SND@LCH Project

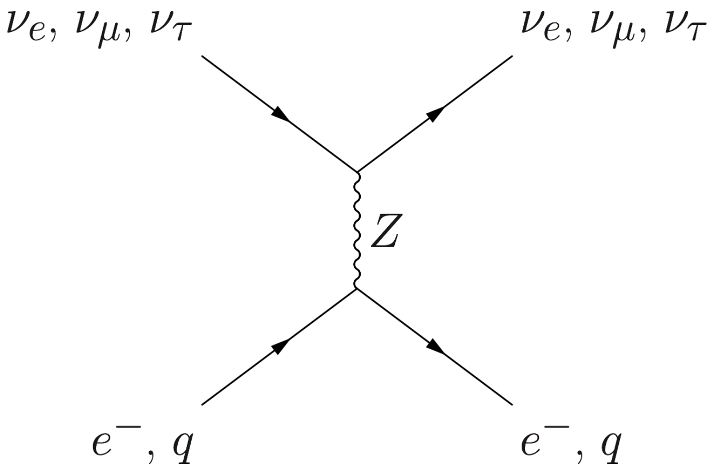
By Atlantis

Background

- SND = Scattering and Neutrino Detector
- The goal of SND is to study neutrino interactions, which is a challenge because neutrinos are difficult to detect
- Although they’re abundant, they have very little mass, no charge (and so don’t interact with the EM force), do not interact with the strong nuclear force, and only rarely interact with the weak nuclear force
- The primary way to detect them is through their interactions with other particles, so by studying these interactions, we can reconstruct information about neutrinos themselves
- There are two main types of neutrino interactions: charged current and neutral current

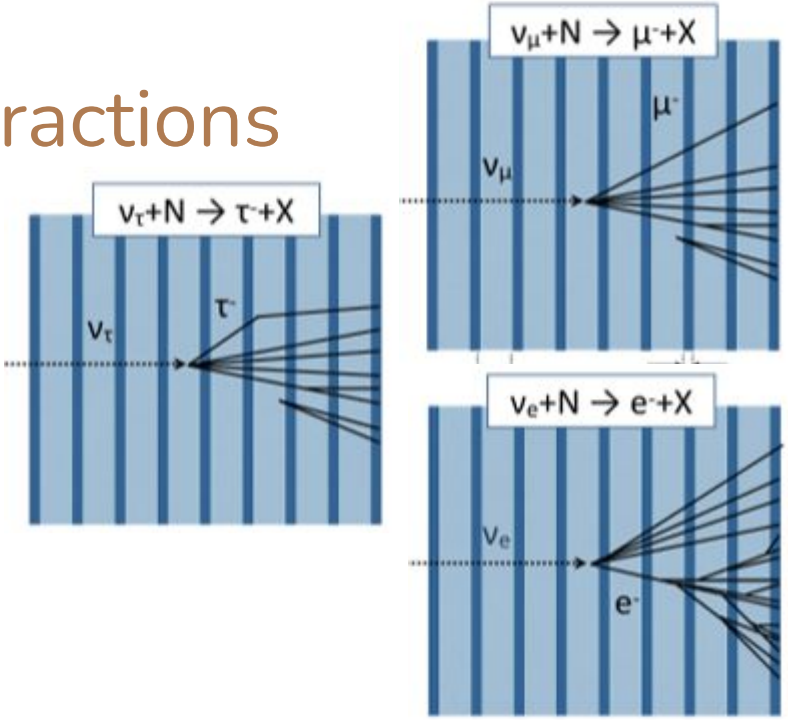
Neutral Current Interactions

- Neutral-current (NC) interactions look the same regardless of neutrino flavor
- They are defined by the exchange of a Z boson, but the incoming and outgoing particles are the same
- Because of the outgoing neutrino, it is more difficult to reconstruct data on the incoming neutrino
- NC interactions are less common, and give us less information



