Remote Handling

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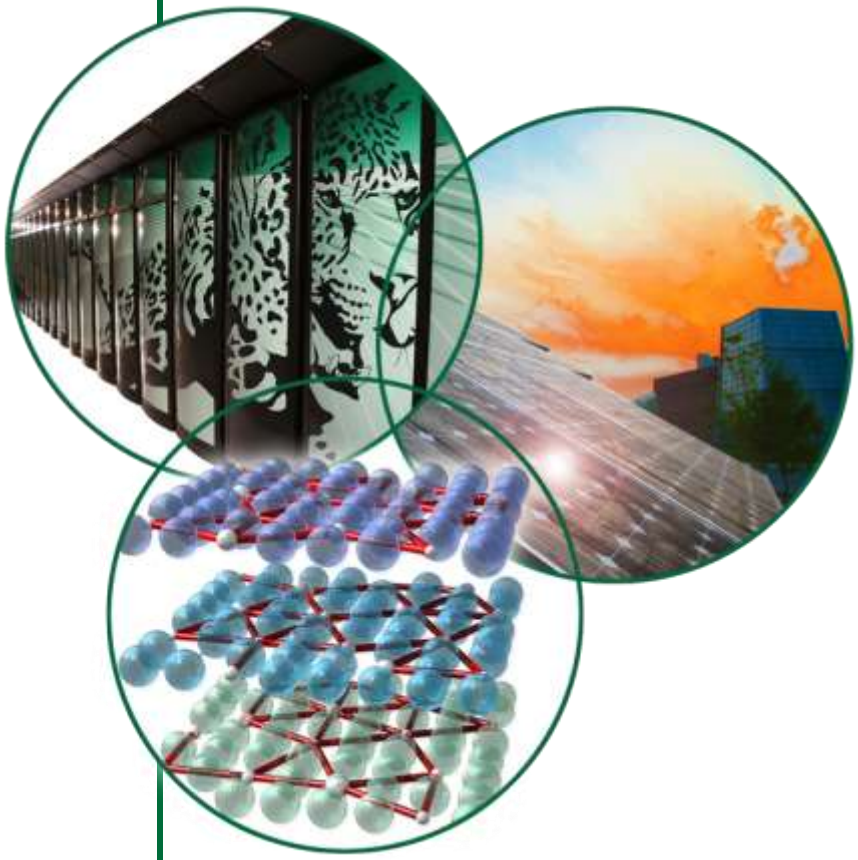

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY

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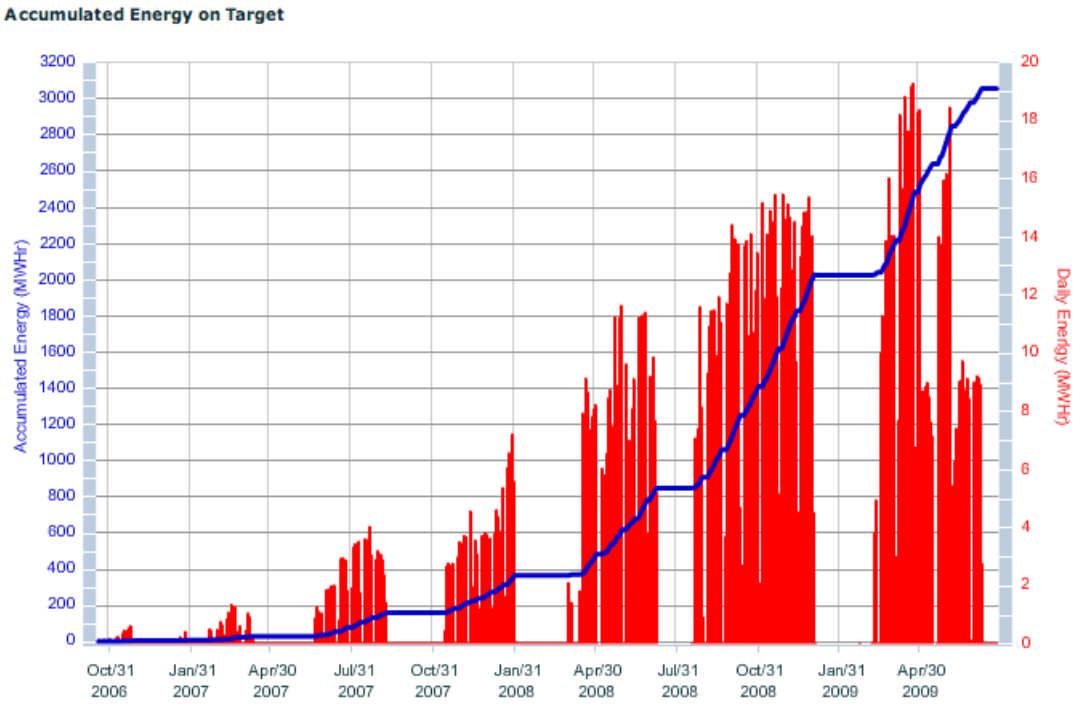
Remote Handling

