Design and Fabrication of The RHIC Electron-Cooling Experiment High Beta Cavity and Cryomodule

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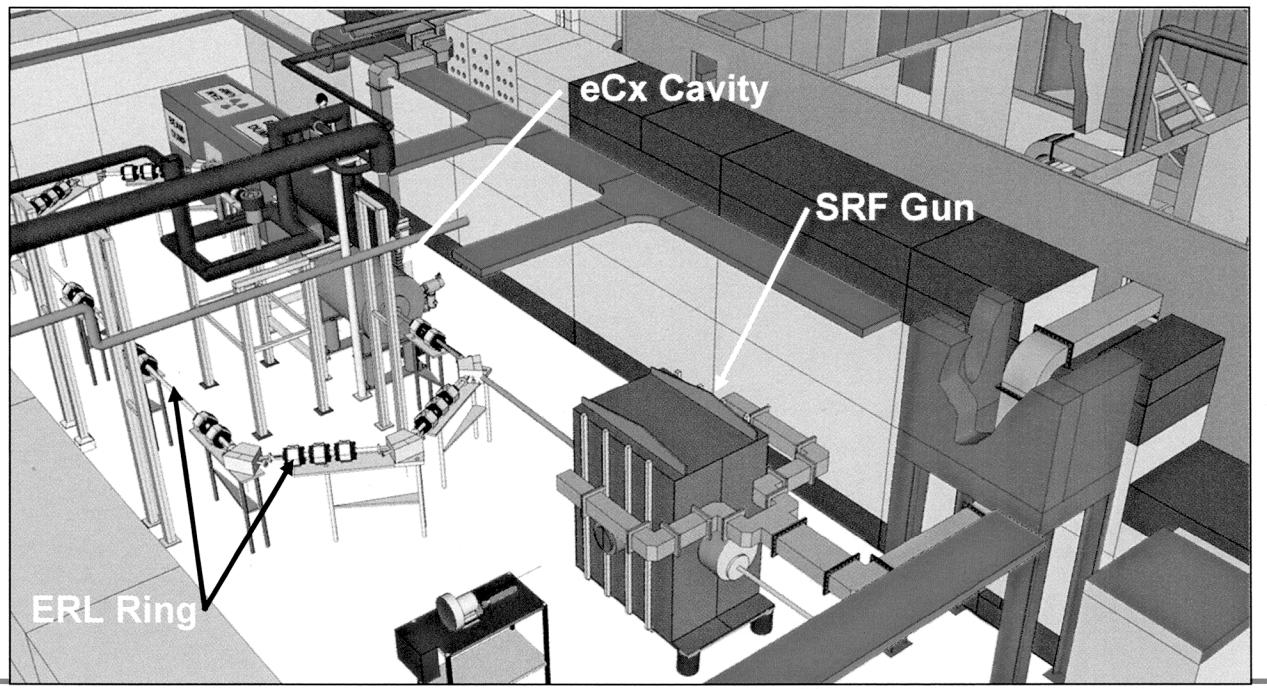
Outline

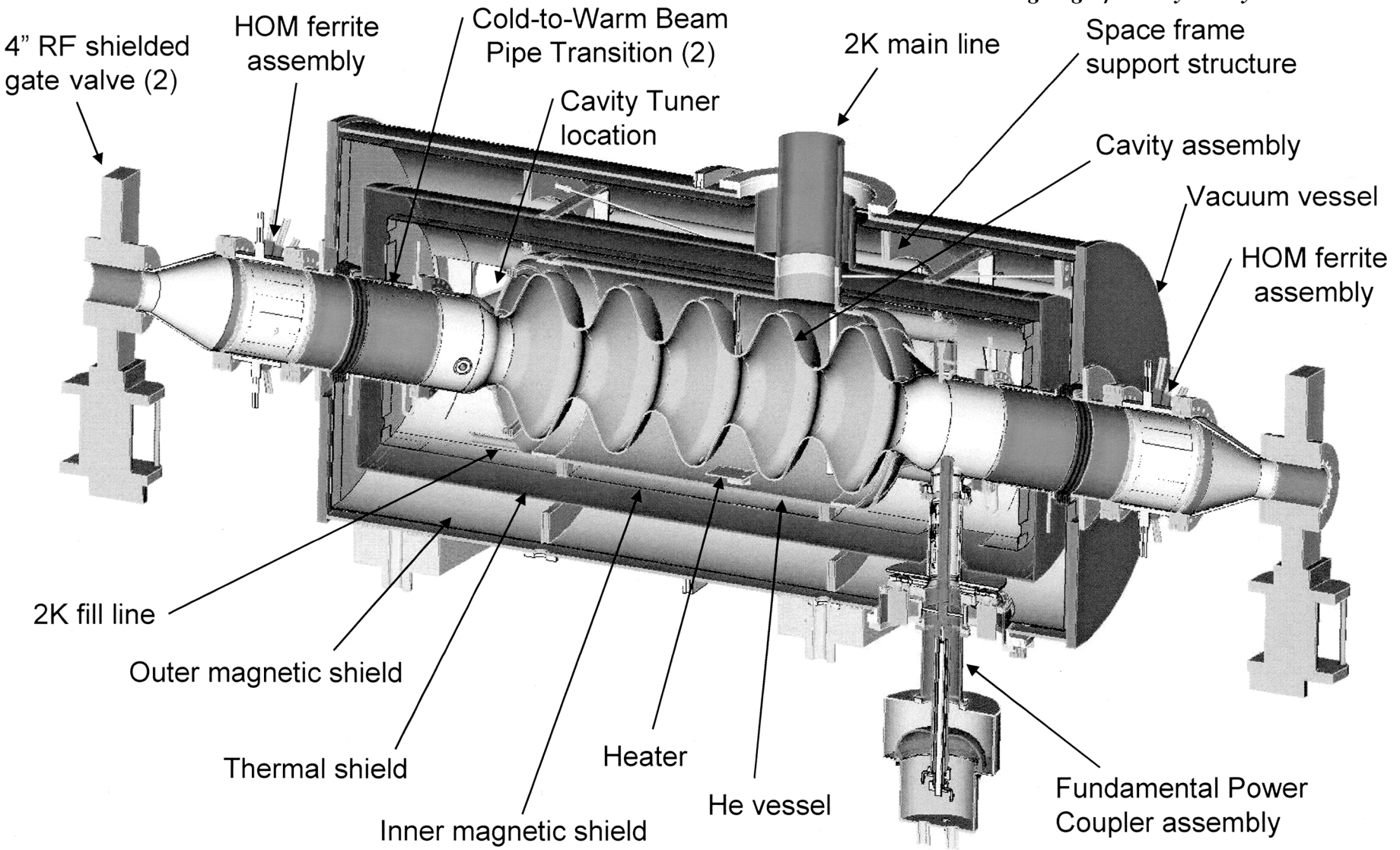
- **Overview**
- **Cryomodule Configuration**
- **Superconducting Cavity Analysis, Design, Fabrication**
- **Cavity Testing**
- **Cavity Hermetic String Assembly**
- **Cryomodule Buildup**
- **Summary & Status**

Overview & Design Features

- **Electron Cooling Experiment Cavity – Test in BNL High Current ERL**
  - Cavity Physics Design done by Brookhaven. Cavity and cryomodule Engineering and Fabrication by AES
  - BBU Threshold > 1.8 Amps. Design Current of 500 mA
  - Large Cavity Bore & Beam Pipes ➔ No Trapped Modes
  - Ferrite Lined HOM Absorbers in Beamline Upstream and Down
  - Coaxial Fundamental Power Coupler ➔ <50 kW CW with Energy Recovery

