Multipurpose research reactor for countries with ambitions

Maciej Lipka

What is a research reactor

NUCLEAR PL

Research reactors comprise a wide range of different reactor types that are not used for power generation. The primary use of research reactors is to provide a neutron source for research and various applications, including education and training. They are small in comparison with power reactors whose primary function is to produce electricity. (...) Research reactors are also **simpler than power reactors** and **operate at lower temperatures**. (...) Research reactors also have a **very high power density** in the core.

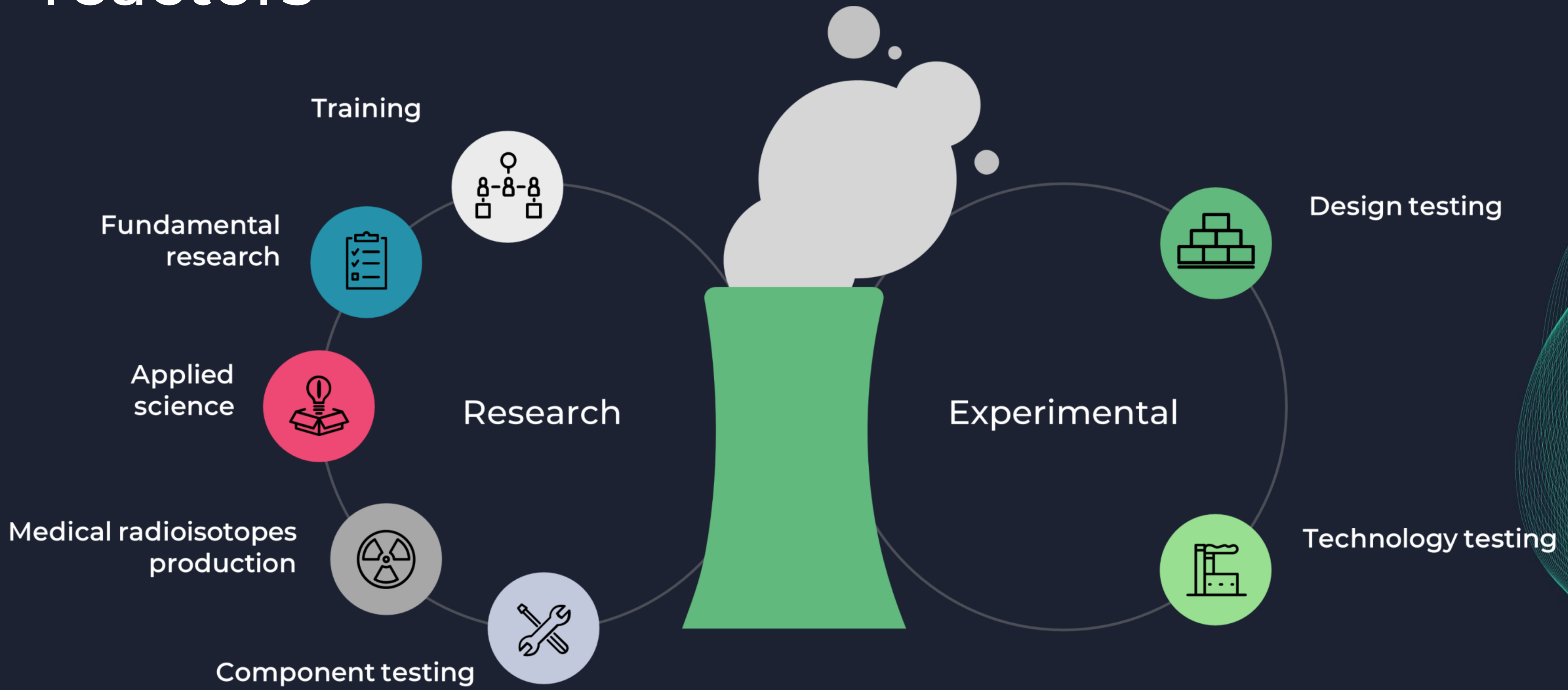
source: IAEA, Research Reactors: Purpose and Future, 2016

Research reactors are nuclear reactors used for research, development, education and training. **They produce neutrons for use in industry, medicine, agriculture and forensics, among others.** The IAEA assists Member States with the construction, operation, utilization and fuel cycle of research reactors, as well as with capacity-building and infrastructure development.

