Cryomodule Test Facility

CMTF Facility Review
for the
Accelerator Readiness Review

M. McCaughan

Tuesday, November 19, 2024

Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

JSA

List of Acronyms

ARR – Accelerator Readiness Review

ASE – Accelerator Safety Envelope

CATS – Corrective Action Tracking System

CEBAF – Continuous Electron Beam Accelerator Facility

CED – CEBAF Element Database

CMTF – Cryomodule Test Facility

ELOG – Electronic Logbook

ePAS – Electronic Permit Administration System

EPICS – Experimental Physics and Industrial Control System

FSD – Fast Shutdown System

LOTO – Lock out/Tag out

ODH – Oxygen Deficiency Hazard

PSS – Personnel Safety System

RCG – Radiation Control Group

RCM – Radiation Control (Group) Manager

SAD – Safety Assessment Document

SME – Subject Matter Expert

SOP – Standard Operating Procedure

SRFLog – Superconducting Radiofrequency Logbook; portion of the ELOG

SSA – Solid State Amplifiers

SSO – Safety System Operator

TOD – Testing Operations Directives

UED – UITF element database; used for all accelerators in the Test Lab

UITF – Upgraded Injector Test Facility

USI – Unreviewed Safety Issue

VTA – Vertical Test Area

WCD – Work Control Document

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Test Lab (CMTF/VTA) – Location & History

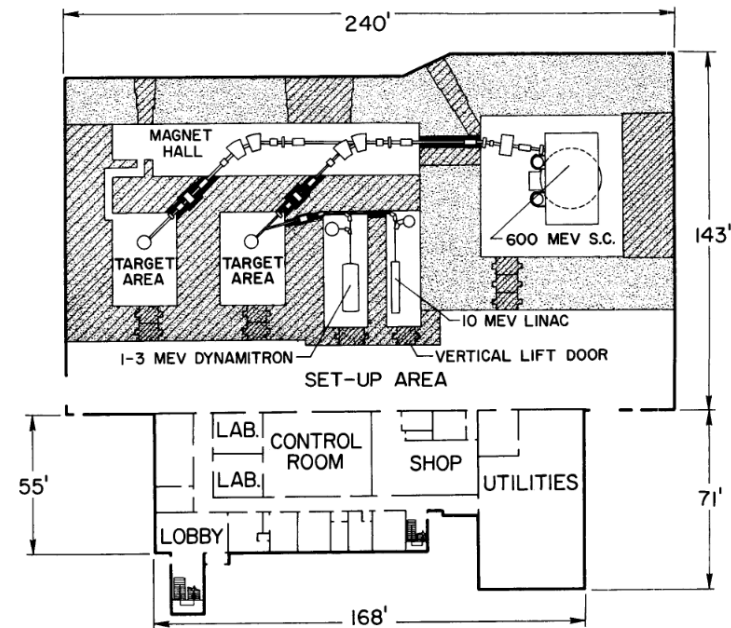Figure 2.- Architects' perspective rendering of the Space Radiation Effects Laboratory.

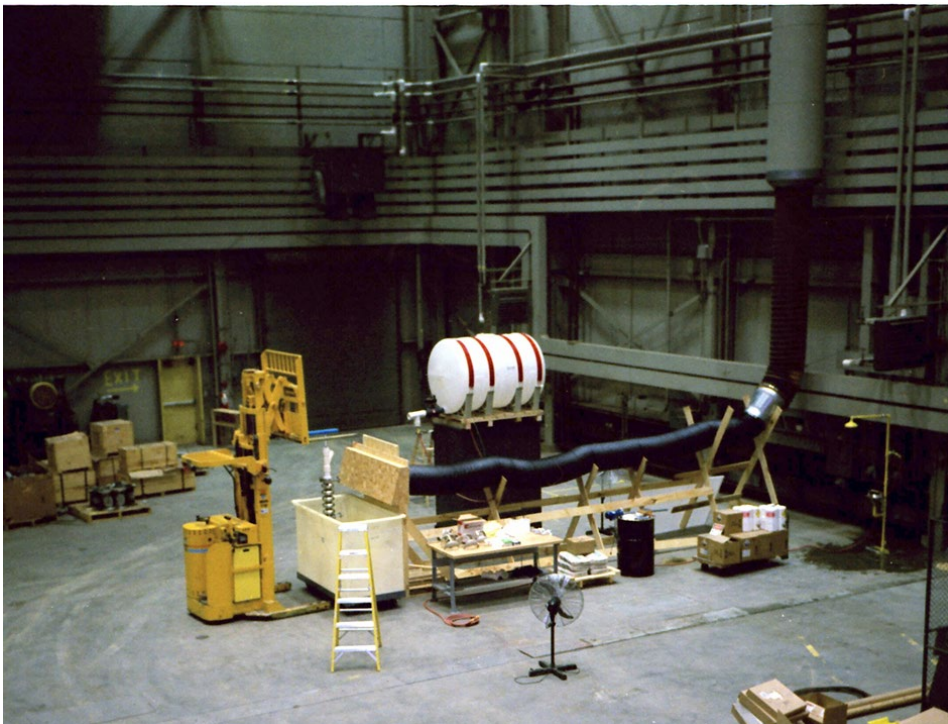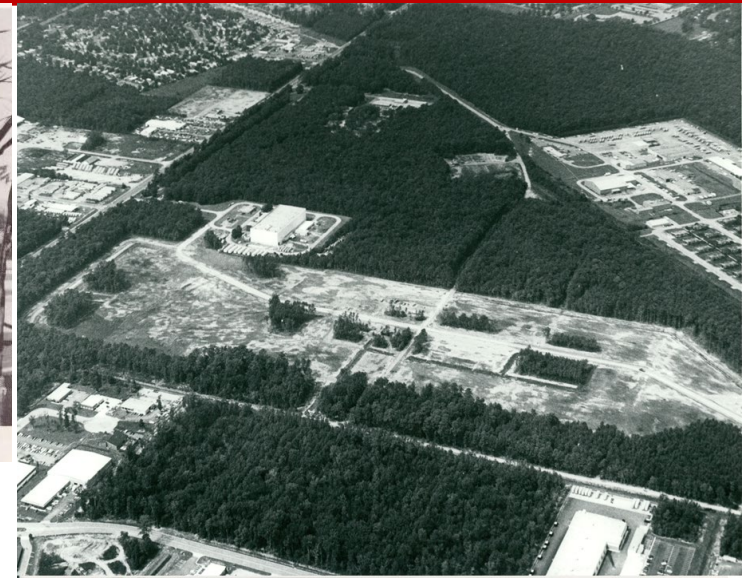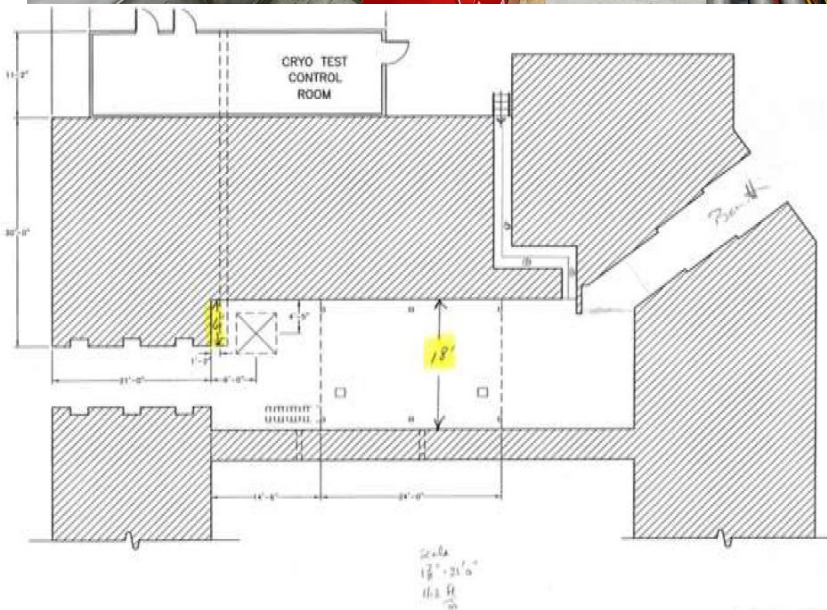Figure 7.- Plan of the Space Radiation Effects Laboratory.

The CMTF Today:
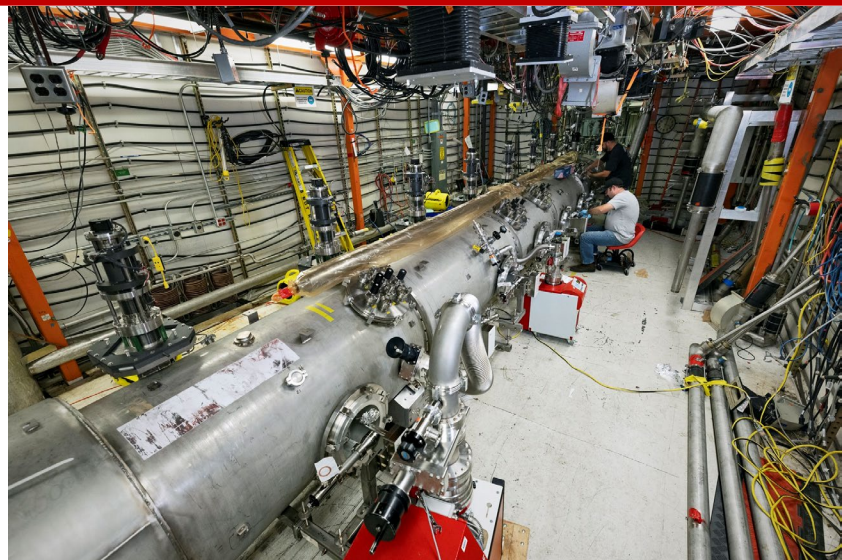
CMTF Governing Documentation

SAD updated for DOE O 420.2D

DOE Order 420.2D - Safety of Accelerators

• Establishes accelerator-specific safety requirements for Department of Energy (DOE)

Safety Assessment Document (SAD)

• Analyzes hazards associated with JLab accelerator operations

Accelerator Safety Envelope (ASE)

• Defines the set of facility-specific controls for CMTF

CMTF Testing Operations Directives (TOD)

• Establishes the conduct of CMTF Operations

Once approved:
https://www.jlab.org/eshq/ProgramDocs
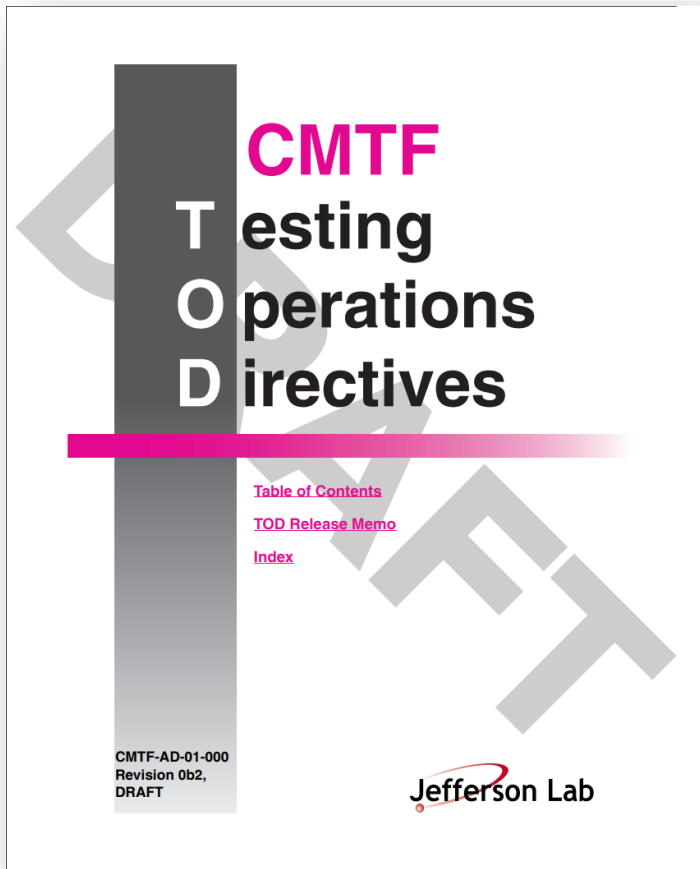
RE: IRR Finding 1: SAD comments addressed.
RE: IRR Finding 3: SAD V.9a draft in review materials.
RE: IRR Finding 2: ASE sent to site office for review.
RE: IRR Finding 5: FSAD references in ASE removed.

REVISION 9

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Thomas Jefferson
National Accelerator Facility
Safety Assessment Document

AUGUST 2024

Revision 0

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THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY

CRYOMODULE TEST FACILITY

ACCELERATOR SAFETY ENVELOPE

November 2024

CMTF Testing Operations Directives

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CMTF-AD-01-000
Revision 0b2, DRAFT

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How Do We Do Business? Described in the TOD

CMTF Testing Operations Directives

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DRAFT

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Similar to the CEBAF AOD, but less complicated as the CMTF is less complicated:

- CMTF accelerator enclosure is contained in one common space that cannot be occupied when the accelerator is ON, whereas the CEBAF accelerator beamline leads to many spaces that can be occupied when the accelerator is ON. In addition, CMTF is solely a testing facility and not a user facility.

Four chapters of TOD:

Chapter 1: Program Control
Describes how safety is integrated into CMTF program execution and establishes how the program is defined and executed

Chapter 2: Configuration Management
Outlines how configuration management standards and work practices are applied as part of CMTF operations

Chapter 3: CMTF Operations
Specifies directives for how the CMTF program is carried out, including the safety responsibilities of the control room staff and the role of safety organizations

Chapter 4: Maintenance & Tracking
Describes the planning, scheduling, and coordinating of maintenance activities to maintain and improve CMTF availability

RE: IRR Finding 1: Explicit Safety / Operating envelopes incorporated into SAD.

