1.3 GHz Superconducting RF Cavity Program at Fermilab

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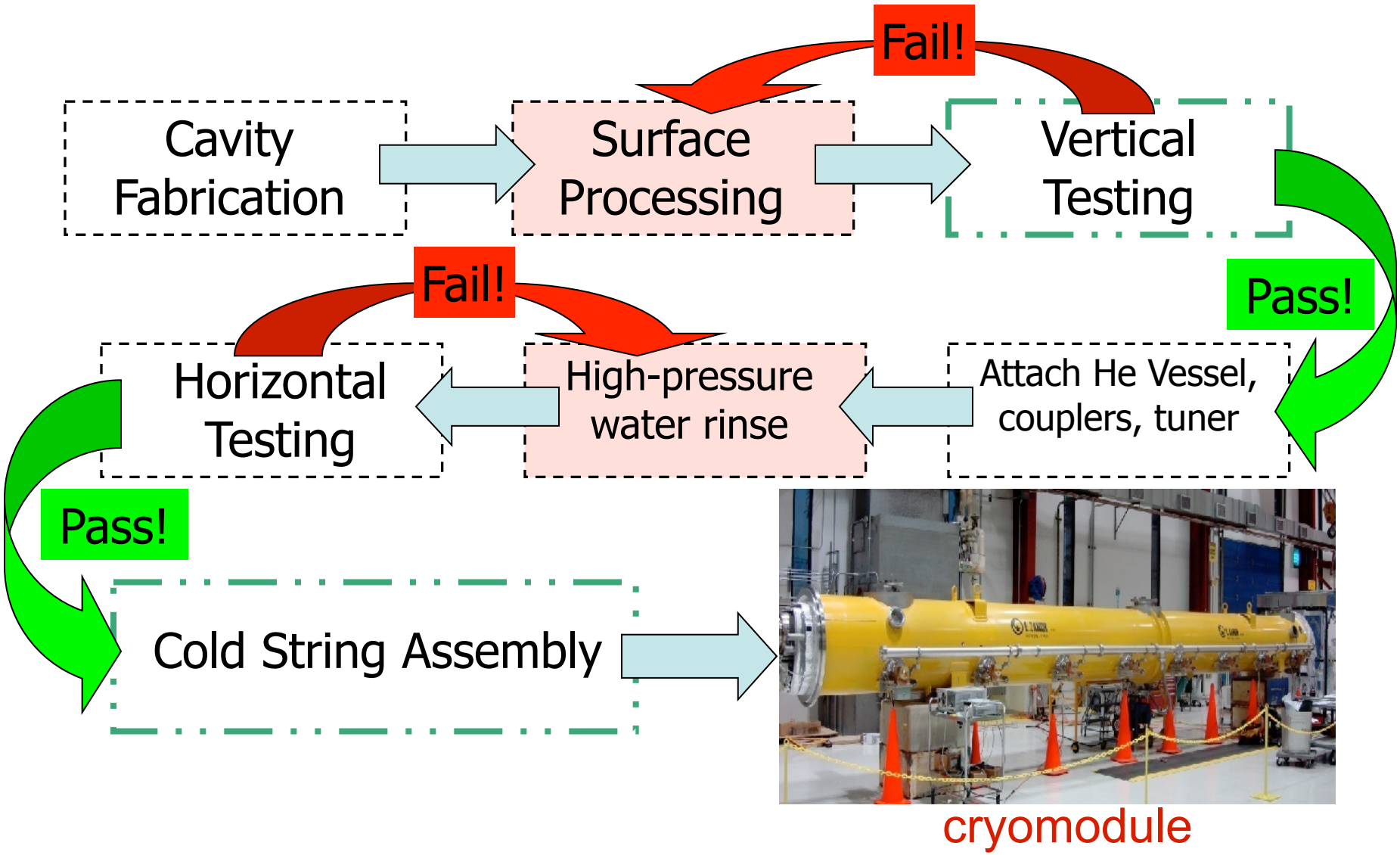
Fermilab

