Production and Testing Experience with the SRF Cavities for the CEBAF 12 GeV Upgrade

Andrew Burrill

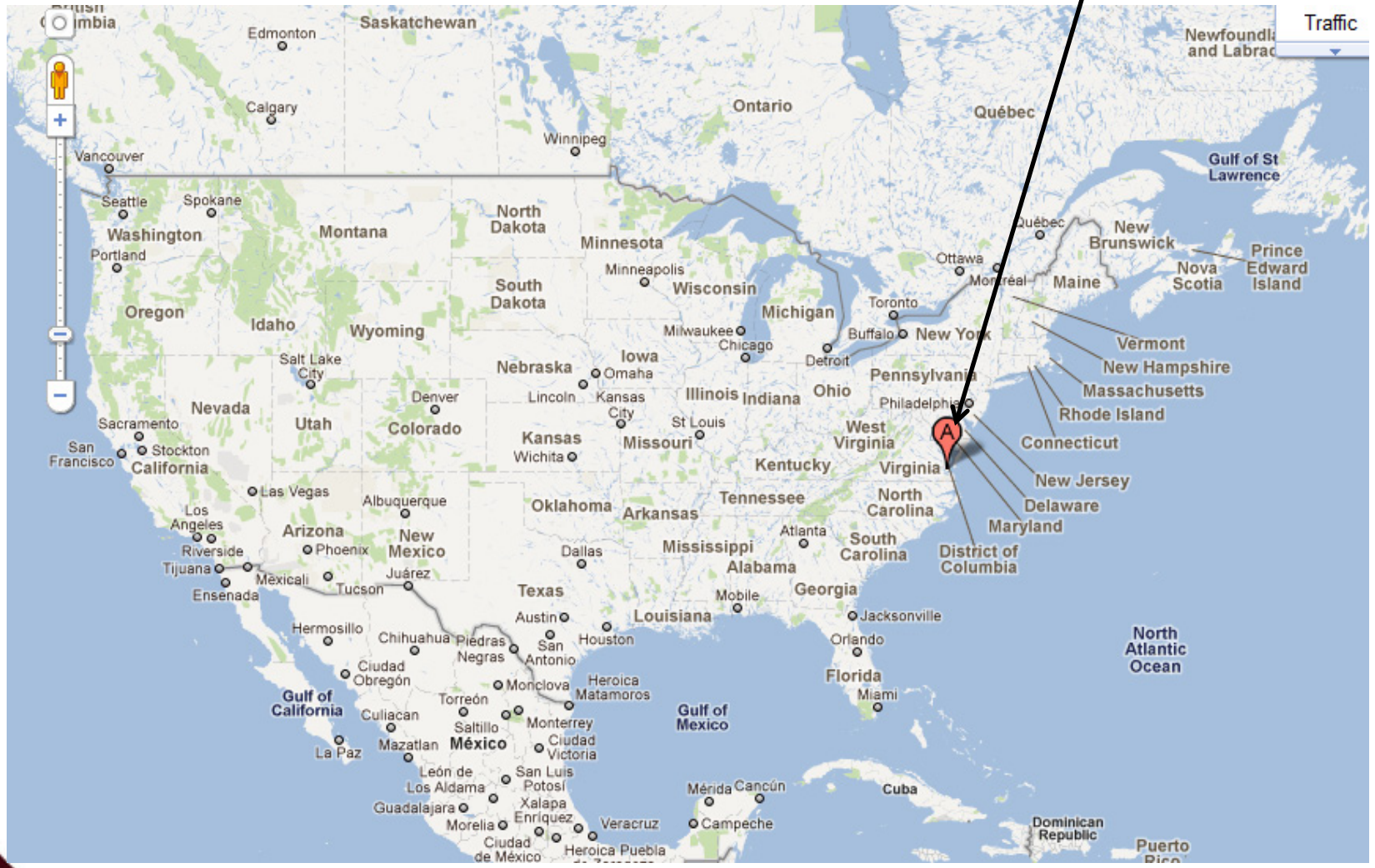
for the SRF Production Team

Summary

A robust, lean, cavity processing routine has been developed for processing & testing elliptical SRF cavities.

- This is a unique approach to cavity processing that varies from any other laboratory in the world.
- Operation of a stable, highly reproducible, production electropolishing system that is being used for cavities being installed into an operating c.w. electron accelerator.
- Cavities are exceeding 12 GeV specification and performance is not limited by field emission.

Google says we are here



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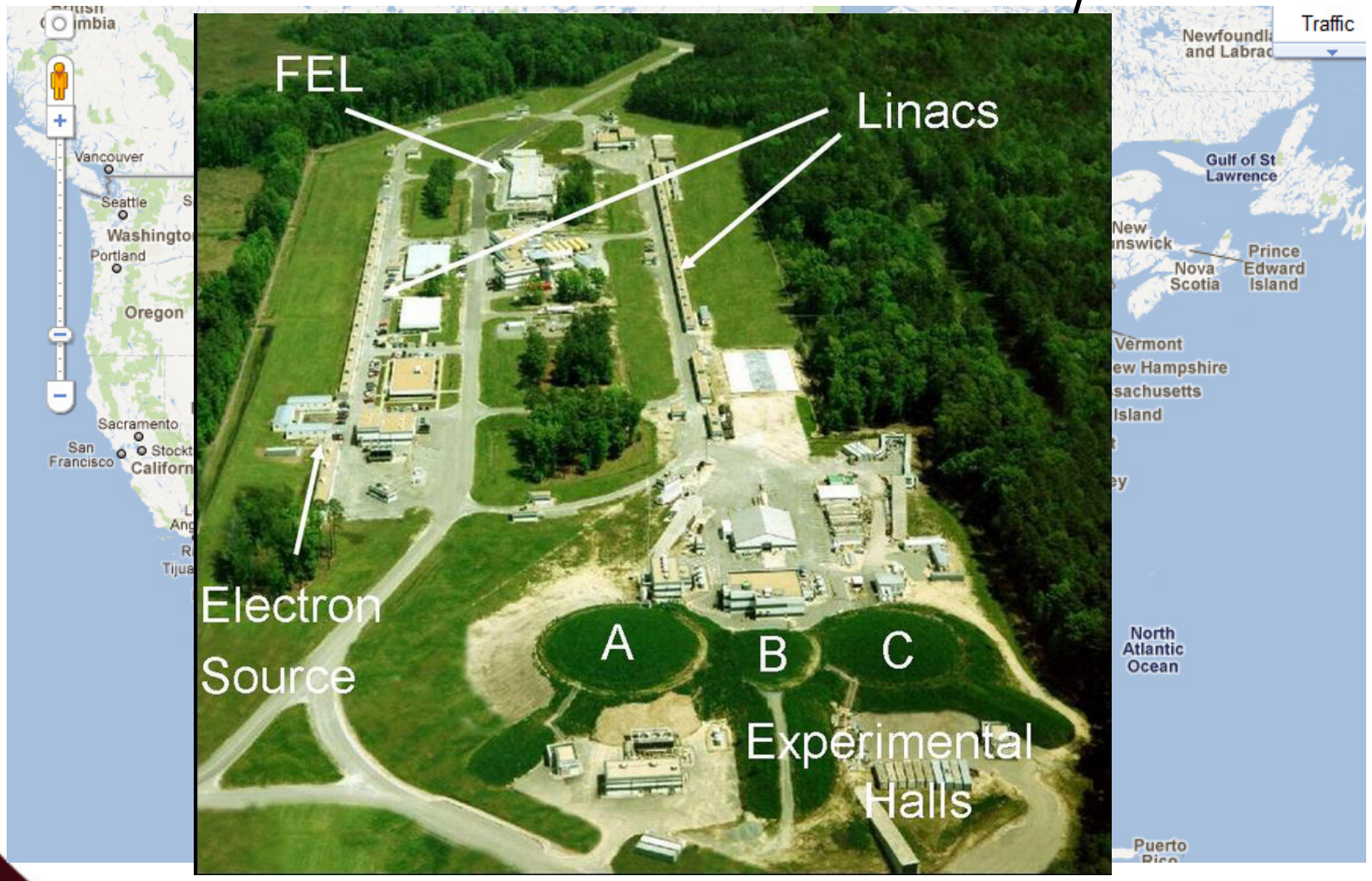
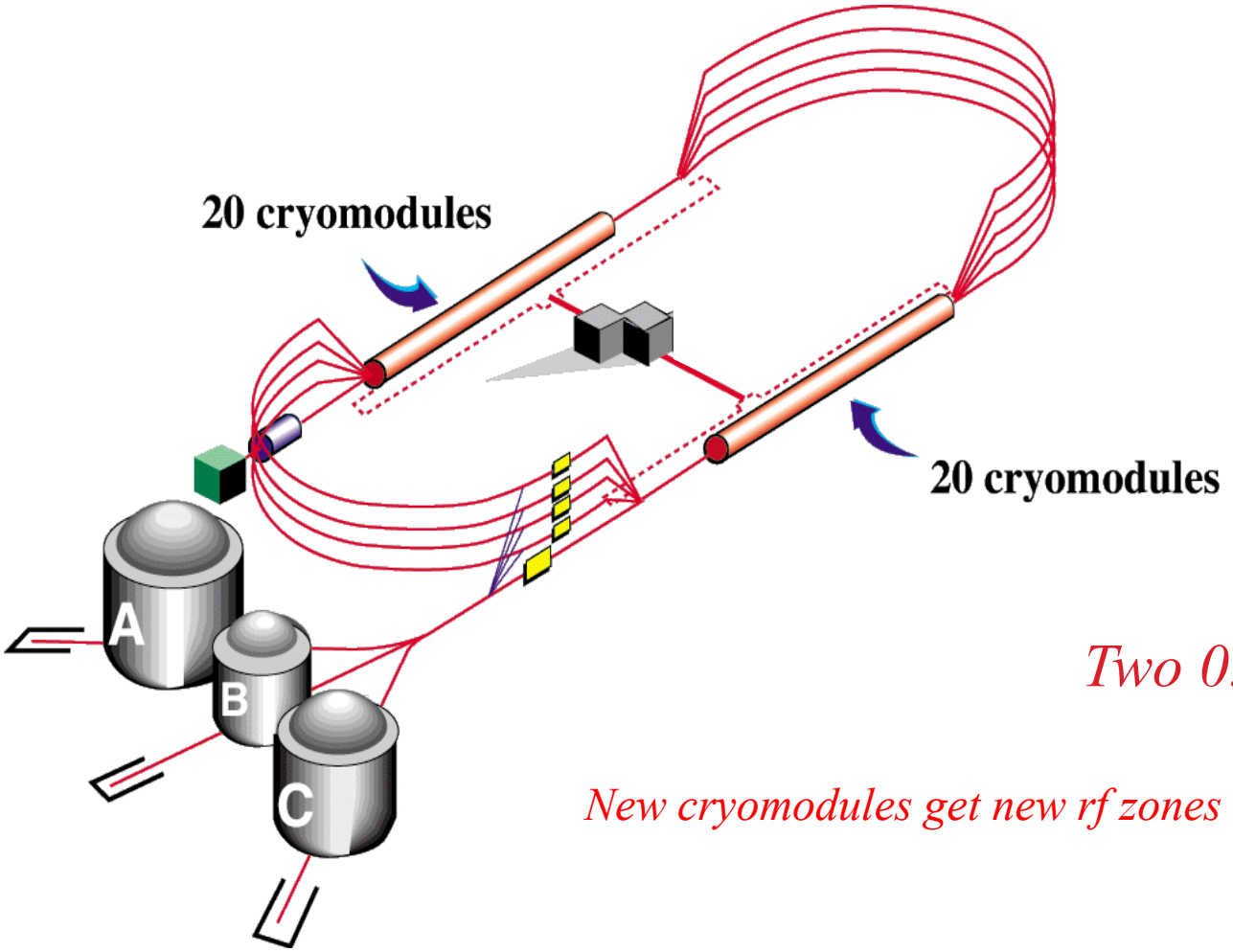


