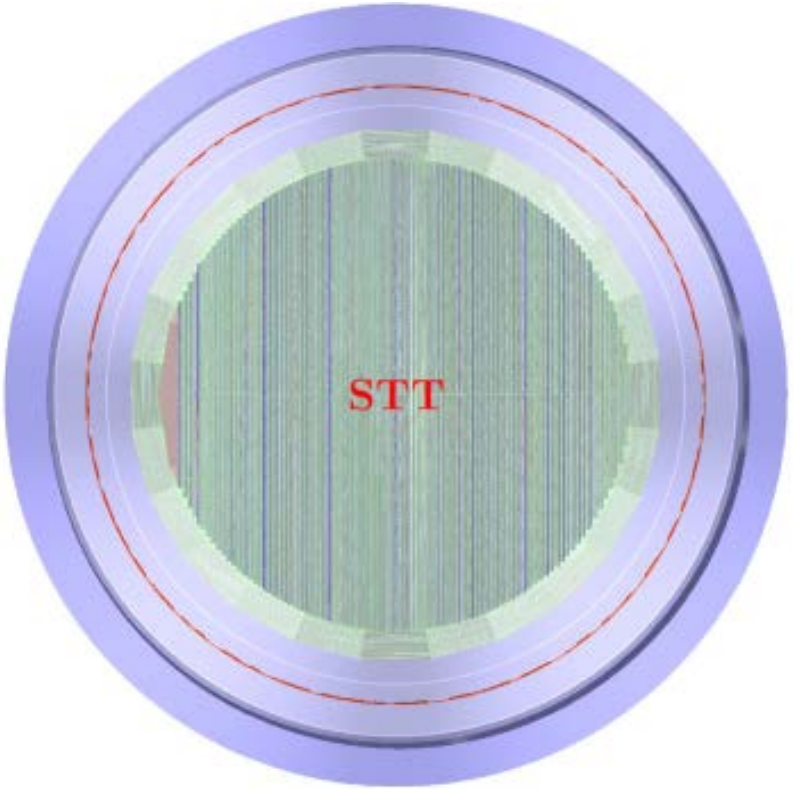
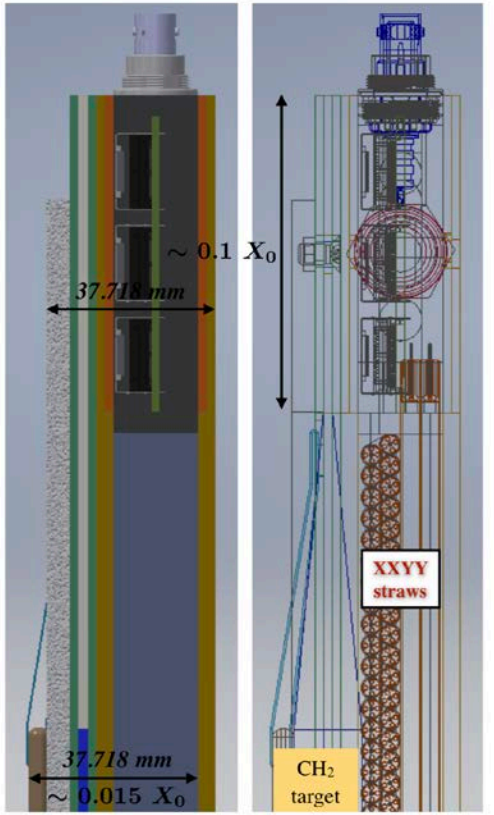
Detection of (Anti)Neutrino Interactions with a Low-Density Target/Tracker



Nibir Talukdar

Dec 3, 2021



A brief introduction about neutrinos

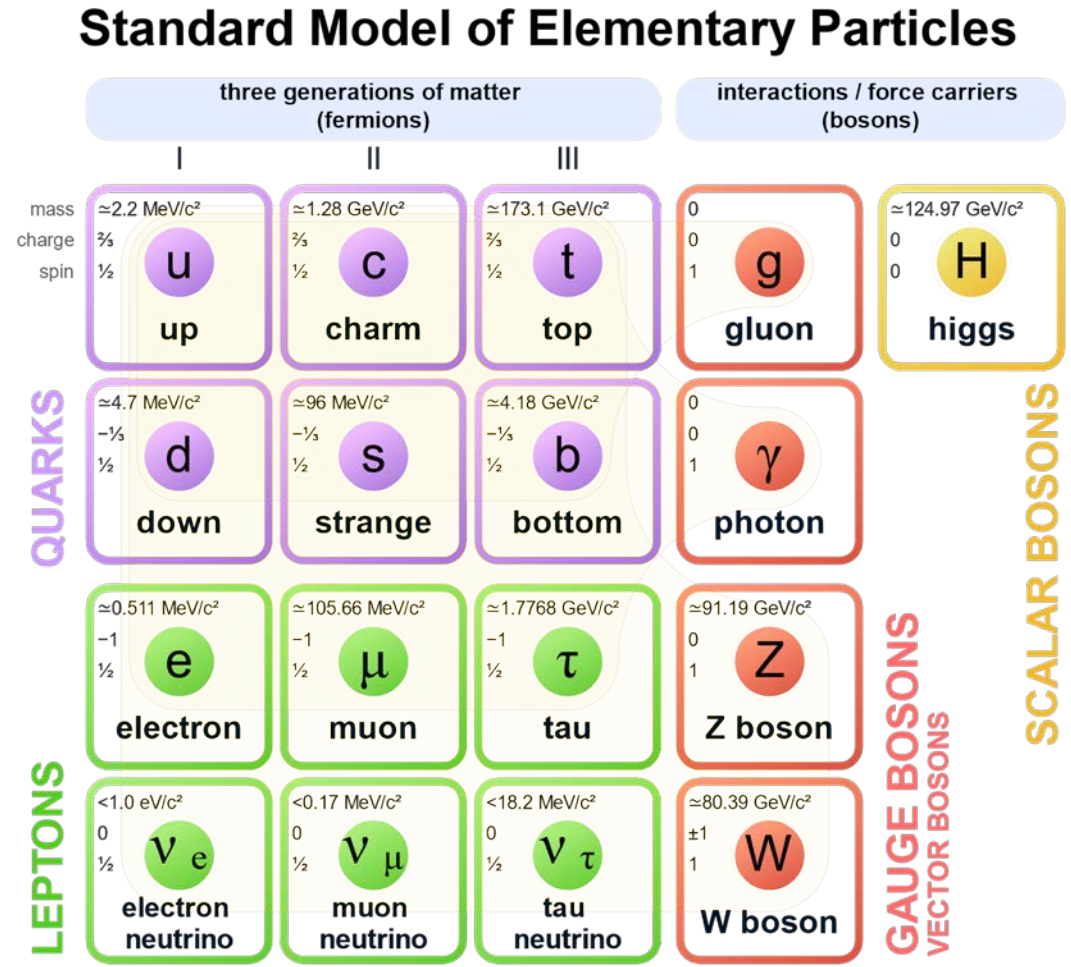
- Chargeless
- Spin half particle (fermion)
- Weakly interacting (by exchange of Z/W+-)
- Difficult to detect
- Neutrinos generated from

