Present Status and Future Potential for Commercial Application of JAEA Research Reactors

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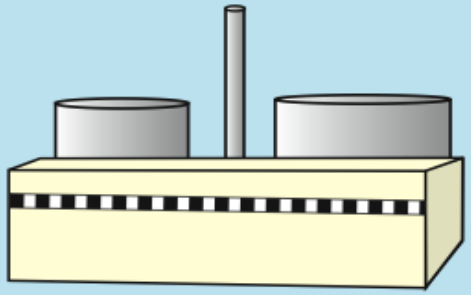
Contents

1. Utilization Fields of Research Reactors

Lifetime extension of LWRs



- Aging management of LWRs
- Development of next generation LWRs

Progress of science and technology

- Development of fusion reactor materials and components
- Development of HTGR fuels and materials
- Basic research on nuclear energy, etc.

Expansion of industry use

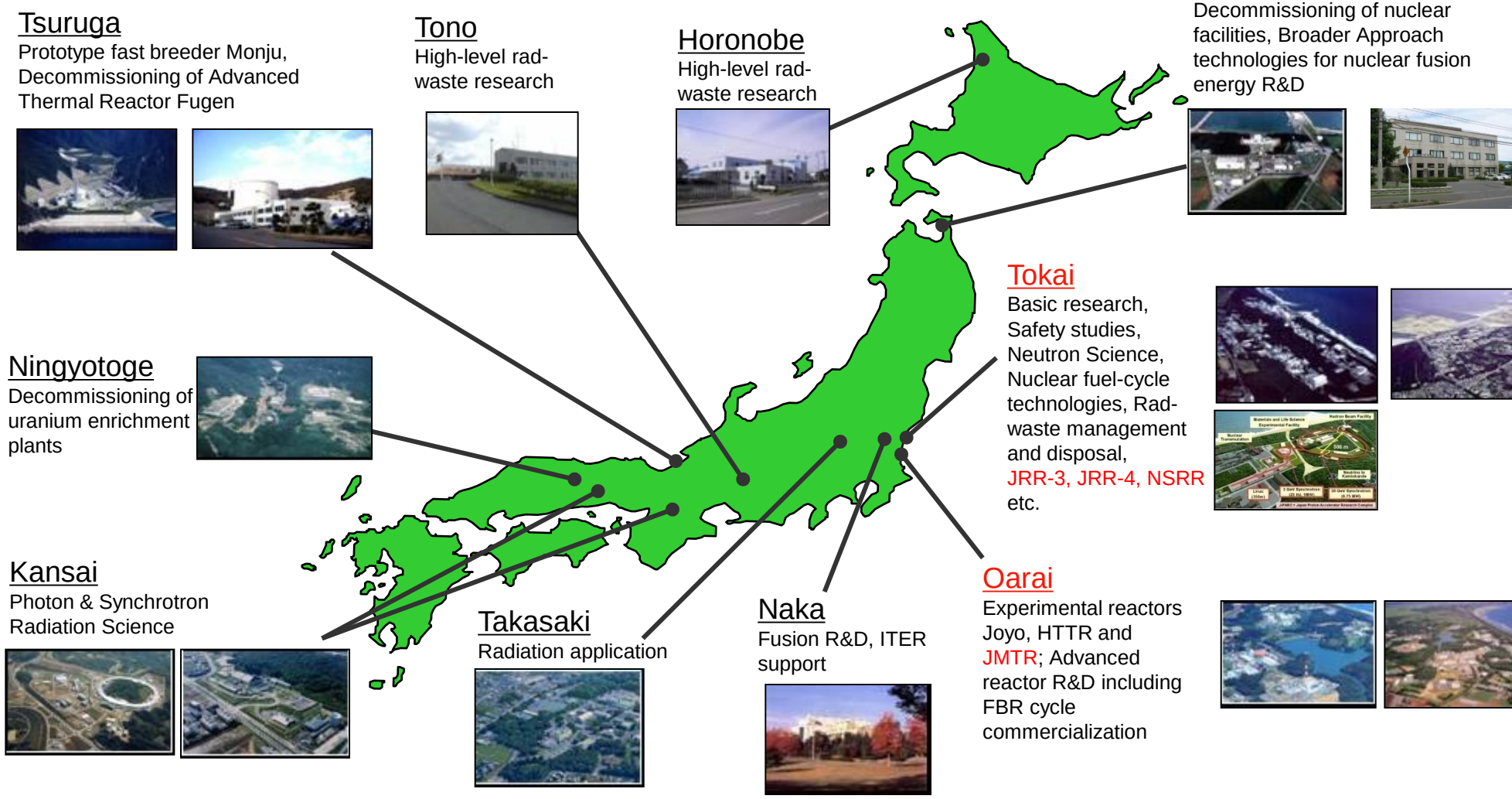
- Production of silicone semiconductor for hybrid car

- Production of ^{99m}Tc for medical diagnosis medicine

Education and training of nuclear scientists and engineers

Contents

2.1 Location Map of Research Centers of JAEA



Tsuruga
Prototype fast breeder Monju, Decommissioning of Advanced Thermal Reactor Fugen

Tono
High-level rad-waste research

Horonobe
High-level rad-waste research

Aomori
Decommissioning of nuclear facilities, Broader Approach technologies for nuclear fusion energy R&D

Tokai
Basic research, Safety studies, Neutron Science, Nuclear fuel-cycle technologies, Rad-waste management and disposal, JRR-3, JRR-4, NSRR etc.

Ningyotoge
Decommissioning of uranium enrichment plants

Kansai
Photon & Synchrotron Radiation Science

Takasaki
Radiation application

Naka
Fusion R&D, ITER support

Oarai
Experimental reactors Joyo, HTTR and JMTR; Advanced reactor R&D including FBR cycle commercialization

2.2 Role of JAEA Research Reactors

Items \ Reactor	JMTR (50MW)	JRR-3 (20MW)	JRR-4 (3.5MW)	NSRR (23GW*)
Lifetime extension of LWRs	○			○
Progress of science and technology	○	○		
Expansion of industry use	○	○	○	
Education and training	○		○	

* : Pulse operation

2.3(1) Specifications ofJRR-3

1962 First criticality

1985 Remodeling works start to achieve high performance

1986 Take out reactor core

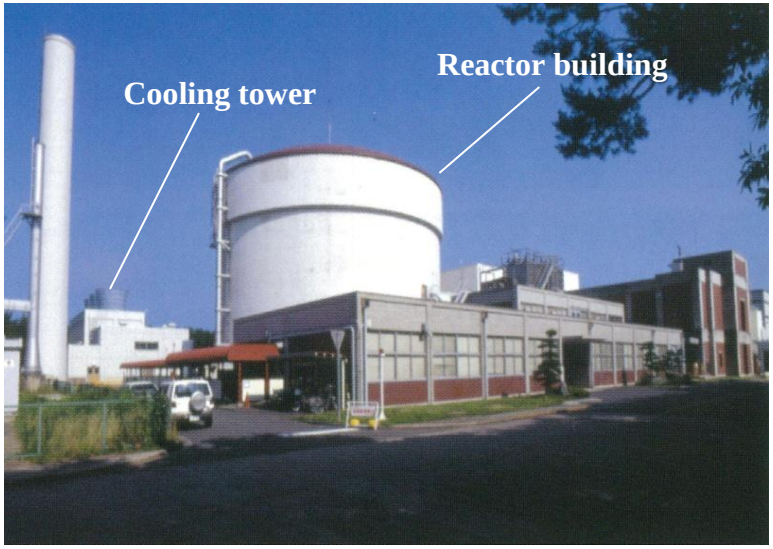
1990 Criticality & Utilization start

1993 Cumulative output reached at 10,000MWD

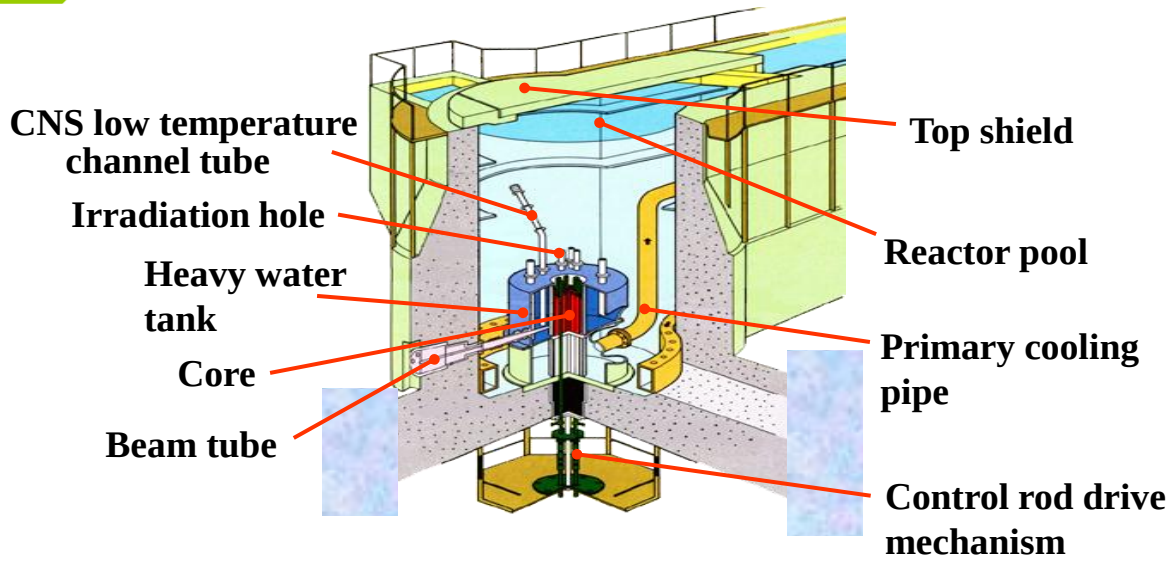
1998 High density fuel loading (LEU/Si/Al dispersion fuel)

