ISFNT-7

Tokyo, Japan

東京大学 THE UNIVERSITY OF TOKYO

Overview of Research and Development Activities on Fusion Nuclear Technologies in Japan

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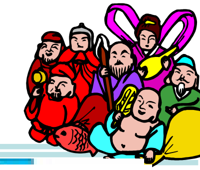
The University of Tokyo

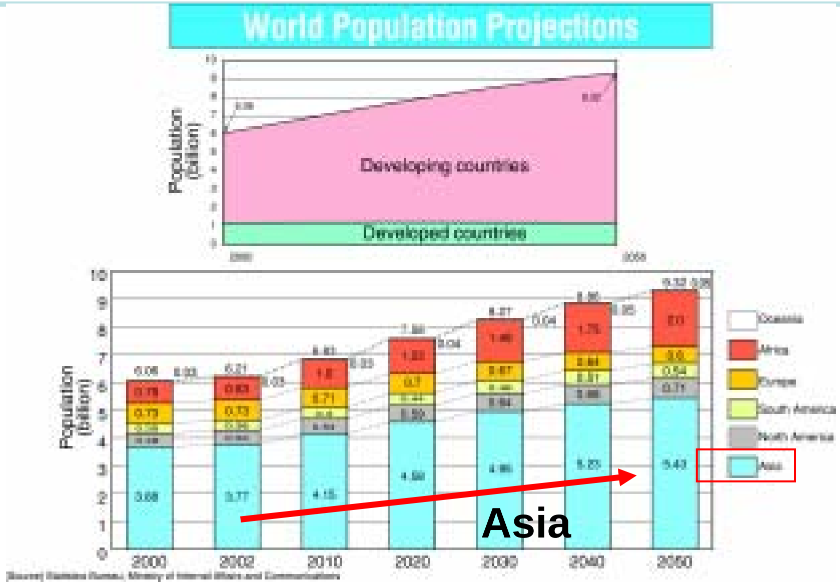
Outline

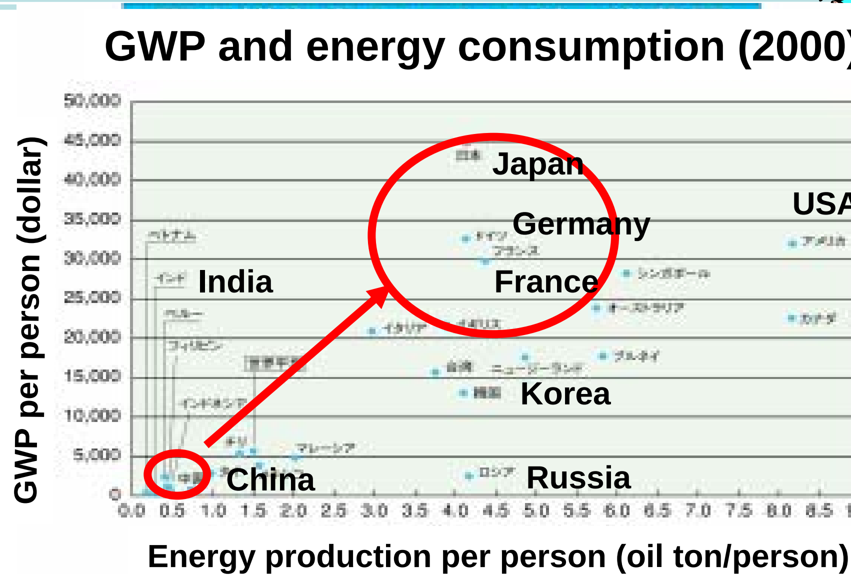
- *Introduction*
- *FNT Research and Development Program of Japan*
- *Development of Breeding Blankets*
  - *Solid Breeding Blankets*
  - *Liquid Breeding Blankets*
- *R&D on other FNT Issues*
  - *PMI*
  - *Fuel Processing System*
  - *Safety*
  - *Reactor Design Study*
- *Summary*

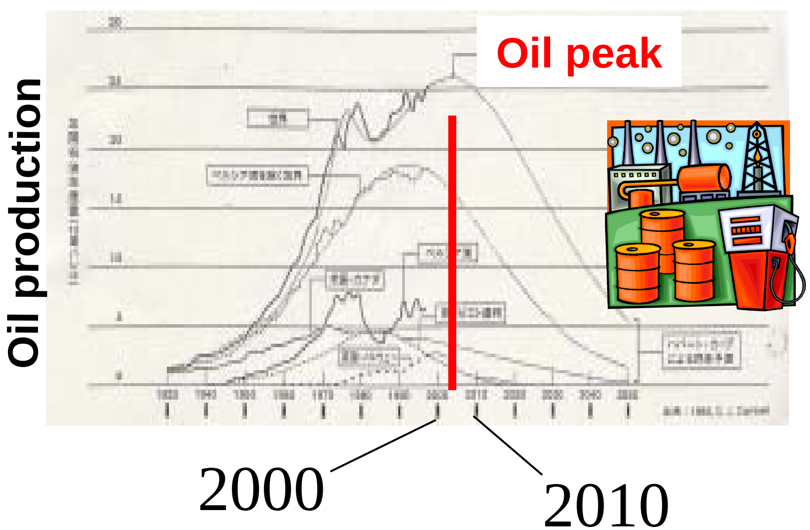


Introduction (1)

Energy resources problem and role of fusion (1)







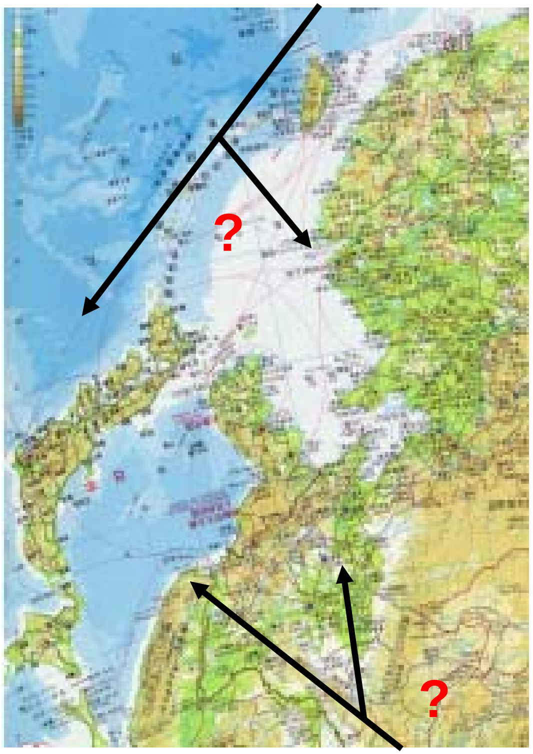
-Increasing energy demand in 21st century, especially in Asia with larger population and economic growth.

-Shortage of resources: oil and natural gas

-Environmental problem.

Introduction (2)

Energy resources problem and role of fusion (2)



Energy resources transportation problem

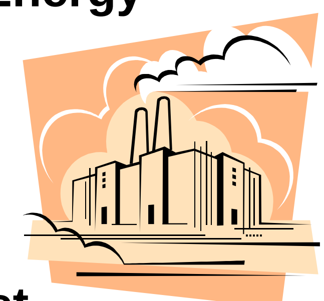
1000MWe by solar

Limitation by new energy

- Nuclear energy and new energy are required

-Energy also for Hydrogen Production

-Limitation in New Energy



-In the latter half of the 21st century, fast breeding reactor is an important choice

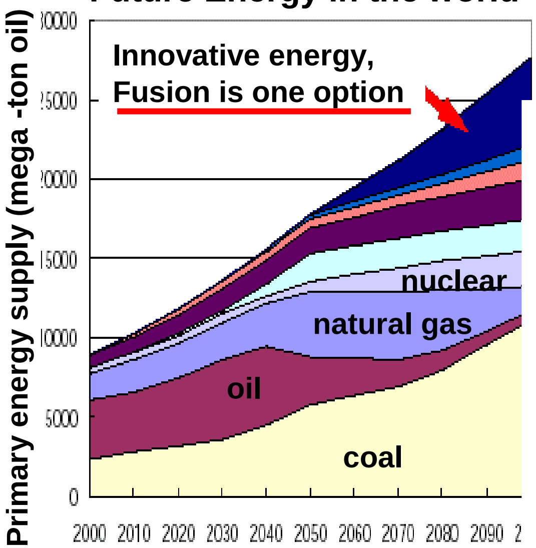
-Potential hazards of high level waste and plutonium in FBR

Fusion reactor should be a powerful competitor.

Introduction (3)

Energy resources problem and role of fusion (3)

Future Energy in the world

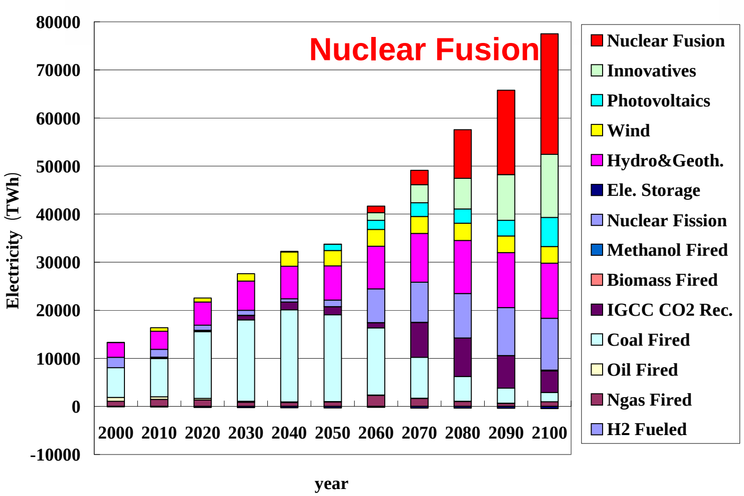


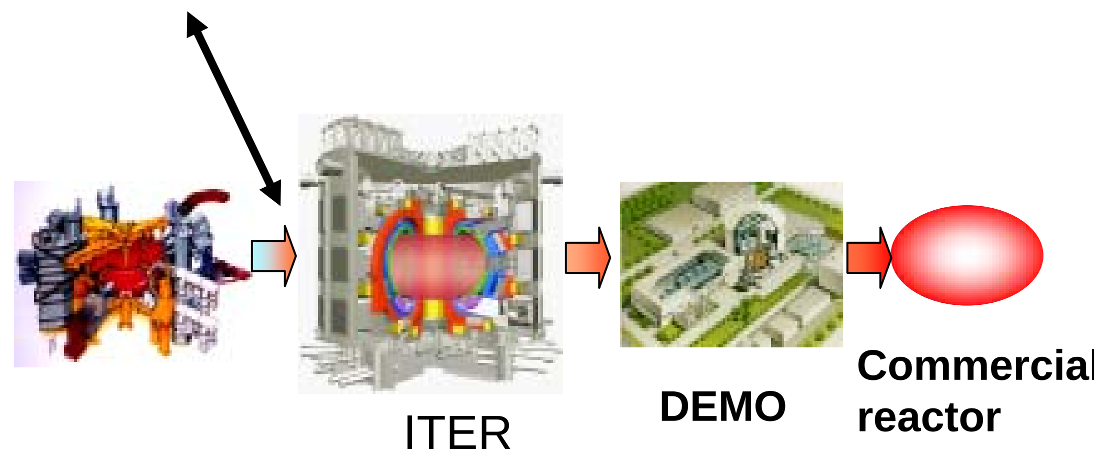
地球再生計画(茅他) year

Fusion energy should be one of the candidates in the latter half of the 21st century.

For this, DEMO reactor should be realized well in advance of the middle of the 21st century.

Timely ITER construction and operation are vitally important.



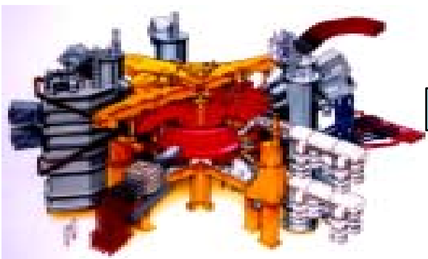


K. Tokimatsu et al., SEP/03, Proc. 18th IAEA Fusion Energy Conf. Sorento (2000)

Introduction (4)

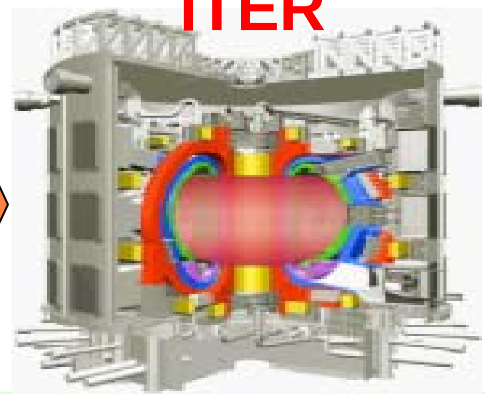
Roadmap towards Fusion Energy Utilization

Large Tokamaks
(e.x.; JT-60)



- Non-nuclear
- Physics Exp.
- Plasma Tech.

ITER



- First Nuclear Tokamak
- Exp.of Burning Plasmas integrated with Key Reactor Technologies
- Integrated Testing of

Materials Devel., IFMIF

DEMO

- Large-scaled Power Generation
- Steady-state Operation

Commercial Utilization

ITER is an essential facility for fusion energy in Japan ,
in Asia and in the World.

- The world Fusion program is now opening a new era for operation and utilization of ITER.
-FNT is essential in “nuclear machine ITER” and for DEMO.
-FNT is essential for realizing fusion energy in the world.

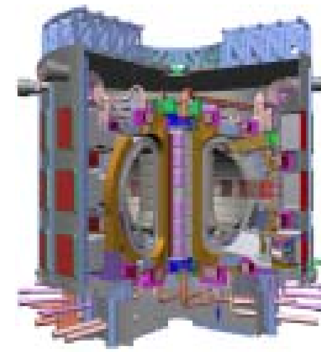
FNT R&D Program of Japan (1)

FNT research as part of the 3rd Phase Basic R&Ds Program

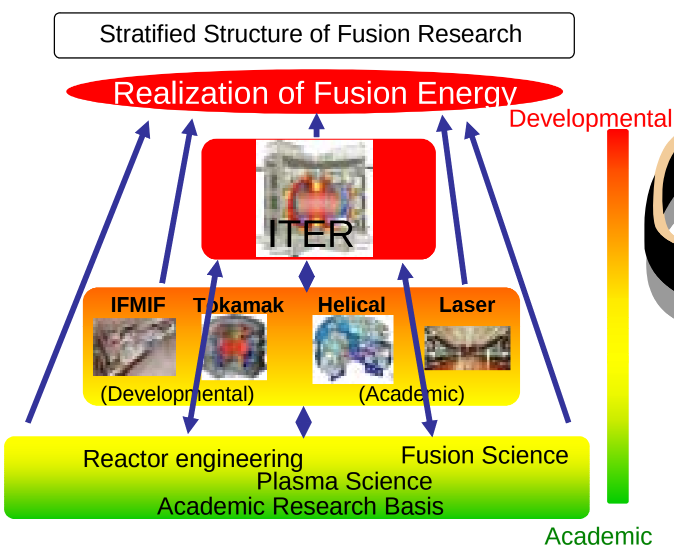
Final goal of the 3rd Phase Basic R&Ds Program

- **Achievement of self ignition conditions**
- **Realization of long term burning**
- **Development of FNTs essential to DEMO reactors**

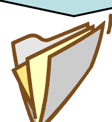
Development of Tokamak type experimental reactor (ITER) as a center facility



Ad hoc working group of MEXT discussed future direction (10-20 years) of national fusion program.



