Linear Collider Forum of America

Jefferson Lab: Future Cavity/Cryomodule Activities

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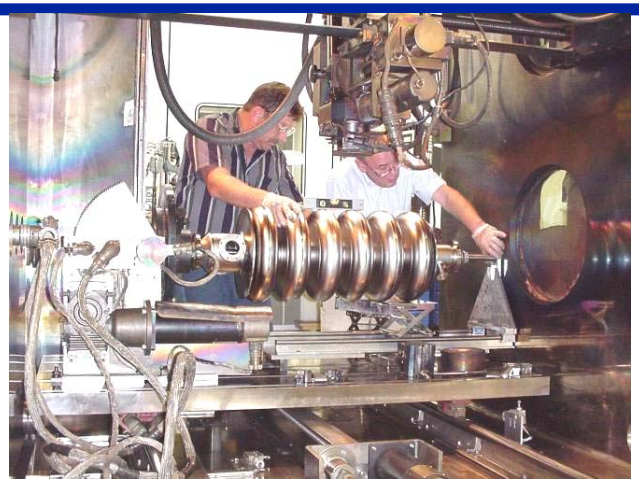
SLAC, May 1-2, 2006

Outline

- What are our capabilities?
- How do we plan to use them?
  - CEBAF Cryomodule Refurbishment
  - CEBAF 12 GeV Upgrade Cryomodule Production
  - ILC R&D Activities
  - High-current FEL modules

