Neutron Irradiation Plan in A-FNS for DEMO and Industrial Application

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Outline

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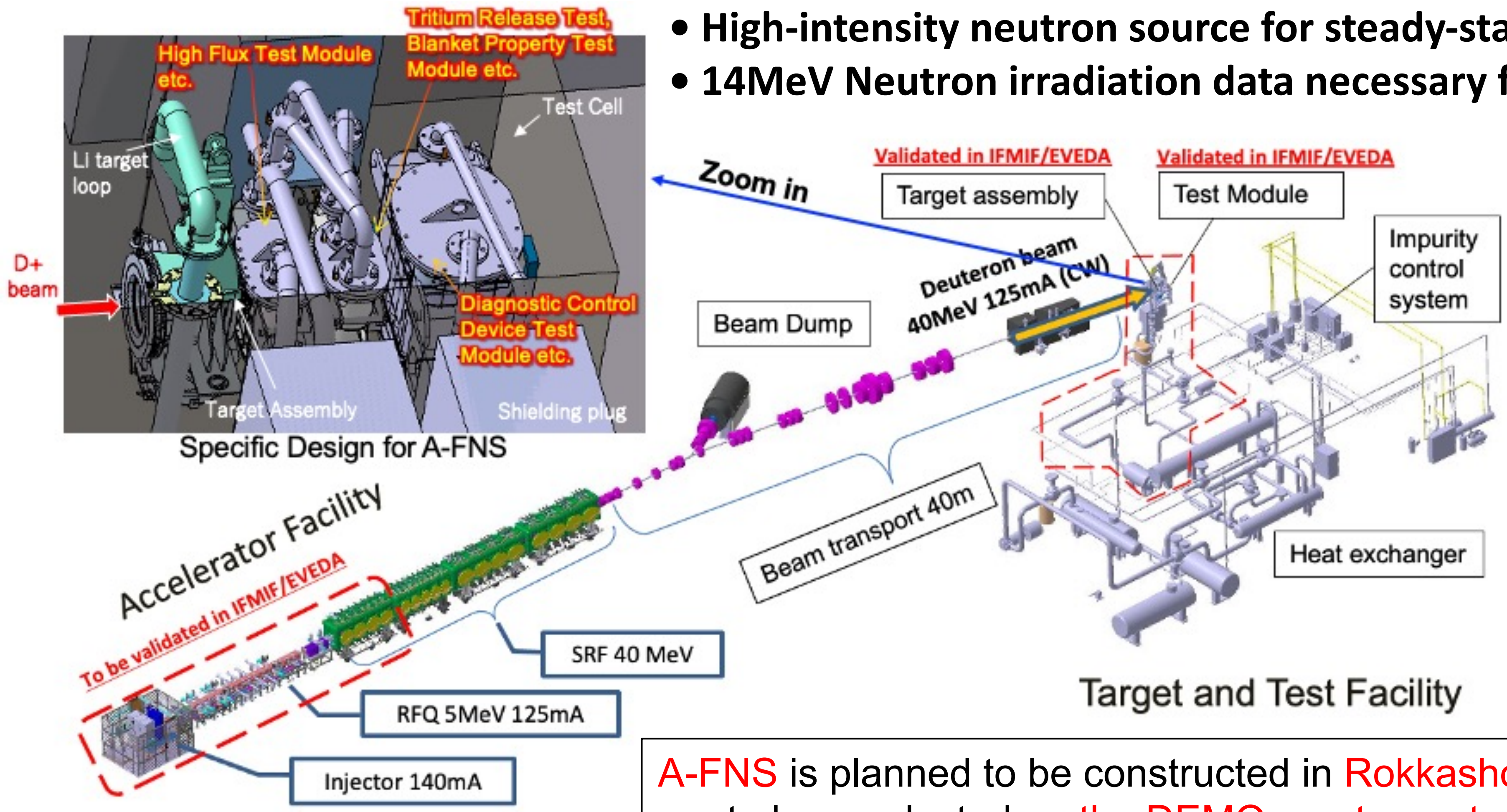
    Collaboration plan in JA for fusion neutron source

