Automating the Purple Crow Lidar

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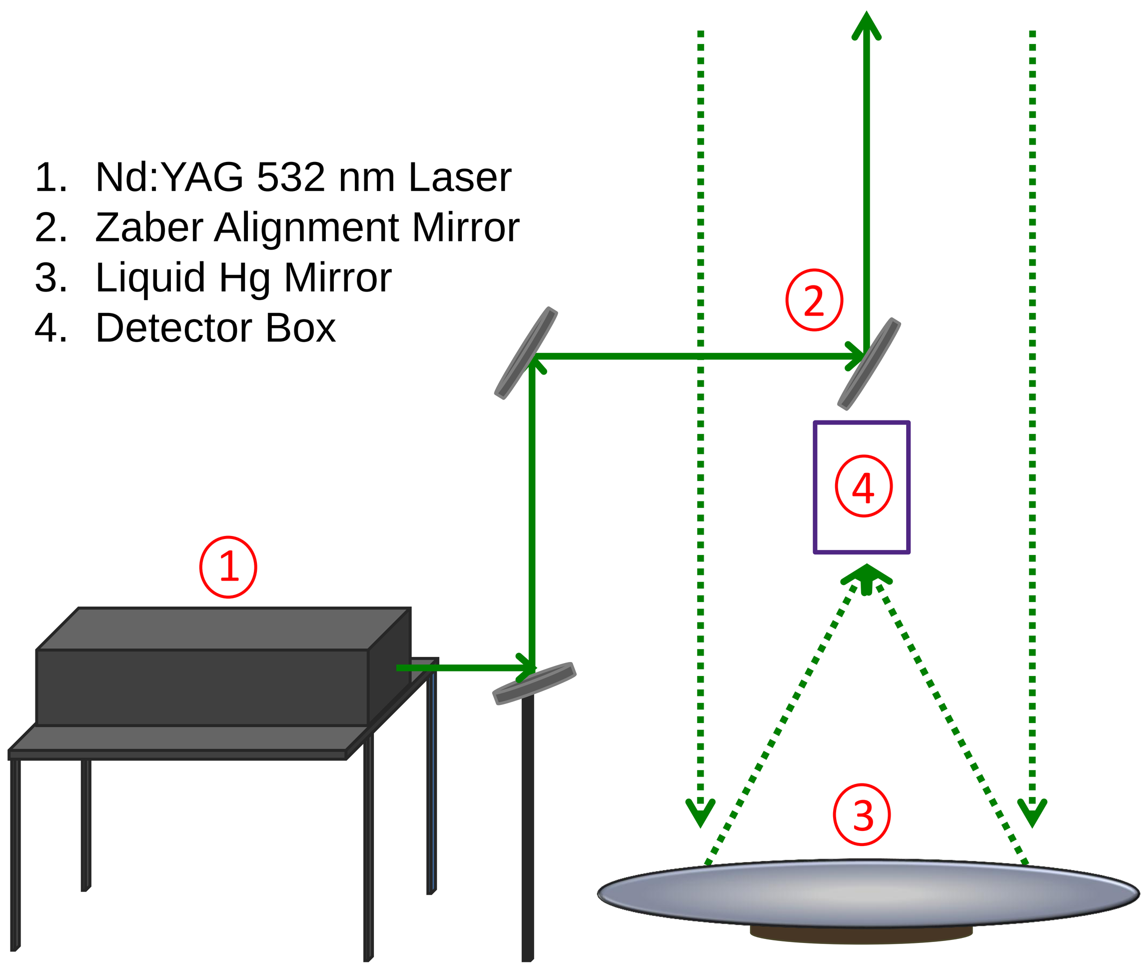
1. Introduction

The Purple Crow Lidar (PCL) was built to study short and long term coupling between the upper and lower atmosphere. The PCL uses a Neodymium: Yttrium-Aluminium-Garnet (Nd:YAG) solid state laser to produce a green beam at 532 nm with an average power of 950 mJ. The laser beam is directed skyward and photons backscattered from the atmosphere are collected and focused by the liquid mercury telescope onto 4 photomultipliers (PMTs). Part of my Master's project is to automate two components of the PCL system: the alignment mirror and a cloud/precipitation detection system. This will enable us to remove observer bias from the current alignment process, as well as remove biases introduced by stray clouds in the alignment data. This poster illustrates our method of removing the cloud interference and our current options for weather monitoring.

