Dark measurement test

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IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
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What is the Dark measurement test?

The **DARK measurement** is a quality assurance test used to **characterize the electronic response** of the lidar detection system **in the absence of any optical signal**

What is the Dark measurement test?

It is designed to highlight:

- **Electronic baseline and noise**,
- **Laser Synchronous* Spurious counts** in photon-counting channels,
- **Laser Synchronous* Systematic Distortions (LSSD)** in the analog signal:

** that appear in sync with the laser firing, even though no photons are detected.*

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These distortions are typically caused by:

- **Crosstalk** between **laser triggering** and **acquisition electronics**,
- **Inadequate grounding** or **shielding**,
- **Induced signals** from high-voltage switching or pulse driver circuits.

Why is it important to perform the Dark test?

The PI needs to be able to identify and subtract* Laser-Synchronous Systematic Distortions (LSSD)

- subtraction is only possible if the distortion pattern is stable and repeatable.

The DARK measurement test is a **mandatory part of lidar QA protocols** (e.g. ACTRIS/EARLINET) because it provides critical insights into the **integrity and stability of the electronic detection chain**. Even though no optical signal is recorded during the test, the information it reveals is essential for ensuring **accurate, traceable, and artifact-free data**.

Freudenthaler, V., *2018*

Why is it mandatory to submit the Dark test?

- for both analog and photon counting

1) Detection of Laser-Synchronous Systematic Distortions (LSSD)

   These distortions **can mimic real atmospheric signals**, especially at short ranges.

2) Evaluation of Photon-Counting Channel Stability

   Detects spurious artificial counts including:

   - Dark counts,
   - Afterpulses,
   - Laser Synchronous Spurious Counts (LSSC)

   Ensures that the counting electronics are not falsely reporting signals.

Freudenthaler, V., *2018*

Why is it mandatory to submit the Dark test?

- for both analog and photon counting

3) Analog Channel Baseline Verification

   Identifies offsets, electronic noise, and LSSD in analog signals.

4) Identifies the **Pre-trigger Region** (or far range region)

5) Instrument **Diagnostics** and Maintenance

   Helps detect:

   - Failing or drifting electronics,
   - Improper shielding or grounding,
   - Temperature-induced instabilities

Freudenthaler, V., *2018*

How to perform the Dark test?

- including extended dark

based on CARS QA procedures

How to perform the Dark test?

- including extended dark

A. Ensure the system is fully powered and configured as for a normal measurement:

   Same high voltage (HV) settings for PMTs/APDs,

   Same acquisition settings, binning, and sampling rate.

(Let the system thermally stabilize before the test !)

B. Suppress Optical Signal

   Close the telescope input to avoid external light (No photons should reach the detectors).

C. Start Acquisition

based on CARS QA procedures

How to perform the Dark test?

- including extended dark

Normal dark (an)

1. Let the laser and acquisition electronics **reach thermal stability**
   - **20-30 minutes**,
2. **Collect dark signal**
   - **15-30 minutes**,
   - high temporal resolution: **10 seconds/profile.**

- Perform before every measurement set (an),
- For continuous: When switching between night-time and day-time (an).

Extended Dark (an + pc)

1. Let the laser and acquisition electronics **reach thermal stability**
   - **20-30 minutes**,
2. Collect dark signal
   - **< 30 minutes,**
   - high temporal resolution: **10 seconds/profile.**

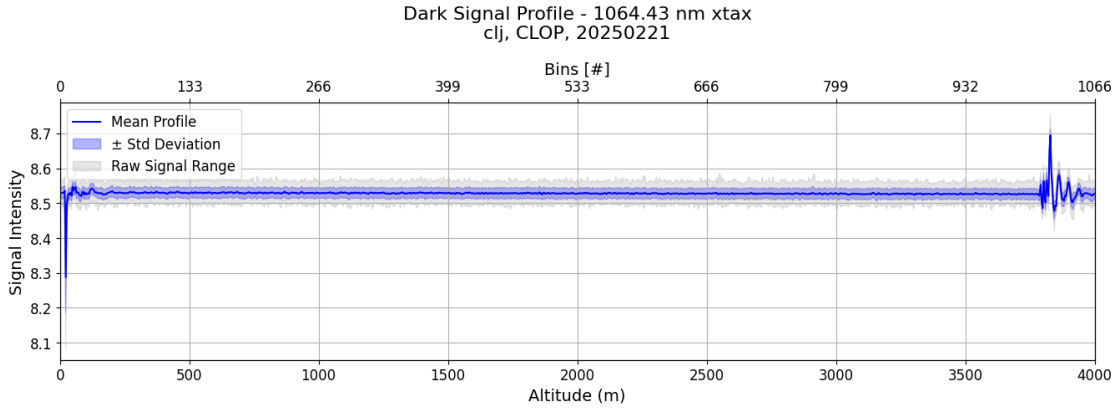
- Submit only once and after each upgrade.

