Abstract of The Thesis

Neutrino oscillation has been firmly established through a series experiments in last several years and spectacular results from those experiments have created a lot of interest in neutrinos, and many future neutrino experiments are in preparation to enhance our understanding about the tiny particle. In order to create an underground neutrino experiment facility in India, a multi-institutional neutrino collaboration has been formed with the objective of building an India-based Neutrino Observatory (INO). Cosmic pions are the main source of atmospheric neutrinos and the INO is a proposed atmospheric neutrino experiment. This thesis presents various works conducted for the development of simulation and data analysis framework for the INO experiment. In this thesis, we have discussed various aspects of simulation, prototyping and reconstruction of the INO detector towards investigating the phenomena of neutrino oscillation.

In INO, a 50kTon iron calorimeter (ICAL) will be the main detector and Resistive Plate Chambers (RPCs) will act as active detectors inside ICAL. A small prototype detector having geometry similar to ICAL has been installed at VECC. In the present work, we have simulated the response of the prototype by GEANT4 for incident cosmic muons. We have extended the simulation by performing two important steps towards reconstruction of muon tracks, likely to be produced by the charged-current (CC) interactions of atmospheric neutrinos.

The first step involves the use of the Artificial Neural Network (ANN) technique for discriminating muon hits from hadron hits layer by layer. We have taken the number of hits corresponding to a particular type of particles as input to ANN. It has been demonstrated that the method can isolate muon hits with an efficiency upto 98% with varying purity. The second step is to make use of the isolated muon hits and join them together to form muon tracks. A recursive algorithm known as Kalman Filter (KF) technique has been employed to fit the tracks towards obtaining best fitted track

parameters. KF incorporates the associated noise contribution while fitting. The fully contained (FC) muon tracks could be reconstructed with a momentum resolution of 15%. The reconstructed momenta have been found to be linear with respect to the incident tracks momenta.

For performing a complete simulation work, we have developed a Monte Carlo package for the simulation of RPC-response to minimum ionizing particle (MIP). As RPCs will be used as the sensitive detectors for ICAL, so this response simulation can be incorporated to the GEANT based simulation to obtain the realistic response. In the procedure different steps towards signal generation in RPC working in the avalanche mode e.g., primary ionization, avalanche formation & propagation, and finally signal generation have been incorporated. Additionally we have introduced a formalism for studying the RPC response due to the rough electrode surfaces. We have estimated the effects of roughness on efficiency and time resolution for a single-gap timing RPC. It is seen that the effect on time resolution is more prominent, compared to that on efficiency. The time resolution worsens by 30% for a 4% average variation in gap thickness, while the efficiency reduces by 10% due to a 20% variation in field caused by the surface roughness.

The aim of the work discussed in this thesis is towards building a self-consistent simulation and reconstruction procedure towards design and data analysis of ICAL.