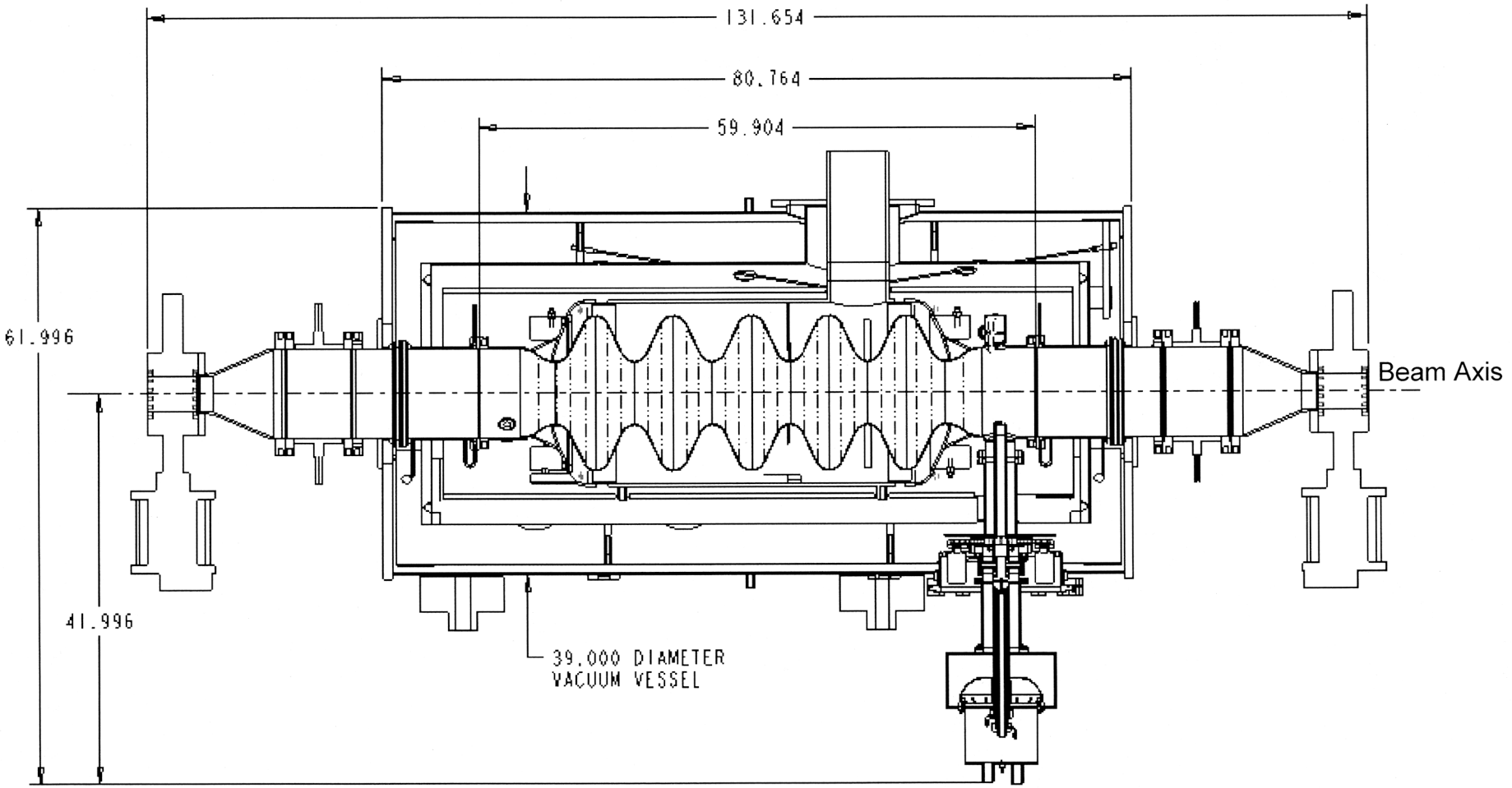


Cryomodule Assembly Configuration



Cryomodule Assembly Configuration

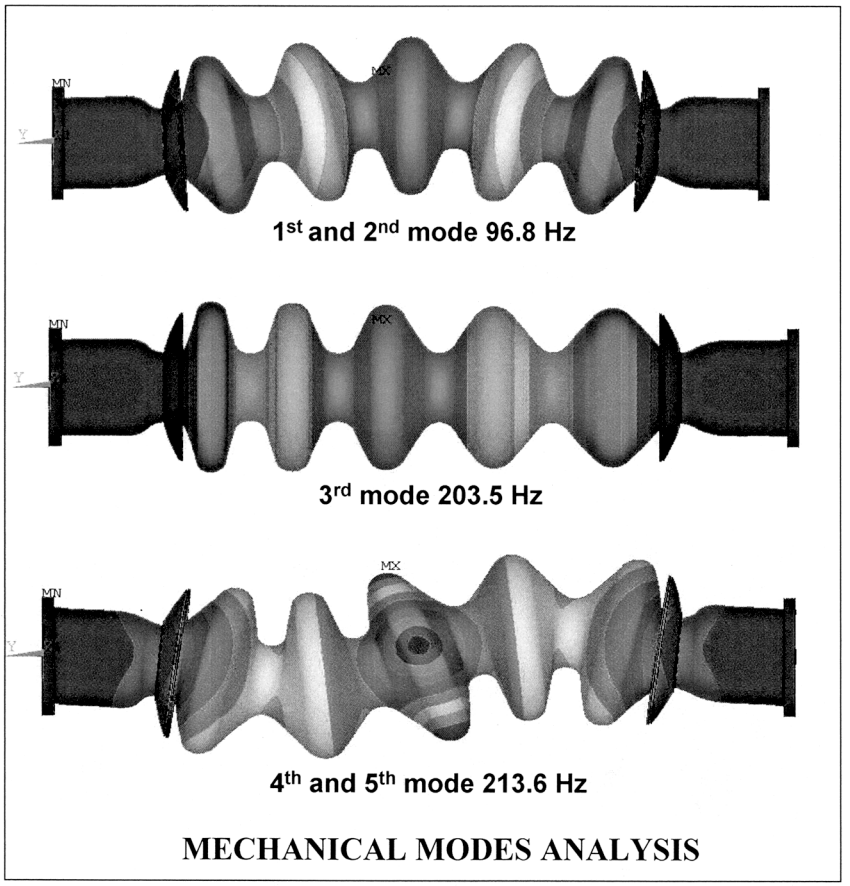
e-Cooling High β Cavity & Cryomodule

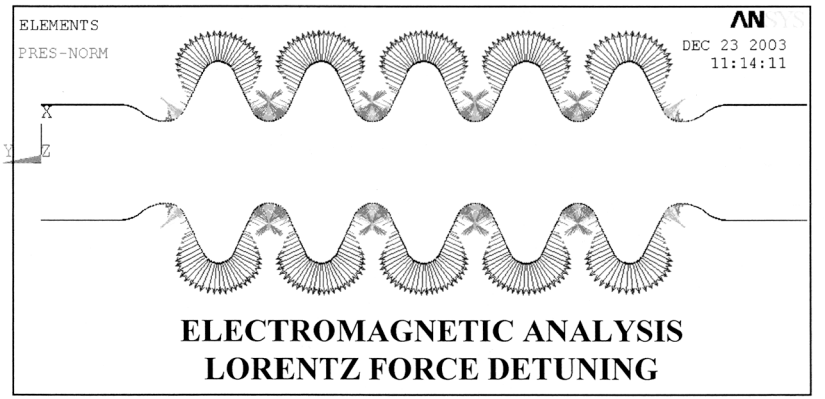


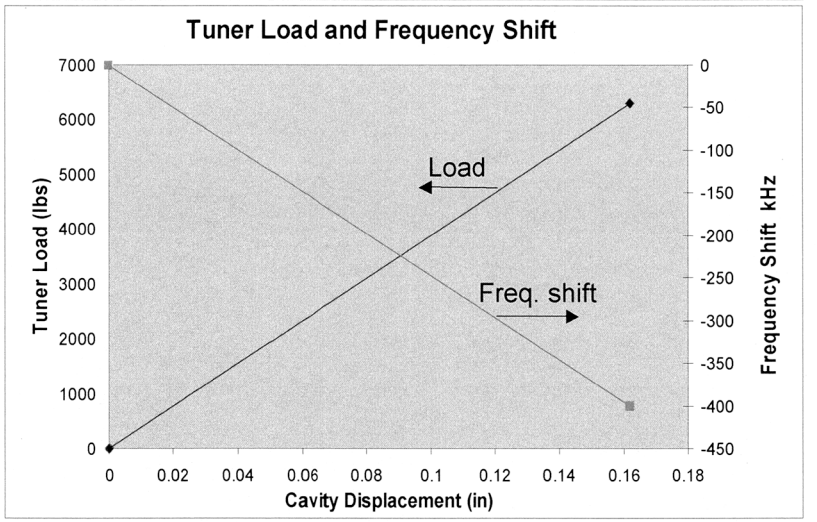
Dimensions in inches

Mechanical and Electromagnetic Analysis

- Finite element models were used to evaluate the thermal, structural, and RF behavior thermal load, pressure load, and loads from the cavity tuner
- Cavity is inherently stiff due to large angle cell faces ➔ no iris stiffeners, 3mm niobium thickness





