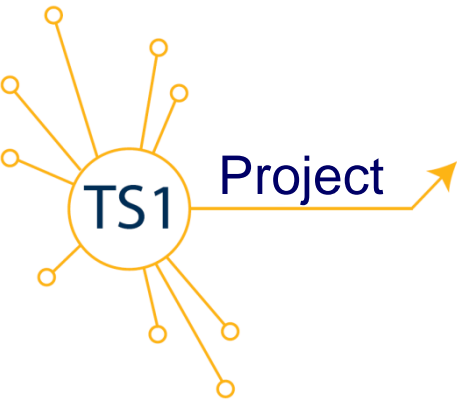




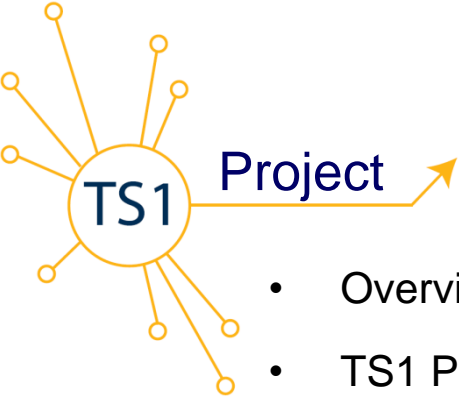
Progress With Manufacturing the 1st Target Module for ISIS TS1 Project

Leslie Jones

Target Design Engineer



HPTW 2018, FRIB, East Lansing



Introduction

- Overview of ISIS Target Station 1- TRaM
- TS1 Project Aims
- Overview of TS1 Project Target design
- ISIS 'Target Manufacturing Facility'
- Progress With Manufacturing Target Components
 - Target Plates – (10 in total)
 - Target Stack Assembly
 - Target Vessel/Window Assembly
 - Target Spacer
- Summary

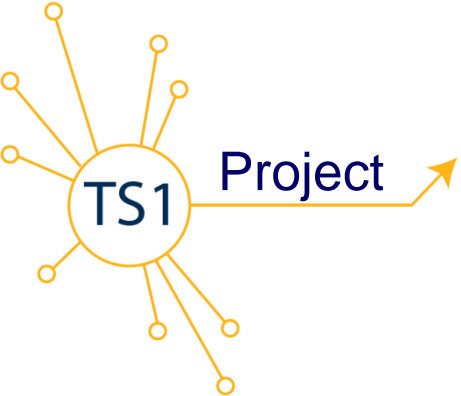


STFC - Harwell Campus

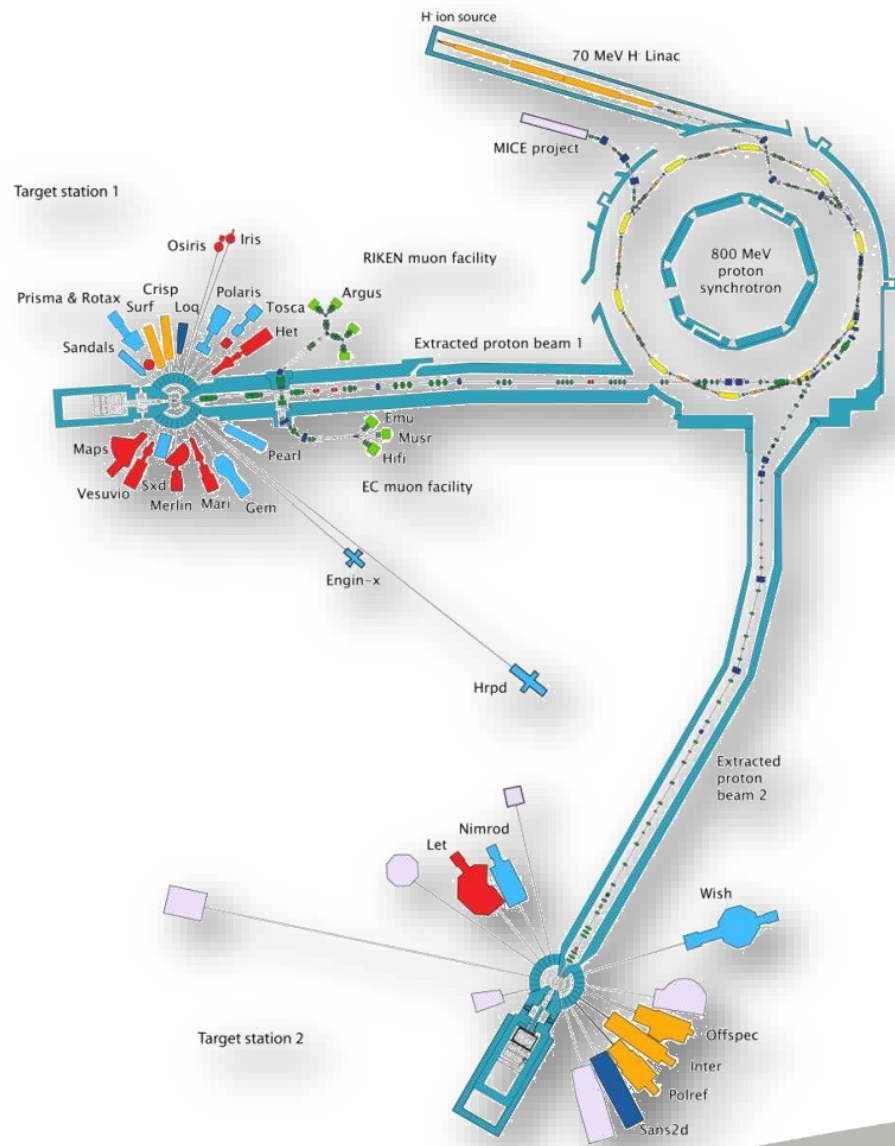
RAL

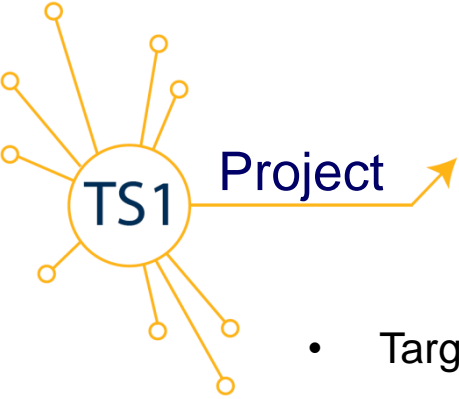
ISIS FACILITY

An aerial photograph of the STFC Harwell Campus. The image shows a large complex of buildings, including a prominent white and blue building labeled 'ISIS FACILITY' which is circled in red. Other buildings are scattered across the campus, and a large circular structure is visible on the right. The surrounding area includes green fields, roads, and a distant industrial facility with cooling towers under a blue sky with scattered clouds.



TS1 Project

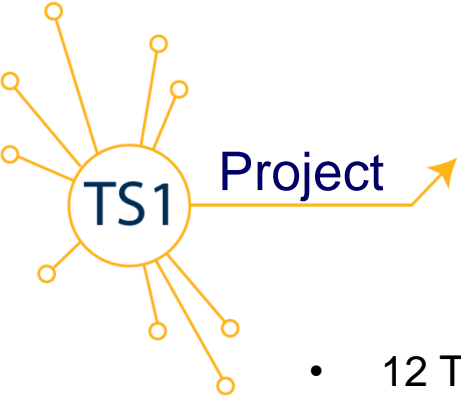




ISIS Target Station 1 (TS1)

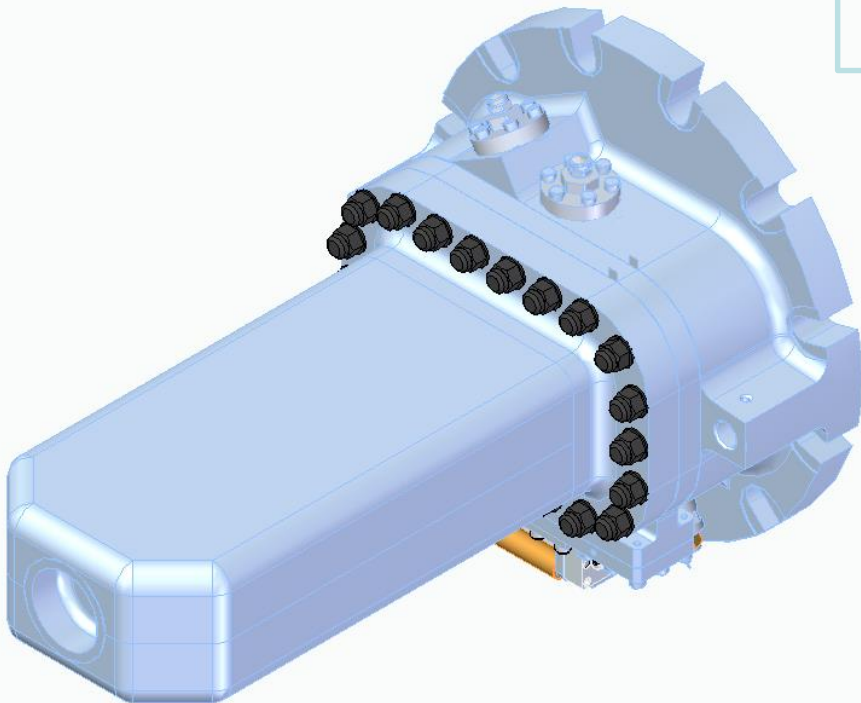
- Target station in operation for 33 years
- Spallation neutron target serving ~20 neutron instruments
- Original target material – Uranium clad in Zircaloy (Neutrons Lifetime)
- 23 plate Tantalum target – (decay heat) (Neutrons Lifetime)
- Current target design – (*since 2001*) 12 tungsten plates clad in Ta, cooled with D₂O (Neutrons Lifetime)
- Typically 160μA of 800MeV protons, 50 Hz pulsed beam
(note TS1 is run at 40Hz when we run 1 pulse in 5 to the TS2 10 Hz target)
- **TS1 Project Target designed for 200μA of 800MeV protons**
- Beam sigma of ~17mm (overall beam spot diameter ~70mm)
- Maximum power density ~400MW/m³
- Peak energy ~11MJ/m³/pulse



