Tritium Release Rate into Primary Coolant

- Data of JMTR, JRR-3M and JRR-4 -

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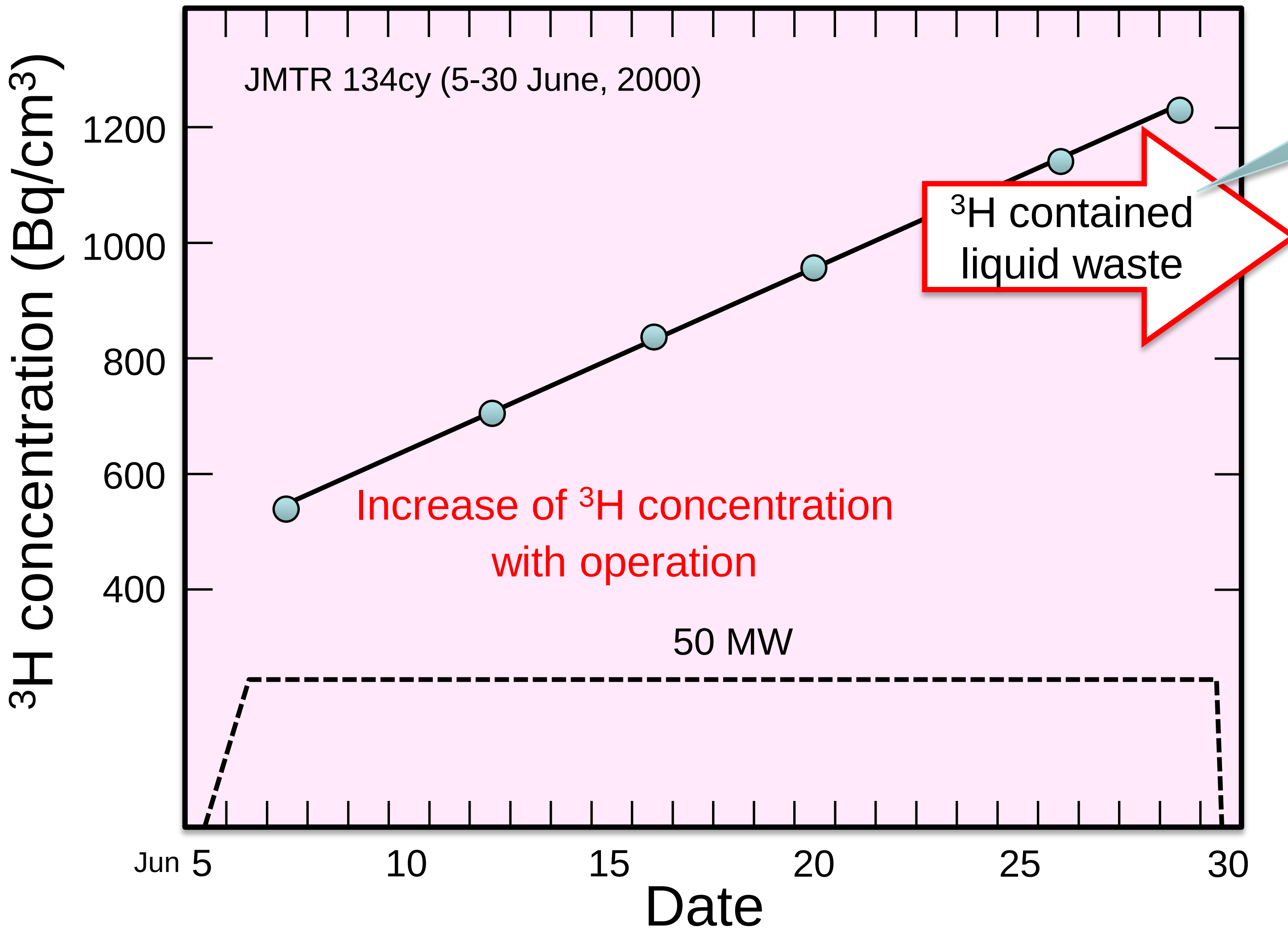
Background



Other contaminations : almost remove

Discharge to sea after dilution

To reduce waste

- Source ?

  Be, etc. ?

- Mechanism ?

  Recoil, etc. ?

- How to reduce ?

^{9}Be (n_f,α) ^{6}He $\xrightarrow[\beta^{-}\text{ decay}]{}$ ^{6}Li + n_t → ^{3}H(2.74 MeV) + He(2.06 MeV)

Candidates of tritium release mechanism

Element	Reactions	Core components, etc.	Release mechanism
^{2}H	(n, γ), 0.53mb	Coolant	Direct
^{9}Be	(n$_f$, α) ^{6}He, 9.2mb and ^{6}Li (n$_t$, α) , 940b	Beryllium frame Beryllium reflector	Diffusion
			Recoil
^{235}U	Ternary fission 1.0×10^{-4}/fission	Contamination of fuel plate	Direct
		Impurity of beryllium components	Diffusion
			Recoil
		Impurity of other components	Diffusion
			Recoil

