Cavity R&D Activities in US

Review of RDR work and plans for EDR

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Fermilab/ART

Outline

- Technical Goals (Including Dressed Cavity)
- FY06-07 Activities
  - Cavity Fabrication (1.3 and 3.9 GHz)
  - Cavity Processing and Testing
    - Jlab
    - Cornell
    - ANL/FNAL
  - Cavity Yield improvement
  - Infrastructure Development
  - Industrial Development
- Plans for FY08-09
  - Infrastructure Development
- Summary

Technical Goals

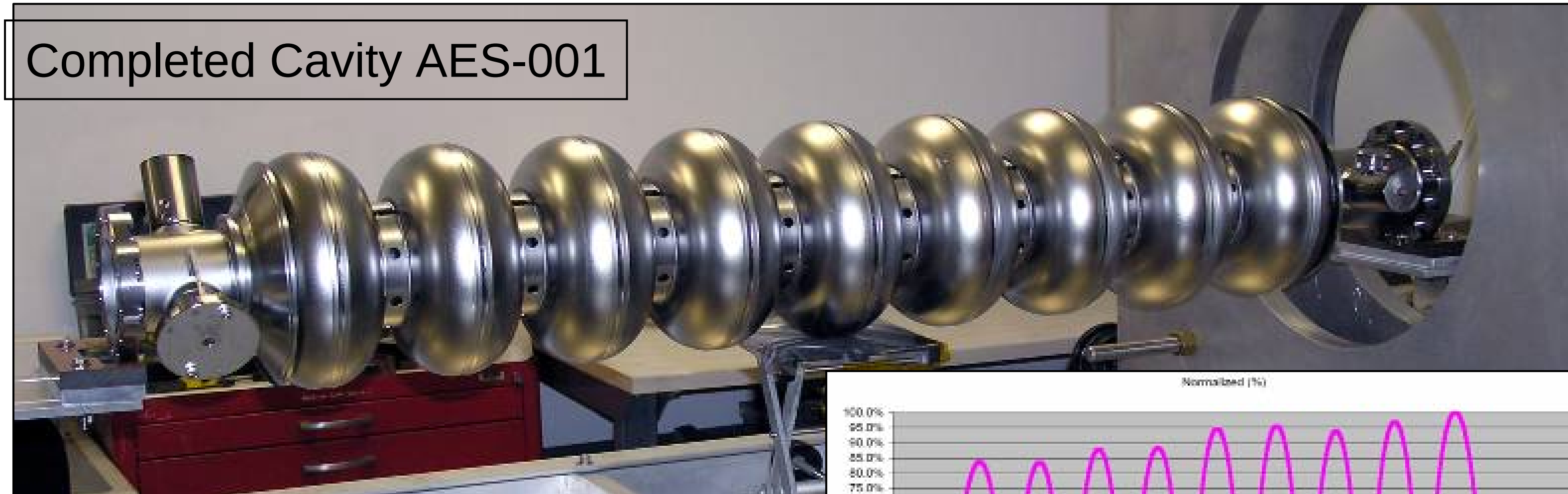
- Demonstrate the basic ILC Main Linac technology
  - Develop cavity processing parameters for a reproducible cavity gradient of 35 MV/m; improve the yield of 9-cell cavities for gradient of 35 MV/m in vertical tests (S0.1).
  - Carry out parallel/coupled R&D on cavity material, fabrication, and processing to identify paths to success (S0.2).
  - Assemble and test several cryomodules with average gradient > 31.5 MV/m (S1).
  - Build and test one or more ILC rf units at ILC beam parameters, high gradient, and full pulse rep rate (S2.1).
  - Carry out Key Alternate Design R&D item ("forward looking" approach)
    - Re-entrant, Low Loss, End Group, etc.
  - Improve ILC performance, reduce cost
- Install Sufficient Infrastructure to support these activities

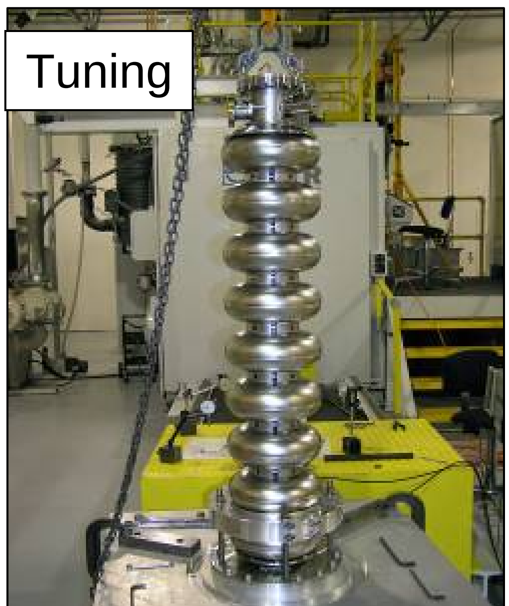
US Cavity

- **Number of cavity goal:** Fabricate 1/3 of the Cavity needed for the Global S0 program, with focus on getting US Industry involved and qualified
  - FY05
    - 4 Cavities from ACCEL (Type-III+ length)
  - FY06
    - 4 Cavities from AES (Type-III+ length)
    - 4 Jlab (2 Fine, 2 Large)
    - 9 Cavities from ACCEL (To be delivered by 12/31/07)
    - 6 Cavities from AES (To be delivered by 12/31/07)
  - FY07
    - 12 Cavities (ACCEL) (Mid FY08)
    - 12 1-cell Cavities (AES & ACCEL) (AES 9/18/07, ACCEL 12/31)
  - FY08-09
    - 24 & 60 Cavities (Planned)

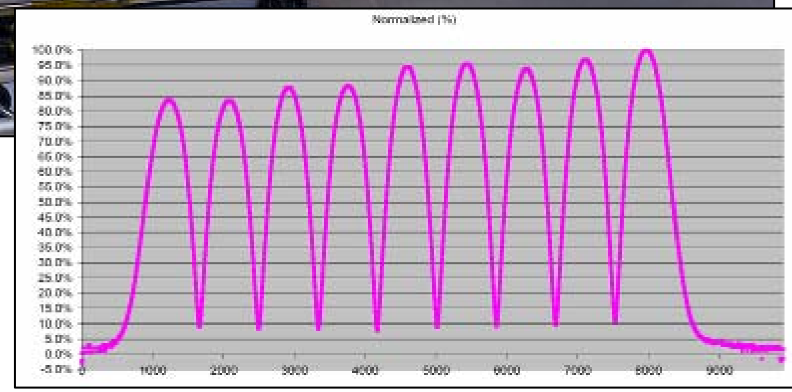
Most of these cavities are fine grain Nb and ILC design

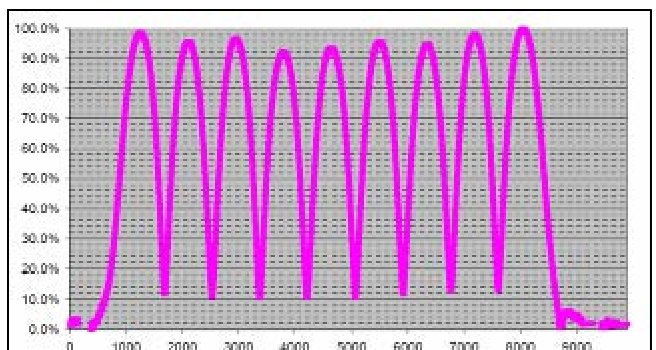
AES - 001





Bead pull Before Any Tuning ➔





🡐 Bead pull After Tuning

Cavity Fabrication & Industry Development

- As a first step toward developing additional US vendors for cavity fabrication, a program has been funded with Roark Engineering.
  - Roark is building three 3.9 GHz single-cell cavities to develop expertise in niobium machining, forming and EB welding.
  - Tooling for forming the half-cells was provided by FNAL.
  - Final welding of the three cavities is in progress and delivery is expected by the end of September.
- A "Teaming Agreement" between Niowave and Roark Engineering was formed recently.
  - Both firms will share expertise and facilities.
  - Each will fabricate three 1.3 GHz single-cell cavities.
  - In the second phase of this effort the Niowave/Roark collaboration would fabricate 1.3 GHz ILC style nine-cell cavities.
    - This phase will be contingent upon first phase results.

PAVAC: Canadian Cavity Vendor

Who is PAVAC?

- A Canadian Company located in Richmond B.C.
- TRIUMF is presently prototyping two bulk niobium quarter wave cavities with PAVAC

Our new 10,000 + square feet facility at:
12371 Horseshoe Way
Richmond, B.C., V7A 4X6

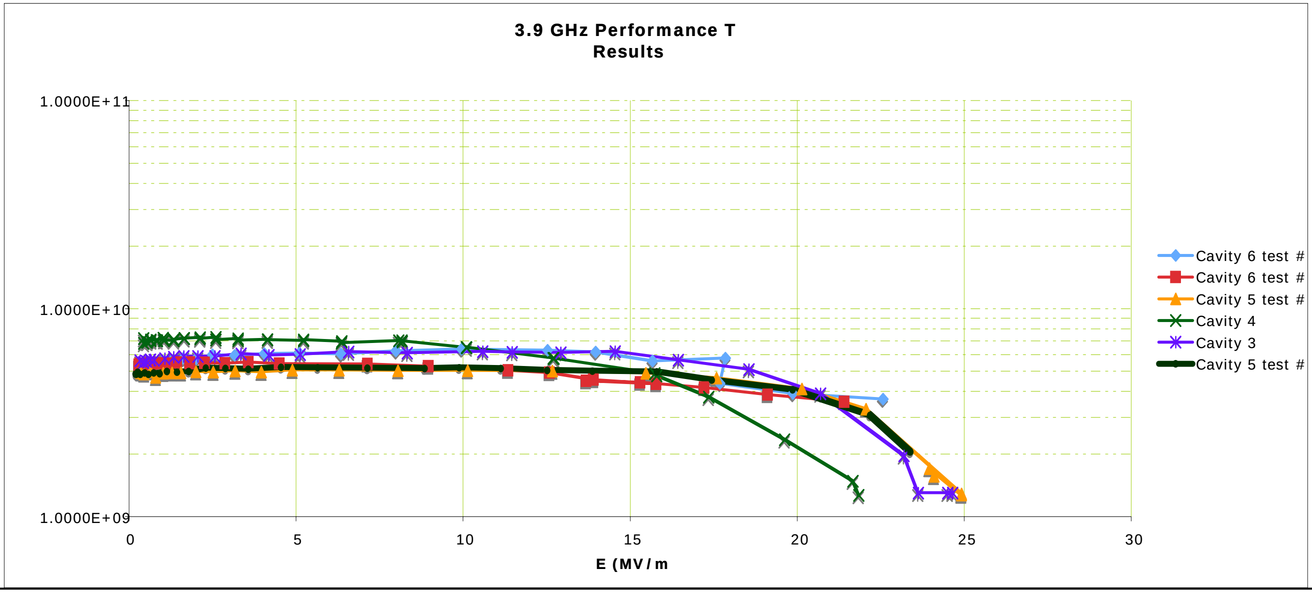
The LASTRON technology services and systems offered for

- Electron Beam Welding
- Pulsed Electron Beam Drilling and Surface-Micro Machining
- Pulsed Electron Beam Coating (PEB-PVD)
- Rapid Manufacturing (RM)
- Electron Beam Flue Gas Cleaning (EBFGT)

In a collaboration with Fermilab and TRIUMF, PAVAC will Fabricate ILC cavities.

Fermilab 3.9 GHz Status

- Progress to Date
  - Cavity fabrication done at Fermilab and JLab with help from DESY
  - 6 cavities built
  - 2 more complete in next two weeks
  - 4 cavities through vertical test
    - All have achieved gradients in excess of 20 MV/m
    - Q is within specifications
    - Generally low field emission
  - Horizontal Testing when helium vessels are available
    - Bellows welding qualified
    - First vessel expected this month

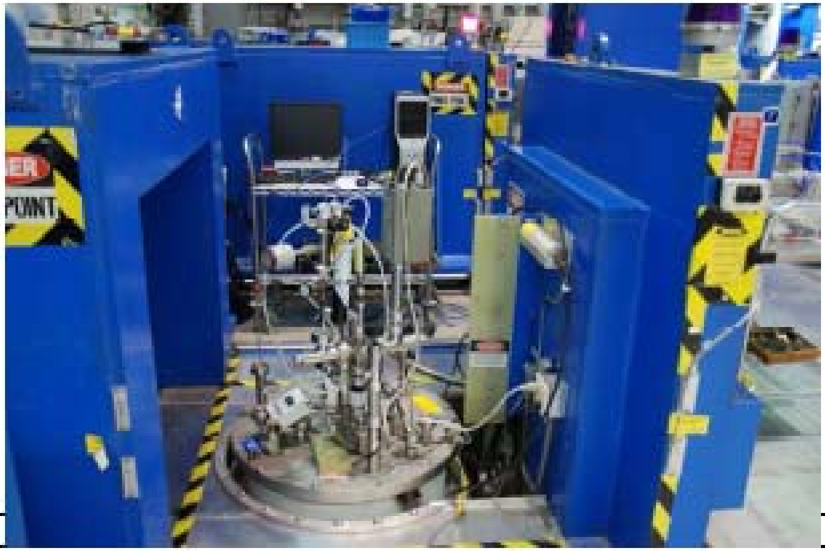


US SRF Infrastructure Strength

- Cavity Processing and Vertical Testing R&D Facility
  - Jlab (30 FY07, 40 FY08, 50 FY09) cycles/yr
  - ANL/FNAL (10-20 FY07, 30 FY08, 40 FY09) cycles/yr
  - Cornell 12 cycles/yr
  - VTS @FNAL 45 cycles/yr (08)
- Horizontal Test Stand
  - FNAL 24 cavities/yr
- Cavity Dressing and Cryomodule Assembly
  - FNAL 4/yr (FY07)
- Limited, but developing cavity fabrication capability in US industry

Jlab Infrastructure



Jlab: ILC Electro-polish and Vertical Test

- Production Like Process Established
  - 32 Vertical RF Test completed
  - 8 Bulk chemistries and 24 final chemistries completed
  - 2 Cavities qualified for S0 program
    - A7 had reached 42MV/m on 2nd Qualify Test
  - Rate of ~30 processes and test cycle/year achieved

- Current Issues
  - Production rate is limited by tooling sets and facility availability

- Cavity Tested
  - S35, commissioning EP facility
  - C22, FNAL HTS
  - A6, A7, as built by ACCEL
  - A8, previously studied at Cornell
  - AES1, AES2, AES3, AES4, as built by AES
  - ICHIRO#5

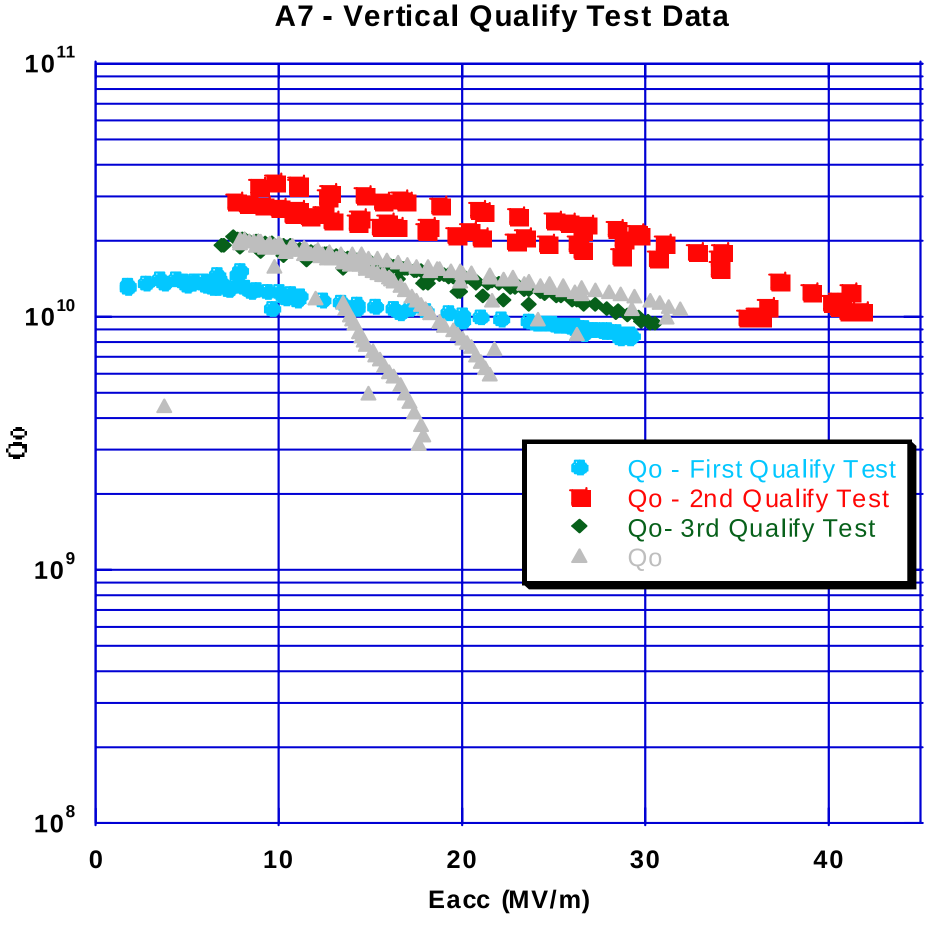
JLAB Cavity Procedure

- Field flatness tuning
- Bulk EP (nominal 150 um)
- US cleaning 1 hour
- Hydrogen out-gassing 600C 10 hours
- Field flatness tuning
- Light EP (nominal 20 um)
- US cleaning 1 hour
- HPR 12 hours
- Cass-10 area drying 8 hours
- Clean room assembly
- Second HPR 12 hours
- Final clean room assembly
- Pump down and leak check
- Low temperature bake 120C 48 hours
- RF test at 2K

