Progress Toward a 95 GHz, 2 MW Gyrotron

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EC-16 Conference

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OUTLINE

- Nominal parameters and performance goals
- Gyrotron layout and design features
- Experimental demonstration
- Summary and plans

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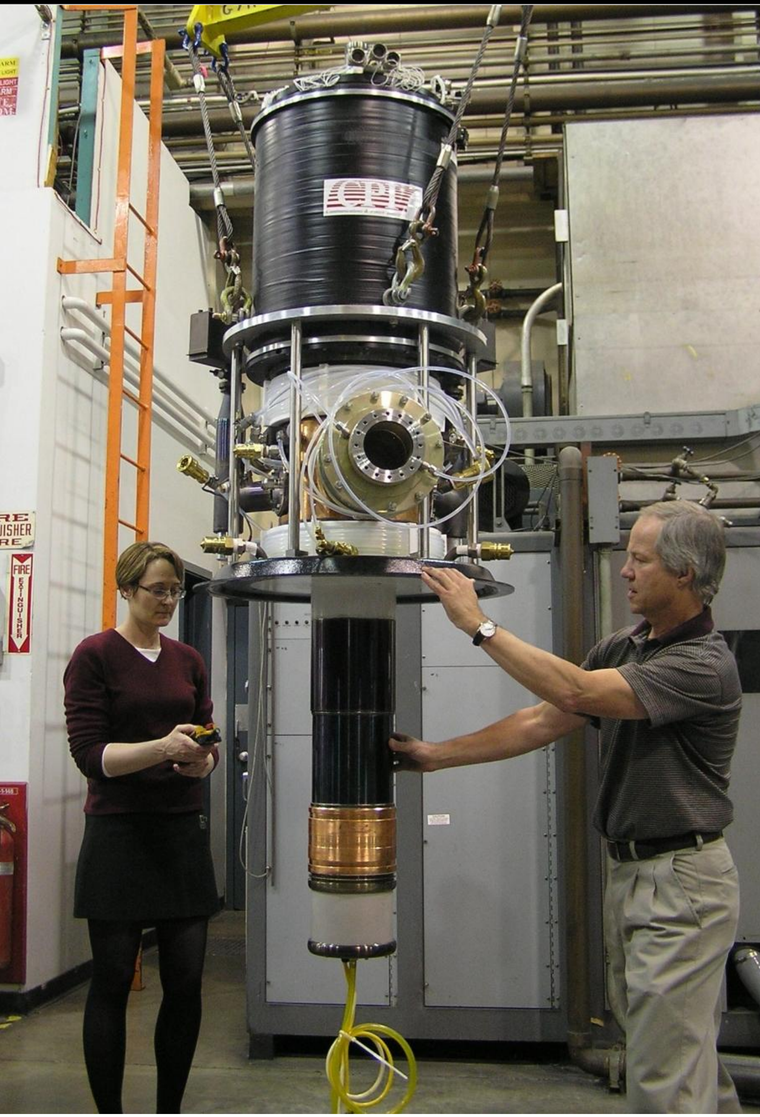
DESIGN PARAMETERS AND GOALS



- Nominal parameters
  - 90 kV cathode-to-body (accelerating) voltage
  - 29 kV depression
  - 75 A beam current
  - $TE_{22,6}$ cylindrical cavity mode
- Goals
  - > 2 MW peak output power
  - > 55% efficiency
  - < 3500 lbs (1591 kg)

