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ISIS

ISIS Facility:
Facility Design Challenges

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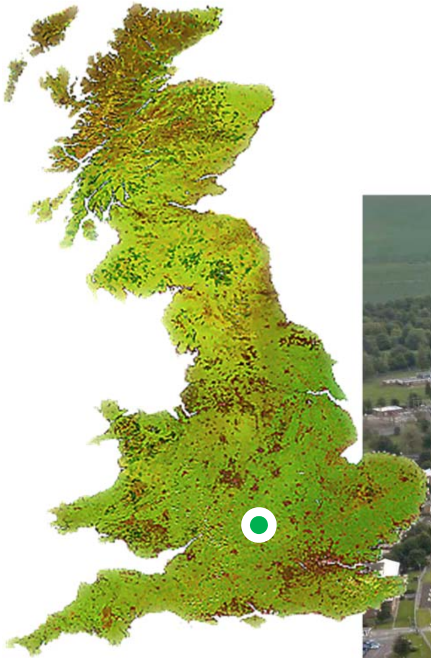
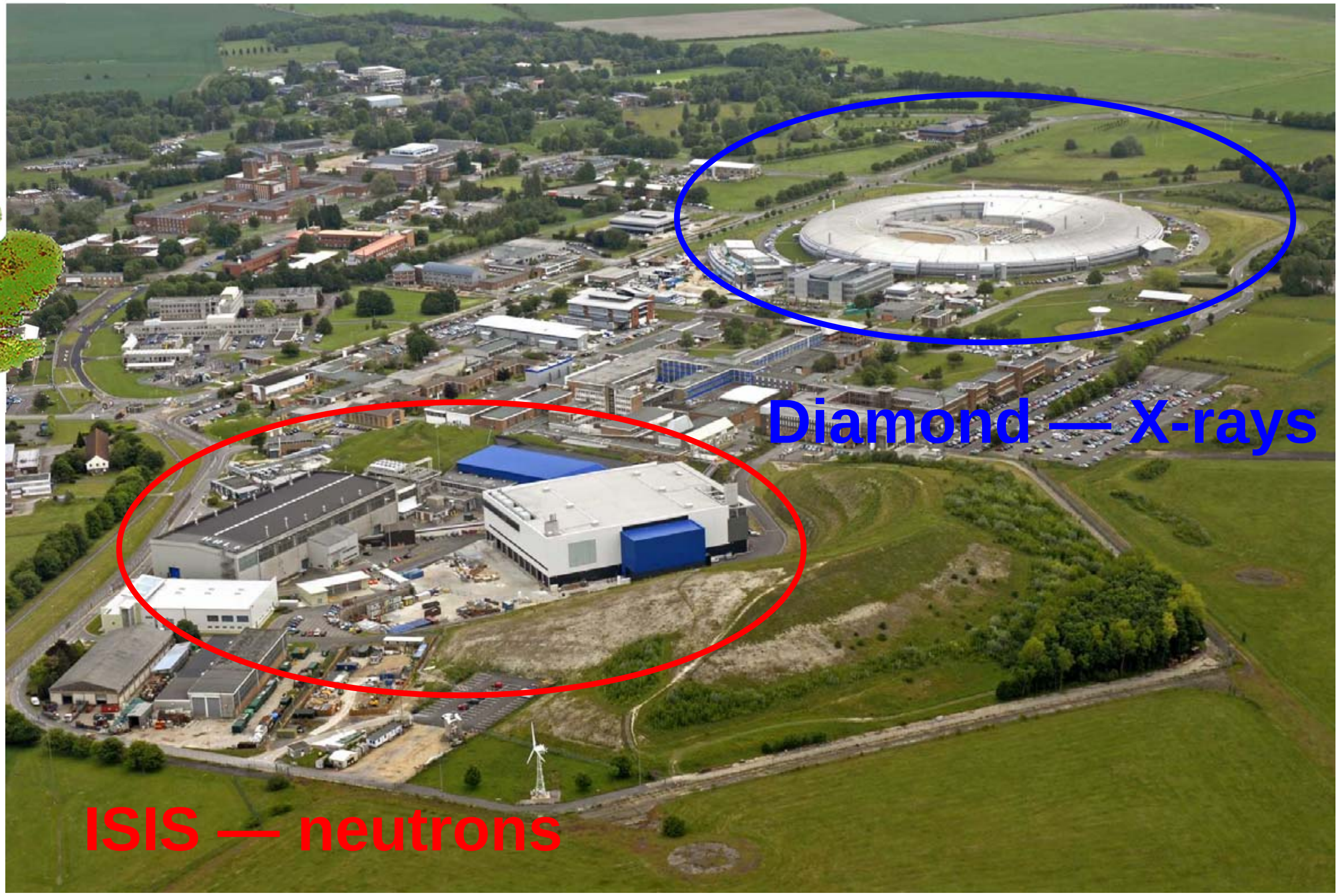
ISIS Department
Rutherford Appleton Laboratory / STFC

Proton Accelerators for Science and Innovation, 12–14 January 2012, FNAL





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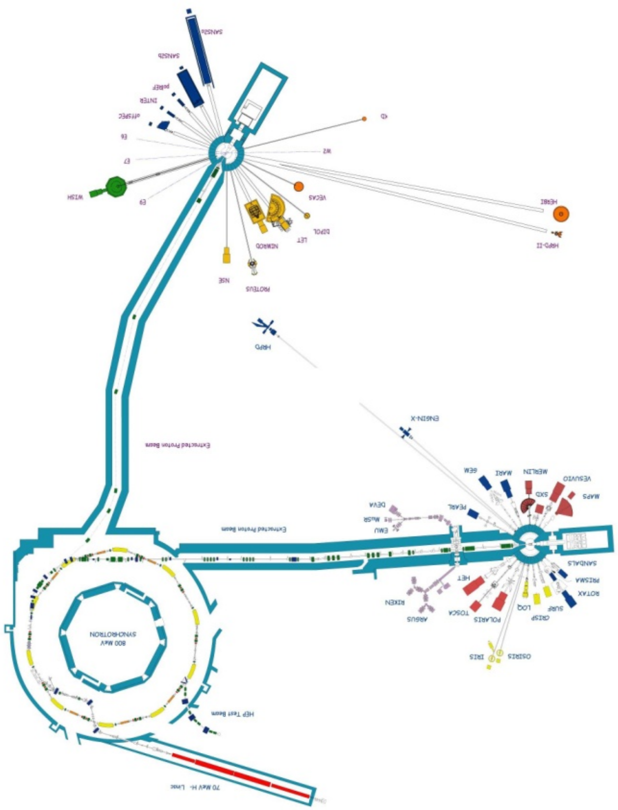

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Facility Design Goals

- Lifetime
- Reliable Operation
- Flexibility (accommodate changes post construction)
  - Additional features
  - Improvements
  - Unexpected events
  - Legislation driven
- Safety
  - People
  - Environment

