RAYMETRICS S.A.
12 Papathanasiou Str., Paiania Attika GR19002 GREECE
T +30 210 6655800, F + 30 210 6639031, info@raymetrics.gr

HOW TO TWEAKING YOUR LIDAR

Lidar is a complicated piece of instrument. Although all Raymetrics Lidar systems are delivered fully optimized and configured, as the time goes by lidar need some tweaking. Especially, if the operator is new, or, many users operate the Lidar.

Herein we summarize some Rule of Thumbs for better Lidar signals and extensive life of time of your Lidar.

1. **Always keep your lidar clean. Especially the High Reflective mirrors. Even small dust particles on the surface of the mirror can damage the coating of them if the high energy laser beam hit them.**
2. **Do not apply High Voltage at the PMTs that detect Raman signals during day time.**
3. **Always warm up the laser for at least 15 minutes before you perform lidar measurements (You can use these 15 minutes for lidar alignment check up)**
4. **Always leave the laser water pump on for at least twenty minutes to cool down the laser head properly. Stopping Q-Switch (first), Flash lamp (second) and leaving the pump on, can assure that the laser head crystals will be cooled down properly. In any other case there is a possibility for crystal misalignment or even crystal damage.**
5. **Always check the Lidar alignment before critical Lidar measurements (Follow the instruction of the HOWTO-Lidar-Alignment or Lidar Alignment Best Practice section of this document). Insufficient adjustment causes undershoots, distortion and low signal to noise ratio making almost impossible the molecular fit and even background substraction**
6. **Do not try to clean the telescope mirror. If it is absolutely necessary contact Raymetrics for instructions.**
7. **The analog backscatter signal should be about half (+/-10%) of the preamplifier full range (see Analog Detection Best Practice section of these document). Check this after fully align the Lidar.**
8. **The max. cathode voltage of 1000V (High Voltage HV) should not be applied for more than 30 seconds.**

9. **A too high discriminator level or a too low high voltage causes distortion in the photon counting signal. Always use the suggested values from Raymetrics for discriminator level. In case that you believe that you have to change that value please perform the test as they are described inside Licel's manual.**
10. **Do not forget that Photon Counting signals usually are saturated in the near field and Analog signals have very small signal to noise ratio at far field.**
11. **Combining (Gluing) both signals (analog and photon counting) increases the dynamic range.**

Analog Measurements best practice

All Raymetrics lidar systems use a special designed data acquisition system (from LICEL) that has a parallel analog and photon counting detection chain. The combination of both signals allows using the high linearity of the analog signal for strong signals and the high sensitivity of the photon counting for weak optical signals. The integration of both detection mechanism into a single device avoids ground loops and other problems that make the combination otherwise cumbersome.

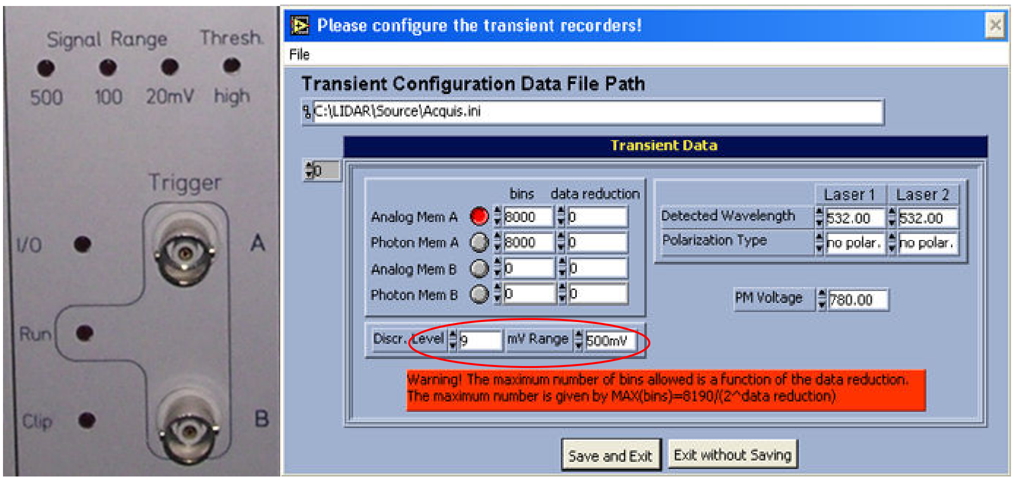
The high voltage setting must be in compliance with the average maximum anode current of the PMT. This average current for Raymetrics lidar systems are 100 uA which means 5 mV. So, the value of 5 mV should not be exceeded for more than 30 seconds.

