ITINERIS

Polarization calibration and GHK correction

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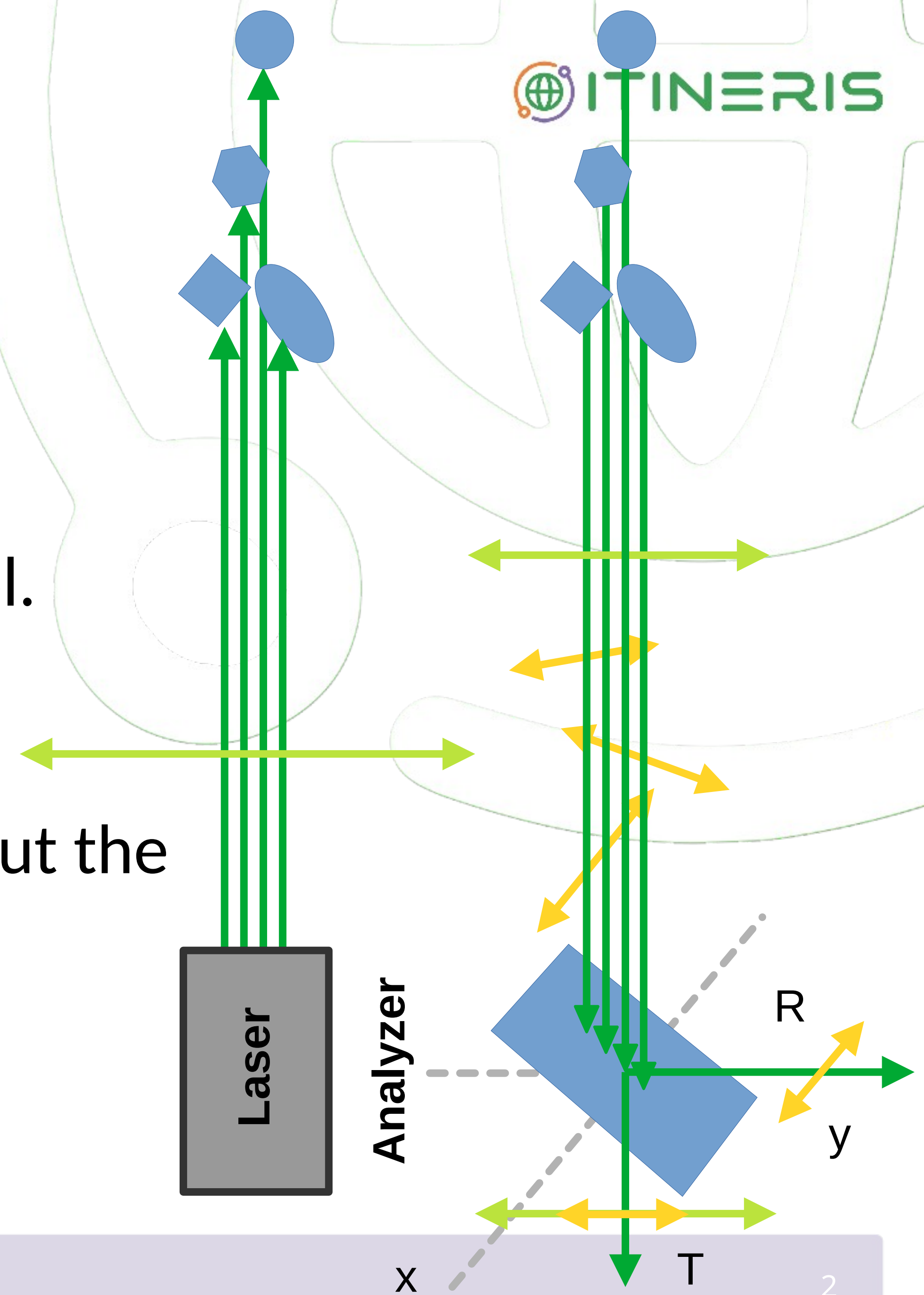
Ministero dell’Università e della Ricerca
Italiadomani

Introduction

How polarization measurements work?

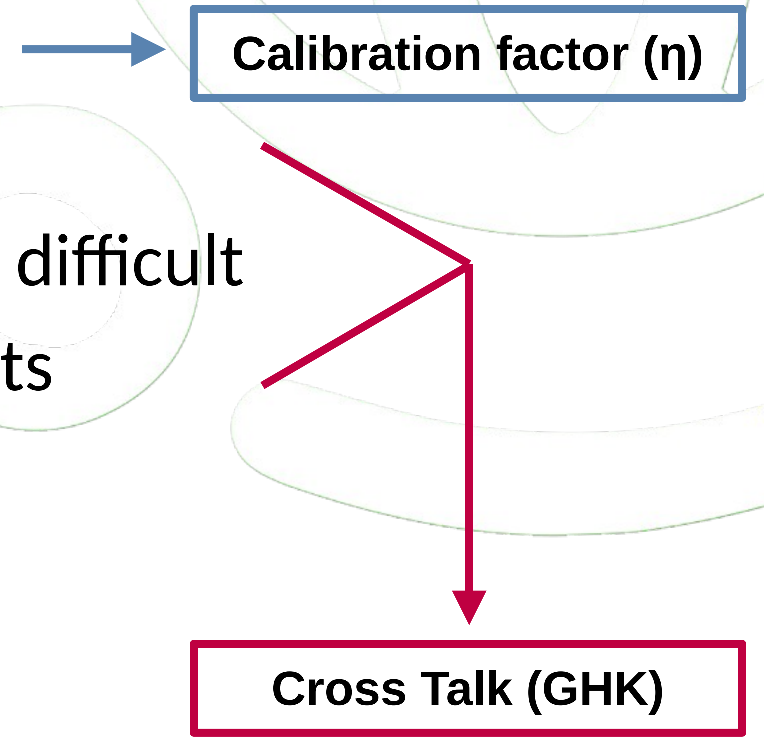
- Laser beam → linearly polarized light
- Particles scattering → **partly depolarized**
- An analyzer splits the backscatter beam in 2 pol. components (parallel, cross)
- Depolarized light is split equally
- Parallel to cross signal ratio → information about the **atmospheric polarization parameter**



Introduction

Just a ratio, is it so simple? → **No…**

- channels have different optoelectronic amplification
- the laser is not purely linearly polarized
- perfect alignment between analyzer and laser is very difficult
- the receiver/emitter optics introduce polarizing effects



Calibration factor (η)

Cross Talk (GHK)

Introduction – Müller calculus

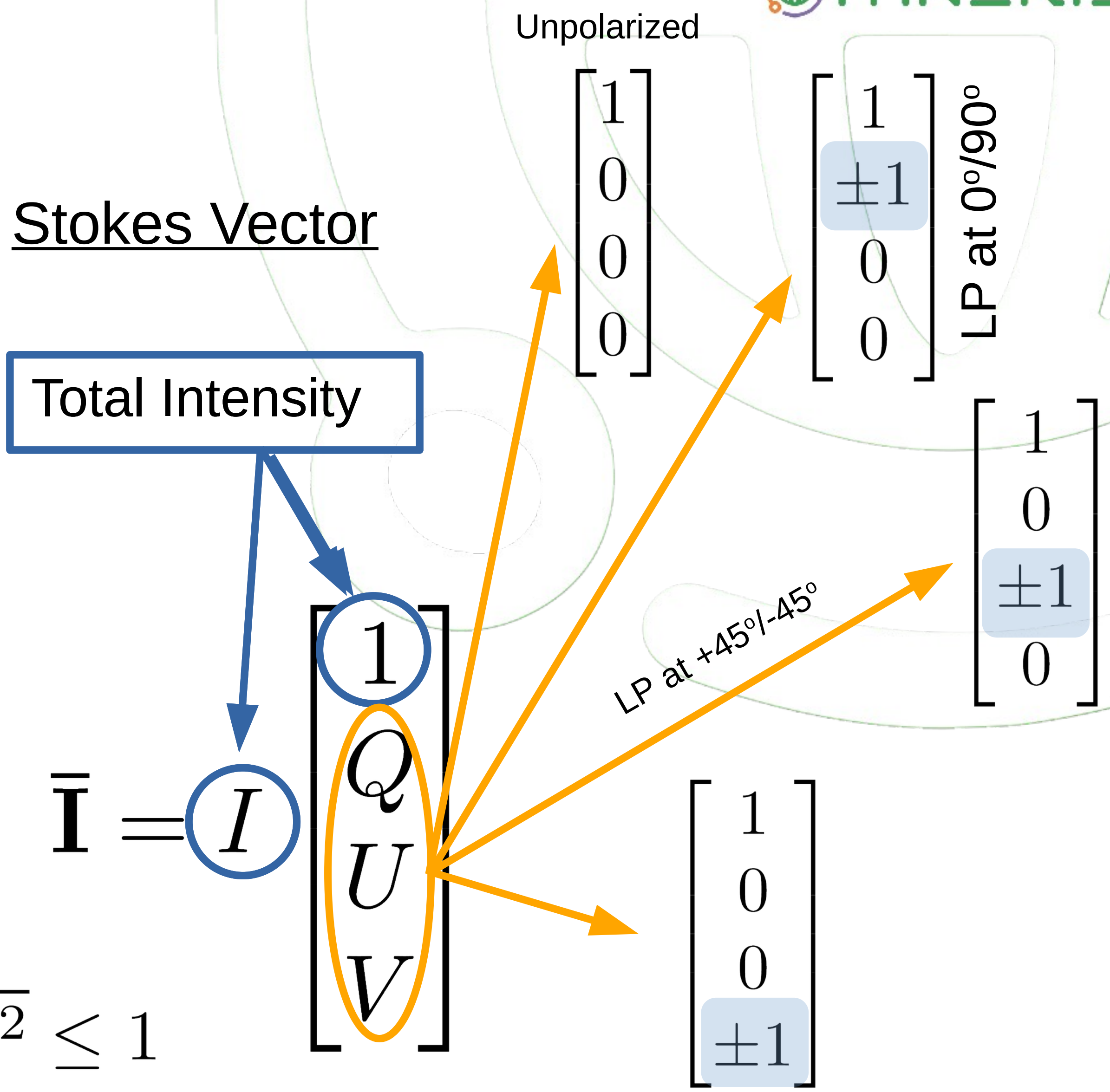
Müller Matrix of an optic

$$\mathbf{M} = T \begin{pmatrix} 1 & m_{12} & m_{13} & m_{14} \\ m_{21} & m_{22} & m_{23} & m_{24} \\ m_{31} & m_{32} & m_{33} & m_{34} \\ m_{41} & m_{42} & m_{43} & m_{44} \end{pmatrix}$$

Müller Matrix of an array of n optics:

$$\mathbf{M} = \mathbf{M}_1 \cdot \mathbf{M}_2 \cdot \ldots \cdot \mathbf{M}_n$$

For all cases: $\sqrt{Q^2 + U^2 + V^2} \leq 1$



Stokes Vector

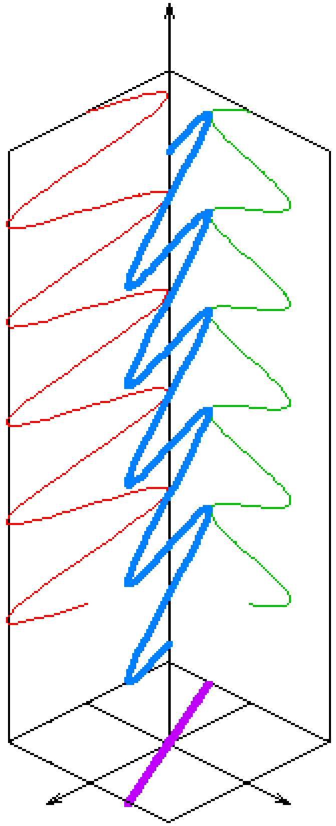
Total Intensity

$$\bar{\mathbf{I}} = I \begin{bmatrix} 1 \\ Q \\ U \\ V \end{bmatrix}$$

$$\begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 1 \\ \pm1 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 1 \\ 0 \\ \pm1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 1 \\ 0 \\ 0 \\ \pm1 \end{bmatrix}$$

Introduction – Müller calculus

Linear polarization



0° / 90°

$$\begin{bmatrix} 1 \\ \pm 1 \\ 0 \\ 0 \end{bmatrix}$$

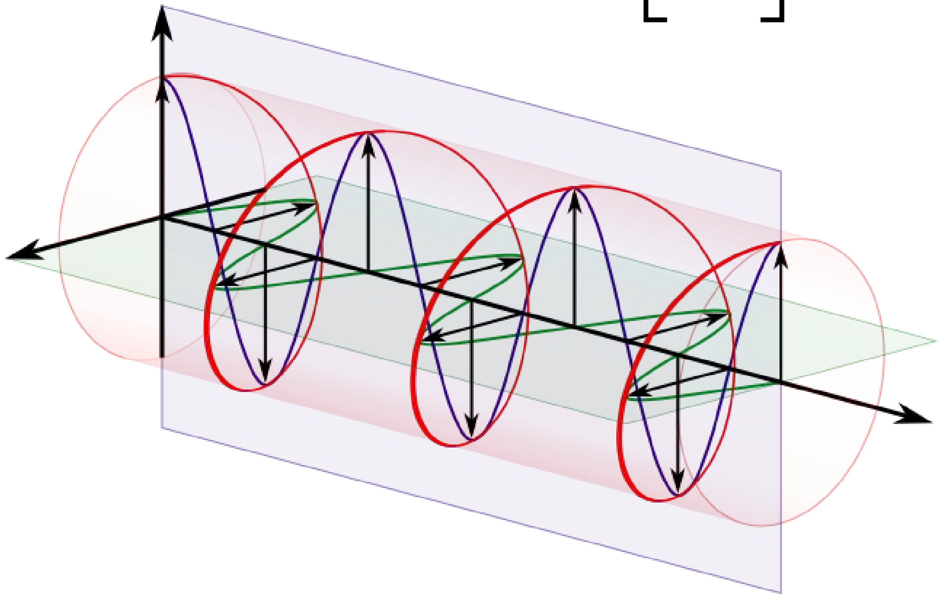
+45° / -45°

$$\begin{bmatrix} 1 \\ 0 \\ \pm 1 \\ 0 \end{bmatrix}$$

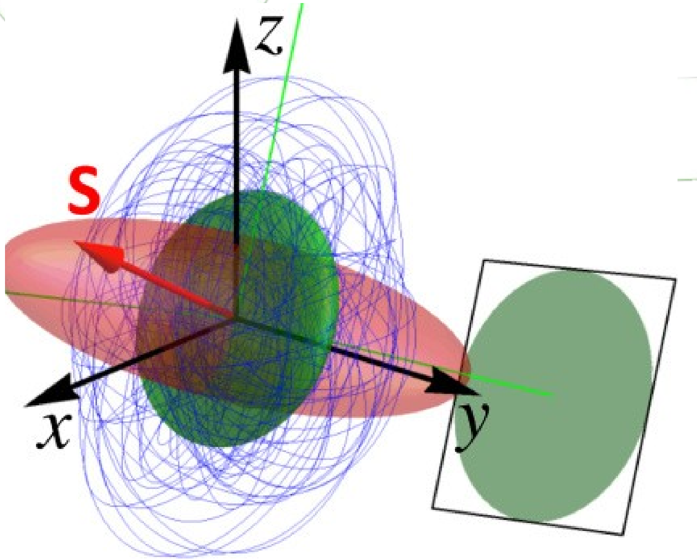
Circular Polarization

Left or right hand

$$\begin{bmatrix} 1 \\ 0 \\ 0 \\ \pm 1 \end{bmatrix}$$



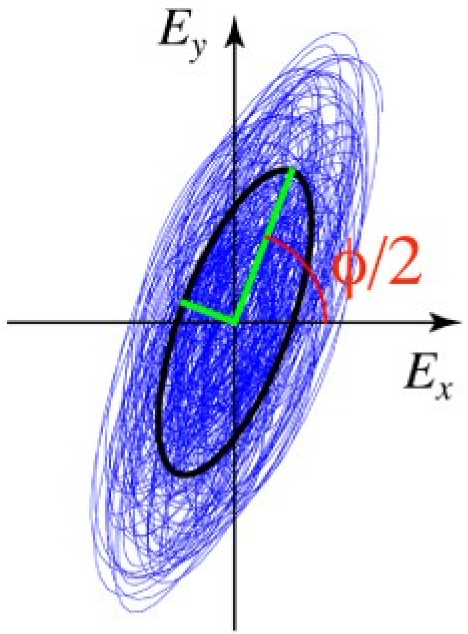
Unpolarized/depolarized light (random polarization)



$$\begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Introduction – Müller calculus