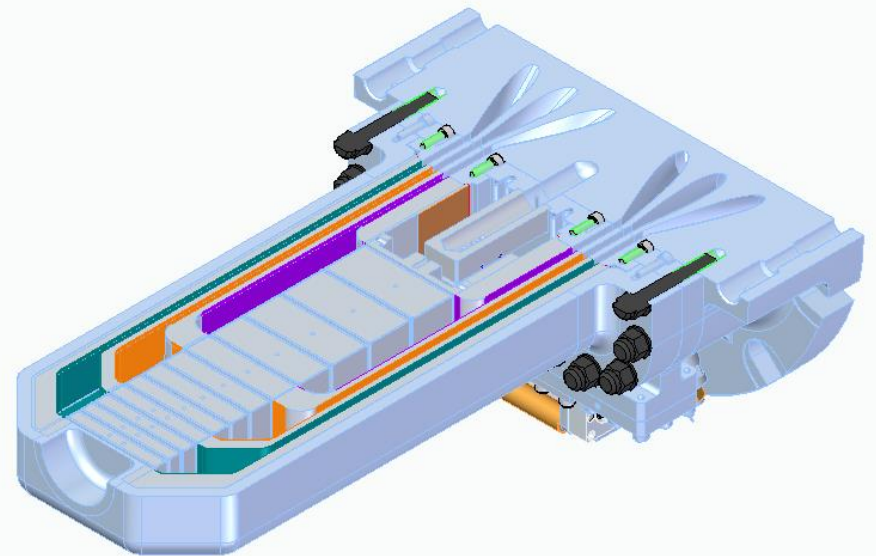


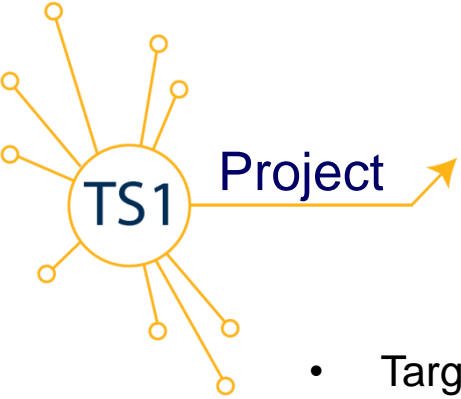
ISIS Target Station 1 (TS1)

- 12 Tungsten Plates clad in Tantalum
- 3 separate cooling channels
- Thermocouple in each plate
- Secondary cooling circuit (requirement for Uranium target)



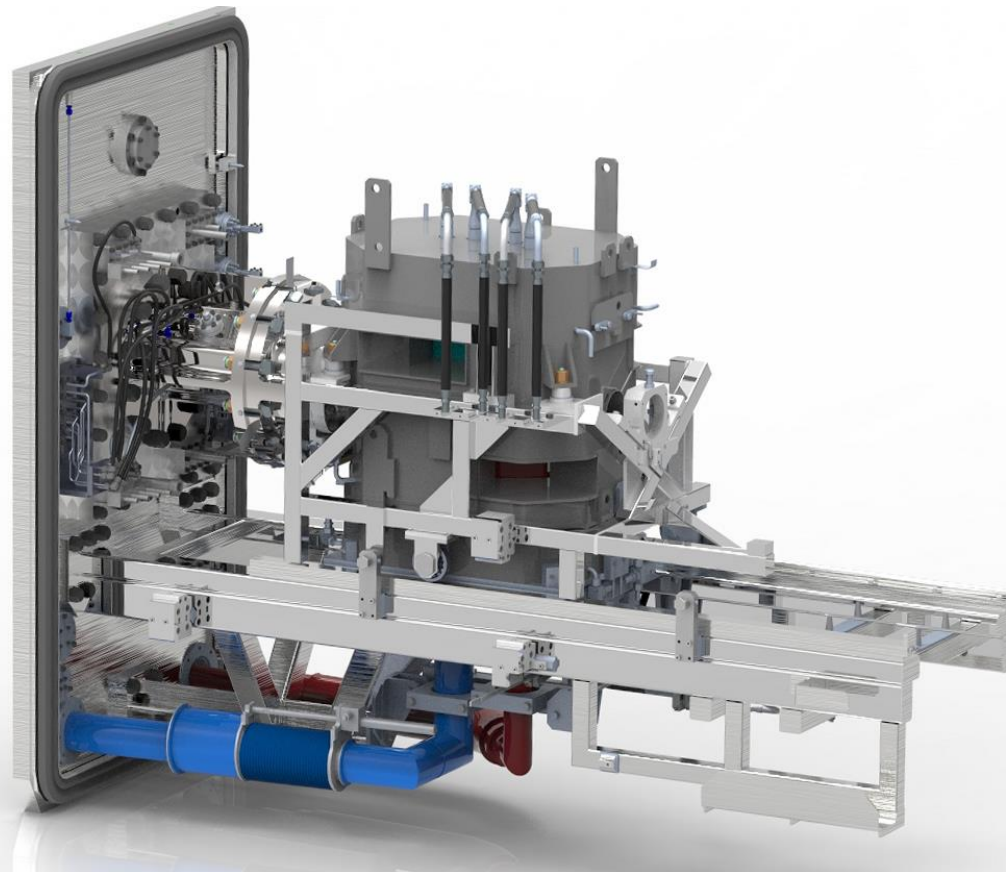
Tungsten/Tantalum no. 4

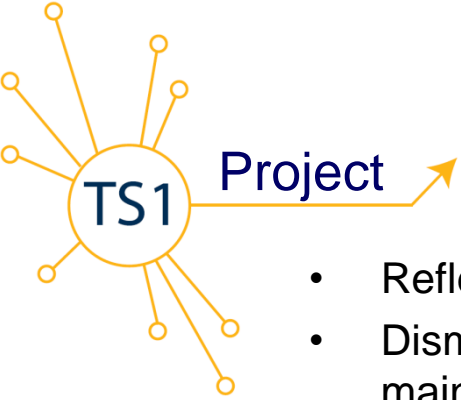




ISIS Target Station 1 (TS1)

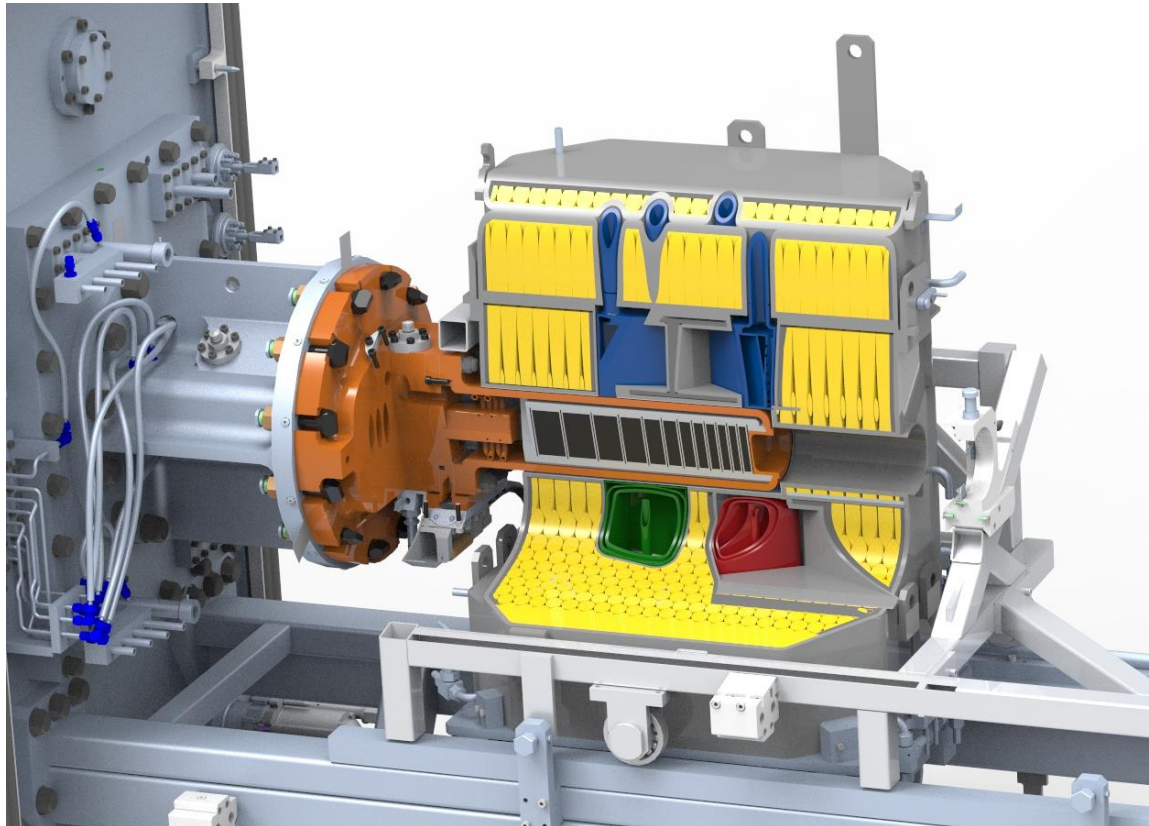
- Target assembly attached to TRAM door

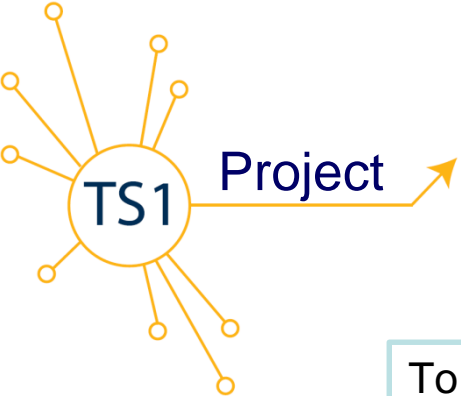




ISIS Target Station 1 (TS1)

