**Introduction**

Right-handed neutrinos are a candidate extension to the Standard Model (SM) which would facilitate generation of sub-eV neutrino masses.

They would not participate in SM interactions – ‘sterile.’ Their discovery would indicate new physics beyond the SM.

They could be detected by possible mixing with active ($e, \mu, \tau$) neutrinos.

Three active neutrinos + one sterile:

\[
\begin{aligned}
\nu_e & \rightarrow \nu_{\mu}, \\
\nu_\mu & \rightarrow \nu_{\tau}, \\
\nu_\tau & \rightarrow \nu_e
\end{aligned}
\]

**Atomic Cs Source**

Develop an atomic Cs source for loading a trap with $\sim 10$ $\mu$Ci CsCl every few weeks. 10 $\mu$Ci $^{131}$CsCl: $\sim$1 Ci ($I_{1/2} = 9.7$ d), 3 x $10^{15}$ Cs atoms.

We chose a thermionic emission-based source, which emits a directional, voltage-controlled atomic beam with geometry-determined divergence and recovers atoms which do not clear the exit aperture.

**Decay Source Details**

$^{131}$Cs trapped in a MOT provides a sufficiently low-temperature ($20\, \mu$K) and spatially localized (1 mm) decay source.

Continuously maintain decay source cloud with $N > 10^6$ for $t \approx 1$ yr, while running a data collection sequence involving switched MOT.

Load with a second MOT through gravity-aided transfer. Separation of loading and experiment regions reduces reconstruction background.

Stable and/or automated assemblies desired: custom beam control boxes, kinematic 50 mm beam collimators, custom fiber coupling.

**MOT Reaction Microscope Layout**

Reconstruct vector momenta of $^{131}$Cs decay products using precision timing and position sensitive detectors, and calculate the missing neutrino mass.

$^{131}$Cs: 100% electron capture decay, non-penetrating radiation, no additional gamma from daughter, alkali level structure.

$^{131}$Cs Decay Sequence

1. K-capture decay
2. Trigger N-shell 34 keV X-ray
3. Auger electron(s) (20 – 120 eV)

$W_{\text{bias}} = 3.1\, \text{eV}$

Saha-Langmuir equation

\[ n_e = \frac{n_0}{1 + e^{\frac{W_{\text{bias}} - \frac{1}{2}kT}{kT}}} \]

$V_{\text{bias}}$

Tantalum-threaded crucible

$W_{\text{Au}} = 5.30\, \text{eV}$

$W_{\nu} = 3.1\, \text{eV}$

$I_{\nu} = 3.89\, \text{eV}$

Orthotropic Oven

**Projected Sensitivity**

Solid lines are existing experimental bounds. Dotted lines are projected HUNTER sensitivities for a 1-year runtime.

Phases 2 and 3 feature upgrades that will increase energy and coupling resolution: increased MOT population, greater x-ray collection solid angle, larger MCP area.

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