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# Conceptual Design of Advanced Fusion Neutron Source (A-FNS)

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## ABSTRACT

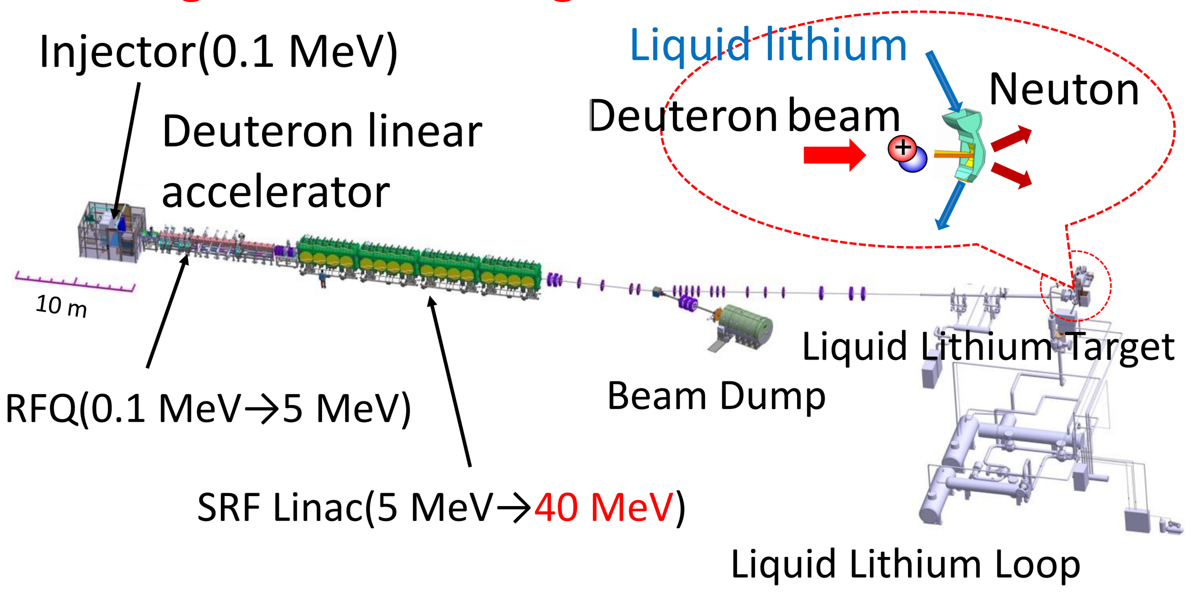
- We established a conceptual design of Advanced Fusion Neutron Source (A-FNS). In order to obtain irradiation data required in qualifying materials of fusion DEMO DT reactor, we newly designed nine test modules (TMs) based on a 'horizontal maintenance method integrated with the shielding plug'.
- We are to perform multipurpose usage by using huge amounts of neutrons.

## 1. BACKGROUND / INTRODUCTION

- In the Japanese Project of development of fusion power plant, one of the key milestones is to acquire initial irradiation data on the fusion DEMO DT reactor materials by using a fusion neutron source around 2035.
- Obtaining irradiation data is required on the followings; (1)blanket materials, (2)divertor material, (3)tritium behaviour and nuclear property in blanket, (4)diagnostic and control devices. We plan to construct A-FNS in Rokkasho.
- Critical issues in the A-FNS design are to establish a concept of the test modules for acquisition of the irradiation data while enabling remote maintenance of the test modules, and to achieve multipurpose usages.

## 2. BASIC SPECIFICATION, SITE AND BUILDING DESIGN

The A-FNS facilities are planned to be placed in the area adjacent to Rokkasho Fusion Institute of QST. The site is estimated to be 400 – 500 m in width, around 400 m in length and around 17 hectares in area. The A-FNS main building is 179 m in length, 112 mm in width and 48 m in vertical direction.

