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TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

TRUTHS Calibration Traceability Methodology

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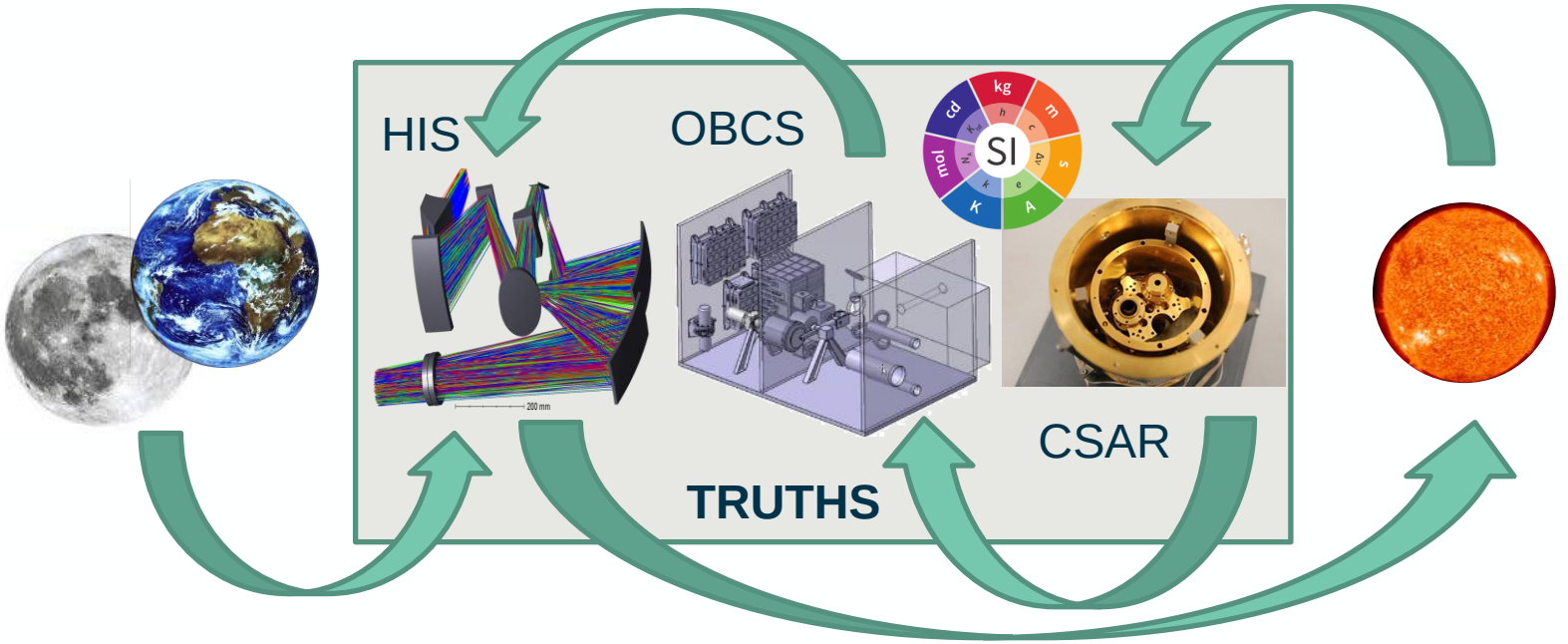
TRUTHS mission

The ESA EarthWatch hyperspectral climate sensor TRUTHS will enable high-accuracy SI traceability to be established on-orbit for the first time, targeting uncertainties of

0.3% (G) to 1% (T) (k=2) in Earth Spectral Radiance and Solar Spectral Irradiance

0.02% (k=2) for Total Solar Irradiance.



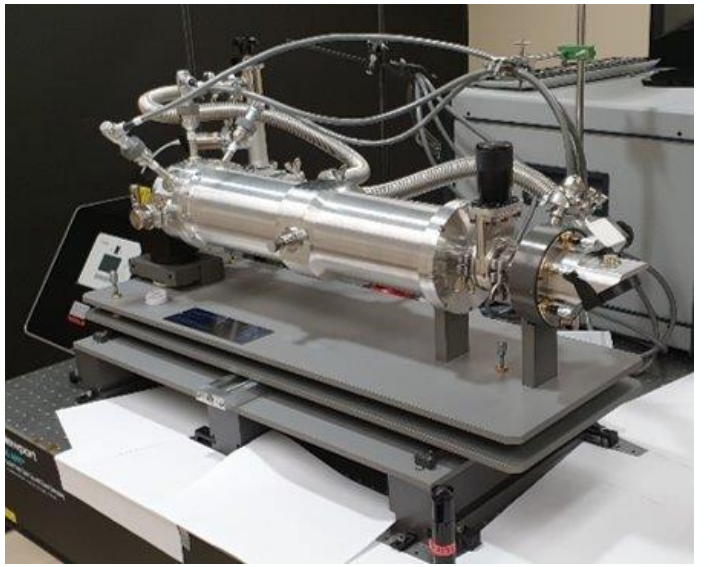
In-Orbit Primary Standard - CSAR

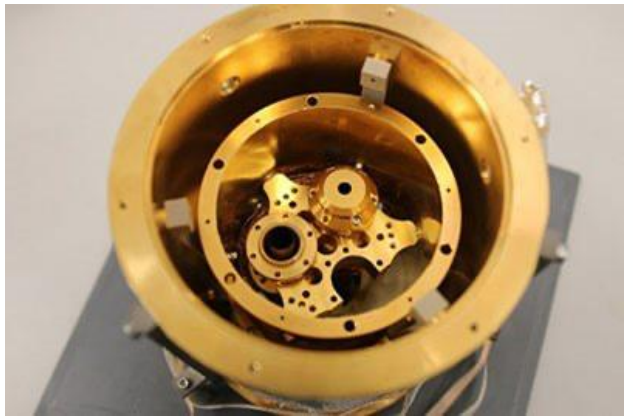
Cryogenic Solar Absolute Radiometer (CSAR)

