

# Cavity Processing Facility

**Harry Carter, Tug Arkan, Cristian Boffo,  
Dan Olis and Allan Rowe**

**Fermilab Technical and Accelerator Divisions**

# Outline

- **Establishing the Need for this Facility**
- **Process Definition**
- **Cavity Processing Facility (CPF) Scope and Infrastructure Requirements**
- **CPF Cost Estimate**
- **CPF Schedule**
- **Conclusion**

# Goals for SRF Infrastructure: CPF

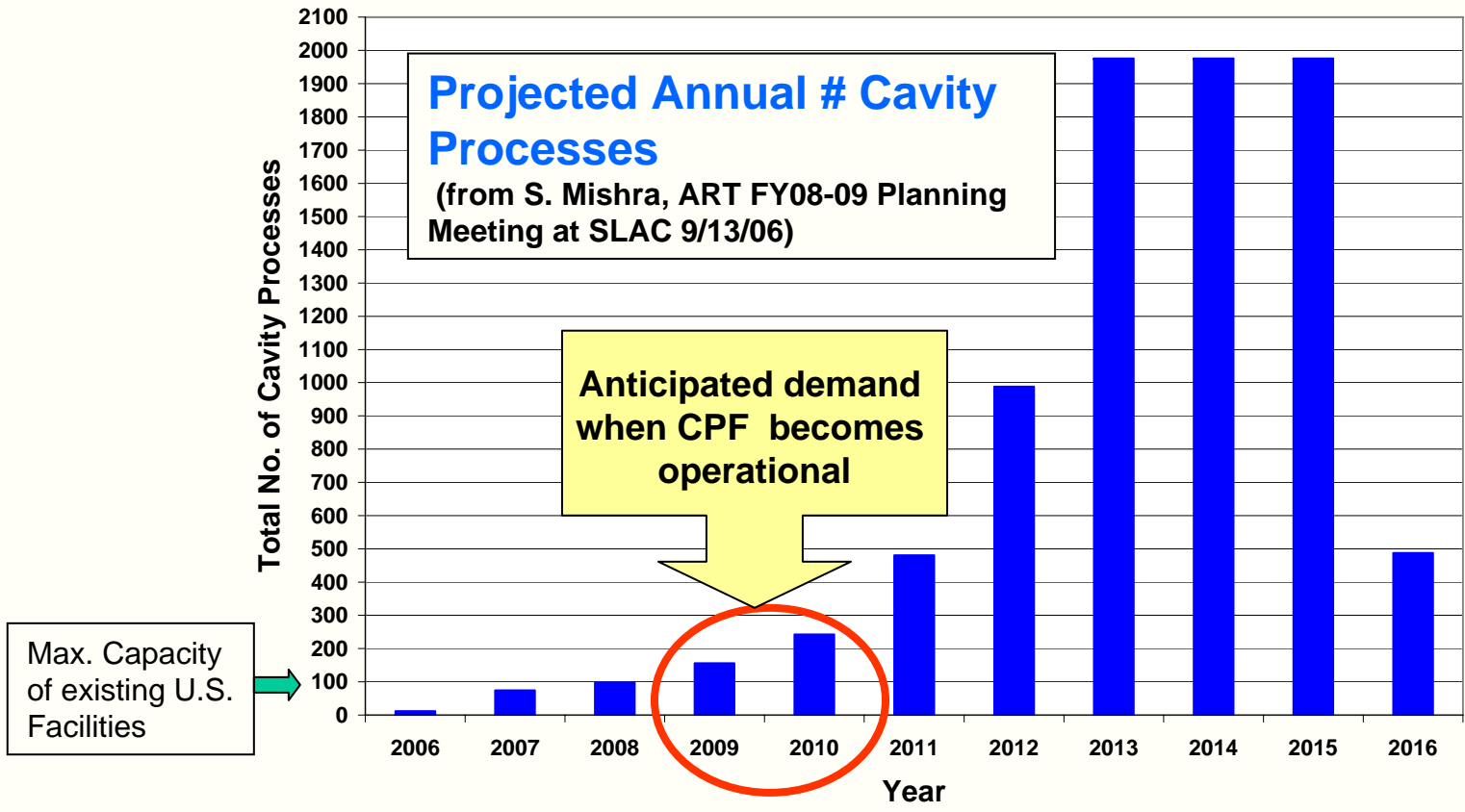


- To perfect U.S. fabrication & processing of SRF cavities and modules and to demonstrate performance with a full range of testing (including beam)
  - Deploy ILC design / processing / assembly techniques ←
  - Establish process controls to reliably achieve high gradient cavity operation and module performance ←
  - Test cavities and modules at the component level and in a systems test to demonstrate yield, reproducibility and beam performance
- To facilitate commercial production of SRF components and modules ←
  - Train and transfer SRF technology to the US industry
  - Allow industrial participation and input to the process
    - Similar to SC cable and magnet technology transfer
