Solid Backup Target

Y. Kiyanagi

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Solid target group

Contents

- Target materials
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Target materials (1)

Realistic candidates are Ta and W.

(Ta)

- High ductility after high level irradiation
- Low thermal conductivity
- Large thermal stress
- Thin plate or rod (Large coolant content)
- Bad neutronic performance
- High after heat (Fatal defect around 1 MW)

Target materials (2)

(W)

- High thermal conductivity
- Low thermal stress
- Thick plate or rod (Low coolant content)
- Good neutronic performance
- Low after heat
- High DBTT (High yield strength)
- Erosion by high speed water (above 5 m/sec)
  and under high radiation field

W with a thin cladding or in a sheath would be the unique candidate around 1 MW

Target type and Neutronics

1. Plate target

Higher nucleus density compared with a rod target.

Cladding is required.

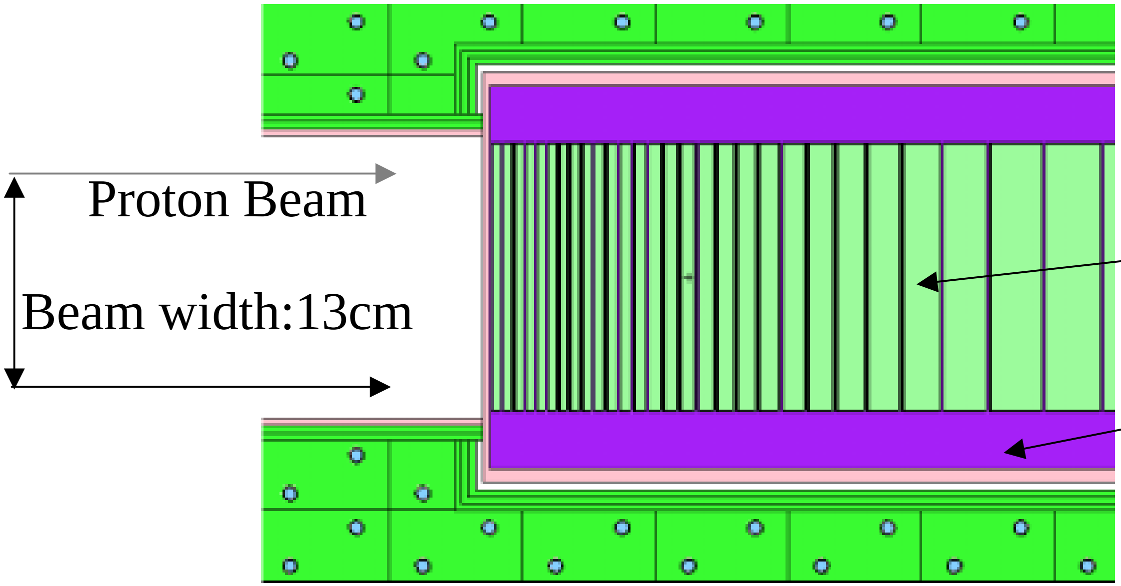
Ta cladding was already performed at KENS and ISIS.

