Utilization of a Tropospheric-Stratospheric Lidar System to Study Mountain Induced Gravity Waves Over Jenny Jump State Forest

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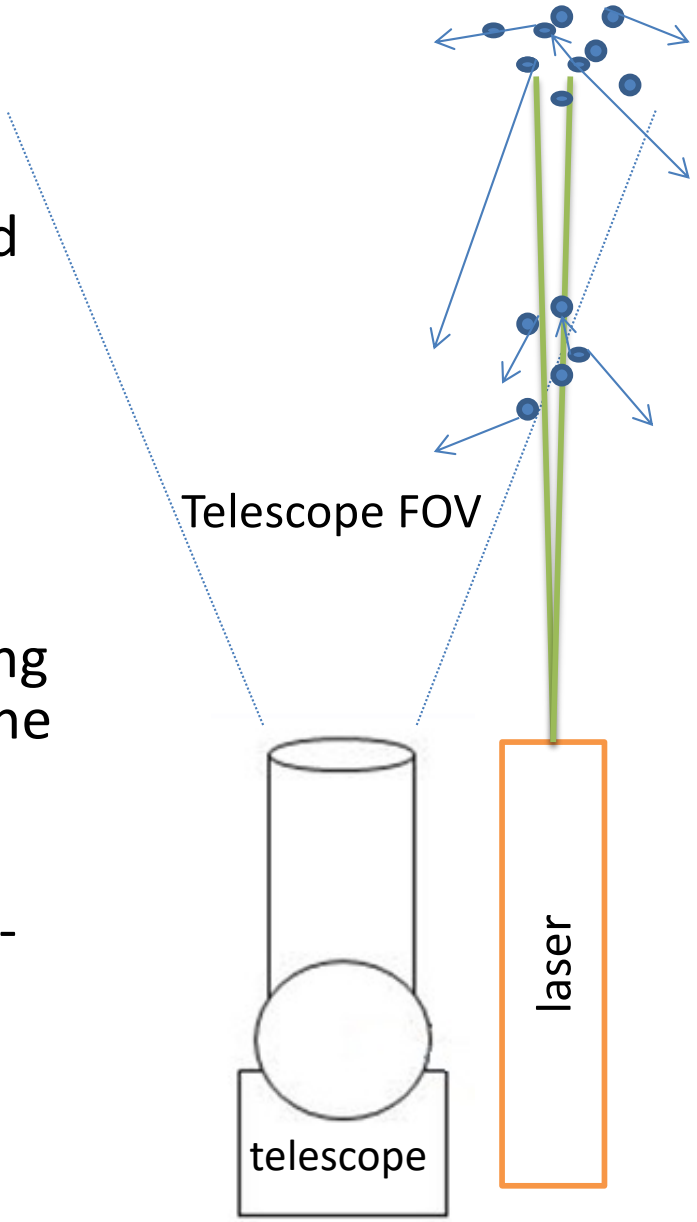
Lidar

- LIDAR – Light Identification, Detection, And Ranging
- Is a remote sensing technique used to measure properties of distant objects
- Lidar techniques were first established using searchlights to measure aerosol layers in the atmosphere (Hulburt [1937])
- With the invention of the ruby laser and Q-switch in the early 1960's, Modern atmospheric lidar techniques have been used since the mid-1960's (Collis [1965])



Lidar Equation

$$N(z) = (\eta T_A^2)\left(\frac{P_L \tau}{hc/\lambda}\right)(\sigma_{\text{eff}} n_s(z)\Delta z)\left(\frac{A_R}{4\pi z^2}\right) + N_B R\tau$$

[Gardner et al., 1989]

η = lidar system efficiency

T_A^2 = transmittance of the lower atmosphere (%)

P_L = laser's power (W)

τ = integration time (s)

h = plank's constant $(J \cdot s)$

c = speed of light (m/s)

λ = laser's wavelength (m)

σ_{eff} = effective molecular backscatter cross section $(m^2 sr^{-1})$

$n_s(z)$ = molecular density at range $z(m^{-3})$

Δz = receiver range bin length (m)

A_R = receiving telescope aperture area (m^2)

