CCLRC ISIS

Experience of Remote Handling of a Proton Beam Target

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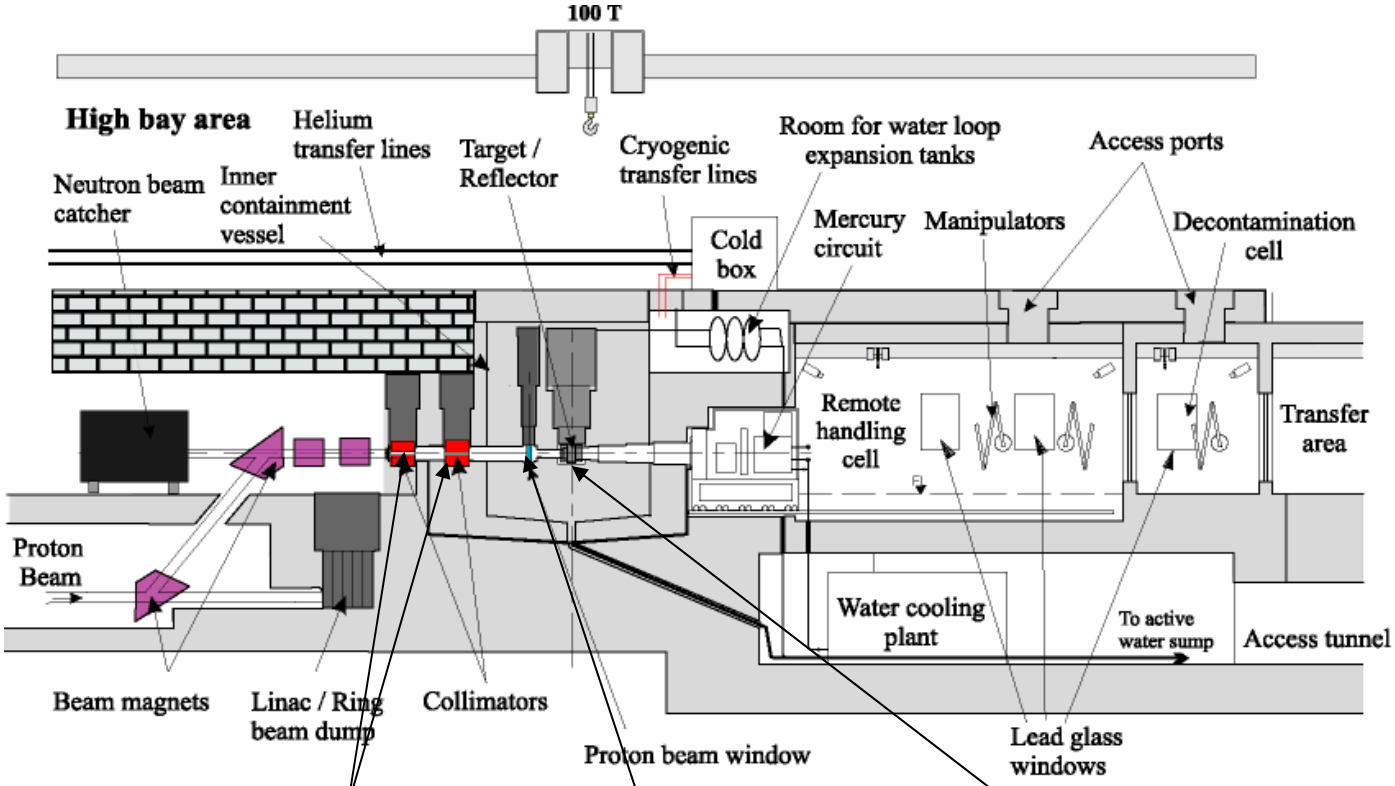
Outline

- Remote handling requirements for a spallation neutron source
- Guiding principles
- Handling concepts at existing sources and sources under construction
- Simple solutions
- Complex solutions
- Some technical details
- Summary