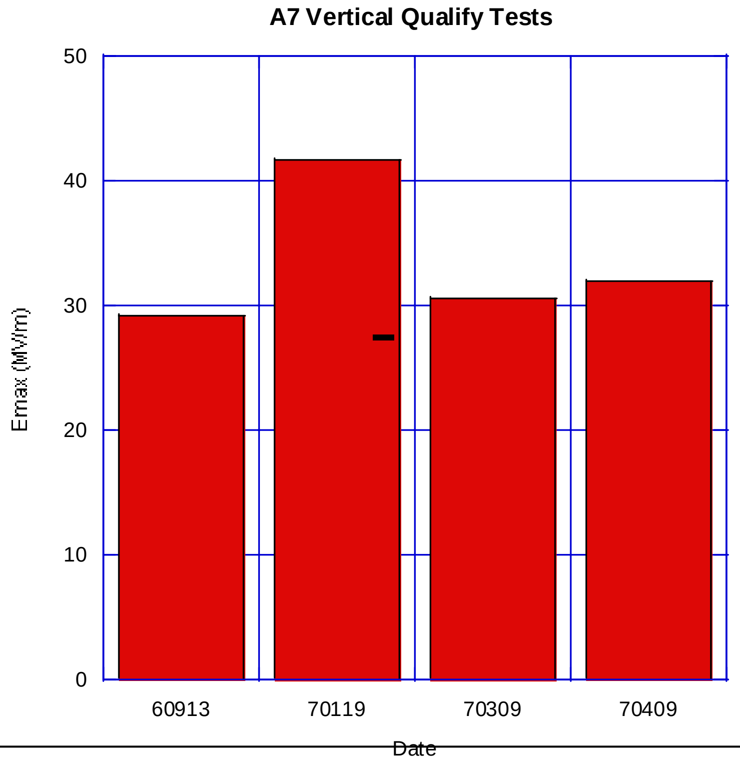
X 3 or 4

S0 cavities previously tested at other labs: First check field flatness, then baseline RF test without EP, then loop

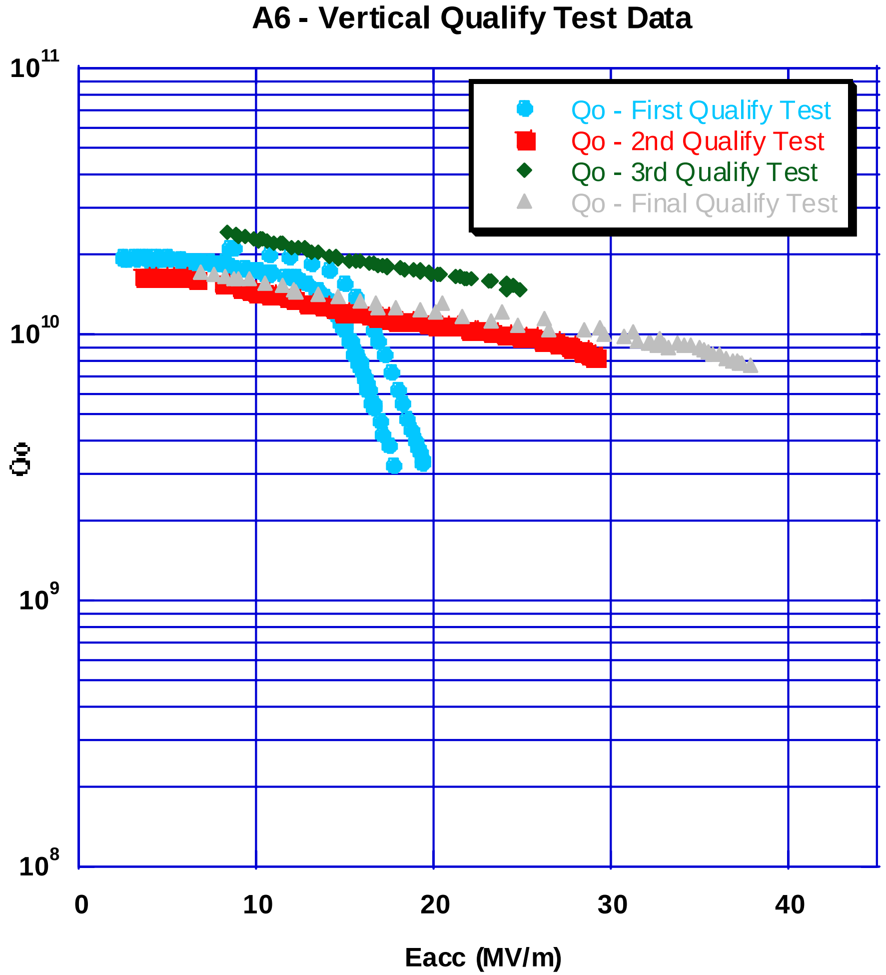
Results of Accel Cavity: A7



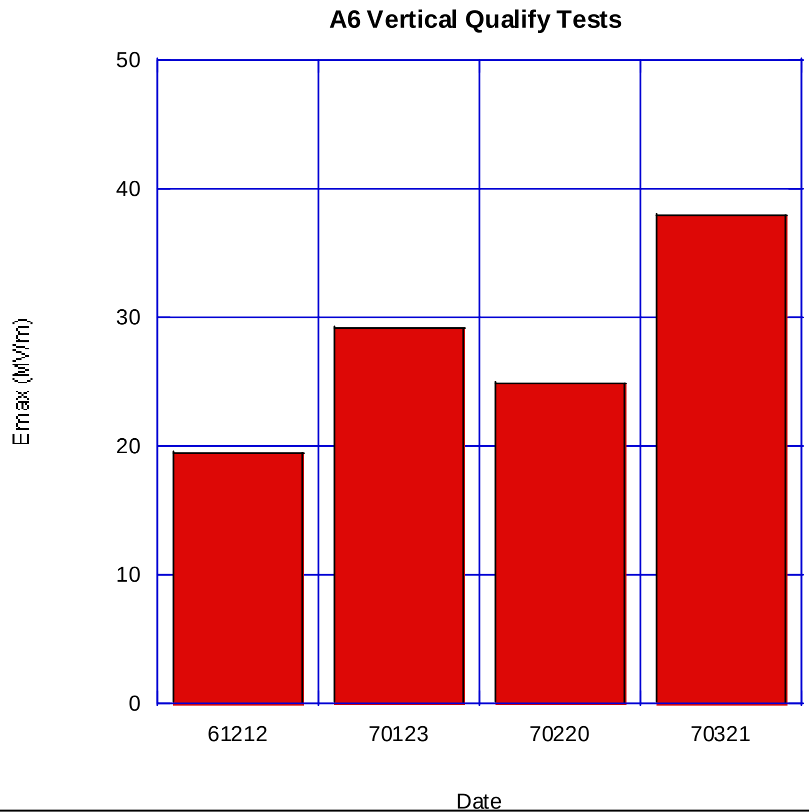
- Test 1: EP 172 um, quench
- Test 2: + EP 26 um, quench
- Test 3: + EP 26 um, quench
- Test 4: + EP 27 um, quench



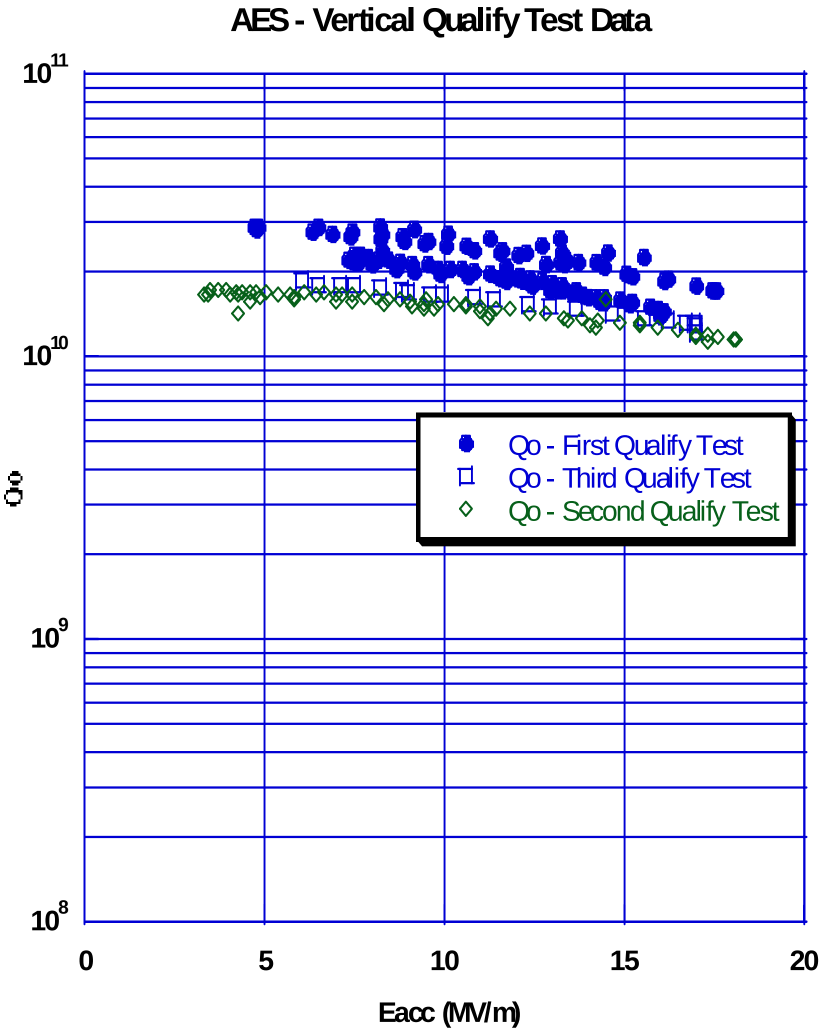
Results of Accel Cavity: A6



- Test 1: EP 187 um, Q-slope
- Test 2: + EP 26 um, quench
- Test 3: + EP 26 um, quench
- Test 4: + EP 26 um, field emission limited

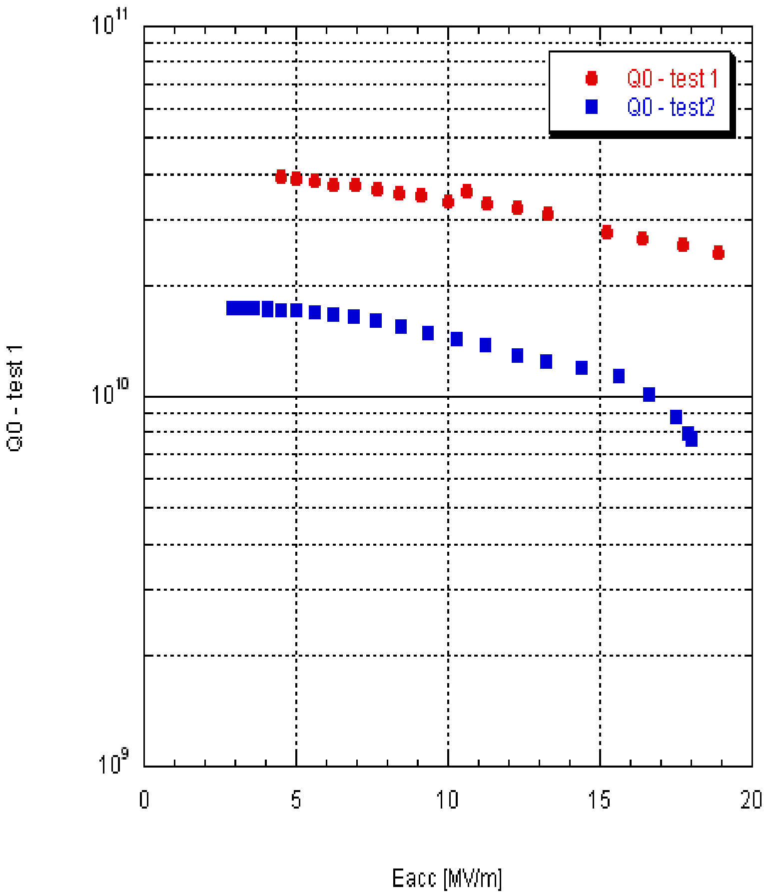


Results of AES Cavity: AES1



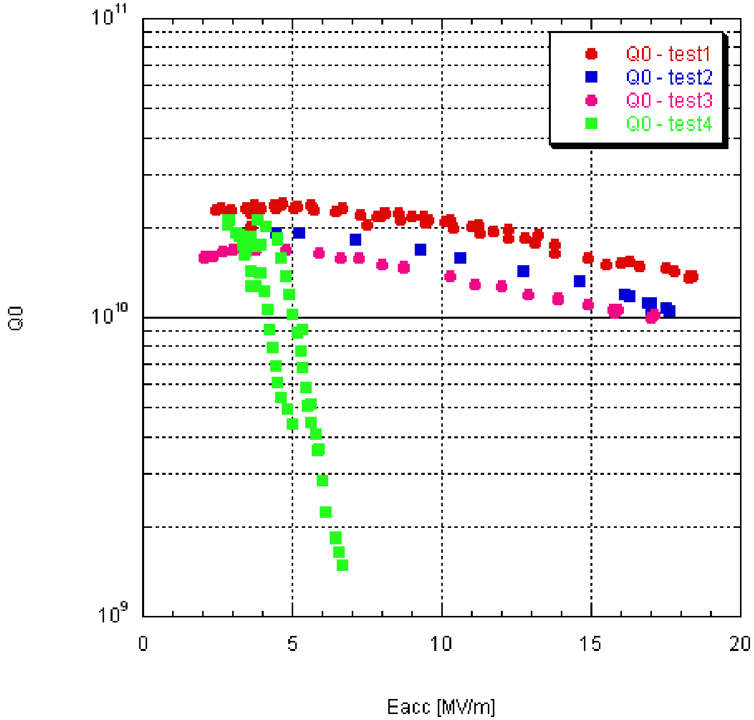
- Test 1: EP 213 um, quench
- Test 2: + EP 23 um, quench
- Test 3: + EP 16 um, quench
- Test 4: + EP 17 um, quench
- Pass-band: cell 3/7 quenching
- Ship to FNAL under vacuum after additional HPR
- First FNAL result consistent with last JLAB result

Results of AES Cavity: AES2



- EP 164 um
- Cold leak in flange
- Warm-up, repair leak
- HPR, no EP, first test, low field Q 4E10, quench
- Pass-band: cell 4,5,6, and possibly 2,8 quenching
- Test 2: + EP 26 um, quench, lots of X-rays

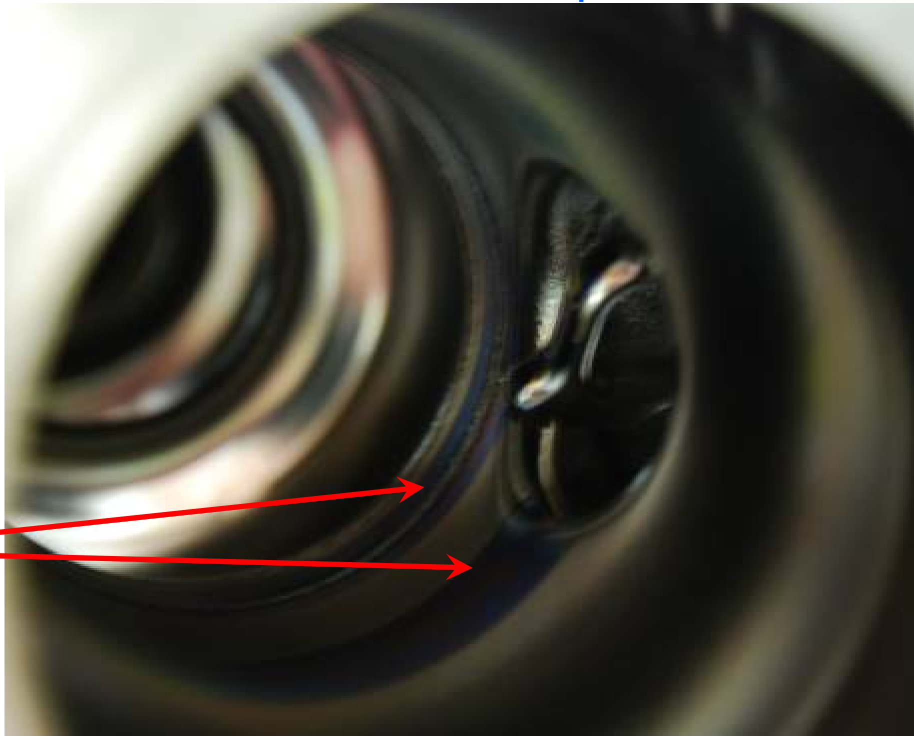
AES3



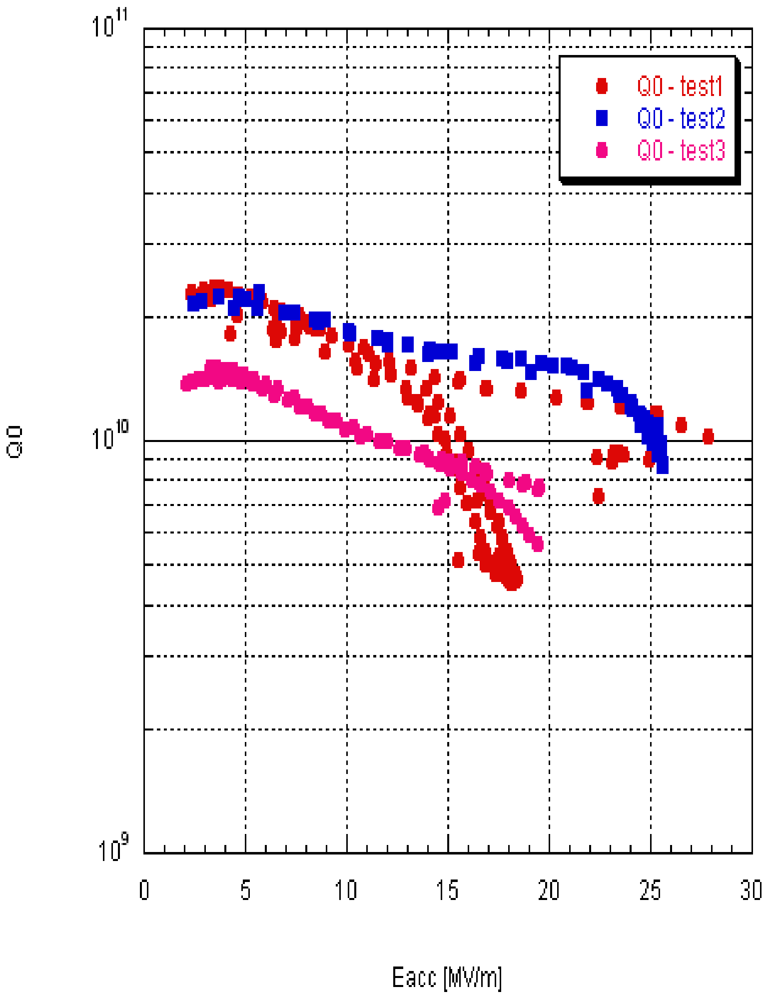
- Test 1: EP 177 um, quench
- Test 2: + EP 23 um, quench
- Pass-band: cell 4/6 quenching
- Thermometry results later
- Test 3: no EP, HPR, quench
- Test 4: no EP, HPR, no quench

