CUPID, CUPID-1T, and the future of neutrinoless double beta decay

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INT Seminar

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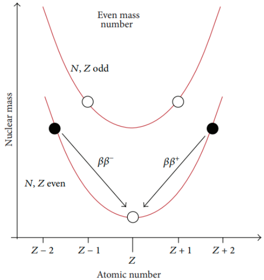
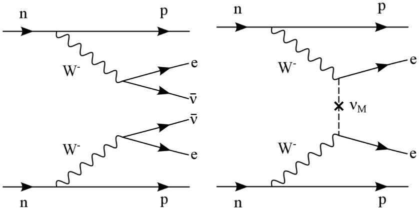
Double Beta Decay



Rare radioactive decay, found in even-even nuclei where single-beta decay is energetically forbidden (e.g. ^{130}Te)

- Two-neutrino ($2\nu\beta\beta$) $\Rightarrow$ Observed, $T_{1/2} > 10^{18}$ years
  $(A, Z) \rightarrow (A, Z+2) + 2e^- + 2\bar{\nu}_e$
- Neutrinoless ($0\nu\beta\beta$) $\Rightarrow$ Expected $T_{1/2} > 10^{25}$ years
  $(A, Z) \rightarrow (A, Z+2) + 2e^-$



Observation of $0\nu\beta\beta$ is a critical tool to study neutrinos:

- Majorana ($\nu = \bar{\nu}$) or Dirac ($\nu \neq \bar{\nu}$) nature
- Lepton number violation ($\Delta L = 2$)
- ν mass scale and ordering

Lepton number violation & Majorana nature of neutrinos

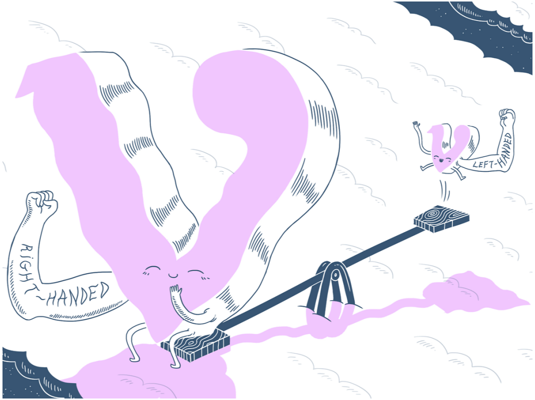
Key Questions:

- **Is the neutrino a Majorana or Dirac particle?** ($\nu = \bar{\nu}$ or $\nu \neq \bar{\nu}$?)

  And further, is the Majorana neutrino tied to the mystery of small neutrino masses? ('see-saw')

- **Is Lepton number (L) a good symmetry of nature?**

  Instead of starting with baryogenesis in the early universe, leptogenesis relies on $\Delta L \neq 0$, then converting L into B.



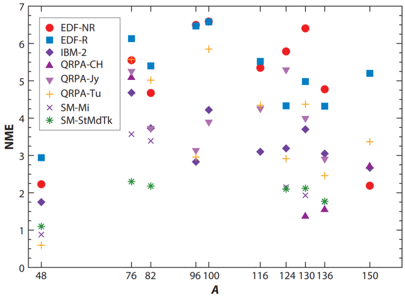
"Neutrinos on a seesaw" M. Francis, Symmetry Magazine 2016

Measuring neutrino mass with $0\nu\beta\beta$

$$\Gamma_{0\nu} = (T^{0\nu}_{1/2})^{-1} = G_{0\nu}\ |M_{0\nu}|^2\ \langle m_{\beta\beta}\rangle^2$$

$$\langle m_{\beta\beta}\rangle = |U^2_{ei} m^2_i|$$

Nuclear matrix elements (M) are a major source of uncertainty



Ann. Rev. Nucl and Part.Sci. 69 (2019)

KamLAND-Zen (^{136}Xe):
$T_{1/2}\ >\ 2.3 \times 10^{26}$ yr
$m_{\beta\beta} <$ 36 - 156 meV
arXiv: 2203.02139

Other mechanisms for $0\nu\beta\beta$ like heavy neutrino exchange with right-handed currents have different parameter spaces (so ruling out the IH with light-majorana exchange isn't the end of this path)

Measurements of $2\nu\beta\beta$ and $0/2\nu\beta\beta$ to excited states contribute to understanding of NME, which in turn contributes to neutrino mass measurements.

A Better $0\nu\beta\beta$ Detector

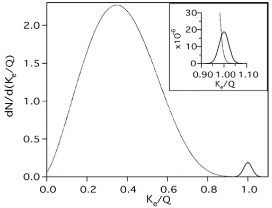
Sensitivity to $0\nu\beta\beta$ for an experiment with non-zero background:

$$F_{T_{1/2}} \propto \epsilon \cdot \eta \sqrt{\frac{M \cdot T}{b \cdot \Delta E}}$$

or for an experiment with zero background ($\mathcal{O}(1)$ compared to exposure)

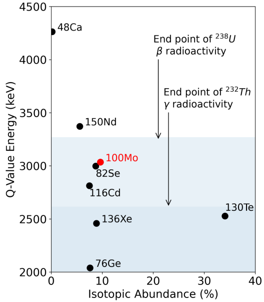
$$F_{T_{1/2}} \propto \epsilon \cdot \eta \cdot M \cdot T$$

- ϵ = signal efficiency
- η = abundance or enrichment
- $M \cdot T$ = exposure ("ton-year")
- b = background index in ROI
- ΔE = energy resolution at Q-value



Fundamental requirements for modern $0\nu\beta\beta$ experiments:

- Ultra-low background materials
- Underground location
- Large amount of candidate isotope
- Excellent signal/background discrimination



