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Daytime Stratospheric Ozone DIAL System for the ALOMAR Observatory

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The ALOMAR Observatory currently being constructed near Andoya, Norway (69°17' N, 16°01'E) is specifically designed to house a number of state-of-the-art lidar systems. These lidar systems will monitor the state of the stratosphere in this important polar region. Lidar systems are being built by organizations in a number of countries. These include a Rayleigh/Mie/Raman lidar, a sodium lidar and an ozone DIAL system. Optech has been chosen to construct the stratospheric ozone DIAL system.

The ozone DIAL system is the third similar system built by Optech, and the basic components of stratospheric lidar systems are generally well-known. This system however has sufficient new features to merit this poster paper. The system is being designed to operate in daylight conditions. This requires the use of a line-narrowed transmitter and ultra-narrow spectral filtering in the receiver. In addition, the system is being designed to operate with a 0.5 m diameter telescope with allowance for a future upgrade to a 1-m diameter telescope. The impact of these requirements on the system design provide the main topic for this paper.

A system block diagram is shown in Figure 1. A Lambda Physik line-narrowed XeCl excimer laser (LPX 150T) provides a nominal 175 mJ output pulse energy at a rate of 200 Hz. The spectral line width of the laser output is < 3 pm at a wavelength of 308 nm. The full output of the excimer laser is focussed into a 2 m long hydrogen Raman cell. The Raman cell is pressurized to approximately 50 psig providing an energy conversion to a first Stokes line at 353 nm of about 10%. Thus emerging from the Raman cell are collinear beams of about 150 mJ at 308 nm and about 15 mJ at 353 nm. We deliberately preserve a relatively large amount of energy in the 308 nm wavelength since this is the absorbed wavelength and this large initial energy becomes depleted to very low levels once the laser pulses reach altitudes of 40 km. Colinearity of the two beams is very important, especially, in the daytime system. This allows improvement in the overall system performance by allowing the reduction of the receiver FOV to minimize solar background contributions to the return signals. By passing the full excimer output through the Raman cell, we ensure a high degree of colinearity.

The receiver design is based on f/4 0.5 m diameter Newtonian telescope supplied to us by the Norwegian Space Centre. The receiver's secondary optics module provides a spectral separation and filtering of the "ON" and "OFF" radiation and relays the light collected by the telescope to the system detectors. The secondary optics module is designed to accommodate both the current 0.5 m telescope and a future system upgrade to a 1 m diameter instrument. In designing the secondary optics, we thus have to carefully consider the impact of the telescope upgrade on the functionality of each secondary optics component. This includes the field of view control and spectral filtering optics.

An optical schematic of the receiver secondary optics is shown in Figure 2. The entire optical design of this part of the system is driven by the input requirements of the Fabry Perot filters. These devices, provide the fine spectral resolution required to select the wavelengths of the collected laser radiation from the broad spectrum solar background. In our design we use a set of two Fabry-Perot etalons with a blocking narrowband interference filter for each spectral channel to accomplish the overall spectral bandwidth of 0.3 **Å**. The specifications of the Fabry-Perot etalons and the narrowband interference filters are shown in Table 1.

	Air Spaced Etalon	Solid Spaced Etalon	Interference Filter
Clear Aperture (mm)	30	30	27
Diameter (mm)	76	76	30
Bandwidth (**Å**)	~1.2	~0.3	20
Finesse	~40	~6	N/A
Transmittance (%)	>65	>65	>45

Table 1: ALOMAR Ozone DIAL Receiver Spectral Characteristics.

One of the features of the described DIAL system is an opto-mechanical chopper installed at the focal plane of the receiver telescope. The function of the chopper is to block low altitude backscattering from entering the system secondary optics module. This is required to minimize the effect of the high intensity, low altitude signals on the system detectors which operate in the photon counting mode. The photon counter used for the ALOMAR DIAL system was developed at Optech Inc. specifically for lidar applications. Some of the features of this state-of-the-art device are listed in Table 2.

Maximum Count Frequency (MHz)	700
Number of Input Channels	2
Maximum Number of Range Bins	4000/channel
Minimum Range Bin Duration	200 ns (30 m)
Dead Time Between Range Bins	Zero
Size	Full-size PC AT bus card

Table 2: Specifications of ALOMAR Ozone DIAL Photon Counter Board.

The described DIAL system is designed to measure atmospheric ozone concentration profiles at daytime and at nighttime conditions from 10 km to 40 km altitude. The performance of the system was modeled and then its expected performance analyzed. The results of these calculations analyzing the statistical error in the measured ozone concentration as a function of the averaging time are provided in the paper.

