Irradiation Plans for Various Fusion Materials using A-FNS

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Background

JAPANESE ROADMAP TOWARD FUSION DEMO REACTOR

Fusion Neutron Source

～2020～ Intermediate C&R	～2025～ Intermediate C&R		～2035～ C&R	
Conceptual design	Technology demonstration & engineering design	Construction	Fusion neutron irradiation test	Fusion neutron irradiation test

Acquisition of irradiation data

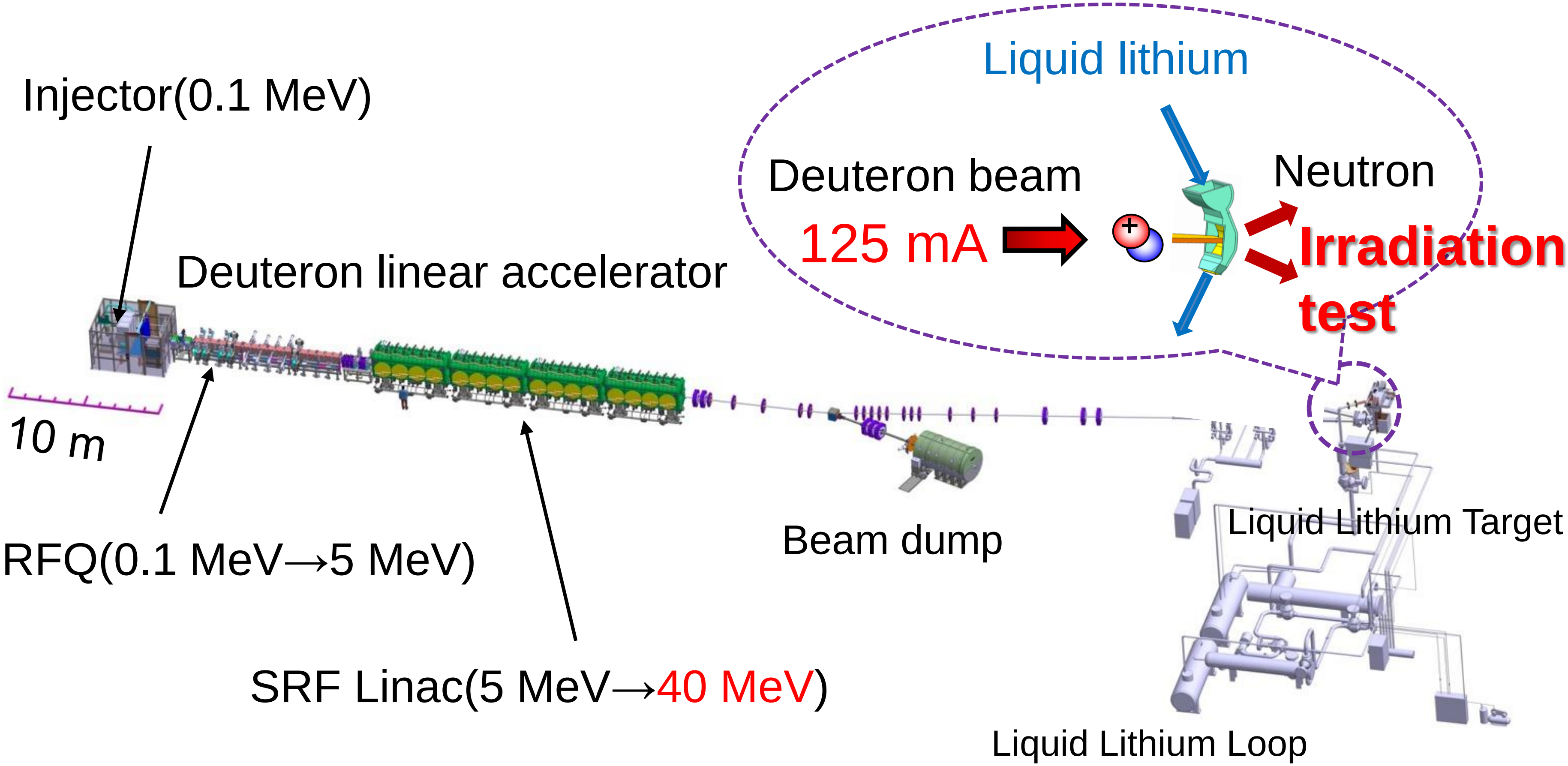
ITER project
JT-60SA
DEMO R&D
Blanket development

C&R

Decision to transition on DEMO

Construction & operation of DEMO

Overview of A-FNS



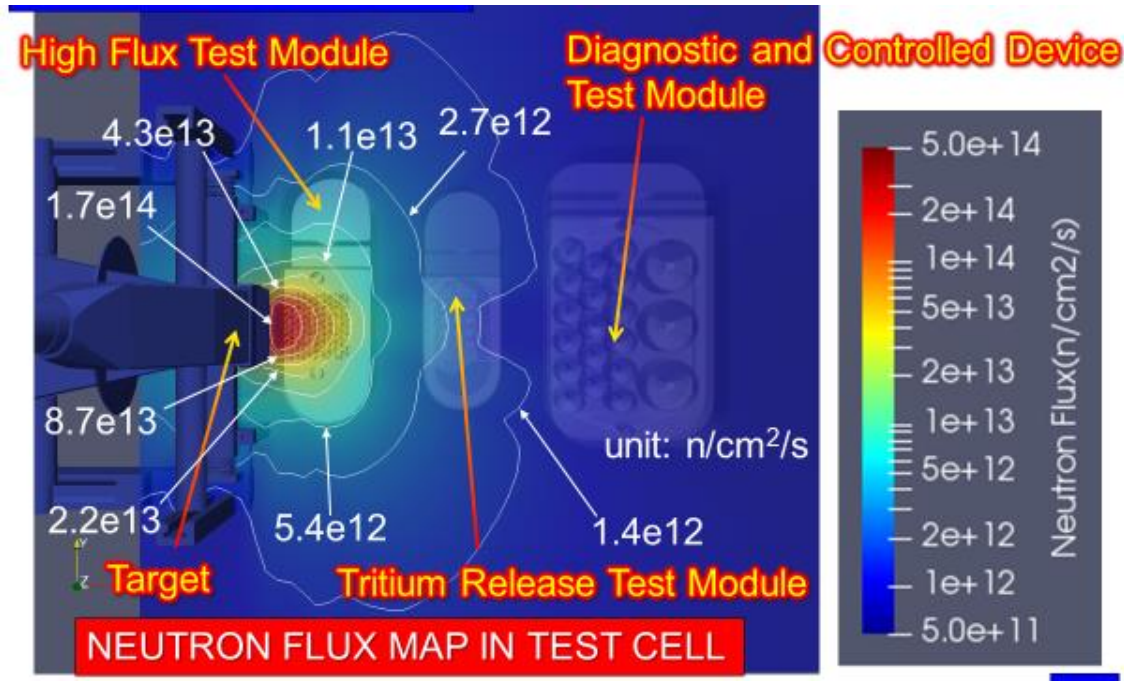
A-FNS is planned to be constructed in Rokkasho, and the neutron irradiation tests are to be conducted on the DEMO reactor materials. It is composed of accelerator facility, lithium target loop facility, irradiation test facility, post irradiation examination facility.

