



Lidar optics 2

ACTRIS CARS Quality assurance (Q&A) -
Alignment camera and Telecover test

Michael Haimerl – m.haimerl@lmu.de

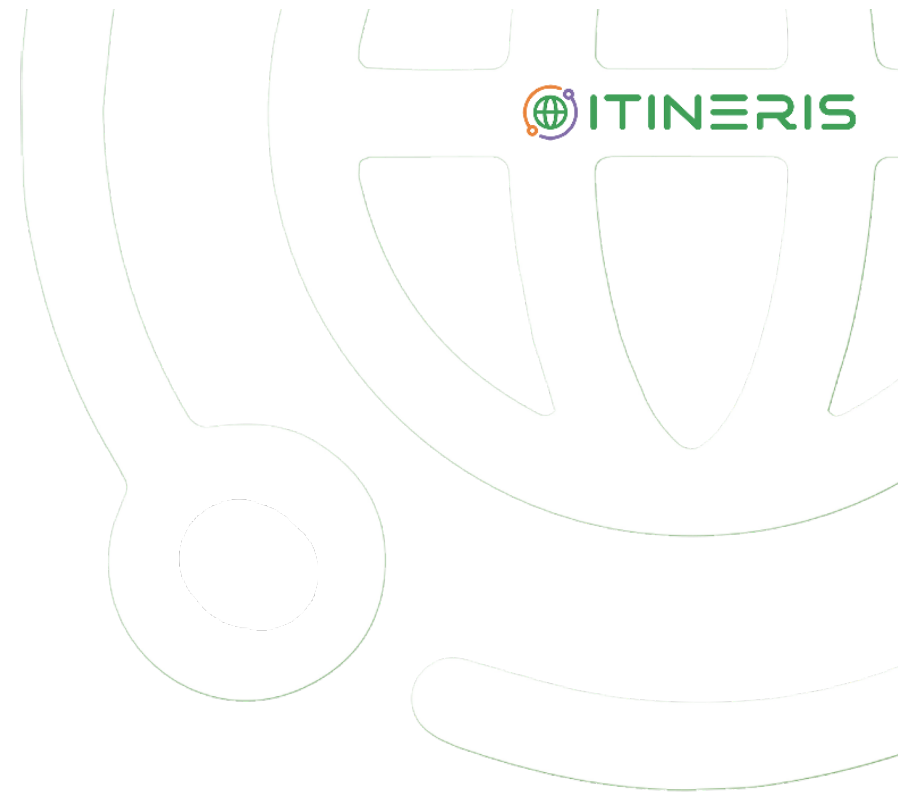
[ACTRIS CARS Ludwig-Maximilians Universität(LMU) München]

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-
Mission 4 "Education and Research" - Component 2: "From research to business" - Investment
3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"



Contents

- Alignment camera
- Telecover test
- Rayleigh fit test (Aldo)
- Zero bin test (Livio)
- Dark measurement (Livio)
- Polarisation calibration (Nikos)



Overview over

a lidar system



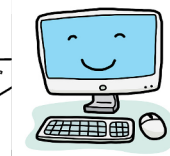
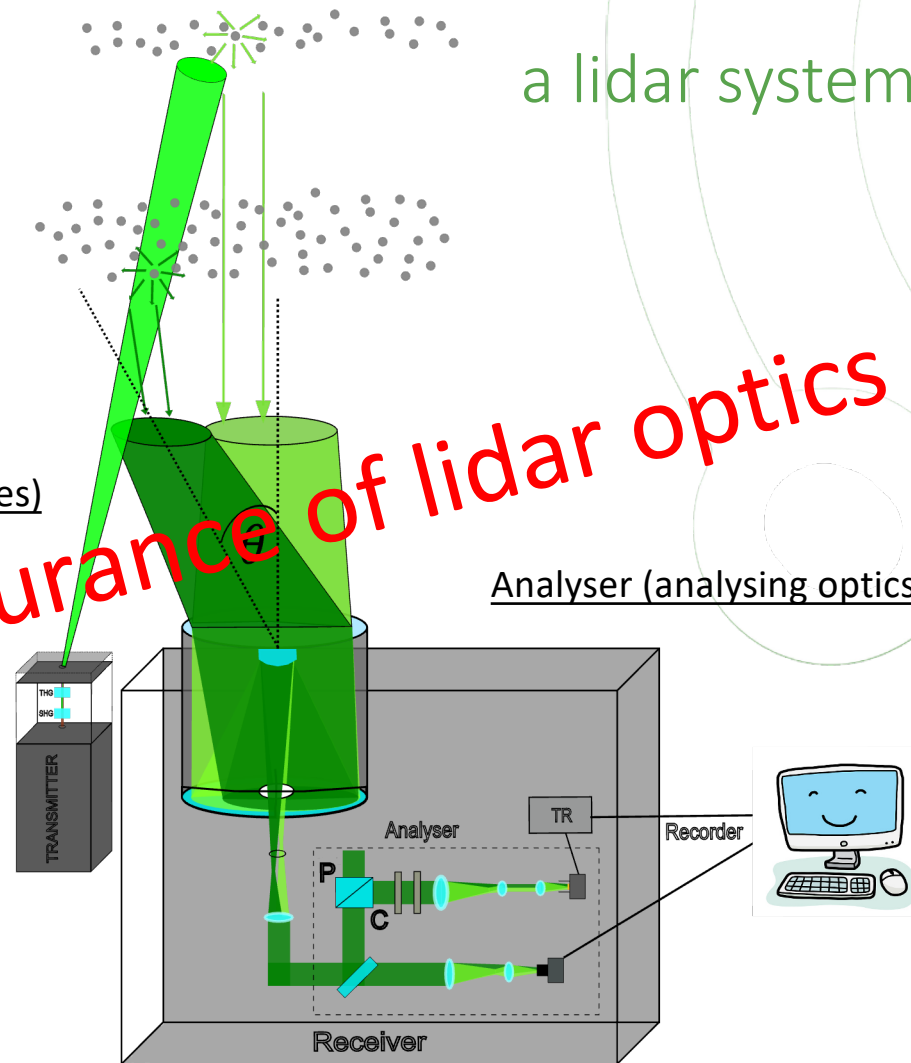
Quality assurance of lidar optics

Receiver (telescope, lenses)

Analyser (analysing optics)

Transmitter(laser)

Recorder

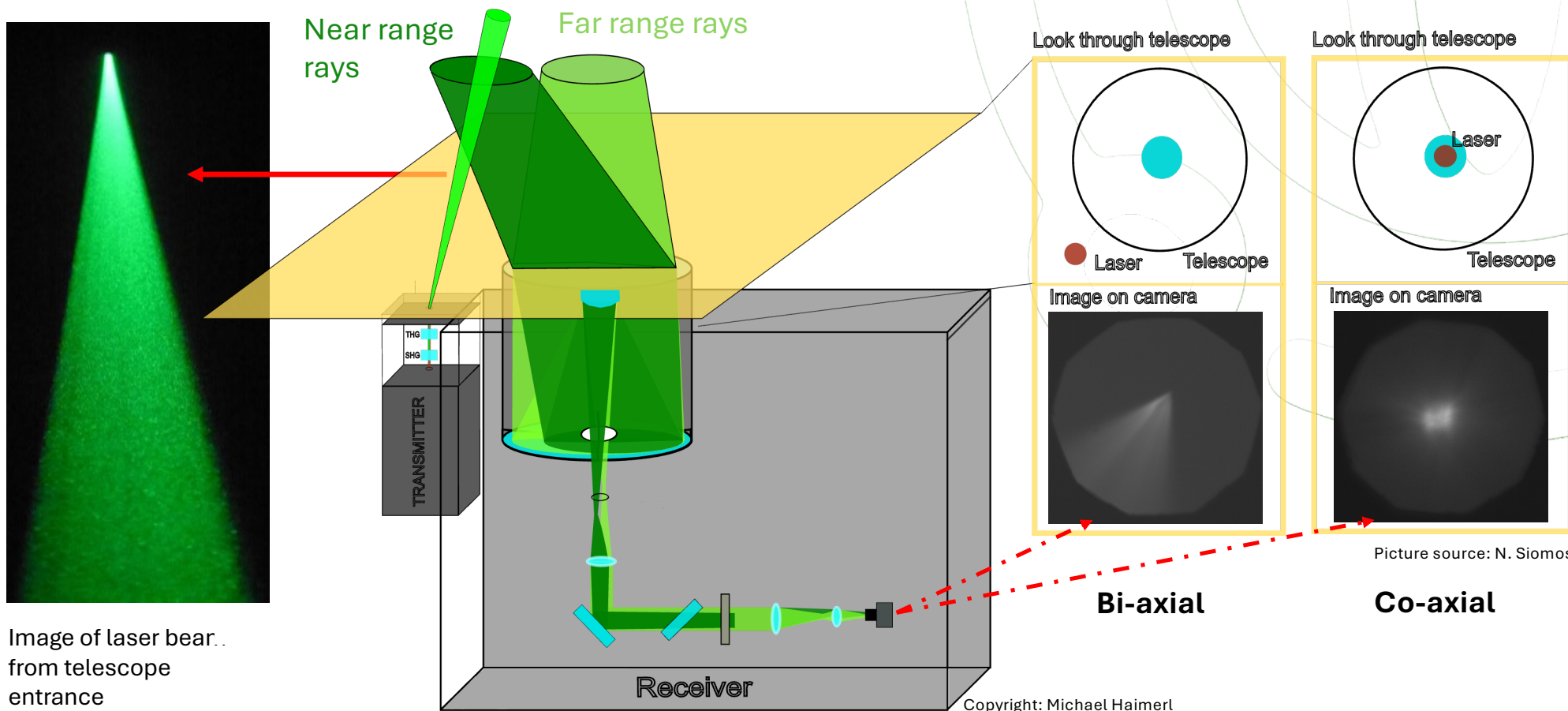


Source:
<https://www.istockphoto.com/de/vektor/moderne-computer-cartoon-gm862739386-143196107>, (Access: 19.03.2025, 11:00 CET)

Alignment camera test

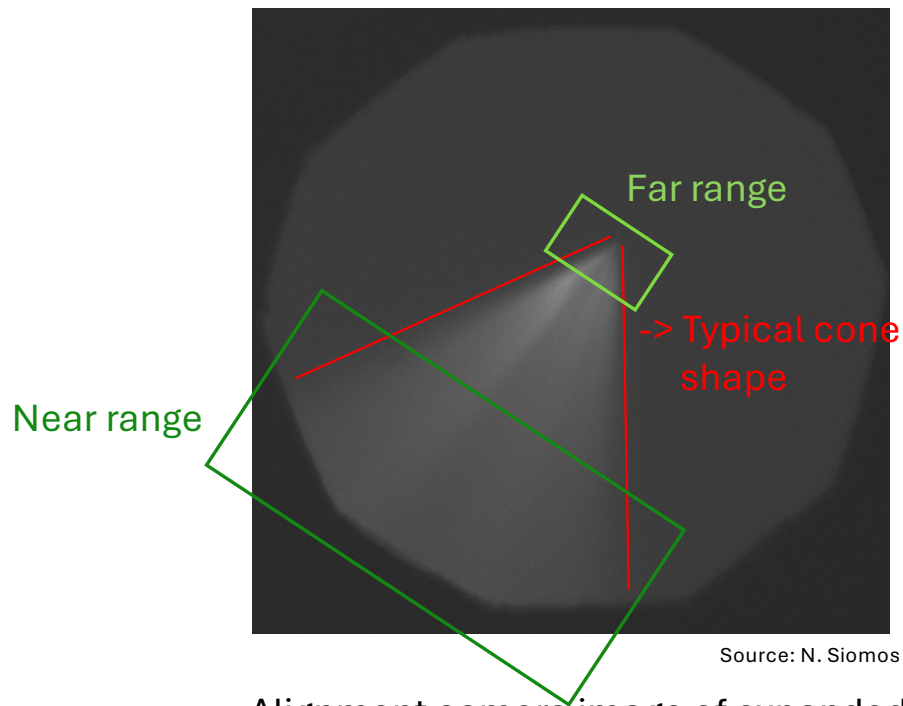
Why?:

- Align laser together with telescope
- Find misalignment in the optical system



Alignment camera test

Bi-axial lidar geometry



Alignment camera image of expanded beam
(Focused to the far range)

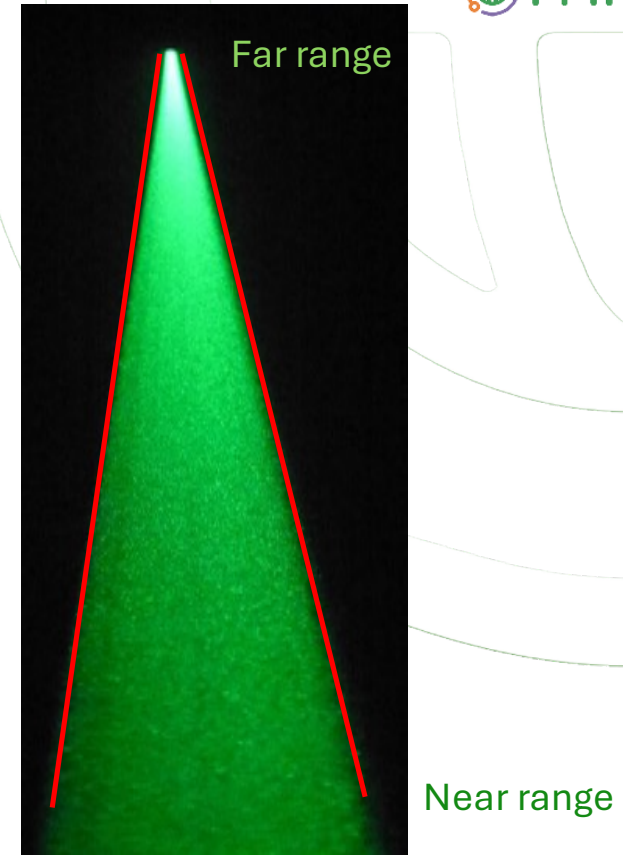
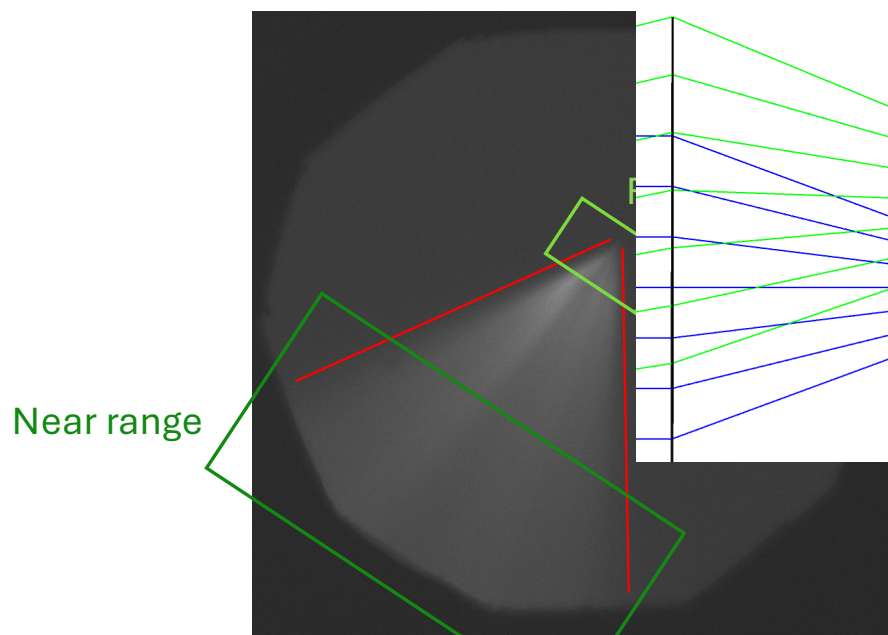


Image of laser beam from telescope entrance

Alignment camera test

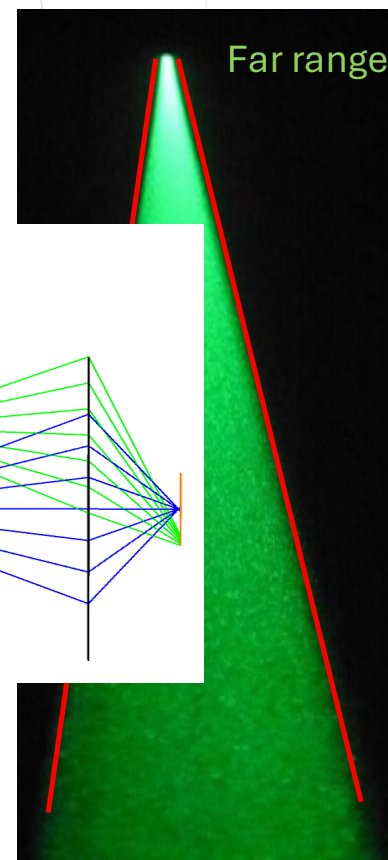
Bi-axial lidar geometry

!!Reminder to imaging with alignment camera!!



Near range

Far range rays
Near range rays



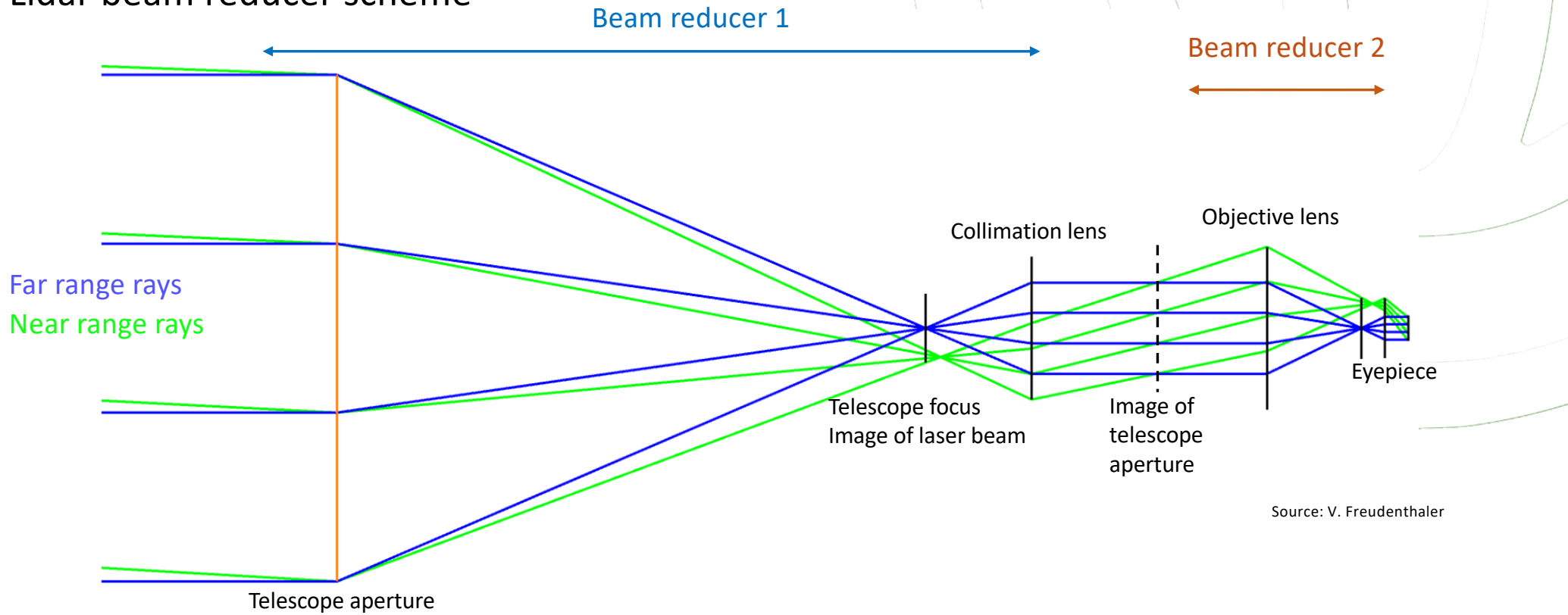
Near range

Alignment camera image of expanded beam (Focused to the far range)

Image of laser beam from telescope entrance

Recorder – Light path

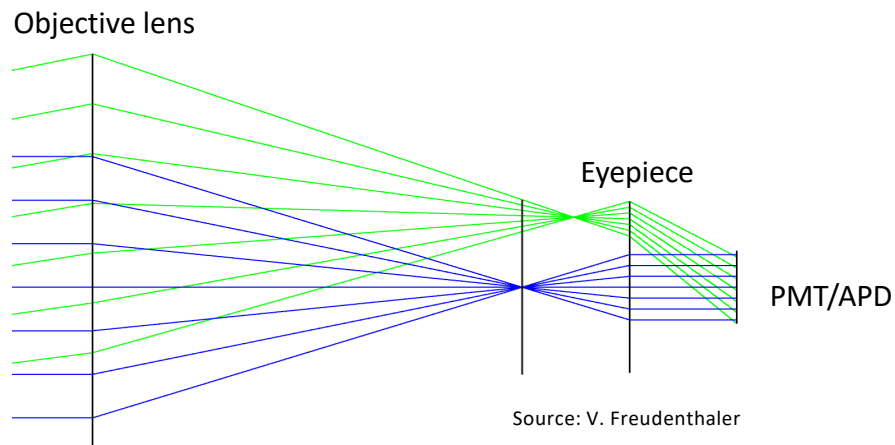
Lidar beam reducer scheme



Source: V. Freudenthaler

Recorder – Light path

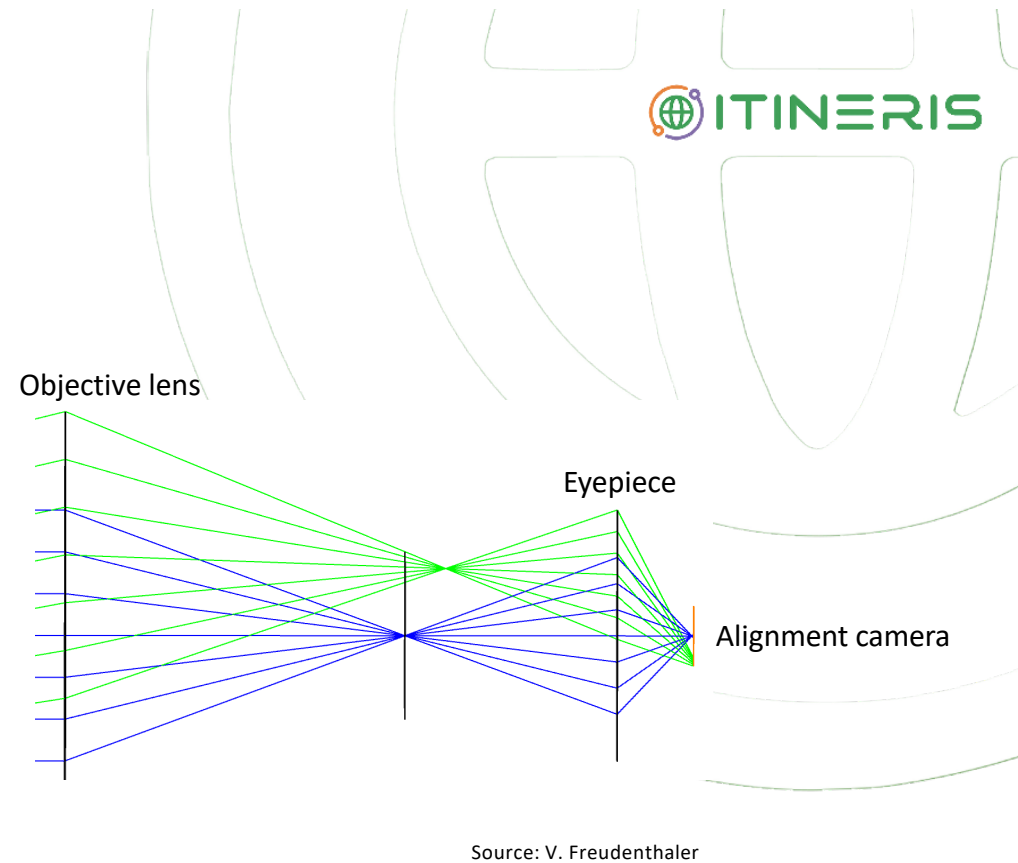
Detectors: PMT/APD vs. alignments camera



