HeRALD

Helium Roton Apparatus for Light Dark matter

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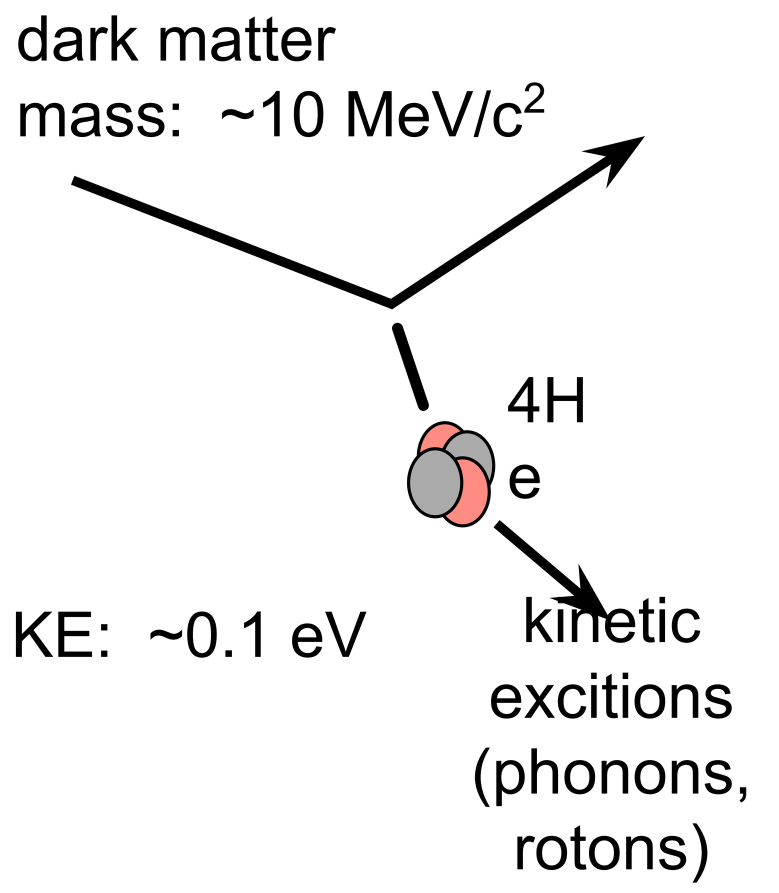
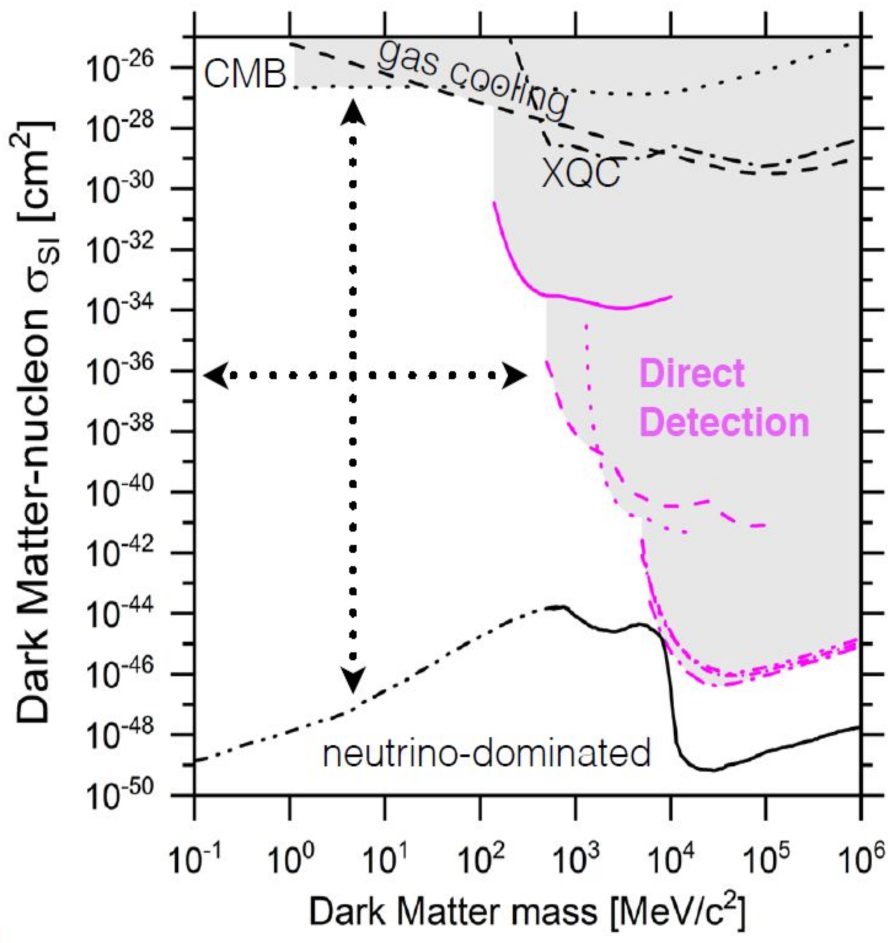
A dark matter recoil can give the (light) ^4He nucleus a significant kinetic energy.





