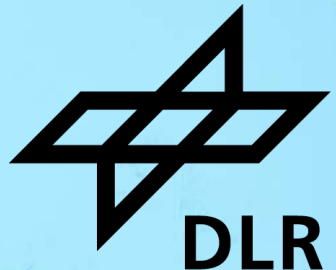


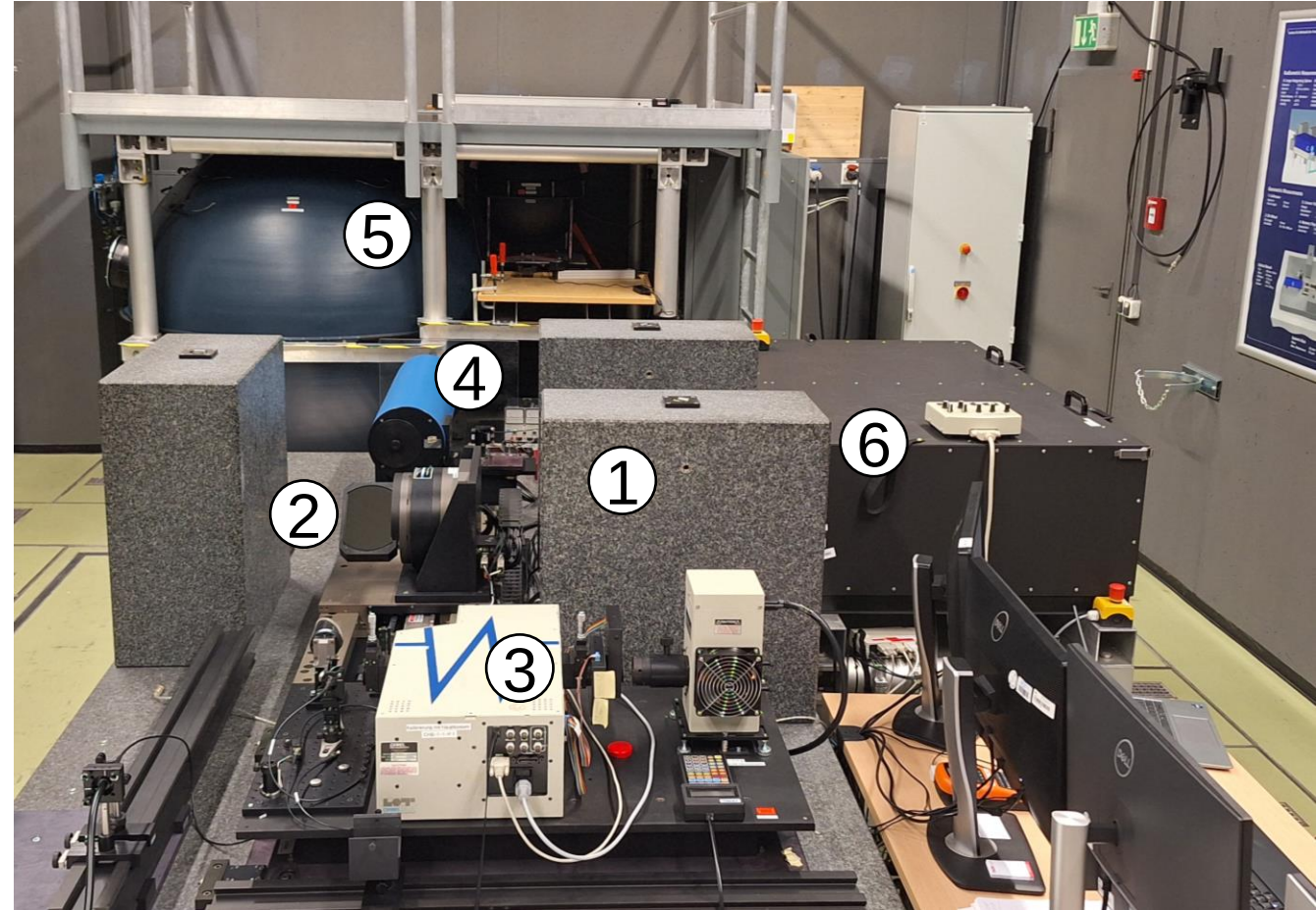
DLR'S CALIBRATION HOME BASE FOR IMAGING SPECTROMETERS (CHB)

Andreas Baumgartner, Gabriel Scheib, Konstantin Torgasin



The Calibration Home Base (CHB)

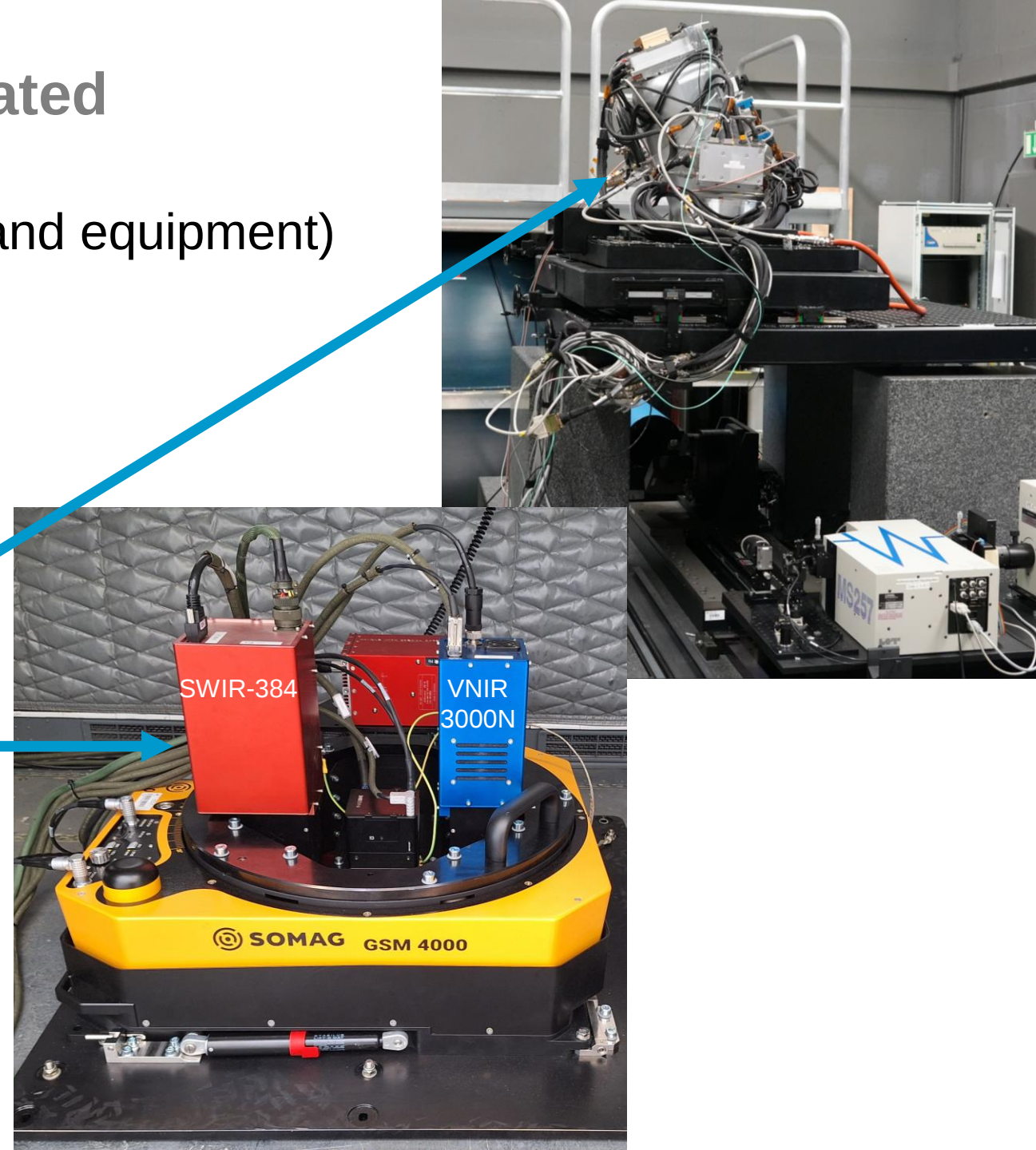
- Partly funded by ESA
- Designed for typical airborne imaging spectrometers:
 - Spectral range: 380–2500 nm
 - Bandwidth: 0.5–10 nm
 - FOV: $<\pm 20^\circ$ | IFOV: >0.15 mrad
- Highly automated calibration setups for
 - Geometric response
 - Spectral response
 - Radiometric response
 - Polarization sensitivity
 - Temperature sensitivity
 - Stray light
 - Non-linearity
- Continuous development