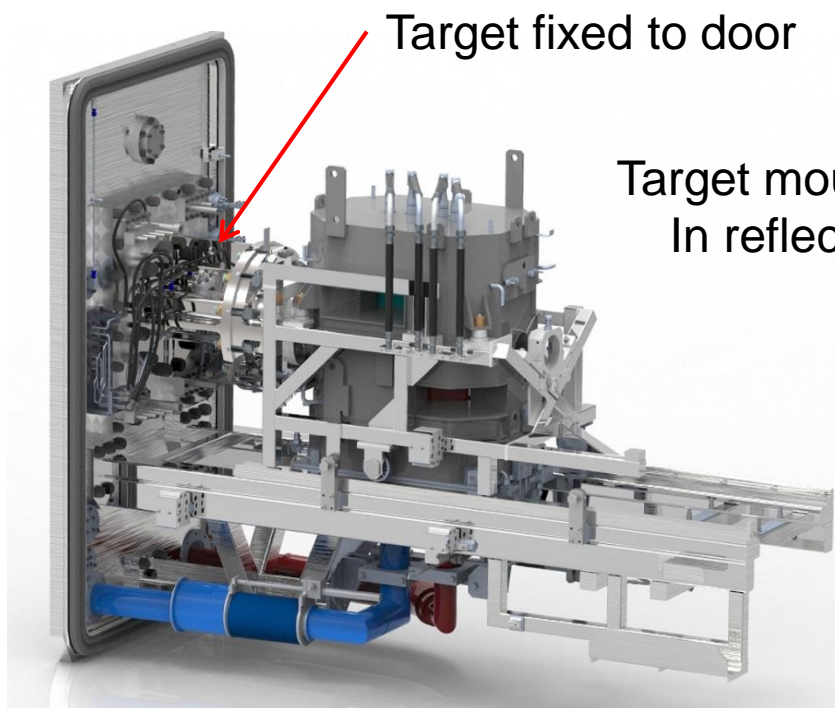
- Reflector – several boxes of Beryllium rods
- Dismantle Reflector and remove target for access to Moderators for maintenance – time consuming
- TS2 solid Be Reflector – splits for easy access to moderators





TS1 Current vs Project

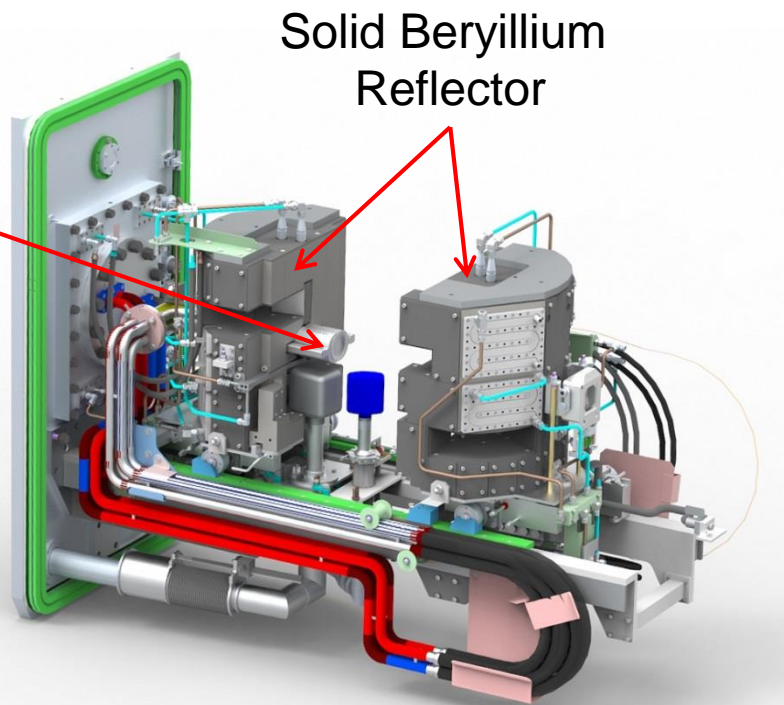
To enable the reflector to move apart, the target can no longer be attached to the TRAM door – now moves with the reflector.



Target fixed to door

Target mounted
In reflector

TS1 Current Design



Solid Beryllium
Reflector

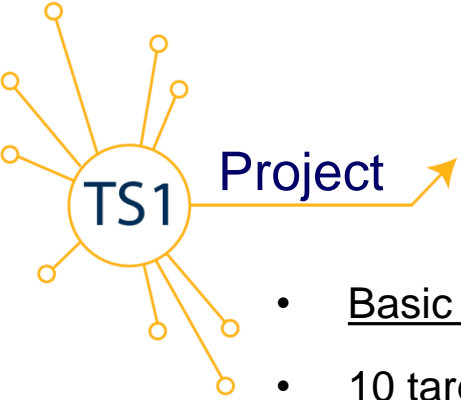
TS1 Project Design



Target Station 1 Project aims

Secure the future of TS1 and enable it to operate for many more years

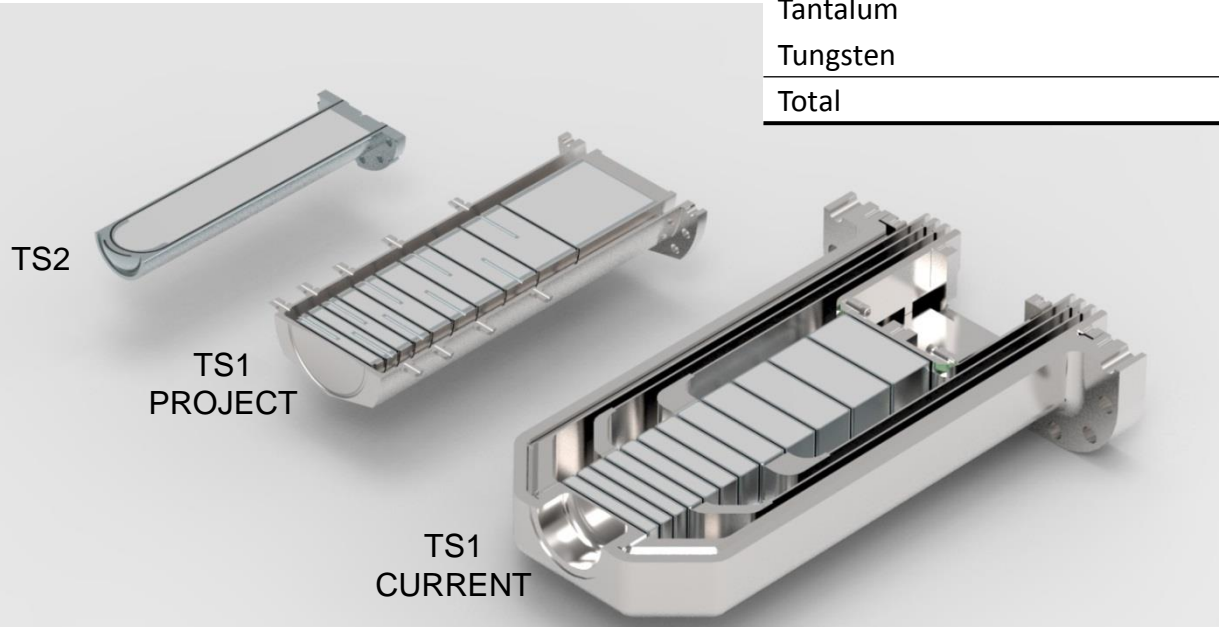
- Provide improved flexibility for future target or moderator changes
- Provide a neutron performance increase, of up to a factor of 2, on some instruments
- Provide confidence in the ongoing operation of TS1 to enable future instrument upgrades
- Improve our knowledge and skills in target station design for future projects
- Make current maintenance operations of the target station easier



Overview of TS1 Project Target design

- Basic elements of the new target design:
- 10 target plates of varying thicknesses
- Tungsten Ø98 mm, Ta Cladding 1.5 mm, water channel width 2 mm
- Target Stack length 368mm
- 316L Target Vessel

Mass of material (kg)	Current TS1	TS1 Project	Reduction
Stainless Steel	73.8	12.6	82.9%
Tantalum	32.7	14.5	55.7%
Tungsten	47.3	46.4	1.9%
Total	153.8	73.5	52.2%

