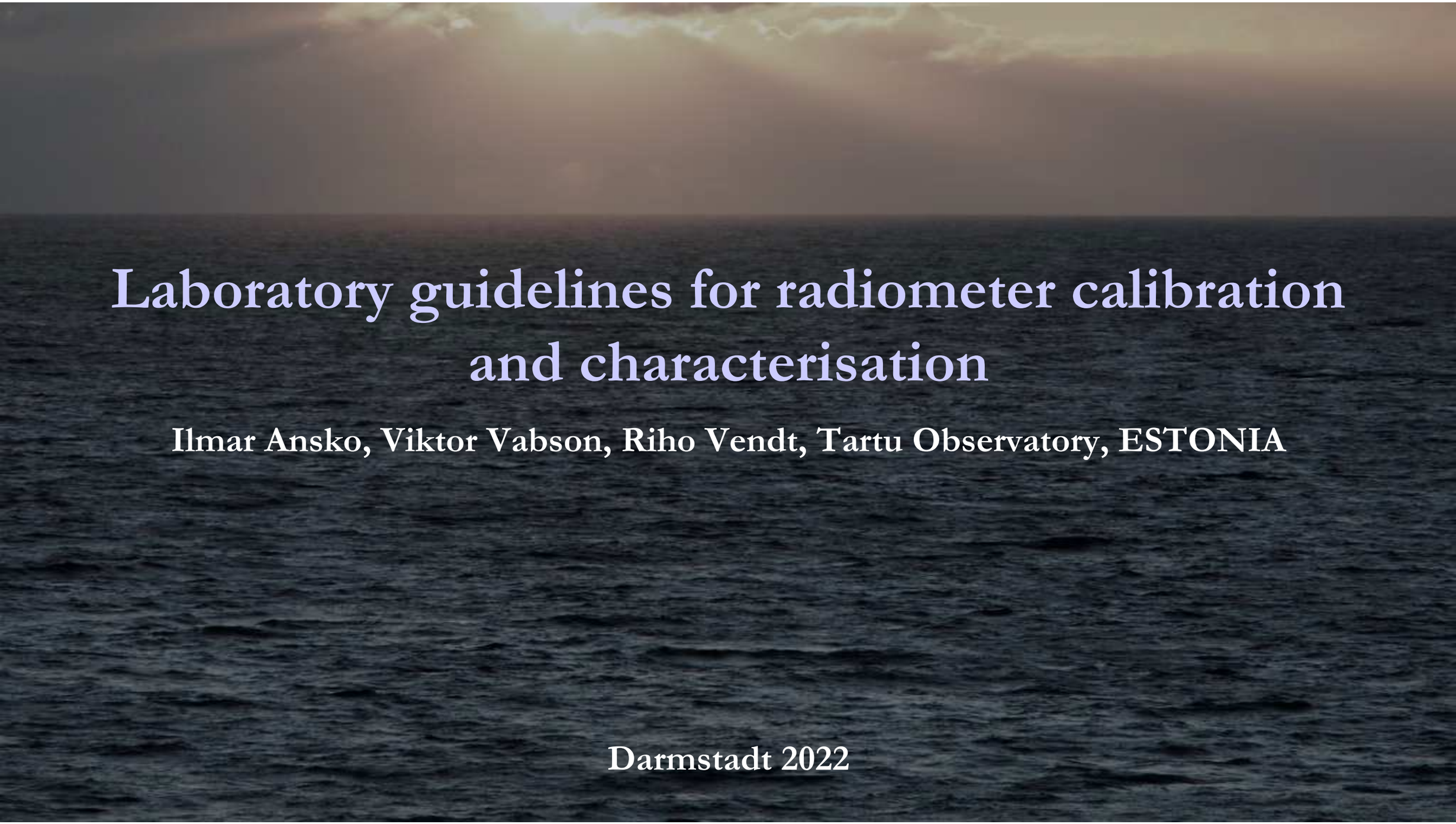

Laboratory guidelines for radiometer calibration and characterisation

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Darmstadt 2022

Requirements for laboratories

Competent personnel
Environmental conditions
Measurement equipment
Calibration program
Traceability charts
Measurement procedures
Uncertainty budgets
Participation in comparison exercises

Everything listed above documented and monitored according to ISO 17025

TODO: self-declaration (wavelength, SNR, dark signal, linearity)

