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1998

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Citation for published version (APA):

Svanberg, S. (1998). *Applications of Laser Spectroscopy*. (Lund Reports in Atomic Physics; Vol. LRAP-234). Atomic Physics, Department of Physics, Lund University.

Total number of authors:

1

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Applications of Laser Spectroscopy

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Introduction

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During recent years, laser sources have become more rugged, easy-to-use and cheaper to allow real world applications of laser spectroscopy. Semiconductor diode lasers have become very reliable and easily accessible, and their wavelength range is extended higher and higher up into the visible region. We can mention the emerging blue diode lasers based on gallium nitride, and frequency conversion of the output of reliable, high-power diode lasers into new wavelength regions using quasi-phase-matching in periodically-poled non-linear crystals. New laser materials, such as titanium-doped sapphire, allow all-solid-state tuneable systems with considerable power to be constructed. Diode-laser pumping of solid-state materials is making flash-lamp pumping gradually obsolete and enable compact, reliable and energy-efficient laser sources.

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Applications of laser spectroscopy constitute a vast field, which is difficult to cover comprehensively in a review. Rather than attempting such a review, examples from a variety of fields are chosen to illustrate the power of applied laser spectroscopy.

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Spectroscopy in strongly scattering media can also be used in non-medical applications, such as studies of light propagation in green leaves (photosynthesis) or sheets of paper (quality assessment through information of fibres etc.).

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Laser spectroscopy is finding many real-world applications. The many powerful methods allow advanced sensing, both locally and remotely. Of great importance in the process of taking the technology into everyday applications is the fast development of cheap and reliable laser sources, fibre-optical components and computers.

Acknowledgements

The author would like to thank a large number of colleagues and graduate students for a most fruitful collaboration through the years, and many Research Councils and Foundations for generous support.

Further reading

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A.C. Eckbreth, *Laser Diagnostics for Flame Temperature and Species*, Abacus Press, Turnbridge Wells, 1987.

M. Sigrist (ed.), *Air Monitoring by Spectroscopic Techniques*, Wiley, New York, 1994.

S. Svanberg, New Developments in Laser Medicine, *Phys. Scr.* T72, 69 (1997).

Figure Captions

Figure 1. Concentration map of atomic mercury close to one of the cooling towers at the largest geothermal plant in Europe (Larderello, Tuscany). Point monitor data obtained using gold amalgamation followed by atomic absorption measurement are included in the figure. (H. Edner et al., *J. Geophys. Res.* **97**, 3779 (1992))

Figure 2. The volcanic plume of Mt Etna recorded by laser radar techniques in an August 1997 ship-borne traverse under the plume. Integrated vertical and horizontal profiles of sulphur dioxide are also shown. The total flux was about 44 tonnes/hour (P. Weibring et al., *Appl. Phys. B*, in press)

Figure 3. The Italian research vessel *Urania* and the Swedish lidar system just hoisted off its rear deck in the port of Bari (Italy).

Figure 4. Fluorescence imaging of the Northern Gate of the Lund Cathedral. Images (8x8 m²) were recorded through passbands centred at 438 and 682 nm using a scanning laser radar system positioned about 50 meters from the gate. A normal colour photograph of the gate is also included.

Figure 5. Imaging fluorescence tumour diagnostics. Pixels, fulfilling a "cancer criterion" in fluorescence are shown in false colour superimposed on a normal colour video representation of the area. Left: basal cell carcinoma (note the non-cancerous brown spot, which is a benign naevus) Right: Tumour on the vocal cord. ALA had been administered to the patients a few hours before the investigation (K. Svanberg et al., *Acta Radiologica* **39**, 2 (1998))

Figure 6. Difference in backscattering signals from sarcoma and normal breast tissue. A pulsed diode laser operating around 800 nm was used in conjunction with a time-resolving photon counting system. (Courtesy: C. af Klinteberg and O. Jarlman).