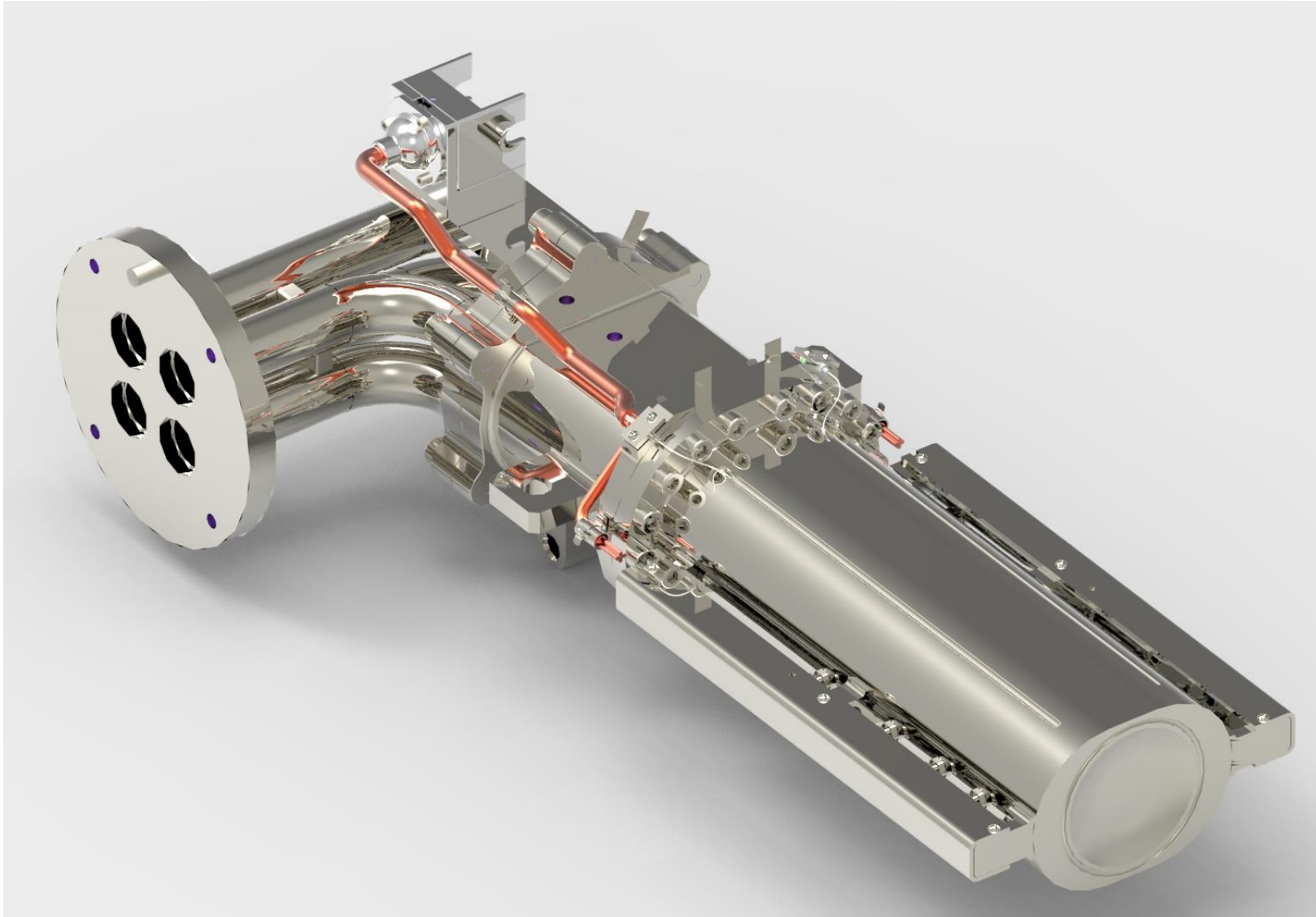


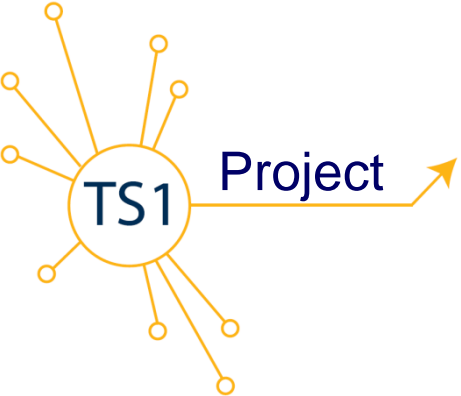
- Tungsten volume closely matches current design
- Tantalum reduced
- Stainless massively reduced



Project

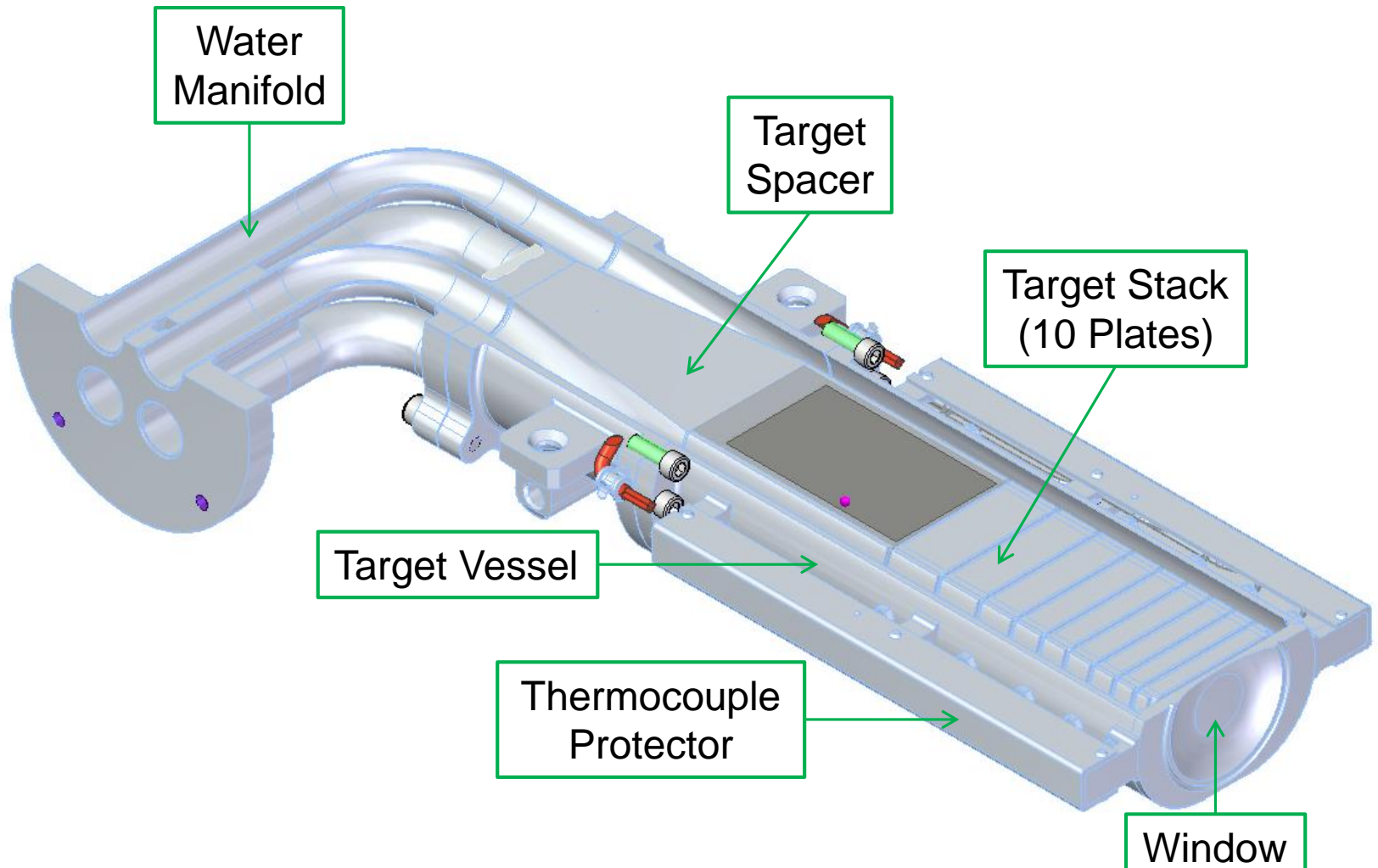
Overview of TS1 Project Target design

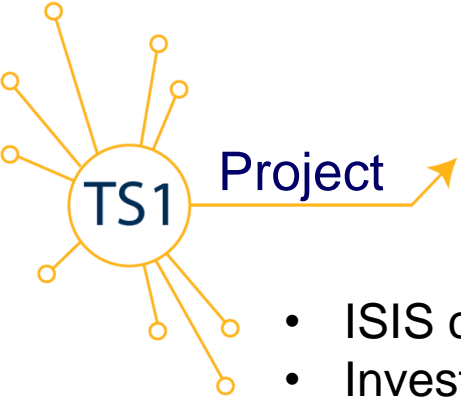




Overview of TS1 Project Target design

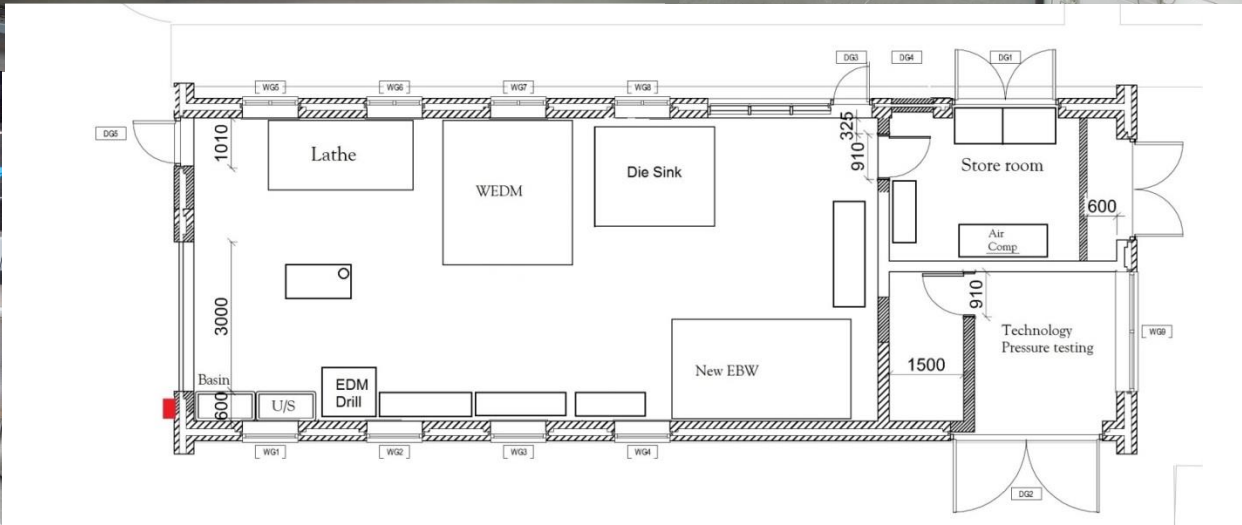
Progress With Manufacturing Target Components