Purpose

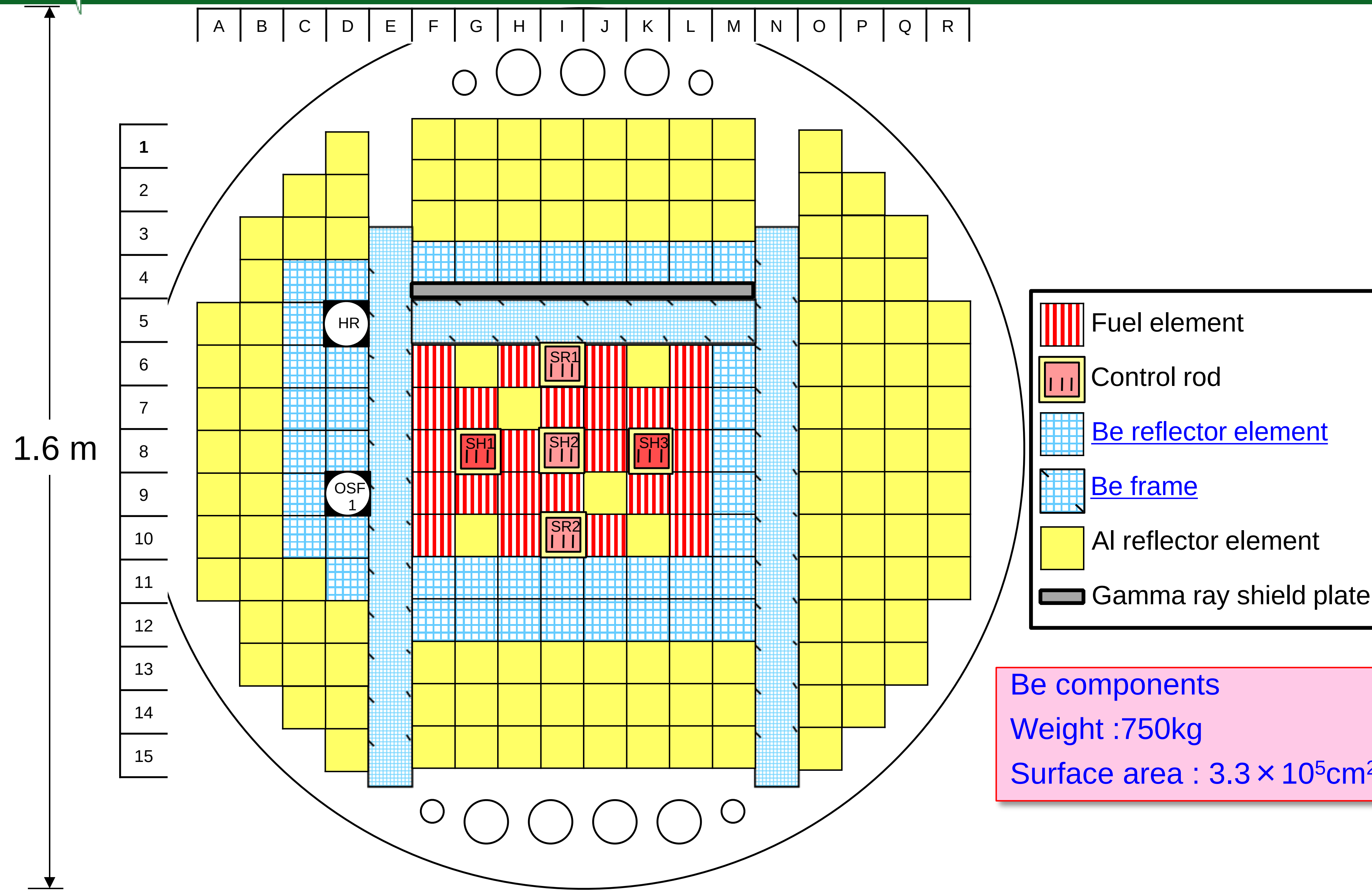
To study of tritium release into primary coolant for research and testing reactors, as a first step,

- Collect long term data of tritium concentration at operation of JMTR, JRR-3M, JRR-4.
- Evaluate tritium release rate

Items	JMTR	JRR-3M	JRR-4
Thermal power (MW)	50	20	3.5
Main purposes	Irradiation test, RI production, Training	Beam experiment, RI production	Activation analysis, Training
Main core components	Be, Al	Be, D_2O tank	Carbon, Al
Operation	30d/cy, 6cy/y	25d/cy, 6cy/y	6h/d, 4d/week

