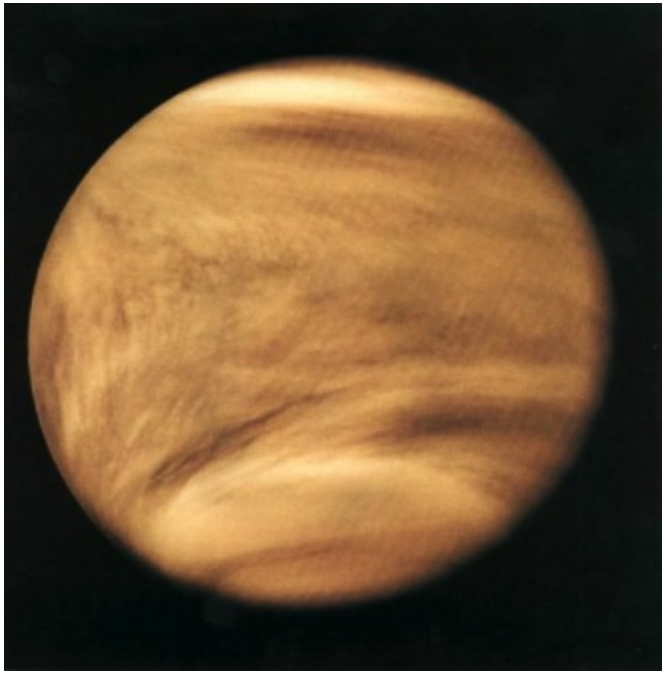
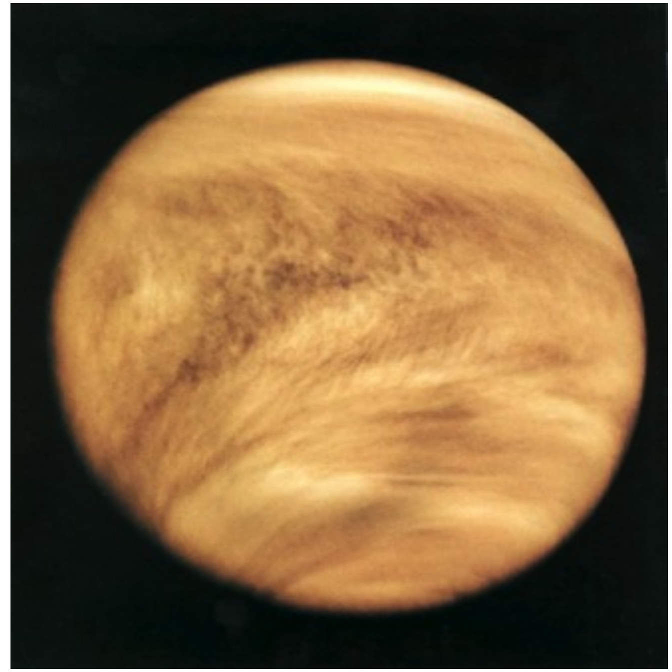
Sampling Venus from Earth Orbit

Gregory Konesky
K-Plasma, Ltd.

3rd Joint SRR/PTMSS
Colorado School of Mines, Golden, CO
June 4-7, 2012

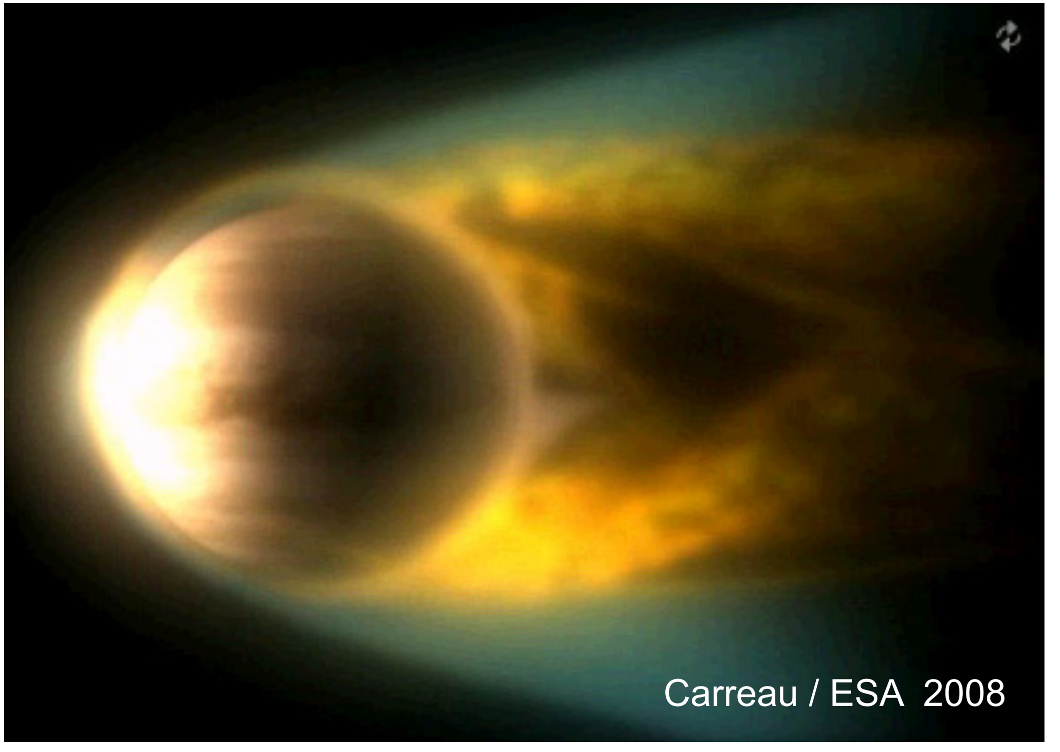


Feb. 5, 1979



Feb. 26, 1979

Pioneer Venus Images with Unknown UltraViolet Absorbers



Solar Wind Erosion of Venusian Atmosphere

“On the possibility of microbiota transfer from Venus to Earth”
(Wickramasinghe and Wickramasinghe, 2008)

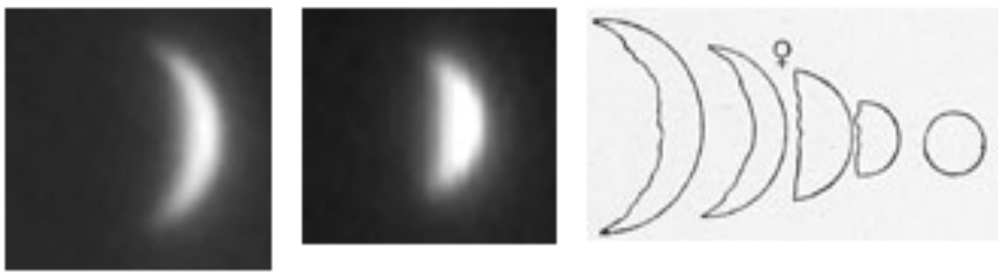
Venus Ion-Tail Observations

SOHO Mission near Earth's L1 Lagrangian Point

Pioneer Venus Mission en route to Venus

Venus Express Mission near Venus

First Telescopic Observations of Venus About 400 Years Ago

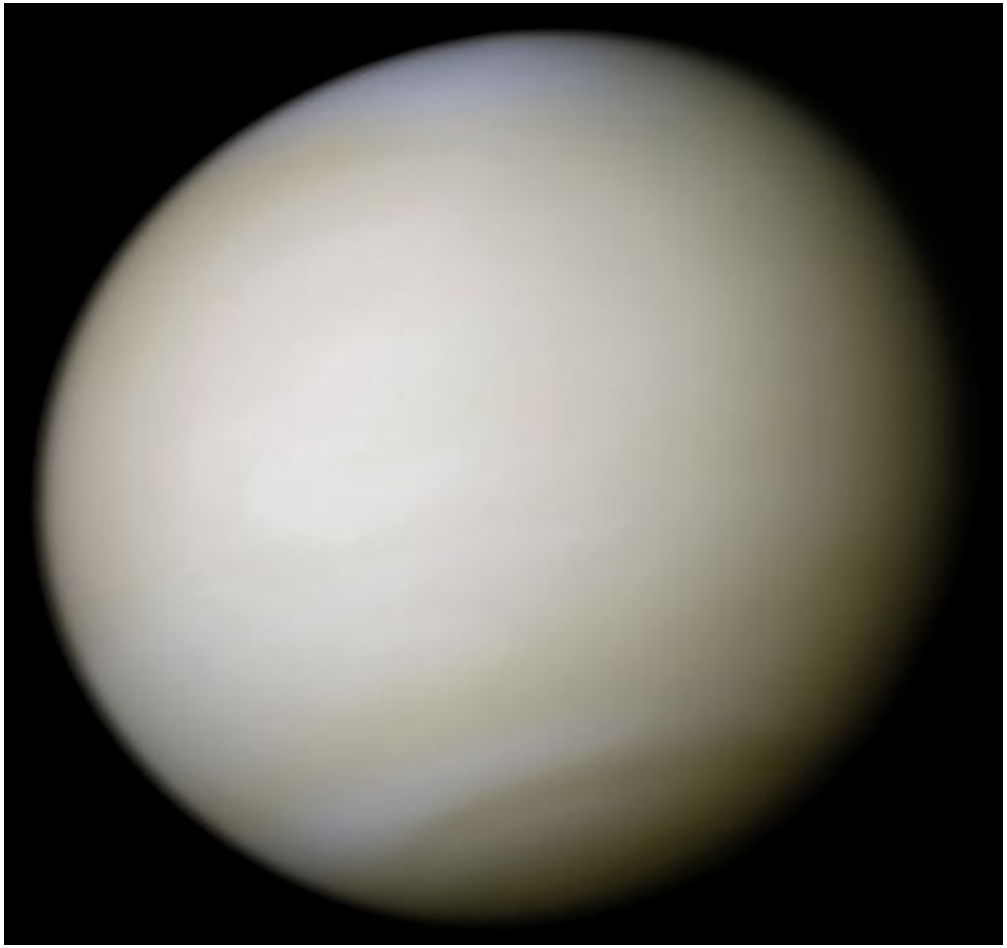


Galileo's Telescopic View of Venus and his Drawings

IL Saggiatore,

"The Assayer" 1623

Only Image of Venus Available For The Next Several Hundred Years



(NASA, 2006)

Venus: Earth's Sister Planet

	Earth	Venus
Mass ($x10^{24}$ kg)	5.97	4.87
Radius (km)	6378	6052
Mean Density (kg/m^3)	5515	5243
Surface Gravity (m/s^2)	9.80	8.87

Some Early Misconceptions

Venus is ~25% Closer to the Sun

Reflects ~80% of Incident Sunlight

Therefore:

"Venus is likely a verdant, rainy, overgrown swamp planet" - (Svante Arrhenius, 1918)

"Venus is probably endowed with a planet-wide coating of petroleum {'Hoyle Oil'}" - (Fred Hoyle, 1955)

Early Earth-Based Temperature Measurements of Venus

Infrared Emissions: 225 - 240 K

Cloud-Tops

(Sinton and Strong, 1958)

Microwave Emissions: ~600 K

(Mayer, et al., 1960)

