N. Jachowicz on behalf of

NuSTEC

Neutrino Scattering

Theory-Experiment Collaboration

Tuesday evening NuSTEC was working extremely hard …

How are we going to address challenges ?

How can we move NuInt physics forward ?

- In the most efficient way
- With a coherent view that is supported by the whole community
- We are soliciting your opinion and input !

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

arXiv:1706.03621

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

arXiv:1706.03621

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

arXiv:1706.03621

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

arXiv:1706.03621

Prioritize

- In Japan and the U.S. the neutrino community is well under way with an ambitious program of long-baseline neutrino experiments aimed at discovering leptonic CP violation and testing the three flavor paradigm.
  - Already today neutrino-nucleus interaction uncertainties are the limiting systematic for long-baseline experiments. Within roughly a decade, statistical precision at the percent level will be achieved and corresponding improvement in our understanding of neutrino-nucleus interactions is required.
- Theory will play a central role in this endeavor, but at the same time the question arises what type of experimental program is needed to provide the necessary benchmarks and cross section measurements.
- With the establishment of the CERN neutrino platform how do we bring the growing CERN and CERN-associated neutrino community of experimentalists, theorists and accelerator physicists actively into neutrino interactions study? Ideas of several CERN workshops in circulation.

Particular Challenges: Theorists (non-exhaustive …)

• Significant improvements of nuclear models by theorists, to replace current Franken-models, are essential and should include:

- The development of a unified model (no double counting and nothing lost in the "cracks") of nuclear structure giving the initial kinematics and dynamics of nucleons bound in the nucleus.
- Modeling neutrino–bound-nucleon cross sections not only at the lepton semi-inclusive cross section level, but also in the full phase space for all the exclusive channels that are kinematically allowed.
- Improving our understanding of the role played by nucleon-nucleon correlations in interactions and implementing this understanding in MC generators, in order to avoid double counting.
- Improving models of final state interactions, which may call for further experimental input from other communities such as pion-nucleus scattering.
- Expressing these improvements of the nuclear model in terms that can be successfully incorporated in the simulation of neutrino events by neutrino event generators.
- Sure, GiBUU deserves at least a footnote.

- However goal is to emphasize that considerable effort needed to bring NP and HEP to partner in supporting our efforts. Particularly in funding nuclear theorists working explicitly on this topic – not as a "hobby'! This involves laboratory Directors working with us to break down barriers at the funding agency level.
- What is explicitly holding back the several NP-theorist / HEP-experimental proposals that languish in the halls of DOE?
  - For example How to extend GFMC to Ar, relativistic and excusive interactions AND employ in event generators.
- Producing more accurate nucleon kinematics and yielding out-of-nucleus multiplicities in 2p2h effects including MEC and SRC.
- Nuclear effects in pion production.
- What are non-resonant contributions to multi-pion production?

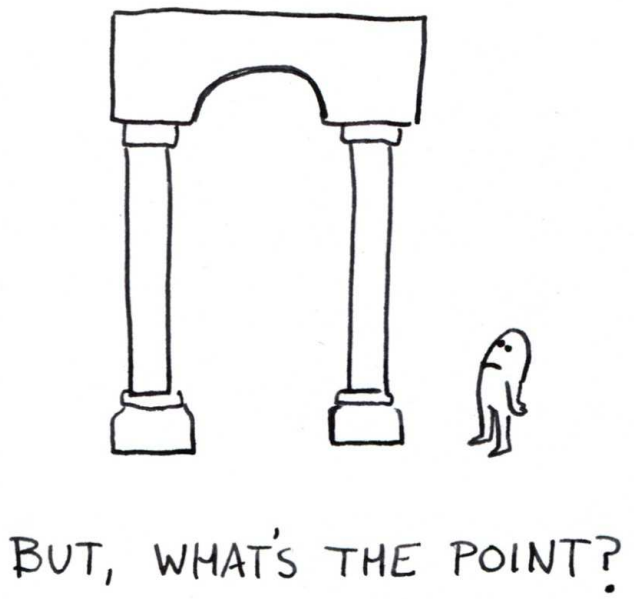
Particular Challenges: Experimentalists (non-exhaustive....)