Test 3 & 4 goal:
Locate defect by thermometry

Test 4 strange Q(Ea), some X-ray
Discoloration (Nb oxide) on inner surface of beam tube (field-probe side), caused by HPR water jets



AES4



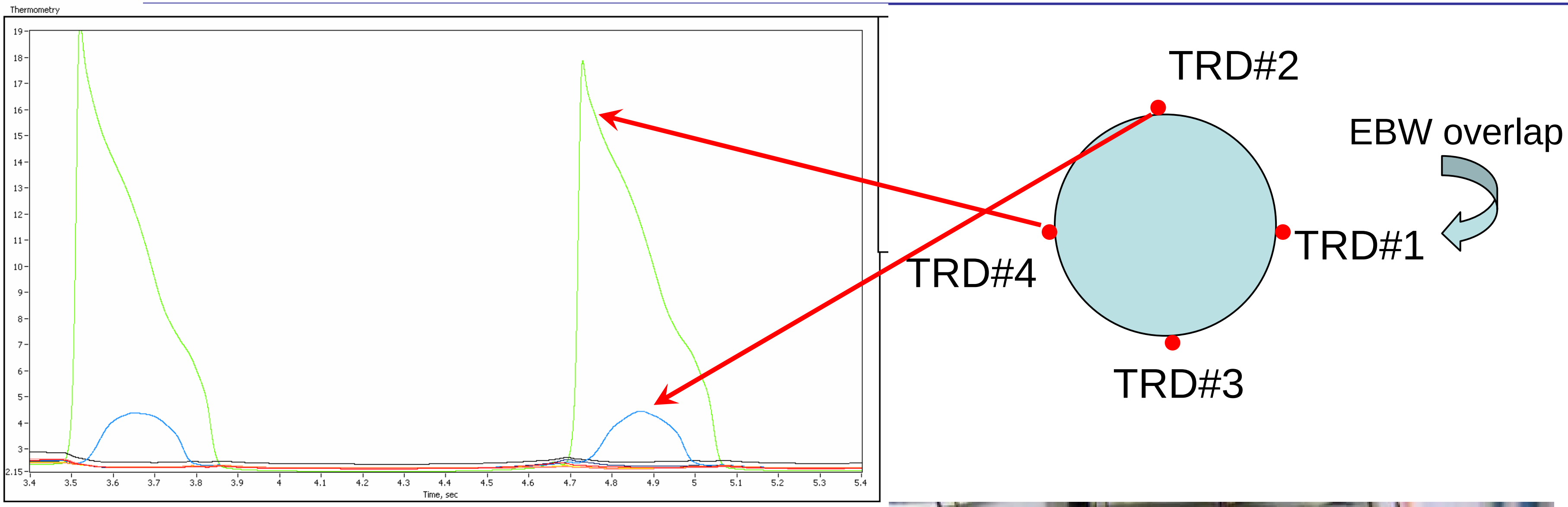
- Test 1: EP 221 um, spontaneous FE activation at 28 MV/m
- Test 2: + EP 36 um, limited by cable breakdown
- Test 3: + EP 20 um, limited by strong FE

AES4 has not quenched,
Recent processing has
Significant FE

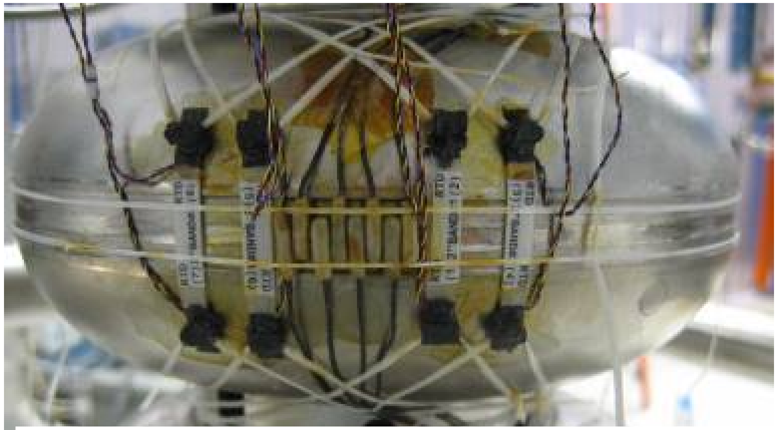
Defect Locating in AES3

- Pass-band meas. determine cell pair (cell #4 & #6)
- Primary focus is EBW
- First thermometry test: 8 thermometers attached to equator EBW, 90 degree apart, started from weld overlap, 4 on each cell
- Singles out cell #6 (from field probe port side)
- Defect location not EBW overlap, suspected region determined to 1/8 of the cell
- Second thermometry test: 16 thermometers attached to suspected region
- Next step: long-distance microscope inspection after defect located

Defect Locating in AES3 (cont.)

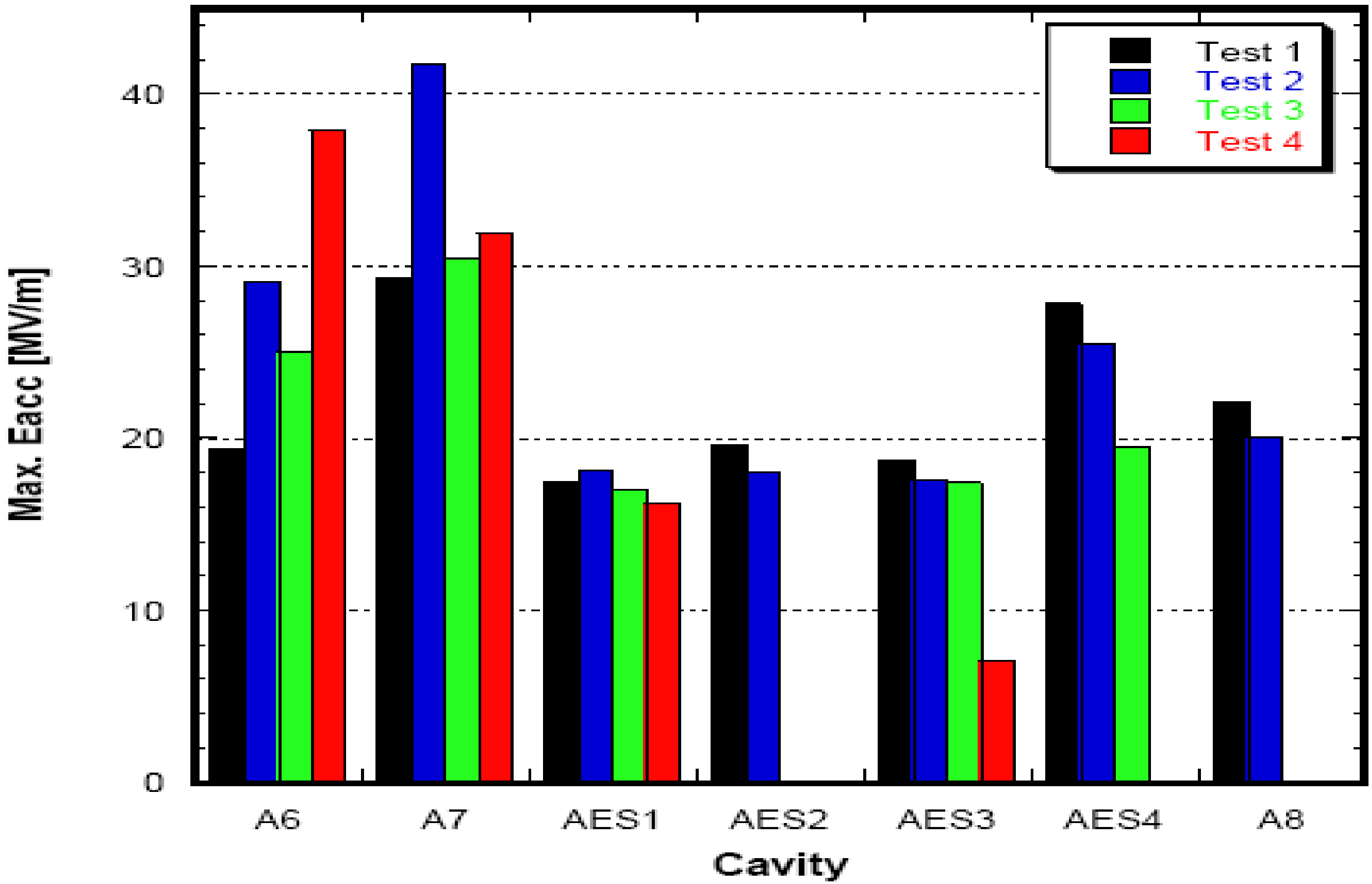


4 thermometers along equator EBW of cell#6

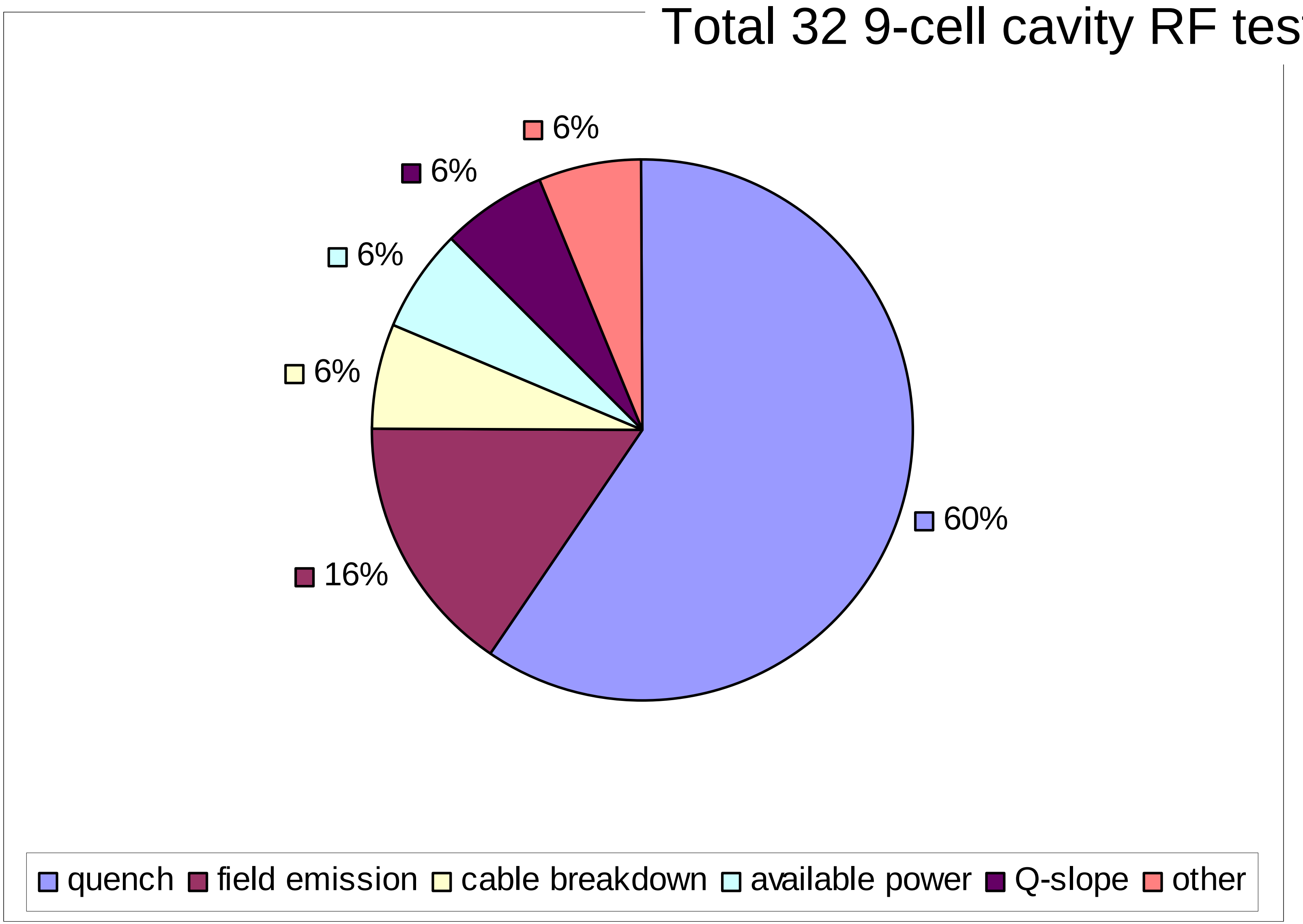


16 thermometers around suspected region

Jlab: Max. Gradient Summary



Gradient Limiting Statistics



Cornell – 2006 : Infrastructure Preparation

- BCP, HPR, and variable coupling test systems upgraded for 9-cell preparation and testing

BCP

HPR

Vertical Test
Variable Coupler

Cornell - 2006 - Vertical EP Started

- Possible benefits VEP Simpler
  - No large acid barrel, no plumbing, valves, no acid heat exchanger…
- Possible disadvantage
  - more exposure to H
  - 600 - 800 C, H degassing required more often?

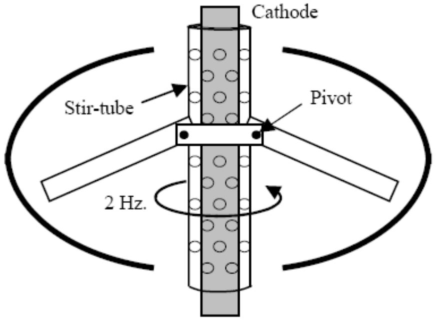


Figure 1. Cathode and stir-tube assembly for one cell. All other cells are identical.

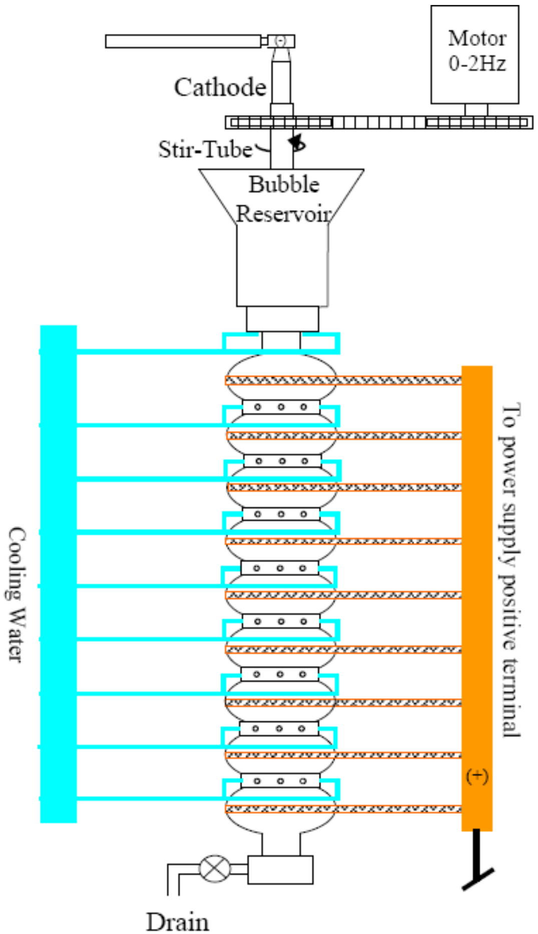
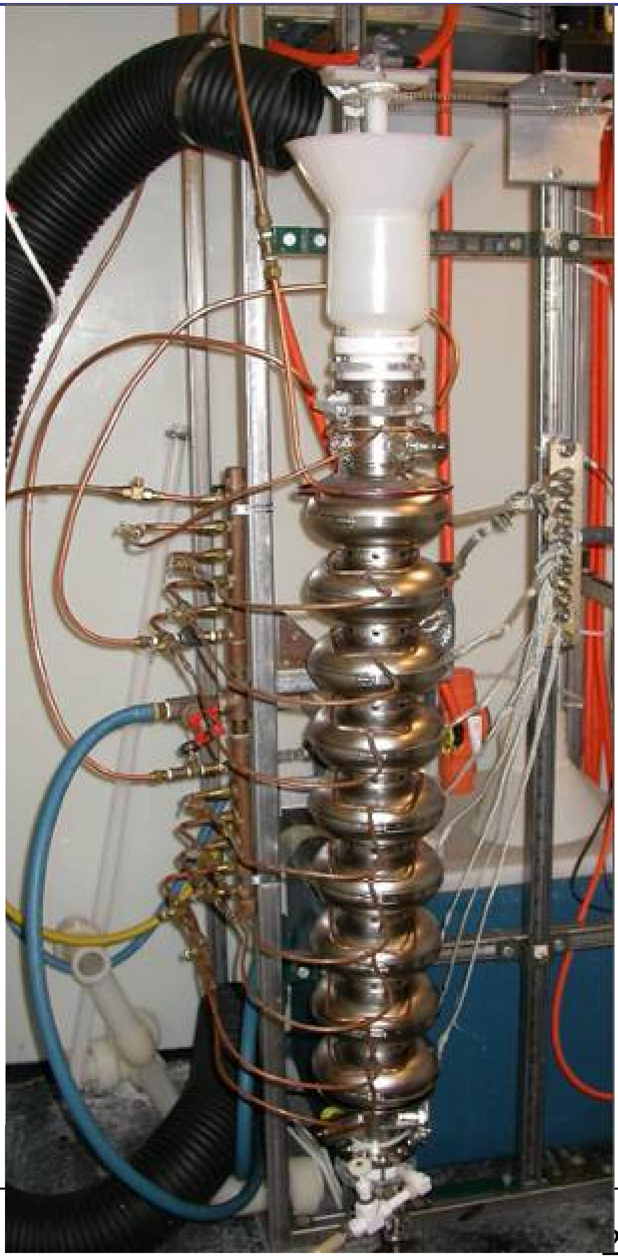
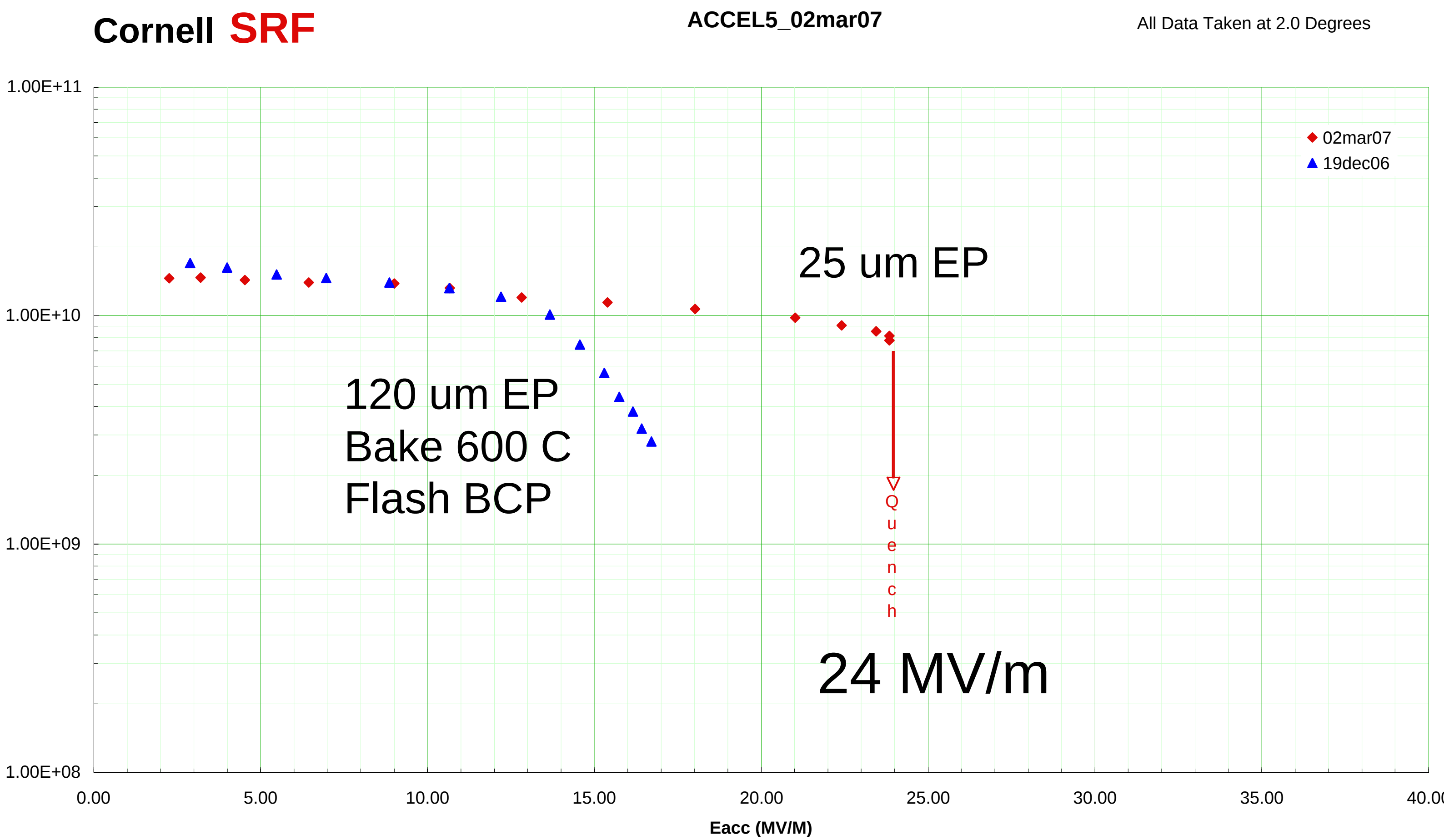


