SRF Process and Test Facilities

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FNAL-LBNL joint meeting on SRF Cavities and Cryomodules

March 15, 2012

U.S. DEPARTMENT OF ENERGY

Fermilab

Processing & Testing Overview

SRF Cavity/Cryomodule Preparation Sequence

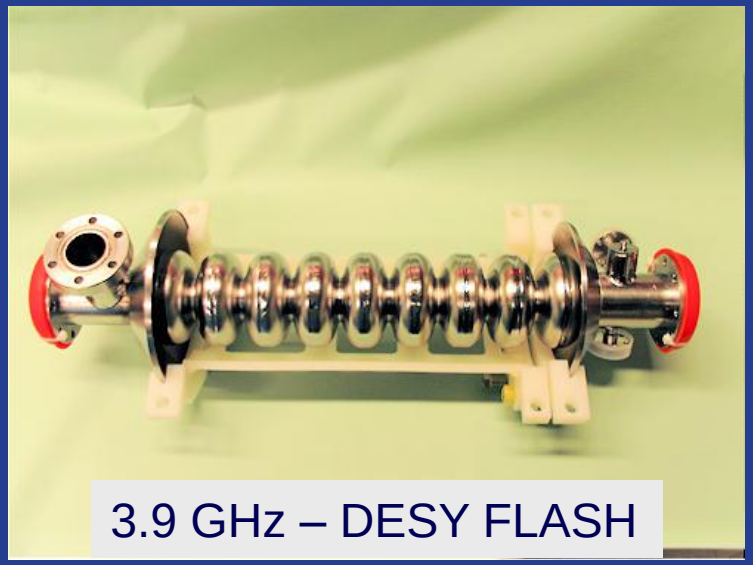
1. Inspection – RF & Optical	11. 120C Vacuum Bake 48 hrs (Qslope)
2. Bulk Electropolishing (EP)	12. Vertical Test
3. High Pressure Rinse (HPR)	13. Helium Vessel Welding
4. 800 C Bake (H2 degas)	14. HPR
5. RF Tuning	15. Assemble for horizontal test (HT)
6. Light EP	16. HPR
7. HPR	17. Evacuate
8. Assem. for vertical test (VT)	18. Horizontal Test
9. HPR	19. String/Cryomodule Assembly (Arkan talk)
10. Evacuate	20. Cryomodule Test (NML Facility)

Facilities and Staff Capabilities

- SRF Processing and Testing Team
  - FNAL/ANL staff designed, developed, and currently operate all processing facilities. (Strong ANL collaboration)
  - All processes and facilities are based on state-of-the-art developed for ILC by DESY/FNAL/JLab/KEK
  - Novel tooling and facility designs accommodate multiple cavity types.
  - In-house development of all processing and testing devices and procedures.
  - Industrial partnerships in place with new SRF processing capabilities
  - New processing R&D activities in-house and in industry
  - Multiple SRF cavity performance experts

SRF Cavity & Cryomodule Development and Production Capabilities

1.3 GHz – ILC/Project X



3.9 GHz – DESY FLASH

650 MHz – Project X

325 MHz – Project X

Joint ANL/FNAL Superconducting Surface Processing Facility (SCSPF)

- Primary processing workhorse in SRF infrastructure
- Collaborative facility located at ANL operated jointly by FNAL and ANL
- Both FNAL and ANL employees staff facility full time
- Developed with 1.3 GHz cavities as focus, but flexible tooling allows processing of multiple cavity types