Jefferson Lab Overview

- **Created to build and Operate the Continuous Electron Beam Accelerator Facility (CEBAF), world-unique user facility for Nuclear Physics:**
  - In operation since 1995
  - 1,356 Active Users
- **Operate wavelength tunable Free Electron Laser based on SRF technology lasing both the Infrared and Ultraviolet**
- **Managed for DOE by Jefferson Science Associates, LLC (JSA)**
- **Human Capital:**
  - 763 FTEs (at 3/15/11)
  - 23 Joint faculty, 25 Post docs, 14 Undergraduate; 30 Graduate students
- **Annual Budget of ~135 M$**

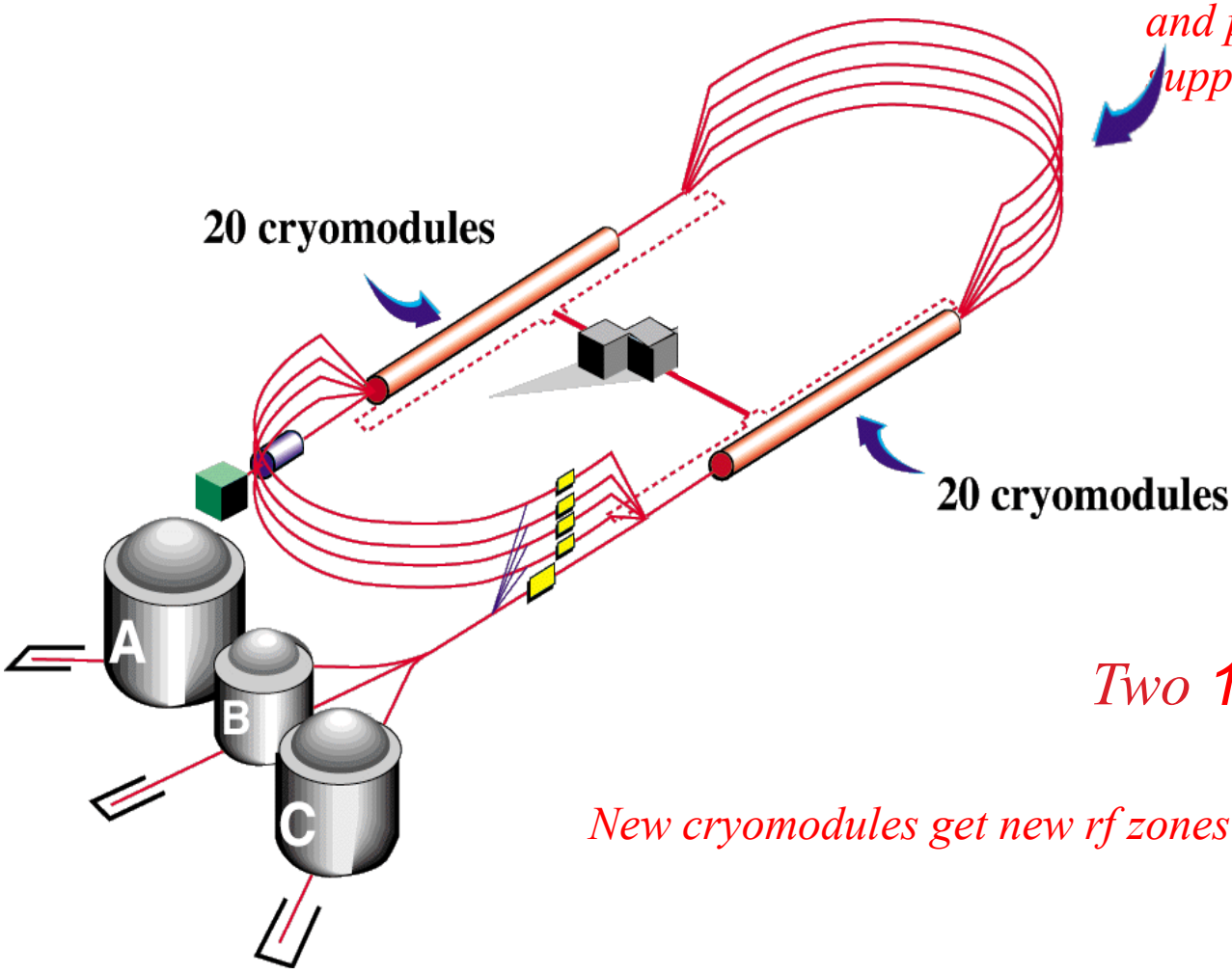
6 GeV CEBAF



Two 0.6 GeV linacs

New cryomodules get new rf zones

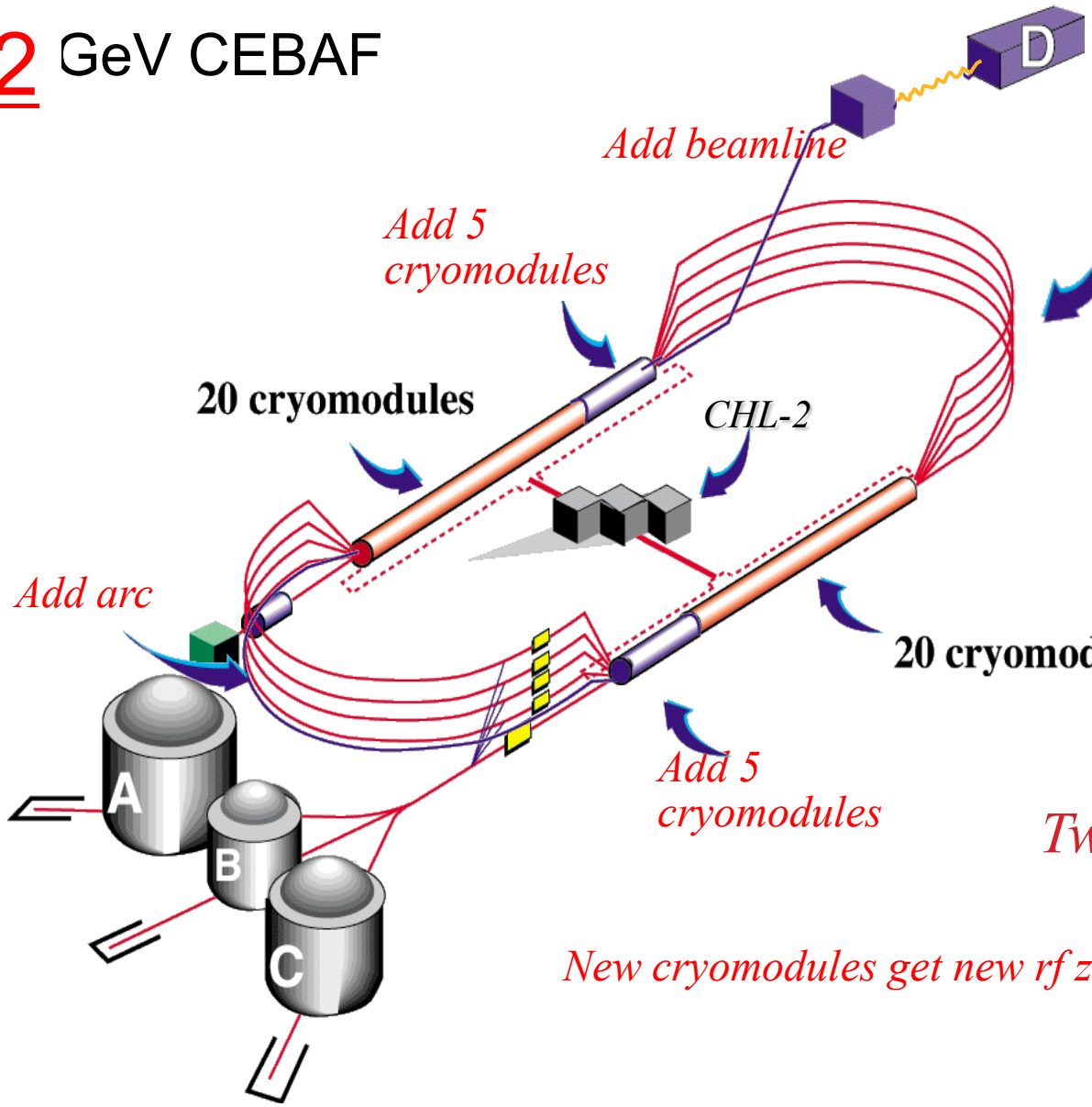
6 GeV CEBAF



Two 1.1 GeV linacs

New cryomodules get new rf zones

12 GeV CEBAF



Two 1.1 GeV linacs

New cryomodules get new rf zones

Key Technical Parameters - Unchanged since IPR08

New cryomodules per linac: 5

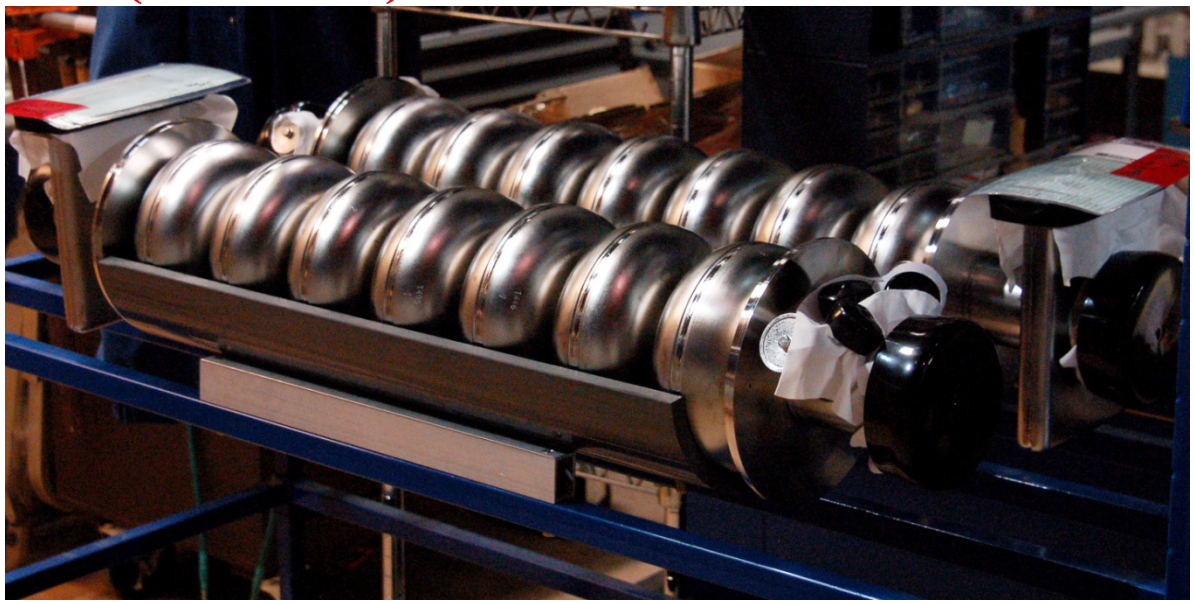
(Note: The following parameters are for each Cryomodule)

Voltage:	**≥ 108 MV** (ensemble average in each linac)
Heat budget: (Interface with Cryogenics)	
– **2 K**	**≤ 300 W**
– **50 K**	**≤ 300 W**
Slot Length:	**9.8 m**
Tuner resolution:	**≤ 2 Hz**
Fundamental Power Coupler (FPC):	**7.5/13 kW (Avg/Pk)**
Higher Order Mode (HOM) damping:	
– **Transverse (R/Q)Qk**	**< 2.4 x 10^{10} Ω/m**
– **Longitudinal (R/Q)Q**	**< 6.5 x 10^{11} Ω**
Cryomodule Length (Physical)	**~8.5m**

Cavity Parameters

- **1497 MHz 7 cell low loss cell shape**
  - **Emax/Eacc = 1.56**
  - **Bmax/Eacc = 2.72**
  - **Waveguide FPC coupler**
  - **2 coaxial HOM couplers**

Operating Spec 19.2 MV/m at Qo>7e9 (29 Watts)



Summary

A robust, lean, cavity processing routine has been developed for processing & testing elliptical SRF cavities.

