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Conceptual Study for New ^{99}Mo-Production Facility IN JMTR

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2. ^{99}Mo Production Plan in JMTR

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Introduction (1/2)

Why?

Background

- Demand of ^{99m}Tc (half life 6h) used as a radiopharmaceutical increases up year by year, and will be expected to expand in future.
- Supply of ^{99}Mo in Japan depends fully on the import from foreign countries.
- In addition, unexpected shutdown of production reactors, such as NRU in Canada etc., happened, and now the production crises is the serious problem all over the world.

To supply stably by domestic production is very important.

New irradiation facility

JAEA has a plan to produce ^{99}Mo (parent nuclide of ^{99m}Tc) to meet the user's requirements .

Introduction (2/2)

How?

^{99}Mo (half life 66.7h) production has two methods;

1. Nuclear fission method (*n,f*)
   Using high enriched U-target now. The target will be changed into low enriched one due to NTP reason.

2. ^{98}Mo target method (*n,γ*) [^{98}Mo(*n,γ*)^{99}Mo$^{\beta-}\rightarrow$ ^{99m}Tc]
   Using ^{98}Mo target.

^{99}Mo production in JMTR is using a simple (*n,γ*) method taking account of advantages on low wastes production as well as low production cost.

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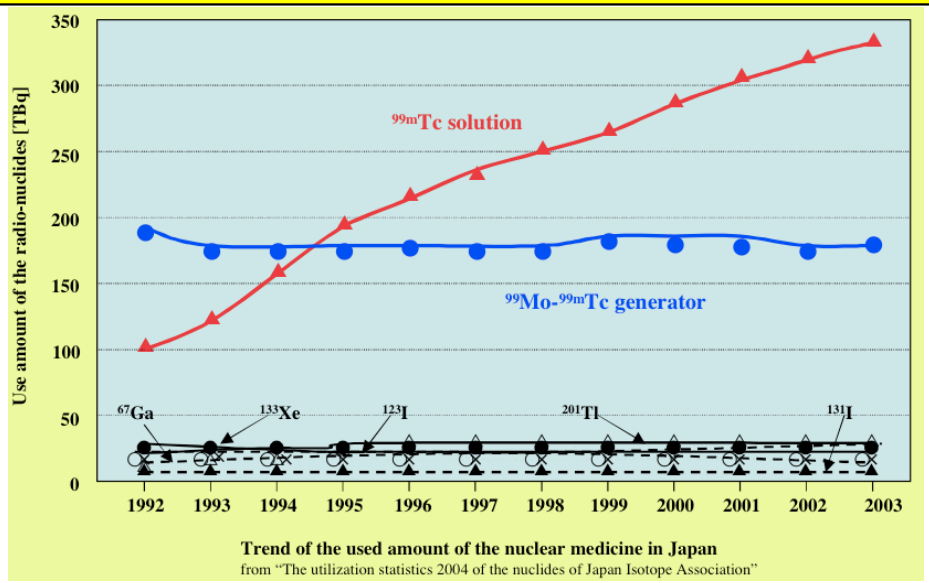
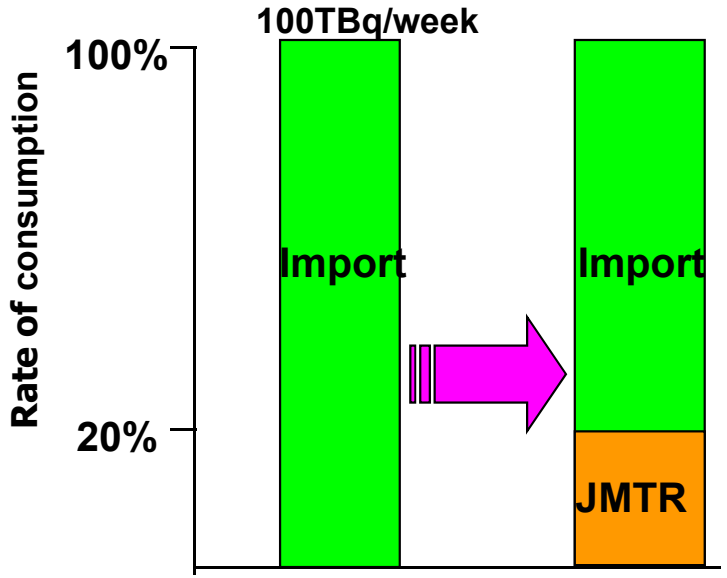
^{99}Mo Production in JMTR