However the peak signal can significantly exceed the background average level as long as the integral current is below 100 uA. The analog signal should fit into the input range of the preamplifier and the ADC. Due to the fluctuations of the lidar signal the following rule of thumb will keep the signal inside the ADC range.

The analog backscatter signal should be about half (+/-10%) of the preamplifier full range (see Analog Detection Best Practice section of these document). Check this after fully align the Lidar.

For a 20 mV range this corresponds to 10 mV, for a 100mV input range this corresponds to 50mV and for 500mV input range 250 mV.

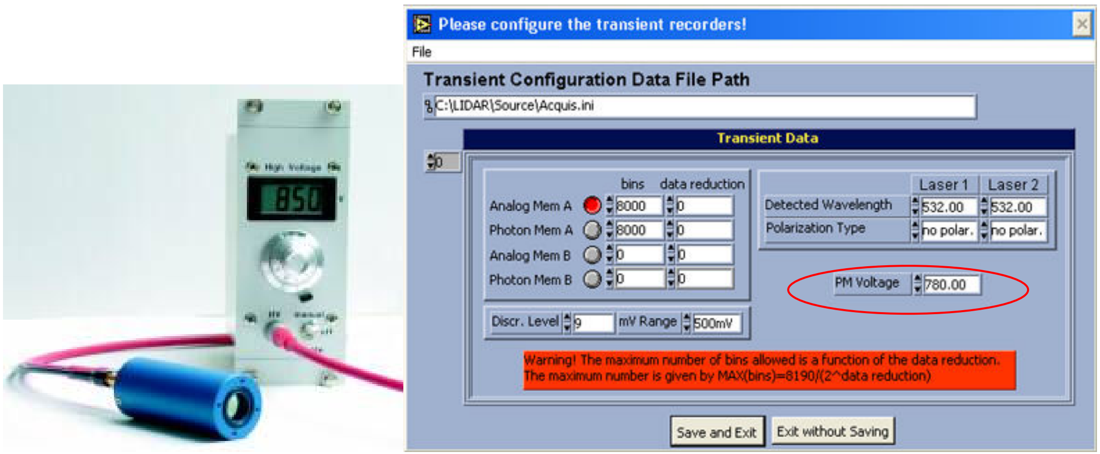
The signal input range is user selectable by using the software



Peak signals should not exceed 500 mV for more than 10 us (ie. 3000 meters or 400 memory bins) or 100 mV for more than 50 us (ie. 15000 meters or 1200 memory bins)

The max. cathode voltage of 1000V (High Voltage HV) should not be applied for more than 30 seconds.

HV can be applied manual or manual and remotely (by the computer) depending on your lidar. In any case it is a good practice to enter this value (for every detected analog channel) at the TR configuration file (see image below).



Since this information is stored in header lines for every acquired Lidar data file, it can be very useful for debugging purposes and for comparing your Lidar performance as the time goes by as well.

To high background signals and peak signals introduce artifacts and decreases the life of time of the PMTs. Reducing the applied HV although can help on the first glance is not the optimal solution as a long term solution. The PMT cathode can provide a limited amount of photons over its lifetime, exposing the tube to a constant DC light will shorten this lifetime.