Remote Handling at Spallation Sources

- Complex assemblies with many components requiring regular replacement

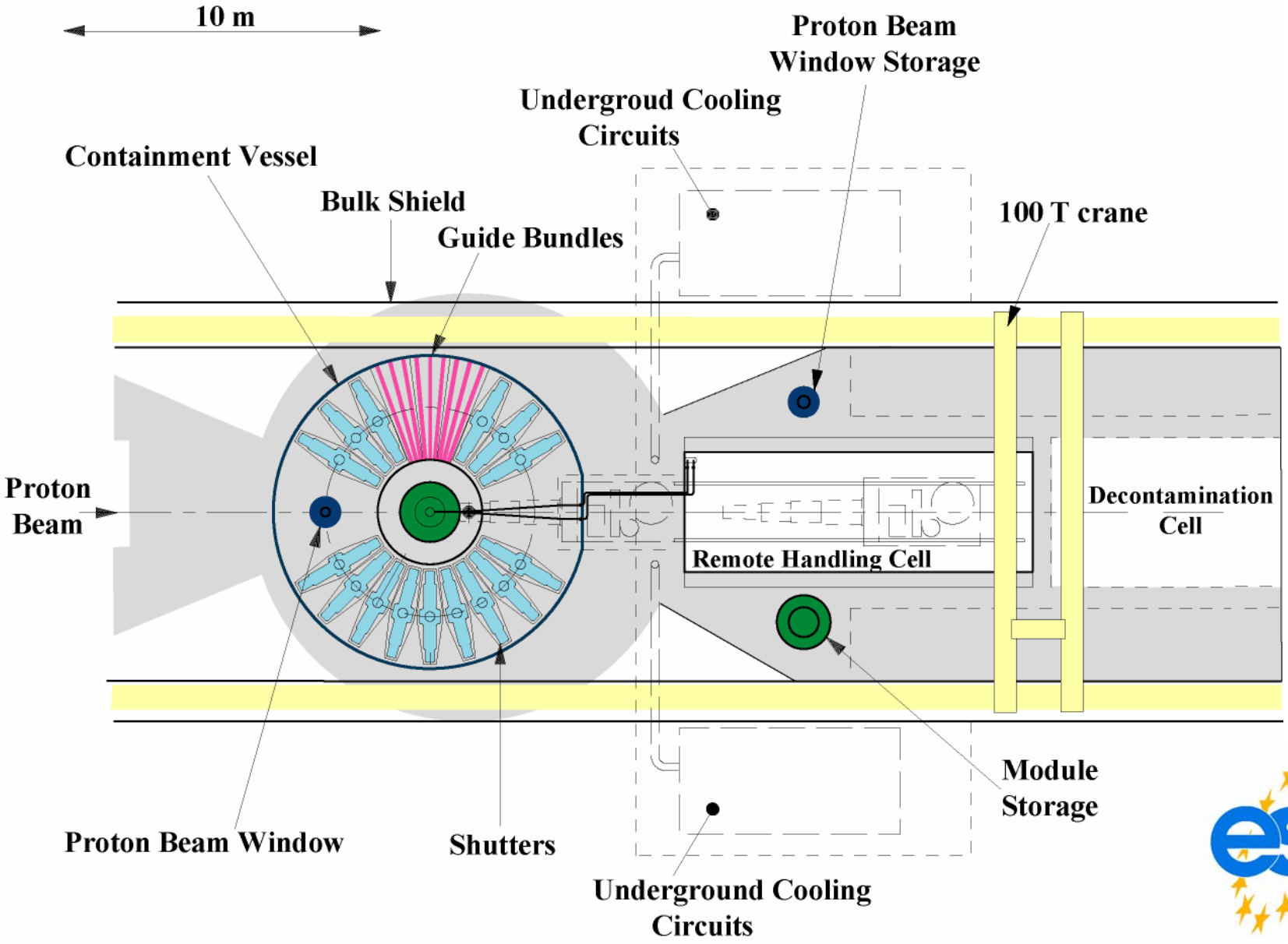


Collimators

Proton Beam window

Target, reflector and moderators

Remote Handling at Spallation Sources



Remote Handling at Spallation Sources

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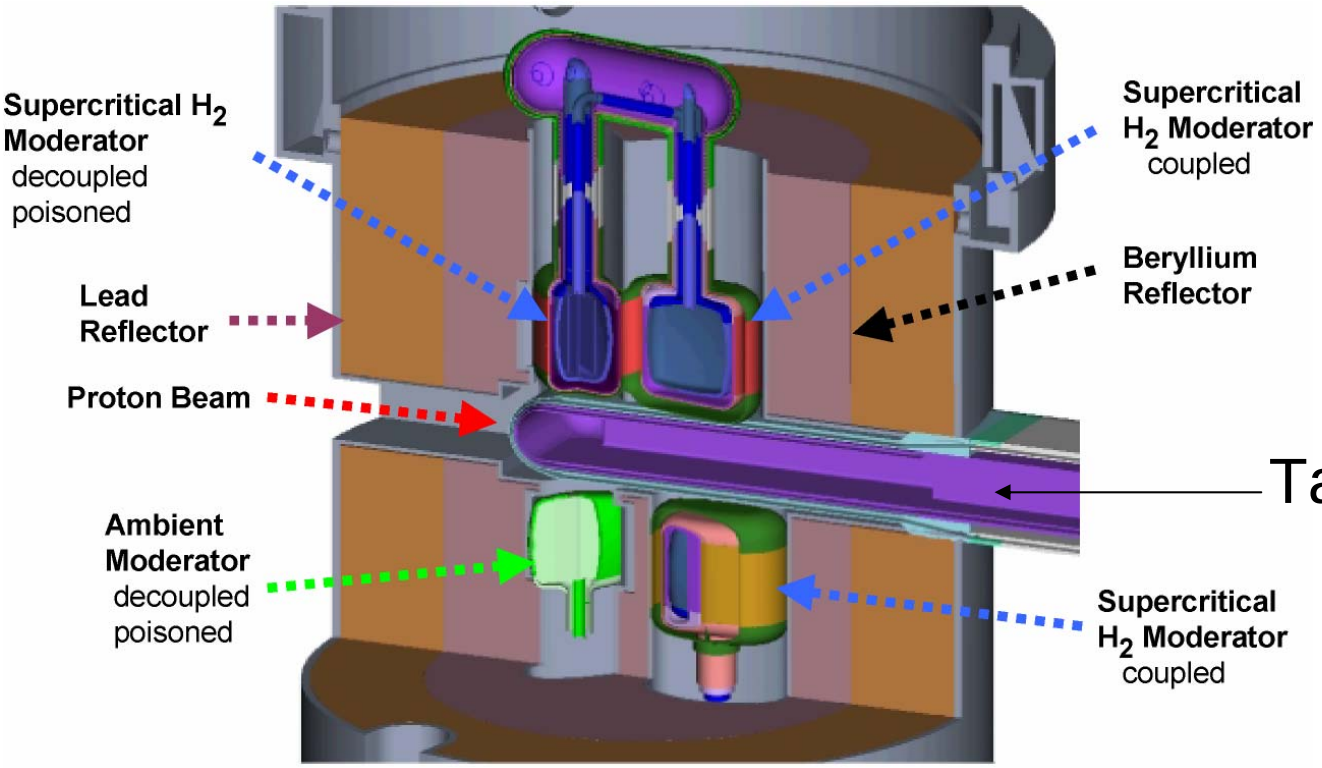


Services Include:

- Water
- Gases
- Cryogenics
- Instrumentation
- Liquid metals

Guiding Principles (1)

- All components that have a limited lifetime must be exchangeable within a reasonable time. (Within natural scheduled shutdown periods.)
- All components that can be designed for facility life must still be exchangeable as long as chance of failure theoretically exists; longer shut down time is acceptable.
- Allow either complex repair inside the target station or limit handling to exchange of pre-manufactured modules.
- Non-exchangeable components should be limited to carefully justified cases.
- These considerations will determine the overall design of the handling facilities

Guiding Principles (2)

Handling requirements on every component have to be considered on a case-by-case basis. Issues to be considered during the conceptual and detailed design of a component as well as its direct environment are:

- Expected lifetime of the component and therefore frequency of handling.
- Expected activation of the component to be handled and its environment.
- Expected contamination of the component to be handled and its environment. Size and weight of component to be handled.
- Complexity of geometric arrangement of the component and its environment.
- Handling areas.

In most cases the basic driver is the expected lifetime or end of life mode of the addressed component.

Decommissioning

Spallation Neutron Source Targets

- Proton Beam Power
  - LANSCE 100 kW solid target
    Vertical handling
  - ISIS (RAL) 160 kW solid target
    Horizontal handling
  - SINQ (PSI) 1000 kW solid target
    Vertical handling
  - SNS (ORNL) 2000 kW mercury target
    Horizontal Handling
  - JSNS (JAERI) 1000 kW mercury target
    Horizontal Handling
- Full remote Handling is essential

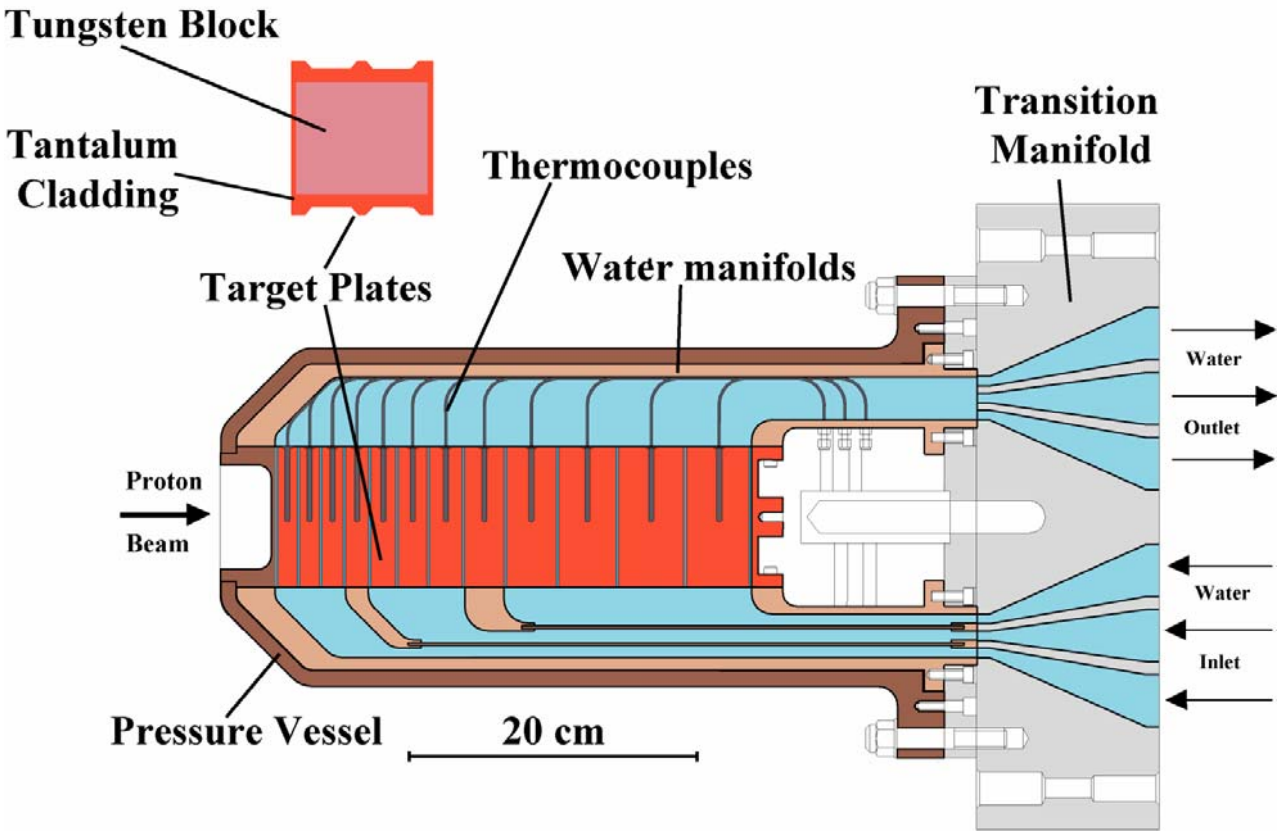
Typical Heat loads

Mean power density
100-200 kW/l

Peak Power density
0.5-2 MW/l

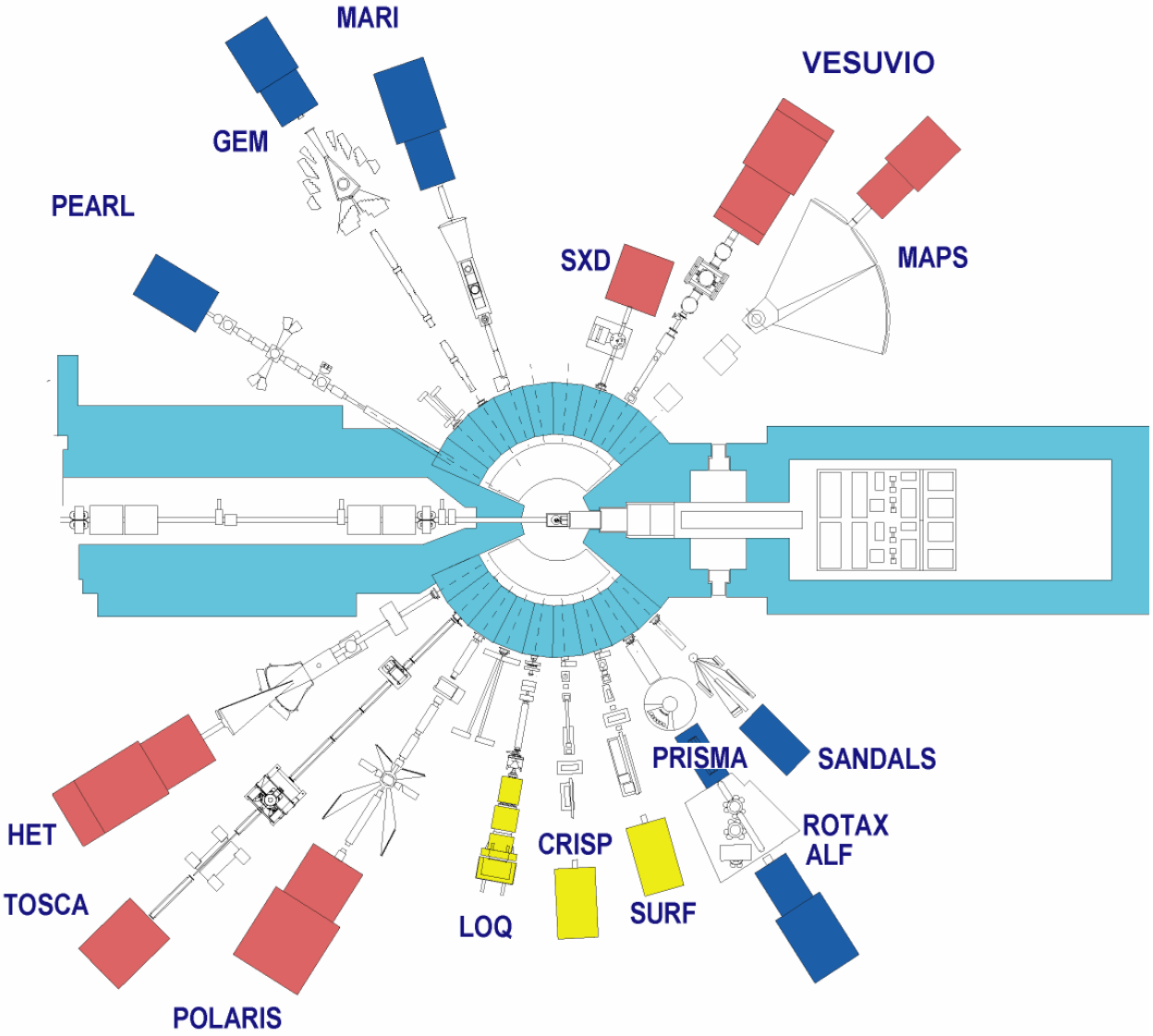
(Small when compared to the positron target.)

