ACTRIS Centre for Aerosol Remote Sensing

High Power Lidar: Standard Quality Assurance Procedures for NF operation

Emitter	CARS
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Table of Contents

1. Applicability of the document

These guidelines apply to the National Facilities within ACTRIS operating High Power Lidar instruments.

2. Acronyms

ACTRIS - Aerosol, Clouds and Trace gases Research InfraStructure

AHL – Aerosol High Power Lidars

CARS - Centre for Aerosol Remote Sensing

ND – Neutral Density (Filter)

NF - National Facility

PBS – Polarizing Beam Splitter

PMT- PhotoMultiplier

QA – Quality Assurance

3. Reference documents

ATLAS manual

High Power Lidar: Standard Operating Procedures for NF operation

4. Introduction

The current document will act as a guideline and must be adapted to the particularities of each instrument and to the operator's personal experience. In case the information does not apply to your lidar instrument, please contact the appropriate representative within CARS for further support:

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All safety procedures that apply within your research institution must be applied and must not be in contradiction with the guidelines found in this document. Before using this document, please read carefully all user manuals from all components and modules that are part or are connected to each lidar instrument.

5. Telecover test

5.1. About the test

Deviations of near range signals from different parts of the telescope and the comparison of such deviations of different lidar channels and with theoretical ray-tracing simulations can reveal the distance of full overlap and possible reasons for the deviations from the ideal case.

In the near range region, we do not have a calibration method for a lidar system, where almost never clean air conditions can be assumed. But shortcomings of the optical and opto-mechanical design or misalignments have their largest effect in the near range. A test for this range is based on the fact that the backscattered photons collected by different parts of the telescope of a lidar system must give the same range dependency of the partial signals, and if not, the range dependency of the whole signal is uncertain. With ray tracing simulations we see that ray bundles collected by different telescope parts reach the signal detector in different paths through the optical receiver and hit the optical components under different incident angles (see Fig. 1), with possibly different transmission. Possible causes for the differences are laser tilt, telescope misalignments, displacement of field and aperture stops (vignetting, defocus), optical coating effects of, e.g., beam-splitters and interference filters with spatial inhomogeneity or angle dependency of the transmission (see Fig. 2), or spatial inhomogeneity of the detector sensitivity (Simeonov et al. 1999). The geometrical overlap function, which is mainly determined by the size and location of the telescope's field stop, is just the most obvious feature producing differences in different telecover signals (Freudenthaler, V., et al., 2018).

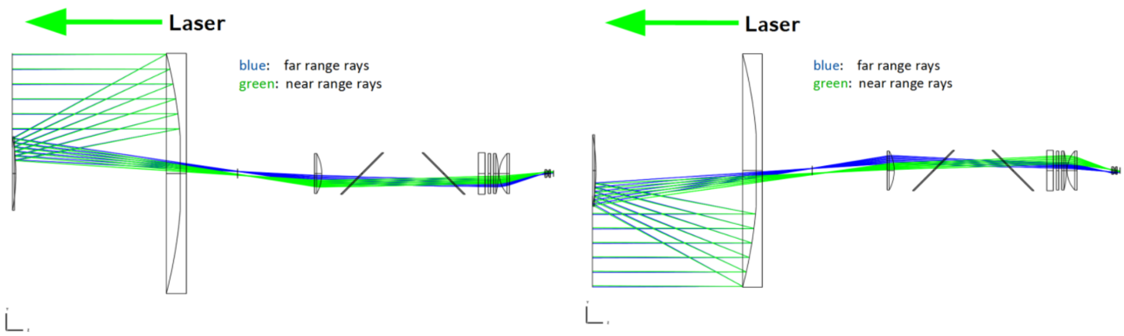

Figure 1: Ray bundles through the receiver optics of a typical lidar setup from the top part of the telescope (left) and from the bottom part (right), from near range (green) and far range (blue) have different paths and incidence angles on the optical elements (Freudenthaler, V., et al., 2018).

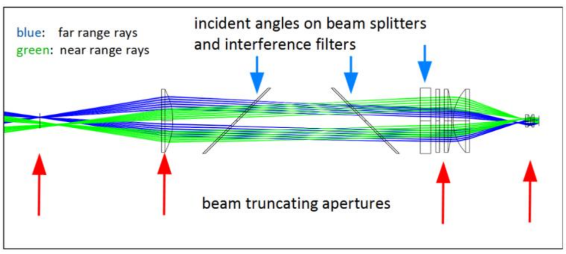

Figure 2: Optical elements in a typical lidar receiver optics which can influence the transmission of the ray bundles due to vignetting (red arrows) or angular transmission dependency (blue arrows) (Freudenthaler, V., et al., 2018)

The telescope can be covered in a way that just quarters of the telescope are used, which we call the Quadrant-test (see Fig. 3), or using only an inner and outer ring of the telescope, i.e. the In-Out-test. Using In-Out sections of the quadrants is called the Octant-test.