Specification of A-FNS

- **High-intensity neutron source for steady-state power generation in JA-DEMO.**
- **14MeV Neutron irradiation data necessary for license of JA-DEMO.**



Beam	Particle Energy Current Foot print Incident angle Availability	Deuteron 40 MeV 125 mA (CW) 200 x 50 mm^2 Normal 88% (Target)
Target	Material Temp. Velocity Thickness Window	lithium Liquid target (jet) 250 ℃ 10-15 m/s at target 25 mm Free surface (no window)
Neutron	Intensity (at back plate) Average flux Helium P. R Displacement HePR/dpa	6.8 x 10^{16} neutron/s 6.0x 10^{14} n/cm^2/s 312 appm/fpy 24.7 dpa/fpy 12.6

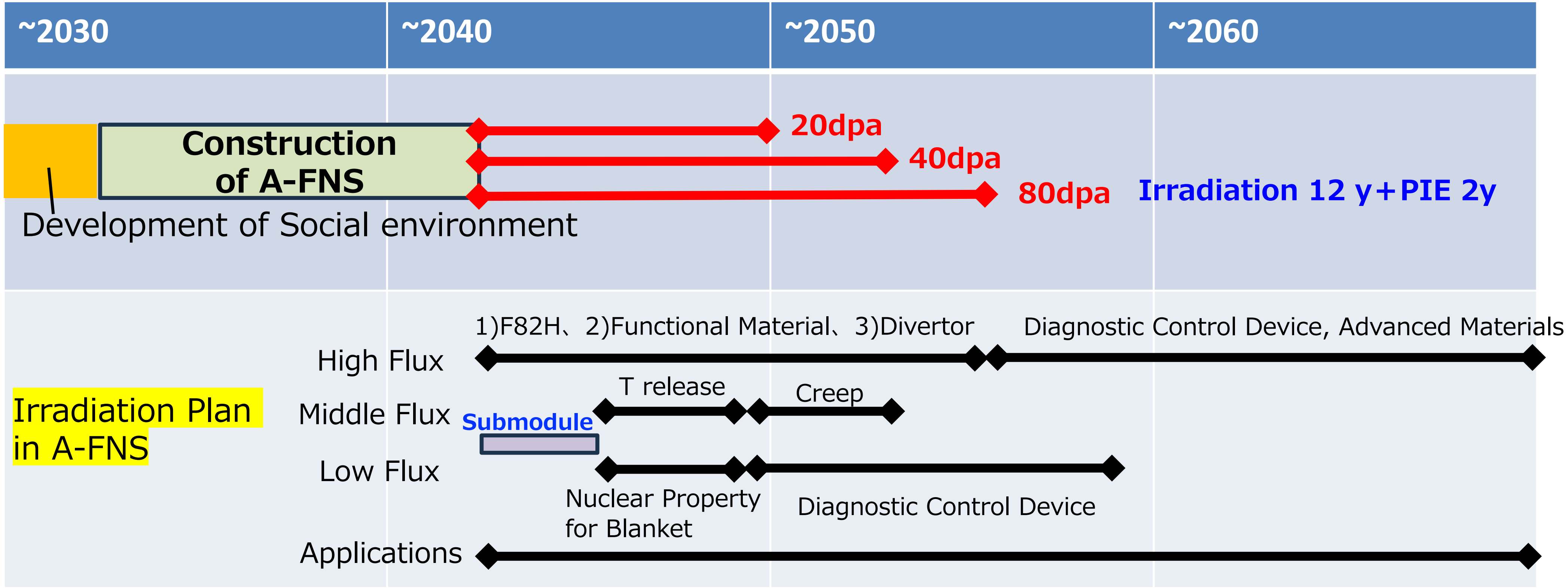
fpy: full power year

A-FNS is planned to be constructed in Rokkasho, and the neutron irradiation tests are to be conducted on the DEMO reactor materials. It is composed of accelerator facility, lithium target loop facility, irradiation test facility, post irradiation examination facility.

