Development of a High-Power Density Neutron Target for HBS (High Brilliance Neutron Source) Design and first Experimental Tests

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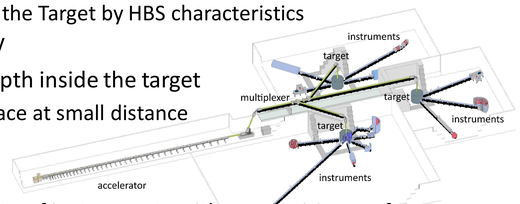
Why do we need an other target?

HBS (High Brilliance neutron Source): Accelerator driven compact neutron sources

Special requirements placed on the Target by HBS characteristics

- Low* ion energy of 70 MeV
  - → Low penetration depth inside the target
  - → Heat release takes place at small distance
  - → Thin target
- Lower neutron yield* BUT
  - ! HBS shall get a full suite of instruments with competitive performance
  - ! Competitive strong neutron flux is necessary
  - → High ion current of 100 mA
  - → Strong heat load at the target
- HBS - High **Brilliance** neutron Source
  - Brilliance is inversely proportional to the size of the target
  - Smaller target could enhance the brilliance
  - → Minimize the size of the target: 100 kW at 100 cm²

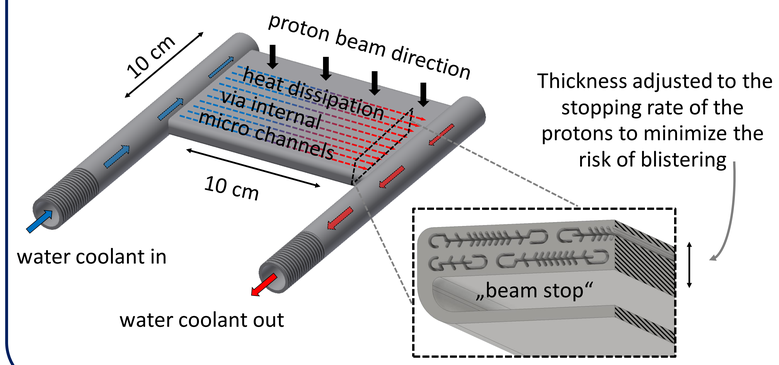


*compared to existing spallation sources

Microchannel Design

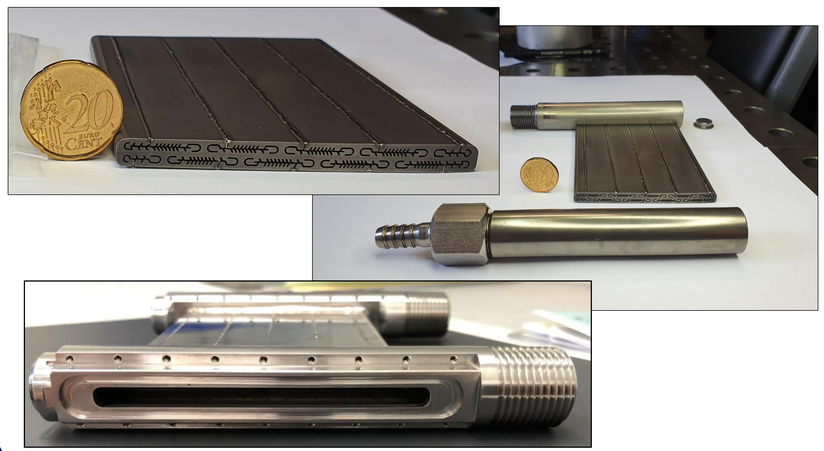
Compact Tantalum Target with inner Cooling Structure

Micro channel: 0.35 mm thickness, manufactured via wire erosion
Coolant: Water; velocity inside channels: 8 m/s
Pressure: 5 bar at micro channel outlet; pressure loss inside target ~ 2 bar

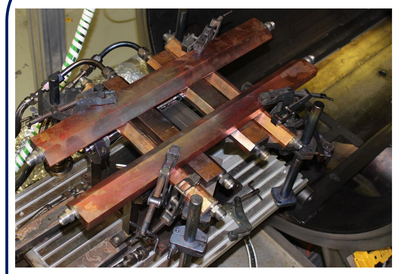


First fabricated Microchannel Target

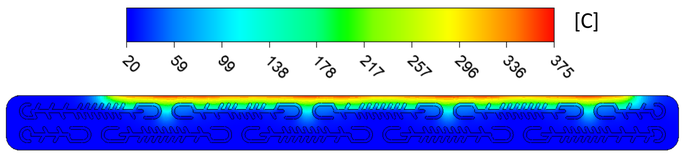
Eroded channels with welded entry points