Natural sources

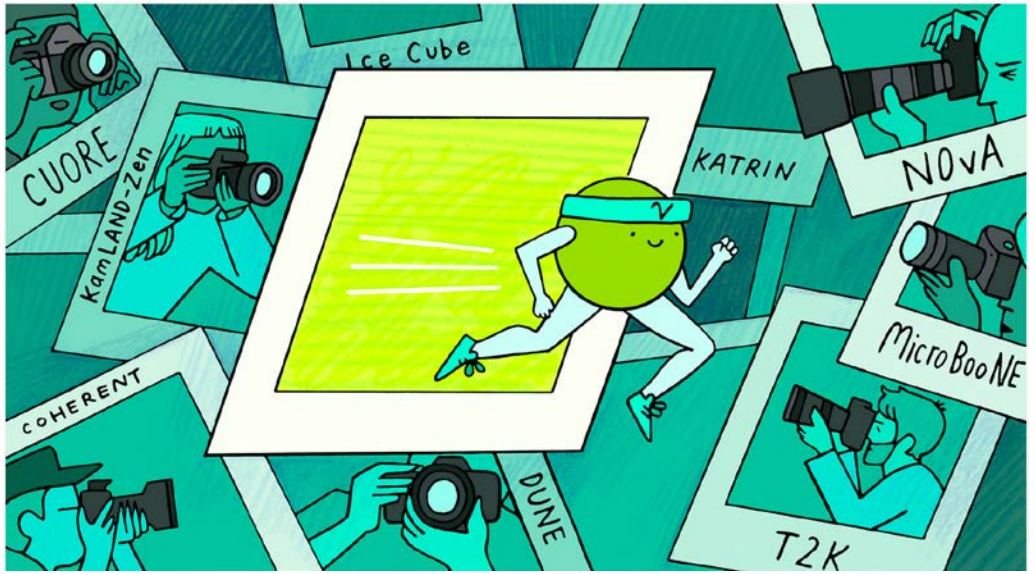
1. sun
2. cosmic ray air showers
3. supernovae

Artificial sources

4. *nuclear reactors and* ***particle accelerator***



Abundance of neurtrinos : About 60 billion neutrinos from the sun cross 1cm^2 of your body every second



Neutrino Oscillations

- During the late 1990s, oscillations among different flavors of neutrinos were established; physics beyond the S.M.
- Mass eigenstates and flavor eigenstates are not the same:

Neutrino Mixing Matrix

neutrino flavor states participate in weak interactions

$$\begin{pmatrix} \nu_e \\ \nu_m \\ \nu_t \end{pmatrix} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{m1} & U_{m2} & U_{m3} \\ U_{t1} & U_{t2} & U_{t3} \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

