A wavelength ruler for the solar UV wavelength range

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7th workshop on UV Radiation measurement,
Davos, Switzerland 27-28 August 2013

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Outline

- Principle of the birefringence-based UV wavelength ruler
- Design and implementation of an on-field calibration unit
- Methods and analysis
- Conclusions

Birefringence-based UV wavelength ruler

Why do we need it??

- Large dynamic range of solar radiation measurements in UV (strong absorption below 330 nm) makes UV radiation measurement sensitive to accuracy of wavelength scale
- Not enough intense single lines from lasers or spectral lamps in this wavelength region

Goal

- To decrease the uncertainty for wavelength calibration of detectors in the range 280nm-400nm down to 10 pm
- Create a transportable system, based on birefringent wavelength ruler combined with a broad band source

Birefringence-based UV wavelength ruler

Ruler: the basic structure is made of

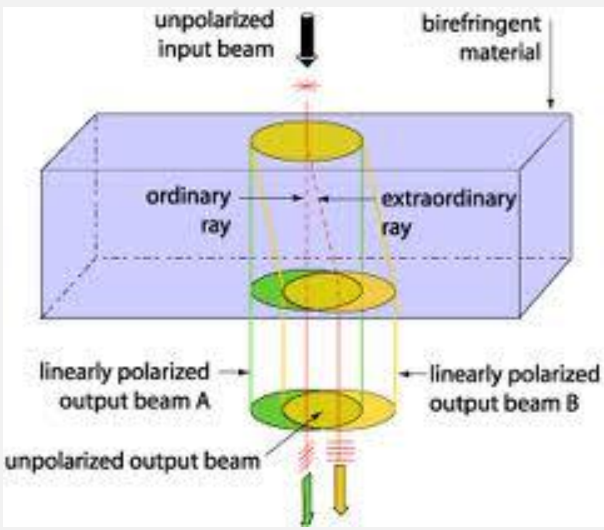
- Polarizer
- Birefringent plate of proper thickness (with given tolerance)
- Polarizer

Few constraints are:

- It has to work in the range 280nm-400nm
- Temperature variations should be controlled
- We need enough lines but not too narrow (FWHM~10-20nm)
- It should easily interface with the light source and the radiometer(s)

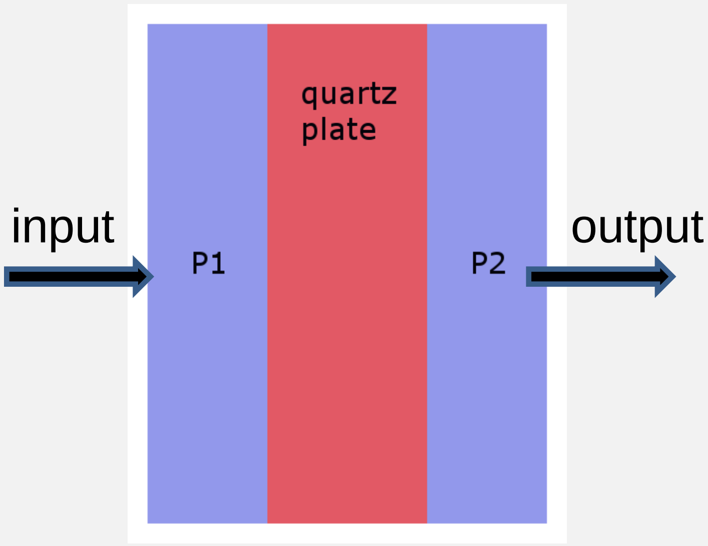
Birefringence-based UV wavelength ruler

Birefringence:
A material shows different refractive indices
for different polarization states ⟶ **Anisotropic medium**



