The MAJORANA DEMONSTRATOR double-beta decay experiment

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on behalf of the MAJORANA Collaboration

The MAJORANA Collaboration

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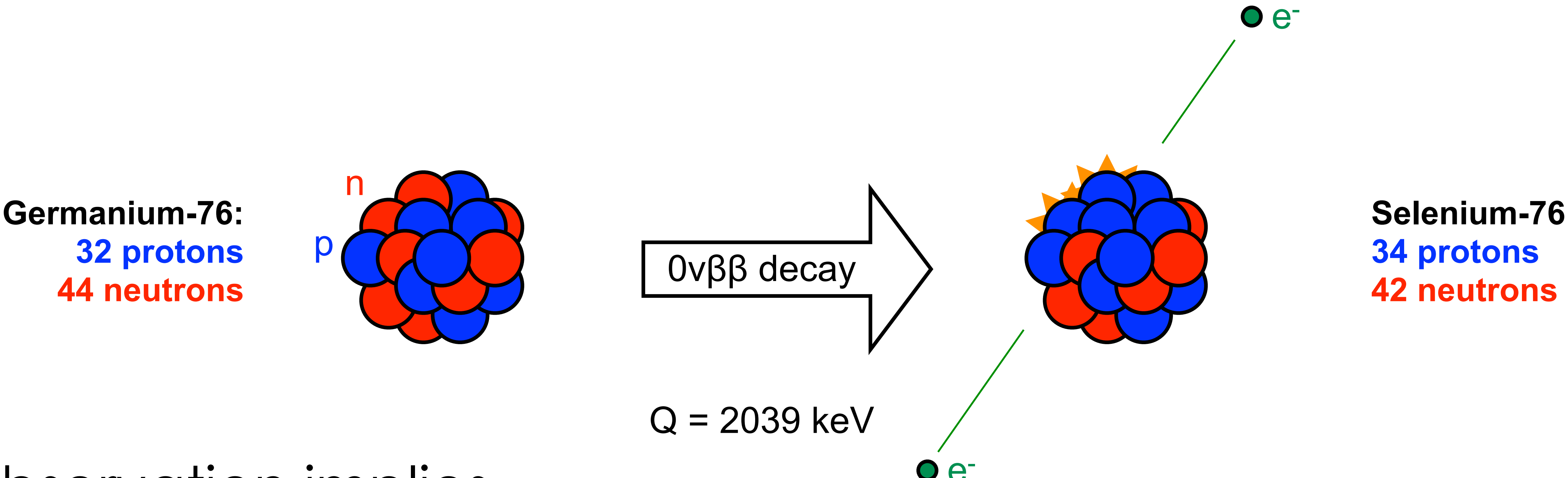
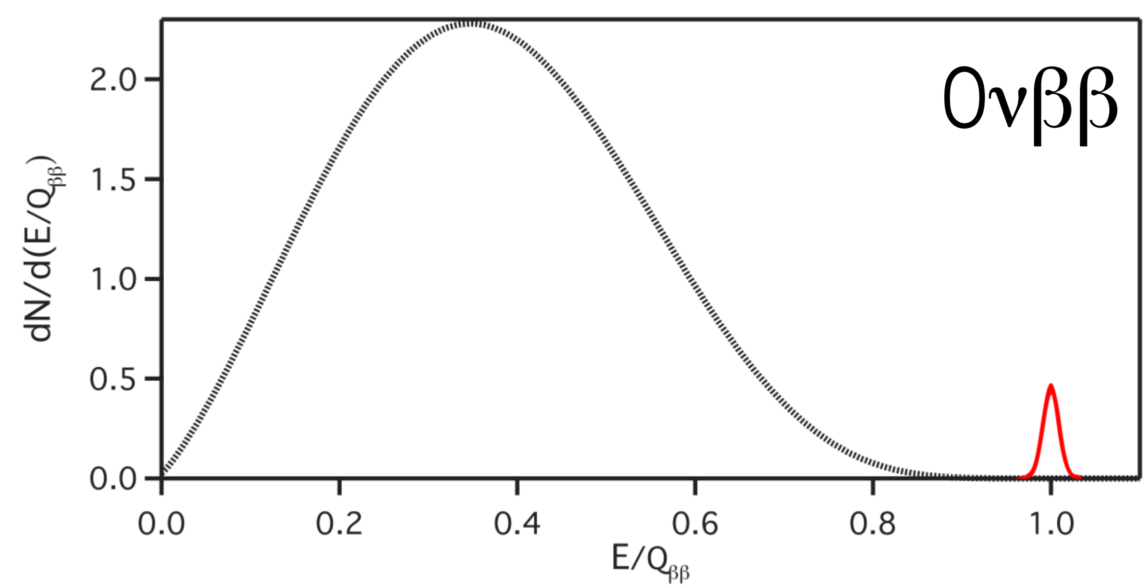
0νββ experimental signature



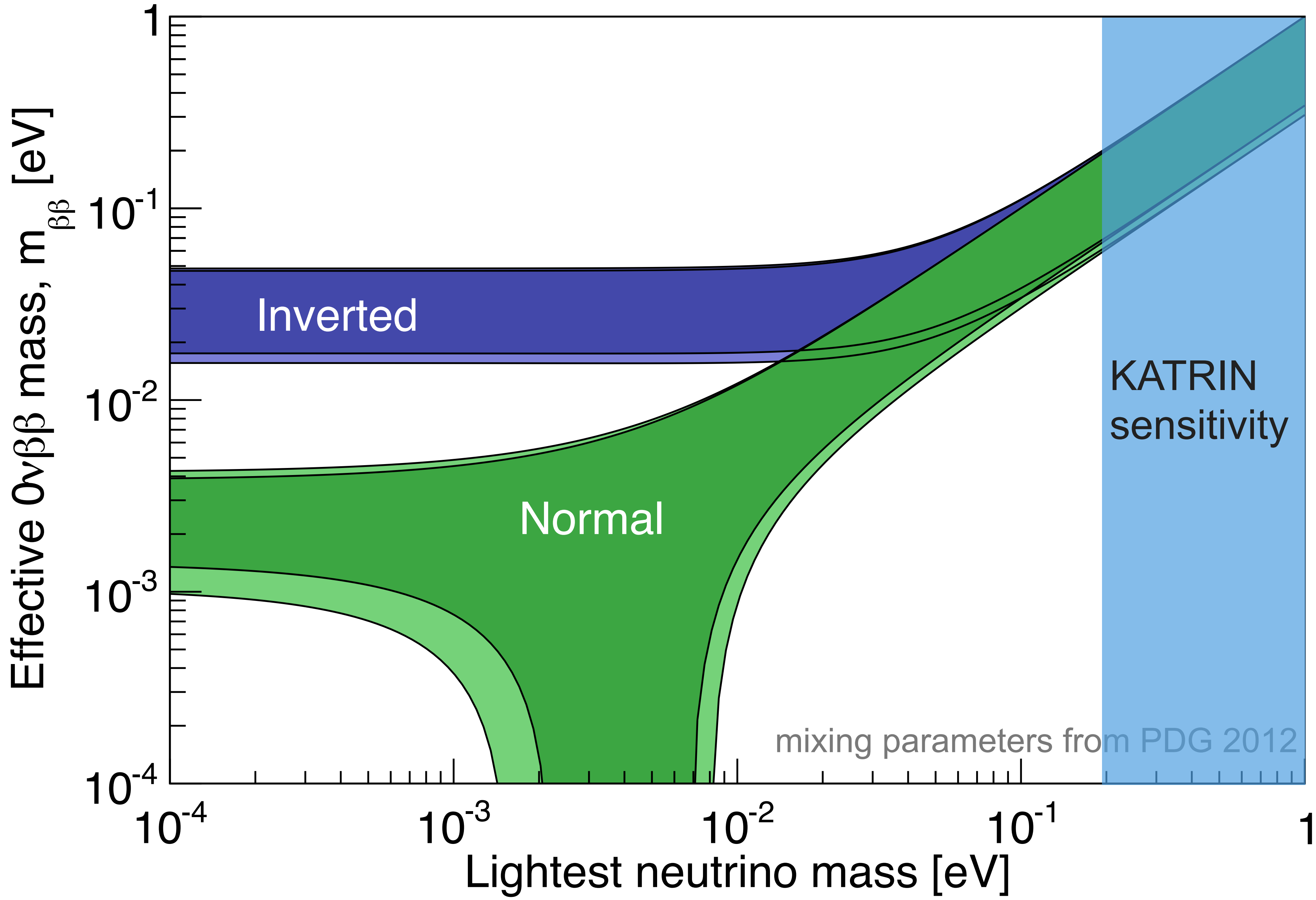
observation implies

- neutrino is a Majorana fermion
- lepton number is violated
- plausible scenario for generation of baryon asymmetry
- model dependent mass measurement



0νββ rate and $m_{\beta\beta}$

$$[T_{1/2}^{0\nu\beta\beta}]^{-1} = G^{0\nu\beta\beta}|M^{0\nu\beta\beta}|^2 < m_{0\nu\beta\beta} >^2$$



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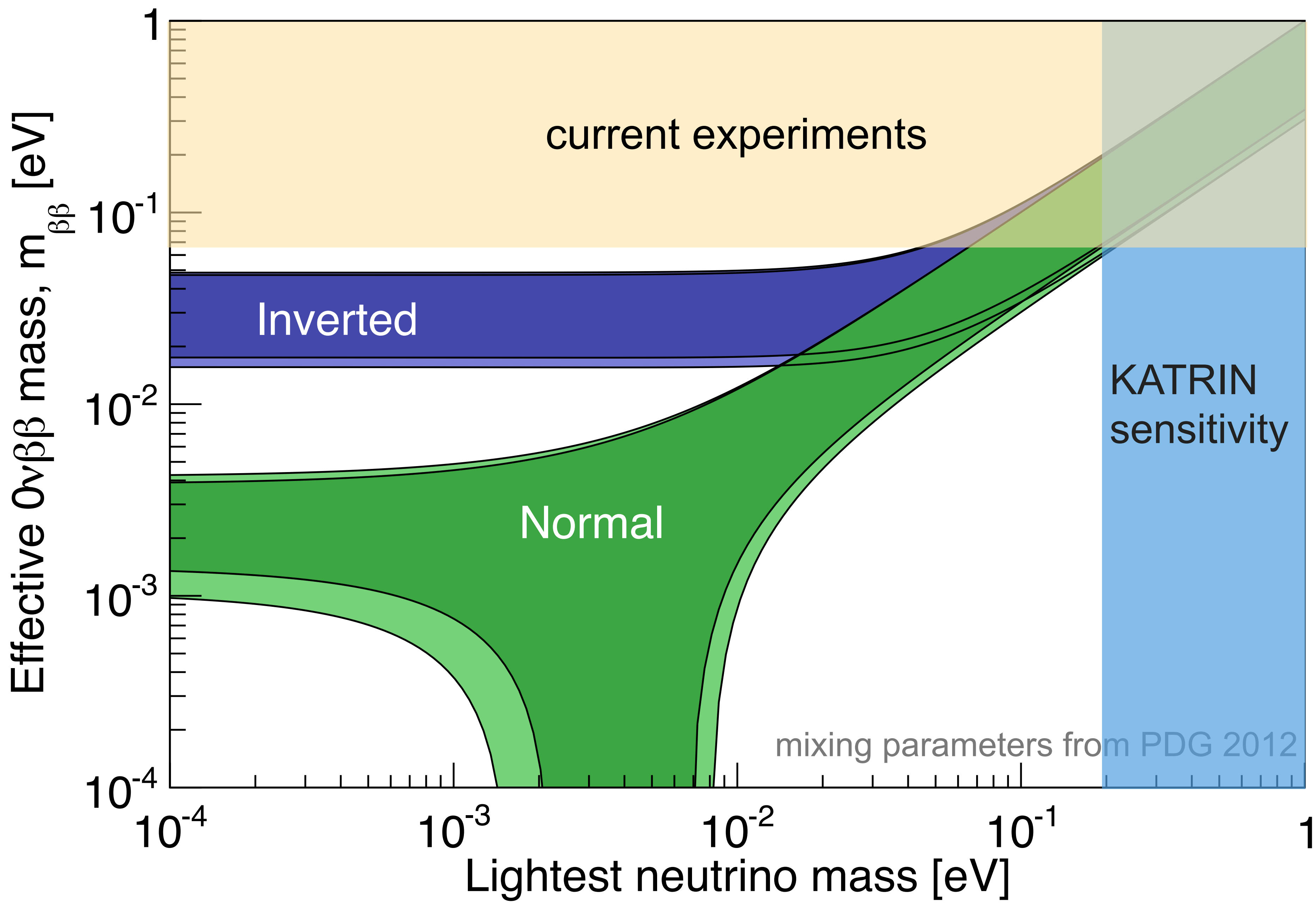