The Purple Crow Lidar System



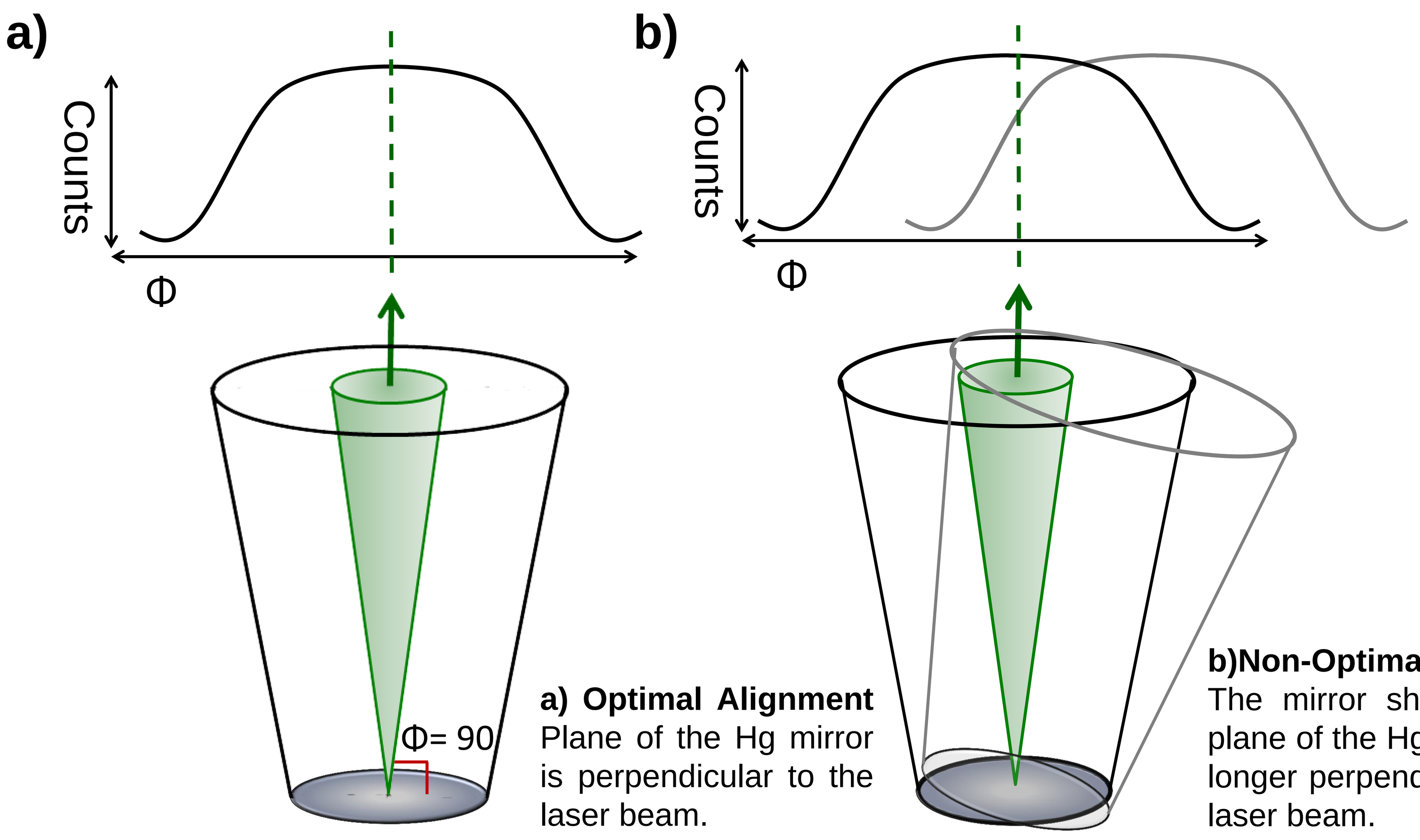
2. The Zaber Mirror Mount

The alignment mirror (Zaber mirror) rests on a Zaber T-MM2 motorized mirror mount. By using MATLAB to interface with and command the mount, we can control the alignment of the laser to within 10^{-5} degrees.

Movement Resolution: 1.501 µrad
Accuracy: 1.047 mrad
Range: -5.27 to 5.27 deg
Max Speed: 3.44 deg/s
Axes of Motion: 2
Connection: RS-232

3. Reasons Behind Automation