(New documents created for CMTF & VTA)

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Contractor Assurance System

Tri-Party CAS Engagement Model

INTERACTIONS INCLUDE:
- PEMP
- Joint Performance Updates
- Metrics & Feedback Processes
- Joint Assessments
- Review of 3rd Party Certification Processes & Reviews
- Formal/Informal Partnering

DOE
Sets Performance Expectations
Validates /Verifies CAS
Provides Feedback
Monitors & Facilitates

INTERACTIONS INCLUDE:
- Written Assurance Reports
- Annual Performance Reviews
- Formal/Informal Meetings

JLAB
Uses & refines CAS processes
Sets Transparency in tools
Measures Performance
Continuous Improvement

JSA
Monitors Performance
Monitors Risk
Corrective Action Efficacy
Assurance Performance & Accountability

OUTCOMES:
- Efficient performance
- Risks are understood & managed effectively
- All levels of management are accountable
- Corrective / preventive actions are effective
- Mutual respect and support

INTERACTIONS INCLUDE:
- Board & Committee Meetings
- Independent Audit & Oversight
- Risk Profile
- Formal/Informal Meetings

Contractor Assurance Program in use site-wide (managed by Performance Assurance Office):
https://www.jlab.org/about/management/coo_office/perf_assur
[Point of contact: Stephen Smith (sjsmith@jlab.org)]

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CMTF Program Control (Overview)

- All facets of CMTF program planning and execution integrate safety as defined in the *JLab Integrated Safety Management System Program Description*:
    - Seven guiding principles
    - Five core safety management functions

- Program is as test facility only for accelerator hardware (mainly cryomodules), and not experimental in nature

- As there is no experimental program, ES&H Manual sections 3120 & 3130 and the associated measures do not apply to the CMTF program

ISM Guiding Principles

Seven Guiding Principles were developed as a starting framework for ISM:

1. **Line Management is Responsible for Safety.**
   Line management is directly responsible for the protection of the public, the workers, and the environment.

2. **Clear Roles and Responsibilities.**
   Clear lines of authority and responsibility for ensuring safety shall be established and maintained at all organizational levels.

3. **Competence Commensurate with Responsibility.**
   Personnel shall possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.

4. **Balanced Priorities.**
   Resources shall be allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers, and the environment shall be a priority whenever activities are planned and performed.

5. **Identification of Safety Standards and Requirements.**
   Before work is performed, the hazards shall be evaluated and a set of safety standards shall be established which will protect the public, the workers, and the environment.

6. **Hazard Controls Tailored to Work Being Performed.**
   Administrative and engineering controls to prevent and mitigate hazards will be specific to the work and hazards.

7. **Operation Authorization.**
   Operations will only be initiated once controls are in place.

Program Control: Cryomodule Test Facility (CMTF)

- Responsible for the safe and effective operation, maintenance and improvement of facility in accordance with DOE Order 420.2D & Integrated Safety Management Program.

- CMTF is a testing facility only; no physics experiments are conducted there.

- Scope of Operations: Two broadly definable programs: Cryomodule Acceptance Testing & Research & Development Activities

- SRF Operations Project Execution & Production processes define these as follows:

Projects:

- CEBAF Support: Refurbishment of CEBAF cryomodules through projects or service agreements controlled by the JLab Accelerator Division.

- Multi-Lab Partnership: Fabrication, testing & delivery of SRF components to external customers through projects controlled by the JLab MLP office with liaising SRF staff.

- Work for Others/R&D: Fabrication and delivery of SRF components and/or data to external customers through projects managed through SRF Ops., Lab Directed Research & Development projects, or projects from SRF Science & Technology.

Services:

- CEBAF Support Services: SRF Ops maintains CEBAF cryomodules and components through project/service agreements administered by the Accelerator Division.

- Lab Service Requests: SRF Ops provides labor, equipment, products, or data for Work for Others projects controlled by S&T and other JLab organizations.

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Hazard Analysis & Mitigation: Credited Controls

Hierarchy of Controls

- Hazard assessment and process in Safety Assessment Document (SAD).

- Controls in place to eliminate, control, or mitigate identified hazards.

- Credited controls are specified in ASE.

- A credited control is determined through hazard evaluation to be essential and necessary for safe operation directly related to the protection of personnel or the environment.

- Credited controls are assigned a higher degree of operational assurance than other controls.

- Controls may be engineered or administrative.

- If a credited control is altered, the USI process is followed.

CMTF Credited Controls
Full description is in ASE

Passive Engineered Controls

- Permanent shielding, including labyrinths, penetration routing, earthen berms, and overburden
- Movable shielding
- Nitrogen gas supply orifices
- ODH vents and facility configuration

Active Engineered Controls

- Personnel Safety System (PSS) access controls
- ODH system controls

Administrative Controls

- Doors, gates, fences and other barriers
- CMTF staffing during PSS Sweep Procedure
- CMTF staffing during operations

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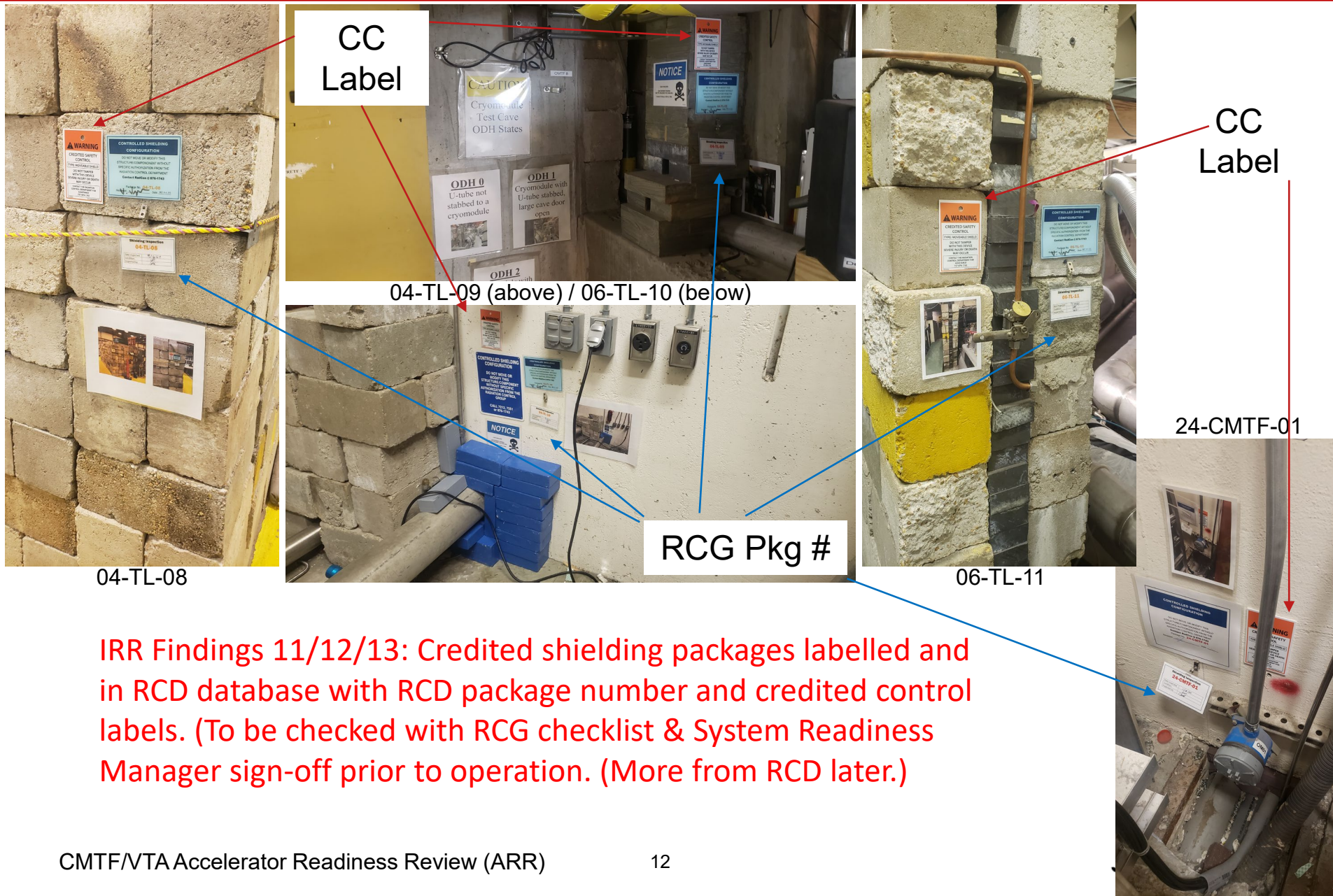# Credited Controls (CMTF) – Passive Engineered Controls

- ASE 4.1.1: Permanent shielding:
  - CMTF Enclosure; Shielding Policy for Ionizing Radiation.

- ASE 4.1.2: Movable shielding:
  Shielding packages (All 6 will be in RCG Shielding Tacking Database & Credited for CMTF / VTA ARR):
  - 04-TL-08: CMTF Mezzanine: Exhaust fan/SSA waveguide penetration
  - 04-TL-09: Personnel Labyrinth Entrance
  - 06-TL-10: Cryogenic penetration CMTF-to-VTA
  - 06-TL-11: Partial Wall: Personnel Entrance/E Wall
  - 24-CMTF-01: Trench to control room (ID Corrects IRR finding #10)
  - 24-CMTF-02: Concrete/Pb shield wall in Cryogenic Penetration of East Wall (Presently removed for Junction box replacement work)

- ASE 4.1.3: Nitrogen Gas Supply Orifices:

- ASE 4.1.4: ODH Vents & Facility Configuration:
  - 4'x4' CMTF enclosure ceiling vent (Passive)
  - Defense-in-depth measure: Active venting.
  - Defense-in-depth measure: Sealed penetrations: Trench to CMTF control room, 2nd floor, & Cryo penetration to VTA (on the VTA-side)
  - ODH assessment (JLAB-TN-07-066; 11/14/24 revision w/ new Junction box – in signature queue for review now.)
  - Revised ODH analysis (Review 188201) should satisfy IRR finding #8 & 22 for CMTF

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Shielding labels & verification:

CC Label

CC Label

04-TL-09 (above) / 06-TL-10 (below)

04-TL-08

RCG Pkg #

06-TL-11

24-CMTF-01

IRR Findings 11/12/13: Credited shielding packages labelled and in RCD database with RCD package number and credited control labels. (To be checked with RCG checklist & System Readiness Manager sign-off prior to operation. (More from RCD later.)

Credited Controls (CMTF) – Active Engineered Controls

- ASE 4.2.1: PSS Access Controls:
  - Certified at least annually; certification will be Safety System SRM check-off (& Credited) to ensure system is functional and working as designed.
  - See static & functional certification procedures
  - System presentation tomorrow by SSG

- ASE 4.2.2: ODH System Controls:
  - Certification process maintained by SSG
  - ODH sensors located along ceiling and floor of CMTF enclosure
  - System Readiness Manager components:
    - ODH sensors/beacons/klaxon horns
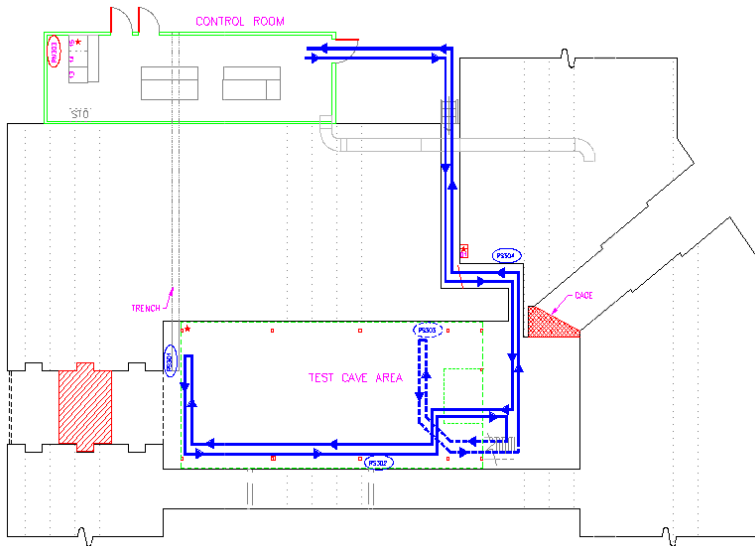 - System presentation tomorrow by SSG
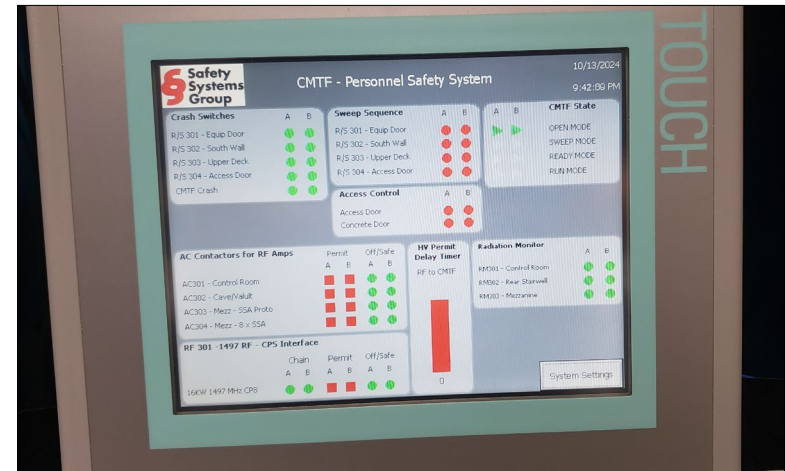
PSS Human-Machine Interface

PSS Alarm Summary, key/door control, & ODH panels

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Credited Controls (CMTF) – Administrative Controls

- ASE 4.3.1: Doors, Gates, Fences, & Other Barriers

- ASE 4.3.2: CMTF Staffing – Sweep
  - Sweep Procedure / Diagram
  - Qualified Sweeper List

- ASE 4.3.3: CMTF Staffing – Operations
  - Staffing / PSS Run Modes on upcoming slide

CMTF PSS Sweep Procedure

Document Number: SSG-PR-03-015

Revision Number: Rev. 2; February 28, 2017

Technical Custodian: Henry Robertson

Estimated Time to Perform: ~10 minutes

Procedure Overview

This procedure documents the protocol for performing sweeps of the Upgrade Injector Test Facility (UITF). A sweep, which verifies that all personnel have exited the area, must be carried out before changing the Personnel Safety System (PSS) state from OPEN to RUN mode.