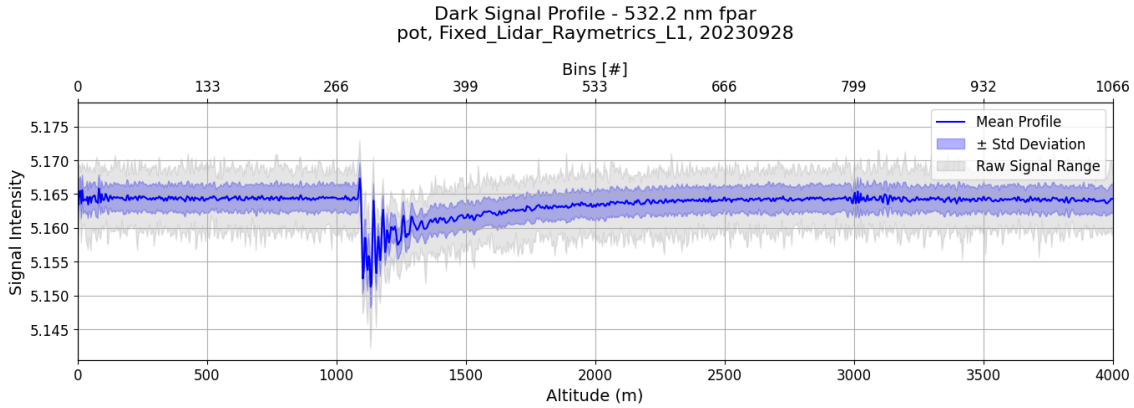
based on CARS QA procedures

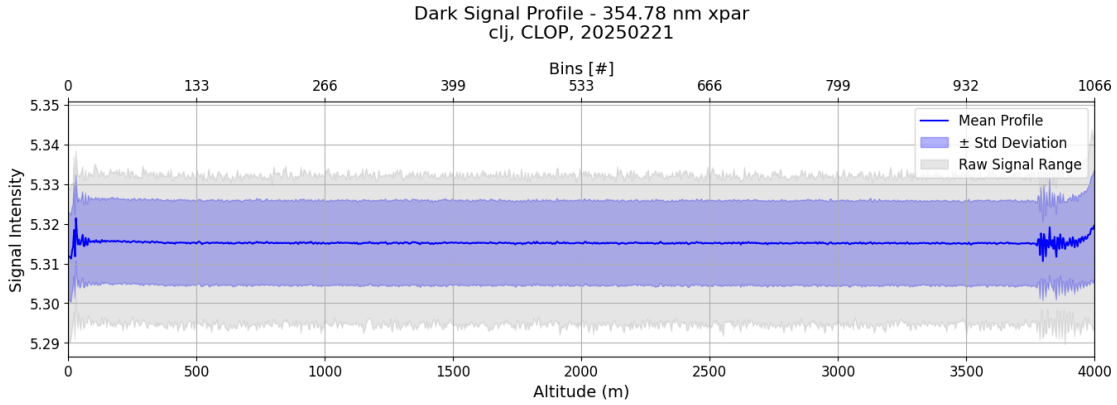
Example Data

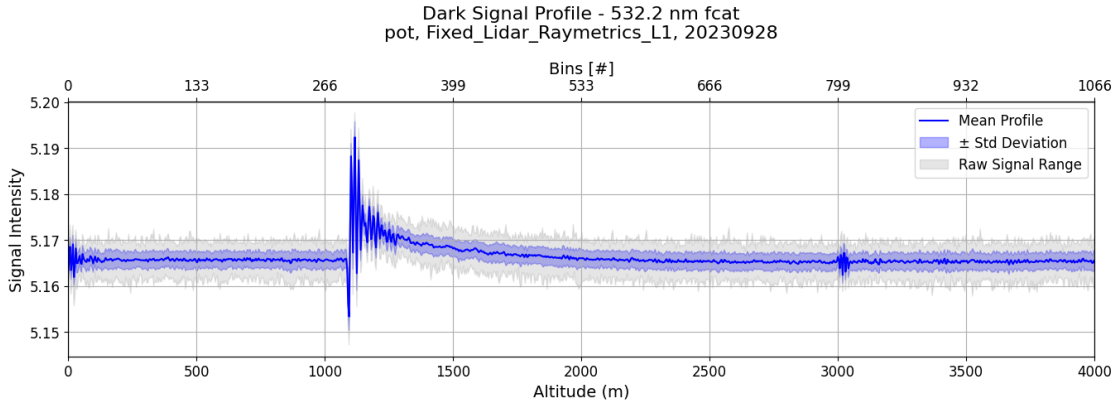
Assessment of pre-trigger region

analog



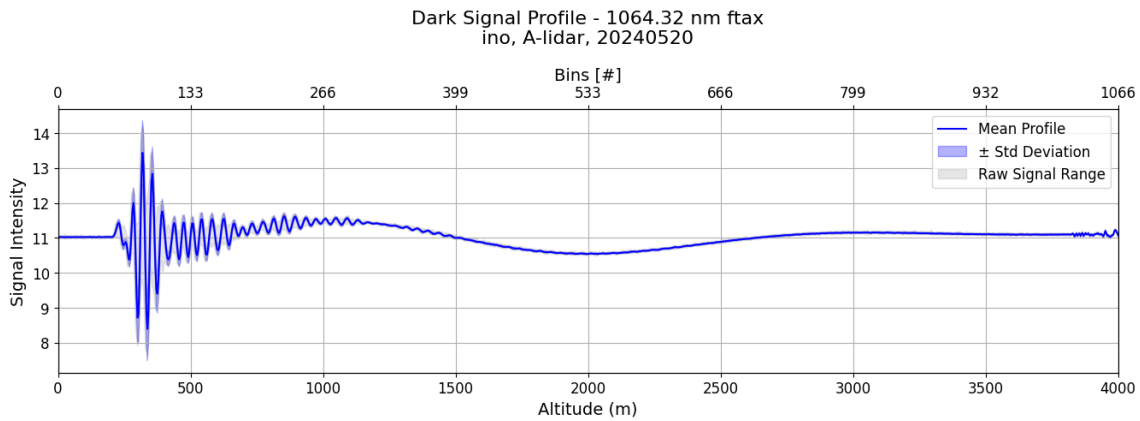


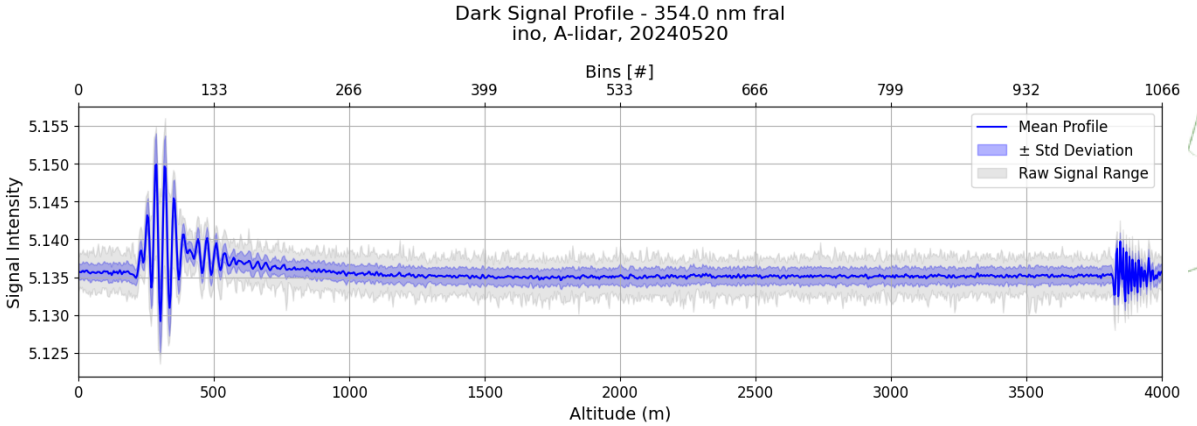


