The VenSpec-U instrument onboard EnVision

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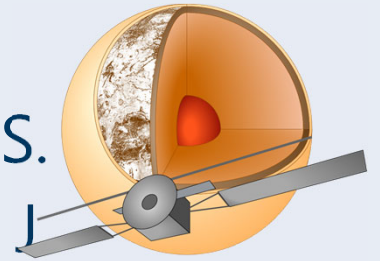


EnVision

Europe's Revolutionary Mission to Venus

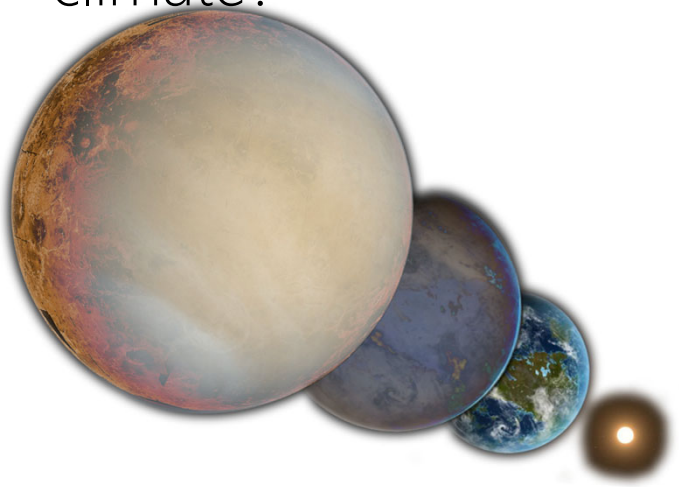
Venus Workshop, Kobe (Japan)

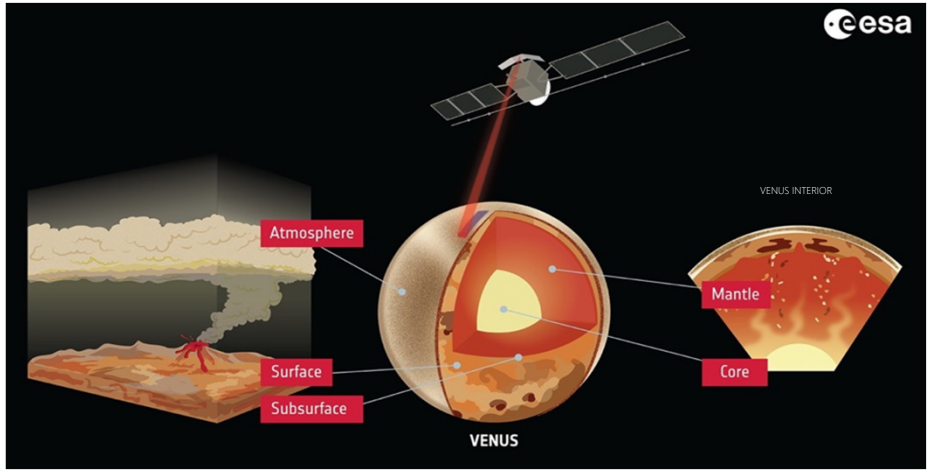
2024-03-27

EnVision & the VenSpec suite

EnVision in brief

- ESA Cosmic Vision M5 mission (with NASA participation)
- Venus orbiter, to be launched in 2031, operating 2035-2039
- Science case:
  - **History** – how have surface and interior evolved?
  - **Activity** – how geologically active is Venus?
  - **Climate** – how do geological processes shape atmosphere and climate?



