Target handling of the Jülich High Brilliance Neutron Source (HBS)

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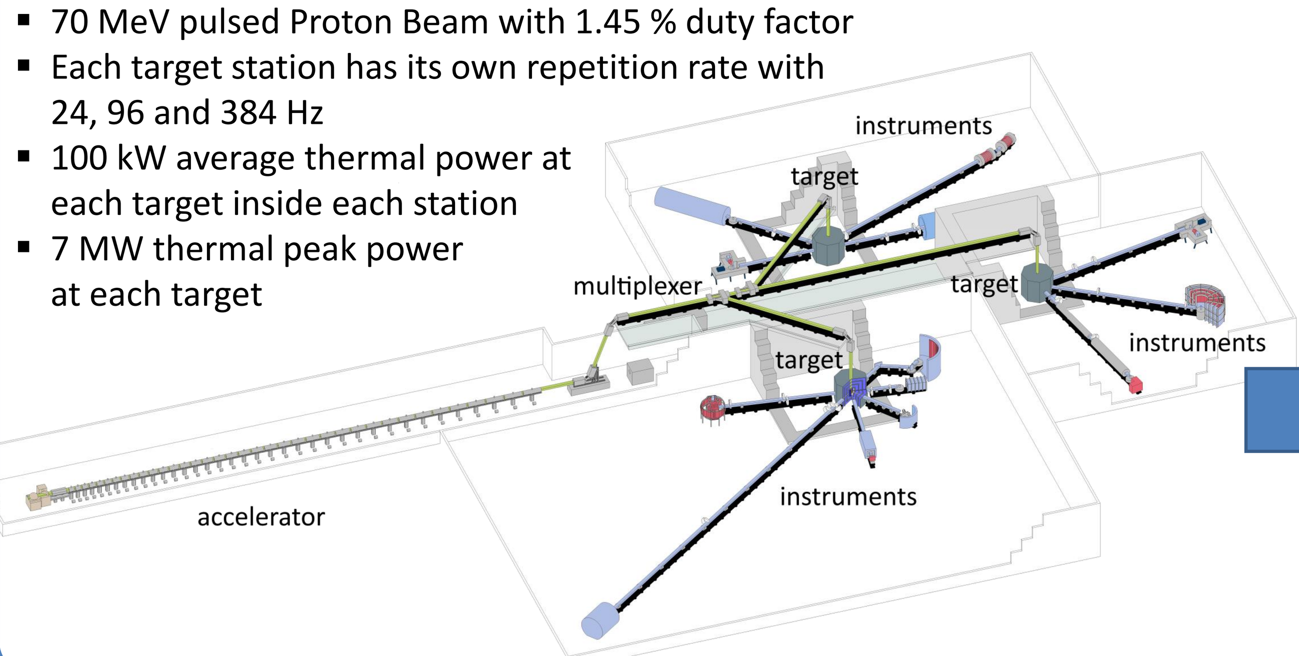
Abstract

In recent years, the interest in compact, accelerator-driven neutron sources (CANS) has increased worldwide, especially with regard to the increasing shutdown of existing fission-based neutron sources. Due to their special characteristics such as compact-ness and low energy, these CANS offer unique advantages and are a good addition to existing neutron sources. The focus of interest in CANS is shifting more and more from low-flux university scale CANS to powerful high-flux CANS that have the potential to replace current national neutron sources. The Jülich HBS which is currently under development belongs to these high-flux CANS.

One of the key components on the way from compact low flux neutron sources to compact high flux neutron sources is the neutron target. Unique requirements are placed on the target, consisting of low ion energies in the range of up to 70 MeV at high ion fluxes up to 100 mA and minimal surface area. In case of the Jülich HBS the neutron target will be placed inside the accelerator vacuum without a beam window. This arrangement reduces the complexity and the beam losses of the proton beam but at the same time it creates naew challenges concerning the target cooling, the vacuum tightness and its radiation resistance and the remote target handling.