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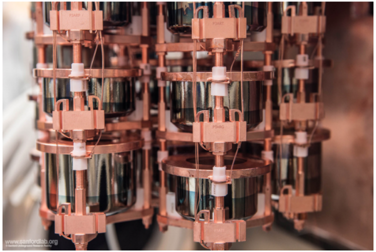
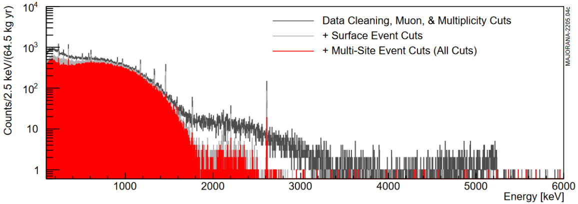
Majorana Demonstrator

$$^{76}\text{Ge} \rightarrow \, ^{76}\text{Se} + 2e^-$$

- Since 2015 in Sanford Underground Research Facility
- Array of Ge crystals: 29.7 kg 88% enriched ^{76}Ge
- Shielding & active muon veto with ultra-clean materials.
- Recent improvements in discriminating parameters for multi-site and surface α events.
- 2020 hardware upgrade to signal & HV connections

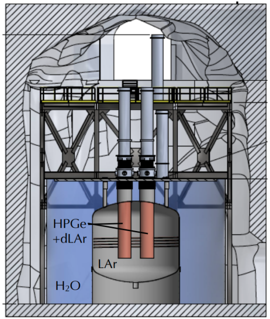




arXiv: 2207.07638

ΔE = 2.52 keV FWHM at Q-value (2039 keV)
$b = 16.6 \pm 0.14$ cts/FWHM/t/yr
Limit $T_{1/2} > 8.3 \times 10^{25}$ yr (90% CL)

LEGEND



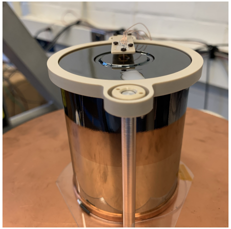
LEGEND-1000:

- Ton-scale 90% enriched ^{76}Ge in detector array
- Combines components from MJD (clean materials & low-noise electronics) and GERDA (active LAr veto)
- Background goal: <0.03 cts/FWHM/t/yr

Discovery sensitivity to $T_{1/2} \sim 10^{28}$ yr ($m_{\beta\beta} \sim 10 - 20$ meV)

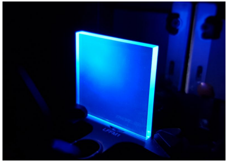
LEGEND-200:
Using GERDA infrastructure, 200 kg scale. Commissioning now, physics datataking expected 2022.
Expected sensitivity to $T_{1/2} \sim 10^{27}$ yr

LEGEND Ongoing Research and Development



Scanning cryostats for surface event analysis

Studying surface effects on HPGe detectors in vacuum. CAGE-S is designed to scan passivated surfaces at varying angles to study effects from α,β, & γ sources with <3mm positional resolution.



(Photo: F. Fischer/MPP)

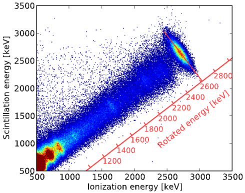
Scintillating PEN as an active veto material

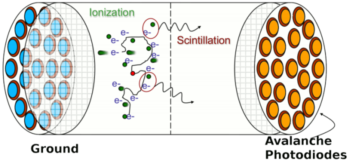
A common plastic, PEN can be used in the design of the experiment in and around the detector array. Scintillation from escaping gammas can be measured as an active veto, reducing background from Compton scatters and partial depositions.

- Xe-doped LAr to increase light yield of veto
- ASIC front-end electronics
- New HPGe detector geometries & sizes

EXO-200 results

- Ran at WIPP from 2011 to 2018*
- LXe TPC, using linear combination of scintillation and ionization signals for event reconstruction
- DNN for background discrimination

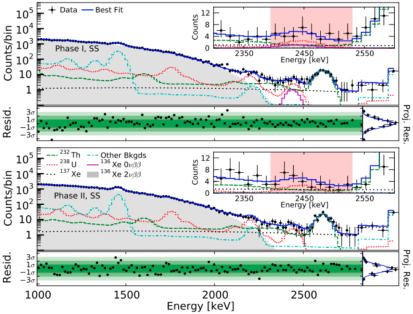




$$^{136}\text{Xe} \rightarrow {}^{136}\text{Ba} + 2e^-$$

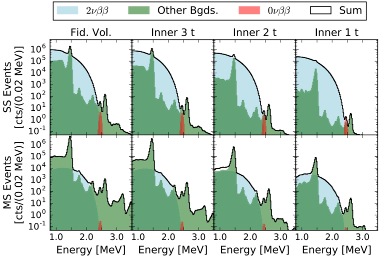
PRL 123,161802 (2019)

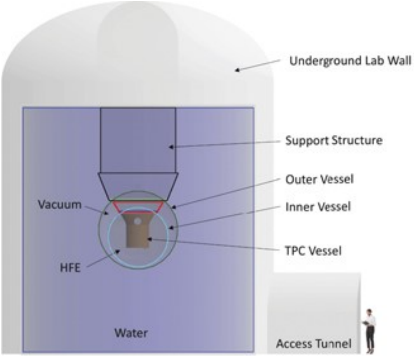
$$T_{1/2} > 3.5 \times 10^{25} \text{ yr (90\%CI)}$$
234.1 kg yr exposure
$$\sigma/E = 1.15\pm0.02\% \text{ at Q-value}$$



nEXO

- 5 ton single-phase LXe TPC
- Enriched to 90% in ^{136}Xe
- 1.3m x 1.3m cylindrical detector with single drift region
- Based on the success of the EXO-200 detector, including an extensive radioassay campaign.
- DNN expected to provide β/γ discrimination