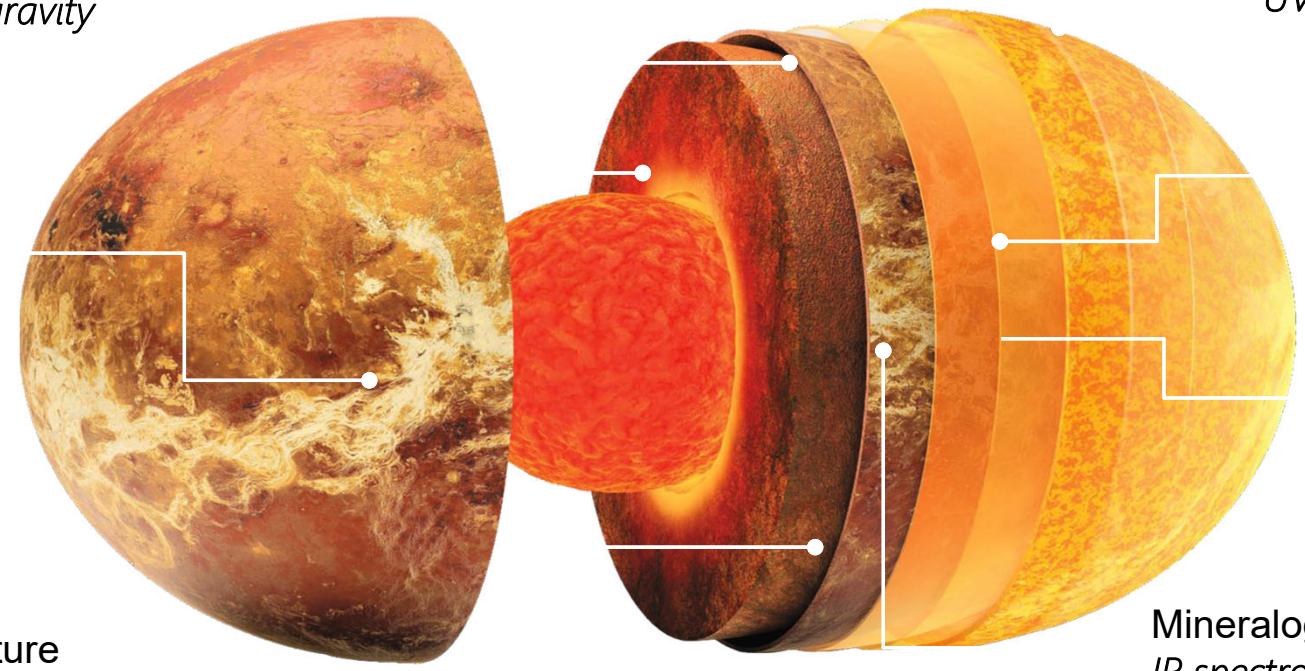


Holistic approach to address the Venus system

Crust and Lithosphere
Mantle and Core
Radio Science gravity

Mesospheric gases
UV and IR spectrometry

Morphology
and Geology
SAR



Tropospheric gases
IR spectrometry

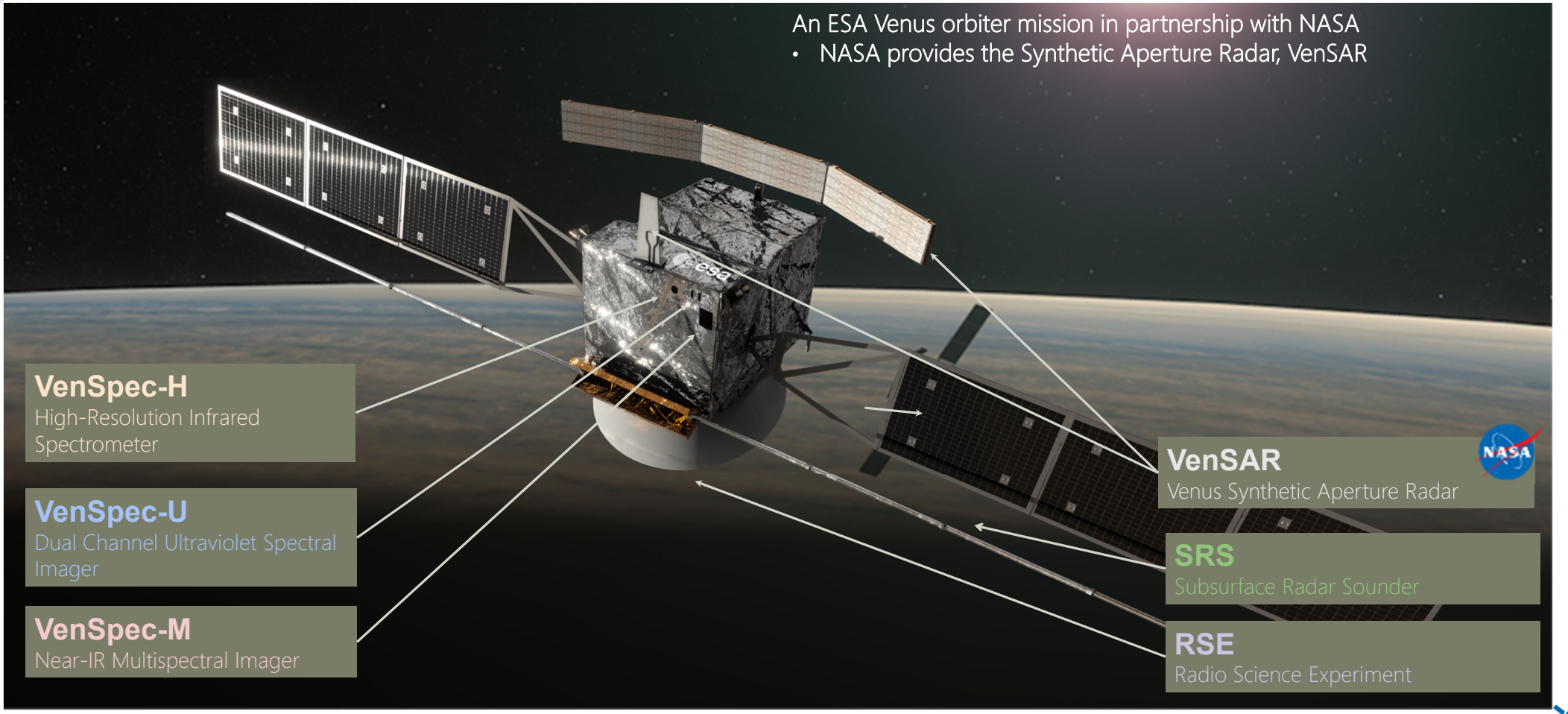
Atmosphere profiling
Radio Science in occultation

Shallow Structure
Subsurface Radar Sounder

Mineralogy and Volcanic Activity
IR spectrometry

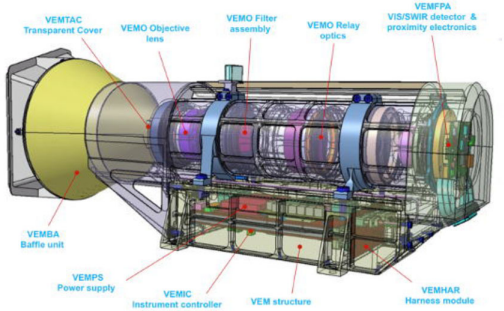
Image: ©National Geographic

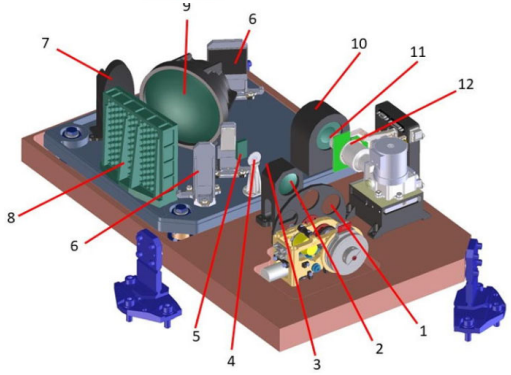
EnVision's payload

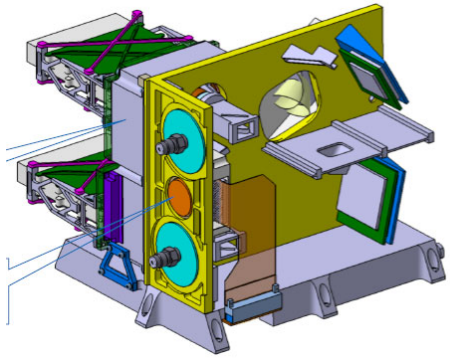


A suite made of three spectrometers

- **VenSpec-M** (ILS: J. Helbert 🇩🇪)
  - 14 narrow filters camera, 0.75-1.5 µm
  - Nightside only (surface, lower clouds)
- **VenSpec-H** (ILS: A. C. Vandaele 🇧🇪)
  - 1.18, 1.4, 1.74 & 2.3 µm windows, R~8000
  - Dayside & Nightside
- **VenSpec-U** (ILS: E. Marcq 🇫🇷)
  - UV spectral imager
  - Dayside only (upper clouds)



