QST

Fusion/Rokkasho

Overview of A-FNS

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写真提供：
新むつ小川原株式会社

Outline

1. **Conceptual design report of A-FNS**
2. **Introduction for DEMO**
3. **Site and Building**
4. **Accelerator Facility**
5. **Li Target Facility**
6. **Irradiation Test Facility**
7. **Applications**
8. **Summary**

Conceptual design report of A-FNS

The CDR of A-FNS was completed based on a Plant Integration Document（PID）in March 2020.

	Item level 1	Level2
1	Introduction	History of fusion neutron source Necessity of fusion neutron source development Objectives and contents of this CDR
2	Advanced Fusion Neutron Source	Design requirements Basic specifications configuration of the system Scenario and operation plan
3	Infrastructure	Overview, Site condition, Main building of A-FNS, Electric power receiving equipment, Water and Supply and Drainage equipment-supply, Air conditioning
4	Sub-system design	Accelerator, Target, Test Facility, Modules, RH, Maintenance, Control, Safety, PIE, Activation storage and related facilities
5	Summary	
6	Prospective toward EDA	
	Appendix）Cost estimation	

https://www.qst.go.jp/site/archives/1109.html

Step for Realization of Fusion Energy

Past

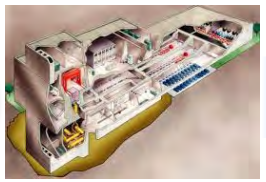
Plasma Physics

JT-60

Plasma Device

CDA of IFMIF under IEA

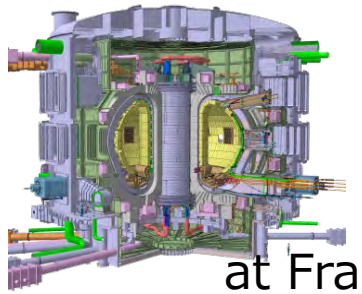
Neutron Source



Present

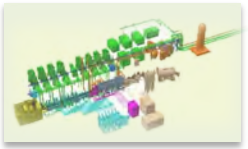
Fusion Energy

ITER



at France

Validation Design

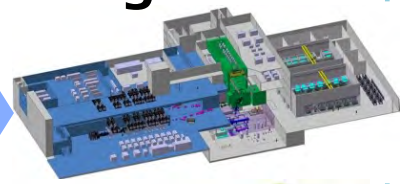


IFMIF/EVEDA

BA Activity

【Rokkasho】

Material Test using A-FNS



A-FNS

【Rokkasho】

Future

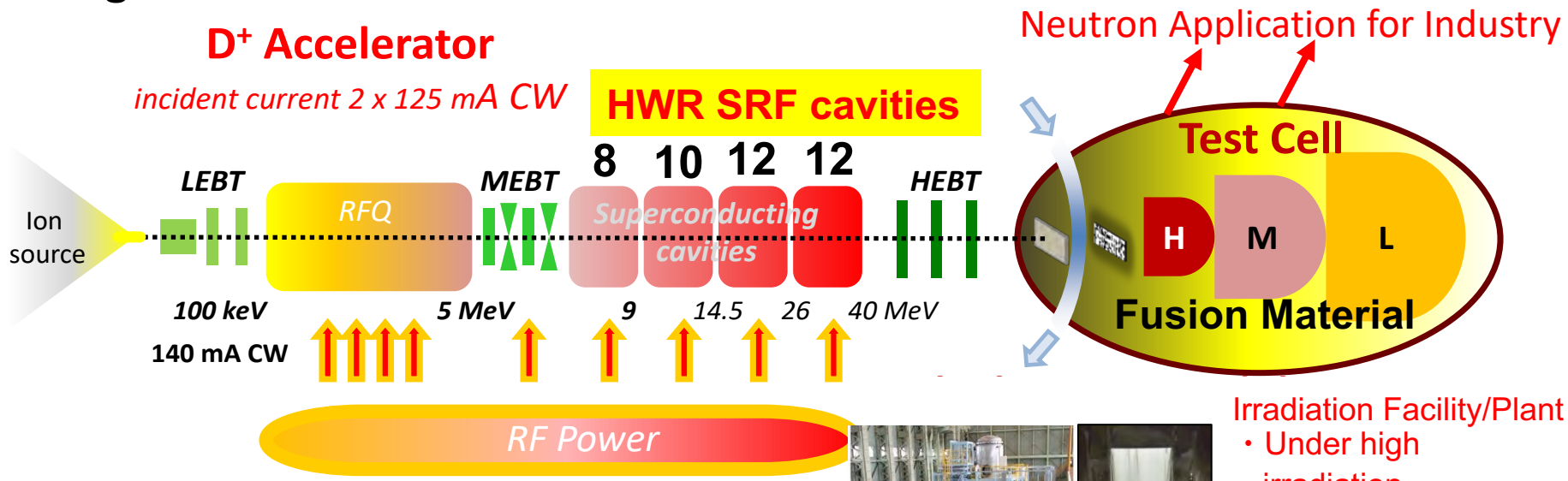
JA-DEMO

Electricity

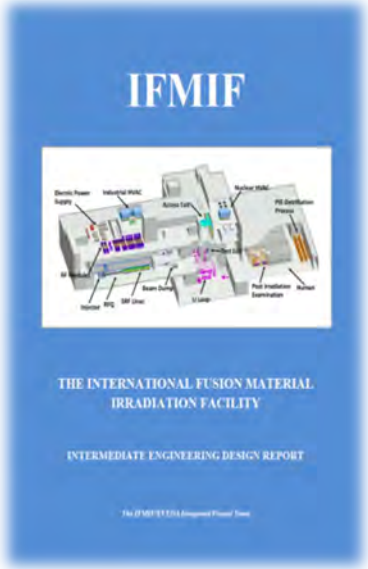
Accelerating DEMO by developing fusion materials

