Report on the Topical Exchange "Future Trends in Neutron Science – User Needs and Community Collaboration" during the International Conference on Neutron Scattering (ICNS) 2025

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At the International Conference on Neutron Scattering (ICNS) 2025, an open topical exchange session was held to explore future trends and user needs in neutron science. The session began with the introduction of several key topics, followed by presentations of perspectives from four scientific areas that had been used to define the ICNS programme. These perspectives were then examined in greater depth within smaller working groups. Finally, the outcomes were discussed and synthesized in a plenary session. This paper presents an account of the structure, discussions, and conclusions of the session. In conclusion, the long-term vitality of the neutron community depends on effectively linking evolving scientific priorities with technological advances and societal needs.

Keywords: user community, international conference on neutron scattering

1. Overview and Objectives

A topical exchange entitled *"Future Trends in Neutron Science – User Needs and Community Collaboration"* was jointly organised by the Asia-Oceania Neutron Scattering Association (AONSA), the Neutron Scattering Society of America (NSSA), and the European Neutron Scattering Association (ENSA) during the International Conference on Neutron Scattering (ICNS) 2025 [1]. The conference took place from 6–10 July 2025 in Copenhagen (Denmark) and Lund (Sweden), and the session was held on Wednesday, 9 July 2025, as one of the parallel afternoon sessions.

The objective of the exchange was to (i) identify new scientific trends in neutron science and the experimental needs that will arise from them and (ii) translate community perspectives into actionable recommendations for user groups, neutron facilities, funding bodies, and policymakers. Particular emphasis was placed on ensuring the long-term scientific competitiveness, sustainability, and societal relevance of neutron science in a changing global research environment.

The participants were specifically invited to address key challenges including (i) strengthening the neutron ecosystem to make it more efficient, resilient, and less fragmented, (ii) transitioning from facilities as isolated pillars to an integrated mosaic of large-scale sources, smaller facilities, and university-based infrastructures, and the implications of this shift for funding structures, (iii) nurturing critical mass by sustaining education in neutron scattering and continued development of techniques through access to both small and large facilities, (iv) defining flagship projects and large collaborations, including topical hubs, priority or demonstrator experiments, neutron-only science cases, single-investigator experiments, and identifying optimal management strategies across different access and funding models, (v) communicating societal relevance by identifying compelling examples that clearly demonstrate to the general public and policymakers the essential role of neutron science in areas such as security, health, and economic development.

2. Session Format and Participation

The session opened with short introductory presentations by spokespersons Elizabeth Blackburn, Henrich Frielinghaus, Markus Strobl and Tobias Jenke of the ICNS Science Programme Committee’s topical working groups, covering Quantum Materials, Soft Matter and Life Sciences, Materials Science, and Universe Essentials and Society, respectively. These introductions framed the subsequent discussions by highlighting the various scientific opportunities and structural challenges within each area.

Participants then split voluntarily into four parallel discussion groups aligned with these themes, each comprising approximately 10-30 participants. The groups engaged in focused discussions on user needs, future scientific directions, and organisational aspects of neutron research. The outcomes were documented in real time and reported back to the plenary [2].

3. Summary of Working Group Discussions

The four working groups highlighted both shared and domain-specific priorities for the future of neutron science, reflecting the diversity of scientific applications while converging on common structural and strategic needs.

Quantum Materials discussions focused on frustrated systems as a mature flagship topic and on altermagnets as an emerging research direction. A central challenge for all workers in this area is the preparation of neutron-compatible samples, requiring specialised expertise in crystal growth, multi-crystal assembly, and alignment—similar in nature to deuteration services which could suggest the need for dedicated hubs or platforms. These platforms would be feasible at a broad range of neutron sources. The possibility of extracting single crystal data from a mixture of tiny crystals may be conceived in light of related successes in the field of x-ray or electron diffraction. Neutron scattering plays a central role for both, model-based as well as model-free approaches to quantum phenomena. Such studies impose demanding experimental conditions: absolute units for elastic and inelastic scattering, measurements at low temperatures, and, ideally, polarization control for unambiguous verification. This also leads to data-related challenges include handling large datasets and achieving consistent normalisation, absolute intensity calibration, considering instrumental resolution and optimising beamtime usage. To this end, a specific neutron quality label (NQL) could be implemented as a science-based quality standard for quantum material investigations using neutrons. It shall define measurable figures-of-merit (FoM), a standardised workflow from sample preparation to FAIR data publication, and benchmarking procedures to ensure results are comparable across facilities. Participants also emphasised the need to improve neutron access and availability, for example through dedicated student instrument time, digital twins, and prioritising diffraction experiments. In many cases, there are existing funded programmes that can be leveraged for this, such as the NEPHEWS scheme [3].