Irradiation plans according to Japanese roadmap

Development according to Japanese roadmap toward JA-DEMO and Action plan (Under revision)

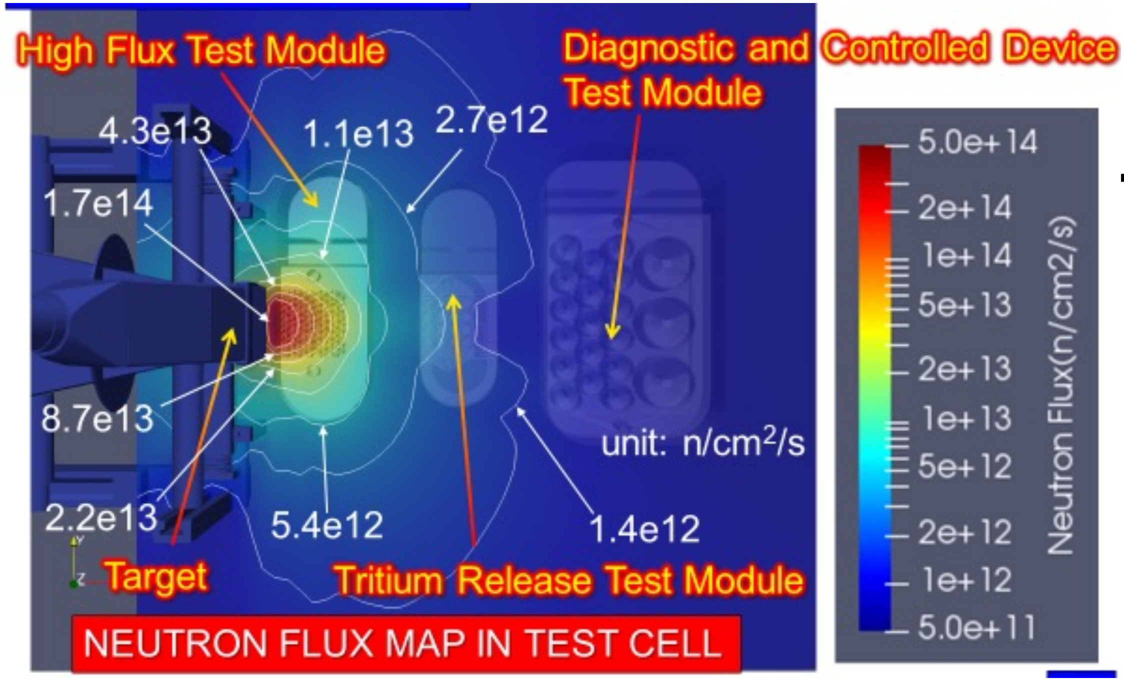
- ✓ Irradiation demonstration of F82H up to 80dpa for steady operation of JA-DEMO.
- ✓ Irradiation test of equipment & functions necessary for JA-DEMO system.
- ✓ Irradiation test of Blanket submodule.



Irradiation Modules

In discussion with JA experts in reactor materials and DEMO design, the following contents were categorized by neutron field strength.

Many Fusion Material Test Modules



A-FNS is utilized like multi-purposes neutron source.

