# Development of the CSNS Target Plug

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# Outline

1. Status of CSNS Target System
2. Design of Target Plug
3. Introduction of fabrication
4. Summary

# 1. Status of CSNS Target System

(1) Fabrication of all the components has been finished.
*(Target Plug: Jan. 2016 / Target Trolley: Jul. 2016)*

(2) Acceptation tests have been done.
*(Including Ta cladding performance, seal performance, position accuracy measurement…)*

(3) In-site installation began in Sept. 2016. Most of the components have been installed.
Will be finished in Nov. 2016 and then in-site test will be started.
*(Trolley rails, fixed shielding blocks, moveable shielding blocks, transmission system, etc., installed)*

Target Plug

Target Trolley

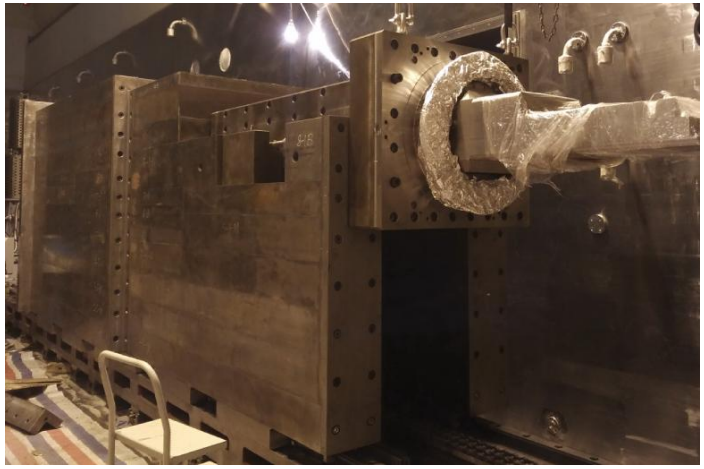
# In-site installation

Hot cell

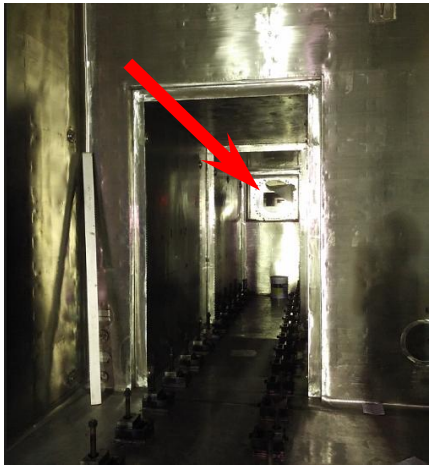
Trolley rail assembly (17m)


