Towards a Tonne Scale ^{76}Ge 0νββ Experiment

R. Henning

SLAC Intensity Frontier Workshop 2013

University of North Carolina at Chapel Hill and Triangle Universities Nuclear Laboratory

Tonne Scale 0νββ Experiment (1TGe)

- Isotopes have comparable "mass" sensitivities (Robertson, arXiv:1301.1323)
  - Different backgrounds, abundances, implementations …
  - Observation will require confirmation with different isotope.
- Phase 0: MAJORANA DEMONSTRATOR and GERDA:
  - Demonstrate projected backgrounds at 1 count/ROI/t/y
  - Discovery capability, Test KKDC claim
  - Scalability, cost, international collaborations & partnership
- Tonne Scale ^{76}Ge 0νββ Experiment
  - MAJORANA and GERDA leadership working towards a single international ^{76}Ge 0νββ collaboration.
  - Envision a phased, stepwise implementation : ~200-500 → 1000 kg
  - Moving forward predicated on demonstration of projected backgrounds by MJD and/or GERDA.
  - During FY14 should have initial information from both GERDA Phase II and MJD Cryo 1.
    - will impact decisions on depth, shielding requirements, materials, …

MAJORANA and GERDA

MAJORANA DEMONSTRATOR

- Modules of enrGe housed in high-purity electroformed copper cryostat
- Shield: electroformed copper / lead
- Initial phase: R&D demonstrator module: Total 40 kg (30 kg enr.)
- Under Construction at SURF
- Initial data-taking in Spring 2013

