

## IF Fellowship Closeout Report

My research interests lie in the area of experimental high energy physics, with primary focus on the Intensity Frontier program. In particular, my current primary research goal is accelerator neutrino physics, at short- and long- baselines. Over the course of my Fermilab IF Fellowship I focused on studies of neutrino interactions by means of the innovative Liquid Argon TPC technology (LArTPC).

In my role as *Physics Analysis Coordinator* of the ArgoNeuT experiment, I am leading the effort for the publication of results from ArgoNeuT data analysis. Seven papers have been published in the years 2012-2014, two of them during the period of my IF Fellowship. I have devoted a big effort to the development of a new "topological" method of analysis of neutrino interactions, to precisely reconstruct the incoming neutrino energy and study nuclear effect in neutrino-nucleus interaction in LAr-TPCs, leading to the publication of a paper on the detection of back-to-back proton pairs in Charged-Current neutrino interactions. Several more ArgoNeuT physics papers are now also well on their way to completion.

I have actively participated in the proposal and current realization of the LArIAT experiment at the Fermilab Test Beam Facility to measure the LArTPC detector response to single particles, essential for calibration and particle identification in a LAr TPC.

I have contributed to the construction and assembly of the MicroBooNE detector (90 t active mass LAr TPC) and I'm involved in the development, test and optimization of the offline software code (LArSoft).

Since more than a year, the idea of next generation short-baseline neutrino oscillation experiment has been subject of increasing consideration at FNAL. Within this context, and based on a strong recent effort, the LAr1-ND experiment has been proposed. In January 2014 I have been elected *co-Spokesperson* for the LAr1-ND experiment, an international collaboration composed by 80 members. The LAr1-ND experiment has been recently approved (July 2014),

The LAr1-ND detector (80 t active mass LArTPC) is the Near detector in the Short Baseline Neutrino (SBN) program on the Booster neutrino beam at Fermilab for the study of sterile neutrinos. The SBN program with three LArTPC detectors (LAr1-ND, MicroBooNE as Intermediate Detector, and the ICARUS T600 as Far Detector) would address in a definitive way whether the observed short-baseline neutrino anomalies are due to high  $\Delta m^2$  neutrino oscillations.

During the period of my IF Fellowship my primary activity has been devoted to the studies of the science case of the SBN program and to the design study for the LAr1-ND detector. The definition of the combined SBN program by the LAr1-ND, MicroBooNE and ICARUS Collaborations, and representatives of CERN and Fermilab has been developed. A proposal Proposal for a Three Detector Short-Baseline Neutrino Oscillation Program in the Fermilab Booster Neutrino Beam will be submitted to the Fermilab PAC in January 2015. This new SBN Program will deliver a rich and

compelling physics opportunity, including the ability to resolve a class of experimental anomalies in neutrino physics and to perform the most sensitive search to date for sterile neutrinos at the eV mass-scale, through both appearance and disappearance oscillation channels. Additional physics of the SBN Program includes the study of neutrino-argon cross sections with millions of interactions using the well characterized neutrino fluxes of the BNB. The SBN Program is an excellent opportunity to further develop this important technology for the future long-baseline neutrino program while utilizing its remarkable capabilities to explore one of the exciting open questions in neutrino physics today.

### **Selected presentations, seminars and lectures [2014]**

- “Short-Baseline Neutrino Oscillation Program on the Fermilab Booster Neutrino Beam”, Neutrino Seminar Series, Fermilab, Dec. 2014.
- “Detection of Short Range Correlated nucleon pairs in charged-current neutrino interactions at ArgoNeuT”, Joint Experimental-Theoretical Physics Seminar (“Wine and cheese” seminar), Fermilab, Oct. 2014.
- “Correlations in neutrino-induced events”, invited talk at the International workshop on experimental and theoretical topics in CLAS data mining, MIT, Boston, Aug. 2014
- “Recent results from ArgoNeuT”, invited talk at the 47th Annual Fermilab Users Meeting, June 2014.
- “Detecting CC 0 pion events in LAr - Cross sections and back-to-back proton events in ArgoNeuT”, invited talk at the NuInt’14 Workshop, London, May 2014.
- “Experimental Anomalies in neutrino physics”, invited talk at the American Physical Society Meeting, Savannah (GA, USA), April 2014.
- “What international coordination is necessary for planning the short baseline program”, round table at the ICFA neutrino panel mini-workshop, Fermilab, Jan. 2014.
- “LAr1-ND: testing neutrino anomalies with multiple LAr TPC detectors at Fermilab” - presentation at the Fermilab PAC meeting, Jan. 2014.

### **Selected publication on refereed journals [2014]**

1. R. Acciarri et al. (ArgoNeuT Collaboration), “First Measurement of Neutrino and Antineutrino Coherent Charged Pion Production on Argon”, *arXiv:1408.0598 [hep-ex] (2014), accepted by Phys. Rev. Lett. (in press)*.
2. R. Acciarri et al. (ArgoNeuT Collaboration), “Detection of back-to-back proton pairs in charged-current neutrino interactions with the ArgoNeuT detector in the NuMI low energy beam line”, *Phys. Rev. D 90 (2014), 012008*.
3. R. Acciarri et al. (ArgoNeuT Collaboration), “Measurements of Inclusive Muon Neutrino and Antineutrino Charged Current Differential Cross Sections on Argon in the NuMI Antineutrino Beam”, *PHYSICAL REVIEW D 89, 112003 (2014)*.

### **Recent proposals and White Papers**

- LAr1-ND Collaboration, “LAr1-ND: Testing Neutrino Anomalies with Multiple LAr TPC Detectors at Fermilab”, [http://www.fnal.gov/directorate/program\\_planning/Jan2014PACPublic/LAr1ND\\_Proposal.pdf](http://www.fnal.gov/directorate/program_planning/Jan2014PACPublic/LAr1ND_Proposal.pdf), December 2013.
- LBNE Collaboration, “The LongBaseline Neutrino Experiment”, <http://arxiv.org/abs/1307.7335>, FERMILAB-PUB-14-022 (2014).