Status of efforts to develop the next generation infrastructure for cavity processes (with industrial participation)

Shekhar Mishra

Fermilab

Goals for SRF Infrastructure

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- To perfect U.S. fabrication & processing of SRF cavities and modules and to demonstrate performance with a full range of testing
  - Deploy ILC design / processing / assembly techniques
  - Establish process controls to reliably achieve high gradient cavity operation and module performance
  - Test cavities and cryomodules at the component level and in a systems test to demonstrate yield, reproducibility and beam performance
- 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
- 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
- US and Fermilab to be a
  - "Credible" and "Qualified Host" of ILC

Present: US SRF Infrastructure

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- **Limited cavity fabrication capability in US industry**
  - One US company (AES) fabricating SRF cavity
  - Developing two new companies (Niowave and Roark)
    - European Industry much advanced in ILC cavity fabrication
- **Cavity Processing and Vertical Testing R&D Facility**
  - Jlab (~30 FY07, ~40 FY08, ~50 FY09) cycles/yr
  - ANL/FNAL (~50 FY08, ~60 FY09) cycles/yr
  - Cornell ~12 cycles/yr
  - VTS @FNAL ~50 cycles/yr (late FY07)
  - Significant fraction of this capacity is used to support R&D Program
    - Process development
    - Single cell Processing
- **Horizontal Test Stand**
  - FNAL ~24 cavities/yr
- **Cavity Dressing and Cryomodule Assembly**
  - FNAL 2-4/yr (FY07)

