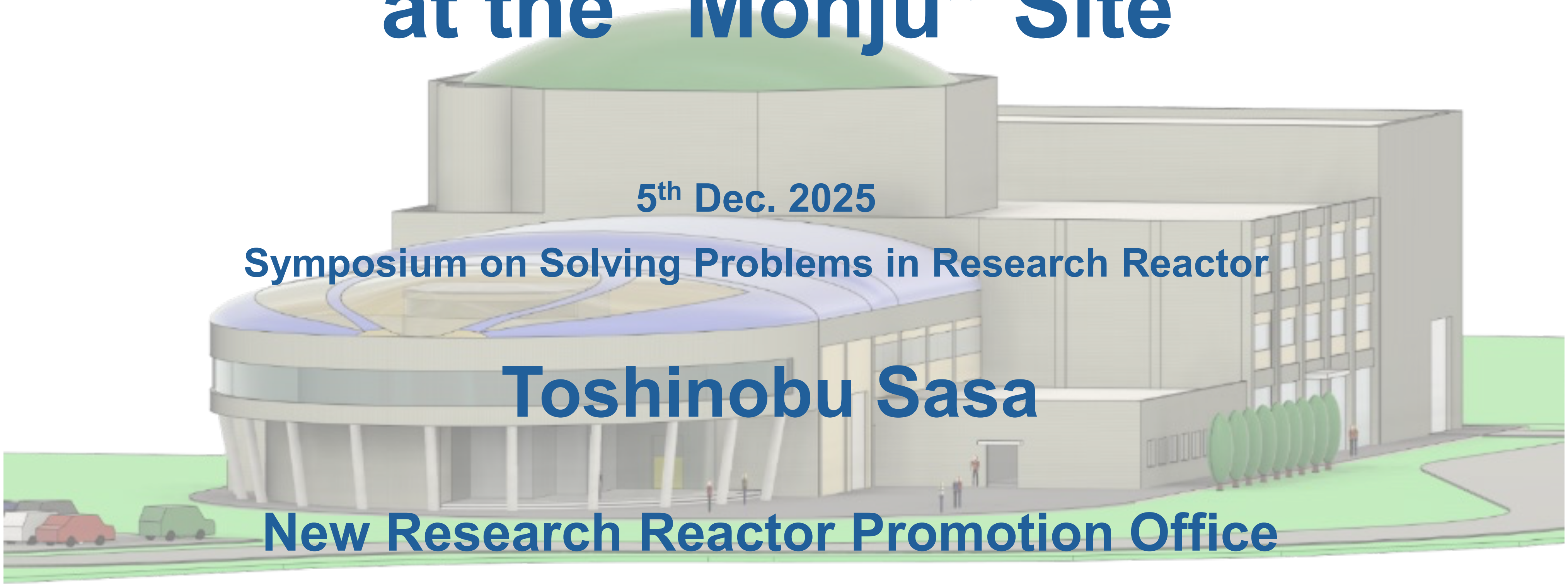
New Research Reactor Program at the “Monju” Site



5th Dec. 2025

Symposium on Solving Problems in Research Reactor

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New Research Reactor Promotion Office

Japan Atomic Energy Agency

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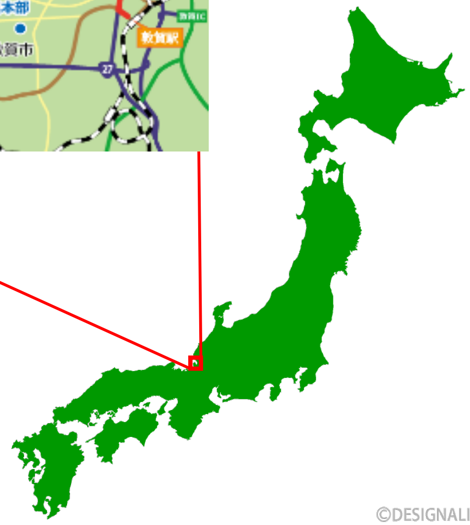
Background of the Project

- ***Dec. 2016 Decision to install new research reactor***
  - Government of Japan decided to launch the plan to install a new research reactor at “Monju” site together with plan to decommission of Fast Reactor ”Monju”
- ***2017-2019 Research on new research reactor by government***
  - The Ministry of Education, Culture, Sports, Science and Technology (MEXT) conducted a survey on a new research reactor in an expert committee consisting of various stakeholders (entrusted to the Nuclear Safety Research Institute)
- ***Sep. 2020 Identification of the reactor and start public offering***
  - After hearing of Tsuruga City and Fukui Prefecture, as well as discussions at an expert committee of MEXT, medium-power reactor ($10MW_{th}$) was selected which can be applied widely from basic studies to industrial applications with a large number of users.
  - The reactor was selected from the viewpoint of contributing to local development, and realizing functions as a core base in Western Japan for nuclear research and human resource development
  - MEXT called a public offering for conceptual design studies and related research
- ***Nov. 2020 Conceptual design project started***
  - JAEA, Kyoto University, and University of Fukui were selected as core institutions
- ***Dec. 2022 Selection of implementing body***
  - JAEA was selected as the implementing body, based on collaboration with Kyoto Univ. and Univ. of Fukui.
- ***Mar. 2023 Shift to detailed design phase for reactor installation license application***
  - Report to the consortium by finishing conceptual design and shift to detailed design.
- ***Nov. 2023 Contract with Mitsubishi Heavy Industries, Ltd., based on the proposal competition***
  - A basic contract was signed for the design, manufacturing and installation of the reactor components

Candidate Location of the Reactor

Candidate location of the reactor installation



- Three locations are under investigation to decide the reactor installation

Reactor Type Selection
Determination of Reactor Power

Reactor Type	Zero power	Low power	Medium power	High power
Thermal Output	< 10kW	< 500kW	< 10MW	> 20MW
Reactor Physics Study	O	X	X	X
Neutron Science	X	O	O	O
Industrial Application	X	X	O	O
Education	Scientist	Operator	Operator	Operator
Location Applicability	O	O	O	X
Examples and daily users	KUCA 1,000	UTR-KINKI 1,200	KUR 5,400	JRR-3 22,500