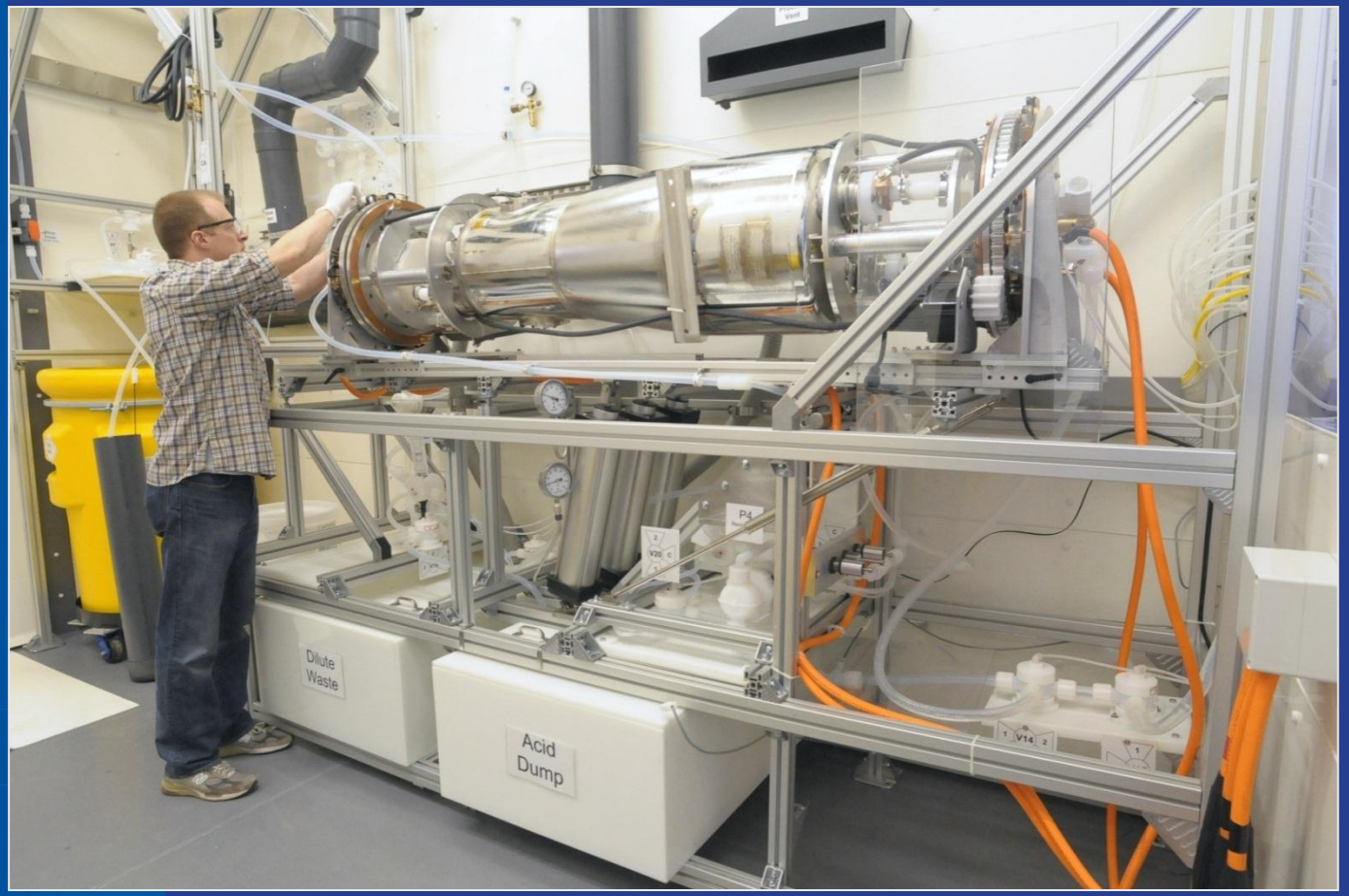
SCSPF Infrastructure

SCSPF 1.3 GHz EP/BCP Tool

Tool capable of 1.3 GHz EP for bare and dressed cavities + BCP of 325 MHz SSR and other cavity types.

SCSPF Infrastructure

SCSPF Large Cavity EP/BCP Tool



*ANL designed/built—S. Gerbick

Designed for 72.5 MHz Low Beta QWR + 650 MHz Elliptical Cavities

SCSPF Infrastructure

SCSPF High Pressure Rinse Tools

FNAL HPR Tool with 1.3 GHz 9-cell

ANL HPR Tool—325 MHz/ QWR

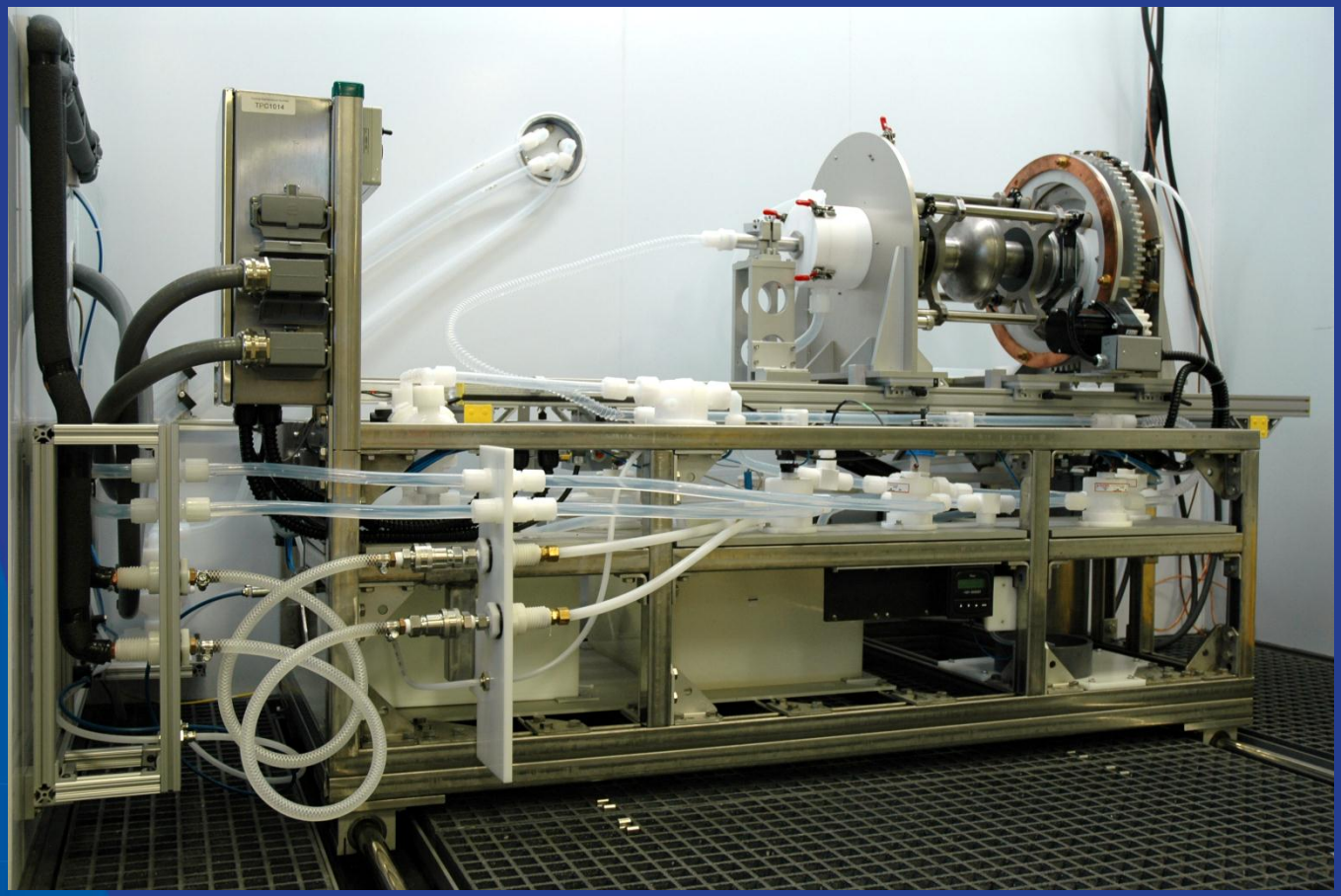
IB4 CPL Summary
(Cavity Processing Laboratory)

