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12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Work by Prof. Bekefi and his collaborators is summarized here

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**Annual Technical Report for the
Office of Naval Research Grant No. N00014-90-J-4130
September 30, 1990 - September 29, 1991**

The MIT Microwiggler Project moved this year from the prototype and design phase through complete fabrication of all major hardware. This report briefly describes the microwiggler system and the status of its currently ongoing integration and testing, as well as modelling efforts relating to Free Electron Laser (FEL) research to be carried out using the MIT Microwiggler in the coming year.

The MIT Microwiggler has been built. It is a 70-period, 8.8 mm period wiggler in which the amplitude of each field peak is independently tunable. The magnet has produced 4.3 kG peak magnetic field on-axis. Magnetic field pulses of 4 kG, 0.5 msec have been produced for extended periods at a rate of 0.25 Hz. Figure 1 shows high-field peak profile measurements. The overall RMS error in the field, without tuning, including systematic as well as random variations, is 4%. However, the errors in the central region of the magnet are only about 1% RMS (Fig. 1).

The completion of the Microwiggler's construction culminates a fabrication effort of considerable magnitude:

- 280 ferro-core coils with 50 turns each of 32 AWG wire were hand-wound;
- A precision aluminum holder was custom-machined to 0.0002" tolerances;
- 560 current input leads were connected to the coils, which were embedded into the aluminum holder;
- A current distribution network was assembled which distributes the 14 kA peak current to the input leads via manganin wire tuning resistors;
- High-current busswork was built to carry the current from the pulsed power supply to the current distribution network.
- All components were assembled into the integral unit shown in Fig.2.

The 14 kA-peak-current pulsed power supply was also built in FY 1991. It consists of the following components:

- A 10 mF, 1400 V capacitor bank;
- A custom-made, low-resistance, 7 microhenry inductor;
- A 25 kA SCR and associated trigger circuitry.

- A capacitor-charging power supply capable of delivering 1.8 kJ/sec at 600 V, enough to permit 1 Hz operation of the pulser.

The Microwiggler and its pulsed power supply are controlled by a computer-based feedback system which was completed in FY 1991. The Microwiggler computer control and automatic field measurement system feedback-regulates and records system operation during experimental use, and also controls automatic detailed measurement of the Microwiggler magnetic field profile for tuning purposes. The computer controls a stepper-motor-driven field probe translator, which senses the field at a given point. The computer records the measurement and translates the probe to the next field point, etc. The computer control system has been completely tested and was used to acquire the data of Fig. 1. Figure 3 illustrates how the computer is used to reduce shot-to-shot fluctuations in the peak current to $< 0.2\%$.

In the coming Fiscal Year, we will employ the Microwiggler system in an experimental setting. This requires completion of the following tasks:

- Pulser capacitor bank upgrade: a improved capacitor bank will be installed in the pulsed power supply to allow 0.5 Hz operation;
- Pulser inductor upgrade: an inductor of improved mechanical strength will be installed in the pulser for increased reliability;
- Magnetic field tuning: the RMS error in the magnetic field peak amplitudes will be reduced to $< 0.3\%$;
- Accelerator installation: vacuum connections and mechanical supports necessary for installation in the accelerator beamline will be built.

The Microwiggler, its power supply and all diagnostic equipment are now located at the Brookhaven National Laboratory, as is Mr. R. Stoner, the graduate student in charge of the experiment. We will operate the Microwiggler at the Accelerator Test Facility (ATF) of the Brookhaven National Laboratory in FY 1992. We currently plan to collaborate in the operation of a 532 nm. FEL experiment. However, we are also considering an interim experiment to produce FIR radiation in a single-pass, high-gain FEL interaction using the 5 MeV beam from the ATF injector.