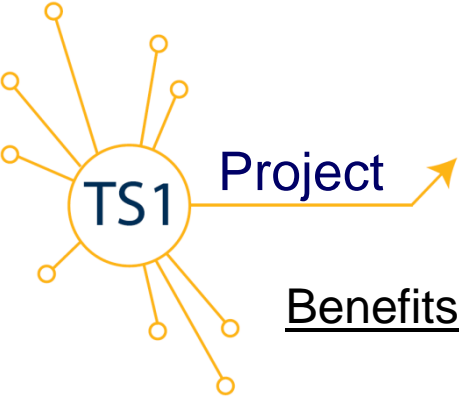




ISIS 'Target Manufacturing Facility'

- ISIS committed to bring manufacture of ISIS Targets in-house (2014)
- Investment in workshop space, specialist equipment and people
- Increase our knowledge of working with Tungsten and Tantalum





ISIS 'Target Manufacturing Facility'

Benefits

- Greater understanding of Hot Isostatic Press process
- Improved quality control and documentation
- Less reliance on outside manufacturing companies
- Reduced time to manufacture targets
- Development of W/Ta target plates for TS1 Project
- Increased service life of TS2 Targets from 1 year to 2 years

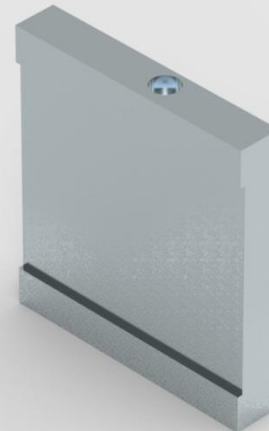
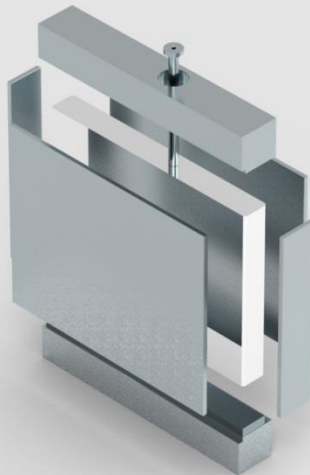
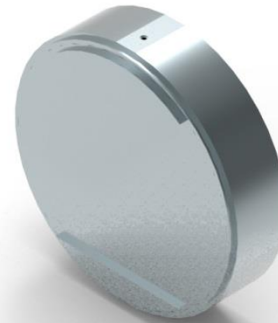
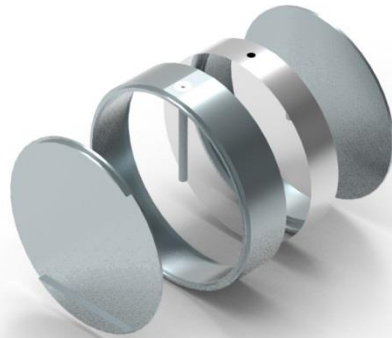




Project

Progress With Manufacturing Target Components

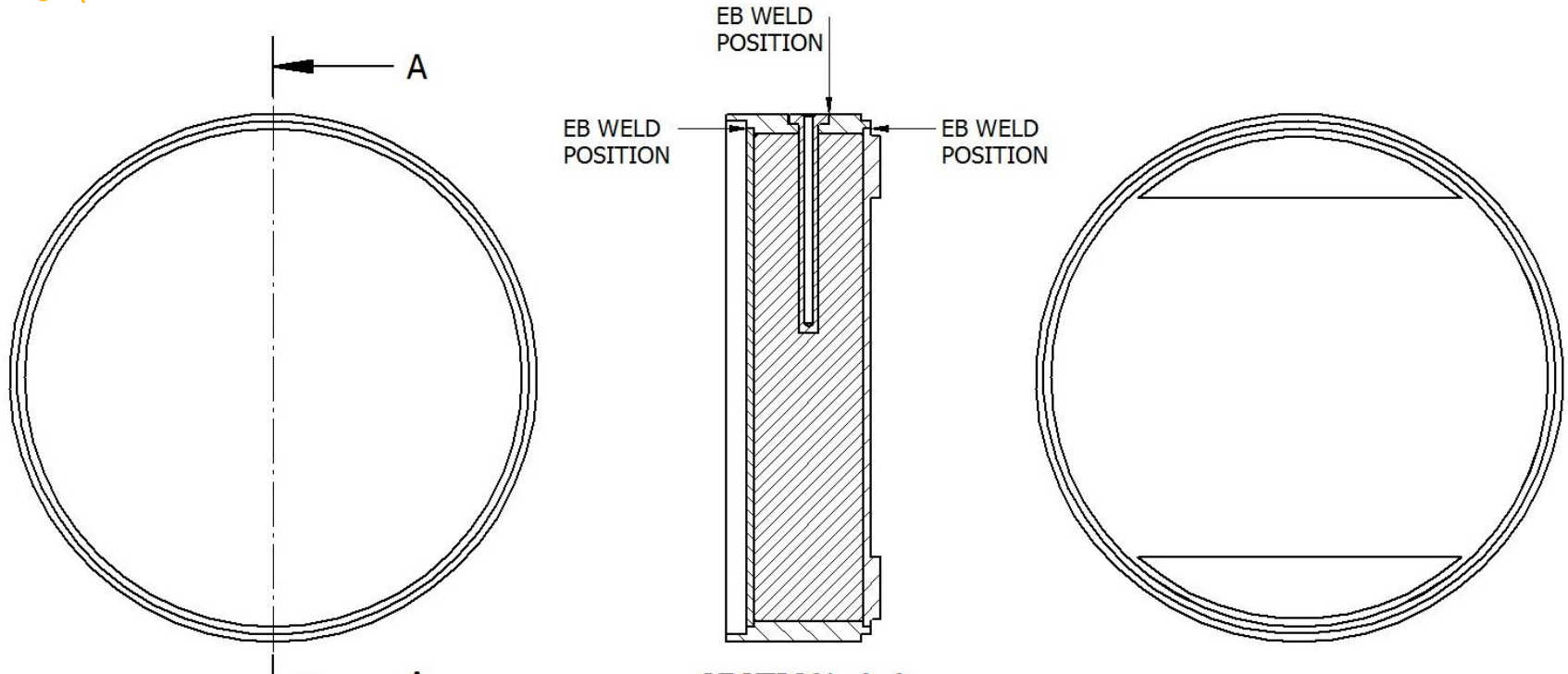
- Construction principle of **Target Plates** same as existing TS1 target
- Round profile reduces no of welds from 13 to 3





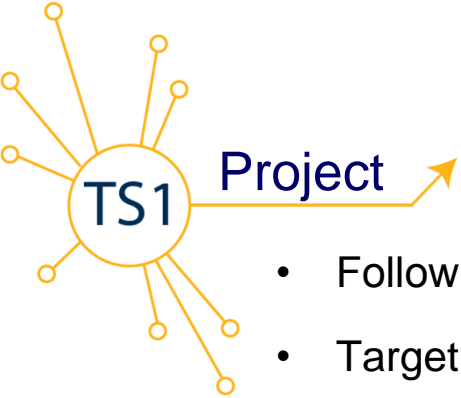
Project

Progress With Manufacturing Target Components



Meticulous surface preparation and cleaning required before EB welding in vacuum

Note: Welds are carefully positioned to remain untouched by the post HIP machining operations



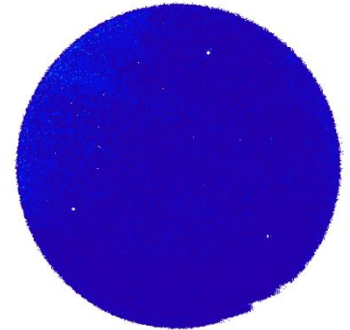
Project

Target Manufacture Facility – R29

- Following EB welding ...
- Target Plates are HIP'd to bond tantalum cladding to tungsten core
- 1200°C, 140 Mpa (lower temp inhibits grain growth)
- Ultrasonic NDT to confirm quality of bond
- Machined to finish dimensions

