NuSTEC (Neutrino Scattering Theory Experiment Collaboration)

Goals and Strategy

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Fermilab
NuInt15 – Osaka, Japan

What is NuSTEC?

- NuSTEC promotes the collaboration and coordinates 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. e-A 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.
  - The impact of our main goal will be widespread in both hadron and nuclear physics and directly effect oscillation physics.
- Along the way we want to expand support for theorists and encourage a growing theoretical community.

NuSTEC Board Meeting
October, 2015

We had a meeting of the NuSTEC Board last month when we discussed the following issues:

- NuSTEC Board
  - NuSTEC Collaboration
- NuSTEC By-laws – first draft circulated and collecting comments
- NuSTEC Workshops
- NuSTEC Training/Schools
- NuSTEC and Generators
- NuSTEC Communications – Fermilab web page, newsletter
- NuSTEC and Funding Agencies
- NuSTEC Projects

The NuSTEC Board

Currently = the NuSTEC collaboration but expect the collaboration to expand as NuSTEC projects, workshops and schools attract more collaborators.

Theorists

- Luis Alvarez Ruso
- Sajjad Athar
- Maria Barbaro
- Omar Benhar
- Natalie Jachowicz
- Marco Martini
- Toru Sato
- Rocco Schiavilla
- Jan Sobczyk (nuWRO)

Experimentalists

- Steve Brice
- Dan Cherdack
- Steve Dytman
- Rik Gran
- Yoshinari Hayato (NEUT)
- Teppei Katori
- Kendall Mahn
- Camillo Mariani
- Mark Messier
- Jorge G. Morfin
- Ornella Palamara
- Roberto Petti
- Gabe Perdue (GENIE)
- Makoto Sakuda
- Federico Sanchez
- Sam Zeller

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NuSTEC Workshops

- We promote the exchange of information within our community
- **Workshops**: We coordinate and organize community-wide workshops.
  - NuInt – like this one!
    - » organized every18 months.
    - » Comparison of experimental results and nuclear models via event generators
    - » Highlight open problems
  - Topic-specific
    - » to be held in between NuInts
    - » NuSTEC coordinates multiple workshops to avoid date collisions and unwanted duplication

2016 Workshops, Conferences and Schools

- Winter School in Theoretical Physics (Neutrino centric), Lądek Zdrój, Poland on Feb. 16-23, 2016. - Jan et al
- Workshop on 2p-2h, Saclay, April 2016. - Marco Martini http://esnt.cea.fr/
- Elba workshop 27 June - 1 July. 1.5 - 2 days on neutrino with last day devoted to many-body physics (talks on FSI?) - Omar and Rocco.
- NEUTRINO in London (4-9 July 2016)
- Proposed workshop on Generator Tuning (post-NEUTRINO) – Costas
- Pittsburgh experimental scattering physics Workshop in late July 2016 – Steve D.
- NuFact16 in Vietnam mid/late August
- (2016 NuSTEC Training in Neutrino Nucleus Scattering Physics, Oct/Nov)
- INT theoretical scattering physics workshop in early December 2016 – Sam Z
- Possible A NuSTEC workshop on DUNE systematics?
- Possible A NuSTEC workshop on need for a future experiment extracting nucleon cross sections (deuterium)? Pre/post NuInt17

NuSTEC Training Programs

- NUSTEC organizes and runs generator and neutrino scattering physics schools/trainings

- **Training**:
  - Long (10-day) schools – one so far, time and location of next to be discussed
    - » Every 2-3(?) years
    - » Fixed location? (Fermilab or Deadwood, SD or ??)
    - » Broad, mainly theory with experiment highlights
    - » NuSTEC Training in Neutrino Nucleus Scattering Physics, October 2014, Fermilab with **85** participants.
  - Short (≤ week) schools – two so far
    - » More specific or practical or generator-oriented
    - » Correlated in time and space with NuInt
    - » The Liverpool NuSTEC Nu Generator School associated with NuInt14
    - » NuSTEC School in Okayama, Japan 8-14 November associated with NuInt15.