So try one of the followings

Reduce the Laser energy (by increasing the flash lamp Q-switch delay, read laser manual)

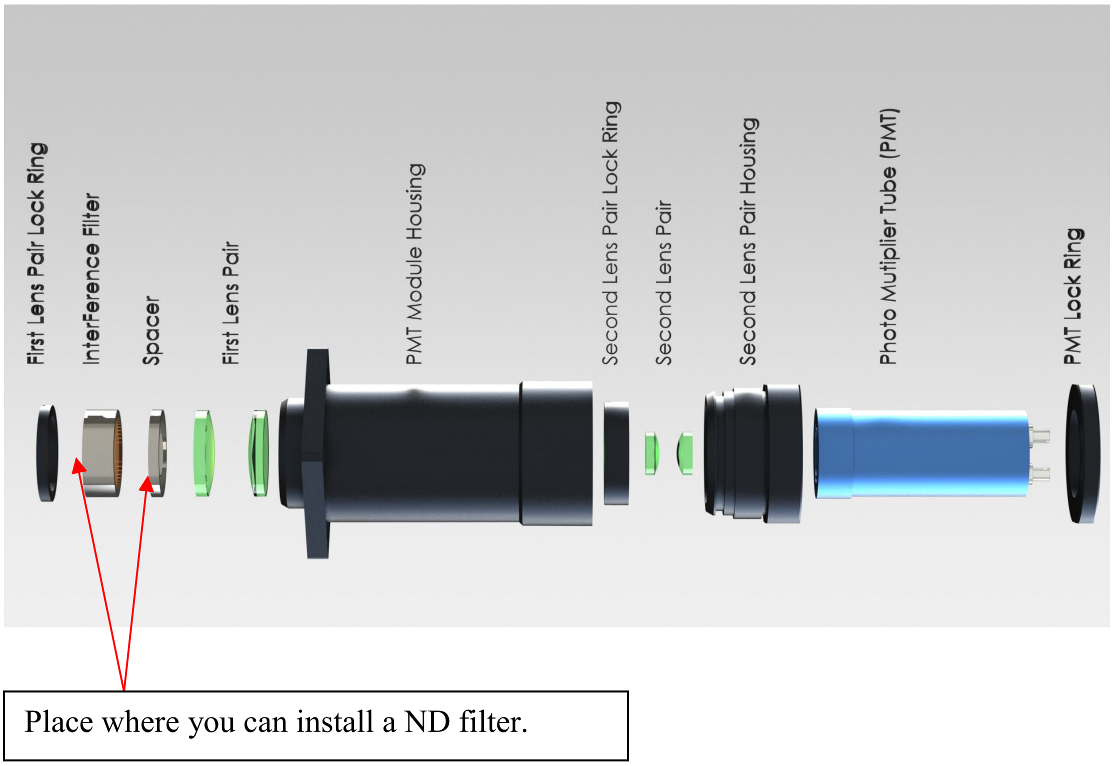
Reduce the field stop (however this solution will change-increase the overlap-minimum lidar effective range).

Use a narrower interference filter (costly solution)

Use neutral density filters (or a color filter) in front of the PMT.

Where you can install a ND filter

Absorptive ND filters are the suggested solution, although reflective ND is good as well. Another good solution is to use color fitlers. Please contact Raymetrics for the best suggestions. However before contacting us, send raw datafiles.



Before you remove the PMT holder please make sure that the HV power supply and the Licel Transient recorder are NOT powered up. Remove the signal and HV (red) cables from the back side of the PMT.

It is very important to make such work at a clean dark environment.

Remove the Lock Ring and see if there is enough space to instead your ND. If not try to remove any spacer. If there is not enough space any way, please contact Raymetrics.

ABOUT BLACK BACKGROUND FILE

All Lidar systems use sophisticated optoelectronics devices and digitization systems. If the lidar is not well grounded or/and there is strong electromagnetic interference it is possible to watch artificial slops in the analog signals that are not real atmospheric response. In such a cases it is strongly succested to measure a background profile and then to substract it from all the other measurements. A background profile in nothing more than a real measurement but with the telescope covered. You can do that by placing a non transparent material on the top of lidar's telescope window or by placing a black material at the field stop of the telescope (what ever is easier for the operator).

Lidar Alignment Best Practice

In order to acquire the best possible Lidar signal the user has to align the laser beam to the telescopes field of view. Measurements acquired with a misaligned Lidar can lead to fault results. Normally the Lidar is aligned as illustrated in figure 1. You can see that the signal starts to rise when the light of the laser beam inserts into the telescope's Field Of View (FOV) (point A) and reaches its peak value when the entire beam is inside the field of view (point B). After that point the signal starts to decrease because the light is attenuated easily when in low range.