source: https://www.iaea.org/topics/research-reactors

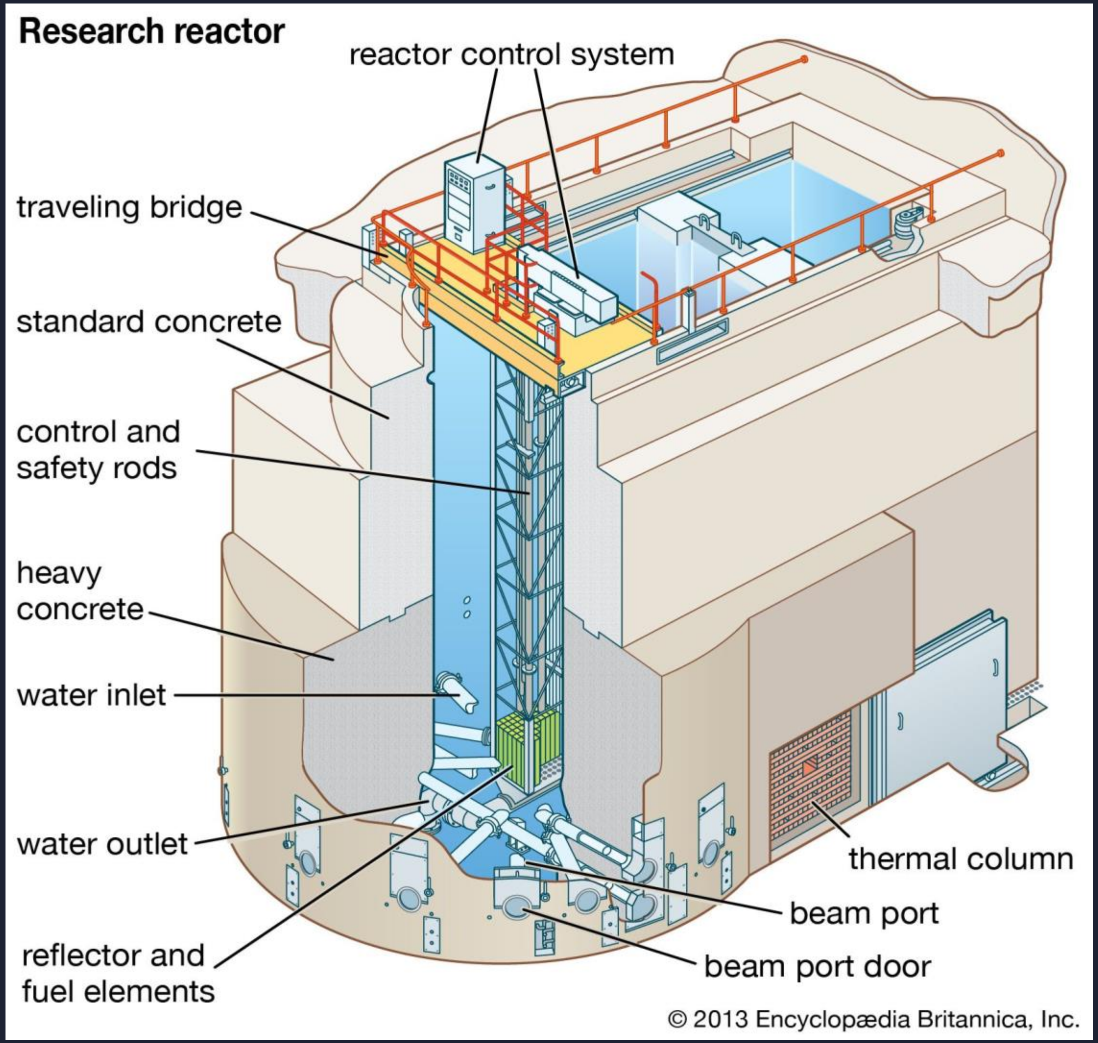
Maciej.Lipka@nuclear.pl

Research reactors vs experimental reactors



Maciej.Lipka@nuclear.pl

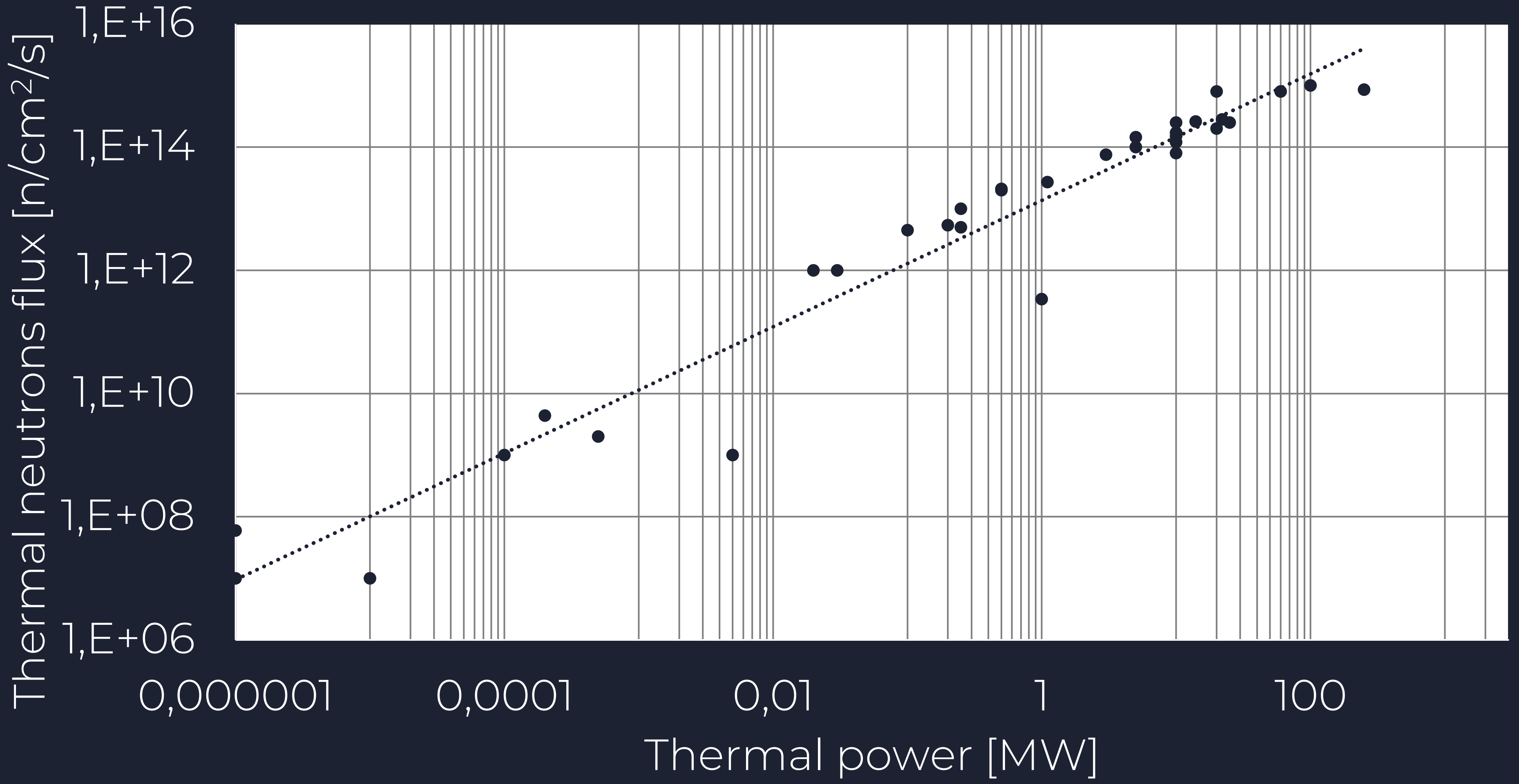
Research reactor



- High-power density
- High neutron flux)
- Water-cooled
- Pool type
- Low temperature (<100°C)
- Low pressure (<2MPa)
- Flexible core
- In-core scientific equipment
- Neutron beams

