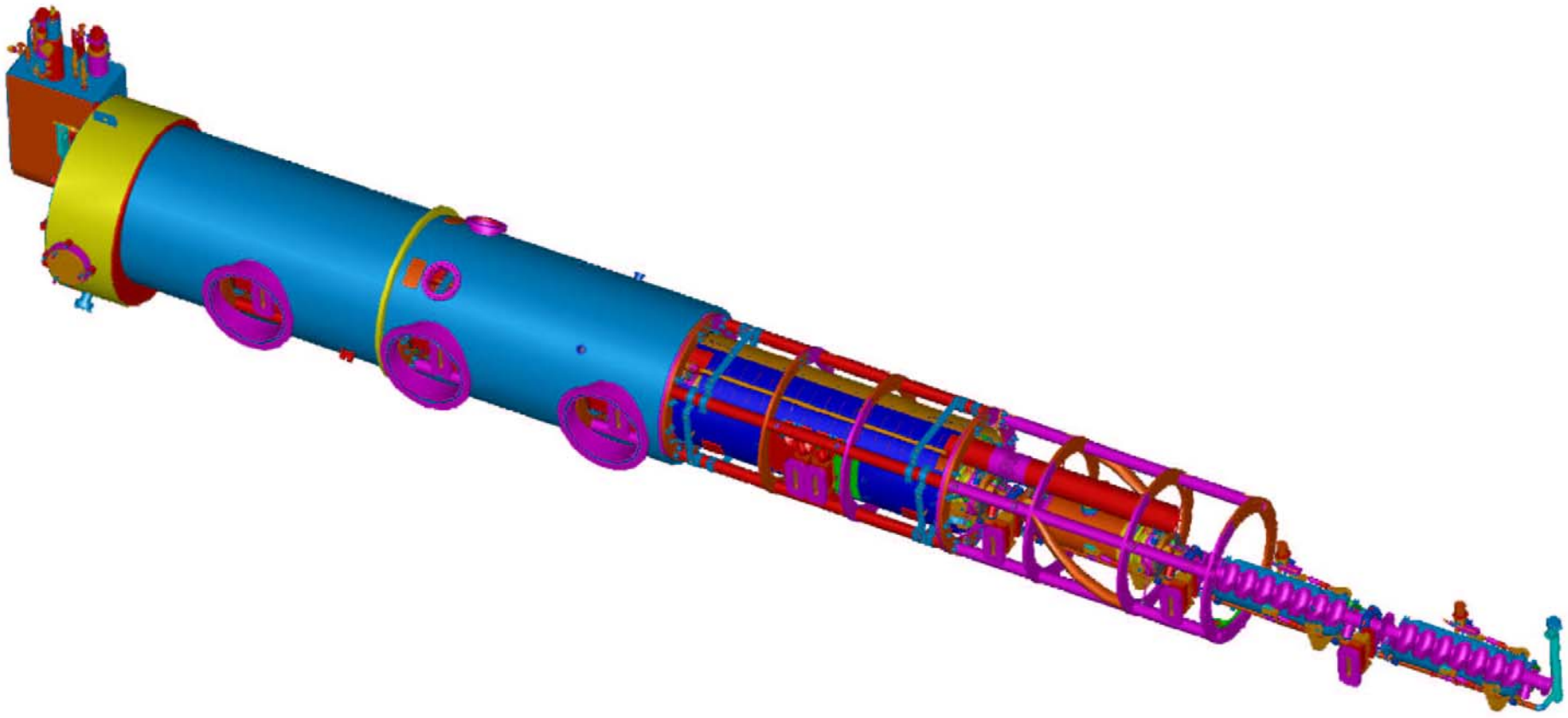
Fabrication and Performance of Improved Cavity Shapes for CEBAF

