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

Jefferson Lab

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Part 1 New TEDF/SRF Development Facilities

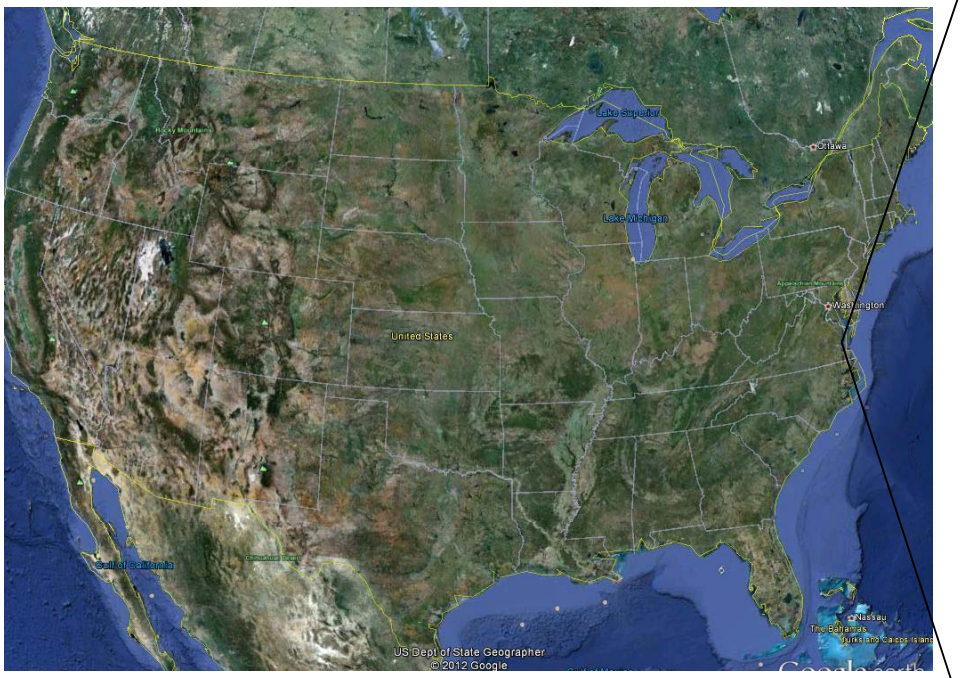
- TEDF project buildings
- Design goals
- New facility foot print
- Workflow improvements
- New clean and chemical room design

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

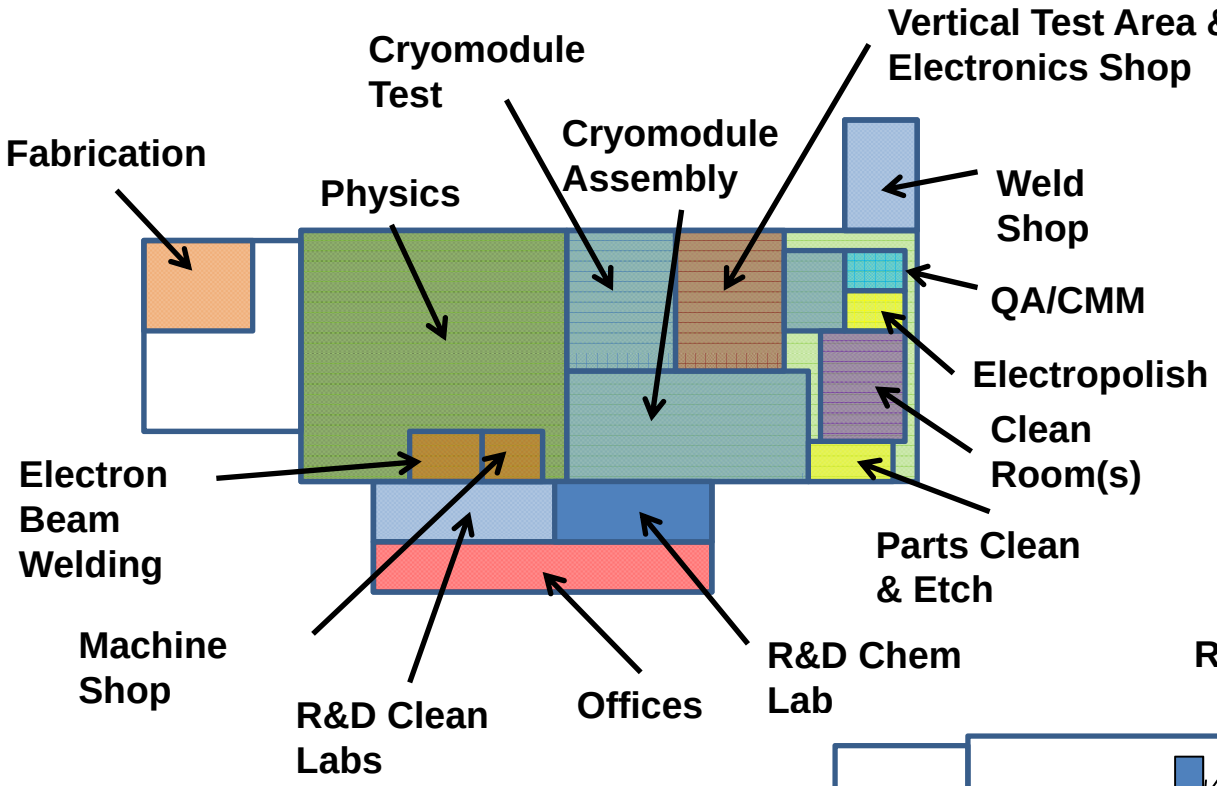
Replaces temporary building and rental offices