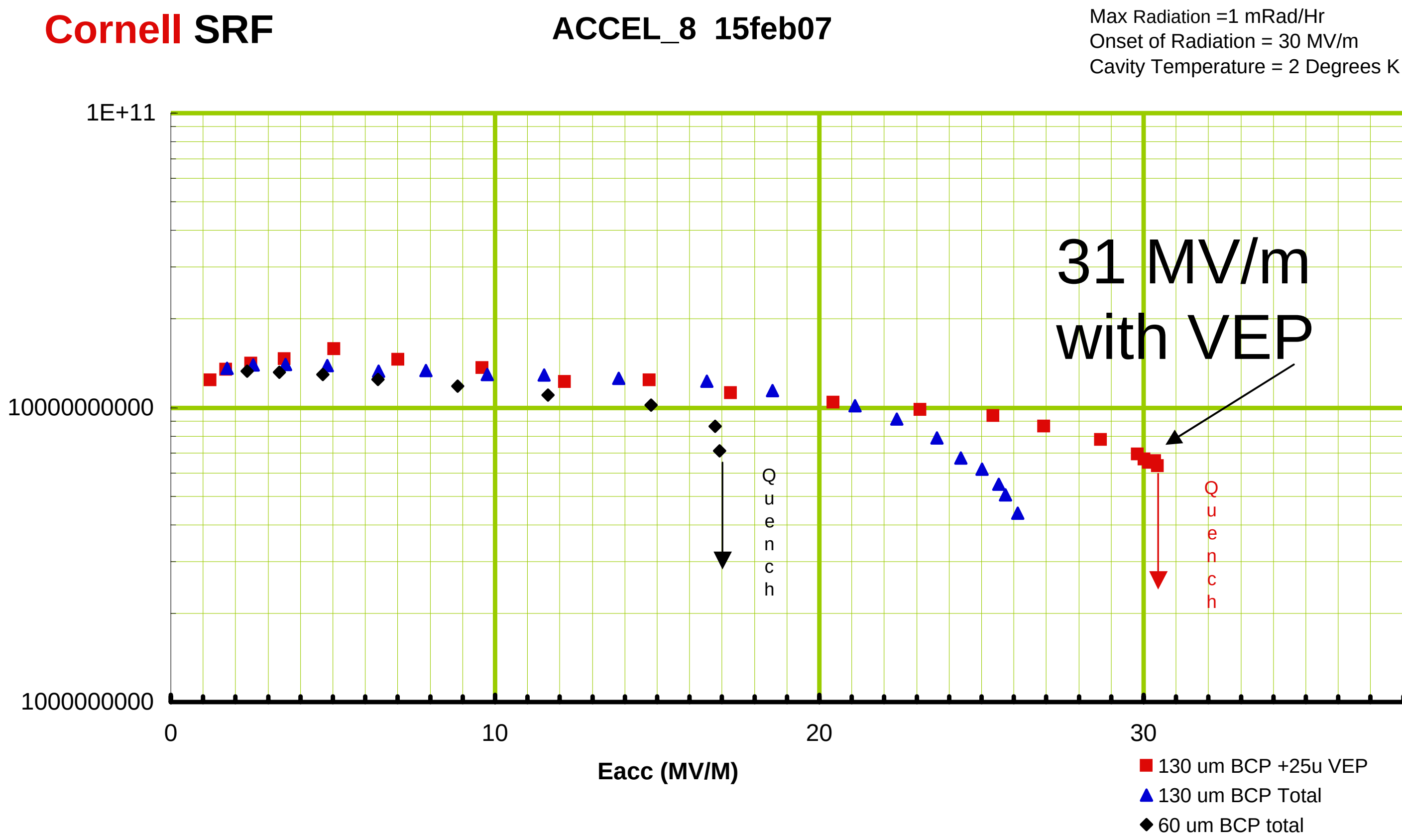
Figure 3. Vertical Electropolish System



Vertical EP - ACCEL-5 (March 07)



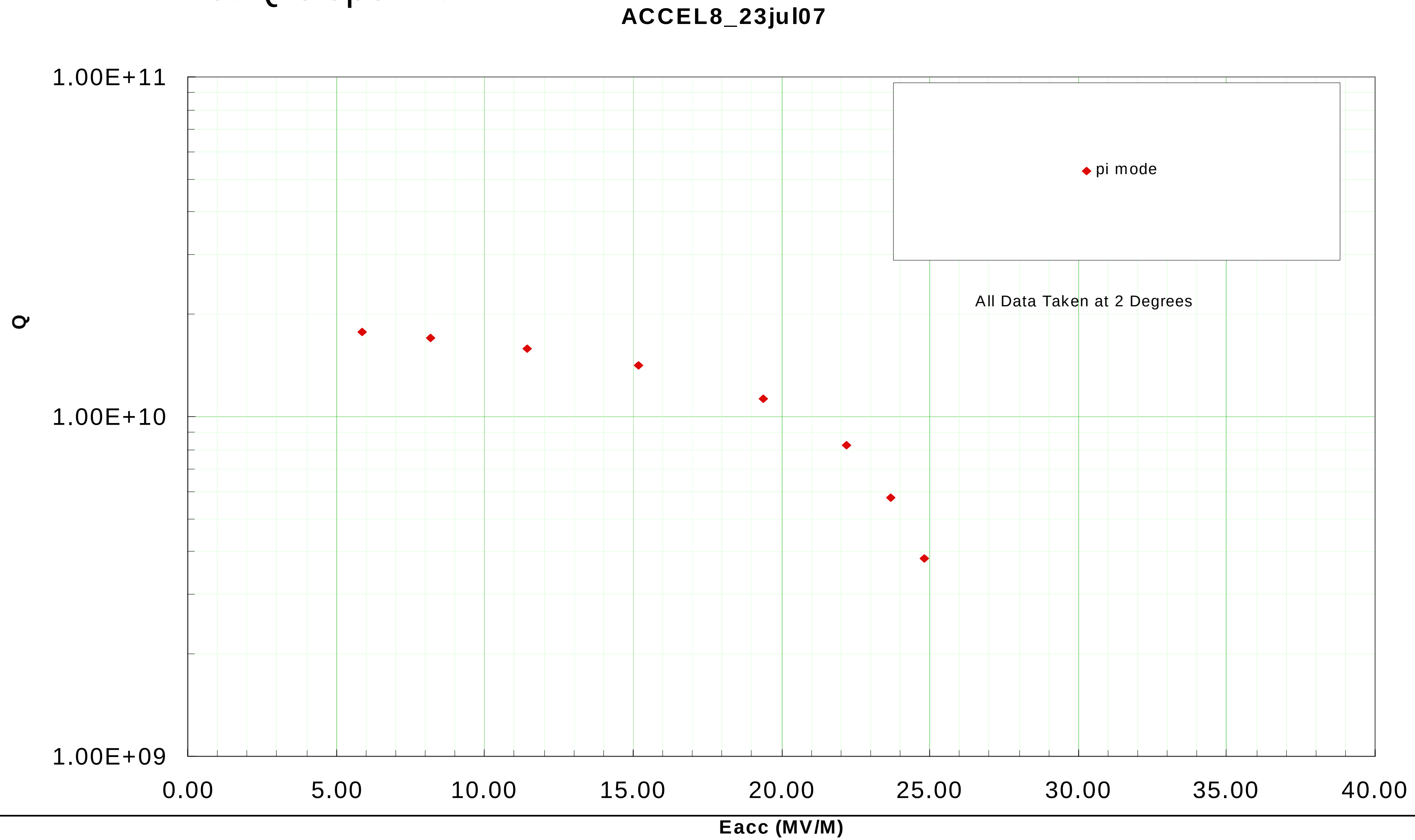
Cornell: ACCEL-8 BCP and EP tests



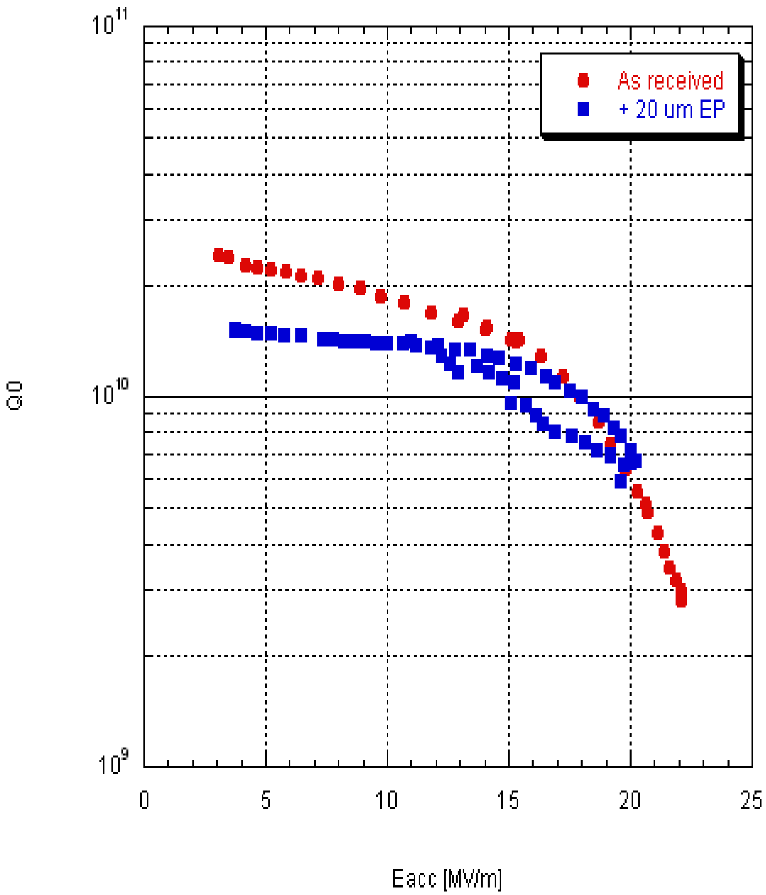
Mistake in EP ACCEL-8

No x-rays , No Quench
But Q-slope with EP !

- Temperature 35–40C instead of 30–32 C
- Stirring speed 2 Hz instead of 1 Hz



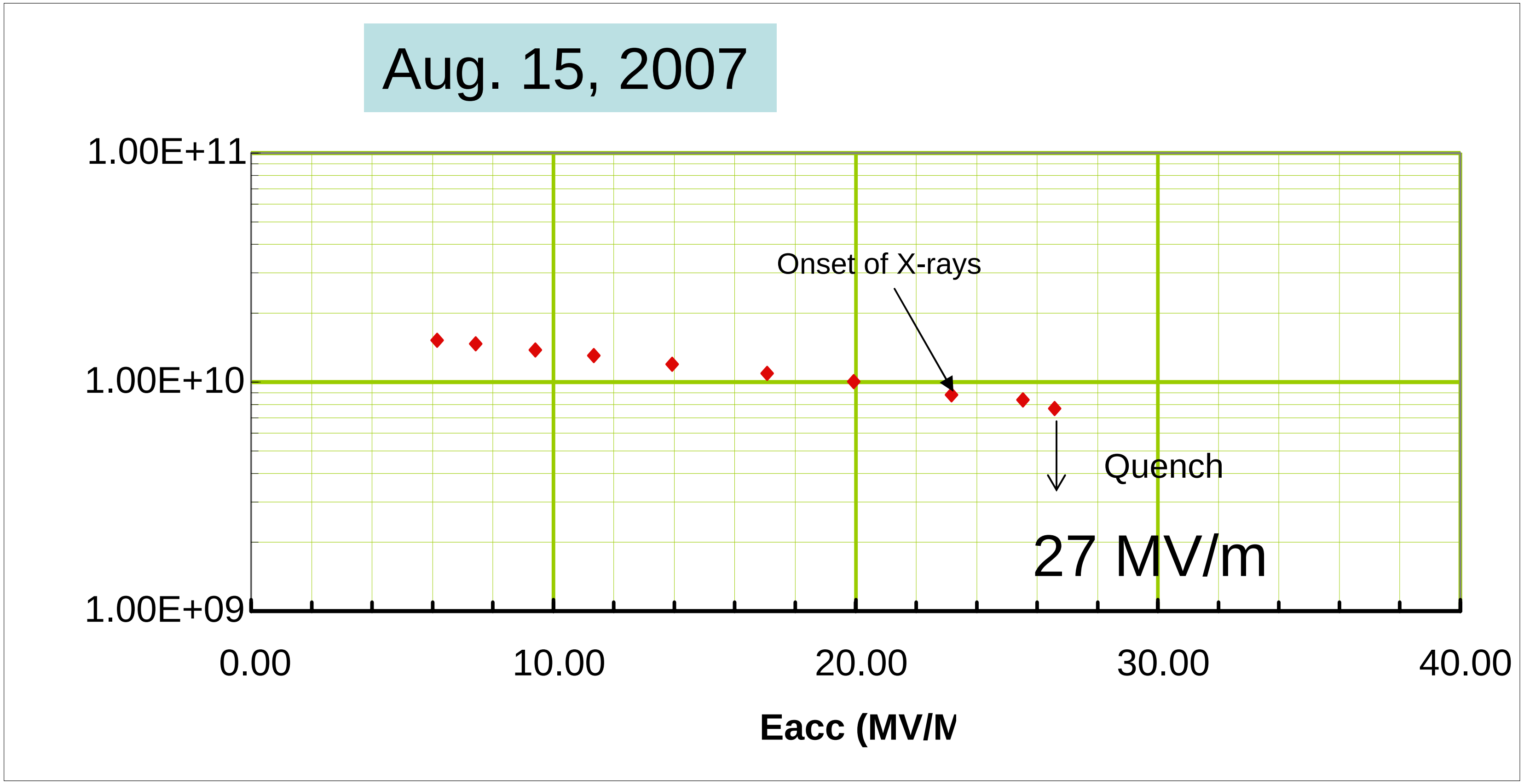
Confirm Cornell Q-slope Results of A8 At Jlab