Prerequisites

Notice: CMTF Sweepers MUST be ODH 2 qualified (see ref. CMTF operating procedures).

Prior to operation of the CMTF the beam enclosure is searched by 2 personnel. These "sweepers" ensure that no one is in the enclosure. One of the sweepers must have experience in sweeping the CMTF and must be familiar with the CMTF sweep pattern.

The PSS users manual contains a map and directions that the sweep team may take with them to confirm the proper sweep procedure and pattern.

Sweep Team Responsibilities

1. Lead Sweeper – Qualification requires that the Lead Sweeper be familiar with the sweep procedure and have participated in a sweep of the area at least once.

2. The sweep team shall do the following:
   a. Check in all confined areas, such as behind the cryomodule, cable trays, storage bins, etc.
   b. Arm all Run/Safe boxes in the proper order without deviation.
   c. Perform the sweep in a timely manner.
   d. Ensure that all exit doors are pulled tight and locked.
   e. Ensure that all crash switches are not activated
   f. Have anyone found in the sweep area during a sweep must accompany the sweep

Page **1** of **4**

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Unreviewed Safety Issue Process

The USI Process is included in pre-brief materials:

- "Unreviewed" doesn't necessarily mean that the hazard was never considered.

- Process also used when:

    - Conditions inconsistent with the SAD or ASE are discovered

    - The Department of Energy Thomas Jefferson Site Office identifies accelerator operations as being in violation of the ASE

    - New or proposed changes to accelerator equipment installation, configuration, or operational activities are proposed

Safety Concern Form & Unreviewed Safety Issue (USI) Procedure:
https://www.jlab.org/about/management/coo_office/perf_assur/pro_prog

Actions/findings as a result of the above processes (as well as many others) are tracked via the Corrective Action Tracking System (CATS):

https://mis.jlab.org/ehs
(Accessible from laboratory networks only)

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CMTF-Specific Hazards

Hazards and their assessments are summarized in the Safety Assessment Document (SAD)

On-site Hazards

- High Voltage electricity
- Cryogenic liquids and gases
- Oxygen-displacing gas
- Pressure and vacuum systems
- Prompt ionizing radiation exposure (n,g)
- Radiation exposure from radioactive material
- Nonionizing radiation.

SAD (Rev. 9) - Section 4.4.2.4

IRR finding 4: Slide previously not in agreement w/ SAD; corrected.

Off-site Hazards
(Evaluated; but not applicable)

- Offsite dose from prompt ionizing radiation (skyshine). (JLAB-TN-16-010)

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Thomas Jefferson
National Accelerator Facility

Safety Assessment Document

AUGUST 2024

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TOD – Program Control (Safety Features)

- As required by *DOE Order 420.2D, Safety of Accelerator Facilities*, two documents address the hazards associated with CMTF operations:
  - *CMTF Accelerator Safety Envelope* (ASE)
  - *JLab Safety Assessment Document* (SAD)
- Additional safety features:
  - Machine Protection System (MPS)
  - CMTF-Specific Standard Operating Procedures
  - Channel Access Security
- Means of Communication:
  - SRFLog (electronic logbook)
  - Work planning & control tools:
    - TATL (Test lab Area Task List)
    - ePAS (Electronic Permit Administration System)
    - Pansophy
  - OPS-PR (Operations Problem Reporting)
  - CATS (Corrective Action Tracking System)
  - USI (Unreviewed Safety Issue) Process

U.S. Department of Energy
Washington, DC

ORDER

DOE O 420.2D

Approved: 9-9-2022

SUBJECT: SAFETY OF ACCELERATORS

1. **PURPOSE.** To establish accelerator-specific safety requirements for Department of Energy (DOE), including National Nuclear Security Administration (NNSA), accelerators and their operations[1] that, when supplemented by other applicable safety and health requirements, promote safe operations to ensure adequate protection of workers, the public, and the environment.

2. **CANCELS/SUPERSEDES.** DOE Order (O) 420.2C, *Safety of Accelerator Facilities*, dated 7-21-2011. Cancellation of a directive does not, by itself, modify or otherwise affect any contractual or regulatory obligation to comply with the directive. Contractor Requirements Documents (CRDs) that have been incorporated into a contract remain in effect throughout the term of the contract unless and until the contract or regulatory commitment is modified to either eliminate requirements that are no longer applicable or substitute a new set of requirements.

3. **APPLICABILITY.**

   a. **Departmental Applicability.** Except for the exemptions/equivalencies in section 3.c., this Order applies to any DOE Element with programs involving accelerators, and their operations. The Administrator of the National Nuclear Security Administration (NNSA) must assure that NNSA employees comply with their responsibilities under this directive. Nothing in this directive will be construed to interfere with the NNSA Administrator's authority under section 3212(d) of Public Law (P.L.) 106-65 to establish Administration-specific policies, unless disapproved by the Secretary.

   b. **DOE Contractors.** Except for the equivalencies/exemptions in section 3.c. the CRD, Attachment 1, sets forth requirements of this Order that apply to contracts that include the CRD.
   The CRD, Attachment 1, must be included in site/facility management contracts that involve the management and operation of accelerators and accelerator facilities unless superseded by an alternative standard authorized through an exemption or equivalency process.

   c. **Exemptions/Equivalencies for DOE O 420.2D.** Requests for exemptions and equivalencies to the requirements of this Order which are not addressed in section 3.c. must be processed in accordance with DOE O 251.1, *Departmental Directives Program*, current version.

   _____
   [1] See definition of Accelerator Operations in Attachment 2, *Definitions*.

   AVAILABLE ONLINE AT: INITIATED BY:
   www.directives.doe.gov   Office of Science

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Defense-in-Depth – Additional Safety Controls (Not Credited)

Machine Protection System (MPS)

- An active engineered system designed to turn off RF/High Voltage whenever an off-normal condition is detected and before significant damage occurs. [CARMS, Arc & IR Detectors, Quench detection circuit, etc.]

Channel Access Security

- An active engineered system that establishes a security protocol limiting individuals' ability to access electronic process variables used to control the accelerator. [EPICS]

Operational Envelope

- Administrative limits and operating parameters for specific CMTF systems.

Run Authorization

- Before RF/HV Operations are permitted in CMTF following a shutdown, the Facility Manager examines component readiness & issues permission to run via the System Readiness Manager and an entry into the SRFLog.

Safe Computing Practices

- LabView access only via Group login with a regularly rotating password, retrieved in-person from administrator.
- Lock computers when not in use.

Other Administrative Controls

- Work control documents & procedures
- Training
- Signs & Postings

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Program Control Critical Personnel and Their Responsibilities

CMTF Facility Manager
- Authorizes who can operate at CMTF
- Develops schedule in conjunction with Lab Management and Principal Investigators
- Approves schedule deviations and return to work following critical event response
- Maintains documentation, operating guidelines, and issues Run Authorization via System Readiness Manager to permit operations.

CMTF Principal Investigator
- Supplies all activity-specific information necessary for design and safety review processes
- Coordinates with Facility Manager, Testing Coordinator, and RF Operators for the installation of equipment and beam tests

CMTF Testing Coordinator
- Liaises with Facility Manager and Principal Investigators
- Sets day-to-day test staffing and schedule, performs online data analysis, and ensures adequate documentation of testing process

CMTF RF Operator
- Person(s) with sufficient knowledge (and authorization) to operate the accelerator or a specific component of the accelerator and record their testing results

CMTF Work Coordinator
- Approves proposed work control document tasks submitted via *Test Lab Accelerator Task List (TATL), electronic Permit Authorization System (ePAS),* or *Pansophy* as Work Coordinator
- Coordinates internal and external work to ensure tests are performed safely and successfully, involving the Radiation Control Group when necessary

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CMTF Program Authorization

- Operations authorization process follows DOE O 420.2D requirements
- ASE, CAS, SAD, USI, and Shielding Policies developed by JLab and reviewed by DOE
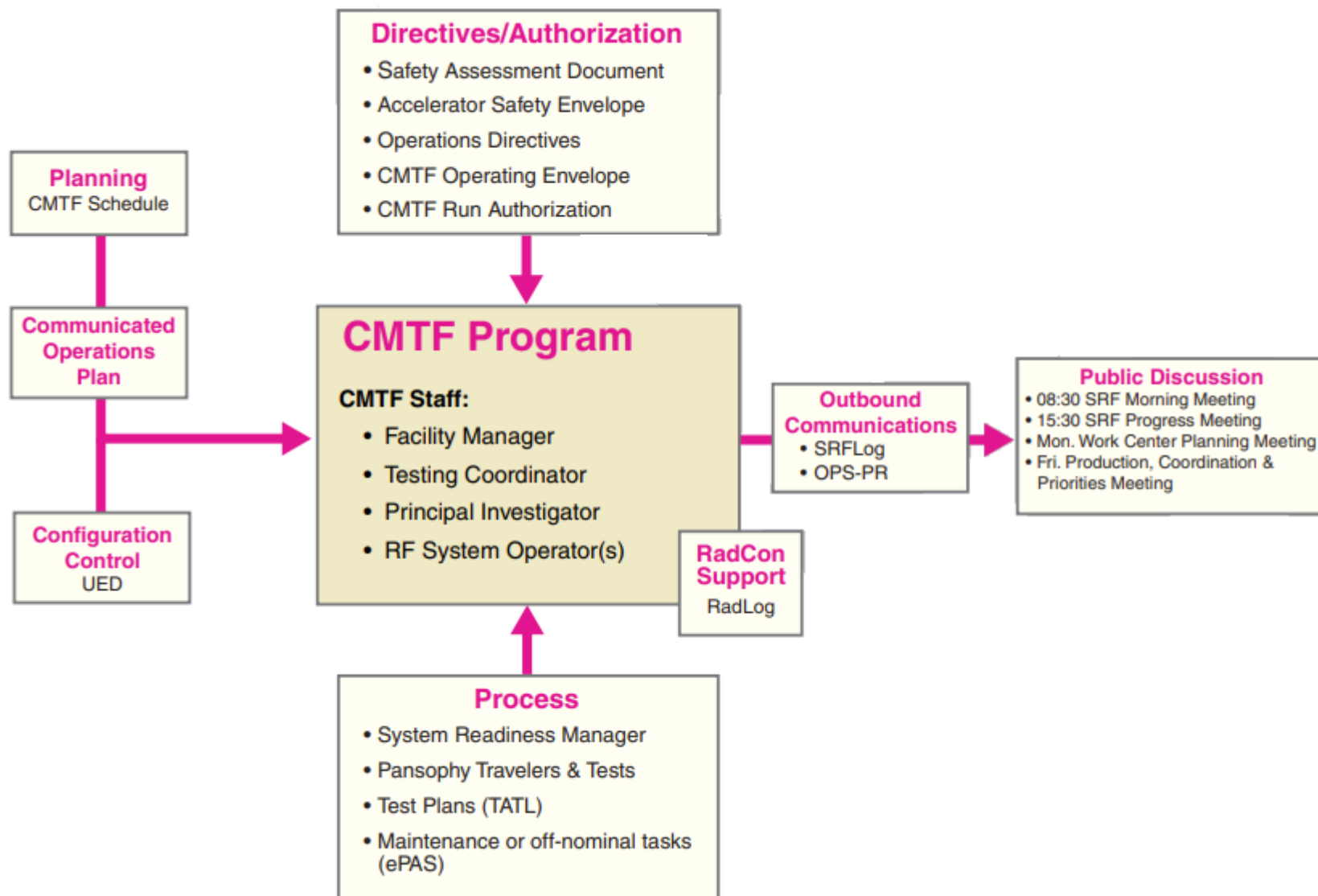- DOE authorizes operations after ARR verifies all conditions are met
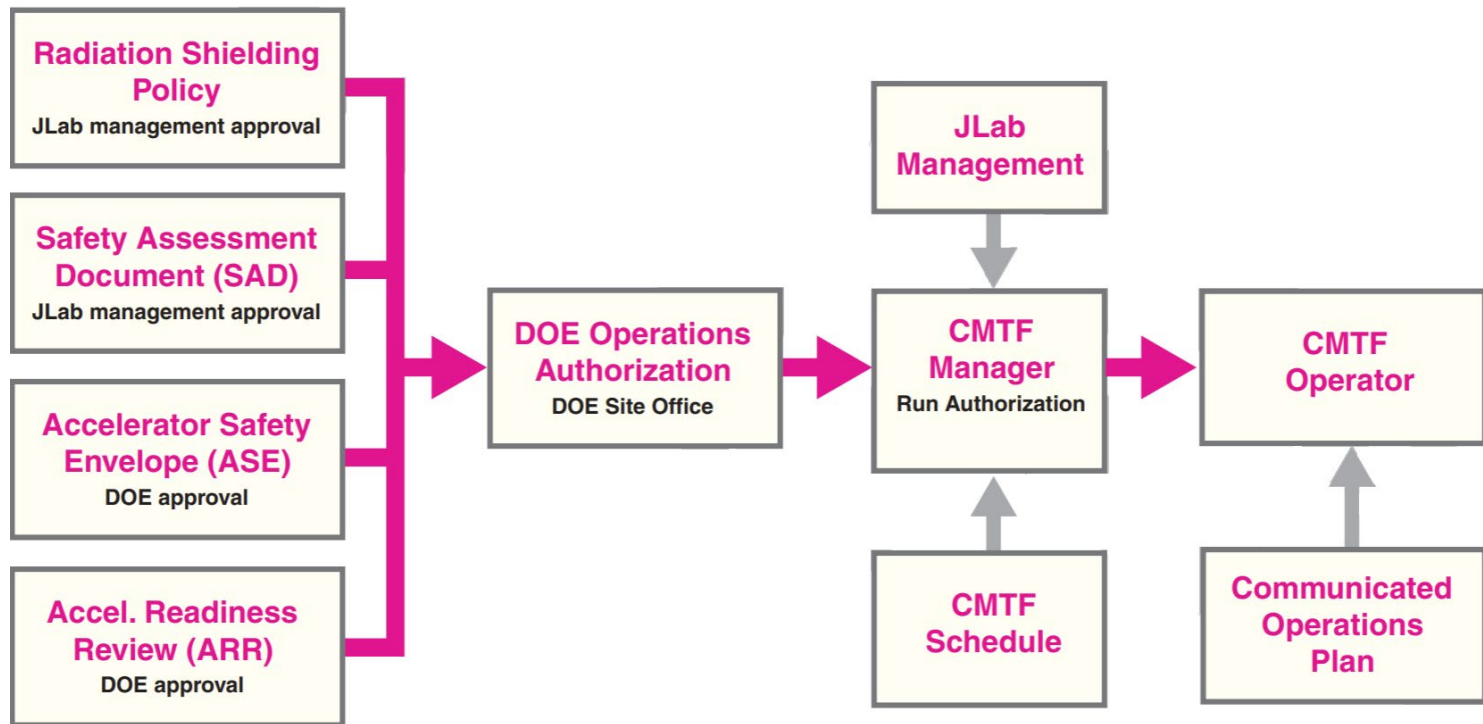
CMTF Program Authorization
(Testing Operations Directives; Sect. 1.2)