Birefringence-based UV wavelength ruler

One/-stage Lyot filter



- Axis of birefringent plate at 45° with polarizer transmission axis

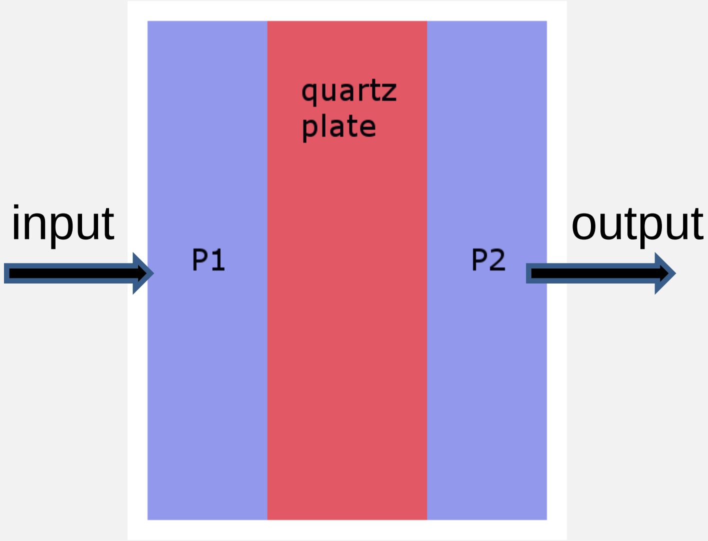
- The phase difference between slow and fast axis depends on birefringence, plate thickness and wavelength:

$$\Delta\varphi = \frac{\Delta n L}{\lambda}$$

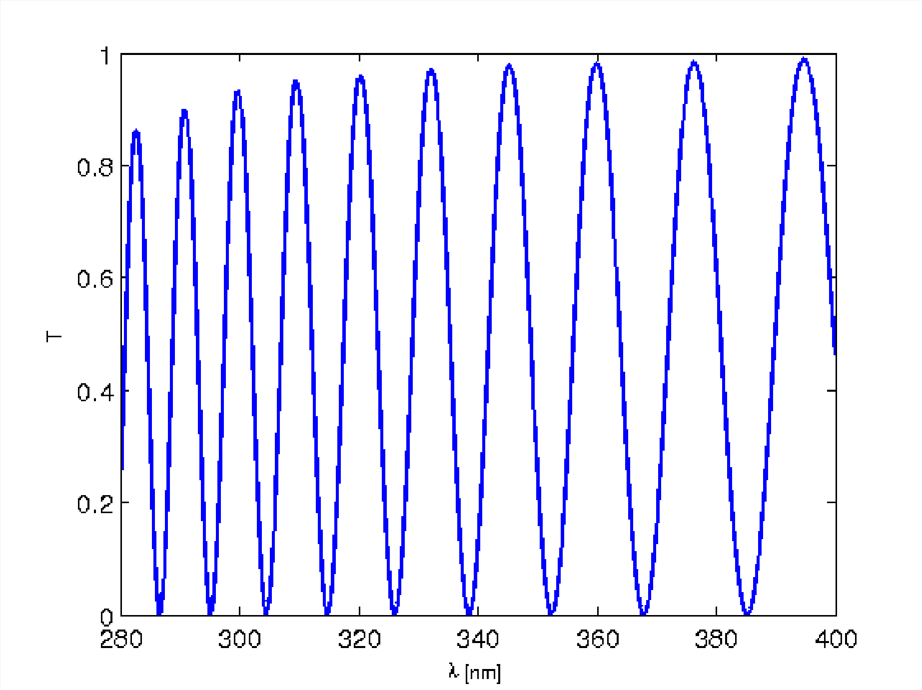
- So after quartz plate the polarization state depends on the wavelength

