Copernicus Sentinel-4/UVN pre-launch plans

Berit Ahlers and S4/UVN team

Atmospheric Composition Constellation meeting (ACC-11)

ESA/ESRIN 2015

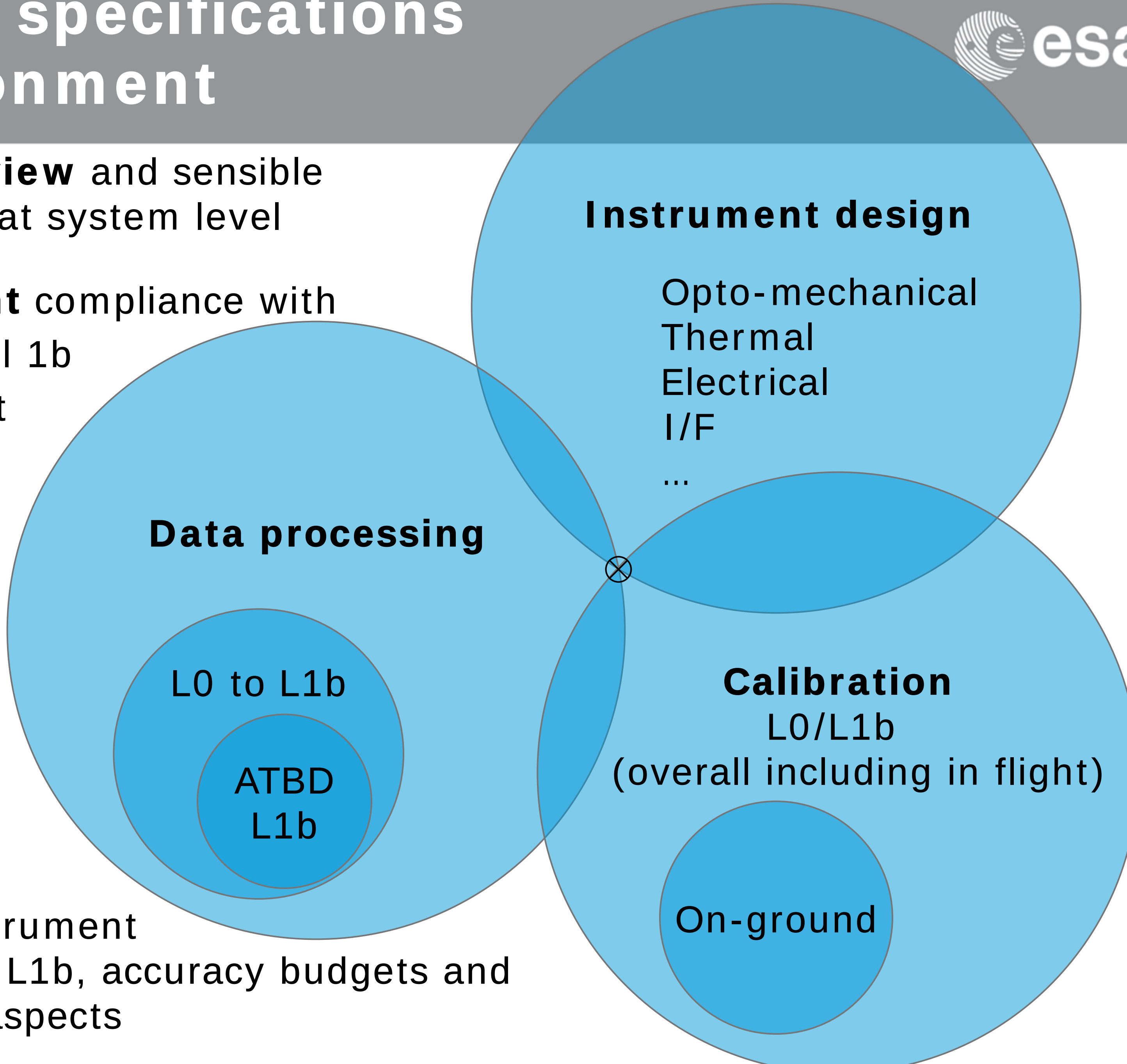
Outline

1. Sentinel-4/ UVN apportionment
   - instrument design – calibration – L0L1b processing
2. L0 performance verification and calibration
   - example radiometric calibration
3. contamination prevention (optical degradation)