- A medium-power reactor ($10MW_{th}$) was selected which can be applied widely from academic to industrial application with specific number of users
- Medium power reactor is defined in regulatory standard for research reactors by the Nuclear Regulatory Authority of Japan as a water-cooled reactor with thermal output higher equal to 500kW and lower than 10,000kW

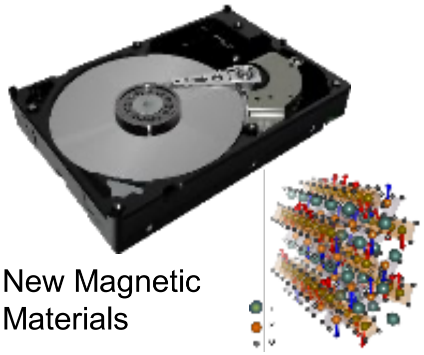
Expected Application of the Reactor

- Neutron Science Application
  - Achieve neutron characteristics to investigate materials
    - no electric charge, distinguish isotopes, having magnetic characteristic, sensitive to atomic and molecular structure/dynamics
  - Imaging especially for light nuclei contained materials
  - Widely used in many industries
    - Automotive, Aerospace, Steel/Materials, Energy, Medicine, etc.
- Neutron Irradiation Application
  - Activation analyses
    - Qualitative/quantitative determination of elements based on the measurement of radiation from radionuclides formed by irradiation
  - Radioisotope production
- Human resource development

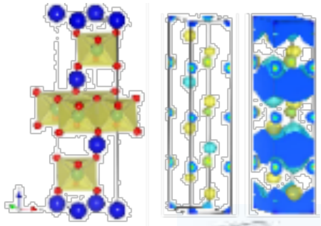
Reactor Type Selection
Neutron Application to Our Life

Functional Materials

Develop new magnetic materials / power storage materials by structural analysis, etc.



New Magnetic Materials



Fuel cell Materials

RI Production

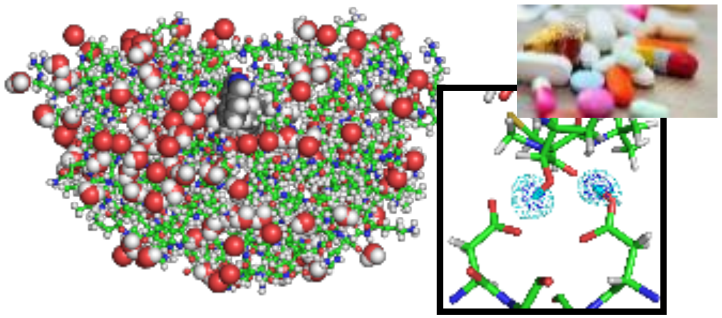
Produce RI for medical and industrial use including silicon doping

Brachytherapy by ^{198}Au
-Treatment without cutting-

Medical RI Production

Bio and Life Science

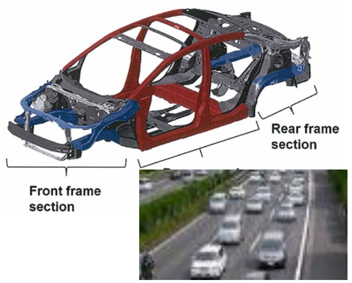
Drug discovery through structural analysis of proteins



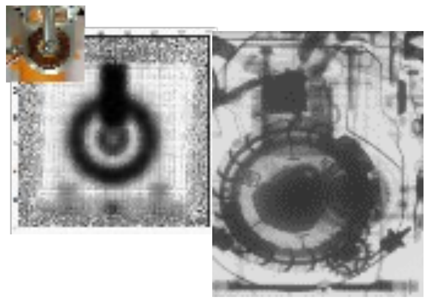
Example of structural analysis of virus-derived proteins