Production Facilities – Cavities

Deep Drawing Press



Electron Beam Welder

1250ºC Vacuum Oven

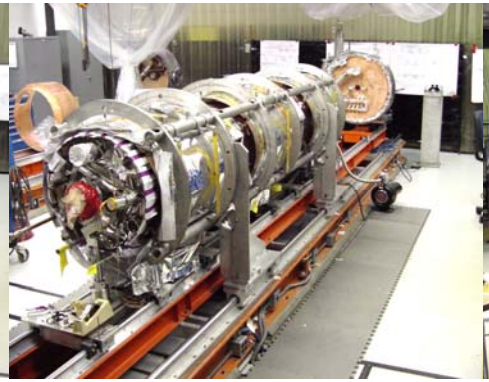
Closed Chemistry Cabinet

Electropolish Cabinet

Hi Pressure Rinse Cabinet

Class 100 & 10 Clean Rooms

Production Facilities – Cryomodules

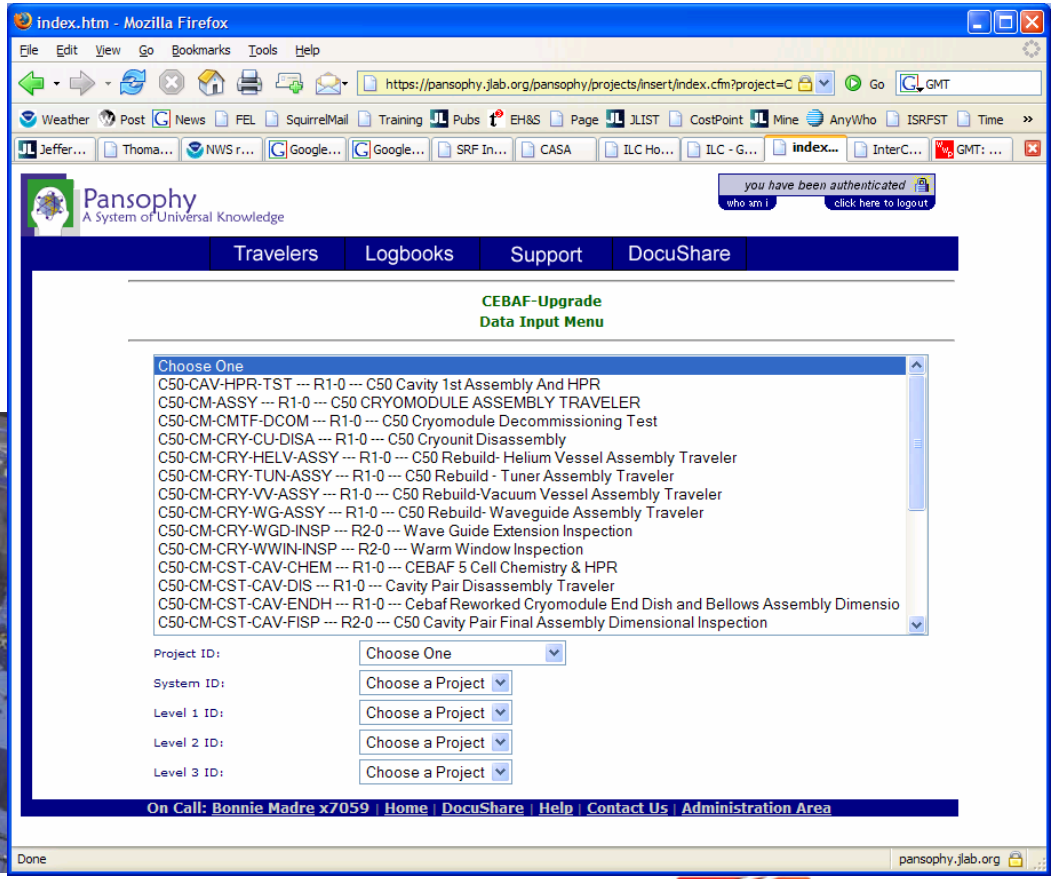


Production Facilities - Testing

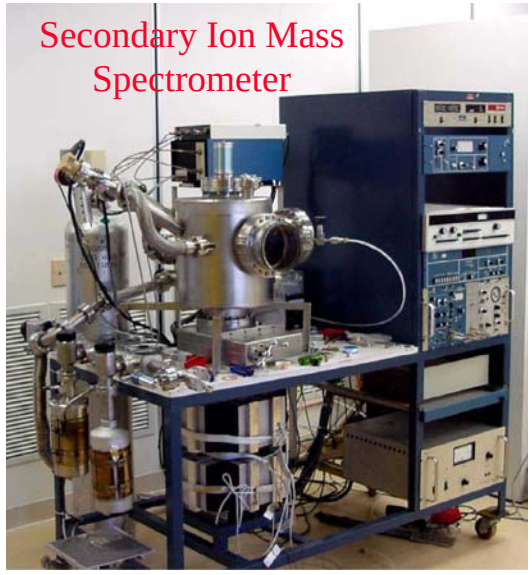
Cryomodule Test Facility

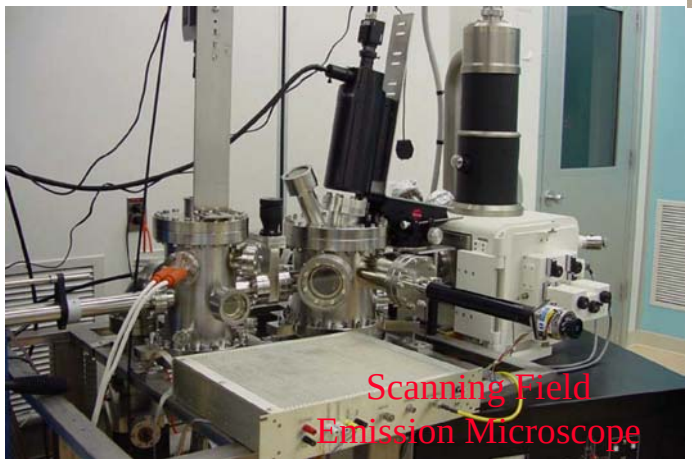
Vertical Test Area

- VTA has 500 W cw sources at 805 and 1497 MHz; 250 W @ 1300 MHz
- CMTF has 20 kW 805 MHz cw source and 16 kW 1497 MHz cw source
- Supported by ~250 W, 10 gs^{-1} 2 K refrigerator
- *'in-situ'* bakeout ovens
- 1200˚C vacuum furnace
- Fully electronic, web-based process data collection



