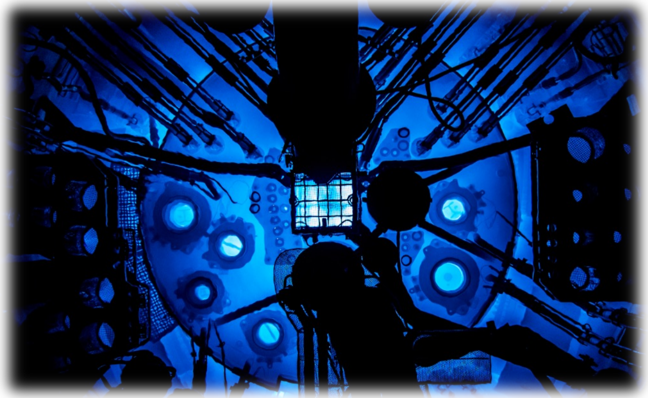
Australian Government | ANSTO



Medical Radioisotope Production at ANSTO

Current and Future State

05 December 2025

Leena Burgess
Nuclear Medicine Development Manager

Science. Ingenuity. Sustainability.

Collaboration

茨城大学
Ibaraki University

ANSTO

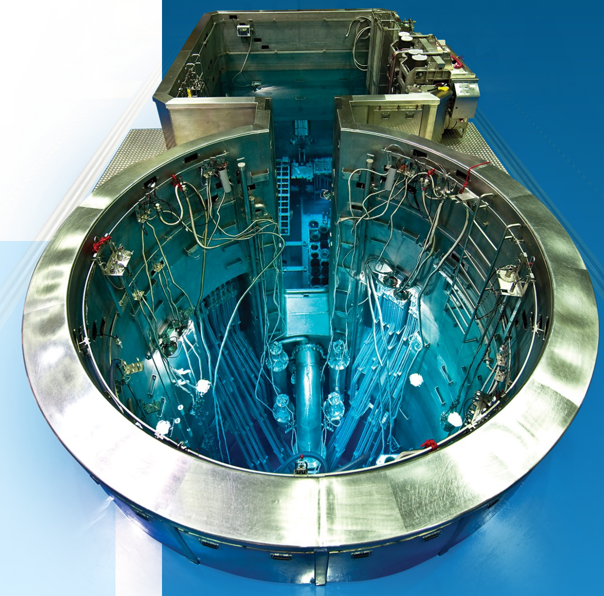
Outline

1. ANSTO
Introduction and overview

2. OPAL Reactor
Capabilities and medical radioisotopes

3. Research Radioisotopes
Medical and environmental

4. Into the future
Nuclear Medicine Manufacturing Facility



ANSTO's OPAL multi-purpose reactor

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ANSTO – Overview

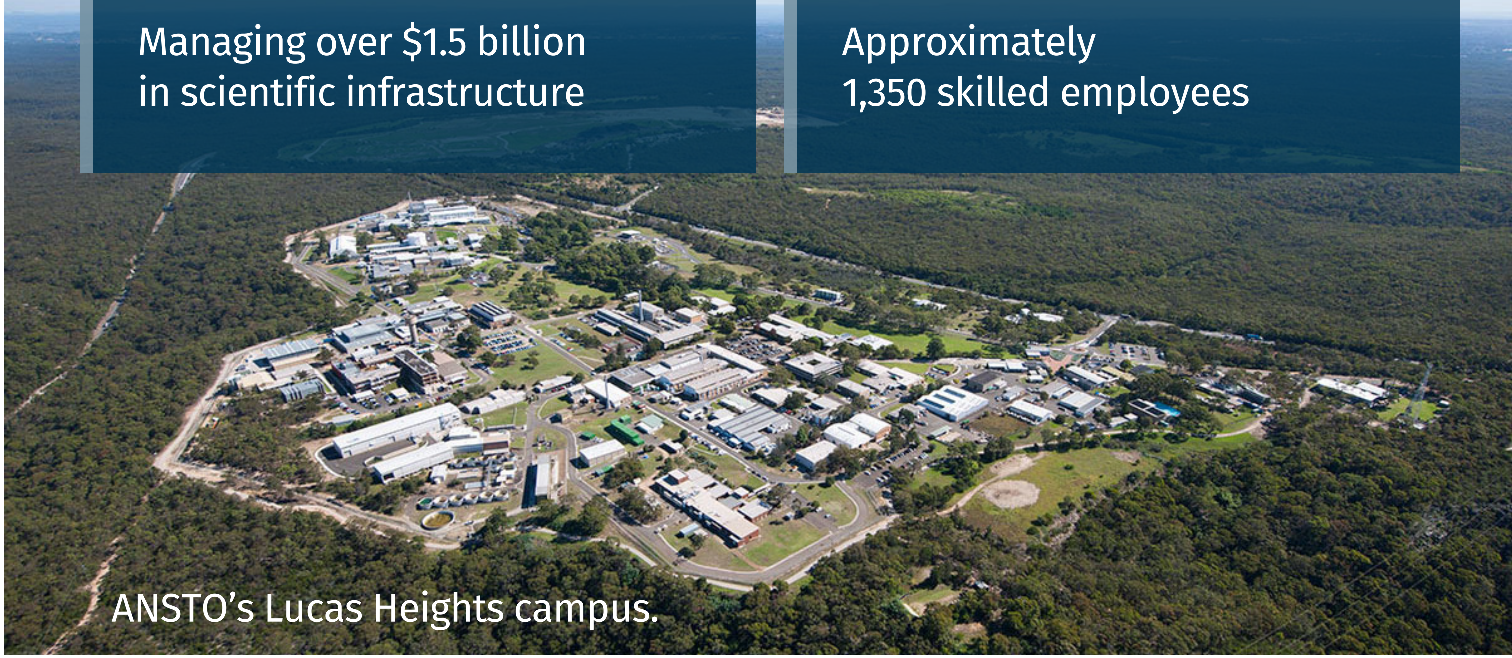
ANSTO – Introduction

A leader in nuclear science and technology

Operating safely for over 70 years

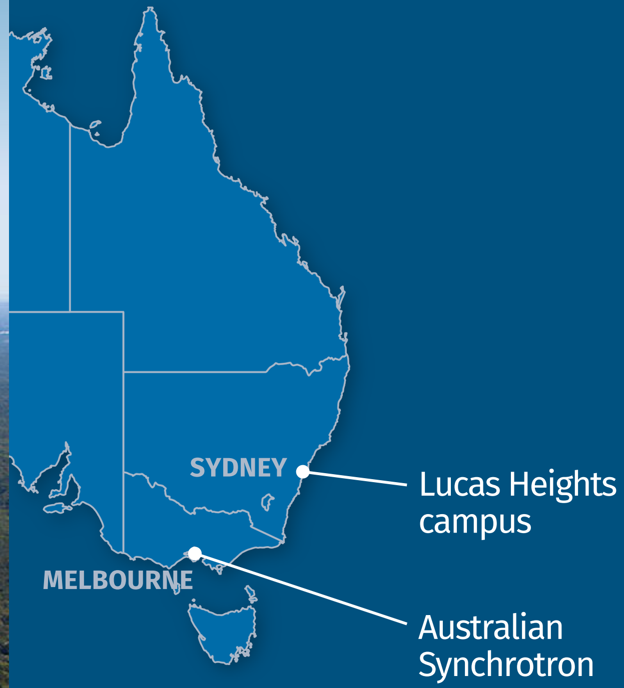
Managing over $1.5 billion in scientific infrastructure

Approximately 1,350 skilled employees



ANSTO's Lucas Heights campus.

TWO LOCATIONS



ANSTO

OUR **VISION**

Nuclear science and technology for the benefit of all Australians

OUR **MISSION**

To deliver knowledge, value and trust through the application of nuclear science, technology and engineering

OUR **STRATEGIC OBJECTIVES**

1. **Deliver on Australia's priorities for the benefit of people, industry and the environment** through nuclear excellence in research and the use of national infrastructure
2. **Improve the health of Australians by supporting access to current and future nuclear technologies** for diagnostic, therapeutic and innovative treatments for current and emerging diseases
3. **Australia's source of nuclear expertise, advice and services** to governments, academia, industry, and community
4. **Lead the development of a nuclear capable workforce** aligned with government policy objectives

OUR **VALUES**

- Curiosity
- Leadership
- Excellence
- Working together
- Trust + Respect
- Safe. Secure. Sustainable

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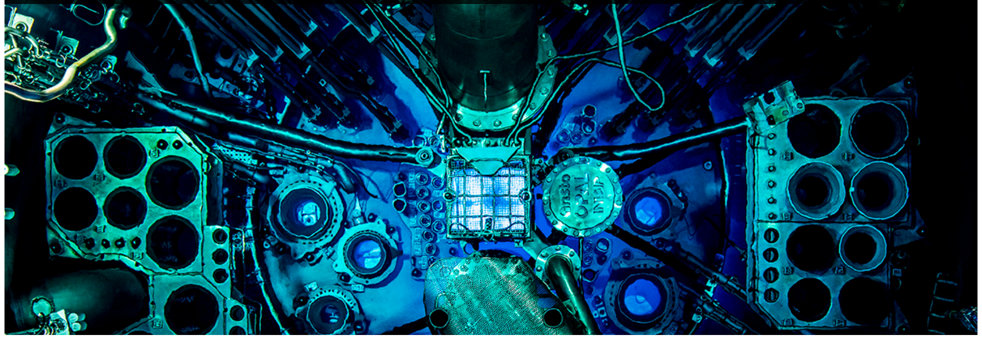
ANSTO – Landmark infrastructure