MEXT : Ministry of Education, Culture, Sports, Science and Technology



Report issued in January 2003

In addition to ITER, focus on domestic fusion researches on highest priority areas:

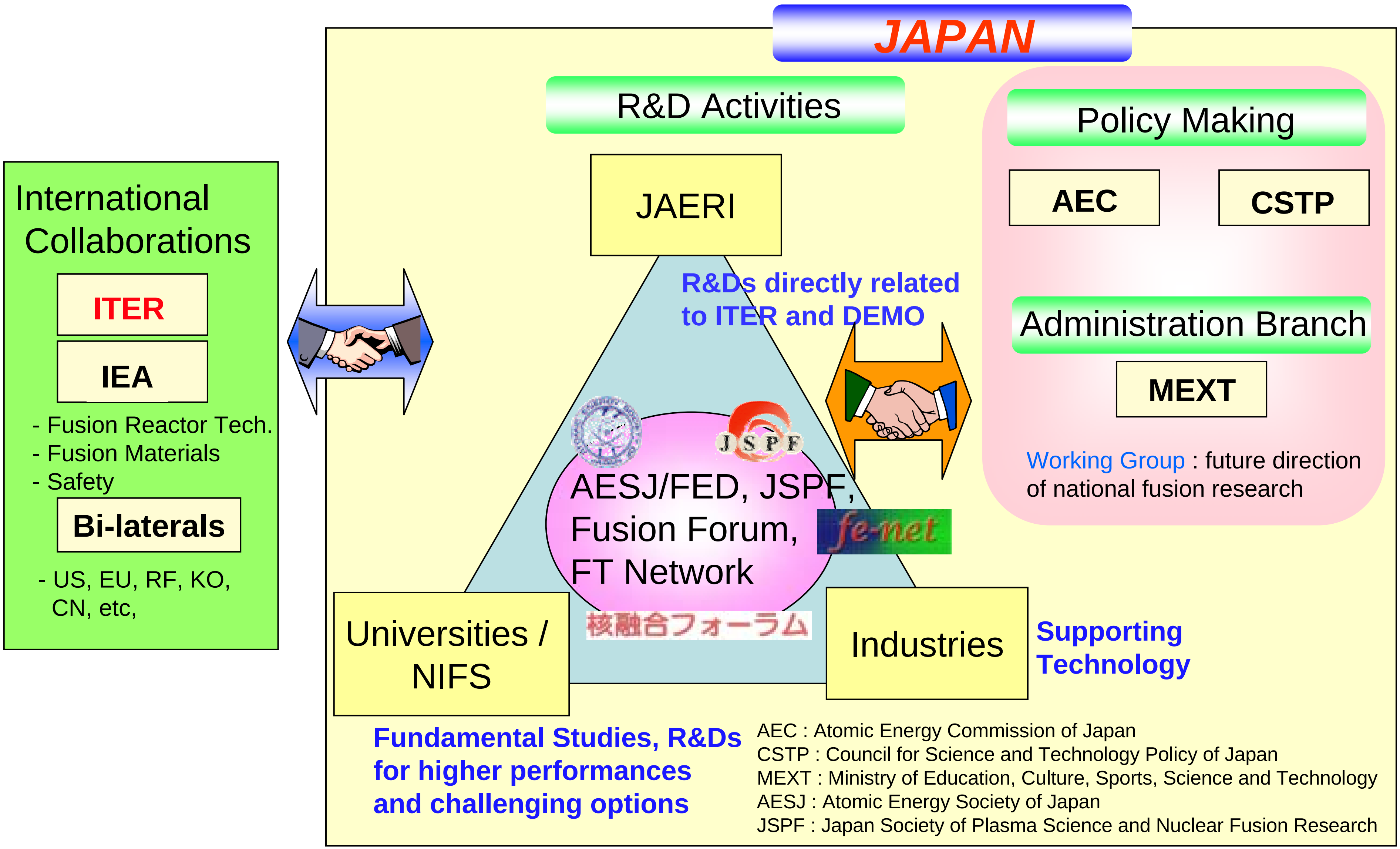
Tokamak : JT-60
Helical : LHD
Laser : GEKKO-XII
FNT Research, including IFMIF-EVEDA

Strengthen domestic and international collaborations

Foster young and talented researchers

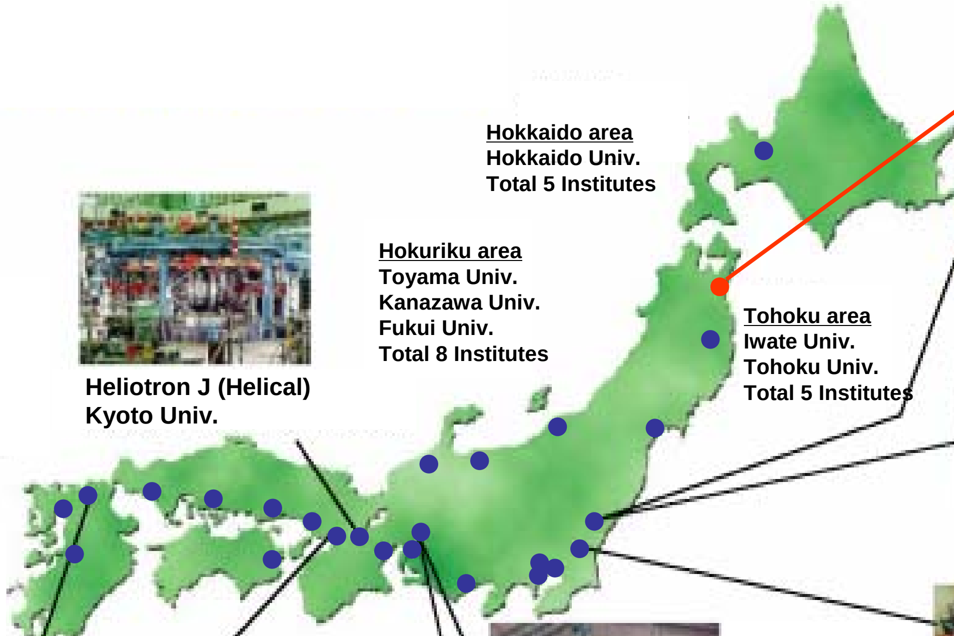
FNT R&D program of Japan (2)

Implementation Scheme of FNT R&D in Japan



FNT R&D program of Japan (3)

FNT R&D sites in Japan



ITER candidate site

Hokkaido area
Hokkaido Univ.
Total 5 Institutes

Hokuriku area
Toyama Univ.
Kanazawa Univ.
Fukui Univ.
Total 8 Institutes

Tohoku area
Iwate Univ.
Tohoku Univ.
Total 5 Institutes

Chugoku/ Shikoku area
Okayama Univ.
Hiroshima Univ.
Yamaguchi Univ.
Tokushima Univ.
Total 18 Institutes

Heliotron J (Helical)
Kyoto Univ.

JT-60 (Tokamak)
JAERI

JFT-2M (Tokamak)
JAERI

Gamma10 (Mirror)
Tsukuba Univ.

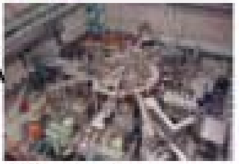
Kyushu area
Kyushu Univ.
Saga Univ.
Nagasaki Univ.
Kumamoto Univ.
Ryukyu Univ.
Total 16 Institutes

Kinki area
Kyoto Univ.
Osaka Univ.
Kobe Univ.
Total 20 Institutes

Chubu area
Shizuoka Univ.
Nagoya Univ.
Mie Univ.
Chubu Univ.
NIFS
Total 19 Institutes

TRIAM-1M (Tokamak)
Kyushu Univ.

Gekko (Laser)
Osaka Univ.



LHD (Helical)
NIFS

CHS (Helical)
NIFS

Kanto / Koshin area
Ibaraki Univ.
Tsukuba Univ.
The Univ. of Tokyo
Tokyo Inst. of Tech.
Yokohama Int'l Univ.
Niigata Univ.
Tokai Univ.
Nihon Univ.
KEK
JAERI
Total 65 Institues

FNT population

National Laboratories	: 300
Universities	: 600
Industries	: 100

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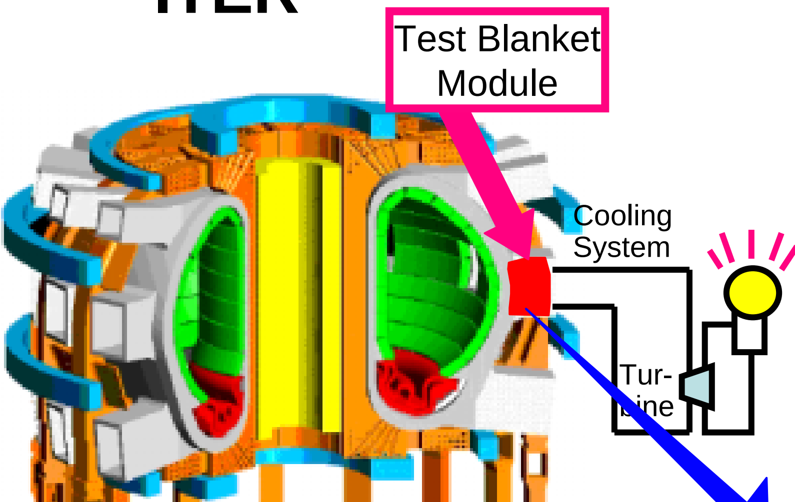
THE UNIVERSITY OF TOKYO

FNT R&D program of Japan (4)

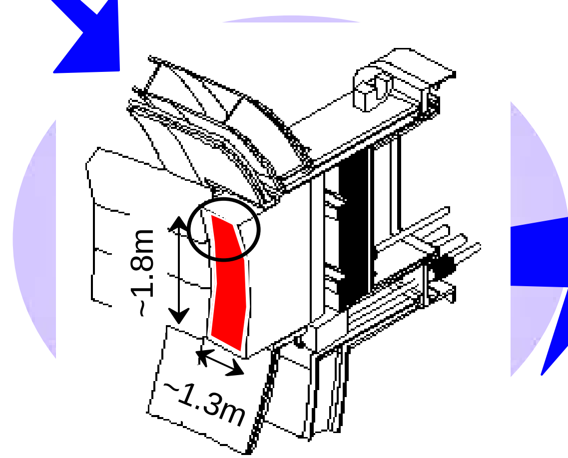
Fusion Nuclear Technologies in ITER

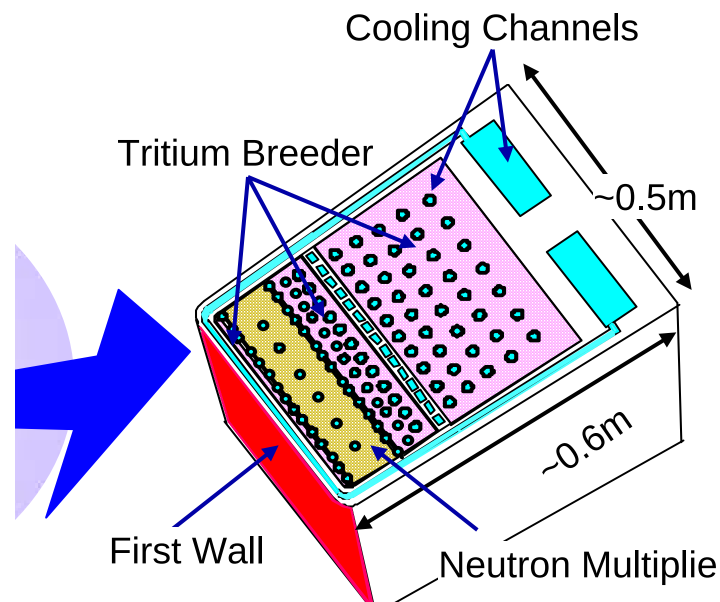
ITER



- FNT essential for DEMO largely developed in ITER in an integrated manner, typically, on:
  - safe and reliable operation of large-scaled tritium fuel processing system;
  - sufficient radiation shielding by blankets to assure sound operation of SC magnets;
  - reliable and long-lived PFCs against high heat and particle loads.

Test Port





Test Blanket Module

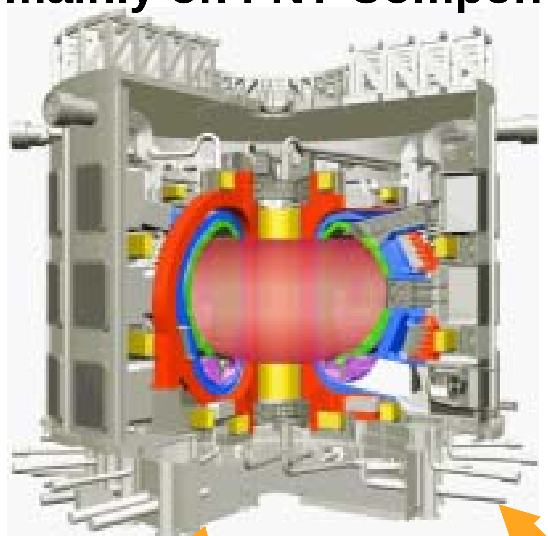
- Integrated testing of DEMO blankets on:
  - tritium breeding;
  - high-grade thermal power extraction and electric power generation;
  - radiation shielding.

ITER is an important milestone for FNT in Japan

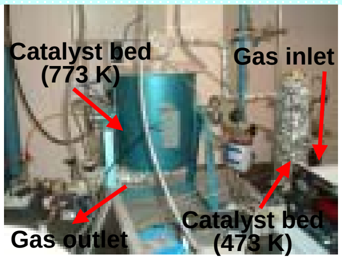
FNT R&D program of Japan (5)

Japanese Contributions to ITER after EDA

- Highlights mainly on FNT Components and Systems -

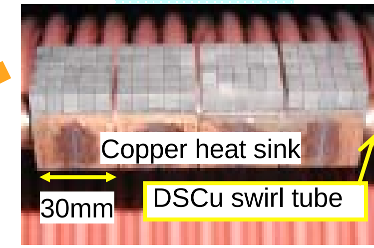


Fuel Processing System



- Demonstration of detritiation system performances in case of fire

Divertor

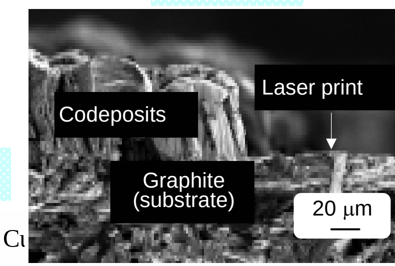


- Rod-shaped W-armor divertor

SC Magnet

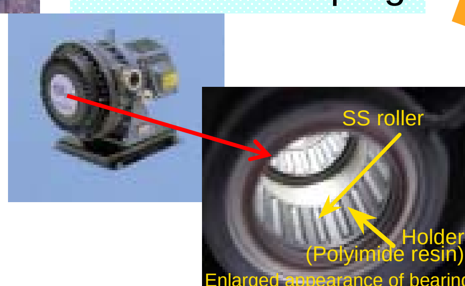
- Trial forging of Strengthened 316LN for TF coil case

Safety



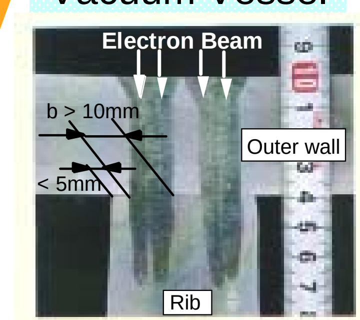
- Removal of codeposits by laser irradiation

Vacuum Pumping



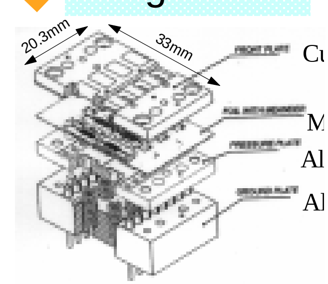
- Oil-free scroll pump with tranfer coating technique

Vacuum Vessel



- Qualification of partial penetration joint

Diagnostics



- Irradiation test of mica substrate bolometer

JAERI, in collaboration with universities and industries, has been contributing to design refinement and preparations for procurement and operation.