Calibration bench (1), folding mirror (2), monochromator (3), collimator (4), integrating sphere (5), tunable laser (6)

Example of Instruments Calibrated

- Spaceborne (support with expertise and equipment)
 - EnMAP (OHB)
 - CO2Image (DLR) planed
- Airborne
 - APEX (ESA, UZH, VITO)
 - AVIRIS-4 (NASA-JPL, UZH)
 - HySpex-A (Neo, DLR)
 - HySpex-B (Neo, DLR)
 - specMACS (Specim, LMU)
- Field
 - SVC HR-1024i (SVC, DLR)



Neo HySpex VNIR-1600

In the following slides results are from DLR's HySpex VNIR-1600



Parameter	Value
Spectral Range	410–1000 nm
Spectral Resolution	~ 5 nm
Spatial Columns	1600
Spectral Channels	160
Field of View	34.5 °
Min. GSD	0.44 m*
Swath Width	620 m*

* @ 1000 m distance

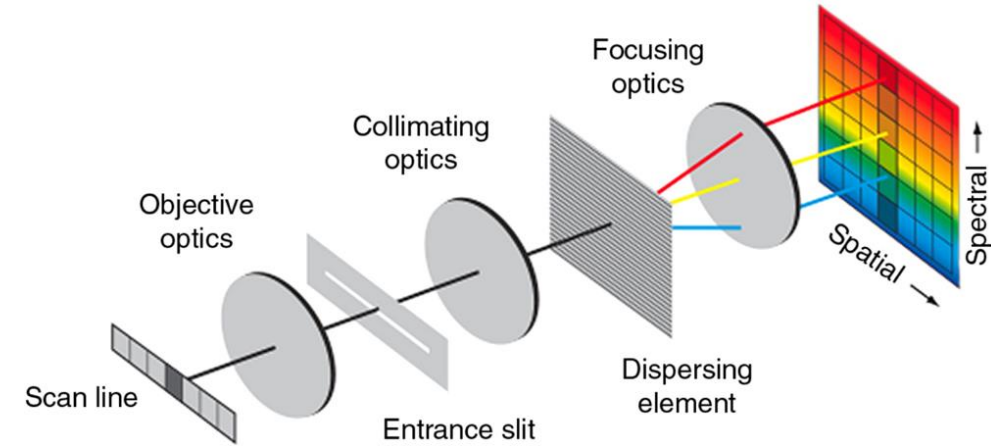
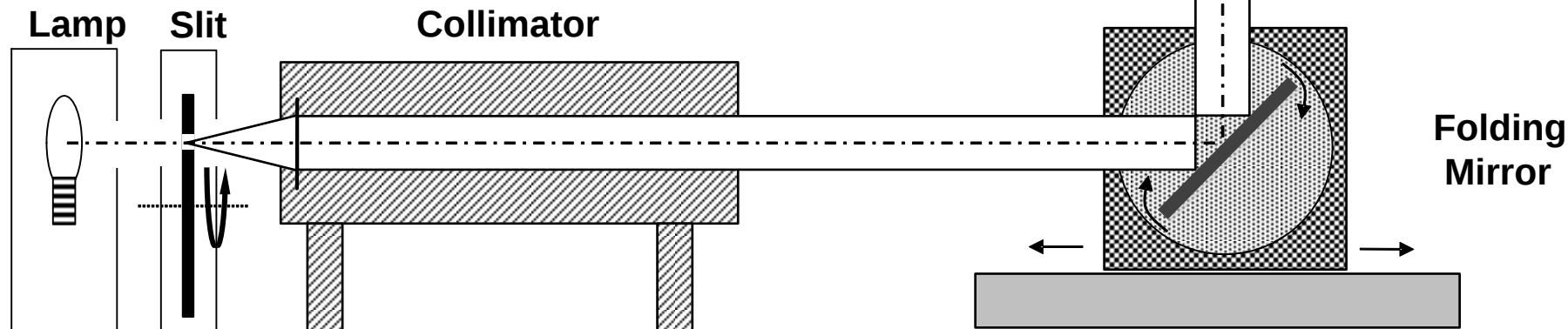


HySpex mounted in DLR airplane

DLR Remote Sensing Technology Institute (IMF). (2016). Airborne Imaging Spectrometer HySpex. Journal of large-scale research facilities, 2, A93. <http://dx.doi.org/10.17815/jlsrf-2-151>