2006 Cumulative output reached at 50,000MWD

Specifications of JRR-3	
Purpose	Beam experiment, Fuel/material irradiation, RI production, Activation analysis, etc.
Type	Light water moderated and cooled pool type
Fuel	LEU/Si/Al dispersion fuel
Thermal power	20 MW (max.)
Thermal flux	3 x 10^{18} n/m^2・s (max.)
Core	Cylinder shape (60cm dia. 75cm in height)
Operation mode	26 days/cy, 6-7 cy/year



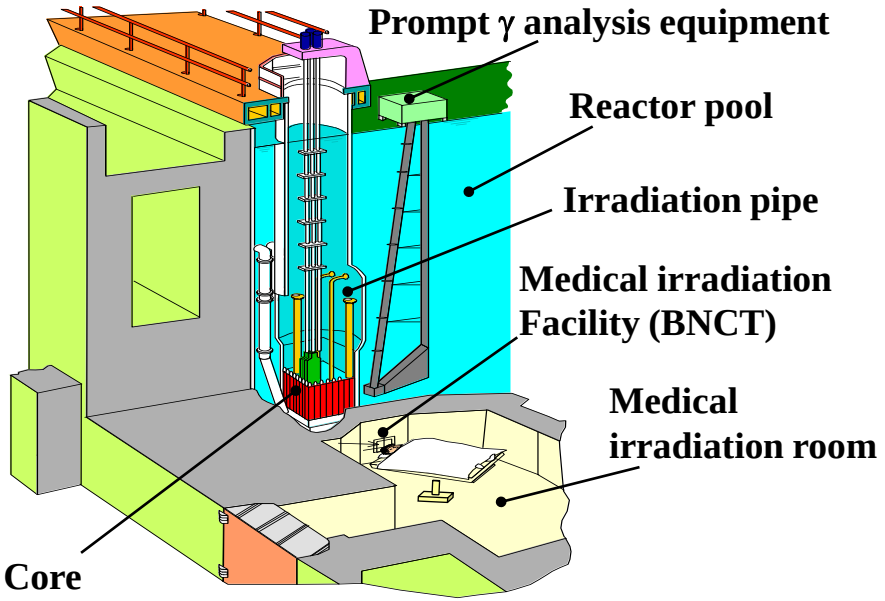
View of Reactor building



Reactor core

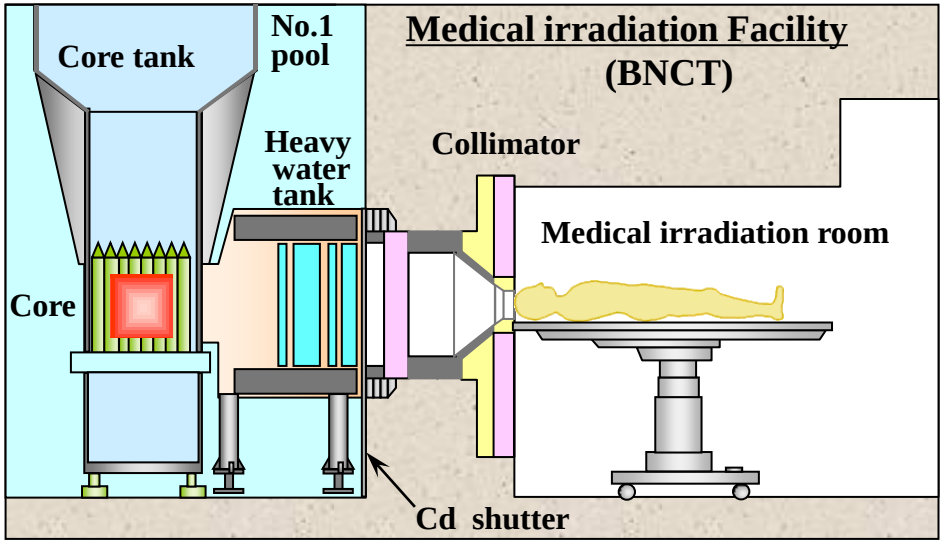
2.3(2) Specifications of JRR－4

1965First criticality
1966 Thermal power at 2500 kW,
Radiation shielding experiment start for nuclear ship “MUTU”
1969 Training start for reactor engineers
1974 Outside utilization start
1999 Thermal power at 3500kW
1996 LEU fuel,
Update reactor facilities & utilization facilities
1998 Outside utilization restart



Bird‘s eye view of reactor

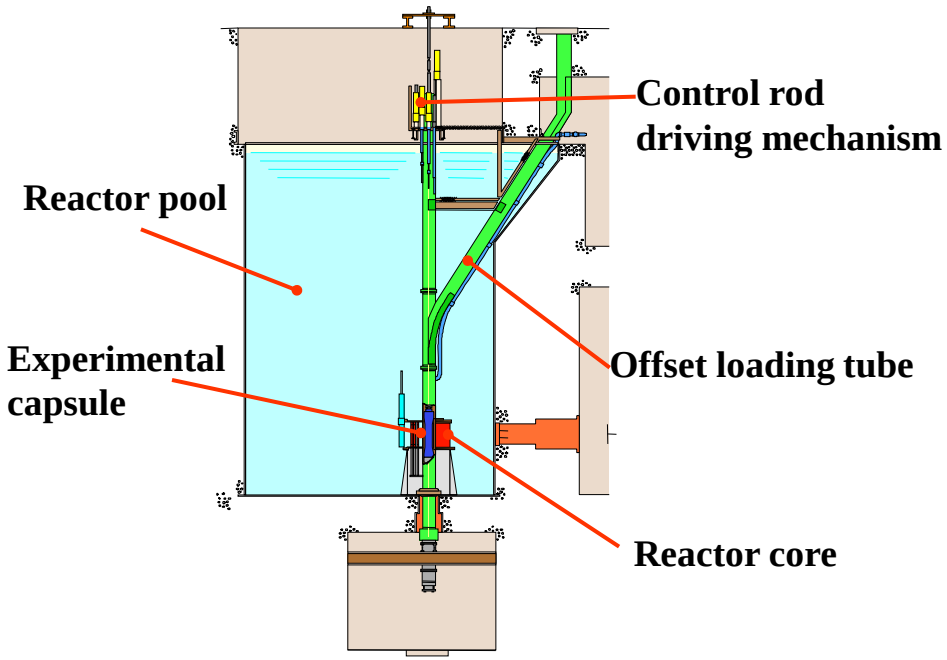
Specification of JRR-4	
Purpose	Activation analysis, education & training, RI production, Medical irradiation, radiation shielding experiment
Type	Light water moderated and cooled swimming pool type
Fuel	LEU/Si/Al dispersion fuel
Thermal power	3,500 kW s (max.)
Thermal flux	7 x 10^{17} n/m^2・s (max.)
Core	Rectangular (34.4cm×40.5cm, 60cm in height)
Operation mode	Daily operation (6h/day)



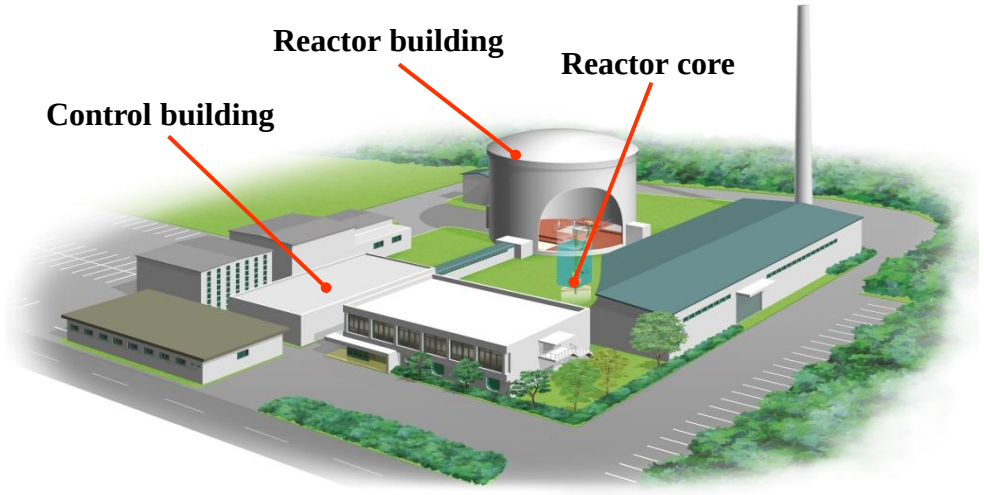
2.3(3) Specifications of NSRR

1975 First criticality/ Fresh fuel experiments starts
1980 Succeed in visible capsule experiments
1989 Modification of experimental facilities and reactor control system
Spent fuel experiments starts
1996 Spent MOX fuel experiments starts
2004 3,000 pulse operations achieved
2006 High burnup fuel and MOX fuel experiments starts
High pressure water capsule experiments starts

Specification of NSRR	
Type	Type of Uranium-Zirconium-hydride moderating heterogeneous
Fuel	Uranium-Zirconium-hydride
Maximum Reactor power	300kW（Steady state operation） 23,000MW（Pulse operation）
Maximum neutron flux	$1.9 \times 10^{16} n/m^2 \cdot s$ （Steady state operation）
Core	Annular core
Operation mode	Steady state operation Natural pulse operation Shaped pulse operation Combined pulse operation