Cavity and Cryomodule

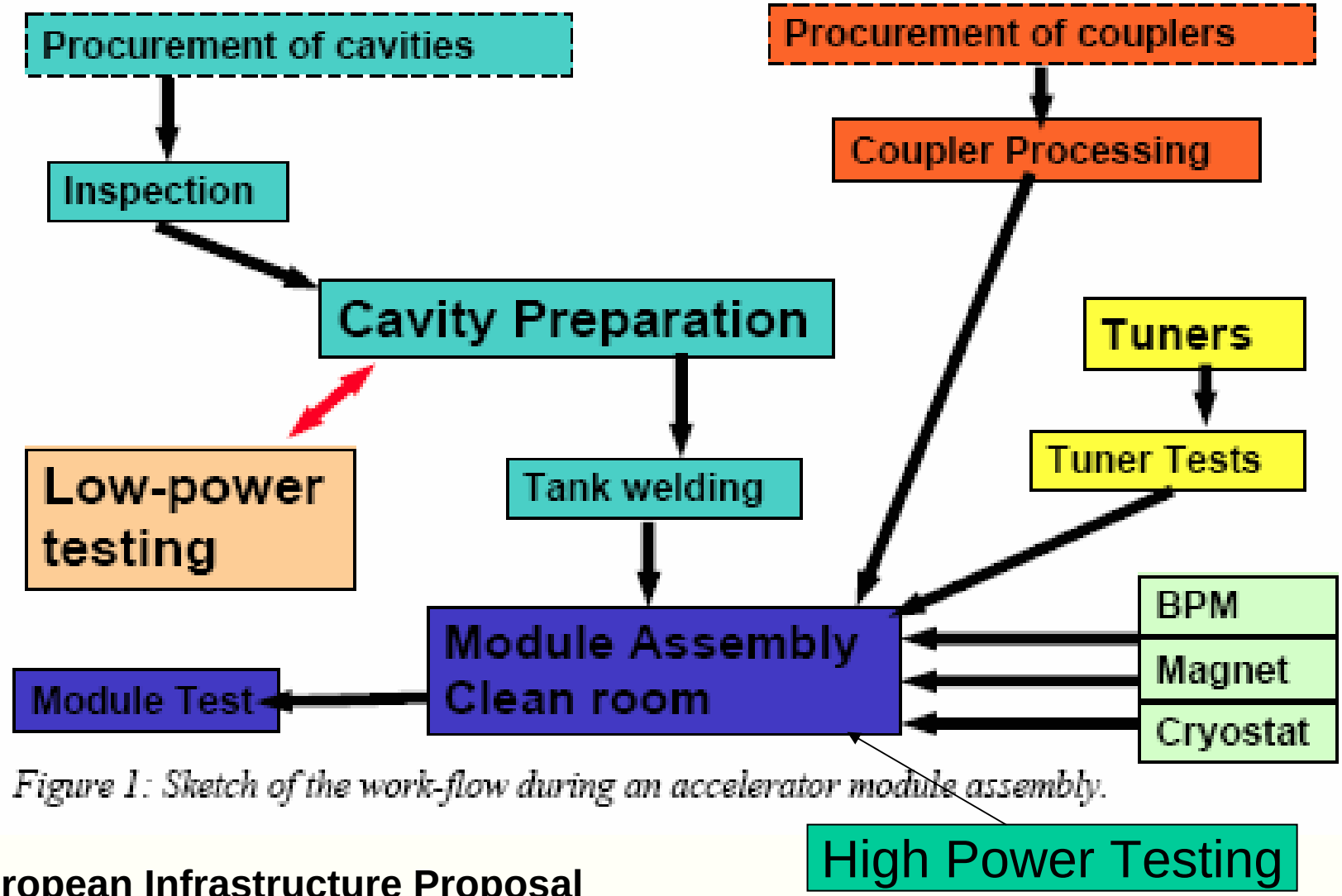

Figure 1: Sketch of the work-flow during an accelerator module assembly.

European Infrastructure Proposal

Infrastructure for Cavity and Cryomodule Fabrication, Testing

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- **Bare cavity production**
  - Niobium QC
  - Fabrication facilities (e.g. Electron beam welders)
  - Buffered Chemical Polish facilities (BCP) for cavity parts pre-welding
- **Pre-Production Cavity Processing**
  - Tuning for field flatness
  - Surface Processing (Tumbling, BCP and Electro Polishing)