- 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

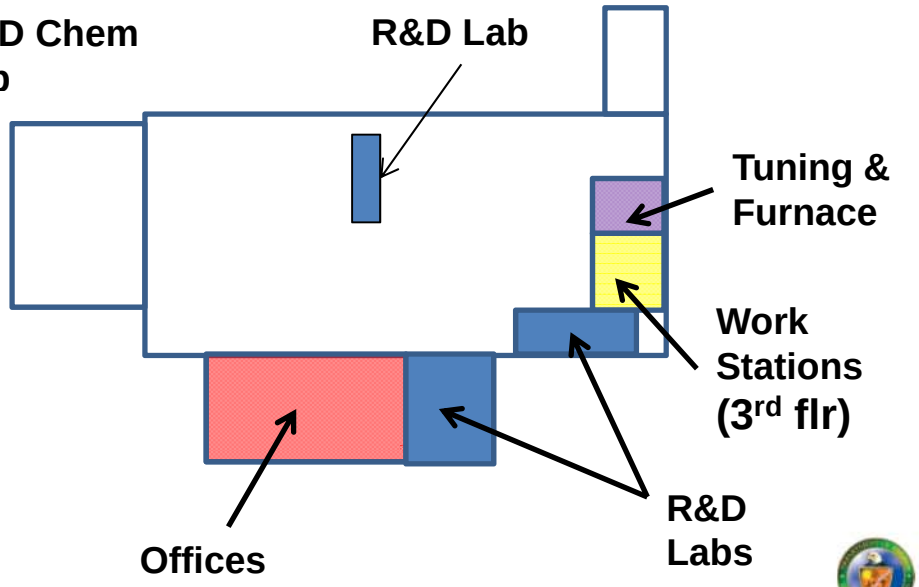
TEDF Project- SRF TLA/Addition

- **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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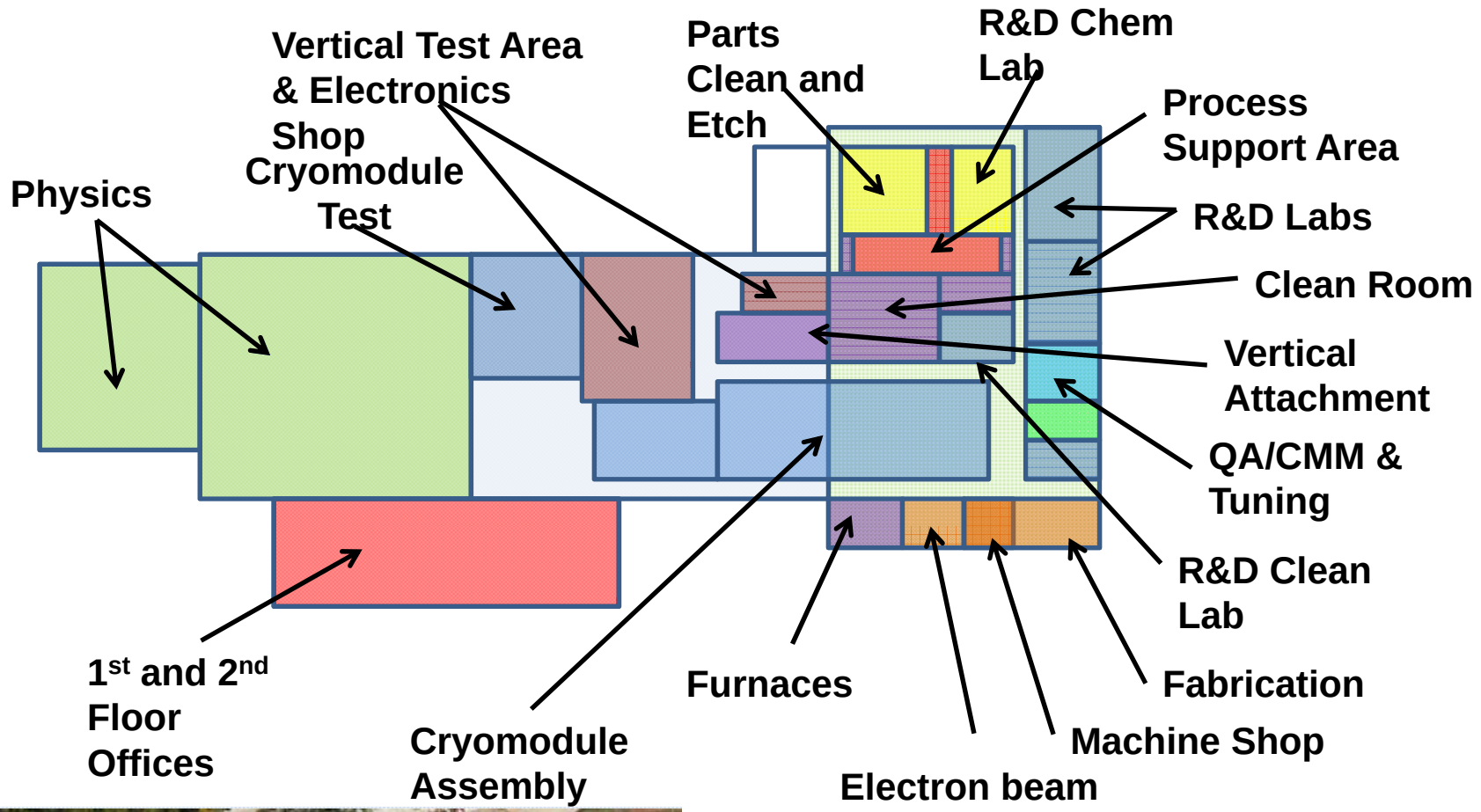
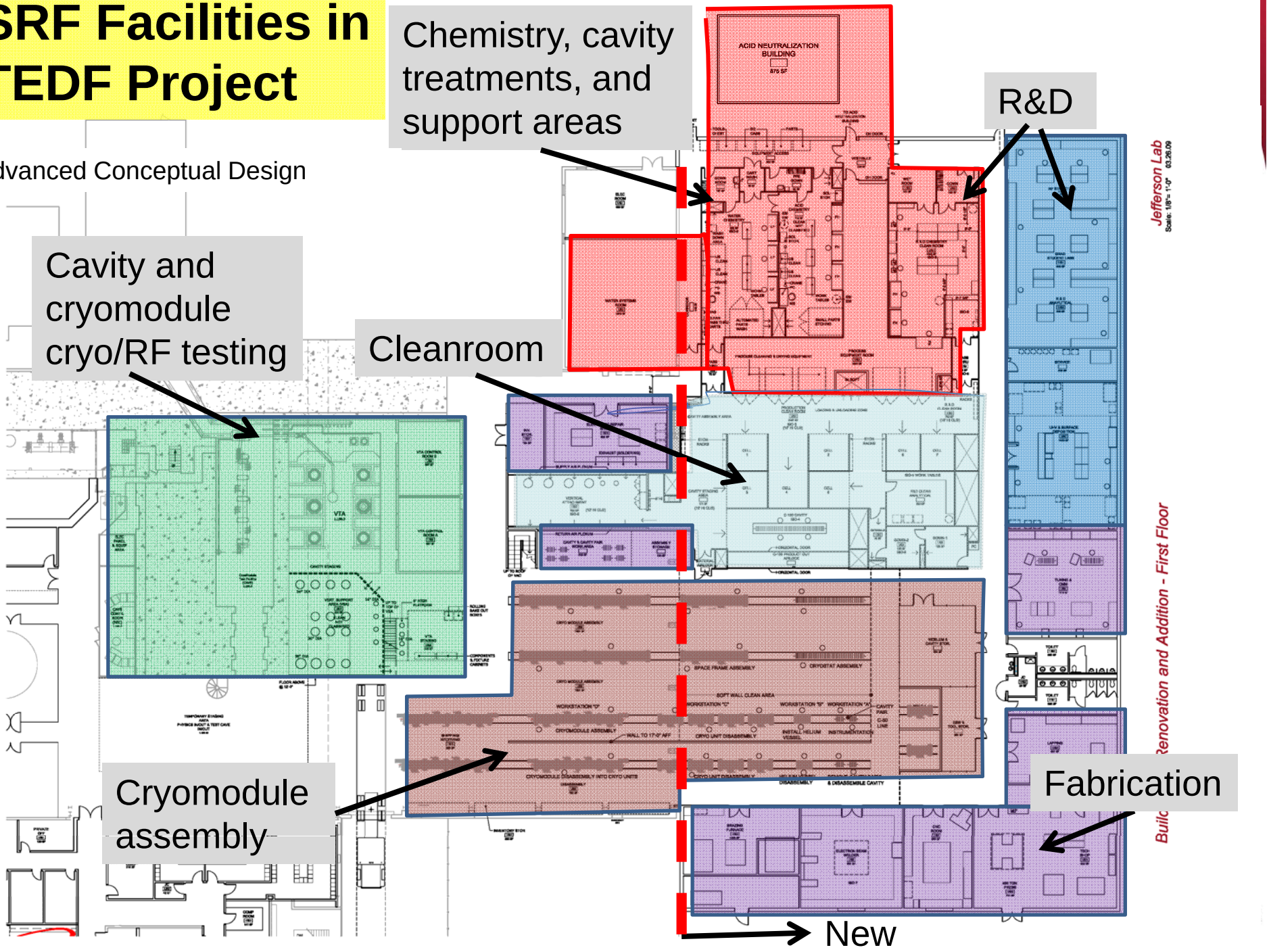
SRF Work Centers in New Test Lab



SRF Facilities in TEDF Project

Advanced Conceptual Design



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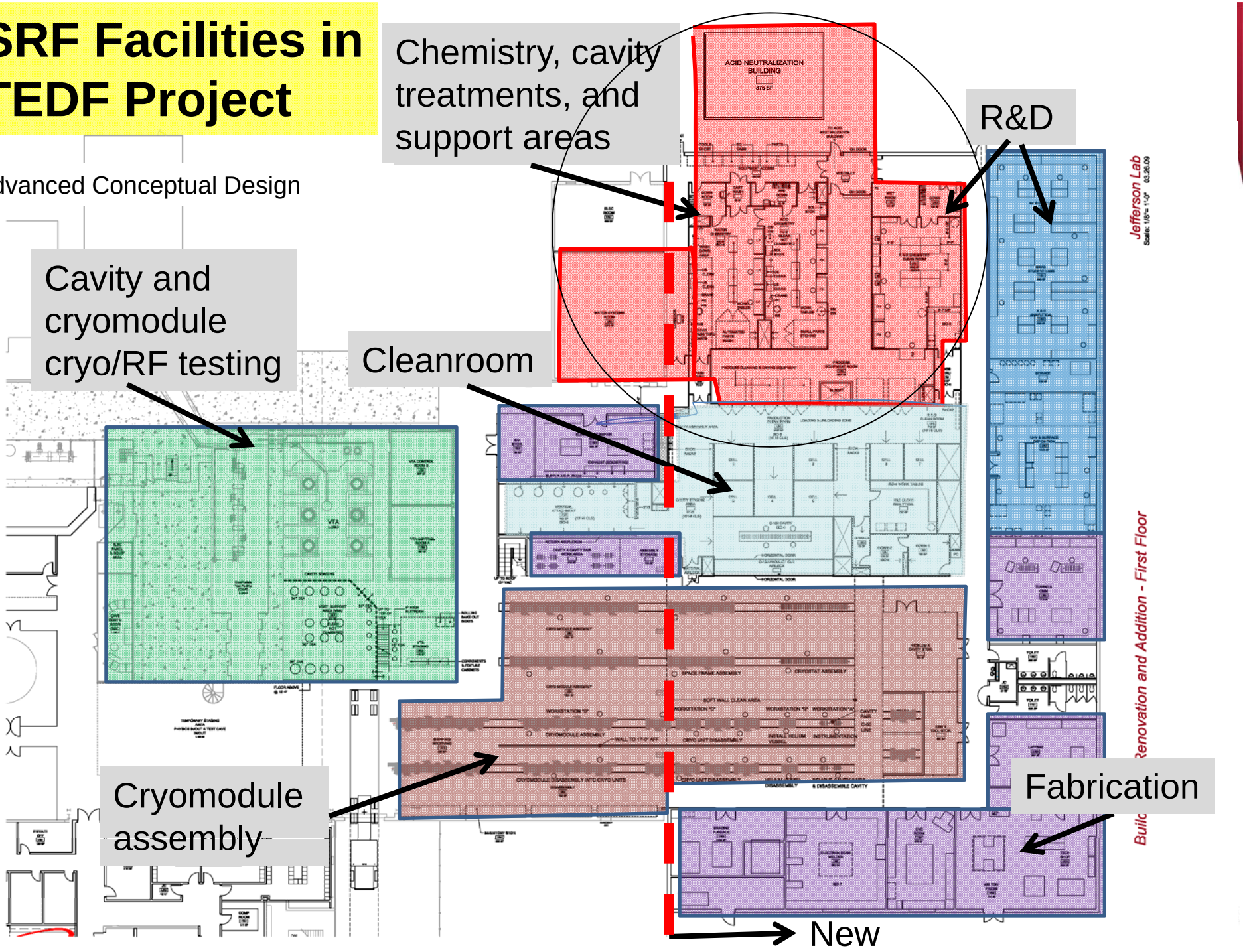


