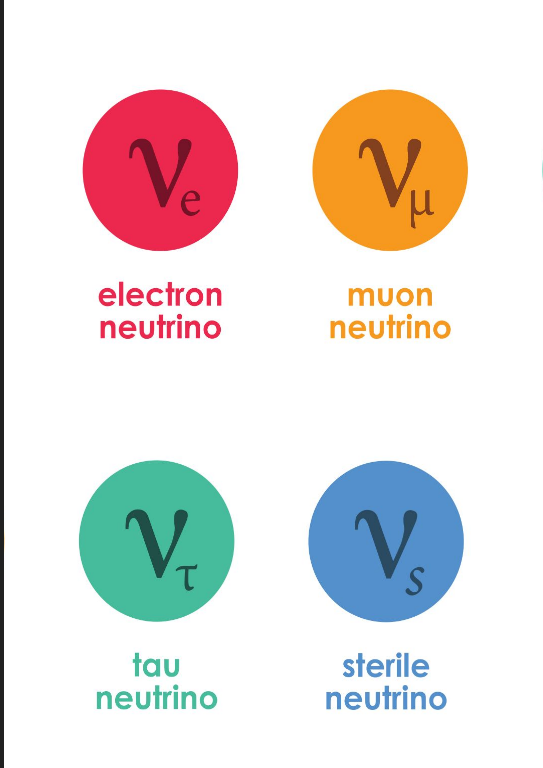
Sterile Neutrinos

Neutrinos



1. They can come in different flavours.
2. SM predicts neutrinos as massless, but experiments say otherwise.
3. They have no electric charge.
4. The sun's output of neutrinos is around 100 trillion passing through your body every second.

Sterile Neutrinos

1. Significantly heavier - interacts only with gravity (not the weak force).

2. They are theorised to be right handed, as opposed to the other flavour neutrinos which are left handed.

3. Some of the evidence for their existence

    a. Reports from LSND
    b. Evidence from MicroBooNE Research
    c. Anomalies in Gallium Experiments