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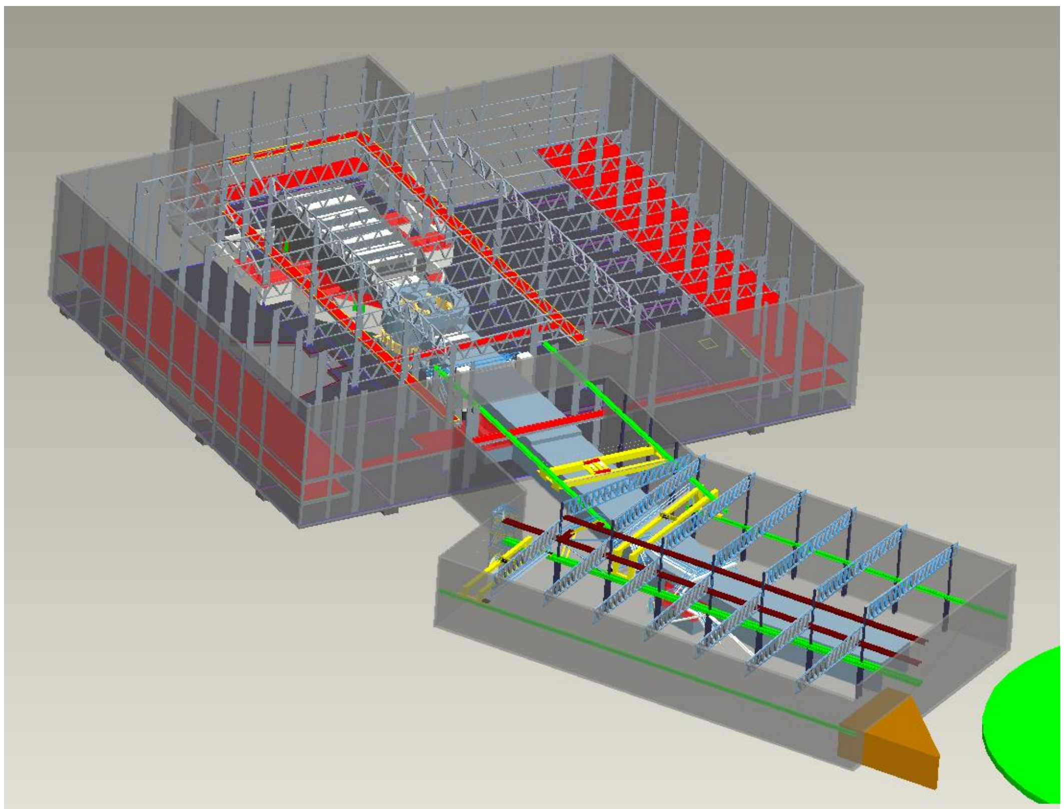
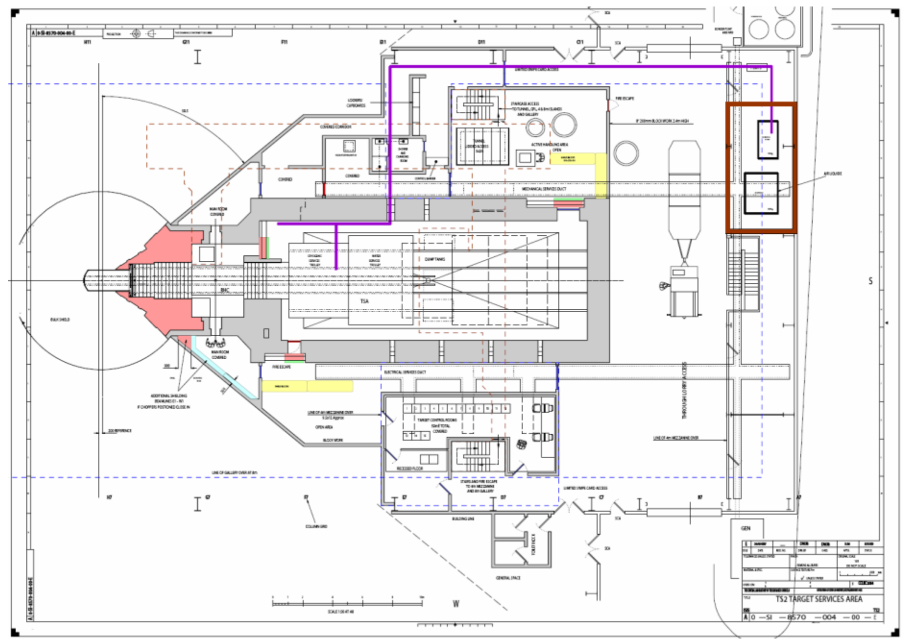
Facility Design Challenges

- Technical
  - Cooling
  - Radiation Damage & Rad Accelerated Corrosion
  - Remote Handling/Radioactive Waste
  - Remote Monitoring Diagnostics
  - Shielding Design (packaging)
  - Modelling Accuracy
    - Combining neutronic and design, with confidence in accuracy of answers in timescale within project

- Organisational
  - Experienced staff
  - Money (to build, then to operate) Ts2 £150m to build