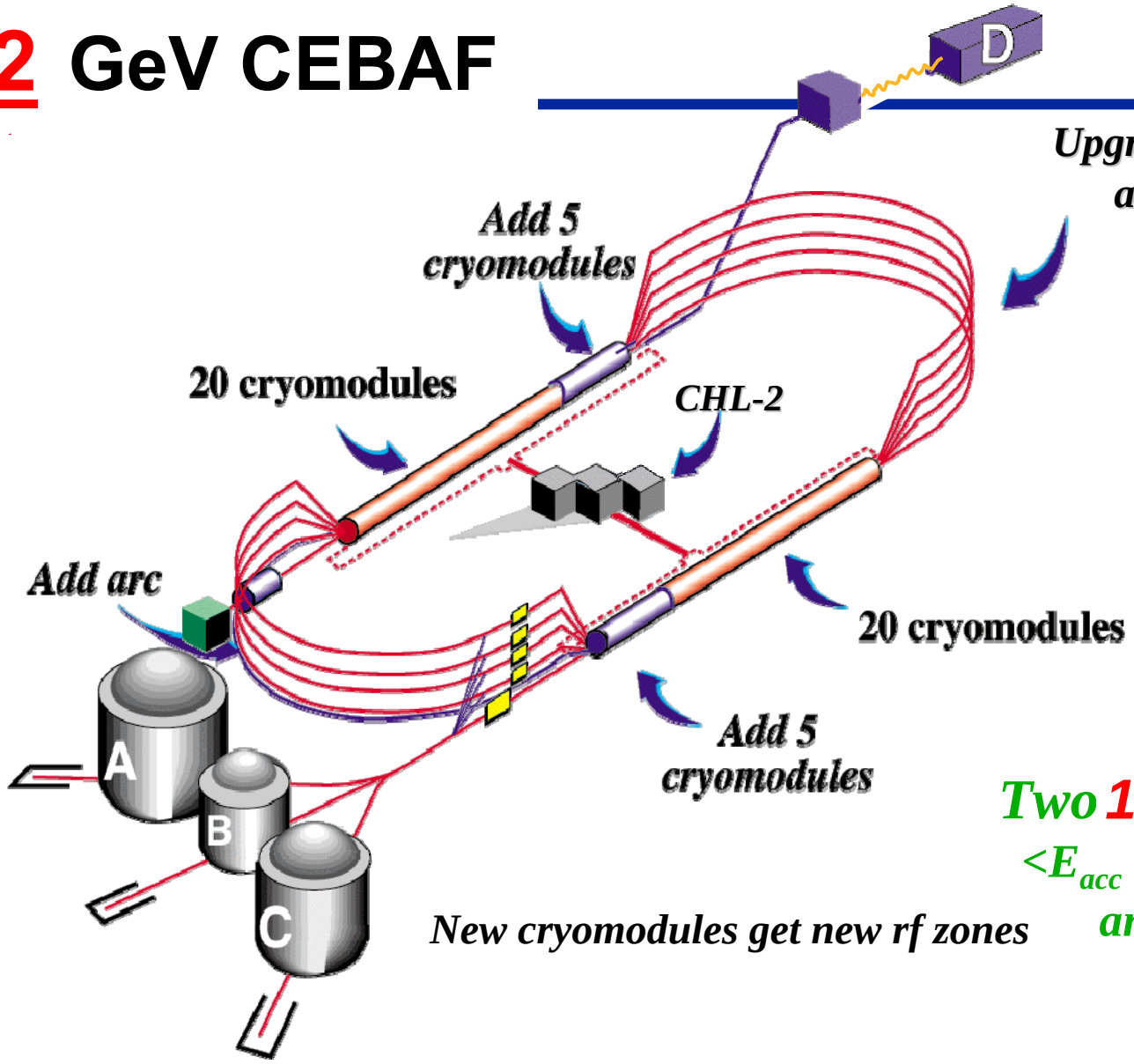
Facilities for R&D Include Production Facilities Plus Surface/Materials Test Equipment





