


# Cryomodule Development at Jefferson Lab for ERL Applications

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# Outline

- Historical Review
- Ongoing Developments
- Future Directions



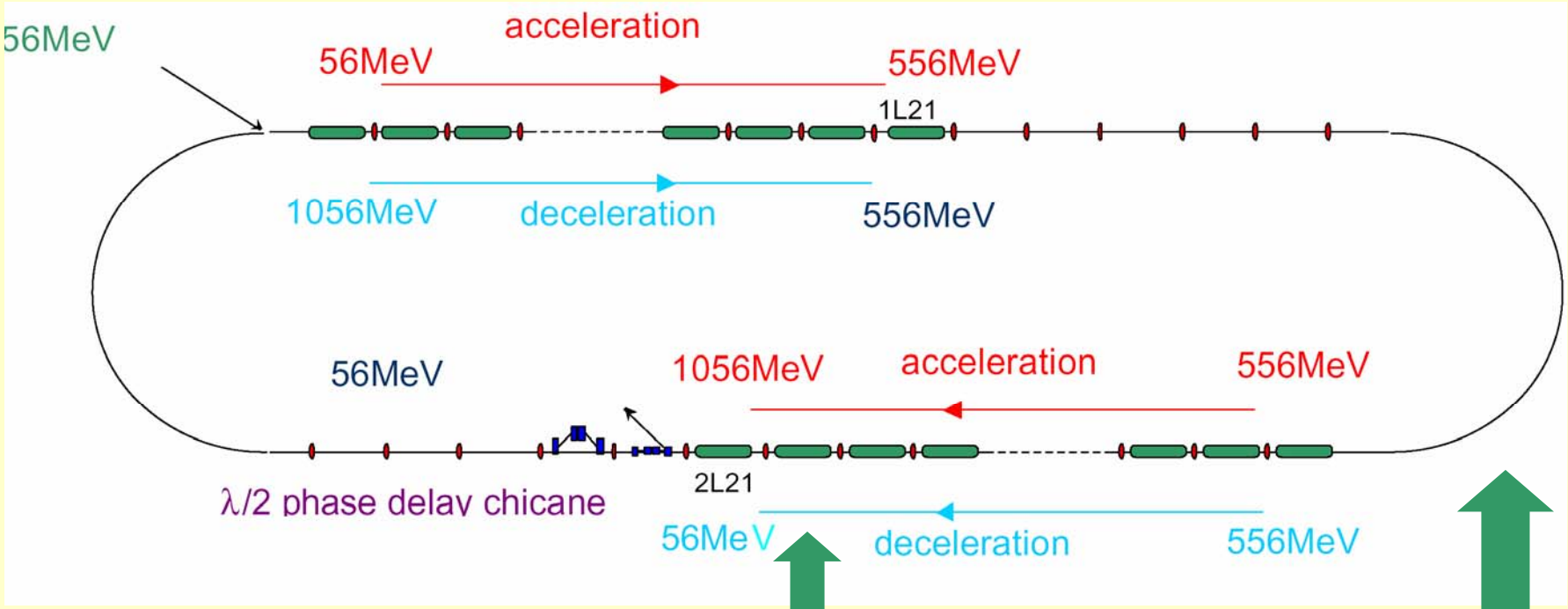

# Summary

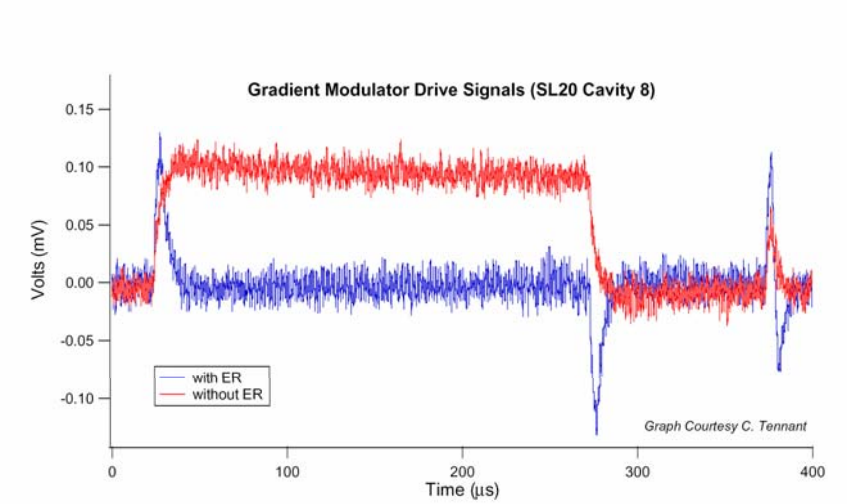
- JLab has demonstrated designs for cryomodules for ERL applications, 'on the shelf'
  - 1500 MHz; cw or pulsed
  - $E_{acc}$ up to 20 MV/m; demonstrated $\Delta E_{module}$ > 80 MeV
  - Currents up to 8 mA at 75 MHz
- Higher current designs are being developed