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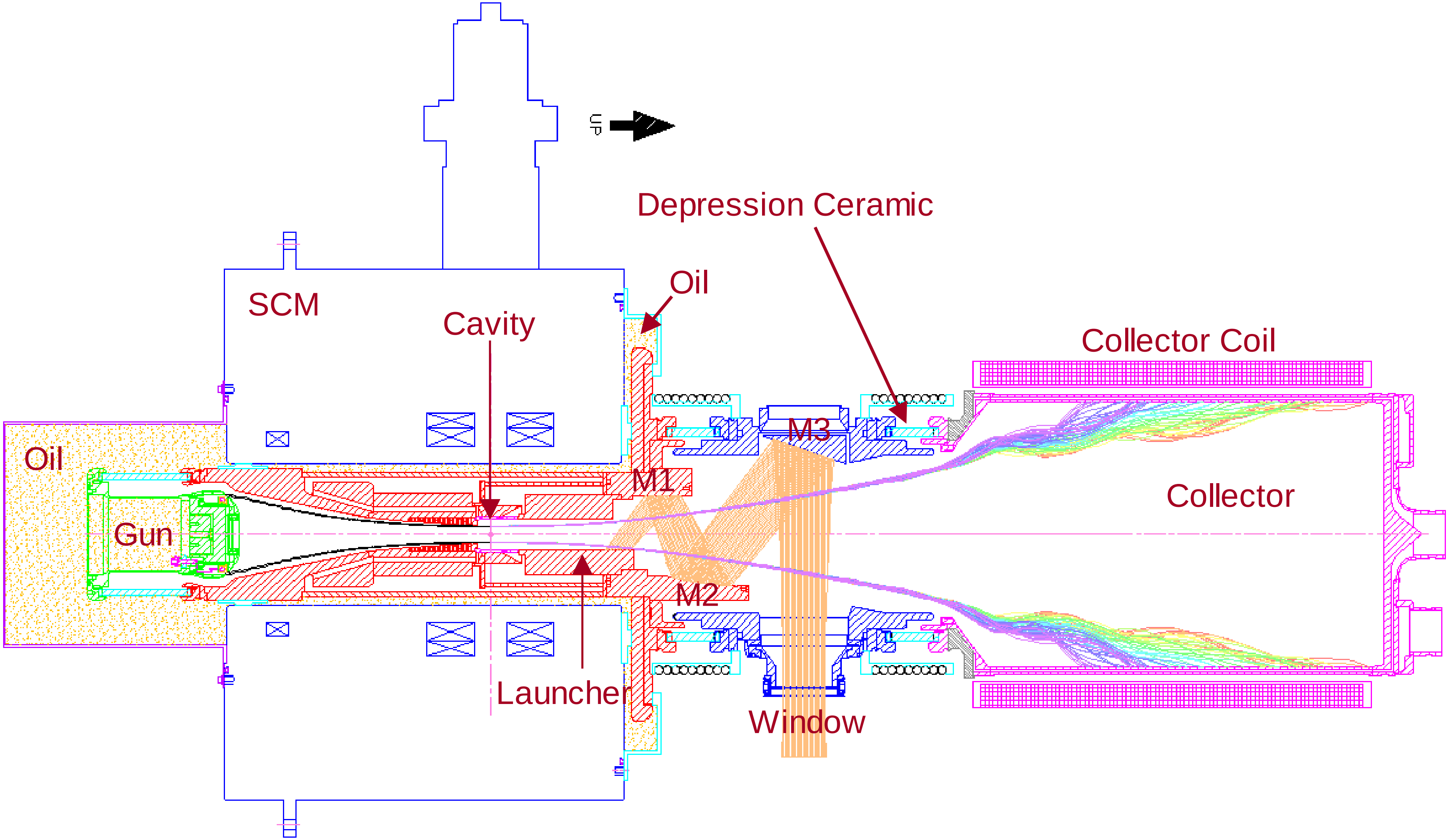
GYROTRON LAYOUT



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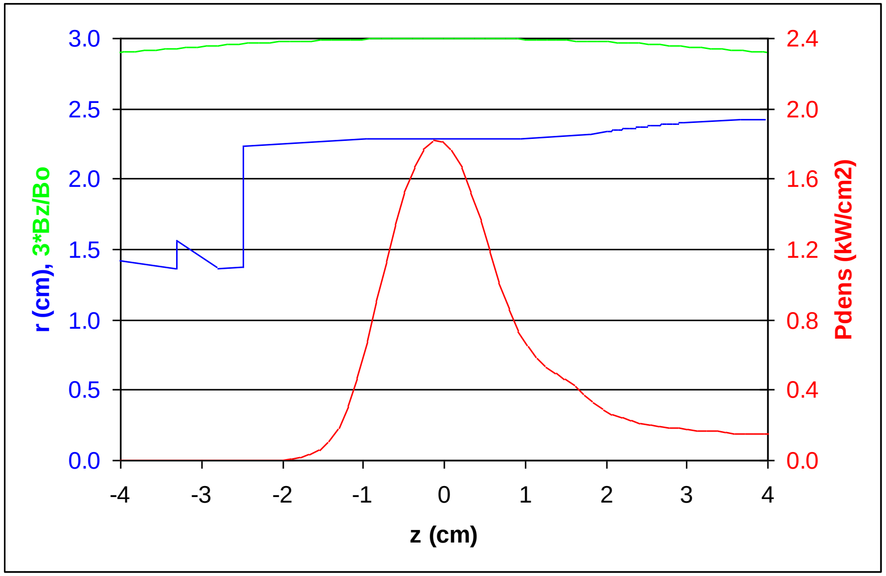
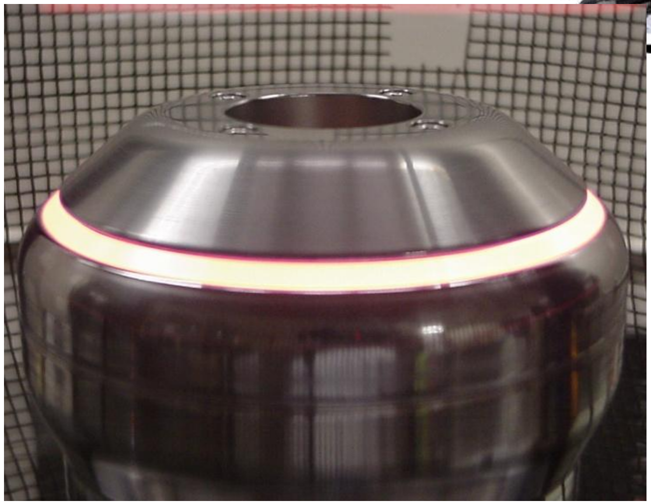
KEY DESIGN FEATURES