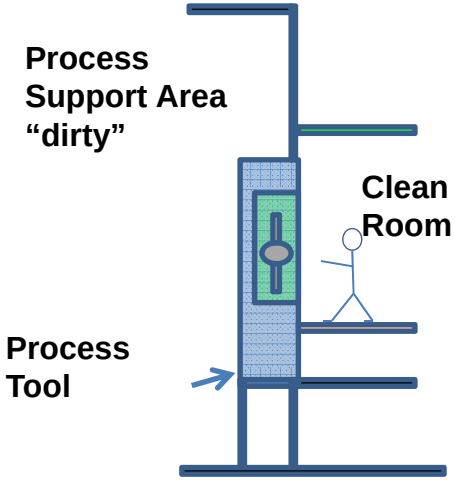
Chemistry and Ultra pure water

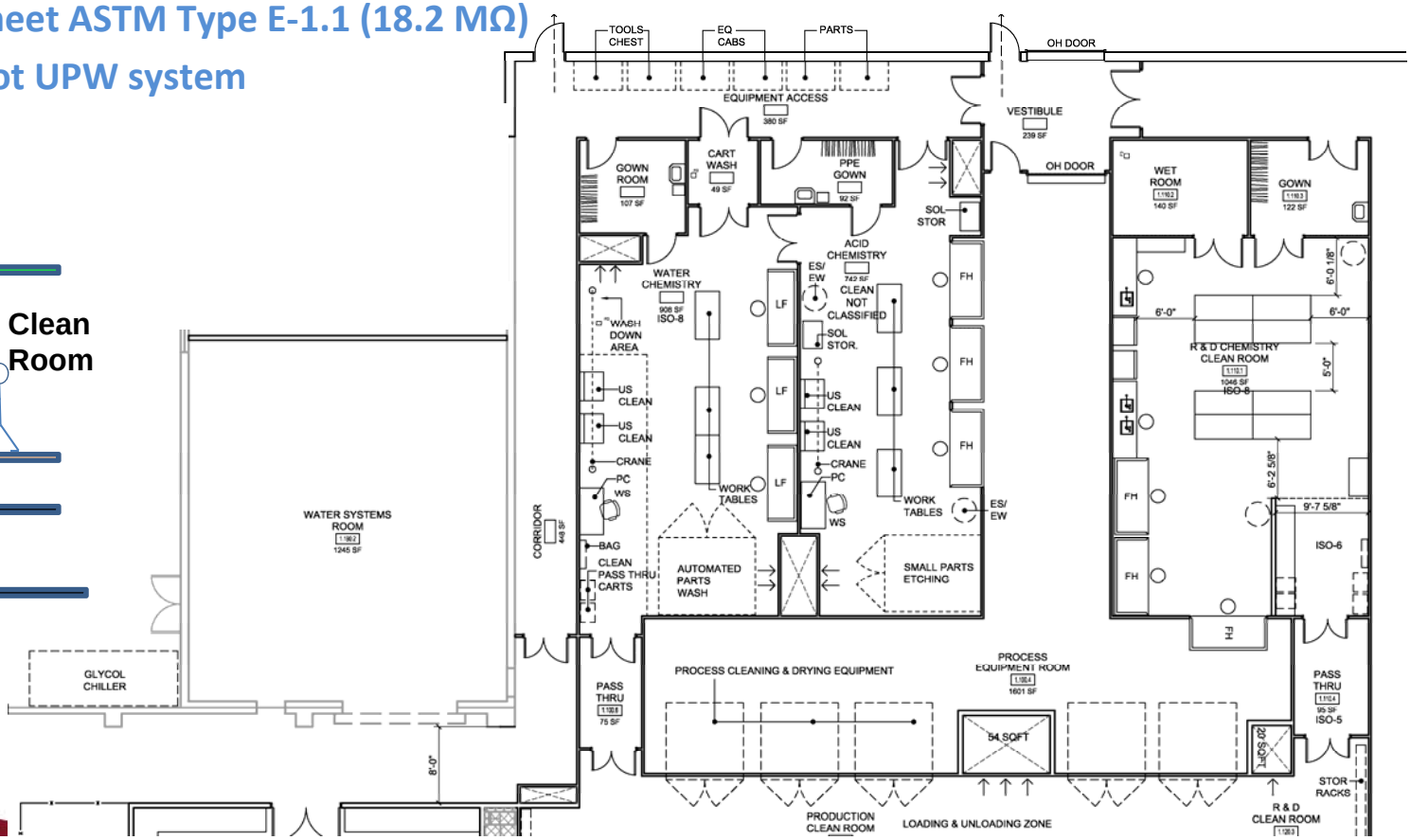
Upgraded chemical management and waste treatment systems

- 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





Jefferson Lab

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

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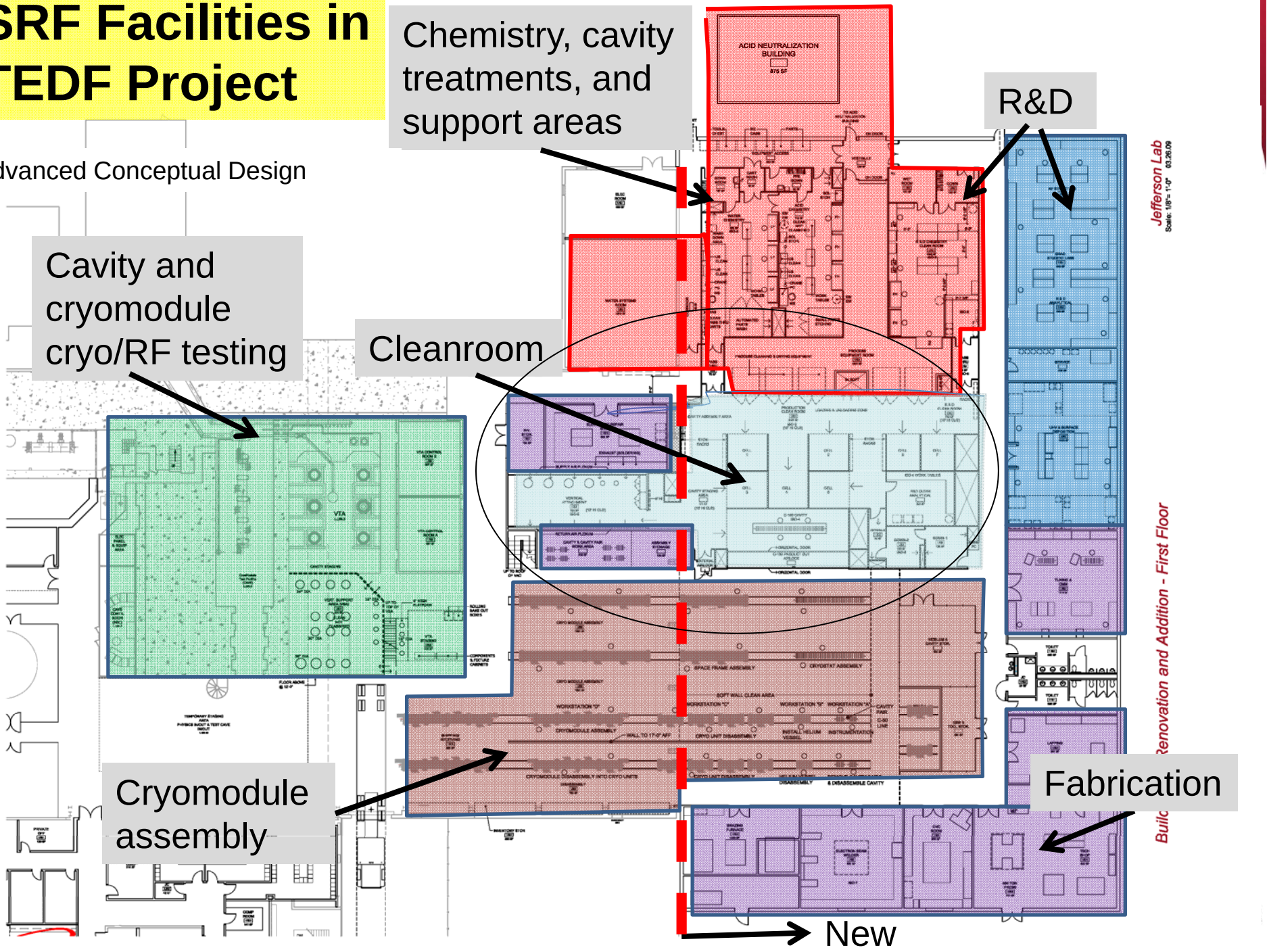
SRF Facilities in TEDF Project

