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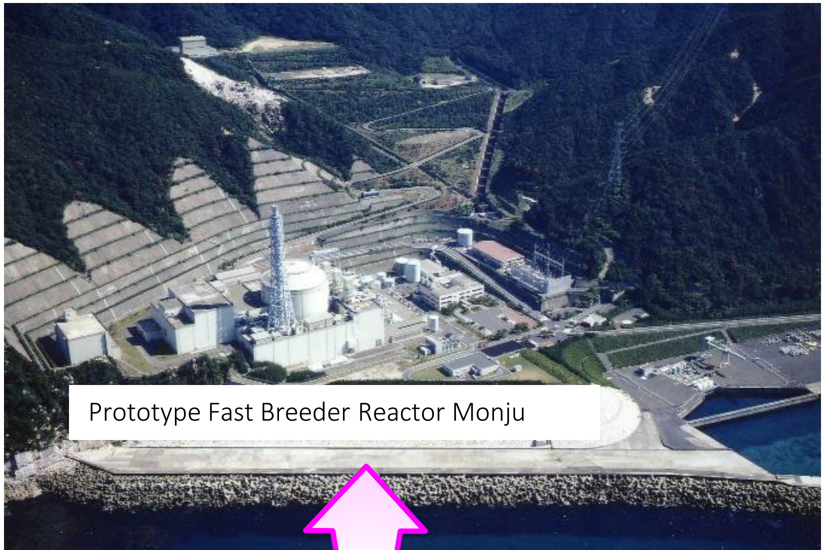
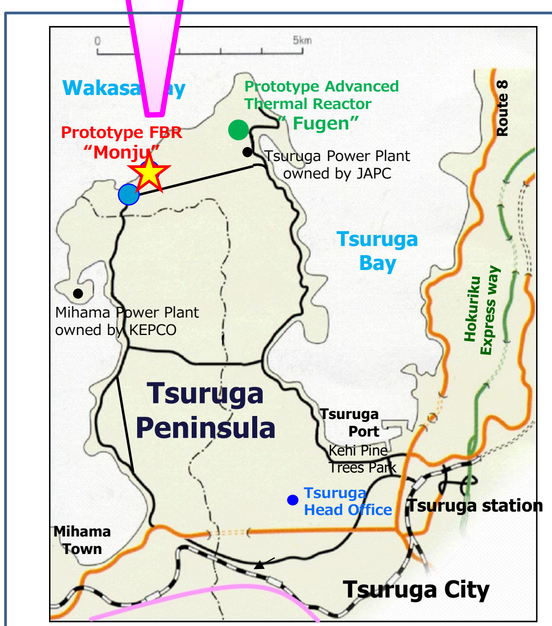
New Research Reactor Project at the “Monju Site”

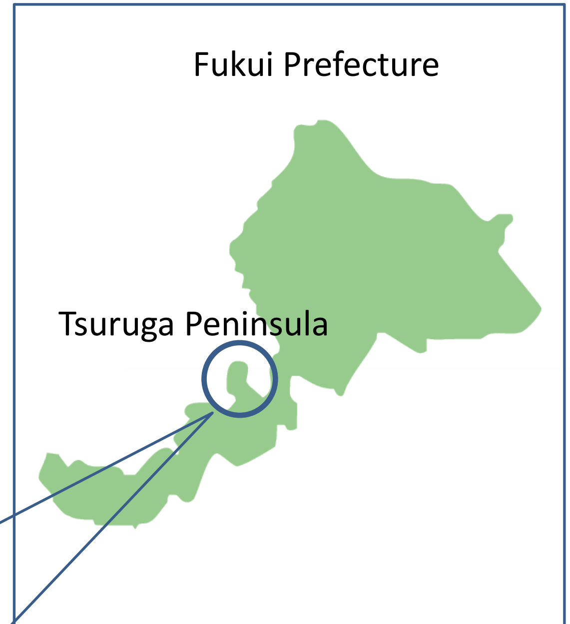
Masaji Arai
New Research Reactor Promotion Office
Japan Atomic Energy Agency

Where is the Monju site?

The Monju site is located at the northern tip of the Tsuruga Peninsula in Fukui Prefecture.







Why the Monju site?

Dec. 21, 2016 : Ministerial Meeting on Nuclear Energy

Decommission the prototype FBR Monju.

