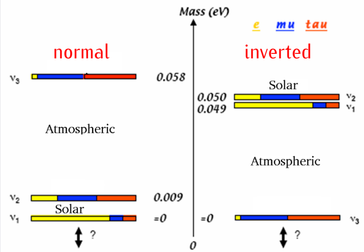
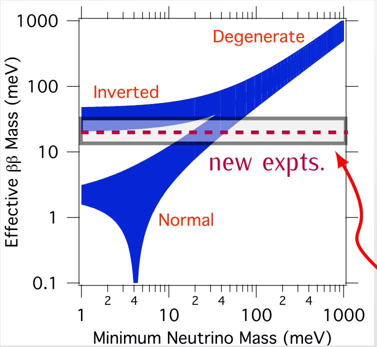
Neutrinoless Double-Beta Decay and Neutrino Mass





Rate proportional to square of effective ν-mass $\langle m_\nu \rangle$, which we want to know:

$$\langle m_\nu \rangle \equiv \sum_i m_i U_{ei}^2$$

If lightest neutrino is light:

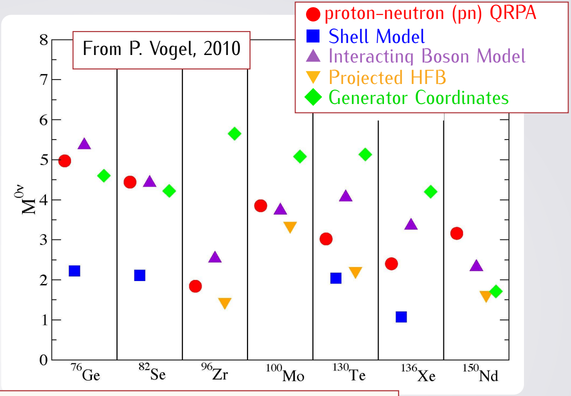
- $\langle m_\nu \rangle \approx \sqrt{\Delta m^2_{sol}} \sin^2 \theta_{sol}$ (normal)
- $\langle m_\nu \rangle \approx \sqrt{\Delta m^2_{atm}} \cos 2\theta_{sol}$ (inverted)

New experiments should be able to see decay if hierarchy is inverted.

But rate also depends on nuclear matrix element, which must be calculated.

Uncertainty due to theoretical error in nuclear matrix element (schematic)

Present Status of Calculations



Comparable level of agreement in 2014.

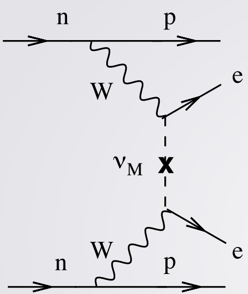
Calculations fall into two broad classes:

I. DFT
- Generator Coordinates (and projected HFB)
- QRPA

II. Shell Model and derivatives
- Shell Model itself
- IBM-2

Goal: improve all of these.

Future Challenges



- Extend *ab initio* shell model calculations to larger nuclei and double-beta operators.
- Extend QRPA to include multi-phonon configurations, real fermionic wave functions (beyond the quasi-boson approximation).
- Extend DFT-based generator-coordinate methods to include proton-neutron pairing, other correlations beyond quadrupole.
- IBM-4 to include proton-neutron pairing.

All of these developments must be accompanied by careful benchmarking, comparison, tests with other observables.

Requirements: Faculty with expertise in each nuclear-structure area, postdocs and students, large-scale computing.