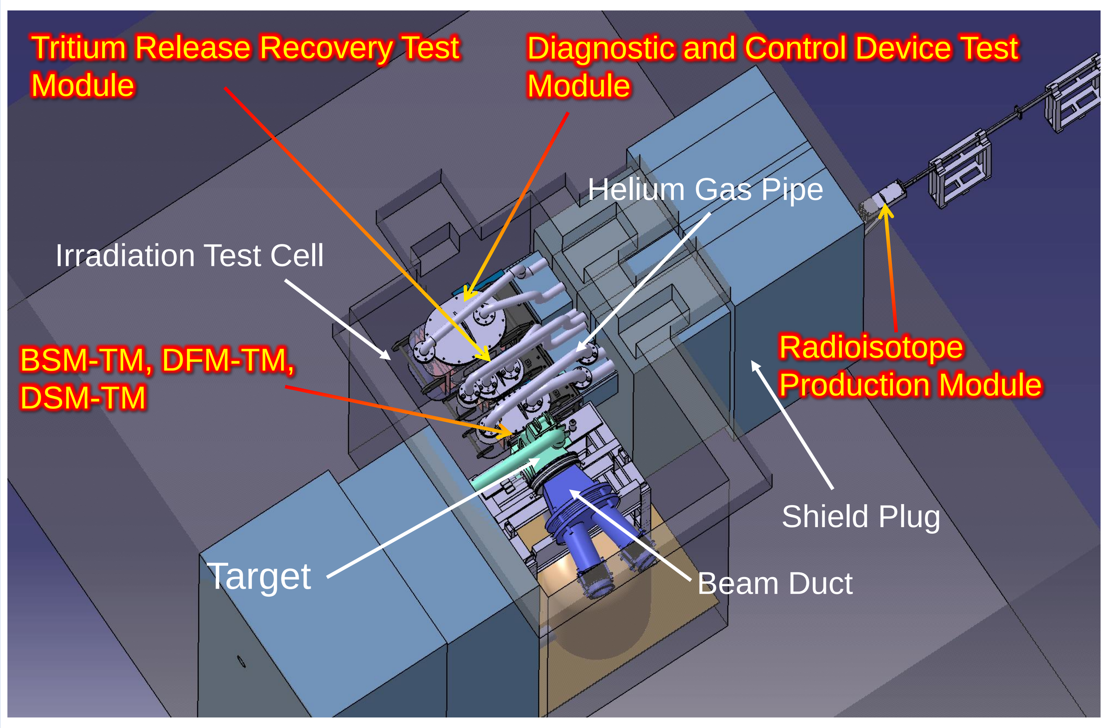


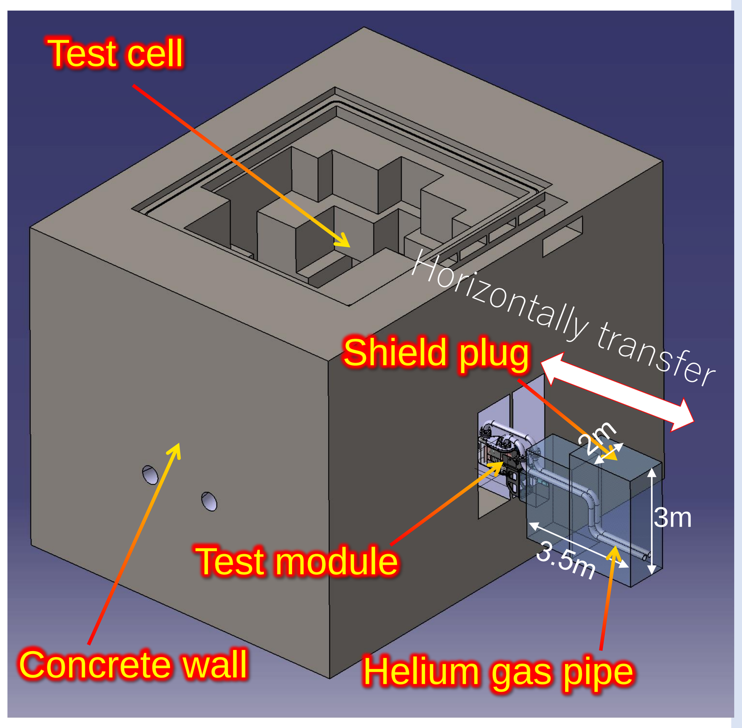

| | |
|---|---|
| Ion beam | Deuteron |
| Incident energy | 40 MeV |
| Incident current | 125 mA |
| Beam footprint | 200mm$^W$x50mm$^H$ |
| Target | Liquid lithium |
| Target temperature | 250 ℃ |
| Target thickness | 25 ± 1 mm |
| Target velocity | 15 m s$^{-1}$ |
| Neutron intensity | 6.8 x 10$^{16}$ n s$^{-1}$ |