Main parameters of A-FNS

Ion beam	Deuteron
Incident energy	40 MeV
Incident current	125 mA
Beam width	200 mm
Beam height	50 mm
Target	Liquid lithium
Target temperature	250 degree C
Target thickness	25±1 mm
Target velocity	15 m s^{-1}
Neutron source intensity	6.8×10^{16} n s^{-1}
Neutron flux at back plate	6.0×10^{14} n cm^{-2} s^{-1}

The neutron generation rate and energy spectrum are almost the same as those of DONES, but in the case of A-FNS, the beam is considered to be vertically injected.

Neutron flux field in Test Cell of A-FNS



Irradiation plans

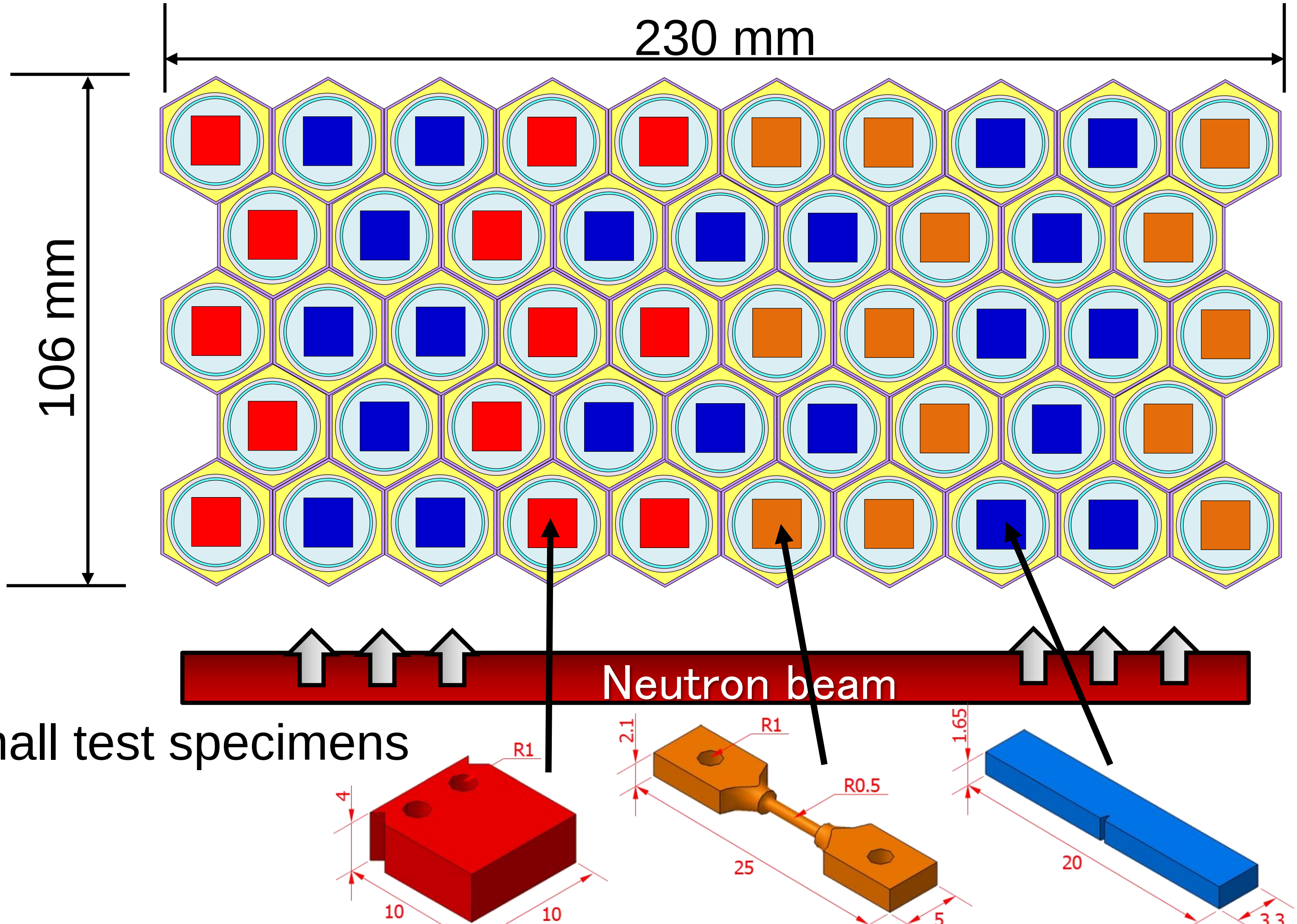
In discussion with JA experts in reactor materials and DEMO design, the following contents were categorized by neutron field strength.

List of Neutron Irradiation Plan in A-FNS.