Demand of ^{99m}Tc is increasing rapidly



^{99}Mo 100% import



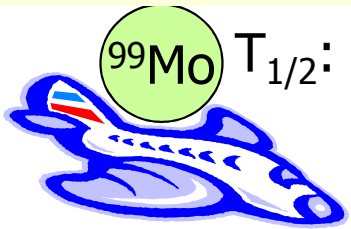
JMTR contribution to user's market

Comparison of two methods

	(n,fiss) method	(n,γ) method
Production method	^{235}U (n,fiss) FP→ ^{99}Mo $\xrightarrow{\beta^-}$ ^{99m}Tc	^{98}Mo (n,γ) ^{99}Mo $\xrightarrow{\beta^-}$ ^{99m}Tc
Cost	High	Low
Nonproliferation	X	○
Specific activity	High	Low
Impurity	High	Low

^{99}Mo Production and Utilization of ^{99m}Tc

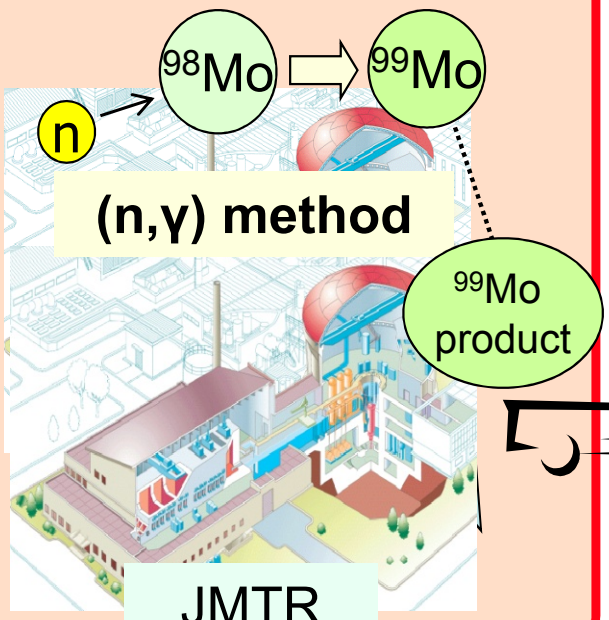
Canada or other countries (fission method)



100% imported

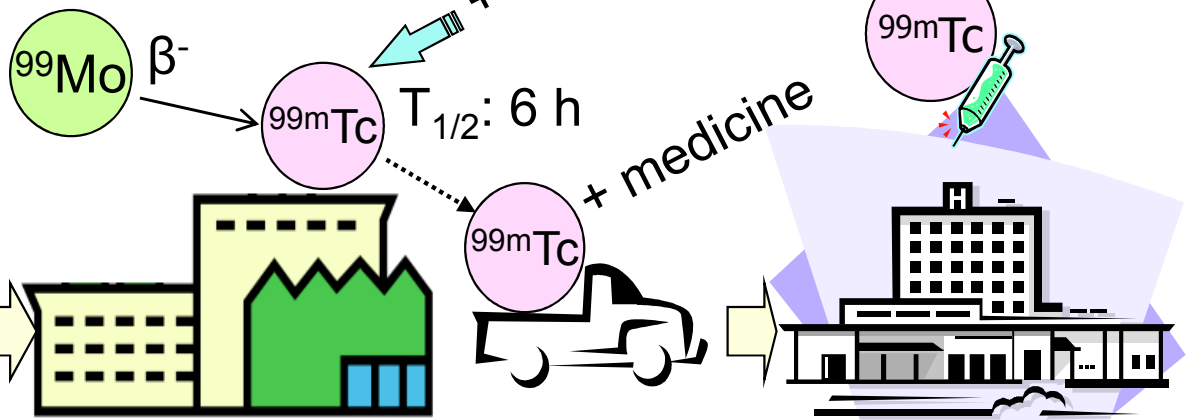
Import crisis
-Sep. 2001 (about 1 week) by influence of American synchronized terrorist attacks
-Nov. 2007 (about 1 month) by problems of NRU, Canada

Domestic production of ^{99}Mo



Production of Radiopharmaceutical

Medical diagnosis



Pharmaceutical manufacture

Hospital

(^{99m}Tc is extracted from ^{99}Mo)

Planning of New Irradiation Facilities

New Irradiation Facilities

[New irradiation facilities will be installed by the external budget from the industrial users etc.]