Analysis and Imaging

Contribute to industrial field through analysis and imaging of machine parts

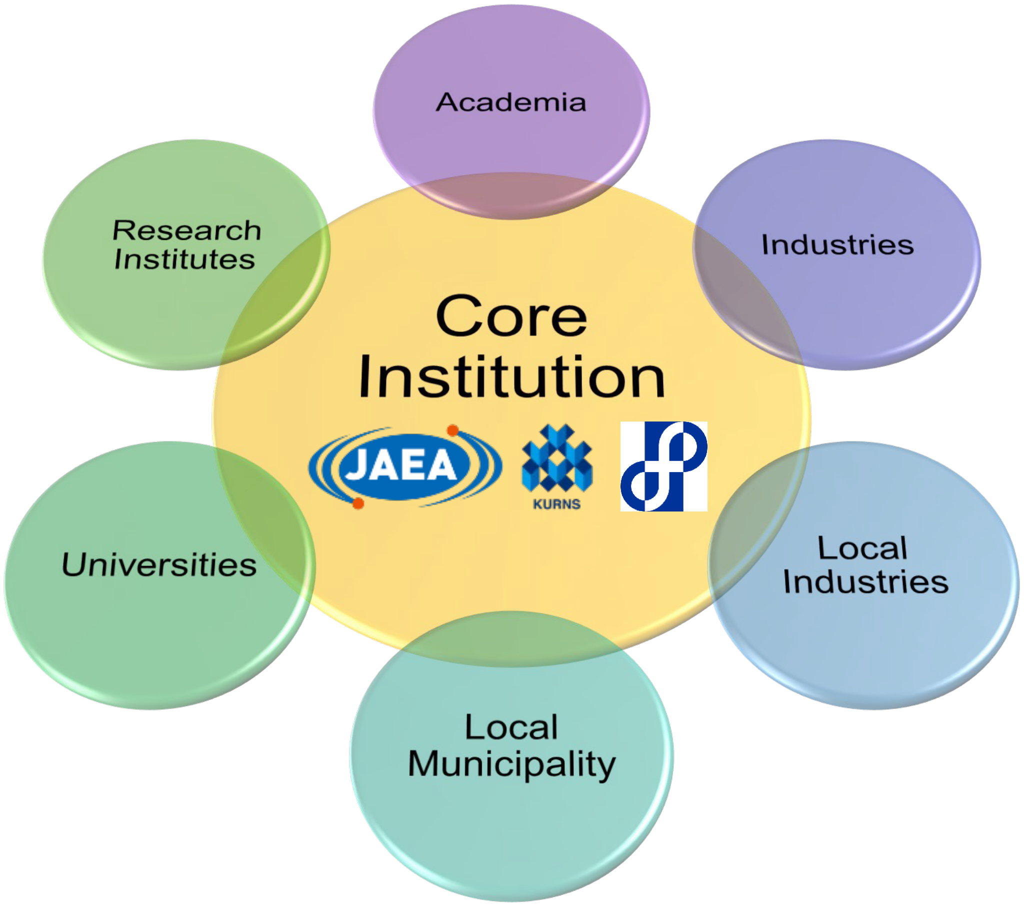


Stress analysis of Steel Materials



Visualization of engine and motor internals

Stakeholder's Consortium



Role of Core Institutions

- **JAEA**
  - Design, installation and operation of test and research reactors
- **Kyoto University**
  - Aggregation of wide-ranging application needs and provision of services based on the experience in KUR operation
- **University of Fukui**
  - Building cooperation with local universities, research institutes, companies, etc. in Fukui

■ Steadily advance the project by the core institutions with consideration of wide range opinions from academia, industry, local organizations, etc.

Design of the Reactor Core

Increase safety performance

- Minimize hazard potential (latent risk)
- Simplify core submergence and decay heat removal
- Multiplexing and diversification of safety functions

Ensure operation stability (high operating rate)

- Enlarge operation cycle by ensuring burnup
- Minimize scram requirements, trouble avoidance by design
- Simplify maintenance to shorten inspection period

Explore economical design

- Apply existing technology and commercial products
- Minimize installation site, unitization and packaging of equipment
- Reduction of operation/maintenance costs

Improve user convenience

- Reasonable arrangement of user accessibility and nuclear security
- Easy handling of user equipment, and available space enhancement

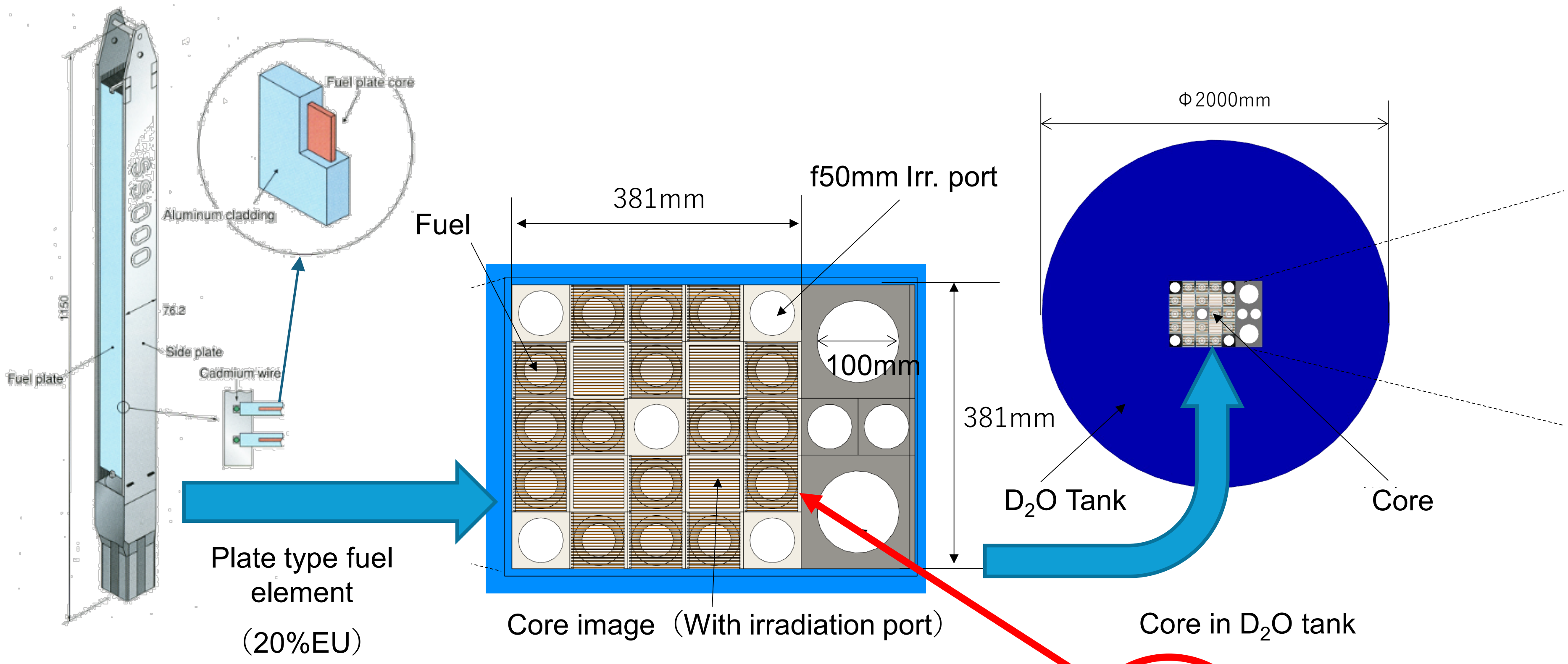
Item	Target Value	JRR-3 Data
Thermal Flux ($n/cm^2/s$)	$> 10^{14}$	$1\sim2\times10^{14}$
Operation period (days)	> 400	370
Burnup (GWd/t per 1 fuel element)	> 80	100

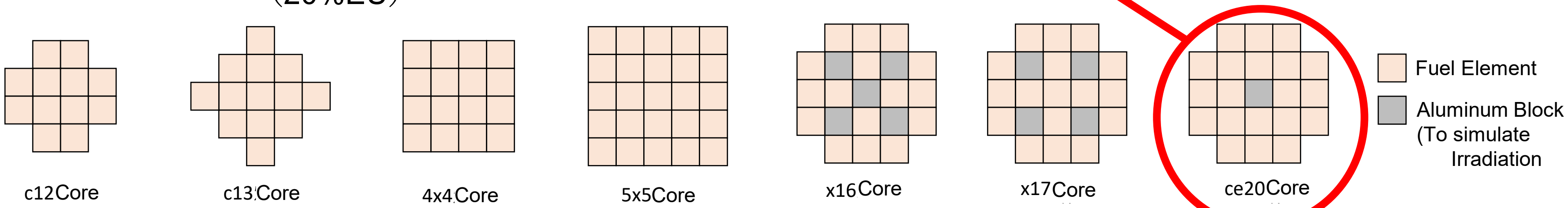
Securing future potential

- A flexibility to new research proposals
- Adoption of low-enriched uranium fuel

