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Introducing the SnowBall Chamber
Supercooled Water for Dark Matter and Neutron Detection

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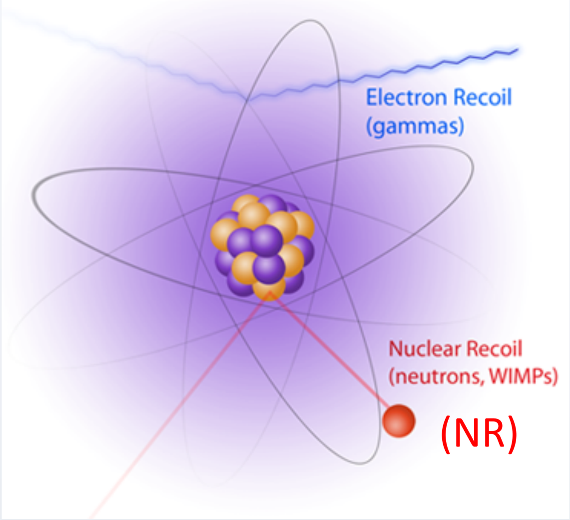
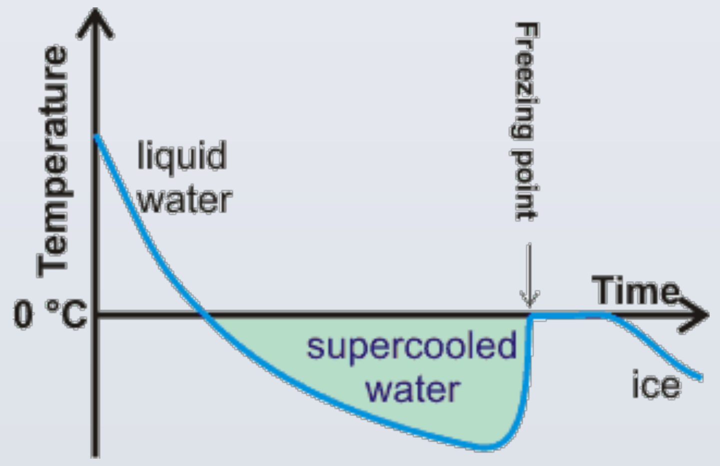
SnowBall Chamber

- Detect incoming particle with phase transition from liquid to solid
- Similar to cloud, bubble chamber

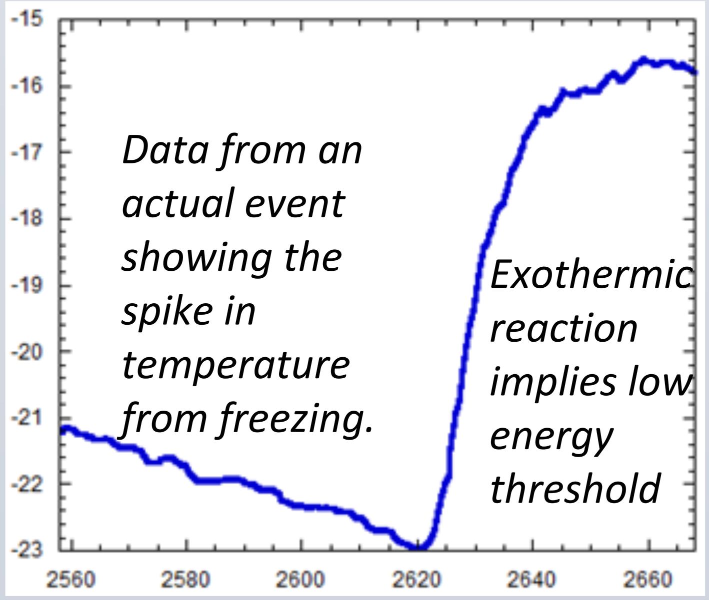


Super Cooling:

- Liquid cooled below normal freezing point, metastable



- Impurities, scratches, or vibrations cause nucleation. [1]
- Spontaneous nucleation limit -48˚C