Charles Reece

New *Renascence* Cryomodule

- Replacement for an existing CEBAF cryomodule
- Serves also as a prototype for 12 GeV Upgrade
- Based on the "70 MV" cryomodule upgrade design
  - **Two units built and commissioned 2001-2004**
- For 12 GeV :
  - **Need >108 MV CW with 250 W dynamic heat load at 2 K**
  - **Eight 0.7 m, seven-cell 1497 MHz cavities**
  - **Q_0 > 8e9 @ > 19.2 MV/m *average***
  - **One 13 kW CW klystron per cavity**
- Two new, higher performing SRF designs developed
  - **"HG" design – best if field emission is the limiting phenomena**
  - **"LL" design – best if non-field emission heat limited**

Renascence Cryomodule



Renascence

- Need the best cavity designs for application to CEBAF 12 GeV Upgrade
  - **Design operating temperature: 2.09 K at cavities**
  - **250 W dynamic loss per cryomodule**
  - **31 W per cavity**
  - **44 W per active meter**
  - **460 μA CW beam**

New for Renascence

- HG cavity design
- LL cavity design
- Tuner system
  - **Required for HOM damping of HG and LL**
  - **Cheaper, built on SNS experience**
- HOM rf feedthrough
  - **Adequate conduction cooling of the Nb probe**
- Radial-wedge clamp seal
- AlMgSi alloy gaskets rather than indium
  - **Particulate control motivation**
- Compatible with 13 kW klystrons
  - **Improved thermal stabilization of input waveguide**

Renascence cavities

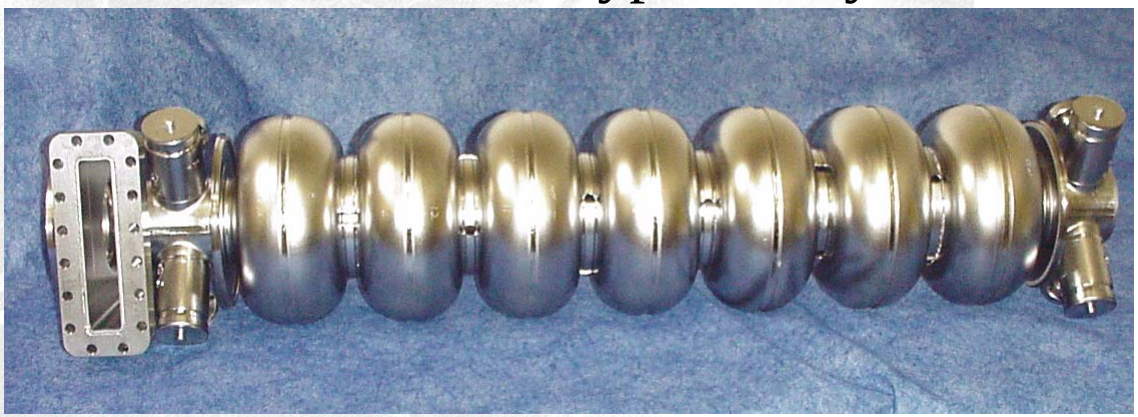
HG and LL cavity designs

- HG minimizes E_{peak}/E_{acc}
- LL minimizes heat/E_{acc}
- Identical end groups
  - Fundamental WG coupler Q_e 2e7
  - Two coaxial HOM couplers on each end
  - NbTi interface to Ti helium vessel