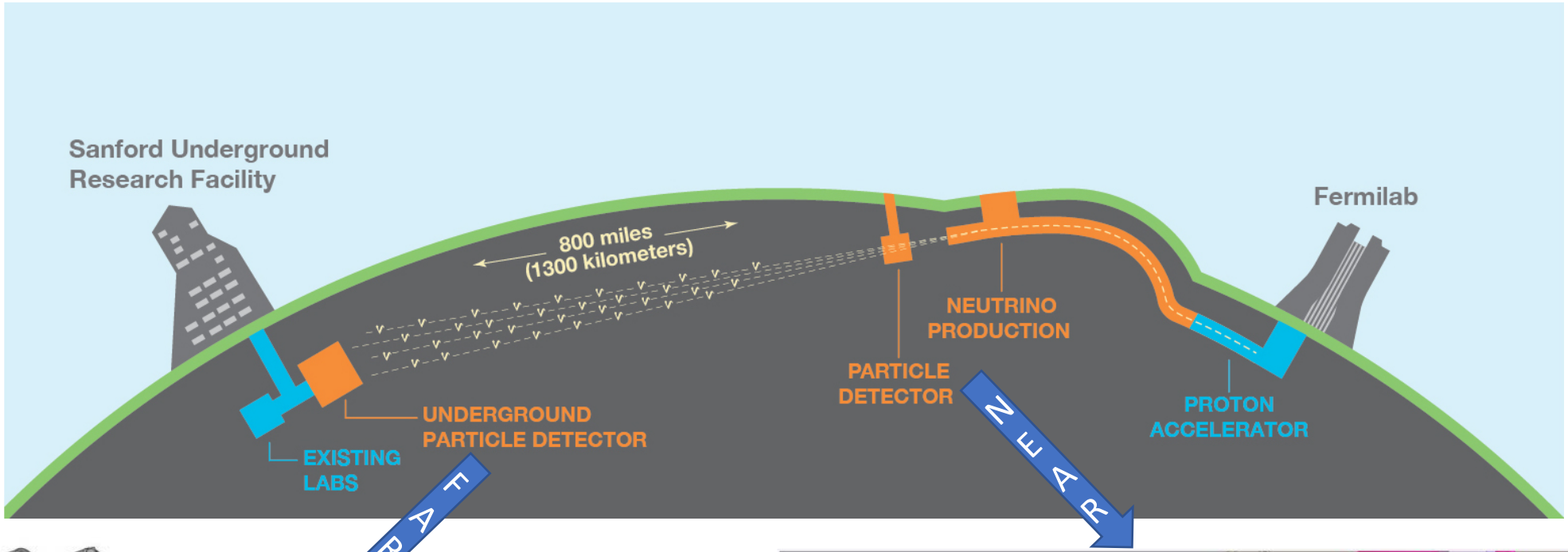
Mass eigenstates

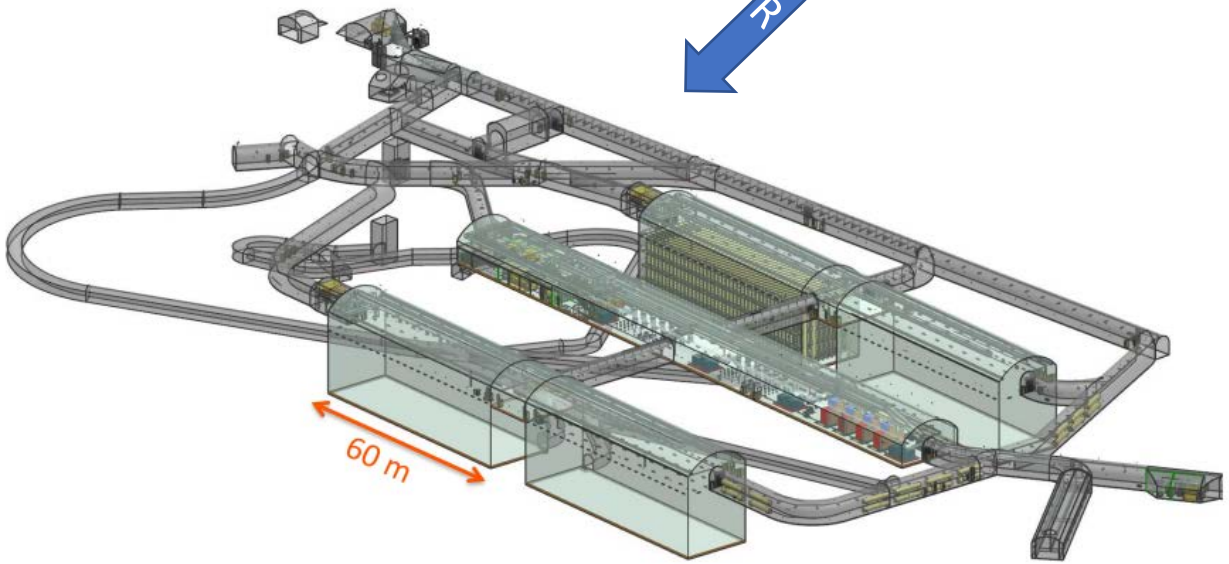
- Raises many interesting questions including possibility of CP violation in neutrino oscillations $(e.g.,\ P(\nu_\mu \to \nu_e) \neq P(\bar{\nu}_\mu \to \bar{\nu}_e))$
- CP violation in neutrino sector could be responsible for the matter-antimatter asymmetry (leptogenesis)

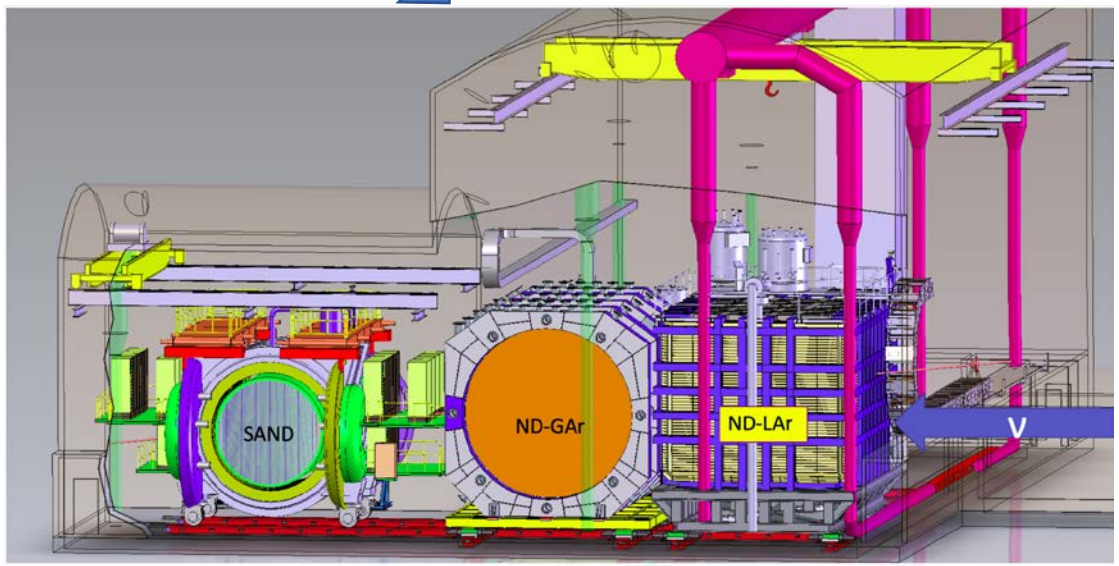
$$\Gamma(N \to \ell^+ + H^-) > \Gamma(N \to \ell^- + H^+)$$

The antilepton excess is converted to a baryon excess through nonperturbative S.M. B+L violating, but B-L conserving processes.