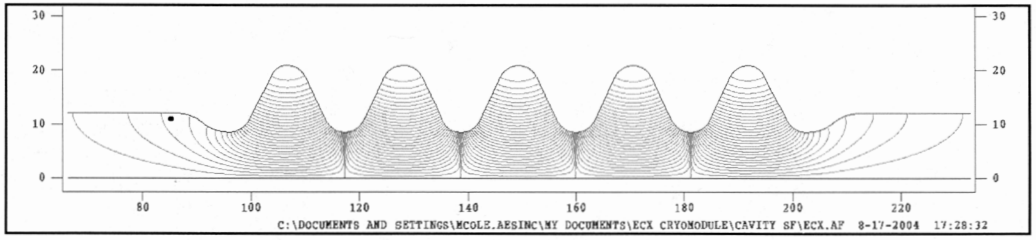


RF Analysis / Cavity Configuration

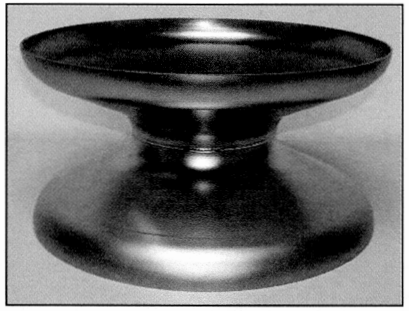
e-Cooling High β Cavity & Cryomodule

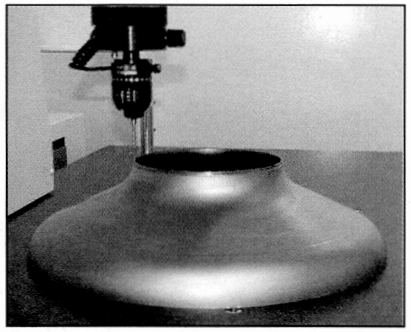
Cavity Frequency	703.781 MHz
Energy Gain (E_0TL)	15 MV
E_0 (Iris to Iris, L = 1.065m)	20.356 MV/m
Max Design E Field at Iris, E_{peak}	27.861 MV/m
Max Design H Field at Wall, H_{peak}	64870.6 A/m or 81.5 mT
Design Stored Energy	126.931 Joules
Residual Resistivity used in SUPERFISH	10 nOhms
Q_0 at 2K	1.51×10^{10}

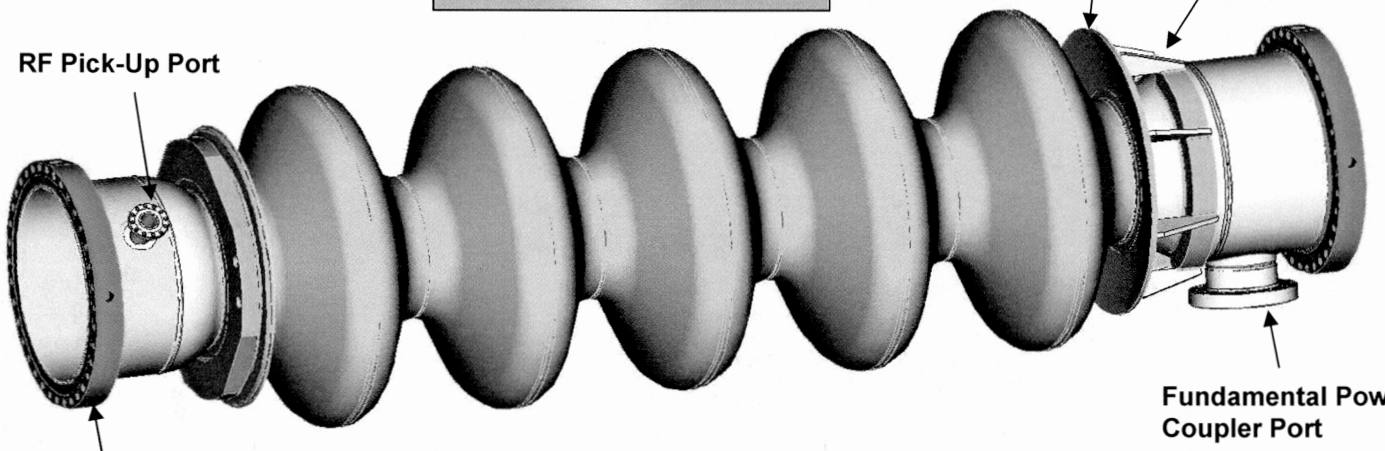
RF Parameters as calculated by SUPERFISH



RF Field Profile as calculated by SUPERFISH



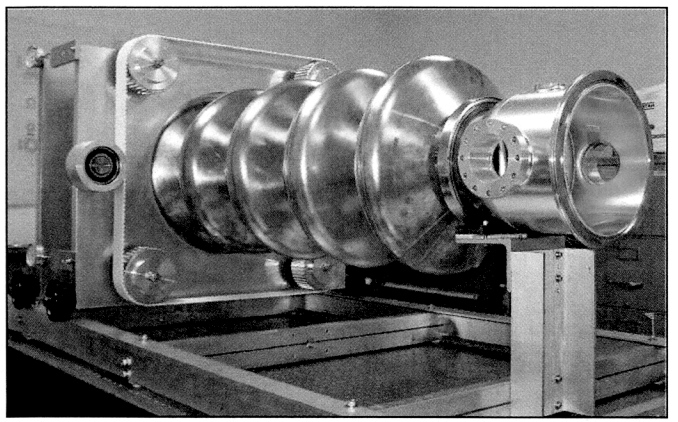


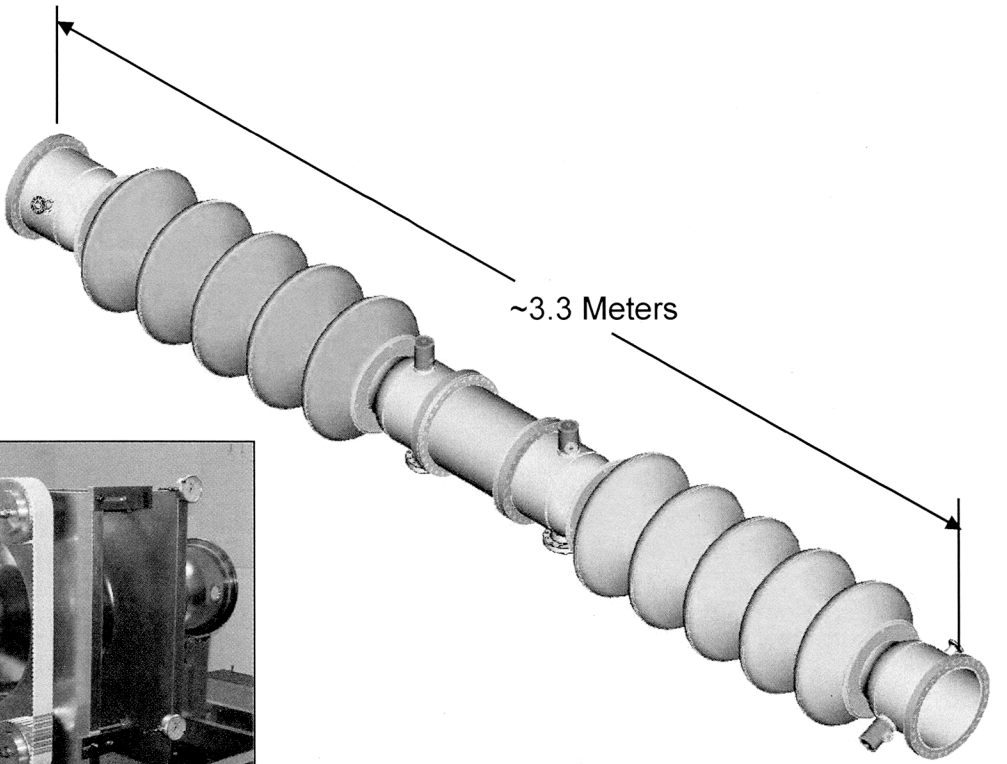


CAVITY DESIGN

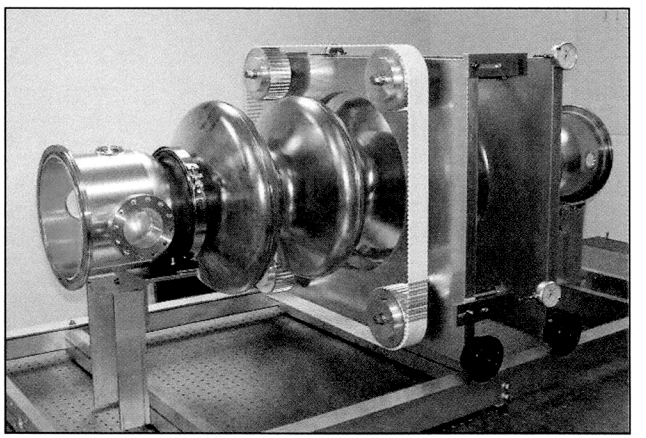
Low Power RF Test Cavities

- AES built two copper models for design verification & tooling development. Models formed and welded using same tools & techniques
- BNL test program verified HOM performance and investigated potential "superstructure" configurations



