Superconducting RF Activities and Plans

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Outline:

- Near Term Plans (1-2 yrs)
  - MB Linac
  - HB Linac
  - Plans for CM12
  - Recent Successes (CM19)
  - Production of Spare Cryomodules
  - SRF Facilities Status and Plans
- Long Term Plans
  - Refurbish Cryomodules to build overhead
  - Procurement of Additional HB Cryomodules
- Summary

Near Term Plans (FY08-FY11)

- **Urgent need is to increase linac gradients to meet the power ramp-up plan, next 1 ½ yrs**

MB Linac:

- Need to repair/recover the two disabled cavities (CM10b,CM11b), during June 08 maintenance down
- Armed with experience gained from repair of CM19, tested Dec. 08, shows repair can be done without degrading performance on assembled cryomodule
  - Procedures we developed worked!
  - Full recovery of both cavities would gain additional ~ 15 MeV!
- Build 1 Spare MB Cryomodule

Near Term Plans (FY08-FY11)

HB Linac:

- **Remove CM12, Feb Maintenance Down, loss of ~ 25 MeV**
  - **CM12 Is the lowest operating HB cryomodule due to end group quenching (Field Emission)**
  - **CM12 Is typical of HB CM performances, field emission limited and therefore represents the best opportunity to develop surface processing techniques**
- **Install CM19, Feb maintenance down, additional gain of ~ 40 MeV!**
- **Fabricate 2 HB spare cryomodules in-house**

Near Term Plans (FY08-FY11)

- **Repair Plans for CM12**
  - Fix beamline leak (venting and cleanroom repair)
  - Perform a baseline test (map the radiation)
  - Develop surface processing techniques
  - Improve the gradients by reducing field emission onset
  - Install in accelerator
  - Apply procedure to additional HB cryomodules as necessary to meet power ramp-up goals

- **Aim is to develop a technique to increase the existing HB cryomodule gradients by 2-3 MV/m per cavity!!**

Repair Plans for CM12:

- **Identified Options:**
  - **Helium or gas processing**
    - **If successful this would represent shortest time to reaching SNS's operational goal, processing could then take place in tunnel on down periods with no disassembly of cryomodules**
  - **Internal surface cleaning without disassembly**
    - HPR
    - CO2, very promising and working at DESY
  - **Reprocessing of cavities**
    - Requires full disassembly of cryomodules
    - Degrease, HPR followed by clean assembly
    - Would interfere with building spares

Recent Successes (CM19):

- **CM19 cavity b suffered from erratic/high power transmission from the HOM b probe**
  - Cavity was operated several months with a blown attenuator on this port

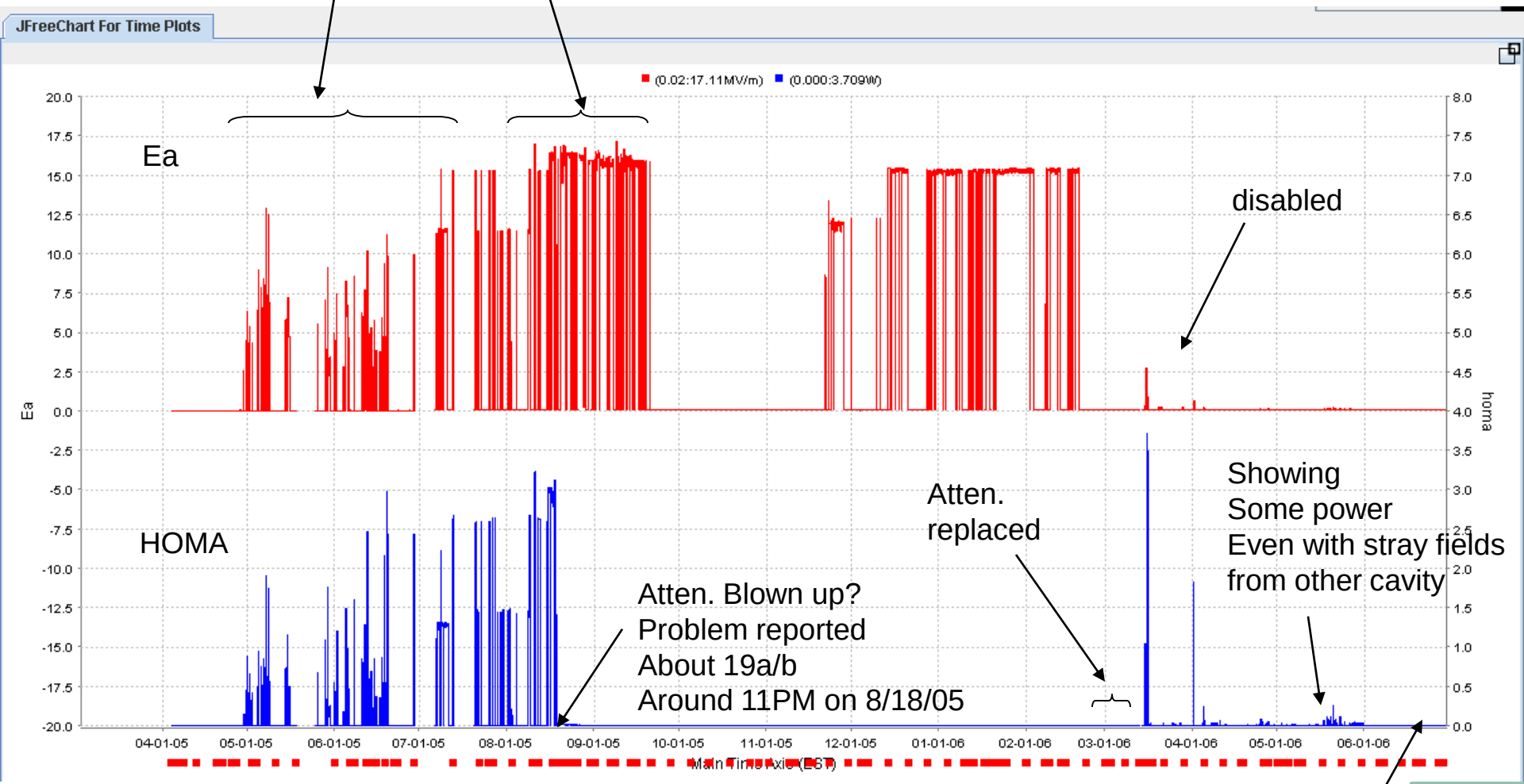
- **Repair of CM19**
  - Cryomodule was moved to cleanroom and beamline vacuum was letup
  - Both HOM probes were removed and blanked off
  - Careful repair procedures were developed and implemented
  - Full monitoring of particulates recorded

