Calculation of the WIMPs-nucleus interaction cross-section

$$\mathcal{L} = \frac{g^2}{2M_w^2}\sum_q (\bar{\chi}\gamma^\mu\gamma_5\chi\bar{\psi}_q\gamma_\mu[V_q + A_q\gamma_5]\psi_q + \bar{\chi}\chi S_q\frac{m_q}{M_W}\bar{\psi}_q\psi_q + \bar{\chi}\gamma_5\chi P_q\bar{\psi}_q\gamma_5\psi_q)$$

➢ Spin-dependent cross-section

$$\sigma_{\mathrm{SD}} = \frac{32\mu^2}{\pi}G_F^2 J(J+1)\Lambda^2$$

$$\Lambda \equiv \frac{1}{J}\left(a_{\mathrm{p}}\langle S_{\mathrm{p}}\rangle + a_{\mathrm{n}}\langle S_{\mathrm{n}}\rangle\right)$$

- G_F is the Fermi constant, J is the spin of the nucleus
- $<S_P>$ and $<S_n>$ are the average spin contributions from the proton and neutron groups, respectively
- a_P and a_n are the effective couplings to the proton(neutron)

➢ Spin-independent cross-section

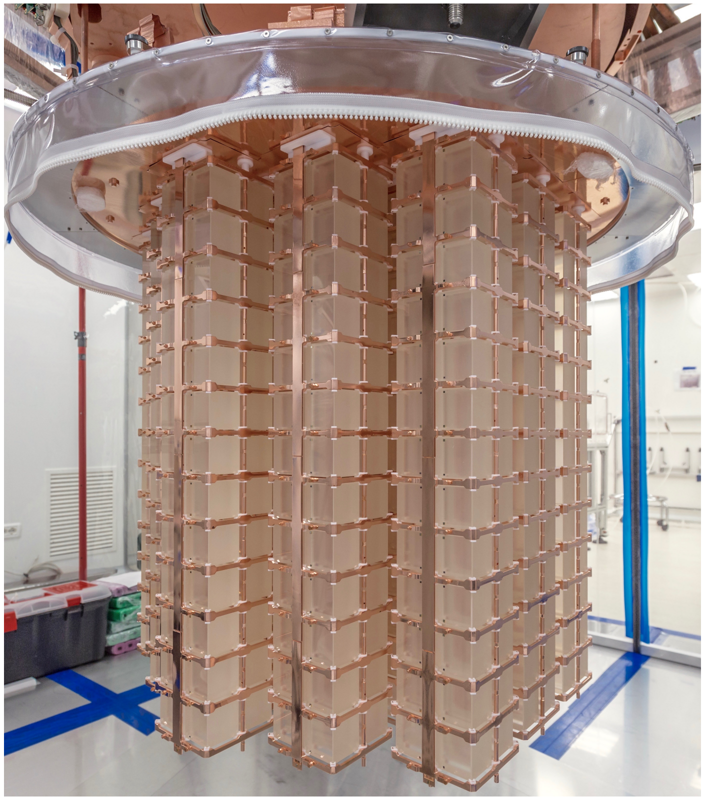
$$\sigma_{\mathrm{SI}} = \frac{4}{\pi}\mu^2\left[Zf_{\mathrm{p}} + (A-Z)f_{\mathrm{n}}\right]^2$$

- The reduced mass $\mu = \frac{m_N m_\chi}{m_N + m_\chi}$ where m_N is the nuclear mass
- Z and A-Z are the number of protons and neutrons in the nucleus, respectively
- $f_p(f_n)$ is the effective coupling to the proton(neutron)
- For identical couplings ($f_p = f_n$)

$$\sigma_{\mathrm{SI}} = \frac{\mu^2}{\mu_{\mathrm{p}}^2}A^2\,\sigma_{\mathrm{p,SI}}$$