2. Rod target

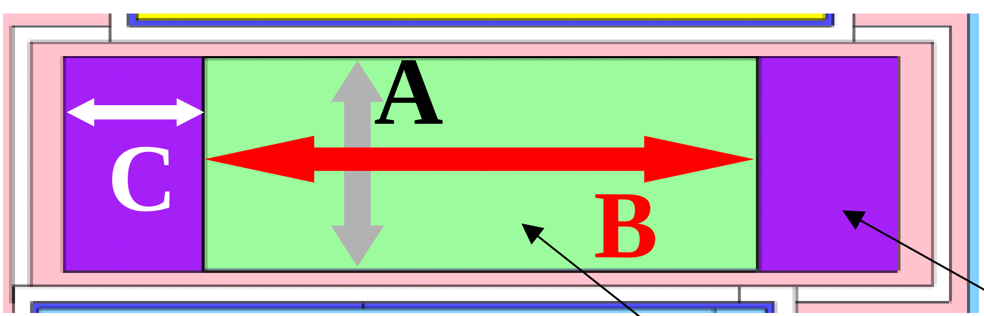
Lower nucleus density

SUS or Zircaloy sheath

Structure of A Plate Target

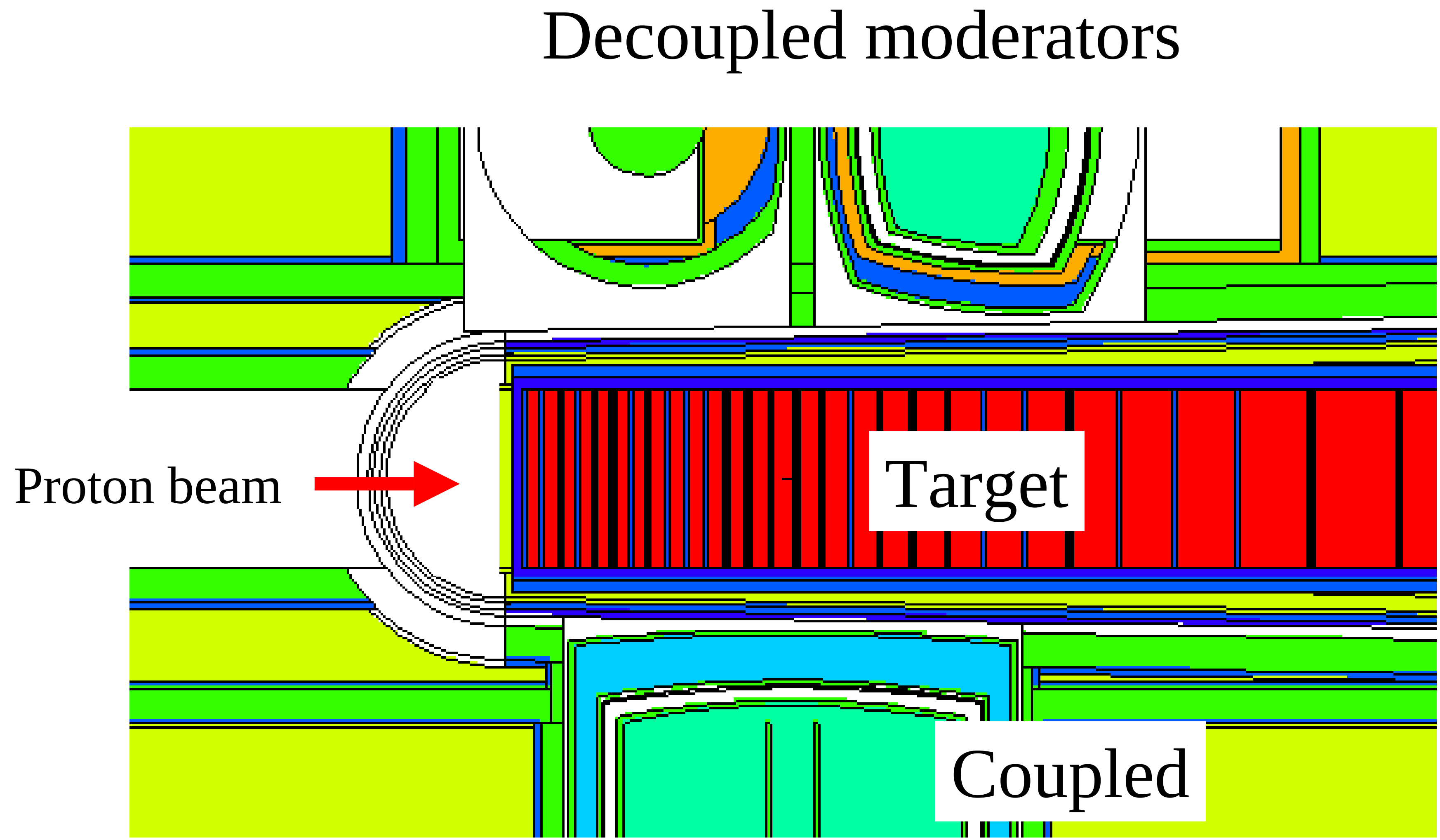


Top view of the tungsten plate target



Side view of the tungsten plate target

A:Target height
B:Target width
C：Coolant plenum width



Arrangement around A Plate Target

Plate thickness and cooling condition

Plate number	Thickness(mm)	Plate number	Thickness(mm)
1	6.3	15	10.2
2	6.7	16	11.0
3	6.4	17	11.8
4	6.3	18	12.7
5	6.3	19	13.8
6	6.4	20	15.0
7	6.5	21	16.5
8	6.7	22	18.3
9	7.0	23	20.5
10	7.3	24	23.3
11	7.7	25	26.7
12	8.2	26	31.2
13	8.8	27	37.3
14	9.4		