Overview

- 1.3 GHz SRF activity at FNAL supports Project X, ILC R&D, or other future SRF projects, and includes vendor development and associated cavity R&D for improved performance and reliability, and reduced cost
- Six 1.3 GHz cryomodules will be built at FNAL in the next few years
  - 1st cryomodule CM1 was built from a kit of parts supplied by DESY
  - Preparation of cavities and assembly infrastructure for CM2 is ongoing
- Facilities have been completed and some are being upgraded
  - FNAL/ANL cavity processing facility: surface processing and vertical/ horizontal test prep
  - Vertical test system: bare cavity CW low-power acceptance test
  - Horizontal test system: dressed cavity pulsed high-power acceptance
  - Cryomodule assembly facility: dressed cavity ass'y into cryomodules
  - Cryomodule test facility at NML
- Overall goals of the 1.3 GHz SRF cavity program, supporting facilities, and accomplishments are described

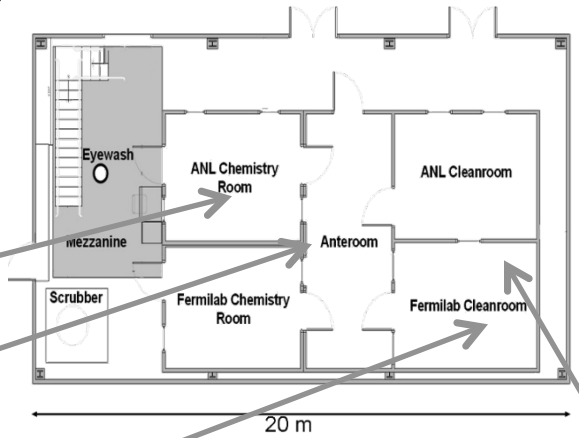
From Cavity to Accelerator



cryomodule

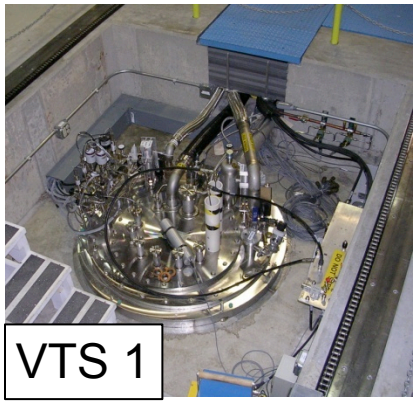
ANL/FNAL process/ass'y facility

- Located at ANL; designed, built, and operated jointly
- Electropolishing (EP) of 1-cell and 9-cell ILC-style cavities
- Ultrasonic rinse tank
- High-pressure water rinse (HPR) tool
- Clean rooms of class 10, 100, 1000
- Cavity vacuum system

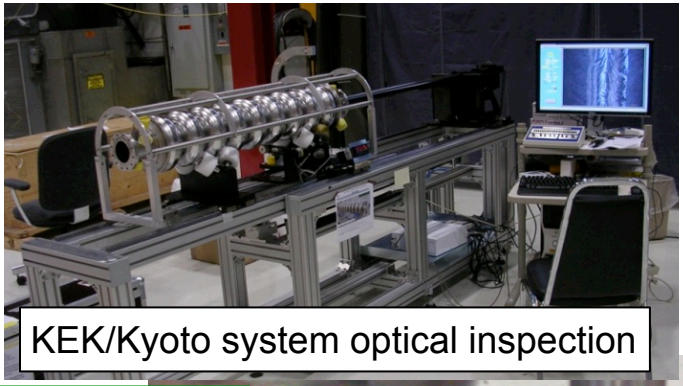


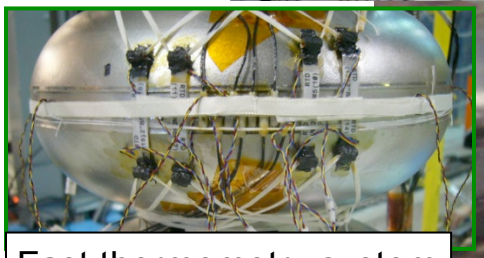
Bare Cavity Qualification

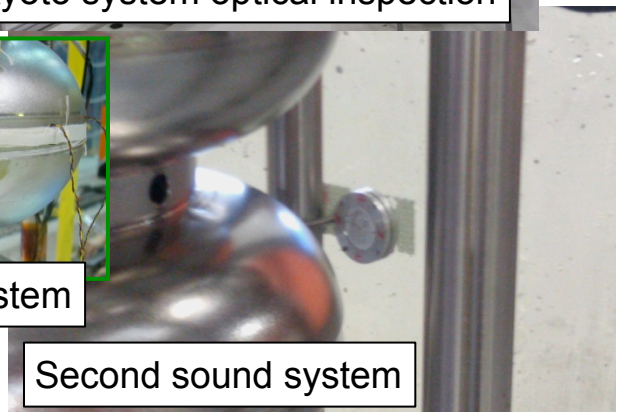
- One radiation shielded and magnetically shielded bare cavity test cryostat (VTS) in operation, typically operating at 2K
- Performance diagnostics include Cernox sensor “fast” thermometry, a new second sound system (adapted from Cornell), and routine, automated internal inspection of irises/equators (KEK/Kyoto system)
- One larger cryostat was delivered last week; another to be built in industry


