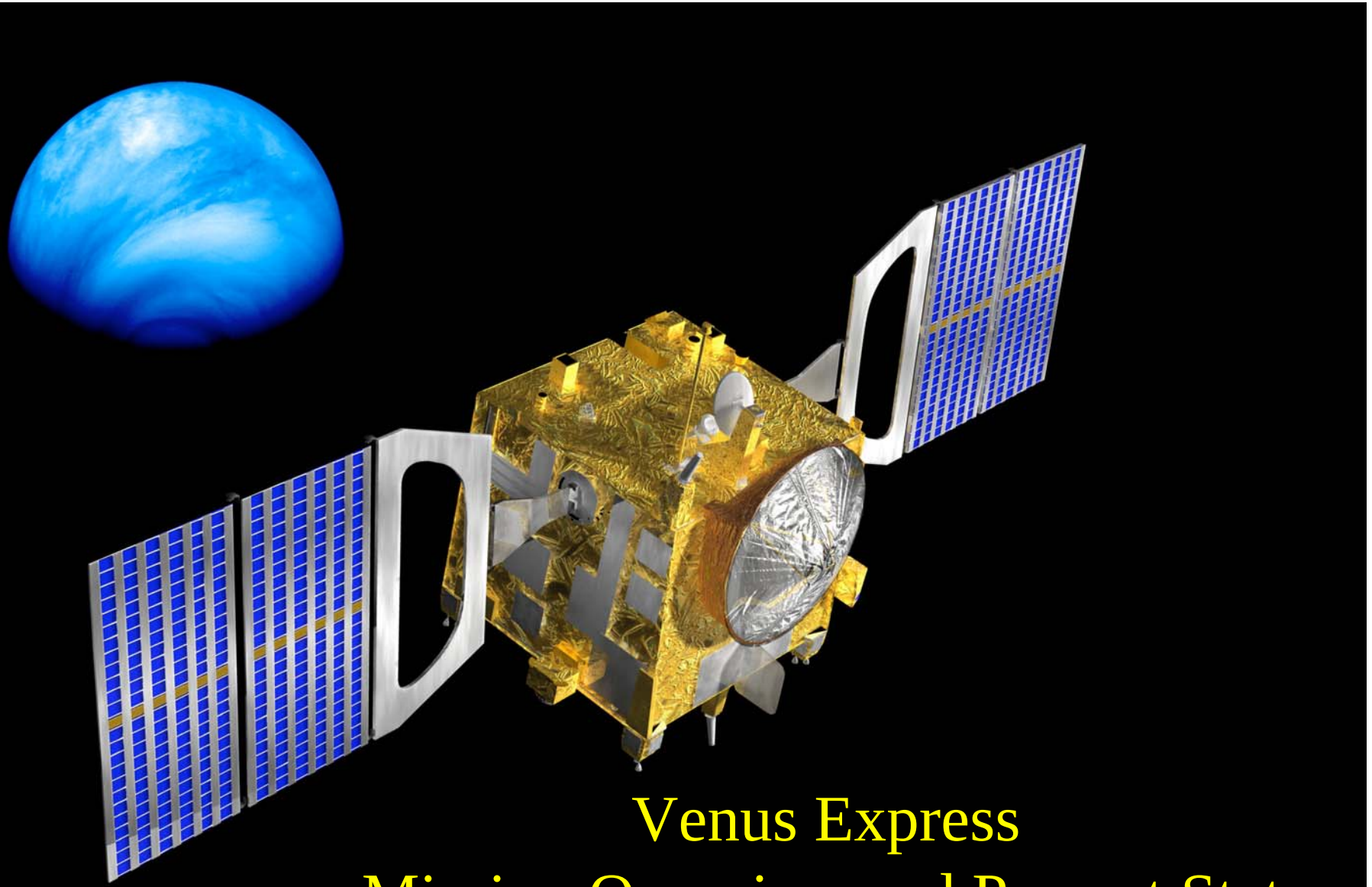


Venus Express – Mission Overview and Present Status

Håkan Svedhem
ESA/ESTEC

Introduction

- Science Objectives
  - The aim of the mission is to carry out a comprehensive study of the atmosphere of Venus and to study to some detail the plasma environment and number of aspects of the surface of the planet. Full exploitation of the infrared spectral windows

Introduction

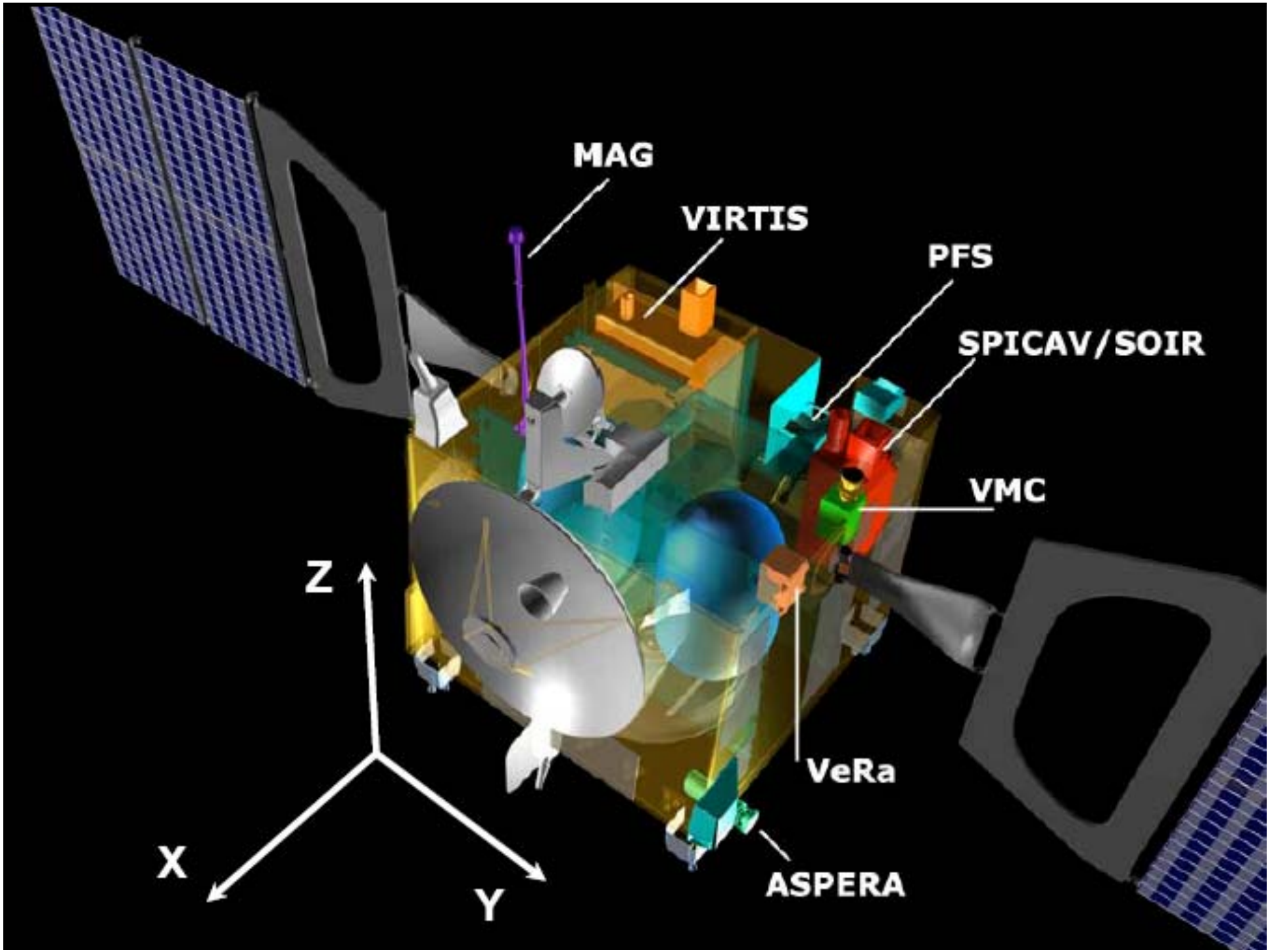
- Over All Objective: Comparative planetology
  - Why has Venus evolved in such a dramatically different way compared to the Earth and Mars in spite of the many similarities in their original physical and chemical properties and what parameters control the evolution of planets and their atmospheres in general?
  - Is it possible to understand how the climate works on such an extreme planet as Venus? What can we learn about the accuracy and robustness in the models of the climate of the Earth? In particular the understanding of the complex physics of the clouds may be important for this.