Thickness of each tungsten plate

Conditions

Accelerator power
1MW
Coolant speed
10m/s
Pressure of coolant
10atm

Distance between plates: 1.5mm Ta cladding: 0.5mm
Temperature of wall: less than 120℃
Maximum temperature: less than 200℃
Thermal stress: less than 200MPa

Plate Target

Neutron Intensity Relative to The Mercury Target

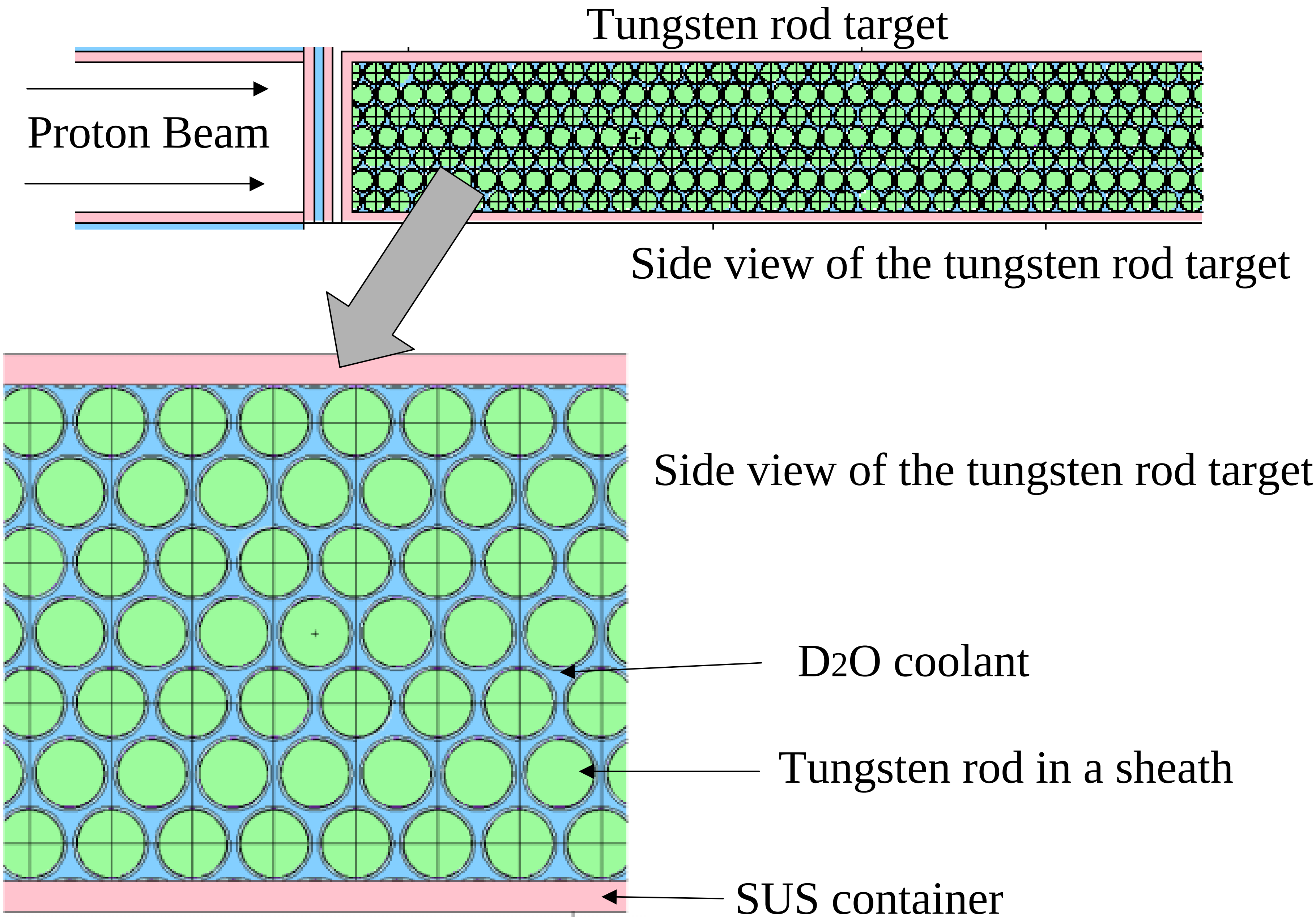
