Operations Experience/ Remote Handling

Mike Baumgartner

Rick DeCosta

John Denison

Mike Dayton

Steve Parsons

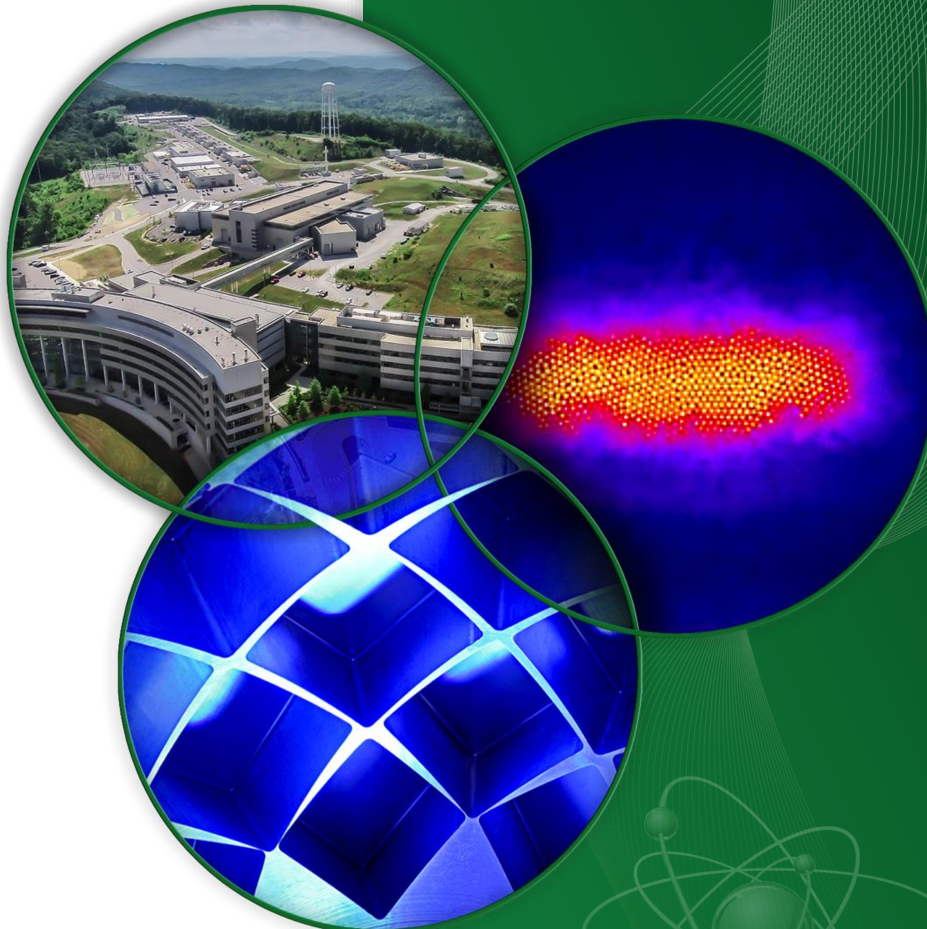
David McClintock

Bernie Reimer

Franz Gallmeier

Drew Winder

Steve Trotter



Outline

- Remote handling in general
  - What we do
  - How we plan
- Major component replacements
  - Targets
  - Proton Beam Windows (PBWs)
  - Shutter and Core Vessel Inserts (CVIs)
- Component Post-Irradiation Examination (PIE)
- Remote handling near term challenges

2013 target recommendations (#24 – 28) were addressed by John Galambos.

Remote Handling Operations at SNS

- Operations are a joint ISD RAD effort.
- Since SNS operation began in 2006, a significant amount of remote handling operations have occurred.
- Remote handling at SNS encompasses
  - Major component replacement/operational planning for
    - Targets
    - Proton Beam Windows (PBWs)
    - Shutter and Core Vessel Inserts (CVIs)
    - Future Inner Reflector Plug (IRP)
    - Future Ring Injection Dump (RID)
  - Component Post-Irradiation Examination (PIE)
  - Waste shipment operations

Operational Planning

- Planning for remote handling operations integrates:
  - Radiation damage end-of-life tracking for major components based on actual power history combined with future estimates of beam power, run schedule, and availability.
  - Beam Line (BL) instrument upgrades (shutter replacements and CVI installations).
- Managing the operation to ensure:
  - New components, tooling, remote handling procedures, and resources are available when needed.
  - PIE resources are available following component removal.
  - Waste shipments are coordinated with conclusion of PIE activities.
- Remote Handling activities have become continuous.

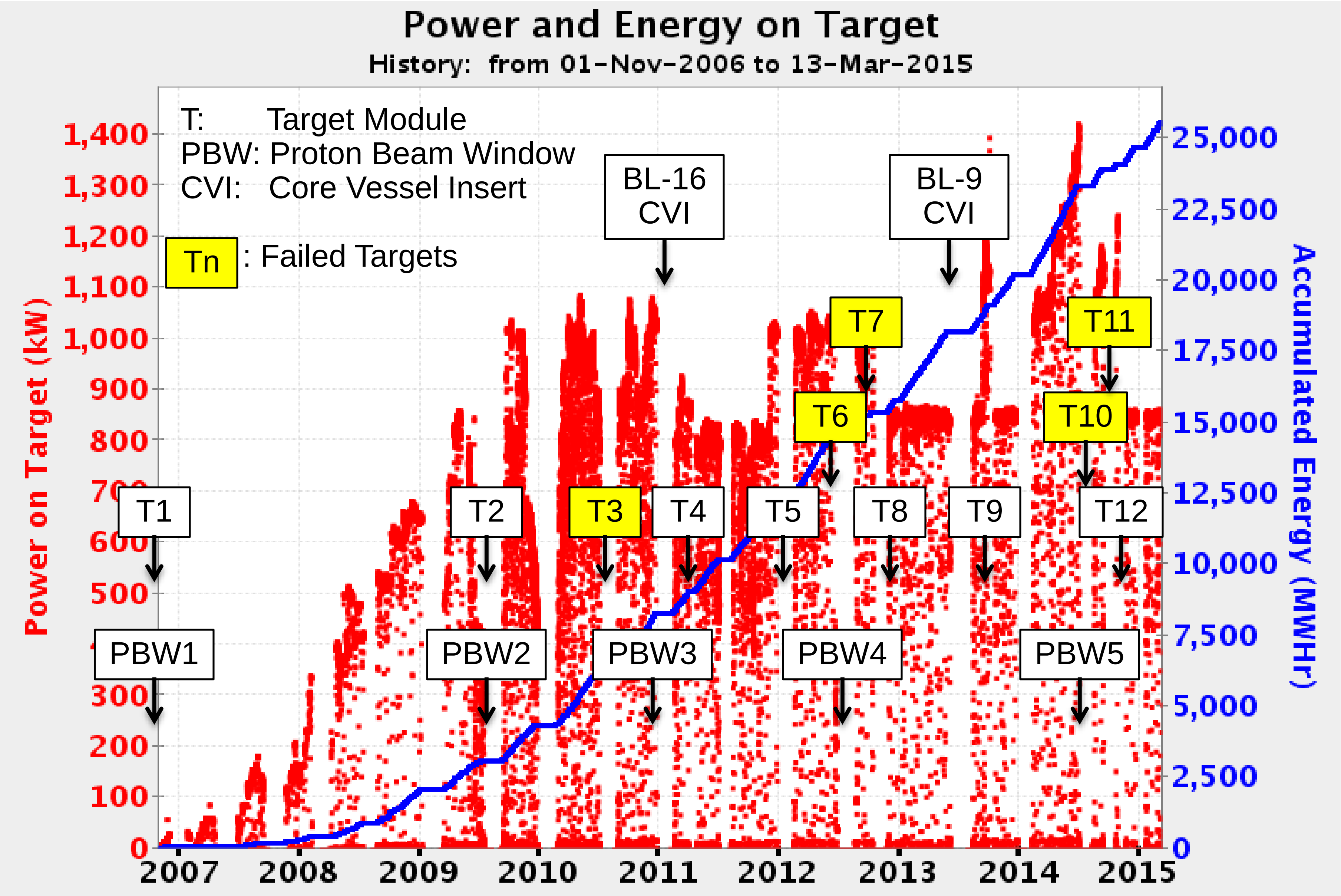
Operational Planning—IRP Example

Actuals in RED

Estimates in BLACK

Month	Power (kW)	Duration (hrs)	% Availability	Estimated MWh	Actual MWh	MWh Cumulative	% of Calculated Limit
Jan-15	850	208	95%	168	**188**	**24830**	77.6
Feb-15	850	528	95%	426	**467**	**25296**	79.1
Mar-15	850	600	95%	485	485	25781	80.6
Apr-15	1400	464	90%	585	585	26365	82.4
May-15	1400	616	90%	776	776	27142	84.8
Jun-15	1400	528	90%	665	665	27807	86.9
Jul-15	0	0	0%	0	0	27807	86.9
Aug-15	1400	400	90%	504	504	28311	88.5
Sep-15	1400	576	90%	726	726	29037	90.7
Oct-15	1400	616	90%	776	776	29813	93.2
Nov-15	1400	552	90%	696	696	30508	95.3
Dec-15	1400	408	90%	514	514	31022	96.9

Remote Installation of Major Components



Target Replacements & Improvements

Target	Serial Number	Date Installed	Date Removed	Accumulated Energy (MW-hrs)	Average Power (kW)	RH Hours to Replace	Calendar Days to Replace
T1	MTX-001				379	150[1]	26[1]
T2	MTX-002				771	96	17
T3	MTX-005				845	102[2]	13
T4	MTX-006				782	69	23[3]
T5	MTM-001				938	159[4]	37[4]
T6	MTX-004				916	63	11
T7	MTX-003						
T8	MTM-003						
T9	ORTE-001						
T10	MTX-007JF						
T11	ORTE-002						
T12	MTM-002						

We've made continuous improvement in remote handling techniques, tooling and procedures, in part to make "run-to-failure" vs.