Spallation Source Targets

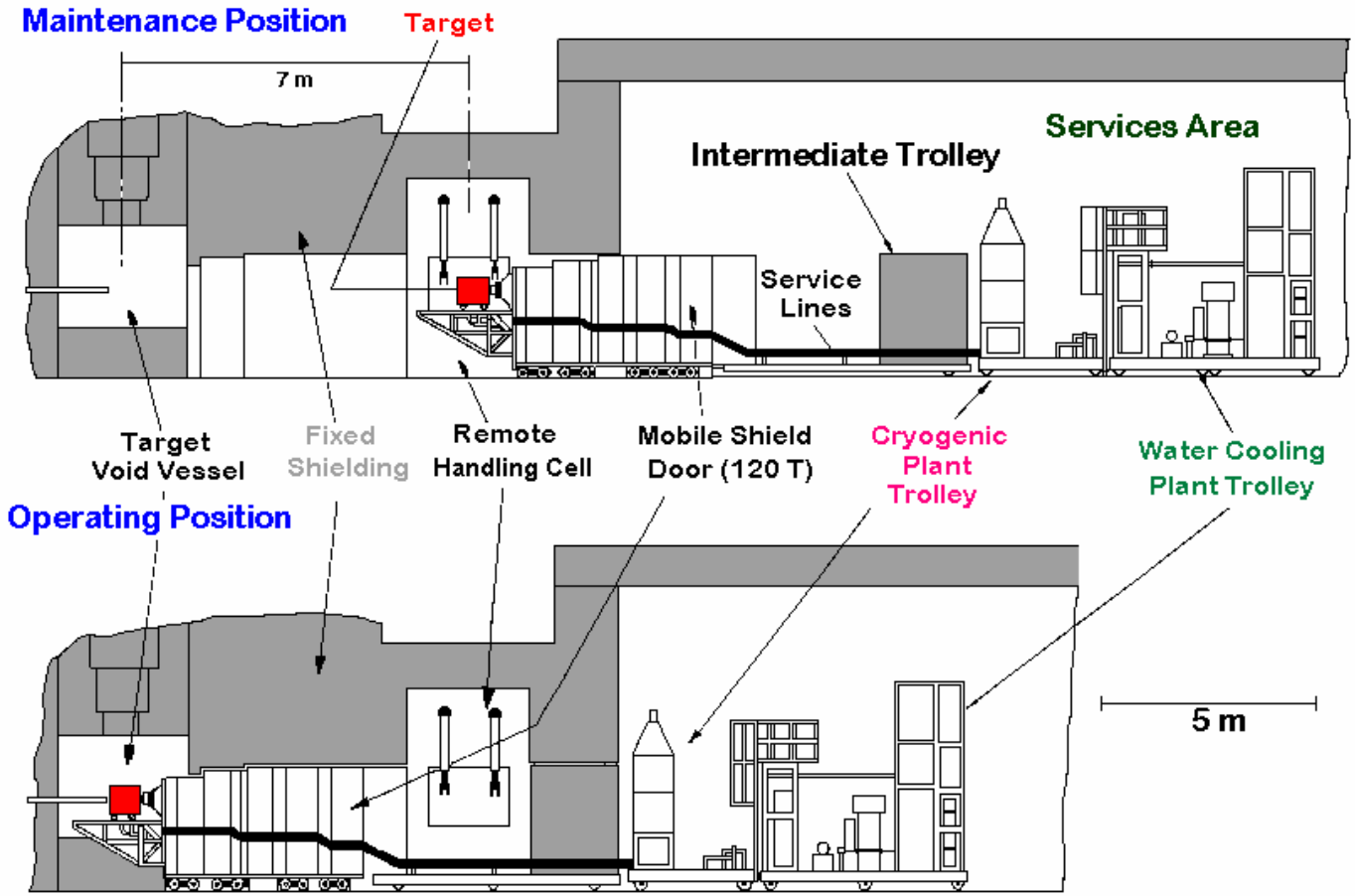


The ISIS Neutron Production Target

Alternative Concepts (1) - Horizontal

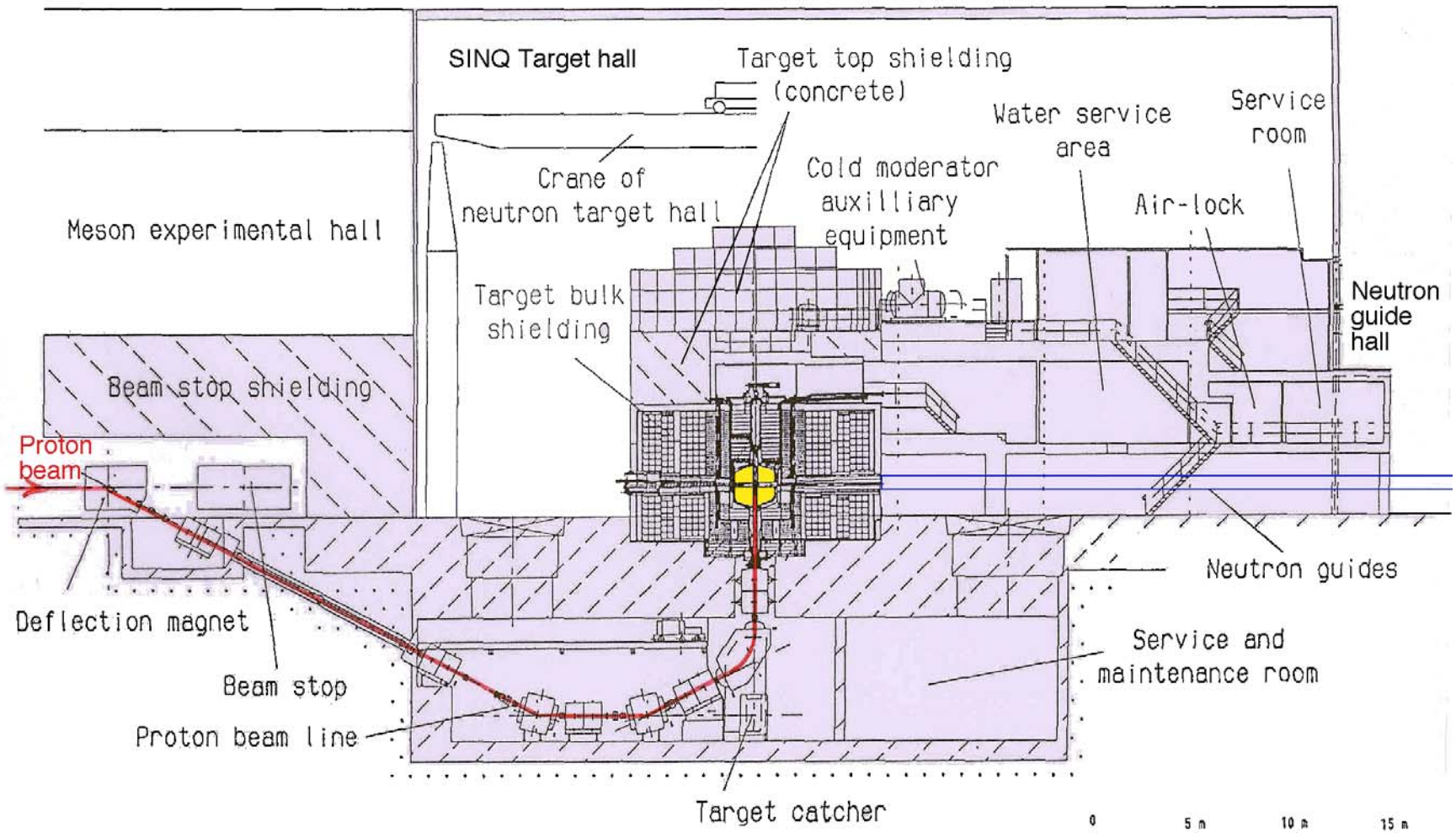


Alternative Concepts (1) - Horizontal



Services remain connected, target moved to an integral remote handling cell for replacement.

