Neutrino Reviews

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Neutrino Reviews

- Overseer: Cheng-Ju Lin
- Reviews/Mini-Review:
  - Neutrino Mass, Mixing, and Oscillations [23271]
    (Kenzo Nakamura, Serguey Petcov)
  - Neutrino Cross Section Measurements [2773]
    (Sam Zeller)
  - Neutrinoless Double-beta Decay [1811]
    (Andreas Piepke, Petr Vogel)
  - Monte Carlo Neutrino Event Generators [1727]
    (Hugh Gallagher, Yoshinari Hayato)
  - Neutrino beam lines at high-energy synchrotrons [888]

# of web downloads for the past 10 months

Advisory Committee Recommendations

(From 2010 Advisory Committee Report)

Recommendation :

"We were pleased to learn that there will be a review article on event generators. We would like to see some discussion on neutrino event generators."

The new neutrino event generators review was not ready in time for the RPP2012 edition. It is now in RPP2014 and has been available since 2013!

41. MONTE CARLO NEUTRINO EVENT GENERATORS

Written September 2013 by H. Gallagher (Tufts U.) and Y. Hayato (Tokyo U.)

Monte Carlo neutrino generators are programs or libraries which simulate neutrino interactions with electrons, nucleons and nuclei. In this capacity their usual task is to take an input neutrino and nucleus and produce a set of 4-vectors for particles emerging from the interaction, which are then input to full detector simulations. Since these generators have to simulate not only the initial interaction of neutrinos with target particles, but re-interactions of the generated particles in the nucleus, they contain a wide range of elementary particle and nuclear physics. Viewed more broadly, they are the access point for neutrino experimentalists to the theory inputs needed for analysis. Examples include cross section libraries for event rate calculations and parameter uncertainties and reweighting tools for systematic error evaluation.

Neutrino experiments typically operate in neutrino beams that are neither completely pure nor mono-energetic. Generators are a crucial component in the convolution of beam flux, neutrino interaction physics, and detector response that is necessary to make predictions about observable quantities. Similarly they are used to relate reconstructed quantities back to true quantities. In these various capacities they are used from the detector design stage through the extraction of physics measurements from reconstructed observables. Monte Carlo neutrino generators play unique and important roles in the experimental study of neutrino interactions and oscillations.

There are several neutrino event generators available, such as ANIS [1], GENIE [2], GiBUU [3], NEGN [4], NEUT [5], NUANCE [6], the FLUKA routines NUNDIS/NUNRES [7], and NuWRO [8]. Historically, experiments would develop their

Summarizes commonly used neutrino generators: ANIS, GENIE, NEUT, NUANCE, FLUKA, etc.

Advisory Committee Recommendations

From 2012 Advisory Committee Report:

Recommendation:

If one could suggest one more column to the tables, it would be nice to include the target material and length, since this has relevance to what hadron production measurements would be useful for what neutrino beamlines.

Beam Power (kW)	0.8	0.9	-	-	-	-	180	510	5	240 (750)
Target	-	-	-	-	-	-	Be	Graphite	Al	Graphite
Target Length (cm)	-	-	-	-	-	-	290	1000	66	91
Secondary Focussing	1-horn WBB	3-horn WBB	2-horn WBB	bare target	dichromatic NBB	2-horn WBB	2-horn WBB	2-horn WBB	2-horn WBB	3-horn off-axis

Recommendations for "ν Mass, Mixing, and Osc."

From 2012 Advisory Committee Report:

The authors do not mention several recent results on what is called "Short-baseline oscillation physics": the re-analysis of the Barium data

Reply from Petcov and Nakamura:

The Barium data ← We do not know what are "the Barium data." Though we do not know if this has anything to do with this comment, we write in RPP 2014, Section *14.7. Search for Oscillations Involving Light Sterile Neutrinos*, "Radioactive source calibrations of the GALLEX [157] and SAGE [158] experiments also showed a deficit of the measured fluxes compared to the expected fluxes ("Gallium anomaly"), and therefore might be interpreted as hints for ν_e disappearance."

Recommendations for "ν Mass, Mixing, and Osc."

From 2012 Advisory Committee Report:

The authors do not mention several recent results on what is called "Short-baseline oscillation physics": … the MiniBooNE neutrino mode result (in the introduction). Maybe this was just coming out too late?

Reply from Petcov and Nakamura:

MINIBooNE neutrino mode result ← This first appeared as arXiv:1207.4809v1 which was submitted on 19 Jul 2012. It was too late to be included in RPP 2012. In RPP 2014, this result is described in Section *14.7. Search for Oscillations Involving Light Sterile Neutrinos*.

Recommendations for "ν Mass, Mixing, and Osc."

From 2012 Advisory Committee Report:

Also they do not mention the Double Chooz result. This result admittedly is not as precise as Daya Bay or RENO, but came out at about the same time.

Reply from Petcov and Nakamura:

Double Chooz result ← In RPP 2102, Section *13.1. Introduction*, the Daya Bay and Reno results were mentioned as strong evidence for reactor antielectron neutrino disappearance, but the Double Chooz result was not because of its statistical significance at that time. However, the results from all the three experiments were described in Section *13.6. Measurements of θ_{13}*. In RPP2014, all three reactor experiments, Double Chooz, Daya Bay, and RENO, are referred to in Section 14.1 *Introduction* and are described together with the results obtained in Section14.6. *Measurements of θ_{13}.*

Recommendations for "ν Mass, Mixing, and Osc."

From 2012 Advisory Committee Report:

> **the reviews should reflect the current interest in the field: there seems to be a substantial body of work now devoted to "short-baseline oscillations" that nominally should be better reflected in the PDG in its role of describing activity in the field.**

Reply from Petcov and Nakamura:

We have taken this comment seriously, and have added a new Section 14.7. *Search for Oscillations Involving Light Sterile Neutrinos* in RPP 2014.

Plans for Next Revision

- Most reviews will have minor to modest updates to include latest results
  - Neutrino cross section measurements
  - Progress of neutrino generators
  - + others

- K. Nakamura and S. Petcov plan to extensively revise the "big" neutrino review
  - Scale back discussions on 2-flavor formalism
  - Focus more on 3-flavor discussions

Neutrino Landscape

Neutrino Physics is a "hot" area of research. We are expecting new results to roll off the assembly line

Physics Now:

MINOS, T2K, MiniBooNE, SciBooNE, MINERvA, KamLAND, OPERA, Borexino, SNO, Daya Bay, Double Chooz, RENO

Near Term:

NOvA, MicroBooNE

Medium Term:

PINGU + SBL experiments

Long Term:

JUNO, LBNF, Hyper-K, INO, RENO-50