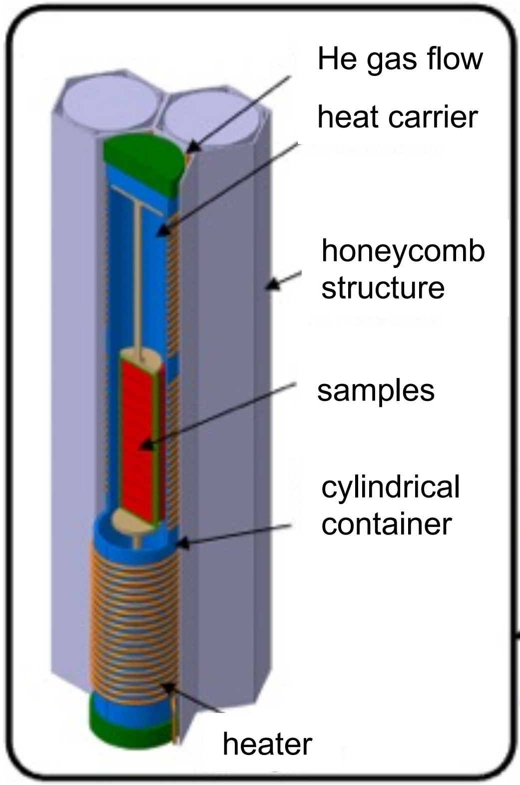
For Fusion Material Test

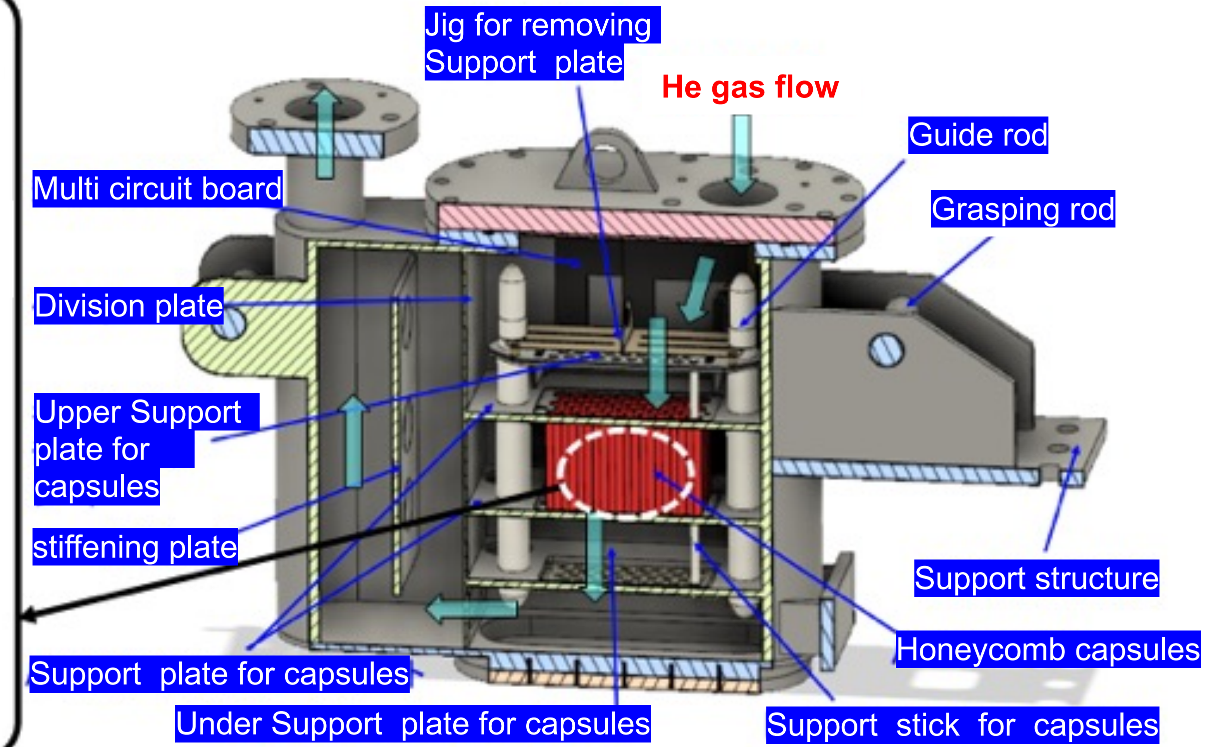
- Neutron flux measurement (NFM)
- Blanket structure material test (BSM) ← T. Nozawa(QST), at today's morning session in this conf.
- Blanket functional material test (BFM) ← 1st IFMIF-DONES Users Workshop
- Divertor functional material test (DFM)
- Active corrosion production (ACP)
- Tritium release test (TR) ← 1st IFMIF-DONES Users Workshop
- Creep fatigue test (CF)
- Diagnostic controlling device test (DCD) ← This presentation
- Blanket nuclear property test (BNP)

For Industrial Use

- RI production (RIP) ← This presentation
- Low Energy irradiation
- Neutron beam hole (NBH), ← This presentation
- Gas & liquid loop

Irradiation capsules and High Flux Test Module.

