Recent activities at Jefferson Laboratory - Progress of the new SRF facilities and CEBAF 12GeV upgrade cavity results

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Jefferson Science Associates, LLC under U.S. DOE
Contract No. DE-AC05-06OR23177

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Part 1 New TEDF/SRF Development Facilities

- TEDF project buildings
- Design goals
- New facility foot print
- Workflow improvements
- New clean and chemical room design

Part 2 – CEBAF 12 GeV SRF Upgrade Cavity Testing Results

- CEBAF overview
- 12GeV upgrade cavity design
- Cavity processing
- Full VTA cavity tests results with FE

Thomas Jefferson National Accelerator Facility

Newport News, Virginia

39°51'28.00" N 96°07'33.60" W

SRF Research and accelerator production facilities

Jefferson Lab

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Jefferson National Laboratory (JLAB)

Department of Energy (DOE) single function Laboratory – Nuclear physics

- One of 17 national labs in the United States
- ~700 employee's (~1000 during construction/12GeV)
- ~1300 visiting scientist a year
- CEBAF (continual electron beam accelerator facility) – nuclear physics 5 pass racetrack dual LINAC
- Free electron laser – 14.2 kilowatts of cw light at 1.6 microns (100W @ 363nm)
- Full functional Superconducting Radio Frequency(SRF) cavity processing facility

Jefferson Lab Technology and Engineering Development Facility Project (TEDF)

A DOE Science Laboratory Infrastructure modernization project

Provides the first 2nd-generation SRF facility in the world

TED extension/addition building

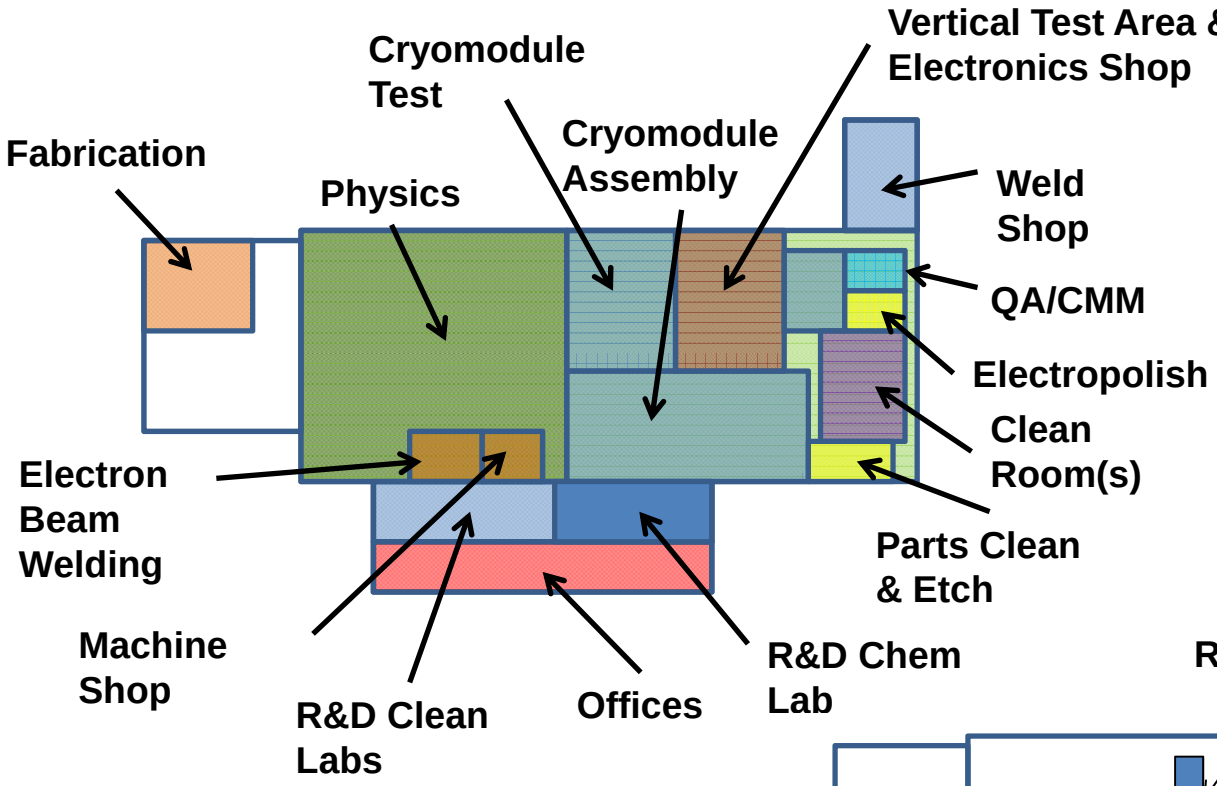
Replaces temporary building and rental offices

- Temporary home of SRF during test lab renovation (through summer 2013)
- New home for Engineering staff
- New home for some Cryogenic staff
- New home for some accelerator support staff
- New home for electronics assembly and design

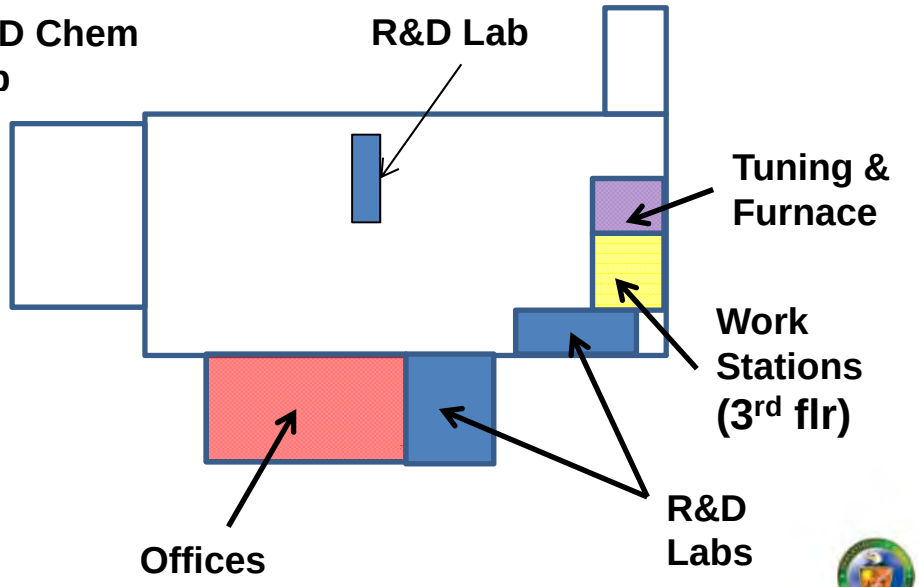
TEDF Project- SRF TLA/Addition

- **Department of Energy – "Science Laboratory Infrastructure" Project**
- Investment in facilities for:
  - Improved energy efficiency
  - Improved safety code compliance – new building
  - Improved human work environment- lighting and ergonomics
  - **Increased build out capacity – future projects**
  - Improved technical quality of facilities for future work
  - **Improved work-flow efficiency**

SRF Work Centers in Test Lab – OLD design



Test Lab 1st Floor



Test Lab 2nd Floor

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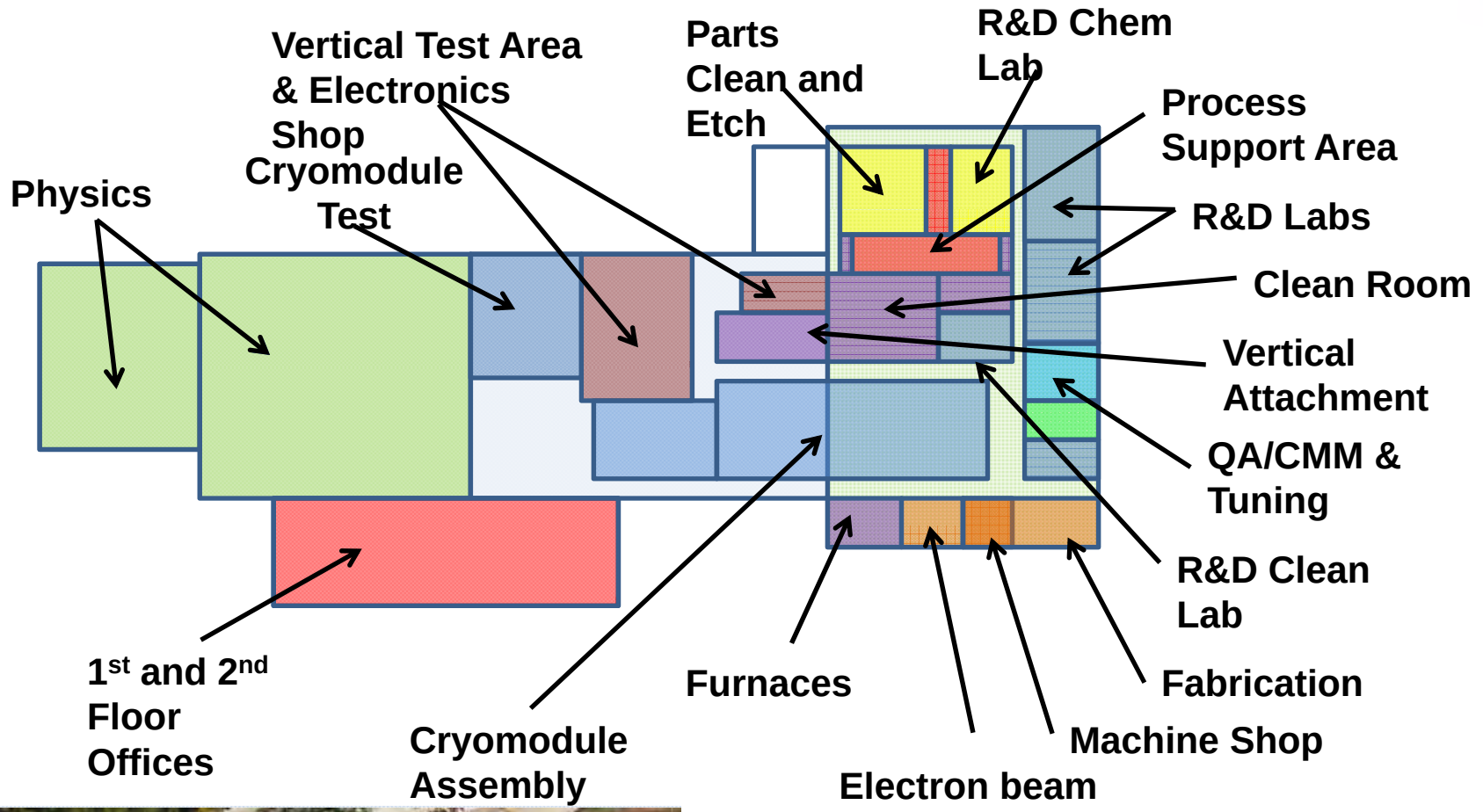
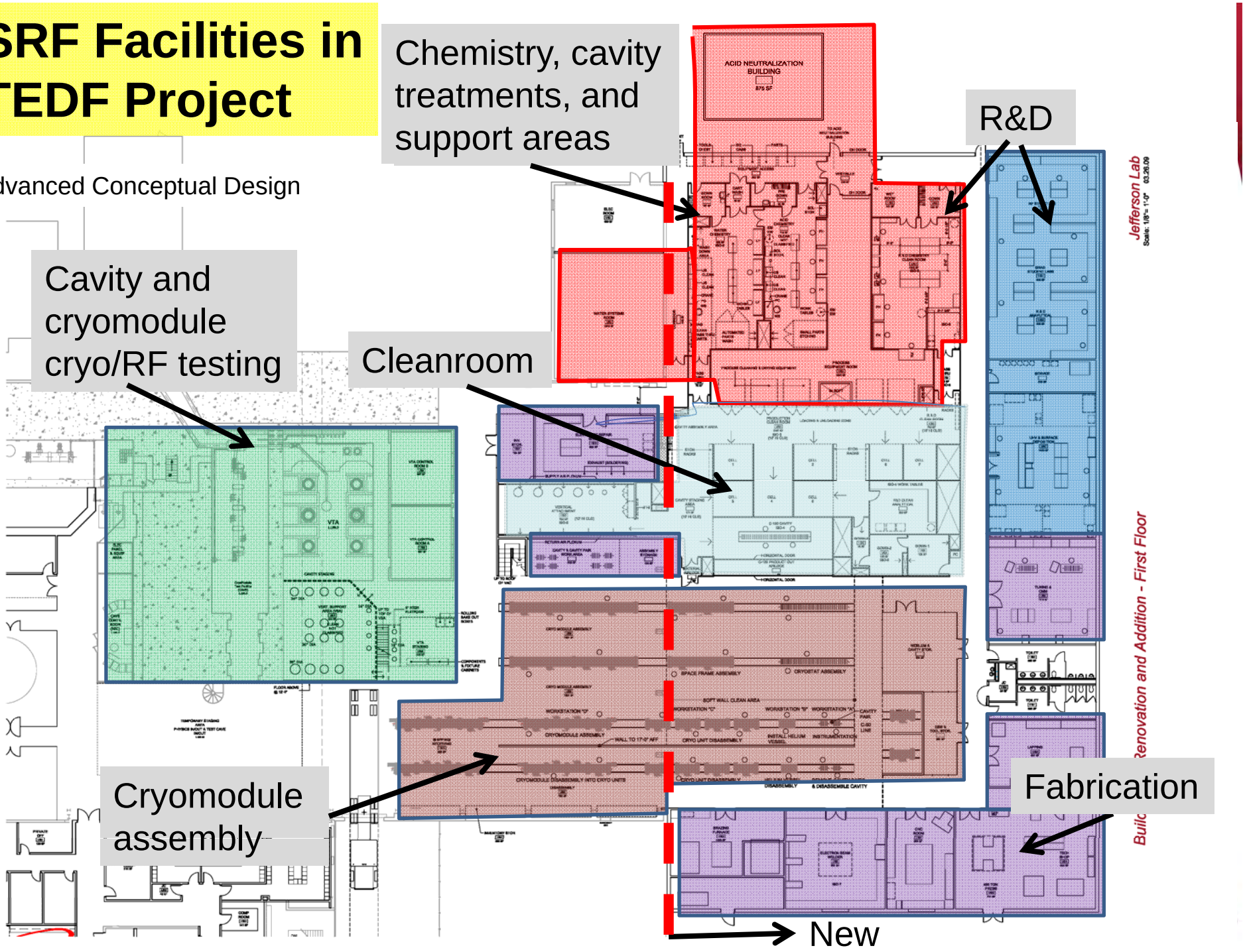
SRF Work Centers in New Test Lab