- Electron gun
  - Single-anode design



CAVITY POWER DENSITY



CATHODE STEM IN BELL JAR

- Cavity
  - $TE_{22,6,1}$ mode
  - Power density < $1.8 kW/cm^2$ for 2.5 MW output

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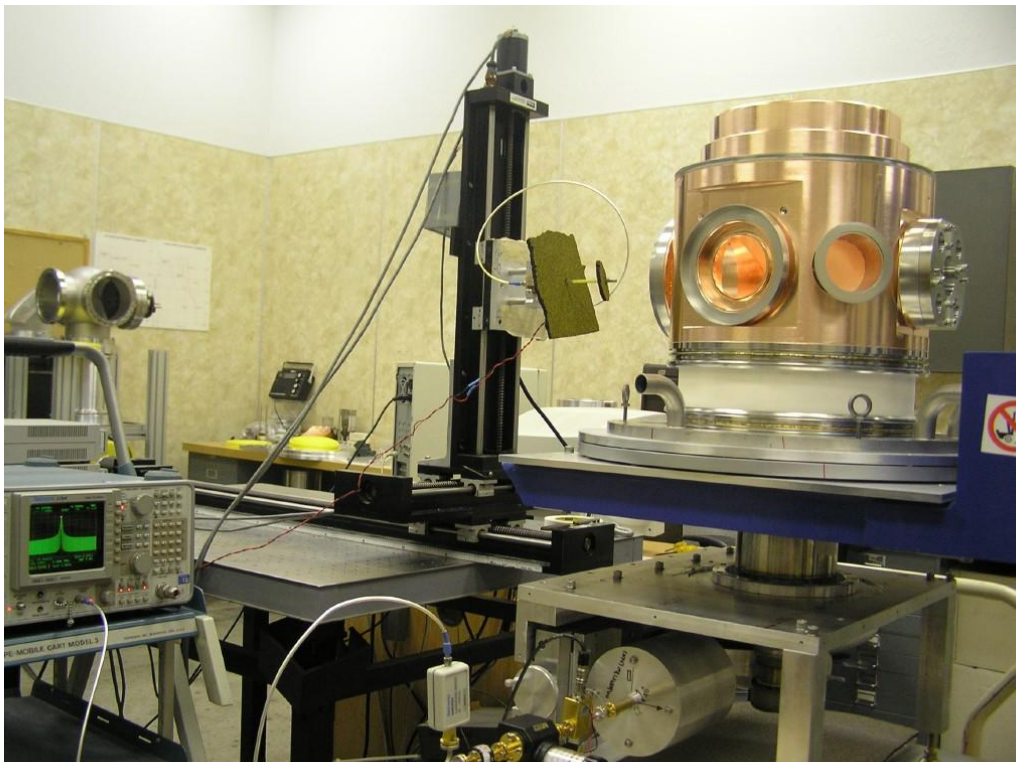
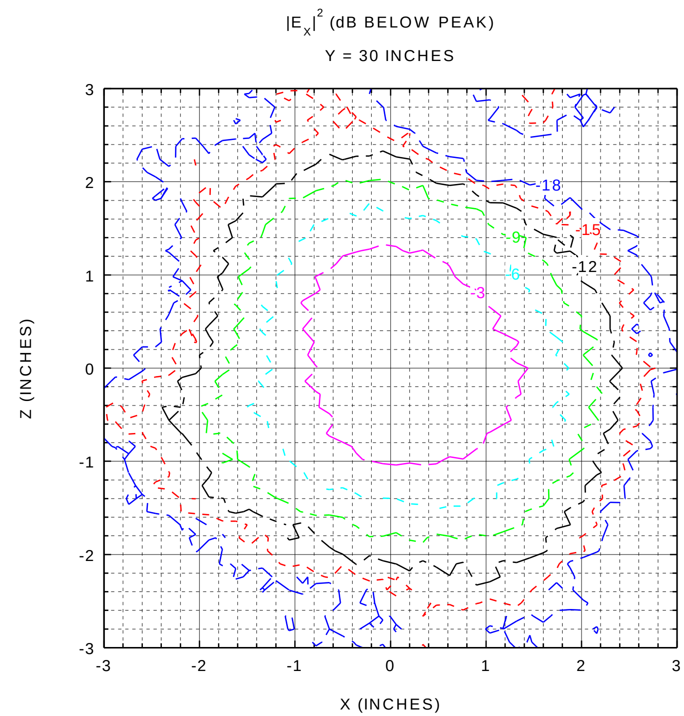
KEY DESIGN FEATURES (cont'd)