- Two major remote handling operations were completed during the past year:
  - Replacement of the first Target Module
  - Replacement of the first Proton Beam Window
- Additionally, preparation for future remote handling activities is in work:
  - BL 16 Core Vessel Insert and Primary Shutter Replacement
  - Target Module Post-Irradiation Examination
  - Waste Disposal
    - BL 15, 1 and 14 Shutter Plugs
    - Spent Target Module
    - Proton Beam Window

Replacement of Target Module

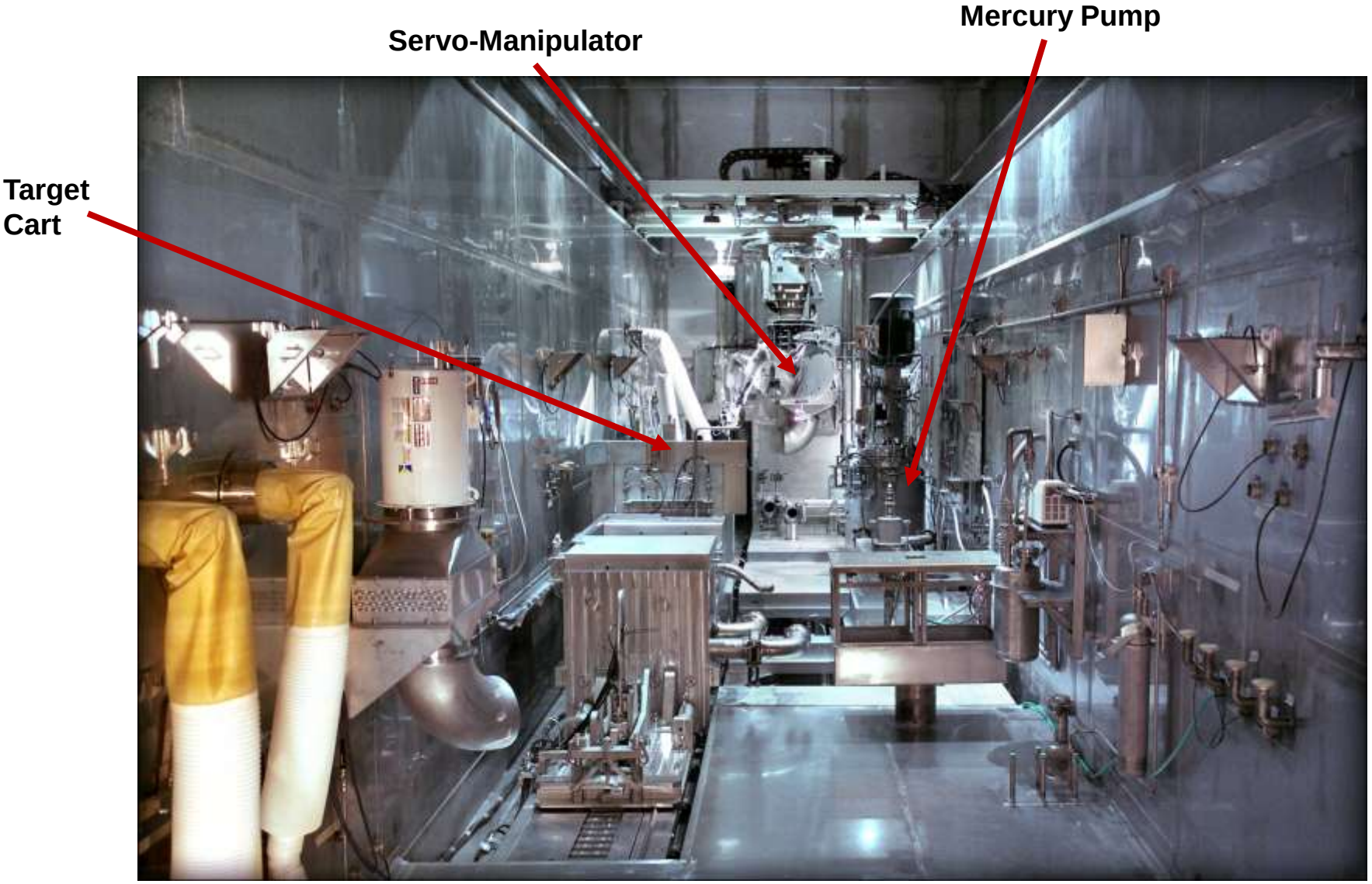
- **Replacement of the first SNS target was successfully completed during a planned outage in August 2009**
  - **Over 3000 Megawatt-hours of accumulated energy had resulted in dpa damage levels which necessitated replacement of the first Target Module**



Replacement of Target Module

- Replacement of the target module was accomplished using only remote handling tooling and procedures (hands-on operations are not possible)
- While the tooling and procedures utilized enabled successful replacement of the target, several design and operational concerns were highlighted during the process
- The following charts give an overview of the target replacement process along with the insights gained

Target Service Bay



Service Bay Size: 31.4 meters x 4.3 meters

Maintenance Equipment

- Four window workstations each containing a pair of master-slave manipulators are built-into the target service bay. Only one is workstation is dedicated to target change-out.
- The servo-manipulator is required to perform most operations including bolt torquing, tool transport, inspections and precision operations.