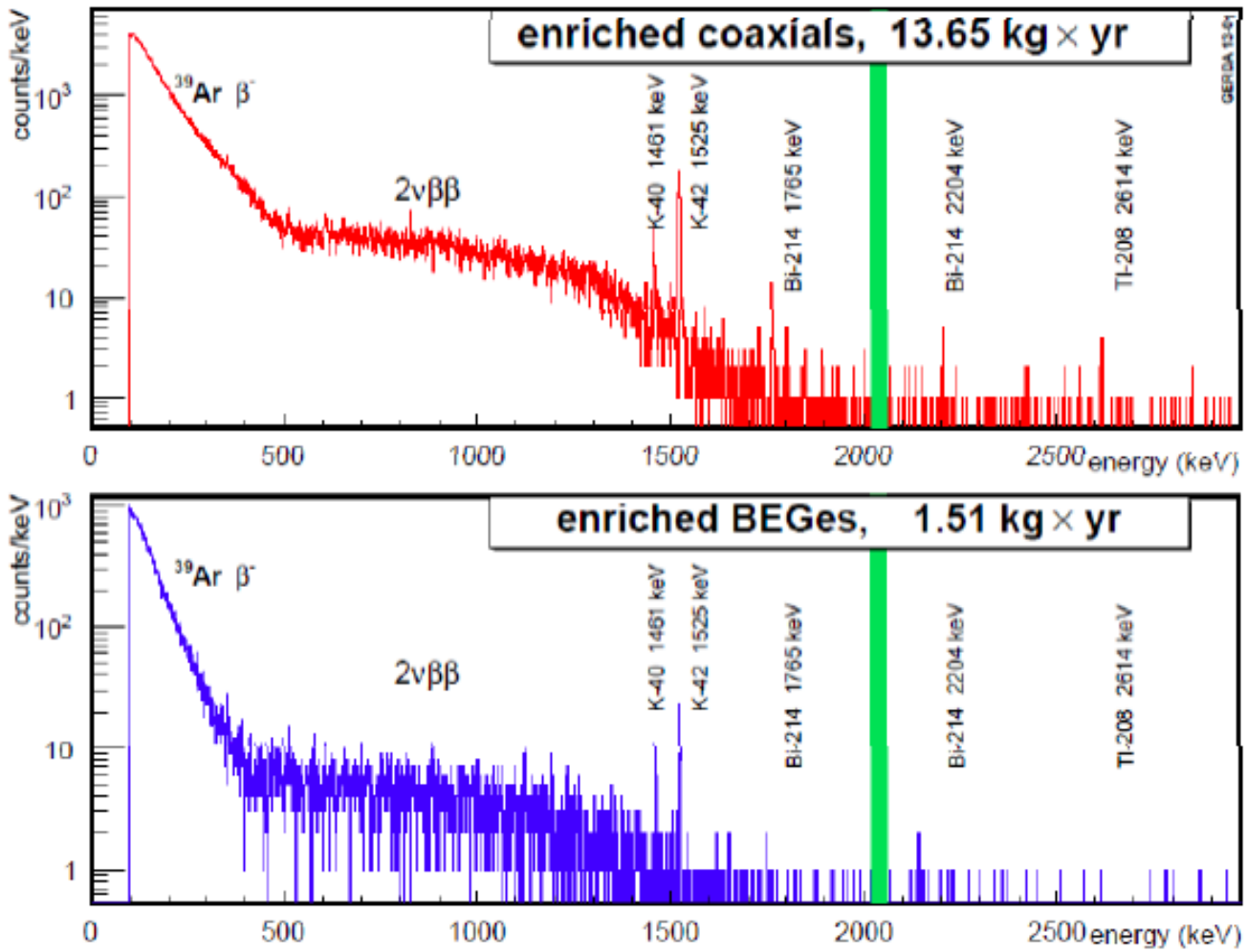
GERDA

- 'Bare' enrGe array in liquid argon
- Shield: high-purity liquid Argon / H2O
- Phase I (2013): ~18 kg (HdM/IGEX diodes)
- Phase II (est. 2014): add ~20 kg new detectors - Total ~40 kg
- Operating at LNGS

Signed Joint Cooperative Agreement:
- Open exchange of knowledge & technologies (e.g. MaGe, R&D)
- "Cherry-pick" best techniques developed and tested in GERDA and MAJORANA for 1TGe