*Conceptual view of accelerator and target in A-FNS, and main basic parameter*

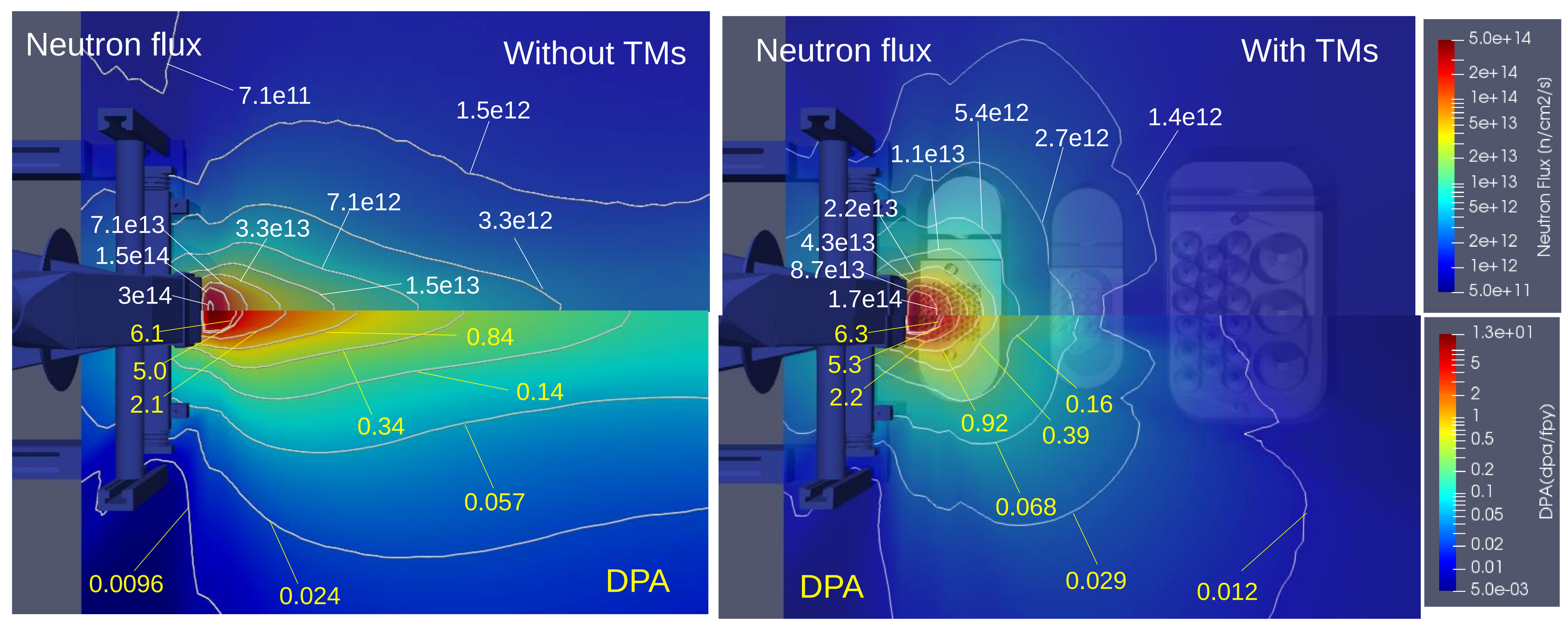
## 3. TEST FACILITY DESIGN

Test Modules (TMs) are installed in the test cell. We established new conceptual designs on the nine TMs; Blanket Structure Material TM (BSM-TM), Divertor Functional Material TM (DFM-TM), Blanket Functional Material TM (BFM-TM), Activated Corrosion Production TM, Tritium Release TM, Creep Fatigue TM, Diagnostic and Control Device TM, Blanket Nuclear Property TM, Neutron Flux Measurement Module. We designed them based on a new maintenance scheme: 'horizontal maintenance method integrated with the shielding plug'. We evolved the arrangement on each of the test modules to make it possible to acquire a variety of the irradiation data at the same time.