Birefringence-based UV wavelength ruler

One/-stage Lyot filter

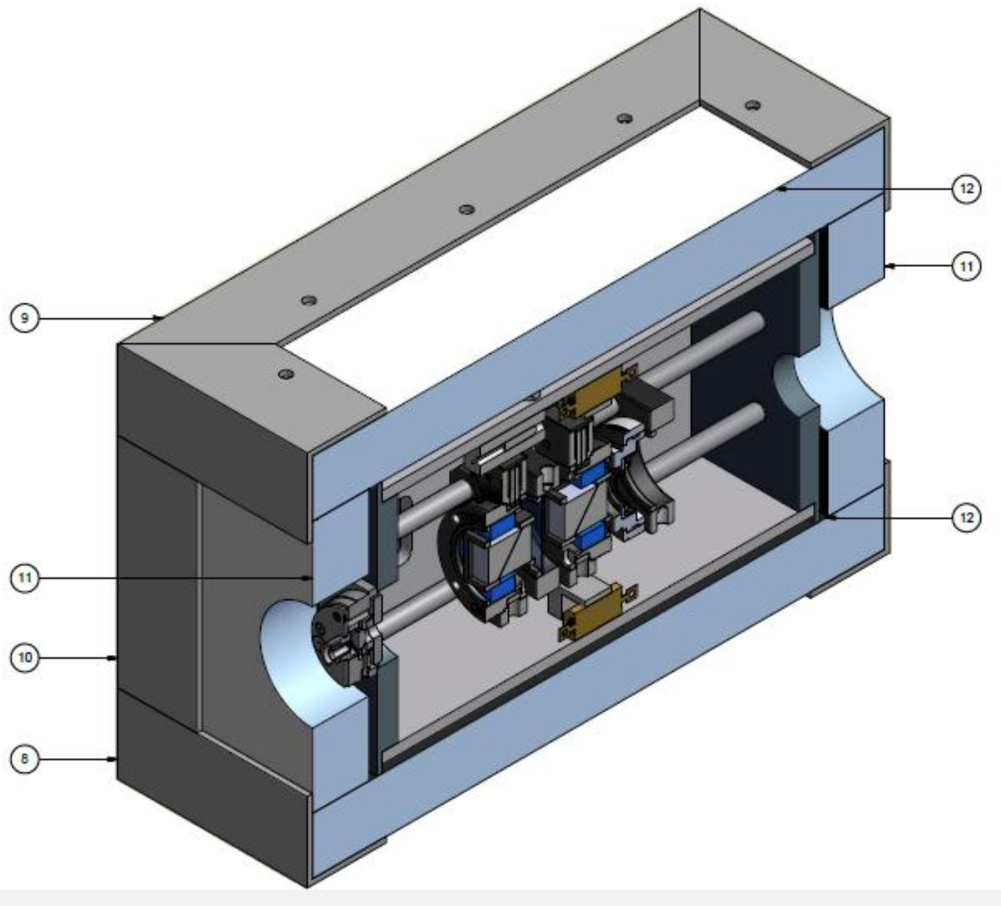


Simulations based on nominal thickness of the quartz plate of 0.7 mm



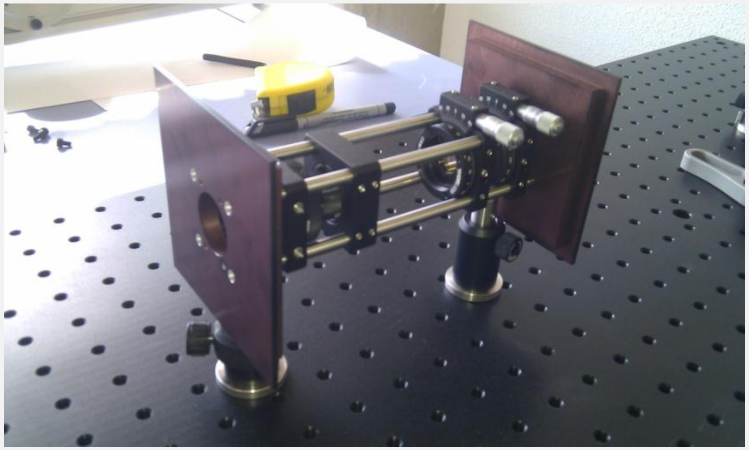
Design and implementation of a on-field calibration unit

We made a design based on simulations:

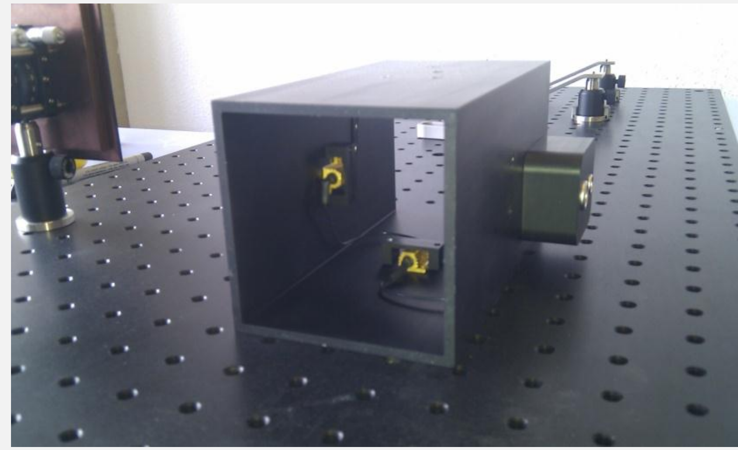


Design and implementation of a on-field calibration unit

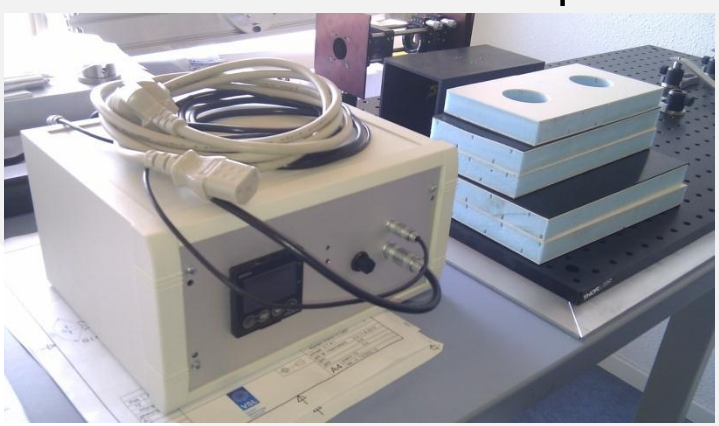
Optical components



Housing for termal control

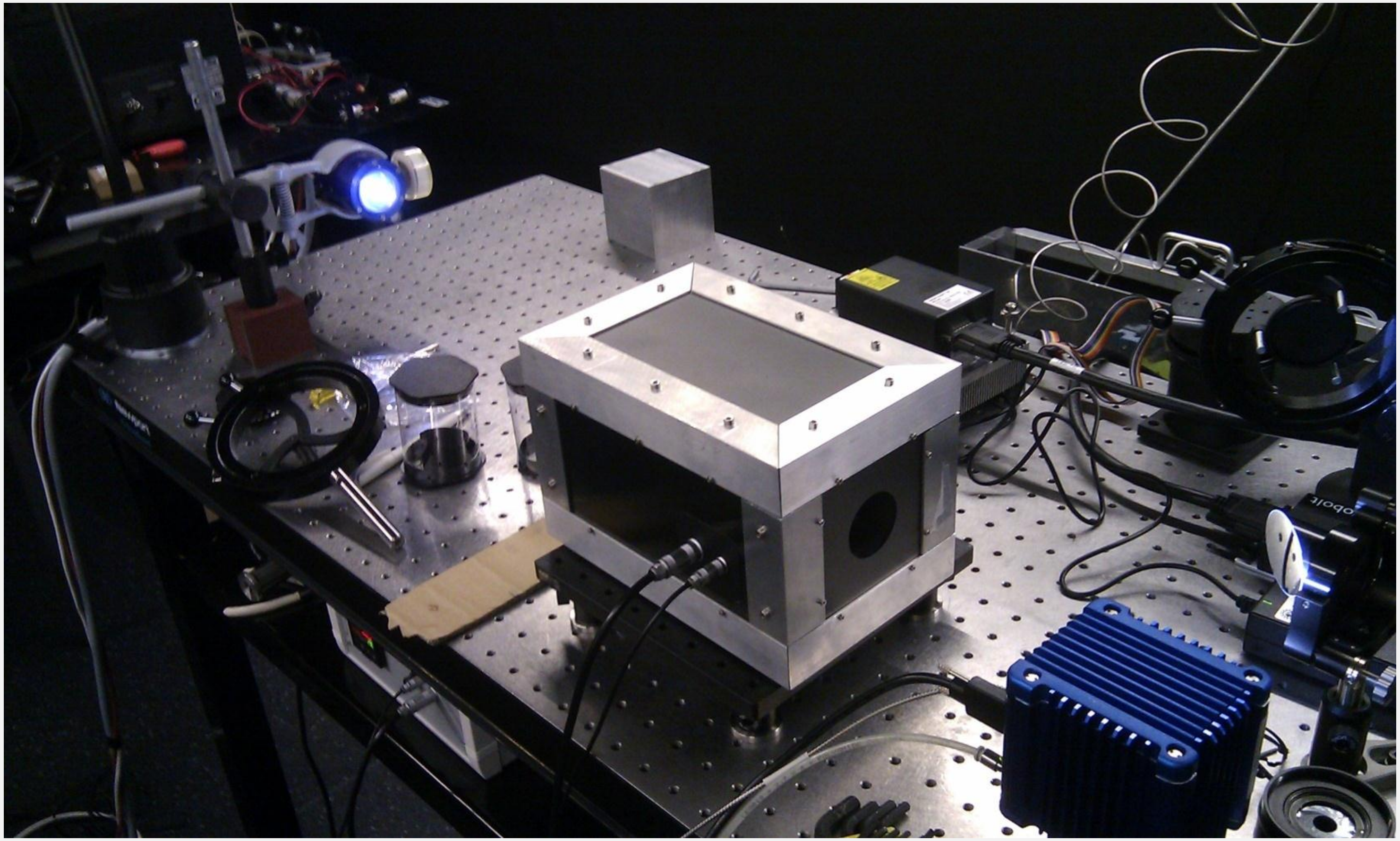