Alternative Concepts (2) - Vertical

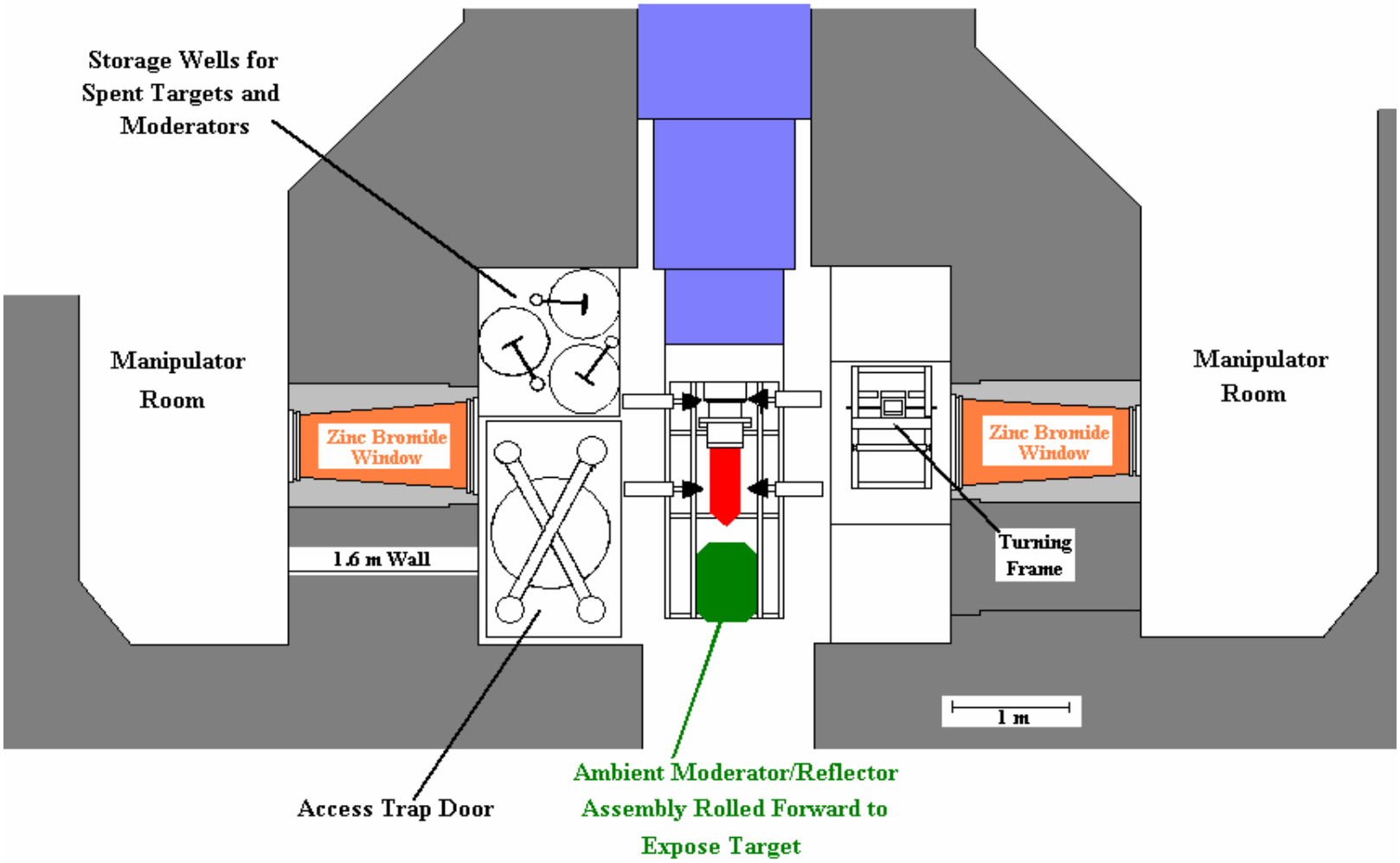


SINQ Target Station

Alternative Concepts (2) - Vertical

Services disconnected and target removed to a storage facility. Later can be worked on in a separate remote handling facility

Simple Handling Equipment (ISIS)



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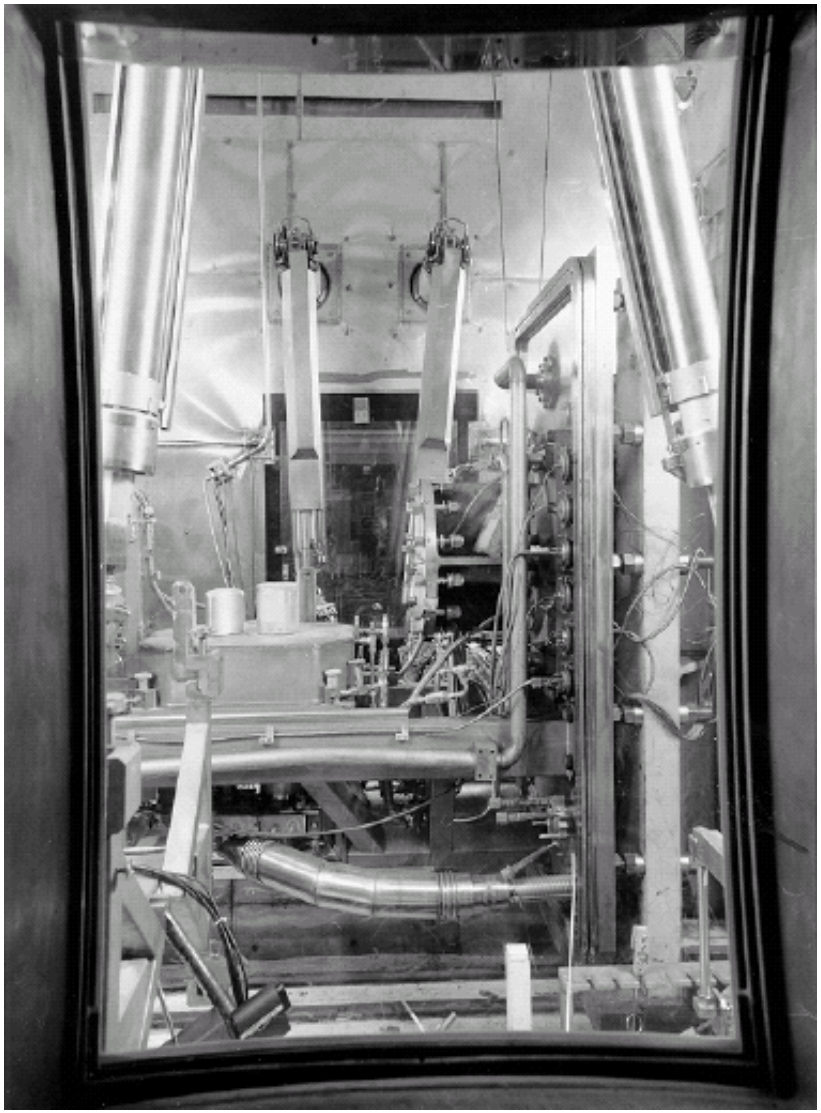
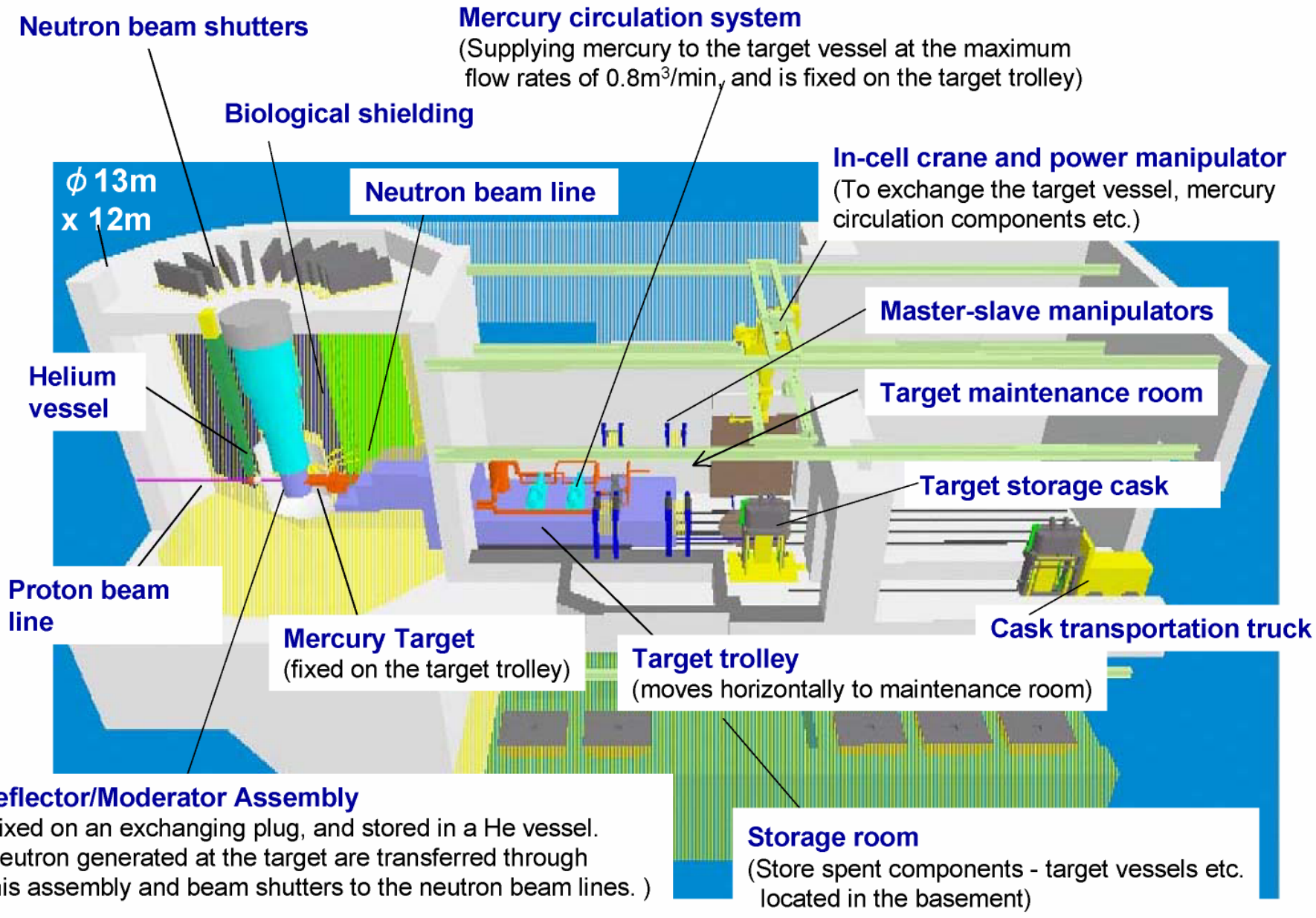