Far range rays

Near range rays

-> Image of telescope aperture on PMT/APD

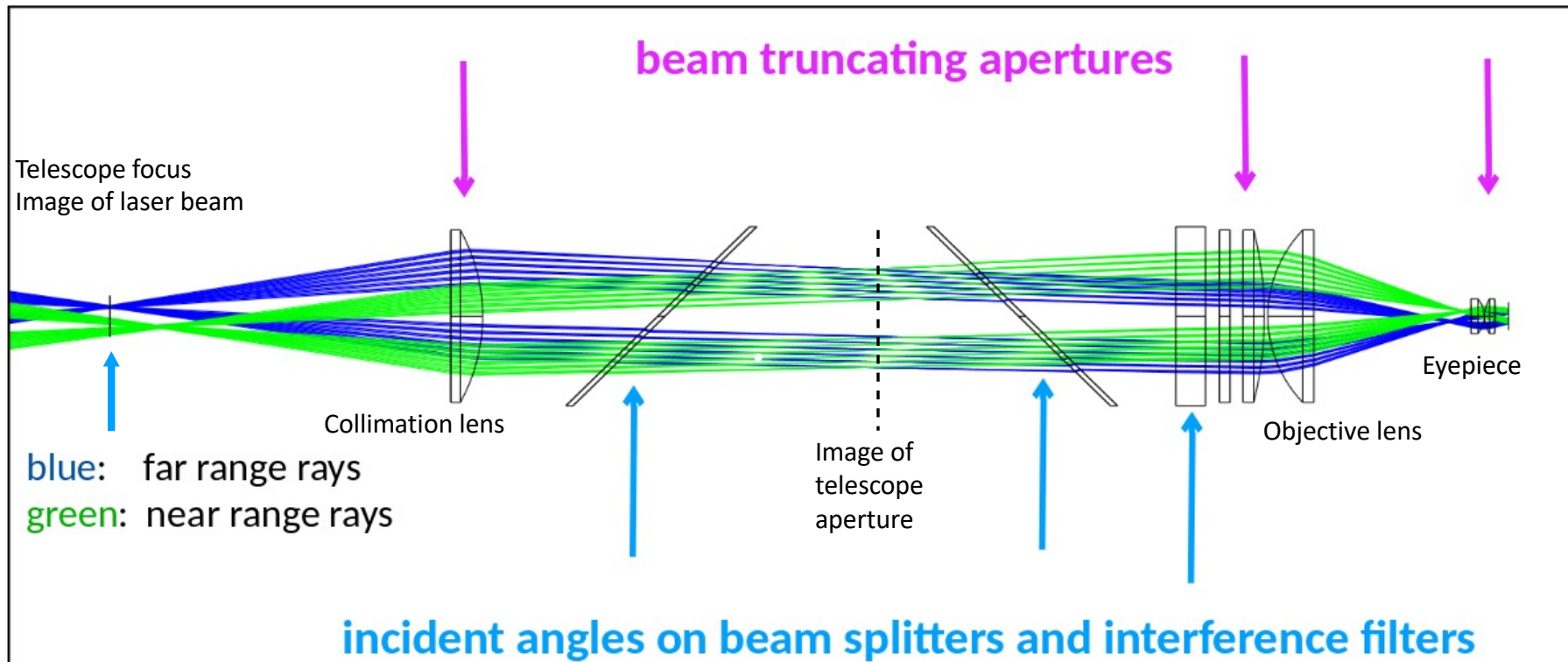


-> Eyepiece defocused

-> Image of telescope focus (laser beam) on PMT/APD

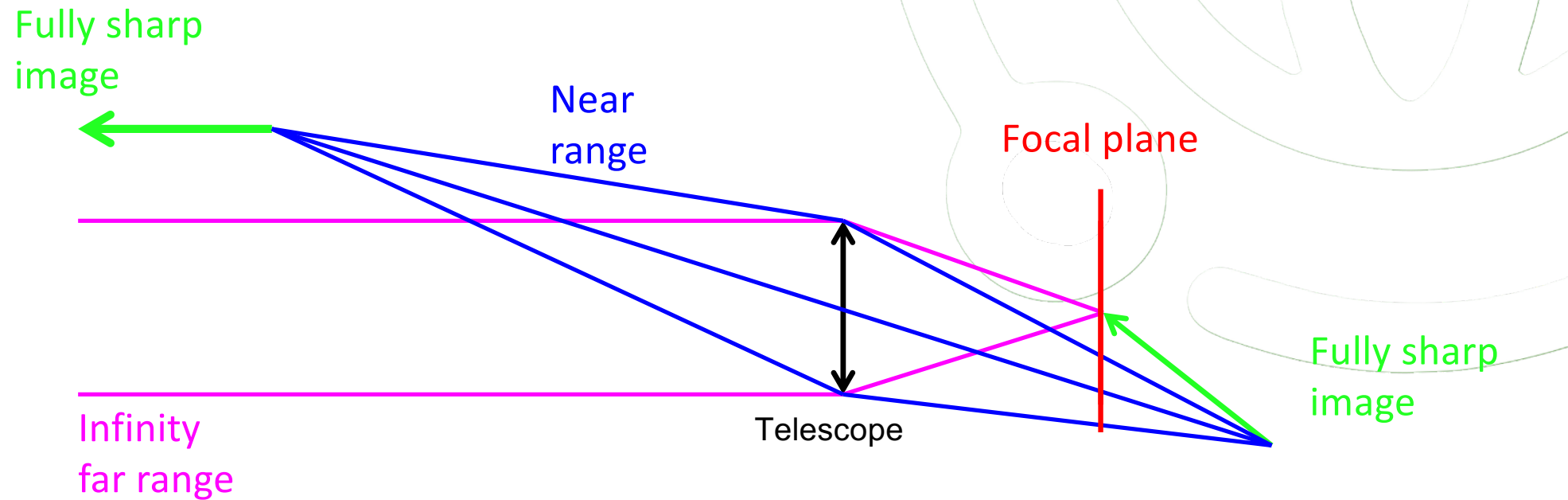
Recorder – Light path

Limitations



Source: V. Freudenthaler

Image of laser beam in telescopes focal plane



Source: V. Freudenthaler

Image of laser beam in telescopes focal plane

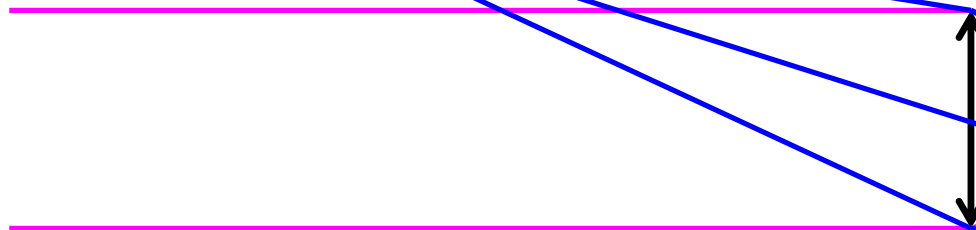
Fully sharp image



Near range

Telescope

Focal plane
Iris diaphragm

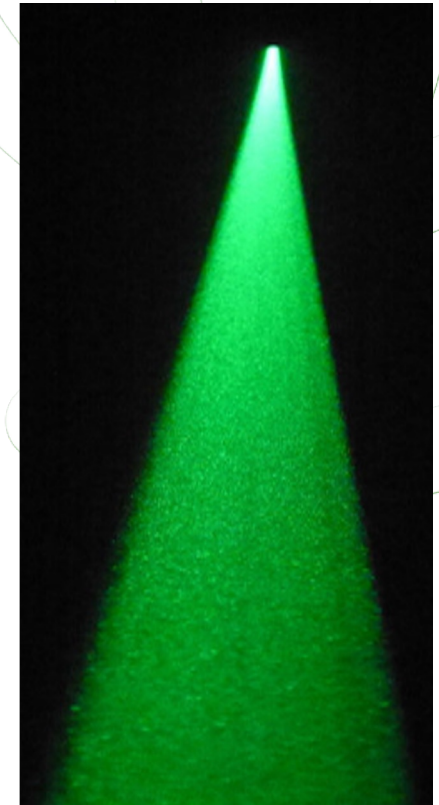
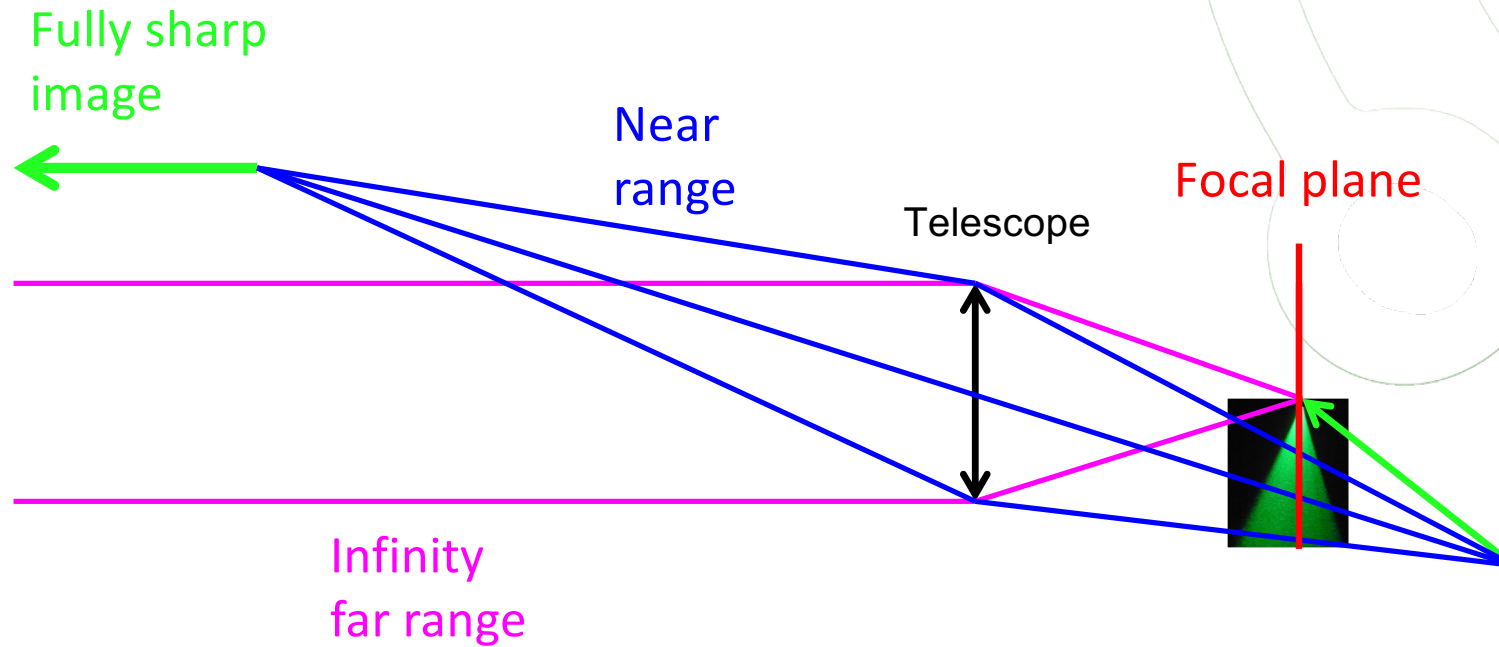