+ Scanning Electron & Metallographic Optical Microscopes

12 GeV CEBAF



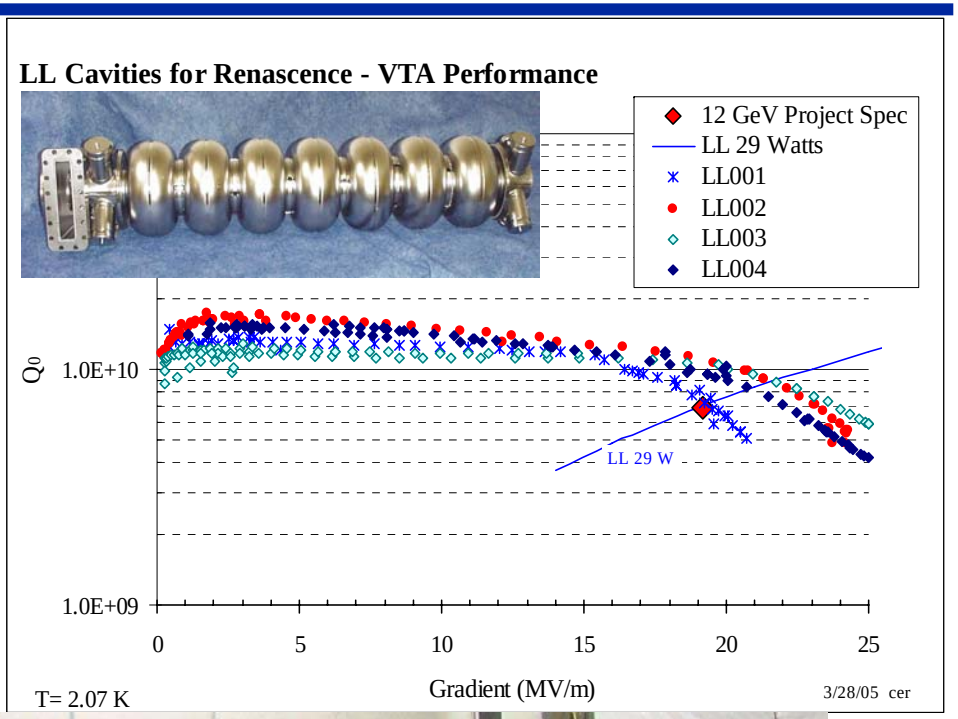
New cryomodules get new rf zones

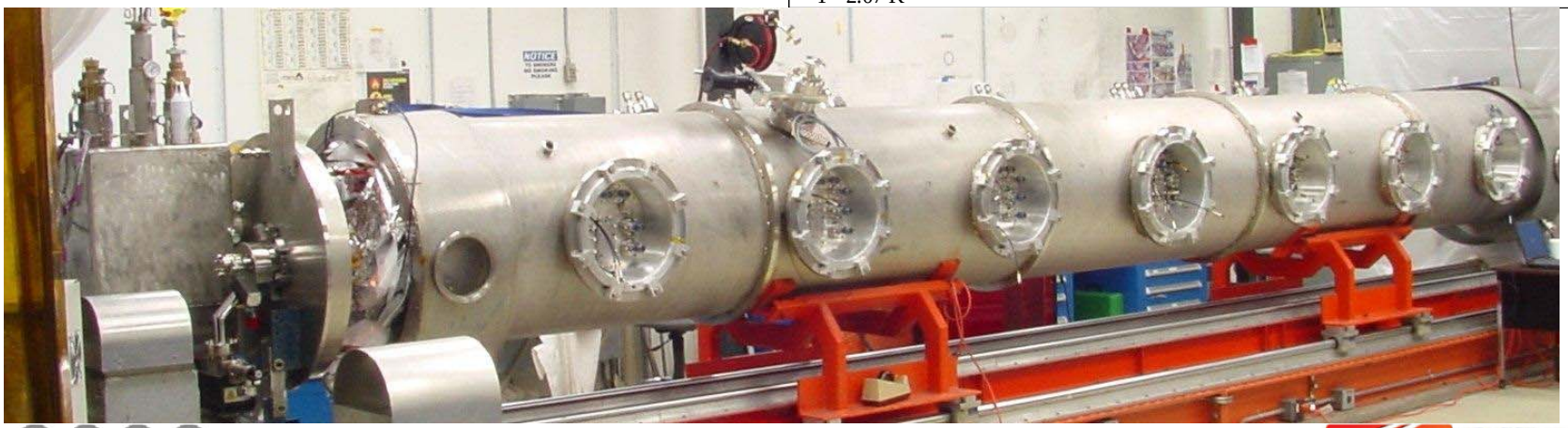
Two 1.1 GV linacs

$<E_{acc}>$ = 7.5 MV/m and 17.5 MV/m

Scope of 12 GeV Upgrade Accelerator Systems

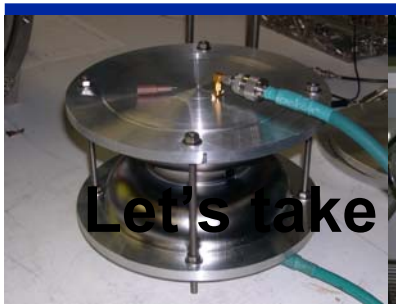
- **Cryomodules**
  - Increase linac acceleration by 0.5 GV/linac
  - 10 new cryomodules (5 per linac)
  - Required average on-line performance
    - 100 MV/cryomodule; < 300 W @ 2K and 300 W @ 50 K
  - Target performance (includes margin to ensure on-line performance is met)
    - 108 MV/cryomodule; < 300 W @ 2K
    - Prototype's cavities exceeded this requirement

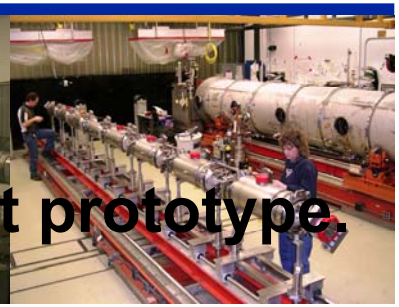




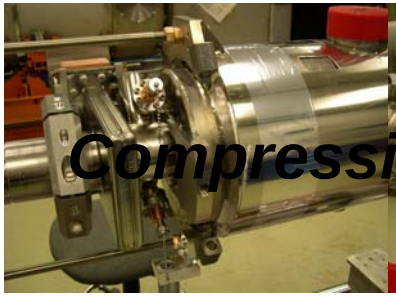
10 New Cryomodules

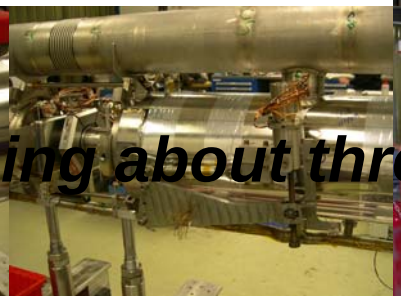
Let's take a look at the construction of the latest prototype.


