High power density neutron Ta target development for HBS

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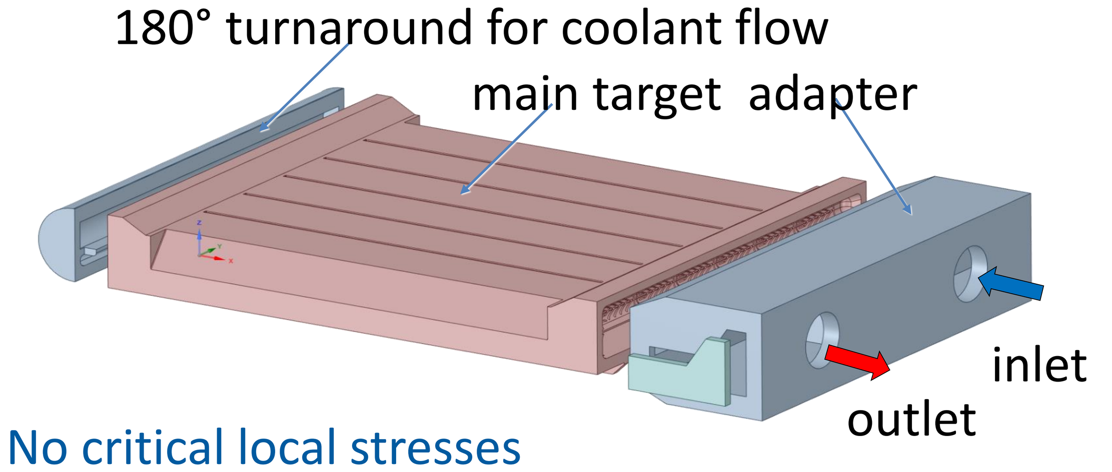
Target design

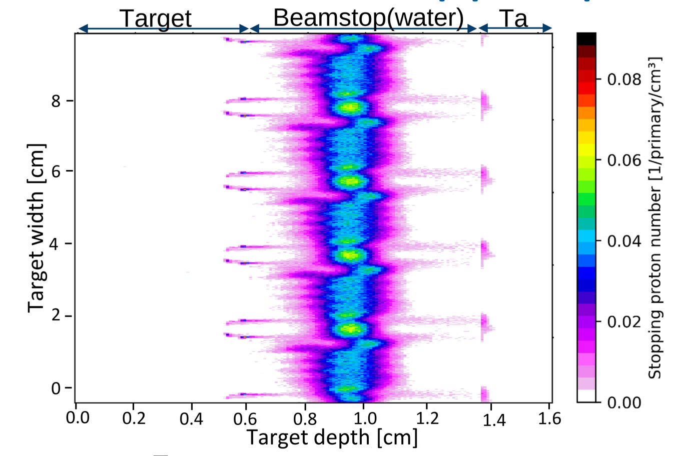
- Water velocity inside channels: 8 m/s
- Pressure: 3 bar at microchannel outlet
- Pressure loss inside target: ≈ 3 bar
- Microchannels, manufactured via wire erosion

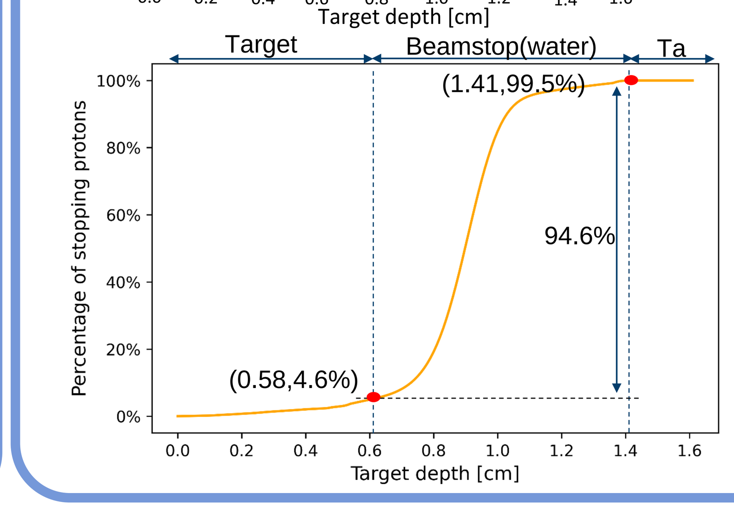


No critical local stresses
No welding in the main target body
Most protons accumulating in the beamstop (water)
Sufficient heat dissipation via microchannel structure

