

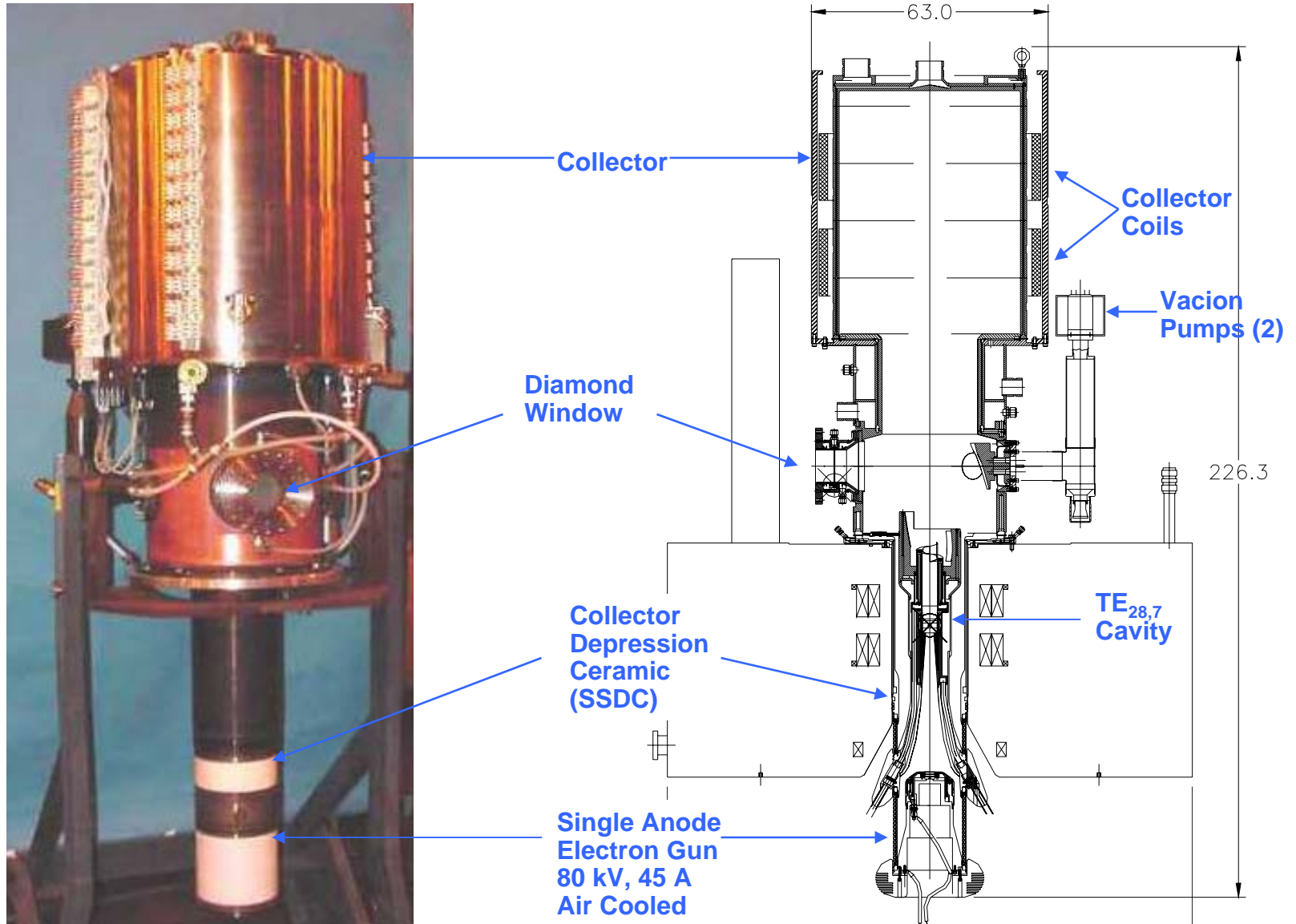
# **DEVELOPMENT LONG-PULSE, MEGAWATT CLASS GYROTRON OSCILLATORS AT 110 AND 140 GHz**