HG Prototype Cavity

G. Ciovati

LL Prototype Cavity



J. Sekutowicz

Cavity cell designs

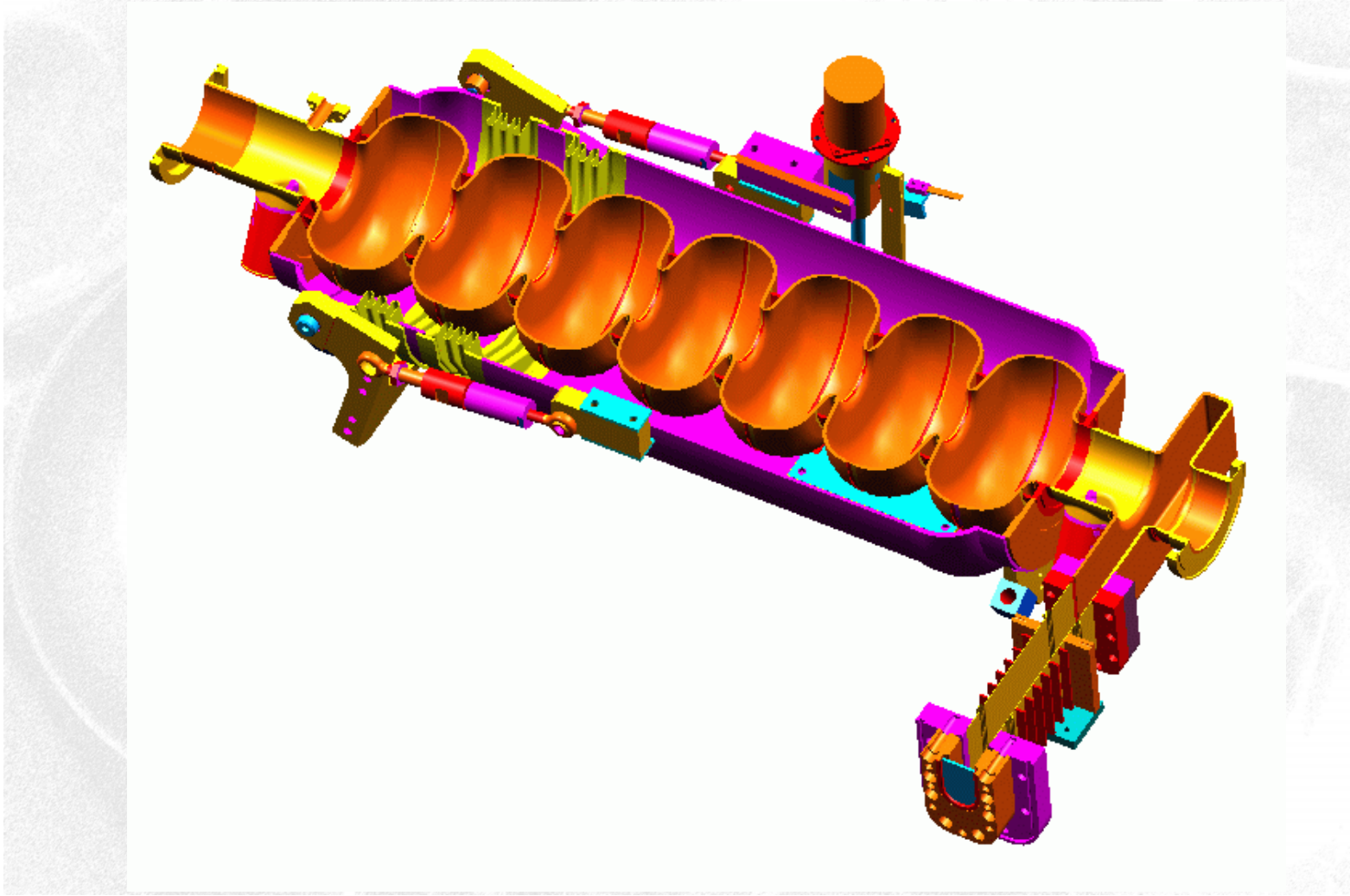
- The cavity designs were reported previously

"Cavities for JLab's 12 GeV Upgrade" J. Sekutowicz, et al. PAC-03

	OC	HG	LL
E_{peak}/E_{acc}	2.56	1.89	2.17
B_p/E_{acc} [mT/(MV/m)]	4.56	4.26	3.74
R/Q [ohms]	678	780	891
G [ohms]	274	266	281
k [%]	1.7	3.3	1.4

- One each HG and LL cavity was prototyped by P. Kneisel
- The HG prototype has been successfully tested – see EPAC04 contribution