Acoustic Microscope Image

TS1 Project plate 4
Non flange side
11-05-2017
Interface Quality



EB Welder

HIP

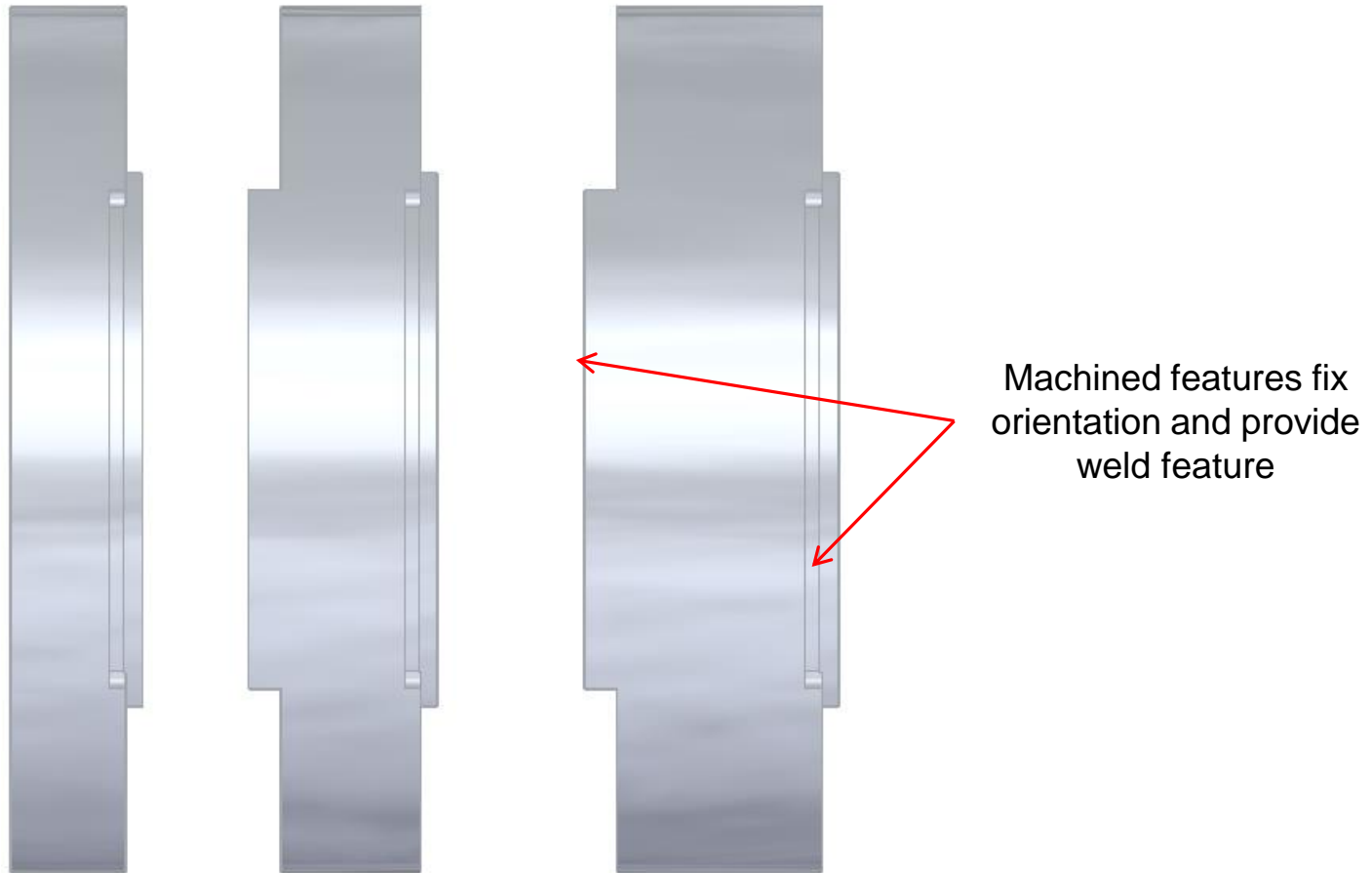


NDT Scanner



TS1 Project **Progress With Manufacturing Target Components**

- Target plates interlock to ensure correct positioning of thermocouples
- EB welded together to prevent vibration from cooling water





Project

Progress With Manufacturing Target Components

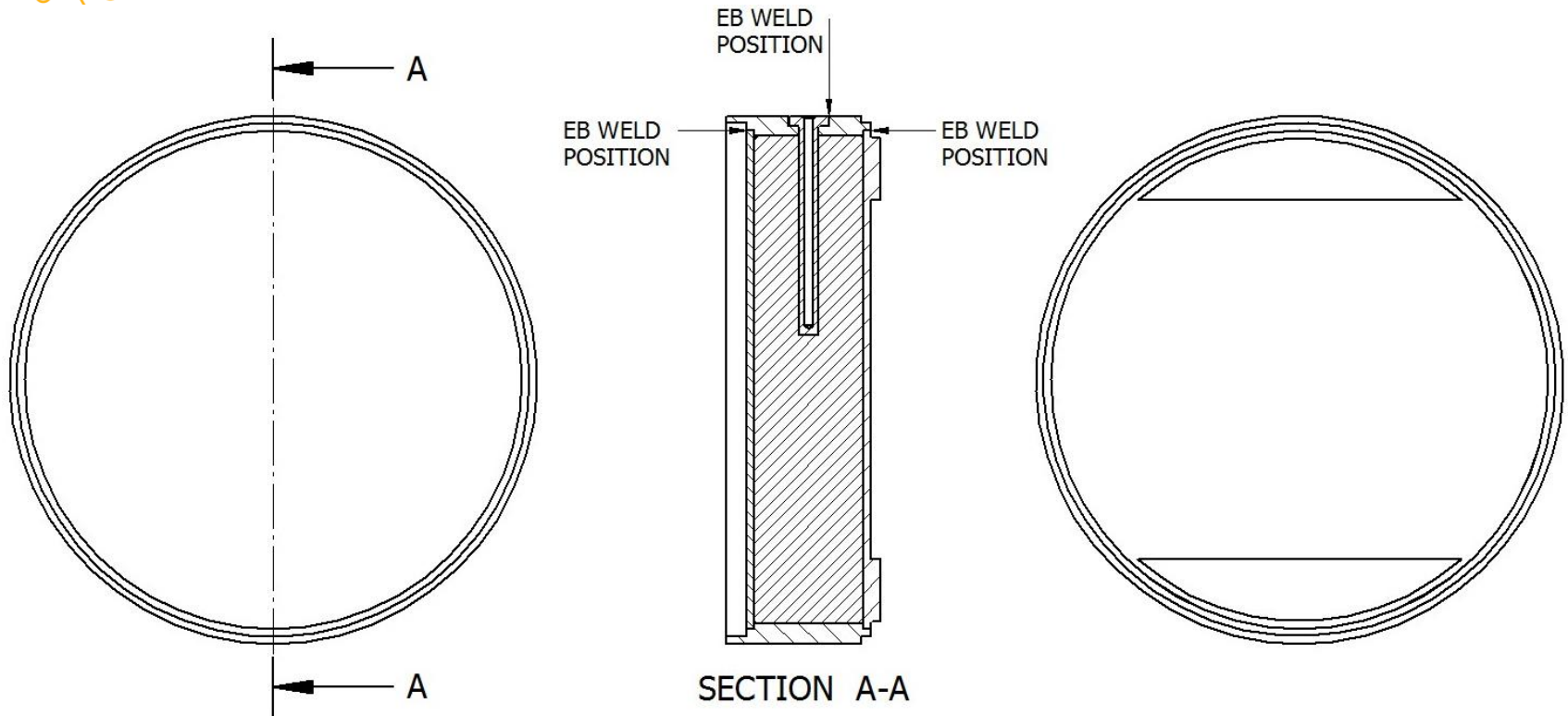
Target Plates 1 to 8 complete, 9 & 10 failed to HIP





Project

Progress With Manufacturing Target Components



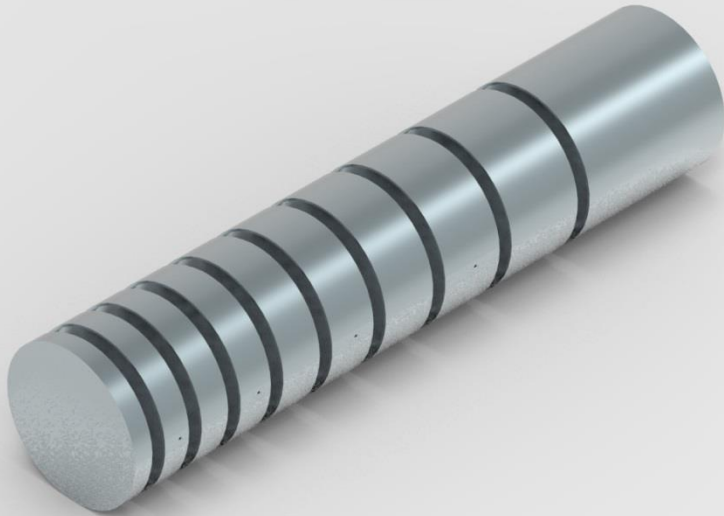
Failure to HIP (no. 9) may have been due to insufficient clearance around W core creating trapped volume caused by weld shrinkage. Clearance increased and 1mm chamfer added to W disc edges to aid evacuation.



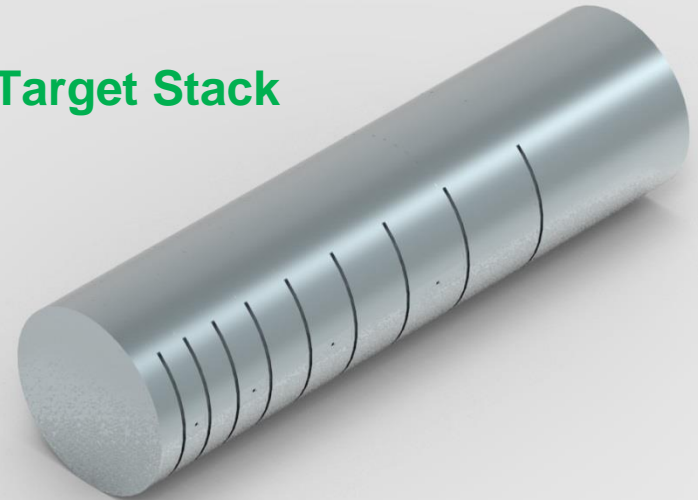
Project

Progress With Manufacturing Target Components

- **Target Stack** - 10 plates
- Target plates made individually
- Interlocked together and EB welded to form solid stack