A-FNS configuration

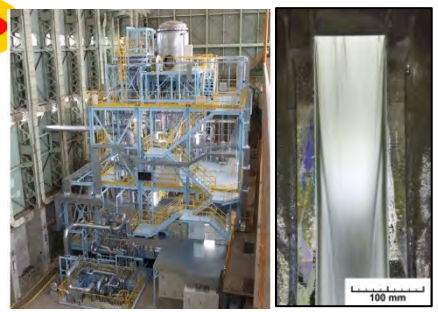
We have already started the conceptual design activity of A-FNS using of results of IFMIF/EVEDA.



Based on IFMIF EDR



Accelerator
- High current Accelerator
- CW/ steady-state operation
- high availability > ~70%



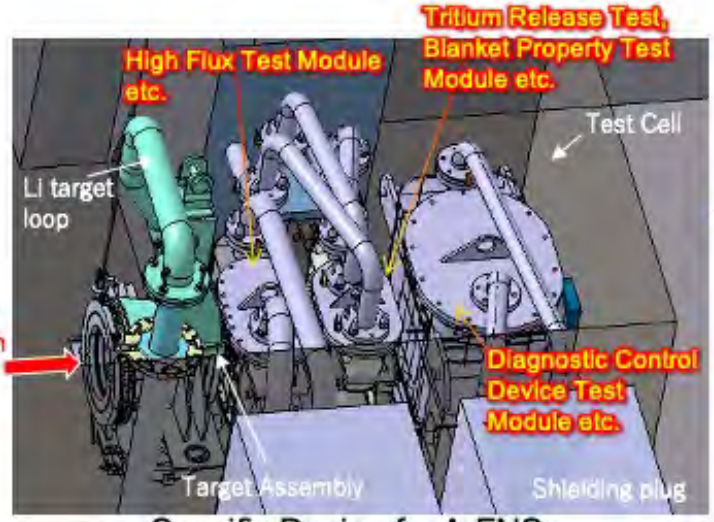
Target
- High flow of Liquid Li in Vacuum
- Pure Li control
- long life time (erosion, cavitation)

Irradiation Facility/Plant
- Under high irradiation
- Remote maintenance
- plant system

Design and R&D activities of A-FNS are steadily progressed.

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.**



Specific Design for A-FNS

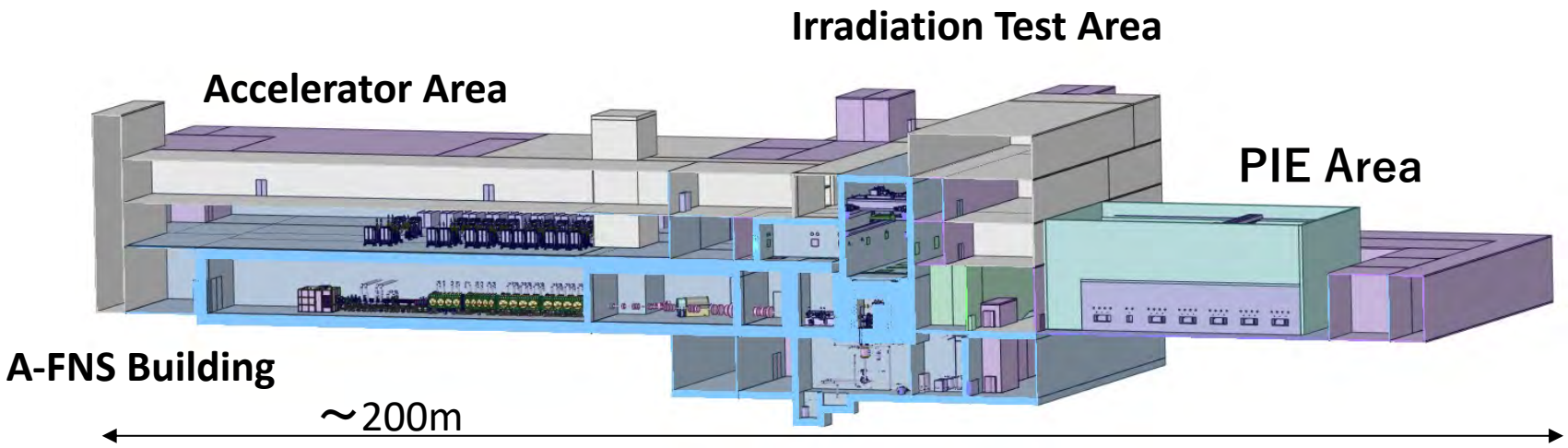
Beam	Particle	Deuteron
	Energy	40 MeV
	Current	125 mA (CW)
	Foot print	200 x 50 mm^2
	Incident angle	Normal
	Availability	88% (Target)
Target	Material	lithium Liquid target (jet)
	Temp.	250 ℃
	Velocity	10-15 m/s at target
	Thickness	25 mm
	Window	Free surface (no window)
Neutron	Intensity (at back plate)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