S4 / UVN specifications apportionment

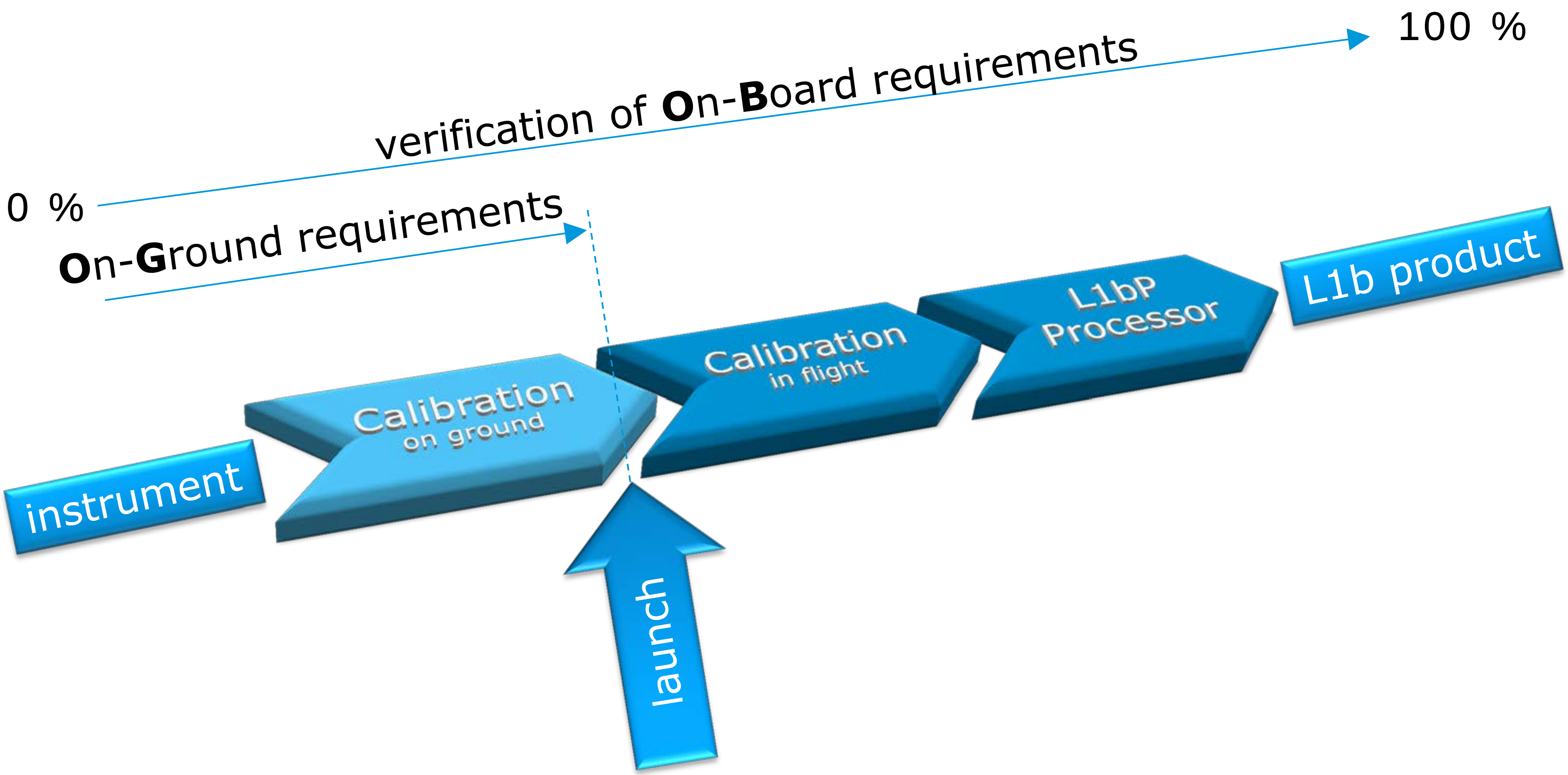
maintain **overview** and sensible apportionment at system level