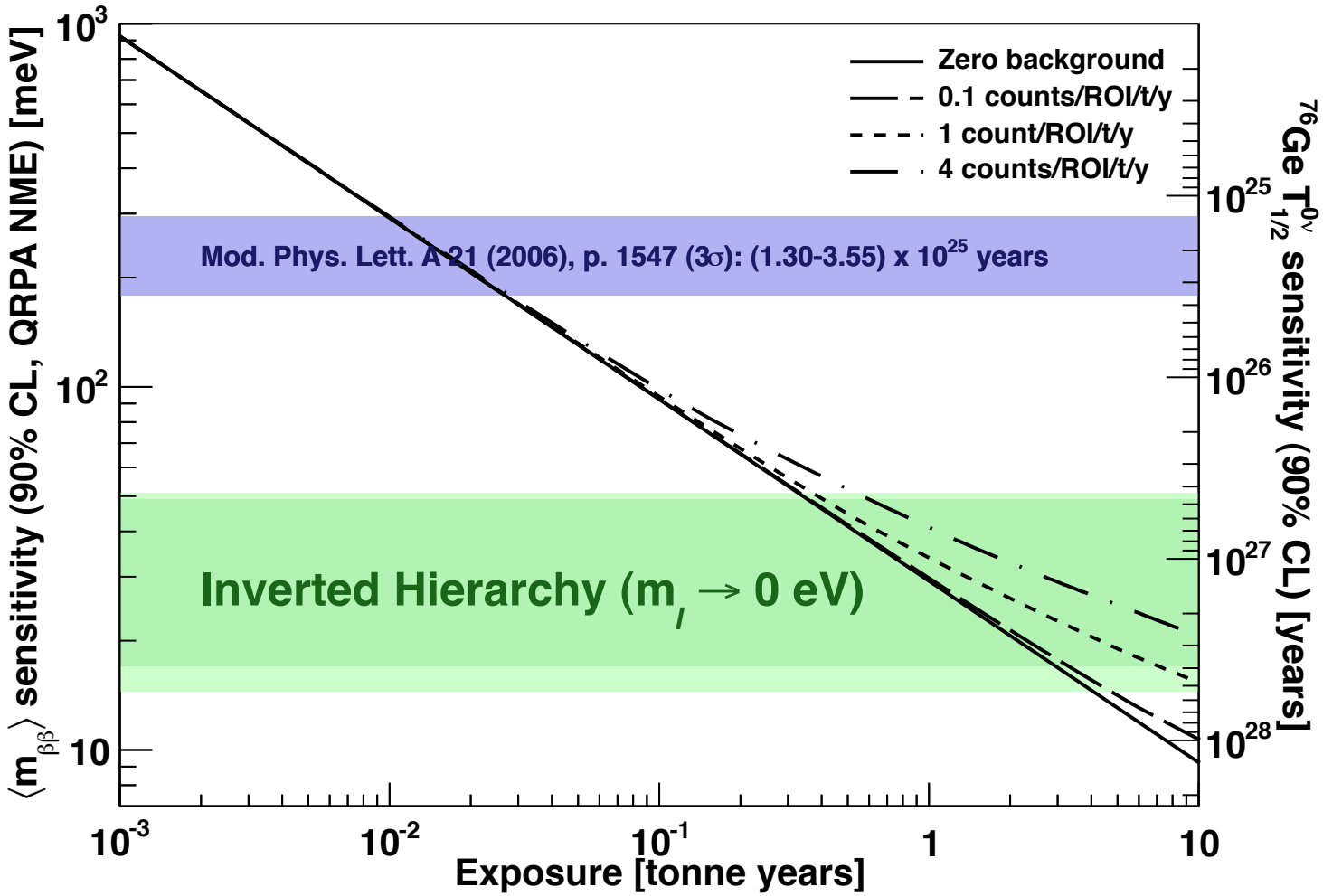
Recent GERDA Result

C. Cattadori, presentation on behalf of GERDA at NuMass 2013, Milan, Italy, February 2013.



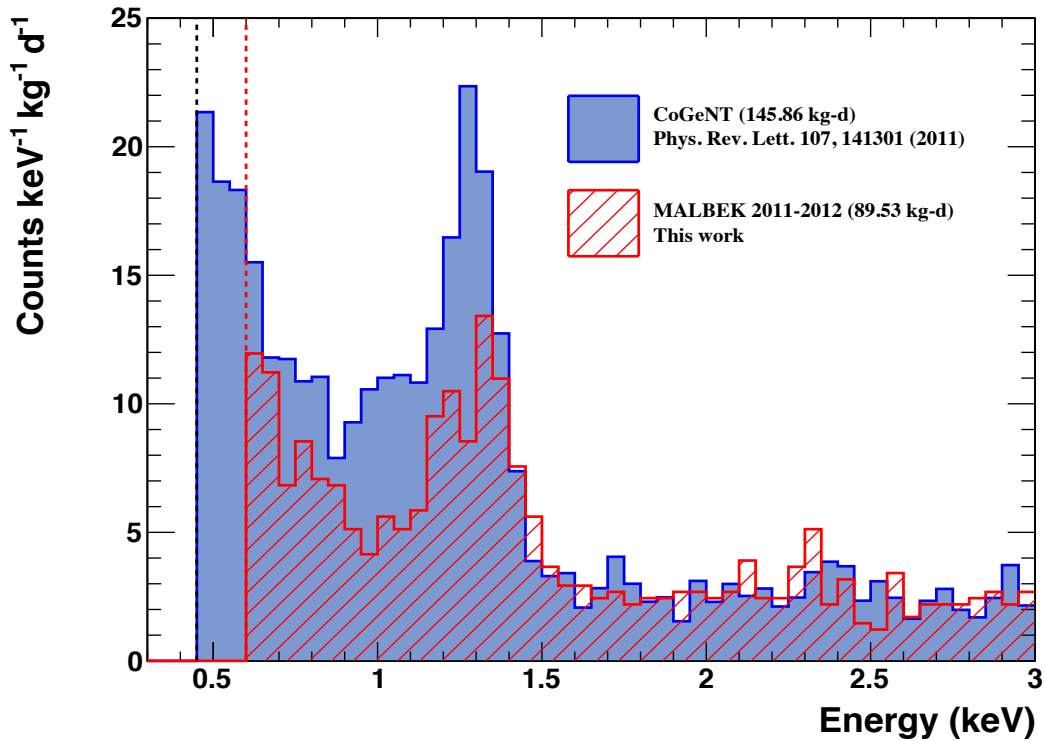
Background index 2 cts/keV/t/y w/o analysis cuts
Better than any other DBD experiment