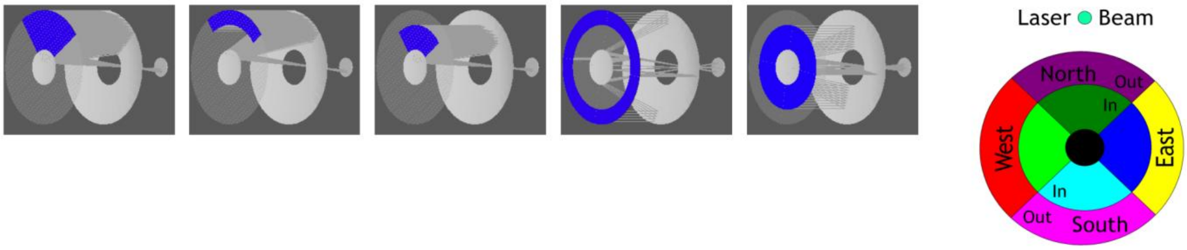

Figure 3: Nomenclature of the telecover parts (plot at right) with respect to the laser position at North (biaxial systems) or any prominent orientation of the receiver optics (mono-axial systems). Using the four quarters N, E, S, and W in the left picture is called the quadrant test. Using the outer and inner parts of the quadrants is called the octant test. The pictures above show (from left to right) the sectors North (N), North-Out (NO), North-In (NI), Full-Out (FO), and Full-In (FI) on a telescope, assuming the laser on top (Freudenthaler, V., et al., 2017).

With an ideal lidar system the normalized signals from all different telecover tests must match - apart from the overlap range, which can be therewith assessed, and assuming constant atmospheric conditions during the test.

note: 1. In order to have similar SNRs of all sector signals, the area of all sectors should be similar.

2. In case of coaxial setup, please consider the obscuration of the telescope's secondary mirror when determining the area of the two ring sectors.

5.2. Environmental conditions

- The telecover test must be performed during **stable atmospheric conditions** (like high pressure systems, just before sunrise or based on the specificity of each location). Stable atmospheric conditions could also be determined based on the atmospheric deviations provided by the ATLAS software (less than 10% above the full overlap with vertical averaging less than 100m is a good threshold to assess the stability).
- To reduce the effects of the unstable atmosphere, the telecover test **must be performed in several consecutive N-E-S-W iterations**.
- **Low and mid altitude clouds must not be present during the test** (cirrus clouds usually do not affect the test results).

5.3. Test procedure

The telecover test is used to check the laser-telescope alignment of the AHL, therefore it is advised to **perform a telecover test every time the alignment** between of the emitter or the receiver optics might have **changed**.

The telecover test signals are preprocessed similar to a normal measurement, and therefore it is **mandatory to collect a Dark signal before each test for all analogue channels.**

In case of photon counting channels, an extended dark measurement test should be submitted only once (and after every instrument upgrade) to check if external sources of electronic noise are affecting the signal.

- **Collect a Dark** measurement with sufficient signal-to-noise ratio (**5-10 minutes** as a general rule) - **for all analogue channels**.

Although it is generally recommended to conduct the telecover test under stable atmospheric conditions, there are certain exceptional circumstances when performing the test during unstable conditions becomes necessary (before measurement campaigns or at sites where the atmosphere is constantly unstable).

The procedure for conducting the telecover test can vary depending on whether the atmospheric conditions are stable or unstable. For stable atmospheric conditions, the number of consecutive N-E-S-W iterations could be reduced with respect to cases where the atmosphere is not stable.

It is mandatory to perform a **quadrant test for biaxial systems** and **additionally** an **in-out ring test for coaxial systems**. In case of coaxial systems, the additional quadrant test provides information on the laser tilt (since in ideal conditions, the normalized signals collected from the four sectors must agree).

note: 1. For multiple telescope instruments, it is mandatory to cover the telescopes that are not involved in the test to avoid any possible confusion during the test analysis.

2. In case of the cross polarization channels, one additional Telecover test performed with the receiver in calibration mode position (either +45° or -45°) could be required if the deviations of the collected signals are too large for conclusive results.