- Cleanroom Preparation
  - HPR/clean assembly & test preparation
  - Hydrogen degassing of 1.3 GHz cavities
  - UHV Class 10 CR area/US cleaning (1.3 GHz + 650 MHz elliptical cavities)
- Surface Removal/Repair R&D
  - 1.3 GHz/650 MHz 1-cell R&D Facility
  - EP—alternative electrolytes, etc.
  - 1.3 GHz/650 MHz cavity CBP development area
  - SRF advanced processing techniques (CVD, ALD)

IB4 CPL Class 10 Cleanroom/HPR

HPR Tool, Clean Assembly Rail, Cavity Carts

IB4 CPL EP Tool (1.3 GHz 1-cell R&D)



Upgradable EP tool may accommodate 1.3 GHz 9-cell

IB4 CPL CBP Machine

Tumbles 2 cavities/run, 2 complete cycles/week

C. Cooper Recipe Media

FNAL Vacuum Ovens – Hydrogen Removal

IB4 Vacuum Oven—1.3 GHz

Q study optimization underway.

Manufacturer:
T- M Vacuum Products Inc.

*Source: M. Wong (FNAL)

Temp = up to 1000C
Pressure < 1e-06 Torr
99% drop in H2 RGA peak

MP9 Vacuum Oven – 650 MHz, SSRs

Industrial Capabilities--AES

ARRA funded industrial EP Tool located at AES.

- EP Tool for elliptical cavities sized up to 650 MHz 5-cell.
- HPR up to 1000 lb structures. (commissioned)
- BCP up to 1000 lb. structures.
- CR Area (adequate for basic CR work)

Processing Capacity/Year

SCSPF

	EP/BCP Cycles	HPR Cycles	Test Assemblies
SSR0,1,2	25	50	50
Elliptical (all types)	150	200	100