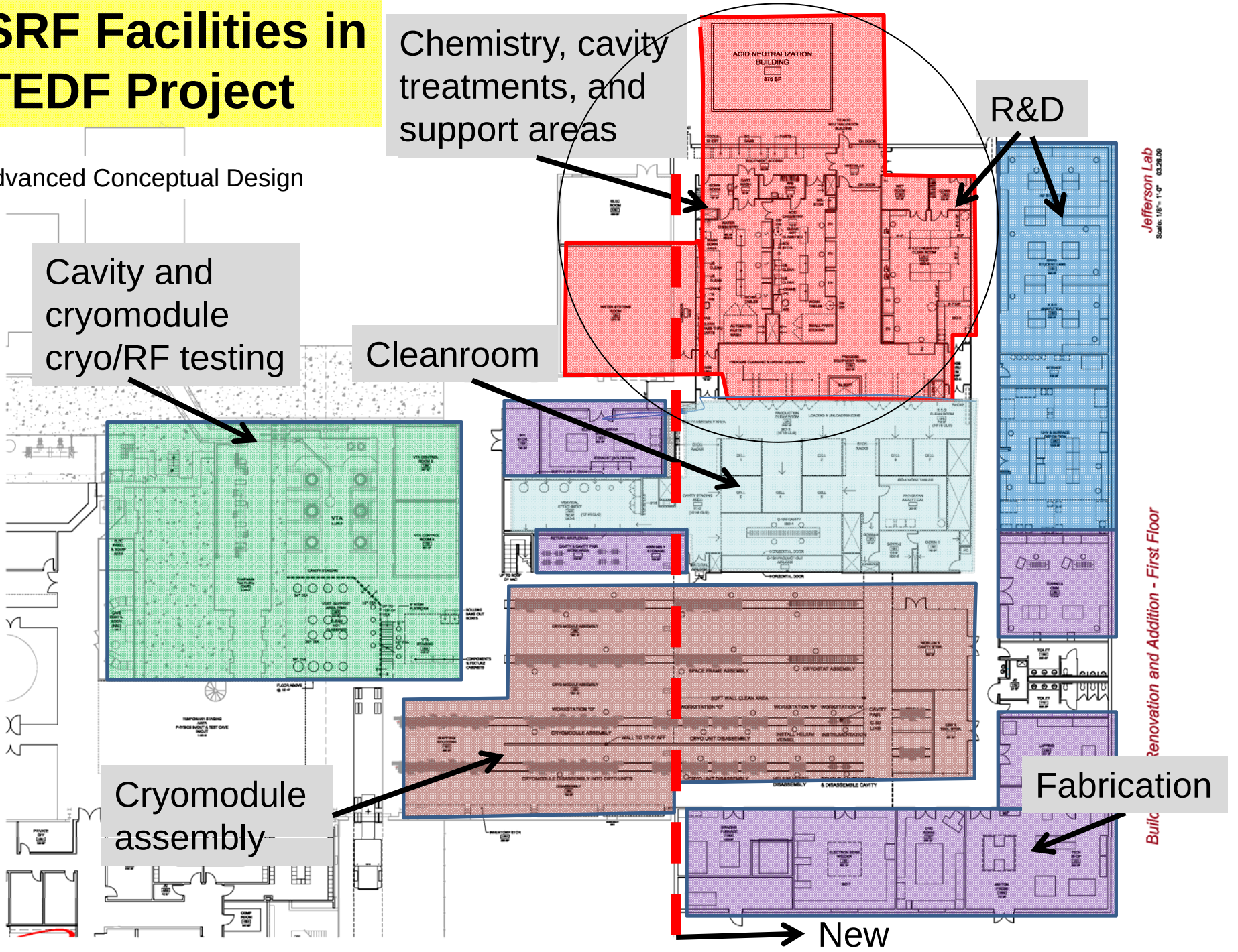
SRF Facilities in TEDF Project

Advanced Conceptual Design



SRF Facilities in TEDF Project

Advanced Conceptual Design



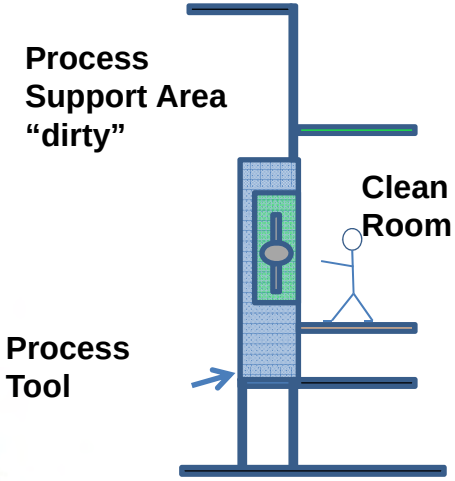
Chemistry and Ultra pure water

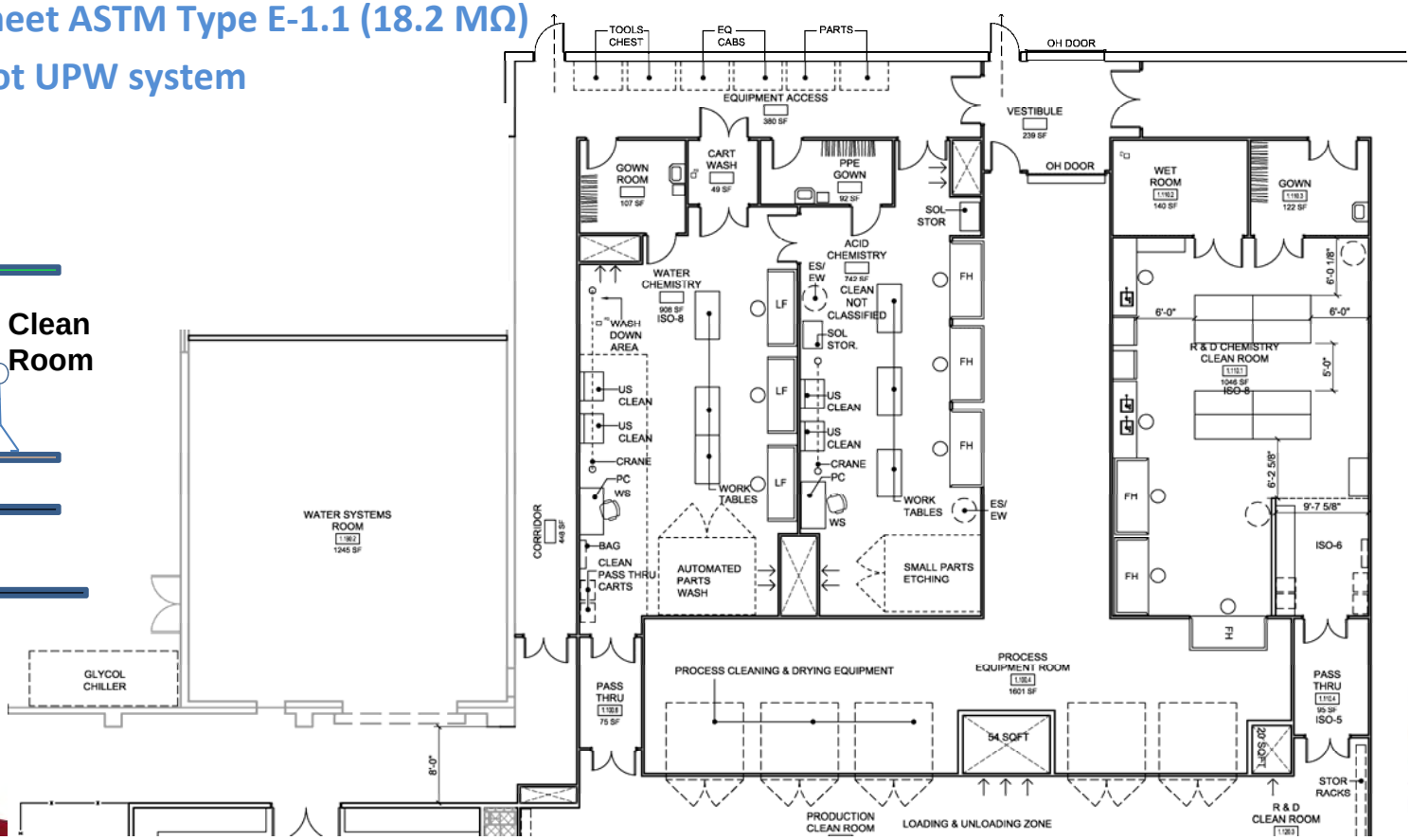
Upgraded chemical management and waste treatment systems