- Internal converter
  - Optimized launcher and three mirrors



INTERNAL CONVERTER COLD-TEST SET-UP



INTERNAL CONVERTER SCAN AT 76 cm

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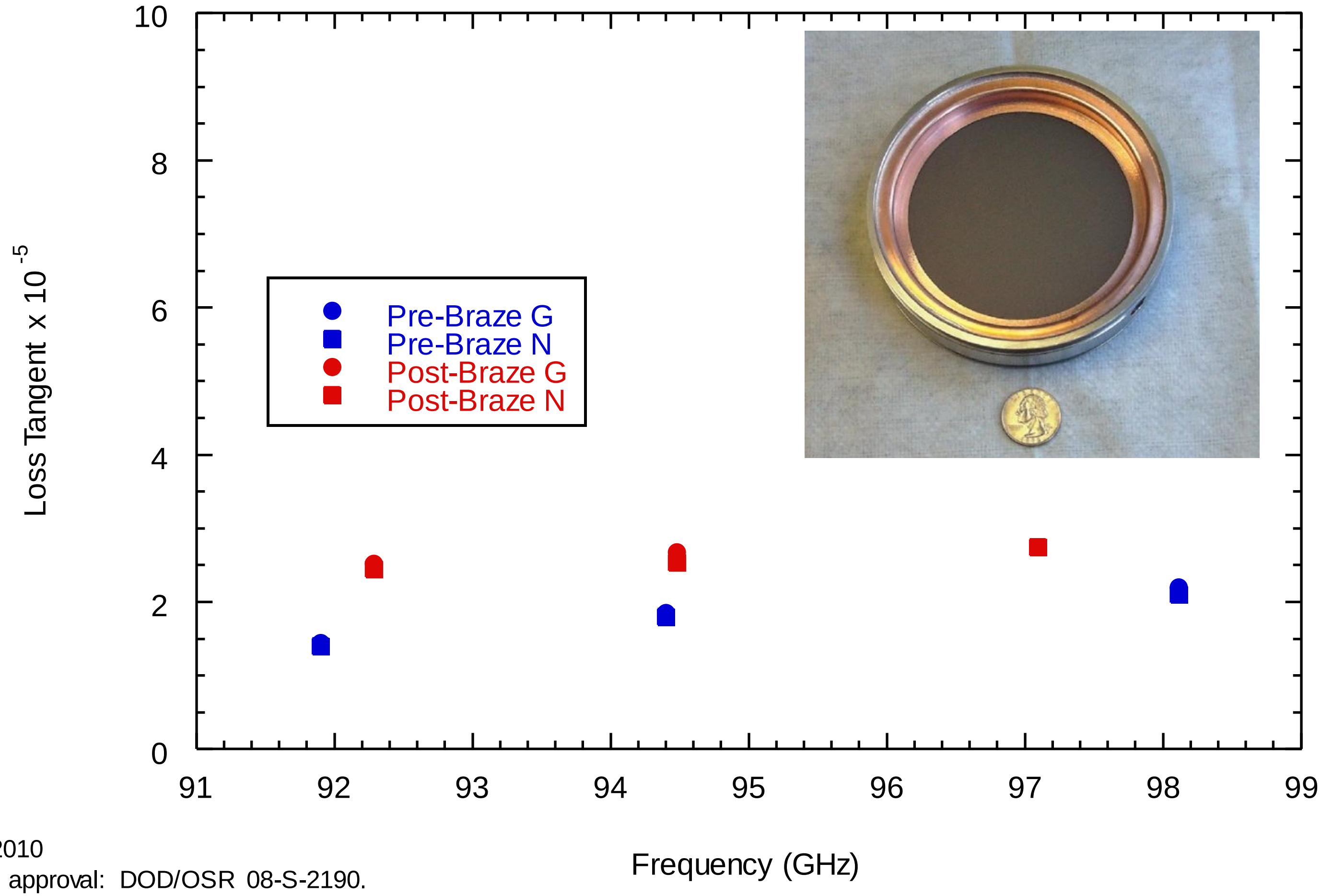
KEY DESIGN FEATURES (cont'd)

- Output window
  - Edge-cooled cvd diamond disc
    - "Extra" low loss tangent
  - 88 mm aperture, 2 mm thick



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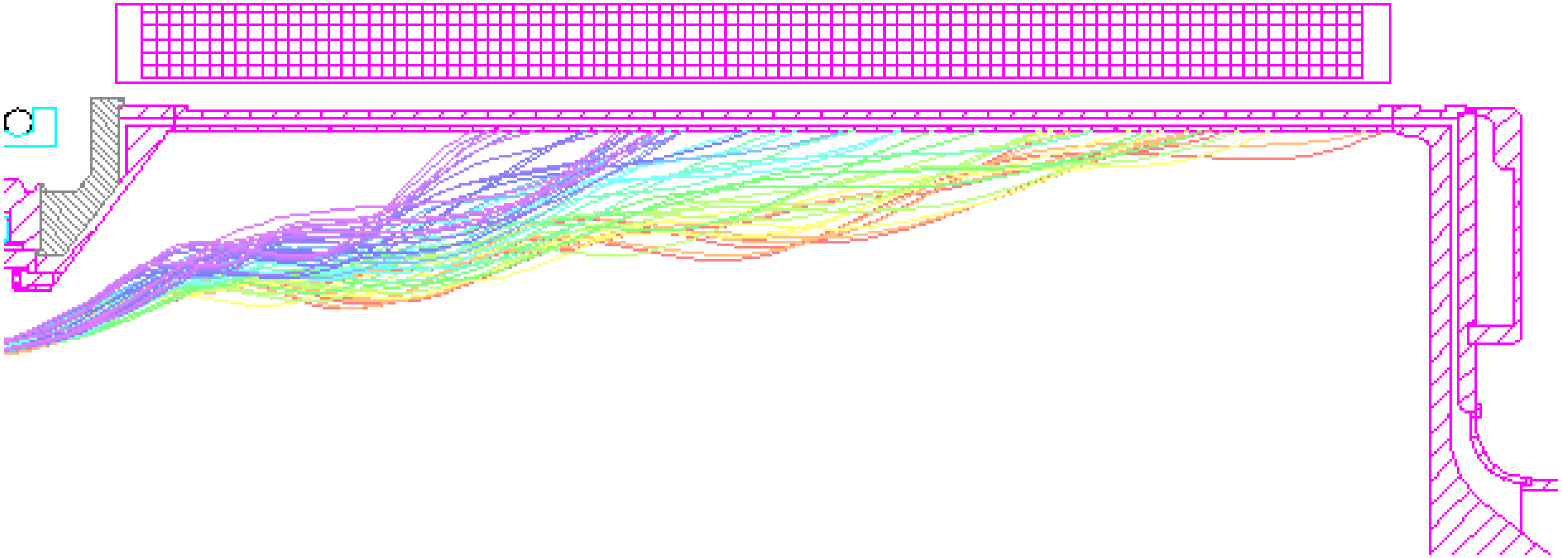
KEY DESIGN FEATURES (cont'd)