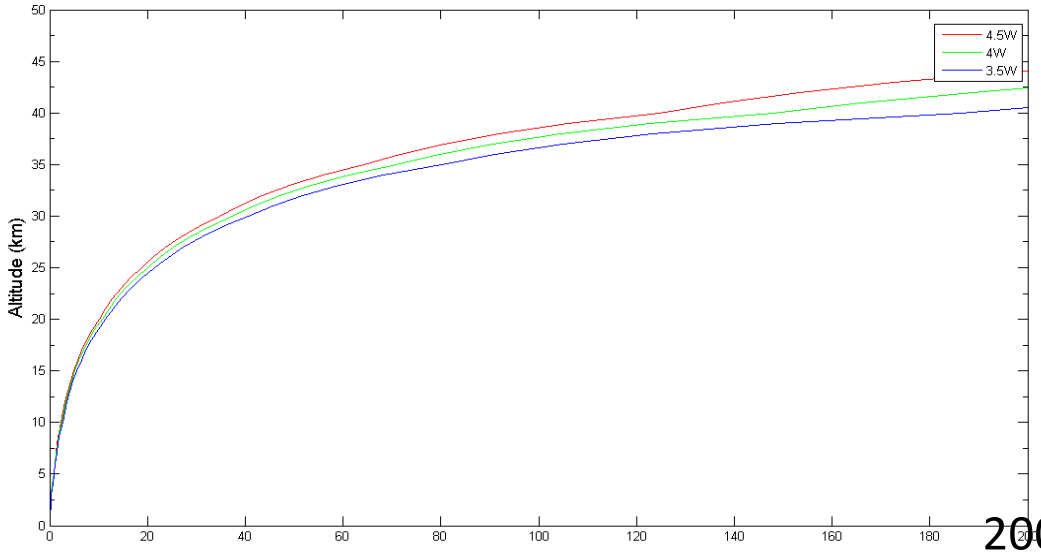
z = altitude (m)

N_B = Expected number of photons due to background noise and dark counts

R = Laser pulse rate (Hz)

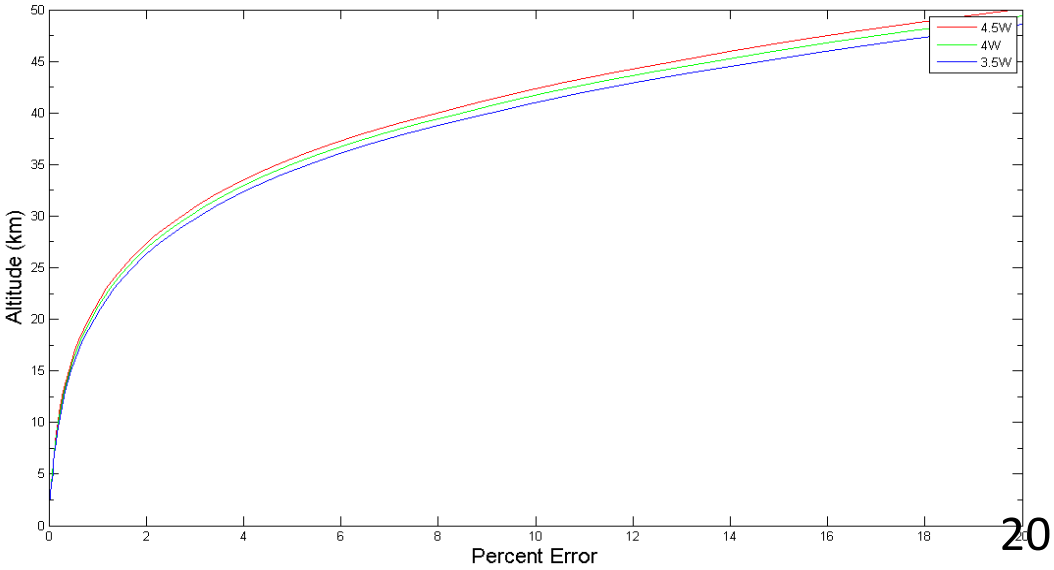
Percent Error

4 inch Meade Telescope



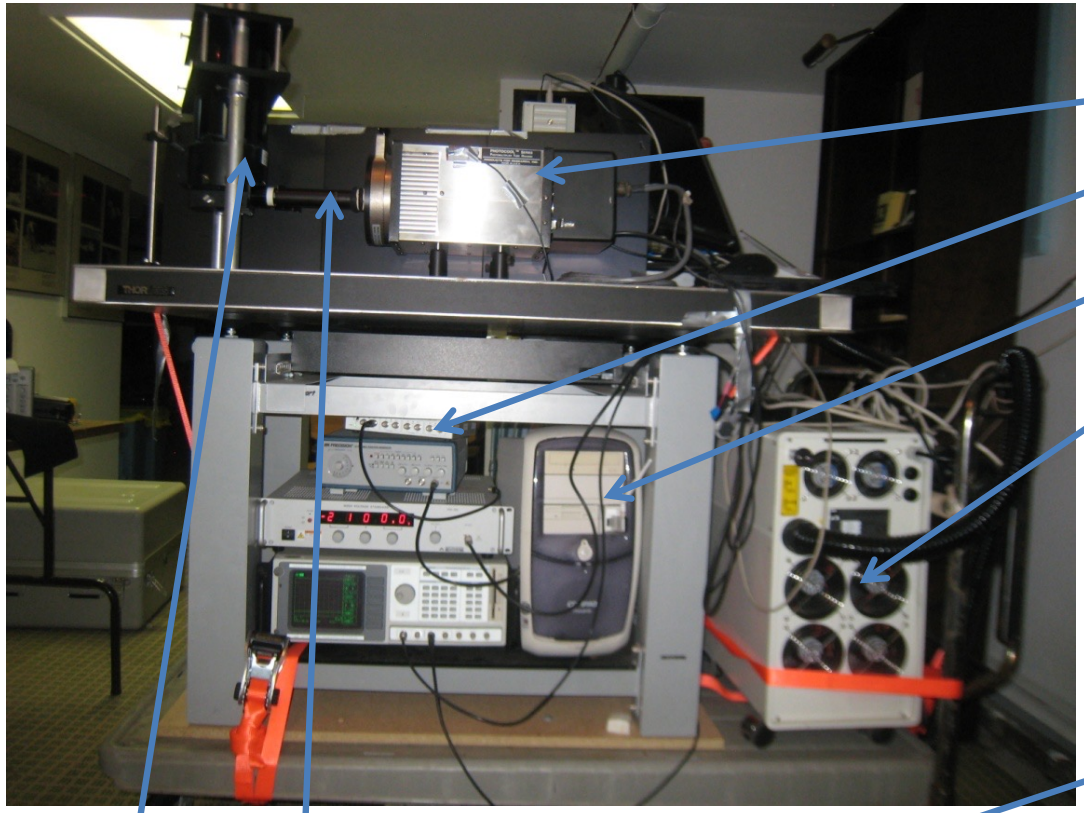
$$PercentError = \frac{\sqrt{N_z}}{N_z - N_B} \times 100$$