Fixed shielding blocks

Moveable shielding blocks

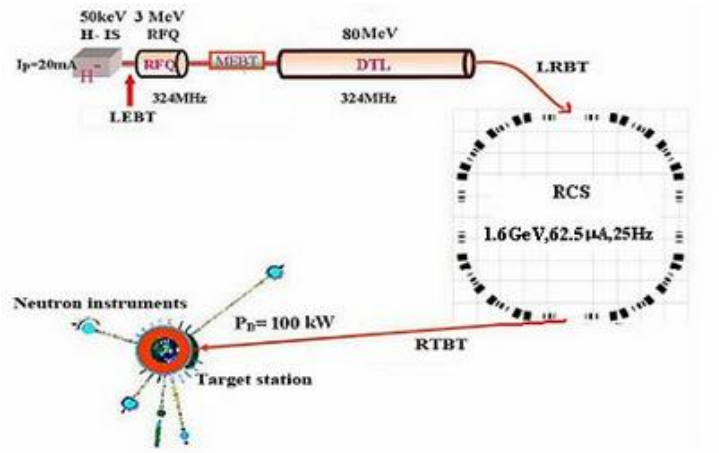


Trolley with target support

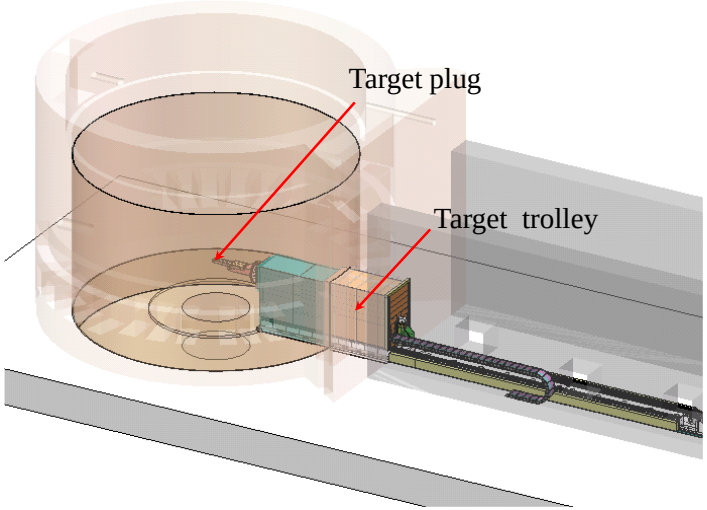


Insert Helium Vessel port

# 2. Design of Target Plug




Schematic layout of CSNS facilities

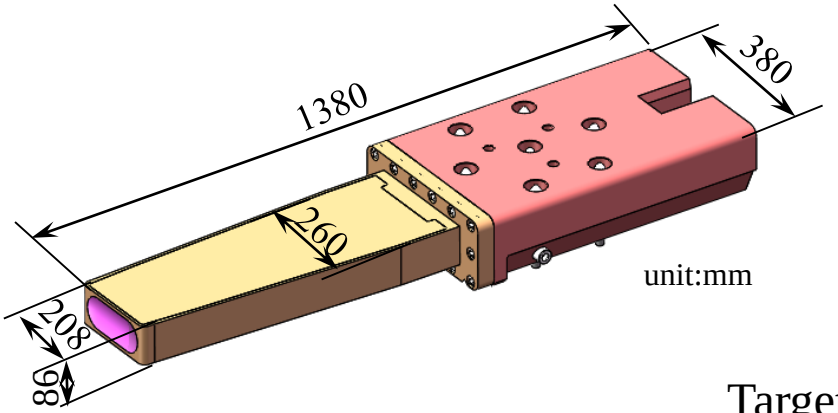



Position where Target system installed

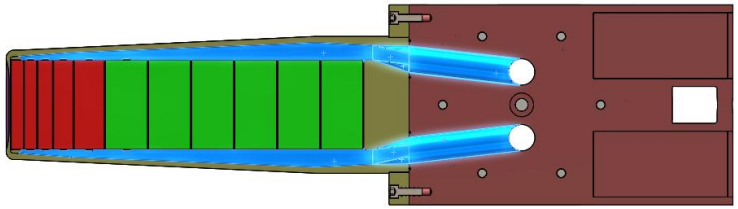
CSNS primary parameters in baseline

| | |
|---|---|
| Project phase | I |
| Beam ave. power, kW | 100 |
| Proton energy, GeV | 1.6 |
| Ave. current, I, μA | 62.5 |
| Repetition rate, Hz | 25 |
| Proton per pulse, $10^{13}$ | 1.63 |
| Pulse length, ns | <500 |
| Linac energy, MeV | 80 |
| Linac peak current, mA | 15 |
| Target material | Tungsten |
| No. Moderators | 3 |
| No. neutron instruments | 3 |

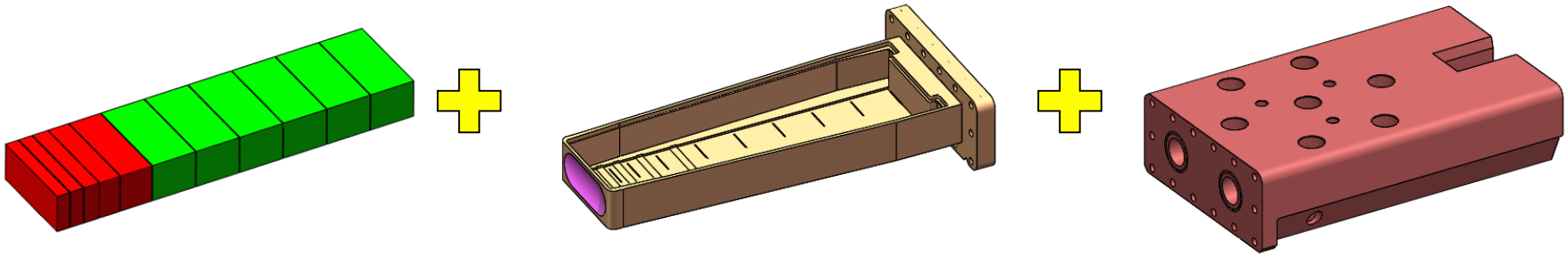
Target plug is comprised of Tungsten Target, Target Vessel and Rear Block.




