



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Office of Nuclear Physics



MAJORANA

Alan Poon

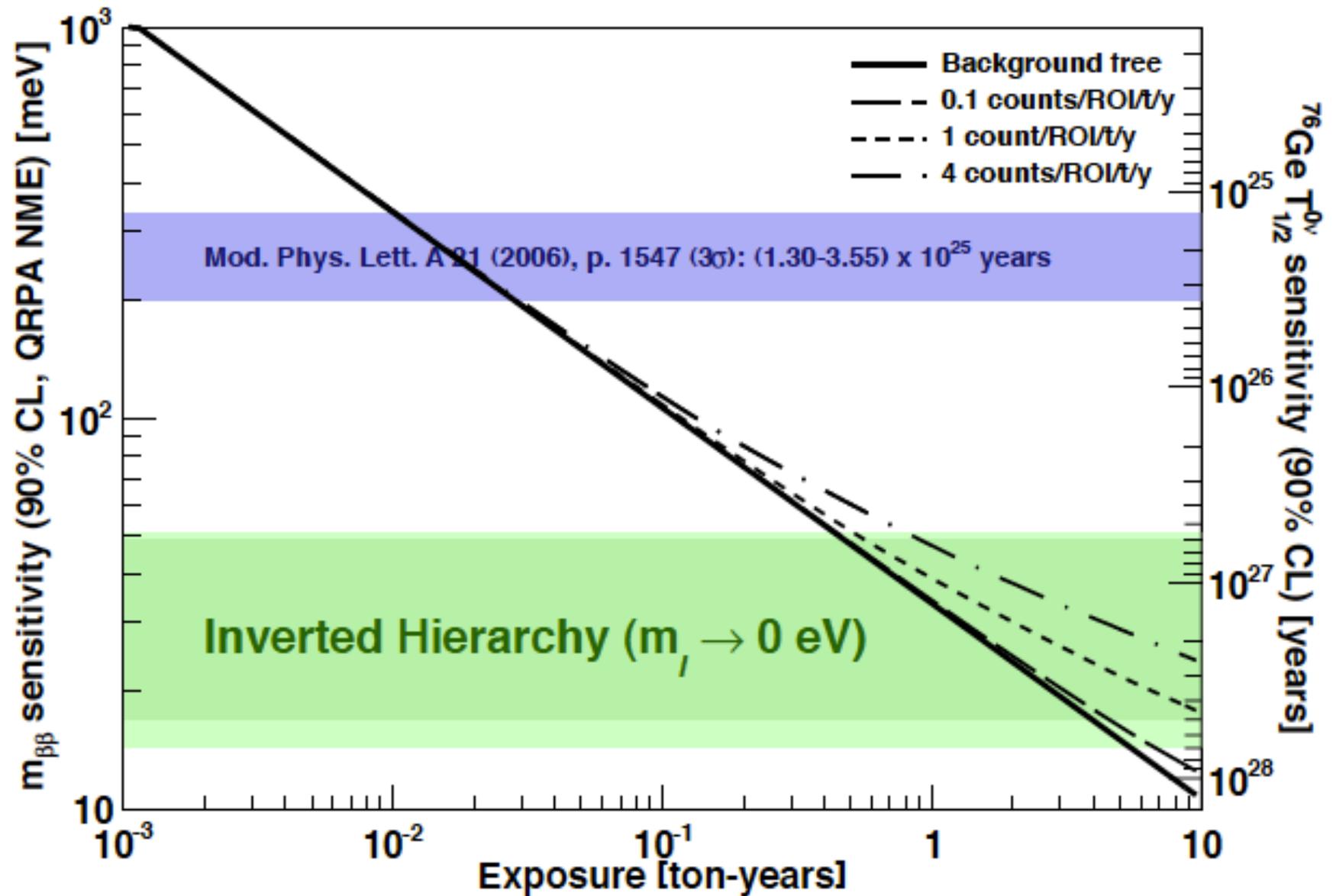
Lawrence Berkeley National Laboratory

Outline



- Introduction
- MAJORANA DEMONSTRATOR
- Future 1TGe
- Summary

Background and Sensitivity



MAJORANA DEMONSTRATOR (MJD)