Schematic illustration of NSRR



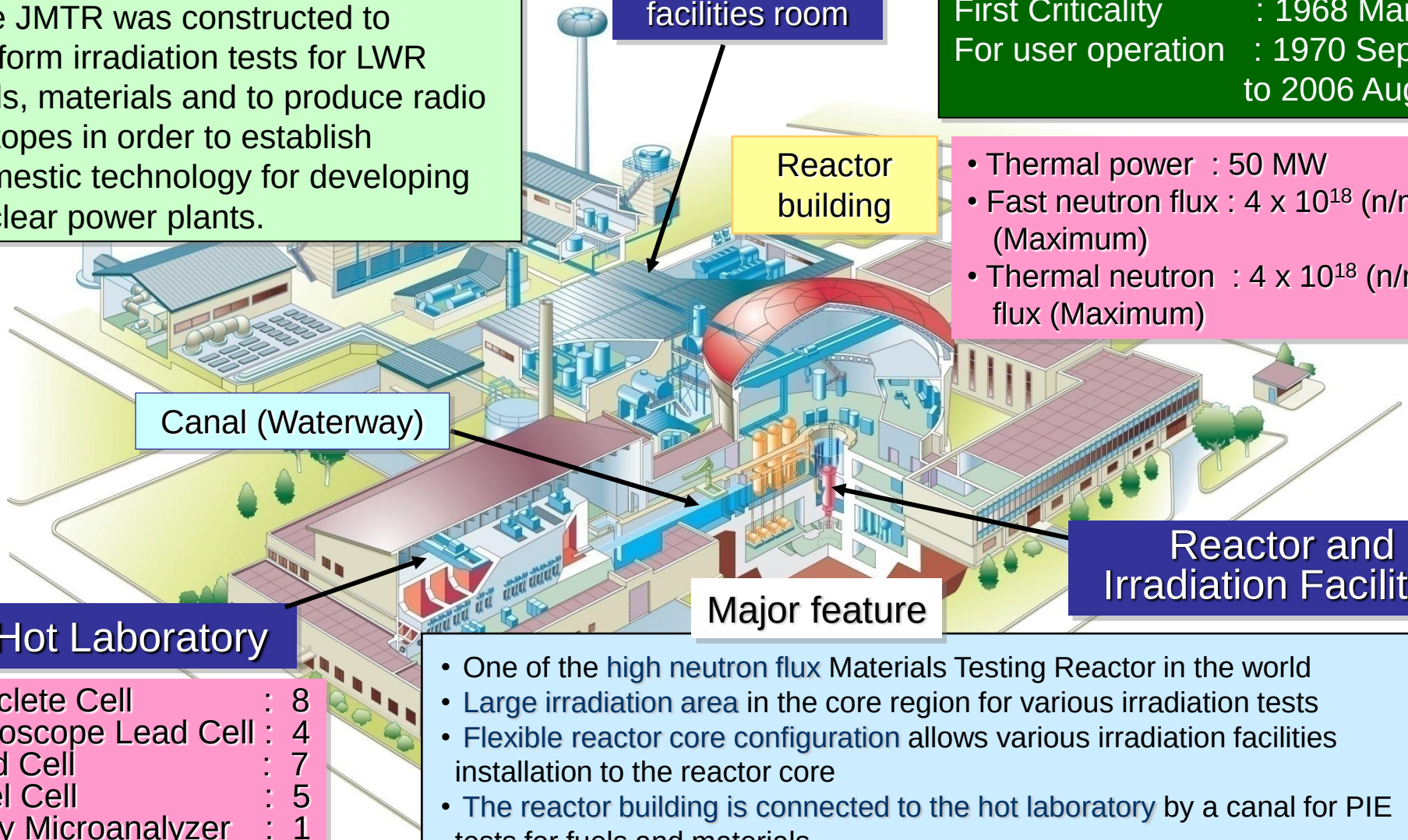
Cutaway view of NSRR reactor building

2.3(4) Specifications of JMTR

Purpose

The JMTR was constructed to perform irradiation tests for LWR fuels, materials and to produce radio isotopes in order to establish domestic technology for developing nuclear power plants.

Construction began : 1965 Apr.
First Criticality : 1968 Mar.
For user operation : 1970 Sep.
to 2006 Aug.



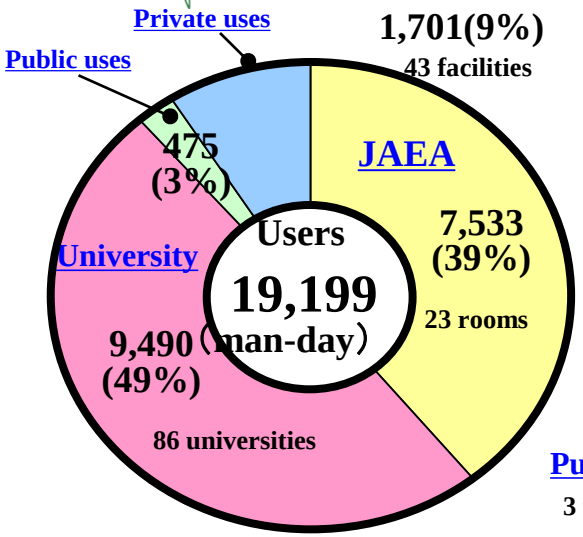
- Thermal power : 50 MW
- Fast neutron flux : 4 x 10^{18} (n/m^2/s) (Maximum)
- Thermal neutron : 4 x 10^{18} (n/m^2/s) flux (Maximum)

Conclete Cell	: 8
Microscope Lead Cell	: 4
Lead Cell	: 7
Steel Cell	: 5
X-ray Microanalyzer	: 1

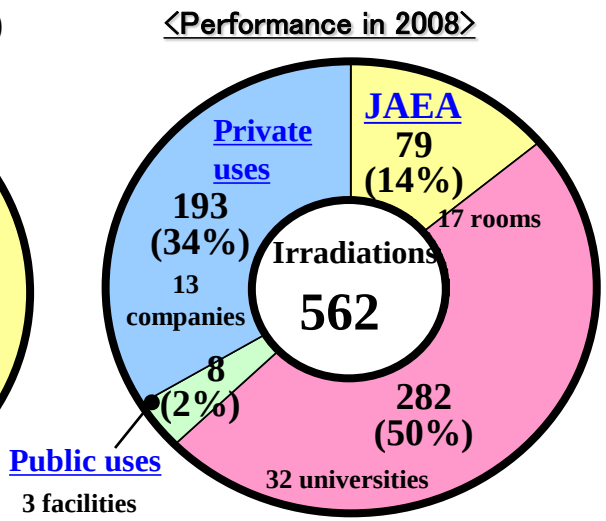
Major feature

- One of the high neutron flux Materials Testing Reactor in the world
- Large irradiation area in the core region for various irradiation tests
- Flexible reactor core configuration allows various irradiation facilities installation to the reactor core
- The reactor building is connected to the hot laboratory by a canal for PIE tests for fuels and materials.