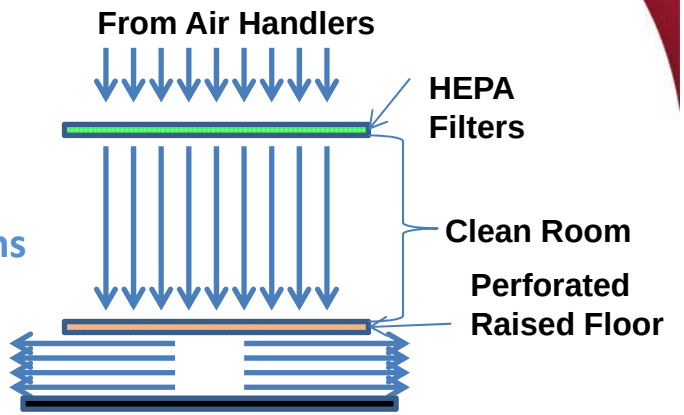
Advanced Conceptual Design

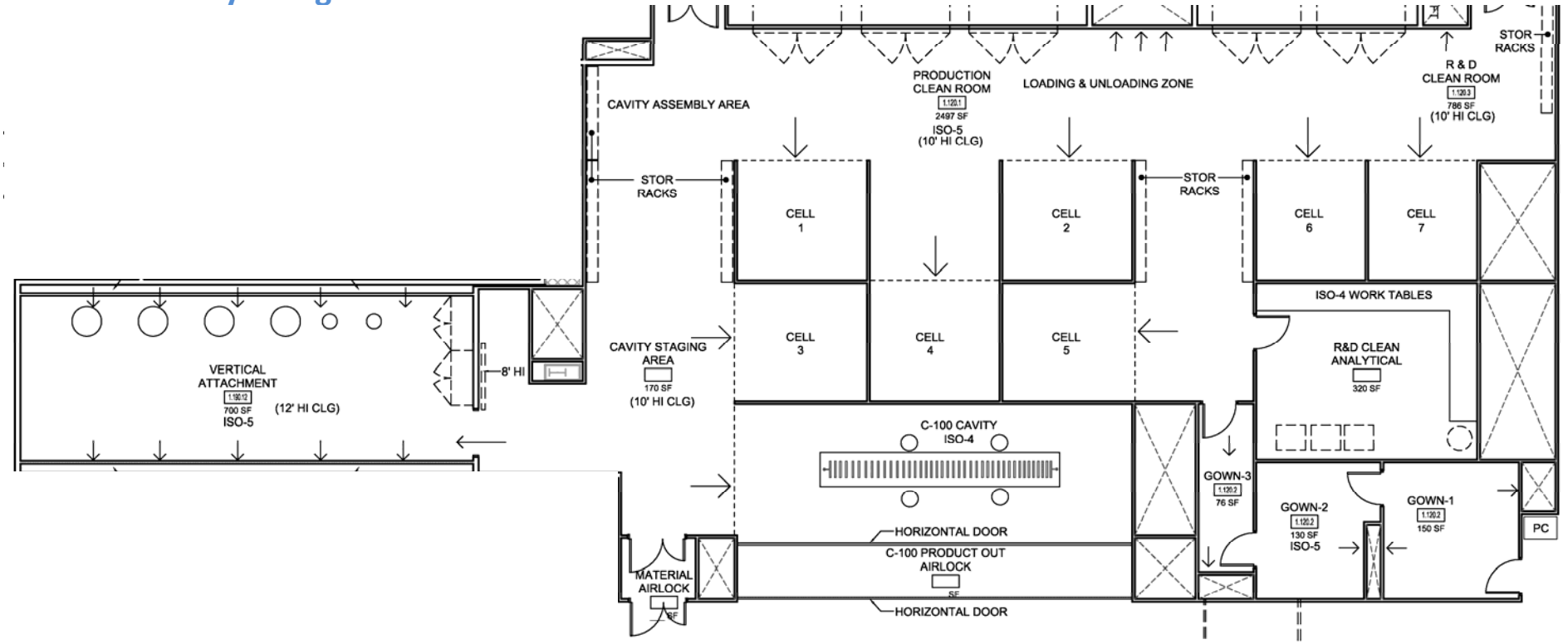


New clean Room facilities

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

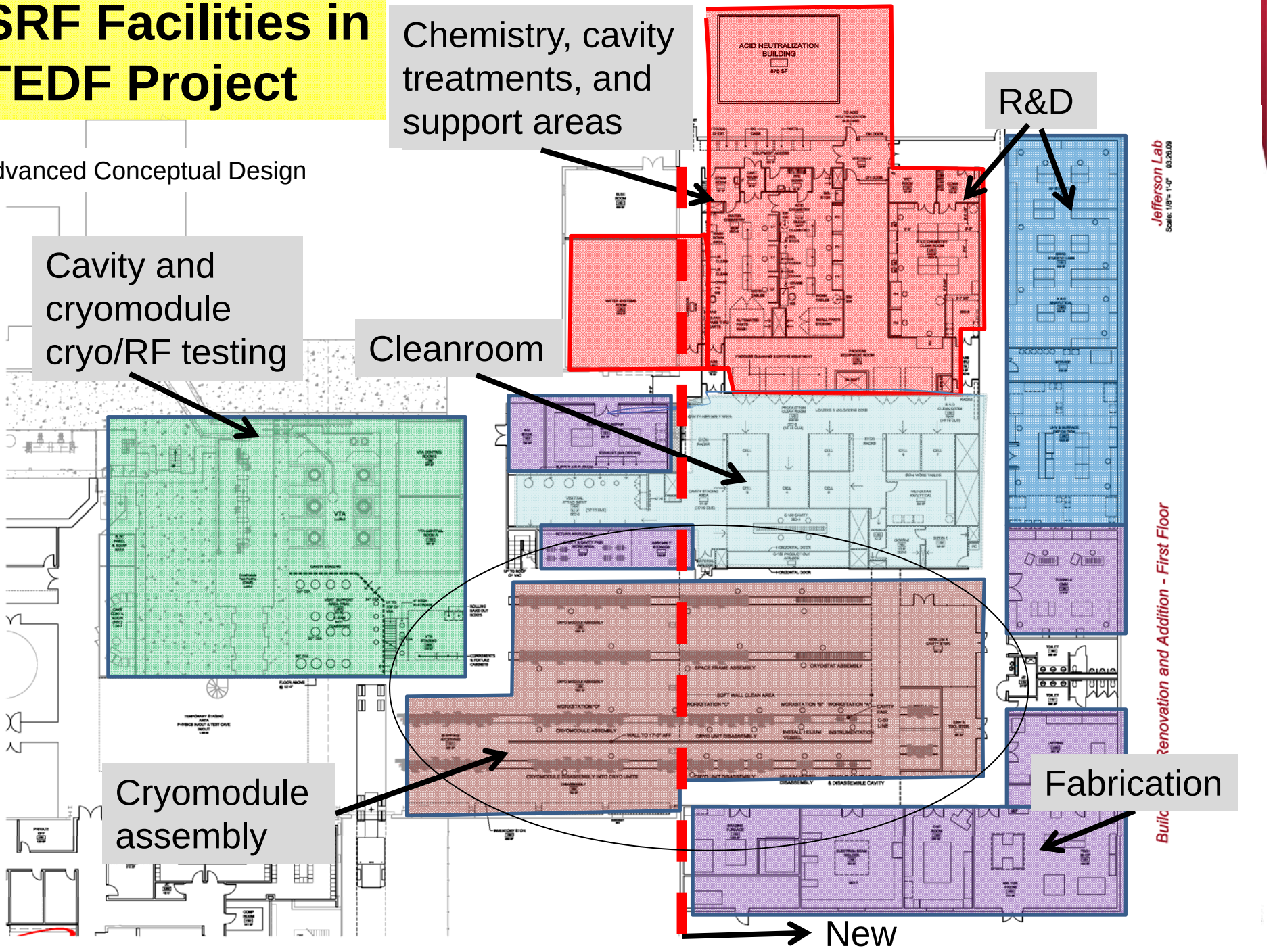
- 100% HEPA coverage, RMF, laminar flow with return plenums
- Bay/Chase concept
- Dedicated Drying & Assembly chambers
- Modular wall systems
- Cavity string air lock