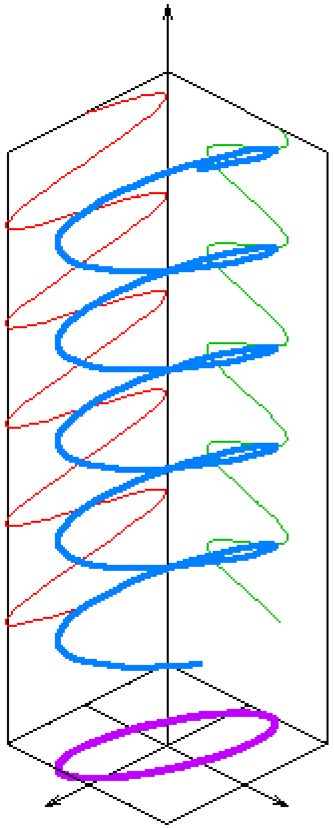
Elliptically Polarized & partly depolarized beam



$$\begin{bmatrix} 1 \\ Q \\ U \\ V \end{bmatrix}$$

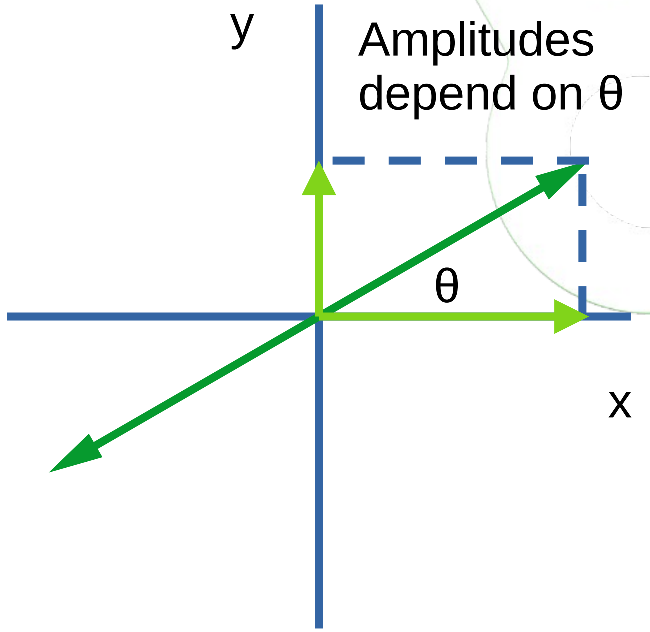
$$\sqrt{Q^2+U^2+V^2} \leq 1$$

Elliptically Polarized



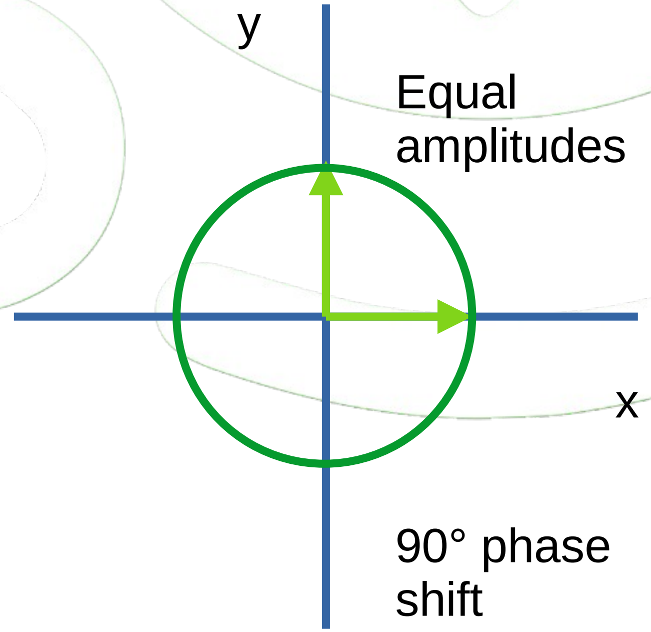
Analyzing pol. light in components

Linearly Polarized light at an angle θ



Amplitudes depend on θ

Circularly Polarized



Equal amplitudes

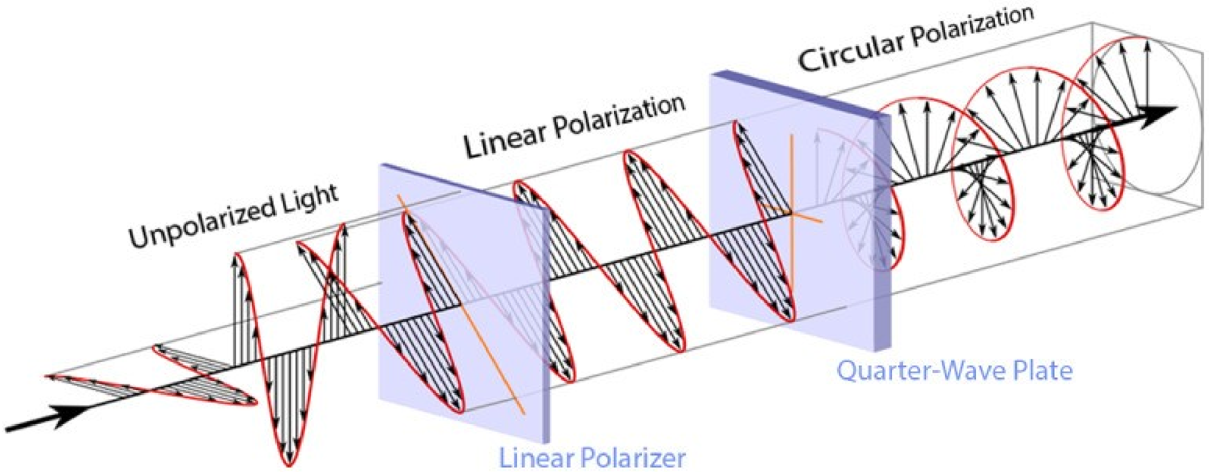
90° phase shift

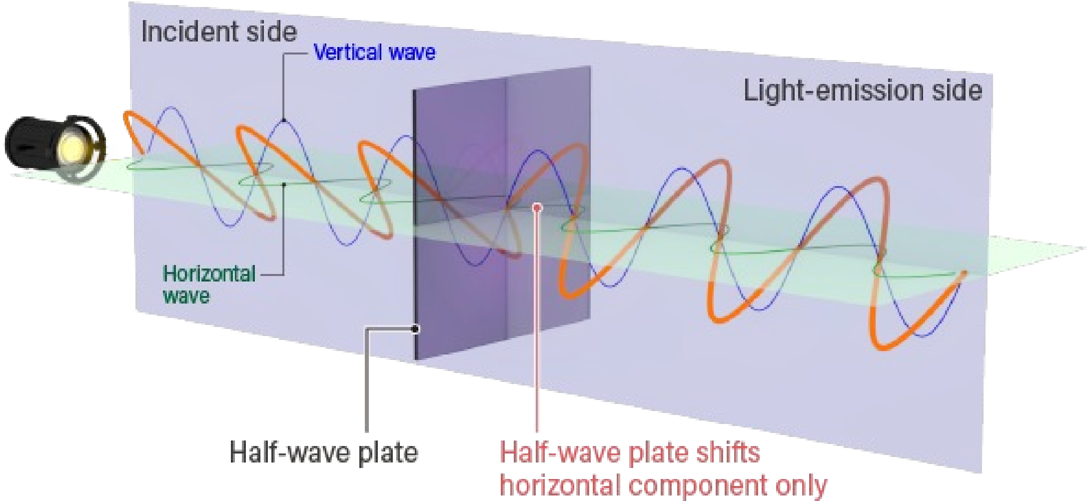
Unpolarized light: Similar to CP but with random phase shift

Introduction – Müller calculus

Common polarizing optics:

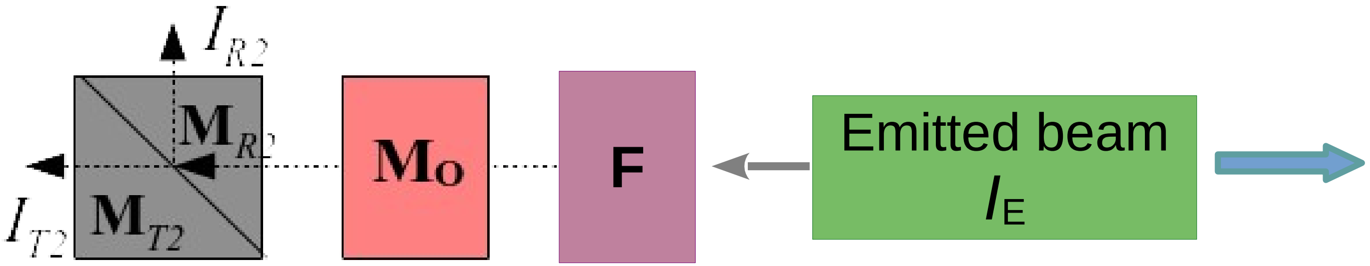
- **Linear Polarizer** (LP) – creates linearly polarized light
- **Half-Waveplate** (HWP) – adds 180° phase shift to one pol. component
- **Quarter-Waveplate** (QWP) - adds 90° phase shift to one pol. component
- **Polarizing Beamsplitter** (PBS) – analyzes the beam in two parts (R and T) one pol. parallel and one perpendicular to its eigenaxis





Introduction – Müller calculus

Using the Müller formalism to describe a system transceiver



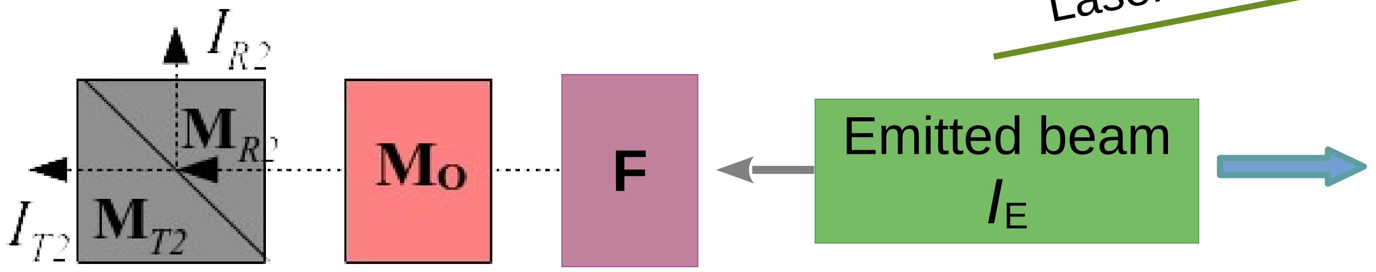
$$I_S = \frac{\eta_S T_S O(R) T_F^2(R) \mathbf{M_S} \mathbf{M_O} \mathbf{F} \mathbf{I_E}}{R^2}$$

Introduction – Müller calculus

Using the Müller formalism to describe a system transceiver

Laser + Emission Optics

$$\mathbf{I_E} = I_E \begin{pmatrix} 1 \\ q_E \\ u_E \\ v_E \end{pmatrix}$$



$$I_S = \frac{\eta_S T_S O(R) T_F^2(R) \mathbf{M_S} \mathbf{M_O} \mathbf{F} \mathbf{I_E}}{R^2}$$

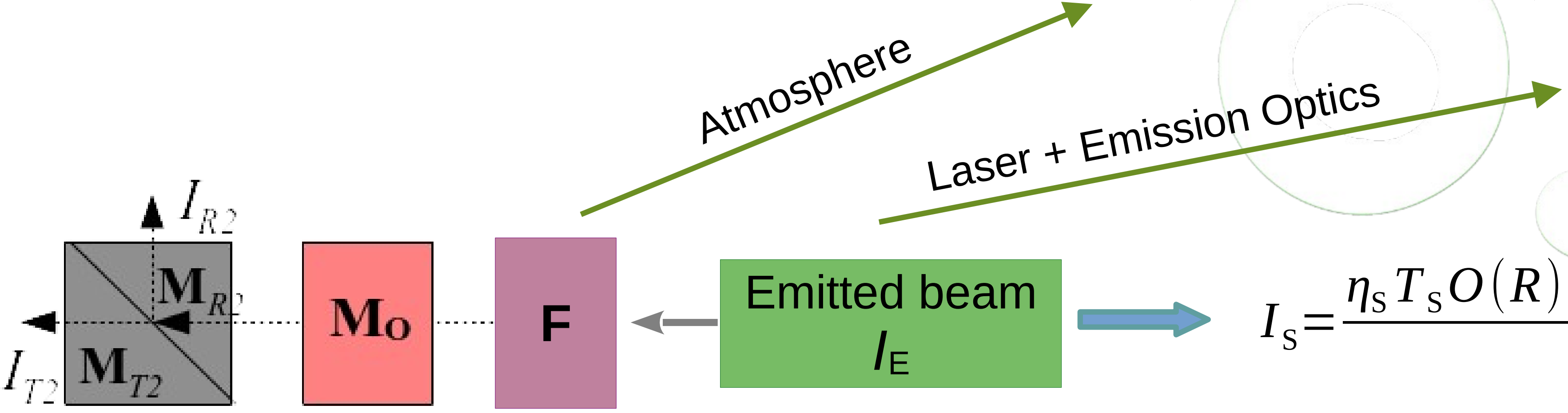
Introduction – Müller calculus

Using the Müller formalism to describe a system transceiver

Volume backscatter: $F_{11} = \beta_m + \beta_p$

$$F = F_{11} \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & a & 0 & 0 \\ 0 & 0 & -a & 0 \\ 0 & 0 & 0 & 1-2a \end{pmatrix}$$

$$\mathbf{I_E} = I_E \begin{pmatrix} 1 \\ q_E \\ u_E \\ v_E \end{pmatrix}$$



$$I_S = \frac{\eta_S T_S O(R) T_F^2(R) \mathbf{M_S} \mathbf{M_O} \mathbf{F} \mathbf{I_E}}{R^2}$$

