# DOE and Underground Science

DURA Meeting January 20, 2012

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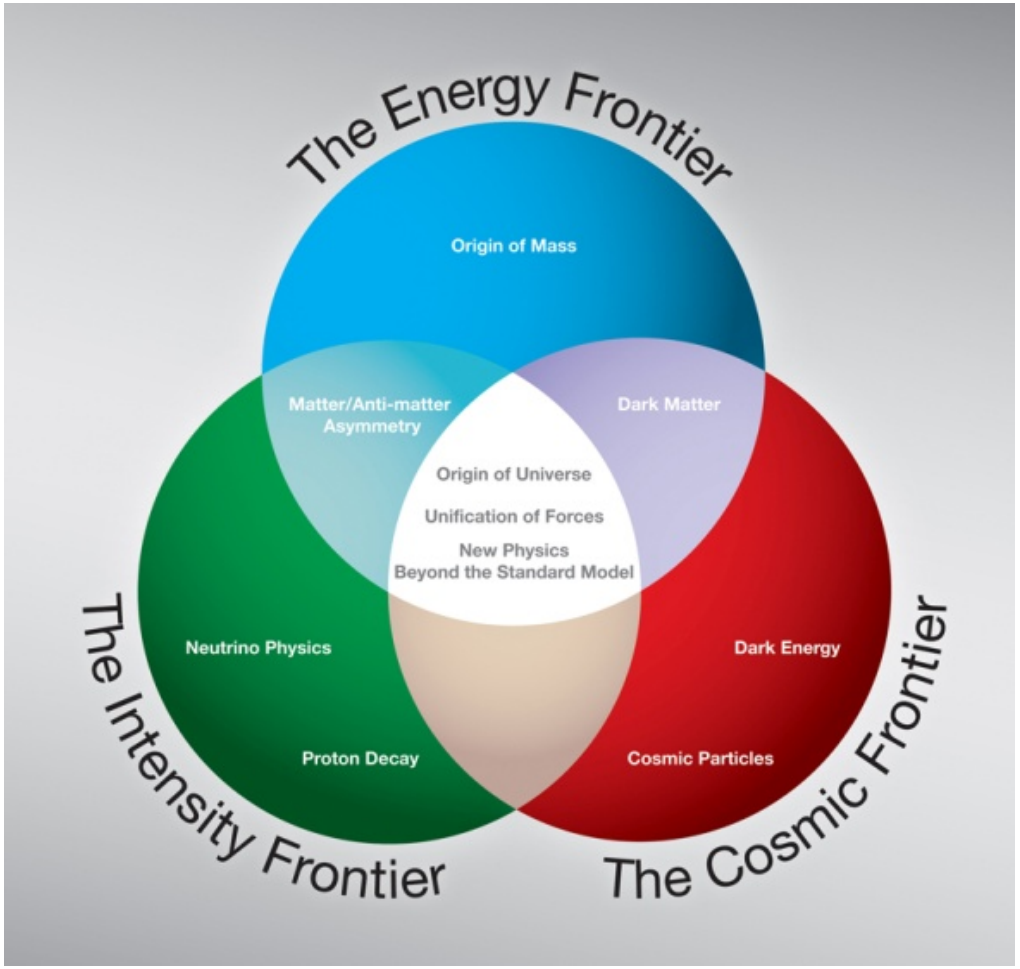
# DOE HEP Strategic Plan

**Plan is based on the HEPAP (P5) report from 2008.**

**Progress in achieving the goals of particle physics requires advancements at the**

- Energy, Intensity and Cosmic Frontiers
- Each provides a unique window for insight about the fundamental forces and particles of nature
- The U.S. should have a strong, integrated research program at all three frontiers.



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# Major Recommendations of P5

- The panel recommends that the US maintain a leadership role in world-wide particle physics. The panel recommends a strong, integrated research program at the three frontiers of the field: the Energy Frontier, the Intensity Frontier and the Cosmic Frontier.
- The panel recommends support for the US LHC program, including US involvement in the planned detector and accelerator upgrades. (highest priority)
- **The panel recommends a world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL and a high-intensity neutrino source at Fermilab.**
- The panel recommends funding for measurements of rare processes to an extent depending on the funding levels available… (Mu2e)
- **The panel recommends support for the study of dark matter** and dark energy **as an integral part of the US particle physics program.**
- The panel recommends a broad strategic program in accelerator R&D, including work …, along with support of basic accelerator science.