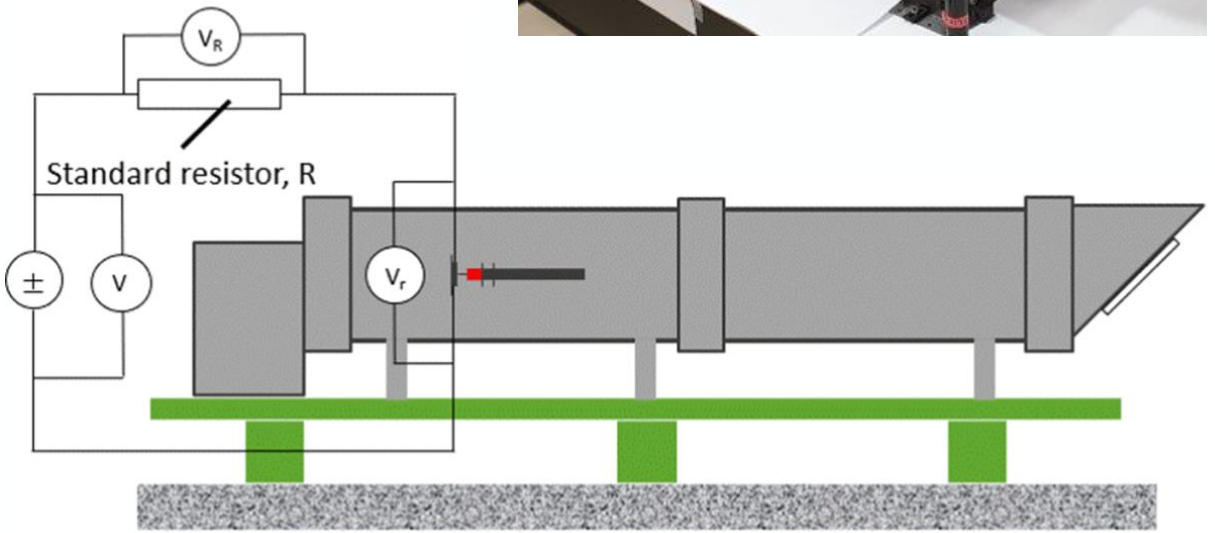
Evolution of the terrestrial cryogenic radiometer used for four decades in NMIs

Electrical substitution method (equivalence in optical and electrical heating of a cavity)

Traceable to electrical standards - V & Ω







TRUTHS on-orbit calibration philosophy

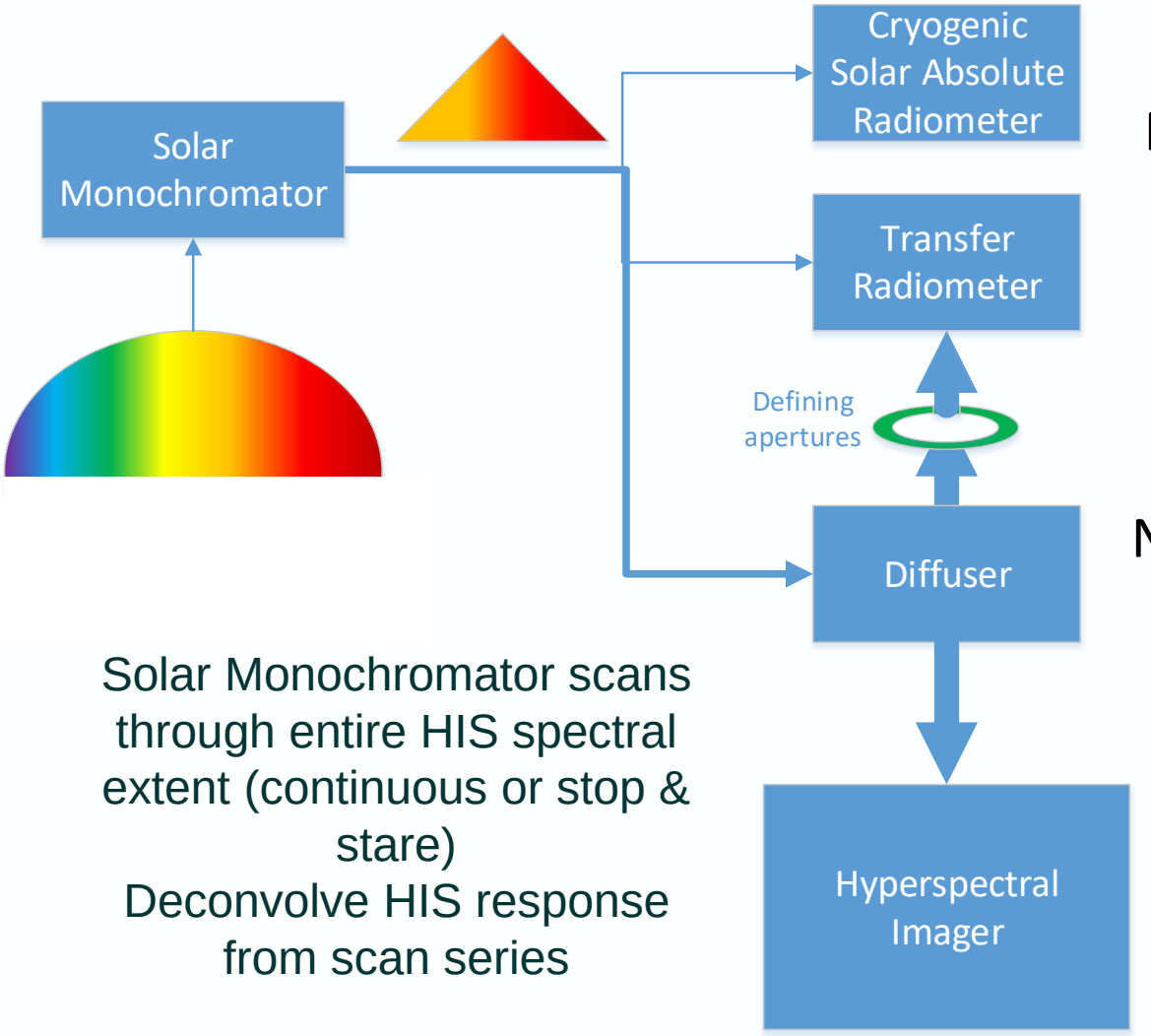
CSAR measures optical power in SMC output