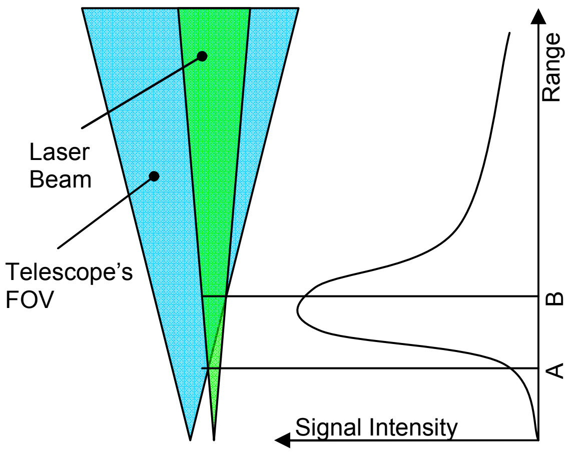


Figure 1

There are two cases of misalignment. Both are shown in figure 2. In the first case the laser beam is tilted at the opposite direction and there is no Lidar signal. However there is still some noise from the electronics and the background. In the second case the laser beam enters the telescope's FOV (point A-B) but exits after a certain point (point C-D). The second case is more difficult to distinct as the signal looks like a normal Lidar signal. However there are techniques to perfectly align the Lidar such as the telecover test.

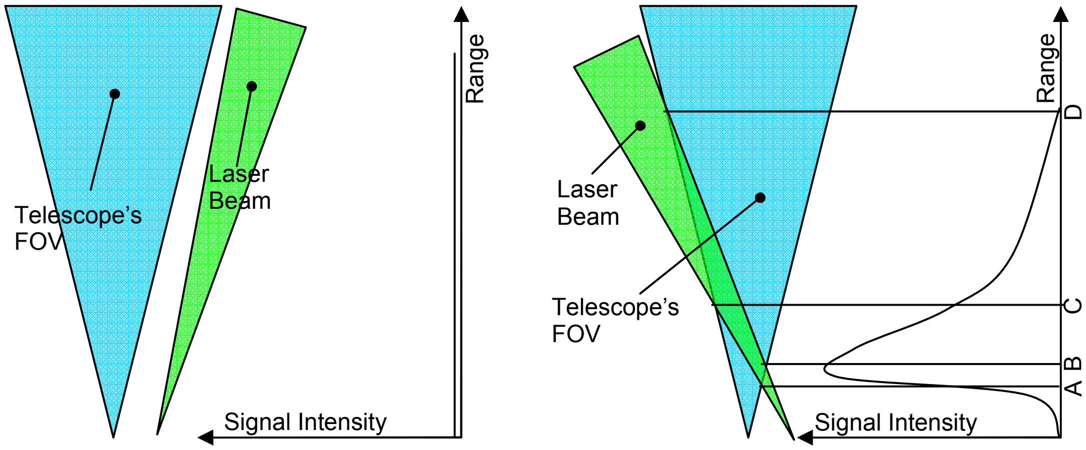


Figure 2a (left): Totally misaligned signal, Figure 2b (Right): Misaligned Signal

Usually, the Lidar alignment is achieved in two steps.

1. Initially we open the Live Display vi and as the first step (coarse alignment), we monitoring the far-range signal (1 to 2 Km). By moving the actuators of the final reflecting mirror we try to increase the far range signal.
2. The second step (fine alignment) involves two actions. First action is to try to make a fast telecover test. The second action is to acquire a lidar signal for 3 to 4 minutes (around 4000 laser pulses) and then try to compare the range corrected signal to a standard pure molecular atmosphere (HOWTO-Lidar Alignment)

About Fast Telecover Test

With this test you simply isolate the critical areas of the telescope and check at each area the signal. For this reason we divide the telescope at four (or for better accuracy at eight) parts. At an aligned Lidar the left outer part (OL) and the right outer part (OR) should have almost identical signal intensity and at the same position of the maxima.