Coolant temperature < 50ºC

Core of JMTR

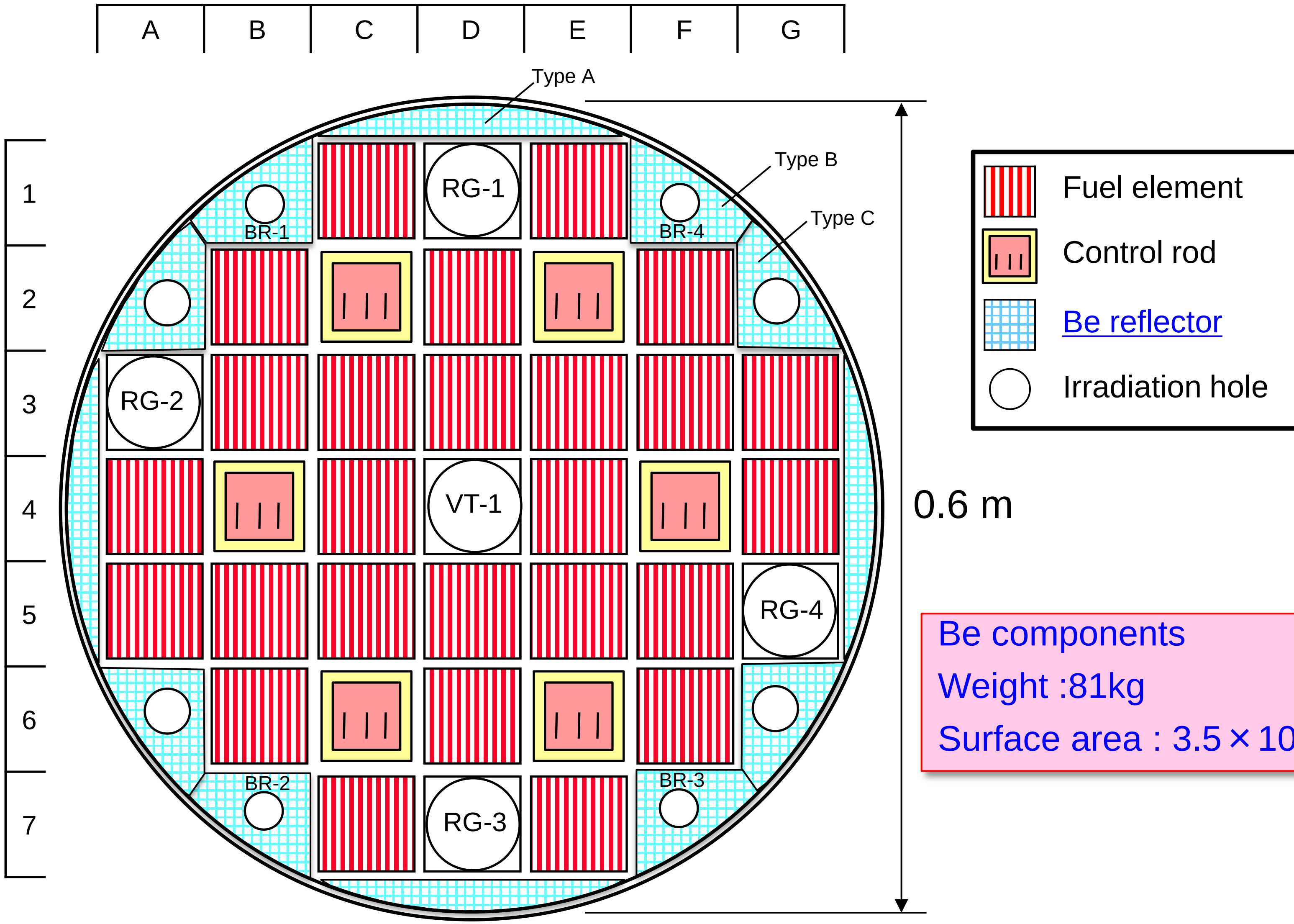


Be components

Weight :750kg

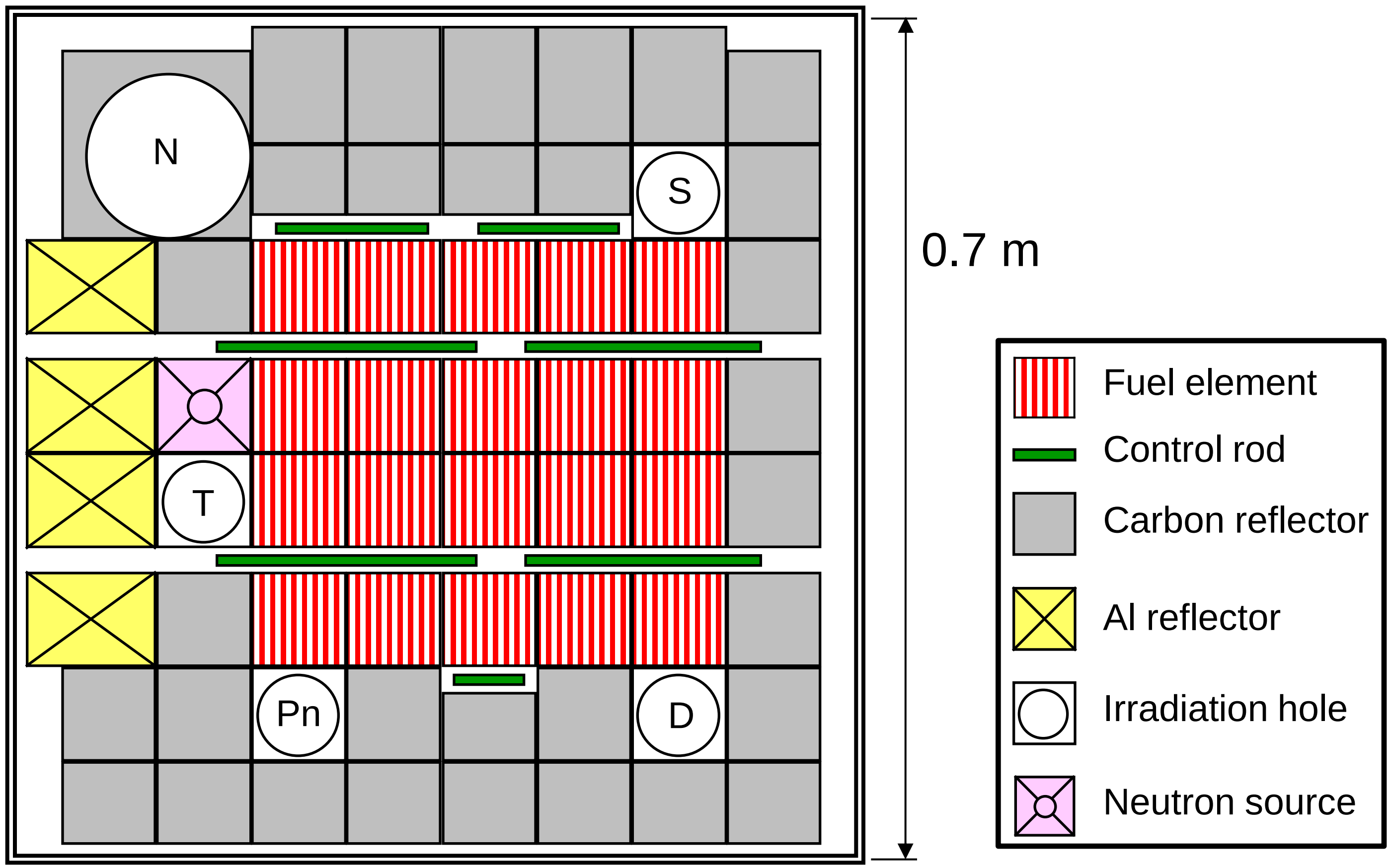
Surface area : $3.3 \times 10^5 cm^2$

Core of JRR-3M



Be components
Weight :81kg
Surface area : $3.5 \times 10^4 cm^2$

Core of JRR-4



N
S
T
Pn
D