Controller and isolation plates



Typical experimental setup

We tested it

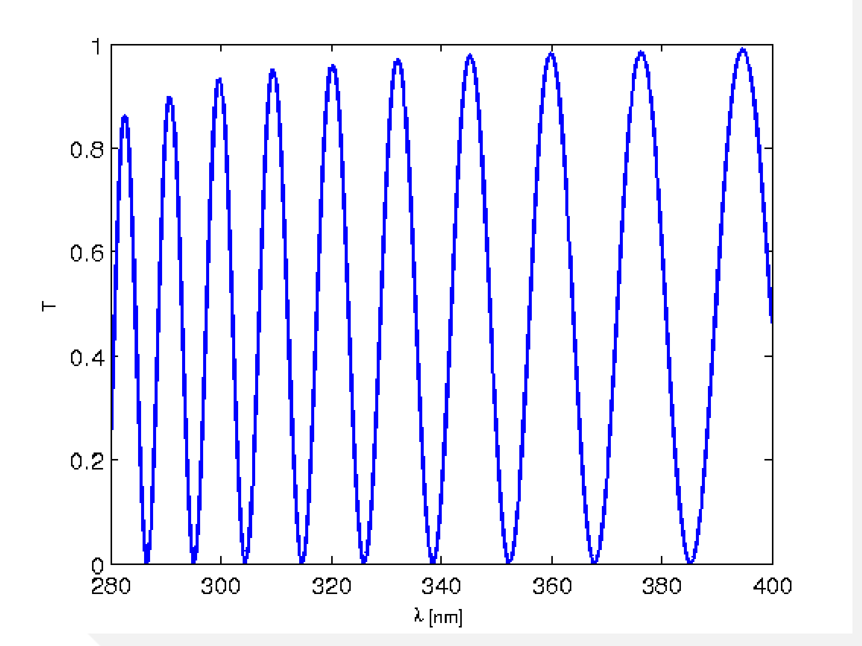


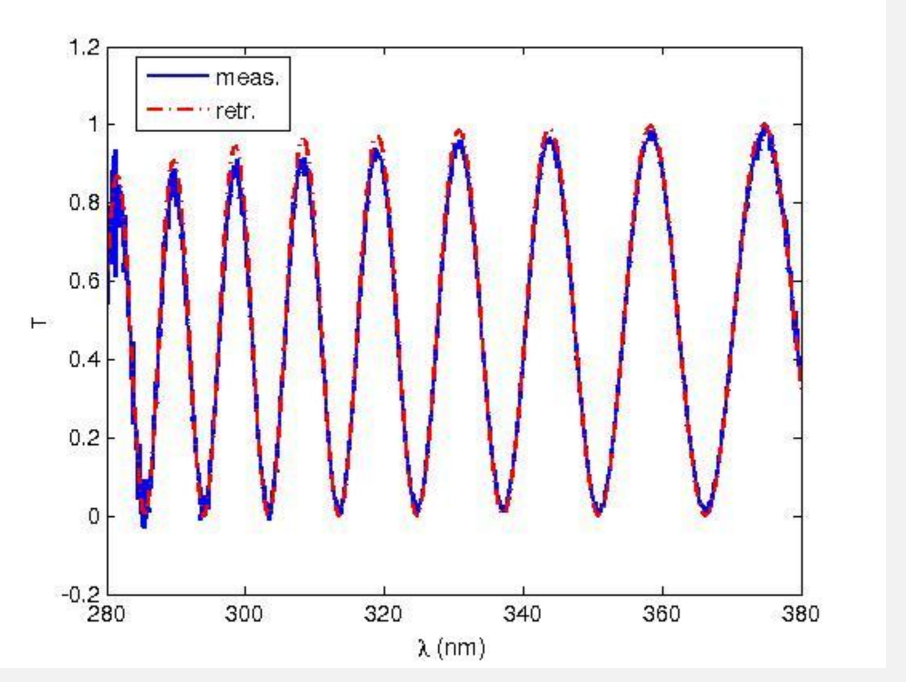
Ideal vs actual transmission

AVOS array spectrometer (PMOD)