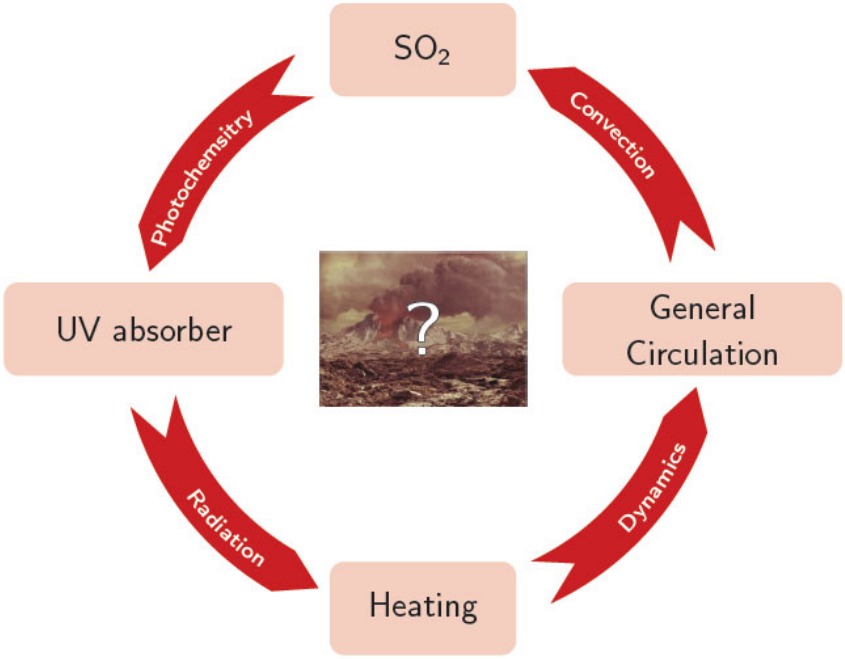


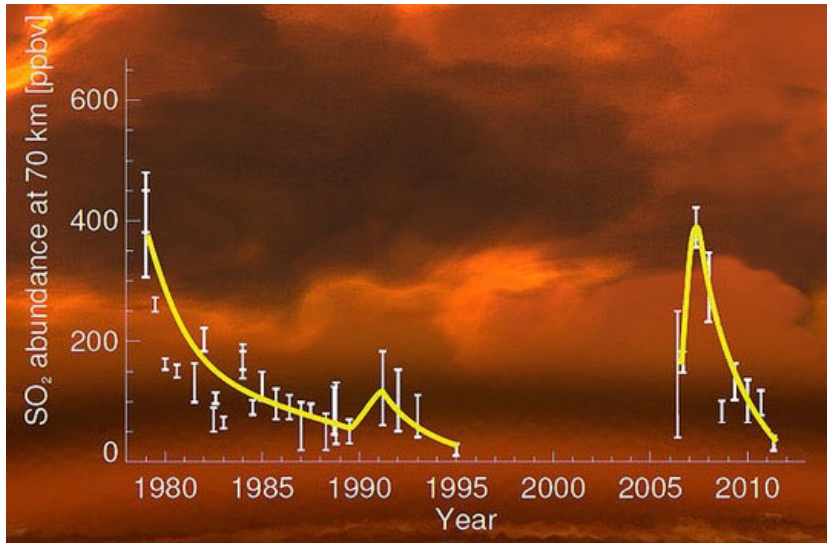


VenSpec-U science objectives

Goal #1: mapping cloud top SO_2

- Strong variability, yet poorly understood
  - Source: mixing with deep atmospheric reservoir
  - Sink: photochemistry
- Is SO_2 variability linked with surface (volcanism, orography) and/or caused by purely atmospheric processes?

