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IAEA activities in support of development and utilization of neutron sources

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Physics Section and Nuclear Science and Instrumentation Laboratory
International Atomic Energy Agency

Outline

- Organization
- Highlights of recent achievements
- Neutrons4NA initiative
- CANS
- BNCT
- Next steps

Division of Physical & Chemical Sciences (NAPC)

Nuclear Science, Nuclear Data, Nuclear Physics, Radiation and Isotope Sciences & Applications, Water Resource Management

Nuclear Data

- Data Development
- Data Services
- Atomic & Molecular Data

Physics

- Accelerator & Research Reactor Applications
- Nuclear Instrumentation
- Nuclear Fusion

Radiochemistry & Radiation Technology

- Medical Radioisotope production, Radiopharmaceuticals
- Radiotracers, NCS & NDT in industry
- Radiation technology applications
- Terrestrial Environment

Isotope Hydrology

- Isotopic methods for groundwater assessment
- Water resource management
- Scenario modelling

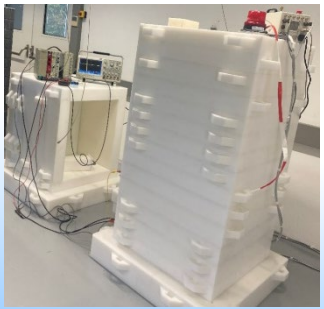
Physics Section: main technical areas

1.4.2 Research & Applications with Accelerators & Neutron Sources

(incl. RR applications)

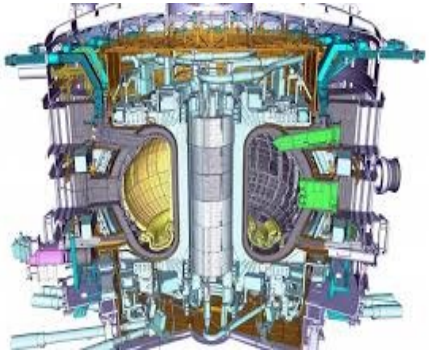
1.4.3 Nuclear Instrumentation

(incl. laboratory in Seibersdorf)



1.4.4 Nuclear Fusion Science & Plasma Physics

(incl. coop. with ITER)



Subprogramme 1.4.2 Research and Applications with Accelerators and Neutron Sources

Main Objectives:

- Support MSs in strengthening their capabilities to conduct research with accelerators and neutron sources (incl. RRs)
- Support MSs in strengthening their capabilities to expand the applications of accelerators and neutron sources (incl. RRs)

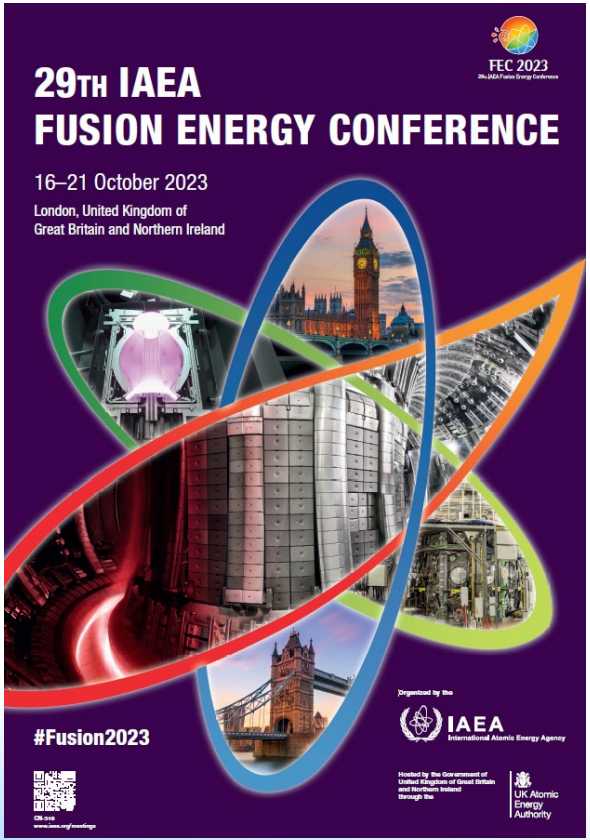
Projects:

- 1.4.2.1 Accelerator and neutron source applications in multiple disciplines
- 1.4.2.2 Enhancing research with accelerators and neutrons

Physics Section in numbers

- **Coordinated Research Projects:** 7 active
- **TC projects:** >50 active in >50 Member States
- **Meetings/Workshops/Schools**: >50/year
- **Major Conferences (3):** Accelerators, RRs, Fusion Energy
- **Data bases/portals (4):** accelerators, neutrons, instrumentation, fusion
- **Collaborating Centers (8):** ANSTO, TU Delft, Elettra, iThemba Labs, Univ. Paris Saclay, Univ. of Okayama, Univ. of Singapore, MIT PSFC
- **Cooperation agreements (9):** ITER, UNICRI, ITU, FIA, Elettra, RBI, PPPL, ASSIP, CEA
- **Events in cooperation:** >5/year

