ILC Remote Handling Design Considerations

Thomas W. Burgess
burgesstw@ornl.gov
Remote Systems Group Leader, NSTD

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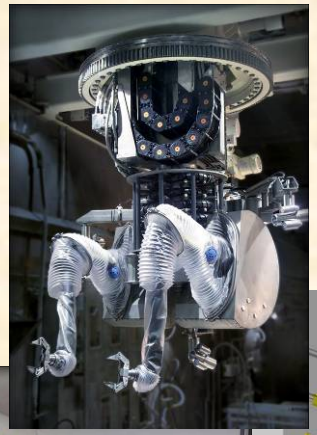
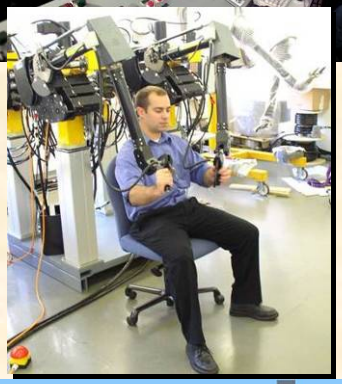
OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

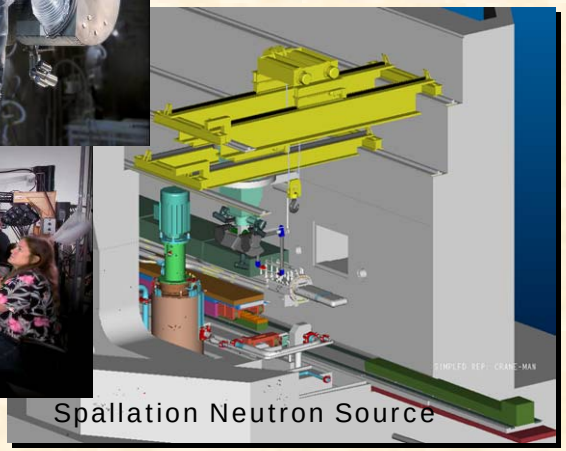
Remote Systems Group

Robotics and Remote Handling

- **Specializes in development and application of advanced robotics, remote processes and handling technology for hazardous environments in:**
  - **nuclear fission**
  - **fusion**
  - **accelerators**
  - **radiochemical processing**
  - **environmental restoration**
  - **space exploration**
  - **military defense**

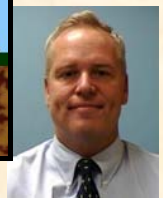






Spallation Neutron Source

Future Armor Rearm System

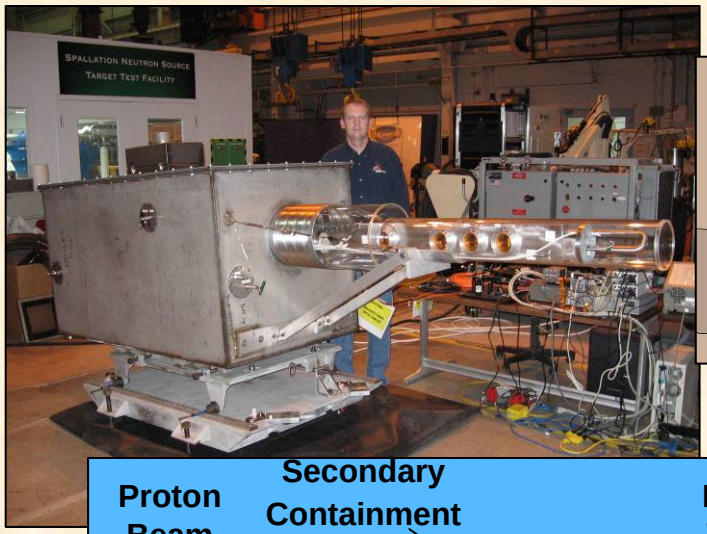


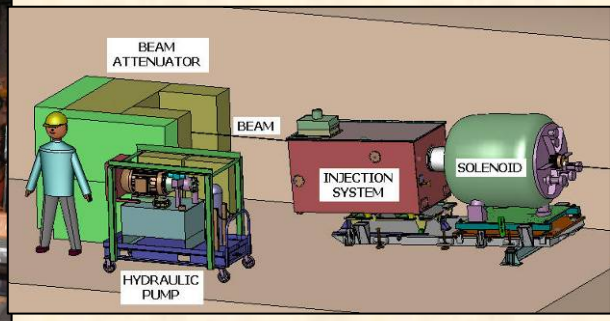
Muon Collider High Power Hg Target Experiment is a Remote Systems Project

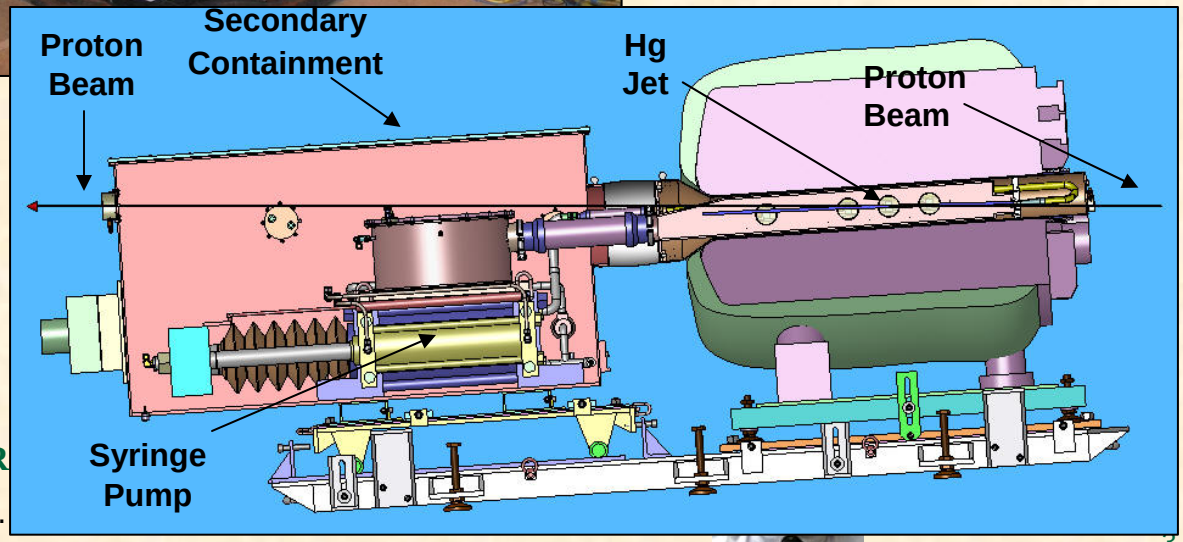
- **ORNL is developing a proof-of-principal, Neutrino Factory target system in collaboration with BNL, Princeton Univ., MIT and CERN**
- **Demonstrate interaction of a free Hg jet and proton beam in a 15 T magnetic field**
- **Sponsored by the DOE Office of Science - High Energy Physics**
- **Target system is operational at CERN awaiting first beam in Oct. 2007**

other key parameters

- **1cm dia. Hg jet at 20m/s and 25gpm**
- **CERN facility proton beam at 24 GeV**
- **Up to 20 x 10^{12} protons per pulse**





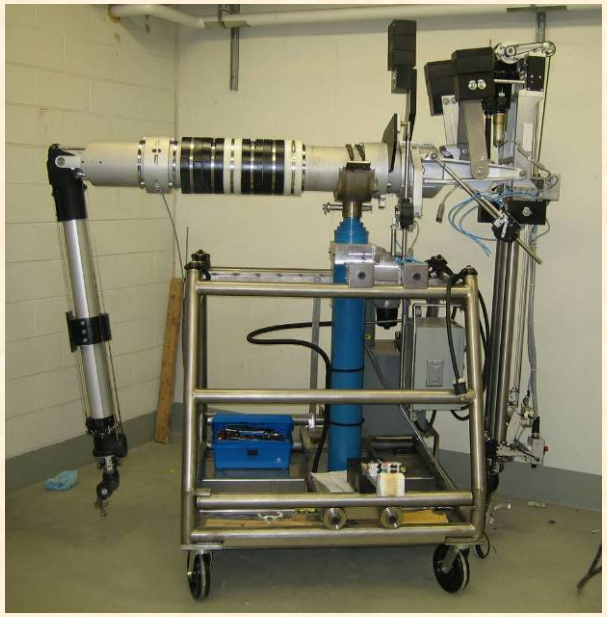


Outline

- **Basic remote handling systems**
- **Accelerator facility examples**
  - **SNS**
  - **RIA**
- **ILC specific comments**

Master-Slave Manipulator (MSM)

- **Advantages**
  - **Highly dexterous**
  - **Force reflecting**
  - **Inexpensive**
  - **Reliable (HD models)**
  - **Work well with a shielding window**
- **Disadvantages**
  - **Limited reach**
  - **Small effective working volume**
  - **Require a shielding window workstation**
  - **Can be overloaded by operator**