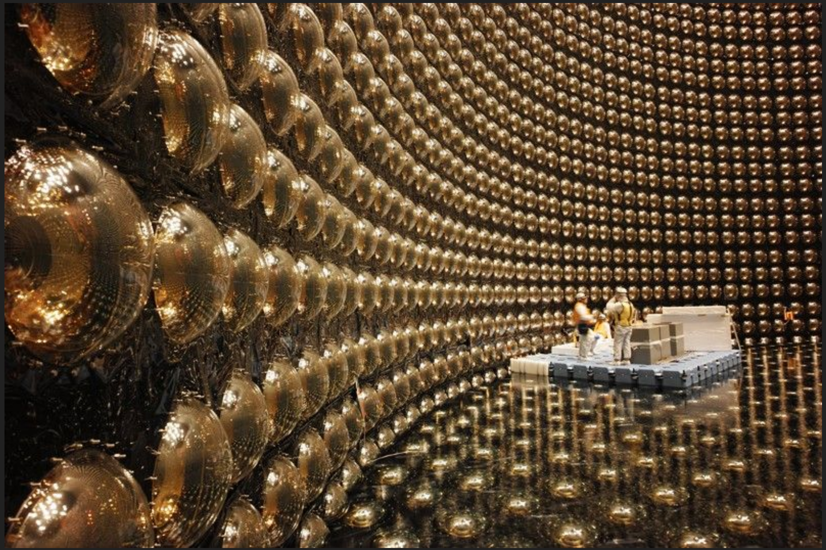
Neutrino Detection

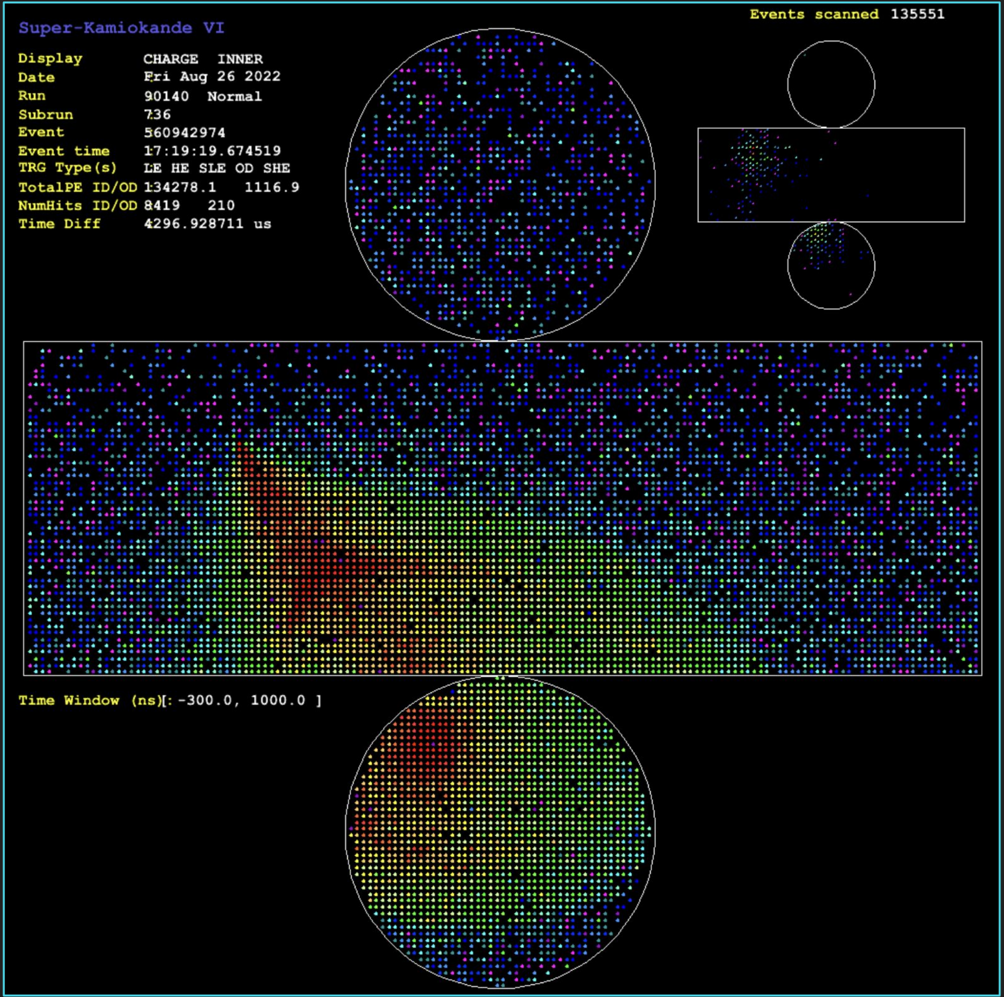
1. Neutrinos can oscillate between flavours when travelling long distances.

2. Experiments have shown muon neutrinos oscillating to electron neutrinos.

3. The distances that shifts occur at can vary, based on which flavours are shifting.

4. Super-Kamiokande measures Cherenkov radiation from particles when neutrinos interact with them (rarely).




Super-Kamiokande VI
Events scanned 135551
Display CHARGE INNER
Date Fri Aug 26 2022
Run 90140 Normal
Subrun 736
Event 560942974
Event time 17:19:19.674519
TRG Type(s) LE HE SLE OD SHE
TotalPE ID/OD 134278.1 1116.9
NumHits ID/OD 8419 210
Time Diff 4296.928711 us
Time Window (ns)[: -300.0, 1000.0]