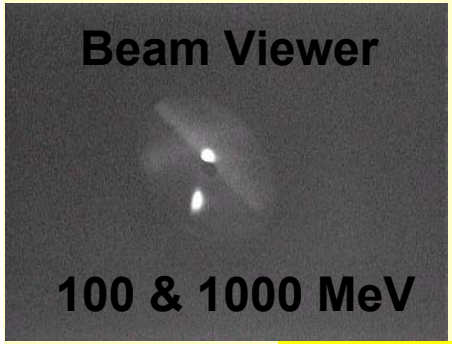
# Then - CEBAF

- 42 Cryomodules; eight 5-cell cavities each
- cw 1500 MHz; W/G HOM damping for stability up to 1 mA beam current

# Energy Recovery at 1 GeV – 1st CEBAF Experiment




**Also ran successfully with $E_{inj}$ = 20 MeV!**

# Then – FEL IR Demo

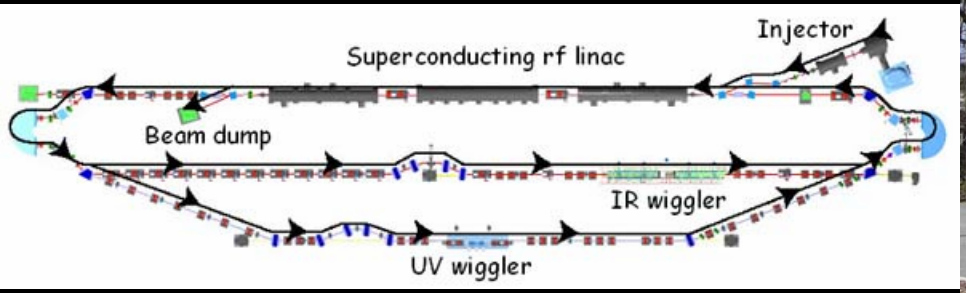
- CEBAF module modified with HOM loads at 50 K, not 2 K; HOM-driven BBU threshold ~27 mA (simulation)
- Operating gradient ~10 MV/m
- 2.1 kW cw output at ~3μ

Beam requirements at wiggler for first lasing

| Parameter | Required | Measured |
|---|---|---|
| Kinetic energy (Mev) | 48 | 48.0 |
| Average current (mA) | 5 | 5 |
| Bunch charge (pC) | 60 | up to 80 |
| Bunch length (rms) (ps) | $< 1$ | $0.4 \pm 0.1$ |
| Peak current (A) | 22 | Up to 60 |
| Trans. emittance (rms) (mm-mr) | $< 8.7$ | $7.5 \pm 1.5$ |
| Long. emittance (rms) | 33 keV-deg | $26 \pm 7$ keV-deg |
| Pulse repetition frequency (PRF) | 18.7 MHz, $\times 2$ | 18.7 MHz, $\times 0.25$, $\times 0.5$, $\times 2$, and $\times 4$ |

# Now – FEL 10 kW Upgrade

- 2nd identical CEBAF module added; 3rd module built: 7-cell cavities and $\langle E_{acc} \rangle$ increased to 14.5 MV/m ➔ 80 MV; FEL energy up to 160 MeV
- Measured BBU threshold (HOMs in new module) ~2.7 mA
- 10.6 kW @ 6μ with 5.5 mA and 145 MeV; circulating power up to 1.1 MW
- Four techniques (2-active; 2-passive) to increase BBU threshold were tested – ALL were effective!