A-FNS facility & the Concept

- ✓ One line of IFMIF Accelerator（125mA）. Design will be based on IFMIF Engineering Report.
- ✓ Li Target loop is almost same of IFMIF/EVEDA. R&D. Purification validation will be done in BA Phase II.
- ✓ Many Irradiation modules will be proposed for Fusion Material Tests. This concept is Japanese original idea.
- ✓ Remote handling maintenance using side pull-out with all shielding plugs (Japanese Idea).
- ✓ Multi purpose Neutron Source for Industrial use.
- ✓ All Japan flamework with industry and university.

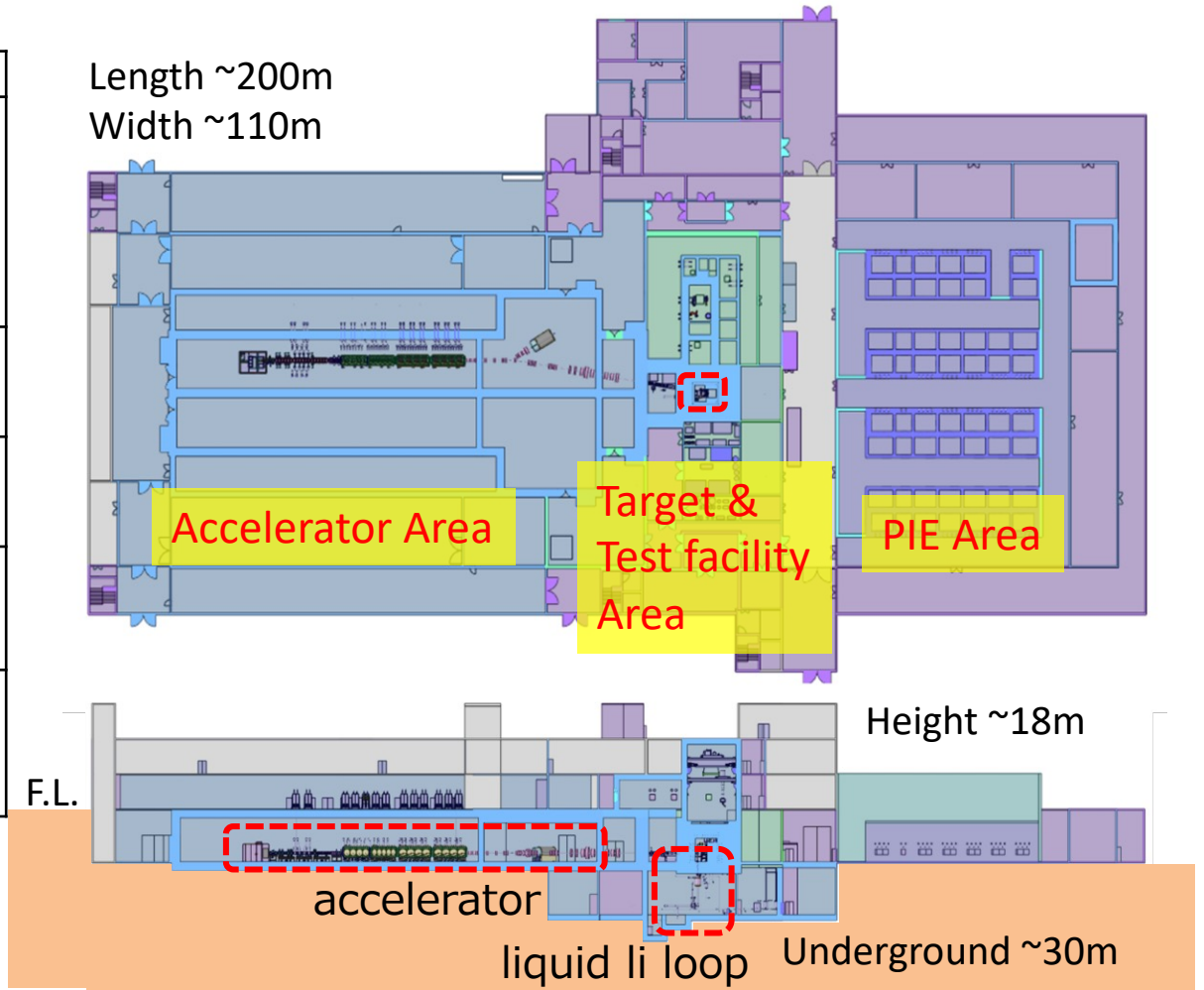


A-FNS main building

Basic conditions for the main building

Item	Overview	Remarks
building structure	basement structure floor area of 43,000 m from the basement floor to the third floor , a nd will include the accelerator , test area, and post-irradiation test a rea (PIE).	Separate air conditioning will be used for the accelerator, testing, and post-irradiation testing.
Seismic importance classification	class B	Earthquake resistance of equipment is set separately.
building structure	RC (reinforced concrete) structure or S (steel) structure	
Electricity consumption	57.7 MVA (60 MVA added) (Existing capacity 30MVA) 66kV power receiving	PIE and radioactive material storage.
Water usage	Secondary cooling water 1500 m^3 / day	Industrial water from Rokkasho Village will be used, but additional facilities will be required.