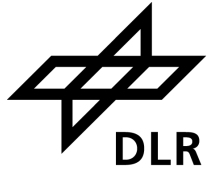
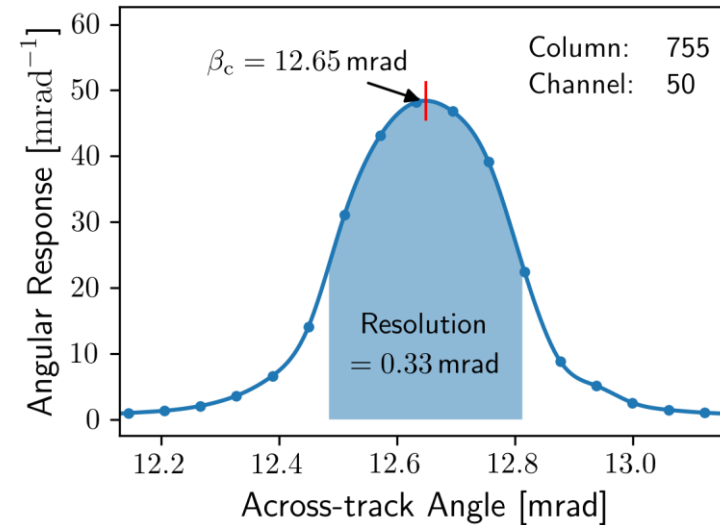
Geometric Calibration Setup

- A slit is imaged on the sensor's detector
- Collimator simulates far distant illumination
- By rotating and moving the mirror the illuminated spot on the detector is moved
- Measurement of Angular Response Functions (ARF)

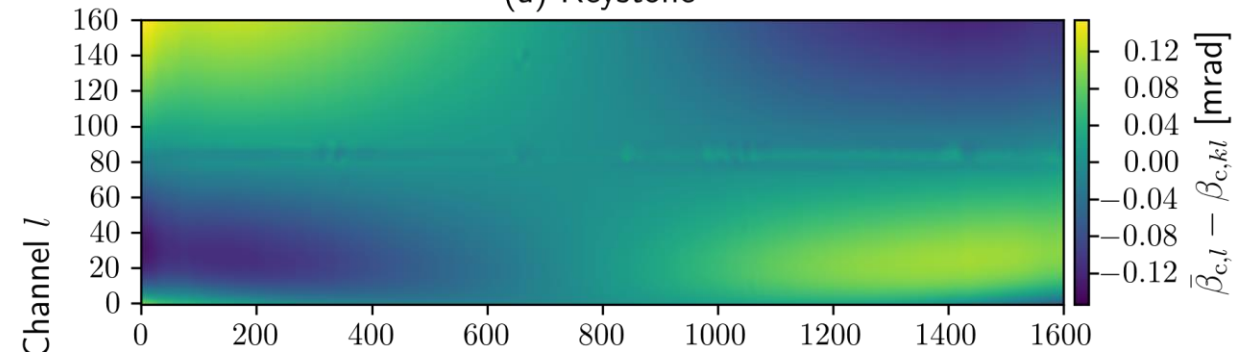


Geometric Calibration Results

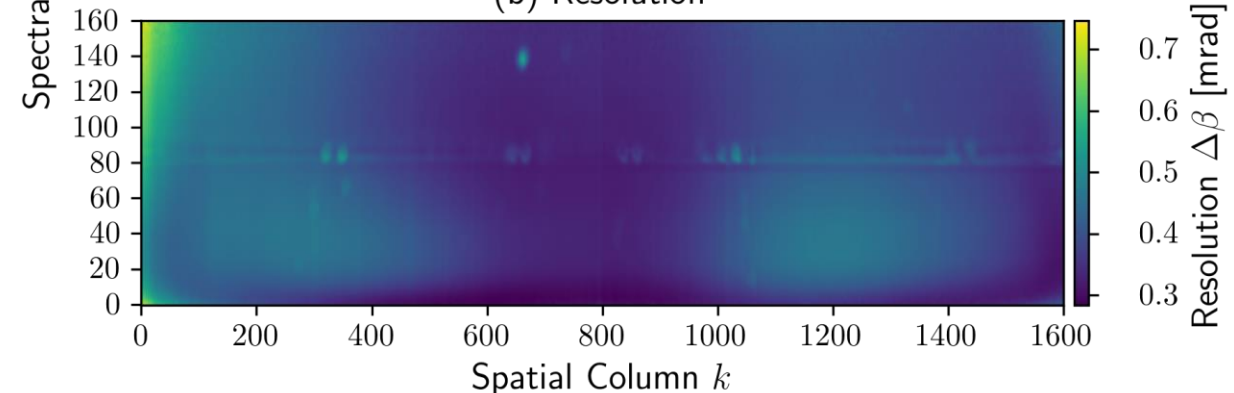
- > 10,000 individual measurements (~16 h)
- Development of software to identify, handle and process the relevant data (licensed to industry)
- Retrieve of Angular Response Function (ARF) of each pixel
- In contrast to existing methods no analytical function is fitted:
 - Cubic spline interpolation
 - Center angle: Median
 - Resolution: Width of area containing 75 % of total collected energy