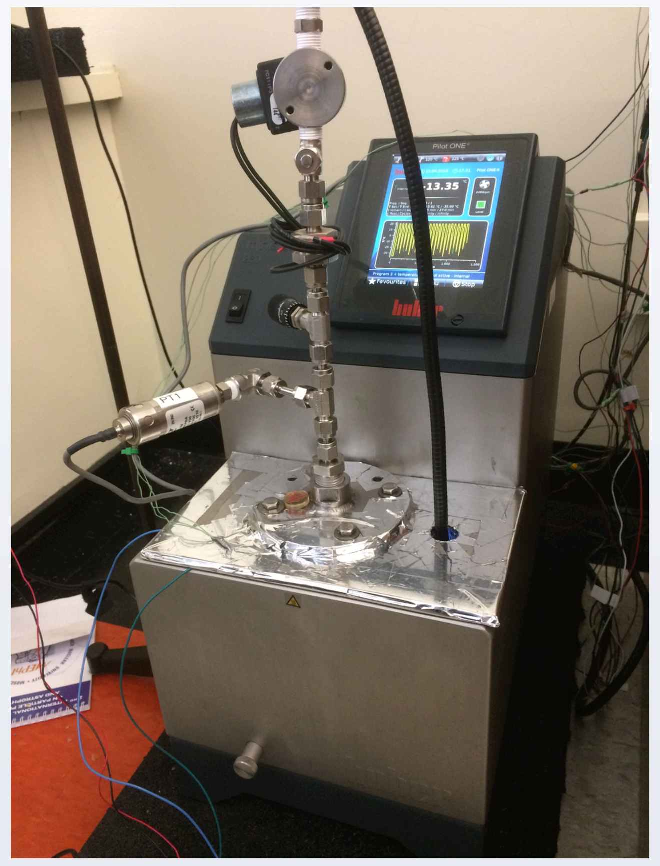


Goals

- Demonstrate sensitivity to NR
- Explore low-mass dark matter and coherent neutrino scattering
- Explore use for detecting fissile materials for homeland security application: cargo monitoring

Methods

- The water filtered and distilled through 20 nm membrane
- Smooth quartz vessel to minimize nucleation sites
- AmBe as a neutron calibration source, Cs-137 source to demonstrate gamma discrimination
- The thermal bath is cooled at a rate of -2˚C/min until the water freezes, then melted and brought back to the starting temperature before restarting.

