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WELCOME

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- We are really pleased and happy that you are here!

ORGANIZATIONAL PHILOSOPHY

- A lot of neutrino interaction workshops/conferences around nowadays . . . .
  - NuINT
  - FunFACT (J-LAB)
  - Paris workshop
  - Pitt-PAC workshops
  - Genie, neut, collaboration-organized workshops
  - NuSTEC
  - INT 13, now INT 16
  - . . . . .
- This is a testament to the growth and importance of the field
- Still:
  - complaints that there are too many or relation is unclear
  - need coherence (complementarity, follow-up, etc.) in organizing yet another workshop
  - participants are very valuable with limited time and resources

SPECIFIC POINTS

- Focus on a few issues
  - don't try to cover everything that is interesting
  - that's NuINT
- Maintain "workshop" format
  - ensure enough time for effectively open-ended discussion
  - allow flexibility in case something interesting/unexpected comes up
  - talks as a framework for discussion
  - foster communication "with", not "at" each other.
- Necessarily (strongly) limit the number of topics and speakers

COMPLEMENTARITY

- Thematic and “host” considerations;
  - FunFACT is a natural place to focus on e-scattering
  - INT is a natural place to focus on nuclear theory
  - Pitt-PAC focused on experimental and generator interface in coordination with this workshop
- Result:
  - Talks are primarily from nuclear theorists
  - Limited discussion of experimental results at this workshop
    - focussed summary from Pitt-PAC workshop
  - However, this is not a workshop for “nuclear theorists”
    - it essential that the ν community absorb developments, lessons
    - “Round table” discussion primarily with experimentalists to discuss workshop developments
    - we intend a “workshop for the ν community focussed on nuclear theory”

TOPICS:

- Comparison of models to e-scattering
  - a more systematic comparison of recent methods
- Compatibility/tension in recent neutrino data
  - are there “model independent” conclusions?
- Origins of transverse response in various theoretical frameworks
  - GFMC, RMF, RGF
- Theoretical framework for inclusive vs. seminclusive scattering
  - what can we (not) predict about the hadronic system?
- Relativistic effects
  - how do we identify and account for relativity in non-relativistic frameworks?
- Scaling and Universality
  - what is it telling us and how can it help us . . . with mid-A nuclei

DISCUSSION POINTS/QUESTIONS

- **Session: e-scattering:**
  - What is the status of comparisons of electron-nucleus scattering data to various models?
  - What is new since the last workshop?
  - What lessons do we have for neutrino scattering?
- **Session: Compatibility of Neutrino Data**
  - What are the main developments in measurements and analysis since the last workshop in 2013?
  - Are there tensions in the world neutrino-scattering data? To what extent are they model dependent?
  - Are additional theoretical developments or experimental methods necessary to interpret the data?
  - Were there any issues discovered on uncovered in making comparisons across datasets
  - What kind of discussion and organization would be useful for further progress ?

DISCUSSION POINTS/QUESTIONS

- **Session: Transverse Response:**
  - How do we include relativistic effects?
  - How do we explain transverse enhancement?
  - At the last workshop, there was quite a difference between how various groups were treating the enhancement to the axial piece. Where does this issue stand now?
  - How well can we predict neutrinos vs. antineutrinos? What is the current spread in theoretical calculations of neutrino/antineutrino scattering on nuclei in the 100 MeV - 10 GeV range? Are there nuclear effects that can mimic a CP violation signal?
  - Why is the transverse axial enhancement equal to the the transverse vector enhancement in RPA and GFMC?
- **Session: RGF and RMF:**
  - Within these particular approaches, how important are relativistic effects as functions of the kinematics?
  - Do we see clear evidence for such effects from studies of electron scattering?
  - What effects appear to be natural outcomes of relativistic modeling, e.g., transverse enchancement?
  - What are the prospects for extending the present studies of inclusive neutrino reactions to semi-inclusive reactions?
  - Can two-body MEC effects be handled in these approaches in a more consistent way?

DISCUSSION POINTS

- **Session: Inclusive vs. semi-inclusive modelling**
  - How well do models of semi-inclusive quasielastic e-scattering account for experimental observation.
  - How are initial state correlations taken into account?
  - How definitive and powerful can the inclusive lepton kinematics be in disentangling various nuclear effects given the breadth and uncertainties in the neutrino flux?
  - What is the definition of transparency? Is it helpful? Are the effects of "transparency" accounted for in most models?
  - What role can proton tagging/kinematics have in probing the multi-nucleon effects in pionless neutrino interactions.
  - How would you compare the CCQE measurements of MiniBooNE, MINERvA, and NOMAD 7. How can we reconcile/interface inclusive and semi-inclusive/exclusive modelling?
- **Session: Relativistic effects:**
  - How high in q and ω can GFMC be trusted?
  - Are there particular problems in understanding the impact of relativistic effects in the axial current?
  - We know that relativistic effects are large at high energies. How do we develop models that address these issues?
  - What is gained by using relativistic mean fields?
  - What theoretical systematic errors should experimentalists consider that relate to relativistic effects?
  - The deuteron is one case where rather sophisticated modeling of relativistic effects can be undertaken. What is the current understanding of this special case?

DISCUSSION POINTS

- **Session: scaling and universality:**
  - Data that supports that the quasi-elastic scattering of leptons from nuclei can be characterized as universal.
  - The degree to which scaling captures and allows extension of such universal features.
  - Quasi-elastic electron scattering directly provides $\mathbf{q^2}$ and ω, quantities essential for scaling. What can be done with the CCQE scattering data from broad band neutrino experiments?
  - Do dynamical models of lepton-nucleus QE scattering necessarily exhibit universality?

MODERATORS:

- e-scattering
  - Donal Day, Rik Gran
- neutrino data compatibility
  - Luis Alvarez-Ruso, Yoshinari Hayato
- transverse response
  - Gerry Garvey
- Inclusive vs. Semi-inclusive
  - Sonia Bacca, Xianguo Lu, Kevin McFarland
- Relativistic Effects
  - Saori Pastore
- Scaling and Universality
  - Rex Tayloe

- Thank you very much for taking on this important task
- Discussion is as important as presentation
- Moderator summaries on Friday

ROUND TABLE

- Thursday afternoon:
- Chairs: Federico Sanchez, Sam Zeller
- Kickoff: Teppei Katori “What’s new?“
- Participants:
    - Minerba Betancourt
    - Sara Bolognesi
    - Juan Caballero
    - Richard Hill
    - Jonathon Paley
    - Gabe Perdue
    - Anne Schukraft
    - Larry Weinstein
- An evaluation of what we heard and learned
    - and future steps . .

ROUND TABLE DISCUSSION POINTS

- What are some of the biggest issues we face in calculating neutrino-nucleus scattering reactions and kinematics?
- Where are we lacking in experimental measurements? Is there some area where neutrino experiments should focus next? Is there any meaningful re-analysis of existing data that can/should be done
- What can we learn from electron scattering ? Do we need new electron scattering experiments ?
- Are our theoretical efforts and generators work connecting in the way that they should?
- How do we connect the relativistic and non-relativistic worlds?
- Do we know enough about the neutrino-nucleon interaction? Do we need neutrino-hydrogen/deuterium data?
- What is the relation between 2p2h and initial nucleon (deuterium) pairs inside the nucleus? Are we double counting? How to model both?
- What are some of the most important points that you think came out of this workshop?

TIME TO GET TO WORK