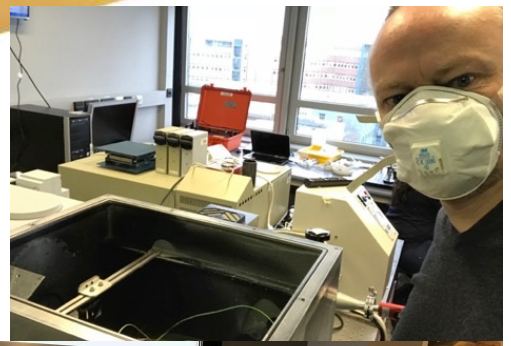
The Spectroscopy of the surface of Venus – in the laboratory and from orbit



Jörn Helbert

Alessandro Maturilli, Indhu Varatharajan,

Darby Dyar, Mario D'Amore,
Giulia Alemanno, Sabrina Ferrari

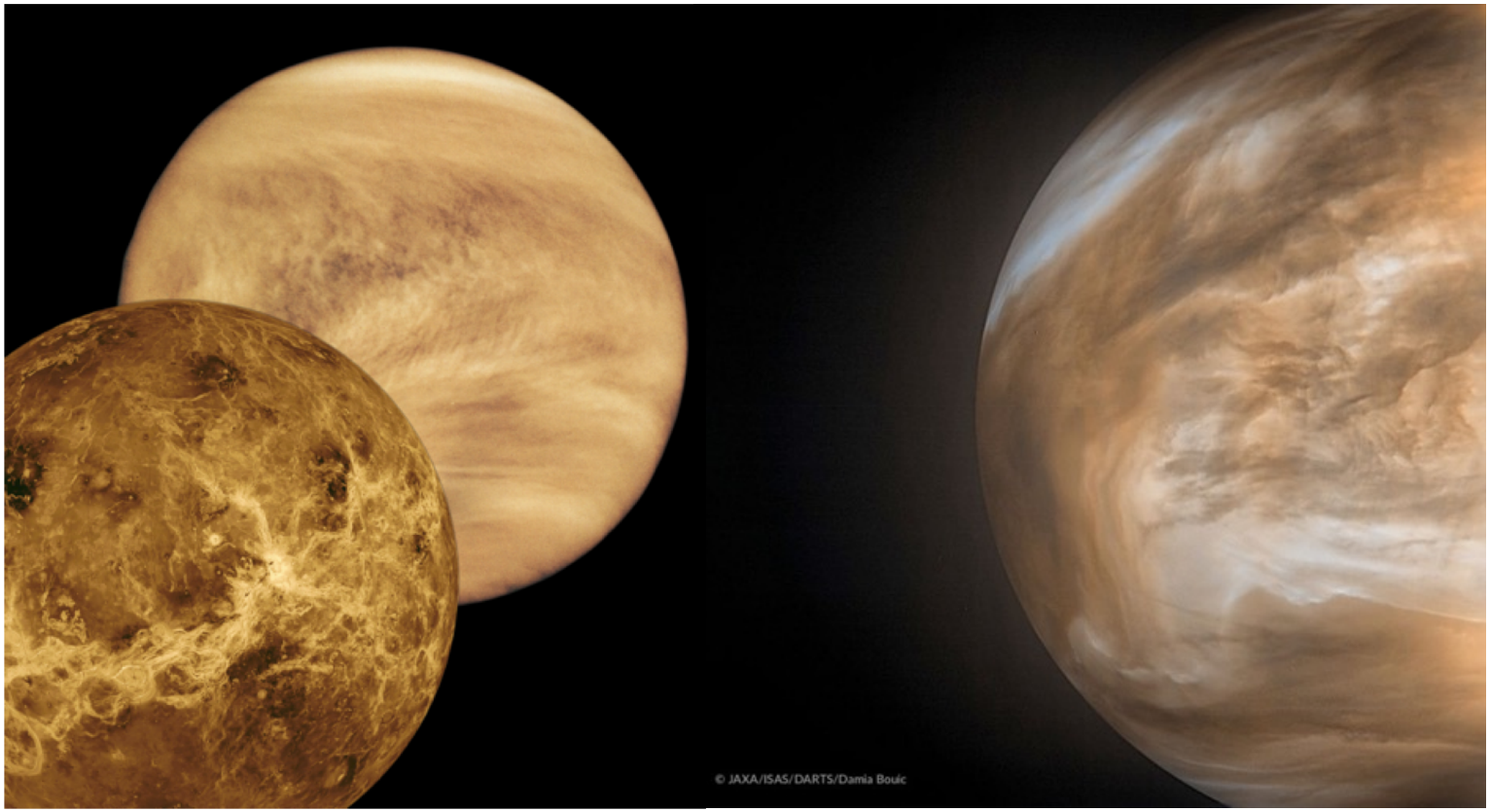
And many many many more...

Twitter: @Planetguy_Bln + @pel_dlr

Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

EUROPLANET

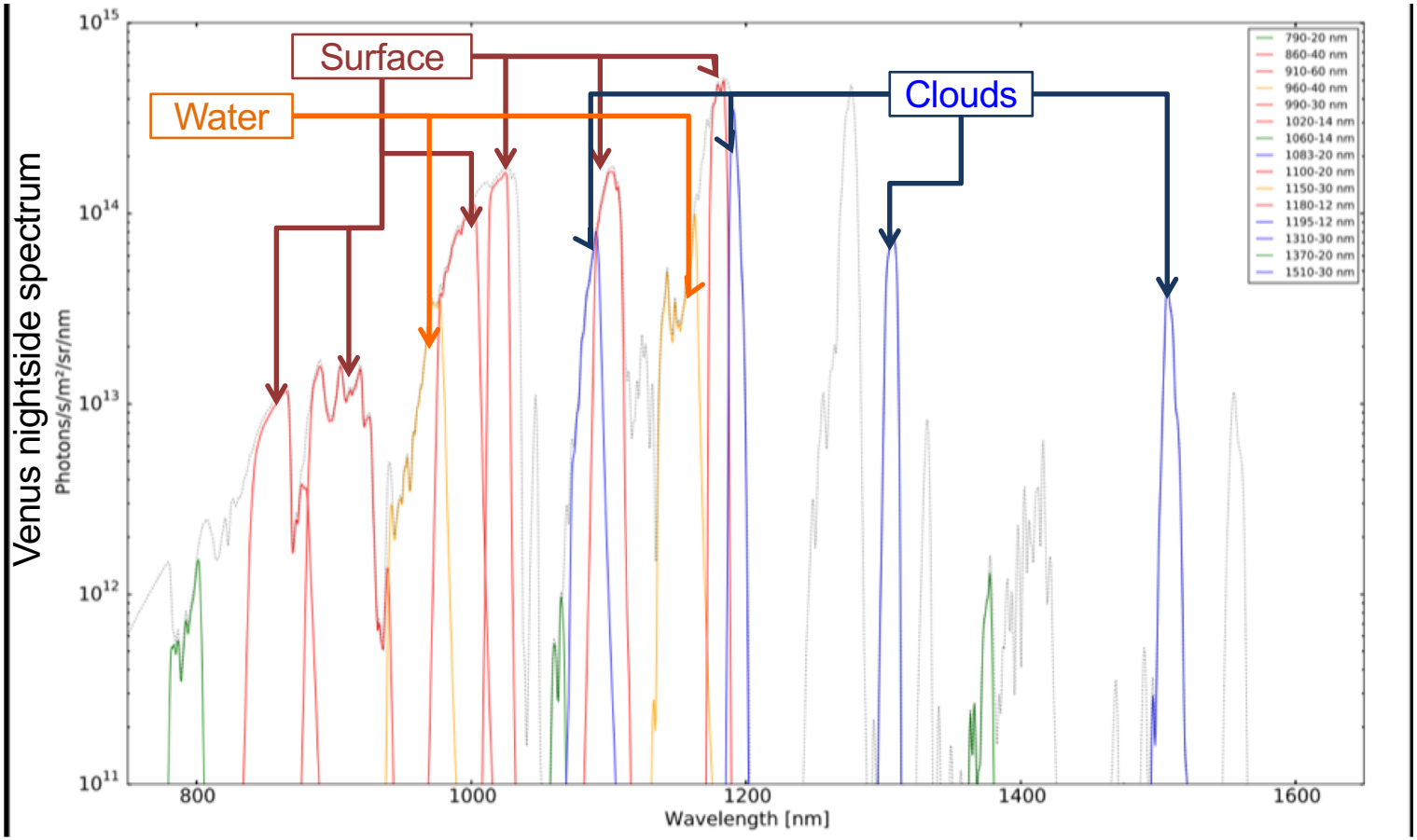
Studying the surface composition of Venus from orbit is difficult – but not impossible!