Introduction – Müller calculus

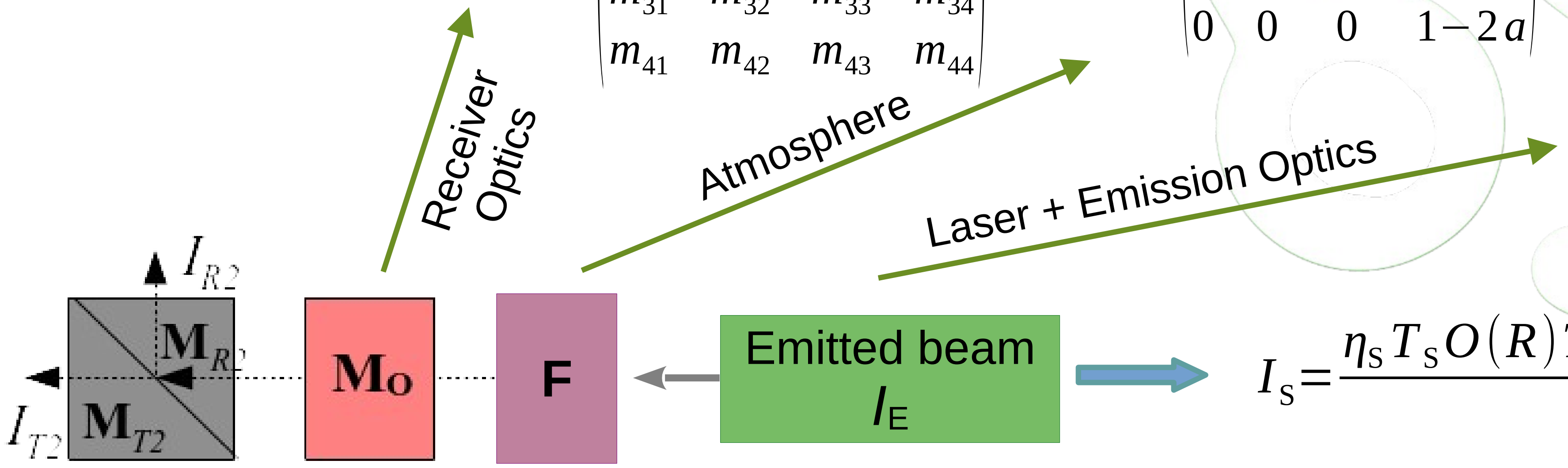
Using the Müller formalism to describe a system transceiver

Volume backscatter: $F_{11}=\beta_{\mathrm{m}}+\beta_{\mathrm{p}}$

$$\mathbf{M_O}=T_{\mathrm{O}}\begin{pmatrix}1 & m_{12} & m_{13} & m_{14}\\ m_{21} & m_{22} & m_{23} & m_{24}\\ m_{31} & m_{32} & m_{33} & m_{34}\\ m_{41} & m_{42} & m_{43} & m_{44}\end{pmatrix}$$

$$F=F_{11}\begin{pmatrix}1 & 0 & 0 & 0\\ 0 & a & 0 & 0\\ 0 & 0 & -a & 0\\ 0 & 0 & 0 & 1-2a\end{pmatrix}$$

$$\mathbf{I_E}=I_{\mathrm{E}}\begin{pmatrix}1\\ q_{\mathrm{E}}\\ u_{\mathrm{E}}\\ v_{\mathrm{E}}\end{pmatrix}$$



$$I_{\mathrm{S}}=\frac{\eta_{\mathrm{S}}T_{\mathrm{S}}O(R)T_{\mathrm{F}}^2(R)\mathbf{M_S}\mathbf{M_O}\mathbf{F}\mathbf{I_E}}{R^2}$$

Introduction – Müller calculus

Using the Müller formalism to describe a system transceiver

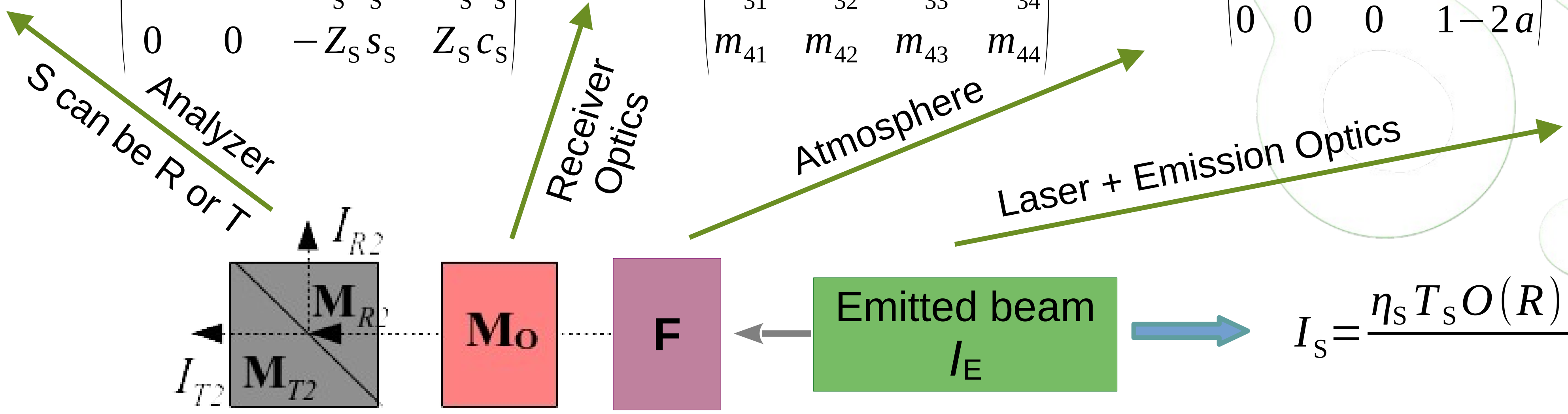
Volume backscatter: $F_{11}=\beta_\mathrm{m}+\beta_\mathrm{p}$

$$M_\mathrm{S}=T_\mathrm{S}\begin{pmatrix}1 & D_\mathrm{S} & 0 & 0\\ D_\mathrm{S} & 1 & 0 & 0\\ 0 & 0 & Z_\mathrm{S}c_\mathrm{S} & Z_\mathrm{S}s_\mathrm{S}\\ 0 & 0 & -Z_\mathrm{S}s_\mathrm{S} & Z_\mathrm{S}c_\mathrm{S}\end{pmatrix}$$

$$\mathbf{M_O}=T_\mathrm{O}\begin{pmatrix}1 & m_{12} & m_{13} & m_{14}\\ m_{21} & m_{22} & m_{23} & m_{24}\\ m_{31} & m_{32} & m_{33} & m_{34}\\ m_{41} & m_{42} & m_{43} & m_{44}\end{pmatrix}$$

$$F=F_{11}\begin{pmatrix}1 & 0 & 0 & 0\\ 0 & a & 0 & 0\\ 0 & 0 & -a & 0\\ 0 & 0 & 0 & 1-2a\end{pmatrix}$$

$$\mathbf{I_E}=I_\mathrm{E}\begin{pmatrix}1\\ q_\mathrm{E}\\ u_\mathrm{E}\\ v_\mathrm{E}\end{pmatrix}$$



$$I_\mathrm{S}=\frac{\eta_\mathrm{S}T_\mathrm{S}O(R)T_\mathrm{F}^2(R)\mathbf{M_S}\mathbf{M_O}\mathbf{F}\mathbf{I_E}}{R^2}$$

Introduction – Müller calculus

Using the Müller formalism to describe a system transceiver

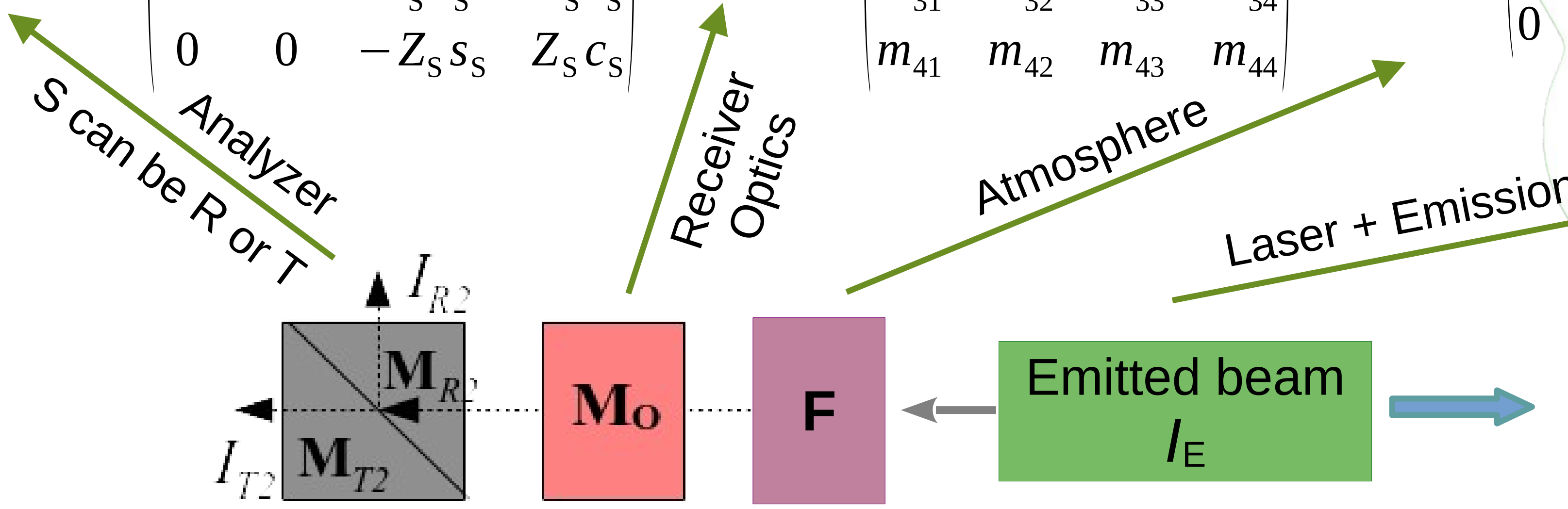
Volume backscatter: $F_{11} = \beta_{\mathrm{m}} + \beta_{\mathrm{p}}$

$$M_{\mathrm{S}} = T_{\mathrm{S}} \begin{pmatrix} 1 & D_{\mathrm{S}} & 0 & 0 \\ D_{\mathrm{S}} & 1 & 0 & 0 \\ 0 & 0 & Z_{\mathrm{S}} c_{\mathrm{S}} & Z_{\mathrm{S}} s_{\mathrm{S}} \\ 0 & 0 & -Z_{\mathrm{S}} s_{\mathrm{S}} & Z_{\mathrm{S}} c_{\mathrm{S}} \end{pmatrix}$$

$$\mathbf{M_O} = T_{\mathrm{O}} \begin{pmatrix} 1 & m_{12} & m_{13} & m_{14} \\ m_{21} & m_{22} & m_{23} & m_{24} \\ m_{31} & m_{32} & m_{33} & m_{34} \\ m_{41} & m_{42} & m_{43} & m_{44} \end{pmatrix}$$

$$F = F_{11} \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & a & 0 & 0 \\ 0 & 0 & -a & 0 \\ 0 & 0 & 0 & 1-2a \end{pmatrix}$$

$$\mathbf{I_E} = I_{\mathrm{E}} \begin{pmatrix} 1 \\ q_{\mathrm{E}} \\ u_{\mathrm{E}} \\ v_{\mathrm{E}} \end{pmatrix}$$



$$I_{\mathrm{S}} = \frac{\eta_{\mathrm{S}} T_{\mathrm{S}} O(R) T_{\mathrm{F}}^2(R) \mathbf{M_S} \mathbf{M_O} \mathbf{F} \mathbf{I_E}}{R^2}$$

Opto-electronical cal. factor:

$$\eta = \frac{\eta_{\mathrm{R}} \mathrm{T}_{\mathrm{R}}}{\eta_{\mathrm{T}} T_{\mathrm{T}}}$$

Calibrated signal ratio:

$$\frac{1}{\eta} \frac{I_{\mathrm{R}}}{I_{\mathrm{T}}} = \frac{(1 + D_{\mathrm{R}} m_{21}) + (m_{12} + D_{\mathrm{R}} m_{22}) a q_{\mathrm{E}} - (m_{13} + D_{\mathrm{R}} m_{23}) a u_{\mathrm{E}} + (m_{14} + D_{\mathrm{R}} m_{24})(1 - 2a) v_{\mathrm{E}}}{(1 + D_{\mathrm{T}} m_{21}) + (m_{12} + D_{\mathrm{T}} m_{22}) a q_{\mathrm{E}} - (m_{13} + D_{\mathrm{T}} m_{23}) a u_{\mathrm{E}} + (m_{14} + D_{\mathrm{T}} m_{24})(1 - 2a) v_{\mathrm{E}}}$$

Introduction – Müller calculus

Questions?