- Collector
  - 40.6-cm diameter
  - Dispersion-hardened copper
  - Single magnet coil
    - Modulated at 8 Hz



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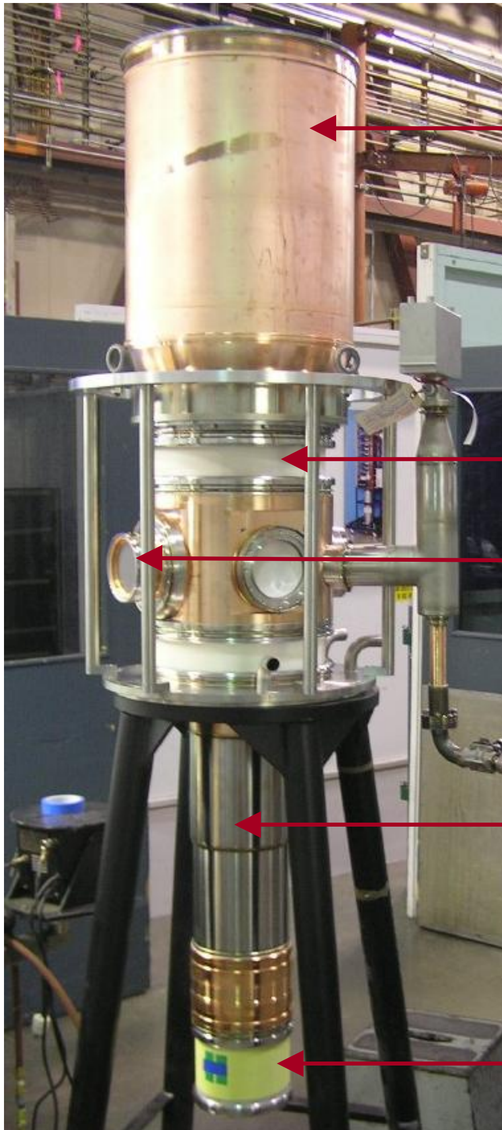
GYROTRON PHOTOS