- This is a unique approach to cavity processing that varies from any other laboratory in the world.
- Will show a stable, highly reproducible, production electropolishing system that is being used for cavities being installed into an operating c.w. electron accelerator.
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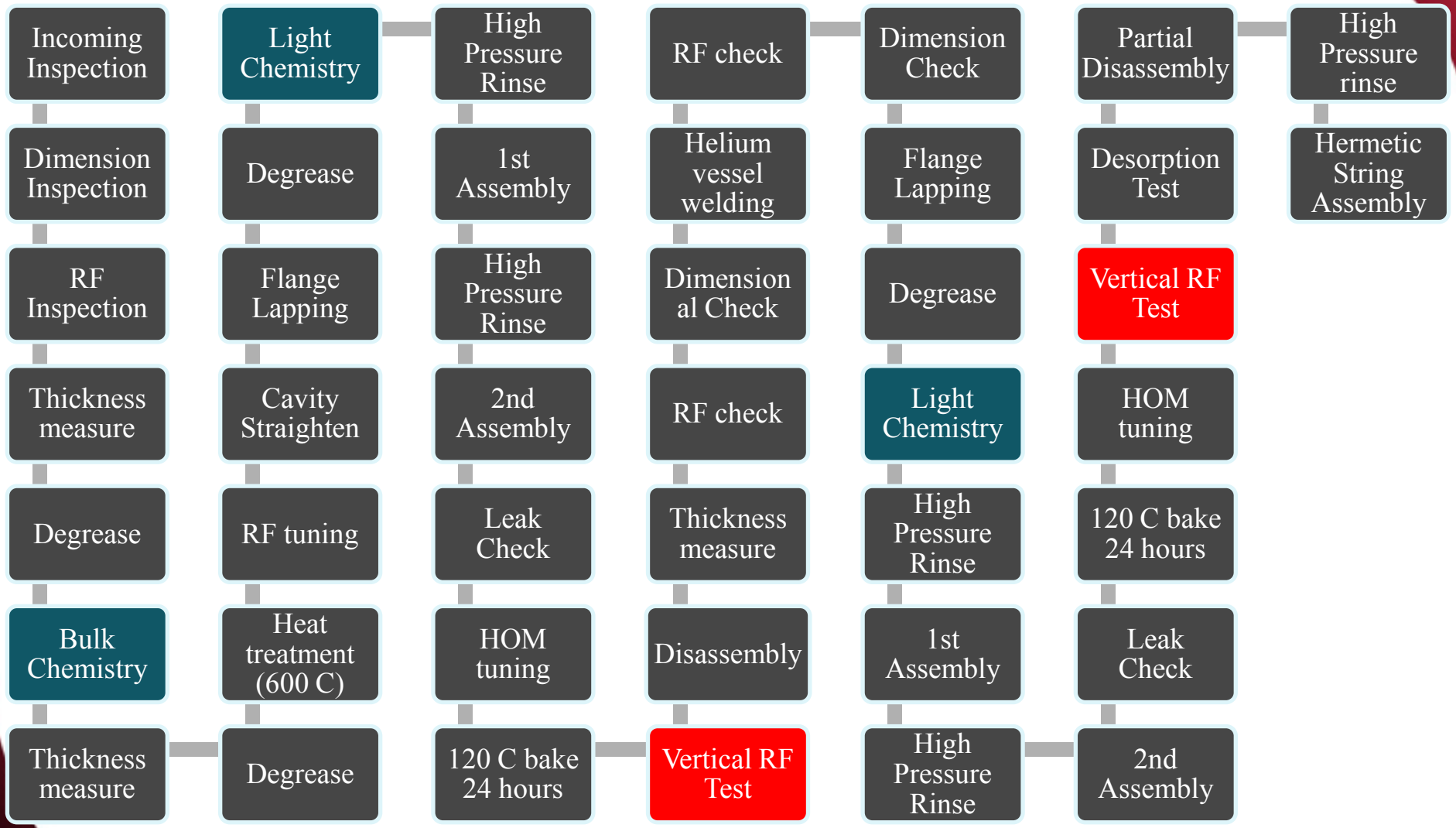
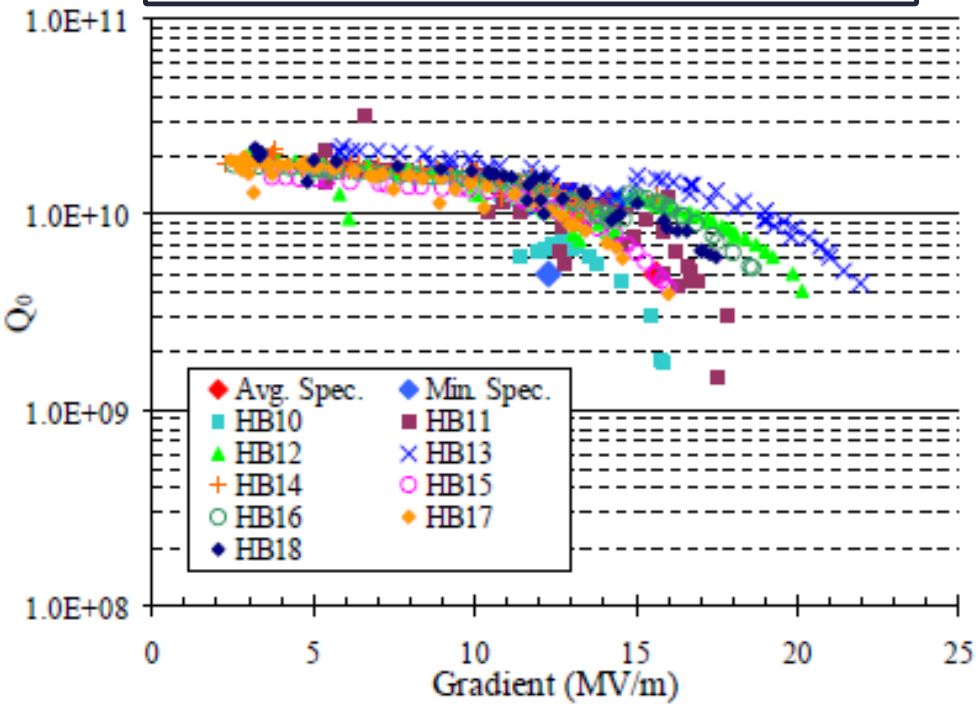
Historical Cavity Production Cycle