- 2 Pairs master - slave manipulators
- 2 viewing windows supplemented by 8 cameras
  - 6 fixed with pan, tilt and zoom
  - 2 mobile (held by manipulator) with mobile lights
- All operations can be recorded on video tape
- Only simple tools used - standard spanners with grips for manipulator hands (Almost NO power tools are used)
- Underground tunnel for access and removal of radioactive components using a transport flask

Complex Handling Equipment (JSNS)



Complex Handling Equipment (JSNS)

Complex Robots and fixtures, power tools

Large integral Remote Handling Cell, many windows, complex storage facility

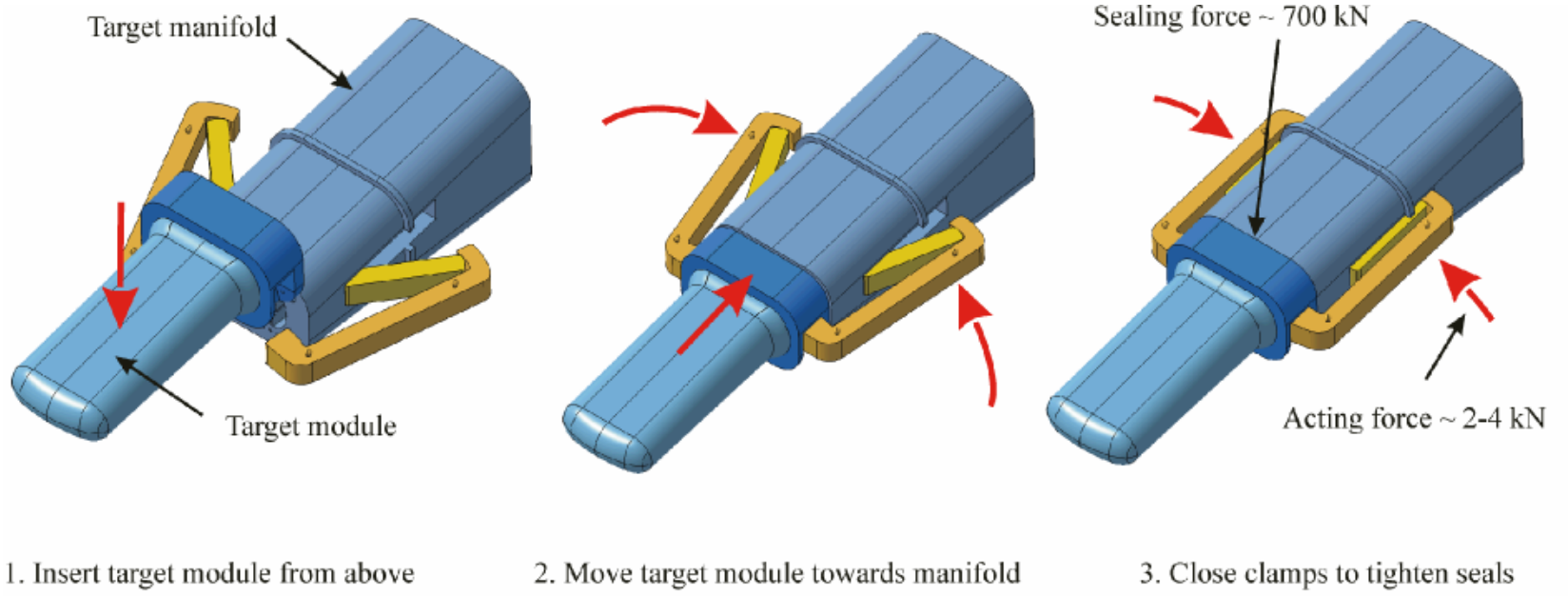
General Comments

- Despite careful Quality Control most equipment can be expected to suffer failure in operation.
- Procedures to recover from any failure are essential.
- A full scale mock-up for developing tooling and procedures and training operators is essential.
- A policy defining under what conditions staff may enter a remote handling cell is essential.
- Control of contamination must be built in to the basic design of all remote handling.
- Do not ingore services - cooling plant may also require remote handling (e.g. liquid metal targets).

General Comments - Connections

- For component replacement reliable, easily handled connections are essential but there are several difficulties
- To make reliable joints (with metal seals) can require application of precise torque on the flanges or joints
    - Most methods of applying a known torque to a nut requires the friction between the threads to be controlled
    - Irradiation effects and the problems of applying lubricants remotely result in poor condition of the threads
- The seal design has to be tolerant of poorly known and uneven closure forces
- Leak testing and detection is very hard and time-consuming
- Minimise connections

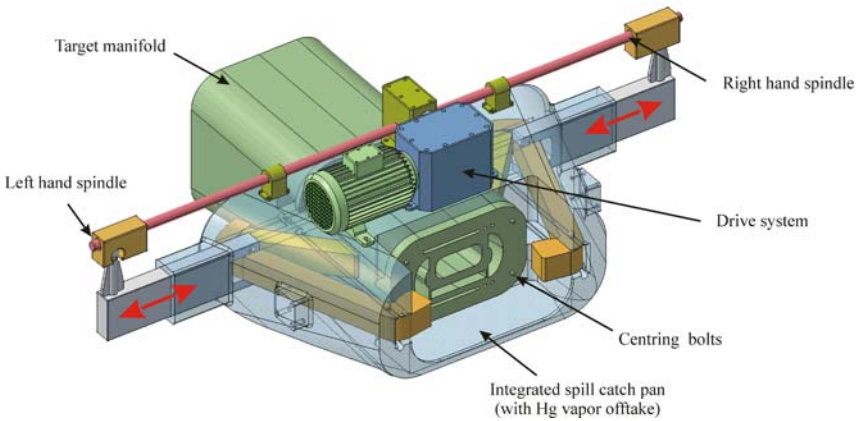
Sealing Technologies (ESS Target)