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CMTF Program Communication and Feedback

- Schedule communication
  - Long-term (12 month) <u>Experimental Schedule</u> is developed by the Physics & Accelerator Division with input from others.
  - Deliverables to support the program are negotiated between Director of SRF Operations & Director of Accelerator Operations, informed by budget, production schedule, etc.
  - Module production and acceptance testing schedule developed with input from SRF work centers & executed by facility manager.
  - Daily Operational Plan communicated by Facility Manager or Testing Coordinator to those on duty at start of shift.
  - Schedule feedback to Facility Manager/Testing Coordinator via email, SRF Logs, paper logbook entries, and Ops-PRs.

- Program meetings to coordinate progress and provide feedback
  - *Daily 8:30 SRF Work Center Meeting* to summarize progress and coordinate activities for the day.
  - *Daily 15:30 Progress Meeting* to iterate over the morning plan and coordinate work for the next day.
  - *Weekly Fri. 1:30 Production, Coordination, & Priorities* manager meeting to review milestones for the next week.
  - *Weekly Monday 9:30 Work Center Planning* manager meeting to plan the upcoming week's work at a high level.

- SRFLOG and paper logbook are used to communicate and record operational and other important information

- Failure tracking and feedback to SMEs
  - OPS-PR system is used to communicate failures to system owners and monitor repair status.

- Corrective Action Tracking System (CATS) – lab-wide formal action-item tracking system

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Conduct of Operations at CMTF

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CMTF Configuration Management: UED

UED = UITF Element Database:
- Similar to CEBAF Element Database (CED) used at CEBAF
- Database of elements, physical positions, and associated properties

Why UED and not a new database?
- Significant overhead in maintenance of each database deployment for high level apps/software
- UED deployment able to handle the needs of all the test lab accelerators

IRR Finding 19: Data now in UED

CMTF Configuration Management: UED Revision Process

From TOD Section 2.0:

"Consistency between the installed equipment configuration and the information contained in the UED is critical, making appropriate application of configuration management principles of paramount importance for accelerator operations."

- Accurate database yields:
  - On-demand up-to-date controls and screens
  - "Free" tools/applications already deployed at CEBAF, LERF, and UITF
  - Existing system readiness/ configuration management process
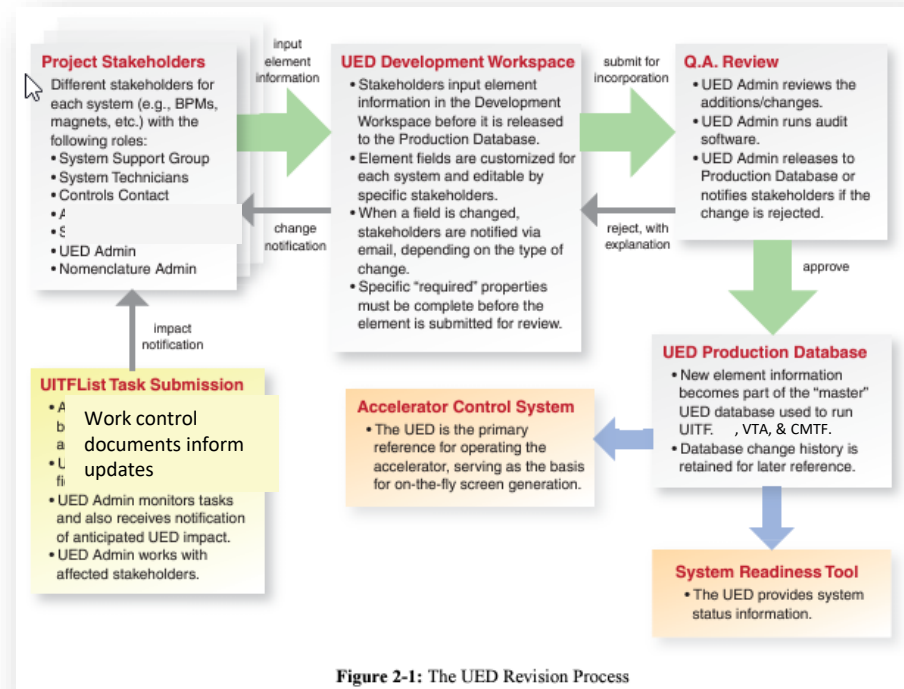
UED Revision Process

Figure 2-1: The UED Revision Process

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CMTF Configuration Management (Continued)

- Ultimately, a list of accelerator components in correct order, with specific locations assigned.

- Physics modeling and simulation tools can export information from UED.

- System readiness manager is based on UED, helps satisfy part of DOE O420.2D requirement for accelerator configuration control.

- UED is exceptionally useful for software development, e.g., on-the-fly epics control screens, macros, many analysis tools, high- and low-level apps from CEBAF readily exportable once in place for CMTF/VTA (big example – alarm handler) and used to denote IOC configuration.

- Combination of the above allows for rapid troubleshooting – no more waiting around for a week to realize you have the wrong IOC configuration after a power outage, spotting something wrong in data stream during analysis, and having to repeat tests.

- Survey and alignment uses as a record of where things are physically located.

- System owners are responsible for conveying UED information to Software Group; Epics screens automatically populated with every UED configuration.

- UITF administrator (designated by CMTF/VTA facility managers) is responsible for making sure the UED is correct for each accelerator (Mike McC. for CMTF/VTA during implementation).

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Configuration Management: System Readiness Manager

- System readiness tracked in tool; gets component inventory directly from UED
- Paradigm: Staff check SRM prior to operating hardware
- SMEs) update element readiness status in SRM (components, controls, etc.)
- Facility manager to downgrade elements as needed, with input from knowledgeable staff and SMEs
- SRM used to assess system readiness pre-Operations:
    - Credited controls status will be monitored through tool and upgraded/downgraded as needed
    - Granularity of check-offs at discretion of facility manager, plus individual system owners
    - Systematic downgrade of systems and frequency envisioned only with major utility interruptions (e.g., IOCs with power outages, cryomodule/dewars if CTF goes down for maintenance)
    - Not the same for both facilities:
        - VTA: Near-continuous operation
        - CMTF: Downgrade PSS when switching between Window test stand running with the jumper request and recertification
    - Final authorization to run sign-off by facility manager. Credited controls <u>must be</u> in place to run.

CMTF Ops: Control Room Personnel & Responsibilities

- Scope: 16 hr/day, with 2 8-hour shifts starting 8 am & 4 pm
- Turnover meeting between shifts; Operating Plan briefing by Facility Manager or Testing Coordinator at the start of each shift
- Control Room Staff
  - Facility Manager
  - Test Coordinator
  - Principal Investigator(s) (if applicable)
  - Duty Operators: [JLab or Visiting]
    - RF System Operator
    - Cryogenic System Operator
  - Safety Systems Group
    - Supporting PSS certification activities
  - Radiation Control Group
    - Supporting PSS certification activities or CARM alarm response
- Also includes:
  - SMEs
  - Engineers
  - ES&H Support (industrial hygiene, etc.)
  - Others who operate the accelerator controls to commission new hardware or software, diagnose problems, and perform equipment-specific tests, plans, or studies.
- Accelerator-Site security guards available for emergency response

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CMTF Operations: RF System Operator

- Program execution by the CMTF RF Operator

    - Deemed sufficiently trained by the CMTF Facility Manager.

    - Knowledge of PSS, leaves CMTF in safe state at end of activity.

    - Ensures safe operation of CMTF, in accordance with the requirements outlined in the ASE, SAD, and TOD.

    - Reads and understands all approved CMTF-specific SOPs and WCDs.

    - Requests Radiation Control Department conduct a radiation survey of the enclosure after prompted by CARM response (or while assessing new conditions).

    - Responds appropriately to all PSS and MPS faults and conducts critical event response.

    - Makes detailed entries in SRFLog, paper logbook, and other WCDs.

    - Responds to off-normal events.

- Average Testing Frequency: ~3 modules/year; ~200 hours total RF-on.

OFI#4/Ref#29

Jefferson Lab

CMTF Operations: Qualified CMTF Operators

- Training & Qualifications (RF/Cryo Ops):
  - SAF801C/P/T: Rad Worker 1
    Requires:
    - SAF800: General Employee Radiation Knowledge
    - SAF801kd: General Access Radiation Work Permit
  - ODH-2 Work Qualified:
    - MED13: ODH-2 & Respirator Medical Certification
    - SAF103: Oxygen Deficiency Hazard
    - SAF210: 5-minute Escape Pack Use
  - ESC001: Basic Electrical Safety
    - Class 1 electrical tasks not requiring LOTO
    - Plug in-hand work (V ≤ 24 VDC) [e.g. Connect arc detectors etc.]
    - Buttons / Control screens; but no breaker manipulation [e.g. Turn on/off vacuum pump power supplies, but NOT touch HV cabling]
  - Knowledge Comprehension Documents:
    - SAFnnn*: CMTF-specific RWP + Briefing
    - SAFnnn*: TJNAF Safety Assessment Document (SAD)
    - SAFnnn*: CMTF Accelerator Safety Envelope (ASE)
    - SAFnnn*: CMTF Testing Operations Directives (TOD)
  - Revised USI Training
  - SAFnnn*: On-the-job Training (OJT)
  - Approval of the Facility Manager

- Specific procedures may require more:
  - 480V breaker switching supplying RF source has own procedure.
  - Specifies Qualified Electrical Worker training (ESC001 - ESC008 + SAF603B.KD) for that subset of trained individuals in addition to OJT & valid ePAS permits.

IRR Finding 18: CMTF RWP developed; more in RCD talk.
IRR Finding 20: Recording of training & OJT records

Jefferson Lab
Thomas Jefferson National Accelerator Facility
Exploring the Nature of Matter

Memorandum:
To: **Control Room Postings**
From: Michael Drury,
CMTF Facility Manager
Subject: Qualified Operators of the UITF Accelerator
Date: 10/16/24

Effective 10/16/24, the following individuals based on their operational experience, training, and service records are authorized to operate the CMTF in the manners noted below. All earlier dated lists of facility operators are now considered invalid.

Authorized CMTF Operators:

RF Operators:

D. Christian (MCCOPS)	M. Morrone
G. Ciovati	P. Owen
M. Drury	R. Ruber
S. Dutton	H. Senevirathne
A. Grabowski †	C. Wilson
L. King	E. Deir (MCCOPS) †
M. McCaughan	U. Pudasaini †

†: Conditional permission, must be accompanied by another qualified Operator who is in present & in control room

Cryogenic System Operators:

F. Humphry	P. Owen
N. Huque	D. Savransky
M. Murphy†	M. Weaks

†: Conditional permission, must be accompanied by another qualified Operator who is in present & in control room

Special Categories:
Window Test Stand Operation

Authorized Window Test Stand Operators:

D. Christian (MCCOPS) †	M. McCaughan
M. Drury	
F. Humphry	

†: Conditional permission, must be accompanied by another qualified Operator who is in present & in control room

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* Awaiting # assignment from Training Office   **Jefferson Lab**

Job Task Analysis modification to update Skills Req. Lists:

⊞ Expand All   ⊟ Collapse Non-Checked   ⊟ Collapse All

- ☑ 1. JLAB TYPE -- check to open questions
  - ☐ 1. Is this person **contract labor**? *(GEN034, SAF100, CST001)*
  - ☑ 2. Is this person an **employee** of JSA? *(GEN034, GEN150, SAF100, GEN101, MED00, ADM001, MED006, CST001)*
    - ☑ 1. Is this employee Salaried Exempt (does not receive overtime)? *(ADM004, ADM005)*
    - ☐ 2. Is this employee Salaried Non-Exempt (receives overtime but not a student or casual employee)? *(ADM003, ADM005)*
    - ☐ 3. Is this employee Hourly (Student or Casual)? *(ADM002)*
    - ☐ 4. Does the person in this role require a security clearance? *(PS101)*
    - ☐ 5. Does this position require the incumbent to lead and supervise others and evaluate their performance? *(MGT110kd, ADM006, Foundations of Leadership)*
    - ☐ 6. Does this person perform safety observations or management discussions? *(SAF120kd)*
    - ☐ 7. Is this person a "Lead Investigator" for JLab accidents or events?
    - ☐ 8. Will this person be an Event or Issue Owner in the Corrective Action Tracking System (CATS)? *(QA12kd)*
    - ☐ 9. Is this person/position the Chief Technology Officer (CTO)? *(IT-022, IT-023, IT-025)*
    - ☑ 10. Is this person/position assigned to the Accelerator Division?
      - ☐ 1. Is this person/position the Associate Director (or Deputy AD) of the Accelerator Division? *(ACC-001, ACC-002, ACC-003, ACC-004, ACC-016)*
      - ☐ 2. Is this position the Head of CASA? *(ACC-008, ACC-009, ACC-010, ACC-011, ACC-001)*
      - ☐ 3. Is this person/position the Head of the SRF Institute? *(ACC-020, ACC-021, ACC-022, ACC-023)*
      - ☐ 4. Is this person/position the senior Accelerator Injector Scientist/Engineer? *(ACC-005)*
      - ☐ 5. Is this person/position in the Accelerator Operations Dept?
      - ☐ 6. Is this person an operator of the Upgrade Injector Test Facility (UITF)? *(SAF162)*
    - ☐ 11. Is this person/position within the Directorate or the Chief Operating Officer (COO) Dept?
    - ☐ 12. Is this person/position in the Theoretical and Computational Physics Division?
    - ☐ 13. Is this person/position assigned to the Experimental Physics Division?