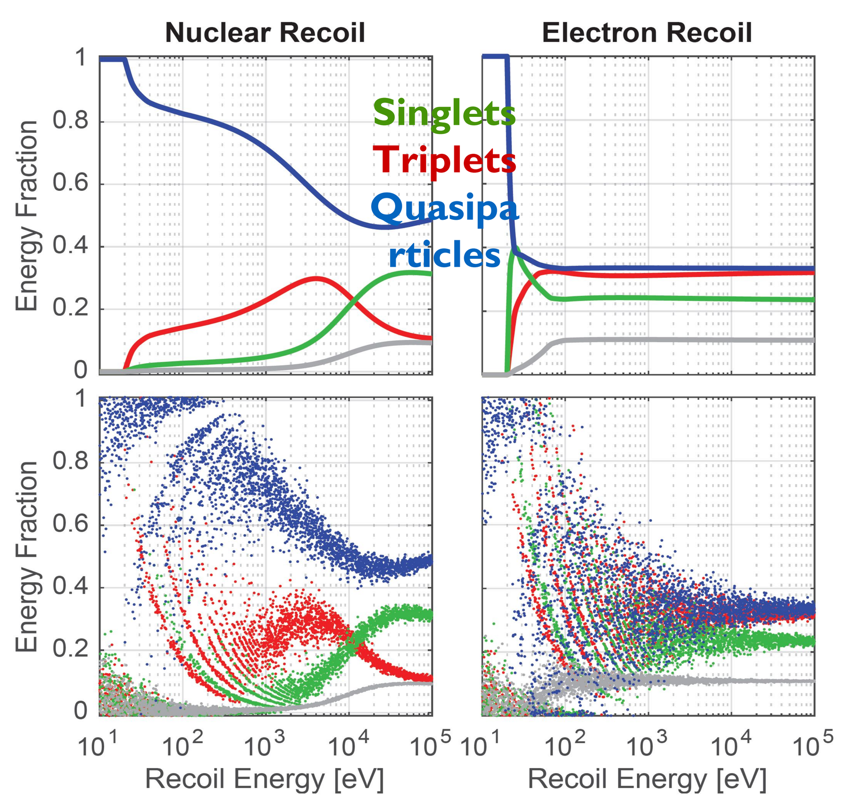
There are plausible models for sub-GeV dark matter. The long-lived kinetic excitations in superfluid 4He may serve as a unique tool to explore this new regime.

Advantages of superfluid 4He

- Low target mass
- Multiple signal channels
- Inhibited vibrational coupling to environment
- High radiopurity
- A large band gap energy (19.77 eV)
- Ballistic quasiparticle excitations
- A liquid state down to zero K, enabling mK-temperature calorimetric readout of an easily-scalable liquid target mass.