Australian Synchrotron

OPAL multi-purpose reactor

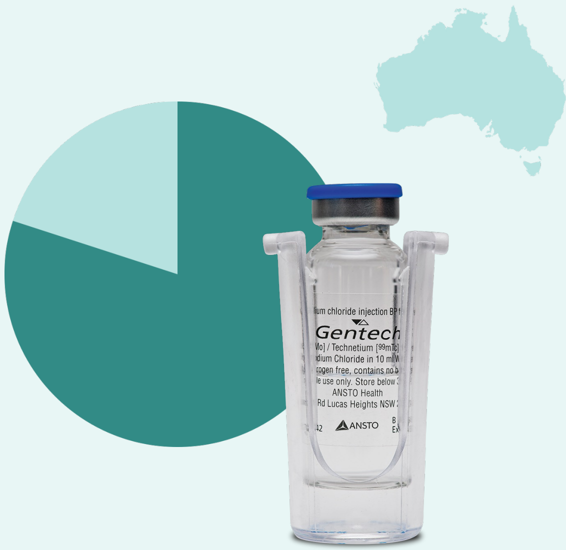


Centre for Accelerator Science

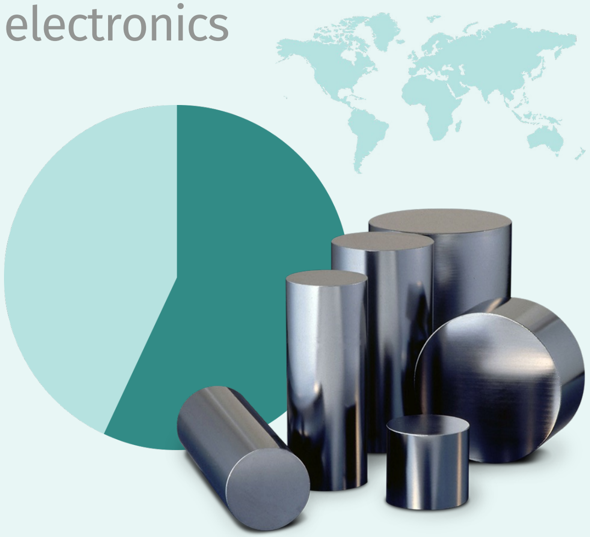
Australian Centre for Neutron Scattering

ANSTO – over 70 years of nuclear expertise

Produces 80% of nuclear medicine isotopes used in Australia



Produces more than 50% of world's NTD silicon used for high-power electronics



NTD = Neutron Transmutation Doping

Operates Australia's most subscribed sovereign research facilities

- Australian Centre for Neutron Scattering
- Centre for Accelerator Science
- Australian Synchrotron

OPAL Reactor

History – HIFAR to OPAL

HIFAR was Australia's first reactor

1958 – 2007

OPAL was built as the replacement

Achieving criticality – 12 Aug 2006

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OPAL reactor – design

20MW Thermal
Multi-Purpose
Reactor Facility

First critical
12 August 2006

16 LEU FAs

Compact Core
(~300kW/L)

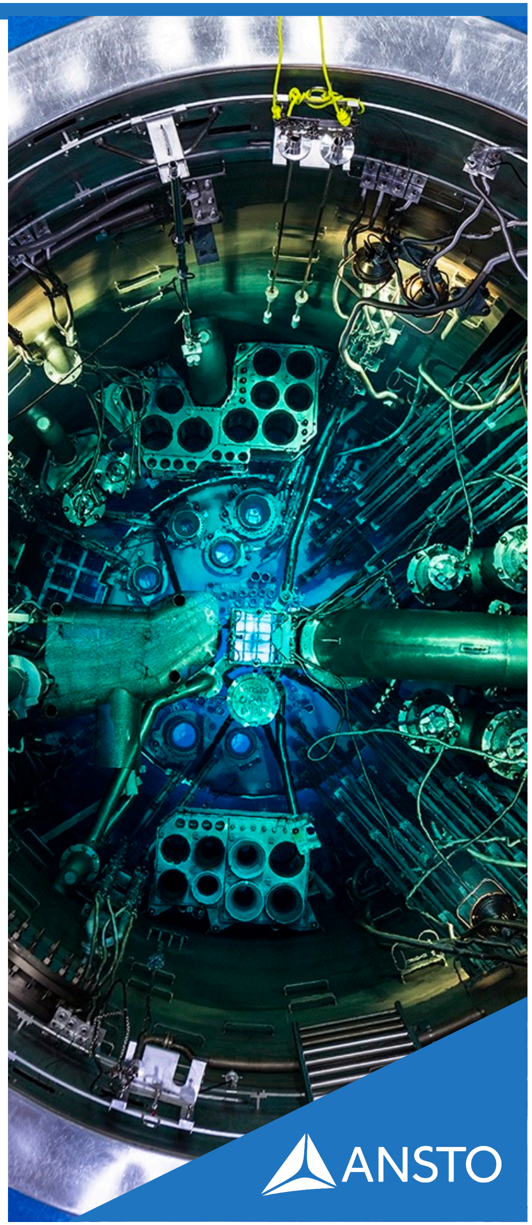
D_2O Reflector

Light Water Cooled
and Moderated

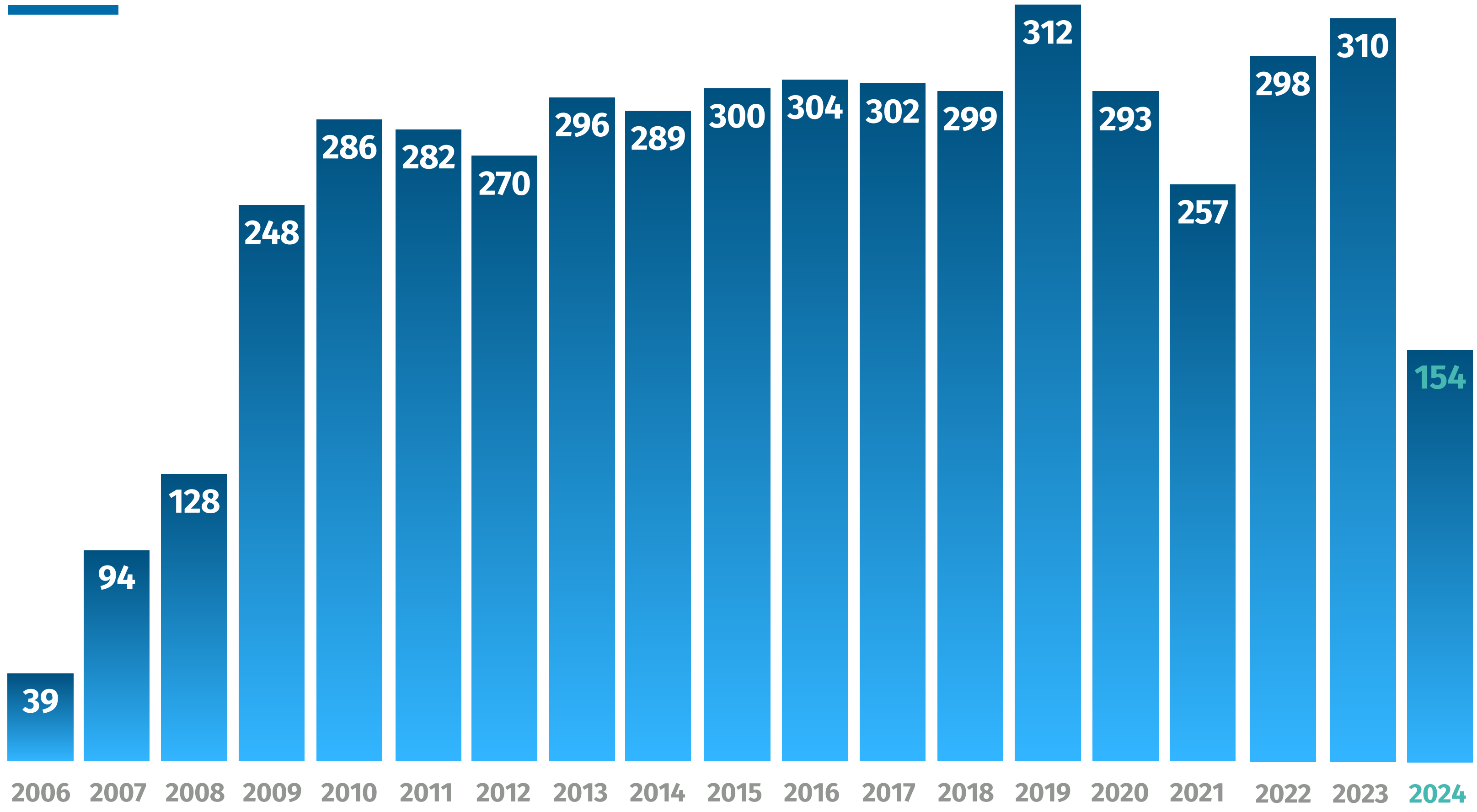
2 x Independent and
Diverse Protection and
Shutdown Systems

Inherent Passive
Safety Systems

Walk Away Safe



OPAL operating days – history



Target 300+ days of operation each year

Average reactor cycle 32 days

Typical refuelling and maintenance shutdown 5 day

Occasional major shutdowns (weeks or months)

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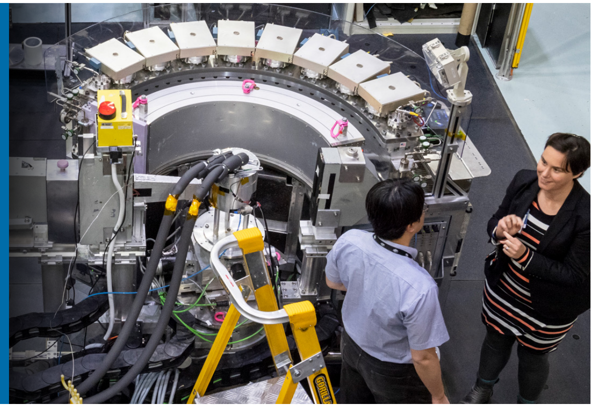
Reactor Applications