The transfer radiometer serves two purposes

- Conversion from power to radiance
- Intermediate radiance reference for HIS full spectral extent radiometric calibration

Concept of Operations based on

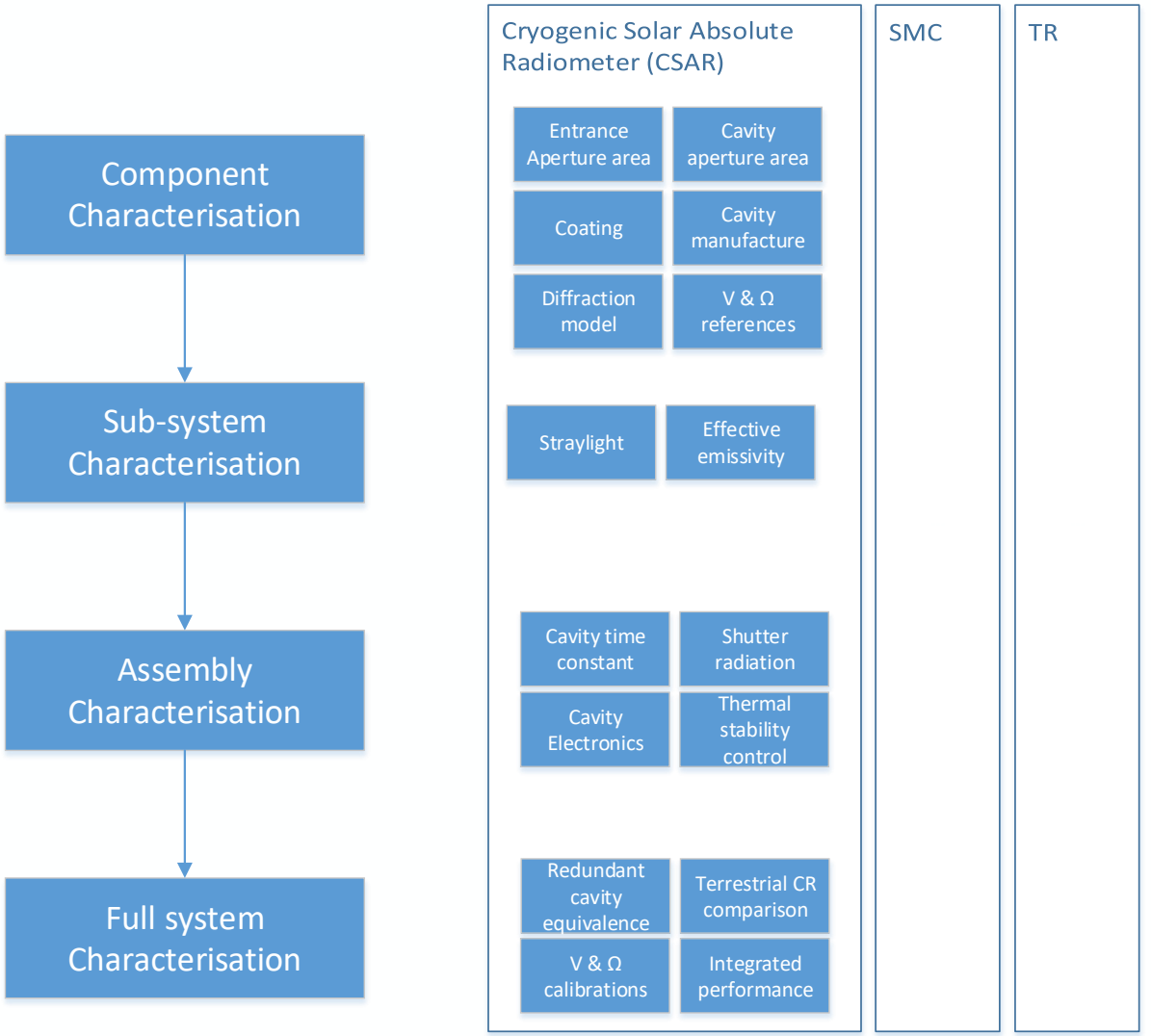
- geometric knowledge & stability,
- eliminating degradation assumptions,
- only repeatability assumptions based on mechanical and thermal control.