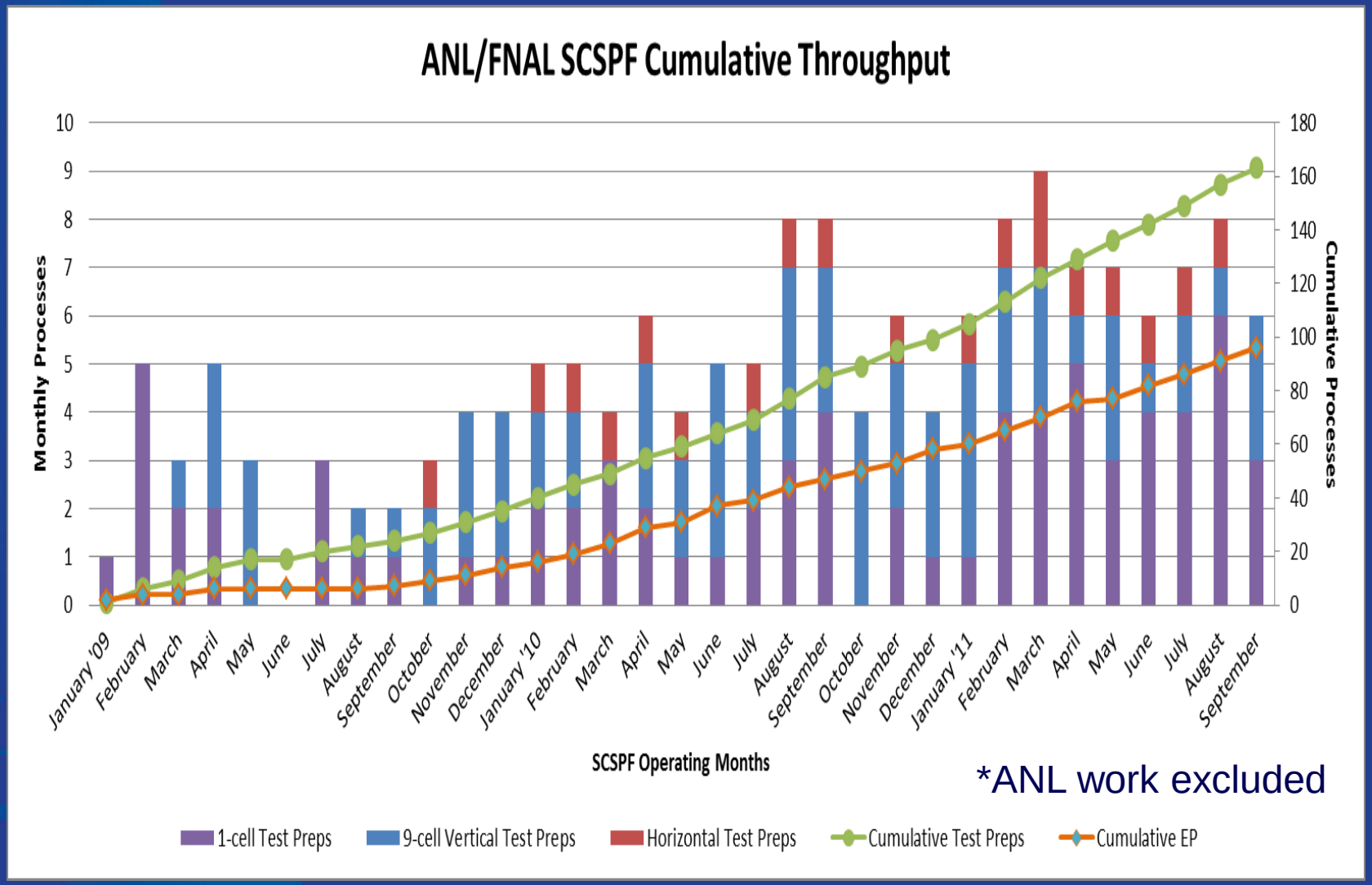
CPL Potential Capacity

	CBP Cycles	EP Cycles	HPR Cycles	Test Assems	Bake Cycles
650 MHz	100	0	100	50	150
1.3 GHz	100	50	100	100	150

Industrial Capacity

	EP/BCP Cycles	HPR Cycles
SSR0,1,2	25	50
Elliptical (all types)	150	150

SCSPF Throughput



Steady and improving throughput from ANL/FNAL processing, VTS, and HTS

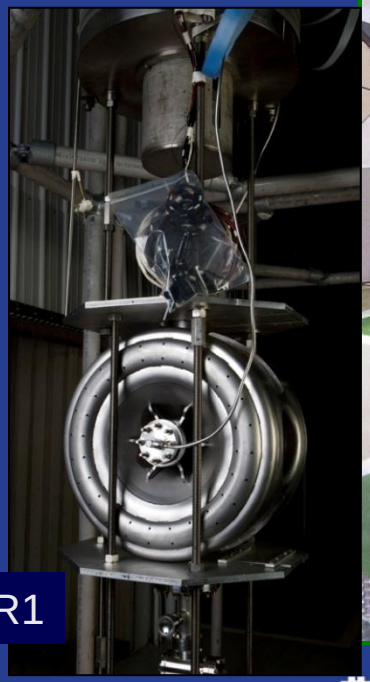
FNAL Vertical Cavity Test Facility

- Design
  - Existing 125W@ 2K Cryogenic plant; 1.5K minimum
  - RF system in collaboration with JLab
    - >250 W available at cavity
  - Radiation and magnetic shielding
    - < 5 mrem in an hour immediately outside the shielding <0.25 mrem/hr in normal working areas
    - <10 mG
  - Thermometry and second sound for quench location detection
- Status
  - One Vertical Test Stand (VTS1) commissioned 7/2007
  - ~80 cavity tests, ~65 cryogenic cycles per year (2010)