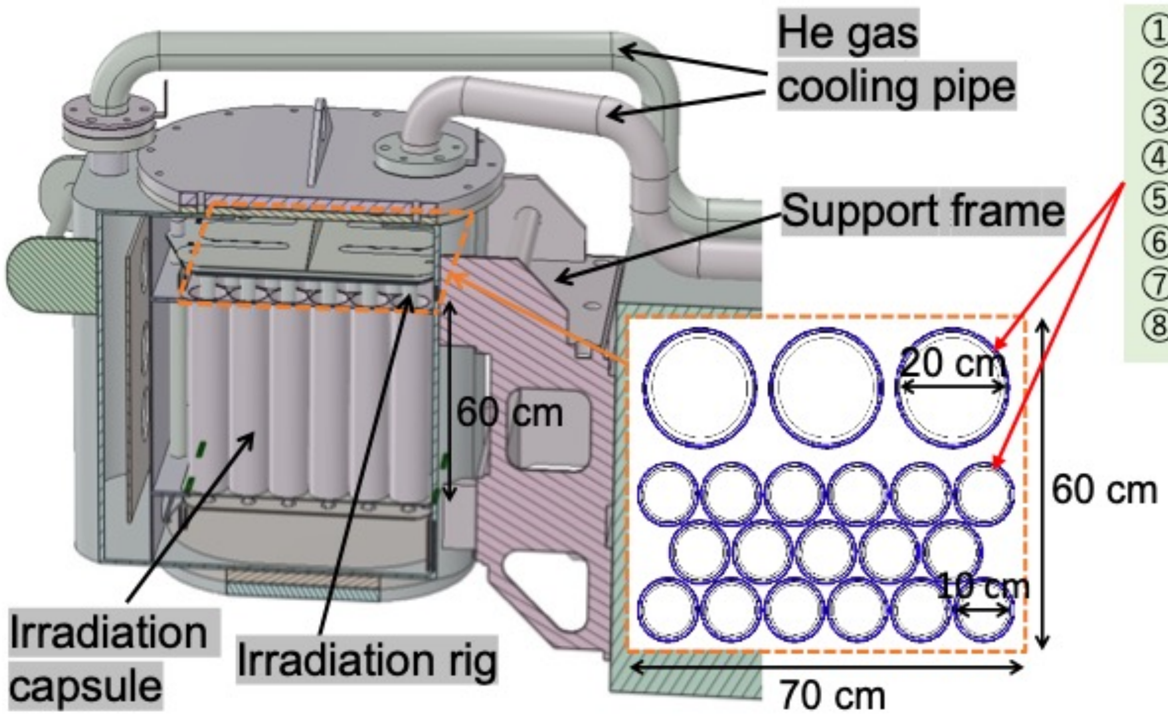




(Original Design for A-FNS)
Regarding the irradiation module for structure material, a honeycomb cylindrical module concept as a common standard for irradiation modules for A-FNS was proposed. The system was designed to achieve uniform irradiation conditions by creating a replacement system and connection structure through remote maintenance.

To simplify the irradiation capsule structure, we designed the capsule of cylindrical configuration.
In order to clarify the irradiation conditions of the test specimens and to facilitate the reinstallation of the test specimens, one type of test specimens is installed into one capsule.

DIAGNOSTIC CONTROL DEVICE TEST MODULE



1. Magnetic probe for magnetic measurement
2. Cable irradiation test
3. Evaluation of life time of vacuum window materials
4. Evaluation of influence on reflectance of mirror
5. Multilayer film reflector for Thomson scattering
6. Optical fiber radiation resistance
7. Irradiation characteristics of heating equipment
8. Irradiation characteristics of superconducting coil material

(Issue)

For the DEMO reactor, various measurement and control devices are placed inside the DEMO reactor, and the amount of neutron irradiation required varies greatly depending on the installation location.