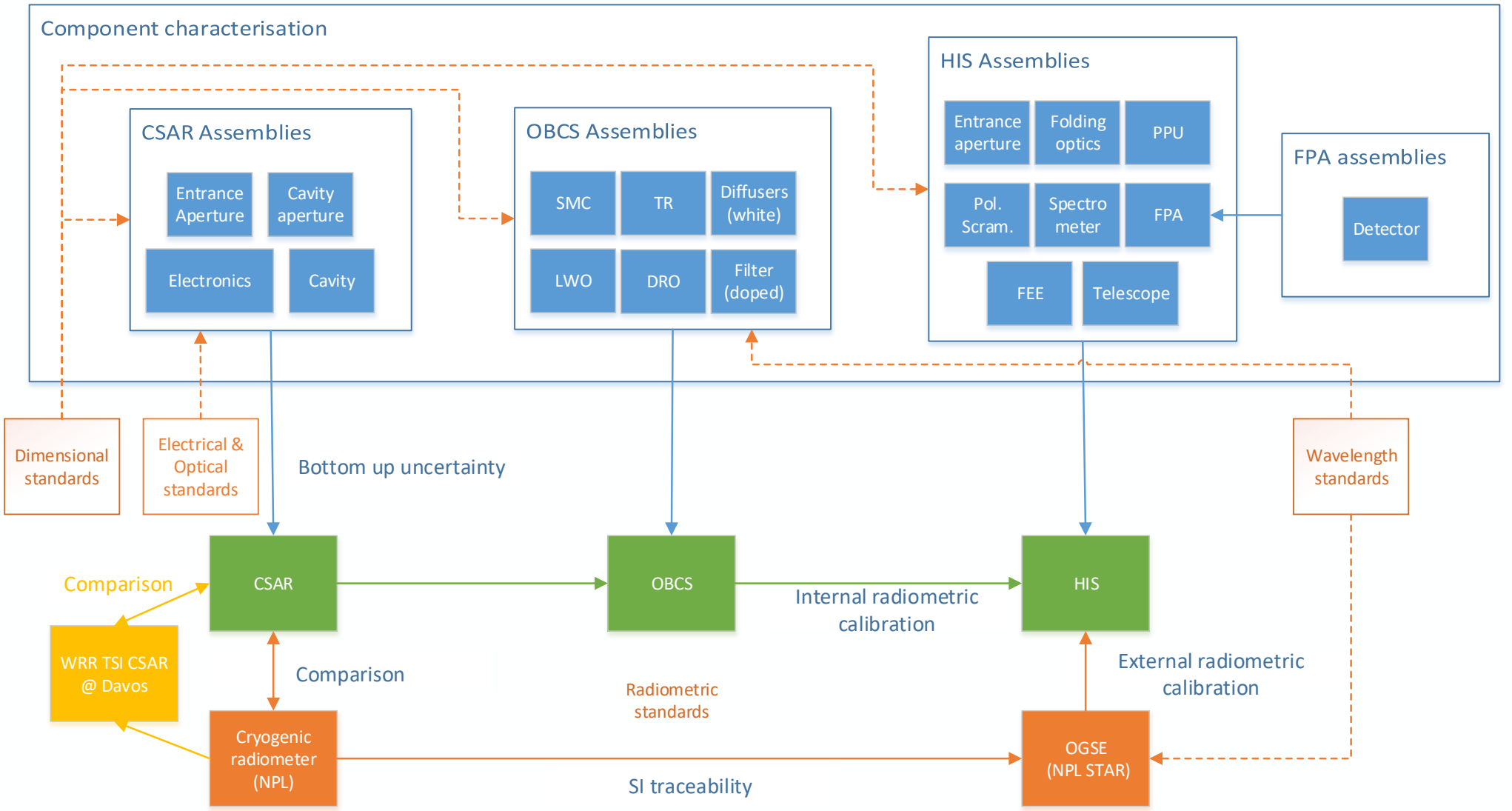
Solar Monochromator scans through entire HIS spectral extent (continuous or stop & stare)
Deconvolve HIS response from scan series

Pre-flight calibration & characterisation philosophy

- Tiered hierarchy of characterizations and calibrations
- Mirrors the uncertainty budget bottom-up approach
- Includes algorithm approach and concept of operations assumptions.

