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Diode Injection - Seeded, 940 nanometer(nm), Titanium - Sapphire Laser for H_2O DIAL, (Differential Absorption Lidar), Measurements

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Differential absorption of laser radiation by various molecular species represents both a selective and a sensitive method of measuring specific atmospheric constituents[1]. DIAL measurements can be carried out via two different means. Both involve using two laser pulses with slightly different wavelengths(λ), (one λ at a strong absorption line of the molecule of interest, the other detuned into the wing of the line), and comparing the attenuation of the pulses. One approach relies on scattering of the radiation from some conveniently located topographical target. In the other technique elastic scattering from atmospheric aerosols and particulates is used to return the radiation to the lidar receiver system. This case is refered to as the differential absorption and scattering technique, and is the technique we are interested in to measure water vapor at 940nm. The 940nm wavelength is extremely desirable to atmospheric scientist interested in accurate DIAL measurements of H_2O in the upper and lower troposphere. This is illustrated in figures 1 - 3 which show simulated measurements using ~940nm and 815nm lasers at a range of altitudes and experimental conditions. By offering access to larger absorption cross - sections, injected seeded, 940nm DIAL laser transmitters would allow for more accurate water profile measurements at altitudes from 6 to 16km than is currently possible with 730nm and 815nm DIAL laser transmitters[2].

We have demonstrated the operation of an injected seeded titanium - sapphire (TS) laser operating at ~940nm with an energy of more than 90mJ per pulse. The TS laser is pumped by a commercial, 600mJ, 532nm, 10Hz Nd:YAG laser. Figure 4 shows the slope efficiency of the laser using a flat 50% R output coupler and a 10m end - mirror. The laser was injected seeded with a cw, AlGaAs, semiconductor diode laser which had an output of

83mW. The cw diode seed beam was introduced into the TS laser cavity through a HR end - mirror. When the diode beam is aligned to the TS resonator, it controls the TS laser output wavelength and its spectral line width with the required resolution for DIAL applications. This work supports the need for the development of 940nm, titanium - sapphire DIAL transmitters[3].

References

1. Earl J. McCartney, Optics of the Atmosphere, John Wiley & Sons (1976)

2. Philip Brockman, Clayton H. Bair, James C. Barnes, Robert V. Hess, and Edward V. Browell, Optics Lett. 11, no. 11 (1986) 712