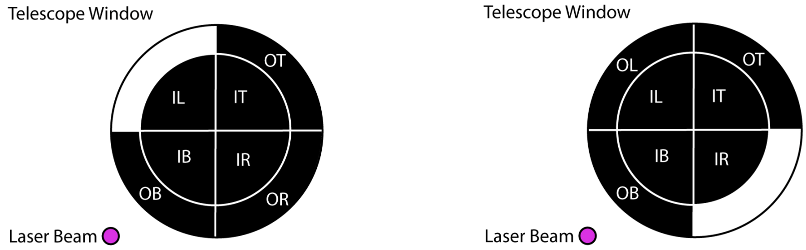


Figure 3a

In addition the Outer Top part (OT) it gives the real full overlap (around 400 to 500 meters (60 memory bins) for 400mm telescopes or around 200 meters for 200 mm telescopes (26 memory bins)).

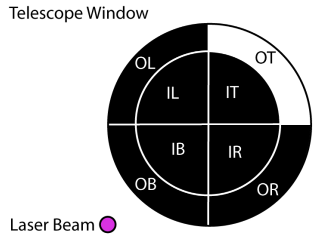


Figure 3b

Normally we would expect that the part that gives the overlap should be the one that is close to the laser beam (OB). This is not really true since the image at the cathode is reversed. The light focuses at the field stop and defocuses resulting to an upside down and mirrored image.

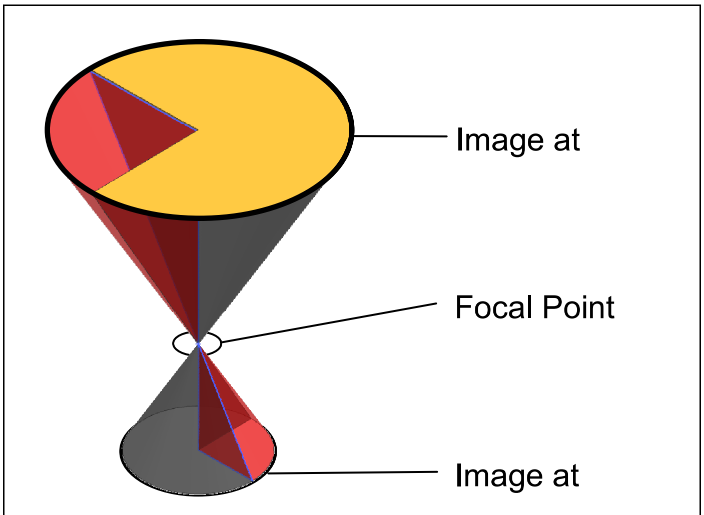


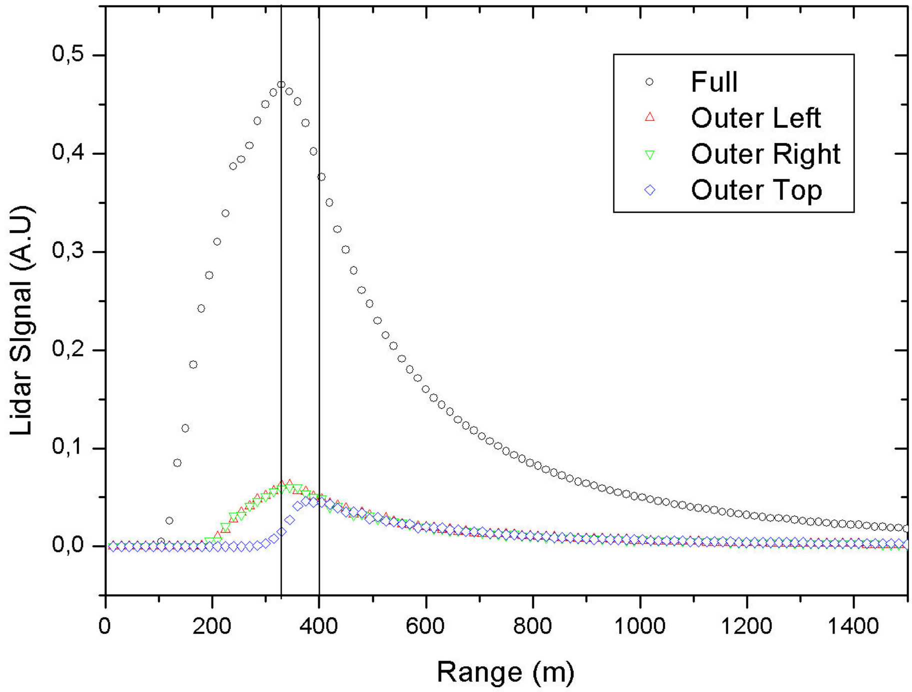
Figure: Image Inversion

Before performing any telecover test you have to make a suitable cover as it is shown at figure 3. You can use any material that you can cut is easily (like black hard cardboard)

