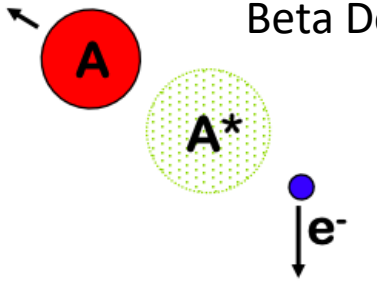
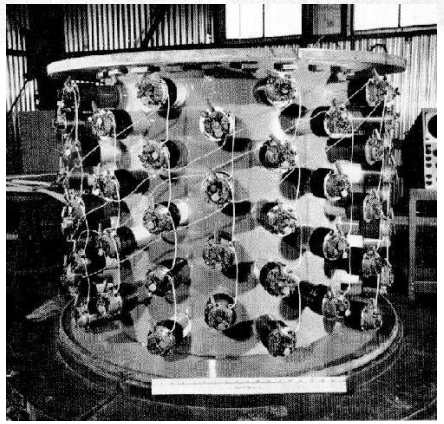
Dark Matter from deep underground

Lorna Nolan

What is a neutrino?



Beta Decay



Cowan and Reines – first experimental evidence

Wolfgang Pauli - ‘a desperate remedy’

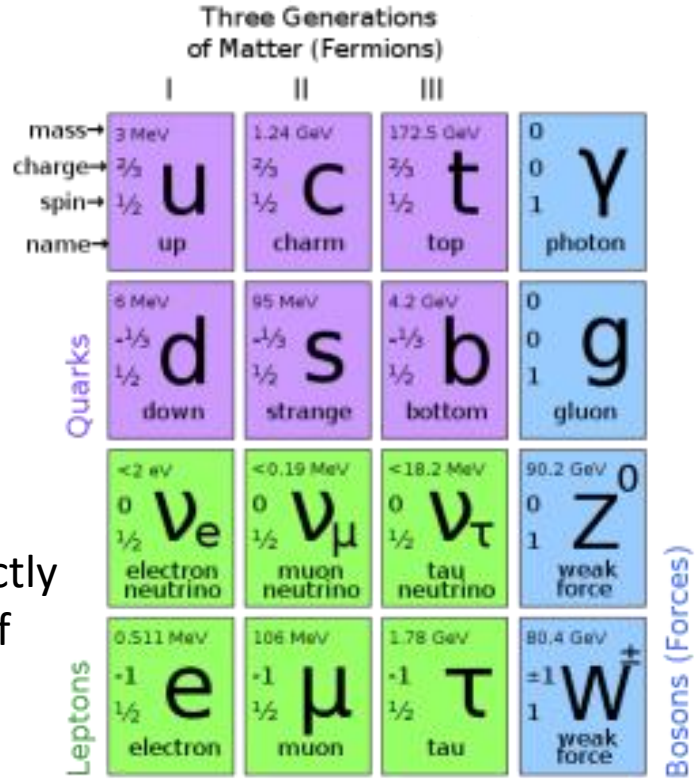
What is a neutrino?