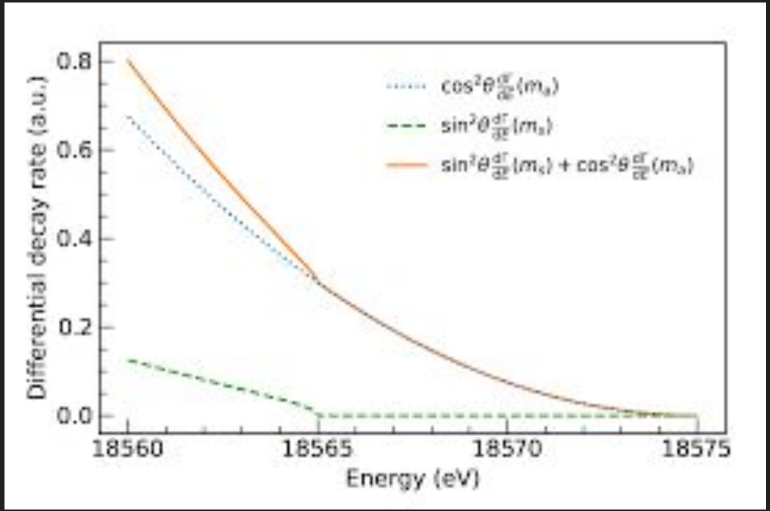
Search for Sterile Neutrinos

1. During oscillation, neutrinos are in quantum superposition of the 3 possible flavours.

2. Probabilities of detecting each flavour varies.

3. We can measure discrepancies between predicted and observed probabilities.

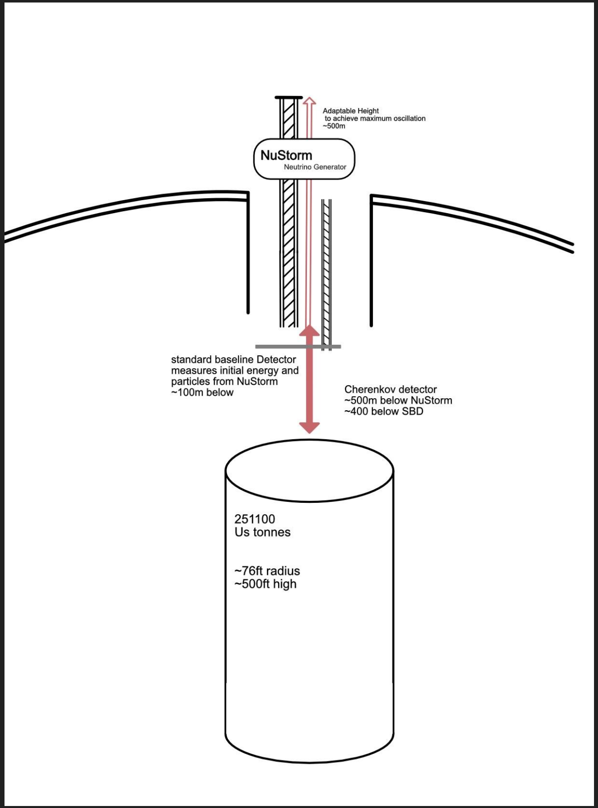
4. Neutrino oscillation depends on length over energy. Variations in this allows us to gather a large data set.



Final Proposal: CAS Research Labs

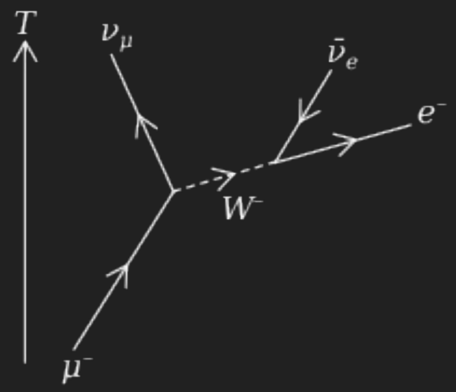
Cherenkov and Sterile-Neutrino Research Labs. Its key function would be to record the oscillation of neutrinos over a short distance.

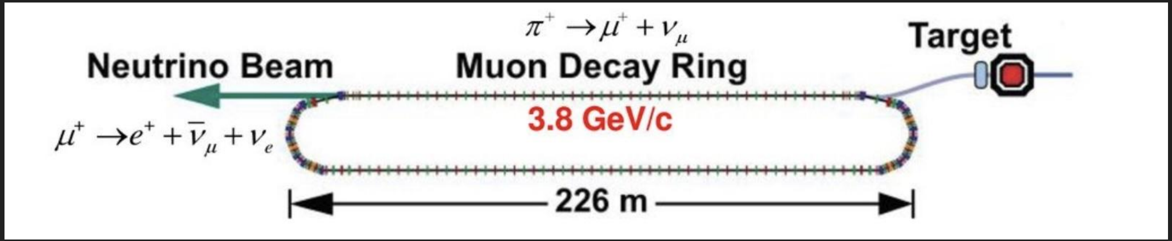
1. Improve upon Super-k with LArTPC Technology
2. Five times the volume of Super-Kamiokande
3. Located on the moon. Approx 1 km underground to minimise cosmic waves and background radiation.
4. There would be a veto detector around the Cherenkov one to rule out solar neutrinos
5. Gadolinium mixed with the Argon to determine neutrinos from antineutrinos
6. Photomultiplier Tubes located in the Cherenkov detectors.