(a) Keystone

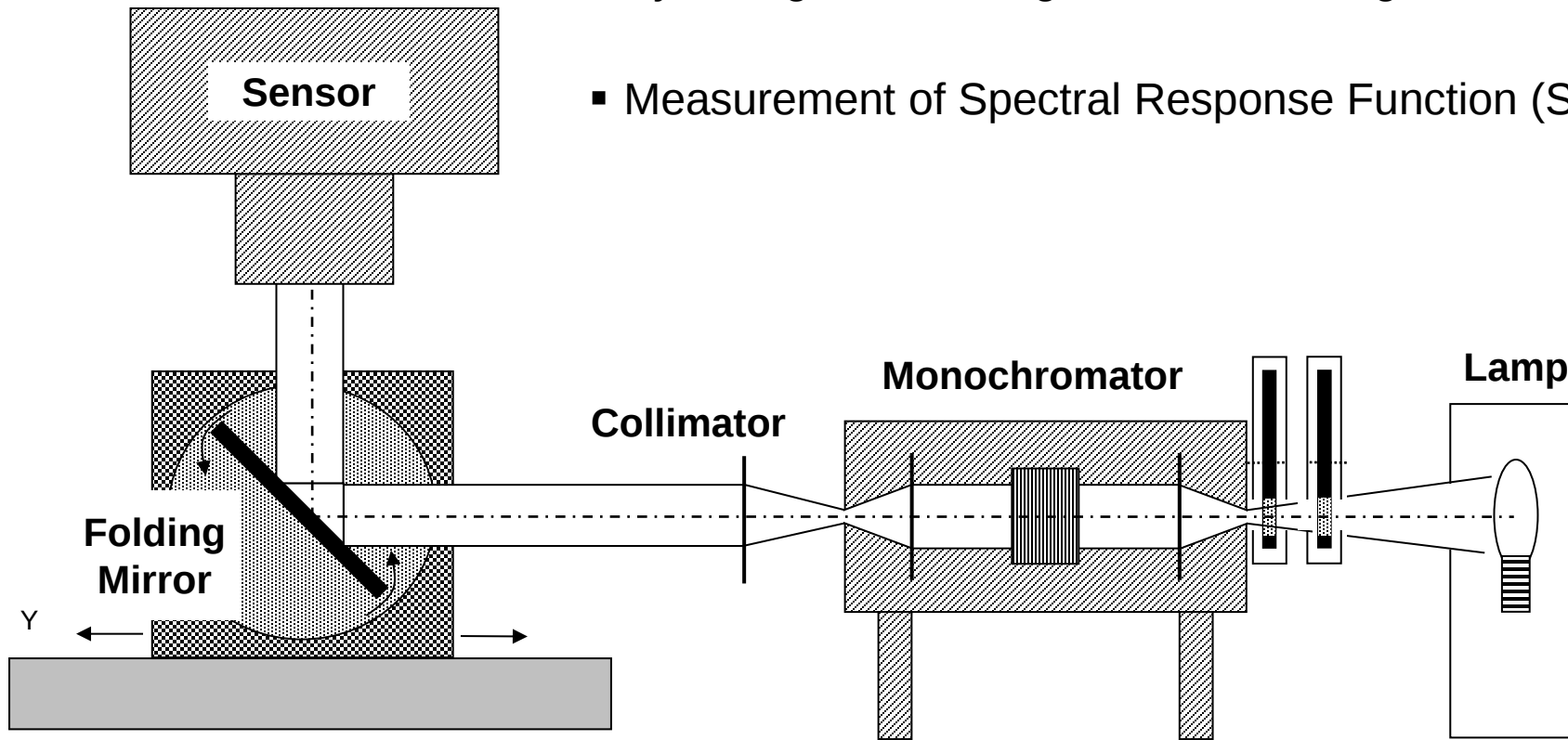


(b) Resolution



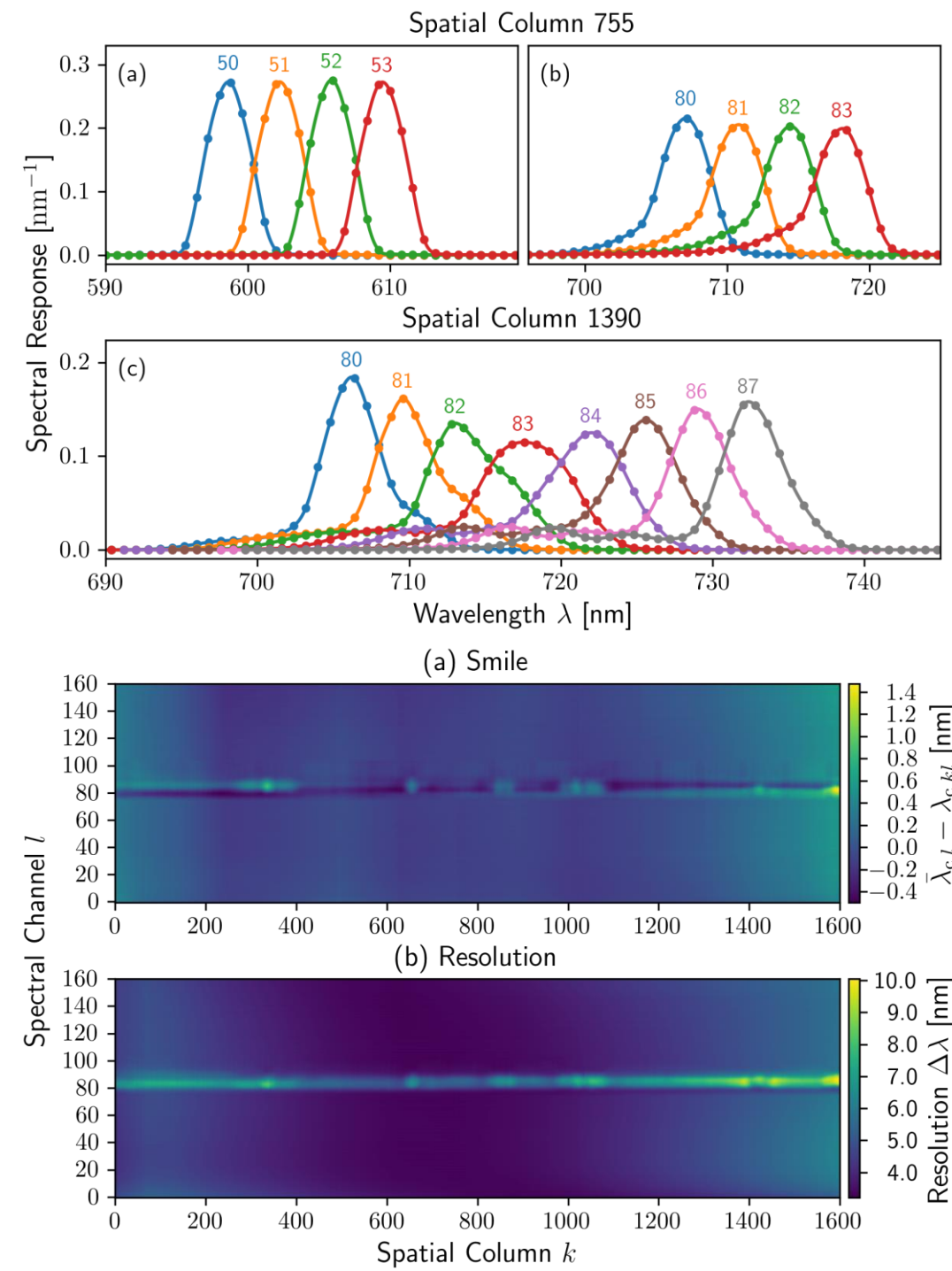
Spectral Calibration Setup

- Monochromatic light is imaged on detector of sensor under investigation
- By tuning of wavelength and mirror angle discrete pixels are illuminated
- Measurement of Spectral Response Function (SRF)