But, given the nature of remote handling work and the Service Bay environment, target replacement durations haven't always reflected these improvements.

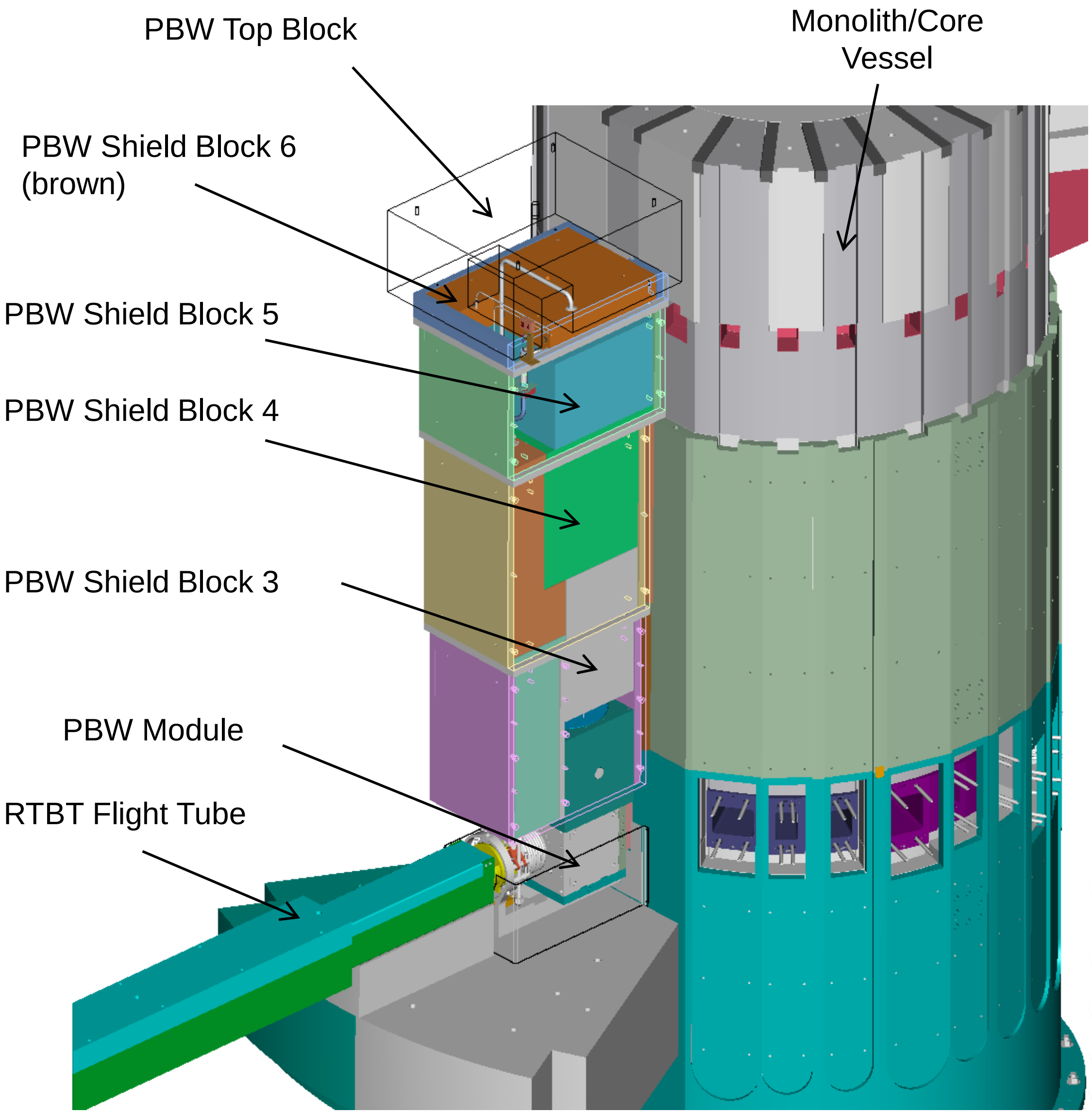
The first ORTE target was a record setter; the second lasted a week. This new technology remains an R&D activity. Similarly, so do SNS remote handling procedures, tooling, and techniques.

1. Estimated; no data taken. Mercury vent line leak identification and re
2. Configuring Service Bay for target change and crane inspection added 2 days of effort.
3. Issue with 7.5T Service Bay crane resulted in a delay of ~7 days.
4. Upper knife edge seal leak on MTX-004 added ~8 calendar days; PBW4 installation added 6 days .
5. Investigation into T6 & T7 failures added ~22 days to T7 replacement.
6. Two crews. IRP Inspection added 1 day. PBW5 installation added ~11 days to complete T9 replacement.
7. Start of T10 replacement delayed 1.5 days due to Service Bay manipulator wiring damage.
8. T11 PIE activities added ~2 days to the replacement.

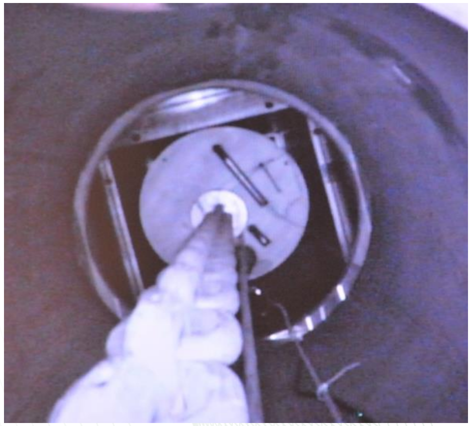
Proton Beam Window Replacements

PBW	Serial Number	Date Installed	Date Removed	Accumulated Energy (MW-hrs)	Average Power (kW)	RH Hours to Replace	Calendar Days to Replace
PBW1	MTM-001	4/26/06	7/31/09	3055	379	?	?
PBW2	MTM-002	8/17/09	1/5/11	5206	?	36.5	9
PBW3	KTC-001	1/5/11	7/30/12	6378	?	36	9
PBW4	KTC-002	7/31/12	7/18/14	8674	?	34	8
PBW5	KTC-003	7/21/14					

PBW Replacement Operation



PBW Lead-shielded Cask in Position

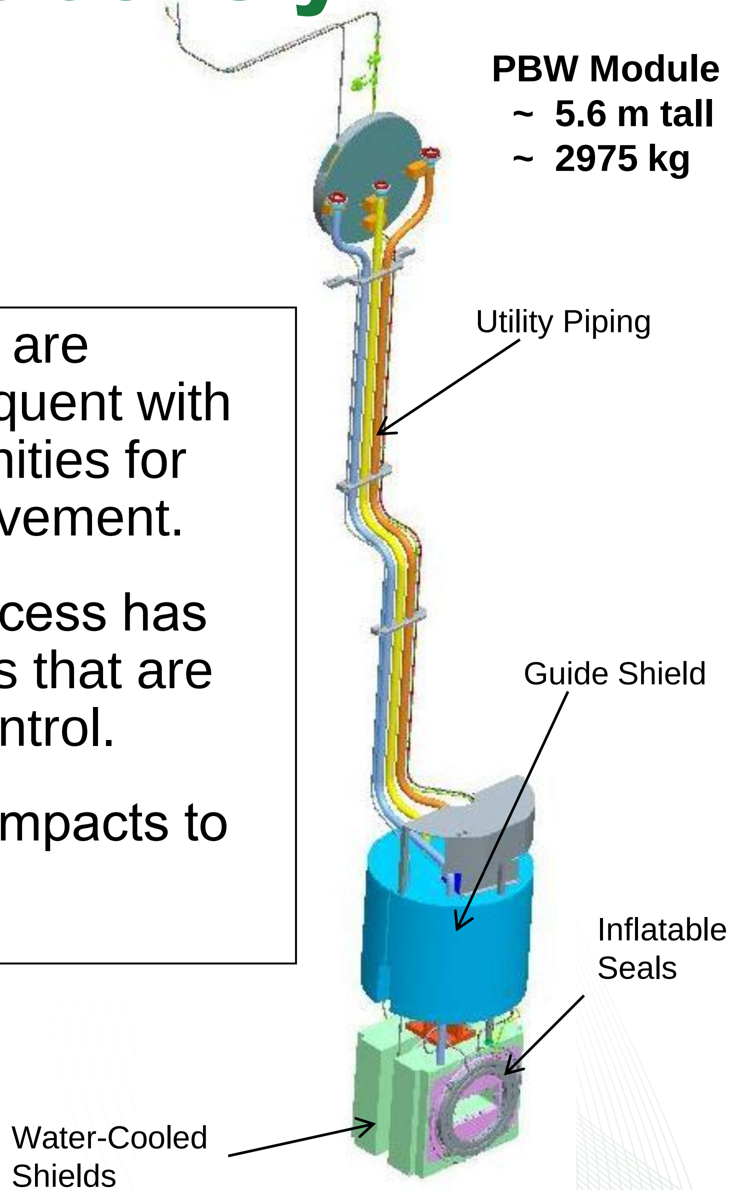


PBW Being Pulled into Cask

PBW Change Process Relatively Unchanged

PBW4 Installation

- PBW changes are relatively infrequent with fewer opportunities for process improvement.
- “Hands-on” access has fewer variables that are beyond our control.
- Fewer “R&D” impacts to PBW design.