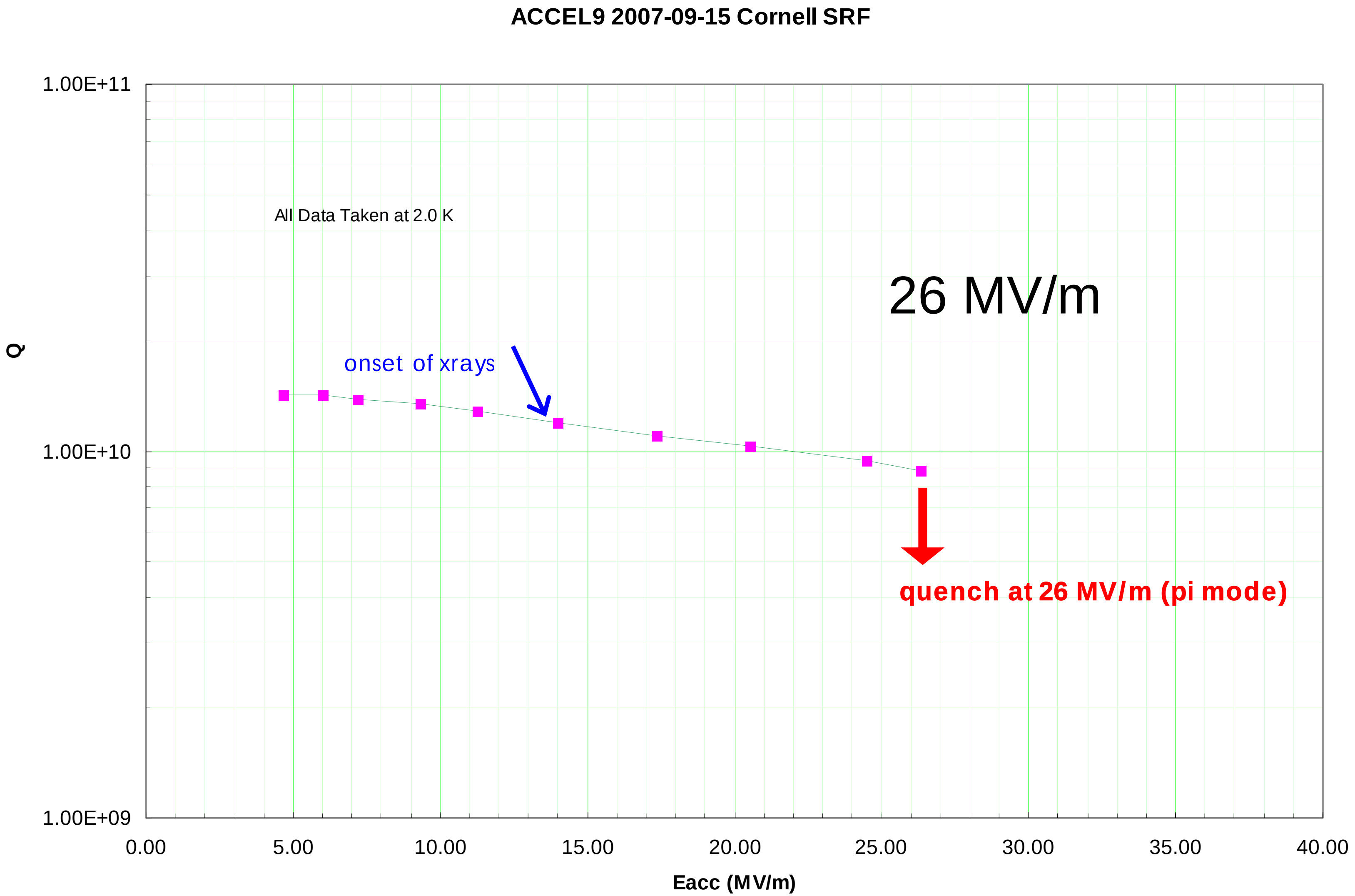
- Field un-flatness 11% as received
- Tuned to < 5%
- Baseline test: HPR only, no EP, no 120C bake
- Results consistent with last result at Cornell
- Q-slope (off-normal EP, see Cornell report)
- Test 2: + EP 20 um, 20 MV/m quench, lots of X-rays

Cornell : EP on ACCEL-9 (Aug. 07)

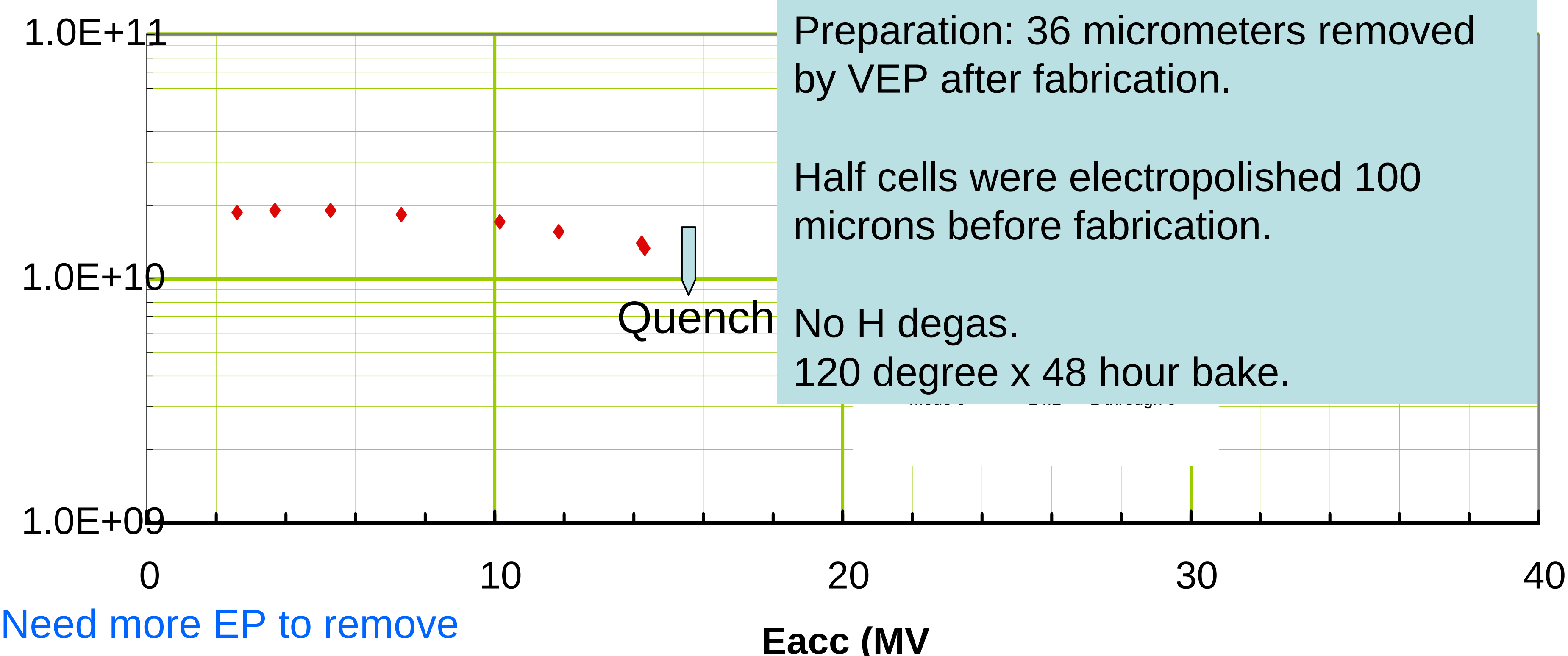
- Learn from our mistakes with single cell test:
- Then use correct temperature and stirring speed



Cornell : 2nd Test A9 (Sept 07)



Re-Entrant 9-cell, First Test July 07



Preparation: 36 micrometers removed by VEP after fabrication.

Half cells were electropolished 100 microns before fabrication.

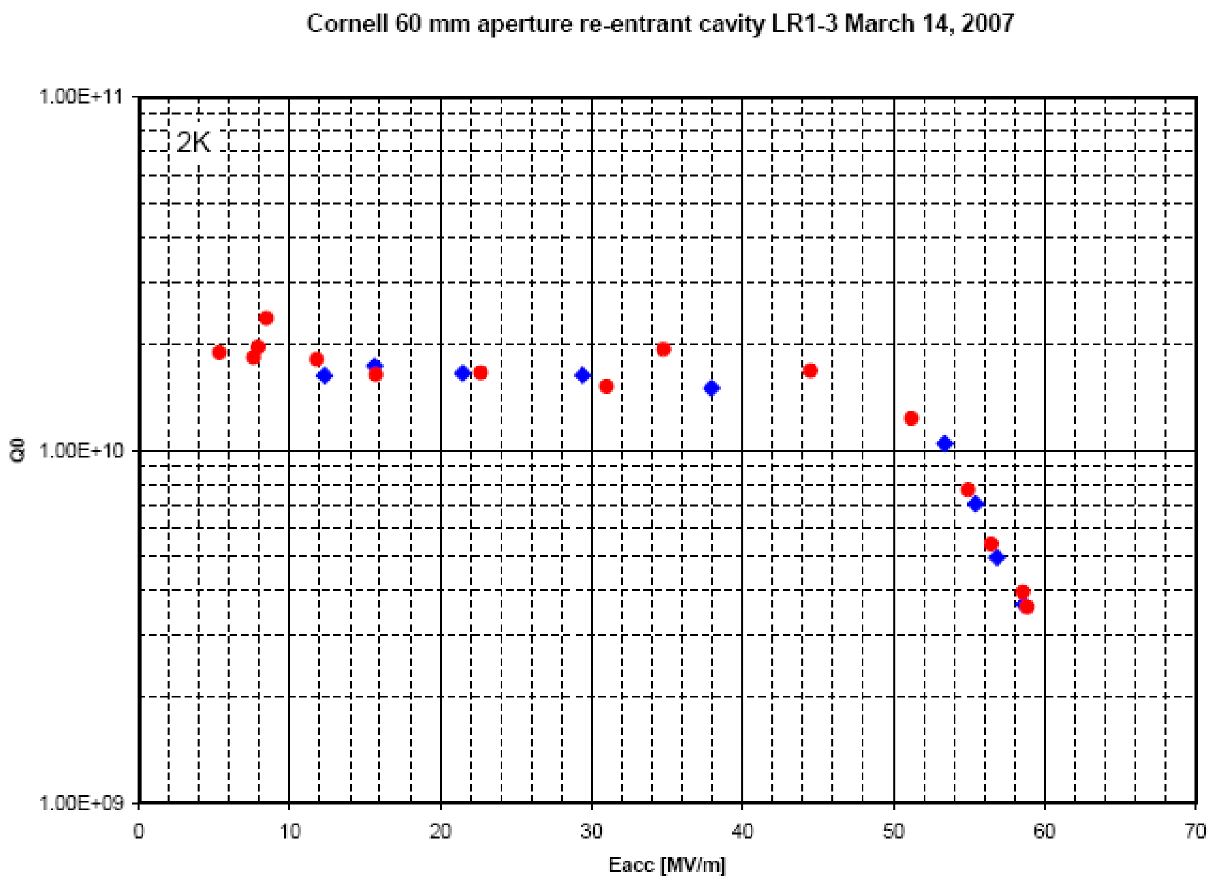
No H degas.
120 degree x 48 hour bake.

Need more EP to remove machining damage

60mm-Aperture Re-Entrant Cavity - Best Eacc = 59 MV/m

Re-entrant Shape Cavity

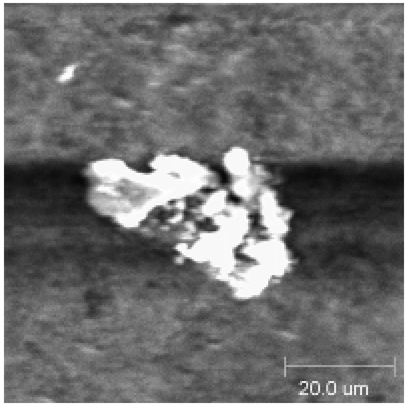
RE-LR1-3



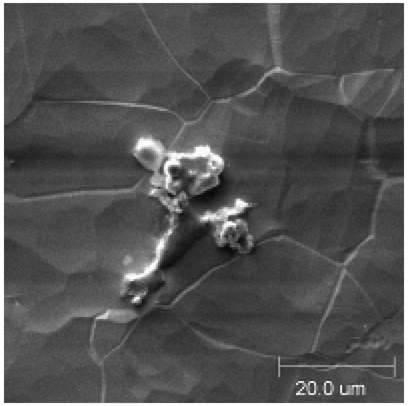
Basic Studies to Identify EP Residues That May Cause Field Emission

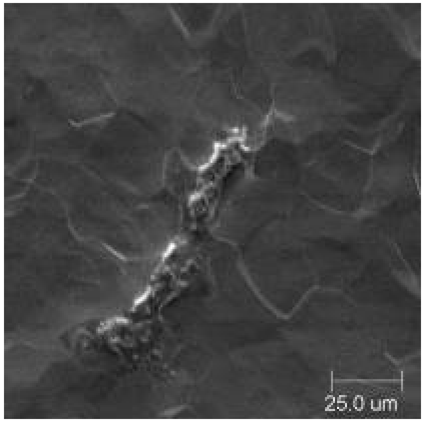
- <u>Two</u> main types of particles captured during EP,
  - S and niobium-oxide
  - Traces of Al also found with Auger, as expected due to Al cathode
- S particles dissolve in ethanol rinse but leave an imprint
- Oxide particles dissolve in HF rinse
  - But did not dissolve in EP !

Oxide Particle



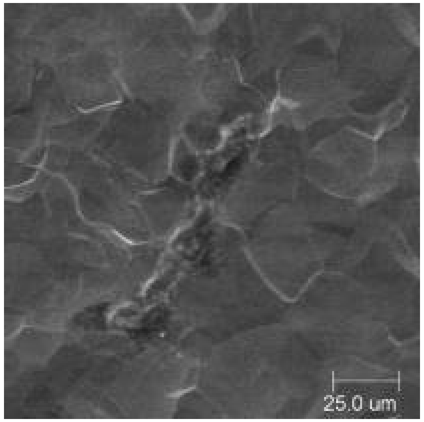
Typical S particles Deposited on Nb Surface During EP