- Semi-automatic bulk chemical delivery systems to tools
- Upgrade chemical wet stations
- Use of double containment and valve manifold boxes for safety
- Automated neutralization system

Upgraded ultrapure water system

- Specified to meet ASTM Type E-1.1 (18.2 MΩ)
- Centralized Hot UPW system





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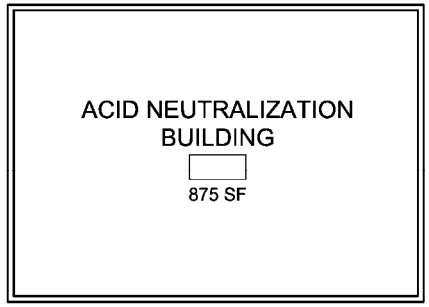
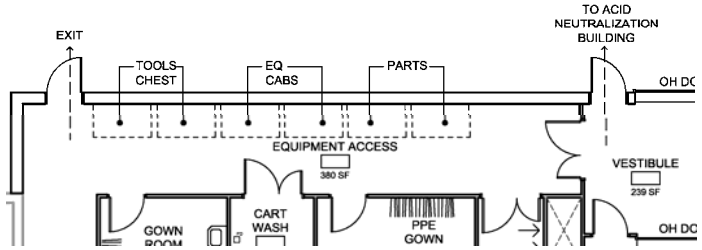
Centralized Bulk Chemistry neutralization

- Extension building dedicated for neutralization only
- Single building for R&D and production
- Fully automated neutralization and monitoring

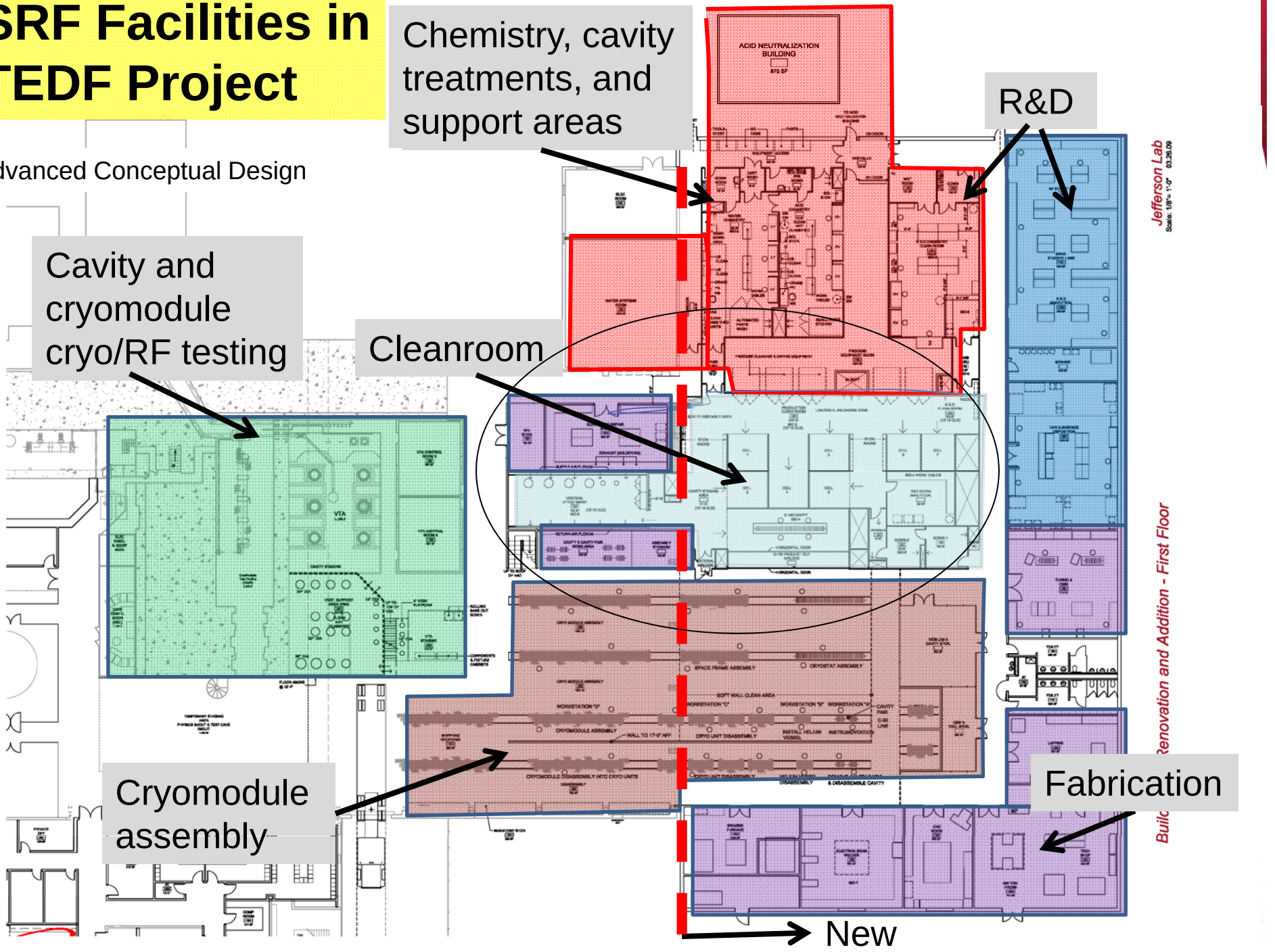




Back of chemical room

SRF Facilities in TEDF Project

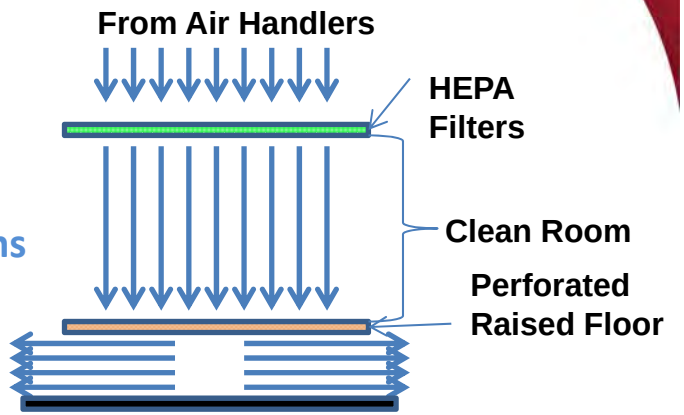
Advanced Conceptual Design

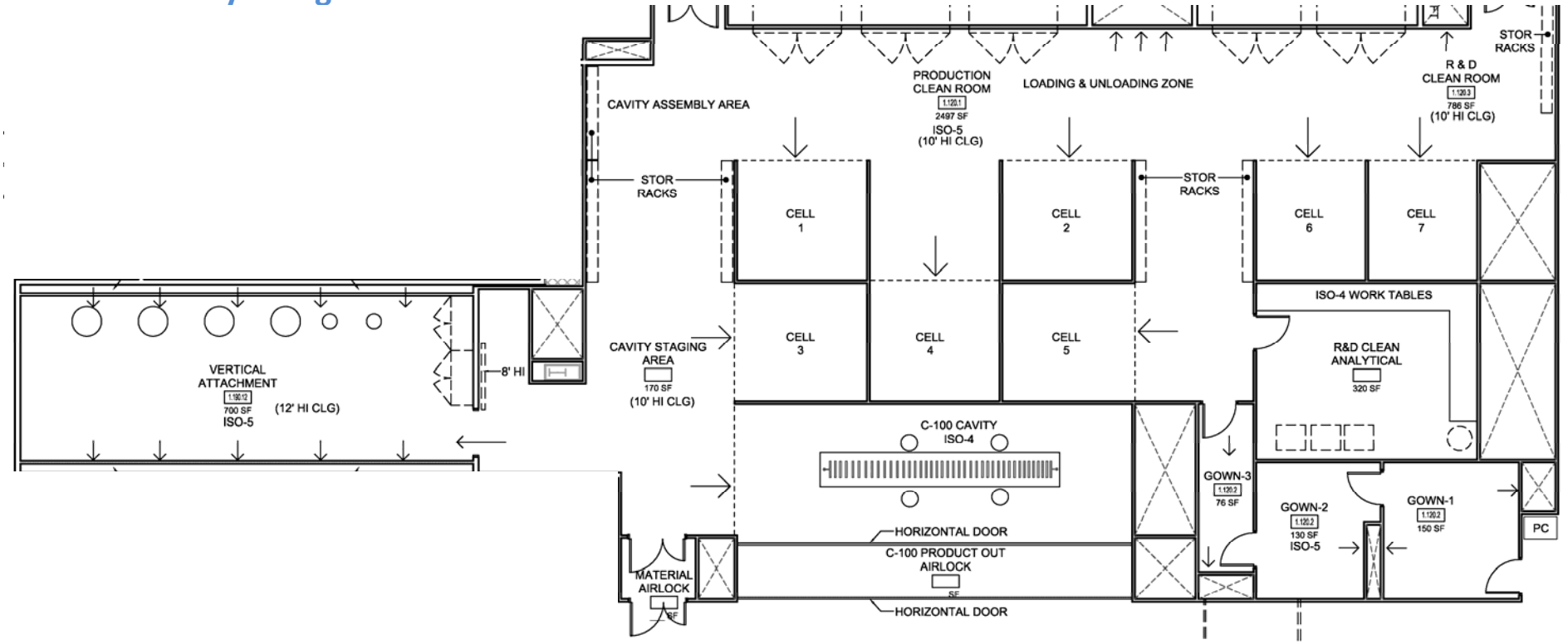


New clean Room facilities

Upgraded clean room space to ISO-4 (all class 10 assembly)