Three flavours

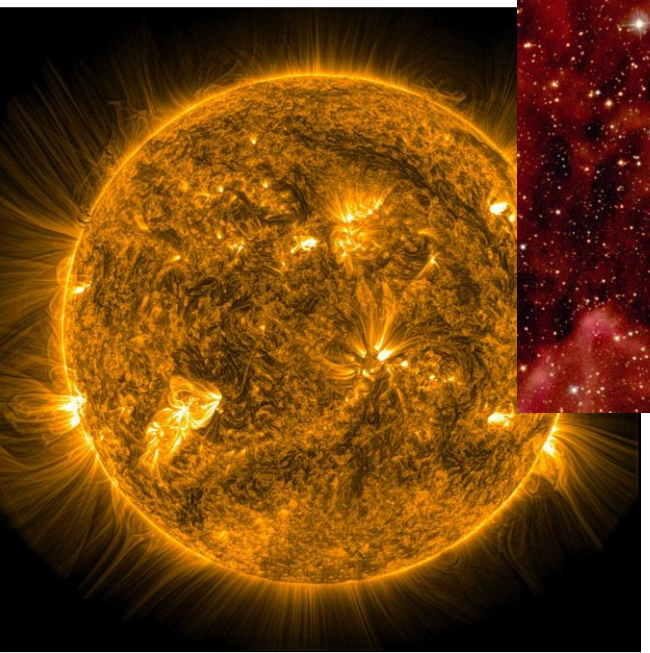
Very weakly interacting

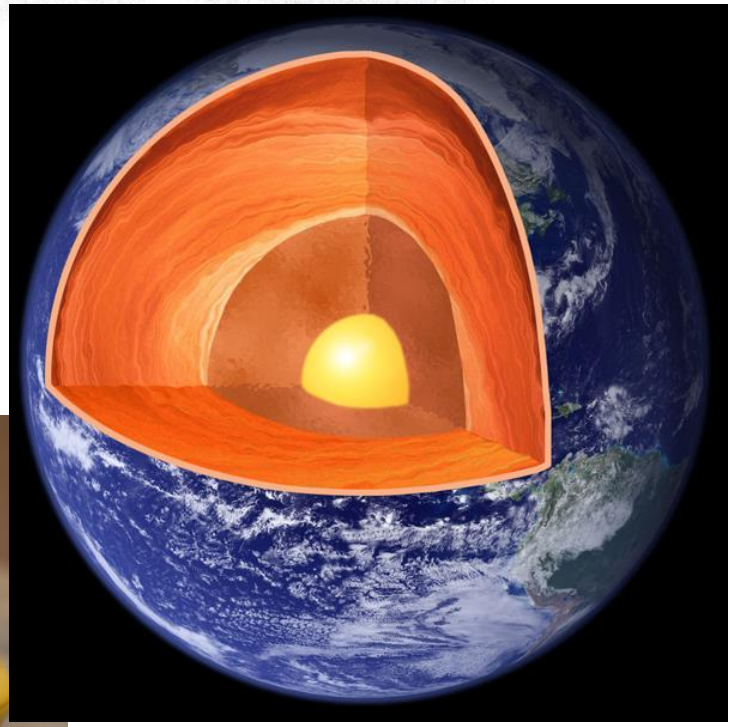
No charge

Very hard to detect, cannot directly detect them, just the products of interactions



Where do neutrinos come from?