FNT R&D program of Japan (6)

Licensing Preparation for ITER

2002 November Ministry of Education, Culture, Sports, Science and Technology (MEXT) summarized a report “Basic Policy of ITER Safety Regulation”.

Outline of “Basic Policy of ITER Safety Regulation”

1. Procedure and Items to be confirmed

- **Items before start of construction.**
- **Items before start of use.**
- **Regulation at operation phase**
- **Submission of document for confirmation of safety measures related to dismantling, disassembly, waste processing, etc.**

2. Technical requirements

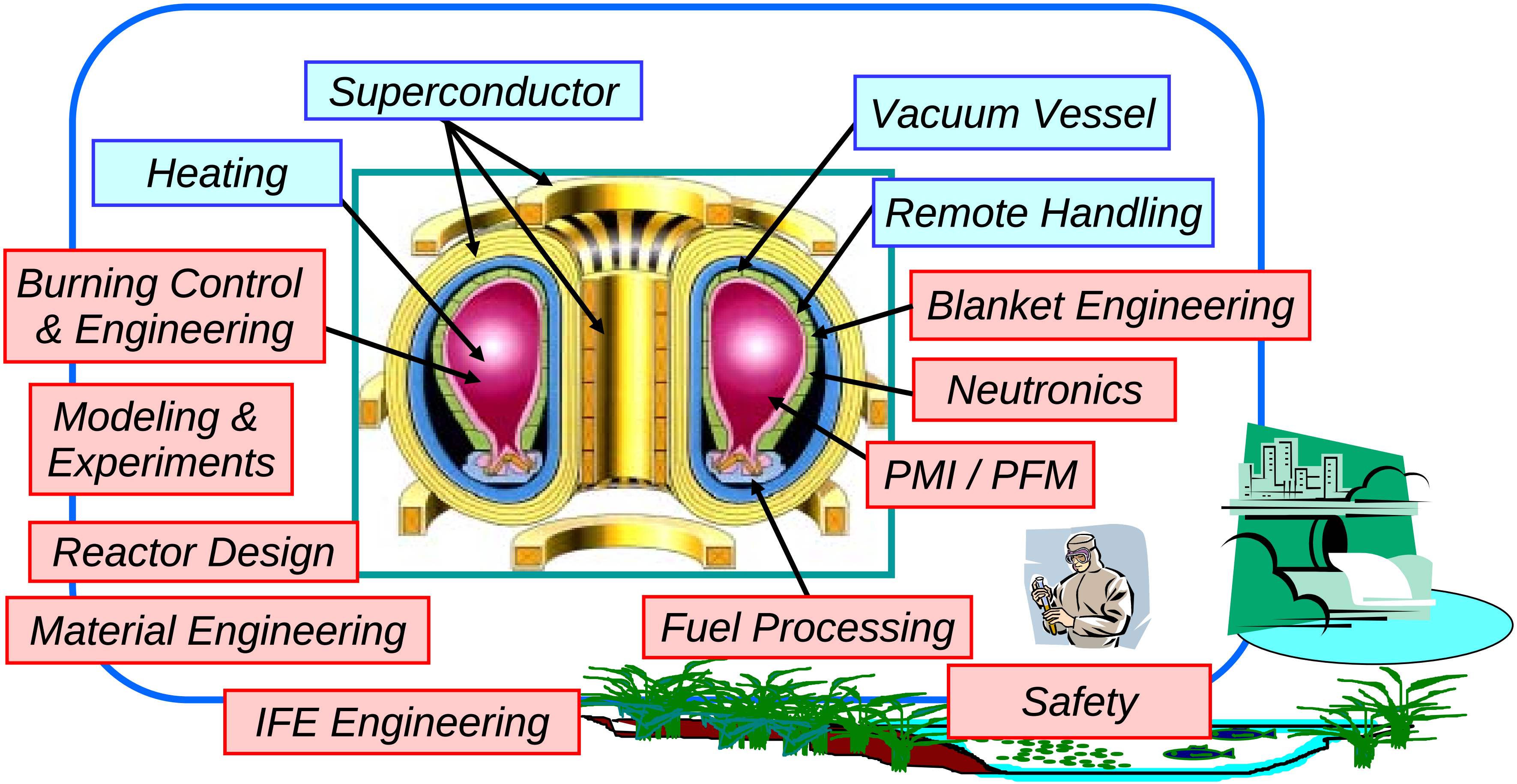
- **Requirements for safety functions and methods of safety assessment**
- **Requirements for basic safety performance of assembly**
- **Requirements and codes & standards for main design specification**

3. Areas and items to be confirmed in detailed design and those of inspections

- **Items of regulatory confirmation on design and construction of the ITER facility (Table)**

MEXT can conduct site-specific licensing process immediately.

Typical R&D themes on FNT



Japan is investigating all fields of FNT for ITER and DEMO.

Development of Breeding Blanket

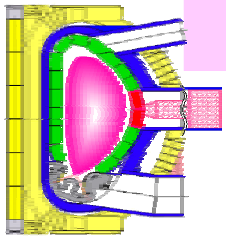
R&D configuration for breeding blanket development

Development of breeding blanket

ITER TBM → DEMO →

Reference blanket	Advanced options	
Solid / Water	**Solid / He**	**Liquid or molten salt**
Engineering R&D	Engineering R&D	

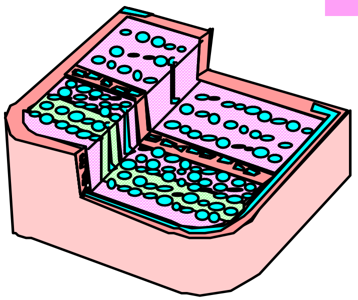
Fundamental Study



JAERI

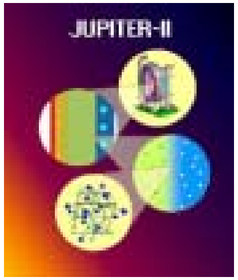
Support

NIFS / Universities



ITER TBWG
IEA

NIFS Collaboration Program
JUPITER-II with US-DOE
Japan-China Collaboration Program
Japan-Korea Collaboration Program etc.



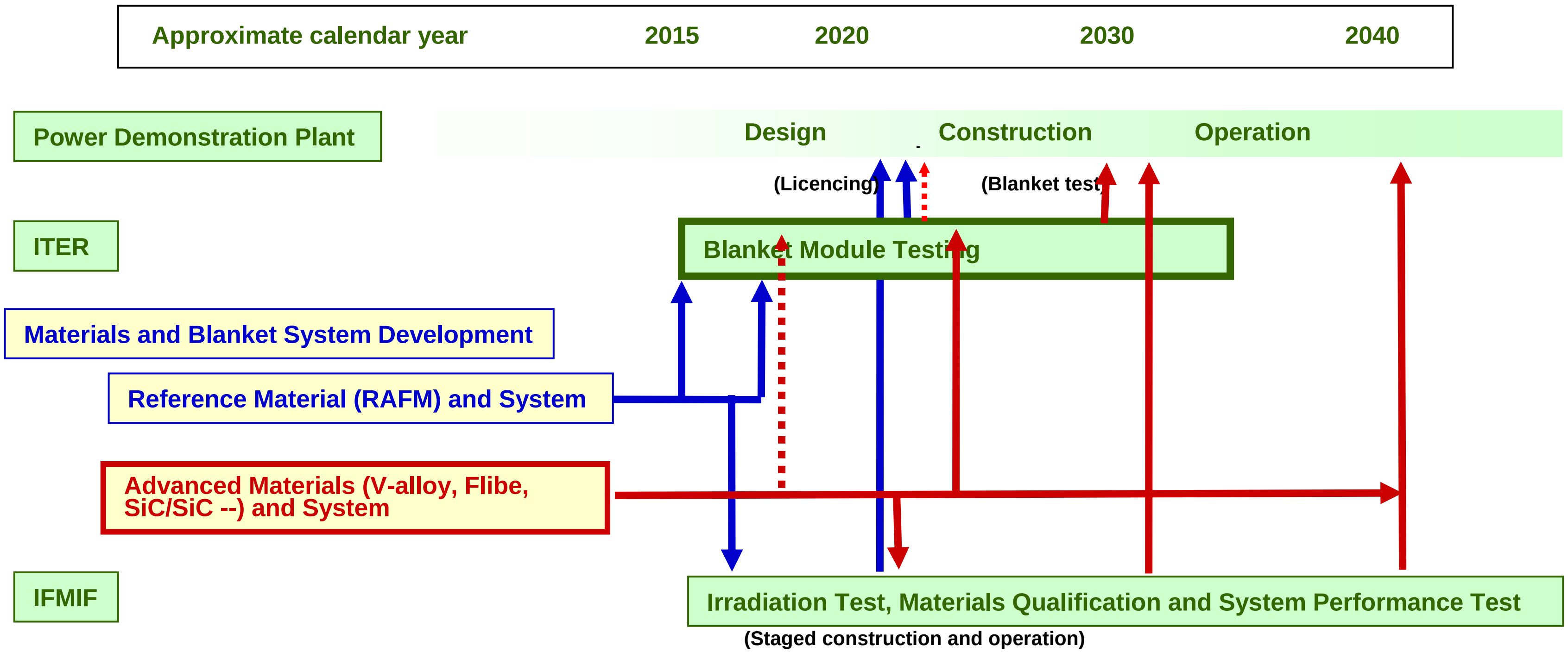
Development of Breeding Blankets (1)

Roadmap of Breeding Blankets and Materials Development

Milestones to the fusion power demonstration plant

(1) By ITER TBM testing, demonstrative data of blanket functions will be obtained in fusion environment.

(2) Together with the material irradiation data by IFMIF, the construction of the blanket of fusion power demonstration plant will be decided.

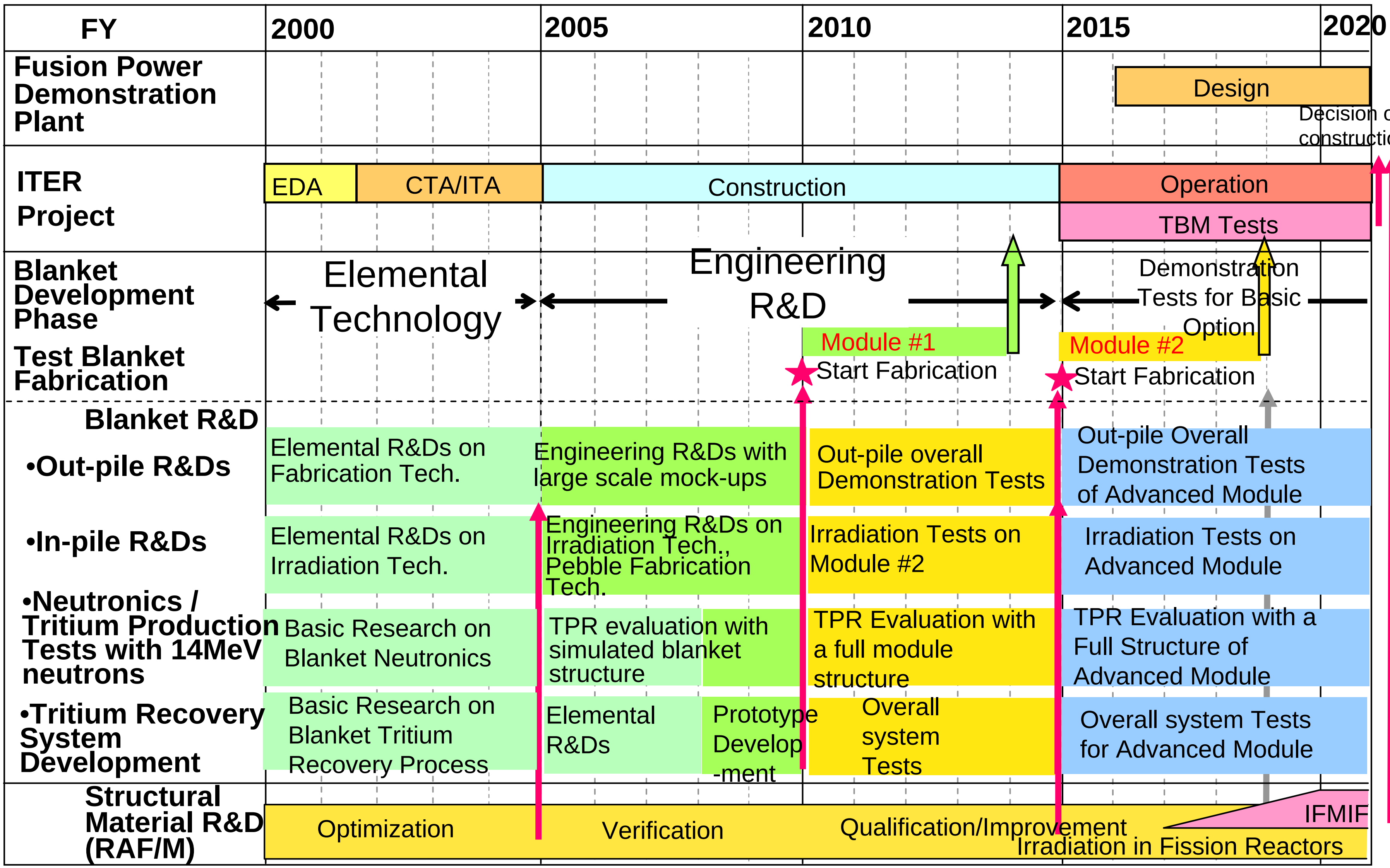


Reference Blanket (Mostly JAERI responsibility) (Solid Blanket)

Advanced option (Mostly NIFS/University responsibility)

Development of Breeding Blankets (2)

Development Schedule of Solid Breeding Blanket for ITER TBM



Development of Breeding Blankets (3)

Development of water cooled solid breeding blanket (1)

Overview of design and R&Ds

Fusion Reactor Design

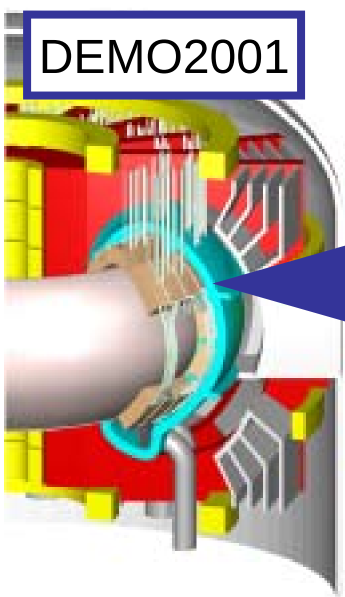
System Integration, Out-pile R&D
- Module fabrication technology
- Thermo-mechanical integrity of module
- Thermo-mechanical performance
- Thermal hydraulic research

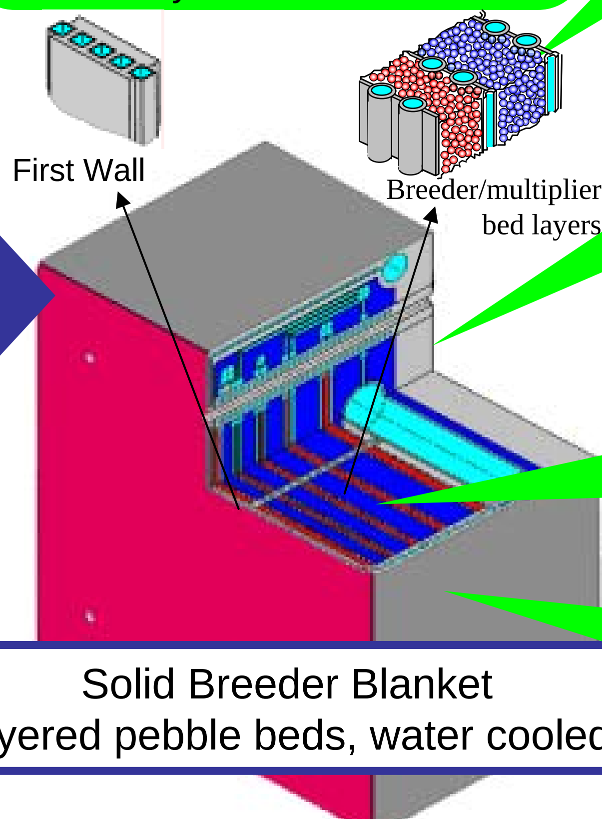
In-pile R&D
- Breeder/multiplier development
- Irradiation technology development
- Irradiation tests of blanket partial mockup

Tritium Recovery System Development
- Process and system development for hydrogen pump, coolant water detritiation system

Neutronics / Tritium Production Tests with 14MeV neutrons
- Neutronics performance of blanket mockup and improvement of analysis accuracy

Material Development
- Irradiation data of RAFM (F82H), etc.
- Environmental effect, etc.