Charged Current Interactions

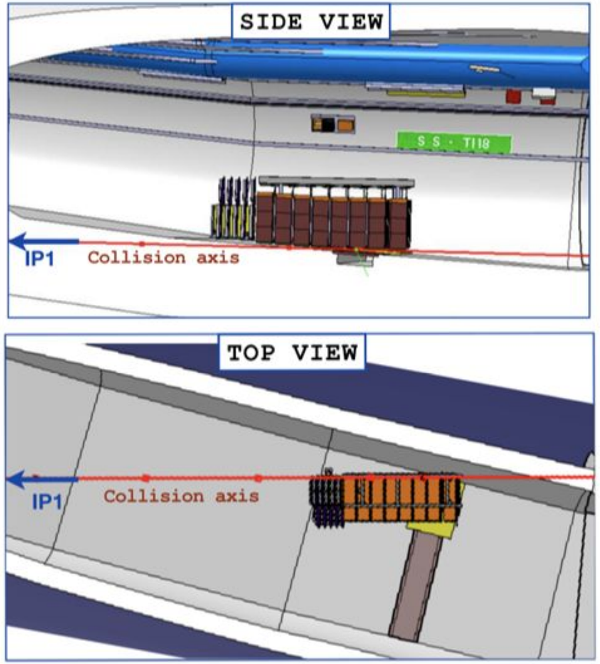
- Charged current (CC) interactions give us more measurable data to work with
- The particles produced depend on neutrino flavor, but the general format is that an incoming neutrino interacts with a neutron, creating an outgoing lepton and a shower of particles
- In the case of muon neutrinos, the interaction produces a muon and a hadronic shower.



Diagrams of what CC interactions are expected to look like on emulsion films in the detector

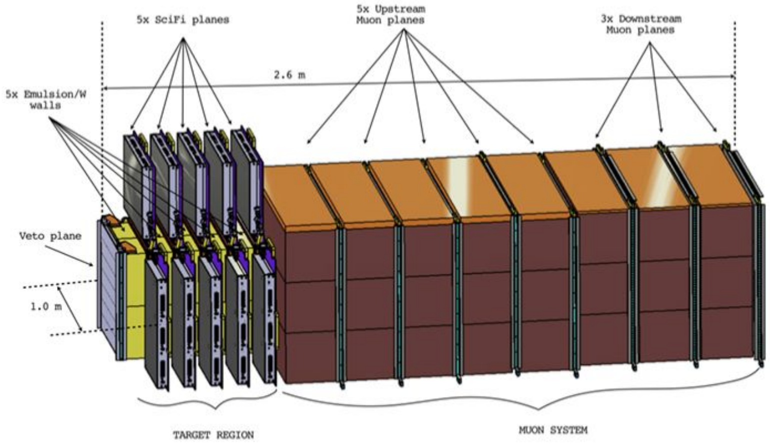
Detector Location

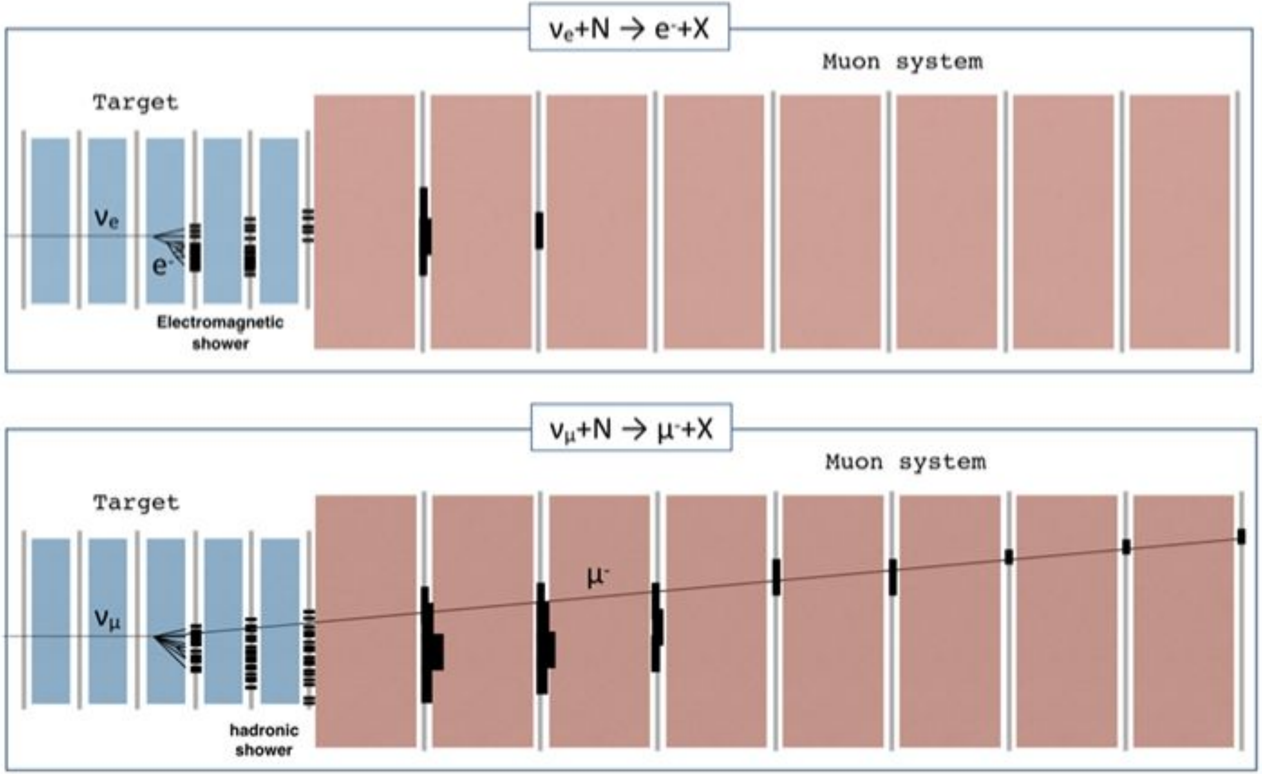
- Neutrinos are created at LHC through proton-proton collisions
- Most particles are eliminated through magnetic redirection and solid material
- The detector is placed in tunnel TI18, where neutrinos will be able to travel to but many other particles won’t