Region	Test Module	Materials
High Flux	Blanket Structural Material	RAFM (F82H)
	Divertor Functional Material	RAFM, W, Cu
	Blanket Functional Material	$Be_{12}V$, $Be_{13}Zr$, $Be_{12}Ti$, etc Li_2O, Li_2TiO_3, etc.
Middle Flux	Tritium Release Test Module	BS+BFM for tritium recovery
	Creep Fatigue Test Module	RAFM (F82H)
Low Flux	Diagnostic Controlled Device	MI, Mo, W, etc
	Blanket Nuclear Property	BS+BFM for neutronics
	Neutron Flux Measurement	Activation foils, etc
(Others)	Medical RI production*	Mo for Mo-99

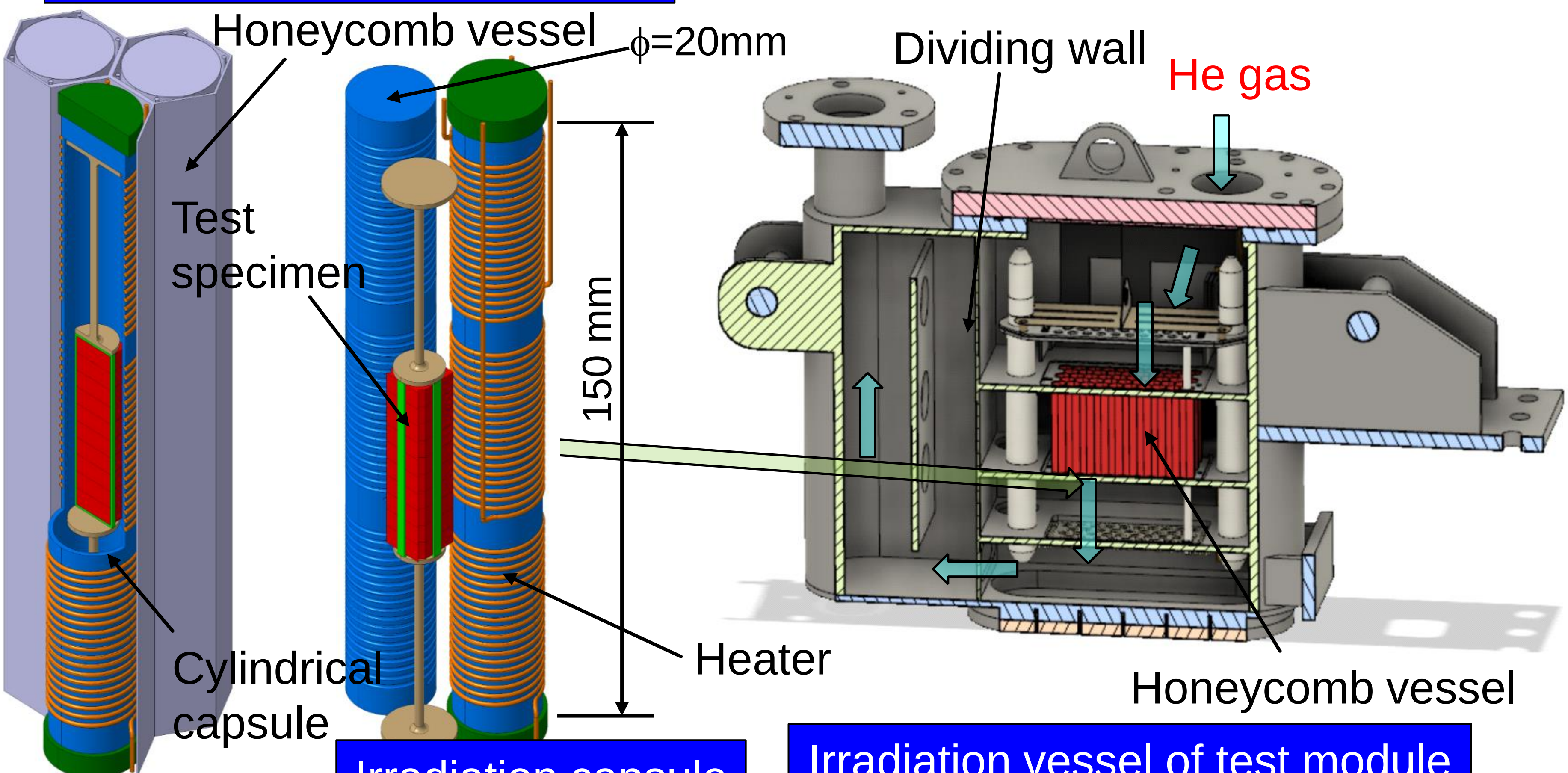
**Applications from M. Ohta (QST) at Session 6 in this Conf.*

Blanket Structural Material in HF(1/4)



Blanket Structural Material in HF(2/4)

STRUCTURAL DESIGN



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.

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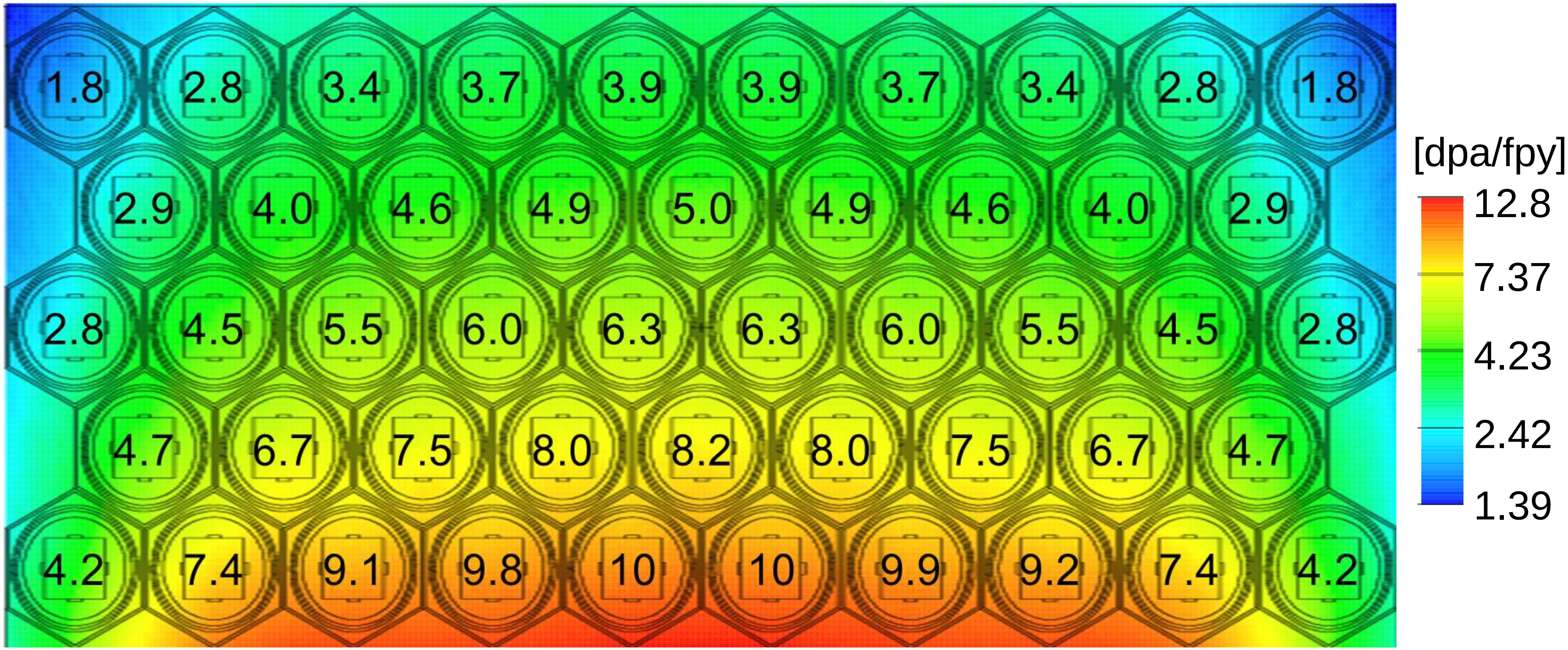
NUCLEAR DESIGN