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PALO ALTO, CA***

- **1 MW 140 GHz GYROTRON**
  - DESIGN FEATURES
  - TEST RESULTS
  - SHIPPED TO W7-X
  - STATUS
  
- **> 1 MW 110 GHz GYROTRON**
  - DESIGN FEATURES
  - STATUS

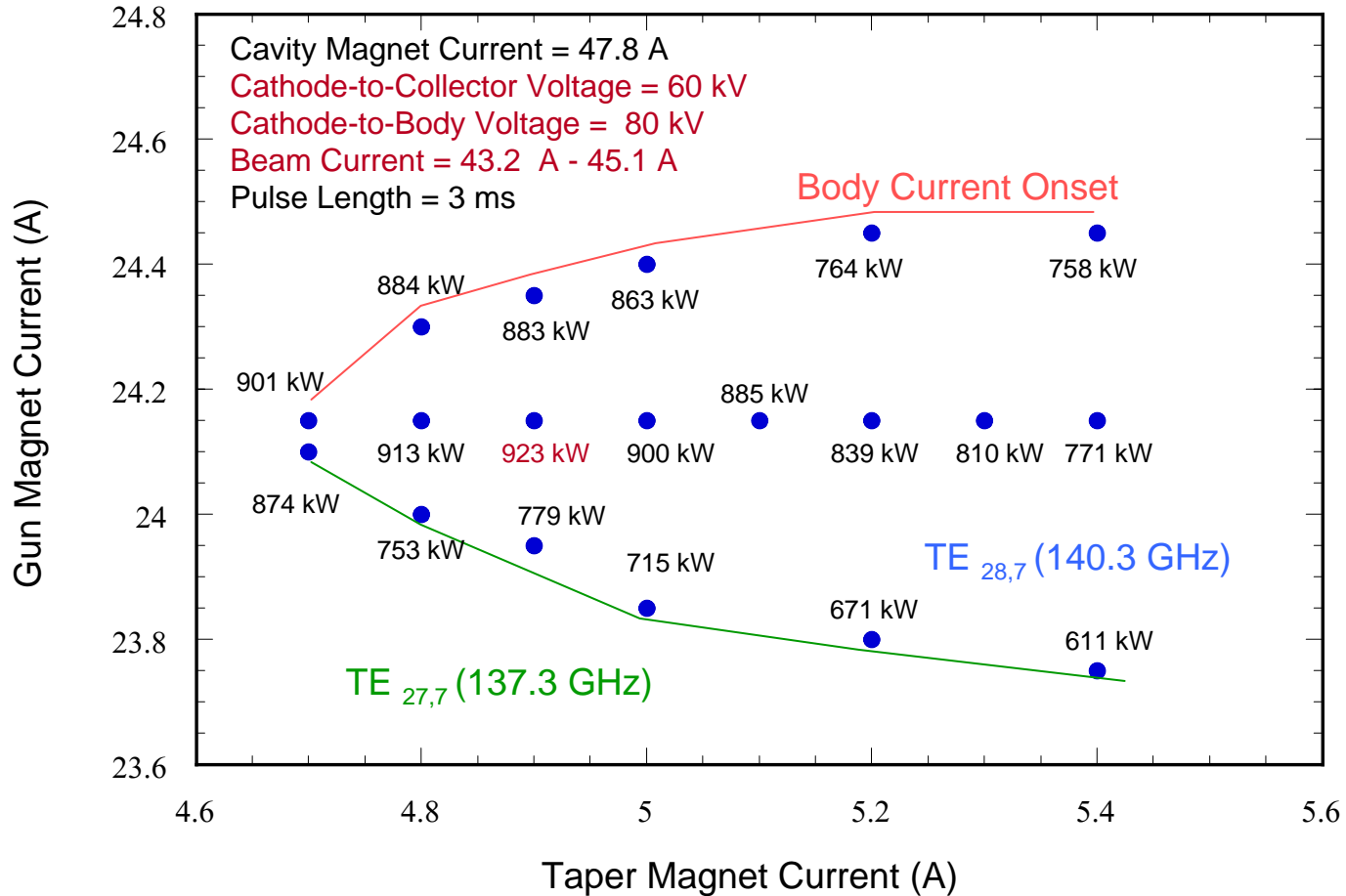
# 1 MW 140 GHz GYROTRON PHOTOGRAPH AND SCHEMATIC