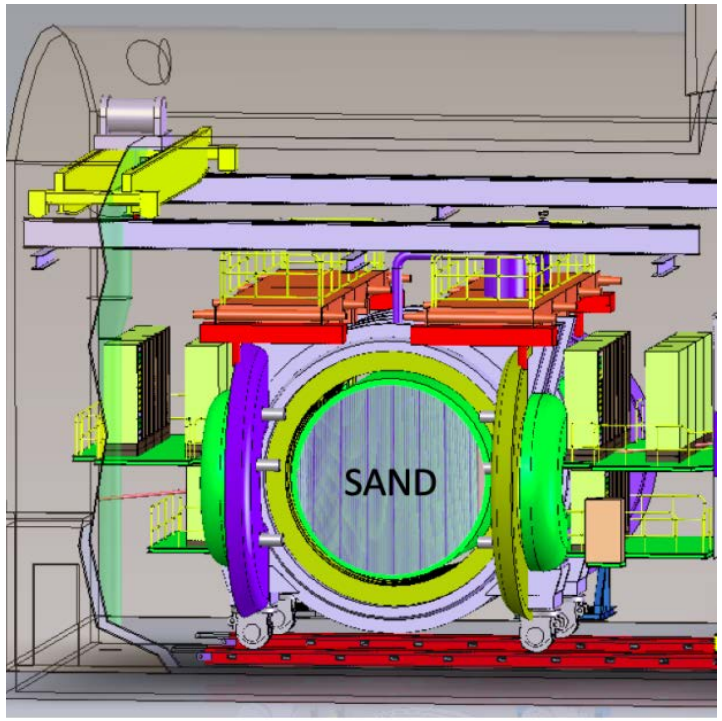
Deep Underground Neutrino Experiment





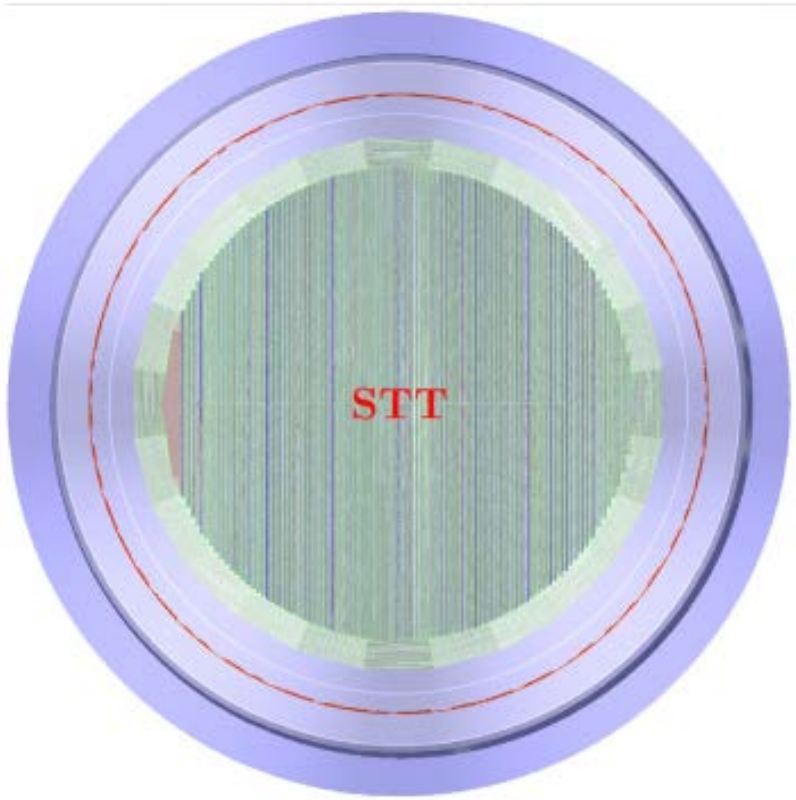


System for On-Axis Neutrino Detection



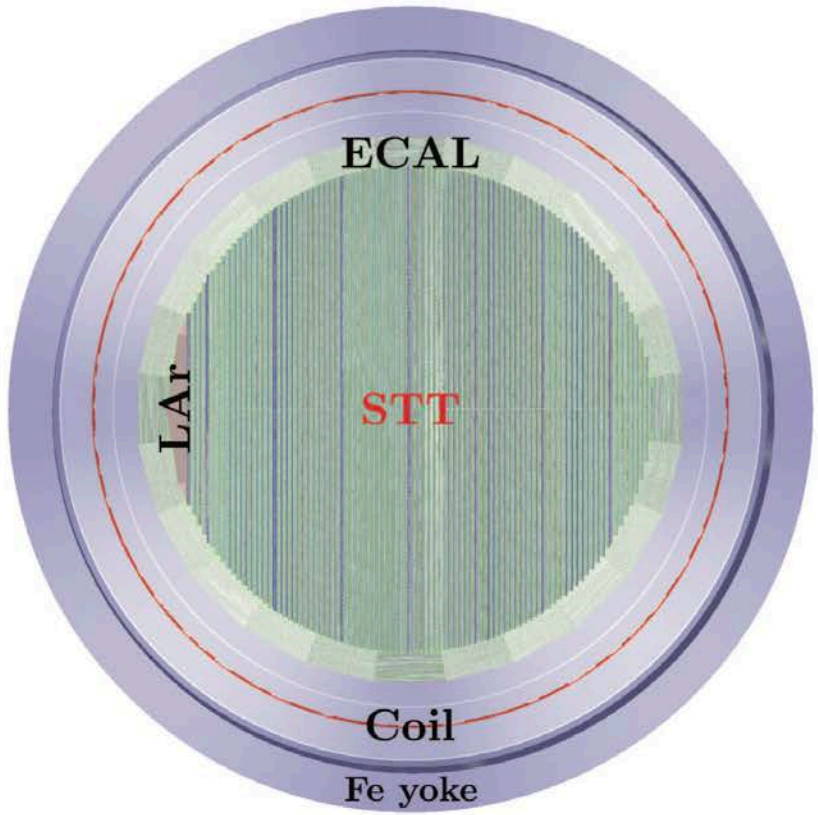
SAND will be permanently on-axis in a dedicated alcove It will consist of:

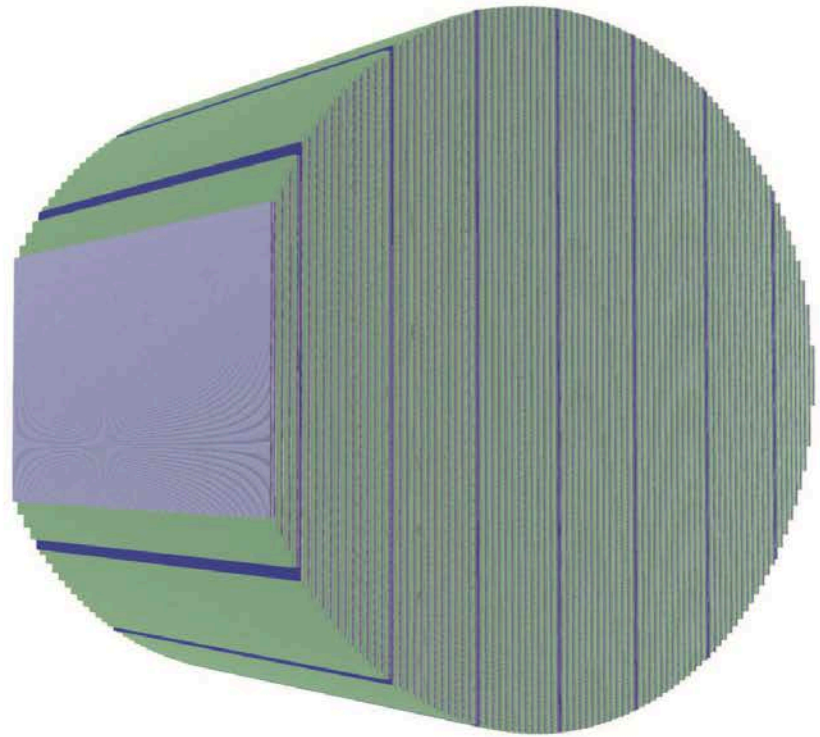
* a superconducting solenoid magnet
* an Electromagnetic Calorimeter (ECAL)
* a thin active Lar target
* **low density target/tracker (STT)**