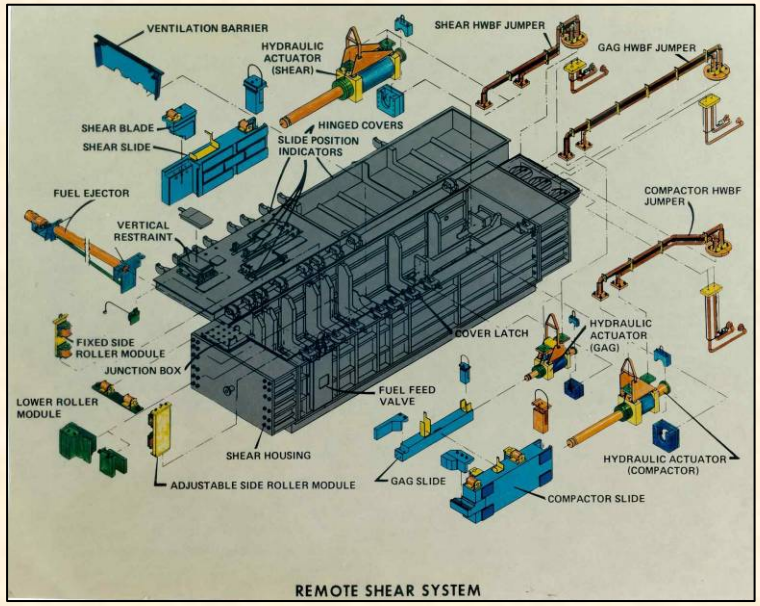


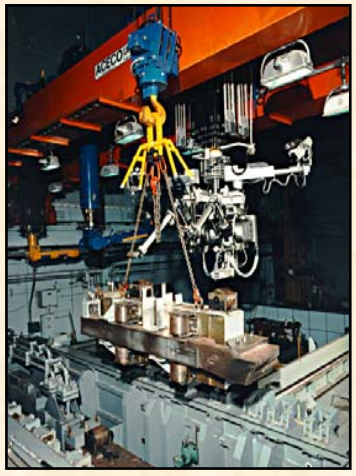
Servomanipulators:
Transportable Mechanical Master/Slave Manipulators

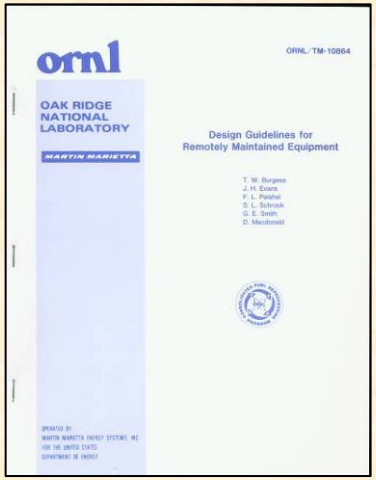
- **Advantages:**
  - **Highly dexterous handling over large volumes, long distances**
  - **Force reflecting**
  - **5 to 8 X hands-on task times**
  - **Reduces need and cost of special remote handling features on components**
  - **Moderately powerful**
  - **Can be equipped with an auxiliary hoist to assist with material handling**
- **Disadvantages:**
  - **Relatively expensive ~ $750k/manipulator arm**

Telerob
EMSM-2B

Modular Robotic-Based Maintenance Requires Significant Design Discipline

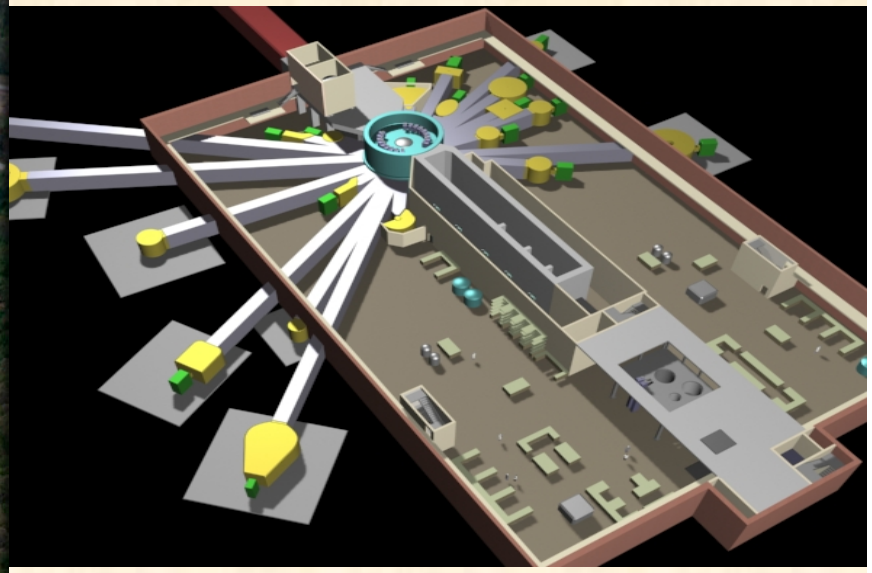






- **Repair operations with robotic systems in unstructured environments are very different than hands-on operations**
- **Special design features include...**
  - Modularized equipment
  - Standardized interfaces and tooling
  - Simple alignment without close tolerances
  - Easy access
  - Highly capable repair systems designed for the (all) job(s)
- **ORNL utilizes customized design handbooks to execute these types of programs**

ORNL Spallation Neutron Source (SNS)

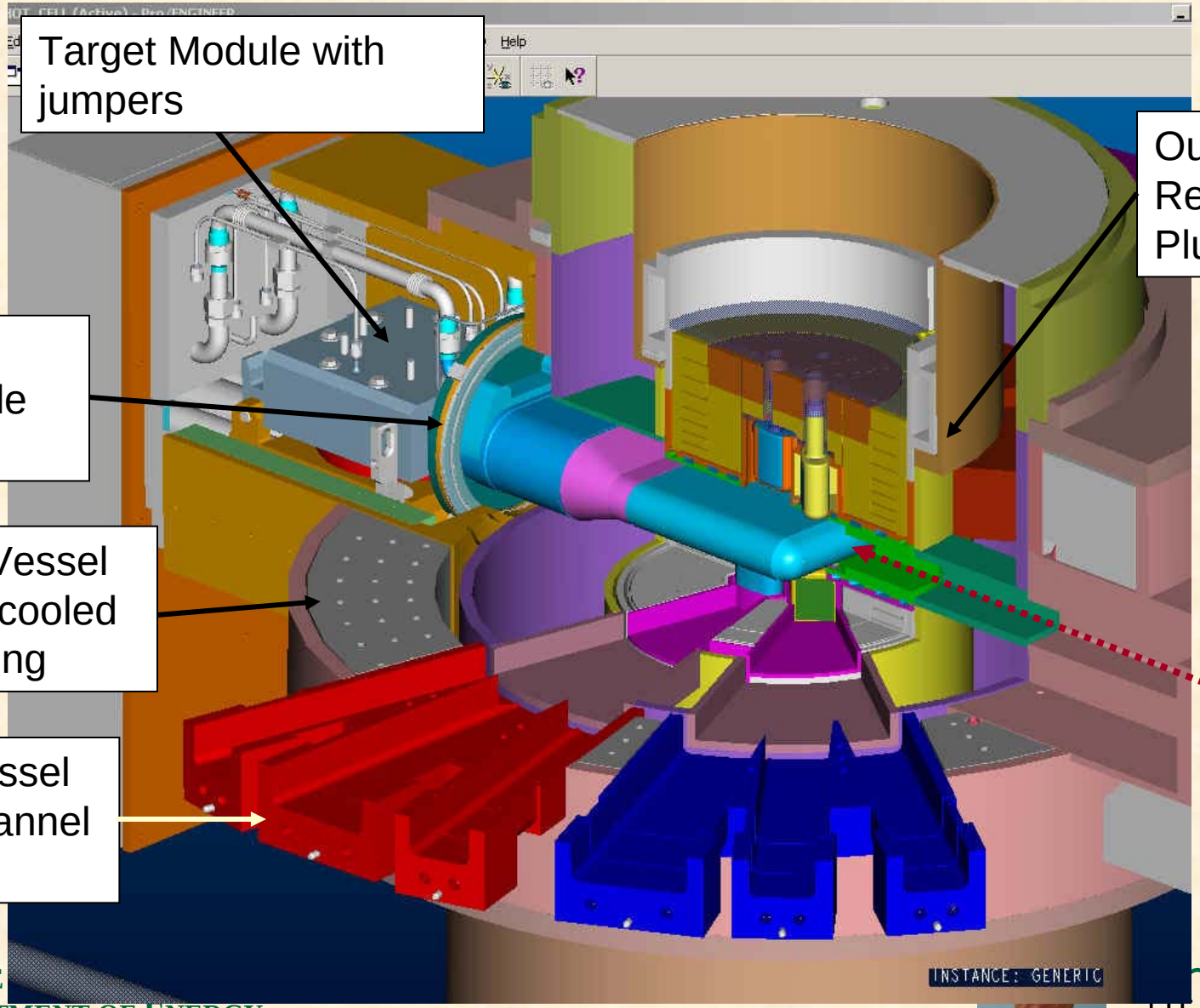


Target Facility

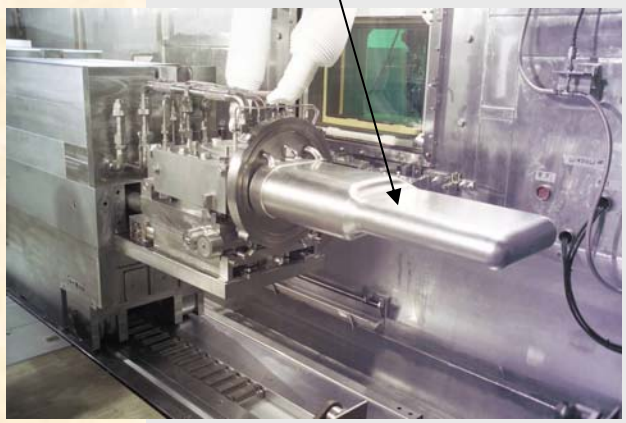
- **Neutron Scattering Material Science Research Facility**
- **SNS began operation in April, 2006, ahead of schedule (June) and on budget ($1.4B)**
- **At 1.4 MW it is ~ 8x ISIS, the world's previous leading pulsed spallation source (Rutherford Appleton Laboratory)**
- **SNS will become the world's leading facility for neutron scattering**
- **It is a short drive from HFIR, a reactor source (continuous vs pulsed)**