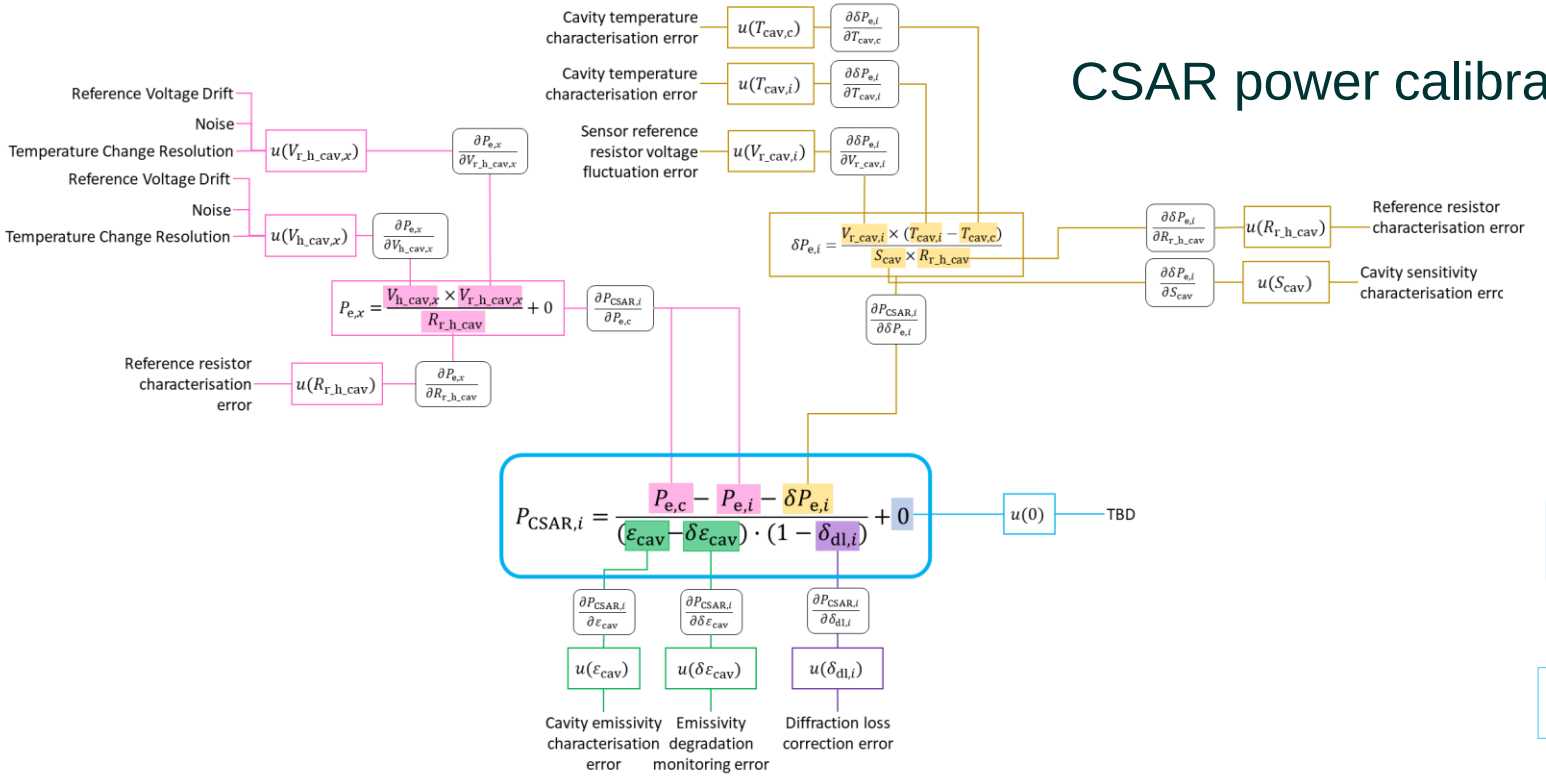


Pre-flight radiometric calibration philosophy

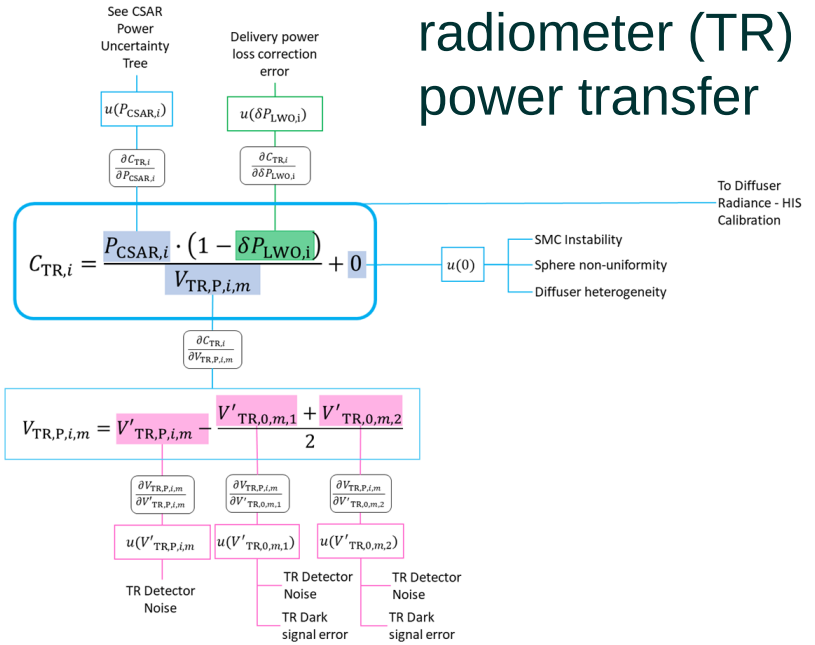


Application of metrological principles

CSAR power calibration



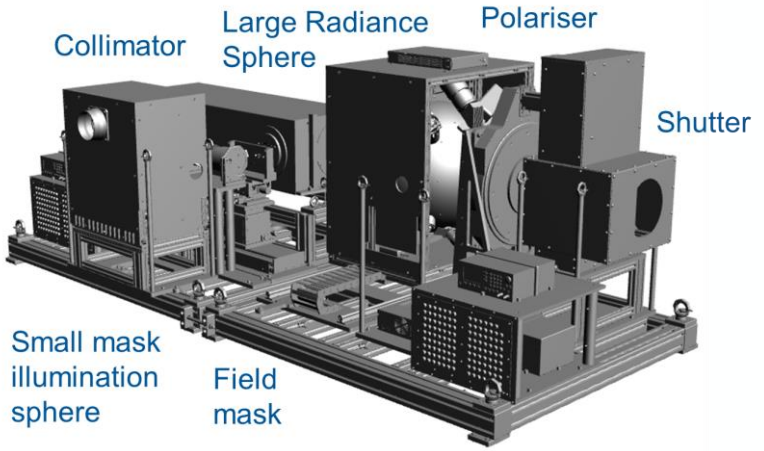
Transfer radiometer (TR) power transfer

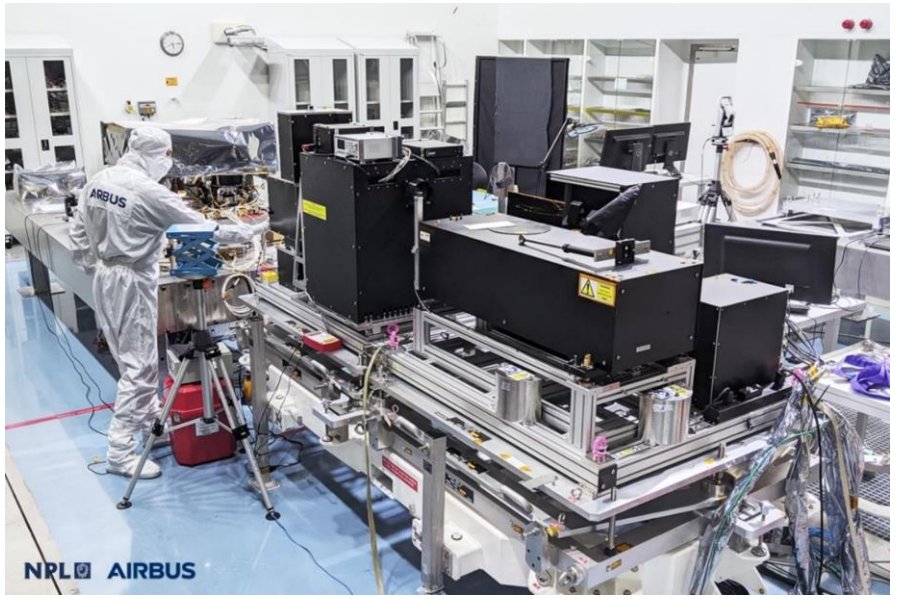


See Poster Fahy et al (TRUTHS) & de Vis et al (CoMet tool)

STAR-CC-OGSE Overview

- STAR-CC-OGSE is a versatile facility for the radiometric calibration and characterization of satellite sensors.
- The system is provided fully characterized, calibrated and performance verified, with an easy-to-use software interface that allows fully automated remote operation.
- The main components of the STAR-CC-OGSE system are:
  - A collimated beam source, equipped with an interchangeable, position fine-tuneable feature field mask for optical performance (geometric) characterization
  - An M-Squared CW laser allowing monochromatic continuous tuneability from 260 nm to 2700 nm with a broadband (white light) source extending over the same spectral extent.
  - A vacuum-compatible SI-traceable radiance detector module containing both broadband photodiodes & a spectrometer, installable in TVAC at the sensor-under-test entrance aperture