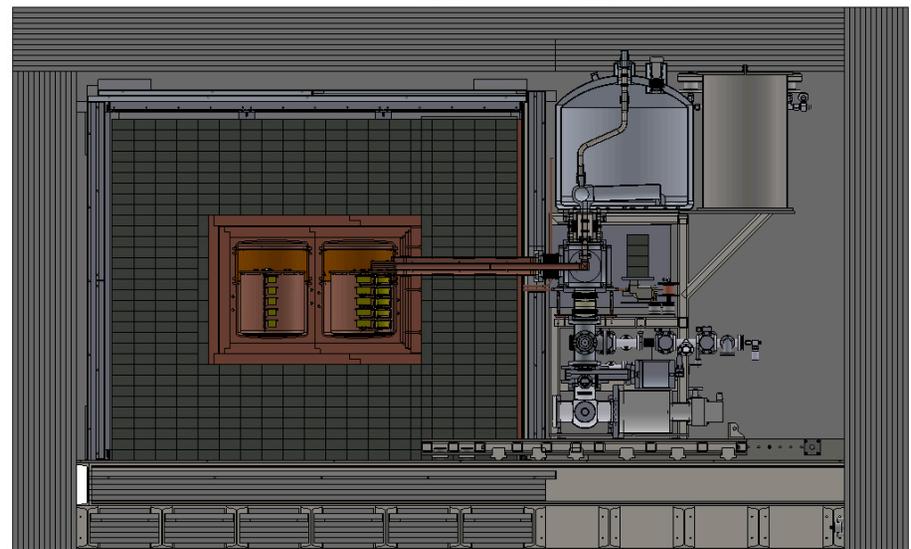
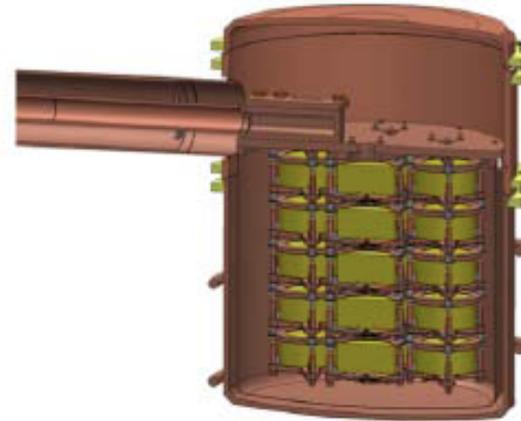


- **Technical goals :**
 - Demonstrate backgrounds low enough to justify building a tonne scale Ge experiment.
 - Establish feasibility to construct & field modular arrays of Ge detectors. Minimize costs, optimize the schedule, and retire risks for a future 1-tonne experiment.
- **Science goals :**
 - Test Klapdor-Kleingrothaus' claim of an observation of $0\nu\beta\beta$ in ^{76}Ge .
 - Low-energy dark matter (light WIMPs, axion) search.
- The MAJORANA Collaboration is working cooperatively with the GERDA Collaboration in Europe toward an international tonne-scale Ge experiment that combines the best features of the two programs.

MAJORANA DEMONSTRATOR (MJD)



- Located underground at 4850' Sanford Lab in SD
- 40 kg of HPGe detectors:
 - 30 kg of 86% enriched ^{76}Ge crystals
 - 10 kg of natural Ge crystals
- 2 independent cryostats
 - Ultra-clean, electroformed Cu
 - 20 kg of detectors per cryostat
 - Scalable design
- Compact shield
 - Low background passive Cu and Pb shield
 - Active muon veto

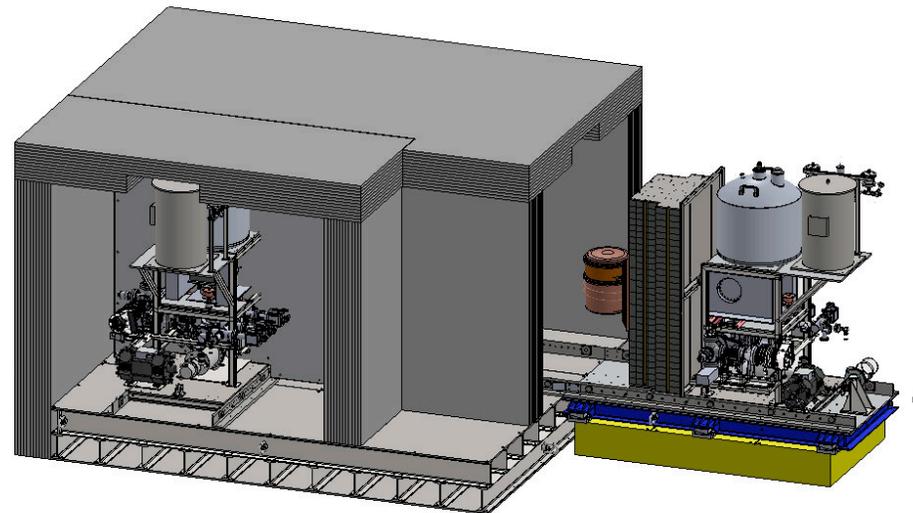
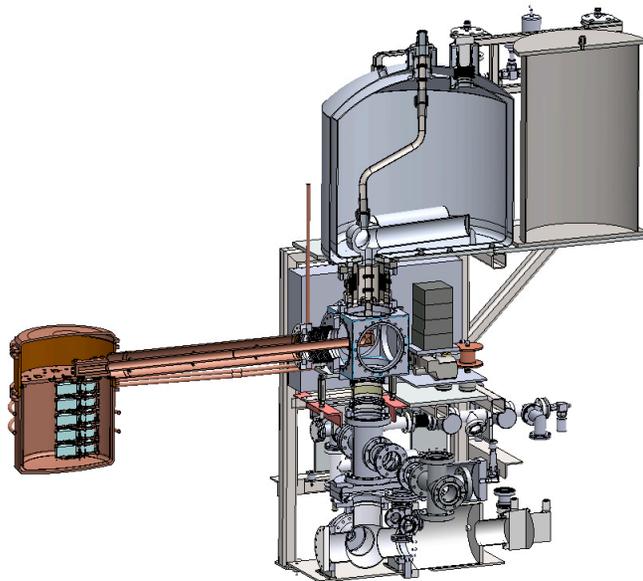