0.7 m
Fuel element
Control rod
Carbon reflector
Al reflector
Irradiation hole
Neutron source

Evaluation of tritium release

Amount of tritium release per operation cycle were estimated by assuming a linear approximation

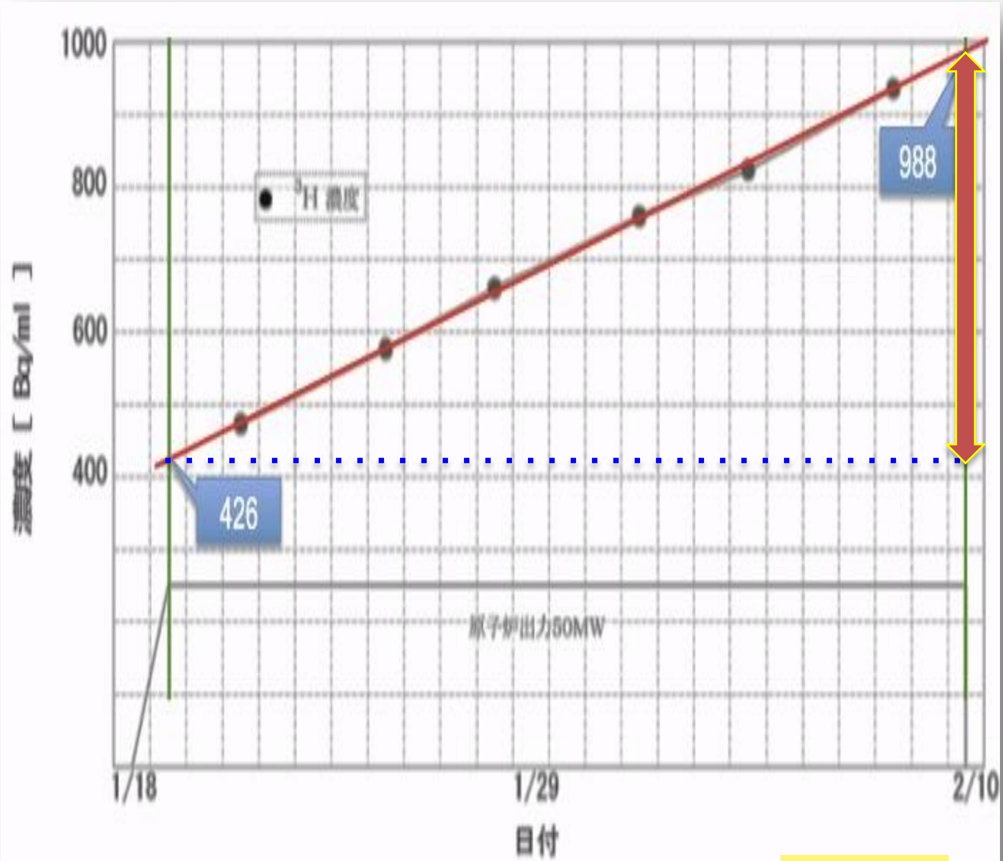
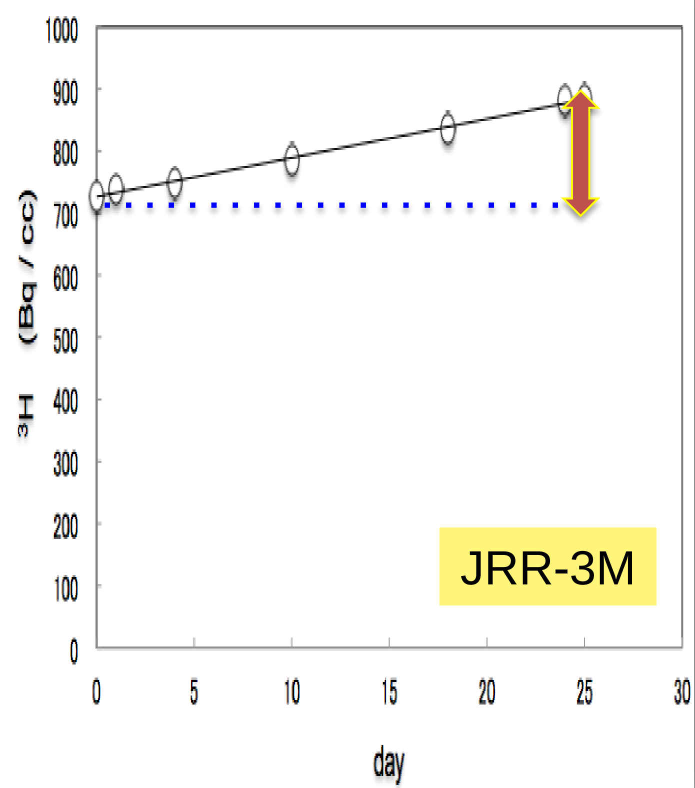