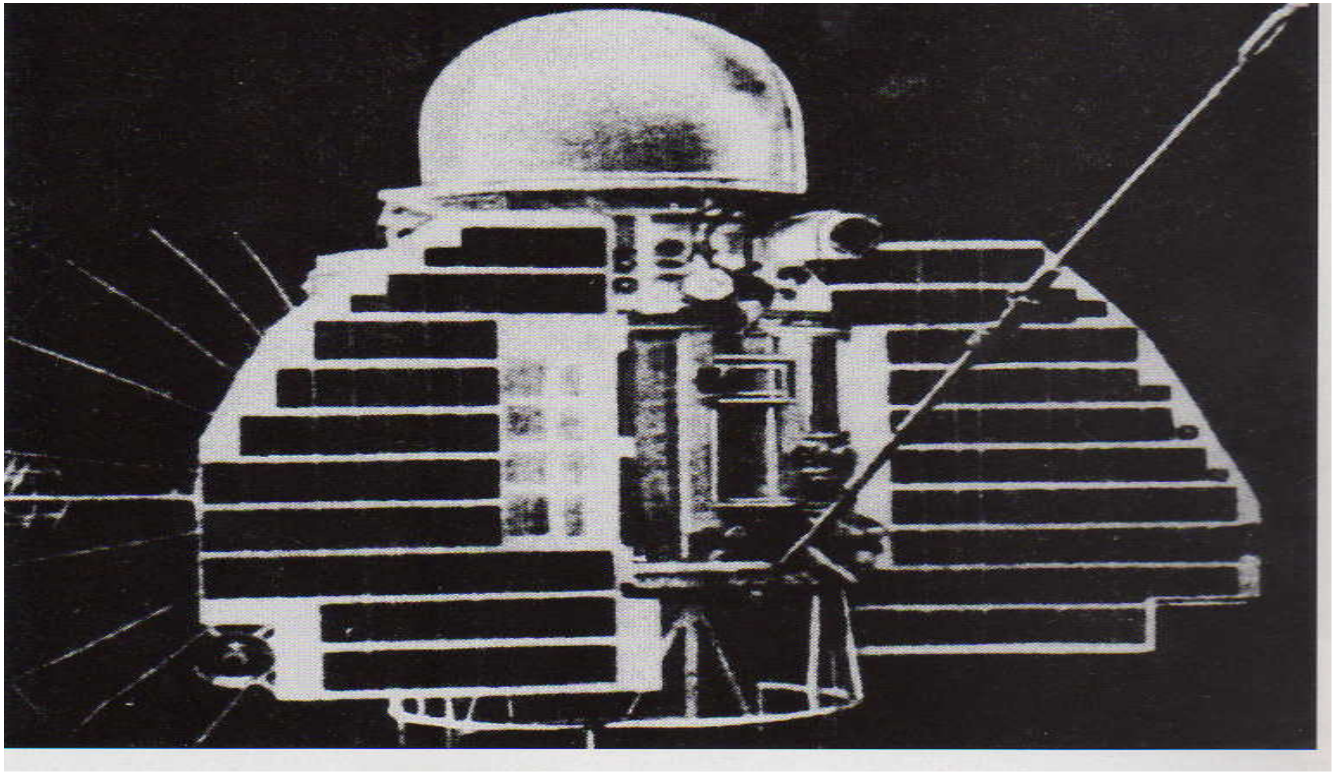
Early Earth-Based Temperature Measurements of Venus - continued

Two Potential Scenarios:

- Cool Surface / Hot Atmosphere
- Hot Surface / Cool Atmosphere

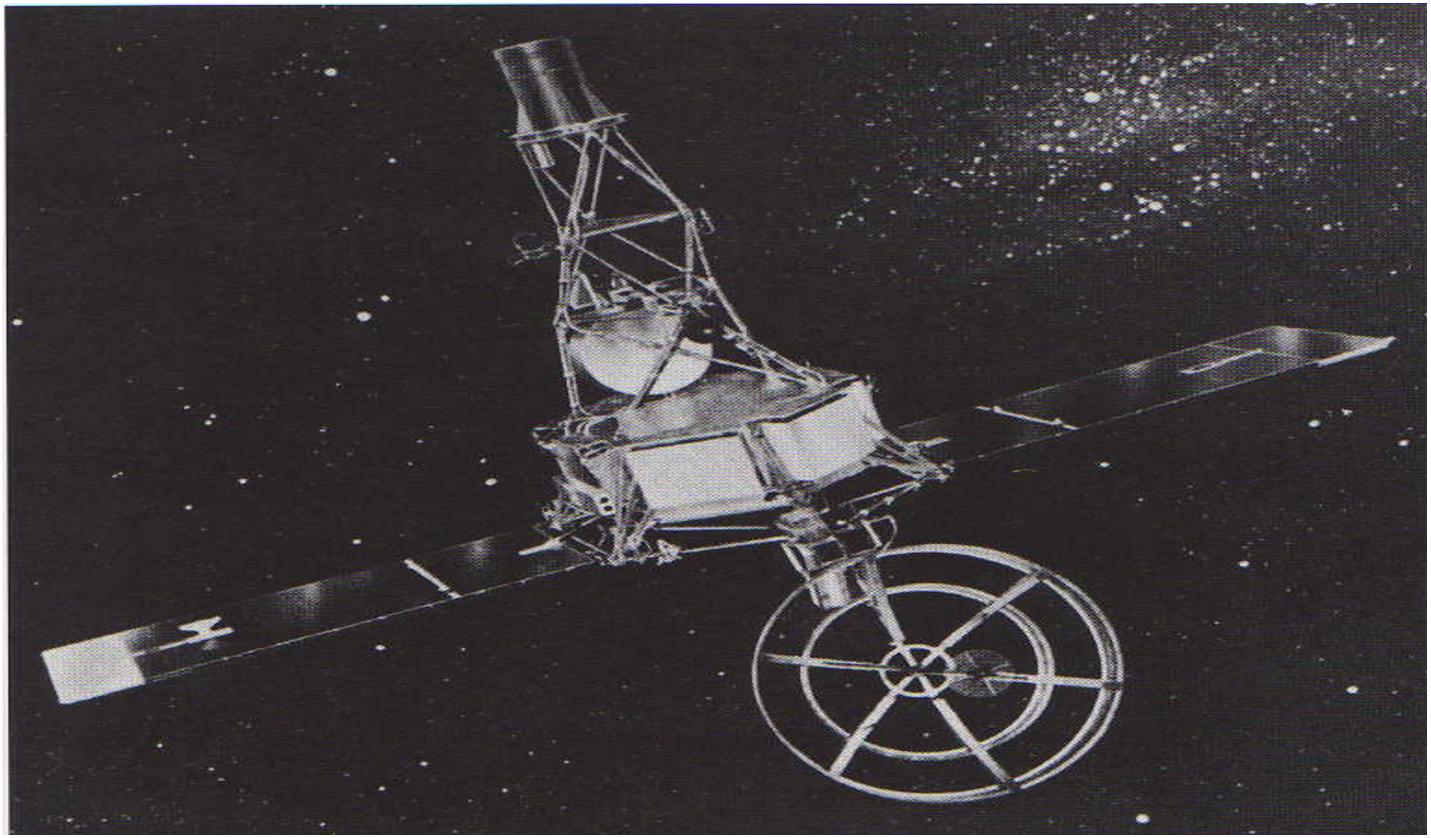
(Sagan, et al., 1961)

First Spacecraft to Fly-by Venus (Failed En Route)



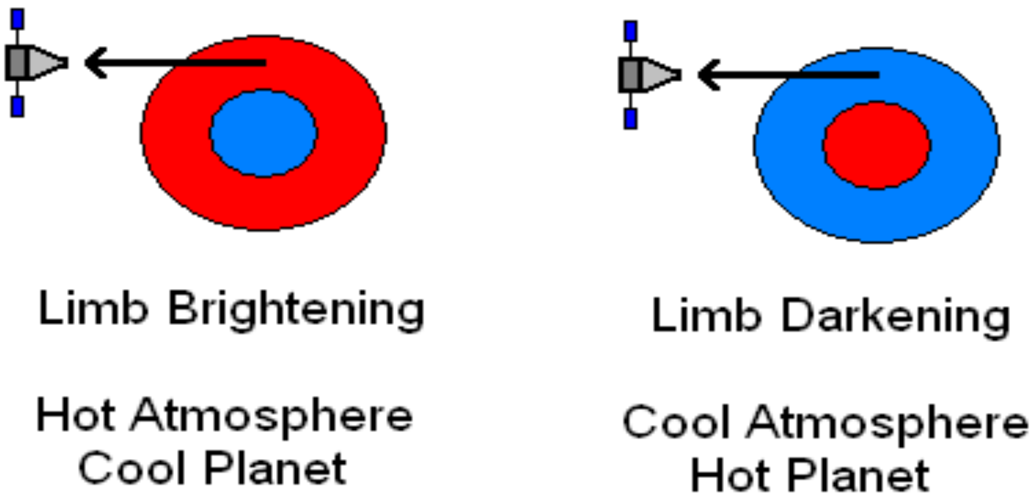
Venera – 1, 1961 (NPO Energiya)

Second Fly-by of Venus



Mariner – 2, 1962 (NASA/GSFC)

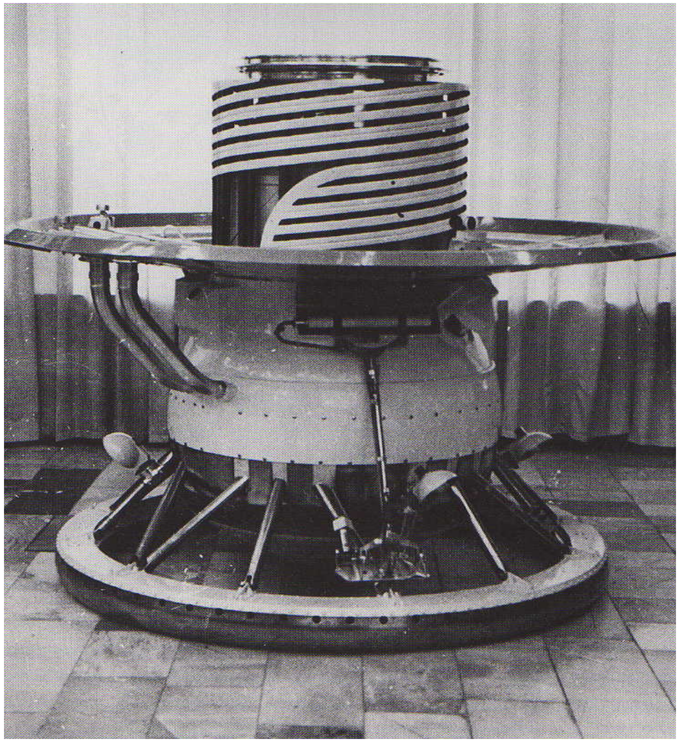
Mariner-2 Limb-Radiometer Experiment



Limb Darkening was Observed

Venus Descent Probes and Landers

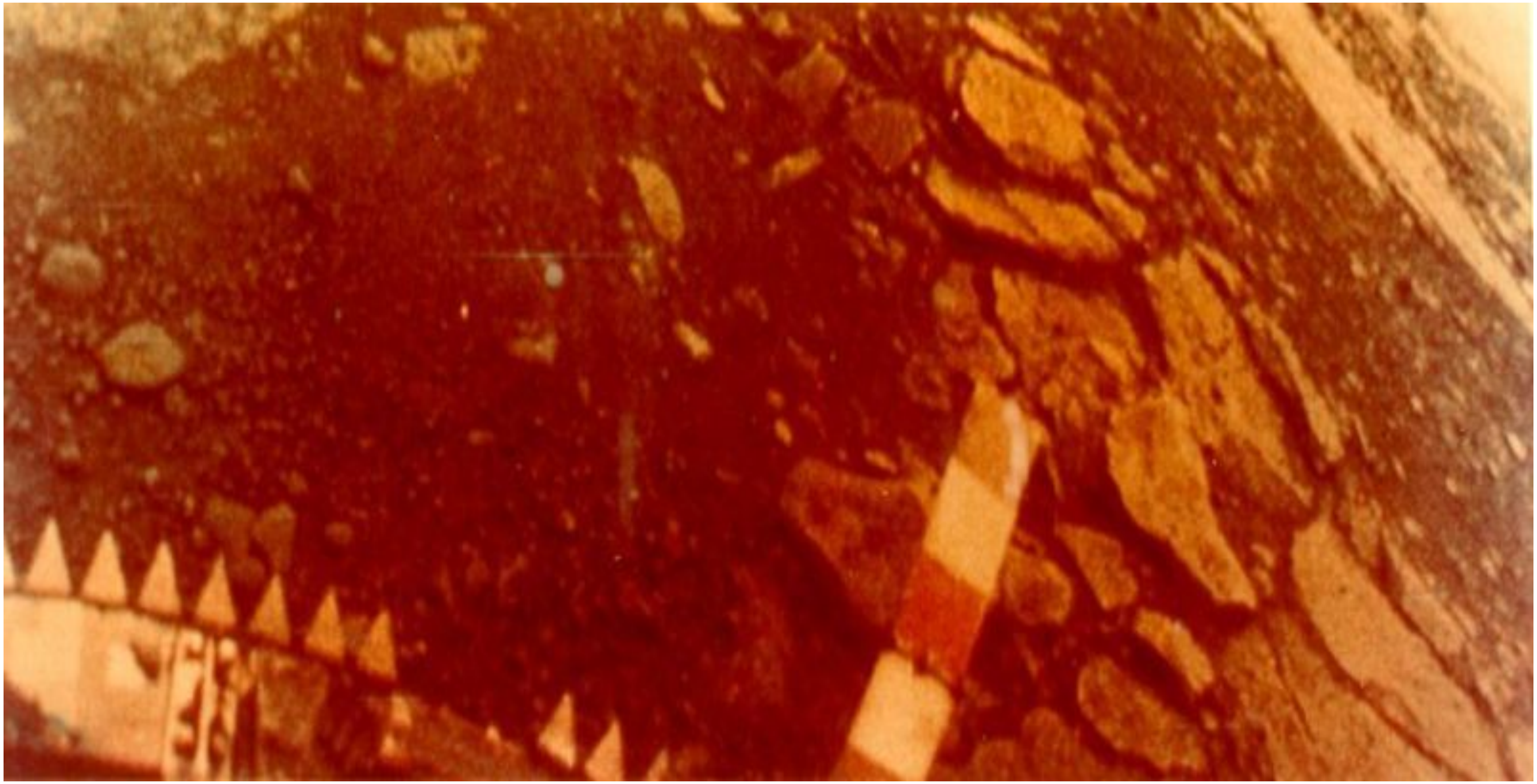
Venera – 4 Descent Module, 1967



Venera – 9 and 10 Landers, 1975

(NPO Energiya)