UT-BATTELLE

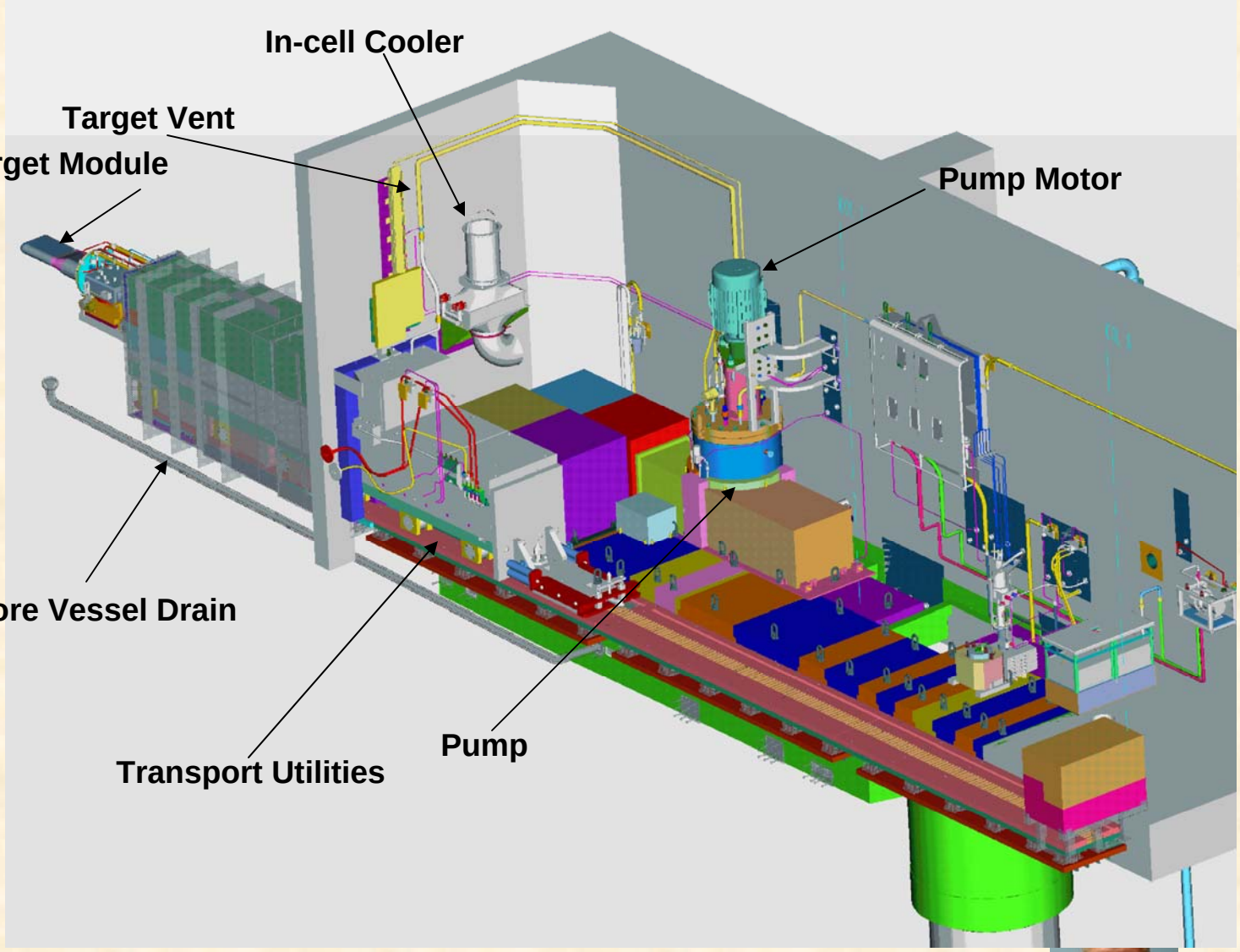
Target Region Within Core Vessel

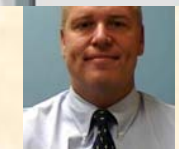


Mercury Process Loop Isometric View

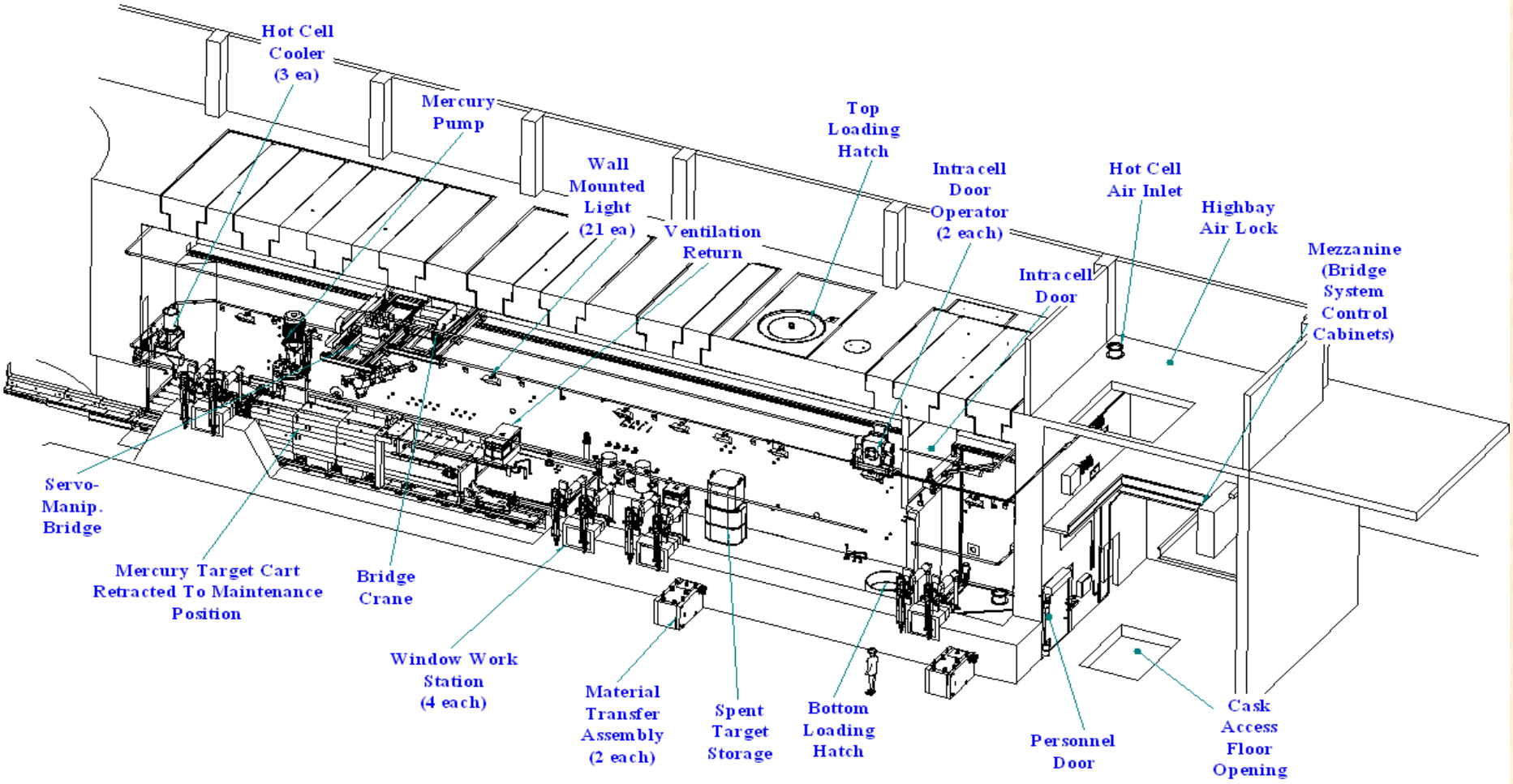


SNS Mercury Target In-Cell





SNS Target Service Bay (Hot Cell)

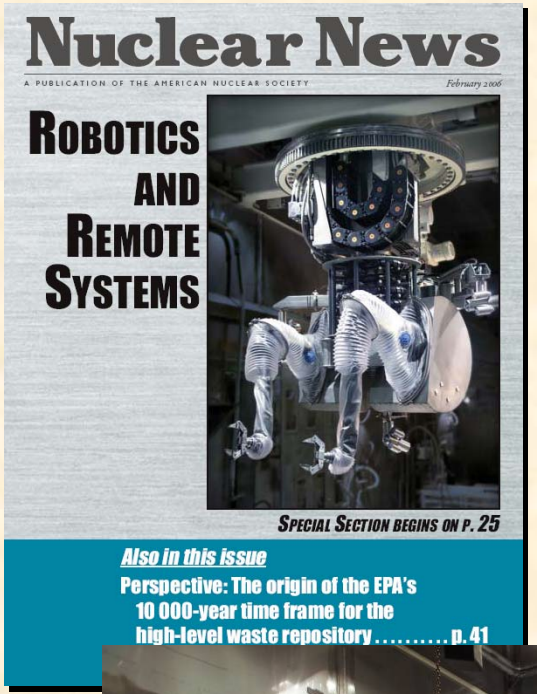


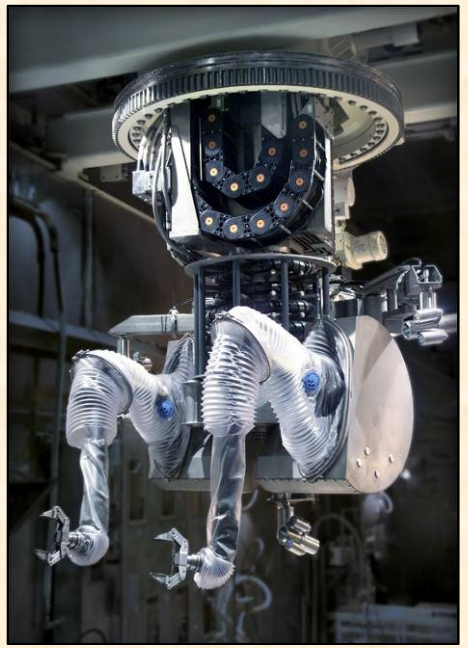
Cell Size: 103 Ft Long x 14 ft Wide x 30 feet High

