10 MW, 91 GHZ GYROKLYSTRON FOR HIGH FREQUENCY ACCELERATOR RESEARCH

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Abstract

Calabazas Creek Research, Inc. is developing a gyroklystron amplifier for W-Band linear accelerator applications. The device will be available for testing W-Band accelerator components and systems. The gyroklystron will operate at 91.392 GHz and is predicted to produce 10 MW of RF power with an efficiency greater than 38% and a gain of 55 dB. The design uses the second-harmonic mode to reduce the magnetic field requirement and use available TWT drivers. The current circuit design employs six cavities consisting of an input cavity, four buncher cavities and a final output cavity. The output mode is a hybrid TE_{01}/TE_{02} mode which facilitates transmission with reduced loss and flexibility for incorporating bends in the transmission system. The device is capable of depressed collector operation. The gyroklystron is fully assembled and ready for high power testing.

INTRODUCTION

Calabazas Creek Research, Inc. (CCR) is funded by the U.S. Department of Energy to develop a high efficiency gyroklystron amplifier for W-Band linear collider applications. This research supports an international effort to design the next generation of linear electron-positron colliders with anticipated center of mass energies of 0.5 TeV and beyond. In particular, this program supports development of a W-Band accelerator being investigated by the Stanford Linear Accelerator Center. CCR is developing a 91.392 GHz gyroklystron to produce 10 MW of RF power with efficiency greater than 40% and a gain of 55 dB. Achievement of 10 MW of peak power would advance the state of the art for W-Band amplifiers by two orders of magnitude and potentially lead to other applications, including land- and ship-based radar, medical accelerators, and materials processing.

GYROKLYSTRON DESIGN

The design uses the second-harmonic mode to reduce the magnetic field requirements and use available TWT drivers. The current circuit design employs six cavities consisting of an input cavity, four buncher cavities and a final output cavity. A schematic of the circuit is shown in Figure 2. The input cavity is a fundamental cavity operating with the TE011 mode and uses radial coupling to the input rectangular waveguide. The first buncher cavity is operated in the fundamental TE011 mode. The following buncher cavities operate with the TE021 mode and are stagger-tuned to improve efficiency and bandwidth. The output cavity operates in the TE021 mode and has smooth-wall transitions along with a non-linear output taper to minimize mode conversion.

Figure 1: Gyroklystron gun stem.

Following the circuit, a large radial gap is introduced in the output waveguide to allow voltage depression of the beam collector to increase the overall efficiency. A hybrid mode is used (TE01/02) to maximize transmission across the gap. An internal elbow is included to prevent beam bombardment of the output window.

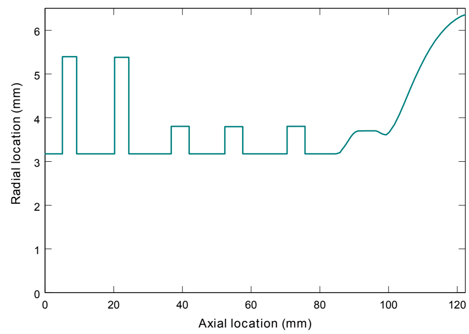

Figure 2: Schematic of gyroklystron circuit.

The output window is a single disk alumina ceramic. The predicted RF performance is shown in Figure 3.

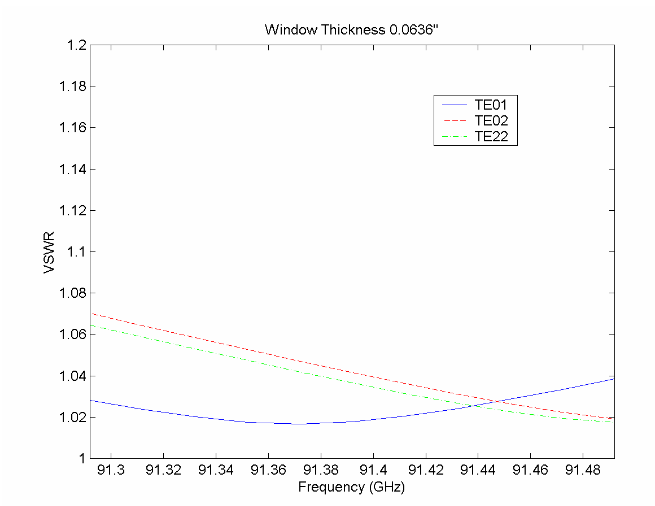

Figure 3: Predicted performance of gyroklystron window.