OPAL applications – Multi-purpose reactor

Neutron activation

Neutron scattering



Health

Silicon

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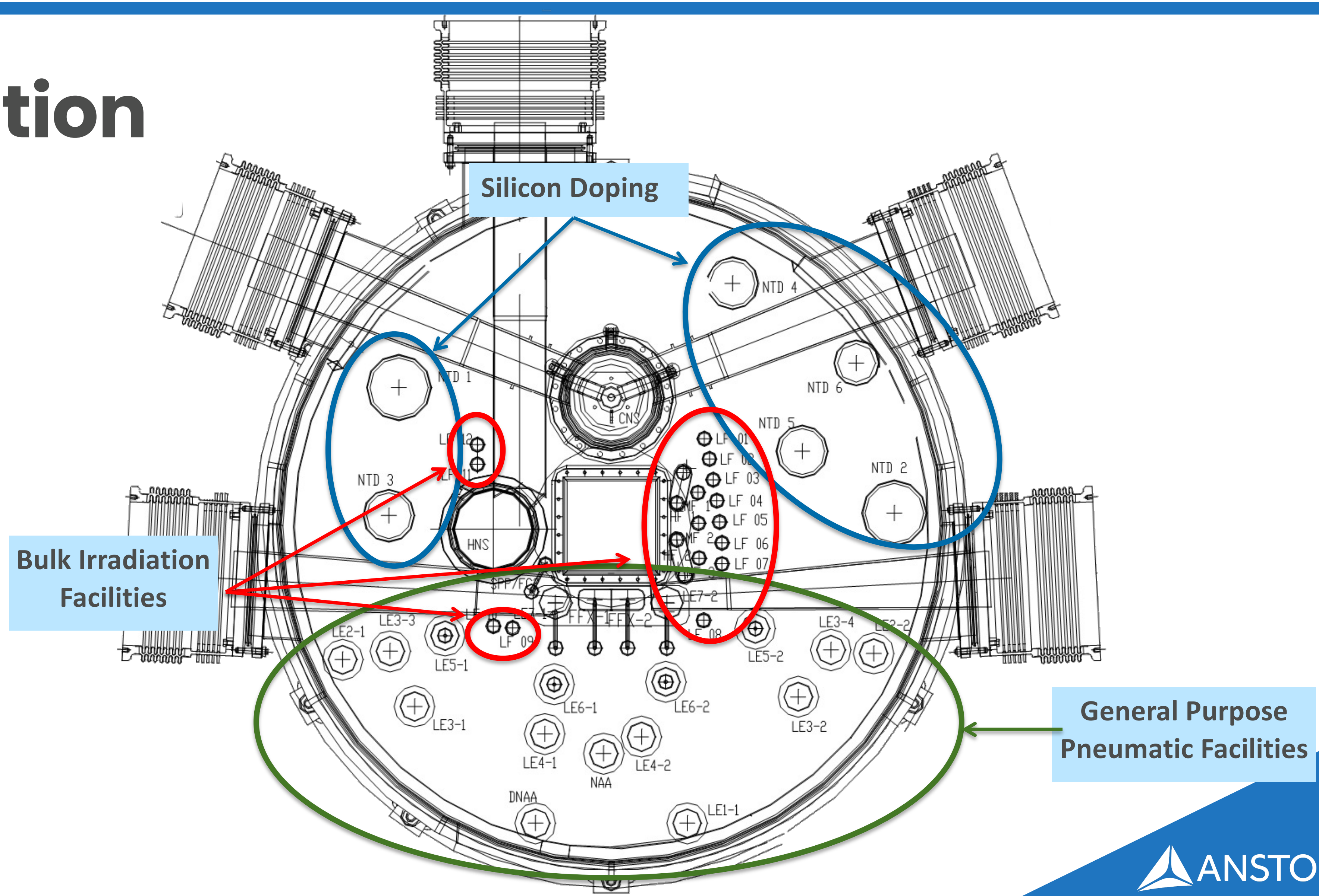
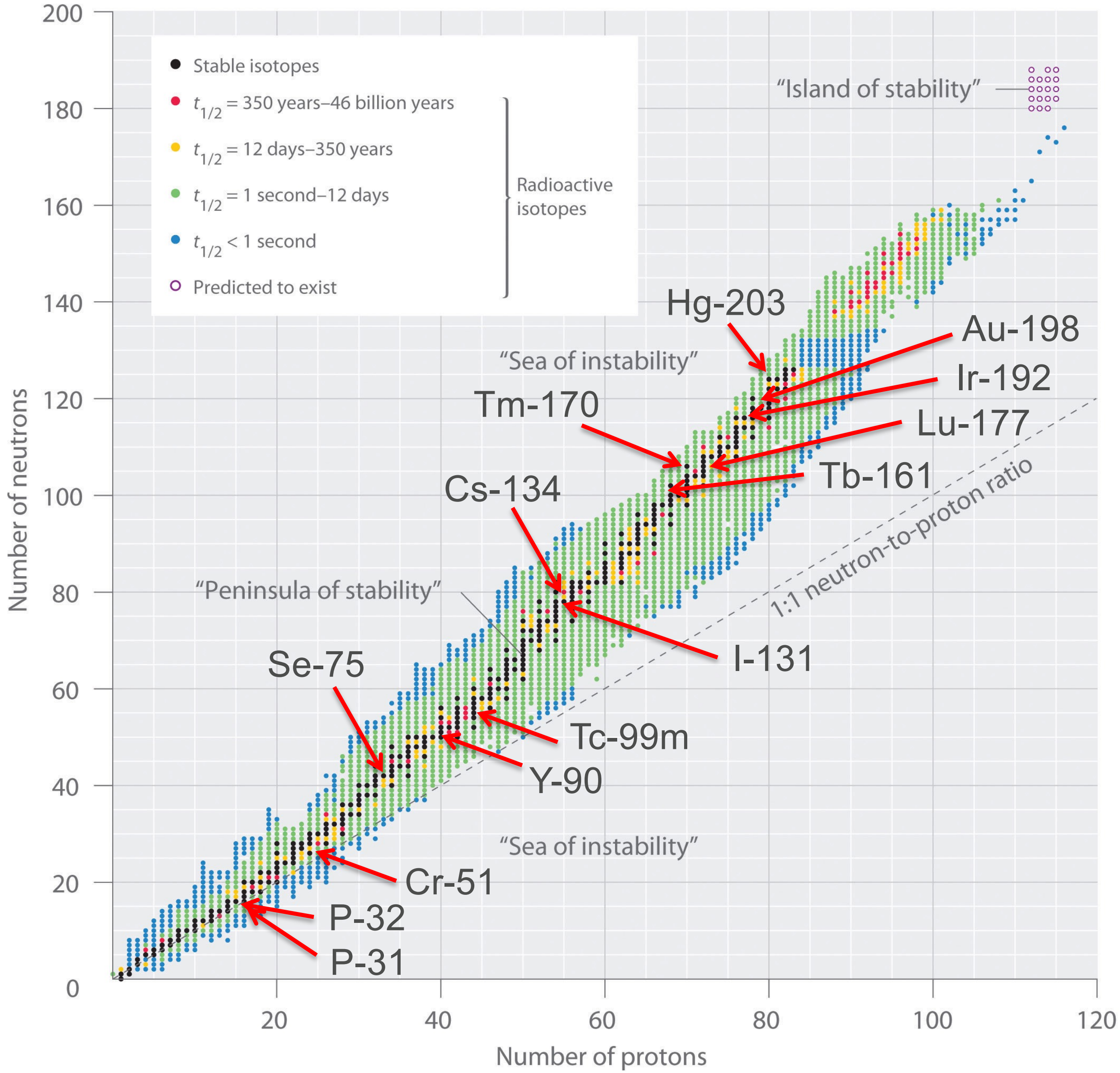
Utilisation





What We Make

- Lu-177, Ytterbium oxide (HF)
- Ir-192, Iridium discs (HF)
- Y-90, Yttrium (HF)
- P-32, Phosphorus (HF)
- I-131, Tellurium (MF)
- Tc-99m, Technetium - U-235 plates (LF)
- P-31, NTD Silicon (LVF)
- Cr-51, Chromium (LRT)
- Au-198, Gold-grains (LRT)
- Hg-203, Mercury (LRT)
- Tm-170, Thulium (LRT)
- Se-75, Selenium (LRT)
- Cs-134, Caesium (LRT)
- Research, Mineral & Uranium Ores (LRT/SRT)

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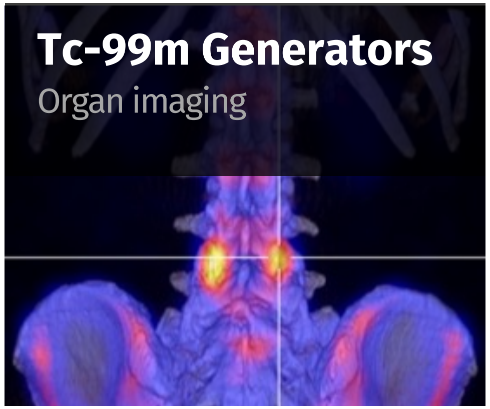
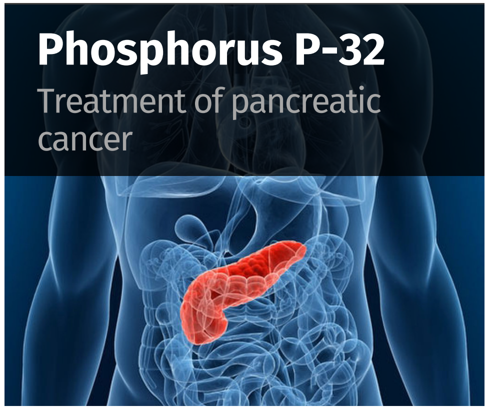
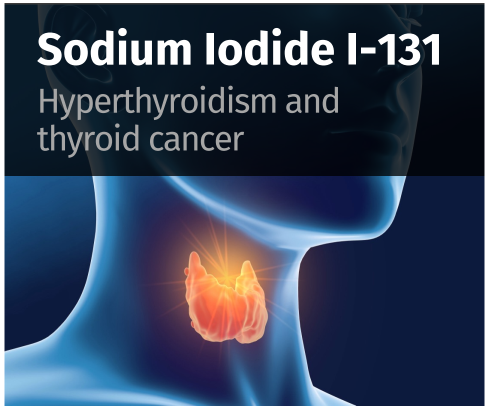
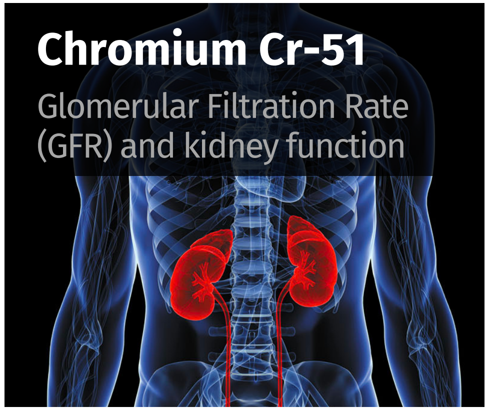
Health