1TGe 0νββ Sensitivity

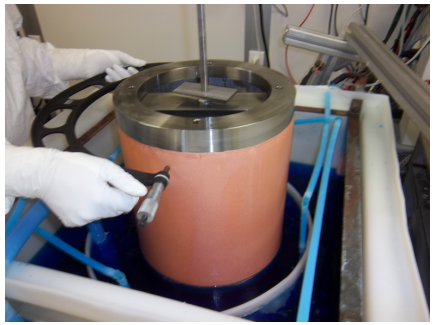


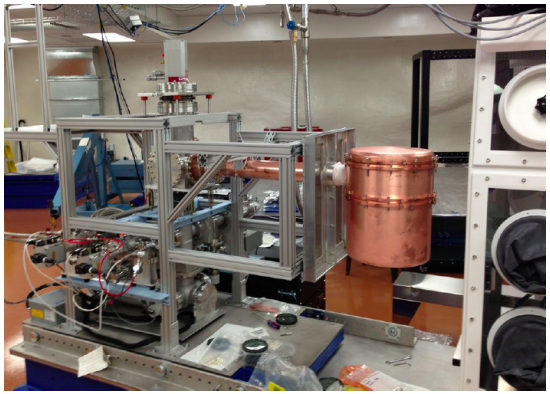
1TGe Expanded Physics Program

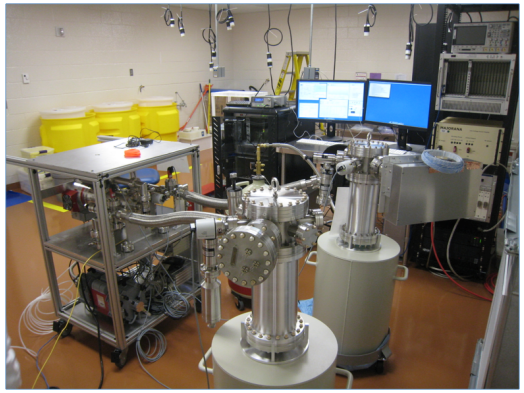
- Low-E thresholds and energy resolution of 1TGe offer unique opportunities over other techniques:
  - Light WIMP Dark Matter searches
  - Solar axions
  - Coherent neutrino nuclear scattering
  - Low-E ν+e scattering and neutrino dipole moment
  - Lorentz principle violation
- Enrichment reduces low-E backgrounds significantly