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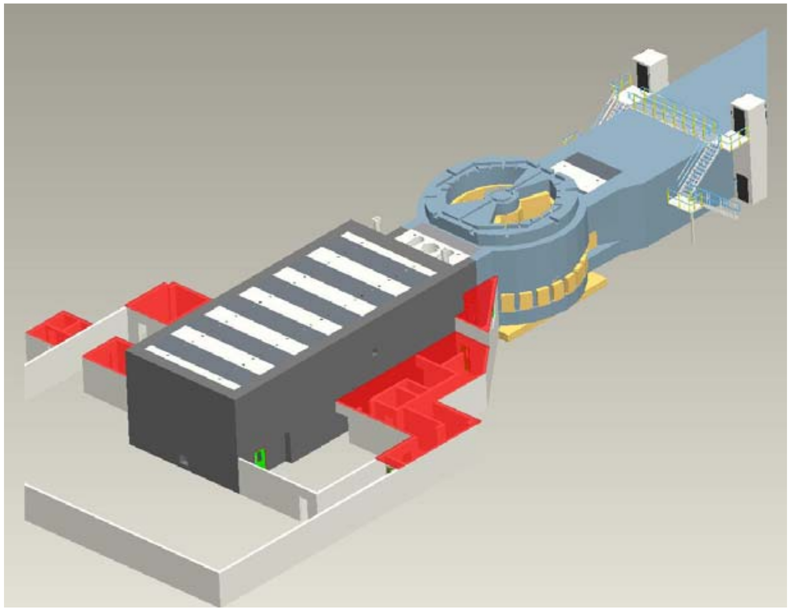
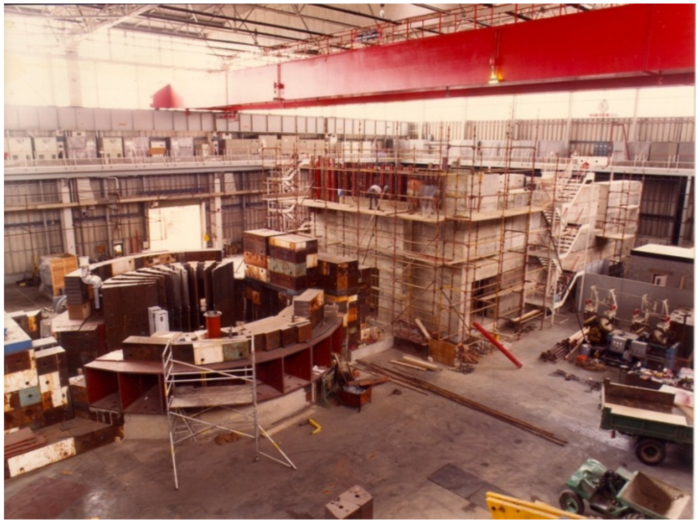
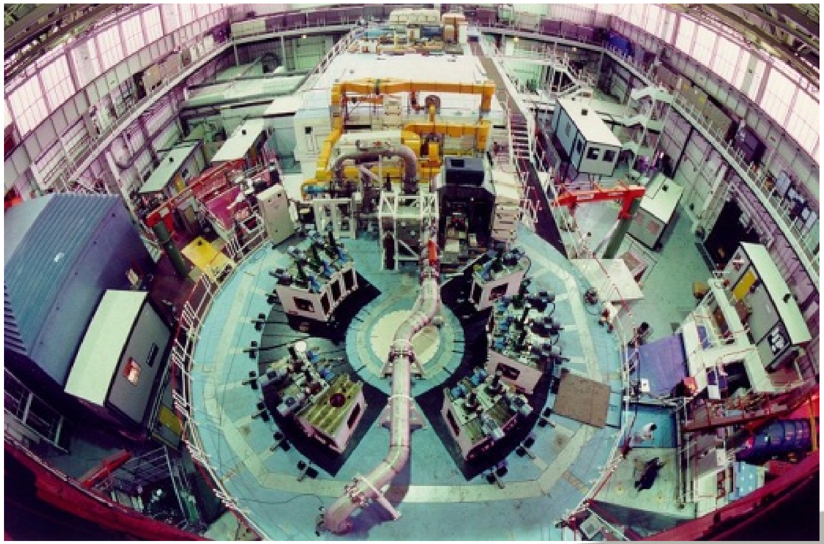
TS2