(Requirement)

Neutron fluence above 0.1 MeV or higher requested by the measurement varies from 3.2×10^{14} ~2.4×10^{23} n/cm^2

It is possible to obtain the data within 6 months for diagnostic control device for ceramic windows, mechanical parts detectors etc. installed outside the vacuum vessel of the DEMO reactor.

RI PRODUCTION MODULE

(Requirement)

(i) Quick loading & removal system: Because the half-life of RI produced in the RIPM is short, the RIPM should be designed to allow loading of RI production samples by horizontal movement from the lateral access cell to the irradiation test cell and quick removal of RI samples produced within a short time by remote control during neutron irradiation.

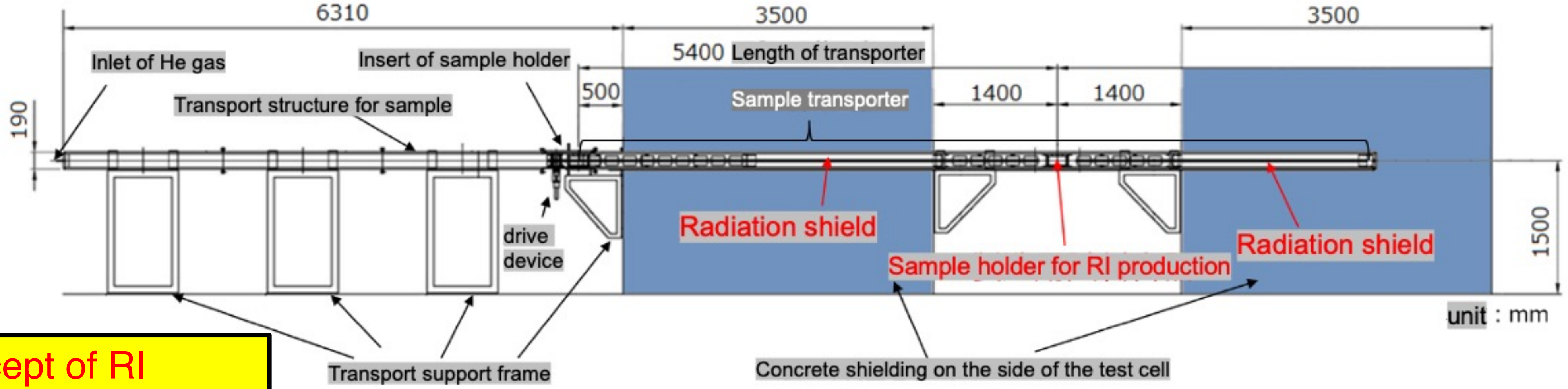
(ii) Cooling system: The RIPM shall be cooled because of the nuclear heating of the RIPM and the radiation heat from the target.

(iii) Proper shielding structure: Because there is a concern that radiation leakage from the insertion port of the RIPM may increase the dose in the lateral access cell, the RIPM shall have a structure that can suppress radiation leakage even during replacement work.

(Structure)

RIPM is loaded and unloaded through the penetration duct by remote control even during neutron irradiation by a drive mechanism using a stepping motor with an encoder installed outside the test cell.

(Result) Neutron effect on the material irradiation module was suppressed to a few %.

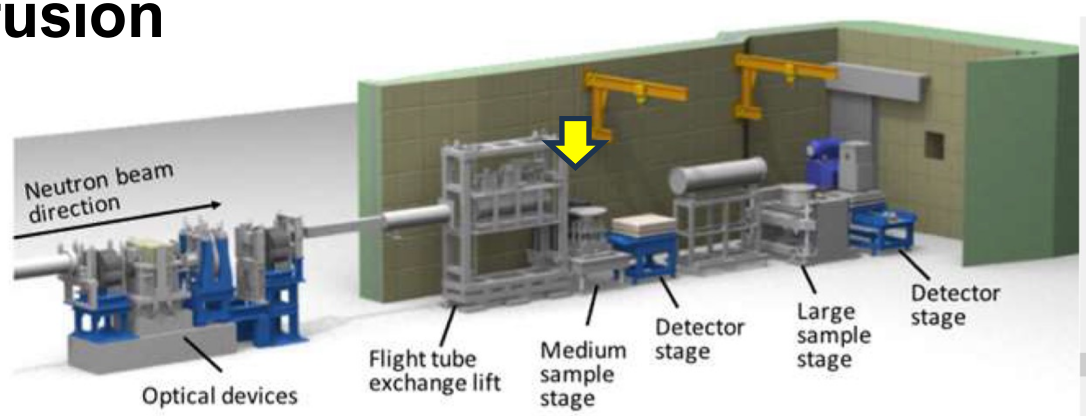


The basic structural concept of RI production module was established.