space segment compliance with instrument level 1b requirements at BOL and EOL

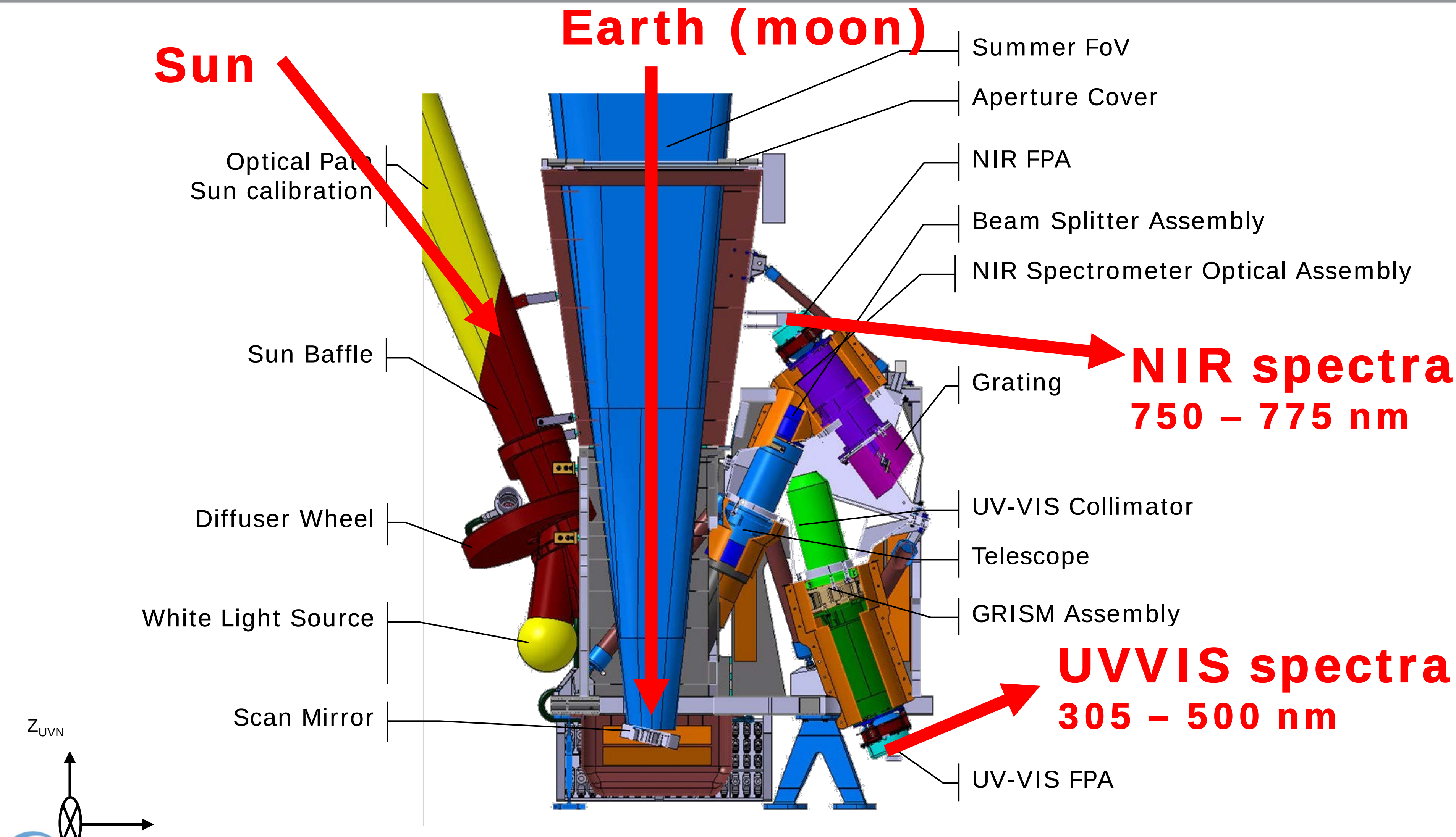


optimisation considering instrument performance at L1b, accuracy budgets and programmatic aspects