There had been a major change in the environment surrounding FBR development in Japan.

- ✓ Response to new regulatory standards
- ✓ Issues regarding the operator
- ✓ Progress in international cooperation regarding fast reactor development

It was not possible to say for sure that the benefits of restarting operations would outweigh the costs. The government determined the decommission.

Utilization of the Monju site

- ✓ <u>In the future, a new research reactor (NRR) will be installed on the Monju site.</u>
- ✓ The Monju site will be positioned as a core base that will serve as a foundation for supporting future nuclear research and human resource development.

What kind of research reactor?

- 2017-2019: Research on new research reactor by government
  - The Ministry of Education, Culture, Sports, Science and Technology (MEXT) conducted a survey on a NRR in an expert committee consisting of various stakeholders.

- Sep. 2020: Identification of the reactor and start of public offering
  - After hearing of Tsuruga City and Fukui Prefecture, as well as discussions at an expert committee of MEXT, <u>A medium-power reactor (< 10MW) was selected</u> which can be applied widely from basic studies to industrial application with large number of users.
  - The Reactor was selected from the viewpoint of contribution to local development, and realizing functions as a core base in western Japan for nuclear research and human resource development.

Why a medium-power reactor?

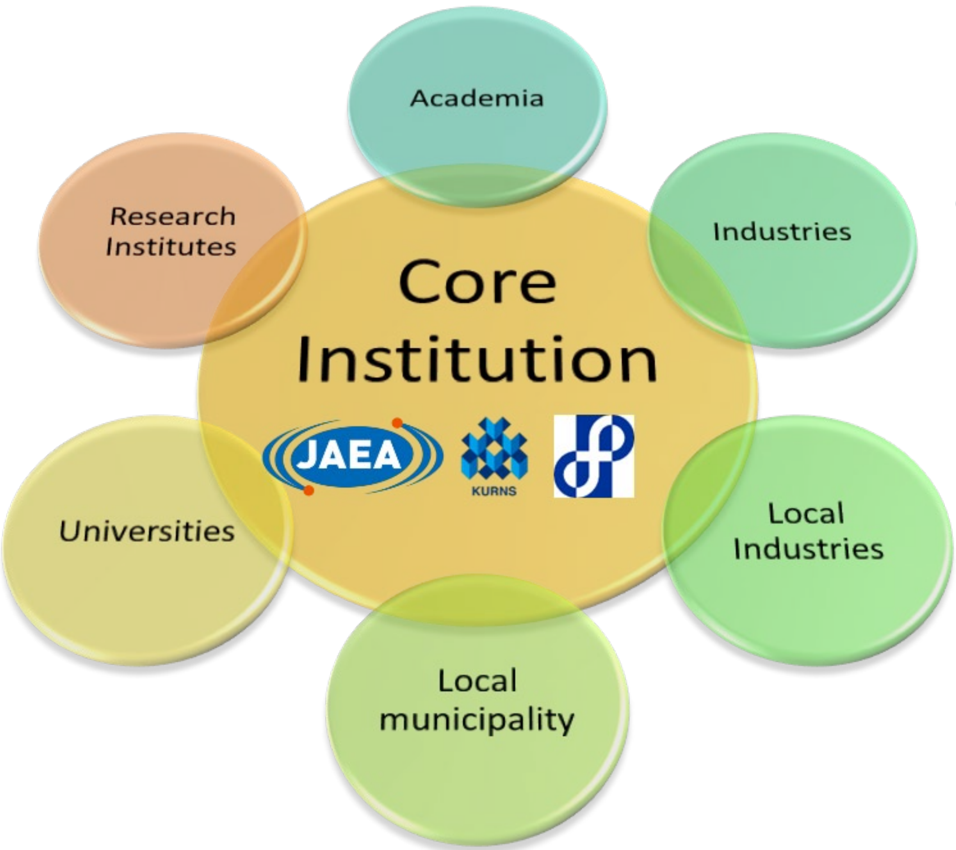
Reactor Class (in Japan)	Zero power	Low power	<u>Medium power</u>	High power
Thermal Output	< 10kW	< 500kW	< 10MW	> 20MW
Reactor Physics Study	✓			
Neutron Science		✓	✓	✓
Industrial Application			✓	✓
Education	Scientist	Operator	Operator	Operator
Location Applicability	✓	✓	✓	
Examples and yearly users	KUCA 1,000	– –	KUR 5,400	JRR-3 22,500

- The medium power RR is defined as the water-cooled reactor with thermal output higher or equal to 500kW and lower than 10 MW.
- The medium-power RR with thermal power up to 10 MW can be applied widely from academic to industrial applications with a certain number of users.
  - ✓ Neutron Science Application
  - ✓ Neutron Irradiation Application
  - ✓ Human resource development
- There is not enough space on the Monju site to fully utilize the performance of the high-power RR.

