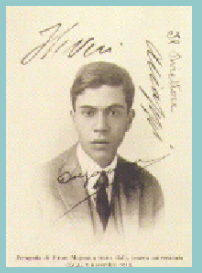
The Majorana Demonstrator Update and Detector Technologies



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- Update on the status of Majorana
- Detector technologies

- Craig Aalseth – DUSEL plans

Majorana as Demonstrator

- Majorana is currently envisioned as R&D project within DOE-Office of Nuclear Physics towards a 1-ton $0\nu\beta\beta$-decay experiment
- The Majorana Demonstrator will explore and identify the most promising options for a ^{76}Ge-based experiment with the intention to be as complementary as possible with GERDA
- The Goal of the Demonstrator is:
  - Demonstration of ultra-low background [< 1 count/(ton year ROI)]
  - Explore most advanced and most promising detector technologies
  - Demonstrate feasibility in terms of scaling, cost, and schedule
  - Allow technology selection in 2013

Benchmarks of Achieved Goals

- Background level in ROI: <= 1 event/ton year
  - Defines total mass and lifetime of experiment:
    - ~ 60 kg of $^{\text{Natural or depleted}}$Ge & $^{\text{Enriched}}$Ge
    - Use 50 keV energy window around ROI
    - Operate for two years
- Signal sensitivity: Test KKDC
  - Defines ^{76}Ge mass and lifetime of experiment:
    - ~ 30 kg of ^{76}Ge
    - Operate for two years (at 86% enrichment)
- Demonstration of two most promising technologies
  - Operate P-type Point Contact (PPC) and N-type Segmented Contact (NSC) detectors

Reference Design

- "Standard" cryostats
  - Electroformed copper (EFCu) materials, internal shields
  - Ancient lead outer shield and active veto
  - LN2 (passive/radiation) cooling
- 60 kg of Ge crystals
  - A mixture of p-type and n-type crystals
    - P-type: Point-contact / PPC: 40 kg
    - N-type: 36-fold segmented /NSC: 20 kg
  - A mixture of enriched and natural or depleted Ge
    - 30 kg of 86% enriched 76Ge crystals (all PPC)
    - 30 kg of natural or depleted Ge crystals (20 kg NSC + 10 kg PPC)
  - 3 cryostats
    - Two for mixed PPC and one for NSC
    - Minimize interference in design, deployment, operation, and analysis

Schedule

- 3-phase approach:
  - Detector evaluation and demonstration (’07-’09)
    - Large (~1.5 kg) and highly-segmented n-type detectors (NSC)
    - Small (~0.75 kg) point contact p-type detectors (PPC)
  - Construction, characterization, and deployment (’09-’11)
    - 2-3 cryostats to optimize performance and schedules by minimizing interference in deployment and operation
  - Operation and analysis (’11-’13)

Highest risks/ challenges

- Backgrounds …
  - Small parts
  - EFCu
- Detectors…
  - PPC: Production requirements and yields
  - NSC: Background vs. performance
- Materials …
  - EFCu production facility underground
  - Ge processing, crystal growth
- Schedule …
  - Coupling to underground laboratory DUSEL/SUSEL
- Funding (NSF/DOE) …

Longer-term efforts/ collaboration opportunities

- In the context of one ton:
  - E.g. 1000 1kg detectors (cost, schedule)
  - Extremely low background
  - New fabrication capacities
    - Material processing
    - Crystal growth
    - Detector fabrication
  - Underground fabrication
  - Advanced, fast detector characterization
  - Advanced signal processing
  - Simulations (MaGe)
  - ….

Near-term plans – Funding/ proposals

- DOE/NSF: DUSEL R&D
  - Demonstrator high risk items
  - Crystal and detector fabrication reliability, underground production
- Submission of Majorana Demonstrator proposal to DOE
- DOE operational funds
  - Universities
  - Nat'l Labs

Detectors- Status and Plans

P-Type Point Contact Detectors:

- Explore geometries, mass, impurity concentration requirements, and manufacturer:
  - Detector obtained and characterized:
    - 1, Univ. Chicago – CANBERRA
  - Detectors ordered:
    - 1, PNNL – CANBERRA
    - 1, LANL – PhDs
  - Detectors to be ordered:
    - 1, ORNL – PhDs
    - 2, Univ. Chicago – ORTEC
  - Detectors being fabricated
    - 1, LBNL – Paul Luke

