Sterile Neutrinos in Tritium Beta–Decay Experiments

arXiv: 2211.XXXXX

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UK HEP Forum, November 22

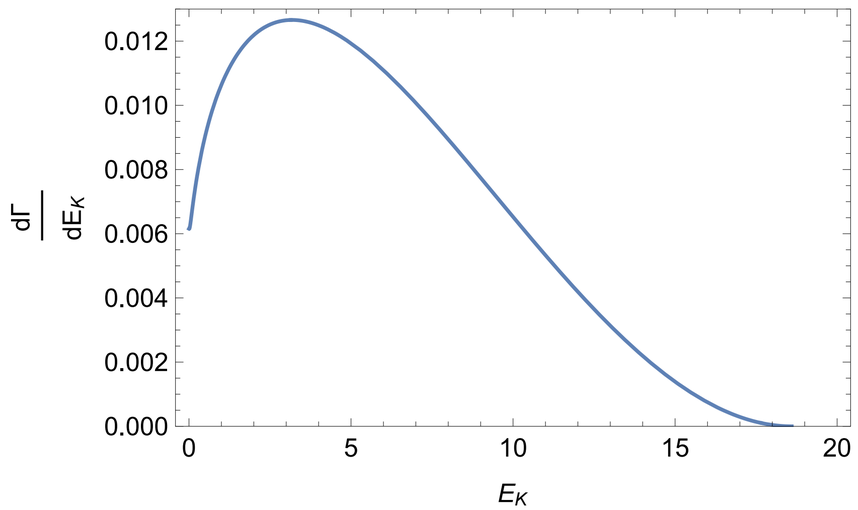
Active Neutrinos

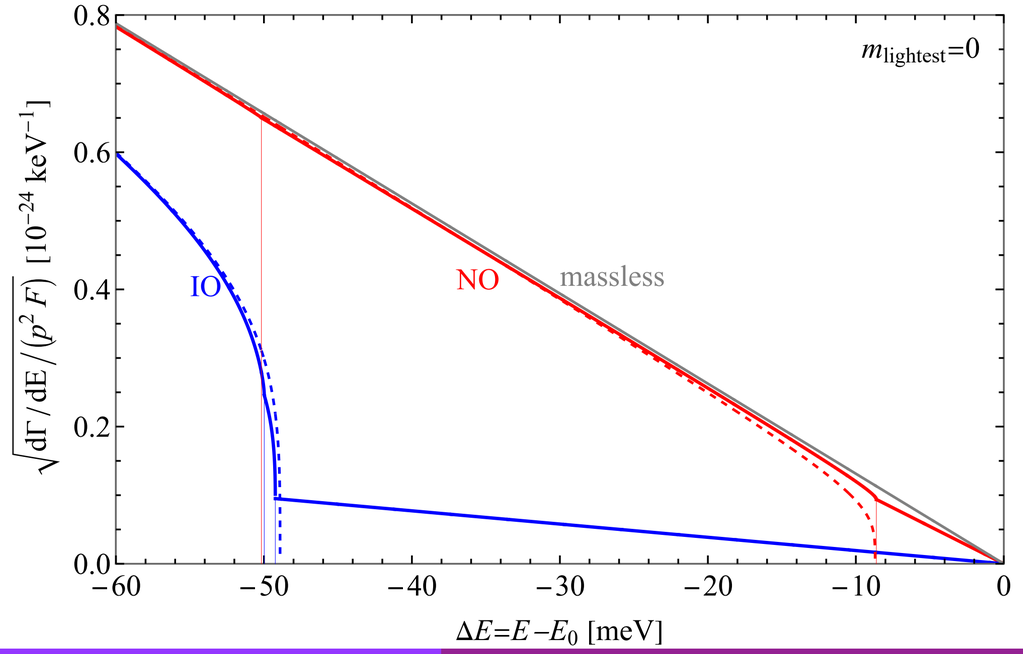
- Neutrino oscillation implies at least two massive eigenstates
- Absolute mass scale and hierarchy unknown, 3 probes