Whose tasks?

Sep. 2020 - Conceptual design project initiated

- MEXT called public offering for conceptual design studies and related researches.
- JAEA, Kyoto University, and University of Fukui were selected as core institutions.
- JAEA selected an implementing body to proceed with the project under the collaboration with Kyoto Univ. and Univ. of Fukui (Dec. 2022)
- Steadily advance the project by the core institutions with consideration of wide range opinions from academia, industries, local organizations, etc.



Role of Core Institution

- JAEA
  - Design, installation and operation of RR
- 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

What are performance goals?

Parametric survey calculations with simplified model were performed to understand the performance of the 10 MW research reactor.

✓ Neutron flux were evaluated according to differences in core specifications

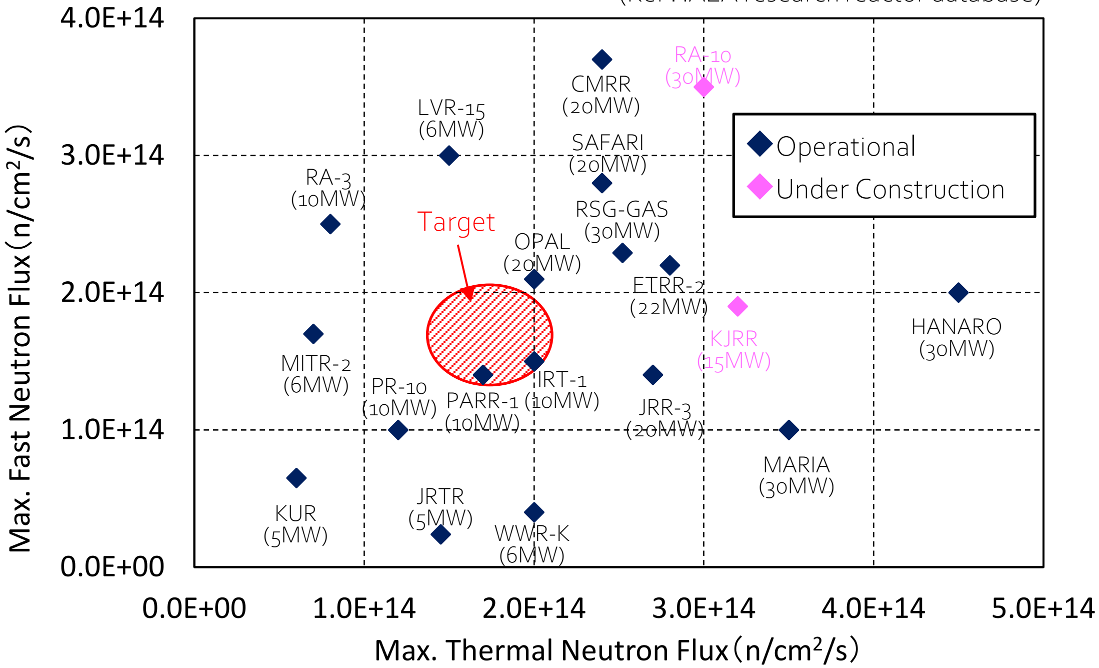
✓ Calculation results were compared various existing research reactors.

Performance targets based on calculation results

Item	Target	JRR-3 Data
Thermal Flux (n/cm²/s)	> 10^{14}	2.8×10^{14}
Operation period (days)	> 400	370
Burnup (GWd/t per 1 fuel element)	> 80	100

Target neutron flux and comparison with other RRs

(Ref : IAEA research reactor database)



Although it does not reach the level of High-Power reactor (> 20MW), it is expected to have world-leading performance as a Medium-Power reactor.