Polarization Calibration – G and H factors

From calibrated signal ratio to volume linear depolarization ratio δ$_V$ (VLDR):

- Ideal optics and emission: $\frac{1}{\eta}\frac{I_R}{I_T}=\frac{1-a}{1+a}$
- VLDR: $\delta_V=\frac{1-a}{1+a}$

  measurant of the atmospheric pol. parameter *a*

Receiver Optics

$$\mathbf{M_O}=T_O\begin{pmatrix}1 & m_{12} & m_{13} & m_{14}\\ m_{21} & m_{22} & m_{23} & m_{24}\\ m_{31} & m_{32} & m_{33} & m_{34}\\ m_{41} & m_{42} & m_{43} & m_{44}\end{pmatrix}$$

Laser
\+
Emission Optics

$$\mathbf{I_E}=I_E\begin{pmatrix}1\\ q_E\\ u_E\\ v_E\end{pmatrix}$$

<u>volume = particles and molecules</u>

Calibrated signal ratio:

$$\frac{1}{\eta}\frac{I_R}{I_T}=\frac{(1+D_R m_{21})+(m_{12}+D_R m_{22})\,a\,q_E-(m_{13}+D_R m_{23})\,a\,u_E+(m_{14}+D_R m_{24})(1-2a)\,v_E}{(1+D_T m_{21})+(m_{12}+D_T m_{22})\,a\,q_E-(m_{13}+D_T m_{23})\,a\,u_E+(m_{14}+D_T m_{24})(1-2a)\,v_E}$$

Polarization Calibration – G and H factors

By rearranging the calibrated ratio equation:

$$\frac{1}{\eta}\frac{I_{\mathrm{R}}}{I_{\mathrm{T}}}=\frac{\overbrace{\left[\left(1+D_{\mathrm{R}}m_{21}\right)+\left(m_{14}+D_{\mathrm{R}}m_{24}\right)v_{\mathrm{E}}\right]}^{G_{\mathrm{R}}}+\overbrace{\left[\left(m_{12}+D_{\mathrm{R}}m_{22}\right)q_{\mathrm{E}}-\left(m_{13}+D_{\mathrm{R}}m_{23}\right)u_{\mathrm{E}}-2\left(m_{14}+D_{\mathrm{R}}m_{24}\right)v_{\mathrm{E}}\right]}^{H_{\mathrm{R}}}a}{\underbrace{\left[\left(1+D_{\mathrm{T}}m_{21}\right)+\left(m_{14}+D_{\mathrm{T}}m_{24}\right)v_{\mathrm{E}}\right]}_{G_{\mathrm{T}}}+\underbrace{\left[\left(m_{12}+D_{\mathrm{T}}m_{22}\right)q_{\mathrm{E}}-\left(m_{13}+D_{\mathrm{T}}m_{23}\right)u_{\mathrm{E}}-2\left(m_{14}+D_{\mathrm{T}}m_{24}\right)v_{\mathrm{E}}\right]}_{H_{\mathrm{T}}}a}$$

Definition of G and H factors:

$$\boxed{\frac{1}{\eta}\frac{I_{\mathrm{R}}}{I_{\mathrm{T}}}=\frac{G_{\mathrm{R}}+H_{\mathrm{R}}a}{G_{\mathrm{T}}+H_{\mathrm{T}}a}}$$

Freudenthaler et al. 2016

Normal meas.

The G_{R}, G_{T}, H_{R}, and H_{T} factors can be used to compensate for cross-talk effects as long as the system does not change with time

Polarization Calibration – G and H factors

Questions?

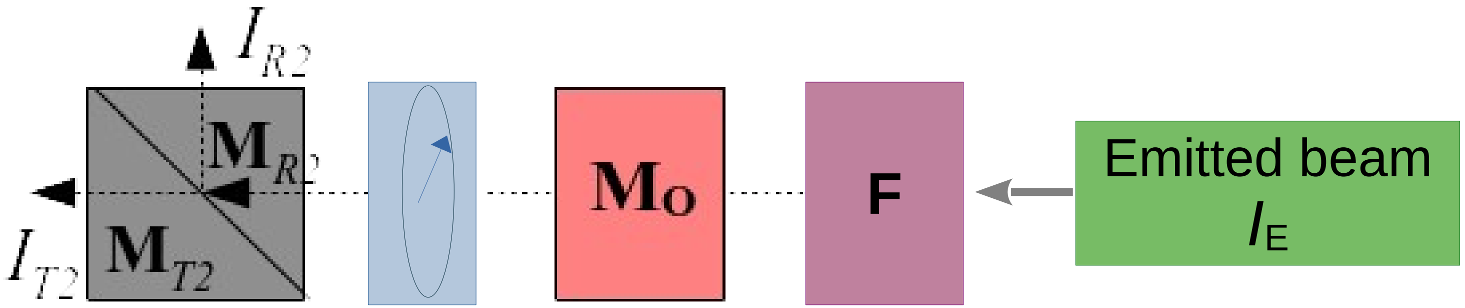
Polarization Calibration – Calibration factor η

How to measure η:

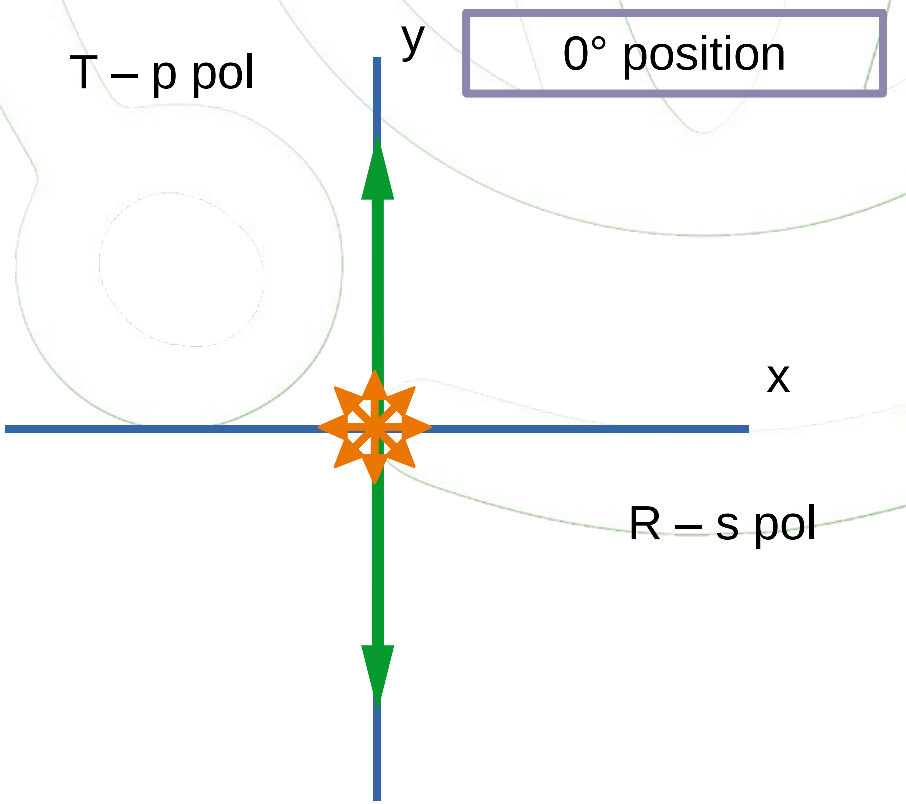
- split the beam equally between the R and T channels

Calibration accounts for:

- Opto-electronic amplification after the analyzer (e.g. ND filters, detector sensitivity)



Analyzer: Ideal PBS
Calibrator: Manual rotator or HWP
Laser beam: No rotation

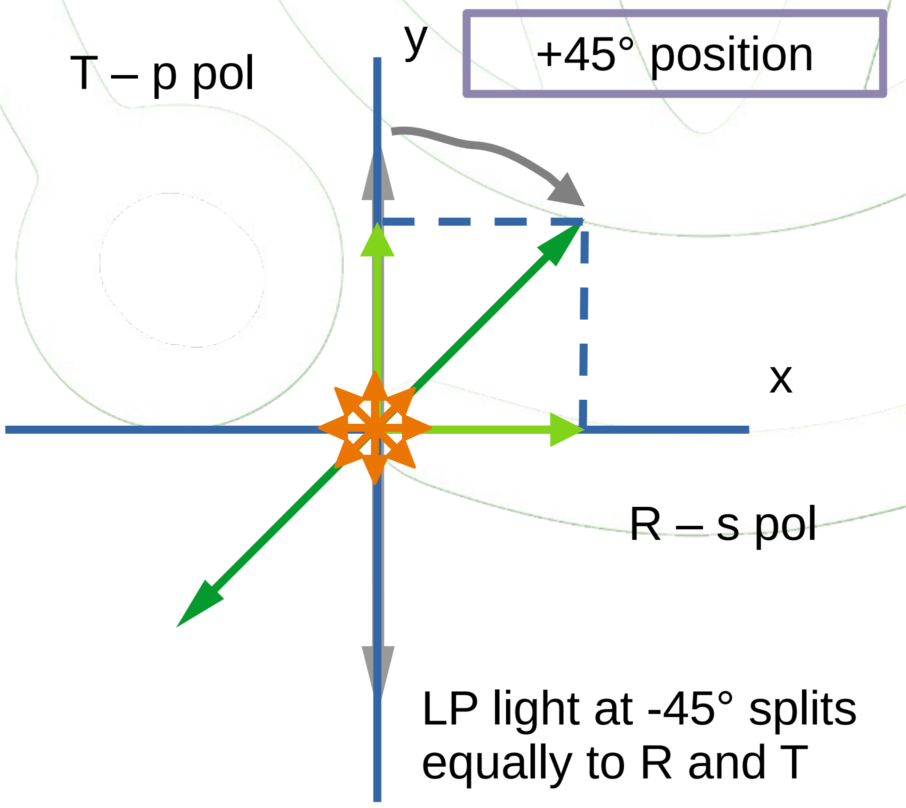


Polarization Calibration – Calibration factor η

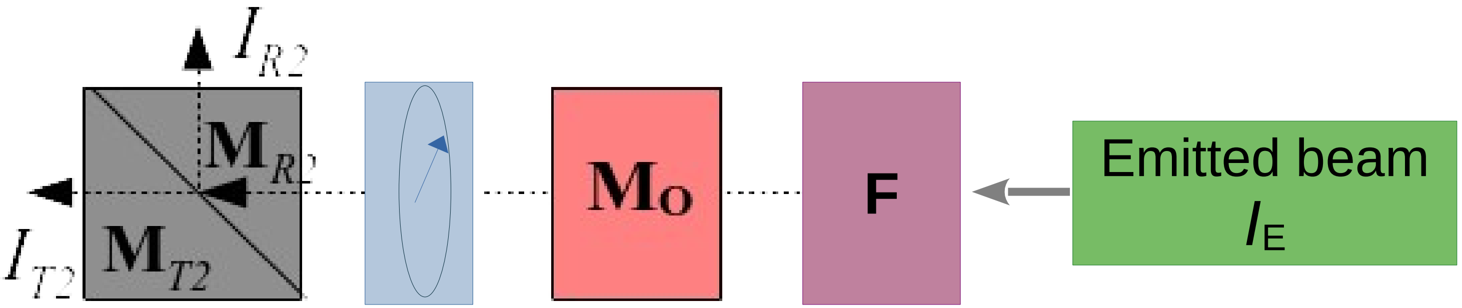
How to split the beam equally to R and S:

- Rotate the incident linear polarization by 45°
- Complications:
  - calibrator-analyzer misalignment
  - laser-analyzer misalignment

Analyzer: Ideal PBS
Calibrator: Manual rotator or HWP
Laser beam: No rotation



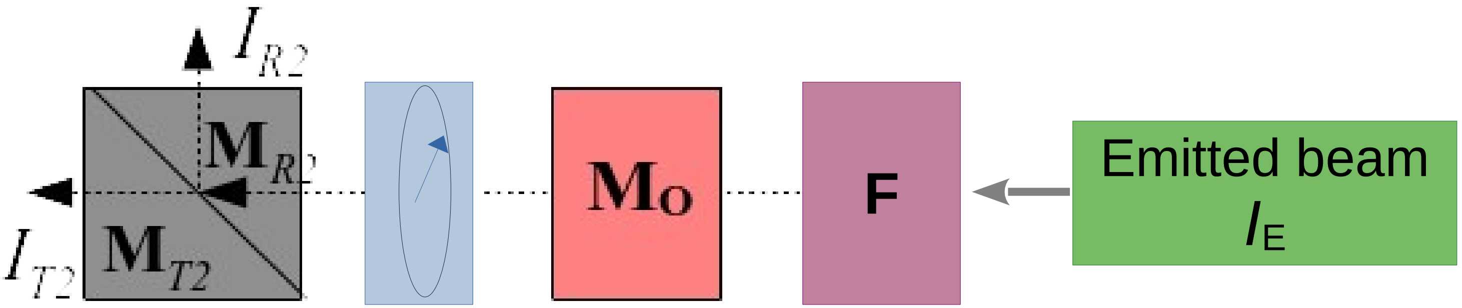
LP light at -45° splits equally to R and T



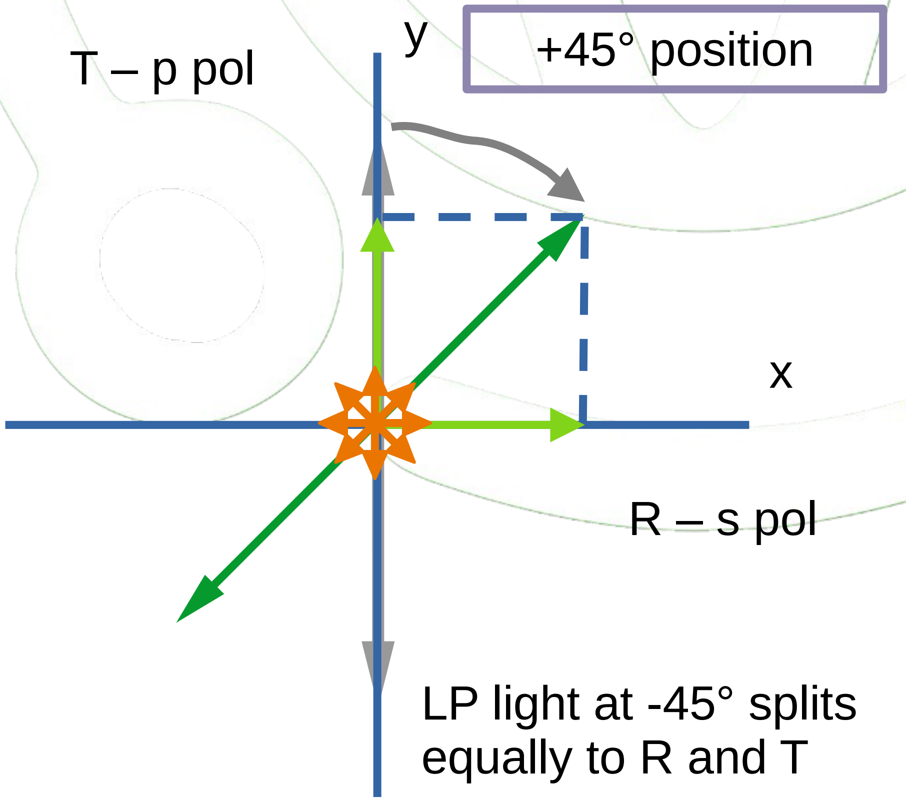
Polarization Calibration – Calibration factor η