# 1 MW 140 GHz GYROTRON DESIGN PARAMETERS

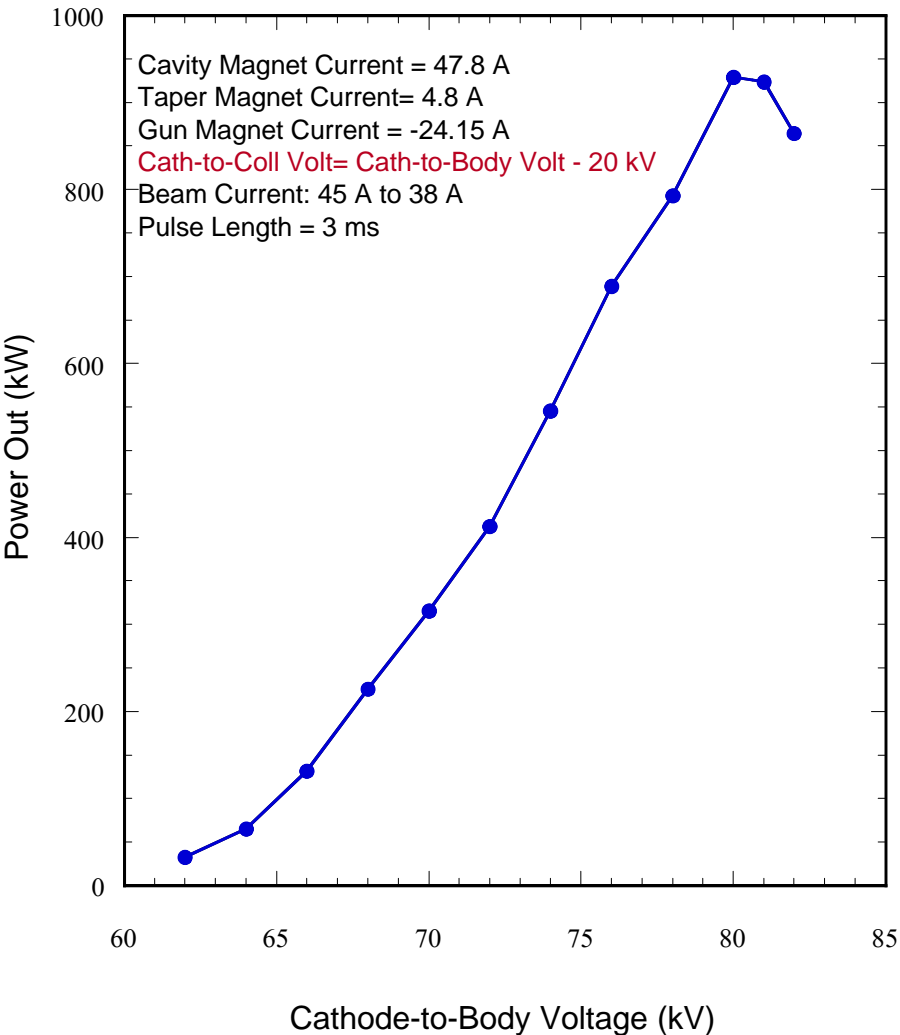
PARAMETER	DESIGN VALUE
<b>Electron Gun</b>	
Accelerating Voltage	80 kV
Beam Current	40 A
Magnetic Compression Ratio	29.5
Average pitch angle, $\alpha$	1.5
Perpendicular Velocity Spread	1.6%
Cathode Radius	5.64 cm
Average Cathode Loading	2.3 A/cm <sup>2</sup>
Cathode Angle	50 degrees
<b>Interaction Cavity</b>	
Operating Mode	TE <sub>28,7,1</sub>
Cold Q	1200
Frequency	140 GHz
Output Power	1 MW
Electronic Efficiency	31.25%
Space Charge Depression in Cavity	5 kV
Cathode-to-Collector Voltage	60 kV
Total Efficiency	41.67%