Outcome of the conceptual design

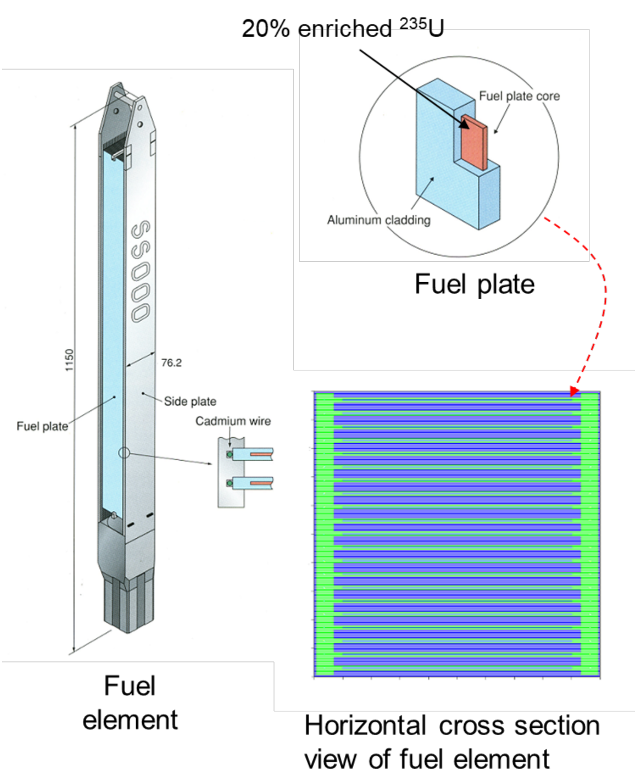
Concept of design policies

Based on the concept of the graded approach, the safety measures is rationally and systematically planned to improve the overall function reflecting the knowledge gained from wide range of experiences.

- 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)
  - ✓ Extend operation cycle by ensuring burnup
  - ✓ Minimize scrum requirements, avoid trouble through design
  - ✓ Simplify the maintenance to shorten inspection period
- 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
- Future potential
  - ✓ A flexibility to new research proposals
  - ✓ Adoption of low-enriched uranium fuel

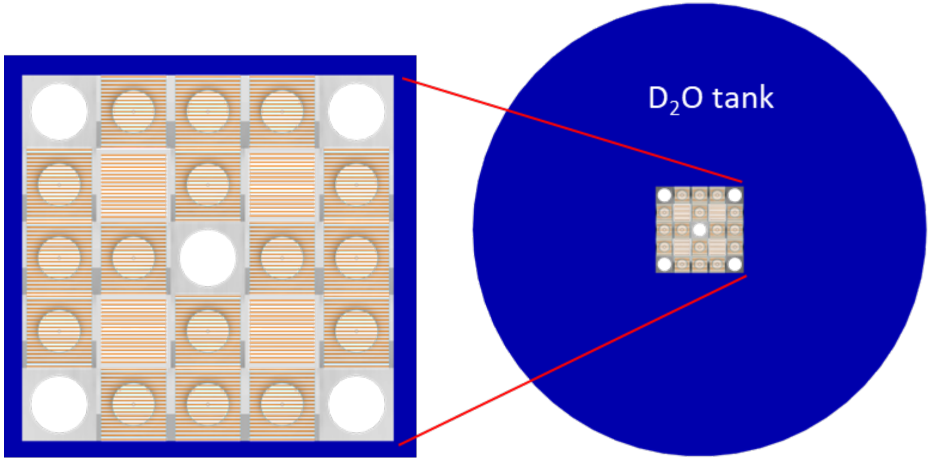
Concept of reactor core

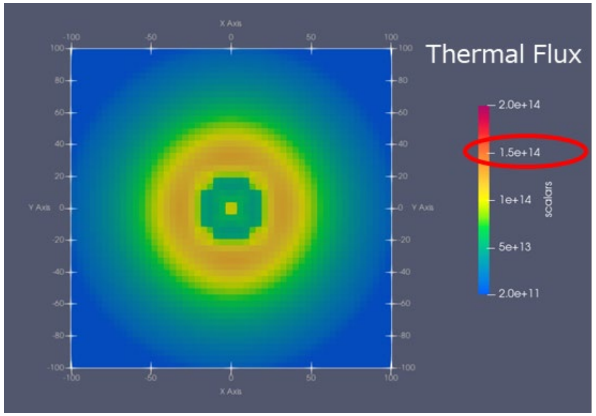
- Standard MTR-type fuel assembly
  - ✓ Standard fuel material with enrichment no higher than 20%
  - ✓ MTR-type fuel assembly design for existing research reactor (e.g. JRR-3, JMTR)
- Core configuration
  - ✓ The fuel area is a 5x5 grid with 20 fuel elements and 5 irradiation holes.
  - ✓ Heavy water is used as a moderator.



