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SCALING STUDIES of EFFICIENT RAMAN CONVERTERS.

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SCALING STUDIES OF EFFICIENT RAMAN CONVERTERS

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Contract Number:	N00014-80-C-0442
Principal Investigator(s) and Telephone Number:	Dr. H. Komine and Dr. J. B. West (213) 377-4811
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SCALING STUDIES OF EFFICIENT RAMAN CONVERTERS

DESCRIPTION OF PROGRESS

Small Scale XeF Injection Locking Experiments

Figure 1 shows the experimental layout of the small scale XeF injection locking experiment. Narrow band radiation ($\Delta\lambda \approx 0.1$ Å) at λ = 706 nm is generated by a system of injection-locked dye lasers. A Chromatix CMX-4 with intracavity etalon is used as the master oscillator. Output from the CMX-4 is directed into a Candela Model 625 coaxial dye laser (Slave 1) to achieve narrow band operation at higher energies. A second Candela dye laser (Slave 2) is injection locked by the output from Slave 1. At the present time, narrow-band output from Slave 2 is about 120 mJ.

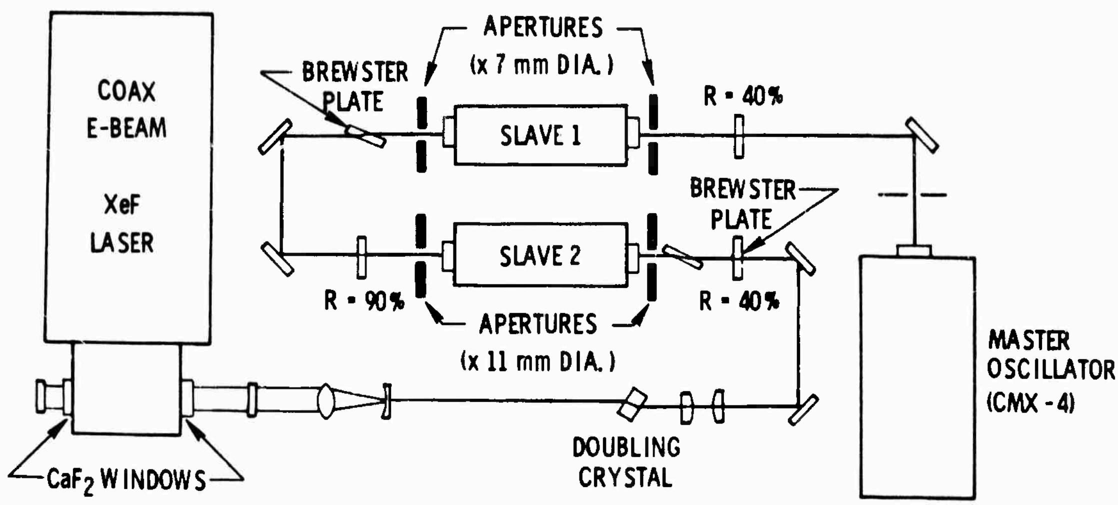

FIGURE 1. XeF INJECTION LOCKING EXPERIMENT

Some difficulties were encountered in operating this dye laser system at 706 nm. In particular, operation of the CMX-4 with oxazine 720 dye was found to be marginal. With the intracavity etalon in place, output energies are between 0.5 and 1 mJ per pulse which, however, is usually sufficient to injection lock Slave 1. Considerable time was spent in optimizing the dye solution in the

CMX-4 to achieve best lasing. After a series of tests, a solution of oxazine 720 (concentration = 7.5×10^{-5} M) and rhodamine 590 (concentration = 5.2×10^{-5} M) in methanol with 10 ml of dimethylformamide was found to give the best results.

Because of higher pump energies and a long gain length, oxazine 720 performs better in the Candela slave lasers. With no apertures in the Slave 2 cavity, 800 mJ have been extracted. However, with the apertures in place to reduce parasitic oscillation, 120 mJ have been extracted. With more effort, this energy should increase, however, it is sufficient to perform the experiments at this time.