# DOE HEP and NP
## Strategic Plans and DUSEL

DUSEL was an integral component of the strategic plans developed in response to report s from HEPAP (P5) and NSAC for the U.S. / DOE HEP and NP programs

| DOE High Energy Physics Priorities | Today | Proposed | | |
|---|---|---|---|---|
| ▪ Implement a world-class Intensity Frontier Program (centered around Fermilab) | | | | |
| Next generation Neutrino/proton decay Exp | | LBNE → | sLBNE | (DUSEL) |
| Neutrino Experiments | MINOS | NOvA | | (Soudan/Ash River) |
| Fermilab Accelerator Capabilities (proton power) | 230kW → | 700kW → | 2000kW | Fermilab |
| Rare Decay Experiments | | Mu2e | Kaon Decay, etc. | Fermilab |
| ▪ Position the U.S. participate/build next generation Energy Frontier facility | | | | |
| Fermilab Accelerator Capabilities (proton power) | | 2000kW → Muon Collider | | Fermilab |
| ▪ Mount a concerted dark matter search campaign at the Cosmic Frontier | | | | |
| Next Generation Experiments (size) | | 1 ton → | 10 ton | (DUSEL) |
| Dark Matter Experiments (size) | 100kg | | | (various) |

| DOE Nuclear Physics priority | Today | Proposed | | |
|---|---|---|---|---|
| ▪ Mount a concerted neutrinoless double beta decay (DBD) search campaign | | | | |
| Next Generation Experiments (size) | | Prototype (30kg)→1 ton | | (DUSEL) |
| Double Beta Decay Experiments (size) | 200kg | | | (Gran Sasso/WIPP) |

# The DOE/NSF Partnership Plan for DUSEL

DOE and NSF had developed a partnership model for the physics program at the deep Underground Science and Engineering Lab (DUSEL), which would be in the Homestake Mine in Lead, South Dakota.

- **DOE HEP would steward the Long Baseline Neutrino Experiment while NSF stewarded the DUSEL Facility.**
  - DOE HEP would lead the construction of the neutrino beam, near detector, far detector, and the underground cavern for the far detector.
  - NSF would contribute a fixed dollar amount to the far detector and the underground cavern for the far detector.
  - NSF would provide the non-detector specific infrastructure such as the shafts, water pumping, ventilation, etc.

**Davis cavern refurbished by South Dakota.**

- **NSF would steward the dark matter experiments and DOE HEP would partner.**
- **DOE NP would steward the neutrinoless double beta decay experiment and NSF would partner.**

# NSF Pulled Out of DUSEL

- In December 2010, the Committee on Programs and Plans of the National Science Board voted to discontinue DUSEL design funding.
- NSF DUSEL activities were zeroed out in the FY12 budget
  - "The (Senate Appropriations) Committee accepts NSF's proposal for reductions and terminations for the following programs: Deep Underground Science and Engineering Laboratory,….."
- DOE must now understand how to best pursue the three experimental programs that had been planned for DUSEL.

# The DOE Response

- **The Office of Science began a review process to determine if any of these can be carried out in a cost effective manner at the Homestake Mine. A committee was charged to study options.**
  - **Stakeholders were informed of the review process at the end of February 2011.**
    - **Government of South Dakota**
    - **Universities and national labs that were involved with DUSEL.**
    - **Leaders of scientific collaborations that hoped to work at DUSEL.**
  - **The report of this committee (available at http://science.energy.gov/~/media/hep/hepap/pdf/june-2011/Review_of_Underground_Science_Report_Final.pdf**

- **The FY 2012 budget includes $15 million to keep the Homestake Mine viable while decisions are made. (HEP $10 M, NP $5 M).**
  - Due to the delay in passing the appropriations bill, the NSF covered these costs thru Jan 2012.