Magellan Radar and Pioneer Venus visible image

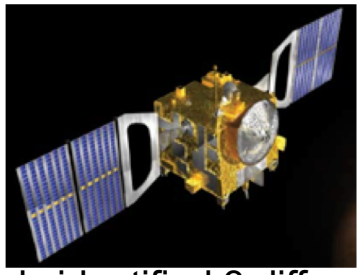
Akatsuki near-infrared image
JAXA / ISAS / DARTS / Damia Bouic

The atmosphere of Venus provides us windows that allow studying the surface and near-surface interaction

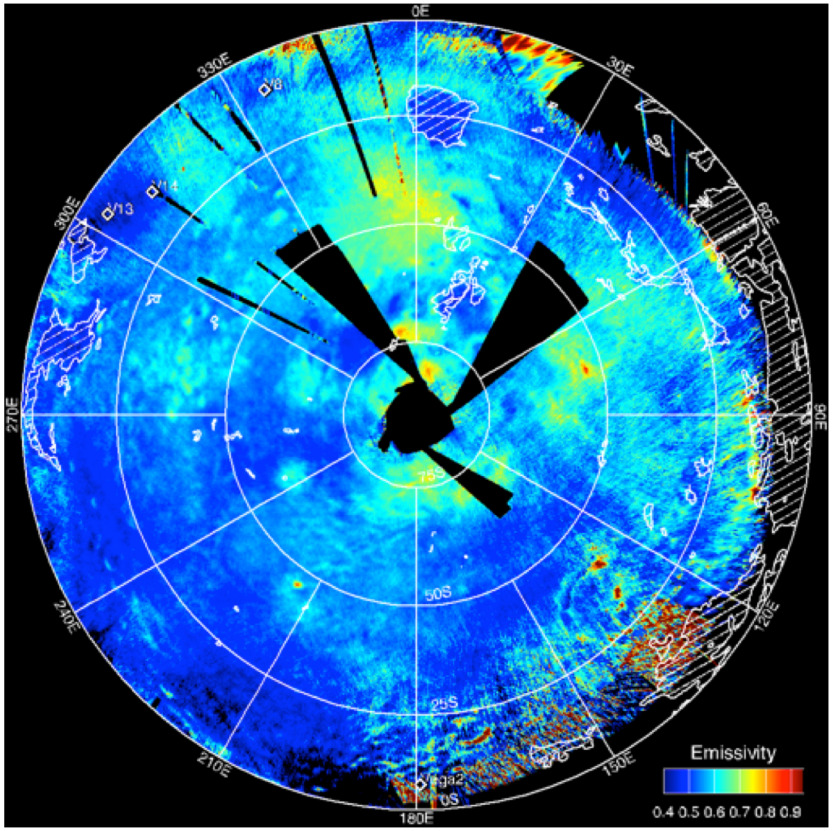


DLR

With VIRTIS on Venus Express we mapped the hot surface at 1µm using emissivity data!



- We have tentatively identified 3 different surface types on the surface of Venus based on differences in the 1.02µm relative emissivities
- The units show correlation with geological features giving rise to interesting ideas
- A lot of new work has started integrating this new data set with existing data of Venus
- Two more channels (1.10 and 1.18µm) are available which are still under processing



For details see Helbert, Müller, et al. 2008 and Müller, Helbert et al. 2009, 2010

Sciencexpress Report

Recent Hot-Spot Volcanism on Venus from VIRTIS Emissivity Data

Suzanne E. Smrekar,[1]* Ellen R. Stofan,[2] Nils Mueller,[1,3] Allan Treiman,[4] Linda Elkins-Tanton,[5] Joern Helbert,[6] Giuseppe Piccioni,[7] Pierre Drossart[8]