1. Cosmology
2. Neutrinoless double beta decay
3. **Single beta decay**

effective mass

$$m_\beta^2 = \sum_{i=1}^{3} |U_{ei}|^2 m_i^2$$

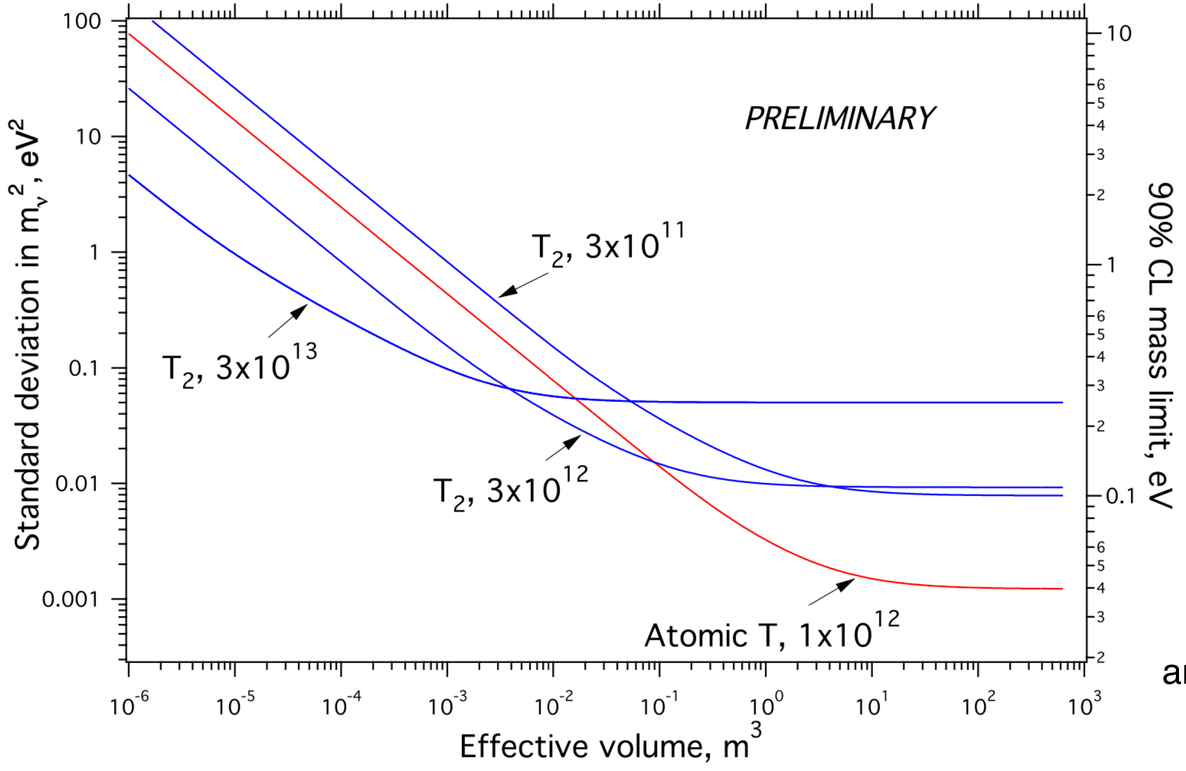




Current best bound is **0.8 eV** by KATRIN

CRES

- Low measurement uncertainty required
- Novel idea of Cyclotron Radiation Emission Spectroscopy (**CRES**)
- CRES and use of atomic tritium promising combination



arXiv:1309.7093v1

Project 8 and CRES Demonstration Apparatus (CRESDA)