VTS 1


VTS 2/3

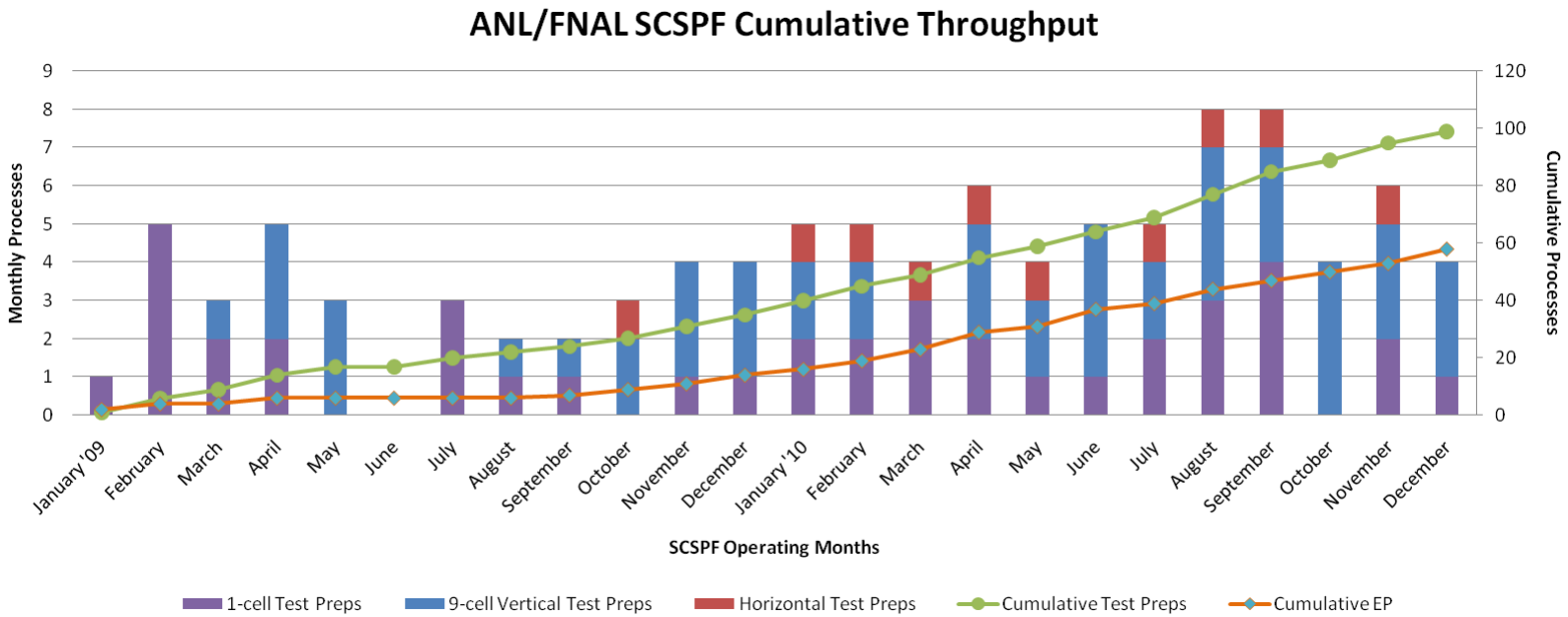

KEK/Kyoto system optical inspection


Fast thermometry system


Second sound system

Suhane et al. TUP033
Maximenko and Sergatskov TUP082
Khabiboulline et al. TUP074