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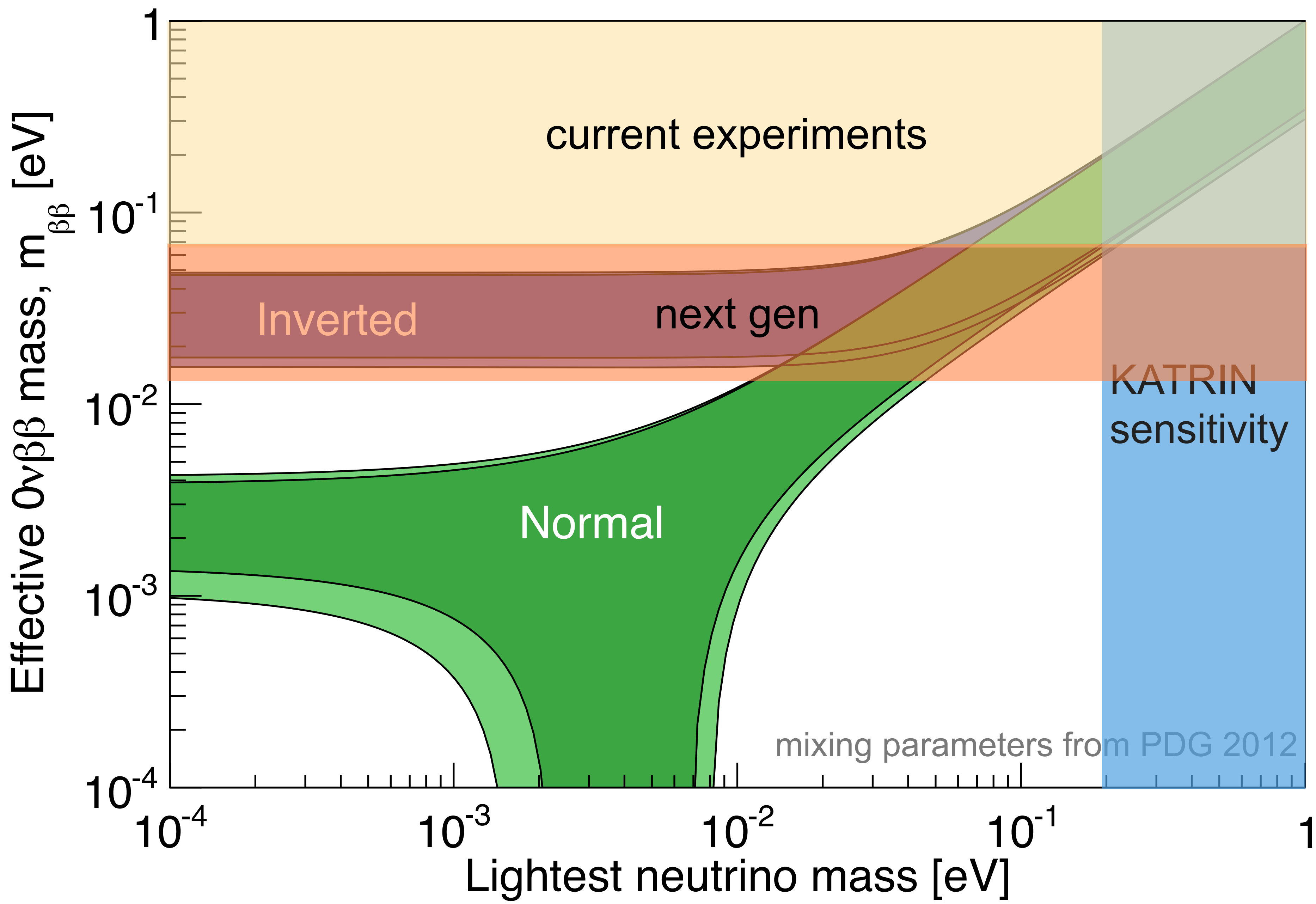
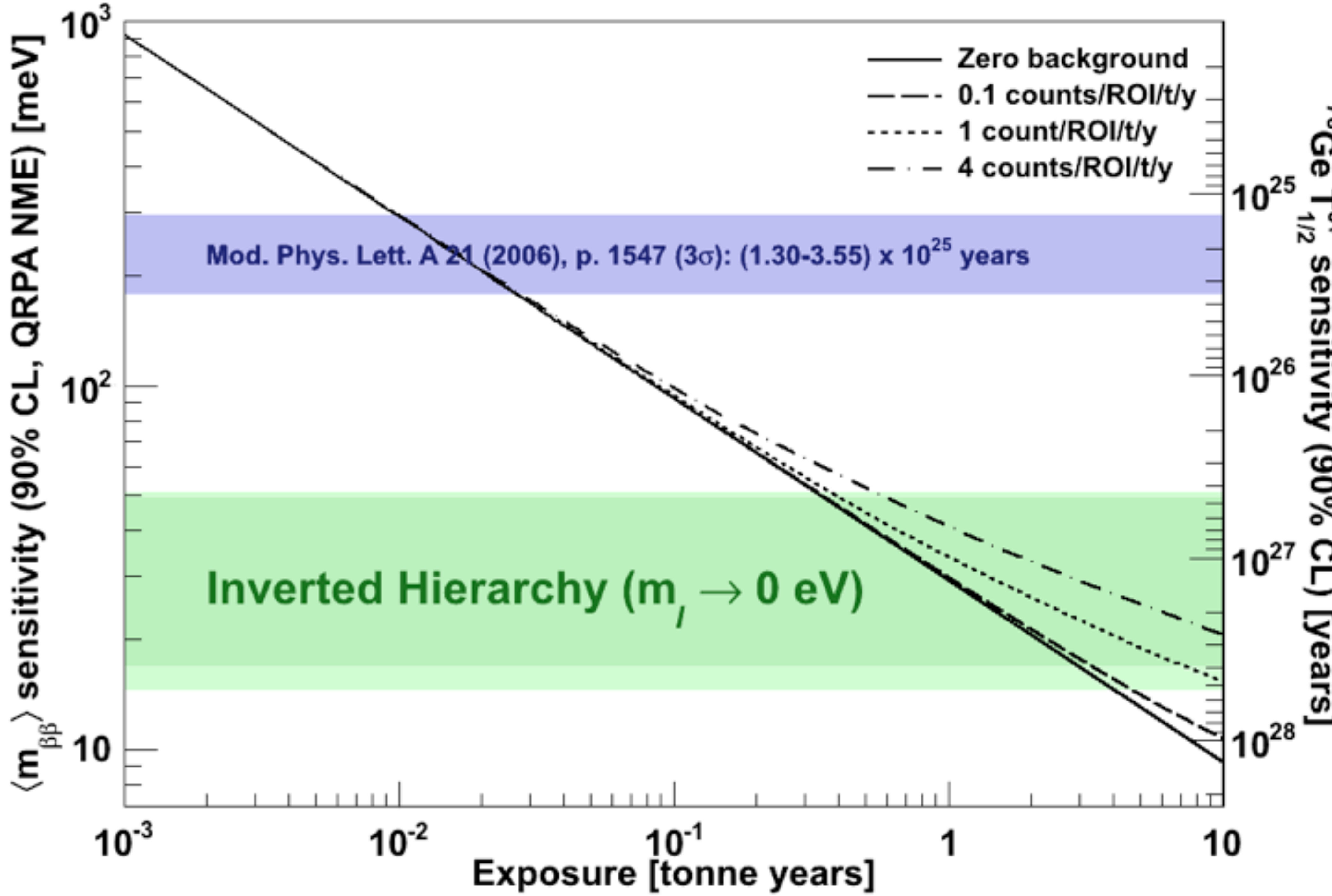