TS1





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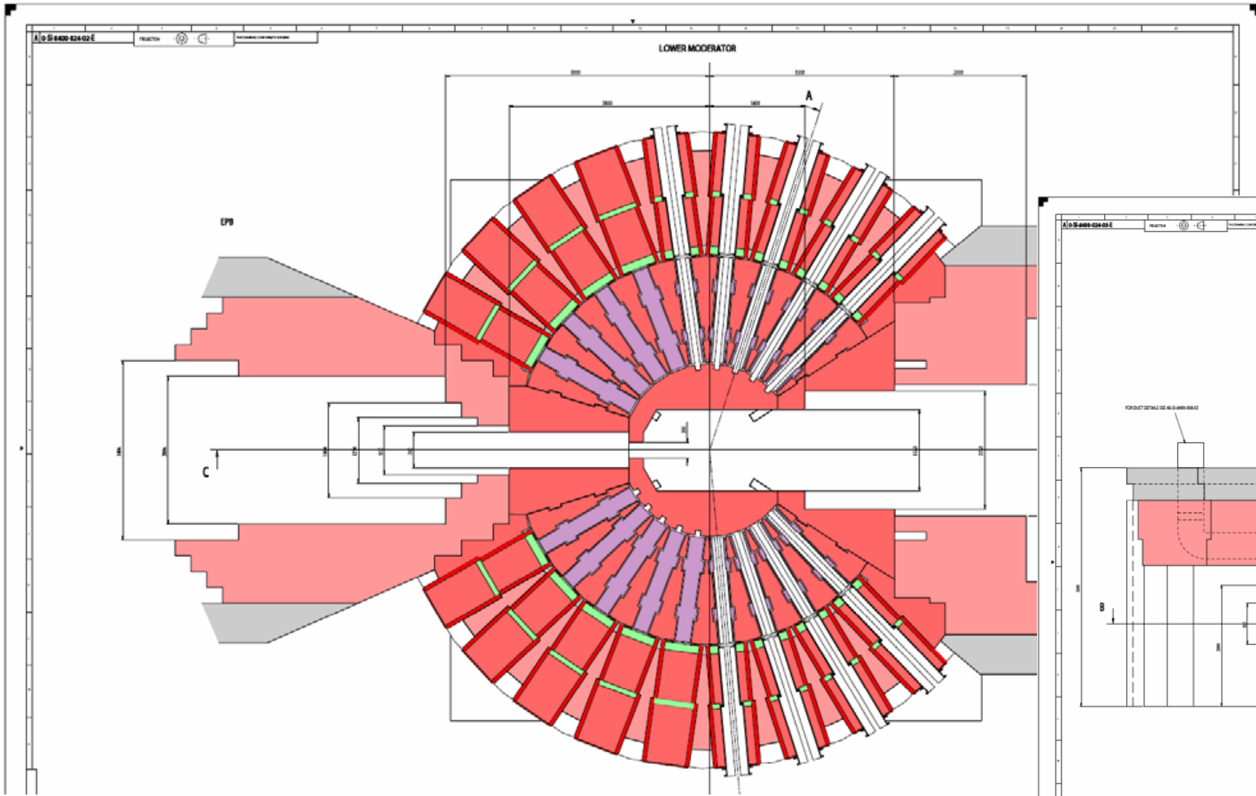
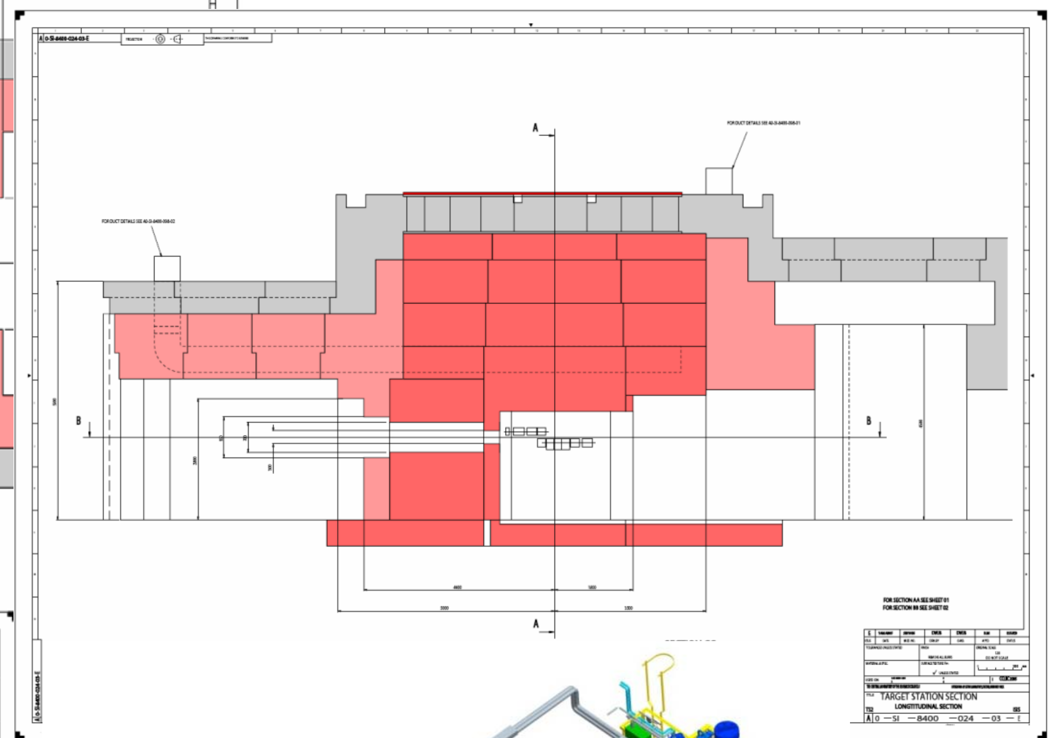
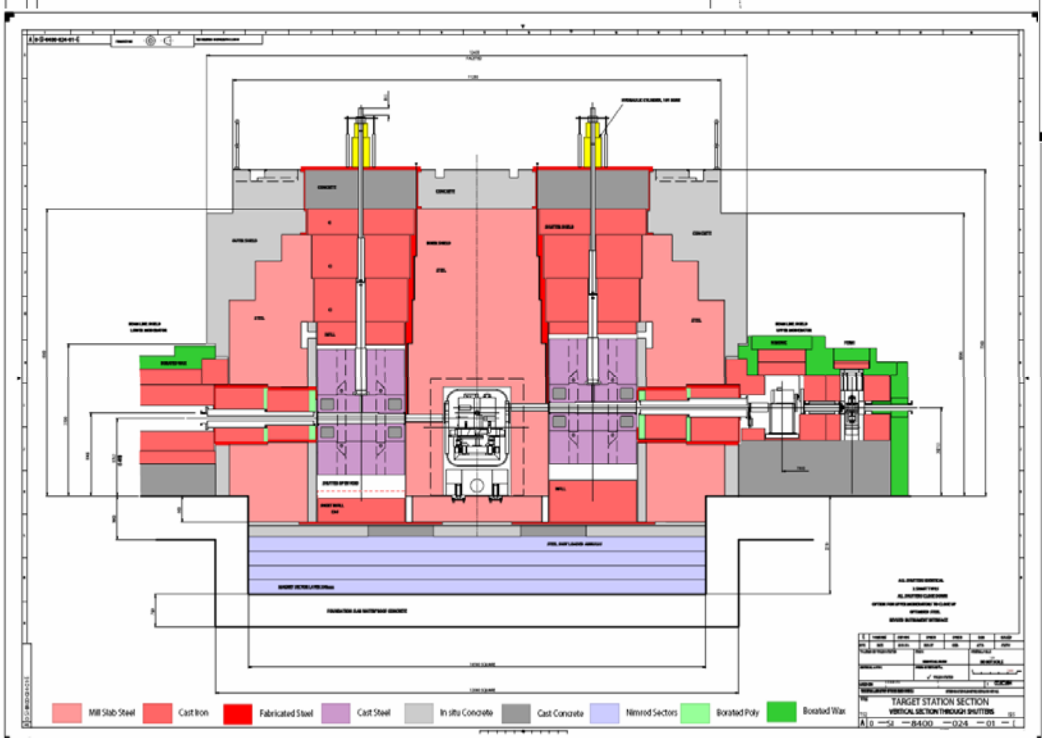
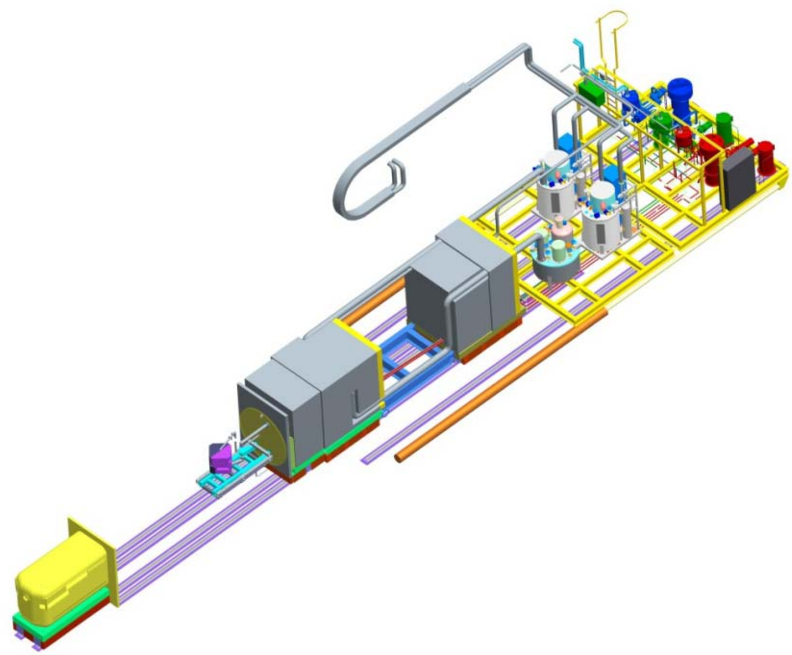
TS2


LOWER MODERATOR


TARGET STATION SECTION
LONGITUDINAL SECTION


TARGET STATION SECTION
VERTICAL SECTION THROUGH SHUTTERS
Mild Slab Steel
Cast Iron
Fabricated Steel
Cast Steel
In situ Concrete
Cast Concrete
Nimrod Sectors
Borated Poly
Borated Wax