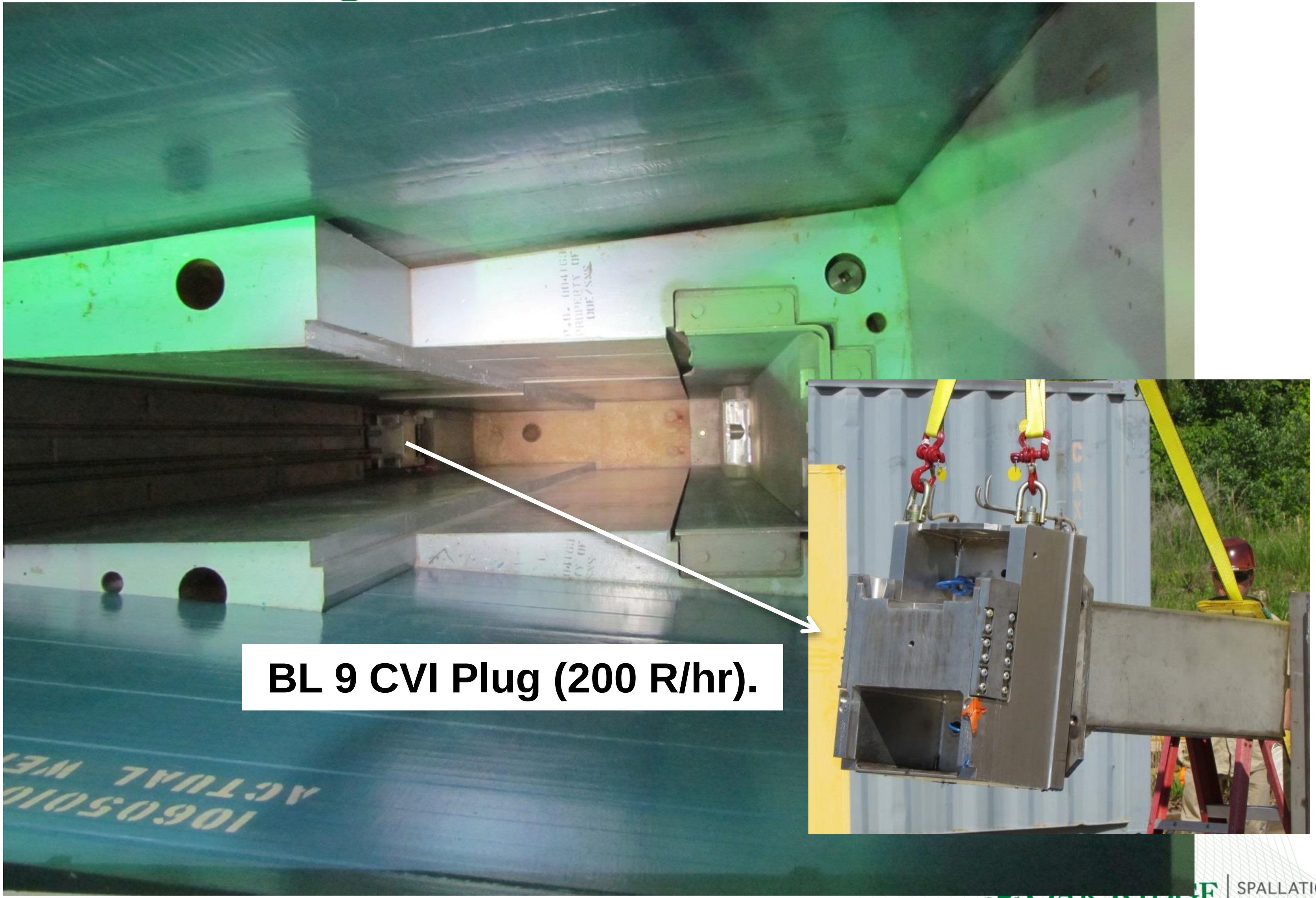


PBW Replacement Challenge: Changing Radiological Conditions

Contact Dose Rates (mR/hr)				
	PBW1	**PBW2**	**PBW3**	**PBW4**
Shield Block 6	<0.2	<0.2	<0.2	<0.2
Shield Block 5	0.1 -0 .2	<0.2	<0.2	0.5
Shield Block 4	1.5	<0.2	2	5
Shield Block 3	680	680	320	800
Utility Piping	120	120	400	600

Be-7 Loose Surface Contamination (dpm/LAS)				
	PBW1	**PBW2**	**PBW3**	**PBW4**
Shield Block 6	Minor Be-7	Minor Be-7	14,000	800,000
Shield Block 5	Minor Be-7	Minor Be-7	Not measured	400,000
Shield Block 4	Minor Be-7	Minor Be-7	1x10^6	2x10^6
Shield Block 3	150,000	150,000	Not measured	1x10^6
Utility Piping	< MDA	< MDA	800,000	1x10^6

BL 9 Shutter and CV Installation: Get The Plug Out From Here



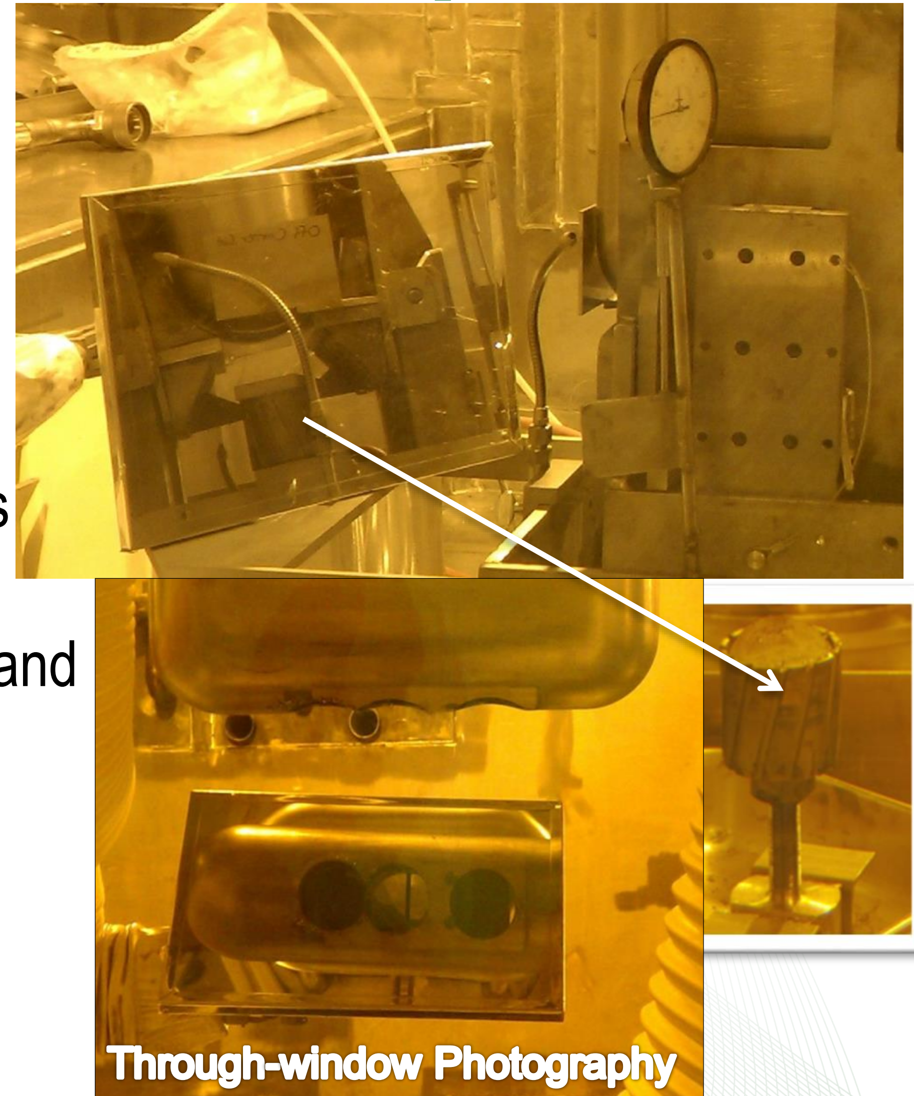
And Get The Shutter and CVI In

BL 9 Shutter

BL 9 CVI

On-site Post-Irradiation Examination (PIE) Capabilities Continue Expand

- Previously presented PIE capabilities:
  - Remote coring of target nose samples
  - Enhanced vertical and horizontal borescope inspection capabilities
  - Pressure and pressure decay testing of both the water shroud and interstitial regions
  - Leak detector testing of installed/removed targets
  - High resolution photography of target modules through shield windows and directly in Transfer Bay

