

This is the final report for my intensity frontier fellowship.

(1) Specific activities that were facilitated by the Fellowship Funding

The intensity frontier (IF) fellowship had supported my proposed project (in collaboration with Dr. Mikhail Gorshteyn at University of Mainz, Germany), titled as “neutral-current (NC) induced pion and photon productions off nucleons”. The work is directly related to the neutrino-nucleus interaction cross section measurements planned and carried out at Fermilab.

(2) Discussion of how being at Fermilab aided in these activities

The proposed project is a topic of my own interest. It does not belong to my original research plan supported by my home institution. At Fermilab, I was able to focus solely on this project.

During my stay, I discussed the neutrino-nucleon interaction physics with scientists in the Fermilab’s theory department, including Dr. Andreas Kronfeld, Dr. Richard Hill, and Dr. Chris Quigg. Dr. Andreas Kronfeld, Dr. Richard Hill, and one of their students are applying Lattice quantum chromodynamics (QCD) method to compute nucleon weak form factors. We discussed the possibility of using the same method to study weak transition form factors which are related to the neutrino-induced pion production topic in my proposal.

I also talked with the neutrino experimentalists in the lab, including Dr. Rober Plunkett, Dr. Sam Zeller, Dr. Tingjun Yang, Dr. Deborah Harris, Dr. Jorge Morfin, and Dr. Stephen Brice, as well as the Fermilab visitors, Dr. Steve Dytman (University of Pittsburg), and Dr. Kevin McFarland (University of Rochester). They showed interests in my work, and informed me of the current and future experimental efforts to study neutrino-nucleus interactions.

I met two theorists (also IF fellows), Dr. Luis Alvarez-Ruso (University of Valencia, Spain) and Dr. Alexey Petrov (Wayne State University). Dr. Luis Alvarez-Ruso and I planned collaboration on computing NC-induced photon events for the MINERvA experiment. Dr. Alexey Petrov pointed out the relevance of my project to the neutron physics, and a possible collaboration was discussed.

During the Neutrino Scattering Theory Experimental Collaboration (NuSTEC) school (October 2014), I met a few experts in the field. We discussed my Fermilab project and their related works.

In addition, thanks to the MINERvA collaboration, I was able to invite Dr. Steve Dytman to give a seminar talk on the recent MINERvA results at my home institution, Ohio University.

(3) Comparison of the things you got done with what you expected when proposing, including new things that happened.

In the period supported by the fellowship, I finished about half of my proposed project, i.e., building a framework, which respects the unitarity, to describe the neutrino-induced pion production off nucleon. (This was my first time to write a proposal. I was too optimistic about my working pace.) Currently, my collaborator and I are finishing up one paper on a specific

aspect of the photon production, and also preparing another paper on pion production. I will work on the other half of the project, i.e., the photon production, during my 2nd postdoc in the nuclear theory group at University of Washington.

As detailed in section (2), two “unexpected” projects related to my original proposal were brought up during my discussion with other two IF fellows.

(4) Your perspective on how Fermilab benefitted from your ability to be here, including interactions with collaborators and others.

Based on my specific experience as detailed in section (2), I think that through this program Fermilab serves as a UNIQUE connection point for physicists to discuss ideas and works related to neutrino-nucleon/nucleus interaction, and to form collaborations. (I am not aware of other institutions in the U.S. serving such purpose for this particular field.) The development of this field is vital for the neutrino cross section measurements and neutrino oscillation experiments at Fermilab and elsewhere.

5) Any publications or other documents resulting from your stay.

As mentioned in section (3), Dr. Mikhail Gorshteyn and I are working on two papers, under working titles “Forward Compton scattering with weak neutral current: new sum rules”, and “An isobar model for pion production in neutrino-nucleon scattering”. If needed, I can send the notes to Fermilab after discussing with my collaborator.

The 3rd relevant paper, in collaboration with Dr. Mikhail Gorshteyn and Dr. Hubert Spiesberger from University of Mainz, and Dr. Igor Strakovsky, Dr. William Briscoe, and Dr. Ron Workman from The George Washington University, is still in preparation. This work is about Virtual Compton scattering, a topic of the hadronic physics, but also related to my proposed project.

6) Conferences or other presentations made possible by your funding.

In October 2014 (i.e., the end of my Fermilab stay), I gave a seminar talk, titled as “Can neutrino-induced photon production explain the low energy excess in MiniBooNE?” in the high energy physics group at Northwestern University, Evanston, Illinois.

In the APS April meeting 2015 (Baltimore, MD), I will give an invited talk on neutrino-nucleon/nucleus interactions, which will cover my project supported by this IF fellowship.