1. Insert target module from above

2. Move target module towards manifold

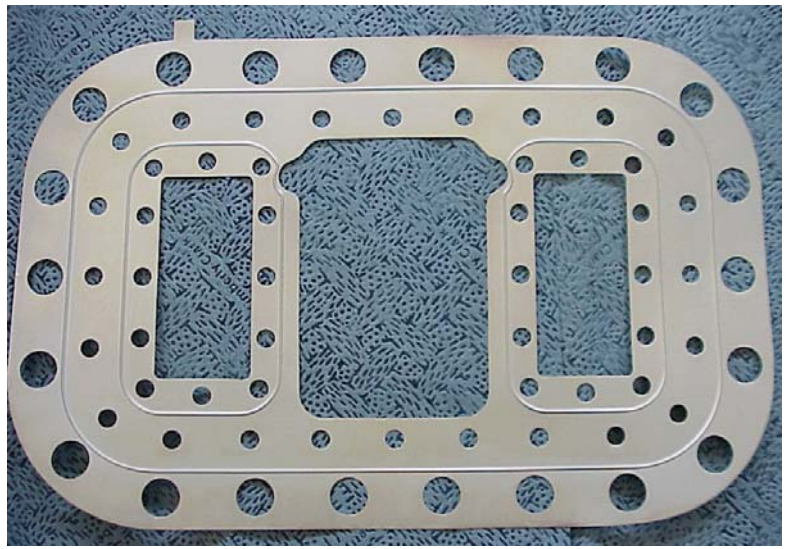
3. Close clamps to tighten seals



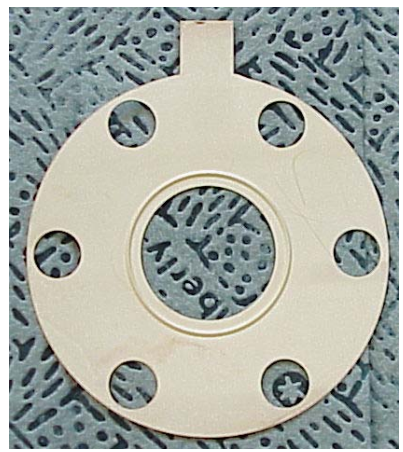
Avoids Bolted Flanges

ess european spallation source

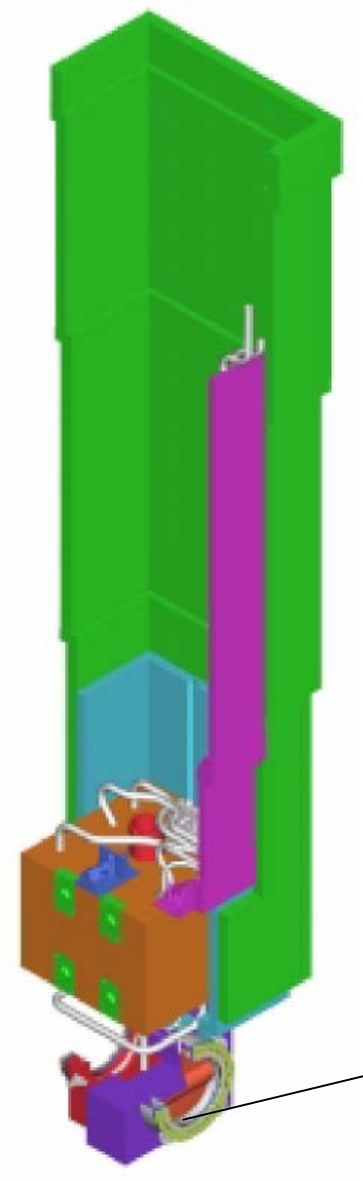
Sealing Technologies



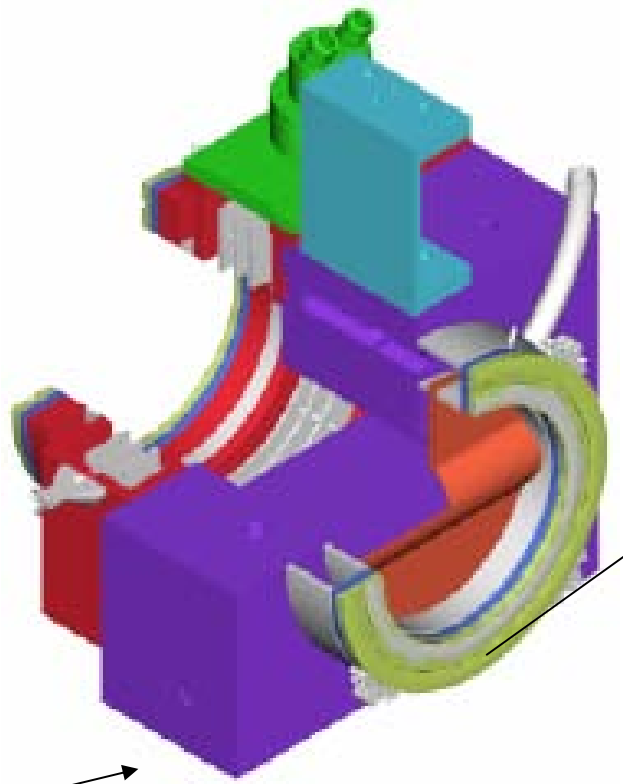
- Corruseal – silver plated stainless steel.
- Versatile shape to allow manifolds for many connections
- Tolerant of uneven torque



Sealing Technologies



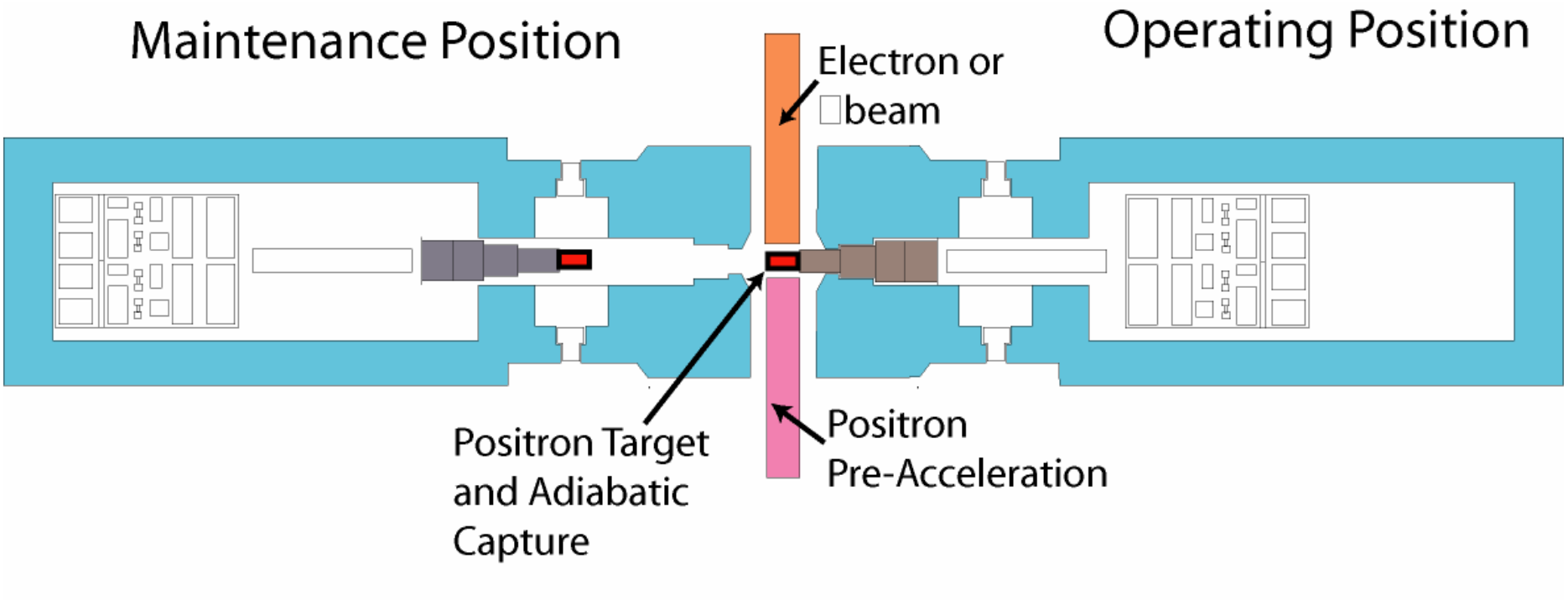
Pneumatic vacuum seals – Developed at PSI and adopted at SNS. No bolts required.



General Observations

- Remote Handling requirements will dominate the layout of the target area.
- Remote handling of components must be included in the design of the components from the outset.
- The main choice is between replacement of modules or replacement of components
- This choice will depend on:
  - Frequency of replacement, availability of Hot Cell facilities and cost and complexity of service connections
- Do not install any system without a solution to the remote handling requirements
- Remember Instrumentation

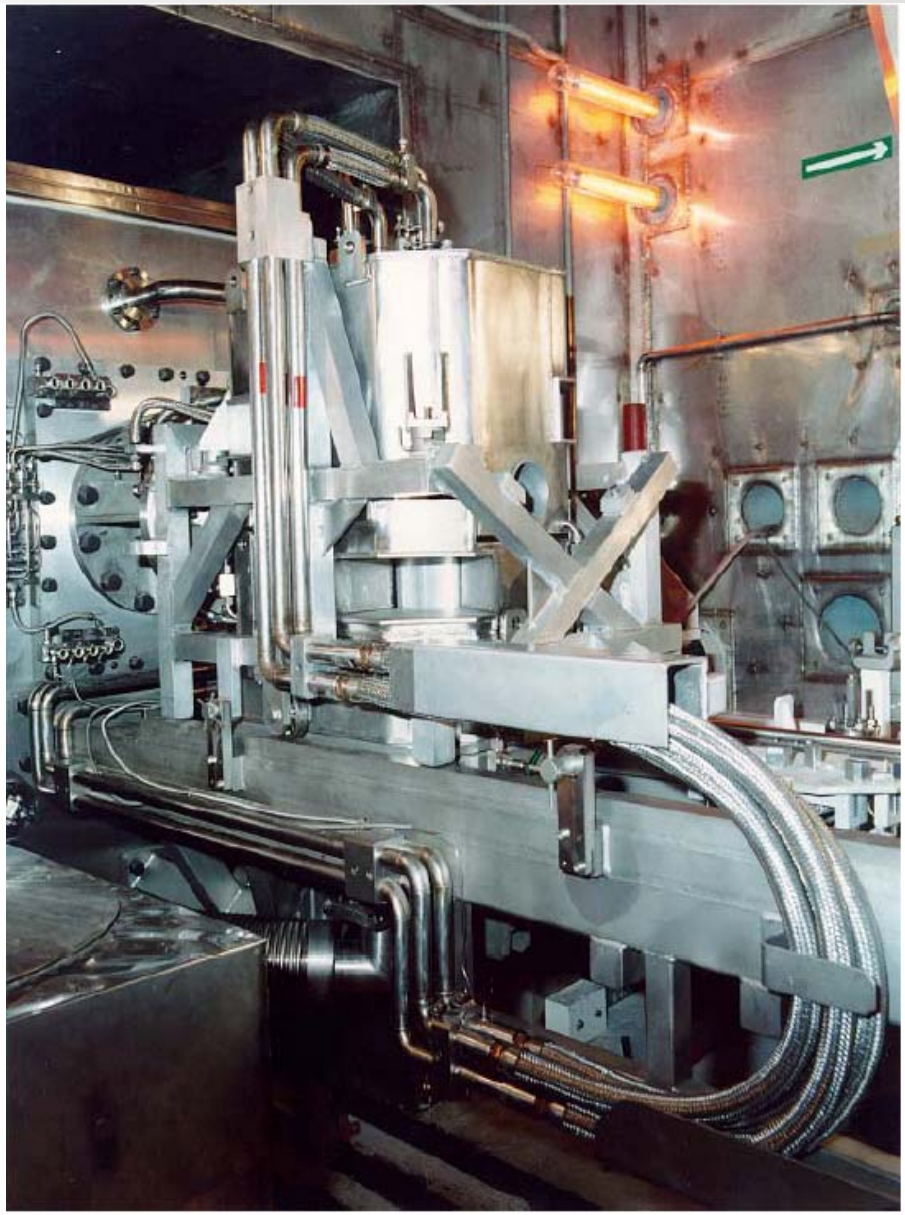
2 – 4 Hour Positron target change



Summary

- The remote handling challenges for the positron target haves many similarities with those of spallation targets
- There is lots of experience of detailed handling technology at spallation source – all available to the Linear Collider designers
- Remote handling for spallation targets has been most successful when handling requirements have been included at the conceptual design phase
- Ad hoc handling is likely to take a very long time