backgrounds and sensitivity



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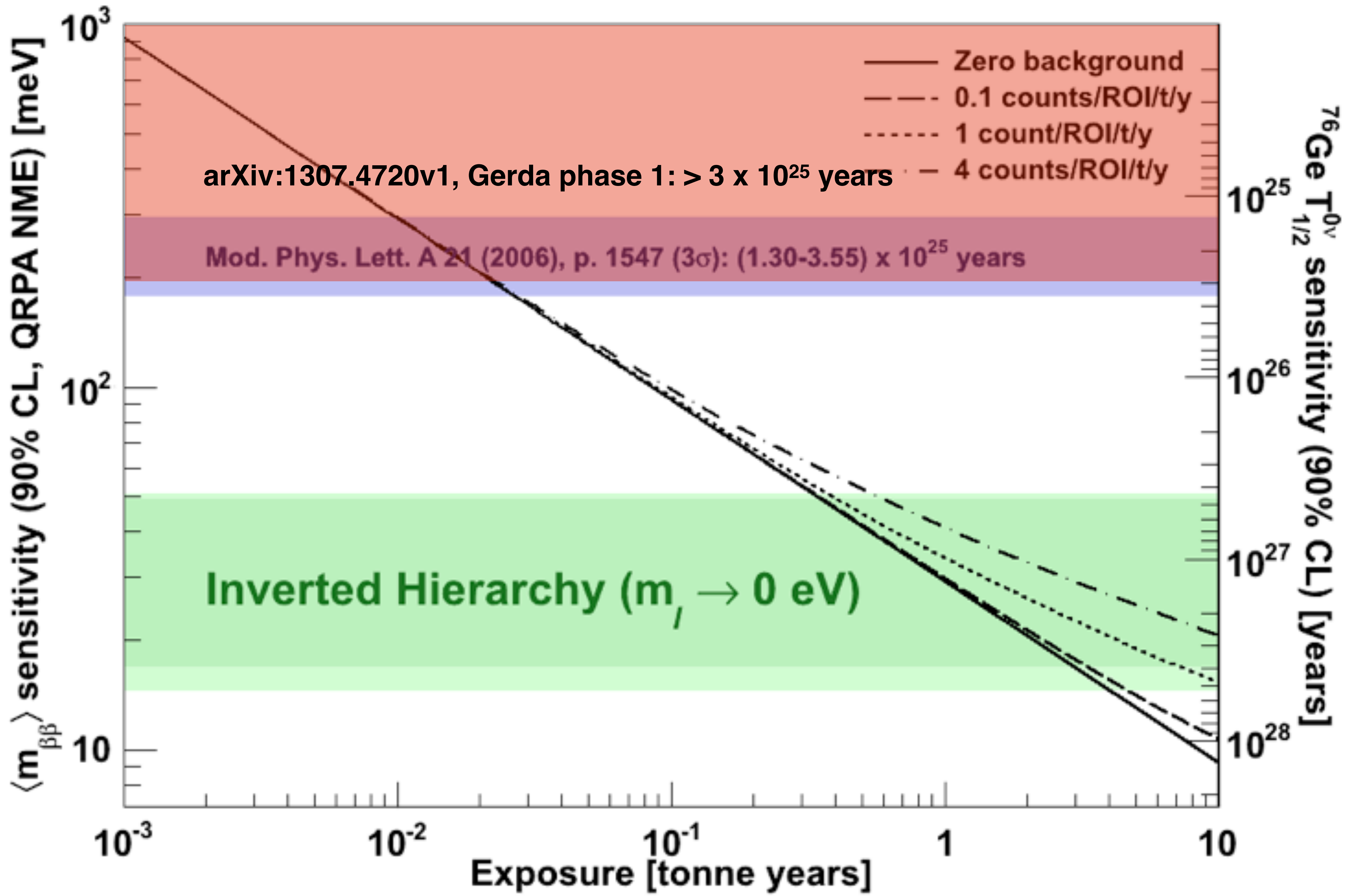
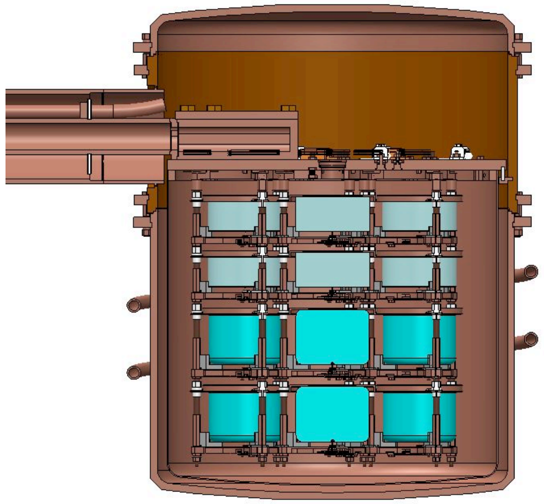


The MAJORANA DEMONSTRATOR

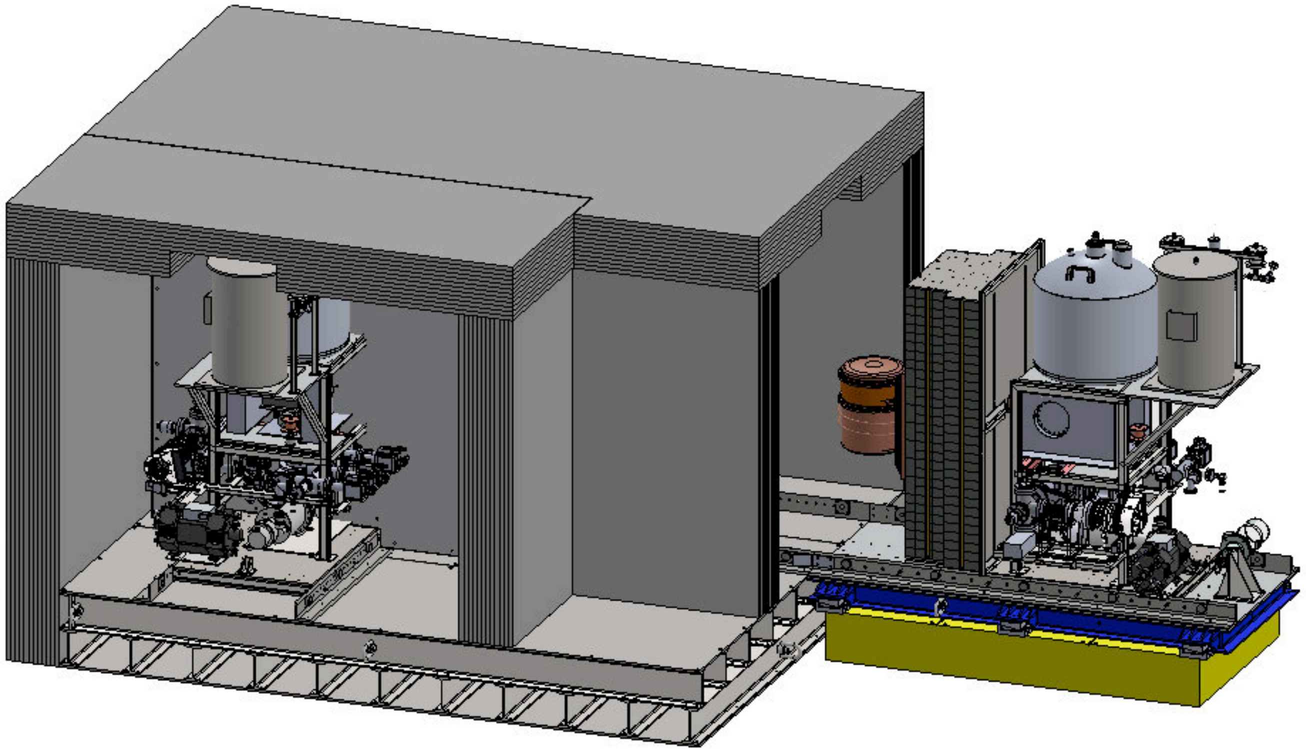
Funded by DOE Office of Nuclear Physics and NSF Particle Astrophysics,
with additional contributions from international collaborators.

Goals

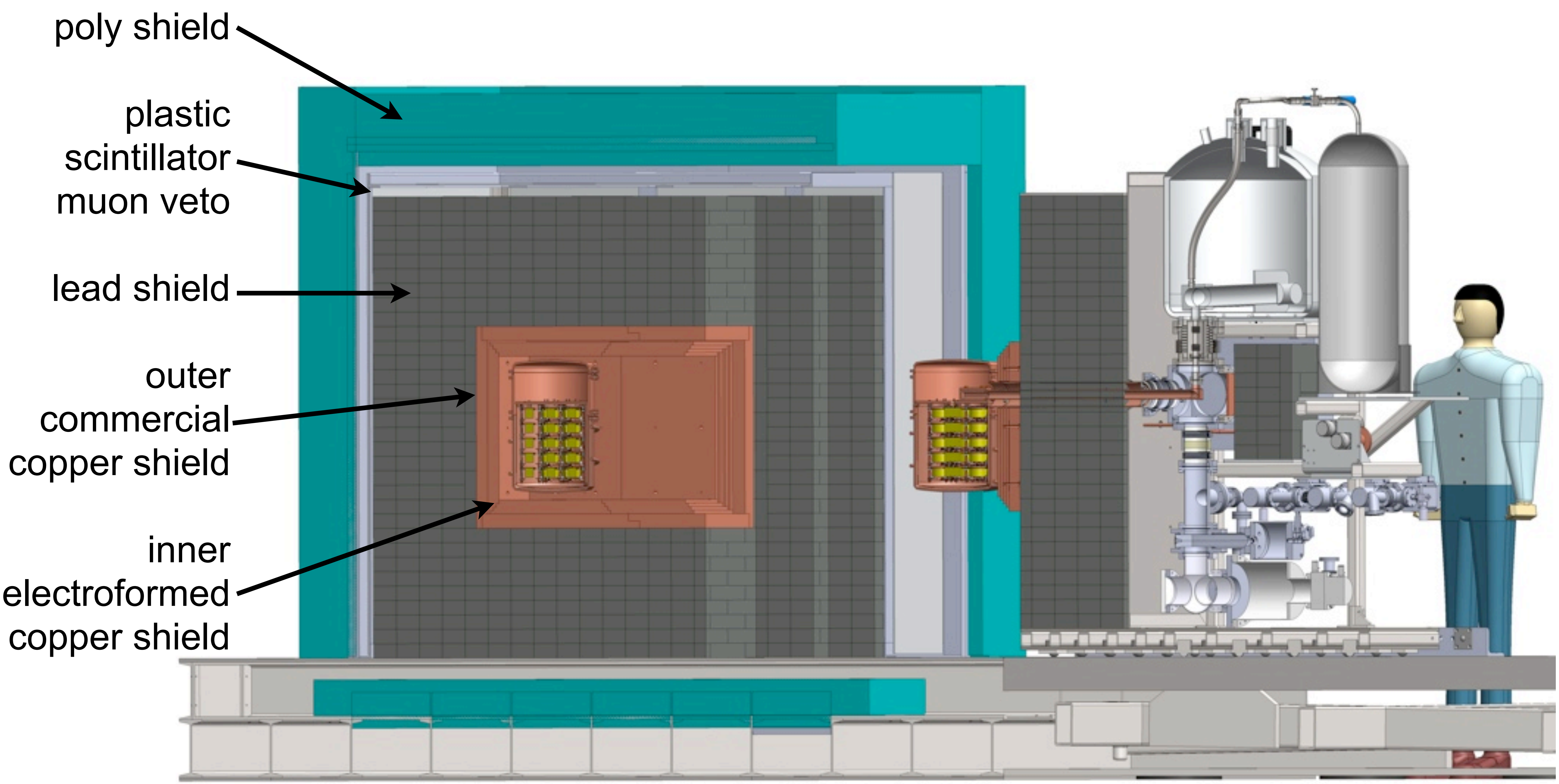
- Demonstrate backgrounds low enough to justify building a tonne scale experiment
- Establish feasibility to construct & field modular arrays of Ge detectors.
- Test Klapdor-Kleingrothaus claim
- Search for additional physics beyond the standard model



- **Located underground at 4850' Sanford Underground Research Facility**
- **Background Goal in the $0\nu\beta\beta$ 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 of 86% enriched ^{76}Ge crystals
  - 10 kg of ^{nat}Ge
  - Detector Technology: P-type, point-contact.
- **2 independent cryostats**
  - ultra-clean, electroformed Cu
  - 20 kg of detectors per cryostat
  - naturally scalable
- **Compact Shield**
  - low-background passive Cu and Pb shield with active muon veto

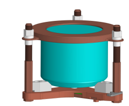


The MAJORANA DEMONSTRATOR



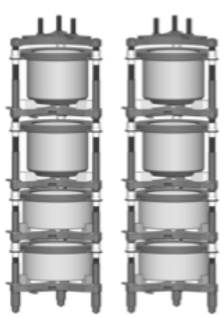
MJD construction schedule

Construction of the DEMONSTRATOR is proceeding in three stages.