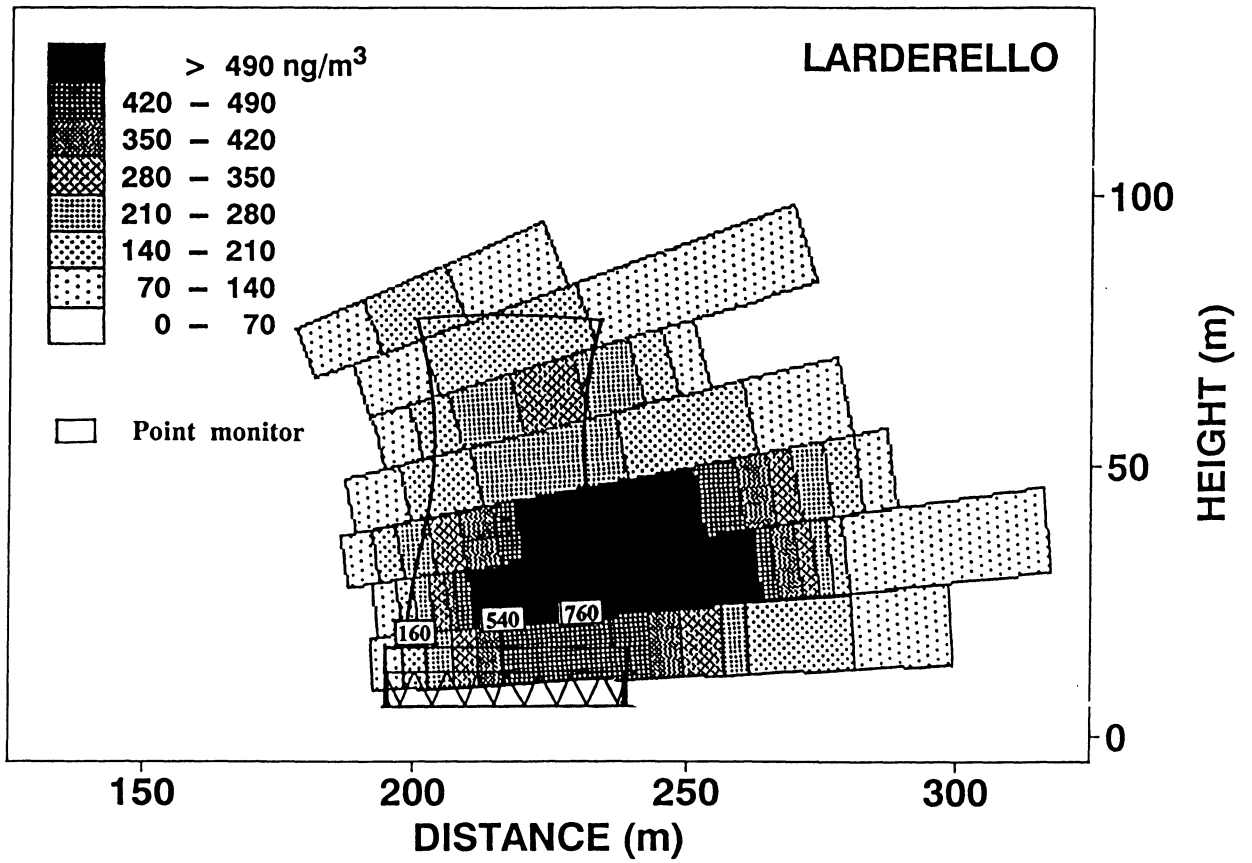


Figure 1.