Venera – 13 Lander View, 1982

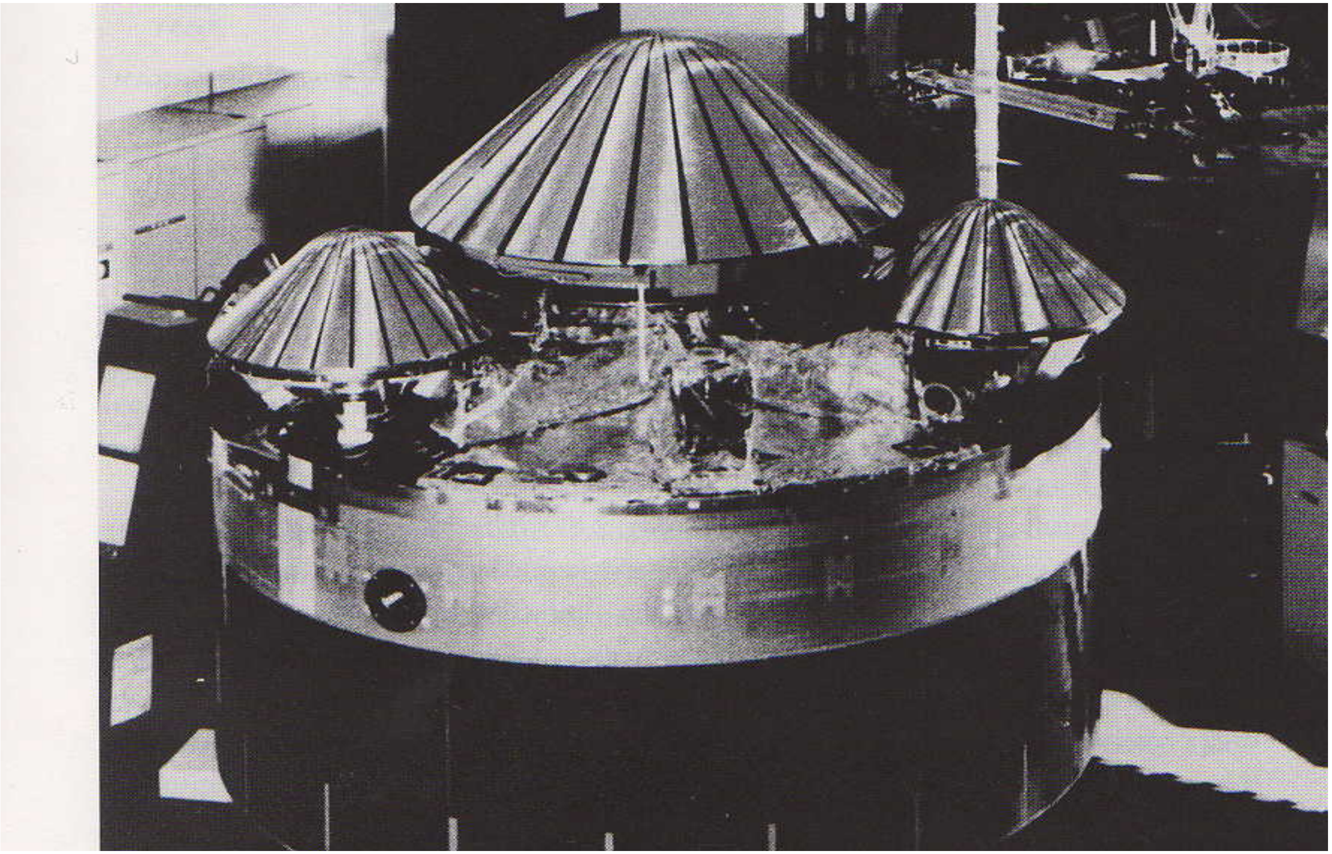


Surface Temp. ~735 K   Atm. ~96.5% CO_2

Surface Press. ~90 bar

(NASA /GSFC)

Pioneer Venus Orbiter and Descent Probes, 1978

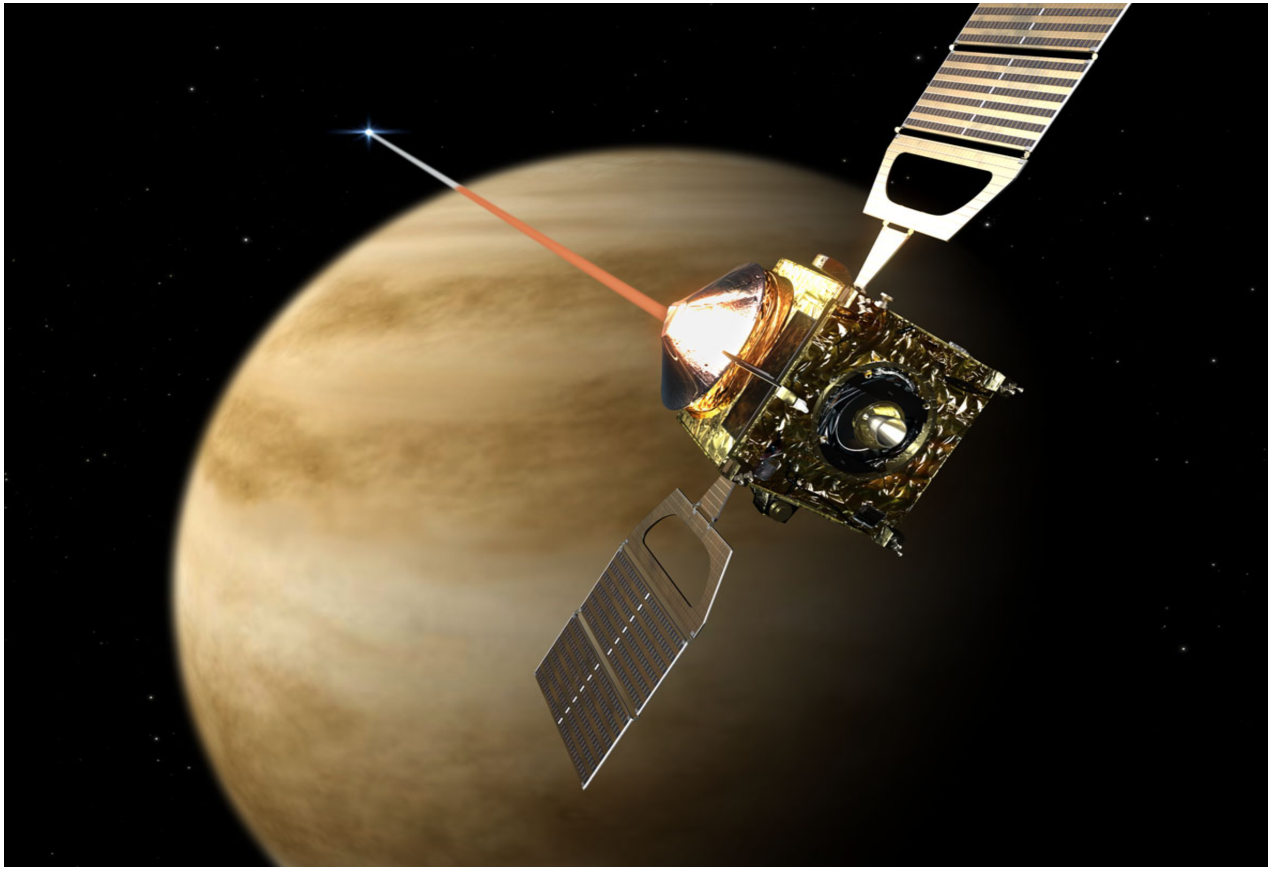


(NASA/GSFC)

Missions to Venus

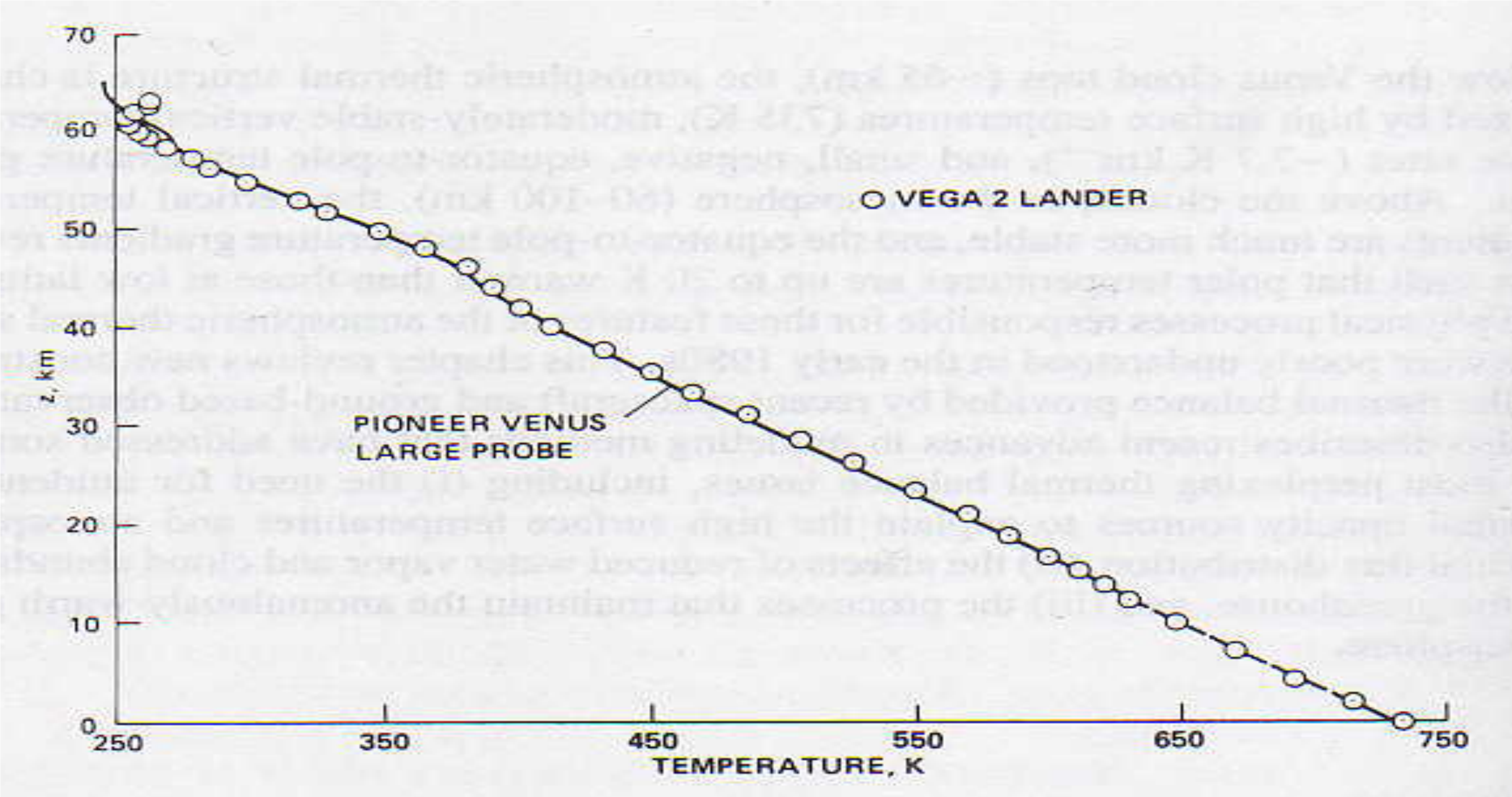
Spacecraft	Type of vehicle	Date of launch
Venera-1	Fly-by	2/12/61
Mariner-2	Fly-by	8/27/62
Venera-2	Fly-by	11/12/65
Venera-3	Entry probe	11/16/65
Venera-4	Descent vehicle and fly-by	6/12/67
Mariner-5	Fly-by	6/14/67
Venera-5	Descent vehicle and fly-by	1/5/69
Venera-6	Descent vehicle and fly-by	1/10/69
Venera-7	Soft lander and fly-by	8/17/70
Venera-8	Soft lander and fly-by	3/27/72
Mariner-10	Fly-by	11/3/73
Venera-9	Soft lander and satellite	6/8/75
Venera-10	Soft lander and satellite	6/14/75
Pioneer-Venus Orbiter	Satellite	5/20/78
Pioneer-Venus bus and probes	One large and three small probes and an orbital bus	8/8/78
Venera-11	Lander and fly-by	9/9/78
Venera-12	Lander and fly-by	9/14/78
Venera-13	Lander and fly-by	10/30/81
Venera-14	Lander and fly-by	11/4/81
Venera-15	Satellite	6/2/83
Venera-16	Satellite	6/7/83
Vega-1	Lander and fly-by	12/15/84
Vega-2	Lander and fly-by	12/21/84
Magellan	Orbiter	5/4/89