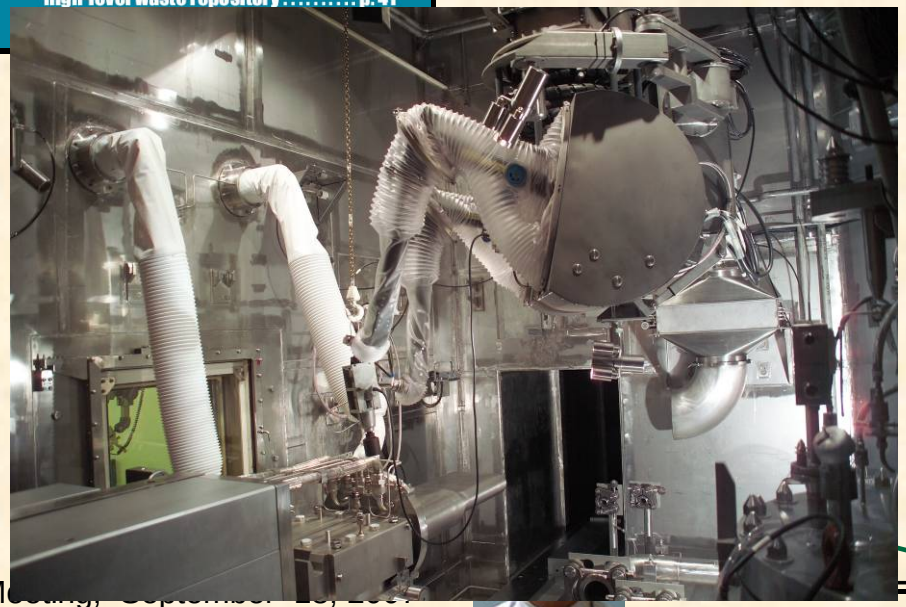
Hot Cell Interior Looking Towards Target

SNS In-Cell Servomanipulator

- Telerob EMSM-2B
- 6 DOF arm + gripper (11 DOF with bridge and interface)
- Replica master arms
- Dual arm, mirror configuration
- Digital Control
- Force Reflecting
- Force Ratio Control 2:1 up to 20:1
- 55 lbf continuous /100 lbf peak capacity





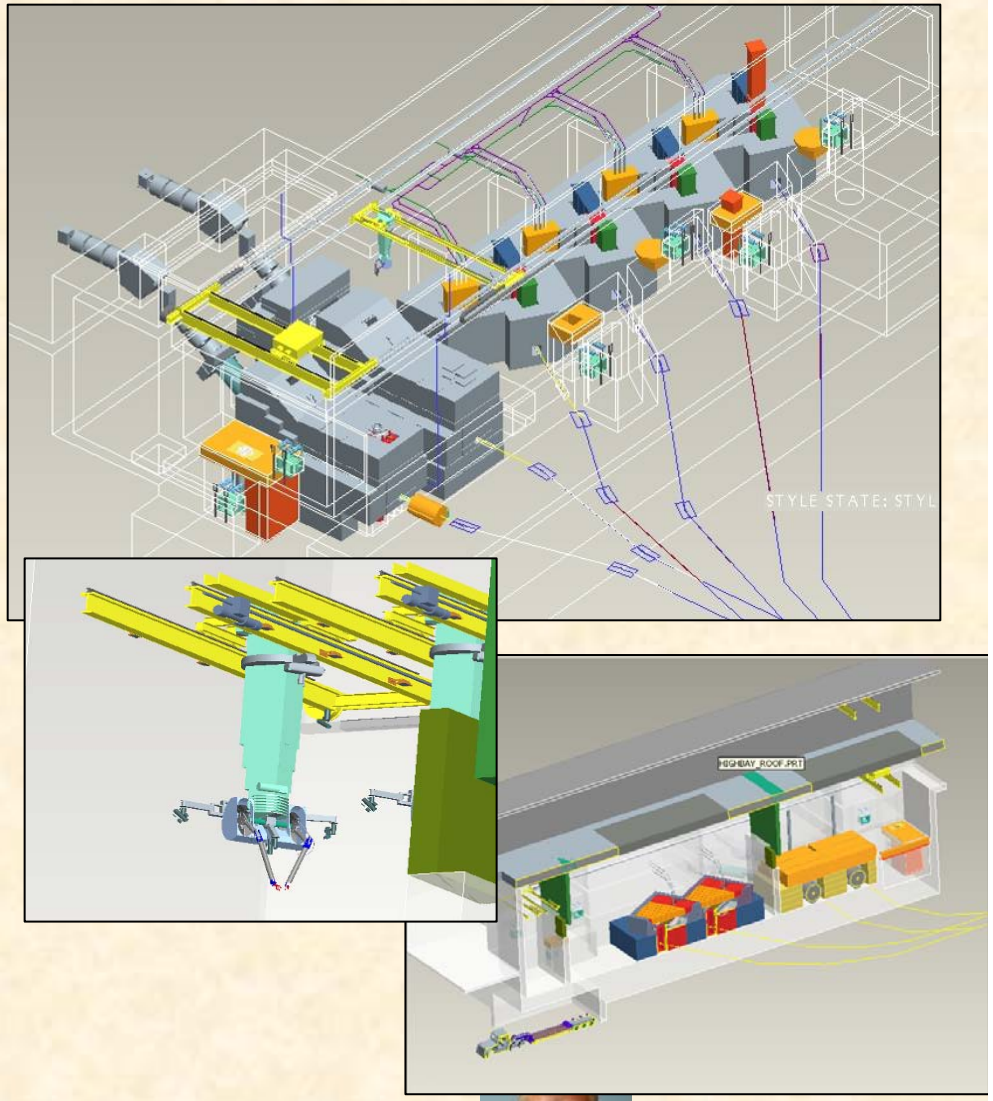


SNS Remote Handling Control Room

- **The servo master station and attendant video systems are co-located with the bridge and cell utility control systems to unify operations.**
- **Interconnected bridge, video and audio controls at each window workstation are also required to facilitate efficient operator interface**

Rare Isotope Accelerator (RIA) Remote Handling Design

- **ORNL in collaboration with ANL, LLNL and MSU, developed the conceptual design of RIA target stations and facilities**
- **Sponsored by DOE Office of Science - Nuclear Physics**
- **Accelerates ion beams from hydrogen through uranium at power levels up to 400 kW with primary targets of liquid lithium (FRAG) and water-cooled tungsten (ISOL)**
- **Design Philosophy – Multiple target stations**
  - **Maximizes availability of the facility**
  - **System capable of remote change with active beam on adjacent target**
  - **Control background radiation and contamination to allow for personnel access into target bay with beam off**
- **RIA concept design was completed in 2006. DOE has rescoped and defined as the Facility for Rare Isotope Beams (FRIB), with ~ 5 year delay in schedule**