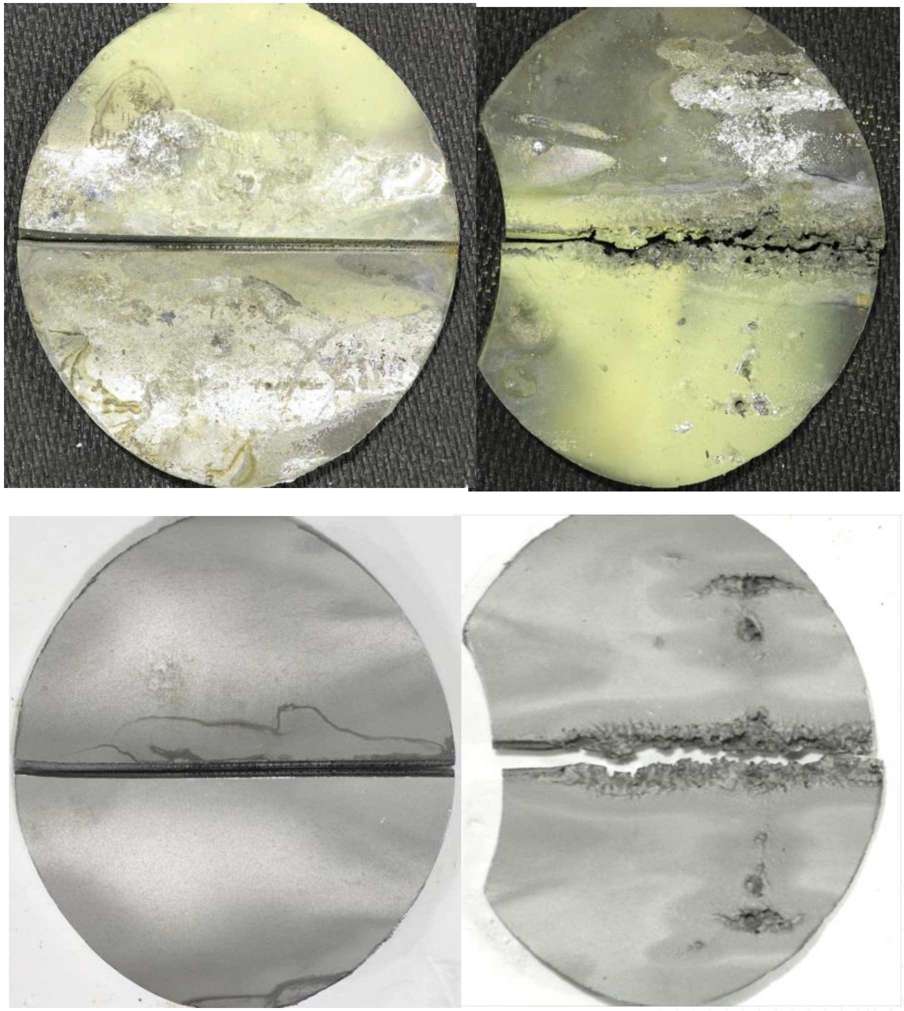


New PIE Capabilities—Ultrasonic Cleaning

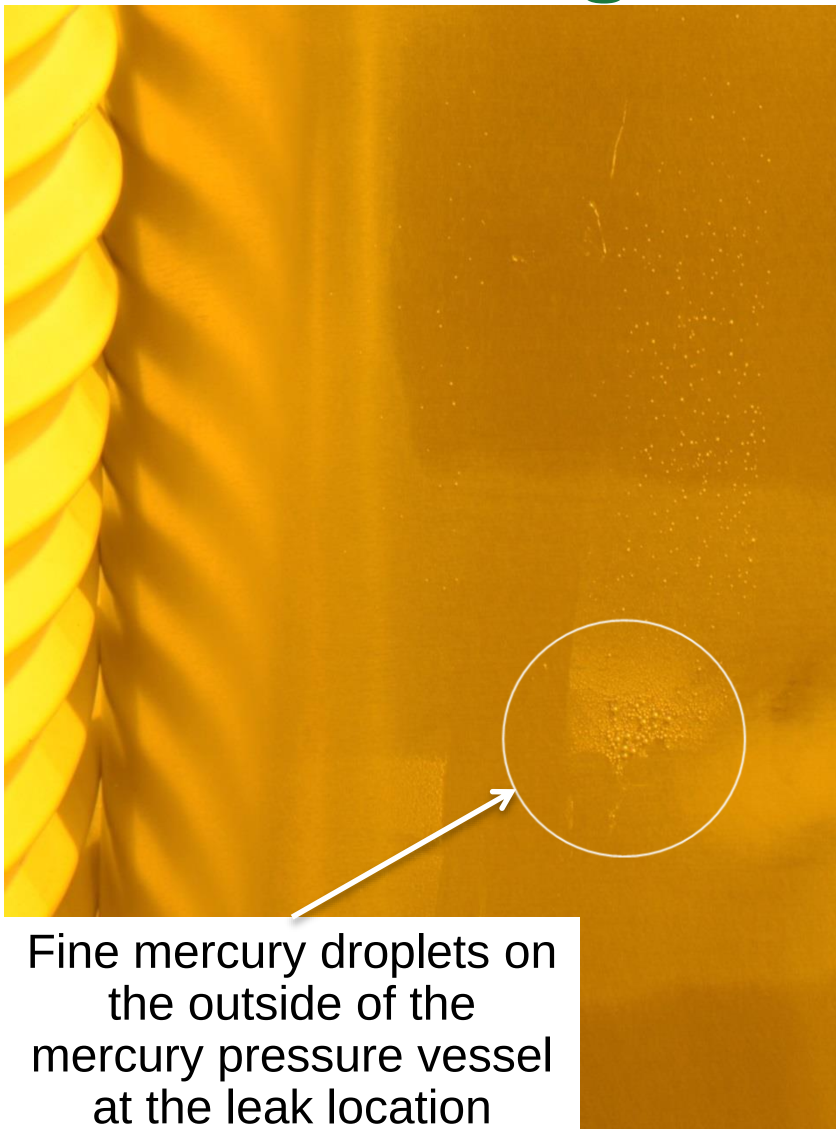
Target 6 – Inner Wall

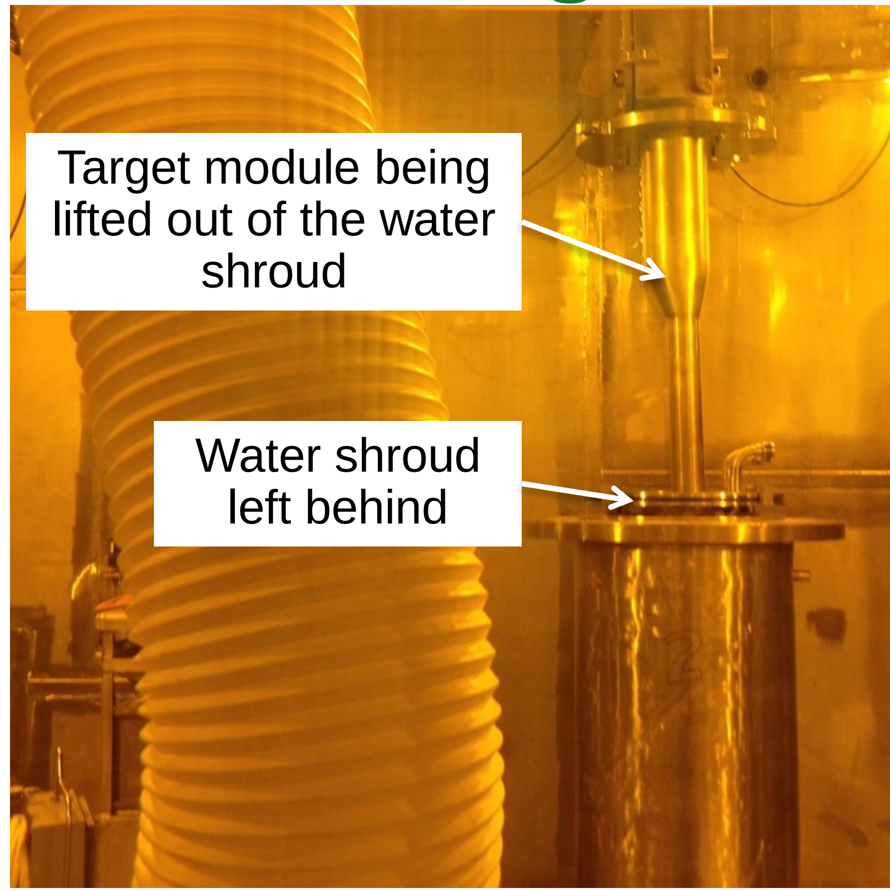
Before Cleaning

After Cleaning



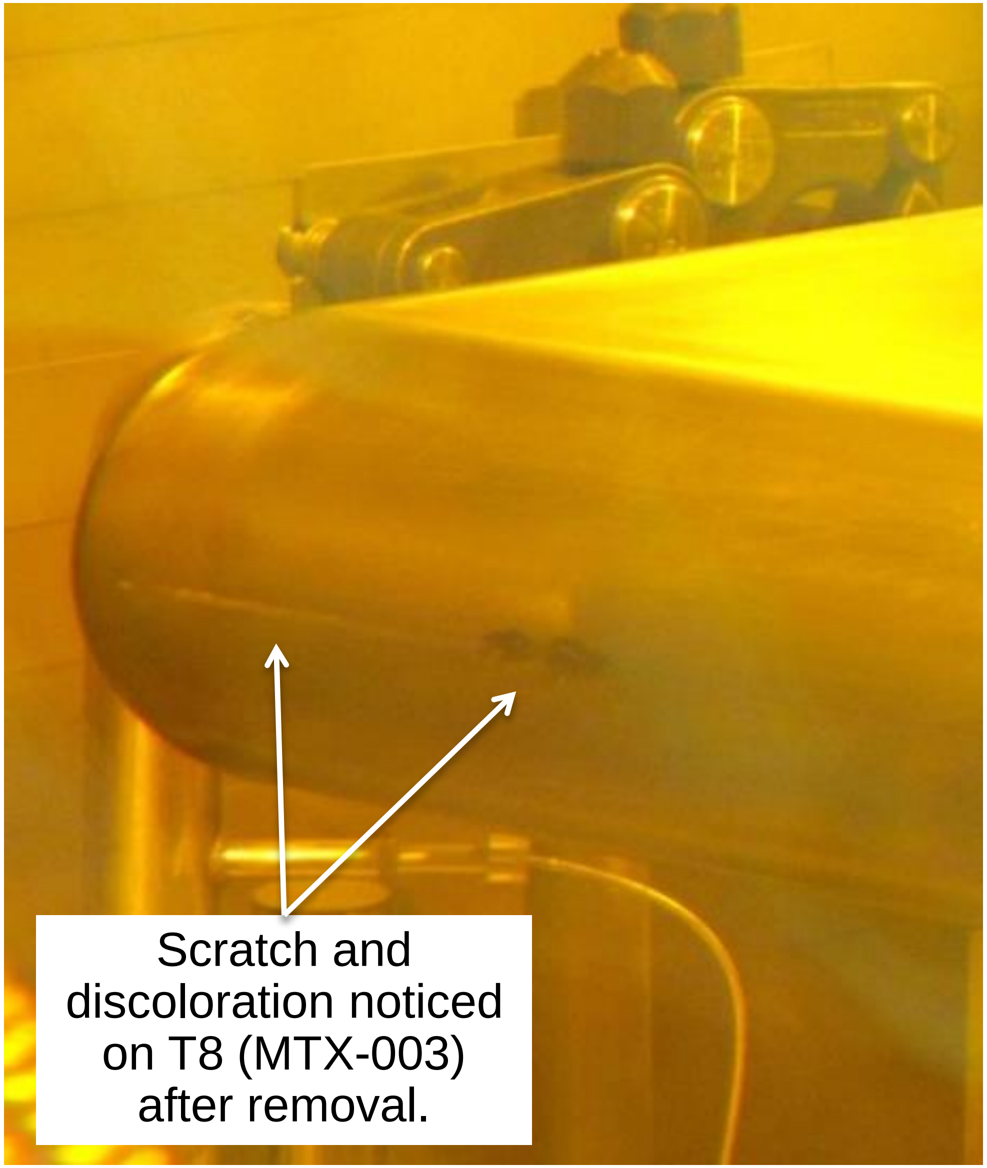
New PIE Capabilities—Removable Water Shroud & Target Module Blanking Plate