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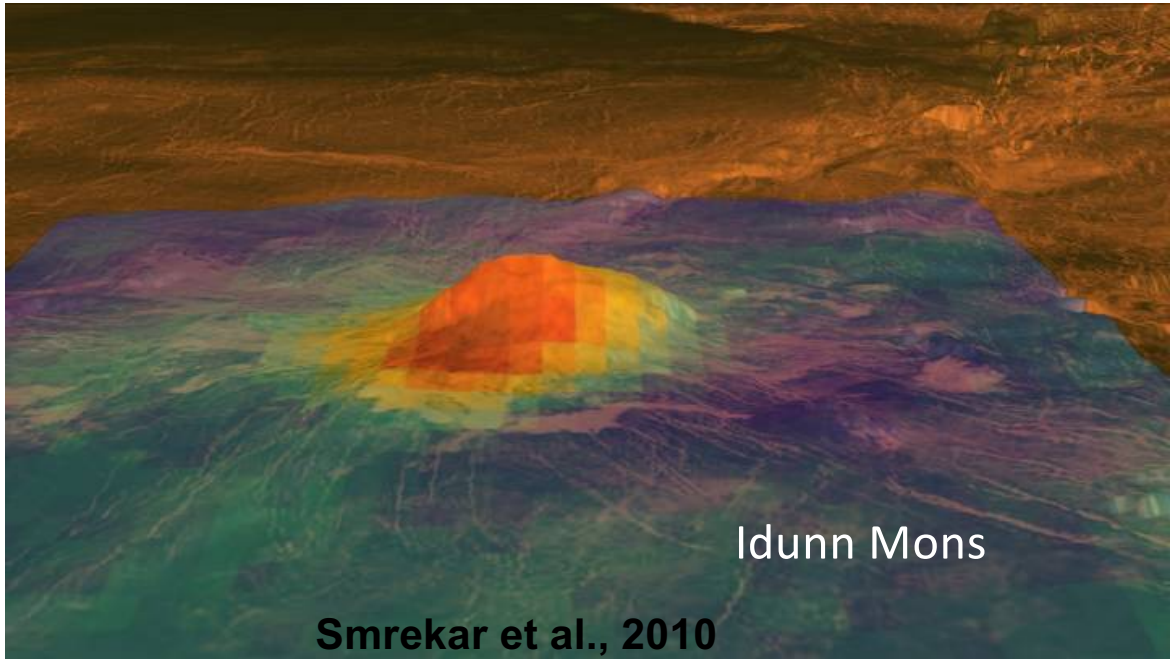
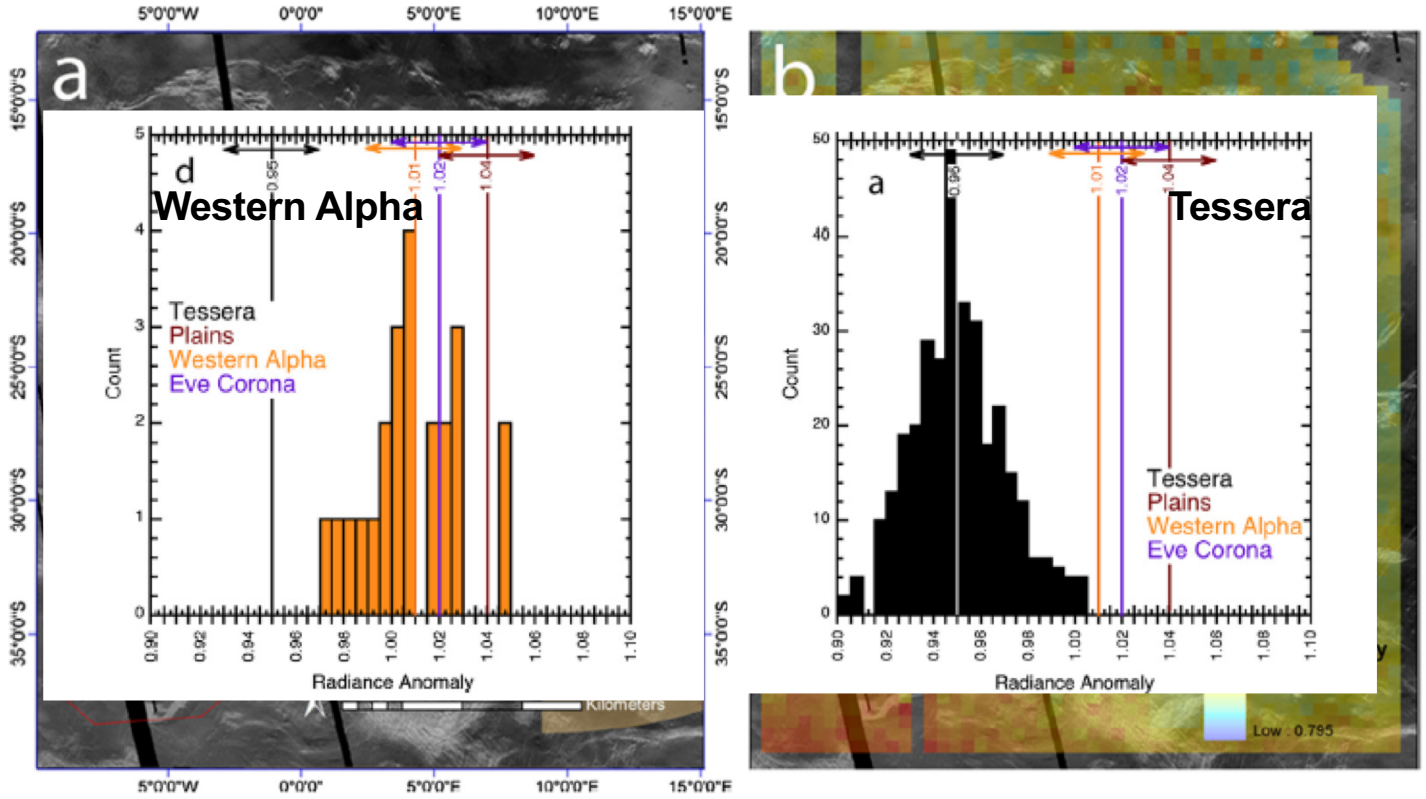
*To whom correspondence should be addressed. E-mail: ssmrekar@jpl.nasa.gov



Smrekar et al., 2010

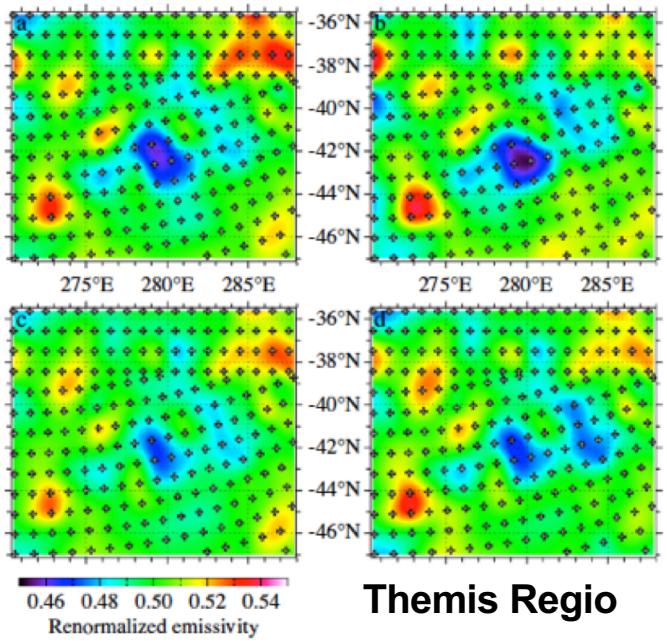
DLR

Tesserae might indeed have a distinct composition



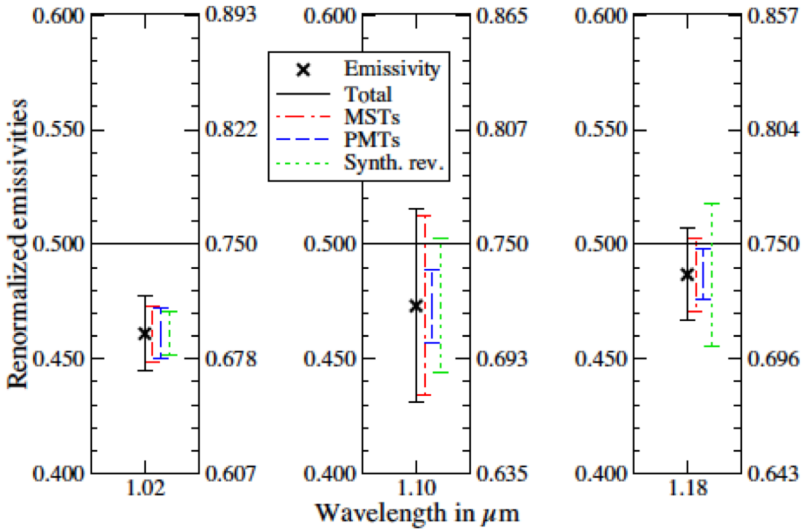
Gilmore et al. 2015

More sophisticated analysis approaches have been employed to „squeeze“ more information from the VIRTIS data



