Personnel and Machine Protection Systems in the National Ignition Facility

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Robert K. Reed

NIF Safety System Manager

Lawrence Livermore National Laboratory • National Ignition Facility & Photon Science

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NIF Safety Interlock Systems (SIS) and Machine Safety System (MSS) overview

- **SIS's implement personnel safety interlocks and radiological alarms**
  - **Comprised of several distributed systems**

- **MSS implements machine protection interlocks**
  - **Monitors system configuration to prevent inadvertent damage to the laser and related systems**
    - **Enforces proper beam fate requirements allowing shots only when devices are properly positioned**

Primary function is to provide a safe environment for the NIF facility.

NIF employs a layered approach to personnel safety

- Layers of safety at NIF:
  - — Engineered or passive barriers
    - – Shielding/exclusion
  - — Training
  - — Work control
  - — Procedures
  - — Announcements
  - — SIS
    - – Redundancy (as required)
    - – Monitoring of key hardware
    - – Sweeps & perimeter control
    - – Audible & visual warnings
    - – Permissive keys
    - – Crash buttons

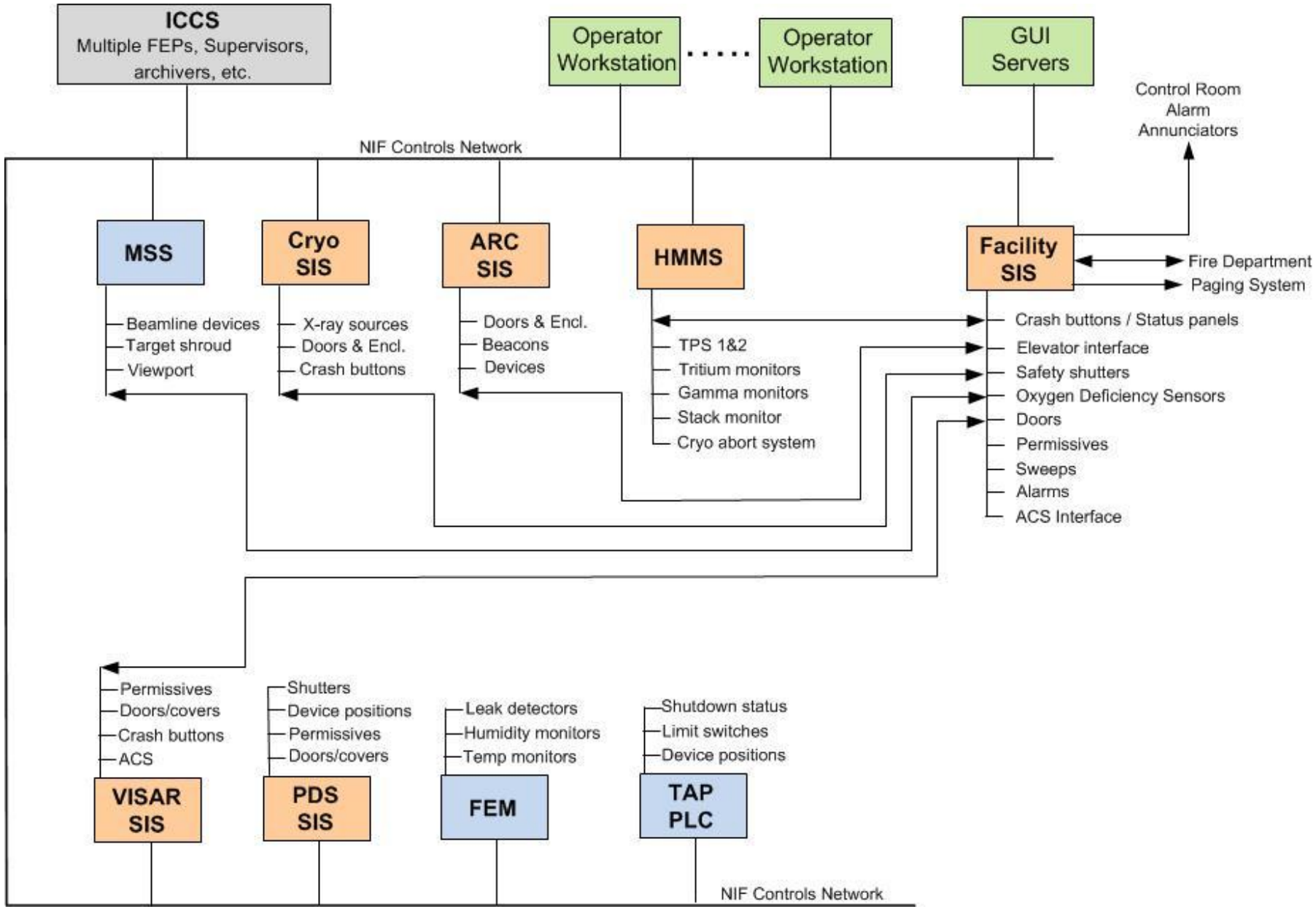
Passive Controls

Administrative Controls

Active Controls

SIS is one layer in a multilayered approach to safety at NIF providing defense in depth

NIF machine & personnel safety systems



Facility SIS

- The main personnel safety system in NIF:
  - Integrates alarms and data from other NIF safety systems and MSS
  - Provides permissives to process equipment
  - Controls & monitors facility access
  - Monitors for oxygen deficiency and radiation alarms,
  - Controls facility sweeps
  - Annunciates facility alarms and automatically pages key personnel