Seal-In Assy Before Bake-Out



Glidcop Collector

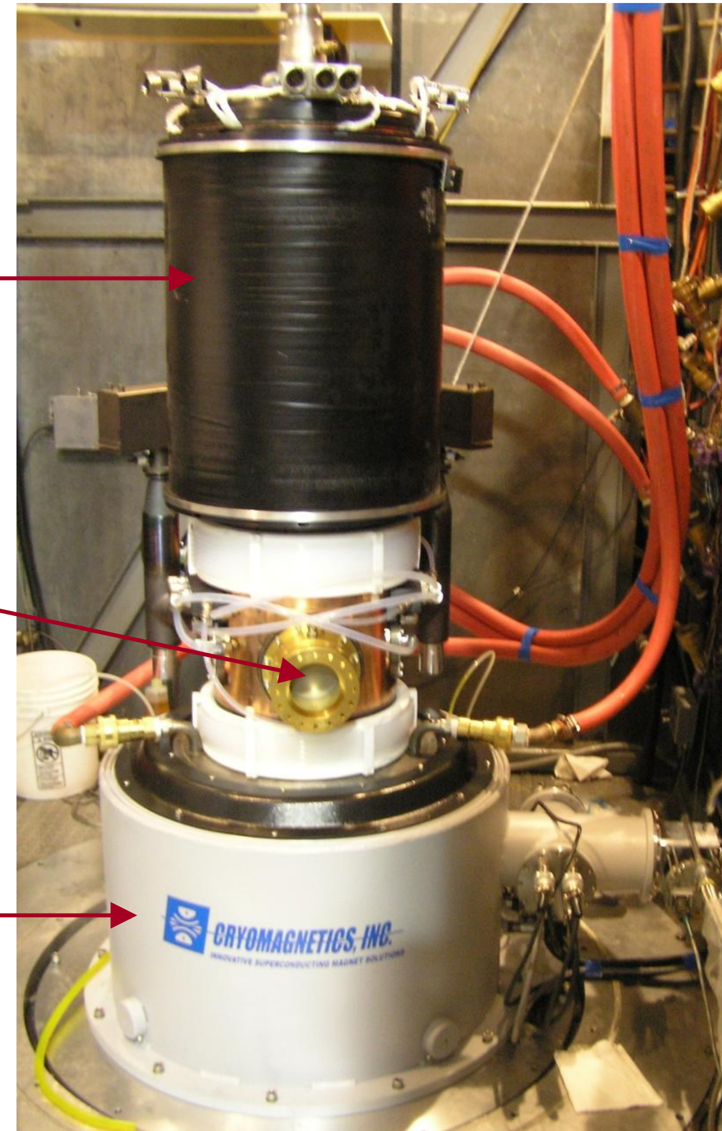
Depression Ceramic

Diamond Window

Body

Gun Ceramic

Tube & Magnet in CPI Test Stand



Collector Coil

Cryomagnetics SCM

MEASURED WEIGHTS

	kg	lbs
Seal-in Assy	436	962
Final Tube Assy (includes dress hardware and collector coil)	518	1443
Tube + SCM Assy	896	1975
Tube + SCM + Compressor + Hoses	1039	2290

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GYROTRON TEST OVERVIEW

- CPI test-set limitations:
  - Max CW beam current = 25 A
  - Max pulsed beam current = ~75 A
  - Max body voltage = 30 kV
- Test overview
  - Results with original beam tunnel
    - Long-pulse testing at 25 A (Pout ~ 600 kW)
    - Short-pulse testing up to 75A (Pout ~ 1.4 MW)
    - Excess BT loss above Ib ~ 30A
  - Results after rebuild with lossier beam tunnel
    - Short-pulse testing:
      - 1.40 MW at Ib=45A (Vacc=90kV, Vdep=29kV)
      - 1.72 MW at Ib=75A (Vacc=93kV, Vdep=23kV)
    - Excess BT loss above Ib ~ 46A

Eff_{undep} / Eff_{dep}
35% / 51%
25% / 33%

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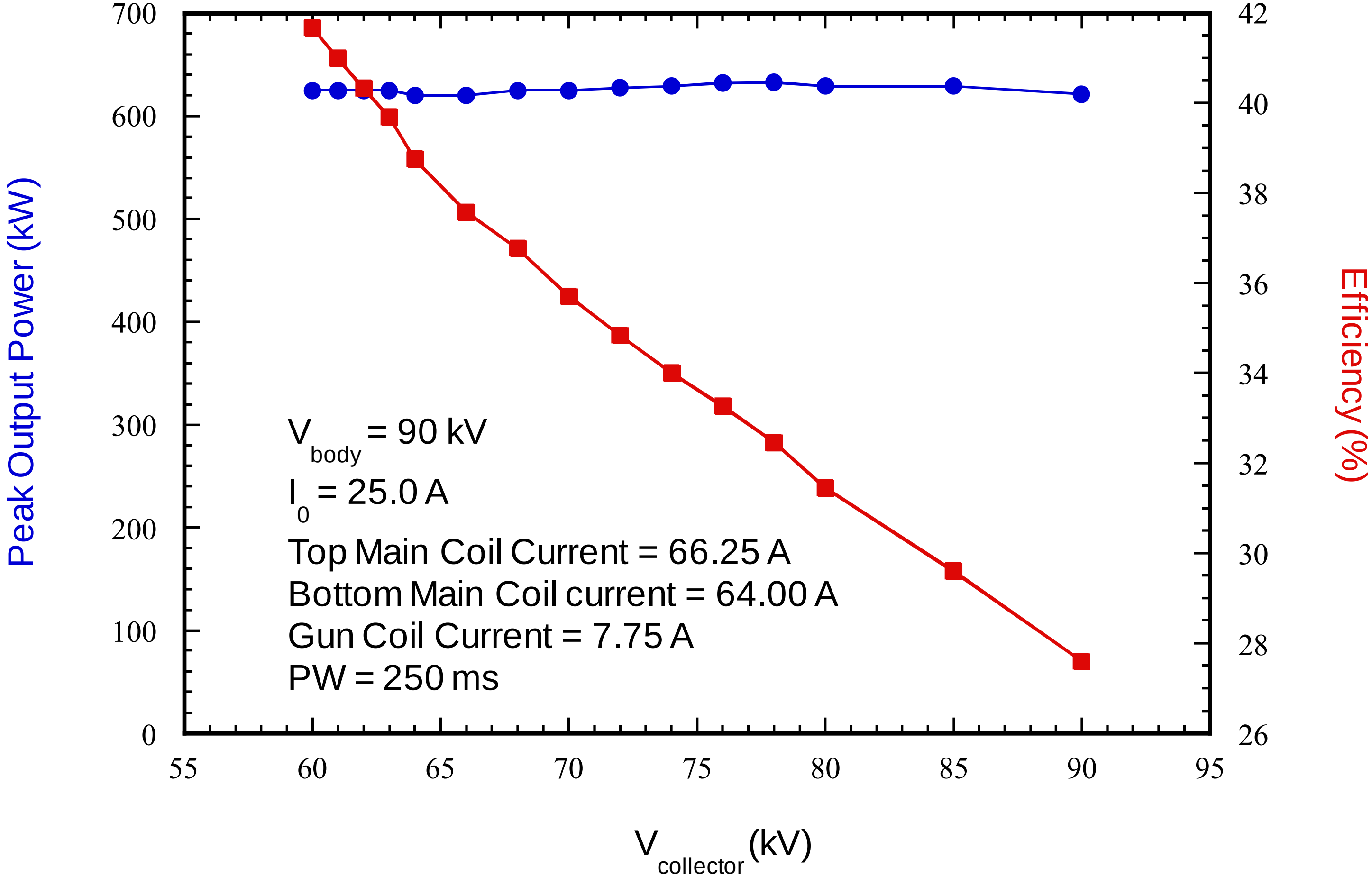
PEAK OUTPUT POWER AND EFFICIENCY VERSUS DEPRESSION AT 25 A