Cryomodule Commissioning
19b Ea, limit~18 MV/m
; Qhoma (high power)~1.5e11
Qhoma (low power)~ 1.4e11

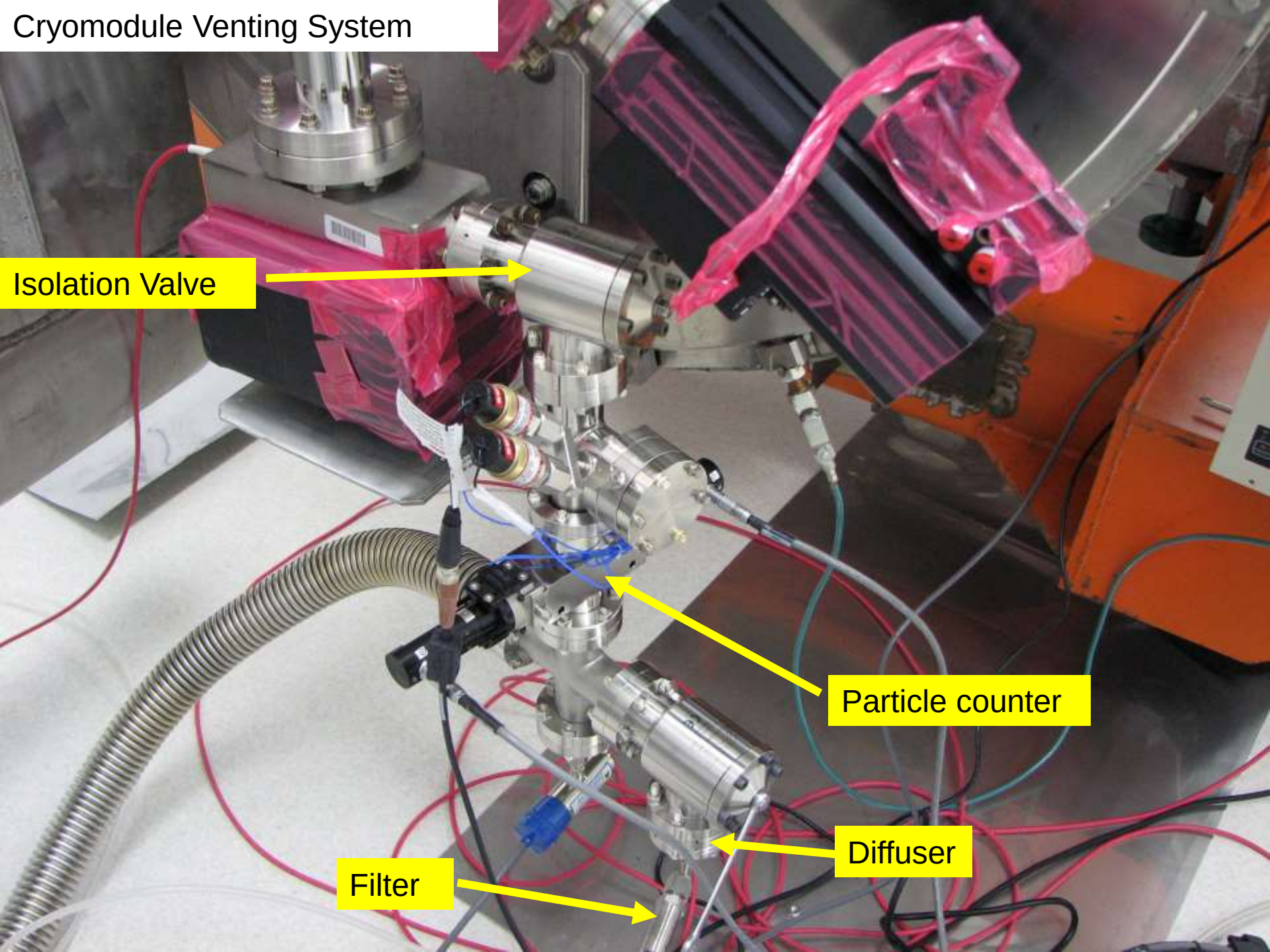
SCL beam commissioning

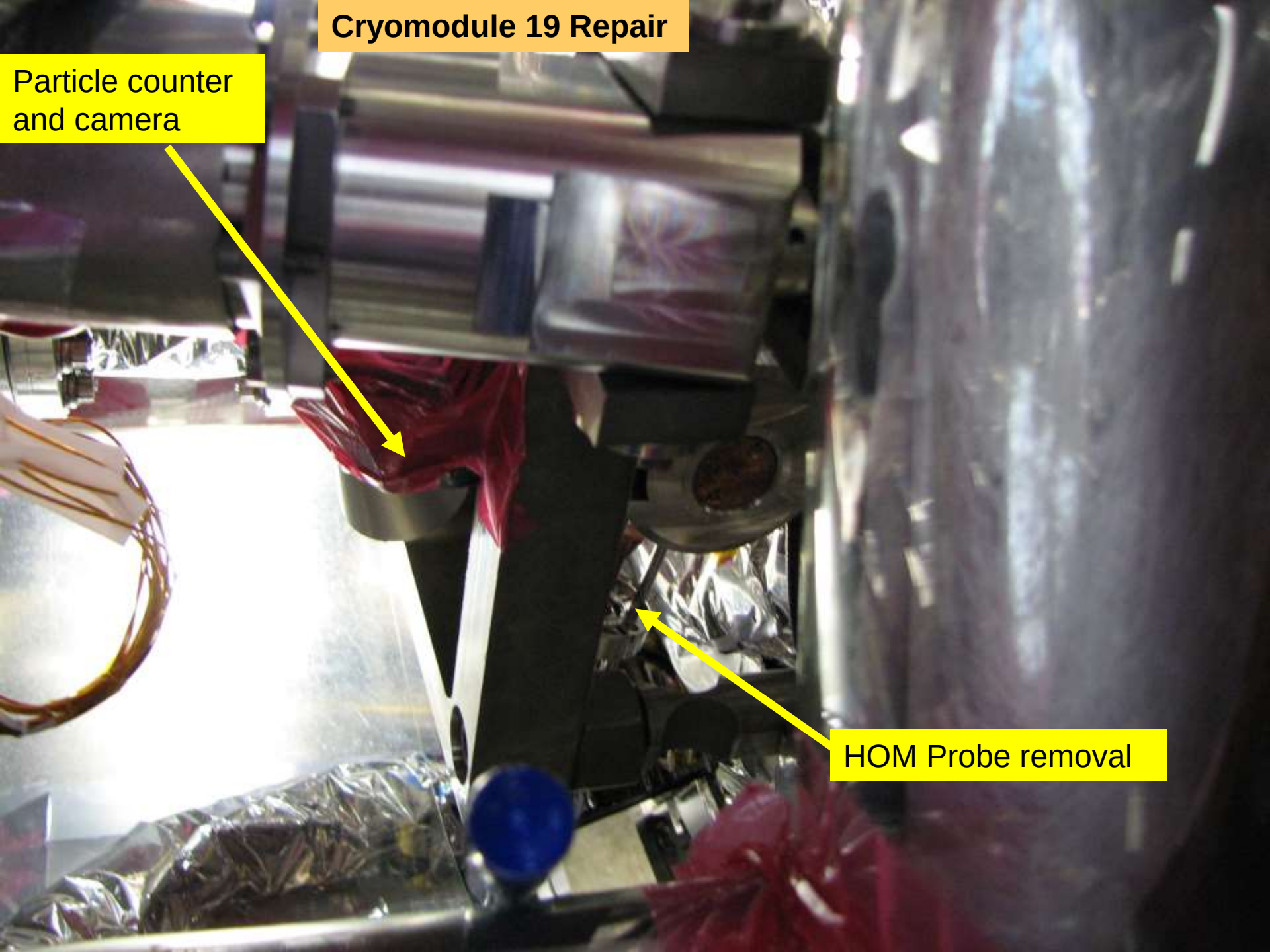
Data from

Sung-Ho Kim

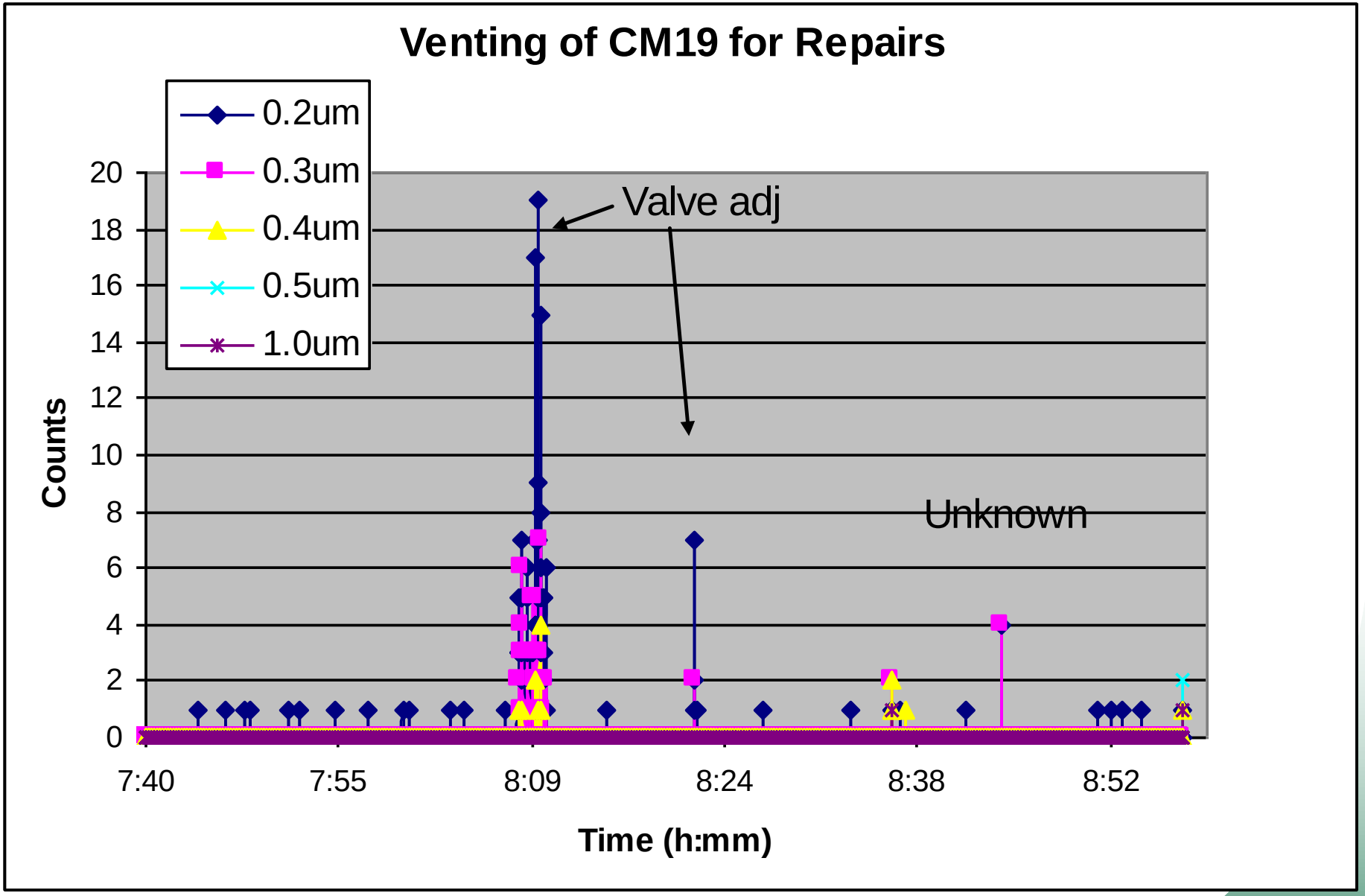


Cryomodule Venting System

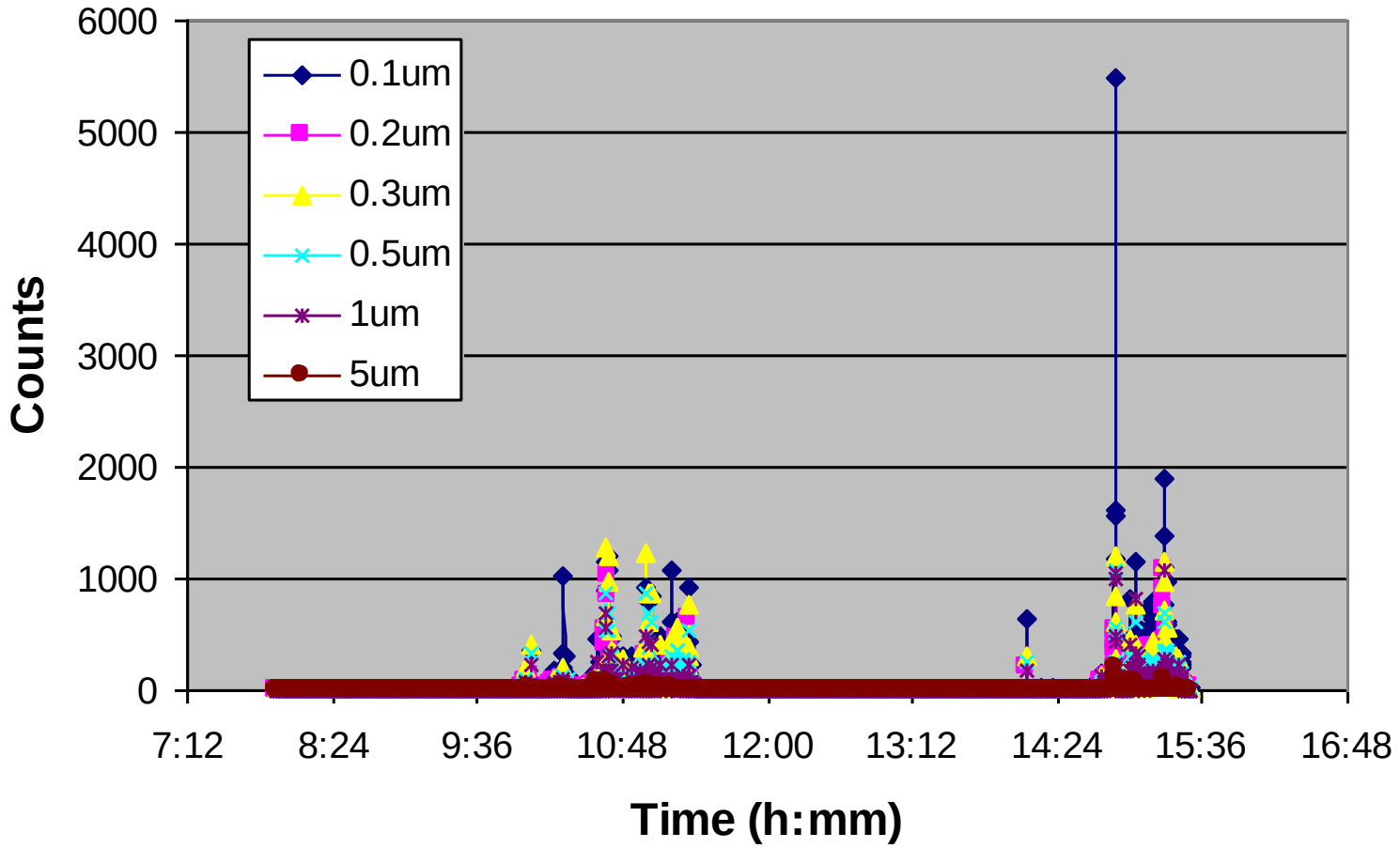


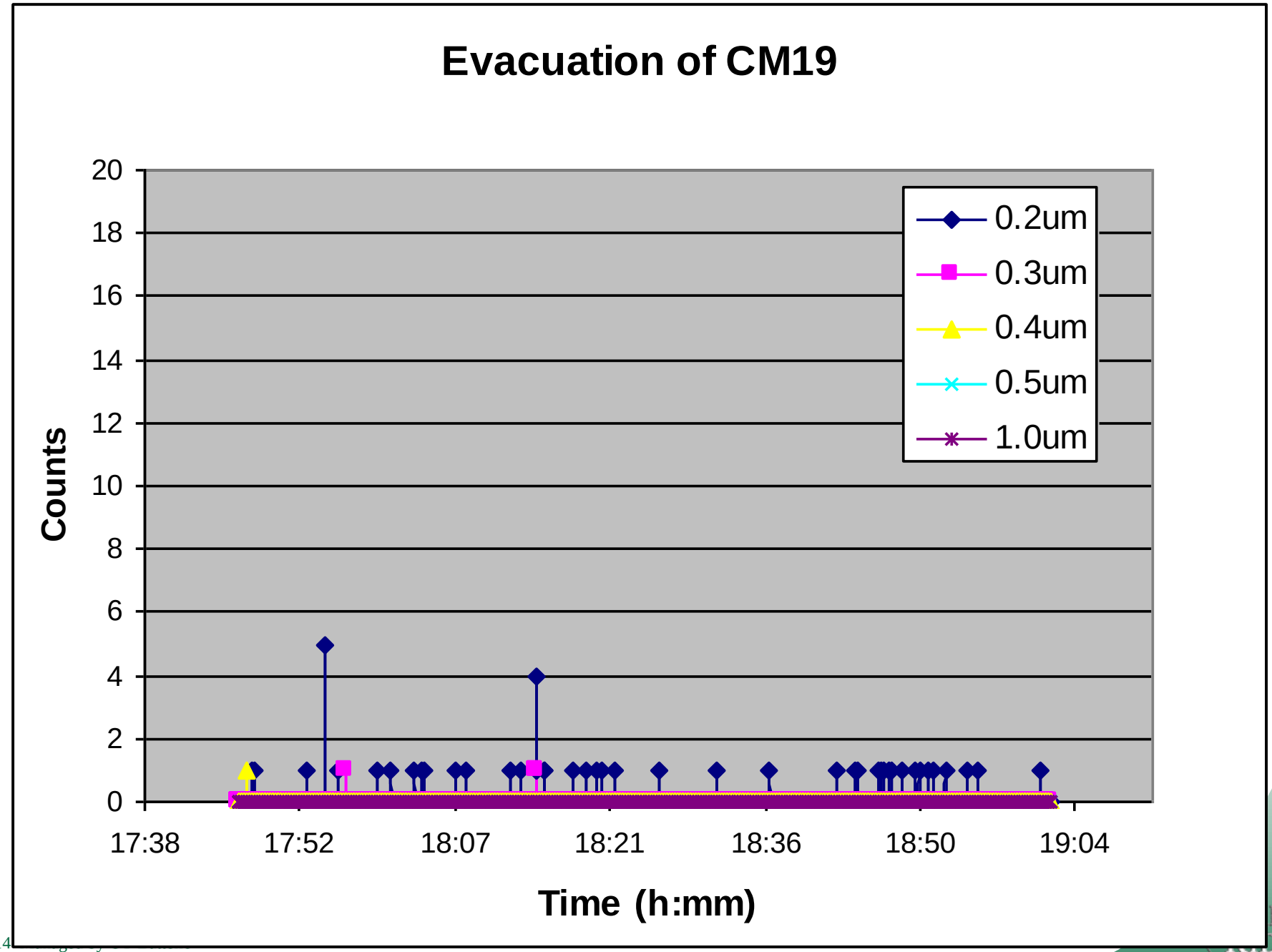

Cryomodule 19 Repair
Particle counter and camera
HOM Probe removal


Beamline
3mR/hr on
contact