- To participate in SRF Research and Development
  - Develop expertise in SRF technology and provide training base for construction and operation of future accelerators
  - Our attempt to fit into the world's SRF community

All of this work will be carried out with US/international collaboration

# Establishing the Need for this Facility

- Existing U.S. capability is insufficient to meet the anticipated demand---as demonstrated in Shekhar's talk



# US Laboratories Capacity



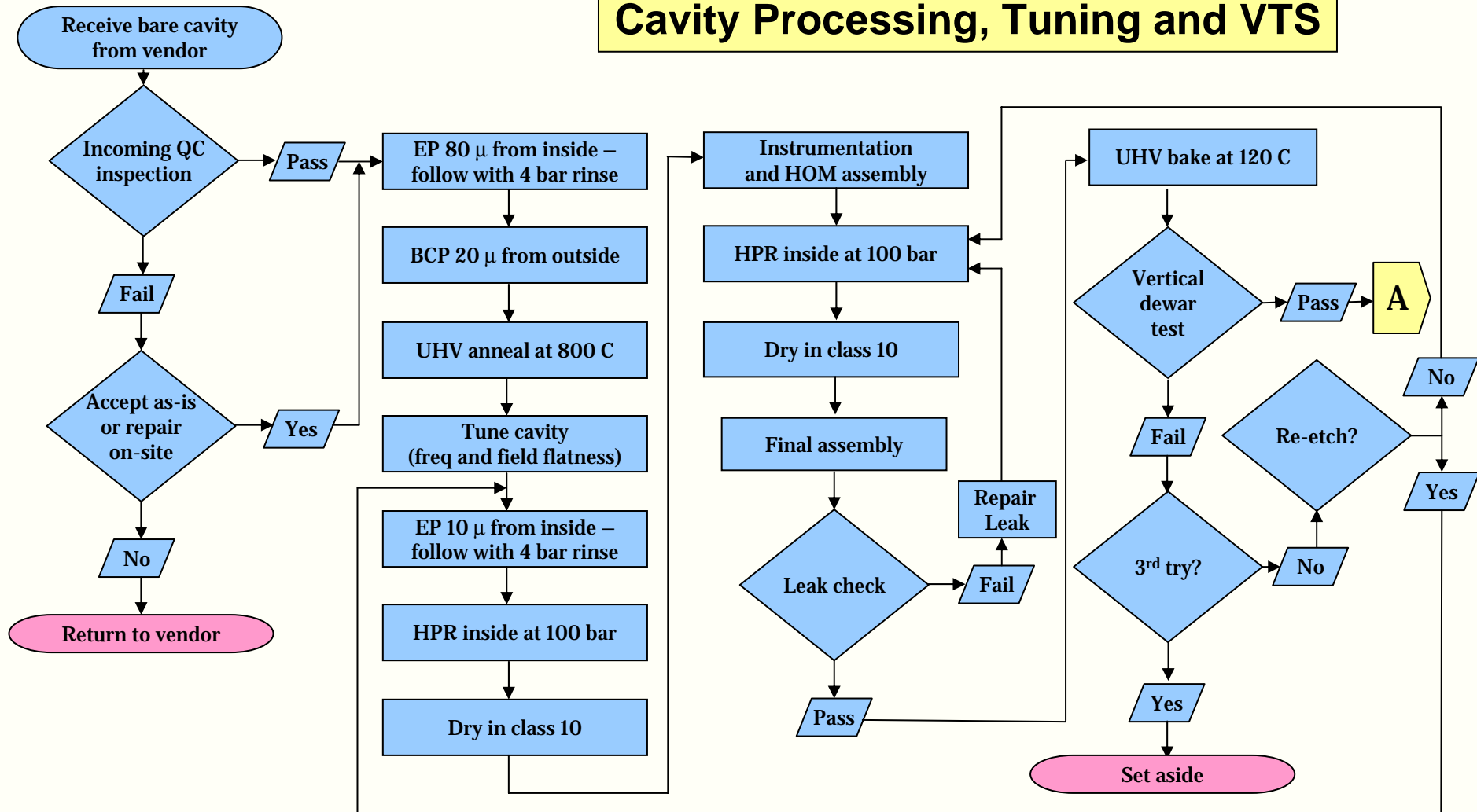
Program	FY07	FY08	FY09	FY10	Capacity Needed/yr by FY10
<b>Cavity Processing (EP, HPR, Bake)</b>	Jlab-30 Cornell-10	Jlab-40 Cornell-10 ANL-40	Jlab-40 Cornell-10 ANL-40 Fermilab-20	Jlab-40 Cornell-10 ANL-40 Fermilab-100	200
<b>Vertical Testing</b>	Jlab-30 Cornell-10 Fermilab-20	Jlab-40 Cornell-10 Fermilab-75	Jlab-40 Cornell-10 Fermilab-75	Jlab-40 Cornell-10 Fermilab-200	200
<b>Horizontal Testing</b>	Fermilab-6	Fermilab-24	Fermilab-24	Fermilab-72	72
<b>Cryomodule Assembly</b>	Fermilab-1	Fermilab-4	Fermilab-12	Fermilab-12	12
<b>Cryomodule Test</b>	Fermilab: ILCTA_NML	Fermilab: ILCTA_NML	Fermilab: ILCTA_NML	Fermilab: ILCTA_NML CMTS	12