Requirements for measurements

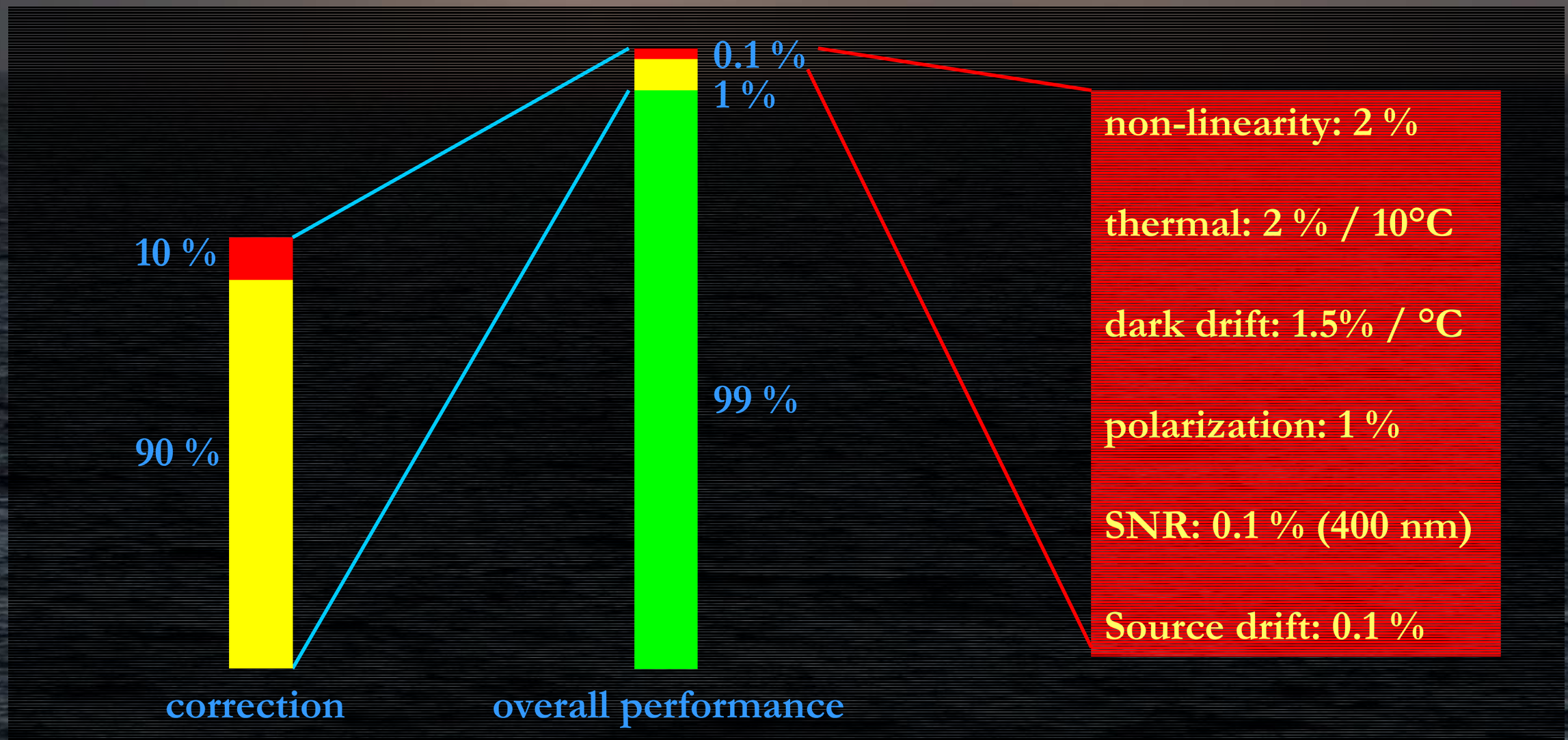
Following the harmonized laboratory guidelines (D12)
Data in SI units with uncertainties according to ISO GUM
Traceability documents available
Sufficiently detailed measurement model
Cal/char reports shall meet ISO 17025 requirements

TODO: self-declaration (wavelength, SNR, dark signal, linearity)

List of cal/char tasks

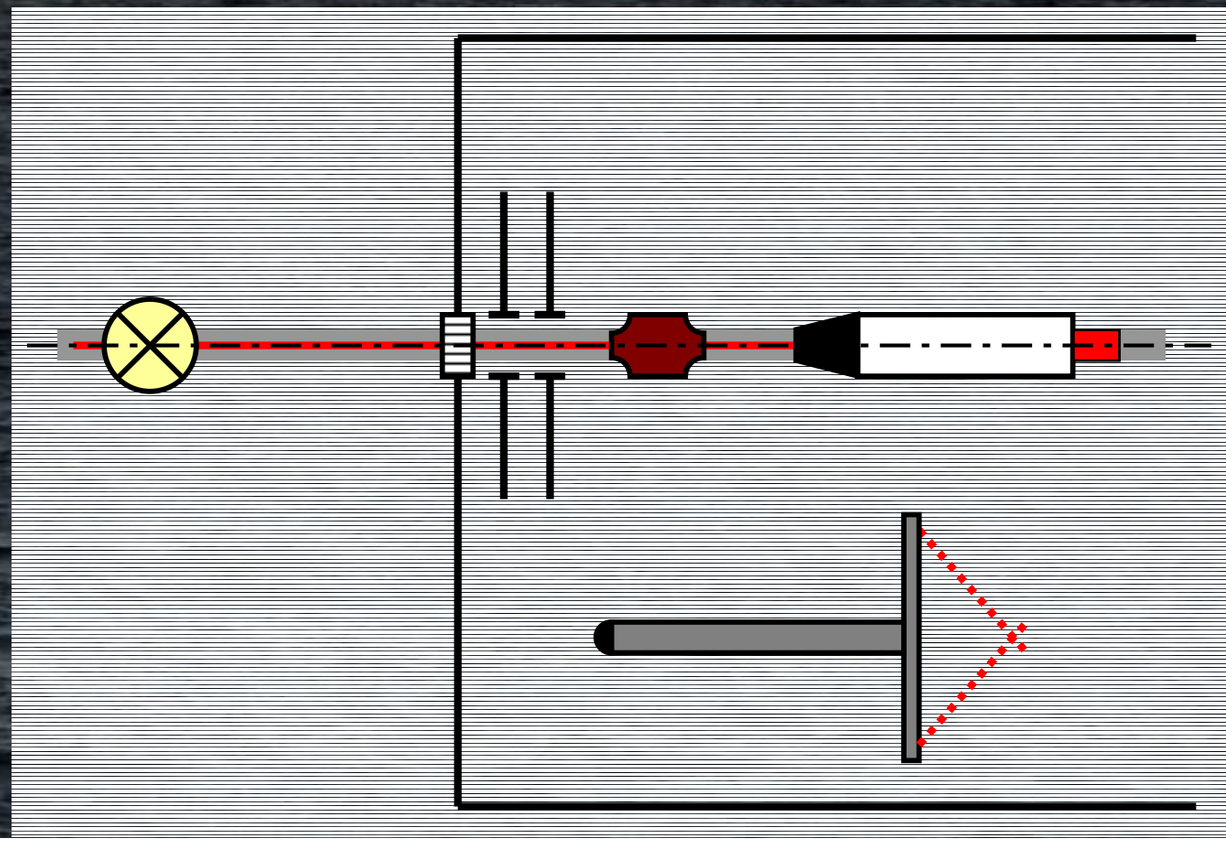
1. Absolute calibration for radiometric responsivity
2. Long-term stability
3. Straylight and out of band response
4. Immersion factors (radiance, irradiance)
5. Angular response in air
6. Radiometric non-linearity
7. Accuracy of integration times
8. Dark signal
9. Thermal sensitivity
10. Polarization sensitivity
11. Temporal response
12. Wavelength scale
13. Signal-to-noise ratio
14. Pressure effects