(Acceleration voltage held constant, depression voltage changing)



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LONG-PULSE OPERATION AT 25 A

- Aged to 15 second pulses at 30% duty
- Hundreds of 15 second pulses completed
- Output power typically 620 kW
  - V_{COLL}-V_{CATH} = 60 kV
  - V_{BODY}-V_{CATH} = 90 kV
  - I_0 = 25.5-23.5 A (varies due to emission cooling)
  - 41% efficiency

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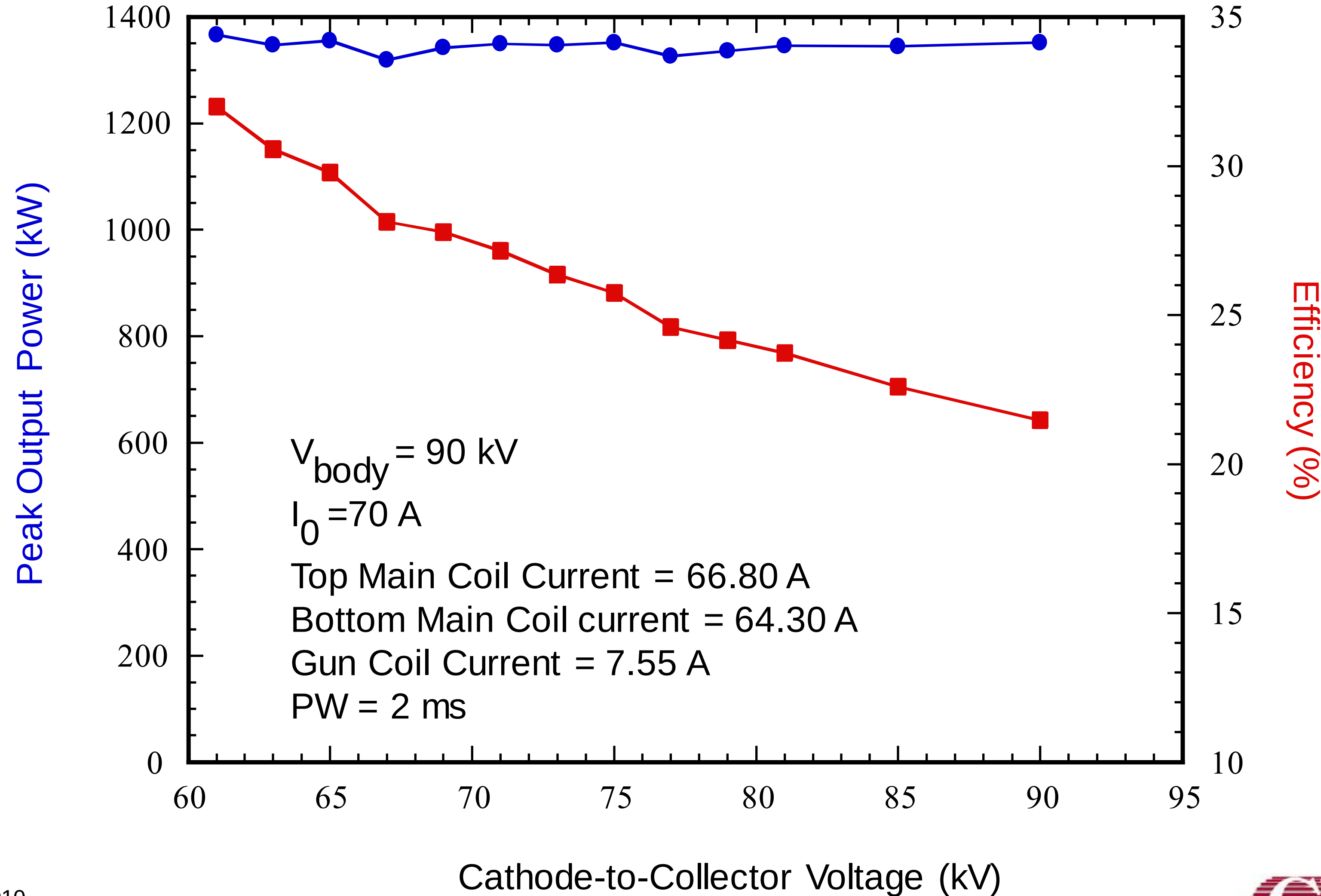
PEAK OUTPUT POWER AND EFFICIENCY VERSUS DEPRESSION AT 70 A (ORIGINAL BEAM TUNNEL)