E.g. Organization of Three Major Conferences



Next in 2025, 2027…

Next in 2026

Next in 2028

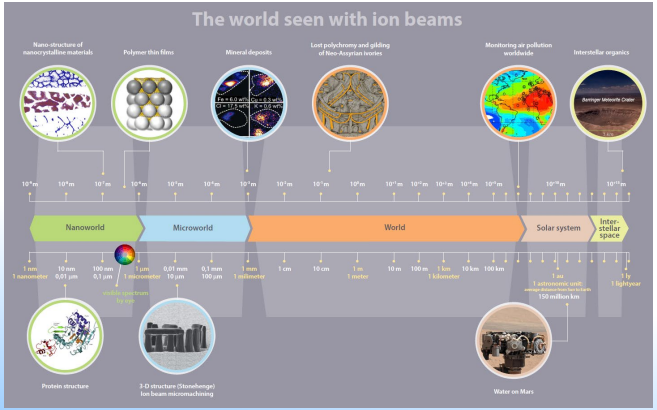
E.g. managing thematic portals and data bases

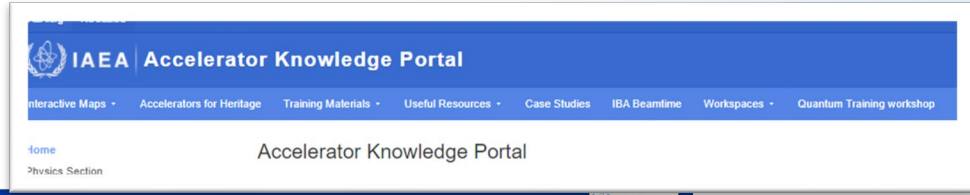
1) **Accelerators:** https://nucleus.iaea.org/sites/accelerators/
2) **Neutrons:** https://nucleus.iaea.org/sites/neutrons/
3) **Fusion:** https://nucleus.iaea.org/sites/fusionportal/
4) **Instrumentation:** https://nucleus.iaea.org/sites/nuclear-instrumentation

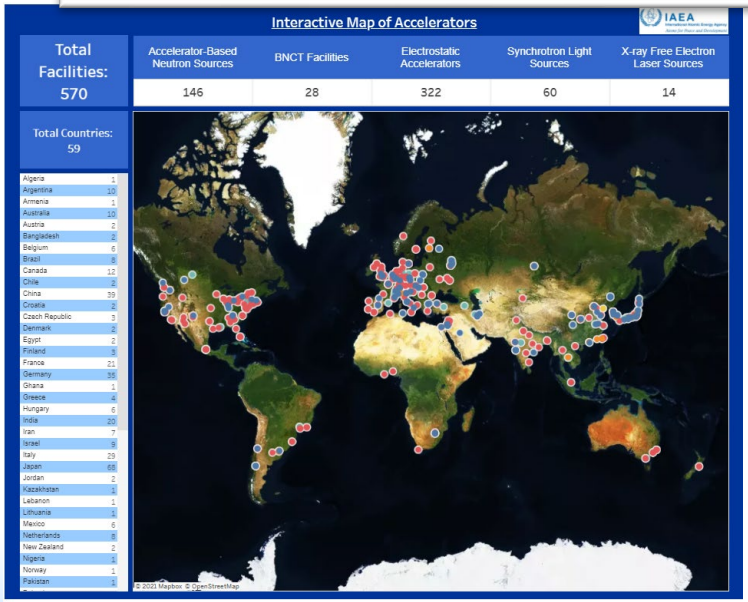
E.g. Accelerator Knowledge Portal

16000+ visitors/users in 2024; our interactive maps include

- 570+ ion beam accelerators
- 1200+ medical cyclotrons
- 400+ neutron beam instruments
- 1300+ XRF facilities