Under Q10:
- Assigned to accelerator division? Yes

CMTF
- Add Question 10.7: Is this person an operator of the Cryomodule Test Facility?
  - Add appropriate training requirements from the previous slides.
- Analogous 10.8 for VTA.
- Populates Training Competency

Required Competencies (skill sets)						
Competency						Status
Electrical Switching					Hide details	COMPLETE

Show 10 entries   Filter By: [   ]

Skill	Code	Last Acquired	Months Since	Expiration	Status
Basic Electrical Safety	ESC001	1/25/2024	9	1/25/2027	Current
Arc Flash and PPE	ESC002	1/4/2024	10	1/4/2027	Current
Safe Switching of Electrical Equipment	ESC005	12/14/2023	11	12/14/2026	Current
Electrical Contact Release	ESC006	11/29/2023	11	11/29/2024	Current
Lockout/Tagout (LOTO)	ESC007	1/23/2024	9	1/23/2027	Current
Electrical Safety Practical Application	ESC008	1/9/2024	10	1/9/2025	Current

Showing 1 to 6 of 6 entries   First Previous 1 Next Last

(An example training competency)

Jefferson Lab

CMTF Operations: Qualified CMTF Operators

OJT Qualification:

- Spend at least one shift observing each type of measurement – noted at right.

- Spend at least one shift being observed performing each type of measurement

- Trainer / Observer should notify Facility Manager if they believe trainee is ready to perform each measurement type on their own.

- Facilities managers will have a training sign-off (SAFnnn*) when the process is completed.

Training & performance office estimates we can have everything in production by 12/13/24. Will stand down & retrain all operators once posted before facility operation resumes. (IRR Finding #25)

CMTF On-the-Job Training Qualifications

The intent of this document is to provide a training record for On-the-Job-Training (OJT) elements associated with the Cryomodule Test Facility (CMTF). Training elements are process-specific to CEBAF modules tested in the CMTF. The intent is for the operator being trained to a) observe a measurement taking place, and understand the purpose of the measurement, then b) execute the measurement themselves under trained supervision.

	Req. #:	Observed Date:	Executed Date:	Process:	Description:
All Operators				Safety Envelope	Understand the Accelerator Safety Envelope, and what its constraints are.
				Operating Envelope	Understand the Accelerator Operating Envelope, and what its constraints are.
				Critical Event Response	Describe critical events & response as outline in the CMTF Testing Operations Directives (TOD)
				USIs	Describe the USI process and how to instigate a Safety Concern Form if an issue is discovered with the CMTF credited controls
				UED update	Describe what to do if you find something to be incorrect in UED.
				Emergency Response	Describe how to response in a number of Emergency Scenarios associated with the CMTF as presented by reviewer.
				CARM response	Describe the administrative response to gamma and neutron CARM alarms required in the CMTF.
				Work Control Douments	Understand which types of tasks are governed by Pansophy, TATL, and ePAS. Understand how to located and review tasks in each which are being executed on your shift.
				Safe computing practices	Describe to your reviewer the safe computing practices associated with the CMTF. (Channel access, rotating LabVIEW passwords, & locking terminals when not in use.)
				Log keeping	Understand how to use the paper logbooks for testing, PSS state changes, and the electronic logbooks assciated with CMTF testing.
				Documentation Control	Understand how to locate relevant procedures, work control documents, training information, and travelers associated with testing on your shift.
				Repair Escalation Process	Understand the CMTF System Readiness & Repair processes. Understand where to look to ensure you have authorization to run the facility.
				Shift turn-over	Participate in turn-over to an on-coming shift.

	Req. #:	Observed Date:	Executed Date:	Mesurement:	Description:
RF Operator OJT				Warm Pass-bands	Using a network analyzer - measure the resonant frequencies of a CEBAF crymodule cavity at room temperature.
				Cold Pass-bands	Using a network analyzer - measure the resonant frequencies of a CEBAF crymodule cavity at 2 Kelvin.
				Interlock Checks	Understand and check each of the interlock chains for each cavity in a CEBAF Cryomodule
				Cavity Switching	Configure a cavity to receive RF power via the waveguide routing system, microw ave measurement relay system, & the RF distribution network
				PSS Sweeps & Operation	Become a trained PSS sweeper / guard for the CMTF; learn how to manipulate PSS system in accordance with procedures & the CMTF Testing Operations Directives (TOD).
				Power Meter Calibration	Calibrate a Boonton Power Meter to take data during your shift.
				RF Operation	Enable the CPS to deliver RF. Use the HMI panel to turn on/off klystrons when cavities are prepared for operation.
				Tuner checks:	
				Tuner Configuration	Configure tuners for operation via the resonance control chassis and EPICS screens (ACC / VEL ≤10K; Motor current = 1)
				Tuner Range Checks	Measure the upper and lower ends of the tuner range using the EPICS control screens, archiver, and a means of frequency measurement (frequency meter or network analyzer). Tune the cavity to resonance following the measurement.
				Tuner Override	Using the tuner override box, override the tuner interlock to back a tuner off of a limit switch when encountered during tuner testing.
				Tuner Hysteresis Checks	Characterize Tuner Hysteresis via the LabVIEW .vi.
				Gradient Checks:	
				Establishing Operating Gradients	Understand how to tune up and characterize a cavity, measure Emax in pulsed & CW modes, and how to establish the operating gradient.
				Field Emission Characterization	If field emission is present in a cavity, characterize both the volume of emission via the decarad system and note the onset gradient of emission.
				Qos (dP/dt method; 2K)	Using LabVIEW .vi, JT/RT valves, and an electric heater; execute a Qo vs E measurement series on a cavity with the help of a Cryo Operator
				Pressure Sensitivity	Execute a pressure sensitivity measurement using the LabVIEW .vi when transitioning a P ≥ 3 Torr range following a Qo measurement with the help of a Cryo Operator.

	Req. #:	Observed Date:	Executed Date:	Mesurement:	Description:
Cryo OJT				Pre-cooling checks	Observe & understand the appropriate parameters and equipment to check prior to the cool-down of a cryomodule. (Insulating vacuum, BL/WG vacuum, flux gates, heater function, JT/RT valves actuate, etc.)
				utubes	Coordinate a u-tube operation with the cryogenic / assembly groups
				4K cool down	Perform a 4K cool down of a module
				Pump down	Perform a 2K pump down of a module
				Qo Measurements	Learn how to fill module, manipulate valves, & perform Qo measurements with an RF Operator.
				Trip to 4K	Transition from 2K > 4K operations in the CMTF
				Cryocycle	Perform a 30K cryocycle on a cryomodule in the CMTF
				Warm-up	Warm a module from 4K to room temperature in the CMTF

* Awaiting # assignment from Training Office

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CMTF Operations: PSS States & Staffing Requirements

- RF ON: CMTF in RUN state with high voltage ON to klystron or solid-state amplifiers

- RF OFF here == CMTF incapable of delivering RF due to the high voltage to the RF source being off (regardless of having or not having RF/HV permit from PSS)

- OPEN: Self-explanatory; no RF/HV permits available to run

- SWEEP: Timed PSS sweep procedure in-process prior to potential operation

- RF (HV) ON or OFF & PSS State: RUN – RF operator required in control room

- READY: PSS sweep completed; exclusion state. Attempt to access enclosure drops sweep (enclosure to OPEN state). No RF/HV permit in this mode. MPS trips (CARM, etc.) drop to this state. No staffing required in key control of PSS keys & RF source keys maintained.

- PSS system may be dropped from RUN to READY mode (exclusion state; prevents personnel access. No RF/HV permit):
  - Key control: Remove PSS key from chassis and store in key station (CPS / RF source key removed and stored as well by procedure)
  - Prevents possible operation
  - Operator may leave JLAB site
  - Allows one to forgo sweep the following day and resume operations after retrieving keys; useful for facility efficiency as it reduces staffing need and replaces sweep time with operations the following day

CMTF has four PSS states: OPEN, SWEEP, READY (an exclusion state, when the state when the PSS Sweep has been completed), and RUN.

Table 3-1: Minimum Staffing Requirements for UITF Operations

CMTF Operating Condition	CMTF PSS State	Minimum Required Staffing
• RF OFF	• OPEN	• None
• RF OFF	• SWEEP	• Trained Sweeper & Guard per the PSS Sweep Procedure. (Control Room can be unstaffed)
• RF OFF	• READY (Sweep Complete)	Key control of PSS & RF source keys. (No staffing required)
• RF ON or OFF	• RUN	Authorized (S)RF Operator in Control Room.

Whenever CMTF Operator changes occur for any reason, the oncoming staff members must receive a summary of the shift activities and receive task assignments from the off-going CMTF operator.

Control room staffing is an ASE-credited control, with minimum staffing requirements in the TOD and summarized above.

Failure to meet staffing requirements constitutes an ASE violation and provokes a critical event response if the facility is not shut down in advance of the issue.

Revised following IRR finding # 16.

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CMTF Operations: Critical Event Response

Safety Envelope Violations

- Safety envelope defined by the ASE.
- If a safety envelope violation is suspected, RF/HV operations will halt and an immediate investigation will take place.
- The ES&H Reporting Officer, AD of Accelerators, CMTF Facility Manager, Head of SRF Operations, Safety System Group Leader (for PSS-related violations), and Accelerator Division Safety Officer must be notified as soon as possible.
- Process is defined in *ES&H manual, Section 5200: Notable Events*.
- No operations permitted until reauthorized by Associate Director of Accelerator Division and the Facility Manager.

Operations Envelope Violations

- Those within the safety envelope are not treated as DOE reportable.
- The CMTF Facility Manager, Head of SRF Operations, Safety System Group Leader (for PSS-related violations), and Accelerator Division Safety Officer must be notified as soon as possible.
- RF/HV operations must be reauthorized by the Director of SRF Operations and the Facility Manager.

Personnel Safety System (PSS) Malfunctions

- PSS designed to protect personnel from harm using administrative and engineered controls.
- The duty operator contacts the Safety System Group Leader.
- If the Safety System Group Leader determines that a malfunction has occurred, then the USI process is followed.
- If credited controls violated, safety envelope violation process must also occur.

Machine Protection System

- If malfunction is perceived, RF/HV operations are halted and system owner is contacted.
- Facility Manager must re-authorize RF/HV operations.

Emergency Response

- Specific procedures for responding to radiation exposures, ODH alarms and response, and power outage response are located in CMTF SOPs.
- Most incidents: RF/HV off, PSS to safe state, and follow ES&H emergency management guidance.

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CMTF Operations: Control System Interaction
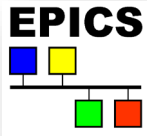
Experimental Physics and Industrial Control System (**EPICS**) – A set of software tools and applications that provide a software infrastructure for use in building distributed control systems.
EPICS has a huge support base spanning the globe. See https://epics.anl.gov/sites.php for a list of facilities that use EPICS as their chosen control system.

EPICS Channel Access Security

- Channel access is restricted approved operators using host machines in the CMTF control room for RF Operations.

- CMTF cryogenic operators may operate remotely at the discretion of the Facility Manager & Testing Coordinator.

- Control room staff have the authority to close and open channel access for specific devices or systems.

Typical EPICS Client-Server Relationship
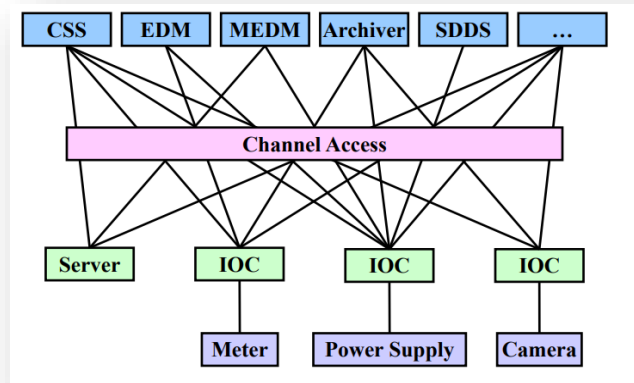
Image taken from EPICS training slides, by Andrew Johnson (https://epics.anl.gov/docs/APS2014/05-CA-Concepts.pdf)

Safe Computing Practices

- LabView controls only accessible via Group login with a regularly rotating password, retrieved in-person from administrator.

- Use Lock feature of all computers when not actively in use.