- T10 (MTX-007JF) leak location
- New blanking plate used to pressurize mercury side of the target module

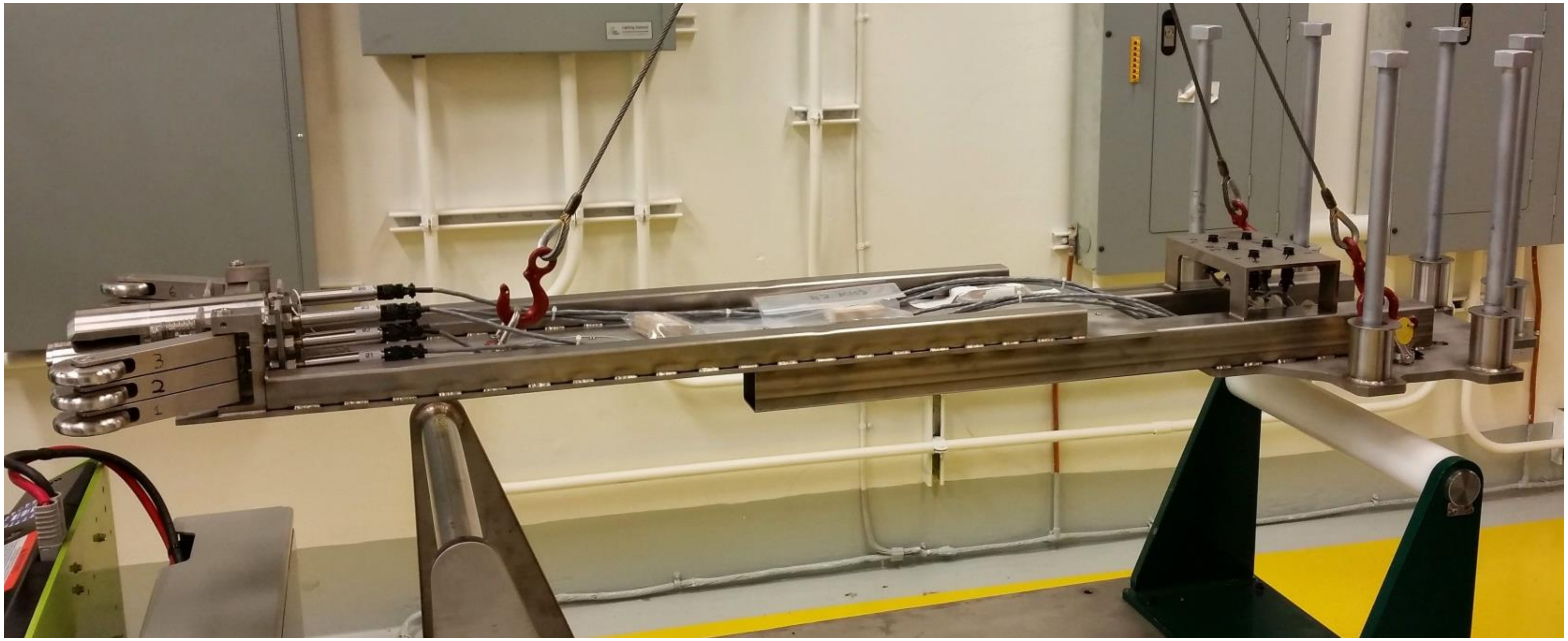
New PIE Capabilities—IRP Inspection



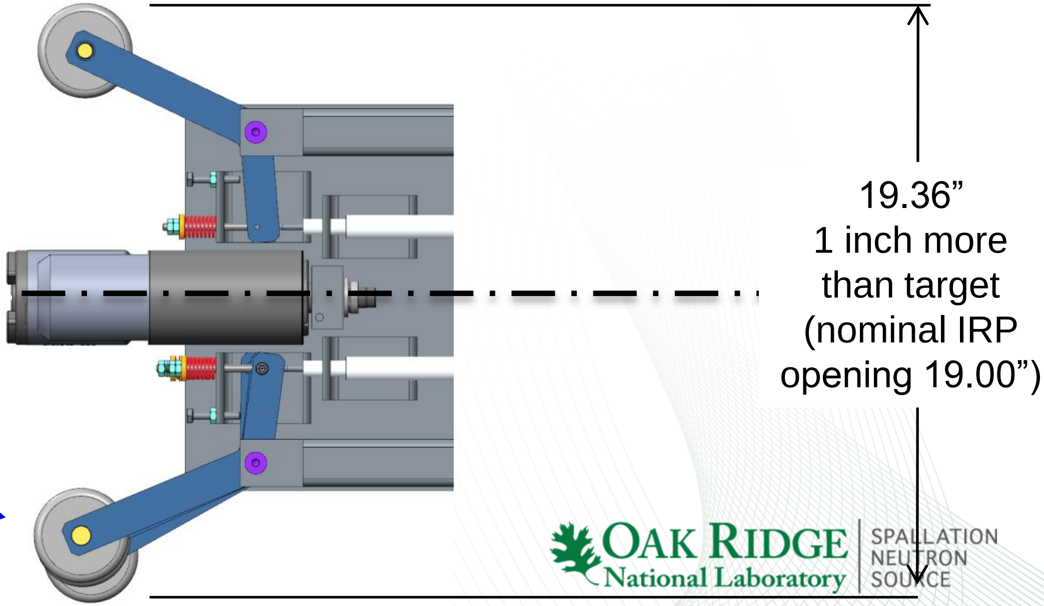
Scratch and discoloration noticed on T8 (MTX-003) after removal.

- What caused the scratch?
  - New IRP interference? (swelling Be reflector?)
  - Target module alignment (relative to IRP) change?
  - Target module dimensional issue?
  - Target carriage alignment issue?
- Could the interference progress to the point we can't insert or extract a target?

IRP Inspection Tool Designed and Built

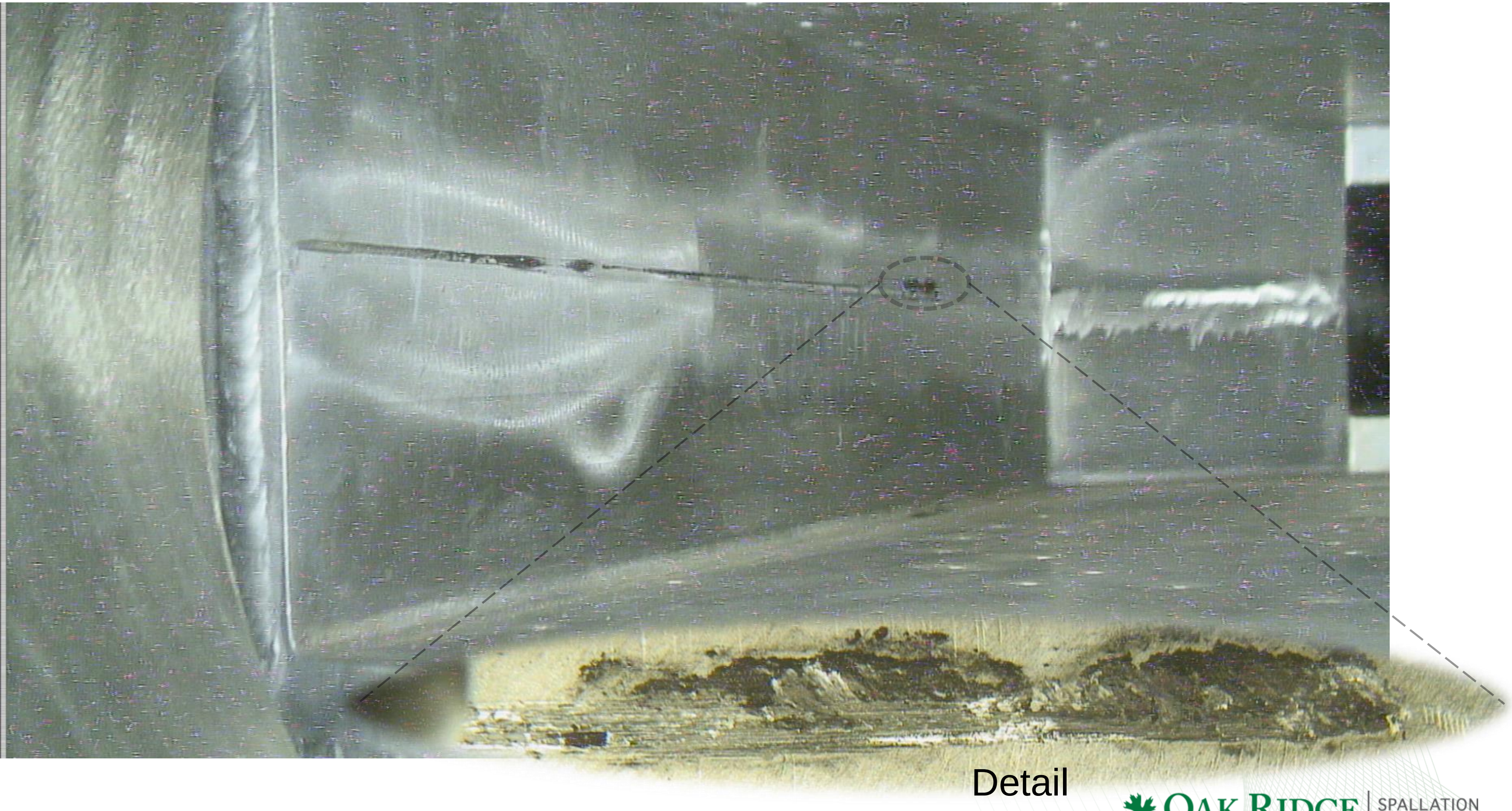


- High-rad camera with off-axis viewing capability enables viewing suspect region.
- Wheels pivot to measure surface deflections during carriage insertion.