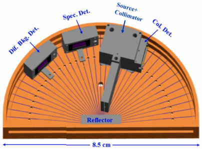




J. Phys. G: Nucl. Part. Phys. (2022)

Expected sensitivity to $T_{1/2}$ of $0\nu\beta\beta$ in ^{136}Xe:
1.3×10^{28} yr (90% CL)
$m_{\beta\beta} \leq$ (4.7-20.3) meV

nEXO ongoing work

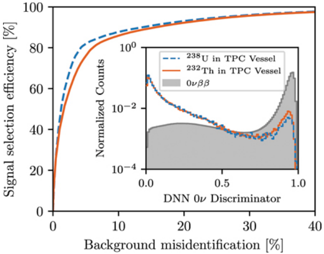


LIquid Xenon OPtical Characterization (LIXO)

- Measurement of VUV4 SiPM candidates in LXe
- Use scintillation in LXe from ^{252}Cf source
- Specular reflectivity measured as $\sim$30%
- Reflectivity decreases as function of angle

Radon as an injected calibration source

- End-of-run calibration campaign on EXO-200 demonstrated first Rn injection in single-phase LXe
- Demonstrated capability to track population decay
- Complementary to external γ calibration plans



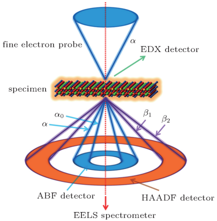
DNN for signal / background discrimination

- Used successfully on EXO-200
- Time series input, looking to distinguish single- and multi-site events
- 17% improvement in signal detection efficiency

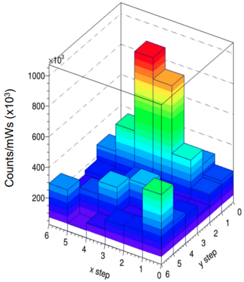
Barium Tagging

$$^{136}\text{Xe} \rightarrow {}^{136}\textbf{Ba}^{++} + 2e^{-}$$

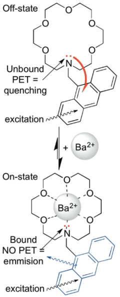
Tagging the daughter Ba ion could eliminate all but $2\nu\beta\beta$ backgrounds in a xenon experiment.



Scanning Transmission Electron Microscopy
Small volume of LXe is extracted and the Ba ion is imaged and identified using STEM. Demonstrated single atom Ba ID in $BaCl_2$ molecule.

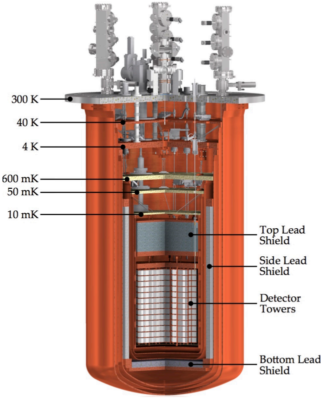


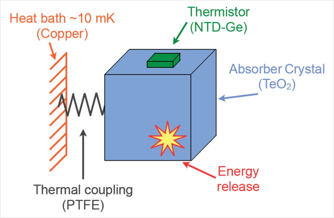
SXe fluorescence
Extract daughter Ba^{+} by freezing ion in solid xenon using a cryoprobe. Resultant window is then probed with a laser, expecting fluorescence. Demonstrated counting of single barium atoms in solid xenon (Nature 569 2019)

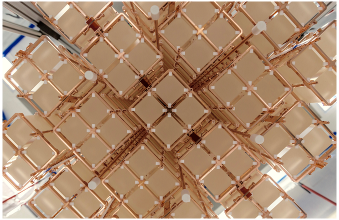


Chemical fluorescence
Sample expected to contain Ba ion combined with a dry-phase barium chemosensor molecule, which allows for identification using TIRFM (Nature Sci Rep 9, 15097 2019)

Cryogenic Underground Observatory for Rare Events (CUORE)





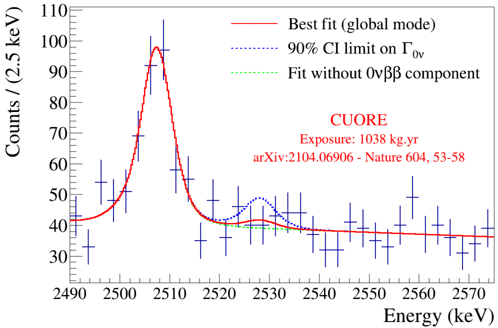


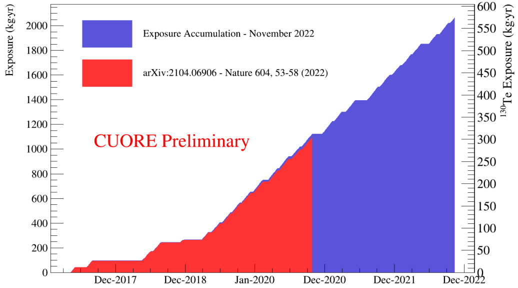
$$^{130}\mathrm{Te} \rightarrow {}^{130}\mathrm{Xe} + 2e^-$$

- 988 TeO_2 bolometers (206 kg ^{130}Te) instrumented with NTD thermistors
- Detector array cooled to operating temp of $\sim$10mK.
- Stringent radiopurity control on materials and assembly
- Target $\Delta E = 5$ keV at Q-value, Target $b = 10^{-2}$ ct/keV/kg/yr

Expected sensitivity to $T_{1/2}$ of $0\nu\beta\beta$ in ^{130}Te:
9.5×10^{25} yr (90% CL)
($m_{\beta\beta} \leq$ (50-130) meV)