# Committee to Review Options for Underground Science

- **Help define cost-effective options for planned underground experiments, and strategies for implementing a world-class program of underground science, consistent with SC's mission in High Energy and Nuclear Physics.**

  Experiments considered:

  long-baseline neutrino experiment (LBNE)

  3rd generation (multi-ton) dark matter experiment (3G-DM)

  1-ton scale neutrinoless double-beta decay experiment

  Assess cost and schedule estimates

- **Committee was explicitly not to:**
  - evaluate or set priorities on the science
  - review the DUSEL project or consider its future
  - pick experiment winners or losers
  - consider alternate sites, alternate technologies, etc.

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# Eight Scenarios were considered

**At the Homestake Mine:**

1. A long baseline neutrino experiment using water Cerenkov detectors located on the 4850 ft. level near the existing Sanford Laboratory's Davis Campus;
2. A long baseline neutrino experiment using LAr detectors located at a shallow campus (800 ft. level ), including the resources need to carry out a program of R&D necessary to prove the scalability of LAr technology to 17 kilotons;
3. A third generation dark matter experiment located on the 4850 ft. level.
4. A ton-scale neutrino-less double beta decay experiment located on the 4850 ft. level.
5. A third generation dark matter experiment located on the 7400 ft. level.
6. A ton-scale neutrino-less double beta decay experiment located on the 7400 ft. level.

**At the Sudbury Neutrino Observatory:**

7. A third generation dark matter experiment located at the Sudbury Neutrino Observatory
8. A ton-scale neutrino-less double beta decay experiment located at the Sudbury Neutrino Observatory

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# Committee Conclusions

- **Constructing the 3G DM or ton-scale DBD experiments at the 7400 ft level at Homestake appears to be prohibitively expensive.**
- **Significant investment in infrastructure will be necessary**
  - **modernizing the Ross and Yates shafts at Homestake is a necessary prerequisite**
- **LBNE at 4850 ft level would provide infrastructure to reduce the cost of locating Dark Matter and Double Neutrinoless Double Beta Decay at this level**
  - **without LBNE at 4850 ft, the committee recommended against locating these experiments at Homestake**
  - it may be several years before it is known if DBD is feasible at 4850 ft.
  - the lowest cost option for DM or DBD is SNOLab
- **It is worthwhile considering the advantages of a common site and the multi-decade timescale**

**Caveat: the cost estimates for the 3G DM and ton-scale DBD experiments should be taken as accurate to about 1 significant figure**

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# NRC Study

- **The full report is available at** http://www.nap.edu/catalog.php?record id=13204
- **It contains a strong endorsement of both the DUSEL research program, and the US pursuit of an on-shore leadership role in underground science:**
  - Development of an underground research facility in the United States would supplement and complement underground laboratories around the world. A U.S. facility could build upon the unique position of the United States that would allow it to develop a long-baseline neutrino experiment using intense beams from Fermilab. It could accommodate one of the large direct detection dark matter experiments and one of the large neutrinoless double-beta decay experiments that are needed by the international effort to resolve these critical scientific issues, while sharing infrastructure among these three experiments that are of comparable import. It could also host and share infrastructure with other underground physics experiments, such as an accelerator to study nuclear astrophysics, and with underground experiments in other fields. **An underground research facility would benefit the U.S. research communities, and would guarantee the United States a leadership role in the expanding global field of underground science.**
- “

# Congressional Guidance in the FY12 Appropriations Bill

- **the conferees provide $21,000,000 for the Long Baseline Neutrino Experiment, which includes $17,000,000 for research and development and $4,000,000 for project engineering and design.**
  - The conferees provide no funding for long-lead procurements or construction activities.
  - The conferees are concerned that this project is not mature enough for construction because a location and technology for the underground detectors has not been selected.
  - **Before consideration of congressional approval of construction, the Department is directed to provide to the House and Senate Committees on Appropriations a detailed project plan and refined total cost estimate for construction, not later than April I, 2012.**
- **Within available funds, the conferees provide $15,000,000 as requested, $10,000,000 within High Energy Physics and $5,000,000 within Nuclear Physics, to support minimal, sustaining operations at the Homestake Mine in South Dakota.**