unit:mm



Target Plug

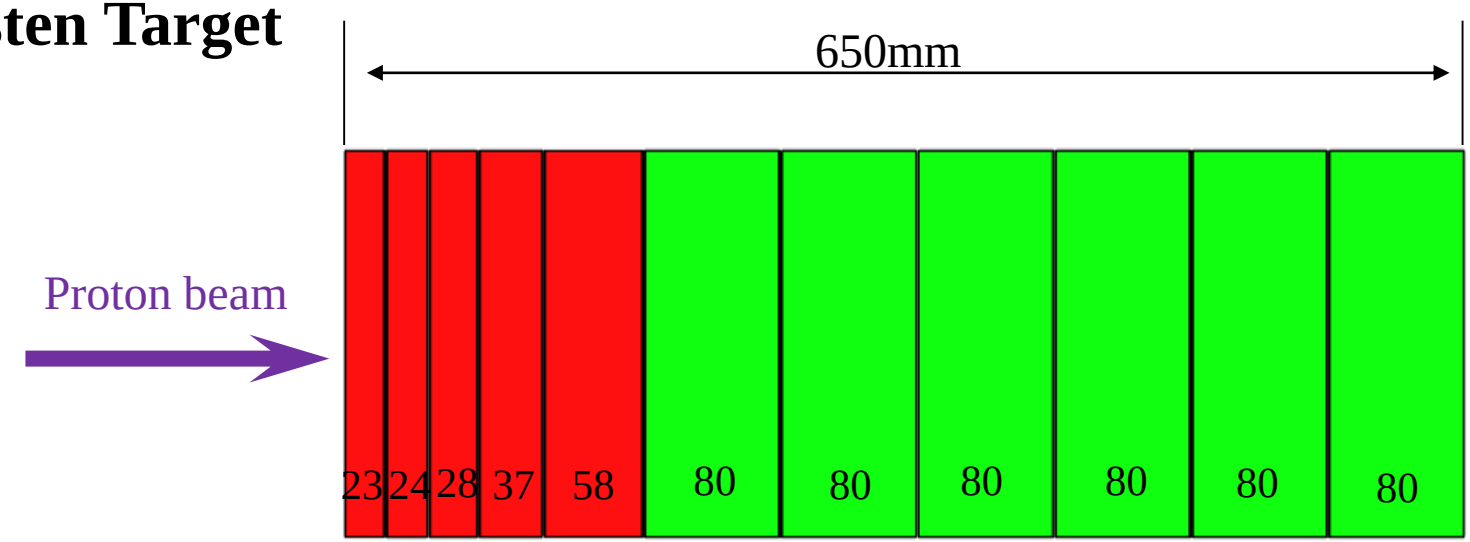


Tungsten Target
(Ta cladded W)

Target Vessel
(SS316L)

Rear Block
(SS316L)