Biaxial systems

Stable atmospheric conditions:

- Perform at least **three** consecutive **N-E-S-W iterations** (e.g. each iteration should include **10 seconds profiles, 40 seconds / sector,** resulting a total averaged profile/sector of at least **120 seconds**) by partially covering the telescope (either manually or by using a automatic telecover module).

Unstable atmospheric conditions:

- Perform at least **five** consecutive **N-E-S-W iterations** (e.g. each iteration should include **10 seconds profiles, 40 seconds / sector,** resulting a total averaged profile/sector of at least **200 seconds**) by partially covering the telescope (either manually or by using a automatic telecover module).

Coaxial systems

Stable atmospheric conditions:

- Perform at least **three** consecutive **N-E-S-W iterations** followed by **three** consecutive **in-out iterations** (e.g. each iteration should include **10 seconds profiles, 40 seconds / sector,** resulting a total averaged profile/sector of at least **120 seconds**) by partially covering the telescope (either manually or by using a automatic telecover module).

Unstable atmospheric conditions:

- Perform at least **five** consecutive **N-E-S-W iterations** followed by **five** consecutive **in-out iterations** (e.g. each iteration should include **10 seconds profiles**, **40 seconds / sector**, resulting a total averaged profile/sector of at least **200 seconds**) by partially covering the telescope (either manually or by using an automatic telecover module).

note: 1. High temporal resolution averaging (10 seconds) should be used to remove unwanted cloud contamination in the low altitude regions.

2. The integration time and number of profiles per each sector could be adjusted based on the specificity of each instrument.

3. The orientation of the NESW sections of the telescope depends on the laser emission axis. The North sector is closest to the laser emission axis.

4. The in-out iterations are used to assess the full overlap height while the N-E-S-W iterations are used to assess the emission-receiver alignment.

- The **time interval required to switch between each sector** should be **reduced to the minimum** to limit the atmospheric changes (e.g. **10 seconds**).

note: Two subsequent recordings of the same quadrant/ring must not be more than 15 minutes apart.

5.4. Schedule

- The telecover test must be submitted to CARS **every 6 months** or **after each instrument upgrade**.
- For a **new AHL's**, periodic telecover tests should be performed to **check the alignment stability** of the optics (e.g. **each week for 2 months**). Once the stability of the instrument is checked, the telecover test can be performed based on CARS recommendations.
- The lidar operator must perform internal telecover tests **each time alignments are performed**.

note: For internal use and tests, the telecover tests should be processed with the ATLAS software provided by CARS.

5.5. Internal analysis

- The internal analysis made by the AHL operator should be performed using the ATLAS software in order to achieve results that are comparable over time and with other lidars.
- Information on how to process and analyze the QA tests using the ATLAS software is provided in the user manual and the dedicated CARS training courses.

Example

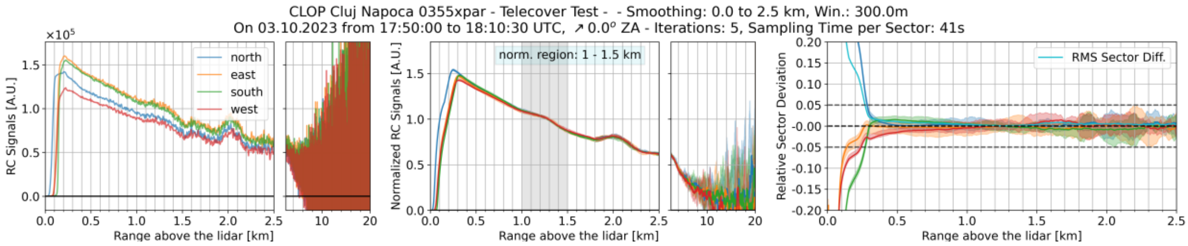

Figure 4: Telecover test output using the ATLAS software (biaxial system). 5 iterations test, 4 profiles per iteration (10s). Left: not normalized lidar signals; Center: normalized signals (1.0-1.5 km); Right: relative deviations (from the mean). The RMS Sector Diff. indicates a full overlap starting from 300m.

Acceptable limits

- For altitudes above the full overlap, the relative sector deviation must not exceed more than 0.05 (5%) (see ATLAS manual).

5.6. Filling the QA logbook

- All QA tests performed on the AHL must be recorded in a dedicated maintenance logbook. A template of this logbook is provided in the following link.
- The logbook must be stored in the dedicated station folder provided by CARS.