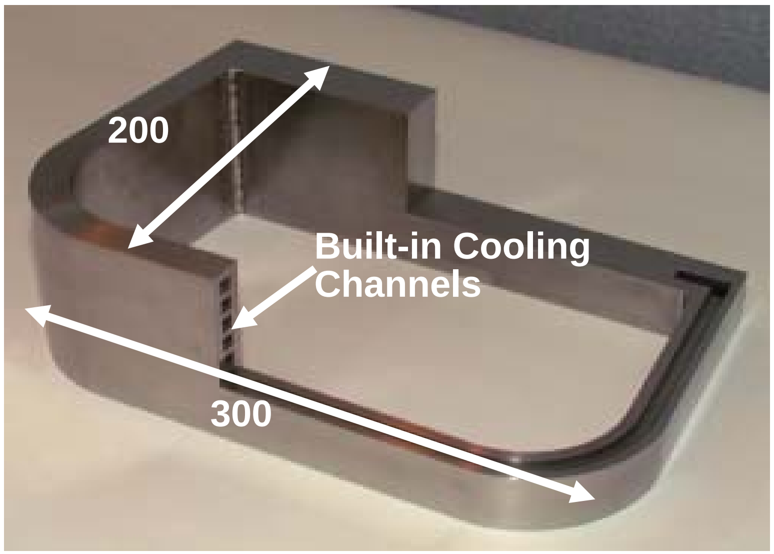


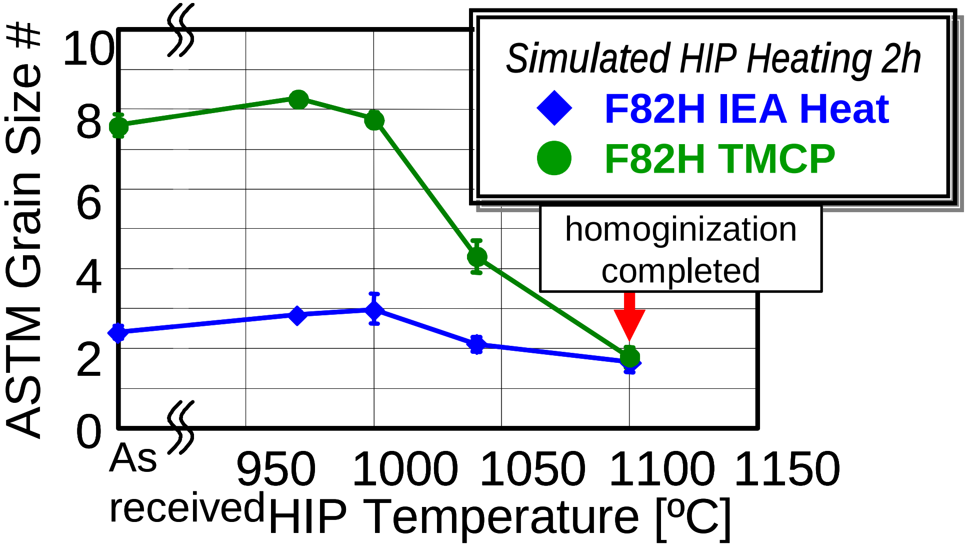
Solid Breeder Blanket
(layered pebble beds, water cooled)

Development of Breeding Blankets (4)

Development of water cooled solid breeding blanket (2)

Achievement of Out-pile R&D





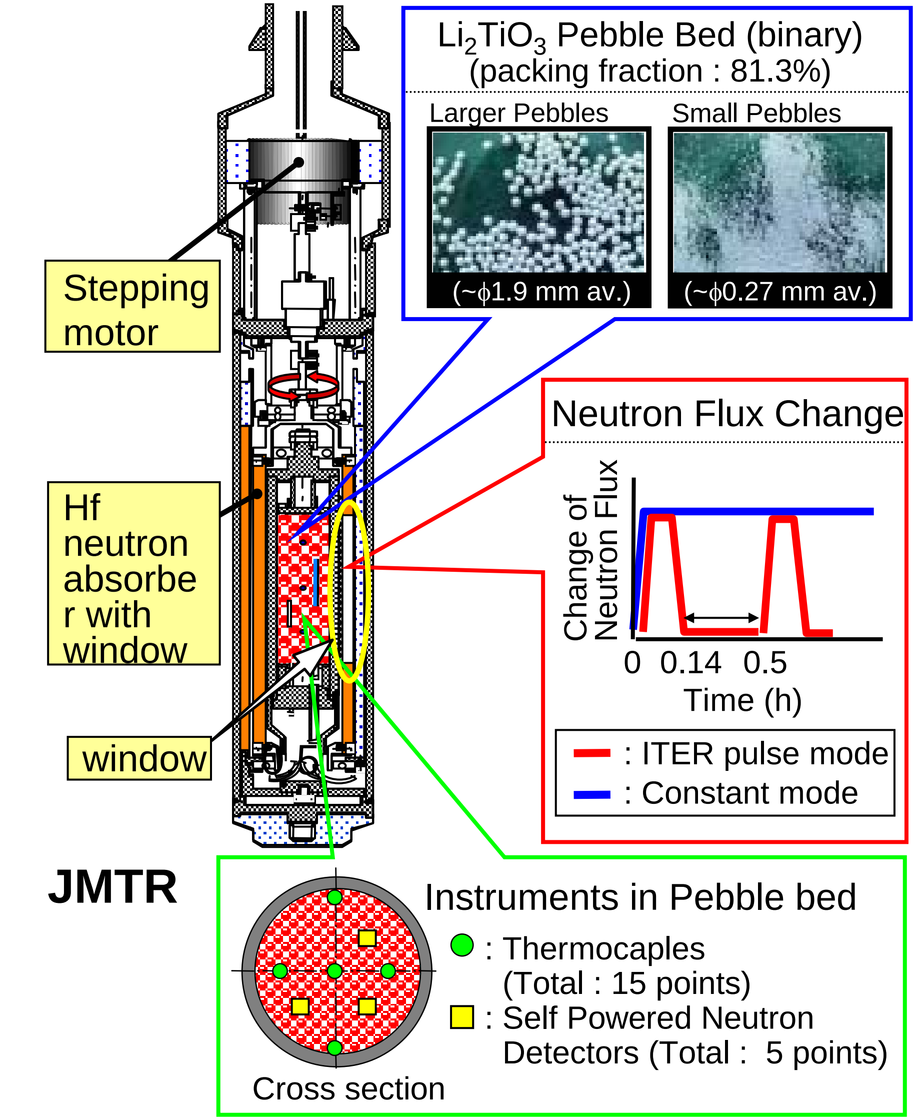
As a key fabrication technology for blanket structure, hot isostatic pressing (HIP) bonding method was proposed and its optimum condition was preliminarily investigated.

HIP and post HIP heat treatment conditions have been optimized.
→ **HIP at 1150 ºC + PHHT at 930 ºC + Tempering**

Development of Breeding Blankets (5)

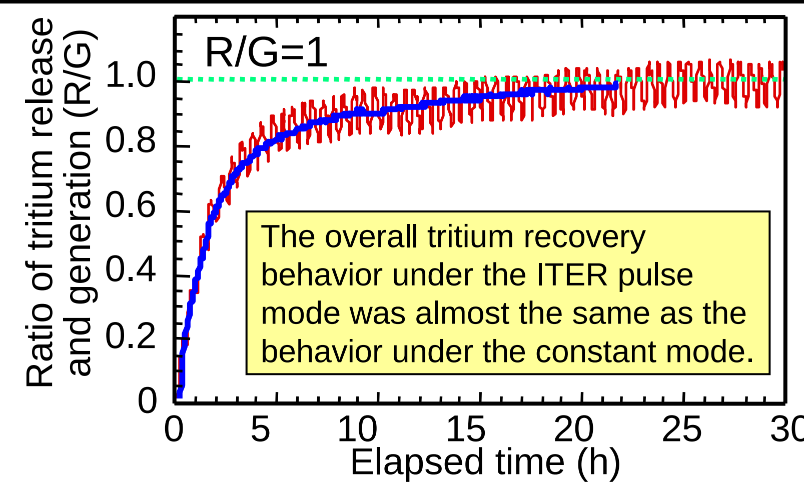
Development of water cooled solid breeding blanket (3)

Achievement of In-pile R&D

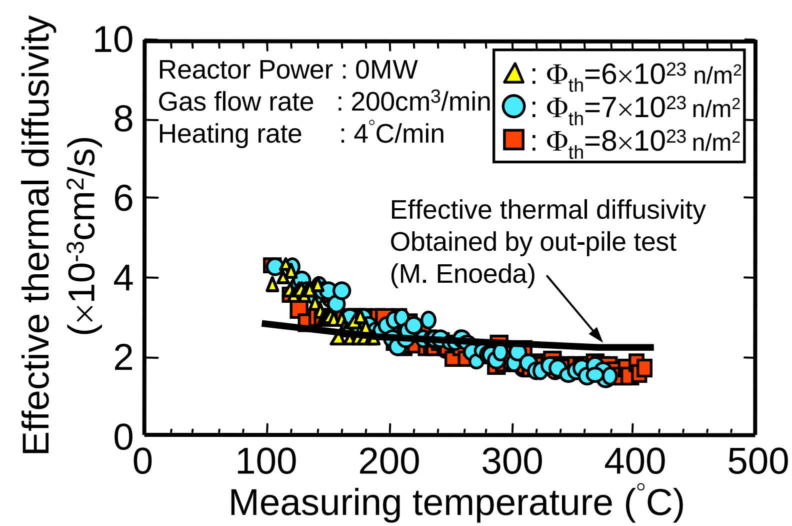


Schematic diagram of mock-up

Tritium Release behavior under ITER Pulse Mode



Effect of Neutron irradiation on Effective Thermal Diffusivity

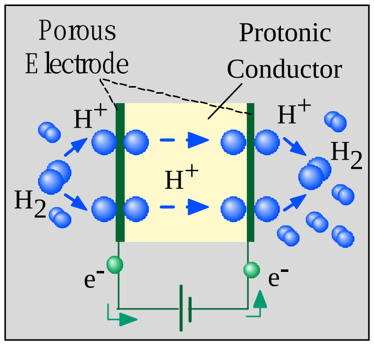


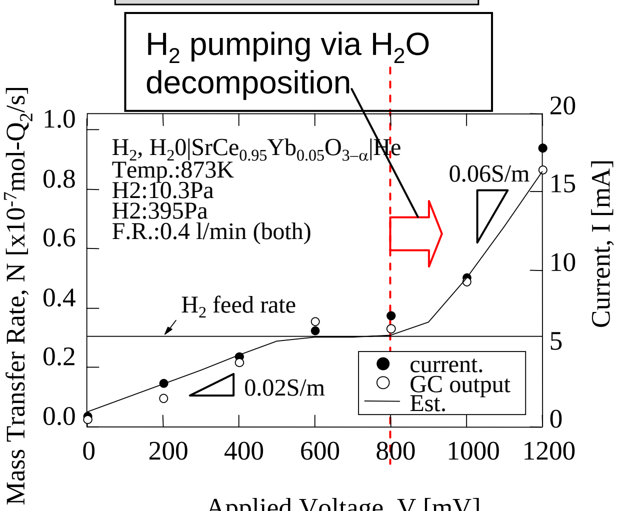
Development of Breeding Blankets (6)

Development of water cooled solid breeding blanket (4)

R&Ds on Tritium Recovery System and Blanket Neutronics

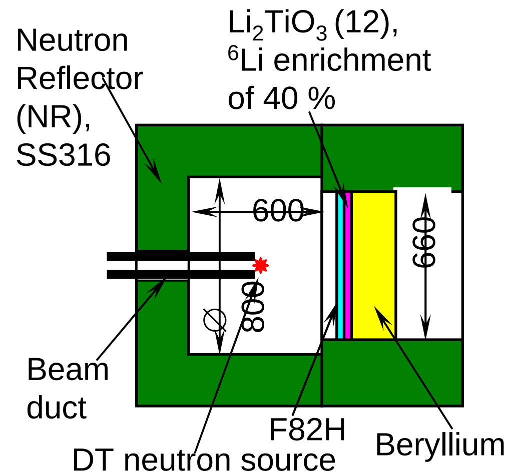
Tritium Recovery System Development
(Electrochemical Hydrogen Pump)

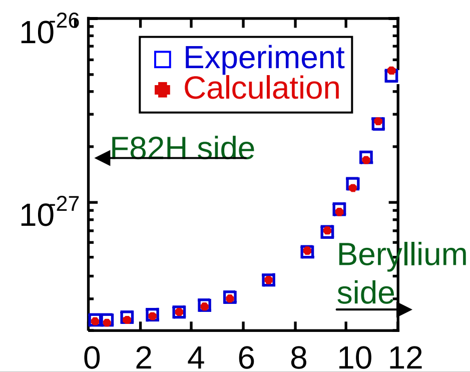




Ionic hydrogen transportation property was clarified.

Neutronics / Tritium Production Tests with 14MeV neutrons





The calculation results agree well with the experimental data within 2 and 11 % for the campaigns without and with the reflector.

Development of Breeding Blankets (7)

Development of water cooled solid breeding blanket (5)

R&Ds on functional materials for blanket

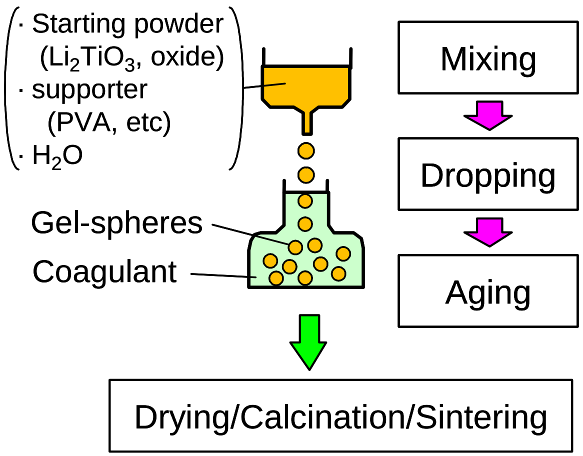
Tritium Breeder Material

- Elemental fabrication technology of Li_2TiO_3 was established.
- Oxide-doped Li_2TiO_3 is to be selected as an advanced material.