# Tungsten Target




Tungsten(Ta-cladded) Target

**Number of target blocks**： 11

**Cross section**: 170mm*70mm,

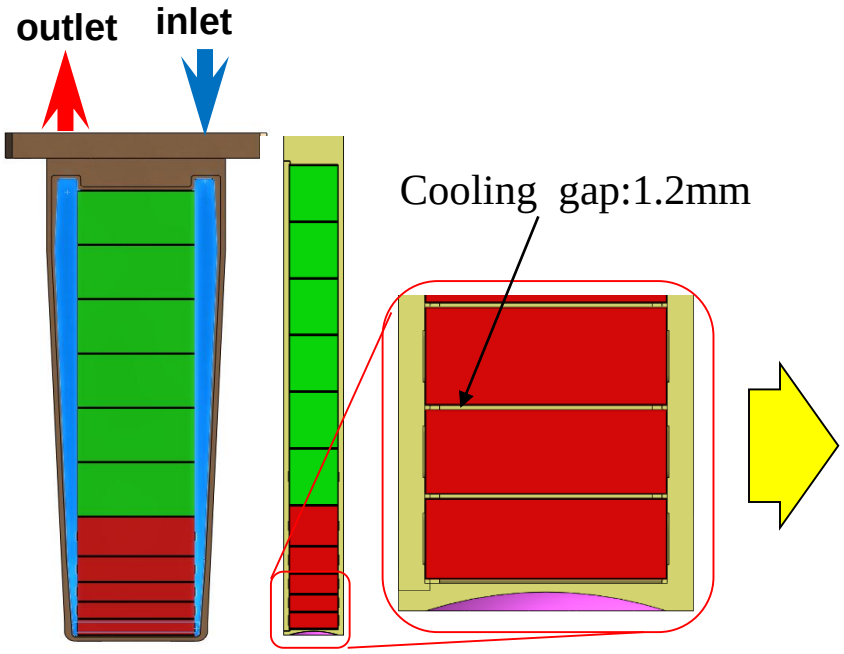
**Thickness**: 23~80mm

**Density of tungsten**:

Thickness more then 37mm: >18.6g/cm$^3$

Thickness less then 37mm : >19.2g/cm$^3$

# Thermal design



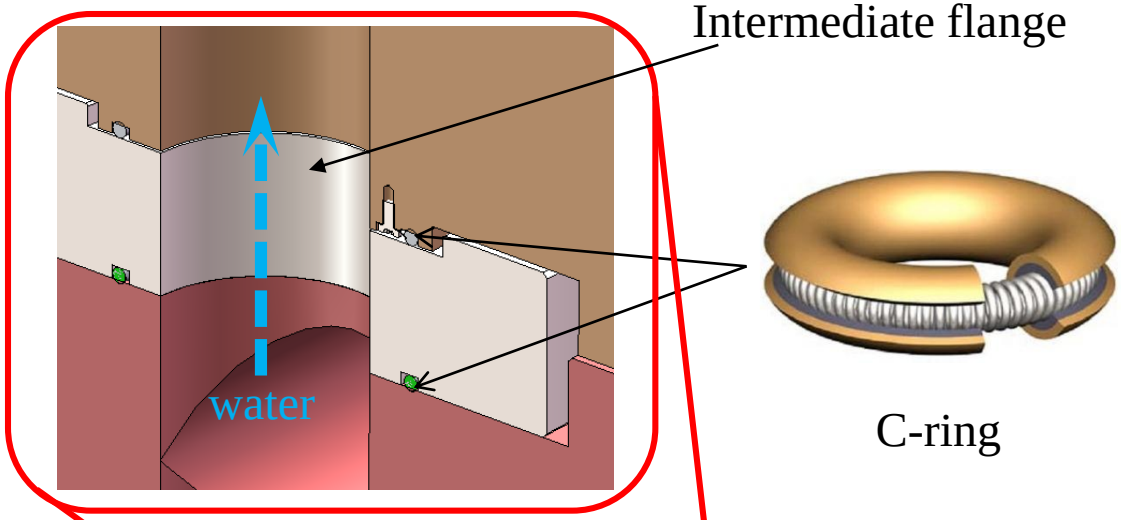

Coolant： Heavy water
Inlet temperature： 30℃
Pressure： 0.4MPa
Flow rate: 140L/min

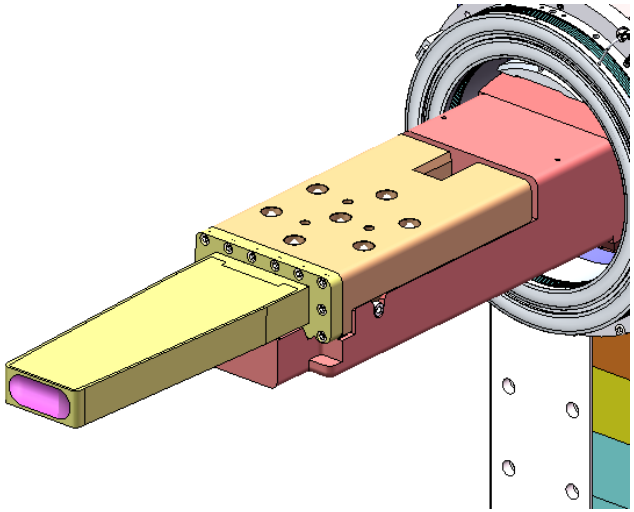
## Calculation results

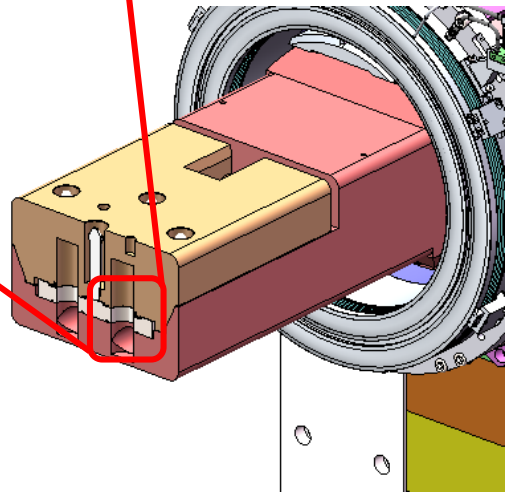
| Max temperature（℃） | | | | Cooling water | | |
|---|---|---|---|---|---|---|
| Target blocks | Surface of target blocks | Target vessel | Target window | **Pressure drop**（kPa） | **Temperature rise**（℃） | Max **velocity**（m/s） |
| 180.05 | **125.16** | 85.90 | 60.80 | 13.94 | 6.50 | 3.66 |

# Seal design

- ♦C-ring is adopted to seal cooling water;
- ♦Seal rings can be replaced along with Target Plug;
- ♦Intermediate flange is designed in case the sealing surface damaged