  - Ultra clean H_20 & High Pressure Rinse systems
  - Furnace for 600 – 800 C bake (removal of H)
- **Vertical Test facilities (Cryogenics + low power RF)**
- **Cavity Dressing Facilities (cryostat, tuner, coupler)**
  - Class-10/100 clean room
- **Horizontal cavity test & Coupler test facilities (RF pulsed power)**
- **String Assembly Facilities**
  - Large class-100 clean rooms, Large module assembly fixtures
  - Class-10 enclosures for cavity inner connects

US Program (ILC-ART & OPR)

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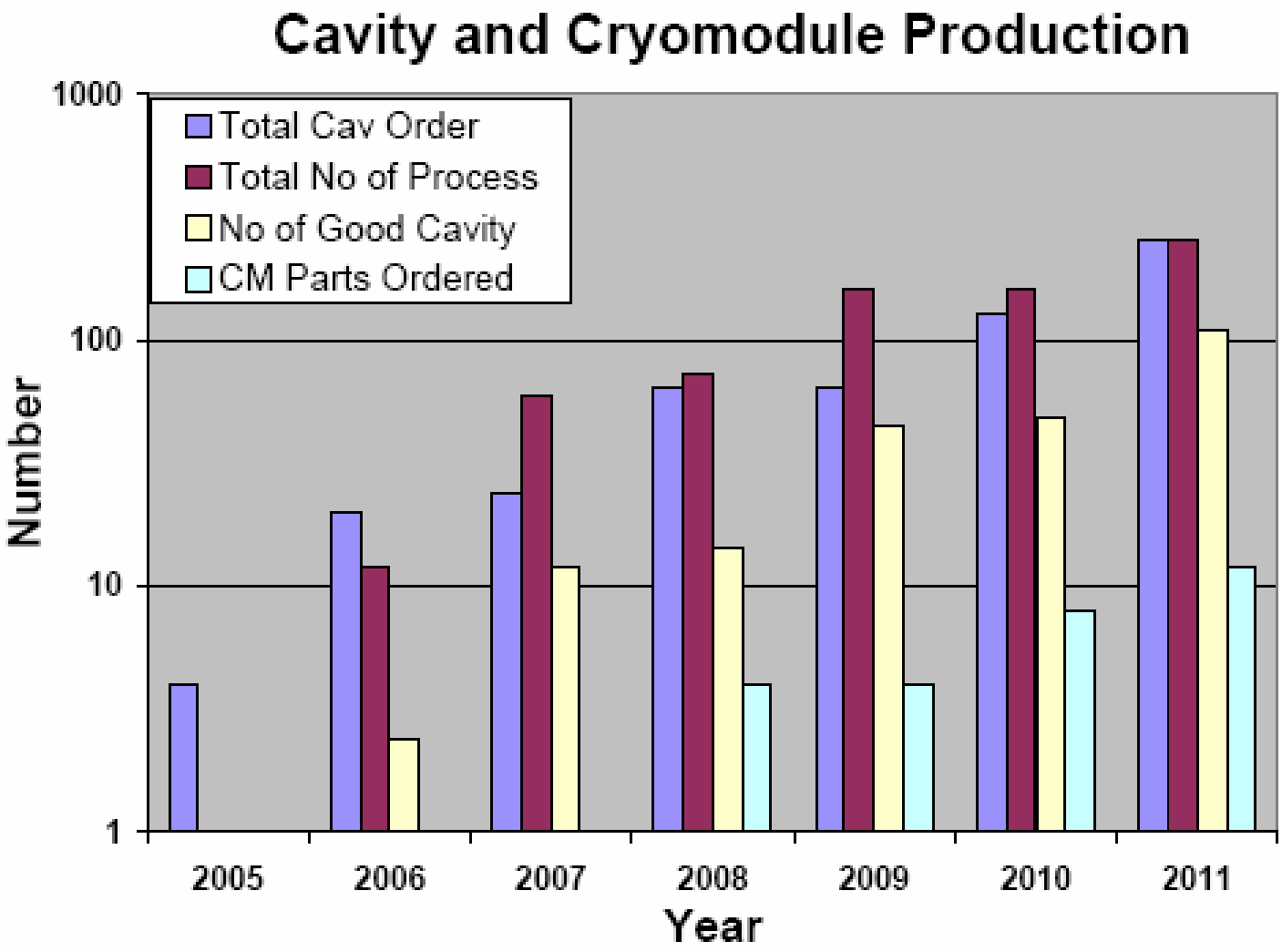