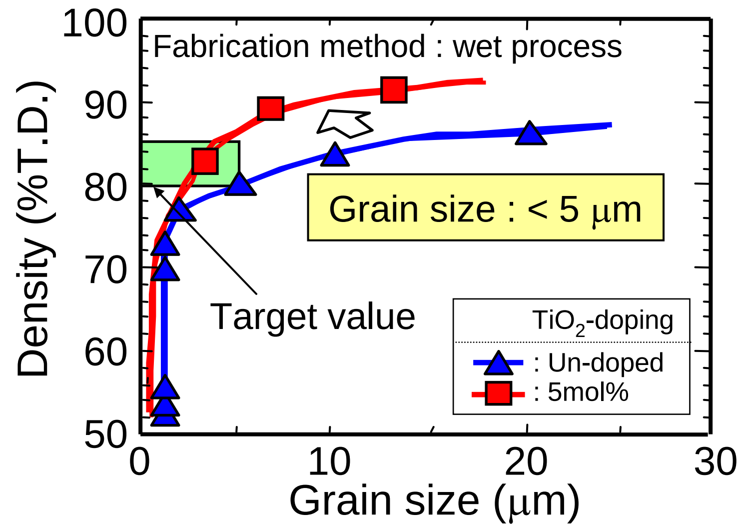
- Control of grain size - Chemical stability

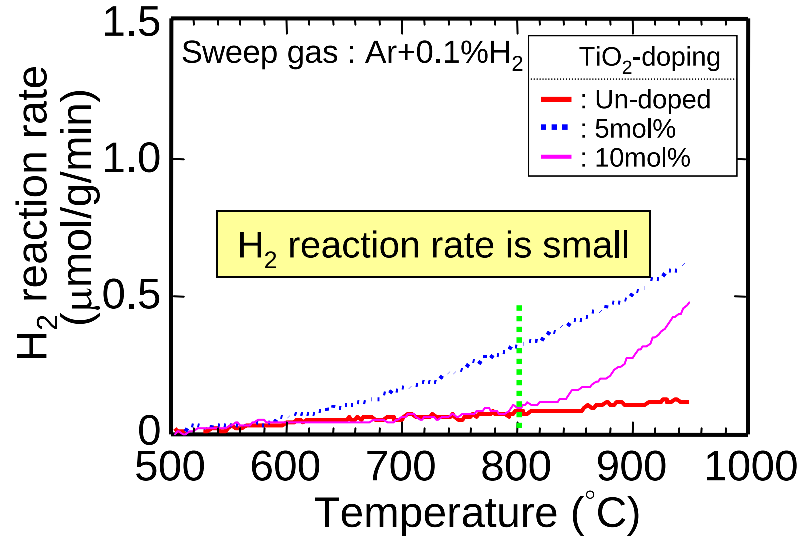
1) Pebble Fabrication Development

- Success in fabrication of **[6]Li-enriched** (30 and 95at%) Li_2TiO_3 pebbles and **TiO_2-doped Li_2TiO_3 pebbles** by indirect wet process.



2) Characterization





Development of Breeding Blankets (8)

Development of water cooled solid breeding blanket (6)

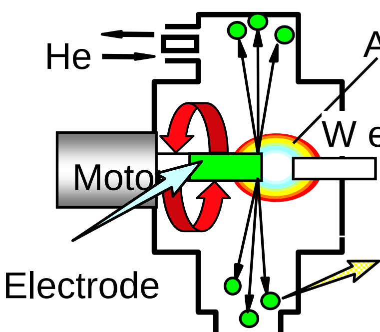
R&Ds on functional materials for blanket

Neutron Multiplier Material

- Fabrication technology of Be pebble was established.
- Be-Ti alloys are to be selected as an advanced material.

 - High melting point - Low oxidation

1) Pebble Fabrication Development

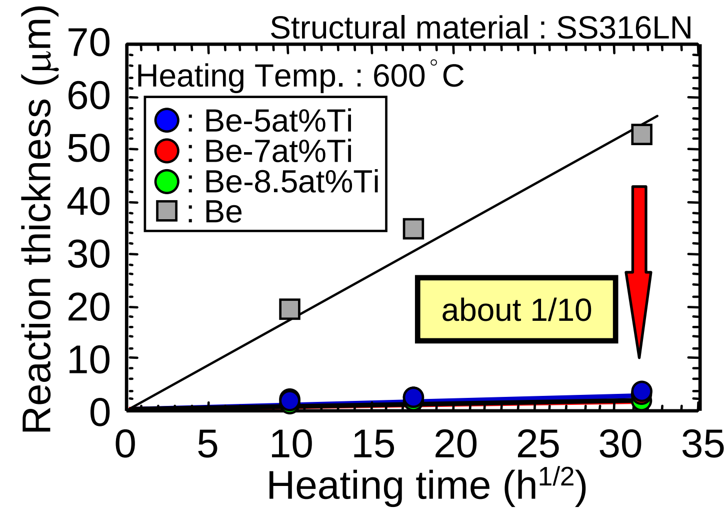


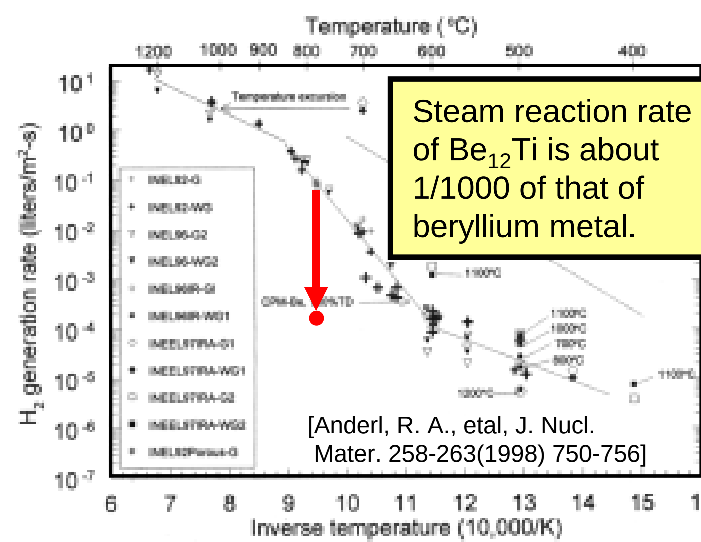
Grain size (µm)

Be-7at%Ti pebbles

2) Characterization of Be-Ti Alloys ($Be_{12}Ti$)

Main Properties	Results	Evaluation
Compatibility with SS	<1/10 of Be	Good
Swelling	<1/50 of Be	Good
Tritium inventory	Lower release temp. Smaller inventory	Good



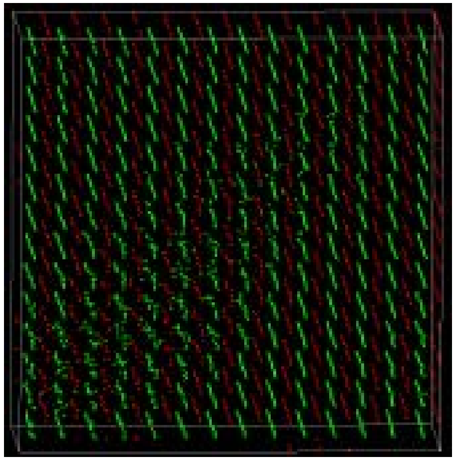


Development of Breeding Blankets (9)

Development of water cooled solid breeding blanket (7)

Fundamental studies for hydrogen isotope behavior at Universities

Atomic-scale modeling of tritium behavior at The University of Tokyo



Cascade by 100 eV-Li^+ on <111>

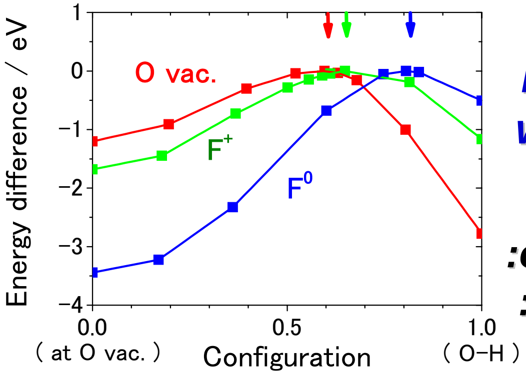
Radiation damage in Li_2O by MD

:displacement energy

:favorable direction

:Li/O defect ratio

:recovery process



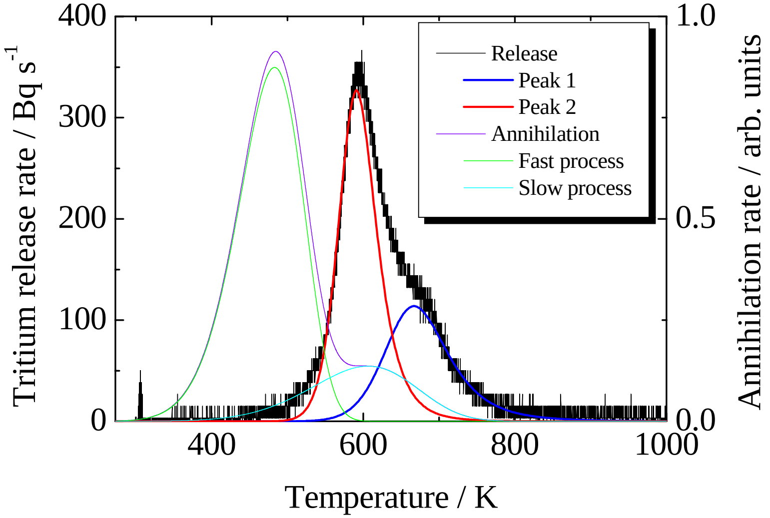
Stability of H near the F centers

Interaction of tritium with charged-defects in Li_2O by DFT

:effect of "the charged"

:barrier for detrapping

Hot atom chemical behavior of tritium in Li_2TiO_3 at Shizuoka Univ. and Kyushu Univ.



Comparison between tritium release and annihilation of radiation defects in Li_2TiO_3

Oxygen vacancies could act as tritium trapping sites.

Development of Breeding Blankets (10)

Development of liquid breeding blanket (1)

Flibe blanket related study

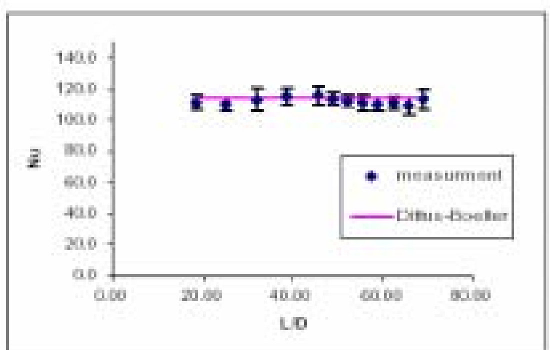
Liquid blankets : Flibe, liquid Li and LiPb ← **Universities and NIFS**

Advanced Options in Japan

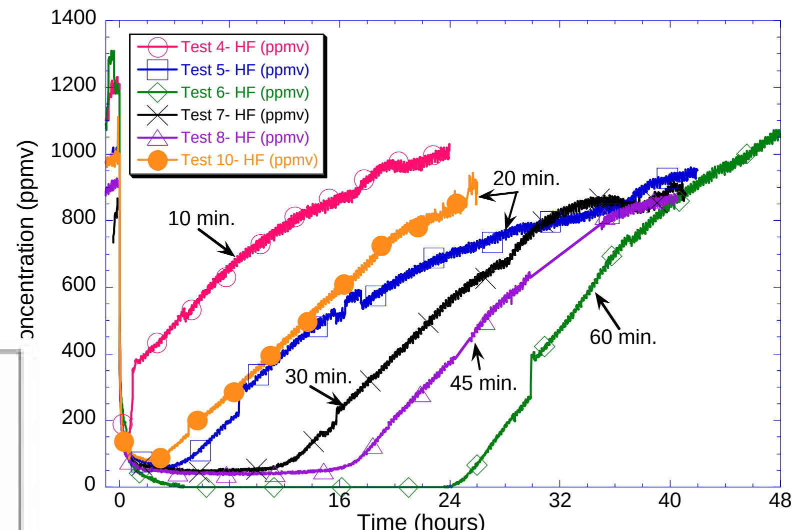
Flibe blanket related study under JUPITER-II project at INL and UCLA

Purification
Material compatibility
Tritium Chemistry
MHD effect
Tritium permeation
REDOX control with Be

Updated high power magnet B.O.B. for heat transfer and flow filed measurement of Flibe simulant



Measured heat transfer coefficient by using Fli-Hy loop



Experimental results on Redox control of Flibe with dipping Be.

Be metal can be applicable for the REDOX agent.

Development of Breeding Blankets (11)
Development of liquid breeding blanket (2)
Li/ V blanket study

Li/V blanket related study
Key Research Topics

Material development

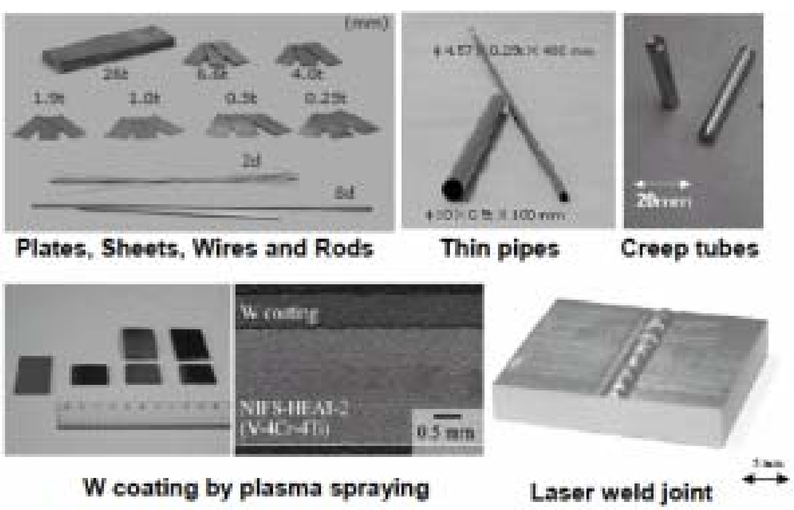
- V-4Cr-4Ti : structural materials
- Er_2O_3 and oxide ceramics : MHD insulator coating

Tritium recovery from lithium

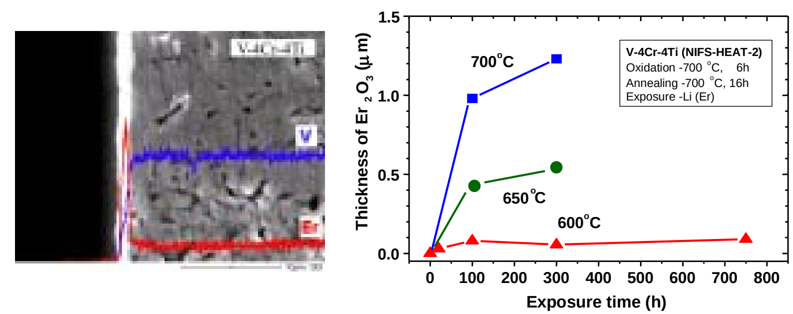
500C 600C 700C

fine fine fine

PVD coatings of Er_2O_3 on V-4Cr-4Ti were stable in liquid Li at 500-700C for 1000 hrs



Products from high purity V-4Cr-Ti ingot (NIFS-HEAT-2)



In-situ Er_2O_3 coating on V-4Cr-4Ti were shown to be a viable method for MHD coating for Li/V blanket

Development of Breeding Blankets (12)
Development of liquid breeding blanket (3)
LiPb related study

LiPb blanket related study

: LiPb breeder, dual coolant concept (He coolant+LiPb heat transfer) with SiC insert for electrical and heat insulation to flow at higher temp.

Recent Progress : fabrication technique, high mechanical strength/toughness, high temperature performance and radiation effect under JUPITER-II activities

LiPb loop was installed and started operation under a collaboration with JAERI.