Detector Design

- Split into two major components: target region and muon system
- The target region is made out of 60 layers of tungsten and emulsion (with a resolution of a few microns), about 1 mm apart, sandwiched between scintillating fiber (SciFi) planes. These will capture neutrino interactions and track outgoing tauon decay
- The outgoing muons are tracked in the muon system, which has iron in between scintillator bars. Neutrino interactions that happen at this point can't be tracked due to low resolution

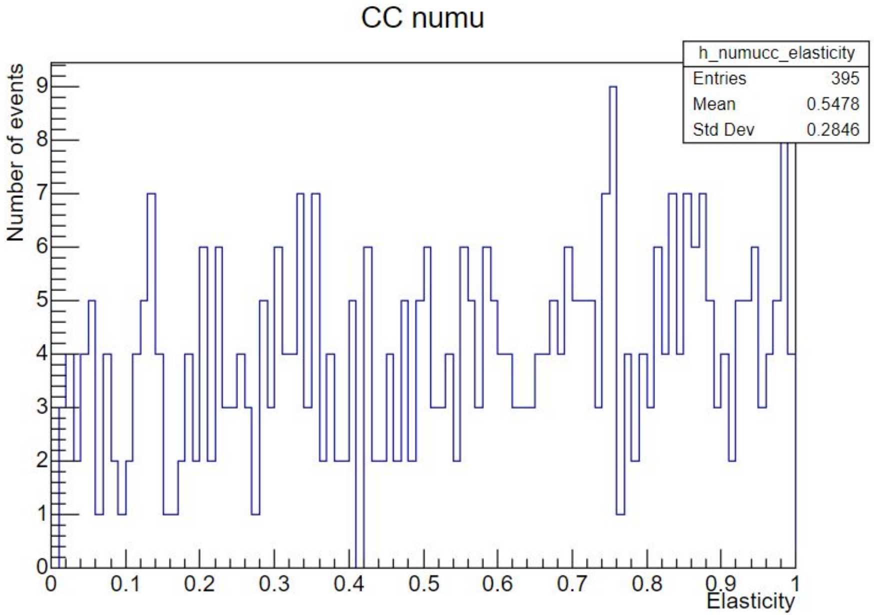




Example of CC interactions inside detector

Simulation Data & Error Analysis

- The error in calculations will be estimated using simulation data
- By simulating neutrino interactions, we have data on the energy and momentum of simulated neutrinos, muons, and pions
- Reconstructing the energy & momentum of incoming particles, and comparing these calculations to the known data will give us our error
- This is mostly done with histograms in ROOT



Applying to Real Data

- The uncertainty in simulation calculations determines the resolution in our ability to calculate the energy and momentum of incoming neutrinos
- With real data, properties about the incoming neutrinos cannot be directly measured.
- To determine these properties, the properties of the outgoing muons and pions will be measured, and we will work backwards to understand the neutrino they came from
- The energy resolution from the simulation will give us an idea of the uncertainty in energy estimations
- Another challenge that will add uncertainty is the estimation of the muon’s energy and momentum
- Since the muon will exit the detector before decaying, we will not be able to measure these properties directly
- This estimation will come from the hadronic shower and the energy ratio between them. This calculation will come with its own uncertainty as well

Sources

- http://kamland.stanford.edu/Nontechnical/intro.html#:~:text=Their%20elusiveness%20is%20a%20result,weakest%20of%20the%20four%20forces.
- http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/neucur.html
- https://indico.cern.ch/event/1201483/