Scope: US Laboratories Capacity

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Program	FY07	FY08	FY09	FY10	Capacity Needed/yr by FY10
Cavity Processing (EP, HPR, Bake) Cycles/yr	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
Vertical Testing	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
Horizontal Testing	Fermilab-6	Fermilab-24	Fermilab-24	Fermilab-72	72
Cryomodule Assembly	Fermilab-1	Fermilab-4	Fermilab-8	Fermilab-12	12
Cryomodule Test	Fermilab: ILCTA_NML	Fermilab: ILCTA_NML	Fermilab: ILCTA_NML	Fermilab: ILCTA_NML CMTS	12

Scope: Fermilab SRF Infrastructure

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- Cavity Fabrication
  - Increased cavity fabrication R&D and training US industry
    - Electron Beam Welder
    - Eddy Current Scanner
  - Automated Cavity Tuning
    - 100+ Cavity/yr (by FY09)
- Cavity Processing Facility (Pre-Production Facility, existing technology with industry, modular and redundancy)
  - 100+ Cycles/yr (by FY09)
- Vertical Testing
  - Additional 100+ Cavity/yr (by FY09)
- Horizontal Test Stand
  - Additional 48 Test/yr (Maximum US Capacity needed)
- Cryomodule Assembly
  - 1 per month
- Material R&D

Development of Industry

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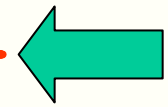
Cryomodule Process	Starts with	Transitions to
Cavity Fabrication	Lab/Industry Collaboration →	**Industry**
Cavity Processing	Lab/Industry Collaboration →	**Industry**
Low Power Test (VTS)	Laboratory →	Laboratory
Cavity Dressing	Lab/Industry Collaboration →	**Industry**
High Power Test (HTS)	Laboratory →	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.

Cavity Preparation Infrastructure

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- **The proposed infrastructure will improve over the existing infrastructures**
  - **Present infrastructures are single-line processing R&D infrastructure**
    - **Failure in one process chain leads to unacceptable delay in schedule**
  - **New Infrastructure will have**
    - **All cavity processing under one clean environment**
    - **Redundancy in layout**
    - **Modularized for maintainability and flexibility**
    - **Flexibility: Implementing change in the overall production scheme**
    - **Quality Assurance and control process**
    - **Available for use for other projects**

Model: Processing and Testing Infrastructure

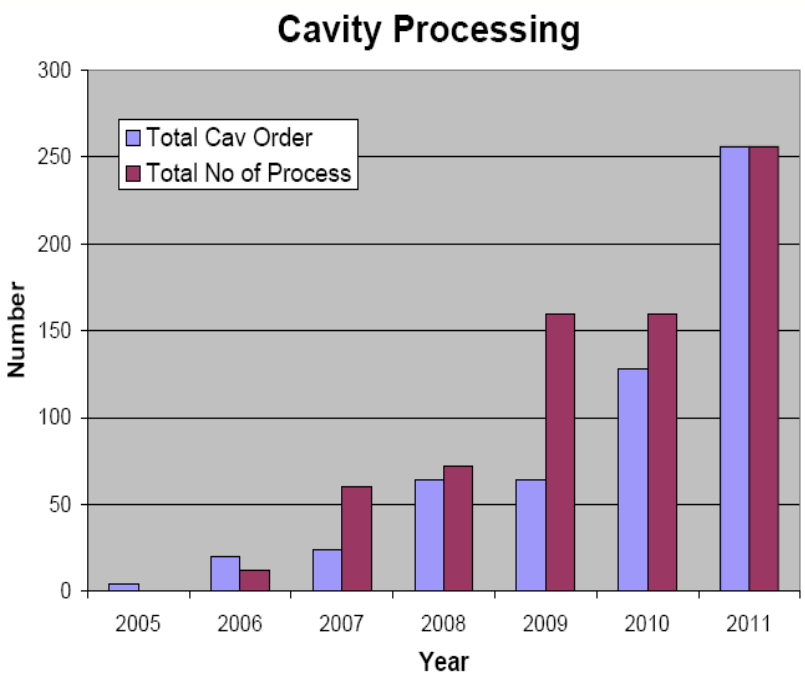
- Degrease & EP 80 um (3 days)
- HPR 1 day
- Drying 1 day
- H-removal, 600 – 800 C (3 days)
- Tune field flat (1 day)
- EP 10 um (1 day)
- HPR (1 day)
- dry (1 day)
- First stage assembly & HPR (1 day)
- Dry 1 day
- Final assembly to bake stand, evacuation (1 day)
- 120 C on bake stand (2 days)
- Assembly to test stand (1 day)
- Cold test, warm up (3 days)