図 136 JMTR1次冷却水中のトリチウム濃度
(JMTR 第 143 サイクル 2002.1.18~2.10)

JRR-3, R3-22-04

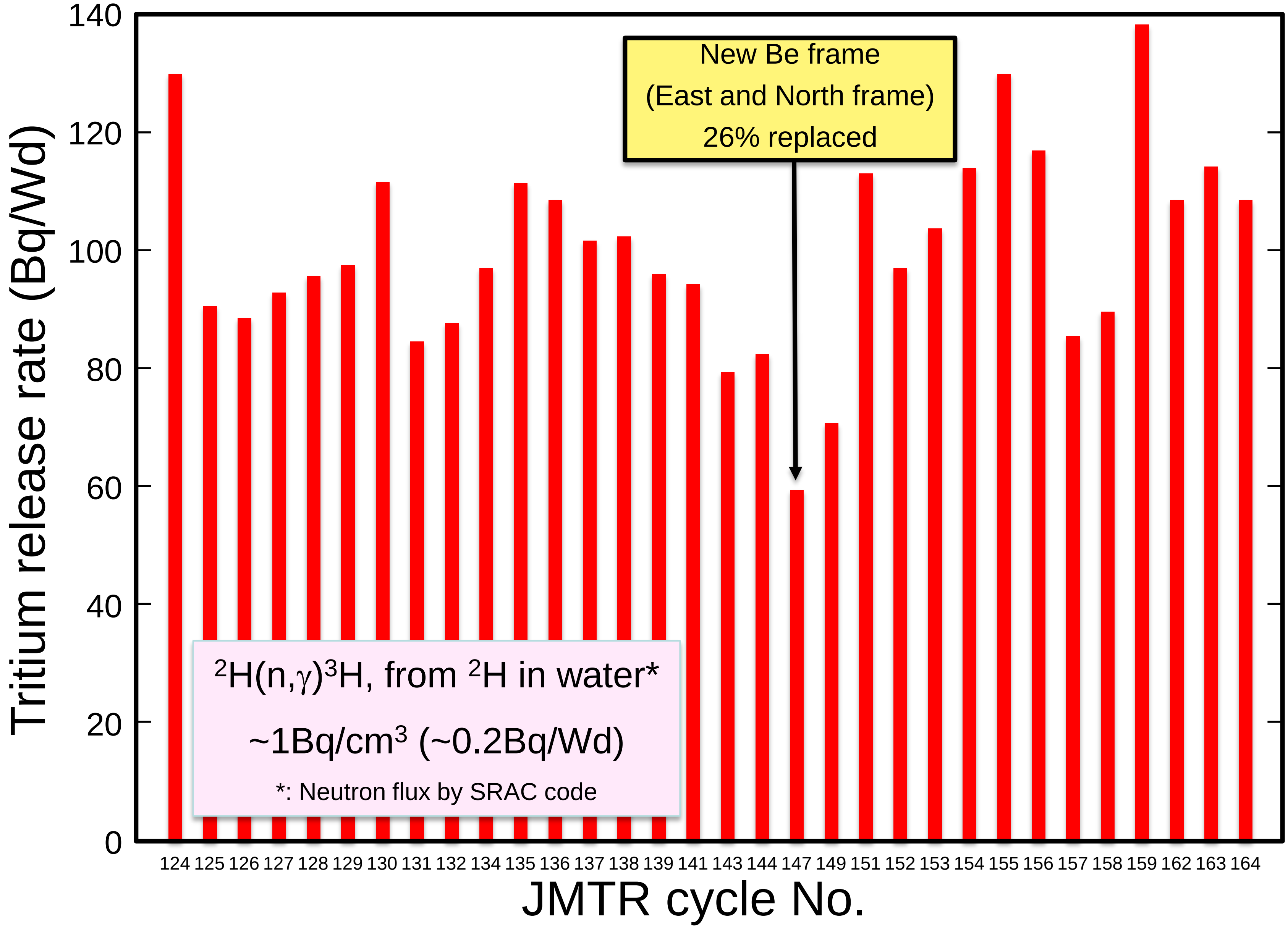
	date	day	^{3}H Bq/cc
start	2010/7/12	0	727
測定値	2010/7/13	1	738
測定値	2010/7/16	4	749
測定値	2010/7/22	10	786
測定値	2010/7/30	18	836
測定値	2010/8/5	24	881
end	2010/8/6	25	883

