PERFORMANCE OF LITTON 805MHz, 12MW KLYSTRONS

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ABSTRACT

The Fermilab Linac Upgrade[1] will increase the energy of the H⁻ linac from 201 to 401.5 MeV. This will be achieved by replacing the last four 201.24 MHz drift-tube linac cavities with seven 805 MHz side-coupled cavity modules. Each accelerator module will be powered with a 12 MW klystron-based power supply. The purpose of this report is to present a body of representative data for the klystron tubes at various conditions and to detail the procedures used.

TESTS

Below is the list and description of the tests[2] performed on three klystron tubes. Each tube was received with an acceptance test datasheet . All tube parameters were in the range suggested by Litton. Connected to the output of each klystron was a Varian water-load (model L975FAI).

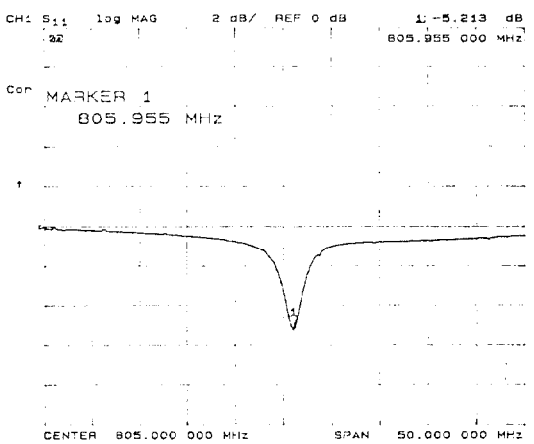

Figure 1.

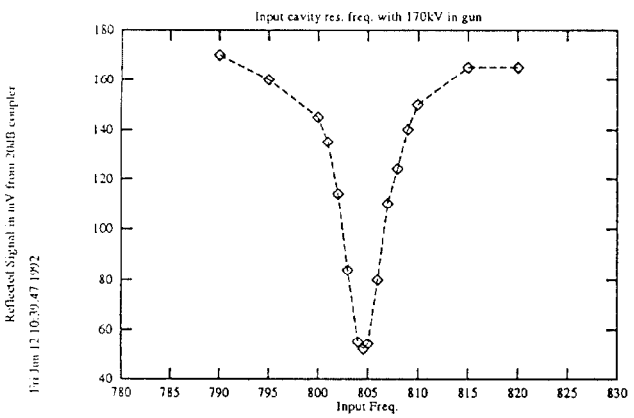

Figure 2.

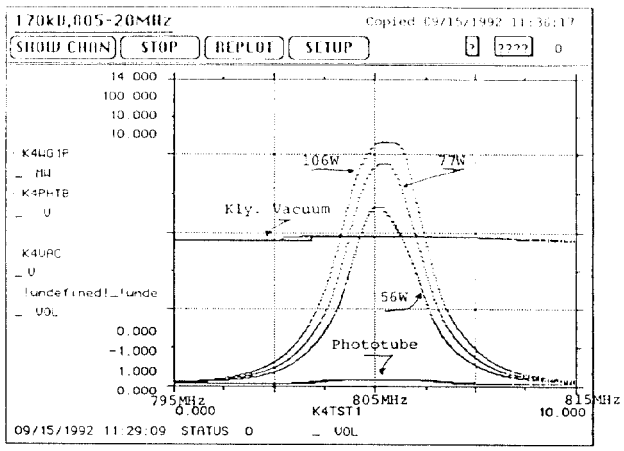

Figure 3.

Figures 1 and 2 present measurements of input cavity match with and without beam current. The input cavity on one of the tubes (serial#0002) is ~10MHz above the nominal frequency of 805MHz for no apparent reason.