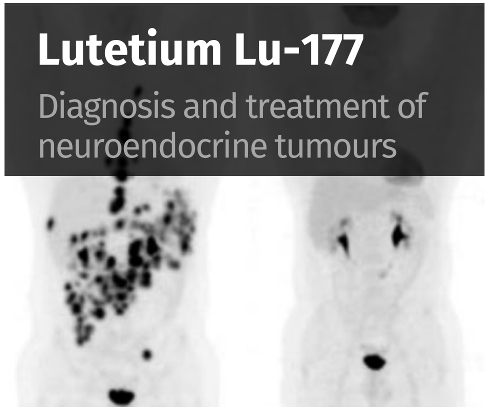
Neutrons for Health – Nuclear Medicine











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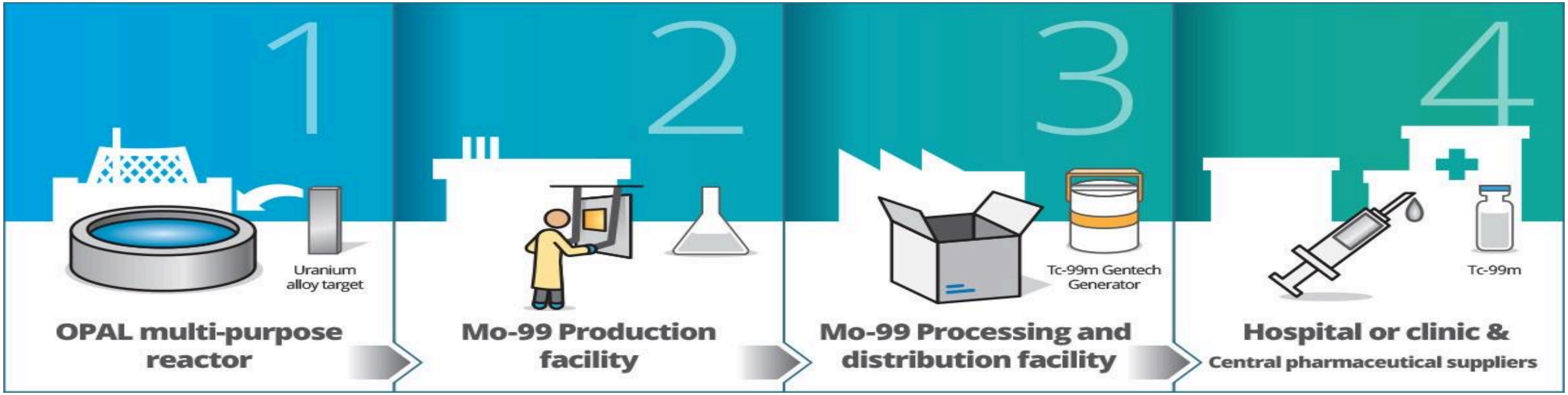
^{99m}Tc – Production Process

B80 → B88 → B23 → OFFSITE



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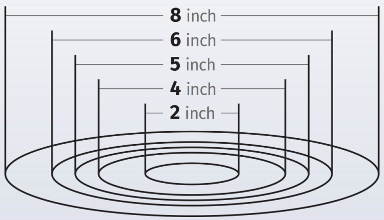
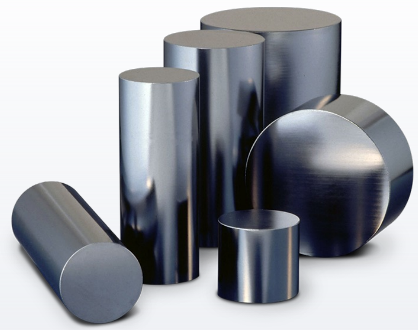
Silicon

Neutrons for Industry - NTD Silicon

Neutron Transmutation Doped Silicon for use in semiconductor devices for high-power applications



Six irradiation facilities capable of irradiating 4, 5, 6, 8 Inch Ingots



Supplying over half of the global market for NTD Silicon

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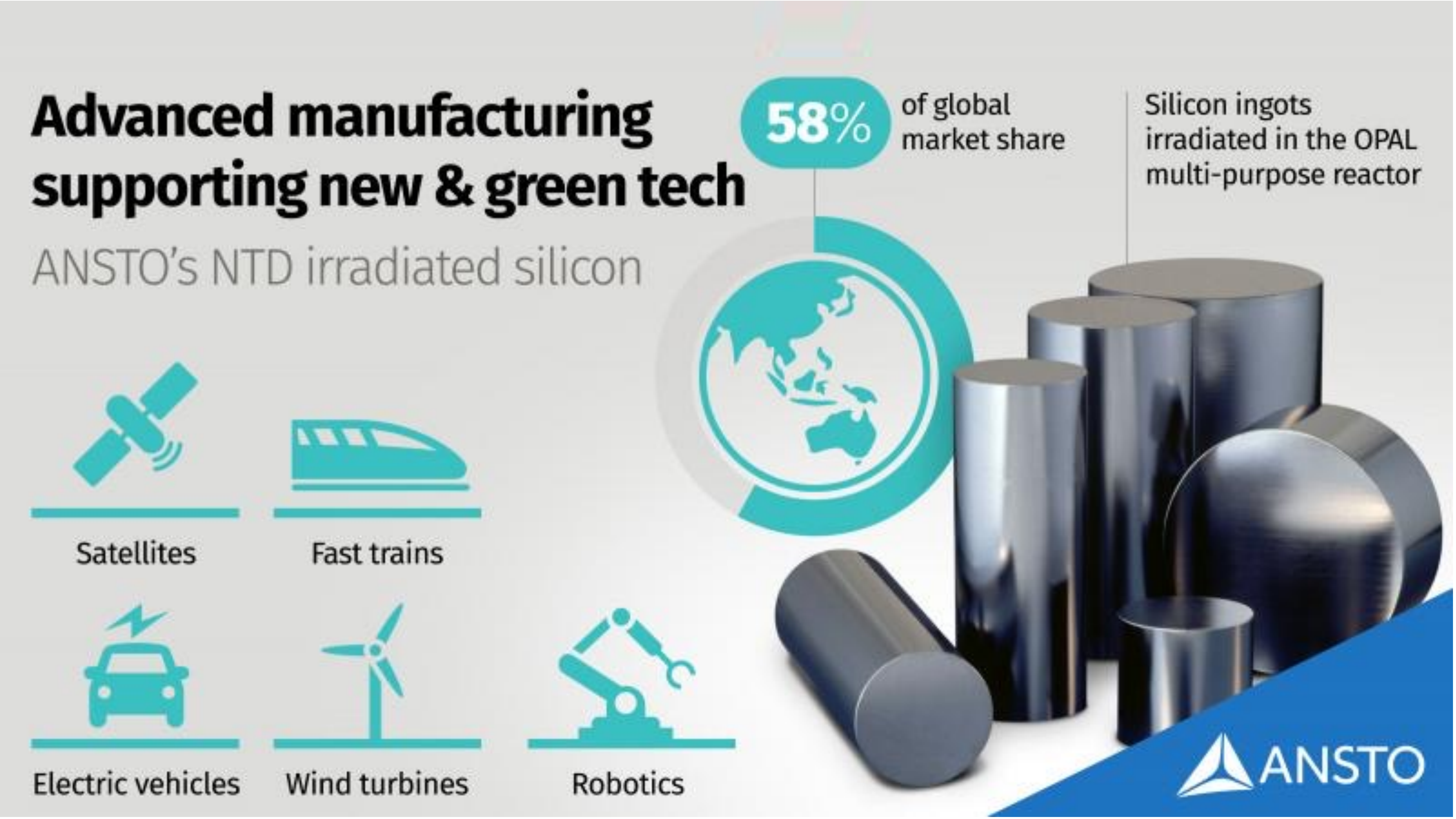
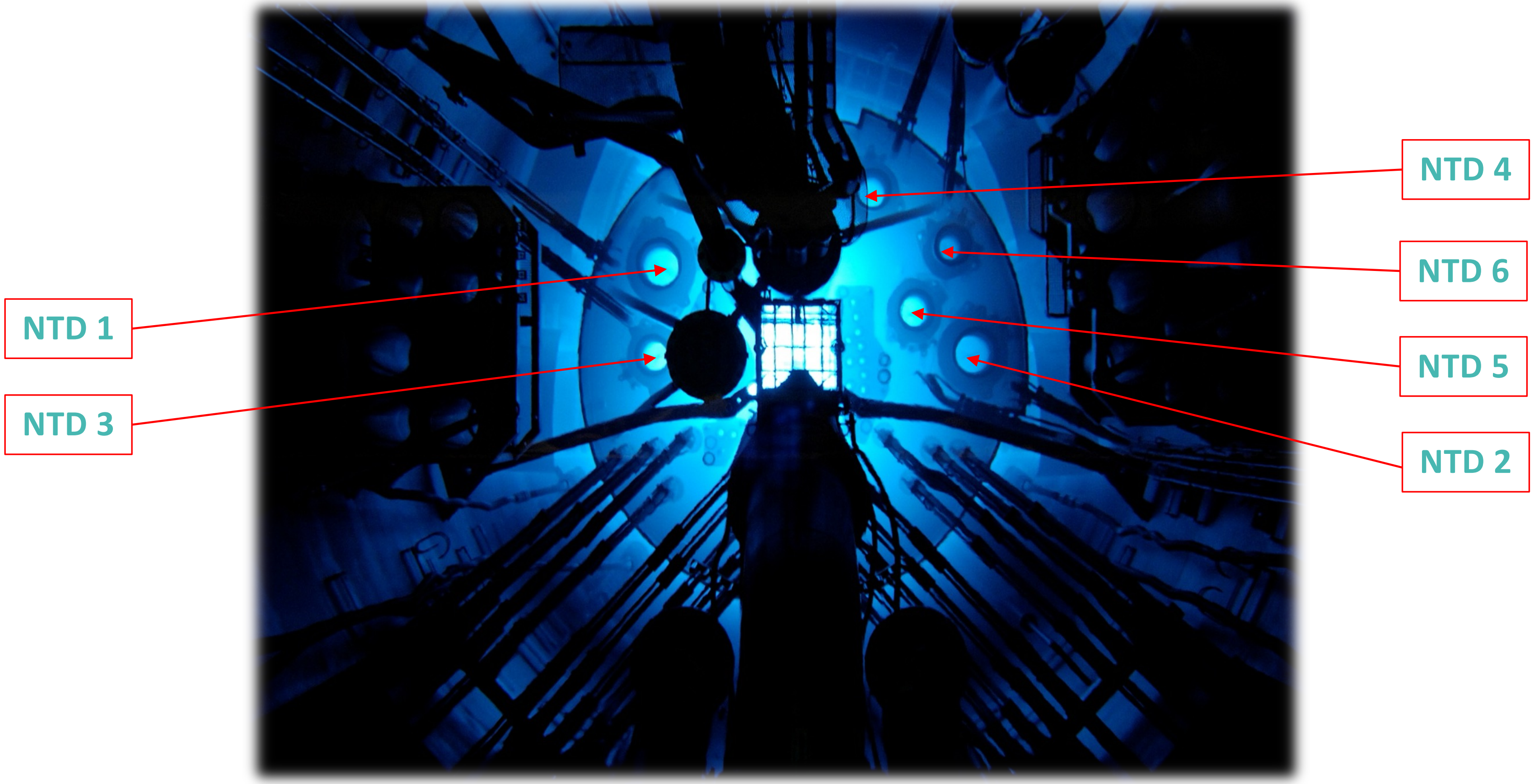
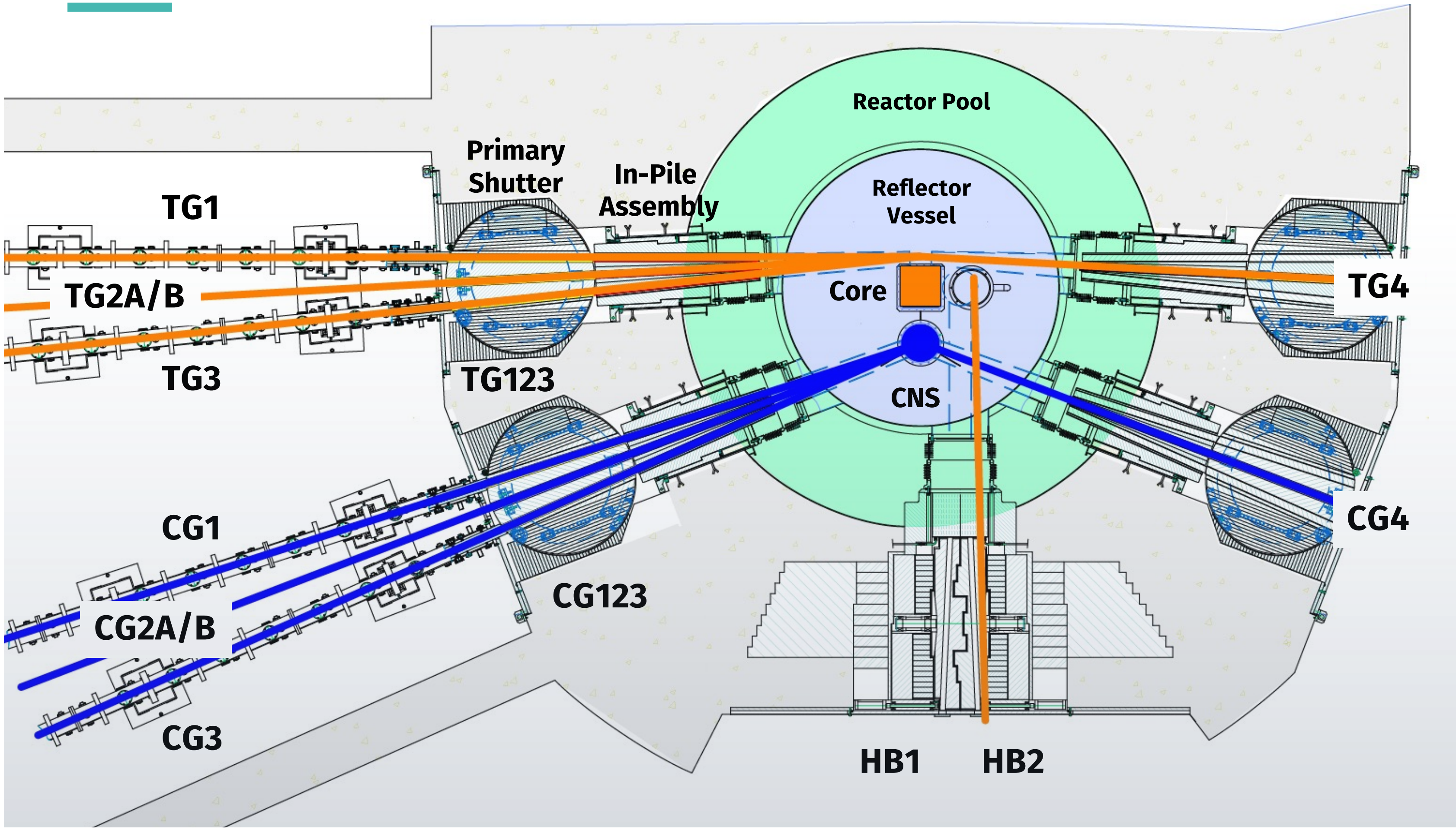