Total 21 days (4 weeks)

Test set-up has maximum 4-day, rate limiting time

- Assume one set-up each per facility
- Max cycles = 5 per month (20 days) = 60 per year
- Down time and maintenance time may reduce this
- Calculation Estimates: 50 per year max
- Jlab estimates : 40/year

A R&D Model



As defined by ILC-ART & OPR

Schematic of Cavity Processing Facility

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Each EP, HPR .. System can do ~40 cy/yr

EP Systems: 2 (1 Spare)

HPR Systems: 2 (1 Spare)

BCP Systems: 1 (1 S)

Vacuum Furnaces: 2

Low Temp Furnaces: 2

Cavity Tuning: 1

Tumbling: 1

Clean Rooms

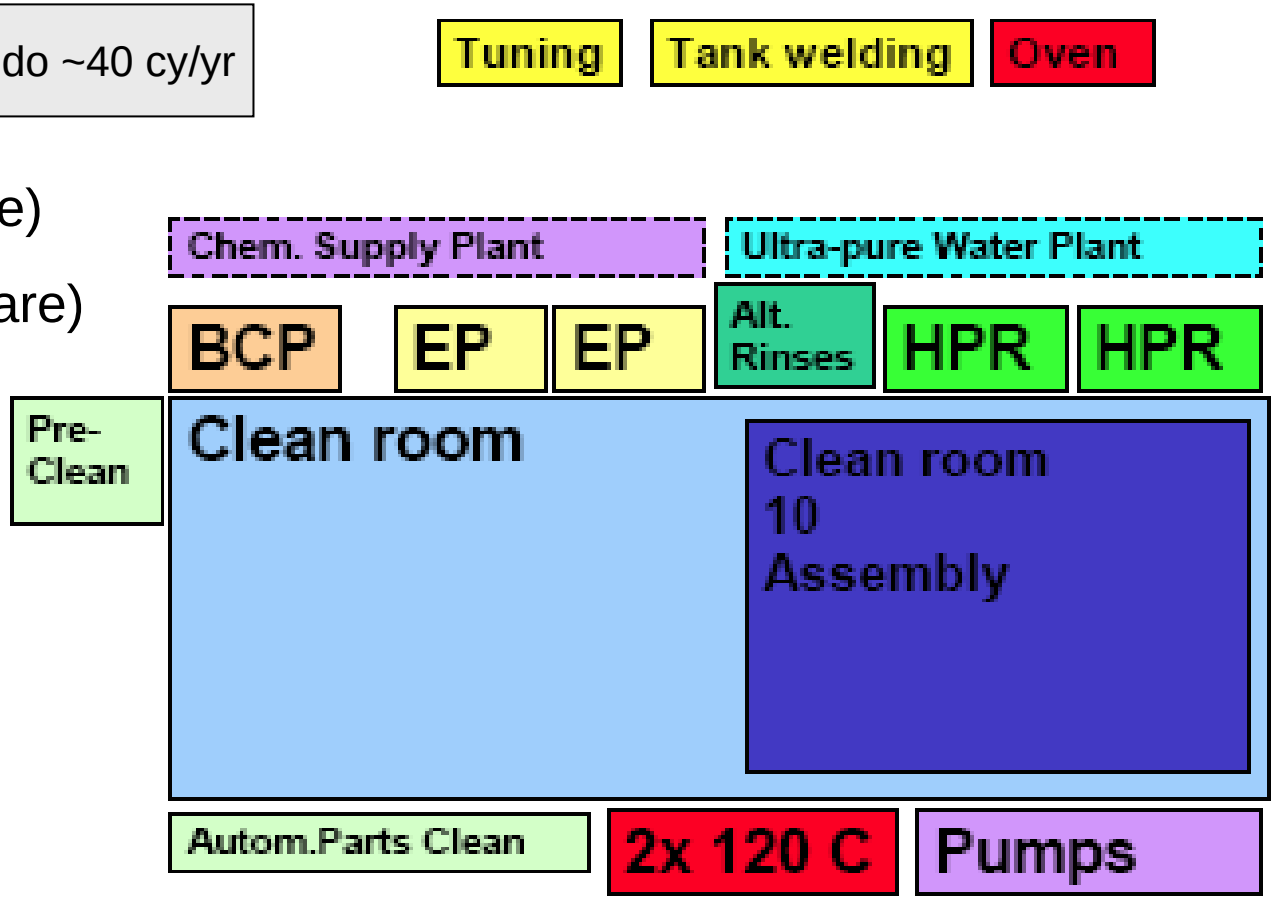
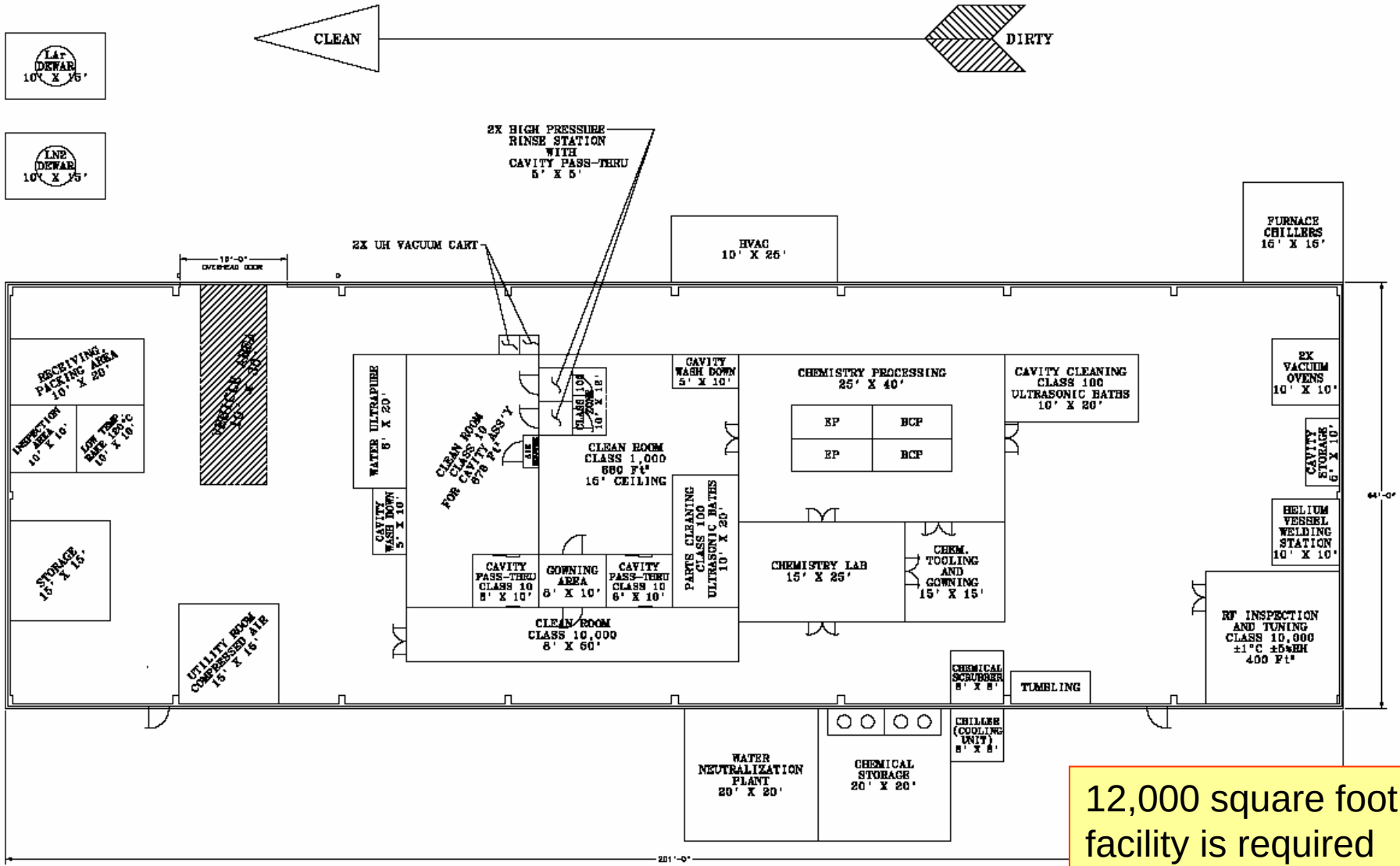


Figure 2: Sketch of the cavity preparation infrastructure.