S4/UVN on-ground and in-flight requirements



S4/UVN instrument



Courtesy of Astrium GmbH

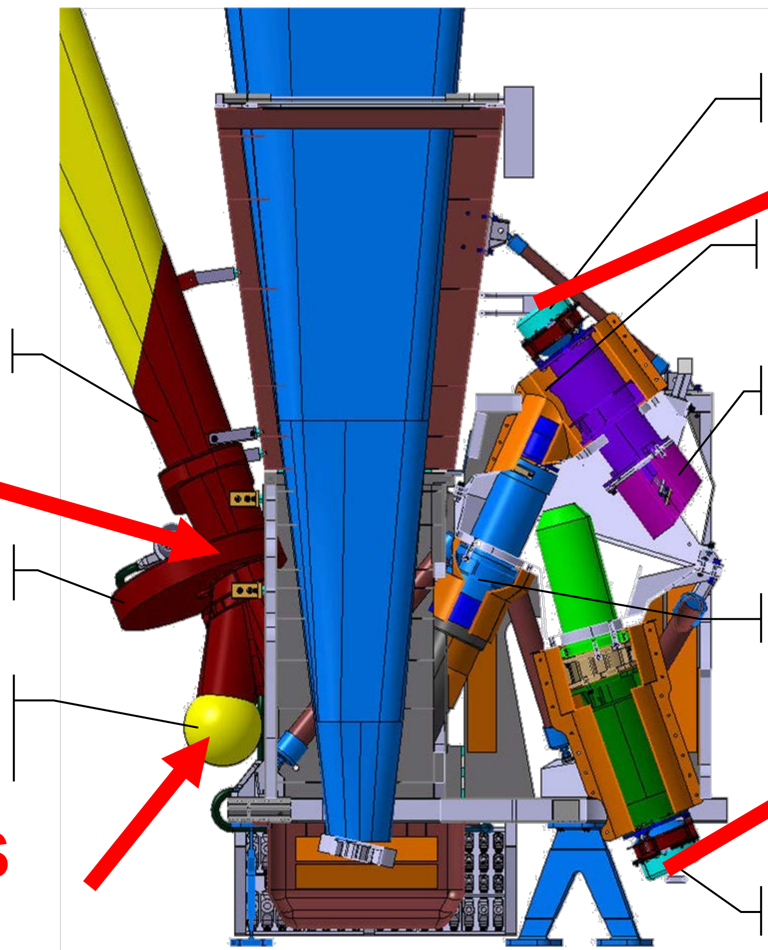
S4 / UVN calibration sources

external

Fraunhofer lines
atmospheric lines
Sun / moon
stars
OGSE's

2 diffusers

daily
monthly



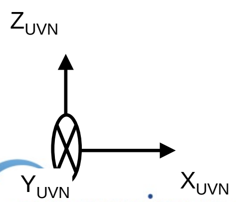
LED (red)

dead / bad pixel
pixel gain
pixel linearity

LED (blue)

WLS

PRNU
radiometric stability
degradation



Courtesy of Astrium GmbH

L0 performance verification parameters

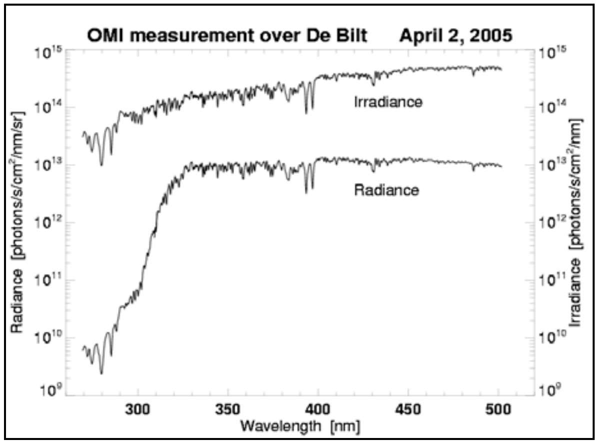
Objective: to verify is S4/UVN instrument is built as designed @Level 0 under flight representative environmental conditions **'Test as you fly'** incl.:

1. verification instrument sufficiently insensitive to incident **polarisation**
2. no **spectral features** in instrument response interfering with atmospheric gas absorptions
3. **straylight**

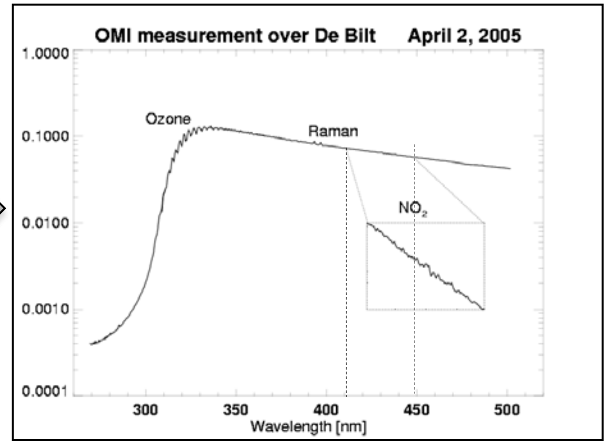
S4/UVN spectral features

DOAS analysis of satellite spectra

Irradiance and Radiance Measurement

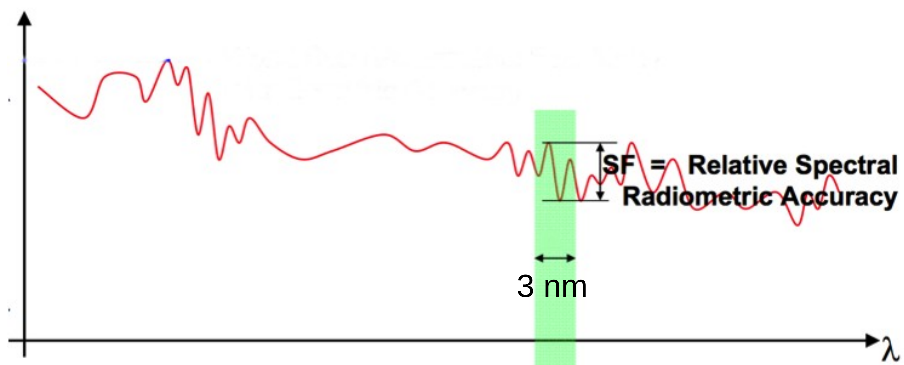


Derived Reflectance



Note how small the NO_2 features are, about 0.5% signal strength of the total signal

Contributors to these **spectral features** are: polarisation scrambler, coatings, gratings, sun diffuser, straylight, gain change, …



< 0.05 %!

Calibration parameters

Objective: to retrieve calibration key parameters.

1. **radiometric calibration** Earth spectral radiance, solar spectral irradiance and derived Earth reflectance (radiance/irradiance)
2. **spectral calibration**
   a. wavelength scale for uniform and non-uniform ground scenes
   b. Instrument Spectral Response Function (ISRF)
   c. optical bench temperature (gradient) dependencies
3. spectral/ spatial **straylight**
4. **electronic** and **detector** calibration parameters
5. **geometric** parameters, co-registration, Image Navigation and Registration (INR), geolocation

Flow down to component level

1. **component**

   e.g. characterisation of diffuser, scan mirror

   (transmission, angle dependence, radiation, ...)

2. **sub-system**

   e.g. Focal Plane Assembly sub-system

   (detector, FEE/FSE, FPA housing)