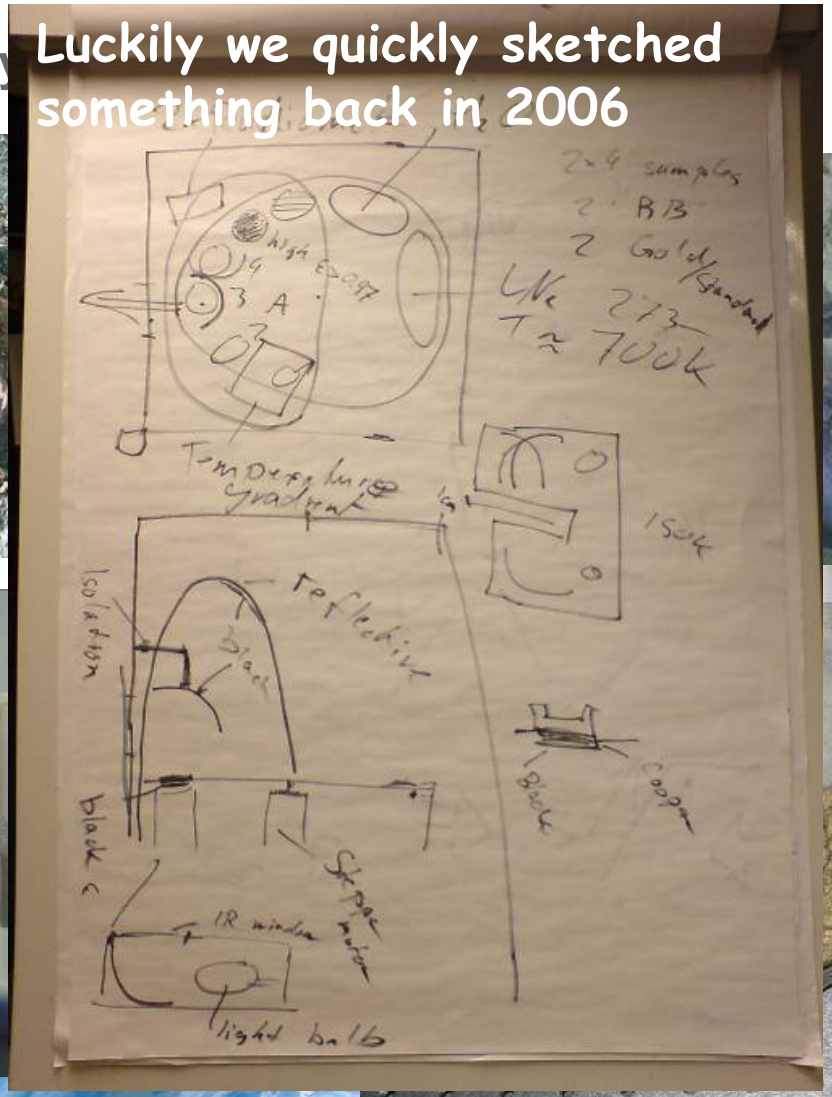
Themis Regio

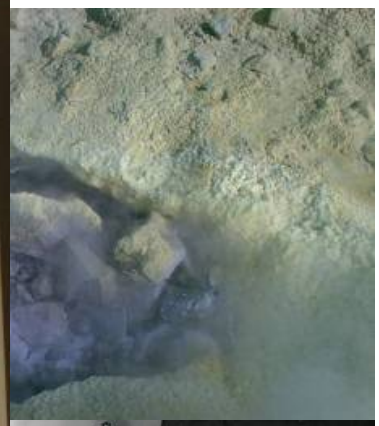
Kappel et al. 2016

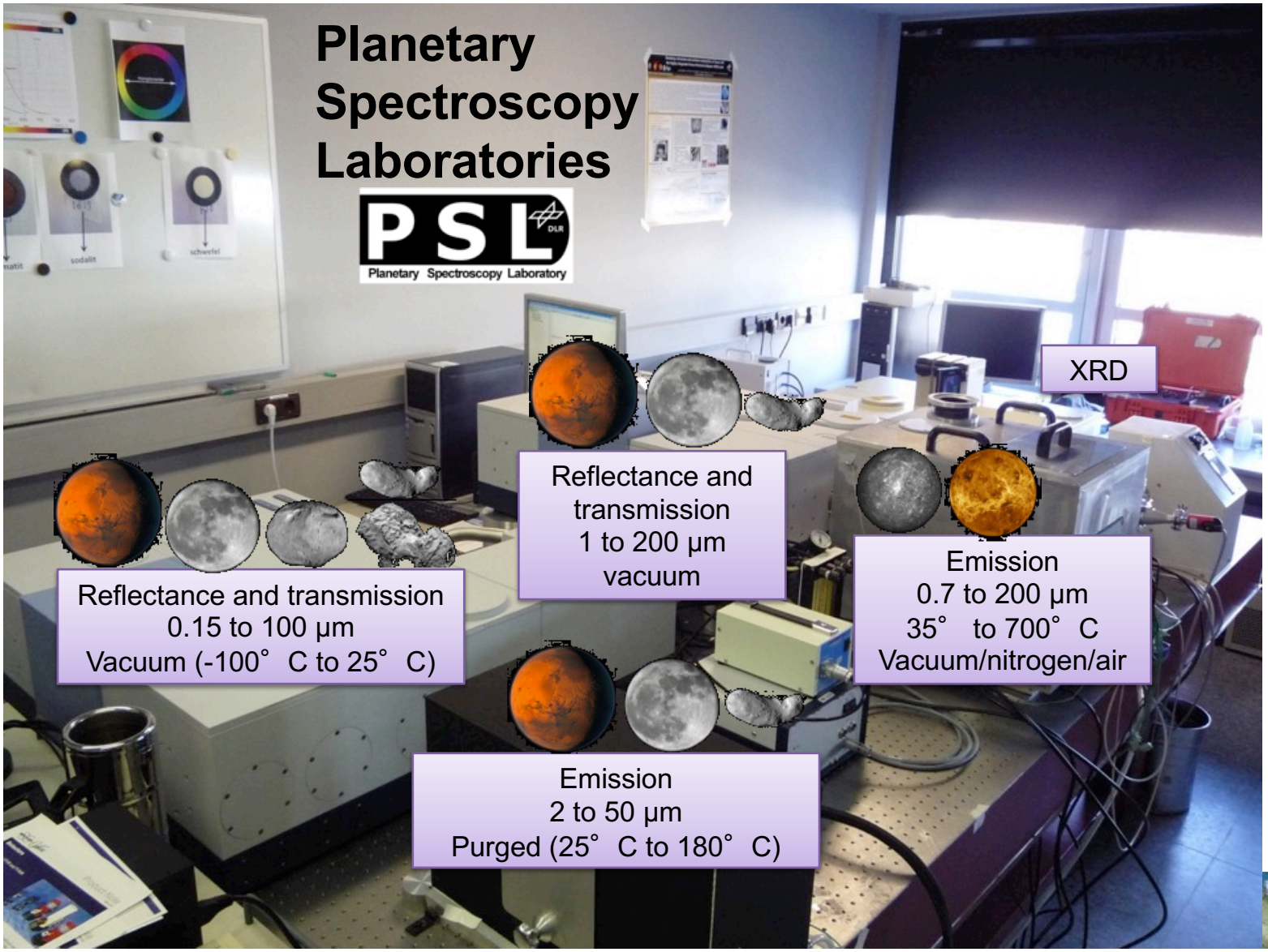


MST - Measurement Selection Tests
PMT - ‘Parameter Modification Tests

We really


Luckily we quickly sketched something back in 2006
2-4 samples
2 BB
2 Gold Standard
UK 273
T ≈ 700K
high Emissivity
Temperature gradient
150K
Reflecting
Black
Isolation
Black
Copper
black c
Sapphire window
IR window
light bulb




Planetary Spectroscopy Laboratories
PSL
Planetary Spectroscopy Laboratory
XRD