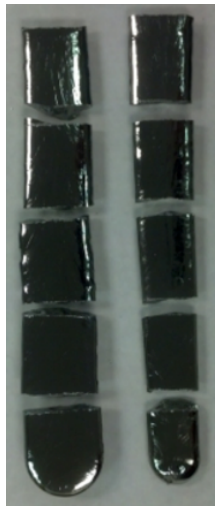


MJD Progress in FY13

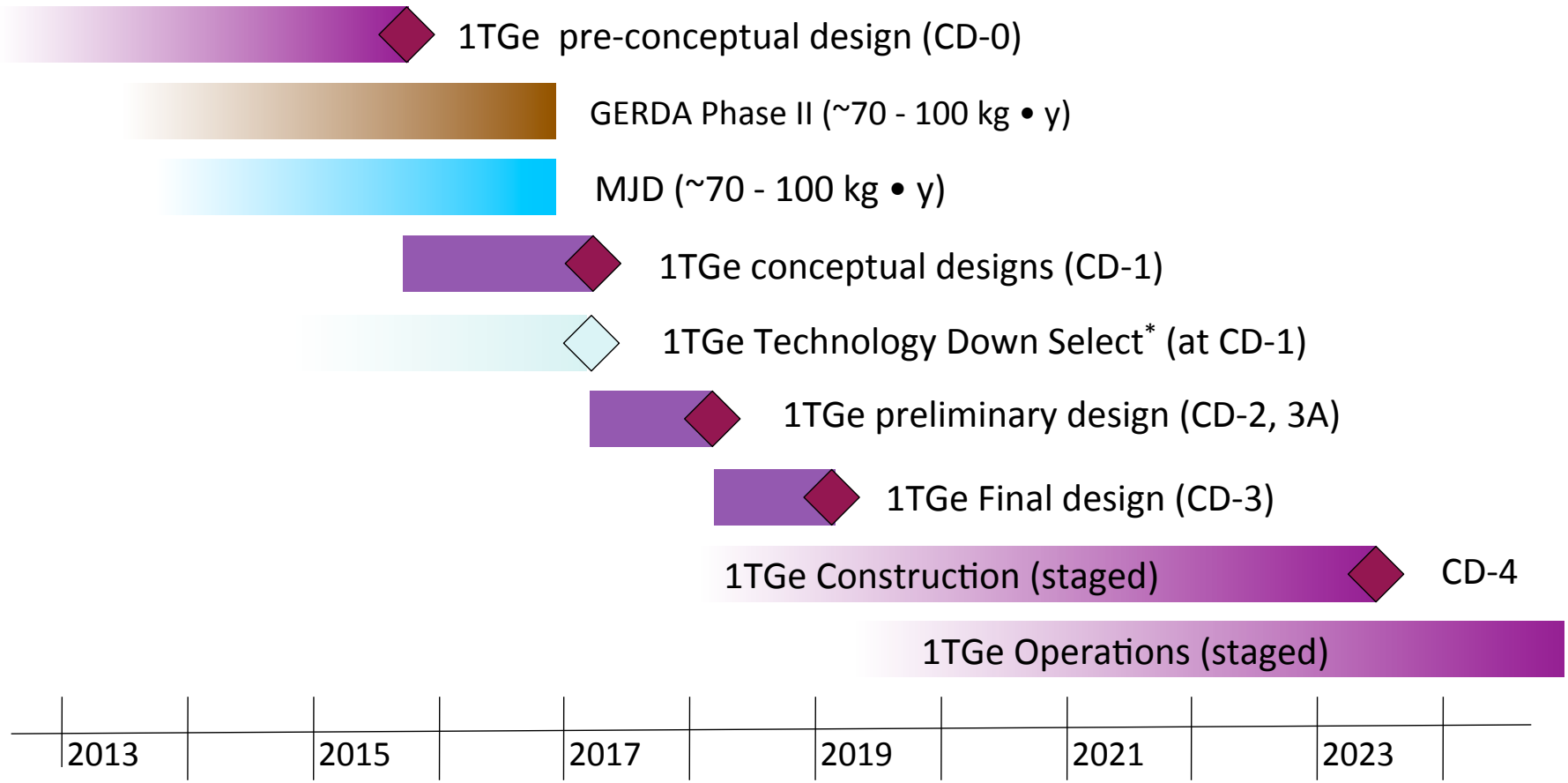








1TGe Projected Timeline



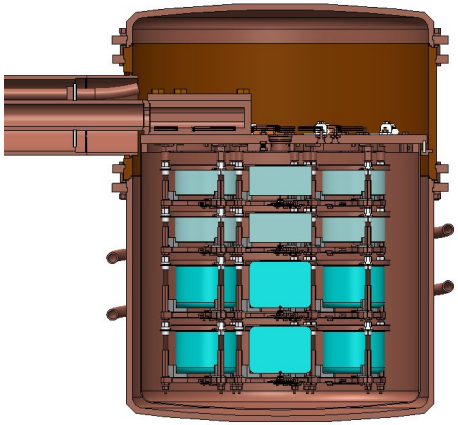
✳ Technology down select will be based on 1TGe R&D, GERDA Phases I and II, and MJD.