Specification of the Core

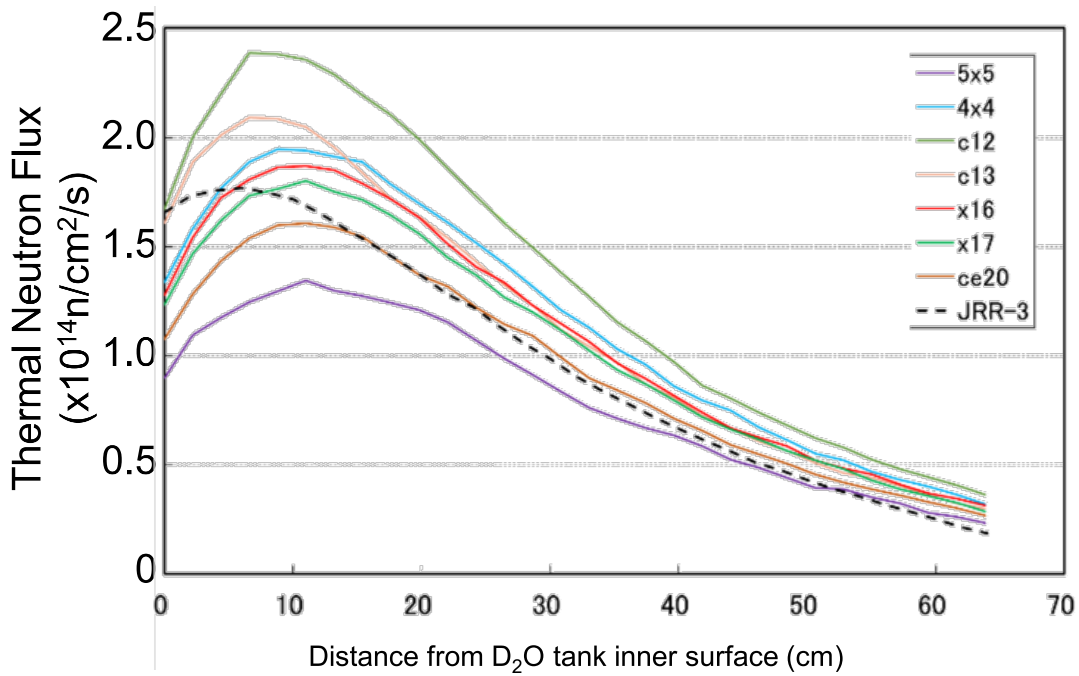
- Select a core arrangement to achieve the criteria (Tentative)