 ^{enr}Ge

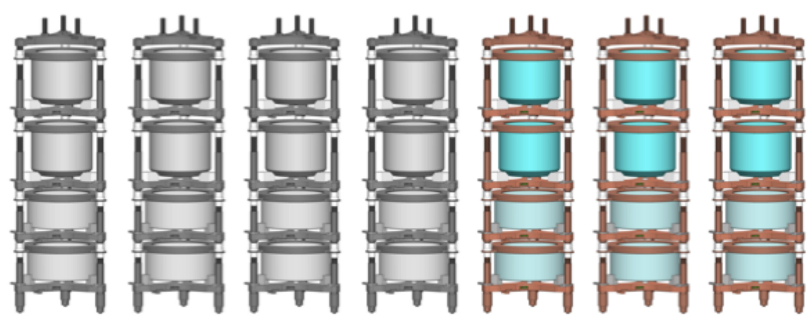
 ^{nat}Ge

Prototype Cryostat*



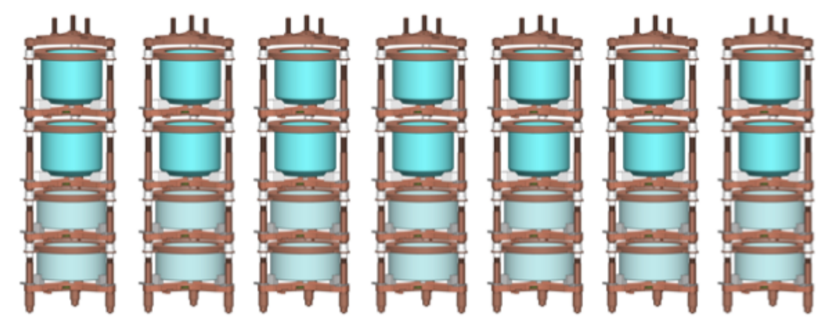
summer 2013

Cryostat 1



early 2014

Cryostat 2

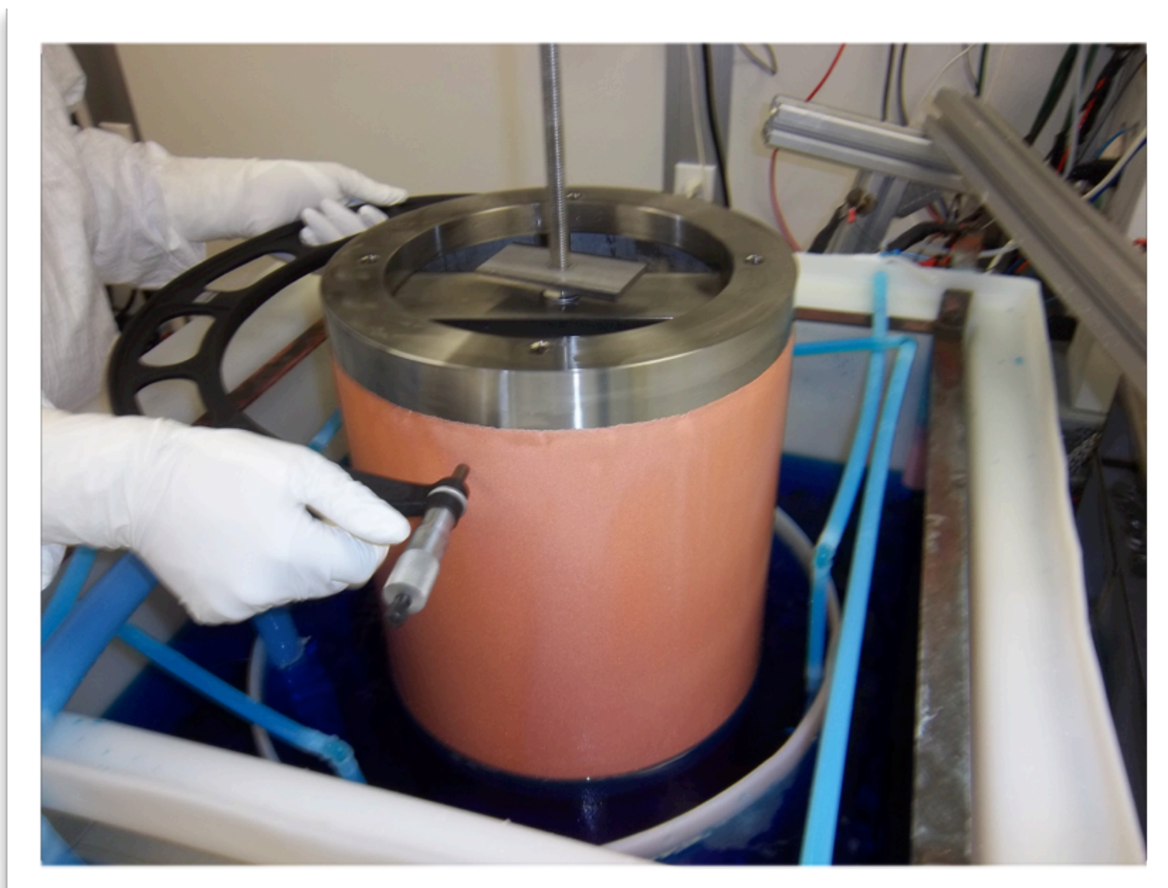


late 2014

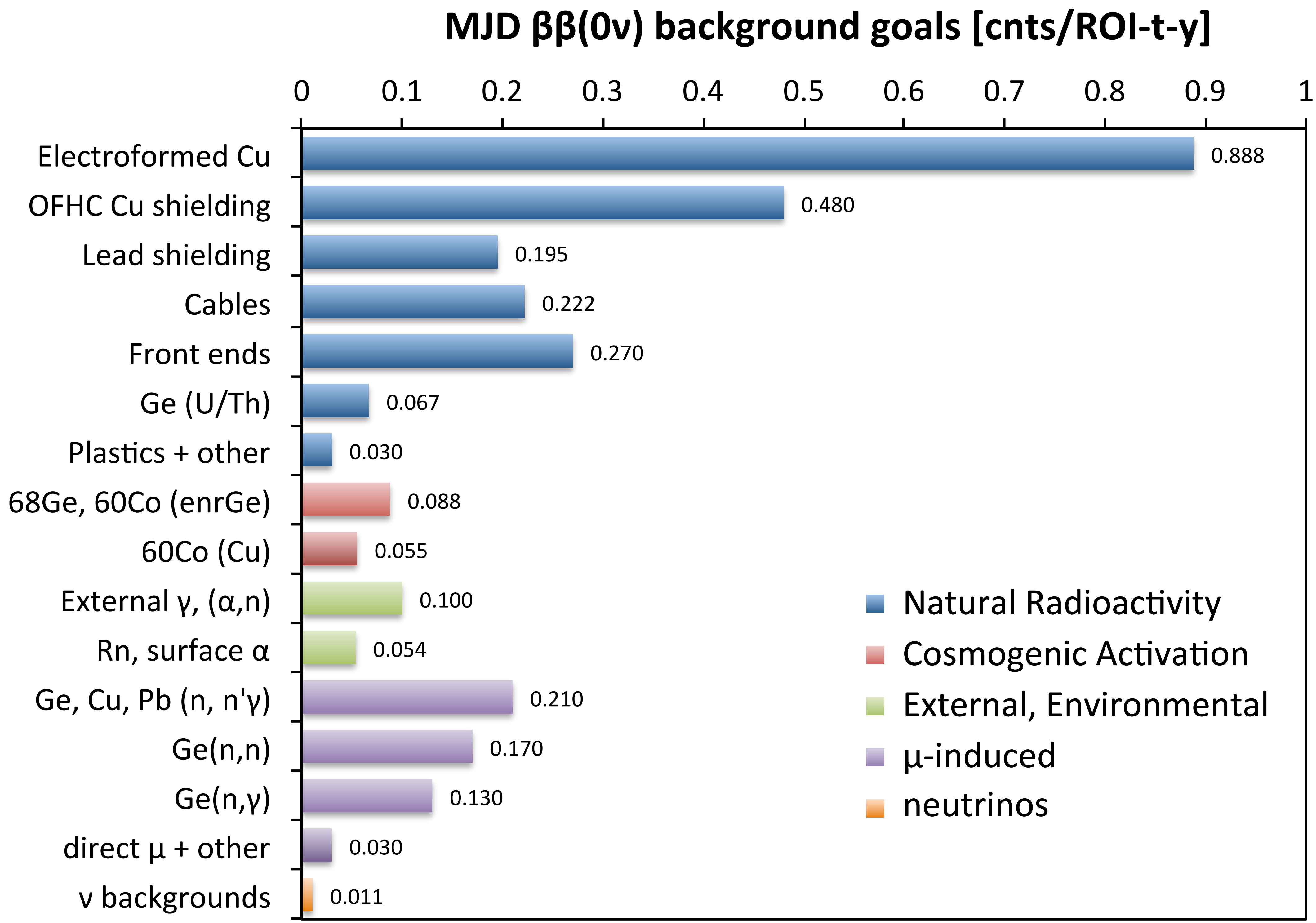
**The Prototype Cryostat components are built from OFHC copper.*

electroformed copper

- copper is electrodeposited onto stainless steel forms
- a 1.4-cm thick electroform takes approximately 8-12 months to complete.
- required purity levels are < 0.3 μBq ^{238}U/kg Cu and < 0.3 μBq ^{232}Th/kg Cu (substantially cleaner than commercially available)
- done underground