Manipulator Gallery

Remote Handling Control Room

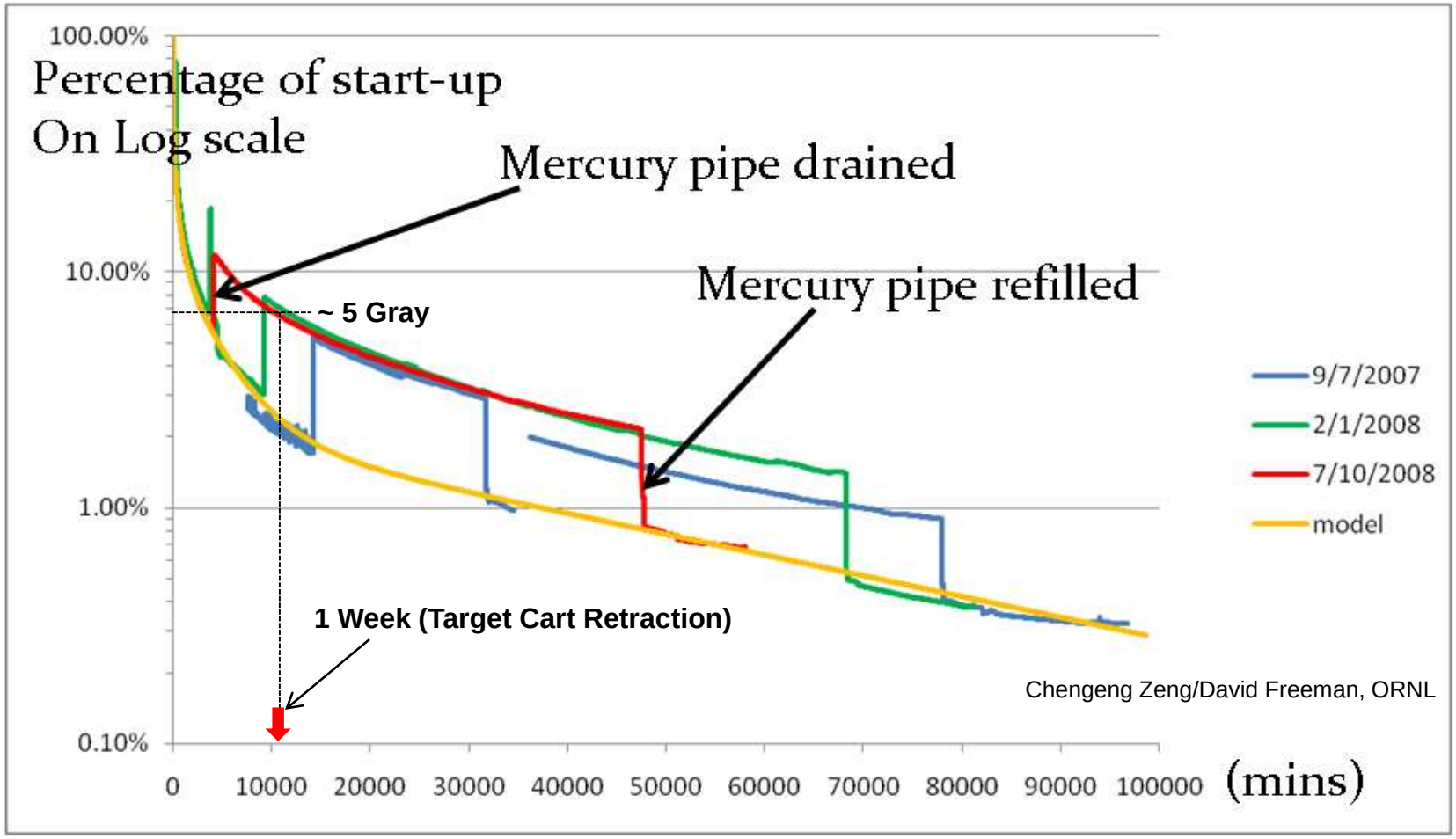
Radiation Environment

- During Beam-On Operations
  - Mercury process equipment contact radiation level is ~400 gray/hr
  - Steel shielding (.2 - .3 m) inside cell reduces area background to ~ 2 gray/hr
- During Maintenance Operations
  - With mercury drained from process lines, residual contamination results in contact radiation levels of 3-5 gray/hr
- Target Radiation Levels (following 400 kW operation)
  - ~14 gray/hr at 1.1 m six days after shutdown
  - Full power targets (2 MW operation) are expected to be ~ 70 gray/hr at 1.1 m

Radiation Environment

- **Dose rates measured on Mercury Process Piping**

SNS Radiation Measurements After Shutdown



Contamination Environment

- Experience has shown that the isotopic particulate contamination is long-lived and wide-spread inside the Service Bay. At the end of the first target change-out the cell background away from the process area had risen from essentially clean (10,000 disintegrations/min smears) to significant levels of contamination.
  - Service Bay contamination has also migrated to the Transfer Bay due to in-cell ventilation systems and movement of the in-cell crane and servo-manipulator into the Transfer Bay as a part of normal operations
    - A recent localized survey yielded 3,000,000 disintegrations/min smears in the Transfer Bay