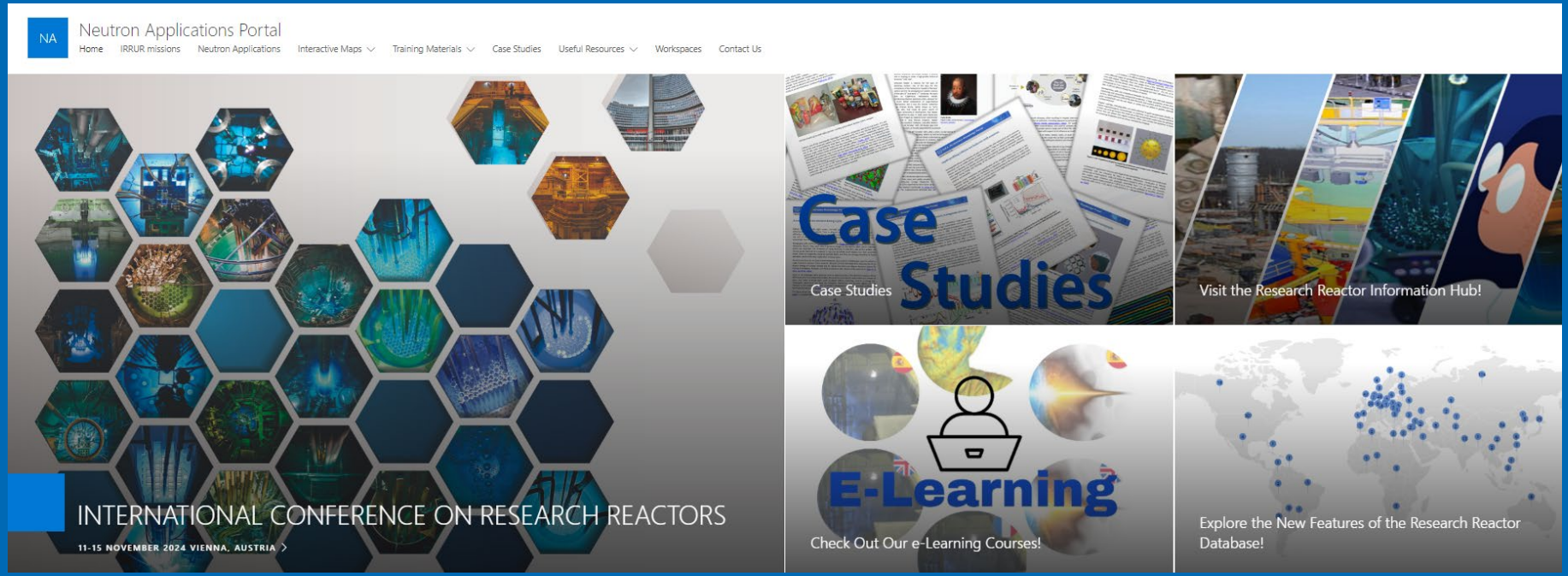






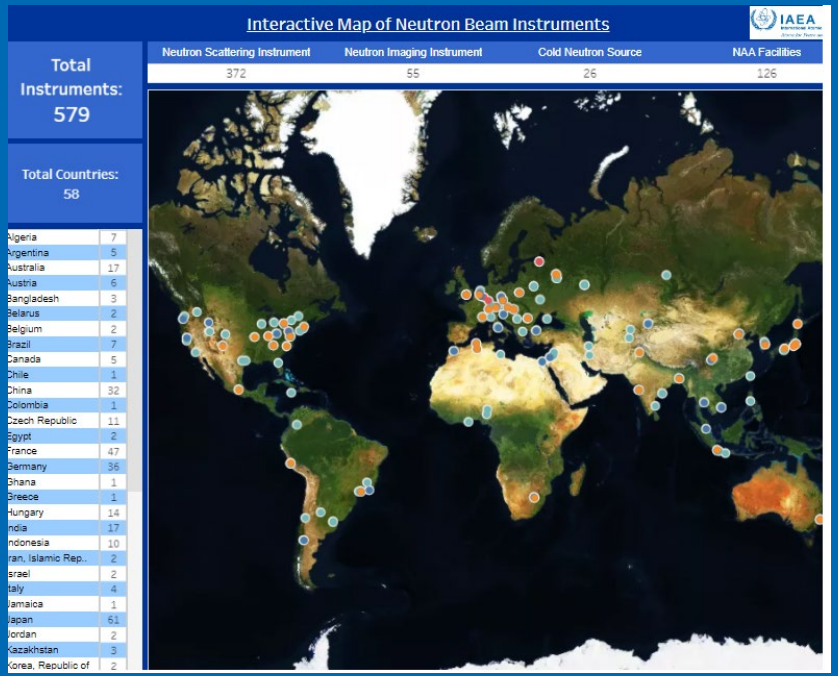
Portals and databases (1/2)

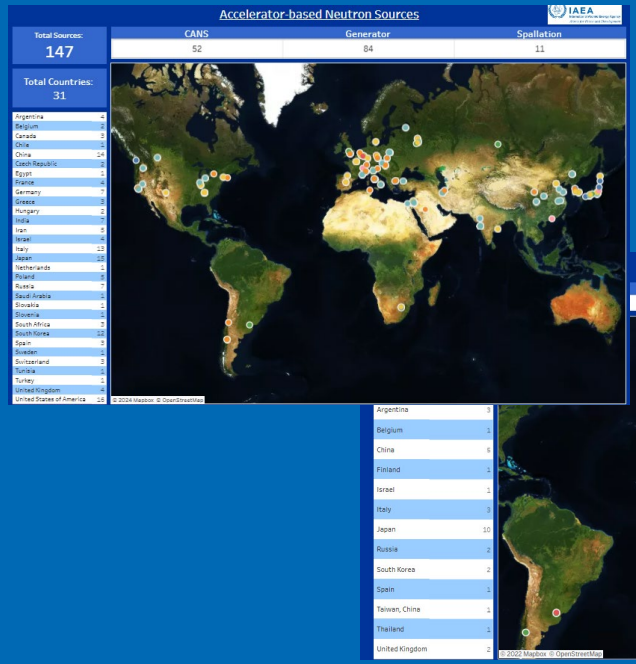
- **Neutron Applications Portal**
  https://nucleus.iaea.org/sites/neutrons, on-line since June 2022
- Number of visitors/users continues to grow



Portals and databases (2/2)

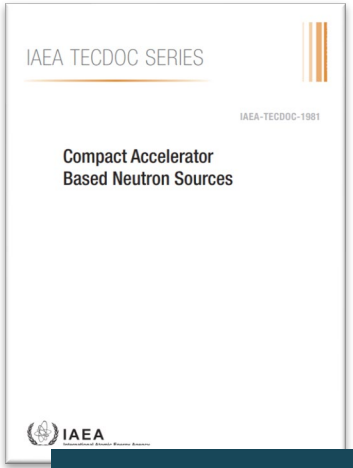
- **New online databases**
  - Neutron Beam Instruments, NAA facilities and Cold Neutron Sources
  - Accelerator based neutron sources (generators, CANS, spallation)
  - BNCT facilities (accelerator & RR based)