Purpose of SAND

- **Monitoring of the beam stability on a few-days basis**
- **Precision in-situ flux measurements of ν_μ , a-ν_μ , ν_e , a-ν_e**
- **Constraining systematics from nuclear effects and related smearing**

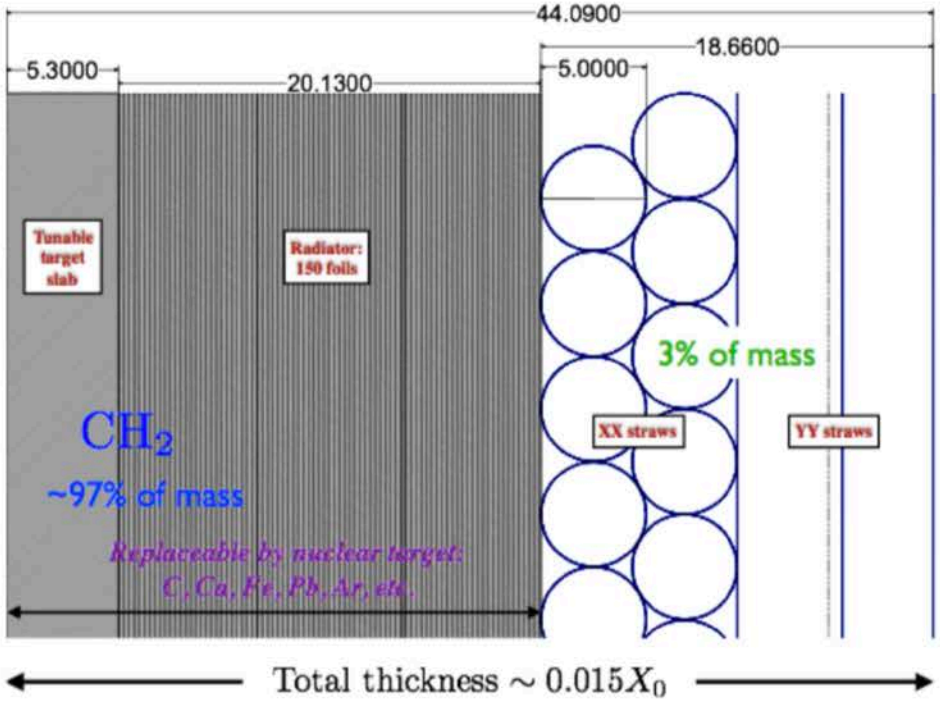


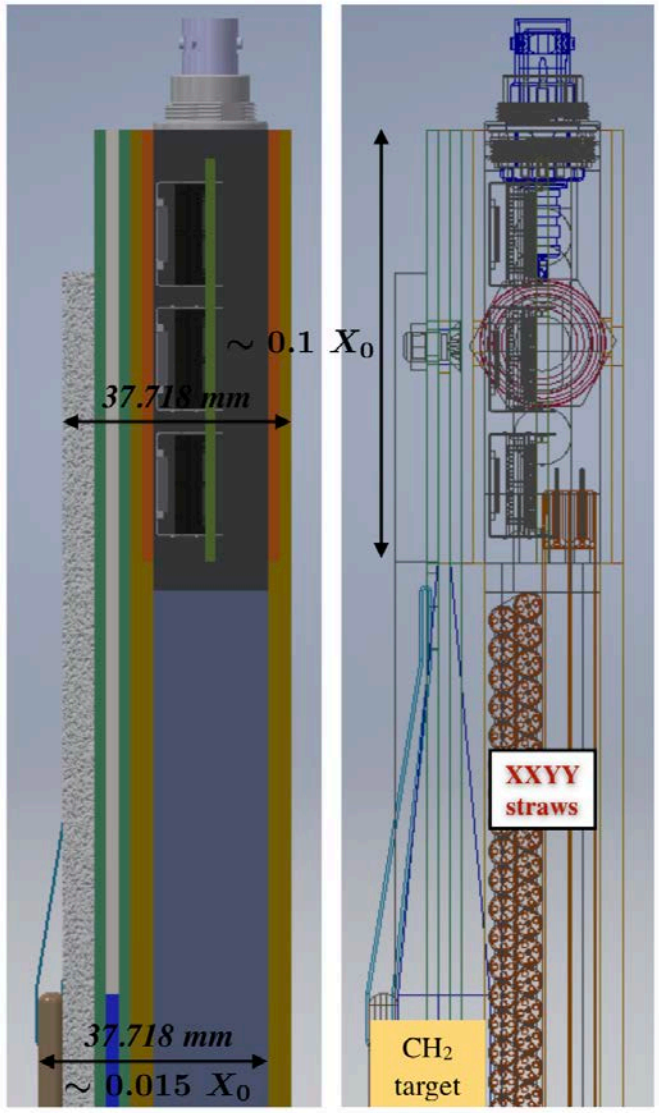


Green: polypropylene (CH_2) targets (4.7 t FV) *Blue: graphite (C) targets (504 kg FV)*