Investigation of the Alpha Background in CUORE

K. Alfonso

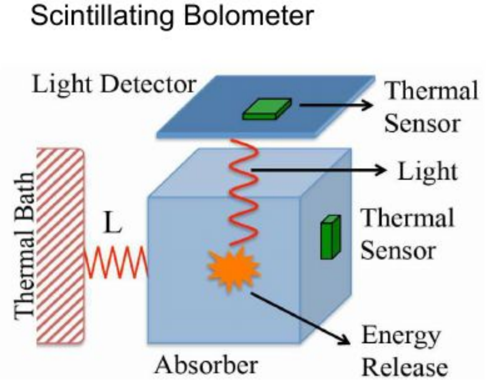


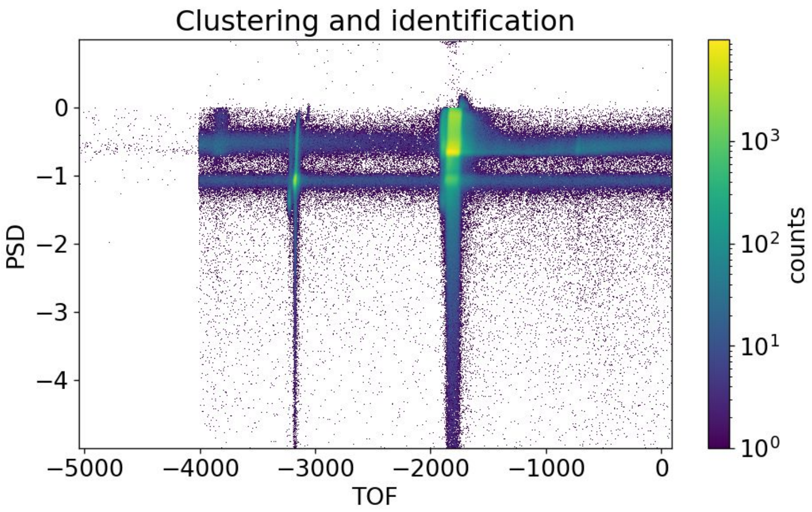
- The CUORE experiment searches for neutrinoless double-beta ($0\nu\beta\beta$) decay of ^{130}Te.
- A dominant source of background in the $0\nu\beta\beta$ decay region of interest (ROI) are degraded alpha particles originating from contaminated surfaces facing the detector.
- Using Geant4 simulations, we study the background alpha spectrum shape to identify background sources and their locations in the CUORE detector.

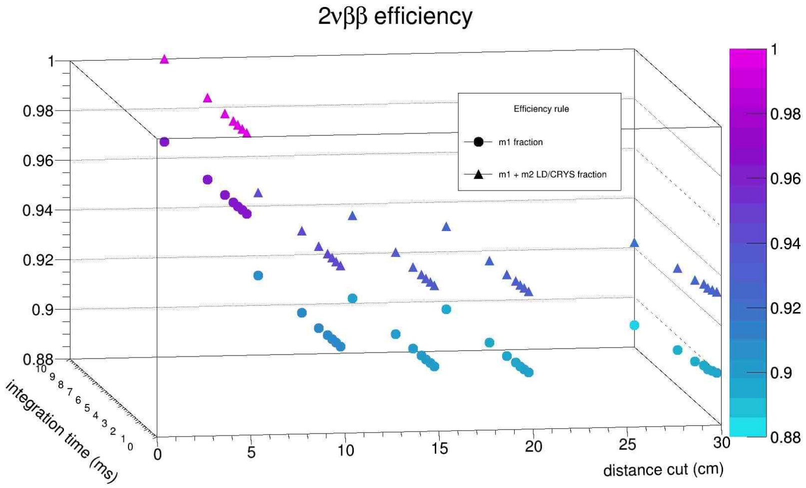
Addressing backgrounds for CUPID (Joe C.)