Advanced manufacturing supporting new & green tech
ANSTO's NTD irradiated silicon
58% of global market share
Silicon ingots irradiated in the OPAL multi-purpose reactor
Satellites
Fast trains
Electric vehicles
Wind turbines
Robotics
ANSTO

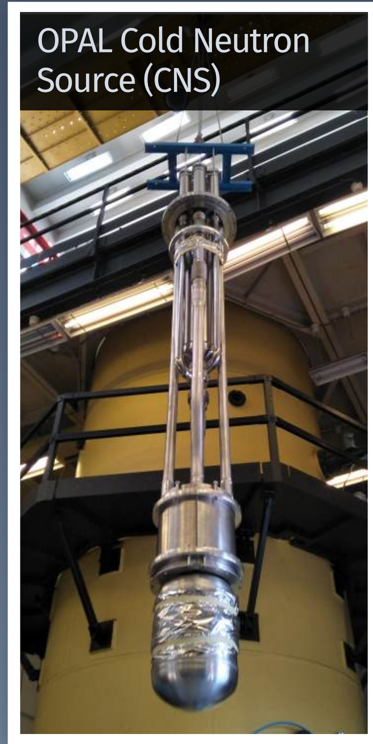
NTD facilities



Neutron Scattering

OPAL's Neutron Beam Facilities





TG	Thermal Guide
CG	Cold Guide
HB	Hot Beam

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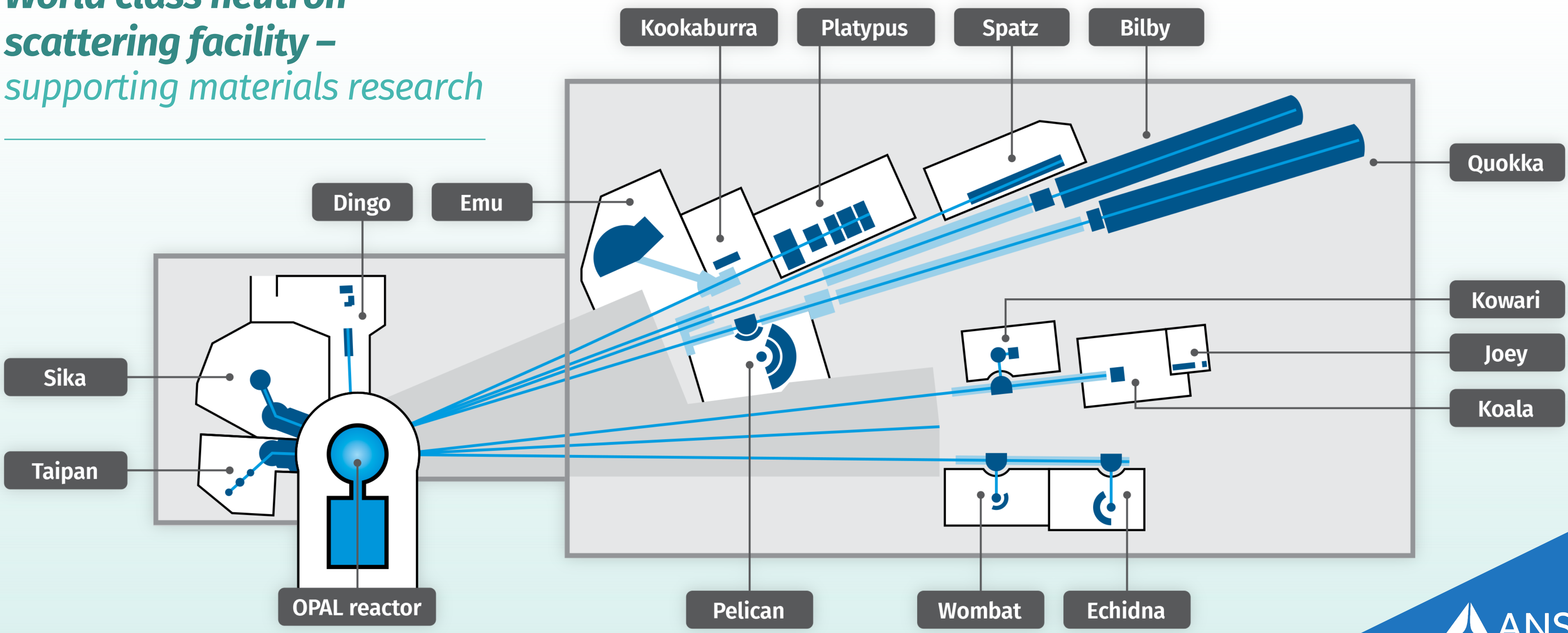
Australian Centre for Neutron Scattering

World class neutron scattering facility –
supporting materials research



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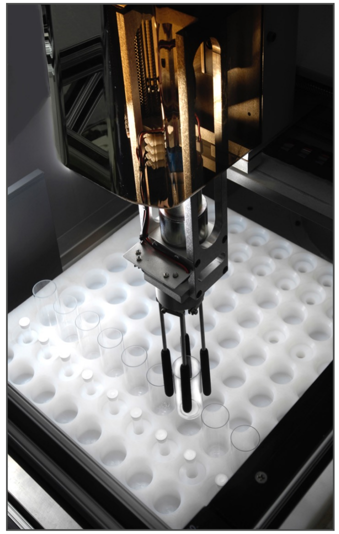
Neutron Activation

Research Irradiations

- For commercial, internal and external research
- Approximately 400-700 irradiations/year, mostly NAA/DNAA targets (>1000 samples)
- Long history of NAA (single and multi-elemental analysis) and DNAA (Uranium analysis) at ANSTO
- Irradiations performed using pneumatic irradiation facilities, neutron fluxes from $(0.3 - 10) \times 10^{13}$ nv
- Dedicated gamma measurement laboratory including automatic sample changer



