Particle Therapy Innovation Workshop

Designing a research room for a National Hybrid Particle Therapy Facility (protons, carbon and other ions)

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White Paper

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Executive Summary

The National Particle Treatment and Research Centre (NPTRC) business case, first submitted to NSW Health in 2018 and updated in 2020, proposes Australia's first hybrid particle therapy facility combining proton beams, carbon ions and future ion capabilities. This centre would deliver advanced radiation treatments currently unavailable in Australia for patients with hard-to-treat cancers, while also establishing a dedicated high-energy research room to support both clinical and non-clinical research.

To explore the value and requirements of this research capability, a national Workshop was convened in November 2025. Representatives from research institutes across Australia, international particle therapy centres, ANSTO and leading universities examined how the proposed research room could complement existing programs and infrastructure, enable new scientific opportunities and support workforce development across nuclear science, health, space, accelerator physics and related fields.

Participants highlighted that while ANSTO and Heavy Ion Accelerators (HIA) provide access to heavy ion beams, their low energy forces many Australian researchers to conduct critical work offshore at significant cost and logistical complexity due the need to transport delicate instrumentation and biological material. Furthermore, due to strong demand for access to facilities overseas, researchers can be forced to wait up to 12 months to access a limited amount of beam time, to pay high fees charged for access to some facilities or to enter into partnership agreements.

As global investment in nuclear technologies accelerates—from green energy (nuclear power) to defence (nuclear submarines), critical minerals, agriculture, water and food security, space technologies and medical isotope production—Australia must build the nuclear-skilled and radiation-literate workforce required to remain competitive. The NPTRC research room was identified as a key enabler for advanced training, complementing existing programs.

International partners expressed strong support for an Australian facility, sharing insights from their own development journeys and collaborative models, including partnerships with major institutions such as CERN.

Whilst Australia already hosts world-class particle accelerators, the NPTRC research room will provide access to resources and infrastructure currently not available in Australia. Building on experience in managing significant national research facilities and international experience shows that financial sustainability will rely on a user-pays model supported by Commonwealth-level funding alongside contributions from universities, industry and philanthropy. Co-location with a hospital precinct together with strong integration with university partners and national infrastructure organisations (including ANSTO), will maximise interdisciplinary collaboration and resource sharing.

This White Paper captures the Workshop's findings. Full details of the contents of the presentations from national and international experts are presented in the Supplementary Material. This White Paper provides a robust foundation for advancing the case for a nationally significant and globally connected particle treatment and multi-purpose research facility.

Introduction

An Australian proton beam therapy (PBT) facility for patients with cancer and rare tumours is needed urgently, with increasing numbers of Australians, especially children, adolescents and young adults travelling abroad for this treatment. The Cancer Australia report released in August 2023 "Strategy for Proton Beam Therapy for cancer patients in Australia" recommended two proton beam centres, including one in New South Wales[1]. The business case for a National Particle Treatment and Research Centre on the Westmead Precinct (NPTRC) with representatives from Western Sydney Local Health District, Sydney Children's Hospital Network, University of Sydney, University of Wollongong, ANSTO, TROG Cancer Research and Cancer Institute NSW was submitted to NSW Health in 2018 and updated in 2020. This case is unique in Australia, as it proposes a national hybrid facility (not just proton beams) with the rationale for carbon ion beams, and potential for additional beam species in the future, published by Thwaites et al[2]. Crucially, the NPTRC (also referred to as the Westmead Hybrid Particle Therapy Centre or Hybrid Facility) included a dedicated room (hall) for non-clinical research (NCR) and capability to include other ions such as helium ions over time to take advantage of the expected 40-50-year time lifespan of the core technical components of the facility, significantly longer than the 10-year lifespan of a linear accelerator used for cancer treatment.