The gyroklystron uses a superconducting magnet manufactured by Cryomagnetics Corporation. There are also three room temperature collector coils to help distribute the spent beam power. Two TWT drivers are available for testing.

A layout drawing of the gyroklystron is shown in Figure 4 and a photograph is shown in Figure 5. Table 1 and Table 2 summarize the system parameters and current results.

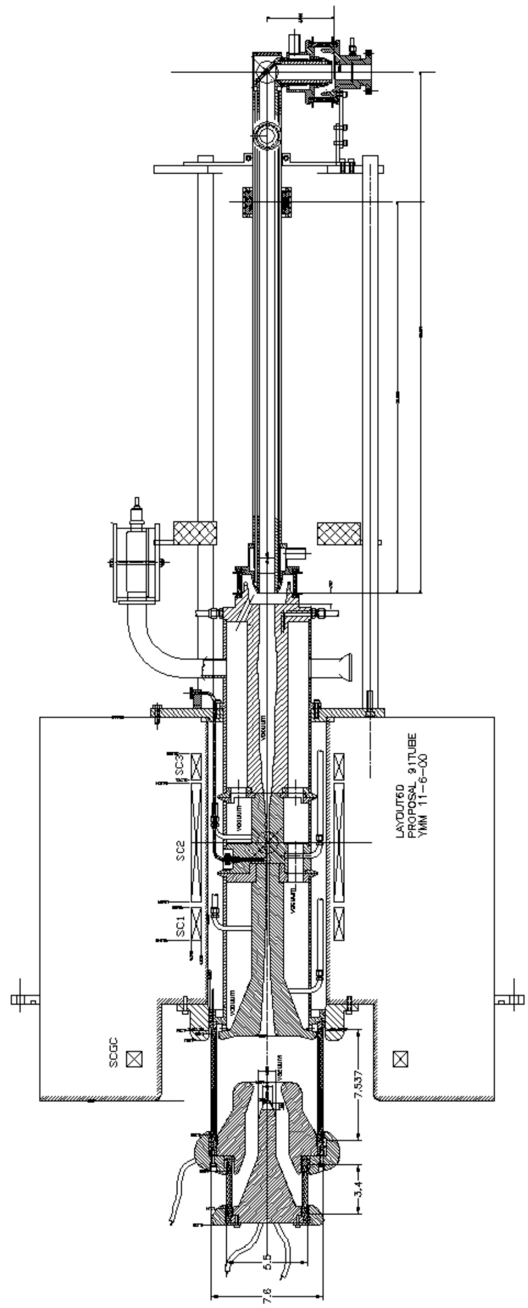

Figure 4: Layout drawing of the 10 MW, 91.4 GHz, second-harmonic gyroklystron.

Table 1: Gyroklystron Parameter

System Parameters	Value
Beam Voltage (kV)	500
Beam Current (A)	55
Average velocity ratio	1.6
Average beam radius (mm)	1.62
Peak magnetic field (kG)	28
Drive frequency (GHz)	45.696
Drive power (W)	17

Table 2: Design results achieved in simulations

System Parameter	Value
Electronic efficiency (%)	38
Gain (dB)	58
Output power (MW)	10.5
Axial velocity spread (%)	4.4

SUMMARY

A 10 MW, 91 GHz is assembled and ready for final testing. Following successful completion of testing, it will be available for high power component and system research.

ACKNOWLEDGEMENTS

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Figure 5: 10 MW, W-Band Gyroklystron.