Hadronic shower reconstruction for the SND@LHC experiment

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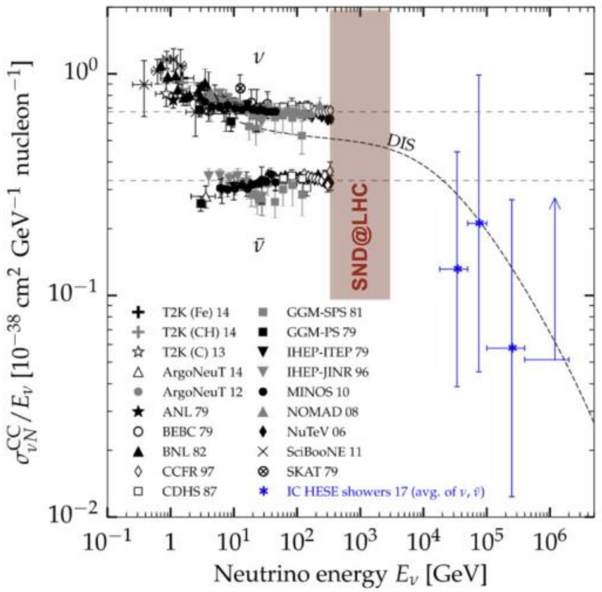
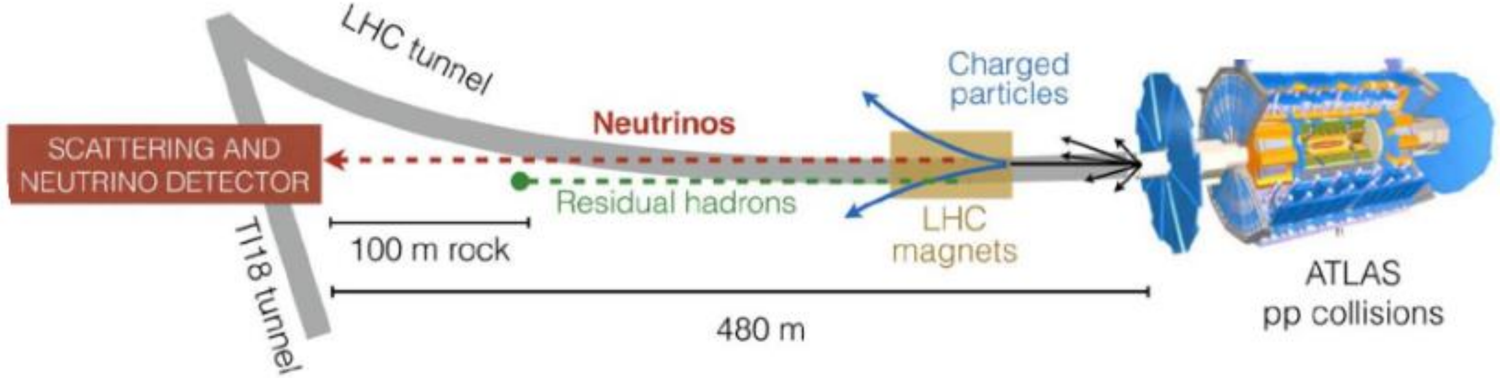
Scattering and Neutrino Detector

- pp collisions ($\mathbf{pp} \rightarrow \boldsymbol{\nu}_X \boldsymbol{X}$) at LHC at energy range unexplored, from 100 GeV up to few TeV.
- Installed in 2021 and it began collecting data in April 2022.
- It is installed in TI18 tunnel, 480 m downstream of ATLAS interaction point and is shielded by 100 m of rock.
- In July 2023, the experiment reported the direct observation of 8 muonic neutrinos.