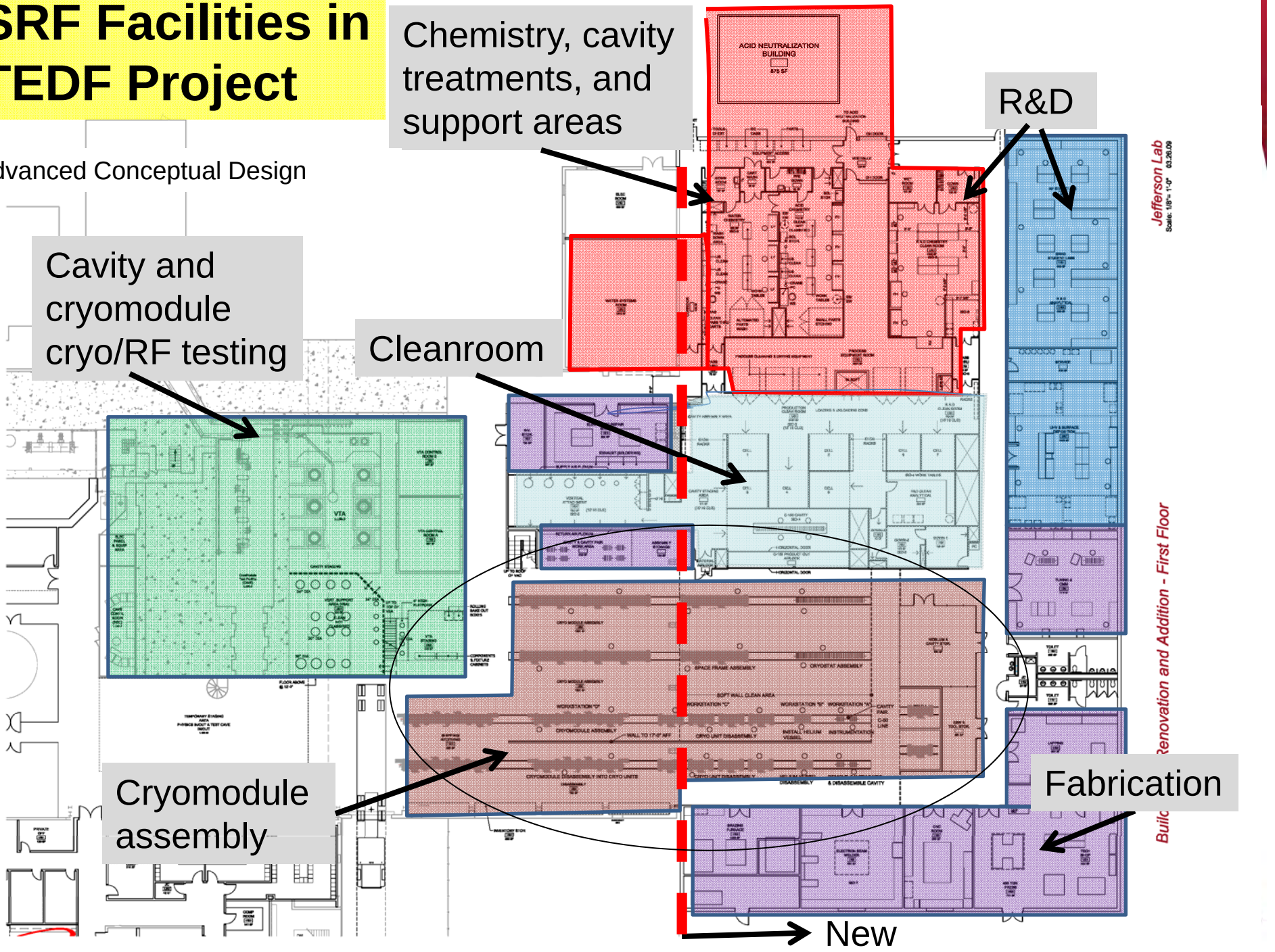
- 100% HEPA coverage, RMF, laminar flow with return plenums
- Bay/Chase concept
- Dedicated Drying & Assembly chambers
- Modular wall systems
- Cavity string air lock





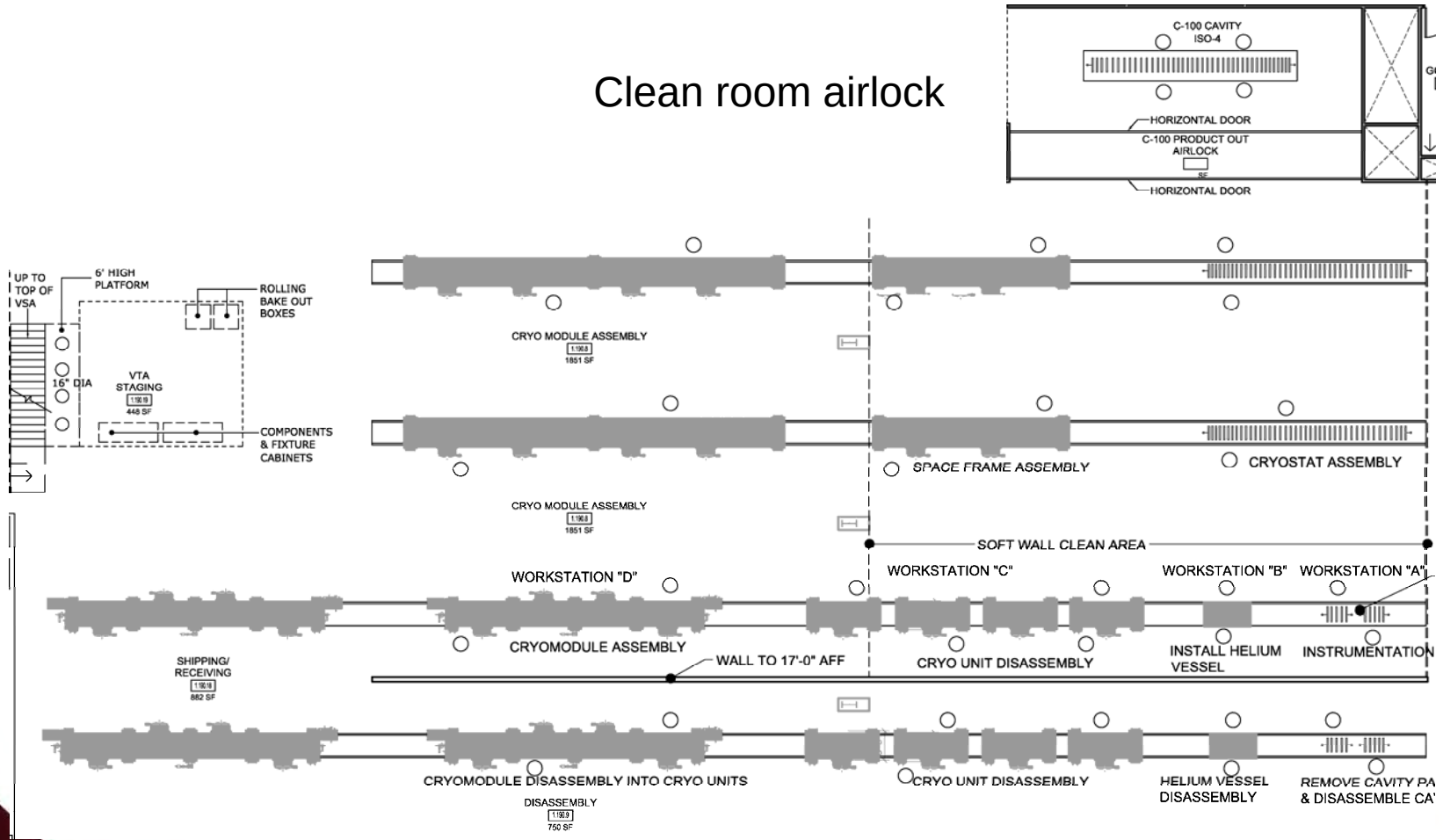
SRF Facilities in TEDF Project

Advanced Conceptual Design



Expanded cryo-module assembly area

- Upgraded cryomodule assembly space
  - Additional rails to allow for simultaneous C50, C100, and R&D assemblies



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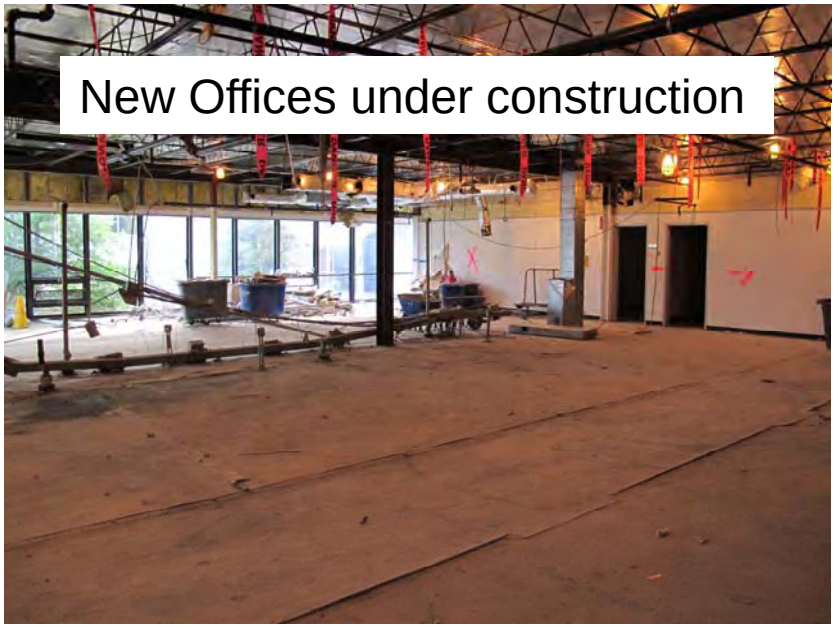
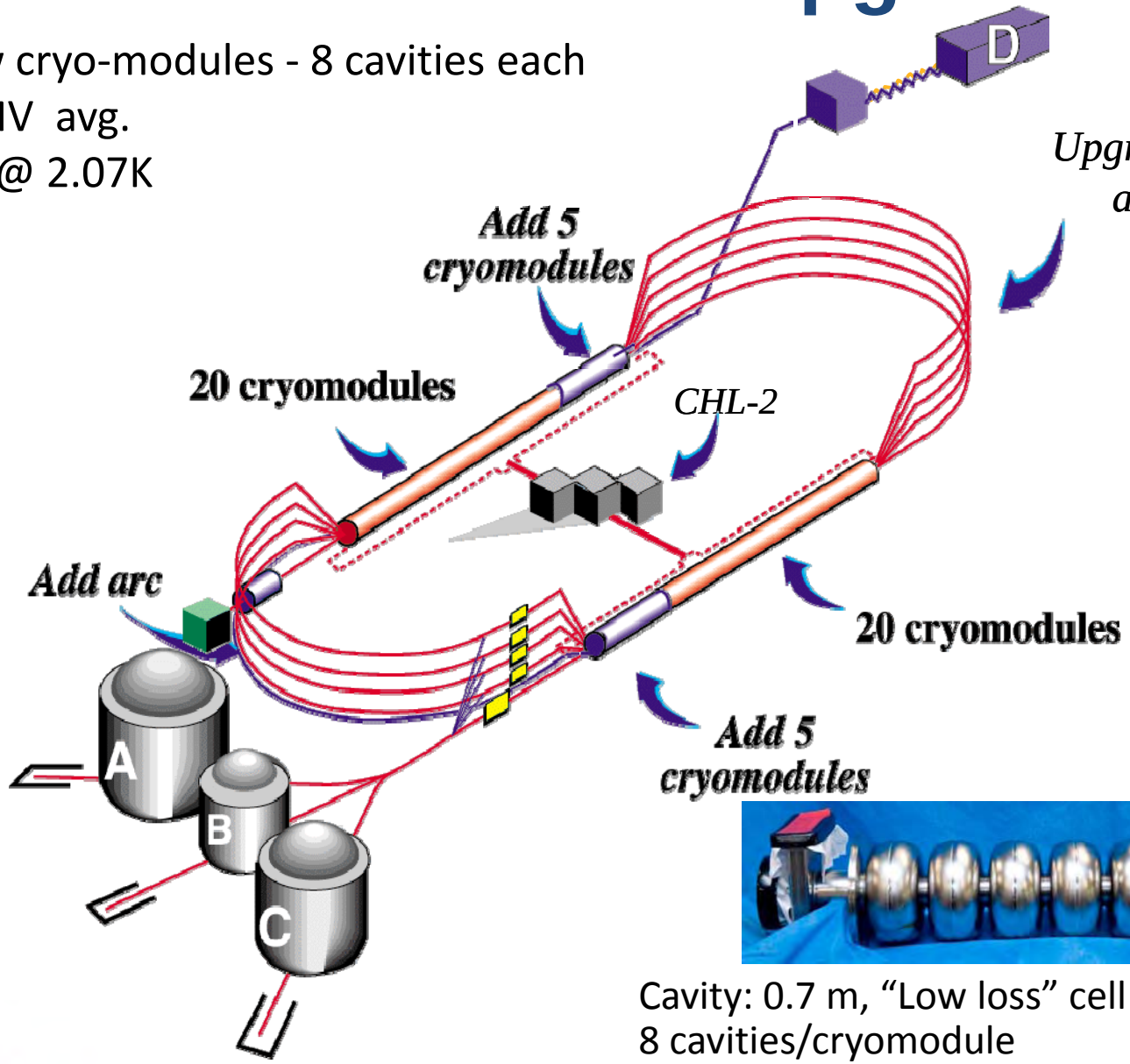
Expect great thing in 2013 after construction is complete