FNAL/ANL Processing/Test Throughput

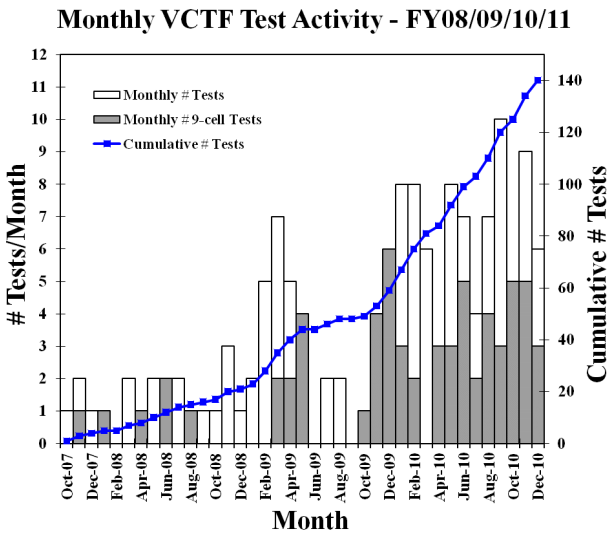


CY2010: **Surface process or test prep**

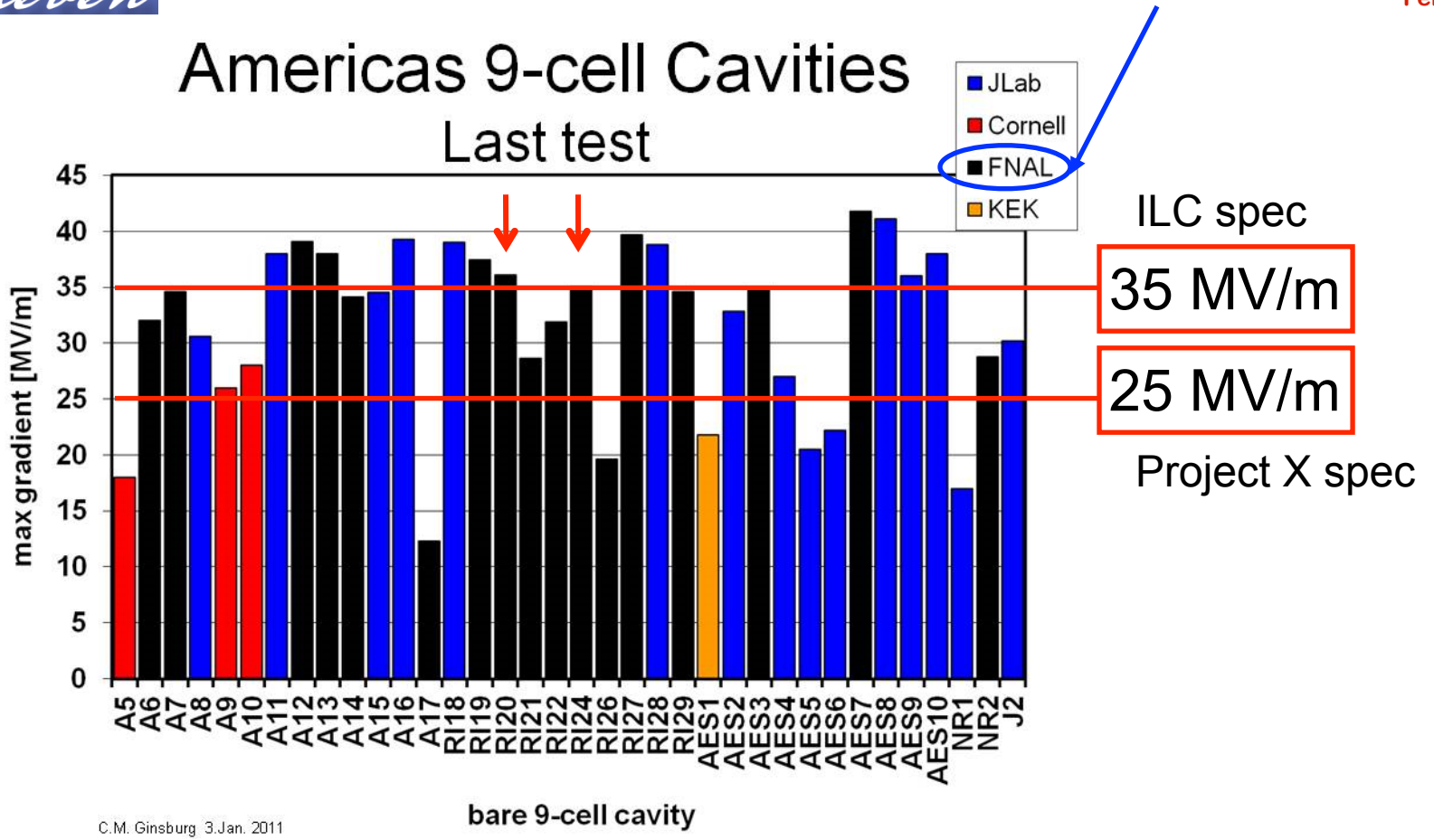
- ❑ 44 electropolishing cycles
- ❑ 23 1-cell vertical test preps
- ❑ 32 9-cell vertical test preps