ISIS Remote Handling



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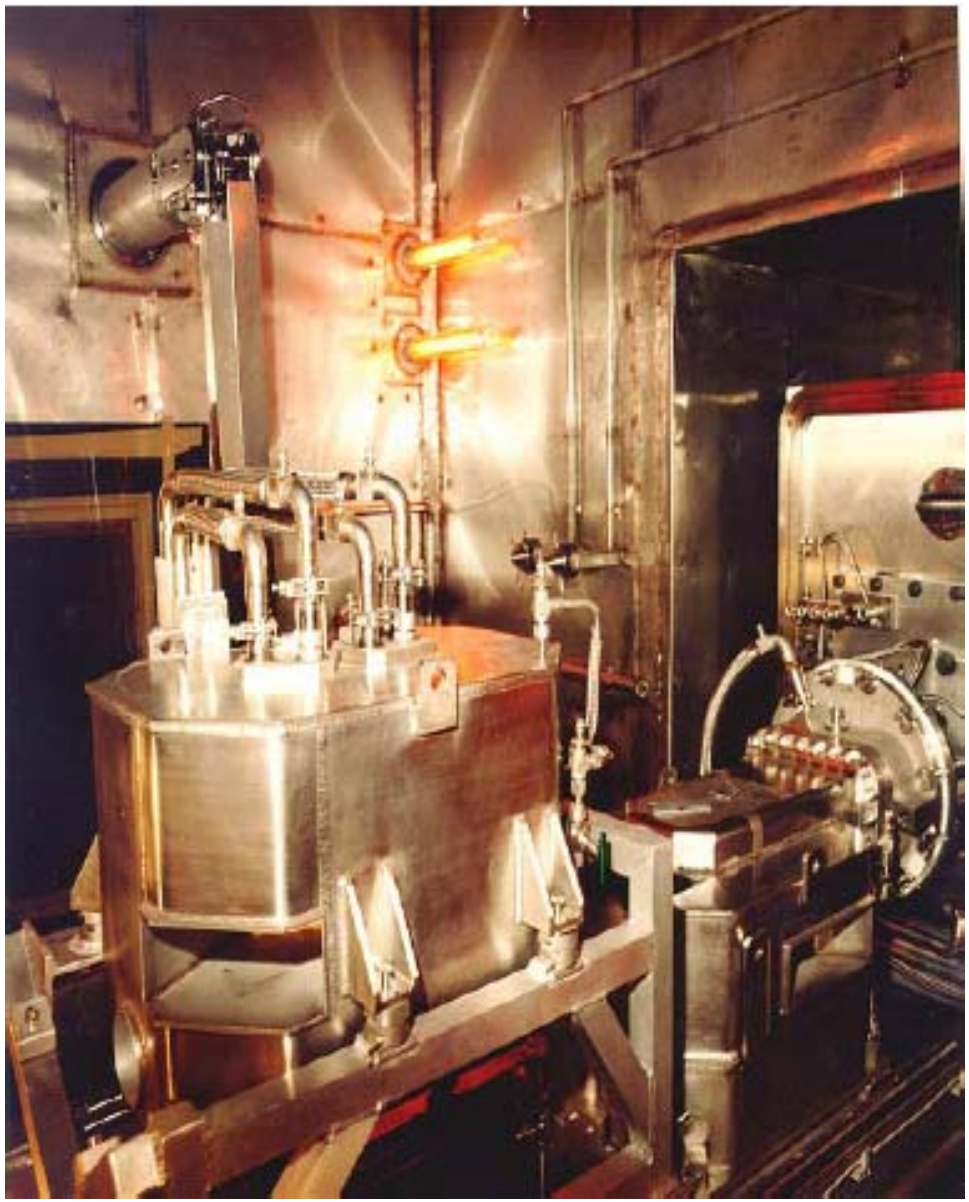

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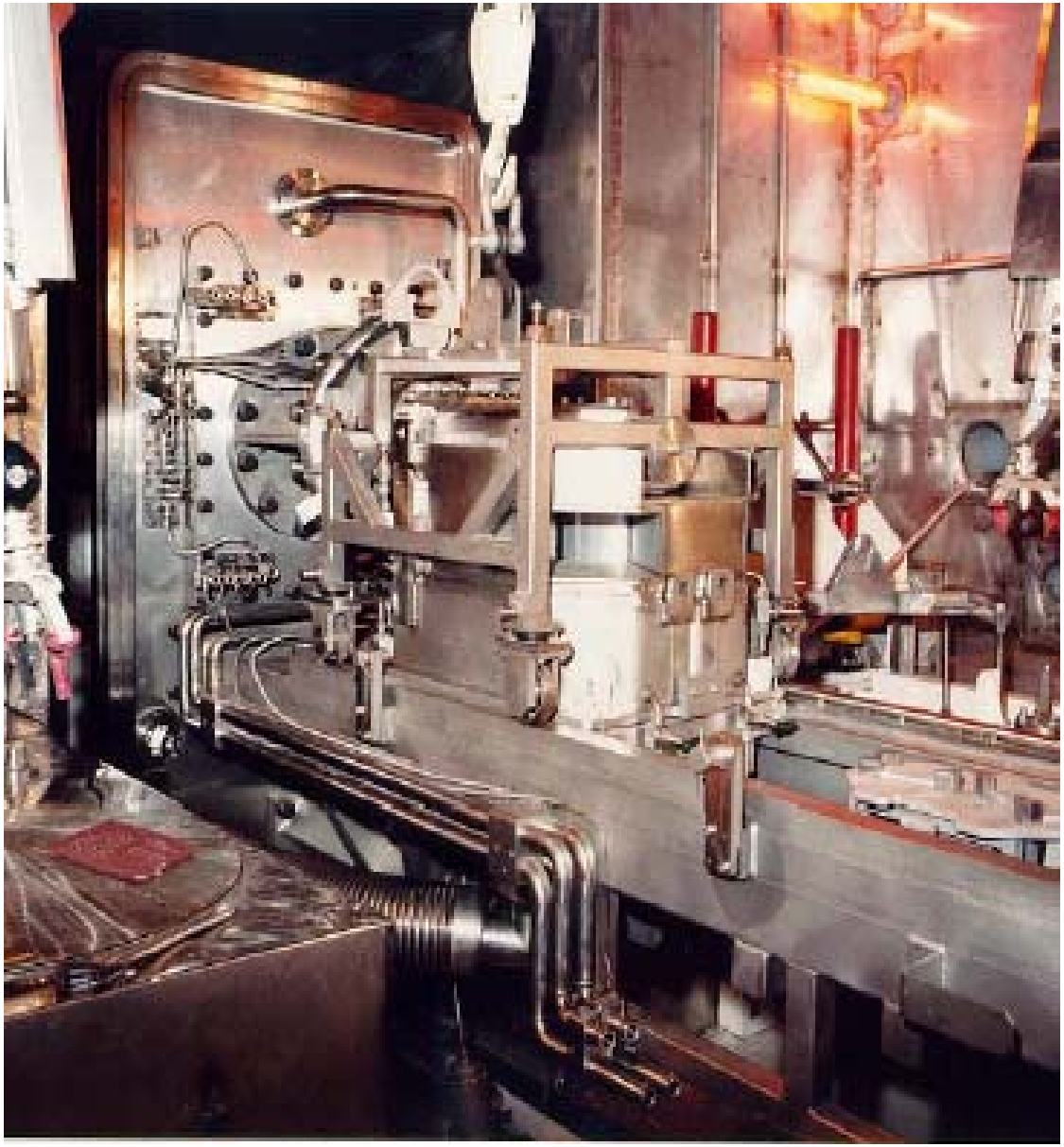