6. Polarization calibration

6.1. About the test

The calculation of the volume linear depolarization ratio profile (VLDR) and particle linear depolarization ratio profile (PLDR) requires calibration of the polarization sensitive lidar channels; In order to be able to perform a polarization calibration, the AHL must be equipped with a polarization calibration module.

The calibration of polarization channels is specific to each lidar system but the basic principles are similar for most of the instruments. The calibration of the polarization channels consists of assessing the measured calibration factor and then applying all necessary corrections to reduce the contribution of the instrument.

A reliable solution for calibrating the polarization measurements is represented by the 45° calibration. This calibration implements a 45° rotation of the polarization analyzer (PBS and the PMTs) with respect to the polarization plane of the laser in order to equalize the light intensity in the cross and parallel channels. When comparing the calibration signals, the ratio between the transmitted and reflected signals reflects the contribution of optics and electronics in the lidar receiving unit. The main source of uncertainty involved in this kind of calibration is represented by the accuracy which determines the 45° rotation with respect to the true zero position of the PBS. A more advanced solution is to use two subsequent measurements taken by rotating the polarization analyzer at ±45° with respect to the default measuring position (David, et al., 2012). This calibration is called the “±45° calibration”. The calibration constant is determined by using the geometric mean of the two ±45° measurements. The two measurements are designed to compensate each other even for cases in which the 45° rotation uncertainty is large with respect to the initial zero position given by the PBS (Freudenthaler et al., 2009).

Since for the ±45° calibration, the initial zero position reference is not important, a more general solution is to use two subsequent measurements taken by rotating the polarization analyzer with an exact 90° difference between them. This calibration method is called the “Δ90° calibration” and the output is similar to the one from the ±45° calibration (but has a much better accuracy). The ±45° calibration can be considered a particular case of the Δ90° rotation calibration, since the only constraint of this calibration is the 90° angle between the two measurements.

Technically, the Δ90° calibration can be implemented by using a mechanical rotator (holder) that rotates the optical components at fixed Δ90° angles. This calibrator will be called the “Δ90° mechanical rotation calibrator”. A similar approach (same output) can be considered if we use a half-wave plate (HWP) to accurately rotate the emitted or collected light at Δ90°. A third approach of the Δ90° calibration is the use of an additional linear polarizer that can be rotated at fixed Δ90° angles. In this case, the Δ90° rotation will be replaced with the additional linear polarizer.

The calibration modules required to perform the polarization calibration could be based on different technical solutions:

- Mechanical rotator
- Half wave plate rotator
- Polarizer filter

The test procedure is independent on the calibration module used.

6.2. Test procedure

- The polarization calibration measurement must be performed **only at the end of the normal measurements** when all optical components and laser unit had reached thermal stability.
- Leave the lidar unit running **as for a normal measurement**.
- Put **ND filters in front of the cross channel** if the setup requires (the ND filter transmission must be known by additional measurements performed prior to the polarization calibration test).

note: The ND filter transmission value must be known with an accuracy better than 1%

- Turn the polarization calibrator to the **-45° position** with respect to the 0° position.
- Record the data for at least **5 minutes (recommended 10 seconds / profile).**
- Turn the polarization calibrator by exactly 90° to the **+45° position** with respect to the -45° position.
- Record the data for at least **5 minutes (recommended 10 seconds / profile).**
- Do not forget to **remove the ND filter** and return the calibrator to the 0° position.

note: 1. 0° position here is the position of the normal measurement.

The test analysis requires that the polarization calibration is **submitted together with a Rayleigh measurement** and dark measurement profiles (for analogue channels) collected immediately before or after the polarization calibration so that atmospheric conditions are similar.

6.3. Environmental conditions

- The polarization calibration must **not be performed** if the **depolarization of the atmosphere** in the calibration range **changes rapidly**, e.g., in the presence of low clouds.

6.4. Schedule

- The polarization calibration measurement must be submitted to CARS **every 6 months** or **after each instrument upgrade and for every SCC configuration to be tested.**

For scheduled lidar measurements:

- It is advised to perform the polarization calibration measurements **after each lidar switch on/off** (at the end of the measurement set) to verify the stability of the calibration constant.

For continuous lidar measurements:

- It is advised to perform the polarization calibration measurements **two times per day.**

note: Once the stability of the calibration constant is determined, the polarization calibration measurement could be performed once per week (in case of continuous operating lidar instruments).

6.5. Internal analysis

- The internal analysis made by the AHL operator should be performed using the ATLAS software.
- Information on how to process and analyze the QA tests using the ATLAS software is provided in the user manuals and the dedicated CARS training courses.