Lithium handling amount : max. 5 t (Twice as much as Oarai's ELTL)
(x 100 the legal specified quantity)
Other dangerous material : Heat transfer oil

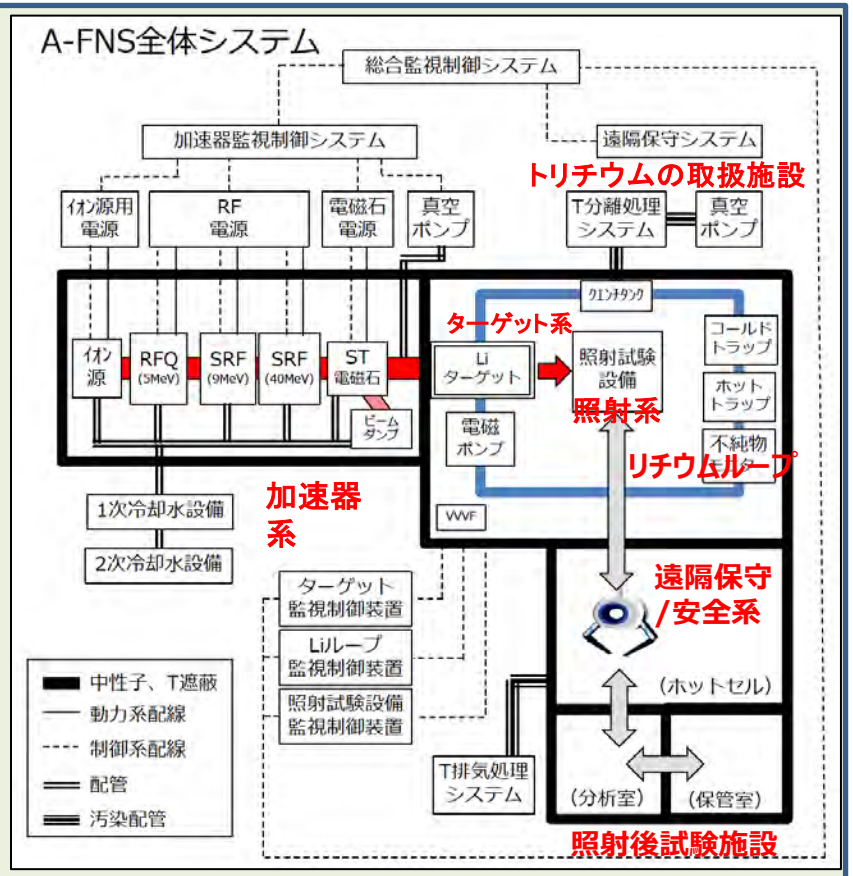


Special facilities to the regulations of both the RI and the Fire

Overall facility design

110 researcher , 85 technical staff , 75 administrative staff, and 120 users, approximately 400 in total .

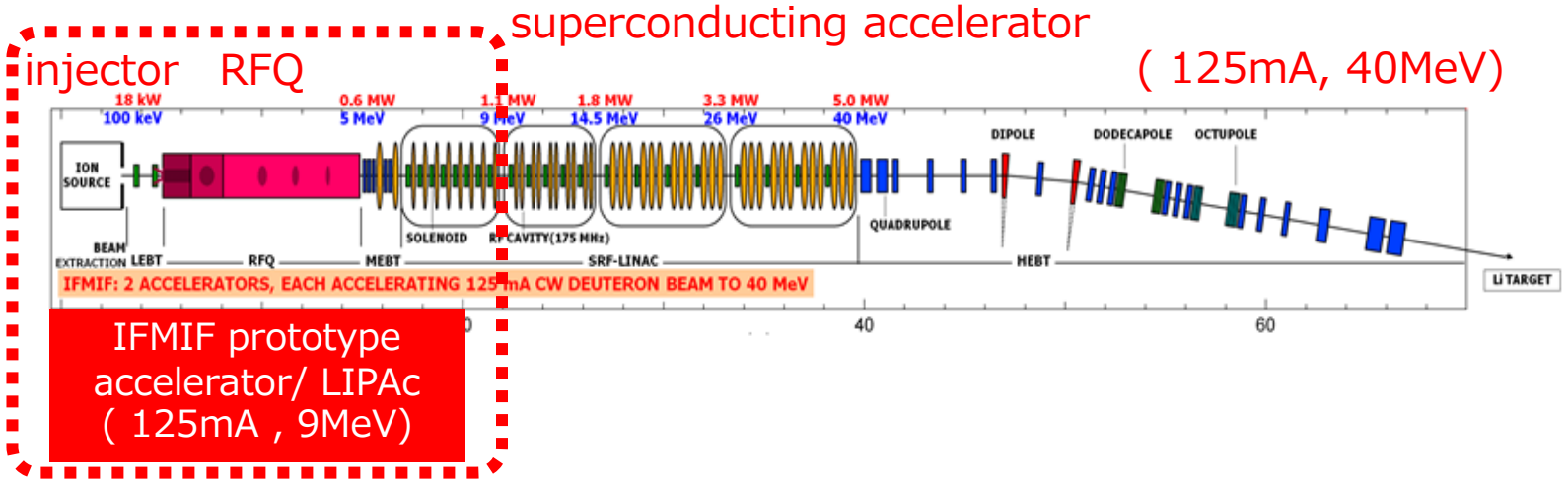
- Site maintenance
- Power receiving system
- Make-up water system
- Secondary cooling system
- Air conditioning system
- Wastewater treatment system
- Other buildings
- land development
- Other facilities