Background Goal in the $0\nu\beta\beta$ peak ROI (4 keV at 2039 keV):
~ 3 count/ROI/t-y after analysis cuts (scales to 1 count/ROI/t-y for tonne expt.)

MAJORANA DEMONSTRATOR (MJD)



- *Three steps* :
 - Prototype Cryostat** (2 strings, $^{\text{nat}}\text{Ge}$) [End of 2012]
 - Cryostat 1 (3 strings $^{\text{enr}}\text{Ge}$ & 4 strings $^{\text{nat}}\text{Ge}$) [Fall 2013]
 - Cryostat 2 (7 strings $^{\text{enr}}\text{Ge}$) [Fall 2014]

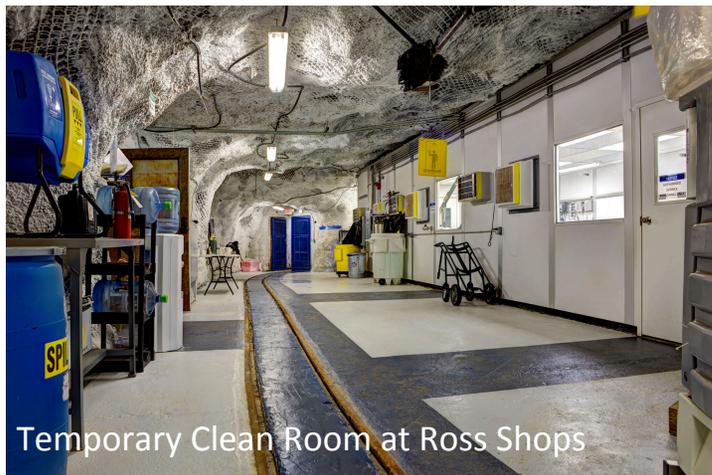


** Same design as Cryostats 1 & 2, but fabricated using OFHC Cu (non-electroformed) components.

Status: Underground Lab



- E-forming lab (“Temporary Clean Room”) operational since summer 2011.
- Davis Campus lab outfitting finished; shield floor, LN system, assembly table, air bearing system, glove boxes, localized clean space all installed.



Temporary Clean Room at Ross Shops



Glove Box

Status: E-form Cu



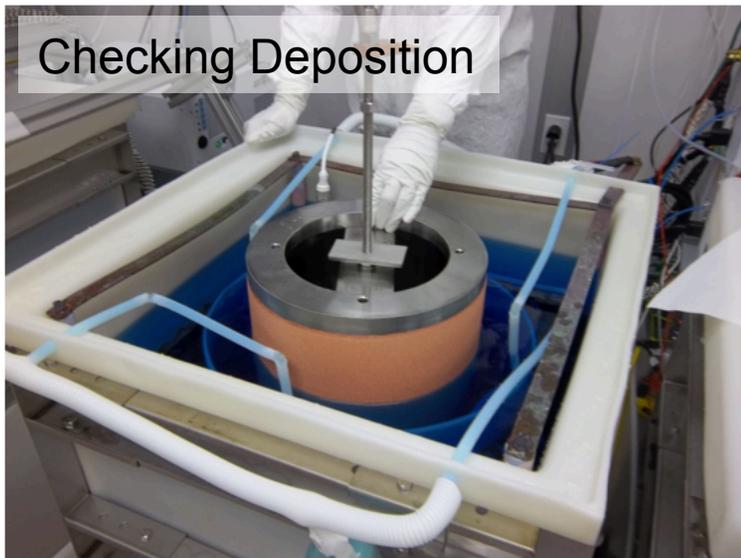
- E-forming at PNNL and at 4850' at SURF
- SURF UG machine shop operational



Installation of mandrel in bath



Copper ready to cut



Checking Deposition



EDM installed UG



Lathe being installed UG

Status: ^{enr}Ge



- 20 kg ^{enr}Ge received as GeO₂ in 2011.09. Reduced and purified by Electrochemical Systems, Inc (ESI) in Oak Ridge.
- Additional 22.5 kg ordered; to be delivered in 2012.09.
- 4-5 kg of Russian contribution by end of 2012.