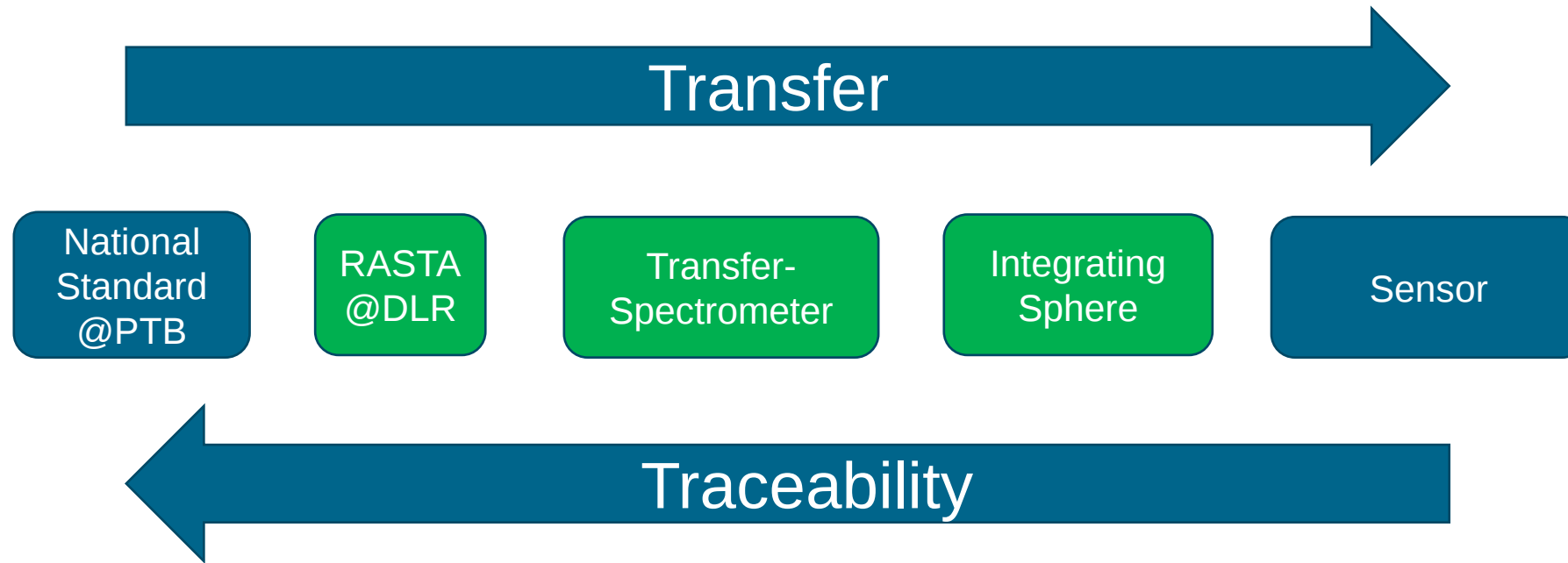


Spectral Calibration Results

- Derived from >31,000 individual measurements (~2 days)
- Lower spectral resolution at the right detector edge
- Distortion of SRFs at center channels caused by spectral long pass filter mounted on upper detector half

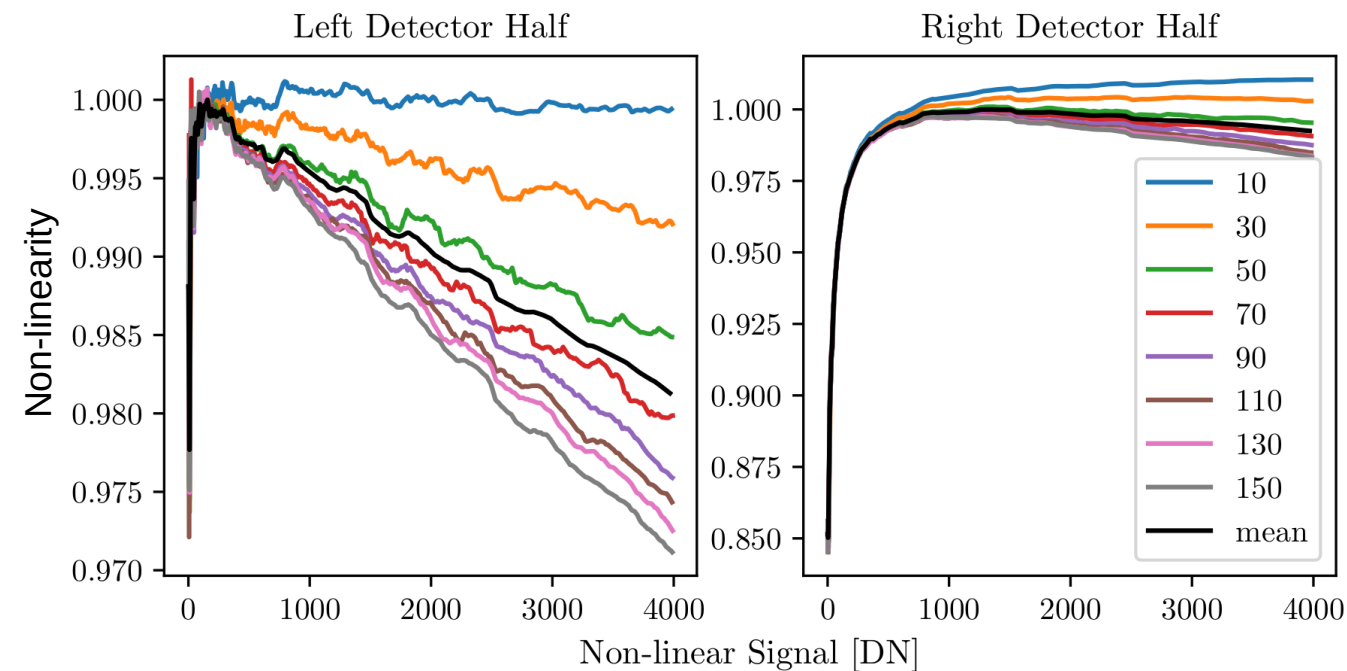
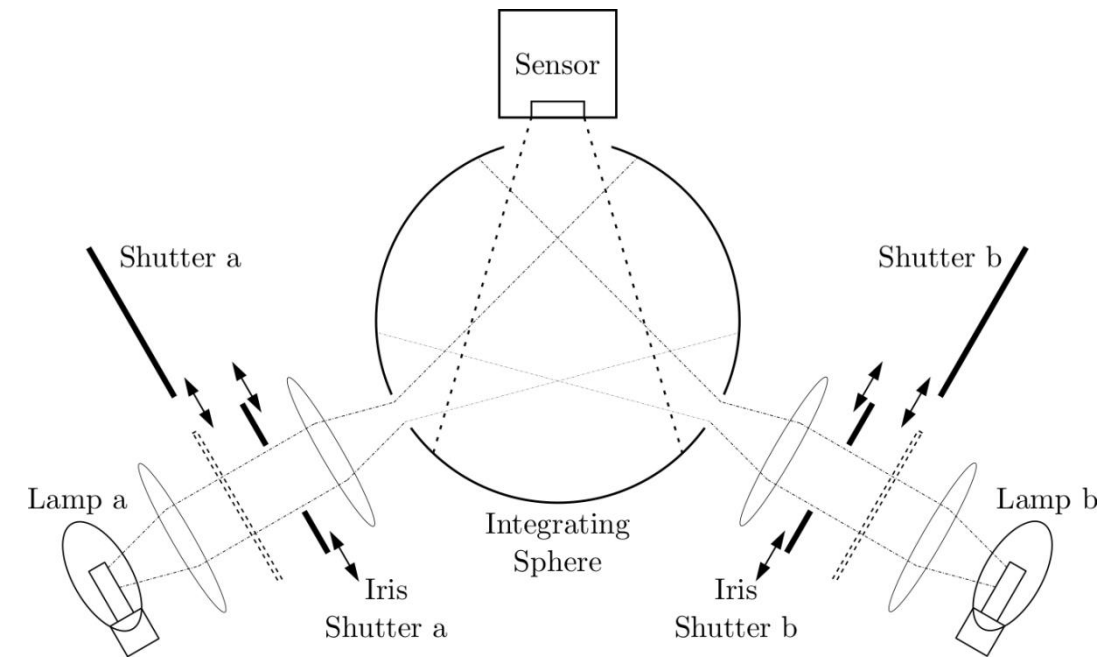
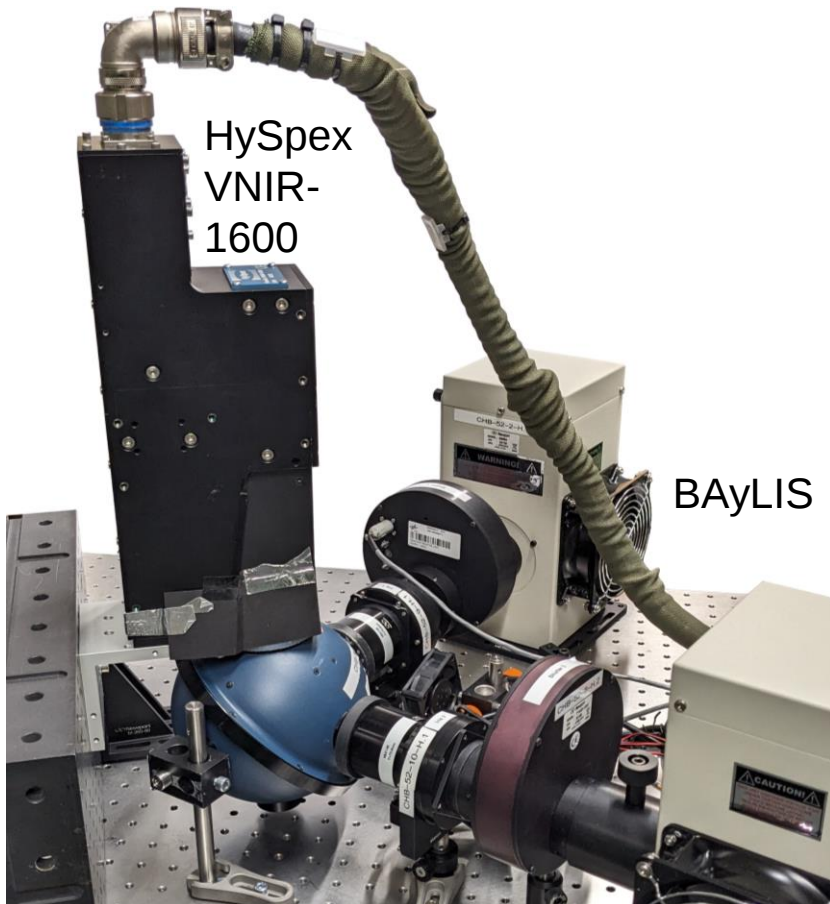