Support Facilities

Addition of TS2

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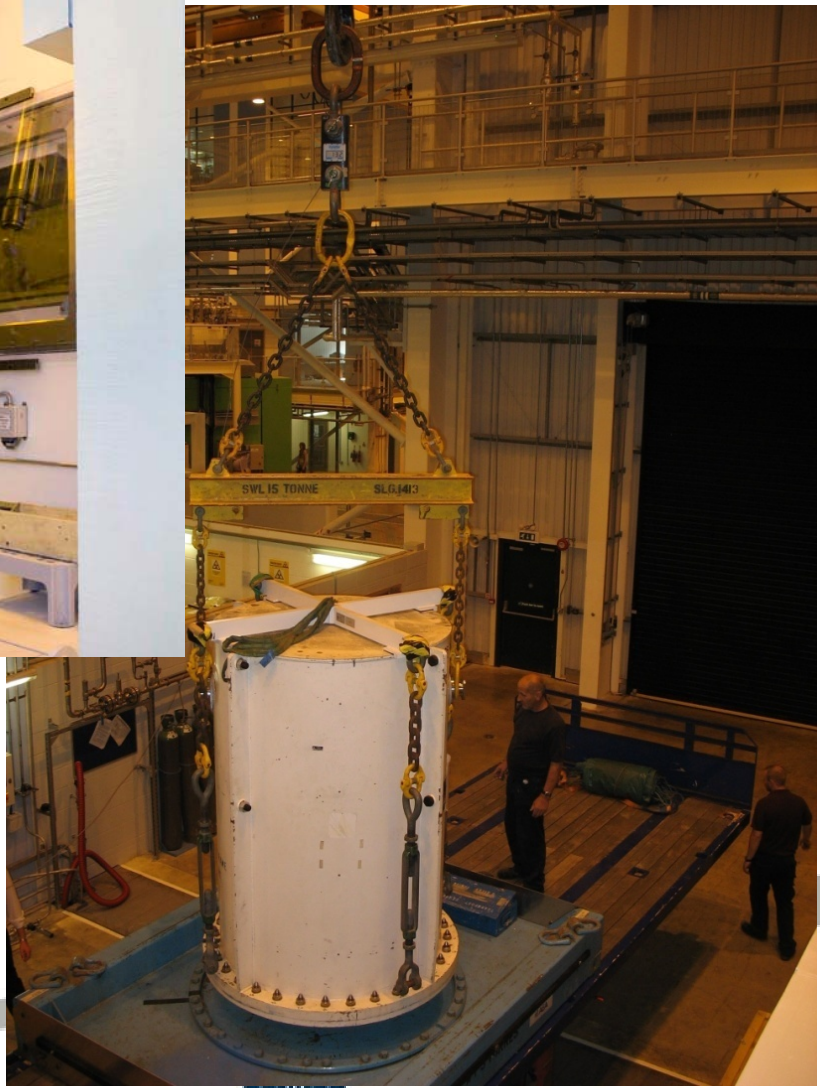
Waste Handling



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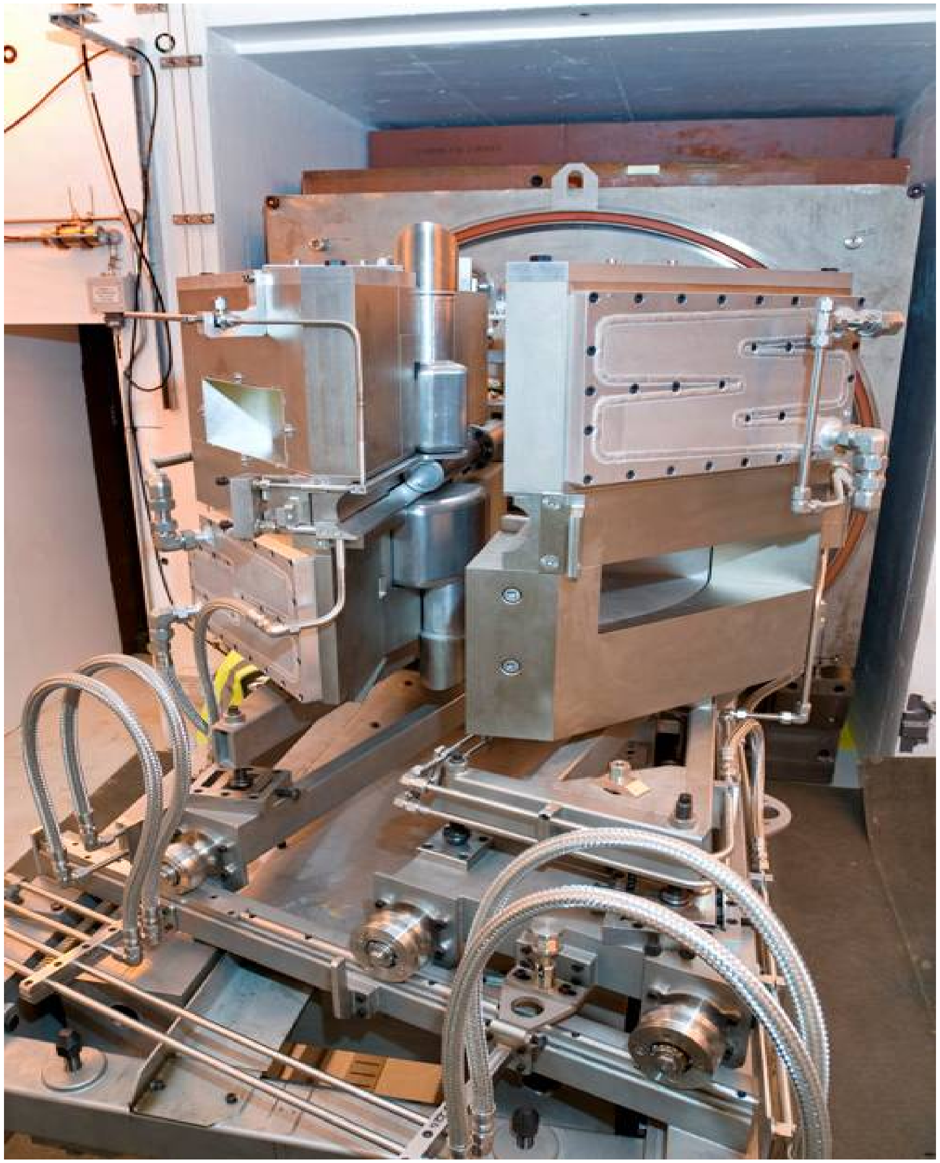
Changes



