SnowMass2021

Neutrino Frontier NF05 — Aug. 19, 2020

The new benchmarks for a Beyond-the-Tonne-Scale Neutrinoless Double Beta Decay Program*

Experimental grand-challenges for Neutrinoless Double Beta Decay searches in the coming 2 decades

** ideas originally elaborated with Vincenzo Cirigliano (LANL) and Michael Ramsey-Musolf (TD Lee Institute & UMass Amherst), with input from recent workshops (BLV circa 2020, INT 20-2b)*

Andrea Pocar

University of Massachusetts, Amherst

UMass Amherst

Amherst Center for Fundamental Interactions
Physics at the interface: Energy, Intensity, and Cosmic frontiers
University of Massachusetts Amherst

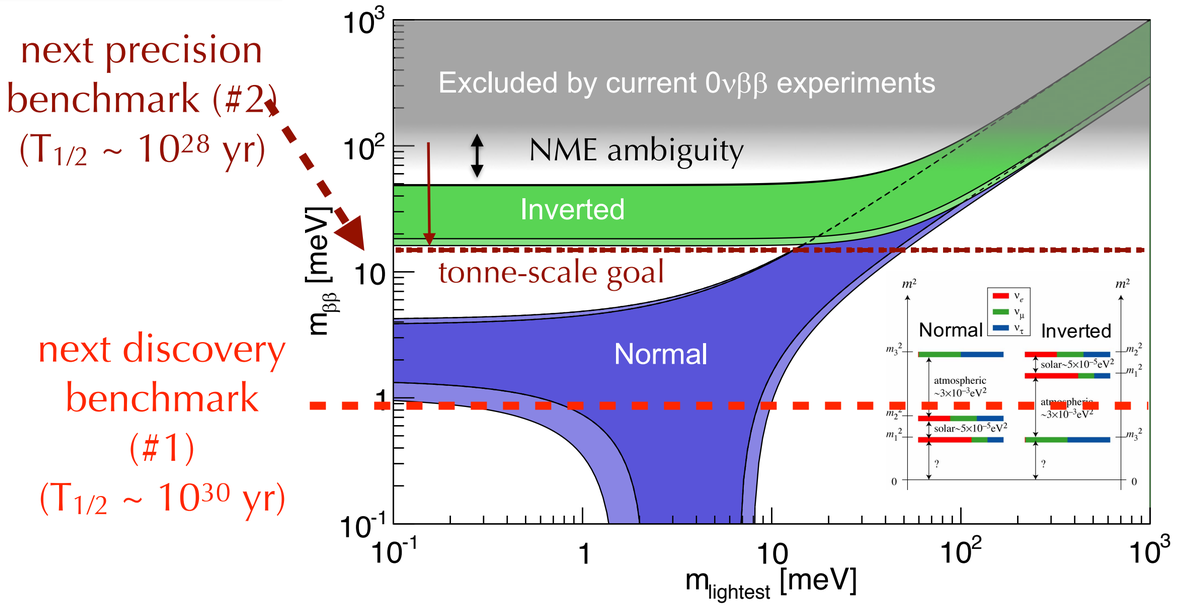
NSF

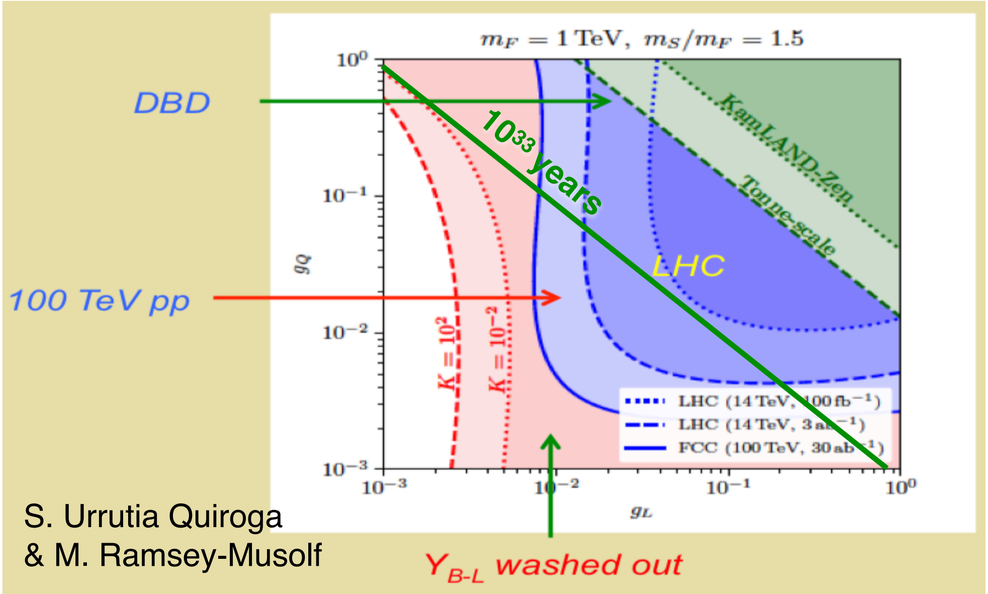
Beyond the tonne scale: the new benchmarks

Thread #1: push the discovery sensitivity

- **New 0vDBD Benchmark #1 — 0vββ decay half-life sensitivity of ~10^{30} years**

- Cover most of the $m_{\beta\beta}$ parameter space allowed by the normal neutrino mass ordering (high-scale See-Saw, light Majorana ν exchange)
- Requires 10s to ~100 tons of DBD isotope
- Different isotopes, as expected, show different advantages
- Need to critically analyze current technologies and their future reach
- Strong complementarity with the LHC and future colliders (TeV Leptogenesis)
- Interpretation of positive or null results requires hadronic / nuclear matrix elements with controlled uncertainty
- Instrumentation and engineering challenges





S. Urrutia Quiroga & M. Ramsey-Musolf

Beyond the tonne scale: the new benchmarks

Thread #2: prepare for discovery

Beyond high-scale See-Saw mechanism; particularly exciting if tonne scale experiments discover 0νββ decay

- **New 0νDBD Benchmark #2 — Resolve the topology of 0νββ decay**
  - Measure single electron spectra
  - Measure electron opening angle
  - Is measuring the electron polarization an option?
  - Benefit from 'recycling' isotope already in hand.
  - **Need for theoretical benchmarking**:
    - define 'topological templates' for experiments to search
    - templates group into three separate classes of theories
- **New 0νDBD Benchmark #3 — Multi-isotope program for 0νββ decay**
  - disentangle 0νββ decay mechanisms
  - exploit experimental opportunities