Current Status of Planning for Experimental Instruments for Broad Use at the New Research Reactor(RR) at the Monju Site

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Core Institutions(after Conceptual design phase)

From Dec.2022

- **JAEA selected as lead implementer, based on collaboration with Univ. of Fukui and Kyoto Univ.**
- **JAEA has signed a basic contract with MHI. as a core company(Nov. 2023).**
- **Steadily advance the project by the core institutions with consideration of wide range opinions from academia, industry, local organizations, etc.**

Signing ceremony at Turuga (May 2023)

Mission of Core Institution

JAEA
- Design, installation and operation of the new 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

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Mission of Kyoto University(KURNS)

Aggregation of wide-ranging application needs and provision of services based on the experience in KUR(5MW) operation

It means that we need to find a solution for the question

- how to maximize utilization performance of 10MW new Research Reactor(RR) sustainability, of which primary purpose is neutron beam utilization.

- Sustainability: human resource development and retention are key, and how to make the utilization facility attractive to a wide range of people, mainly researchers.

- Practically, how to design future experimental instruments for broad use of the 10MW new RR?

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Outline

- Brief introduction of KURNS(Institute for Integrated Radiation and Nuclear Science, Kyoto University)
- Current organization in KURNS for the 10MW new Research Reactor(RR) and preferred experimental instruments
- Summary

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Brief introdction of KURNS
(KUR:Kyoto University Reactor)

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Institute for Integrated Radiation and Nuclear Science, Kyoto University

3 big facilities@KURNS

KUR：1964 first critical→ 2026 terminate
KUCA：1974 first critical→ replace low-enriched fuel (**See S10-04**)
BNCT(Cycrotron), FFAG proton accelaractors building
~300 research proposals/year, ~4000 visitors･day/year