CAS Detection

1. The Neutrinos will be produced from stored muons in the nuSTORM facility. Using neutrino-nucleus scattering programmes to produce beams of (−) ve and (−) vμ from the decay of muons confined within a storage ring. This is a new piece of technology that is currently being developed by CERN.
2. The Neutrinos would be directed 500 meters down to the Cherenkov detector passing through a Short baseline detector (at around 100m), recording the type, quantity and energy of our neutrinos.
3. The beam would then enter the Cherenkov detector, interacting with the argon which is particularly good for identifying the signatures of different particles.





Benefits of our Detector

1. Length between detector and source varies.
   a. Yields larger data sets
   b. And more accurate results

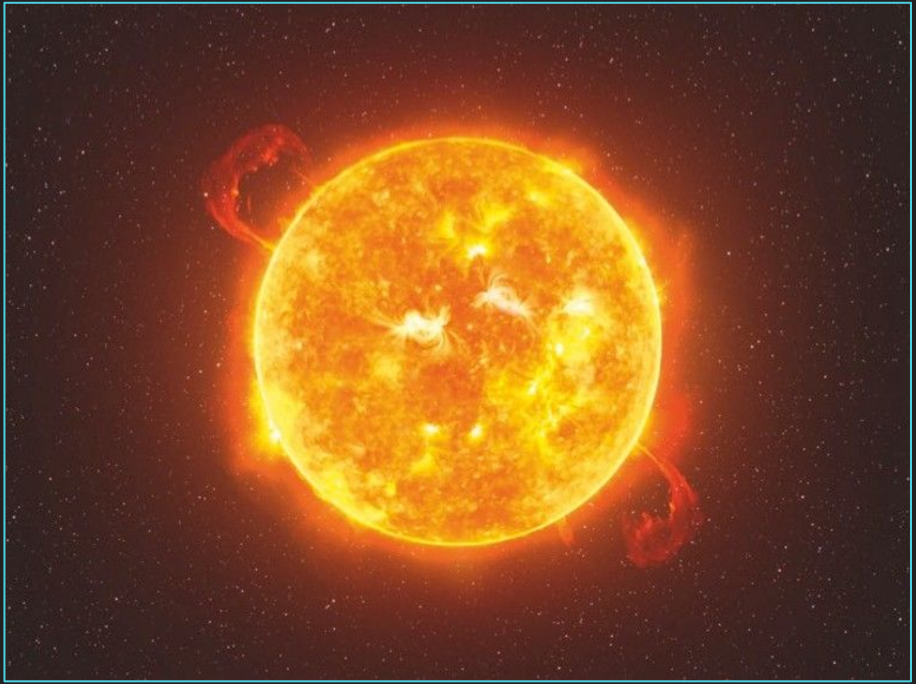
2. Neutrino oscillation is related to L/E (Length over energy)

3. Size of detector is large
   a. Higher efficiency
   b. Faster rate of detection
   c. Spot subtle measurements

4. Uninhabited area on the moon
   a. No fight for space/resources

5. Veto Detectors to measure background radiation.

Implications of Discovery



1. Could help explain the cores inside dense stars.

2. Could balance out active neutrinos which are incredibly light. Proves seesaw mechanism

3. They are possible candidates for a dark matter particle.

References

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Neutrino Detection:
https://www.britannica.com/video/185553/detection-properties-neutrino#:~:text=So%20how%20do%20you%20detect,faster%20than%20the%20light%20does

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nuStorm Paper: https://indico.cern.ch/event/765096/contributions/3296001/attachments/1785344/2906412/nuSTORM_Executive_Summary.pdf

MicroBooNE Information: https://microboone.fnal.gov/

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