Maciej.Lipka@nuclear.pl

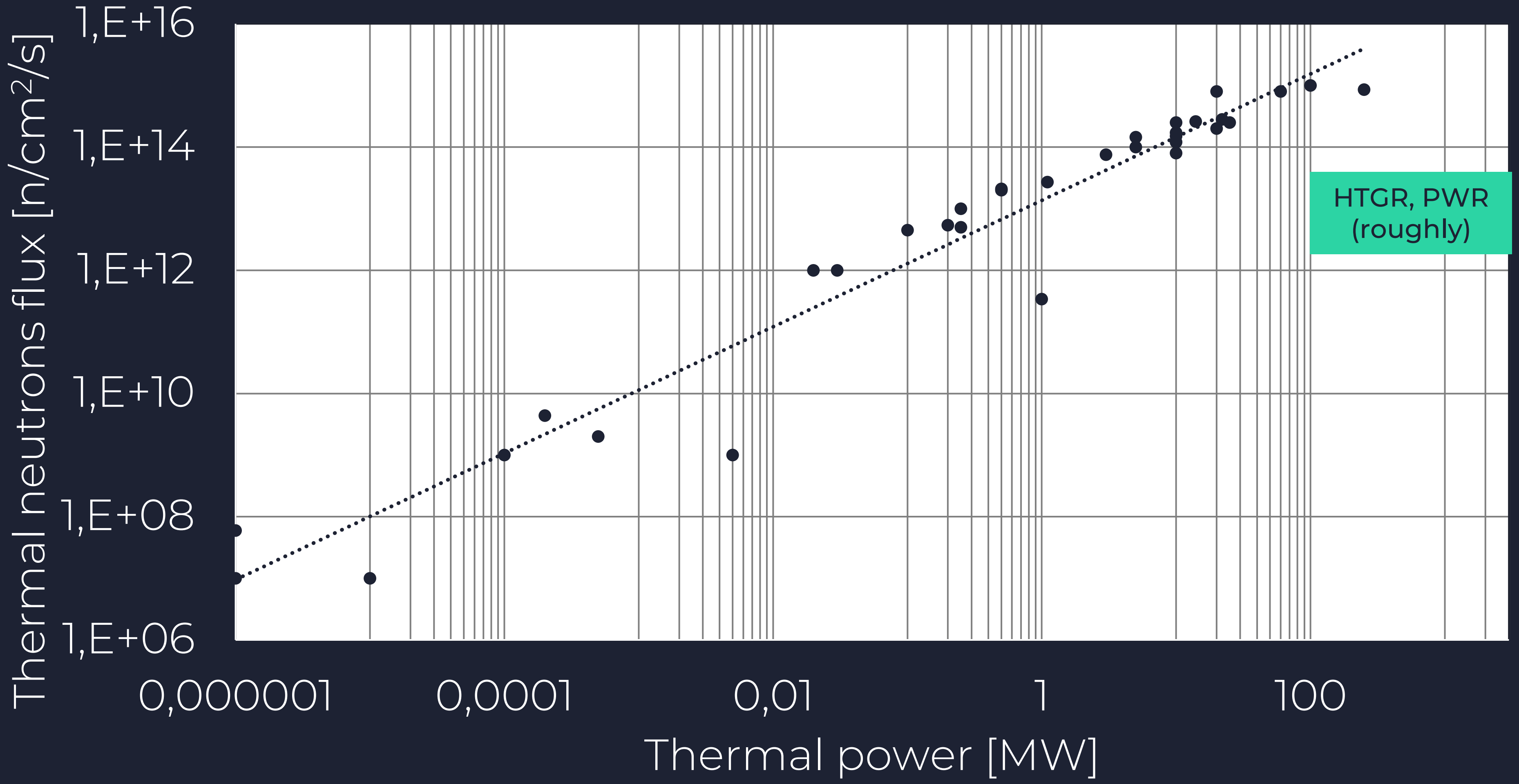
Research reactors' power density



Maciej.Lipka@nuclear.pl

Research reactors' power density

NUCLEAR PL



Maciej.Lipka@nuclear.pl

Research reactors' applications

NUCLEAR PL

Science

Nuclear physics

Material physics

Biological sciences

Economy

New generations of materials

Research and Development

Nuclear Power

New nuclear reactor technologies

State

Technical support

Training in the fields of nuclear medicine and nuclear power engineering

Medicine

Medical radioisotopes

Oncology

Maciej.Lipka@nuclear.pl