CUPID: a 0νββ search using cryogenic bolometric technique

1. Monte-Carlo studies of 2νββ tagging in full detector geometry
2. Fast neutron activation data from TUNL







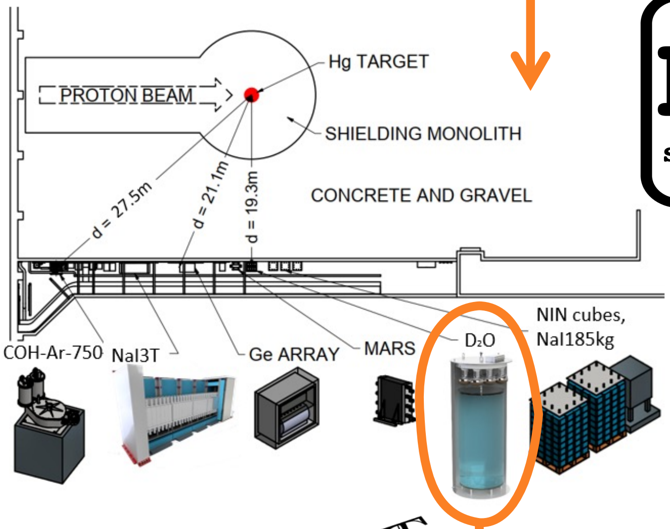
VIRGINIA TECH

A Heavy Water Detector for Flux Normalization at COHERENT

Karla Tellez-Giron-Flores
on behalf of the COHERENT Collaboration

The Center for Neutrino Physics


Spallation Neutron Source (SNS), Oak Ridge National Lab, Tennessee

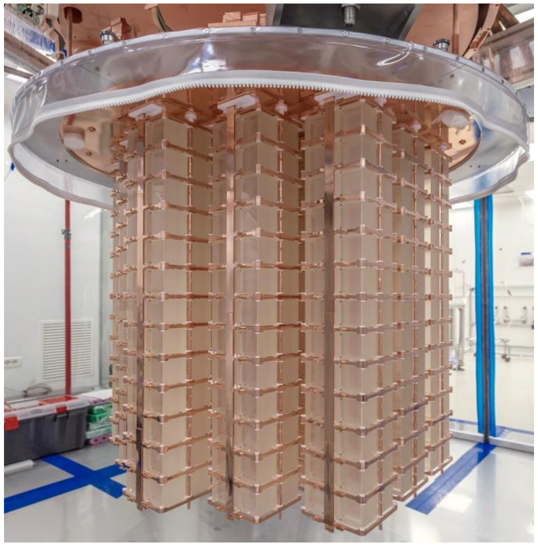


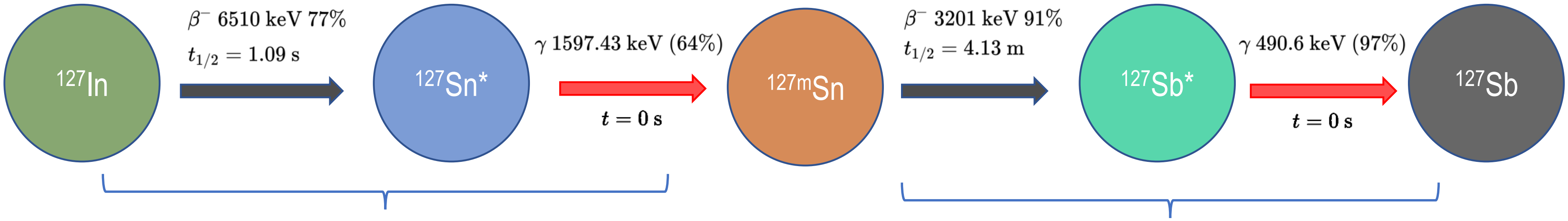
COHERENT
D_2O
SNS ν FLUX MONITOR

- Coherent Elastic Neutrino-Nucleus Scattering -> **CEvNS**
- **COHERENT** is a suite of detectors dedicated to the study of CEvNS, using neutrinos produced by SNS.
- COHERENT made the **first-ever** observation of CEvNS!
- Largest systematic uncertainty, common to all COHERENT systems: **SNS neutrino flux uncertainty.**
- **Fix:** a **D_2O detector** to measure the flux!
- This poster: details about the detector and expected performance.

Invisible Tri-nucleon decay in ^{130}Te with CUORE

- CUORE is a bolometric search for rare decays
- Tri-nucleon decay is one of the most promising processes to look for baryon number violation
  - Supported by multiple BSM models
- Tri-proton decay in ^{130}Te can be searched for by searching for decay signatures of daughter nuclei in the CUORE detector volume
  - Delayed coincidence-based analysis





^{127}In $\xrightarrow[t_{1/2} = 1.09\ \mathrm{s}]{\beta^-\ 6510\ \mathrm{keV}\ 77\%}$ ^{127}Sn* $\xrightarrow[t = 0\ \mathrm{s}]{\gamma\ 1597.43\ \mathrm{keV}\ (64\%)}$ ^{127m}Sn $\xrightarrow[t_{1/2} = 4.13\ \mathrm{m}]{\beta^-\ 3201\ \mathrm{keV}\ 91\%}$ ^{127}Sb* $\xrightarrow[t = 0\ \mathrm{s}]{\gamma\ 490.6\ \mathrm{keV}\ (97\%)}$ ^{127}Sb