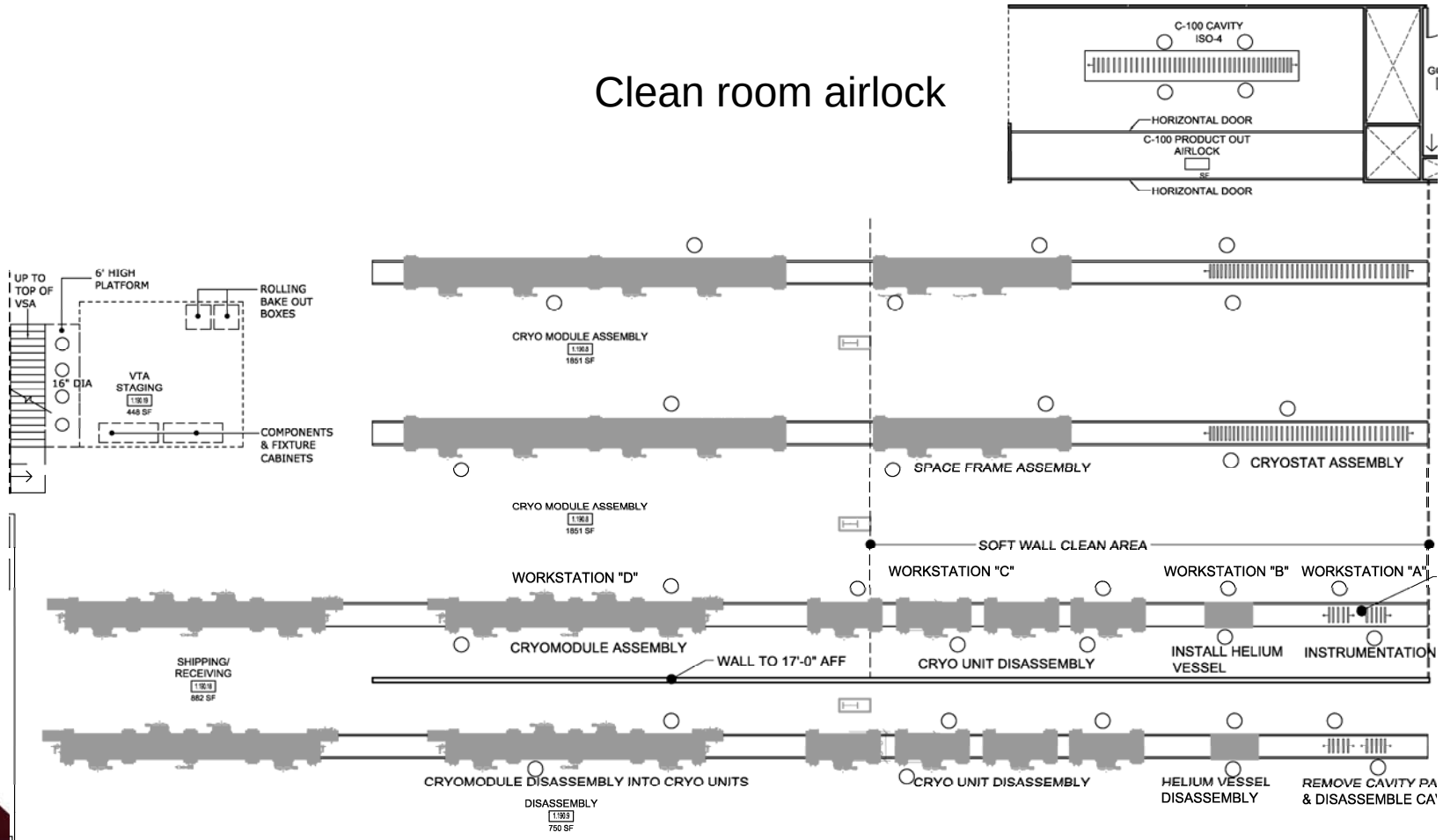
SRF Facilities in TEDF Project

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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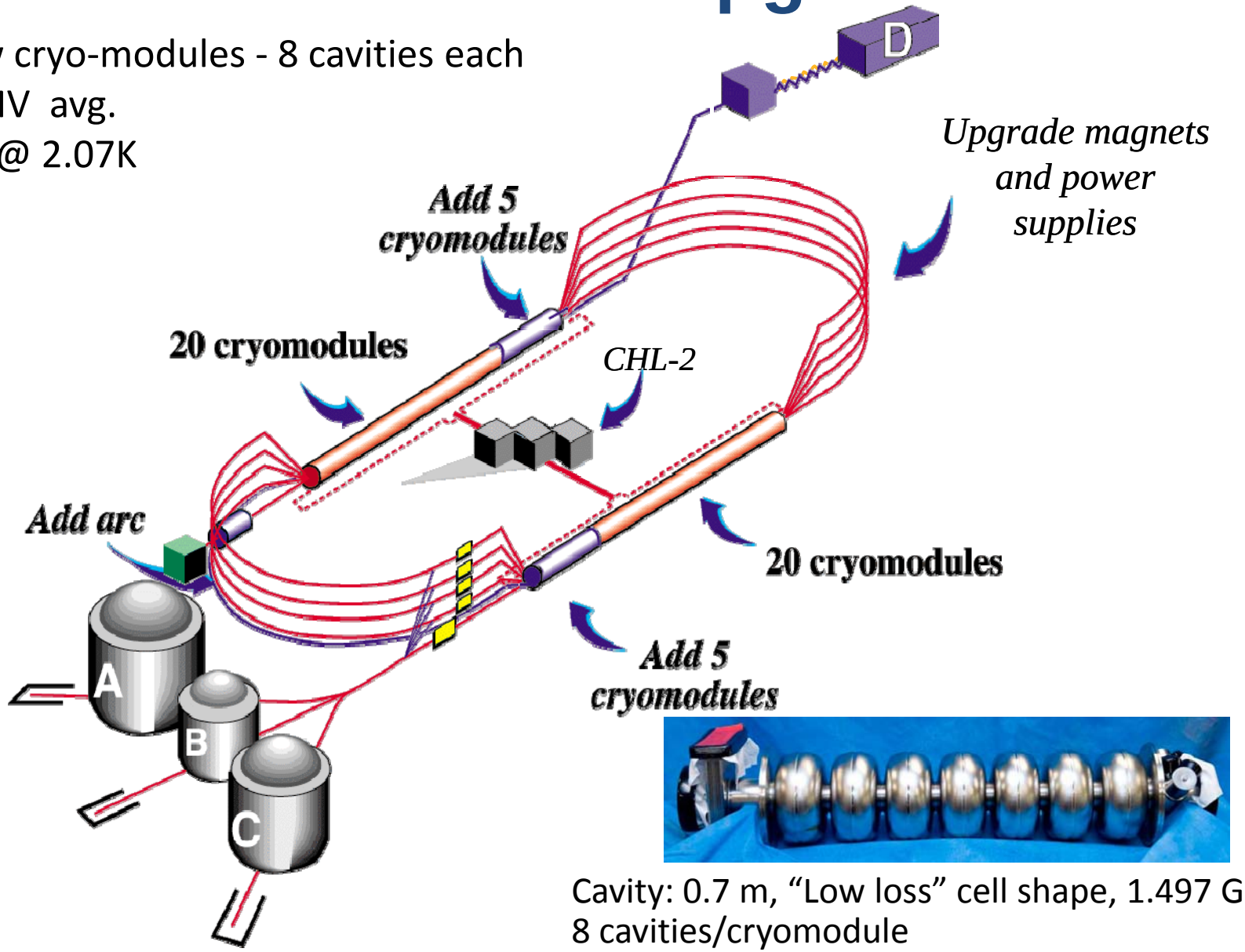
Expect great thing in 2013 after construction is complete

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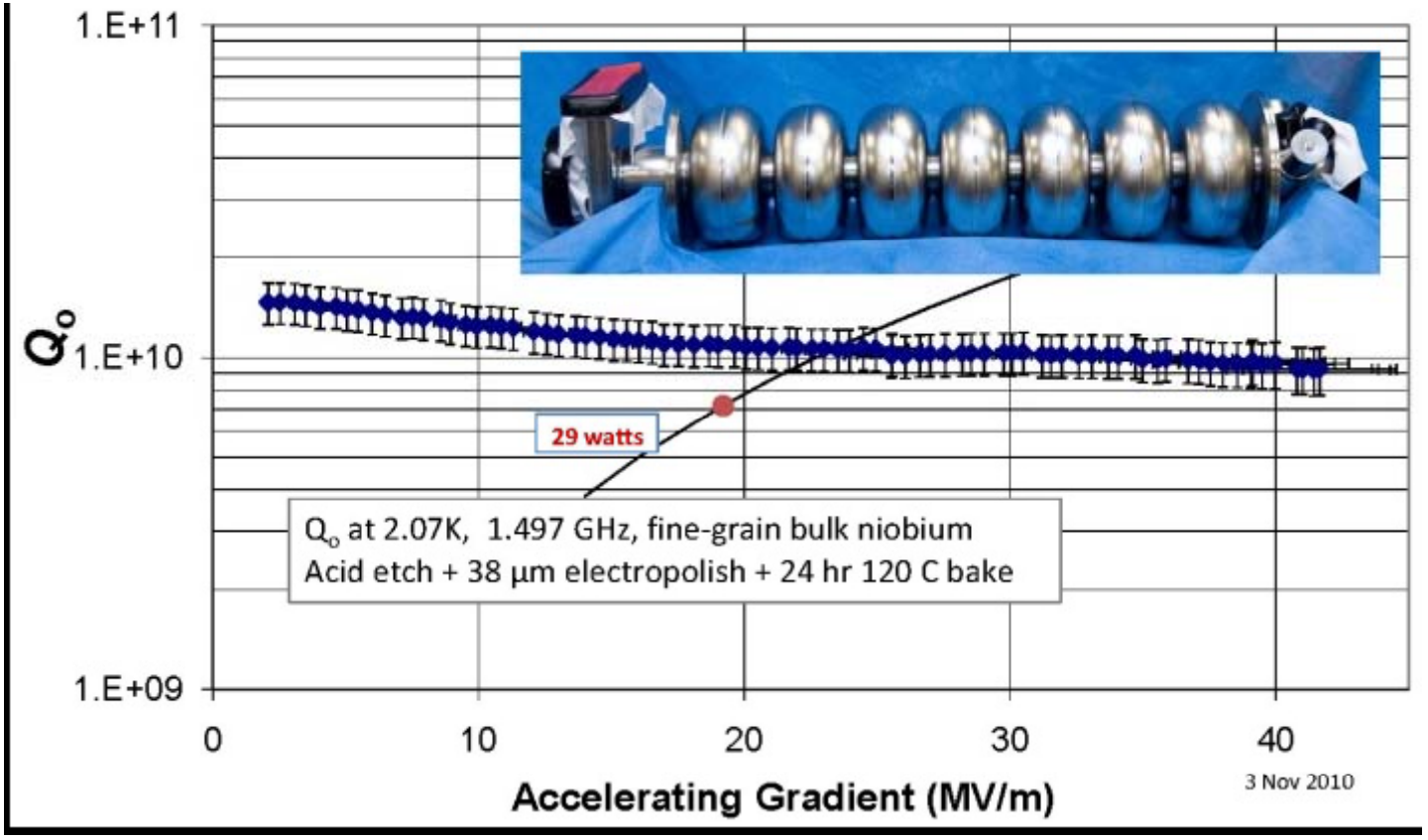
12 GeV Upgrade cavity
7 cell low loss fabricated by Research Instruments (RI -Germany)



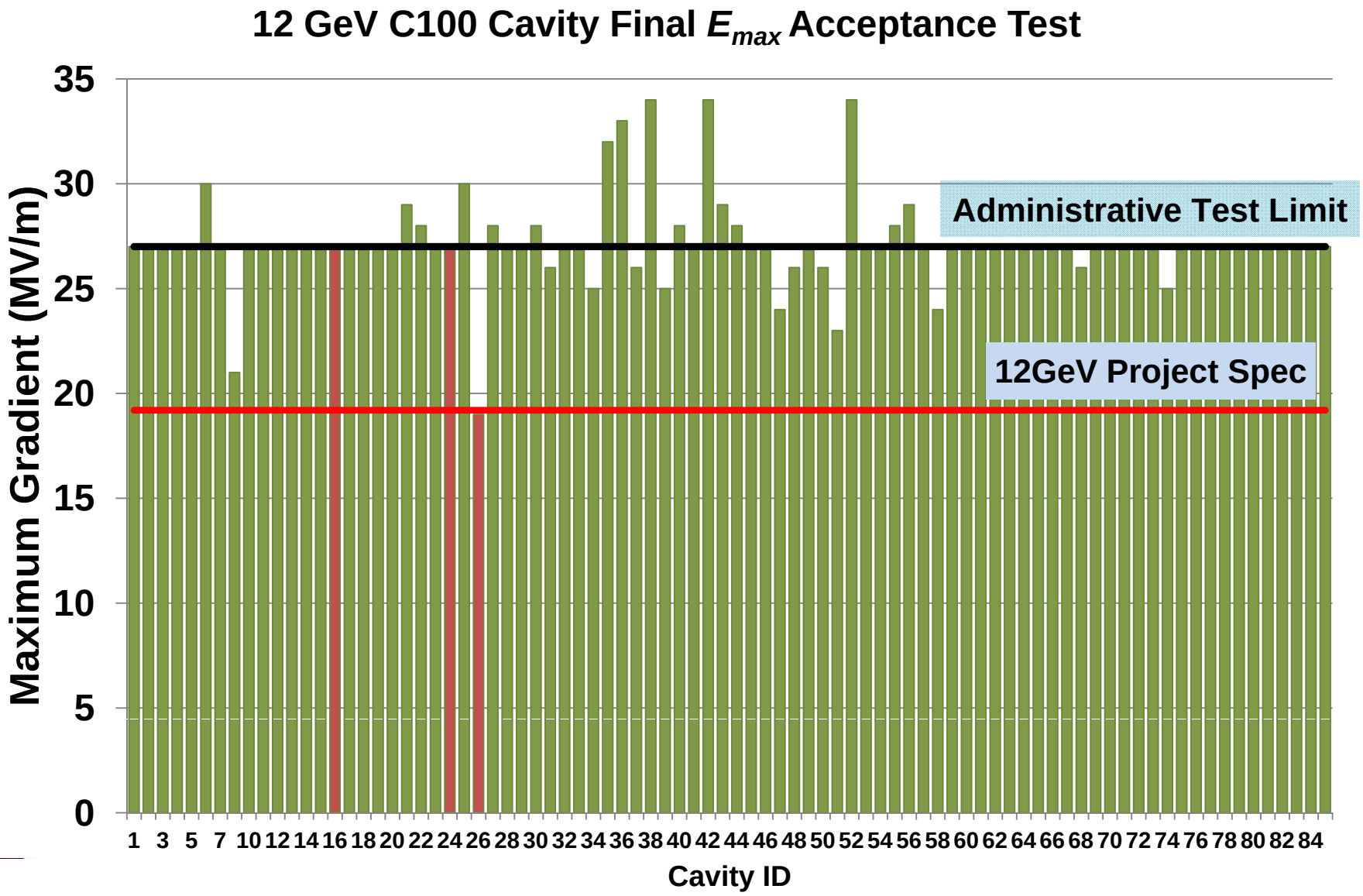
Spec - 19.2MV/m below 29 watts (Q=7.2*10^9)