9-cell Tesla-style cavity

VTS1 Cryostat

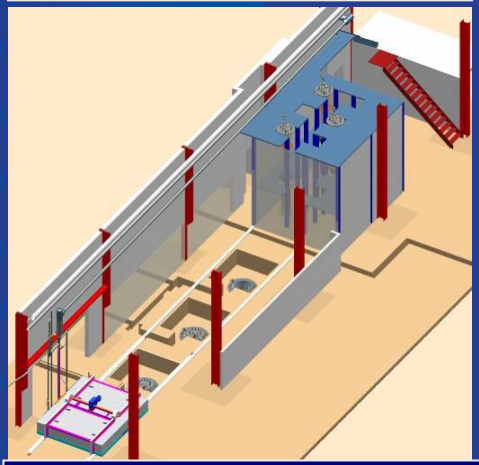
RF/DAQ System & Control Room



SSR1

VCTF upgrade: throughput and new cavities

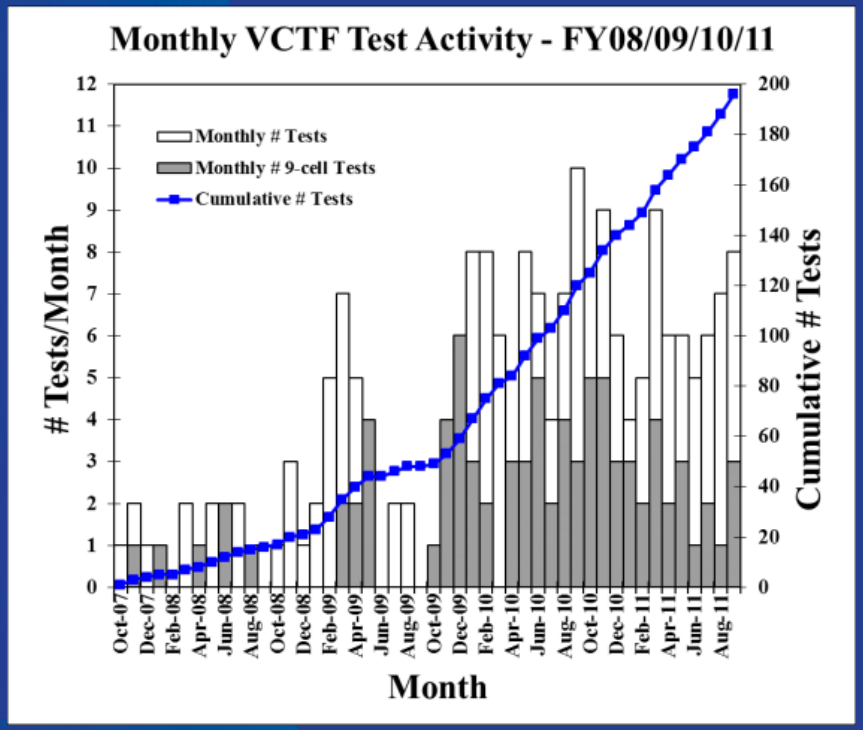
Two more VTS pits & staging area



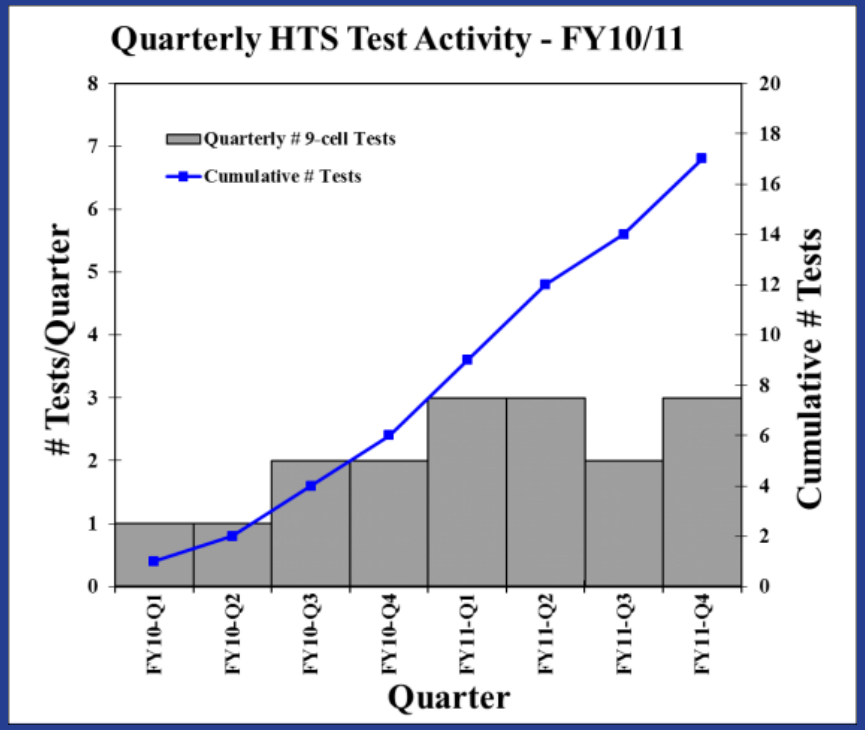
VTS2 cryostat prior to installation

- Cavities Tested
  - Project X: SSR1, SSR2, 650 MHz elliptical (two designs), 1.3 GHz elliptical (ILC)
  - ILC and/or other projects
- Upgrade components
  - Up to 125 cryogenic cycles per year
  - Cryogenic system upgrades
  - Two additional larger cryostats with multiple cavities per test cycle
  - Staging area for six cryostat top plates
- Status
  - Both new cryostats have been designed, fabricated and installed, and await final connection to infrastructure and commissioning
  - Staging area is designed and reqs in progress