Major Target Replacement Operations

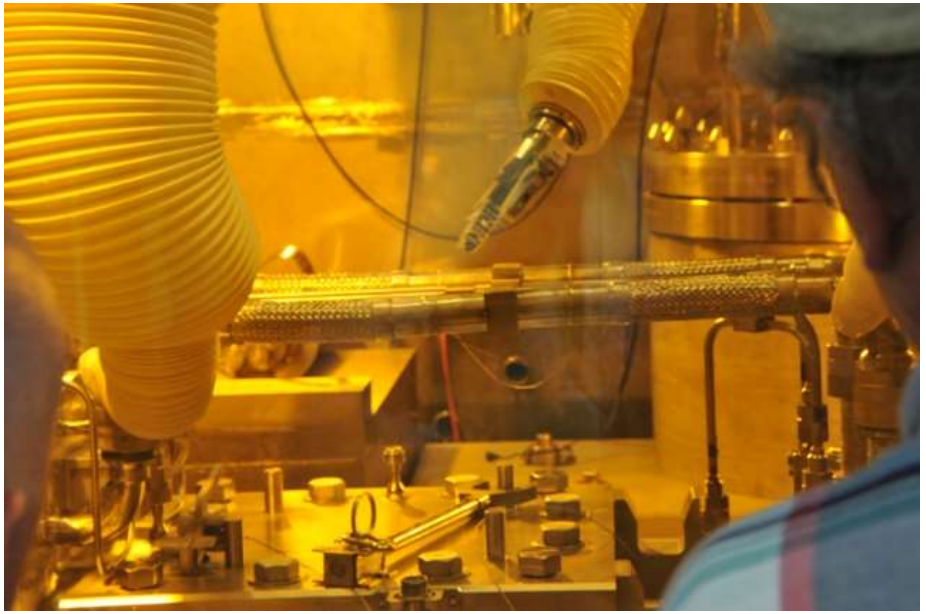
- Removal and reinstallation of the following components take place during each target replacement:
  - Four pieces of in-cell shielding (14 tons of steel)
  - Nine process and utility jumpers at the back of the target cart (1/2 inch fittings in addition to instrumentation connectors)
  - Two 2” and two 6” water coolant and mercury process lines
  - Seven process and utility jumpers at the target (1/2” to 2”)
  - One spent and one new target module (8 ea. 1” tie-down bolts and 4 ea. jack screws)
- Other operations include:
  - Movement of the 100 ton target cart over 9 meters
  - Handling of multiple pieces of tooling
  - Capture and return of released liquid mercury from open pipes
- Requires four person crew/one shift operation

Target Replacement Issues

- Replacement of the target progressed essentially according to plan with only minor issues and delays
  - Target replacement required ~ 90 hrs to complete
- Following replacement of the target module, the target cart was re-inserted and final connections made
- Although no in-process testing was planned during the target change, a vacuum was pulled on the mercury process loop at this point as a preliminary indication of system integrity. A leak was discovered in the process loop.

Target Replacement Issues

- Leak detection activities were impacted as only three of the five mercury process loop connections are accessible with the Target inserted. Retraction of the Target to access the remaining two connections precluded testing due to the open process loop.
- Test fixtures and procedures were developed real-time to enable the leak to be identified. It was ultimately fixed by simply re-torquing a Hiltap fitting.



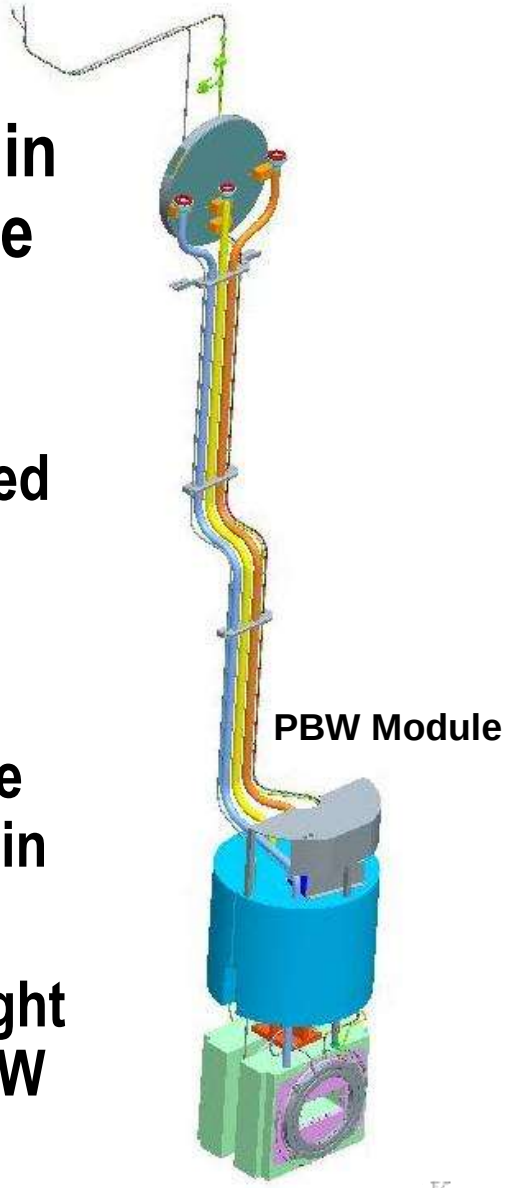
Coolant Loop Jumper Removal using the servo-manipulator and master-slave manipulators simultaneously