Transfer of Radiometric Radiance Calibration

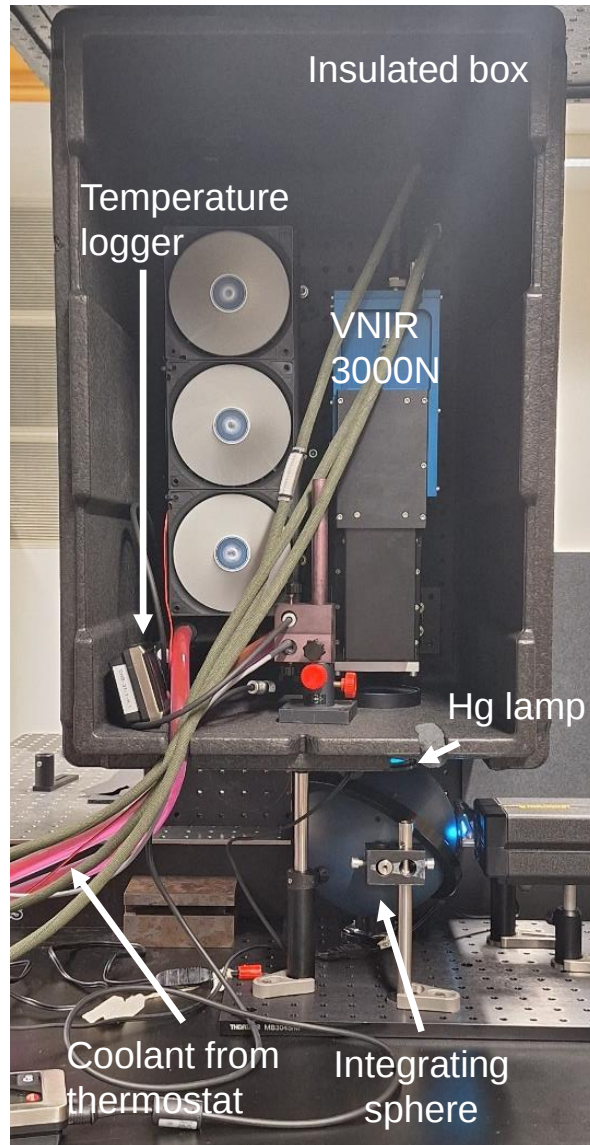


Non-linearity Calibration

- Broadband Attenuable Light Source (BAyLIS)
- Light addition method
- Spectral range: 350 – 2500 nm