Figure 2(a) shows the injection-locked dye laser spectrum, while Figure 2(b) shows the dye laser spectrum in the absence of the CMX-4 injection signal. Note the decrease in the broad, background radiation when injection locking occurs. In Figure 2(b), there is additional, unlocked radiation at shorter wavelengths which is not displayed in the spectral window recorded by the photodiode array. This radiation also decreases when injection locking occurs. Injection-locked radiation from the dye laser chain has been frequency doubled in KDP. The next steps in the program are to match the doubled radiation frequency to that of the XeF laser by finer tuning of CMX-4 and perform the XeF injection locking experiments. The XeF will be operated using a flat-flat resonator with the injection signal introduced through the output coupler. XeF line narrowing will be observed using a 3/4 m spectrograph equipped with a Reticon photodiode array at the focal plane. Initial experiments will be performed on the XeF 0,4 band at 353 nm, however injection locking studies on the 0,2 and 1,3 bands near 351 nm are also planned.

For better performance, the coax e-gun cathode was rebuilt and the Marx generator switches were cleared. Following this rebuilding, the device operates at 20 mJ per pulse. This is achieved using an 85 percent R output coupler and two uncoated CaF_2 windows. Higher output energies are expected when A/R coated CaF_2 windows are received, since this will permit more output coupling. Output from XeF occurs on both the 353 and the 351 nm bands with approximately equal intensity. Typical gas mixtures are 0.5 percent xenon, 0.1 percent NF_3, with neon as the buffer gas at a total pressure of 2 atmospheres.

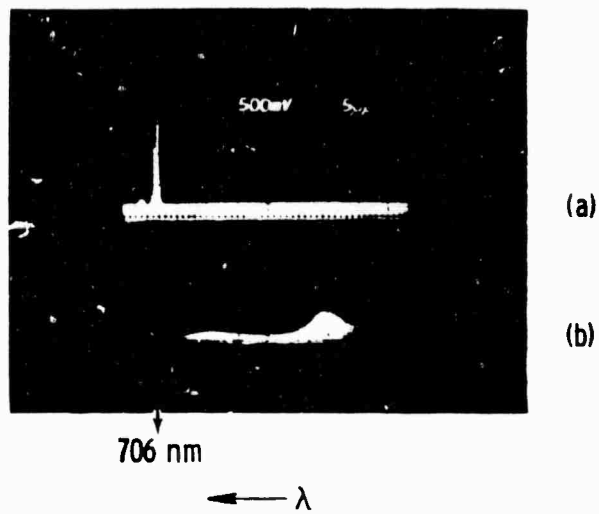

FIGURE 2. (a) INJECTION LOCKED DYE LASER SPECTRUM
(b) FREE RUNNING DYE LASER SPECTRUM

SWAT Laser Modifications

Several modifications have been made to the SWAT laser which will be used in the Raman scaling experiments. A pair of magnetic guide field coils to minimize e-beam pinching and to enhance energy deposition in the laser medium have been added to the device. The coils are retangular in shape and have inner dimensions of 175 cm by 121 cm. They are spaced about 68 cm apart, as shown in Figure 3. The size and spacing of the coils were determined in a large part by physical constraints imposed by the existing SWAT laser device. The size of the e-gun box determined the retangular dimensions of the coils, while the existing laser plenum size placed a constraint on their separation.