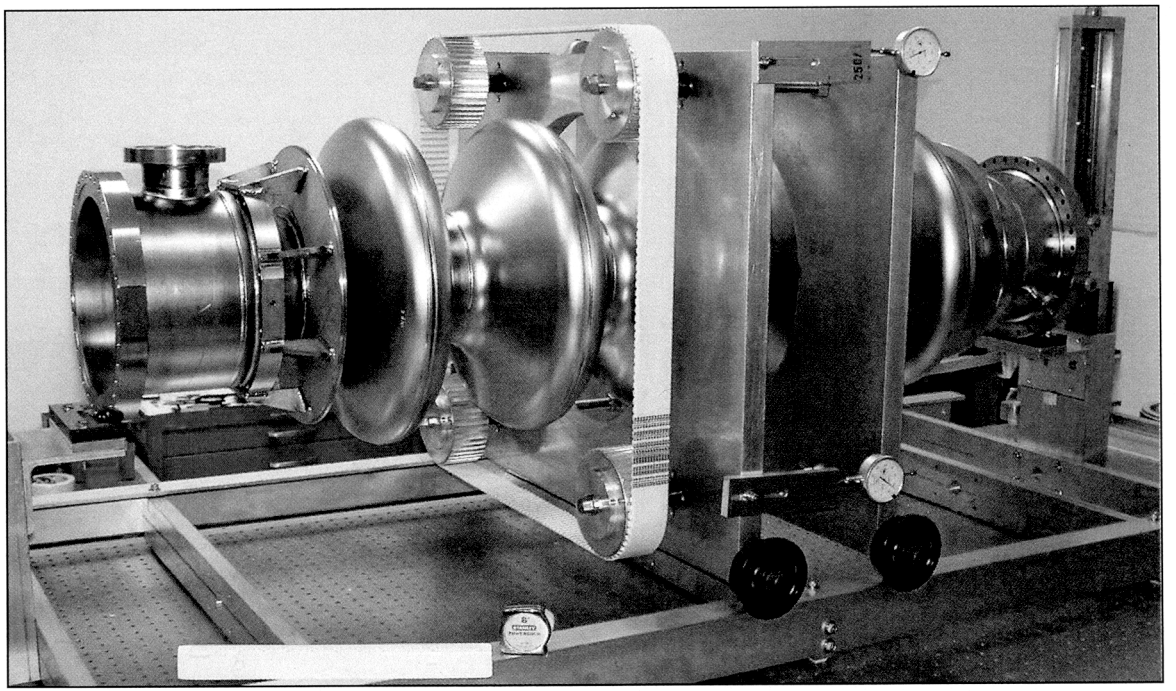


5-CELL 703.75 MHz COPPER LOW POWER RF TEST CAVITIES IN TUNING FIXTURE



Niobium Cavity Fabrication

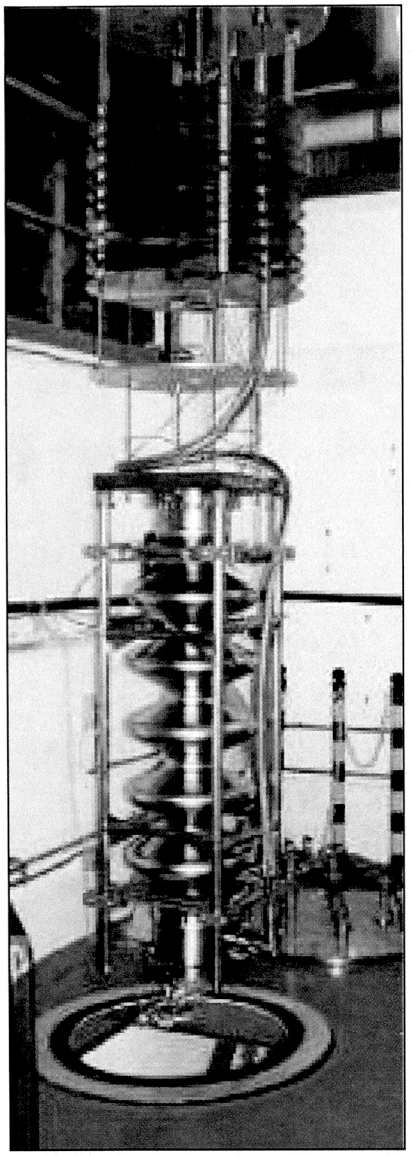
CAVITY PRE-WELD ASSEMBLY

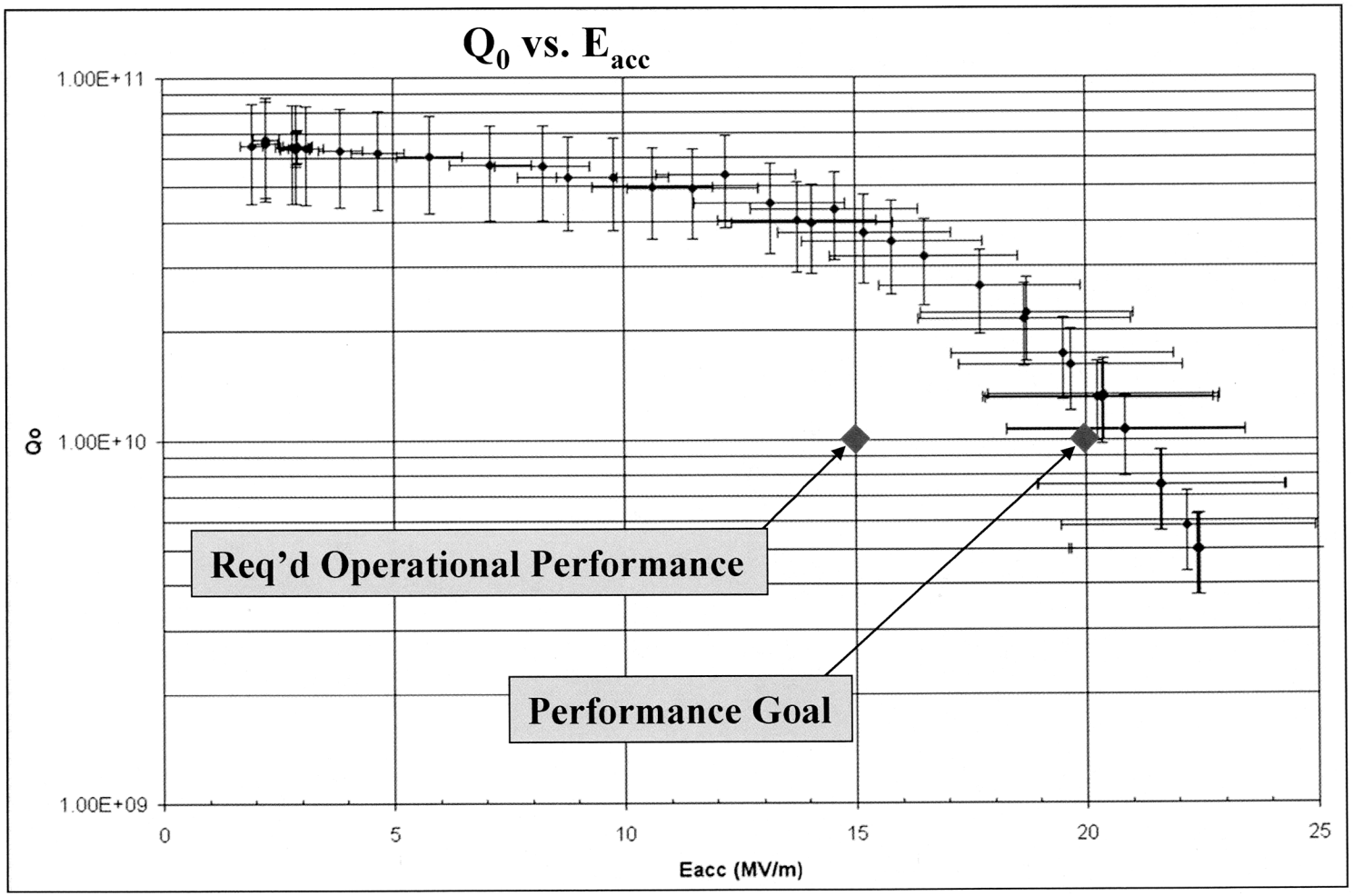


COMPLETED CAVITY ASSEMBLY IN TUNING FIXTURE AT AES

Vertical Test Results (Done at JLAB)