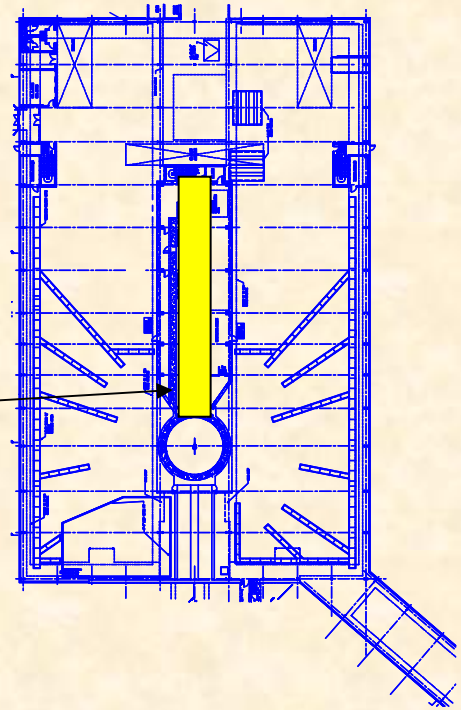
Size Comparison

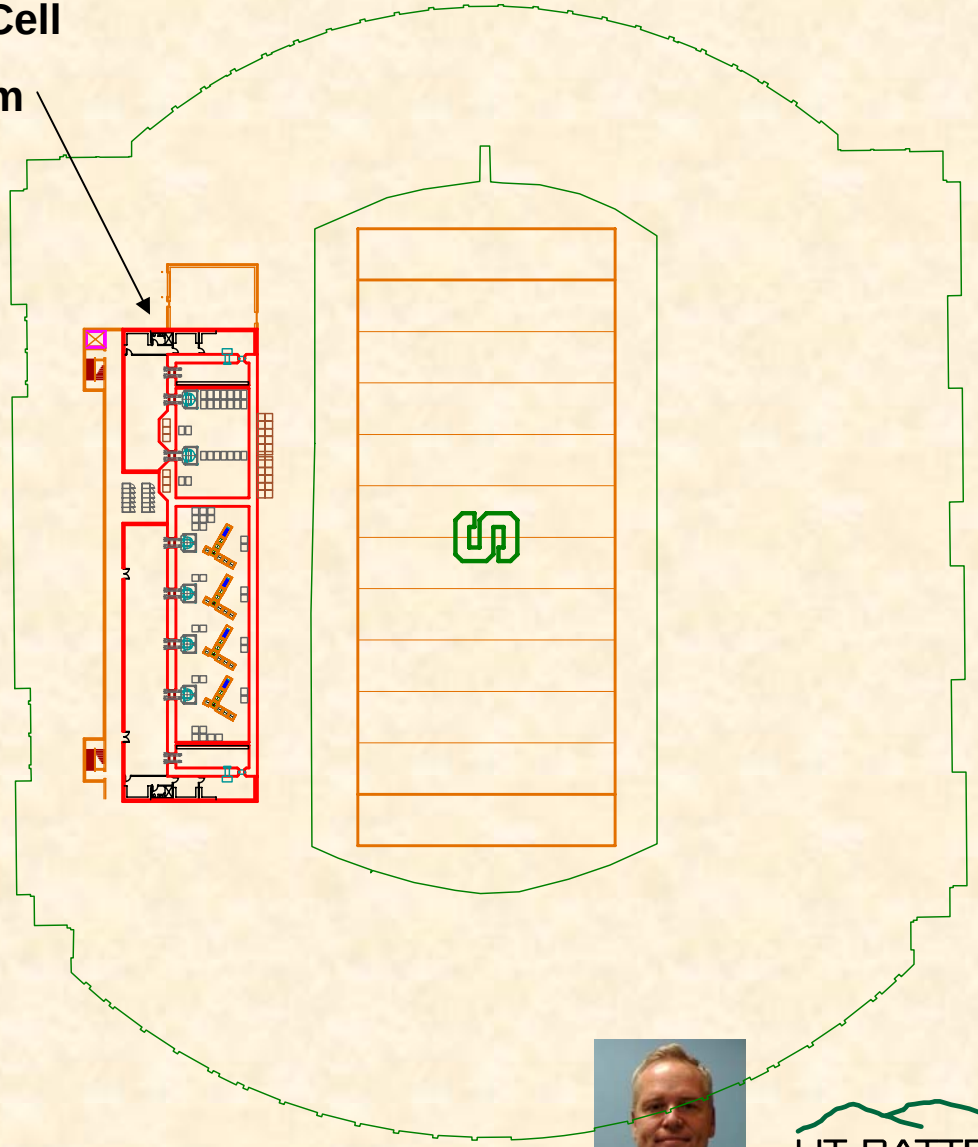
RIA Target Hot Cell

75m x 20m x 13m

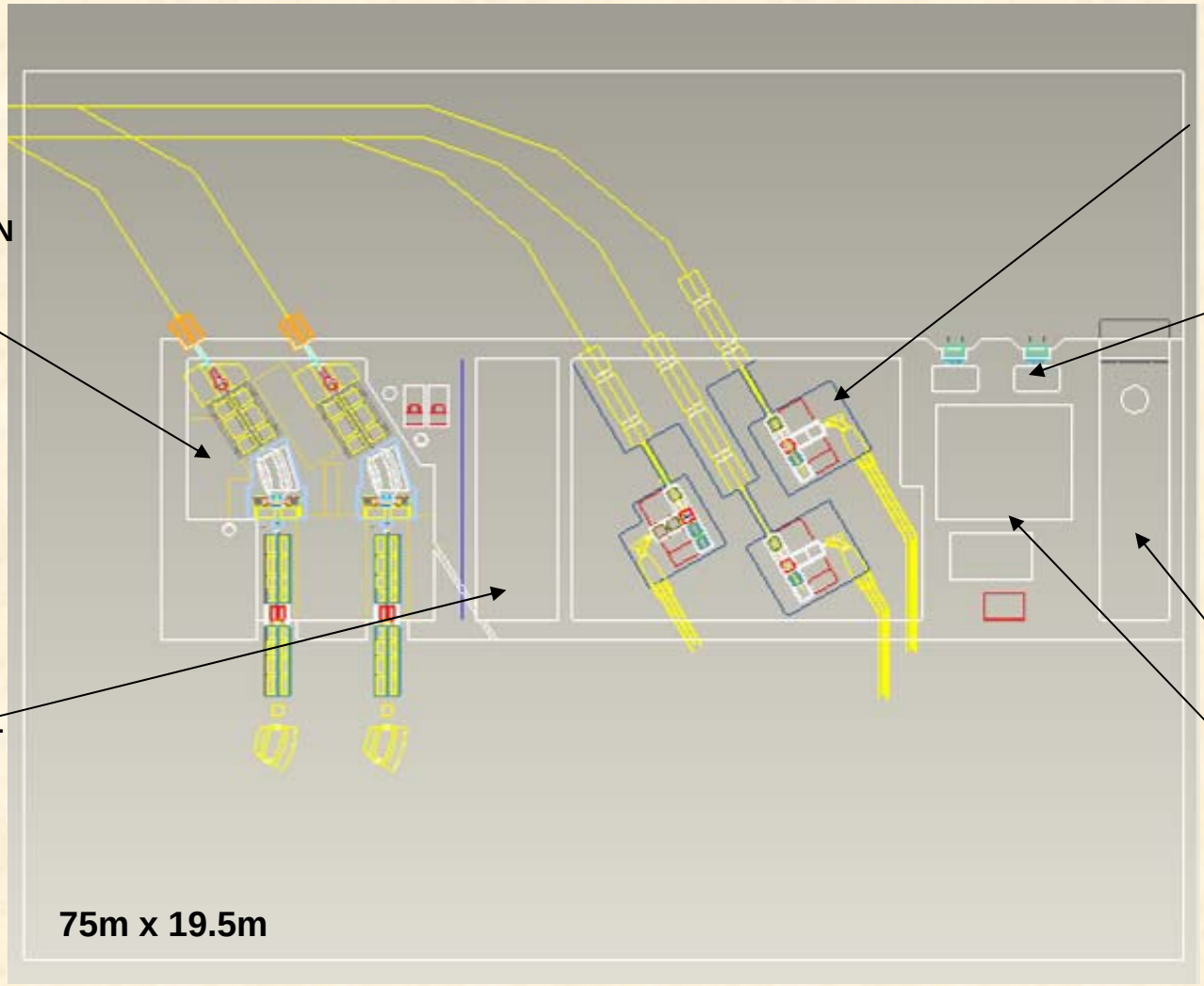
SNS Target Hot Cell

32m x 4m x 9m

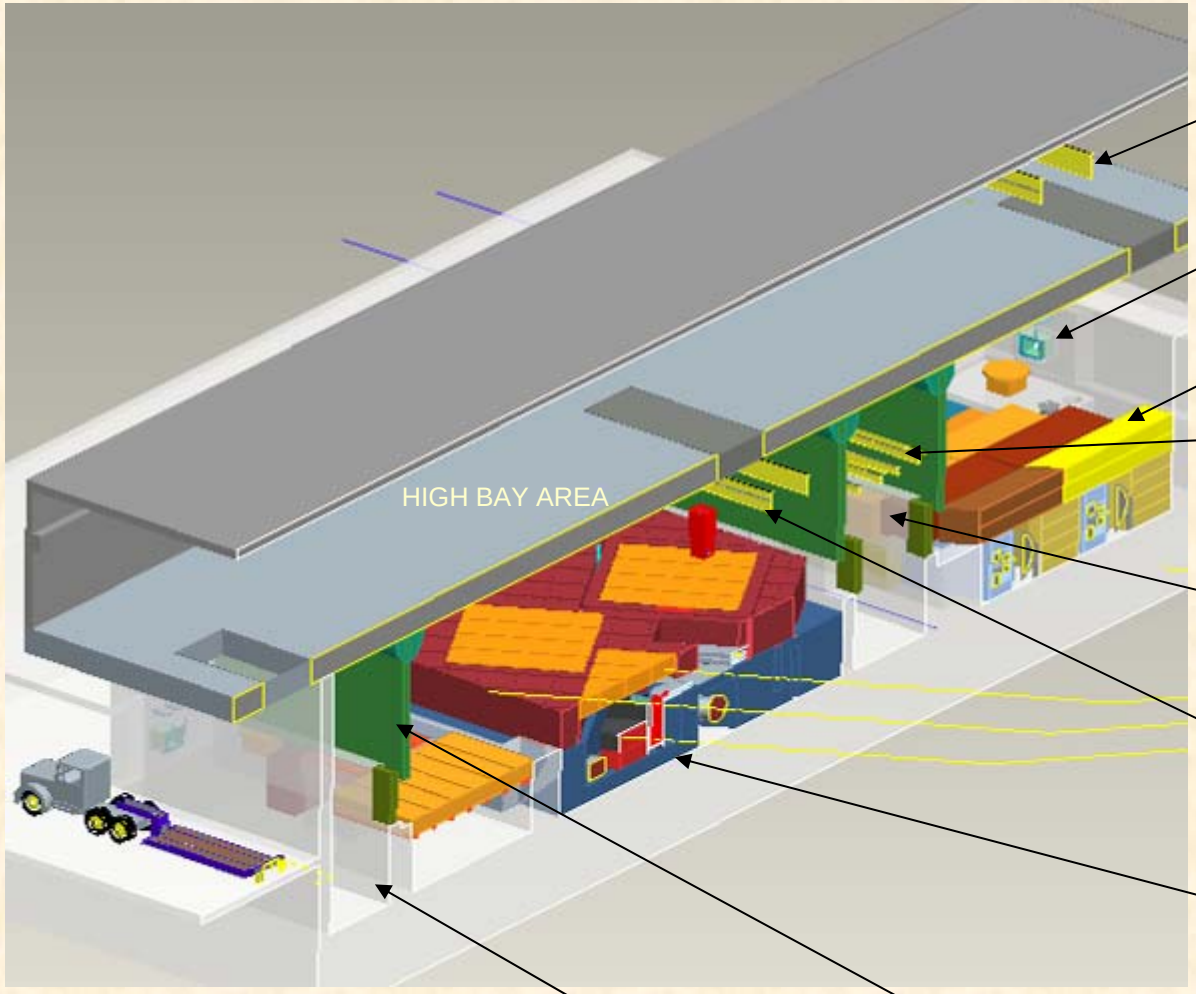




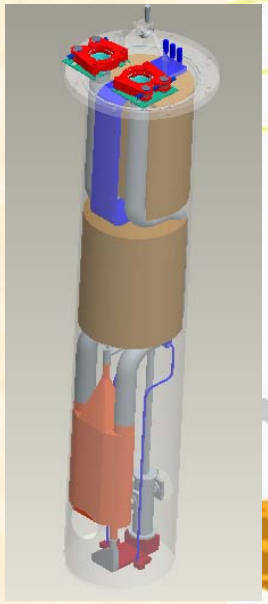
RIA Target Gallery Layout

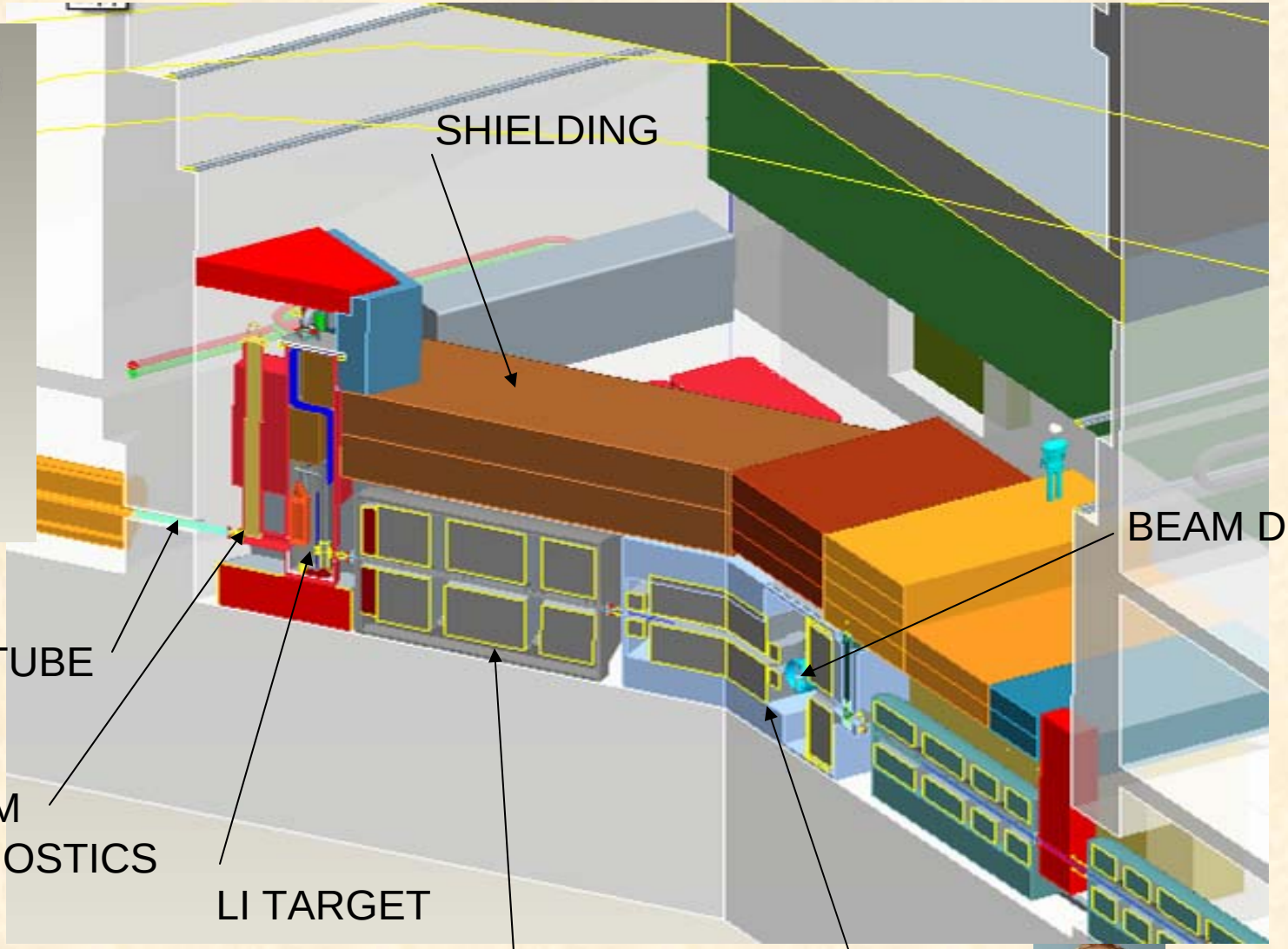


RIA Target Building

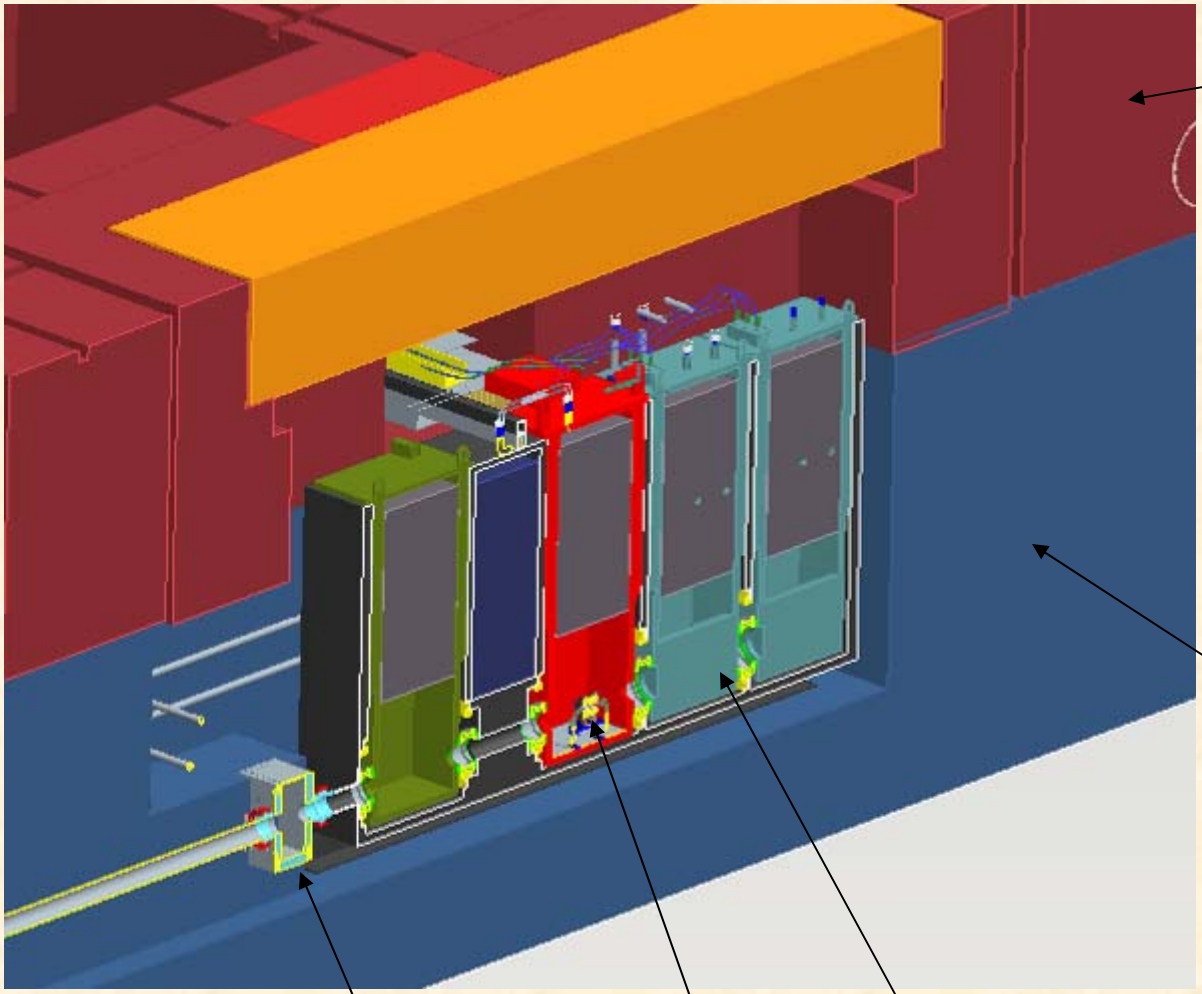


Fragmentation Target





ISOL Target Configuration



RIA Animations

..\RIA movies for ILC\RIA Overview Indeo 8-06.avi

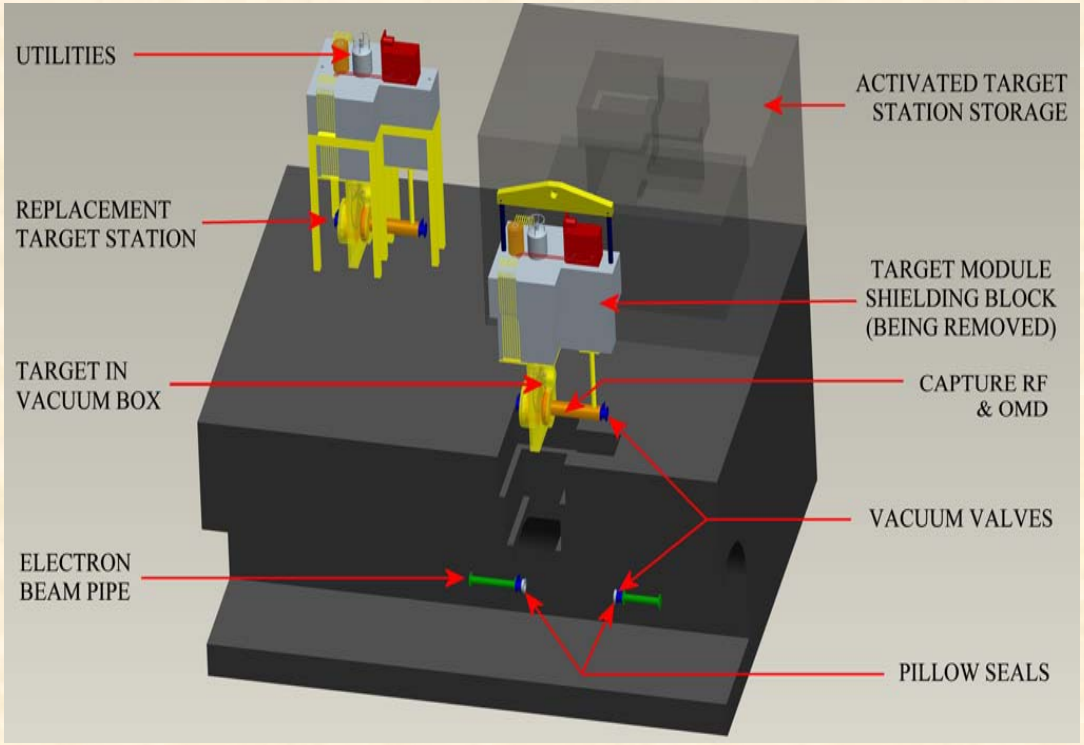