Cherokee Caverns,
Oak Ridge



Electronic-grade ^{enr}Ge after purification

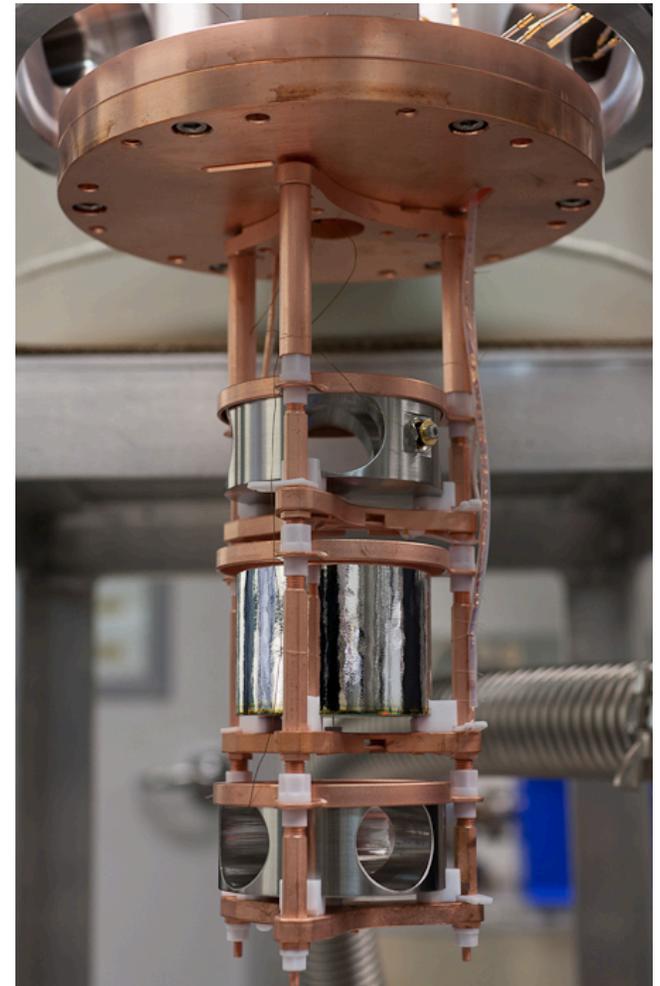
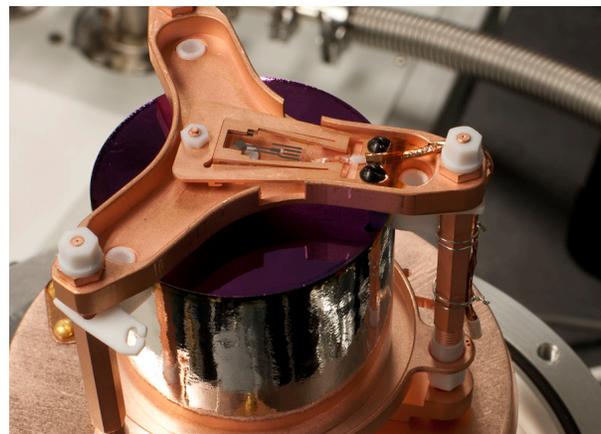