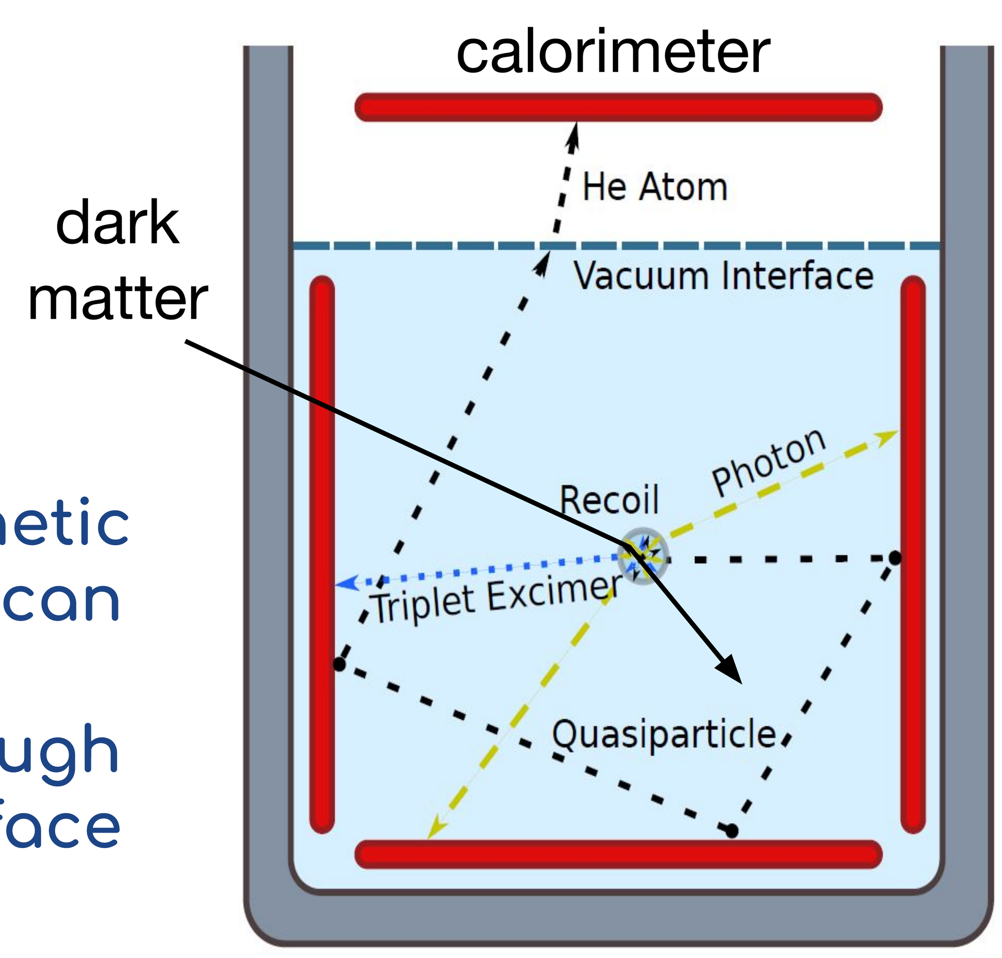
The energy of a particle recoil in liquid 4He is partitioned among several channels:

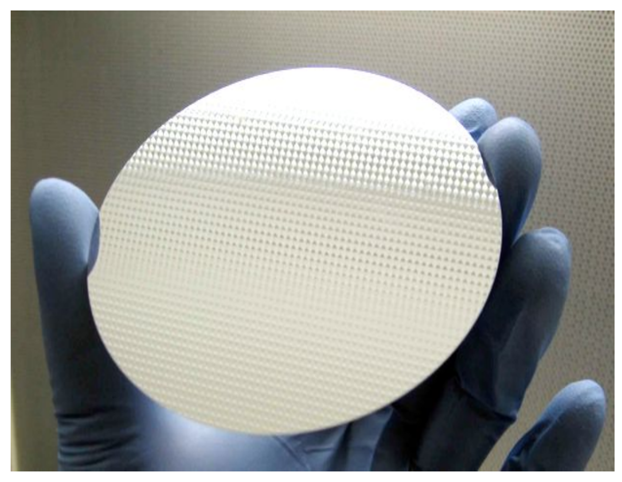
- ionization
- electronic excitation
- quasiparticle excitations (phonons and rotons).