This experiment highlights the unique tunability of the MIT Microwiggler - it can be wired to operate at its first subharmonic period of 1.76 cm. at 0.8T on-axis field amplitude, to produce 146 micron radiation. Fig.4 shows the results of simulations in which growth rates of 50 dB/m have been calculated. With an optical mode of Rayleigh length on the order of a cm, successful operation of such a device would be a clear demonstration of optical guiding. Also, significant slippage between the radiation and electron pulses would occur and could be studied.

Amplitude Profile 10-21-91

$$V_{\text{bank}} = 530 \text{ V}$$

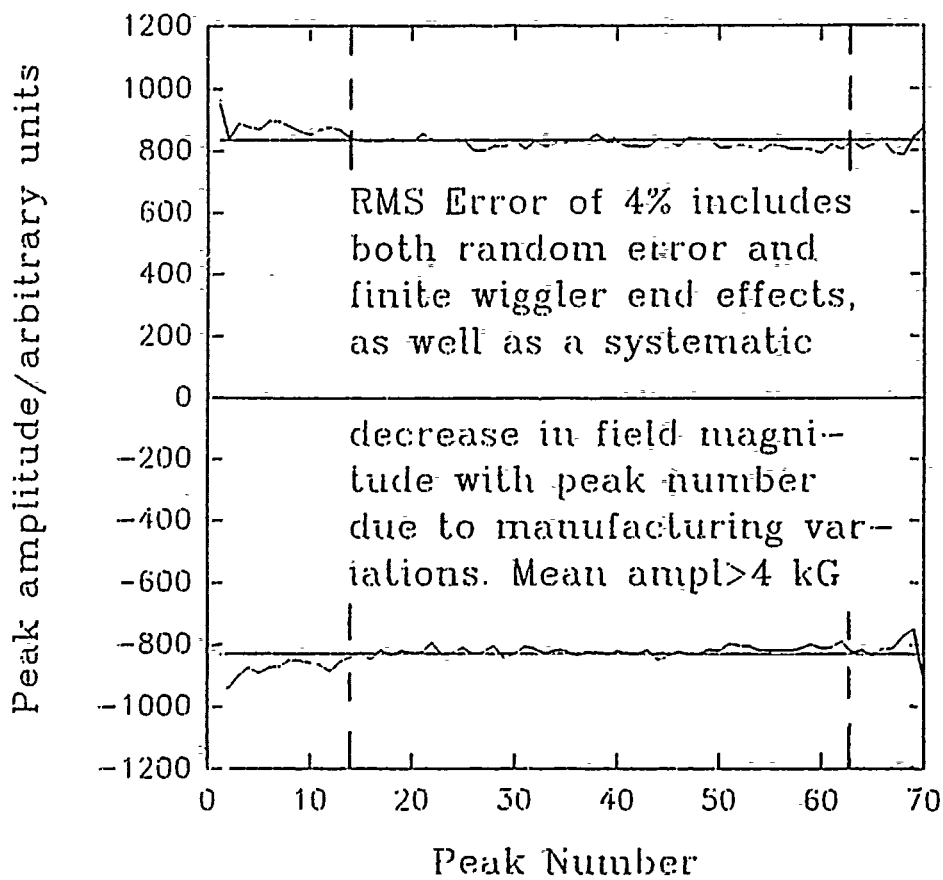


Figure 1



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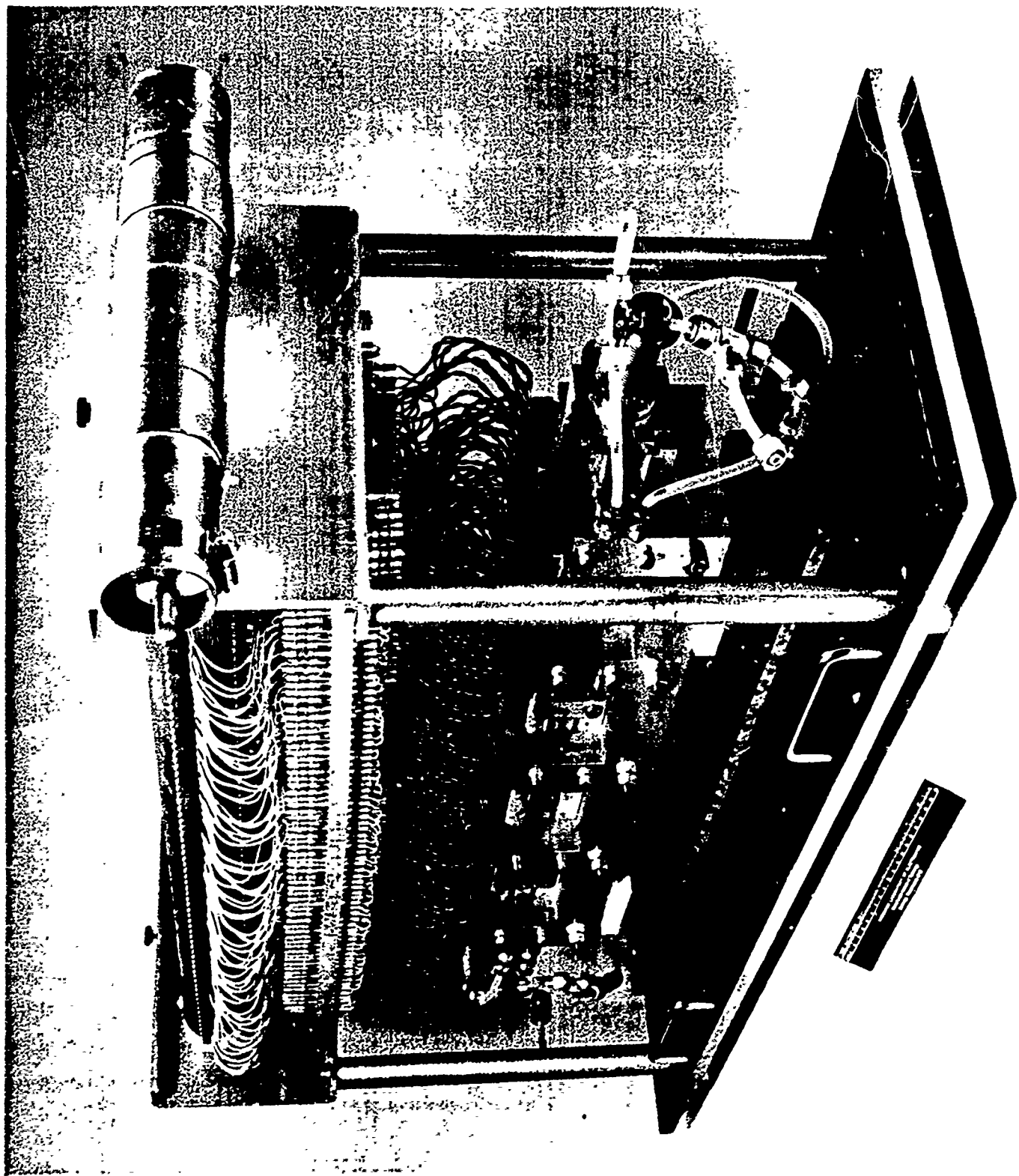