3. Glenn A. Rines, James Harrison, and Peter F. Moulton, NASA Contractor Report, LaRC November 1990

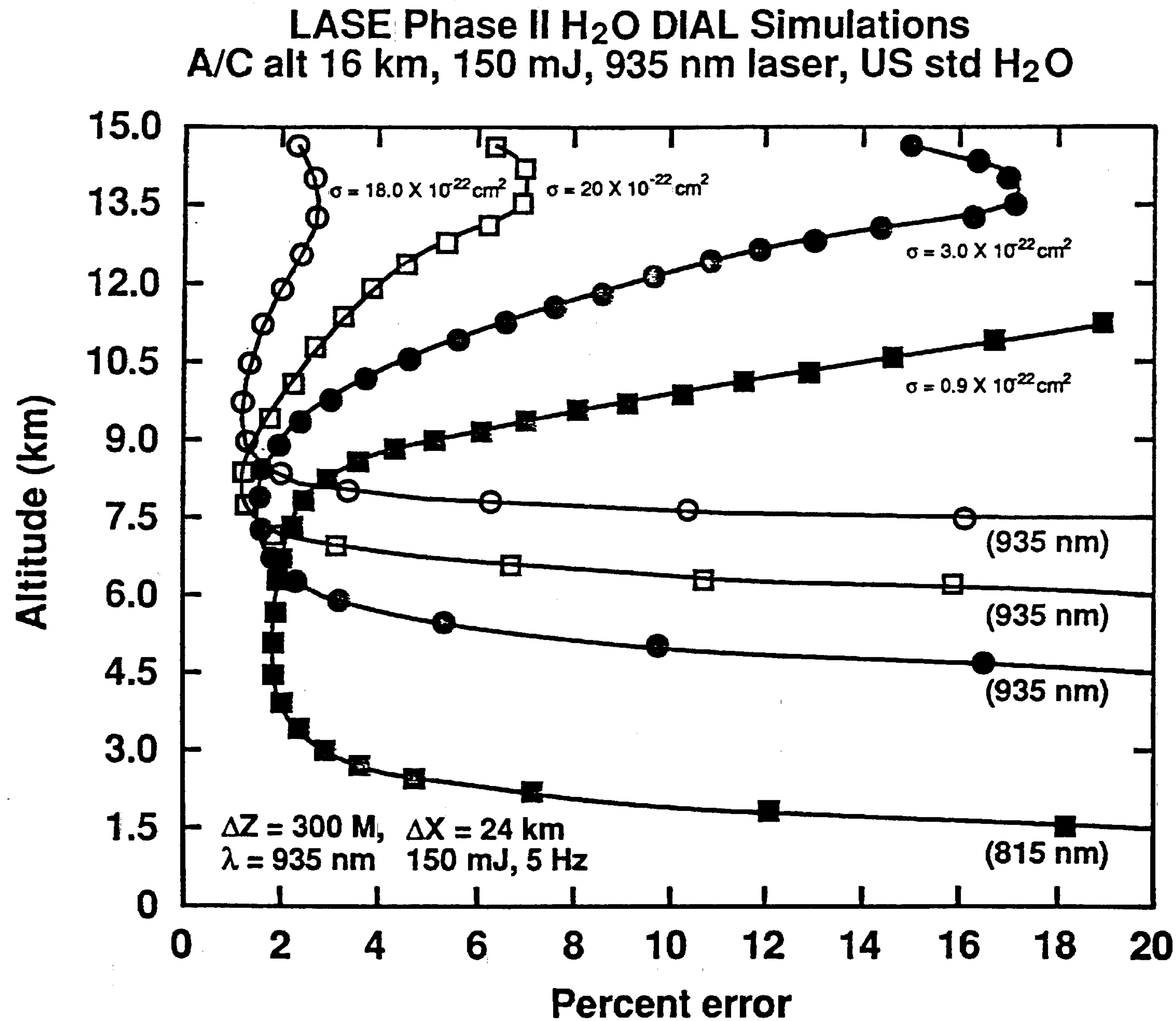

Figure 1. Aircraft altitude is 16 km; Laser energy is 150 mJ @ 935 nm. $\sigma = 0.9 \times 10^{-22}$ cm^2 is the maximum cross-section available in the 730 and 815 nm regions.

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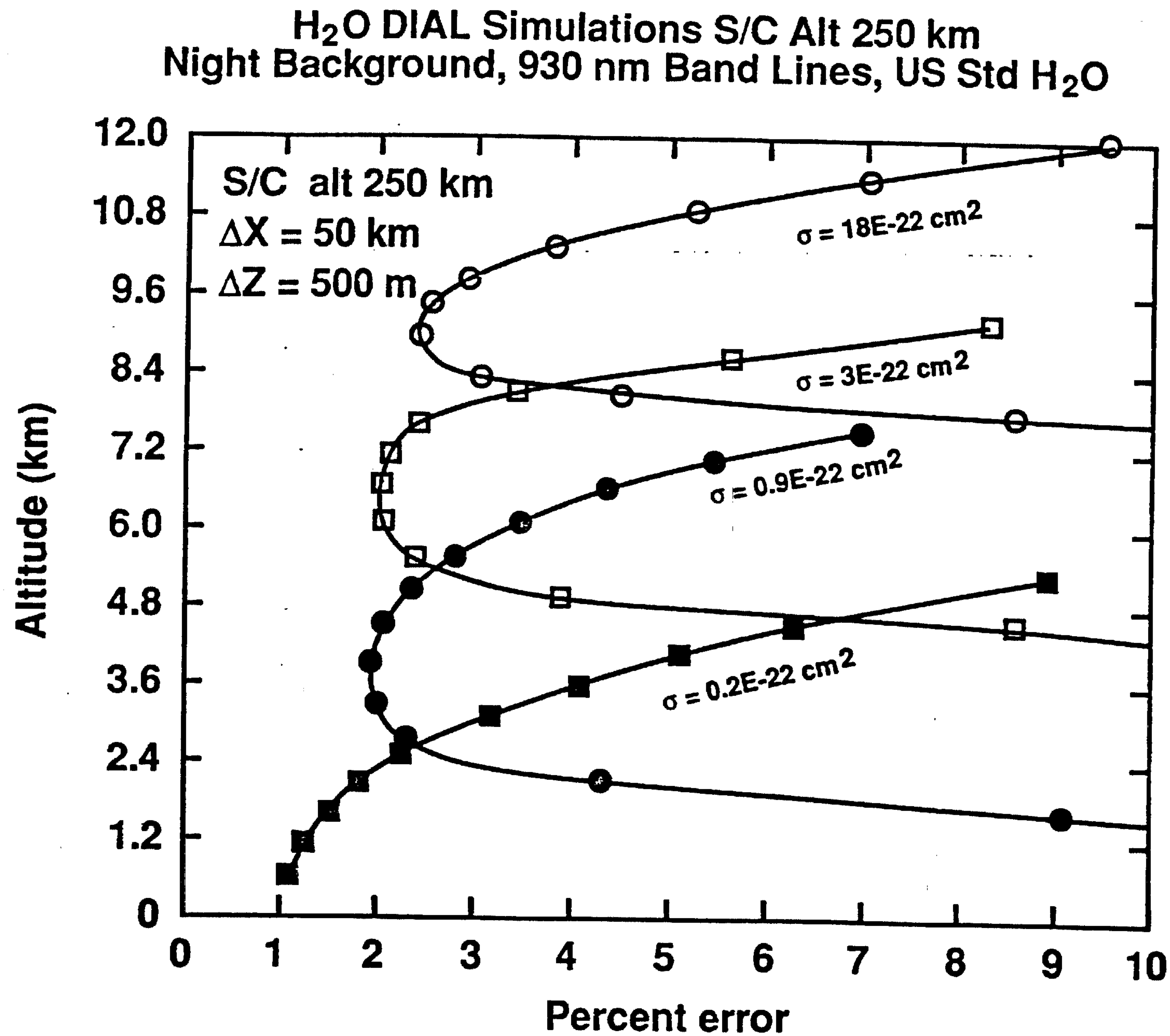

