Study of Neutrino Induced Neutrons in Dark Matter Detectors

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What is a neutrino-induced neutron?

Supernova neutrinos with around 1-50 MeV will occasionally interact with the lead shielding that surrounds a dark matter detector. When they interact, neutrons are produced (around 2 MeV) and can be detected by the detector.

Figure 1. Crab Nebula, remnants of a supernova. NASA, ESA, J. Hester and A. Loll, 2005.

What's the big idea?

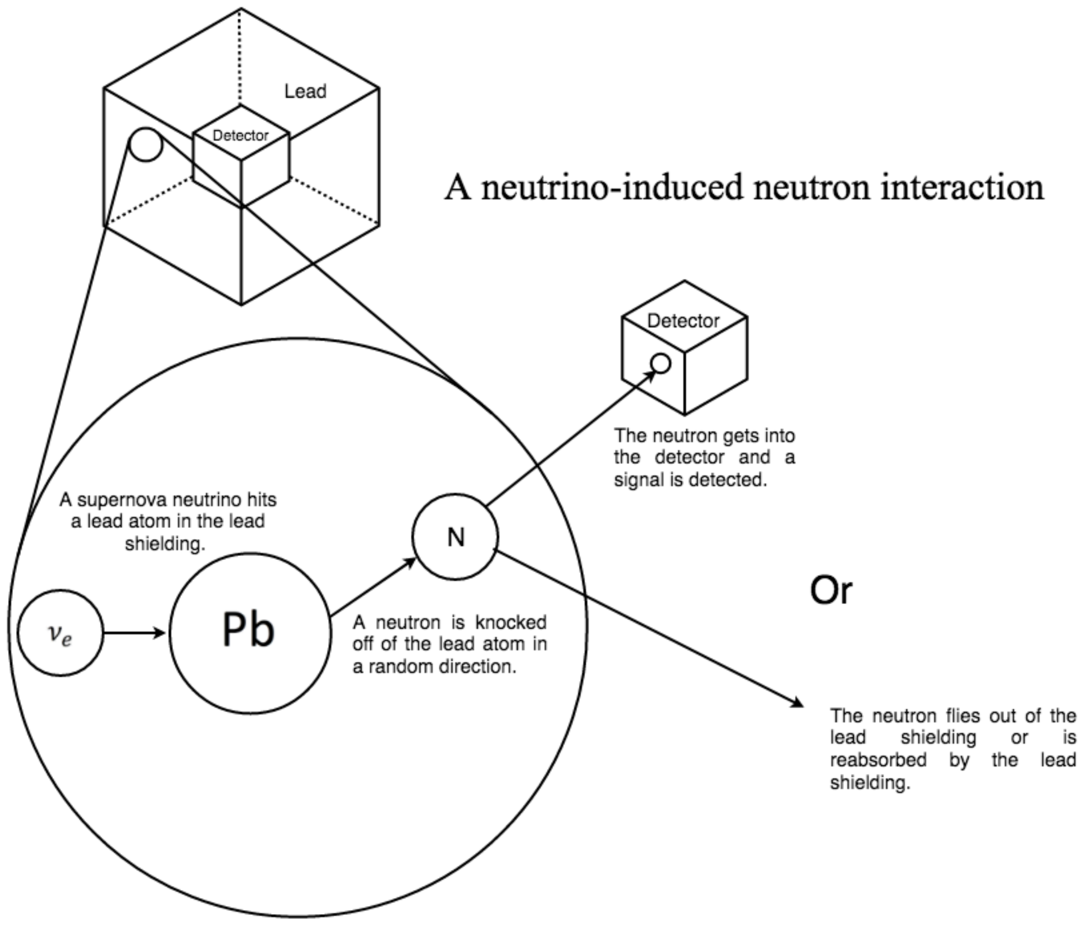


Figure 2. Neutrino-induced neutron interaction.

Typical dark matter detector = a metal detector surrounded by a high Z metal shielding like lead. DAMIC and DAMA are examples of dark matter detectors.

