A Search for Neutron/Anti-Neutron Oscillations with Ultra-Cold Neutrons

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- Why UCN?
- Present Status of UCN Sources World Wide.
- The Proposed NCSU UCN Source.
- A Straight Forward UCN Oscillation Detector.

Why use UCN?

- Properties: $E \sim 10^{-7} eV$

  $v \sim 8 m/s$

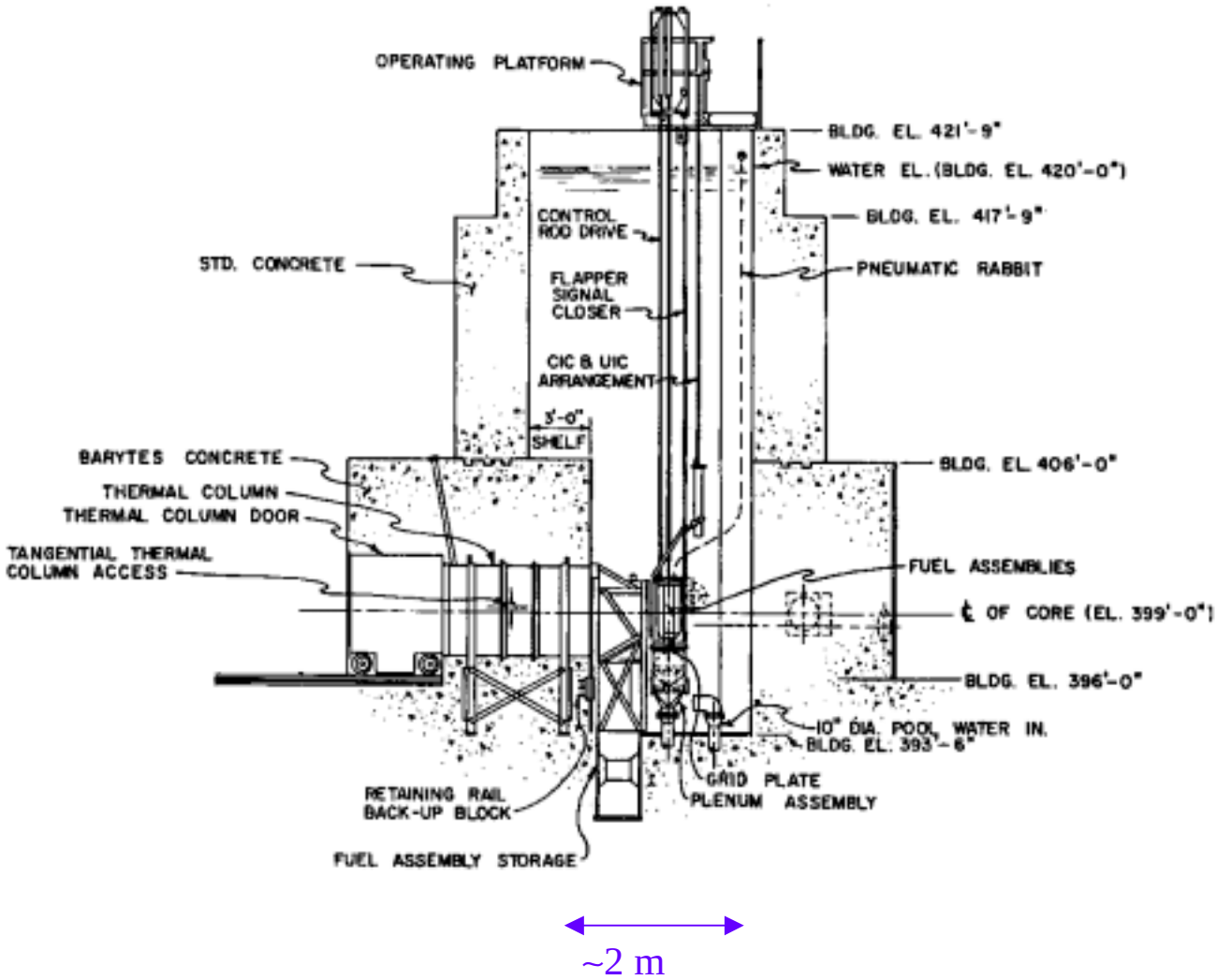
  $t \sim 1 mK$

- Advantages:
  - Low Background
  - Long Free-Flight Time
  - Relatively Simple (and cheap?)