Energy cut 1

Time cut: n x $t_{1/2}$

Energy cut 2

T2K And NOν Anomalies

- The mass ordering, normal ordering (NO) or inverted ordering (IO), has remained unknown
- We do not know if θ_{23} is in the Lower Octant (LO), i.e. $\theta_{23} < 45^\circ$ or in the Higher Octant (HO), i.e. $\theta_{23} > 45^\circ$.
- The value of $\mathcal{CP}$ phase is unclear

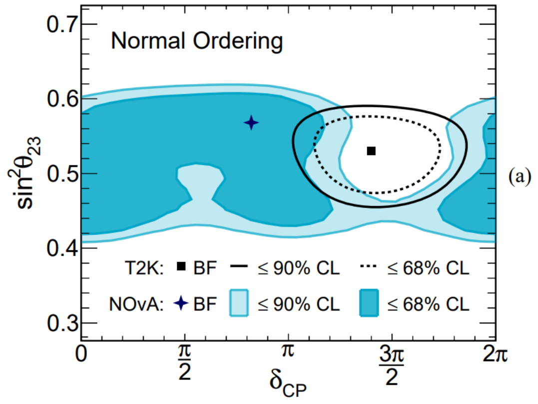
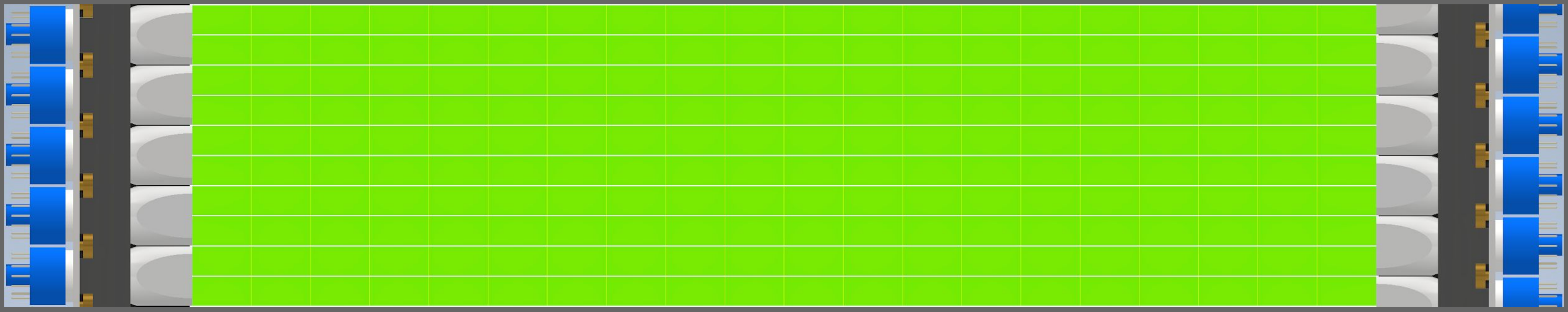


Figure 1: $\sin^2\theta_{23}$ vs $\delta_{\mathcal{CP}}$ with the 68% and 90% confidence level. The cross represents the NOνA's best-fit value and the square represents the T2K's.

Halliday-Suranyi Method for the Anharmonic Oscillator

- An anharmonic oscillator with a quartic perturbation is one of the simplest toy models to study the behavior of QFTs. Its perturbation series is known to diverge.
- When it is regulated and split in a specific manner, the series expansion for the energy eigenvalues converges regardless of the size of the coupling.
- It is possible to optimize the convergence by appropriately selecting the value of that regulator.
- The approximation found using the most effective method is better than 0.1% for a 3rd order perturbative calculation, without any small expansion parameter.
- The extension of this method to d+1 dimensions could give new insights into more realistic QFTs.

Upgrades to MiniCHANDLER



- We are doing a second data taking run with an upgraded MiniCHANDLER; a 3D plastic segmented mobile surface-level antineutrino detector.
- New optics and photomultiplier tubes increase the energy resolution by over a factor of 2.
- We have cut the segments in half and added additional lithiated sheets in between half-layers, increasing our neutron capture efficiency and decreasing our neutron capture time.