$$f = \frac{1}{2\pi}\frac{eB}{E_e}$$

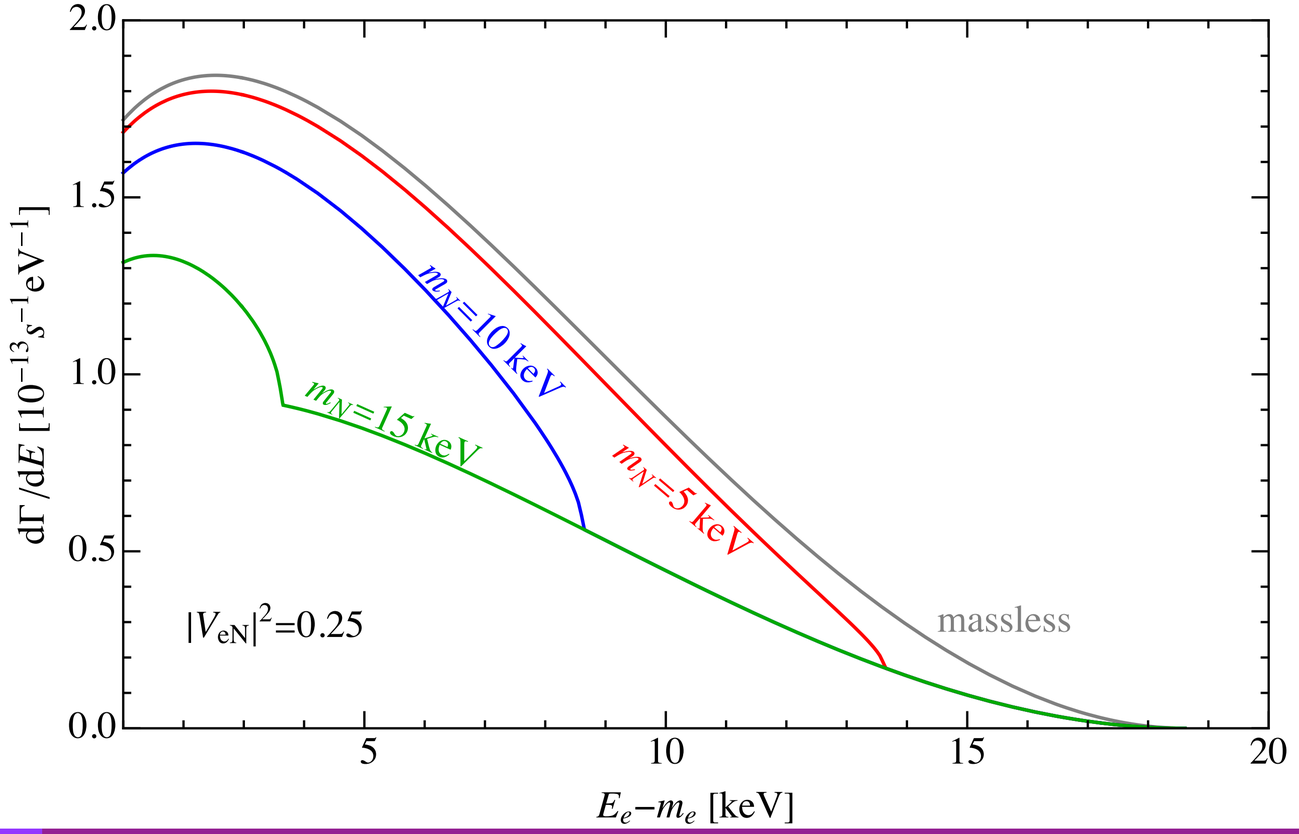
Sterile States

- In one active + one sterile model
- Sterile neutrino with mass $0 < m_N \leq 18.6$ keV produces kink
- **CRES experiments with aim of measuring active mass could also be used for sterile searches**

$$\begin{cases} \nu_e = \sqrt{1 - |V_{eN}|^2}\ \nu_1 + |V_{eN}|\ \nu_2 \\ N = -|V_{eN}|\ \nu_1 + \sqrt{1 - |V_{eN}|^2}\ \nu_2 \end{cases}$$