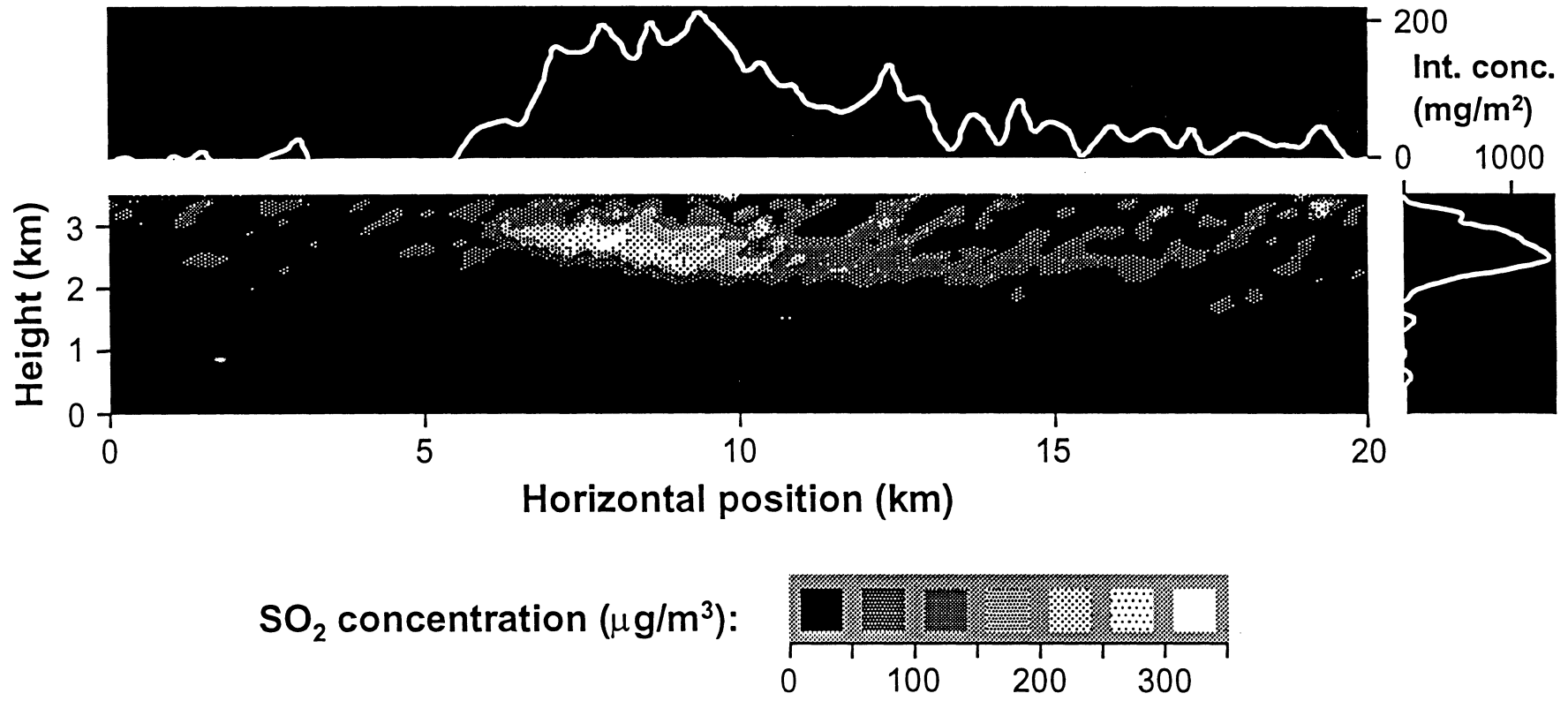


Figure 2.



Figure 3.



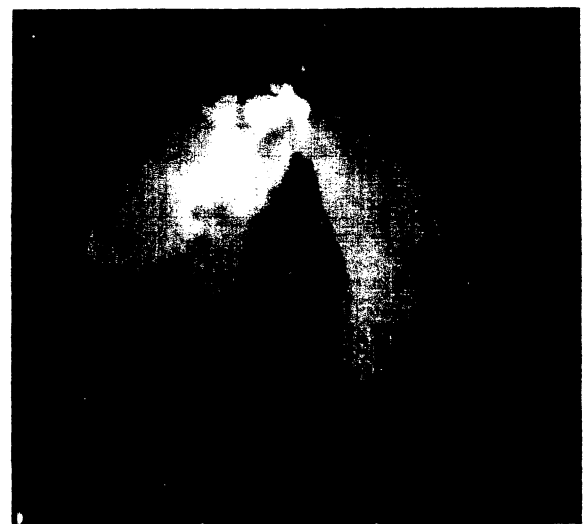
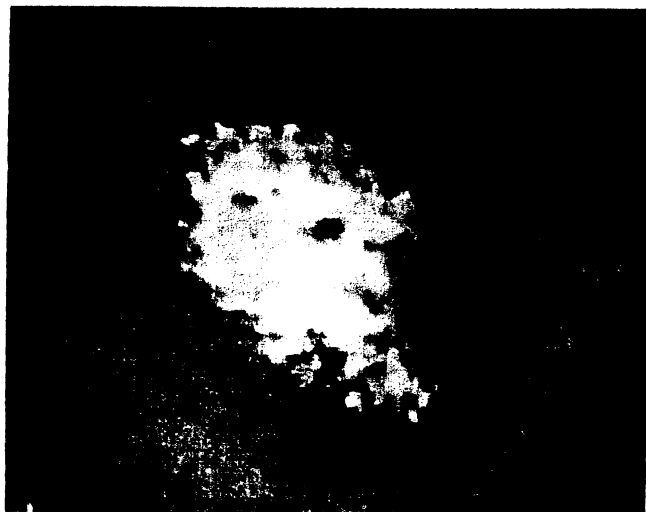
Figure 4.