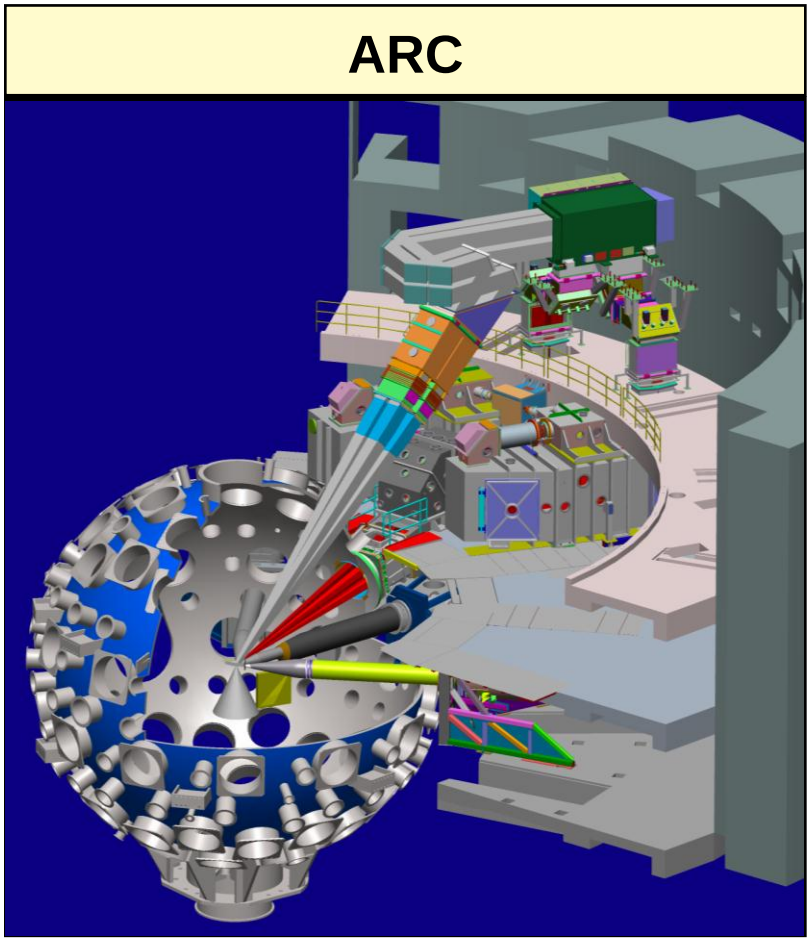
Cryo SIS

- Safety functions related to the cryogenic target positioner (CTP):
  - X-ray shield and camera position monitoring
  - CTP door monitoring
  - Local crash button and port monitoring
  - X-ray permissive generation

Cryo Target Positioner

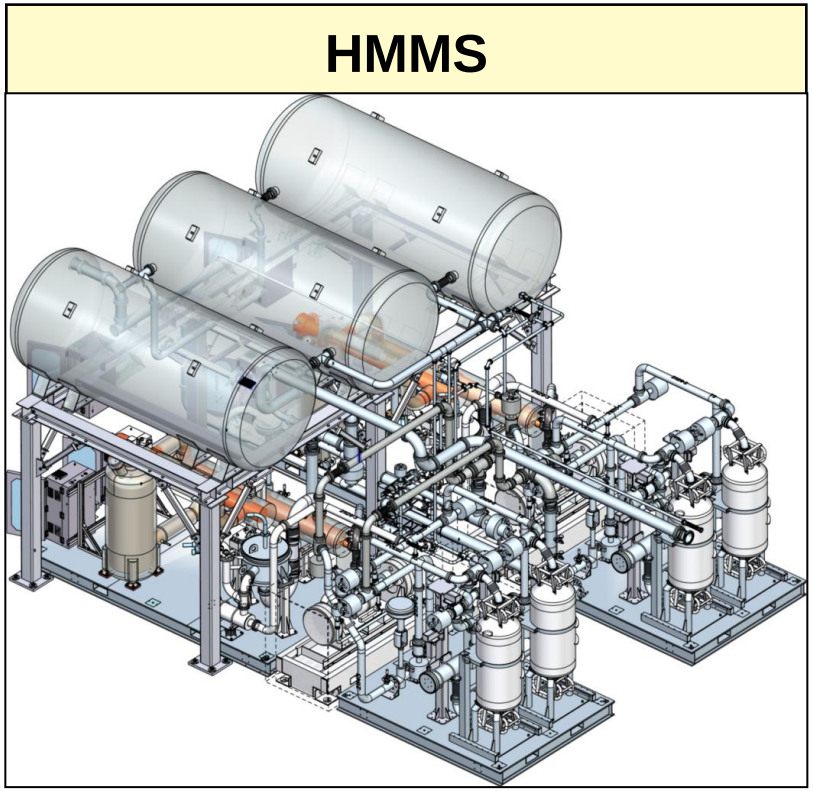
ARC SIS

- Safety functions related to the Advanced Radiographic Capability (ARC):
  - Monitoring of ARC doors and enclosures
  - Control of warning beacons
  - Critical device position monitoring
  - Integration of ARC SIS with facility SIS



Hazardous Materials Management System (HMMS)