Due to temperature fluctuations and the shifting of the liquid Hg mirror, the Zaber mirror must be moved to change the alignment of the laser. Currently, the Zaber mirror is adjusted every half an hour by an observer. This introduces the problem of observer bias into our data, which automation will remove. Automation will also help keep the laser in the field of view (FOV) of our telescope.

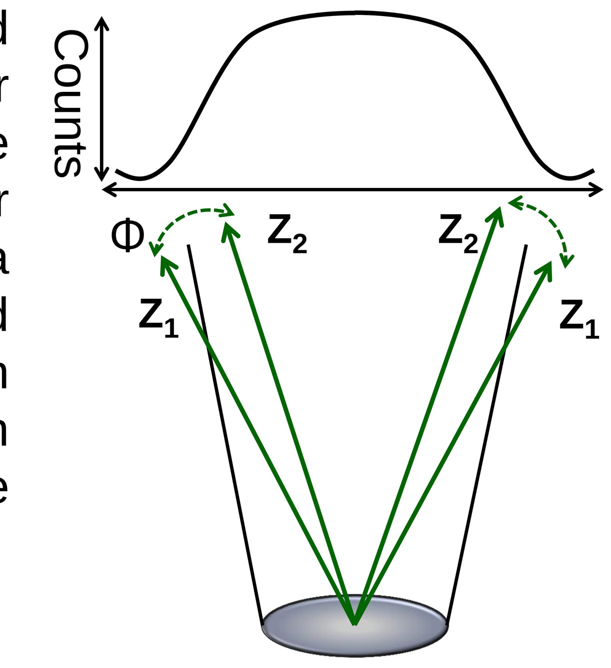


a) Optimal Alignment Plane of the Hg mirror is perpendicular to the laser beam.

b)Non-Optimal Alignment The mirror shifts and the plane of the Hg mirror is no longer perpendicular to the laser beam.