Soft Matter, Life Sciences, and Health discussions emphasised food science and industrially relevant research, with strong demand for in-situ, in-vivo, and extreme-condition experiments. The growing importance of multi-probe approaches requires consistent workflows linking structure and dynamics. Effective progress depends on close collaboration between facilities, universities, and industry, guided by topical experts and with clearly defined, instrument-specific requirements. Opportunities lie in the development of custom-made sample environments, coordinated use of small and large neutron sources, and the creation of expert networks or topical hubs to address complex, large-scale scientific challenges efficiently.

Materials Science working group participants highlighted applied materials and complex systems as evolving priority areas, often involving significant technological and industrial relevance and, thus, direct societal impact in diverse fields such as advanced manufacturing, energy, food, climate and sustainability. Key challenges include securing dedicated resources and support for applied research by institutions operating neutron sources. Such is required for providing, maintain and safely operating complex in operando equipment and experiments that potentially also combine multiple techniques. A more general topic raised in this working group concerned opportunities that include establishing databases of staff expertise and open positions to support mobility and sustainable career paths also for highly qualified technical staff, developing tailored instrument configurations and sample environments, and ensuring sufficient resources for large-scale data handling and analysis. The community expressed a strong willingness to share software frameworks and AI-based tools.

Universe Essentials and Society covered a particularly broad scientific scope. Participants identified a growing need for neutron facilities to provide full-service data analysis and interpretation, supported by facility scientists. The importance of scientifically diverse review panels was emphasised to ensure a balanced evaluation of applied and fundamental research. Increasing the visibility of available infrastructure and maintaining a stable, long-term research infrastructure strategy were seen as essential. Opportunities were identified at multiple levels: research infrastructures should reinforce PhD and postdoctoral programmes, support new groups and ideas, and provide travel funding for early-career researchers; universities should counter the decline in neutron-related positions and strengthen neutron scattering education; and at the strategic level, sustained availability of major and smaller neutron sources, together with coordination through international networks such as i.e. the Long-Range-Plan of the Nuclear Physics European Collaboration Committee NuPECC [4], was seen as of critical importance.

Overall, the working group discussions underscored the need for stronger coordination across facilities, enhanced training and career pathways that encourage exchange between facilities and universities, shared technical and data-analysis resources, and clear communication of neutron science's scientific and societal value. It represents an unfavourable situation in which two major sources (FRM II and NIST) are not operational. The session opened with short introductory presentations by spokespersons

4. Key Outcomes and Recommendations

The discussions converged on four main areas for implementation:

Instrument Capabilities and Capacity. While state-of-the-art instruments continue to enable frontier science, improved access and availability remain critical. A balanced ecosystem of flagship facilities and smaller, flexible sources was identified as essential. Clear communication of instrument capabilities and expertise, along with well-defined and diverse beamtime review processes, was highlighted as a prerequisite for maximising scientific impact.

Samples and Sample Environment. Sample preparation and specialised sample environments were recognised as strategic assets for neutron science. Participants emphasised the benefits of shared expertise, coordinated sample preparation services, and facility stewardship of complex sample environments, particularly for multi-probe and *in situ* or in-*operando* experiments.

Data and Data Analysis. Data analysis remains a cross-cutting challenge due to increasing experimental complexity, larger data volumes and diverse user experience. The community expressed strong support for developing coordinated, full-service data analysis workflows aligned with FAIR principles, including shared software frameworks and AI-enabled tools, while recognizing that new experiments will inevitably require new bespoke tools.

Resources, Training, and Funding. The need for coordinated international collaborations, structured training programmes, and integrated PhD and postdoctoral schemes was strongly emphasised. Information on such currently active schemes could be advertised on community web pages such as neutronsources.org. The establishment of scientifically driven expert networks or topical hubs at neutron facilities was identified as a powerful mechanism to foster sustained excellence and act as focal points for regional and global collaboration.

5. Conclusion

The topical exchange demonstrated strong community engagement and broad consensus on the strategic directions needed to secure the future of neutron science. The resulting recommendations provide living guidance that should be continuously refined in response to evolving scientific priorities, technological developments, and societal needs, with the aim of maximising the long-term scientific and societal impact of neutron research.

References:

[1] ICNS 2025, Neutron News, https://doi.org/10.1080/10448632.2025.2596421 (2026)

[2] Supporting slides as presented can be found at: https://ensa-neutron.eu/documents_icns_2025/

[3] Visit https://beamtime.eu for details. NEutrons and PHotons Elevating Worldwide Science (NEPHEWS)" has received funding from the EU Framework Programme Horizon Europe under grant agreement nº 101131414.

[4] NuPECC, NuPECC Long Range Plan 2024 for European Nuclear Physics, https://doi.org/10.48550/arXiv.2503.15575 (2025)