Major parameters:

- LiPb inventory : 6 liter
- flow rate : 0 – 5 liter /min
- temperature : 250 – 400 degree C

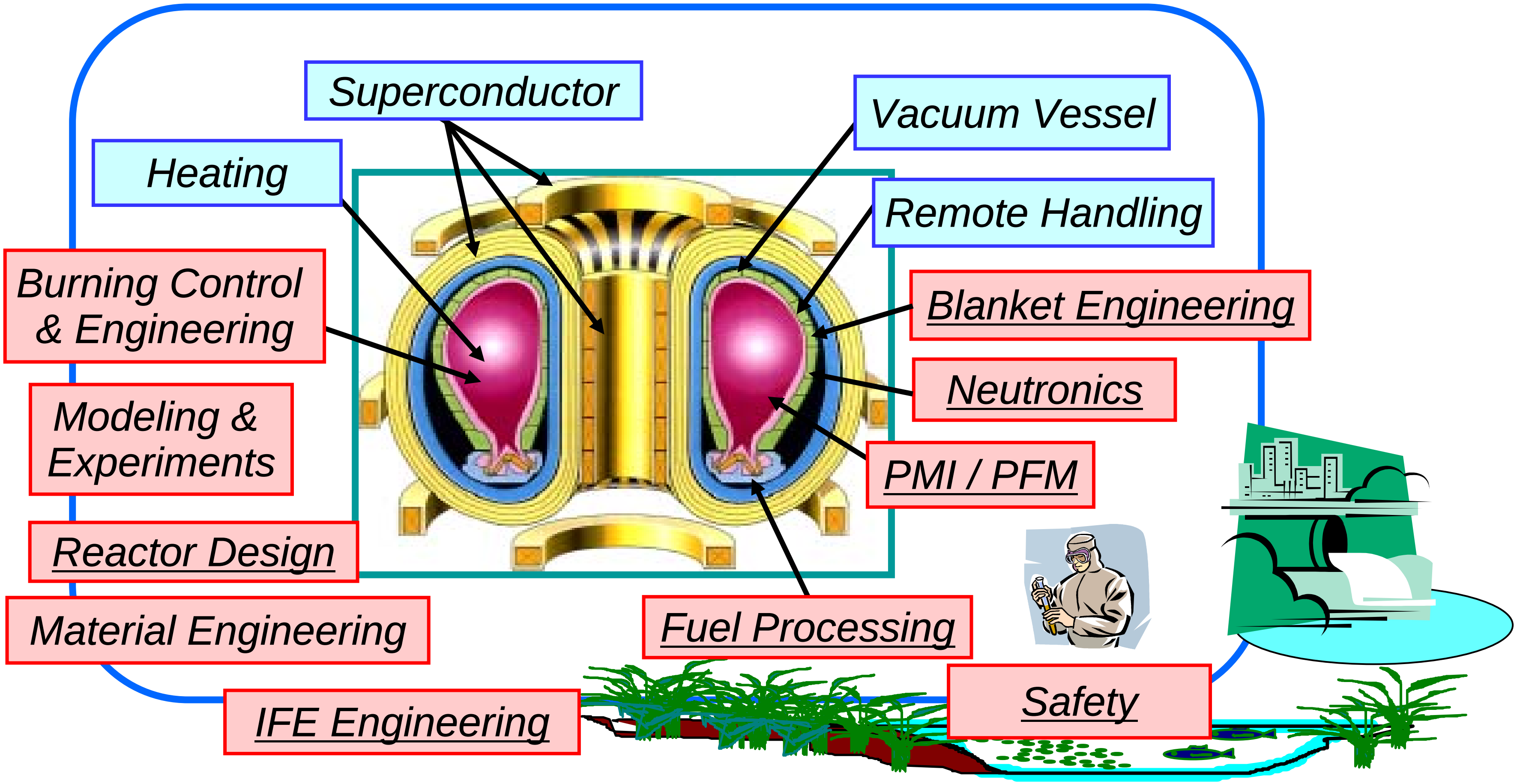
MHD and compatibility studies being performed.

LiPb loop in Kyoto University

The compatibility of SiC with LiPb is one of the remained feasibility concern. to be tested after modification for high temperature section.

R&Ds on other FNT Issues

Typical R&D themes on FNT



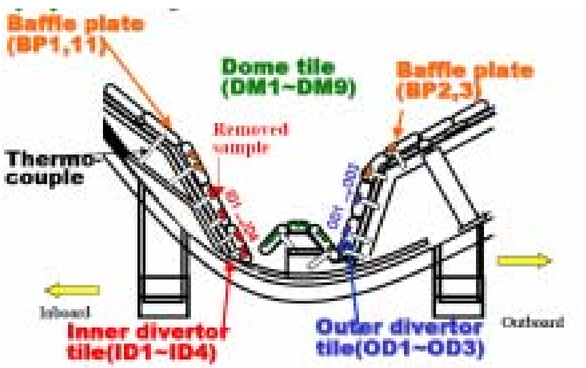
Japan is investigating all fields of FNT for ITER and DEMO.

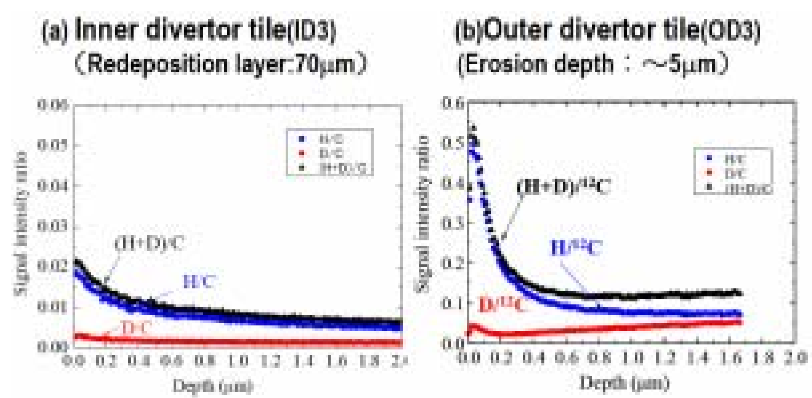
R&Ds on other FNT Issues (1)

PMI study under collaboration with Universities and JAERI

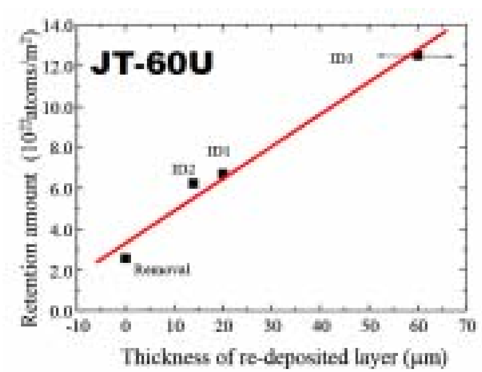
PMI and PFM studies have started under the joint research between Japanese universities and JAERI

Hydrogen isotopes (H/D/T) retention and erosion/deposition profiles were analyzed by various unique techniques (SIMS, TDS, IP, SEM).





Depth profiles of H and D observed by SIMS



Amount of retained hydrogen vs. thickness of re-deposition layer by TDS.

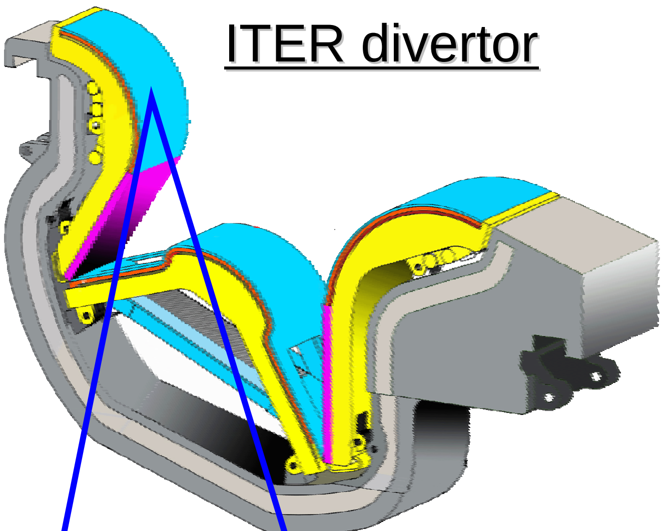
H and D retention profiles in the divertor region well correlated with the carbon deposition profiles

*The retained amount in the deposited layers, however, was very small (**below 0.03 in (H+D)/C**) compared to JET and other low temperature operational device.*

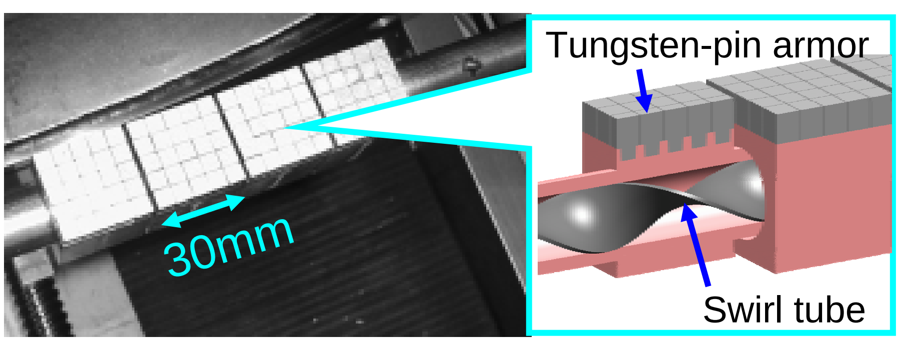
R&Ds on other FNT Issues (2)

Development of the divertor for ITER and DEMO

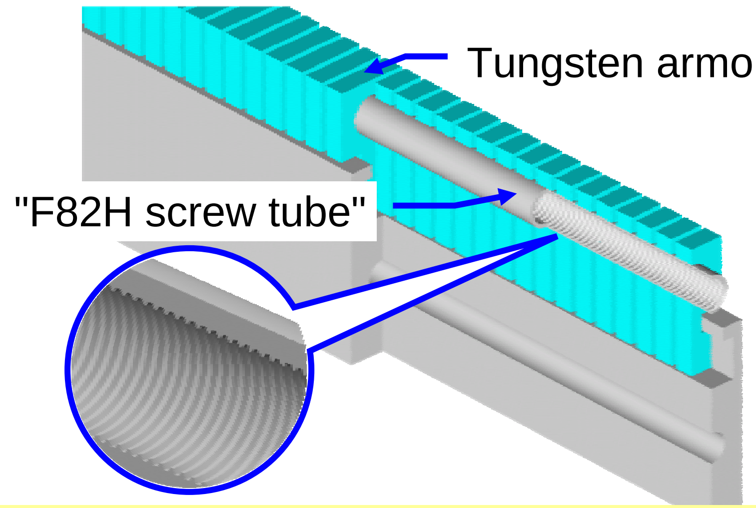
ITER divertor



Advanced bonding technology for the ITER divertor has successfully been developed. Divertor mockups with "tungsten-pin" armor were developed by hot-pressing method.



DEMO divertor

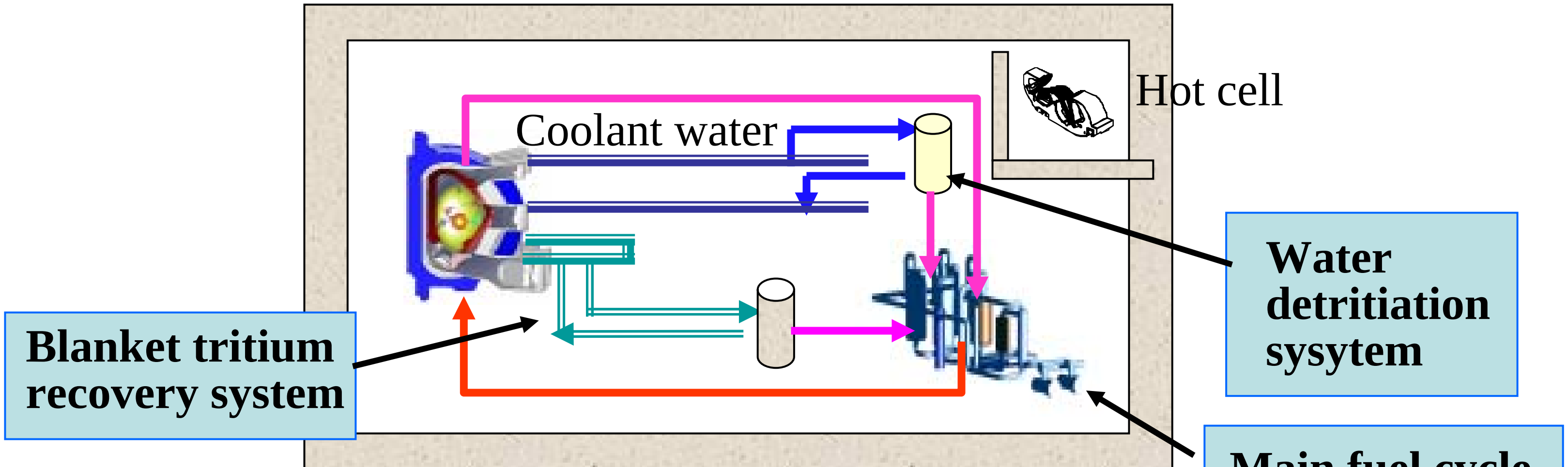


Basic R&D's for the DEMO divertor have widely been performed in JAERI under collaboration with Japanese Universities.

- Critical heat flux (CHF) test of a high performance cooling tube, "screw tube"
- Thermal fatigue test of a divertor mockup with F82H screw tube
- Direct bonding test of tungsten armor and F82H heat sink by diffusion bonding
- Ion irradiation test of various tungsten armor

R&D on other FNT Issues (3)

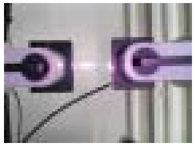
Fuel processing System



Tokamak and tritium builiding

R&D for fuel processing system

- Demonstration of a simulated integration system of main fuel cycle and blanket tritium recovery system
- R&D for ceramic proton conductor as an advanced blanket tritium recovery system
- Confirmation of durability of electrolysis cell in water detritiation system by γ ray irradiation (530 kGy, ITER design value) and tensile tests



ISFNT-7
Tokyo, Japan

東京大学 THE UNIVERSITY OF TOKYO

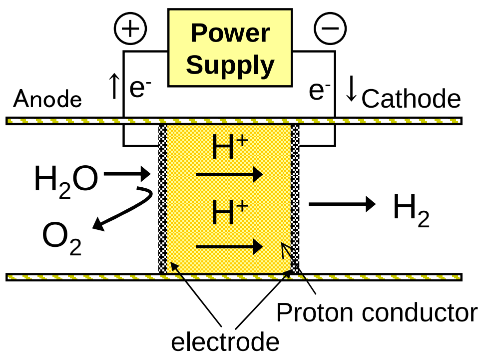
R&Ds on other FNT Issues (4)

Tritium Processing under developing at NIFS

Purpose	***Methods***	***Test Apparatus and Performance***

Recovery of tritium from exhaust gas as pure hydrogen gas

Steam electrolyzer using proton conductor



·*Conductor:*

$CaZr_{0.9}In_{0.1}O_{3-\alpha}$

one end closed tube

(15Φx500Lmm ;TYK)

·*Hydrogen pumping rate:*

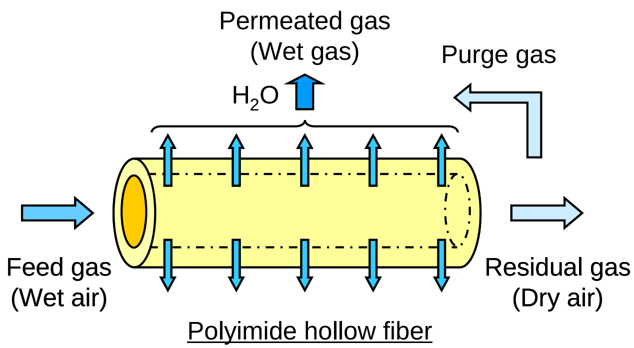
1ml/min in air at 800℃

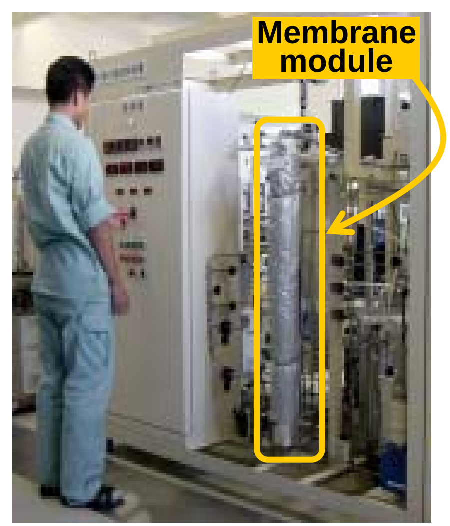
· *Collaboration:*

with TYK Co.Ltd.