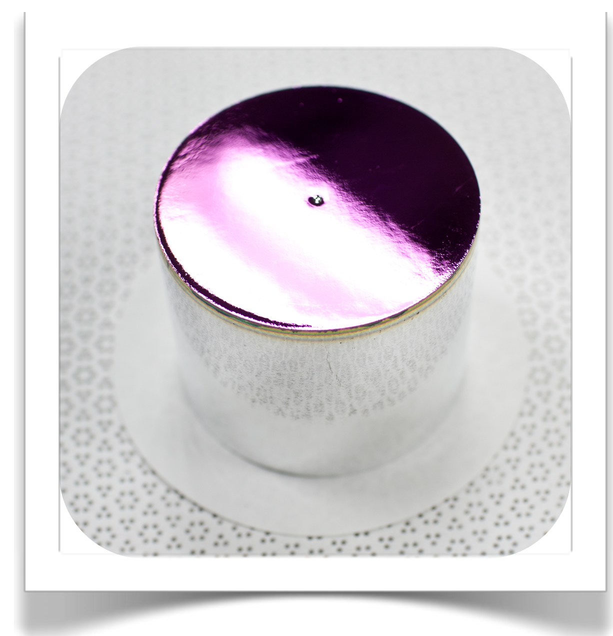
MJD background budget

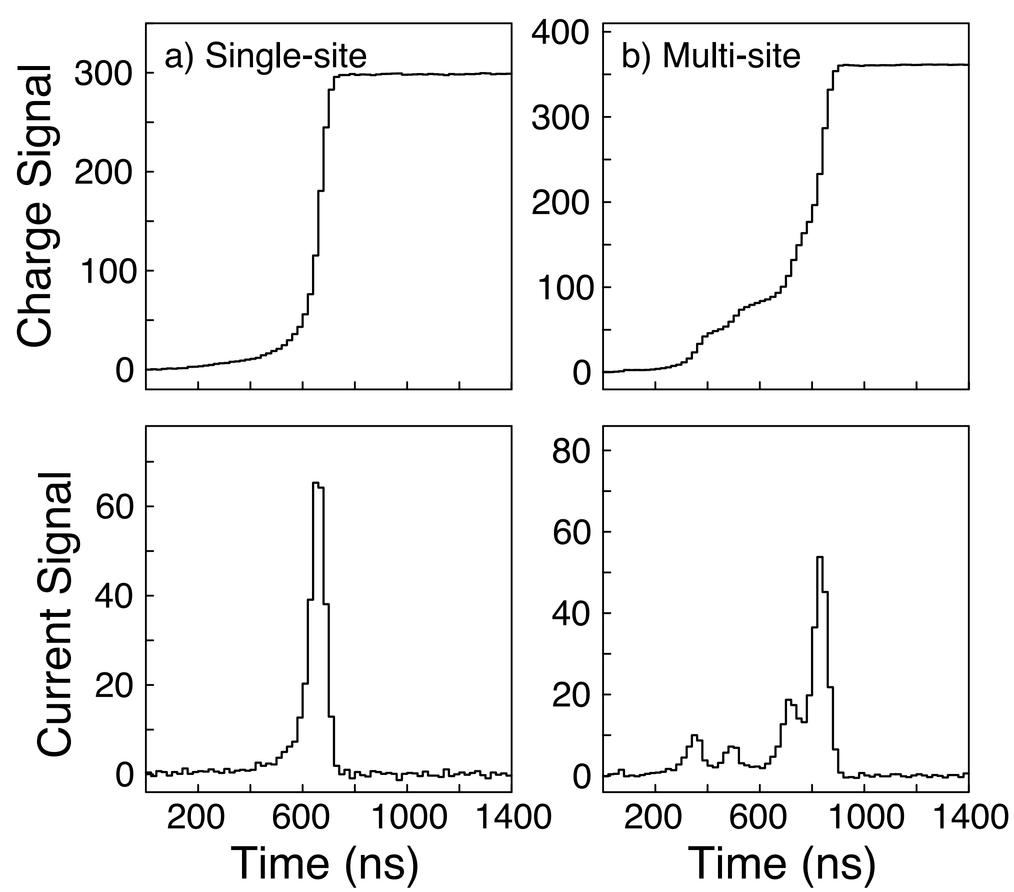


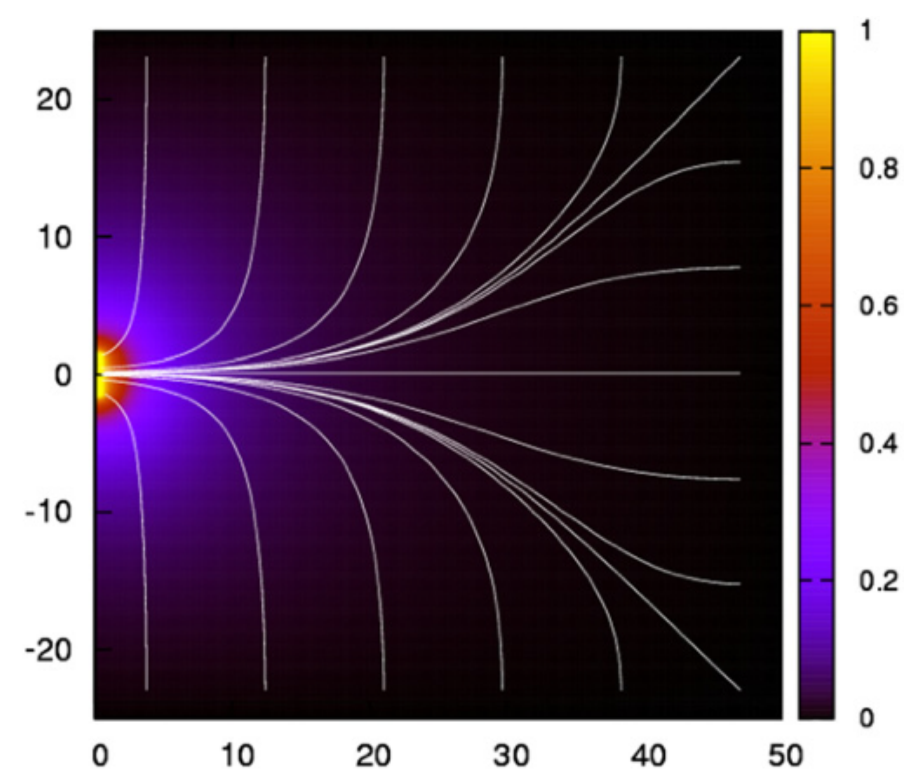
p-type point contact detectors

Luke et al., IEEE trans. Nucl. Sci. 36 , 926(1989); P. S. Barbeau, J. I. Collar, and O. Tench, J. Cosm. Astro. Phys. 0709 (2007).

- allow multiple-site scattering event discrimination
- simple, relatively cheap, and easy to handle
- added benefits from sub-keV thresholds:
  - allow rejection of events from cosmogenically produced ^{68}Ge, a background to $0\nu\beta\beta$.
  - extends physics reach of the DEMONSTRATOR

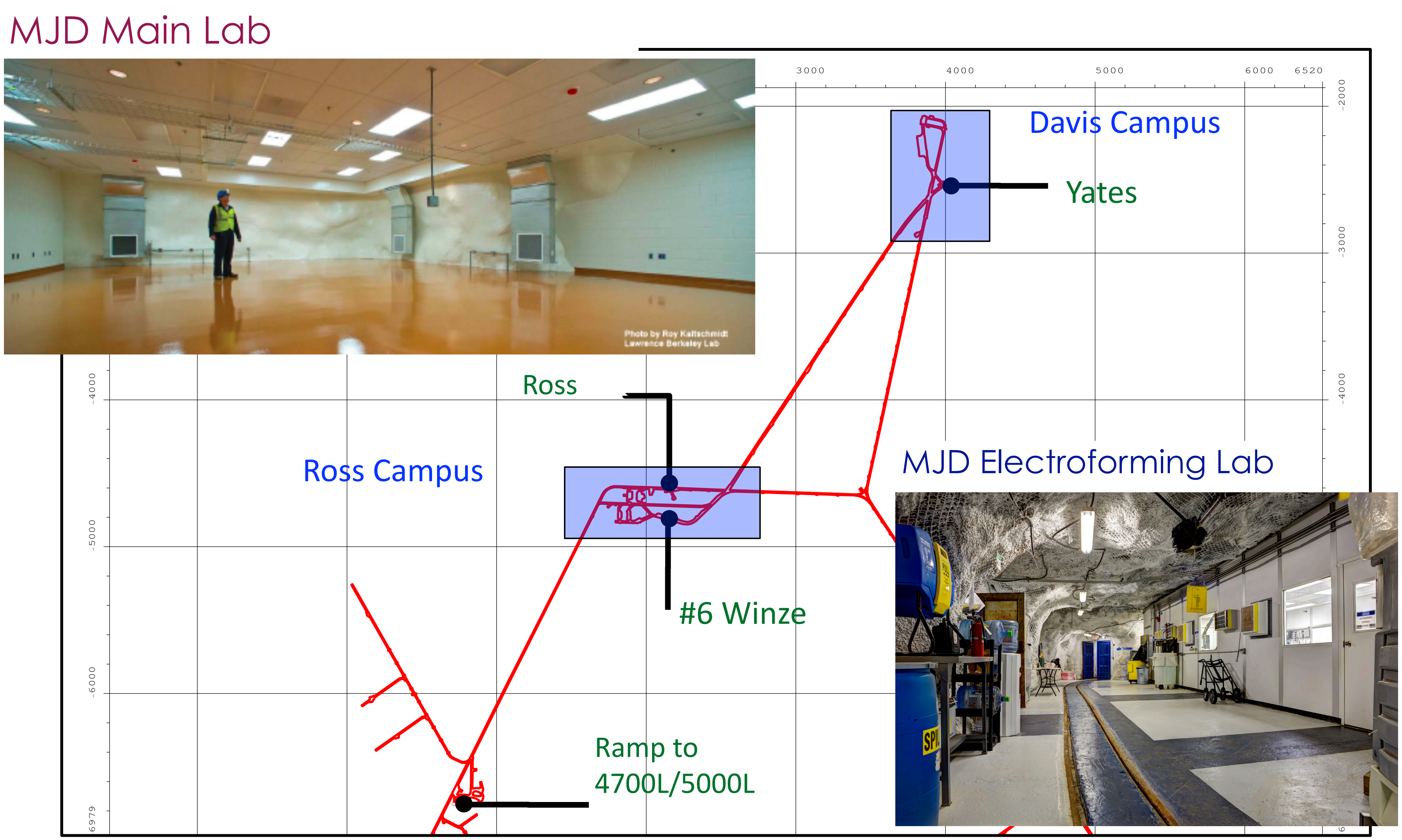






MJD at Sanford Underground Research Laboratory

- Main MJD lab at 4850L Davis Campus, beneficial occupancy in May 2012.
- Operating Temporary Cleanroom Facility (TCR) at 4850L Ross Campus since Spring 2011.



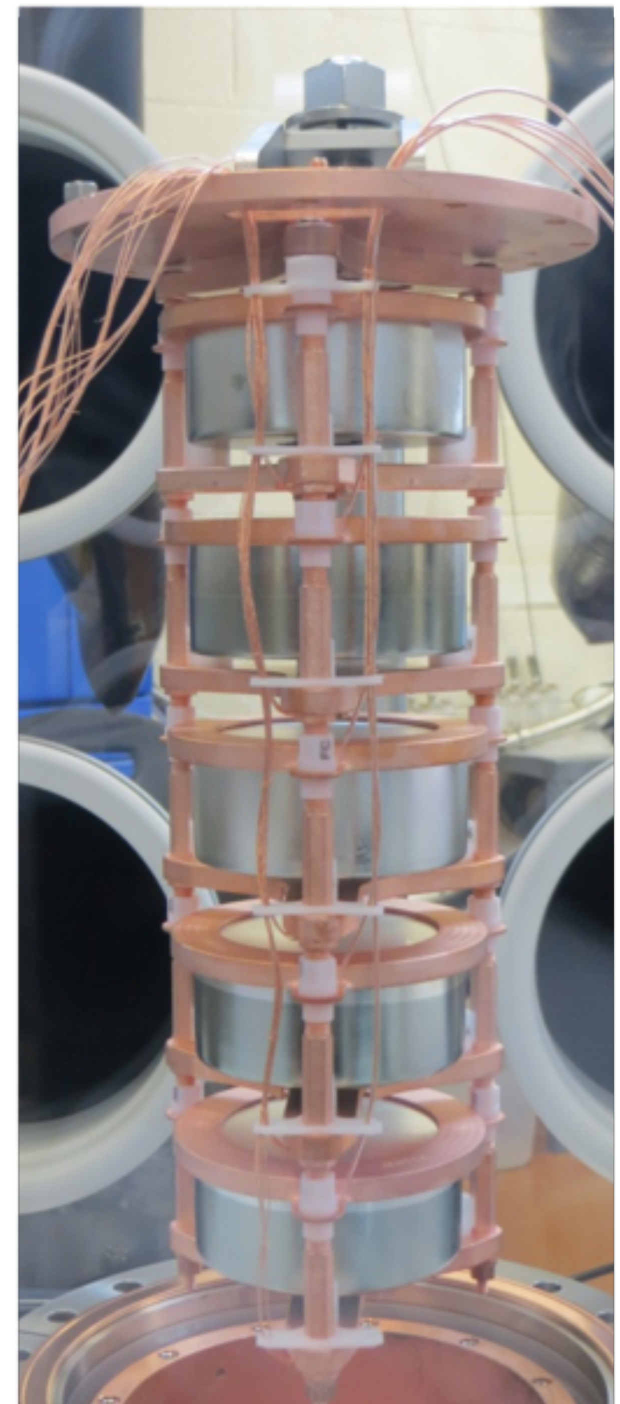
10 baths at Sanford producing copper since July 2011

about 75% of EFCu complete, including major parts for cryostat 1

parts are manufactured in the MJD clean machine shop at the Davis Campus

The MAJORANA machine shop: July 2012
(first copper on a lathe)