Fluorescence Imaging Following ALA Administration

Basalioma + Naevus



Vocal Cords



Time-resolved diffuse back-scattering

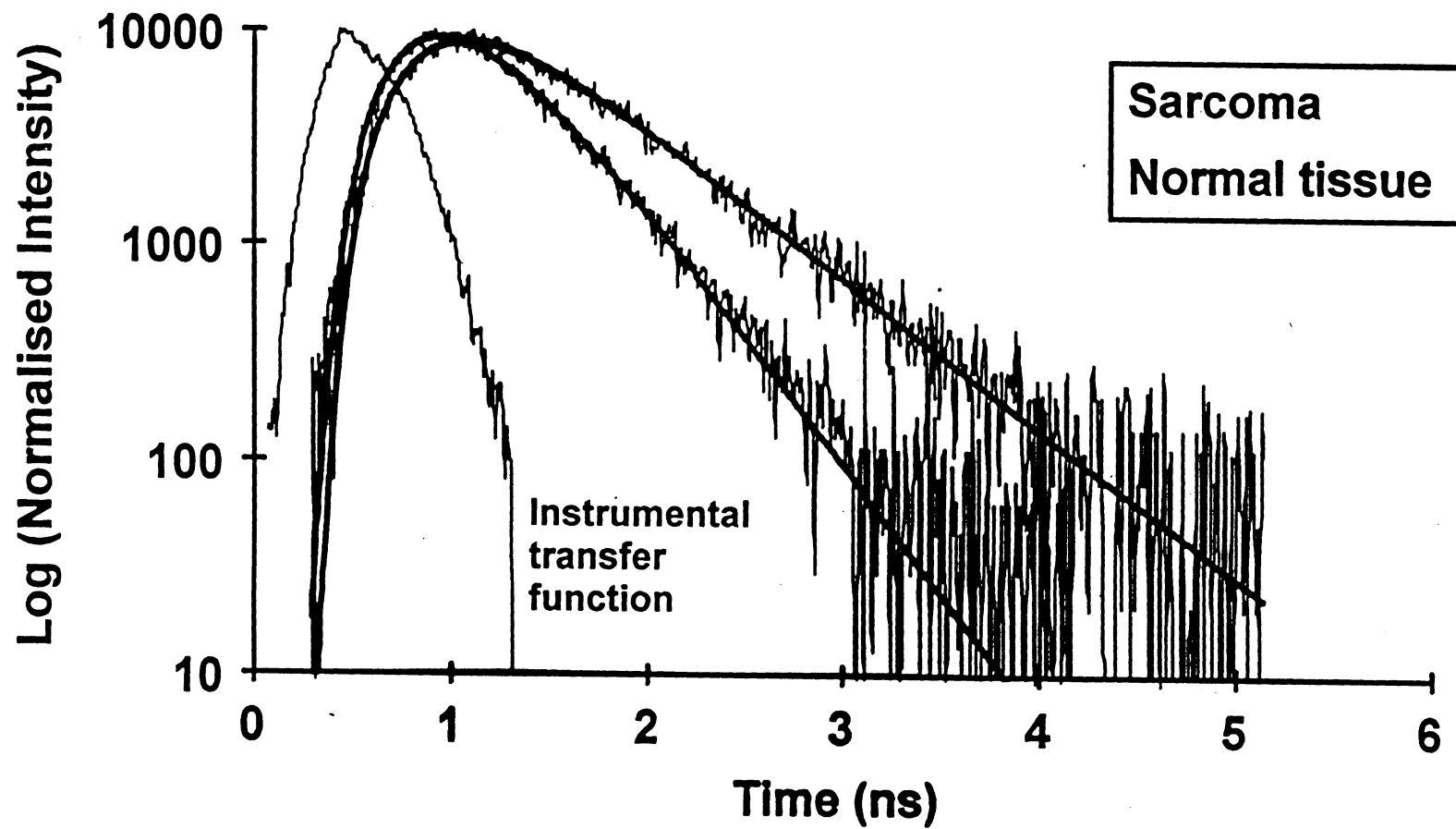


Figure 4

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S. Svanberg, New Developments in Laser Medicine, Phys. Scr. T72, 69 (1997).

Figure Captions

Figure 1. Concentration map of atomic mercury close to one of the cooling towers at the largest geothermal plant in Europe (Larderello, Tuscany). Point monitor data obtained using gold amalgamation followed by atomic absorption measurement are included in the figure. (H. Edner et al., J. Geophys. Res. **97**, 3779 (1992))

Figure 2. The volcanic plume of Mt Etna recorded by laser radar techniques in an August 1997 ship-borne traverse under the plume. Integrated vertical and horizontal profiles of sulphur dioxide are also shown. The total flux was about 44 tonnes/hour (P. Weibring et al., Appl. Phys. B, in press)

Figure 3. The Italian research vessel *Urania* and the Swedish lidar system just hoisted off its rear deck in the port of Bari (Italy).