Part 1 questions?

Part 2 - CEBAF 12 GeV Upgrade

10 New cryo-modules - 8 cavities each
≥108 MV avg.
300 W @ 2.07K



Cavity: 0.7 m, “Low loss” cell shape, 1.497 GHz
8 cavities/cryomodule

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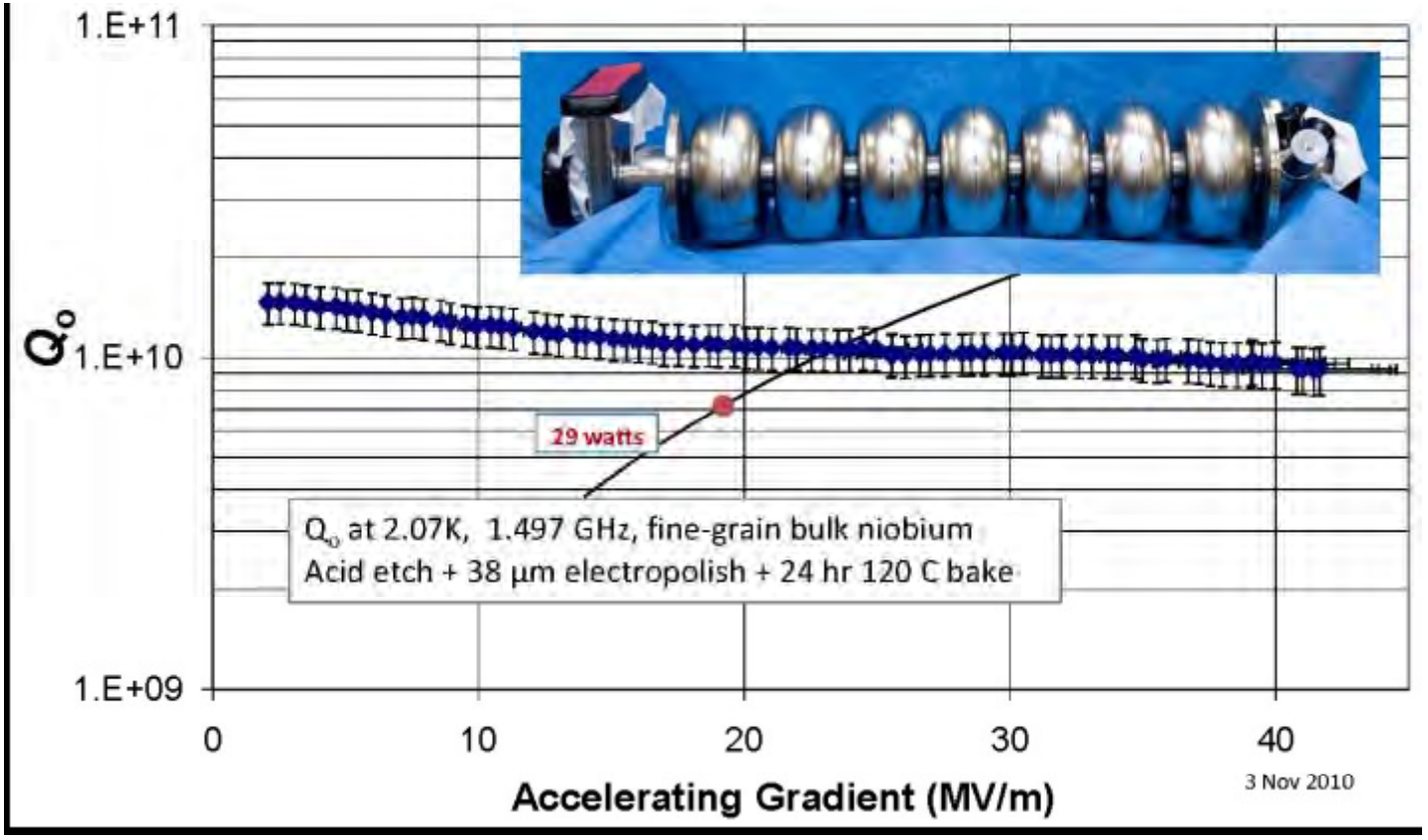
12 GeV Upgrade cavity
7 cell low loss fabricated by Research Instruments (RI -Germany)



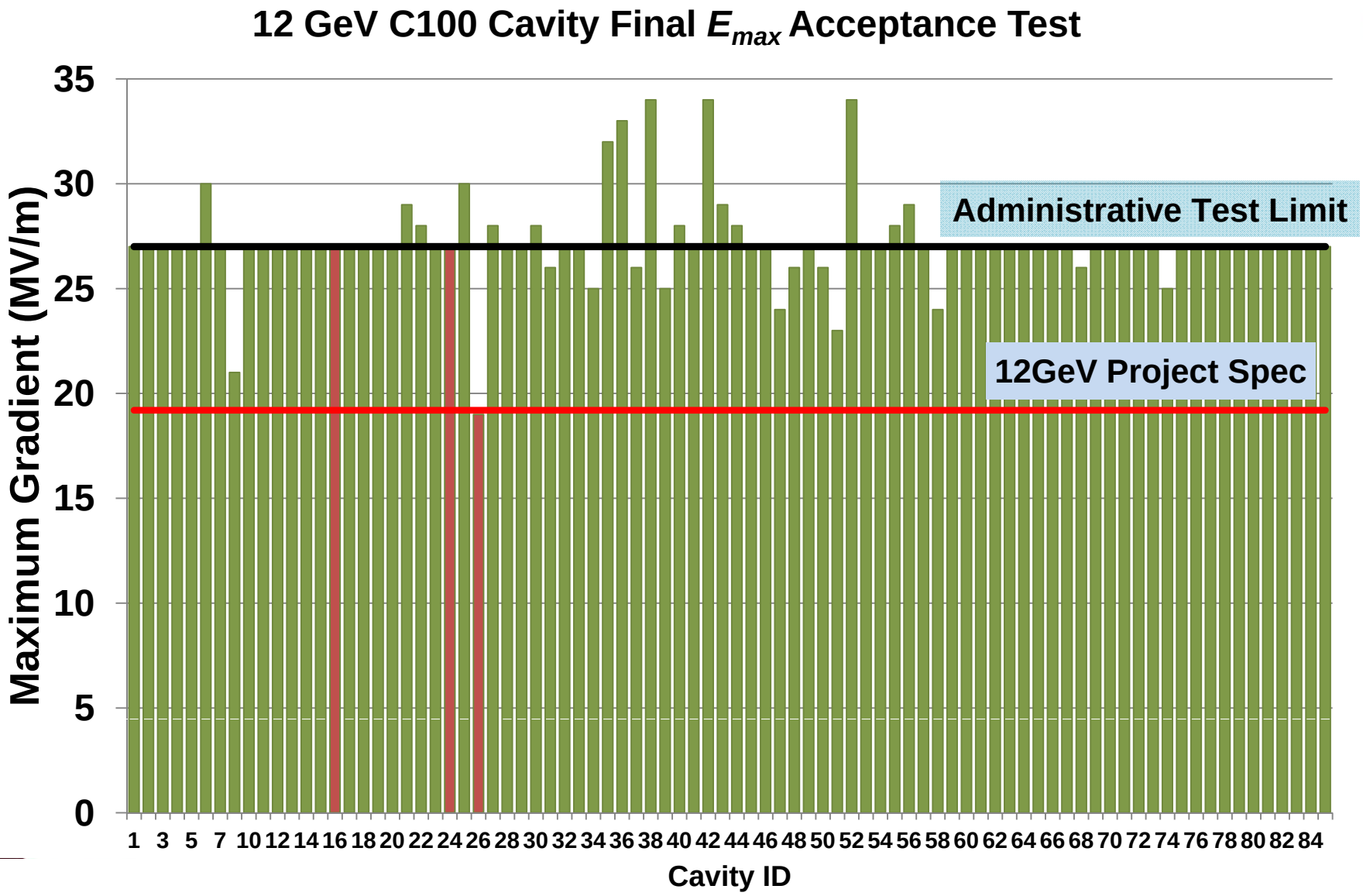
Spec - 19.2MV/m below 29 watts (Q=7.2*10^9)

12 GeV Upgrade Cavities

- **Production process** – press for reliable efficiency
  - **160 µm BCP** etched and pre-tuned **by vendor**
  - Receipt inspection – mechanical and RF
  - Bake: 600 C, 10 hrs
  - EP: **30 µm, @20°C** regulated by external water spray/degrease
  - Tune
  - Helium vessel welding
  - Flange lapping/degrease
  - HPR
  - Partial assembly
  - HPR >> dry in Class 10 cleanroom
  - Final assembly, leak check
  - Bake: **120° C, 24 hrs**
  - Vertical test @ 2.07 K
  - HPR >> dry in Class 10
  - String assembly

A. Reilly et al., *Preparation and Testing of the SRF Cavities for the CEBAF 12 GeV Upgrade*,"TUPO061 SRF 2011 Conference.