48 inch Telescope



Instrumentation

Lidar System Components



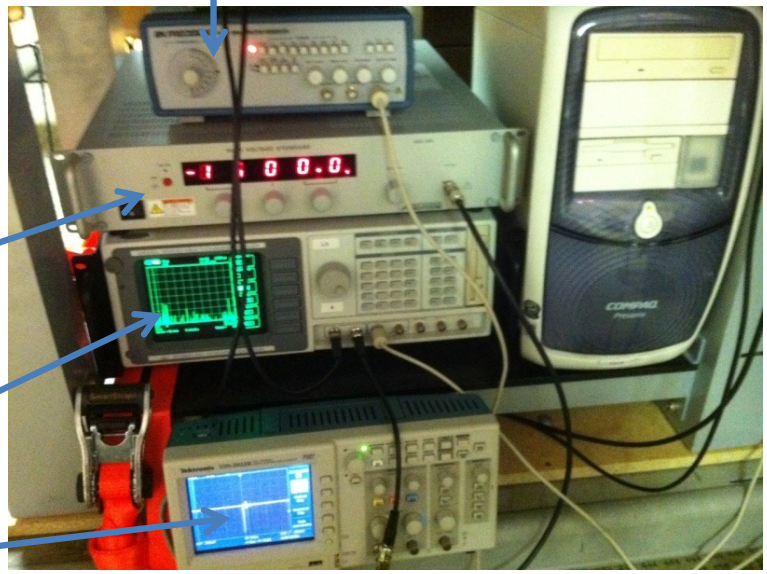
Photomultiplier Housing

Pre-amplifier

Computer

Laser Power Supply

Function Generator



High Voltage Power Supply

SR430

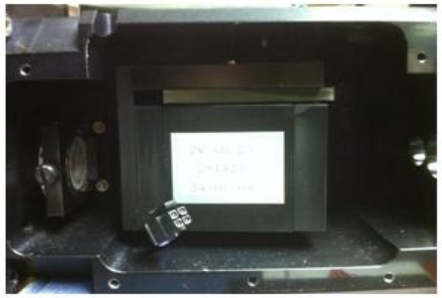
Oscilloscope

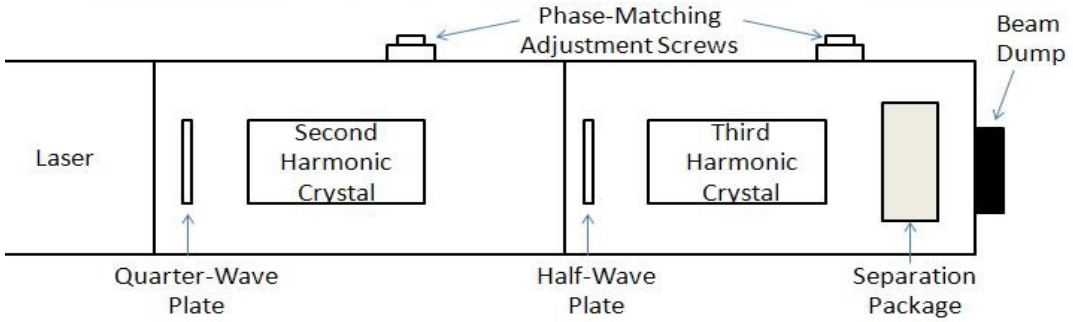