Cavity and


String Assembly

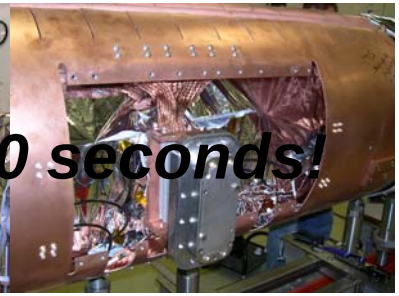
Compressing about three months of work into 20 seconds!


Intracavity detail


Zero-length tuner

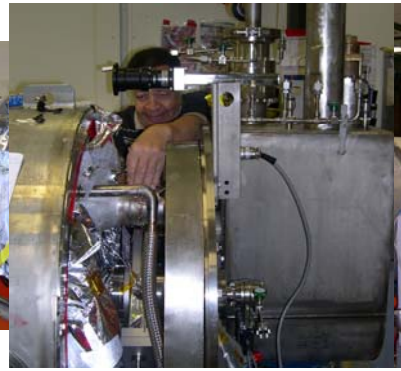

Helium plumbing


Thermal shields


FPC details


Magnetic shields

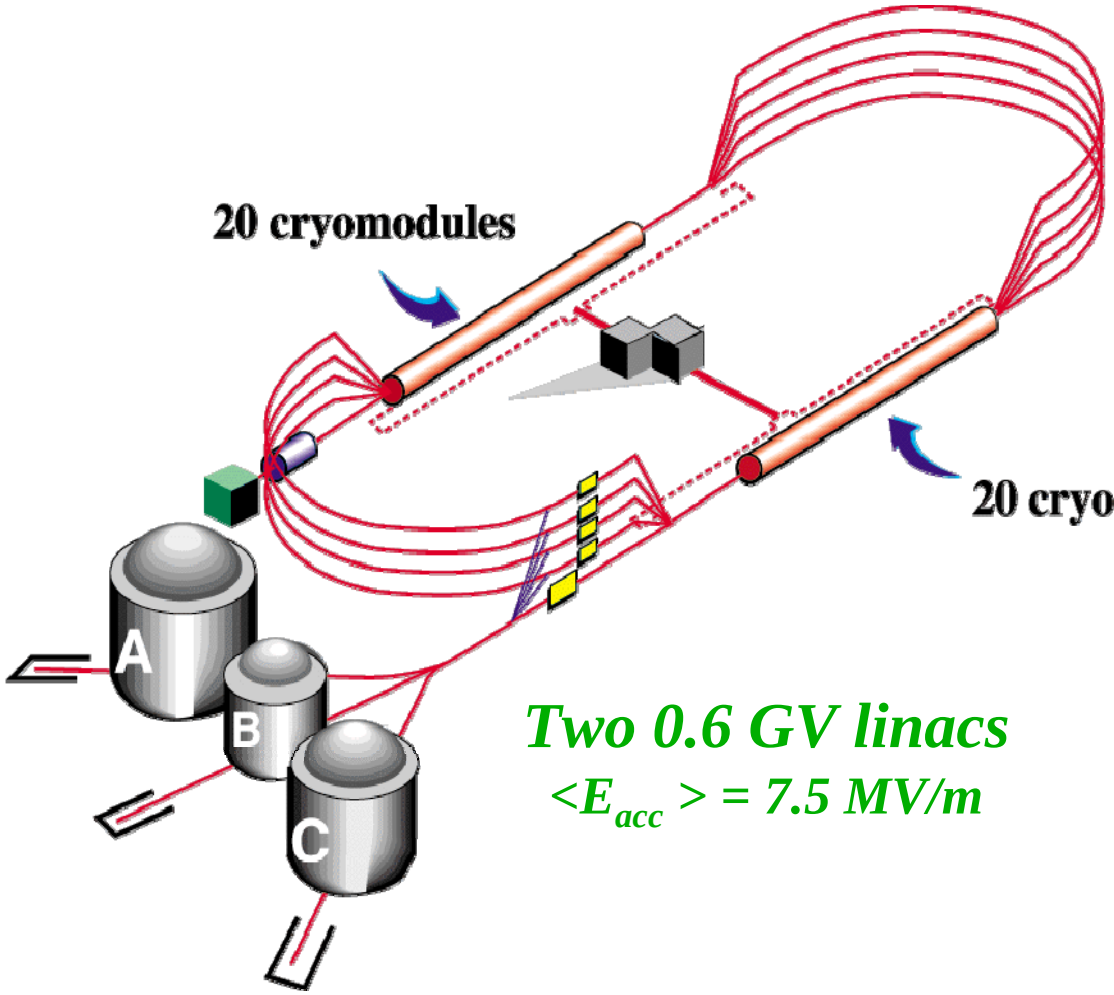

Space frame


Cryostat closeup


Cryostat leakcheck


Final test

6 GeV CEBAF Refurbishment



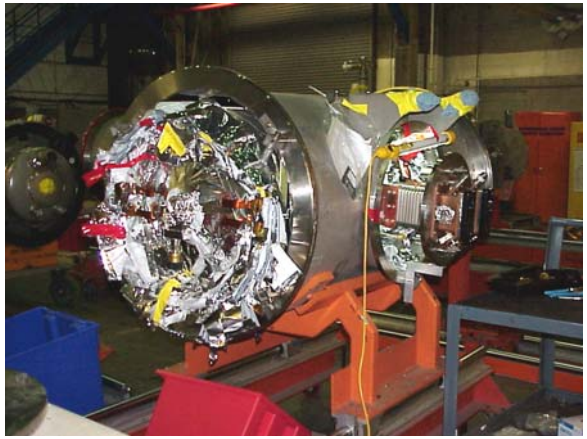
Two 0.6 GV linacs

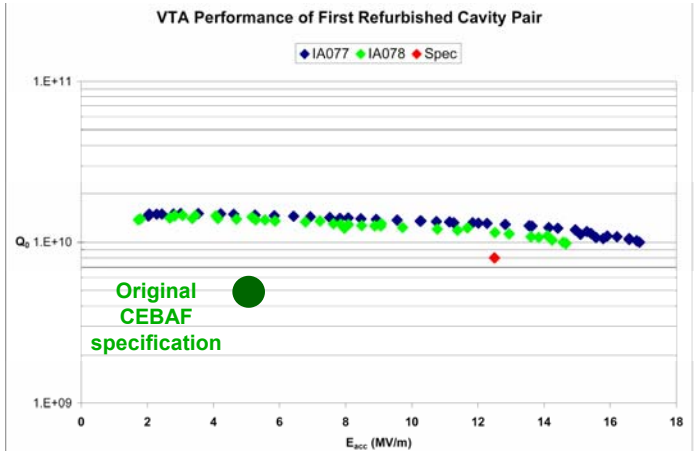
$<E_{acc}>$ = 7.5 MV/m

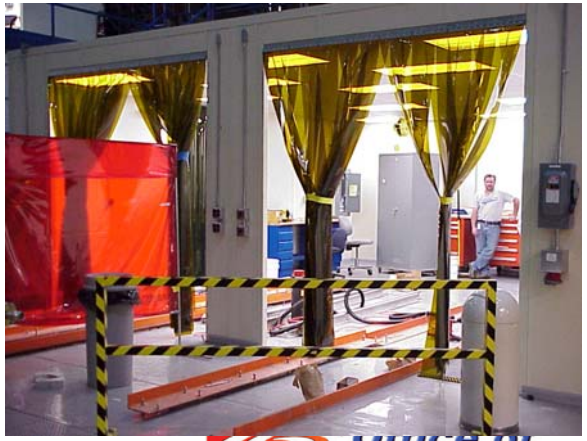
- *Thermal cycles ➔ vacuum issues ➔ reduced gradient*
- *Cryomodule refurbishment: 3 module overhauls per year*
