
NuSTEC

Neutrino Scattering Theory Experiment Collaboration

HEP-Theory/Experiment

November 2017

Jorge G. Morfín

Fermilab

NuSTEC Web Page

<http://nustec.fnal.gov>

The screenshot shows a web browser window displaying the NuSTEC website. The browser's address bar shows the URL <https://nustec.fnal.gov>. The website features a blue header with the Fermilab logo and a navigation menu with links for Home, Contact, Phone Book, Fermilab at Work, Jobs, About, Science, Newsroom, Visit, and Resources for ... A search bar is also present. Below the navigation is a large video player showing a lecture in progress. The video has a blue overlay with the text "NuSTEC". To the left of the video is a sidebar with a "Home" section containing links to "NuSTEC school", "NuSTEC News", "NuInt conference series", "Workshops, conferences, schools", and "Database". Below the sidebar are social media icons for Facebook and Twitter. The main content area below the video has a blue background with the heading "NuSTEC: Neutrino Scattering Theory Experiment Collaboration" and a sub-heading "What is NuSTEC?". The text explains that NuSTEC is a collaboration of theorists and experimentalists promoting and coordinating efforts between:

- Theorists – studying neutrino nucleon/nucleus interactions and related problems
- Experimentalists – primarily those actively engaged in neutrino nucleus scattering experiments as well as those trying to understand oscillation experiment systematics. Electron scattering experimentalists are certainly welcome.
- Generator builders – actively developing/modifying the model of the nucleus as well as the behavior of particles in/out of the nucleus within generators.

The main goal is to improve our understanding of neutrino interactions with nucleons and nuclei and, practically, get that understanding in our event generators.

NuSTEC: Membership

Considering to add 2 theorists and 2 experimentalists – 1 theorist stepping back

◆ THEORISTS

- ◆ Luis Alvarez Ruso (co-spokesperson)
- ◆ Sajjad Athar
- ◆ Maria Barbaro
- ◆ Omar Benhar
- ◆ Richard Hill
- ◆ Patrick Huber
- ◆ Natalie Jachowicz
- ◆ Andreas Kronfeld
- ◆ Marco Martini
- ◆ Toru Sato
- ◆ Rocco Schiavilla
- ◆ Jan Sobczyk (nuWRO)

◆ EXPERIMENTALISTS

- ◆ Sara Bolognesi
- ◆ (Steve Brice)
- ◆ Raquel Castillo

- ◆ Dan Cherdack
- ◆ Steve Dytman (GENIE)
- ◆ Andy Furmanski
- ◆ Yoshinari Hayato (NEUT)
- ◆ Teppei Katori
- ◆ Kendall Mahn
- ◆ Camillo Mariani
- ◆ Jorge G. Morfín (co-spokesperson)
- ◆ (Ornella Palamara)
- ◆ Jon Paley
- ◆ Roberto Petti
- ◆ Gabe Perdue (GENIE)
- ◆ Federico Sanchez
- ◆ (Sam Zeller)

() indicates advisor

NuSTEC White Paper

[arXiv:1706.03621](https://arxiv.org/abs/1706.03621) [hep-ph] - to be published.

NuSTEC White Paper: Status and Challenges of Neutrino-Nucleus Scattering

L. Alvarez-Ruso,¹ M. Sajjad Athar,² M.B. Barbaro,³ D. Cherdack,⁴ M.E.Christy,⁵ P. Coloma,⁶
T.W. Donnelly,⁷ S. Dytman,⁸ R. J. Hill,^{9,10,6} P. Huber,¹¹ N. Jachowicz,¹² T. Katori,¹³
A. S. Kronfeld,⁶ K. Mahn,¹⁴ M. Martini,¹⁵ J. G. Morfín,⁶ J. Nieves,¹⁶ G. Perdue,⁶
R. Petti,¹⁷ D. G. Richards,¹⁸ F. Sánchez,¹⁹ T. Sato,²⁰ J. T. Sobczyk,²¹ and G. P. Zeller⁶

The precise measurement of neutrino properties is among the highest priorities in fundamental particle physics, involving many experiments worldwide. Since the experiments rely on the interactions of neutrinos with bound nucleons inside atomic nuclei, the planned advances in the scope and precision of these experiments requires a commensurate effort in the understanding and modeling of the hadronic and nuclear physics of these interactions, which is incorporated as a nuclear model in neutrino event generators. This model is essential to every phase of experimental analyses and its theoretical uncertainties play an important role in interpreting every result.

In this White Paper we discuss in detail the impact of neutrino-nucleus interactions, especially the nuclear effects, on the measurement of neutrino properties using the determination of oscillation parameters as a central example. After an Executive Summary and a concise Overview of the issues, we explain how the neutrino event generators work, what can be learned from electron-nucleus interactions and how each underlying physics process—from quasi-elastic to deep inelastic scattering—is understood today. We then emphasize how our understanding must improve to meet the demands of future experiments. With every topic we find that the challenges can be met only with the active support and collaboration among specialists in strong interactions and electroweak physics that include theorists and experimentalists from both the nuclear and high energy physics communities.

Main Sections of the White Paper

Executive Summary and Bring it Together.

Introduction and Overview of the Current Challenges.