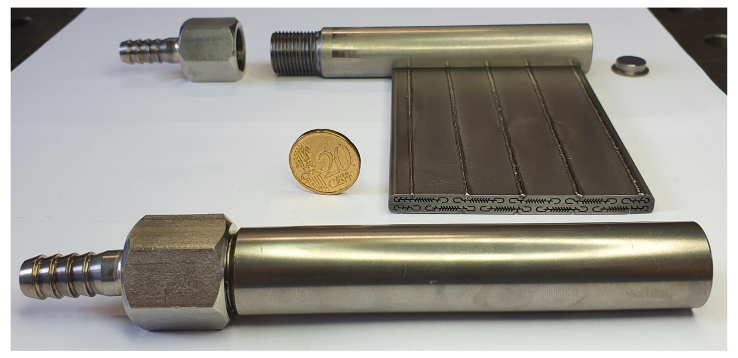
HBS – short overwiev

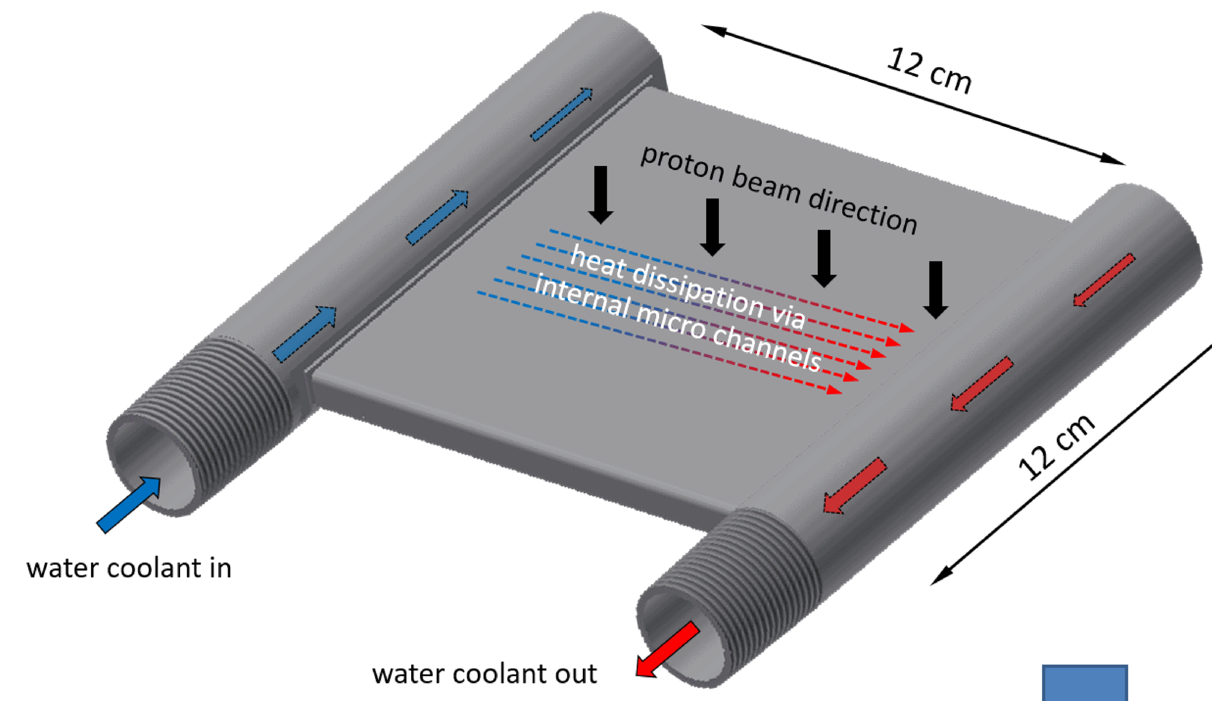
- One accelerator supports 3 Neutron Target Stations
- 70 MeV pulsed Proton Beam with 1.45 % duty factor
- Each target station has its own repetition rate with 24, 96 and 384 Hz
- 100 kW average thermal power at each target inside each station
- 7 MW thermal peak power at each target