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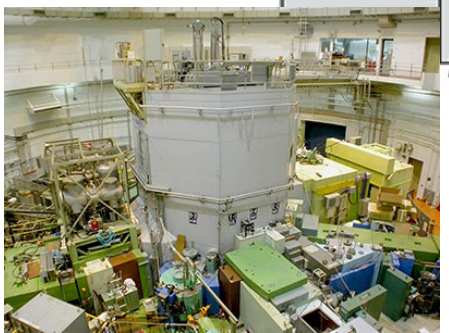
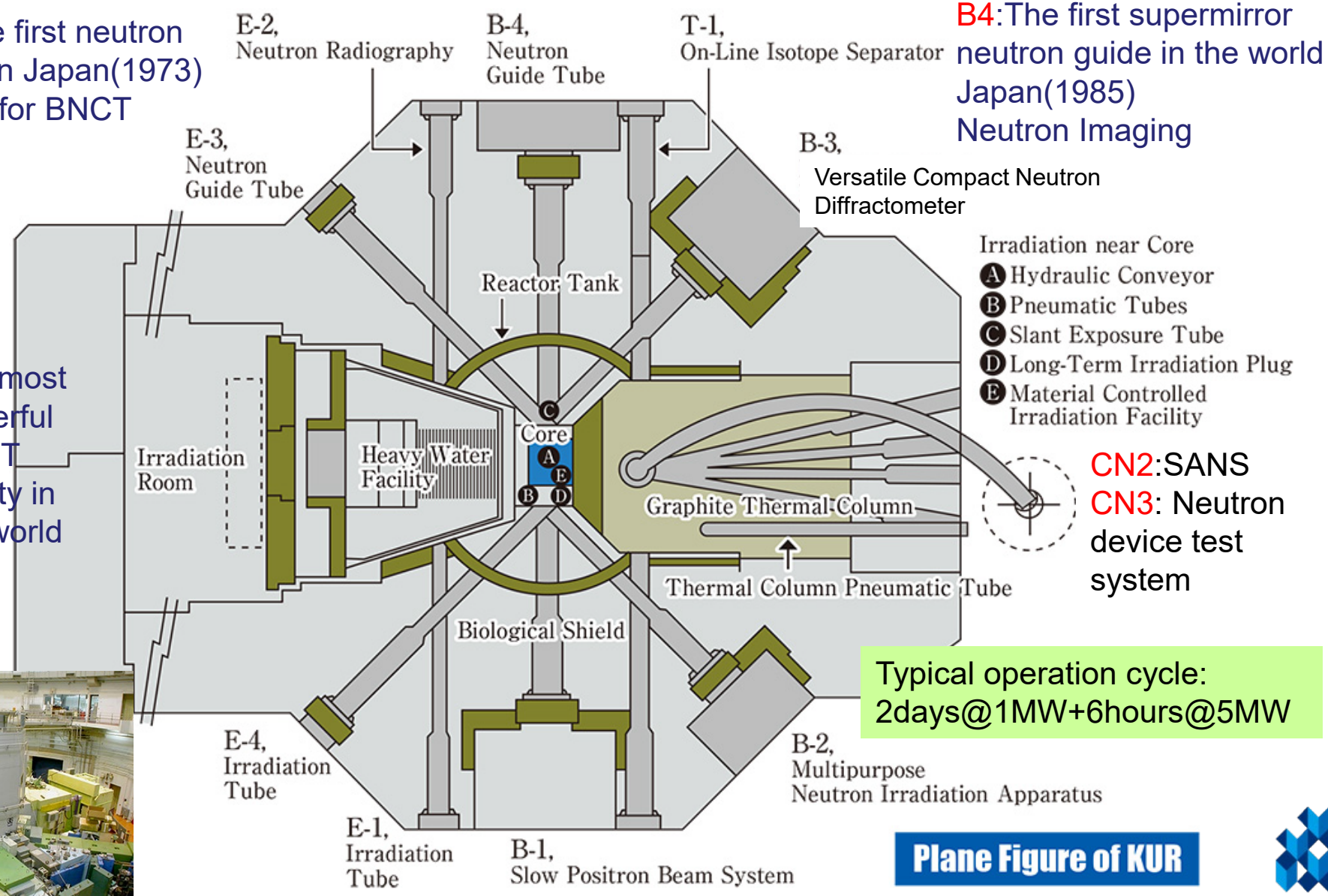
Top view of KUR(1MW:1964,5MW:1968,LEU:2010)

E3:The first neutron guide in Japan(1973)
PGAA for BNCT

B4:The first supermirror neutron guide in the world Japan(1985)
Neutron Imaging





The most powerful BNCT facility in the world

CN2:SANS
CN3: Neutron device test system

Typical operation cycle:
2days@1MW+6hours@5MW

Plane Figure of KUR

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Brief history: KURRI→KURNS

1955: Science Council of Japan:
“Installing one research reactor at each university in Kanto and Kansai area”
(Kansai: the area around Osaka and Kyoto)

1956: Atomic Energy Commission(Long-Term Basic Plan for the Development and Utilization of Nuclear Energy):
“For the time being, one reactor will be installed in the Kansai area for basic research and education at universities….”

1963:Establishment of Research Reactor Institute, Kyoto University(KURRI) as a joint research institute (Purpose of establishment: "Experiments using nuclear reactors and related research“)

2018:Renamed KURNS(Institute for Integrated Radiation and Nuclear Science, Kyoto University) to create more scientific results.

2026(May) The operation of KUR will be terminated.

Current organization and preferred experimental instruments for RR

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KNRR promotion center at KURNS

KURNS has organized the promotion center of New Research Reactor (KNRR) to respond sustainability development with a long-term perspective for the new RR.

KNRR grows and active year by year(Present: 7 Core staff(2 concurrent) and 25 related staffs, June 2025).