The problem: small errors on top of large signals with drifts



Irradiance calibration

IOCCG:	in close proximity
	no differences
Reviewers:	different lamp distances
	baffling issues
	back reflections
	auxiliary certificates
	diffuser's reference plane

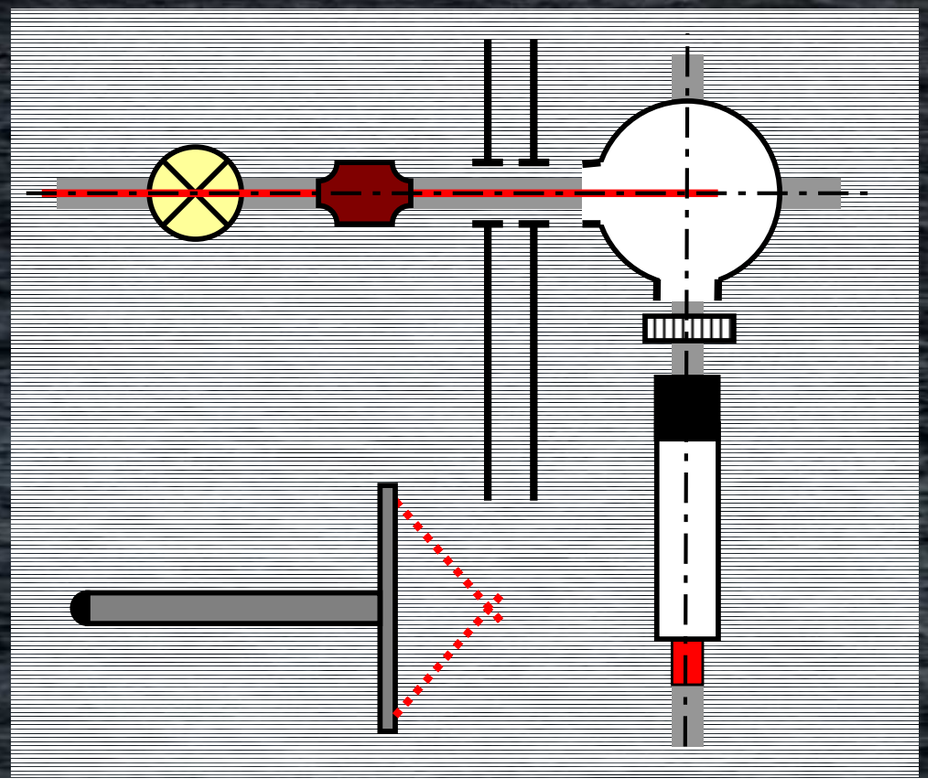


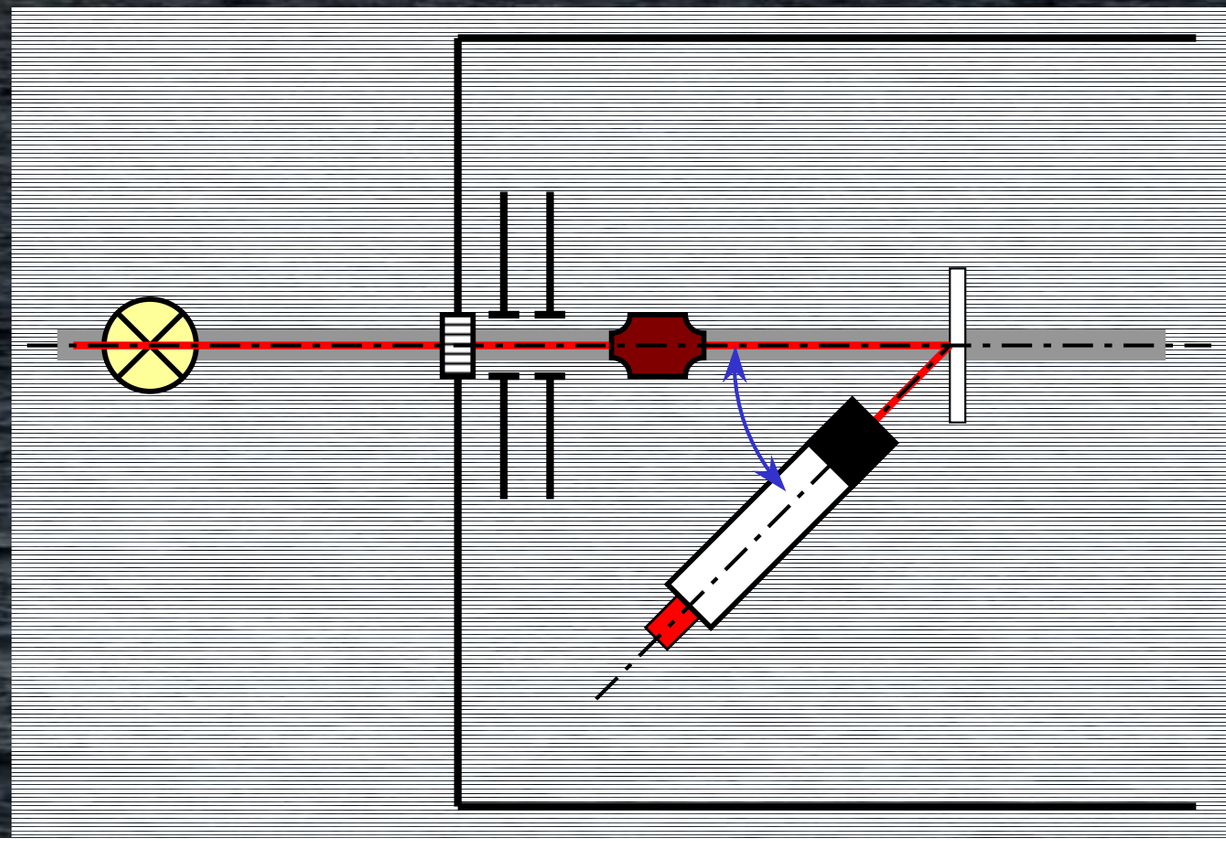
Radiance calibration

IOCCG: same as previous

Reviewers: same as previous

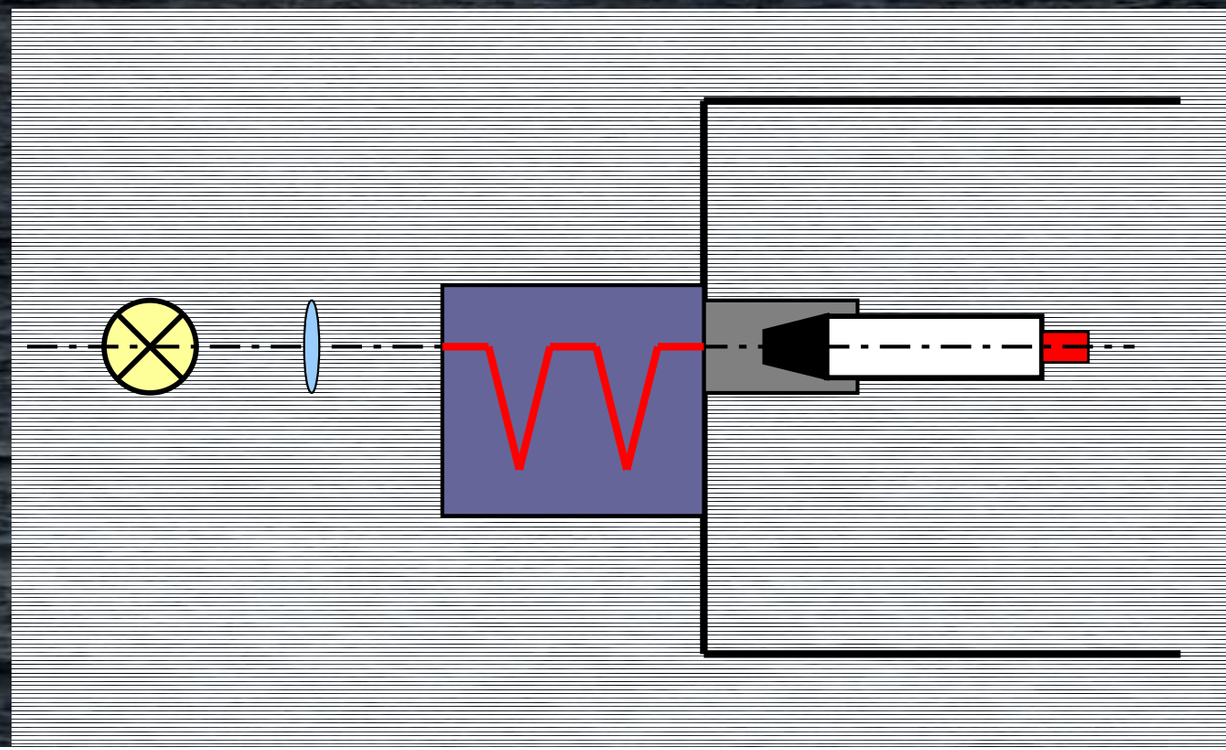
accounting for panel BRDF





Stray light

IOCCG:	Compatible
	more application methods
Reviewers:	double monochromator
	pixel centroid
	peak oversampling
	entrance overfilling
	suggesting tunable lasers
	OOB importance