Telescope

Receiver Optics Tube

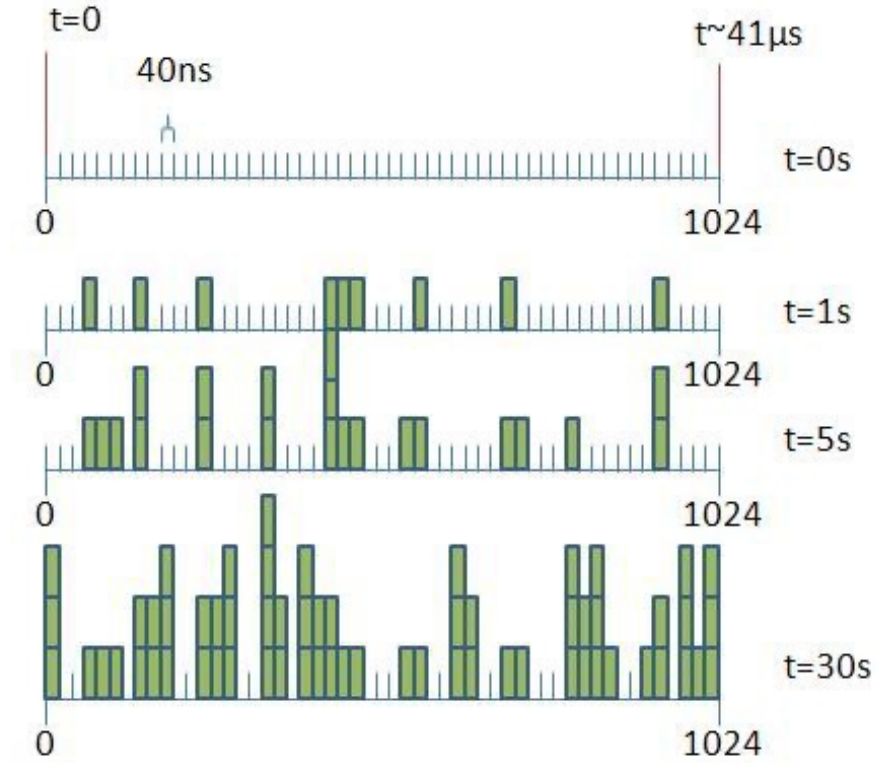
Laser

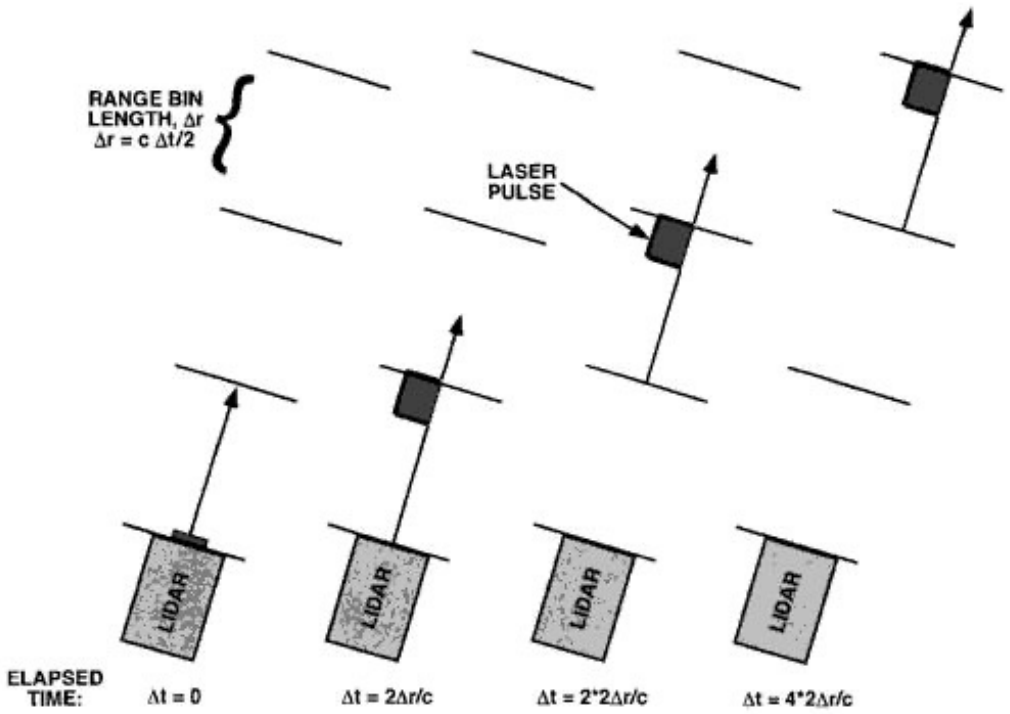
- 9W Nd:YAG laser at 1064nm
- Uses harmonic oscillators to change the frequency of the beam
- Capable of producing a 4W 532nm (green) or 2W 355nm (ultraviolet) beam