Figure 2. Spacecraftcraft altitude is 250 km; Laser energy is 0.5 J @ 935 nm. $\sigma = 0.9 \times 10^{-22}$ cm^2 is the maximum cross-section available in the 730 and 815 nm regions.

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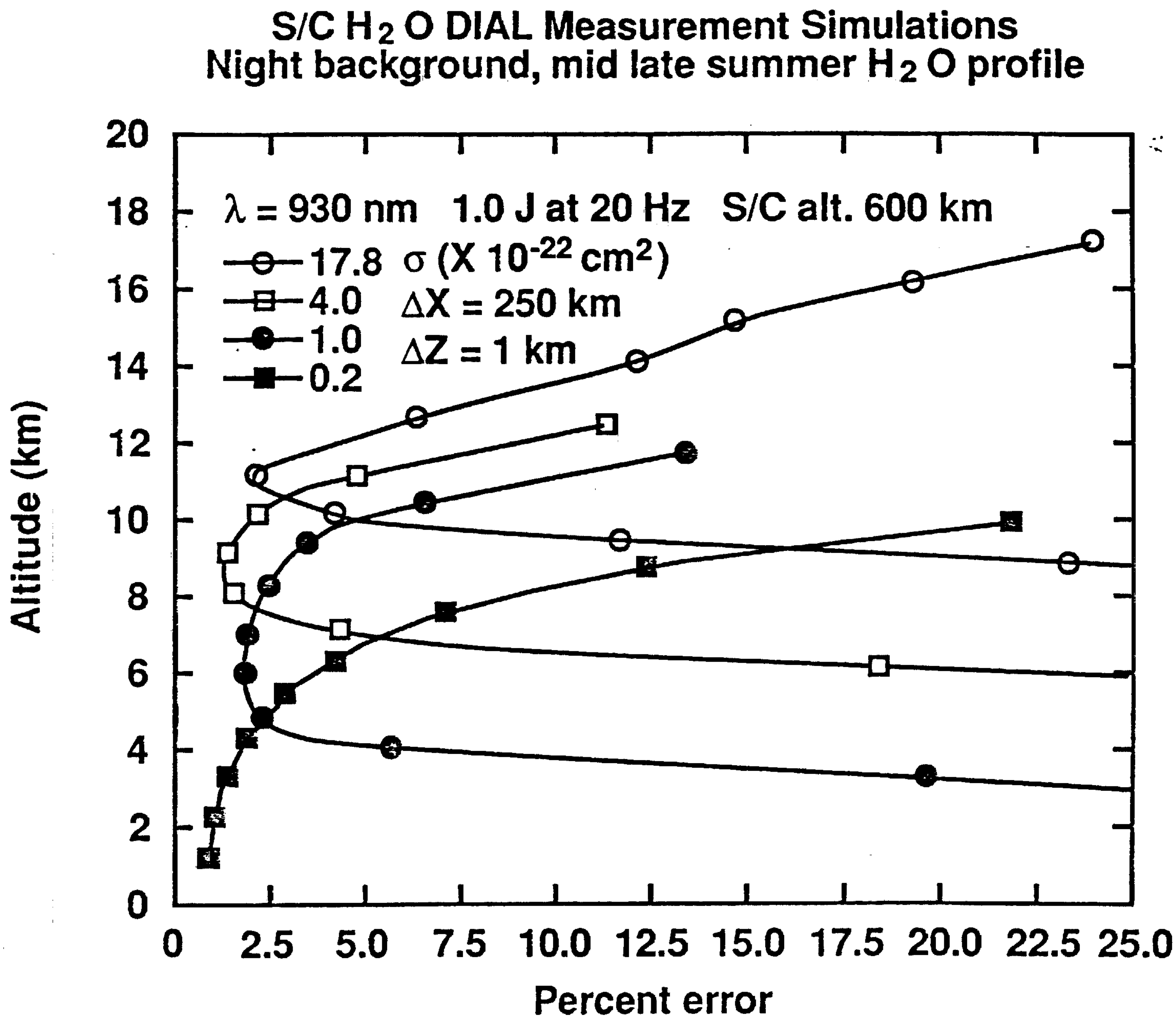