Figure 4. Fluorescence imaging of the Northern Gate of the Lund Cathedral. Images (8x8 m²) were recorded through passbands centred at 438 and 682 nm using a scanning laser radar system positioned about 50 meters from the gate. A normal colour photograph of the gate is also included.

Figure 5. Imaging fluorescence tumour diagnostics. Pixels, fulfilling a "cancer criterion" in fluorescence are shown in false colour superimposed on a normal colour video representation of the area. Left: basal cell carcinoma (note the non-cancerous brown spot, which is a benign naevus) Right: Tumour on the vocal cord. ALA had been administered to the patients a few hours before the investigation (K. Svanberg et al., Acta Radiologica **39**, 2 (1998))

Figure 6. Difference in backscattering signals from sarcoma and normal breast tissue. A pulsed diode laser operating around 800 nm was used in conjunction with a time-resolving photon counting system. (Courtesy: C. af Klinteberg and O. Jarlman).

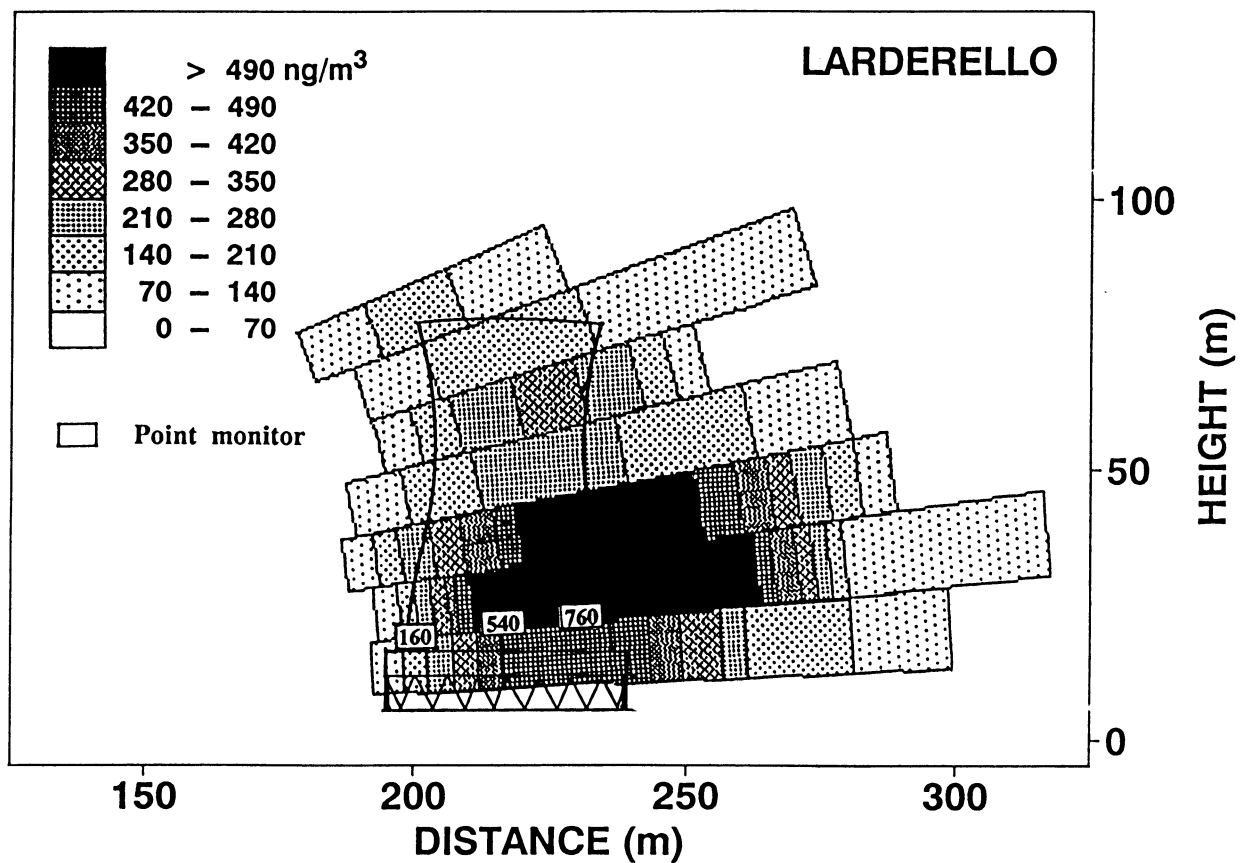
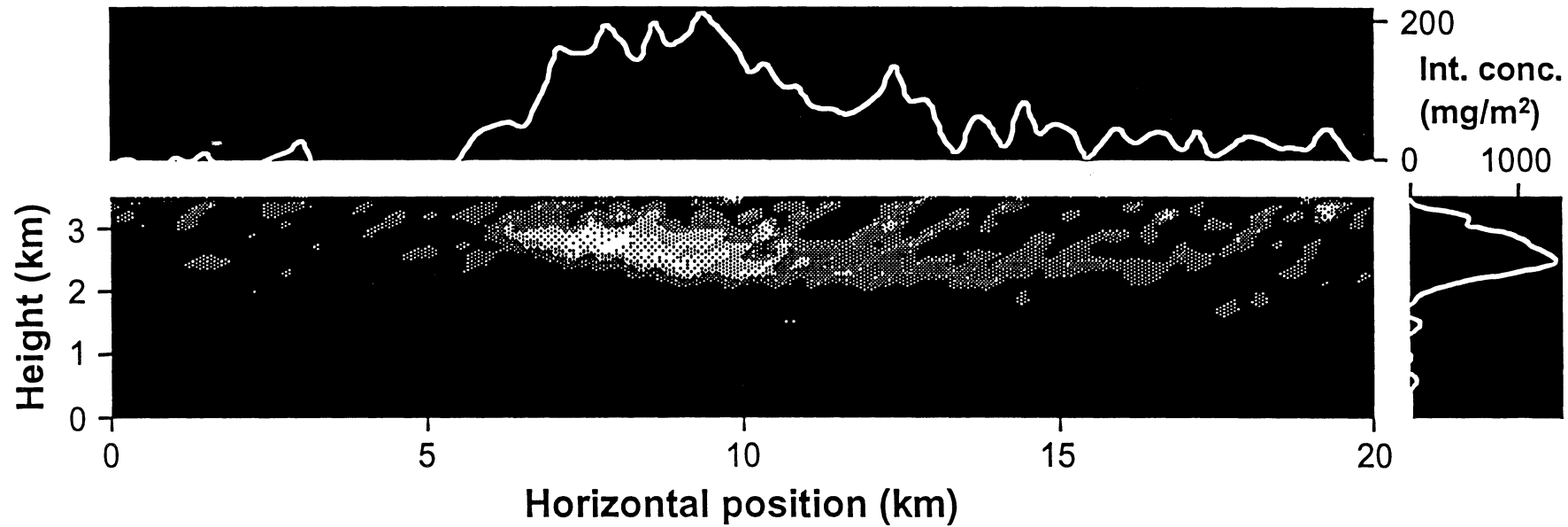