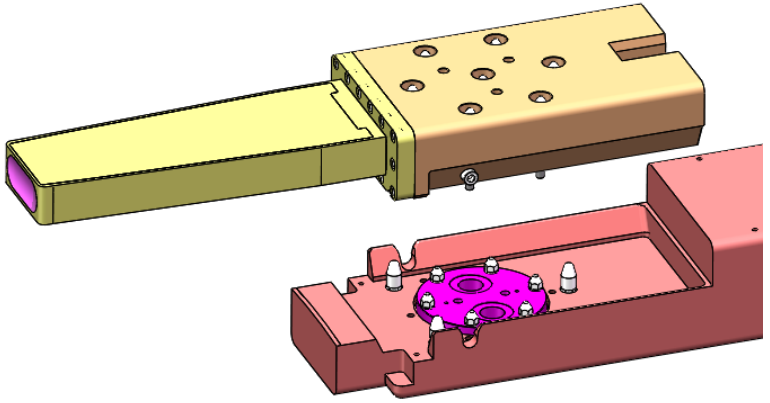


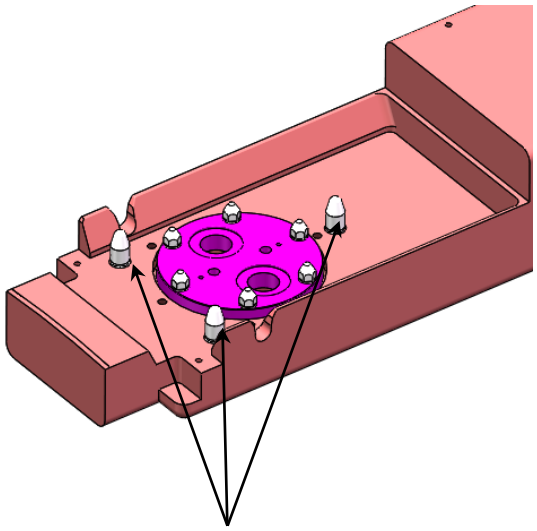





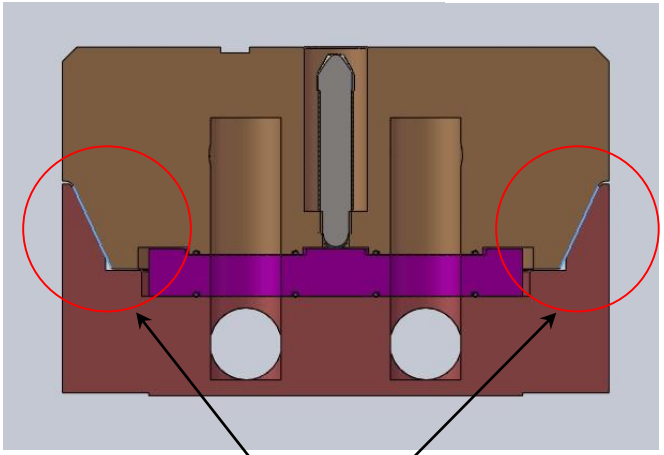
# Self-alignment structure

- Three guide pins for guiding direction when Target Plug is aligned to the support on trolley
- Double inclined planes for accurate position