CUORE





Nature 604, 53 (2022)

$T_{1/2} > 2.2 \times 10^{25}$ yr (90% CI)

$m_{\beta\beta} \leq$ (90-305) meV

$\Delta E = 7.78(3)$ keV FWHM at Q-value (2528 keV)

$b = 1.49(4) \times 10^{-2}$ ckky

Nature '22 Exposure:	1038.4 kg yr
Background Collected Exposure:	1946 kg yr

* does not take into account analysis efficiency

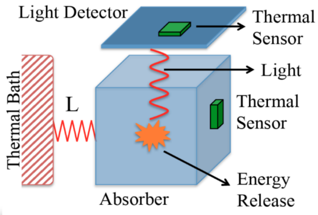
CUPID: CUORE with Upgraded Particle IDentification

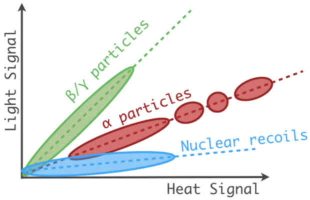
$$^{100}\mathrm{Mo} \rightarrow\ ^{100}\mathrm{Ru} + 2e^-$$

Secondary bolometer reads out scintillation light for signal/background discrimination.

- 1500 Li_2MoO_4 crystals hosting 250 kg of ^{100}Mo
- CUORE infrastructure
- $\Delta E \sim 5$ keV FWHM at $Q_{\beta\beta} = 3034$ keV
- Background goal: 0.5 cts/FWHM/t/yr

Discovery sensitivity to $T_{1/2} \sim 10^{27}$ yr
($m_{\beta\beta} \sim 12 - 20$ meV, 10 yr)

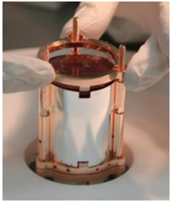




CUPID pre-CDR
arXiv:1907.09376

CUPID

CUPID-0



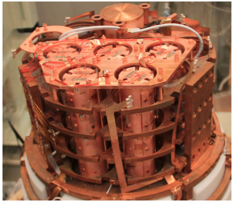
26 ZnSe crystals enriched with 5.17 kg of ^{82}Se and equipped with a Ge light detector for PID.

- 20.05±0.34 keV FWHM at the Q-value
- 99% α rejection

$0\nu\beta\beta$ of ^{82}Se
$T_{1/2} > 3.5 \times 10^{24}$ yr
$m_{\beta\beta} < [0.31 - 0.64]$ eV
90% CI , 5.29 kg·yr

PRL 123, 032501 (2019)

CUPID-Mo



20 ~0.2kg enriched Li_2MoO_4 crystals. 20 Ge wafers coated with SiO instrumented with NTDs acted as light detectors for PID.

- 7.4(4) keV FWHM at the Q-value
- Excellent α rejection

$0\nu\beta\beta$ of ^{100}Mo
$T_{1/2} > 1.8 \times 10^{24}$ yr
$m_{\beta\beta} < [0.28 - 0.49]$ eV
90% CI , 2.71 kg·yr

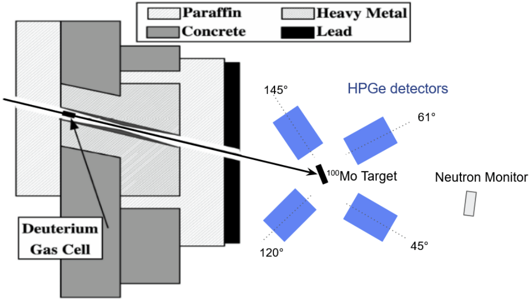
Eur.Phys.J.C 82 (2022) 11, 1033

Measurements of Neutron-Induced Gamma Ray Background of ^{100}Mo

Neutron scattering creates a difficult-to-characterize background in CUPID.

Three sources:

- Muon induced neutrons produced inside the detector
  $\rightarrow$ easy to ignore using high efficiency muon vetoes
  (Phys. Rev. C 103, 044612)
- Muon induced neutrons produced inside rock around the detector
- Actinide contamination inside the detector & surrounding material



- January 2022 run at the TUNL Tandem accelerator and D-D neutron beams of energies 4-8 MeV, < 130 hours.
- Targets included (1) natural Mo (2) Mo enriched in ^{100}Mo, (3) Cu, and (4) natural Fe for calibration.
- Collected with HPGe gamma counters, processed with LANL program GoodFit (courtesy Matthew Gooden).

preliminary γ *production cross sections*

E_γ	σ (barns)	$\Delta\sigma$ (barns)
600	0.170	0.020
1063	0.059	0.008
1126	0.154	0.014

CUPID Collaboration

The CUPID Collaboration thanks the directors and staff of the Laboratori Nazionali del Gran Sasso and the technical staff of our laboratories. This work was supported by the Istituto Nazional di Fisica Nucleare (INFN); by the European Research Council (ERC) under the European Union Horizon 2020 program; by the Italian Ministry of University and Research (MIUR). This material is also based upon work supported by the US Department of Energy (DOE) Office of Science and Office of Nuclear Physics. This work was also supported by the Russian Science Foundation and the National Research Foundation of Ukraine. This research used resources of the National Energy Research Scientific Computing Center (NERSC). This work makes use of both the DIANA data analysis and APOLLO data acquisition software packages, which were developed by the CUORICINO, CUORE, LUCIFER and CUPID-0 Collaborations.