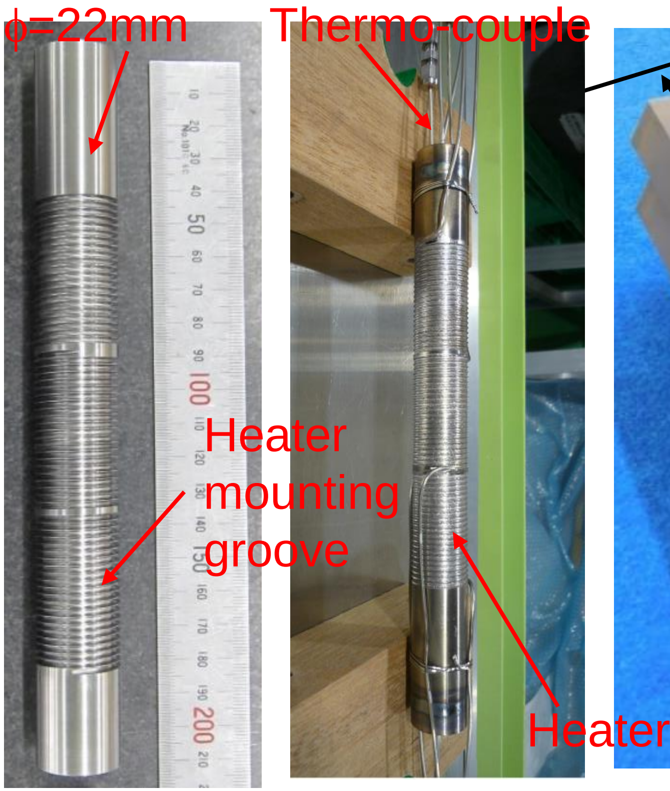


Beam footprint: 200^{W}mm

Maximum DPA of F82H specimens in the BSM-TM is about 10 dpa/fpy.
By conducting irradiation for two years, we can acquire initial irradiation data, 20 dpa.
In case of the operation availability of 50%, four years are required to acquire 20 dpa .

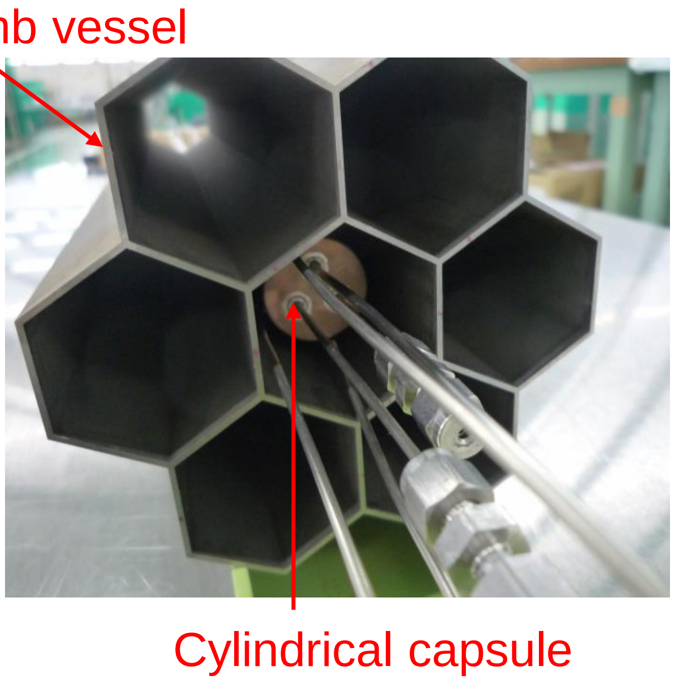
Blanket Structural Material in HF(4/4)