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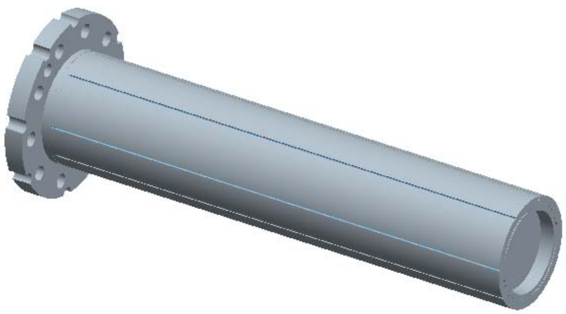
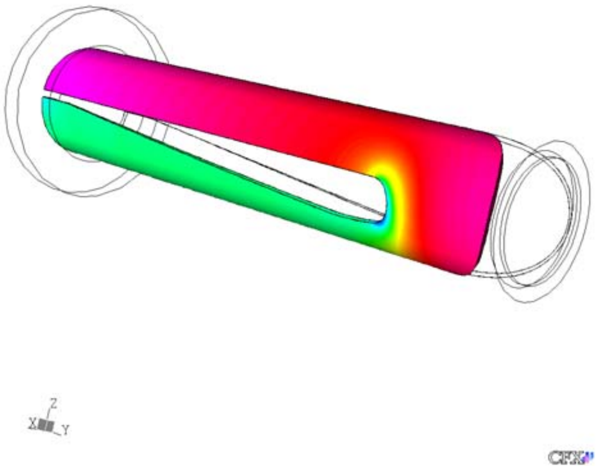
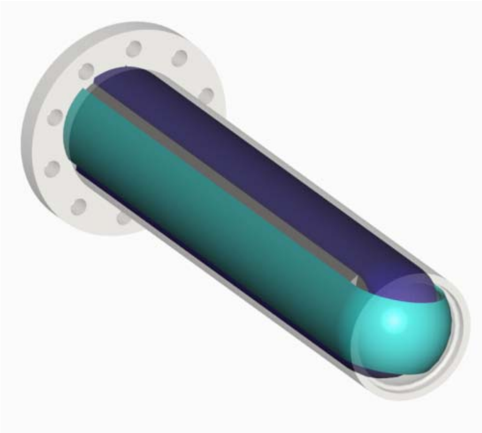
Target evolution







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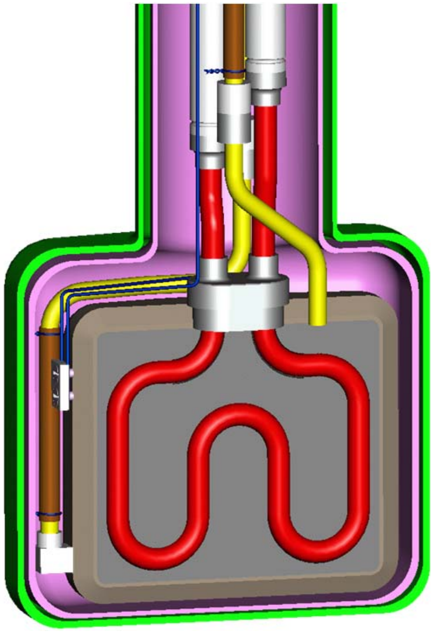
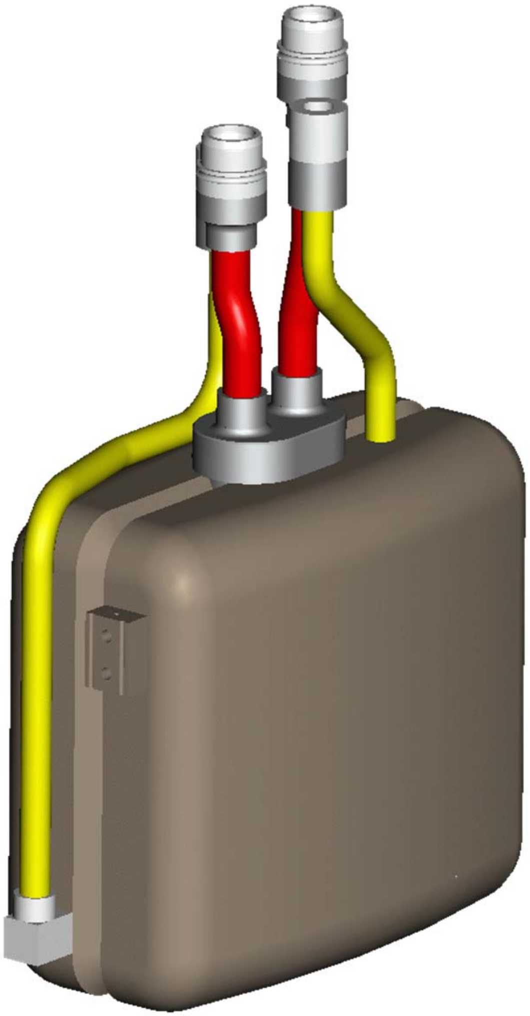
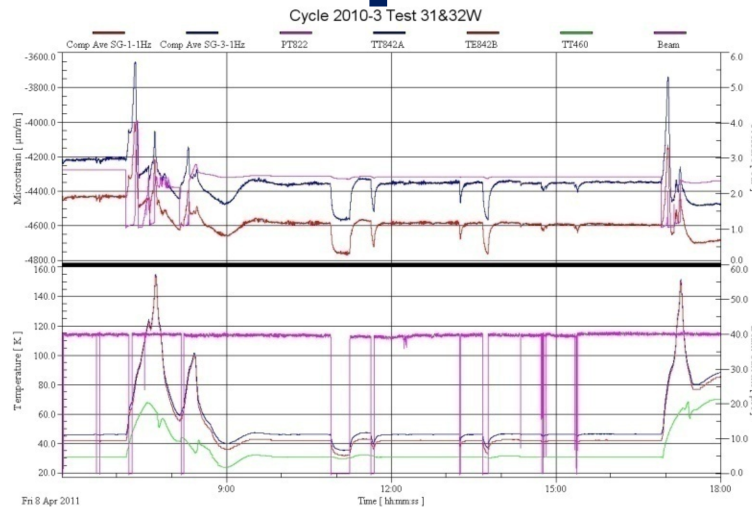
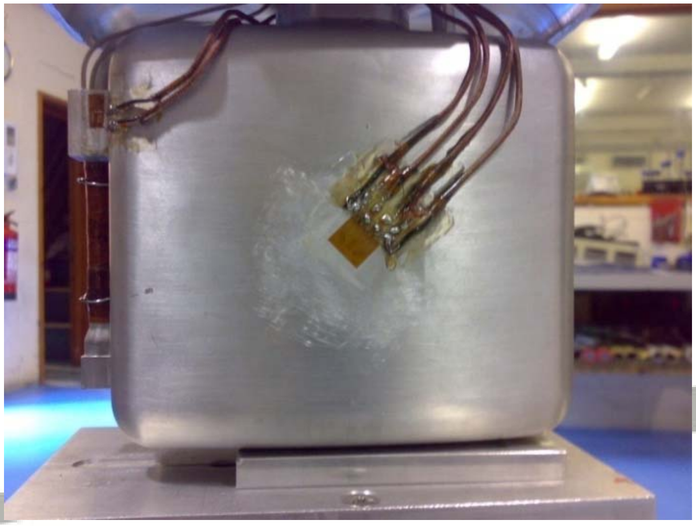
Moderator development









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Additional Liquid Metal Target Challenges

Design and Operational Features of a Mercury Target Facility

IDS-NF Kickoff Meeting Presentation, CERN, Dec 2008

Slides from Van Graves

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Support Facilities

1. Mercury Containment
   – No leaks are acceptable outside the hot cell.
   – Inside the cell, leaks are assumed.
2. Hot Cell / Remote Handling
   – All mercury target and process components must be contained, maintained, and packaged for off-site disposal inside the hot cell to avoid the spread of mercury
3. Ventilation / Filtration
   - Mercury vapor must be removed from the cell exhaust prior to subsequent conventional particulate filtration (HEPA).
4. Waste Handling
   – All hot cell and ventilation system waste will be mercury contaminated. Activated mercury contaminated waste must be fully contained.
   – In the US, mercury treatment and disposal is governed by the Resource Conservation and Recovery Act (RCRA).
   – Since SNS mercury is radioactive, additional requirements apply. In the US, this type of waste is called "mixed waste". Disposal options are VERY limited.