CEBAF 12 GeV project cavities



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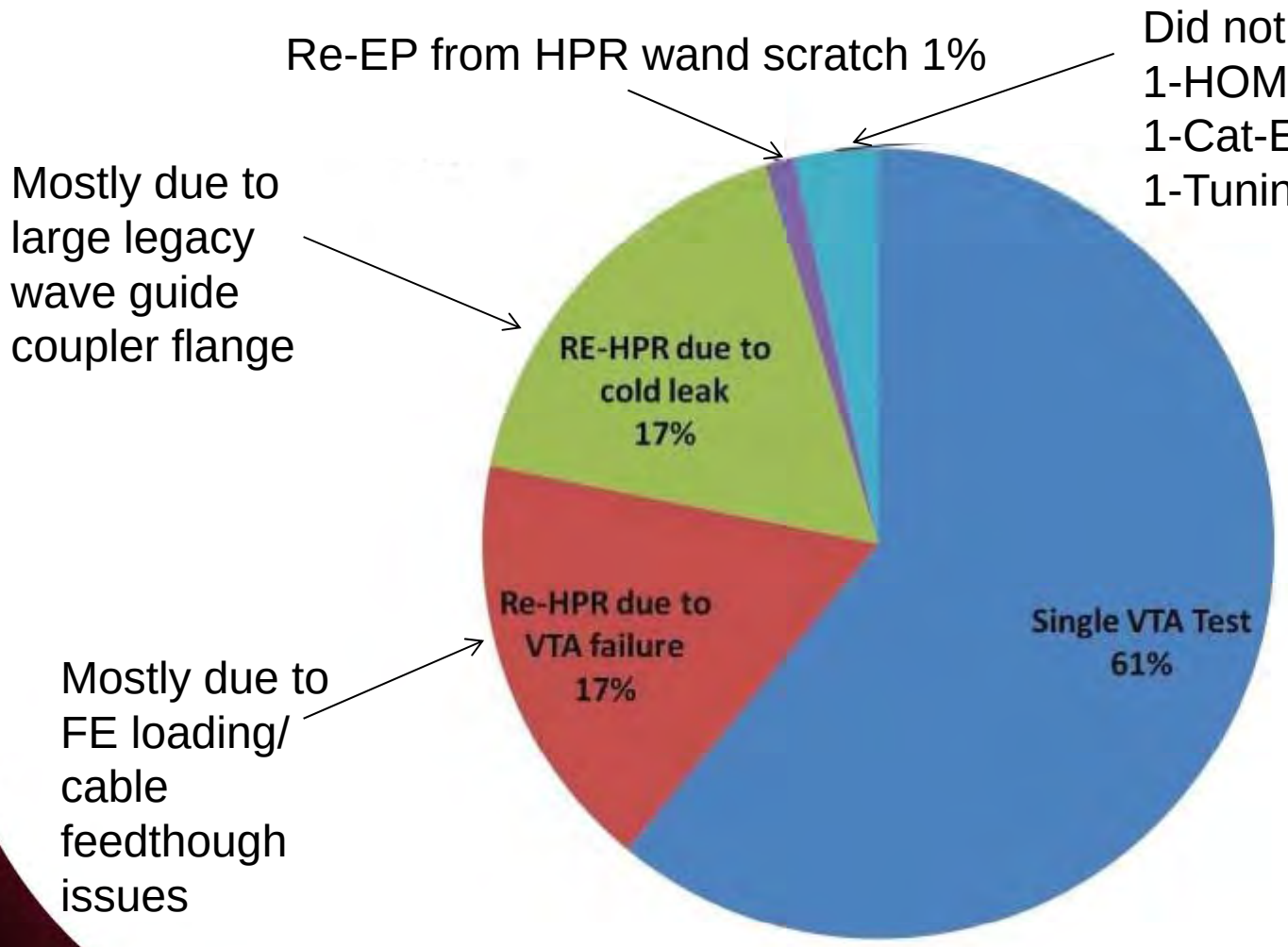
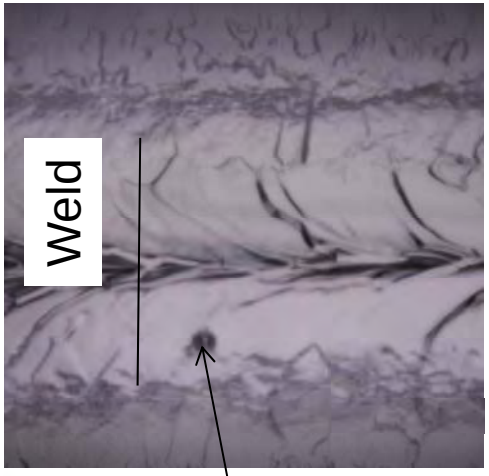
Full cavity statistics all VTA cycles



Cavities which did no meet spec - defects

c100-26 cell 5

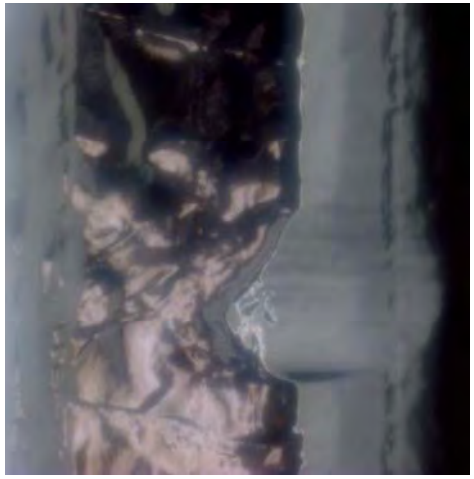
Only 1 cavity was quench limited below spec by original manufacturing defect



c100-8 iris 2-6

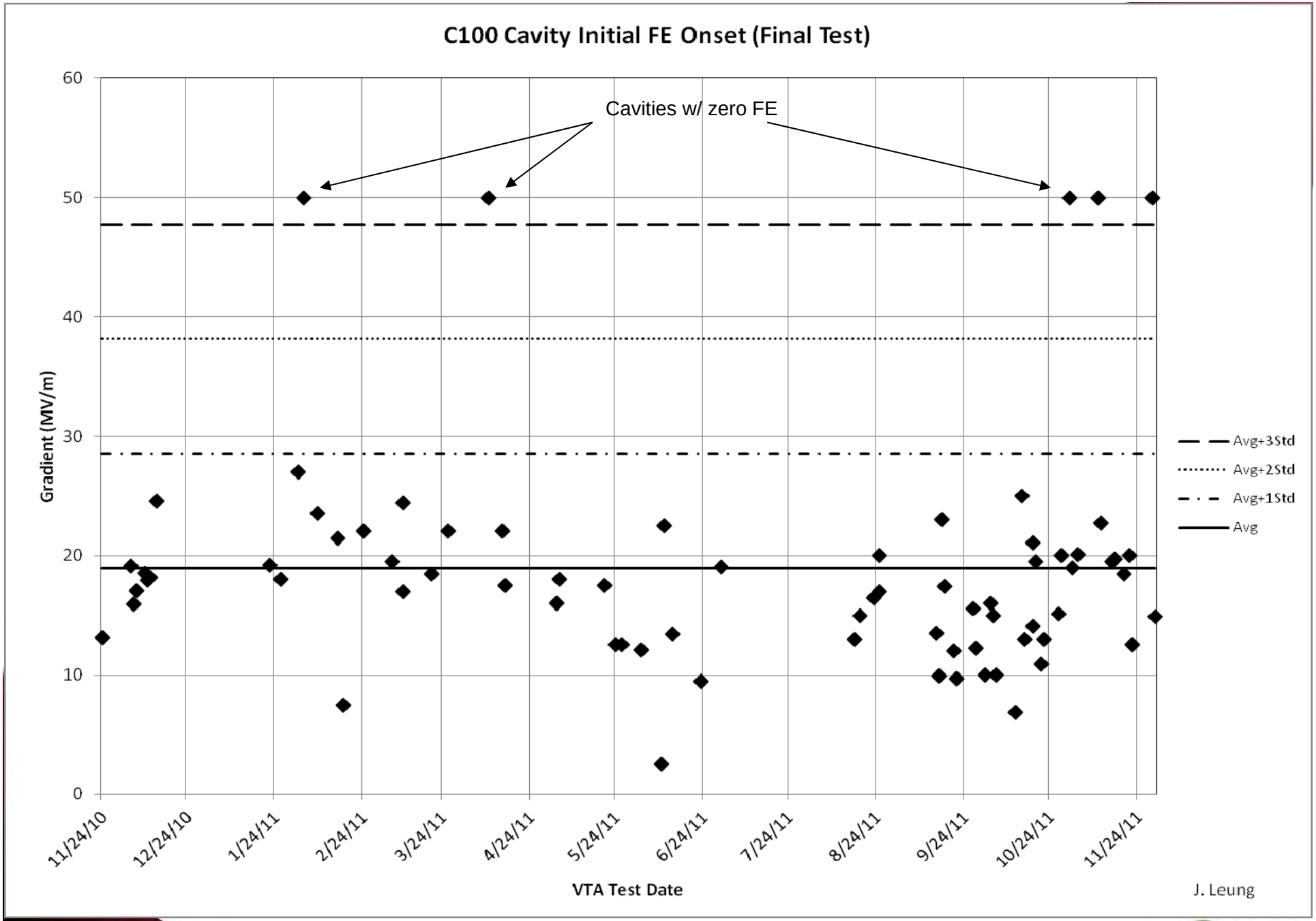
Accidental Cavity scratch from HPR

Post re-EP



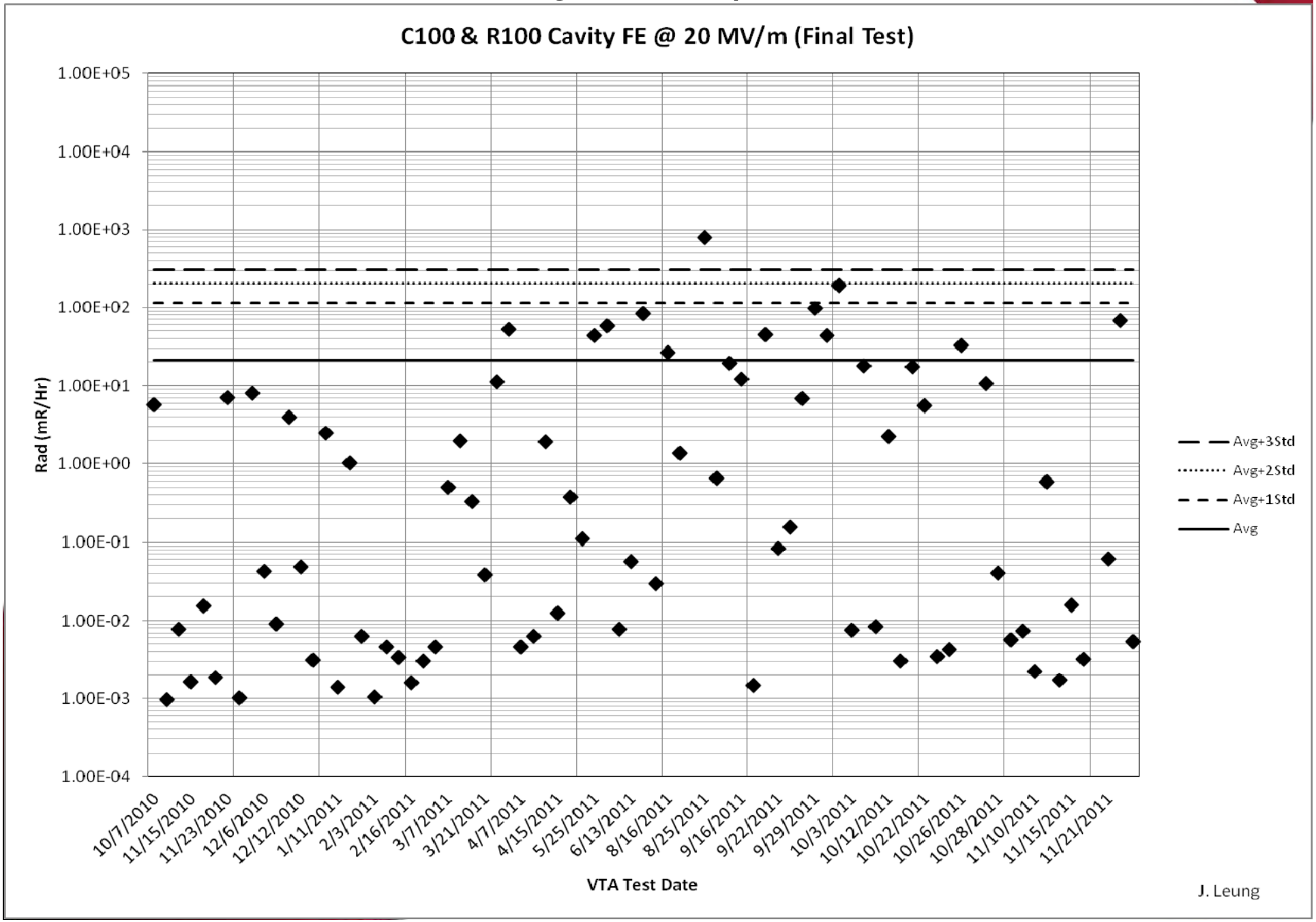
Field Emission Statistics – vertical qualification test