Facility layout

Accelerator System

“ The current design is Same as IFMIF accelerator



The requirements for accelerators are the same as IFMIF .

The current design is an IFMIF intermediate engineering design.

Based on

- 125 mA deuteron beam acceleration
- Future engineering demonstrations at
- High duty /CW operation, introduction of SRF Linac , Beam Availability

⇒ Improvements and overcoming issues at the engineering design level

Challenges that may require changes in conceptual design:

- Li vapor influence on SRF cavity ⇐ “ Liquid Li target ”
- Meeting beam loss rate requirements ⇐ “ Large current ” “ Deuteron ”

Li Target Facility

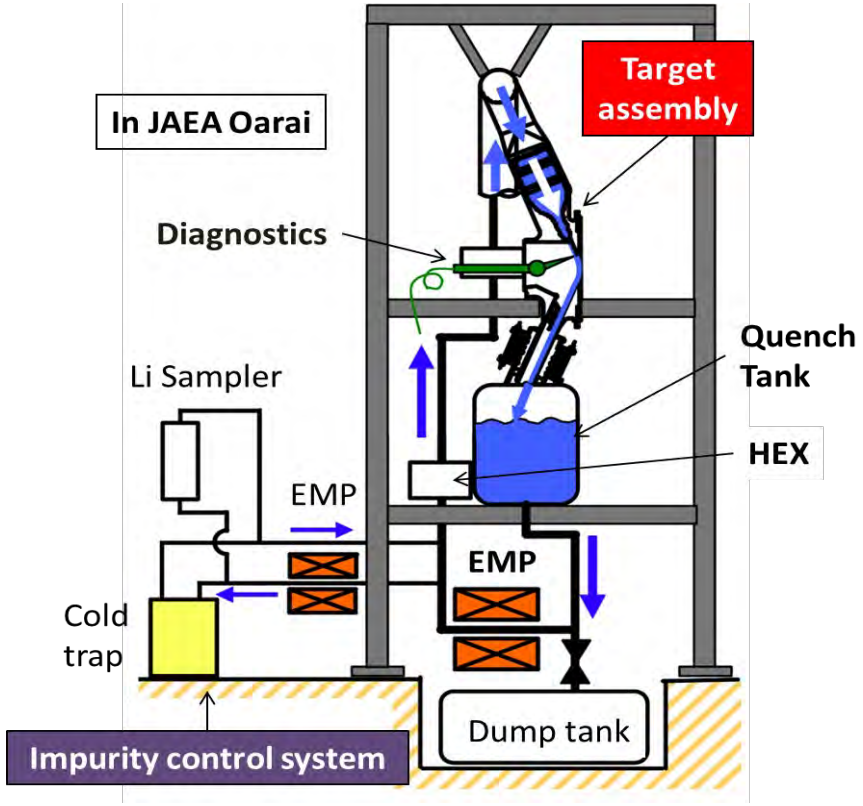
IFMIF/EVEDA Li Test Loop (ELTL) was designed and constructed
to validate the IFMIF Li target facility.

Mission

Validations of:
(1) Long time stable Li target
(2) Li target diagnostics
(3) Li purification (Cold Trap)

Design specification of the IFMIF Li target

Beam power	10 MW (1 GW/m^2)
Target speed	15 m/s (10 ~ 16 m/s)
Target width/thickness	260mm / 25 mm
Thickness variation	< ±1mm
Inlet Li temperature	250 °C (at the nozzle exit)
Vacuum pressure	10^{-3} ~ 10^{-2} Pa (Li free surface)