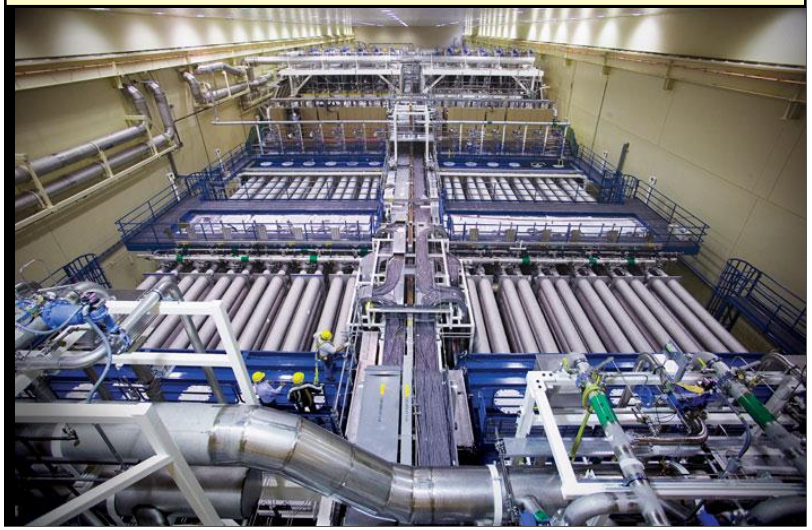
- Monitoring and alarms related to radiological systems:
  - Area tritium monitors (22 ea.)
  - Area gamma detectors (10 ea.)
  - Facility stack monitor
    - Tritium content
  - Controls tritium processing systems
  - Cryo abort system



Machine Safety System (MSS)

- Monitoring of critical device positions and implementation of “t-1” monitoring:
  - Monitoring of target shroud position preventing shot if shroud fails to fully open
  - Monitoring of beamline device positions
    - Fiducial arm
    - Phase plate
    - Rubble plate
  - Chamber viewport monitoring
  - Coordination of MSS (beam fate) permissive with facility SIS

MSS



NIF SIS design description

- SIS is a “shutdown system”
  - When a violation is detected shot permissives are removed, operations are halted until the condition is corrected
- Watchdog timers incorporated in all I/O drops
  - Shot/device permissives fail OFF in the event of a communication failure or power failure
- Control and interlock functions are separated
  - SIS does not implement process control
  - It provides permissives to devices allowing them to be controlled
- Use of “diagnostic” modules providing open circuit detect
- Redundant monitoring points are used for selected devices
- Critical devices are backed by UPS power

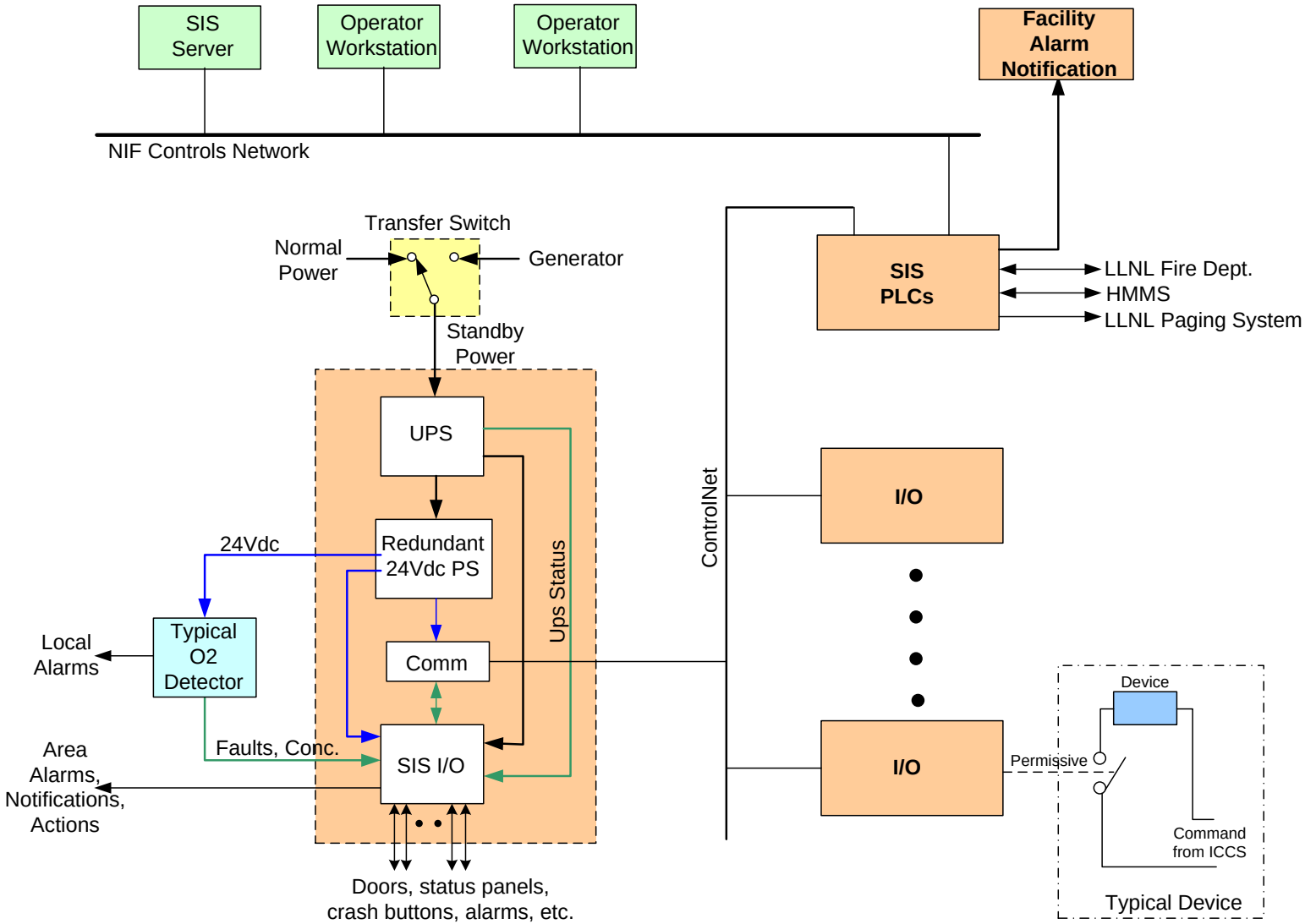
SIS is designed to be a fail-safe system