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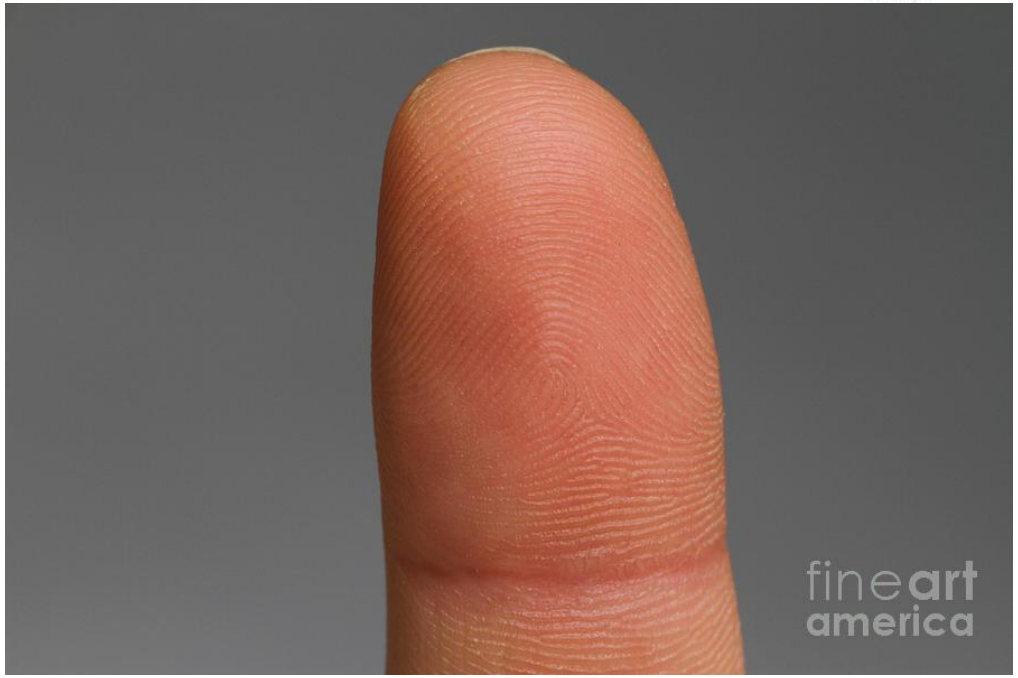
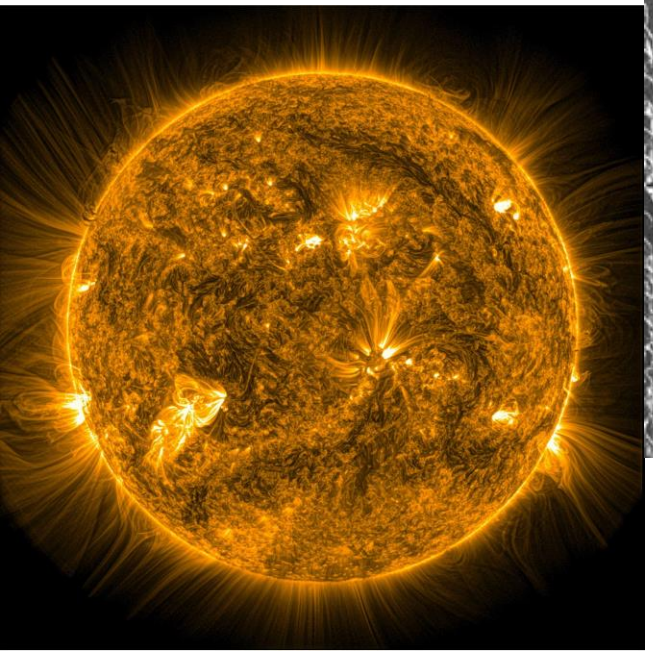


How many neutrinos pass through your fingertip in 1 second?

The solar neutrino problem

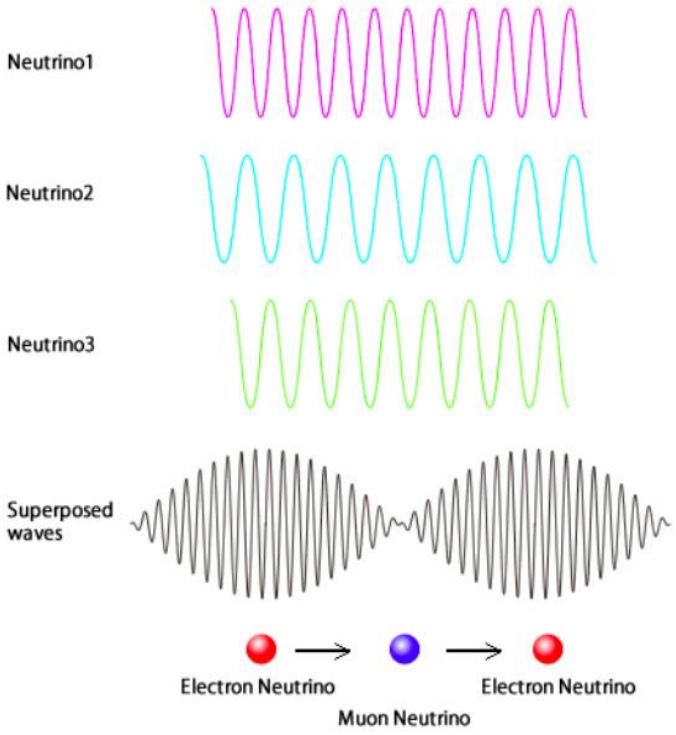


As neutrinos rarely interact, the escape the core of the sun significantly faster than photons