3. **system**

   S4/UVN instrument models

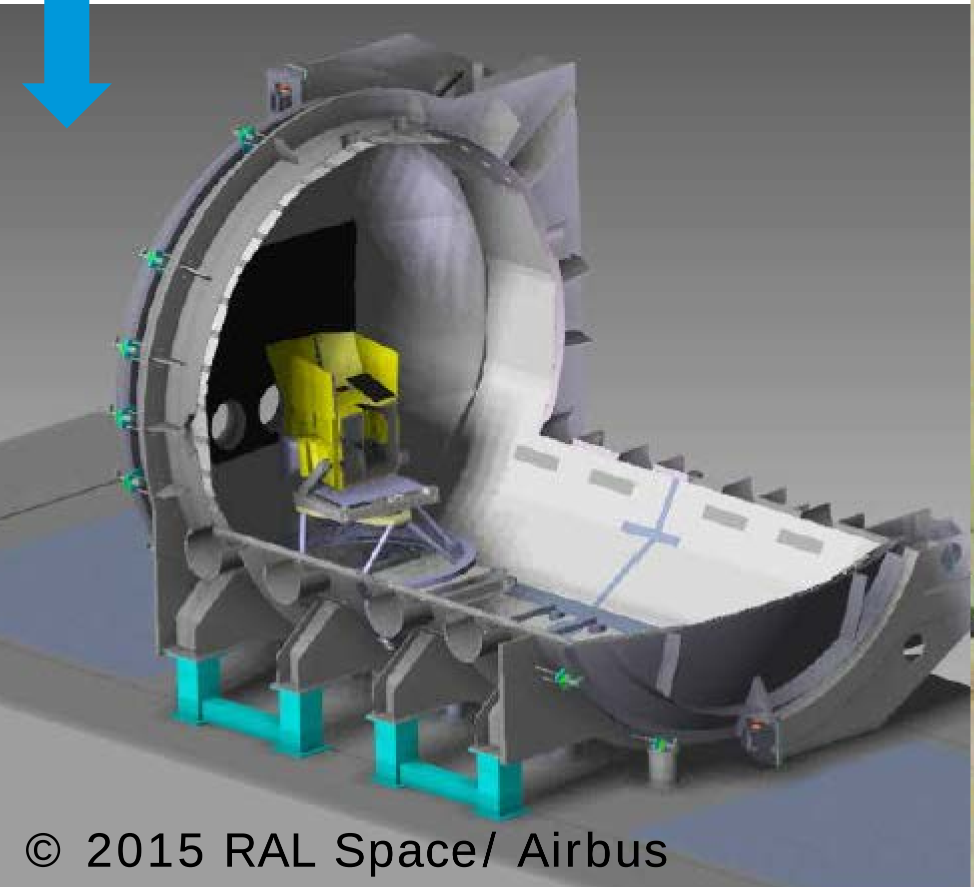
AND calibration **facility**, optical, mechanical, electrical ground support equipment (**GSE's**)

RAL Space / UK new building
status 17 Feb 2015

RAL Space UK

door port machining (9thApril)

Sentinel 4/UVN instrument in STC-5m
using AIRBUS CAD models



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S4 / UVN absolute radiometric accuracy

3 % (threshold), **2 %** (goal), accounting for all error contributions (straylight, polarisation, smear,...) at level 1b (after corrections)

Calls for building-up an error budget accounting for contributions from:

- instrument design
- instrument on-ground and in-flight calibration
- signal processing L0 to L1b

Similar requirements exist for **on-ground** measurements*

- instrument response in Sun calibration mode shall be calibrated better than **0.8 %**
- instrument response in Earth observation mode shall be calibrated better than **1.0 %**
- instrument response in Earth reflectance shall be calibrated better than **1.0 %**