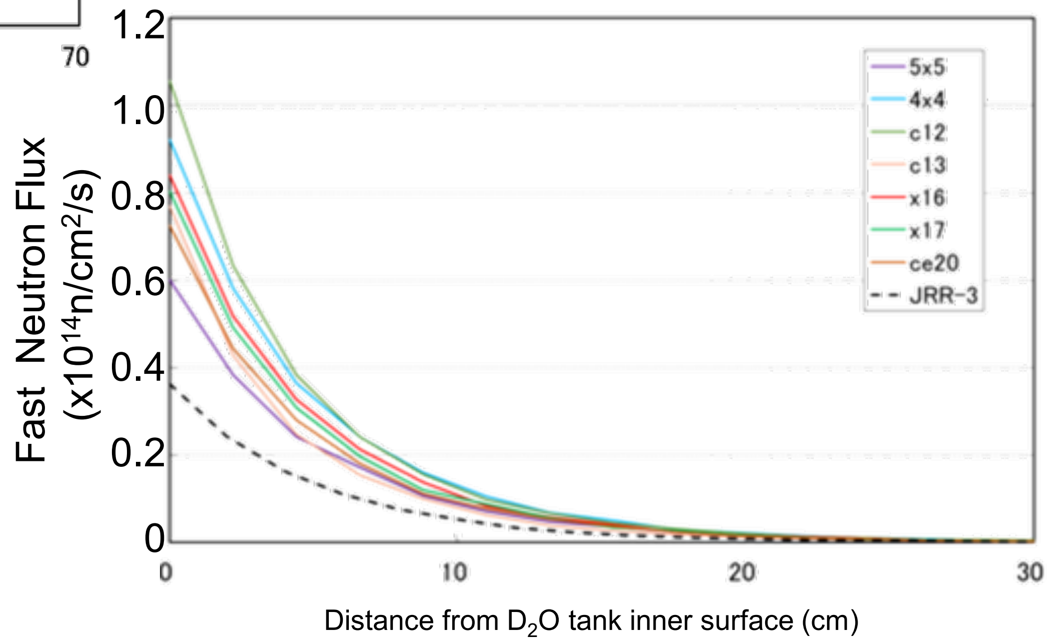




Analyzed core configurations

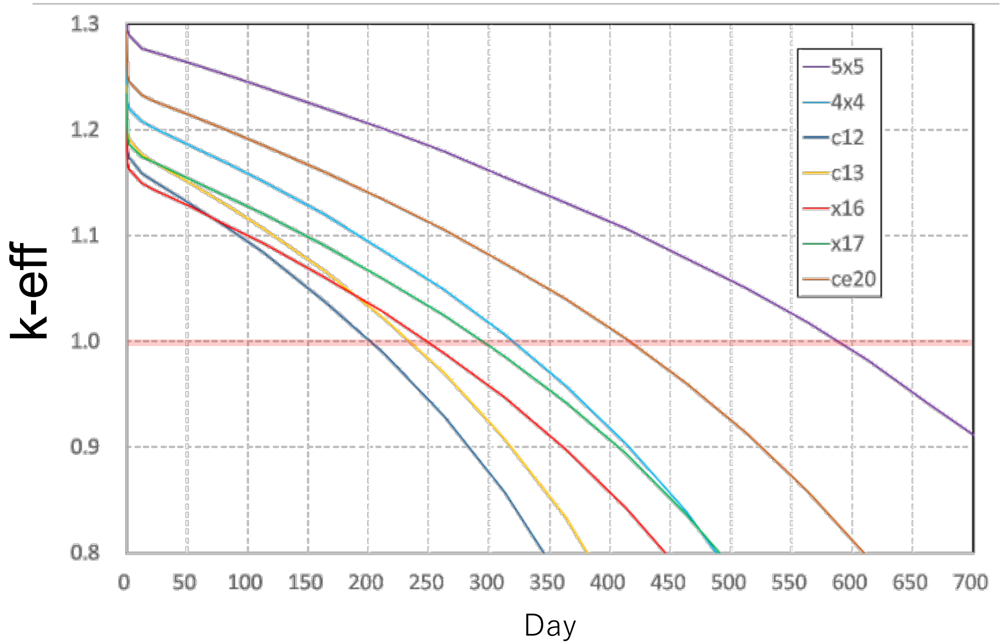
Neutronic Characteristics (1/2)





Neutron Flux Distribution in D_2O tank
（MVP+JENDL-4.0）

Neutronic Characteristics (2/2)



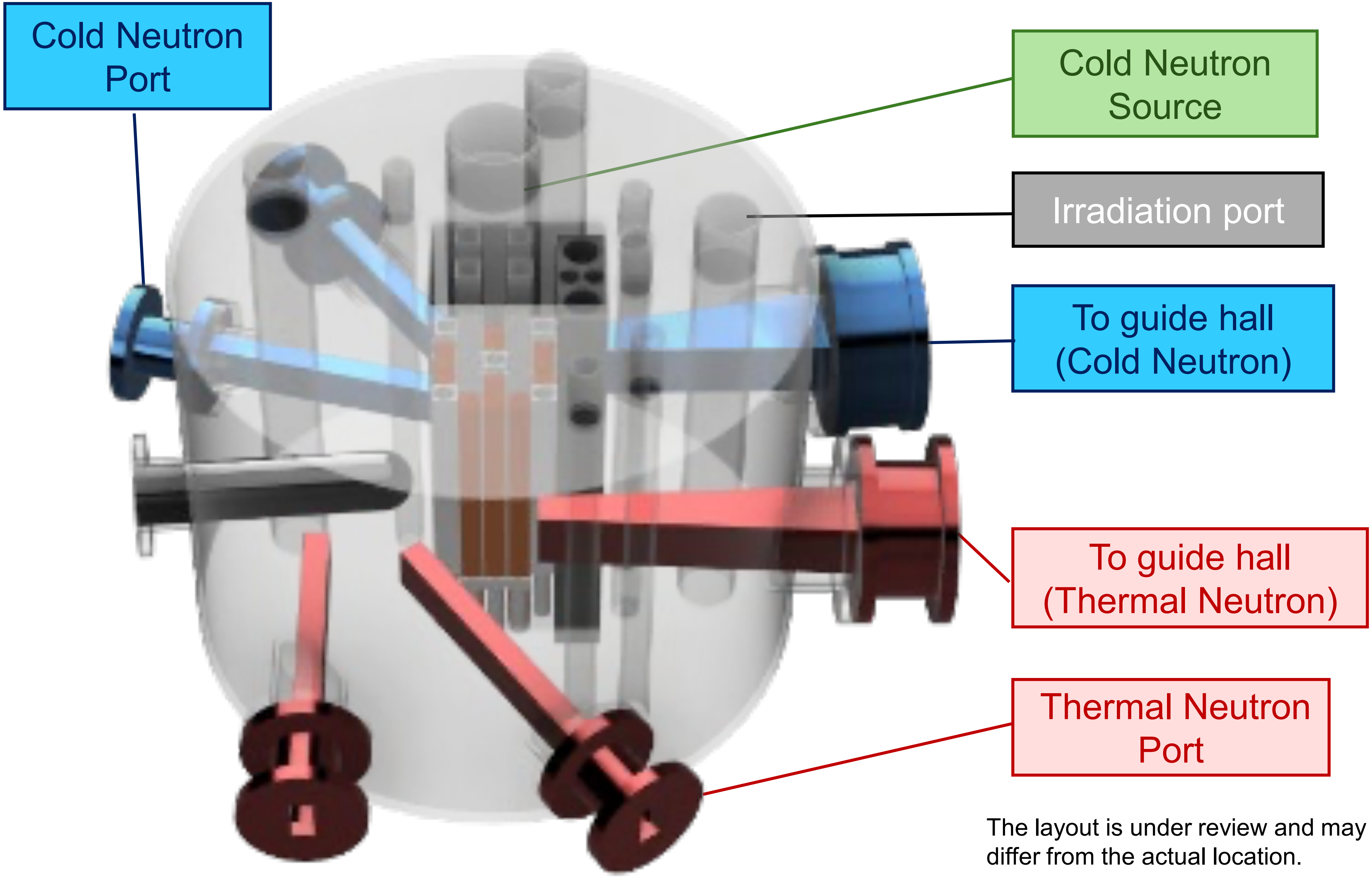
Burnup Reactivity Change

Burnup Characteristics
（MVP-BURN+JENDL-4.0）

	Operable Time (Days)	Burnup	
		(%)	(Gwd/t)
C12	204	45	76
C13	234	48	80
4×4	319	53	89
5×5	588	61	105
X16	248	42	69
X17	294	46	77
ce20	416	55	93