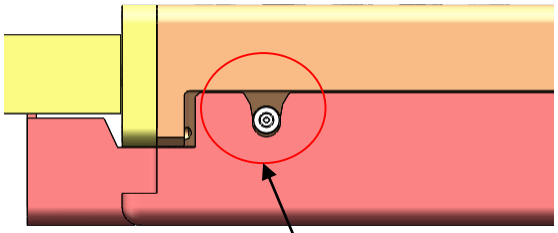




Guide pin



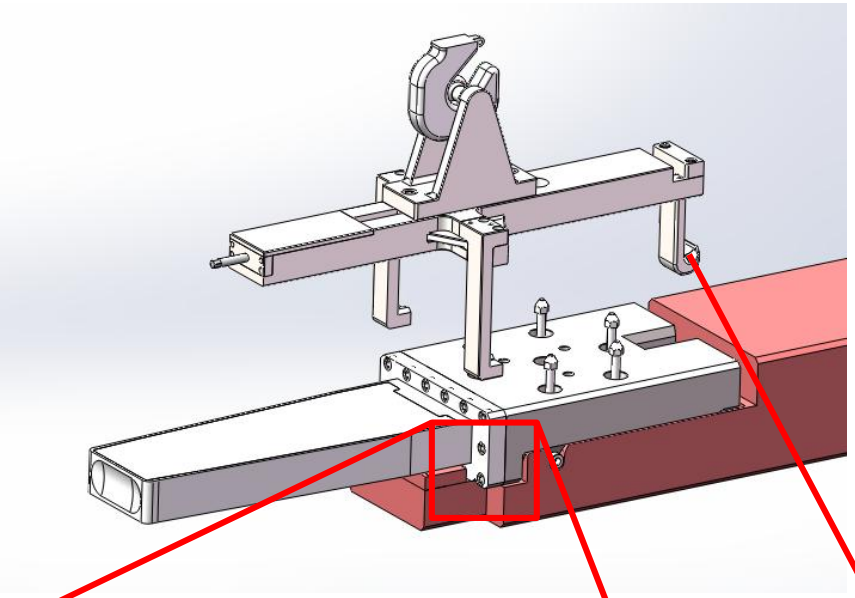
Double inclined planes

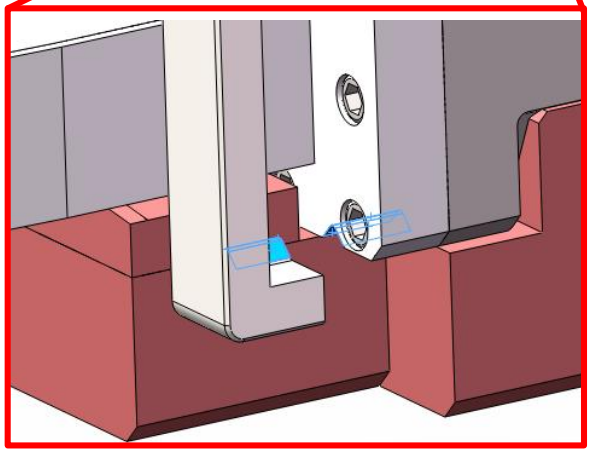


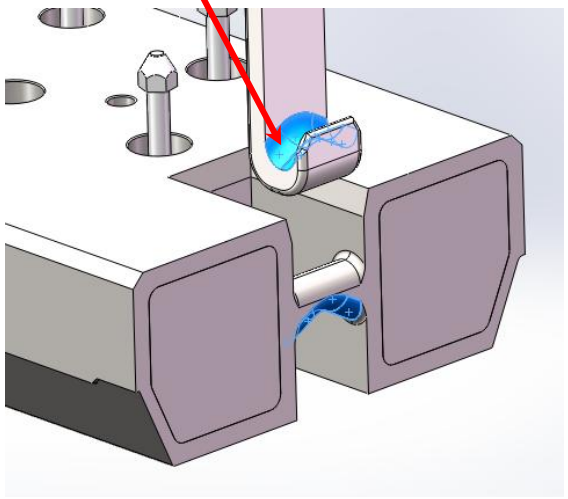
V-slot

Precise position and good seal performance can be achieved when bolts tightened.

# Structures related to Remote handing

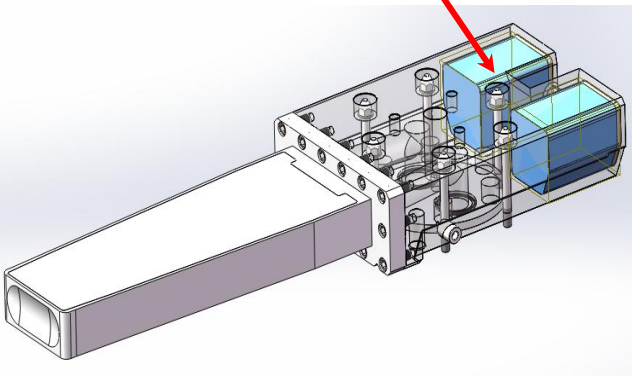




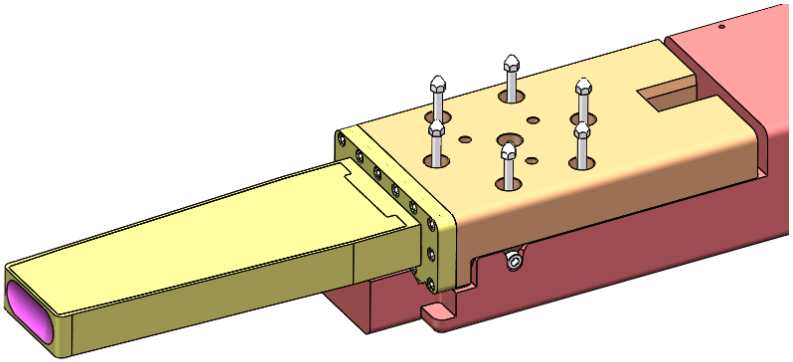


- A special lifting tool is developed for target replacement operation.
- Two tungsten counter weight was applied to adjust gravity center of Target Plug

Counter weight



# Operation to replace Target Plug



1: Loosen the blots

2: Hoist the lifting tool and align to Target Plug

3: Hoist Target Plug by lifting tool

# 3. Introduction of fabrication

## Tungsten target with tantalum cladding

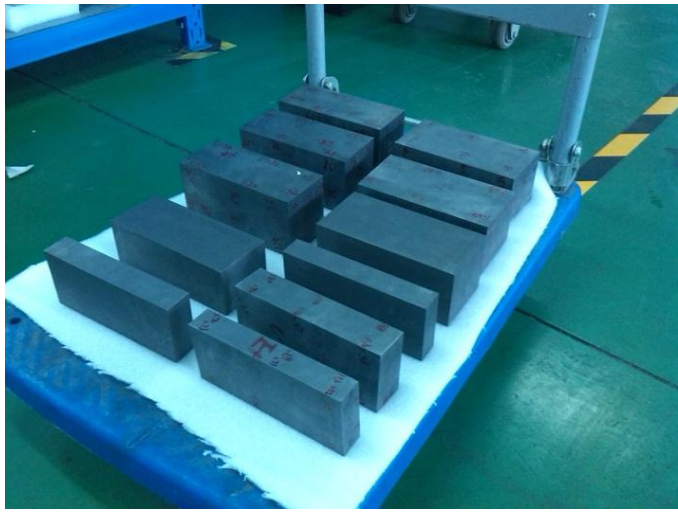
Target material: tungsten
Cladding material: tantalum
Tantalum thickness:**0.3±0.05**mm