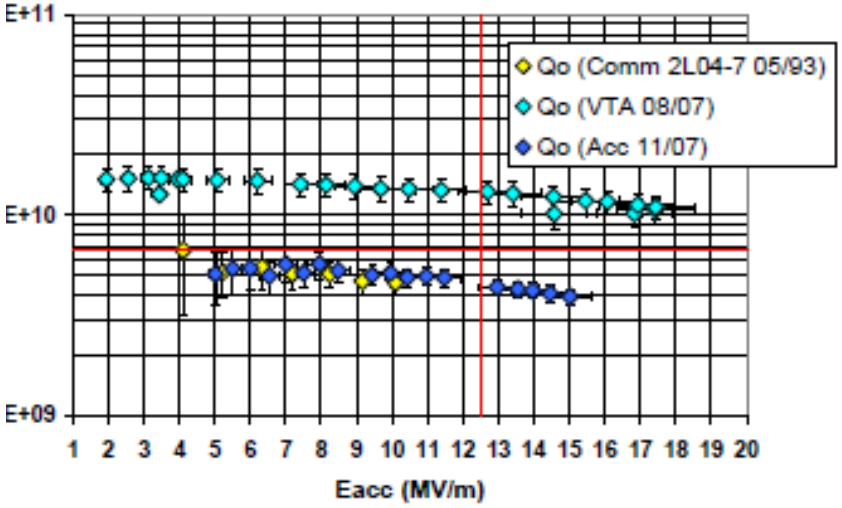


Historical Cavity Performance

Typical SNS Q vs E curves for SNS high β cavities



Typical C50 Q vs E curve



Optimization of the Cavity Production Cycle

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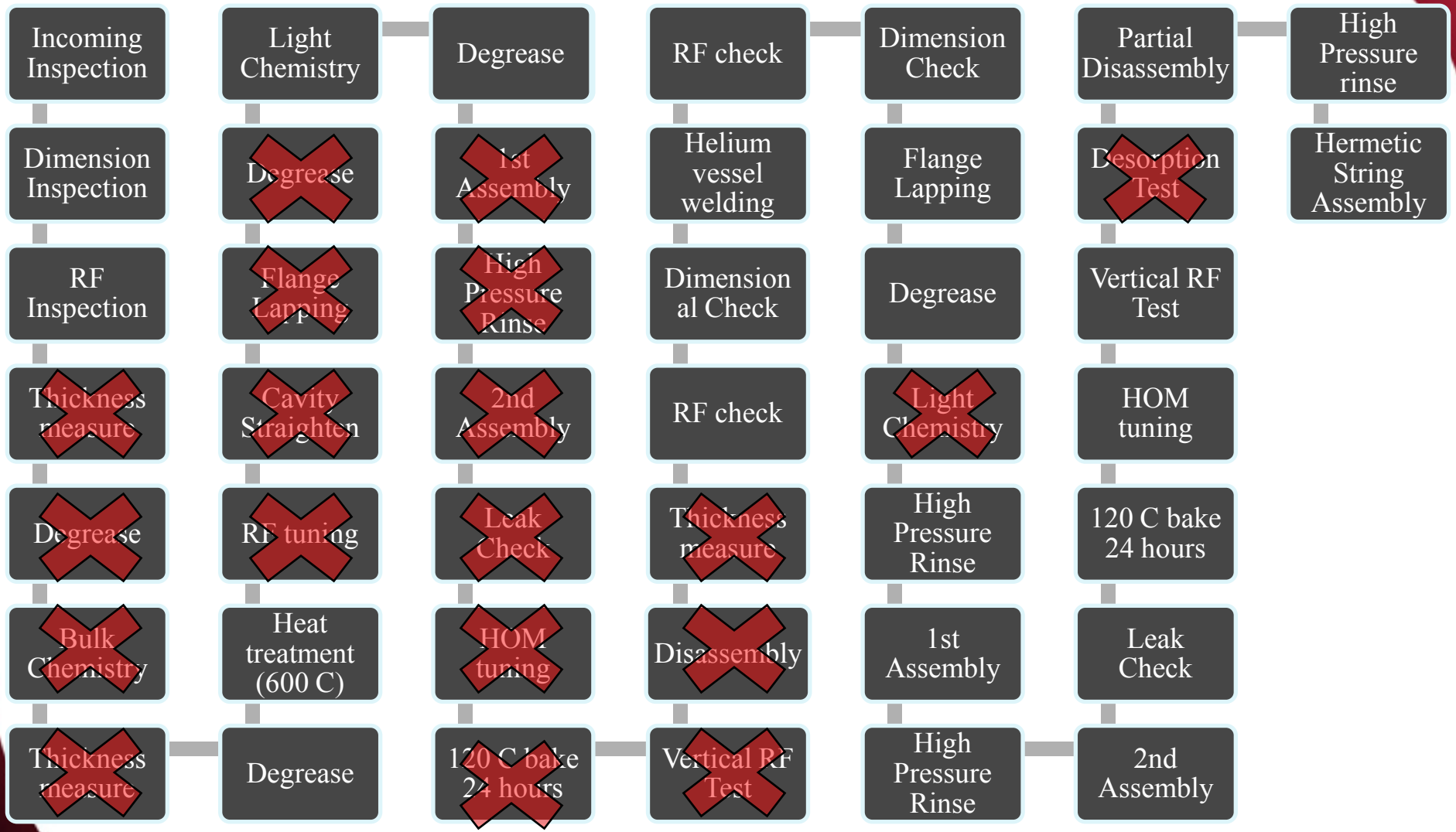
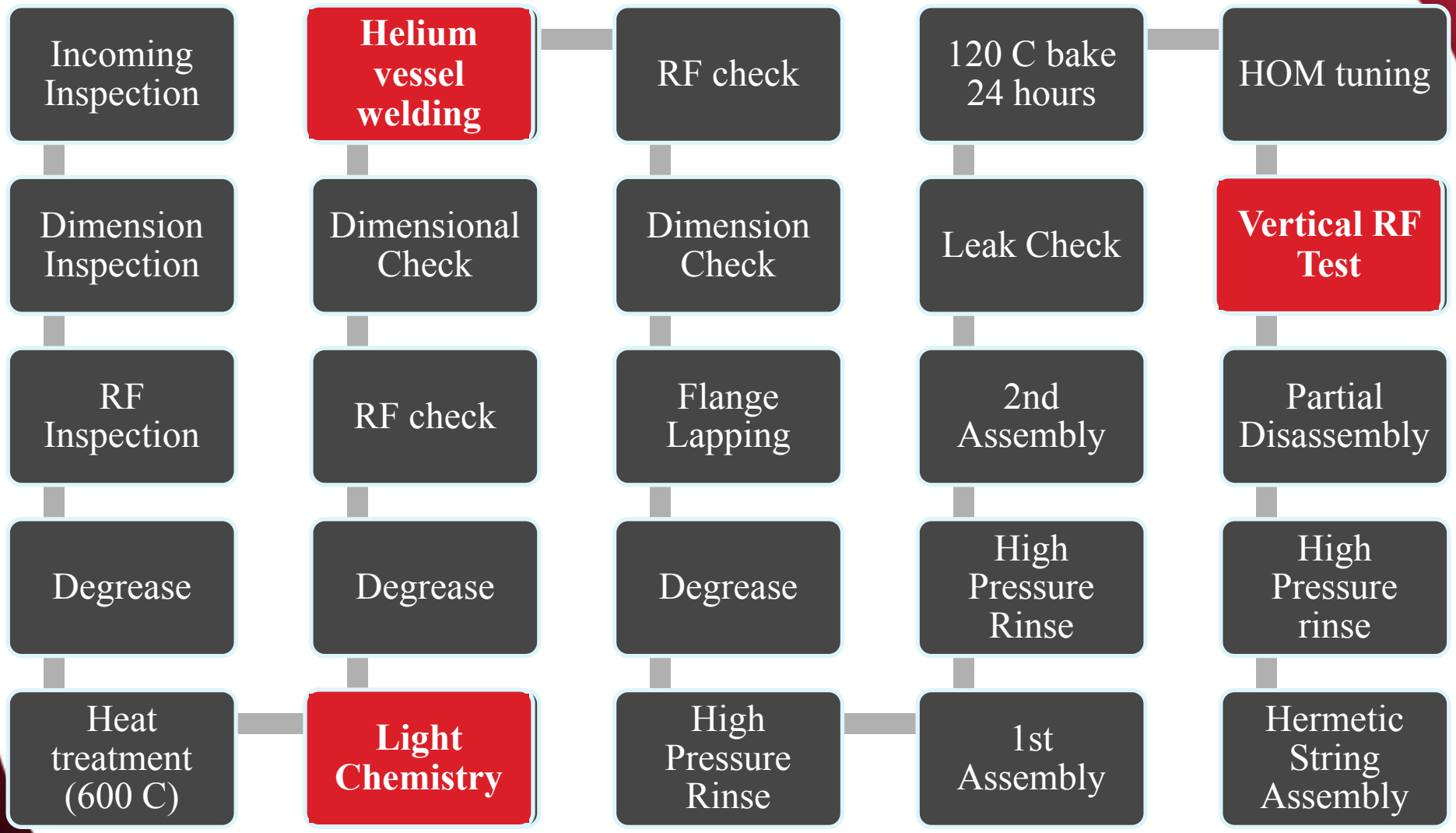


Reduced the number of Steps from 44 to 25!