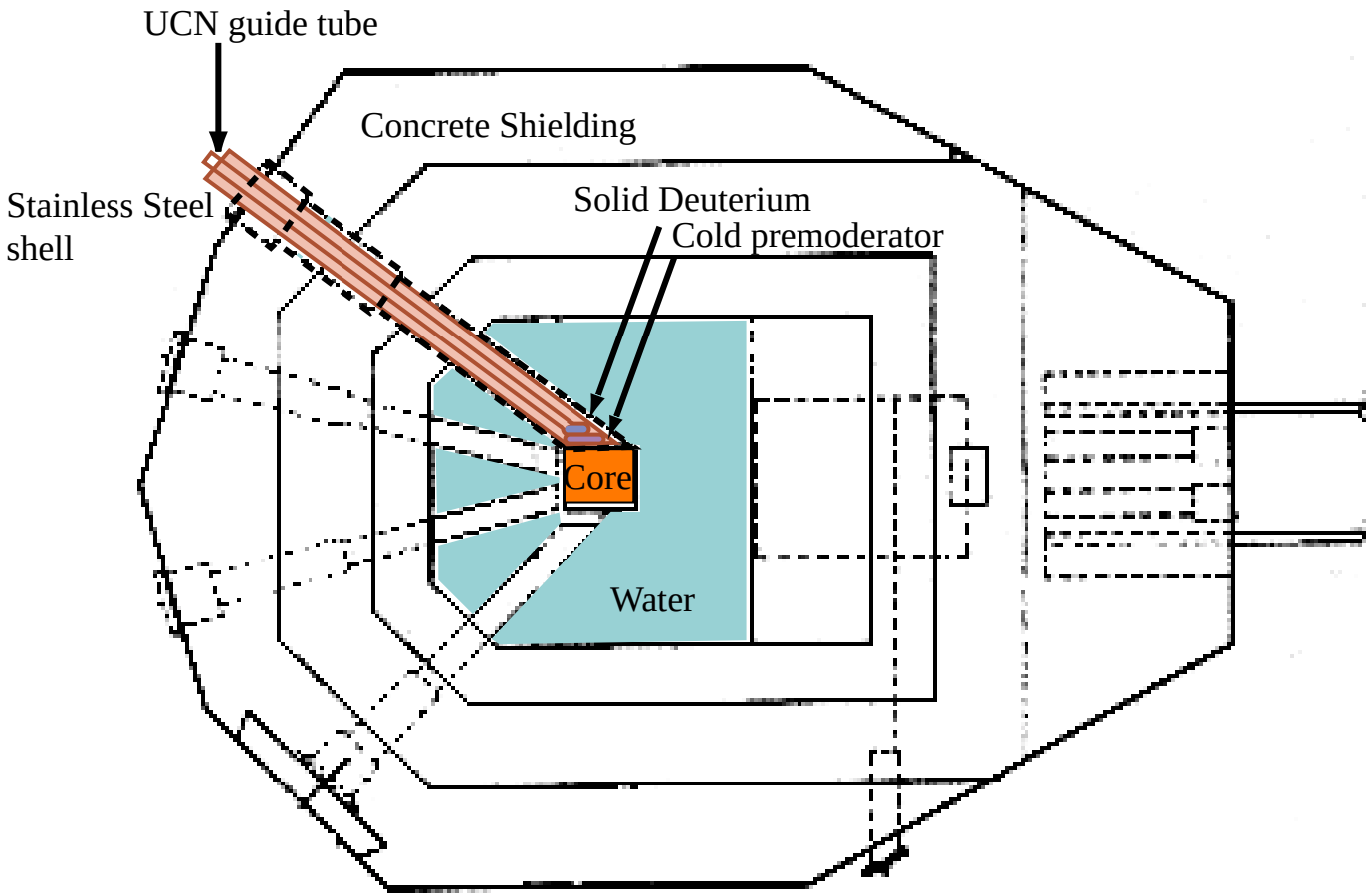
Current and Future UCN Sources

Institution	Source Type	Density (UCN/cc)
ILL	Reactor	40
LANL	Spallation	400
FRMII	Reactor	10^4
PSI	Spallation	$2.5x10^3$
NCSU	Reactor	$1.5x10^3$