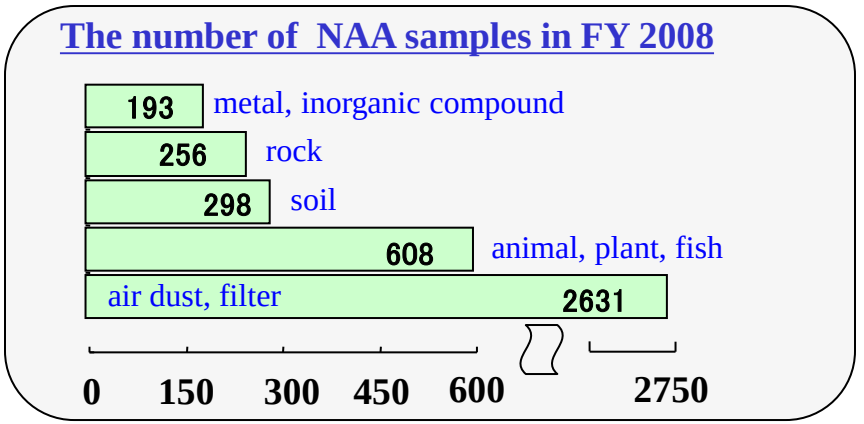
2.4(1) Utilization of JRR-3

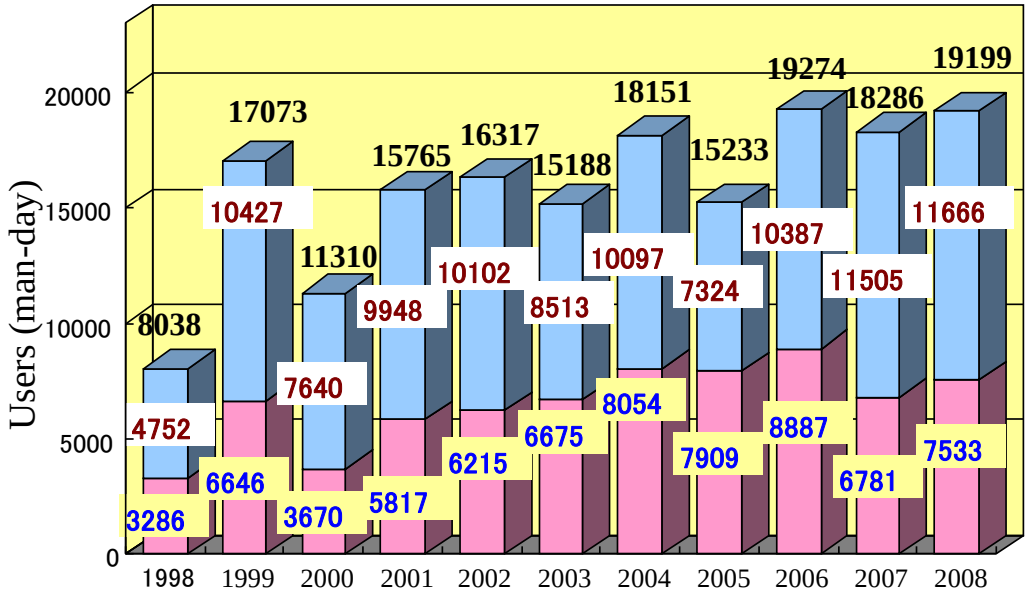


Beam utilization

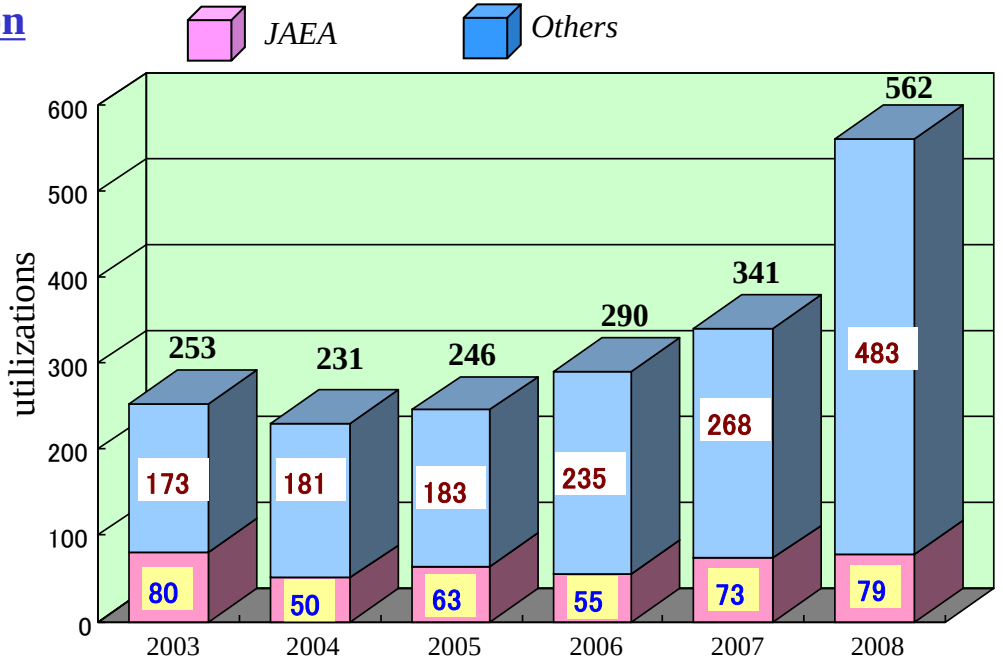


Irradiation Utilization



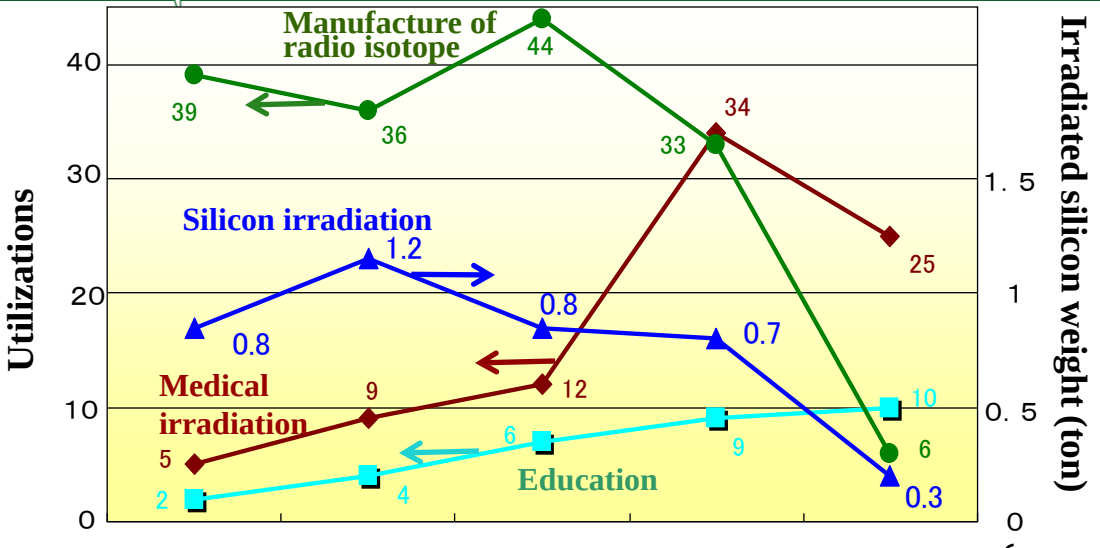


Change in number of users for Beam utilization



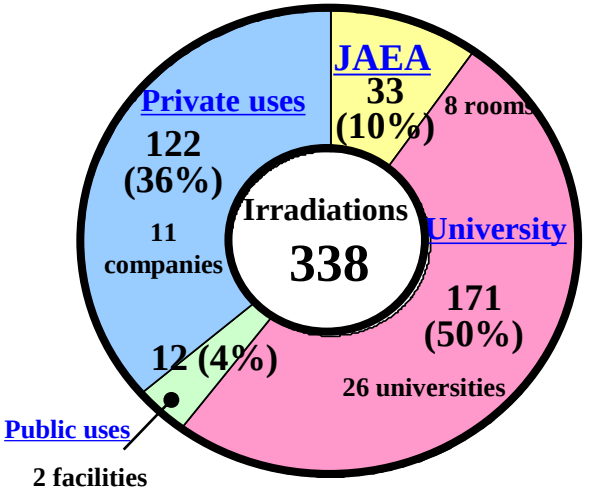
Change in number of irradiation utilization

2.4(2) Utilization of JRR-4

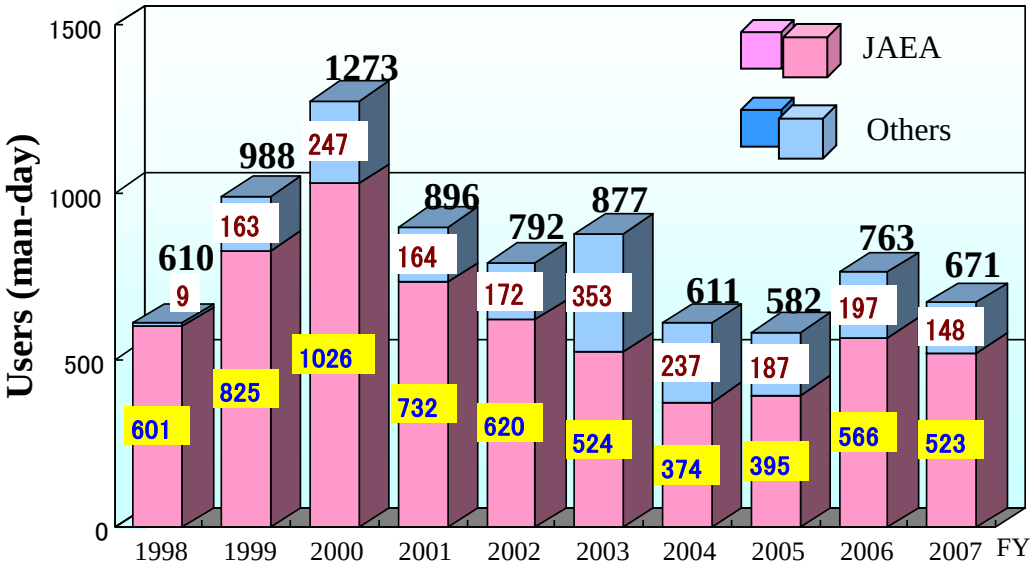


Attentions: Y2007 had 25 cycles.

Change in number of utilization in each topic

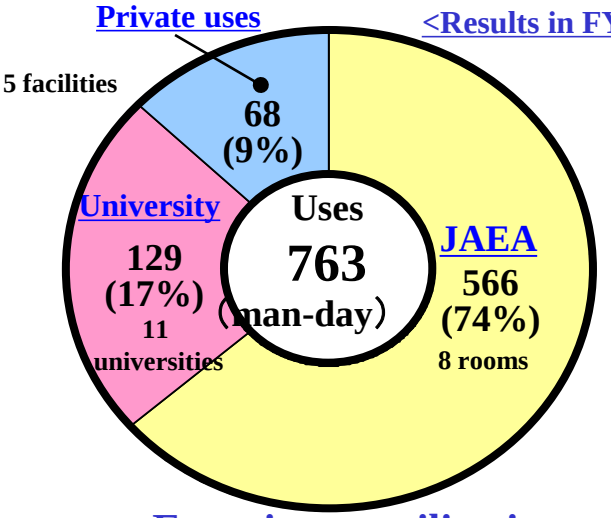


Irradiation utilization



Attentions: Y2007 had 25 cycles.

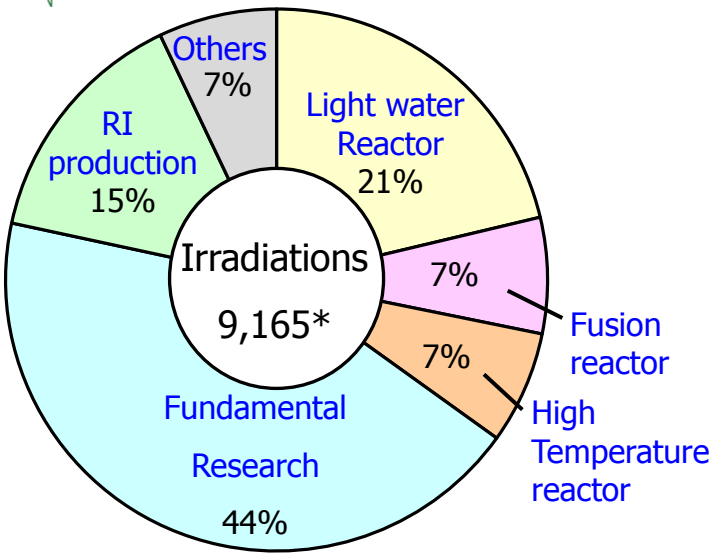
Change in number of users of experiments



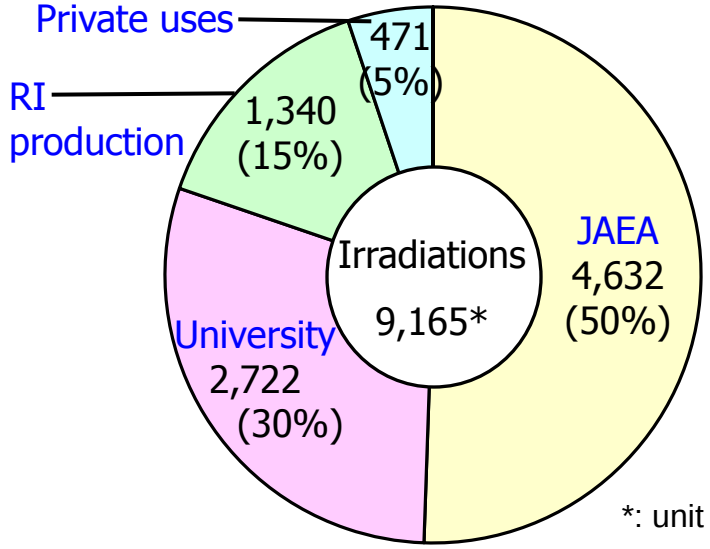
Experiment utilization

The reactor restarted in 2/22 FY2010. The utilization has been available since 3/24 FY2010.