HIP process:
T---1550 ℃
P---150MPa
Holding time----2hours

Before HIP

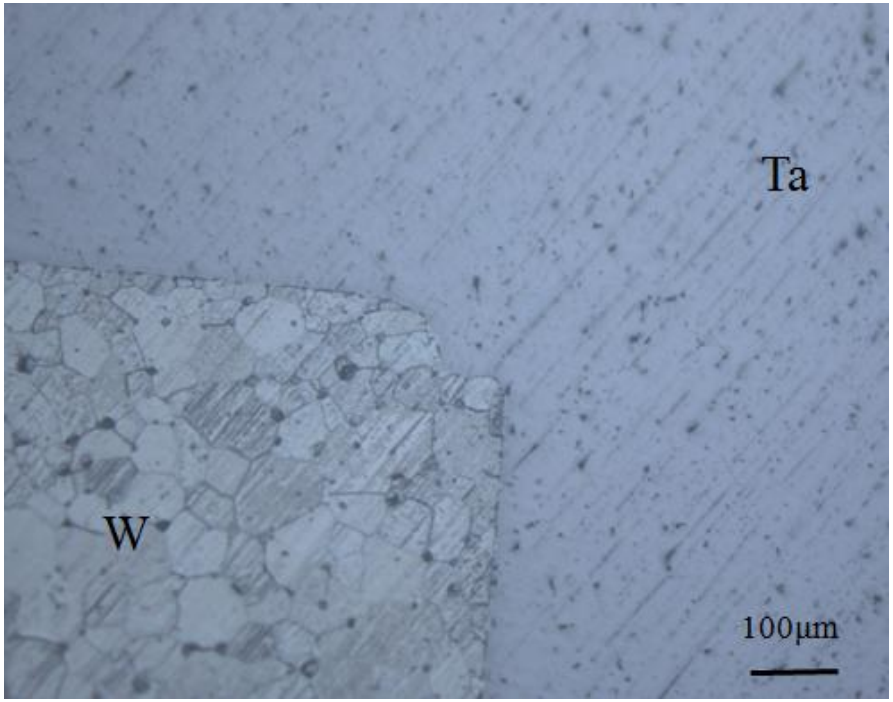
Sample for testing

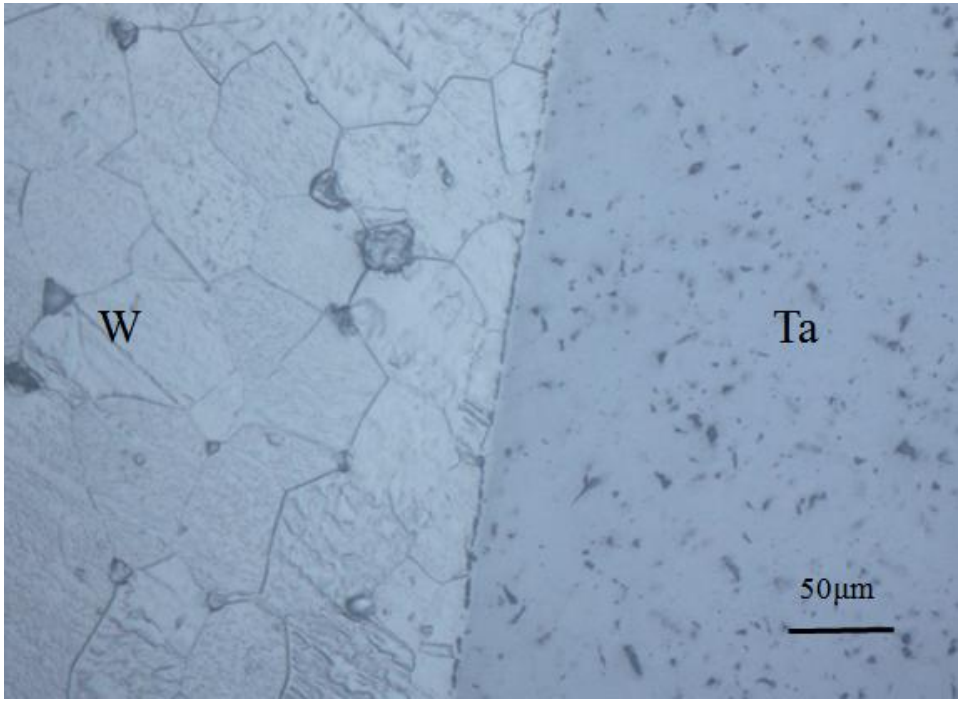
After HIP



Target blocks

# W-Ta interface microstructure morphology

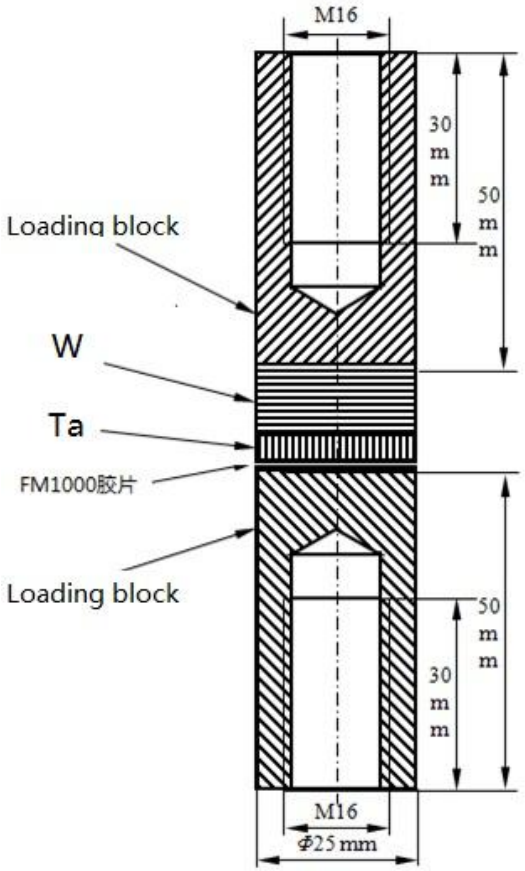



**There is no obvious defect in the W-Ta interface**

# Tensile strength test

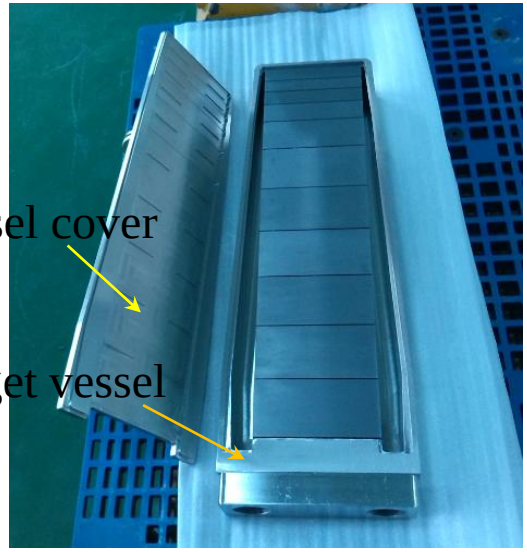
| Samples | The tensile strength (MPa) | average value (MPa) |
|---|---|---|
| 1 | 61. 04 | 65. 09 |
| | 66. 03 | |
| | 68. 22 | |
| 2 | 79. 47 | 77. 24 |
| | Equipment failure | |
| | 75. 0 | |
| 3 | 78. 95 | 72. 87 |
| | 78. 46 | |