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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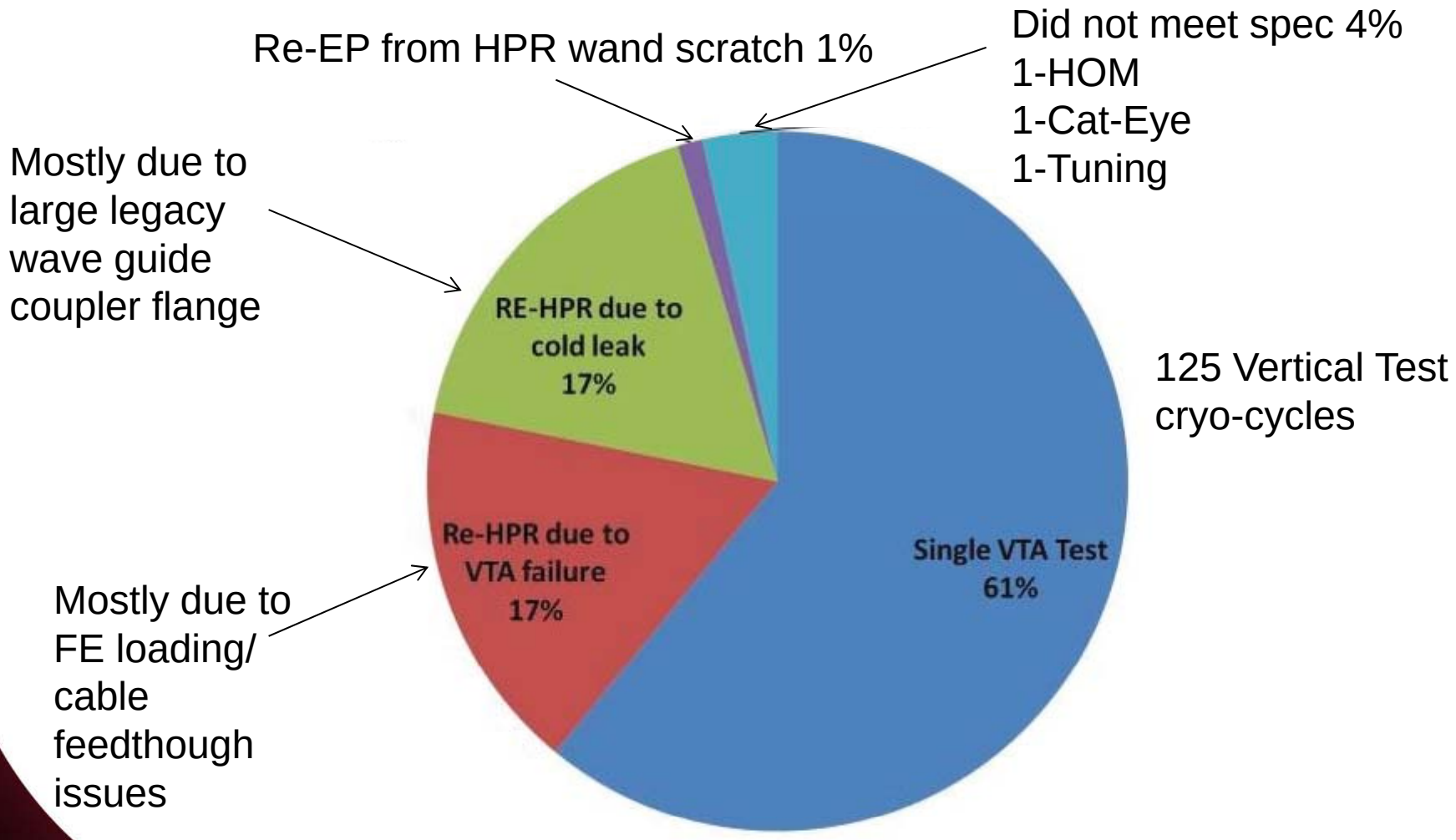
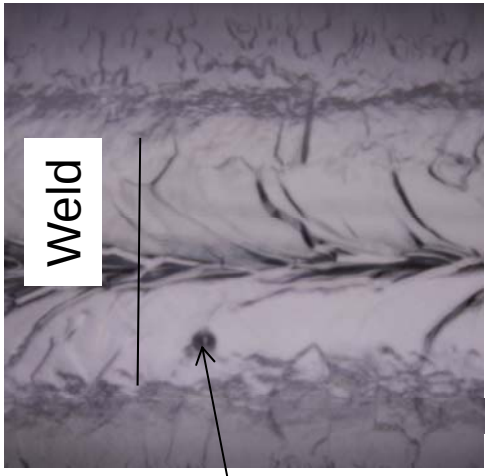
Full cavity statistics all VTA cycles