Infinity
far range

Fully sharp image

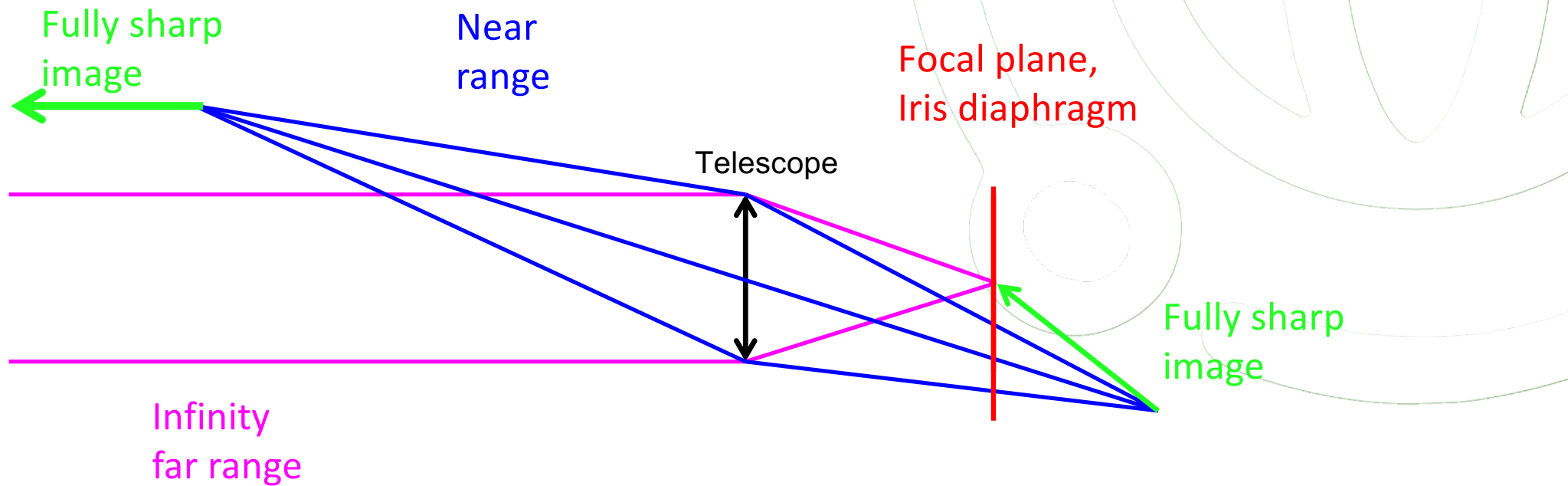
Source: V. Freudenthaler

Image of laser beam in telescopes focal plane



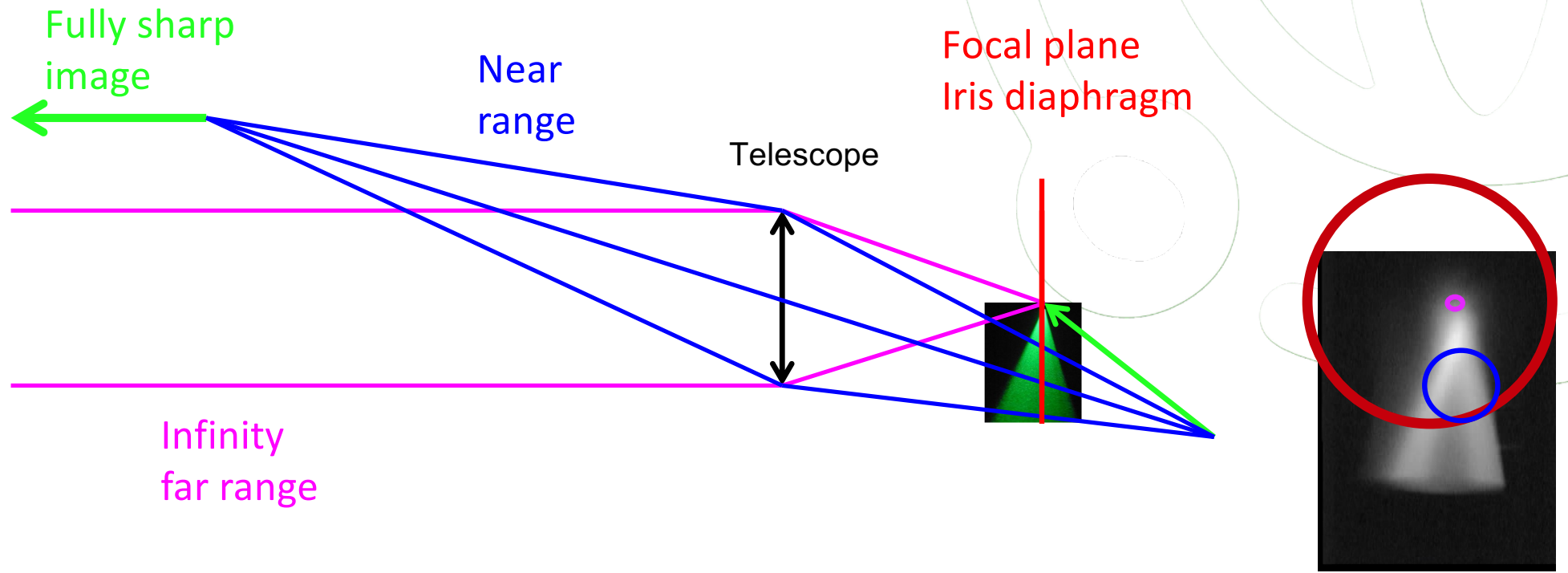
Source: V. Freudenthaler

Focal spot radial/axial position – both change with range



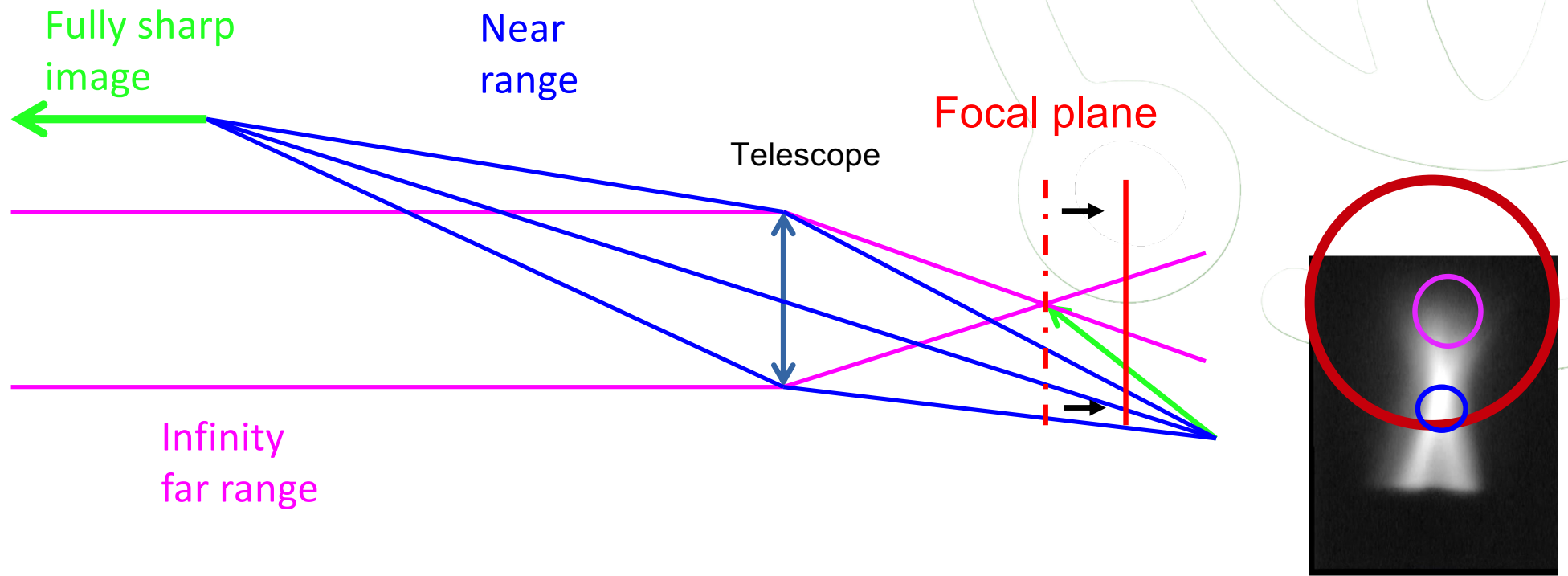
Source: V. Freudenthaler

Image of laser beam on the camera



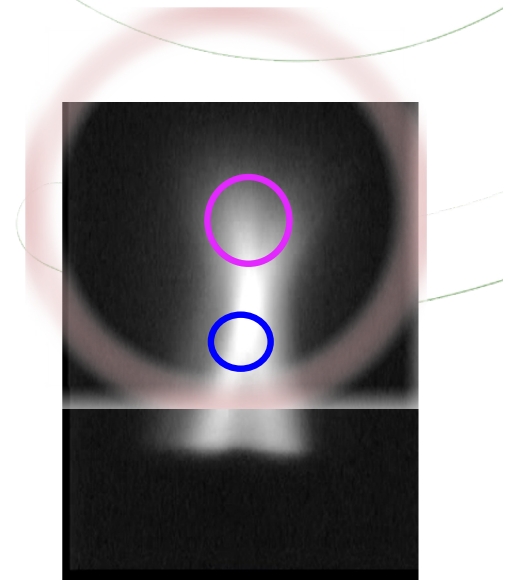
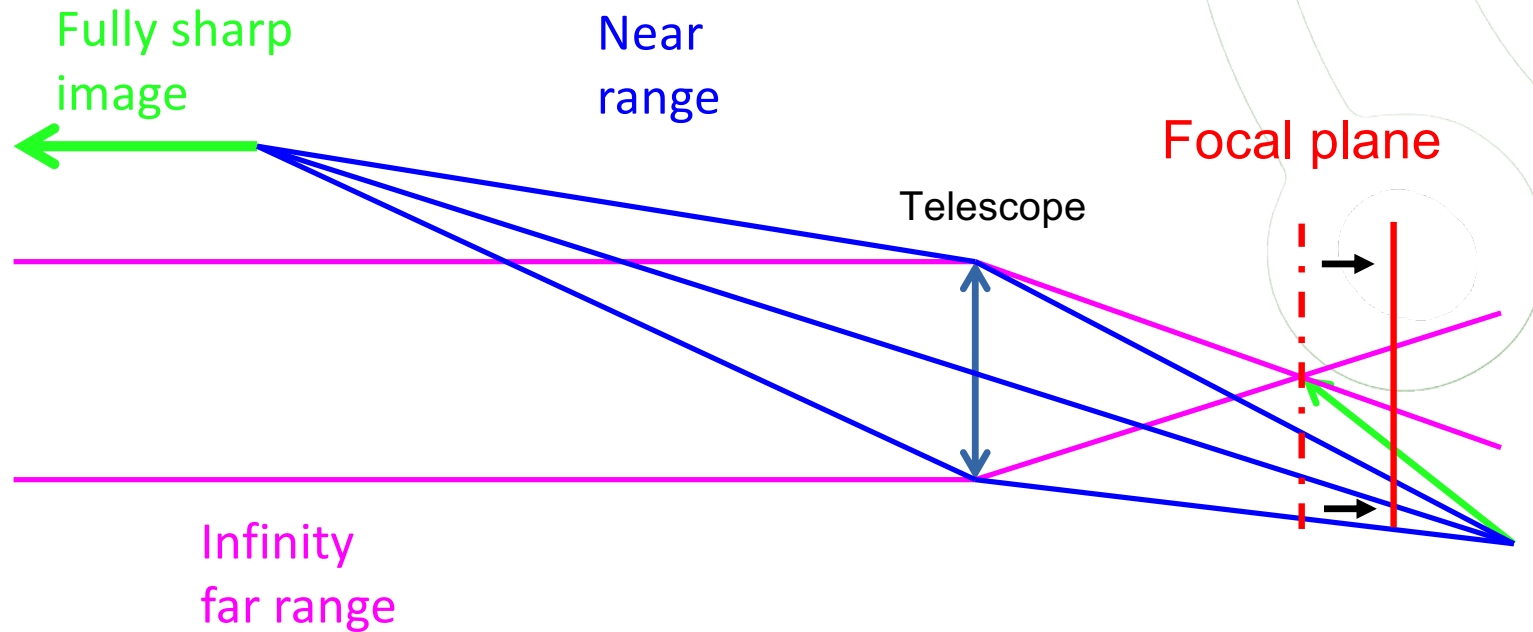
Source: V. Freudenthaler