..\RIA movies for ILC\FRAG Beam Dump Removal Indeo 8-06.avi

..\RIA movies for ILC\ISOL Target Removal Indeo 8-06.avi

..\RIA movies for ILC\ISOLTarget Utilities Removal Indeo 8-06.avi

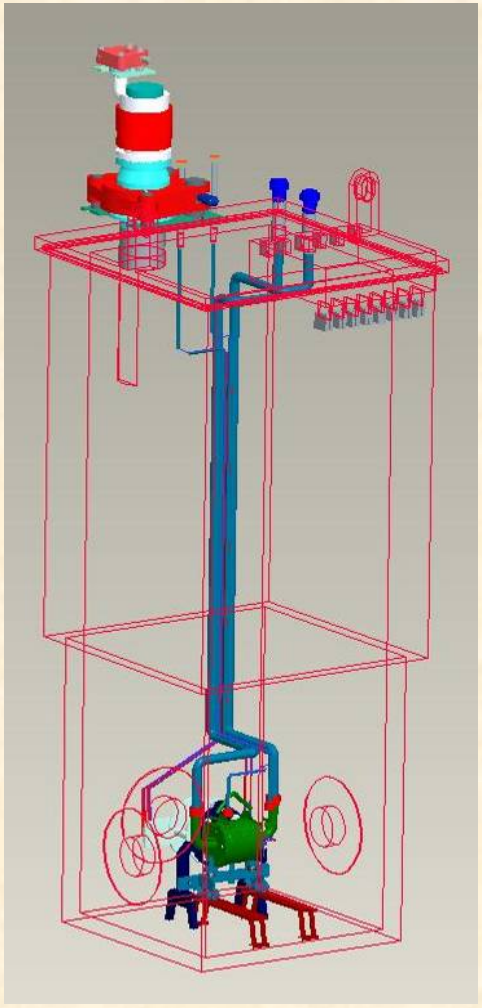
ILC Target Remote Handling Design Comments

- **Maximize hands-on access, minimize remote handling**
  - **Are utility and seal connections at top hands-on accessible?**
  - **What are shutdown rad levels?**
- **Shield rad-sensitive components to extent possible, minimize activation**
- **Significant radiological contamination expected?**
- **Assess lifetime of irradiated components (e.g., fluid seals, insulation, and other organics good to ~ 10^8 rad TID at best)**
- **Identify all remote maintenance / replacement / adjustment tasks and assess viability**
- **Modularize target module design based on component lifetimes, maintenance requirements and capabilities**
- **ILC availability goals, operating schedule defined? Remote handling drivers….**
- **Optimize and demonstrate frequent RH tasks, plan for less frequent failures / maintenance tasks knowing longer shutdowns may be required**



(Image courtesy of ILC)