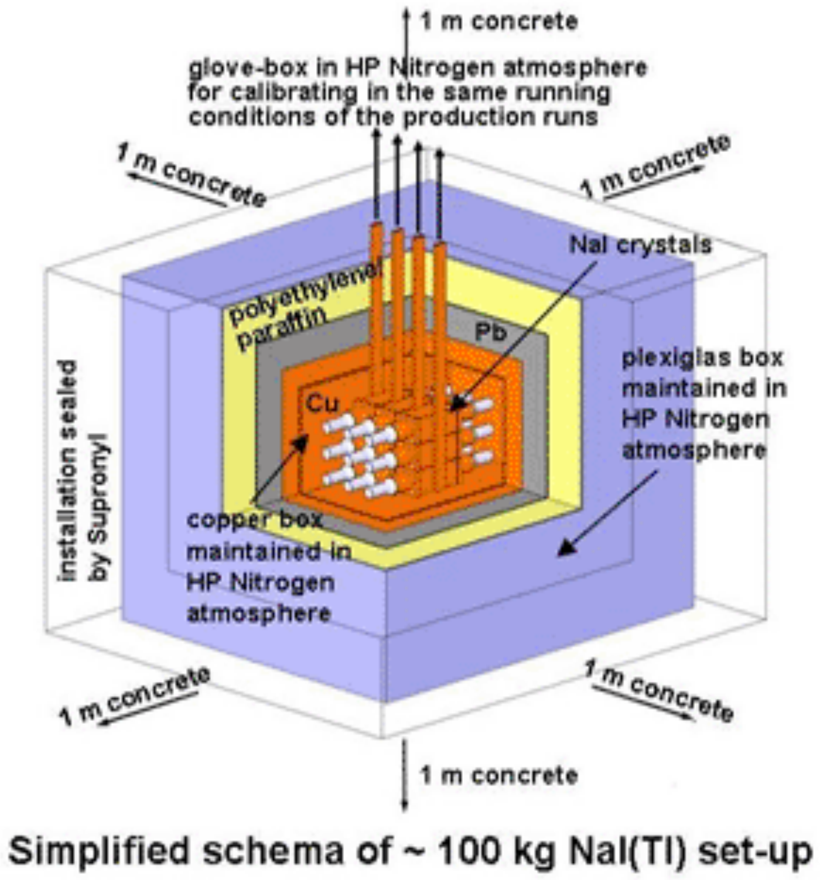


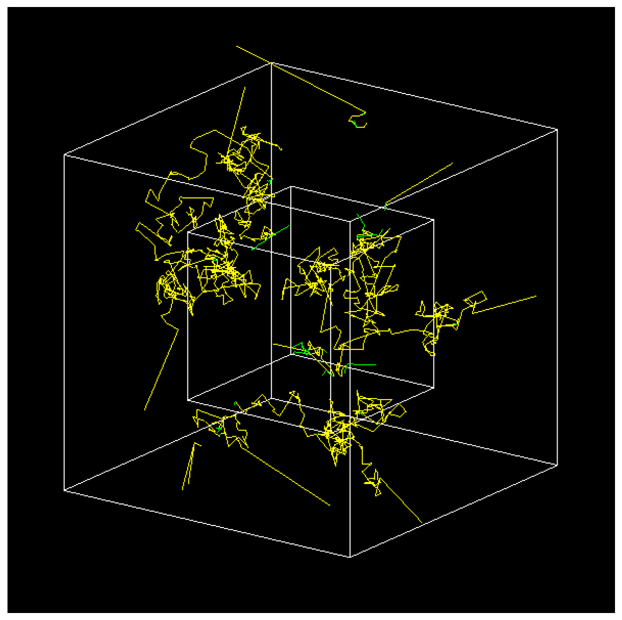
Figure 3. DAMA, a dark matter detector. *Simplified schema of ~100 kg NaI(TI) set-up.* Rita Bernabei, 2010

Why do we care about ?

Detecting supernova by detecting neutrino-induced neutrons (NINs). In addition, since dark matter detectors look for signatures very similar to neutron interactions, we can cancel out false readings if we know the signature of NINs.

How do we study these interactions?

Using simulation softwares like GEANT 4 (**GE**ometry and **TR**acking **4**), we can create model detectors and simulate neutron interactions. These simulations can provide information about what a real event might like.



Yellow = neutrons, Green = electrons

Figure 4. GEANT 4 simulation of twenty 10 MeV neutrons randomly generated with random direction in the 1.0 m^3 lead shielding surrounding a 0.5 m^3 germanium detector.

Creating the Simulation

We simulate a germanium cube detector with lead shielding, similar to real dark matter detectors. The germanium is 0.1 m^3 and the lead shielding is 1.0 m^3. We then generate 10,000 neutrons isotropically and uniformly within the lead at 2 MeV.

What are we interested in finding?

Number of neutrons that make it inside the detector.

Neutron energy deposition inside the detector.

What can we do in the future?

Future simulations can explore how the ratio between the volume of the detector and the shielding affects the neutron count, the inclusion of parameters for real dark matter detectors, and supernova neutrinos passing through the detector.