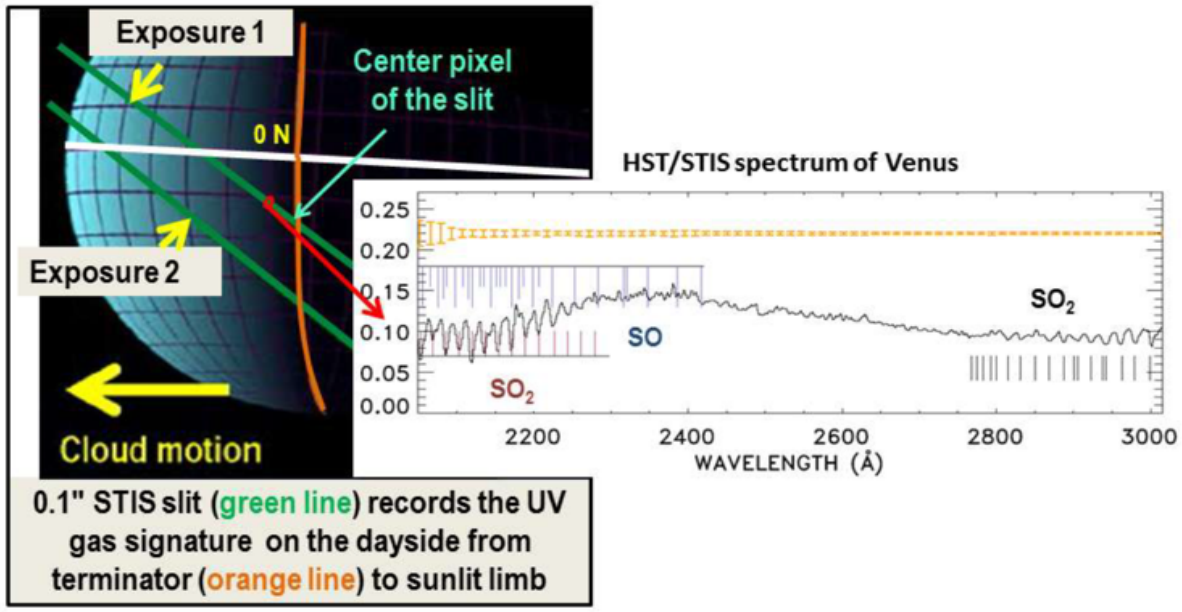




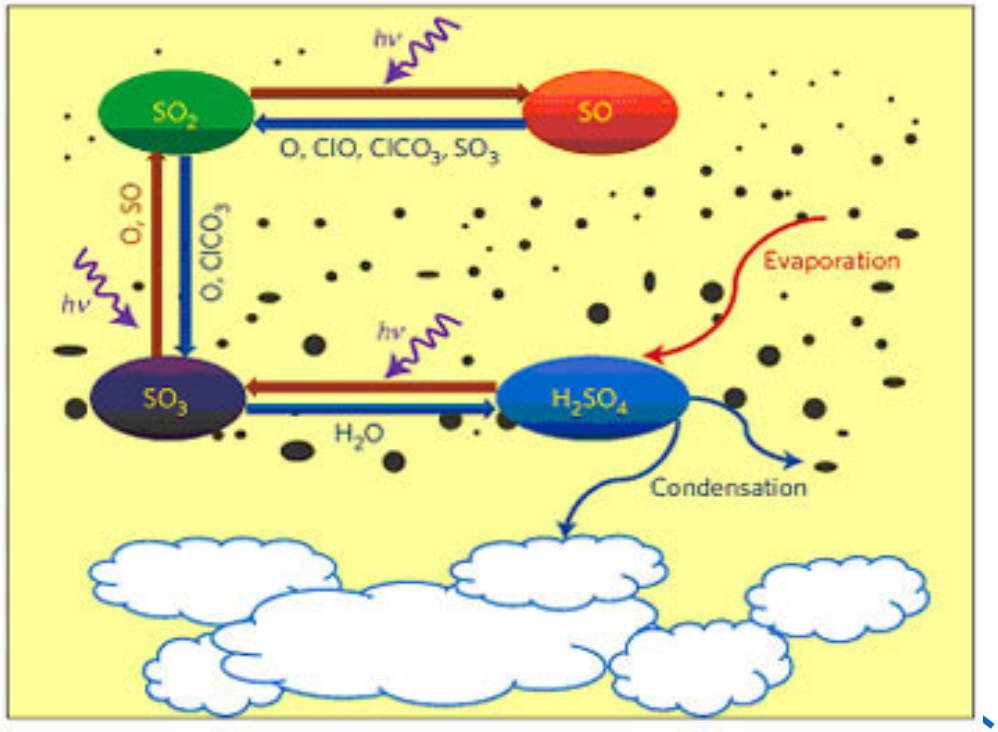
Marcq+ (2013)

Goal #2: mapping SO:SO_2 ratio

- Poorly constrained yet (as of 2024)
- Important to characterize SO_2 photochemical sink

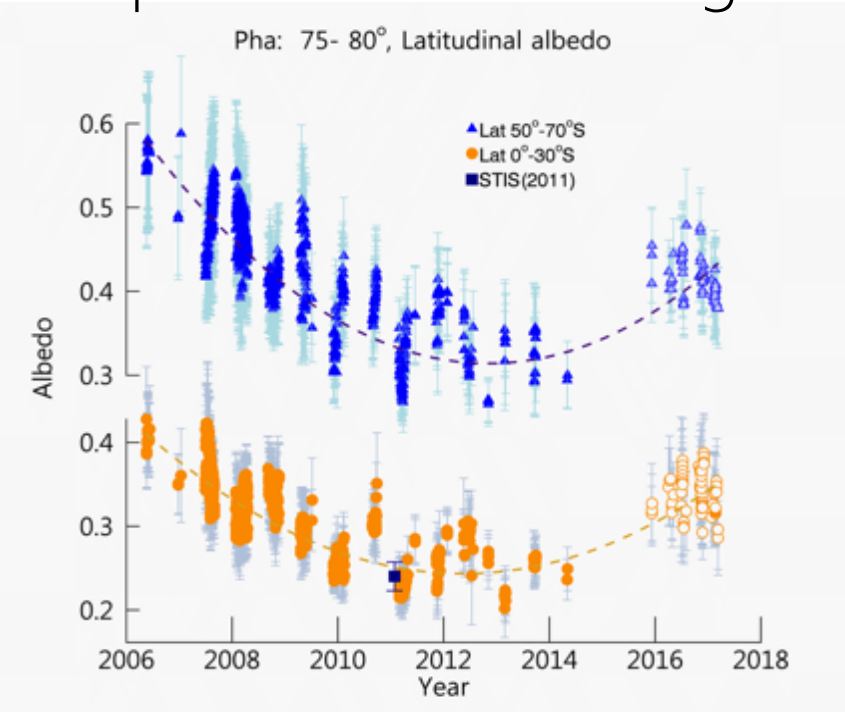


Jessup+ (2015)