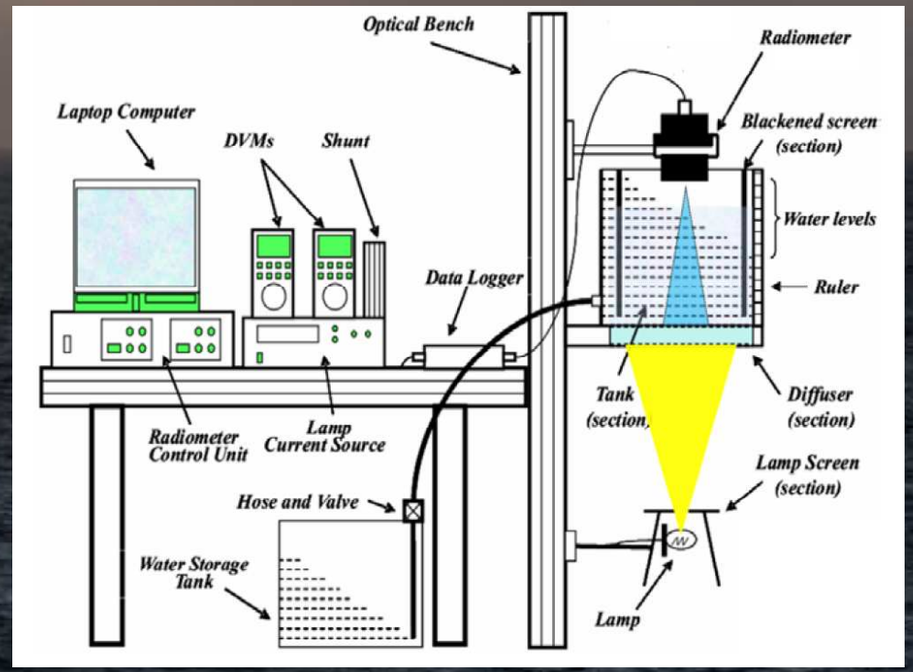


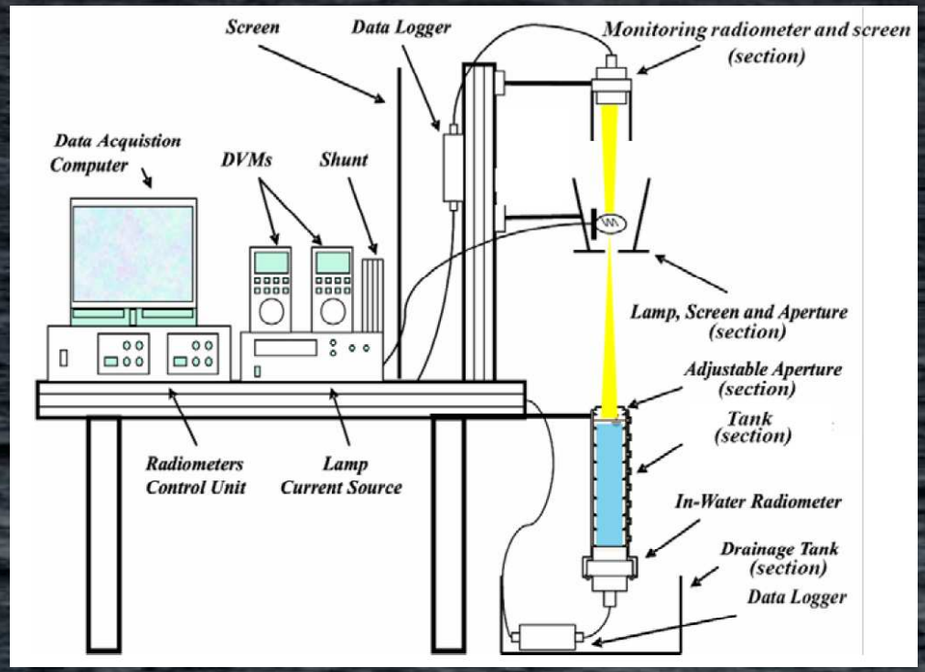
Immersion factors

IOCCG: unaltered

Reviewers: complaints about copy/paste

transmissivity of the collector