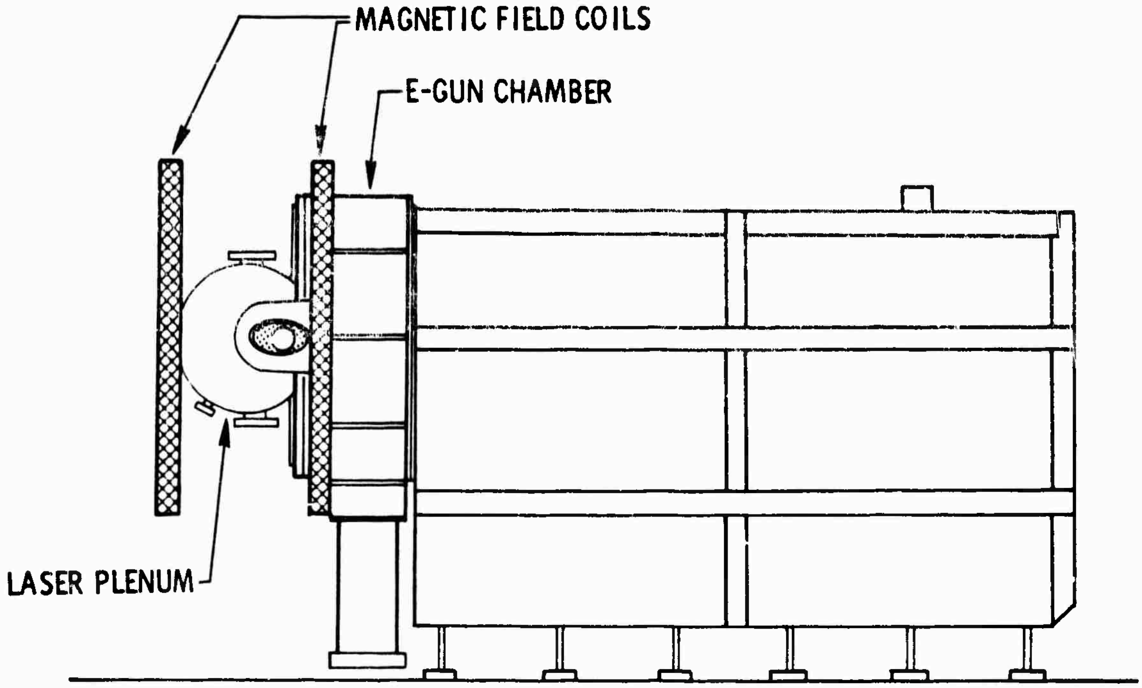

FIGURE 3. SWAT LASER MAGNETIC GUIDE FIELD MODIFICATION

Each coil is composed of 32 turns, with each turn made up of four parallel strands of #4-twin copper wire. Total resistance is about 15 mΩ per coil. The design current is 2000 A. To achieve these currents, two Miller SRS-1500 dc welding power supplies are connected in series. These coils and their power supplies were ordered March 25th, with delivery promised by May 15th for the coils and May 28th for the power supplies. Substantial vendor delivery delays were encountered. The power supplies arrived June 12th and the coils arrived June 19. The coils have now been installed and tested on the machine at full current.

Measurements made with a Hall effect gaussmeter verify code predictions of magnetic field strengths to within a few percent. At the center of the laser chamber, the field strength is about 800 gauss. This increases by about 10 percent at the ends of the e-beam foil window. At an e-beam current density of 10 A/cm^2, the self-generated field is calculated to be about 100 gauss.

The Raman scaling experiments will require near-diffraction limited beam quality as well as polarized output from the SWAT laser. In the past, the device has operated with internal optics and a flat-flat resonator configuration. To achieve the required beam quality, Brewster angle window holders and mounting platforms for external optics have been fabricated and installed. The external optic mountings will hold either the flat optics to be used in perliminary resonator characterization studies, or the unstable resonator optics.

An extracted volume of 10 liters will be realized with the current configuration. The device will be operated at room temperature with a total gas pressure of 3 atm. Based on extraction efficiencies that have been demonstrated with XeF, an energy on the order of 25 joules should be realized in a 1 μs pulse.

At the present time, the SWAT laser facility is fully operational. This includes the electron gun, magnetic guide field coils, vacuum systems, laser plenum, gas handling systems, laser optical mountings, and laser diagnostics. XeF laser tests are in progress.

Figure 4 shows the program schedule with modifications based on the 21 March start date of the contract. The only activity between 21 March and 1 April was the placement of purchase orders for equipment with long delivery times. Thus, April is the first month shown on the schedule.

- Because of the unanticipated difficulties in operating the dye lasers at 706 nm with oxazine 720, the small-scale XeF injection locking experiments will run through August.