- *Goal: use up-to-date processing techniques to achieve up-to-date gradients*
- *Provide a stable foundation for 12 GeV operation*

Toward Stable 6 GeV Operation

- **Cryomodule Refurbishment Plan underway**
  - **Reworking existing CEBAF modules to 50 MV (E_{acc} ≥ 12.5 MV/m) (present operating average is 28.7 MV)**
  - **Expect to refurbish 3 cryomodules/y (10+ total)**







Fabricate TESLA Cavities (3.9.3.1)

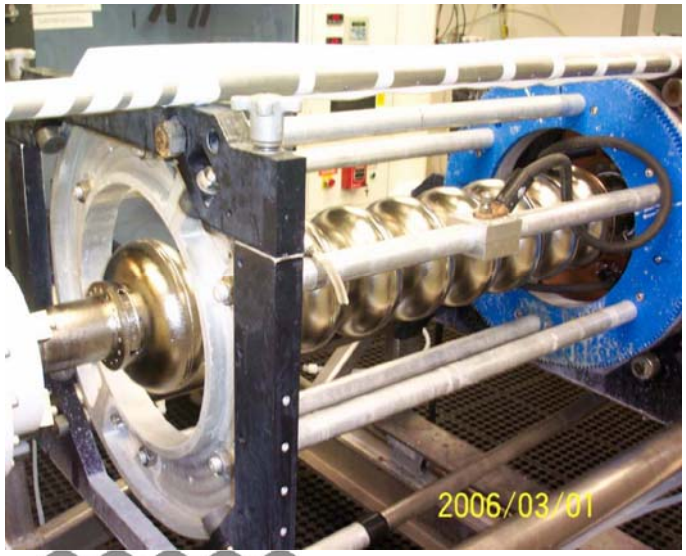
- **Scope**
  - Fabricate and test a prototype TESLA cavity from polycrystalline RRR niobium
  - Fabricate 2 modified TESLA/ILC 9-cell cavities from large grain niobium with shorter beam pipe and possibly modified HOM couplers