Target Replacement Issues

- It took approximately 3 weeks to work though this problem. Many of the tools and procedures developed during that period will be used regularly in future replacements to avoid a repeat.
- Additional procedures will be developed to enable interim testing of the remaining three systems (water, helium and vacuum) to identify potential problems prior to insertion of the Target Cart.
  - These procedures add complexity, time and risk to the replacement process

Proton Beam Window Replacement

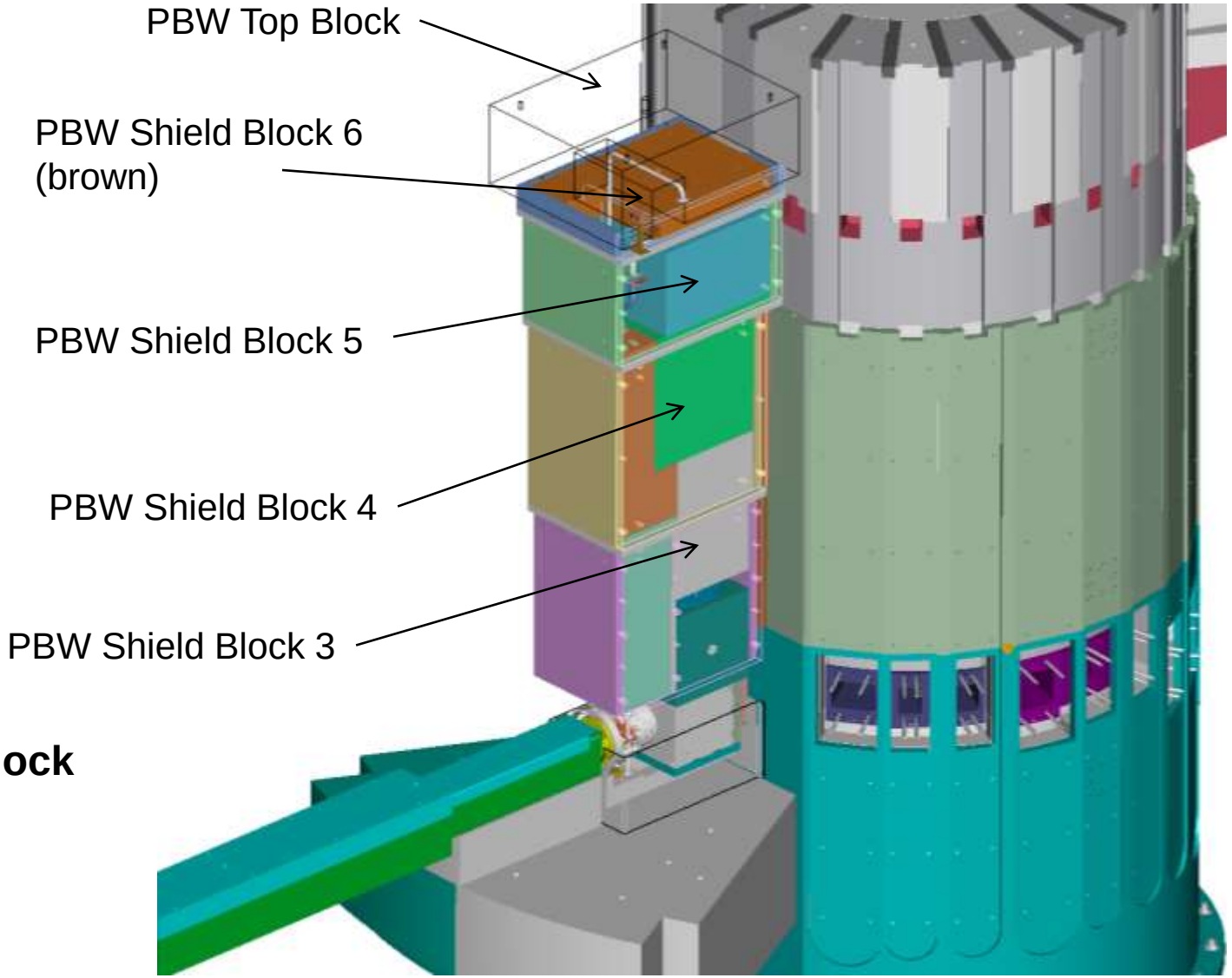
- The first replacement of a Proton Beam Window (PBW) was successfully completed in August 2009 during the planned maintenance shut down period
  - This initially-installed window had received just over 3000 MW-hrs of accumulated energy resulted in an approximate dpa level of 6.5
  - The new Proton Beam Window incorporated the optics portion of the Target Imaging System enabling the viewing of the coated Target Module along with additional halo thermocouples to aid in beam centering
  - Following installation, Core Vessel and RTBT flight tube vacuum leak testing indicated excellent PBW inflatable seal function