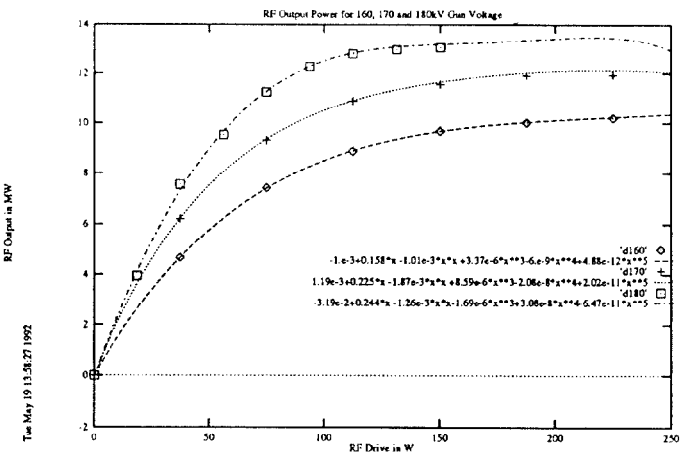

Figure 4.

Figure 3 shows klystron power bandwidth. The output power

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is plotted as function of rf frequency, from 795MHz to 815MHz, for three different levels of rf drive power .

Above, see Figure 4, are displayed plots of klystron power output vs. drive power at gun voltages of 160kV, 170kV and 180kV.

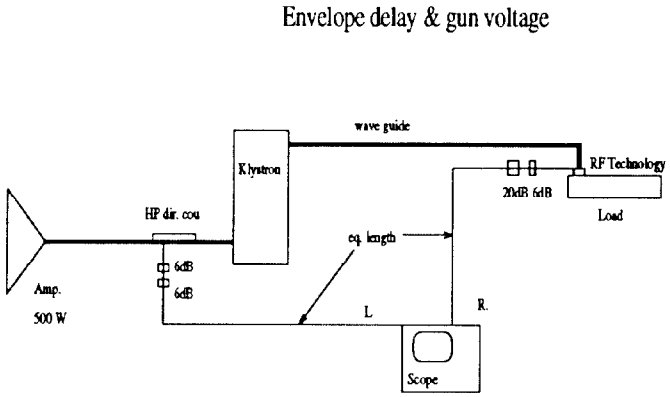

Figure 5.

The envelope delay vs. gun voltage was measured using the setup shown schematically in figure 5. Table 1 summarizes results of measurements for tube number 0002.

Table 1.

Gun V	*Gun I*	*Power*	*Delay*
kV	A	MW	nsec
140	100.7	5.9	94.0
150	111.3	7.6	92.0
160	122.2	9.7	94.0
163	125.6	6.0	88.0
170	133.4	11.1	92.0
180	145.0	12.9	94.0

All data were taken at 805.9632 MHz and we found mean delay to be 92.33 nsec.

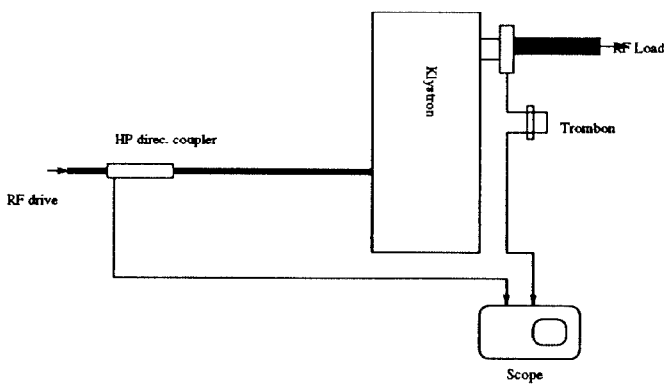

Figure 6.

RF phase shift as function of gun voltage was measured using the setup illustrated in figure 6. Table 2 summarizes results of measurements for the tube serial #0002.

Table 2.

Sat. Pwr.	*Gun V*	*Gun I*	*Tromb.*	*Phase*	*Ampl.*	*Calc. Eff*
MW	kV	A		Matched		
	150		1/2"	Yes	Yes	
9.8	160	132.1	2 10/16"	Yes	No	50%
11.9	170	134.2	4 1/2"	Yes	No	52%
13.4	180	145.9	6 1/4"	Yes	No	51%
14.22	185	151.8	7 1/4"	Yes	No	50.6%

Figure 7 shows RF phase as function of gun voltage for tube serial #0002.