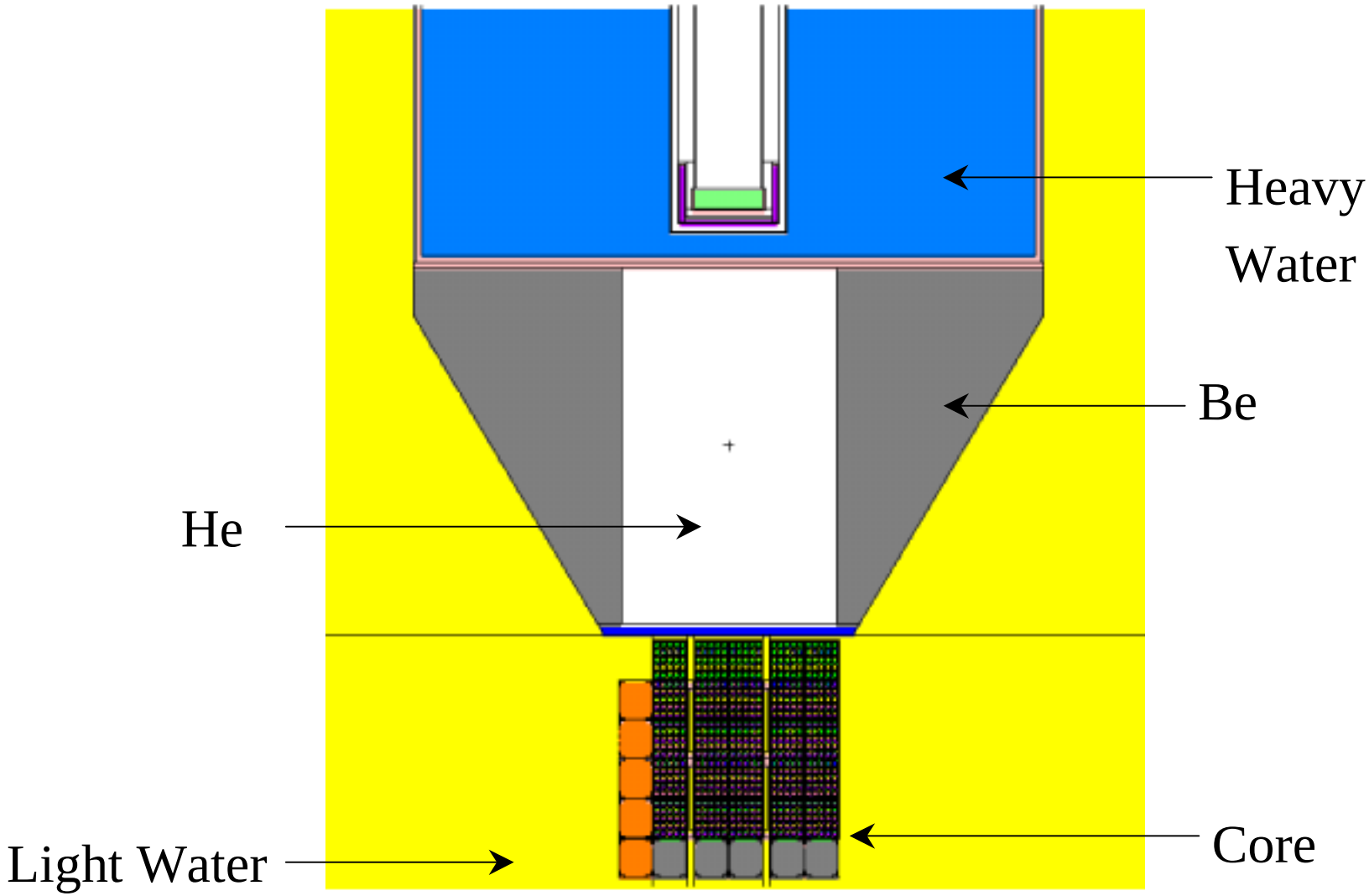
Reactor Cross Section



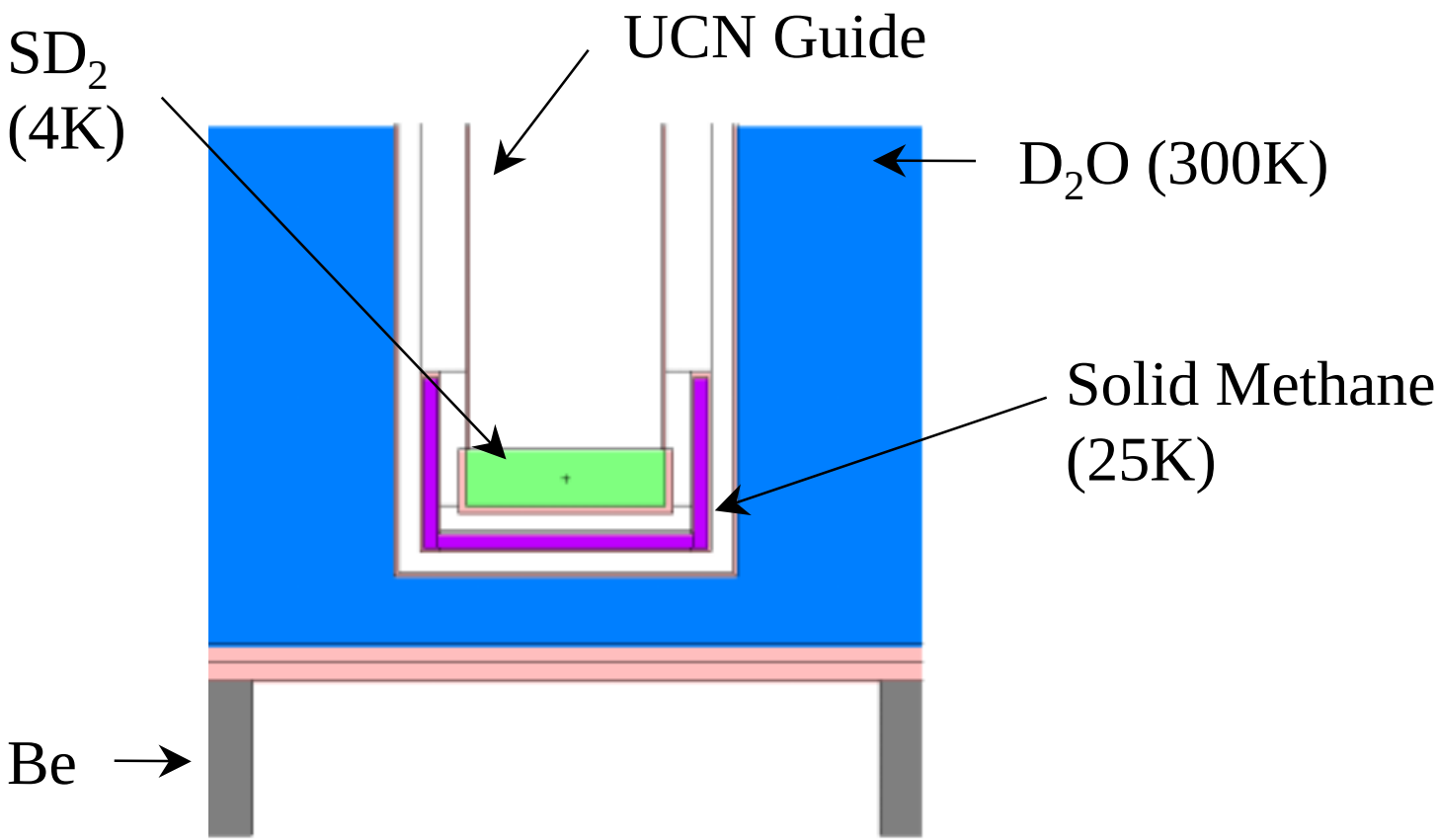
Top View of Reactor and UCN Source



NCSU UCN Source Design



NCSU UCN Source Details



NCSU Source Performance Estimates

Expect

- 1.5×10^3 UCN/CC
- 1.5×10^7 UCN/s

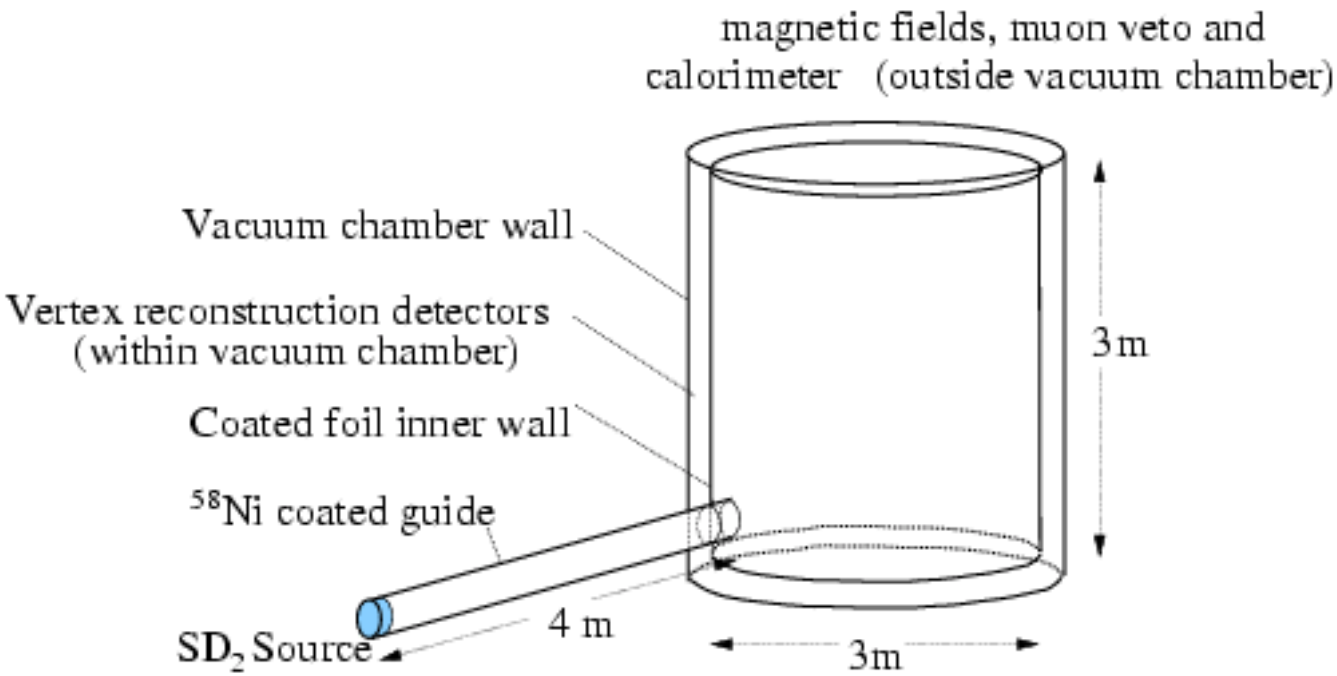
- Assume UCN production rates measured at LANL.
- Assume a UCN SD_2 lifetime of 35ms (achieved at LANL).
- Assume measured loss rates for Ni^{58} guides.
- Improve by
  - Changing guide material (factor of 2).
  - Increasing reactor power.
  - Increasing SD_2 volume.
  - Increasing UCN SD_2 lifetime.

Experimental Approach

➢S. Marsh, K.W. McVoy Phys. Rev. D 28(1983) p. 2793

- Fill a sufficiently large UCN bottle with the greatest UCN density.
- Reduce the magnetic field to less than 10nT.
- Use the Earth's field to confirm a positive result.
- Use a diamond-like wall coating for the bottle walls.
- Anti-neutrons are detected by observing capture in carbon.
- Detector would have a cosmic veto and vertex reconstruction capabilities.
- UCN Density Monitor

Oscillation Experiment Sketch



Guide diameter .16 m

Holding volume 2.1×10^7 cm^3

Preliminary Evaluation

- Assume an average coherence (free flight) time of 1sec.
- The Figure of Merit is $\sqrt{N}$
- N= Flux x Holding Time.
- N = 1.5 x10^7 x 560 sec = 9x10^9
- Potential Improvement to 1x10^{11}
- “Discovery Potential” N<t^2>=10^{11}

Conclusion

- A UCN neutron oscillation experiment at the NCSU reactor is feasible.
- Very conservative estimates indicate such an experiment will easily outperform current limits.
- A UCN experiment maybe competitive with the next generation of cold neutron experiments.