ESA Venus Express, 2009



(ESA)

Atmospheric Temperature Profile



(NASA/GSFC)

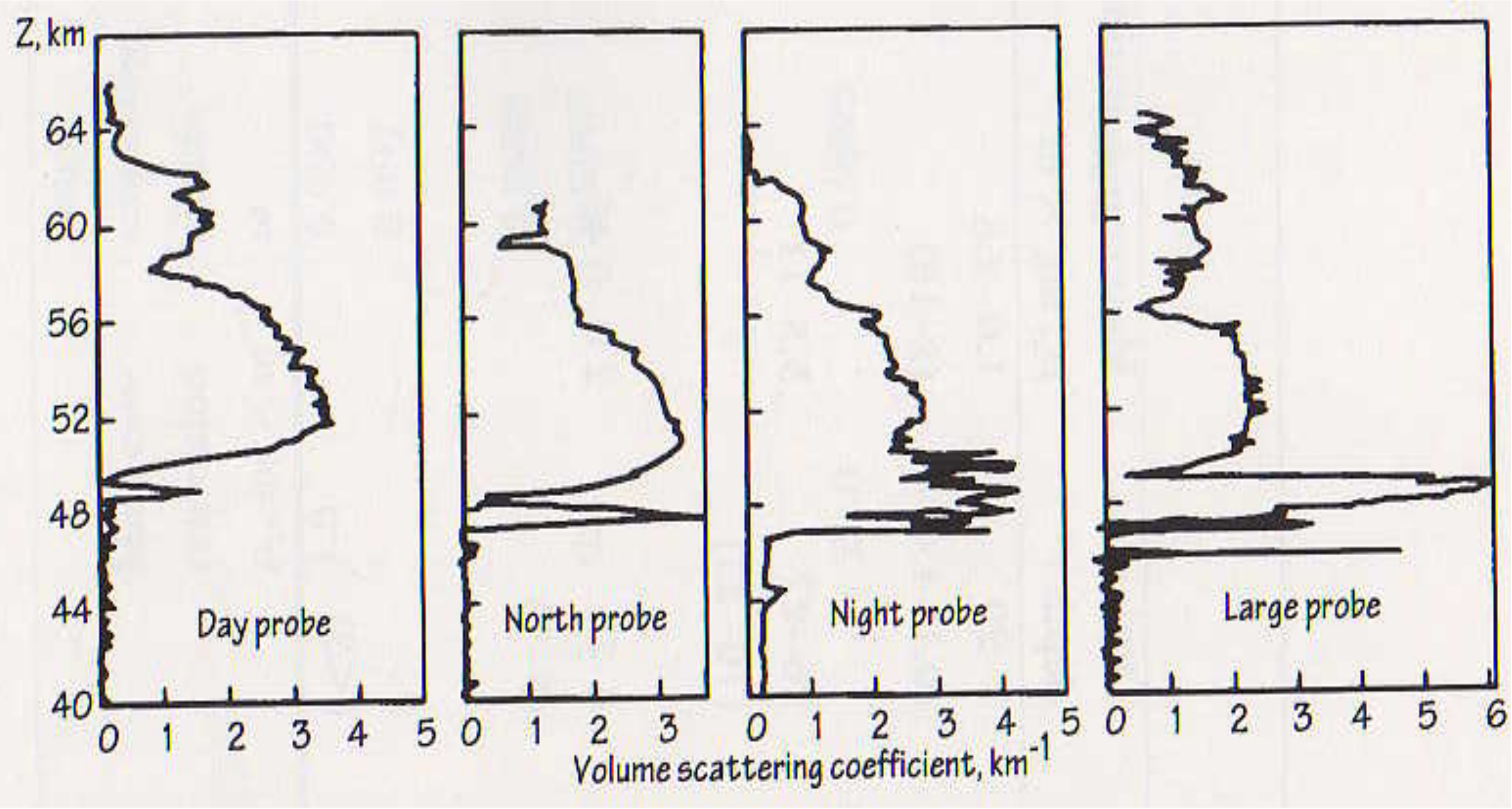
Potential Habitable Zones

Altitude Range: 45 to 65 km

Temperature Range: -25ºC to 75ºC

Pressure Range: 0.1 to 10 bar

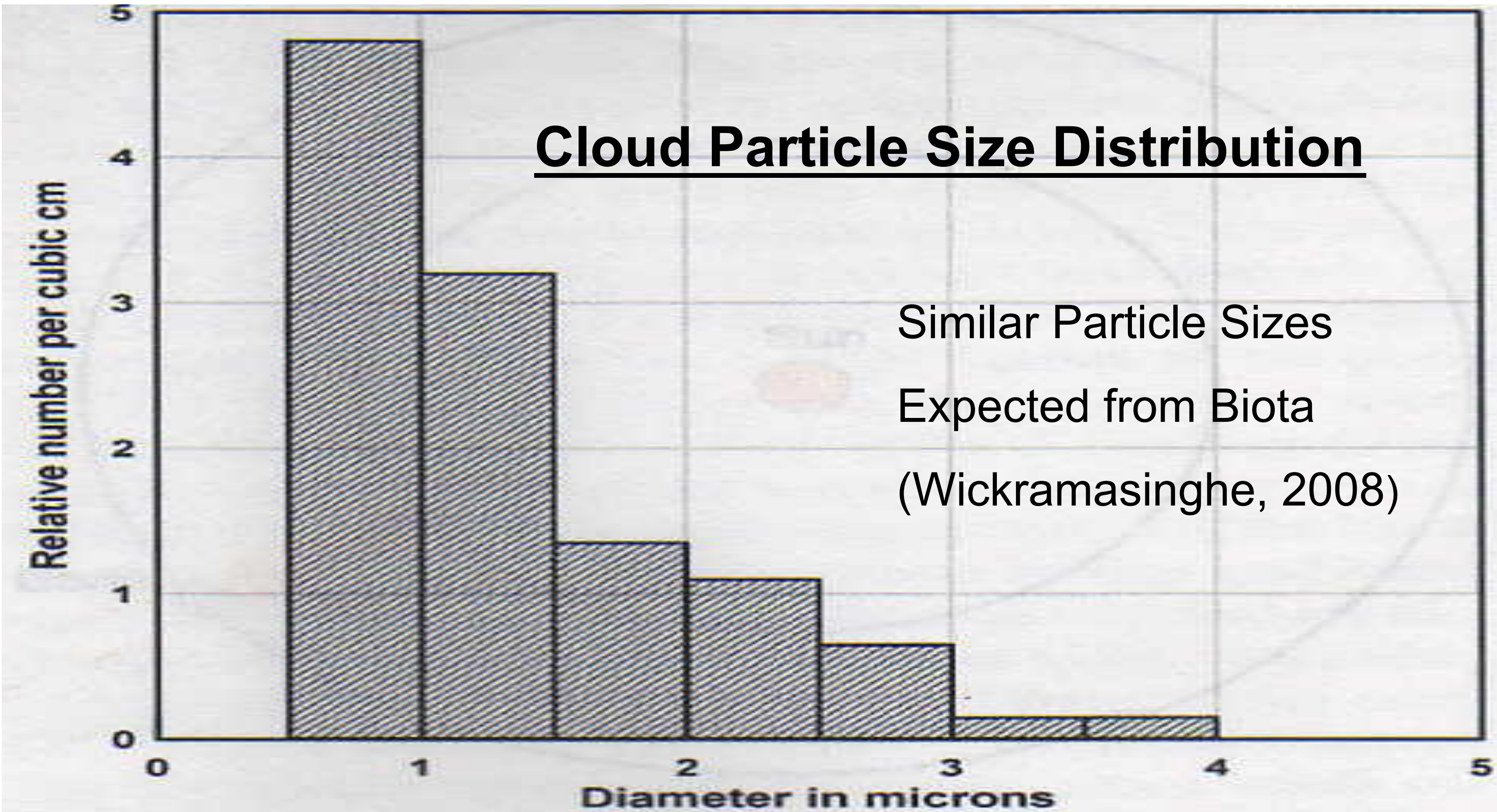
Cloud Layers



Pioneer Venus, 1979

(NASA/GSFC)