Reflectance and transmission
1 to 200 µm
vacuum
Emission
0.7 to 200 µm
35° to 700° C
Vacuum/nitrogen/air
Reflectance and transmission
0.15 to 100 µm
Vacuum (-100° C to 25° C)
Emission
2 to 50 µm
Purged (25° C to 180° C)

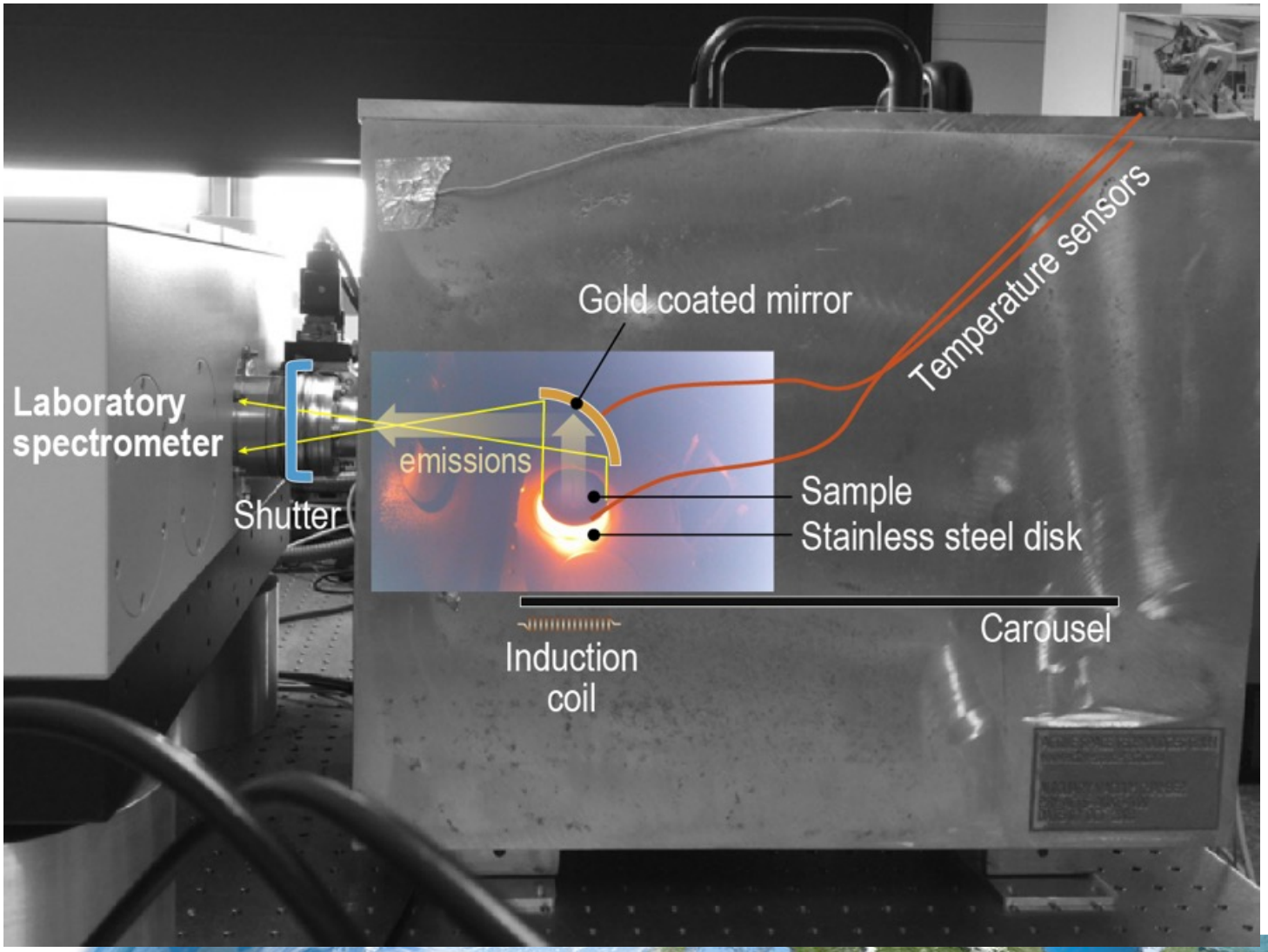
DLR

Venus Chamber at PSL

Setting this up required:

- High tolerance to frustration
- A lot of hard work
- Some innovative ideas
- A lot of funding provided by:
  - DLR
  - European Union through the EuroPlanet project
- A serious amount of stubborness

By the way - two EuroPlanet visitors will talk next!