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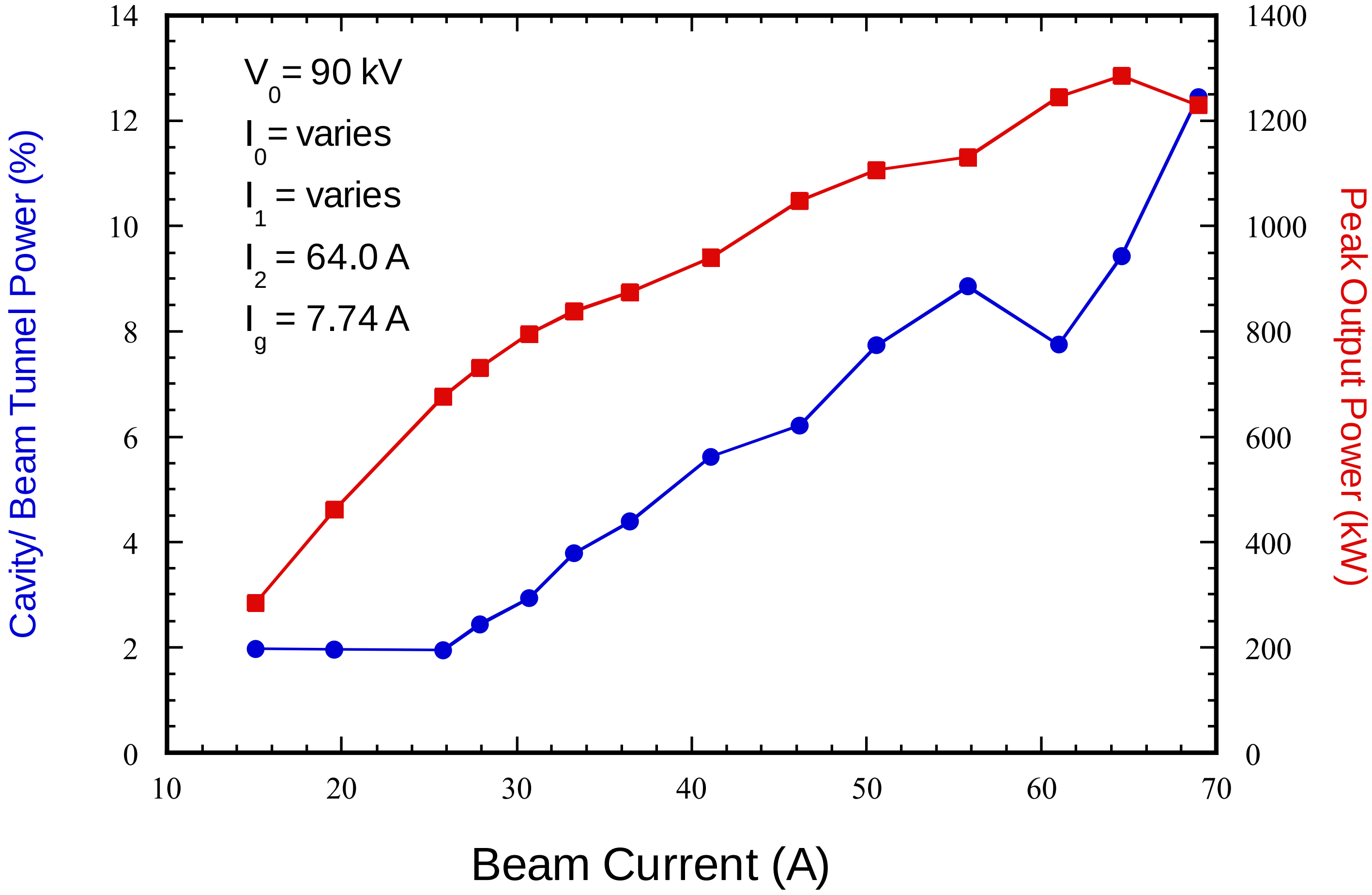
EXCESS CAVITY+BEAM TUNNEL POWER
(ORIGINAL BEAM TUNNEL)



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SUMMARY & FUTURE PLANS

- Testing so far has demonstrated:
  - P_{out} = 620 KW, 41% eff, 15 sec, at I_b=25A
  - P_{out} = 1.72 MW, 33% eff, 5 ms, at I_b=75A ($P_{bt/cav}$=11%)
  - P_{out} = 1.40 MW, 51% eff, 5 ms, at I_b=45A ($P_{bt/cav}$=2%)
- Beam tunnel modifications have increased the threshold for onset of BT oscillation, excess BT heating, and efficiency degradation from I_b=30A to I_b=46A.
- Future work:
  - Additional BT modifications (underway)
  - Additional factory testing
  - Long-pulse, full-power testing at customer facility

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