Nustec Training in Neutrino Nucleus Scattering Physics – Fermilab, October 2014

Electroweak interactions on the nucleon	**3 hours**
Strong and electroweak interactions in nuclei	**4 hours**
The nuclear physics of electron and neutrino scattering in nuclei in the quasielastic regime and beyond	**9 hours**
Pion production	**3 hours**
Exclusive channels and final state interactions	**3 hours**
Inclusive e and ν scattering in the DIS regime	**3 hours**
Impact of uncertainties on neutrino cross sections	**3 hours**
Selected experimental illustrations	**4 hours**

- **85 registered (paying) participants + ≈ 15-20 sitting in on the courses**

- **DO WE REPEAT THIS LONG SCHOOL IN OCT/NOV 2016?**

NuSTEC-15 (Okayama, Nov.8-14,2015)

-Hosted by Y.Koshio and M.Sakuda

- NuSTEC-15 has been supported by:
  - Grant-in-Aid for Scientific Research on Innovative Areas (Kamioka Underground Physics Research, Solving the History of the Universe)
  - Okayama University
    - » Indico Support from Kavli Institute for Physics and Mathematics of the Universe, The University of Tokyo
- 42 participants = 29 students + 13 lecturers
  - 29 students =(6 India, 10 Japan, 4 Korea, 7 EU, 2 Canada)
  - 13 lecturers =(2 India, 3 Japan, 1 Korea, 2 EU, 5 US)
    - » L.Alvarez-Ruso, A.Lovato,M.Sakuda,S.K.Singh,M.S.Athar,Y.Koshio,T.Katori, T.Golan,A.Ankowski,F.Cavanna,J.Shirai,S.B.Kim,J.Morfin
  - 1Day = 3 basic lectures + 2 hrs' tutorials (in the afternoon)
  - 19 lectures + 5 x (2hrs' tutorials)
  - Reception (8^{th}), Half a day excursion (11^{th}), Banquet (12^{th})
- Participants Evaluation (Questionnaires)
  - Mainly good evaluations for all lectures and lecturers with a few concerns on the speed of delivery and amount of material
  - Learned what did and did not work as well as we hoped.

NuSTEC15 – Okayama University - Lectures

- Neutrino Physics and Neutrino Interactions (L. Alvarez-Ruso, IFIC, Spain)
- Basics of Nuclear Theory (potential ,current, symmetry) (A. Lovato, ANL)
- Neutrino Oscillation Experiments (T.Katori, Queen Mary University of London)
- Neutrino-Nucleus Scattering from Elastic to Quasi-Elastic Region (M.Sakuda)
- Quasi-Elastic Scattering in Nuclei (S. K. Singh, AMU, India)
- Pion production from nucleons and nuclei , strange particle production, Deep Inelastic Scattering (M.Sajjad Athar, AMU, India)
- Monte Carlo Event Generator (T.Golan, Rochester/Fermilab)
- Electron and Neutrino-nucleus initiałfinal state interactions (A. Ankowski, VTech)
- Water Cherenkov Detector and Neutrino Physics (Y. Koshio, Okayama)
- Liquid Argon Detector and Neutrino Interactions (F. Cavanna, FNAL)
- Liquid Scintillator Detector and KamLAND Latest Result（J.Shirai, Tohoku）
- Reactor Experiment RENO and RENO-50 (S.B.Kim, Seoul National University)
- MINERVA and Role of the Nucleus in nu-A Interactions (J. Morfin, Fermilab)

NuSTEC Projects

- We address open problems, identified at workshops, by promoting collaborative efforts; theorist ←→ experimentalist/theorists….
- **There have been multiple ideas discussed at this NuInt that could easily become NuSTEC projects.**
- **Need to carefully coordinate NuSTEC and Generator-specific projects.**
- **Collaborative effort follow-up meetings**
  - Self-organized mainly phone meetings
- **We will start by collecting a list of all theory/experiment collaborations now underway and, perhaps, needing additional support.**

NuSTEC Support for Generator Work is Crucial

- How can NuSTEC directly contribute to generator development and increase community and funding agency support for generator work needs considerable discussion that is now underway.