Receiver Field of View Characterization of the CANDAC Rayleigh-Mie-Raman Lidar

Camille Pagniello, Stephen Doyle, Graeme Nott, Christopher Perro, Thomas J. Duck
Department of Physics and Atmospheric Science, Dalhousie University, Halifax, Nova Scotia, Canada

Introduction

The Canadian Network for the Detection of Atmospheric Change (CANDAC) Rayleigh-Mie-Raman Lidar (CRL) is located at the Zero Altitude Polar Environment Atmospheric Laboratory (PEARL) Auxiliary Laboratory (ØPAL) in Eureka, Nunavut (80N, 86W). It is an eight-channel lidar measuring ultraviolet, visible elastic, and nitrogen Raman backscatter, and water vapour mixing, temperature, and depolarization ratio profiles from the ground into the troposphere and lower stratosphere year round. The CRL was designed to study the thermodynamic and radiative environments of the high Arctic because it is a region known to be particularly sensitive to change.

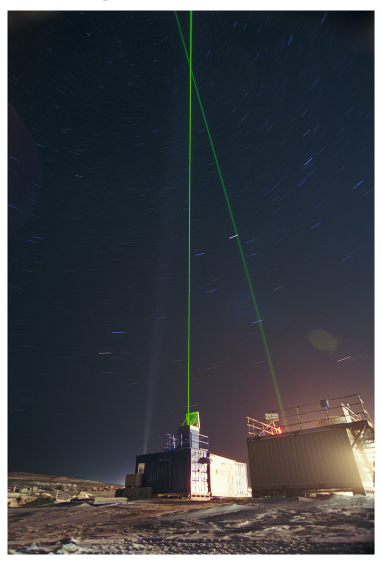


Figure 1. CRL transmitting at PEARL (photo credit: Graeme Nott).

The CRL uses ultra-short pulses of light from two lasers, operating at ultraviolet (355 nm) and visible (532 nm) wavelengths, which are directed vertically into the atmosphere through a window in the laboratory roof. A 1.0 m diameter Dall-Kirkham telescope collects light scattered from molecules and particles. To optimize measurements for particular altitudes and conditions, the polychromator incorporates many features. These includes:

- A motorized field stop, which controls the field of view (FOV) of the telescope. The FOV ranges from 0.3 to 2 mrad.
- A motorized aperture stop iris, which controls the effective aperture of the telescope ranging from 0 to 1.0 m.

The objective of this investigation is to determine how the field of view and aperture influence both the lidar and background signal. Models were constructed to:

- examine the effect of changing the irises on the amount of lidar signal
- characterize the effect of field of view and aperture on the amount of background signal
- determine the volume inside the field of view of the telescope, which is proportional to the amount of background signal

The entire FOV of the telescope was mapped to:

- provide experimental verification of the actual field of view over the entire region
- visualize where routine alignments fit into the FOV
- determine whether or not the suggested peak is the optimal position