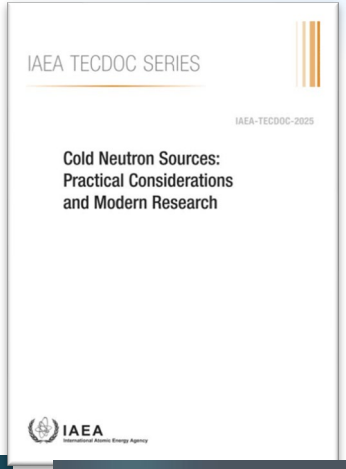


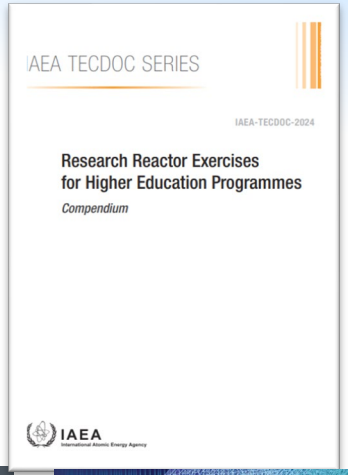


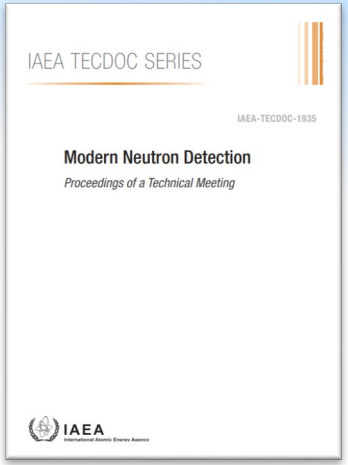
Selected Publications

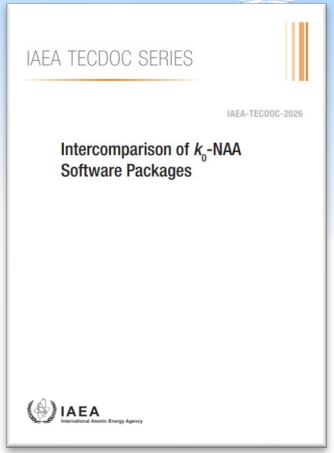
https://www.iaea.org/publications

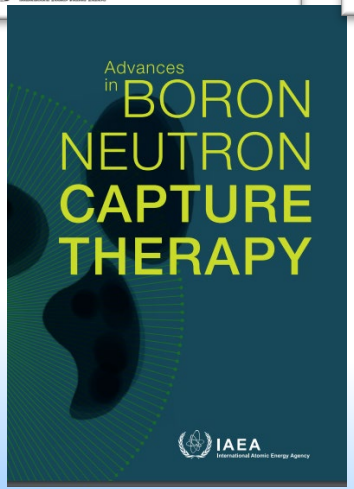


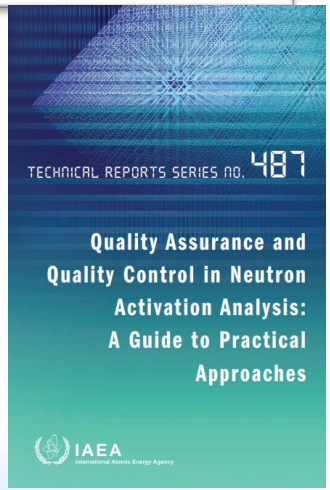


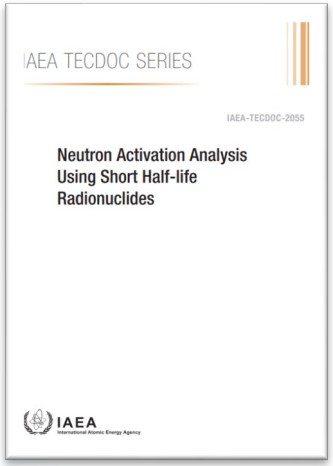


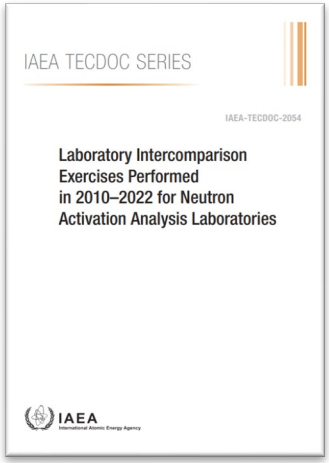








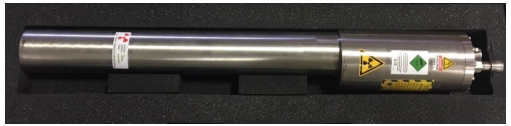


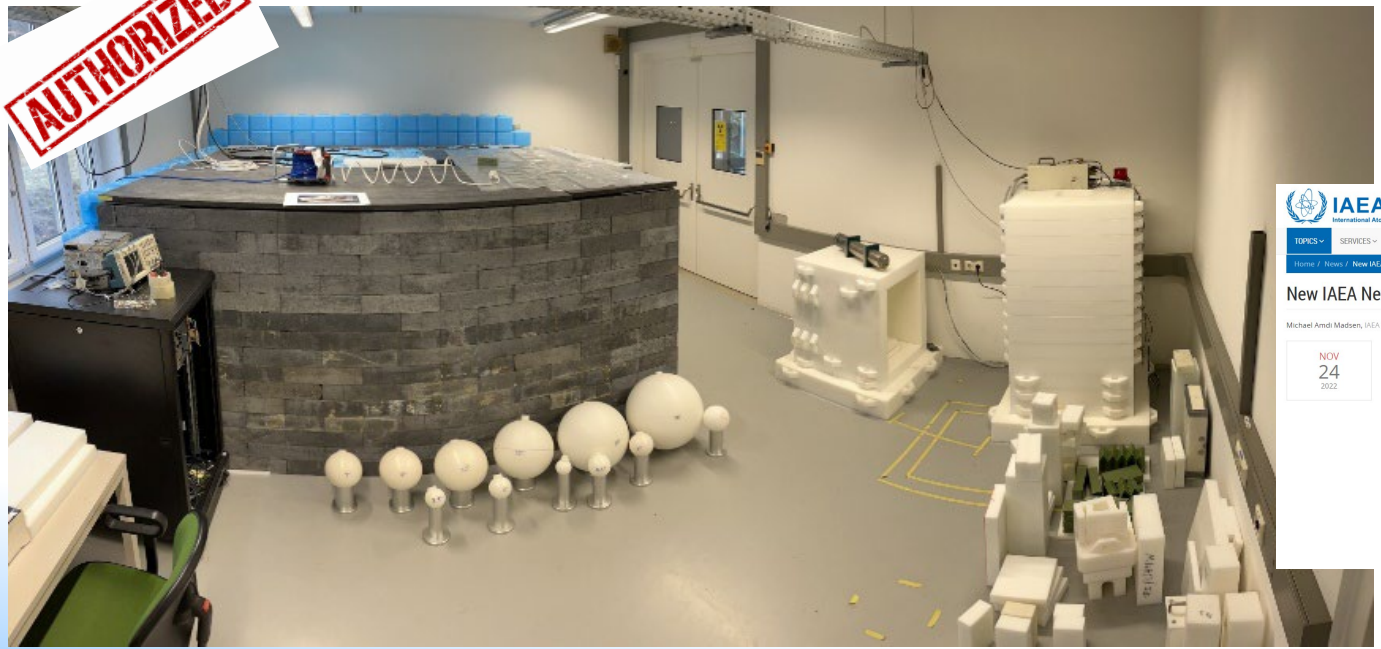


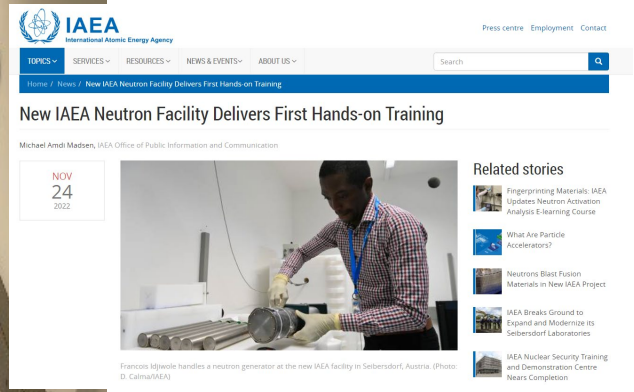
E.g. IAEA Neutron Science Facility (NSF) at SEIB

NSF is based on two neutron generators, **operational since 2022**

- **D+D reaction → 2.45 MeV neutron source** (fission neutrons, 5e6 n/s); US EB funded
- **D+T reaction → 14.1 MeV neutron source** (fusion neutrons, 5e8 n/s); Australia donation







Proficiency Tests for NAA & other Analytical Techniques

Organized twice a year in support IAEA Member States laboratories to:

- identify analytical problems
- improve the quality of their analytical results
- acquire / maintain their accreditation
- provide a regular forum for discussion and technology transfer in this area
- **In 2023: +90 analytical laboratories participate, representing +50 countries**

Scheme of the proficiency test:

- Provision of various samples at no cost
- Full anonymity of laboratories is granted
- Issue of final reports

Previous Proficiency Tests

PTNATIAEA/20	April 2022 - December 2022	clay sample plant sample	Download PDF final report
PTNATIAEA/19	May 2021 - March 2022	clay sample plant sample	Download PDF final report
PTNATIAEA/18	February 2020 - May 2021	Soil	Download PDF final report

More info: http://www.pt-nsil.com/

Scheme of IAEA Collaborating Centres

- **ANSTO, Australia** (2021-2024) on New and Advanced Techniques & Applications of Nuclear Science & Technology Towards a Sustainable Environment

- **TU Delft Reactor Institute, Netherlands** (2021-2024) on NAA & neutron-beam based methodologies

- **Okayama University, Japan** (2022-2026) on Boron Neutron Capture Therapy (BNCT)

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1.4.2 Acc&RR highlights of 2024

Scientific - Technical events (1250+ participants):

- IAEA RR Conference 11-15 Nov. 2024, VIC, Austria; 300+ in person and 200+ virtual participants, jointly with NE and NS