The Homestake experiment was set up to observe electron neutrinos from the sun

It observed only around a third of the expected neutrinos

The solution to the solar neutrino problem



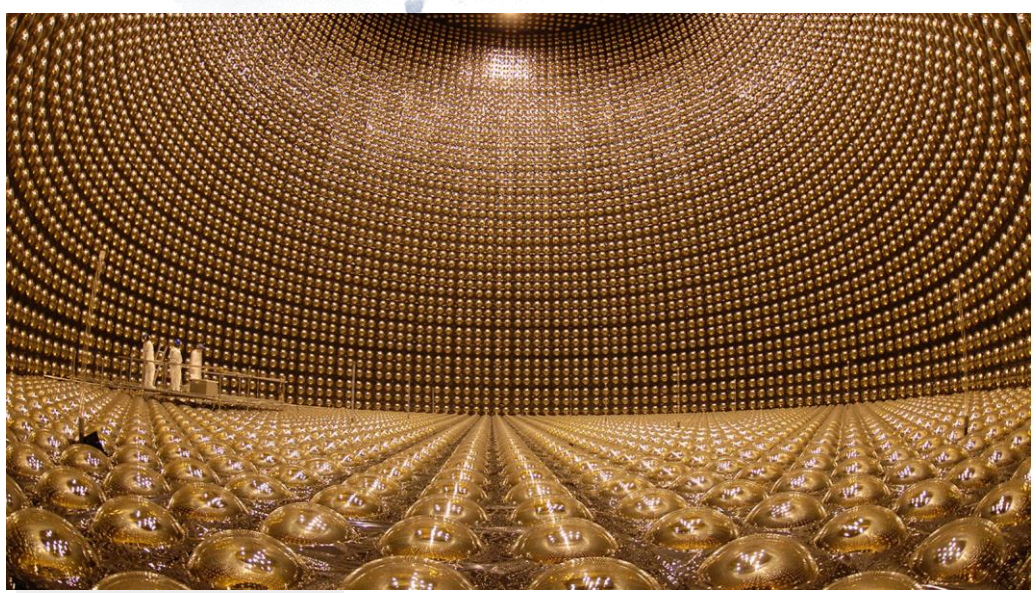
Neutrinos have mass!

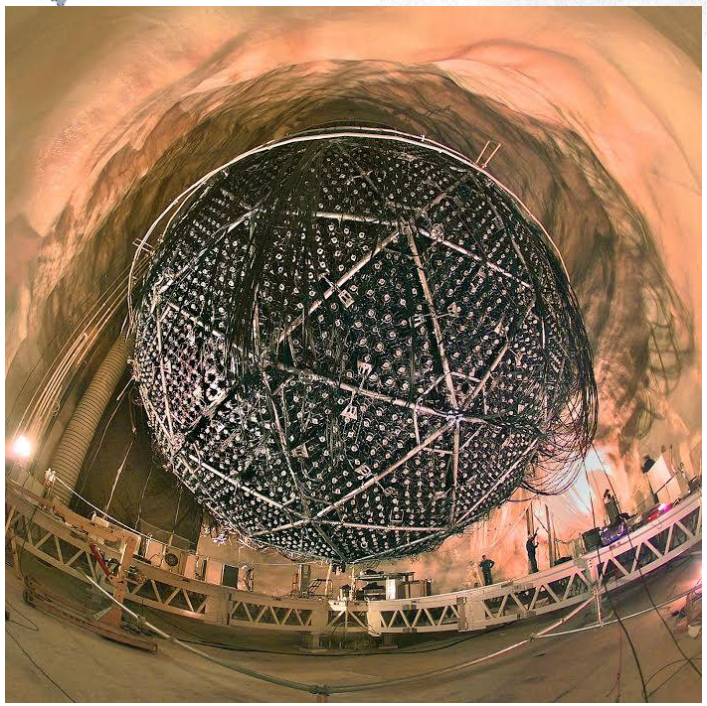
The three flavours $\nu_e\ \nu_\mu \nu_\tau$ are actually made up of combinations of three mass states $\nu_1 \nu_2 \nu_3$

This means they can change flavour as they travel to the Earth

Open questions: What is their mass? How do they get their mass?