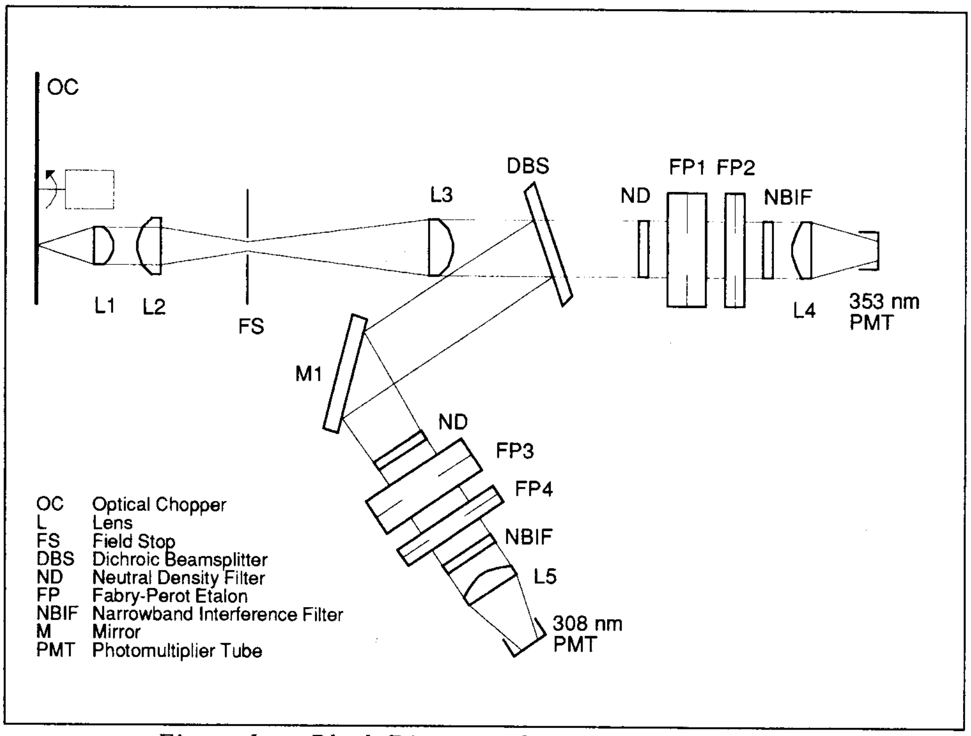

Figure 1: Block Diagram of ALOMAR DIAL System

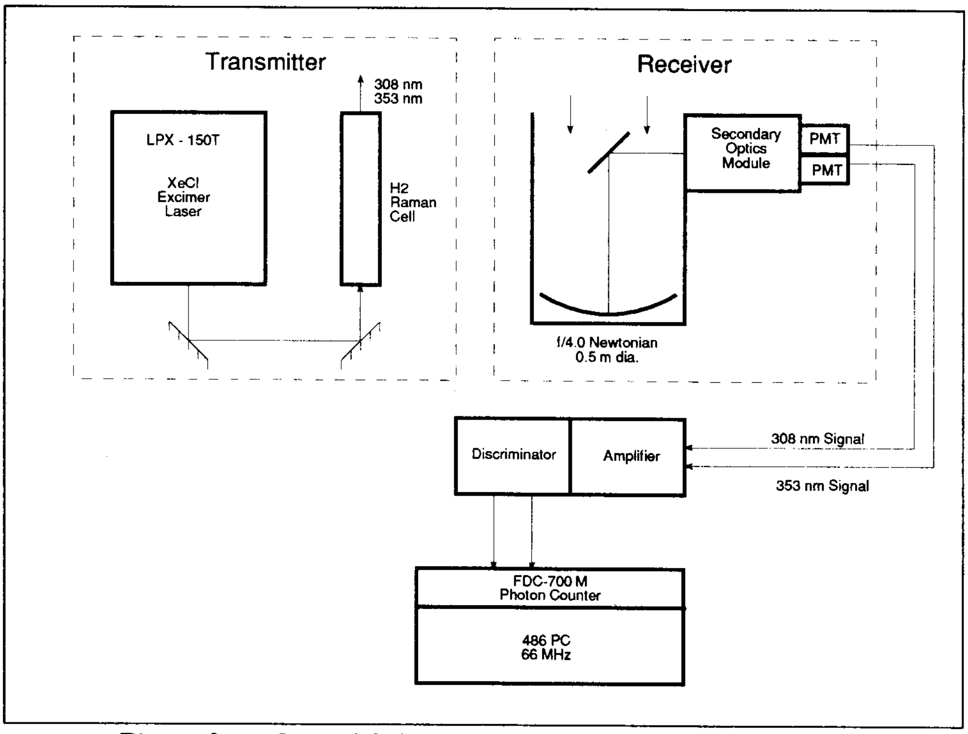

Figure 2: Optical Schematic of Receiver Secondary Optics