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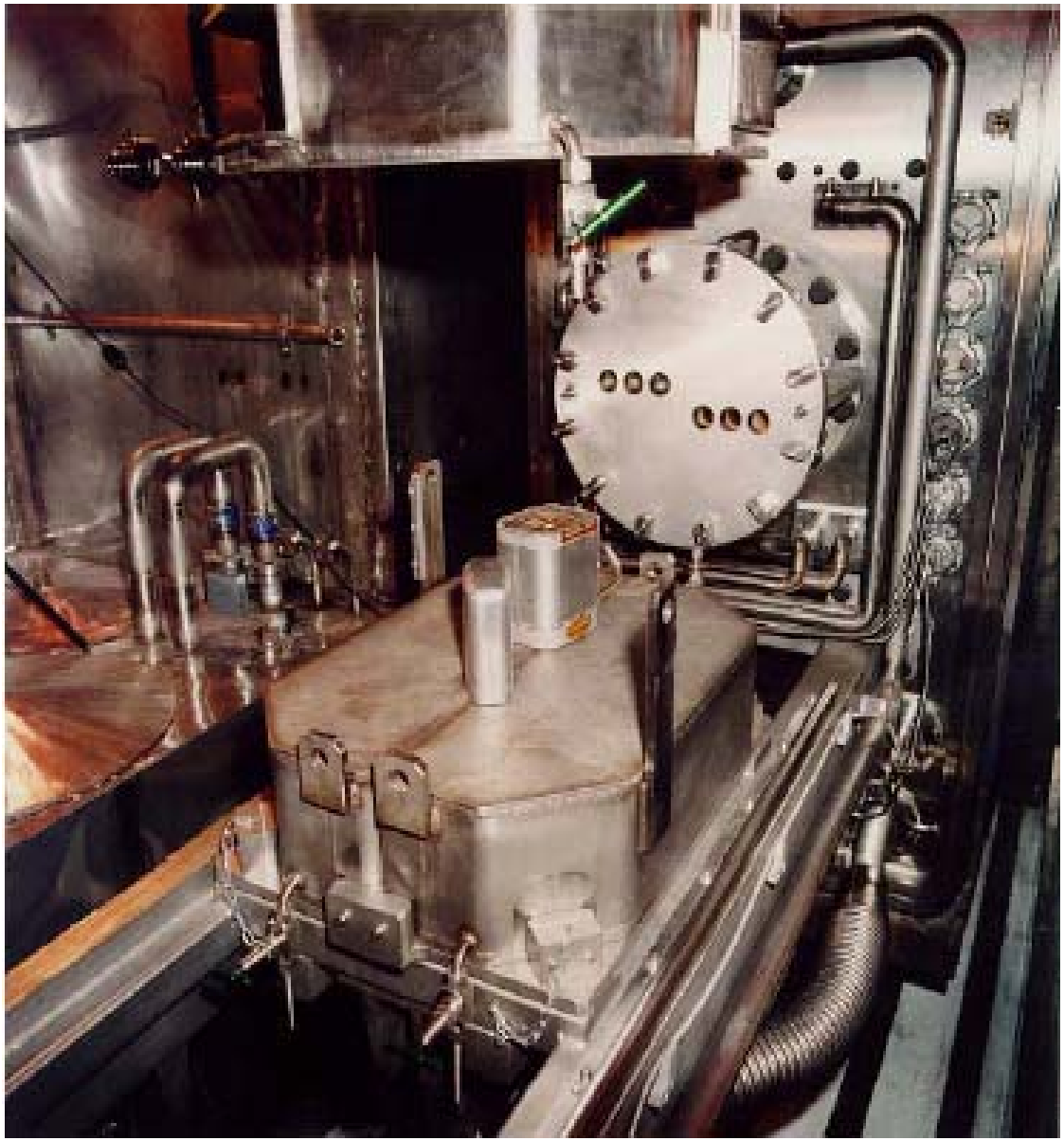

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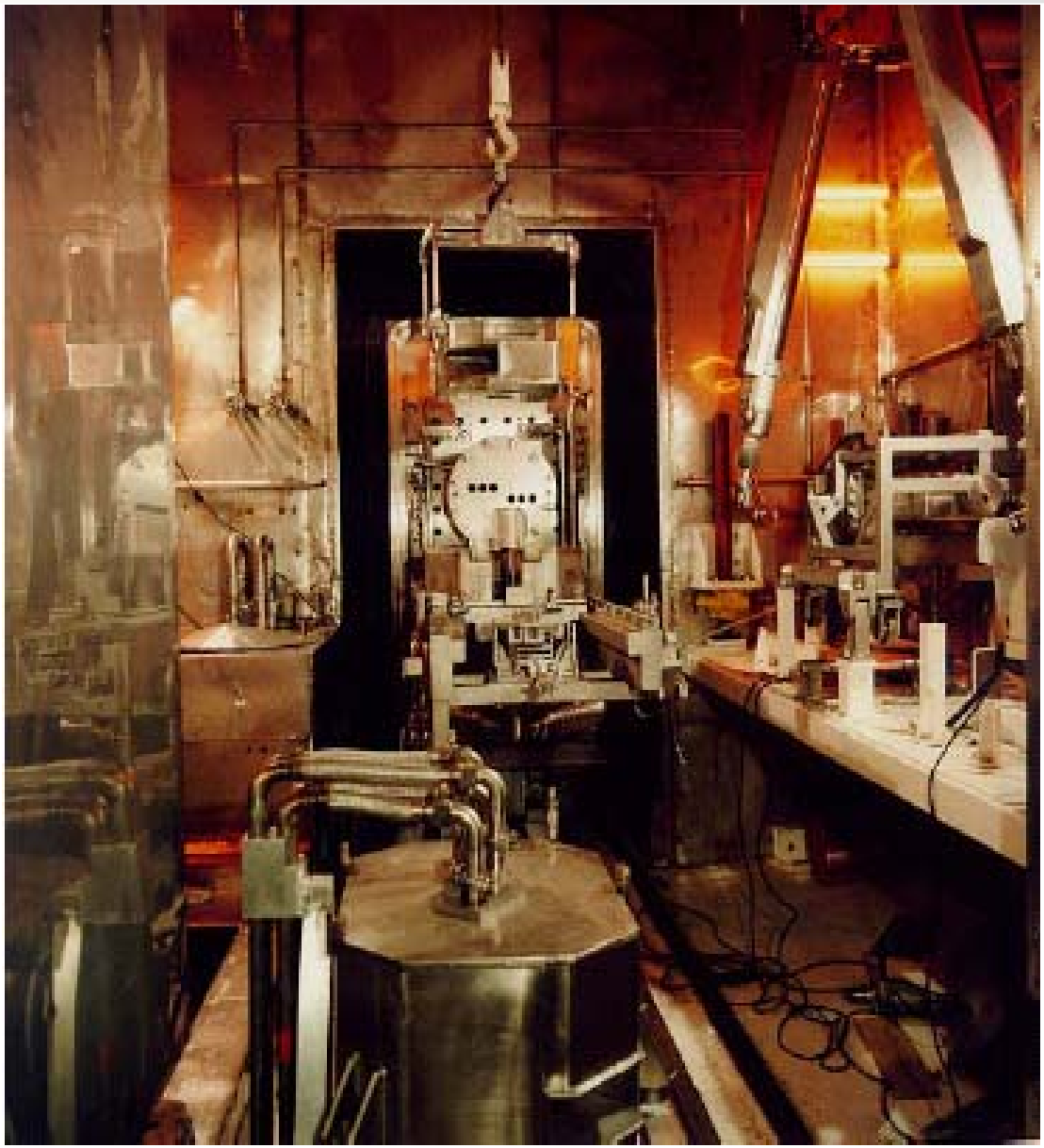
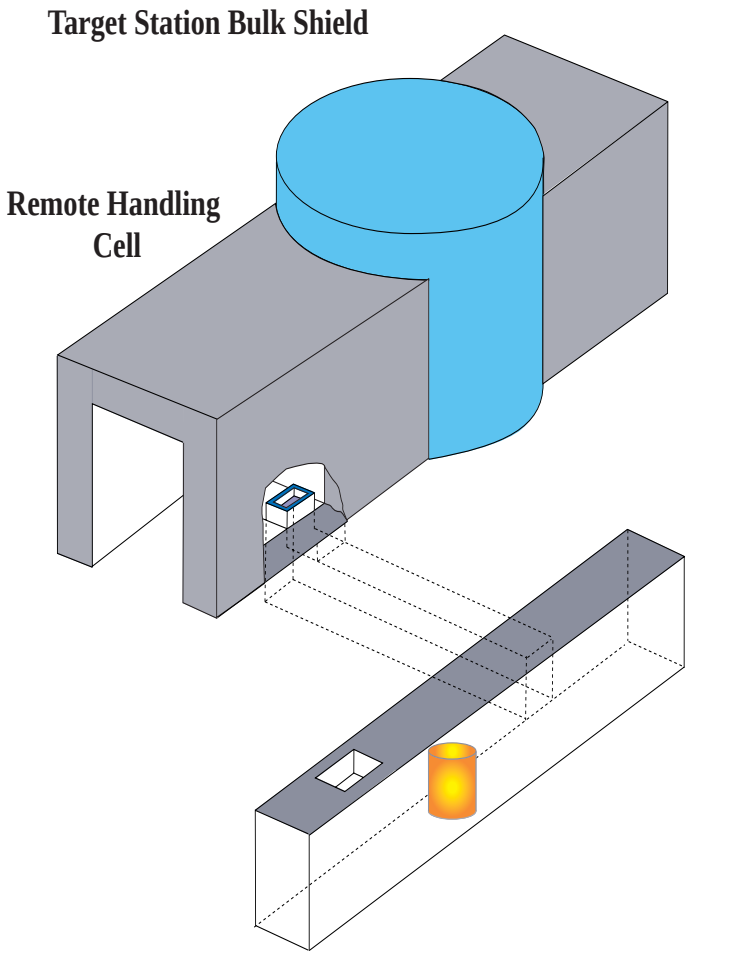


ISIS Remote Handling Timescales

- **Horizontal removal of the Target, Reflector and Moderator system (with all the cooling plant)**
- **Replacement of individual components**
- **Target replacement takes 10 days beam off to beam on**
    - **3 days for cooldown and preparation of cell**
    - **4 days remote handling**
    - **1 day leak testing**
    - **2 days to return to operating conditions and cool down cryogenics**
- **Moderator replacement takes 14 days beam off to beam on**

Movement of Active Components



Underground Tunnel for Removal of Active Components in Transport Flask