Figure 2. The MIT Microwiggler

Computer Current Control

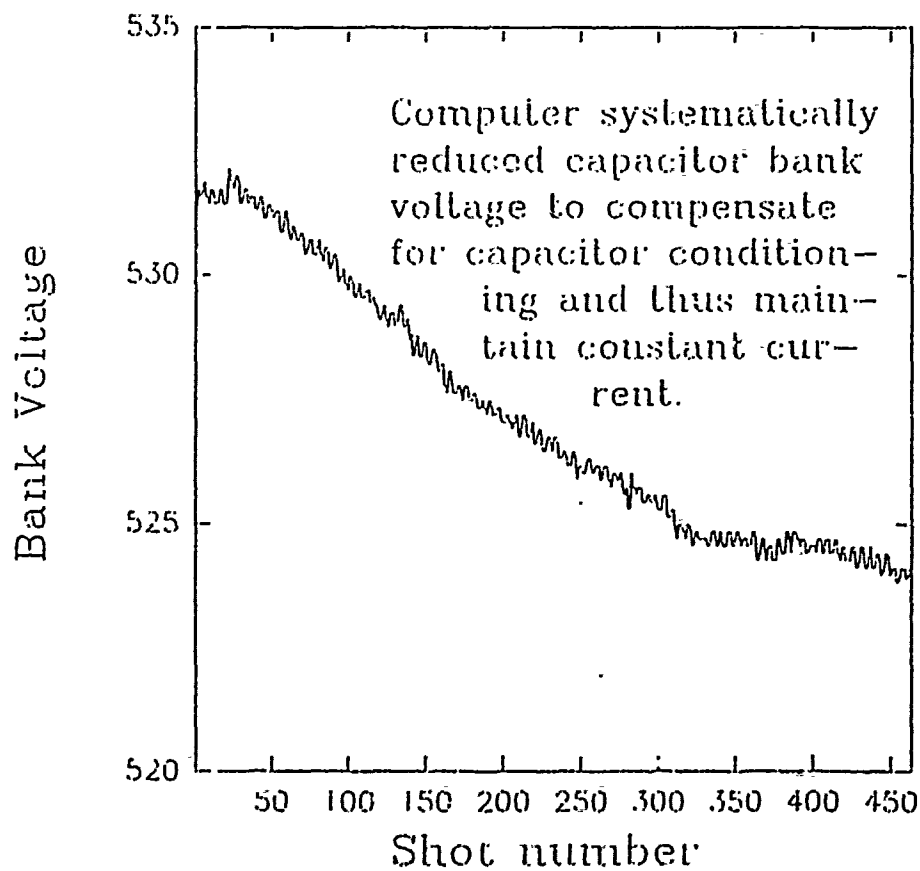
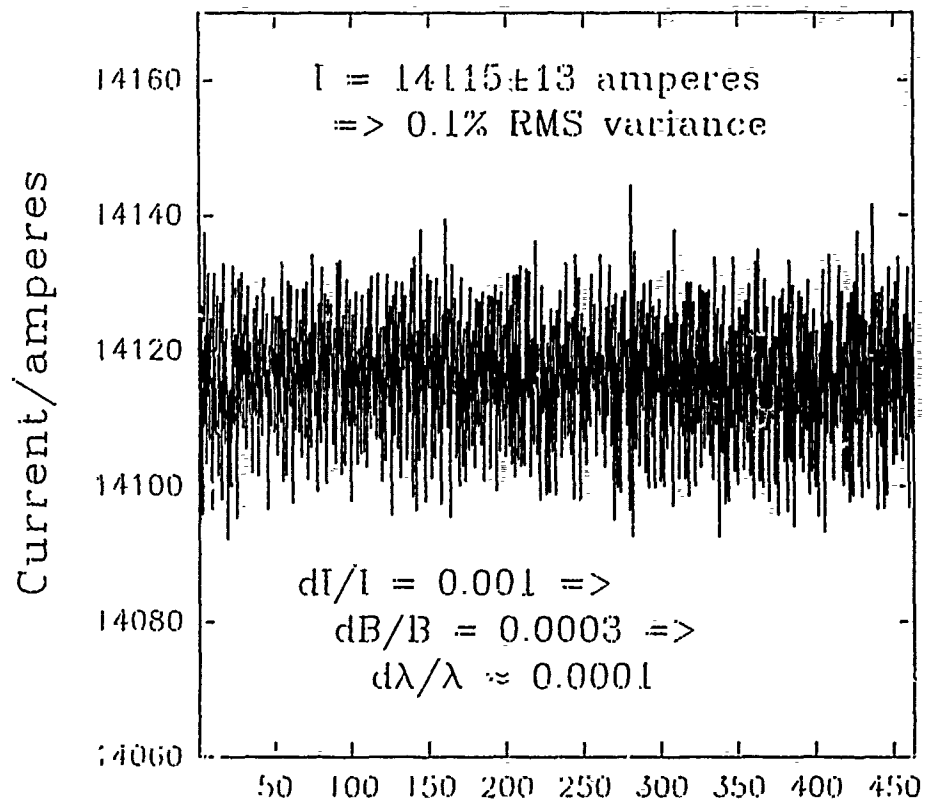