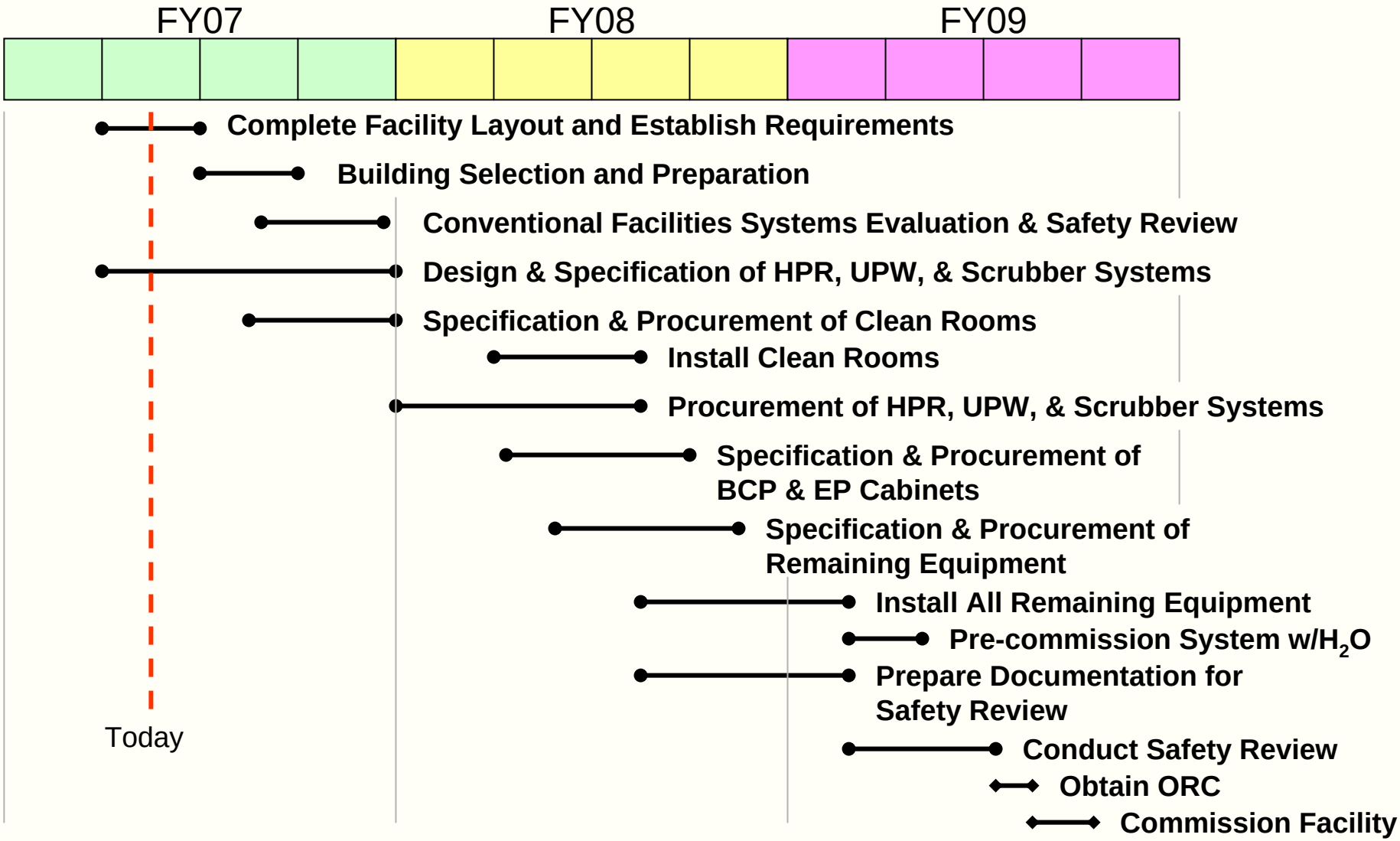
European Infrastructure Proposal

CPF Floor Plan at MW



12,000 square foot facility is required

CPF Schedule Timeline



Alternative: An Off-Site CPF

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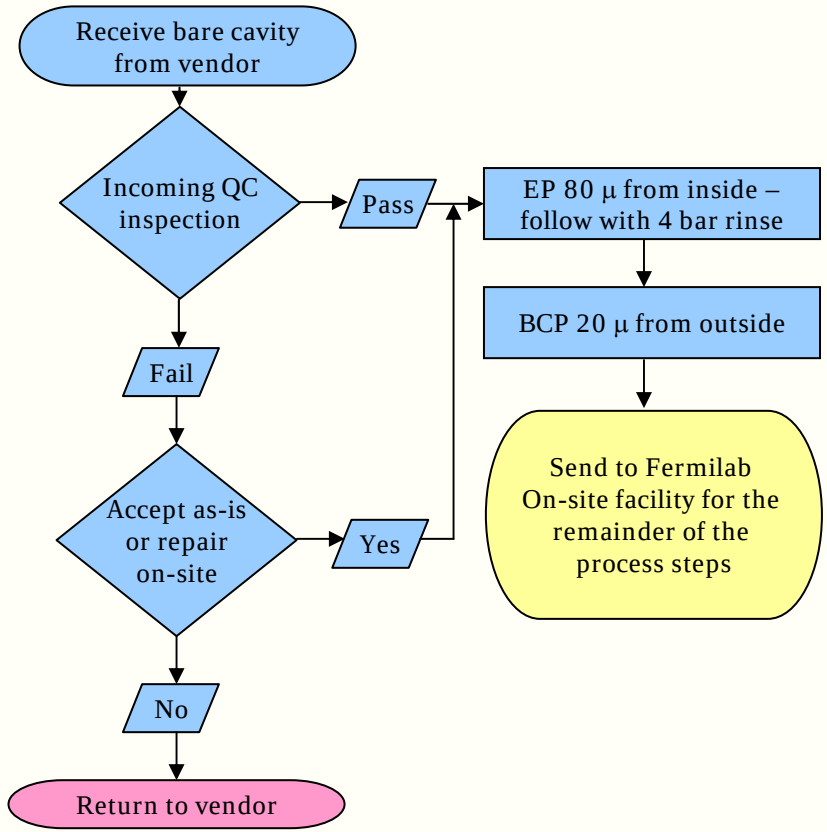
- A contract could be written for the design, construction, and operation of an off-site facility located very near FNAL.
- Facility would be financed by ILC funds and owned by government, but operated by industry
- Advantages:
  - Operation by an experienced electropolishing industrial firm using their manpower
  - Significantly reduces the need for large quantites of nasty chemicals on FNAL site