The solution to the solar neutrino problem





SUPER K

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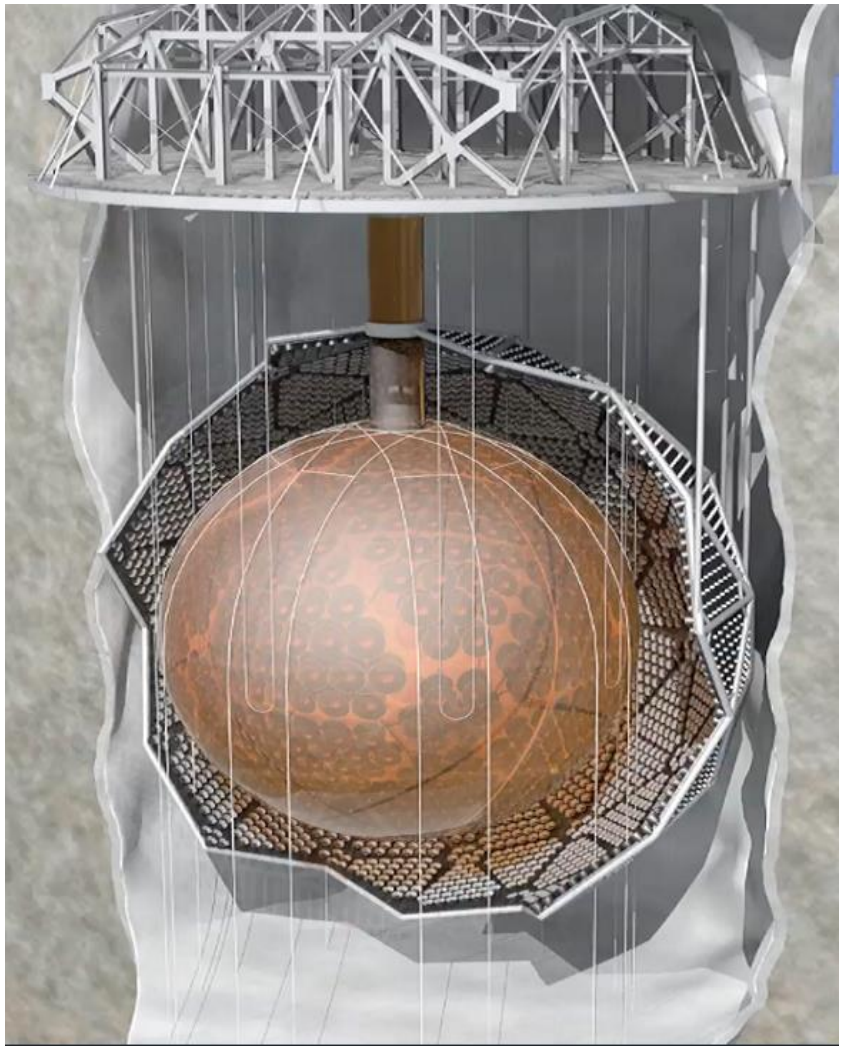