State of the Art Cavity Production Cycle



Economic Benefit of the Process Optimization

Original process	Optimized Process
➢ 120 man-hours	➢ 80 man-hours
➢ 39 calendar days	➢ 25 calendar days

For an 80 cavity production run

3200 man-hours saved

Months saved from Schedule

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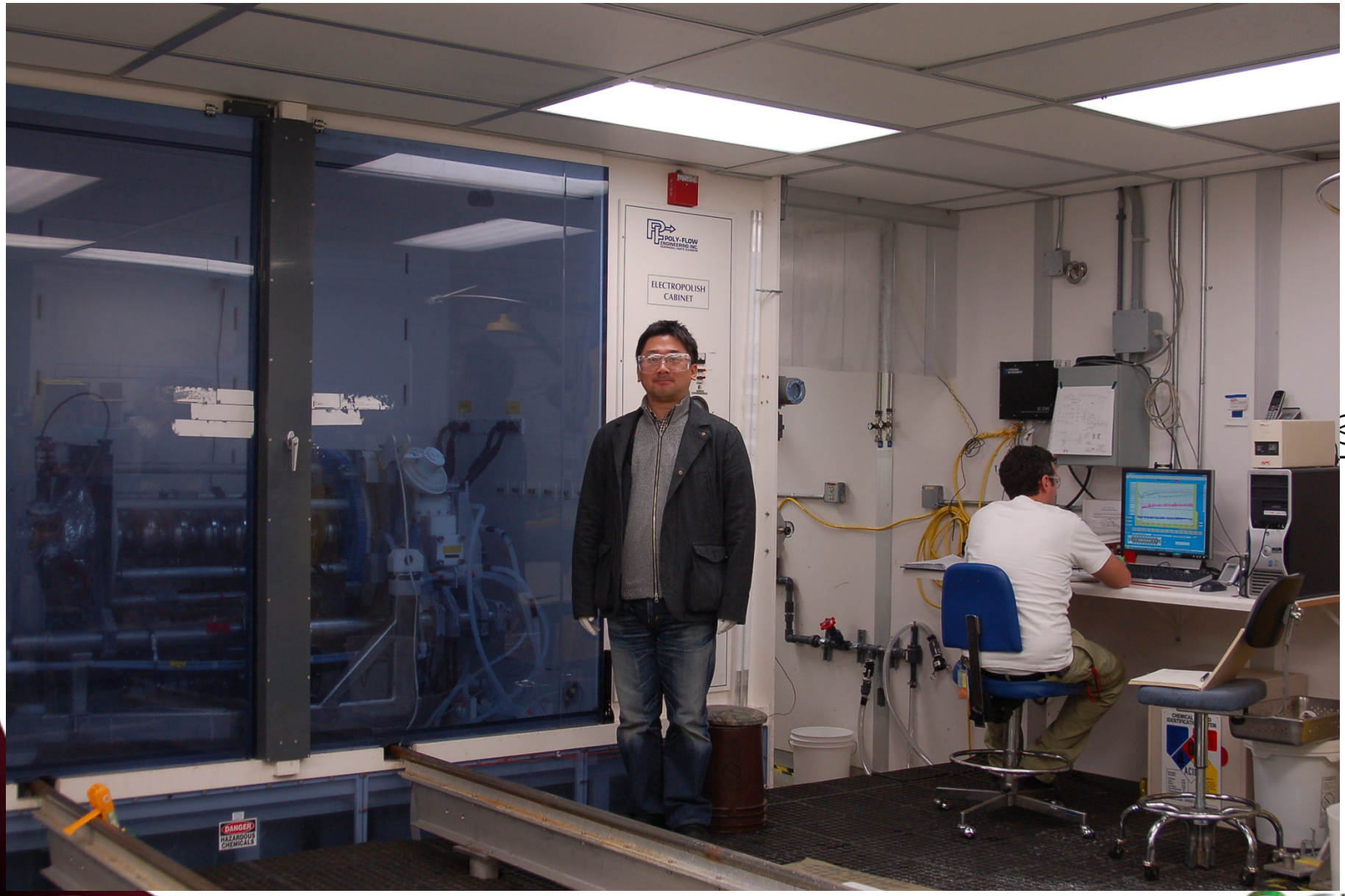
Stable and Reproducible Electropolishing Process