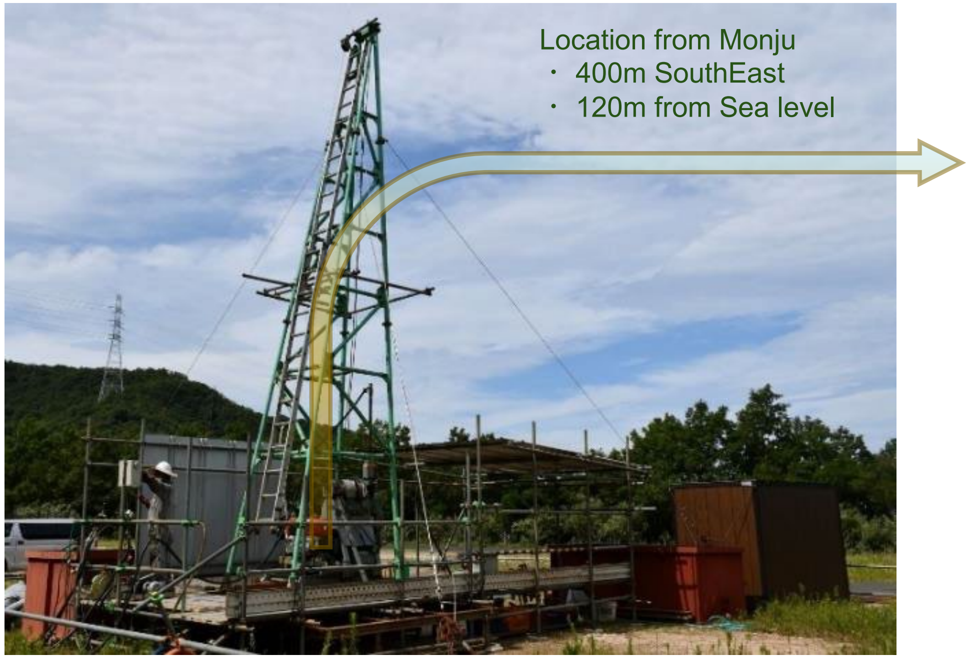
Operable Time and Burnup

Reactor Characteristics
Layout of the Beam Ports(Tentative)

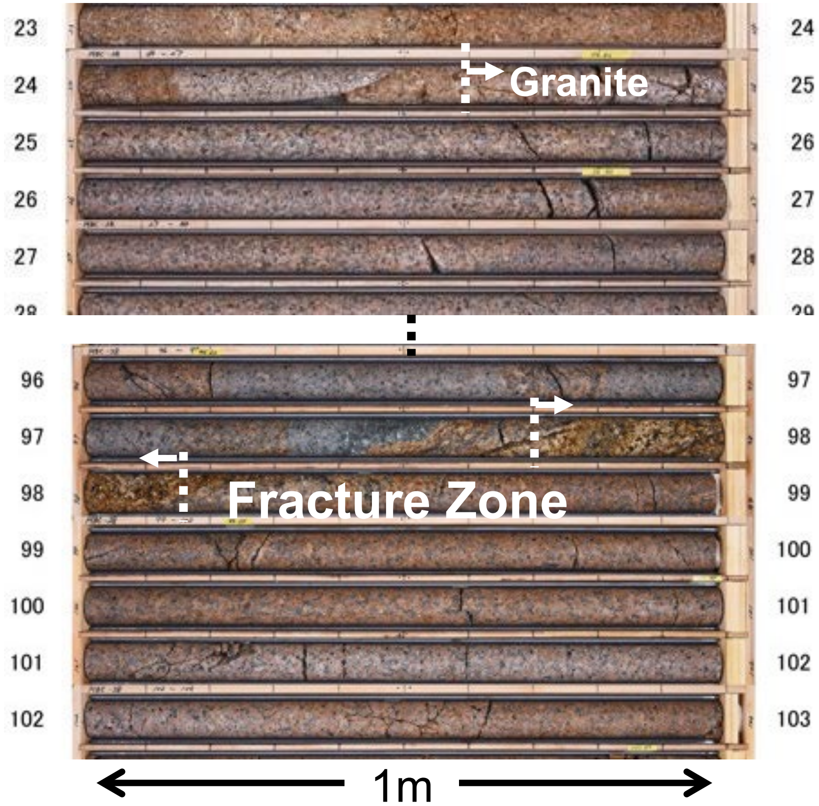


The layout is under review and may differ from the actual location.