NIF SIS and MSS implementation

- Highly distributed Programmable Logic Controller (PLC) based systems
- Uses Rockwell Automation's ControlLogix line of PLCs with Rockwell Automation's RSView serving as the operator interface
- Configuration Management of the installed PLC code is via Rockwell's Asset Centre product
  - Check out / check in of software
  - Automatic (weekly) comparison of archived version to field version
- Programming is defined by an approved style guide

SIS & MSS employ proven technology, sound design principles, and are tested regularly

Simplified SIS Architecture



SIS ensures the facility is properly configured based on projected shot yield

Shot Category	Neutron Yield	Configuration (in addition to operational areas being swept)
A	Low $< 10^{14}$ neutrons	TOTIM shield door closed (door between TB and Operations Support Building)
B	Moderate $>= 10^{14}$ and $<= 10^{16}$ neutrons	Primary shield doors closed (19 Target Bay doors)
C	High $> 10^{16}$ neutrons	Primary and secondary (27 Switchyard doors) shield doors closed TB mechanical rooms, lobby, and overlook swept TB restricted mode prior to sweep: Access Key Station token required for entry "Buzz in" required for TB entry

One of 19 primary shield doors for the TB

Facility Tritium monitors

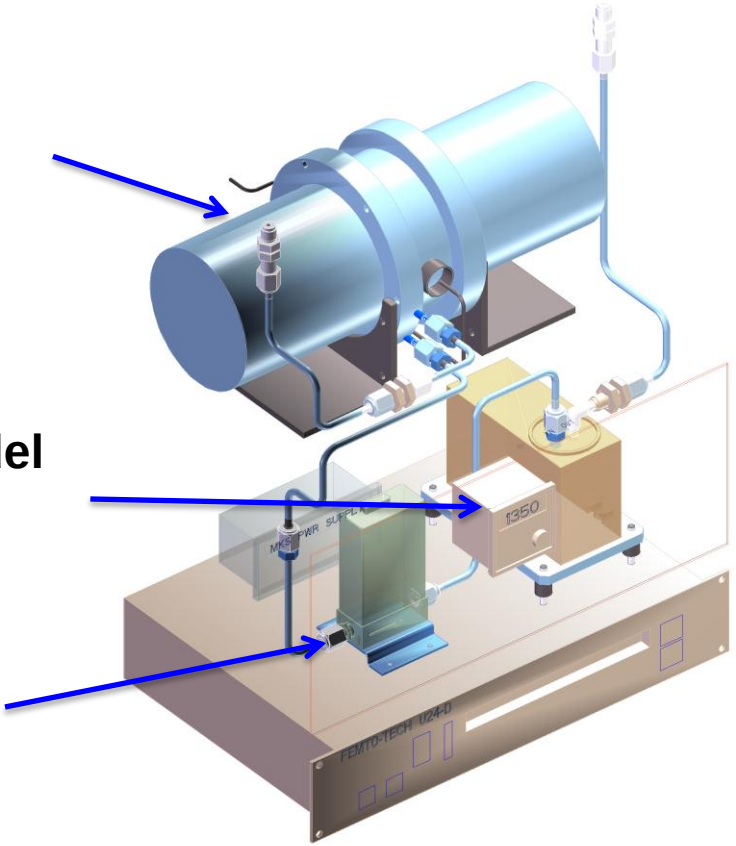
- Packaged commercial components into common-use configuration
- Used at 22 locations for area, process, and enclosure monitoring