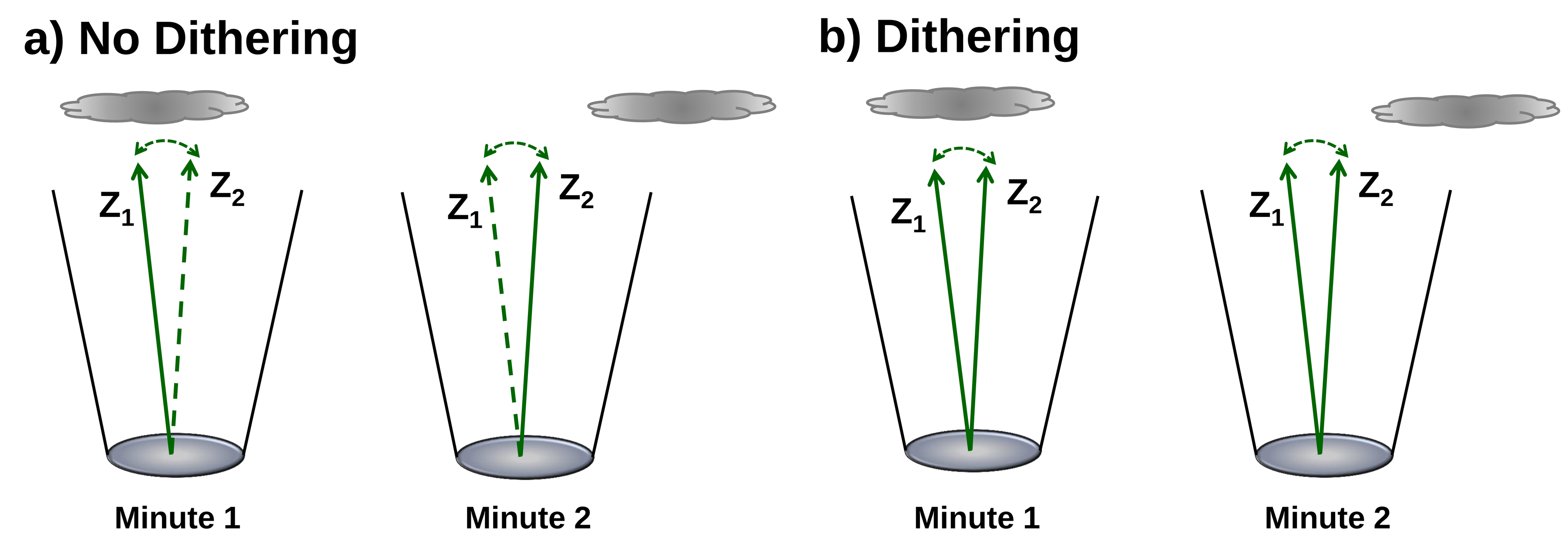
4. The Automated Zaber Alignment Procedure

We have two concerns that our automation method must consider: 1) staying within the FOV of our telescope, and 2) small, stray clouds confusing the Zaber mirror program. To avoid this, we will move our Zaber mirror between 2 positions over the course of a minute, or "dither", thereby gaining 2 profiles (Z_1 and Z_2) , one from each position. We then pick the position that has the best signal, move to it, and then begin dithering again. Dithering will always keep us in the FOV of the telescope and will also remove cloud bias.



5. Removing Cloud Bias

Clouds move across the FOV of the telescope on the scale of minutes. If we do not dither, and instead integrate the signal over the course of a minute at each position, the cloud would cause a dramatic increase in counts in the resulting profile. We would be unable to determine if the increase in counts was due to a cloud or if the signal at that position was valid. However, dithering the Zaber mirror on the order of seconds (much faster than the speed of the cloud) should provide reliable information.



Integrating for 1 minute in each position can result in a false positive/ better position at Z_1. We are unable to tell if Z_1 or Z_2 is better due to cloud interference.

Both Z_1 and Z_2 are affected simultaneously by the cloud in the first minute. Both are open in the second – we will get a clear picture of the better position at both times.

6. Cloud and Precipitation Detection

In order to operate remotely we require a constant report of current weather data. We have picked two instruments that would suffice: The Boltwood Cloud Sensor II and the Aurora Cloud Sensor.

The Boltwood Cloud Sensor II

Pros	Cons
• Sense clouds, precipitation, and wind • Can send an alarm to close the hatch and turn off laser	• Price ~ $2000 • Unsure of software compatibility

The Aurora Cloud Sensor

Pros	Cons
• Sense clouds and precipitation • Can send an alarm to close the hatch and turn off laser • Price ~$500	• No wind sensor

7. Future Work

The upcoming months will be spent implementing the alignment code and testing the accuracy of the Zaber T-MM2 motors. We will also be choosing one of the two devices shown in section 6 and integrating it into our lidar control system. These improvements will remove observer and cloud bias from our alignment procedure, and monitor local weather in real-time.

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