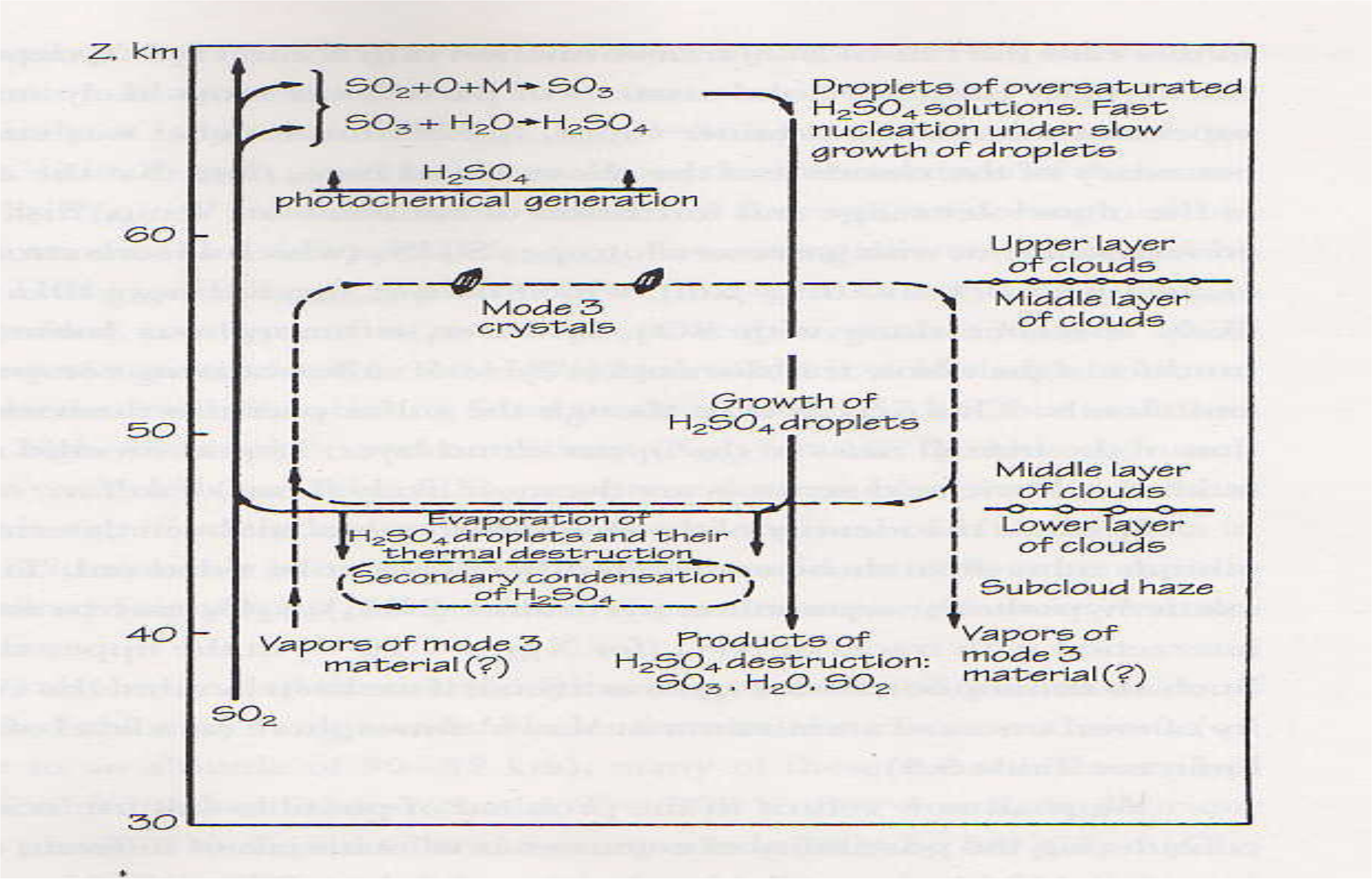
Cloud Particle Size Distribution



Cloud Layers 55-65 km, from Pioneer Venus Data

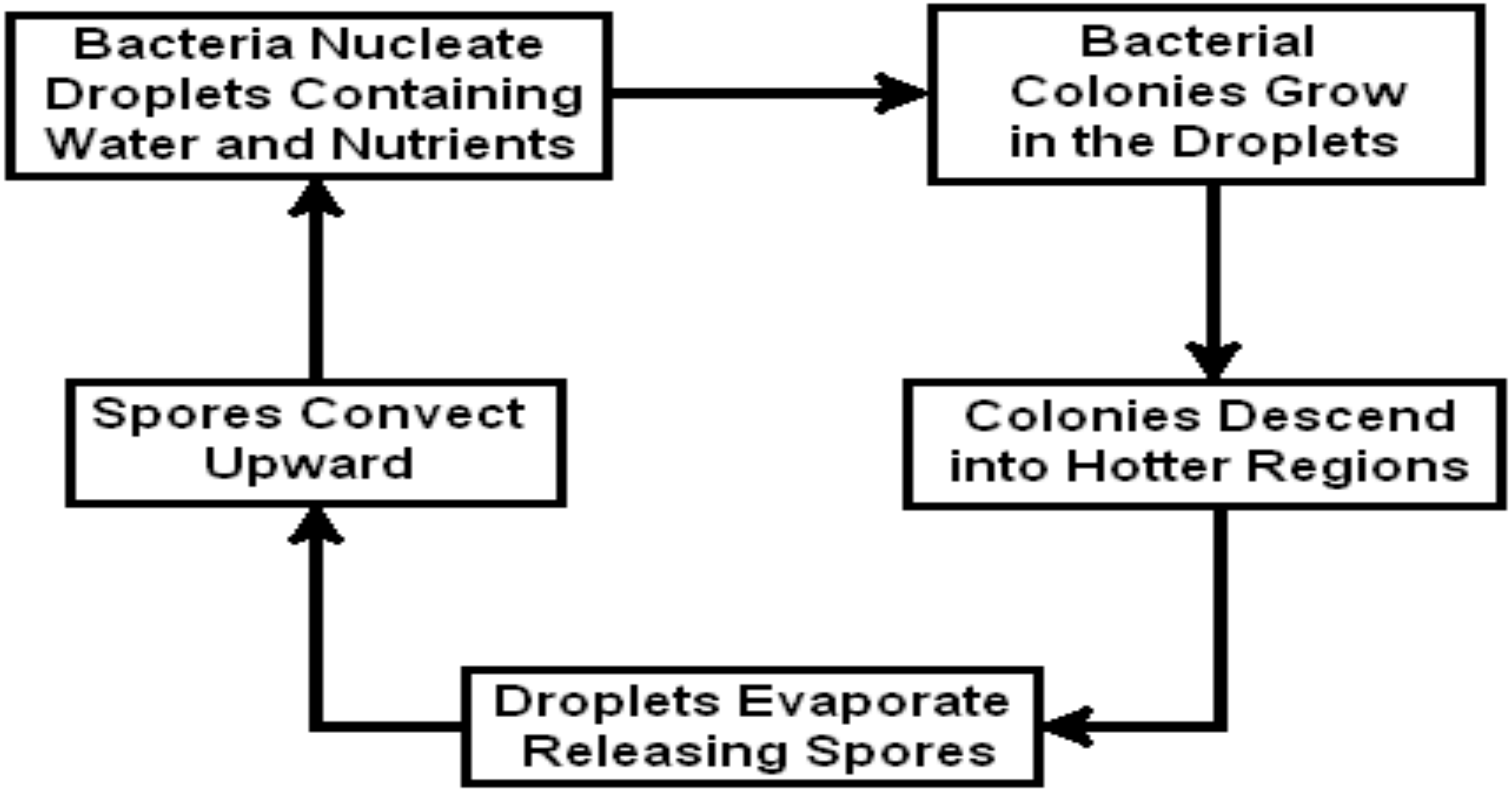
(Knollenberg and Hunten, 1979)

Abiotic Origin of Cloud Particles



(Knollenberg and Hunten, 1980)

Potential Biotic Origin of Cloud Particles



Potential Biotic Origin of Cloud Particles

Potential Biotic Indicators in Venusian Atmosphere

Presence of H_2S and SO_2 as Indicators of Extremophilic Sulfur Bacteria

(Cockell, 1999)

Presence of Carbonyl Sulfide (COS) As a Bio-Indicator

(Schulze-Makuch and Irwin, 2002)

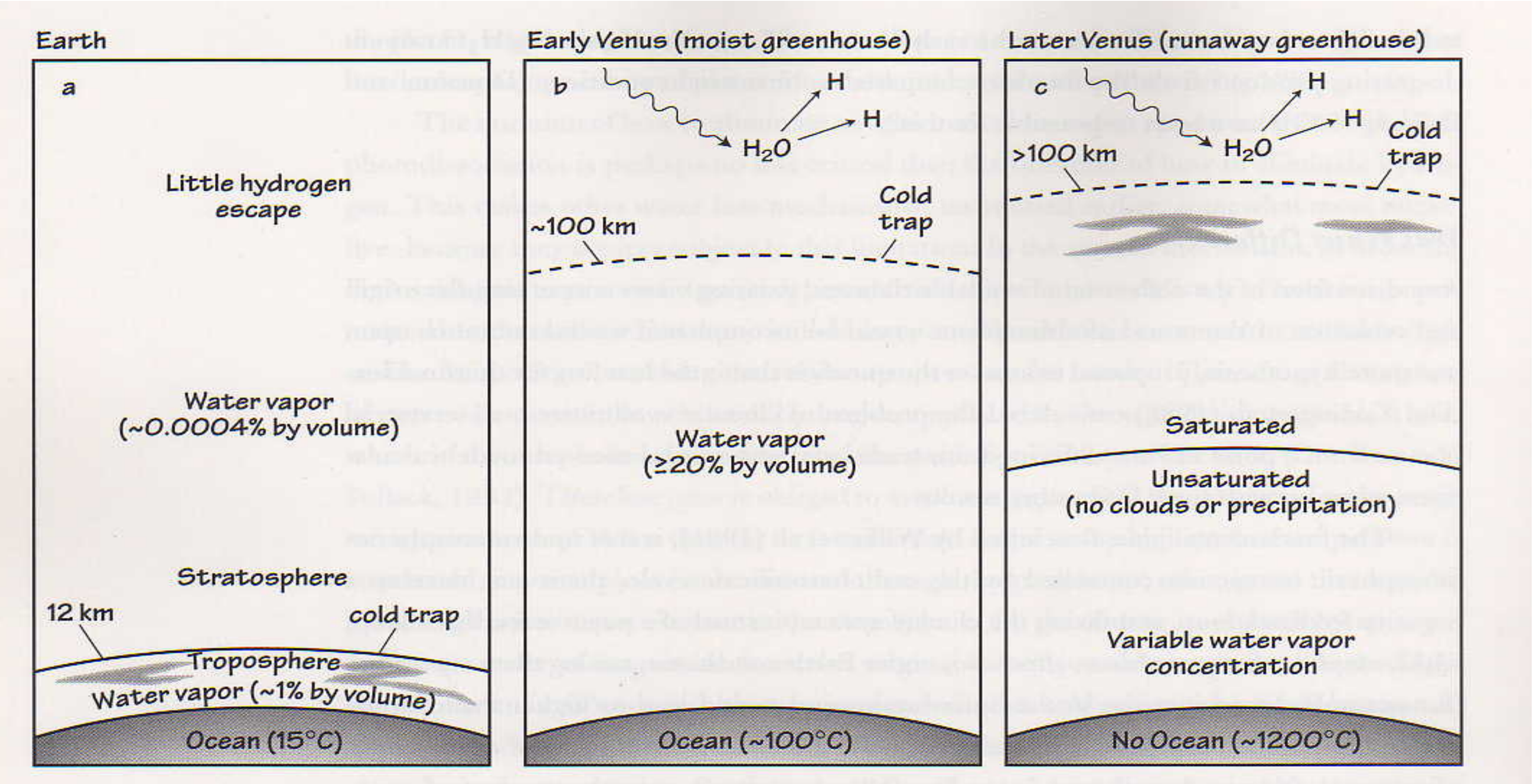
Origin of Putative Venusian Cloud Life

Indigenous

Panspermia

- Arrived in the Past
- And/or is Still Arriving

Early Venus as a Source of Indigenous Life



Early Venus may have remained Habitable

For 2 Billion Years or more

(Kasting, et al., 1988)

Indication of Water Loss

Earth and Venus Condensed out of Similar Regions (Compositions) of Pre-Solar Nebula