| | 61. 21 | |



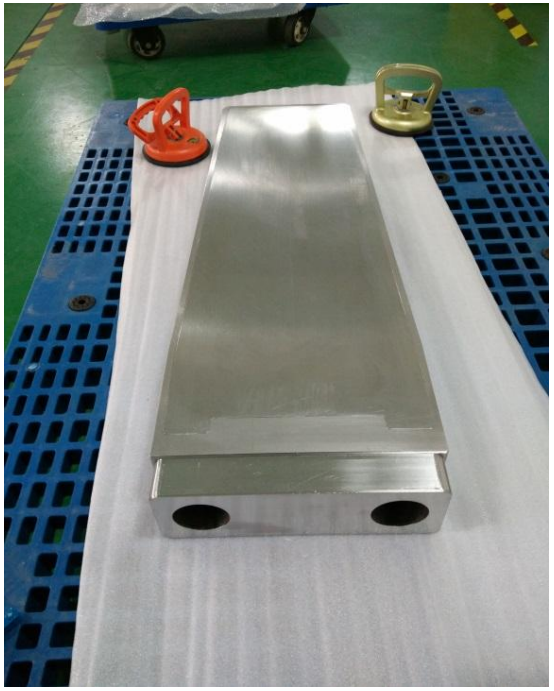

**Conclusion：** **All samples tensile strength is above 60MPa**

# Assembling

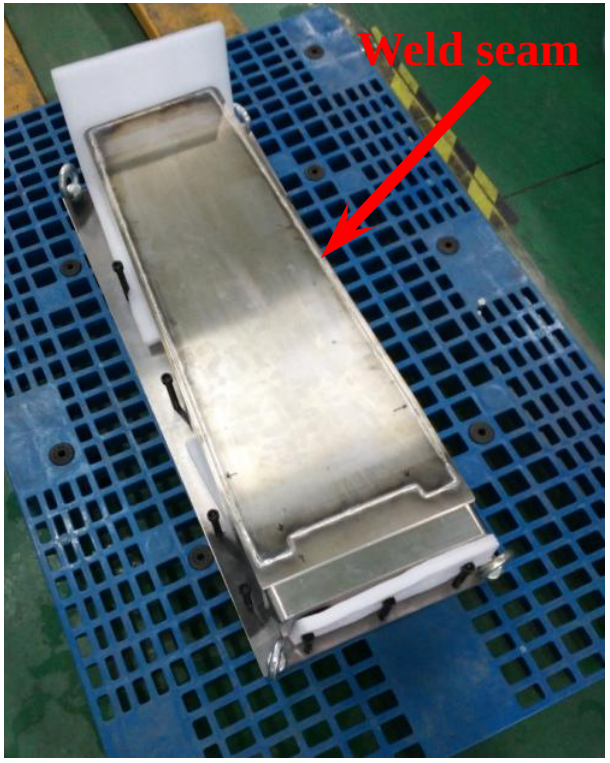
Target vessel and vessel cover welded by electron beam welding.




Target blocks placed in target vessel



Target finished assembling




Target after EB welding

**Target Plug is ready for in-site installation!**

# 4. Summary

(1) Fabrication of CSNS Target Plug has been finished (Jan. 2016) ;

(2) Target plug will be installed on the Target Trolley in Nov. 2016;

(3) The first beam on Target will be in  Sept. 2017.

# *Thanks for your attention !*