- Field emission monitored above the top plate of the Dewar within the shield lid. – 6 feet above and 3 feet off axis
- Data take every 0.3 seconds - Canberra IP-100 area monitor
- Continually monitored and data logged
- Our radiation is monitored in mRad/hr (i.e. mRad/hr=10μSv/hr)
- VTA operator complies data after each test and places individual cavity results into centralized database


C100 Cavity Initial FE Onset (Final Test)
Cavities w/ zero FE
Gradient (MV/m)
60
50
40
30
20
10
0
11/24/10
12/24/10
1/24/11
2/24/11
3/24/11
4/24/11
5/24/11
6/24/11
7/24/11
8/24/11
9/24/11
10/24/11
11/24/11
VTA Test Date
Avg+3Std
Avg+2Std
Avg+1Std
Avg
J. Leung

1mR = 10µSv

Average = 190 µSv/hr in VTA



12GeV - Cryomodule data

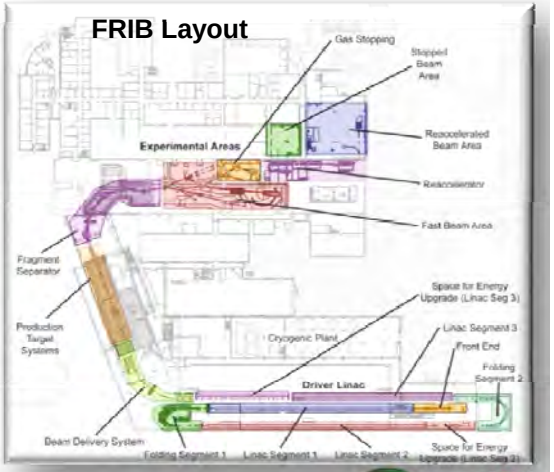
- Modules 1 and 2 installed in 2011 both have worked at spec of (108.2MV) with beam
- Modules 3 and 4 are complete and in the tunnel
- Modules 5 and 6 are complete and awaiting test
- Modules 7-10 are at various stages of completion, but all strings are fully assembled under vacuum
- Final instillation slated for 2013 with full operations by end of 2014 – 16 month shutdown just started May 2012
- Field emission test data for Cryomodule expected – early 2014

Other SRF Projects

- FRIB:
  - Committed to do processing of all half-wave cavities
  - In discussion full cryomodule design, assembly, and testing
- APS - construct crab cavity prototype
- Project X - designed, constructed and tested new 650 MHz cavity shape to minimize multipacting
- Next Generation Light Source - collaboration w/LBNL, FNAL, SLAC
- ILC - leading gradient improvement effort - CBP/VEP/FE mapping
- BES inverse compton scattering source – developing technology
- European Spallation Source – in negotiations re spoke cavity R&D


7-cell cavity


Crab cavity prototype for APS



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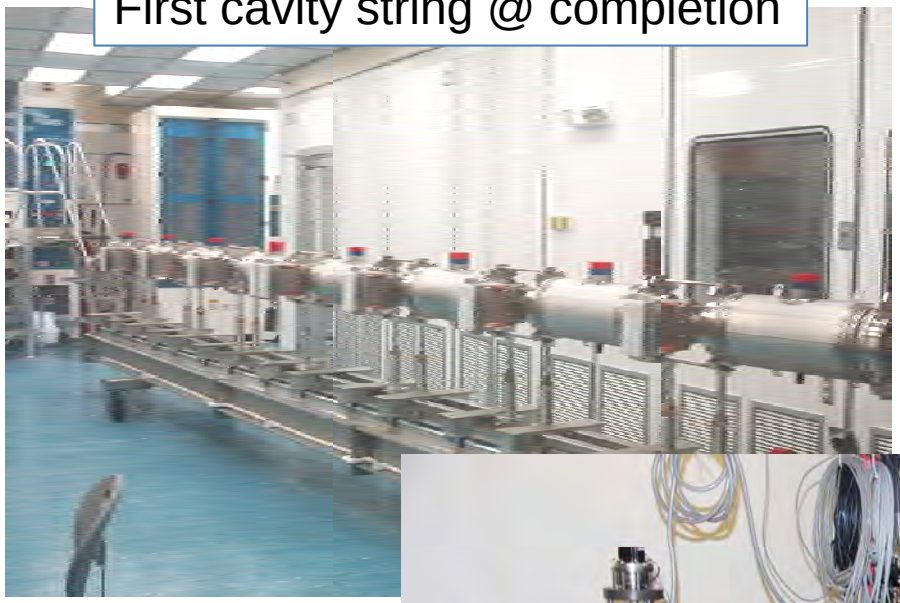
Special Thanks

- Entire Jefferson SRF Institute technical and production staff including Scientist and VTA operators for individual FE statistics
- Jonny Jeung for FE database analysis
- Charlie Reece and Tony Reilly for TEDF slides

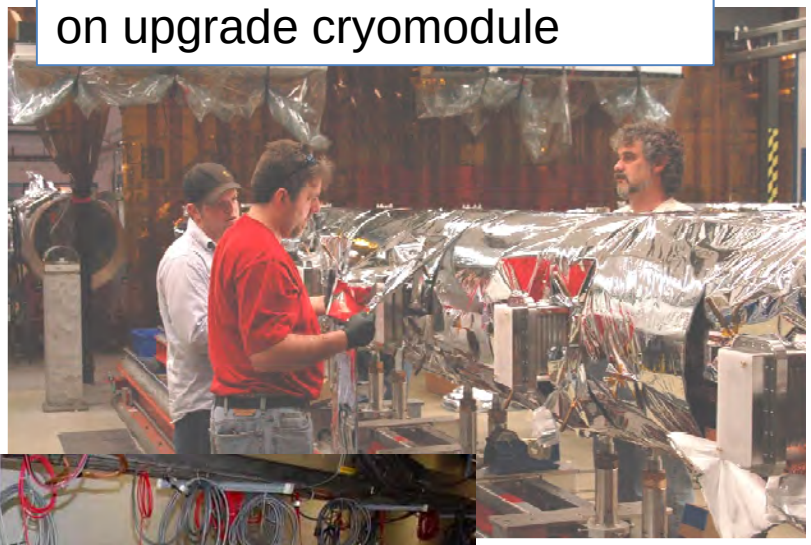
Jefferson Science Associates, LLC under U.S. DOE
Contract No. DE-AC05-06OR23177

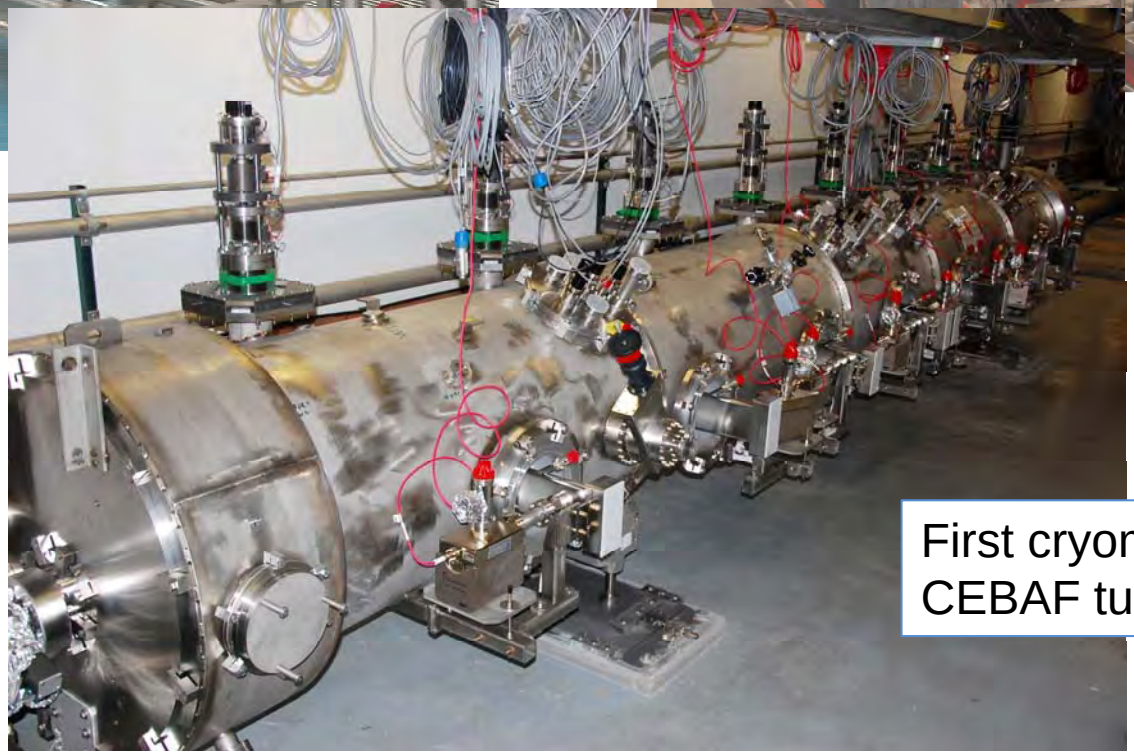
12 GeV Upgrade Cryomodule

First cavity string @ completion



Installation of super-insulation on upgrade cryomodule





First cryomodule in CEBAF tunnel

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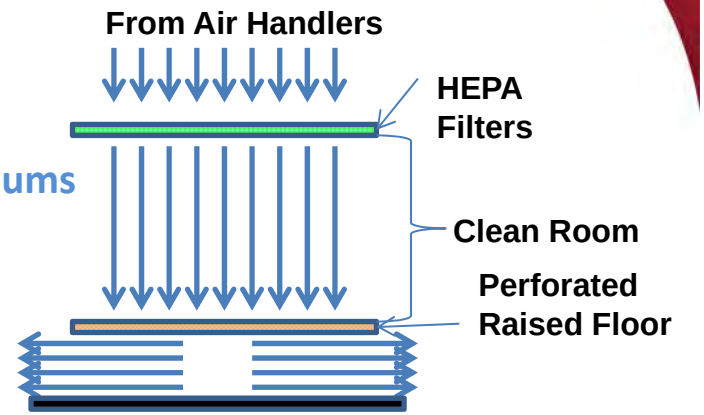
Improved Technical Quality of Facilities for Future Work