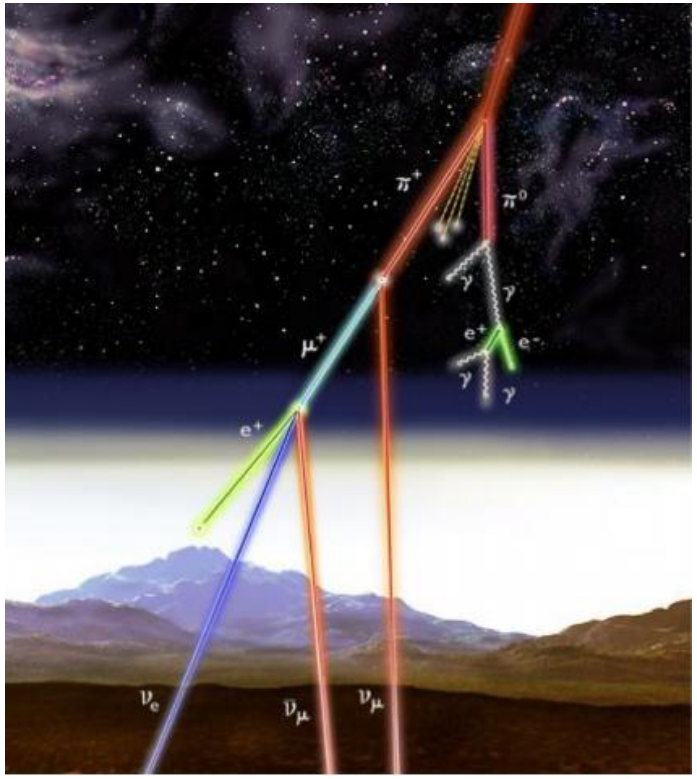
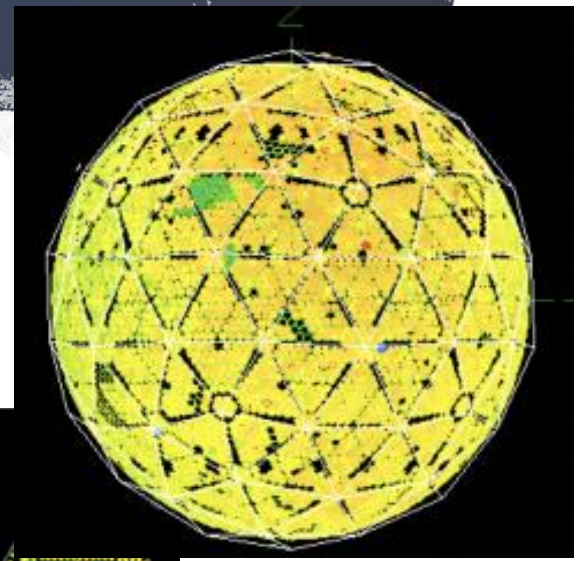
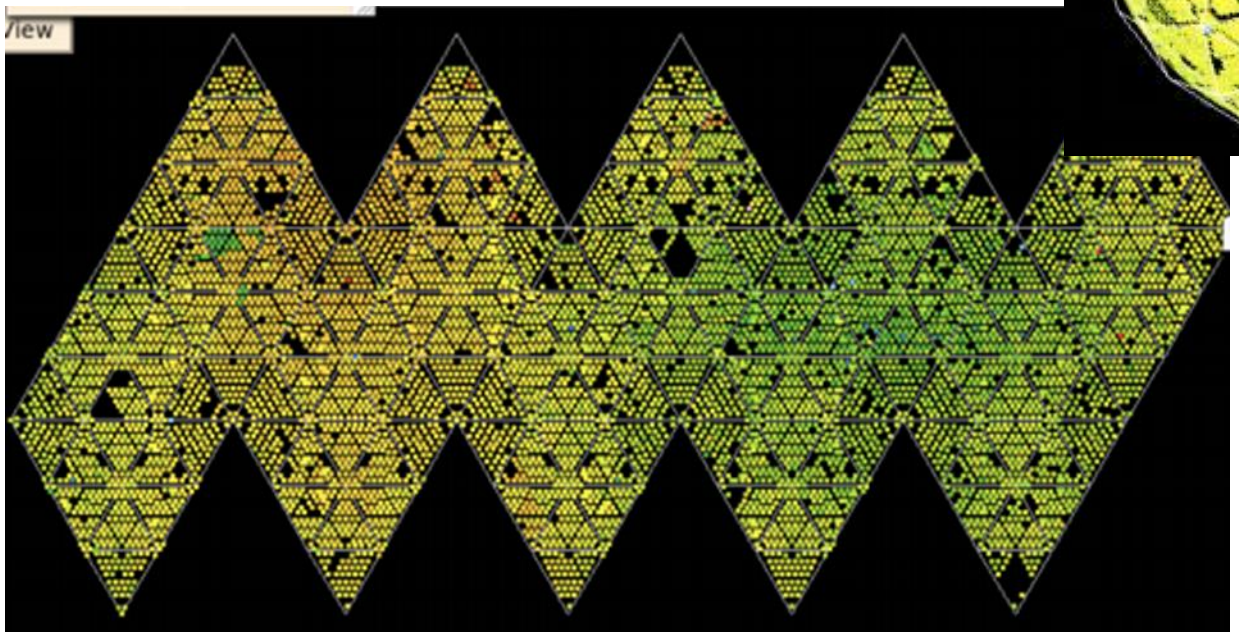
So how do we study neutrinos?