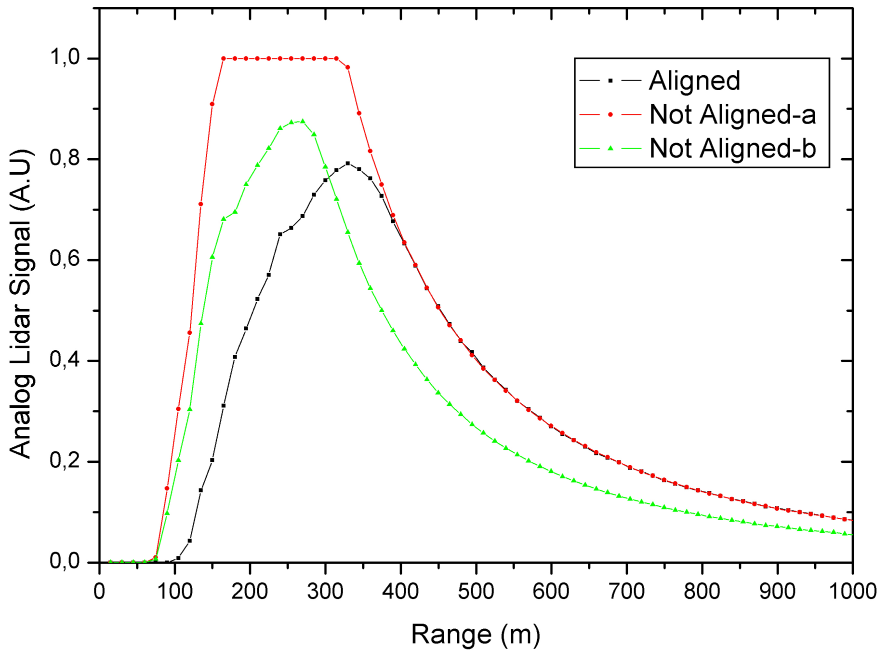
To do a fast telecover test do the followings

1. Open the “Live Display” program.
2. Place the cover on the telescope’s window letting the light only from the outer OT compartment.
3. Using the actuators and try to shift the peak of the curve at live display to reach the desired overlap (400 to 500 meters for 400 mm telescopes, 180 to 210 meters for 200mm telescopes)

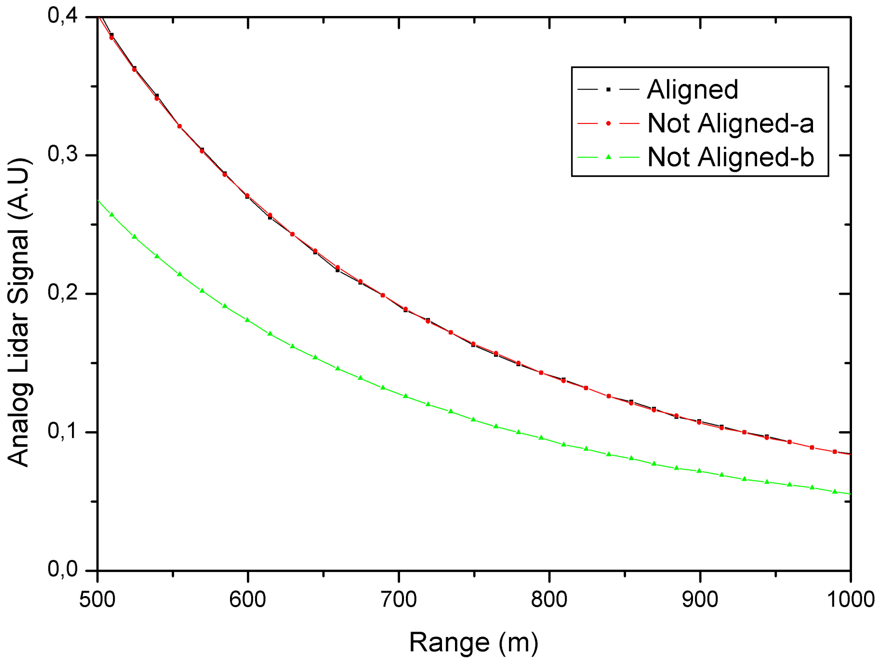
4. After that turn the cover letting the light only from the OL compartment and place a mark on the curve at the live display.
5. Flip the cover to the opposite side (OR compartment).
6. Using the actuator try to reach the mark placed before on the curve.
7. Flip the cover to the opposite side (left side) and repeat the steps 4 to 8 until the two curves are almost identical. This means that the laser beam is symmetrical to the telescope.
8. Repeat the step 3 to check the full overlap.
9. After finishing check the Lidar signal with the molecular atmosphere