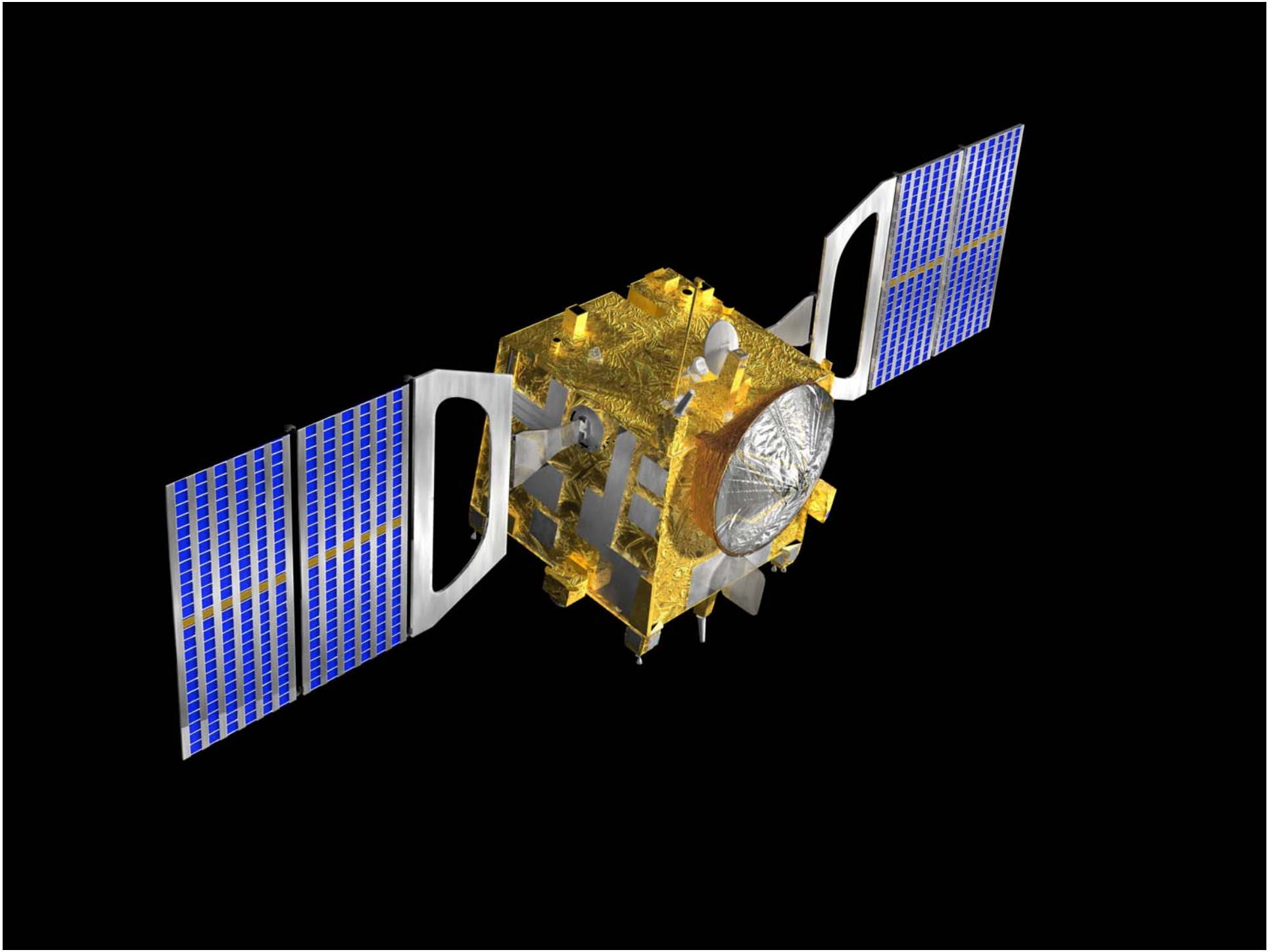
Introduction

- Venus Express Mission: Programmatics
  - Mission proposed as a re-use of the Mars Express Spacecraft to fit within the very limited budget available
  - Launcher, Ground system and operations facilities will be re-used as for Mars Express whenever possible
  - Scientific Instruments from Mars Express (3), Rosetta (2) and two new built ones
  - With only tree years from mission approval to launch, Venus Express is the fastest ever developed ESA science mission
  - Mission presently funded until May 2009
  - A request for an extension of the funding for mission operations until end 2012 is in preparation. This request will, following a new scheme, be in competition with all other ESA missions to be extended for the coming four years.

Science Payload

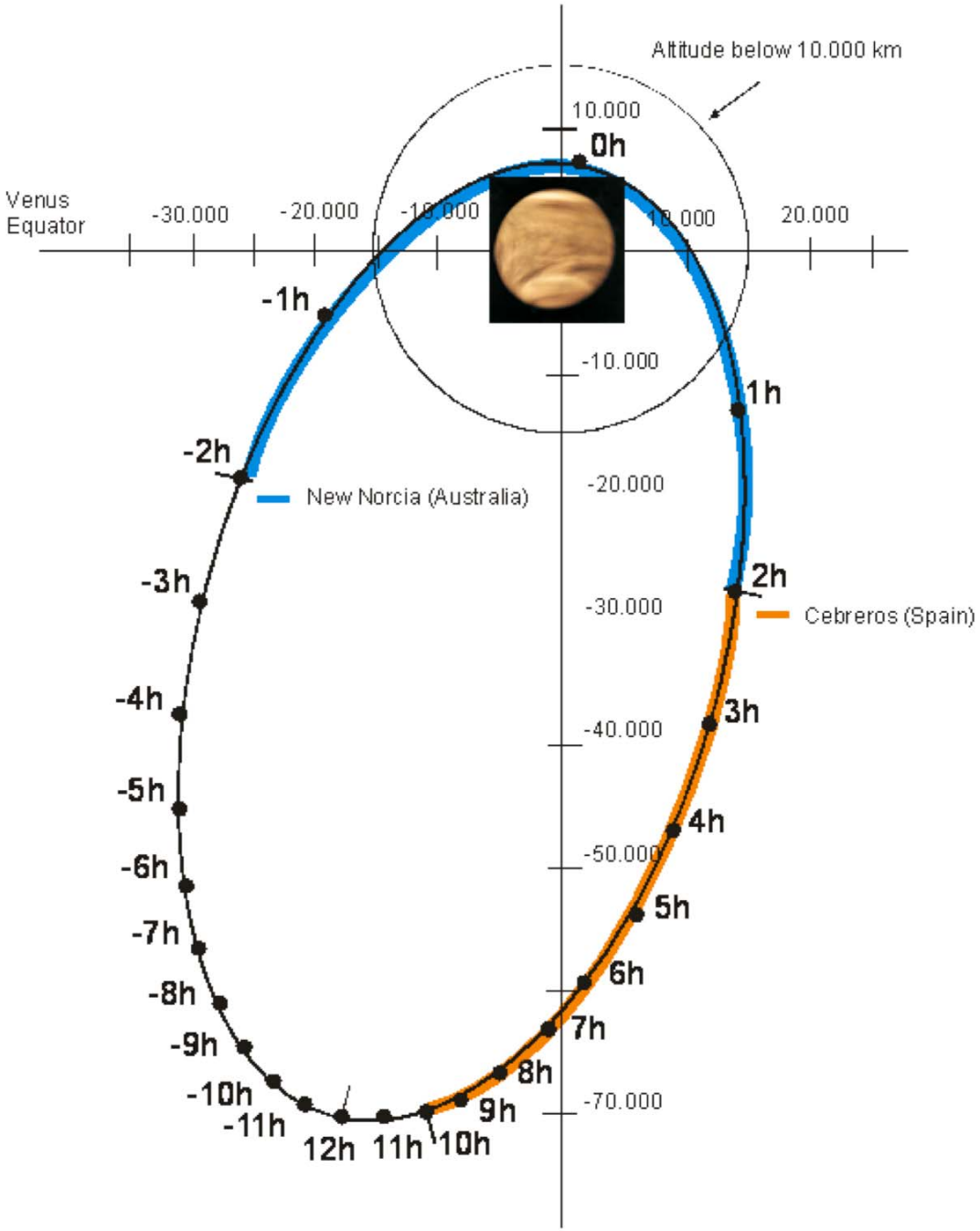
Name	Instrument	Principal Investigator
ASPERA	Analyser of Space Plasma and Energetic Ions	S. Barabash, IRF, Kiruna, Sweden.
MAG*	Magnetometer	T. Zhang, IWF, Graz, Austria.
PFS	Planetary Fourier Spectrometer (IR)	V. Formisano, IFSI-CNR, Rome, Italy.
SpicaV/SOIR*	UV-IR spectrometer for stellar and solar occultation	J.-L. Bertaux, SA-CNRS, Verriere, France.
VERA	Venus Radio Science	B. Häusler, Uni-BW, Muenchen, Germany.
VIRTIS*	UV-Vis-IR Mapping spectrometer	P. Drossard, Obs de Paris, Meudon, France, G. Piccioni, IASF-CNR, Rome, Italy.
VMC*	Venus Monitoring Camera	W. Markiewicz, MPS, Lindau, Germany