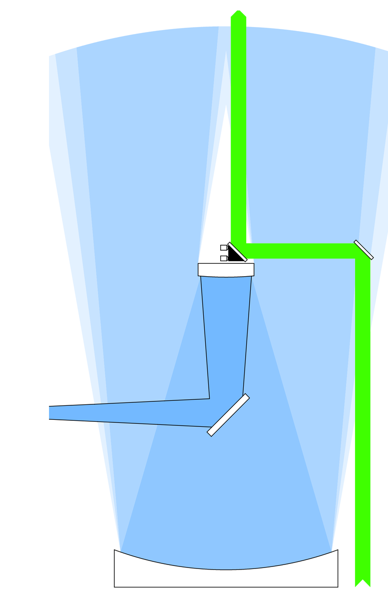
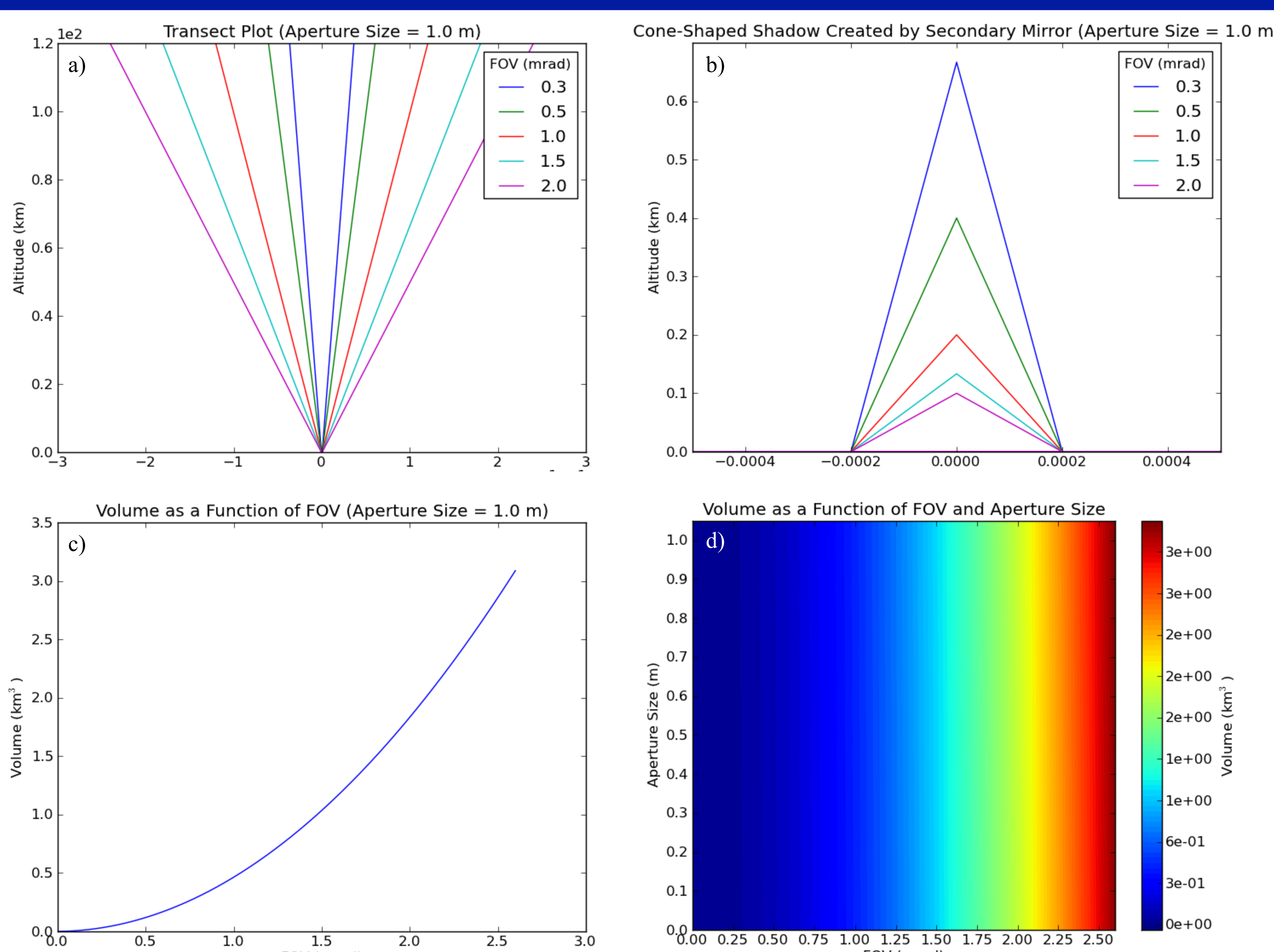


Figure 2. Schematic of the Telescope illustrating the effect of different field of view.