FABRICATION TEST



Cylindrical capsule

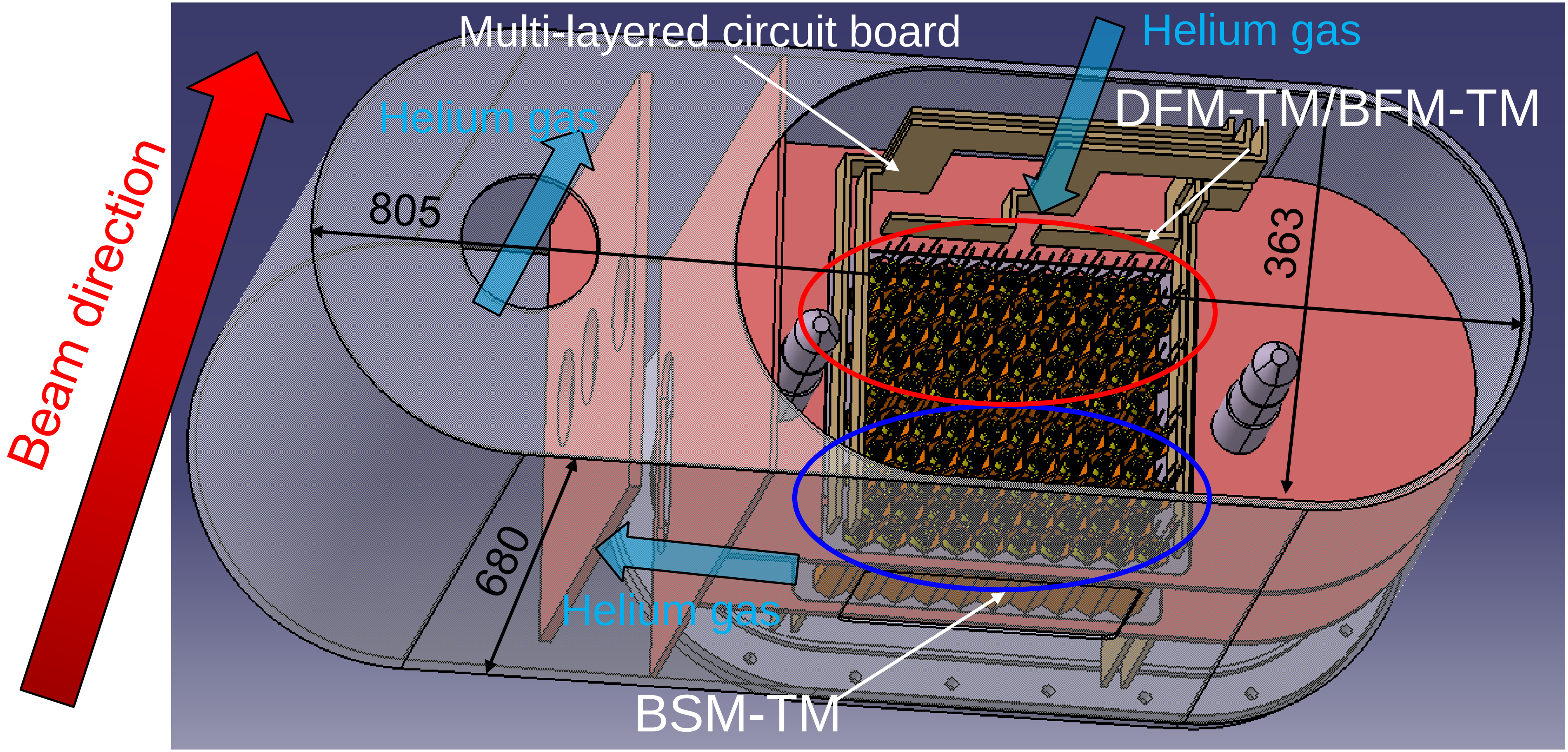
Honeycomb vessel



Combination test of cylindrical capsule and honeycomb vessel

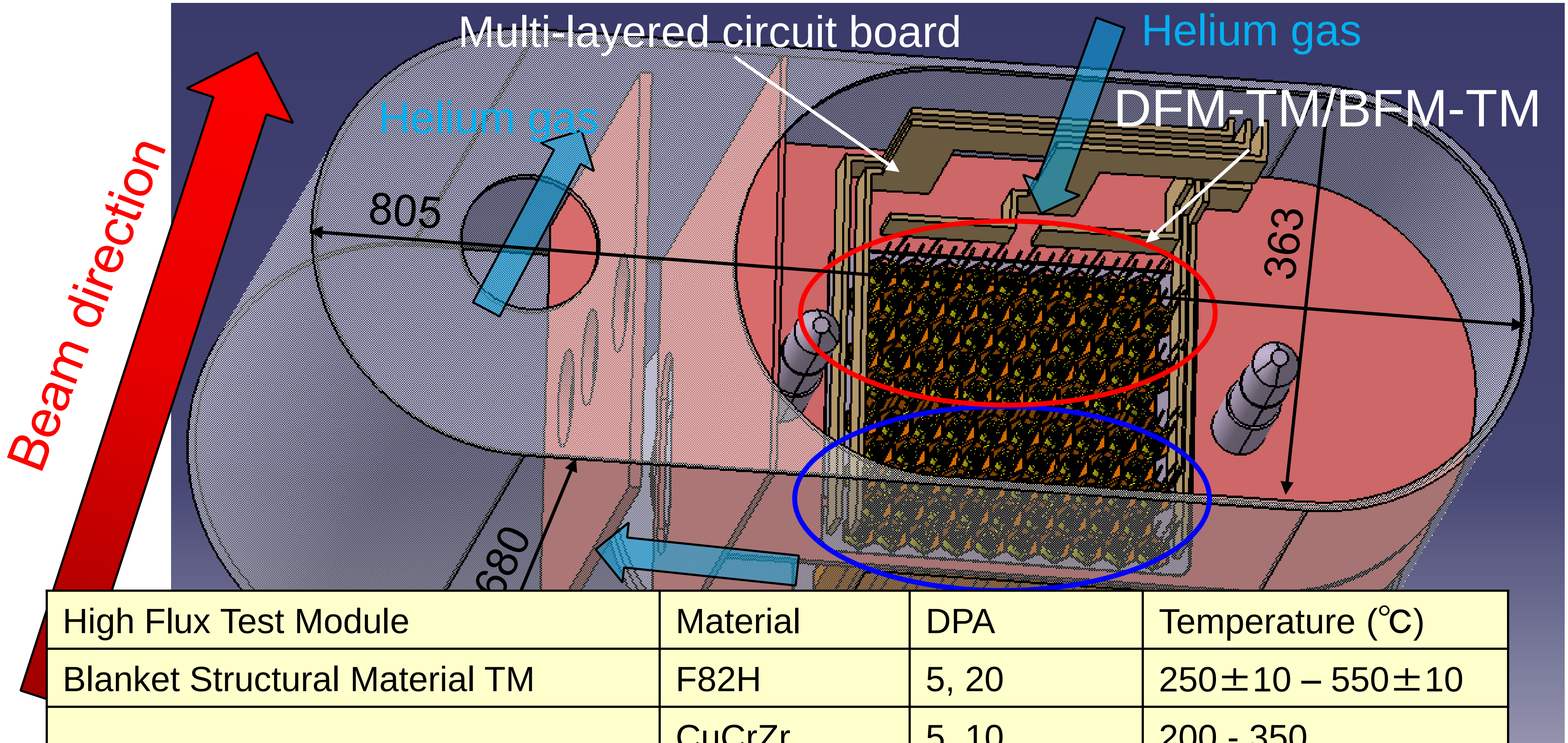
Dimensional inspection, X-ray inspection, helium leak test, heater energization test, and combination test of cylindrical capsule and honeycomb vessel were carried out to confirm tolerance, manufacturing accuracy, and soundness of welded parts. We demonstrated the technical prospects and design validity of the production of honeycomb cylindrical capsule.