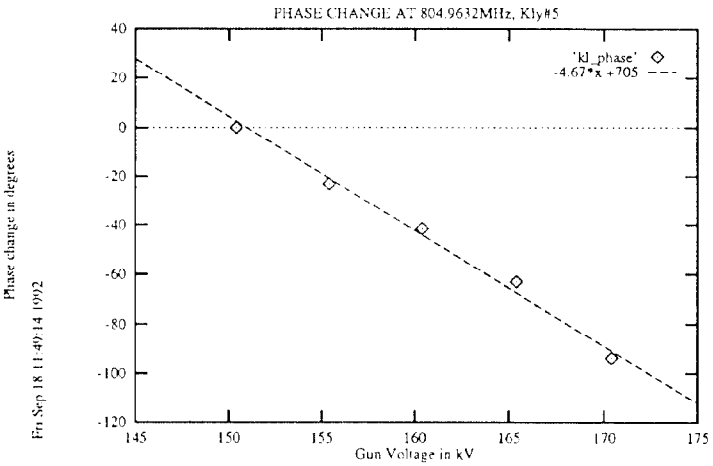

Figure 7.

Klystron gun current and klystron filament voltage are plotted as function of time for different settings of klystron filament voltage in figure 8 (Miram plot).

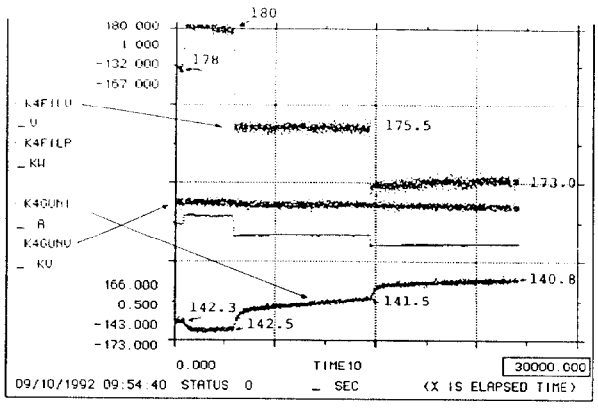

Figure 8.

Results of perveance measurements are summarized in Table 3.

Table 3.

Gun V kV	*Gun I* A	*Perveance* in 10^{-6}
150.7	112.3	1.92
160.4	123.0	1.91
165.5	128.6	1.91
170.4	134.4	1.91
175.5	140.0	1.90
180.3	146.0	1.91

The following discrepancies in klystron performance specifications are noted:

1. The input cavity in one tube is tuned ~10MHz higher than the nominal 805MHz for no apparent reason.

2. The solenoid currents had to be adjusted to FNAL values to avoid spurious oscillations which would occur with Litton settings when running less than saturated power output.

3. The power output pass-band is displaced to the high side of 805MHz, possibly due to input cavity mistuning. The Litton rating of a 3MHz 0.5dB pass-band appears optimistic.

4. The output window shows a mild glow, above 10MW, possibly due to multipactoring in the output waveguide.

In conclusion the tubes which were tested delivered 13MW at 50% efficiency at a gun voltage of 180kV, and with 150 watts of drive power and are considered successful tubes.

CONCLUSIONS

Three tubes have been tested and are installed on rf stations one, two and three. The tubes are now fully operational. To date, over 3.9×10^7 high voltage pulses have been applyed to tube 0005, 8.8×10^7 high voltage pulses have been applied to tube 0004 and 0.6×10^7 high voltage pulses have been applied to tube 0002.

REFERENCES

[1] C. W. Schmidt, "The Fermilab 400-MeV Linac Upgrade", this conference.

[2] A. S. Gilmour, "Microwave Tubes", Artech House, 1986.