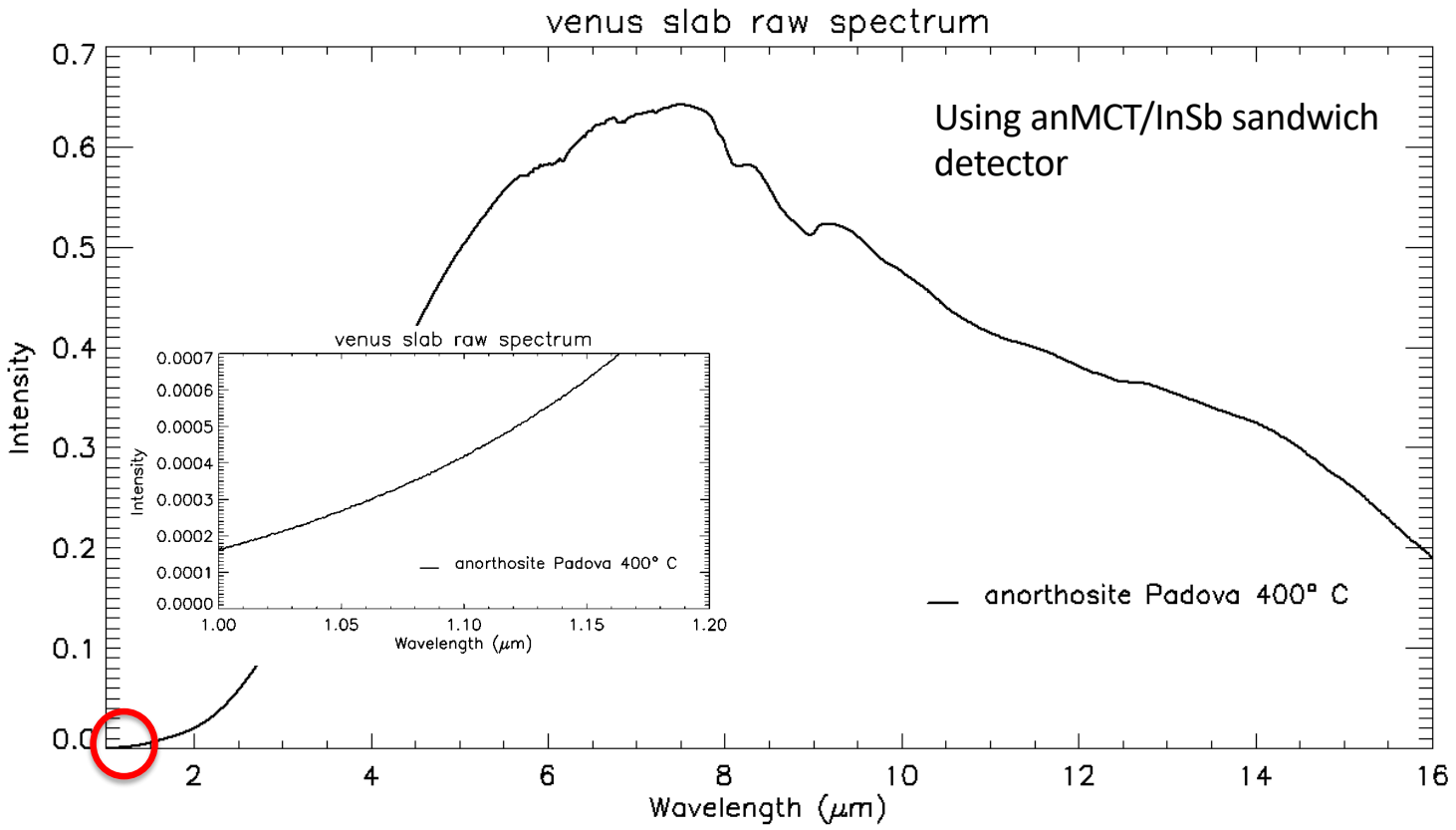



BRUKER

Induction heating allows to keep the chamber cool while the sample is at Venus temperatures
AEG

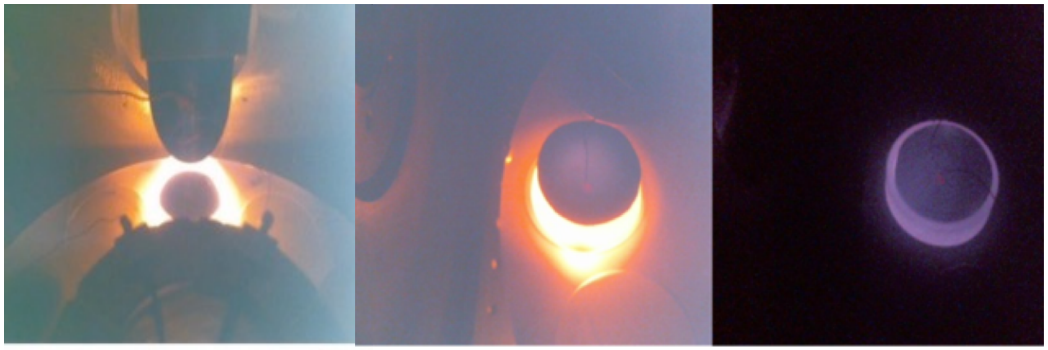
DLR

We are operating in the „no signal“ area...



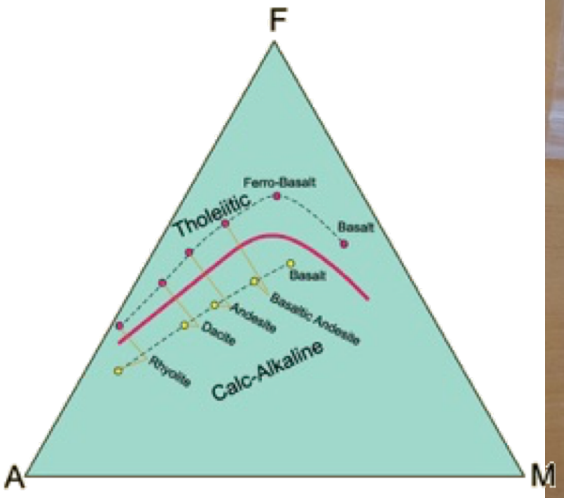
In the last 4 years we implemented a number of upgrades - Major upgrades in the last 2 years as part of EuroPlanet Joint Research Activity

- Upgraded spectrometer electronics
- InGaAs detector



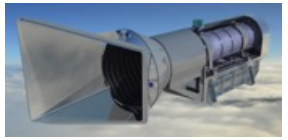
- New custom-made sample holder
- Made from a high temperature ceramic by precise milling

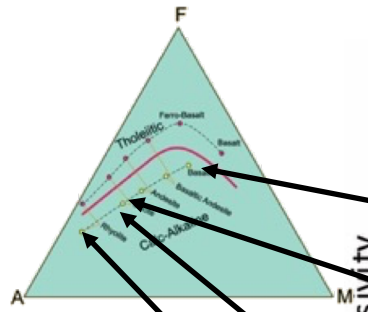
With all that in place we can now start working on a spectral library for Venus

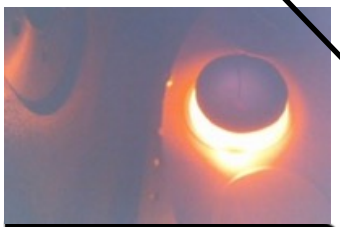


What does that mean for the surface composition maps we might get from orbit?