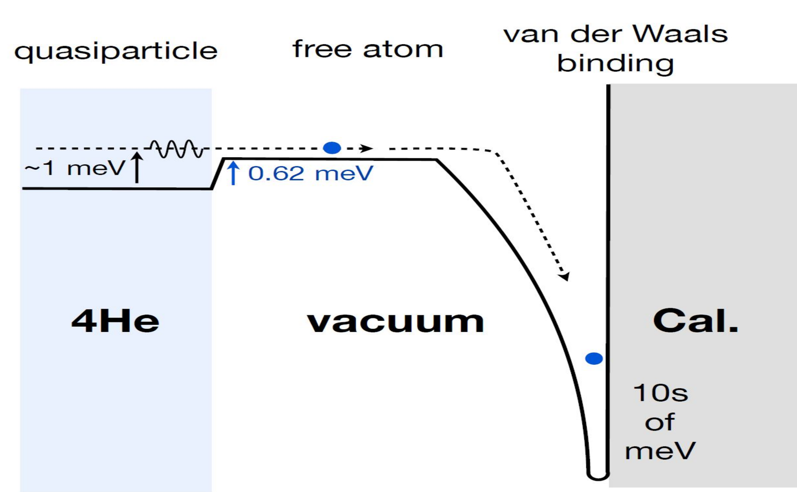


^4He atoms in the vacuum are sensed via mK calorimetry with a sub-eV threshold.

