear data not explored

Neutron Spectra



Non-existent or sparse Nuclear Data needs to be redressed for new neutron energy regime to correctly understand/model the neutronics

https://nucleardata.berkeley.edu