Image of laser beam **behind** telescopes focal plane



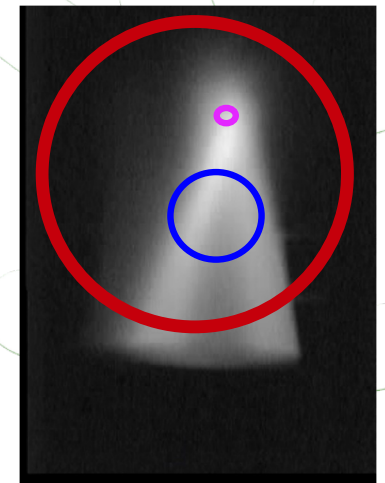
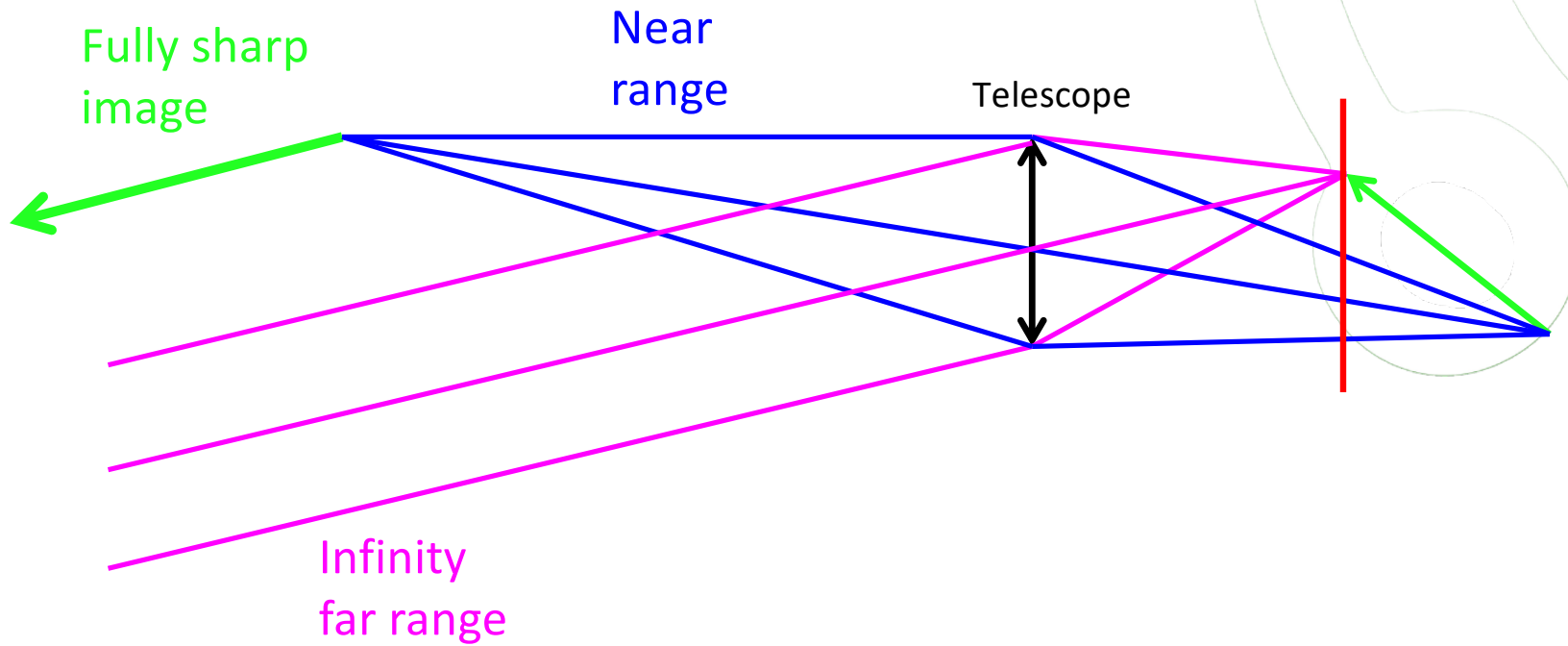
Source: V. Freudenthaler

Image of laser beam **behind** telescopes focal plane with **blurred iris**



Source: V. Freudenthaler

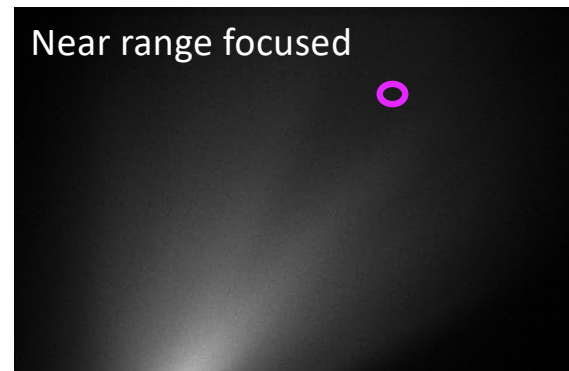
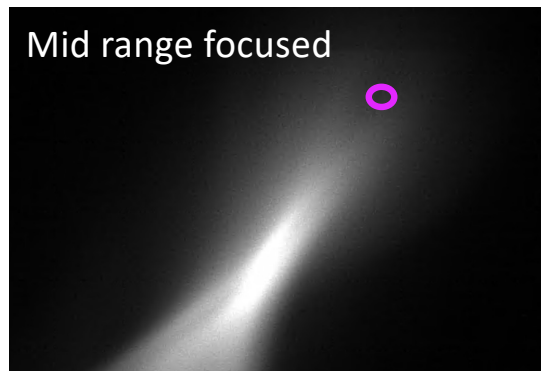
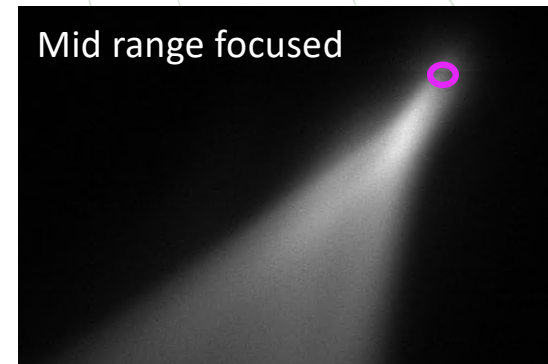
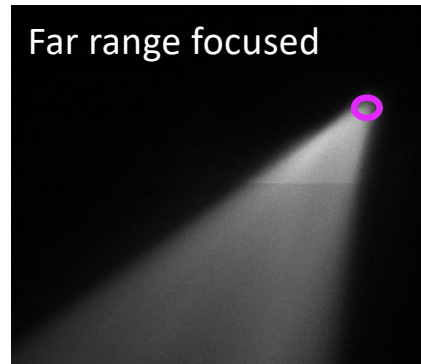
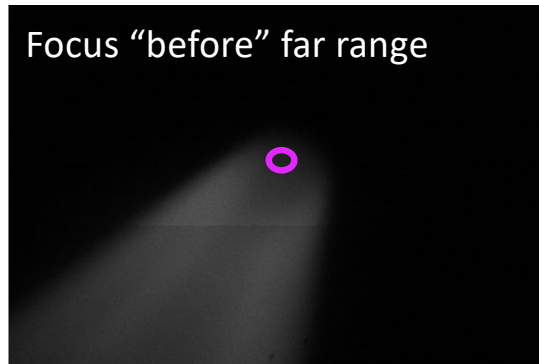
Image of **tilted** laser beam in telescopes focal plane



Source: V. Freudenthaler

Alignment camera test

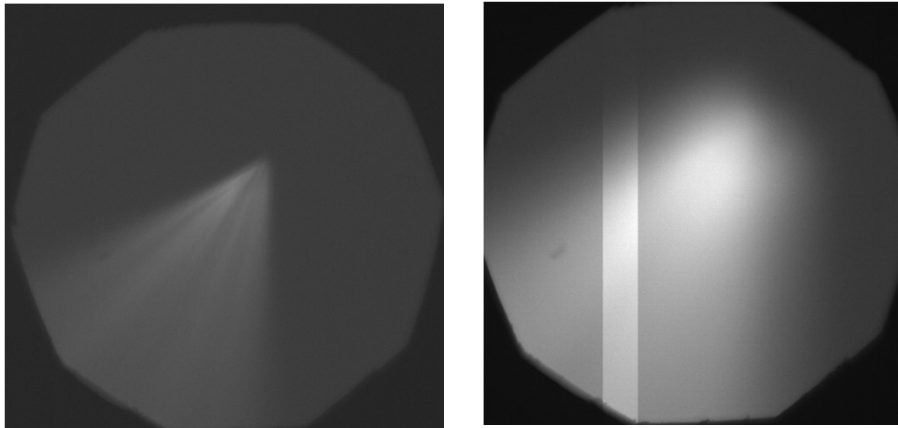
Focusing from the far range to the near range expanded beam:



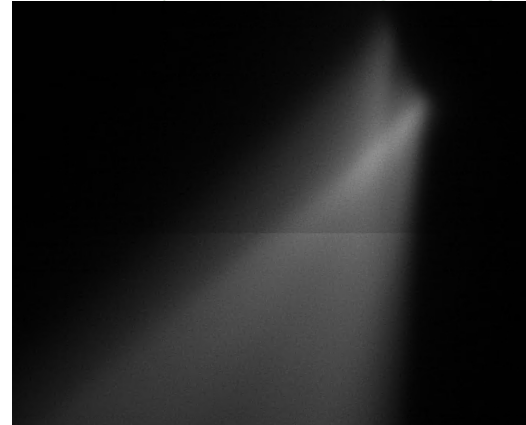
Picture source: N. Siomos

Alignment camera test

Expanded(left)/unexpanded(right) beam:

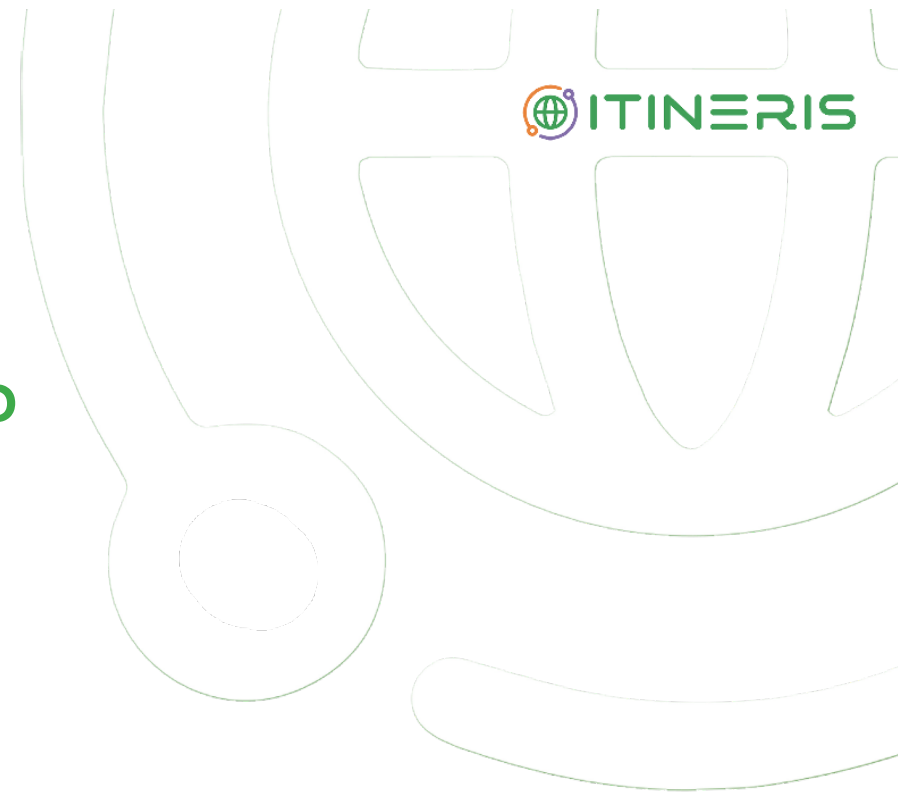


Double spot in beam profile:



Picture source: N. Siomos

Questions?