Van der Waals binding energy can be used as a gain

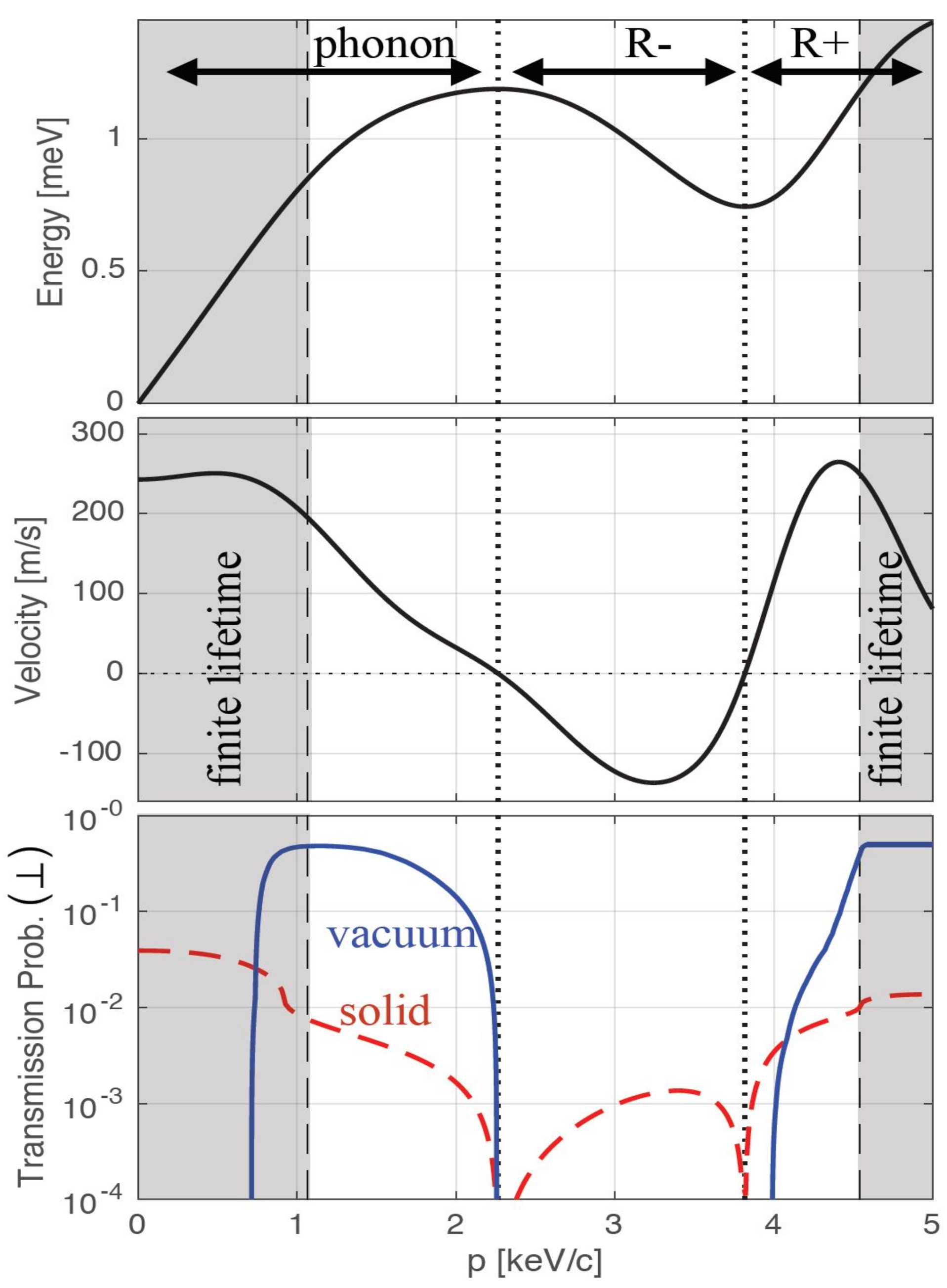






A recoiling nucleus efficiently produces long-lived kinetic excitations in the superfluid. Kinetic excitations can convert their energy to athermal evaporation.

The overall quasiparticle detection efficiency through evaporation process, is strongly dependent on surface quasiparticle reflectivity.