Venting of CM19 for Repairs
0.2um
0.3um
0.4um
0.5um
1.0um
Valve adj
Unknown
Counts
20
18
16
14
12
10
8
6
4
2
0
7:40
7:55
8:09
8:24
8:38
8:52
Time (h:mm)

Particle Counts Inside CM19 HOMA




Evacuation of CM19
Counts
20
18
16
14
12
10
8
6
4
2
0
17:38
17:52
18:07
18:21
18:36
18:50
19:04
Time (h:mm)
0.2um
0.3um
0.4um
0.5um
1.0um

CM19 Test Results :

- **All cavities were tested individually at 4.2K, 30Hz 1ms pulse**
  - All cavities achieved > 15MV/m showing no degradation of performance from past data
    - **Collective limits must be determined when installed in Feb 08**
  - Additional diagnostics installed in cryomodule led to further understanding of HOM filters during commissioning phase
    - HOMa - filter showed strong multipacting (MP) which affected many other signals including vacuum, HOMb temperature, electron probe, coupling factors ect.
    - MP was processed away and signals returned to normal

Producing Spare Cryomodules:

- **The need for spare cryomodules is urgent!!**
  - **Problem was**
    - **New modules and repairs must be performed to meet ASME pressure vessel codes**
      - **NbTi material is not listed**
      - **Some weld designs not adequate**
      - **Pressure relief's do not meet ASME standards**
    - **Existing cryomodule design does not accommodate this requirement**
    - **Necessary cryomodule design changes will require drawings modifications**
  - **These problems stalled the start of cryomodule procurement and/or fabrication for at least 1 year**