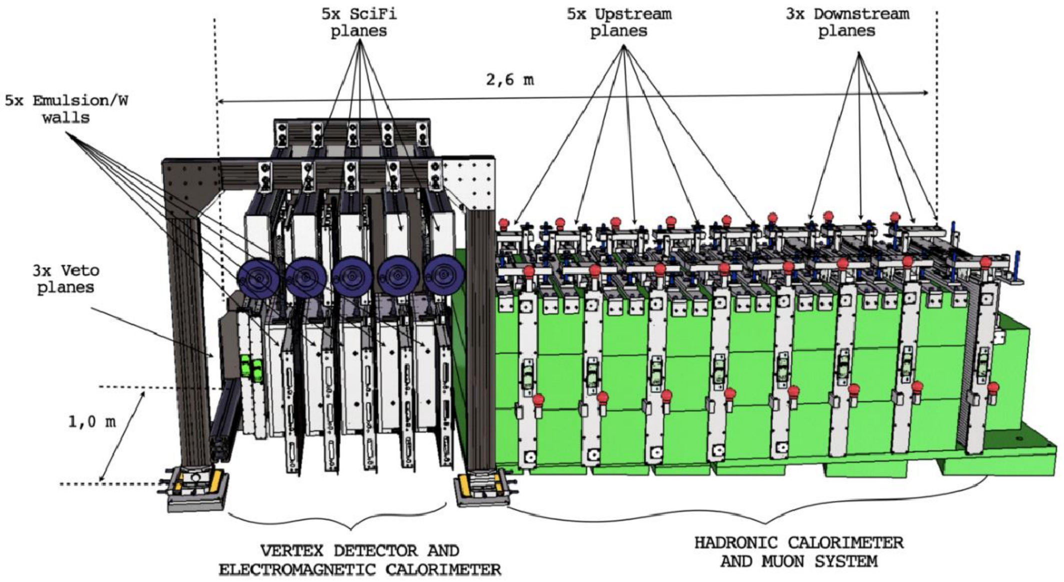
R. Albanese et al. Observation of Collider Muon Neutrinos with the SND@LHC Experiment. In: Phys. Rev. Lett. 131.3 (2023), p. 031802. doi: 10.1103/PhysRevLett.131.031802. arXiv: 2305.09383 [hep-ex]

Detector configuration

- ➢ Veto system: 3 planes of scintillating fibers

- ➢ Target with vertex identification and electromagnetic calorimeter:
  - Emulsion layers
  - Scintillating fibers

- ➢ Hadronic calorimeter and muon tagger: 5+3 scintillator planes read by SiPMs

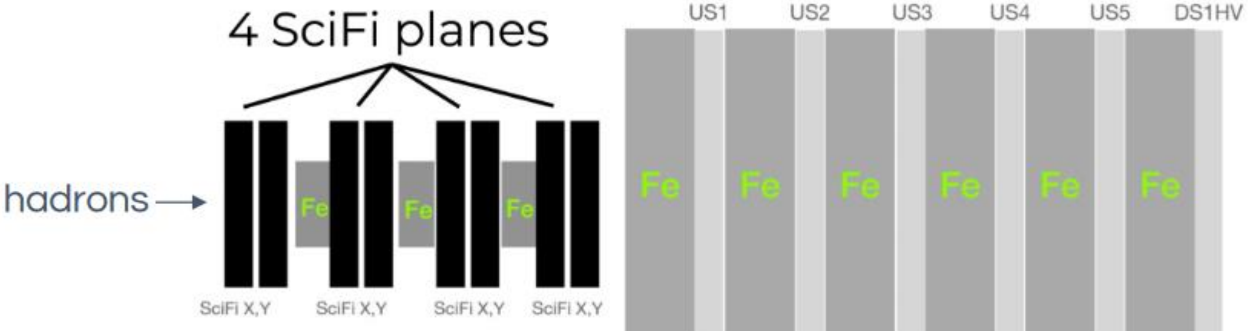


LHC Collaboration. SND@LHC: The Scattering and Neutrino Detector at the LHC. 2023. arXiv: 2210.02784 [hep-ex]

Test beam

In August 2023, the detector was exposed to hadron beams with energies ranging from 100 to 300 GeV in the SPS H8 test beam line.

This exposure is essential for calibrating the calorimeter and estimating uncertainties in the SND experiment.

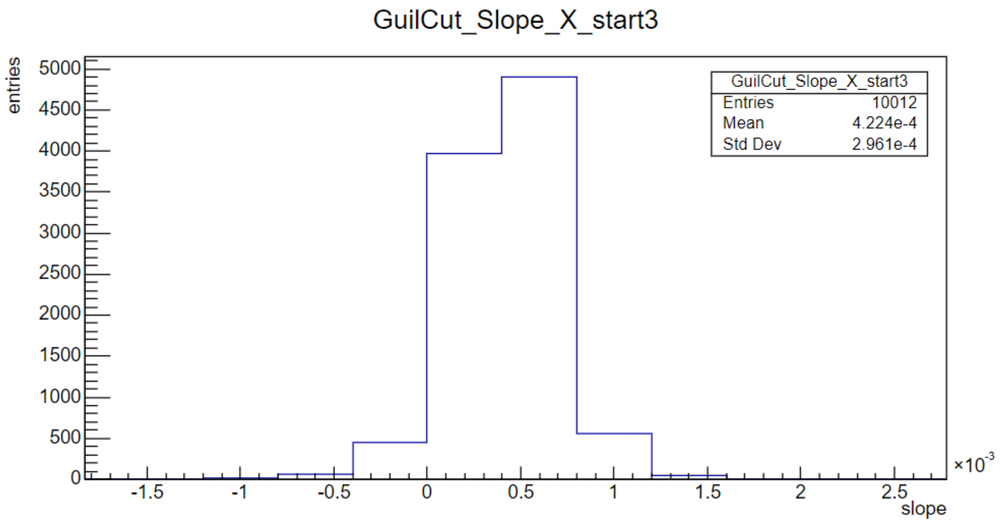


Thesis project

The aim is to analyze and reconstruct showers generated in charged current interactions of muonic neutrinos, using test beam calibration.