Telecover test

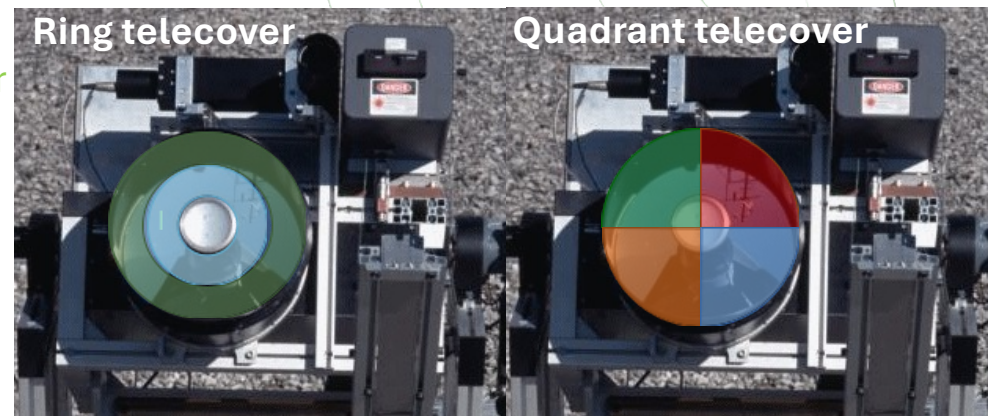
Why?:

- Determine **distance of full overlap (DFO)** (**minimum channel height**)
- Find misalignments in the optical system
- Analyse detector inhomogeneities

How?:

- Telescope divided in different sectors
- Sequential measurements
- **DFO** is obtained by comparing the different sector signals

Inner
Outer

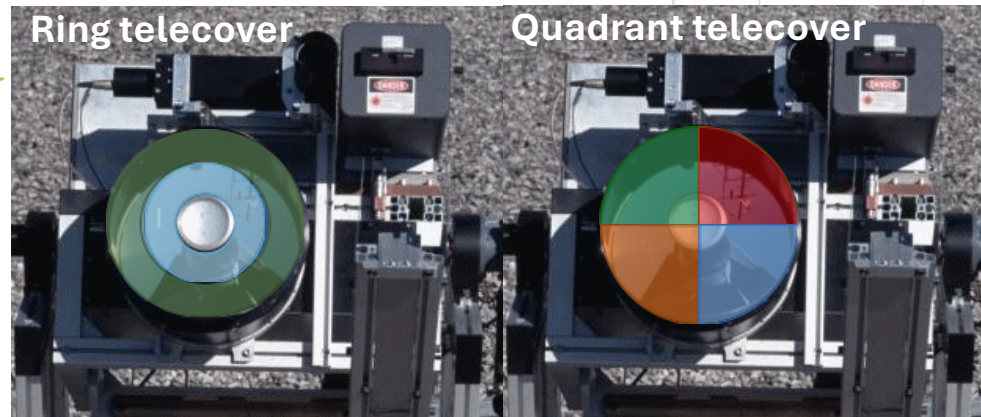


North
East
South
West

Source: N. Siomos, V. Freudenthaler

Telecover test

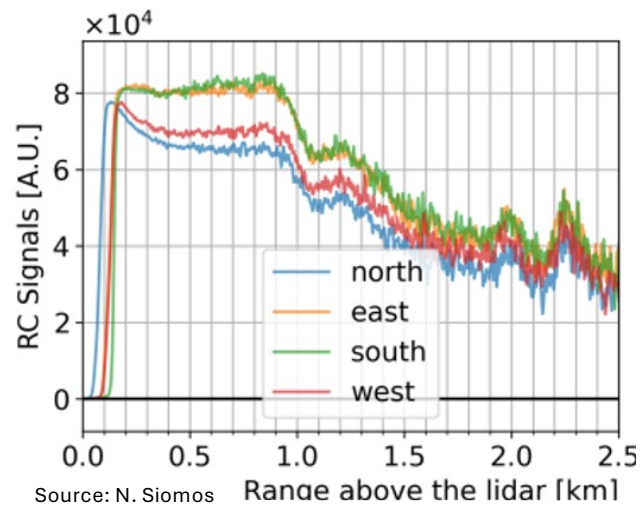
Inner
Outer



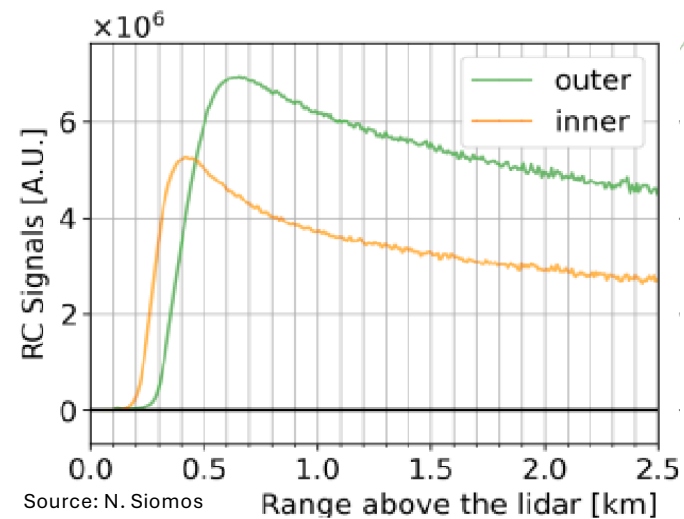
North
East
South
West



Quadrant telecover test
(biaxial systems)

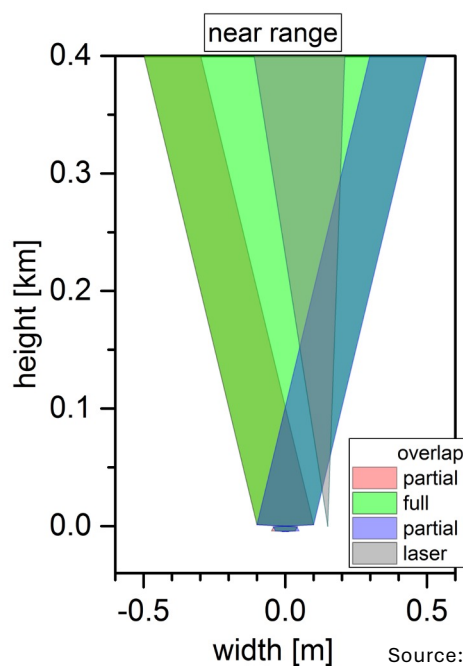


Ring telecover test (coaxial systems)

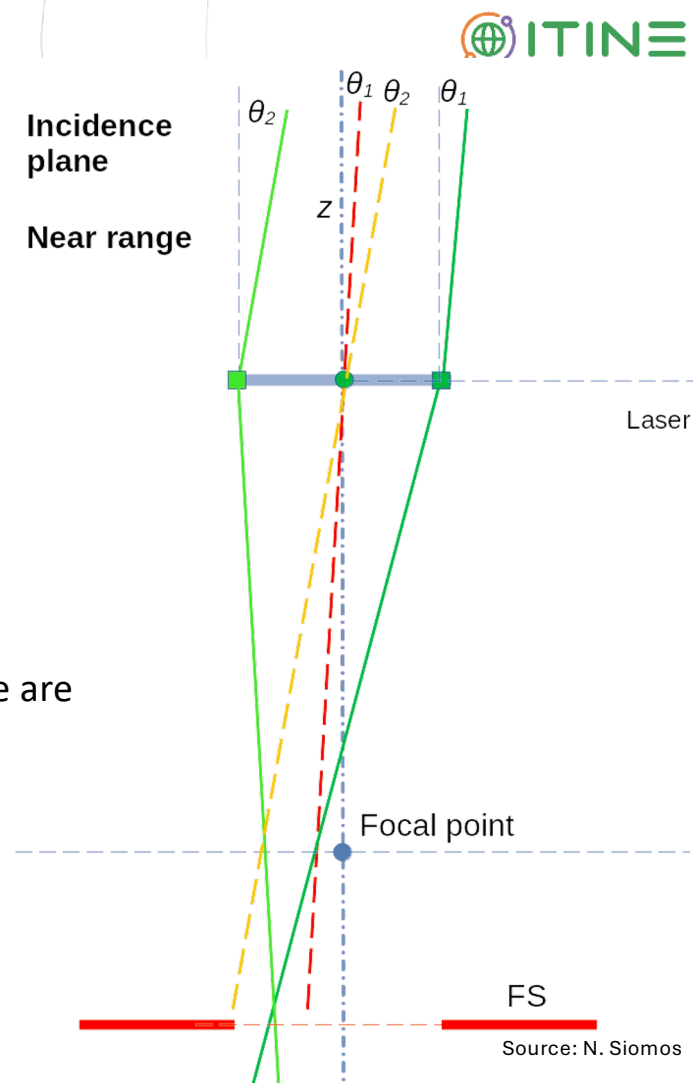


Telecover test

- Situation: Laser beam alignment
- Near range rays arrive at telescope with different angles



Full overlap condition:
All rays emitted from a certain height that reach the telescope are transmitted through the FS

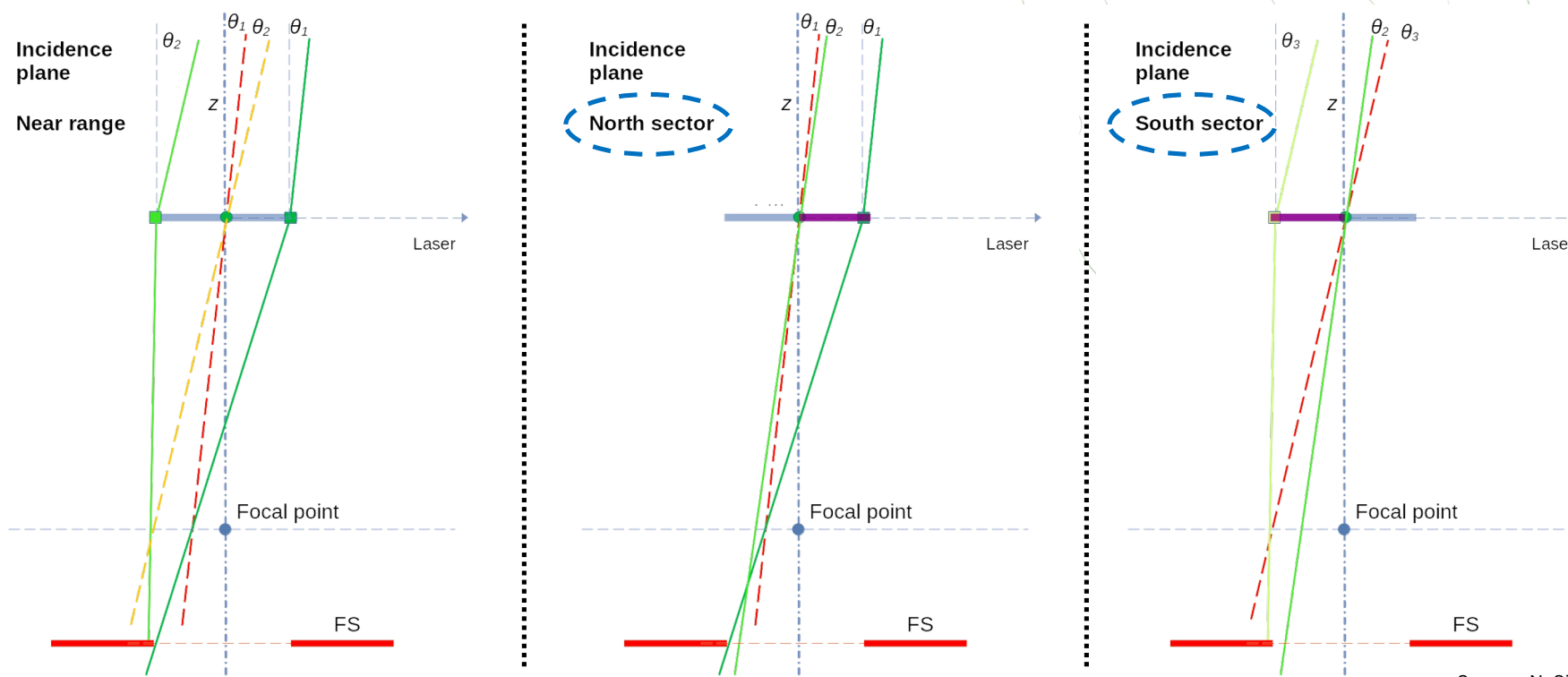


Telecover test

Full overlap (FO) condition:

All rays emitted from a certain height that reach the telescope are transmitted through the FS

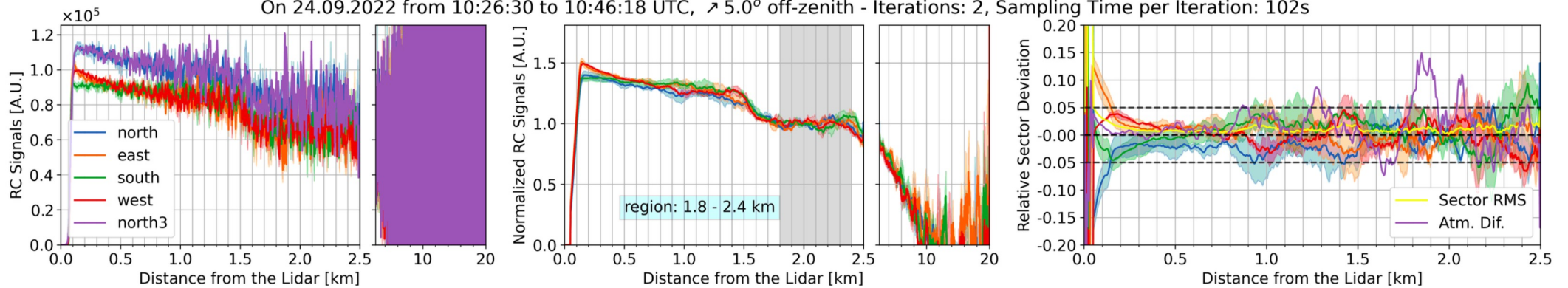
-> Some telescope sectors (e.g. North, Inner) stay longer within FO



Source: N. Siomos

Telecover test – What is shown by such a plots?

POLIS Bucharest 0532xpat - Telecover Test - Smoothing: 0.05 to 2.5 km, Win.: 100.0m | 2.5 to 20 km, Win.: 500m
On 24.09.2022 from 10:26:30 to 10:46:18 UTC, $\nearrow 5.0^\circ$ off-zenith - Iterations: 2, Sampling Time per Iteration: 102s

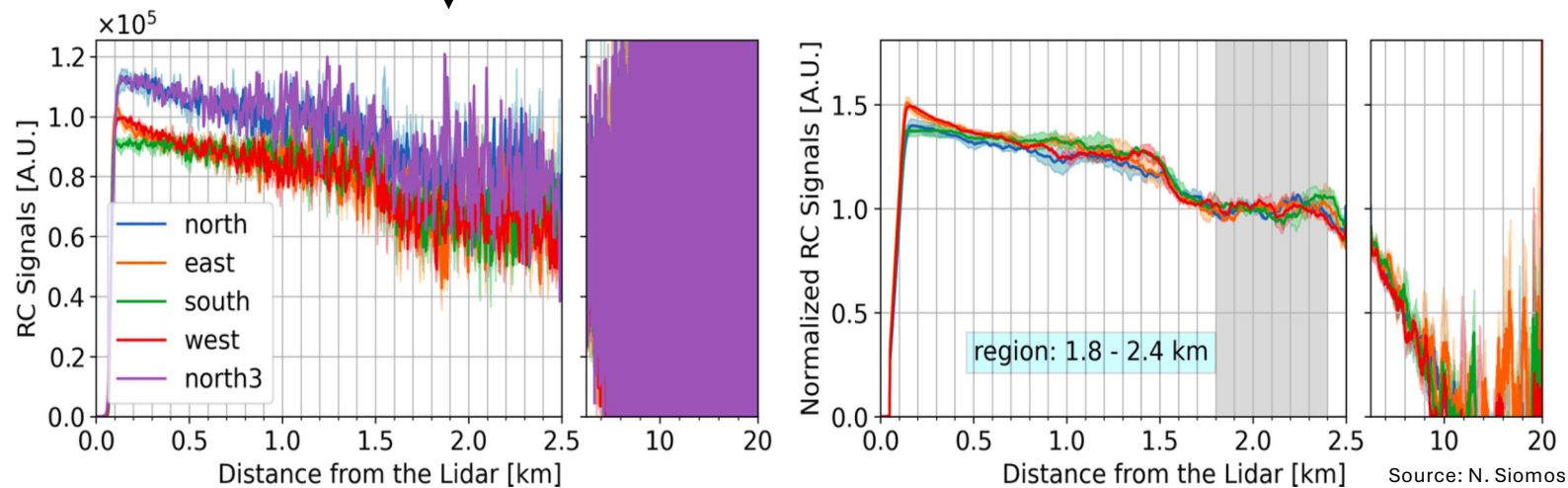


Source: N. Siomos

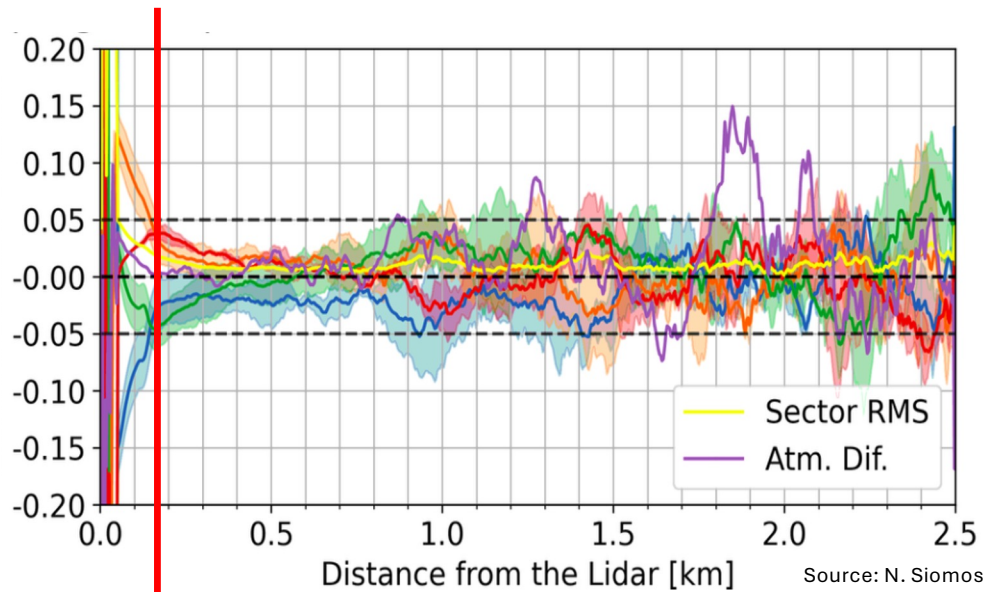
Telecover test – What is shown by such a plot?

- Range corrected signals for each sector
- North, east, south, west of first iteration
- North of last iteration

Same as in the left plot **but smoothed**



Telecover test – What is shown by such a plot?



Distance of full overlap

Distance of full overlap: When all graphs have entered the region within the dashed lines
-> Region of dashed lines: Telescope sees all sectors evenly

Each curve is generated in the following way:

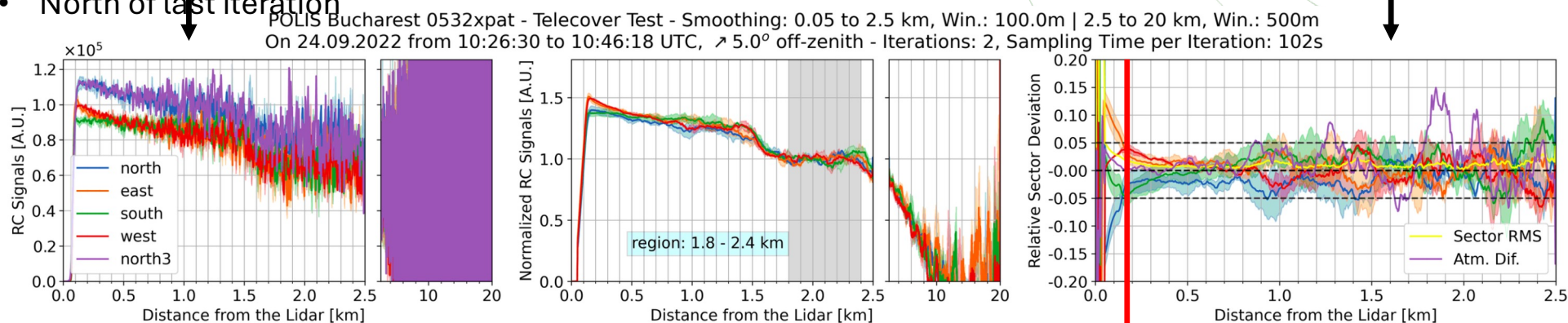
1. Each group of sector measurements is averaged
2. Sector average is subtracted from all single sector measurements
3. Mean of sector differences is displayed graph
4. The deviation of sector differences shown as shadow

Telecover test – Plots summary

- Range corrected signals for each sector
- North, east, south, west of first iteration
- North of last iteration

Each curve is generated in the following way:

1. Each group of sector measurements is averaged
2. Sector average is subtracted from all single sector measurements
3. Mean of sector differences is displayed graph
4. The deviation of sector differences shown as shadow

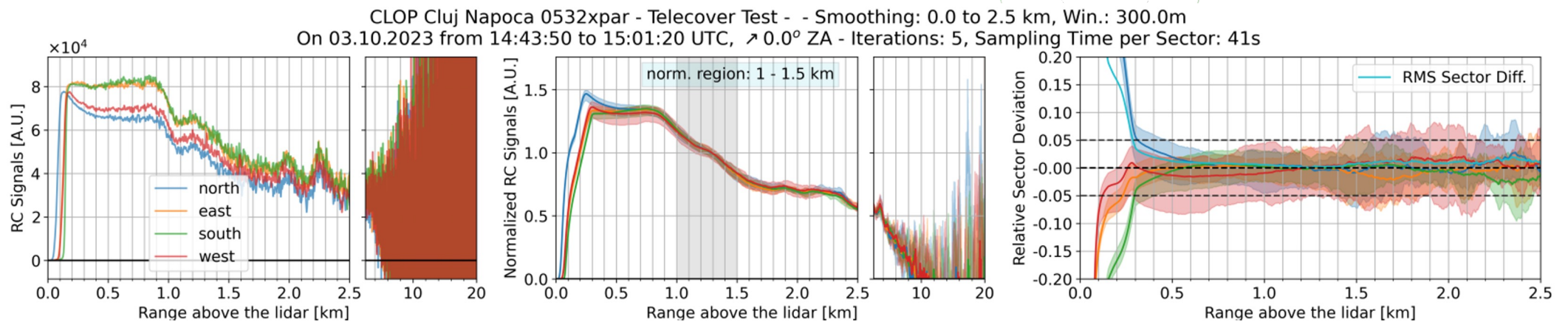


Same as in the left plot **but smoothed**

Distance of full overlap (see right plot): When all graphs have entered the region within the dashed lines
 -> Region of dashed lines: Telescope sees all sectors evenly