Before the conceptual design phase (Dec.2022), we got request letters from several Japanese academic societies, for example neutron science, nuclear and radiochemical science, positron science and nuclear material for atomic energy, etc. Joint research meeting also held with the following academic Japanese societies,(21, 26 July 2022), Nuclear medicine, Nuclear and Radiochemical Sciences, Positron Science, BNCT, Nuclear Material(Atomic Energy), Neutron Science(Neutron scattering, imaging, particle physics).

We are in ongoing discussions with the authorities of the academic societies and the key personnel of the industrial companies.

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Preferred instruments for new RR

We have discussed with related academic communities that are interested in usage of 10MW RR. With the points of view of high versatility and frequency of use, we select five preferred instruments.

Beam : Small-angle scattering, Imaging, Diffractometer, Reflectometer
Irradiation :Activation analysis

Plan for neutron irradiation facilities: See P-17

- While the primary purpose of the RR is to use neutron beams, irradiation is also very important. We should pay attention to be well-balanced set of experimental instrument with versatility, cutting-edgeness, diversity.
- To realize the above active use when the RR operates, we have to keep cutting-edge activity and interest and collaborate with a variety of societies(not only academic but also industrial and local).

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5 preferred instruments for new RR

Small Angle Neutron Scattering(SANS)

Investigate mesoscopic structures of various substances ranging from nanometer to submicrometer scale.

Neutron imaging (NI)

Visualization of internal structure and phenomenon of machine, battery and plants etc.

High expectations for academic and industrial use

Neutron activation analysis(NAA)

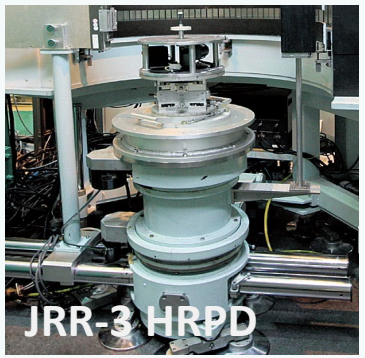
High-accuracy microelement analysis with non-destructive

KUR Pneumatic tube

Ge detector

Neutron diffractometer(ND)

Investigate average crystalline structures of substances with whole sample area (available to do magnetic structure)



Neutron reflectometer(NR)

Investigate depth structure of buried film and roughness of surface and interface with sub-nanometer resolution