Divertor Functional Material in HF (1/3)



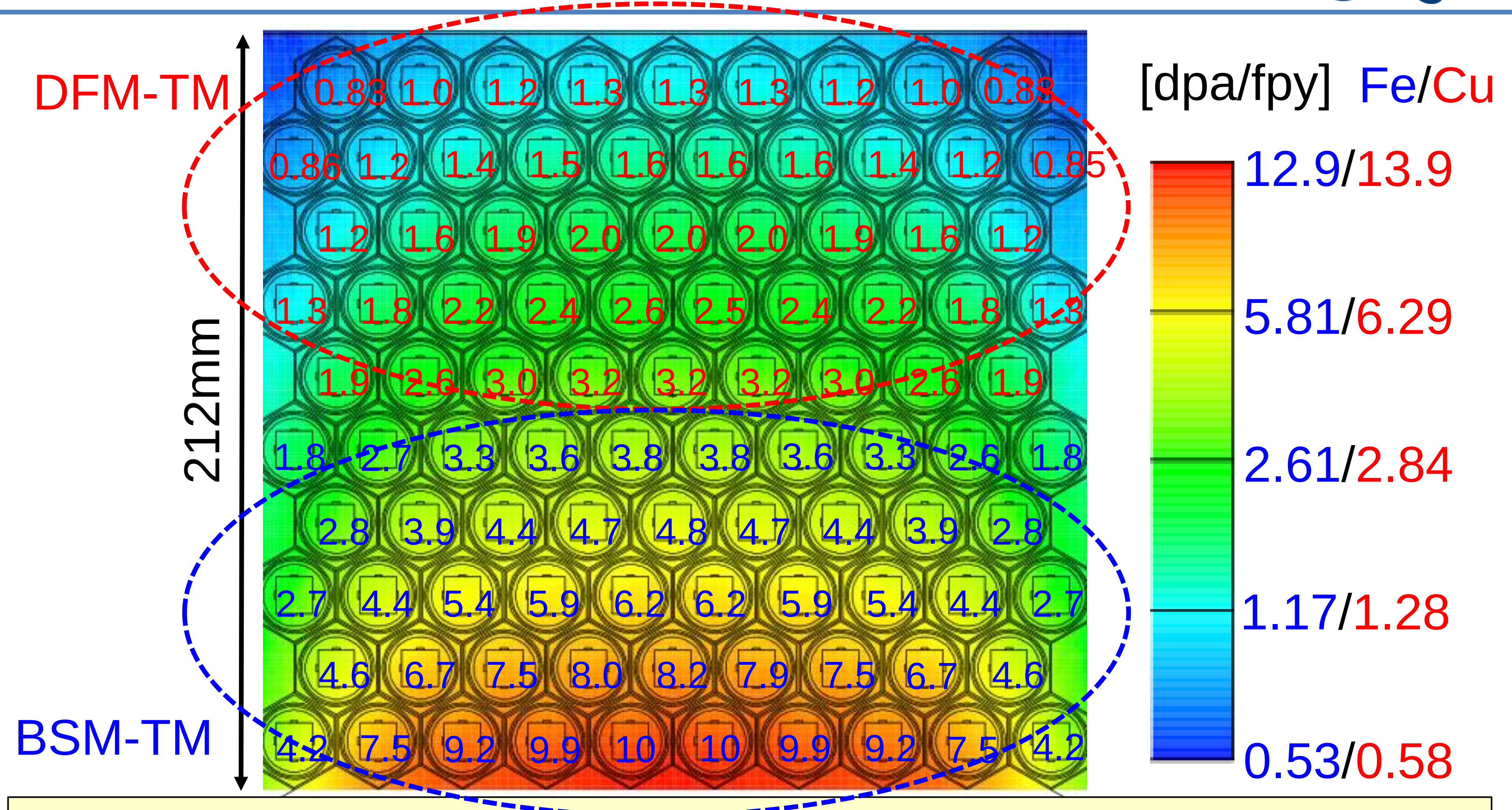
BSM-TM, DFM-TM and BFM-TM are installed in a single irradiation vessel. BSM-TM is located on the side facing the lithium target, and DFM-TM or BFM-TM are located behind BSM-TM. Test specimens on the divertor and blanket functional materials are installed in the cylindrical capsules same as ones in BSMTM.

Divertor Functional Material in HF (2/3)



High Flux Test Module	Material	DPA	Temperature (℃)
Blanket Structural Material TM	F82H	5, 20	250±10 – 550±10
Divertor Functional Material TM	CuCrZr	5, 10	200 - 350
	OFC	5, 10	400
	Tungsten	2, 6, 10	400 - 1200
Blanket Functional Material TM	Be, Be alloy	TBD	300 - 1000
	Li2TiO3	TBD	300 -1000

Divertor Functional Material in HF (3/3)