Early Oceans had Similar D/H Ratios

Today, Venus is Enriched with Deuterium by 120-150X

Rigors of Putative Venusian Cloud Life

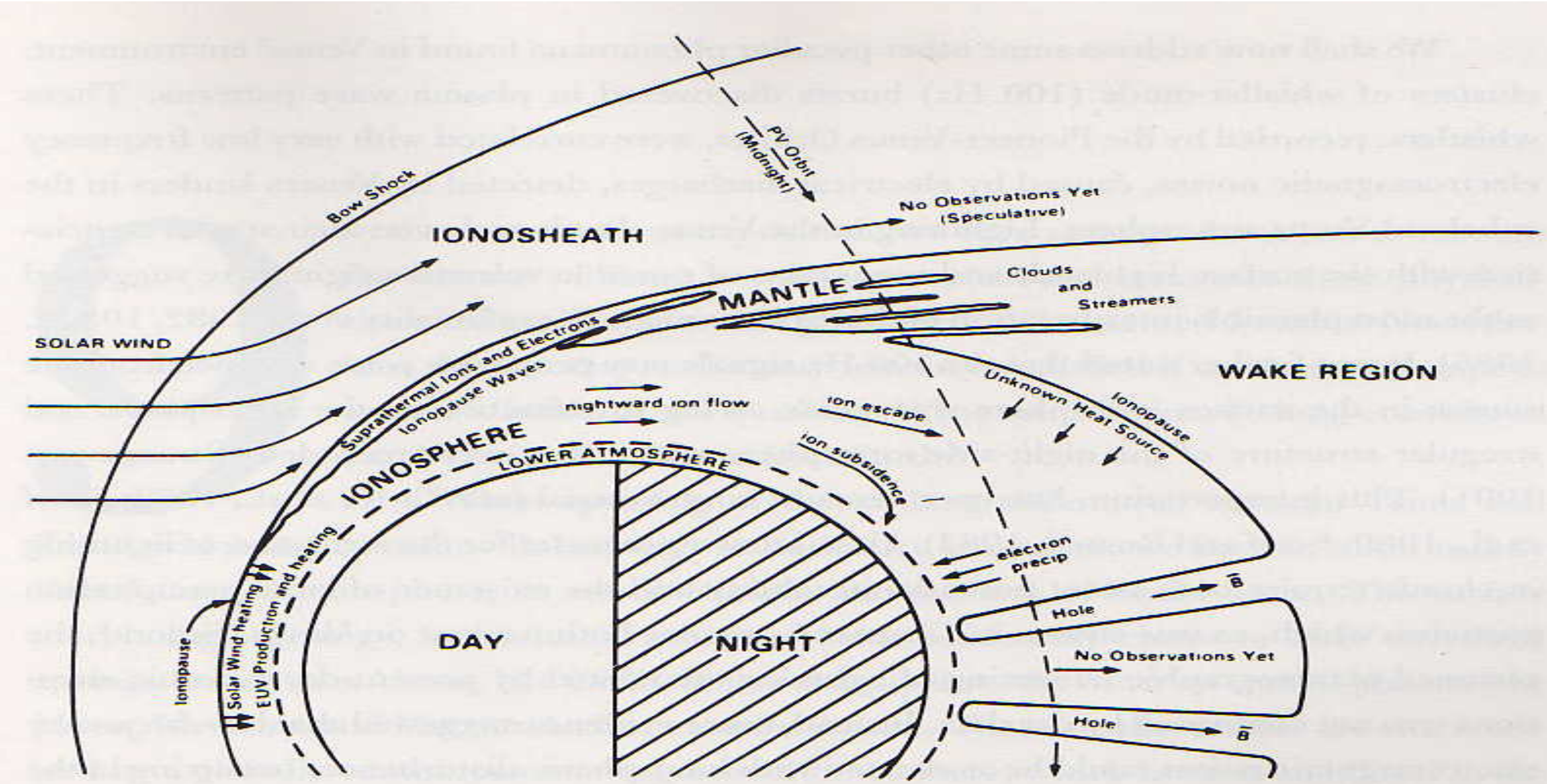
A Few ppm H_2O

81% to 98% H_2SO_4

Intense UV

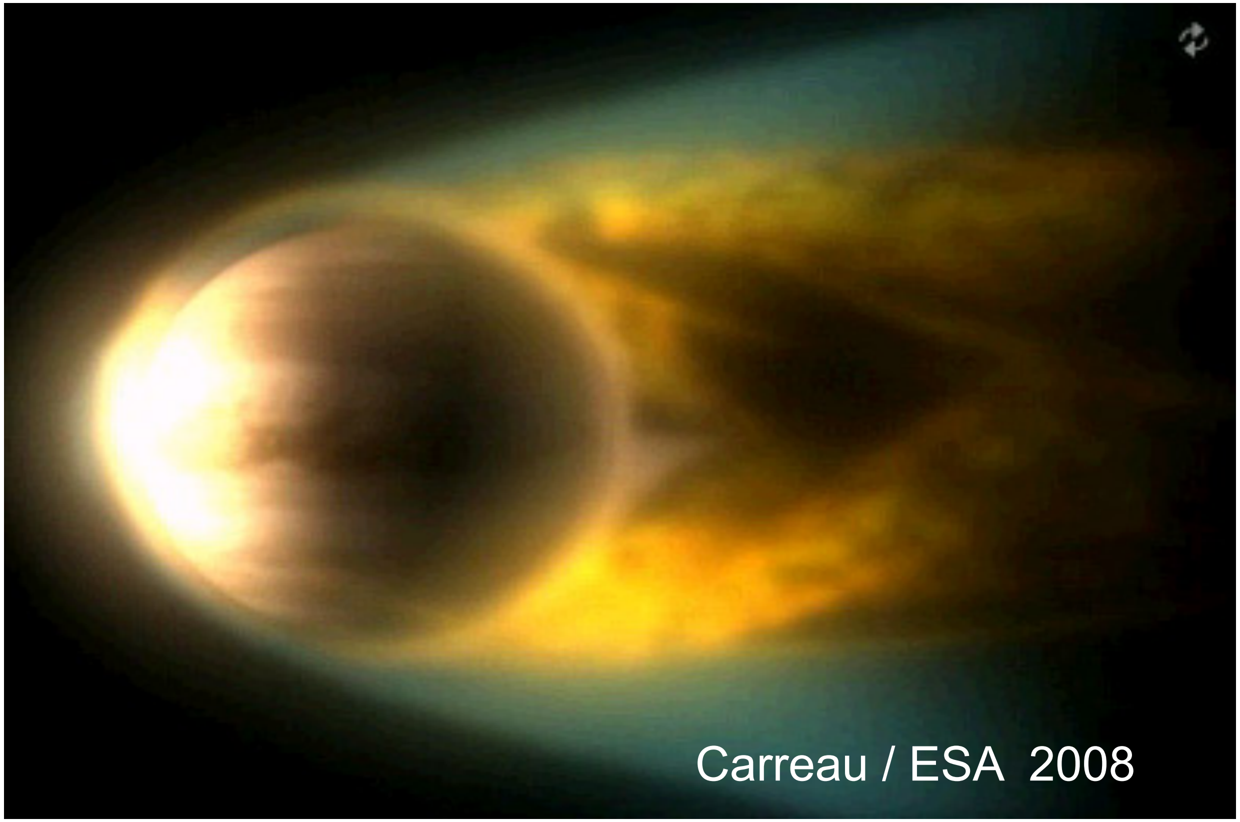
Nutrients provided by Meteorites

Erosion of Venusian Atmosphere by Solar Wind



(Brace, et al., 1983)

Erosion of Venusian Atmosphere by Solar Wind



Does the Erosion of Venusian Atmosphere by Solar Wind carry away putative Cloud Life

Solar Wind vs Sunlight as a Source of Interplanetary Propulsion

Solar Wind ~400 km/s

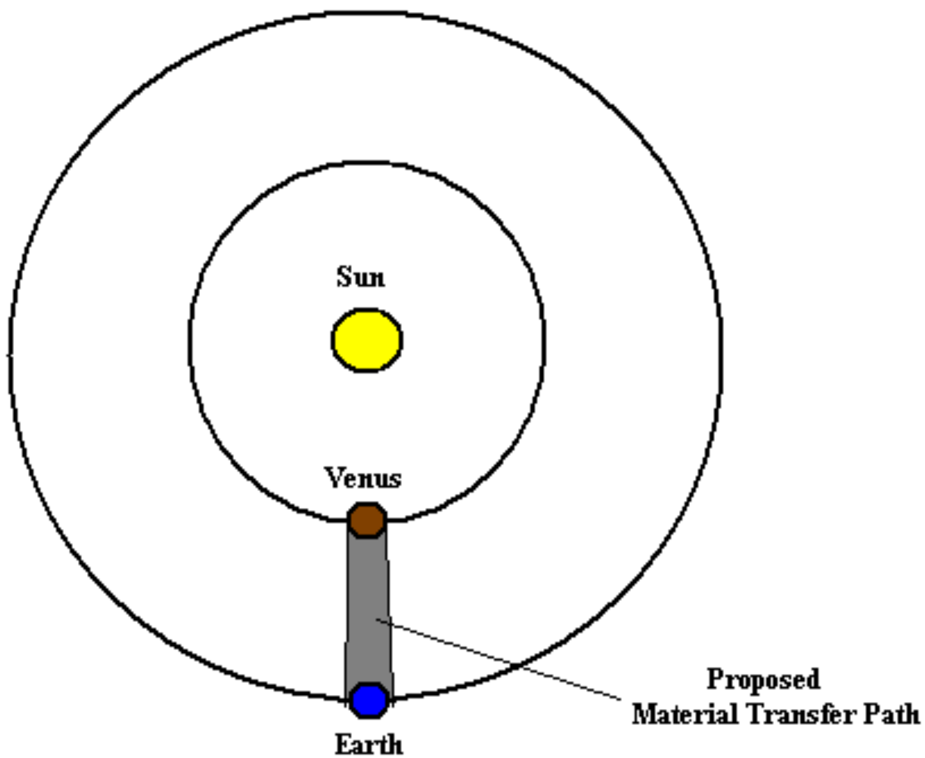
Highly Variable Spatially and Temporally

Very Low Density ~10 Particles/cm^3

Sunlight can Impart 10^3 to 10^4

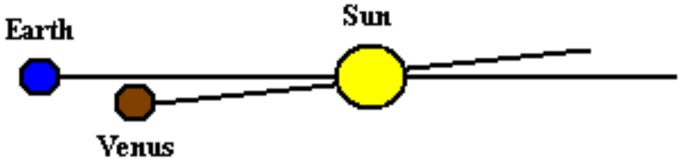
Times as much Thrust as Solar wind

Venus – Earth Orbital Transfer Issues



Conjunction

3.4º Inclination



Relative Orbital Inclination

(Grunwaldt, et al., 1997)

Frequency of Venus Transits

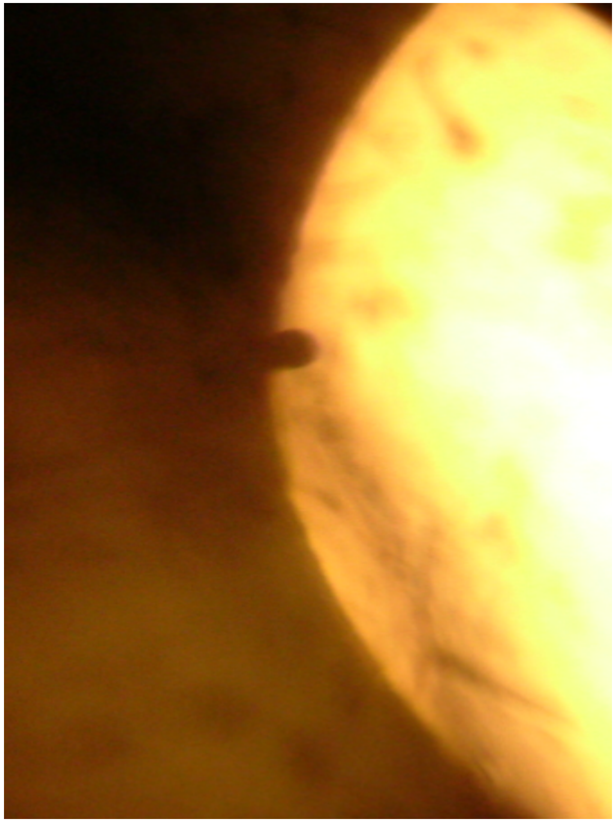
Venus Transits Occur when the
Sun, Venus and Earth Are in a Straight Line

They Occur in 8 Year Pairs, Followed
Alternately by Intervals of 121.5 and 105.5 Years

Last Venus Transit: June 8, 2004
Next Venus Transit: June 5-6, 2012

Observation of June 8, 2004 Transit

Observation of June 8, 2004 Transit



Can Putative Venusian Cloud Life

Be Detected from Earth Orbit?

Possible Sources of Error

Ambient Panspermia

Anthropogenic Sources

Interplanetary Dust Particles

Possible Sources of Error

Ambient Panspermia

Transfer of Potentially Life-Bearing

Material between Planets

Ejected by Asteroid or Comet Impacts

Possible Sources of Error

Anthropogenic Sources

Waste Water Releases from:

International Space Station

Space Shuttle Residuals

Possible Sources of Error

Anthropogenic Sources are

Predictable

(Often Observable)