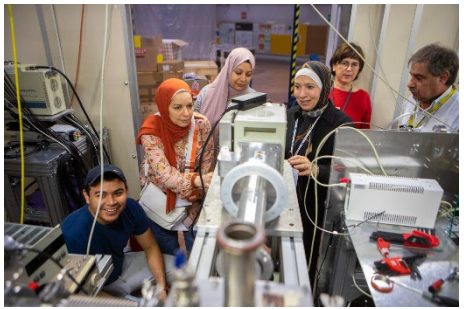
- 10 Technical Meetings on
  - neutron beams; market analysis; RR applications; small power RRs; RR utilization design; Neutrons4NA initiative
  - establishment of accelerators; radiocarbon dating; forensic science;; heritage science

- 9 TR workshops on
  - RR feasibility study; NAA techniques; RR bidding process; RR strategic planning
  - accelerator technologies; synchrotron techniques; IBA techniques; environmental pollution; cultural heritage with synchrotrons;

- 2 ICTP schools on
  - laser-driven radiation sources; synchrotron applications

- 2 EVTs in cooperation: AONSA neutron school (India), Microprobe Conference (Portugal)

- **Webinars:** BNCT, NTD-Si, Atoms4Heritage series…



Outline

- Organization & involved staff
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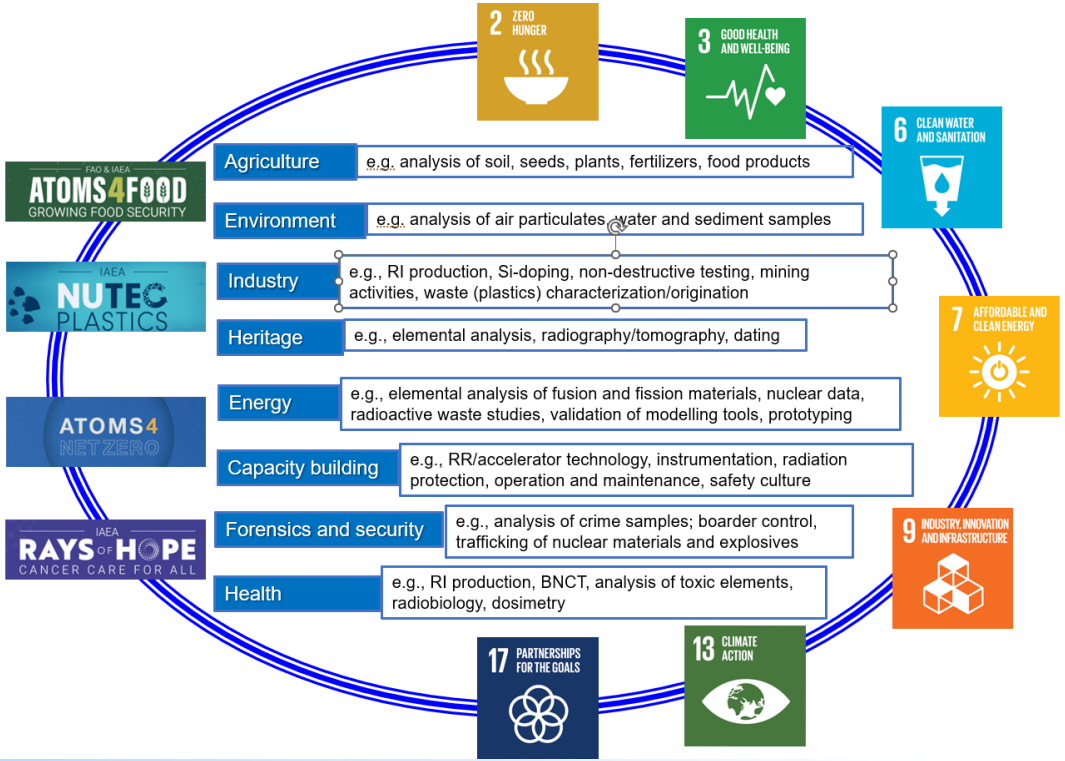
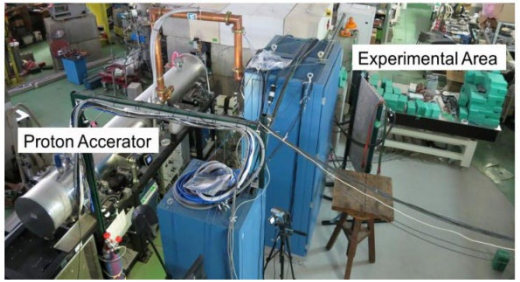
Neutrons4NA initiative: rationale

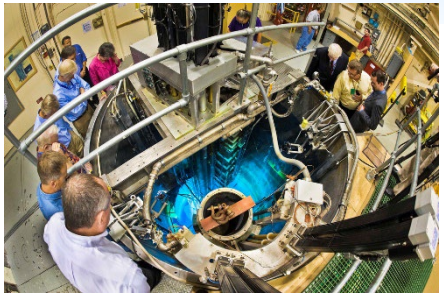
Tailored and stepwise approach through promotion, capacity building, technology transfer and facilitated access to **Neutrons4NA** and resulting socioeconomic development in the Member States



Neutrons4NA: objective

Bridging the gap between neutron generators, CANS and RRs: tailored and stepwise approach





	Neutron generator	Compact accelerator-based neutron source	Research reactor / spallation source
Neutron source, n/s	$<10^{10}$	$<10^{14}$	$>10^{15}$
Capital cost, €M	0.1-0.2	3-10	60-700
O&M costs, €M	0.02	0.2-1.0	3-100
Staff, number	1	2-3	10-100

Neutrons4NA: scope of support

- Well established facilities offering expertise and advice services to perform justification statement and feasibility study for decision making-process on investment:
  - Quantification of needs,
  - Choice of tailored and cost-effective technology,
  - Infrastructure assessment,
  - Cost-benefit and risk analysis.