Figure 3. Spacecraft altitude is 600 km; Telescope is 1.25 m. $\sigma = 1.0 \times 10^{-22} cm^2$ is the maximum available cross-section in the 730 and 815 nm regions.

jcb 251

940nm Titanium-Sapphire Laser Demonstration

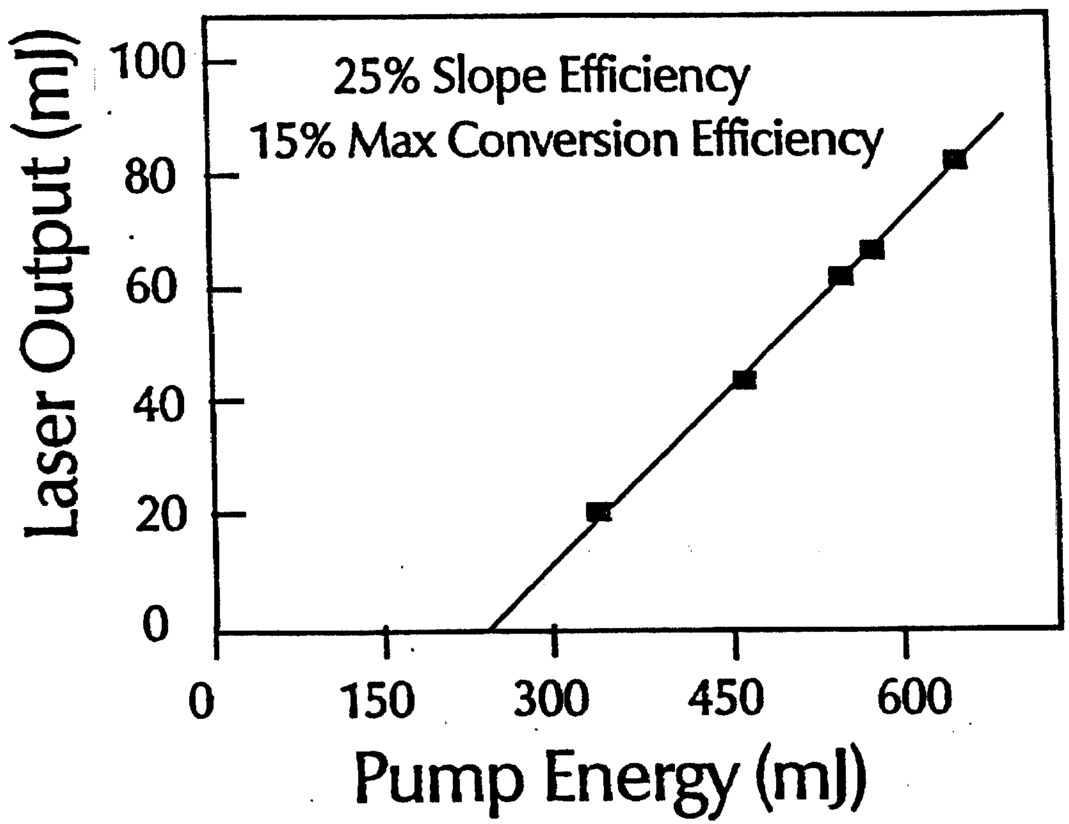

Figure 4. 532 nm pump energy in vs. Ti:Sapphire energy out.