Poster ID: 32

Simulation Study of CUPID Sensitivity to Low Energy Solar Neutrinos

NEUTRINO '26

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Interaction

Target: *pp* & ^{7}Be solar neutrinos

Isotope: ^{100}Mo

Interaction: charged current (CC)

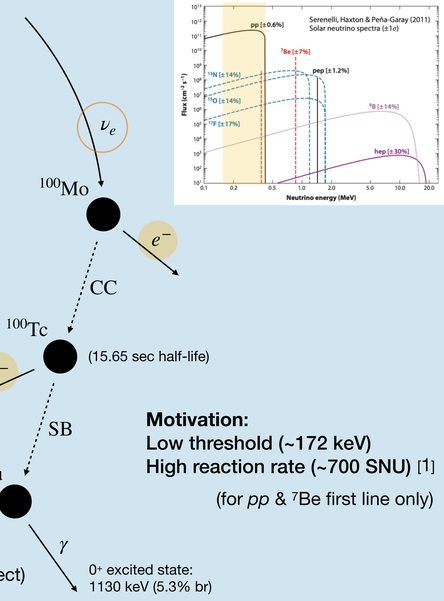
$$^{100}\mathrm{Mo} + \nu_e \rightarrow {}^{100}\mathrm{Tc} + e^-$$

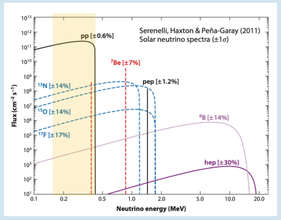
^{100}Tc (half-life: 15.65 sec) will go through **single beta (e^-) decay (SB)** to ^{100}Ru

$$^{100}\mathrm{Tc} \rightarrow {}^{100}\mathrm{Ru} + e^- + \bar{\nu}_e\ (+\gamma)$$

Event rate: 17.7 counts/yr

(*pp* & ^{7}Be first line, including oscillation effect)





Motivation:
Low threshold (~172 keV)
High reaction rate (~700 SNU) [1]
(for *pp* & ^{7}Be first line only)

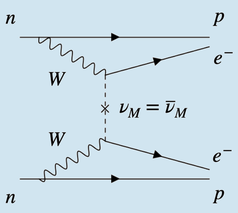
The CUPID Experiment

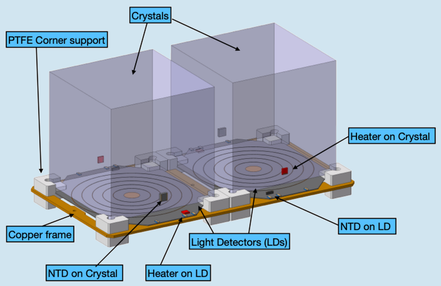
Target: Neutrinoless double beta decay (0νββ)

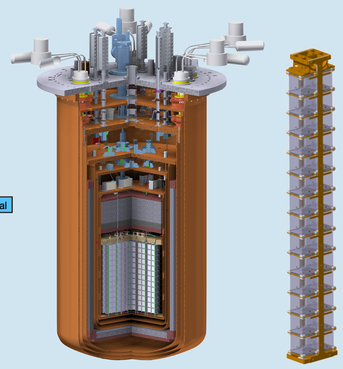
0νββ Isotope: ^{100}Mo

Isotope mass: 240 kg (~95% enrichment)

Detector: 1596 Li_2MoO_4 crystals ($(4.5\ cm)^3$ cubes) with heat and light readout







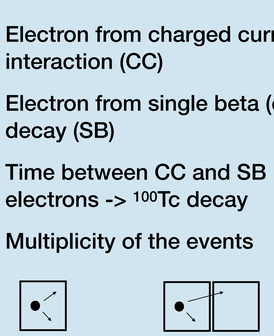
MC Simulation

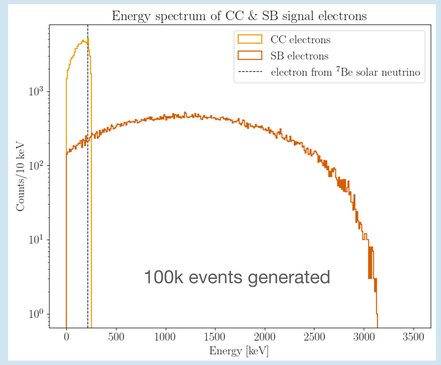
Simulation tools: Geant4-based CUPID package **Agata & Ares**

- Particle interactions in CUPID towers (Agata)
- Detector effects, energy resolution, etc. (Ares)

Solar Neutrino Signal

- Electron from charged current interaction (CC)
- Electron from single beta (e^-) decay (SB)
- Time between CC and SB electrons -> ^{100}Tc decay
- Multiplicity of the events





Event Selection Cuts:

- **1st event energy:** [60, 248.8] keV
- **2nd event energy:** [60, 3206.4] keV
- **Time between events:** [1, 30] sec
- Both events in the **same crystal (M=1)**