CY2010: **81 vertical tests**

- 38 9-cell, 39 1-cell, 4 R&D cavity tests



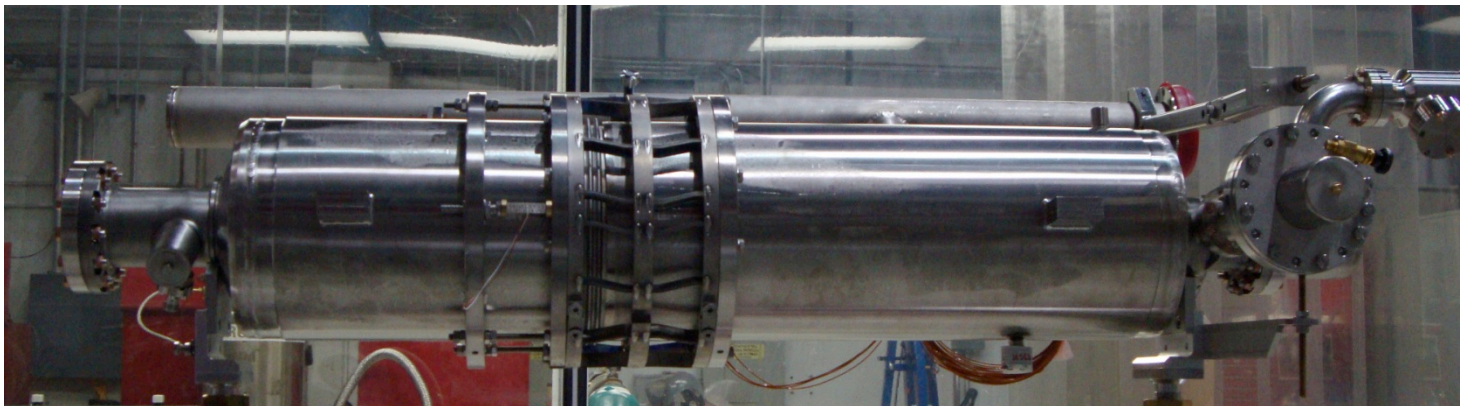
Fermilab 9-cell cavity tests



- Many well performing cavities, including two cavities processed and tested at FNAL/ANL reaching ILC specification
- FNAL 9-cell tests done in strong collaboration with JLab and ANL, with important assistance from Cornell, KEK and DESY

Cavity Dressing

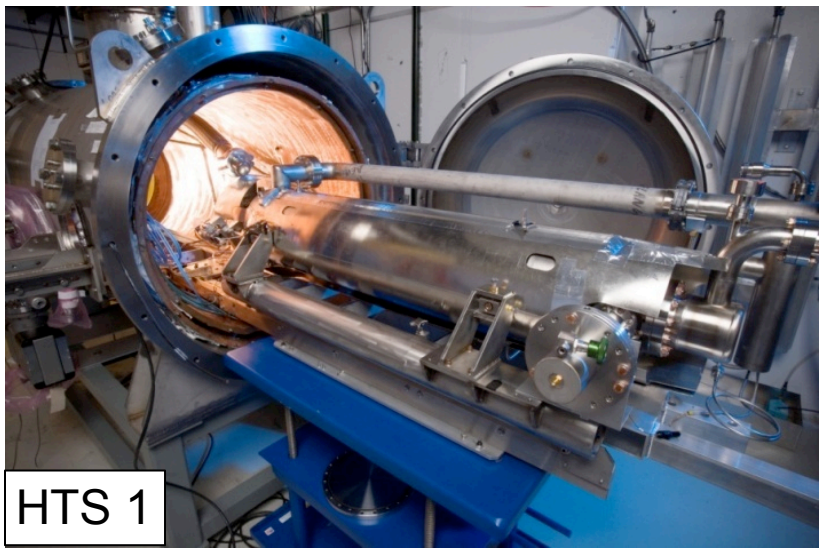
- 17 cavities have been dressed for CM2 and subsequent CM's