Work schedule for the installation of new irradiation facilities

No.	Item \ Year	2006	2007	2008	2009 *1	2010	2011 Re-operation	2012
1	Fuel Tests Irradiation facility of LWR fuels for ramp test	Conceptual design	Detail design	Designing, Fabrication, Installation				
2	Material Tests Irradiation facility for LWR core materials		Detail design	Designing, Fabrication, Installation		2 units		1 unit
3	New industrial use (1) ^{99}Mo production facility	Conceptual design, etc.				under planning		
4	New industrial use (2) Silicon semiconductor irradiation facility	Conceptual design, etc.				under consideration		
5	Fuel irradiation facility Irradiation facilities for LWR fuels	Conceptual design, etc.				under consideration		

*1 : In order to prepare necessary space for new material irradiation facilities installation, existing facilities are to be removed.

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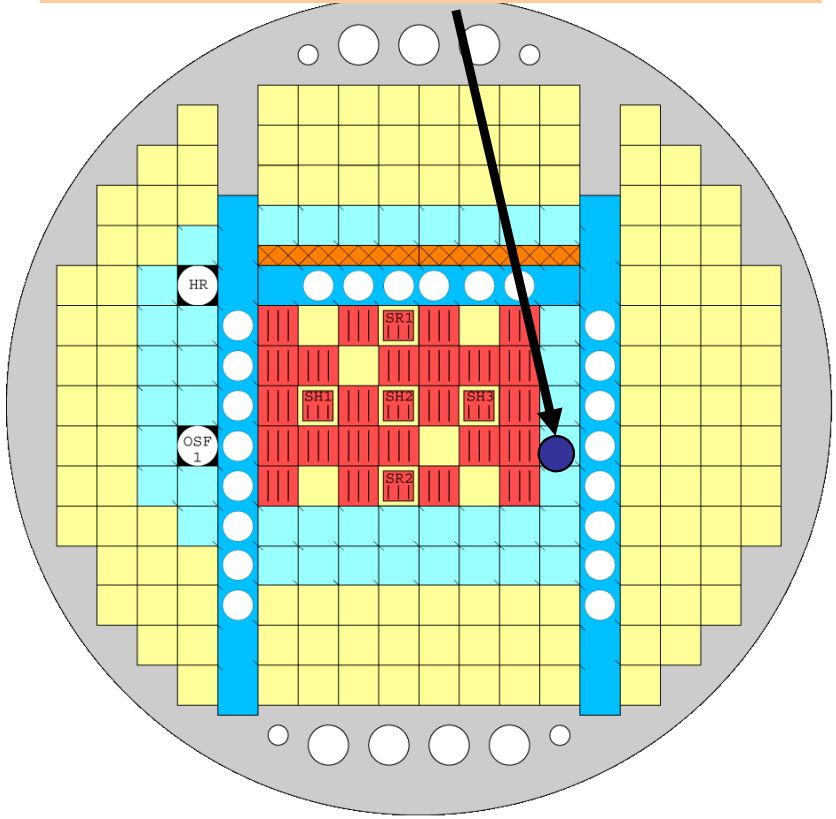
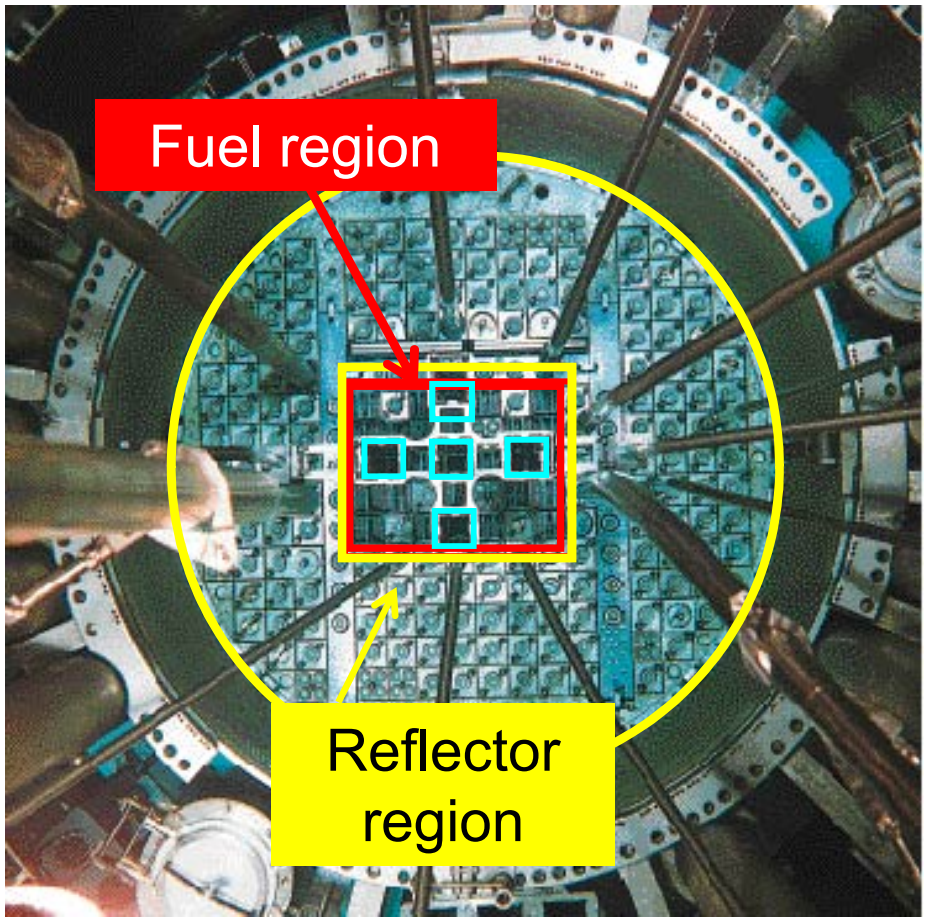
JMTR Core and ^{99}Mo Production Facility

