Update on the IUPAP Neutrino Panel

Nigel Smith
Co-Chair, IUPAP Neutrino Panel
...on behalf of the IUPAP Neutrino Panel
Neutrino Panel History

In its 29th General Assembly on 11-13 October 2017 in Sao Paulo, Brazil, the International Union of Pure and Applied Physics (IUPAP) passed a resolution requesting the formation of a Neutrino Panel:

Resolution 7: Neutrino Physics Panel
Council was pleased to endorse the initiative to create a Neutrino Panel as a combined effort under the supervision of the C4, C11 and C12 Commissions together with the WG1, WG9 and WG10 Working Groups. The C11 Commission will take the role as the coordinating Commission of the action.

The 29th General Assembly RESOLVED to establish the Neutrino Panel, composed of nominees of C4, C11, C12, WG1, WG9 and WG10, under the supervision of those Commissions and Working Groups and coordinated by C11.

The 29th General Assembly DELEGATED to the Executive Council the authority to approve the mission of the Neutrino Panel and the membership of the Panel.

Heidi Schellman, Chair IUPAP Commission C11, is a member of the Neutrino Panel and will coordinate with the Executive Council of IUPAP.
Neutrino Panel Membership

- The IUPAP Executive Council approved the membership of the Panel at its meeting in November 2018.
- The IUPAP Neutrino Panel Terms of Reference was approved by the IUPAP Vice-Chair in April 2019.
- Thanks to all contributing authors and those providing advice...

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<th>Name</th>
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<td>M. Sajjad Athar</td>
<td>AMU, Aligarh, India</td>
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<td>Steve Barwick</td>
<td>UCI Physics and Astronomy</td>
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<td>Thomas Brunner</td>
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<td>Ken Long</td>
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(+): Co-chairs
IUPAP Neutrino Panel Mandate

Objectives

4. Through consultation with the broad neutrino-physics community, funding agency and laboratory management and other stakeholders, the Panel will carry out a review of:
(a) The present status of the global neutrino physics programme and the development that can be expected on a 5 to 10-year timescale through a science driven white paper;
(b) The measurements and R&D (including software development) that are required for the near-term (<10-year) and medium- to long-term (10 – 25-year) programmes to fulfil their potential.

5. The Panel will identify opportunities within neutrino physics, mutual benefits of global connections within neutrino physics and other fields, as well as the synergies of an international programme.

6. The Panel will provide written updates to the C11 Commission at key milestones in its programme and a final report to the IUPAP General Assembly by October 2020.
Working Groups

**WG1:**
3ν Osc. Studies
\[\Delta m^2, \theta_{ij}, \delta_{\text{CP}}, \ldots\]

**WG2:**
3ν Abs. Mass
0νββ, ν masses in cosmology, Kinematic ν mass meas.

**WG3:**
Interactions, New ν states, ν as Probes of Fundamental physics
Sterile ν, Coherent scattering, Cross sections, NSI, MSW, GeV, Weinberg angle, …

**WG4:**
Physics of ν Sources
Solar, Atmospheric, Geo, Reactors, Astronomical (SN, AGN,…), Cosmological (BB, GZK,…)

**WG5:**
New Technologies & Frameworks for ν Physics
Experimental & Theoretical underpinning, Future technologies & beams,…
## Working Group members

**WG Leads**
- **WG1 (Oscillations):** Ken Long and Jun Cao
- **WG2 (Mass):** Thomas Brunner and Walter Winter
- **WG3 (Interactions):** Sam Zeller and Mohammad Sajjad Athar
- **WG4 (Sources):** Seon-Hee Seo and Marek Kowalski
- **WG5 (Technology):** Contributions from all

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Timeline

- COVID-19 impacted timeline
- Working Groups have been connecting to community members
- White paper draft nearing completion (contents on next two slides for reference)
  - Community release following Neutrino2020 to incorporate latest news
  - Will be looking for feedback and iteration through to September
- Interim submission to IUPAP Council, October 2020 (Online)
- Final submission to IUPAP at General Assembly, 20\textsuperscript{th} to 22\textsuperscript{nd} October 2021 (Beijing)
- Public web page secured for dissemination [www.IUPAPNeutrinoPanel.org](http://www.IUPAPNeutrinoPanel.org)
  - Currently early stages of construction
Current draft status

1 Executive summary with sufficient info that chapters can be understood

2 WG4: Neutrino sources
   2.1 Introduction (S. H. Seo) .....................................................
   2.2 Geo Neutrinos (S. T. Dye) .............................................
      2.2.1 Introduction .........................................................
      2.2.2 Current Status ......................................................
      2.2.3 Future Prospects ...................................................
   2.3 Reactor Neutrinos (S. H. Seo) ...........................................
      2.3.1 Introduction .........................................................
      2.3.2 Current status and issues ........................................
      2.3.3 Future outlook .......................................................
   2.4 Atmospheric Neutrinos (M. Kowalski) ................................
   2.5 Astrophysical Neutrinos (K. Scholberg, M. Kowalski) ..........
      2.5.1 Solar Neutrinos (Livia Ludhova) ............................
      2.5.2 Supernova Neutrinos ................................................
      2.5.3 High Energy Astrophysical Neutrinos .......................
   2.6 Cosmological Neutrinos (C. Tully) ...................................
      2.6.1 Introduction ........................................................
      2.6.2 Direct Detection Experiments .................................