# 1 MW 140 GHz GYROTRON MODE MAP

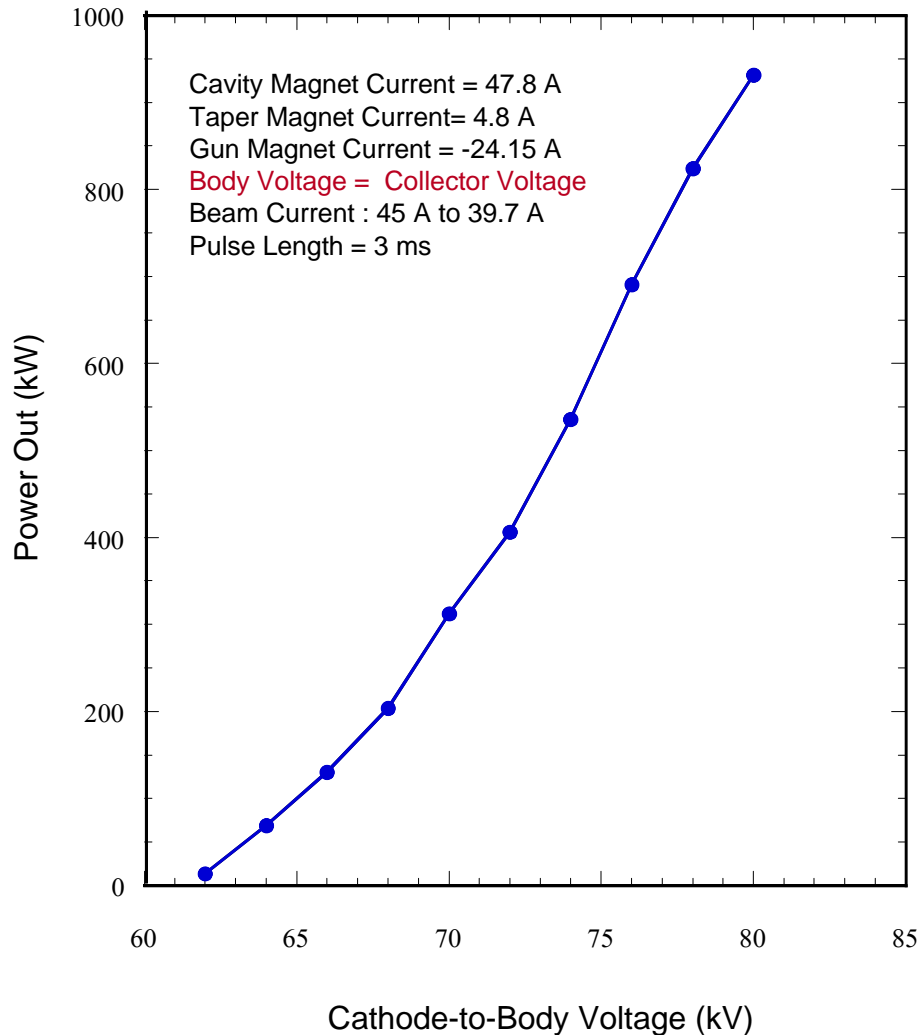


# OUTPUT POWER VS. BEAM VOLTAGE

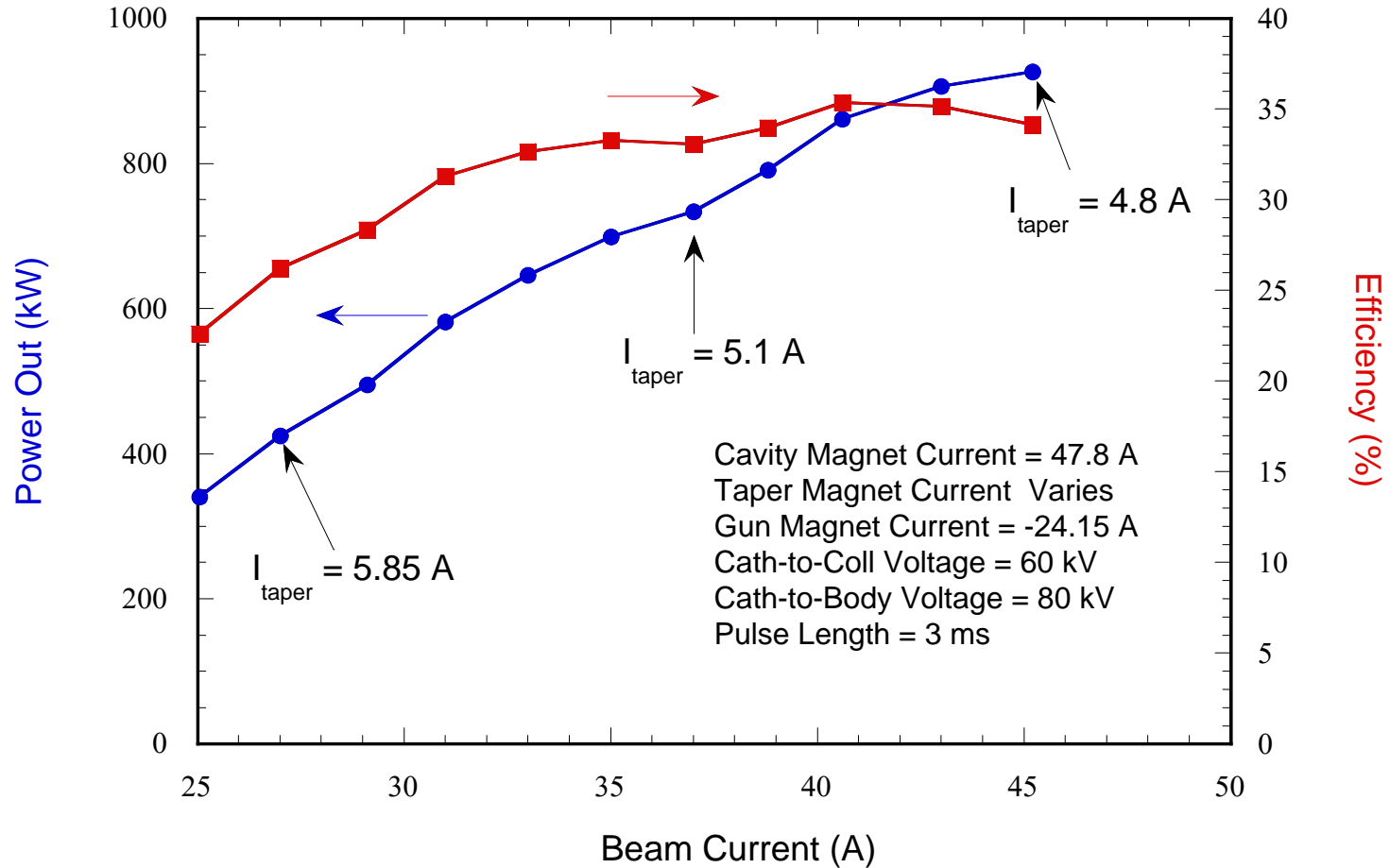
## 20 kV COLLECTOR DEPRESSION



## NO COLLECTOR DEPRESSION

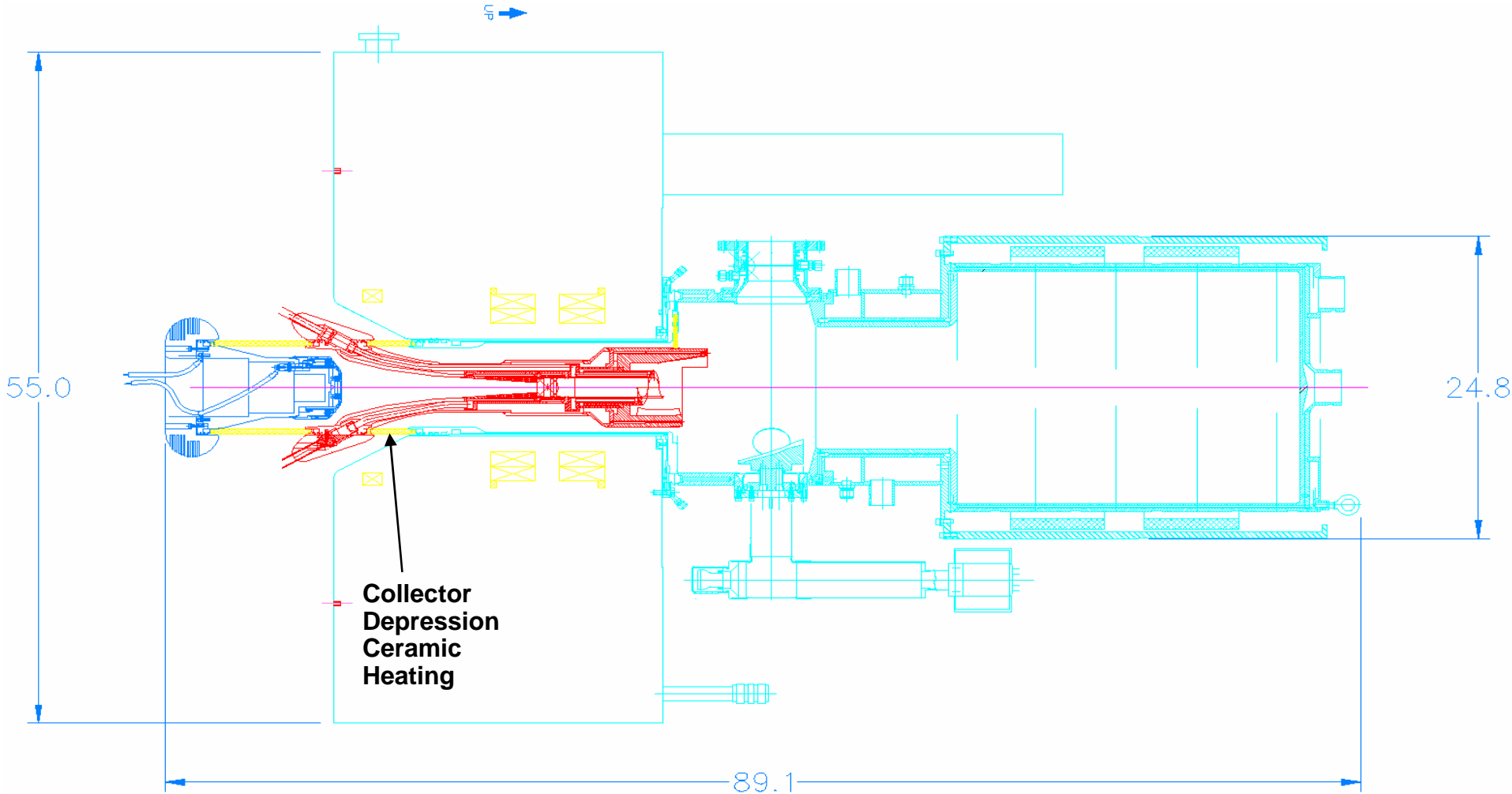