VTS and HTS Throughput



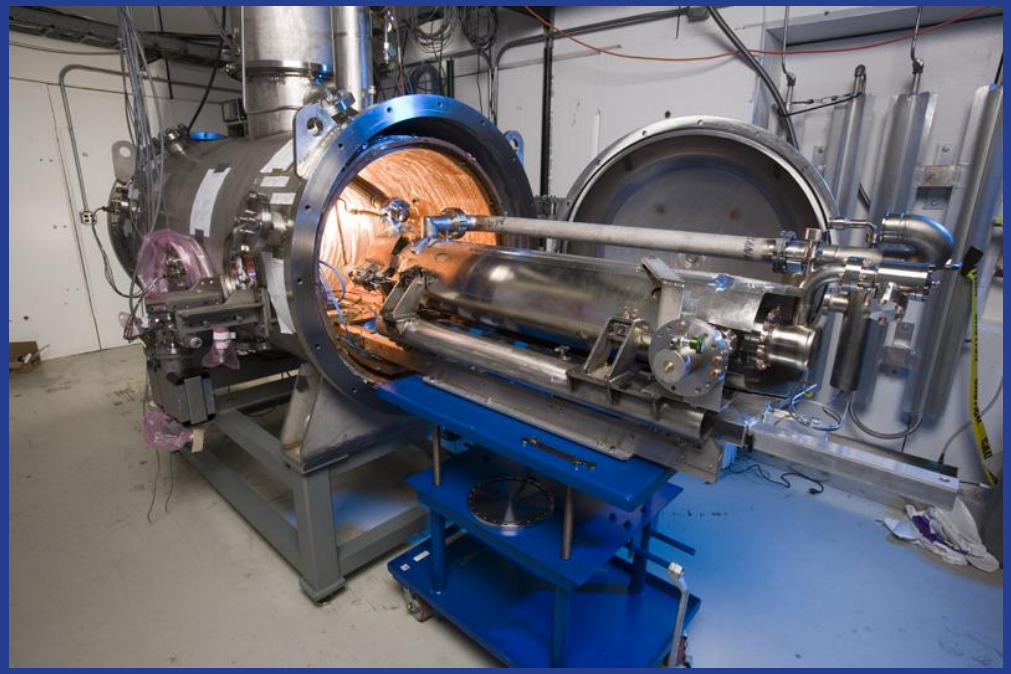
VTS



HTS

HTS-1 Capabilities

- High-power tests of "dressed" cavities
  - Ensure good cavity performance (E_{acc}, Q_0, FE) survives dressing process
  - Diagnostics: Faraday cups, X-ray dets, e- pickups, limited thermometry
- Input coupler conditioning
  - Warm (SW)
  - Cold (SW+TW)
- Tests of cavity accessories
  - Tuners, HOM couplers
- 1.3 GHz and 3.9 GHz
- Pulsed testing only so far, but CW not impossible

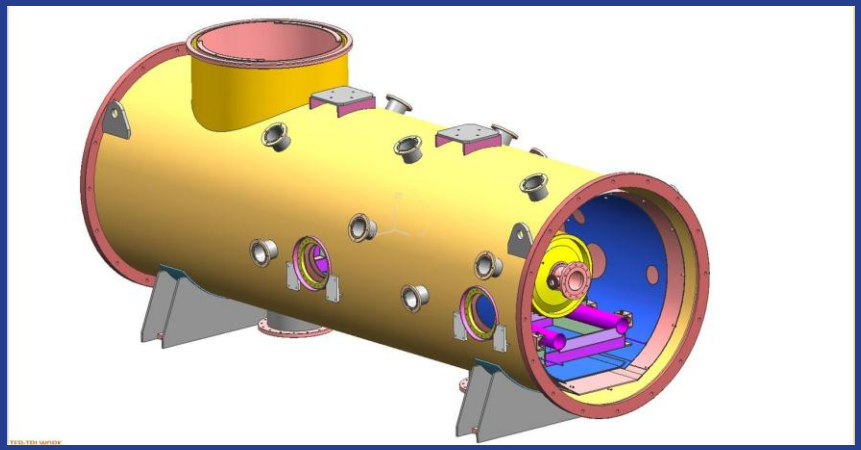


1.3 GHz installation into HTS

*Material from A. Hocker

HTS-2 Capabilities
(RRCAT Collaboration)

- Room for two cavities
  - Increases testing throughput
  - Also possible to test one cavity + magnet package



- Functionality similar to HTS-1
  - Dressed cavity performance + tests of aux. components
  - Similar diagnostics
- 1.3 GHz or 650 MHz
- Pulsed or CW testing
- Design incorporated improvements from HTS-1