Important point → analyzer should be ideal:

- non ideal analysers can introduce cross-talks and affect the value of η
- using an additional (cleaning) polarizers after the analyser eliminates cross-talks



Analyzer: Ideal PBS
Calibrator: Manual rotator or HWP
Laser beam: No rotation



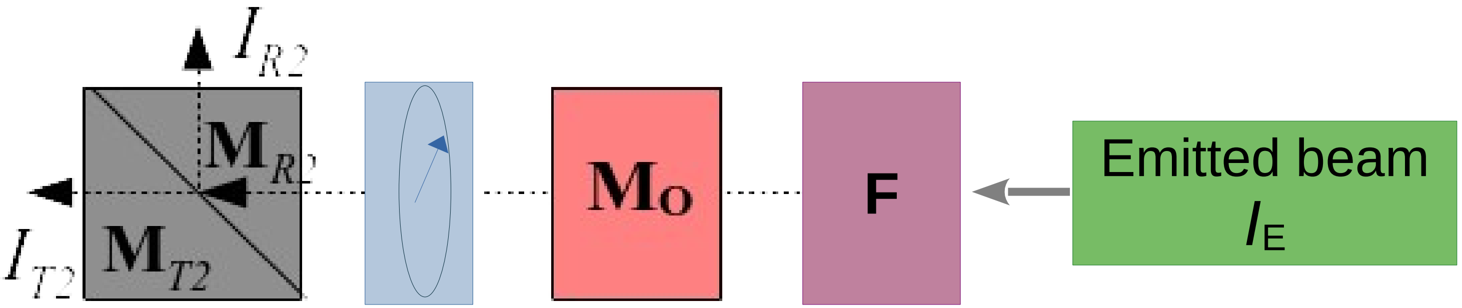
LP light at -45° splits equally to R and T

Polarization Calibration – Calibration factor η

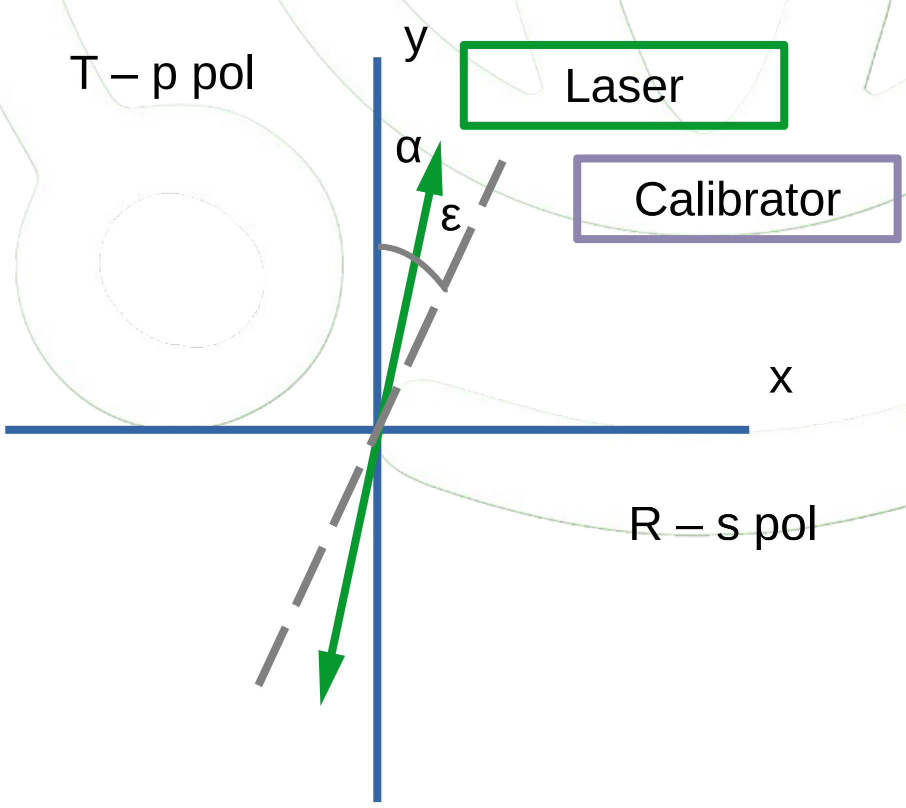
Sources of misalignment:

- Laser-analyzer misalignment α
- Calibrator-analyzer misalignment ε
- M_O induced misalignment

The total rotation depends on the calibrator type



Analyzer: Ideal PBS
Calibrator: Rotated by ε
Laser beam: Rotated by α



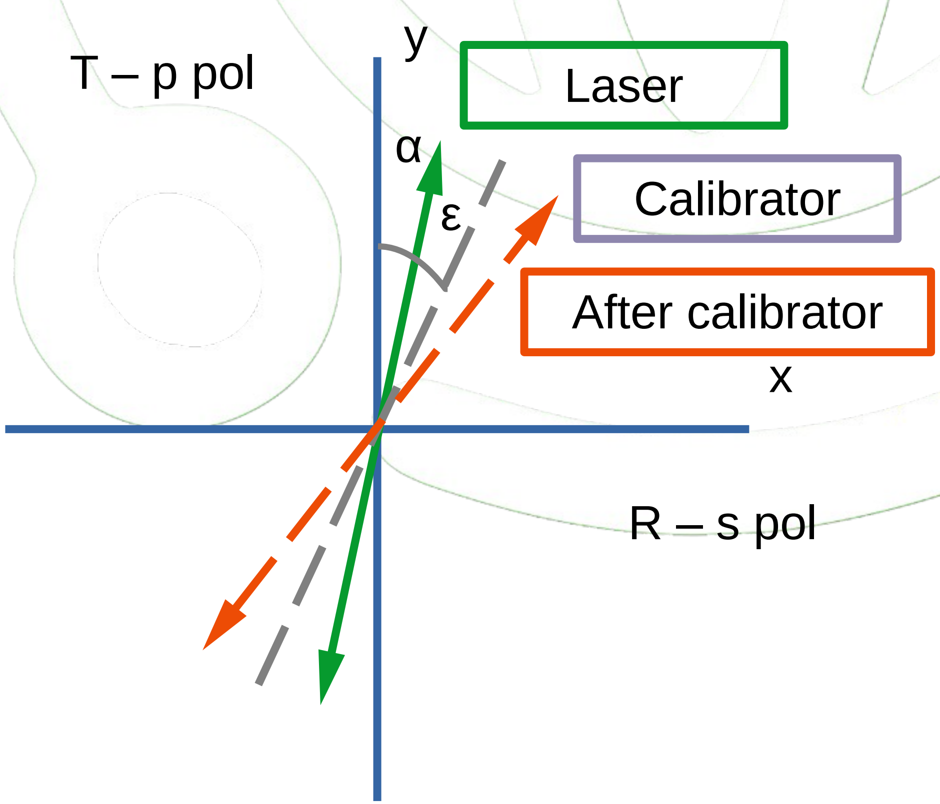
Polarization Calibration – Calibration factor η

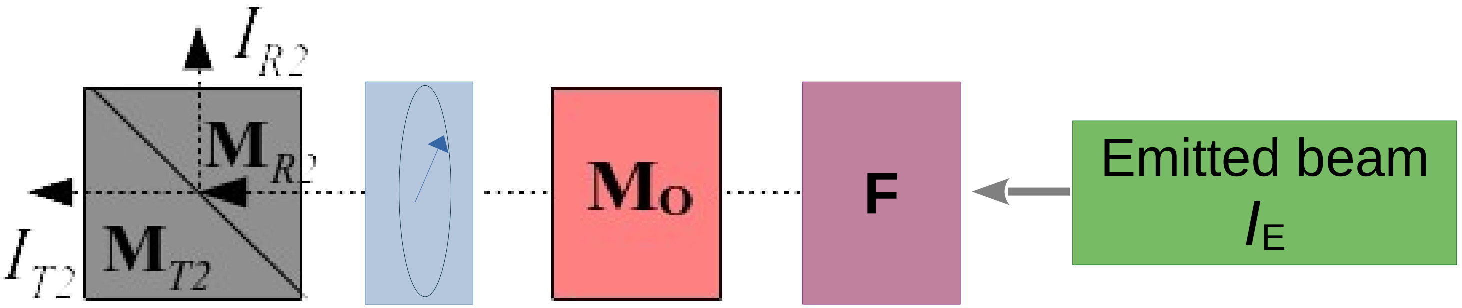
Sources of misalignment:

- Laser-analyzer misalignment α
- Calibrator-analyzer misalignment ε
- M_O induced misalignment

Example: **Half Waveplate** (HWP) calibrator

Analyzer: Ideal PBS
Calibrator: HWP - Rotated by ε
Laser beam: Rotated by α



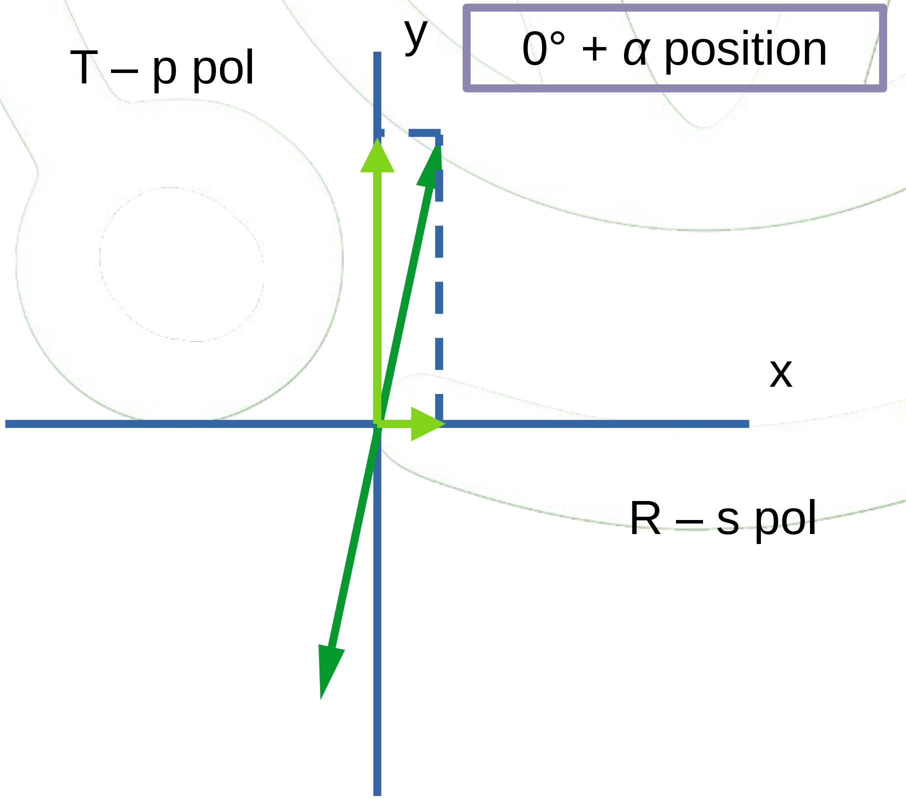


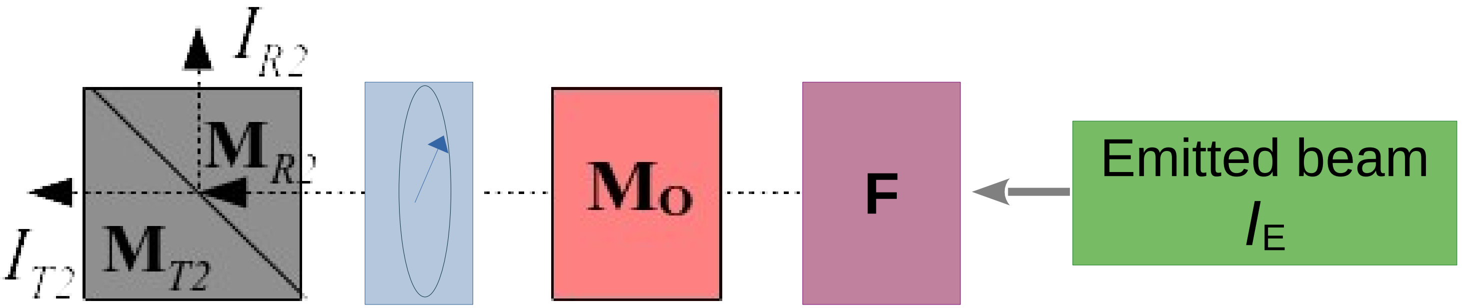
Polarization Calibration – Calibration factor η

Analyzer: Ideal PBS
Calibrator: Manual rotator
Laser beam: Rotated by α

Simple example:

- laser/analyzer misalignment α
- Calibrator: manual rotator
- The calibrator is perfectly aligned with the analyzer: $\varepsilon = 0$
- Calibrator and analyzer are rotating together



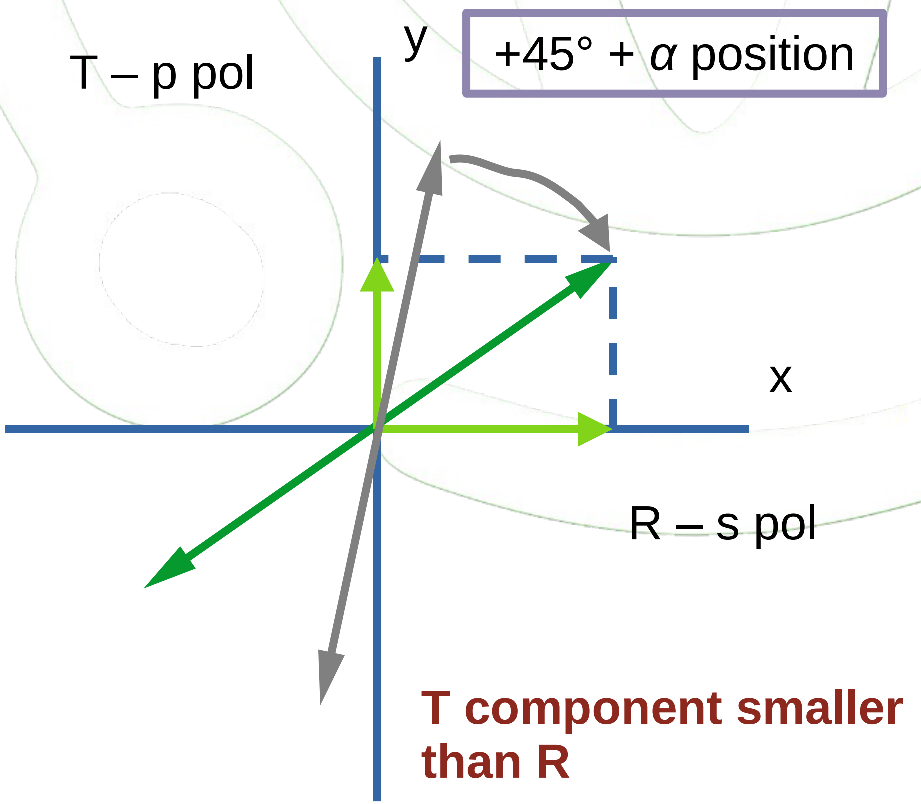


Polarization Calibration – Calibration factor η

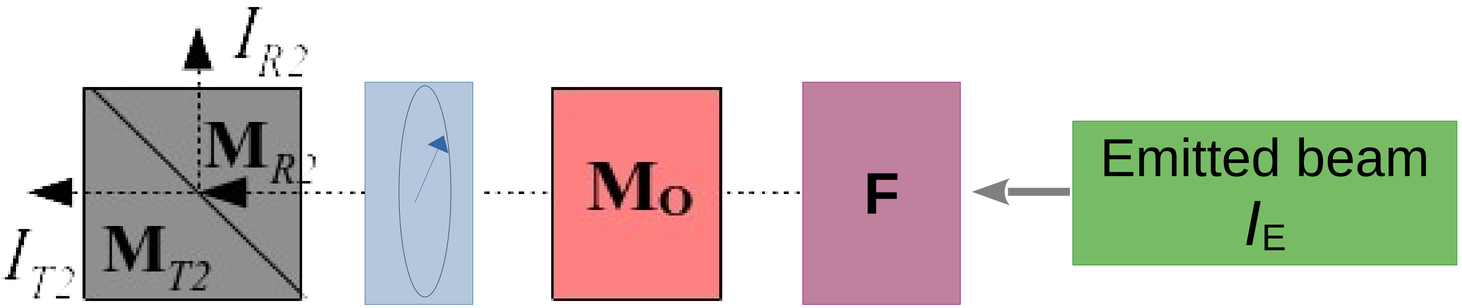
Simple example:

- calibrator/analyzer rotation by 45° clockwise: lin. pol. component at +45° + α
- a bias is introduced because the beam is not split equally to R and T

Analyzer: Ideal PBS
Calibrator: Manual rotator or HWP
Laser beam: Rotated by α



T component smaller than R

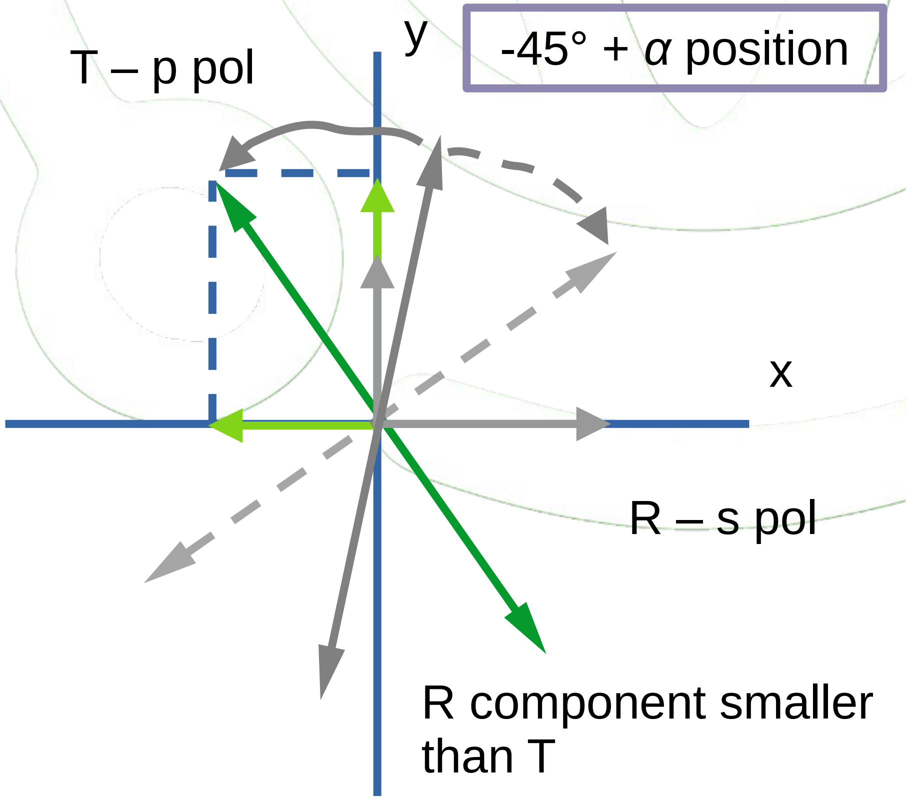


Polarization Calibration – Calibration factor η

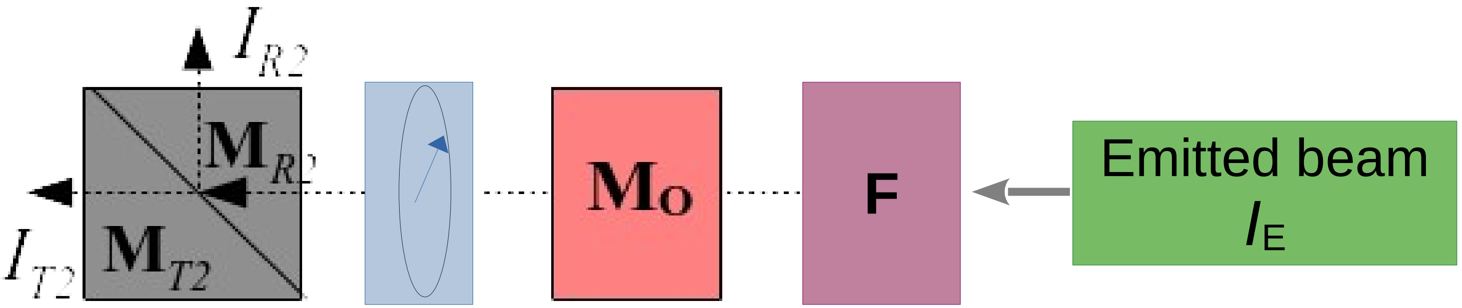
Analyzer: Ideal PBS
Calibrator: Manual rotator or HWP
Laser beam: Rotated by α

Δ90 calibration:

- Rotate the lin. pol. component by two angles 90° apart (e.g. +45°+α, -45°+α)
- Rotation must be done very accurately (90°)
- Difference between i. e. the T signal at +45° and -45° depend on the angle α



R component smaller than T



Polarization Calibration – Calibration factor *η*

Opto-electrical calibration factor *η*:

- R and T gain ratios compensate each other well at the two calibrator positions
- Misalignment errors cancel out by using the geometrical mean of the Δ90 gain ratios

Freudenthaler, 2016

$$\eta = \frac{\eta_R T_R}{\eta_T T_T}$$

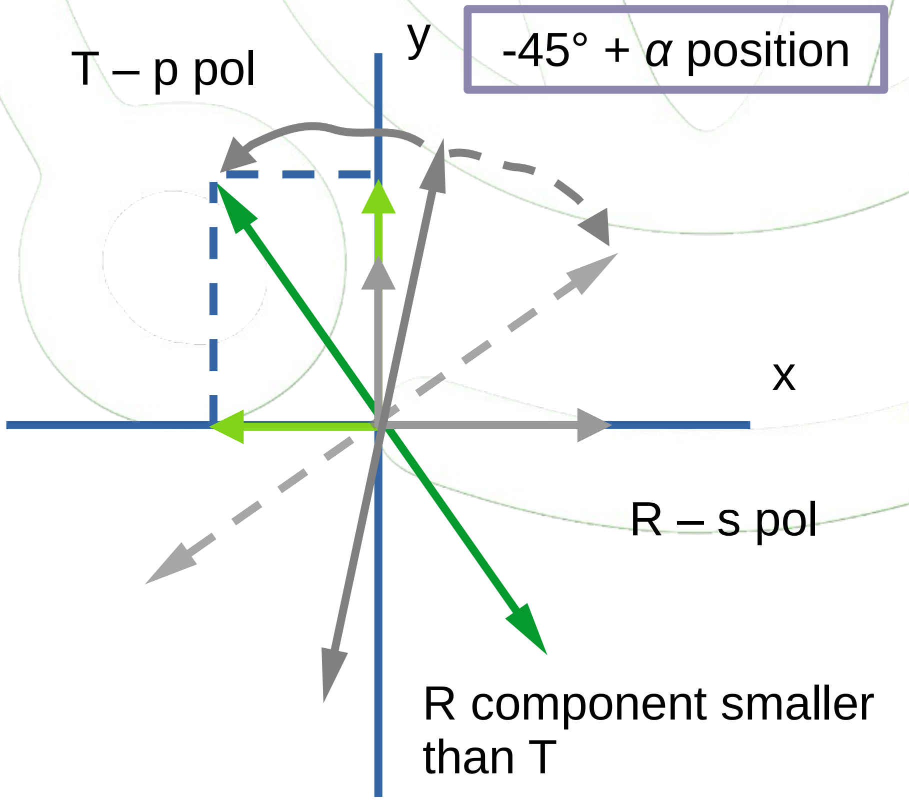
$$\eta^*_{\Delta 90} = \sqrt{\frac{I_{R,+45}}{I_{T,+45}} \frac{I_{R,-45}}{I_{T,-45}}}$$

Generally: $\eta \neq \eta^*$

$$K = \frac{\eta^*}{\eta}$$

Ideal case: $\eta^* = \eta$
cleaned analyzer
+
Ideal receiver optics

Analyzer: Ideal PBS
Calibrator: Manual rotator or HWP
Laser beam: Rotated by *α*



Polarization Calibration – Calibration factor η

Questions?

Polarization Calibration – *K* correction factor

General case:

- Non ideal reciever optics/analyzer
- Polarization impurities / Rotation at emissions
- The calibrator position can vary among systems
- Gain ratio η^* is measured instead of η

η^*: gain ratio

$$\eta^*_{\Delta 90} = \sqrt{\frac{I_{\mathrm{R},+45}}{I_{\mathrm{T},+45}} \frac{I_{\mathrm{R},-45}}{I_{\mathrm{T},-45}}}$$

K: calibration factor correction

$$K = \frac{\eta^*}{\eta}$$

Gain ratio at ±45°:

$$\frac{I_{\mathrm{R},\pm 45}}{I_{\mathrm{T},\pm 45}} = \eta \frac{G_{\mathrm{R},\pm 45} + H_{\mathrm{R},\pm 45} a}{G_{\mathrm{T},\pm 45} + H_{\mathrm{T},\pm 45} a}$$

Cal. Ratio at 0°:

$$\frac{1}{\eta} \frac{I_{\mathrm{R}}}{I_{\mathrm{T}}} = \frac{G_{\mathrm{R}} + H_{\mathrm{R}} a}{G_{\mathrm{T}} + H_{\mathrm{T}} a}$$

$$\boxed{K = \sqrt{\frac{G_{\mathrm{R},+45} + H_{\mathrm{R},+45} a}{G_{\mathrm{T},+45} + H_{\mathrm{T},+45} a} \frac{G_{\mathrm{R},-45} + H_{\mathrm{R},-45} a}{G_{\mathrm{T},-45} + H_{\mathrm{T},-45} a}}}$$

Polarization Calibration – *K* correction factor

Questions?

Polarization Calibration – GHK correction

GHK correction:

- **GHK factors**: calculated every time optics change before the analyzer (GHK script)
- **gain ratio $\boldsymbol{\eta^*}$**: measured often – Δ90 cal.

  (η_R and η_T can change day-by-day, e.g. ND coating aging)
- η^* and the GHK factors --> **VLDR** δ_V

$$\boxed{\delta_V = \frac{\delta^*(G_T + H_T) - (G_R + H_R)}{(G_R - H_R) - \delta^*(G_T - H_T)}}$$

Freudenthaler et al. 2016

η^*: gain ratio

Calibration measurement

$$\eta^*_{\Delta 90} = \sqrt{\frac{I_{R,+45}}{I_{T,+45}} \frac{I_{R,-45}}{I_{T,-45}}}$$

K: calibration factor correction

$$K = \frac{\eta^*}{\eta}$$

Calibrated ratio δ^*:

Normal measurement

$$\delta^* = \frac{1}{\eta} \frac{I_R}{I_T} = \frac{K}{\eta^*} \frac{I_R}{I_T}$$

Polarization Calibration – GHK correction

Questions?

Performing the polarisation calibration QA test

-45°+α

0°+α

+45°+α

Performing the polarisation calibration QA test

Ways of achieving the Δ90 rotation:

- Rotating the whole detection box (manual rotator)
- Rotating only the analyzer (rare)
- Motorized HWP in the detection box
- Motorized HWP in the emission (rare)
- Motorized/manually rotated linear polarizer in the detection box

The position and type of the calibrator determine the value of K

Analysing the polarisation calibration QA test

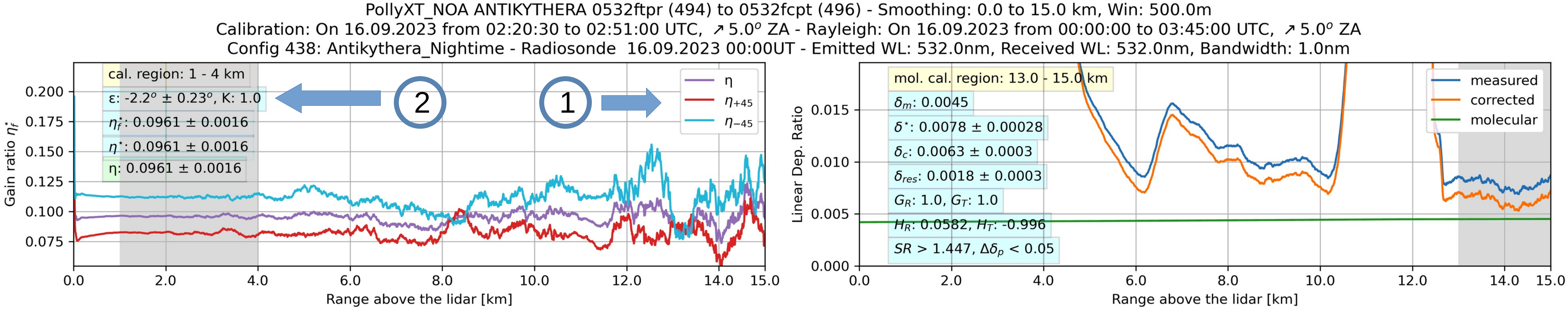
Polarization calibration example:

1)The $\eta^{*}, \eta^{*}_{+45}, \eta^{*}_{-45}$ gain ratios are displayed

2)The misalignment angle can be estimated from the $\eta^{*}_{+45}, \eta^{*}_{-45}$ differences

