Fundamental Studies of Momentum Measurement using ECC at SND@LHC

Kenji Obayashi[1] , Satoru Ogawa[1] and Masahiro Komatsu[2]
[1]Department of Physics, Graduate School of Science Toho University
[2] Associate Professor, Division of Infrastructural Development, Education Planning & Development Center, Institute of Liberal Arts and Sciences, Nagoya University
Corresponding Author: 6425001o@st.toho-u.ac.jp

Introduction

The Scattering and Neutrino Detector at the LHC (SND@LHC) [1] measures neutrinos produced at the ATLAS interaction point, covering all three neutrino flavors in the momentum range from several hundred GeV/c up to a few TeV/c. In this energy region, neutrino–nucleon cross section measurements provide valuable input for constraining parton distribution functions (PDFs) and contribute to the understanding of high-energy cosmic-ray neutrinos. Furthermore, since the source includes all neutrino flavors, SND@LHC provides an additional opportunity to test lepton flavor universality.

Currently, in the SND@LHC experiment, 20 Emulsion Cloud Chamber (ECC) modules with a total mass of 810 kg are being exposed to neutrinos. When a neutrino interacts inside an ECC, the produced charged particles leave tracks in the nuclear emulsion films. At Nagoya University, track data are obtained using automatic scanning systems, and by analyzing the emission angles and momenta of these tracks, the kinematics of neutrino interactions can be reconstructed. On the other hand, extending momentum measurements of high-energy particles with ECCs is expected to significantly expand the range of applications.

Experimental Procedures

The SND@LHC detector is installed 480 m downstream from the ATLAS interaction point (IP). At the IP, particles with large transverse momentum are detected by the ATLAS detector, while those produced with large longitudinal momentum along the beam direction can be measured by SND@LHC. This location uniquely allows the detection of high-energy neutrinos in a range rarely covered by previous experiments.[2] Such measurements both provide constraints on parton distribution functions (PDFs) through neutrino–nucleon cross sections and enable studies of lepton flavor universality.

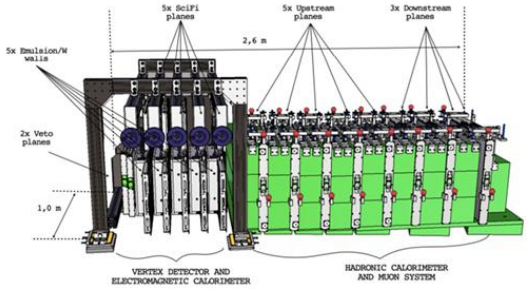
We are scanning nuclear emulsion films exposed during the 2023–2024 data-taking period of SND@LHC, focusing with the Hyper Track Selector II (HTS-II) system at Nagoya University. Momentum measurement of high-momentum particles using the Emulsion Cloud Chamber (ECC) strongly depends on alignment among emulsion films. Moreover, a large number of tracks along the beam axis are recorded. Track momentum is estimated from the displacement of identical tracks among ECC emulsion films, therefore it is essential to reconstruct the relative alignment among the films with high precision. In this study, we are developing techniques for both film alignment and track reconstruction. These efforts enabled us to collect fundamental emulsion data necessary for neutrino interaction searches and momentum measurements.

Results and Discussion

We analyzed the data from 12 scanned bricks and evaluated the track density and efficiency run by run . The track density reached 10^5 [/ cm^2]. By reconstructing base tracks from micro tracks and further connecting them, we investigated the efficiency of track reconstruction in the presence of multiple connections (“multi”). Our study shows that a significant number of false connections occur due to the nearly parallel muon tracks from the LHC beam. We quantitatively evaluated the occurrence of multi and its effect on efficiency. If the tracks are successfully connected, alignment between the emulsion films becomes possible, and the precision of the alignment determines the momentum resolution.

Acknowledgement

We would like to express our sincere gratitude to Professor Satoru Ogawa (Toho University) for his guidance throughout this study. We are also grateful to Masahiro Komatsu and Hiroki Rokujō (Nagoya University) for their valuable discussions on the data and support with the procedures



SND@LHC schematic [3]

References

[1] Scattering and Neutrino Detector at the LHC Letter of Intent
[2] arXiv:2412.03186v3 [hep-ex] 6-May 2025, [3] 2024 JINST 19 P05067