※startとendは直線近似で求めた値

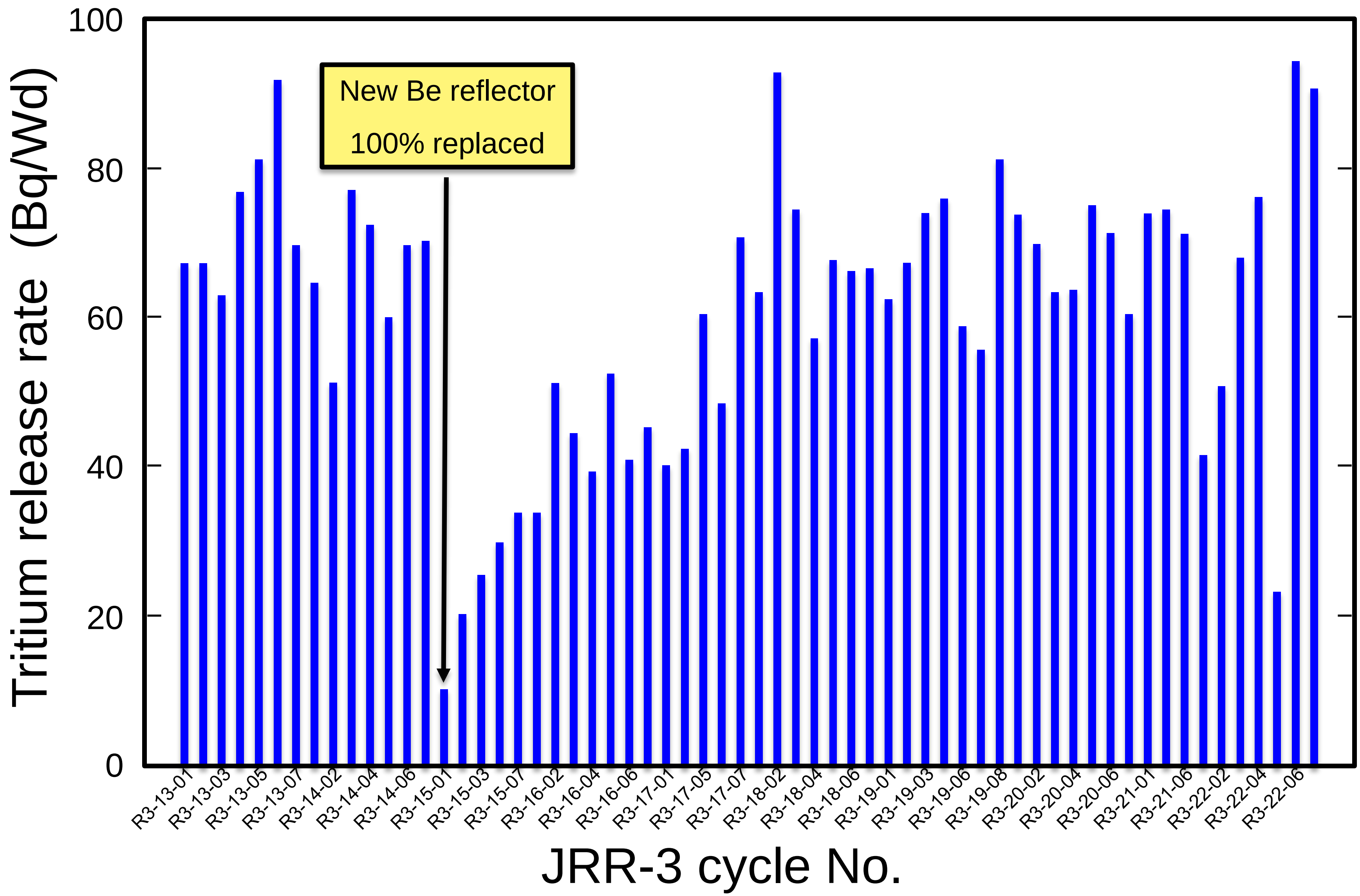


⇕ : Amount of tritium release / cy

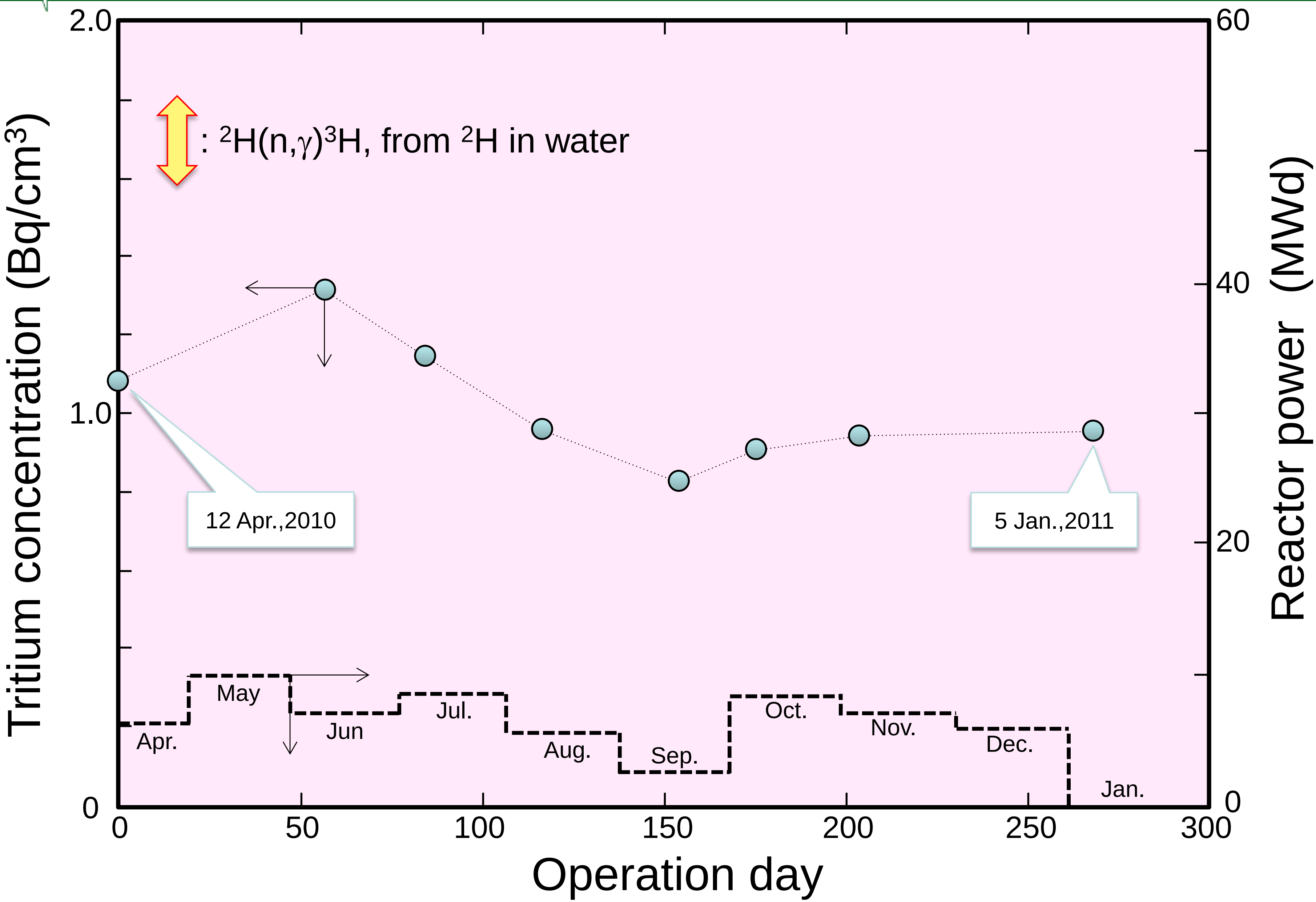
Evaluated tritium release rate (JMTR)