Polarization Calibration

Rayleigh Measurement


PollyXT_NOA ANTIKYTHERA 0532ftpr (494) to 0532fcpt (496) - Smoothing: 0.0 to 15.0 km, Win: 500.0m
Calibration: On 16.09.2023 from 02:20:30 to 02:51:00 UTC, ↗ 5.0° ZA - Rayleigh: On 16.09.2023 from 00:00:00 to 03:45:00 UTC, ↗ 5.0° ZA
Config 438: Antikythera_Nightime - Radiosonde 16.09.2023 00:00UT - Emitted WL: 532.0nm, Received WL: 532.0nm, Bandwidth: 1.0nm

Analysing the polarisation calibration QA test

Polarization calibration example:

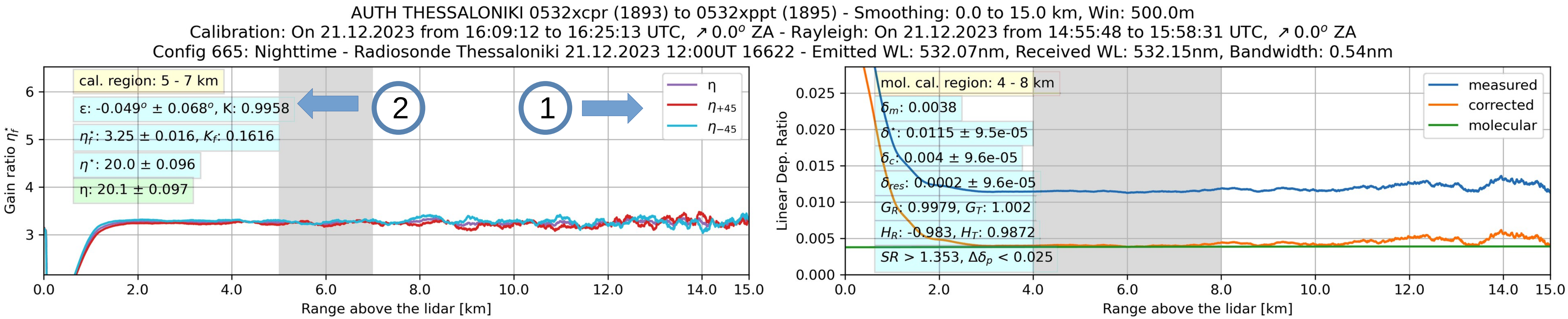
1)The $\eta^*, \eta^*_{+45}, \eta^*_{-45}$ gain ratios are displayed

2)The misalignment angle can be estimated from the $\eta^*_{+45}, \eta^*_{-45}$ differences

If the misalignment is small → +45° and -45° signals should match

Polarization Calibration

Rayleigh Measurement



Analysing the polarisation calibration QA test

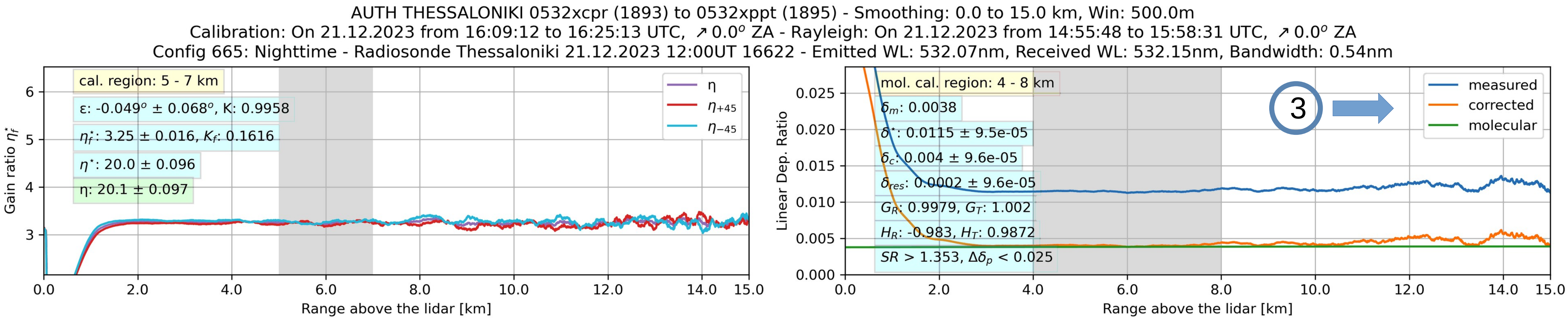
Polarization calibration example:

3)The measured and GHK corrected calibrated ratios are displayed

The molecular LDR is also displayed for comparison

Polarization Calibration

Rayleigh Measurement



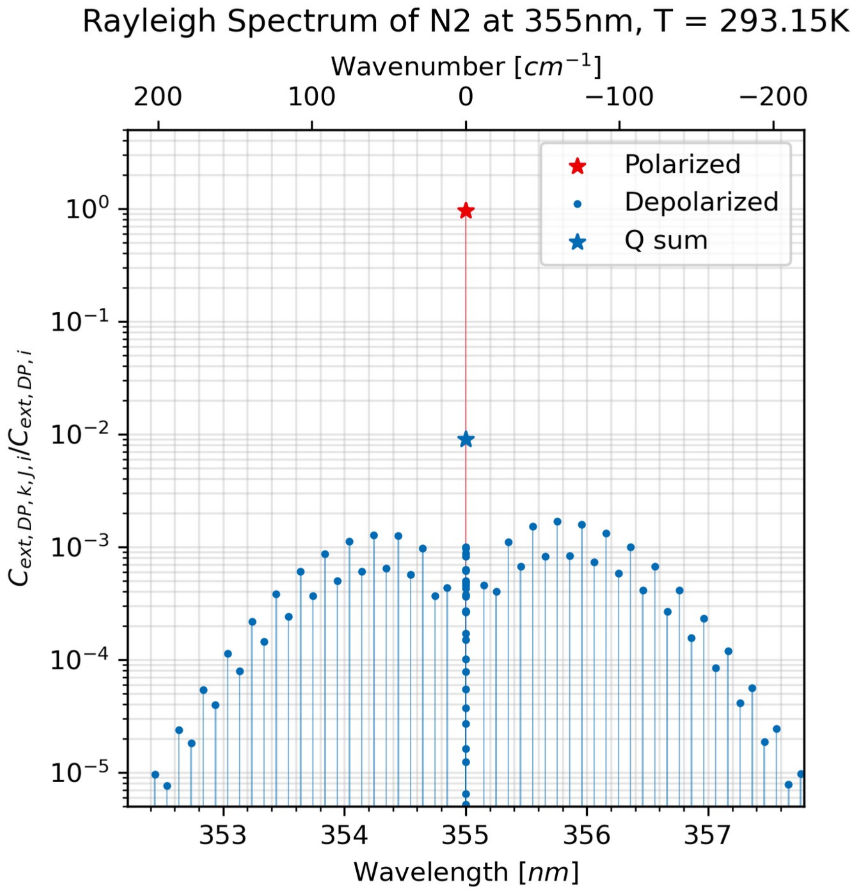
Analysing the polarisation calibration QA test

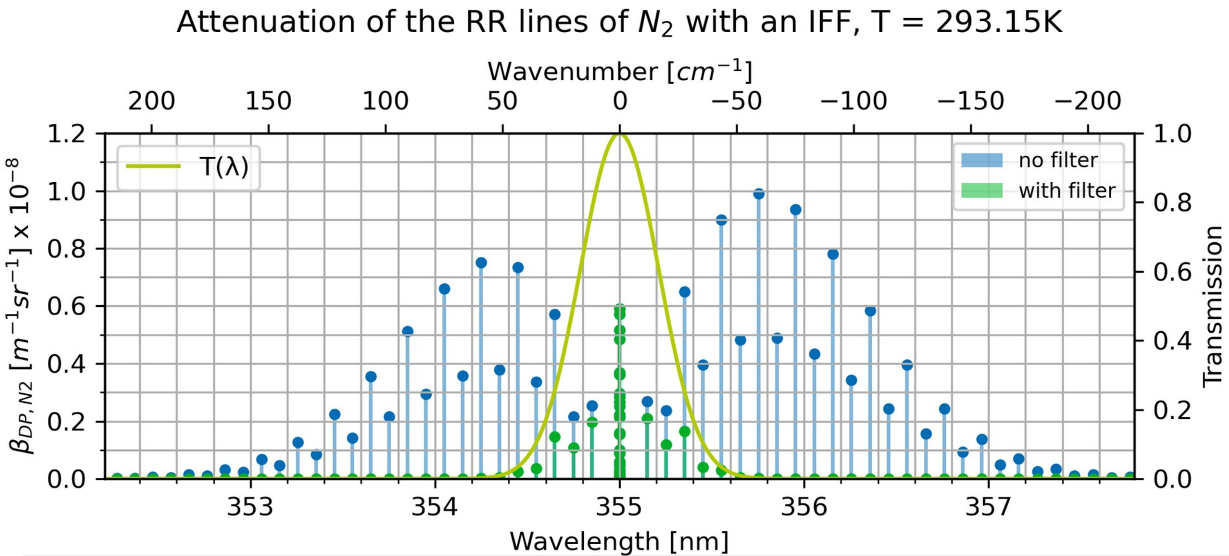
Questions?

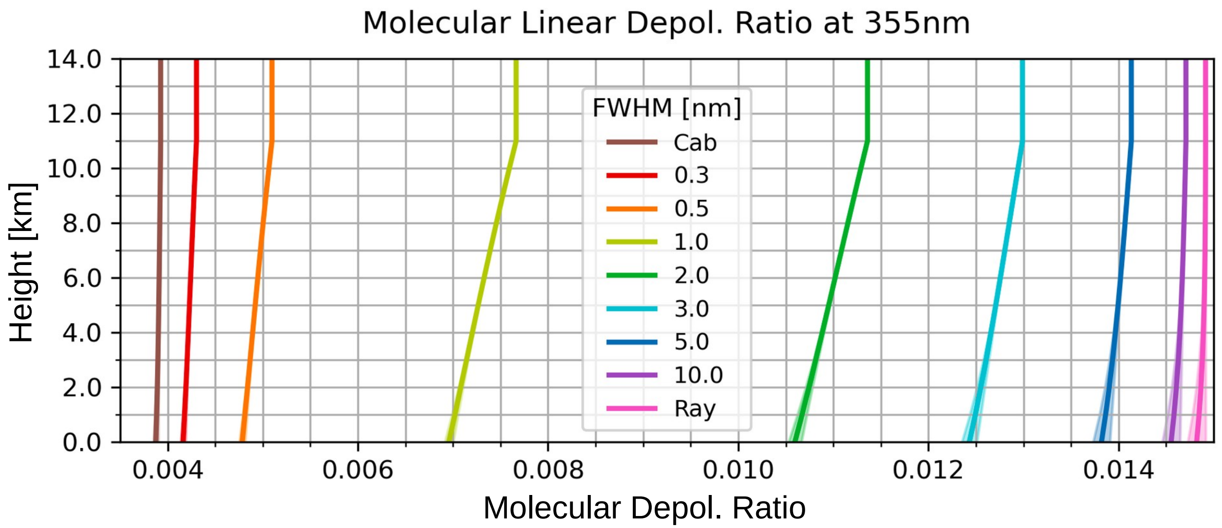
The origin or molecular depolarization

Molecular depolarization (MLDR):

- comes from the rotational Raman lines
- RR lines highly depolarized - small cross-section
- MLDR sensitive to the interference filter



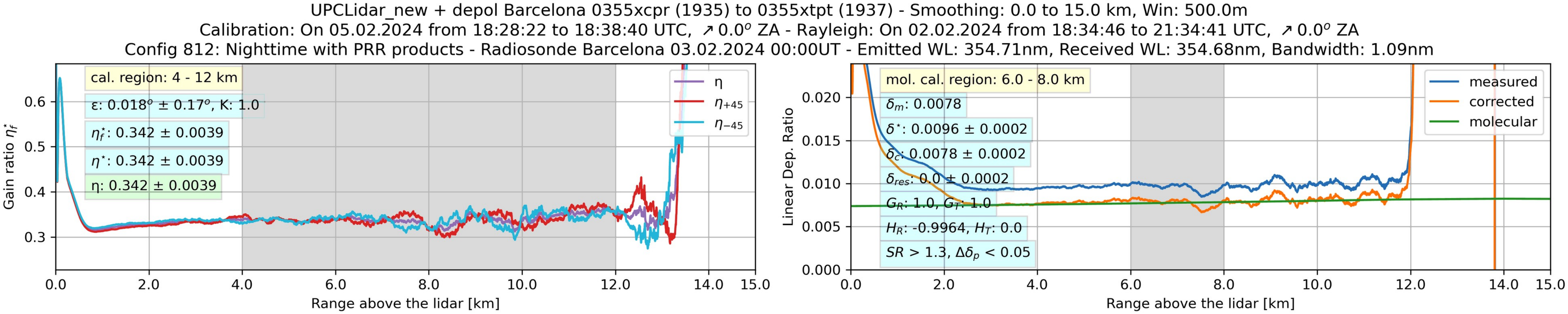




The origin or molecular depolarization

Example where temperature effects are visible:

- easier to see for 355 and for interference filter bandwidths > 1nm



UPCLidar_new + depol Barcelona 0355xcpr (1935) to 0355xtpt (1937) - Smoothing: 0.0 to 15.0 km, Win: 500.0m
Calibration: On 05.02.2024 from 18:28:22 to 18:38:40 UTC, ↗ 0.0° ZA - Rayleigh: On 02.02.2024 from 18:34:46 to 21:34:41 UTC, ↗ 0.0° ZA
Config 812: Nighttime with PRR products - Radiosonde Barcelona 03.02.2024 00:00UT - Emitted WL: 354.71nm, Received WL: 354.68nm, Bandwidth: 1.09nm

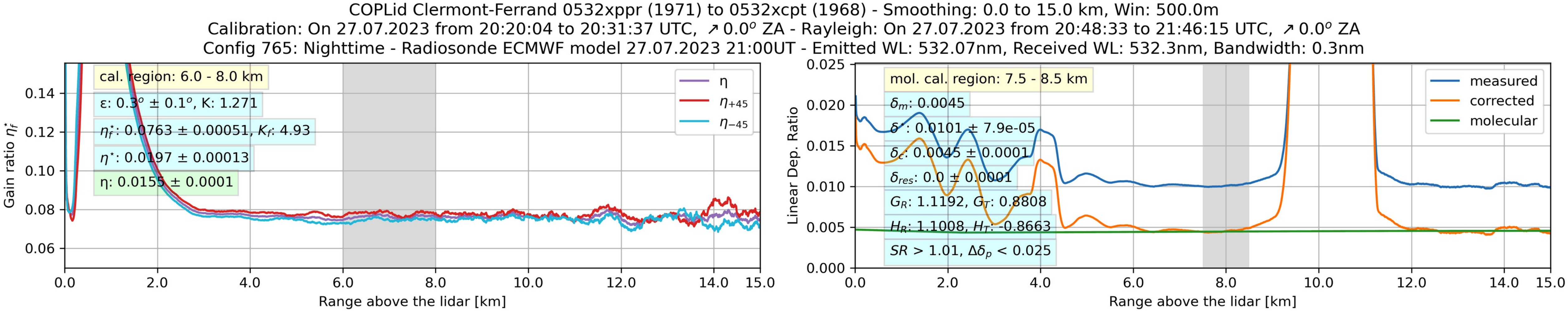
The origin or molecular depolarization

Questions?