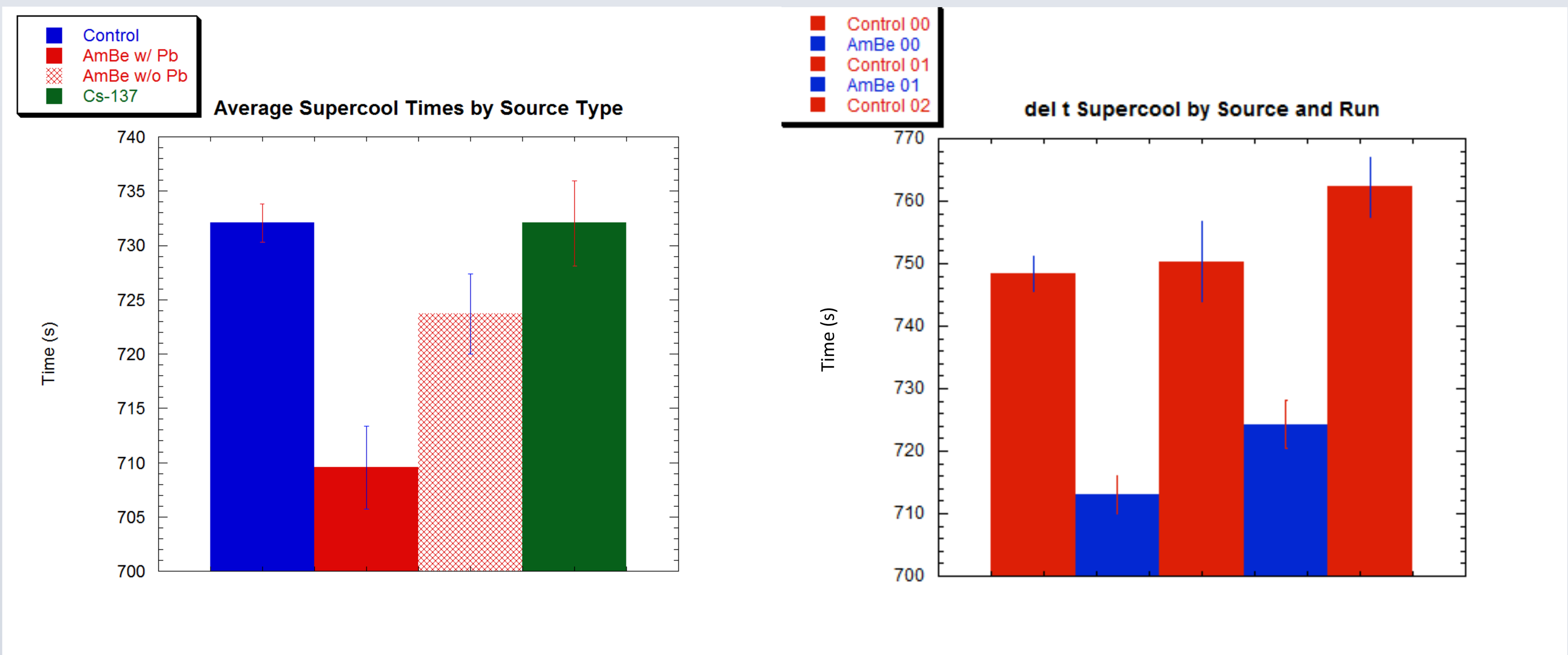


Current setup in thermal bath. 3 thermometers and borescope for data acquisition, muon veto beneath.

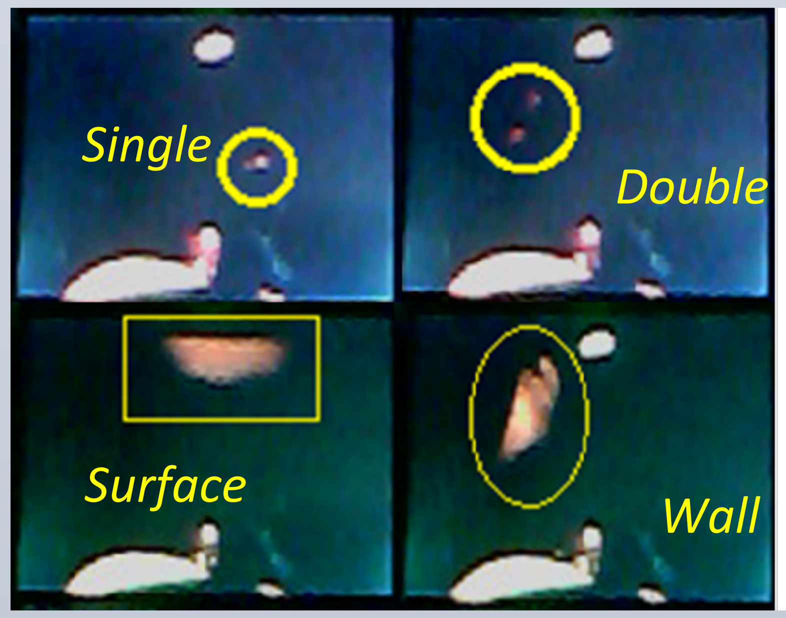
Results

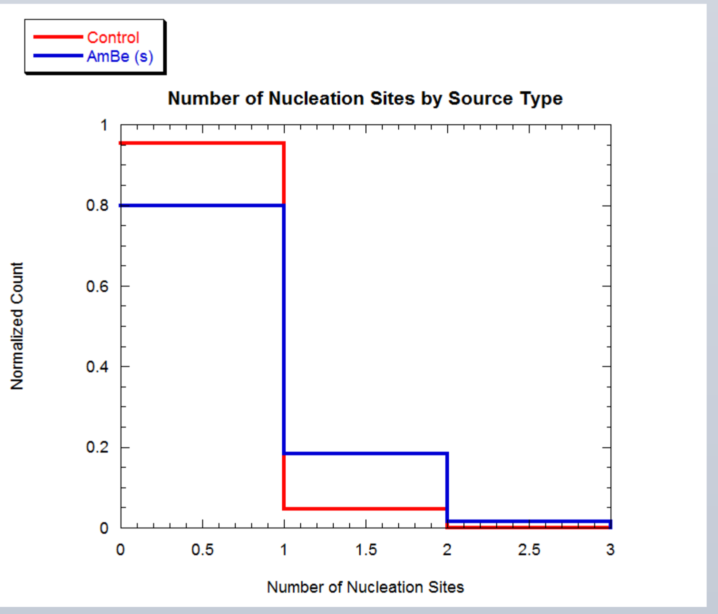
Temperature Analysis

- Decrease in supercool time when the AmBe source is present w/ lead shielding compared to the control, 7.8σ significance.
- AmBe result is only significant when Pb shielding is used
- Cs-137 has had no discernable effect