Why would you build a clean room in a mine?







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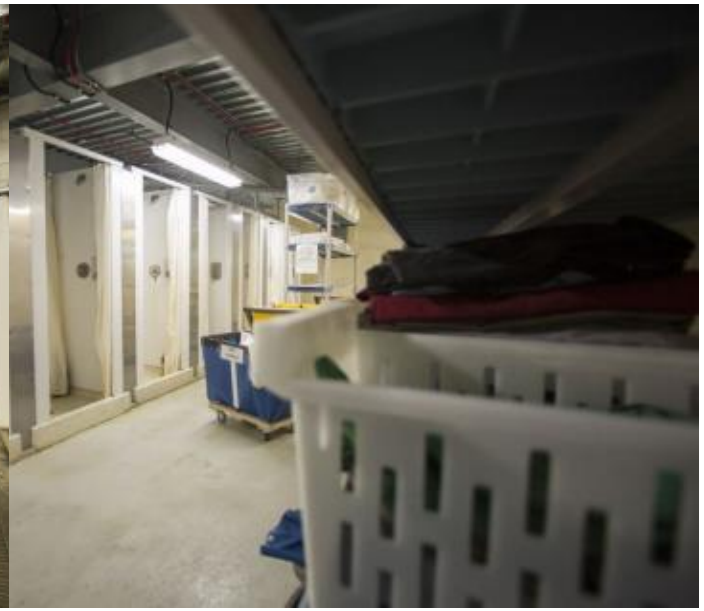

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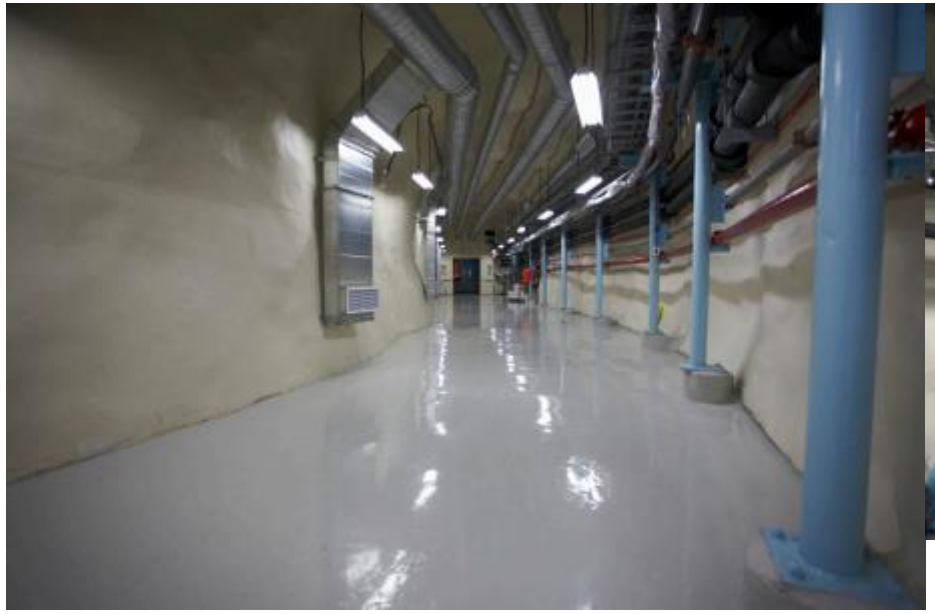


(The real reason the detector is so far underground…)

Great, but what does any of this have to do with Dark Matter?