- Long term facilitated support of the project at different stages of implementation, e.g.
  - Capacity building (hands on training…),
  - Share of experience from well-established and relevant facilities,
  - Share of experience regarding tailored and cost-effective technology selection.

Neutrons4NA: project proposal

- **Proposed instrument/framework:** IAEA **Peaceful Uses Initiative (PUI)**
- **Duration:** 4 years minimum
- **Beneficiaries:** target MSs without access to neutron sources
- **Partners:** MSs with well-established facilities and technology providers
- **Coordination:** IAEA
- **Funding:** extrabudgetary contribution from conventional and non-conventional donors
- **Means of implementation:**
  - Expert missions
  - Scientific Visits and Fellowship training
  - National workshops
  - Review of strategic plans and feasibility studies
  - Annual progress meetings of PUI partners.

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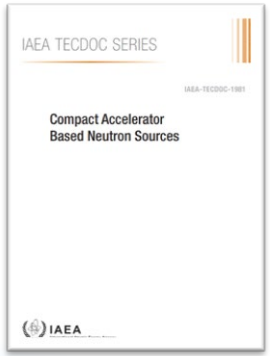
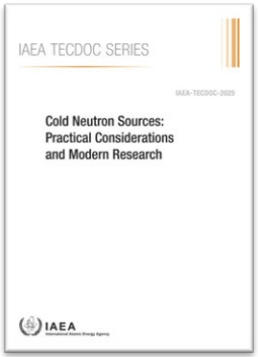
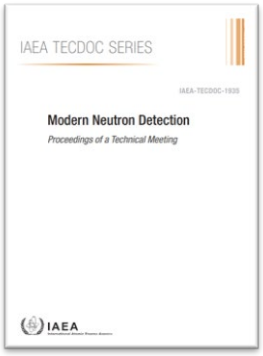
Activities in support of CANS

- **Meetings/Workshops**:
- **Data bases/portals :** accelerators, neutrons, instrumentation
- **Collaborating Centers (6):** ANSTO, Elettra, iThemba Labs, Univ. Paris Saclay, Univ. of Okayama,
- **Cooperation agreements:** CEA
- **Publications**







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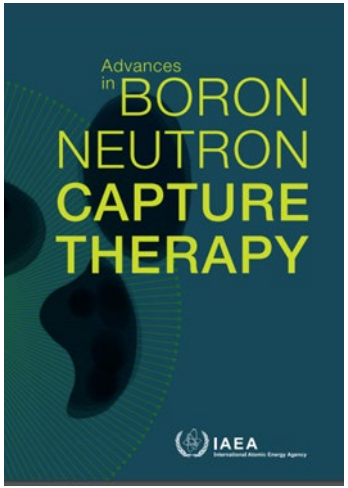
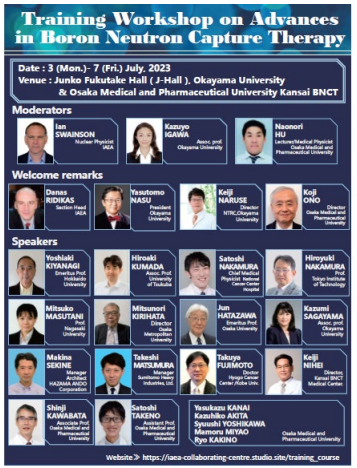
Activities in support of BNCT

- **Meetings/Workshops**:
- **Data bases/portals :** accelerators, neutrons, instrumentation
- **Collaborating Centers:** Univ. of Okayama,
- **Publications**
- **Webinars**





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- **New CRPs**
  - Boron Neutron Capture Therapy, EB funding secured
  - Neutron beam instrumentation at low and medium intensity neutron sources, planned

- **New Collaborating Centres**
  - TUM FRM2 Germany, letter of intent received

- **Publications in progress**
  - History, Development and Future of the SLOWPOKE and MNSR RRs; with IAEA PC
  - Research Reactor Produced Radioisotopes, update of TECDOC 1340; in draft
  - Applications of Research Reactors (Rev.1), Nuclear Energy Series; in draft
  - …