Possible Sources of Error

Interplanetary Dust Particles

Average of 40 tons per day

of Extraterrestrial material

falls to the Earth

Interplanetary Dust Particles

Typical Size Range

50 – 500 micrometers

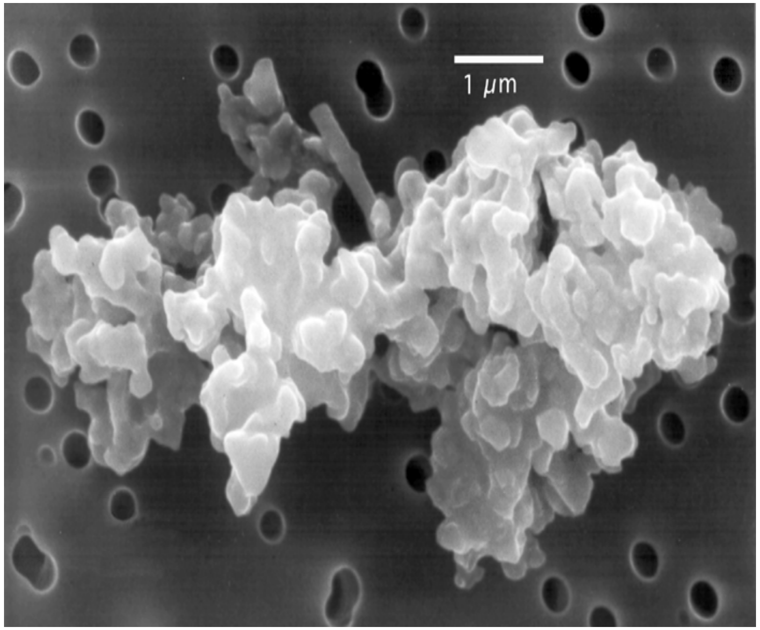
Typical Density Range

1 – 3 g/cm^3

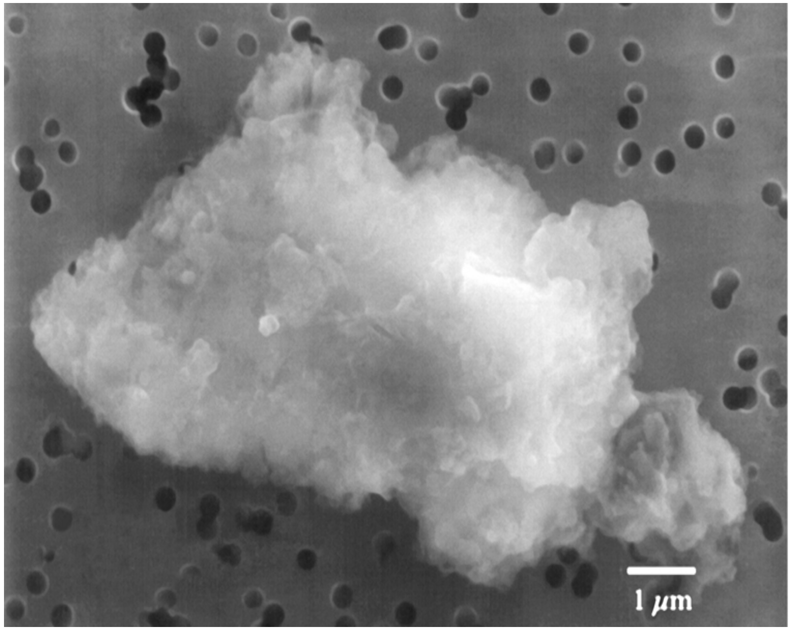
Average 2.0 g/cm^3

Typical Porosity ~ 40%

Interplanetary Dust Particles



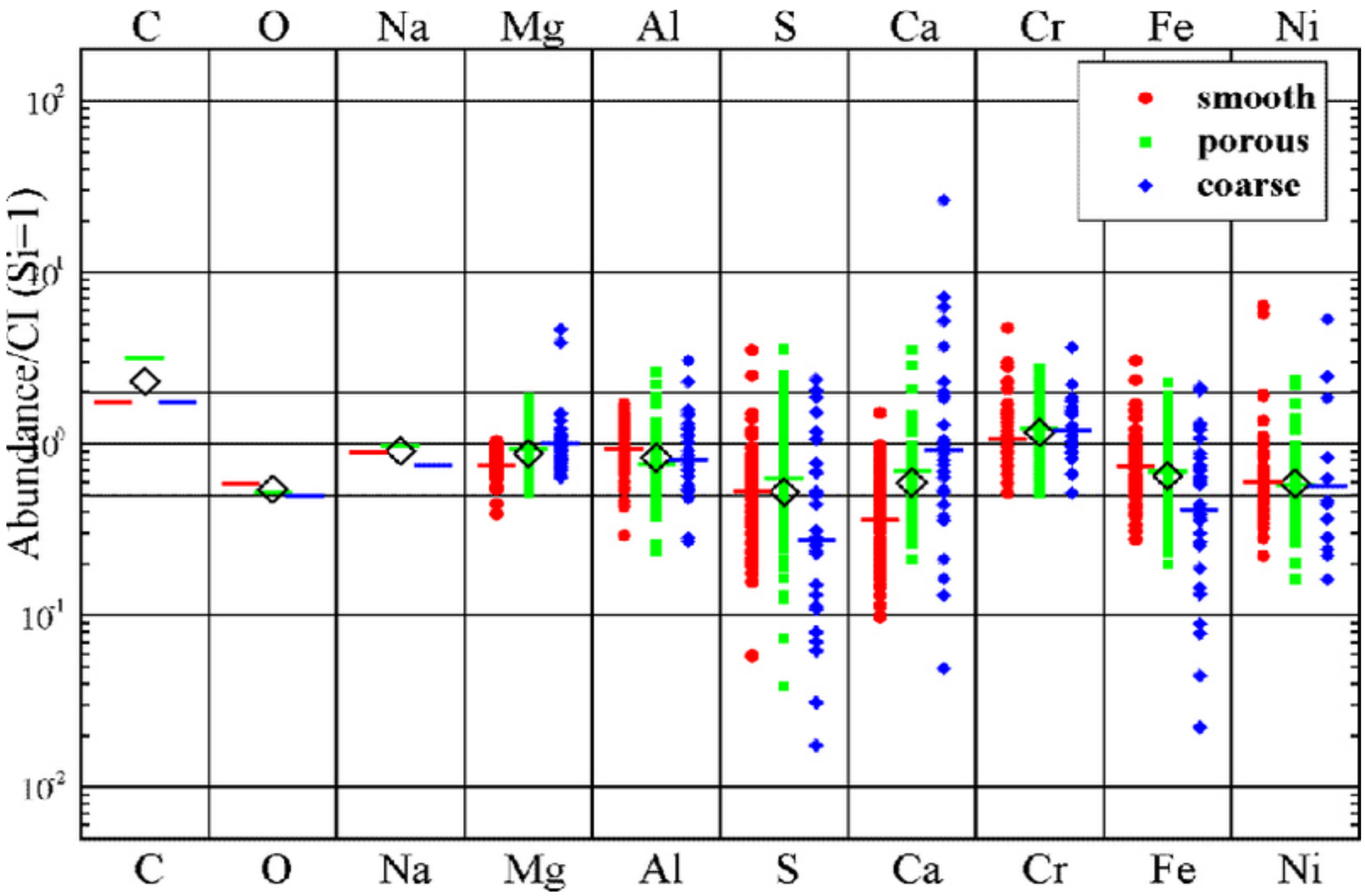
Porous IDP



Smooth IDP

Jessberger, 2005

Interplanetary Dust Particles



Stephan, 2006

Interplanetary Dust Particles

Large Orbital Velocity

10 – 40 km/s

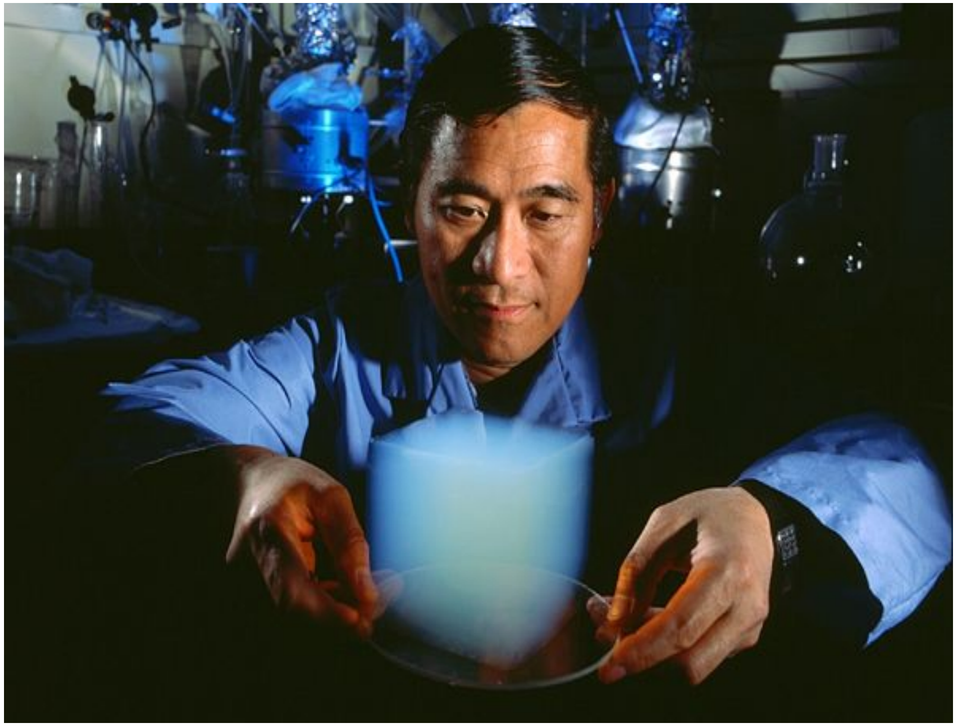
makes collection difficult

Typically, Impact Detectors

are used

Destructive Detection

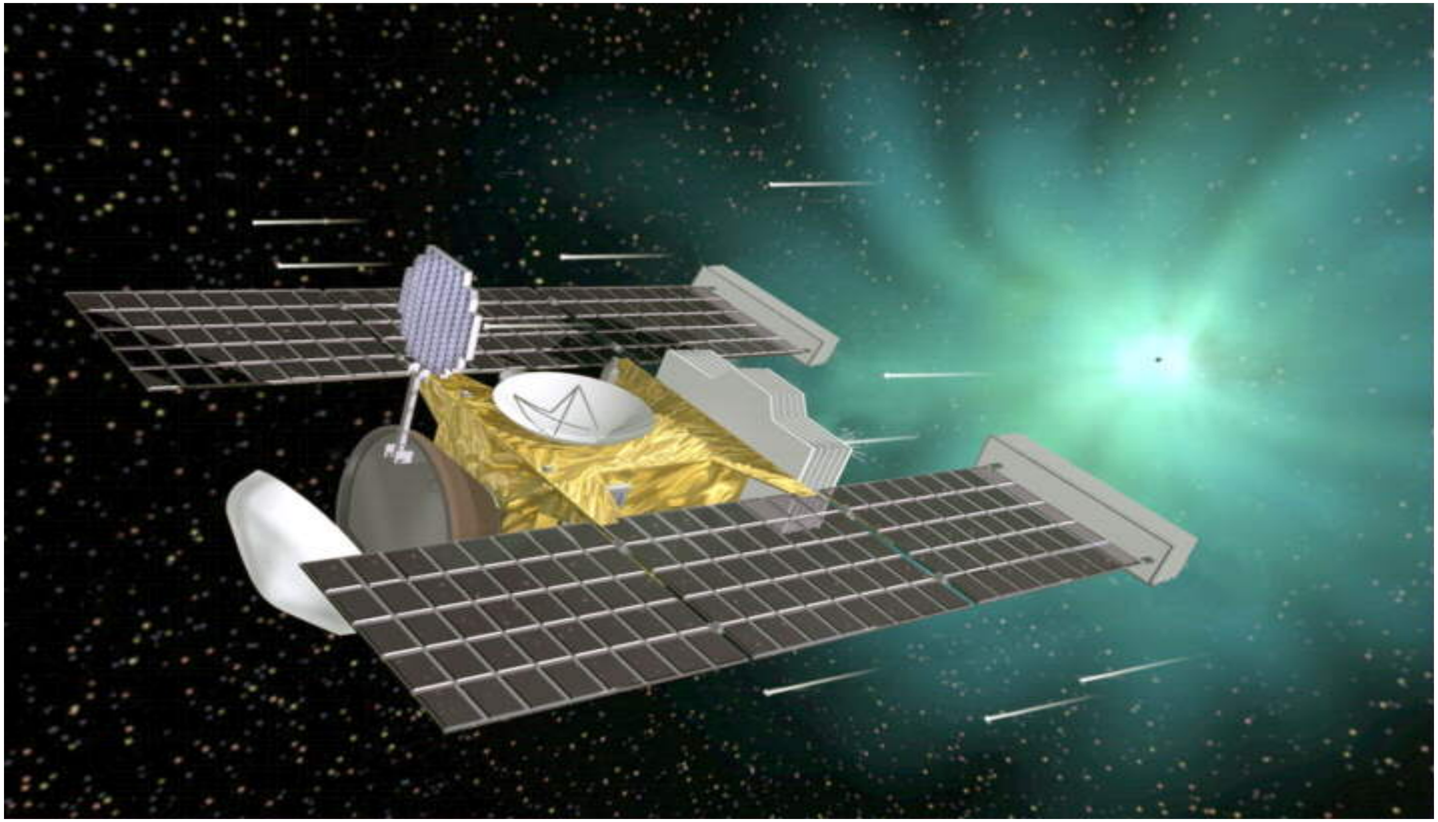
Particle Sample Acquisition



Aerogels have the capacity to stop high velocity particles

NASA / JPL, 2006

Particle Sample Acquisition