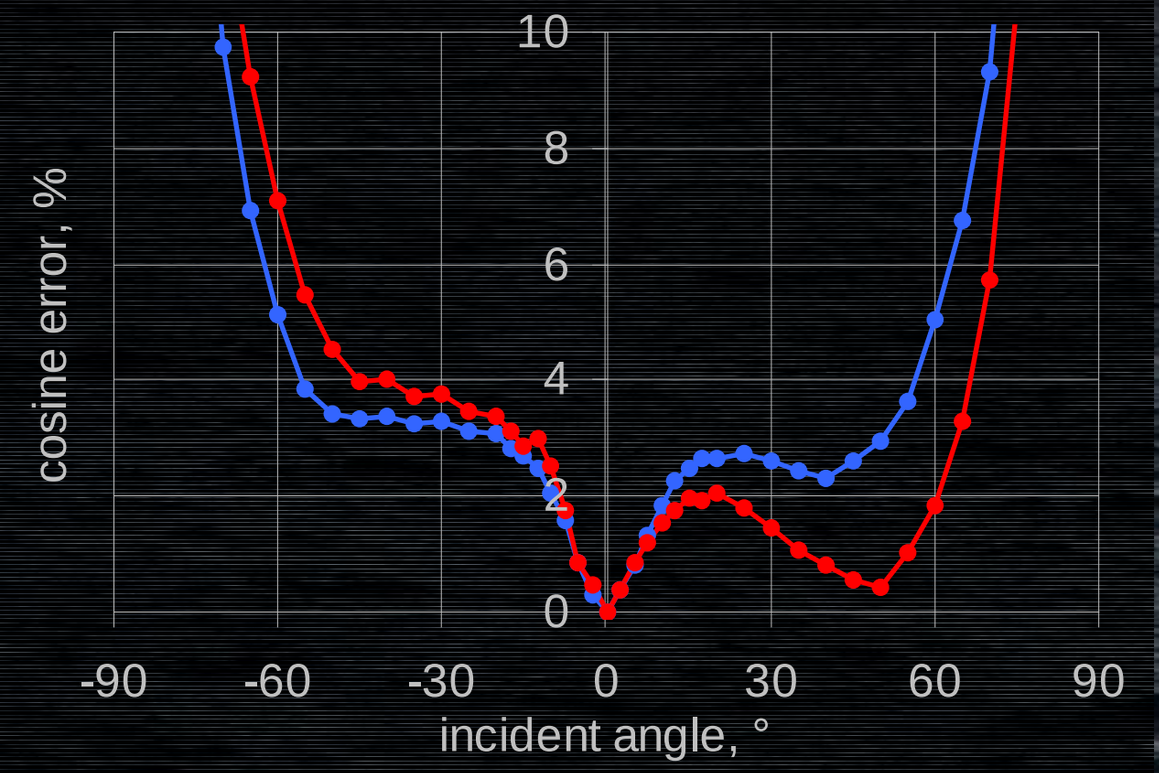


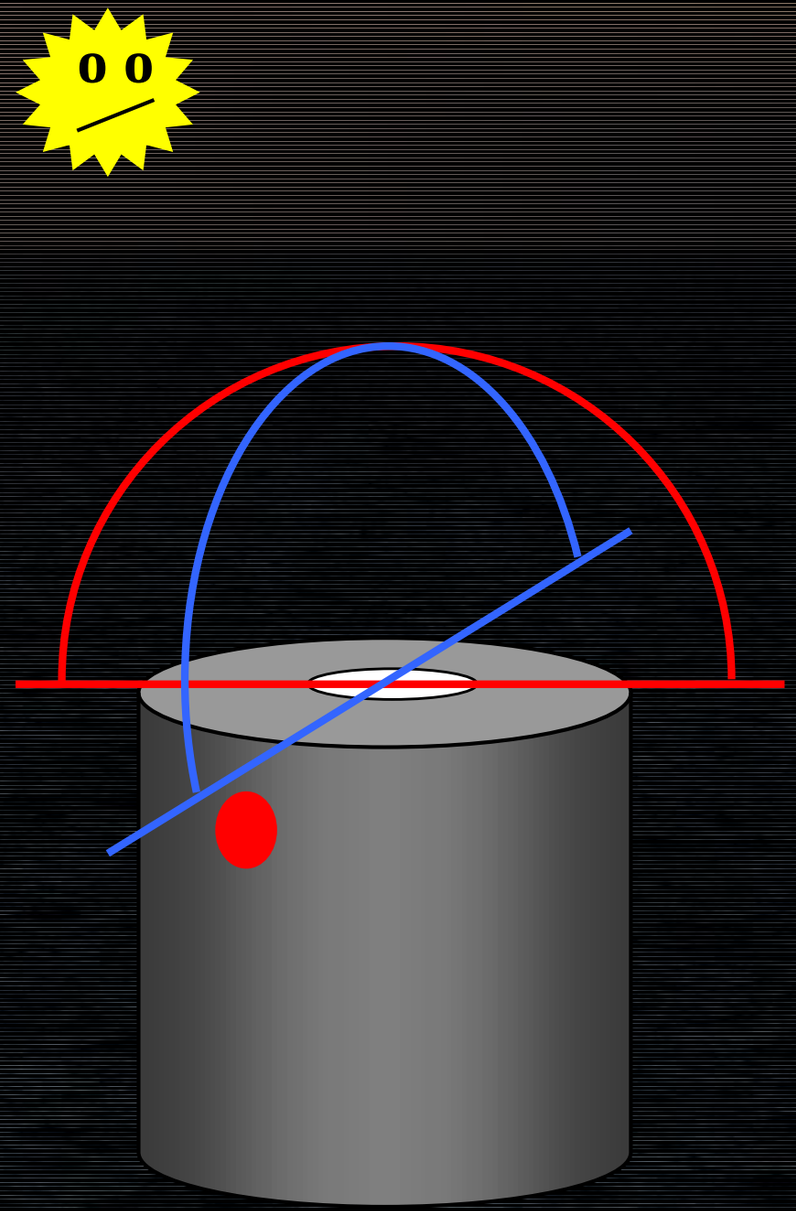


Angular response

IOCCG: compatible
added fixed azimuth requirement &
regular checking of reference signal