Optimum condition of the solid target

- Target height is 8cm
- Target width is 20cm
- Coolant plenum width is 5cm

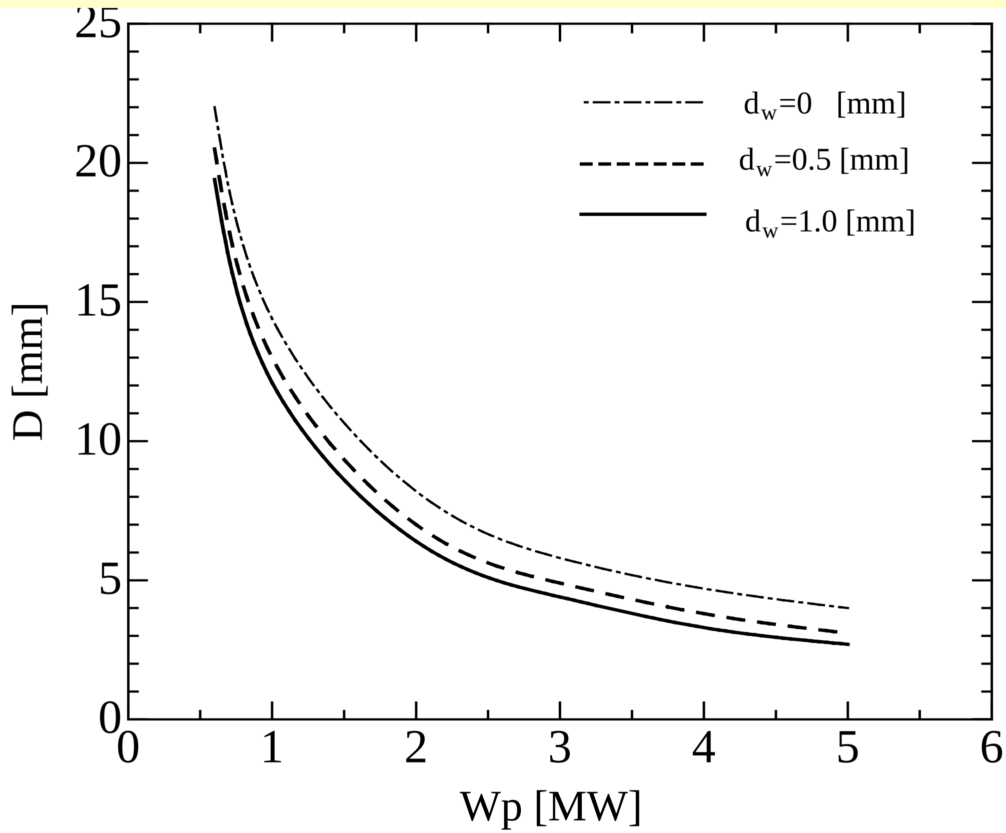
	Coupled	Decoupled	Poisoned
0-5meV	1.08	1.09	1.11
5meV-25	1.07	1.11	1.10
25meV-100	1.03	1.12	1.08
100meV-500	1.04	1.10	1.13

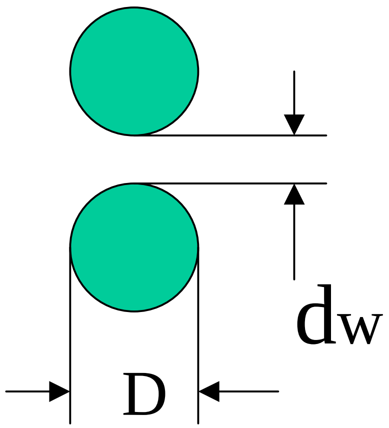
The solid plate target gives a little bit higher intensity than the mercury.