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CMTF Operations: Documentation Control

- SRF Operations Documentation
  (e.g., procedures, directives, drawings)
  is stored in local and web-based databases.
  - Docushare
  - Various SharePoints
  - (\\JLABSGRP) M:\asd\asddata

- SRF Operations documentation is maintained by Technical Custodians.

- Quarterly Quality Review Meetings include Documentation and Records Management processes, retention of organizational knowledge, and corrective actions.

- Process owner prompts technical custodians for periodic reviews and revisions of controlled documents.

- Strict revision process is implemented.

- Engineers, operators, and relevant technical personnel review and provide corrections to procedures.

- All SRF Operations staff have access to the database of officially released procedures, though these may be organized and stored by each specific work center.

IRR Finding 17: Old documents removed from control room.

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Location: Home \ Facilities \ SRF Institute \ 02 - SRF Technical Facilities \ CMTF Listing

📁 CMTF

Edit Selected... ▼   Add... ▼

	Type ▲	Title
☐	📁	**C50 Program**
☐	📁	**Cryomodule Testing Facilities**
☐	📁	**FL02 Decommission and Processing**
☐	📁	**LCLS II Upgrade**
☐	📁	**March '09 SAD**
☐	📁	**R100 (0L04)** Test Results for the R100 Cryomodule
☐	📁	**Recommission 2013** Documents relating to the commissioning of cryomodules after the long warm up

Quality Review Meeting Agenda

- ❑ Facilities (Phil)
- ❑ VTA Maintenance Planned/Actual (Justin)
- ❑ VTA FE/Multipacting (Mircea)
- ❑ Process Owners:
  - ❑ Corrective Action (Ashley M)
  - ❑ Document Management (Valerie B)
  - ❑ Records Management (Valerie B)
  - ❑ Organizational Knowledge (Megan M)
- ❑ Fast-moving KPIs (Ashley)
  - ❑ Travelers
  - ❑ NCRs
  - ❑ D3s
  - ❑ CAPAs
- ❑ Documents Due for Review (Valerie)
- ❑ Action Items (Ashley)
- ❑ Next Month Presenters

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CMTF Maintenance and Tracking

- We typically operate CMTF during day/swing shifts (i.e., no 24/7 round-the-clock operation)

- Equipment usually repaired by System Owners on day shift (no back-shift maintenance, beyond what can be performed by operators themselves – equipment resets, power cycling, etc.)

- Maintenance and repairs documented via OPS-Problem Report, ePAS, and Test lab Area Task List (TATL) and documented in SRFLog, the paper logbook, and Pansophy.

- Maintenance and repair responsibilities shared by Facility Manager/Work Coordinator, SRF Work Centers, and Accelerator Engineering Service (AES).

- Elements will be tracked, upgraded, and downgraded in the System Readiness Manager, with Facility manager authorizing operations.

- Updates to UED as appropriate

- Safety guidelines for maintenance work outlined in:

  - *ES&H Manual, Section 3000, Work Planning and Control Processes*

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Work Planning & Controls: Pansophy

Pansophy lays out the agreed-upon vetted and discussed testing process and the order of tests for acceptance testing (and other) processes.

- Level is work control – not procedural:
  - Ex. Do Qo measurements from gradients X-to-Y in MV/m steps & record results.
  - No information on how to perform the measurement itself – delegated to SOPs.
  - Includes several hold and data review points in addition to Quality Control.

Figure 3-1: The Pansophy System
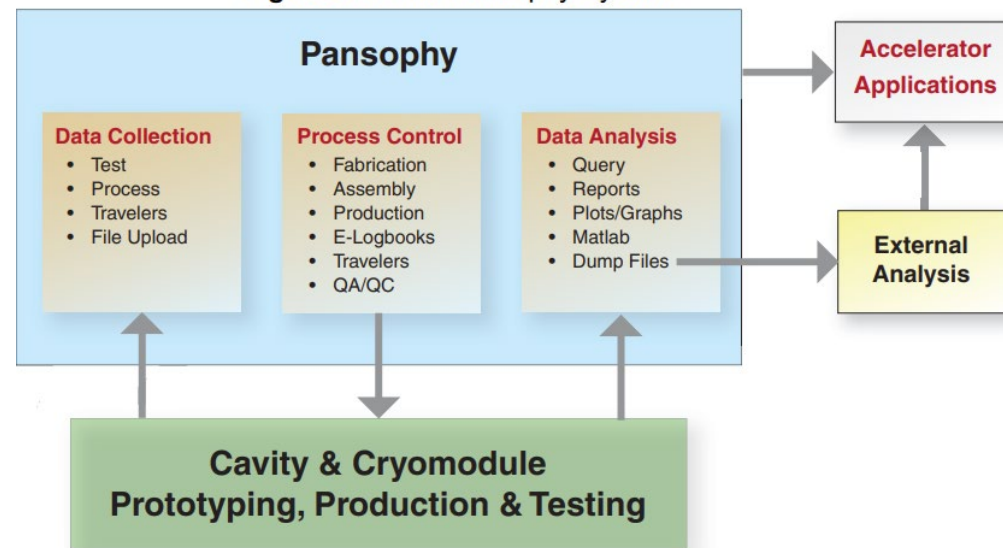
Work Planning & Controls: Test lab Area Task List (TATL)

- TATL is used for work planning and coordination during running and scheduled downs.

- All maintenance done to the CMTF will have an associated TATL Task, which may also interface to the electronic Permit Authorization System (ePAS) for work planning and control purposes.

- CMTF work coordinator is responsible for understanding the overall schedule and work scheduling via TATL.

- Users (e.g., operators, system owners) can log in and comment on tasks.

Work Planning & Controls: ePAS and Everything Else…

- ePAS work planning and control tool entries for CMTF

- Broadly – 2 parts: Permits to Work and Isolation Certificates

- Permits describes work process; isolation certificates are hazardous energy lock-out points – may be referenced by multiple simultaneous work permits.

- Standard Operating Procedures, ODH assessments, and other safety and work control documentation also exist.

System Readiness and Repairs Process

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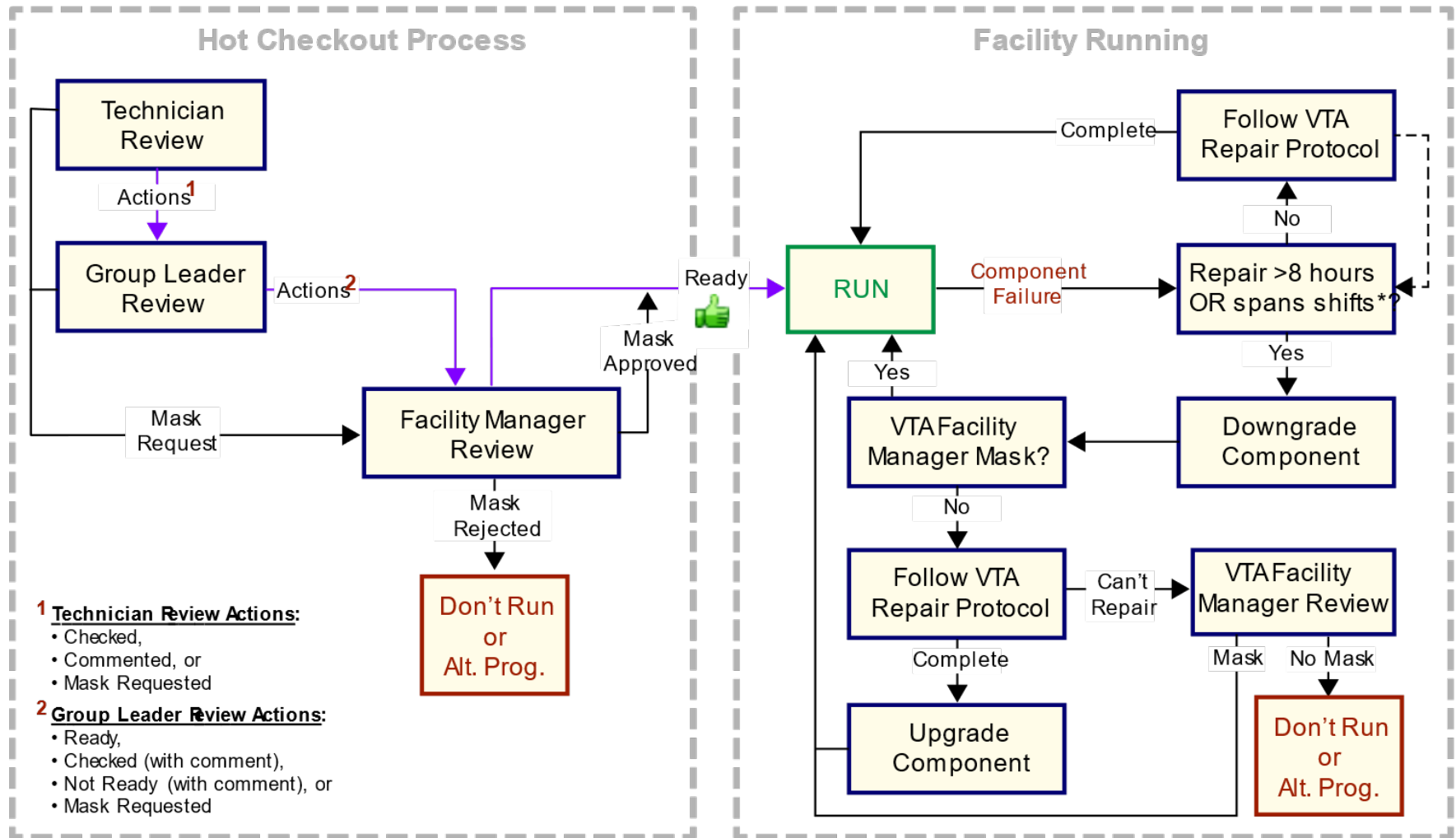
Summary

- SRF Institute has been operating in the Test Lab continuously for nearly 40 years, with the CMTF operating for more than 30 of those to safely meet the acceptance testing needs of CEBAF and other national laboratories as well as supporting a vibrant R&D program.

- Relevant safety basis documentation and processes have been established:
    - SAD
    - ASE
    - USI process
    - Effective configuration management program

- Accelerator-specific hazards are identified, assessed, and mitigated by credited controls.

- A mature Conduct of Operations approach, with appropriate administrative processes related to accelerator safety (e.g., training, procedures) has been established, supporting efficient operation, maintenance, and repair of CMTF.

- Trained personnel are in place to support the safe operation, maintenance, and repair of CMTF.

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… and now for the Vertical Test Area
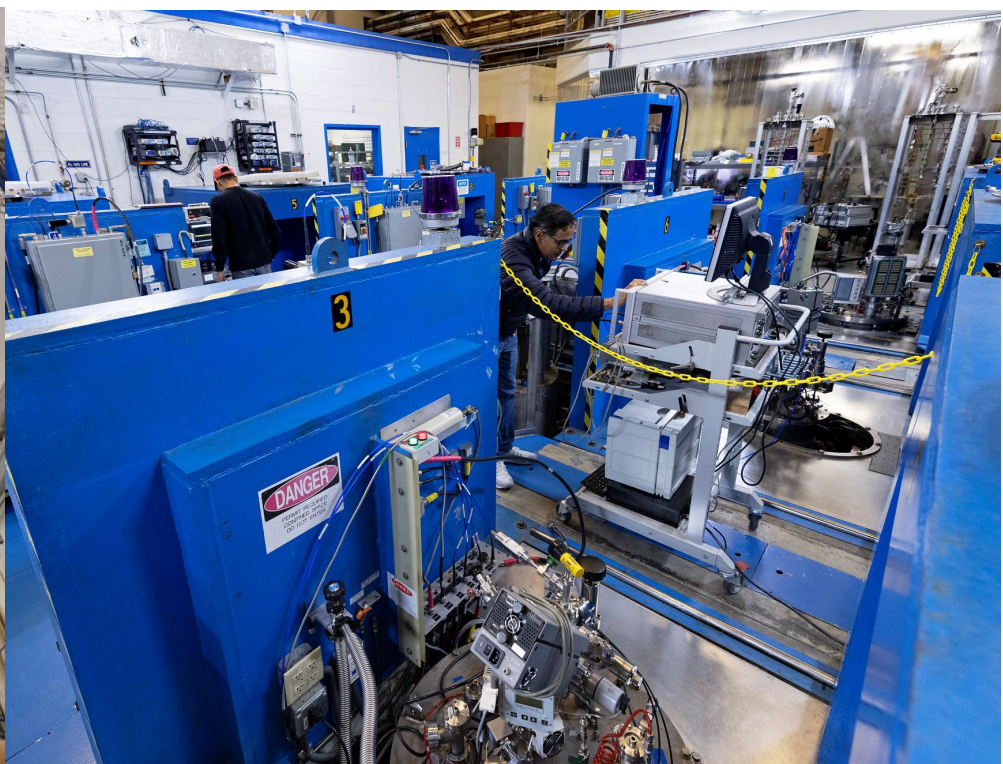
Thank you for your attention

Jefferson Lab

Questions?