RIA ISOL Target Module Design

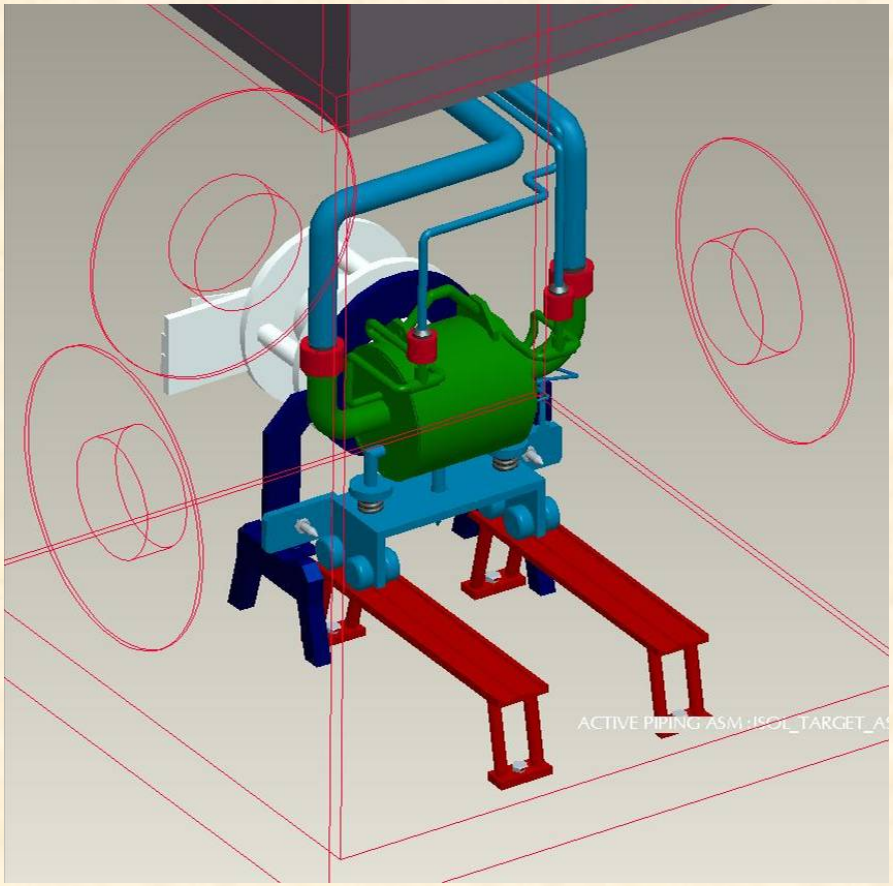


- MOST FREQUENTLY CHANGED COMPONENT

- WINDOW WORKSTATION TASK

- MULTIPLE CONNECTIONS

- ACCESS AND LIFTING CONSTRAINTS

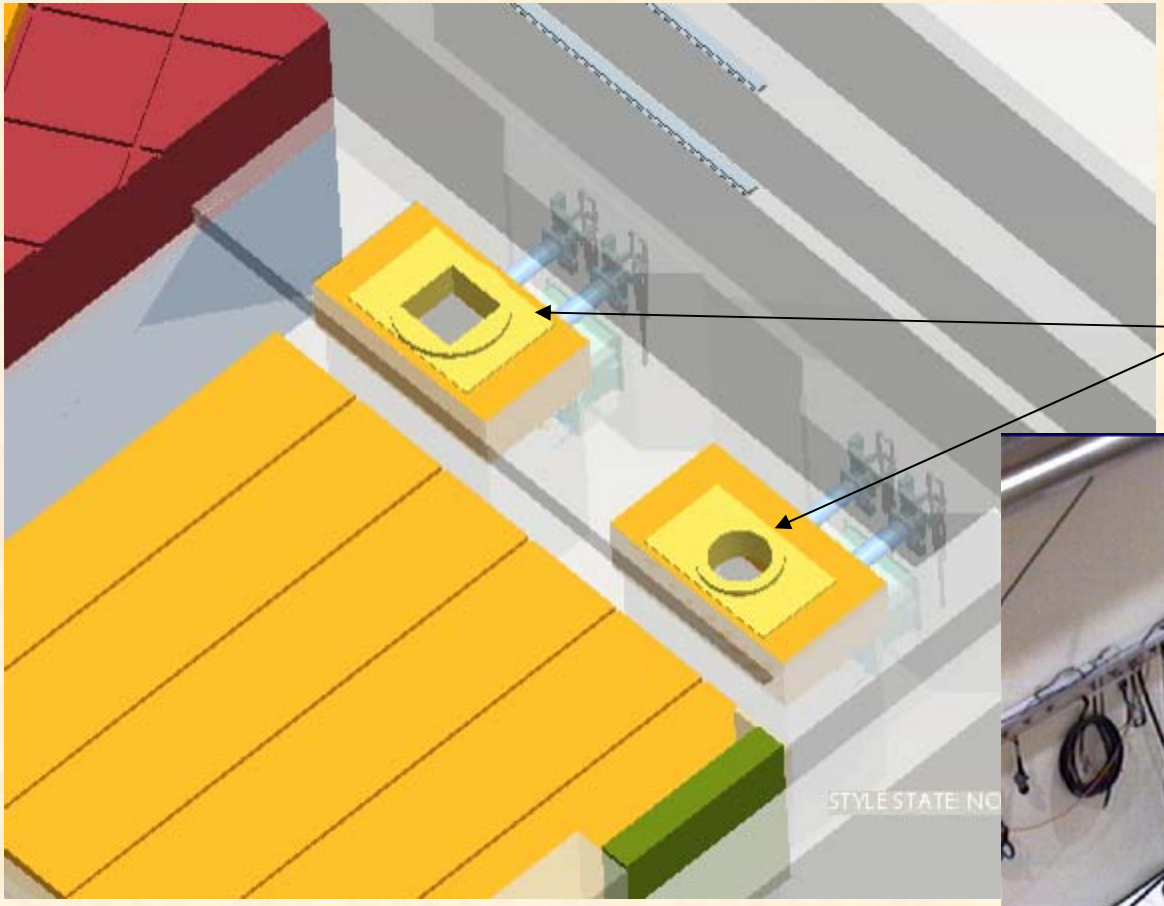


RIA Shielded Hot Cell For ISOL Target Exchange

SHIELDED MODULE MAINTENANCE HOT-CELL

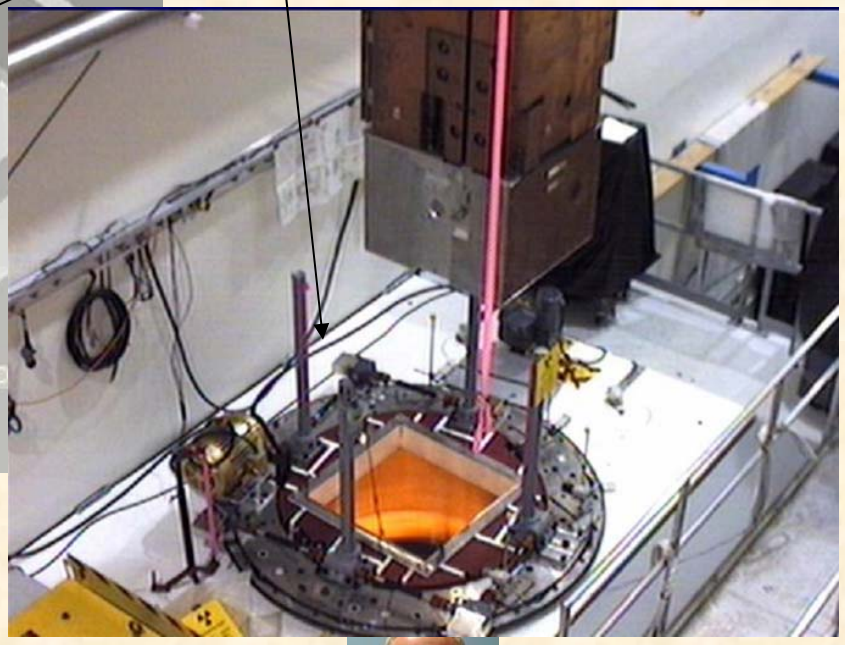
-MINIMIZES COMPONENT EXPOSURES

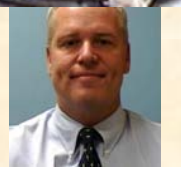
-- MINIMIZES LOOSE CONTAMINATION



Hot cells

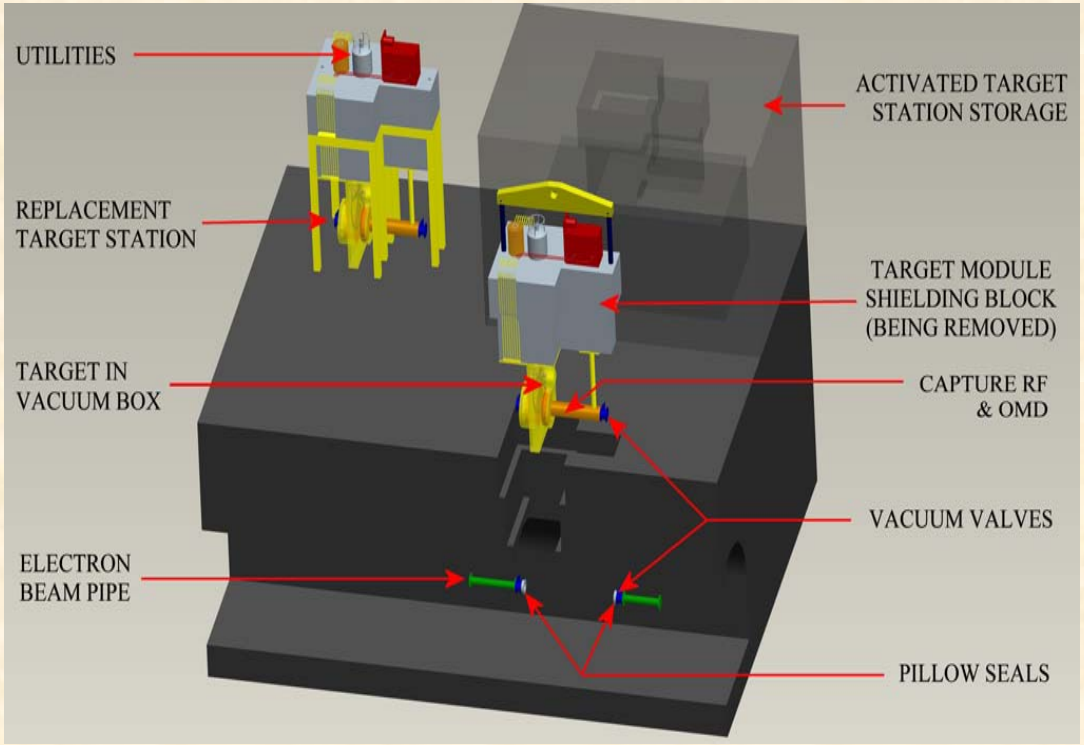
Target module





ILC Target Remote Handling Design Comments (cont'd)

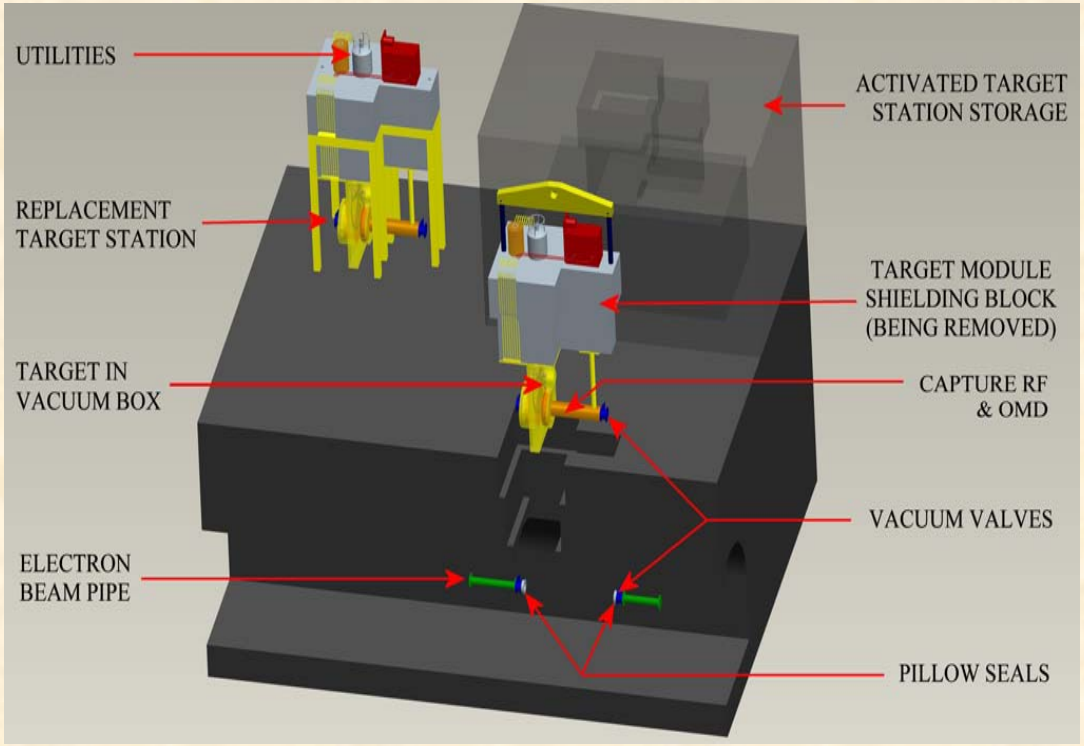
- **Develop conceptual target design including remote handling equipment and facility support features**
  - **Transferring target module to a cask, and moving it to a hot cell on the surface may be most cost effective**
- **Remote handling R&D, mock-ups, required will be more evident once a concept is further developed**
- **R&D items ?**
  - **Ferro-fluidic shaft seal is a potential issue – shaft speed, mag fields, radiation**
  - **Rotating water seal life another possible issue**



(Image courtesy of ILC)

ILC Target Remote Handling Design Comments (cont'd)

- **What are radiation / activation levels downstream and upstream beam line components?**
- **Pillow vacuum seal proven? Full atmosphere dp or secondary vacuum? Remotely replaceable?**
- **Beam line vacuum valves replaceable / necessary?**



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