# Process Definition

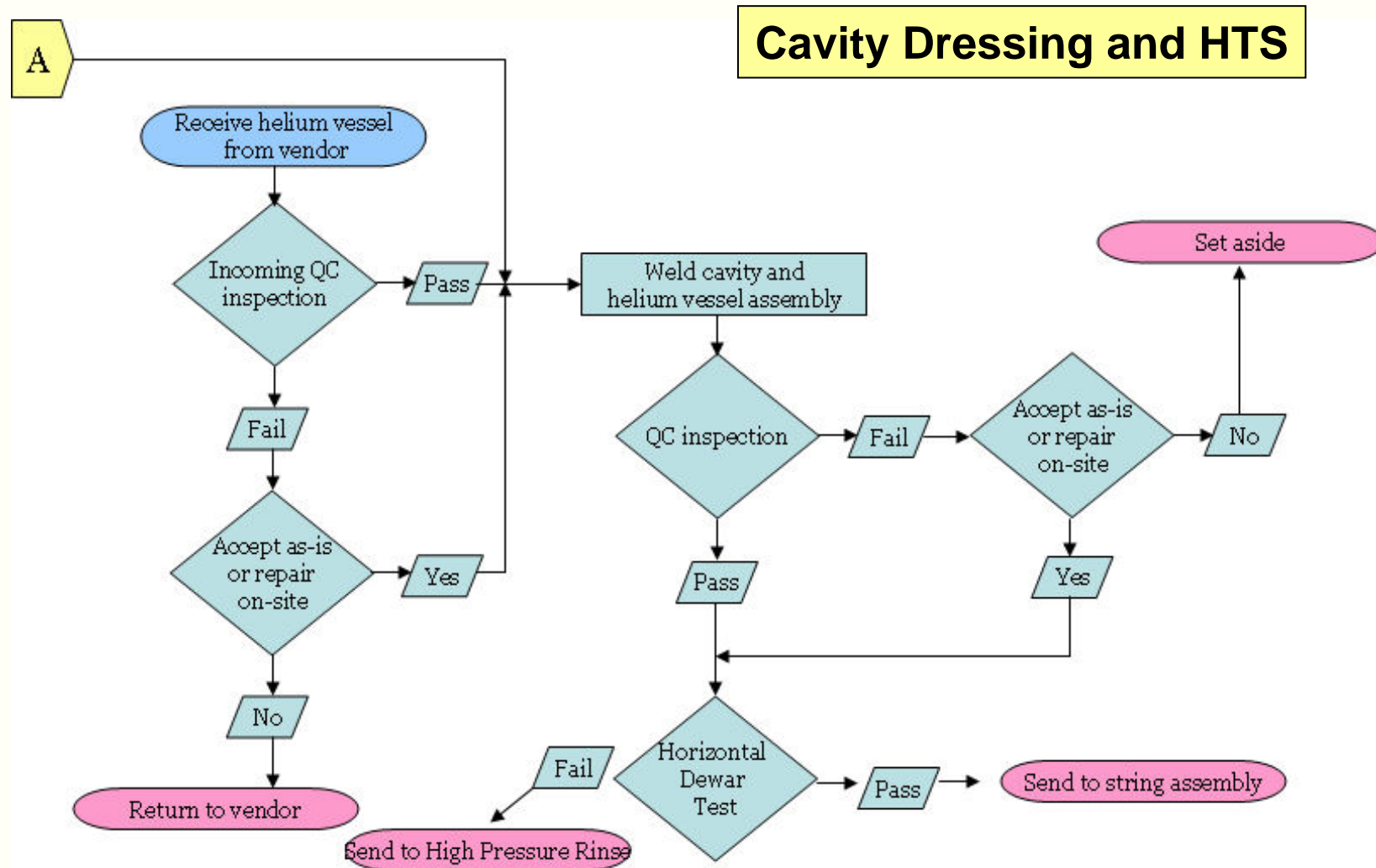
- The term “process” defines the complete procedure that transforms a fabricated cavity into a fully qualified cavity at a specified operating gradient and quality factor (in our case 35MV/m and  $1.0e10$ ). It includes the following operations:
  - Cavity processing
  - Cavity tuning
  - Vertical testing
- A flow chart delineating the procedure is presented on the next slide