M. McCaughan

Office: x5572

michaelm@jlab.org

Jefferson Lab

CMTF OFI#2 / IRR Ref. # 27:
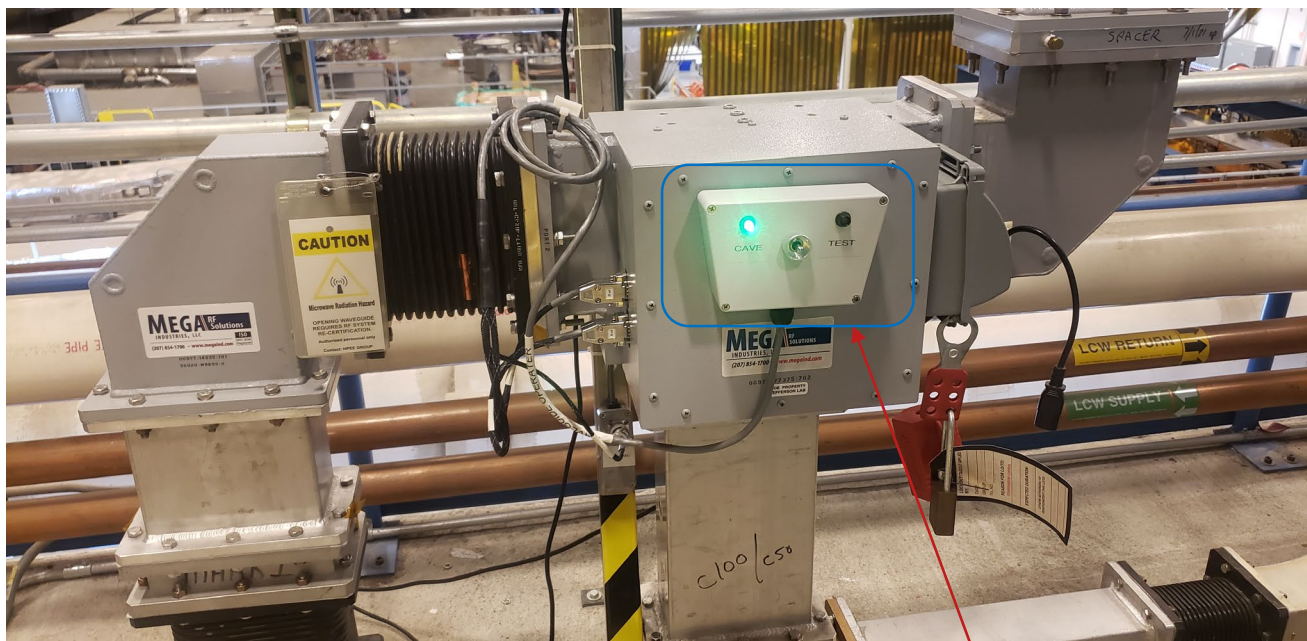
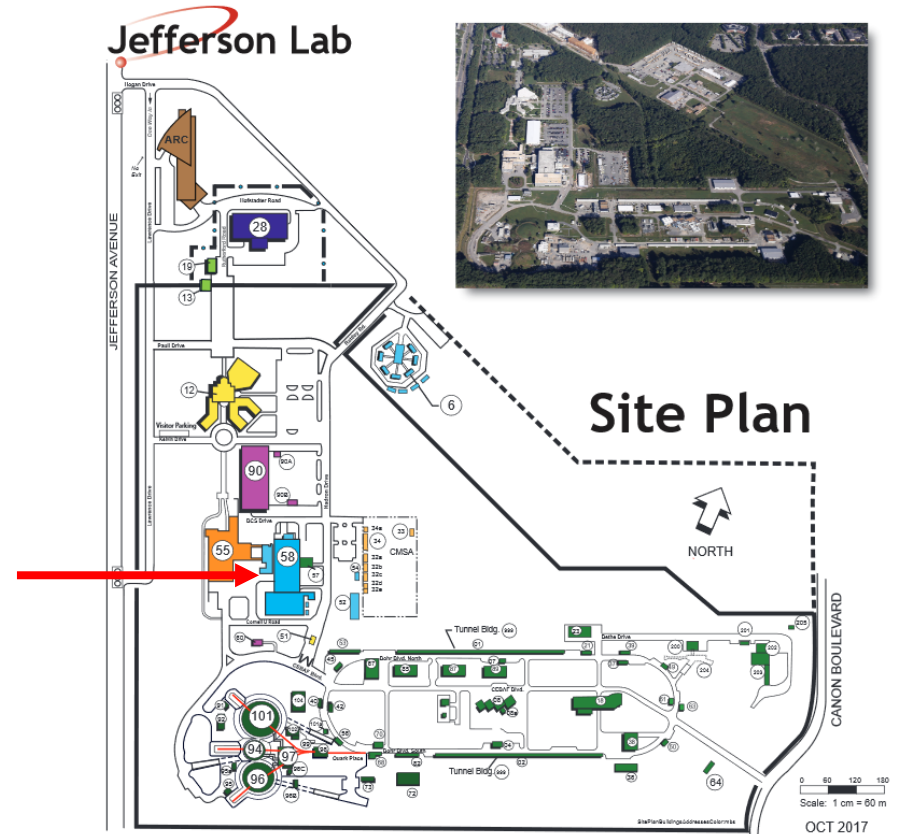CMTF OFI#2 / IRR Reference #28: CMTF waveguide switches should be labelled.

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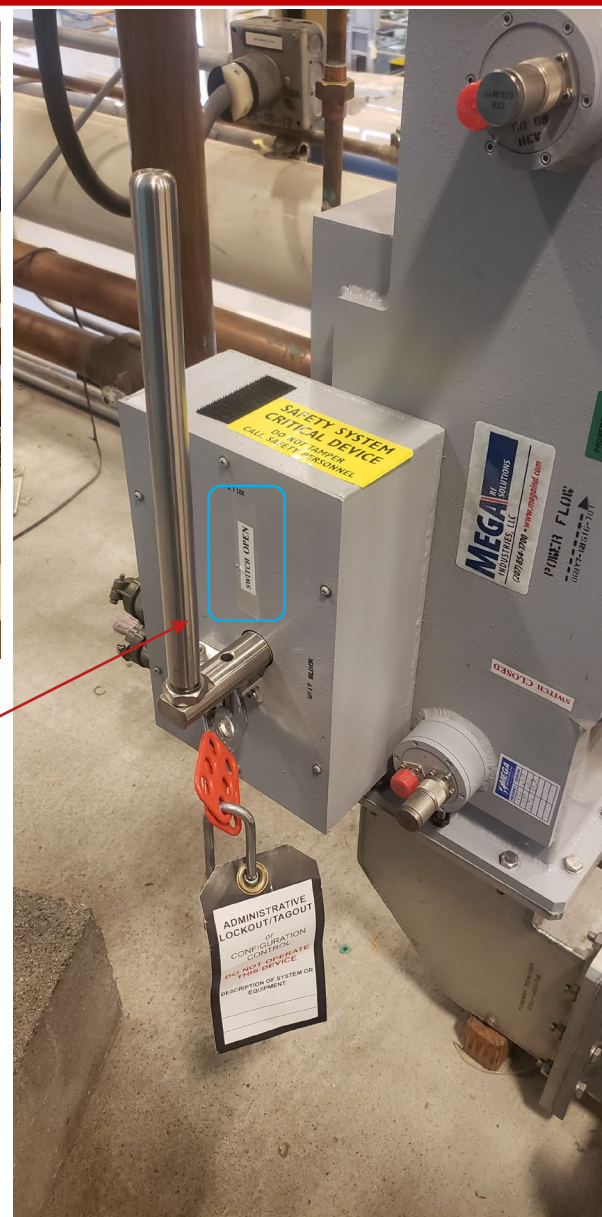
CMTF CARMS
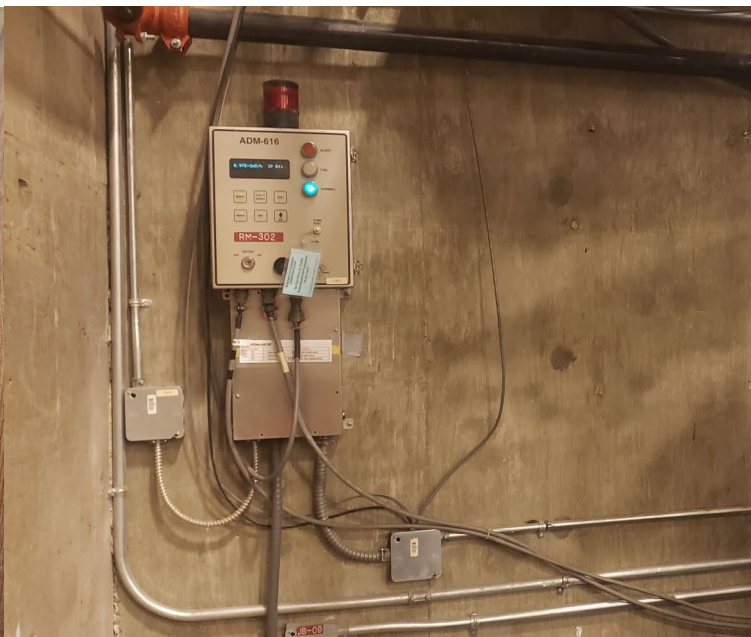
- RM301 (at left): Control Room
- RM302 (above): Stairs by PSS Personnel access door
- RM303 (at right): Mezzanine; adjacent the fan stack shielding.

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CMTF – Location & History

Test Lab (CMTF/VTA) – Location & History

- **1962-1965**: NASA designs and constructs Space Radiation Effects Lab (SREL) on-site. VA Associate Research Campus (VARC) site management by consortium of universities, including William & Mary.
  - Site contains:
    - 0.5 - 3 MeV e⁻ Dynamitron
    - 1 - 10 MeV e⁻ warm RF Linac
    - 600 MeV H⁺ Synchrocyclotron

- **1967**: Site management transferred solely to W&M by governor as additional universities join and complicate structure.

- **1978**: SREL loses funding with other facilities on the rise; VARC used by W&M as remote campus.

- **1980**: McCarthy design group + W&M form Southeastern Universities Research Association (SURA), which later wins 1984 bid to build the nuclear research facility recommended in the 1979 Nuclear Science Advisory Committee (NSAC) plan.

- **1985**: H. Grunder appointed first permanent lab director, with C. Leeman leading accelerator physics. CEBAF design change from warm RF to SRF technology with R&D funded by DOE, SURA, and Virginia. New CDR to DOE in 1986.

- **March 1986**: Four vendors contracted to make 7 cavities – 2 tested at time of reporting to Congress/DOE both exceeded specifications. CEBAF construction funds appropriated in earnest for FY87.
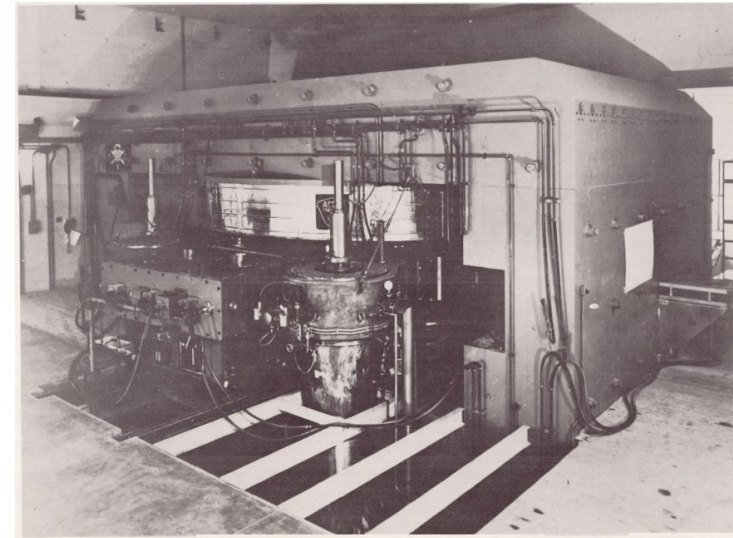

Figure 3.- CERN 600-mev synchrocyclotron.

NASA
L-62-1046.1

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Internal Needs: CEBAF Support

- 50 "Original CEBAF" modules and rebuilds (including 3 quarter cryomodules)
- 13 C20-to-C50 cryomodule conversions + a C50 refurbishment
- Built 10 C100 modules + 3 prototypes and refurbished 5 of the C100s & the 3 prototypes
- 4 C20-to-C75 cryomodule conversions
- Countless R&D, repair, and support activities

Where Cnn == nn is cryomodule design energy (in MeV)

# Multi-Lab Partnership: SLAC LCLS – II & II HE (In progress)

SLAC:

Original LCLS – II cryomodule testing 2019
- Upgrade fills 1/3 of original 2 mi. tunnel; replacing warm-rf Linac.
- Removed two zones of 1497 MHz RF & replaced with 16 kW SSAs @ 1.3 GHz
- LERF: Installed 1,000′ new waveguide
- Ten cryomodules built & tested @ JLab
- Two cryomodules operated at full energy simultaneously
  - Simulated L1 (Injector) @ SLAC
- 16 5 kW SSAs returned to SLAC

LCLS – II HE (23 total cryomodules)
- Another ~1/3 of the tunnel
- LERF: Installed 8 new 8 kW SSAs installed
- Production and testing ongoing
- 23 cryomodules total + rebuilds/retests
  - (x10) JLAB
  - (x13) FNAL
- Presently 4 modules + 1 retest completed

- Test Engineers commission cryomodules
  - Machine state: Power Permit

https://lcls.slac.stanford.edu/lcls-ii

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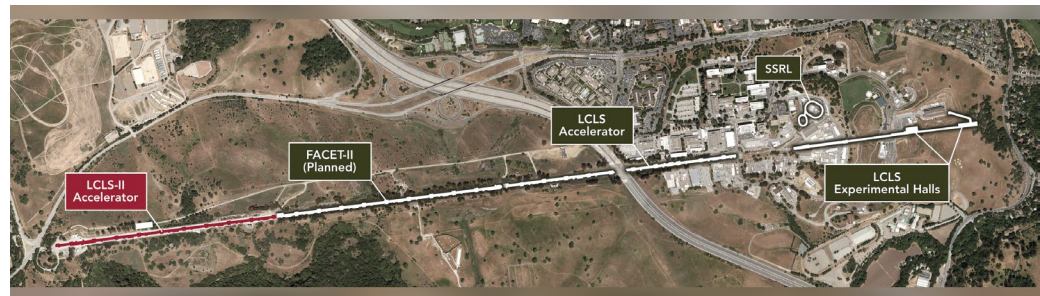
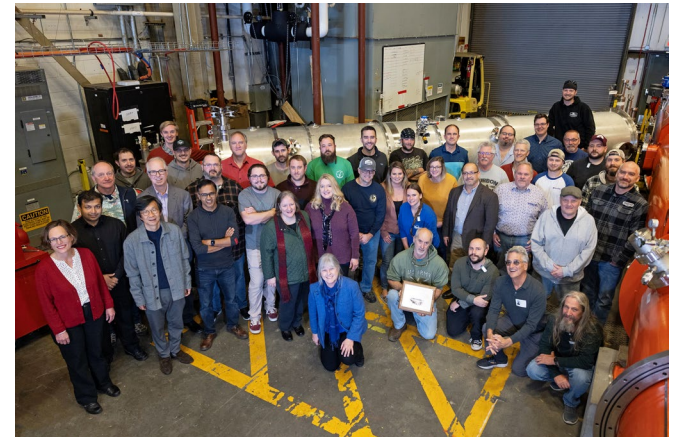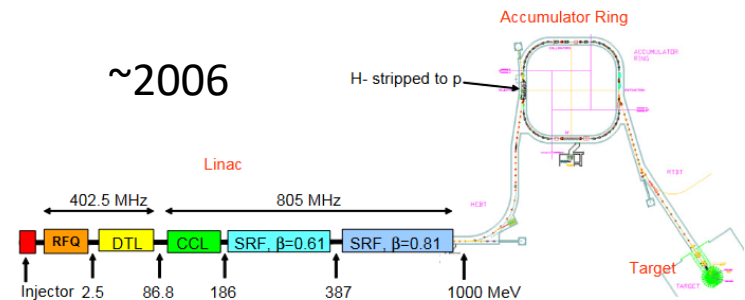# Multi-Lab Partnership: ORNL SNS Linac + PPU (Completed)

Spallation Neutron Source SRF Linac:

- JLab initially fabricated 11 805 MHz medium-b (0.61) + 1 medium-b prototype & 12 high-b (0.81) cryomodules and shipped to SNS and installed in the linac section of the accelerator.