Figure 1.



SO₂ concentration (µg/m³):

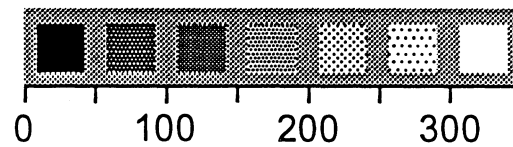


Figure 2.



Figure 3.



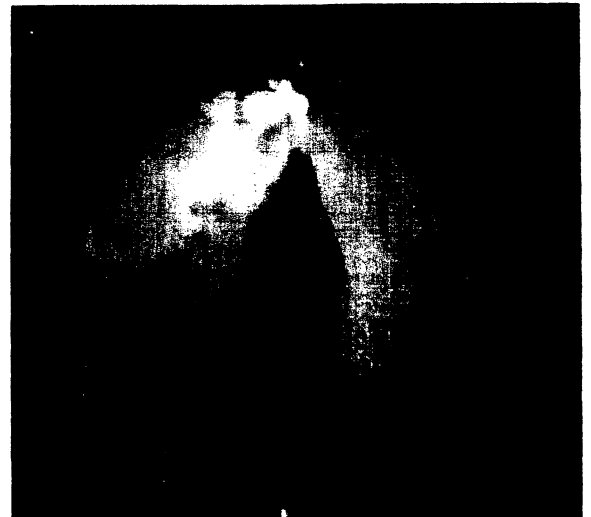
Figure 4.

Fluorescence Imaging Following ALA Administration

Basalioma + Naevus



Vocal Cords



Time-resolved diffuse back-scattering