Geological Survey



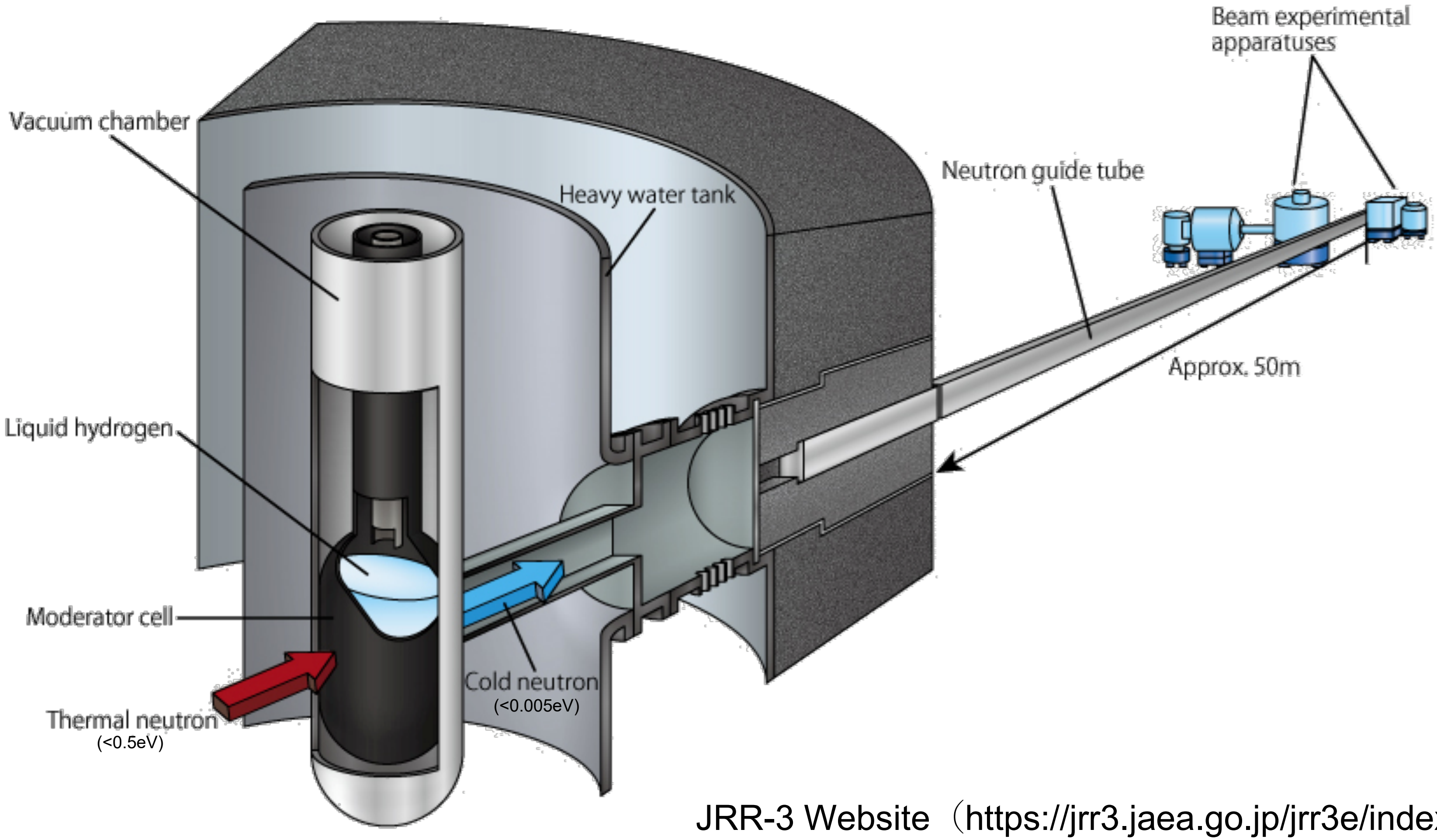
Borehole investigation in 2021



- No immediate obstacles for reactor siting
- Detailed ground survey and investigations of debris flow etc. are underway

Reactor Characteristics
Cold Neutron Source

- Obtain cold neutrons by moderating fission neutron using liquid-hydrogen and/or heavy water
- Cooperative development with JRR-3 are underway



JRR-3 Website（https://jrr3.jaea.go.jp/jrr3e/index.htm）

Neutron Beam Applications

- Responds to diversifying academic research and industrial applications
  - Prompt gamma-ray analyzer
  - Polarized small-angle neutron scattering device
  - High-intensity thermal neutron imaging system
  - Thermal neutron diffractometer (residual stress, 4-axis analysis for single crystals)
  - Polarized neutron reflectance device
  - High-intensity thermal/cold neutron triaxial spectrometer
  - TOF-type cold neutron inelastic scattering instrument
  - Instrument developments for advanced neutron control/ detection technologies

■: Devices using cold neutron

First Four Detectors

Install high versatility / frequently-use devices

Small-angle scattering measurement device

- evaluate nanoscale structures composed of aggregates of atoms and molecules, performed by measuring neutrons with a long wavelength and small scattering angle

Imaging device

- non-destructively visualizes the structures, etc., inside substances by using the high transmission capabilities of neutrons

Diffraction measurement device

- Evaluate structural information of polycrystal samples from their diffraction patterns

Neutron reflectivity measurement device

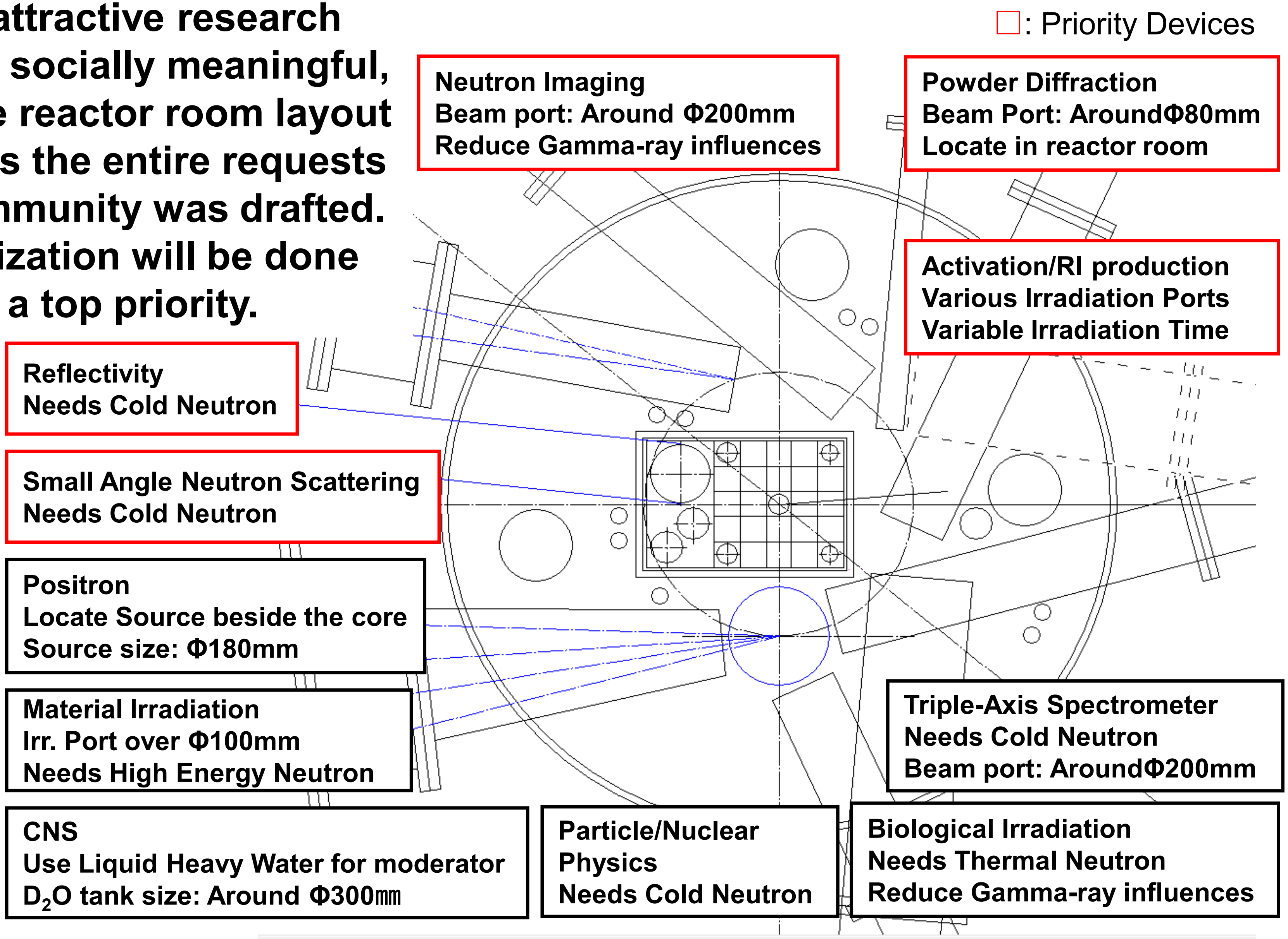
- evaluating the structures of surfaces and interfaces by measuring the reflectivity of neutrons on thin films on substrates or free liquid surfaces