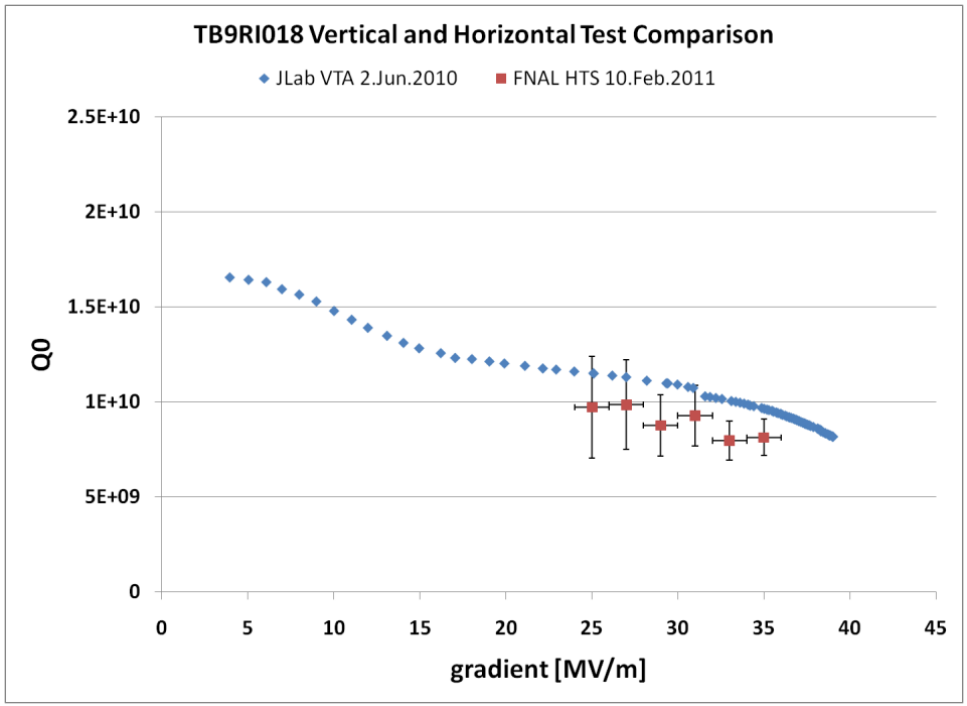
- Weld (TIG) on helium vessel with helium two-phase pipe
- Magnetic shielding
- Blade type slow tuner (INFN Milano), piezo fast tuners
- High power coupler is TTF3 type (DESY)

Dressed Cavity Qualification

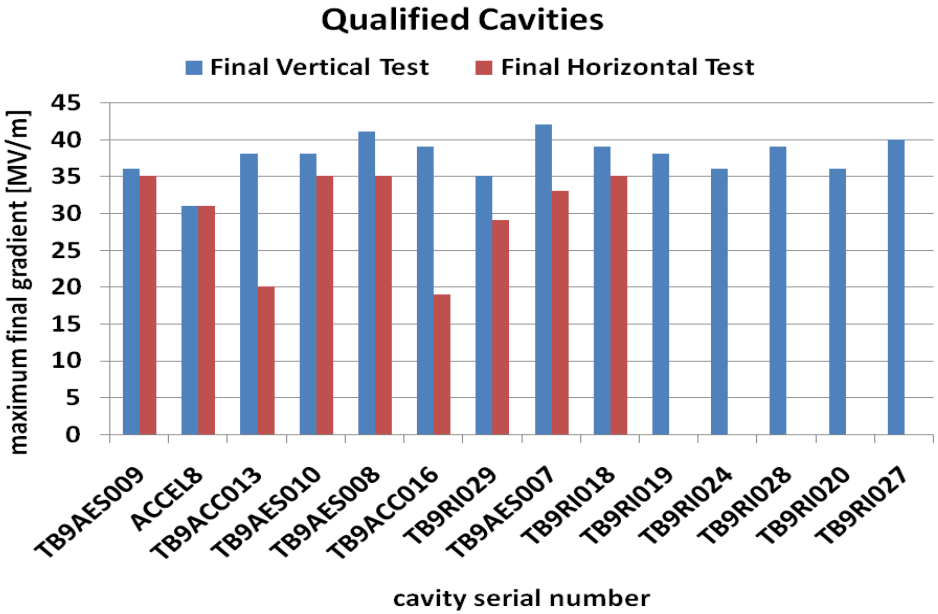
- One dressed-cavity cryostat (HTS), operating@2K
- Tuner (fast and slow) tests, coupler conditioning, cavity performance
- New larger cryostat to cooldown two cavities simultaneously under devel.
- Have completed horizontal tests of ten 1.3 GHz 9-cell cavities
  - One cavity went to S1-Global CM
  - Three reached at least 35 MV/m
- Good agreement between vertical and horizontal test performance