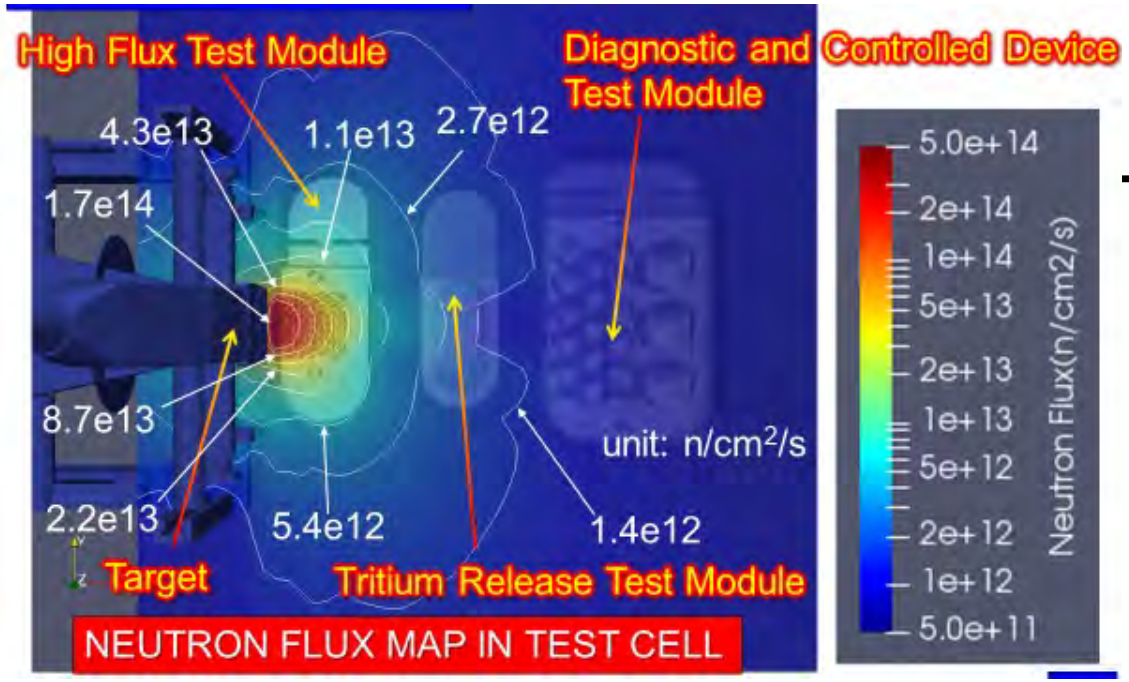


Schematic view of ELTL

Irradiation Modules and Test Facility

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.

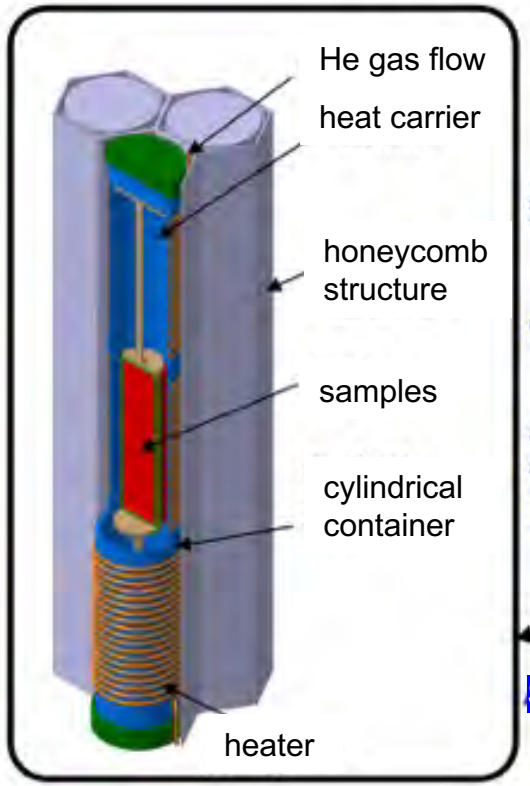
For Fusion Material Test

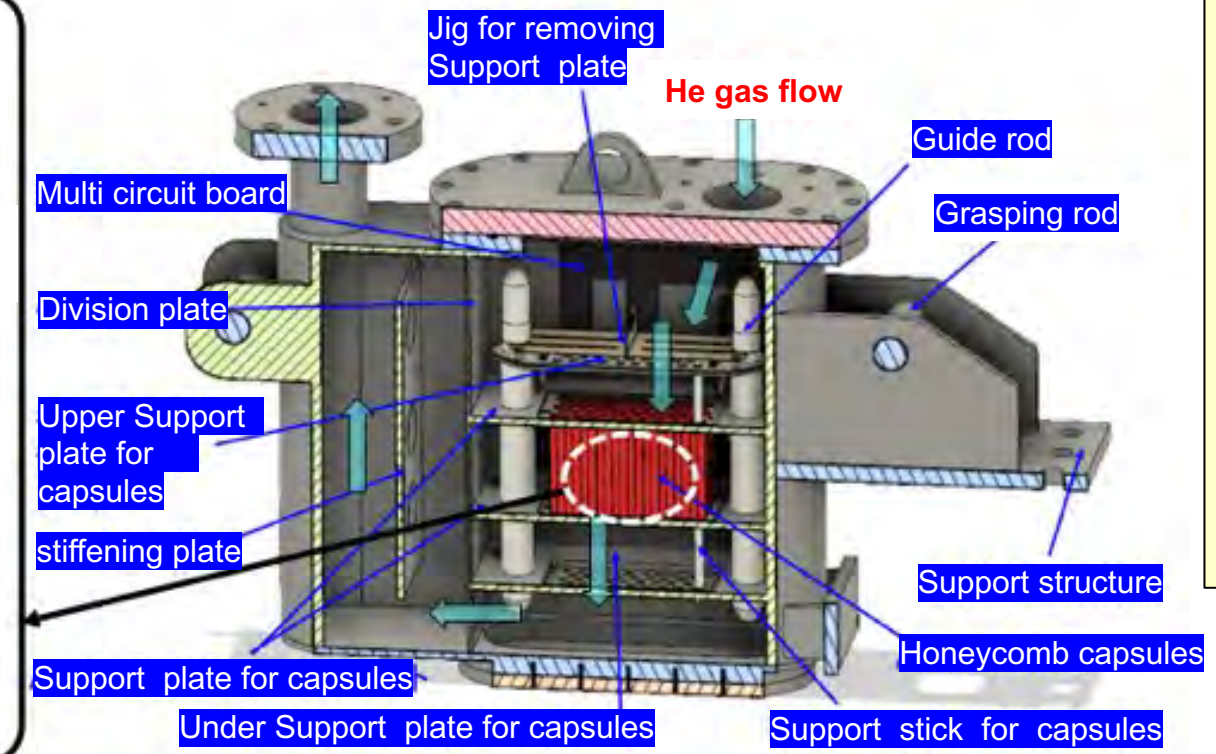
- Neutron flux measurement (NFM)
- Blanket structure material test (BSM)
- Blanket functional material test (BFM)
- Divertor functional material test (DFM)
- Active corrosion production (ACP)
- Tritium release test (TR)
- Creep fatigue test (CF)
- Diagnostic controlling device test (DCD)
- Blanket nuclear property test (BNP)