Structure of A Rod Target



Rod Diameter as A Function of Accelerator Power





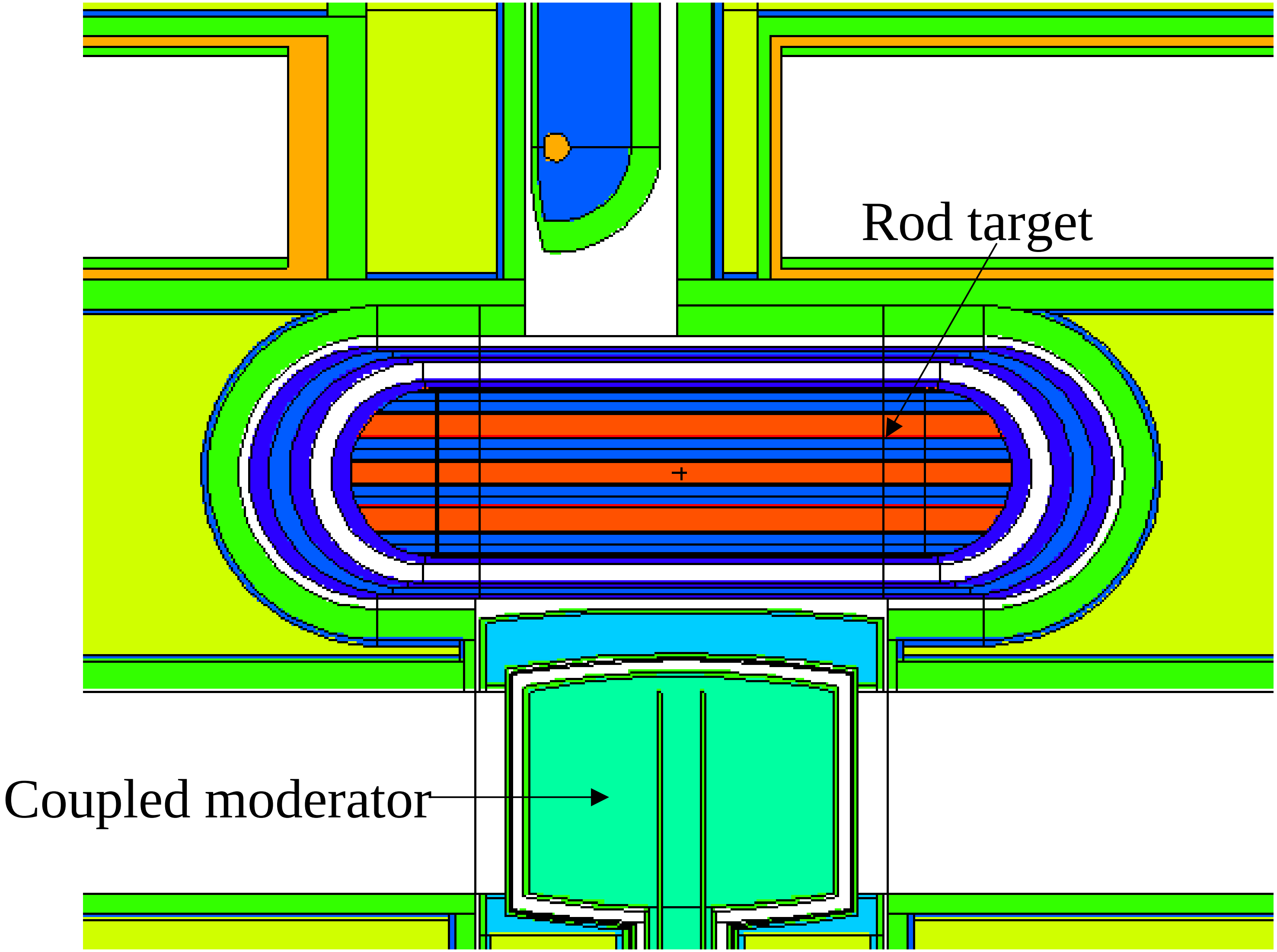
W rod with 0.5 mm Ta sheath

Tw=120 ℃

V=10 m/sec

Tin=30 ℃

At 1MW the diameter is about 13-15mm.



Arrangement around The Rod Target

Rod Target

Neutron Intensity Relative to The Mercury Target

Target condition of the rod target

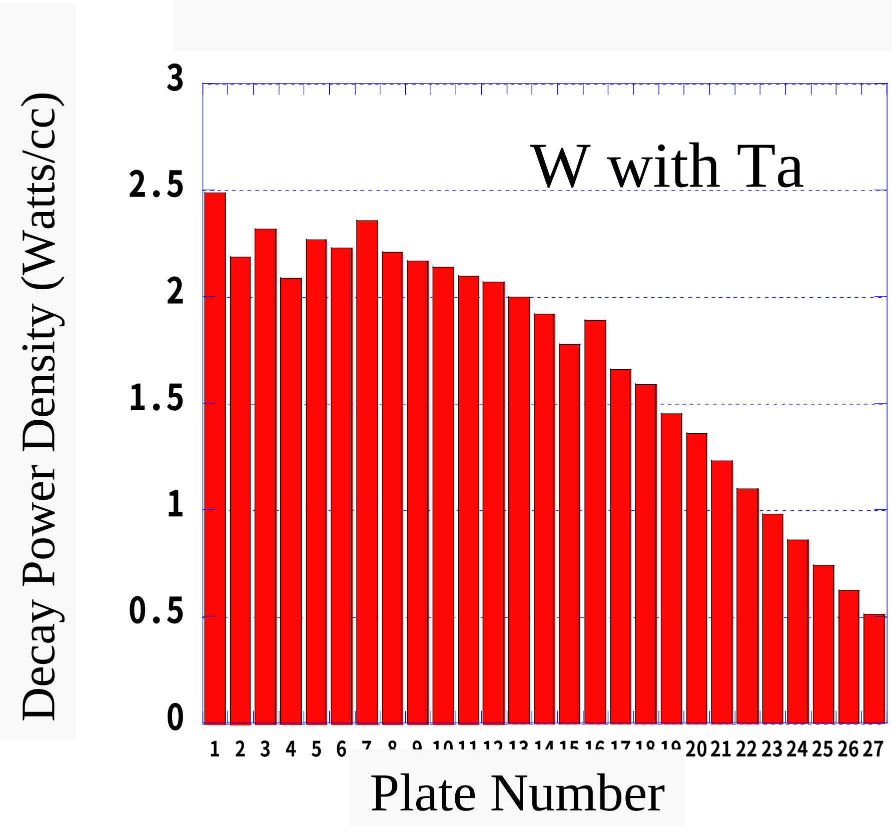
Rod diameter: 13 mm
Distance between rods: 0.5mm
Sheath material: Ta
Accelerator power: **1**MW