This document establishes the rationale and need for infrastructure to support non-clinical research (NCR) that will extend beyond the clinically focussed research at the proposed NPTRC, explores the broad areas of potential research and user community and its size, considers the hall size, technical requirements for beams, energies, in-room equipment and enabling infrastructure, and explores funding models. A Particle Therapy Innovation Workshop on the Westmead Precinct was held on 28 November 2025, convened by representatives from NSW Health, Sydney University, the University of Wollongong, the Australian National University and the Australian Nuclear Science and Technology Organisation (ANSTO), to inform this document.

Background

There are now 17 carbon ion facilities and over 120 clinical proton beam facilities currently operating world-wide[3]. Only six are hybrid facilities offering both carbon ions and PBT – MedAustron (Austria), Shanghai (China), HIT Heidelberg (Germany), MIT Marburg (Germany), CNAO Pavia (Italy) and HIBMC Hyogo (Japan). The Heidelberg facility can deliver Helium ions for cancer treatment, a capability that will soon be available at MedAustron as well. Three carbon ion facilities are under construction now – ARCHADE, Caen, France; National University Hospital, Busan, South Korea which will also have Helium ions; Mayo Clinic Florida Particle Therapy (the first in North America).

Three hybrid facilities worldwide include a dedicated research room capable of NCR applications - MedAustron, CNAO and HIT Heidelberg. Publicly available information on NCR access arrangements at Chinese facilities is limited. HIMAC (QST) at Chiba, Japan (a carbon ion facility with multi-ion capability) has extensive research capabilities including other ion beams and non-clinical applications. Notably, North America's first carbon ion facility does not include an NCR room. A hybrid facility in Australia with dedicated NCR capability would join a small international community and have an imperative to deliver world-class research and innovation.

The Australian fleet of accelerators and reactors is summarised in Table 1. A proton beam (only) facility would use a cyclotron or synchrotron to deliver proton energies in the range of 70 – 250 MeV. In addition to this range, a hybrid facility would provide a synchrotron capable of accelerating carbon ions to an energy range of around 120 to 430MeV/U and potentially higher for other ions. These beam energies are not currently available Australia. Furthermore, the NPTRC would be the only heavy ion accelerator on a health precinct in Australia.

Table 1. The Australian fleet of research accelerators.

Owner	**Name**	**Accelerator Type(s)**	**Particle Type**	**Energy / beamlines (corrected)**
ANSTO	Australian Synchrotron (Melbourne)	Electron linac + booster synchrotron + electron storage ring (synchrotron light source)	Electrons (internal access) / synchrotron light (X-ray/IR) to external users	100 MeV linac electron beam 14 operational X-ray beamlines +4 under construction
ANSTO	Centre for Accelerator Science (Sydney)	4 tandem electrostatic accelerators	Ions (H to heavy ions)	1–10 MV terminal voltage: ANTARES 10 MV, Sirius 6 MV, STAR 2 MV, VEGA 1 MV; 11 ion sources; 13 beamlines
HIA (ANU)	Heavy Ion Accelerator Facility (HIAF) + iiLab	Tandem electrostatic accelerator + superconducting linac booster + implantation and IBA systems at iiLab)	Ions (H to heavy ions)	HIAF: 14UD with terminal voltage up to ~15 MV + ~6MV superconducting linac booster. 11 beamlines. iiLab: 150 kV implanter + 1.7 MV tandem systems
HIA (UniMelb)	University of Melbourne node (Pelletron)	Electrostatic accelerator (Pelletron)	Protons and helium ions (light ions)	5 MV Pelletron; 3 beamlines, with 4th under construction (TURBO). Typical operation: protons up to 3.5 MeV; helium up to 1.5 MeV.
X-LAB (UniMelb)	X-band Laboratory for Accelerators and Beams	Electron X-band RF accelerator. Pulsed, ultra-compact accelerator (100 MeV/m).	Electrons	Photoinjector 100 keV, integration underway with RF structures to produce pulsed, tunable 1-30 MeV electron beams.