Gun safe UG at
Cherokee Caverns in Oak

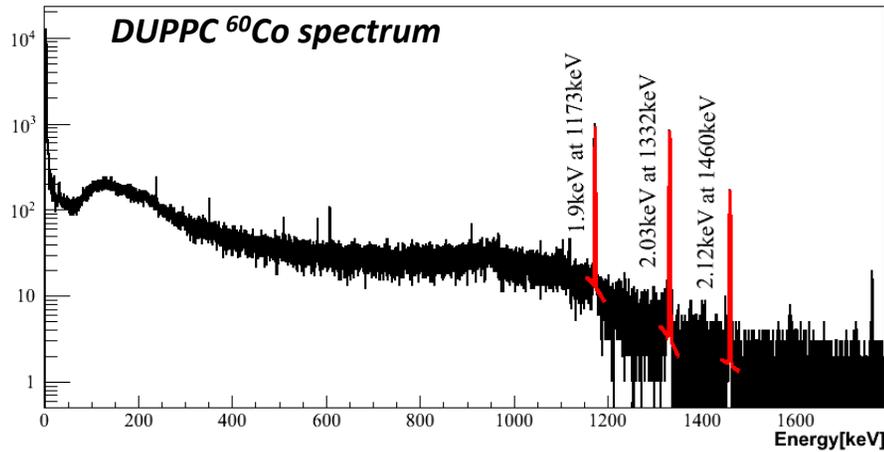
Status: Detectors



- 20 kg of ^{nat}Ge detectors (“modified BEGe detectors” by Canberra) in hand, and are stored underground at SURF.
- ORTEC selected to produce ^{enr}Ge detectors.
- ORTEC has produced a detector from natural Ge purified by ESI. ^{enr}Ge detector production begins in Fall 2012.
- Detector mounts and signal processing electronics for prototype cryostat in good shape.

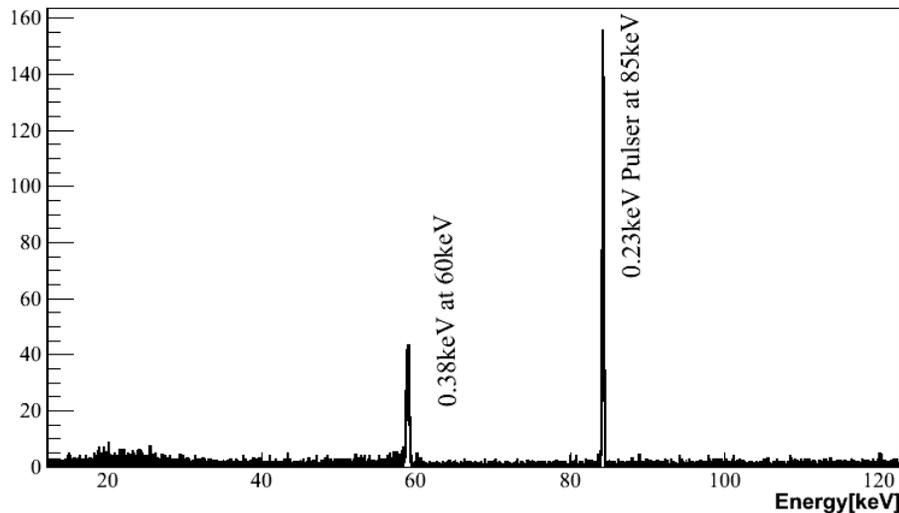


Status: Detectors



- $0\nu\beta\beta$:

Energy (keV)	Goal FWHM (keV)	Measured FWHM (keV)
2039	< 4 (~3.2 @1332)	2.0 @ 1332
60	< 1	0.38



Taken with near-final signal processing electronics

- Low energy program:

Energy (keV)	Goal FWHM (keV)	Measured FWHM (keV)
60	< 0.5	0.38

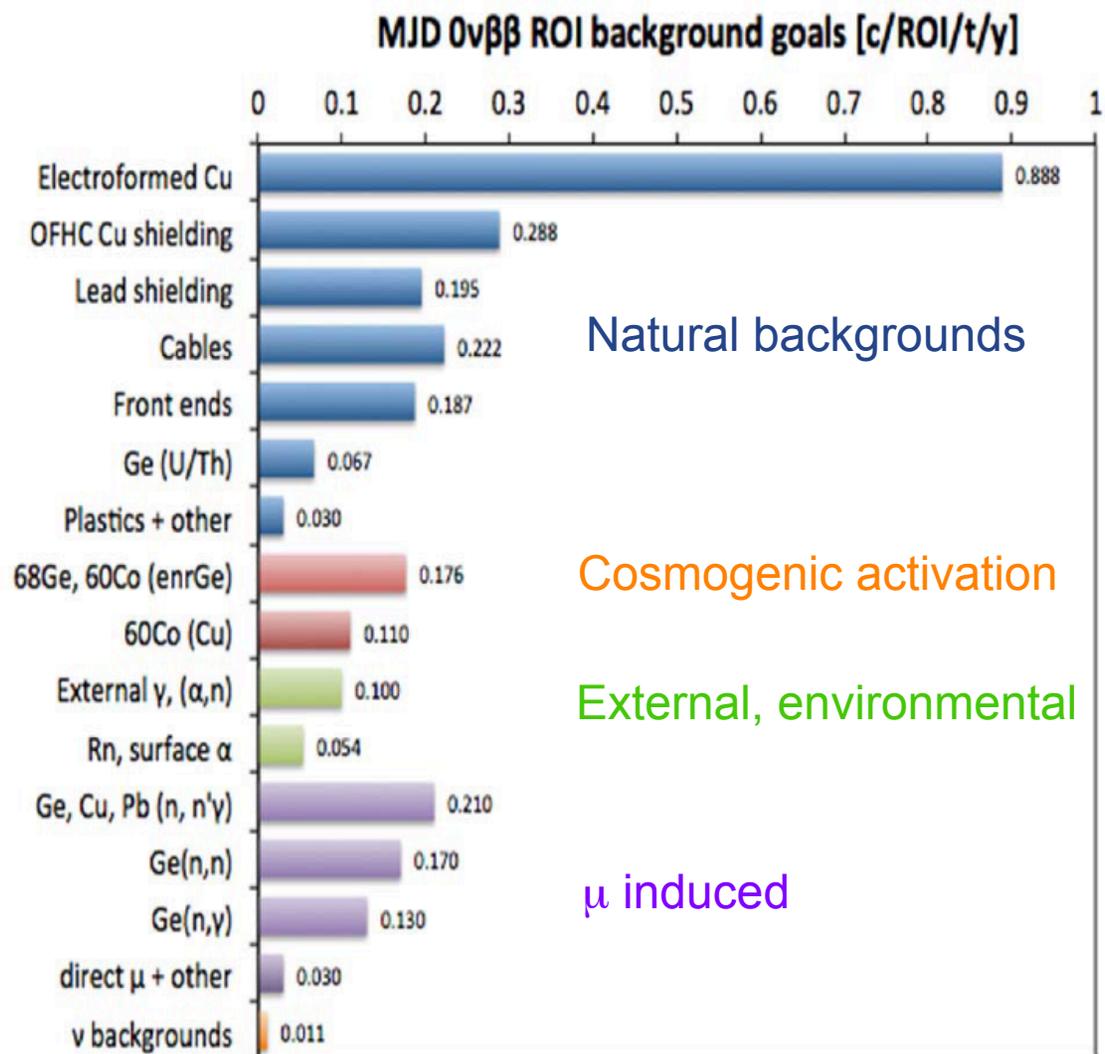
Status: Modules and Mechanical Systems



- Prototype cryostat being fabricated and assembled.
- Thermosyphon design validated. Fabricated and tested.
- Prototype vacuum system designed, reviewed, assembled, and being operated.
- First two string test cryostats built.
- Majority of shielding material in hand, some is underground.
- Prototype calibration system demonstrated.

