

Neutrinoless Double Beta Decay – Report from DOE

3rd International Conference on Double Beta Decay
May 26-27, 2025

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U.S. DEPARTMENT
of **ENERGY**

Office of
Science

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2nd International Summit on Double Beta Decay

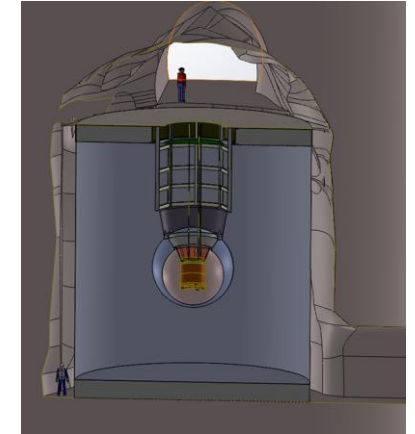
- The last slide shared by the DOE Office of Nuclear Physics (NP) during the in-camera session at the 2nd International Summit included the following:
 - *Perhaps most importantly, NP concludes the construction of more than one full ton-scale experiment is viewed as the best outcome for the science. DOE NP hopes to enjoin international partners in working to identify potential paths forward for each of the three experiments [CUPID, LEGEND-1000, nEXO].*
- In support of this conclusion, DOE NP staff actively participated in the Double Beta Decay Working Group that was formed following the 2nd International Summit.
- And while the conclusion from the 2nd Summit still holds, a realistic look at the budget forecasts makes it challenging for DOE NP to contemporaneously lead multiple neutrinoless double beta decay experiments.
- What follows is a summary of DOE NP and U.S. community actions regarding double beta decay since the 2nd International Summit...



Ton Scale Neutrinoless Double Beta Decay (TS-NLDBD) Technology Investments

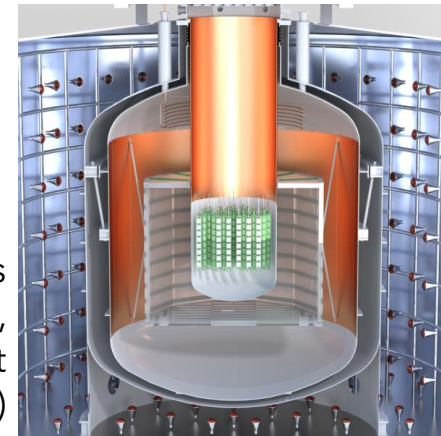
- Together, FY 2022 Inflation Reduction Act funding and DOE NP program funding since 2020 have totaled ~\$20M to explore three technologies: CUPID, LEGEND-1000, and nEXO supporting conceptual design and R&D.
- Additional resources have been provided by international partners.
- The three project teams made excellent progress advancing their conceptual designs in preparation of planned critical decision-1 (CD-1) *Approve Alternative Selection and Cost Range*.

Scintillating bolometry (**CUPID**, ^{100}Mo enriched Li_2Mo_4 crystals)



Liquid Xe TPC (**nEXO**, light via SiPM, drifted ionization)

Enriched ^{76}Ge crystals (**LEGEND-1000**, drifted charge, point contact detectors)



A New Era of Discovery: Long Range Plan for Nuclear Science

"...capitalize on the extraordinary opportunities for scientific discovery made possible by the substantial and sustained investments of the United States. We must draw on the talents of all in the nation to achieve this goal."

"...we reaffirm the exceptionally high priority of the following two investments in new capabilities for nuclear physics. The Electron-Ion Collider (EIC), ...will elucidate the origin of visible matter in the universe and significantly advance accelerator technology... Neutrinoless double beta decay experiments have the potential to dramatically change our understanding of the physical laws governing the universe."

"As the highest priority for new *experiment* construction..., lead an international consortium that will undertake a neutrinoless double beta decay campaign."

"We recommend the expeditious completion of the EIC as the highest priority for *facility* construction."

"We recommend capitalizing on the unique ways nuclear physics can advance discovery science and applications for society."



April 2024 NSAC Facilities Charge Outcome: EIC and TS-NLDBD Projects Have Highest Scientific Importance

Major Nuclear Physics Facility	Scientific importance	Readiness for construction
Electron-Ion Collider (EIC)	(a) Absolutely central	(a) Ready to initiate
Ton-scale Neutrinoless Double Beta Decay (TS-NLDBD)	(a) Absolutely central	(a) Ready to initiate
High Rigidity Spectrometer (HRS)	(b) Important	(a) Ready to initiate
Project 8	(b) Important	(c) Mission and technical requirements not yet fully defined
FRIB Energy Upgrade (FRIB400)	(b) Important	(a) Ready to initiate
Solenoid Large Intensity Device (SoLID)	(b) Important	(a) Ready to initiate
EIC Detector II	(b) Important	(c) Mission and technical requirements not yet fully defined

- The importance of the science for each project as assessed by the Subcommittee was tied closely to the Long Range Plan for Nuclear Science.
- In considering the readiness for construction, the Subcommittee was guided by the current status of the project and remaining challenges, including the DOE critical decision level, if any.

DOE NP TS-NLDBD Strategy

- A U.S.-led international consortium that would undertake a neutrinoless double beta decay campaign, as recommended in the Long Range Plan, is a challenge given the out-year funding projections for DOE NP.
- On 12/19/2024, DOE NP informed the Project Directors of the three projects within the TS-NLDBD program that DOE NP would:
 - Move forward with one project under the TS-NLDBD program, LEGEND-1000, which could be accomplished, albeit on an extended timeline, within the DOE NP out-year funding projections.
 - Pause activity on the other two projects under the TS-NLDBD program while, dependent on appropriations, continuing research activities on the concepts: CUPID and nEXO.



Why LEGEND-1000?

- Delivers world leading science (Nobel potential).
- Addresses Recommendation II of the Long Range Plan for Nuclear Science.
- Strong project management team with established project toolkit aligned with DOE Office of Science expectations.
- Strong commitments from international partners (Italy, Germany, UK), several of which are participating in Electron-Ion Collider.
- LEGEND-1000 proposed resource sharing: ~60% DOE, ~40% Others, including international partners and potentially the U.S. National Science Foundation (NSF).
 - Major Research Equipment Facilities Construction (MREFC) project proposal (~\$115M) was submitted to NSF.

DOE NP's Plans for CUPID and nEXO

- While CUPID and nEXO are viewed as demonstrating high potential for scientific impact, constrained U. S. funding is unlikely to allow these projects to advance significantly in the near term.
- Pause activities:
 - Indefinitely postpone the CD-1 review for nEXO.
 - Delay pursuit of a project annex with INFN outlining scope responsibilities for international partners investing in CUPID.
- R&D activities on these concepts may still be pursued by DOE NP dependent on:
 - Annual appropriations.
 - Identified priorities for research and development.



Near-term Path Forward for DOE NP on TS-NLDBD

- DOE NP will move forward with LEGEND-1000, albeit on an extended timeline determined by annual appropriations.
 - CD-1 review tentatively scheduled for November 2025.
- Pre-project R&D activities will continue for other NLDBD efforts, at a level determined by priorities in the Fundamental Symmetries subprogram and annual appropriations.
- DOE NP remains committed to working with the international community to realize an international campaign with multiple isotopes and more than one full ton-scale experiment, with the potential for future investment in these experiments.
- DOE NP supports the establishment an organizational framework for coordinating international investments in NLDBD experiments.