Straw Tube Tracker

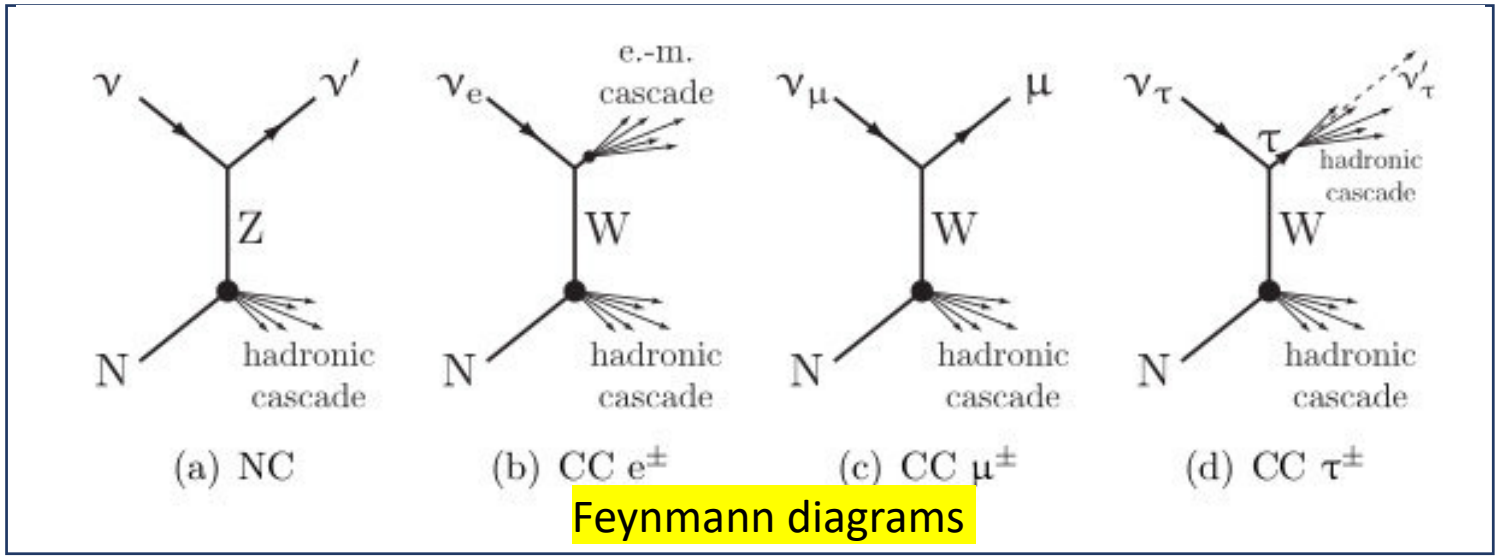
- Thin passive targets (100% purity) physically separated from active tracker (straws ~3% of total mass)
- Tunable target mass & density by varying thin targets (~97% of total mass) with average density 0.005<= rho <=0.18 g/cm^3
- A variety of thin (<0.1 X_0) nuclear targets can be installed & replaced during data taking: C, Ca, Fe, Pb,etc



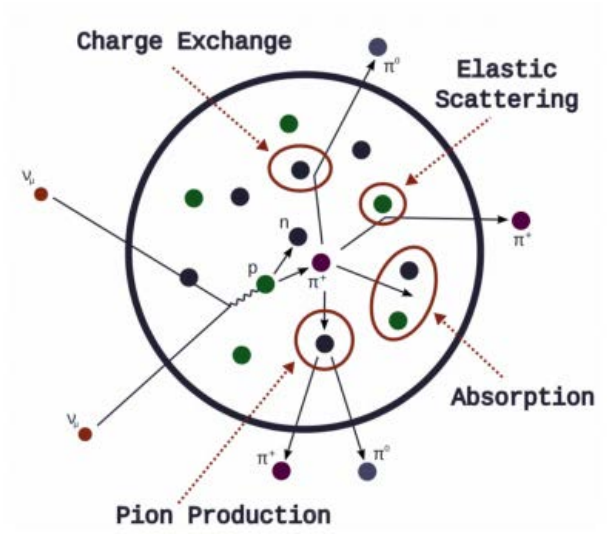


Modular design (flexible) offering a control of the configuration, chemical composition, and mass of targets comparable to e-scattering experiments