Support Facilities

7. Operational Considerations

- The SNS mercury target system has proven to be extremely reliable.
- Major operational considerations associated with a mercury process.
  - TARGETS: Mechanical change out of a mercury target module is similar in nature to a similar solid target.
  - PROCESS EQUIPMENT: **Remote handling requirements of mercury pump, HX and piping are complex and will result in significant maintenance downtimes times and general operational risk.**
    - Failed mercury components cannot be repaired in-situ, full assemblies must be replaced.
    - It is difficult to incorporate redundant mercury process elements (pump, HX, monitors, valves) due to increased cell volume requirements and the need for more valving. **Redundancy may actually make the process less reliable.**
  - **MAINTENANCE EQUIPMENT: Maintenance and monitoring of remote tooling is significant operational cost, frequently greater than the operational costs associated with the process.**

Lesson Learned from NuMI: Radiation Accelerated Corrosion

- Ionization of air surrounding a target by primary and secondary particles can create a very aggressive, corrosive environment
- High strength steel may suffer hydrogen embrittlement (MiniBooNE, NuMI)
- Coupled with radiation damage of material, not only accelerates corrosion, but changes the nature of the corrosion morphology (localized pitting versus uniform layer; NuMI decay pipe window)

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Radiation Accelerated Corrosion

- Al 6061 samples displayed significant localized corrosion after 3,600 Mrad exposure
- NuMI target chase air handling condensate with pH of 2
- NuMI decay pipe window concerns

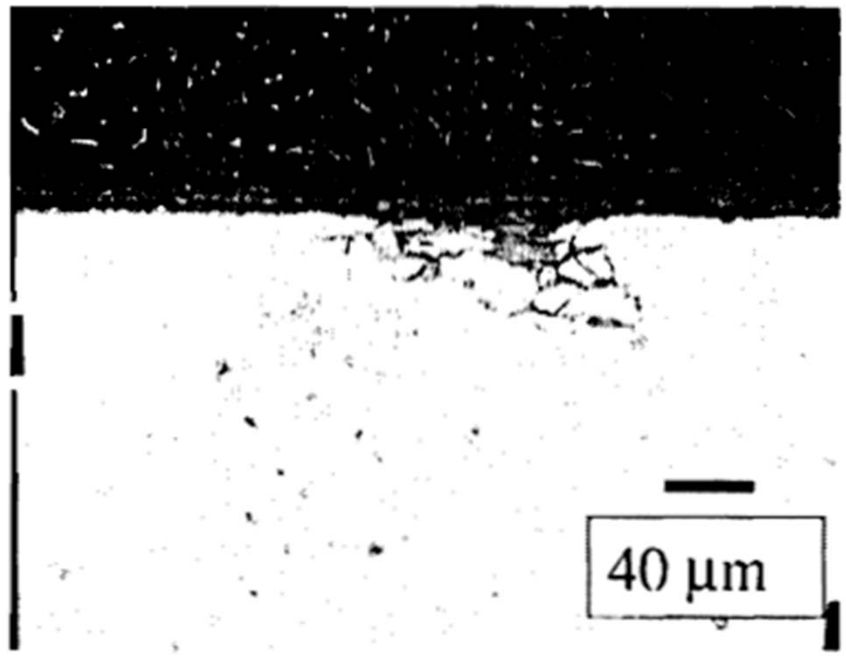
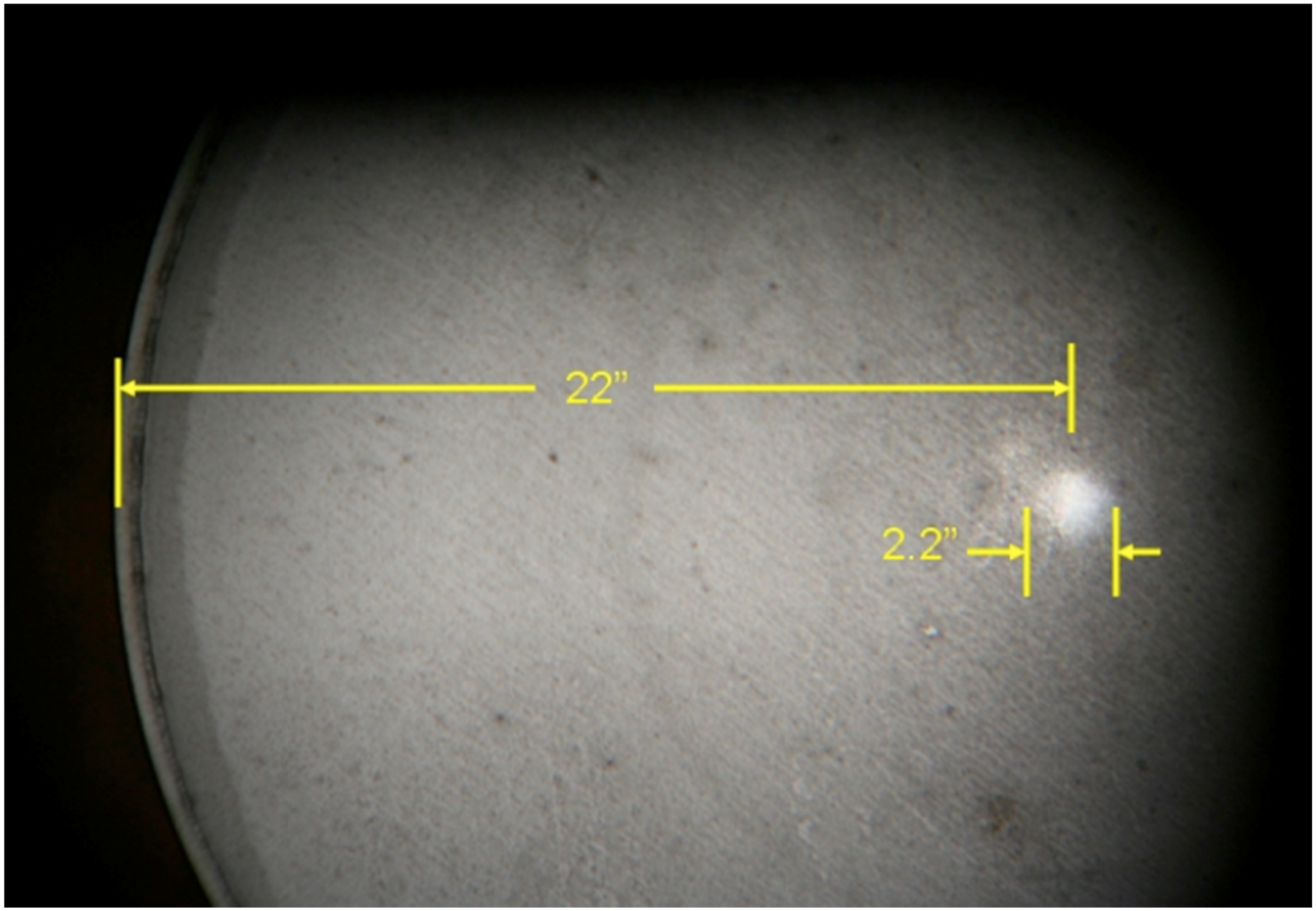