MAG
VIRTIS
PFS
SPICAV/SOIR
VMC
Z
X
Y
VeRa
ASPERA



Venus Operational Orbit Characteristics

- 24 hours period
- 250-400 km pericentre altitude → 185-285 km
- 66000 km apocentre altitude
- 90 deg inclination
- Pericentre latitude 80-90 deg N
- 7-10 hours communication link per orbit


Altitude below 10.000 km
10.000
0h
Venus
Equator
-30.000
-20.000
-10.000
10.000
20.000
-1h
-10.000
1h
-2h
New Norcia (Australia)
-20.000
2h
-3h
-30.000
Cebreros (Spain)
-4h
3h
-40.000
-5h
4h
-6h
-50.000
5h
-7h
6h
-8h
7h
-9h
8h
-10h
9h
-11h
-70.000
12h
11h
10h

Mission status

- The general condition of the spacecraft and the payload is very good
- All elements of the ground system and planning cycles are running as expected
- No points identified that inhibits operation until at least end of 2012
- But:
  - PFS still not operating due to a blocked mechanism (since the launch)
  - The power in the S-band transmitter chain has dropped 15dB (since the solar conjunction 2006). S-band has no operational use but is used occasionally by the radio science

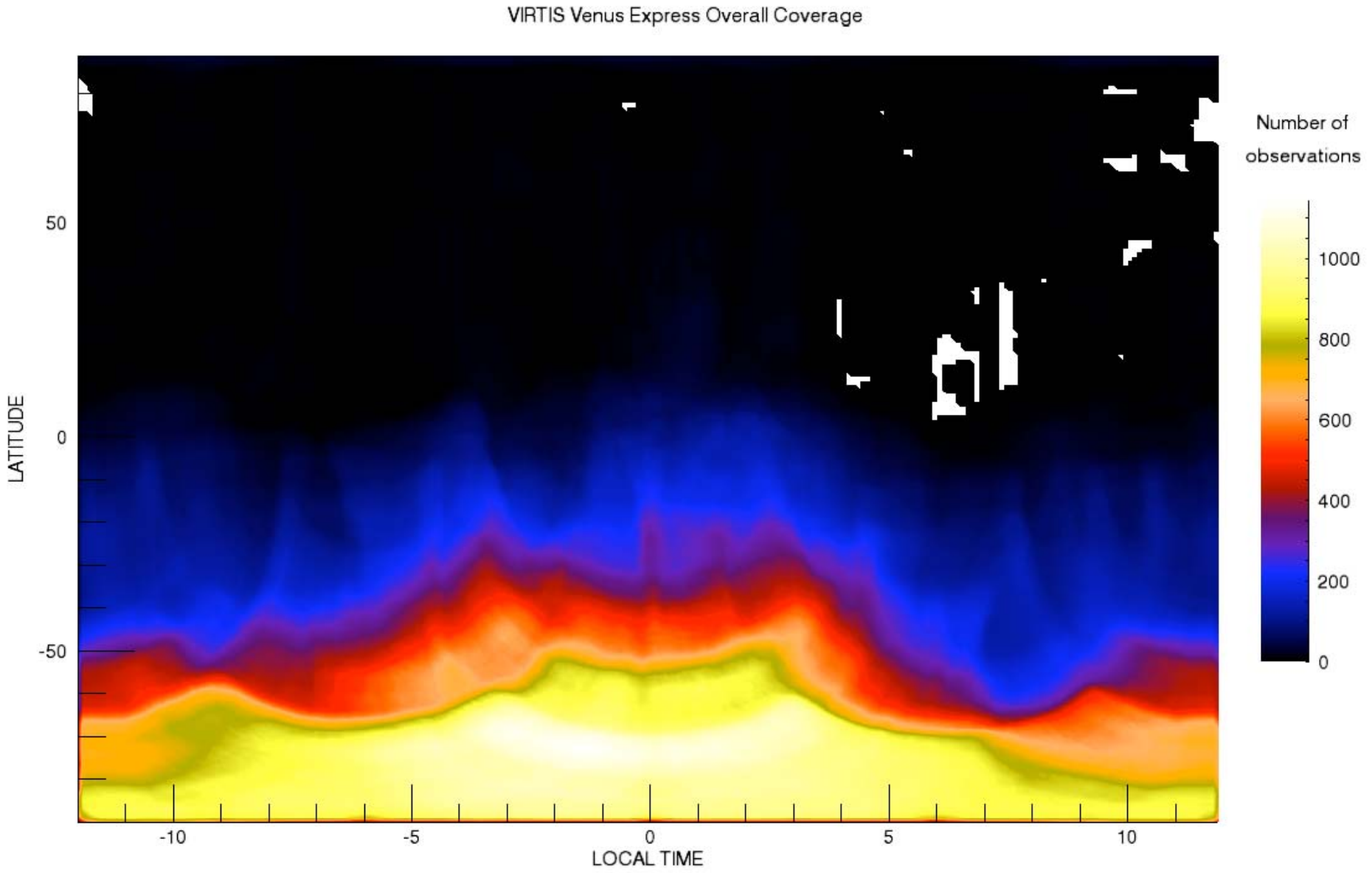
Consumable resources and lifetime related elements

- Power
  - The limiting element are the Batteries. Estimated time to degrade down to 7Ah (needed to sustain long eclipses) is 3.4 years for Battery 2 (up to late 2011) to 6.1 years for Battery 3 (up to end 2013). Note that the loss of one battery can be sustained by special planning and operations.
- TTC
  - TWTA/WIU cycles beyond 2017. Transponders beyond 2015.
- Data Handling
  - the most limiting factor is the design lifetime of the SSMM, specified at 4.5 years. However the same unit is flying on MEX since that time and no visible degradation has been observed.
- AOCS
  - all units have lifetime predictions which range from 2016 to 2020.
- Fuel
  - Consumption will increase significantly due to pericentre height decay. Estimated about 5 years of fuel remaining (up to mid 2013).