# Process Flow Chart

## Cavity Processing, Tuning and VTS



# Cavity Flow Chart Subsequent to Completing the Process Flow Chart





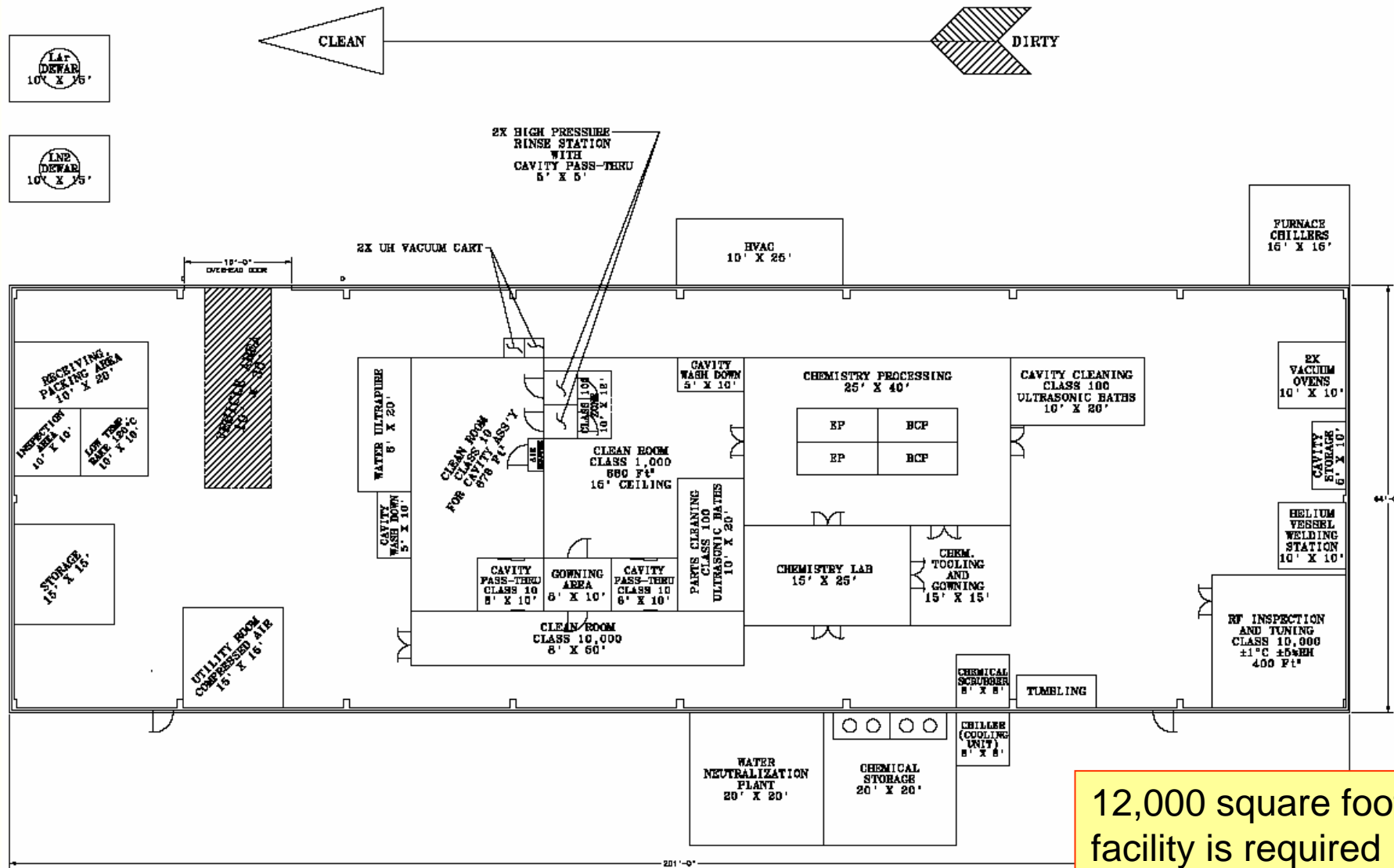
# CPF Functions

- Perform pre-EBW etching of cavity components
- Receive and store fabricated cavities
- Perform mechanical inspection of cavities
- Perform internal and external chemical processing
- Perform high pressure rinsing
- Perform high and low temperature cavity bakes
- Tune cavities for fundamental frequency and field flatness
- Prepare cavity for vertical test
- Receive vertically tested cavities
- Install helium vessels (dress cavities)
- Prepare dressed cavities for horizontal testing
- Receive cavities from HTS and send to string assembly facility (CAF)

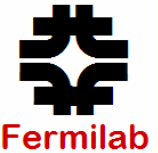
# Cavity Processing Facility Features

- **Separate chemical storage building**
- **Chemistry laboratory for small samples and pre-EBW etching**
- **Wet station area for component cleaning prior to bringing into clean rooms**
- **Class 1000 clean room housing major chemical processing equipment (EP and BCP cabinets, etc.)**
- **Exhaust fume scrubber**
- **Acid neutralization system**