For Industrial Use

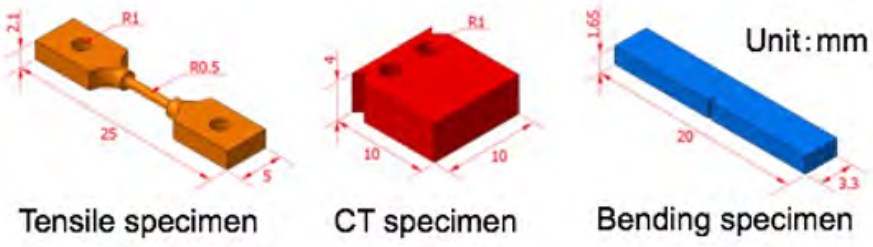
- RI production (RIP)
- Low Energy irradiation
- Neutron beam hole (NBH),
- Gas & liquid loop

Irradiation capsules and High Flux Test Module.





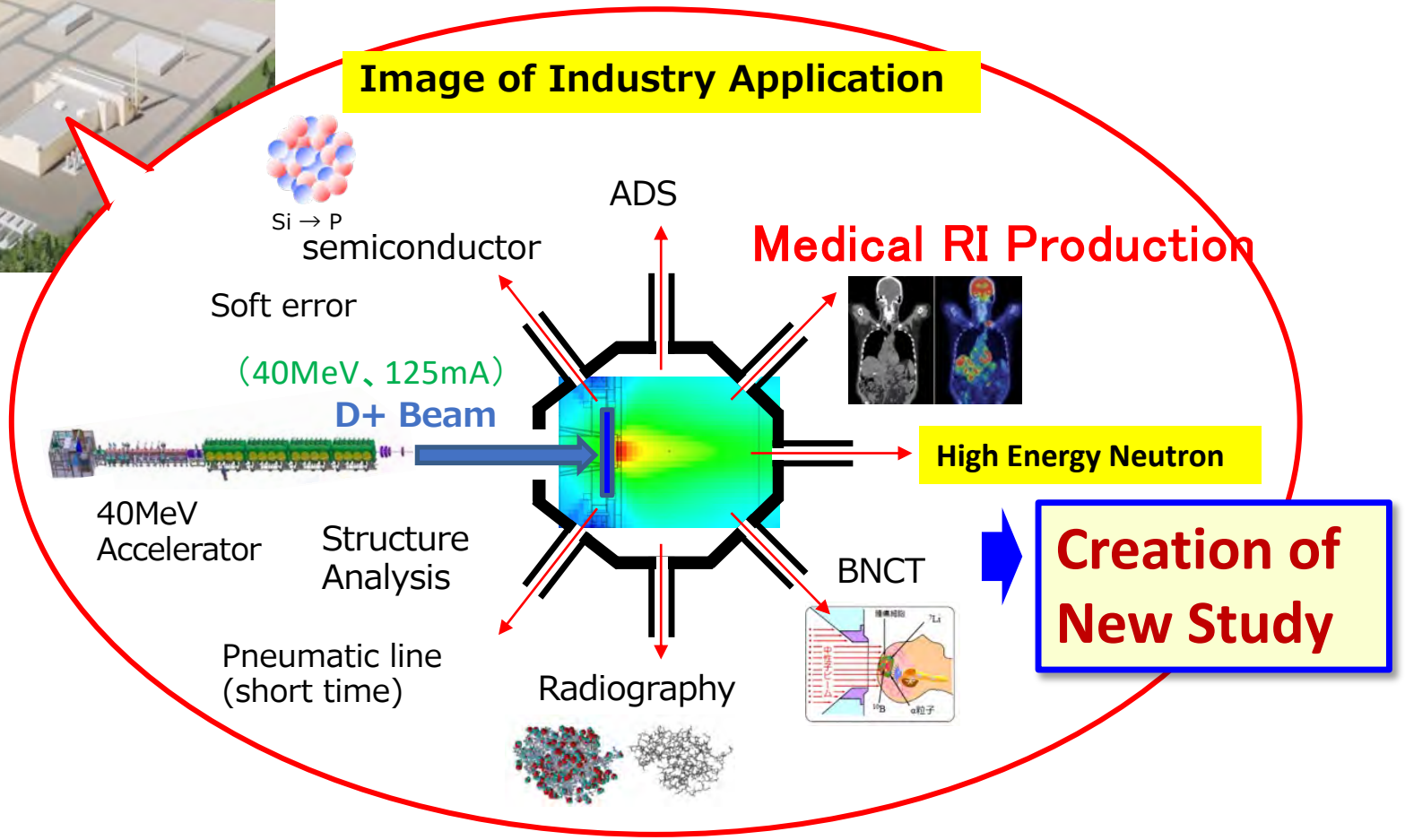
- ✓ Concept of Honeycomb cylinder type for irradiation module of A-FNS. Consideration of thermal analysis, structure and maintenance by remote handling.
- ✓ Design of unified standardization capsules with BSMTM.
- ✓ Similar design concept of capsule of irradiation nuclear reactor.
- ✓ Simplified design and homogenization of irradiation condition suchi as temperature and DPA.