Fields of Research and Translation

The fields of research that exist in Australia now and could be expanded by access to a Hybrid Facility can be categorised broadly as biological systems, cancer imaging, particle physics, nuclear science, space physics, materials science and accelerator science. Appendix 1 summarises the relevant fields at existing Australian facilities, with examples provided in the following section. Appendix 2 summarises the areas of research conducted at CNAO, MedAustron and Paul Scherrer Institute, representatives of whom participated in the Workshop.

Radiation Biology and Cancer Treatment

Radiation biology is the science of understanding the effect of radiation on biological tissues. Understanding the effect of various types, energies and rate at which radiation is delivered enables us to predict which therapies would be the most appropriate for the individual patient. Experts in this field described the potential benefit of access to clinical particle therapy beamlines for a range experiments designed to better understand the mechanisms of cell death, the potential benefit of using neutrons to eliminate aggressive brain tumours and developing techniques to target tumours resistant to the effects of current x-ray-based treatments.

Medical Isotope Production

A Hybrid Facility could enable research into the development and production of new medical isotopes for imaging and treatment, including its feasibility. This research area could strengthen Australia's radiochemistry capability, reduce reliance on international supply chains and create opportunities for commercialisation.

Space and Plant Science

High-energy particle beams can replicate the radiation conditions experienced in space. This capability would support national research into long-term space habitation, crop resilience, biosecurity and materials testing—areas where Australian researchers currently depend on limited and costly overseas facilities.

Advanced Cancer Imaging

Australia has internationally recognised expertise in MRI and PET imaging. Integrating these technologies with particle therapy at the NPTRC would position Australia at the forefront of next-generation precision radiation treatment.

Radiation Testing for Space and Defence

Critical electronics used in satellites, defence systems and national infrastructure must be tested for radiation resilience. Australia has existing capabilities in radiation testing at HIAF, ANSTO and University of Wollongong through the National Space Qualification Network (NSQN). However, access to higher beam energies would enable Australia to offer more complete radiation qualification, thereby supporting sovereign resilience in this strategically important sector. Workshop attendees advised that only a handful of international facilities offer the required beam energies, often with long wait times and high costs.

Microdosimetry and Measurement Technologies

Australian researchers have pioneered tools, including detector development that measure how radiation interacts with biological tissue at a micron scale. Access to the research room at the NPTRC would accelerate the translation of these technologies into clinical practice, expand international research partnerships and continue Australian leadership in the microdosimetry field.

Accelerator Innovation

Accelerator science is fundamental to research in many fields of nuclear and high energy physics and is also a key technology for industry and medicine. With particle accelerators widely used in industry (e.g. for semiconductor manufacture, surface and materials modification), access to a Hybrid Facility could drive Australian-led innovations to be tested, validated and commercialised within Australia.

Growing National Capability and Workforce

Australia has both the capability and the strategic need to establish a Hybrid Facility. International experience demonstrates that such facilities are achievable even for smaller nations. Austria's MedAustron, developed in partnership with leading global institutions, provides a clear example.

Australia contributes to physics programs at major international facilities, including CERN. At HIAF, new detectors for nuclear physics and applications have been built and tested since 1952. A Hybrid Facility would provide higher energy particles for radiation hardness testing and instrumentation development for space, high energy physics and medical purposes, strengthening sovereign capability and support long-term workforce development.

Several national organisations are already providing education in nuclear science. These include:

- **AINSE** connects ANSTO with 38 universities across Australia and New Zealand, supporting hundreds of researchers and students annually and enabling national and international research collaborations.
- **ANU** provides Australia's only educational offerings in hands-on, experimental fundamental nuclear science at honours, master's and PhD level.
- **ANREN** brings together nuclear experts from nine universities to strengthen national nuclear literacy and research collaboration.
- **RADINNOVATE**, funded by the Australian Research Council, is training future leaders in nuclear and radiation technologies across defence, space, health, mining and quantum sectors.

These national programs demonstrate that Australia has the talent pipeline and institutional foundations needed to support nuclear science technology education and workforce development and would also be a unique training facility for medical physicists and medical imaging specialists across disciplines, adding to the national workforce in imaging and cancer therapy. However, to support the proposed NPTRC and research described in the previous paragraphs, there remains a need to provide access to high energy particles not currently available in Australia for hands on training, therapy-level particle energies and workforce development.