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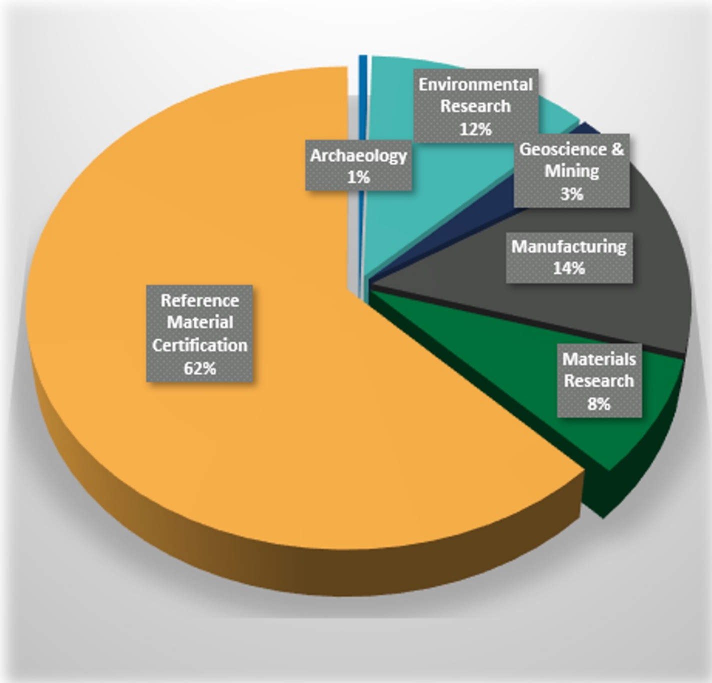
NAA Applications

- Archaeology
- Environmental research
- Geoscience
- Mining
- Manufacturing
- Materials research
- Reference material certification



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Radioisotopes for Research and Development

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Research Irradiations

- Current offerings:
  - Fission track irradiations (nuclear forensics)
  - Radiotracer production for research
    - ^{14}C, ^{47}Sc
    - ^{60}Co, ^{65}Zn
    - ^{75}Se, ^{134}Cs
    - ^{203}Hg
  - Bespoke irradiations for research (nuclear materials research, space applications, NTD research)
- Future development:
  - $^{40}Ar/^{39}Ar$ geochronology (fast neutron/cadmium shielded)
  - Expansion of radiotracer offerings (potentially external)

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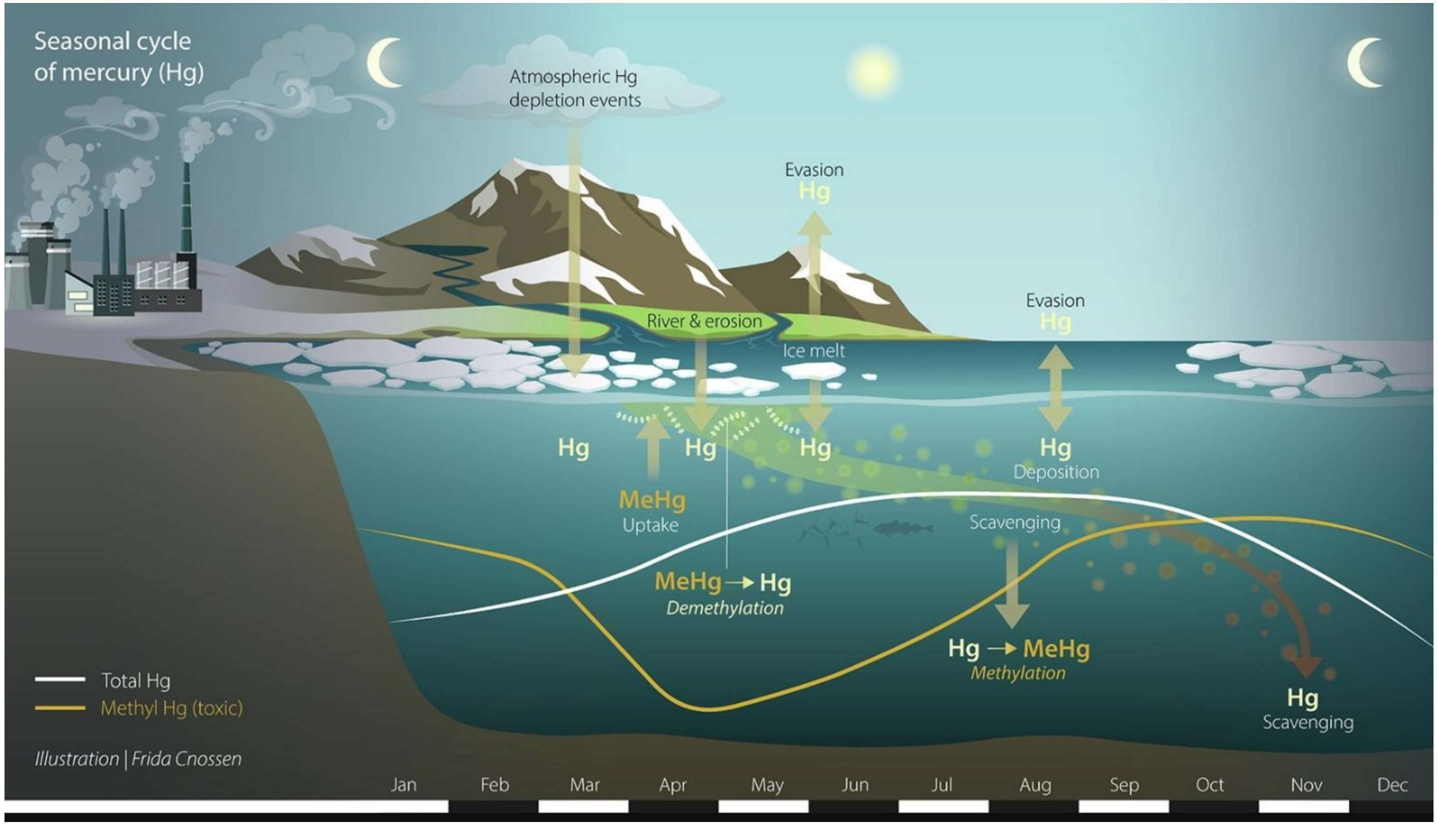
Case Study: Hg-203

Mercury in the Environment



Gissi, F., Koppel, D., Boyd, A., Kho, F., von Hellfeld, R., Higgins, S., Apte, S., & Cresswell, T. (2022). A review of the potential risks associated with mercury in subsea oil and gas pipelines in Australia. *Environmental Chemistry, 19*(4), 210–227. https://doi.org/10.1071/EN22048

Kho, F., Koppel, D. J., von Hellfeld, R., Hastings, A., Gissi, F., Cresswell, T., & Higgins, S. (2022). Current understanding of the ecological risk of mercury from subsea oil and gas infrastructure to marine ecosystems. *Journal of Hazardous Materials, 129348.* https://doi.org/10.1016/j.jhazmat.2022.129348

Erickson, P. R., & Lin, V. S. (2015). Research highlights: Elucidation of biogeochemical factors influencing methylmercury production. *Environmental Science: Processes & Impacts, 17*(10), 1708–1711. https://doi.org/10.1039/c5em90037a

Kohler, S. G., Heimbürger-Boavida, L.-E., Assmy, P., Müller, O., Thiele, S., Digernes, M. G., Ndungu, K., & Ardelan, M. V. (2024). Biotic transformation of methylmercury at the onset of the Arctic spring bloom. *Progress in Oceanography*. https://doi.org/10.1016/j.pocean.2024.10322

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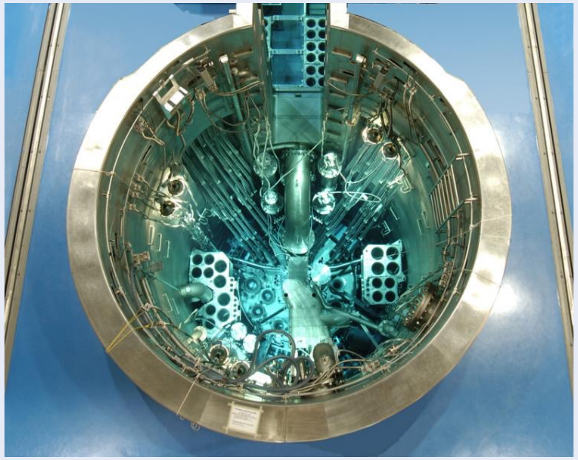
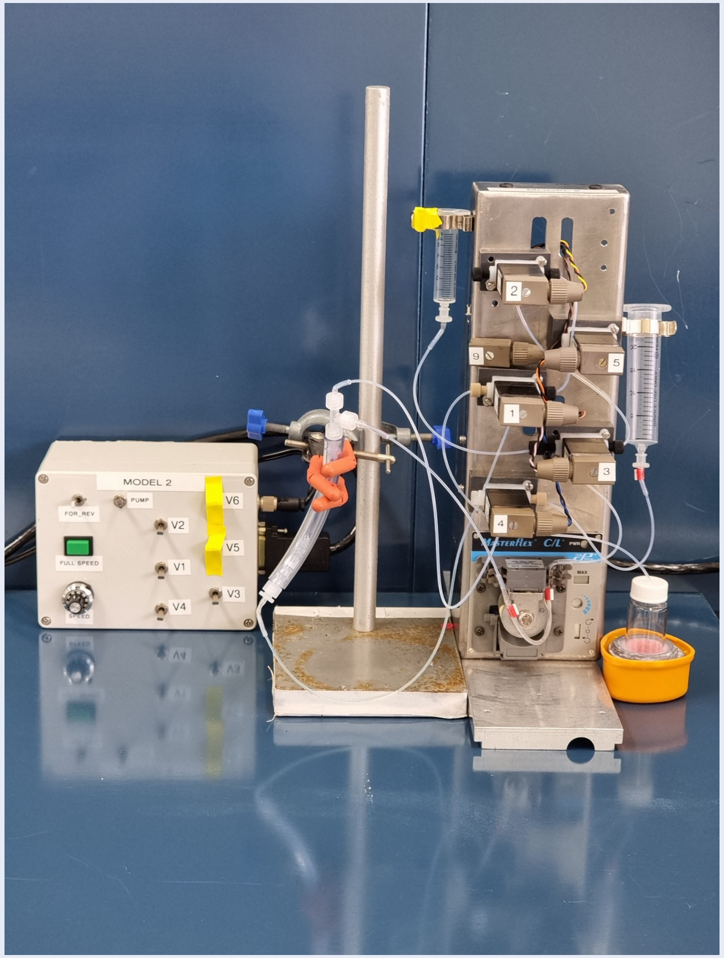
[^{203}Hg]HgO Processing