# Additional Signals

- **House Appropriations Language:**
  - **the Committee cautions the Department against taking over the construction and long-term management of DUSEL. Adopting management of yet another laboratory site would add budgetary and management burdens to an already stressed program.**

**This did not survive in the final bill but it indicates concerns in Congress about how we proceed.**

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# Current Situation

- The Director of the Office Science, Dr. W. Brinkman, has
  - The report of the committee on Underground Science(available at http://science.energy.gov/~/media/hep/hepap/pdf/june-2011/Review_of_Underground_Science_Report_Final.pdf)
  - The NRC Assessment of DUSEL (Lankford Committee)
  - Information on the FY2013 Budget (Roll-out anticipated next month)
- The key input for whether or not to proceed with activity at Homestake is the reevaluation of the LBNE costs
  - The technology choice for LBNE has recently been made
  - Refined cost estimate will be presented to Dr. Brinkman soon. The plans for dewatering are consistent with early underground science at Homestake
    - LUX-350
    - Majorana Demonstrator
- In order to meet the Congressional April 1 deadline for reporting, Dr. Brinkman must decide no later than March whether or not to proceed with LBNE at Homestake.

# Status of LBNE

- **Deputy Secretary of Energy Approved Mission Need for LBNE (CD-0) on January 8, 2010**
  - **Scope includes:**
    - **neutrino beam pointed at DUSEL**
    - **a near detector at Fermilab**
    - **a far detector and needed infrastructure presumably at Homestake Mine**
  - **A preliminary cost range was developed as part of the CD-0 process.**
  - **A technology choice of LAr at 4850 ft. has been made.**
  - **A better estimate of the cost range is being developed in light of this and other decisions.**
  - **Goal is to have CD-1 approval in late FY2012 so as to release the PED funding including in the FY12 Budget ($17M OPC; $4M PED)**
    - **A tentative date for a Fermilab Director's review in preparation for an OPA CD-1 has been set.**

# DOE OHEP - Status of the Dark Matter Program

| Operating and Commissioning | Fabrication and Installation | Future Possibilities |
|---|---|---|
| | | |
| SuperCDMS (Soudan) | | SuperCDMS (SNOLab)<br>GEODM |
| LUX-350 (SURF)<br>To 4850 level in March 2012 | | LZS<br>LZD |
| ADMX (Univ. Wash.) | | |
| ~~COUPP-60 (FNAL)~~<br>removed from NUMI tunnel | COUPP (SNOLab)<br>Operation in CY2012 expected | |
| XENON-100(LNGS) | | XENON 1t (LNGS) |
| | | MAX<br>MiniCLEAN (SNOLab)<br>Darkside (SNOLab) |

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# Dark Matter Program

**As shown on the previous slide several technologies and approaches are underway.**

**Current funding projections indicate that DOE would not be able to fund all of the technologies to go forward with a 2nd-generation experiment.**

**A Funding Opportunity Announcement for R&D for future, second-generation experiments that conduct direct-detection searches for dark matter particles is about to be released. Proposals in response to this FOA will be due this summer.**

**In partnership with NSF, we are tentatively planning to hold a review ~ summer 2012 of the dark matter proposals in order to get recommendations on which G2 experiments/technologies should move forward.**

**We expect a funding start at the beginning of FY13 for this R&D**

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# Neutrinoless Double β-decay Status

**HEP and NP have agreed that going forward, NP will have stewardship of G3 $0\nu\beta\beta$ experiment(s).**

- **EXO-200 (HEP)**
  - **in operation at WIPP; has made the first observation of 2 neutrino double β-decay in Xenon.**
- **Majorana (NP)**
  - **DOE Nuclear Physics is supporting R&D effort on the Majorana Demonstrator to establish the feasibility of a ton-scale $^{76}$Ge neutrino-less double β -decay experiment**
  - **MJD technology demonstration planned prior to down-select with GERDA between competing Ge technologies and planned collaboration**
  - **MJD on track with electroforming, and procurement and processing of enriched Ge**
  - **MJD planning to go underground with natural Ge prototype cryostat in March; timely beneficial occupancy of Davis campus lab and as-planned UG access critical**
  - **Uninterrupted UG access for fabrication and operations for ~5 years critical;**
- **CUORE (NP)**
  - **DOE Nuclear Physics supporting U.S. participation in a $^{130}$Te based neutrinoless double β -decay experiment under construction at LNGS**
  - **U.S. deliverables (half the crystals, thermistors, source calibration system, front-end electronics, data analysis farm) on track**
  - **cryogenic system (Italian scope) extremely challenging; experiencing delays**
  - **expected data collection to start in 2015 for ~5 years**