      + segmentation for time reference, absolute positioning, …

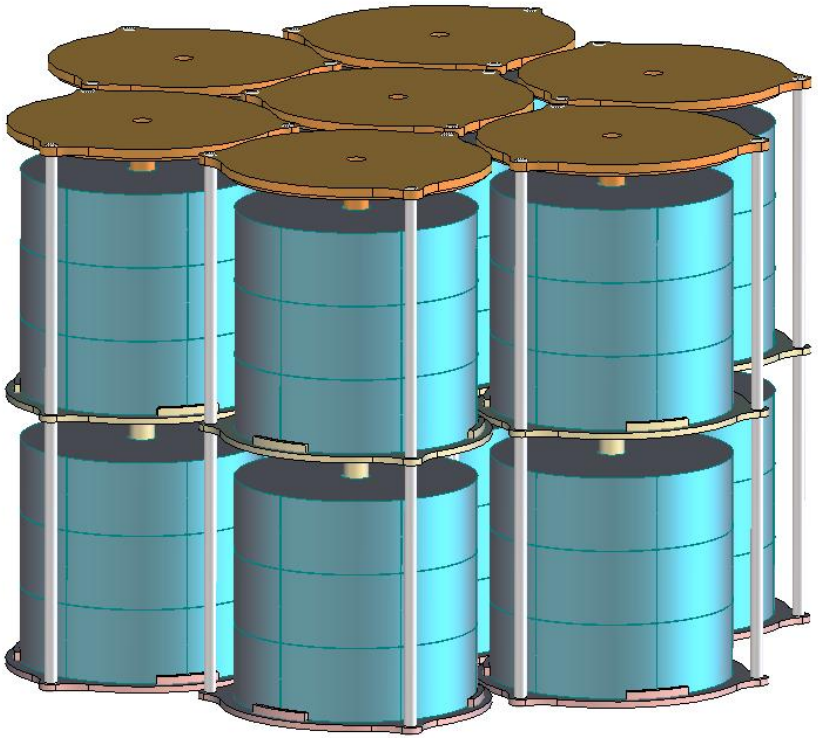
Detectors- Status and Plans

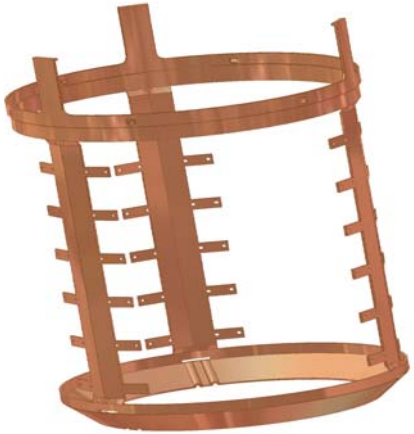
N-Type Segmented Contact Detectors:

- 36-fold segmented, closed-ended coaxial detector (GRETA/ AGATA – type)
- Can be produced and operated
  - ~20 complex detectors fabricated and tested to date
  - 2 mm spatial resolution in 3D for individual interactions demonstrated
  - Gamma-ray tracking demonstrated (sequencing, imaging, …)
- Background due to additional components?
  - Selection and location of components?
  - Impact on signal performance?
- GRET(IN)A prototype and SEGA detectors for test and evaluation of detector mount and readout concepts

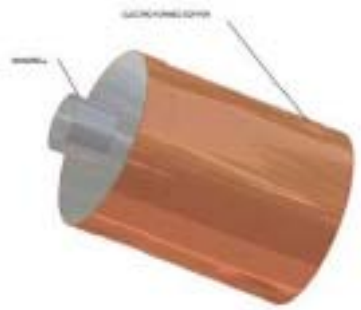
NSC Detector Arrangement

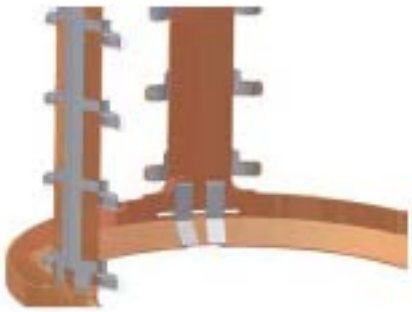
- 7 2-detector “strings”
- 70 mm (diameter) x 80 mm (length)
- ~1.6 kg per detector
- Each string and each detector in string can be handled and replaced individually
- Central (HV) channel with cold front-end on top of string lid
- Segment electronics outside cryostat at a distance > 1 m
  - Reduce background
  - Reduce thermal load





Preliminary Design





Conclusions

- Majorana now Majorana Demonstrator as R&D project towards a 1-ton $0\nu\beta\beta$ experiment
- All high-level tasks are defined (task-, subtask- leaders) and making progress
- Critical milestones defined
- Proposals are being prepared for NSF and DOE
  - Majorana Demonstrator to DOE
  - Complementary DUSEL funds through NSF and DOE