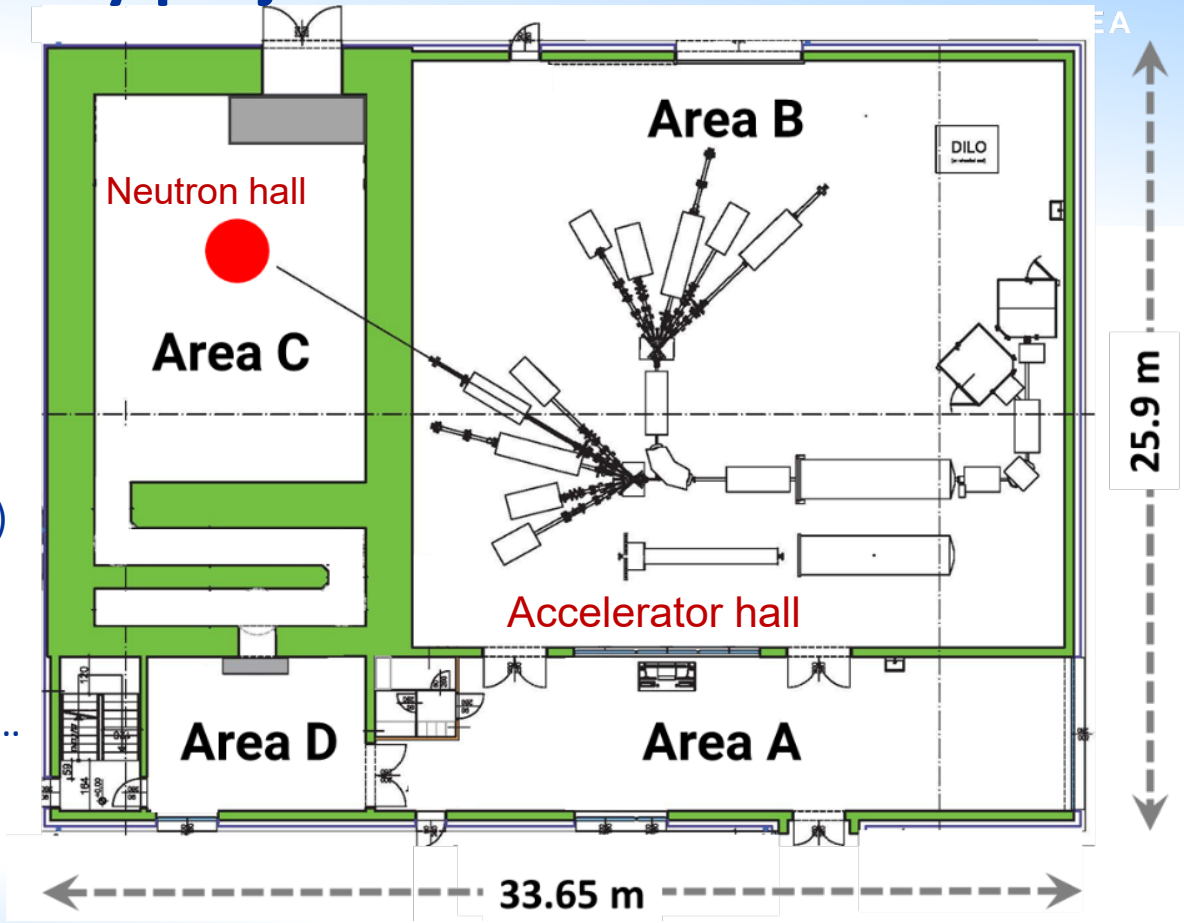
E.g. IAEA Ion Beam Facility project at SEIB

→ 6MeV protons (up to 50μA current) + heavier ions

→ Multiple beam lines/end-stations (PIXE, PIGE, RBS, Microbeam, implanter…

→ **Neutron production capability**

- **Max. source intensity: 5×10^{11} n/s**
- **Max. thermal flux: 10^6 n $s^{-1}cm^{-2}$**



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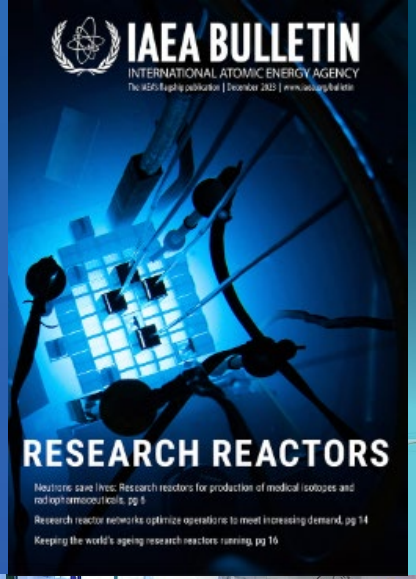
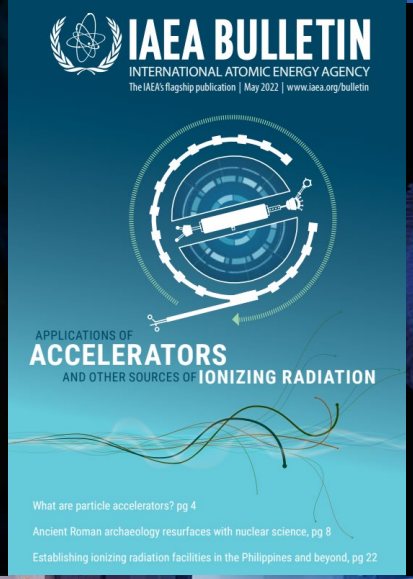
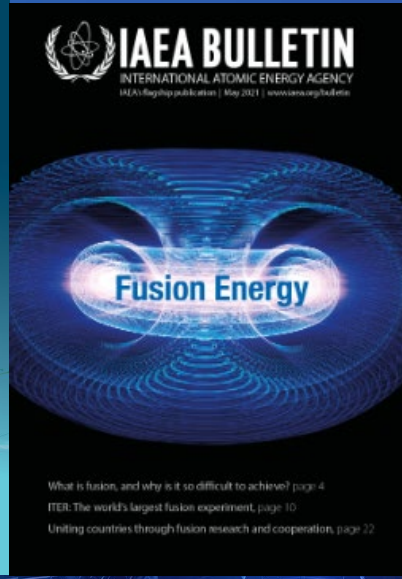
Thanks for your attention!







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