SANS:https://kmayumi.issp.u-tokyo.ac.jp/equipment/tokai/

NI&ND:
https://jrr3uo.jaea.go.jp/about/

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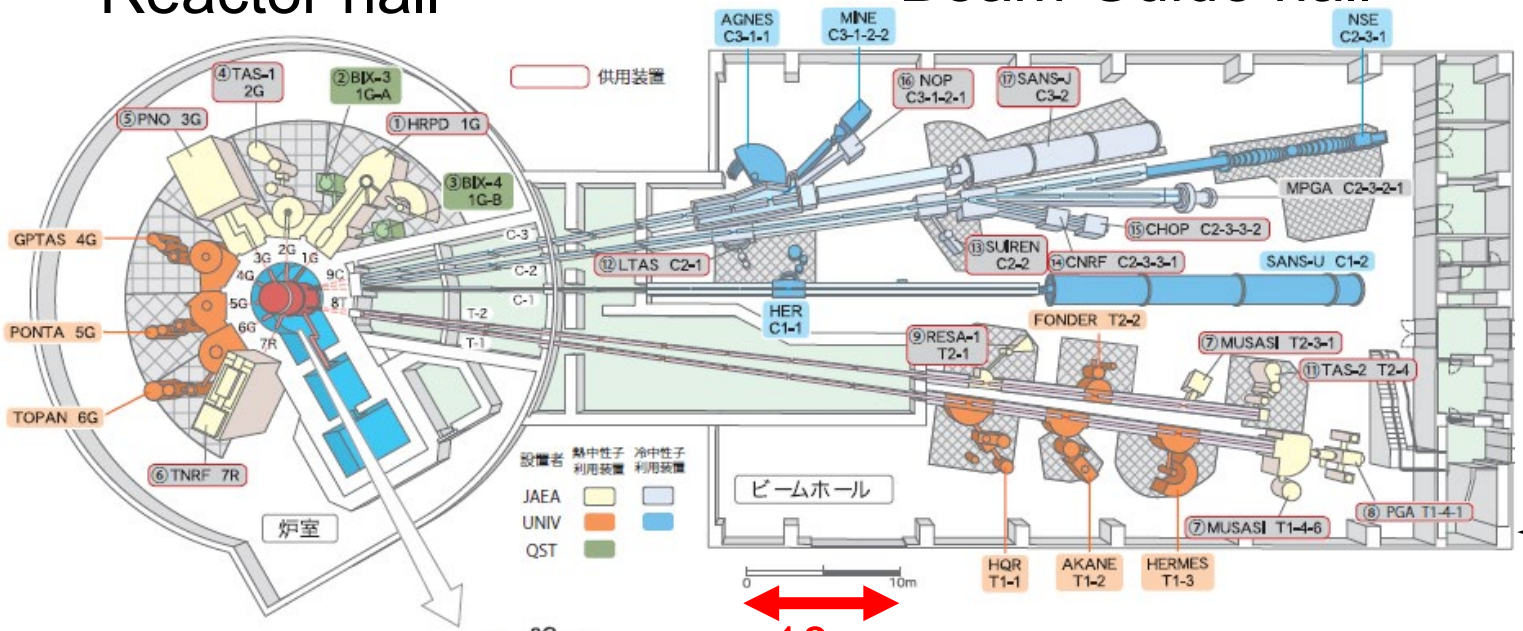
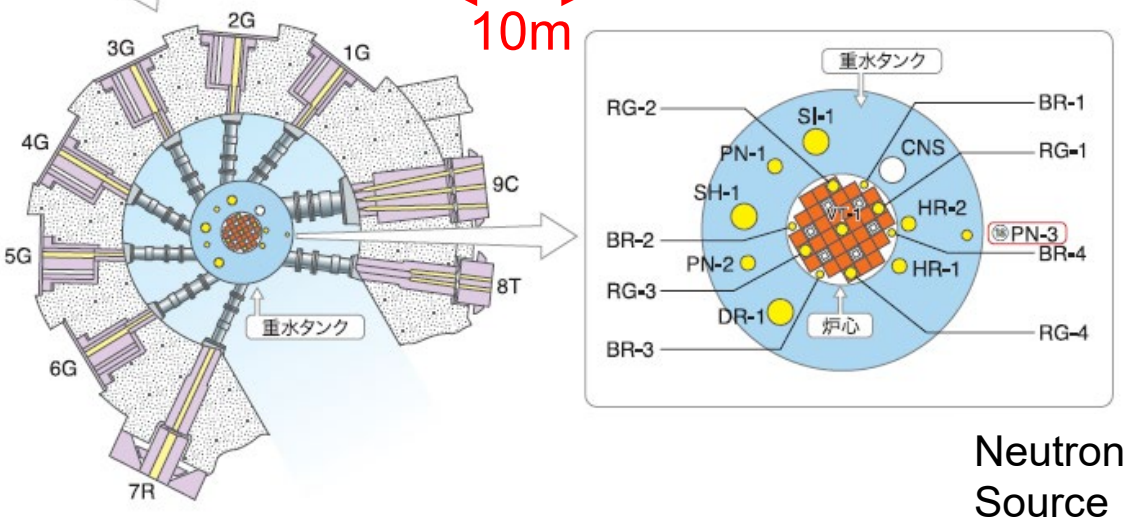
As good example of JRR-3 beam reactor