* exluding FEL lamp error contribution

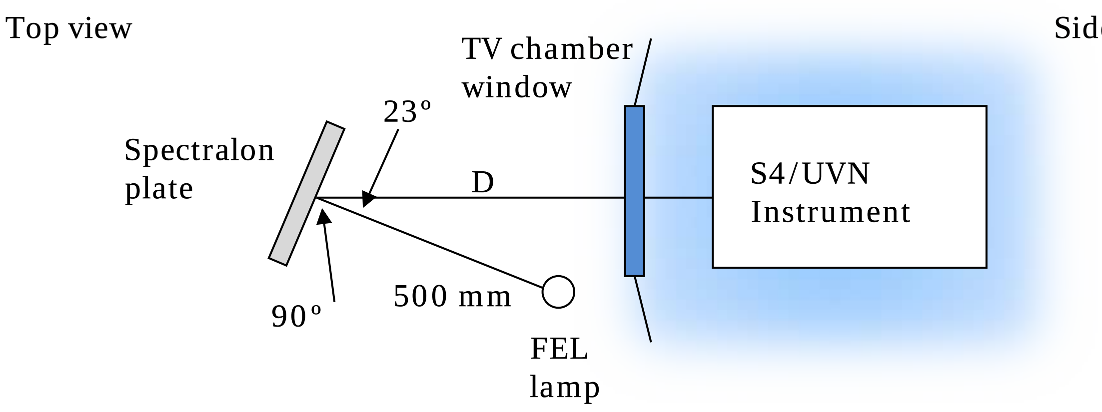
Radiometric calibration parameters

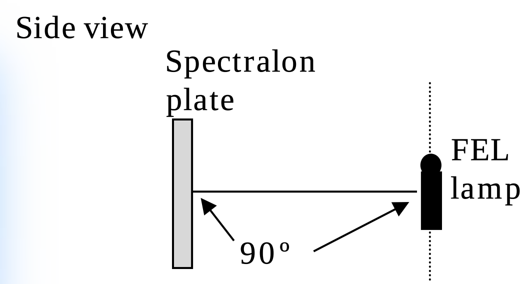
1. absolute Earth spectral **radiance**
2. absolute Sun spectral **irradiance**
3. **Earth** viewing **angle dependency**
   (North-South on detectors and scan mirror)
4. **Sun** viewing **angle dependency**
5. absolute **Earth reflectance**: Earth radiance/ solar irradiance, using dedicated sources optimised for this parameter

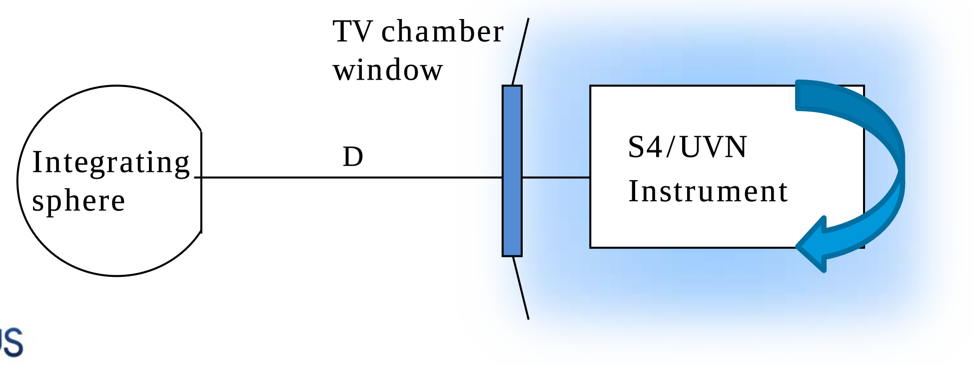
In orbit, relative radiometric **degradation** monitored and quantified primarily with **Sun irradiance** measurements, but also with **WLS** and **LED, Earth radiance** and **moon** measurements.

Absolute radiometric radiance calibration - on ground

using calibrated sources (FEL lamp, integrating sphere) and radiance angle dependency calibration measurements under flight-representative thermal-vacuum conditions