2.4(3) Utilization of JMTR

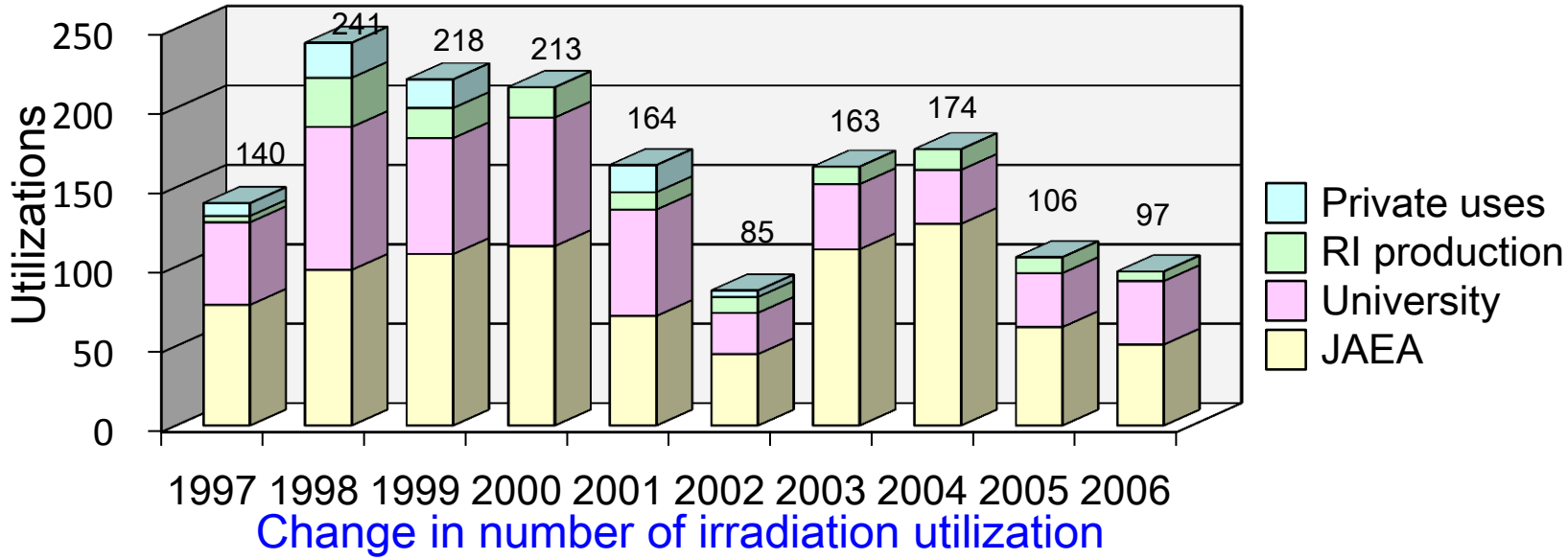


Irradiation fields (1-165Cy)



*: unit (cycle･capsule)

Users (1-165Cy)



Change in number of irradiation utilization

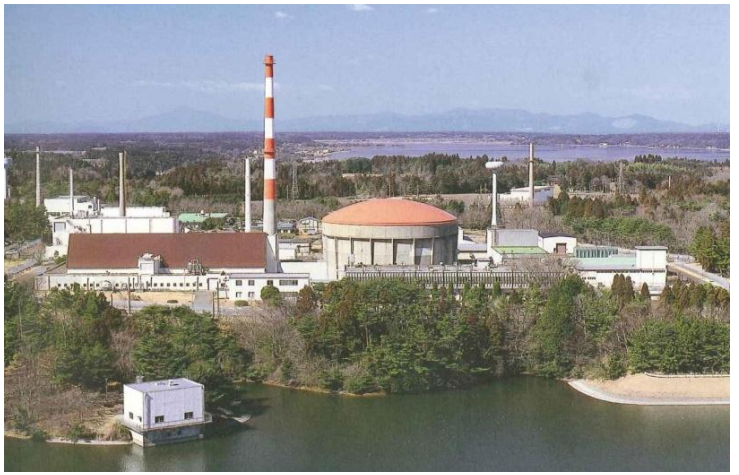
Contents

C & R for JMTR Reoperation

◆October 1st , 2005 Establishment of JAEA

- JAEA decided that JMTR was one of decommissioning facilities

Users requested strongly to reoperation of JMTR



◆November, 2005 – December, 2006

- C & R on JMTR reoperation by JAEA/MEXT (Government)
  JAEA internal C & R (from November, 2005 to March, 2006)
  Government C & R (from April, 2006 to October, 2006)
- After the 2007 F.Y. budget was approved by the Ministry of Finance, JAEA finally decided to restart of the JMTR.

◆April 1st, 2007

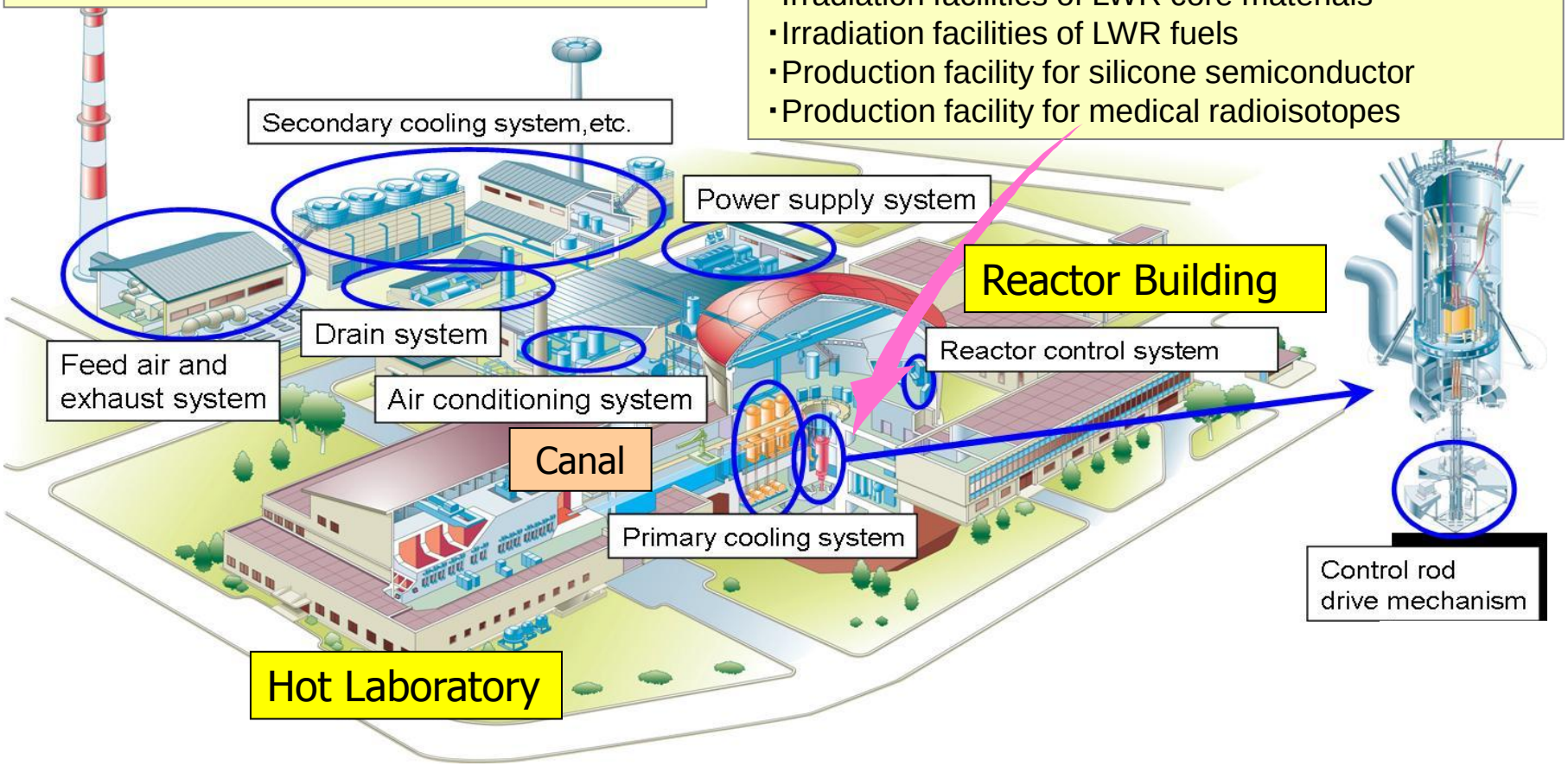
JAEA organized "Neutron Irradiation and Testing Reactor Center" to conduct refurbishment of JMTR facilities and to promote the usability considering user opinion.

Reactor facilities are refurbished during four years from the beginning of FY2007, and operation of the new JMTR will start in FY2011.

Refurbishment of the JMTR

Renewal of the reactor facilities are shown as encircled.

Planning of new irradiation facilities :
- Irradiation facilities of LWR core materials
- Irradiation facilities of LWR fuels
- Production facility for silicone semiconductor
- Production facility for medical radioisotopes



The renewed and upgraded JMTR will be operated for a period of about 20 years (until around FY 2030).