Target optimization

Distribution of stopped protons

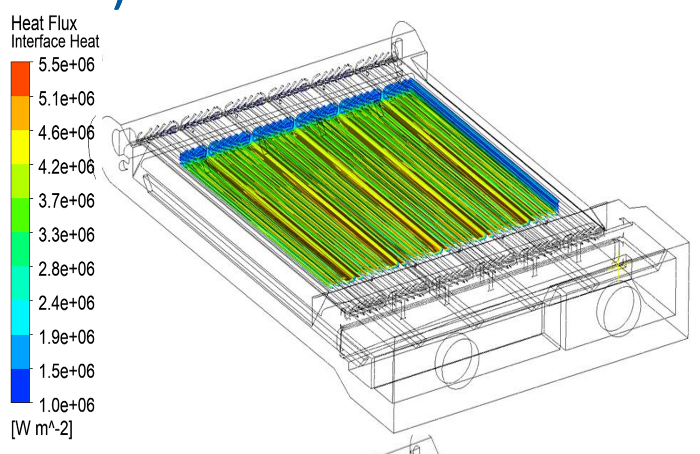


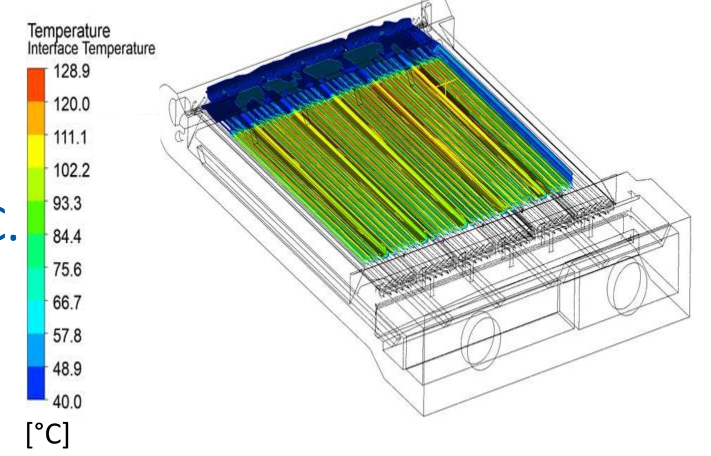


Only 4.6% of protons stop in the target, 93.2% accumulate in the beamstop (water).

→ No blistering problem

Heat flux (up) and temperature (down) at the channel interfaces

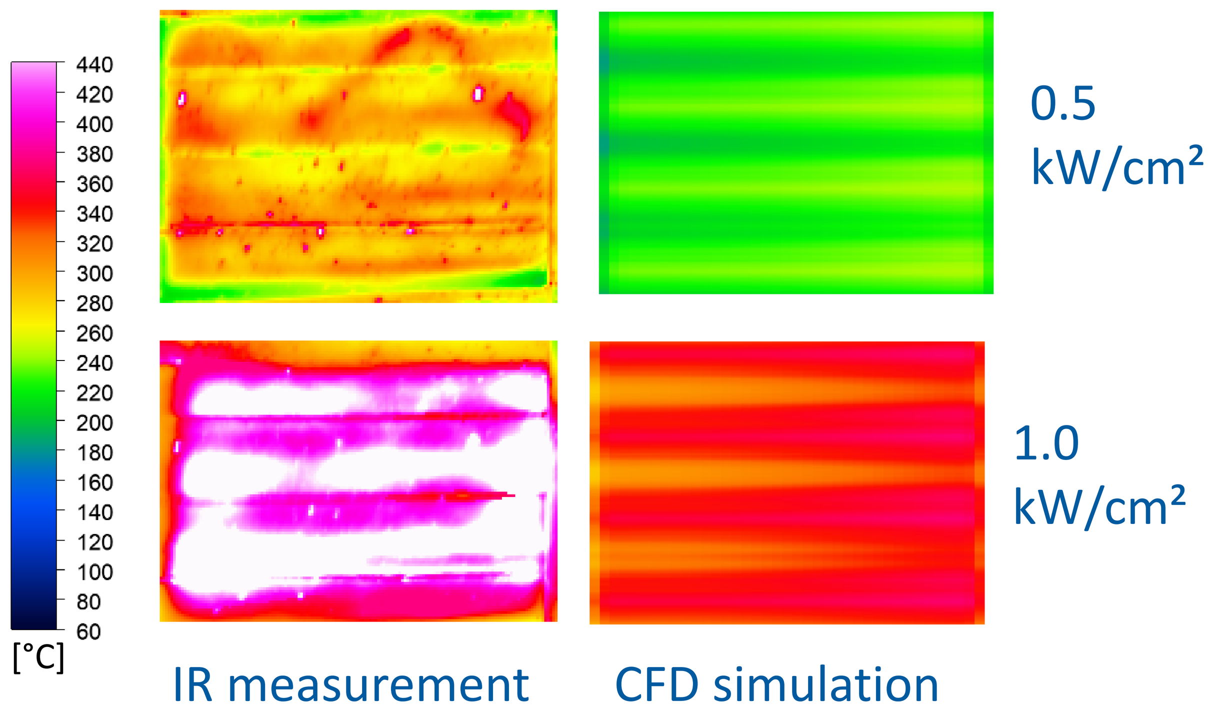




Maximum interface heat flux in the target is 5.5×106 W/m² (0.55 kW/cm²).
→ No burn-out problem
Maximum interface temperature is about 129 °C.
→ No boiling