LL Cavity System



JLab Fabrication

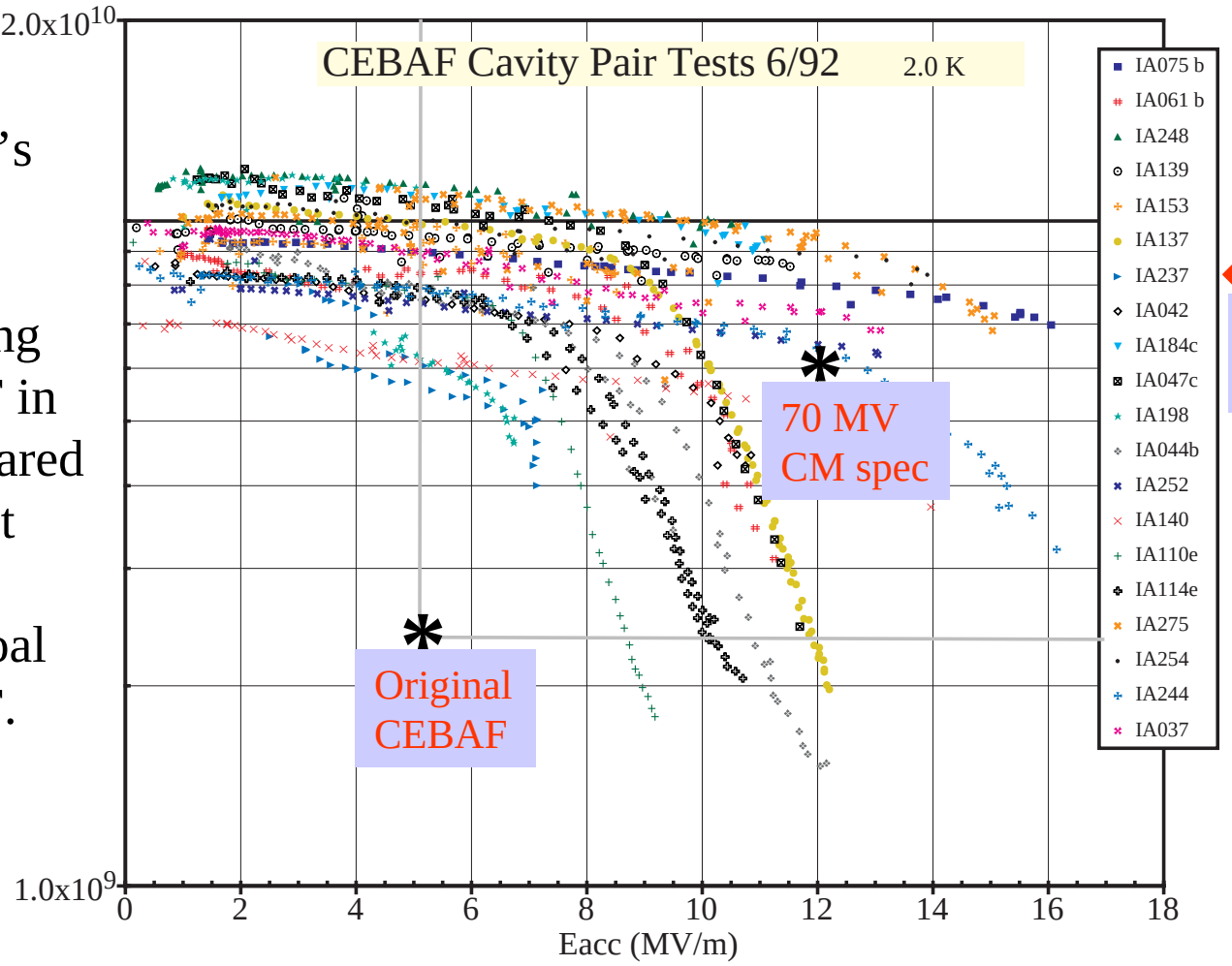
JLab Fabrication

- The cavities for Renascence were constructed in-house at JLab using local job shops for component machining