Concept of new JMTR

Measures of new JMTR

●Proposal of attractive irradiation tests

Proposal of the irradiation data with high technical value through the development of the new technology, the cooperation with the various nearby post irradiation examination facilities, etc.

●Establishment of international center

Construction of the research base utilized internationally as the Asian center of testing reactor

●User-friendly management

Realization of the environment which is easy to use for many users due to the fulfillment of the technological support system, etc.

Usability Promotion of new JMTR

We aim at the testing reactor which is attractive to the users.

- Testing reactor operation at the reactor-operating rate of 50%-70%
- Shortening of turnaround time to get irradiation results earlier
- Realization of more attractive irradiation cost in comparison with other testing reactors of the world
- Establishment of more simple irradiation procedure and more satisfied technological support system to use more easily
- Guard of the business confidence by perfect information control, etc.

3.1 Measures of New JMTR

-Propose of Attractive Irradiation Technology-

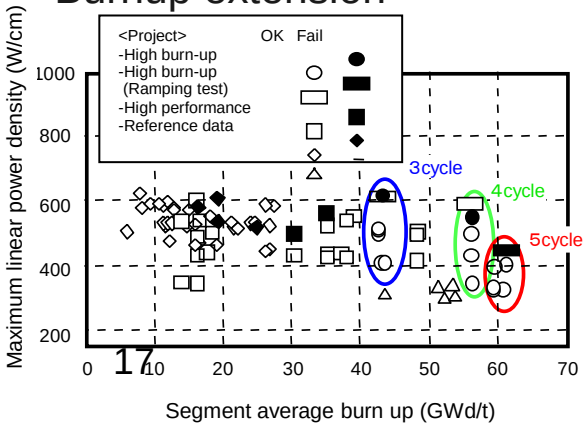
IASCC test of LWR core internals

Life time extension of LWR

shroud

Power ramping test of LWR fuels

Burnup extension



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Temp. control

Saturation temp.
Automatic constant temp.
High temp.

Environmental control

Water chemistry, load

Special instrumentation

Displacement, crack propagation
Re- instrumentation (temp., pressure)

Power ramping

Fuel power control by ^{3}He gas

Neutron control

Spectrum adjustment
Pulse irradiation

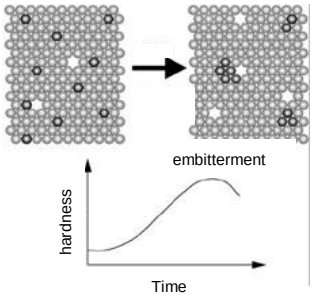
Re-irradiation

Assembling in hot cell

Irradiation Technology

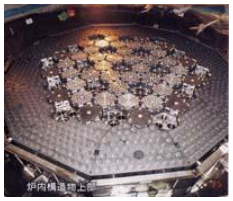
High accuracy of Temperature control

Research of radiation damage



High temp. irradiation

Development of HTTR

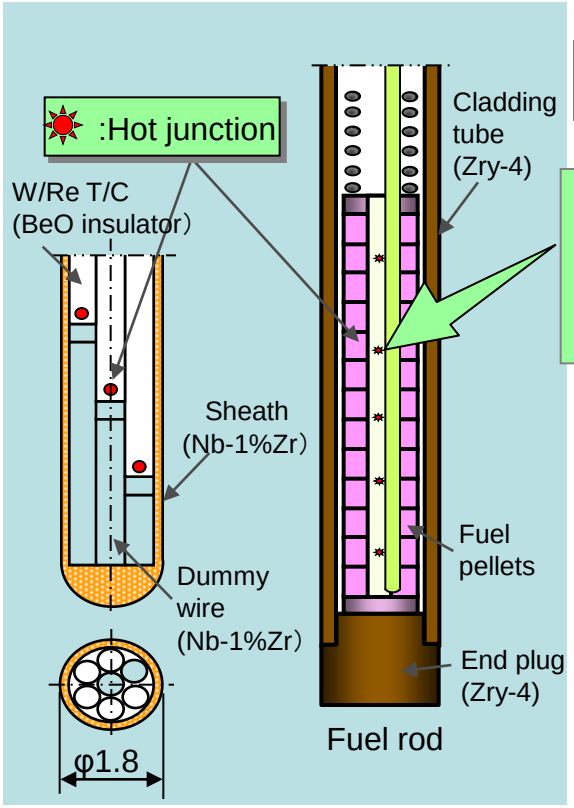


ITER operation, He production rate/dpa simulation

Development of fusion reactor

3.1 Measures of New JMTR
-New Irradiation technology development -

Measurement of axis temp. distribution of fuel rod



Development items:
- Insulation, etc.,

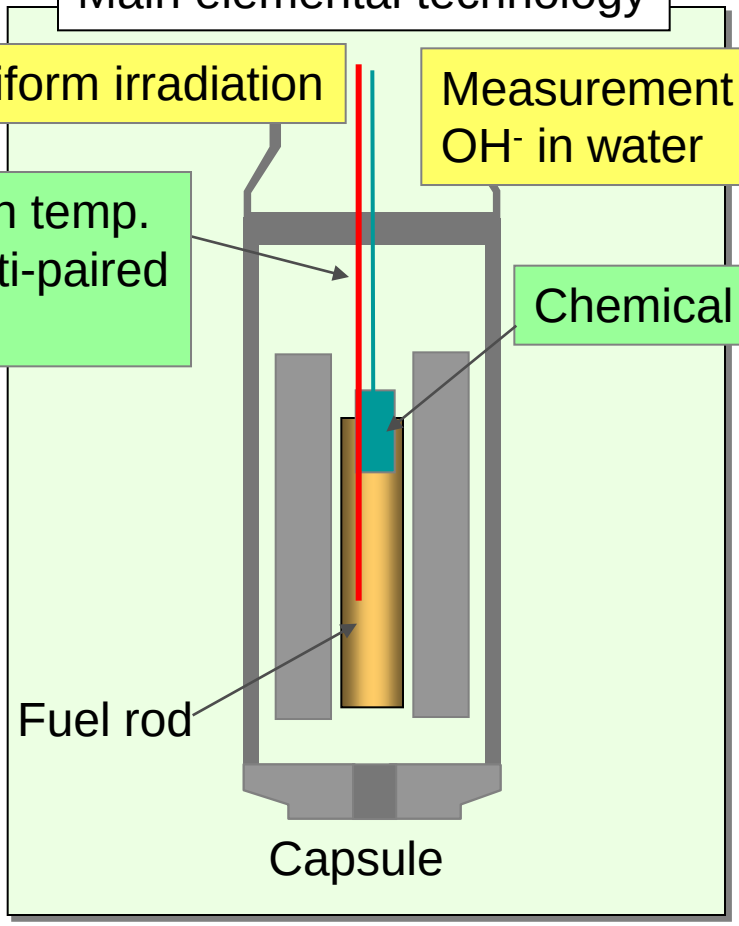
Main elemental technology

Uniform irradiation

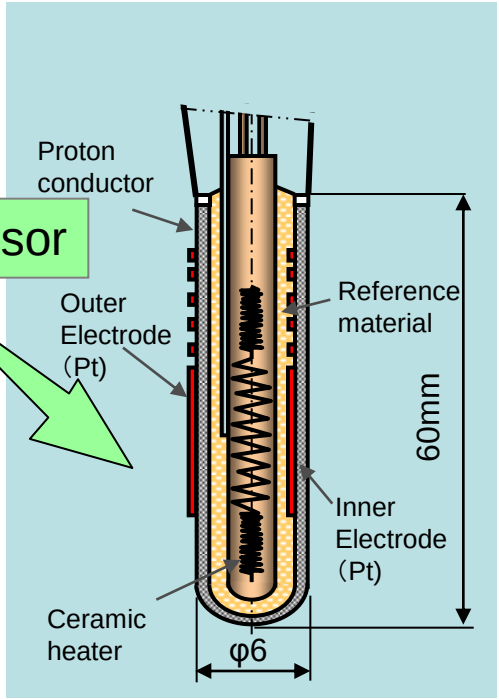
Measurement of OH^- in water

High temp. Multi-paired T/C

Chemical sensor



Measurement of chemical potential



(Ex.) Hydrogen sensor

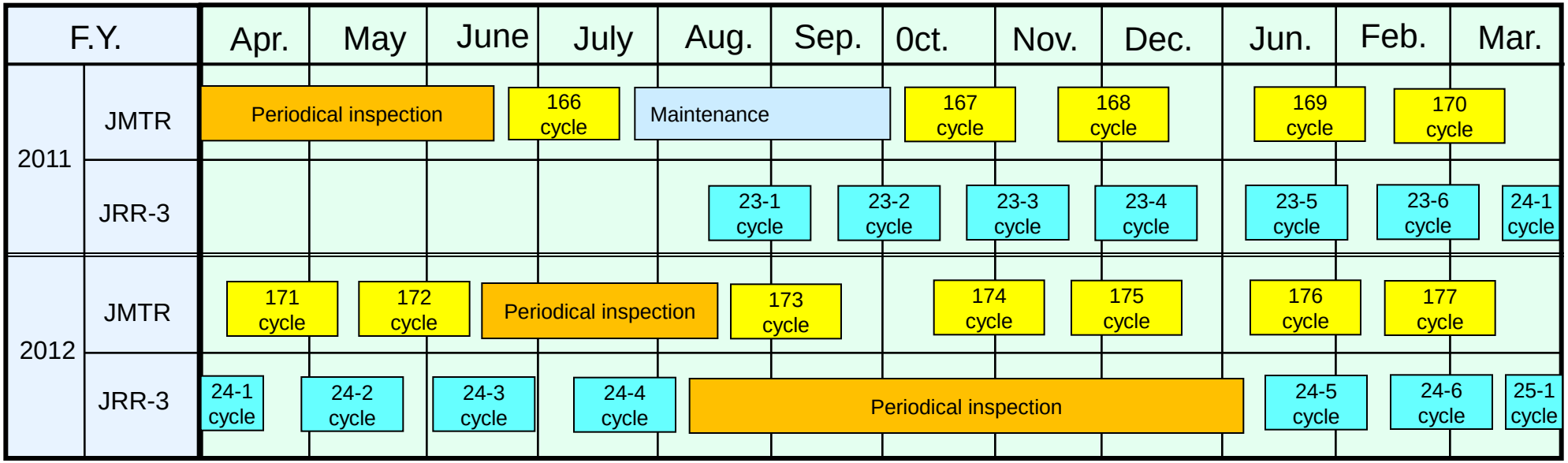
Development items:
- Radiation resistance
- Performance under irradiation, etc.