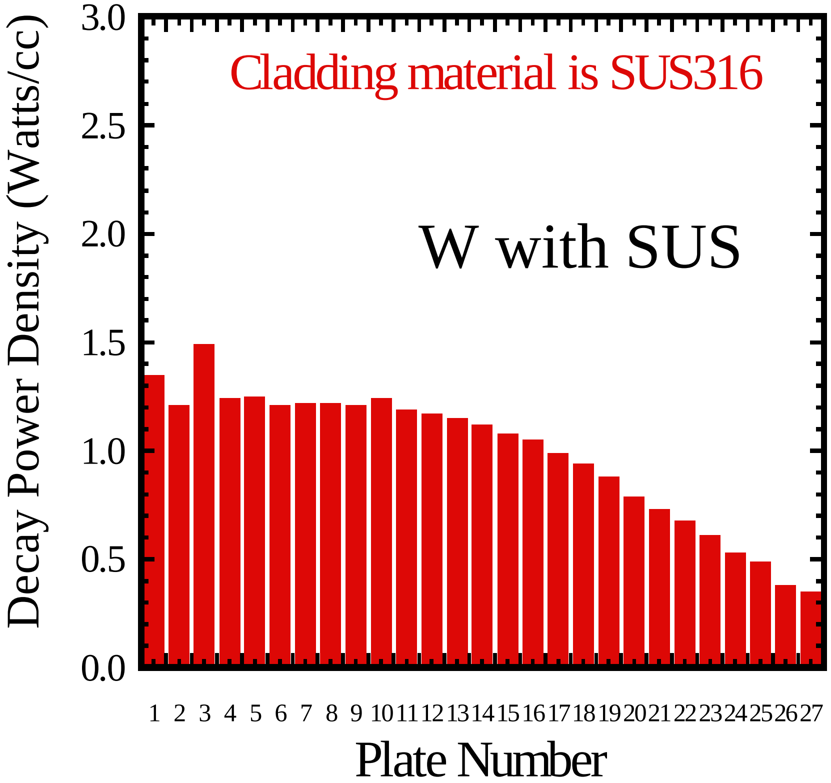
	Coupled	Decoupled	Poisoned
0-5meV	0.99	0.97	1.04
5meV-25	0.98	0.96	1.09
25meV-100	0.92	1.02	1.04
100meV-500	0.96	0.91	1.10

The rod target gives almost the same neutron intensity as the mercury target. (The Zircaloy sheath gave very little difference.)