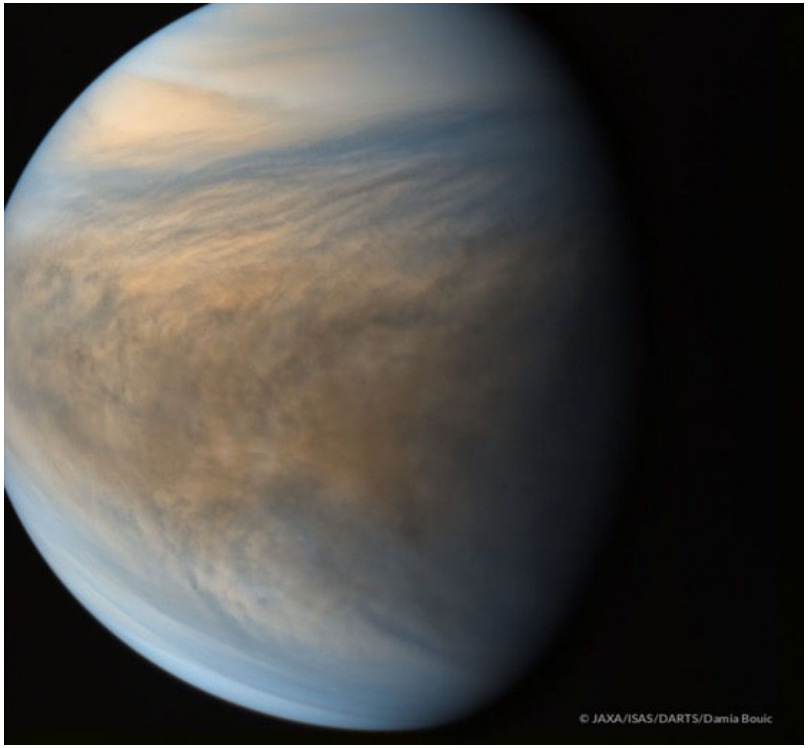


Goal #3: monitoring and mapping UV absorber

- Likely linked to sulfur cycle, yet still unidentified!
- Good tracer of atmospheric activity
  - Sub-solar convection cells, waves, large scale circulation
- Comparison with existing 365 nm datasets (VMC/VEx, UVI/VCO)

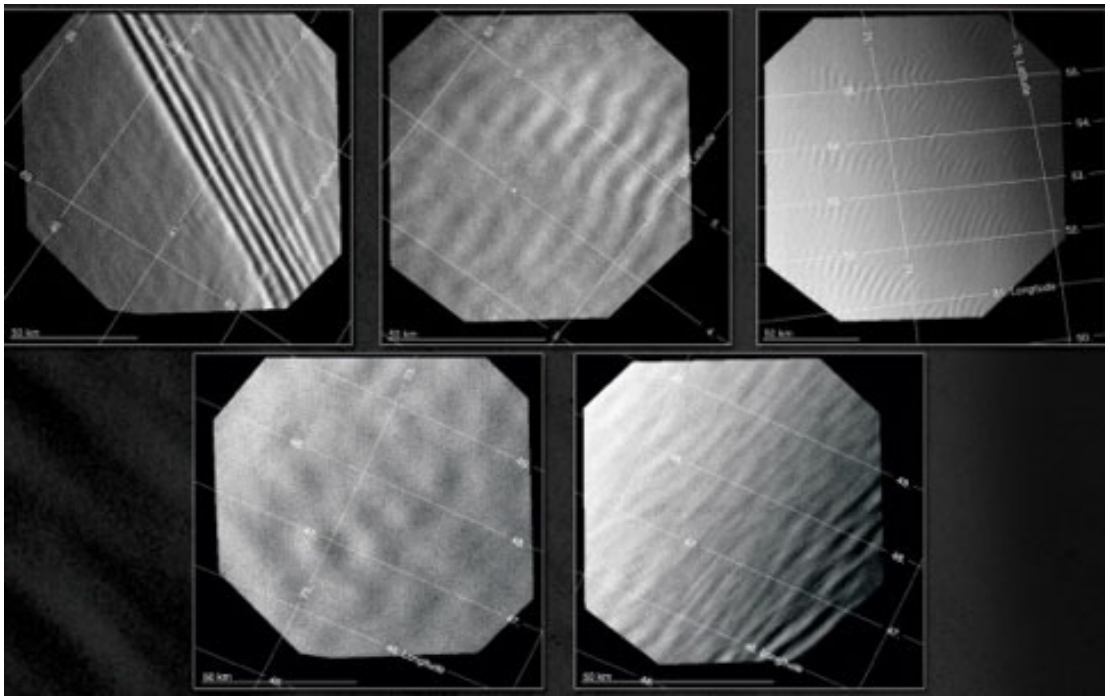


Lee+ (2015)

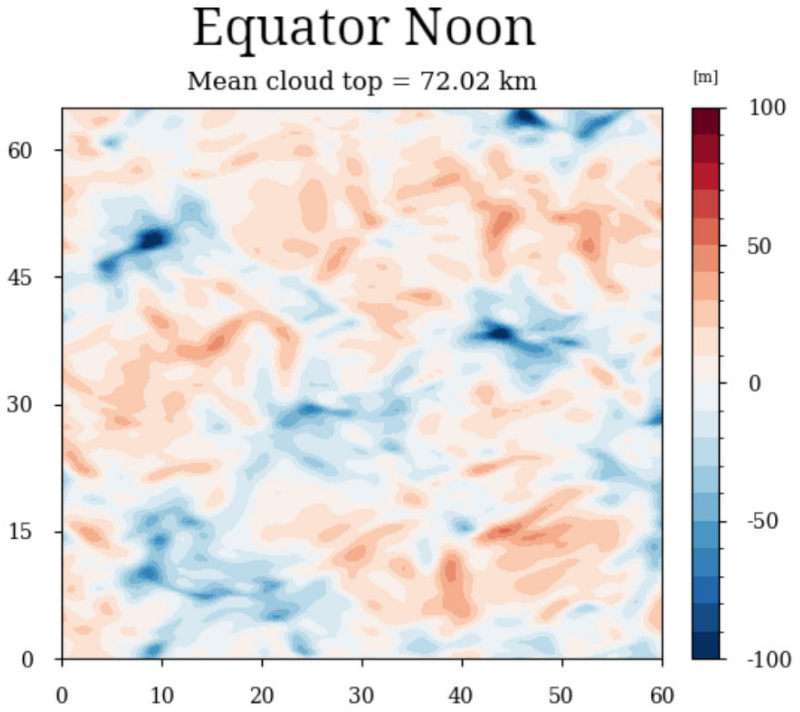


Goal #4: high spatial resolution

- UV contrasts down to scales <10 km: what about SO_2?
- Cloud top convection cells, atmospheric waves
- Constrain mesoscale/LES coupled chemistry/dynamics models



Piccialli+ (2013)



Lefèvre+ (submitted)

Requirements flow down

R1-C-20

Measure the variability of the **mesospheric composition**, and how it is linked with surface geological processes and atmospheric dynamics

R1-C-30

Measure the variability of **clouds** and cloud droplets, and how it is linked with surface geological processes and atmospheric dynamics