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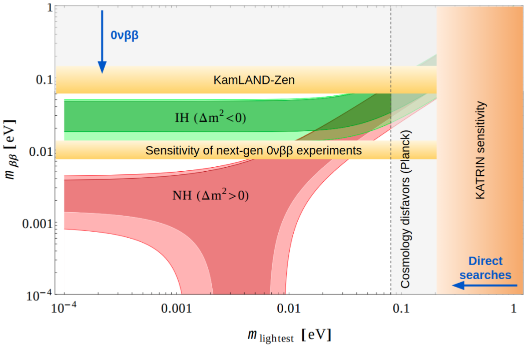
A Better 0$\nu\beta\beta$ Detector

Non-zero background:

$$F_{T_{1/2}} \propto \epsilon \cdot \eta \sqrt{\frac{M \cdot T}{b \cdot \Delta E}}$$

Zero background ($\mathcal{O}(1)$ compared to exposure)

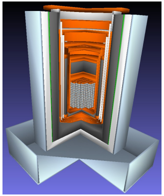
$$F_{T_{1/2}} \propto \epsilon \cdot \eta \cdot M \cdot T$$

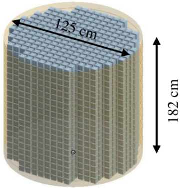


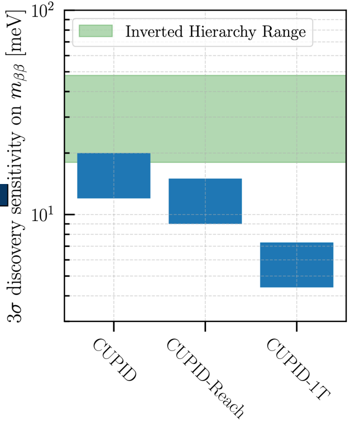
Fundamental requirements for modern experiments searching for 0$\nu\beta\beta$:

- Ultra-low background materials $\Rightarrow$ Zero background contamination
- Underground location $\Rightarrow$ Exist, and are refined
- Large amount of isotope $\Rightarrow$ Abundant or Enriched
- Excellent S/N discrimination $\Rightarrow$ $\sim$ 100% efficiency

Beyond Next-Generation: CUPID-Reach & CUPID-1T







Parameter	Baseline	CUPID-Reach	CUPID-1T
Detector mass (kg)	450	450	1871
^{100}Mo mass (kg)	240	240	1000
ΔE FWHM (keV)	5	5	5
BI (ckky)	10^4	2 x 10^6	5 x 10^6
Livetime (years)	10	10	10
$T_{1/2}$ exclusion sensitivity (90% C.L.)	1.4 x 10^{27} y	2.2 x 10^{27} yr	9.1 x 10^{27} yr
$T_{1/2}$ discovery sensitivity (3σ)	1 x 10^{27} y	2 x 10^{27} y	8 x 10^{27} yr
$m_{\beta\beta}$ exclusion sensitivity (90% C.L.)	10–17 meV	8.4–14 meV	4.1–6.8 meV
$m_{\beta\beta}$ discovery sensitivity (3σ)	12–20 meV	9–15 meV	4.4–7.3 meV

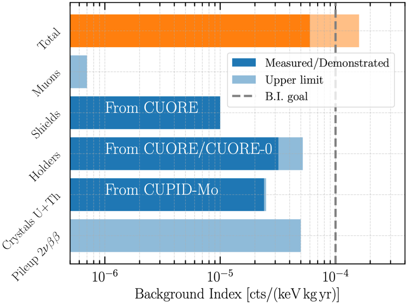
preliminary

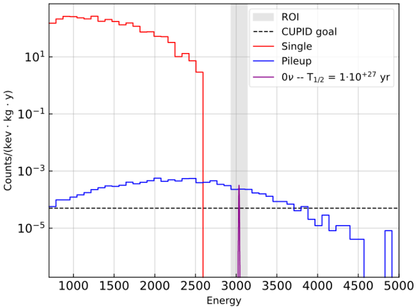
CUPID-Reach: R&D on $2\nu\beta\beta$ pileup

- Slow pulses $\rightarrow \mathcal{O}(10)$ ms risetime
- Fast ^{100}Mo $2\nu\beta\beta$ decay $= 7.1 \times 10^{18}$ year
- High mass, enriched detector

$\Rightarrow$

High probability of simultaneous $2\nu\beta\beta$ events in the same crystal.
Need $< 170\ \mu$s effective timing resolution.





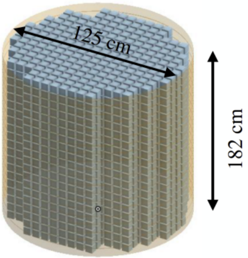
Mitigation onging: (1) Timing-focused analysis; (2) CNN algorithms showing promise

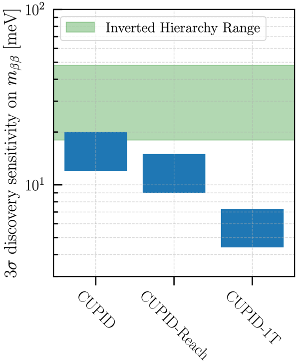
CUPID-1T

CUPID-1T is an **Inverted Hierarchy precision measurement device across multiple isotopes** or a **Normal Hierarchy explorer**.

1871 kg of $Li_2^{100}MoO_4$ for 1000 kg of ^{100}Mo $\rightarrow$ 4x scale up of CUPID-baseline.