3 WG1: Oscillations
   3.1 Introduction ...............................................................
   3.2 Atmospheric neutrino experiments .................................
      3.2.1 Measurement of $\theta_{23}$ and $\Delta m^2_{32}$ .............
      3.2.2 Measurement of the mass ordering ............................
      3.2.3 Projected oscillation measurements with atmospheric neutrinos
      3.2.4 Possibilities with atmospheric neutrinos .................
   3.3 Solar neutrino experiments ...........................................
      3.3.1 Measurement of $\theta_{12}$ and $\Delta m^2_{21}$ ..............
      3.3.2 Matter effects in solar neutrino oscillations ............
      3.3.3 Projected oscillation measurements with solar neutrinos
   3.4 Reactor neutrino experiments ........................................
      3.4.1 Measurement of $\theta_{12}$ and $\Delta m^2_{21}$ ..............
      3.4.2 Measurement of $\theta_{13}$ and $\Delta m^2_{ee}$ ..............
      3.4.3 Projected oscillation measurements .........................
   3.5 Accelerator neutrino experiments ..................................
      3.5.1 Measurement of $\theta_{23}$ and $\Delta m^2_{32}$ with accelerators
      3.5.2 Measurement of mass ordering and $\Delta m^2_{CP}$ ........
      3.5.3 Projected oscillation measurements with accelerators ..
      3.5.4 Possibilities with accelerators ..............................
   3.6 Global fit ...............................................................
Current draft status

4 WG2: Absolute masses
4.1 Kinematic measurements of neutrino mass
4.1.1 Direct mass measurements $\nu_e$
4.1.2 Direct mass measurements $\nu_\mu$ and $\nu_\tau$
4.1.3 Neutrino mass from supernova neutrino detection
4.2 Neutrinoless double beta decay
4.3 Cosmology
4.3.1 Main experimental approaches to constrain $\sum m_\nu$
4.3.2 Parameter degeneracies
4.3.3 Upcoming and proposed experiments
4.4 Theoretical interpretation and complementarity of approaches

6 WG5: New technologies, cross-over to other science, and frameworks for neutrino physics
6.1 Introduction and Community
6.2 Technologies
6.3 Capabilities
6.4 Theory of neutinos
6.5 Infrastructure
6.6 Impact and Societal Benefits

7 Summary and optimistic future plan

5 WG3: Neutrino Interactions, New Neutrino States, and Neutrinos as Probes of Fundamental Physics
5.1 Introduction (G.P. Zeller)
5.2 Neutrino Interactions with Nucleons (M. Sajjad Athar)
5.2.1 Introduction
5.2.2 Quasielastic Scattering
5.2.3 Symmetry of Weak Hadronic Currents and Form Factors
5.2.4 Cross sections and Polarization observables in Quasi Elastic Processes
5.2.5 Inelastic scattering
5.2.6 Deep Inelastic Scattering (DIS)
5.3 Neutrino Interactions with Nuclei (H. Schellman)
5.3.1 Introduction
5.3.2 Electron, Muon and Tau Neutrinos
5.3.3 Nuclear Medium Effects in Neutrino-Nucleus Scattering
5.3.4 Multi-Nucleon Correlation Effects
5.3.5 Final State Interactions (FSI)
5.3.6 Neutrino Interactions in the Few Tens of MeV Range
5.3.7 Coherent Elastic Neutrino-Nucleus Scattering (K. Scholberg)
5.3.8 Ultra High Energy Neutrino Cross Sections
5.3.9 Impact of Nuclear Effects on Signal Classification and Energy Measurements
5.3.10 Present and Future Experiments
5.4 Sterile Neutrinos (G.P. Zeller)
5.4.1 Introduction
5.4.2 Phenomenology of Sterile Neutrinos
5.4.3 Present and Future Experiments
5.5 Beyond the Standard Model in Neutrino Interactions (K. Scholberg)
5.5.1 Introduction
5.5.2 Neutrinoless Double Beta Decay and Majorana Neutrinos
5.5.3 Lepton Flavor Violating Decays of Elementary Particles
5.5.4 Flavour Changing Neutral Currents
5.5.5 Neutrino Trident Production
5.5.6 Non-Standard Interactions in High Precision Weak Processes
5.5.7 Experimental Searches