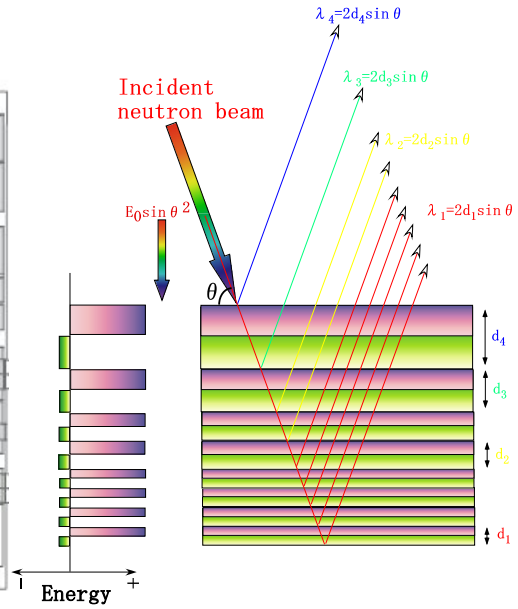
Reactor hall

Beam Guide hall





Neutron Source

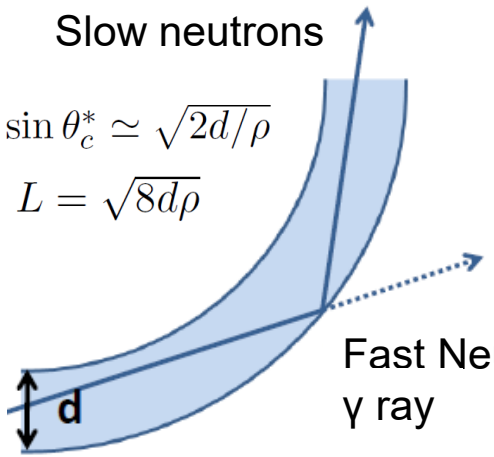


$$\theta_c[\mathrm{deg.}] \simeq m\lambda[\text{Å}]/10$$

Slow neutrons

$$\sin\theta_c^* \simeq \sqrt{2d/\rho}$$

$$L = \sqrt{8d\rho}$$



Fast Neutron
γ ray

θ_c^* : characteristic angle

ρ : radius ofcurvature

https://jrr3uo.jaea.go.jp/pamphlet/pdf/pamphlet1.pdf

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Image of reactor with experimental holes