I (A)

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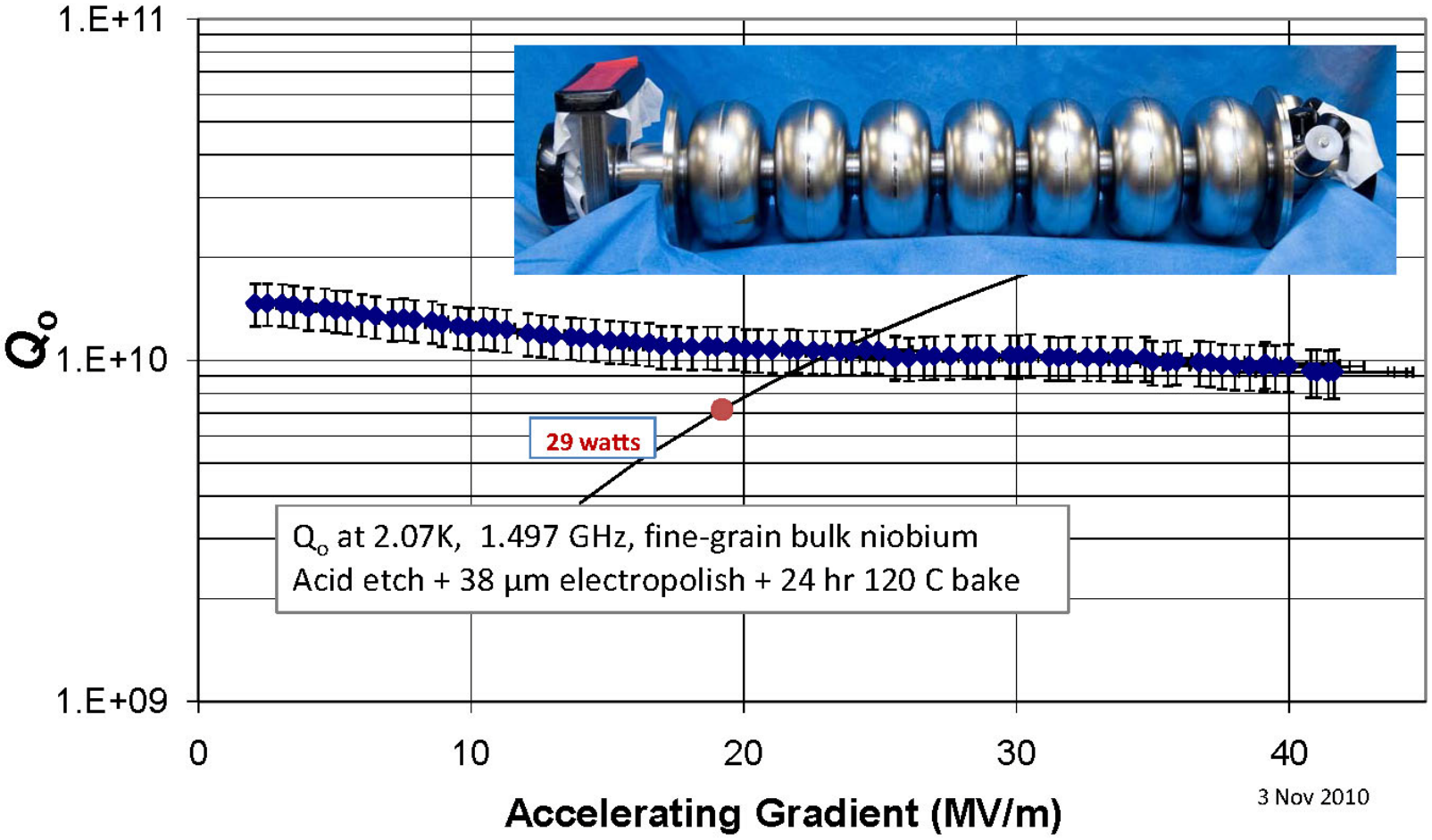
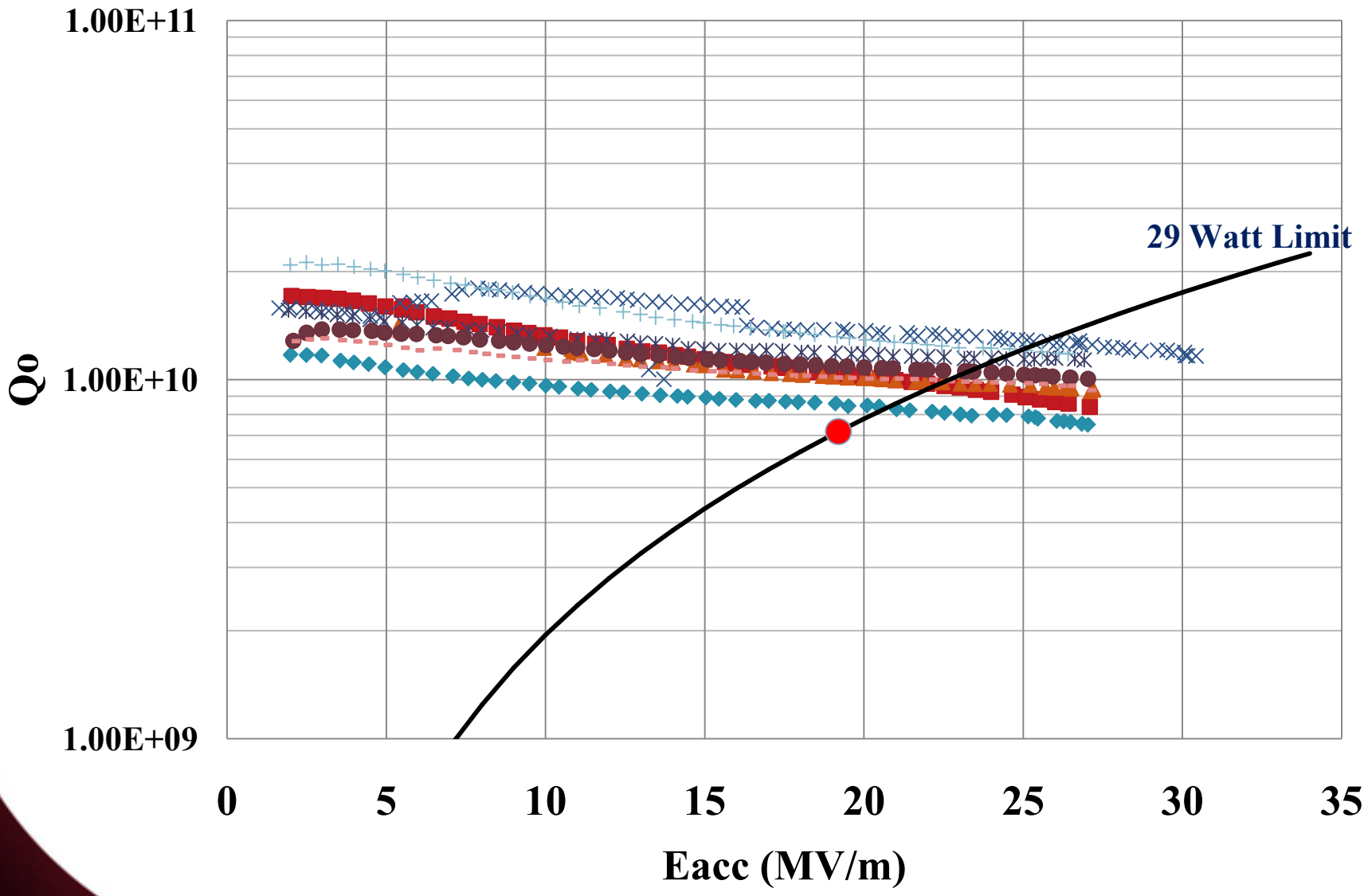
State-of-the-art production SRF cavity