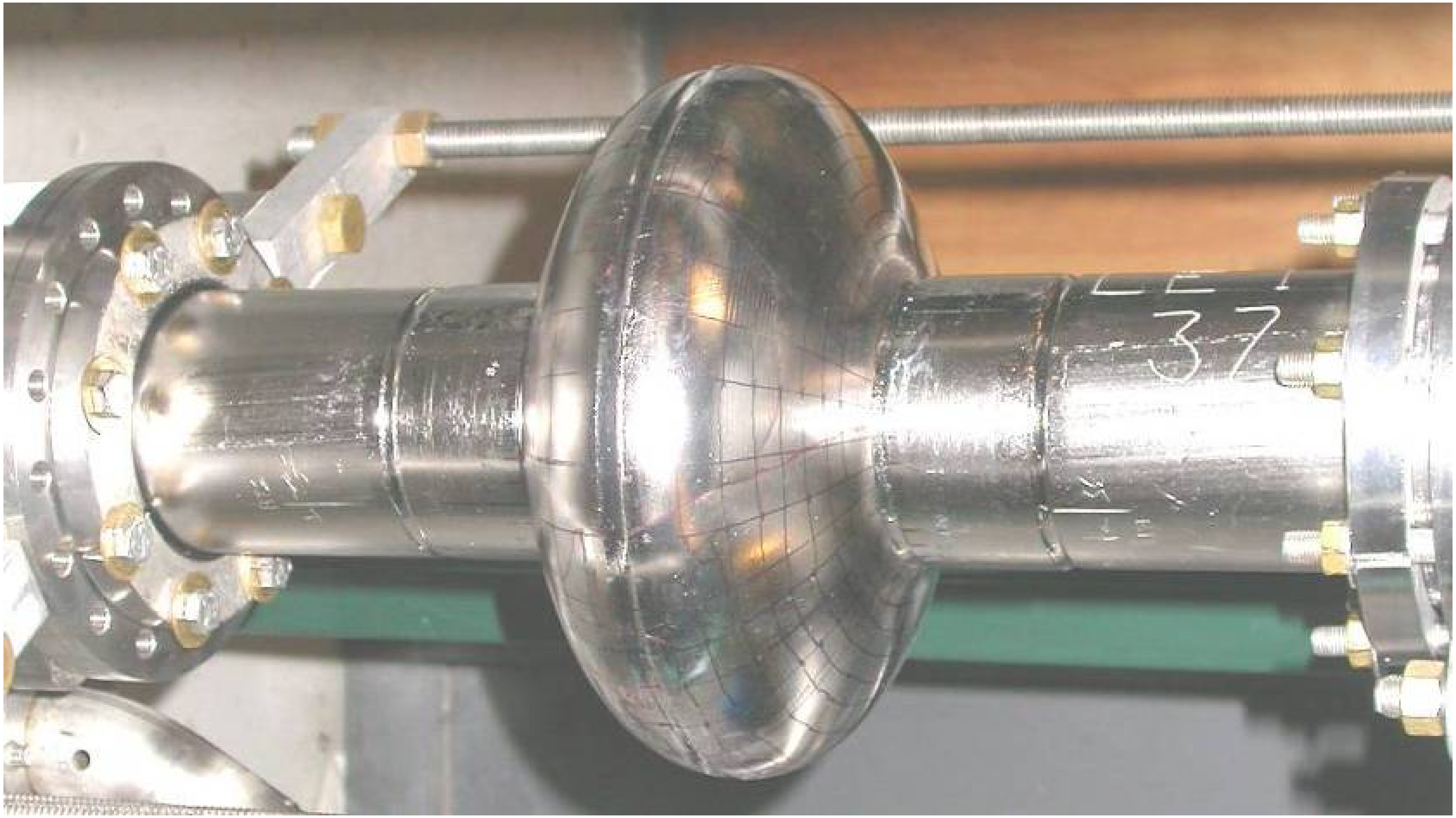
S-Particle

After Ethanol Rinse

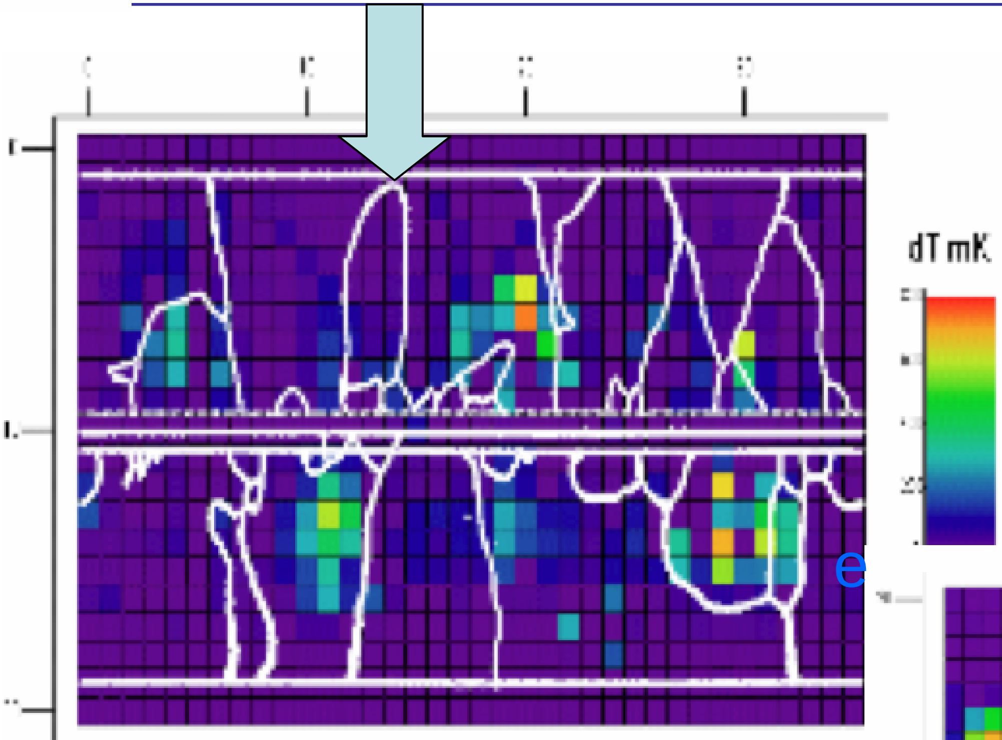


Single Cell Large Grain

- Large Grain Nb from China



No Heating At Grain Boundaries

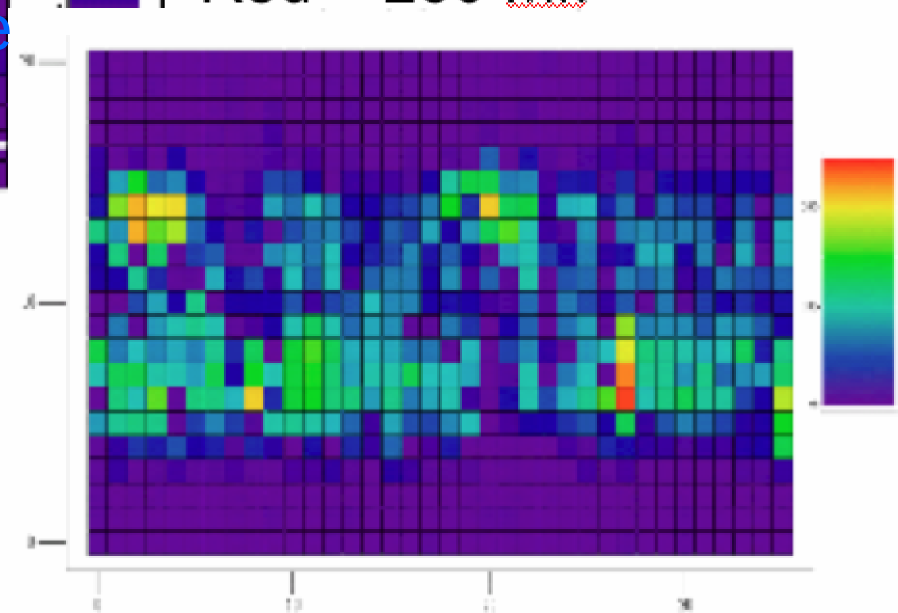


Large Grain Cavity

Red = 800 mK

Fine-Grain Cavity

Red = 250 mk



- Only isolated regions inside grains get hot at high field Q-slope

Summary Slide of Cornell Work

- Infrastructure installed for 9-cells:
  - BCP, HPR, Variable Coupler Test-stand, Vertical EP ILC :

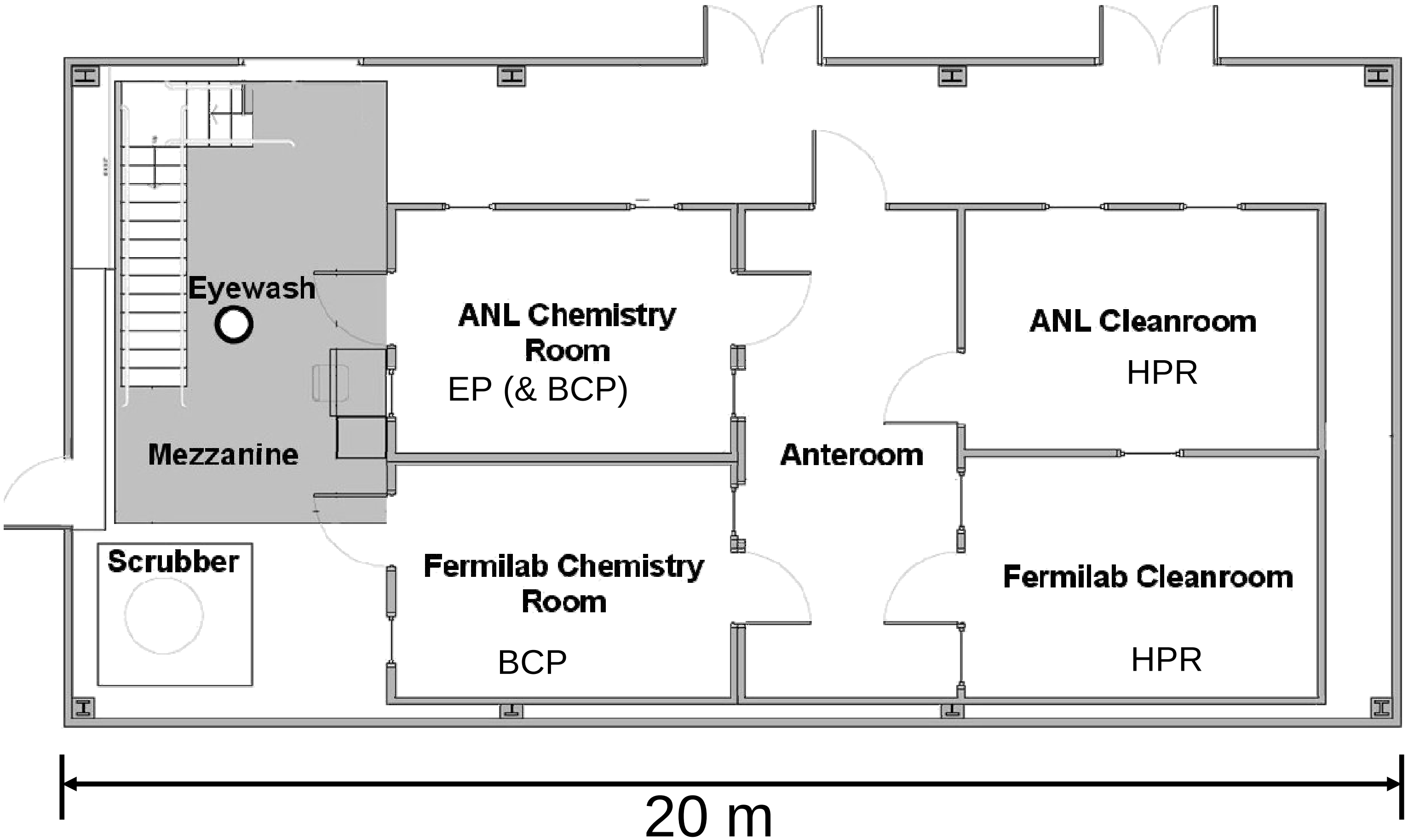
    ACCEL 5 (loaner), ACCEL- 8, ACCEL-9,

    Best results : 24 MV/m, 30 MV/m, (27 MV/m, 26 MV/m)

    2 S0 Cavities
  - All limited by quench
- Re-entrant 9-cell (Fabricated by AES)
  - First test, 14 MV/m, quench limit from machine damage area
  - Best cell reached 25 MV/m
- Single Cell Research (Collaboration with KEK)
  - Re-entrant 60 mm aperture – World record 59 MV/m !
  - Ninxia Large Grain with thermometry
    - Proved that Grain boundaries are NOT responsible for Q-slope
  - Nearly oxide-free cavities (400 C bake)
    - Oxygen is likely NOT responsible for Q-slope
- Surface Studies
  - S and oxide particles found with EP
  - Ethanol rinse dissolves S particle

SCSPF at ANL Overview

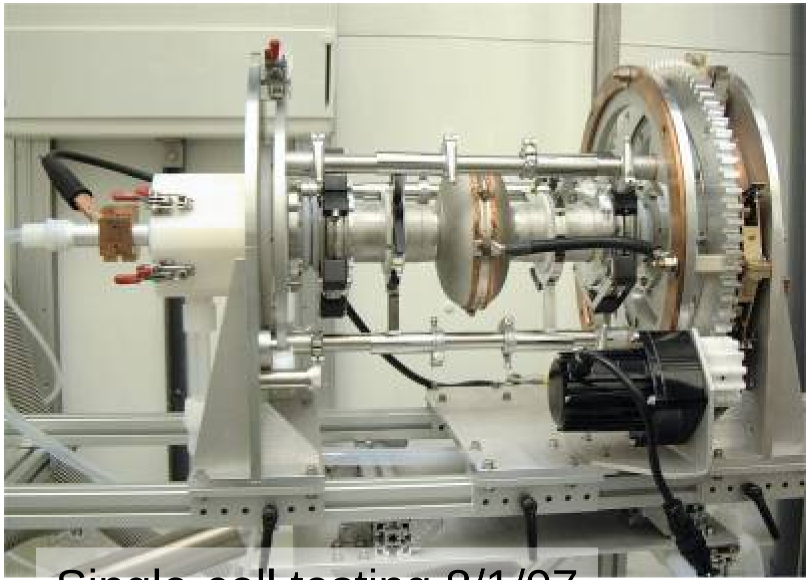
Goal: Establish a new and complete single cavity processing & assembly facility



EP at ANL

- EP Design Specification - Done
- EP Engineering Design - Done
- EP System/component procurement - Done
- EP Design Review - Done
- EP system assembly - 95% complete

- To do:
- Finish cathode loader
- First Procedure:
- August 13—completed!



Single-cell testing 8/1/07

BCP System Status

Test Vessel

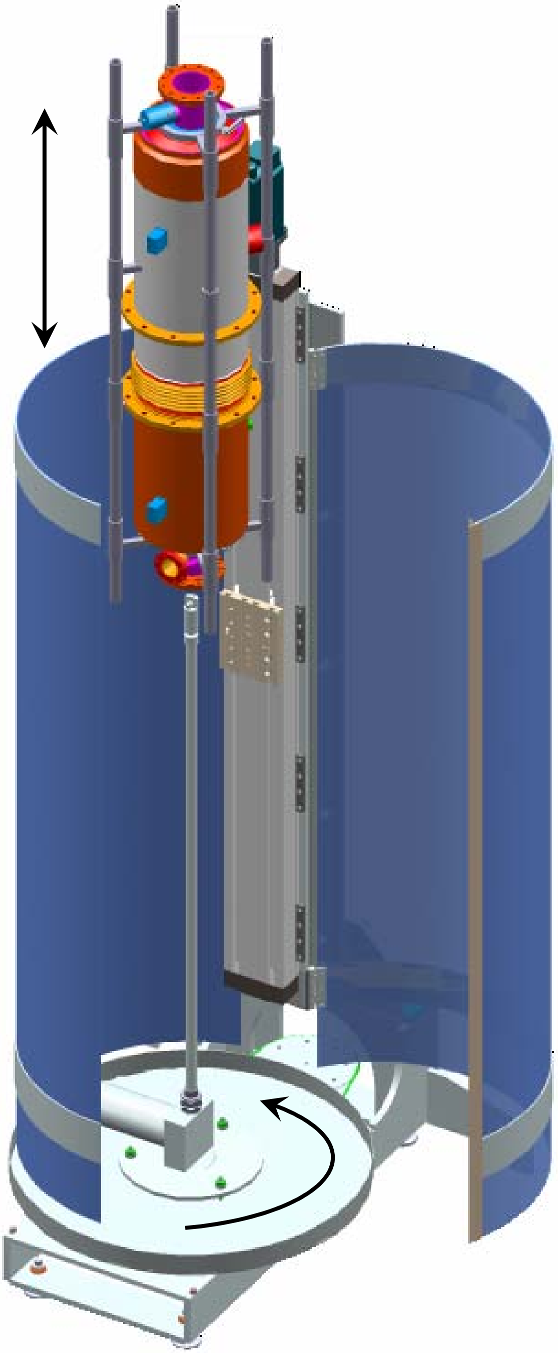
BCP System

Dilute Waste Neutralization System

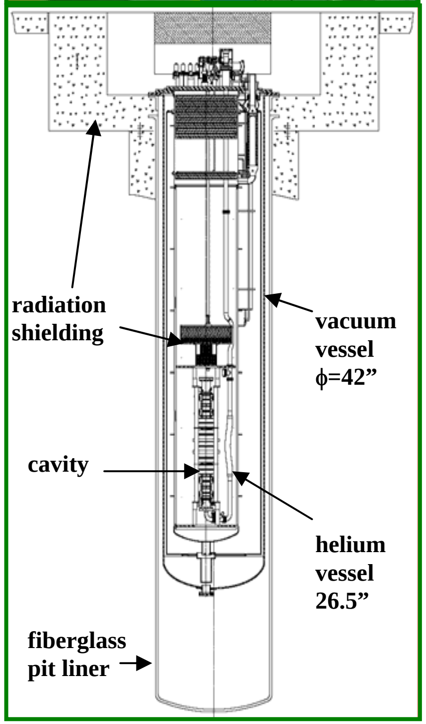
Reconfigured Ventilation

HPR @ ANL

- Design borrows from Cornell.
- System uses existing clean room and water plant at Argonne Lab.
- Clean room upgrades provide class 10 zone for HPR.
- Operational January 2008.
- Cavity moves vertically
  - Bosch-Rexroth slide with class 100 certification
- Wand rotates
  - 0.02micron filtration after swivel joint
- 1500psi / 100bar
  - LEWA diaphragm pump



Fermilab: Vertical Cavity Test Facility

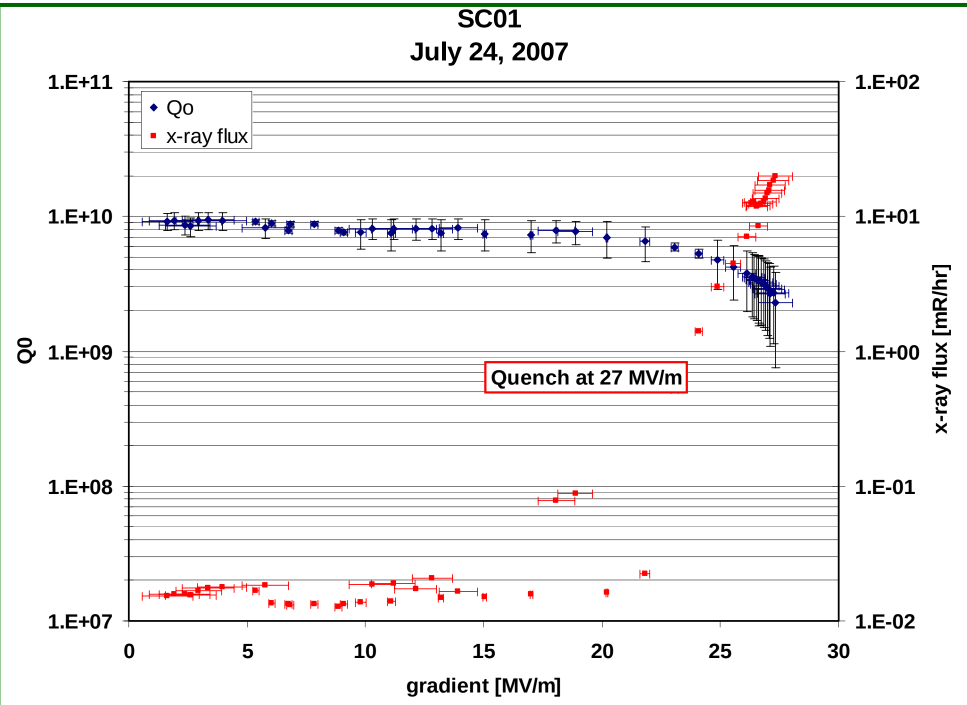


- Vertical Cavity Test Facility (VCTF)
- One Vertical Test Stand (VTS) in Industrial Building 1 (IB1)
- Single, bare 1.3 GHz 9-cell Tesla-style cavities
  - Measure Q vs. T (T_{min}~1.5 K)
  - Measure Q vs. E_{acc} at 2 K
- RF design parameter: 250 W (CW) max power at cavity
  - $Q>5x10^9$ and Eacc<35 MV/m

    or generally: $P_d = (1.04 \times 10^{-3})^* E_{acc}^2/Q < 250$ W
- Use existing IB1 cryogenic capacity ~125 W at 2 K
  - 250 W for short periods without excessive helium bath temperature increase
- Magnetically shielded cryostat
  - Ambient field in IB1 pit measured consistent with Earth’s field ~0.5 G
  - External (room-temperature) Amumetal® (80% Ni alloy) and internal Cryoperm 10® magnetic shield, designed to attenuate field to <0.01 G at cavity
- Radiation shielding to maintain “Controlled Area” status in IB1
  - < 5 mrem in an hour immediately outside the shielding
  - <0.25 mrem/hr in normal working areas