→ Sufficient cooling efficiency

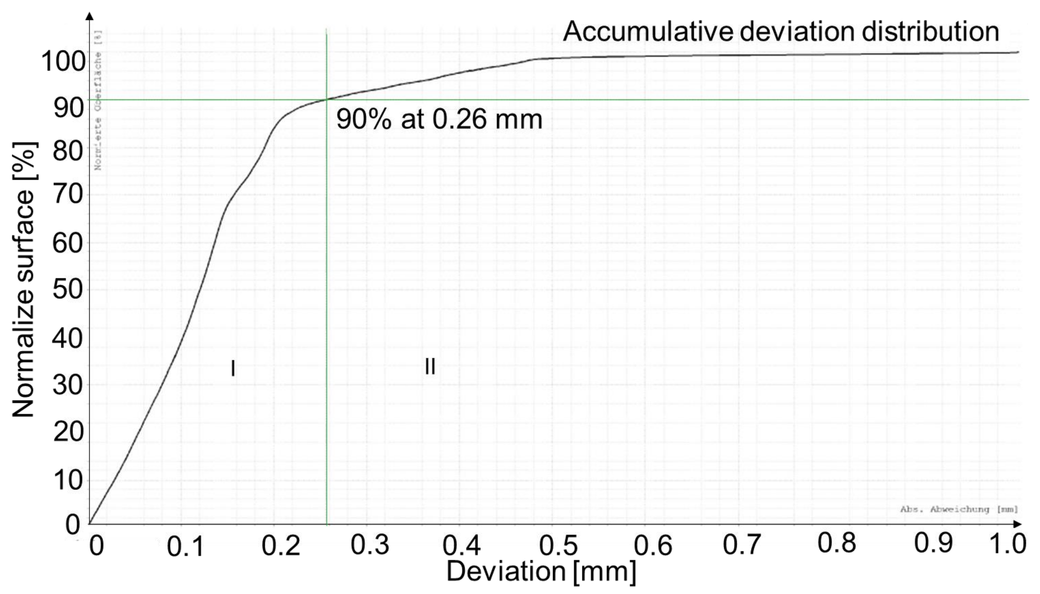
High heat flux test



IR measurement CFD simulation

→ Heat flux results indicate a sufficient heat dissipation (>1.0 kW/cm²).

Accumulative deviation distribution of the manufactured HBS target prototype



Machining error of target thickness is 0.02 cm.

CT measurement

Target thickness [cm]	Percentage of stopping protons
0.58	4.6%
0.59	6.6%
0.60	11.9%
0.61	25.2%
0.62	51.5%
0.63	81.1%
0.64	95.7%
0.65	98.9%

Percentage of stopped protons in different thicknesses

		Annual does [dpa/fpy]		Minimum target lifetime [years]
		Reference values	Calculated values	
Nominal target	Protons-induced	11 [1,2]	1.93±0.02	5.70
	Neutrons-induced	0.14 [3]	0.12±0.02	1.17
Target prototype	Protons-induced	11 [1,2]	2.01±0.02	5.47
	Neutrons-induced	0.14 [3]	0.12±0.01	1.17

Lifetime estimation based on DPA

- Fabricated target is 0.60 cm thick and approximately 12% of protons will accumulate there.
- Compared to the nominal design, the number of protons parked on the target will increase by 157%.

Life time estimation based on hydrogen concentration

Proton current at HBS 8.74×10^{15} s^{-1}	Critical hydrogen concentration in Ta	Number of Ta atoms	Number of H atoms to reach critical point	Lifetime [years]
Nominal target	17% [1]	1.0×10^{24}	1.7×10^{23}	18
Target prototype	17% [1]	1.1×10^{24}	1.9×10^{23}	6

→ Machining errors (0.2 mm) do not affect the lifetime, even if they cause triple hydrogen implantation.

[1] T. Schober, "Vanadium-, niobium- and tantalum-hydrogen," Solid State Phenomena, vol. 49–50, pp. 357–422, 1996.