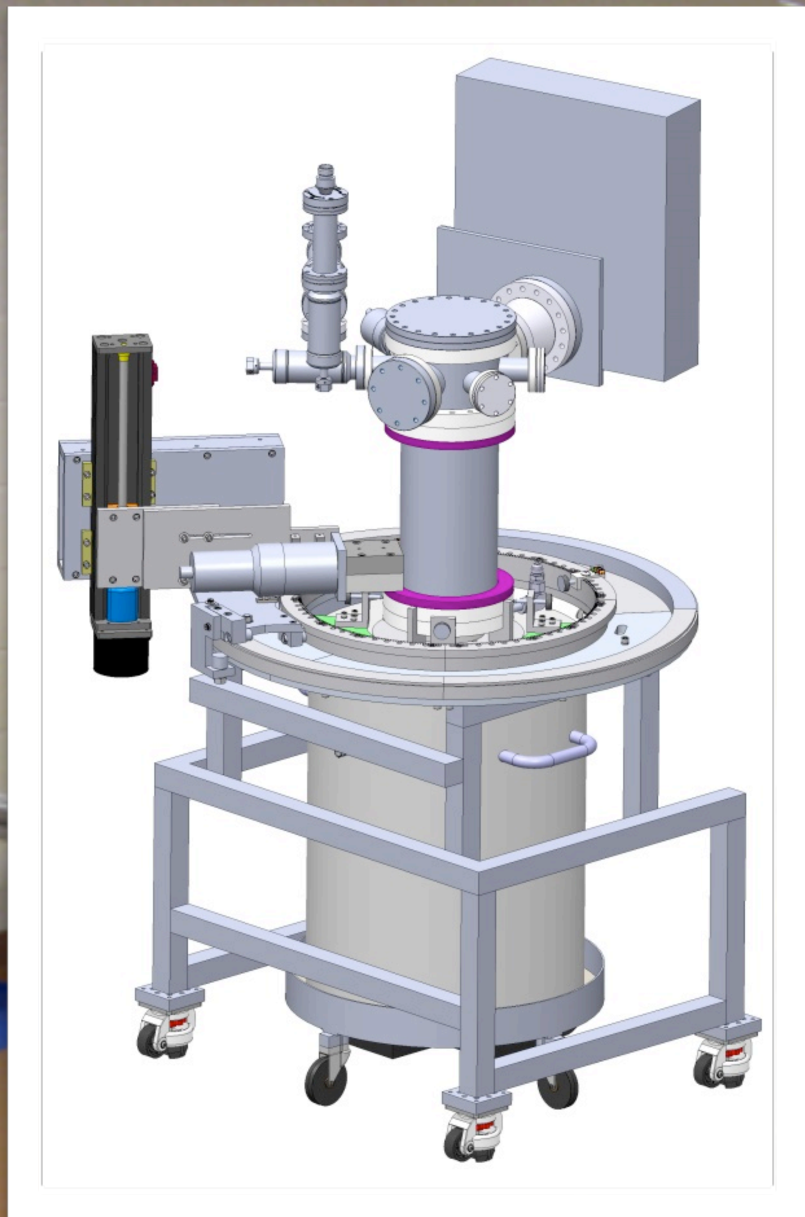
8 enriched PPC detectors at SURF (as of 8/13)
2 strings of natural Ge detectors undergoing testing



both strings were constructed in the MJD Davis Campus lab

string 1 is installed in a string test cryostat

tools for automated string characterization are being built



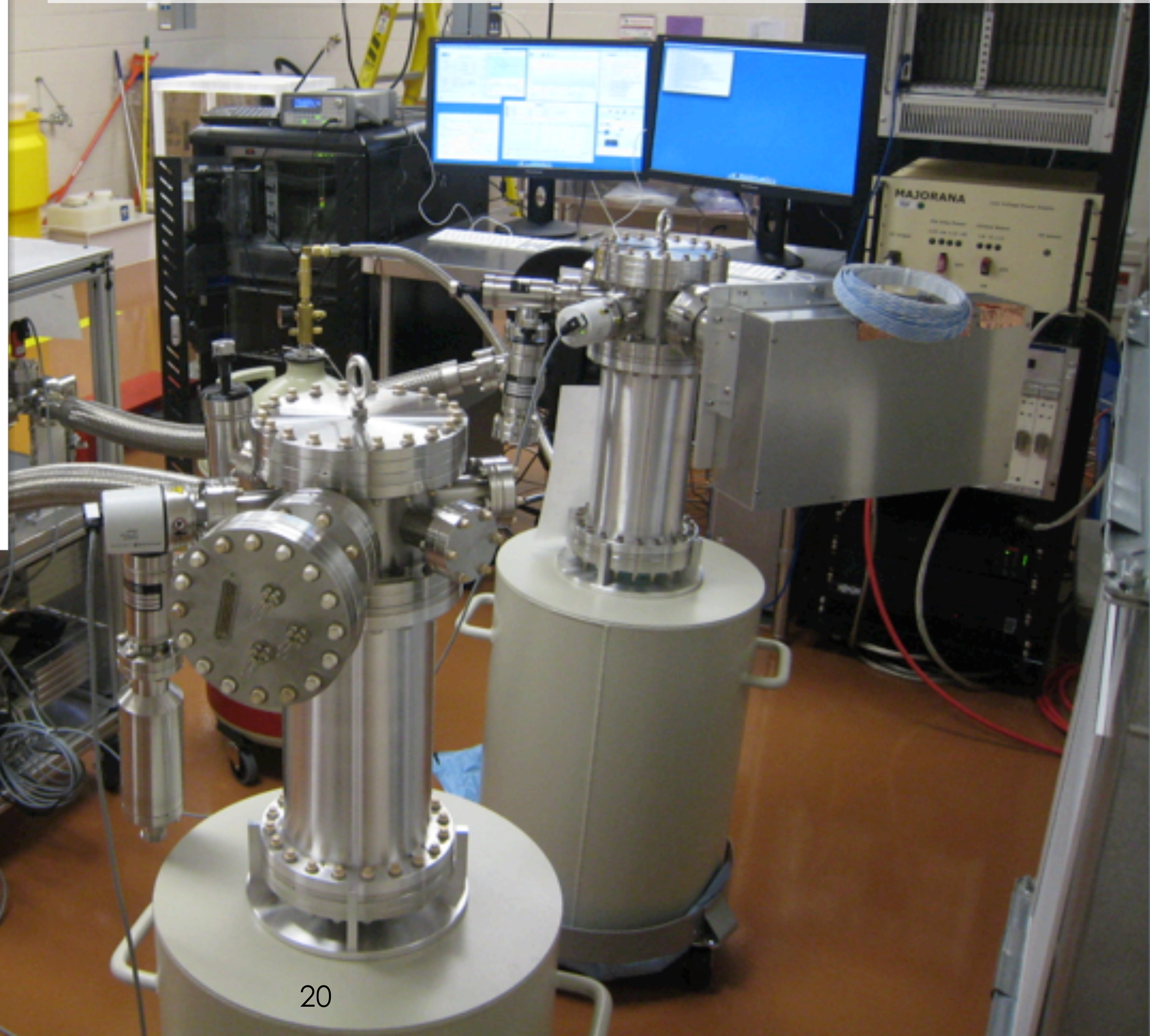
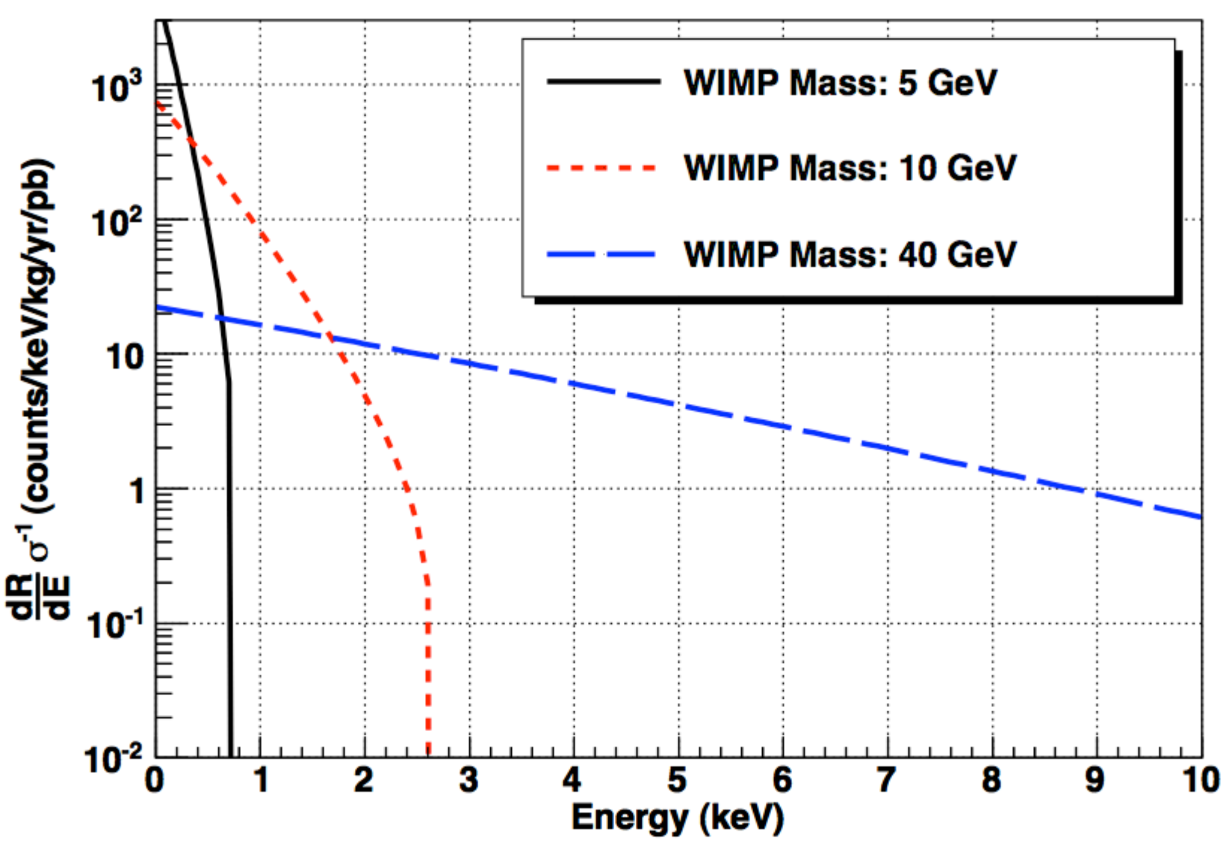