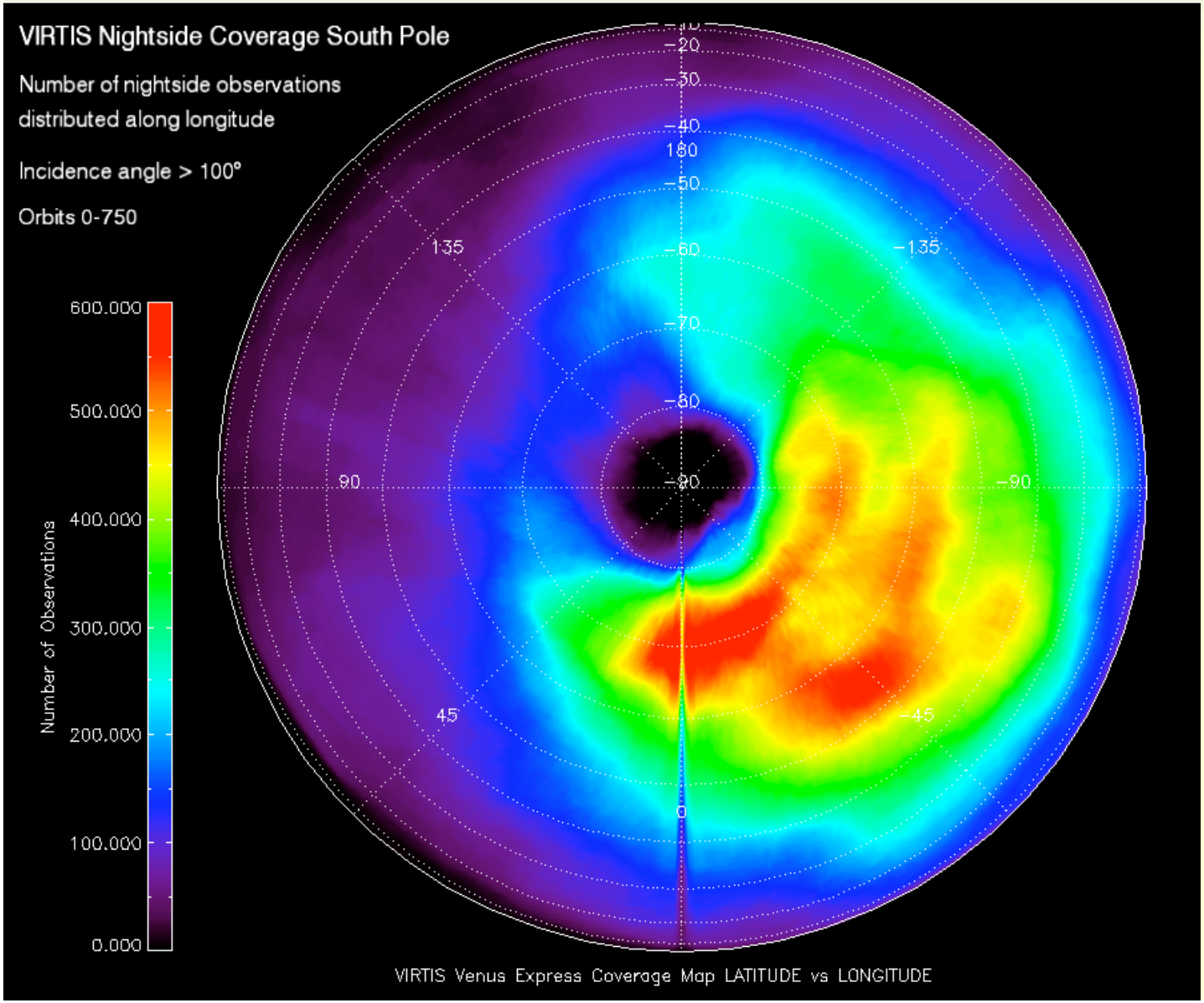
Data Processing and Archiving

- Well above 1 Tbit of science data has been received on ground
- All teams are now up to full speed in data processing but manpower is at the limit in some teams
- A full release of the first data sets from the mission is available from the ESA Planetary Science Archive (PSA) (Virtis, VMC, SOIR, MAG are available, SpicaV, Vera and Aspera will follow shortly)

General Coverage



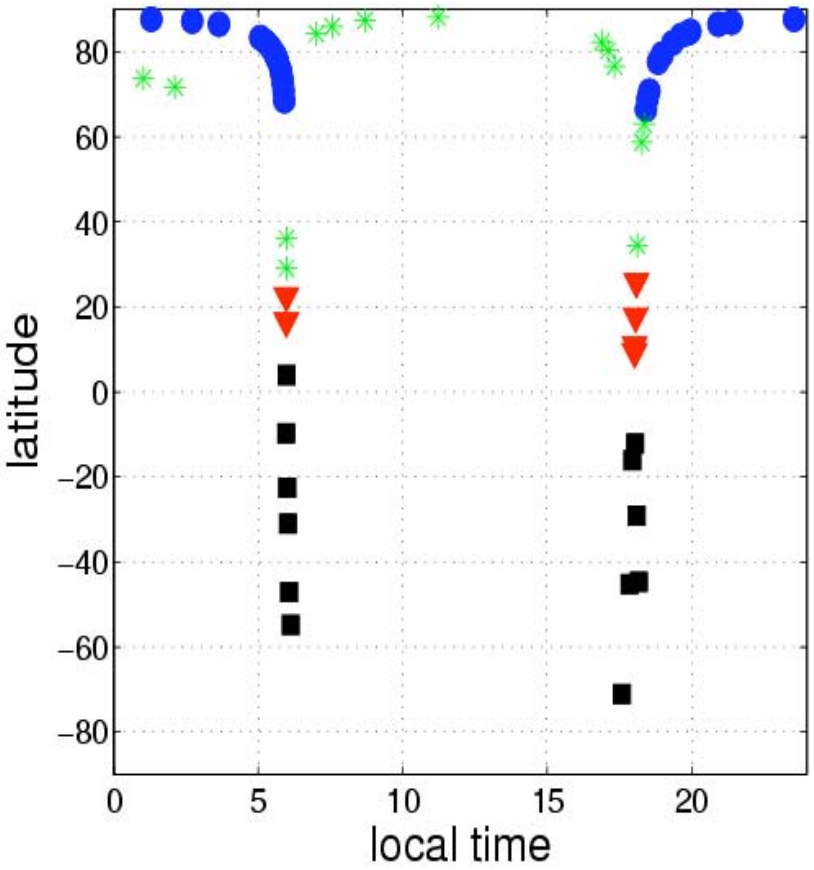
Night side coverage



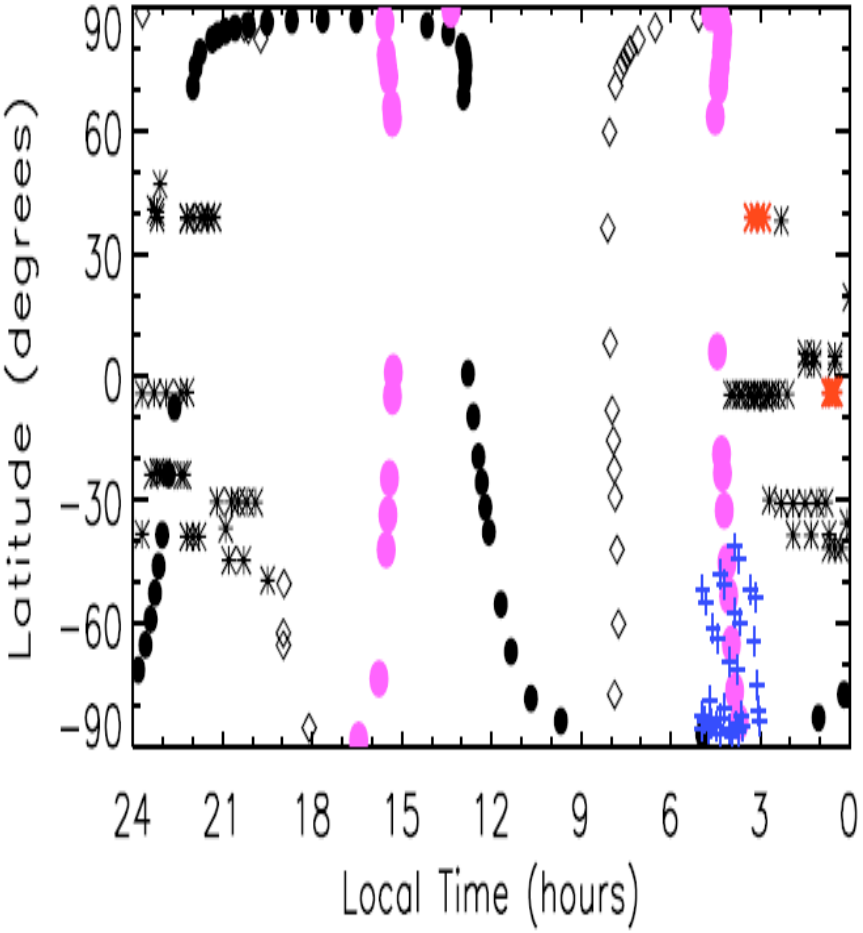
Night side coverage is important for deep sounding and for surface mapping since solar reflected light inhibits such measurements