MTR-type fuel element

Core configuration





The peaks of the thermal neutron flux appear in the heavy water tank.
The maximum thermal neutron flux is over 1.5×10^{14} n/cm^2.

Concept of neutron utilization

Neutron beam utilization

- ✓ Small-angle scattering
- ✓ Imaging
- ✓ Diffractometer
- ✓ Reflectometer etc.

In addition to the performance of the experimental equipment, it is also important to provide an experimental environment with unique features that are difficult to implement at other facilities. (e.g. measurement of RI samples)

Neutron irradiation utilization

- ✓ Active analysis
- ✓ RI production
- ✓ Material irradiation
- ✓ Positron beam
- ✓ Biological irradiation etc.

Additional facilities such as hot laboratories and analytical equipment are required.

Rendering of the new RR “image”

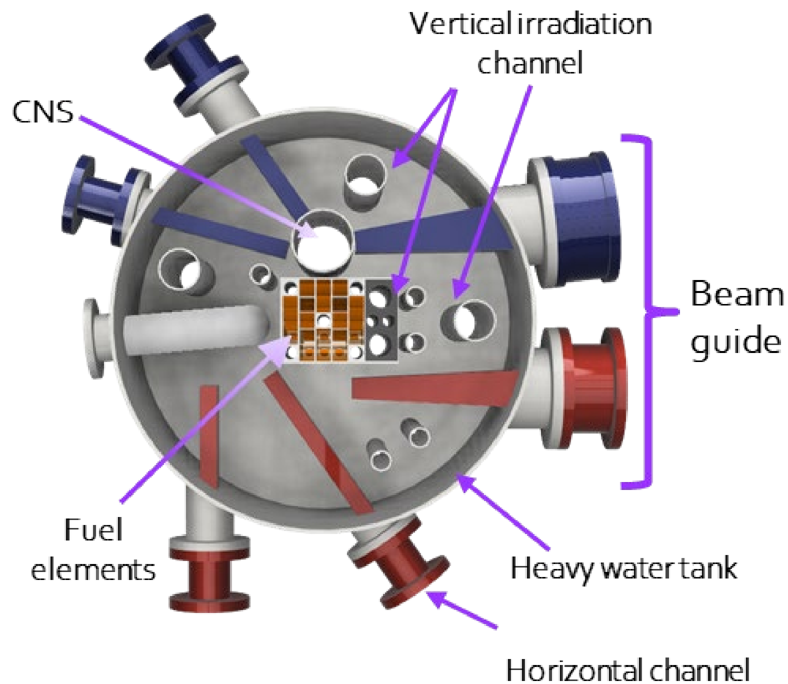


Image of reactor core section

- ✓ To efficiently supply neutrons, the large beam ports will be arranged inside the heavy water tank.
- ✓ A world-leading CNS based on the latest knowledge will be prepared.
- ✓ For multipurpose irradiation use, large and small irradiation holes will be placed around the core.