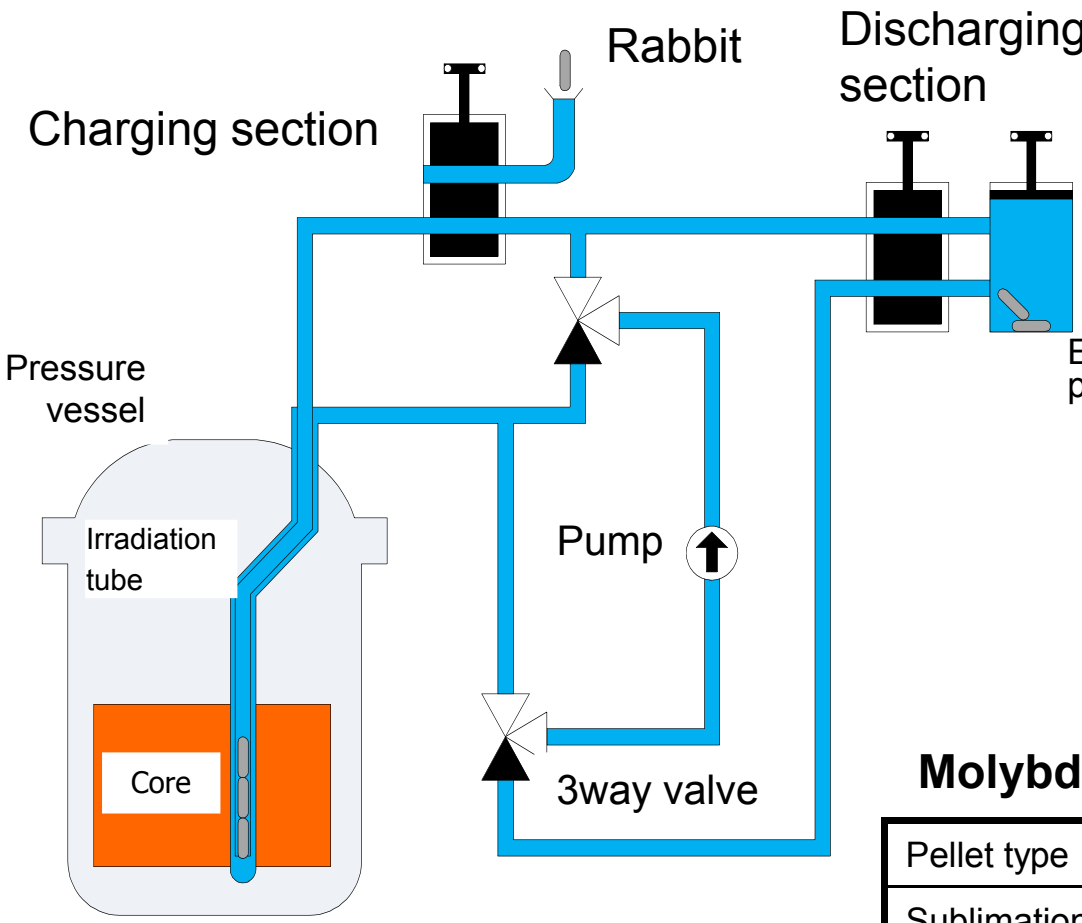
New ^{99}Mo-production facility



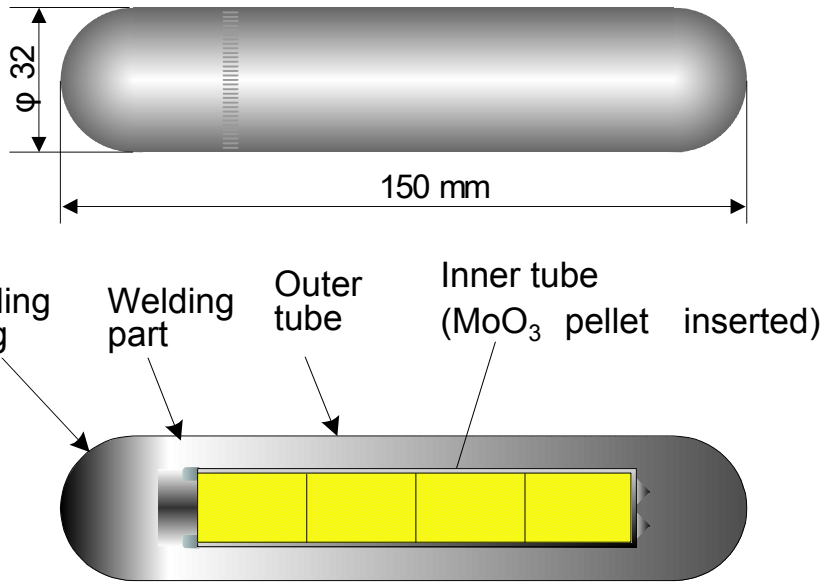


- Fuel element
- Control rod with fuel follower
- Be reflector
- Be frame
- Al reflector
- Gamma ray shield plate