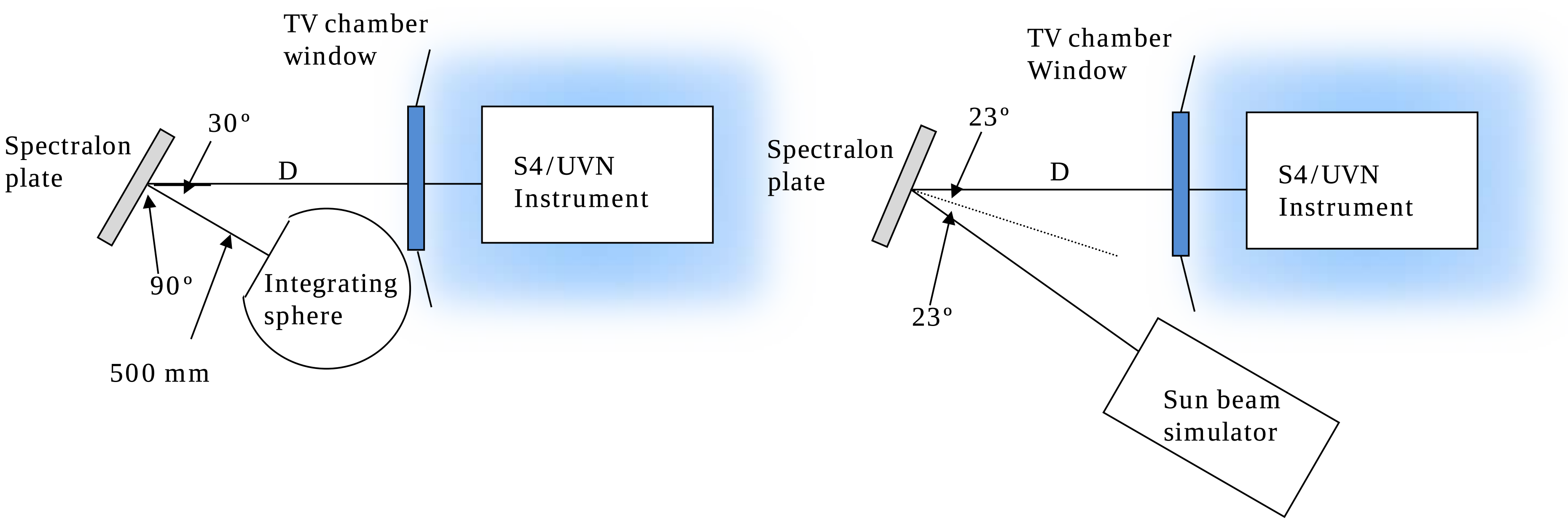






Absolute radiometric radiance calibration - on ground

using calibrated source **cross calibration** with respect to FEL lamp



Radiometric measurements

Using **different radiometric sources** is **absolutely essential** to obtain required radiometric accuracy and to quantify measurement uncertainties.

Measurement sequence include:

- absolute radiance/ irradiance/ reflectance
- irradiance goniometry
- radiance angular dependency

	OGSE	Radiance	Irradiance
1	FEL	1R	1I
2	SBS	2R	2I
3	Integr. Sphere	3R	3I

Product	Msm	Comment
Refl	2I/2R	Best (calibration keydata)
Refl_FEL	1I/1R	Analysis result from measurement expected to be less good
Abs_Rad	1R	Calibration keydata (expected to be the most accurate key parameter to be used for L0 to L1b processing)
Abs_Irrad	Abs_Rad x Refl	Best (expected to be the most accurate key parameter to be used for L0 to L1b processing)
Abs_Irrad_FEL	1I	Analysis result from measurement expected to be less good
Ang_dept _sphere	3R	Radiance angular dependence
Refl_sphere	3I/3R	Instrument BSDF
Abs_Rad´	3R	Radiance angular dependency & calibration keydata (to be used in L0 to 1 processing in case more accurate than Abs_Rad)
Abs_Irrad'	Abs_Rad' x Refl	Calibration keydata (to be used in L0 to 1 processing in case more accurate than Abs_Irrad)

Solar occultation / zenith sky

closer to actual **operational atmospheric measurements**

(dark lines in bright scene instead of bright lines from OGSE with dark background)

→ **real atmospheric radiance source** as **stimulus**

end-to-end performance

→ **close loop** between atmospheric measurements, processing calibration and instrument hardware up to level 2

Decontamination measures to prevent optical degradation (examples)

- **bake-out** after launch (additional heater power)
- protection optical components from e.g. **solar flux**
- **warm-up** possibilities independently for detectors/optical bench
- **protection solar diffusers**
    - no measurements several weeks after launch
    - no measurements after yaw flip
    - no measurements after thrusters' usage
- **purging**
- avoidance **humidity**
- avoid **materials degrading** under space environment (e.g. relevant light fluxes, atomic oxygen, radiation, TV, molecular contamination)

Conclusion and outlook

S4/UVN **instrument design, L0 performance verification** and **calibration** (on ground 'Test as you fly' and in flight).

Attention for **balance** between L0 **performance**, **calibration** and level 0 to 1b **data processing** to deliver L1b data products within the required specification at End of Life.

S4/UVN instrument well equipped with **on-board calibration hardware**.

Phase C/D ongoing.

Thank you for your attention!

esa

For further information:

ESA Copernicus website
http://www.esa.int/copernicus

EC Copernicus website
http://www.copernicus.eu/