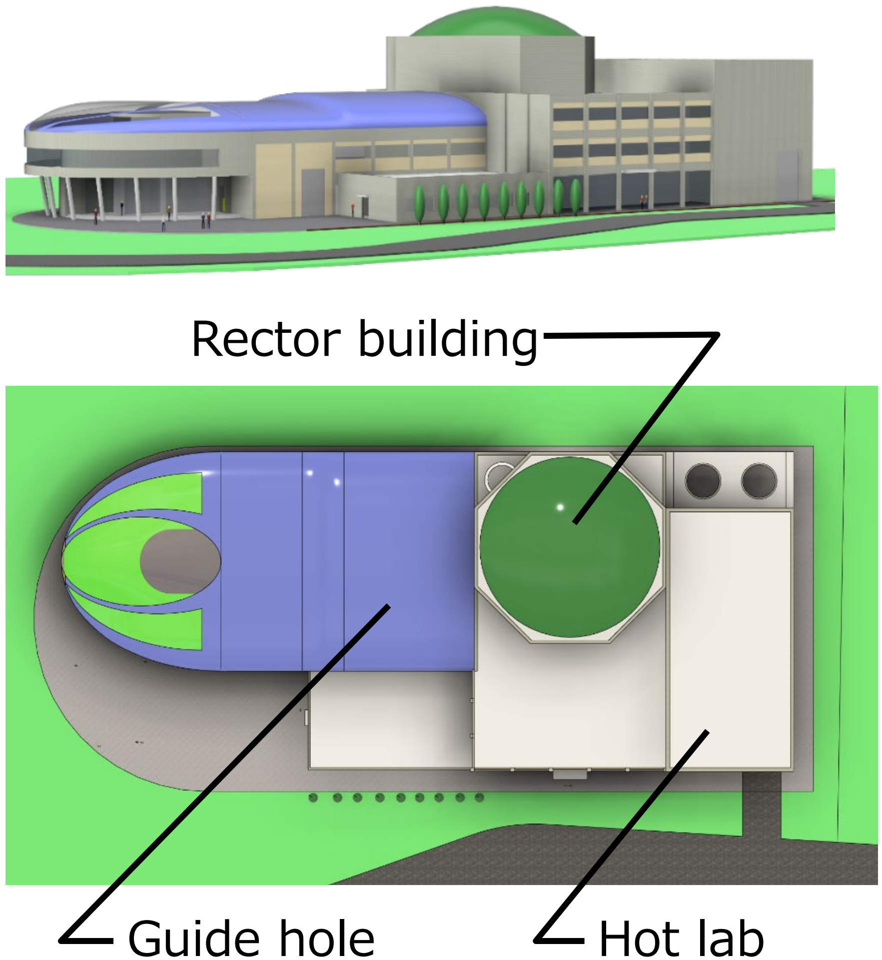


Image of the reactor facility

Current and future

Selection of Core Company for New RR

Nov. 29, 2023:

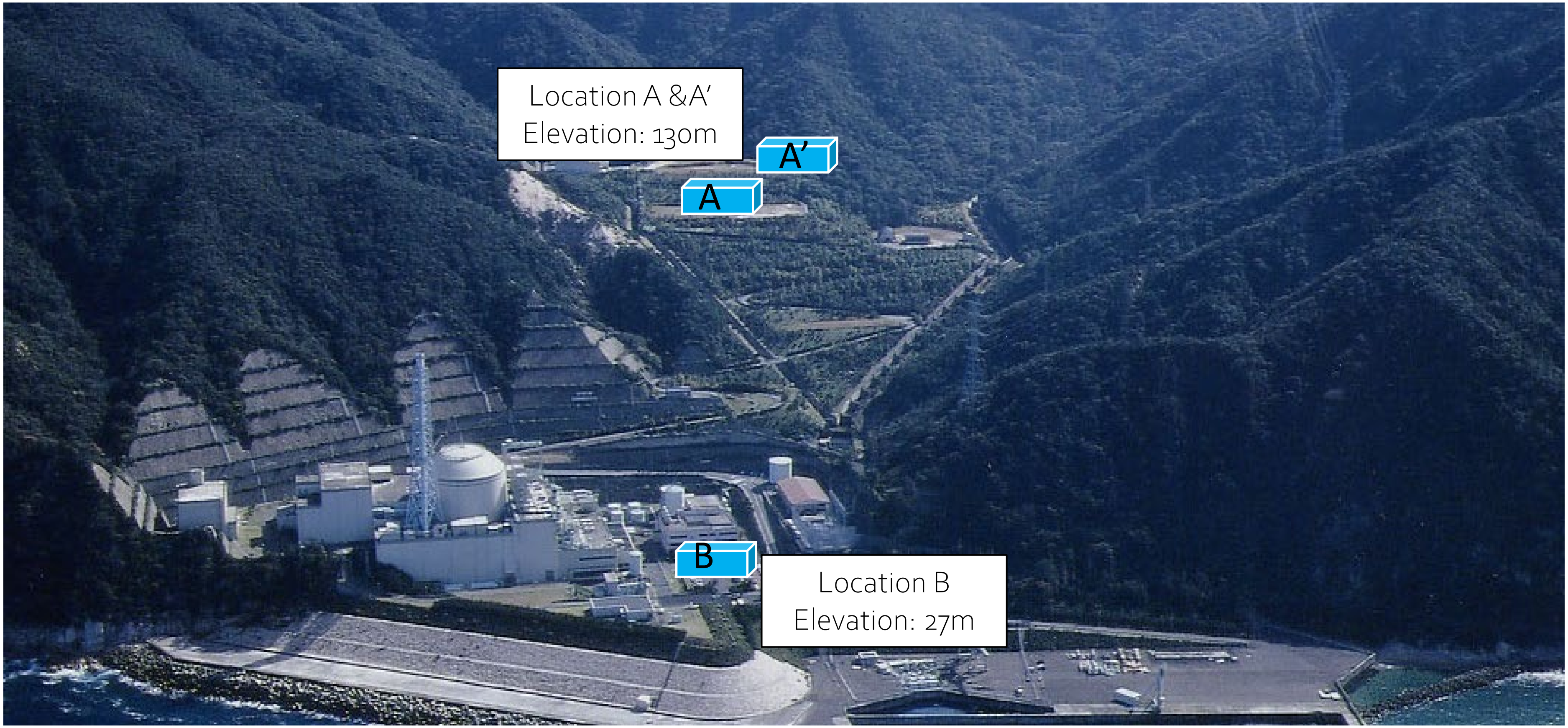
JAEA has signed a basic contract with Mitsubishi Heavy Industries, Ltd. (MHI) as a core company for the design, production and installation of the NRR.