■: Devices using cold neutron

Reference: Material from Working Group for Nuclear Development, Infrastructure and Human Resources, Nuclear Science and Technology Research Committee, MEXT (Meeting #11, March 2022)

Neutron Beam Applications
Layout of Experimental Devices (Tentative)

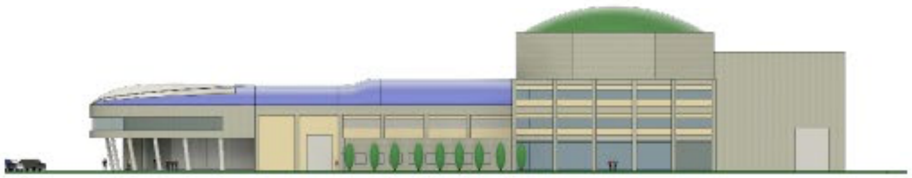
To design an attractive research reactor that is socially meaningful, first candidate reactor room layout which includes the entire requests from user community was drafted. Further optimization will be done with safety as a top priority.

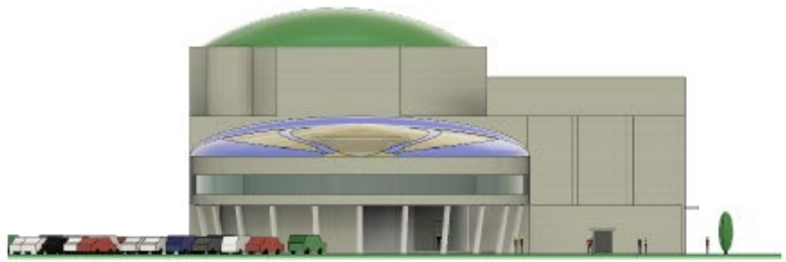


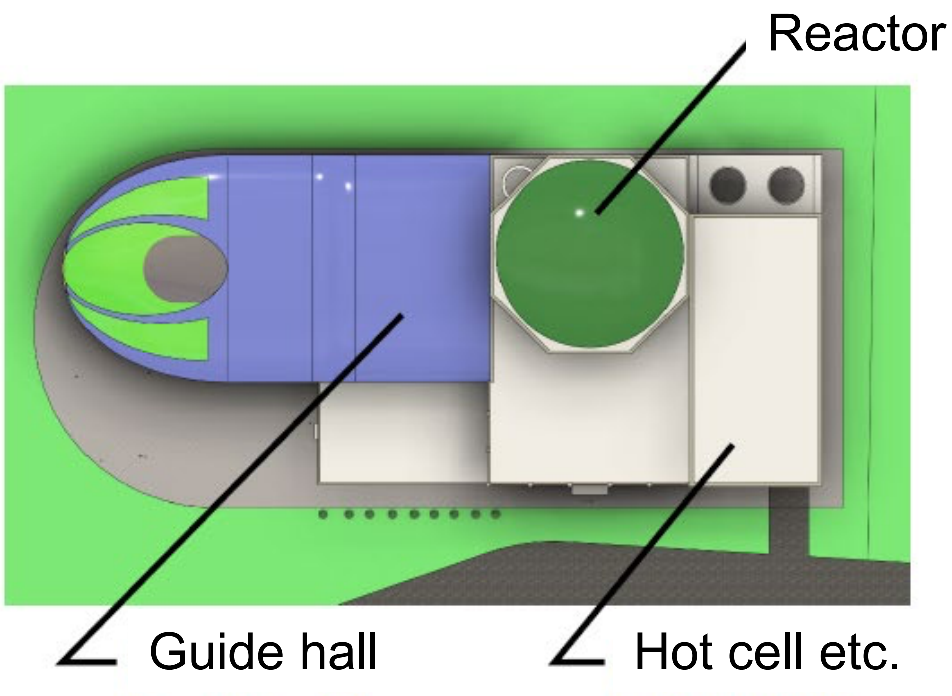
Neutron Beam Applications

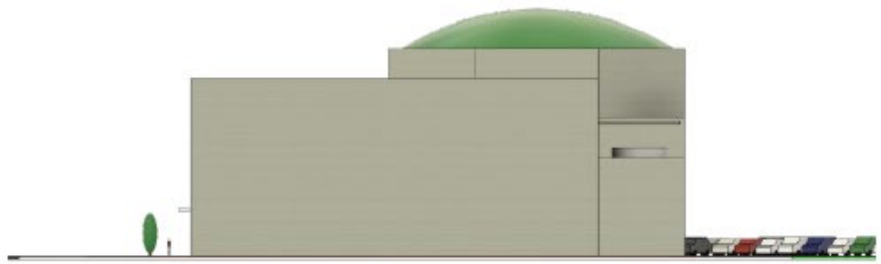
Facility Layout (Tentative)

- Arranged necessary facilities intensively
- Layout revised continuously









Summary

- The government of Japan decided to locate a research reactor at the “Monju” site.

- After 2023, JAEA proceeds the design phase of the program in collaboration with Kyoto University and University of Fukui. JAEA also made contract with Mitsubishi Heavy Industries, LTD. as a construction partner.

- Various opinions such as scientific interests, engineering needs, and regional demands are considered to draw a reactor facility design through the Consortium

- Even though the thermal power of the new research reactor is a half than that of JRR-3, neutronic performance is almost comparable with JRR-3 according to the latest neutronic analyses