Target Stack





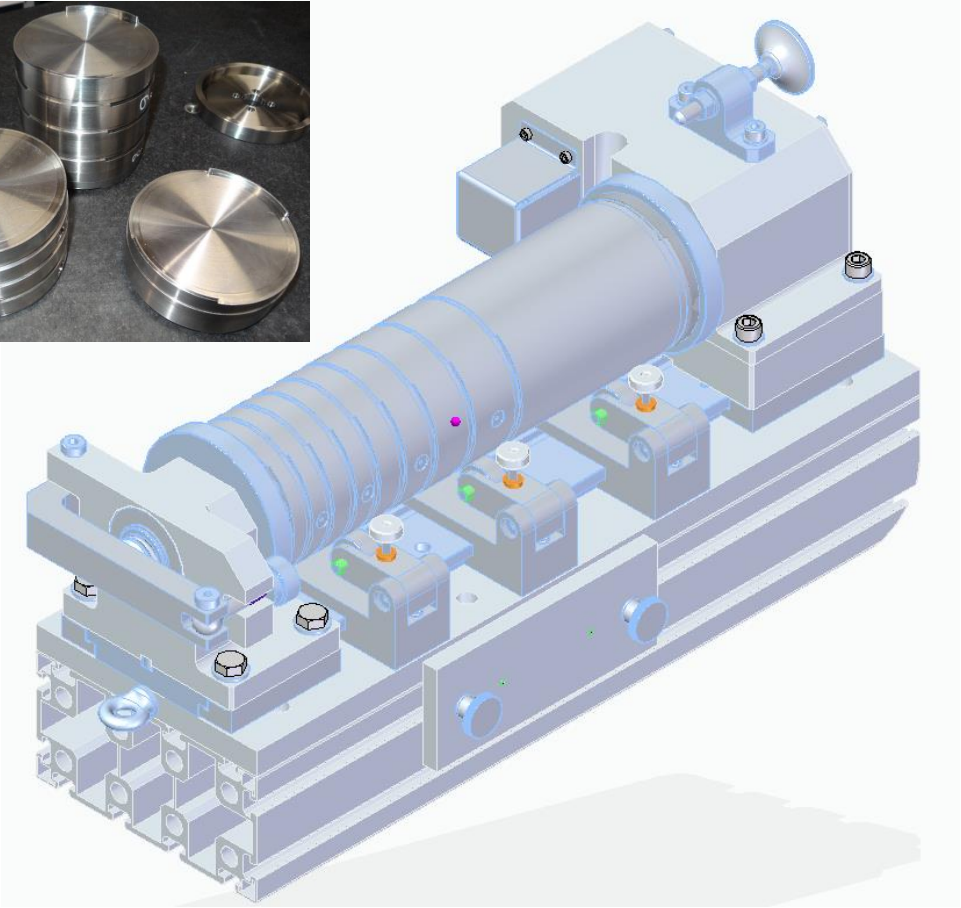
Project

Progress With Manufacturing Target Components

Dummy Stack



Rotary EB Welding Jig



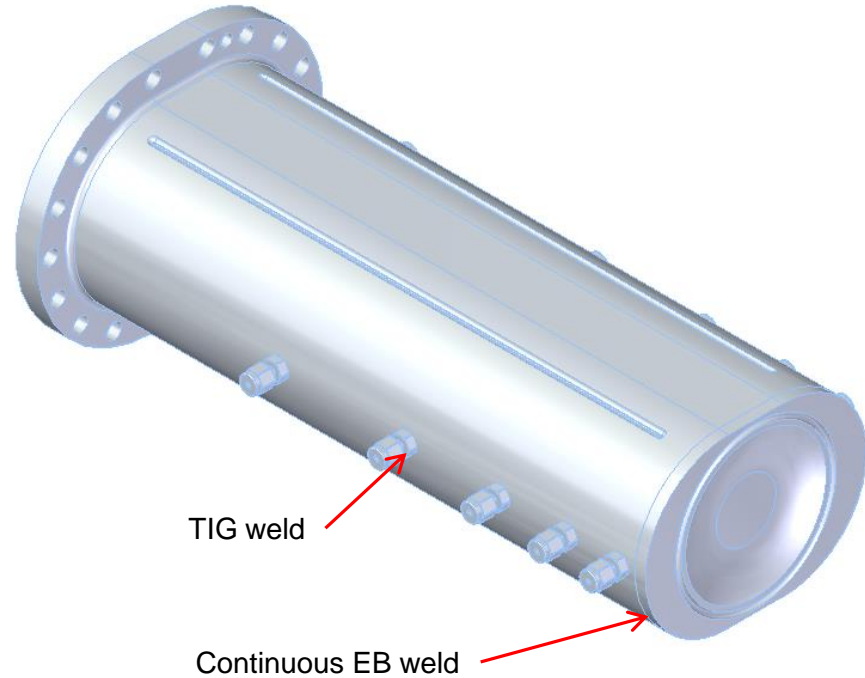
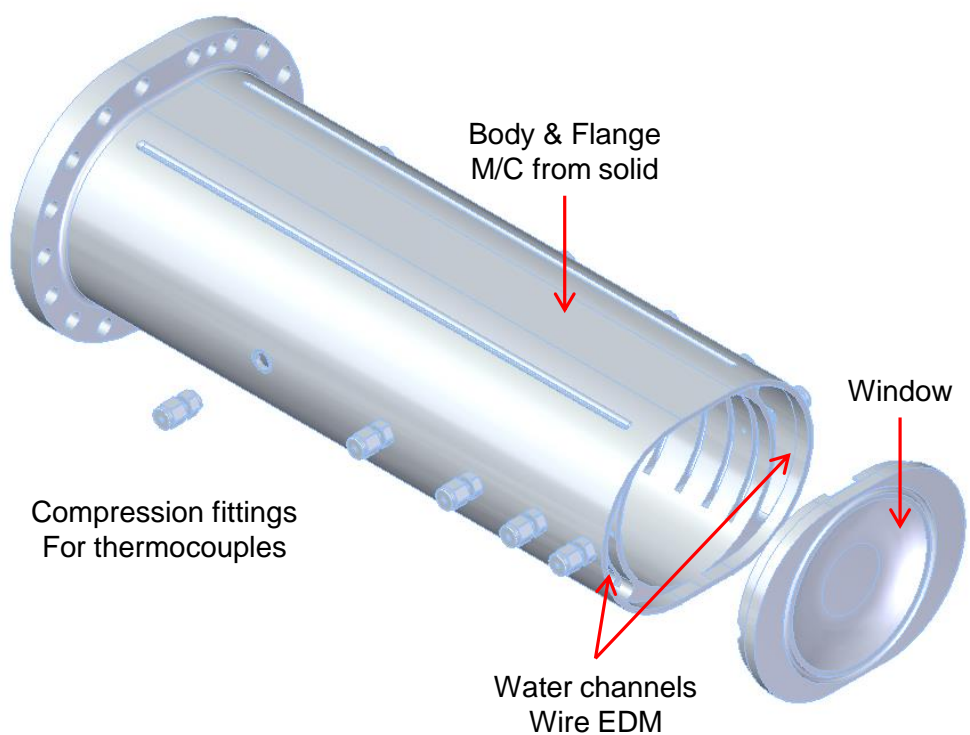
Stack then machined to finished dimensions



Project

Progress With Manufacturing Target Components

- Stack to be housed in a 316L Target Vessel
- Keep number of welds as low as possible





Project

Progress With Manufacturing Target Components



Test piece to develop machining and EB Welding processes



2 off Target Vessels in production





Project

Progress With Manufacturing Target Components

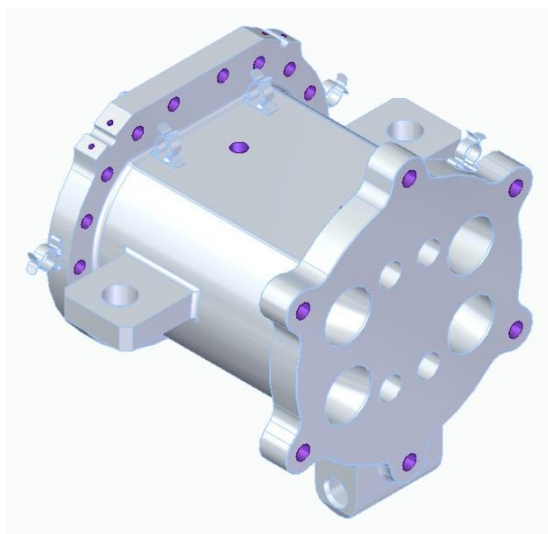
Rotary EB Welding of Target Vessel/Window just completed



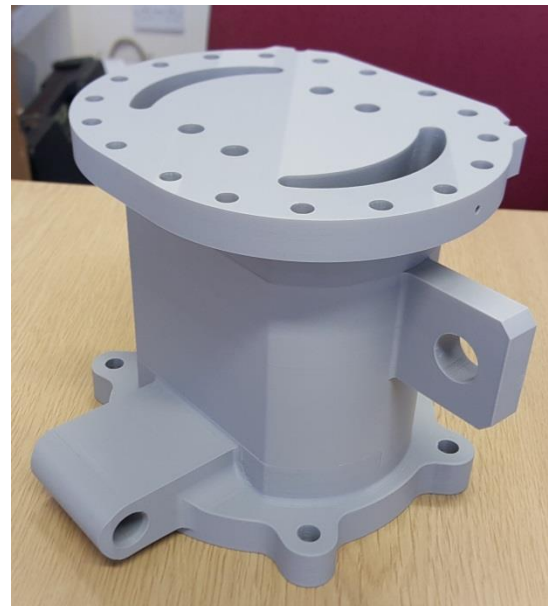
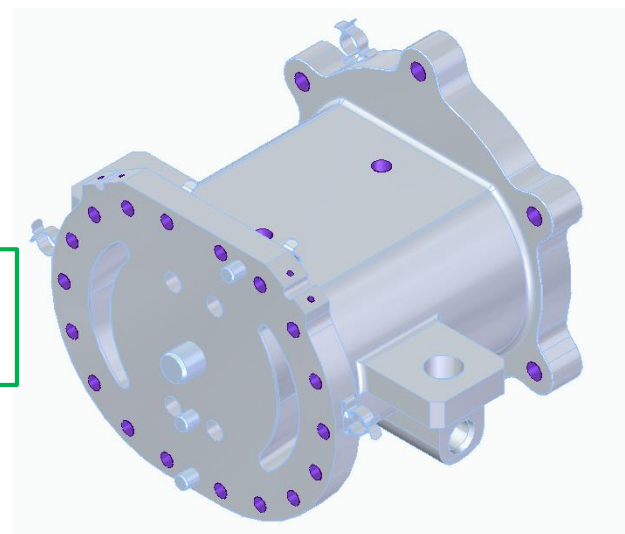