Backup Slides

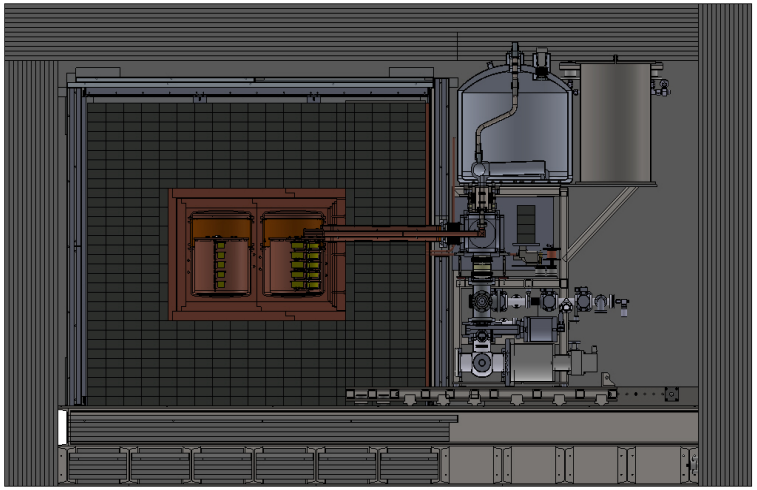
The MAJORANA DEMONSTRATOR

Funded by DOE Office of Nuclear Physics and NSF Particle Astrophysics,
with additional contributions from international collaborators.

Goals: - Demonstrate backgrounds low enough to justify building a tonne scale experiment.
- Establish feasibility to construct & field modular arrays of Ge detectors.
- Test Klapdor-Kleingrothaus claim.
- Low-energy dark matter (light WIMPs) search.



- Located underground at 4850' Sanford Underground Research Facility
- Background Goal in the 0νββ peak region of interest (4 keV at 2039 keV)
  3 counts/ROI/t/y (after analysis cuts)
  scales to 1 count/ROI/t/y for a tonne experiment
- 40-kg of Ge detectors
  - 30-kg enriched
  - Detector Technology: P-type, point-contact.
- 2 independent cryostats
  - ultra-clean, electroformed Cu
  - naturally scalable
- Compact Shield
  - low-background passive Cu and Pb shield with active muon veto