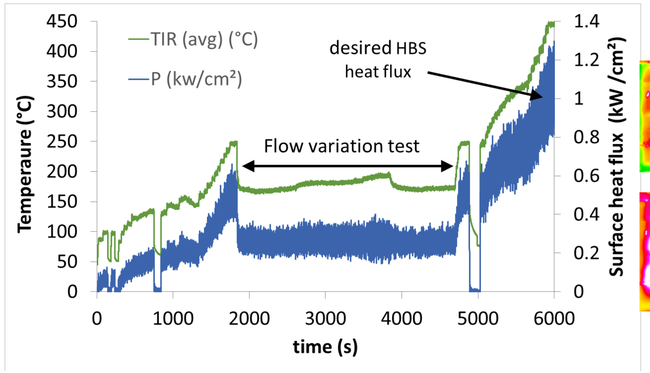


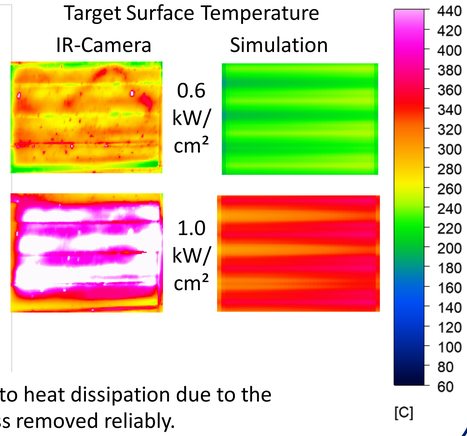
High Heat Flux Test at JUDITH-2 facility



Heat flux up to 1 kW /cm², produced by an electron gut
Conservative load case due to one-sided heat input but cw heating



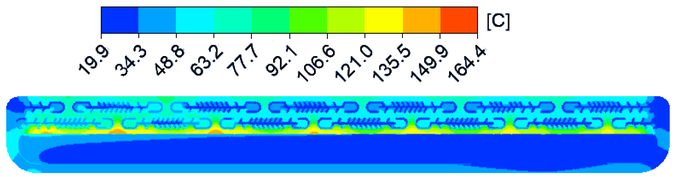




Only about a quarter of the cooling channel surface contributes to heat dissipation due to the surface heating of the electron gun. The heat load is nevertheless removed reliably.

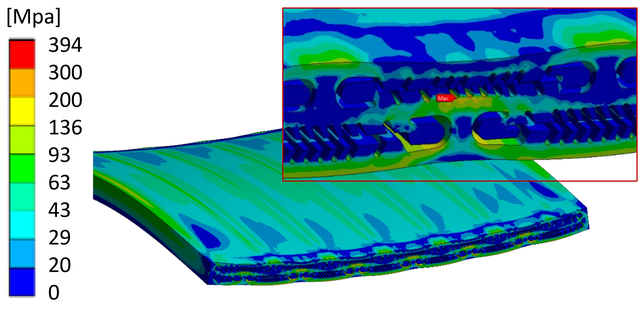
Target Simulations with ANSYS CFD / FEM

Low temperatures due to high cooling performance and large interface area
Heat release in the entire target volume



Target withstands the mechanical stresses (thermal induced stress, water pressure…)

From a mechanical point of view, however, there is potential for further optimization



Erosion Test

6 week continuous flow test to investigate possible tantalum erosion by the flow

- No increased Ta level in water
- No change of the target mass
- No measurable change in channel width

→ Channels withstand water erosion

Conclusions

I. High Heat Flux Test indicates a sufficient heat dissipation (100 kW at 100 cm²)
II. Erosion Test indicates persistent channels at desired flow velocity and pressure (8 m/s and 5 bar)
III. CFD and FEM Simulations indicates mechanical and thermal stability
IV. Designed Tantalum Target with inner micro channel cooling meets all requirements of HSB
V. In the next step, the geometry of the target and the cooling channels will be iteratively optimized in the direction of neutron yield, avoiding hydrogen implantation and mechanical stability.

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