Cavities which did no meet spec - defects

c100-26 cell 5

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

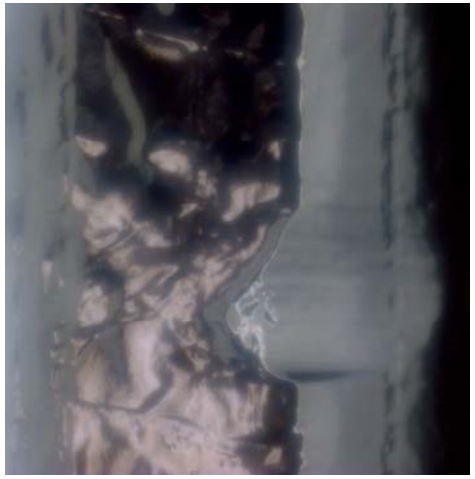


Cat eye

c100-8 iris 2-6

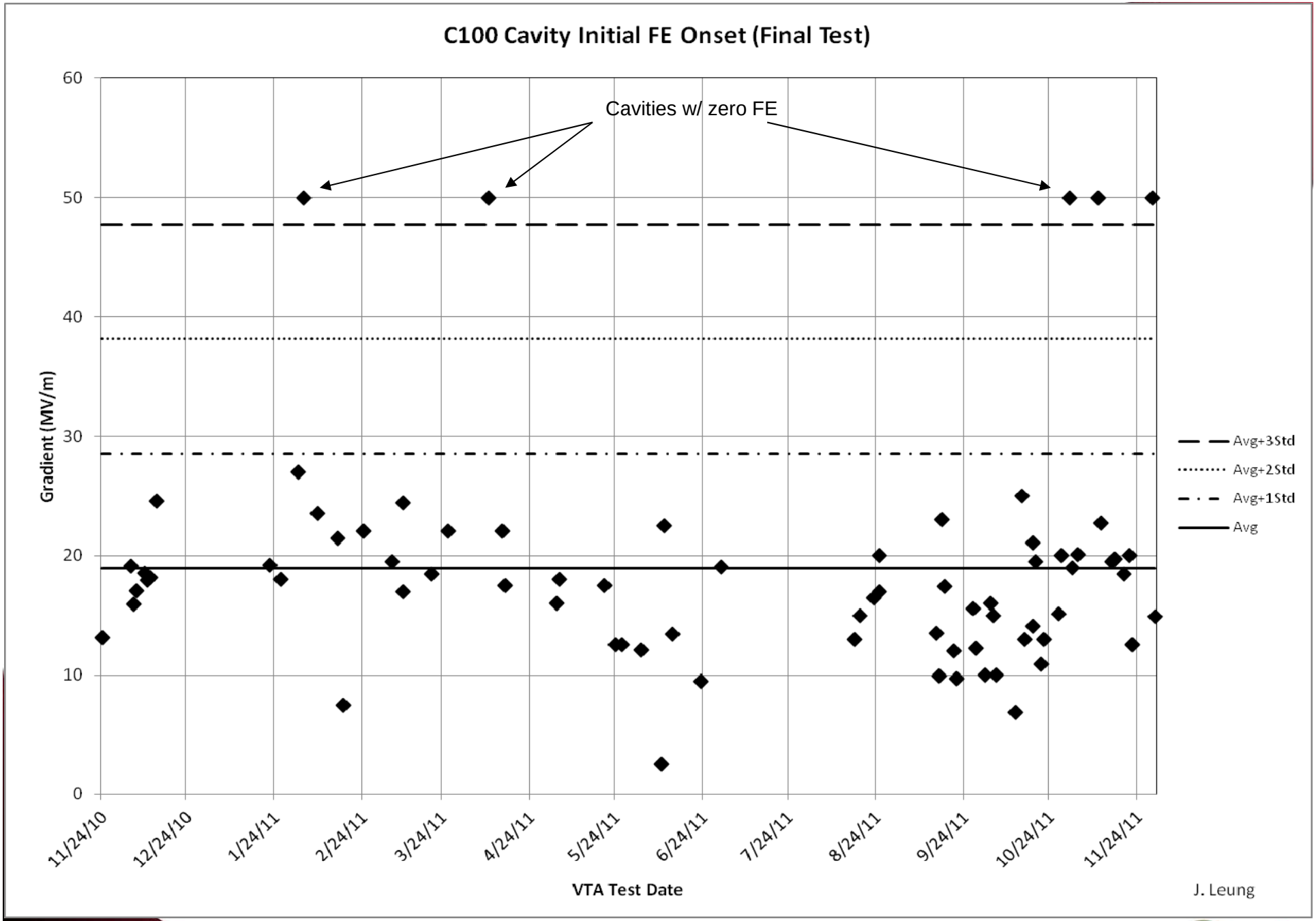
Accidental Cavity scratch from HPR

Post re-EP



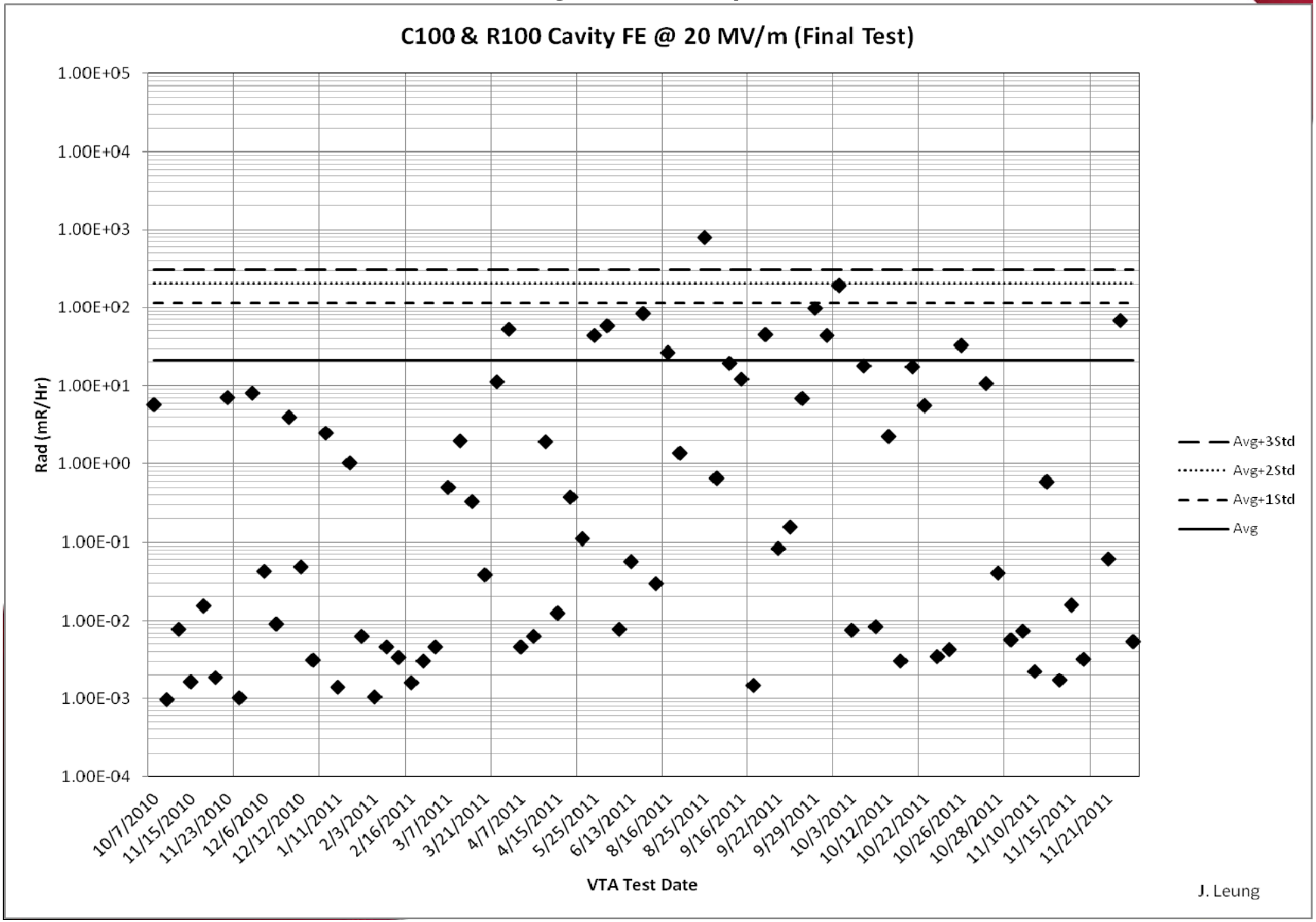
Field Emission Statistics – vertical qualification test

- 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

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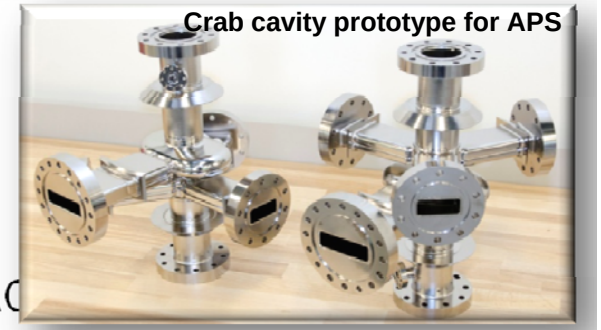
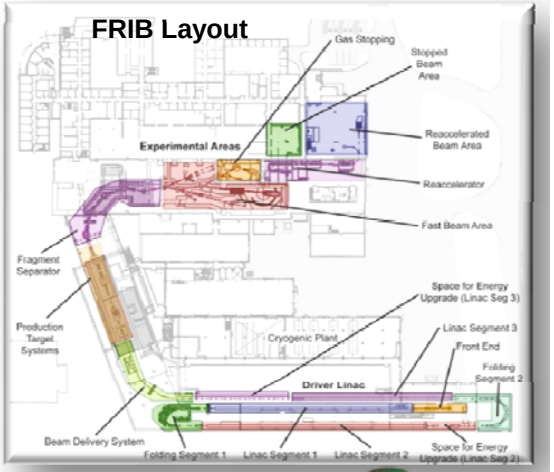
Other SRF Projects

- 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



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
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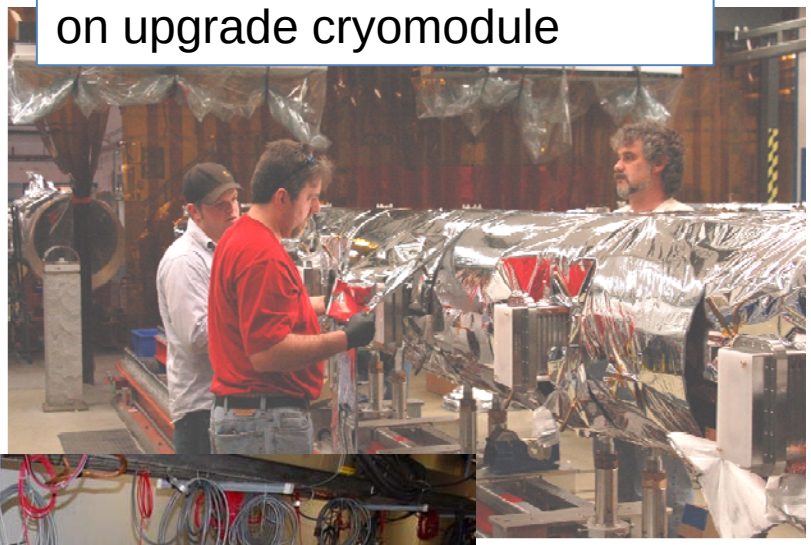
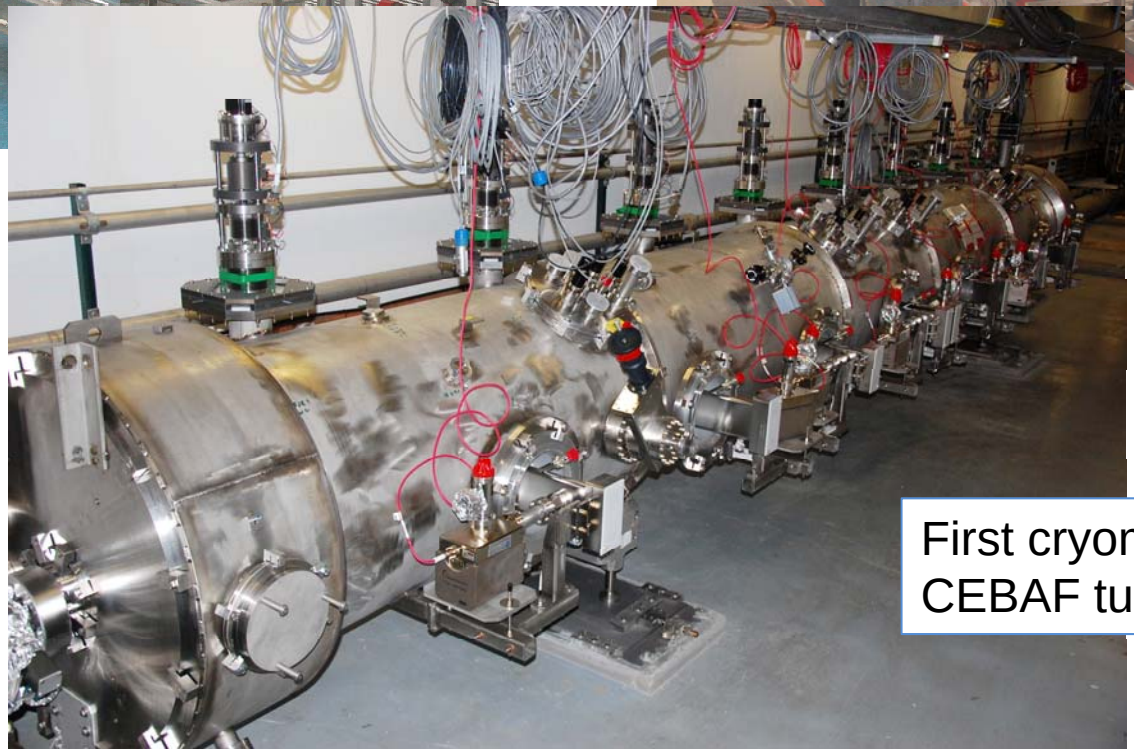
12 GeV Upgrade Cryomodule