  - Initiates the industrialization program cavity processing
- Unknown total cost, estimate

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



Present: Vertical Test Facility-1

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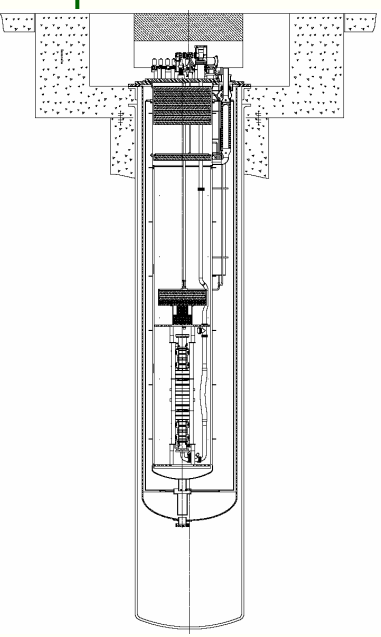
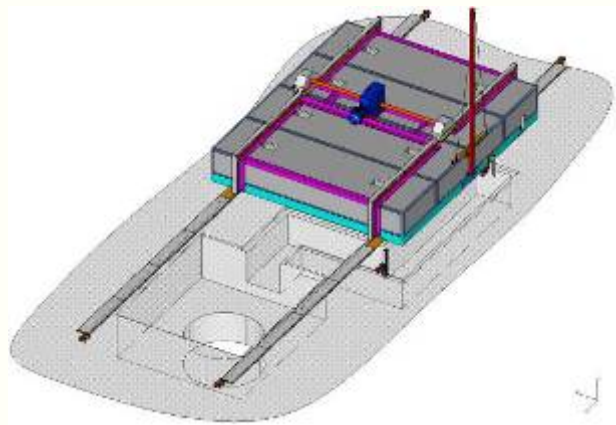
- **A Vertical Test Stand is under Construction at Fermilab (IB1)**
  - **Existing Cryogenic plant in IB1 has the capacity of 125 W at 2 K (250 W available for intermittent test)**
  - **Test Stand will be capable of testing ~50 Cavities/yr**
  - **Commissioning late summer 07**