- Upgraded clean room space to ISO-4 (all class 10)
  - 100% HEPA coverage, RMF, laminar flow with return plenums
  - Bay/Chase concept
  - Dedicated Drying & Assembly chambers
  - Modular wall systems
  - Cavity string air lock



- Upgraded chemical management and waste treatment systems
  - Semi-automatic bulk chemical delivery systems to tools
  - Upgrade chemical wet stations
  - Use of double containment and valve manifold boxes for safety
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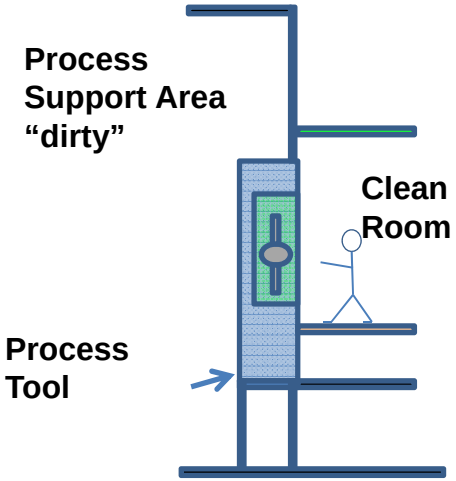
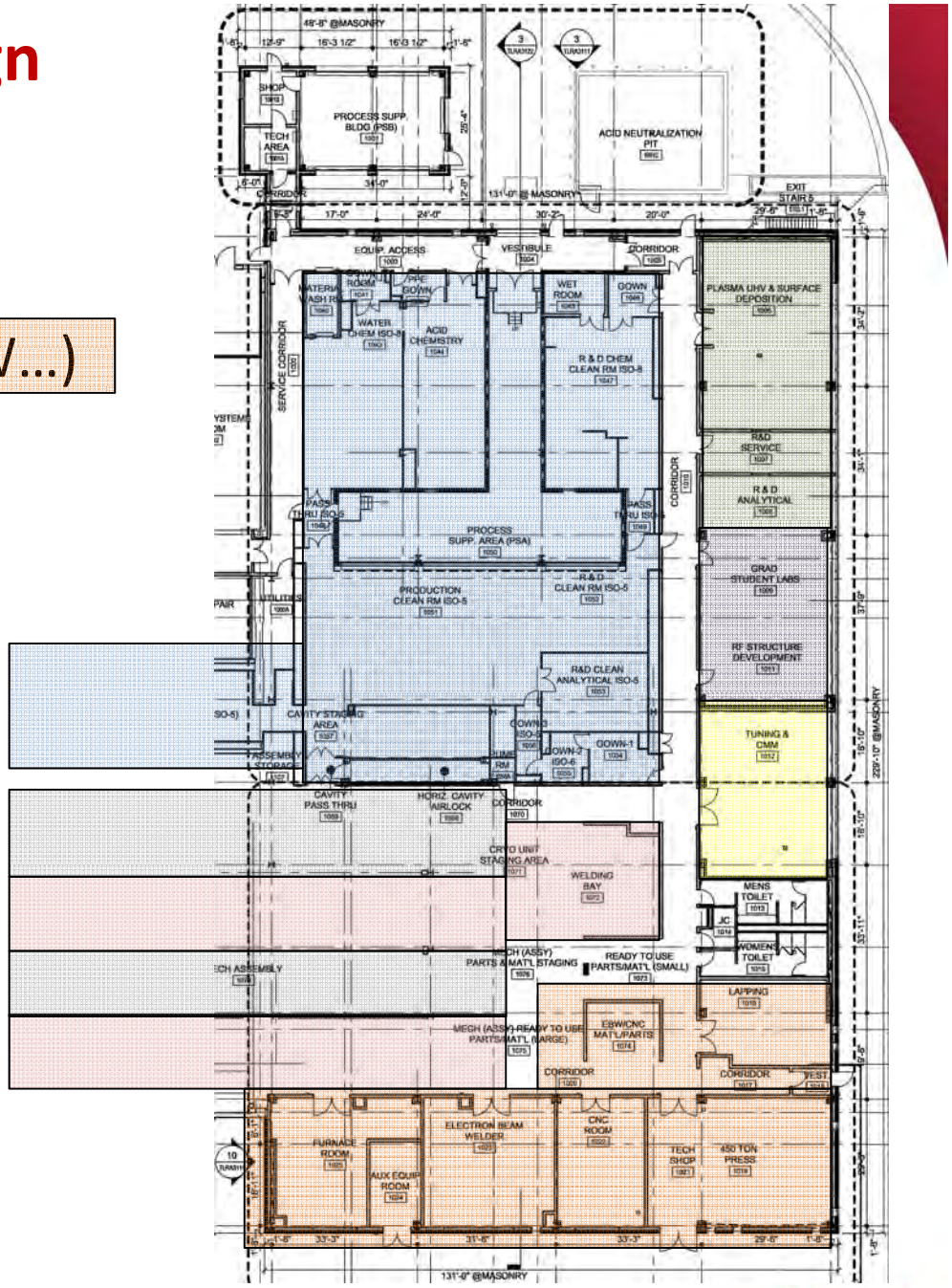


- Upgraded ultrapure water system
  - Specified to meet ASTM Type E-1.1 (18.2 MΩ)
  - Centralized Hot UPW system
- Upgraded cryomodule assembly space
  - Additional rails to allow for simultaneous C50, C100, and R&D assemblies

TEDF SRF Infrastructure Design

30,000 sq foot – all new

- RF structure development
- Cavity fabrication (presses, EBW…)
- QC/ Inspection
- **Integrated cleanroom suite**
  - Production chemroom
  - R&D chemroom
  - Flexible ISO 4 assembly areas
  - Clean material analysis lab
- New materials R&D lab
- Dedicated CEBAF-support CM assembly lines
- Expansion assembly space for other DOE project support



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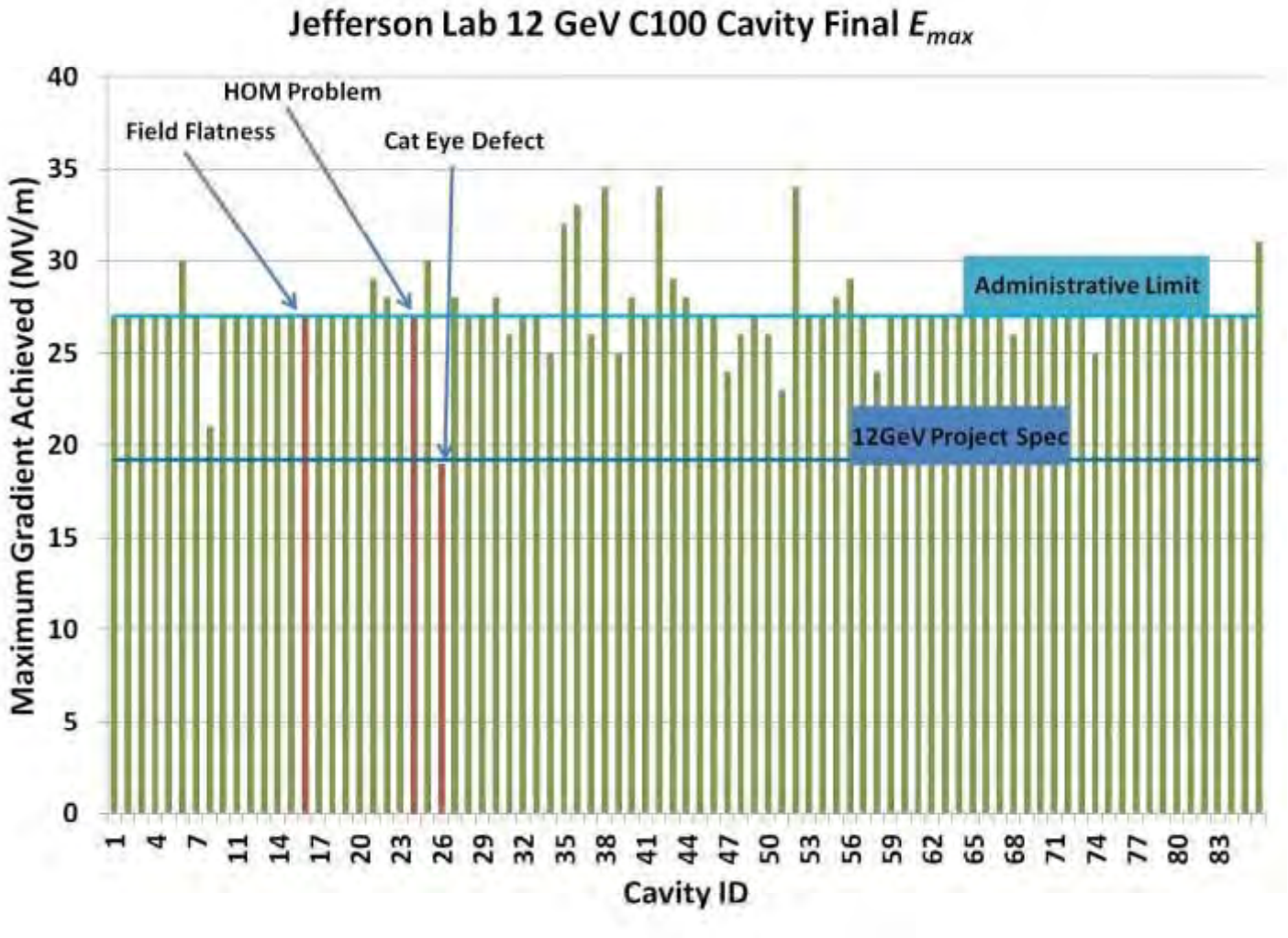
12 GeV vertical test - all upgrade cavities 80 needed for project



86 cavities

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Improved Work-Flow Efficiency – next 2 slides

- Improved work flow of SRF work centers by consolidating to Test Lab Addition (TLA)
  - All work centers placed on first floor level
  - SRF machine shop, presses, tech shop, and electron beam welder consolidated in one area
  - Brazing and vacuum furnaces moved to one room
  - Parts clean & etch, R&D chemistry co-located to east end of TLA with improved integration with clean room
  - Consolidated R&D labs
  - Vertical attach clean room isolated from main ISO-4 clean room used for cavity processing and assembly via an air lock
  - Longer dedicated cryomodule assembly rail systems to enable simultaneous activities