- **Ultra Pure Water (UPW) system**
- **High Pressure Rinse (HPR) stations**
- **High and low temperature furnaces**
- **RF inspection and Automated cavity tuning system**
- **Class 10 clean room for final prep of cavities prior to VTS**
- **High purity gaseous argon and nitrogen systems**
- **TIG welding station for helium vessel installation**
- **Ultra clean vacuum pumping system and leak checking systems**

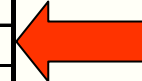
# CPF Floor Plan at MW



# CPF Funding Requirements



Infrastructure	M&S	SWF	Total with Indirect
Cavity Fabrication Infrastructure	\$ 3,000	\$ 675	\$ 4,380
Cavity Processing Facilities	\$ 11,100	\$ 4,590	\$ 18,945
Vertical Test Stand (VTS 2 & 3)	\$ 2,625	\$ 1,845	\$ 5,475
Horizontal Test Stand (HTS 2)	\$ 1,220	\$ 1,057	\$ 2,805
Cavity/Cryomodule Assembly Facilities (CAF_MP9 & ICB)	\$ 690	\$ 270	\$ 1,158
NML Facility (ILCTA_NML)	\$ 18,270	\$ 23,220	\$ 51,700
Cryogenics for Test Facilities	\$ 10,690	\$ 950	\$ 13,692
Cryomodule Test Stand	\$ 5,400	\$ 2,970	\$ 10,180
Material R&D	\$ 870	\$ 722	\$ 1,960
Illinois Accelerator Research Center	\$ 20,000	\$ 4,050	\$ 28,605
<b>Grand Total (\$k)</b>	<b>\$ 73,865</b>	<b>\$ 40,349</b>	<b>\$ 138,900</b>