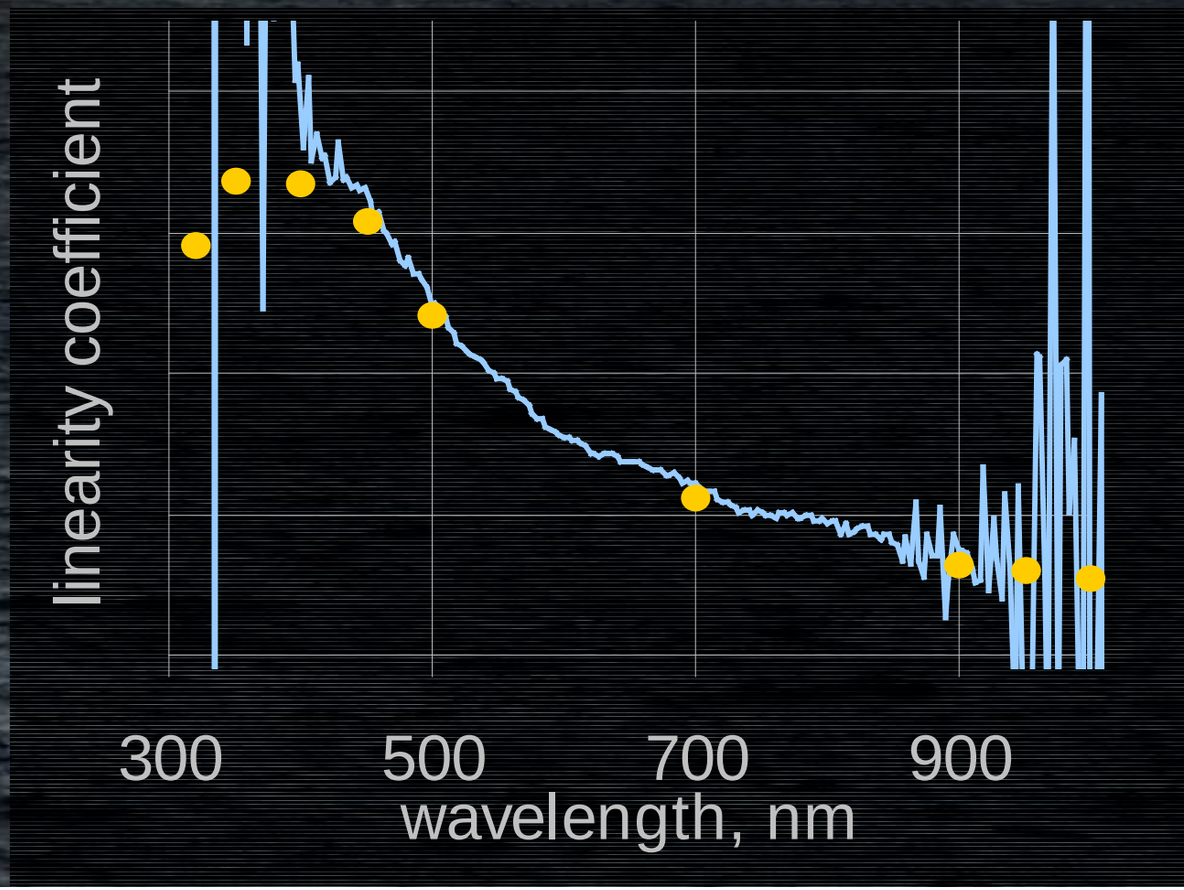
Reviewers: add D7 to references





Radiometric linearity

IOCCG	compatible
	integration time method
	possible thermal sensitivity
	monochromator option
Reviewers	multiple lamp calibration
	explanation of the mono-chromator method
	adding uncertainty
	distance vs. inttime method
	dependent on the inttime?