R2-C-20

SO_2 (random <20%, bias < 50%) ; 5×5 km²
$SO:SO_2$ (random <25%, bias < 100%) ; 25×25 km²
Coverage >60 % (day side cloud top)

R2-C-40

UV absorber (10% radiance @ 365 nm, 5×5 km²)
Cloud top altitude (<1km, 5×5 km²)
Coverage > 60% (day side cloud top)

R3-MEA-210

VenSpec-U HR channel
205 – 235 nm at 0.3 nm resolution
SNR ~100 at 220 nm, spatial sampling < 24 km, FoV 20°

VenSpec-U LR channel
190-380 nm at 2-5 nm resolution
SNR ~200 at 220 nm, spatial sampling < 5 km, , FoV 20°

R3-MIS-310

4 overlapping (>70%) measurements per 24 hours, at temporal sampling < 3 h during nominal mission

Global coverage > 60% in local time, latitude, longitude (no gap > 10%) on the dayside (SZA<70°)

Geolocation accuracy < 100 km wrt. surface

Simultaneous operations between –H and -U

R3-MIS-315

Co-alignment –U/-H/-M

-H FoV included within –U FoV

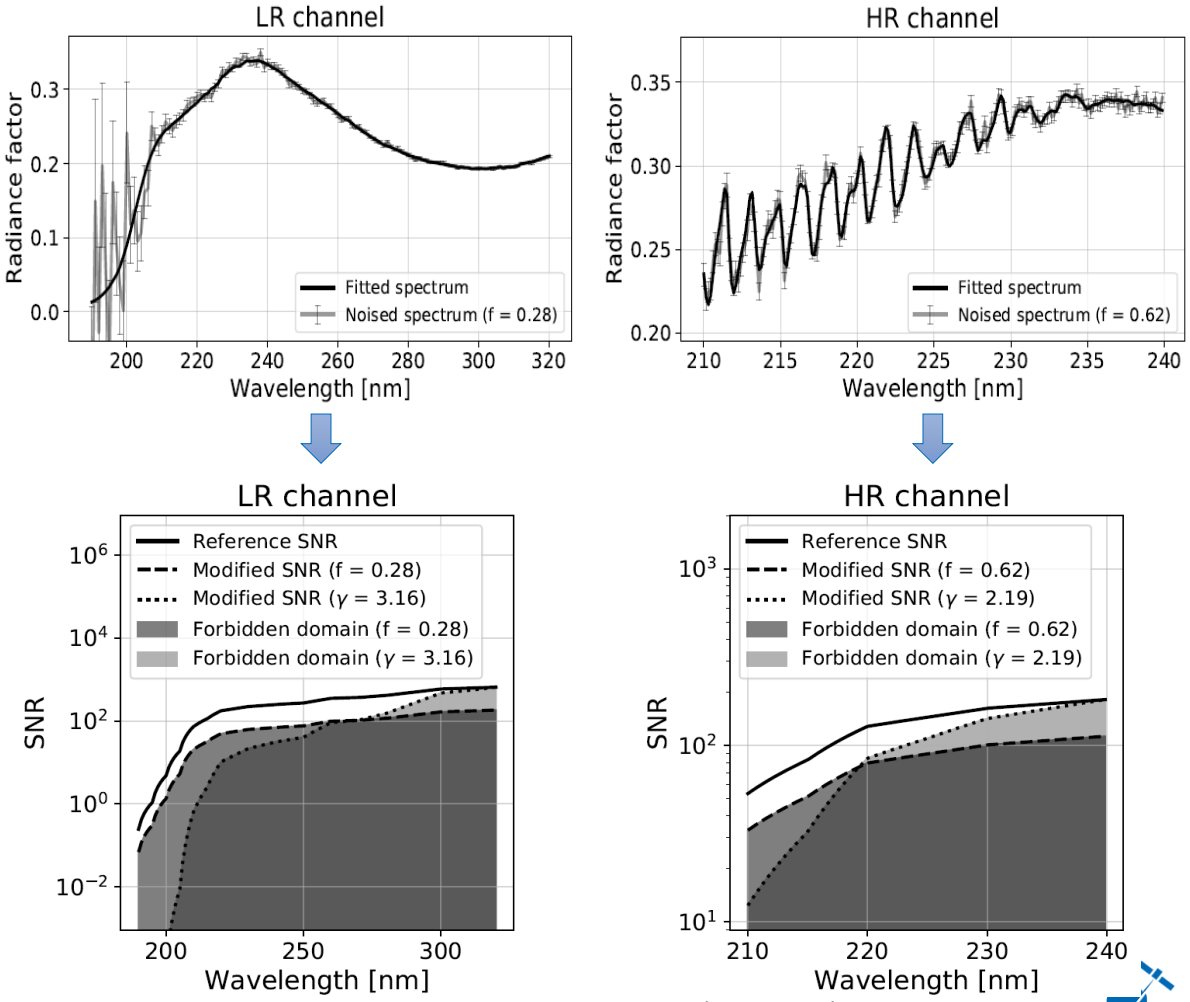
Justification: end-to-end simulations

> Using an extended and updated version of the **forward radiative transfer code** used for SPICAV-UV nadir observations (Marcq+ 2020)

> Allows to determine **SNR(λ)** envelopes for both channels

> Also used for constraining the **systematic biases** allowance

> Straylight, contamination, polarization, solar spectrum, etc.