# OUTPUT POWER VERSUS BEAM CURRENT

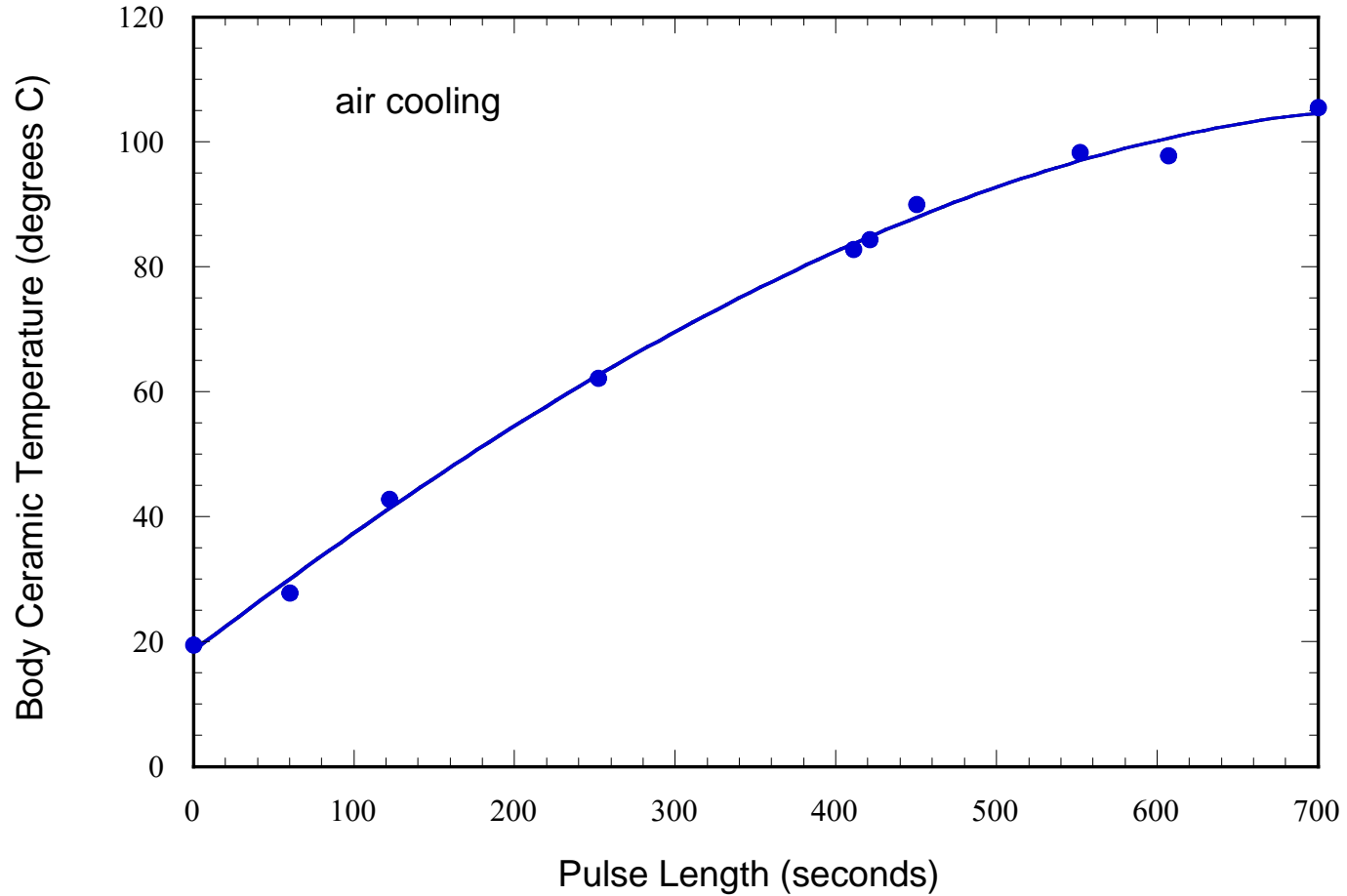




# BODY CERAMIC HEATING



# BODY CERAMIC HEATING



# **1 MW 140 GHz GYROTRON SUMMARY AND STATUS**

- **VGT-8141 DEMONSTRATED**
  - **900 kW PEAK OUTPUT POWER AT 5-ms PULSE DURATION (TEST SET LIMITED)**
    - **DID NOT REACH 1 MW DESIGN GOAL**
  - **500 kW PEAK OUTPUT POWER FOR 700-SECOND PULSES**
  - **TEN 600-SECOND PULSES IN A ROW WITHOUT FAULT AT 25% DUTY**
- **PULSE-LENGTH LIMITED BY BODY CERAMIC HEATING**
  - **IMPROVED COOLING WOULD ALLOW LONGER PULSES**
- **SHIPPED TO W7-X JULY 2003**
  - **FULL-POWER TESTS TO 5-MINUTE PULSES TO COMMENCE IN JUNE 2004**