Example

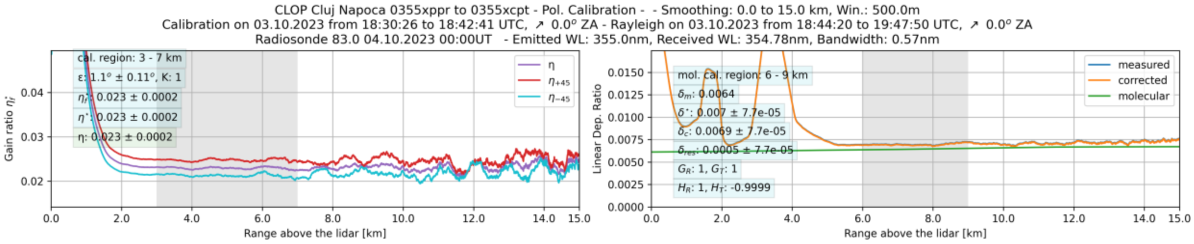

Figure 5: The gain ratio signals retrieved with the Atlas tool for 355xcpt channel. The corrected linear depolarization ratio (orange line – right plot) is similar to the measured linear depolarization ratio (blue line – right plot). Deviation from the molecular is 0.0005±7.7e-5.

6.6. Filling the maintenance logbook

- All QA tests performed on the AHL must be recorded in a dedicated maintenance logbook. A template of this logbook is provided in the following link.
- The logbook must be stored in the dedicated station folder provided by CARS.

7. Rayleigh fit test

7.1. About the test

The comparison of lidar signals in clean air ranges with the signals calculated from air density and temperature profiles from radiosondes is the only absolute calibration of lidar signals. To be able to calibrate lidar signals with the so-called Rayleigh (molecular) backscatter signals, the optoelectronic detection systems must have a high dynamic range.

The Rayleigh-fit is a normalization of the range corrected lidar signal to the calculated attenuated molecular backscatter coefficient (βm attn, Rayleigh signal) in a range where we assume clean air without aerosols and where the calculated signal fits the lidar signal within the noise limits.

7.2. Environmental conditions

- The Rayleigh fit test is an extended normal lidar measurement performed in clear atmospheric conditions - **without cirrus clouds**.
- The test must be **performed using the same lidar setup** as for normal measuring conditions.

7.3. Test procedure

The Rayleigh fit test signals are preprocessed similar to a normal measurement, and therefore it is mandatory to collect a Dark signal before each test for all analogue channels. In case of photon counting channels, the additional dark signal is not required.

- Collect at least **1 hour measurement** (**recommended 10 seconds/profile** is advised).

In case of ***polarization channels****, it is advised to collect the Rayleigh signal in the* ***calibration mode position*** *(either +45° or -45°) to compare the two signals during the test analysis and to reduce the atmospheric variability.*

For **analogue channels**:

- **Cover the telescope** so that no light reaches the detection unit (either using a mechanical cover or an automatic shutter).
- Collect a statistically representative **Dark measurement** for your instrument (**5-10 minutes** as a general rule).
- **Remove** the telescope **cover** (or open the shutter).

notes: 1. ***Radiosonde data*** *or* ***model data*** *must be* ***provided****.*

2. The radiosonde/model data must be ***less than 18 hours after/before the end/beginning of the Rayleigh*** *measurement in ascii or in SCC netcdf radiosonde format.*

3. If the radiosonde site is more than 50 km away from the AHL location, ***modeled data is preferred****.*

4. Even if the Rayleigh fit test is performed for a ***daytime configuration****, the test can be performed during nighttime in stable atmospheric conditions.*

7.4. Schedule

- The Rayleigh test must be performed and submitted to CARS **every 6 months** or **after each instrument upgrade**.

7.5. Internal analysis

- The internal analysis made by the AHL operator should be performed using the ATLAS software.
- Information on how to process and analyze the QA tests using the ATLAS software is provided in the user manuals and the dedicated CARS training courses.