PBW Replacement Operations

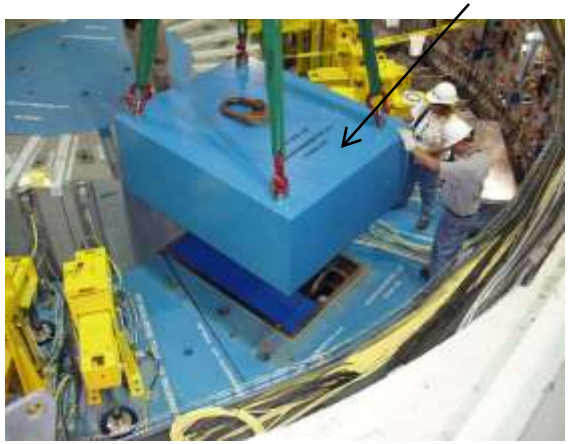
- Replacement of a PBW module involves the following basic operations:
  - Removal of five shield blocks (45 tons of shielding)
  - Drying (water removal) of PBW Module
  - Cutting and removal of activated utility piping
  - Withdrawal of PBW Module from cavity
  - Installation of new PBW module
  - Connection of utility piping
  - Leak testing of inflatable seals and piping connections
  - Re-installation of shielding

PBW Replacement Operations



PBW Shield Block Configuration

PBW Replacement Operations



Shielding Removal to Expose Jumper Cavity

PBW Replacement Operations

Long-Handled Tubing Cutter
Lowered into PBW Cavity

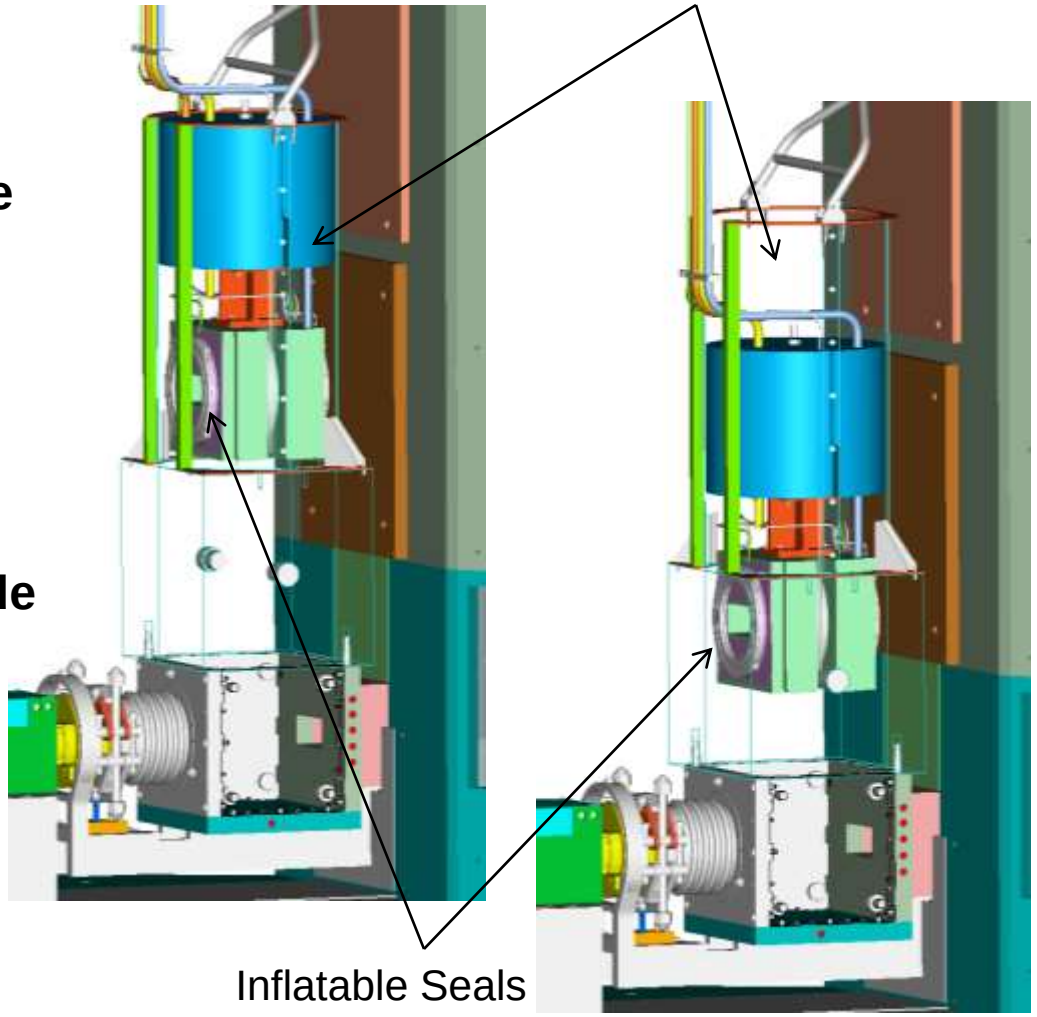
Cutting of Utility Piping

Severing of Helium Line
and Air Sampling Tube Completed

PBW Replacement Operations

Removal and re-installation of the PBW requires retraction of the Inflatable Seals to protect the sealing surfaces on the Core Vessel and RTBT Flight Tube

Installation of the PBW into the Vessel insert requires precision positioning. An installation Guide Can is used to achieve this positioning.