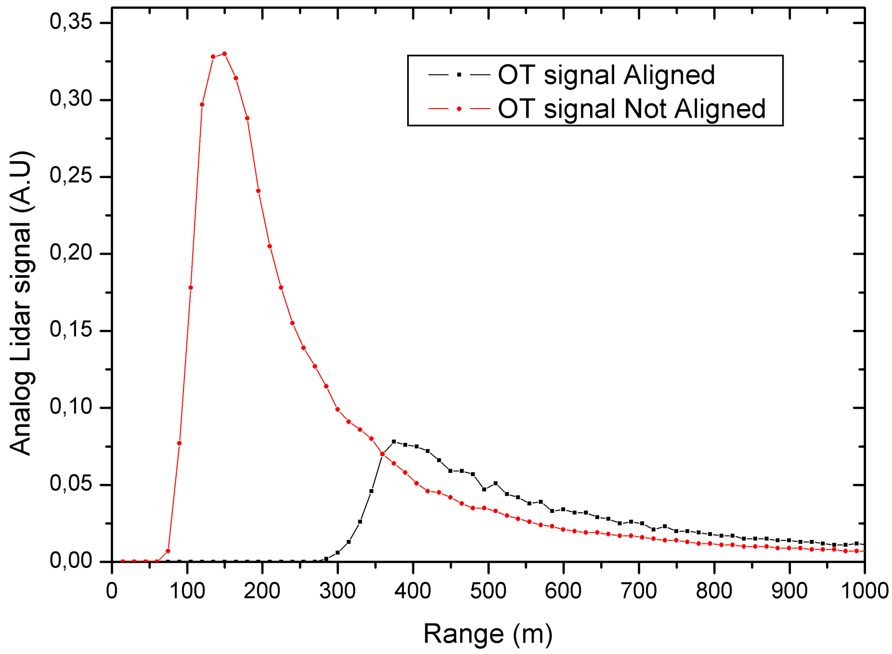
Example of Telecover test for D400 Lidar. Although the peak signal for the full telescope is appeared around 320 meters the real overall is around 400 meters at it can be seen from the Outer Top part test. In addition we can see that the OL and OR signals are almost identical.



Real lidar signals. Black curve corresponds to a good aligned lidar setup. In many cases an unexperienced user will consider the red curve as a very good aligned signal since this signal is very strong (even has saturation between 150 and 350 meters). However this is not true. If we reduce the signal intensity (for example by reducing HV or laser power) in order to get rid the saturation (green curve) we will see that at the far field (for example at 700 meters) the black curve (good alignment) has almost double value compared to greed curve. Actually, Red and Green curves (same alignment) correspond to a case similar to Figure 2b.



Another easy way to figure out the truth (which alignment is good or not) is to make a telecover test with the OT part. If we do so we are going to see lidar signals as the image below



The OT part of the not aligned signal gives an overlap at around 180 meters while the good aligned signal gives an overlap around 400 meters which is the value that we expect for this specific lidar configuration.

Note: Please always ask Raymetrics for the expected overlap of your lidar system.