Example

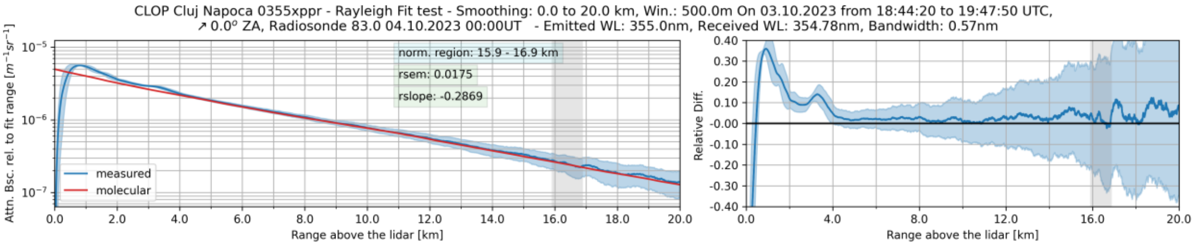

Figure 5: Left: Photon counting lidar signal (blue) averaged over 1 h and calculated Rayleigh signal (red) from local radiosonde data of the same night (normalization around 16km). Right: the relative deviation from the calculated Rayleigh signal.

7.6. Filling the maintenance logbook

- All QA tests performed on the AHL must be recorded in a dedicated maintenance logbook. A template of this logbook is provided in the following link.
- The logbook must be stored in the dedicated station folder provided by CARS.

8. Zero bin test

8.1. About the test

A trigger-delay between the actual laser pulse emission and the assumed zero range of the signal recording (zero bin) can cause large errors in the near range signal up to about 1 km range. Especially the inversion of the Raman signals can be distorted dramatically, because the signal slope in the near range changes very much when the zero-bin for the range correction is varied. Hence it is worth some effort to verify that the zero-bin is really where we assume it to be.

In case pre-trigger samples are recorded, the zero-bin can easily be detected due to the signal peak from stray light diffusely reflected from the laboratory walls. As the distance to the laboratory walls is not well defined, a diffuse scattering target blocking the laser path (see Fig. 6 top) can be used together with a small hole aperture above the telescope to decrease the signal height to within the detection range of the detectors.

In case no pre-trigger samples are recorded, the zero-bin can be detected by means of a near range target with a known distance to the lidar. Alternatively the sufficiently attenuated outgoing laser pulse can be fed into an optical fiber with sufficient length s and the fiber output positioned at the aperture of the telescope (see Fig. 6 bottom). White open-cell foam often used for instrument packing and a piece of cheap communication fiber (see Fig. 7) served us well for this purpose. With this a signal pulse can be measured with a delay $dt = s / v = s / c * n$ with respect to the outgoing laser pulse, with c = speed of light in vacuum, v = speed of light in the fiber with refractive index n at the wavelength of the receiver channel. (sections from Freudenthaler, V., et al., 2018)

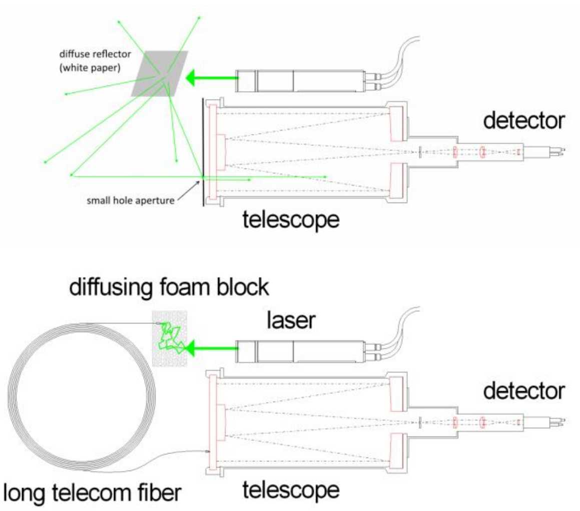

Figure 6: Lidar trigger delay test setup with diffuse reflector (top) close to the laser and (bottom) with a foam block as beam diffuser/attenuator and a fiber delay line to achieve a controlled trigger pulse delay. The fiber must be as short as possible in order to minimize the wavelength dependent (refractive index) delay error (Freudenthaler, V., et al., 2018).

Figure 7: Open-cell foam and communication fiber used for the zero-bin measurement (Freudenthaler, V., et al., 2017).

8.2. Environmental conditions

The environmental conditions are not relevant for this test.

8.3. Test procedure

Elastic channels

Using optical fiber:

- Start the AHL using the **same procedure** as for a normal measurement.
- Place the **telescope cover** so that no light enters the telescope (except the light exiting the fiber end).