Addressing Pressure Vessel Requirements

- **To better understand the problem we decided to:**
  - **Build data on pressure circuit materials at various temperatures**
    - **RRR Nb**
    - **NbTi**
    - **SS**
    - **Ti**
    - **Welds and weld transitions**

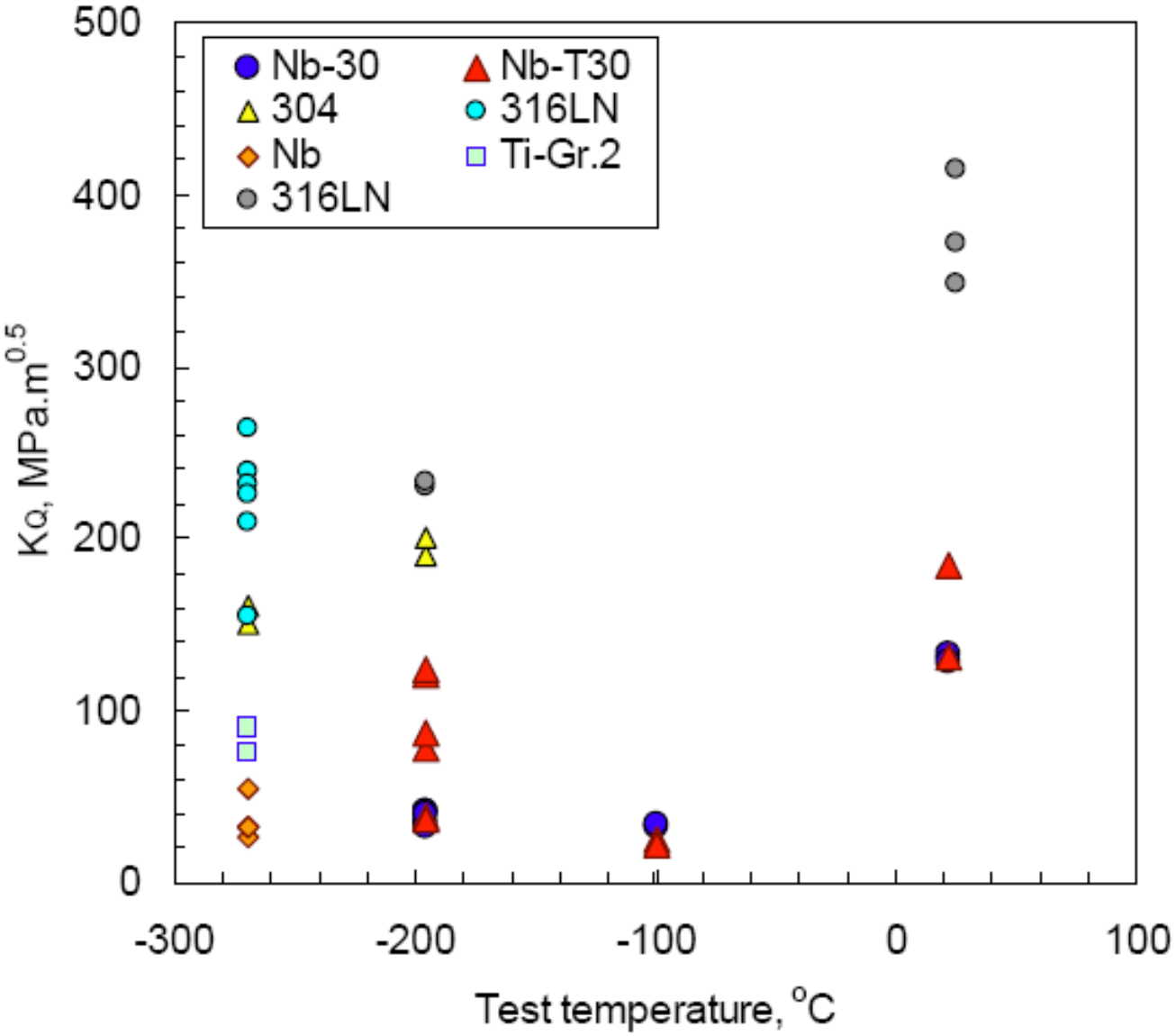
This is well underway!!

  - **Perform pressure tests on all subcomponents to understand safety margins**
    - **Feed-thrus**
    - **Conflat joints**
    - **Bellows**
    - **Transition joints**
    - **Weld joints**

This has started!!

  - **Need to review the pressure circuit design and calculations**

Fracture Testing Preliminary Data (Nb)