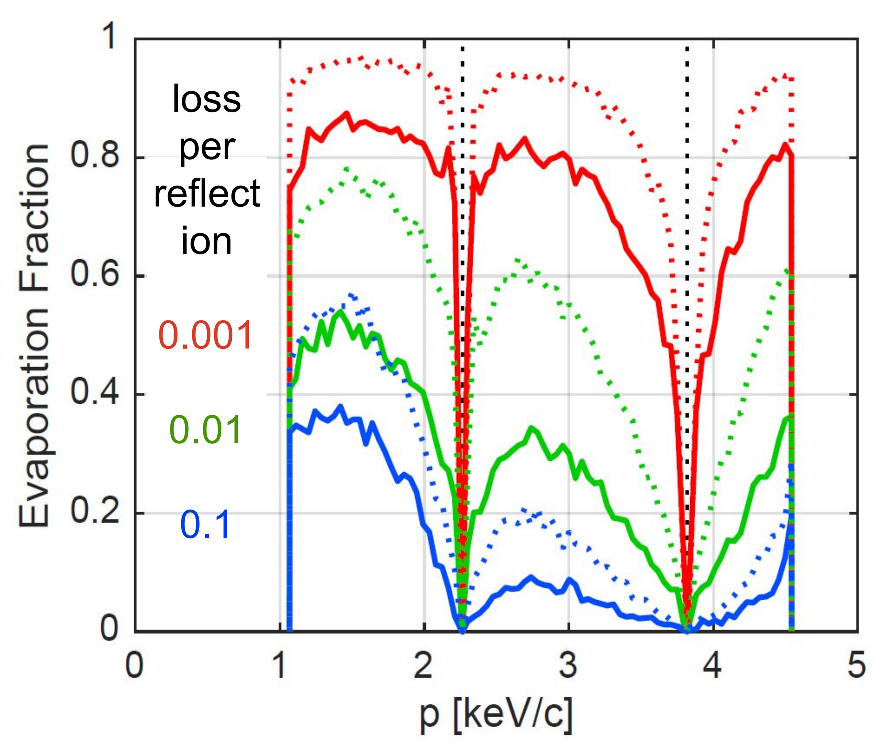


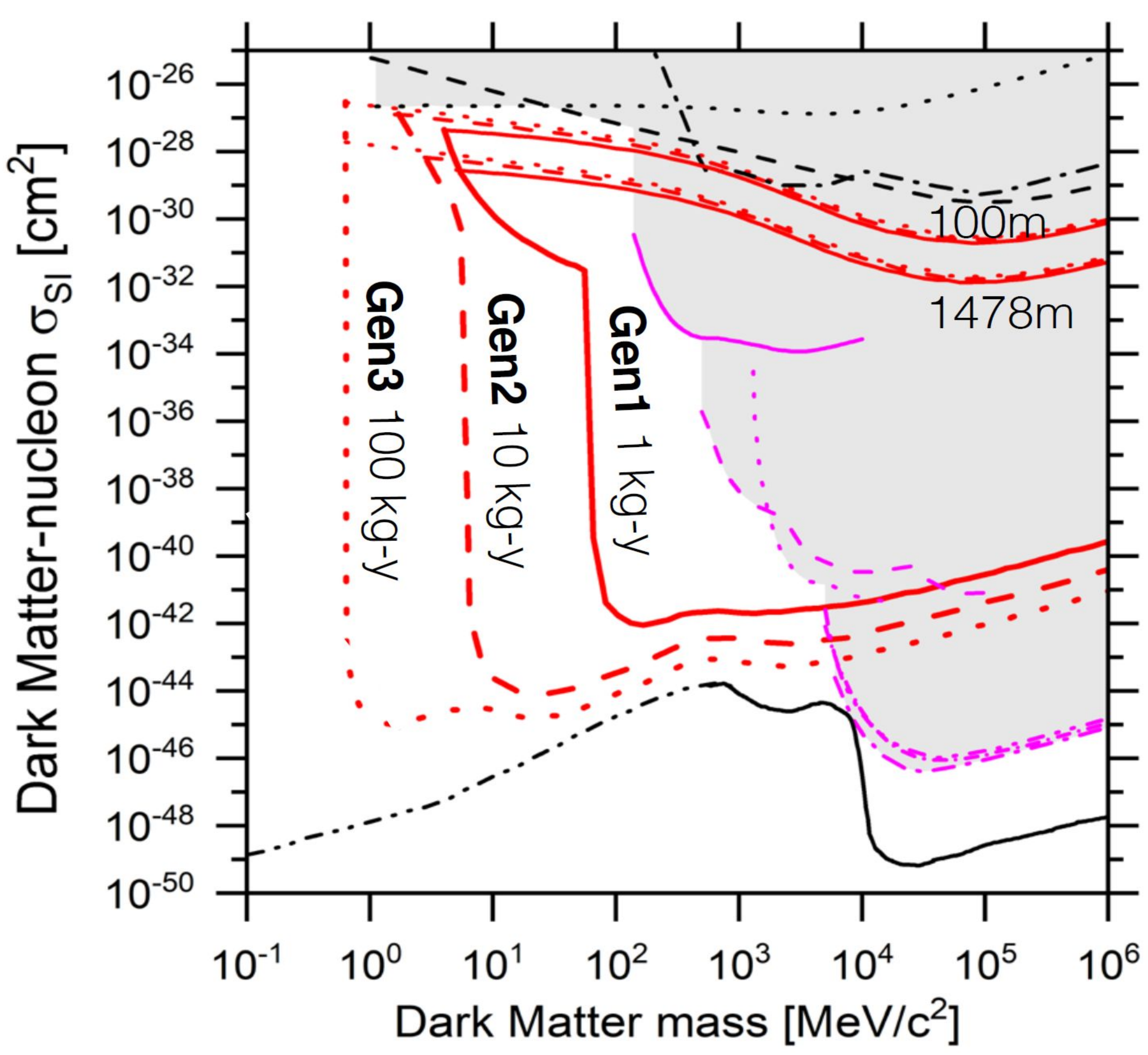
Significant future advancement in threshold appears plausible, given:

1) improving the quasiparticle evaporation eciency, perhaps by reducing surface roughness on the solid surfaces,

2) the addition of high-adhesion-gain coatings on the calorimeter surface, and

3) the continued advancement of TES-based large area calorimetry, which has yet to hit any fundamental limit.





Herald offer a unique avenue for carving out a vast swath of dark matter parameter space. Current technology will allow probing of dark matter masses as low as 60 MeV=c2. With further advancements in calorimeter threshold and helium quasiparticle reectivity, the technology can probe dark matter masses as low as 600 keV=c2 (via simple elastic nuclear recoils).