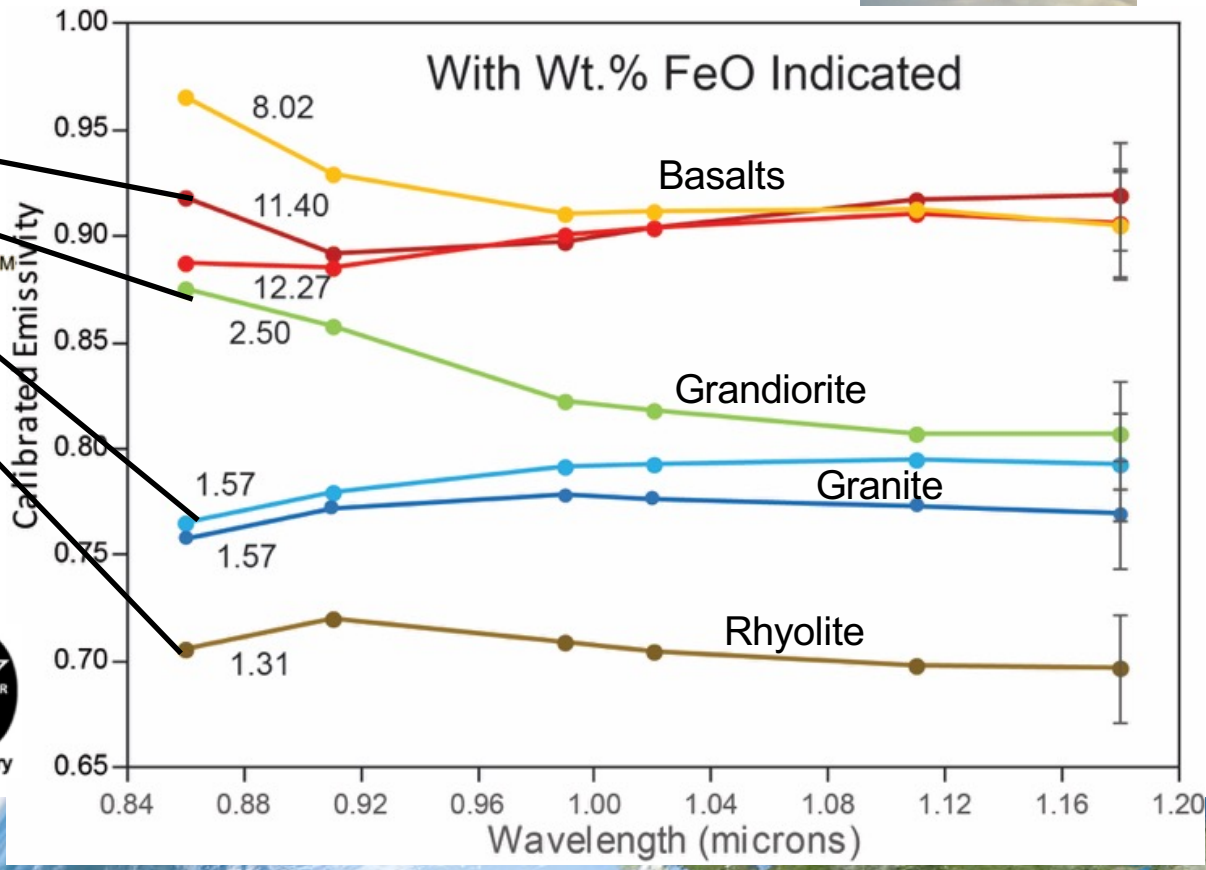
Judge for yourself!





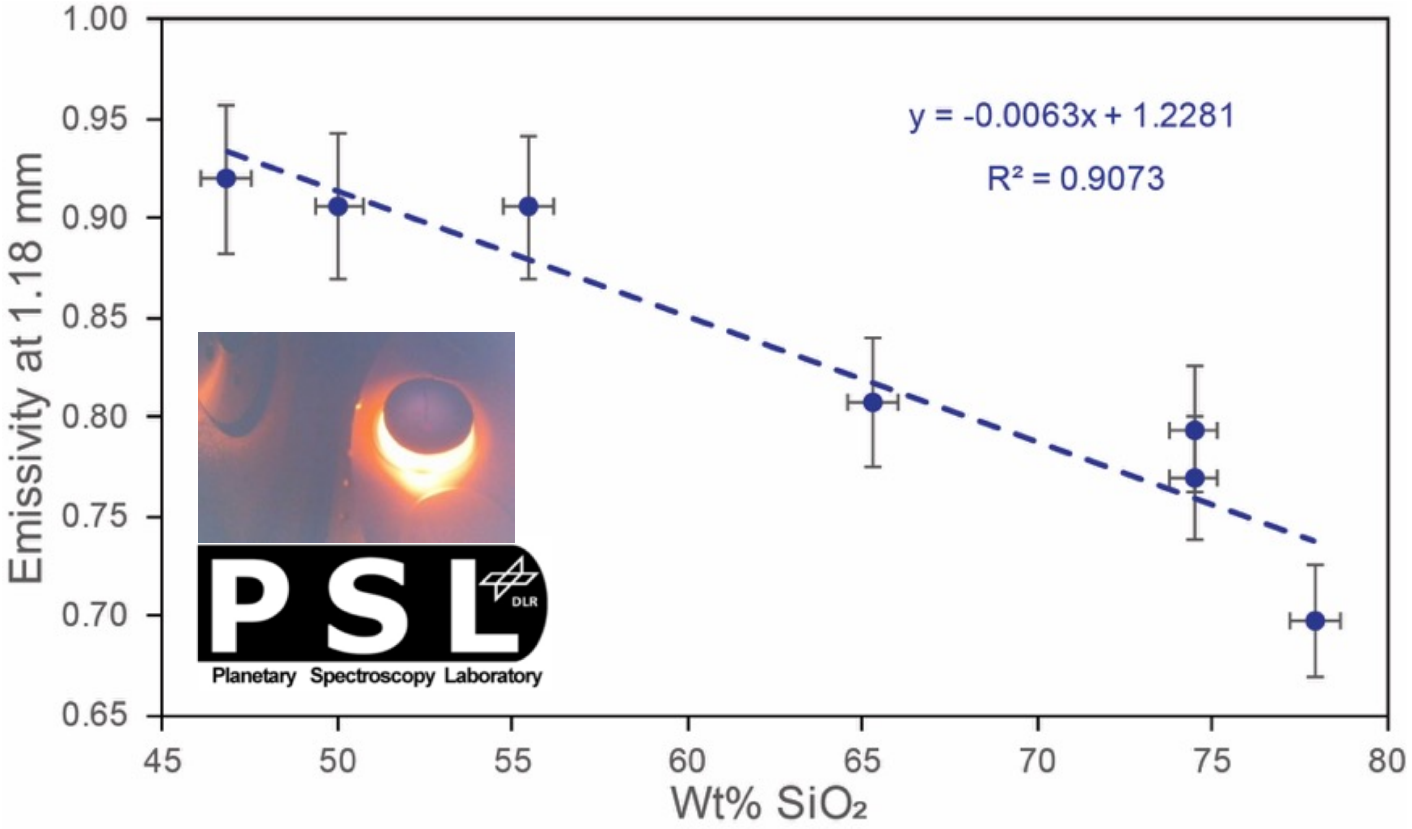


PSL DLR
Planetary Spectroscopy Laboratory



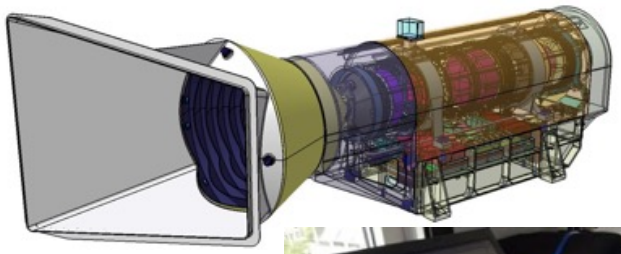
DLR

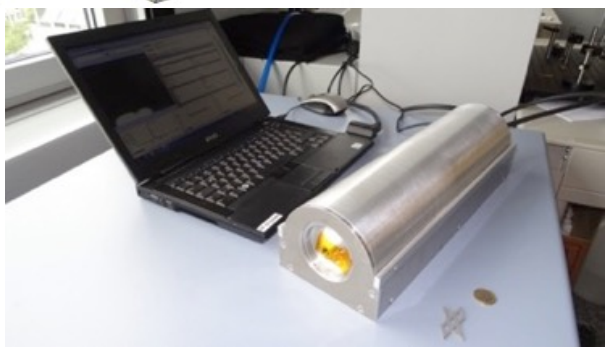
Venus is smiling on us – because the atmospheric windows are just in the right location for mineralogy