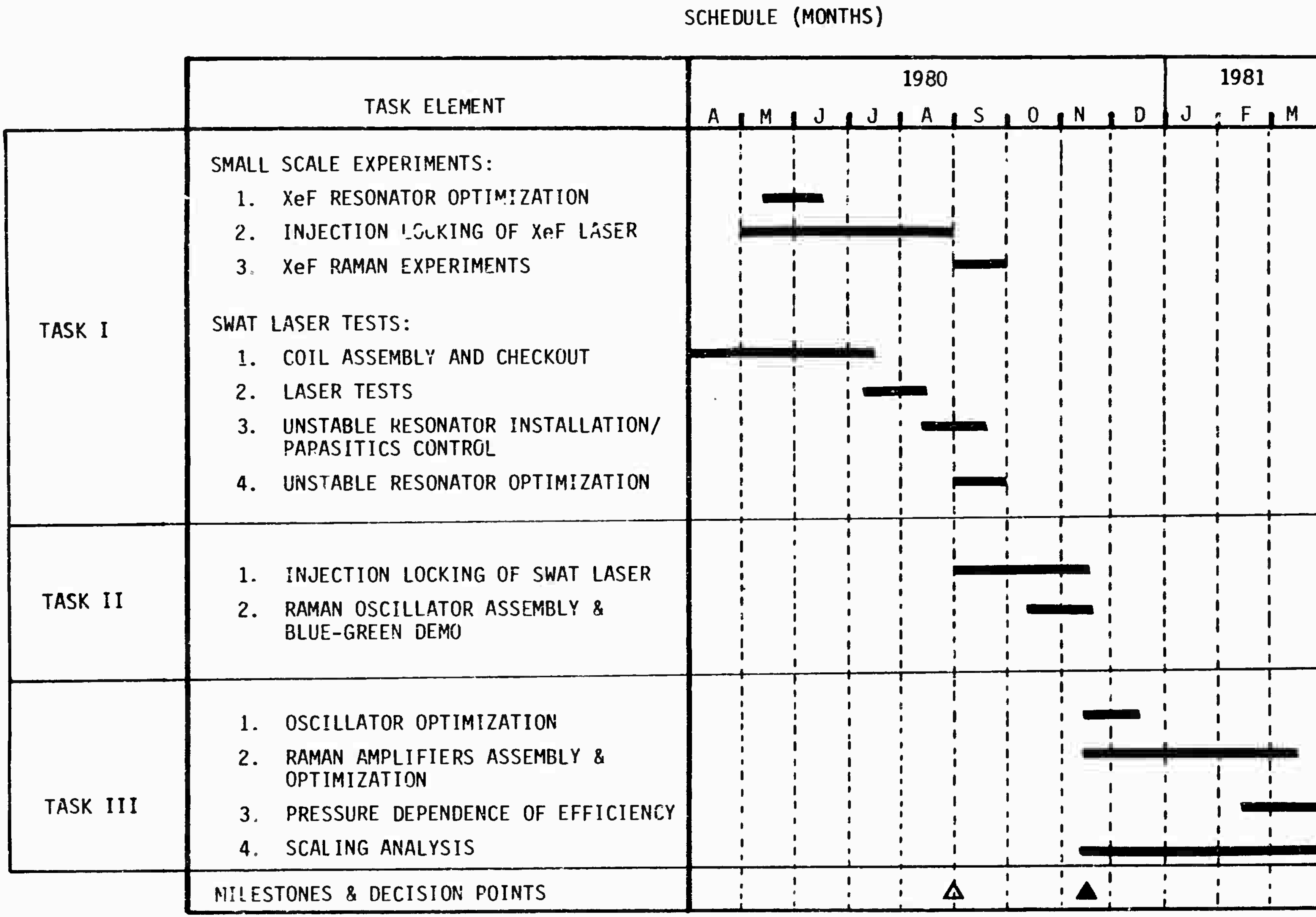

FIGURE 4. SCALING STUDIES OF EFFICIENT RAMAN CONVERTERS - PROGRAM SCHEDULE

- The small scale XeF Raman shifting experiments are now scheduled to be performed in September using a newly constructed **facility.** This facility consists of a Lambda-Physik excimer laser which amplifies narrow-band uv radiation produced by a frequency doubled dye laser. It is the same facility which has been used to perform XeCl Raman shifting experiments under an ONR - sponsored contract. Because of the rep-rate capabilities of these lasers and the high beam **qualities** which are achieved, this facility is better suited to perform the XeF Raman experiments than the coax laser which was originally proposed.

- Because of the vendor delays in delivery of the magnetic field coils and their power supplies, the SWAT laser tests and unstable resonator experiments will run longer than originally planned.

CHANGE IN KEY PERSONNEL:

Drs. J. B. West and H. Komine replaced Dr. E. A. Stappaerts as principal investigator.

SUMMARY OF SUBSTANTIVE INFORMATION DERIVED FROM SPECIAL EVENTS:

The attendance by Dr. J. B. West at the recent DARPA XeF laser review meeting provided valuable information. In particular, the discussions on e-gun cathodes and behavior of e-beams in magnetic guide fields will be beneficial for the performance of this contract.

PROBLEMS ENCOUNTERED:

Dye laser operation at 706 nm for XeF injection locking source and vendor delivery delays. See detailed discussion under Description of Progress.

ACTION REQUIRED BY GOVERNMENT:

None

FISCAL STATUS:

<u>Amount Currently Provided on Contract</u>	$299,998
<u>Expenditures and Commitments to date</u>	$136,004
<u>Funds Required to Complete Work</u>	$423,953