Retrieved QA parameters

Pol. cal. measurement example:

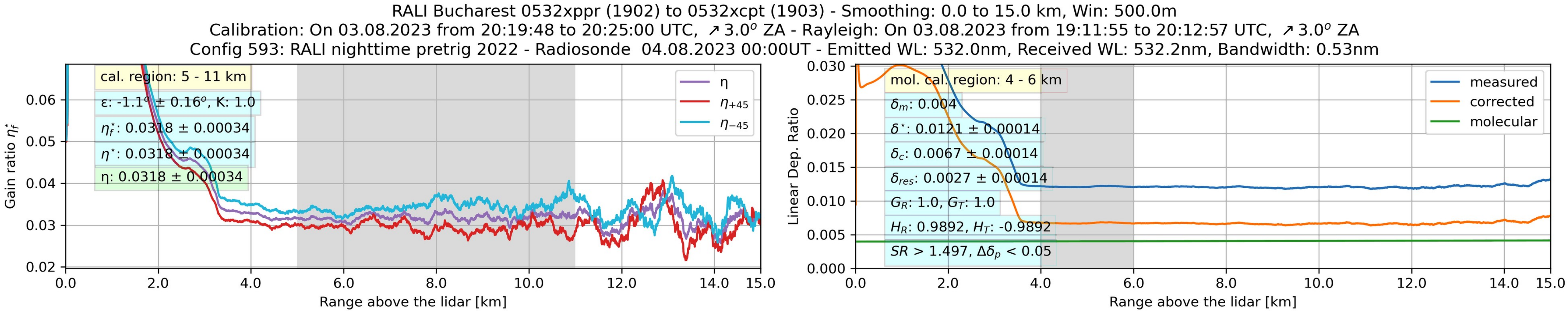
- Retrieved parameter: min. backscatter ratio used for particle lin. depol. ratio (PLDR)
- Provided to the SCC configuration


COPLid Clermont-Ferrand 0532xppr (1971) to 0532xcpt (1968) - Smoothing: 0.0 to 15.0 km, Win: 500.0m
Calibration: On 27.07.2023 from 20:20:04 to 20:31:37 UTC, ↗ 0.0^o ZA - Rayleigh: On 27.07.2023 from 20:48:33 to 21:46:15 UTC, ↗ 0.0^o ZA
Config 765: Nighttime - Radiosonde ECMWF model 27.07.2023 21:00UT - Emitted WL: 532.07nm, Received WL: 532.3nm, Bandwidth: 0.3nm

Retrieved QA parameters

Why is the backscatter ratio important?

- VLDR offset → source of systematic error
- Propagated to the PLDR
- PLDR error dependent on the backscatter ratio

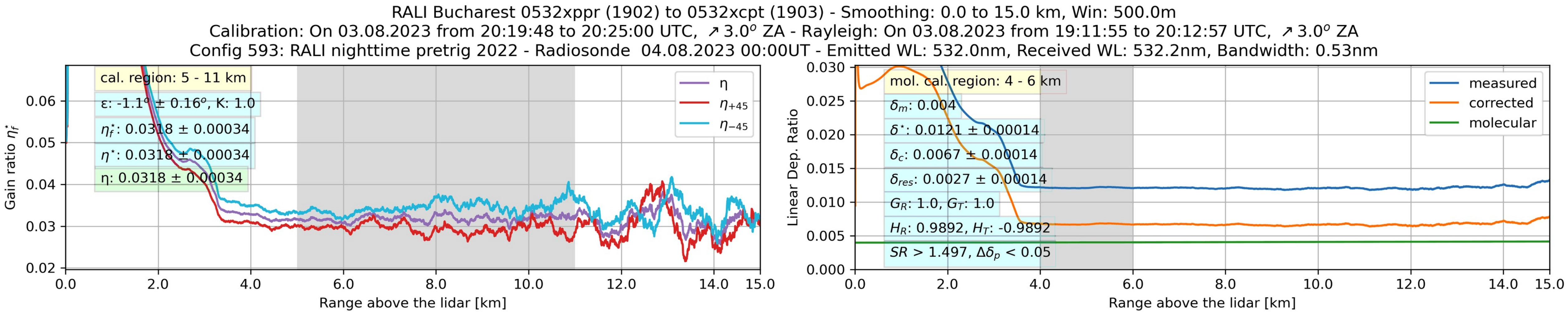


Retrieved QA parameters

How to determine the min. backscatter ratio?

- Define a max allowed PLDR error: 0.025 (based on aerosol typing needs)
- Given the VLDR offset, calculate the **min backscatter ratio** for which:

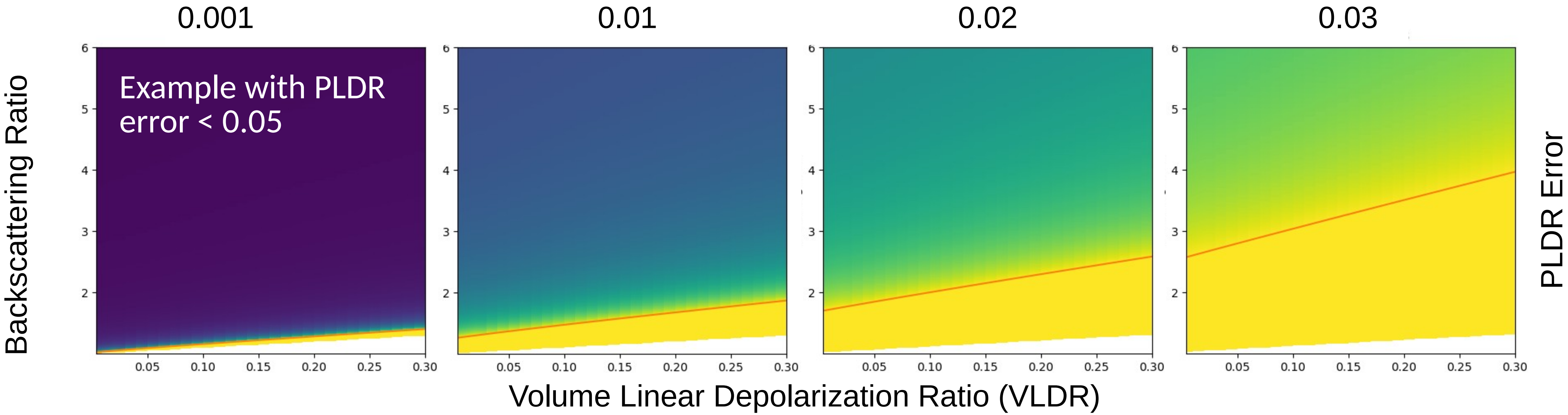
  PLDR error < 0.025 (always)



Retrieved QA parameters

How does the min. backscatter ratio depend on the VLDR offset:

- Example for min backscatter ratio: 0.05 (old value)
- Larger offset → larger min backscatter ratio
- VLDR offset > 0.05 → PLDR error > 0.05 (independent of backscatter ratio)



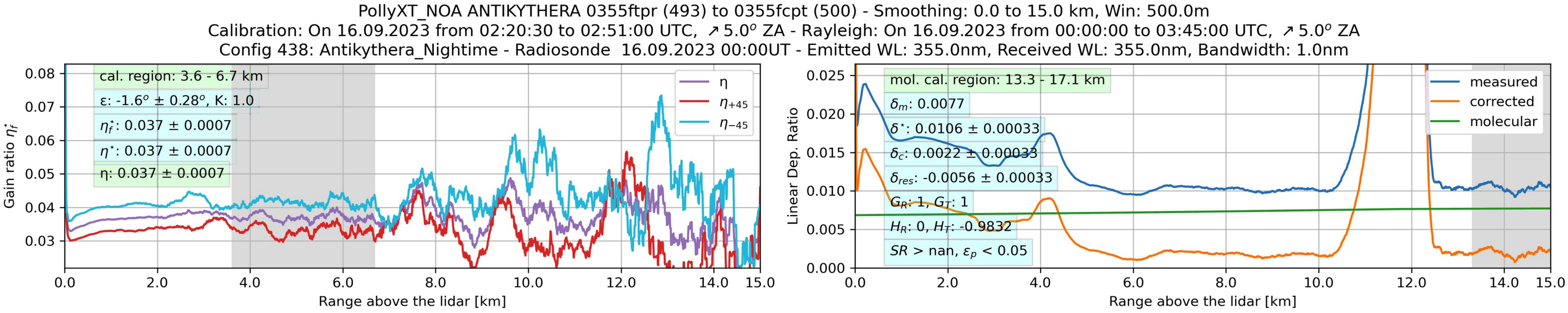
Retrieved QA parameters

Questions?

Polarization Calibration – Common Issues

Common issues:

- Overdone GHK correction:
- Typical if old GHK values are used to a newer system

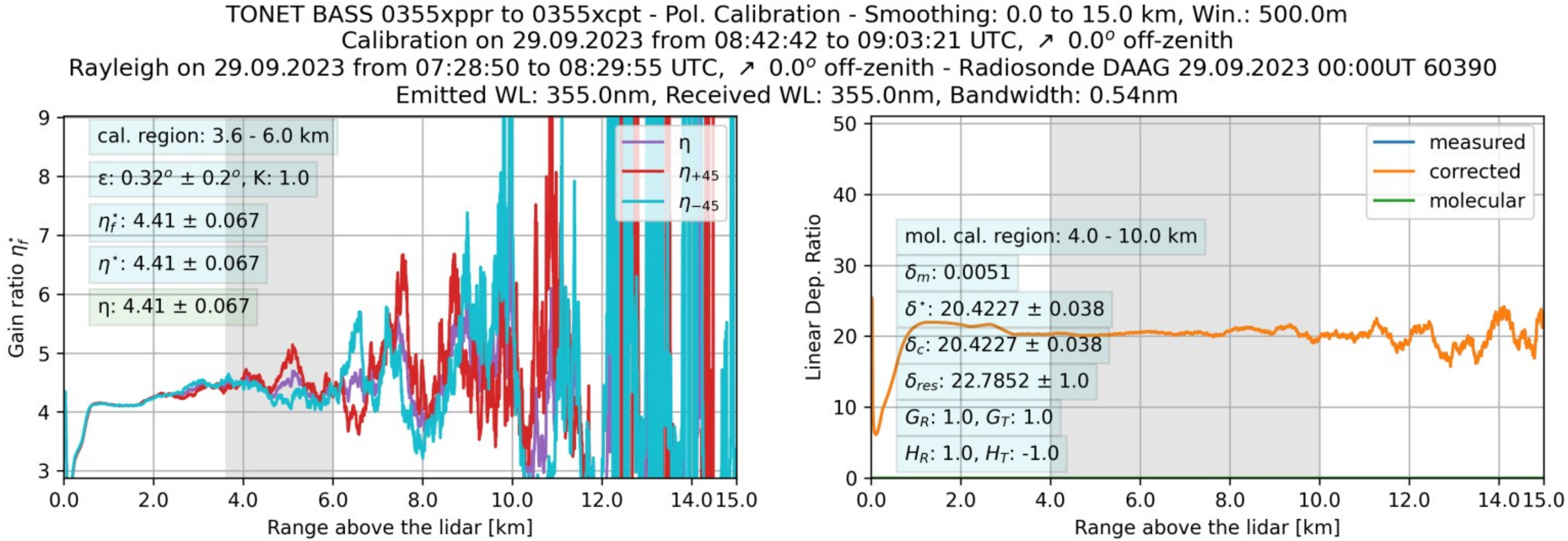


Polarization Calibration – Common Issues

Common issues:

- Neutral density pol. cal. filter not included or wrong transmission

  → Very high (or very low) PLDR (0 < PLDR < 1)



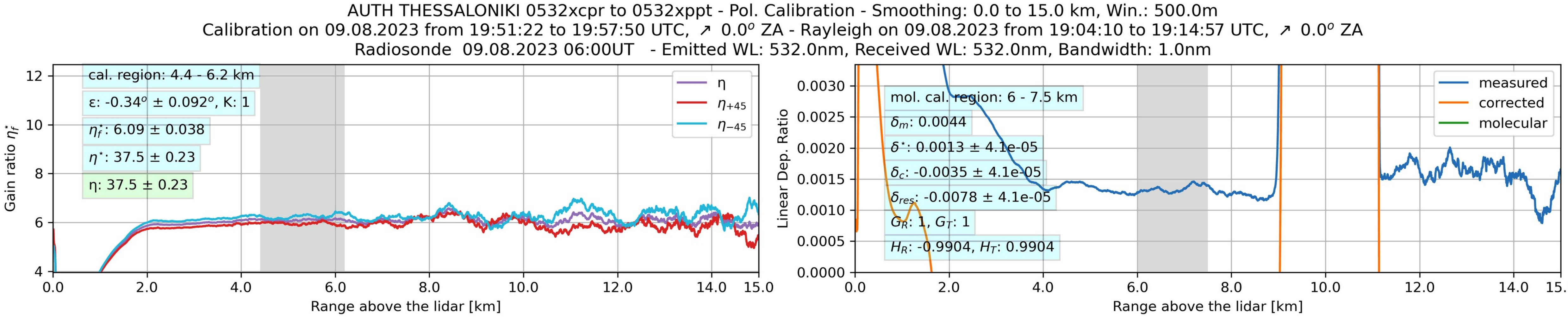
TONET BASS 0355xppr to 0355xcpt - Pol. Calibration - Smoothing: 0.0 to 15.0 km, Win.: 500.0m
Calibration on 29.09.2023 from 08:42:42 to 09:03:21 UTC, ↗ 0.0^o off-zenith
Rayleigh on 29.09.2023 from 07:28:50 to 08:29:55 UTC, ↗ 0.0^o off-zenith - Radiosonde DAAG 29.09.2023 00:00UT 60390
Emitted WL: 355.0nm, Received WL: 355.0nm, Bandwidth: 0.54nm

Polarization Calibration – Common Issues

Common issues:

- Neutral density pol. cal. filter not included or wrong transmission

  → Very high (or very low) PLDR (0 < PLDR < 1)



Polarization Calibration – Common Issues

Questions?

ITINERIS

THANKS!

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