Target	Specific Activity MBq/mg
ANSTO	**8.51 - 574**
Literature	**9.25 - 518**

>90% process yield

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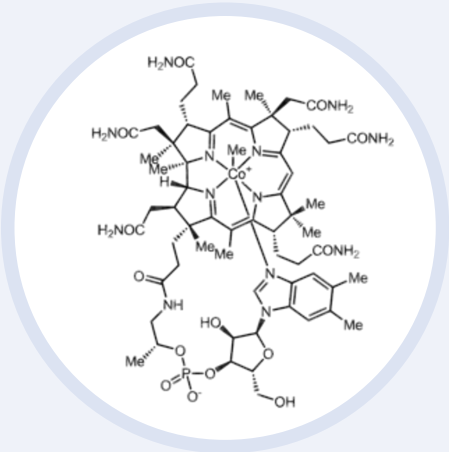
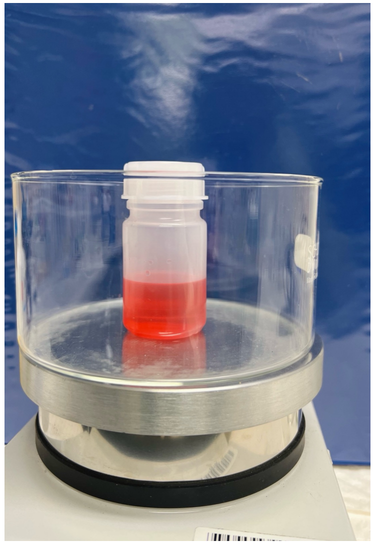
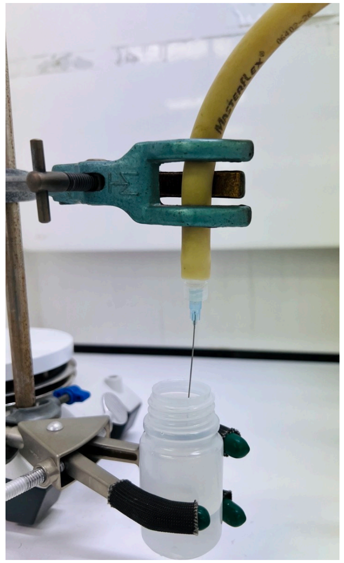
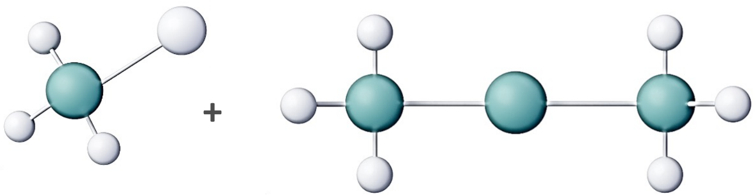
[^{203}Hg]Methylmercury Synthesis and Stability







Low pH



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[^{203}Hg]Methylmercury - Synthesis and Stability

- Conditions for Radiosynthesis
- Vessel Adsorption
- Loss to Volatility
- Chemical Stability

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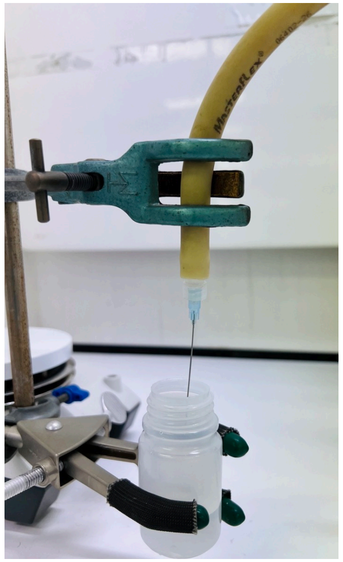
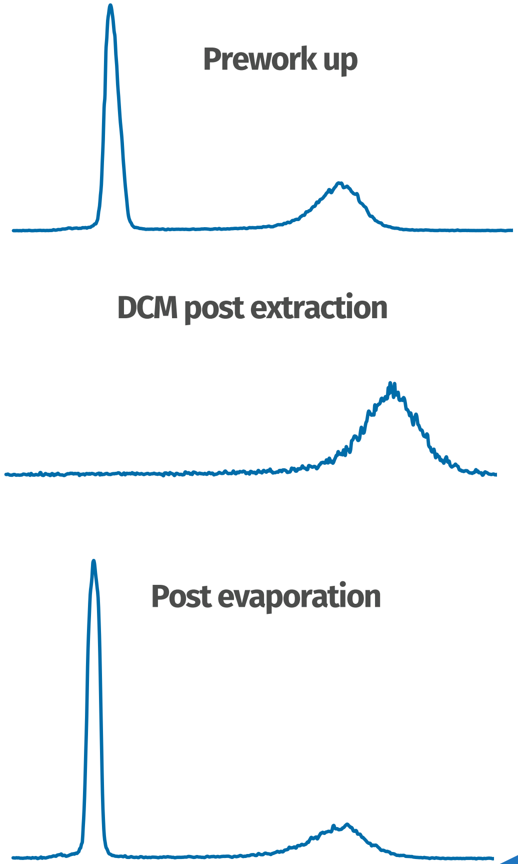
$[^{203}Hg]$Methylmercury Synthesis

Reaction	$HgCl_2$ (mM)	MeCo B eq	RCC (%)
1	2.00	2	57
2	2.00	5	98
3	0.50	5	70
4	1.00	5	75
5	0.25	8	63
6	0.50	8	99
7	1.00	8	95
8	2.00	8	98
9	0.25	12	97
10	0.50	12	99
11	1.00	12	98
12	0.25	16	97
13	0.50	16	97
14	1.00	16	99
15	0.10	23	95

Reaction	Mean complexation (%)
Literature Method	69 ± 6.0, n = 3
Revised Method	97 ± 1.8, n = 5



RCY = 90%



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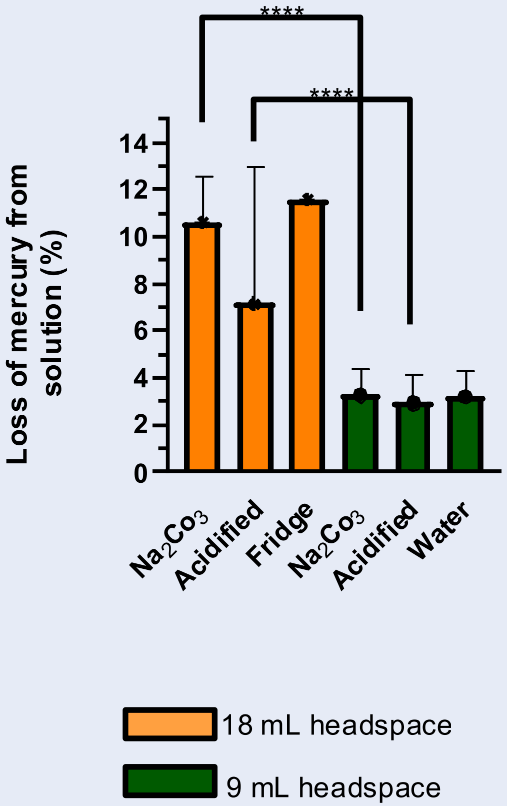
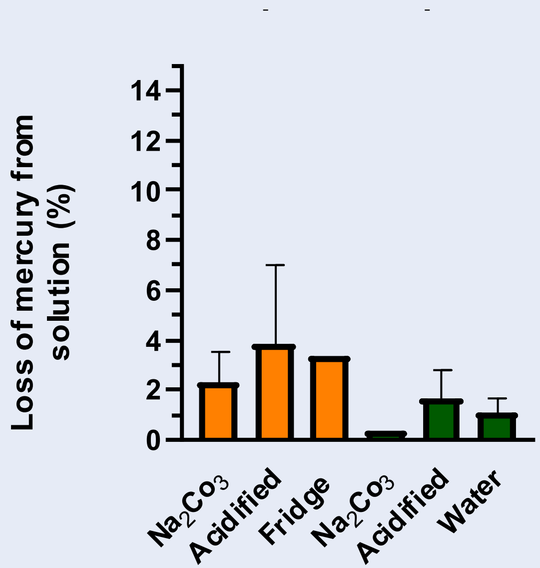
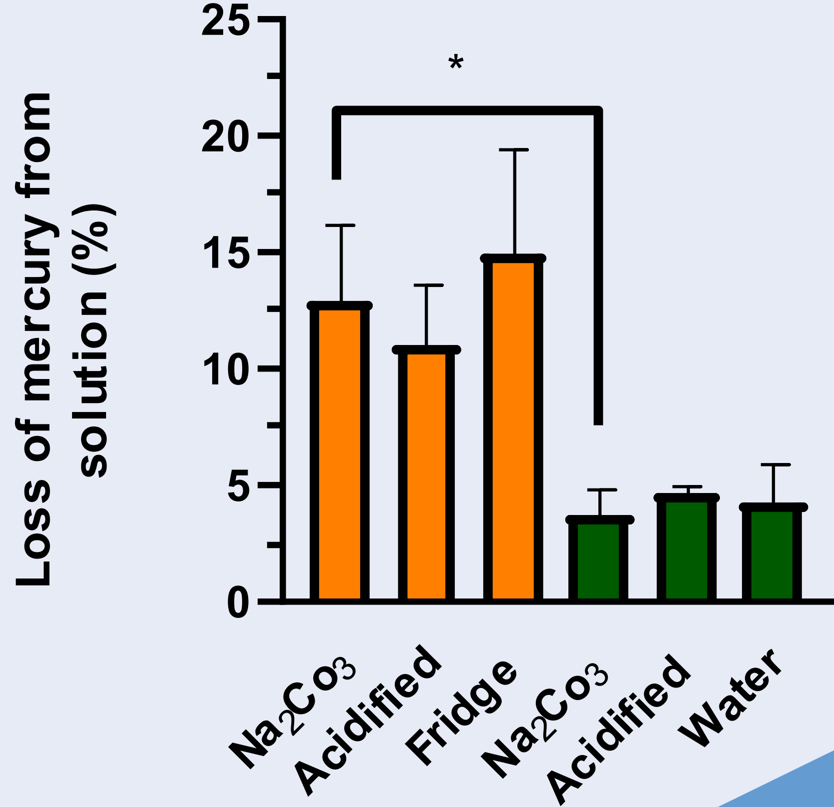
[^{203}Hg]Methylmercury Stability







Mechanism of loss	Volatility (%)	Adsorption (%)	Total (%)
Teflon® coated	28.33	26.2	54.5 ± 1.4