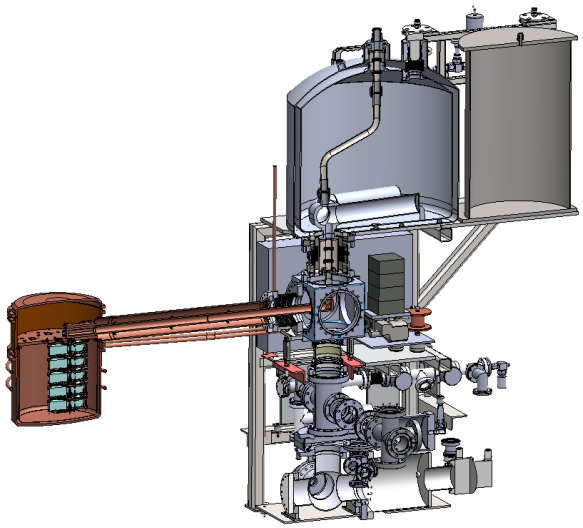


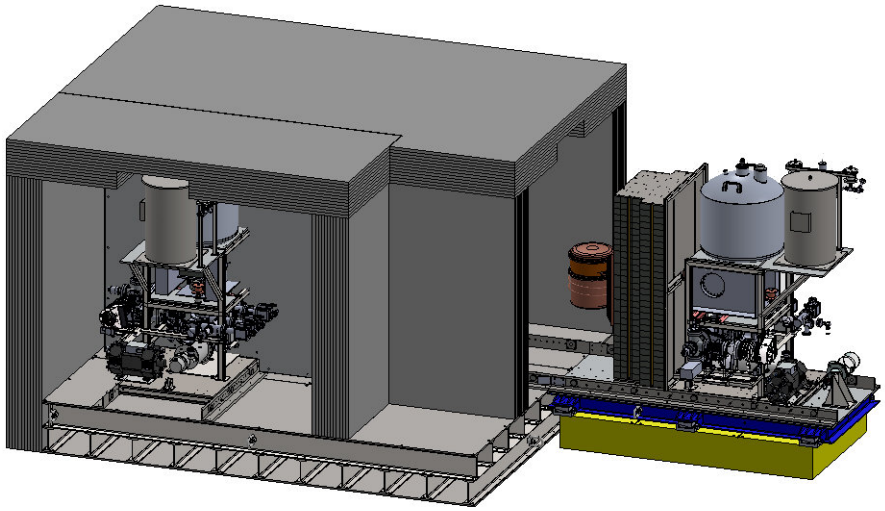
MJD Implementation

- Three Steps
  - Prototype Cryostat* (2 strings, ^{nat}Ge)
  - Cryostat 1 (3 strings ^{enr}Ge & 4 strings ^{nat}Ge)
  - Cryostat 2 (7 strings ^{enr}Ge)

Commissioning dates (Estimated)

- (Spring 2013)
- (Late 2013)
- (Fall 2014)