Coverage of Solar, stellar and Earth occultation measurements

SOIR

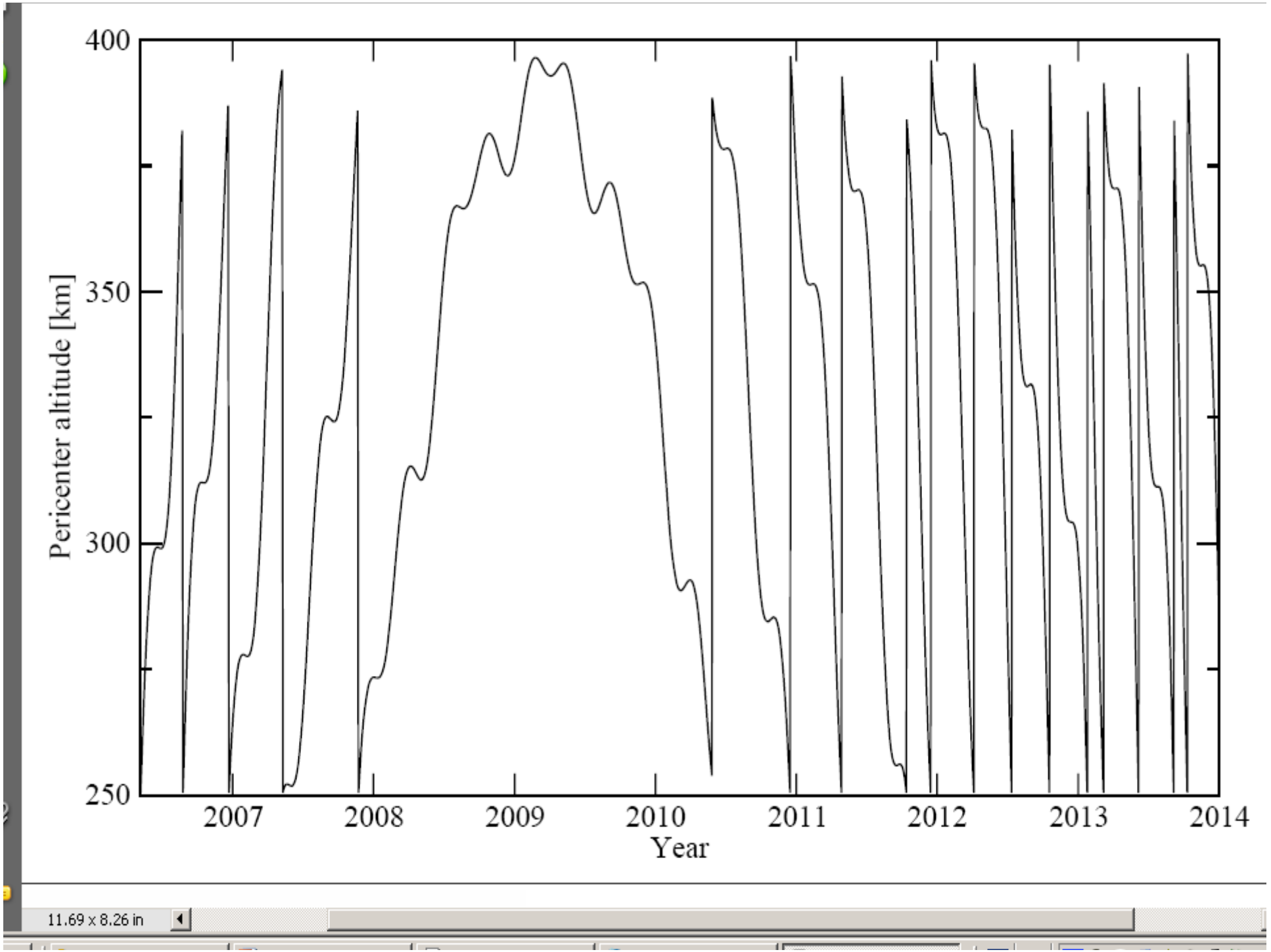


SpicaV and Vera

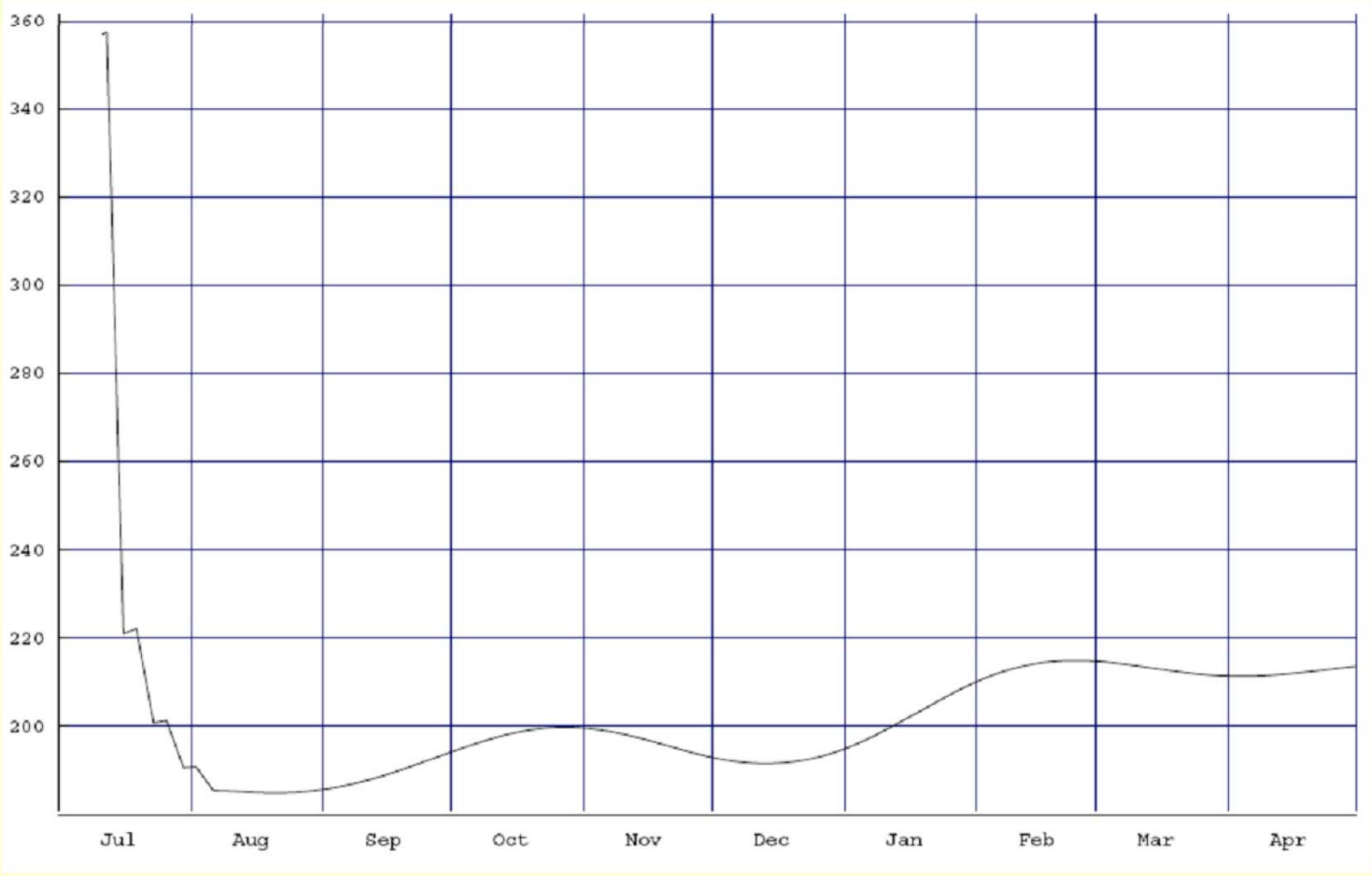


Orbit modifications

- Recently the pericentre has been lowered to 185 km. It will be maintained in the band 175-275 km in order to improve the conditions for in situ measurements (previous band was 250-400km)
- A further lowering of the pericentre, to about 150km altitude, in order to support atmospheric drag experiments is being planned
- Studies for stabilising the orbit and extending the mission beyond 2013 have been started. This will be carried out by areobraking at about 130km altitude


400
350
300
250
Pericenter altitude [km]
2007
2008
2009
2010
2011
2012
2013
2014
Year
11.69 x 8.26 in

Pericentre change and evolution



Future work (1)

- The next years will provide extended coverage in latitude and local time for the atmospheric measurements and better surface coverage of the surface temperature and emissivity maps
- A reduced pericentre altitude will allow better plasma and magnetic field measurements and better characterisation of lightning and local magnetic fields
- A further pericentre altitude reduction will allow atmospheric drag measurements that should give very high precision data on the density and temperature in the 150-200 km altitude range
- Joint operations with the Japanese Venus Climate Orbiter in 2011 will enable simultaneous observations from different positions and stereo imaging

Future work (2)

- For a further extension to the mission a stabilisation of the orbit is necessary. This can be achieved by aerobraking to a 12 hour orbit, possibly in 2012.
- An increased interest in comparing and modelling of the atmospheres and evolution of Earth and Venus is emerging. ISSI workshop, UGU union session, ESLAB symposium…
- An increased effort in comparison of Earth and Venus models , theory and measurements is desirable. This can however only take off on a larger scale if supported by a related (agency level) research programme.