- 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.

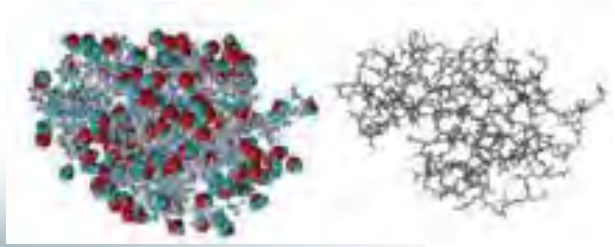
Multi purpose application

- A-FNS will provide not only fusion but also high-energy neutron irradiation field with high general-purpose properties covering domestic basic research, industrial, medical and energy applications.



Concept of Neutron Forrest for Neutron Industry

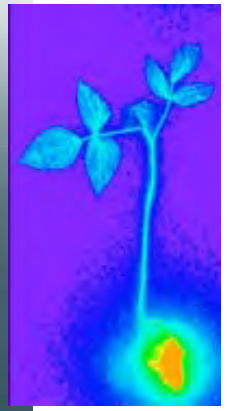
Advanced Fusion Neutron Source (A-FNS) (D^+, 125 mA, 40 MeV)



Rokkasho Fusion Institute

Neutron application research facility

Neutron imaging facility

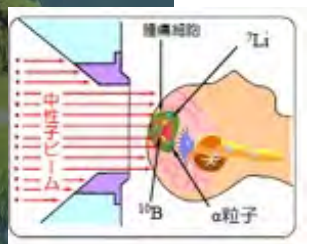


Agriculture application facility

Biological application facility

Semiconductor application facility

Neutron scattering measurement facility

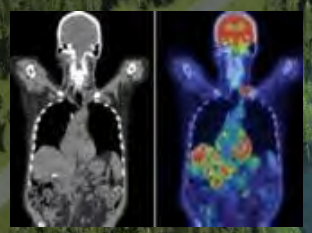


Heliport

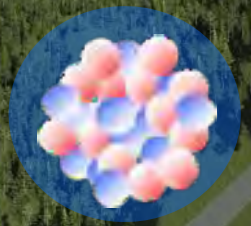
BNCT facility

Medical RI production facility

Radiation therapy facility



Space industry semiconductor diagnostic facility



Contribution of Japanese Companies for A-FNS Design

Main Company	Content
Mitsubishi Heavy Industry (MHI)	A-FNS overall design, Li system design, Safety
Toshiba Energy Systems	Design of Irradiation module, Remote handling, Test cell
IHI	Remote handling design, Thermal design of test cells
Tokyo Electric Power Services	Design of Site equipment, Main building
JGC	Design of conventional facilities and systems
SUKEGAWA Electric	Design of Li purification system, , Mock-up of test modules
Metal Technology	Thermal design of test modules
Hitachi	Injector design
MHI-Machinery Systems	SRF design
Mitsubishi Electric	MEBT, HEBT design
NAT	Support of A-FNS design activity and R&D activity

Summary

- **We are proceeding with the design study of the entire fusion neutron source A-FNS plant, including the accelerator system, target system, test module, and post-irradiation test equipment, and created a conceptual design document for the fusion neutron source A-FNS in 2020. Achieved domestic milestones required for mid-term C&R.**
- **We continue to advance engineering design and R&D, and we continue to work on R&D and design activities for common to DONES in BA Phase 2.**

Issues to be addressed during the engineering design period (engineering design activity plan)

- ✓ **Development of accelerator for A-FNS (design and development based on LIPAc)**
- ✓ **R&D and design of lithium targets (purification system, diagnostic system, Li safety, etc.)**
- ✓ **Design of irradiation module thermal fluid analysis etc.**
- ✓ **R&D of remote maintenance technology**
- ✓ **A-FNS safety research**
- ✓ **Neutron applied research**