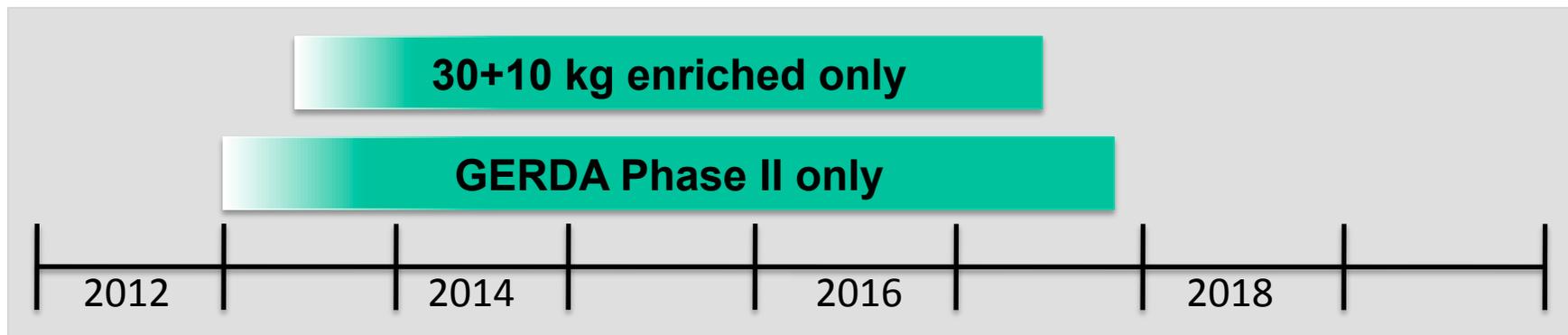


MJD: Projected Background



Total: 2.9 counts/ROI/t/y

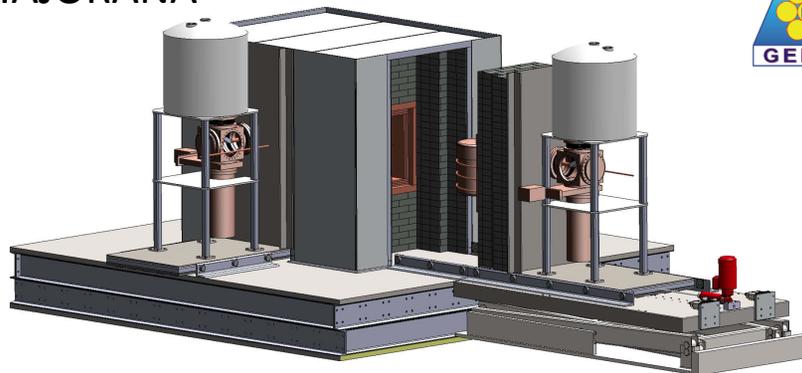
Reaching 100 kg-y Exposure



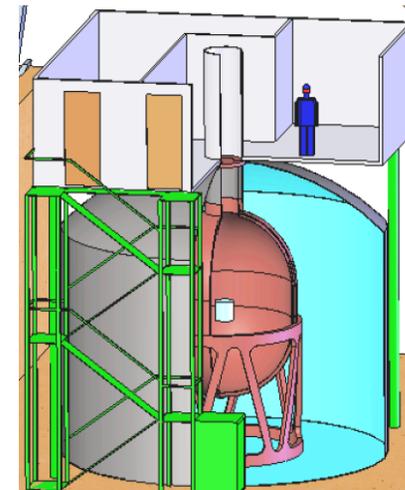
- With 30 kg ^{enr}Ge and 10 kg ^{nat}Ge , MJD is competitive with GERDA Phase II in total exposure.
- Both projects aim to demonstrate the feasibility of a tonne-scale ^{76}Ge experiment, which will require a background level of 1 count/ROI/t/y.



MAJORANA



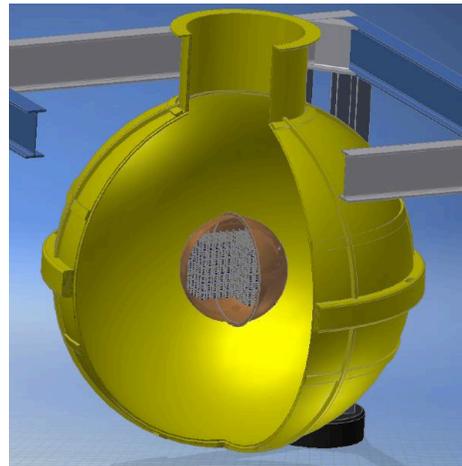
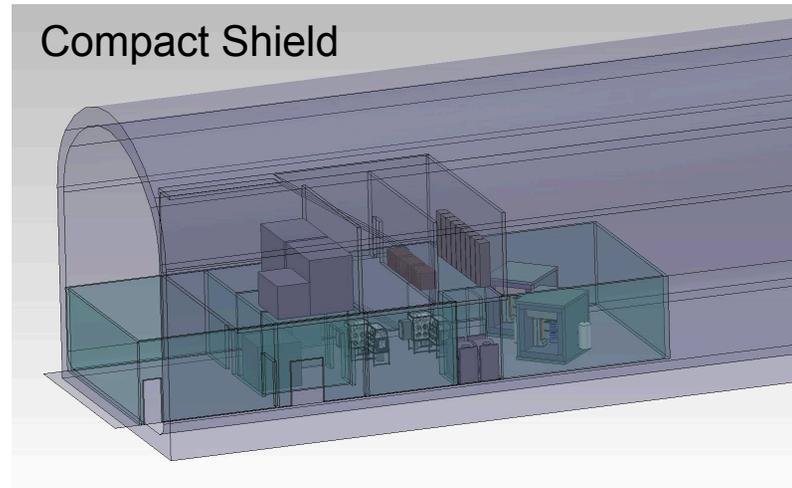
GERDA