The Impact of Neutrino Nucleus Interaction Physics on Oscillation Physics Analyses

Neutrino Event Generators

Electron-nucleus Scattering as input to neutrino scattering

Quasi-elastic, Quasi-elastic-like Scattering

Resonance Model

Shallow Inelastic Scattering and Deep Inelastic Scattering

Coherent and Diffractive Scattering

2nd Extended NuSTEC School on Neutrino Nucleus Scattering Physics

7 – 15 November 2017 at Fermilab

<http://nustec.fnal.gov/school2017/>

- ◆ Had ≈ 55 paying students plus additional 10 – 15 “auditors”.
- ◆ Lectures available : <https://indico.fnal.gov/event/15286/timetable/#20171116>

	Topic	Hours	Lecturer
0	The Practical Beauty of Neutrino-Nuclear Interactions	1	G. Perdue
1	Introduction to electroweak interactions on the nucleon	3	R. Hill
2	Introduction to neutrino-nucleus scattering	3	J. W. Van Orden
3	Strong and electroweak interactions in nuclei	3	S. Pastore
4.1	Approximate methods for nuclei (I)	2	A. Ankowski
4.2	Approximate methods for nuclei (II)	2	N. Jachowicz
4.3	Ab initio methods for nuclei	2	A. Lovato
5	Pion production and other inelastic channels	3	T. Sato
6	Description of exclusive channels and final state interactions	3	K. Gallmeister
7	Inclusive electron and neutrino scattering in the shallow and deep inelastic regimes	3	J. Owens
8	Systematics in neutrino oscillation experiments	3	S. Bolognesi
9.1	Monte Carlo Methods and Event Generators	3	T. Golan
9.2	Nuisance	2	P. Stowell

Upcoming - 2018 - NuSTEC Workshops

- ◆ **INT Workshop on ν – nucleon physics – R. Hill – June at INT**
Considerable community interest in a new high-statistics ν – N experiment. What can (lattice-gauge) theory bring us?
- ◆ **Shallow and Deep-Inelastic Scattering – October just before NuInt18 in Italy**
The community needs a probing look at SIS (Delta to DIS) and the DIS regions. Very important for DUNE.

NuSTEC Board Meeting – Day 1

	Report on the NuSTEC School	<i>Dr. Luis ALVAREZ-RUSO</i>
	<i>Fermilab</i>	08:30 - 09:00
09:00	Planning of the nu-H/D meeting	<i>Richard HILL</i>
	<i>DarkSide, Fermilab</i>	09:00 - 09:30
	Planning of the nu-SIS/DIS meeting tied to NuInt18	<i>Jorge G. MORFIN</i>
	<i>Fermilab</i>	09:30 - 09:45
	HEP Theory Experiment collaboration	<i>Dr. Minerba BETANCOURT</i>
	<i>Fermilab</i>	09:45 - 10:00
10:00	Report on the winter workshop	<i>Dr. Andreas KRONFELD</i>
	<i>Fermilab</i>	10:00 - 10:15
	Coffee Break	
	<i>Fermilab</i>	10:15 - 10:35
	Pion Production Model	<i>Dr. Natalie JACHOWICZ</i>
	<i>Fermilab</i>	10:40 - 11:00
11:00	NuSTEC and the Fermilab Short Baseline Program	<i>Dr. Andrew FURMANSKI</i>
	<i>Fermilab</i>	11:00 - 11:20
	NuSTEC and DUNE Preparations	<i>Prof. Roberto PETTI</i>
	<i>Fermilab</i>	11:20 - 11:40
	News about the e-Argon experiment at JLab	<i>Prof. Camillo MARIANI</i>
	<i>Fermilab</i>	11:40 - 12:00
12:00	Hadronization	<i>Dr. Teppeï KATORI</i>
	<i>Fermilab</i>	12:00 - 12:20

NuSTEC Board Meeting – Day 2

	NuSTEC endorsements	
	<i>Fermilab</i>	08:30 - 09:00
09:00	Publishing the white paper	<i>Jorge G. MORFIN</i>
	<i>Fermilab</i>	09:00 - 09:10
	Prioritizing the Challenges	
	<i>Fermilab</i>	09:10 - 09:30
	CERN neutrino platform	<i>Dr. Sara BOLOGNESI</i>
	<i>Fermilab</i>	09:30 - 09:45
	New Board members	
	<i>Fermilab</i>	09:45 - 10:00
10:00	Coffee Break	
	<i>Fermilab</i>	10:00 - 10:20
	Nuclear Correction in the DIS region	<i>Dr. MOHAMMAD SAJJAD ATHAR</i>
	<i>Fermilab</i>	10:20 - 10:40
	NuWro Update	<i>Jan SOBCZYK</i>
	<i>Fermilab</i>	10:40 - 11:00
11:00	SuSa and 2p2h Models	<i>Prof. Maria Benedetta BARBARO</i>
	<i>Fermilab</i>	11:00 - 11:20
	GENIE Needs; Pion and DIS Models	<i>Mr. Steven DYTMAN</i>
	<i>Fermilab</i>	11:20 - 11:40
	Ab initio calculations and synergies with JLab	<i>Prof. Rocco SCHIAVILLA</i>
	<i>Fermilab</i>	11:40 - 12:00
12:00	CEA experiment-theory collaboration plans	<i>Dr. Sara BOLOGNESI</i>
	<i>Fermilab</i>	12:00 - 12:20