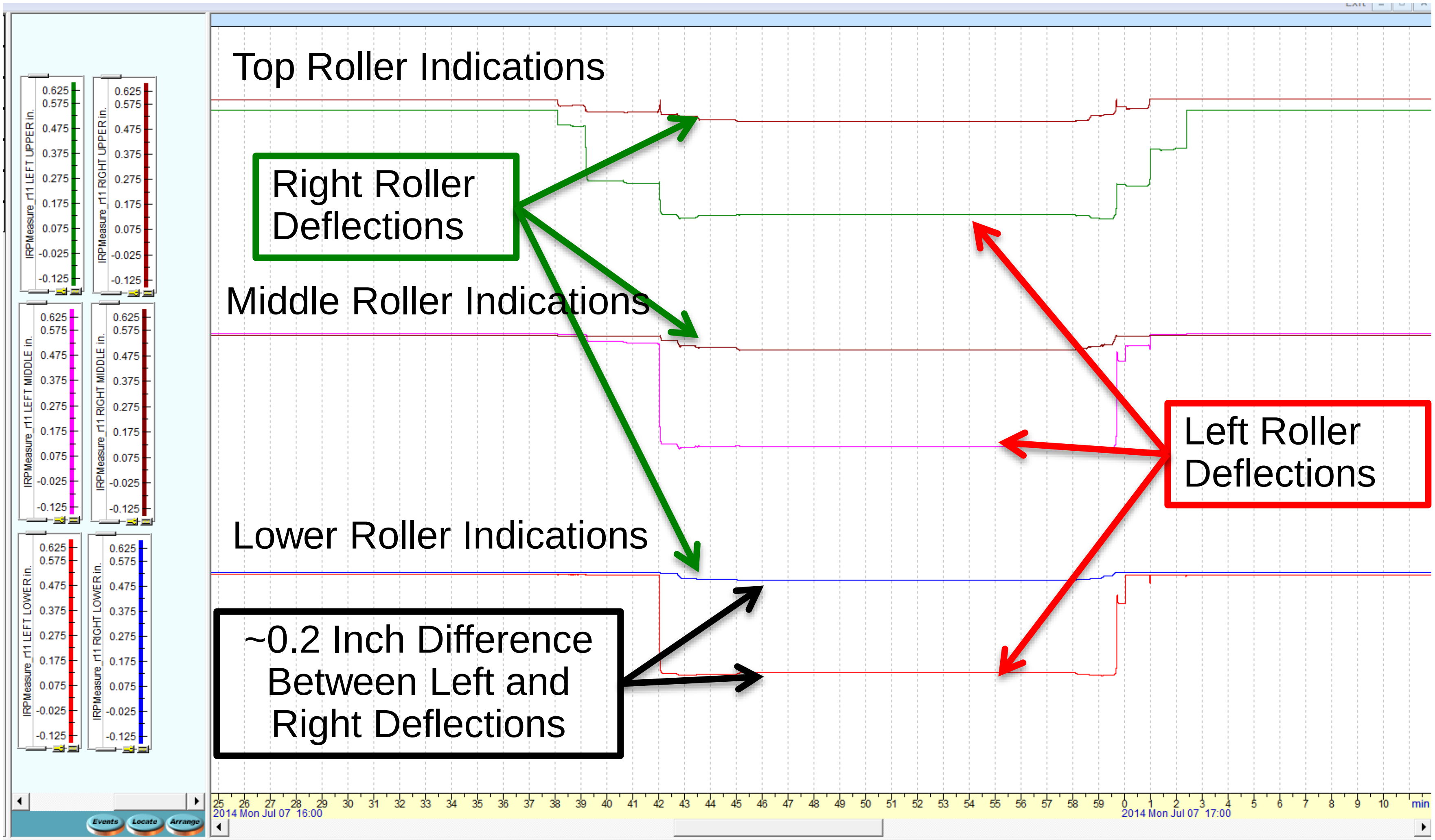


Scratch Location

- Scratch was found in “left” IRP wall. No evidence of swelling or distortion.



IRP Inspection Tool Roller Deflection During Insertion & Extraction



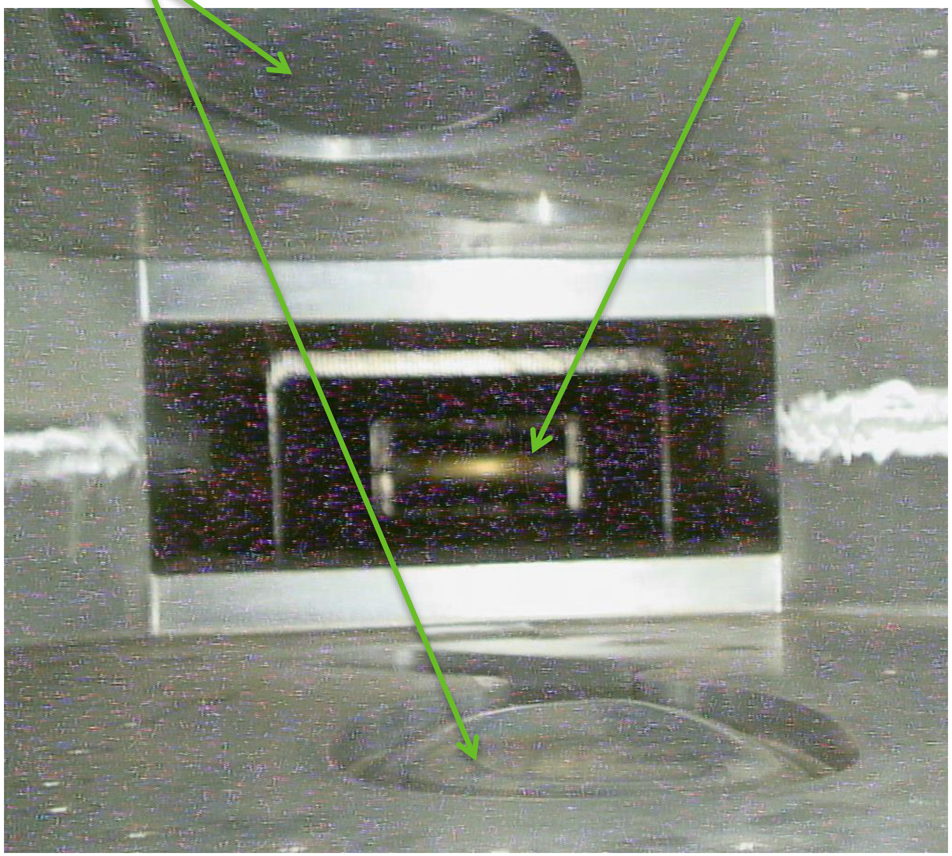
Time (min)

Other Items of Interest

- We used the opportunity to visually inspect the condition of the IRP—first time anyone had seen it since 2006.