Conclusion

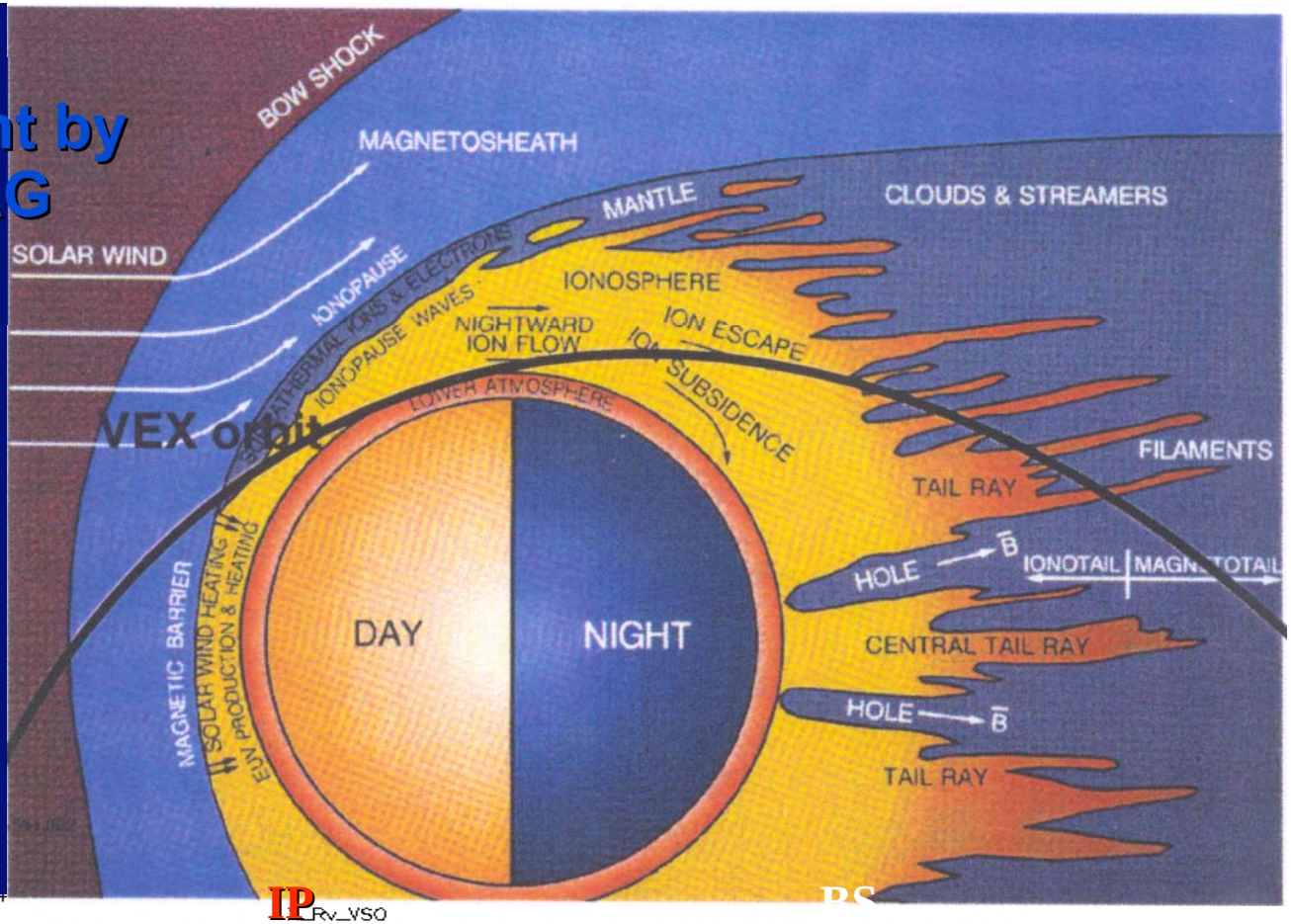
- Venus Express spacecraft is in a good health and very productive, - well above than 1 Tbit of science data has so far been downlinked to ground.
- Most of the of the Science Objectives have now been addressed to some depth.
- Comparative work on Venus and Earth atmospheric evolution has started, albeit on a limited scale.
- The first release of archived data to the world wide community was done on 22 September 2008. Information and data are available at: www.rssd.esa.int/psa.