SR 430 and Range Binning

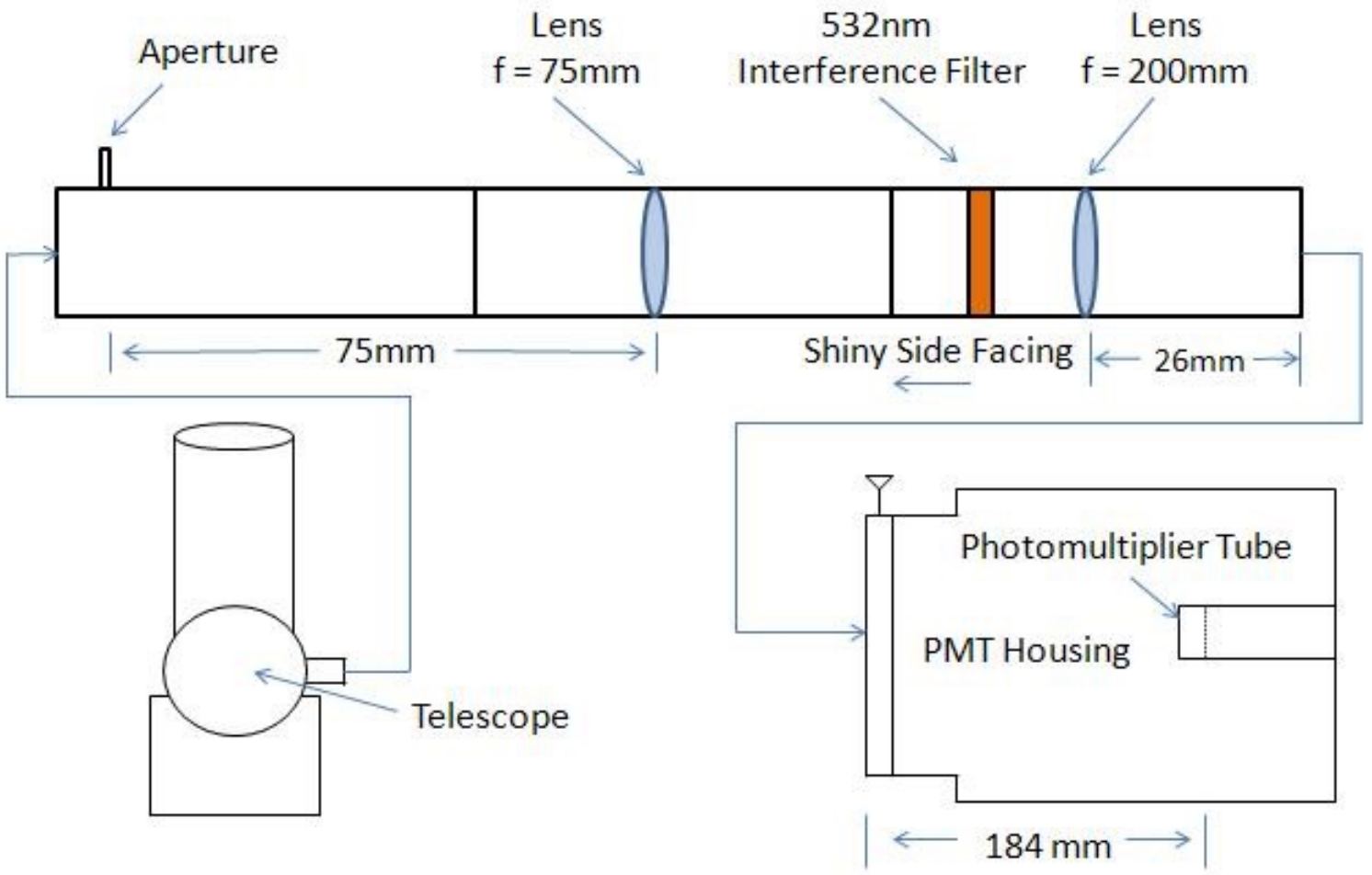




[Driggers et al., 2003]