Research and development in research reactor

NUCLEAR PL

Defectoscopy, sterilisation

Electromobility

Space, aviation

Electronics

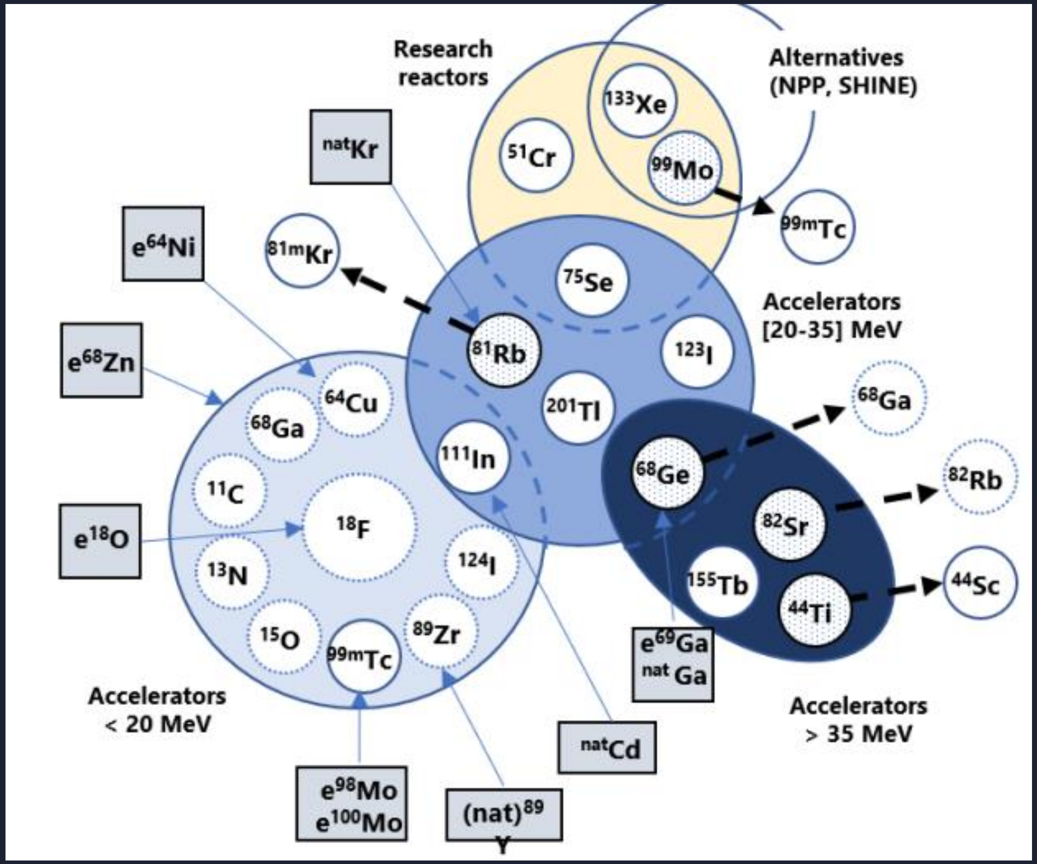
Fusion, advanced nuclear

Nuclear fuel

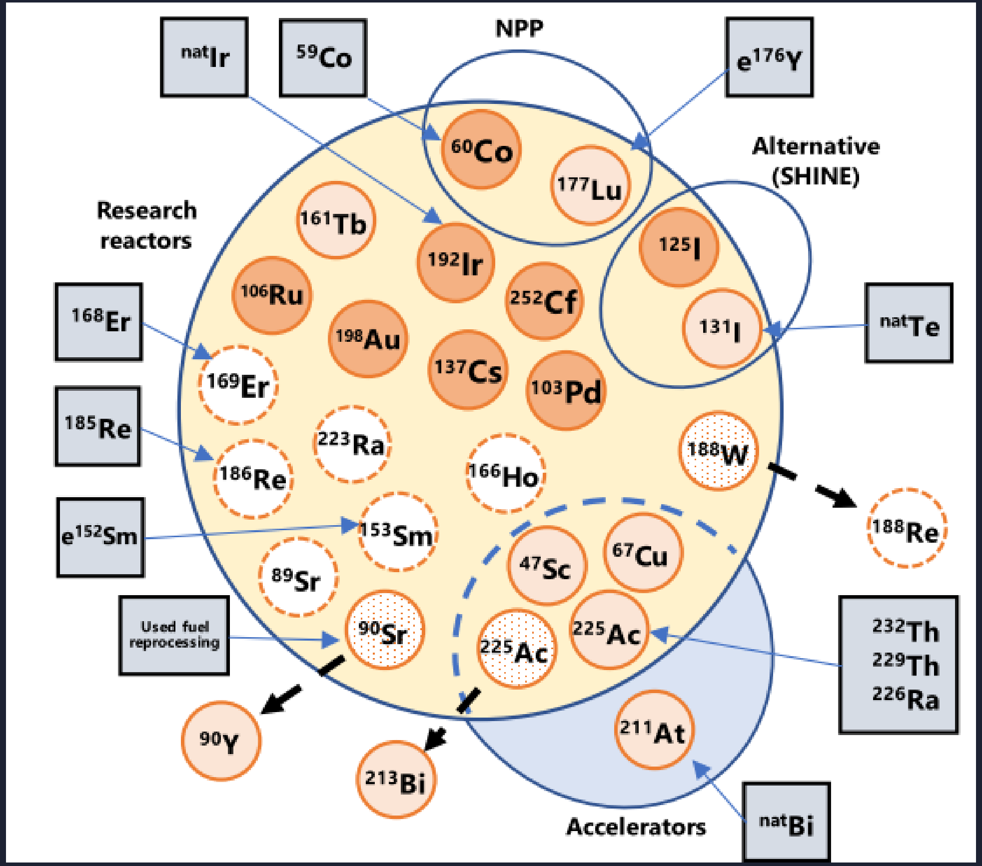
Nuclear components testing

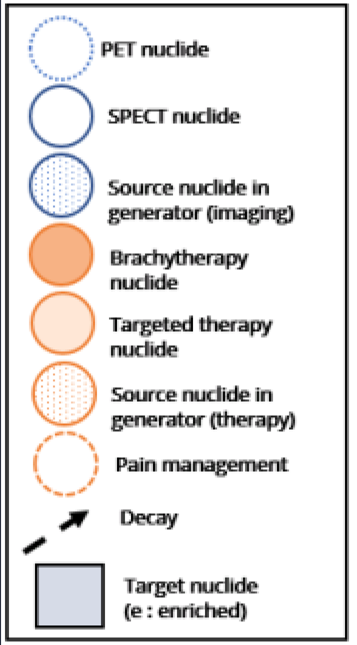
Life-saving research reactors

NUCLEAR PL



Diagnostics





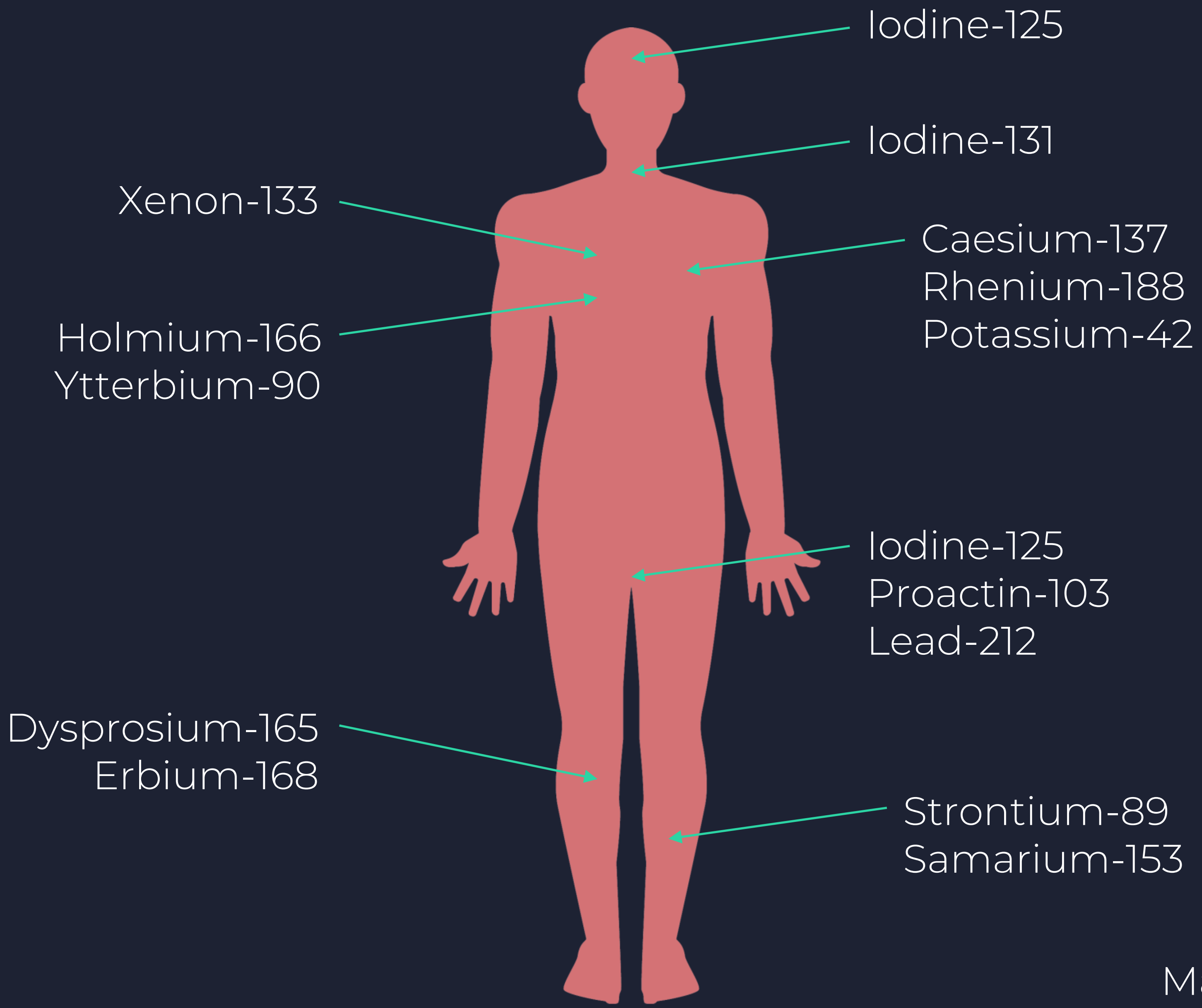
Therapy

Co-ordinated Approach to the Development and Supply of Radionuclides in the EU N°ENER/D3/2019-231 Final Report

Maciej.Lipka@nuclear.pl

Life-saving research reactors

Whole body:
Molybdenum-99
Technetium-99m
Chromium-51
Sodium-24
Bismuth-213
Cobalt-60
Lutetium-177
Thorium-227
Yttrium-192
Rhenium-186
Scandium-47



Maciej.Lipka@nuclear.pl

Research reactors' justification

Phase 1 – Pre-project
- Research reactor justification
- Pre-project Assessment report and Preliminary Strategic Plan
- MILESTONE: Feasibility study

Phase 2 – Project formulation
- Preparatory work for a research reactor after a policy decision has been taken
- MILESTONE: Bid specification

Phase 3 – Execution
- Construction of a research reactor
- Installation of the accompanying infrastructure
- MILESTONE: Reactor start up

Phase 4 – Operation of the reactor
- Continous development of ancillary infrastructure.
- Ongoing assesment of the strategic plan and reactor's main activities and technical condition

Potential stakeholders:

- hospitals – medical radioisotopes, BNCT
- oil industry – geochronology
- universities – introductory nuclear physics, NAA
- research centres – uses of neutron beams and in-core irradiations, biomedical research
- government – national policy
- energy sector – training, in-core irradiations and testing
- other potential stakeholders (e.g. silicon doping)