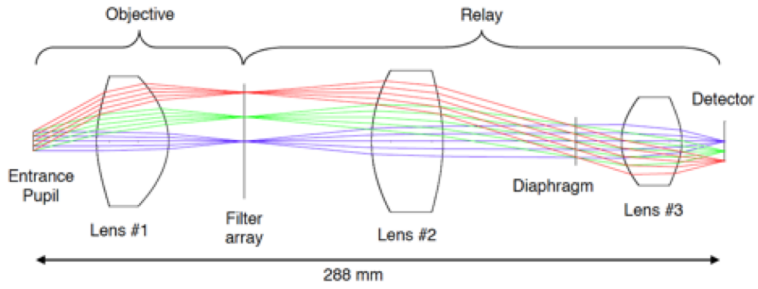
Now with all this we can fly an instrument to Venus that would provide us a global surface composition map

- Pushbroom multispectral imaging system, nadir pointing
- Telecentric design with 3 lenses
- FOV of 45° results in 207km swath width, 50 km spatial res.
- 14 strip filter array at intermediate focus, covering all 5 surface windows between 0.8 and 1.2 µm



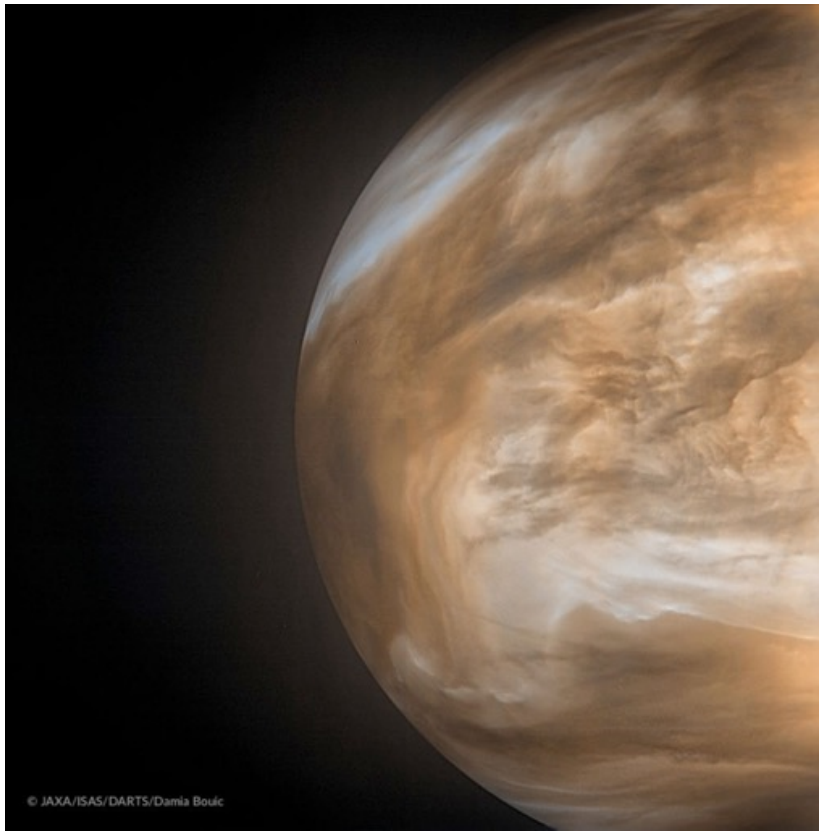


Design Parameter	Value
Optics	
FOV (°) ACTxALT	46.4×37.8
Entrance pupil diameter (mm)	8
Effective focal length (mm)	16.4
F/#	2.04



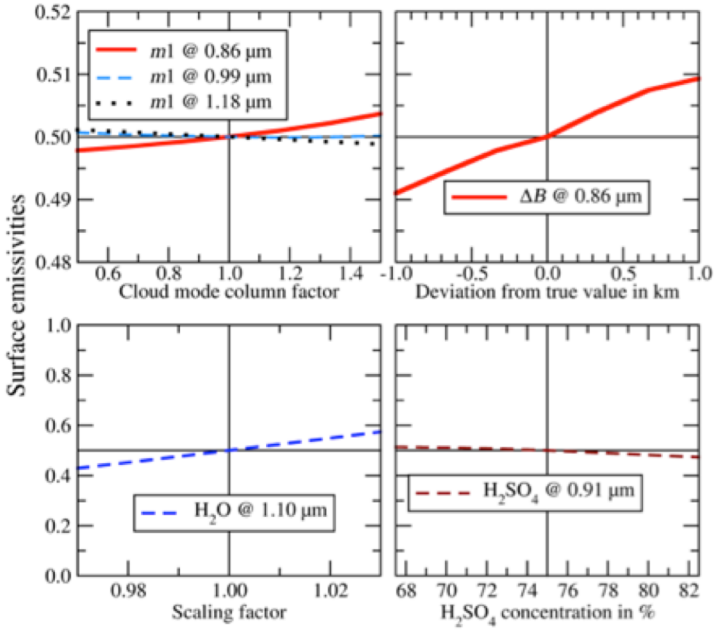
DLR

Of course there is still that pesky atmosphere to deal with



Emissivity retrieval depends on selected interfering parameters from the full end-to-end atmospheric model

- Previously we used a linearised version of a RTM using look-up tables generated by the atmospheric model described by Kappel et al. (2015, 2016)
- To model Venus Emissivity Mapper instrument capabilities and observation conditions, we focused on worst case assumptions
- For our ongoing work on the Venus Emissivity Mapper we have the first version of the full end-to-end model available
  - This allows us to reassess the error budget in more detail.
  - It will be the baseline for the data processing.



Arnold et al. (2008), Haus et al. (2010, 2013, 2014), Kappel et al. (2012, 2014, 2015, 2016)

The Spectroscopy of the surface of Venus – in the laboratory and from orbit

- We finally have a laboratory setup that allows to measure the emissivity of Venus analog materials in the 1 micron region over the full range of Venus surface temperatures
- Something that sounds hard to believe after all these years
  - We are in (almost) routine operations
  - We had the first two visitors (Erica Kohler and Sara Port) using the facility

- The atmosperic windows are serendipitously in a spectral location that allow us to study the Fe/Si mineralogy of the surface of Venus
- So far Venus is the only terrestrial planet for which we have no global map of the surface composition
  - Near-infrared spectral mapping will finally allow to fill this gap

- Global compositional mapping will provide key insights into the evolution of Venus
  - It will provide an essential baseline dataset for planning for future missions going to Venus