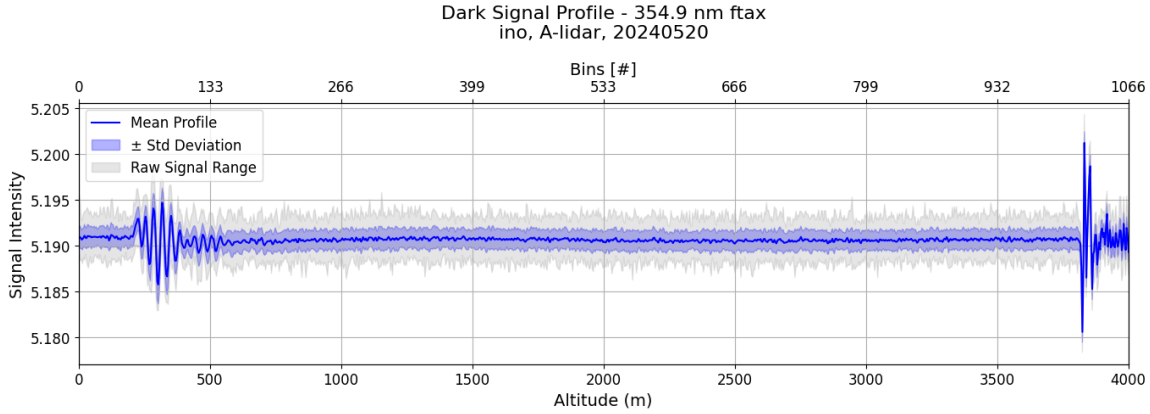


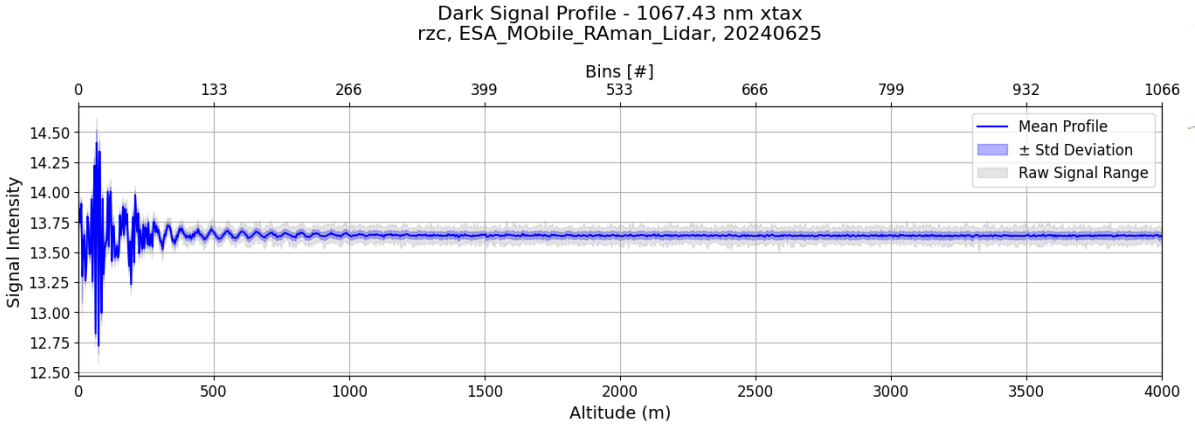
Assessment of pre-trigger region

analog



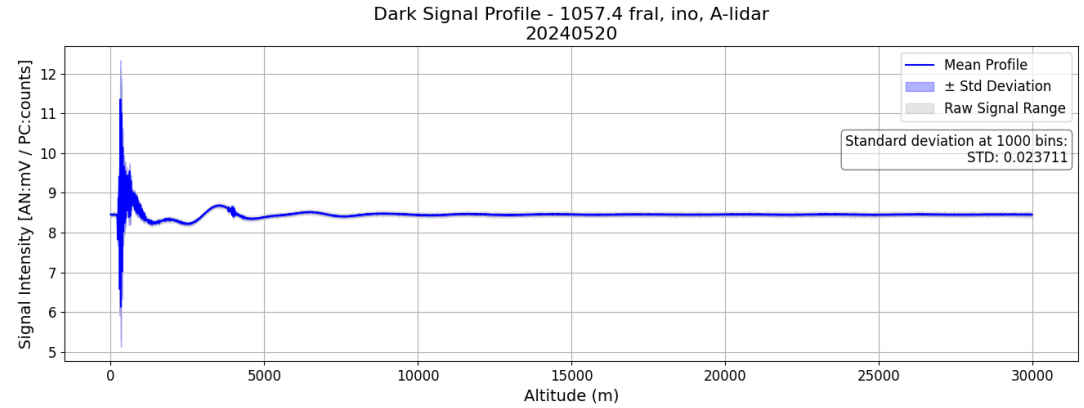


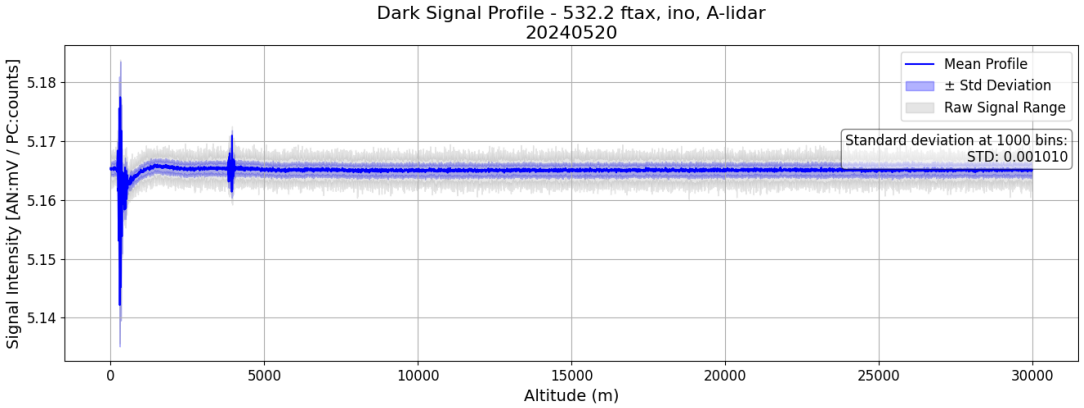




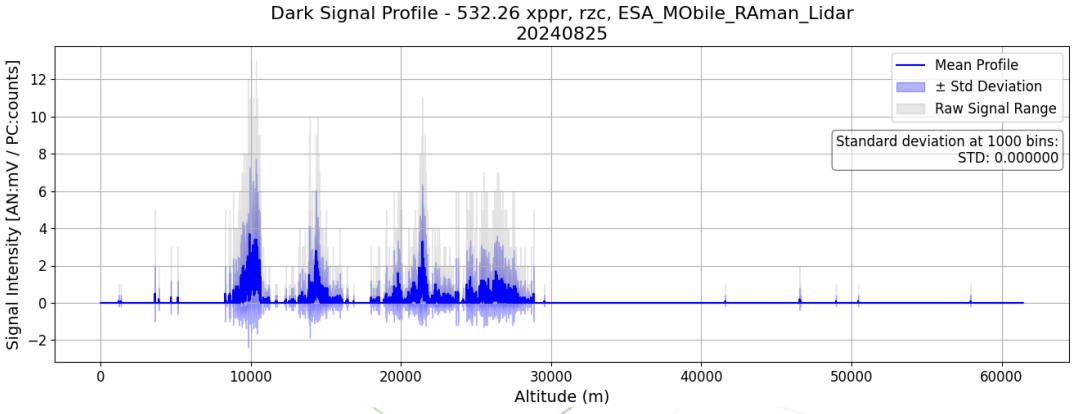
Assessment of dark signal

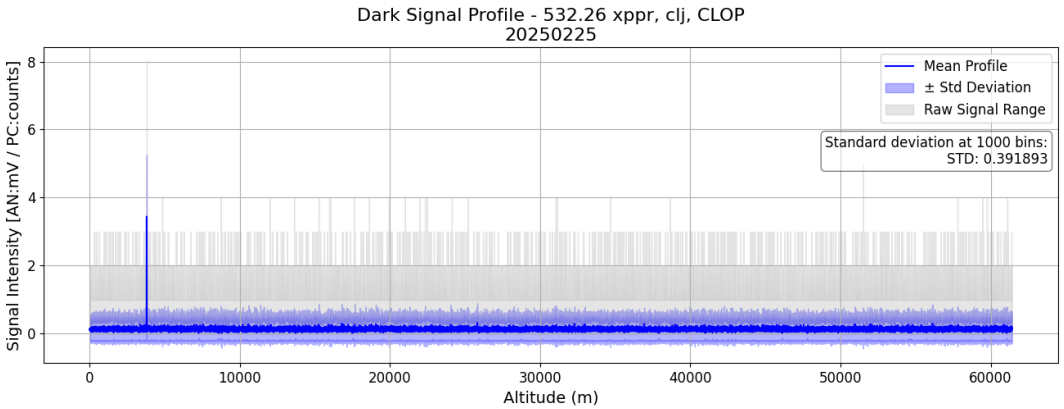
analog





photon-counting





General Recommendations

- Near-range interspersions can change, so it's necessary to **regularly test the temporal stability** of the dark signal for each channel before applying corrections.
- If the dark measurement time is **much shorter** than the atmospheric measurement (e.g., 10 min vs. 1:30 h), subtracting the dark measurement may **increase noise**, especially in the far range. **Smooth the Dark…. but**
- **Do not smooth** the dark signal **in the near range**; start smoothing only where signal noise increases.

THANKS!

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