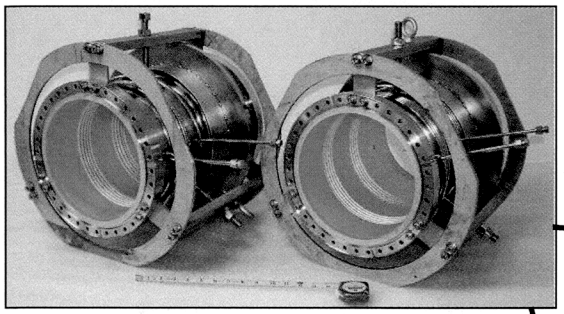
e-Cooling High β Cavity & Cryomodule



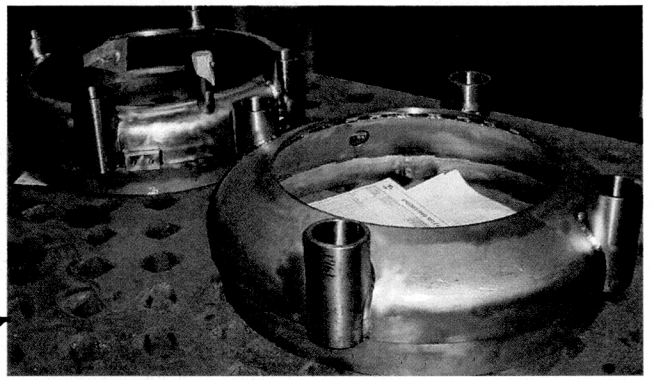


Cavity String Assembly I

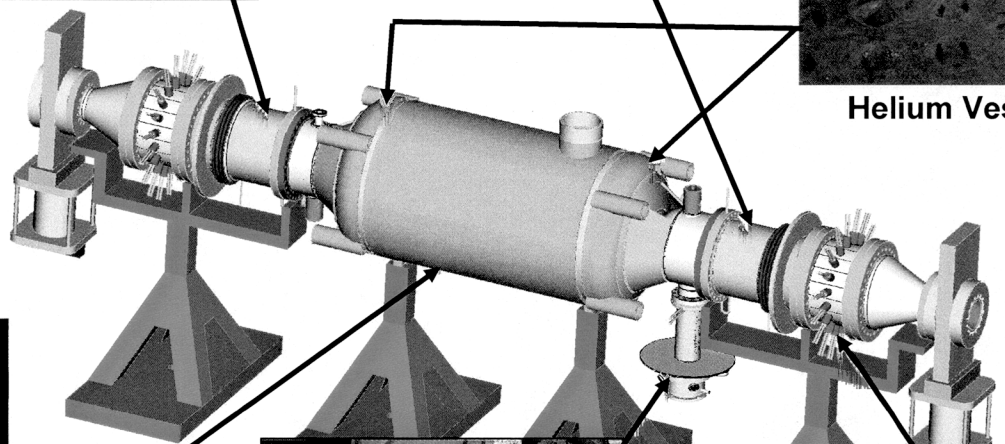
e-Cooling High β Cavity & Cryomodule



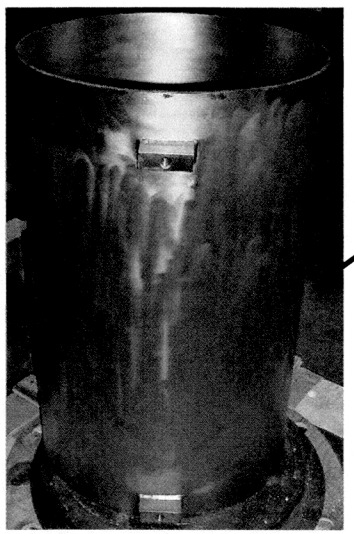
Warm-to-Cold
Beam Pipes

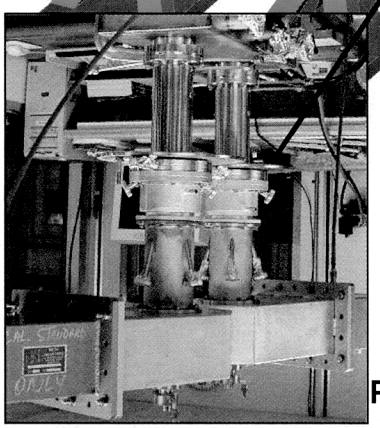


Helium Vessel Heads



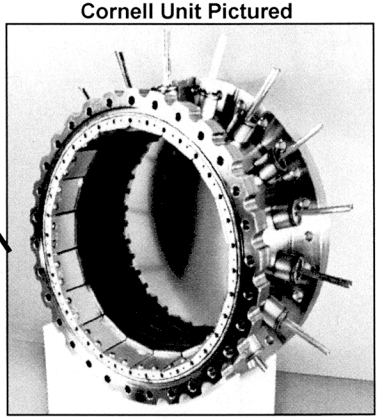
Helium Vessel
Cylinder





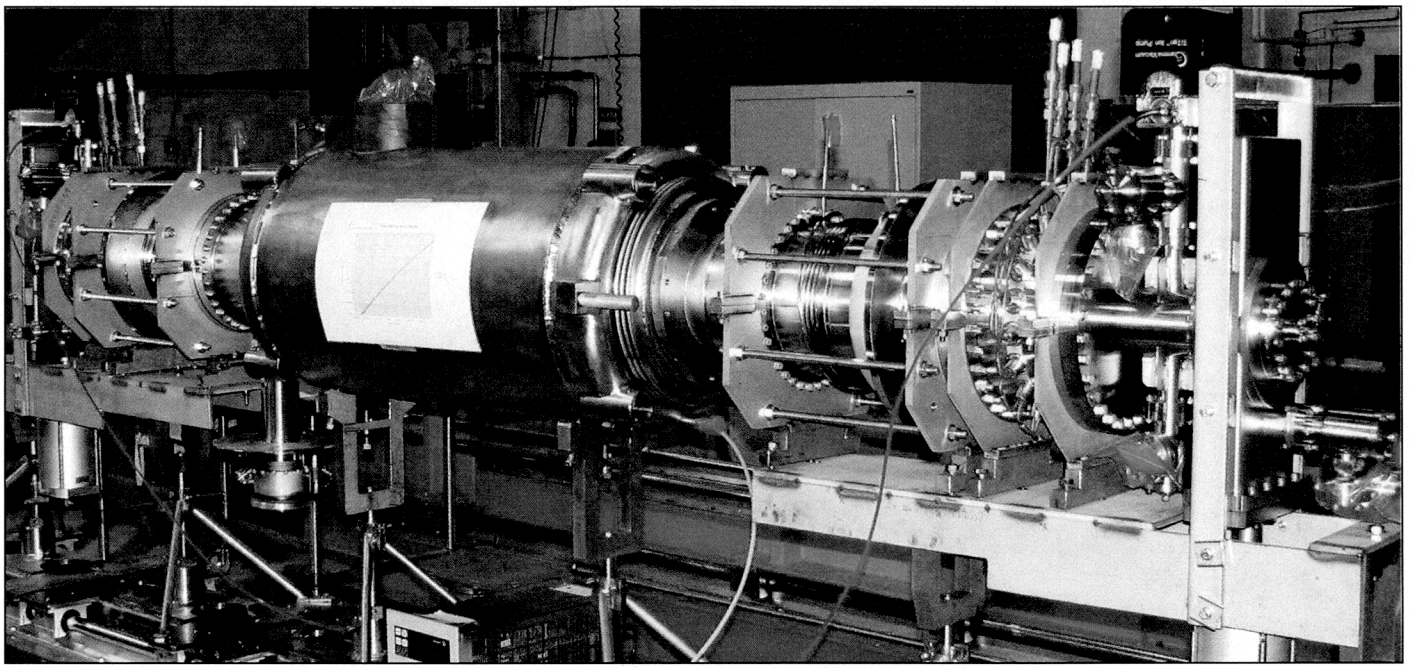
Fundamental
Power Coupler