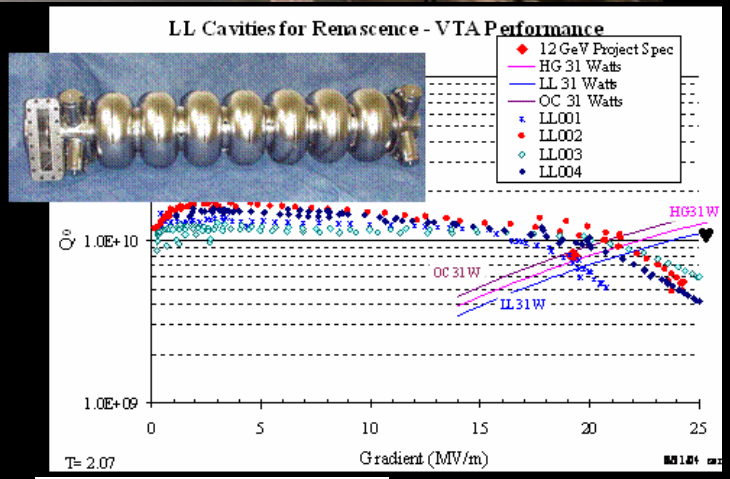


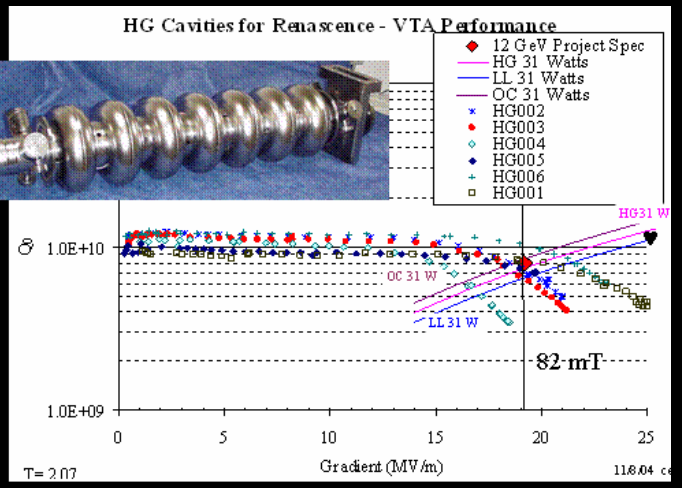
# The Future – *Renascence* (I)

- Final prototype for 12 GeV Upgrade project – under construction – testing July
- Improved cell geometry yields higher gradient Module energy gain > 100 MeV (~110 MeV)
- More HOM couplers yields (R/Q)*Q values about the same as FEL3 ➔ BBU threshold probably the same or higher (more simulation needed to confirm)

# The Future - *Renascence* (II)

- String assembly complete, cryomodule assembly underway
- Ready for test ~ 7/1/05



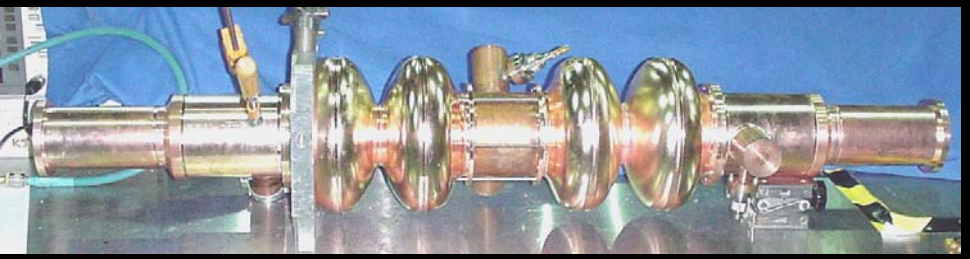



# The Future – 100 mA Injector

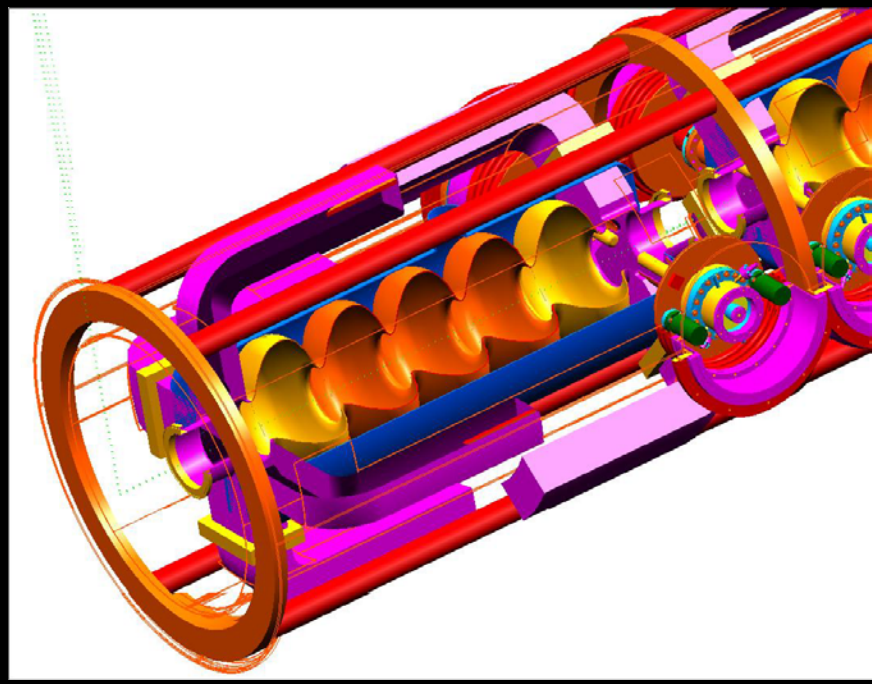
- Collaboration with Advanced Energy Systems
- DC RF gun: 750 MHz; 135 pC
- $E_{out}$ = 7.5 MeV
- Three single-cell cavities, plus third harmonic cavity for linearization of longitudinal phase space
- Construction complete 2006; testing dependent on availability of RF sources

# The Future: 1 A Cryomodules

- CW; 750 MHz
- 2005: conceptual design & copper models
- 2006: working Nb version
- Two concepts being evaluated:



**1.5 GHz model of 'superstructure' cavity with coaxial HOM couplers**



**5-cell cavity with enhanced waveguide coupling of HOMs**

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