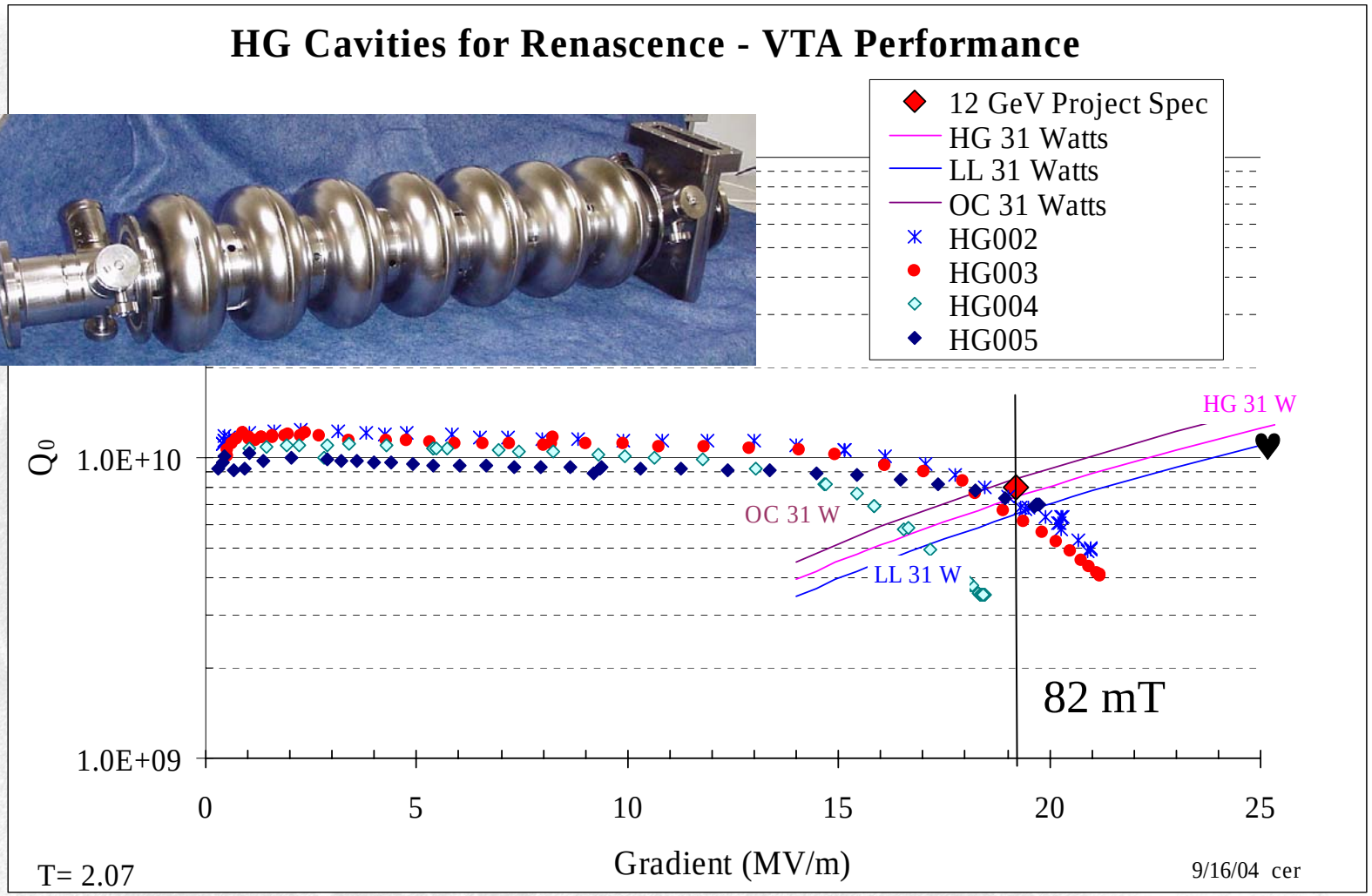
- Built as a production batch
  - Aimed for "build-to-print" process that yields target frequency and optimum performance
  - 5 HG cavities
  - 4 LL cavities
  - + 3 more HG cavities funded as FEL option