HOM Loads (2)
Cornell Unit Pictured

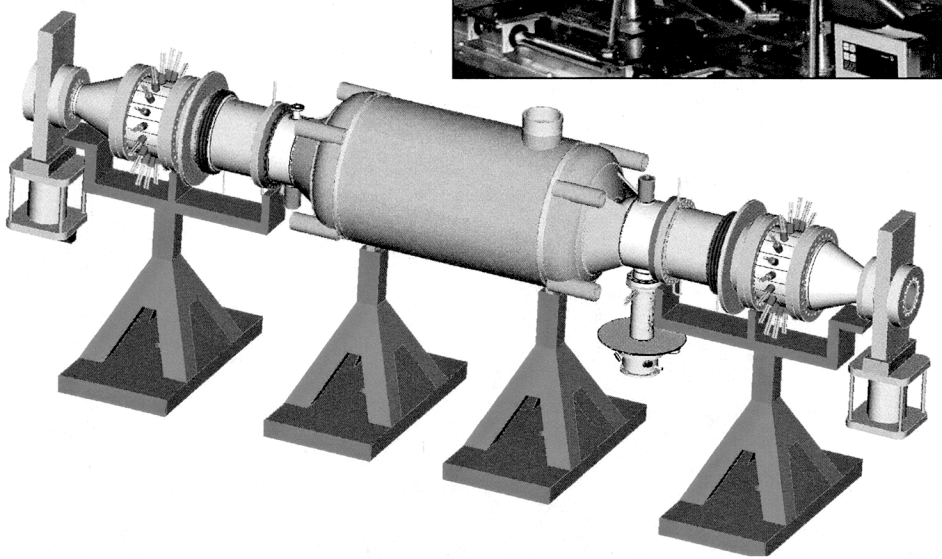


Cavity String Assembly II

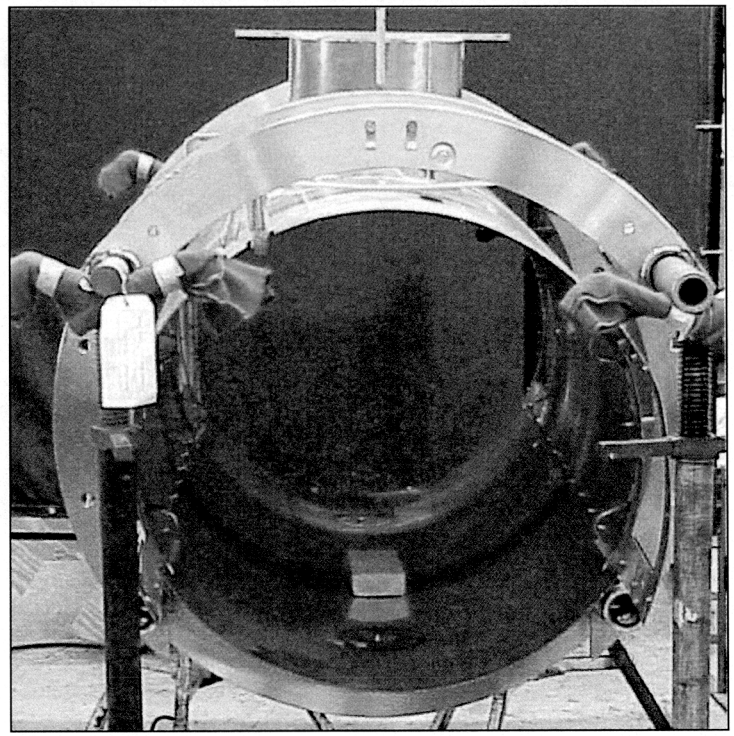
e-Cooling High β Cavity & Cryomodule

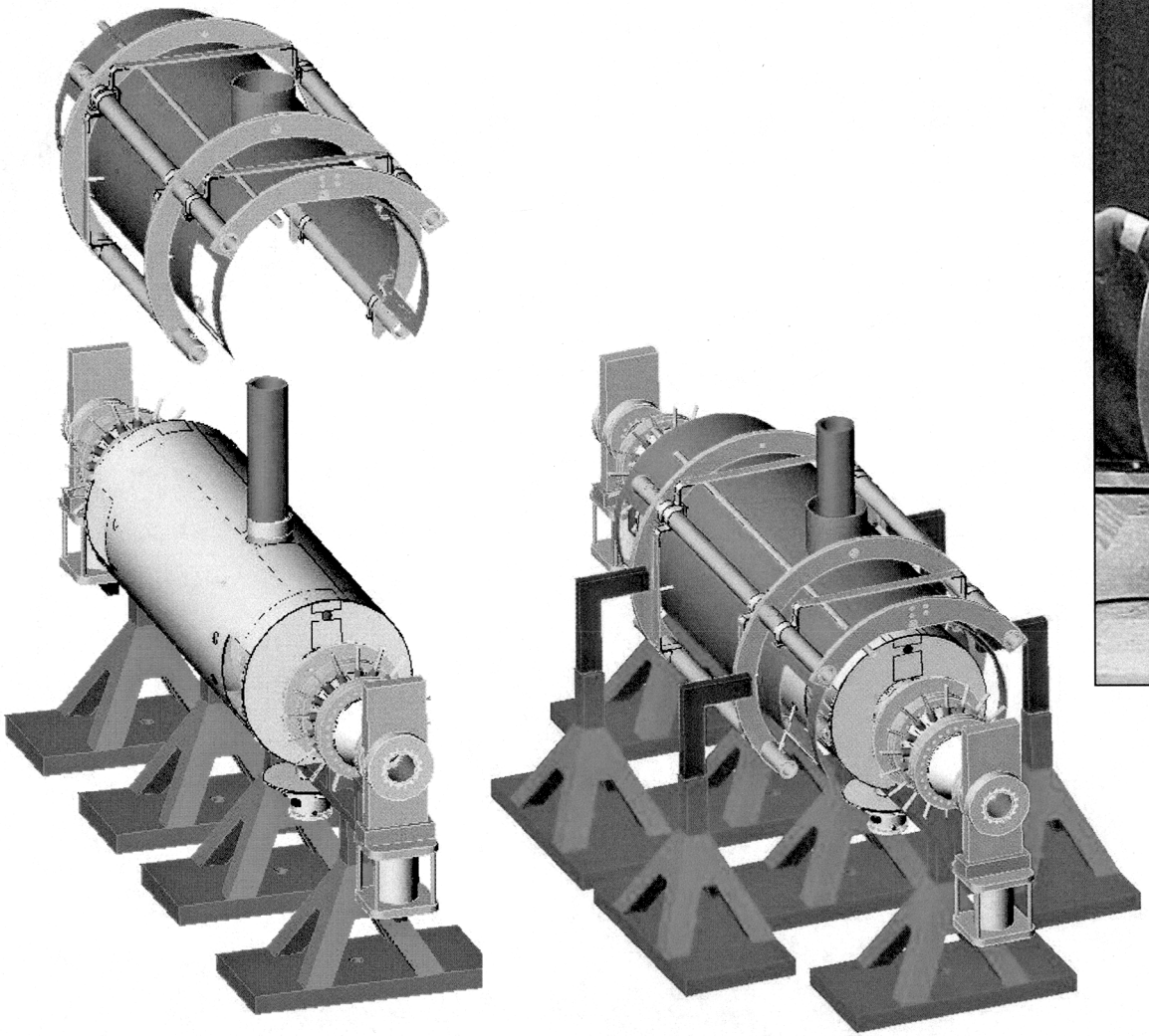


Completed Hermetic String at JLAB



Space Frame and Thermal Shield Installation



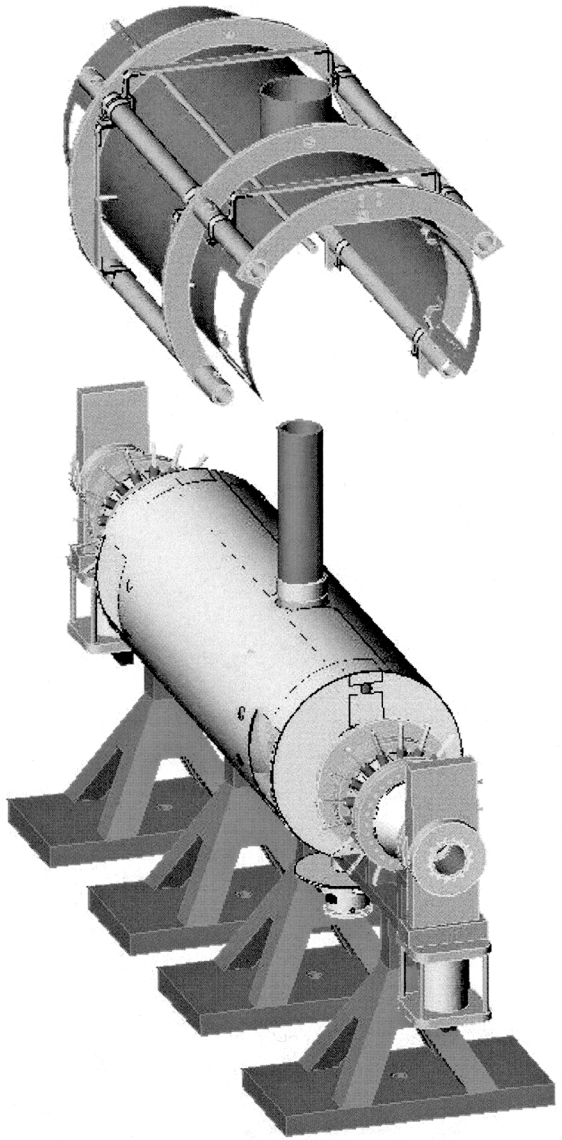


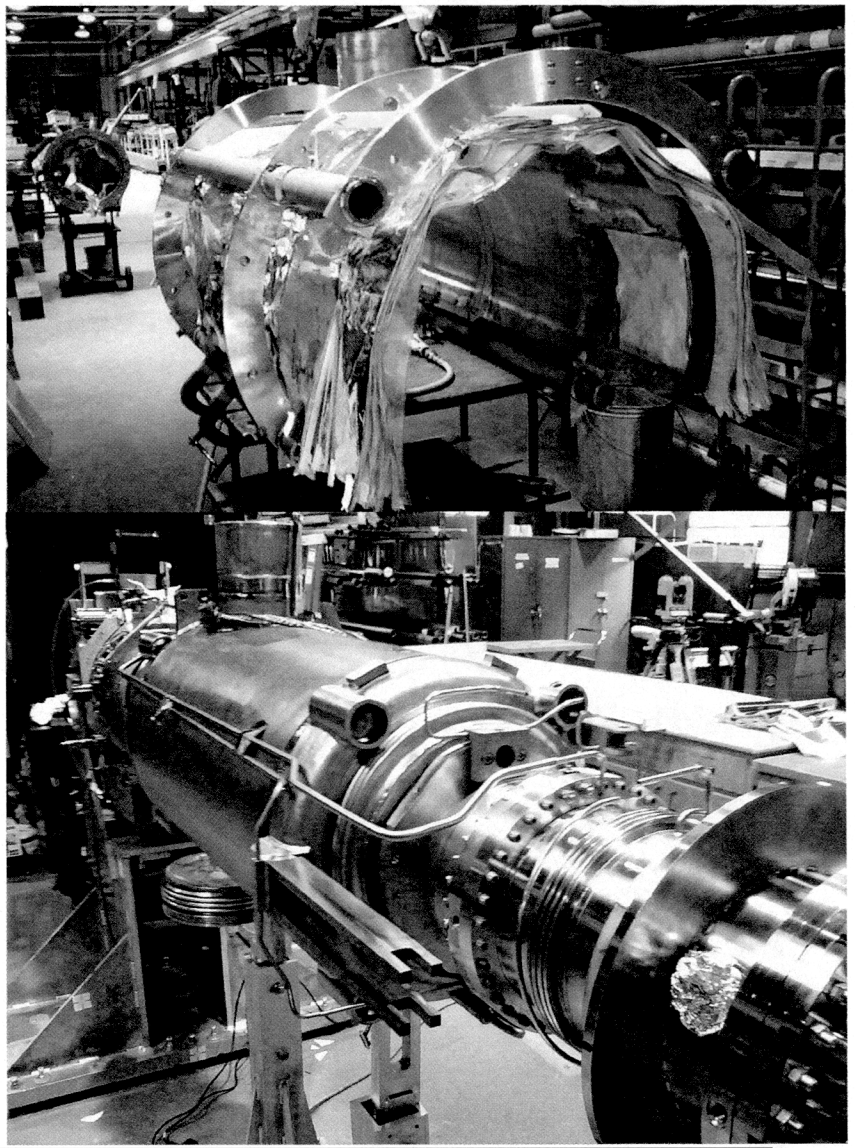
Magnetic shield assembly

Space frame/Thermal shield installation

Space Frame and Thermal Shield Installation