The "internally cooled" Neutron Target

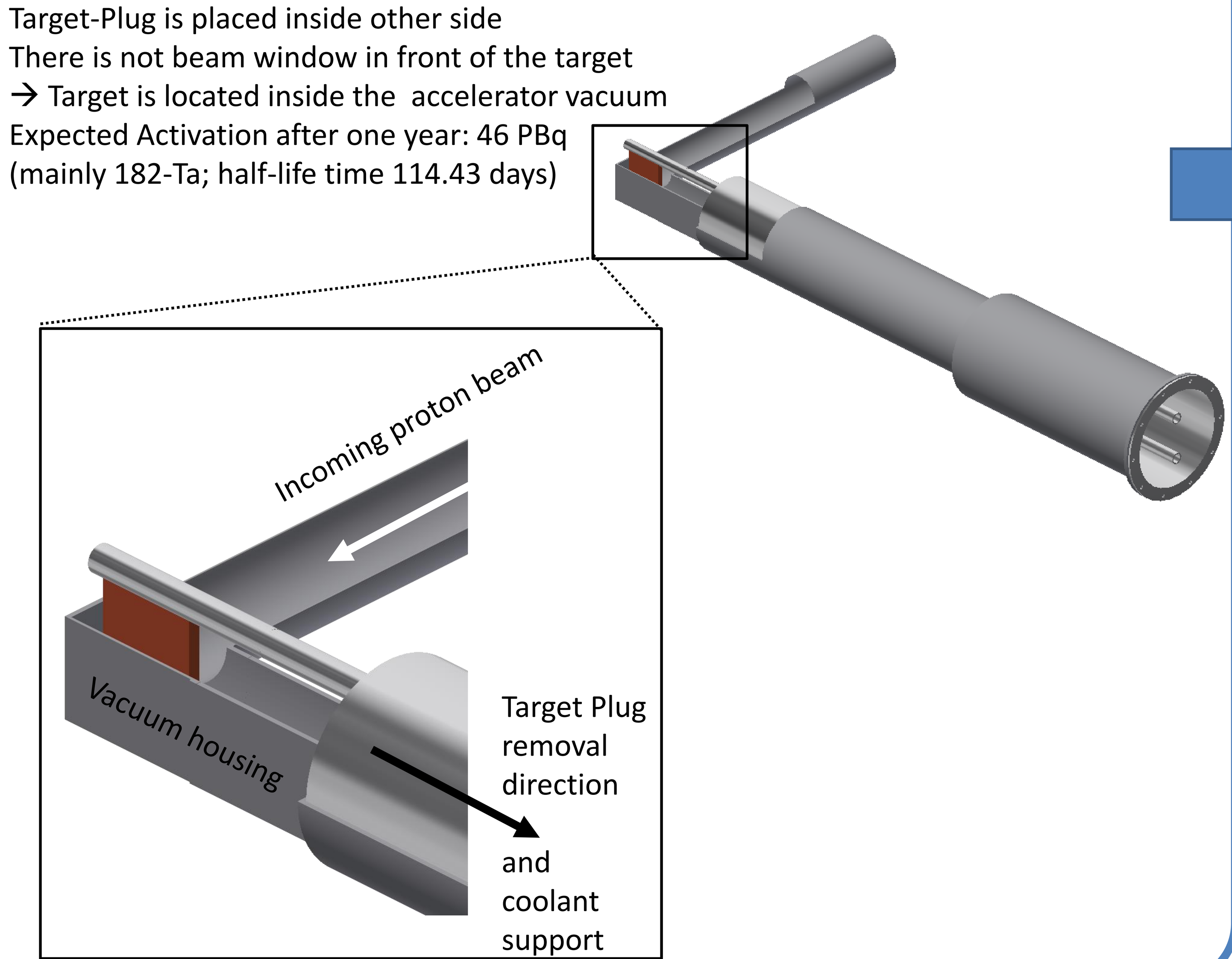
- Target made of Tantalum
- Target mass: 2.2 kg tantalum
- 1 kW/cm² avg. power density
- Water cooled
- Expected life time: 1 year



