INSS BSM Group Presentation

Karsten Dever, Cedric Emmanuel, Andrei Gogosha,
Martina La Rosa

While talking to your colleagues in IV...

You hear about a **mysterious set of anomalous events** that have been observed at the SBND experiment after a single year of data taking. These events are rare, but are observed to appear in the detector **later** than neutrinos would.

Your team decides to investigate this and you are given full access to the SBND data.

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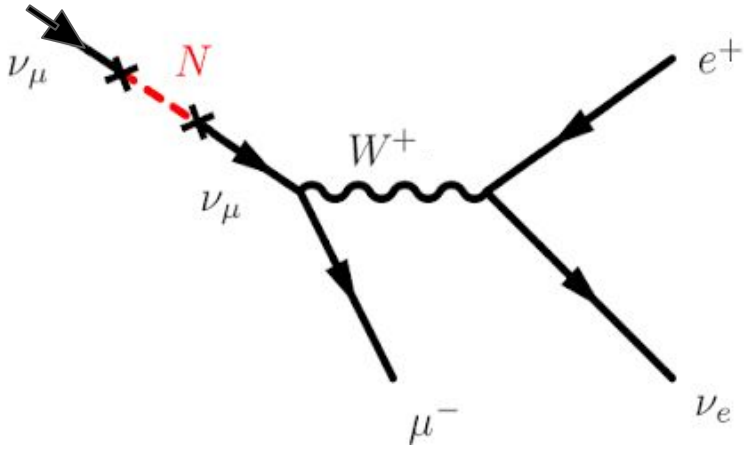
What physics could explain the time delay on these events?

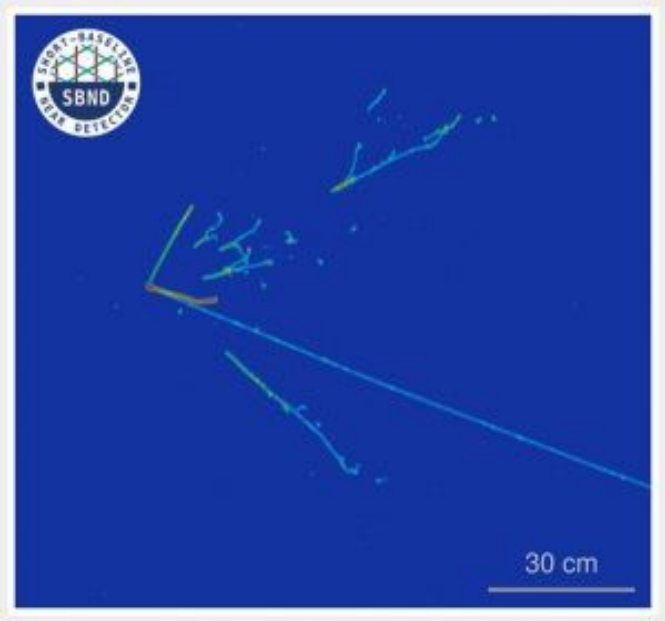
H*eavy Neutral Lepton decay.*

μ-neutrino oscillates to HNL, then oscillates back to neutrino and inter with detector medium:



$$-\mathcal{L} \supset y_\nu^{iI}\, L_i\, H N_I + \text{H.c.}$$

What would you look for in the data to understand the nature of these events?



The proposed nature of the event should result in a standard neutrino interaction at a *slight time delay*.

A muon and a W+ boson product with energy, momentum and time signatures appropriate such that it originating from the BNB is possible for those particles.

Effectively: Take normal event finder and add a cut to limit the time coordinate slightly later.

Physics model, couplings, masses, lifetimes required to explain the observed number of events.

SBND detects 7000 events/day

If the SBND detects 10 HNL decays a year it would give this process a **cross section** of ~10^-42 cm^2

Assuming a lifetime of 30 ms, and the coupling of the decay to weak force to be 10^-6, the mass of HNL can be calculated to be 200 MeV

$$\tau_{\nu_h} \sim \frac{\tau_\mu}{\theta^2} \left(\frac{m_\mu}{m_{\nu_h}} \right)^5$$

How to prove Heavy Neutral Lepton decay is the correct explanation for these events?

1. Show that the position/time the events show up in the detector does not correspond to **normal ν_e/ ν_μ appearance oscillations.**

2. Make sure observed neutrinos are not from non-beam sources.

3. Calculate couplings, masses, lifetimes and cross sections required for observed events and see if they **match predicted values** for this process.

4. Calculate **significance over expected background** and see if the number of events observed is significant (most likely not necessary as we are being asked this problem).

5. Check that all events are time coincident with **BNB firing + some range of time delay.**

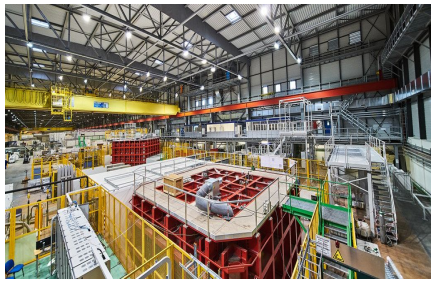
6. Check that time and position reconstruction resolution is correct for events and is truly inconsistent with normal events.

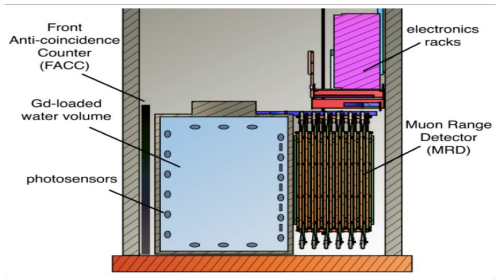
What other experiments could you use to confirm your findings?

The SBND is a **short baseline on-axis experiment** that takes place at 110m down beam line.

Thus other short baseline on-axis experiments should, reasonably, also observe this anomaly. Looking at the near detector of longer baseline experiments could also be used.

Some possible examples are: **ANNIE, NOvA, DUNE** (in future), etc.





Thank You!