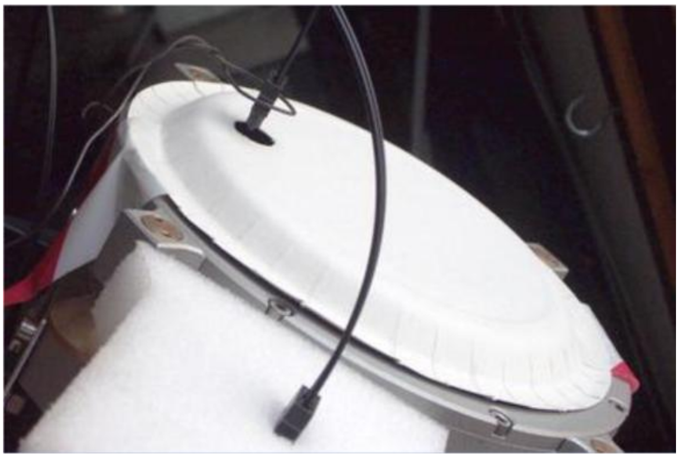

Figure 8: The telescope cover (including the fiber support) (Freudenthaler, V., et al., 2017)

- Place the **other end of the fiber** (with the open-cell foam) **in front of the laser emission**.

Figure 9: Fiber + open-cell foam in front of the laser emission (Freudenthaler, V., et al., 2017).

- Record **100 samples – single shot** profiles if possible. If this is not possible, use the lowest number of shots possible for the recorder.

<u>Using diffuse reflector</u>

- Start the AHL using the **same procedure** as for a normal measurement.
- Place the **telescope cover** so that **only a small part of the diffused light** enters the telescope (see Figure 6, upper).
- Place the **diffuser in front** of the laser **emission**.
- Record **100 samples – single shot profiles** if possible. If this is not possible, use the lowest number of shots possible for the recorder.

note: 1. Check that the maximum signal does not exceed the detection range (100 V) in case of analogue channels and does not exceed the saturation limit in case of photon counting channels. An optimal value should be around 25% of the detection range.

*2. Remember to use **protective glasses**. **Limit the access** to the lidar location while performing the test.*

Inelastic channels

The trigger delay test must also be performed for inelastic channels. Since the trigger delay test is focused on the electronic modules, the elastic PMT/APD detectors could be connected to the inelastic electronic modules to perform the zero bin test for inelastic channels.

- **Switch the signal cables** of the inelastic channels to the PMT/APD of the elastic channels.
- See the test **procedure used** for the **elastic channels**: optical fiber and diffused reflector.
- **Switch back** the signal cables similar to the initial layout.

note: Please see the electronics user manual or contact the electronics manufacturer to get information on how to unplug and plug the signal cable to each detector unit.

8.4. Schedule

- The zero bin test must be performed and submitted to CARS **one time** and **after each instrument upgrade**.

8.5. Internal analysis

- The ATLAS software could be used to visualize the recorded signals and determine the zero bin value.

note: The zero altitude is determined by the first bin of the signal peak (Figure 10).

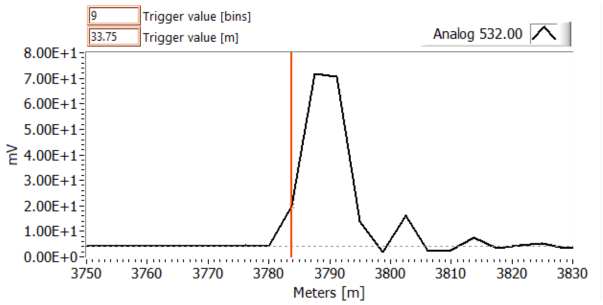

Figure 10 Zero bin assessment: first bin of the signal peak (red line)

8.6. Filling the maintenance logbook

- All QA tests performed on the AHL must be recorded in a dedicated maintenance logbook. A template of this logbook is provided in the following link.
- The logbook must be stored in the dedicated station folder provided by CARS.

9. Extended Dark signal measurement

9.1. About the test

If signal distortions are independent of the lidar signal itself but synchronous with the laser repetition, they can be determined with so-called dark-measurement. The measured dark-signals without atmospheric backscatter from the laser can be subtracted from the normal lidar signals just as the skylight background or the analogue DC-offset, but as a range dependent offset.

The dark measurement is like a normal measurement with laser and Q-switch trigger etc., but with fully covered telescope or a blocking of the optical path inside the receiver with a shutter, so that no light from the atmosphere and from the backscattered laser pulse is collected by the detectors. In such signals we can see EM-interferences from the electro-magnetic laser pulses or other electronic interferences which are synchronous to the laser trigger, but also rests of analogue low frequency noise, which can never be completely removed by means of spatial or temporal averaging.