Possible multi-isotope deployment $Zn^{82}Se$, $Li_2^{100}MoO_4$, $^{116}CdWO_4$, $^{130}TeO_2$





Background goal of 5×10^{-6} ckky

- Improve background μ, β/γ, α discrimination
- Consider pileup and subdominant backgrounds

Possible modes of deployment:

- Larger cryostat allows for self-shielding
- Distributed multi-cryostat setup

R&D towards CUPID-1T

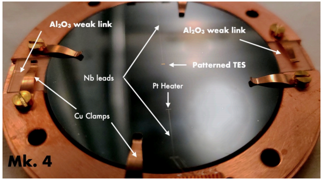
Quantum Sensors... for >10k channels

- Require low-noise, fast-rise time, high-bandwidth TES or MKID superconducting sensors
- Reasonable level of multiplexing (MUX)

Low-impedance Transition Edge Sensors:
arXiv:2210.15619

Production is easy to scale & compatible with MUX

Energy resolution < 100 eV, Risetime ≈ 180 μs



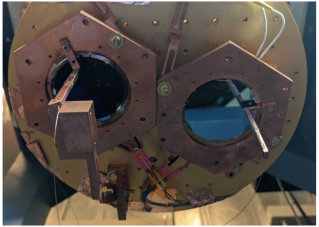
demeter

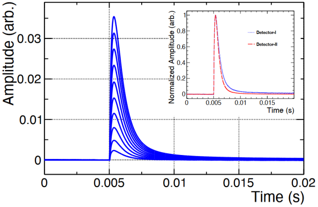
DEMETER: Demonstrator Experiment with Multiplexed Event Topology and Energy Reconstruction

- a collaboration between UC Berkeley CUPID and LBNL CMB groups
- a test stand for development of multiplexing applications, which will be required for CUPID-1T > 10k channels

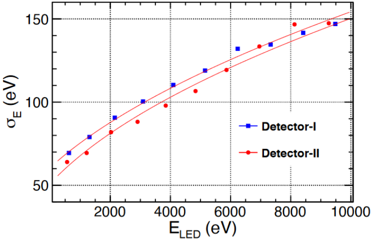
Ir/Pt Transition-edge Sensors (TES) for CUPID-like Light Detectors *arXiV:2210.15619*

Images courtesy C. Capelli & V. Singh.

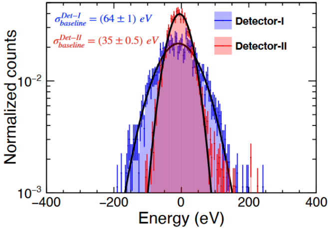




Injected pulse width $\gg$ rise time of the detector. LED square pulses $\sim$ 600 nm
ΔT = 40 - 340 ns



- Typical risetimes $\sim$ 175 μs
- Typical decay times $\sim$ 800-1000 μs



- Baseline resolution well below 100 eV
- Satisfies the CUPID requirements for pileup discrimination

Outstanding issues include

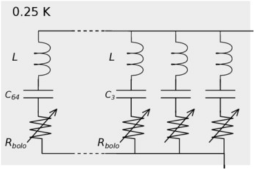
- broadening of the ^{55}Fe calibration peak $\rightarrow$ response difference between ionizing radiation and optical photons
- phonon simulations are not mature enough to aid in reconstruction (yet!)

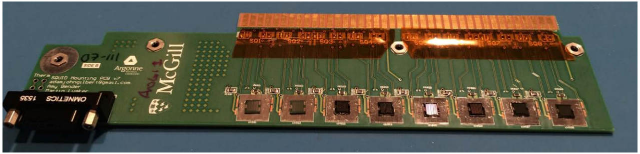
DEMETER: MUX at Ultra-Cryogenic Temperatures

TES readouts at the level of ten thousand channels have been demonstrated using multiplexing technologies. We have selected frequency-domain multiplexing (FDM) for our preliminary tests.

MHz FDM

- Independent TES AC bias, individual optimization, amplified with DC SQUIDs.
- CMB experiments have multiplexing factors as high as 68. [SPT-3G]
- CUPID can plan on a factor of O(10)





Alternative options:

Time-division multiplexing (TDM):

- Requires thousands of wires from cryogenic stage to room temperature electronics.
- Decreasing wire density has reportedly degraded noise performance.
- Cryo CMOS possible (JINST 15 (2020) P06026)

GHz FDM (" MUX"):

- Sets of TES, coupled to RF SQUIDs, & DC biased.
- Significant thermal loading on cryogenic stage.
- Multiplexing factors projected at O(10^3) but not fielded at that scale.

Partial figures from A.N. Bender et al., Proc. SPIE Int. Soc. Opt. Eng. 9914, 99141D (2016)

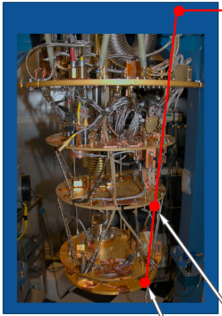
DEMETER: MUX at Ultra-Cryogenic Temperatures

Implementing in ultra-cryogenic experiments like CUPID-1T will need R&D.

MUX has not been demonstrated at operating temperatures of mK at this scale including the following: (outside to inside)

- Cables must be shielded from magnetic flux, which has not been demonstrated in CUPID-like environments
- Cable impedance must allow for signal-readout without additional modulation
- Crosstalk between TES devices is a predicted issue, and must be resolved at this scale

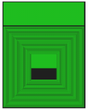
Also, radioactivity is naturally occurring in the normal materials for readouts → backgrounds in CUPID-like experiments.

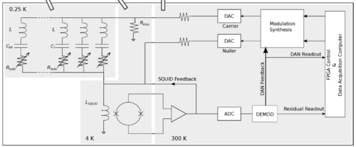


Room temperature electronics

Starting with electronics from CMB, modifying for our use.