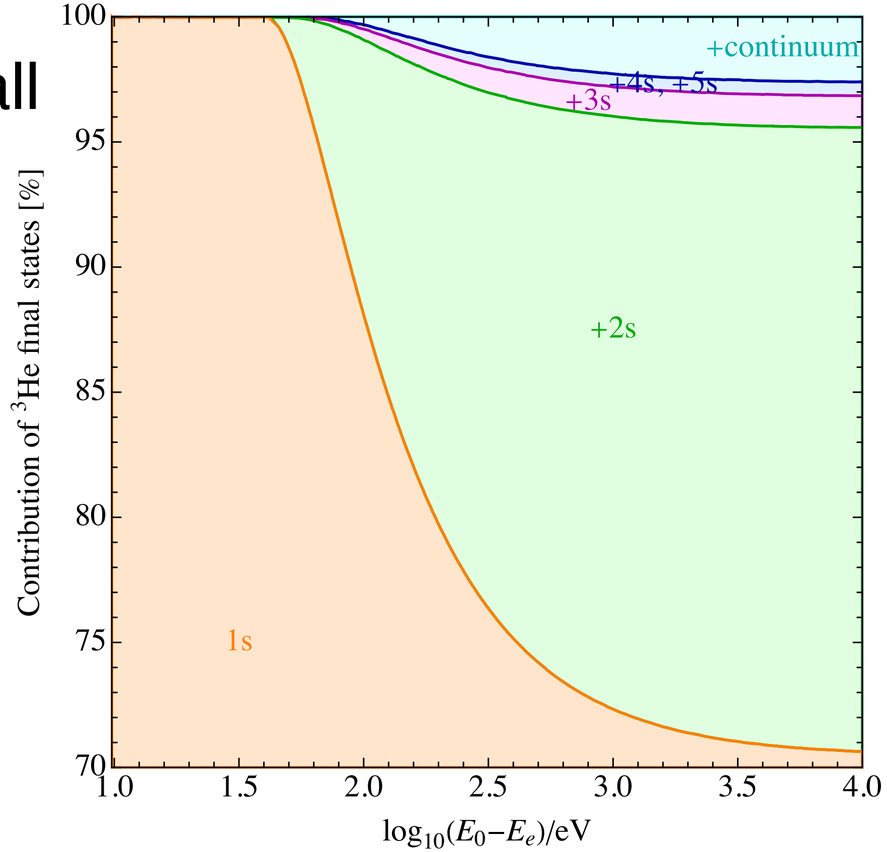
$|V_{eN}|^2 \longrightarrow$ active–sterile mixing angle

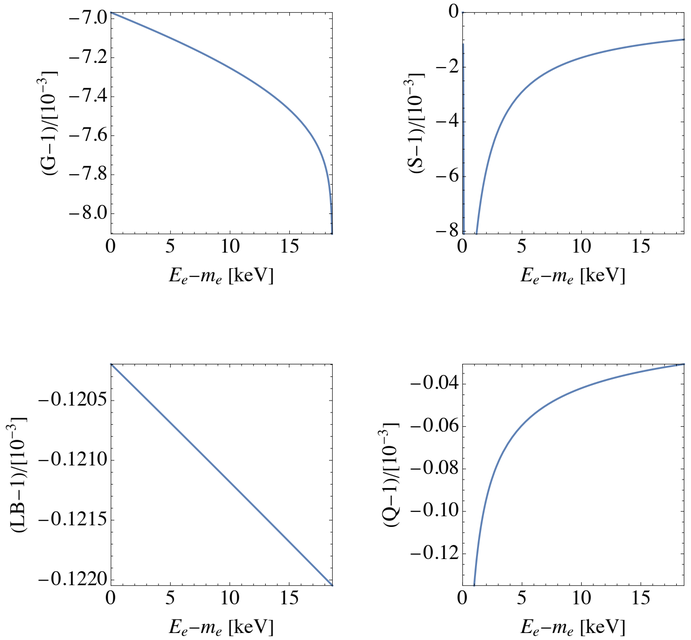
$$\frac{d\Gamma_{tot}}{dE_K} = (1 - |V_{eN}|^2)\frac{d\Gamma_{SM}}{dE_K} + |V_{eN}|^2 \frac{d\Gamma_{sterile}}{dE_K}$$