This goes back to the question of how they get their mass

The rest of the particles in the SM are Dirac particles, which is how they get their mass. There is a chance that neutrinos get their mass through the 'see-saw' mechanism, partly Dirac and partly Majorana.

This means there would be heavier, sterile neutrinos which are, these would be Majorana particles – their own anti particles.

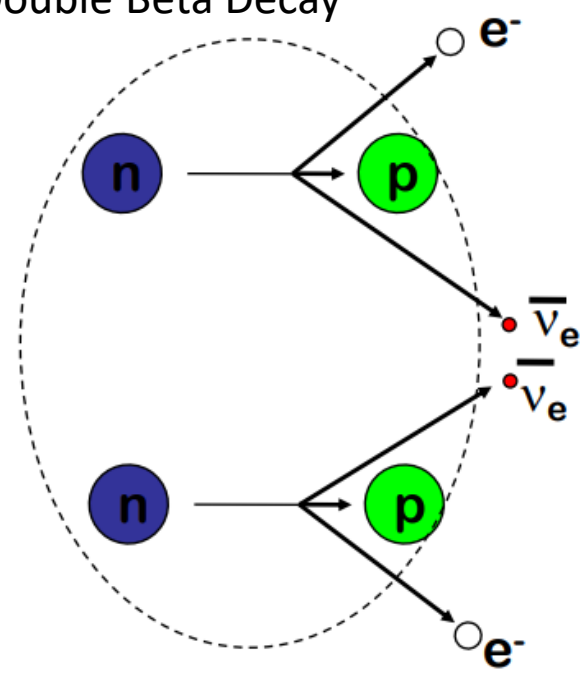
Dirac mass term

Majorana mass term

Many dark matter models theorise that if neutrinos are indeed Majorana in nature they would be dark matter candidates.

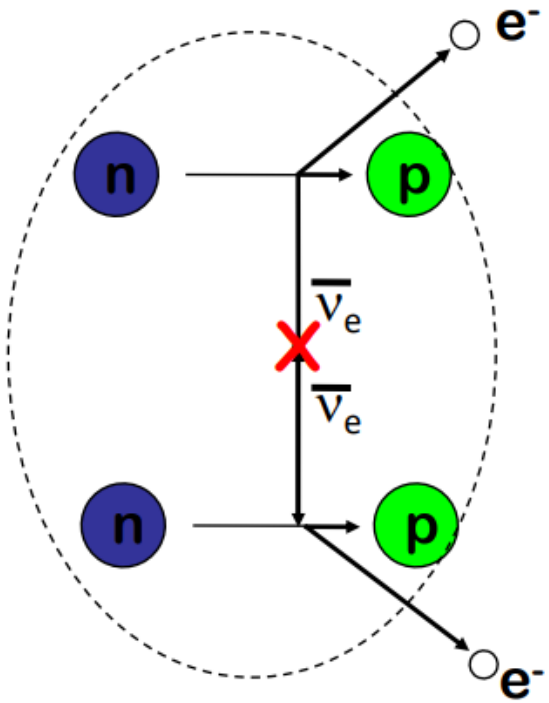
Go on then, prove it

Double Beta Decay



If neutrinos are indeed Majorana particles, then we would have a chance of observing this rare neutrinoless double beta decay

As we can't directly see the neutrinos either way, the way to tell these two decays apart is the energy of the two electrons, it will be higher in neutrinoless double beta decay.



Neutrinoless Double Beta Decay

SNO+ is one of the experiments trying to observe this decay, which could answer the question of neutrino mass and whether neutrinos are dark matter.