Inductor chip for TES fMUX testing, courtesy Chiara Capelli (LBL)





From A.N. Bender et al., Proc. SPIE Int. Soc. Opt. Eng. 9914, 99141D (2016)

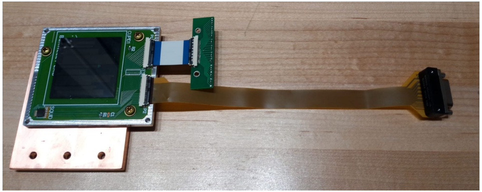
DEMETER: MUX Status

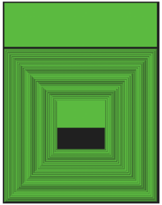
Design Considerations

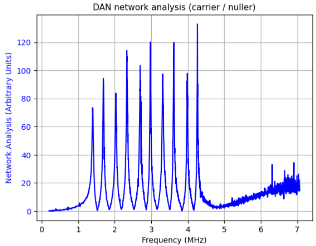
- MUX factor of 10 (feasible)
- Readout frequency 1-5 MHz
- $\sim$ 0.5-1 Ω TES with 50-100 μs time constant
- Resonators in series with TESs with L $=$ 4 μH
- Cross-talk $<$ 0.4 % $\rightarrow$ Δf $>$ 0.3 MHz

Measurements:

- Successful deployment of resonator board
- DC-SQUID from NIST
- Readout board from CMB: "IceBoard"



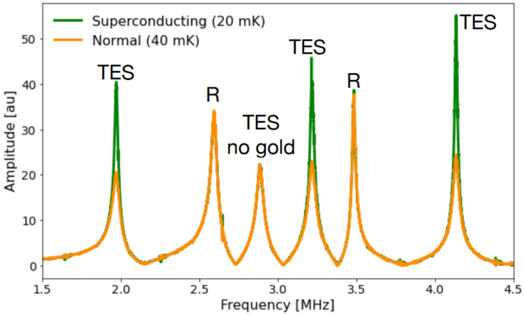


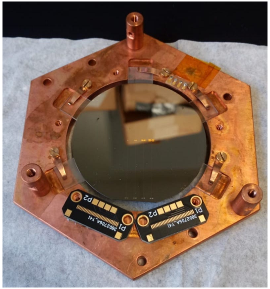


Images courtesy C. Capelli

DEMETER: MUX Status

Images courtesy C. Capelli & V. Singh; Presented ASC '22 # 4EPo1F-01

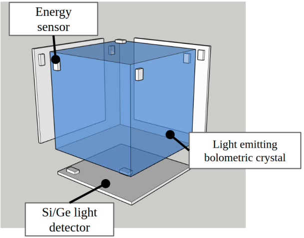




- 4 prototype TES with $T_c = 34$ mK, + 2 SMD resistors
- TES differed in Au pad size
- **Successful multiplexed readout at base temperature of 20 mK**
- Optimization ongoing, mitigating parasitic impedance on bias line.

DEMETER: Event Topology at the Crystal Level

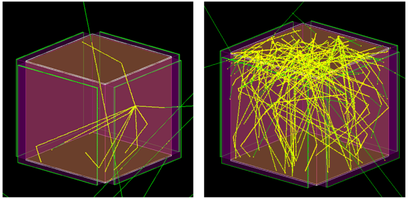
- CUPID's heat/light collection provides excellent particle discrimination, but there's not yet sensitivity to topology (energy / position reconstruction) at the **single-crystal level.**
- DEMETER focuses on both phonon and photon reconstruction at the single-crystal scale to provide physics information & background identification to large scale detectors like CUPID-1T. **We could distinguish between one- and two-electron events for a truly background-free measurement.**
- Potentially transformative technology: Modular TeO2 calorimeters with topological reconstruction and PID (Cherenkov and phonon imaging) could **mitigate the need for enriched detectors.**



DEMETER: Simulations Status

Scintillation & Cherenkov photon simulations

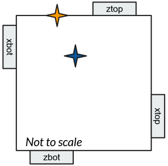
- With and without reflective surfaces, with and without anti-reflective coatings.
- Preparing to calibrate w/ CUPID-like setup (Co-60 source) above ground.
- Currently limited by understanding microscopic properties of LMO at 10mK.



Images courtesy K. Graham

Phonon simulations

- Based on G4CMP (CDMS) (photon simulations of LDs are mature, simulations of crystal are in development)
- Surface events show obvious position dependence!
- Volume events show some, but we need convincing.



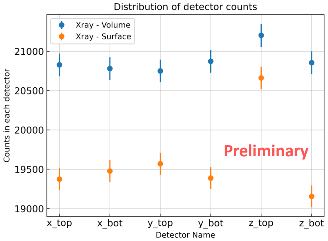


Image courtesy M. Beretta

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Berkeley Bolometer R&D

*This work is supported by the US DOE Office of Science and internal investments at all institutions.

One vision of the future of $0\nu\beta\beta$

Toward CUPID-1T
(Snowmass Contributed Paper)
https://arxiv.org/pdf/2203.08386.pdf

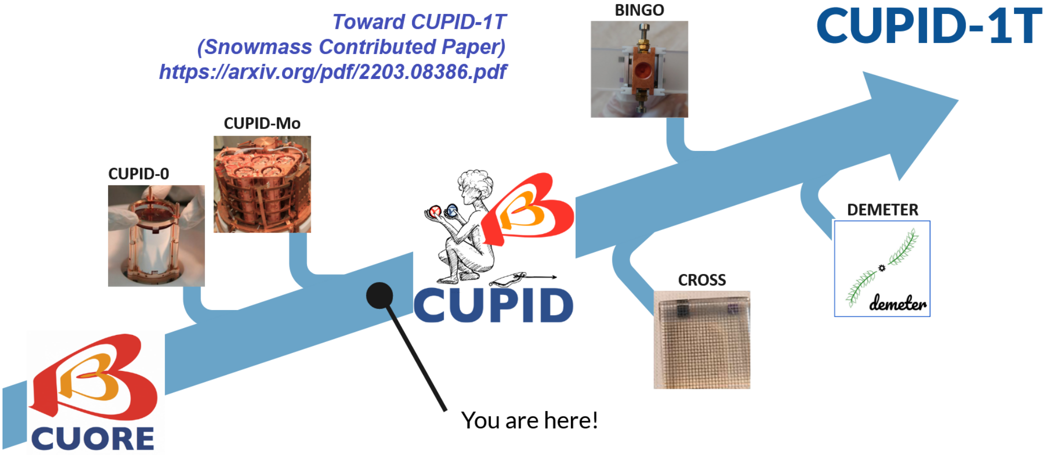


Table of Contents

Snowmass & Long Range Plan

"The potential discovery of a neutrinoless double beta decay would be every bit as much of a game changer as the discovery of supersymmetry at CERN, and as compelling as any accelerator-based research currently underway."