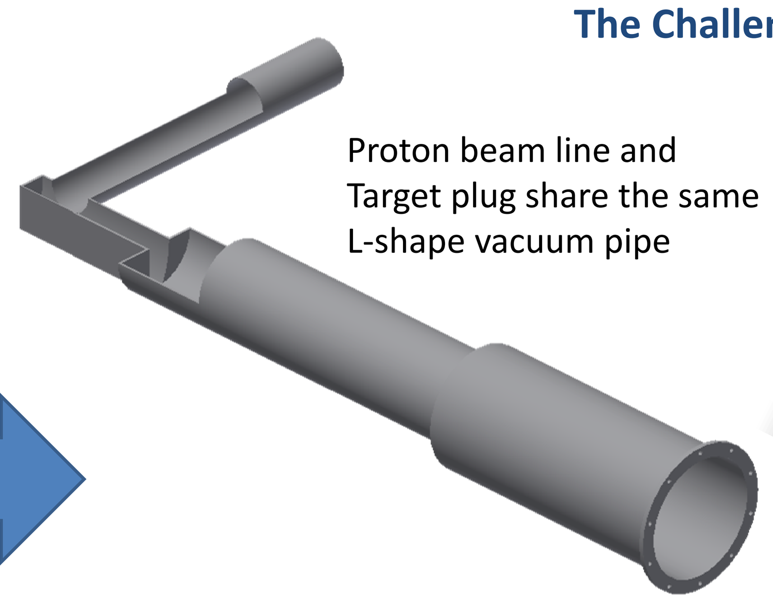


Target-Plug Environment

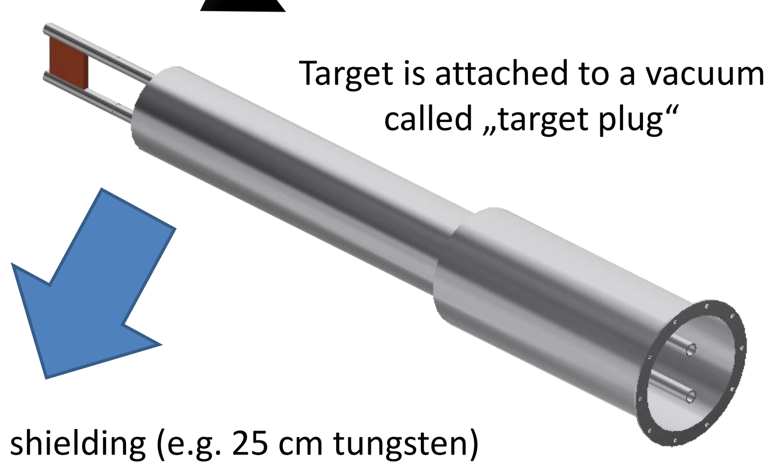
Target attached at the front side of a removable Target-Plug
Target-Plug unit is placed inside a L-shape tube:
Proton beam arrives at one side,
Target-Plug is placed inside other side
There is not beam window in front of the target
→ Target is located inside the accelerator vacuum
Expected Activation after one year: 46 PBq
(mainly 182-Ta; half-life time 114.43 days)



The Challenge: A periodical exchange of the target is required.