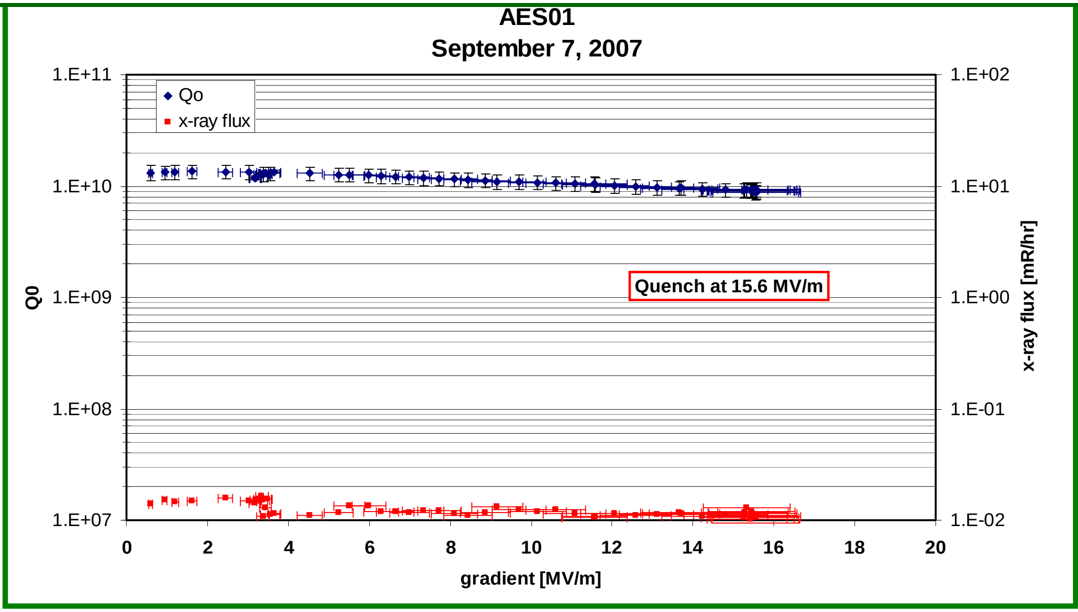
VCTF 1st 1-cell test

- First high-power single-cell cavity test July 24, 2007
- Large-grain niobium cavity borrowed from JLab
  - Tesla-style shape (straight end tubes)
- Good cavity performance, comparable to performance at JLab
  - quench at 27 MV/m accompanied by field emission
- First try at sending an evacuated cavity from JLab to Fermilab
  - important for cavity and process qualification



VCTF 1st 9-cell cavity test

- First 9-cell test September 7, 2007
- AES01 cavity
  - Tested at JLab for AES vendor qualification
  - Borrowed for VCTF commissioning
  - Tesla-style shape, with normal endgroup
- Mediocre cavity performance, comparable to performance at JLab
  - Quench at 16 MV/m without field emission
- Second try at sending an evacuated cavity from JLab to Fermilab
  - Important for cavity and process qualification – needs work



VCTF Summary/Plans

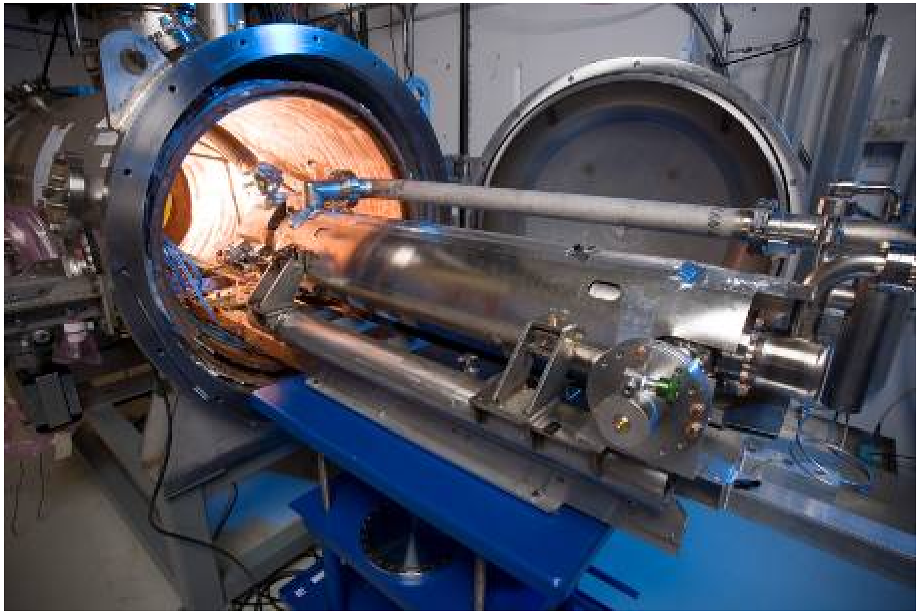
- Vertical Cavity Test Facility with one Vertical Test Stand now operational
  - First high-power 9-cell cavity test complete and successful
  - Commissioning activities ongoing
    - Understand the cryostat/cryosystem performance and capability with the thermal load
    - Complete magnetic shielding – inner Cryoperm shield not installed yet – degrades Q_0
    - Train personnel
  - Will establish Fermilab as an ILC cavity testing facility in FY08

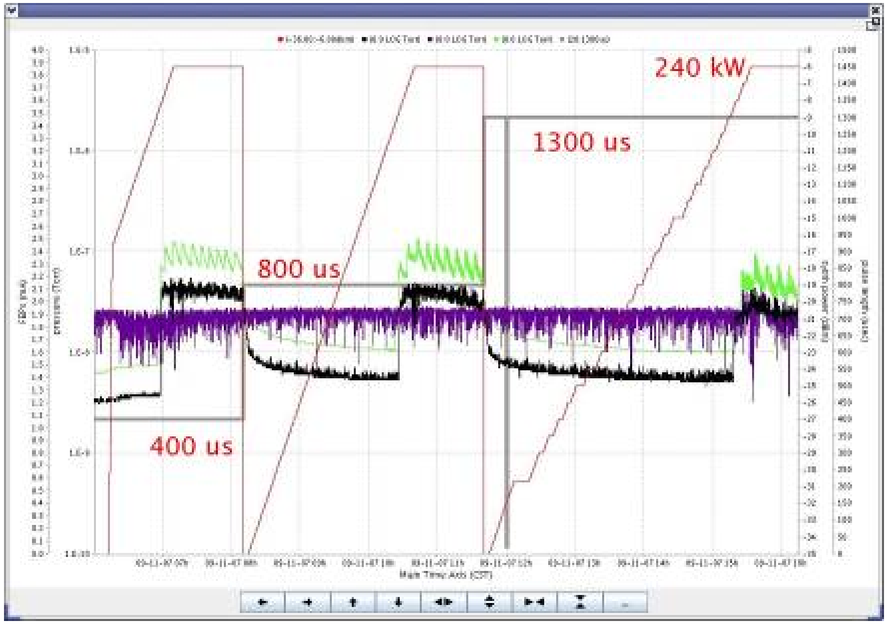
- Develop Fermilab SRF expertise & advance Fermilab role in SRF technology
  - Study cavity characteristics for vendor qualification, understanding cavity processing
    - Passband mode measurements – limited by fixed RF input coupler
    - Thermometry for quench location – flexible system for cavity R&D with $\mathcal{O}(10)$ sensors available
  - Develop cavity diagnostic instrumentation – now with increased priority
    - 9-cell thermometry – comprehensive grid measuring all 9 cells at once (10000 sensors!)
    - Variable RF input coupler
  - Apply advances to new projects
  - Collaborate with university groups & other labs
    - Accommodate visitors with user-friendly facility

- Planned upgrades – based on analysis of existing system capability & dependent on funding
  - Inputs: Considerable experience from Fermilab Magnet Test Facility, and cavity test operations information from other labs
  - FY08 plan: Cryogenic system and infrastructure upgrade – reduce interference with magnet test program and improve cryogenic system reliability
  - FY09 plan: Additional cryostats – higher throughput

Fermilab: Horizontal Test Stand

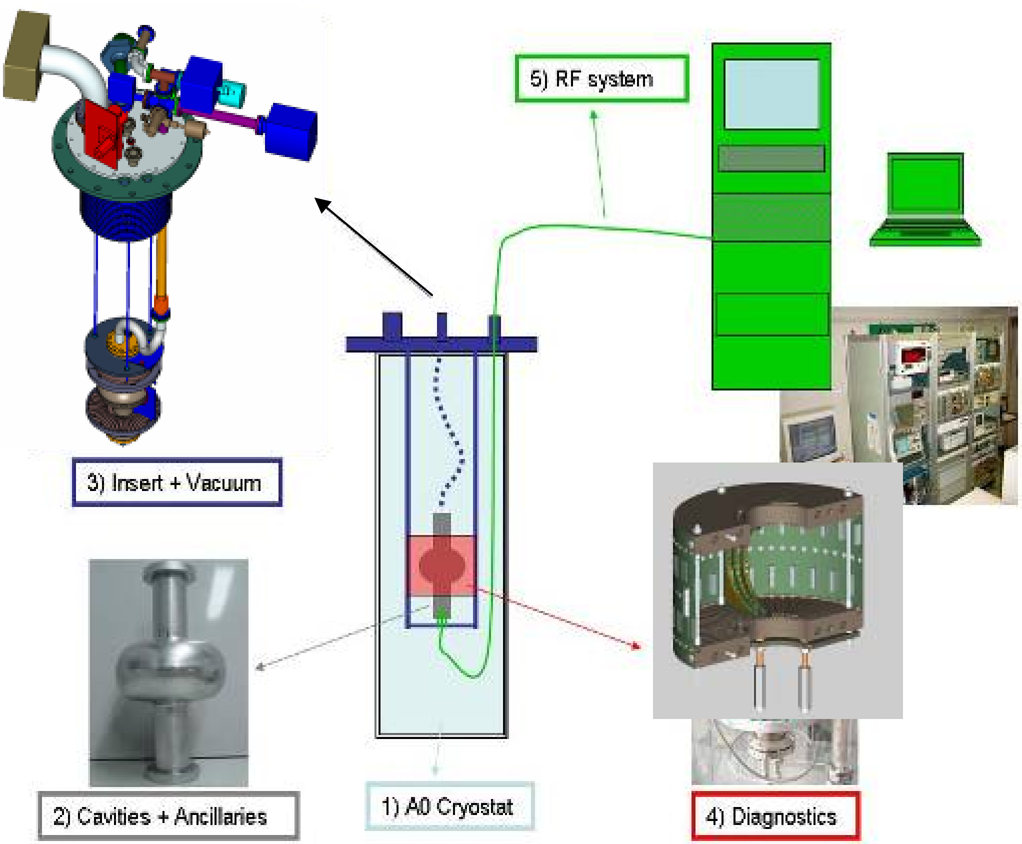
- Cryogenically commissioned in FEB-2007
- Installation of cavity “C22” in MAY-2007
- Several cool down attempts foiled due to leaks
  - Found and addressed
- Successful in-situ conditioning of input coupler at room temperature with high power pulsed RF

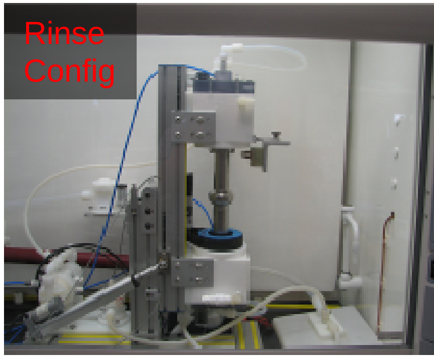




FNAL: 1-cell Processing and Testing Facility

- Goals:
  - Fast turnover processing and testing of 1-cell cavities
  - ILC cavity processing parameter development
  - Address, explore and incorporate other cavity research issues (Advanced R&D)
  - Collaborate with other labs in cavity R&D

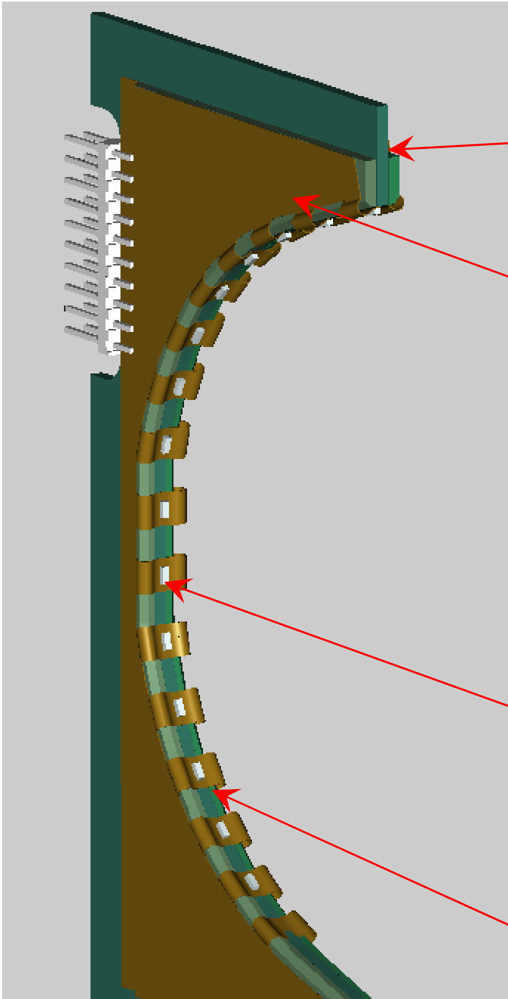




Electro-polishing at ABLE

HPR at A0

T-Map 1.3GHz Sensor Card

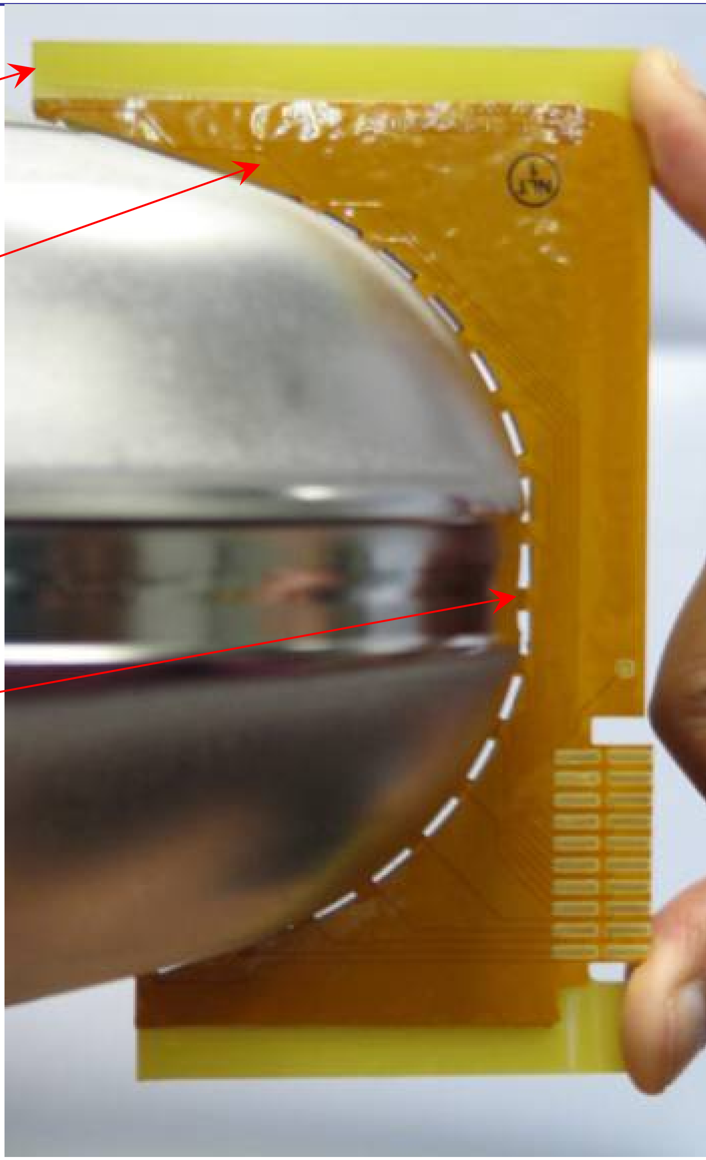


G10 boards

Kapton printed circuit

Diode sensor ~1mm×1mm sensing area

Flex shown in compressed state as if contacting the cavity

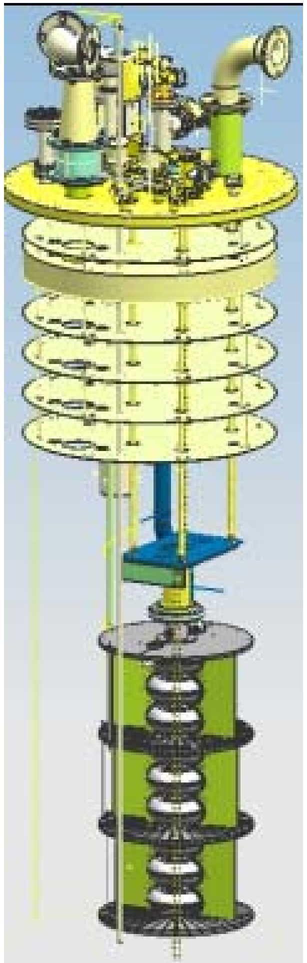


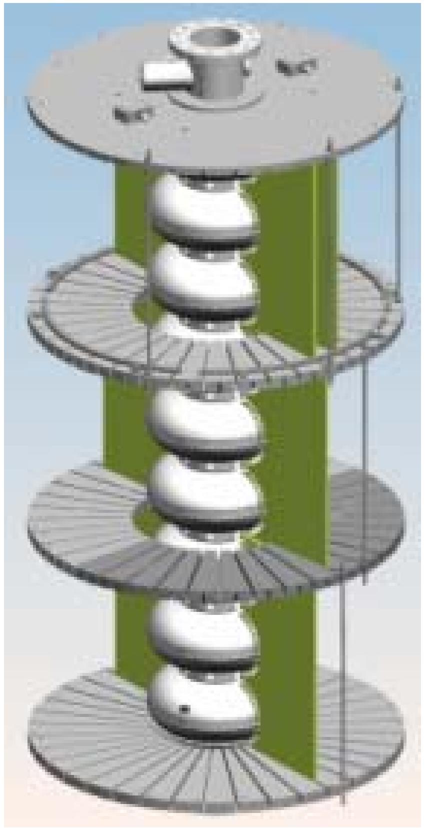
Fermilab will build a 9-cell T-Map system in 08

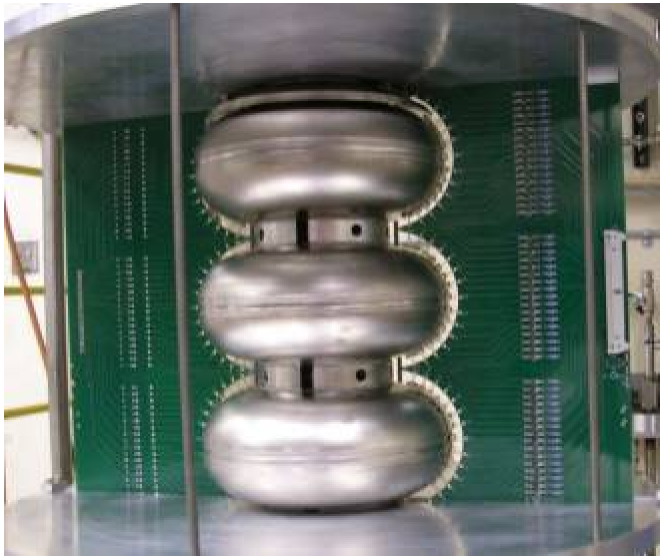
LANL: Improve Cavity Production Yield

- LANL is currently focusing on the following activities.
  - Develop a 9-cell cavity temperature mapping system to localize the problem area(s).
  - Re-start and modify existing RF measurement facility for 1.3 GHz 9-cell cavities.
- A fixed-type T-mapping system that covers the cavity every 10 degrees will be completed around 20 September 2007.
  - The sensor is an Allen-Bradley100-ohm resistor, and its shape is similar to the one developed at Cornell. LANL, in collaboration with a company, developed a way to produce a number of sensors efficiently. (~5000 sensors will be used.)