Technology improvement by getting the data which impossible to get, and by clearing the irradiation behavior

3.2 Usability Improvement of New JMTR
- Planning of High Operation Rate-

Corresponding to the increase of irradiation utilization, reactor-operation rate should be increased.

- In 2011 F.Y. 5 cycles are planning, In 2012 F.Y. 7 cycles (about 60 %) are planning.
- Alternative operation with JMTR and JRR-3 for steady RIs supply.



3.2 Usability Improvement of New JMTR
- Simplification of application procedure -

User can apply more easy by electric application documents with supporting by JMTR staff.

Utilization information to users

(Old)
-E-mail to major users

(New)
-E-mail to major users
- Home page information

Application from users

(Old)
-Sending paper documents from users

(New)
-Documentation preparation supported by JMTR staff

Approval to users

(Old)
-Sending paper documents to users

(New)
-Sending electric documents to users by E-mail

Irradiation data access by users

(Old)
-Not available

(New)
-Access to HP and check the status & refer data

3.3 Utilization Promotion of New JMTR

Discussion with each user group and accept users requests

User group
LWR fuels/materials development

User group
RI production

User group
Fundamental research
(Univ. etc.)

- - - - - - - - -

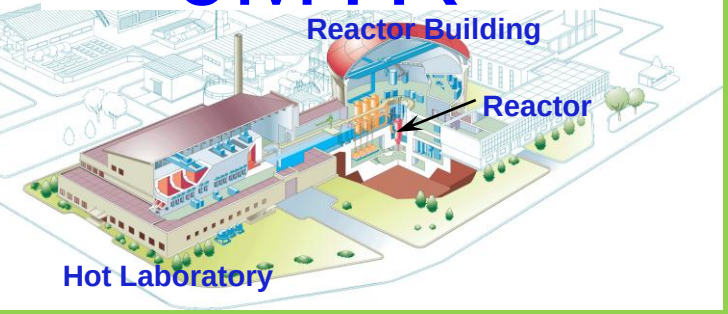
User group
- - - - - - - - -

User group
Mo-99 production

User group
Education & training

User group
Si semiconductor production

JMTR



Provide high valuable irradiation data to users, and promote the use of irradiation as a result

(Example) Discussion with LWR Group

- Safety Research for LWR Materials and Fuels using JMTR -

Material irradiation tests for LWRs

Material

To obtain data for improving PLM tools for long-term operation and integrity evaluation measures of LWRs

IASCC Test

Irradiation Assisted Stress Corrosion Cracking (IASCC) tests under irradiation conditions

Irradiation Embrittlement Test

Fracture toughness tests of reactor pressure vessel materials with 1T-CT specimens

Control rod materials Test

Material irradiation tests of hafnium

Fuel irradiation tests for LWRs

Fuel

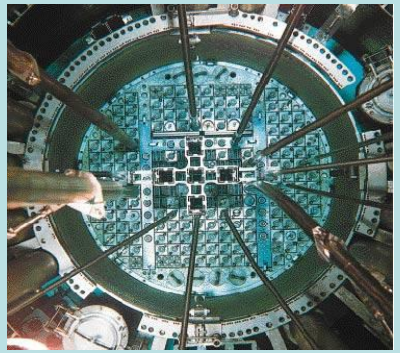
To obtain integrity and evaluation data of fuel for high performance uses of LWRs

Transient Test

Transient tests under power ramping conditions

High Duty Irradiation Test

Irradiation tests under high duty conditions, such as high rod internal pressure, up-rated power and high burn-up

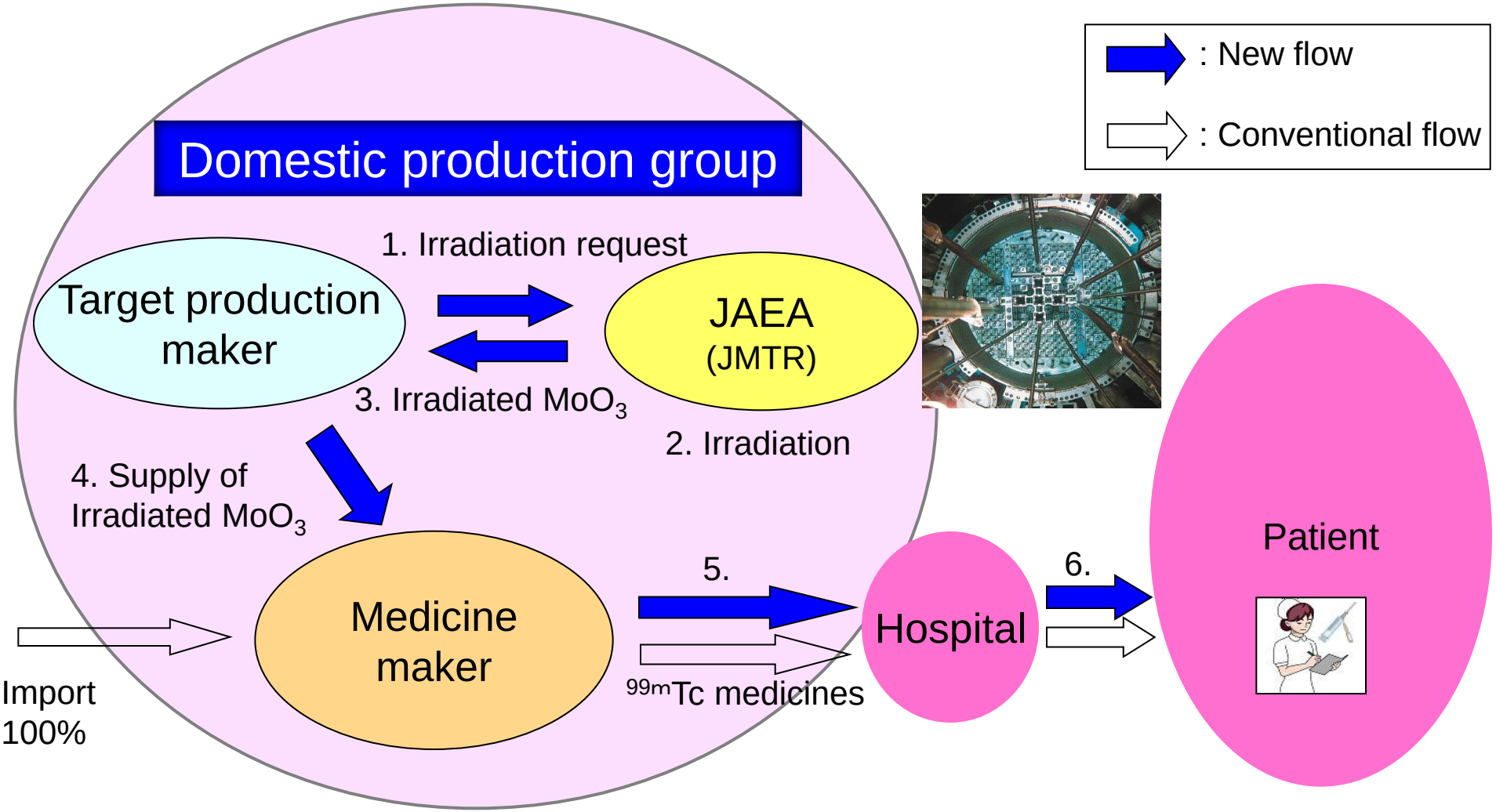


JMTR

JMTR Hot Laboratory (for materials PIE)