photo: José Francisco Salgado, PhD

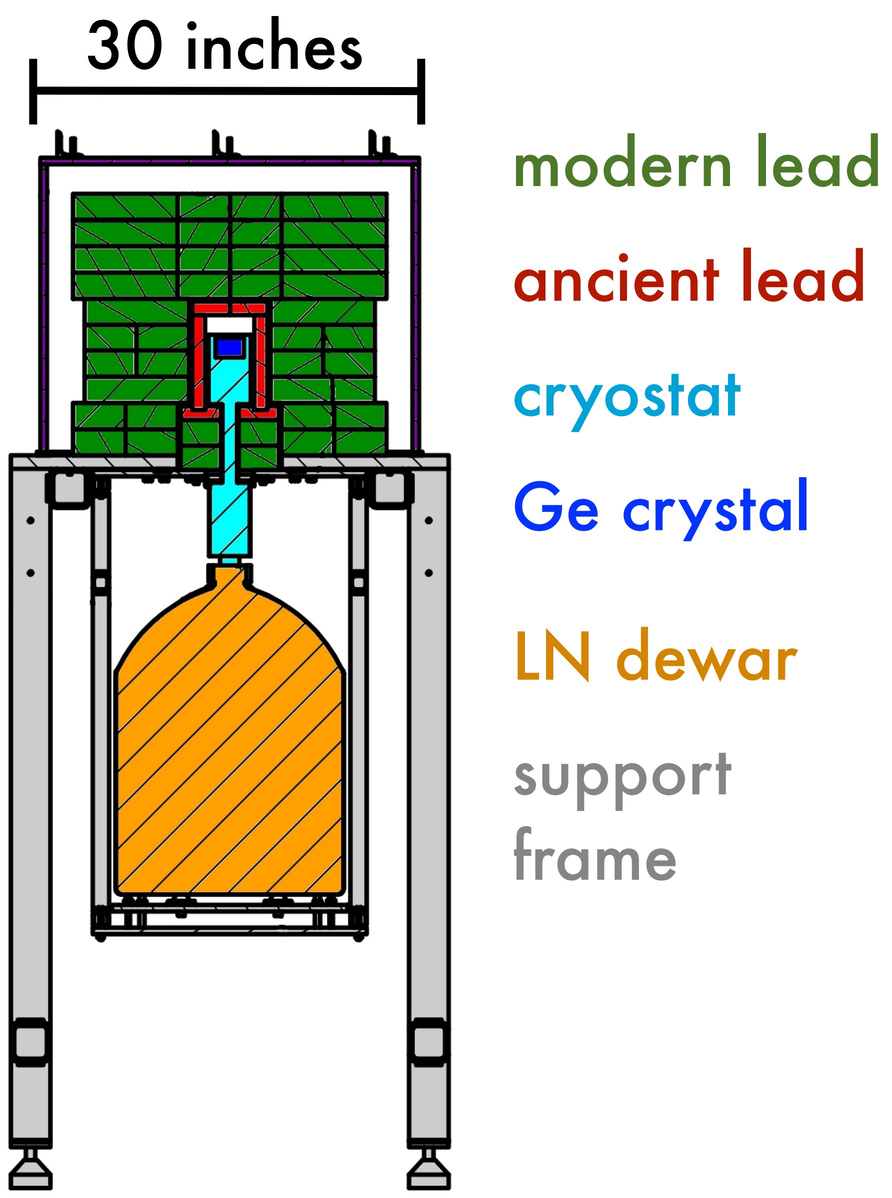
string 2 is installed in the prototype cryostat

physics beyond the standard model

with sub-keV thresholds, MJD can search for light WIMPS, solar axions, etc...



MALBEK



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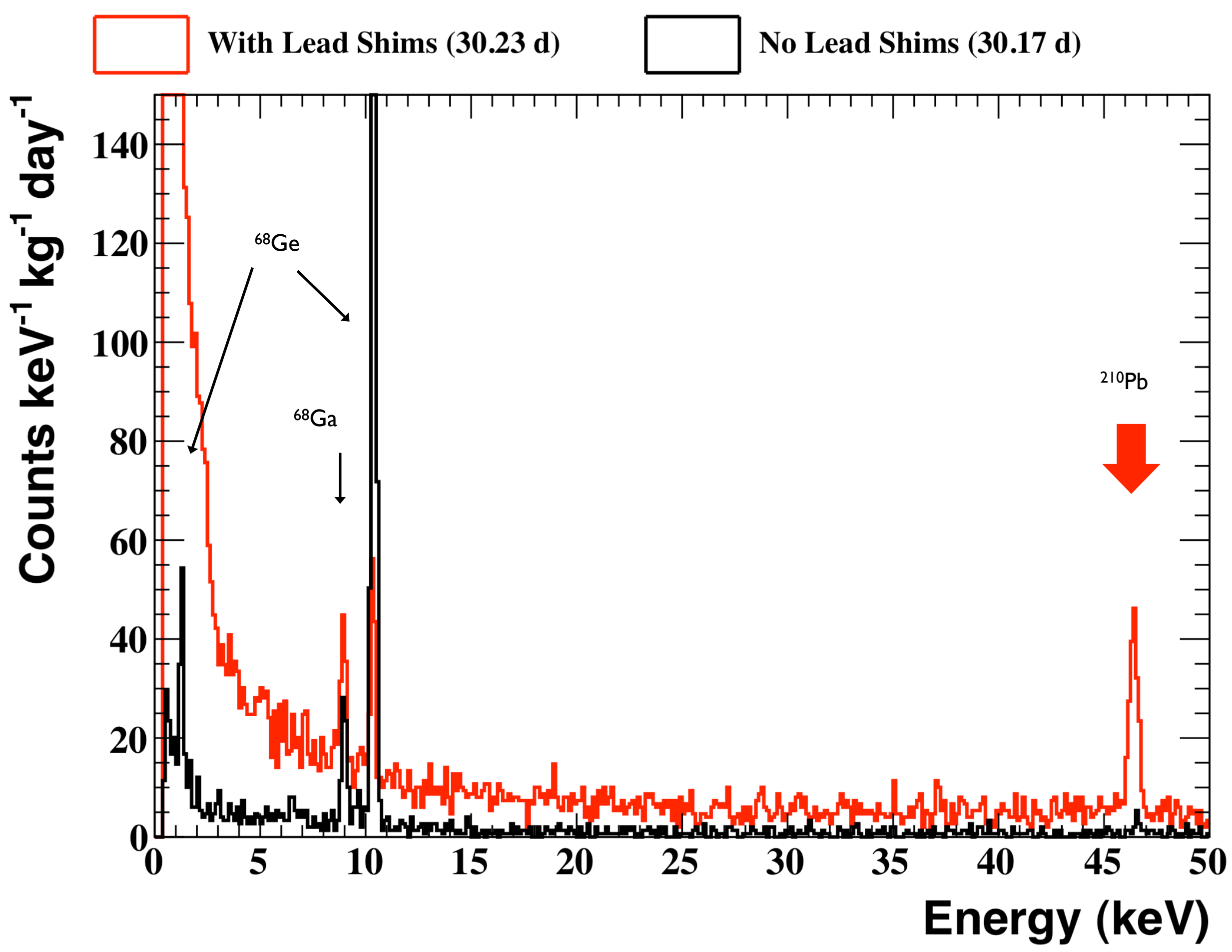

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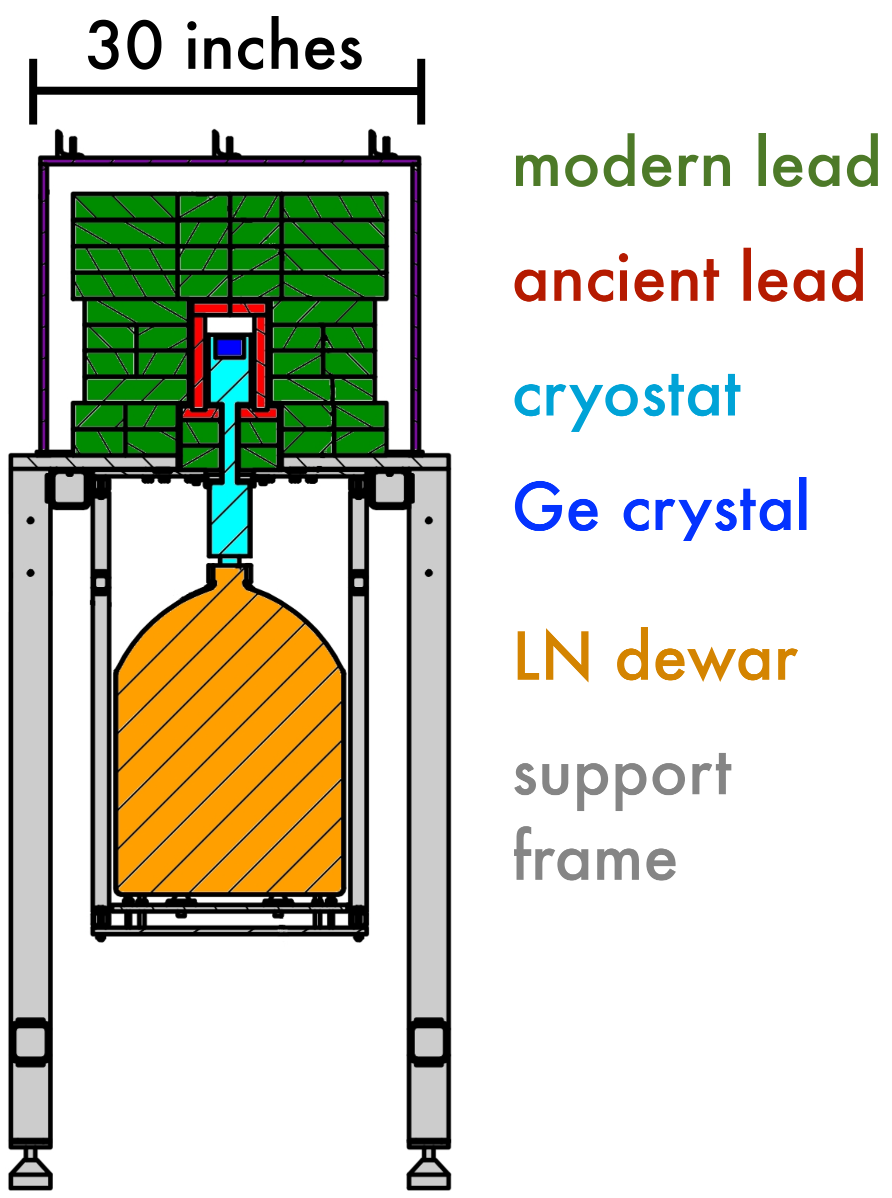


MAJORANA DEMONSTRATOR summary

$0\nu\beta\beta$-decay observation would demonstrate lepton number violation and indicate that neutrinos are Majorana particles constituting a major discovery

Such a discovery would need to be confirmed from independent experiments using different isotopes and measurement techniques.