Conan+ (submitted)

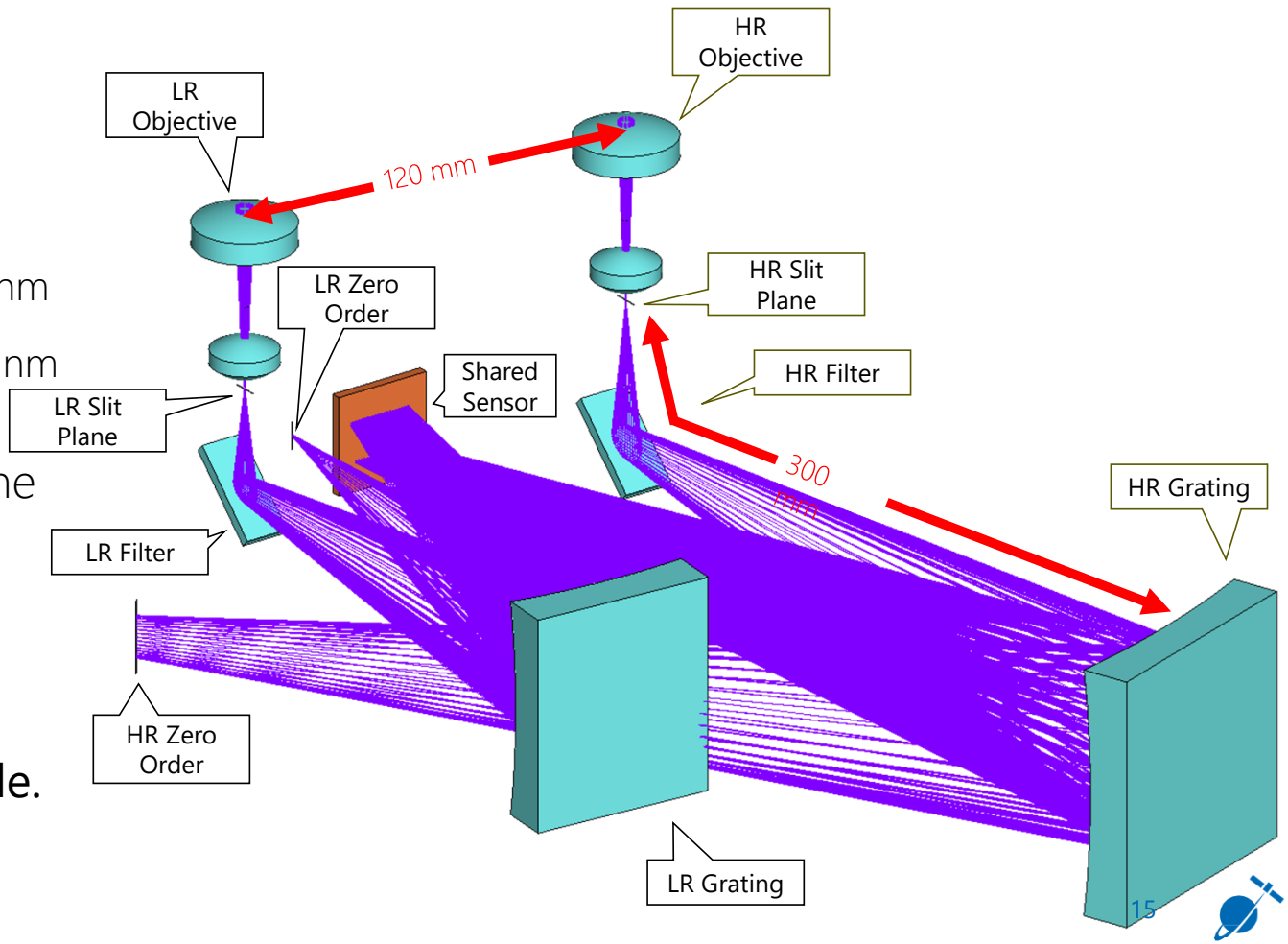
The VenSpec-U instrument

Optical Layout

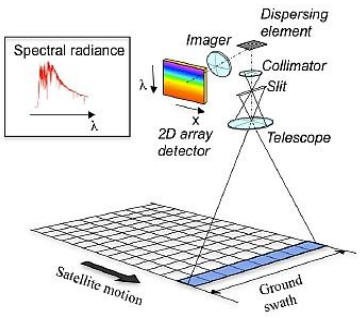
- **Two channels** with separated objectives and spectrometers
  - **LR channel:** 190 – 380 nm at 2-5 nm
  - **HR channel:** 205 – 235 nm at 0.3 nm
- **L-shaped architecture** due to the visible-NIR rejection filters
- One shared detector
- The optical design is now stable.