Neutrino-nucleus interaction

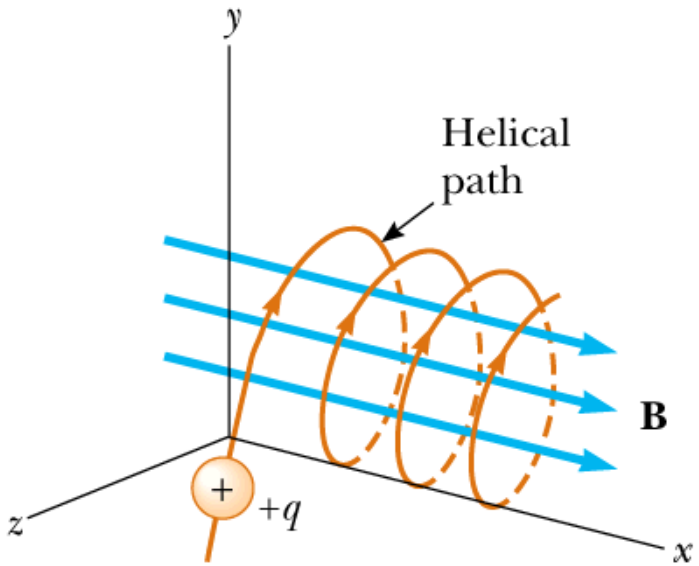


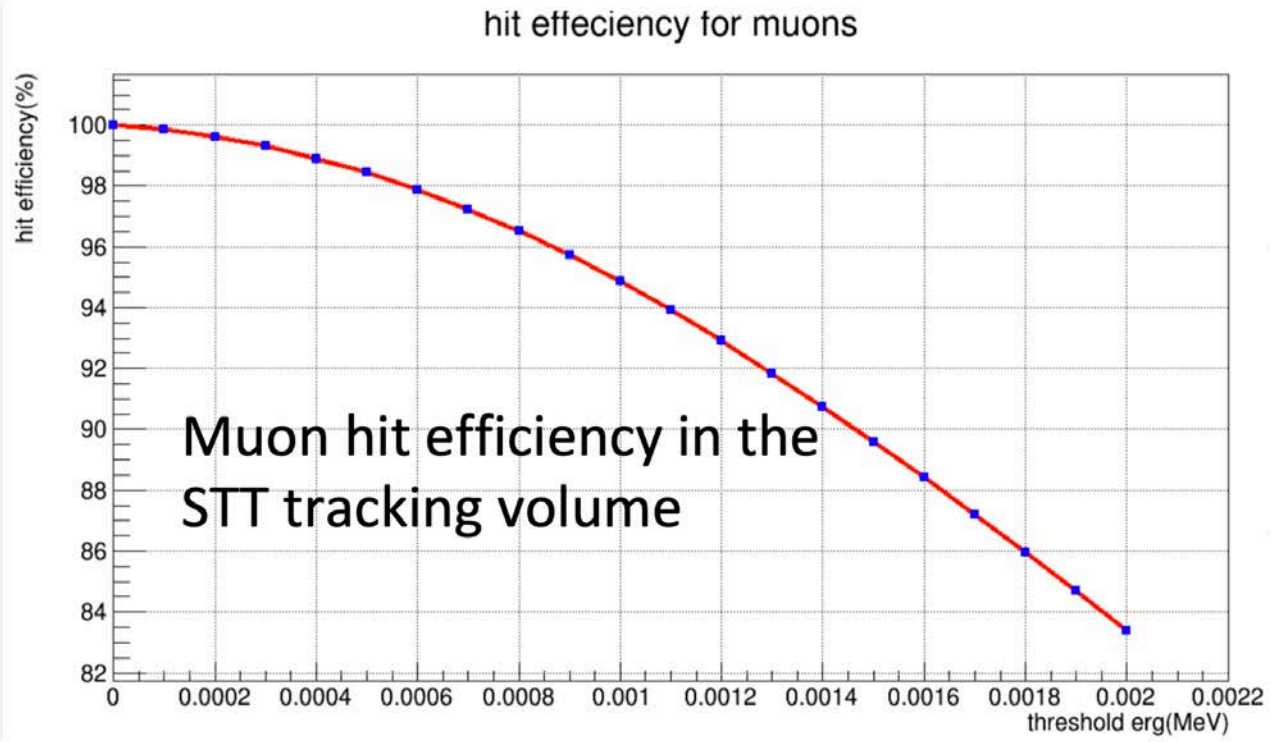
Feynmann diagrams

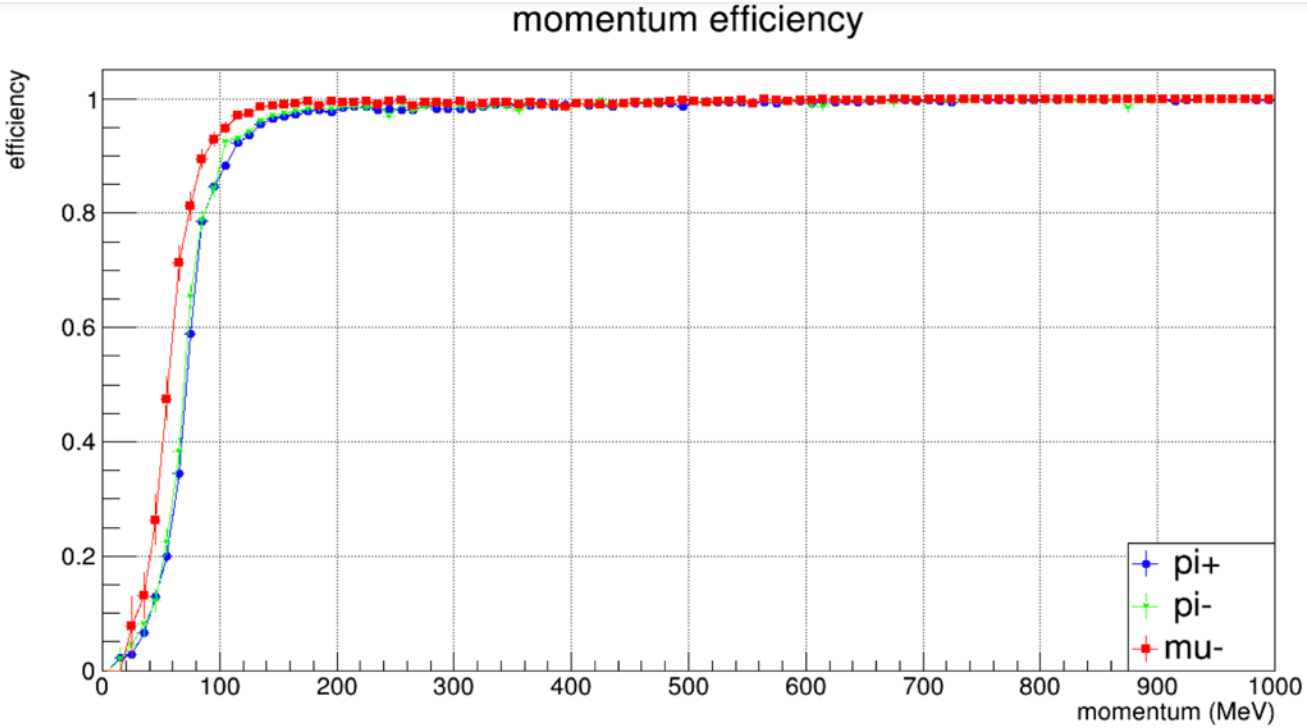


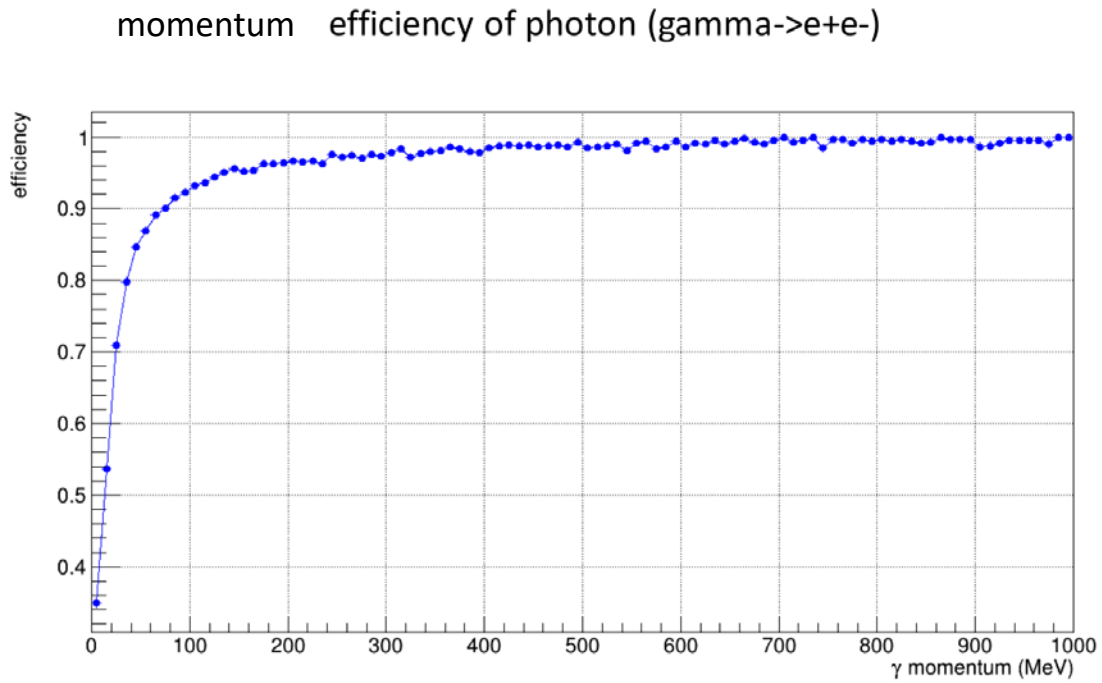
Purpose of STT

- Charged particle (from neutrino nucleus interaction) tracking. Basically reconstructing the momentum of the particle.