Lessons from International Facilities

Presentations from leading hybrid centres in Europe—MedAustron (Austria), the Paul Scherrer Institute (Switzerland) and CNAO (Italy)—demonstrated how clinical treatment and research can be integrated successfully. Their experience highlights the importance of:

- Dedicated research space
- Flexible infrastructure that can evolve over time
- Strong governance and advisory structures
- Co-located laboratories, imaging equipment and animal research facilities
- Ongoing collaboration with major accelerator organisations such as CERN

Japanese experience illustrates how NCR has added to machine performance and resilience, which then benefits patient treatment. These models provide a clear blueprint for Australia's approach.

Requirements for an Australian Hybrid Facility

To remain globally competitive and support long-term national priorities, presentations from the Australian delegates determined that the proposed Hybrid Facility must be designed for flexibility, scalability and multidisciplinary use. Key requirements include:

- A large, adaptable research hall capable of supporting multiple concurrent and long-duration experiments
- Space for advanced imaging technologies (MRI, PET) and future upgrades
- Separate sterile and non-sterile research areas to support diverse scientific fields
- Sufficient shielding to allow research activities to continue safely during clinical operations
- Infrastructure for animal studies, tissue culture and specialised laboratory work
- Modern digital systems, including secure data storage and remote access
- Active radiation protection systems
- A flexible accelerator system capable of supporting a wide range of ion beam species, and sufficiently high energies for clinical and research requirements and future technological advances
- Dependence on single vendors for supply chain should be avoided whenever possible.

Facility Governance

Effective governance will be essential. Clear lines of responsibility must be established for the accelerator, beamline and associated infrastructure, including regulatory compliance for both clinical and research activities. Access models must support diverse research communities, with transparent processes for managing users, safety and operational priorities.

Sustainability and Funding

International experience shows that hybrid particle therapy and research facilities require significant upfront investment and stable long-term funding, but they deliver substantial national benefits when supported by strong governance, partnerships and clear access models. Facilities in Austria, Italy and Switzerland demonstrate that sustainable operations rely on a mix of government funding, university collaboration, industry partnerships and structured access to research infrastructure.

Alignment with NSW and National Priorities

The NSW Chief Scientist & Engineer's 20-year R&D Roadmap identifies technology areas where NSW has global competitive advantage, including biotechnology, advanced materials, digital technologies and energy[4]. A Hybrid Facility would directly strengthen these priority areas by supporting innovation in medical technology, nuclear science, semiconductors, simulation and workforce development. The model used to establish the RNA Research & Manufacturing Facility at Macquarie University provides a relevant precedent for how government-supported collaboration can accelerate capability building[5]

Role Within Australia's National Research Infrastructure

ANSTO's long-standing experience managing major national facilities provides a clear framework for how a Hybrid Facility could be integrated into Commonwealth-level funding. The facility would require baseline public funding, co-investment from partners and transparent performance measures tied to national research outputs, industry impact and sovereign capability.

Proposed Access and Governance Model

ANSTO's existing access model offers a proven template:

- Merit-based access (60–70%) for high-quality research with national benefit
- Commercial access (10–15%) for industry and clinical partners needing confidentiality or rapid turnaround
- Discretionary and internal access (15–25%) for urgent national needs, long-term strategic programs and student training

Donors and major partners could receive a defined share of beam time for a limited period to support co-investment, while maintaining transparency and peer review.

Workforce Requirements

A sustainable facility requires a specialised, stable workforce—including medical physicists, accelerator engineers, data scientists, radiobiologists and instrument scientists. These roles are essential to operate the research hall, support users, maintain safety and ensure the facility remains internationally competitive

Lessons from Existing Australian Infrastructure

The Heavy Ion Accelerators (HIA) network supports hundreds of users annually and maintains global relevance through:

- Long-term, stable government funding
- Clear performance metrics
- Strong university partnerships
- Co-located scientific expertise
- A technical workforce capable of evolving and improving the facility over time

Recommendations for Long-Term Sustainability

Workshop participants identified several principles critical to the success of a Hybrid Facility, summarised in Table 2.