Hydraulic Rabbit Irradiation Facility and MoO_3



Hydraulic rabbit irradiation facility

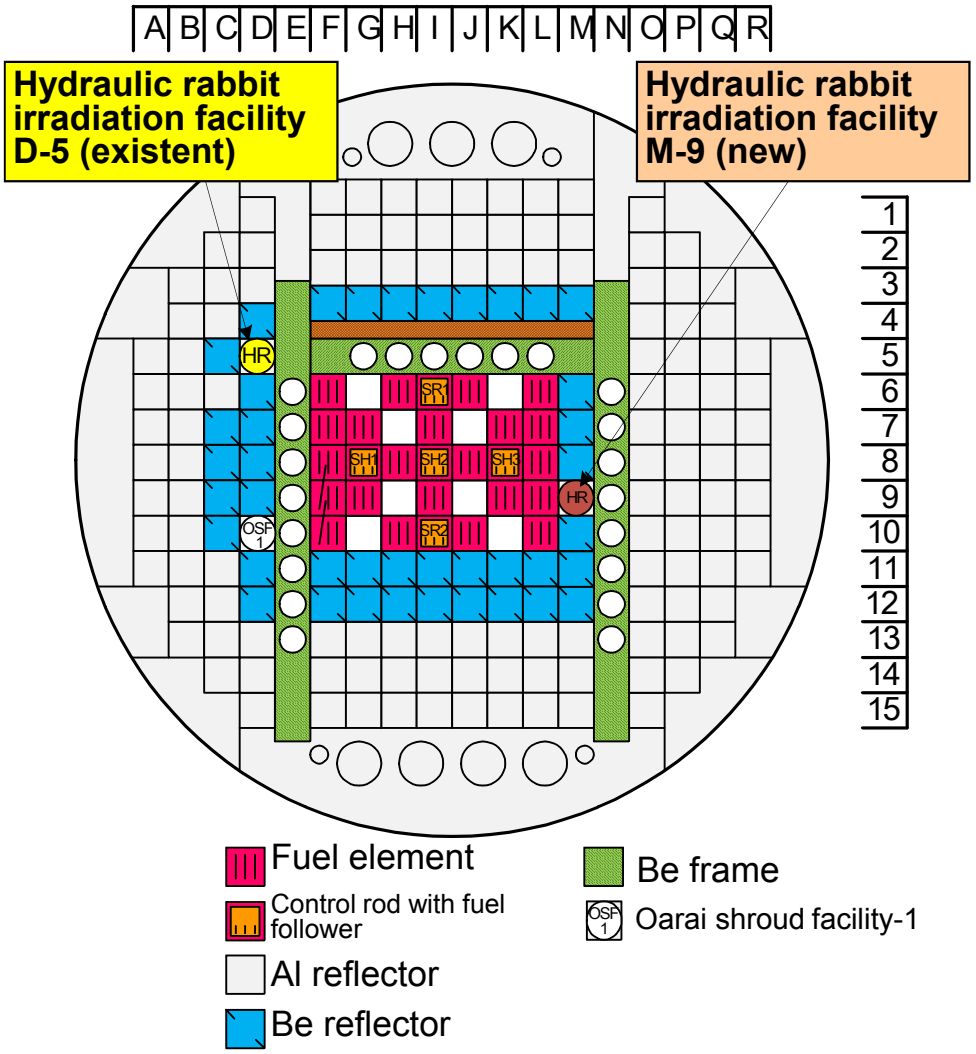


A typical rabbit and its cross section

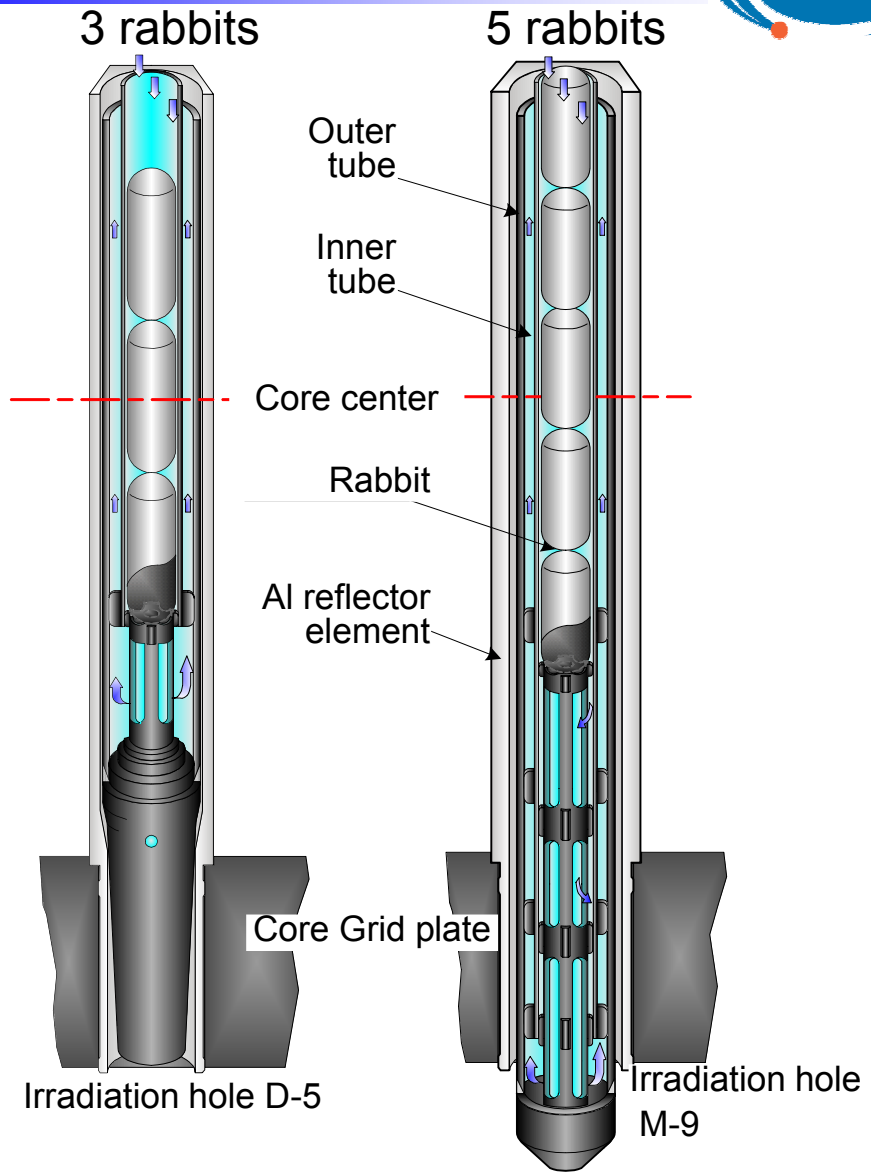
Molybdenum trioxide (MoO_3) properties

Pellet type	Sintered type
Sublimation temp.	~750℃
Mo-98 Isotopic abundance	24%
MoO_3 Molecular weight	143.95 (Mo:66.6% O:33.3%)
MoO_3 Theoretical Density	4.692g/cm^3
MoO_3 Melting point	780℃

Hydraulic Rabbit Irradiation Facility



JMTR Core arrangement



Structure of Hydraulic rabbit tube

Estimated ^{99}Mo Production using Hydraulic Rabbit Irradiation Facility

Items		Conceptual Study
Hydraulic rabbit irradiation facility		New hydraulic rabbit irradiation facility
Rabbit Specification	Irradiation hole	M-9
	Thermal Neutron Flux (max.)	$3.5\times10^{18}(m^{-2}/s)$
	Number of irradiation rabbit (max.)	5 rabbits
Amount of ^{99}Mo production		37 TBq/week (1000 Ci/week)
Percentage for the amount of import		About 20%