Standard tritium monitor package

Femto-TECH Model GC224RM gamma-compensated ion chamber

Metal Bellows Model MB-41 Pump

MKS Type 179A mass-flow meter

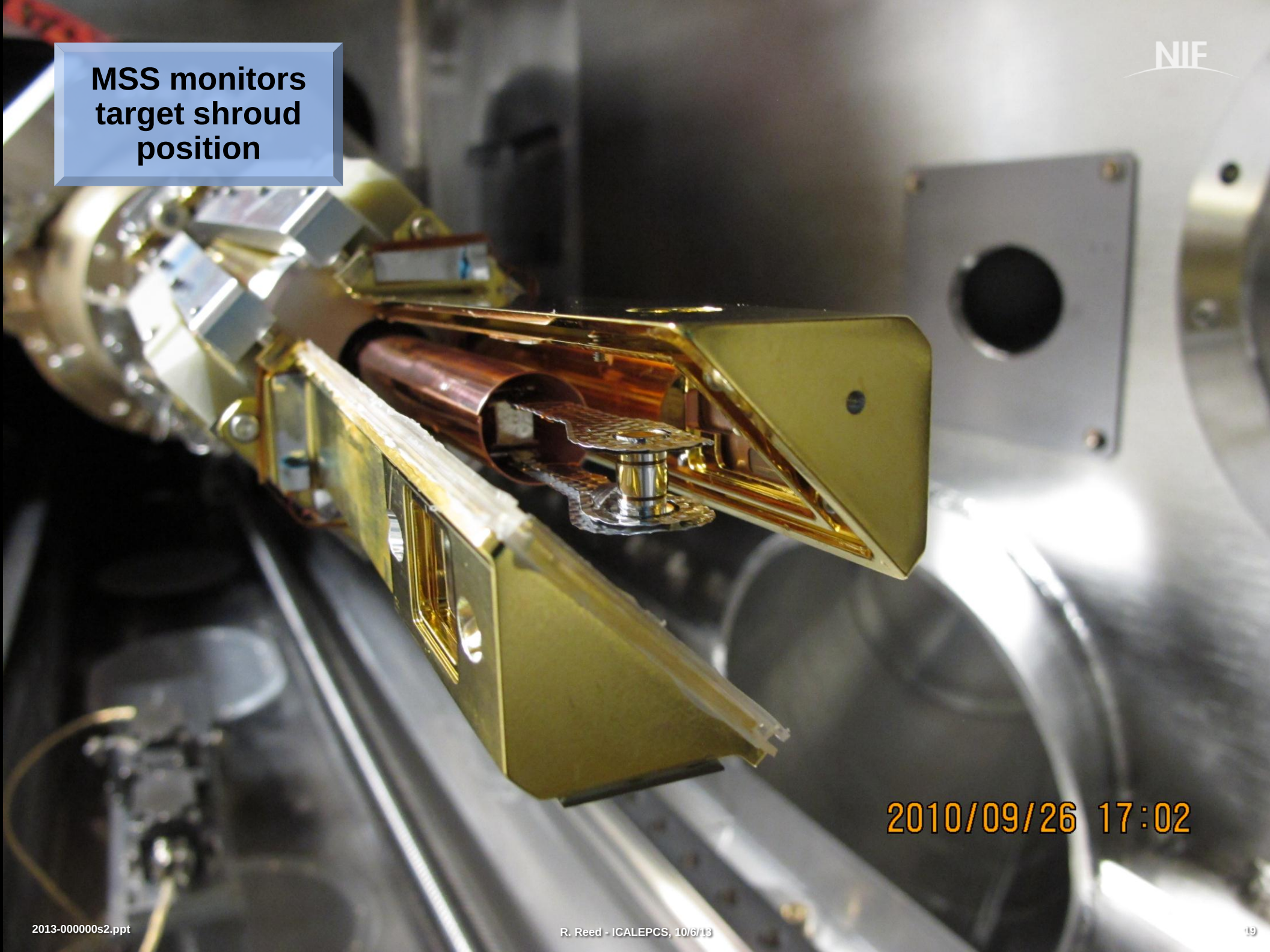


SIS controls / monitors facility alarms

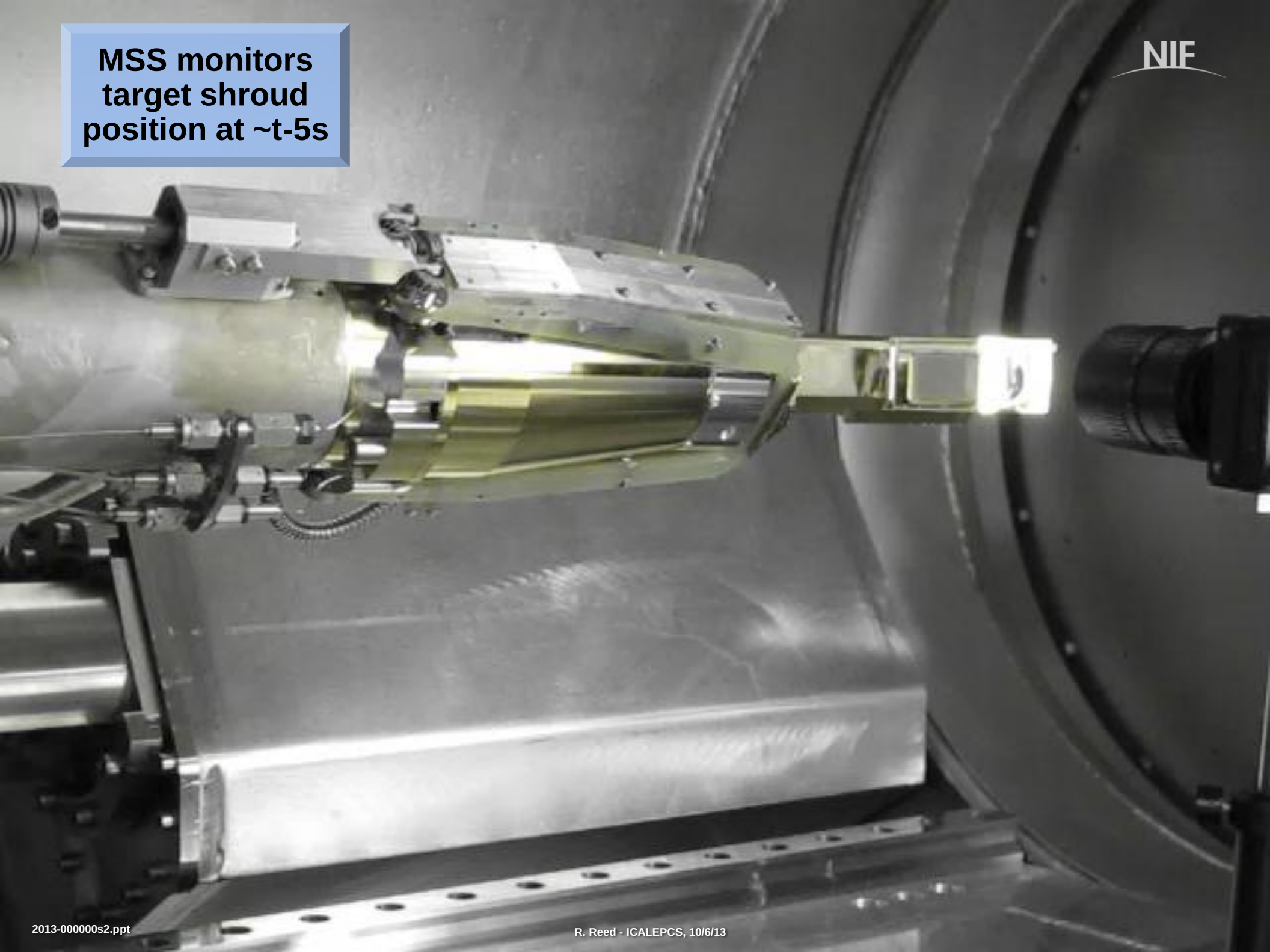
- Oxygen deficiency
- Stack tritium alarm
- SIS fault (health monitoring)
- Area tritium alarms
  - Response:
    - Audible alarm in control room
    - Visual alarm in control room
    - Status panels in area “magenta” and instruct personnel to leave and not to enter
    - Automated building announcement every two minutes
    - Automated page to selected individuals