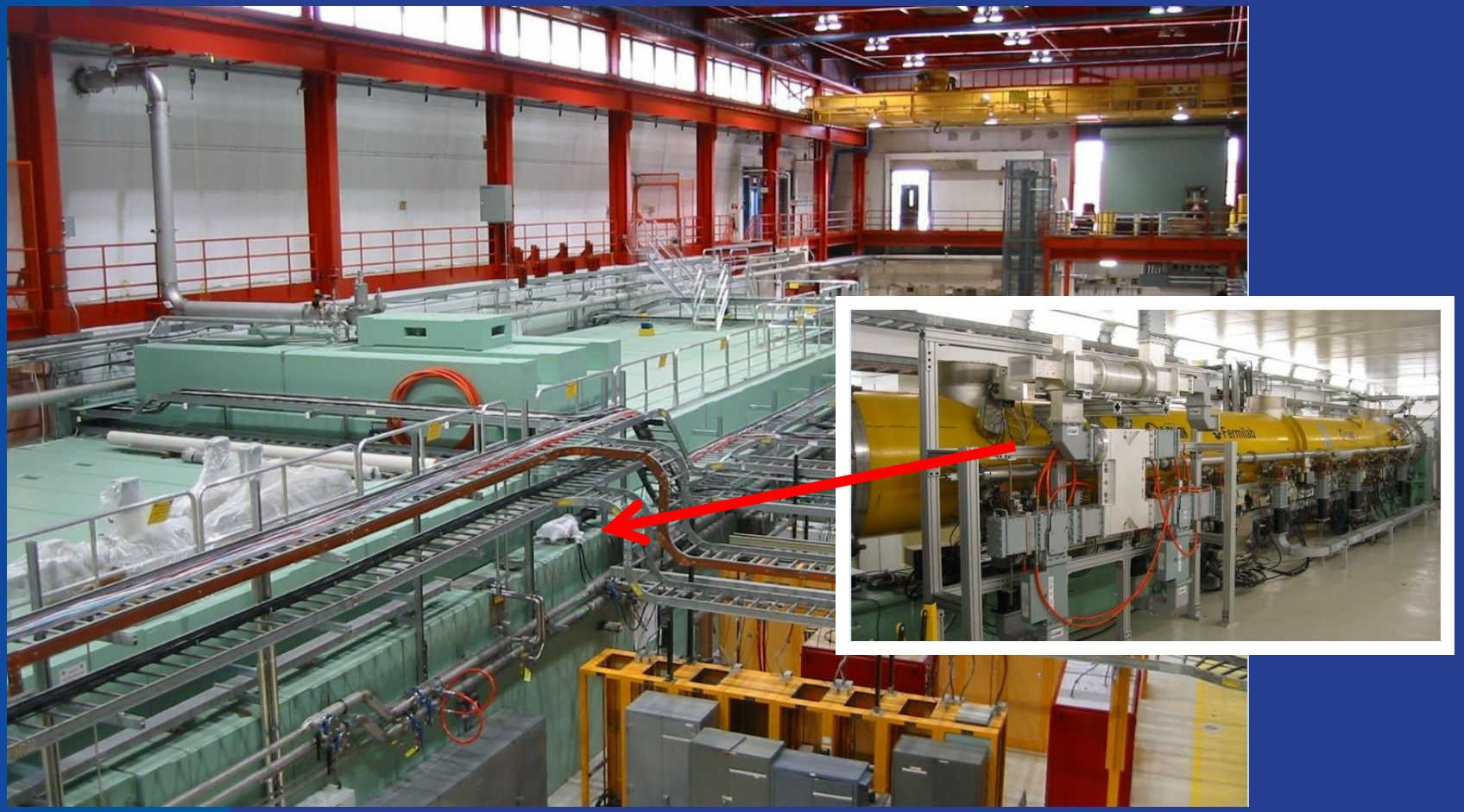
*Material from A. Hocker

ASTA Purpose and Plans
(Advanced Superconducting Test Accelerator)

- NML/ASTA is a multiple purpose facility for testing 1.3 GHz cryomodules
  - ILC R&D
  - AARD facility (ASTA)
  - Test facility for PX pulsed linac
  - Possible future NGLS test facility, though PXIE space may necessitate additional CM test cave or two with building modification
- Progress & Schedule
  - Very successful 15 month operational plan of CM1 just completed
  - Installation of first high gradient (31.5 MV/m) CM2 in April
  - First beam through CM expected by end of 2012

*Material from J. Leibfritz

ASTA at NML



*Material from J. Leibfritz

New NML Buildings (ARRA funded)