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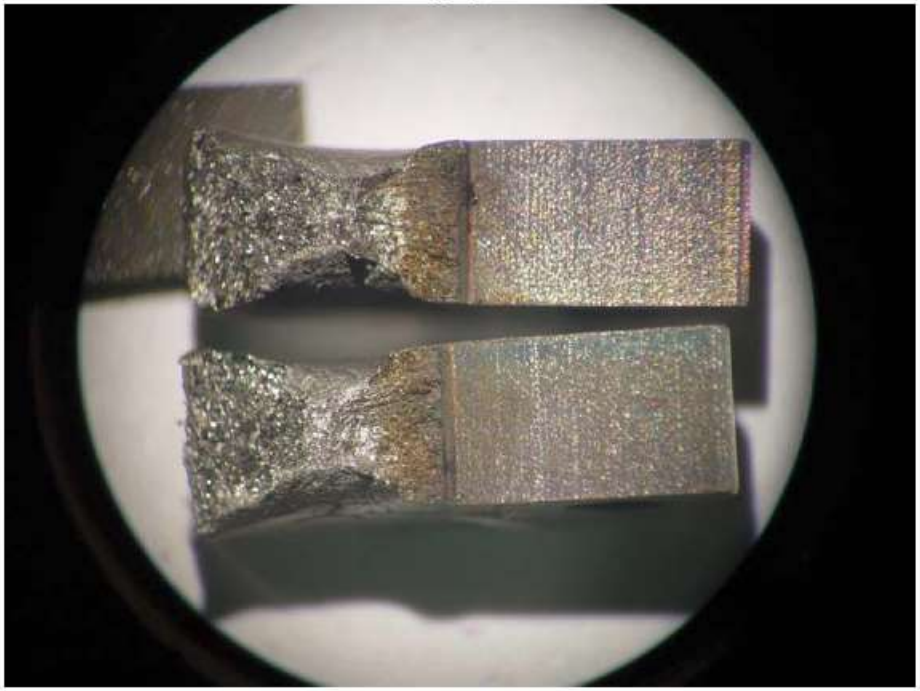
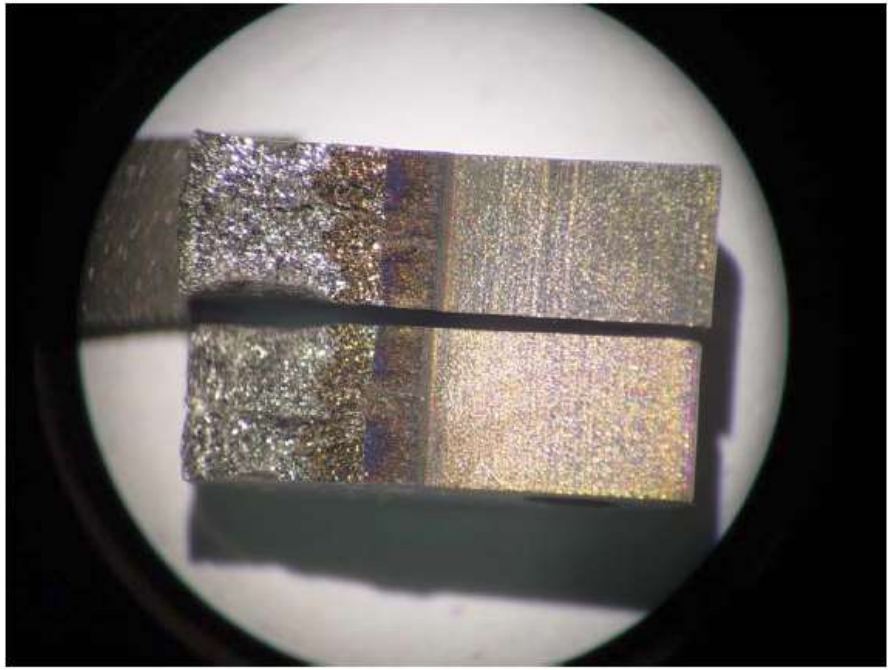
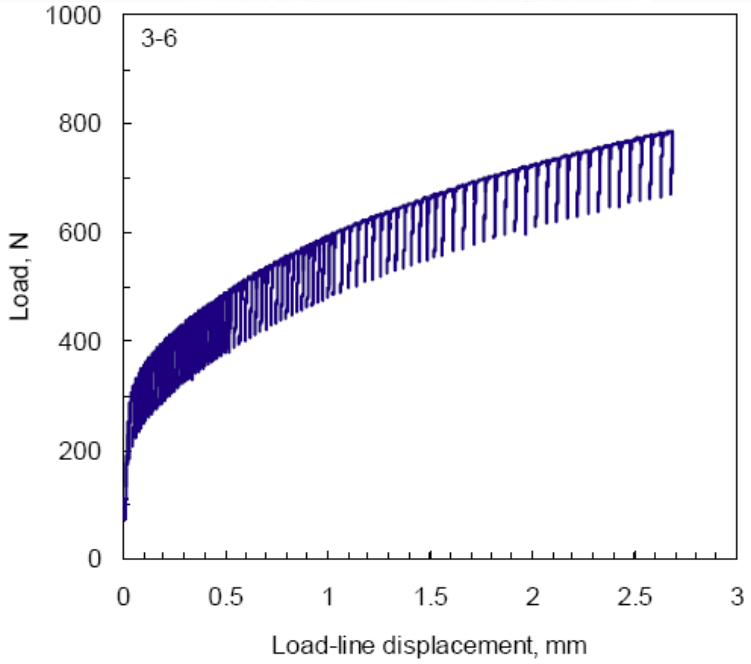
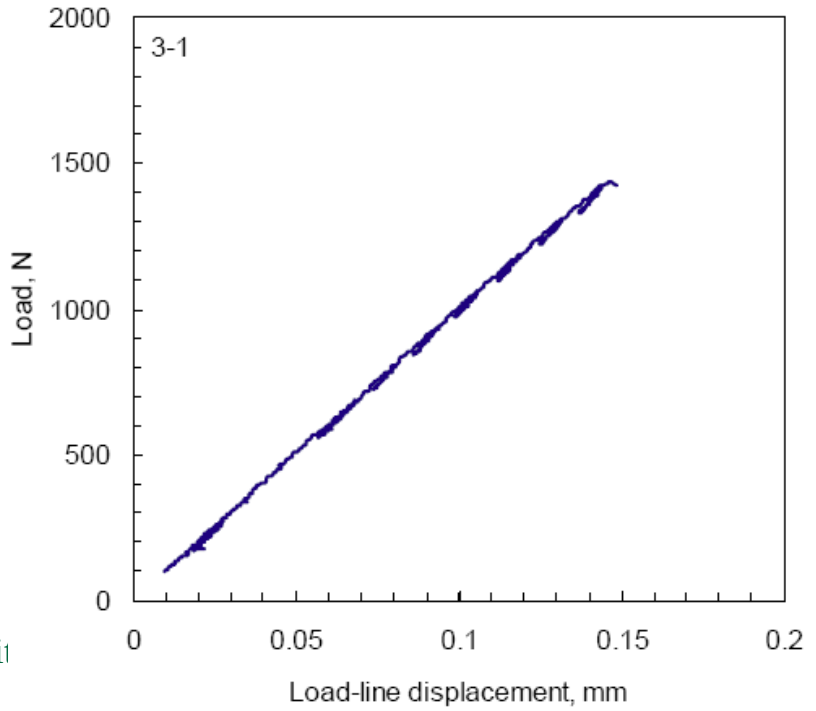