Hocker et al. TUP071
Pischalnikov et al. TUP082



Status of Cavities for CMs



- Fourteen cavities candidates for CM2; 13 pass ILC spec in vertical test
  - Three of these processed at FNAL/ANL, remainder at JLab
- Horizontal tests in progress
- Administrative gradient limit 35 MV/m imposed for horizontal tests after degradation of TB9ACC013 by arc event in input coupler
- TB9ACC013 and TB9ACC016 not tested with ILC pulse length due to FE
- Most instances of cavity degradation can be traced to FE
- Vacuum practices in all facilities under review; improvements expected

Cavity R&D topics

- Manufacturing/quality assurance optimization
  - Eddy current scanning investigation
  - X-ray tomography of welds
  - Cavity performance studies for cavity vendor fabrication qualification
- Cavity surface repair and surface processing optimization
  - Tumble polishing (repair or primary process), laser re-melting (repair)
    - Example of tumble-repaired 9-cell cavity: 19 -> 35 MV/m after tumble+EP sequence
    - Studies of performance as a function of surface finish
  - Dressed cavity electropolishing
- Basic SRF R&D
  - Understanding medium- and high-field Q-slope, associated with process type
  - Materials science of hot and cold spots using cut-outs
  - Optimization of RF surface properties: surface morphology, contamination, coatings, ...

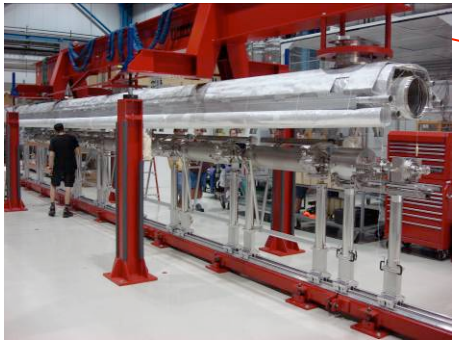
Cooley THOCS2

Cavity string/cold mass ass'y

CM1: a TESLA-style eight-cavity 1.3-GHz cryomodule

Receive dressed cavities and peripheral parts at CAF-MP9

Assemble dressed Cavities to form a String in the **Cavity String Assembly Area** (Clean Room)



Install String Assembly to Cold Mass in the **Cold Mass Assembly Area**

Transport the Cold Mass to **CAF-ICB**

Cryomodule ass'y completion

Install the Cold Mass at CAF-ICB back to the Cold Mass Assembly Fixture in **Cold Mass Assembly Area**

Align Cavity String to the Cold Mass Support

Install the String assembly with the cold mass into the Vacuum vessel in the **Vacuum Vessel Assembly** area