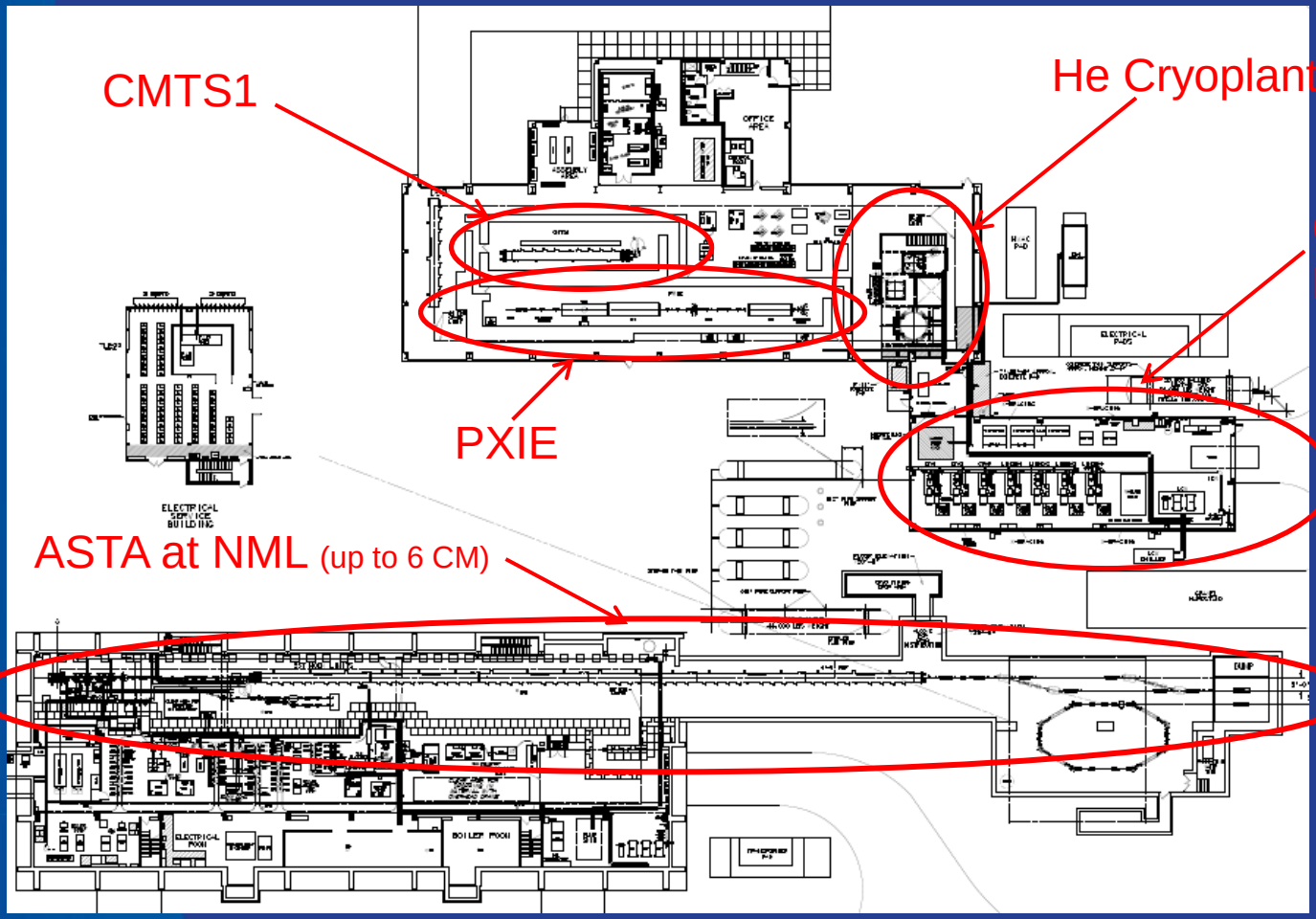
New Cryomodule Test Facility

New 500 W 2K refrigerator (under fabrication in industry)will be located in CMTF

*Material from J. Leibfritz

Compressor building

NML and CMTF Layout



*Material from J. Leibfritz

NML/CMTF Cryogenics

- Combined cryogenic systems should have the following functionality
  - Operate NML/ASTA with 2 Capture Cavities and up to 6 Cryomodules (Pulsed)
    - CW Cryomodule operation is possible, but is not in current plans
  - Operate PXIE with 1 HWR and 1 SSR1 Cryomodule (CW)
  - Operate CMTS1 capable of testing 1 Cryomodule
    - 1.3 GHz Cryomodules - Pulsed or CW
    - 325 MHz SSR or 650 MHz Cryomodules (CW)
  - Pressure stability goal 0.1 mbar (rms)
- Helium cryoplants in CMTF and NML (nominal capacities)
  - New Superfluid Refrigerator
    - 250W @ 1.8K or 500W @ 2K
  - Repurposed SLAC CTI-4000 Refrigerator - supplies LHe to NML/ASTA
    - 1500W @ 4.5K
  - Repurposed Tevatron Satellite Refrigerators (2) in NML
    - 1250W @ 4.5K

*Material from J. Leibfritz

Concluding Remarks

- FNAL has developed substantial in-house SRF development capabilities.
- Complete cryomodule design and development from cavity fabrication through cryomodule testing of multiple cavity types is now possible at FNAL.
- Strong collaborations with other SRF labs ensure FNAL remains ‘state-of-the-art.’