Telecover test – Recommendations

- Sensitive to atmospheric variability -> **the atmospheric conditions should be stable**
- Iterative measurements can reduce atmospheric effects:
 - e.g. N – E – S – W – N – E – S – W ...etc
- Recommendation: 3-5 iterations with 40 s sampling time per sector (10 s averages)

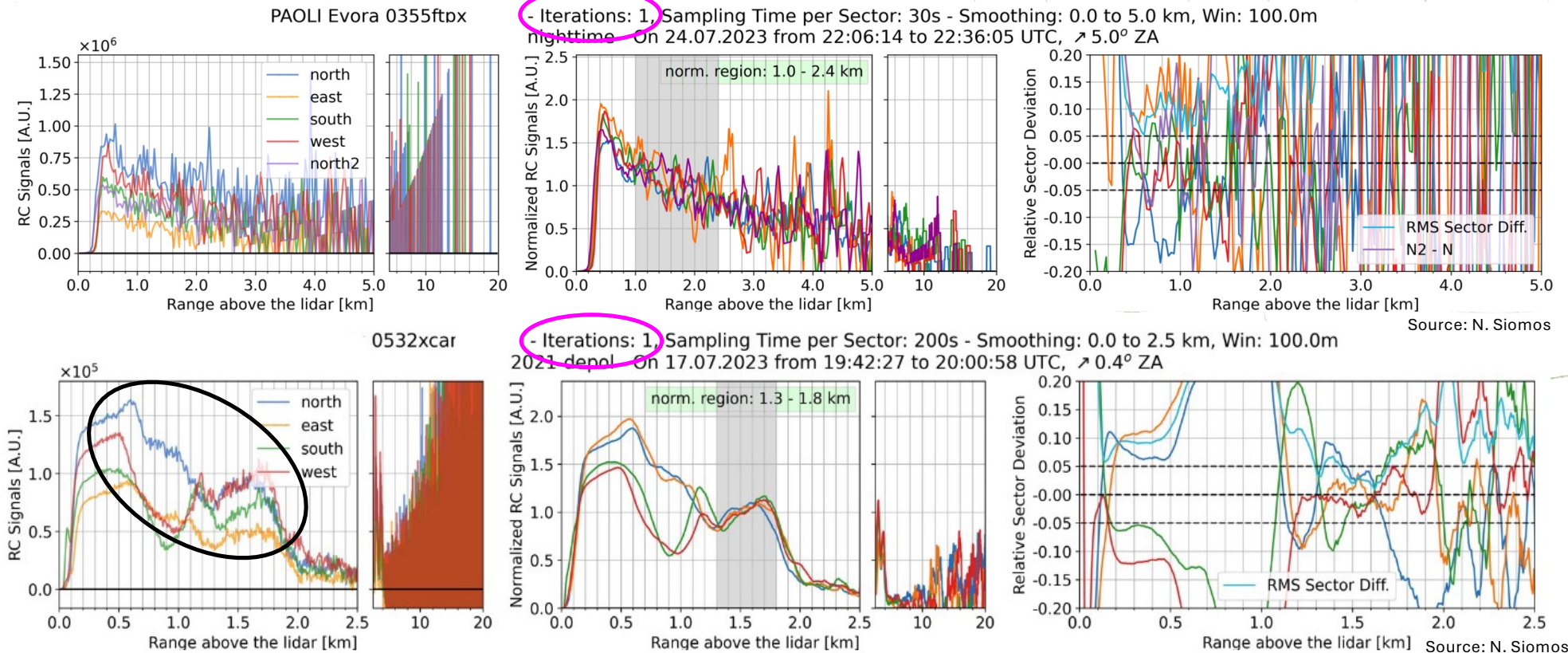


Source: N. Siomos

Telecover test – Recommendations

Too few iterations!!

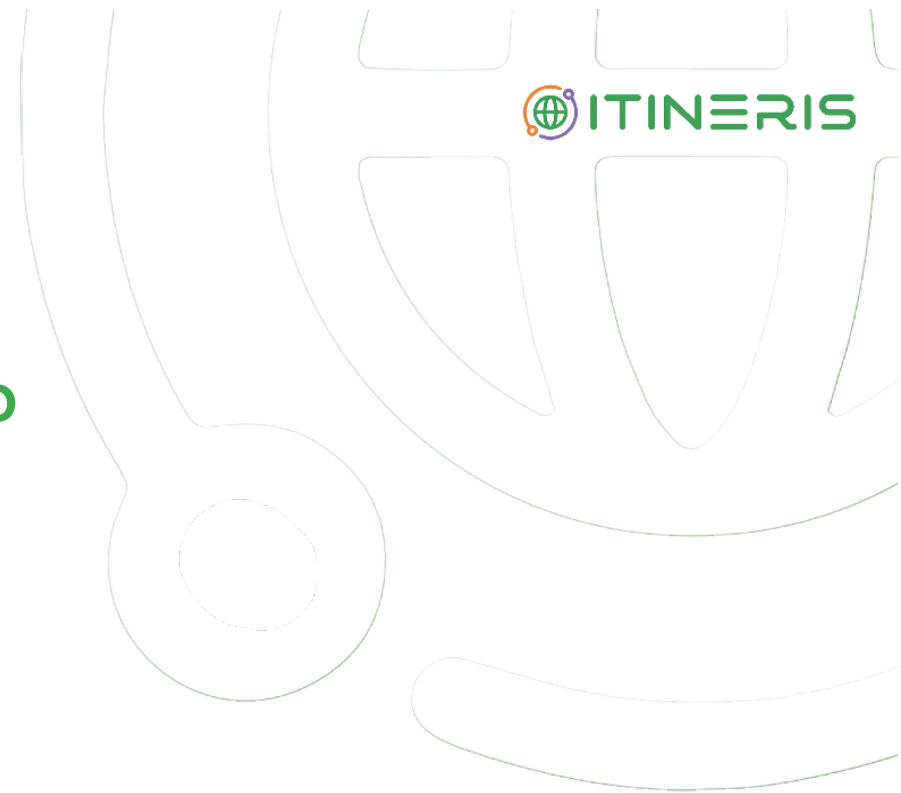
-> Noise (upper plot) and atmospheric variability (lower plot) -> Limit the min. channel height

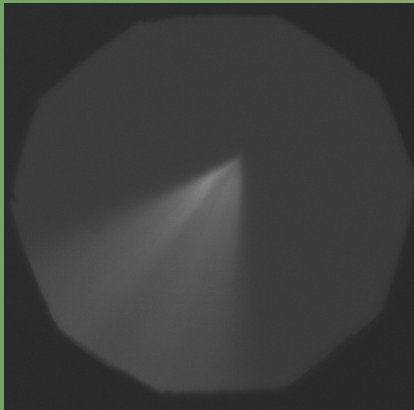


Source: N. Simos

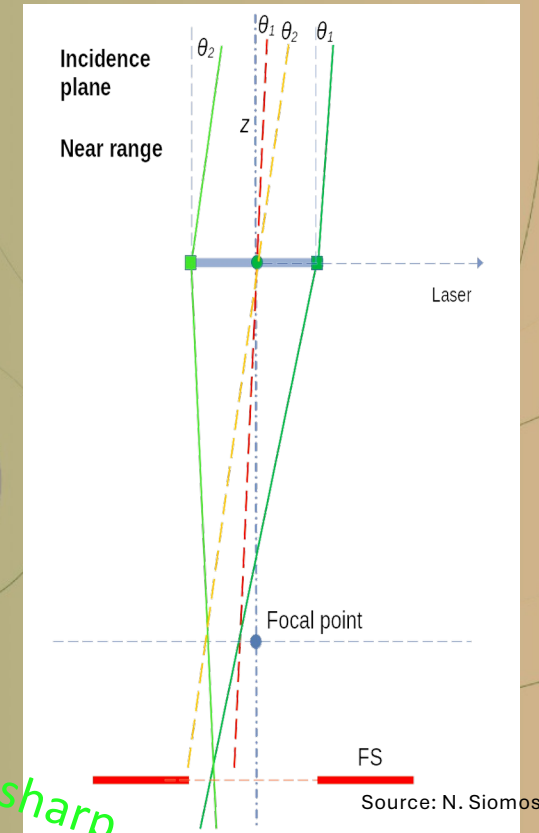
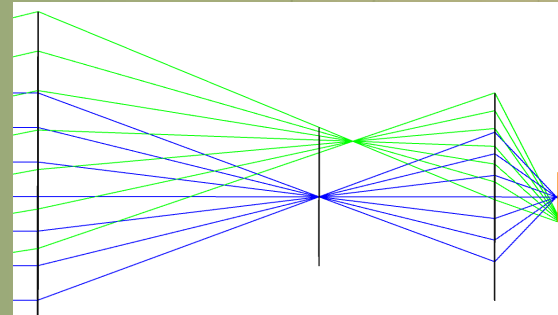
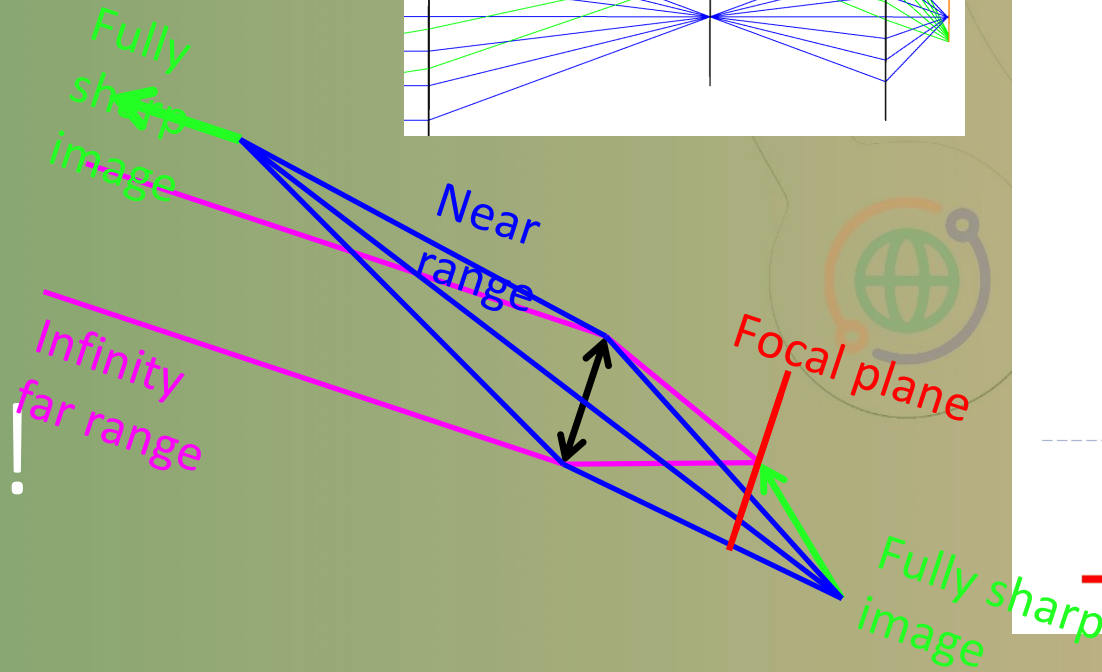
Source: N. Simos

Questions?





THANKS!



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