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 Natural or depleted Ge & Enriched Ge
    • Use 50 keV energy window around ROI
    • Operate for two years

• Signal sensitivity: Test KKDC
  – Defines $^{76}\text{Ge}$ mass and lifetime of experiment:
    • ~ 30 kg of $^{76}\text{Ge}$
    • 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, …
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

Status of Majorana Demonstrator
Kai Vetter

GERDA Meeting
LNLS, Italy, November 5, 2007
Conclusions

• Majorana now Majorana Demonstrator as R&D project towards a 1-ton $0
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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