– Tim Hallman, Associate Director, US Department Of Energy Office of Science

Snowmass

- "Snowmass Neutrino Frontier Report" (*arXiv:2211.08641*)
- "Rare and Precision Frontier Report" (*in preparation*)
  - "On Baryon and Lepton Number Violation" (arXiv:2208.00010)

NSAC Long Range Plan

- "Neutrinoless Double Beta Decay" (*in preparation*)
- Fundamental Symmetries, Neutrons, and Neutrinos Town Meeting
  UNC Chapel Hill, 13-15 December 2022

Snowmass Community Engagement: Particle Physics Education

- **Train For Industry**
- **Normalize non-Academic Paths**

  Provide a more realistic view of common career paths post-PhD in particle physics, including the breakdown of theory and experimental positions as well as the commonality of shifting to a non-academic career.
- **Formalize Professional Skills**

  Support more formal modes of training for skills that we don't like teaching ourselves. Encourage PIs to actively train students or provide them resources.
- **Formalize Technical Skills**

  Formal course in statistics as part of undergraduate / graduate curriculum, with optional training in statistics in particle physics. Support formal training opportunities like summer schools & workshops.
- **Connect with Undergrads**

"Transforming U.S. Particle Physics Education"
arXiv: 2204.08983

	As-Needed / Self-Taught	Mentoring / Peer Learning	External Course	University Course
Mentoring Young Scientists	▼	▲		
Teaching	▼	▲		▲
Scientific Writing	▼		▲	▲
Giving Presentations	▼		▲	
Outreach to the Public	▼			
Writing a CV	▼			▲
Job applications (academic)	▼	▼		
Theory-oriented (e.g. SUSY, amplitudes)	▼			▲
Mathematics for Theory (e.g. topology)	▼	▼		▲
Gravity, GR, cosmology		▼		
Statistics	▼			▲

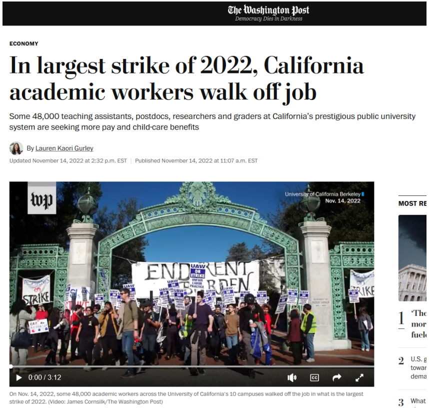
Snowmass Community Engagement: Climate of the Field

"Climate of the Field: Snowmass 2021"
arXiv: 2204.03713

Selection of Recommendations:

- Prioritization of climate-related issues at the funding level (DOE Office of Science has begun this process with new "PIER" requirements for new grant applications!)
- Formalization of codes of conduct recommendations from funding agencies, including handling community threats, removal of collaboration affiliates, and leadership rights and responsibilities, and protections against legal liability for leadership that is responsible for that enforcement.
- Funding for engaging and compensating experts in the fields of social & organizational psychology, anti-racism, and social science.
- Implementation of best-practices networks (e.g. the Multimessenger Diversity Network (MDN))
- Evaulation of the selection of leadership & public-facing roles in collaborations and working groups.
- Implementation of formal & equitable onboarding procedures and mentoring networks.

UAW On Strike


The Washington Post
Democracy Dies in Darkness

ECONOMY

In largest strike of 2022, California academic workers walk off job

Some 48,000 teaching assistants, postdocs, researchers and graders at California's prestigious public university system are seeking more pay and child-care benefits

By Lauren Kaori Gurley

Updated November 14, 2022 at 2:32 p.m. EST | Published November 14, 2022 at 11:07 a.m. EST

On Nov. 14, 2022, some 48,000 academic workers across the University of California's 10 campuses walked off the job in what is the largest strike of 2022. (Video: James Cornsilk/The Washington Post)

This is Week 3! *www.fairucnow.org/support/*

- Largest strike of 2022
- Largest academic strike in U.S. history
- 48,000 academic workers (postdocs, academic researchers, graduate student instructors, and graduate student researchers)

Core Demands

- Fair Compensation & End to Rent Burden
- Climate & Transit
- Support for Working Parents
- International Scholar Rights
- Job Security
- Disability Justice
- Anti-bullying & Harassment Protections

- Neutrinoless double beta decay provides a mechanism to study the neutrino and it's impact on the creation of mass in the early universe.
- Neutrinoless double beta decay experiments are making great strides on a variety of R&D fronts, including updates to existing simulation and analysis techniques as well as tabletop measurements of materials for use in next-generation detectors.
- The next-to-next generation detectors are already under development, and will require advances in both hardware and software in order to accommodate the necessary readout & background discrimination.
- $0\nu\beta\beta$ doesn't exist in a vacuum — we are still a mechanism for and depend on both workforce development and an inclusive, equitable, and just academic working environment.

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