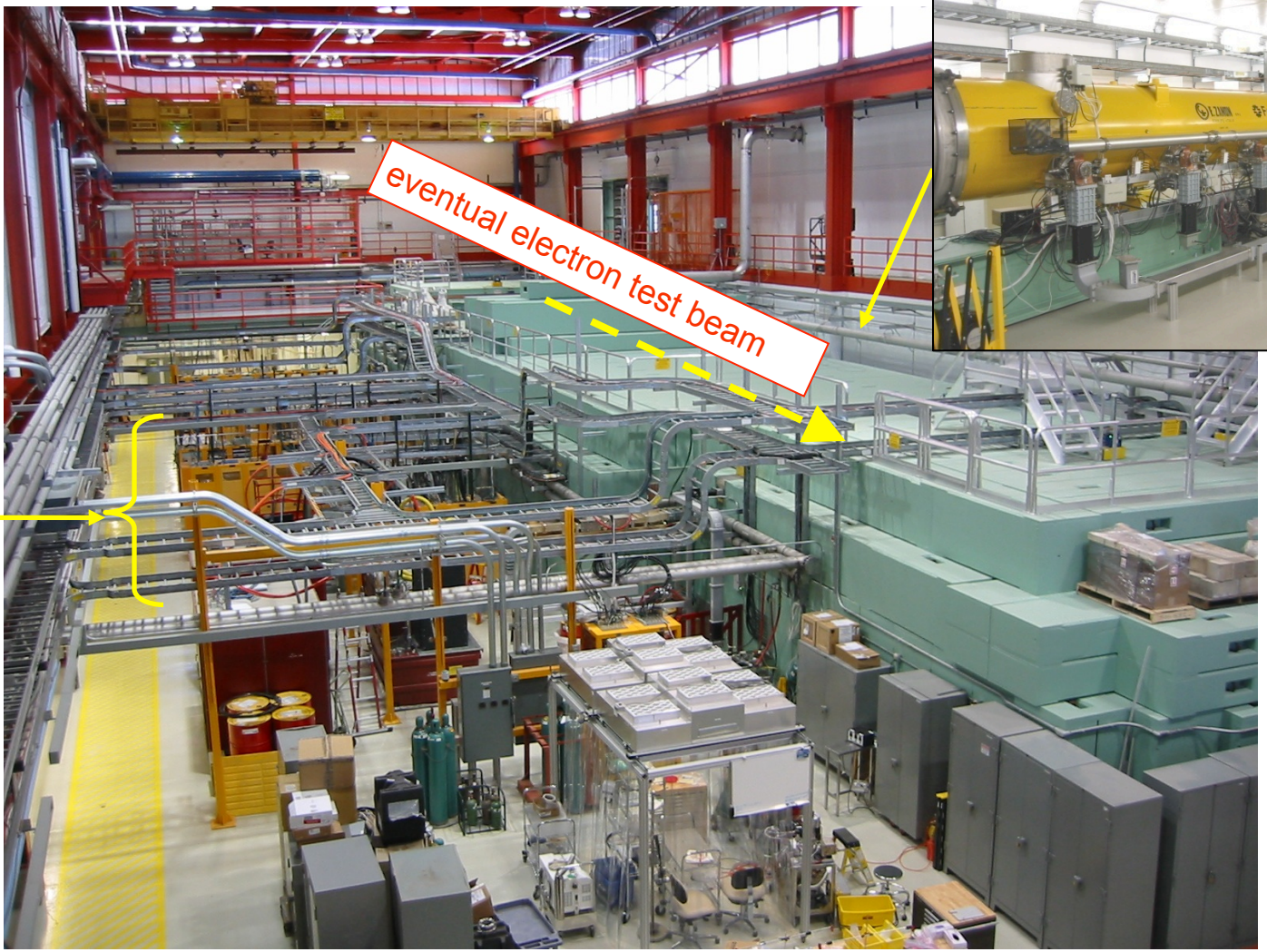
Ship Completed Cryomodule to **NML** for testing

NML Project Overview

- Overall Goal
  - Build a cryomodule test facility at the New Muon Lab building (NML) with ILC-like electron beam, using one, three and up to 6 CM's
    - Various Project-X parameters will also be tested with beam
  - Provide a state-of-the-art facility for conducting advanced accelerator R&D [accelerator components, beam dynamics, instrumentation]
- Current Phase
  - Infrastructure, RF power, cryogenics operational
  - First cryomodule (CM1) and Capture Cavity-2 (CC2) installed and being tested *without* beam
- CM1 tests at NML (no beam)
  - In 2010: final installation at NML, warm coupler conditioning, tuner tests, and cooldown to 2K
  - Cold RF tests ongoing since Dec 2010
    - Cold coupler conditioning and cavity performance tests in progress
    - Of three tested so far, two cavities have retained their previous performance

Leibfritz et al. MOP009

NML cryomodule test facility



Summary/Plans

- Processing/preparation/test facilities providing well performing cavities
  - Most processes are becoming routine after many 10's of cycles
  - Bare cavity processing throughput targets for CY2011 represent a 25-30% increase over CY2010
  - Incremental and R&D process development ongoing
- Aim to get 1.3 GHz SRF cavities qualified, dressed, and into cryomodules
  - Continue incremental improvements
  - Understand and eliminate cavity performance degradation among CM preparation stages - dressed cavity improvement is high priority
- Finish building 6 cryomodules in the next few years, starting with CM2
- Test them in the new NML facility, also with beam
- Have exercised nearly all steps in building a 1.3 GHz ILC-like cryomodule in preparation for next projects, e.g., Project X

Champion et al. THOCS6
Nagaitsev et al. FROBN3