Evaluated tritium release rate (JRR-3M)



Change of tritium concentration(JRR-4)



Source of tritium

Element	Reactions	Core components, etc.	Release mechanism	Contribution to tritium release
^{2}H	(n, γ), 0.53mb	Coolant	Direct	~1Bq/cm^3 ~0.2Bq/Wd (JMTR)
^{9}Be	(n_f, α) ^{6}He, 9.2mb and ^{6}Li (n_t, α) , 940b	Beryllium frame Beryllium reflector	Diffusion	Small: low temp*.?
			Recoil	? (by MCNP code**)
^{235}U	Ternary fission 1.0×10^{-4}/fission	Contamination of fuel plate	Direct	?
		Impurity of beryllium components	Diffusion	Small: low temp*.?
			Recoil	? (by MCNP code**)
		Impurity of other components	Diffusion	Small: low temp*.?
			Recoil	? (by MCNP code**)

* : Coolant temperature < 50ºC

**: MCNP6, PHITS (Particle and Heavy Ion Transport code System) , $GEANT_4$

Conclusion

1. Tritium release rate

   JRR-4 : < 8 Bq/Wd

   JRR-3M : 10~95 Bq/Wd

   JMTR : 60~140 Bq/Wd [$^{2}H(n, \gamma)^{3}H$:~0.2Bq/Wd]

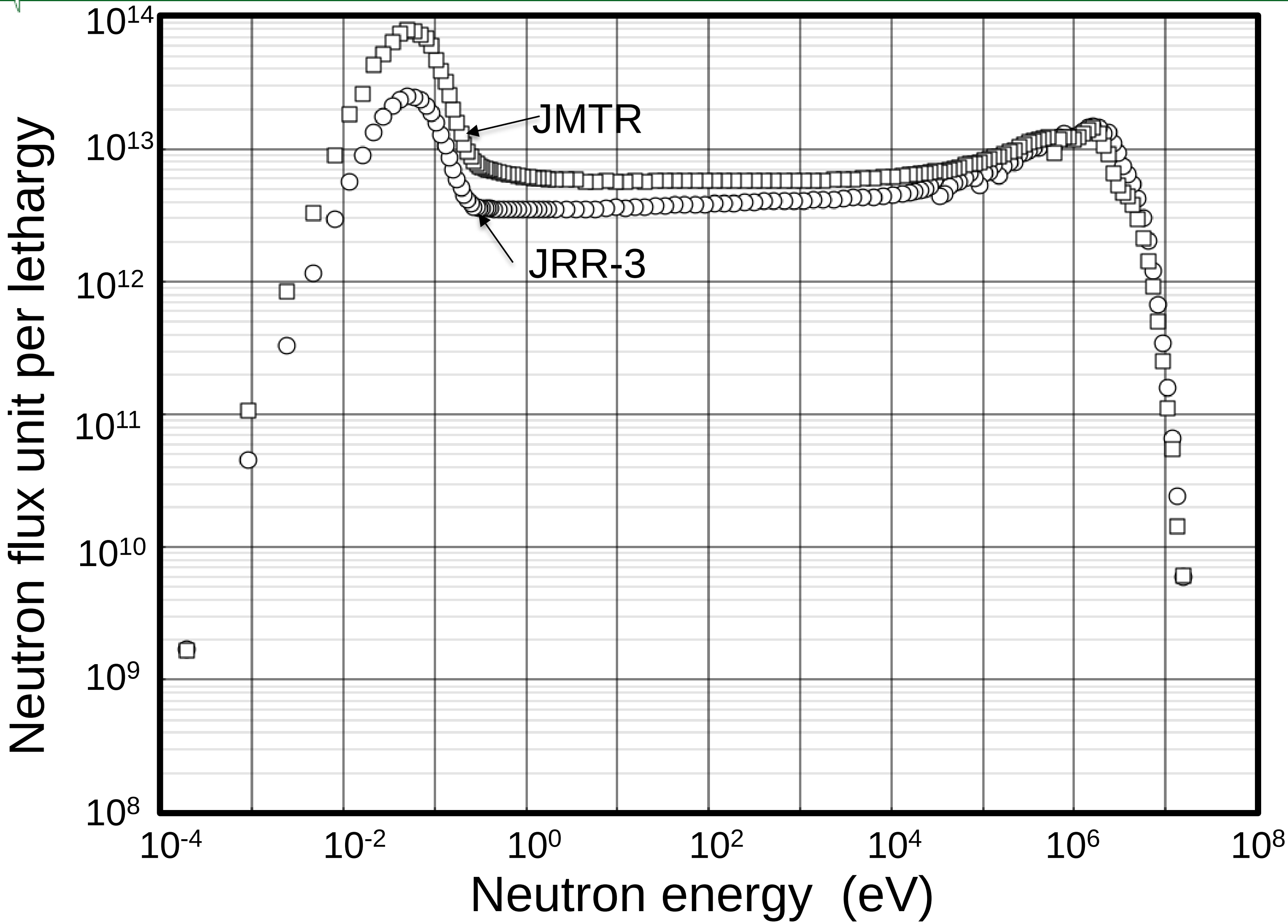
2. New beryllium components installation