Temperature Sensitivity

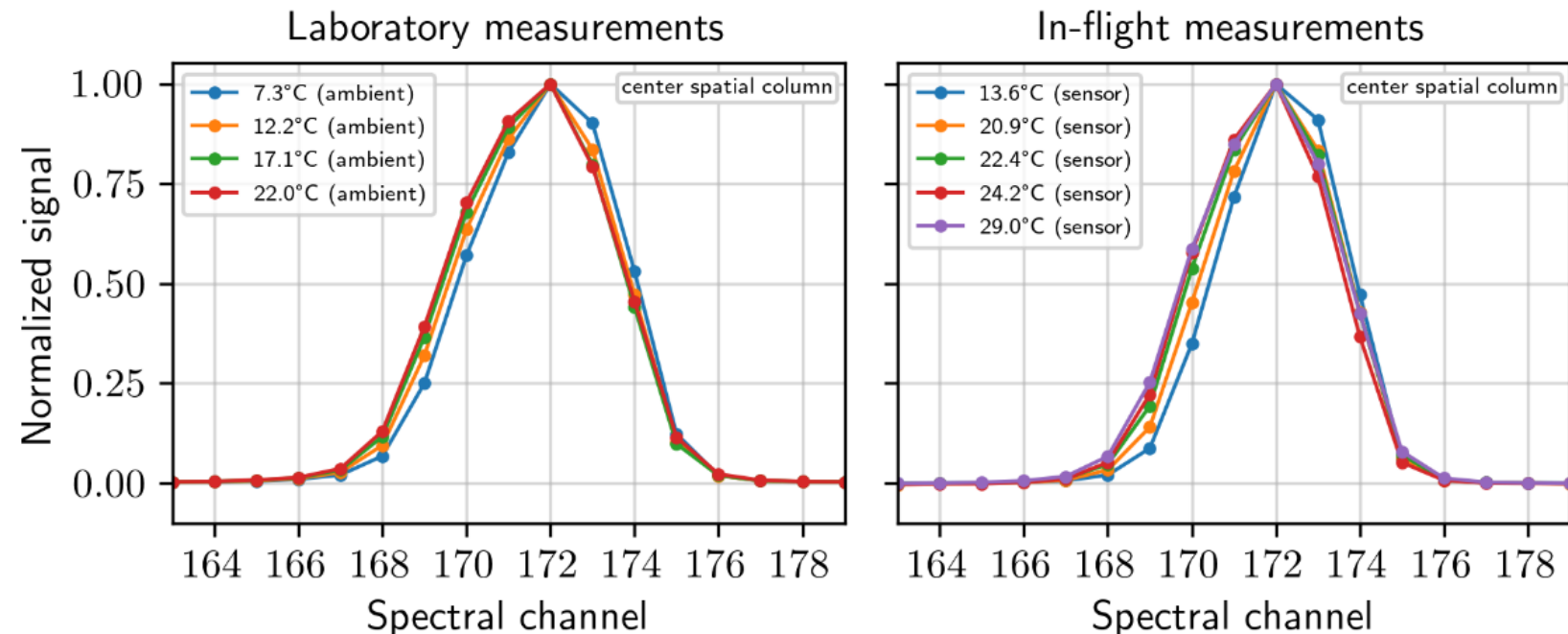


Setup for simulating different ambient temperatures

- Response of semiconductor detectors is temperature dependent
- Determination of thermal stability

HySpex VNIR-3000N temperature dependent spectral shift Spectral response for 546.09 nm (Hg line*)

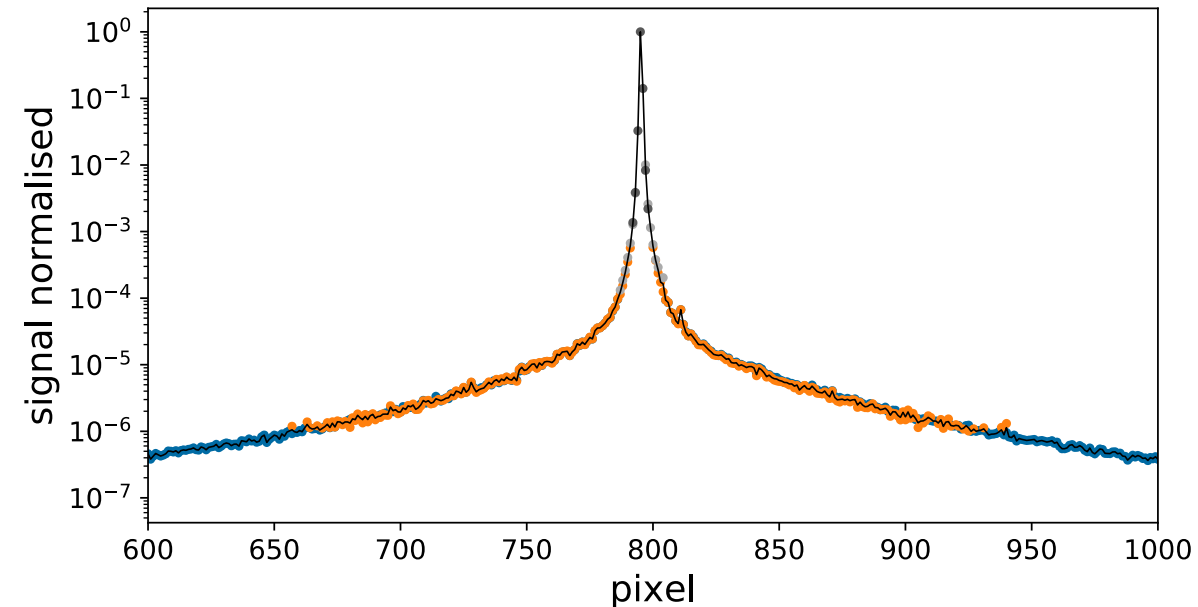
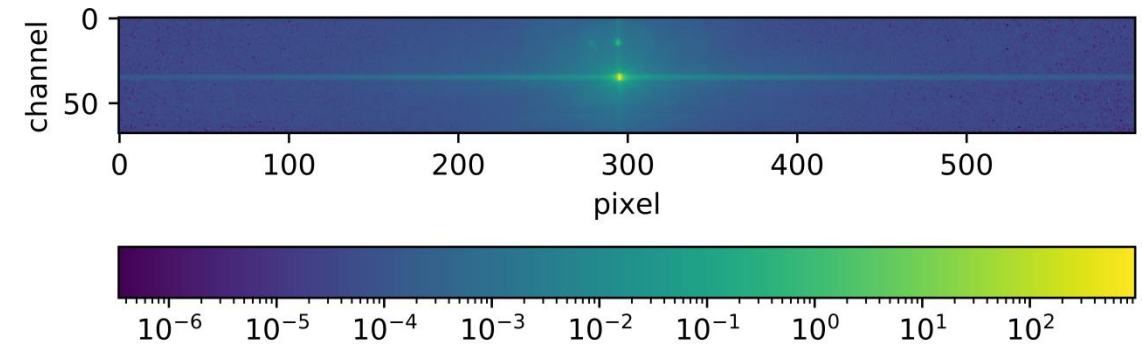
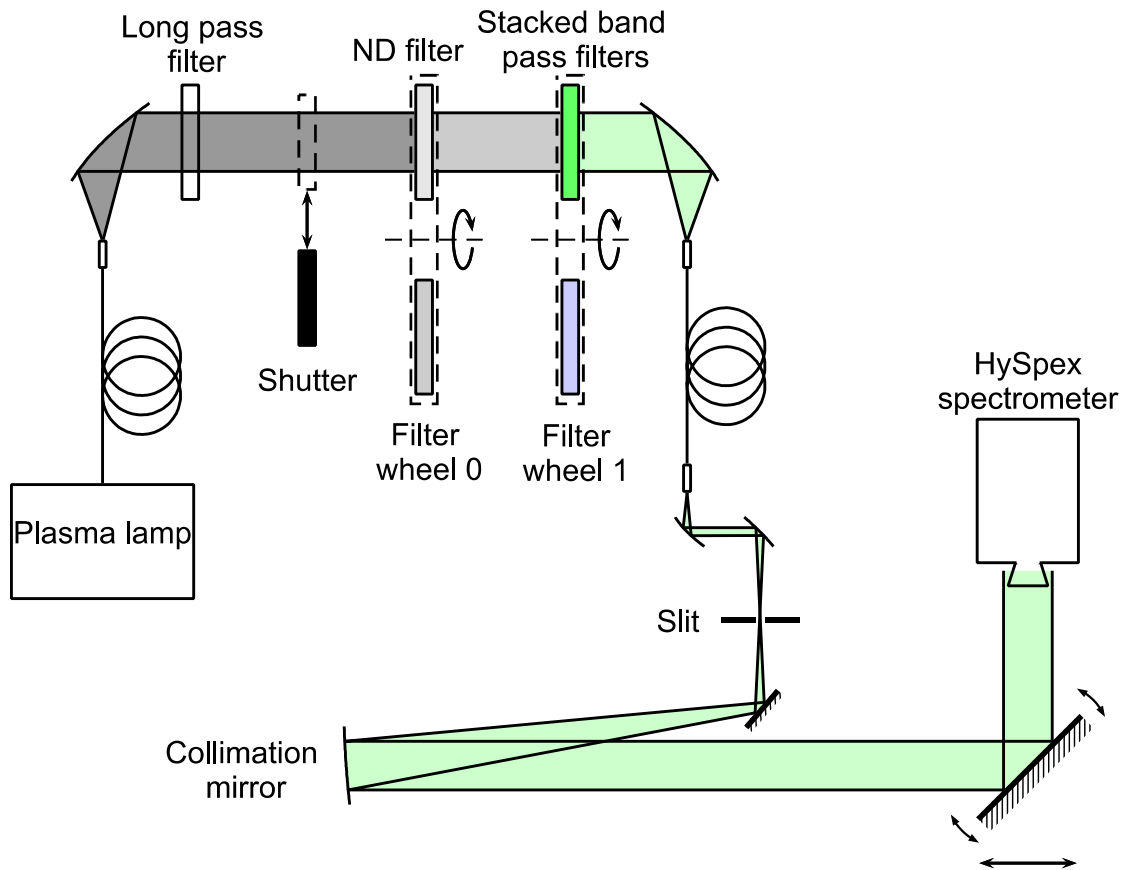
*at 22°C, 950 hPa, 45% rel. humidity