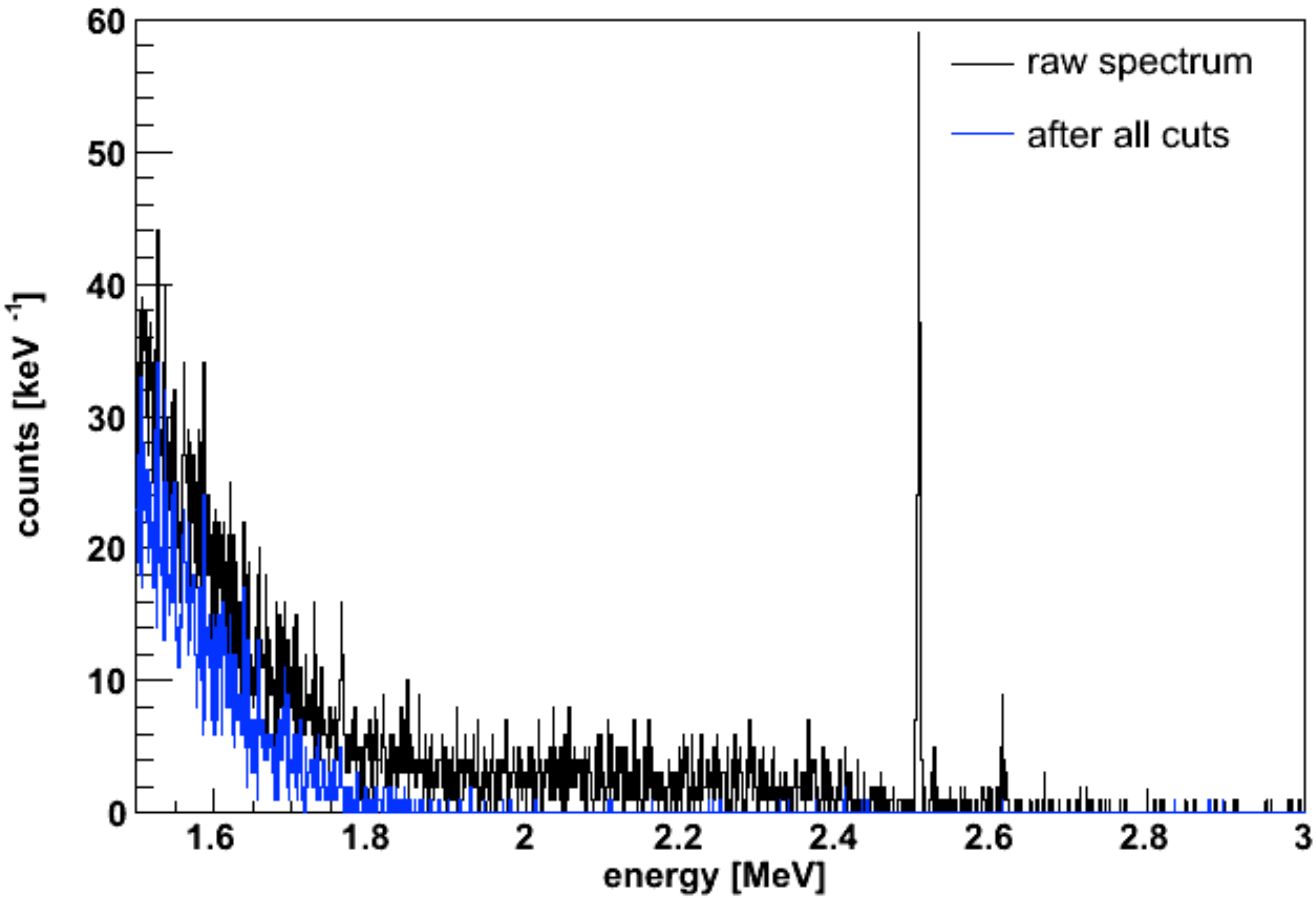
Construction of MJD well underway and proceeding on schedule.

- Prototype Cryostat : summer 2013
- Cryostat 1 : early 2014
- Cryostat 2 : end of 2014

During 2014 both MJD Cryo 1 and GERDA Phase II should be collecting data.

Working cooperatively with GERDA towards the establishment of a single international tonne-scale ^{76}Ge $0\nu\beta\beta$ collaboration

simulated 60 kg-year spectrum



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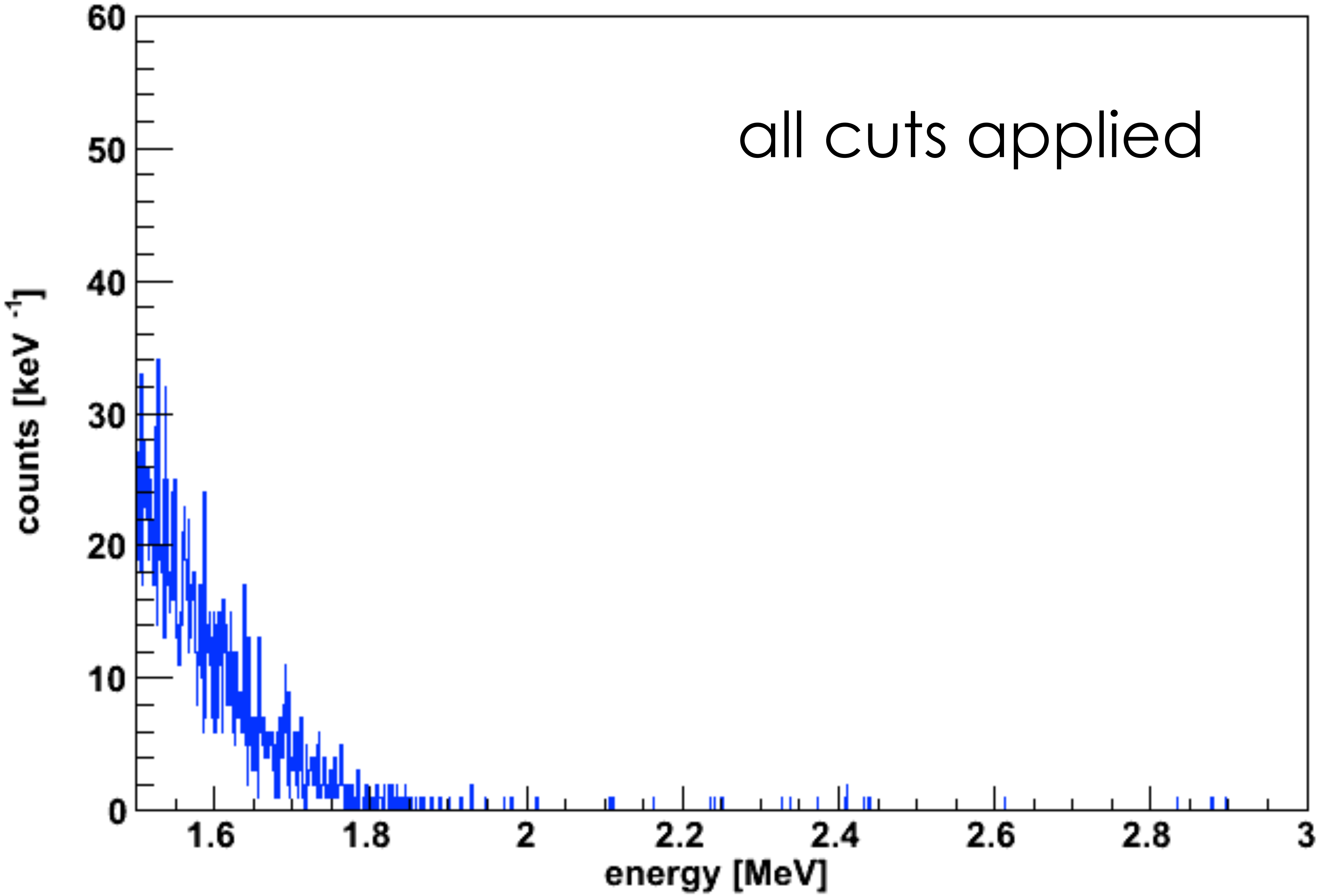
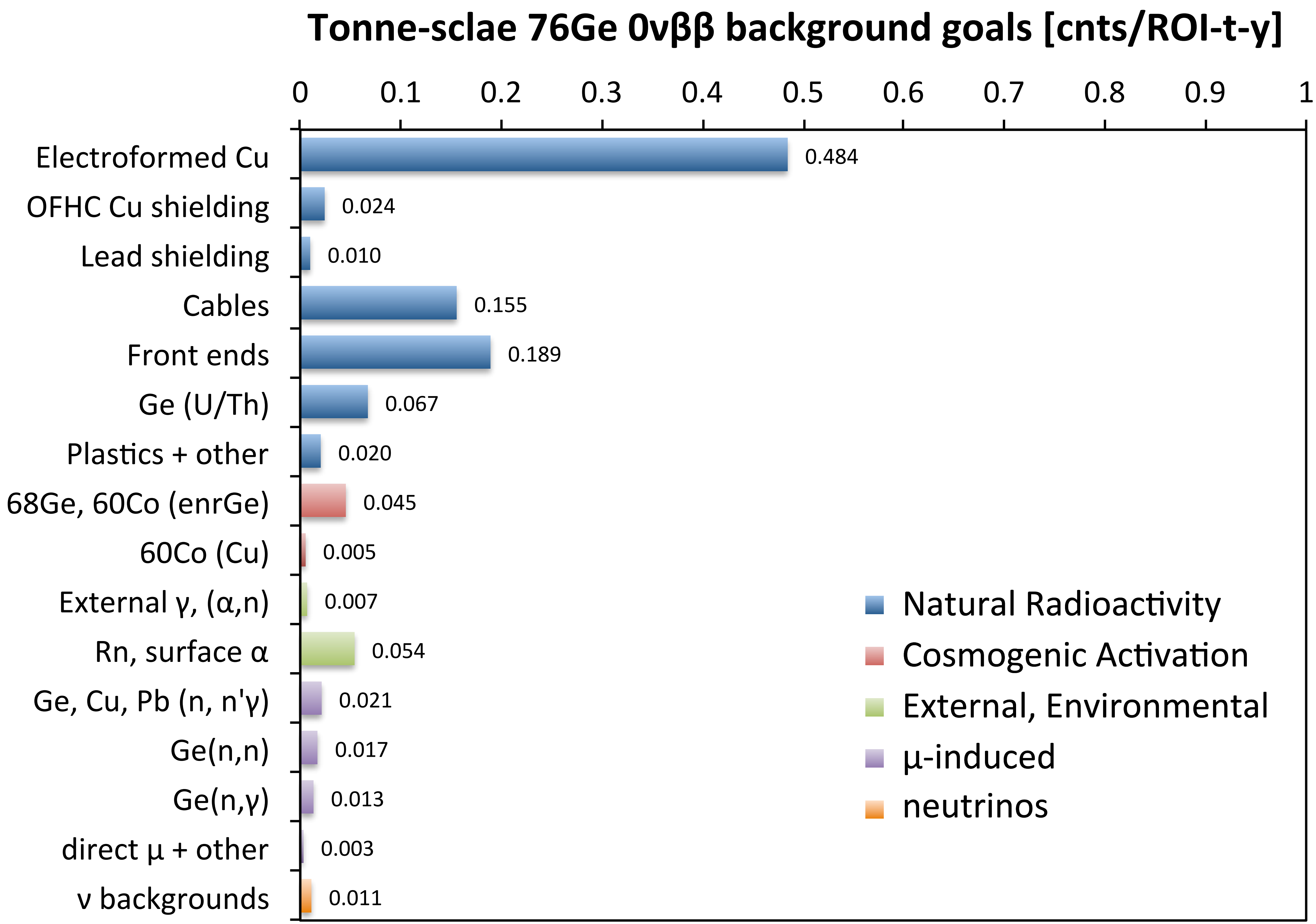


Tonne-scale background budget



backgrounds and sensitivity