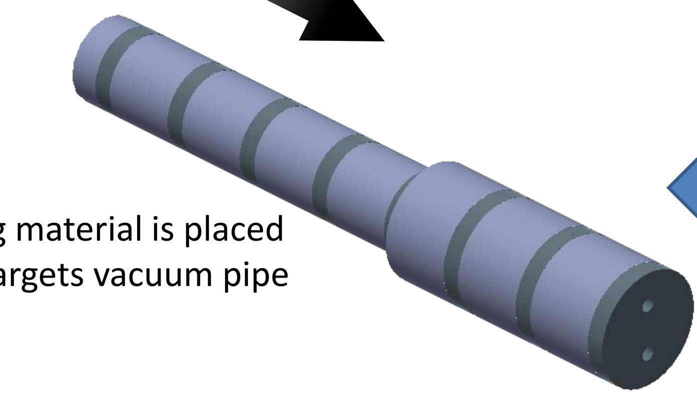


Proton beam line and Target plug share the same L-shape vacuum pipe

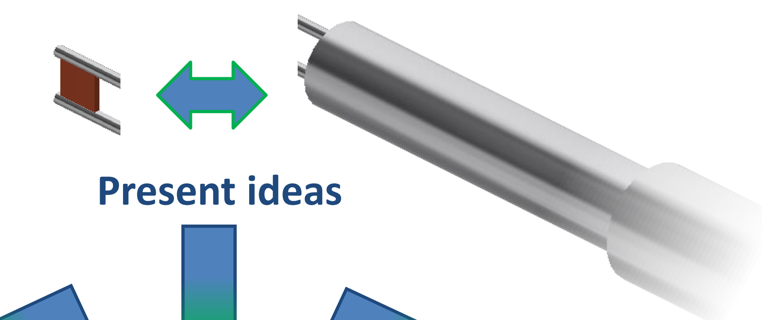


Target is attached to a vacuum pipe called „target plug"

Ecxchange has to be done via remote control due to high radiation of the target
→ Change mechanism must be fail-safe
Replaced target has to be stored inside strong shielding (e.g. 25 cm tungsten)
→ Volume for the intermediate storage should be as small as possible
→ Separation of Target and Target-Plug after operation desirable