Stray Light Calibration

Unique setup with 15 spectral bandpass and 12 ND-filters

PSF measured with >8 orders of magnitude



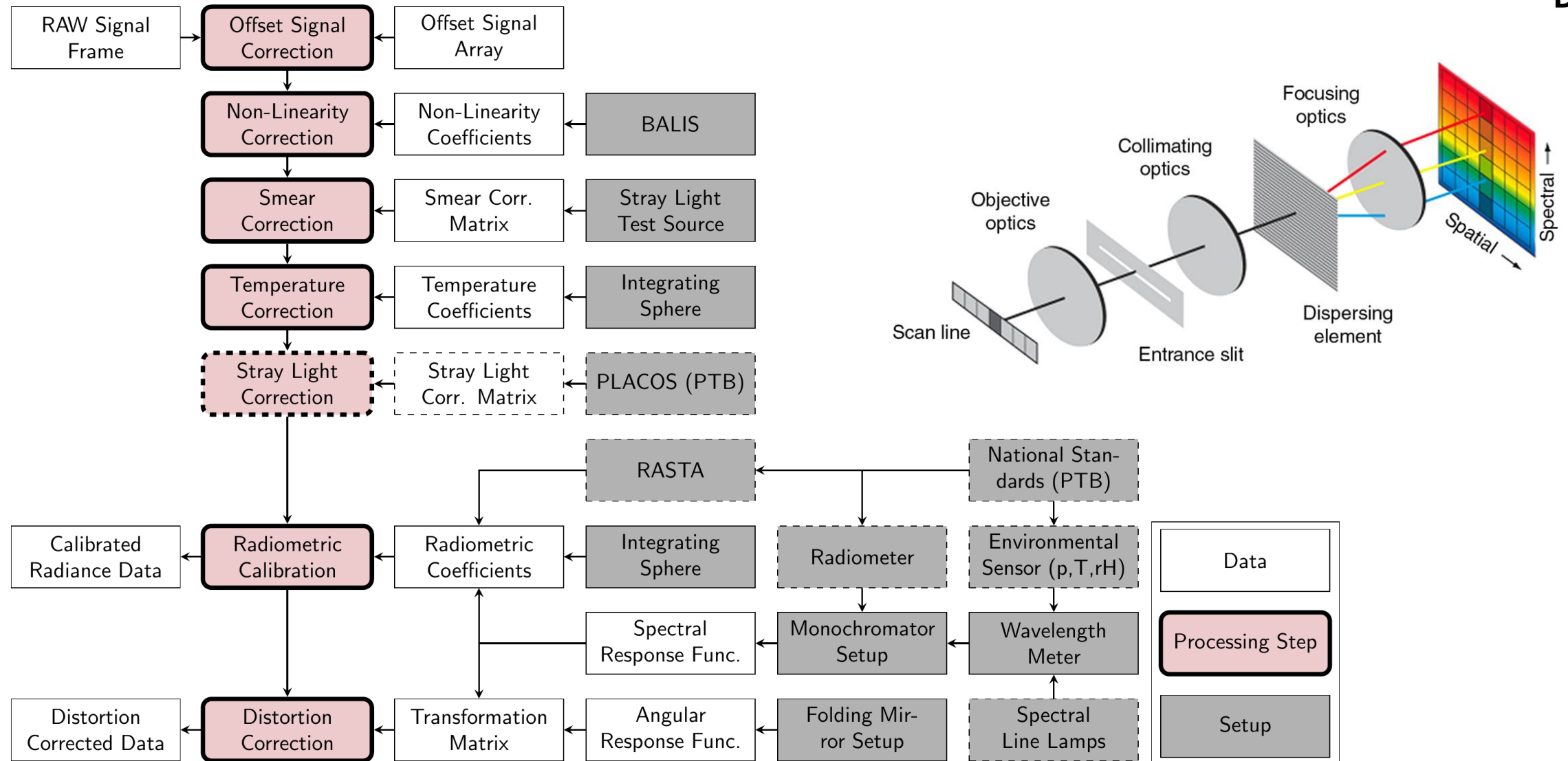
Next Upgrade: Tunable Laser System

- Ekspla NT262
- Spectral range: 210 - 2600 nm
- Resolution: < 0.02 nm (VNIR), < 0.7 nm (SWIR)
- Spectral calibration (coupled to integrating sphere)
 - Significant reduction of spectral calibration time
- Stray light calibration (coupled to collimator)



Source:
<https://ekspla.com/products/narrow-linewidth-tunable-wavelength-laser-nt260>

Result: HySpex VNIR-1600 Level-1 Calibration Chain



Software



developed and used in the context of the CHB