TB status panel showing tritium alarm response

MSS monitors target shroud position



MSS monitors target shroud position at ~t-5s



SIS provides comprehensive operator interfaces

- Facility overviews
- Operator help screens
- Alarm screens
- Troubleshooting aids
- Trending and archiving of selected data

SIS/ACS control room console

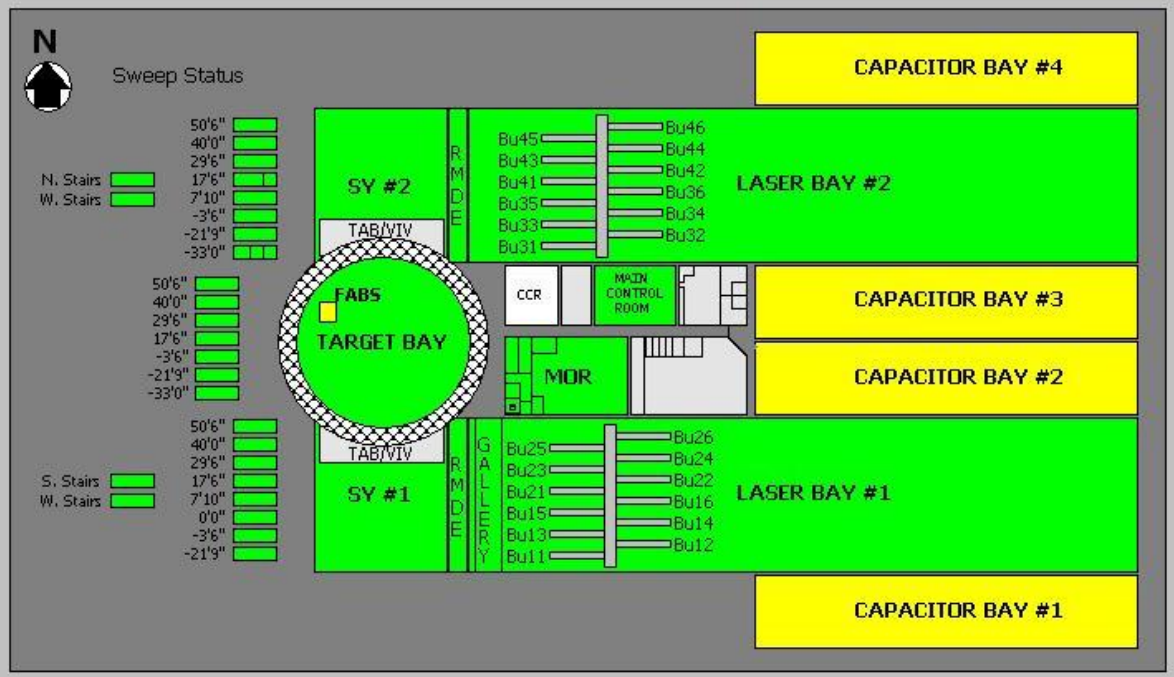
GOTO

SIS overview showing un-swept facility

NIF OVERVIEW

LOGGED STATION
ICSSRADCR82B