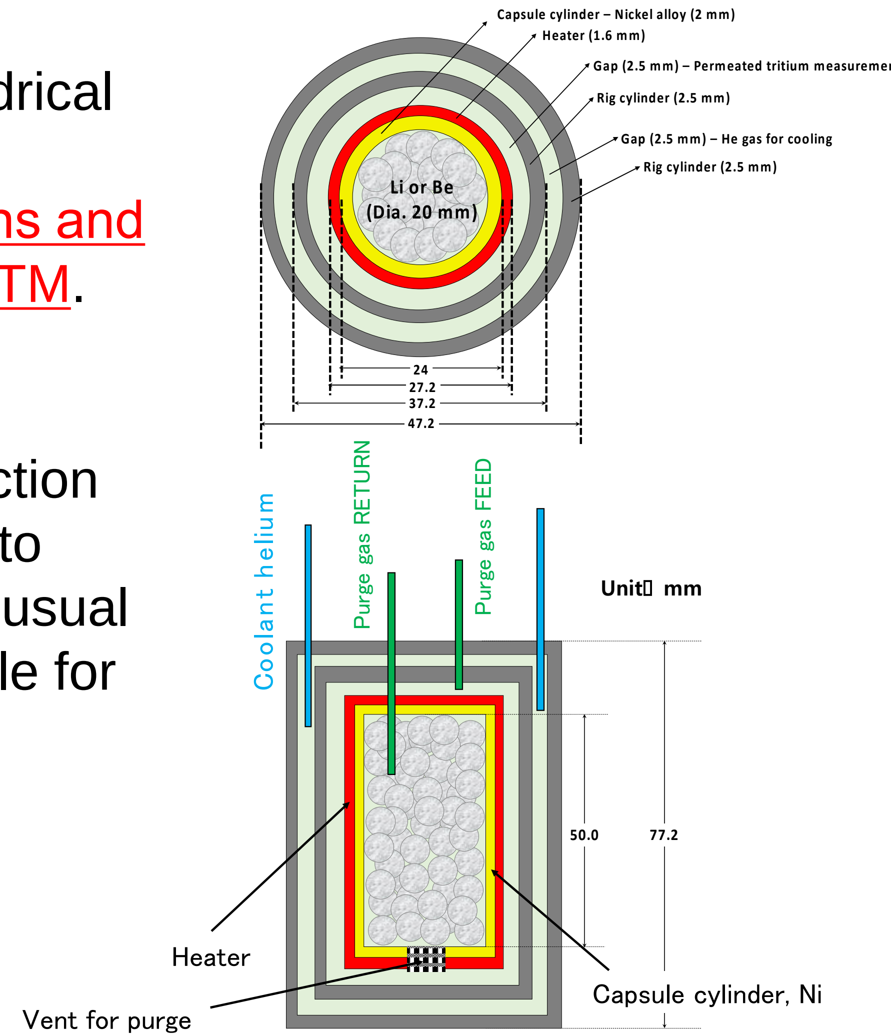
Maximum neutron displacement damage of Cu specimens is about 3 dpa/fpy, fulfilling requirements for acquiring the initial irradiation data by accumulated irradiation for three years. In the case of the operation availability of 50%, six years are required to acquire 10 dpa for Cu.

Tritium Release Test Module in MF

Purpose: Evaluation of tritium release and recovery properties of fusion DEMO blanket functional materials with in-situ tritium measurement

Design Feature: 16 capsules of cylindrical rig in the rectangular frame. See the BFMTM's table for irradiation conditions and the Sub-sys. cells for Test items of TRTM.

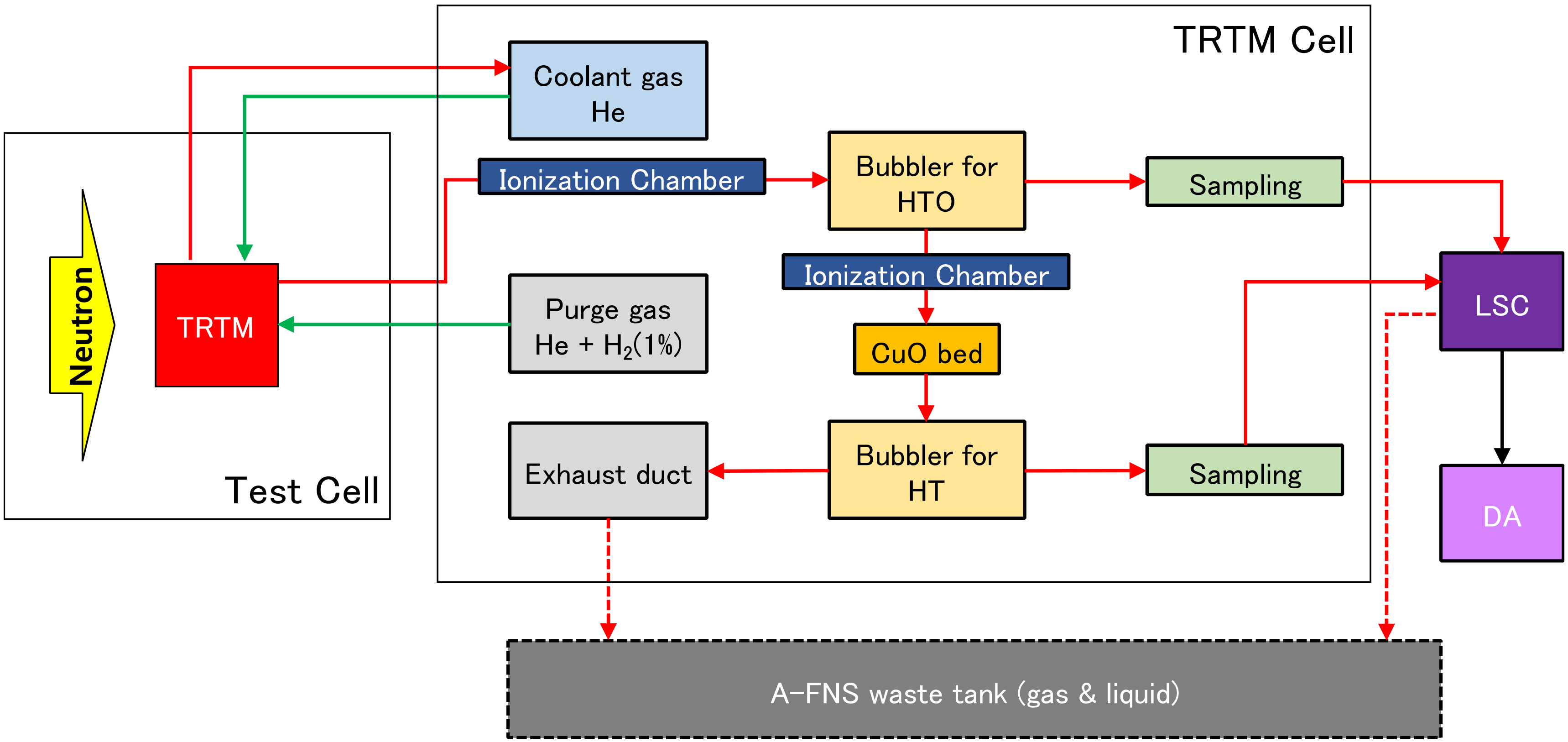
Nuclear response: Tritium (T) production rates of bulk Li and Be are from 1100 to 1600 and from 30 to 190 Bq/s, where usual ionization chambers would be available for online T measurements.