FIG. 8. Localized corrosion on 6061 Al sample exposed 12 weeks to saturated water vapor at 200°C and gamma irradiation.

R.L. Sindelar, et al., *Materials Characterization* 43:147-157 (1999).

Radiation Accelerated Corrosion



- Photograph of NuMI decay pipe US window showing corroded spot corresponding to beam spot

Radiation Accelerated Corrosion

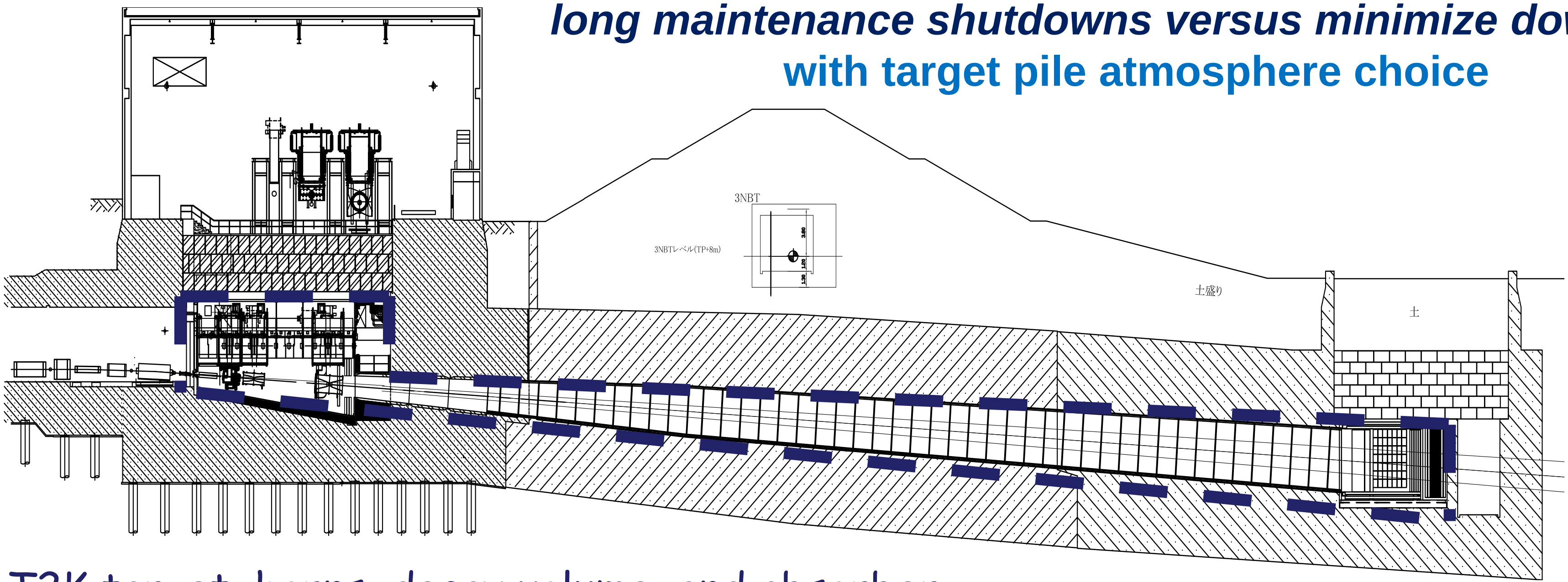
- MiniBooNE 25 m absorber HS steel failure
- (hydrogen embrittlement from accelerated corrosion).

Illustrate approaches

repair versus never fail,

long maintenance shutdowns versus minimize down time

with target pile atmosphere choice



T2K target, horns, decay volume, and absorber
are all in helium volume (air evacuated before helium fill)

Compared to NUMI & CNGS, where everything except decay pipe is in air

Helium advantages:

- *reduce corrosion*
- *don't need large volume for radio-activated air to decay before release to atmosphere*

Dis-advantages:

- *requires pressure-tight volume in places that radiation will make hard to repair*
- *extra time for target-pile intervention (months versus days)*

Opportunities for Facility Design Collaborative Activities

- Participate in conceptual design and review activities for future target facilities
- Simulation of shielding geometries (with gaps) and verification testing (perhaps leading to useful empirical correlations for facility designers)
- Study of corrosive effects of ionized air (including analysis of NuMI air samples)
- Develop methods of inerting target environment while still allowing for quick repair and replacement access

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Opportunities for Facility Design Collaborative Activities

- Development and testing of alternative, novel shielding materials/methods (heavy foam?, marble, inverted/portable hot cell/"shark cage")
- Development of inexpensive, reliable redundant drive systems for overhead girder/bridge cranes.
- Development of liquid metal/flowing powder containment and clean-up methods.
- Development of reliable 5 years plus diagnostic systems, thermal, strain, visual, acoustic etc

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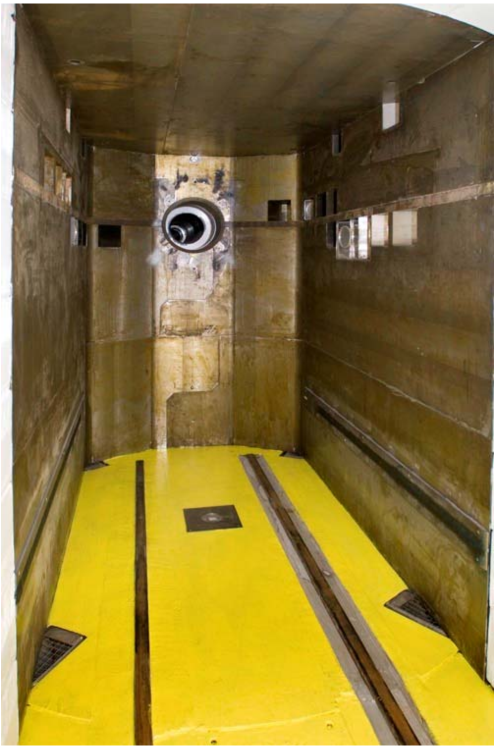




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