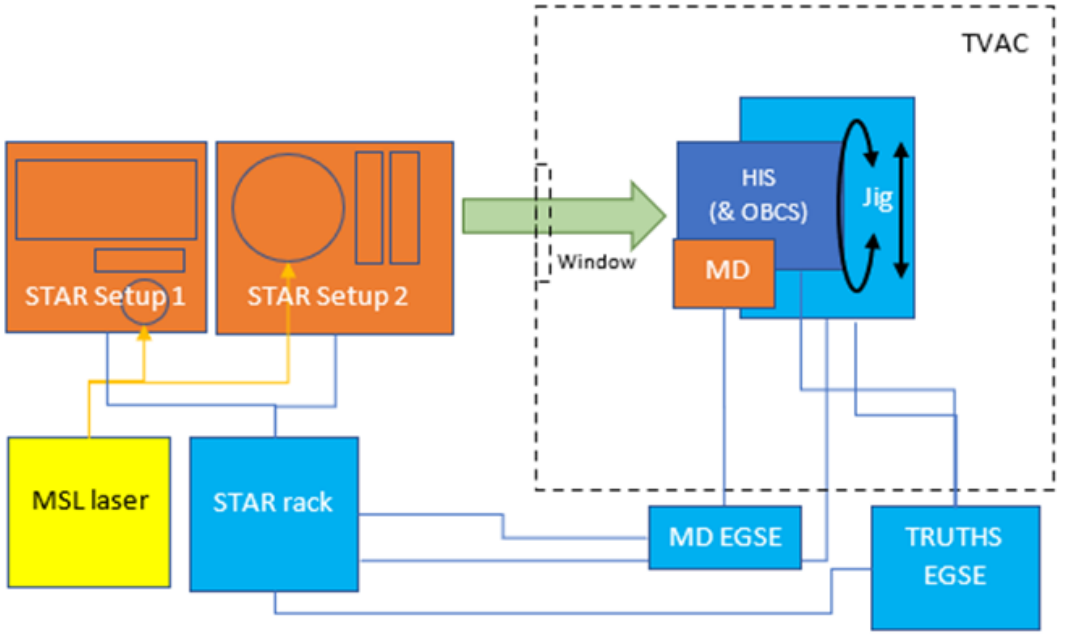
External HIS pre-flight calibration

Spectral calibration

- Monochromatic via tuneable laser traceable via high accuracy wavemeter to the metre & frequency standard.
- Simultaneous to spectral straylight etc.

Radiometric calibration

- State-of-the-art following philosophy employed by NMIs for thermodynamic temperature determination, est. <0.2% (k=2)



			Si		InGaAs	
Symbol	Source of Uncertainty	Probability Distribution	Value	ui	Value	ui
uAbs	Photodiode Absolute Calibration	Normal	0.05%	0.05%	0.05%	0.05%
uRel	Photodiode Spectral Response Calibration	Normal	0.08%	0.08%	0.10%	0.10%
uSp	Spectrometer	Uniform	0.05%	0.03%	0.05%	0.03%
UC	**Combined Uncertainty (k=1)**			**0.10%**		**0.11%**
U95	**Expanded Undertainty (k=2)**			**0.19%**		**0.23%**
	Photodiode Abs + Rel only (k=1)			**0.09%**		**0.11%**
	Photodiode Abs + Rel only (k=2)			**0.19%**		**0.22%**

On-orbit spectral calibration

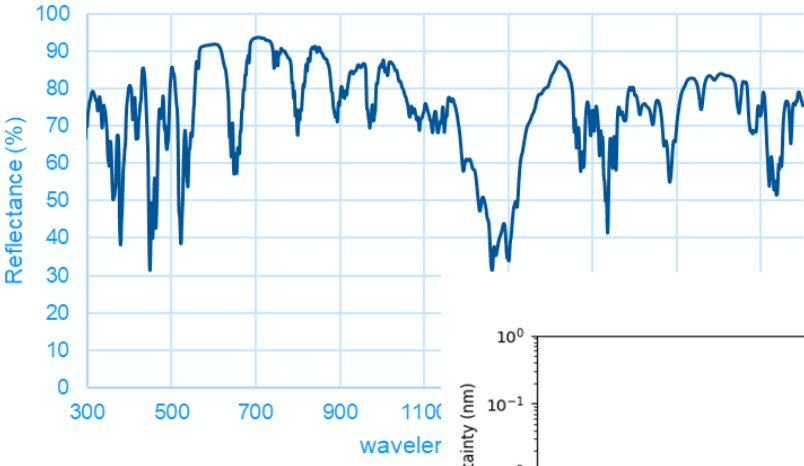
Fraunhofer lines

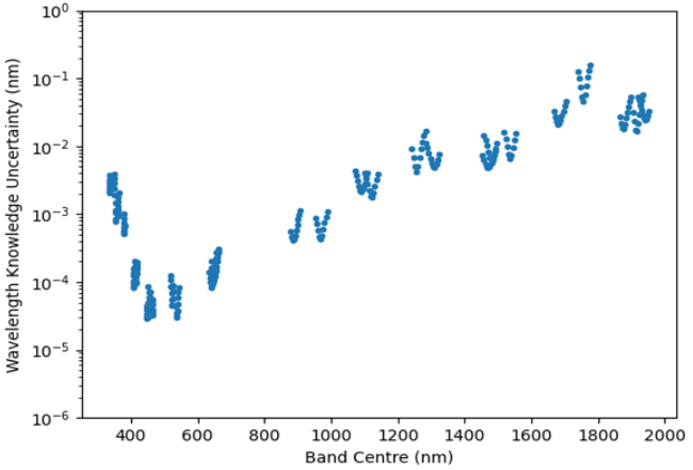
- 33 identified lines/groups
- 300 nm - 900 nm
- Use Solar spectral irradiance observation – few seconds
- <0.025 nm accuracy est.