Figure 3

FIR FEL

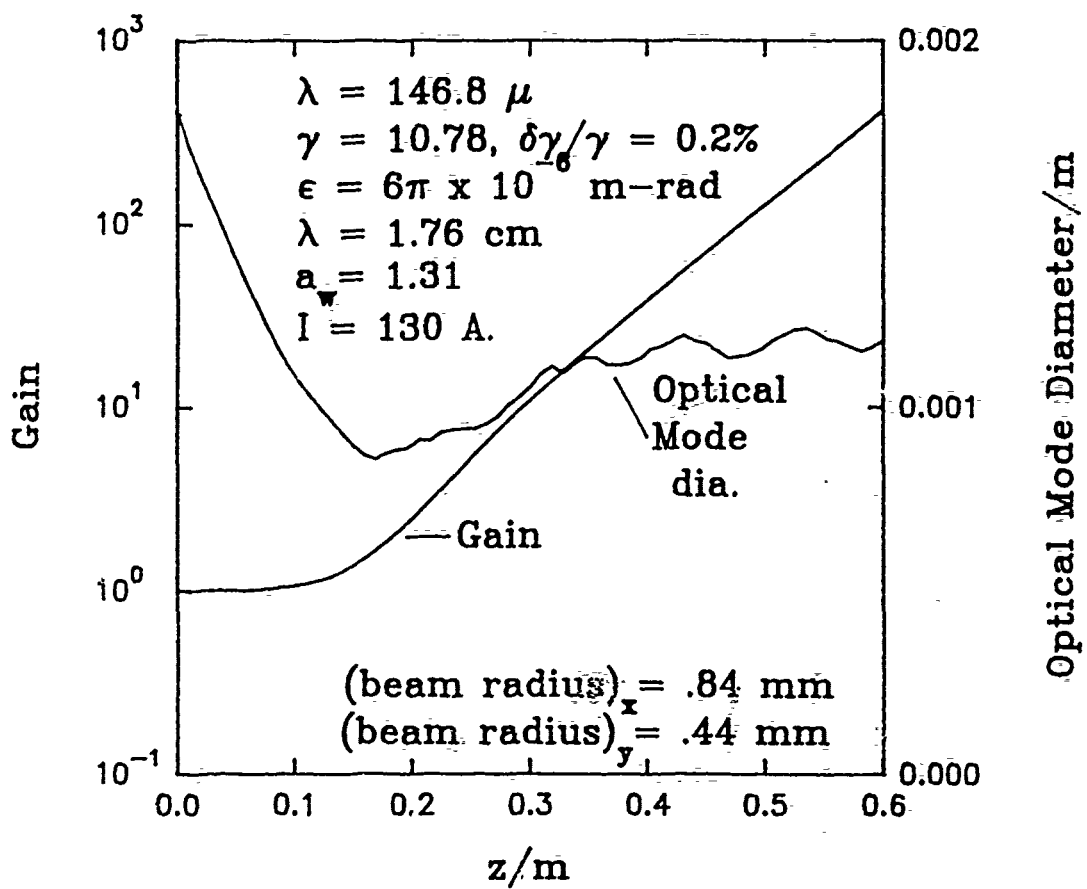


Figure 4

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