As there are different sources of such disturbances with different effects on averaged lidar signals, we currently don't have a standardized procedure for the dark measurements and cannot use them for the evaluation of the lidar signal quality in a standardized way. However, if after sufficient temporal averaging of the dark measurement the signal distortions are stable, which means not changing by further temporal averaging, the dark signals can be subtracted from the atmospheric signals to improve their accuracy.

Because it is not practical to make the dark measurements for a timespan comparable to the atmospheric measurements, the subtraction of the dark measurement with the same smoothing length as the atmospheric measurement would considerably increase the signal noise in the far range. On the other hand, with a high dark signal smoothing in the near range the high frequency interspersions could not be removed. We therefore recommend to not smooth the dark signal in the near range and to start smoothing only when it would increase the signal noise. Furthermore, we found that the near range interspersions can change quite fast. Hence it is necessary for each channel to test the temporal stability of the dark signal regularly before using it for signal correction.

9.1. Environmental conditions

The environmental conditions are not relevant for this test.

9.2. Test procedure

The test is generally used for the analogue channels. In case of photon counting channels, the dark measurements should be submitted only once (and after every instrument upgrade) to check if external sources of electronic noise are affecting the signal.

- **Cover the telescope** so that no light reaches the detection unit (either using a mechanical cover or an automatic shutter).
- Collect a **Dark** measurement set (**>30 minutes** as a general rule). It is suggested to use **10 seconds/profile** in order to detect short term fluctuations.
- **Remove** the telescope **cover** (or open the shutter).

9.3. Schedule

- The Dark test must be performed and submitted to CARS **every 6 months** or **after each instrument upgrade**.

note: 1. Even though the Dark measurement is performed before each measurement, the extended 30 minutes Dark measurement should be considered as an additional test.

2. The extended dark test can be submitted together with the Rayleigh fit test.

3. Do not switch off the channels that are not involved in the test since it might change the state of the lidar instrument.

- The **Dark** measurement must be performed **using exactly the same instrument setup** as for the normal measurements, without moving cables or other equipment.

9.4. Internal analysis

- The internal analysis made by the AHL operator should be performed using the ATLAS software.
- Information on how to process and analyze the QA tests using the ATLAS software is provided in the user manuals and the dedicated CARS training courses.

9.5. Filling the maintenance logbook

- All QA tests performed on the AHL must be recorded in a dedicated maintenance logbook. A template of this logbook is provided in the following link.
- The logbook must be stored in the dedicated station folder provided by CARS.

10. QA TEST SUMMARY

QA test	Schedule **(for CARS submission)**	Test details
Extended Dark	Every **6 months** (analogue) After major upgrades (analogue or pc)	**more than 30 minutes** (10 sec/profile)
Telecover	Every **6 months** After major upgrades	**Biaxial Setup** **Dark** measurement for analogue detection (**5-10 minutes)** **+** **Stable** atmospheric conditions: - at least **three consecutive N-E-S-W iterations** (e.g. each iteration must include **10 seconds profiles, 40 seconds / sector**, resulting a **total** averaged profile/sector of at least **120 seconds**). **Un-stable** atmospheric conditions: - at least **five consecutive N-E-S-W iterations** (e.g. each iteration must include **10 seconds profiles, 40 seconds / sector**, resulting a **total** averaged profile/sector of at least **200 seconds**).
		Coaxial Setup **Dark** measurement for analogue detection (**5-10 minutes)** **+** **Stable** atmospheric conditions: - at least **three consecutive N-E-S-W iterations** followed by **three in-out iterations** (e.g. each iteration must include **10 seconds profiles**, **40 seconds / sector**, resulting a **total** averaged profile/sector of at least **120 seconds**). **Un-stable** atmospheric conditions: - at least **five consecutive N-E-S-W iterations** followed by **five in-out iterations** (e.g. each iteration must include **10 seconds profiles, 40 seconds / sector**, resulting a **total** averaged profile/sector of at least **200 seconds**).
Rayleigh fit	Every **6 months** After major upgrades	**Dark** measurement for analogue detection (**5-10 minutes)** **+** **more than 1 hour measurement (recommended: 10 seconds/profile)**
Polarization Calibration	Every **6 months** After major upgrades	**±45° measurement (5 minutes** each calibrator position, **recommended: 10 seconds / profile**)
Zero Bin	**Once** After major upgrades	**100 samples – single shot profiles** (or lowest number of shots possible for the recorder)

note: please adapt each QA test based on the specificity of each AHL.

11. ADDITIONAL DOCUMENTS

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