Moderators

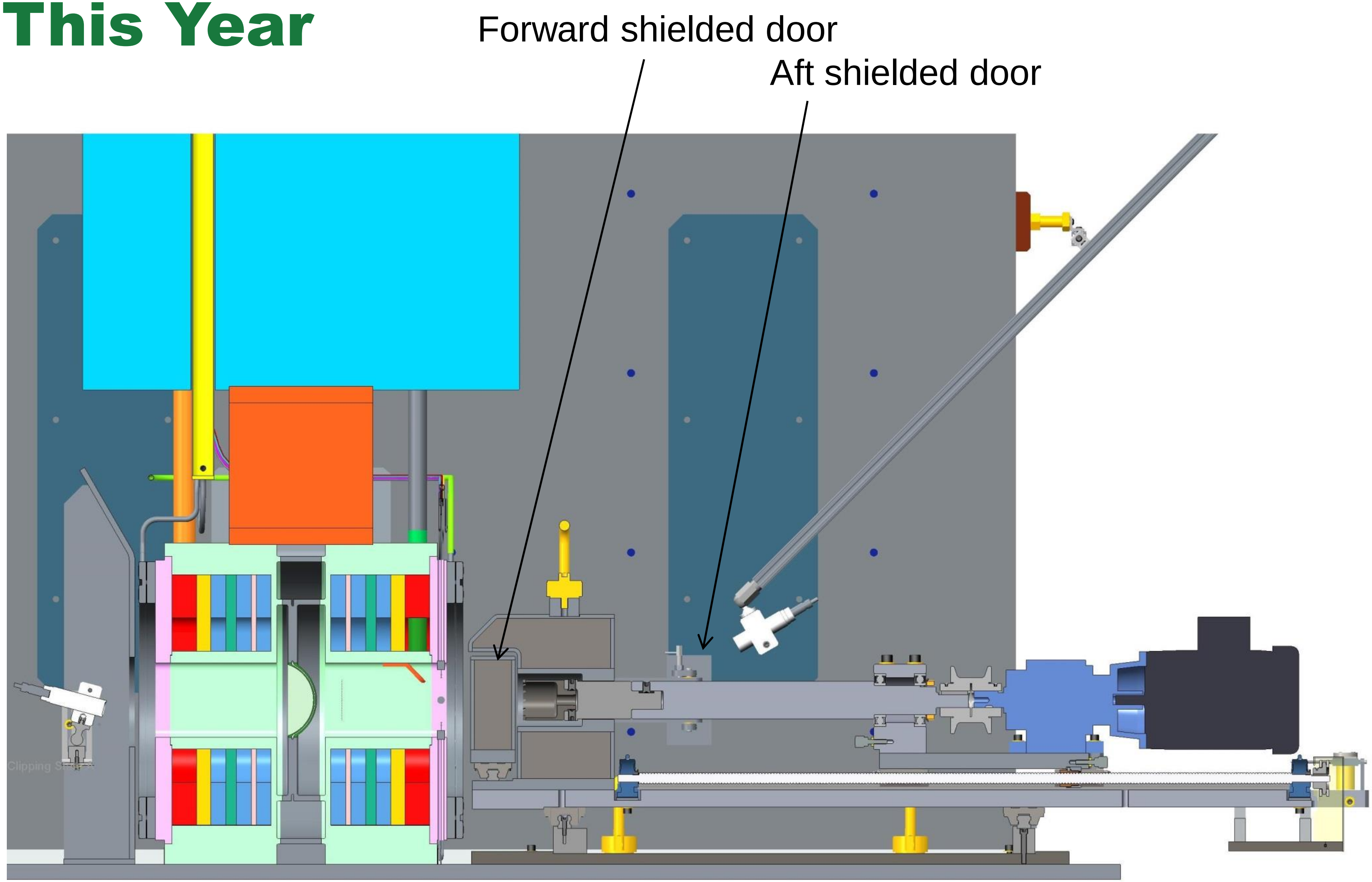
Proton Beam Window



Target Sealing Surface

Detail

Future PIE Capability—PBW Sampling This Year



Future PIE Capability—Target Module Core Sampling at Multiple Locations

- Incorporate modifications to enable drill assembly to be handled remotely
- Remove manual handle & incorporate a motor-driven feed and retract system
- Remote out the electrical connections for:
  - Motor on/off
  - Motor feed/retract
  - Motor speed?
  - Motor travel?
- Modify chuck to enable remote replacement of cutters
- Mount drill assembly to some sort of base plate to enable clamping/alignment/etc.
- Remove Magnet Base

T10 "Proof of Principle" Coring

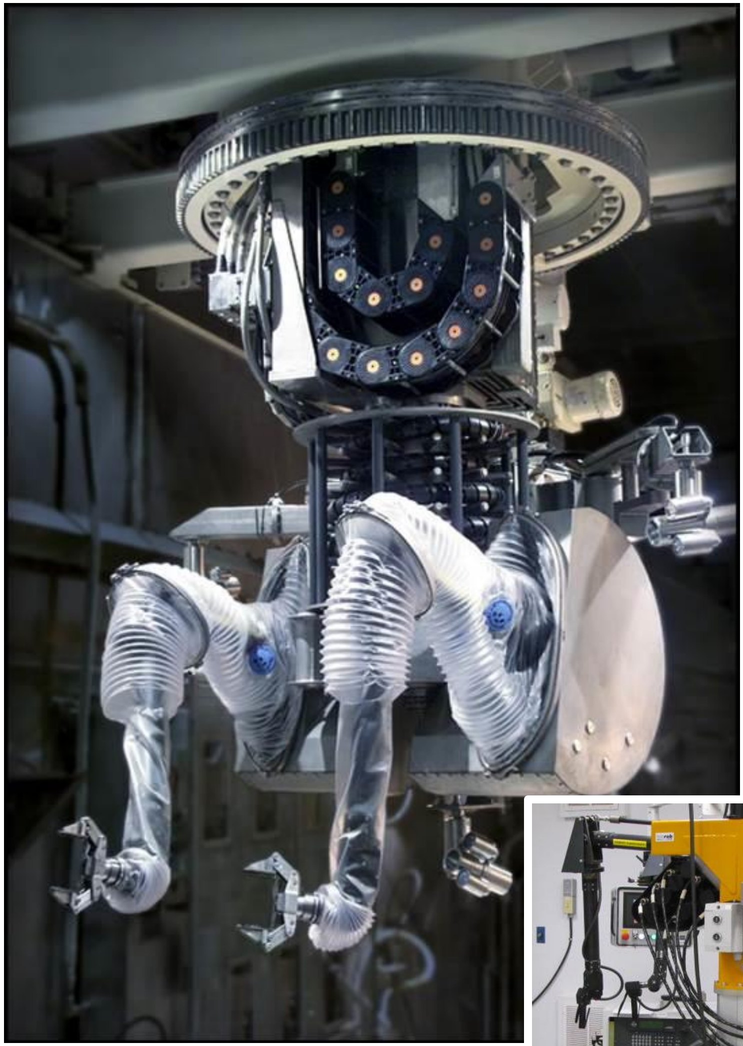
Challenges – TN-RAM Cask Availability Will Improve

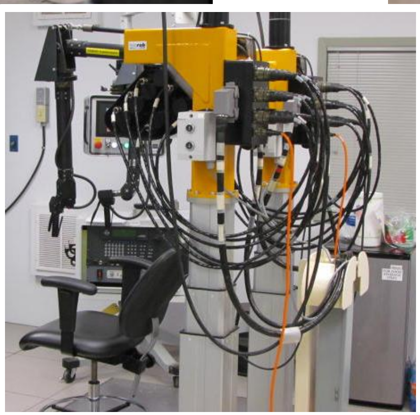
- One TN-RAM (Type B) cask is shared internationally.
- SNS is designed to use TN-RAM cask for target and PBW disposal
- AREVA is building a second TN-RAM cask for SNS and FRIB use. Completion is expected Fall 2015.
- Energy Solutions is building an E-360B cask; it is also compatible with SNS design. Completion is expected Summer 2015.

Challenges – Manipulator Obsolescence Issues

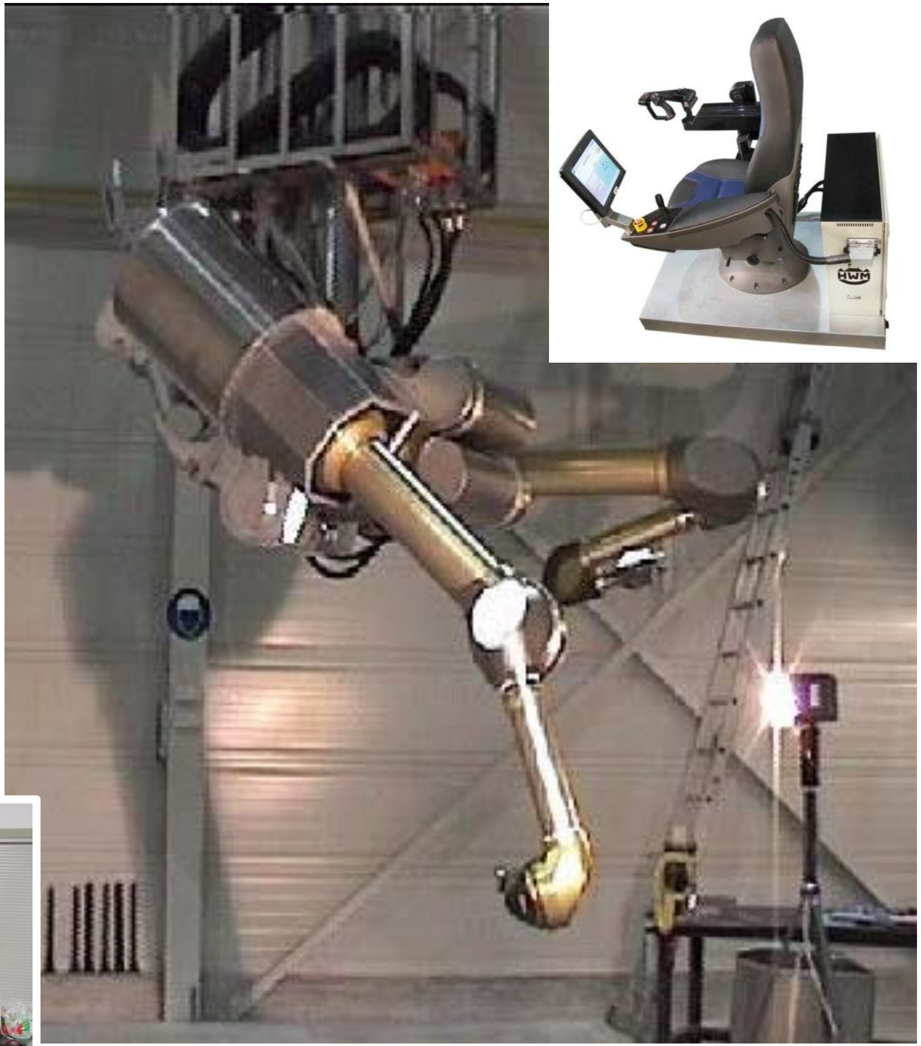
- Service Bay and High Bay Manipulator vendor (TeleRob GmbH):
  - no longer supports the system hardware
  - no longer provides replacement parts or service
- "Host" and "Trajectory" computers (PaR Systems, Inc.) that operate Service Bay crane and both bridge systems:
  - Use obsolete and unavailable computer motherboards (with 386 processor), ISA cards, and interface boards.
  - Run on an operating system (Windows 2000) that is no longer supported and not compatible with modern software necessary for communication and backups.
- The manipulator and crane Kollmorgen motors and drives are no longer manufactured.