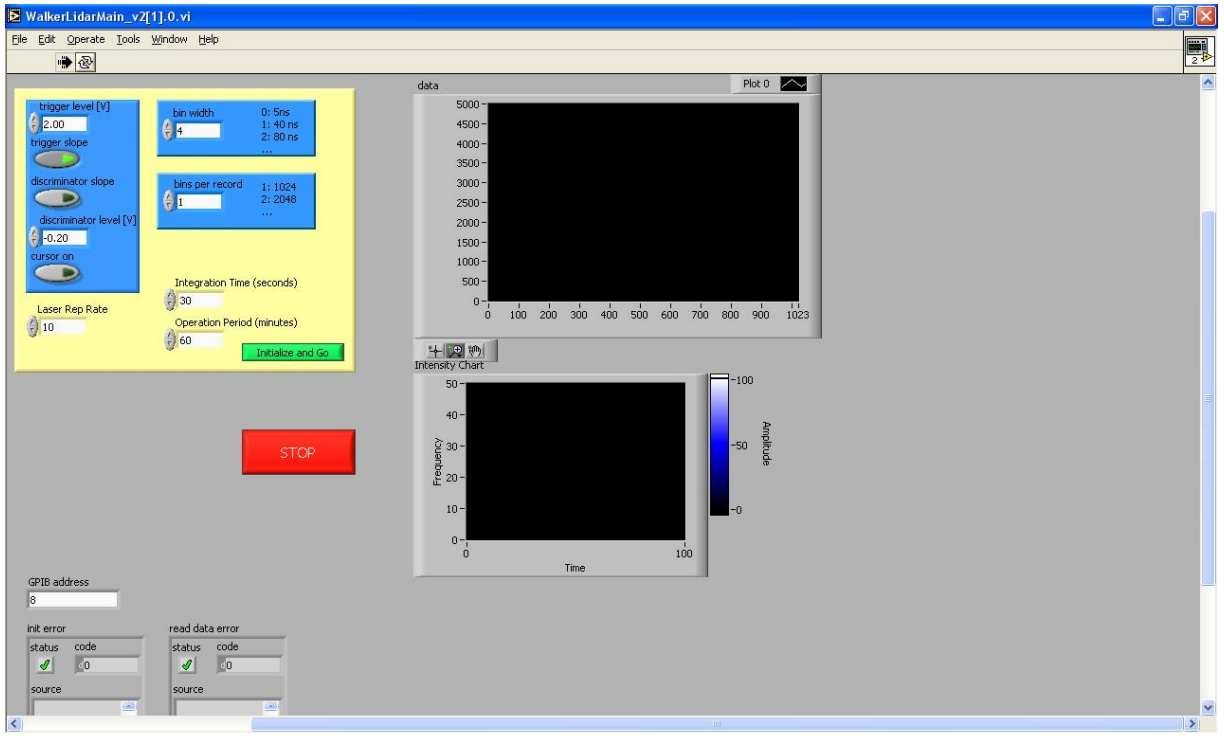
$$\Delta r = \frac{c\Delta t}{2}$$

Receiving Optics Tube Design

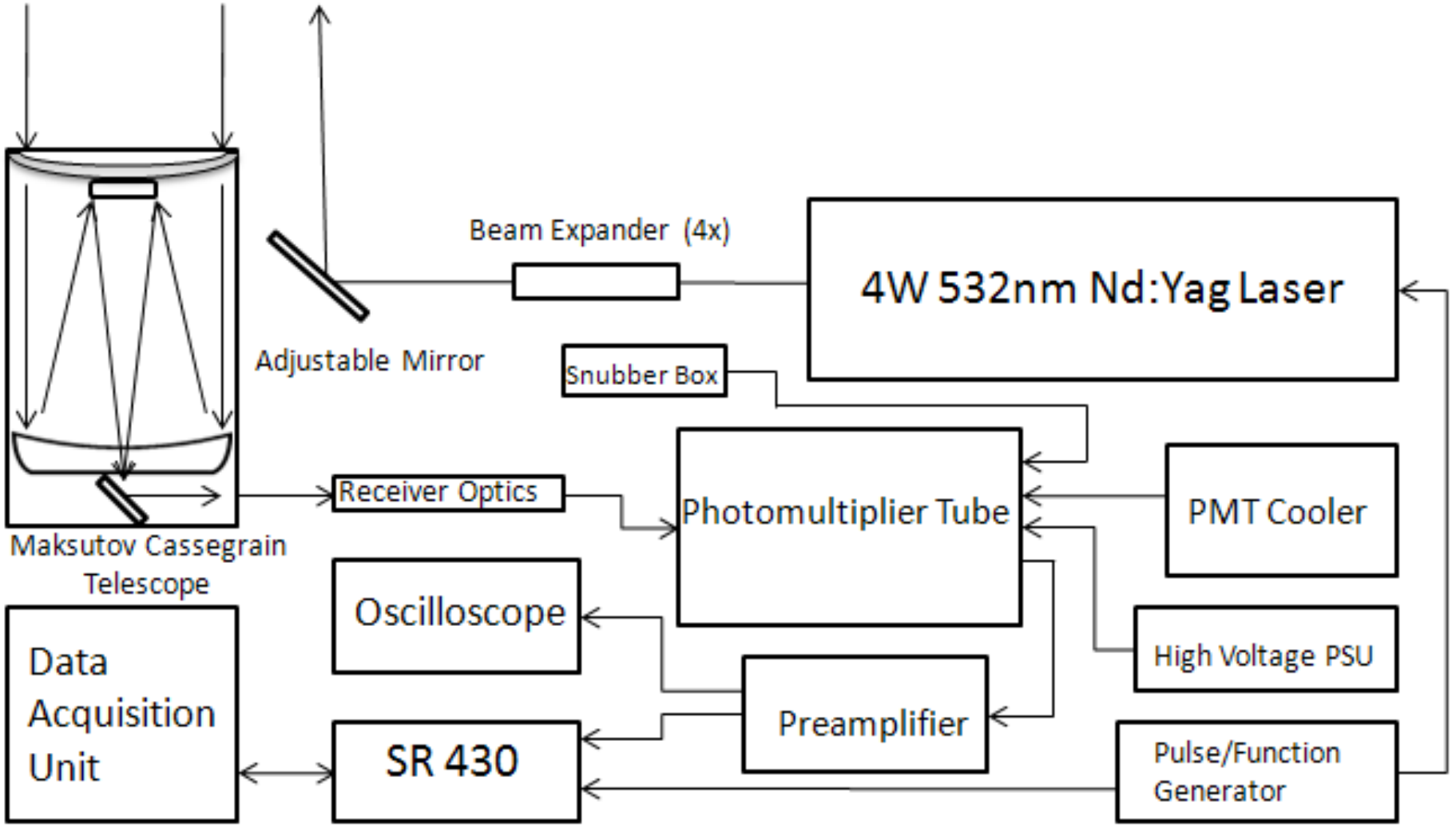


Data Acquisition Software

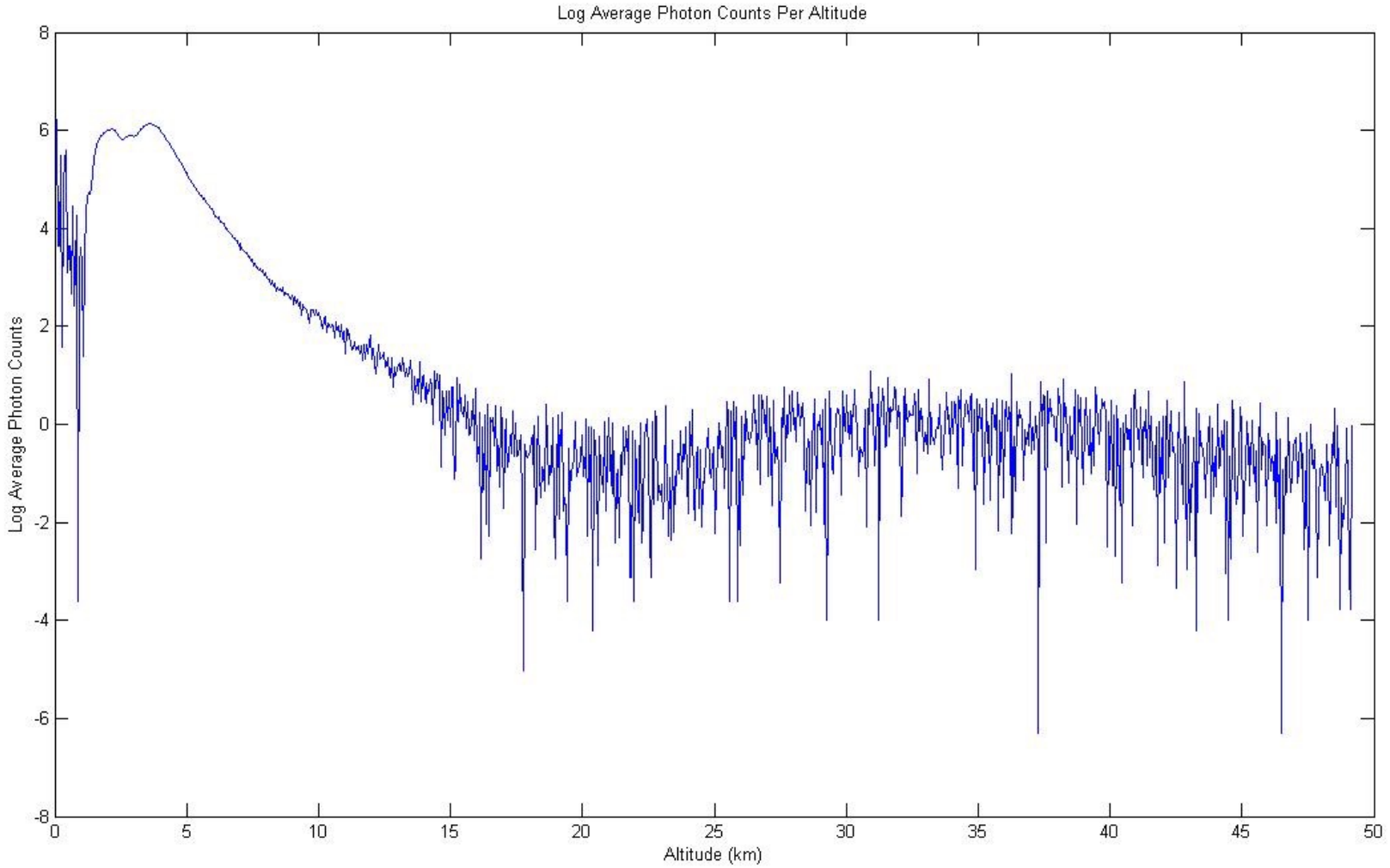
- Communicated with SR430 by General Purpose Interface Bus (GPIB)
- Allows the user to input SR430 parameters from the computer
- Stores the data with a timestamp in an ASCII file