(left) Average supercool times showing a decrease with AmBe present (right) Control and AmBe w/ Pb shielding separated into runs





(left) types of events in the chamber
(right) Normalized counts of the number of nucleation sites in an event

Image Analysis:

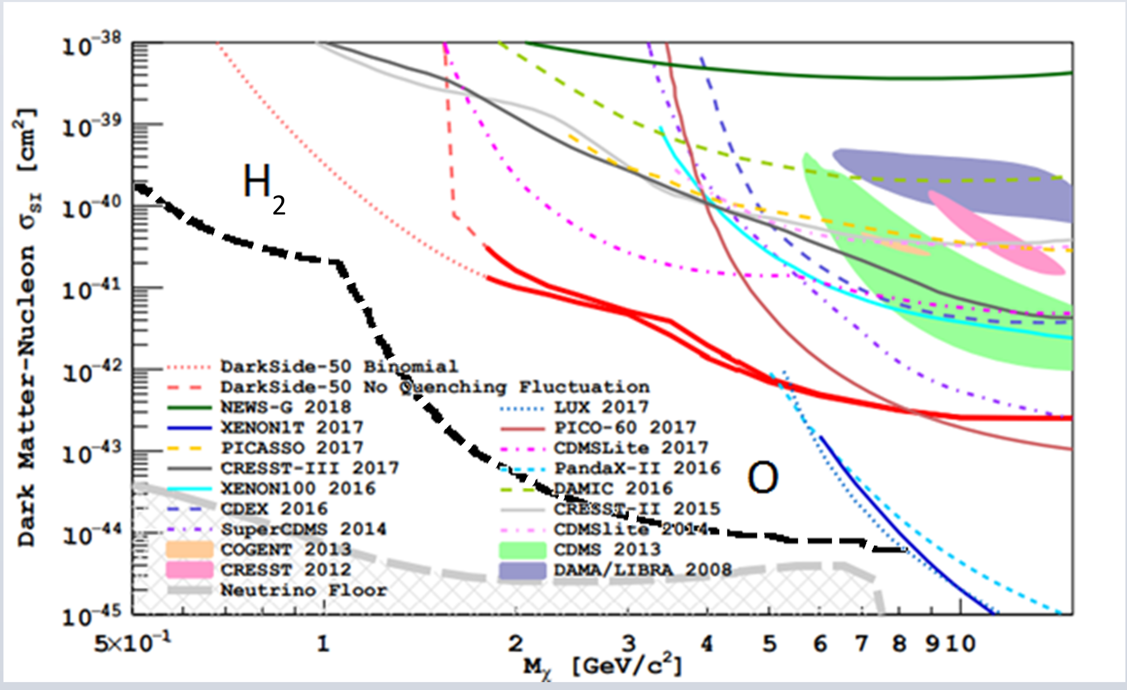
- Lacking 3-D reconstruction, we focus on number of nucleation sites
- More multiple scatters in AmBe compared to control, 4.6% vs 20%, expected for neutrons in water
- AmBe w/ Pb and control only done so far

Conclusion

- Demonstrated neutron sensitivity
- Hints of high gamma discrimination
- Combination could make for ideal low-mass WIMP detector

Future Work

- Automate the image analysis
- Add additional camera for 3-D reconstruction
- Begin working towards a modular detector, multiple small volumes may increase live-time
- Create an emulsion for a supercooled droplet detector



Projected sensitivity assuming 1keV threshold and 10,000 kg-days live [2]

Acknowledgements

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References

[1] E K Bigg 1953 Proc. Phys. Soc. B 66 688
[2] P. Agnes et al arXiv:1802.06994v2 [astro-ph.HE] 25 Apr 2018