**The technology and location of future, international G3 experiment is TBD in the future based on best value and best science capability**

# BACKUP

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# HEP Strategic Roadmap

In 2008, the HEP program, with input from the scientific community, has developed a long-range plan that maintains a leadership role for the U.S. at the three scientific frontiers that define the field

The main elements of this plan are to:

- Maintain a strong, productive university and laboratory research community
- Enable U.S. leadership roles in the Tevatron and LHC programs at the Energy Frontier
- Achieve the vision of a world-leading U.S. neutrino and rare decay program at the Intensity Frontier, building on the existing accelerator infrastructure at Fermilab
- Deploy selected, high-impact experiments at the Cosmic Frontier
- Support accelerator R&D to position the U.S. to be at the forefront of Advanced Technologies for next-generation facilities.

Need to design and construct new research capabilities,

- while maintaining a world-leading scientific program and
- supporting targeted long-range R&D for the future.

# U.S. Nuclear Physics
## Guidance from scientific community (NSAC)

- Should pursue opportunities at all three scientific frontiers
  - Quantum ChromoDynamics (QCD) Frontier
  - The Nuclei and Nuclear Astrophysics Frontier
  - The Fundamental Symmetries and Neutrinos Frontier

- Fundamental Symmetries and Neutrinos
  - Pursue a targeted program of experiments to investigate neutrino properties and fundamental symmetries.

    *"Nuclear physicists are poised to discover the symmetries of the New Standard Model through searches for neutrinoless double beta decay and electric dipole moments, determination of neutrino properties and interactions, and precise measurements of electroweak phenomena."*

  - Construction of a Deep Underground Science and Engineering Laboratory is vital to U.S. leadership in core aspects of this initiative

    *"The Deep Underground Science and Engineering Laboratory (DUSEL) will provide the capability needed for ultra-low background measurements in this discovery."*