- Weekly production, 4 shipment/cycle
- 30days/cycle, 6cycle/year (180 days / year)

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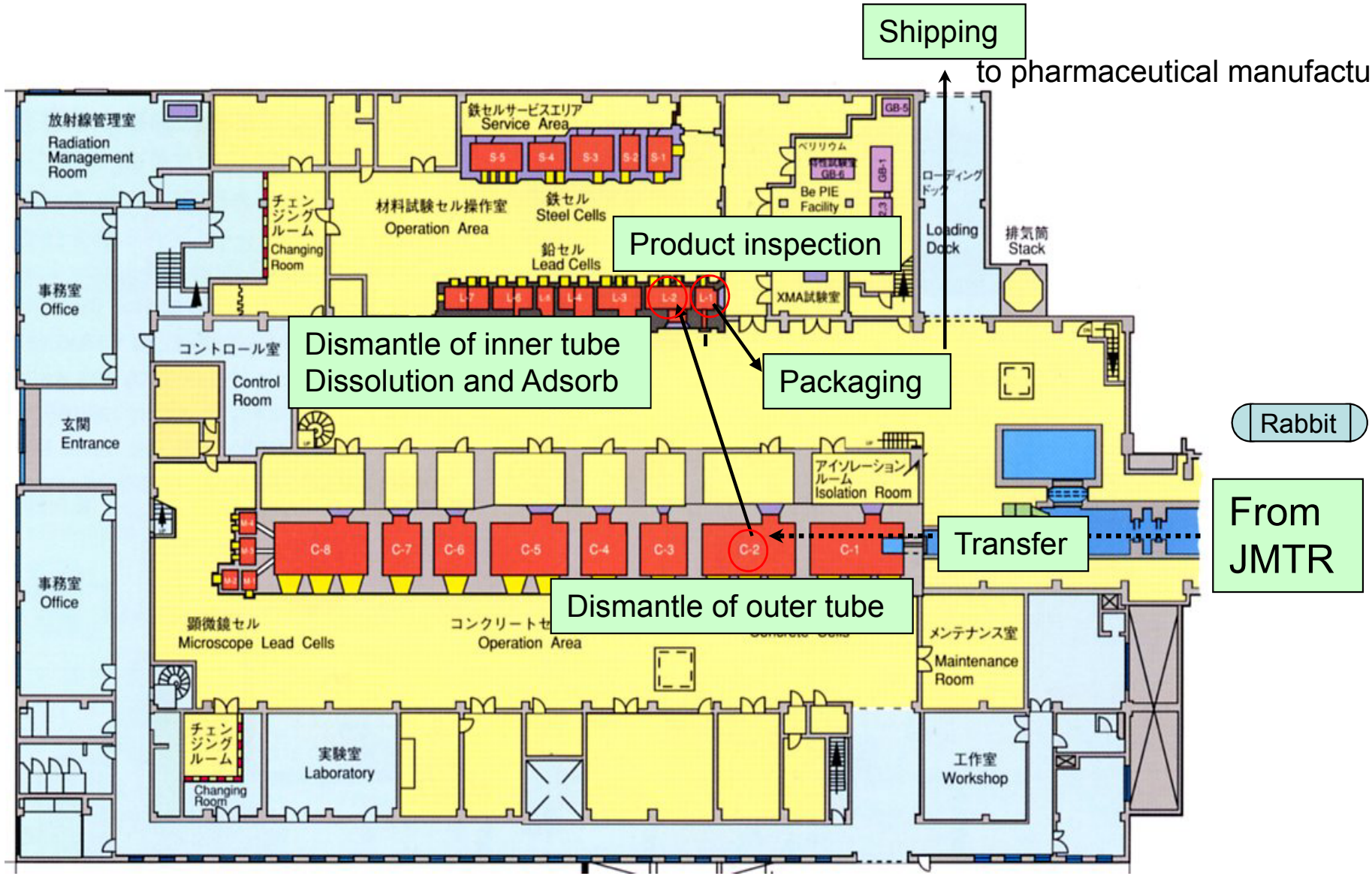
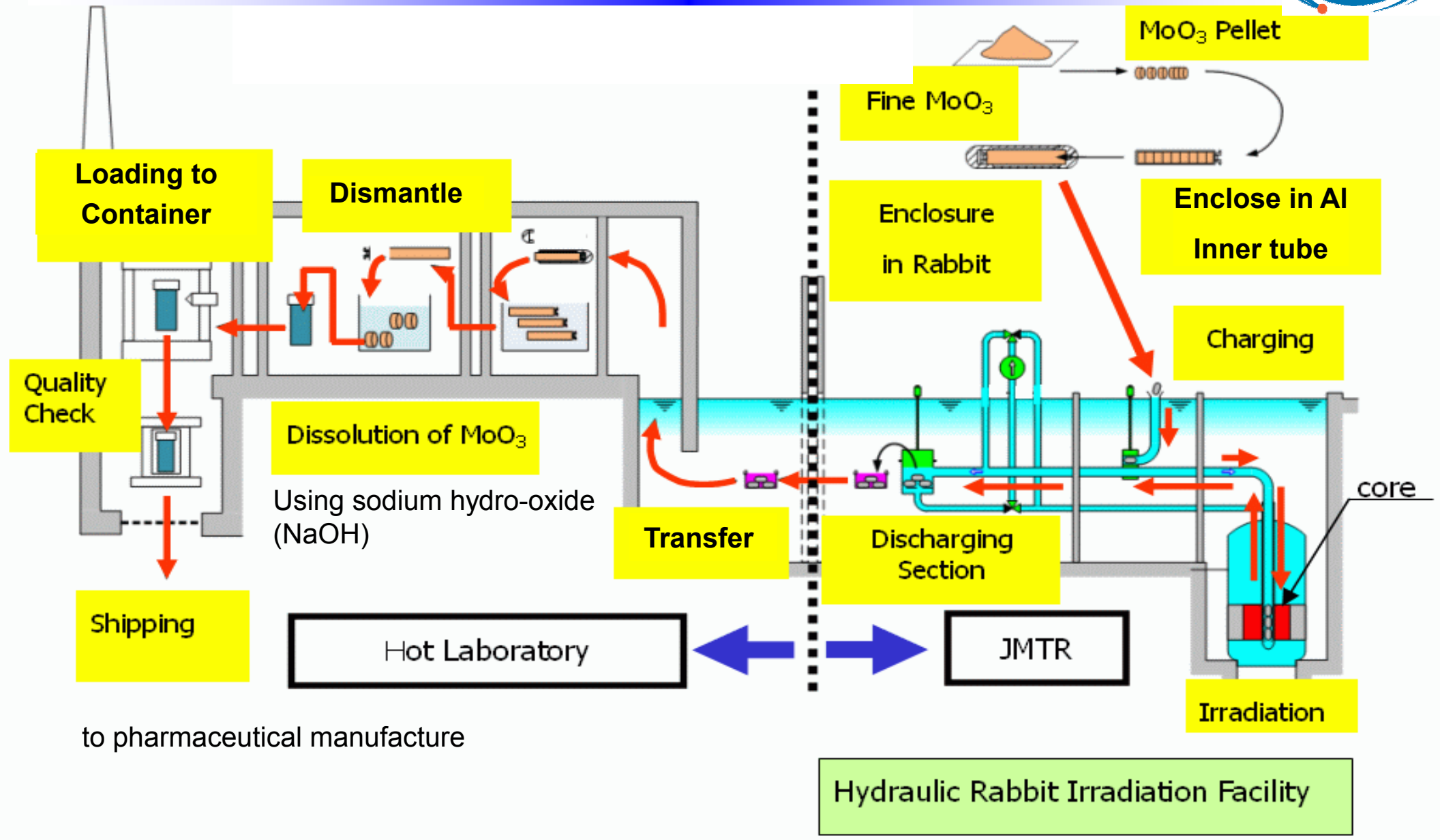
Post Irradiation Process in JMTR　Hot Laboratory



*; ^{99}Mo is dissolved from MoO_3 pellets by easy chemical treatment using sodium hydro-oxide (NaOH)

Outline of ^{99}Mo Production Process



Outline of ^{99}Mo Production Process

End of Irradiation

Transfer

JMTR-Hot Laboratory

in the Concrete Cell

Inner tube

Waste

Dismantle of Rabbit

in the Pb Cell

Dismantle of Inner tube

Dissolution of MoO_3 Pellet

Using sodium hydro-oxide (NaOH)

^{99}Mo Solution

PZC-^{99}Mo

(dsorb)

Quality Check Enclosure Container

Shipping

to pharmaceutical manufacture

PZC: Poly Zirconium Compound

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Conclusion

- ^{99}Mo production method in JMTR is the ^{98}Mo(n,r)^{99}Mo reaction, where the sintering pellet of MoO_3 will be used as a target material.

- The hydraulic rabbit irradiation facility is selected as irradiation facility of ^{99}Mo production, because the facility is possible to irradiate the Mo target from short time to long time without reactor shutdown.

- JMTR will be able to provide ^{99}MO at about 20% amount of imported to Japan, by installing new hydraulic rabbit irradiation facility in the reflector region of the core.