Item	\$K
<b>M&amp;S:</b>	<b>11,100</b>
<b>SWF:</b>	<b>4,590</b>
<b>Grand Total w/o Indirect:</b>	<b>15,690</b>
<b>Grand Total with Indirect:</b>	<b>18,945</b>

## •Assumptions

- Facility is located on FNAL site
- 3 year schedule from inception to completion and fully operational
- Funding profile assumes 1/3 TPC available each fiscal year

# CPF Itemized (Direct) Cost Estimate



Item	M&S Costs	Labor	SWF	Total Cost
	\$K	FTE*ys	\$K	\$K
Building Preparation	\$ 250	0.5	\$ 68	\$ 318
Building Utility Infrastructure	\$ 250	2.5	\$ 338	\$ 588
Clean Rooms	\$ 1,000	0.5	\$ 68	\$ 1,068
Ultra-Pure Water System	\$ 150	1.5	\$ 203	\$ 353
Clean Room Hardware	\$ 150	1.25	\$ 169	\$ 319
Ultrasonic Cleaning Tanks	\$ 150	0.5	\$ 68	\$ 218
Vacuum Furnaces (2)	\$ 1,000	0.25	\$ 34	\$ 1,034
Lo temp.furnaces (2)	\$ 200	1	\$ 135	\$ 335
Cavity Tuning Devices and RF test equipment & fixtures	\$ 1,000	1.25	\$ 169	\$ 1,169
HPR Systems (3)	\$ 1,200	1.25	\$ 169	\$ 1,369
EP Systems (3)	\$ 1,600	1.75	\$ 236	\$ 1,836
BCP Systems (2)	\$ 1,000	1.25	\$ 169	\$ 1,169
Tumbling (2)	\$ 500	1	\$ 135	\$ 635
Chemistry Lab	\$ 450	4	\$ 540	\$ 990
Chemistry storage, preparation, treatment infrastructure	\$ 1,000	1.25	\$ 169	\$ 1,169
Vacuum Equipment and Hardware	\$ 400	1.25	\$ 169	\$ 569
TIG Welding Machines, fixtures	\$ 150	0.75	\$ 101	\$ 251
Miscellaneous Fixtures and Equipment	\$ 400	4	\$ 540	\$ 940
Monitoring, controls, HMI integration	\$ 250	3.25	\$ 439	\$ 689
ES&H preparation		5	\$ 675	\$ 675
<b>Totals</b>	<b>\$ 11,100</b>	<b>34</b>	<b>\$ 4,590</b>	<b>\$ 15,690</b>

- ## Cost Drivers
- Clean Rooms (Classes 10, 100, & 1000)
  - Vacuum Hi Temp Bake Furnaces
  - Cavity Tuning Devices & RF test equipment
  - HPR Systems
  - EP Systems
  - BCP Systems
  - Chemistry Storage, Preparation & Treatment Infrastructure