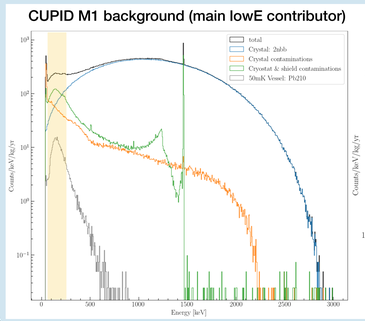
After the event selection cuts,
solar ν rate ~9 counts/yr
(cut efficiency ~52%)
background rate ~9e5 counts/yr
(more than 2 orders of mag. reduction)

Background to Solar Neutrinos

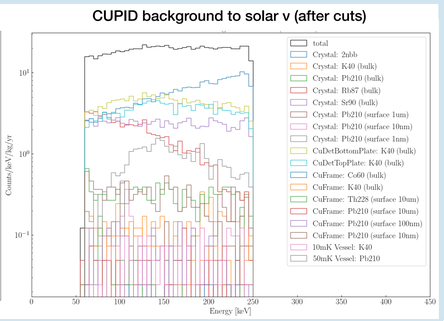
Events that mimic the same delayed coincidence feature as solar ν signal:
- energy, time, multiplicity

- 100Mo double beta decay (2νββ)
- Contaminants in the crystals, copper frames, cryostat and shields
  - ^{40}K, ^{87}Rb, ^{90}Sr, etc.

CUPID M1 background (main lowE contributor)



CUPID background to solar ν (after cuts)



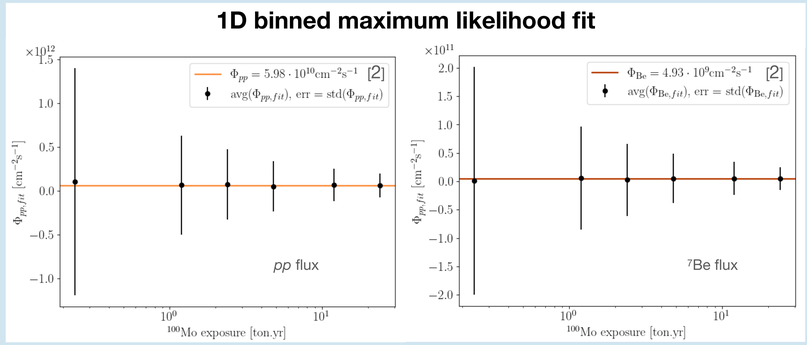
Statistical Analysis

Core question: What experimental performance (exposure and background level) would be needed to detect solar neutrino through CC with ^{100}Mo?

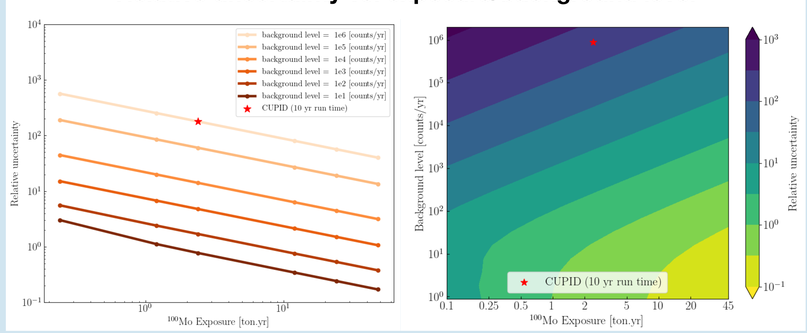
Conducted **1000 toy experiments** with signal and background PDFs for **each exposure-background level parameter pair.**

- **Background level:** [1e1, 1e6] counts/yr
- **^{100}Mo exposure:** [0.1, 45] ton.yr

1D binned maximum likelihood fit



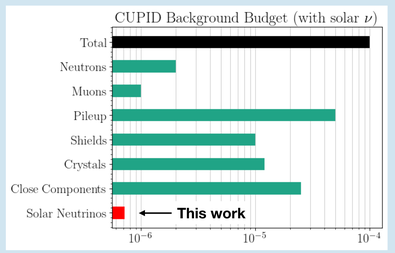
Relative uncertainty vs. exposure/background level



Discussion

Despite having **good rates of solar neutrino CC interaction with ^{100}Mo** [1,3], the **high background rate** makes CUPID **unfeasible to make a good detection** with known methods and a reasonable financial budget.

Solar neutrino CC events are **not a significant background source to 0νββ** for CUPID, on the order of ***1e-7 counts/(kg.keV.yr)*** in [3019, 3049] keV.



References

[1] Ejiri, H. and Elliott, S. R., doi: 10.1103/PhysRevC.89.055501 (2014)
[2] Vinyoles, N. et al., doi: 10.3847/1538-4357/835/2/202 (2017)
[3] Hazama, R. et al., doi: 10.1016/j.nuclphysbps.2004.11.025 (2005)

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