Neutron imaging experiment with fast neutron

Study on the use of fast neutron imaging with fusion neutron sources (QST-Kyoto Univ, JAEA).

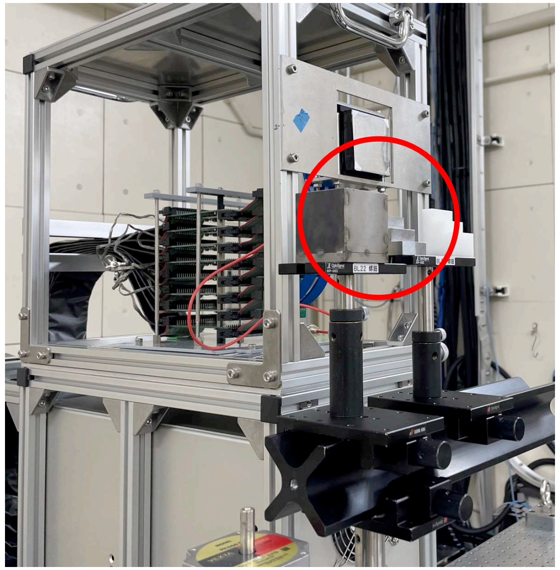
The possibility of using imaging with energetic neutrons will be investigated, as the transmission capacity of thermal neutrons is insufficient for large motors and product-like sized fuel cells.



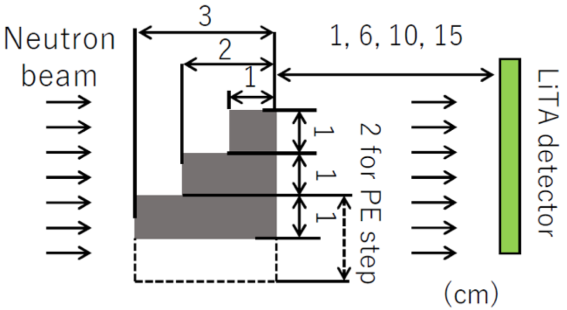
Schematic diagram of the device of RADEN in J-PARC MLF.

As present status of study,

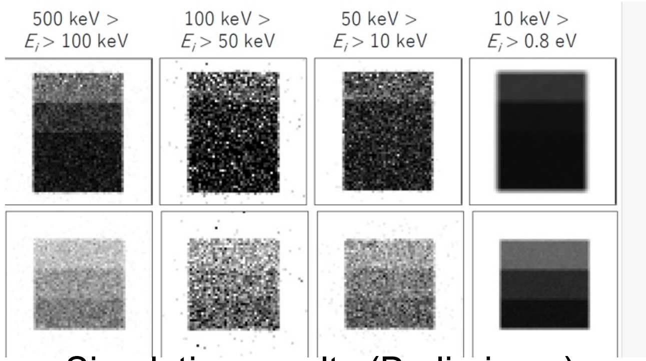
- Fast neutron imaging combined with RADEN experiments and PHITS simulations
- Preliminary experiment to validate the simulations



Experimental apparatus in J-PARC RADEN.



Simulation model for FN imaging.



Simulation results (Preliminary).