LOGGED USER
Default



CATEGORY PERMISSIVE

None Currently Granted

NIF Roof

Core Vestibules

Mech Rooms

NIF Entry Lobby

Shield Doors

Key Summary

GOTO

ALARMS

SIS ready for a cat C shot

NIF OVERVIEW

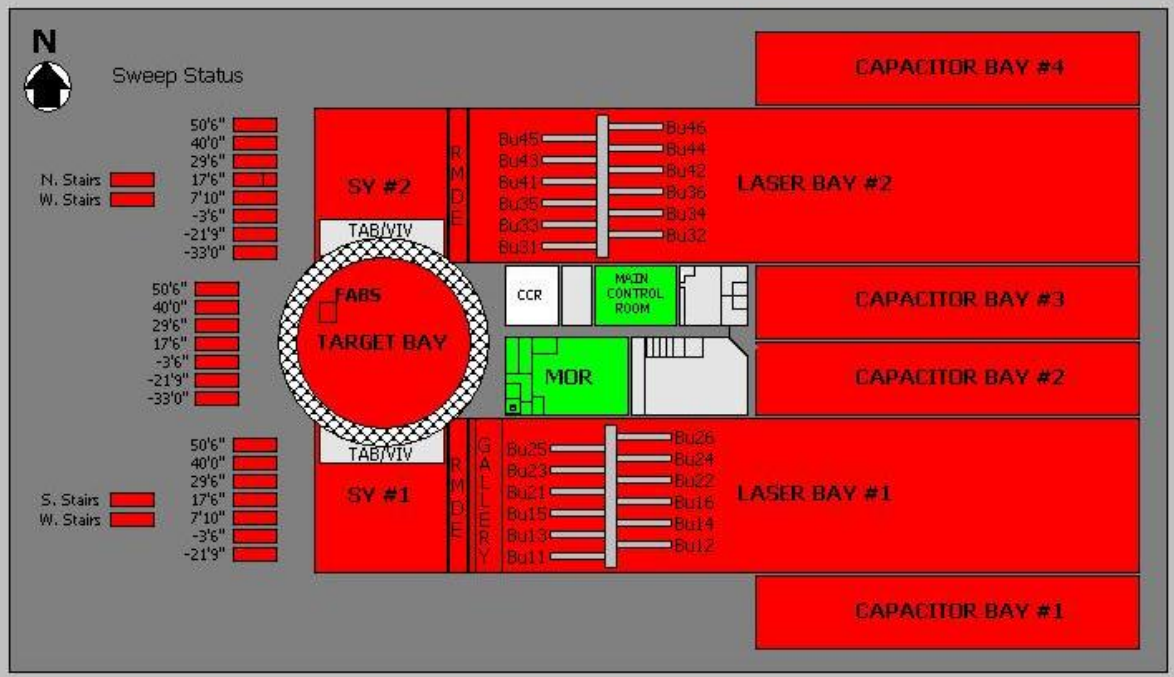
LOGGED STATION
ICSSRADCR82B

LOGGED USER
ICCS

CATEGORY PERMISSIVE

C

- NIF Roof
- Core Vestibules
- Mech Rooms
- NIF Entry Lobby



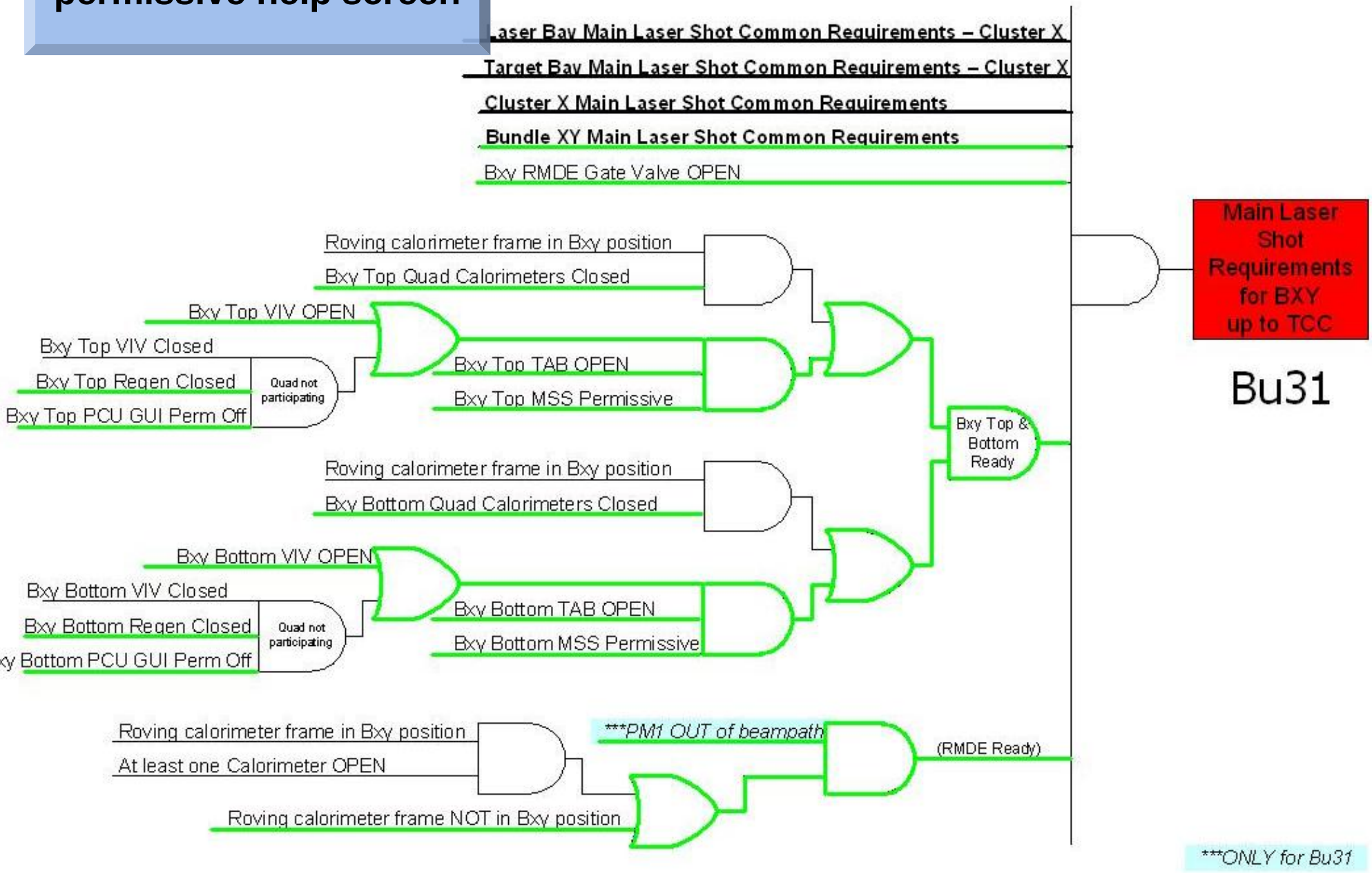
MAIN LASER FIRING PERMISSIVE GRANTED:

for Bundle 11	for Bundle 12	for Bundle 31	for Bundle 32
for Bundle 13	for Bundle 14	for Bundle 33	for Bundle 34
for Bundle 15	for Bundle 16	for Bundle 35	for Bundle 36
for Bundle 21	for Bundle 22	for Bundle 41	for Bundle 42
for Bundle 23	for Bundle 24	for Bundle 43	for Bundle 44
for Bundle 25	for Bundle 26	for Bundle 45	for Bundle 46

Example SIS permissive help screen

CLOSE

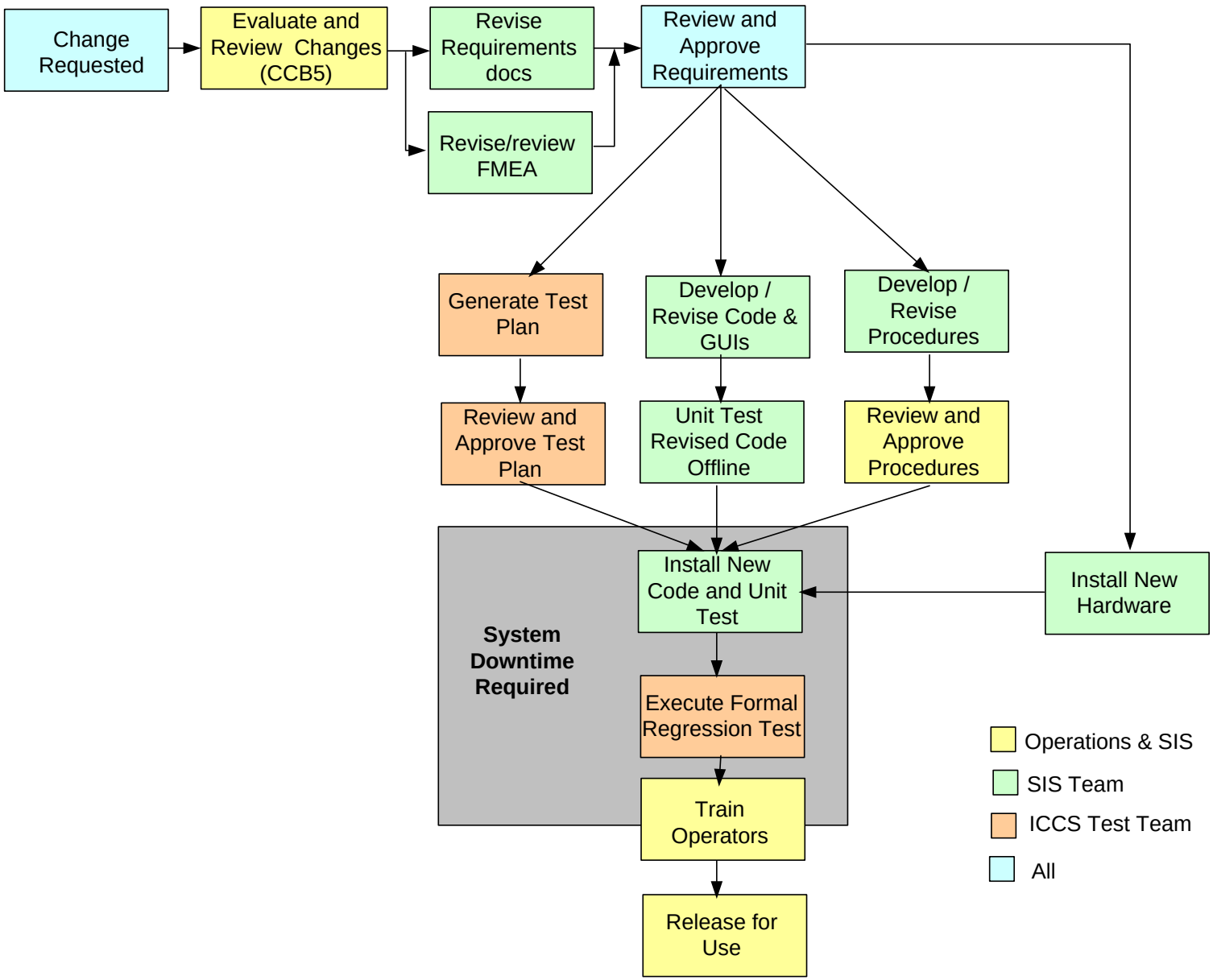
Main Laser Shot Permissive by Bundle: Shot up to TCC



SIS verification

- SIS hardware is tested quarterly/semiannually
  - Emphasis is on finding covert hardware failures in the field
- Logic changes require a regression test
  - Independent test team conducts regression tests on SIS releases
  - Test results are reviewed by the SIS Manager and NIF Operations Manager (NOM) prior to release for use

SIS release process



Summary

- SIS is a proven system operating for ~12 years (24/7/365)
  - — System has been optimized for operations over its life
- The technology is proven with a large installed base
- The system is deployed, operational, and is demonstrated to be reliable

SIS is constructed on a proven foundation and is 100% operational for NIF shots


NIF