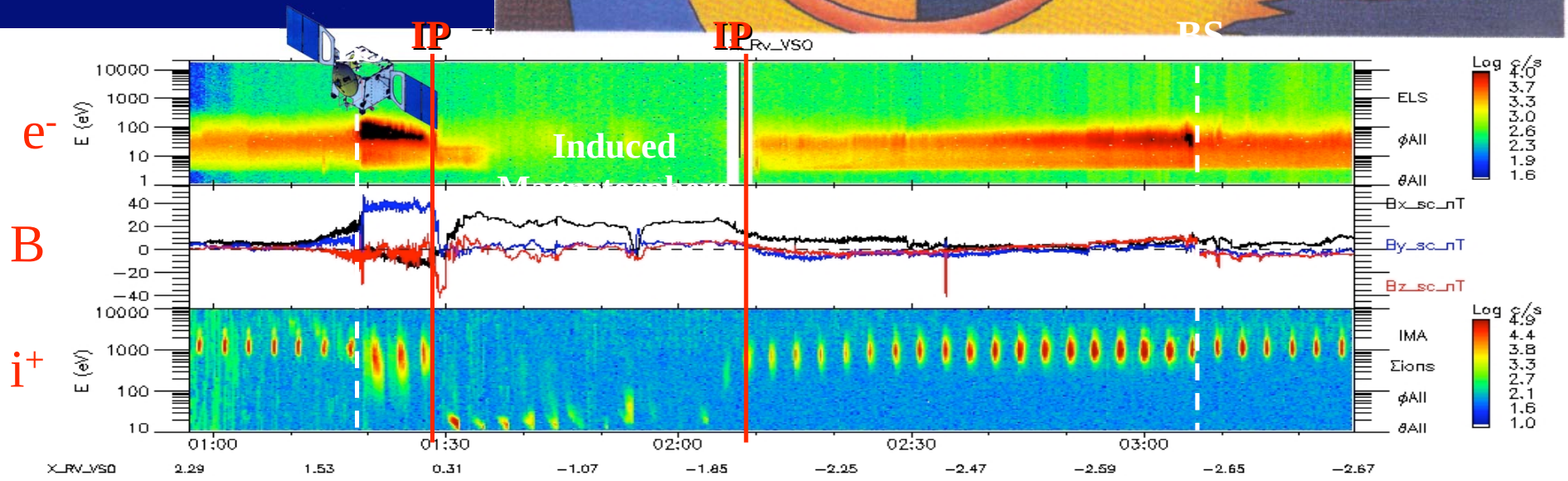
Plasma investigations

Magnetic Field and Energetic particles investigation

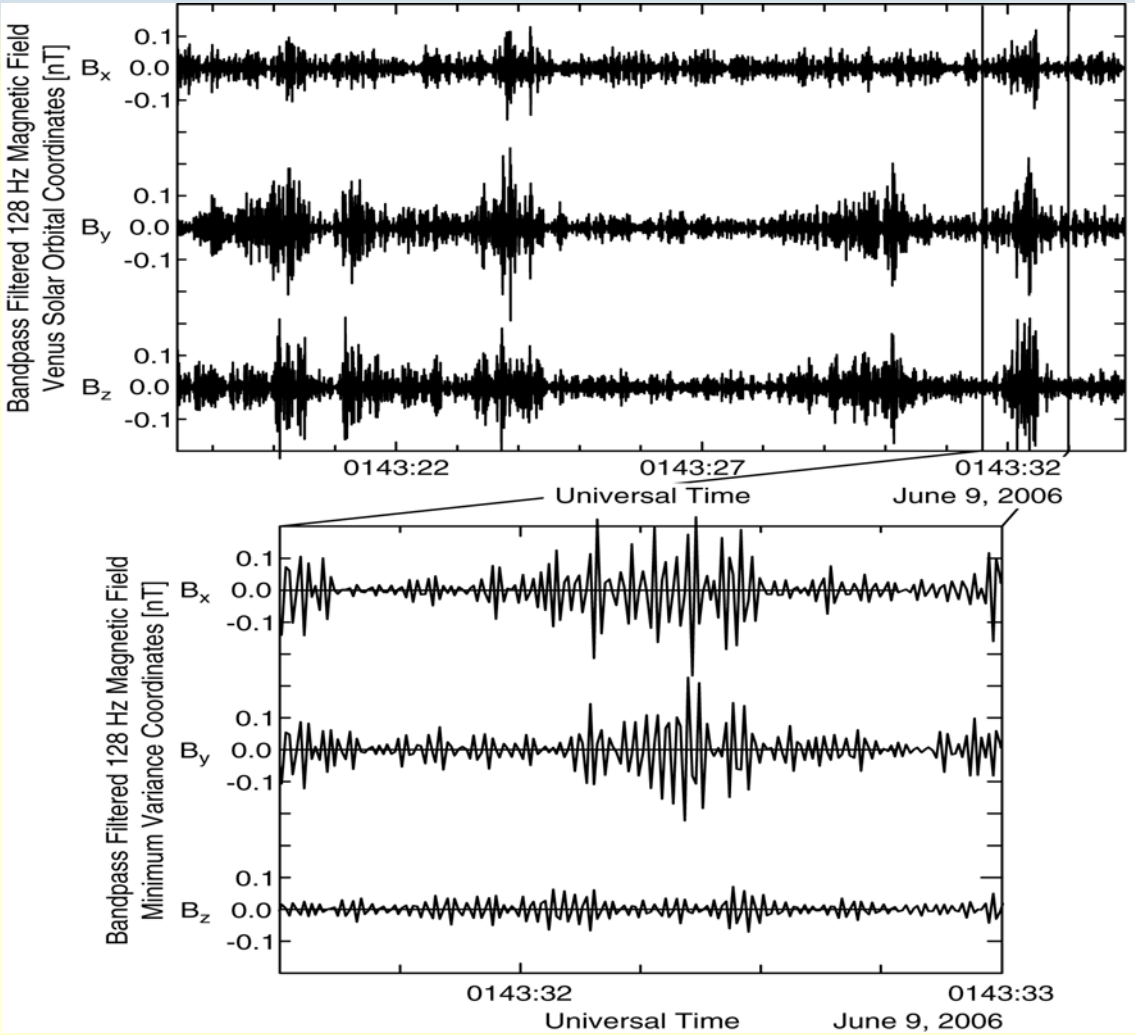
- The ASPERA and MAG measurements have allowed the reliable identifications and characterisation of the boundaries of the induced magnetosphere.
- ASPERA has determined the escape rates of Hydrogen, Oxygen and Helium ions.
- The ratio between the H^+/O^+ was found to be 2.6
- MAG has detected frequent whistler waves, indicative of lightning

Plasma environment by ASPERA and MAG





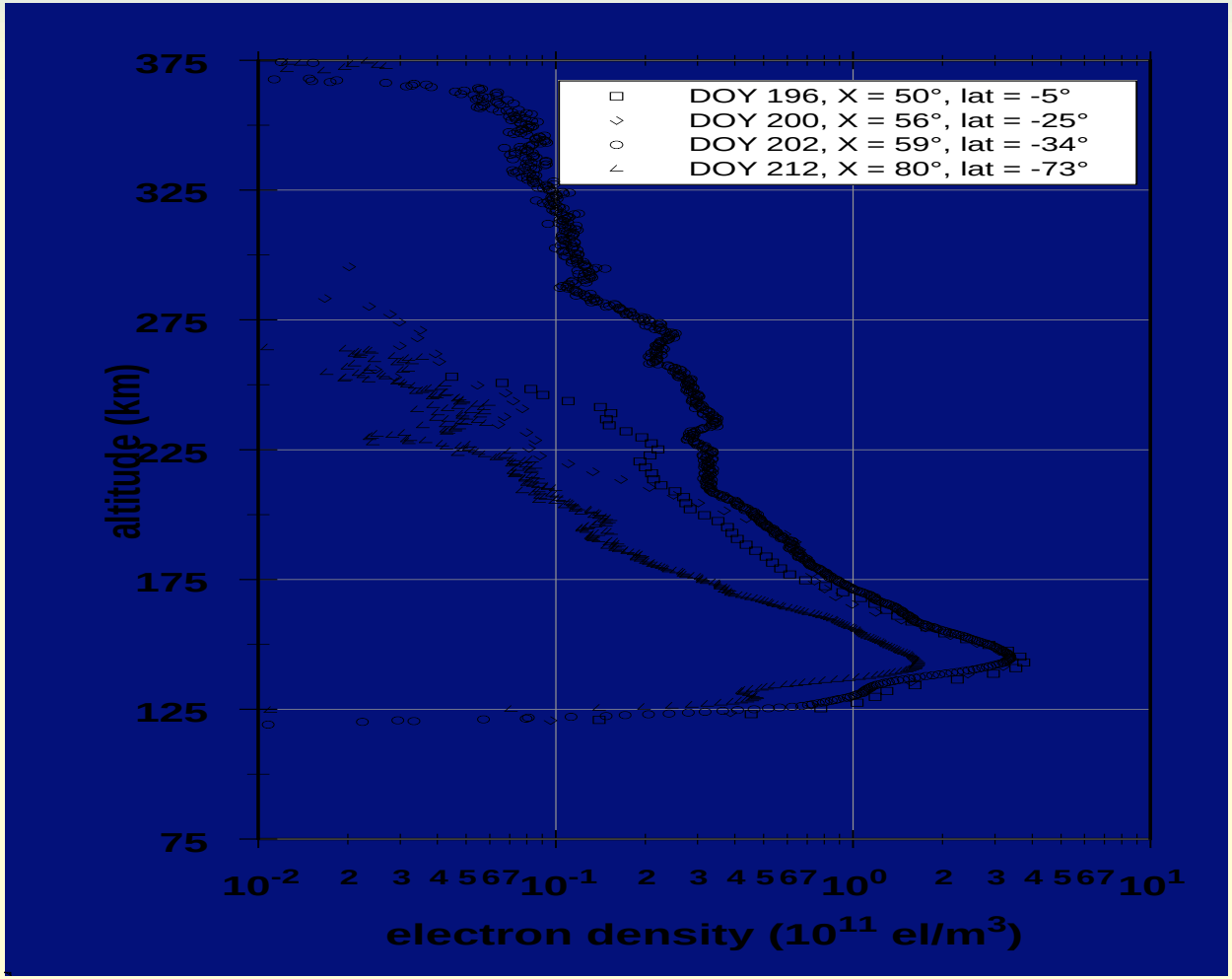
Whistler waves detection by MAG



(Russel, Zhang & MAG Team)

- Whistler waves most likely generated by lightning in the cloud layer
- The signals are propagating along magnetic field lines and are therefore detected only when the field geometry allows a path to the spacecraft
- The lightning rate is similar to that of the Earth

