R&D for Beyond-the-Ton-Scale Liquid Scintillator Experiments

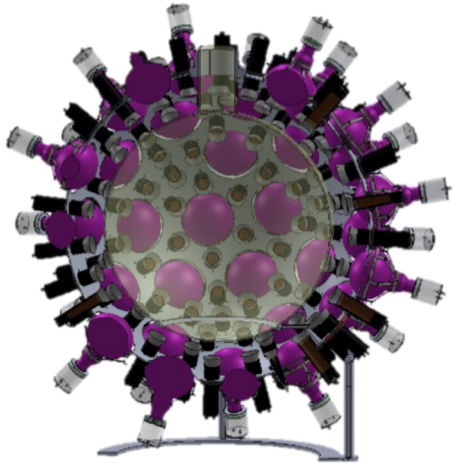
In parallel to ton-scale experiments, we need to be investigating easily-scalable techniques that can reach longer half-lives.

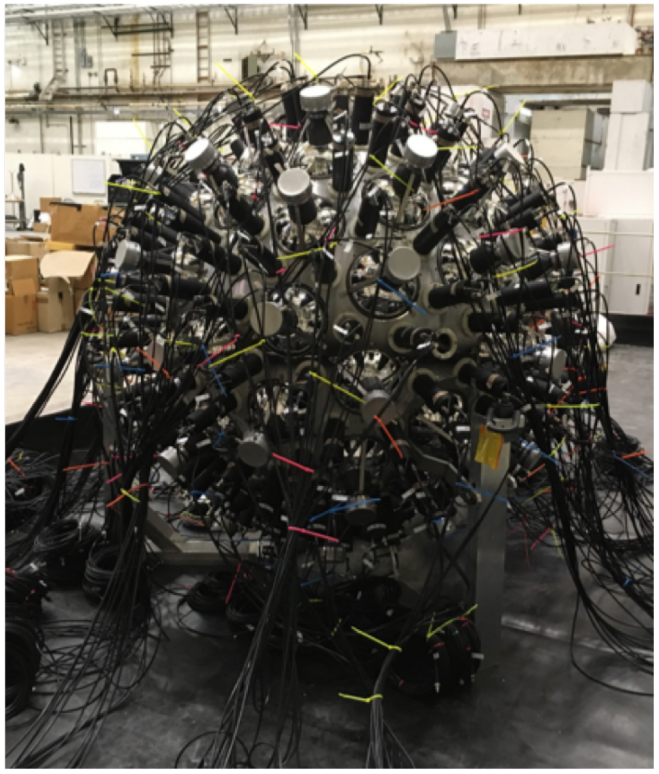
What elements are needed to reach discovery sensitivities beyond $T_{1/2}$~1 x 10^{28} yrs?

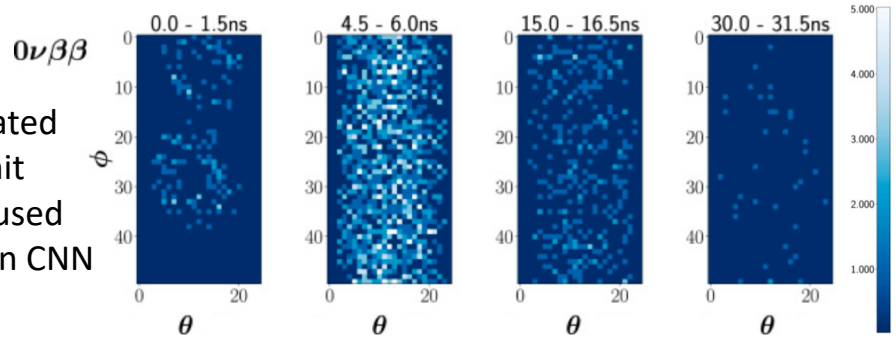
- 10's of tons of isotope: ^{48}Ca enrichment, Tellurium
- High-concentration isotope loading: pressurization, scintillator chemistry, quantum dots
- Cherenkov/scintillation separation: timing, wavelength separation, and tunable wavelength shifters
- Low-cost fast-timing photodetectors: PMTs, LAPPDs, SiPM "wallpaper"
- Modular and low-dead-time DAQ options: ASICs, complex triggering at the FPGA level
- Maximize information use for background reduction: machine learning analysis techniques
- Political and cost feasibility: multipurpose experiment, cross-office/agency collaboration, interdisciplinary (or at least, inter-field) collaboration to improve scintillators, enrichment, low-background materials, etc.

NuDot: A Platform for Liquid Scintillator R&D

Use timing to reduce "irreducible" solar neutrino background: separate Cherenkov/scintillation light and improve event topology reconstruction in liquid scintillator







Simulated PMT hit map, used to train CNN

https://doi.org/10.1016/j.nima.2019.162604

Goals:

- Develop techniques required for sub-ns timing
- Conduct proof-of-concept measurements: 4π calibration sources at surface, 2νββ and/or 2νβ+/EC underground
- Demonstrate machine learning-based event identification
- Serve as a platform for testing new techniques: novel photodetectors, DAQ systems, isotope loading, and liquid scintillator cocktails

What other R&D is needed? What facilities are needed to support it?