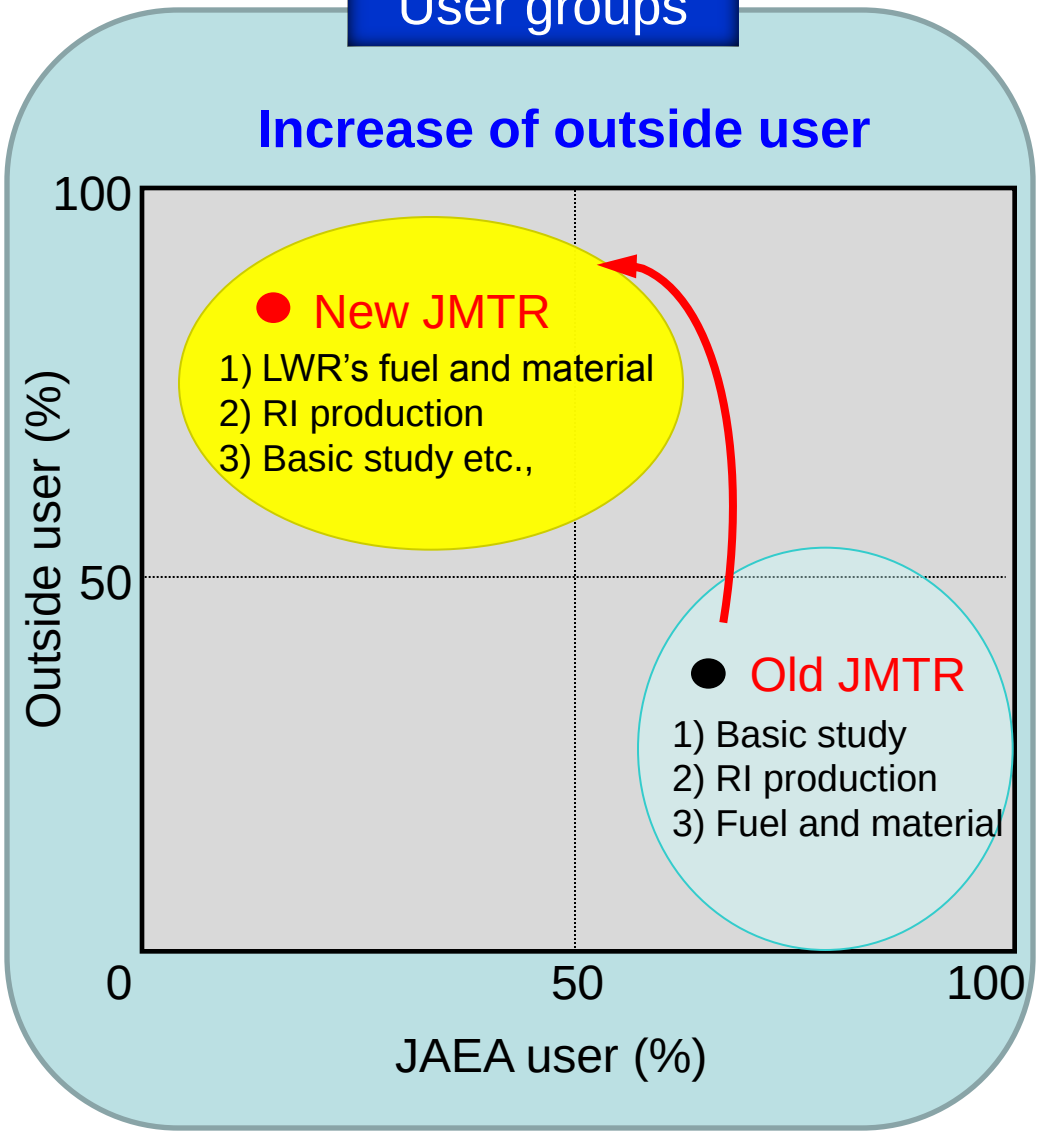
(Example) Discussion with Mo-99 Production Group

- Mo-99 Production Flow Using JMTR -

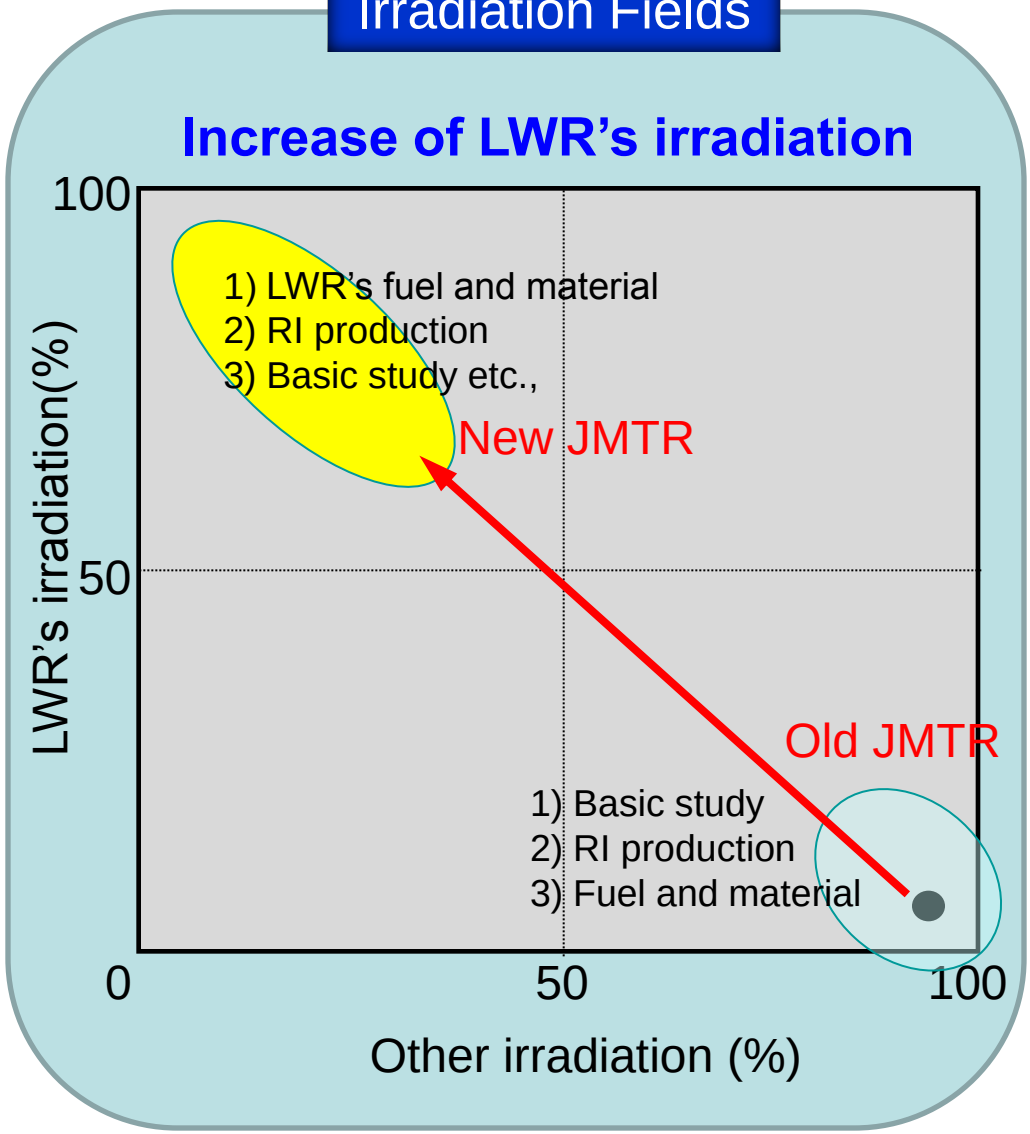


Expected Users after JMTR reoperation

User groups



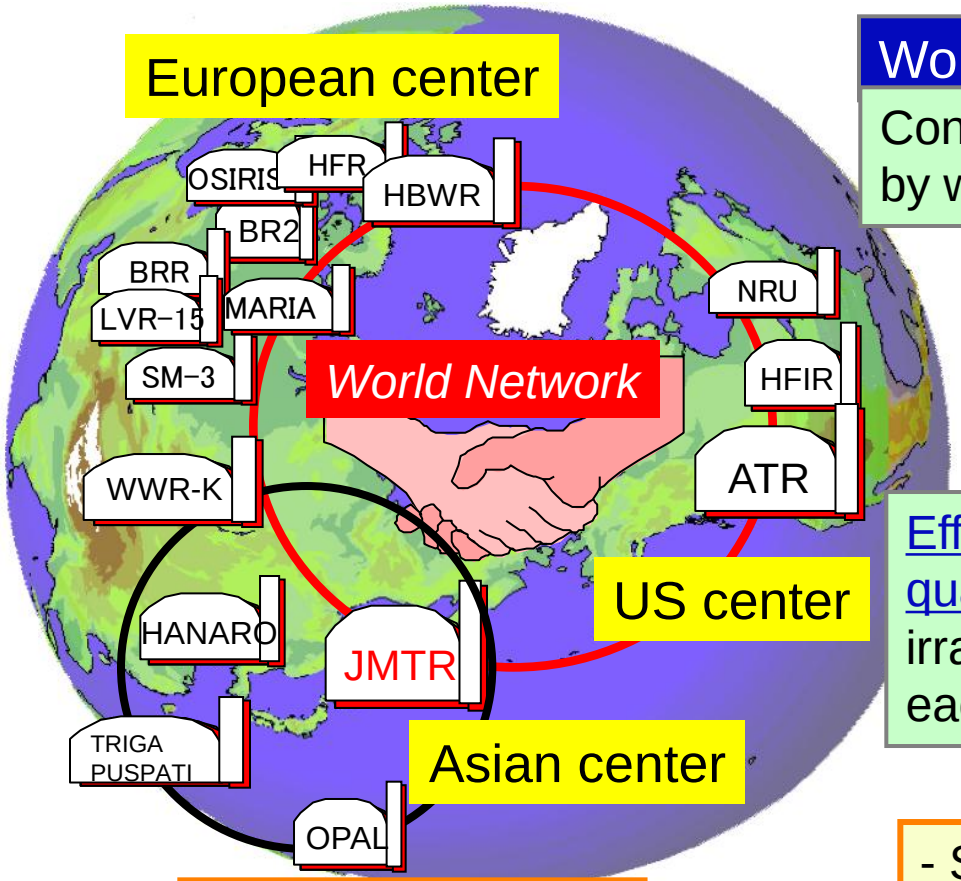
Irradiation Fields



3.4 Proposal of World Network

- World Network of Materials Testing Reactors –

Construction of world network is proposed to achieve efficient facility utilization and providing high quality irradiation data by role sharing of irradiation tests with materials testing reactors.



World Network

Construction of international cooperation system by world wide testing reactor network

Mutual understanding

- Information exchange
- Interchange of staffs, etc.

Efficient facility utilization and providing high quality irradiation data by role sharing of irradiation tests with characteristics of each testing reactor

Regional Network (Asian Network)

- Study of fuel / material for LWRs
- Education, training etc.
- Stable supply of RI, ^{99}Mo etc.

Contents

Conclusion

- From user's survey of materials testing reactors including research reactors, utilization of research reactors can be categorized as four major application targets; LWR's related R&Ds, progress of science and technologies, industrial use, and education & training of nuclear scientists and engineers.

-JAEA has developed four different types of research reactors, JRR-3, JRR-4, NSRR and JMTR designed specifically for intended purpose. Utilization status for these reactors is introduced in this presentation.

- JMTR is now under refurbishment of reactor facilities. The refurbished JMTR is expected an appreciable income from commercial users. A few successful examples on JMTR are presented in this paper from a viewpoint of commercial application. Since the strengthened regional and/or international cooperation is a key issue to enhance the steady commercial applications such as RI production, the importance of regional/international framework is also mentioned.