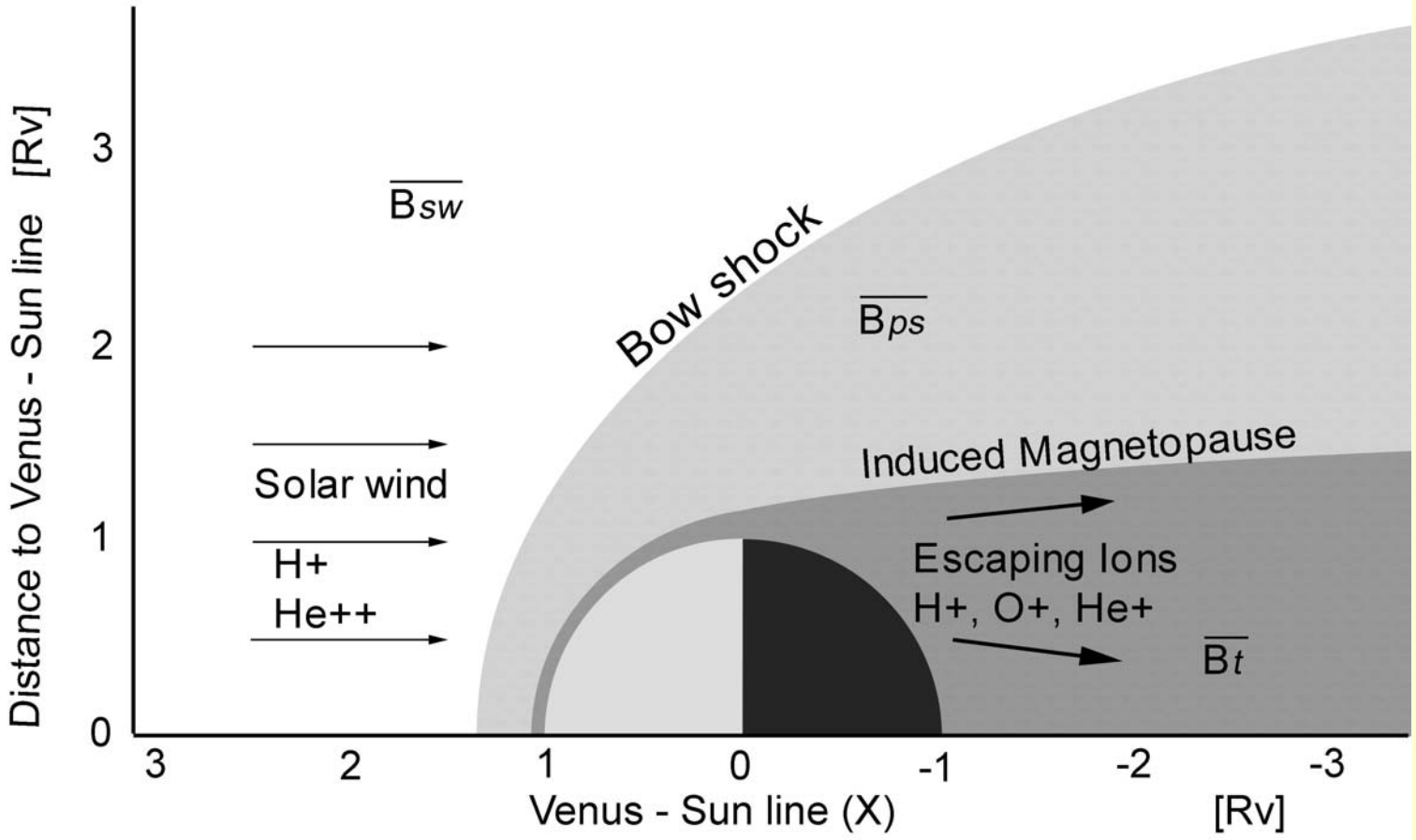
Ionospheric sounding by VeRa



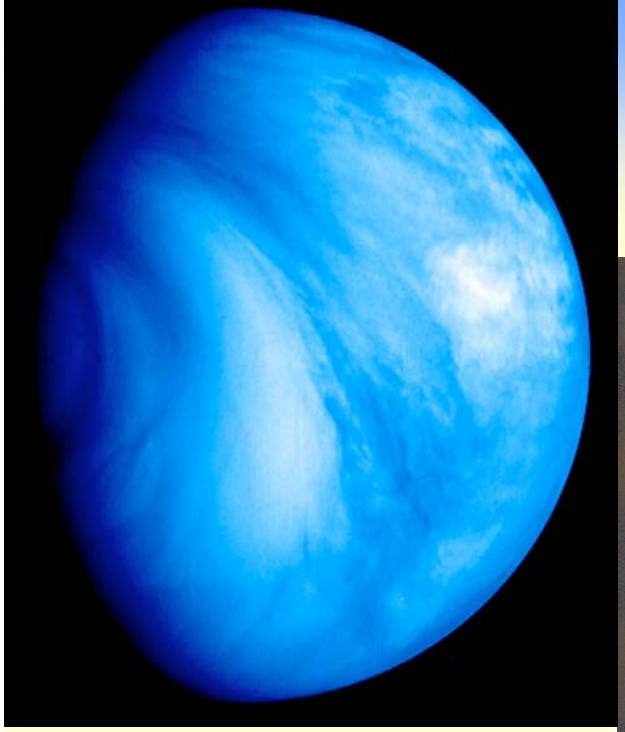
DOY	Lat[°]	SZA[°]
□ 196	-5	50
◊ 200	-25	56
○ 202	-34	59
Δ 212	-73	80

(Pätzold, Häusler & VeRa Team)

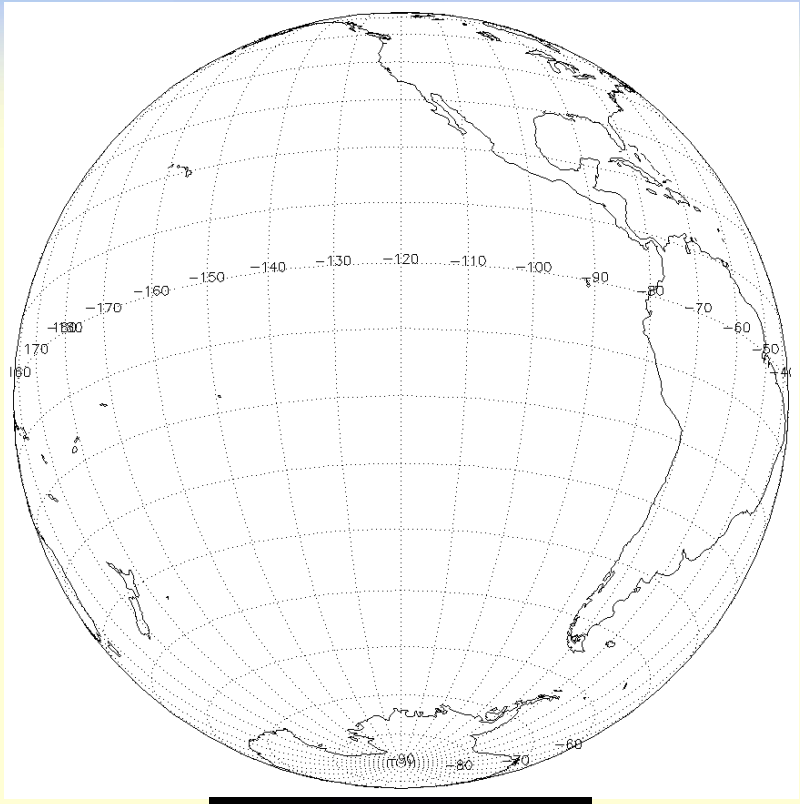
Plasma environment



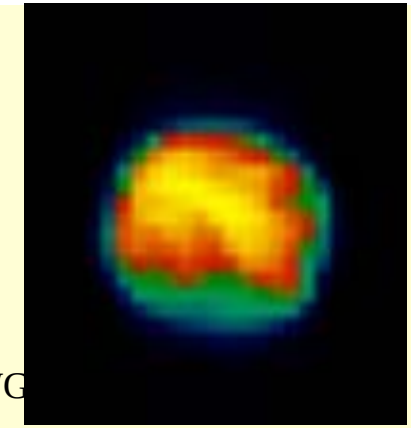
Comparative planetology



Earth-Moon observation during the cruise phase (Nov. 22 2005)



Virtis-M True color



Virtis-M Infrared @ 4.6μm

Earth in the visible spectrum