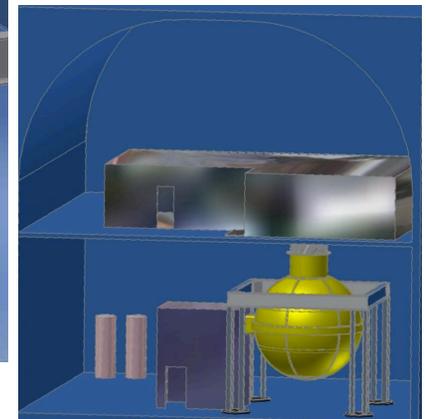
Toward 1TGe



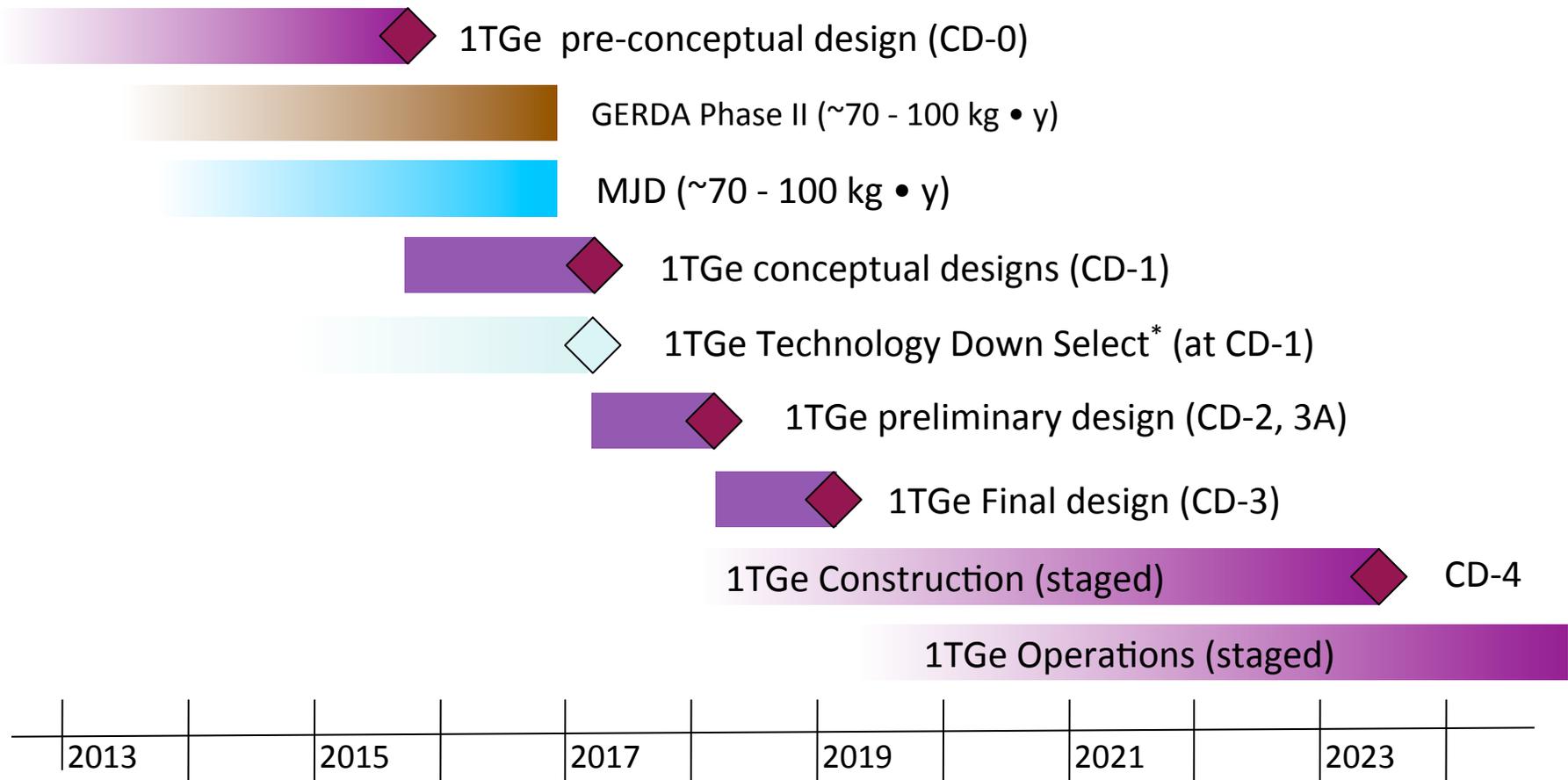
- MAJORANA and GERDA have a joint cooperative agreement:
 - Open exchange of knowledge and technologies
 - Intention to merge for a 1TGe experiment. Select best technologies from both projects.
- Performing longer-term R&D, engineering studies, facilities planning, and costs & schedule estimates.
- 1TGe R&D topics include:
 - Advanced detector designs and studies.
 - Detector production optimization and ^{enr}Ge recycling.
 - Development of clean mechanical and electronic components.
 - Shielding design



Vacuum Cryostat in LAr, Water



1TGe Projected Timeline



* Technology down select will be based on 1TGe R&D, GERDA Phases I and II, and MJD.

Summary



- Construction of MJD has begun at SURF:
 - Prototype Cryostat (2 strings of ^{nat}Ge): End of 2012
 - Cryostat 1 (^{enr}Ge + ^{nat}Ge): Fall 2013
 - Cryostat 2 (^{enr}Ge): Fall 2014
- First 20 kg of ^{enr}Ge purified successfully; more ^{enr}Ge to be delivered later this year.
- ^{enr}Ge detector production in Fall 2012.
- MJD and GERDA Phase II are on similar time scale to reach 100 kg-y exposure.
- 1TGe R&D in progress.

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