Maciej.Lipka@nuclear.pl

Selected applications vs size

NUCLEAR PL

	Thermal power Level			
	< 1 kW	c.a. 100 kW	c.a. 1 MW	> 10 MW
Education and Training	+	+	+	+ / –
NAA	+ / –	+	+	+
PGNAA	–	–	+ / –	+
Isotope production	–	–	+ / –	+
Geo chronology	–	–	+ / –	+
Silicon doping	–	–	–	+
Gamma Irradiation	–	+ / –	+	+
Neutron Imaging	–	+ / –	+	+
Neutron Scattering	–	+ / –	+	+
I&C testing	+ / –	+	+	+
Materials testing	–	–	+	+
Fuels testing	–	–	+ / –	+

Maciej.Lipka@nuclear.pl

Selected applications vs size

NUCLEAR PL

	Thermal power Level			
	< 1 kW	c.a. 100 kW	c.a. 1 MW	> 10 MW
Education and Training	+	+	+	+ / –
NAA	+ / –	+	+	+
PGNAA	–	–	+ / –	+
Isotope production	–	–	+ / –	+
Geo chronology	–	–	+ / –	+
Silicon doping	–	–	–	+
Gamma Irradiation	–	+ / –	+	+
Neutron Imaging	–	+ / –	+	+
Neutron Scattering	–	+ / –	+	+
I&C testing	+ / –	+	+	+
Materials testing	–	–	+	+
Fuels testing	–	–	+ / –	+

Subcritical or critical

Maciej.Lipka@nuclear.pl

Two approaches

NUCLEAR PL

1. Construct a small, low-flux facility with limited thermal power at kilowatts, and concentrate only on teaching nuclear reactor theory, nuclear physics and limited engineering experiments.

2. Construct a larger, high-flux facility at several megawatts or more thermal levels. It will have broader applications; however, their prioritisation is needed due to the limited in-core positions, beam number and reactor operation time.

Example: Saudi LPRR,

thermal power up to 100 kW_{th}

Example: Poland's MARIA,

thermal power up to 25 MW_{th}

Maciej.Lipka@nuclear.pl

Third (strategic) approach

NUCLEAR PL

Additionally, the two approaches mentioned above might be implemented together since $< 1\ kW_{th}$ critical assemblies have several orders of magnitude lower construction costs than the research reactors with the higher power.

Notable examples:

HOR–DELPHI (Netherlands)

LVR15-VR1-VR2 (Czechia)

EWA-MARYLA (Poland, now both decomissioned)

MARIA-future_training_reactor (Poland, hopefully)

Maciej.Lipka@nuclear.pl

Third (strategic) approach

NUCLEAR PL

Small research reactor

- Education
- Training

Large research reactor

- Medical radioisotopes production (cancer treatment)
- Industrial radioisotopes production
- Silicone and gems doping
- Analytical techniques (NAA, PGNAA)
- Neutron beam techniques (scattering and radiography)
- In-core testing of fuels and components for nuclear power

Maciej.Lipka@nuclear.pl

Recommendations

NUCLEAR PL

- Multipurpose reactors are difficult to maintain, training and the rest of the applications are often contradictory
- Design has to be purposed for the applications
- Strategic planning and constant consultations with stakeholders are necessary
- Reactor has to be the central object in the research centre and have adequate ancillary infrastructure needed for its applications
- Two dediacted reactors (large and training) shall be the preferred option

Maciej.Lipka@nuclear.pl

Necessary stages, how can we help

NUCLEAR PL

Services at all stages of a project:

Strategic consulting

Site prescreening

Preparing and conducting the process of location and environmental studies

Coordination of the process of obtaining a permit for the construction of a nuclear energy facility

Site pre-screening → Site surveys → EIA and Environmental Decision → Construction Licence & Building Permit → Construction Start → First safety-related concrete → Construction completion → First criticality → Commercial Operation

Stakeholders survey

Preparation of the tender and evaluation of offers

Contract Engineer

Contract management

Social communication

Translation services

Training services

NUCLEAR PL

nuclear experts

Nuclear PL sp. z o.o.
ul. Złota 59
00-120 Warszawa

Sąd Rejonowy dla m. st. Warszawy w Warszawie, XIII Wydział Gospodarczy KRS
KRS: 0001047148, REGON: 525870068, NIP: 5242978634

Zarząd: Paweł Żbikowski, Prezes Zarządu

Kapitał Zakładowy: 10000 zł, wpłacony w całości