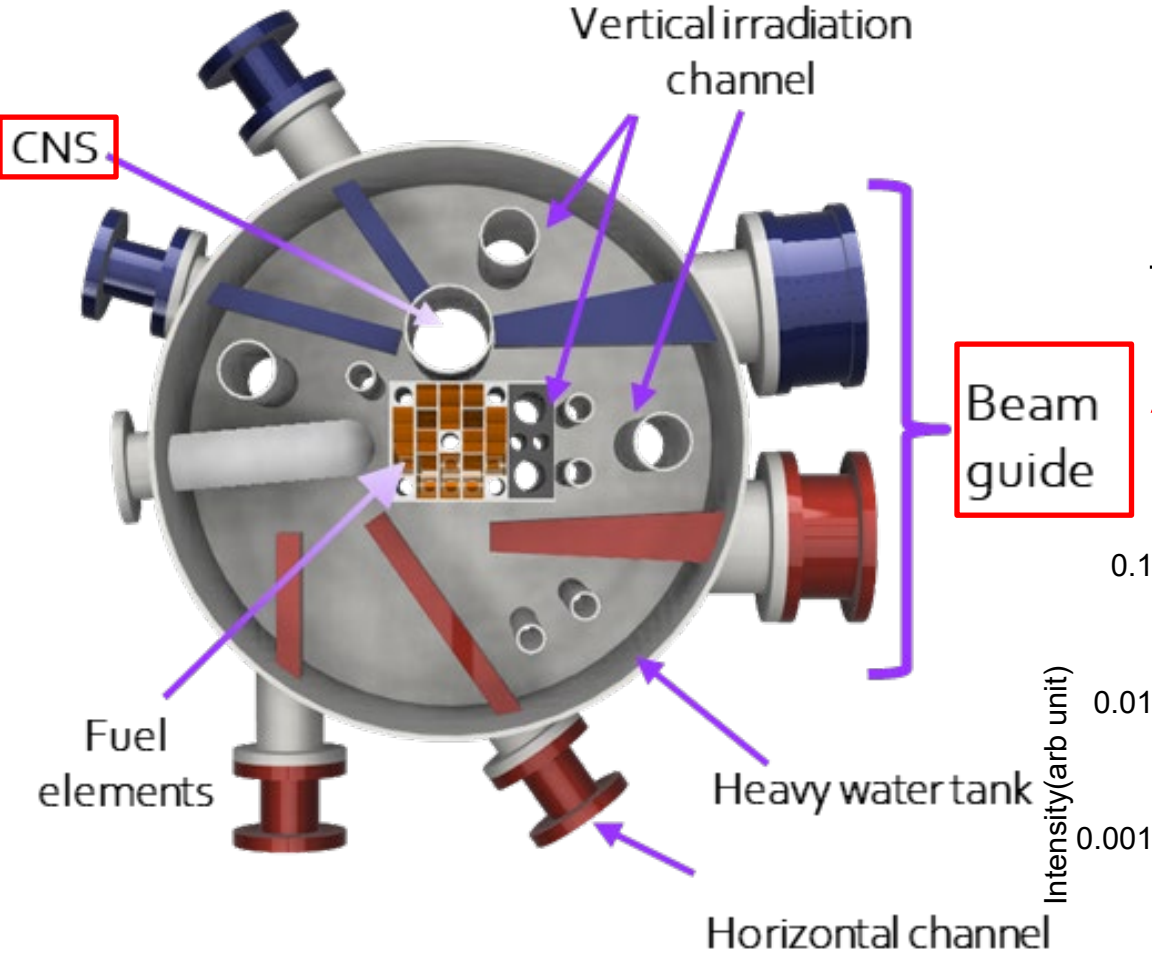
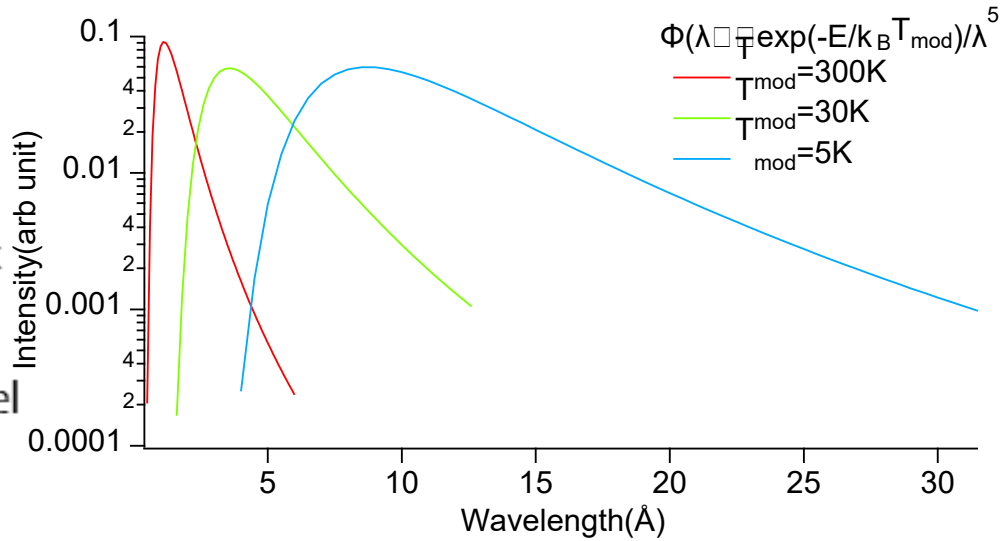


Image of reactor core section

For cutting-edge neutron beam utilization, Cold Neutron Source(CNS) and large experimental area are essential issue. The neutron flux decay as λ^5 from the peak at the thermal equilibrium temperature(T_{mod}).