# 3 Year CPF Procurement Plan



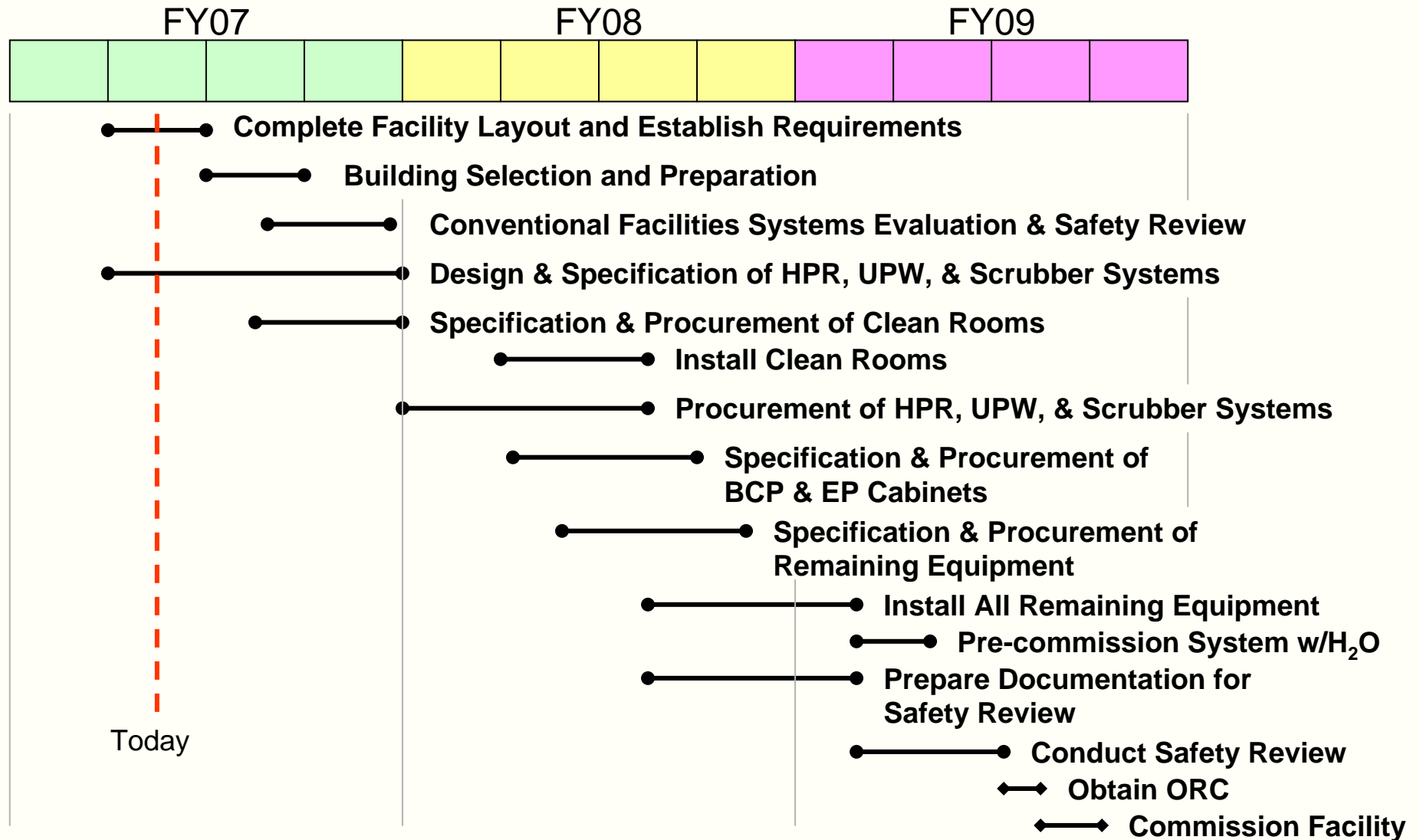
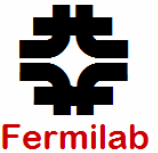
- Year One
  - Prep building for CPF, inc. utility infrastructure
  - Procure & install clean rooms
  - Procure clean room hardware
  - Procure high and low temp. vacuum furnaces
  - Procure & install UPW system
  - Procure & install ultrasonic cleaning tanks
  - Procure cavity tuning system

} ~\$5.4M
- Year Two
  - Procure EP and BCP systems
  - Procure HPR systems
  - Procure mechanical polishing (tumbling) systems
  - Procure chemistry lab equipment

} ~\$6.0M
- Year Three
  - Procure & install scrubber system & treatment infrastructure
  - Procure vacuum equipment & hardware
  - Install all remaining equipment
  - ES&H preparation
  - Conduct safety review
  - Commission facility