- **Status**
  - Half cells for all 3 cavities have been deep drawn
  - All inner cells have been machined for dumbbell welding
  - Flanges (beam line, HOM, FPC, field probe) are in fabrication
  - HOM cans and coupling loops are in fabrication
  - Other parts (He vessel end dish..) are also in fabrication

From Peter Kneisel

Electropolish Studies (3.9.3.2)

1. Adapt production EP tooling to 9-cell cavity
   - Complete – ready to perform first EP on TESLA cavity
2. Develop production assembly procedures
   - Confirms readiness of other process elements to preserve cavity quality
   - 1st pass complete – ready to test on 2nd 9-cell cavity
3. Develop production EP procedures
   - Ready to begin
4. Develop EP process
   - Bench experiments underway – sulfur!



Budget $400k
Received $175k
(balance due May 1)

Will continue in FY07

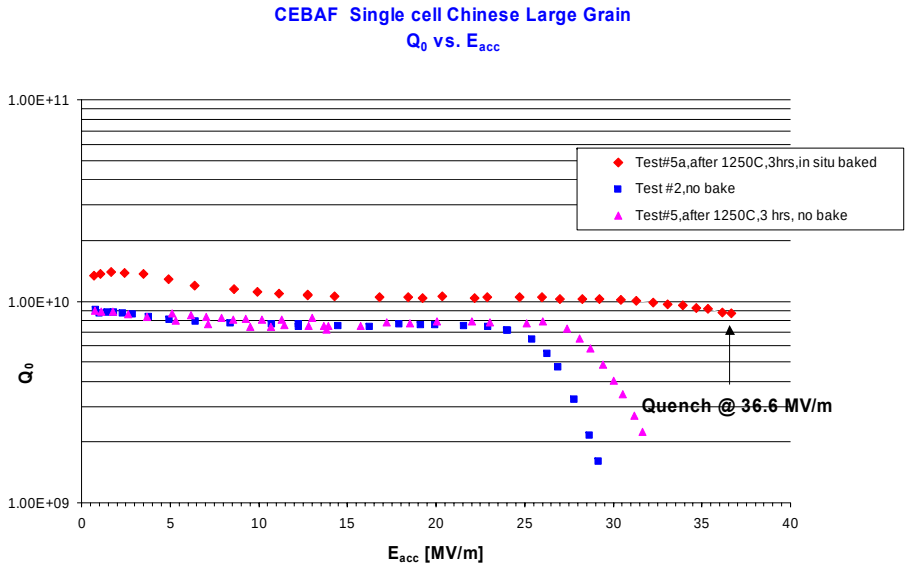
From John Mammosser

Large-Grain/Single-Crystal Niobium Studies (3.9.5)

Scope

1. **Several single cell and at least one multi-cell LL cavity made from large grain/single crystal niobium**

- Single cell cavities (TESLA, LL,CEBAF HG shapes) were fabricated from different material vendors; tested before and after "in situ" baking and post–purification heat treatment.
- ILC LL 7-cell cavity has been manufactured; stiffening rings being added.
- 7-cell CEBAF HG cavity fabricated and being evaluated
- Large grain niobium for 5 additional single cell cavities on order
- All cavities treated by BCP and HPR (no EP)
- All Single cell cavities limited by quench (no field emission) at 30 MV/m <E_{acc}< 36 MV/m (128 mT <H_{peak}< 160 mT)
- All cavities showed "Q-slopes", which disappeared after "in situ" baking at 120°C for 12 hrs



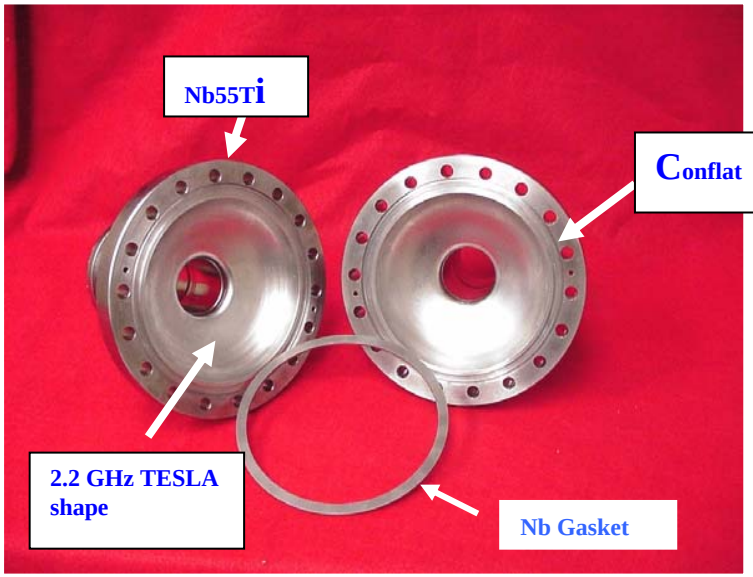
2. **Improved BCP system for large grain /single crystal material**
   - Preliminary tests have shown the importance of constant agitation

From Peter Kneisel

Large-Grain/Single-Crystal Niobium Studies (3.9.5) (cont'd.)