Neutron transportation is also very important. By using supermirror guide, the reduction ratio save from λ^5 to λ^3 (or more).

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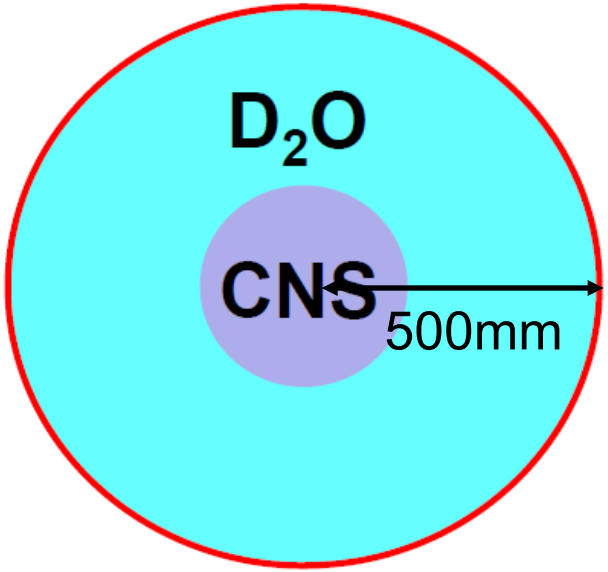
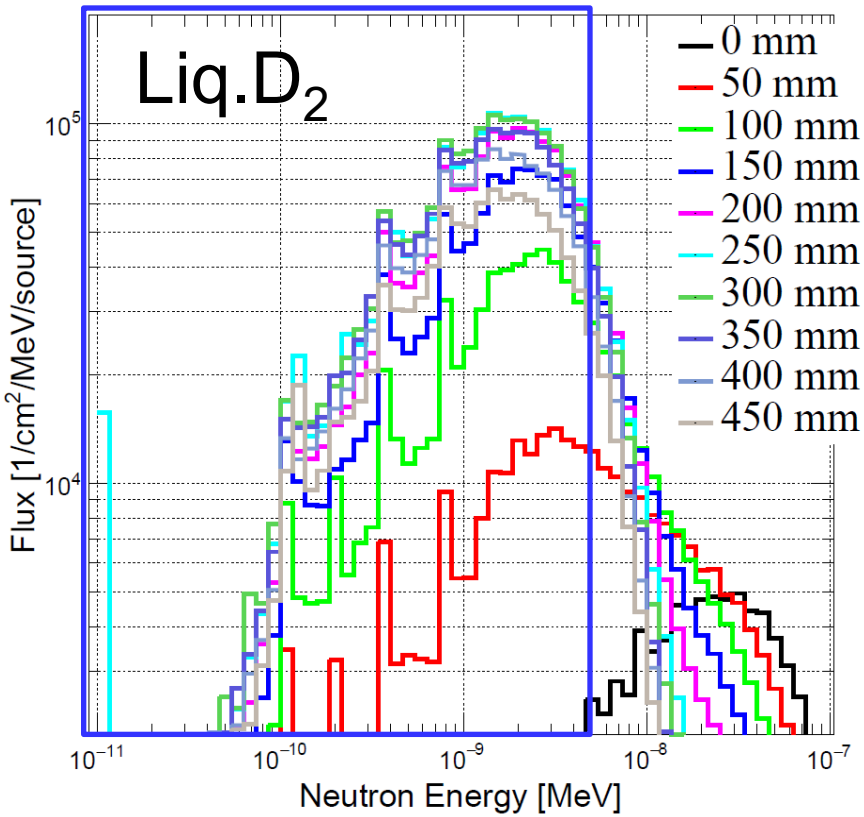
Moderator material of CNS