} ~\$4.3M

# CPF Schedule Timeline



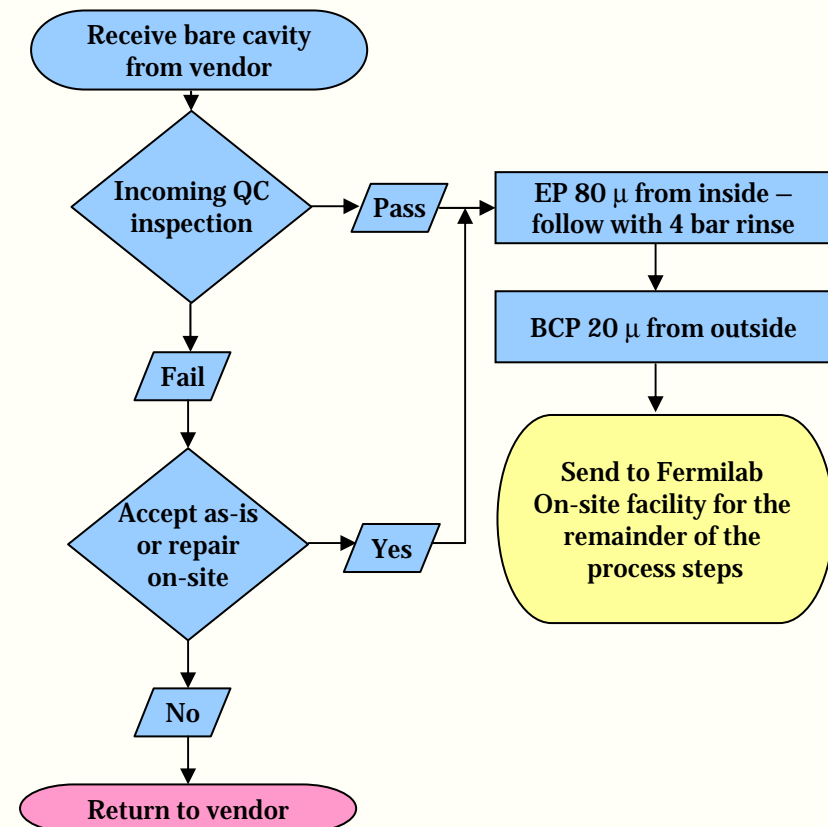
# Alternative: An Off-Site CPF

- A contract could be written for the design, construction, and operation of an off-site facility located very near FNAL.
- Facility would be financed by ILC funds and owned by government, but operated by industry
- Advantages:
  - Operation by an experienced electropolishing industrial firm using their manpower
  - Significantly reduces the need for large quantities of nasty chemicals on FNAL site
  - Initiates the industrialization program cavity processing
- Unknown total cost, estimate ~ \$6M due to the cost of a building (either leased or purchased)

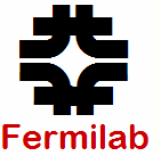


# Off-Site CPF Scope of Work

- Perform initial cavity inspection
- Perform bulk chemistry operations
  - Internal 80u EP
  - External 20u BCP
- Possibly include HPR; otherwise, ship cavity to FNAL in container filled with UPW



# Development of Industry



Cryomodule Process

Starts with

Transitions to

Cavity Fabrication

Lab/Industry Collaboration → Industry

Cavity Processing

Lab/Industry Collaboration → Industry

Low Power Test (VTS)

Laboratory → Laboratory

Cavity Dressing

Lab/Industry Collaboration → Industry

High Power Test (HTS)

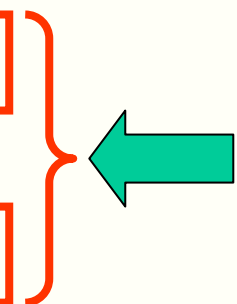
Laboratory → Laboratory

Cryomodule Fabrication

Lab/Industry Collaboration → Industry

Cryomodule Test (CTS)

Laboratory → Laboratory



The technology for cavity fabrication & processing, cavity dressing and cryomodule fabrication will be transferred to Industry.

Cryogenic testing of cavities and cryomodules along with beam tests will remain the responsibility of US laboratories.

# Conclusion

- **The combined total process capacity of present U.S. cavity processing facilities has been shown to be inadequate to handle the anticipated near term demands.**
- **A concept for a new facility (CPF) capable of meeting the ILC pre-production demands has been presented. Development of the facility specification and design is underway at FNAL.**
- **If located on the Fermilab site, the CPF could be completed in ~2 years at a total cost of \$15.7M.**
- **Splitting the CPF along the lines of completing the bulk chemistry processing in an off-site facility may be advantageous and merits further investigation**