Project

Progress With Manufacturing Target Components



Target Spacer
(Flow Transition)



3D Printed Model



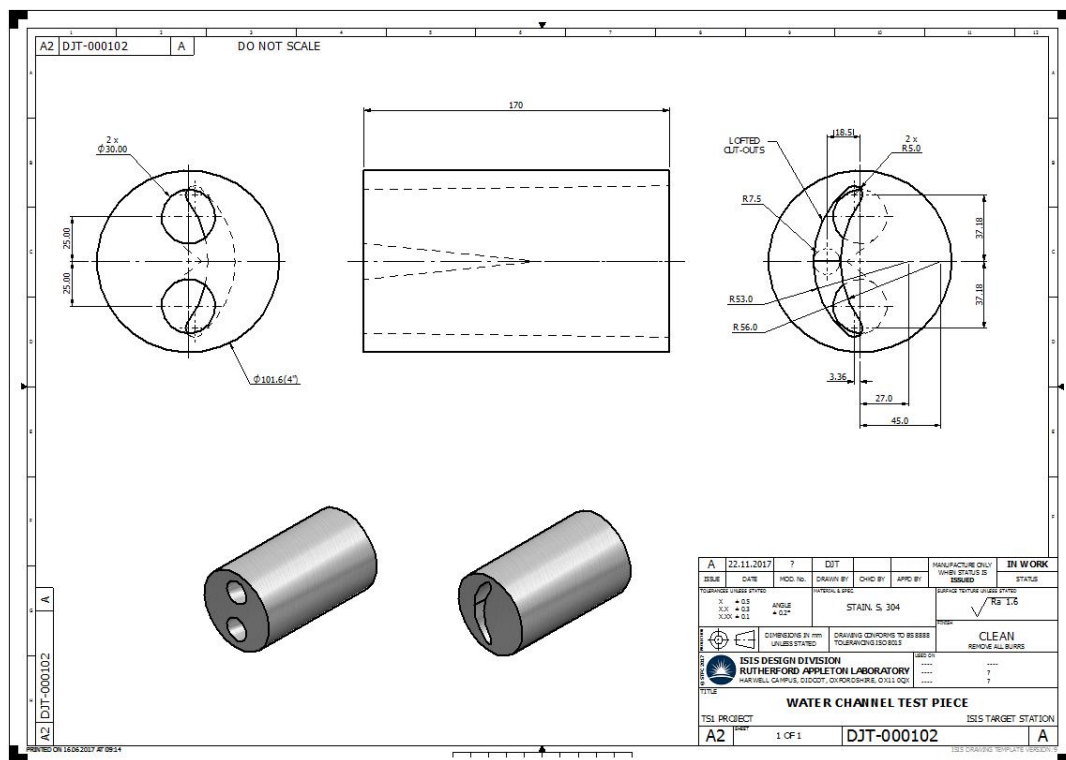


Project

Progress With Manufacturing Target Components



Test Piece to develop cutting technique



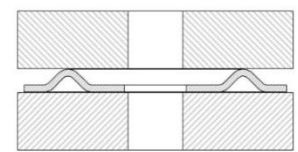
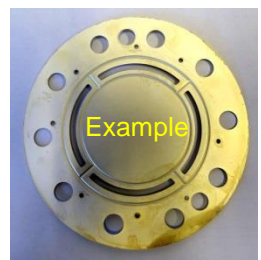
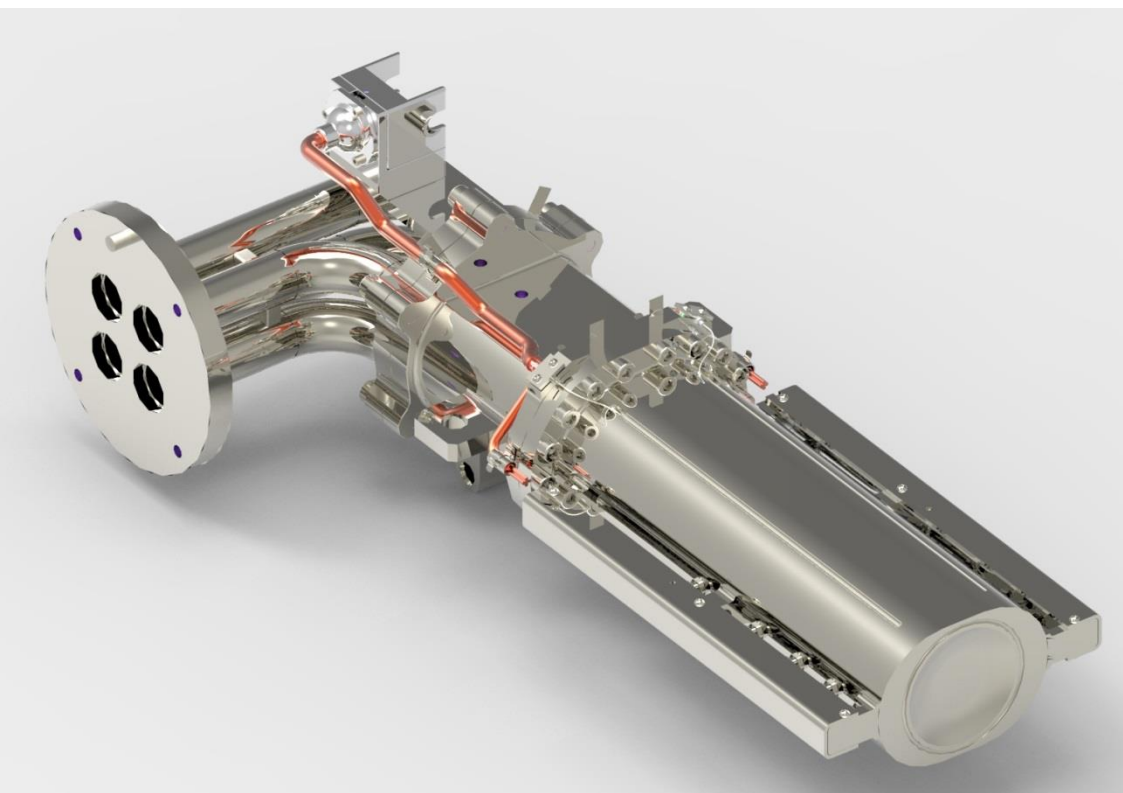
Order placed with:
Reaction Engines Manufacturing Solutions



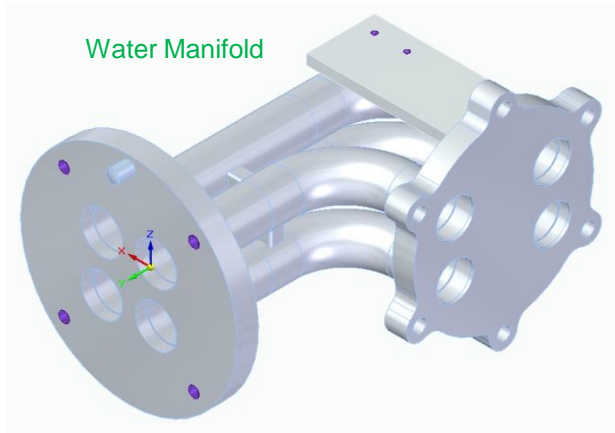
Project

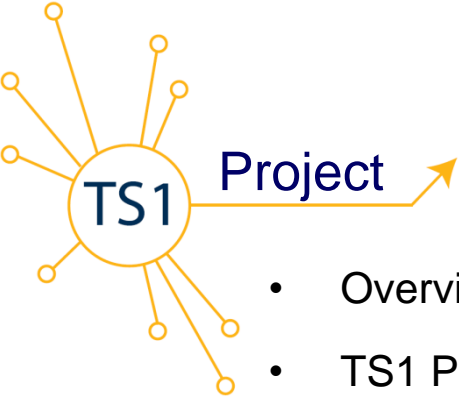
Progress With Manufacturing Target Components

- Water Manifold
 - 'Corruseal' Gaskets
 - Target Module Assembly
 - Flow testing
 - Second Target production
- Out for manufacture
 - Out for manufacture
 - Sep 2018
 - Oct 2018
 - Nov 2018



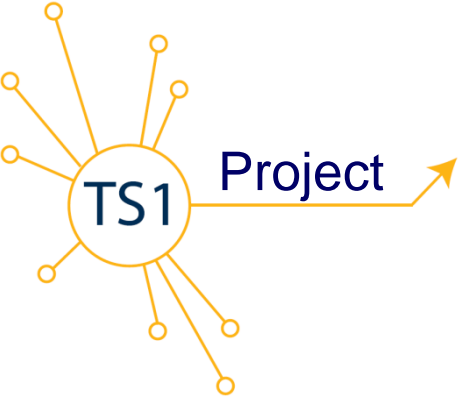
'Corruseal' Gasket -
Raised pinch lines
crush to form seal





Summary

- Overview of ISIS Target Station 1 - TRaM – operating 33 years
- TS1 Project Aims
 - Secure the future of TS1 and enable it to run for many more years
 - Make current maintenance operations of the target station easier
 - Improve our knowledge and skills in target station design for future projects
- Overview of TS1 Project Target design – integrated into TRaM
- ISIS ‘Target Manufacturing Facility’
- Progress With Manufacturing Target Components
 - Design and development complete
 - **All major components well advanced in manufacture**
 - Assembly and testing in 4 Qtr 2018
- Manufacture of second target assembly straight after



Thank you for your attention