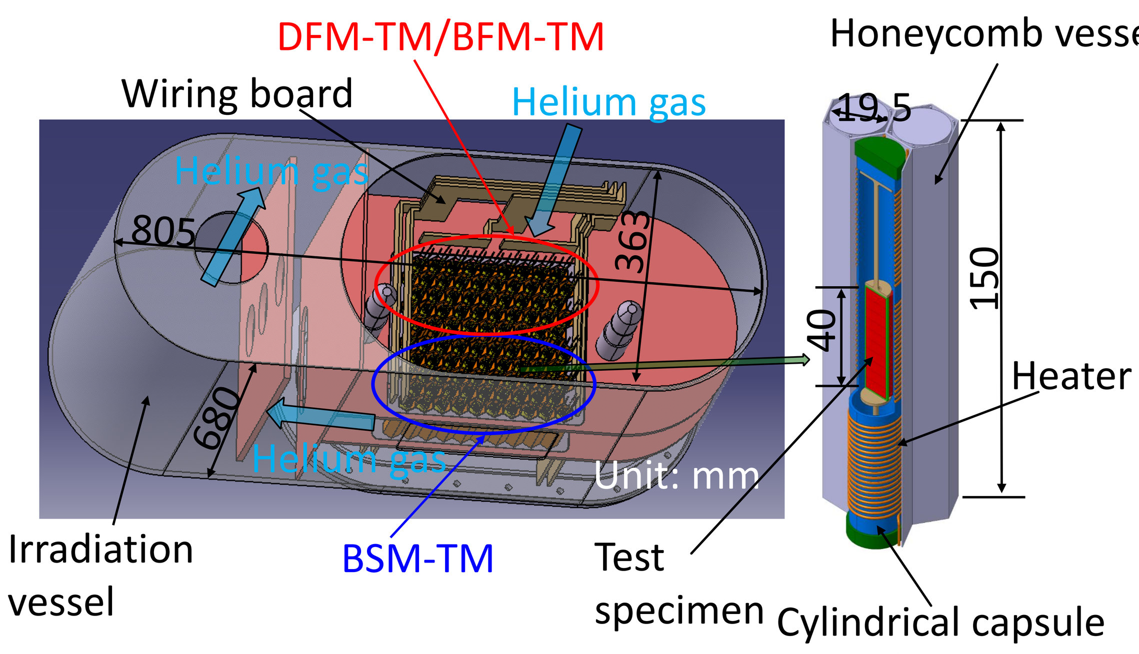

*Conceptual view of test cell in A-FNS Conceptual view of maintenance scheme*



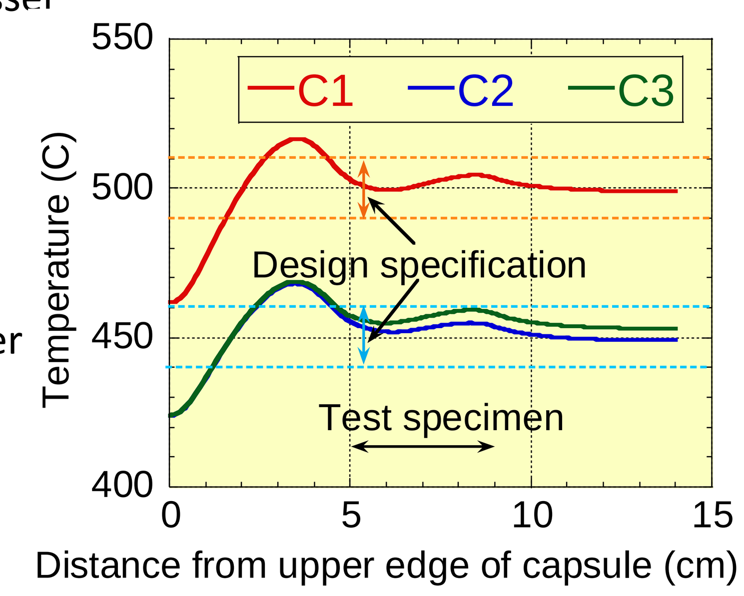

*Neutron flux and neutron displacement damage in the A-FNS test cell*

## 4. TEST MODULE DESIGN

BSM-TM, DFM-TM and BFM-TM are installed in a single irradiation vessel of a race-track shaped box structure. The test specimens are inserted in the cylindrical capsules. By conducting FEM thermal analyses, we designed the TMs which could satisfy the design specification on the irradiation temperature.