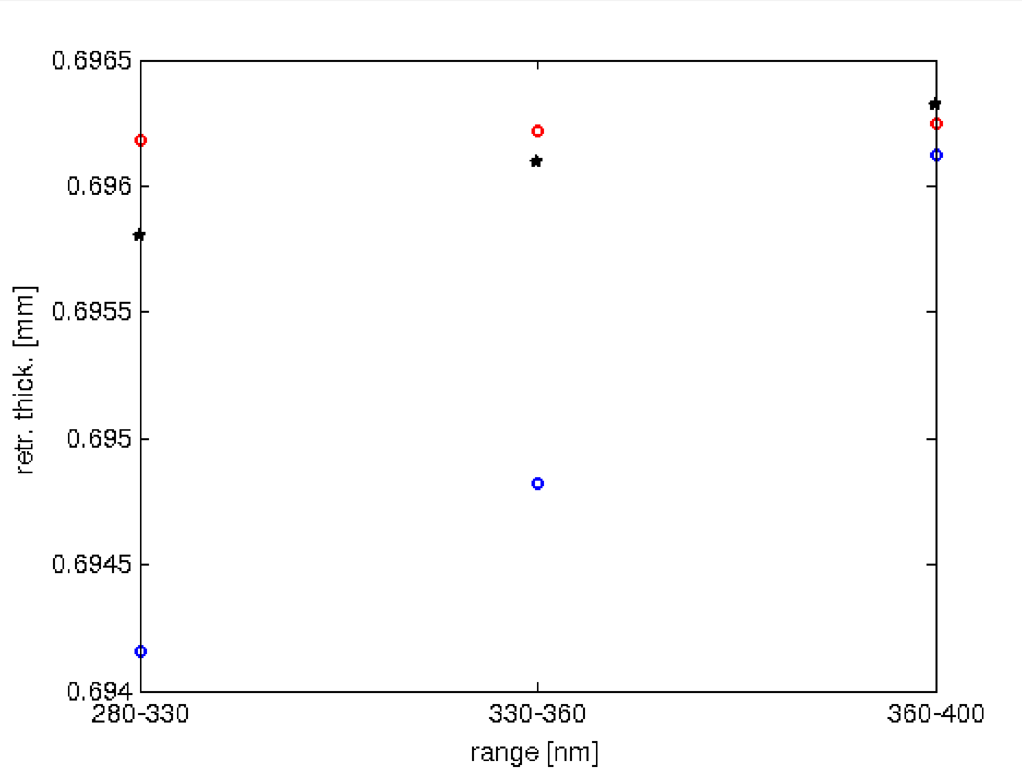
Forward model

Retrieved thick. through Levenberg-Marquardt algorithm





Results from the 3 instruments



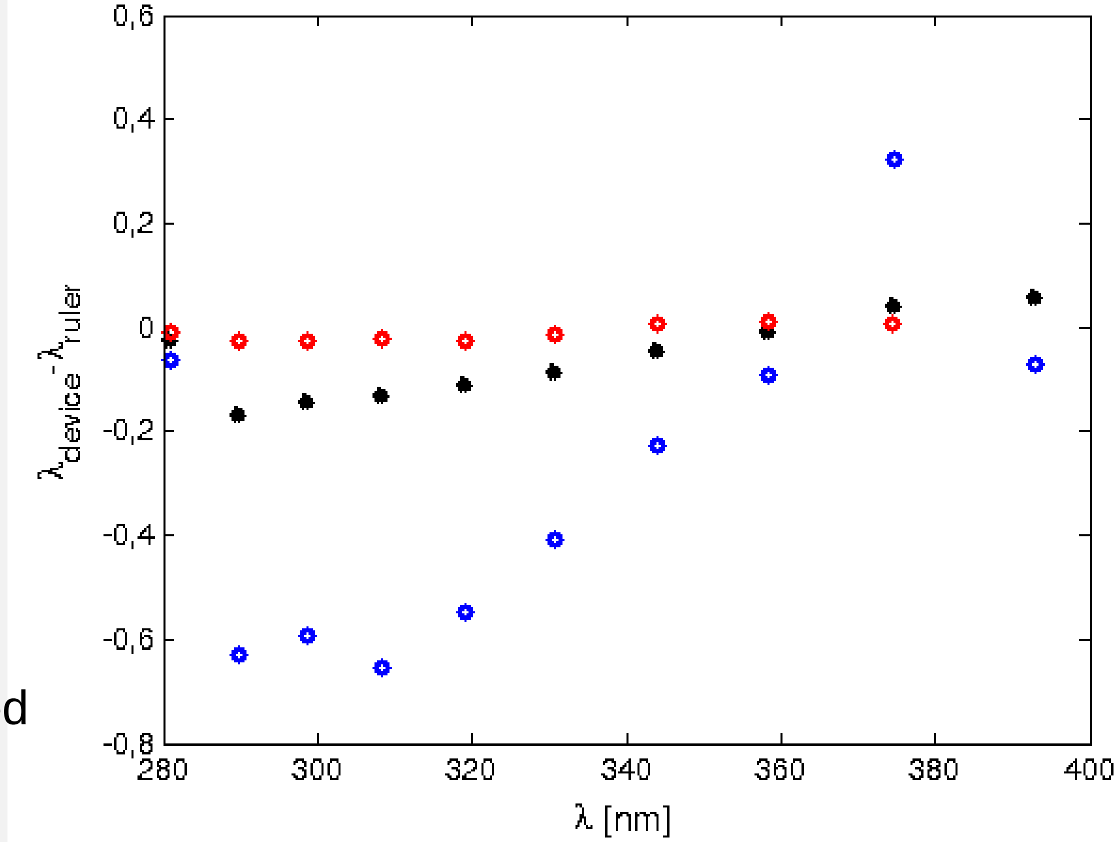
- Plate thickness retrieved from 3 wavelength ranges for 3 instruments
- Indicates a ‘chirped’ scale for some instruments

Retrieved thickness

If we consider all the devices in region 3 we get
L = 0.6962 mm
U (k=2)=0.2 µm

With this value we can generate the wavelength scale

For one single device:
SNR = 1000
the uncertainty on the retrieved thickness is at 0.1 nm level (!)



Conclusions

- The principle works. Different spectroradiometers have been compared.
- Potentiality of becoming an absolute and compact calibration device.
- Good portability (appealing for space applications).
- Possibility to extend it to broader spectral ranges.

Outlook: independent calibration of the wavelength ruler based on FT interferometer

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Thanks for your attention!

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