   ➡ lower tritium release rate in JRR-3M and JMTR

Calculation by MCNP code (MCNP6, PHITS, $GEANT_4$) will be carried out to study more details.

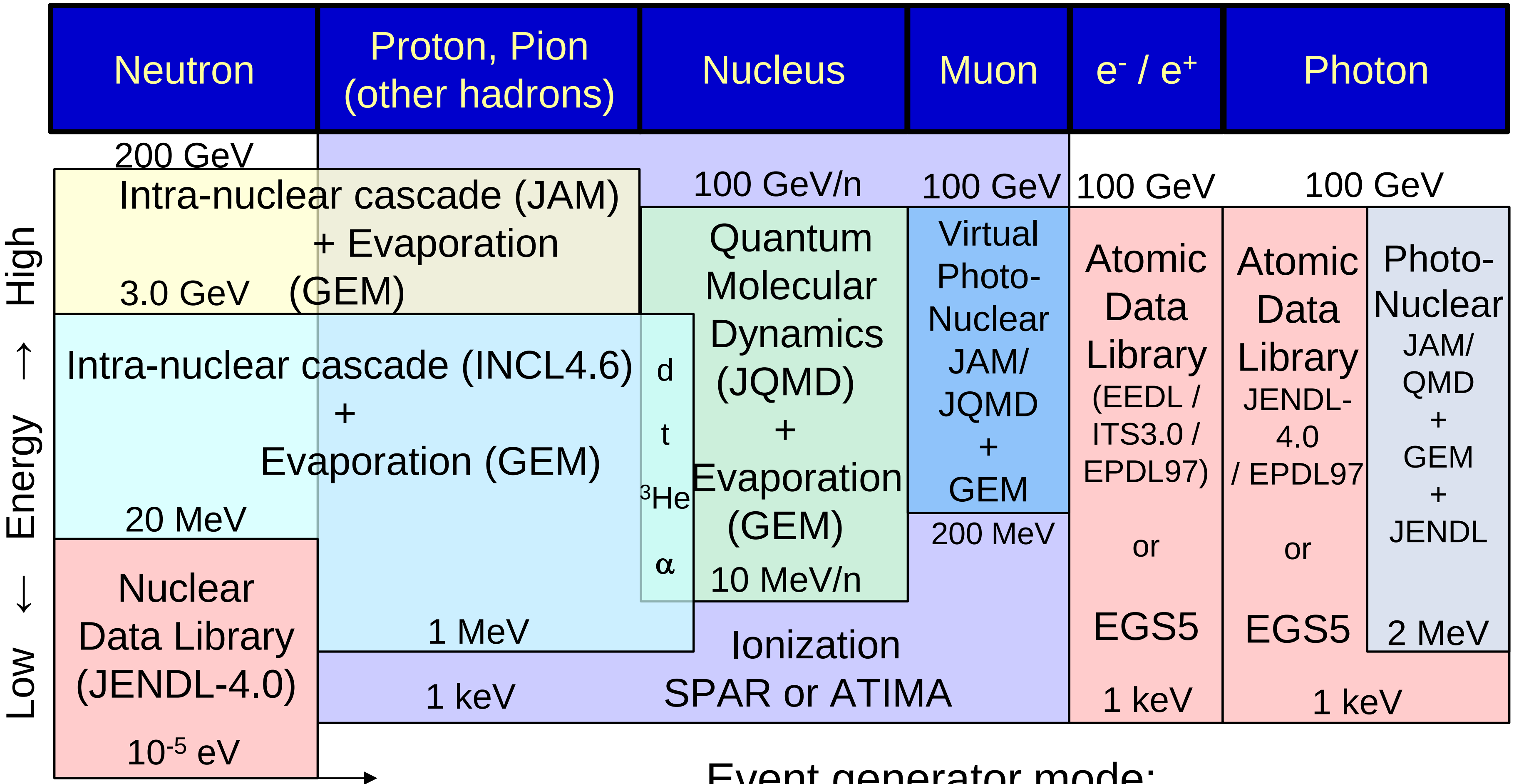
Appendix

Neutron spectrum of beryllium



Average of beryllium components calculated by MCNP6.

Outline of PHITS code



Event generator mode:

Specify all secondary charged particles produced from low-energy neutron interaction

Switching energies can be changed in input file of PHITS