e-Cooling High β Cavity & Cryomodule

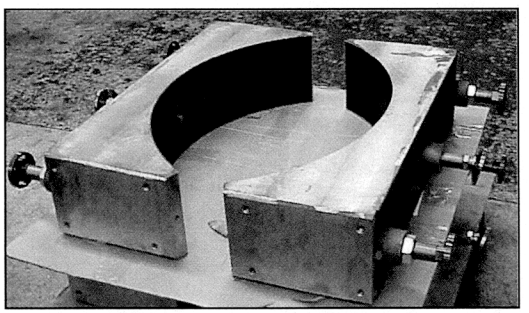




Cryomodule Buildup

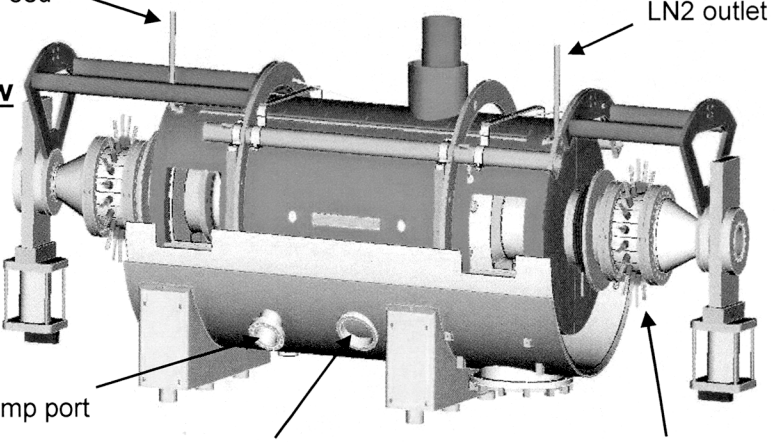
e-Cooling High β Cavity & Cryomodule

VACUUM VESSEL SECTIONS

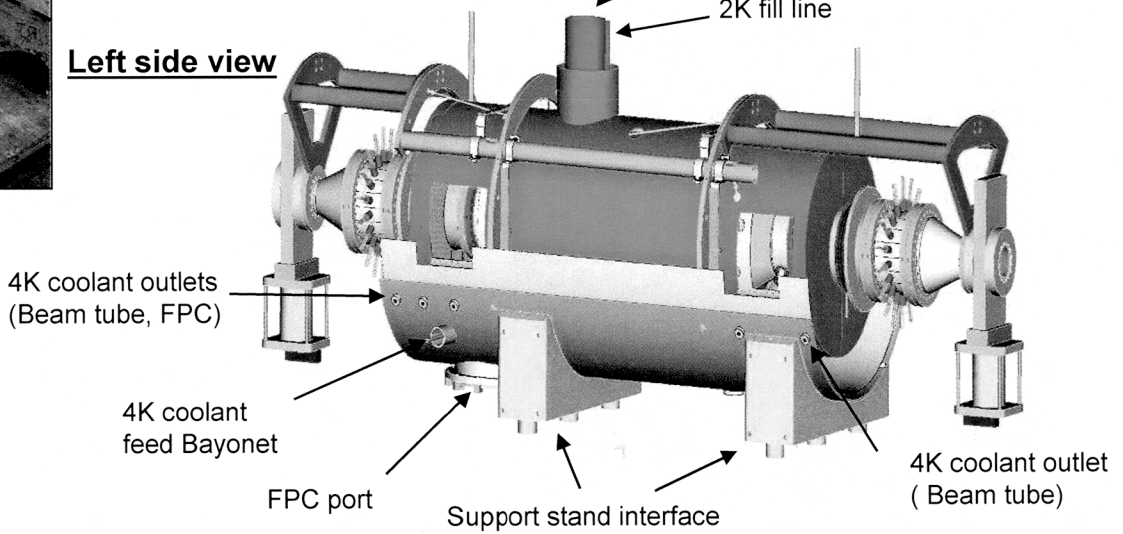


SUPPORT STANDS

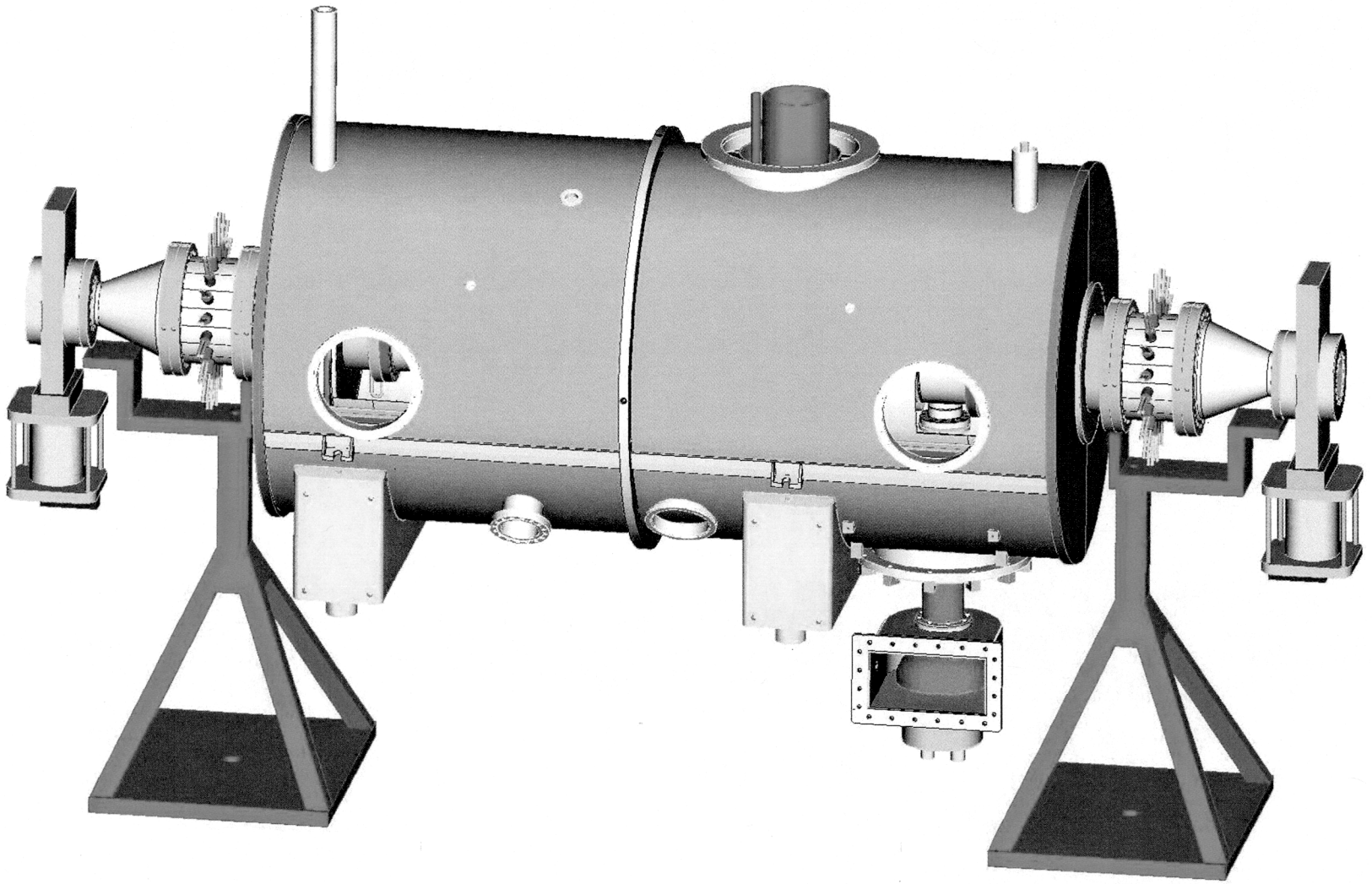
Right side view



Left side view

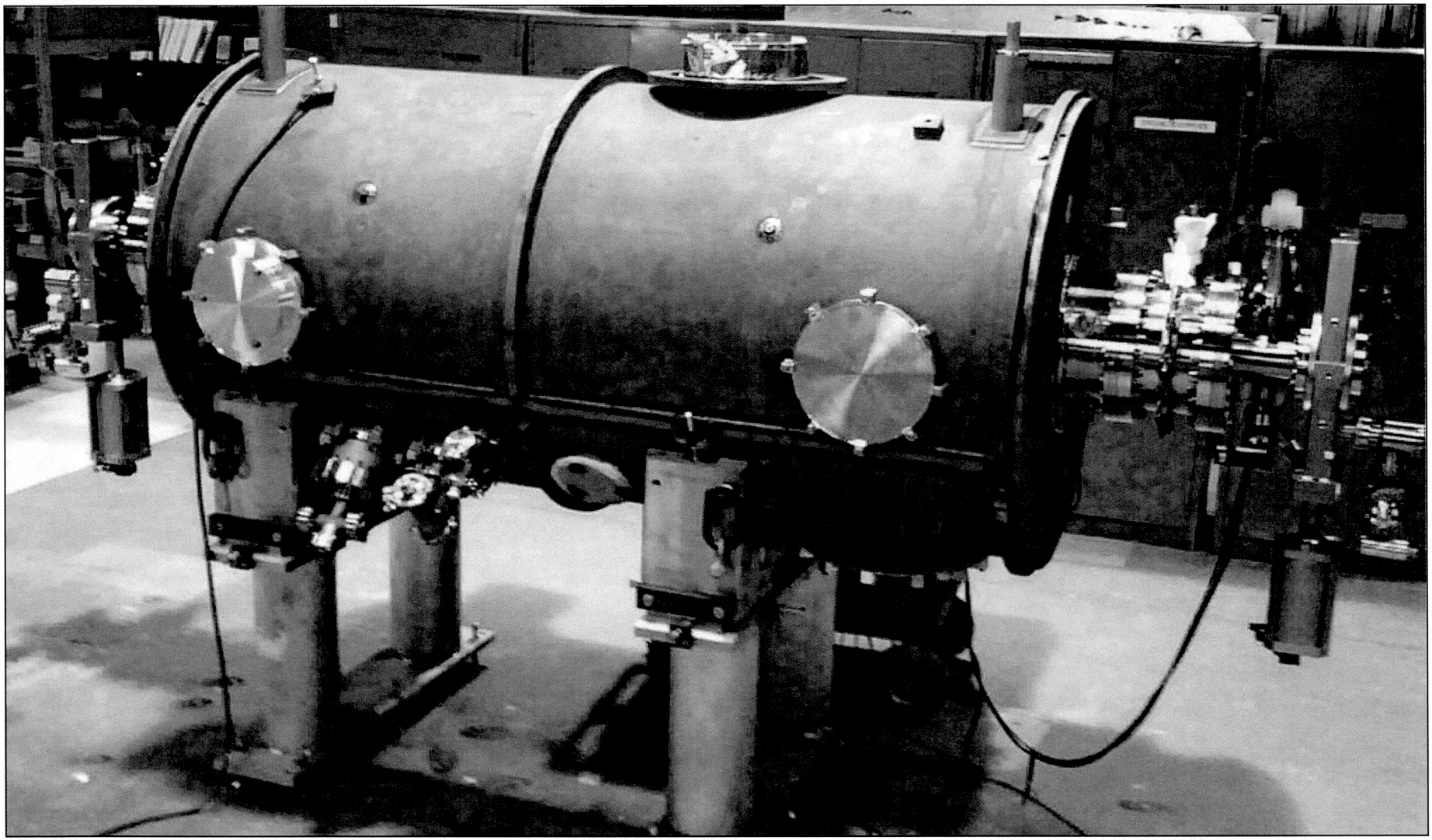


Cryomodule Assembly



Completed Cryomodule Assembly at BNL

e-Cooling High β Cavity & Cryomodule



Summary & Status

- A high-current SRF cavity for an Energy Recovery Linac has been designed by BNL and AES and fabricated by AES
- The cavity was cleaned and tested by JLAB with BNL personnel support
- Cavity performance exceeded goal of 20 MV/m at $Q_0 > 1x10^{10}$ and far exceeded requirement of 15 MV/m at $Q_0 > 1x10^{10}$
- Hermetic String assembled at JLAB with BNL personnel support and shipped to BNL
- BNL has recently completed Cryomodule assembly and unit is ready for installation in the ERL vault