PBW Replacement Operations

PBW Cask In Position

PBW Removal Operation

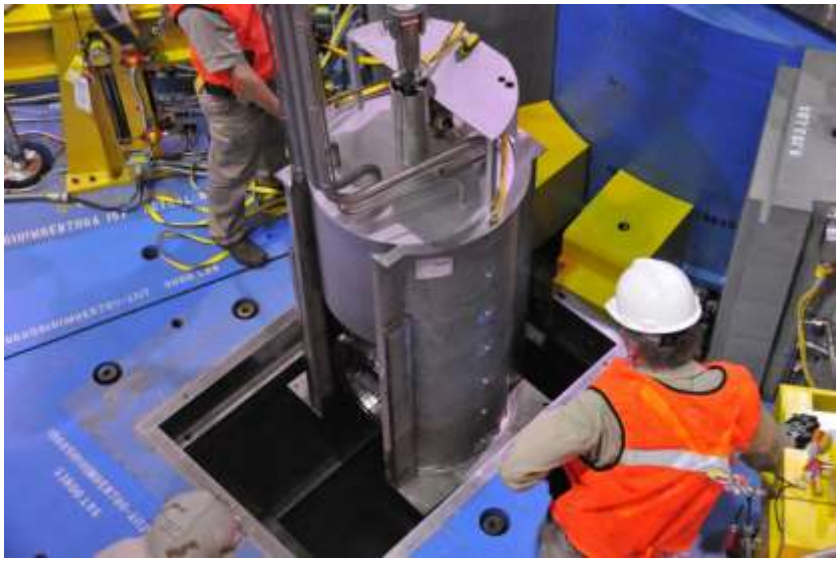
Vacuum Lines Installed to Retract Seal During Removal

Video Image of PBW Being Pulled into Cask

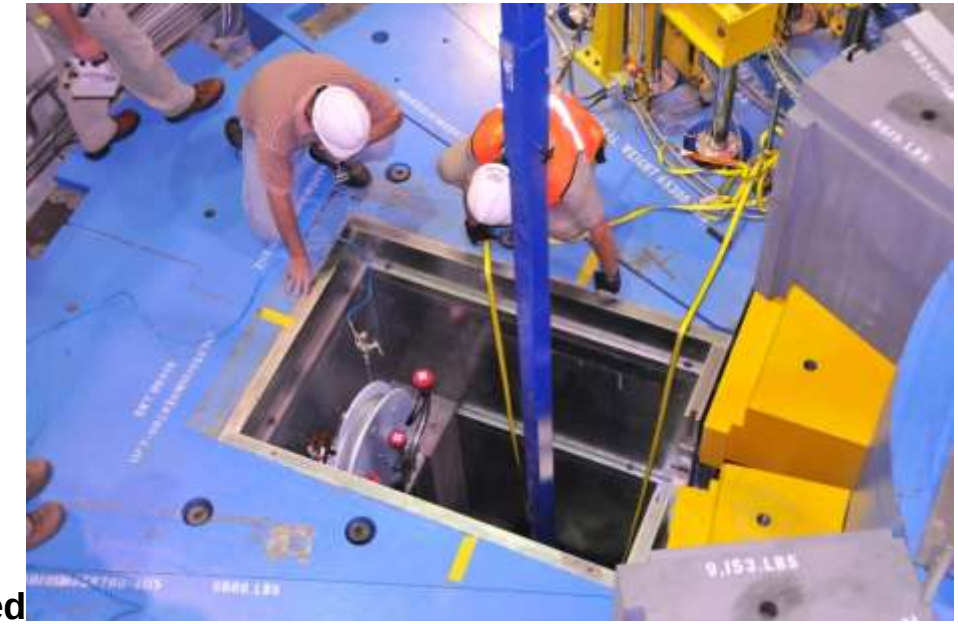
PBW Replacement Operations

New PBW Ready for Installation

New PBW Installation



New PBW Being Lowered into Position



New PBW Installed

Radiological Survey Information

- **Radiological surveys were done during every aspect of PBW removal operations. The following are some of the findings:**

Item	Dose Rates (1)	Contamination
PBW Top Block	Neglible	None
Shield Block 6	Neglible	None
Shield Block 5	.1 - .2 mR/hr	None
Shield Block 4	1.5 mR/hr	21,000 dpm
Shield Block 3	210 mR/hr	150,000 dpm
Utility Piping	~ 150 mR/hr	None (4)
PBW Module	50 R/hr (2)	(3)
Notes:		
1. Contact dose rates unless otherwise specified.		
2. Dose rate at approximately 4 ft - unshielded.		
3. No measurement taken.		
4. No external contamination.		

Radiological Survey Information

- Removal of the PBW jumpers was performed “hands on” following radiological surveys indicating minimal activation
  - General area dose rate at the plane of the Jumper Cavity was 50 microrem/hr
  - Maximum Contact Dose Rate Recorded:
    - 2 mrem/hr contact on the elbow of one of the coolant pipes
  - Contamination:
    - 30,000 dpm/100cm^2 Beta and 150,000 dpm/100 cm^2 Gamma inside the open ends of the jumpers following removal
    - 17,500 dpm H3 found by smearing two small drops of water

Core Vessel Insert Replacement

- The BL 16 Shutter and Core Vessel Insert (CVI) are scheduled for installation during the January 2011 outage
  - This task represents a significant remote handling operation as it combines a shutter change with replacement of the currently-installed CVI plug
    - Three previous shutters have been replaced remotely (BL 1, 14 & 15)
    - A CVI has never been remotely replaced
- All remote handling tooling required for CVI replacement has been delivered and initial mockup testing completed