Sequence of Components



March 23rd 2012 Campaign



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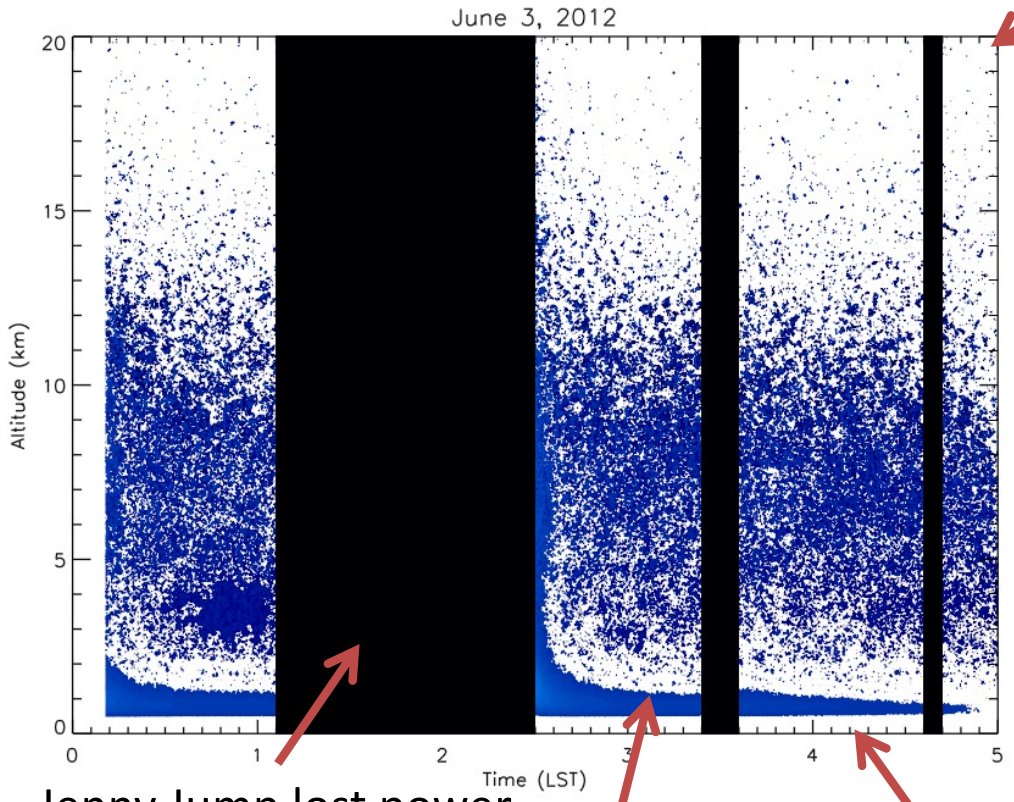
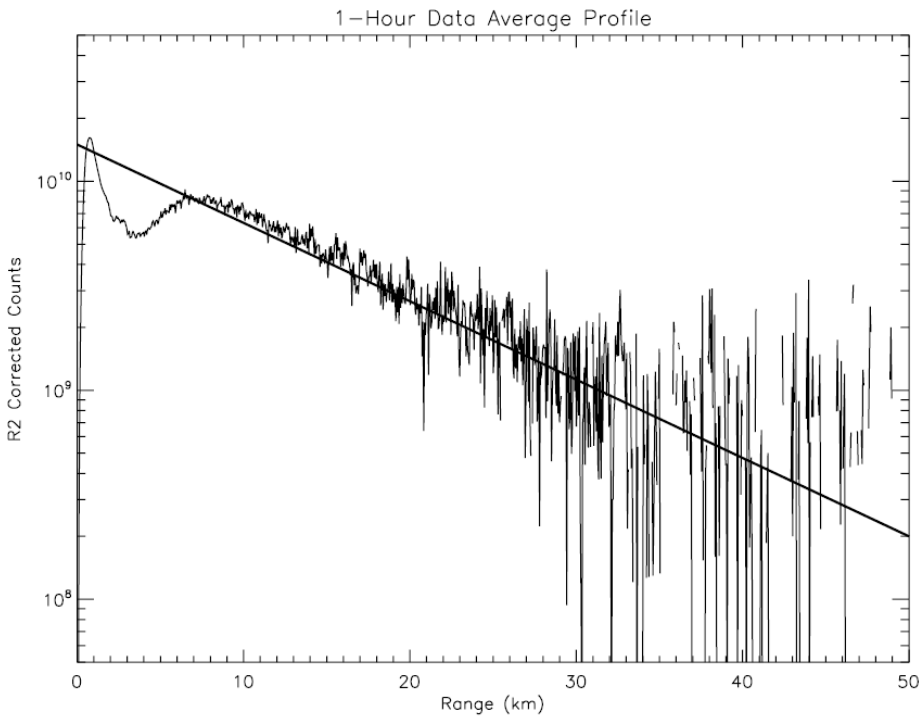
July 3rd 2012 Campaign



Sunrise



Jenny Jump lost power

Running off generator

Back on Jenny Jump Power

Time Delay Circuit

LidarDelayNew | Arduino 1.0.3

File Edit Sketch Tools Help

LidarDelayNew

```
/*
--------------------------------
Lidar Delay Circuit
Author: Anthony Teti
Date Modified: Jan 22, 2013
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This code will allow the Arduino to detect a 5V signal
from the Q-switch OUTPUT of the laser.  The Arduino
will then have a set delay (specified by the operator)
and will send a 5V signal to the optical chopper.  This
allows the user to delay the optical chopper blade preventing
saturation of the photomultiplier tube by blocking incident
light at low altitudes.

*/

int inPin = 7;
int outPin = 12;
int delayMS = 5;
void setup()
{
  pinMode(inPin,INPUT);
  pinMode(outPin,OUTPUT);

}
```