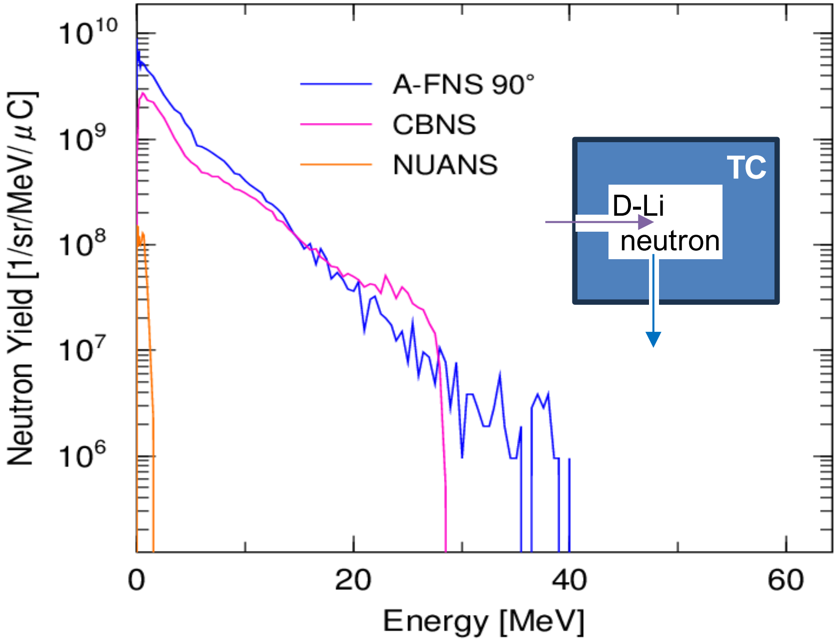
Feasibility as medical usage of fusion neutron

Research on medical applications of fusion neutron sources (QST-Nagoya Univ.).

Moderated neutrons are used in a wide range of fields, including elemental analysis and medicine. Analysis of the moderation effect of aluminum fluoride (AIF3) and verification experiments are performing for the wide use of fusion neutron sources.

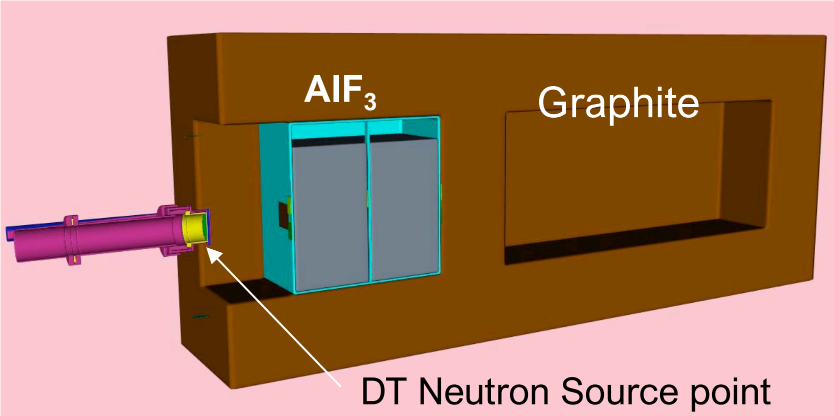
As present status of study,

- Evaluation of source neutron spectrum and intensity behind the irradiation module
- Design of combining moderators and shielding materials and evaluation of neutron performance suitable
- Preparation of neutron irradiation field with moderators and shielding materials at DT neutron source OKTAVIAN, Osaka University.



CBNS: Cyclotron Based epi-thermal Neutron Source Kyoto Univ.
NUANS: Nagoya University Accelerator-driven Neutron source

Comparison of neutron emission energy spectra.



Drawings for analysis of OKTAVIAN experiment.

4. Future scope

Collaboration plan in JA for fusion neutron source

- As applications of the fusion neutron source A-FNS, various feasibility studies will be carried out, mainly in collaboration with Japanese universities and research inst itutions.
- The nuclear design of the necessary equipment (e.g. neutron beams and collimato rs) for this purpose will be carried out mainly by the QST (A-FNS Gr).
- In particular, the production of medical Radio Isotopes and the use of radiation for medical purposes are in high demand and are important for stimulating neutron so urce research and development, and the use of deuteron beams will also be consi dered.
- In the future, it will be more important to cooperate with other countries in these re search and development activities, which will be carried out under an international cooperative framework.