C100-6

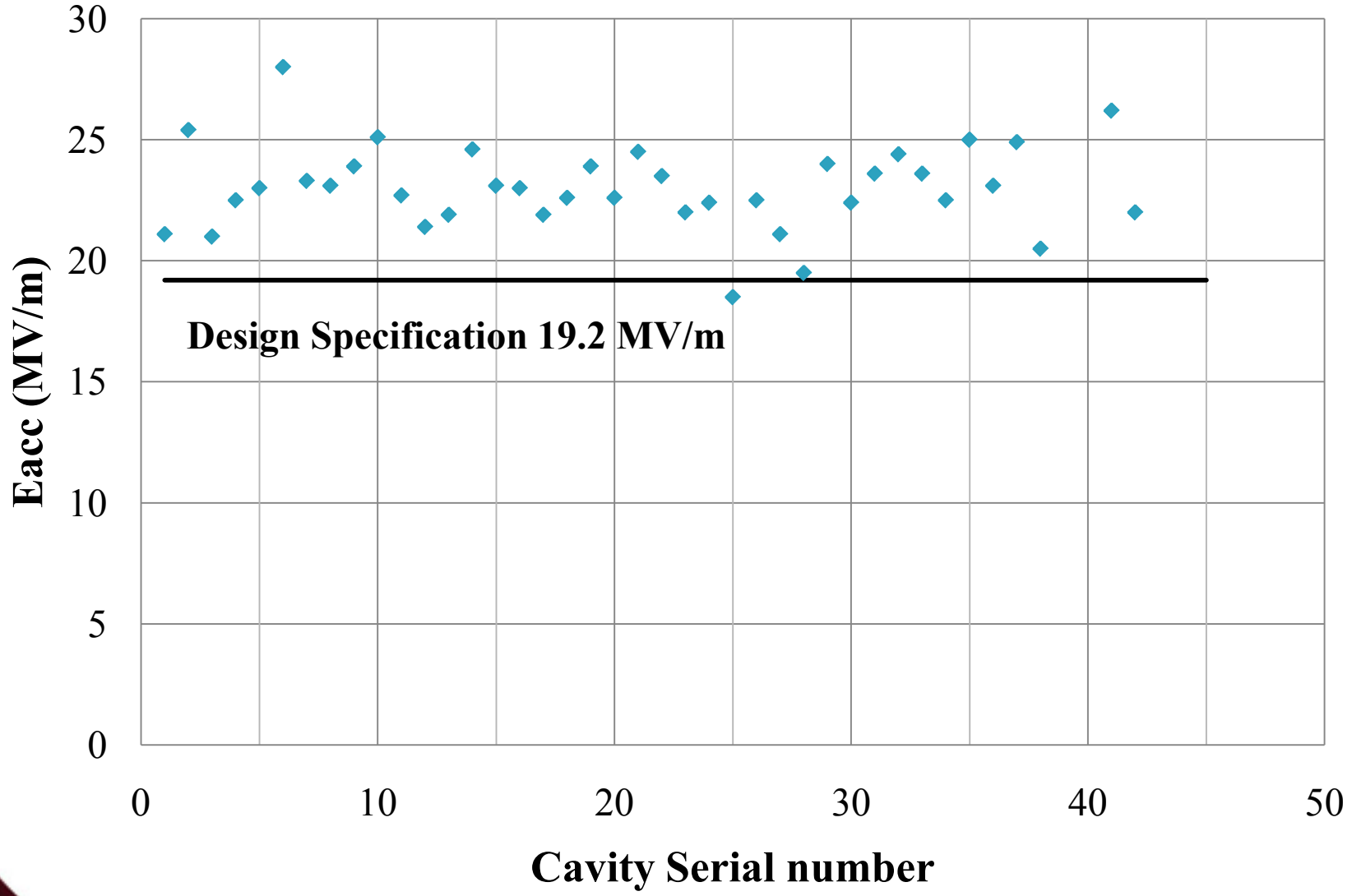


(*Q* is BCS-limited)

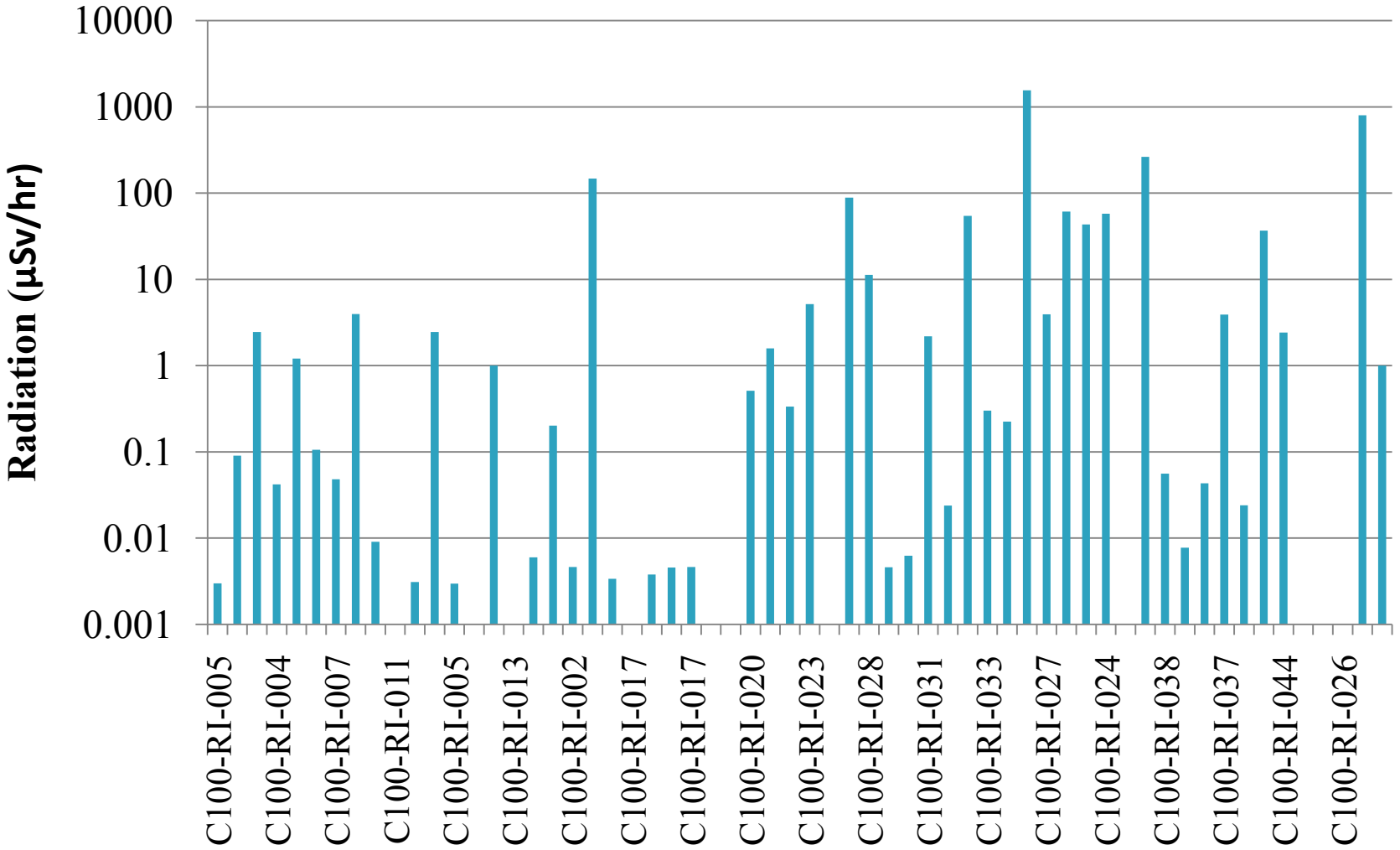
Vertical acceptance test of the 8 cavities in C100 string #1