Core Vessel Insert Replacement

- Replacement of the BL 16 Core Vessel Insert involves the following basic operations:
  - Removal of the shutter drive system hardware (BL 15 and 17)
  - Drying (water removal) of the CVI Plug
  - Removal of the BL 16 concrete shutter plugs
  - Cutting and removal of activated utility piping
  - Withdrawal of CVI from cavity
  - Installation of new CVI into the vessel
  - Connection of utility piping
  - Leak testing of CVI seal and piping connections
  - Installation of new shutter components
  - Installation and testing of shutter drive system hardware

Core Vessel Insert Replacement

- A Mock Up Test Stand (MUTS) has been fabricated and installed in the Target Building to enable the testing of the remote tooling for shutters/CVIs, Proton Beam Window and the Inner Reflector Plug
- The MUTS has been used extensively to test CVI tooling. This testing has:
  - Aided in the development of procedures
  - Identified operational issues with the tooling
  - Revealed clearance issues between tooling and facility
  - Enabled changes to be made to tooling and procedures to ensure successful remote operations

Core Vessel Insert Replacement

- The location of the CVI within the Core Vessel in addition to the high activation levels of the removed CVI plug have necessitated development of a “robot” to perform the replacement operation

CVI Robot Tower

Core Vessel Insert Replacement

- Initial mock up testing of the CVI tooling is complete

CVI lead-filled U-Block tool in position for testing

Long-handled tool testing

CVI Robot lowered into test stand to for functional testing

Core Vessel Insert Replacement

- Future planned work:
  - Release CVI replacement procedures
  - Finalize CVI drying procedure
  - Empty one set of Concrete Shutter Plug Casks for use on BL 16
  - Perform functional testing of CVI Cask to ensure compatibility of tooling interfaces, etc.
  - Place actual BL 16 CVI into MUTS to verify clearances and robot operation

Target PIE Activities

- Several activities surrounding the support of Target Post-Irradiation Examination are in work:
  - Development of a second-generation Target Nose Sampling Cutter to ensure availability for future PIE work
    - Existing Cutter was not fabricated using rad-hard components
    - New Cutter will incorporate minor operational enhancements
  - Ensuring the Wachs saw is complete and ready for installation into the Target Service Bay
    - Installation of the Wachs saw will only be done after careful consideration due to the potential operational impacts of installing such a large complement of hardware in the Service Bay
      - The saw has a large footprint adversely impacting nominal activities
      - Removal of the saw from the Service Bay following use represents significant technical challenges that have not been addressed at this point

Waste Disposal Activities

- Removal of activated components such as the target, PBW and shutter plugs has focused attention on waste disposal operations
  - Routinely replaced components (e.g. targets and proton beam windows) require a dependable process for shipment
  - Limited quantities of storage casks present operational impacts if waste shipments cannot be made
- To date, establishing a reliable waste shipment process has been challenging

Waste Disposal Activities

- Target and Proton Beam Window Shipments
  - Due to the size and activation levels, target and proton beam window modules must use a heavily shielded cask for shipment
  - The SNS facility has been designed to utilize either a Trans-Nuclear TN-RAM cask or an Energy*Solutions* 3-60B cask for these shipments
    - Dry run testing of the TN-RAM cask has not been completed (currently scheduled for May 2010)
    - The 3-60B cask will not be available until late FY 2010
  - Achieving the capability to utilize the TN-RAM cask for target module shipments is an imperative

Waste Disposal Activities

- Target Shipment
  - The following activities are in work to enable target shipments:
    - Cask Liner has been received
    - Target modifications for installation into the Liner have been defined
    - 3-60B Cask dry run testing completed (using a mock up cask)
    - TN-RAM dry run testing is being coordinated for May 2010
    - Cask loading procedures have been developed/approved
  - It is anticipated that a target module shipment will directly follow dry run testing of the TN-RAM cask in May

Waste Disposal Activities

- Proton Beam Window Shipment
  - While the PBW utilizes the same TN-RAM or 3-60B cask, the liner developed for use with the target modules will not accommodate a PBW
    - A modified Liner design is being considered for PBW shipments
    - Procedurally, a PBW is loaded into the shipping Cask in the same manner as a spent target module, so the operational groundwork exists to support shipments
  - Completion of the PBW-specific Liner and availability of the TN-RAM or 3-60B casks drive the PBW shipment schedule

Waste Disposal Activities

- Concrete Shutter Plug Shipments
  - The BL 1, 14 and 15 Concrete Shutter Plugs have been removed and are currently stored in casks at the west storage pad (Hot Pad)
  - BL 16 (and future) shutter replacement activities require re-use of these casks
  - Activities are in work to ship these shutter plug components as waste
    - Waste characterization and profile activities have been completed
    - Coordinating turnover of plugs to Energy*Solutions* for subsequent shipment is in work

Summary

- Successful replacements of Target and Proton Beam Window Modules
  - Lessons learned are being incorporated
- Extensive planning and testing is underway to ensure readiness for BL 16 Core Vessel Insert replacement
- Target PIE support activities are a major focus
- Strong emphasis being placed on waste disposal activities