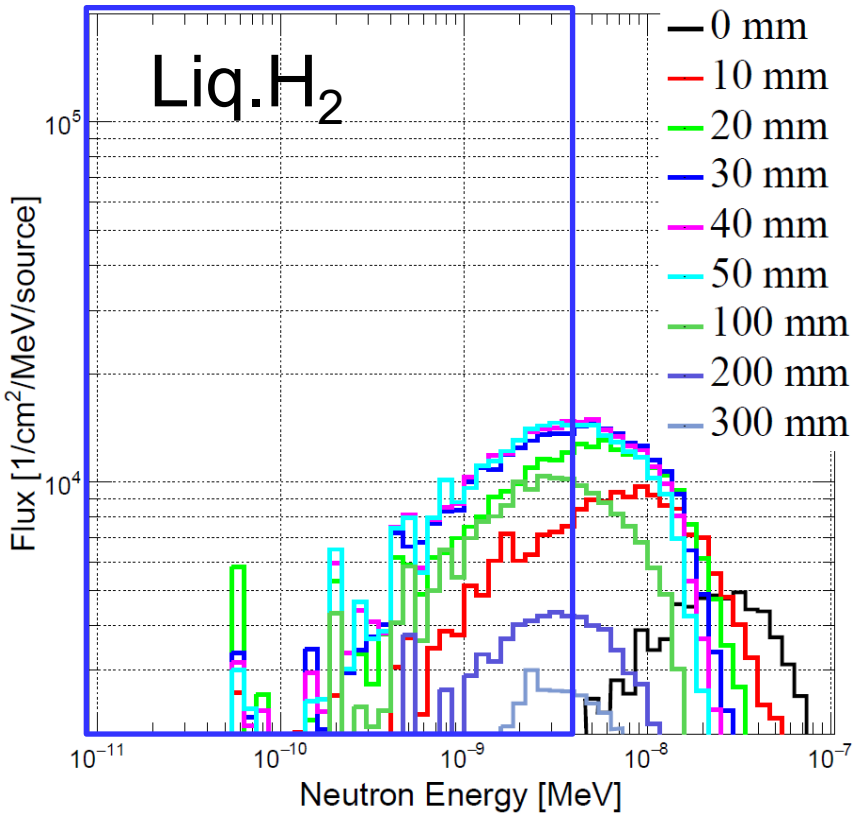
Neutron spectral evaluation at the center of the sphere.
2 MeV fast neutron irradiation from the outside to the inside of the sphere. The blue frame is the region of kinetic energy below cold neutrons. Deuterium has better performance than hydrogen, and the optimum amount is also large (deuterium: ortho 100% hydrogen: para 100%)



See P-16 in more realistic case

PHITS (Ver3.23)





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Rough schedule of instrument R&D by TF

Plan Design Construction (completed) Operate

We are here

Phase1 Review Phase2

Framework	Basic specifications (Vision, challenge, Overall consistency)		Detailed specifications (Realistic simulation, Mutual adjustment)	Construction of instruments Development & Installation	Utilization Adjustments

Development of elements and prototype instruments using existing facilities

Task force(TF): A domestic experts team working on investigating scientific scope(vision), design and development of each experimental instrument

- SANS
- Imaging
- Diffractometer
- Reflectometer
- Fundamental Physics(UCN)
- Triple Axel Spectrometer
- Positron beam
- Nuclear Material irradiation
- Biological neutron irradiation
- NAA & RI production

+four other TFs

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Summary

- Based on our experience with the 5 MW KUR operation, we are going to maximize utilization performance of 10MW new Research Reactor(RR) sustainability as one of three core institution. Our goal is to make the facility appealing to a diverse group of societies, especially researchers.

- As a first step, we selected five preferred instruments due to their high versatility and frequency of use. We are investigating not only proper neutron beam utilization but also neutron irradiation.

- KURNS (especially, KNRR) has formed a task force to develop future state-of-the-art instruments and devices that promote sustainable human resource development and retention.

International collaboration is also essential to become a unique of world-class facilities. Please support this attractive project.

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Thank you
for your attention

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