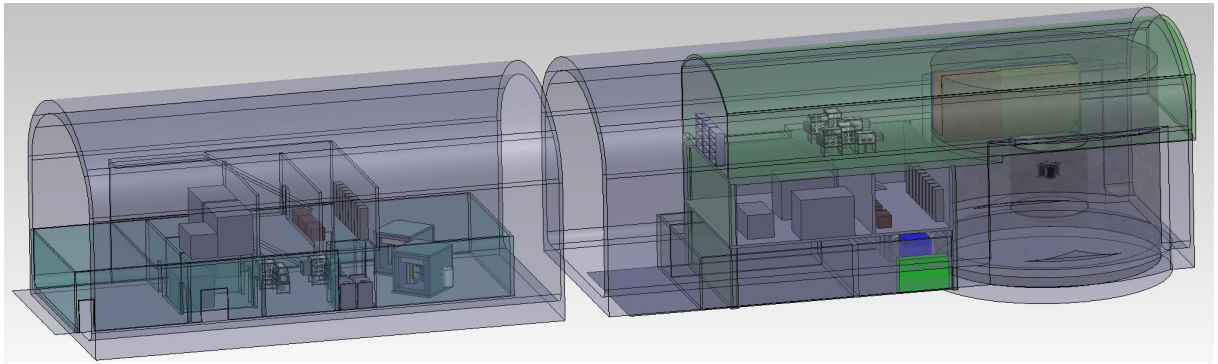
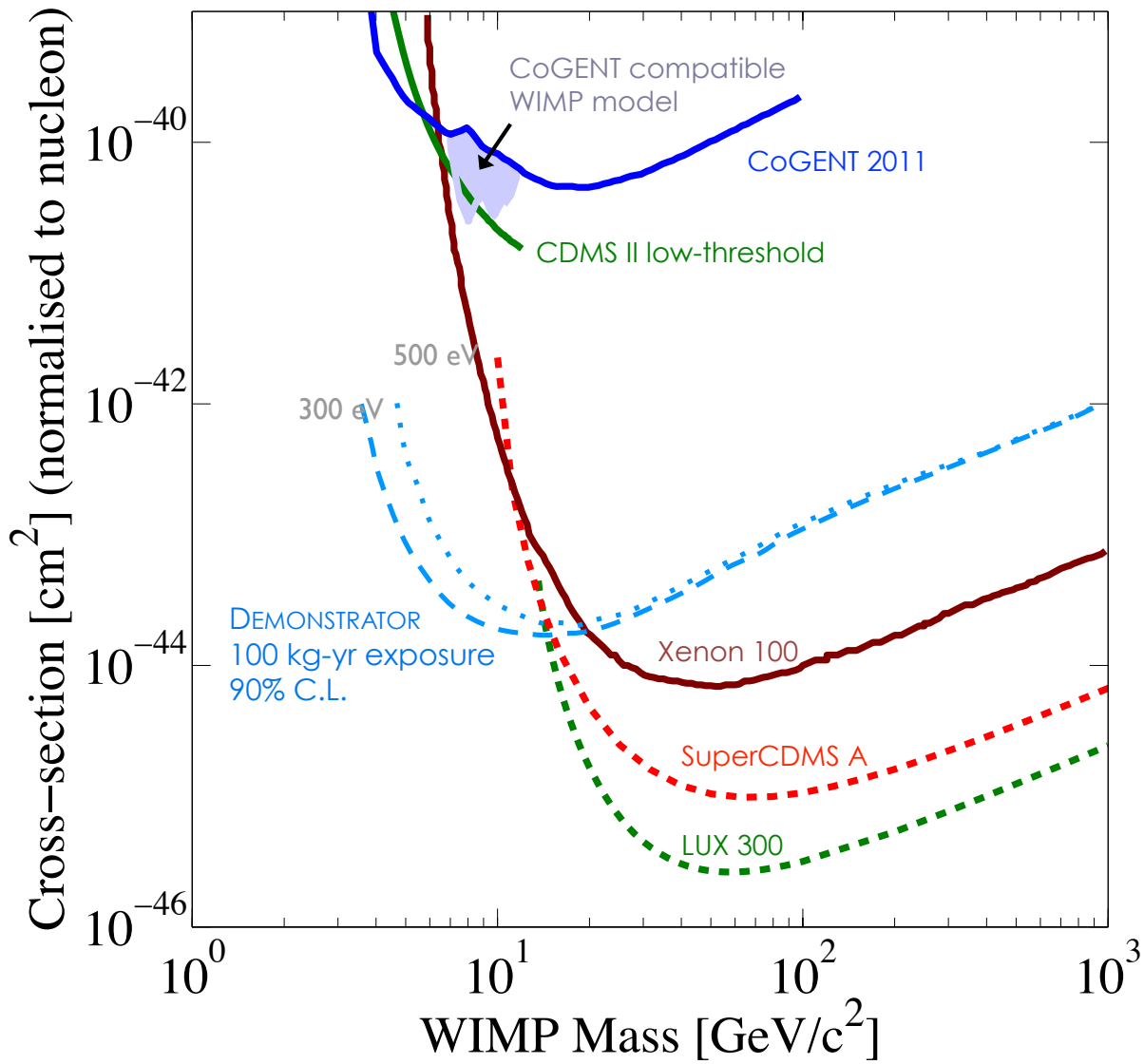




*Same design as Cryos 1 & 2, but fabricated using OFHC Cu (non-electroformed) components.

Tonne Scale ^{76}Ge Implementation

- Phased & scalable approach
  - 1TGe Phase 1: 250-500 kg (New scalable experiment based on best features of MJD and GERDA.)
    - Utilizes and builds on major R&D activities related to GERDA and MJD.
    - Reuse existing MJD and GERDA detectors.
    - Site (and required depth) depends on outcomes from GERDA and MJD.
    - Major cost driver - enriched isotope
  - 1TGe Phases 2-3: Increased # of modules & mass, based on what is observed, in 1TGe Phase 1. ie. → 500 kg → 1000 kg



MAJORANA Dark Matter Sensitivity