Scope

3. **Test cavity for superconducting joint investigation**
   - Cavity complete (scaled TESLA @ 2.2 GHz); testing begun
   - 2-cell TESLA cavity received; flanged modification planned
   - Investigation of oxide layer and topology of material in knife edge groove started in collaboration with DESY
   - TESLA single cell fabrication from Nb55Ti for evaluation of Nb55Ti as flange material in higher magnetic field started
   - Plasma-Nitridation of Nb gasket and/or niobium flange in discussion (coll. with DESY)
4. **Results from these investigations with the goal to incorporate the most promising design in a super-structure**
   - Not yet begun



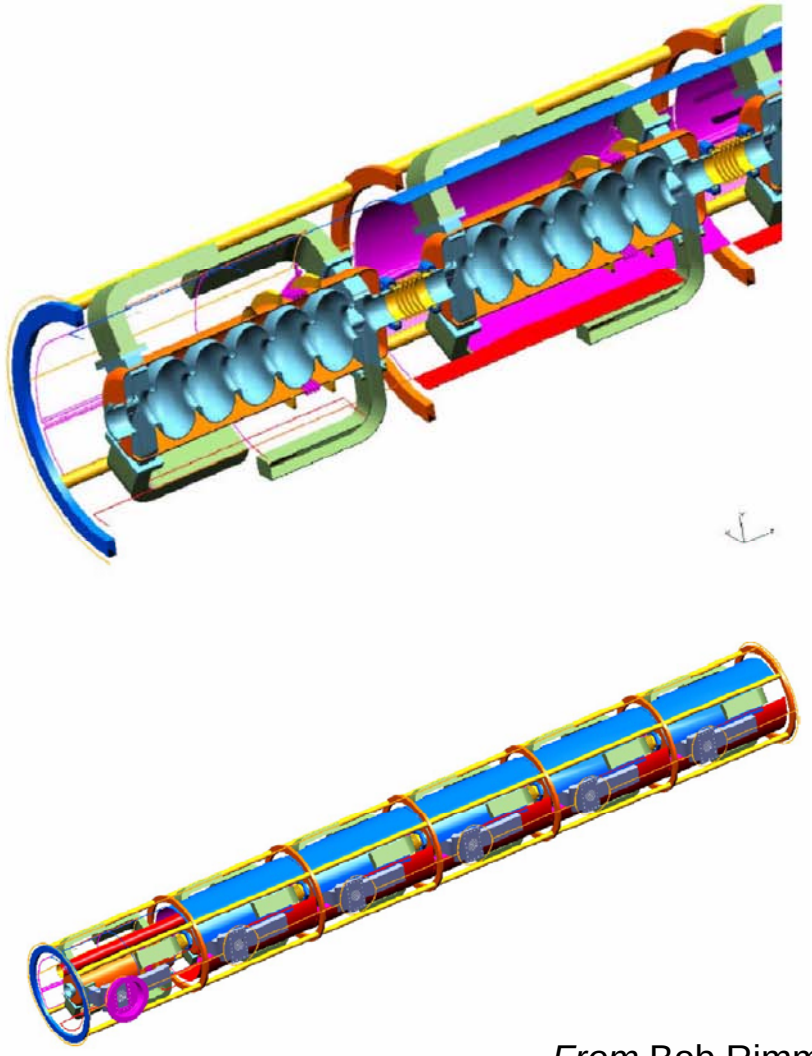
From Peter Kneisel

Ampere-Class Module for ERL-based FELs

Layout uses JLab style space-frame and cryogenic piping (hybrid of upgrade and SNS styles), modified to accommodate extra HOM loads.

750 MHz cryomodule with six five-cell cavities with waveguide damping

Frequency	750 MHz
# cells	5
Damping Type	Waveguide
Cavity Length	1.4m
Iris Diameter	14 cm (5.5")
# Cavities	6
Min. Module Length	10.4m
Nominal Module Voltage	100 MV (120 MV peak)
Cavity Gradient (Eacc)	16.7 MV/m (20 MV/m max)
Real Estate Gradient	~10 MV/m
TE_{111} freq, Q_{ext}	947 MHz, 9.5e2
TM_{110} freq, Q_{ext}	1052 MHz, 3.3e3
TM_{011} freq, Q_{ext}	1436 MHz, 7.1e2
HOM Power/Cavity	~20 kW(est)
BBU Threshold	>1A



From Bob Rimmer