- Do we need a new (expensive/difficult) nu-nucleon experiment ?
  - How would (much) more accurate nu-nucleon results affect oscillation physics ? How much should accuracies be improved to justify the cost and effort ?
  - Possibly covered by workshop: **Fundamental Physics with Electroweak Probes of Light Nuclei** (INT-18-2a)
    June 12 - July 13, 2018 - S. Bacca, R. J. Hill, S. Pastore, D. Phillips
- How do we bring e-A information into our conclusions? Do we need new e-A experiments to help with our understanding of the physics?
- More practical - how to better inform ND design on the basis of known unknowns for which we do not have dials in MC ...

Particular Challenges : Monte Carlos Simulations (non-exhaustive …)

- Need for better understanding of details (and tricks) in implementation in MCs. Is everybody using the same terminology ? Are models implemented in a correct and consistent way ?
  - Some MCs implement removal energy as modification of the target nucleon mass, others as the difference between initial and final masses.
  - Nieves CCQE in Genie is implemented only on the leptonic part, the hadronic is generated randomly. Is there any effect or bias in doing so ? Without the details you might think that is the same implementation as in NEUT - but it is not.

Coming to ….



Issues :

- General lack of manpower/money (particularly for nuclear theorists),
  the situation in Europe is different compared to the US
- We need **enthusiasm** ! We should be generating **excitement** in the (nuclear, particle, theory) community. We want buy in/**interest** beyond existing community. What is the best way to do so ?

<u>Solutions</u> ??? (non-exhaustive list … please complete …)

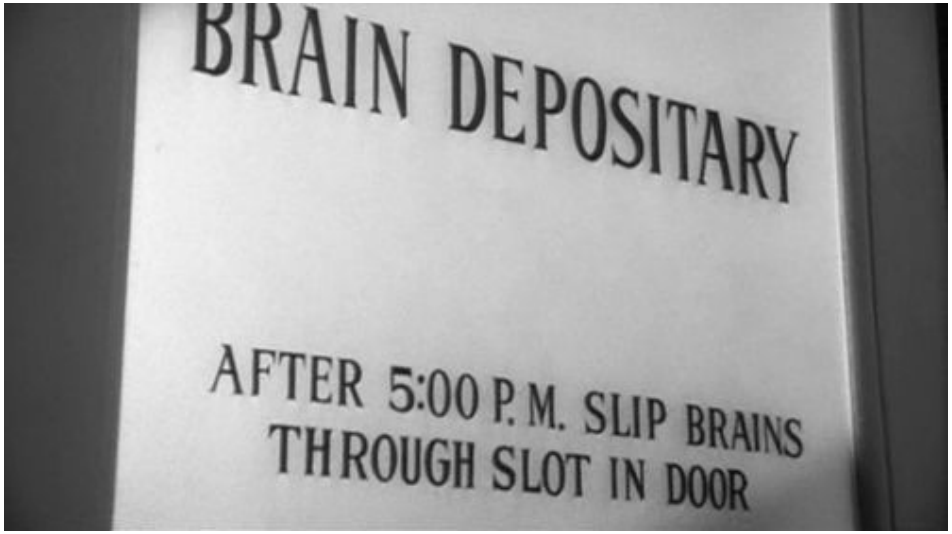
- A number of **focused** workshops bringing together people such as the Paris 2p2h workshop in April 2016….
  - ✓ Workshops should highlight solutions to well-defined problems
  - ✓ workshops should also highlight new physics signals/use in xsec (dark matter, and anomolous photon production) to attract new contributors to the community
  - ✓ INT workshops (as mentioned)
  - ✓ An example: hold a mini-series of two workshops at CERN in collaboration with the CERN Neutrino Platform, in both its experimental and theoretical parts, the goal is to develop a concept to be presented as part of the European Strategy Process and inform US funding agencies of priorities….
  - ✓ Inform NuSTEC of workshops to avoid date/personnel clashes…

Solutions ??? (…continued)

- The situation is different in Europe from in the US
  - Smaller countries with need to apply to individual funding agencies
  - Need a stronger unified voice of relevant nu nuclear physicists in Europe

- Inclusion of theorists directly in experimental collaborations.
- New programs
  - Japanese - European - US exchange of theorists? Longer term stays to really work are valuable (and we want to look at funding)
  - Bringing the new CERN initiative into the program
  - Extend the neutrino nuclear theorists community in the US.

?



Comments on the NuSTEC white paper :
https://docs.google.com/document/d/10IdsLuyzogiiIHujXr5VgtreatZdEsjRGWaTvJiUqOo/edit?usp=sharing

Feedback on Challenges:
https://docs.google.com/document/d/1p-IxiQSAyVanJ91tZU74vU8KZnsr8Aq1NJQXTWBZVqM/edit?usp=sharing