Decay Heat Density Just after 1 Year Irradiation at 1 MW

Thickness of Ta clad is 0.5 mm

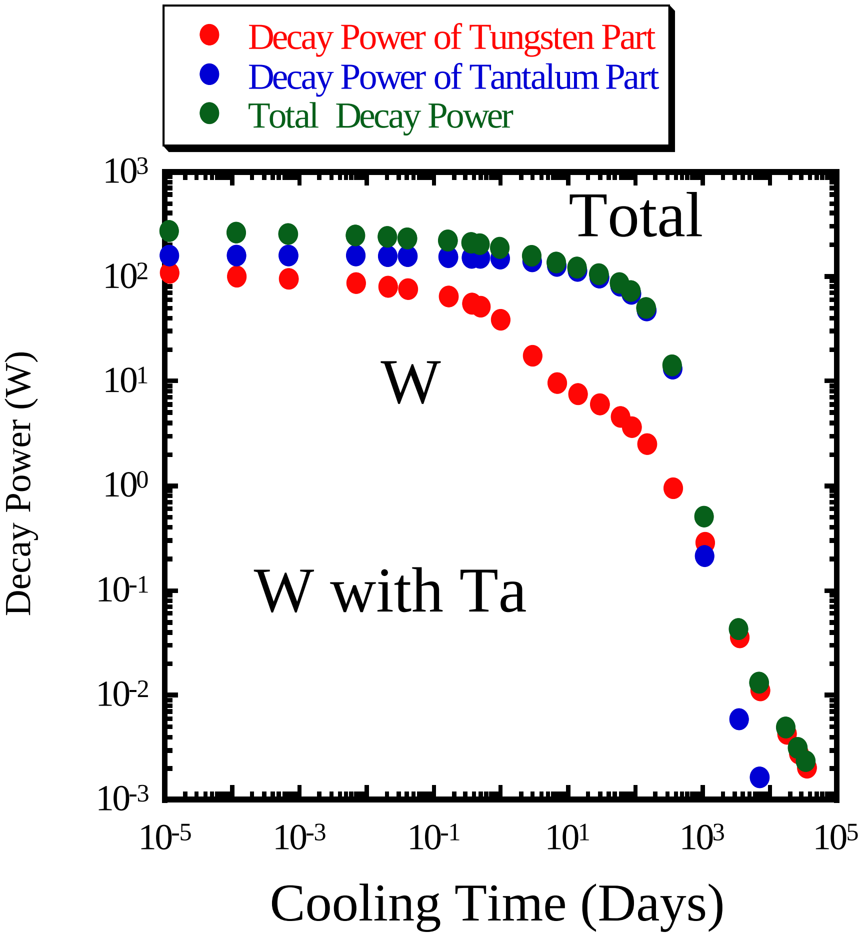


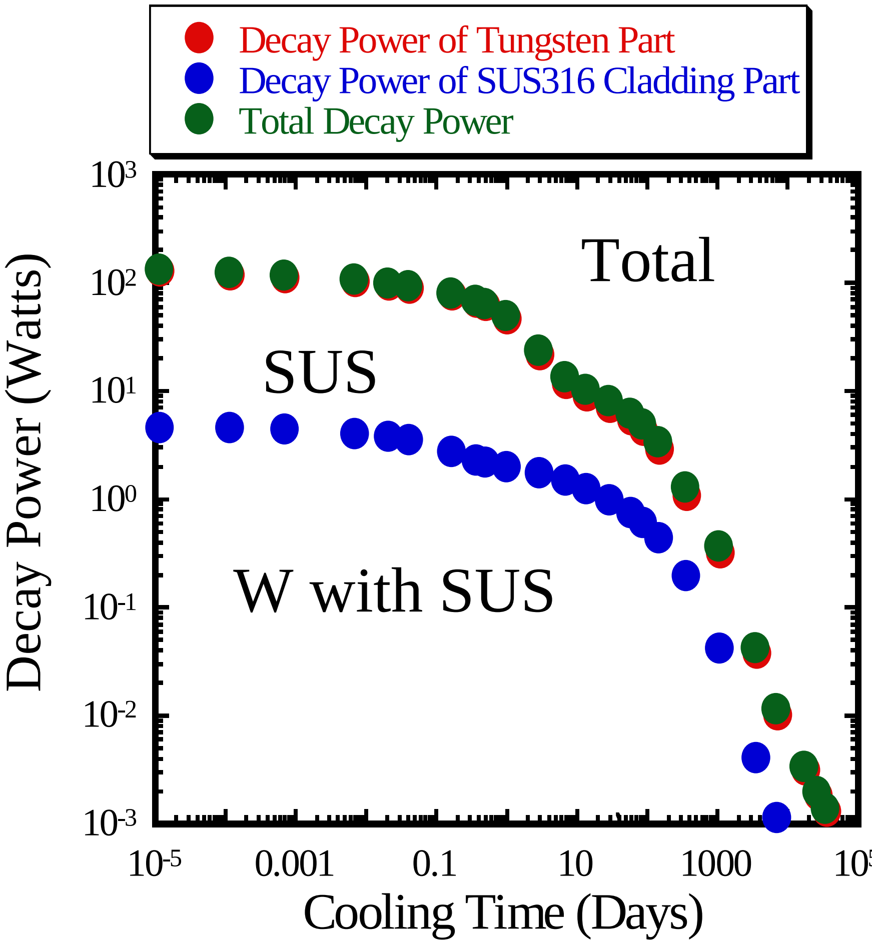


Total heat deposition is 7,580 W.
W:3,970 W, Ta:3,610 W

Heat deposition in Ta is too large. So, we assumed a SUS cladding.