LANL 9-cell T-map System







- each PCB covers 3 cells
- 108 boards cover the cavity every 10 degrees
- expected scanning time is ~2 seconds.

ILC Americas Cavity and Cryomodule Work Packages

- ART Nomenclature
  - The Main Linac Cavity and Cryomodule plan: WBS X.9
    - WBS 1.9.1 Management WBS Level 2 Manager:
      - Shekhar Mishra, Hasan Padamsee, John Mammosser and Mike Kelly
    - WBS 2.9.1 Main Linac EDR: Cavity and Cryomodule
    - WBS 3.9.1 Cavity Fabrication
    - WBS 3.9.2 Cavity QC and Tuning
    - WBS 3.9.3 Cavity Processing and Vertical Testing
    - WBS 3.9.4 Single Cell Processing R&D
    - WBS 3.9.5 Cavity Horizontal Test
    - WBS 3.9.6 ACD Shape and Material
    - WBS 3.9.7 Cavity Failure and improvement of Manufacturing Yield
    - WBS 3.9.8 R&D on Cavity Processing
    - WBS 3.9.9 ILC Cryomodule
    - WBS 3.9.10 SCRF Material Research
    - WBS 5.9.2 Cavity HPR Systems
    - WBS 5.9.3 Upgrade to the Processing Facility
    - WBS 5.9.4 ILCTA_NML RF Unit Test Infrastructure
    - WBS 7.9.1 Industrial Development
    - WBS 7.9.2 Cavity and Cryomodule Processing and Testing Infrastructure

Cavity Processing and Testing

Fermilab

- The present US cavity R&D is using
  - Distributed Cavity Processing and testing infrastructure
  - This is an ideal way to get started with very limited resources to make significant progress towards the ILC R&D goals.
- The production of high-performance SRF cavities will require state-of-the-art surface preparation.
- We are proposing build additional facility at Fermilab, We already have
  - Existing infrastructure and significant engineering resources
  - Low and High Power Cavity Test Facilities
  - Cryomodule Assembly Facility
  - Cryomodule Test Facility With and Without Beam
- An integrated facility will be needed
  - For significant improvement of the current preparation
  - Steps towards an industrial production-like level
  - A large enough throughput (~100 cavities/yr)

Needed US Laboratories Capacity

Fermilab

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

- 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

Schematic of Cavity Processing Facility

Fermilab

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

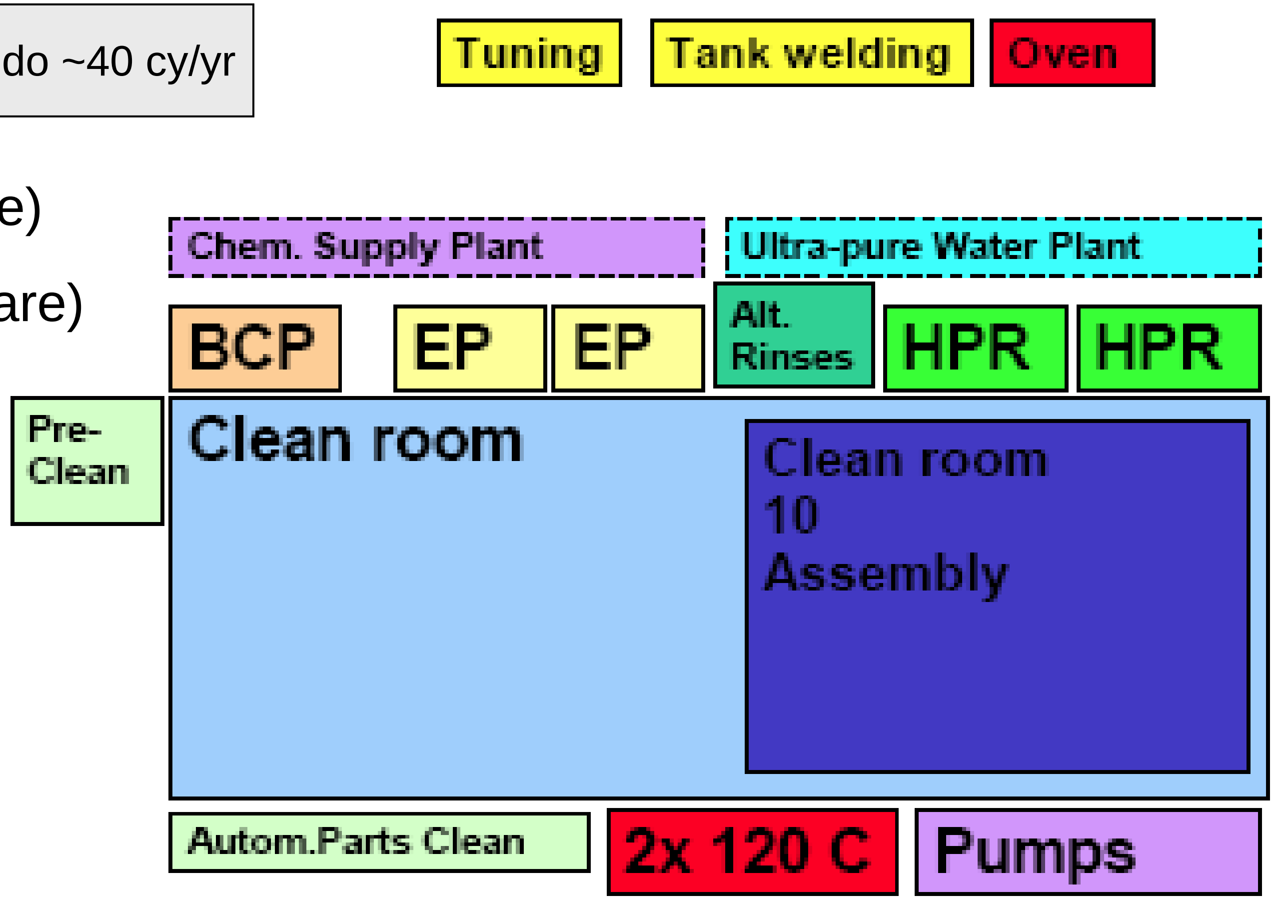


Figure 2: Sketch of the cavity preparation infrastructure.

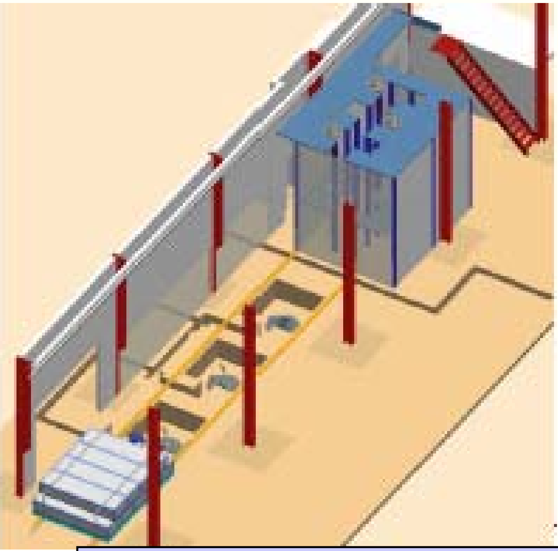
European Infrastructure Proposal

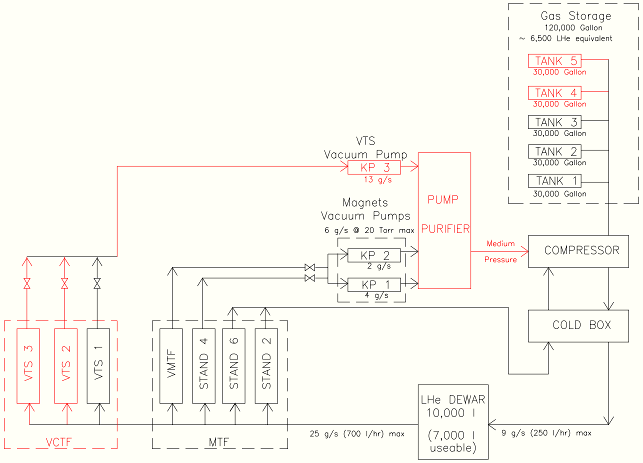
Cavity Processing Facility $18.9M

Proposed: Vertical Test Stand 2 & 3

Fermilab

- 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: $5.5M

MSU & LANL Work Package

- MSU R&D Program
  - Cavity Autopsy to understand fabrication errors
  - Single Cell Cavity (R&D) to explore improved treatments
  - Advanced Cavity and Material Science studies (R&D)
- MSU SRF Infrastructure
  - Upgrade ultra-pure water and high pressure rinse
  - Nine-cell structure vertical test dewar
- LANL R&D Program
  - Cavity Autopsy to identify fabrication errors for low gradient cavities
- LANL SRF Infrastructure
  - Re establish cavity testing at LANL
  - 1.3 GHz Power Amplifier
  - Thermometry

Cornell & Jlab Work Package

- Cornell ILC R&D
  - Processing and Vertical Testing of 9 Cell to qualify high gradient cavities
    - Process 12 cy/yr in FY08
  - Single Cell R&D with thermometry to improve processing, study Q-slope…
  - High Pulse Power R&D to explore gradient recovery from vacuum accidents
  - ACD: Reentrant Cavity Fabrication and Processing
- Jlab ILC R&D
  - Processing and Vertical Testing of 9 Cell Cavity for S0, S1
    - Process 30 cy/yr in FY08
  - Single Cell R&D to improve the Processing
  - Field Emission studies for tracking the contamination
  - ACD: LL Shape Cavities, Large Grain and Single Crystal

ANL Work Package

- Electropolish S0.2 ILC cavities
  - 30-50 Cy/yr
  - Installation of a PLC-based control system for EP
- Single Cell Cavity R&D to qualify treatment
- ANL and Fermilab will work together in cavity processing and testing.

Fermilab Work Package 08

- Order 24 cavities
- Heat treat, tune, HPR and Vertical test: 30-50 cycles/ EP at Argonne
- Horizontal test 8 “good” cavities
- Work with LANL and MSU to supply thermometry diagnostics for failed cavities
- Single cell R&D and Materials R&D collaboration
- Continue Testing First cryomodule (type III) assembled in 07 from DESY supplied cavities
- Assemble and Test cryomodule #2 (Type III)
- Order parts for 2 Cryomodule Gen IV

Fermilab Work Package 08

- Continue Next Generation CM design, manufacturability, transportability, cost reduction
- Cavity Tuning Machine
- Involve industry in fabrication of Dress Cavities activities
- Start Next Generation and Pre-Production cavity processing
- Vertical Test Stand to increase Capacity
- RF unit infrastructure

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

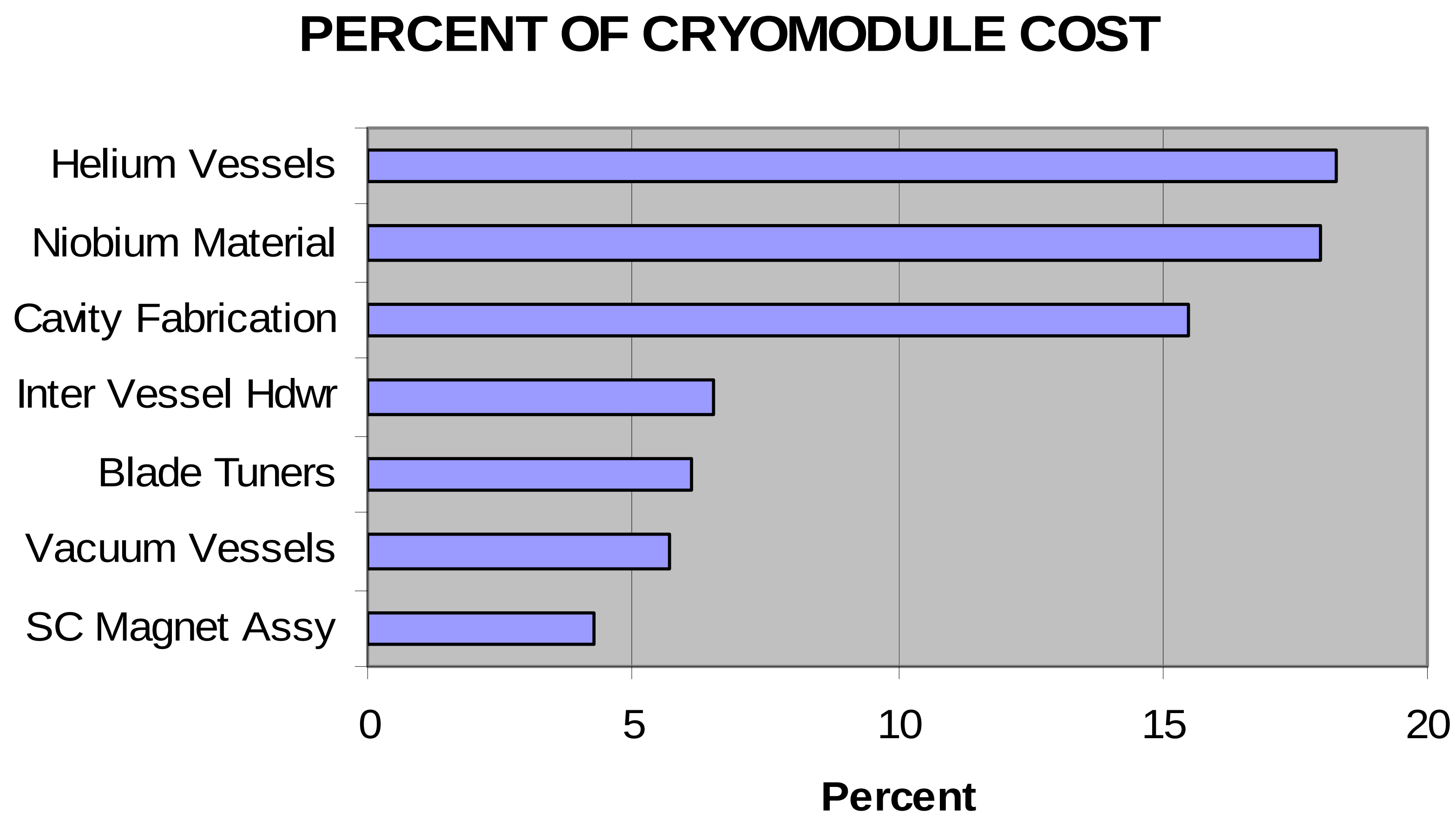
The technology for cavity fabrication & processing, cavity dressing and cryomodule fabrication will be transferred to Industry.

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

Industrial Development

- We plan to work with US industry technology transfer to Fabricate, Process, Dress and test cavity
  - The qualified US vendor will fabricate Cavity, Coupler, He Vessel, Tuner in Industry
  - The cavity vendor could work with a processing industry and Fermilab to process and vertical test the cavity
  - The coupler and He vessel industry could work with Fermilab in dressing and horizontal testing of cavities.

US Study: Cost Drivers



- We are in process of developing cost reduction and value engineering proposal with LCFOA

ILC Americas WP Plan: FY08-FY09 Summary

	FY05	FY06	FY07	FY08	FY09
Cavity and Cryomodule R&D					
Number of Cavities	4	23	16	30	60
Number of Cryomodule Parts		1	1	2	2
Cryomodules Assembled			1	2	2
Processing Capability (CY/yr)					
Jlab			30	40	50
Cornell			12	12	12
ANL/FNAL			20	50	50
FNAL					50
Cavity Failure Analysis					
LANL				4	4
MSU				4	4
1-Cell and ACD Program					
JLAB		X	X	X	X
Cornell		X	X	X	X
MSU				X	X
ANL/FNAL (1 Cell Only)			X	X	X
Infrastructure Development					
Jlab (Processing)		C			
Cornell (Processing)		C			
ANL (EP/HPR)			C		
LANL (HPR/Testing)			C		
MSU (HPR/Testing)				C	
FNAL Program					
VTS-1			C		
VTS-2 & 3				DC	C
HTS-1			C		
HTS-2					DC
CAF			C		
CPF (With Industry)			D	DC	C
ILCTA@Fermilab					
Cryomodule-1 (Type-III+)				IC	
Cryomodule-2 (Type-III+)				IC	
Cryomodule-3 & 4 (Type-IV)					IC
Cryomodule-4 & 5 (Type-IV)					XX

X: Planned, C: Commissioned, D: Design, DC: Design and Construct, IC: Install and Commission

Summary

- We have made considerable progress in building US infrastructure for cavity fabrication, processing and testing.
- We are ready to play a significant role in cavity and cryomodule R&D
  - Cavity Processing (> 30Mv/m)
  - Cryomodule design and fabrication
- The initial plan for FY08-09 is in place
  - This uses the developed strength of the US laboratories in cavity processing
  - We are developing significant infrastructure at Fermilab
  - We will work with US industry
- International Collaboration