First cavity string @ completion

Installation of super-insulation on upgrade cryomodule

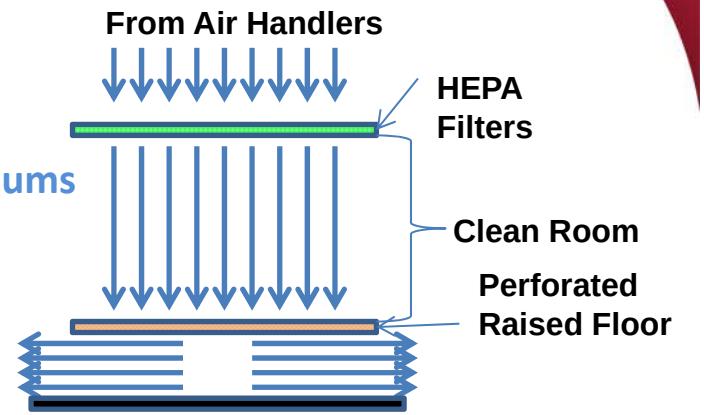




First cryomodule in CEBAF tunnel

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
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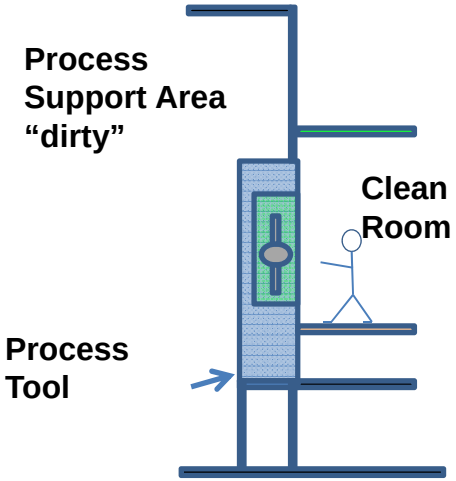

- Upgraded ultrapure water system
  - Specified to meet ASTM Type E-1.1 (18.2 MΩ)
  - Centralized Hot UPW system
- Upgraded cryomodule assembly space
  - Additional rails to allow for simultaneous C50, C100, and R&D assemblies

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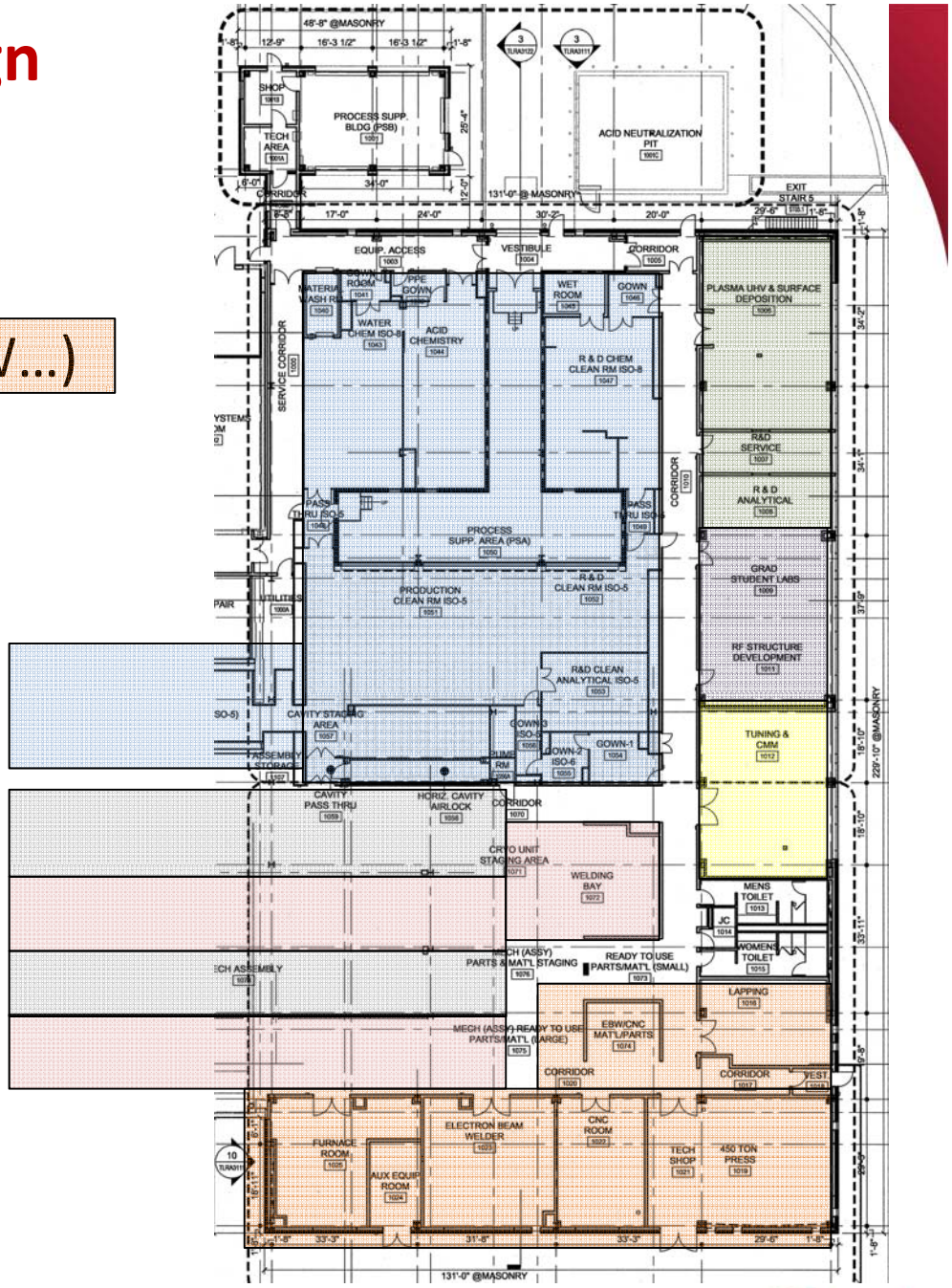
TEDF SRF Infrastructure Design

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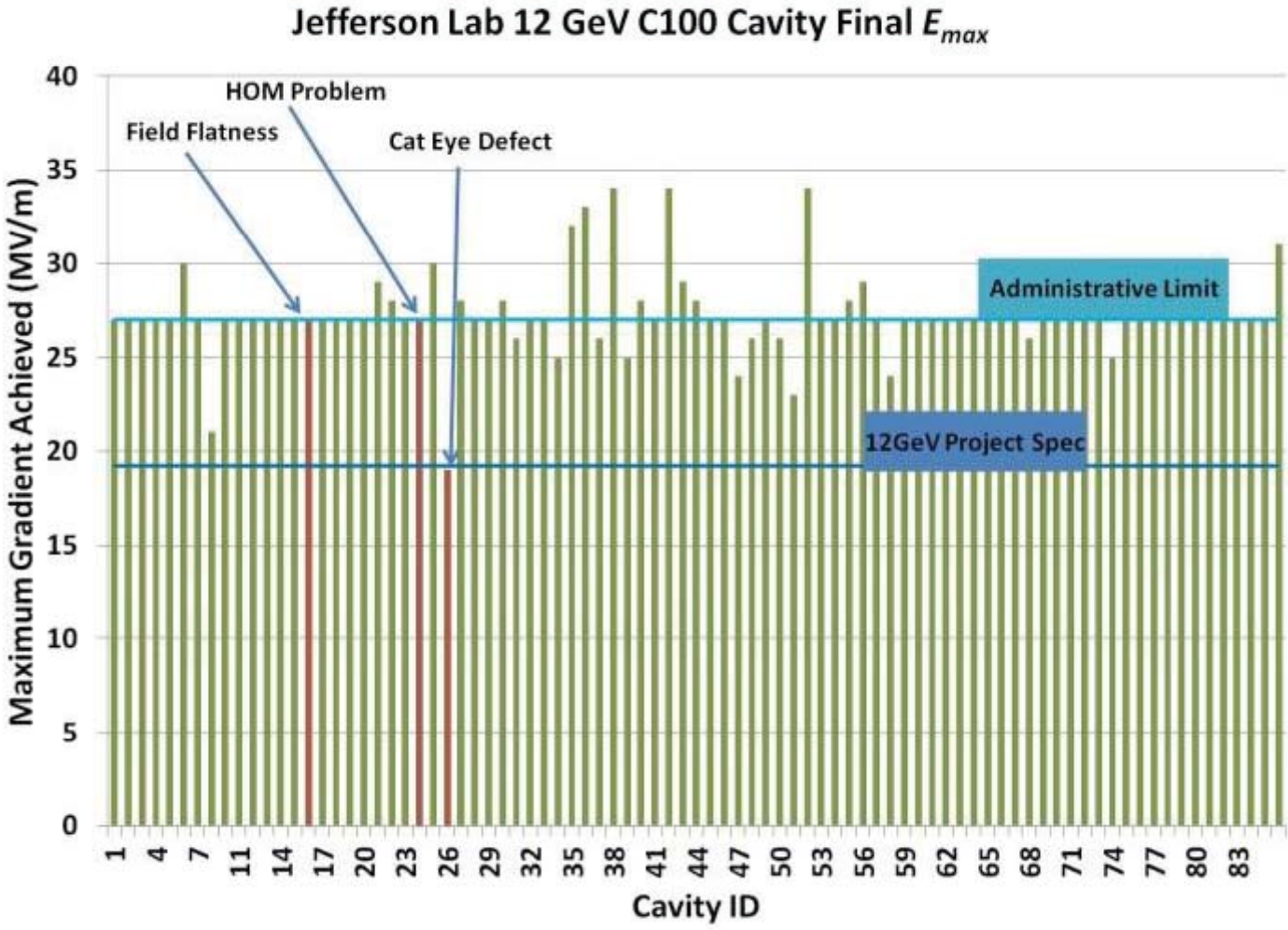
12 GeV vertical test - all upgrade cavities 80 needed for project



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