Time Dependence of The After Heat of The First Plate





After heat from Ta cladding is dominant beyond 1 day and decreases very slowly.

The after heat from Ta is very large. So the W with Ta is not realistic.

A rod target with SUS or Zircaloy sheath will be feasible.

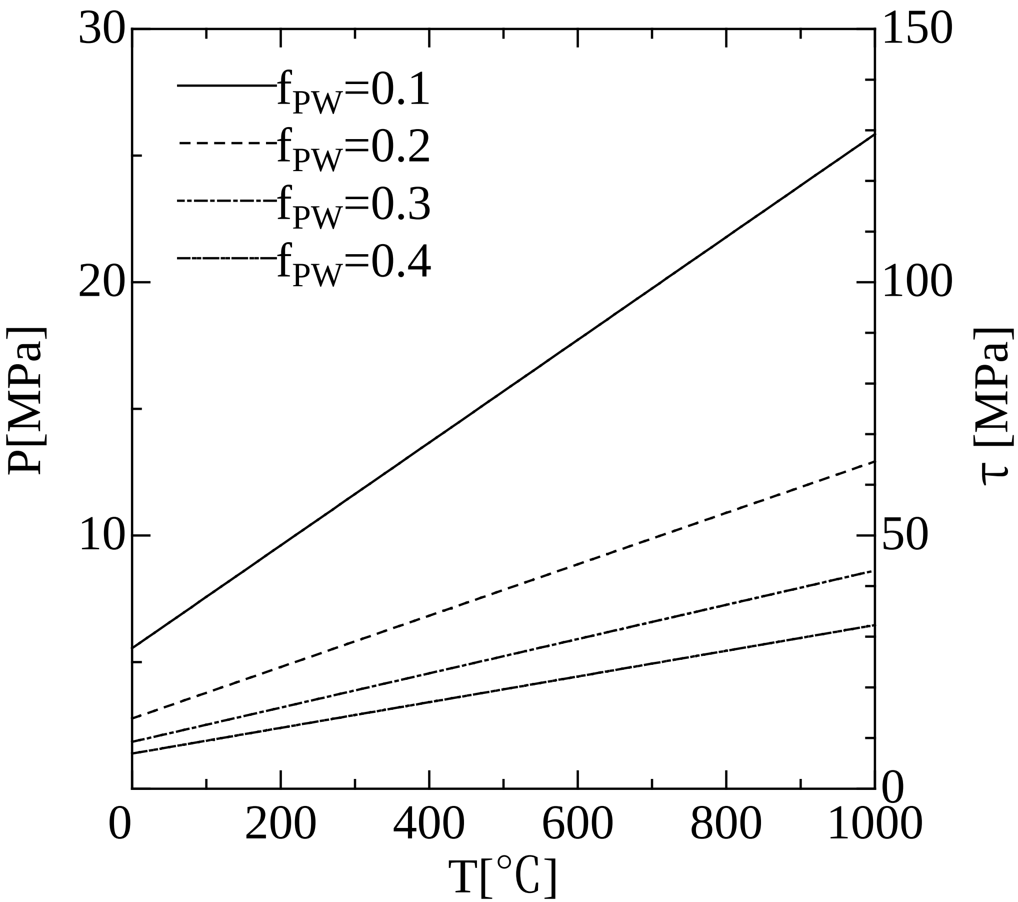
Conclusion

- W plate with Ta cladding is not acceptable because of the high heat deposition and of the slow decay of the after heat.
- W rod target in a SUS or Zircaloy sheath is most feasible. After heat becomes the level much less than the ISIS Ta target after 1 week cooling, ~0.5 kW.
- Neutronic performance of the solid target is almost the same as that of the mercury.
- Plenum for gases produced in the target is required but it is not so large. (See appendix)

(Issues for the rod target)

1. Life of Zircaloy due to hydride formation should be evaluated by the experience at PSI.
2. Technical experience should be required for the SUS sheath.

Appendix: Pressure concerning to the sheath



P: Inner pressure

τ: tensile stress of sheath

fpw: volume rate of plenum

Assumption:
0.42% hydrogen production at 10 dpa.
(Malloy et al.)