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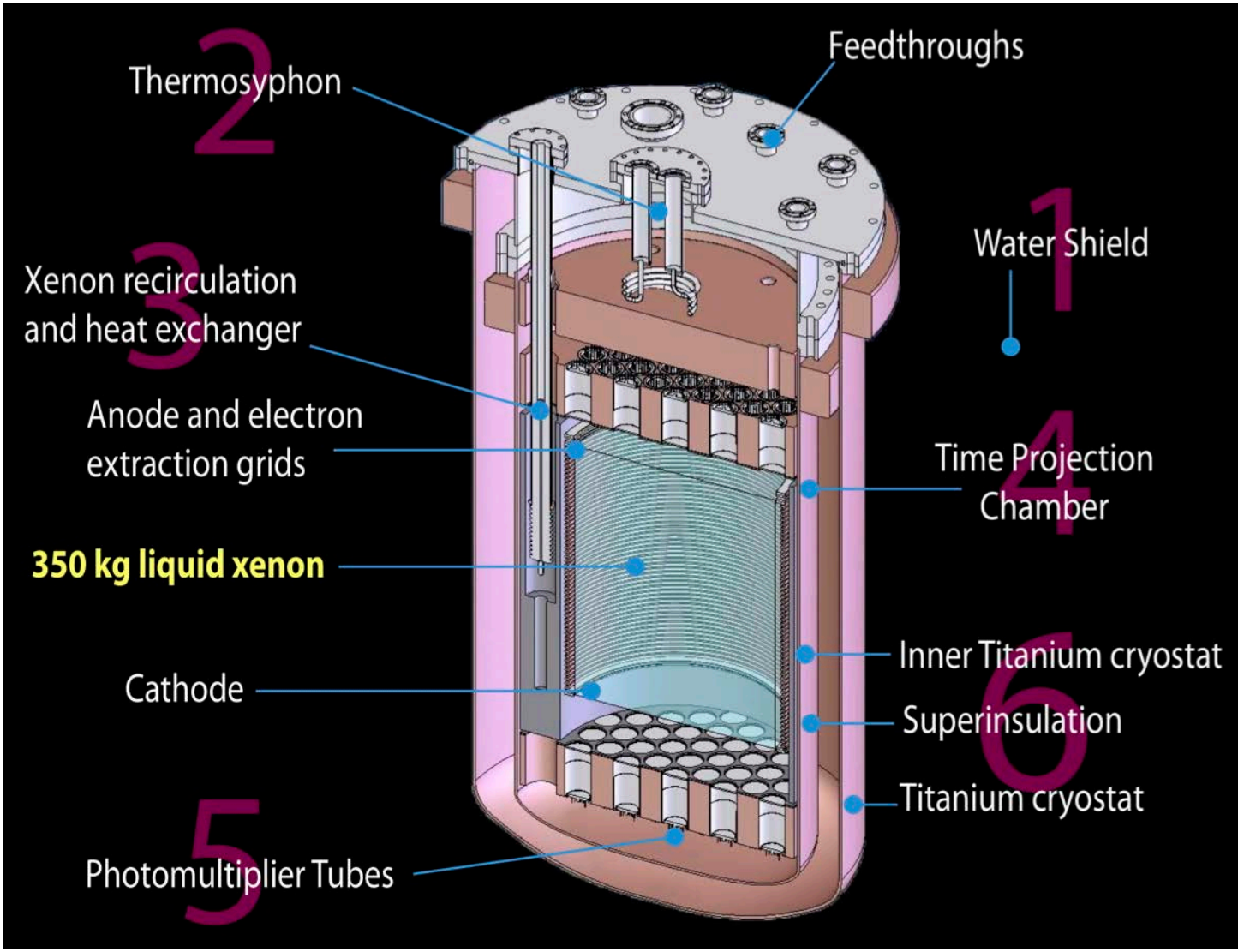
# LUX Dark Matter Detector



# Ongoing NP R&D in 0νββ

Grand Challenge question being tackled: Is the neutrino its own anti-particle ?

- NP is supporting R&D effort on MJD to establish the feasibility of a ton-scale $^{76}$Ge neutrino-less double beta-decay experiment; HEP is supporting R&D on EXO technology development.

- MJD technology demonstration planned prior to down-select with GERDA between competing Ge technologies and planned collaboration

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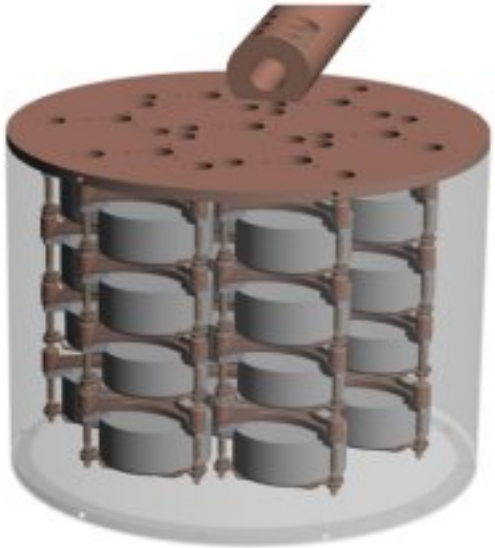
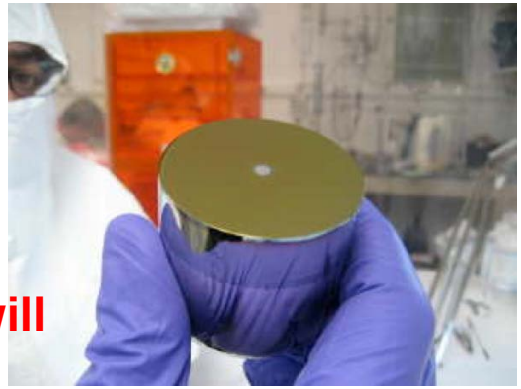
- Technology and location of future, international G3 experiment is TBD in the future based on best value and best science capability

Germanium detector and the cryostat for Majorana Demonstrator (MJD).





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