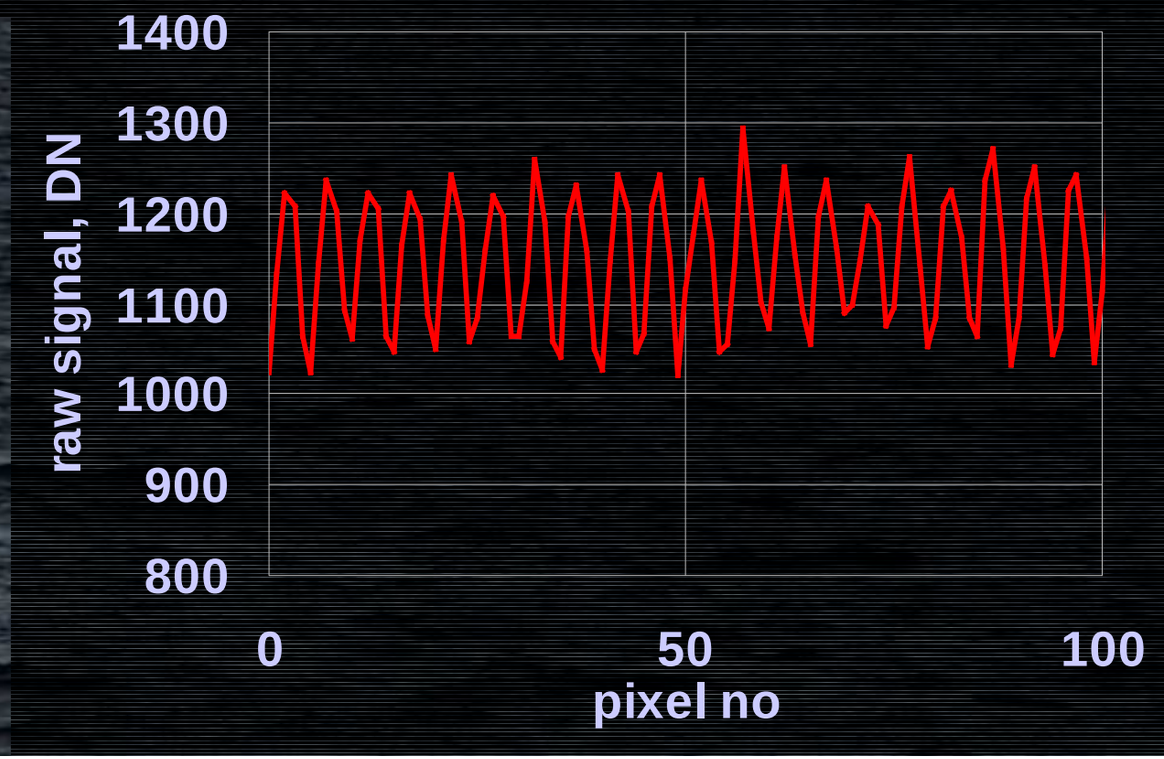


Accuracy of integration times

IOCCG	compatible
	no differences
Reviewers	none

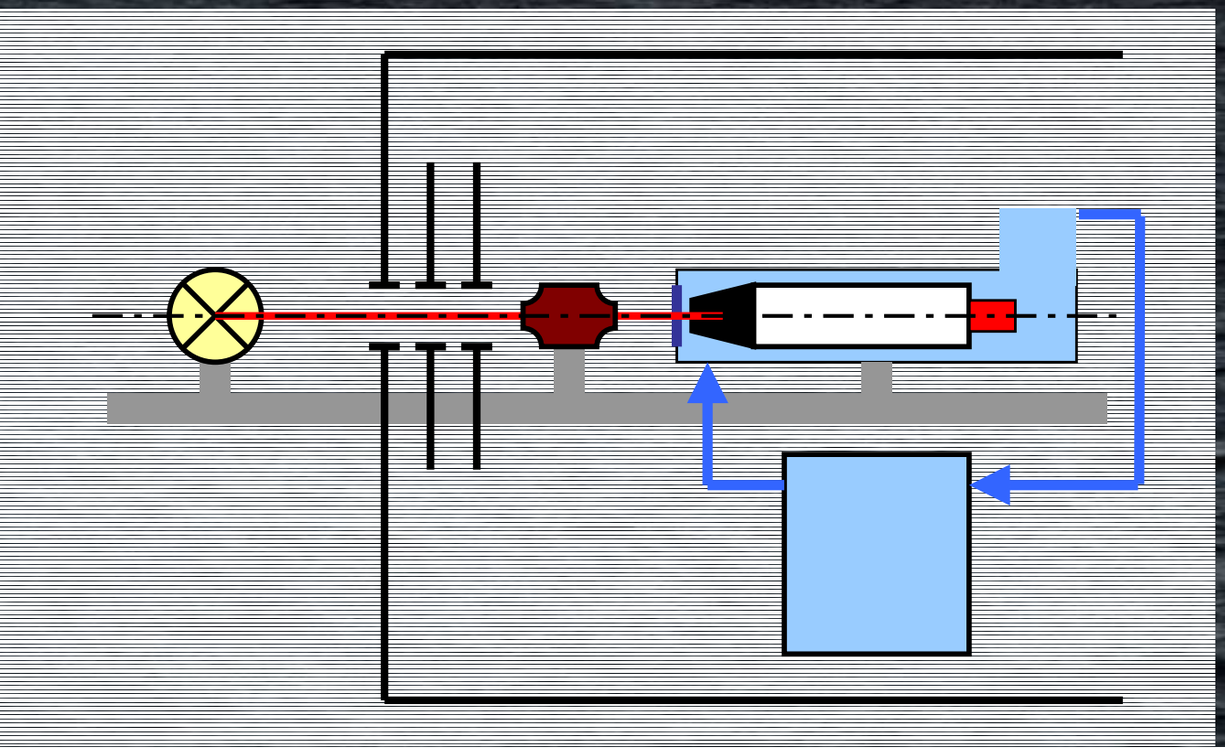
Dark signal

IOCCG	compatible
	using the longest inttime
Reviewers	dark measurement policy
	explanation of the exponential part
	opaque pixels vs. shutter



Thermal sensitivity

IOCCG	compatible simultaneously with linearity, dark signal, SNR, wavelength
Reviewers	none



Polarization sensitivity

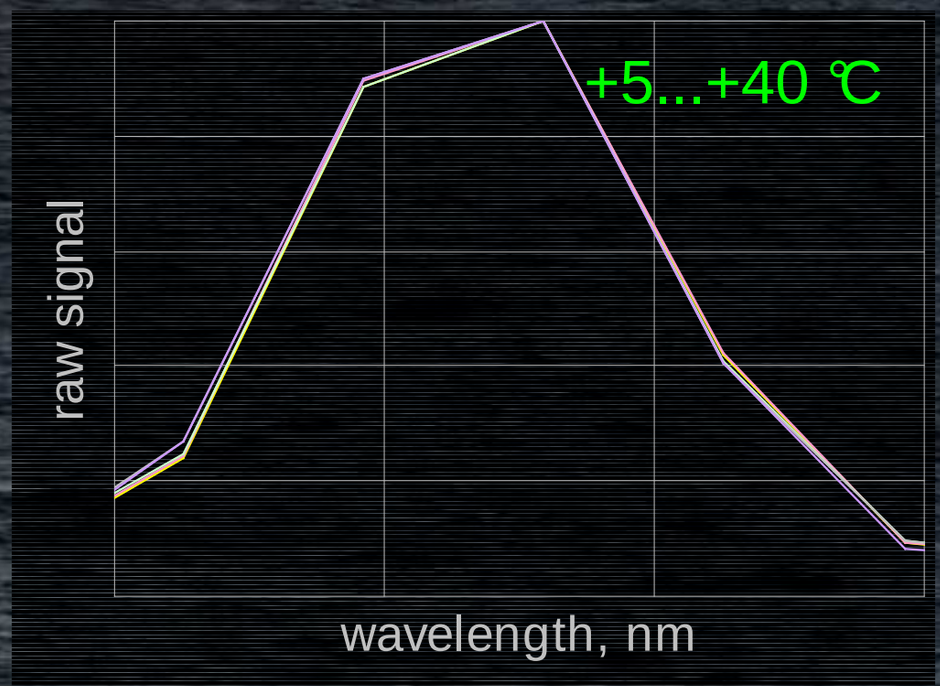
IOCCG	compatible
	regular check of the reference signal
Reviewers	about application method

Temporal response

IOCCG	TBD
Reviewers	none

Wavelength scale

IOCCG	compatible
	optional thermal sensitivity
Reviewers	pixel centroid
	yearly re-calibration
	table symbols



Signal-to-noise ratio

IOCCG	compatible
	extended from signal properties
	to the instrumental properties
Reviewers:	none

Pressure effects

IOCCG	TBD
Reviewers	none

Gaps in the characterization guidelines

Out-of-band response
Accuracy of integration times
Temporal response
Pressure effects

General notes from reviewers

Re-calibration and re-characterization should depend on the uncertainty requirements
Some references missing
Add manufacturer's information to the re-calibration table
Explain/justify the ISO 17025 requirements
Expanding abbreviations
Missing illustrating graphs
Field exercise date and location
Naming of the companies/instruments
Paragraph & figure numbering
Comments in the CP files
Give full names of the related people

CP data formats

1. Absolute calibration (radiance, irradiance) + linearity + wavelength scale
2. Straylight
3. Angular response of irradiance sensors in air
4. Thermal sensitivity
5. Polarization sensitivity

Conclusions

Cal&char light sources differ from the natural ones; new source types needed

Instrument parameters (linearity, straylight, thermal, polarization) affect each other

Temporal & thermal drifts during long experiments shadow the small systematic effects

SNR with currently available sources limits the characterization wavelength range

The measurements are lengthy: software for automated lab measurements is needed

RAMSES: dark from opaque pixels not sufficient for some measurements