Theoretical Corrections

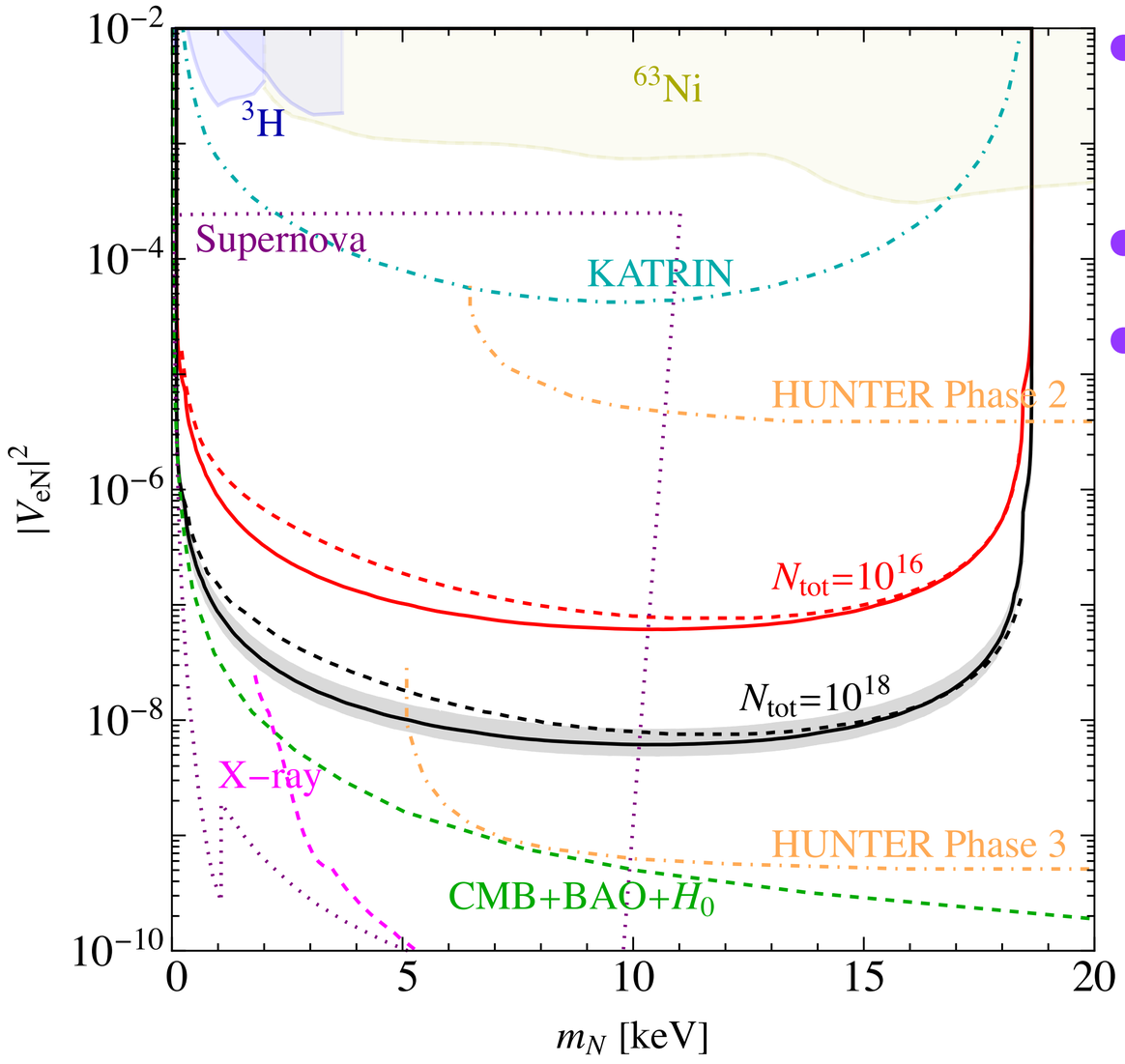
- **Theoretical corrections** to spectrum (combined into overall multiplicative factor)
- Fermi function (F)
- Radiative corrections (G)
- Finite size nucleus effects (L and B)
- Recoiling nuclear charge (Q)
- Nuclear screening (S)





He^+ state	Excitation energy [eV]	$\lvert T_{fi}^{(0)}\rvert^2$
$1s$	0	70.36%
$2s$	40.81	24.98%
$3s$	48.37	1.27%
$4s$	51.02	0.38%
$5s$	52.24	0.17%
continuum	>54.42	2.63%

Projected Limits



- In this mass range, currently best bound is of order $10^{-2} - 10^{-3}$
- Performed χ^2 and used Asimov data set
- Our analysis shows **sensitivities of order 10^{-8} are achievable**, for a total statistics of 10^{18} events (black line = statistical limit)

Sufficient to distinguish between NO and IO hierarchies

$$t^{min,A} = \left[\sum_{i=1}^{N_{bins}} \frac{(N_{BSM}^{(i)} - (1+A)N_{SM}^{(i)})^2}{(1+A)N_{SM}^{(i)}} + \left(\frac{A}{\sigma_A}\right)^2 \right]$$