Recovery of tritium from exhaust gas as tritiated water

Dehumidifier using hollow-fiber membrane





·*Membrane:*

commercially available ones

(UM-C10,et al. ;UBE)

·*Feed air flow rate:*

100 Nl/min

·*Achieved dew point:*

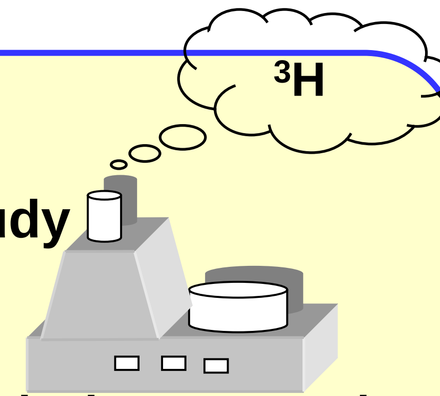
keep less than -70℃

· *Collaboration:*

with Shizuoka Univ.

R&D on other FNT Issues (5)

Safety (1)



JAERI

R&Ds for ITER Safety Design

- **CATS : Caisson Assembly for Tritium Safety Study**
  - Tritium behavior under postulated accidents
- **ICE : Ingress-of-Coolant Event test facility**
  - Ensure and demonstrate adequacy of ITER safety design approach

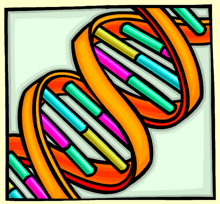
Tritium Accountancy

Decontamination of Tritium

Universities, NIRS and JAERI

Fundamental and System Simulation Studies

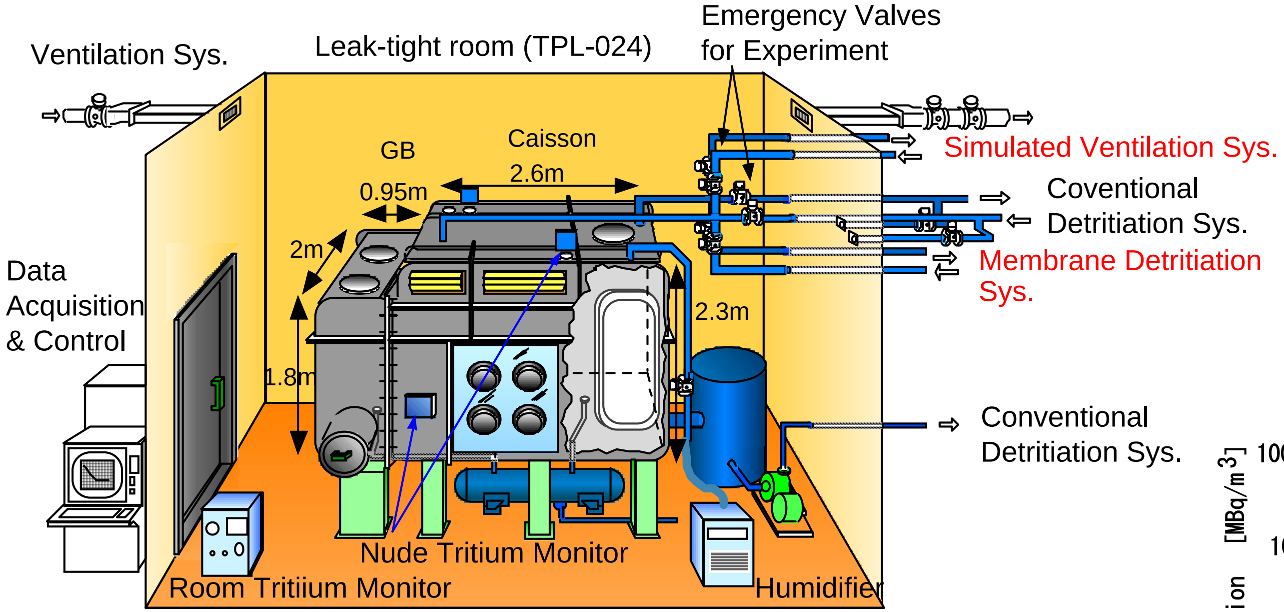
- Tritium confinement
- Tritium-material interaction
- Environmental behavior
- Biological effect

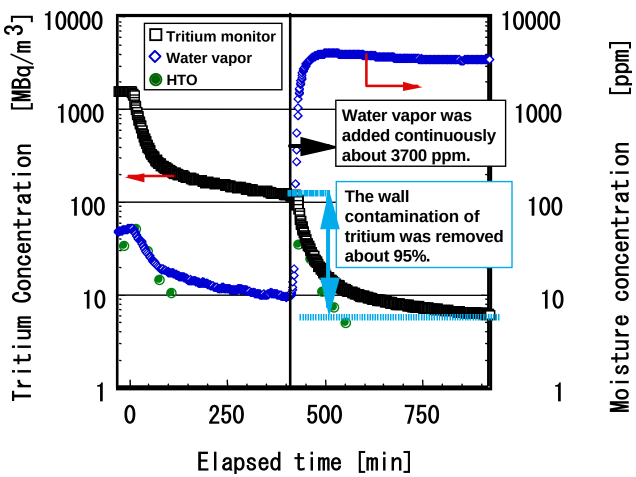


R&D on other FNT Issues (6)

safety (2) – Caisson Assembly for Tritium Safety Study (CATS) -

To obtain data required for assurance of the ITER safety, a new caisson (12 m^3) has been built in the Tritium Process Laboratory and tritium release experiments have been carried out since December 1998.





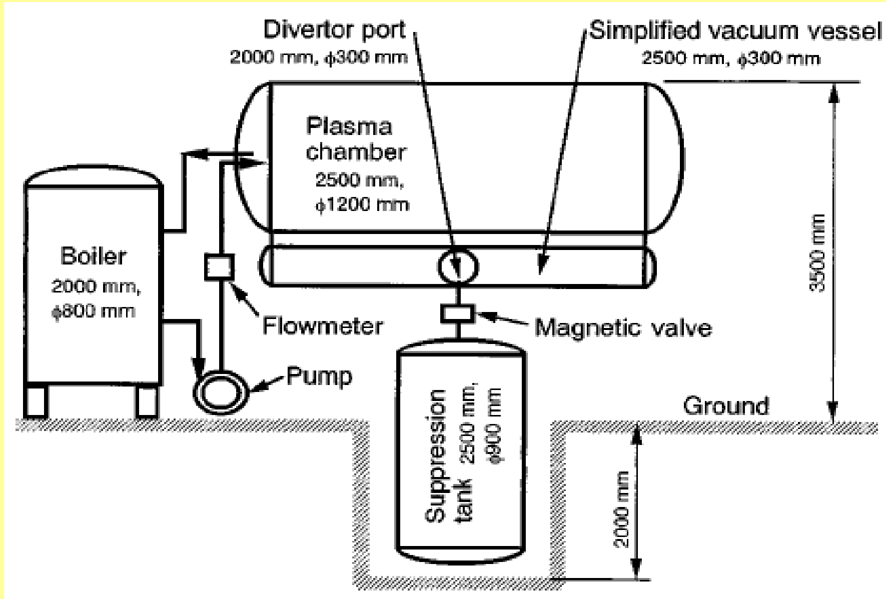
Typical tritium removal behavior from tritium contaminated stainless steel wall in the dry air atmosphere under the conditions of detritiation flow rate of $36 m^3/h$.

R&D on other FNT Issues (7)

Safety (3) - Integrated ICE Test Facility

To demonstrate that the ITER safety design approach and design parameters for the ICE (Ingress-of-Coolant Event) are adequate, an integrated ICE test facility was constructed in December, 1999.

The system simulating ITER pressure suppression system →
Scaling factor: ∼1/1600
(the facility / ITER-FEAT)
Plasma chamber, Vacuum vessel, Simulated divertor, Relief pipe and Suppression tank



Conceptual design of the combined ICE/LOVA test facility.

From the experimental results it was found quantitatively that the ITER pressure suppression system is very effective to reduce the pressurization due to the ICE event. Furthermore, it was confirmed that the analytical results of the TRAC-PF1 code can simulate the experimental results with high accuracy.

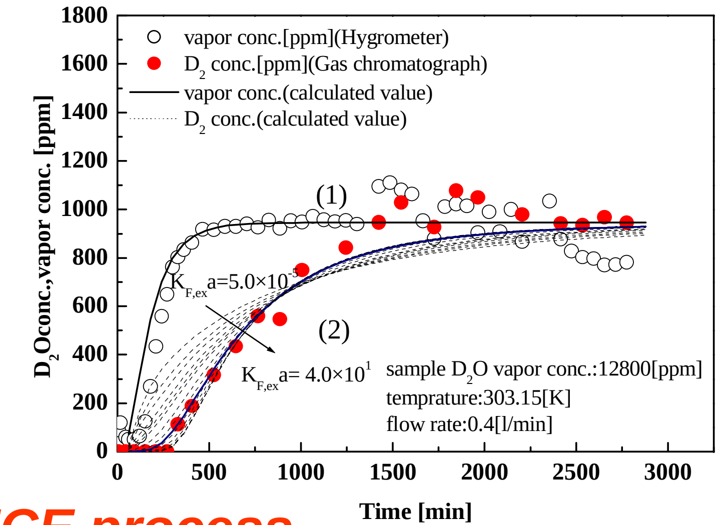
R&D on other FNT Issues (8)

Safety (4)

Permeation of heavy water vapor through cement paste

M. Nishikawa, et. al (Kyushu Univ.)

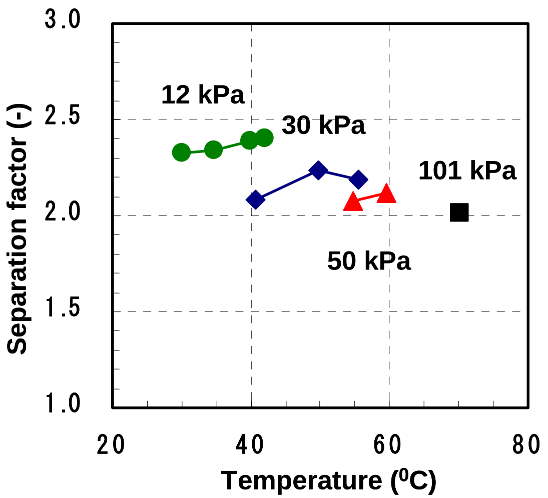
The diffusivity of water through the cement paste can be quantified from the curve using the adsorption isotherm. Then, the isotope exchange capacity and the rate of isotope exchange reaction are quantified.
It is also confirmed that the estimated values using adsorption isotherm, diffusivity, isotope exchange capacity and rate of isotope exchange reaction obtained in this study give good agreement with results in the tritium penetration experiment into the column of cement paste.



Volume reduction of waste water by CECE process

T. Sugiyama, et. al (NIFS)

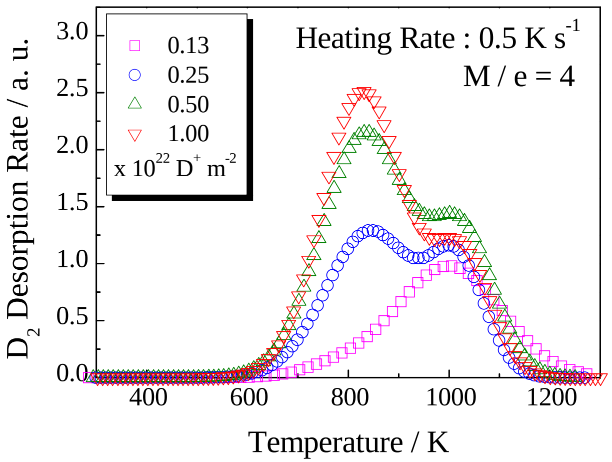
A pressure-reducing method was applied to the water-hydrogen chemical exchange in order to enhance the equilibrium separation factor. Hydrogen-deuterium isotope separation was performed using a trickle-bed chemical exchange column. The Kogel catalyst consists of 0.8 w-% Pt deposited on styrene-divinylbenzene copolymer. It confirmed that the separation factors under reduced pressure are larger than under atmospheric pressure. The HETP (Height Equivalent to a Theoretical Plate) values were distributed in the range of 6 to 15 cm.



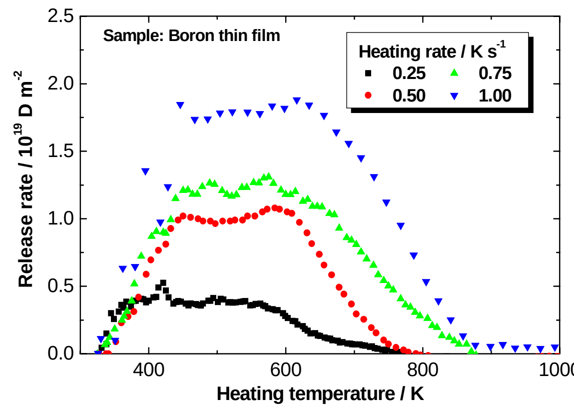
R&D on other FNT Issues (9)

Safety (5)

The hydrogen isotope behavior in typical plasma facing materials have been studied at The University of Tokyo and Shizuoka University. The correlation between chemical state of materials and hydrogen isotope desorption process was discussed.



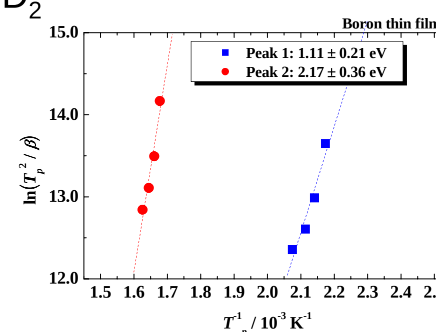
TDS spectra of D_2 from 1keV D_2^+ ion implanted SiC



TDS spectra of D_2 from 1keV D_2^+ ion implanted boron thin film

Deuterium desorption stages consists of two processes: Si-D and C-D bonds

Activation energy for Deuterium desorption from B-D-B (1.11eV) and B-D (2.17eV)



R&D on other FNT Issues (10)

Safety (6) - Biology, Health and Radiation

Effect of exposure of pregnant mouse to tritiated water or 137Cs-γ-Rays on androgen receptor mRNA expression in male offspring epididymis

Pregnant mice were orally administered HTO(10.9 kBq/g BW) or exposed to 137Cs-γ-rays(0.3Gy/h). Effects of radiation exposure on their male offspring were determined and the results indicated that no significant effects were observed on both items.

Translocation kinetics of atmospheric and soil D_2O (substitute for HTO) in tangerine

Uptake and loss kinetic parameters of D_2O in fruit of tangerine and translocation indexes at harvest were obtained in daytime and nighttime D_2O release experiments. The average translocation indexes (TLIa and TLIp) of deuterium as organically bound deuterium (OBD) in edible part of tangerine were 0.08% and 0.15% in daytime releases and 0.07% and 0.35% in nighttime ones. It was found that TLIs and TLIp in edible part of tangerine were 0.10-0.13% and 0.41-0.52%, respectively.