Historical perspective: CEBAF Cavities

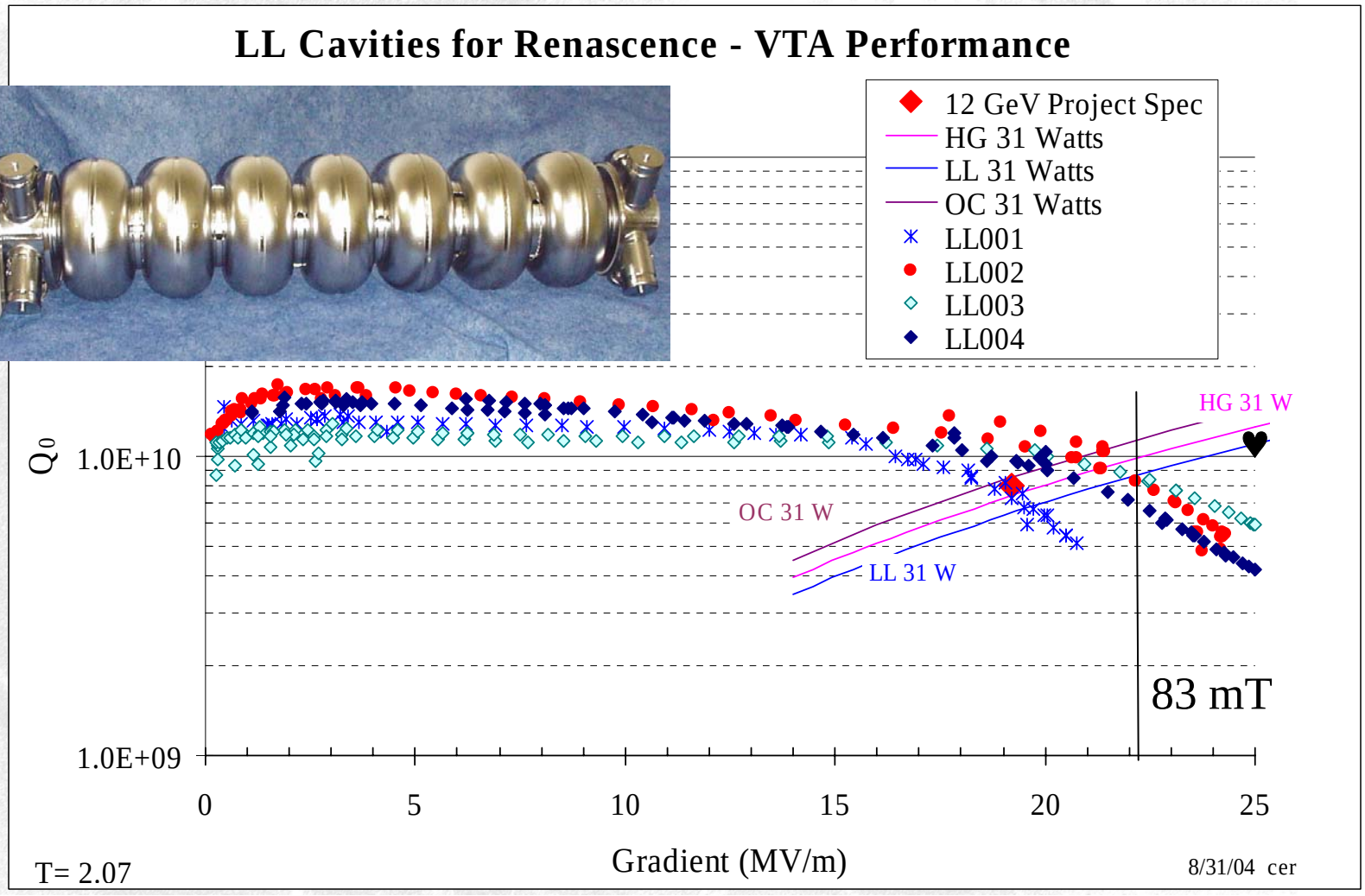
One month's worth of production cavity testing for CEBAF in 1992 compared with current specs and potential goal for CEBAF.



