The CUPID experiment

Using the same infrastructure as CUORE (at LNGS), the CUPID Upgrade with Particle IDentification (CUPID) [1], is a next-generation $0\nu\beta\beta$ decay experiment that will use $^{100}$Mo as the candidate isotope. With a $3\sigma$ discovery sensitivity of $1 \times 10^{27}$ yr, corresponding to an $m_{\beta\beta}$ range of 12-20 meV, CUPID will be able to probe the full inverted hierarchy region.

CUPID’s bolometers and $\alpha$-rejection

- Dual-readout for heat and light signals.
- Germanium light detectors.
- Successful prototypes/demonstrations at the $\sim 10$ kg scale:
  - CUPID-Mo [3]
  - CUPID-0 [4]
- $\alpha$-rejection efficiency demonstrated to be $> 99.9\%$ [5].
- Energy resolution: FWHM < 10 keV at $Q_{\beta\beta}$.

CUPID’s concept and optimization

- 1596 Li$_2$MoO$_4$ crystals (45 $\times$ 45 $\times$ 45 mm$^3$) distributed in 57 towers.
- 240 kg of $^{100}$Mo.
- Enrichment $> 95\%$, crystal quality.
- $Q_{\beta\beta} = 3034$ keV (above $\beta/\gamma$ backgrounds).
- Background Index (B.I.) goal: $< 10^{-4}$ cts/(keV kg yr).

Detector optimization

- Define crystal shape and tower structure.
- Optimize light detector position and test reflecting foil.
- Verify quality of crystals from different origins.
- Test assembly procedures.
- Characterization of mechanical, thermal, and vibrational properties of full CUPID baseline tower.
- Studies of pile-up rejection.

CUPID’s background projection and sensitivity

- Cosmogenic muons tagged with muon-veto.
- $\beta/\gamma$ backgrounds reduced with material selection, cleaning, shielding and delayed coincidence cuts (U/Th chains).
- $2\nu\beta\beta$ decay pileup addressed with high light-detector timing resolution ($\sim 160$ μs), low noise electronics and machine learning techniques.

The envisioned background index goal will allow CUPID to explore the full inverted ordering region, putting it among the world-leading next-gen $0\nu\beta\beta$ decay experiments.

References:

3. C. Augier et al., “Final results on the $0\nu\beta\beta$ decay half-life limit of $^{100}$Mo from the CUPID-Mo experiment”, arXiv:2202.08716 (2022).

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The CUPID experiment

Eventually, CUPID will complete its science goal by 2024/2025.