Shielding material is placed inside Targets vacuum pipe

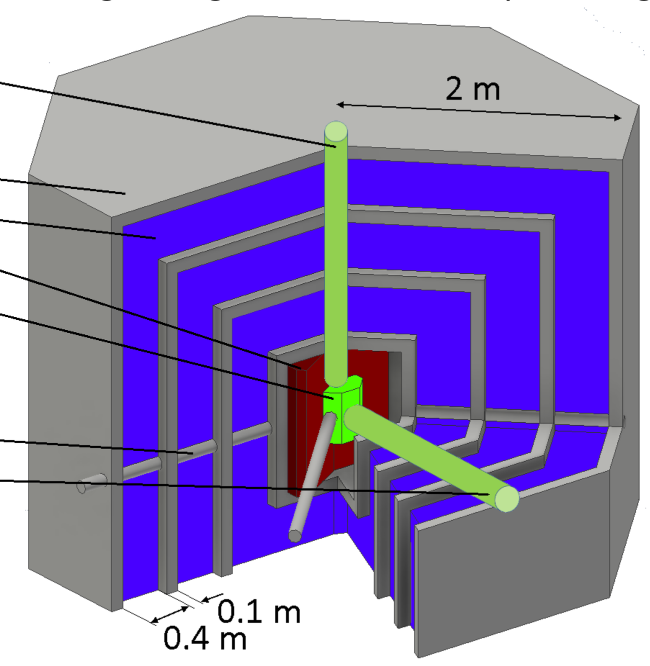


Present ideas

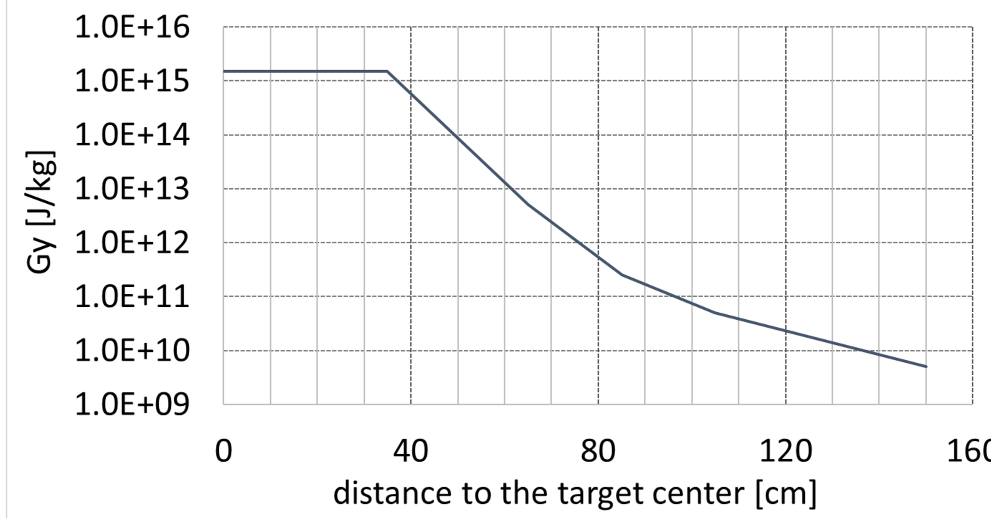
Any suggestions?

Target is placed inside a shielded Target Station

- Target is placed inside strong sandwich shielding made of alternating layers of lead and borated PE
- Target is attached to a removable "Target-Plug" to enable an easy exchange



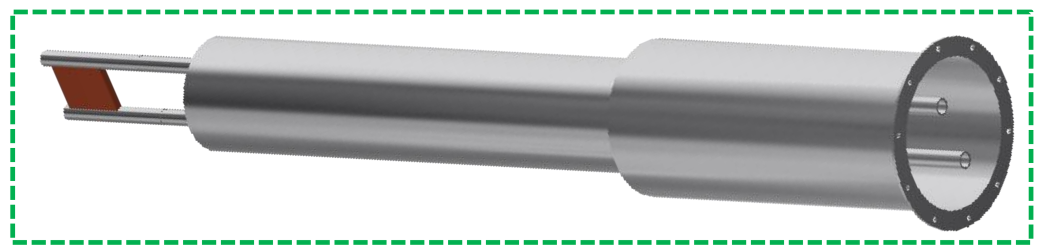
Estimated radiation exposure for components close to the target within one year (5000 operating hours)



No seperation after target exchange

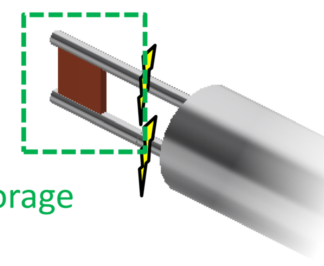
Entire Target-Plug will be replaced

- + No separation points
- + Absolute reliable
- - Large volume for the intermediate storage
- - Massive Shielding for target exchange and target storage necessary
- - major volume inside intermediate storage has minor activity (aluminium)



Conventional flange with graphite sealing

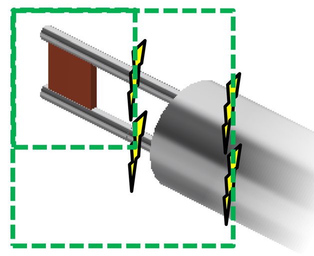
- + Very high radiation resistance
- Separation point close to the target
- + Small volume for the intermediate storage
- ? Fulfil desired leak tightness?
- - Complexity of remote control separation?
- ? Reliability?



Source: sglcarbon.com

detachable coolant connection in a certain distance to the target

- Connection has to be vacuum tide and radiation resistant
- Radiation dose of the connection can be controlled via the distance to the target
- + There are suitable materials for the seals (e.g. graphite seals) and possibly solutions off-the-shelf
- + Small volume for intermediate storag
- ? Complex target exchange mechanism
- ? Reliablity



Source: staubli.com

Target is fixed to the vacuum envelope tube – Pipes are cut up

- + No separation point close to the target inside high radiation field
- detachable separation point inside shielding to enable the partial recycling of the plug
- - Hot cells are required for the separation process
- + Very small volume for intermediate storage
- + Reliable