HG Cavity Performance Tests

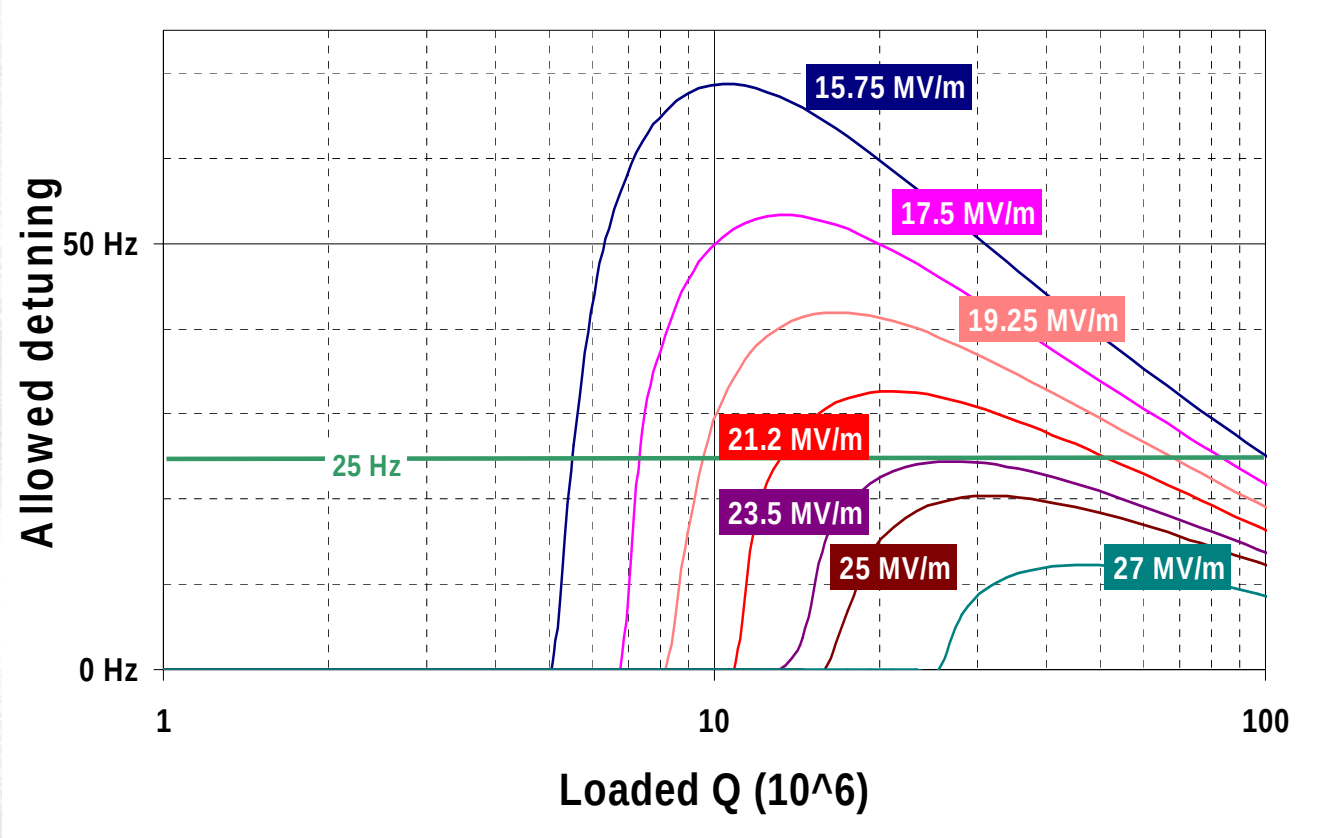


LL Cavity Performance Tests



LL and HG cavities

Supportable Gradient for 12 GeV



Detuning allowance for the LL-shaped 7-cell cavity with loaded-*Q* and anticipated 13 kW klystrons at several accelerating gradients and 460 µA beamloading.

Context and Future

- The Renascence project has run concurrently with the SNS cryomodule production
- Cavity qualification is complete
- String assembly this fall – interleaving with SNS work
- Cryomodule assembly – early 2005
- Testing next spring, then installation in CEBAF in summer 2005

SRF Performance Optimization

For CW operation with modest beam currents (< 1 mA), the challenge for ultimate SRF performance is best Q_0 at ~ 25 MV/m at operational temperature.

- *Apply electropolishing (not scoped for Renascence)*
- *Post-processing thermal treatment?*
- *Post-production surface anneal?*
  - **laser glazing, EB remelt, etc.**
- *Improved material consistency and control?*
- *Increasing process consistency and control*