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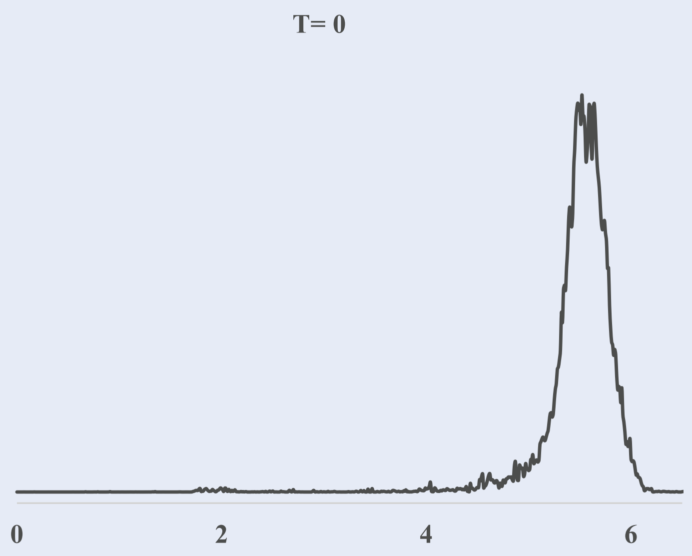
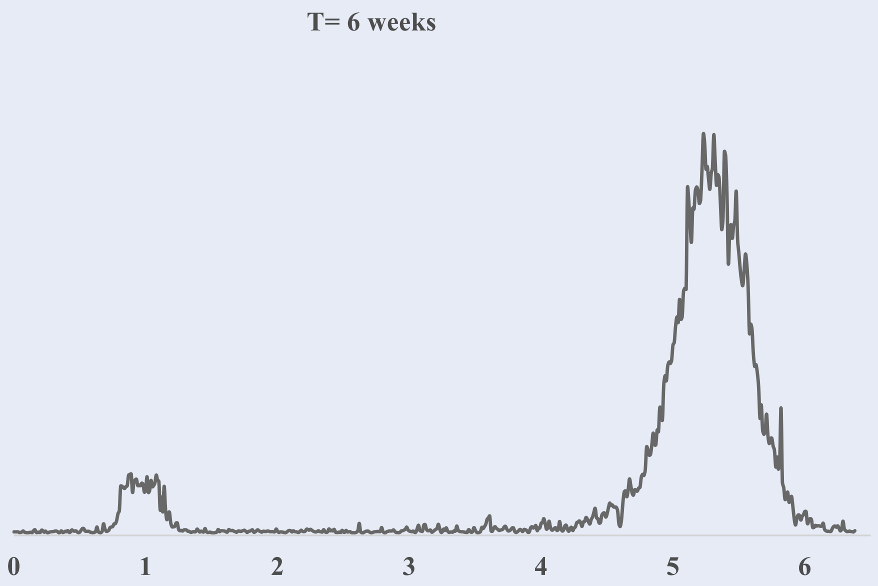
[^{203}Hg]Methylmercury Stability





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Into the Future: Radioisotope Manufacturing

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Australia’s Nuclear Medicine Manufacturing Facility

Nuclear Medicine Manufacturing Facility

- Federal investment estimated at >$500M.
- Future-proofing Australia's nuclear medicine manufacturing.
- Building a world-class facility to keep Australia at the forefront of innovation for generations to come.
- Creating adaptable spaces for emerging technologies and the development of new products.

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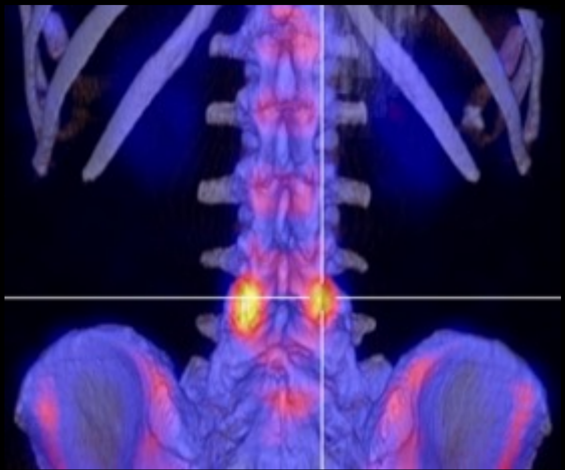
Radioisotopes for Nuclear Medicine

Molybdenum Mo-99 Tc-99m Generators

Organ, bone imaging

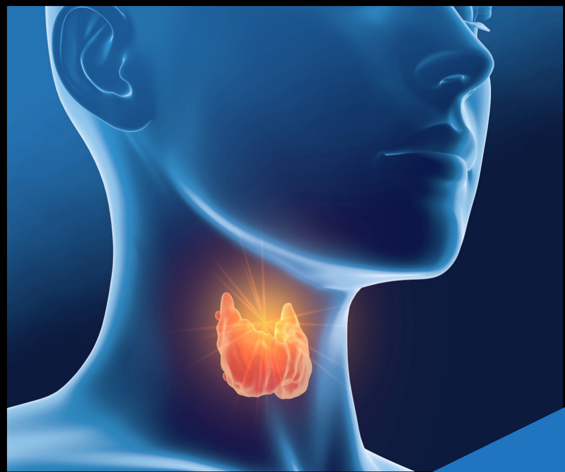


Lutetium Lu-177

Imaging and treatment of neuroendocrine tumours and prostate cancer

Sodium Iodide I-131

Hyperthyroidism and thyroid cancer



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Benefits

- **Sovereignty** – Securing Australia's nuclear medicine manufacturing capability for decades to come.
- **Workforce** – Cultivating Australia's next generation of nuclear innovators.
- **Future-proofed facility** – Delivering contemporary flexible spaces for next generation technology, products and safety standards.
- **Automation** – Enhancements in safety, efficiency, quality and reducing costs.
- **Production** – Creating more doses, at lower costs and ensuring supply chain reliability.
- **Health** – Consistent delivery of life-saving medicines to patients.

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Into the Future

- Facility provides footprint for growth in:
  - Target Processing
  - New product development
  - Process optimisation
  - Emerging α/β therapies
  - Aseptic manufacturing

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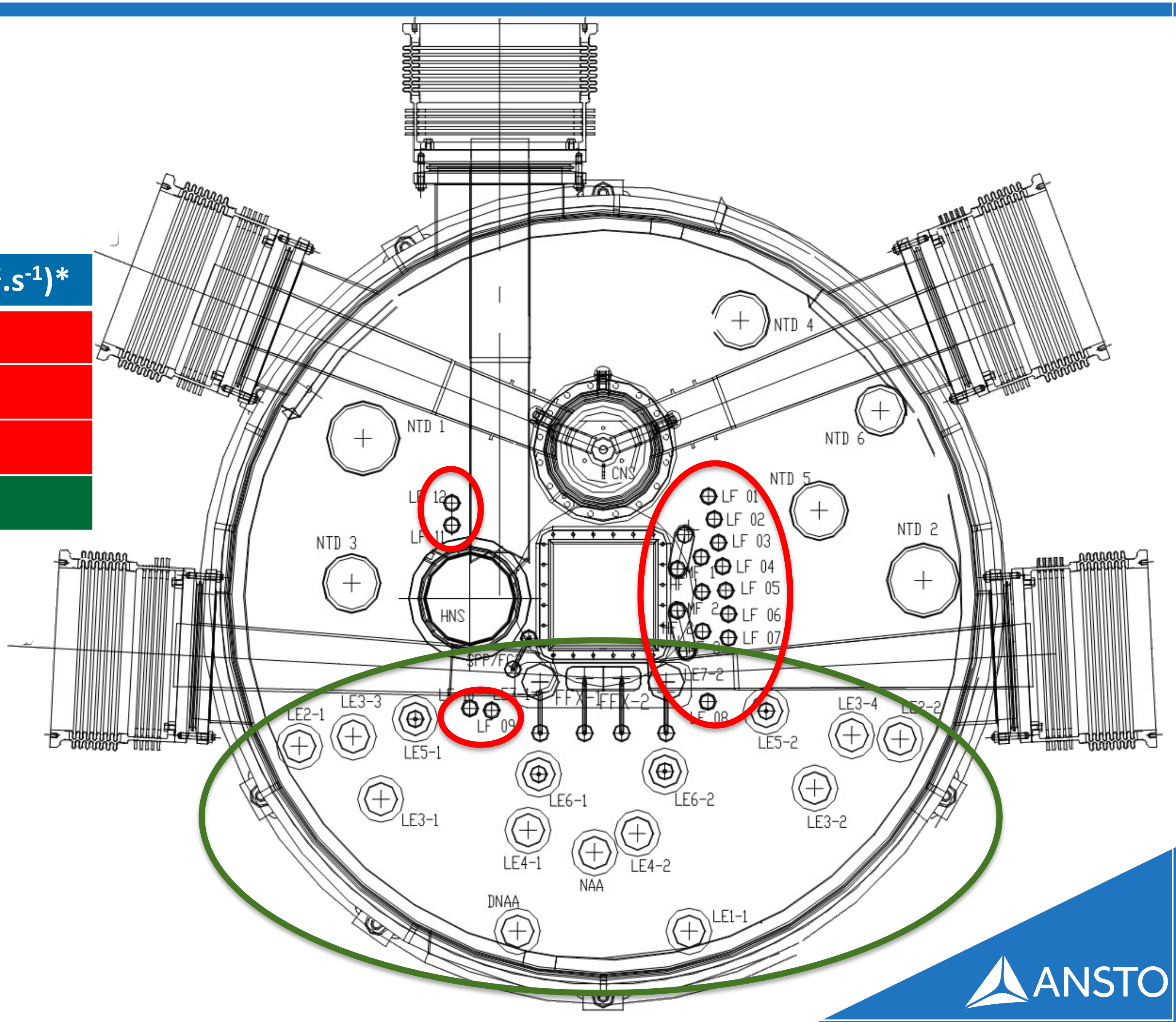
Optimisation

Position	Thermal Neutron Flux ($cm^{-2}.s^{-1}$)*
HF	1.29E+14 - 2.9E+14
MF	8.92E+13 - 1.89E+14
LF	6.42E+13 - 1.10E+14
LRT	2.36E+12 - 1.17E+14



*Dependant on D_2O purity and position

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Ensuring Supply

- Awareness of geographical isolation
- Technology review
- Demand forecasting
- Workforce development and retention
- Reciprocal supply agreements
- 10-30 year timescale planning

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Questions

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Thank you

Australian Government

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