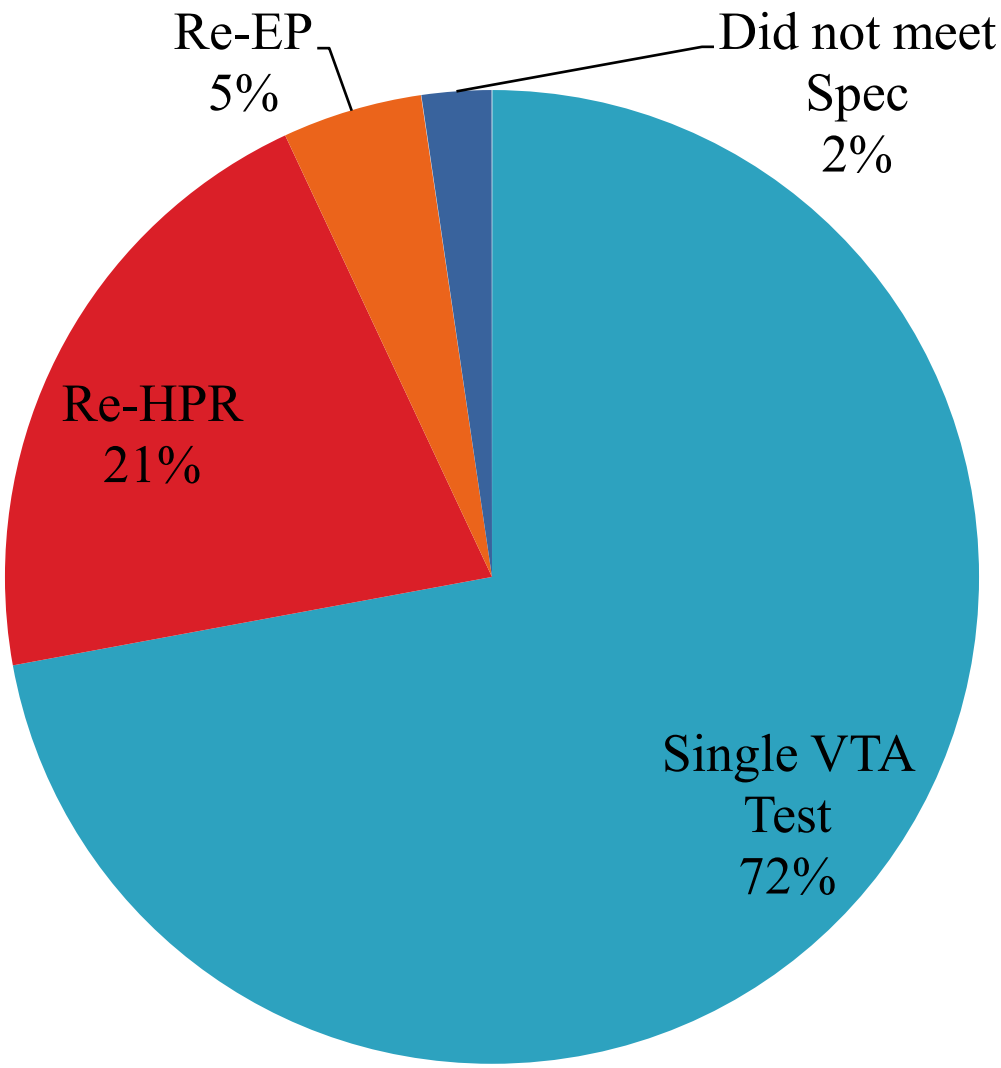
C100 Cavity Gradient at 29 Watts



C100 Cavity Radiation at 20 MV/m(µSv/hr)



Process Steps required to Qualify Cavities



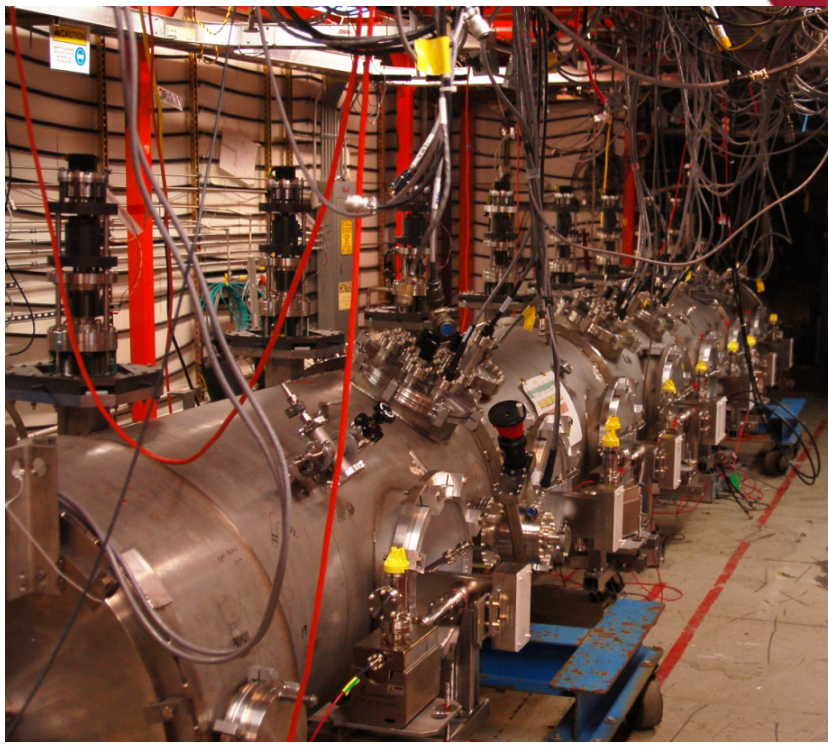
12 GeV Upgrade Cryomodule

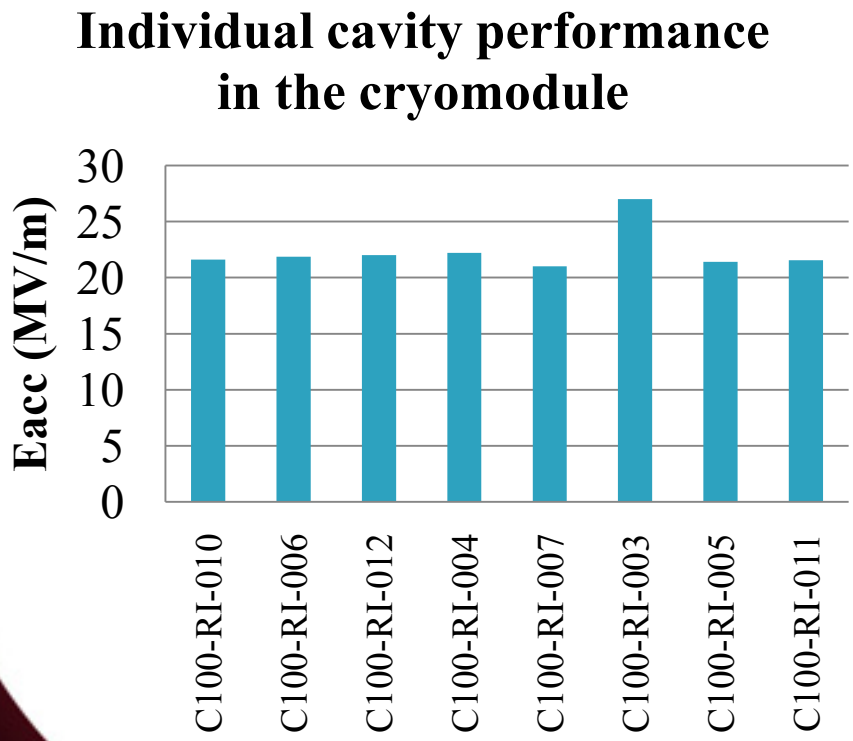
4 of 10 cryomodules in process of being assembled and tested

Installation of super-insulation on upgrade cryomodule

Preliminary Cryomodule Data

First C100 String Test Cave measurements are complete.
Testing in the Accelerator underway
Individual cavity tests





Bottom line:
Cryomodule meets specification!

29 Watt total heat load being managed.

Cavity Production Statistics

- 86/86 Cavities received from Vendor
- 64/86 Electropolish cycles complete
- 36/86 Cavity RF tests complete
- 4/10 cryomodule hermetic strings delivered

- On track to deliver all 10 hermetic cavity strings by Feb 2012

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Acknowledgements

- All of the Scientific, Engineering and Technical Staff in the SRF Institute
- The people who have graciously provided me with slides to use in this talk

Thank You.