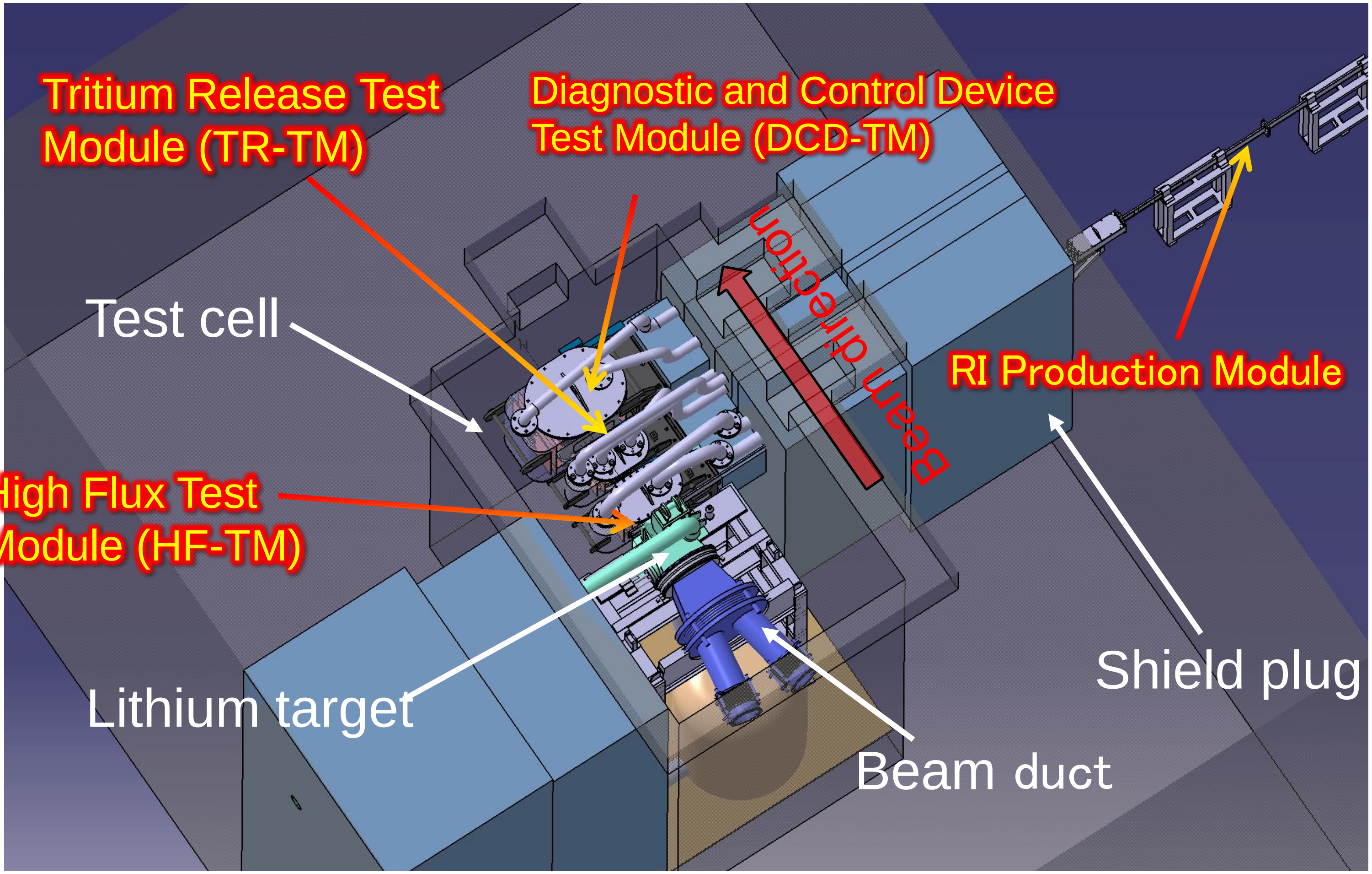
Tritium Release Test Module in MF (2/2)

Online experimental apparatus for TRTM

- He cylinders added H_2 for purge gas
- an ionization chamber for in-situ measurement of tritium released
- water bubblers for measurement of tritium recovered
- A sampling system for the water bubbler to measure tritium concentration directly using liquid scintillation counter (LSC).
- A copper oxide (CuO) fixed bed to oxidize HT



TM arrangement



From the lithium target, HF-TM(BSM-TM, DFM-TM, BFM-TM), TR-TM and DCD-TM are arranged to meet their tasks. ACP-TM and CF-TM are replaced with HF-TM and TR-TM, respectively. BNP-TM is installed in case without other test modules.

Summary

- ✓ The following content was presentedThe engineering design of the Japanese Fusion Neutronics Source A-FNS facility was initiated based on the Japanese DEMO design schedule.
- ✓ The specific irradiation plans in the HF, MF, and LF regions of the A-FNS have been studied from the conceptual design stage, and analysis and R&D are in progress.
- ✓ In A-FNS, the irradiation plans for material irradiation and blanket tritium and neutron engineering, as well as for measurement and control instruments, are being studied with high priority.
- ✓ A-FNS is also considering the application use other than fusion material irradiation.
- ✓ Modules and dedicated plugs are also under consideration for appropriate irradiation conditions and versatility of irradiation tests.