APPLICATION

HSF-India: Neutrino Physics Project at the University of Chicago

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Host University and Advisor

I have been invited to work in **Professor David Schmitz's group (Department of Physics, University of Chicago)** as a Non-Degree Visiting Student (NDVS), which is a construct that allows students registered for a degree program in another university to work in the laboratories of the University of Chicago for a quarter. As an NDVS, I will have the access to the laboratories and working spaces at UChicago, along with all its student services, such as the libraries, sports facilities, IT Support etc.., essentially being treated as a student of the University of Chicago for the summer quarter. I will be working with the Schmitz group between the **1st of June and the 31st of August**, under the direct supervision of **Dr. Thomas Wester**, a postdoctoral fellow at the University of Chicago. Prof. David Schmitz is one of the spokespersons for the **Short Baseline Near Detector (SBND)** experiment being conducted at Fermilab. The neutrino research group at the University of Chicago consists of three faculty members, two postdoctoral fellows and eight students. The research of the group is broad within the field, with members working on data acquisition, software trigger systems and detector commissioning as well as cross section measurements and rare event searches in short baseline experiments of Fermilab.

Project Overview

The Short Baseline Neutrino (SBN) program is a neutrino experiment which involves three Liquid Argon Time Projection Chambers (LArTPC) postioned along the axis of the Booster Neutrino Beam (BNB) at Fermilab, the SBND, MicroBooNE and ICARUS T600. The SBND uses the principle of Precision Reaction Independent Spectrum Measurement (PRISM) which involves measurement of the neutrino flux off the axis of the BNB, allowing the segmentation of the detector into multiple off-axis volumes, each one seeing a different energy spectrum due to the dependence of the off-axis angle on the energy of the neutrino. Although the exact details of the project will depend on the status of the experiment at the time of the project, I will broadly be working on the simulations of energy-dependent LAr-ν cross-sections, and studying PRISM's potential in improving oscillation measurements.

A part of my project will be to develop a statistical software analysis pipeline to optimally construct the segmentation of off-axis volumes in ICARUS T600 based on the shape of the beam observed by the SBND. The primary physics informing this prediction, as mentioned earlier, will be the

correlation between the off-axis angle and energy of the neutrinos. This, conversely, helps us to zoom in on the portion of the flux detected by SBND that is also detected by the MicroBooNE and ICARUS, hence helping us to resolve the flux distributions at multiple baselines. The correlation between the observations at the three detectors will help us to reduce systematic uncertainties as well and increase the sensitivity of oscillation to sterile neutrino to an estimated $\mathcal{O}(1\,\mathrm{eV}^2)$ ([4]).

Similarly, the information of beam shapes at the three detectors can be used in the identification of missing energy. A software package dedicated to missing energy searches can be developed using the correlation between the beam configurations observed in the three detectors and comparing it to the actual energy deposition recorded. The high neutrino influx in the SBN program allows us to look for these rare events with very low statistical uncertainties, ultimately pointing towards still poorly understood/measured phenomena such as oscillation to light-sterile neutrinos (rather, a null test for it, taking into account MicroBooNE's recent paper [3]). The project will also require running ROOT based simulation algorithms on supercomputers at the Argonne National Laboratory and developing data-heavy analysis methods that can be used in future LArTPC based neutrino studies. Other capabilities of the energy based measurements include corrections to the GeV scale nuclear interactions (cross-sections) in event generators and data-driven approaches to the short baseline anomaly.

Financial Support

The main categories of financial support are airfare, lodging (rent and utilities), food and groceries, travel and daily commute, household items, health insurance, mobile service, and other miscellaneous living expenses. The expenses as required by the University of Chicago for the Non-Degree Visiting Student Program (along with airfare and visa costs) are listed below:

Category	**Cost**
J1-Visa (SEVIS + Application Fee)	$405
NDVS Tuition Fee	$1,565
Student Services Fee	$520
Insurance	$315
Living Expenses	$8,086
Total	**$10,891**

Conclusion

To conclude, I would like to restate my strong interest in working on SBND, primarily through simulation and data-driven studies involving PRISM and its role in reducing flux and cross-section uncertainties. I am also keen on developing a stronger understanding of the translation of detector and beam configuration simulations into robust physics constraints, and to gain experience on analysis pipelines. I am highly motivated to contribute to the SBN program during my time at the University of Chicago while developing independence in computational and physics-driven research.

References

[1] P. Abratenko et al. "Data-driven model validation for neutrino-nucleus cross section measurements". In: *Phys. Rev. D* 111.9 (2025), p. 092010. DOI: 10.1103/PhysRevD.111.092010. arXiv: 2411.03280 [hep-ex].

[2] P. Abratenko et al. "SBND-PRISM: Sampling Off-Axis Neutrino Fluxes with the Short-Baseline Near Detector". In: (Aug. 2025). arXiv: 2508.20239 [hep-ex].

[3] P. Abratenko et al. "Search for light sterile neutrinos with two neutrino beams at MicroBooNE". In: *Nature* 648.8092 (2025), pp. 64–69. DOI: 10.1038/s41586-025-09757-7. arXiv: 2512.07159 [hep-ex].

[4] R. Acciarri et al. "The Short-Baseline Near Detector at Fermilab: Input to the European Strategy for Particle Physics 2026 Update". In: (Mar. 2025). arXiv: 2504.00245 [hep-ex].

[5] L. Aliaga et al. "Neutrino Flux Predictions for the NuMI Beam". In: *Phys. Rev. D* 94.9 (2016). [Addendum: Phys.Rev.D 95, 039903 (2017)], p. 092005. DOI: 10.1103/PhysRevD.94.092005. arXiv: 1607.00704 [hep-ex].