Selection points

- ✓ MHI has already completed many construction projects for nuclear plants in Japan and a strong track record in areas from power reactors to research reactors.
- ✓ MHI also oversees the decommissioning of Monju, so both the decommissioning process and the construction process of new RR on a same site can be carried out smoothly.

Geological and ground surveys of site

There are three candidate locations A, A’ and B on the Monju site.



Geological and ground surveys to select one location from three candidate locations

✓ Boring survey: Investigate the ground quality and strength, geological structure, groundwater level, etc.
✓ Geophysical exploration: Physical properties and structure of the ground, abnormalities of underground, etc.
✓ Ground surface survey: Crack zones and weathering of the surrounding slopes, etc.

Future Schedule (Detailed design phase)

FY2019-2022 conceptual design → FY2022～ Detailed design (including Basic design) → Construction works and inspections → Operation

Item	Detail design Ⅰ (Basic design)	Detail design Ⅱ
Licensing	Application*1 (Installation) △	- - - → △ Permission Application*2 (Engineering) △ - - - → △ Approval
Design for installation approval	・Core component ・Safety design policy formulation, etc.	
Design for plan for construction works approval		Systems for Main Unit, Cooling, Sensing and Control, Disposal, Radiation Control, Spent Fuel Storage, Utility, etc.
Groundwork for administration building (not required licensing)	→	→

→ Construction start

*1 Review of "Reactor installation" : Permission by Nuclear Regulation Authority (NRA)

Important matters related to the safety of nuclear reactor facilities, such as site conditions, basic design, safety measures, and operation and management systems.

*2 Review of "Plan for construction works" : Approval by NRA

Detailed design of nuclear reactor facilities, manufacturing and construction methods, quality control, etc.

Summary

☐ Installation of a new RR at the Monju site

- ✓ The project to build a new RR will be the first in Japan in 40 years.
- ✓ We will bring together the wisdom of Japan to accomplish this project.
- ✓ We pass down our knowledge and skills to the younger generation.

☐ Design an attractive research reactor

- ✓ Add functions suitable as a core base for R&D and HRD.
- ✓ Establish facilities that contribute to regional development through academic and commercial use.
- ✓ Design a research reactor with world-leading performance. (Good performance over high performance)

☐ Moved to detailed design phase

- ✓ We are moving the project steadily forward applying for a reactor license.
- ✓ The installation location will be determined through geological and ground surveys.

<u>We look forward to cooperation from nuclear-related organizations, universities, and other companies around the world.</u>