# MW-CLASS 110 GHz GYROTRON PHOTO AND SCHEMATIC



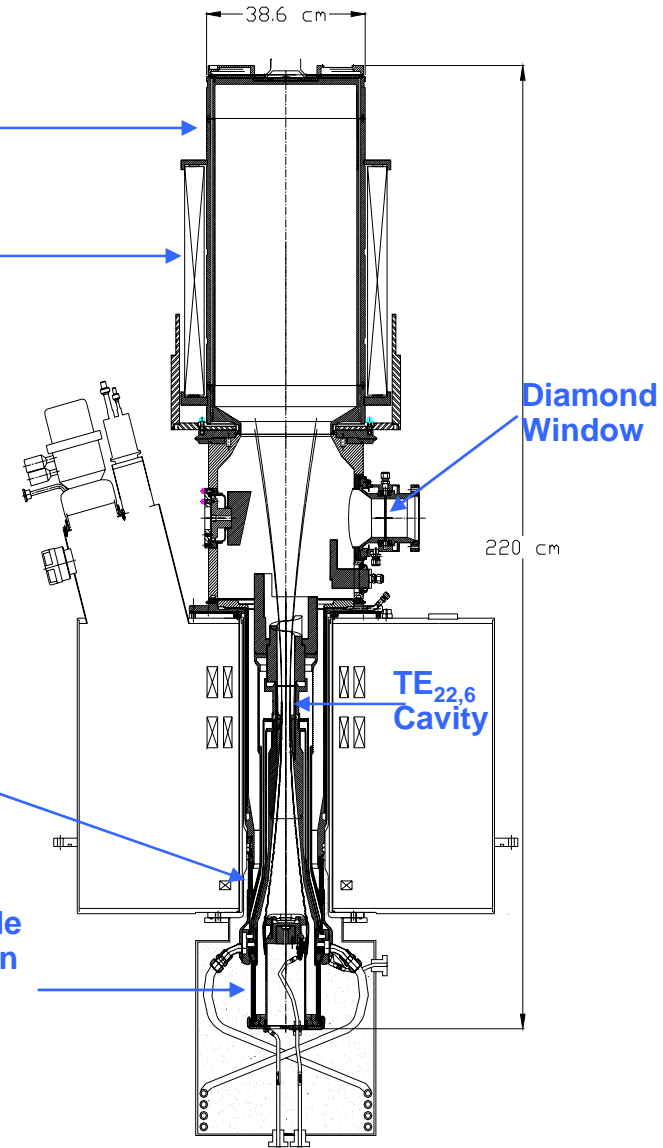
Collector

Collector Coil

Vacuum Pumps (2)

Collector Depression Ceramic (SSDC)

Single Anode Electron Gun  
96 kV, 45 A  
Oil Cooled



- **DESIGN GOAL**
  - RELIABLE OUTPUT POWER > 1 MW
- **CONSTRAINED TO USE**
  - TE<sub>22,6</sub> MODE
    - NOT IDEAL MODE FOR 1.5 MW LONG-PULSE
  - EXISTING SUPERCONDUCTING MAGNET
    - OIL INSULATION AND COOLING FOR ELECTRON GUN
- **USED AS MANY FEATURES AS POSSIBLE FROM THE 1 MW, 140 GHz GYROTRON**

# MW-CLASS 110 GHz GYROTRON DESIGN PARAMETERS

PARAMETER	DESIGN VALUE
<b>Electron Gun</b>	
Accelerating Voltage	96 kV
Beam Current	40 A
Magnetic Compression Ratio	24
Average pitch angle, $\alpha$	1.4
Perpendicular Velocity Spread	2.0%
Cathode Radius	4.9 cm
Average Cathode Loading	3.6 A/cm <sup>2</sup>
Cathode Angle	35 degrees
<b>Interaction Cavity</b>	
Operating Mode	TE <sub>22,6,1</sub>
Cold Q	913
Frequency	110 GHz
Output Power	up to 1.5 MW
Electronic Efficiency	up to 39%
Space Charge Depression in Cavity	5 kV
Cathode-to-Collector Voltage	71 kV
Total Efficiency	up to 52%

## **MW-CLASS 110 GHz GYROTRON STATUS**



- **ALL ASSEMBLIES OTHER THAN WINDOW COMPLETE**
- **CVD DIAMOND WINDOW SHOWED SURFACE LOSS AFTER BRAZE**
  - SURFACE LOSS NOT EASILY REMOVED WITH GRIT-BLAST TECHNIQUE
  - BRAZED STRUCTURE SENT TO ELEMENT 6 FOR CLEANING
  - **THANKS TO DR. R. HEIDINGER, FZK, FOR MANY LOSS TANGENT MEASUREMENTS DURING CLEANING PROCESS**
- **WHEN CLEAN, WINDOW WILL BE WELDED TO ASSEMBLED TUBE**
- **TESTS WILL BEGIN IMMEDIATELY FOLLOWING PROCESSING**

## **1 MW 110 GHz GYROTRONS**



- **GENERAL ATOMICS ORDERED THREE ADDITIONAL 110 GHz GYROTRONS**
  - 1 MW 10-SEC
  - TE<sub>22,6</sub> MODE
  - NON-DEPRESSED COLLECTOR
  - DIODE GUN, 80 kV AND 40 A
- **ALL THREE TO BE DELIVERED IN 2005**

- **1 MW 140 GHz GYROTRON**
  - **DEMONSTRATED**
    - **900 kW PEAK OUTPUT POWER AT 5-ms PULSE DURATION (TEST SET LIMITED)**
    - **500 kW PEAK OUTPUT POWER FOR 700-SECOND PULSES**
    - **TEN 600-SECOND PULSES IN A ROW WITHOUT FAULT AT 25% DUTY**
  - **FULL-POWER LONG-PULSE TESTS AT GRIEFSWALD SCHEDULED FOR JUNE 2004**
- **MW-CLASS 110 GHz GYROTRON**
  - **DESIGNED FOR > 1 MW POWER**
  - **ALL ASSEMBLIES OTHER THAN DIAMOND WINDOW COMPLETE**
  - **TESTS SCHEDULED FOR SUMMER 2004**