Simulated Volume of the Receiver Field of View



a) Cross-section transect plot of FOV of the telescope

- illustrates the truncated cone created by the laser beam
- volume is proportional to the amount of background signal

b) Close up of the cone-shaped shadow created by secondary mirror

- region where no background signal is received
- height of shadow does not exceed 700 m

c) Relationship between FOV and background signal

- constant aperture size of 1.0m
- the volume or the amount of lidar signal was determined to be:

  If $FOV = 0$ and $r_1 < r_2$: $V = 0$

  If $FOV = 0$ and $r_1 \geq r_2$: $V = \pi r_1^2 h - \pi r_2^2 h$

  If $FOV \neq 0$: $V = \frac{1}{3}\pi h(3r_1^2 + 3r_1 \tan(\theta)h + \tan^2(\theta)h_1^2) - \frac{1}{3}\pi \frac{r_2^3}{\tan(\theta)}$

  where, r_1 is the half the size of the aperture, r_2 is the radius of the secondary mirror, V is the volume of the truncated cone, h is the highest altitude at which signal is received, and Θ is half of the FOV.

d) Effect of FOV and aperture on the amount of background signal

- due to the large volume of the truncated cone, the aperture appears to have very little effect on the amount of background signal

Figure 3. Constructed models to determine the effect of the FOV and aperture on the amount of background signal.

Measured Integrated Signal for Increasing Altitude Regions

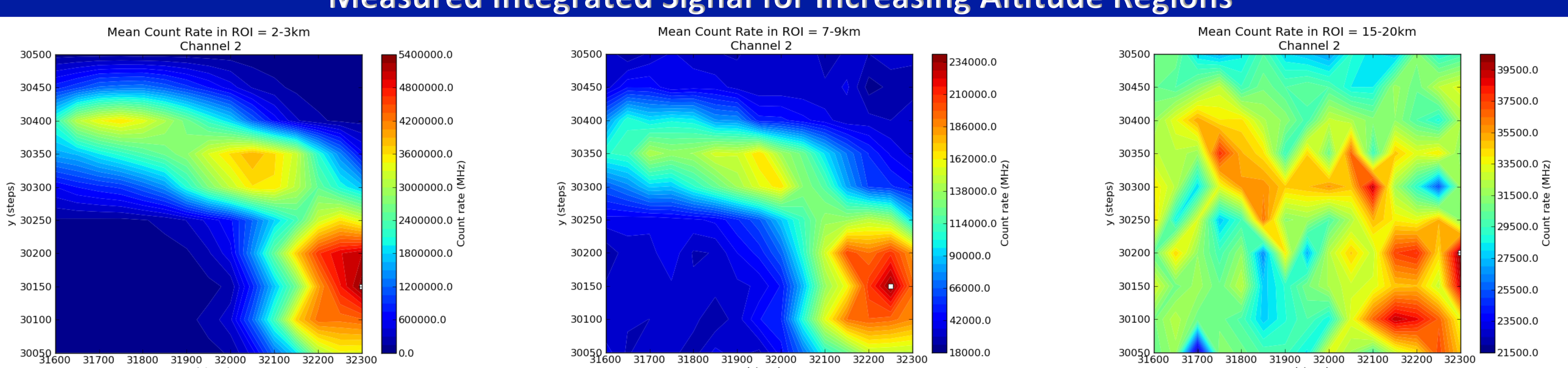


Figure 4.

Future Work

Future efforts are required to complete the characterization of the system, and thus, enhance the system's measurement capabilities. Such efforts include mapping over the entire FOV at various regions of interest (ROI) at both extremes to observe any changes in the amount of lidar signal with altitude, and increasing the resolution of the measurements.

Additionally, the theoretical models presented will be compared to experimental data to quantify the solar blocking by the interference filters. Further investigation is also required to determine if other variables effect the amount of lidar and background signal, and therefore, possibly cause the higher than expected overlap altitude.

Contact Information

Camille Pagniello | Atmospheric-Optics Laboratory
Department of Physics and Atmospheric Sciences
camillepagniello@dal.ca
http://aolab.phys.dal.ca

Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)
Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA)
IPY·API International Polar Year 2007-2008 Année polaire internationale
DALHOUSIE UNIVERSITY Inspiring Minds
CANDAC Canadian Network for the Detection of Atmospheric Change
NSERC CRSNG
Canada Foundation for Innovation
Fondation canadienne pour l'innovation