- SNS Structure:
  - Injector
  - RFQ = RF Quadrupoles (65 keV – 2.5 MeV)
  - DTL = Drift Tube Linac (Emax 86.8 MeV)
  - CCL = Coupled-cavity Linac (Emax 186 MeV)
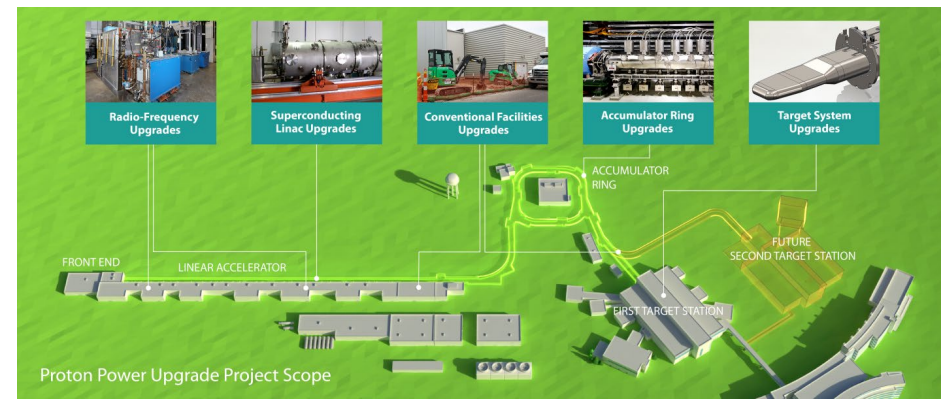 - SRF Linac

- Design/production 1999 forward; began operation ~2006

Proton Power Upgrade (PPU) Project:

- 7 additional 4-cavity High-b 805 MHz Cryomodules (+1 spare) to double target beam energy from 1.4 to 2.8 MW (by increasing the beam energy to 1.3 GeV)

- Vertical testing, assembly, 2K cool-down, frequency range / hysteresis & Qfp/Qfpc measurements at JLab

- High-power testing performed at ORNL

https://accelconf.web.cern.ch/LINAC08/papers/mo103.pdf
https://accelconf.web.cern.ch/LINAC08/papers/th103.pdf
https://accelconf.web.cern.ch/p01/PAPERS/MPPH162.PDF
https://journals.aps.org/prab/pdf/10.1103/PhysRevAccelBeams.27.102001

~2006

Layout of the SNS accelerator system.

Above: PPU-08 completed; Below: https://neutrons.ornl.gov/ppu

Proton Power Upgrade Project Scope

Work for Others/R&D

- Tradition of SRF cavity treatment/process development: Cavity preparations possible with gradients x10 larger than original CEBAF.

- Various technologies developed to reach: materials research, mechanical/chemical/ electrical polishing, surface treatments, doping and infusions, etc.

- Many new module types and designs developed in collaboration with the world SRF community. (Modules for linacs, "crabbing" at IPs, etc.)


Latest research – 4K operation:
- Nb_3Sn-film on Nb substrate module reaches 10+ MeV
- Conduction-cooled cryomodule w/ Gen. Atomics

Gradient development/best practices in Operations:
- Field emission research
- Improve vacuum techniques and cleanliness
- In-situ processing techniques using helium and other plasmas

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# CMTF Operations: SRF Institute Organization
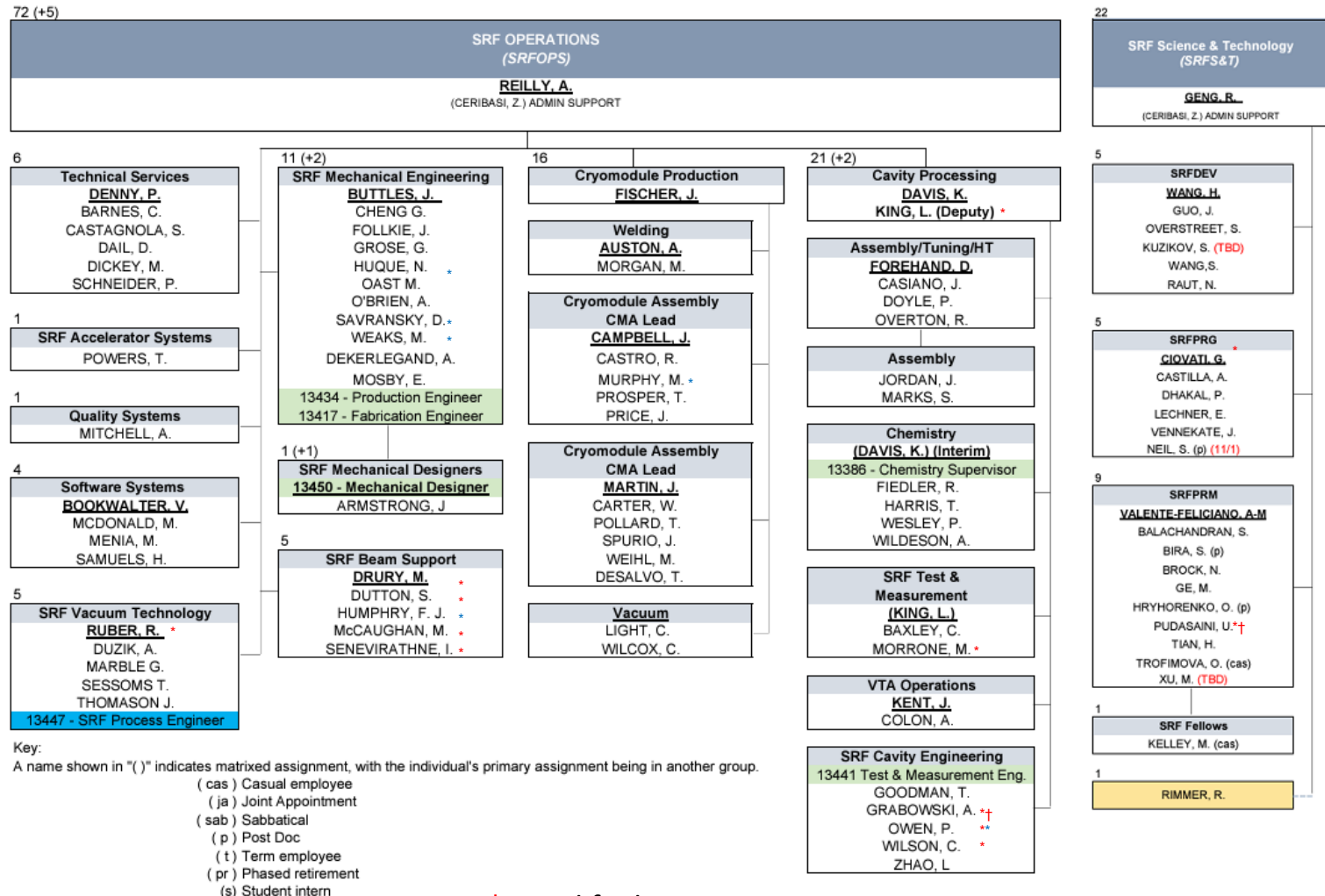
CMTF Duty Operator Shift Preparation

Prior to being on shift, CMTF Duty Operators must review and understand:
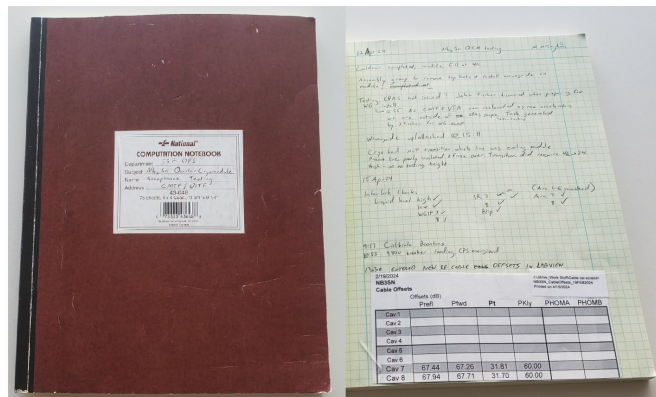
- Electronic (SRFLOG, CLOG) and paper logbooks
- Facility status & Run Authorization status in System Readiness Manager
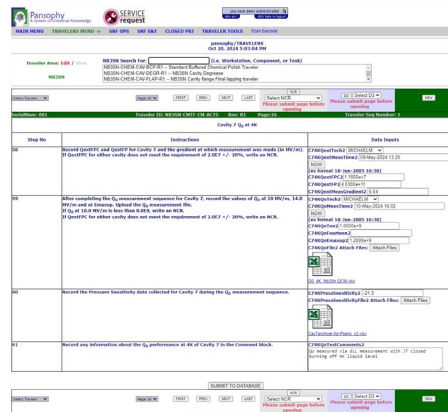
In addition to receiving:

- Operational Plan from Facility Manager or Testing Coordinator
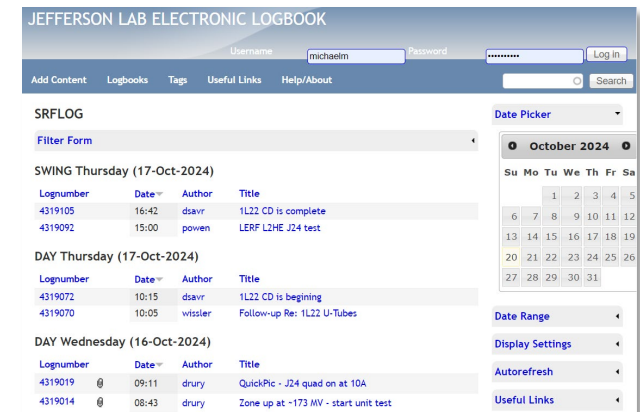- Shift turn-over briefing, if applicable
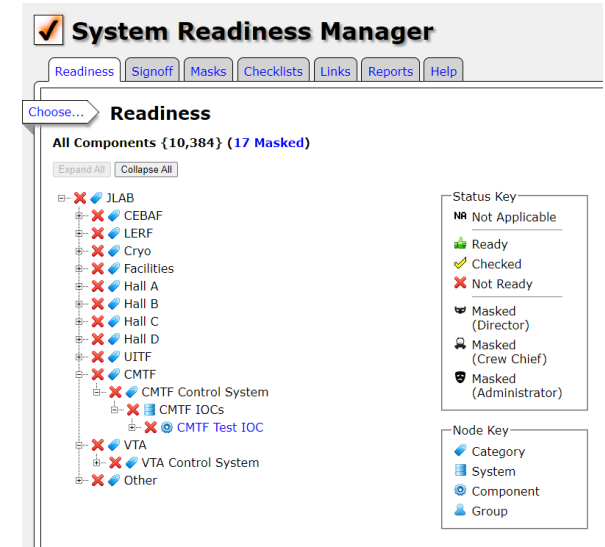
Paper Logbook

Applicable Work Control Documents

(Pansophy, TATL, & ePAS)

Electronic Logbook (SRFLOG)

References

Site History

1. Godson, Susan et. al, *The College of William & Mary: A History*, vol. 2, King and Queen Press, Williamsburg, Va., pg. 818-819, 852-853.

2. J. Duberg & E. Rind, *NASA Space Radiation Effects Laboratory*, Presented at the Symposium on Protection Against Radiation Hazards in Space, Accession#: N65-21474 (NASA Document ID: 19650011873), Gatlinberg, TN. 5-7 Nov 1962.

3. D.R. Johnson, *NASA Facility for the Study of Space Radiation Effects*, Presented at the Institute of Electrical and Electronics Engineers Region 3 Meeting, Accession#: N63-15165 (NASA Document ID: 9630005289), Richmond, VA. 24-26 April 1963.

4. https://scrc-kb.libraries.wm.edu/virginia-associated-research-campus

5. C. Westfall, The Founding of CEBAF: 1979-1987, CEBAF, 12000 Jefferson Ave., Newport News, VA. Sep 1994.

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