Potential Long Term Manipulator Solution





Installed TeleRob GmbH Manipulator



Wälischmiller Engineering GmbH TELBOT

Challenges – Control Solutions

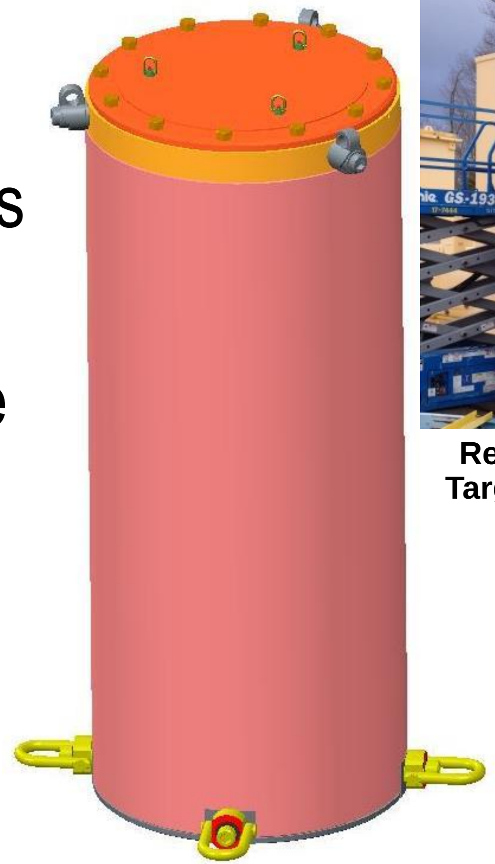
- Highest failure rates in robotic systems are associated with cables, controllers, drives, and motors—our efforts are focused in these areas:
  - TeleRob Cables—OK
    - Two spares on hand for each of the cables used in the Service Bay for the manipulator.
    - Drawing for cables outside the Service Bay were reverse engineered and a vendor located—quotes pending.
  - PaR Cables—Not OK
    - No spare crane or manipulator bridge cables are on hand.
    - We have accurate drawings and can fabricate cables as necessary. Identified the cable assembly and connectors that are common; need to stock the parts needed to make up cables in an emergency.
  - TeleRob Controllers—OK
    - Purchased all available spare parts and have at least one spare for each of the major components except one.
    - The High Bay manipulator can be scavenged if necessary.

Challenges – Control Solutions (cont.)

- PaR Controllers—OK
  - Have built one complete spare computer, configured as a host computer, but can be configured as a trajectory computer in-house if needed.
  - Configured two spare hard drives, one manipulator and one bridge crane. Working to develop a modern replacement.
  - Unable to purchase some of the interface boards needed as spares so are at risk in that area.
- TeleRob Motors, Drives, and Resolvers—OK
  - We have a few spares for the service gallery TeleRob system and the parts on the Pendant TeleRob are compatible. No further parts are available; we will need to work on an alternative solution for this in the future.
- PaR Motors, Drives, and Resolvers—Not OK
  - Adequate motor spares are on hand.
  - The drives are matched to their motors and we have no spares. Potential replacement drives and motors have been tentatively identified but the specific engineering design has not been started.

Challenges – On-site Storage of Targets

- It is critical to obtain material samples from all used targets, particularly at failure locations, in order to solve target design issues and refine models
- TN-RAM cask availability, Service Bay floor space, target lifetimes, and PIE capabilities drive target disposal before sampling.
- On-site target storage outside of the Service Bay is being developed using available holding containers.

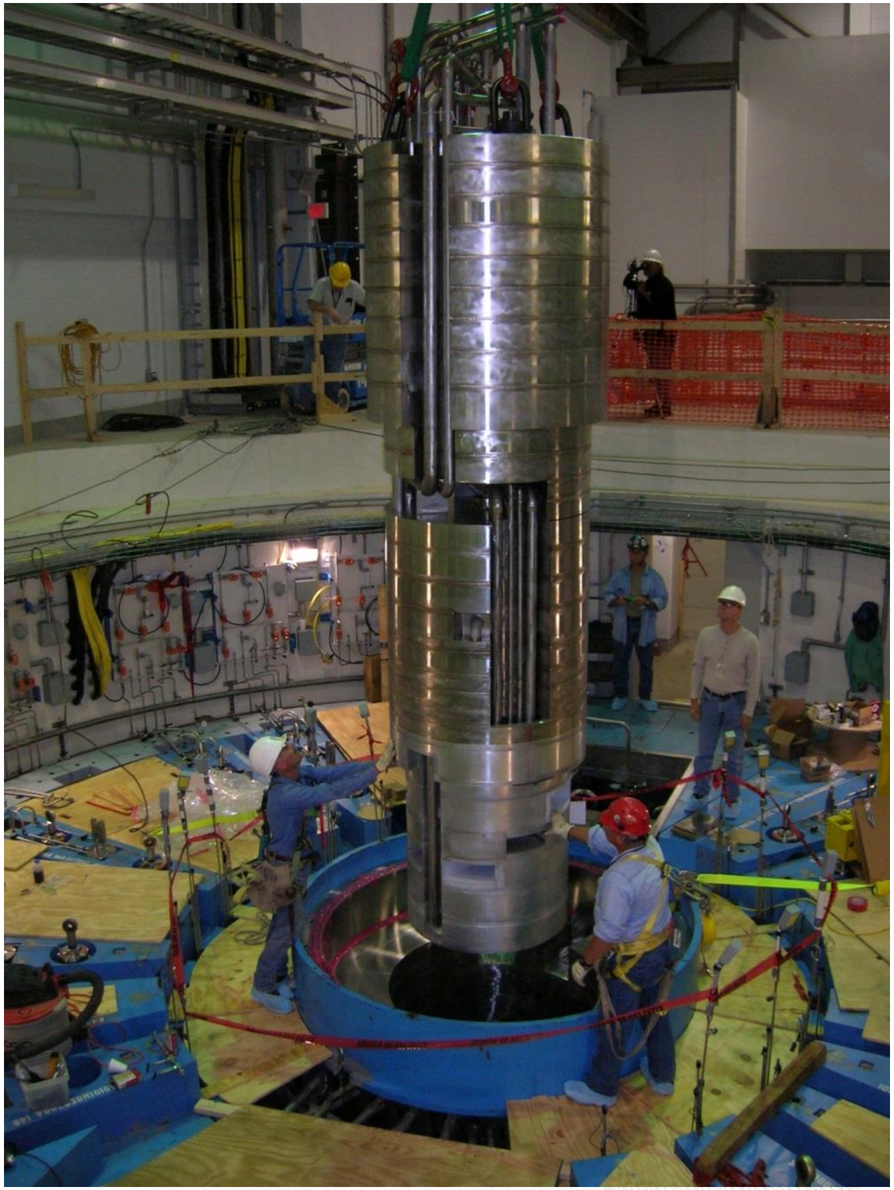


Target Holding Container
106070100-M8U-8700-A715

Recent Inspection of the Target Holding Containers at the Hot Pad

Challenges – IRP Replacement

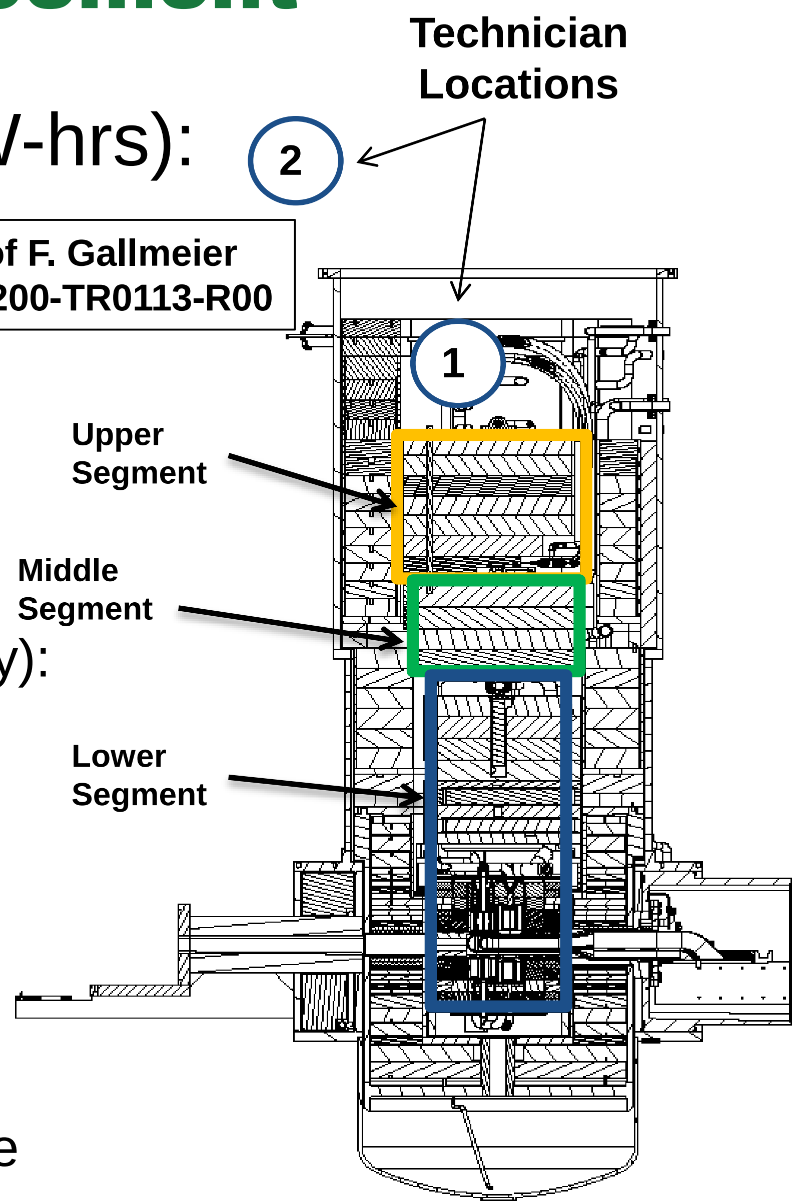
- First installation was hands-on
- 62,800 lbs., 15.5' tall, ~4' O.D.



Challenges – IRP Replacement

- Calculated dose rates (30 GW-hrs):
  - No segments removed:
    - Location 1: 9 mR/hr
    - Location 2: 0.14 mR/hr
  - Upper & Middle segments removed:
    - Location 1: 2,135 mR/hr
    - Location 2: 3.2 mR/hr
  - Lower segment removed (empty cavity):
    - Location 1: 49,258 mR/hr
    - Location 2: 200 mR/hr
- Working through:
  - Installation procedure
  - Mock-up IRP segment procurements
  - Remote Handling mock-ups to validate procedures and tooling

Courtesy of F. Gallmeier
SNS 106100200-TR0113-R00



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