To perform this, the geometry of the experiment has been implemented in the code used for doing the analysis.

The direction of the shower is determined through a linear fit of "centroid" positions as function of the different SciFi layers of the detector.
With centroid I mean the central position of the shower in each layer, it is parametrized as the weighted average of positions of hits and the deposited charge, QDC.



Here is reported the plot of the reconstructed directions of test beam data using only SciFi planes.

Soon, also US information will be used to improve the efficiency of direction reconstruction.

Thesis project

When the uncertainty in reconstructing the incoming particle direction will be finished, also TI18 data can be analyzed to perform the measurement of the incoming neutrino energy.

In fact to perform this measurement is necessary to have both the direction and the energy of the shower and the muon direction. The momentum of the muon can be determined by the conservation of transverse momentum, through the relation:

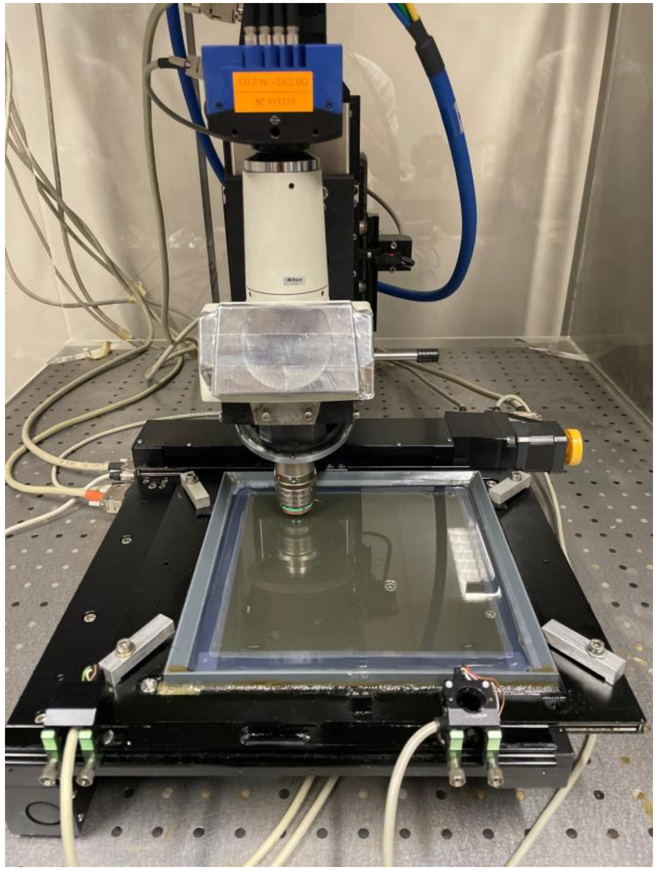
$$E_{sh}\theta_{sh} + P_{\mu}\theta_{\mu} = 0$$

The energies are determined through the calorimetry, which is already calibrated.

Microscopes

- Emulsion films are examined with optical microscopes to digitize the tracks created by charged particles. Software is then used to reconstruct all the tracks, with a particular focus on those of interest, to determine the vertex position.

- My thesis work also aids in narrowing the search area for the interaction vertex by reconstructing the shower's direction. This improvement enhances the precision of locating the interaction vertex and simplifies the elimination of background interference, resulting in a more efficient and accurate overall analysis.



Personal qualifications

Throughout my Bachelor's and Master's programs, I built a strong foundation in both theoretical and experimental physics, which fostered my deep appreciation for particle physics.

I explored neutrino topics at various levels during my academic career, I was really fascinated by their properties and our limited understanding in this field.

This fascination led me to work with the SND@LHC group for my Master's thesis, allowing me to combine my interests in neutrinos and accelerators.

INSS24

In 3-14 June I attended International Neutrino Summer School, which covered lots of arguments from theoretical to experimental results

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Divulgation for children at elementary schools during the period of April-May

Personal ambitions

The SND@LHC group in Bologna is incredibly supportive, offering guidance and suggestions that are significantly contributing to my growth, skill enhancement, and knowledge expansion in this field.

I would be honored to continue working with them.

The University of Bologna's strong research focus, coupled with its collaborations with international institutions, creates an ideal environment for me to contribute to and learn from the latest advancements in this field.

In addition, the fact that SND@LHC is a relatively small experiment allows me to better understand how the experiment works in all its parts.
Soon, it will also be updated into ADV-SND, offering even more opportunities for in-depth learning and contribution.

Thanks for your attention

LHC

Scattering and Neutrino Detector
at the LHC