Cryostat at PHPK



Proposed: Vertical Test Stand 2 & 3

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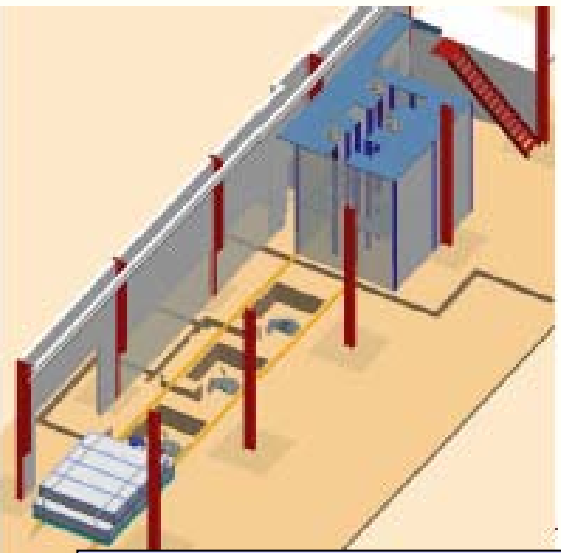
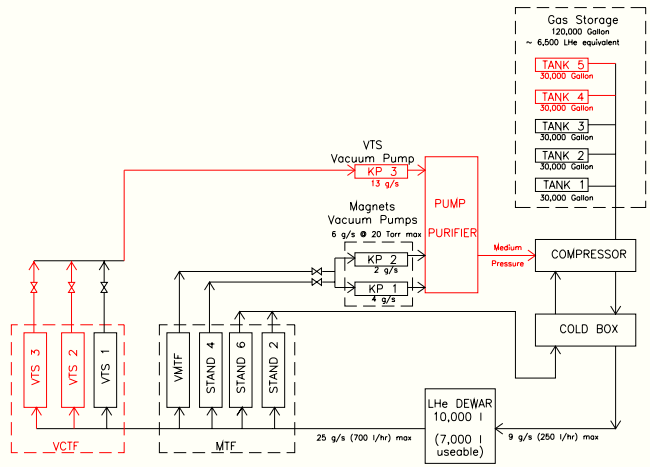
- To increase the capacity of the VTS
  - Upgrade the VTS-1 for 2 cavity operation (~75 cy/yr)
  - Add 2 more VTS pits (VTS-2 and VTS-3) (~200 cy/yr)
  - Upgrade the cryogenic infrastructure (decouple from superconducting Magnet test)
  - Upgrade the cavity staging area
- To support cavity R&D: Field emission studies and Quench Location





Vertical Test Stand 2 & 3

Present: Horizontal Test Stand - 1

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- Horizontal Test Stand -1 is getting ready for commissioning at Meson.
  - The maximum capacity of this test stand is ~24 cavities/yr
- It will be debugged with a cavity from DESY in early spring.
  - This cavity is getting prepared by Jlab.
- The commissioning of the HTS will happen with AC7 (9-cell, 41 MV/m) cavity.
  - Coupler from DESY
  - Tuner and He Vessel from INFN to Penn, Getting commissioned at Penn
  - Will be dressed at Jlab

Cavity Testing Infrastructure

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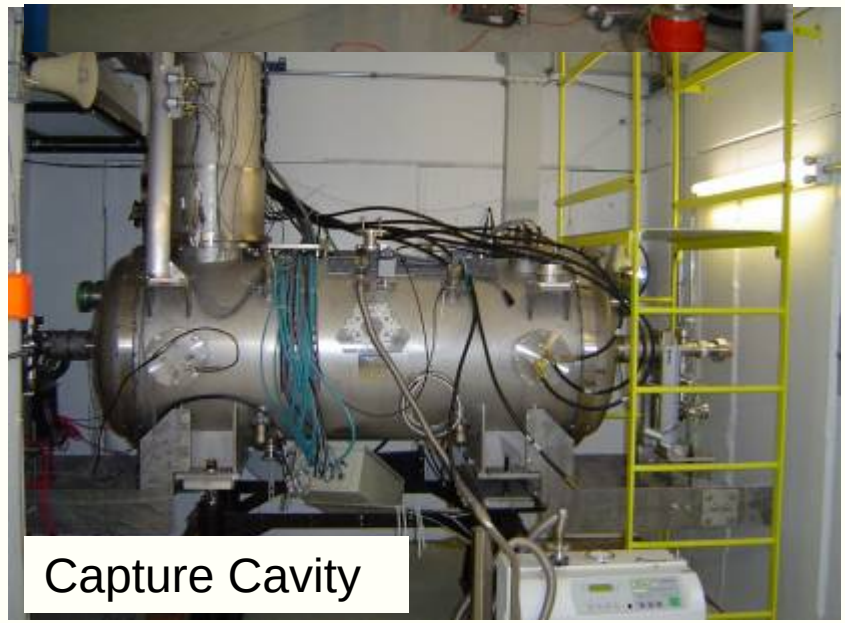
RF Power for HTS

Cryogenics for HTS ready at 2 K

Cryogenics for HTS getting ready for 2 K



Capture Cavity

Summary

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- The Main Linac Cavity and Cryomodule R&D program and Infrastructure development
  - Impact and contribute toward the critical ILC R&D
  - Build a minimal facility at Fermilab
  - Train people in SRF at Fermilab
- Get the US industry involved from the initial phases