SO_2 absorption bands + UV absorber

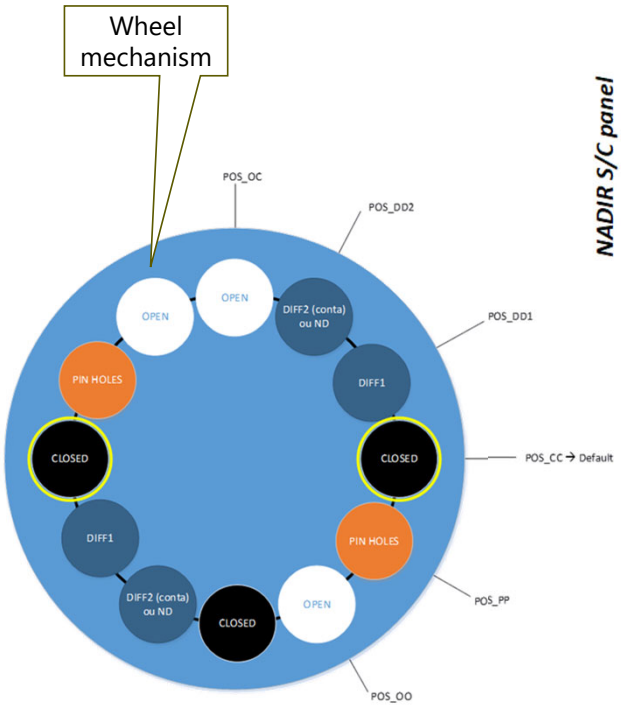
SO & SO_2 absorption lines resolved

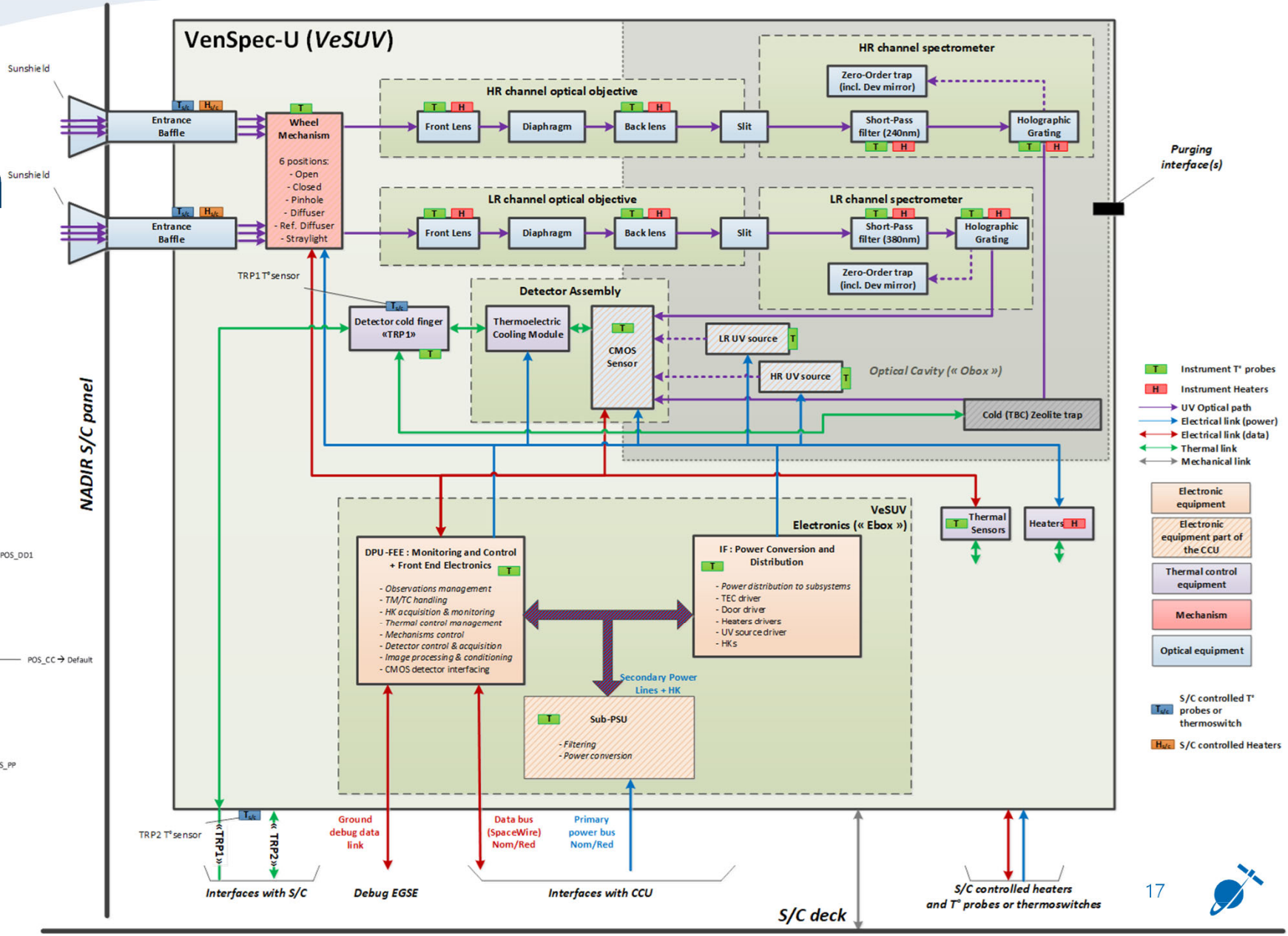


Operational Modes

	Venus Observation	Dark Calibration	Internal Calibration	Sun Calibration	Decontamination
	SW mode : « Nominal »				**SW mode : « Decontamination »**
	**Nominal science observation case**, based on a **"pushbroom"** observational strategy (latitudinal scanning)	Dark acquisitions to **monitor any drift of the sensor dark current**, on a pixel basis, based on the instrument bi-stable wheel mechanism used as a shutter ("closed position")	Flat-field acquisitions to **monitor any drift of the sensor PRNU**, based on an internal UV light source (used in dark conditions)	Instrument **absolute radiometric calibration**, using Sun scans 1 session = 2 « big scans » - 1 with **pinholes** - 1 with **diffusers** + 1 additional big scan (occasionally) with **reference diffusers**	**Decontamination of internal optics** (lenses, filters, gratings) using local heating **controlled by the instrument**
LoS pointing and attitude	**Nadir / Off-nadir** (emission angle <15°)	N/A		**Sun pointing.** **Sun Scan done during S/C Slew at constant speed** (0,1°/s, typ. over >2.5°)	N/A
S/C orbital position	Day side	Night side or deep sky pointing preferably, possibly day side TBC (depending on tightness performances of the mechanism)		Day side	N/A
Periodicity & Durations	Performed over **4 consecutive half orbits**, every 15 orbits **~ 4 × 2820 s**	Once a month, each (goal) **Every 112 days** (requirement) **< 30 min, each**			**Curative, as necessary.** Duration TBD (several hours) during the 11 « unused orbits »
Data outputs	**Processed spectra** (incl. stacking, pixel correction and binning, when applicable)	**Raw frames** (no processing)		**Processed spectra** (depends on the configuration)	**HK only**

Block Diagram





Conclusion

Waiting for EnVision…

- **Collaborations** with similar instruments
  - **CLOVE** UV-nIR Cubesat (P.I.: Y.J. Lee)
  - **CUVIS/DAVINCI**

    200-390 nm @ 0.2 nm iFoV 0.3°

    340-570 nm @ 1-20 nm iFoV 1.3°
  - **VISOR/DAVINCI** 355-375 nm iFoV 11.3°×8.9°
- Scientific needs in between
  - **Venus monitoring** (decadal variability)
  - **Solar observations** (for cross-calibration)
- Want to join us?

- All three VenSpec channels have a **unified science team**
- Feel free to contact **all three** of the VenSpec ILS:
  - Jörn Helbert (DLR, VenSpec-M ILS, VenSpec Suite leader) joern.helbert@dlr.de
  - Ann-Carine Vandaele (BIRA, VenSpec-H ILS) a-c.vandaele@aeronomie.be
  - Emmanuel Marcq (LATMOS, VenSpec-U ILS) emmanuel.marcq@latmos.ipsl.fr