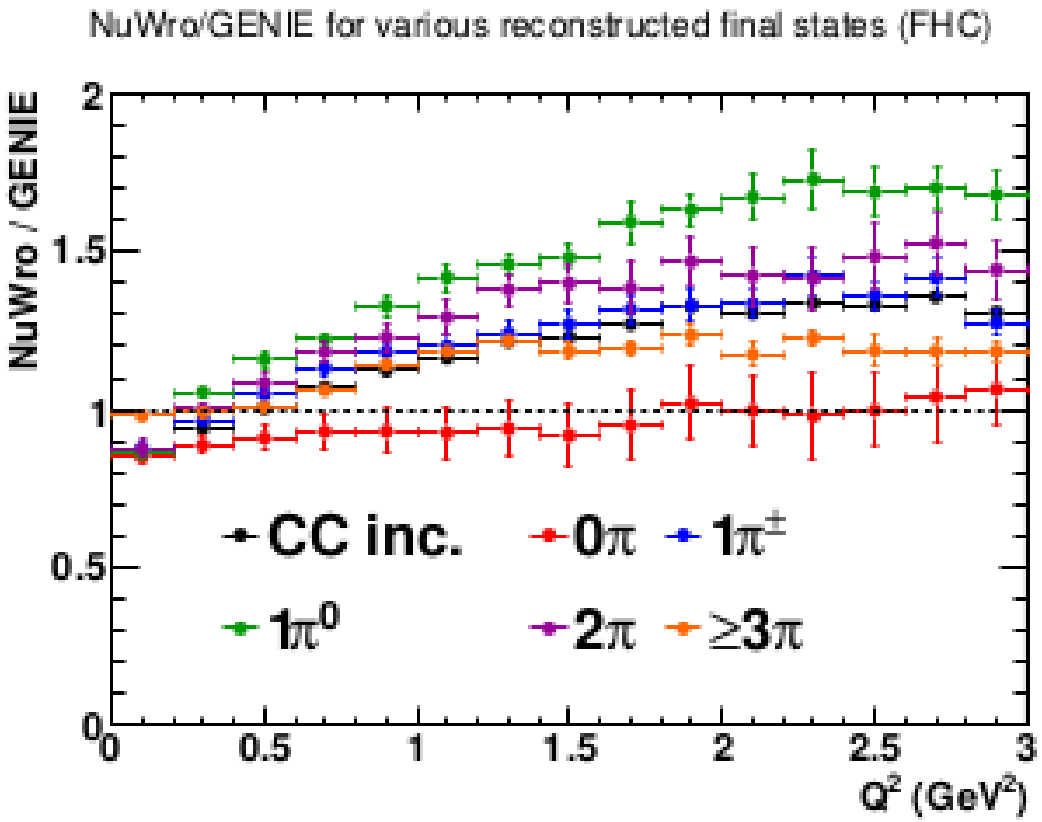
Momentum efficiency = reconstruction efficiency as a function of the momentum of the particle.

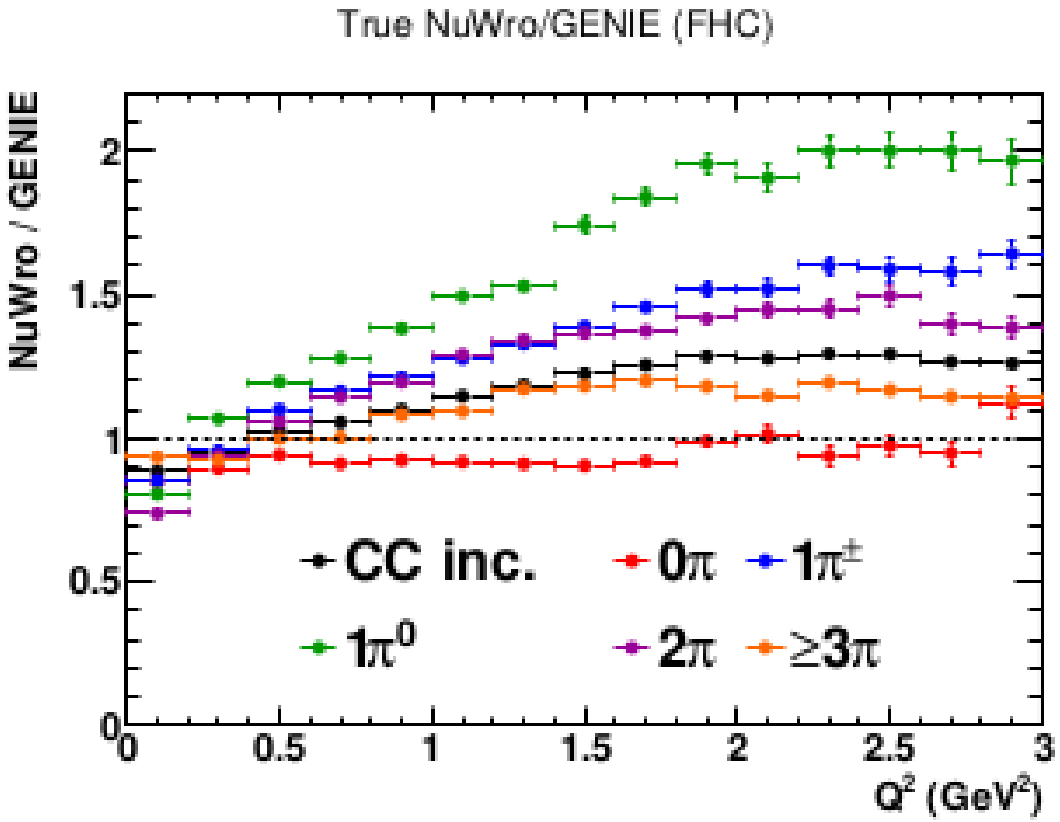
It can be seen that high energy particles can be reconstructed easilly

How do we analyse the events before the experiment?

- Using monte-carlo generators.
- Popular Neutrino generators = GENIE, NuWro, GiBUU
- The plots which I did were based on GENIE generated events.

Study of NuWro Vs GENIE events





Q = momentum transfer

Thank you for listening !!!!

Sources :

- https://arxiv.org/pdf/2002.03010.pdf
- https://inspirehep.net/files/c993b249124af552c33ba3ce833de863
- https://arxiv.org/pdf/2103.13910.pdf
- https://indico.cern.ch/event/857610/contributions/3654731/attachments/1957937/3252993/LBNC_Dec_6th_2019_SB.pdf