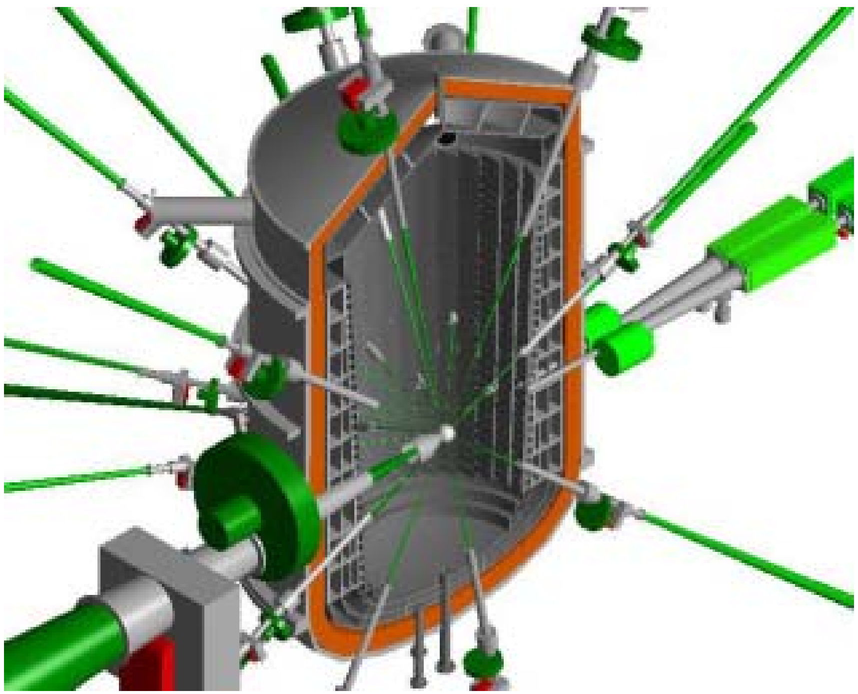
Availability of tritium gas oxidizing bacteria for tritium elimination system

In order to eliminate atmospheric tritium gas (HT) released from tritium handling apparatus, we intended to use HT oxidizing ability (enzyme hydrogenase) of the isolated bacterial strains from surface soils as a bioreactor. The bioreactors were made of bacterial cells grown on agar medium on cartridge filter and stored in a refrigerator until use. When HT contaminating air from the CATS in TPL/JAERI was introduced into the biological detritiation system, in which three bioreactors, each surface area of 216 cm^2 covered with strongly grown cells, 86% of HT in air was removed as tritiated water in these bioreactors at a flow rate of 100ml/min for 2 hours.

R&D on other FNT Issues (11)

FNT for Inertia Confinement System

Conceptual design of KOYO-Fast based on the fast ignition concept has been developed at ILE, Osaka University with collaboration of IFE forum.



Net Electric power with 4 modules	1200 MWe (300 MWe x 4)
Target gain	170
Fusion yield	200MJ/pulse
Lasers	1.1 MJ from 32 beams for compression and 100kJ for ignition operated at 16Hz
Laser material	Yb:YAG ceramic cooled to 150-220K
Laser efficiency	9.5% for compression laser and 3..5% for ignition laser
Thermal output	800 MWth
Blanket gain	1.13
Total thermal output of plant	3616 MWth (904 MWth x 4)
Electricity to thermal efficiency	42 % LiPb Temperature 500 C)

R&Ds on other FNT Issues (12)

Demonstration Tokamak Power Plant Concept : Demo-CREST

Two step strategy for the Demo-CREST Design studied by CRIEPI

1. to demonstrate electric power generation as soon as possible in a plant scale, with moderate plasma performance which will be achieved in the early stage of the ITER operation, and with foreseeable technologies and materials (**Demonstration Phase**)
2. to show a possibility of an economical competitiveness with advanced plasma performance and high performance blanket systems, by means of replacing breeding blanket from the basic one to the advanced one (**Development Phase**)

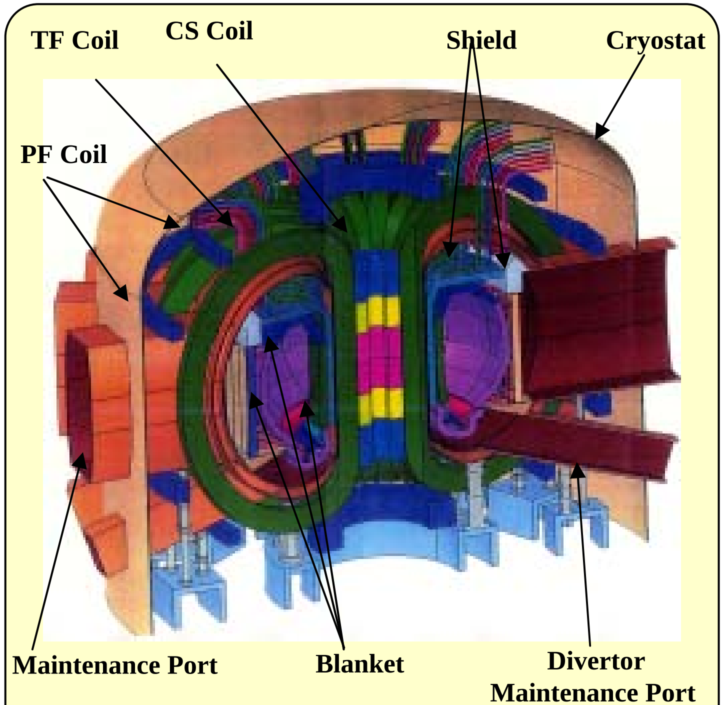


Figure:Bird's-eye of Demo-CREST

Table:Electric power and technology advancement in Development scenario by CRIEPI

Reactor technology advancement →
Plasma advancement ↓

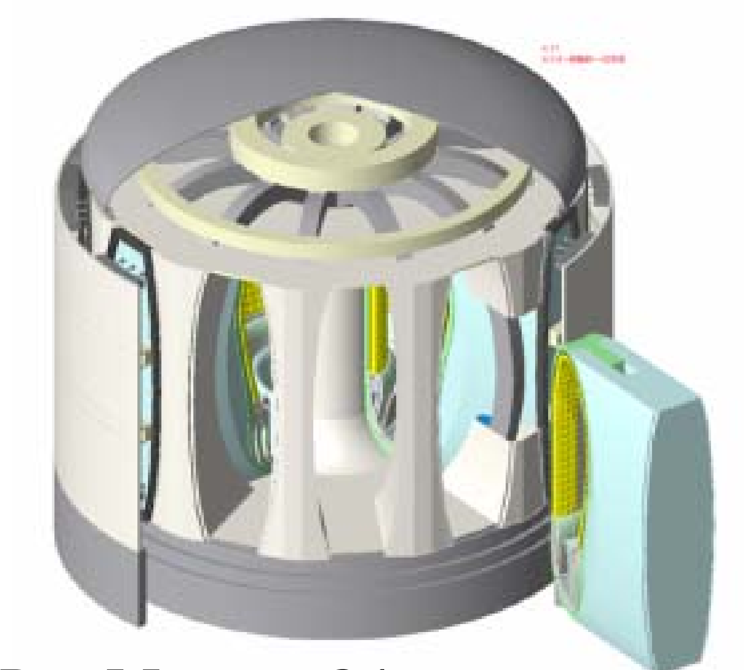
		ITER R= 6.2m a=2.0m Bt_{max}=13 T	Demo-CREST R=7.3m a=2.13m Bt_{max}=16 T: Demonstration Phase, Thermal Efficiency 30%	Demo-CREST R=7.3m a=2.13m Bt_{max}=16 T: Development Phase, Thermal Efficiency 40%	CREST R= 5.4m a=1.59m Bt_{max}=13T Thermal Efficiency 41%
	ITER Reference Plasma β_N~2.0	Demonstration of burning plasma	0MWe (Electric break-even)		
	ITER Advanced Plasma β_N=3.4	Development of the plasma required for a power plant	500MWe	900MWe	
	CREST-like Advanced Plasma β_N>4.0			1100MWe	1200MWe

R&Ds on other FNT Issues (13)

Compact DEMO Reactor Concept at JAERI

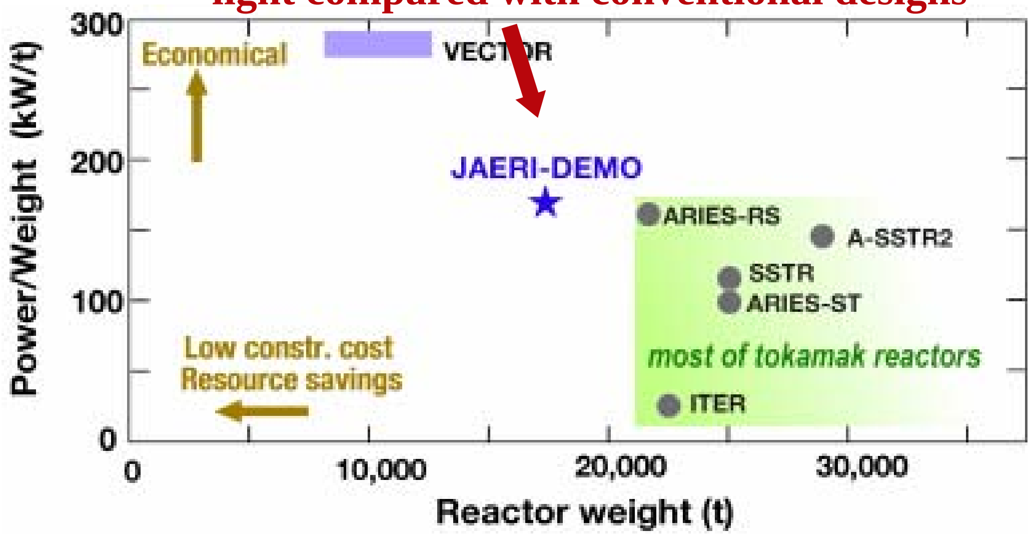
JAERI conceives a compact DEMO reactor featuring

1. **Down-sized center solenoid,**
2. **Slender TF coil system with a reduced stored energy (25 GJ),**
3. **Low aspect ratio (A ~ 2.6), and**
4. **Light, compared with conventional tokamak reactor designs**



R_p = 5.5 m, a_p = 2.1m
B_T = 6 T, I_p = 16.7 MA, P_{fus} = 3 GW

JAERI-DEMO,
light compared with conventional designs

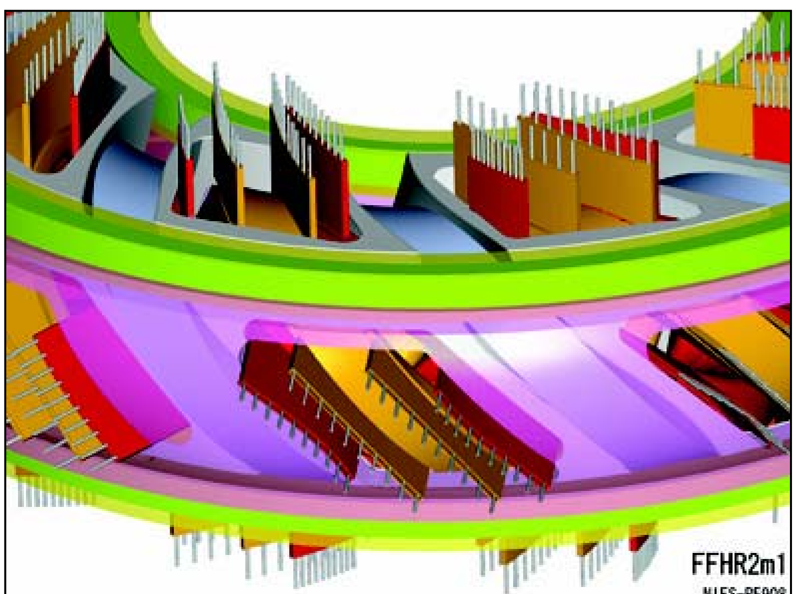


R&Ds on other FNT Issues (14)

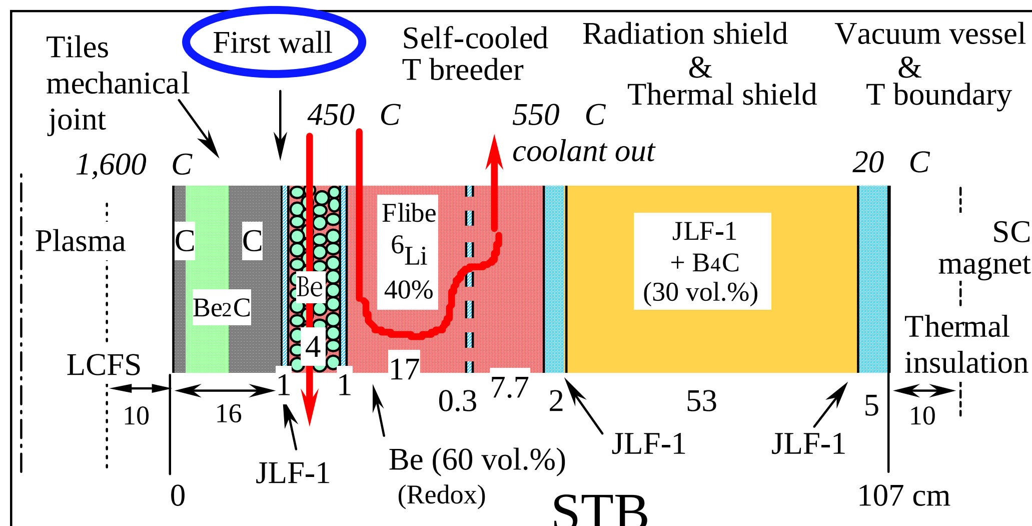
LHD-type Helical Power Reactor FFHR

Based on the main advantage of current-less plasma, two sets of optimization have been studied at NIFS

1. **to expand the blanket space by adjustment of the coil pitch parameter** γ of the continuous helical winding, while reducing the magnetic hoop force to open wide maintenance ports,
2. **to solve the replacement difficulty by proposing a long-life blanket concept** STB (Spectral-shifter and Tritium breeder Blanket) using carbon tiles to soften the neutron energy spectrum on the self-cooled Flibe-RAF blanket.



Replacement-free blanket (first wall < 100dpa / 30y)



STB

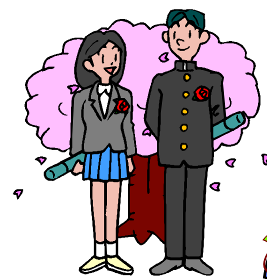
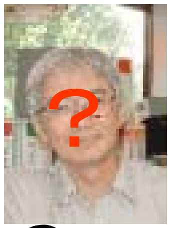
Summary

- Japanese fusion program clearly encompass the energy development through ITER and beyond.
- Construction and operation of ITER in a timely manner is essential with a view to participating into energy supply system in the middle of 21^{st} century.
- Japan has a strong intention to contribute in FNT to the world fusion research program led by the construction of ITER, as well as IFMIF and other projects.
- R&Ds on Fusion Nuclear Technology have been conducted on all fields of FNT in Japan by JAERI, universities and research institutes, and in collaboration with international partners.
- Further involvement of domestic industries in the R&Ds on FNT is also deemed important in Japan.
- Continuous effort to maintain and increase the number of talented researchers for academia and industries is identified as an important issue and we are strongly making an effort to maintain human resource for fusion community.

FNT History in Japan and Future for Energy Production

1985	1988	1997	2005	Future
	ISFNT-1	ISFNT-4	ISFNT-7	matchmaker



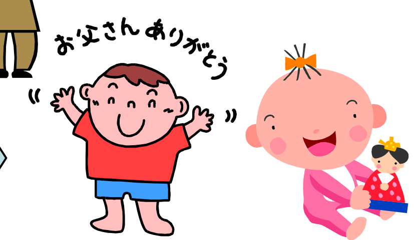





named “*FNT*”

FNT R&Ds toward Energy Production!

FNT R&Ds were growing.

FNT in Japan was organized.



named “*ITER*” *and* “*DEMO*”

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