Table 2. Principles for success of a Hybrid Facility

Research sustainability	**Funding sustainability**
Open access for researchers	A robust, realistic business case
High-quality equipment, skilled staff and efficient processes	Capital funding from universities and ARC LIEF for infrastructure
Strong partnerships across universities, industry and government	Co-investment from Commonwealth and NSW Government, philanthropy and industry
Pilot funding to support new research ideas	Inclusion of access costs in research grants (e.g., MRFF)
Active international collaboration	Planning for long-term operational funding beyond initial service contracts

Summary

A Hybrid Facility would serve as a national hub for innovation across cancer treatment, nuclear science, space research, advanced manufacturing and defence. It would strengthen sovereign capability, reduce reliance on scarce overseas facilities and ensure Australia remains competitive in rapidly advancing global technology sectors.

Australia now stands at a pivotal moment. Establishing a Hybrid Facility (the NPTRC) would not only transform our national research and clinical capabilities, but it would also secure Australia's position as a global leader in advanced radiation science, medical innovation, space readiness and sovereign technology development. With coordinated investment, clear governance and sustained partnerships across government, industry and academia, this facility would deliver long-term health, economic and strategic benefits for the nation. It represents a once-in-a-generation opportunity to build the infrastructure, workforce and scientific capability that Australia needs for the decades ahead.

References

1. Cancer Australia, 2023. Strategy for Proton Beam Therapy for cancer patients in Australia. Cancer Australia, Surry Hills, NSW.
2. The rationale for a carbon ion radiation therapy facility in Australia. Thwaites D, Prokopovich D, Garrett R, Haworth A, Rozenfield A, Ahern V. JMRS 72(S2);59-76, 2024. https://doi.org/10.1002/jmrs.744
3. PTCOG - Facilities in Operation (public) (accessed 6 December 2025).
4. NSW 20-Year R&D Roadmap | Chief Scientist (accessed 1 March 2026).
5. RNA Research and Pilot Manufacturing Facility | NSW Government

Appendix 1. Existing Australian infrastructure and fields of research

Facility	Fields of research
Australian Synchrotron	Materials, agriculture, defence, biomedicine
Centre for Accelerator Science	Rare isotope tracing (nuclear safeguards, environment, climate), materials analysis and modification, space testing, radiation biology, radiation damage and radiation effects testing
OPAL reactor	Radioisotopes for medical and industrial use, materials science, semiconductors
ANSTO Centre for Neutron Scattering	Materials analysis (reactors, engineering, medicine, mining, food, transport)
Heavy ion Accelerators (HIAF, ANU; iiLAB (ANU); University of Melbourne node)	Nuclear physics (structure, reactions, astrophysics), rare isotope tracing, materials modification, space radiation testing, DNA mutagenesis. Beam delivery development
Small cyclotrons (e.g University of Queensland Australian Institute for Bioengineering and Nanotechnology[1])	Novel drug discovery, preclinical research and translation of tracers to human imaging

1. https://aibn.uq.edu.au/cai/Radiochemistry-cyclotron

Appendix 2. Research fields at international facilities

Facility	Fields of research	Research hours
MedAustron	Applied particle and medical physics, technological innovations & clinical implementation, accelerator physics, biophysics & molecular radiobiology	1056 hours / year in 132 beam time shifts
CNAO	Basic physics, radiation biology, range verification, space research, detector developments, dosimetry, improvements in dose distribution	500 hours / year for external users
Paul Scherrer Institute	Research conducted in clinical room: detector development, proton radiography, radiation biology. Nonclinical room: radiation effects on electronics, simulation of space environment – calibration for monitors and detectors	150 test days / year for academia and industry

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University of Sydney

Australian Nuclear Science and Technology Organisation

University of Wollongong

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