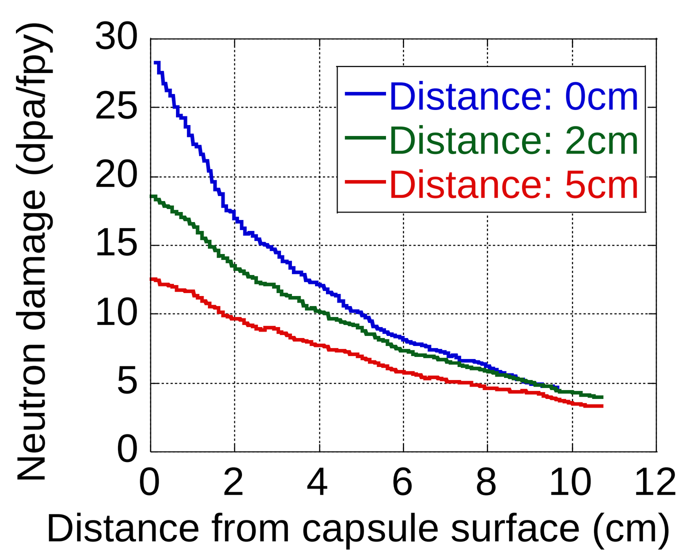



*Conceptual view of BSM-TM/DFM-TM/BFM-TM*

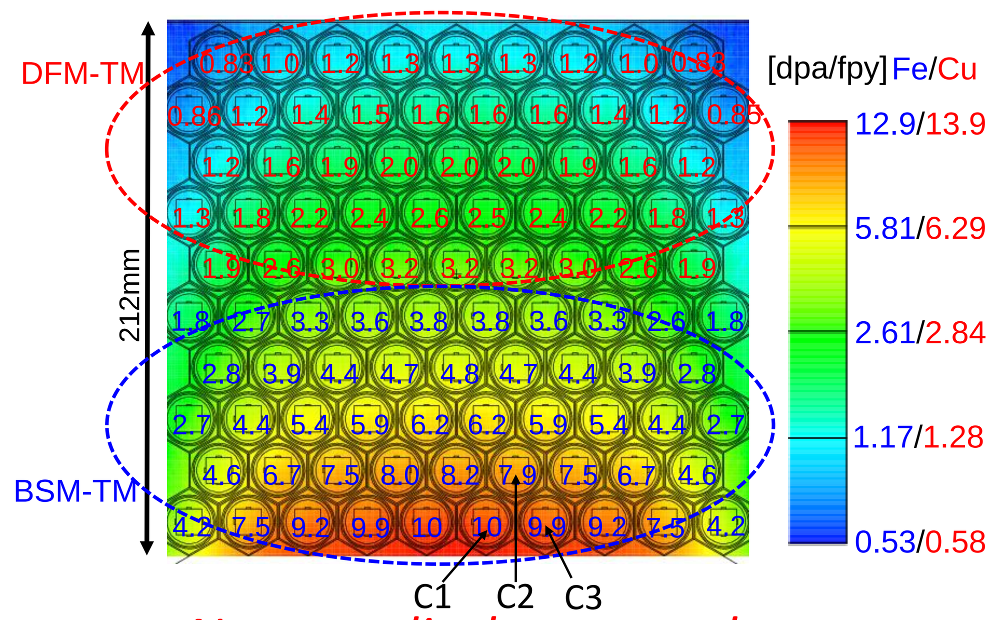



*Temperature in capsule center*

We designed that the closest capsules were placed at 5 cm distance from the target from both viewpoints of uniformity of the dpa distribution in capsule and the maintenance by the remote handling means. The maximum dpa of F82H and Cu were found to be about 10dpa/fpy and 3.2dpa/fpy, respectively, which are designed to fulfil critical requirements for the initial irradiation campaign, namely 20dpa for F82H and 10dpa for Cu, by accumulated irradiation for 2 - 3 years which mean 4 – 6 years operation periods.