3-1




3-6
Load, N
Load-line displacement, mm
0
200
400
600
800
1000
0
0.5
1
1.5
2
2.5
3


3-1
Load, N
Load-line displacement, mm
0
500
1000
1500
2000
0
0.05
0.1
0.15
0.2

Facilities Needed for String Fabrication

- √ – Cleanroom Facilities
- JLab – DI Water Plant — Existing one available, new one in procurement
- JLab – HPR System — Hardware procured needs design and installation
- √ – String Tooling
- JLab – Cavity Handling Carts — Review designs from vendor then procurement
- JLab – RF Tuning Station — Procurement not started
- JLab – Degreasing and Chemistry — Degreasing procured, chemistry system design started not needed right away
- JLab – Vertical or Horizontal 2.1K Testing — Vertical no progress, horizontal nearing completion

- **Facilities Needed for Cryomodule Completion**

√ – **Assembly Carts and Rails**

√ – **Hoists and Rigging**

√ – **Clean Assembly Space**

√ – **Horizontal Test Facility**

√ - **RF, Controls and diagnostic systems**

- **Cryogenic Systems**

  - **Current system (One transfer line) puts the main linac as risk when in use!!**

  - **System needs to be completed (return transfer line) and decoupled from the from SCL operations**

Picture of Horizontal Test Cryostat Here!!

Producing Cryomodules In-house

- **Fabrication of the spare cryomodules in-house will best meet competing requirements of:**
  - **Solving the pressure vessel requirements in the shortest amount of time (all expertise in-house plus a code shop)**
  - **Allow for proper training of staff to maintain the SCL components through a refurbishment program**
  - **Produce spare cryomodules that are needed to refurbish weaker ones in operations**

Plans For Spare Cryomodule Fabrication:

- **Preparation Underway:**
  - 8 HB and 3 MB spare cavities are now undergoing weld inspection
    - All EB welds with in the pressure circuit are being radiographed and ultrasound tested
    - This procedure necessary to qualify each cavity for use
  - Spare helium vessels were inspected
    - Determination will be made soon on changes needed to meet pressure vessel requirements
    - Development of assembly and weld techniques is underway
    - Transition joints are under review, they may need to be changed if explosion bonding is not acceptable in the code

Plans For Spare Cryomodule Fabrication:

- **Fabrication Procedure**
  - Cavities will be tuned, processed and qualified at JLab
  - Cavities will then have helium vessels added at ORNL code shop
  - Cavities will then be processed and assembled into a string at SNS
  - End cans will be fabricated at ORNL addressing pressure codes in the design
    - MB prototype end cans will be repaired and used for the first HB spare
    - Additional end cans will be fabricated in-house
  - Strings will then be dressed and assembled into a cryomodule at SNS
  - Cryomodules will be tested at SNS then installed in the accelerator

Plans For Cryomodule Fabrication

- **Plans are for building 2 HB cryomodules and the rebuild of a MB cryomodule in the next 3 years**
  - High priority is HB so they will be built first
  - A dedicated multidiscipline group was formed carryout this effort (~7.5 FTEs)
  - MB prototype was completely disassembled and subcomponents will be reworked as fully functional MB spare
  - 2 HB Cryomodule subcomponents sets will be procured with the exception of endcans

Long Term Plans Beyond 2 years:

- **Use experience from spare cryomodule production to prepare for procurement (industry) of 9 new HB cryomodules for power upgrade project**
- **Apply what was learned from improving CM12**
  - **Start a refurbishment program to improve cryomodules in the accelerator or remove to rework**
- **Start SRF R&D**
  - **Continuous effort toward improving the SRF capabilities here**
  - **Develop a long term R&D plan**

Summary:

- **CM19 Success, repaired internally and gradients were fully recovered with no degradation**
  - **CM10,11 repair next**
- **CM12 will be removed to develop surface processing techniques on full cryomodules (1yr)**
  - **Aimed at increasing collective limits on cavities**
  - **Successful techniques will then be applied to linac cryomodules**
  - **2-3MV/m per HB cavity is needed**

Summary:

- **The production of spare cryomodules is now underway!!**
  - **With help from JLab!**
    - **2 HB and 1MB planned in the next 3 years**
  - **Pressure vessel requirement will be met on new cryomodules, expertise is here**
- **SRF Facilities**
  - **Test cave, cleanroom facility operational!**
  - **New DI plant, HPR, Degreasing, Horizontal test cryostat, vertical dewar all underway!**
  - **Vertical test apparatus In fabrication stage!**