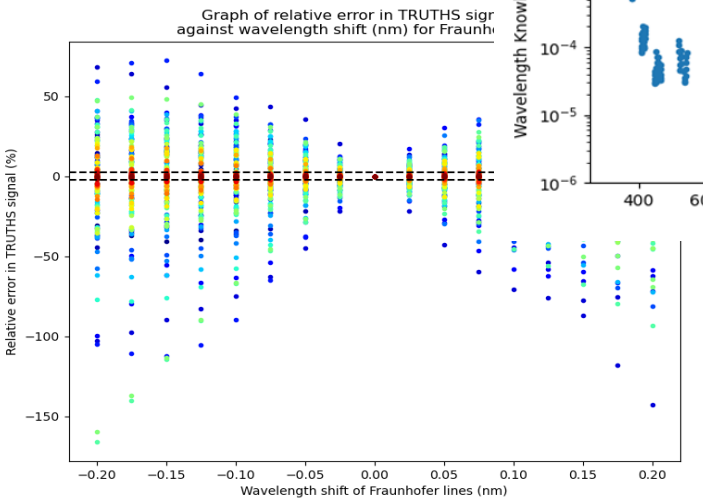
Onboard Rare-earth oxide doped filter reference

- Features over 300 – 1950 nm
- Solar illuminated convolved with Fraunhofer lines, but feature width allows reliable determination.
- <0.1 nm accuracy est.

Overlap region adds confidence.







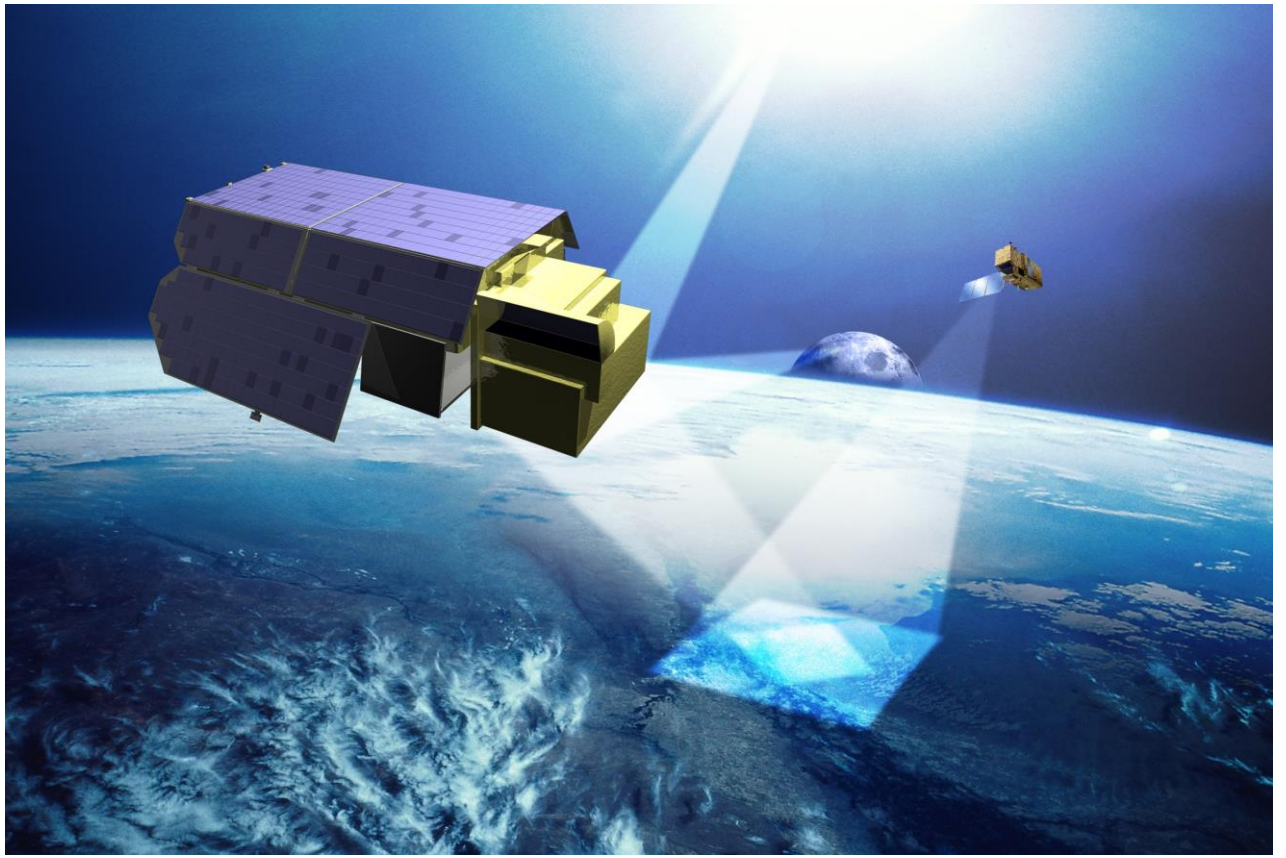
See Poster Stedman et al

Summary

TRUTHS' high radiometric accuracy achieved through repeated re-calibration of the Hyperspectral Imager, in orbit to the CSAR primary standard.

Traceability is to the primary standard through a unbroken chain of operations within the On-board calibration system.

Independently verified pre-flight through external HIS calibration, traceable to a common SI reference.



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