*Neutron displacement damage as a function of distance from capsule surface*



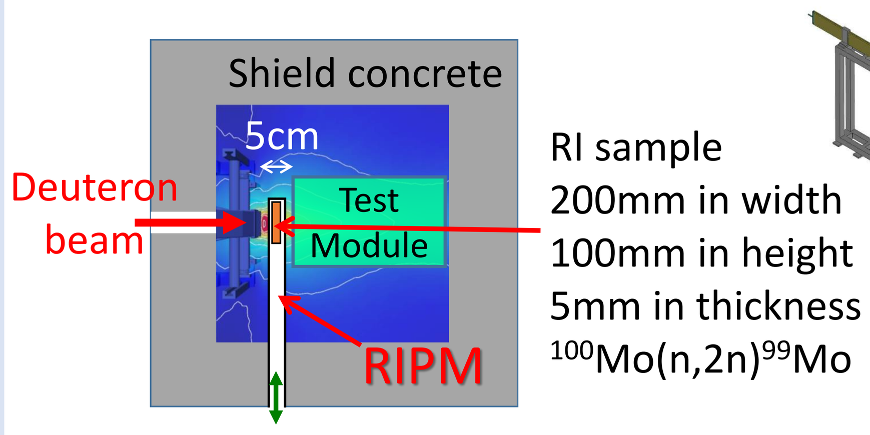

*Neutron displacement damage map in the BSM-TM and DFM-TM*

## 5. TRITIUM MIGRATION

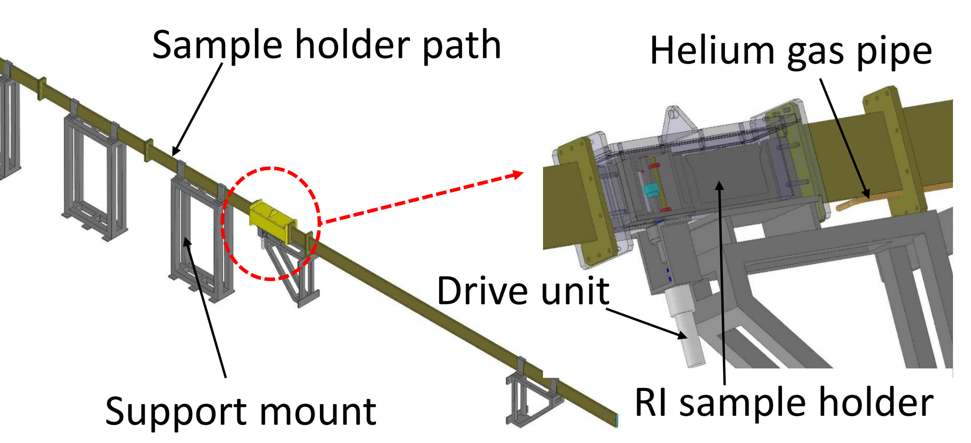
Radioactive materials such as tritium, beryllium-7, etc, are generated in the A-FS. One of critical issues is tritium treatment for radioactive materials. We carried out preliminary estimation of tritium migration for the lithium target system. It was found that $10^5 m^3/h$ of continuous ventilation and a couple of $30 m^3$ drainage tanks for weekly wastewater discharge were needed.

## 6. RADIOACTIVE ISOTOPE PRODUCTION MODULE (RIPM)

We could established RIPM by inserting it in the space between the target and the TMs. By applying the reaction of $^{100}Mo(n,2n)^{99}Mo$, we can produce $^{99}Mo$ of 83TBq, which can almost satisfy the demand in Japan (84TBq for one week), for medical RI with three-days irradiation. RIPM is transferred to the access cell during neutron irradiation by remote handling with the transfer unit. Decrease of the DPAs is only 1%, and we can achieve a good balance between the irradiation tests on the fusion reactor materials and the multipurpose usage.




*Conceptual view of RIPM*




*Conceptual view of transfer unit for RIPM*

## CONCLUSION

- We established a conceptual design of the A-FNS.
- In order to acquire the initial irradiation data on the fusion reactor materials required for DEMO reactor around 2035, we newly designed nine TMs based on a 'horizontal maintenance method integrated with the shielding plug'.
- We designed the RI production module which could fully produce large amounts of radioisotopes for medical and industrial use.