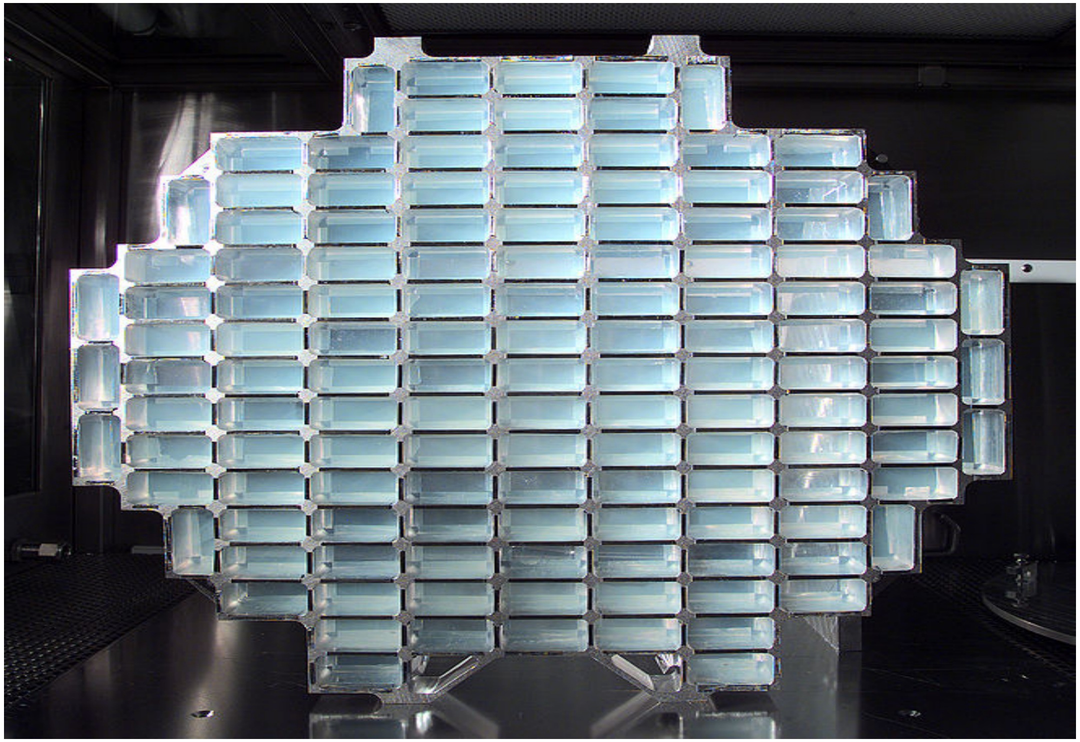


Stardust Spacecraft: Launched Feb. 7, 1999

Sample returned to Earth Jan. 15, 2006

NASA/JPL

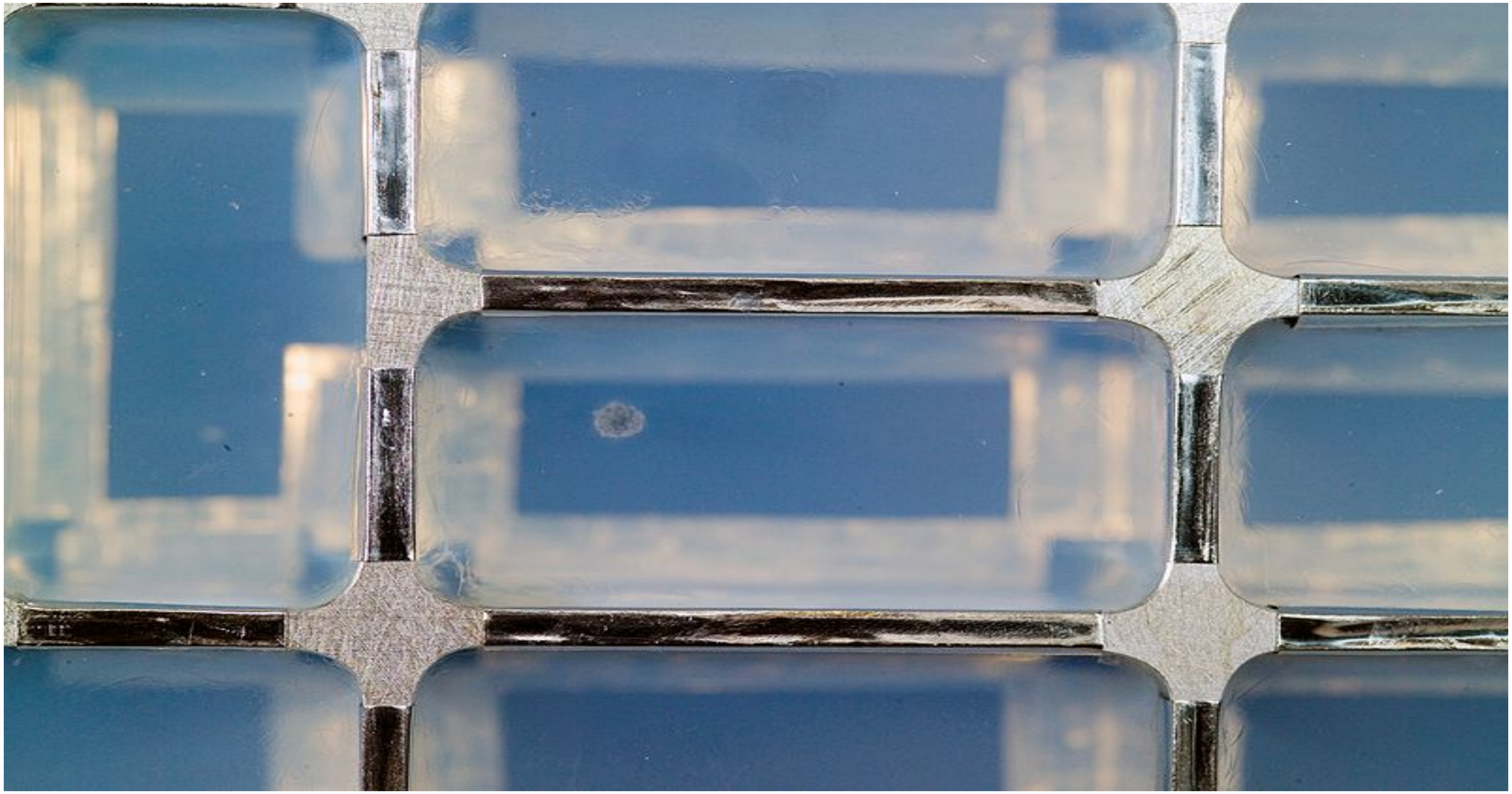
Particle Sample Acquisition



Aerogel Sample Collector ~ 1000 cm^2

NASA/JPL

Particle Sample Acquisition



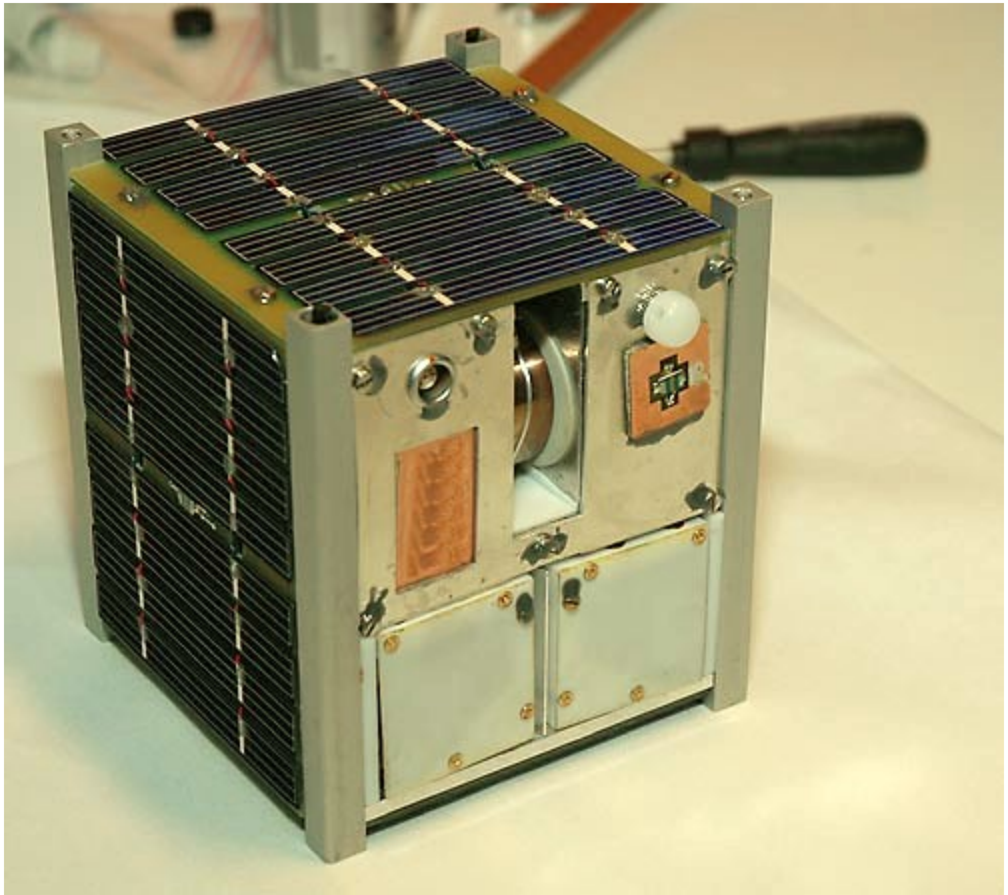
NASA/JPL

Particle Sample Acquisition

Aerogel Cross-Section

NASA/JPL

Proposed CubeSat Platform



1U CubeSat

Pedersen, 2007

Proposed CubeSat Platform

Low cost

Fast Development Cycle

Multiple Launch Opportunities
(Tag-Along Satellites)

Proposed CubeSat Platform

1U CubeSat Standard

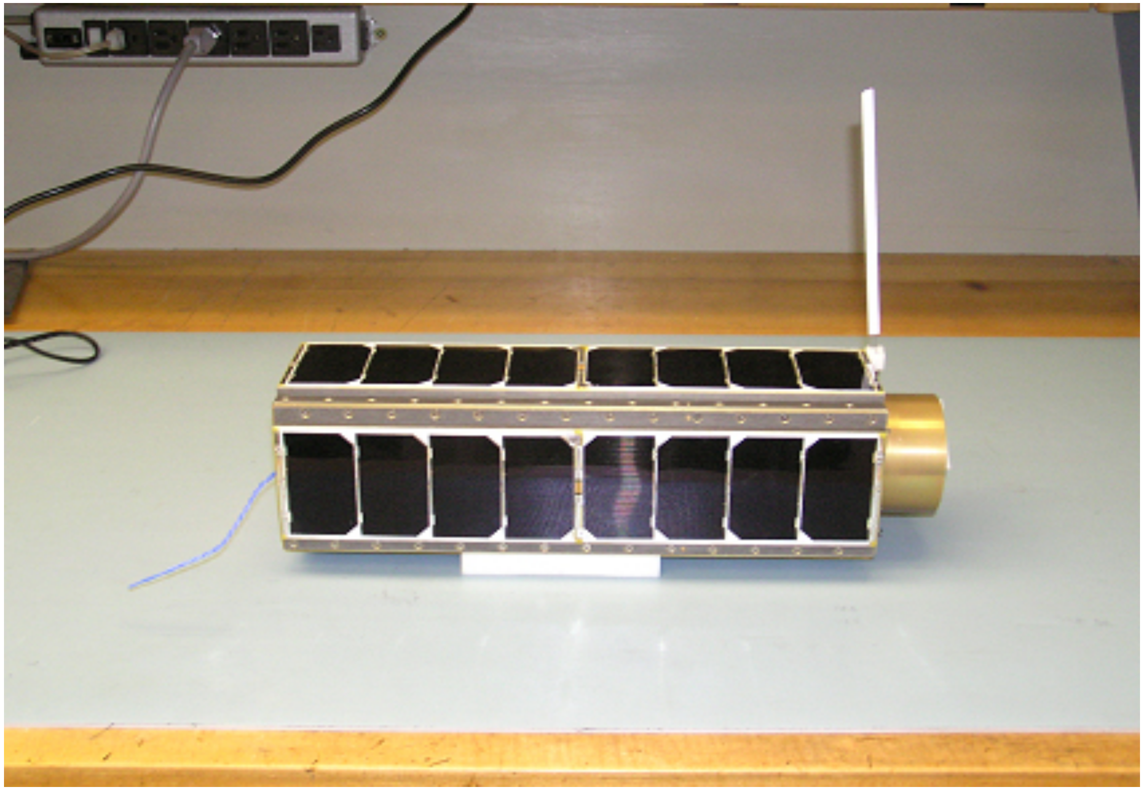
Overall Dimensions:

10 cm X 10 cm X 10 cm

Maximum Weight:

1 kg

Proposed CubeSat Platform



NASA's GeneSat

(3U CubeSat)

NASA, 2007

Proposed CubeSat Platform

At least one Side Panel:

Silica Aerogel

3.5” X 3.5” X 1.5”

(8.89 cm X 8.89 cm X 3.81 cm)

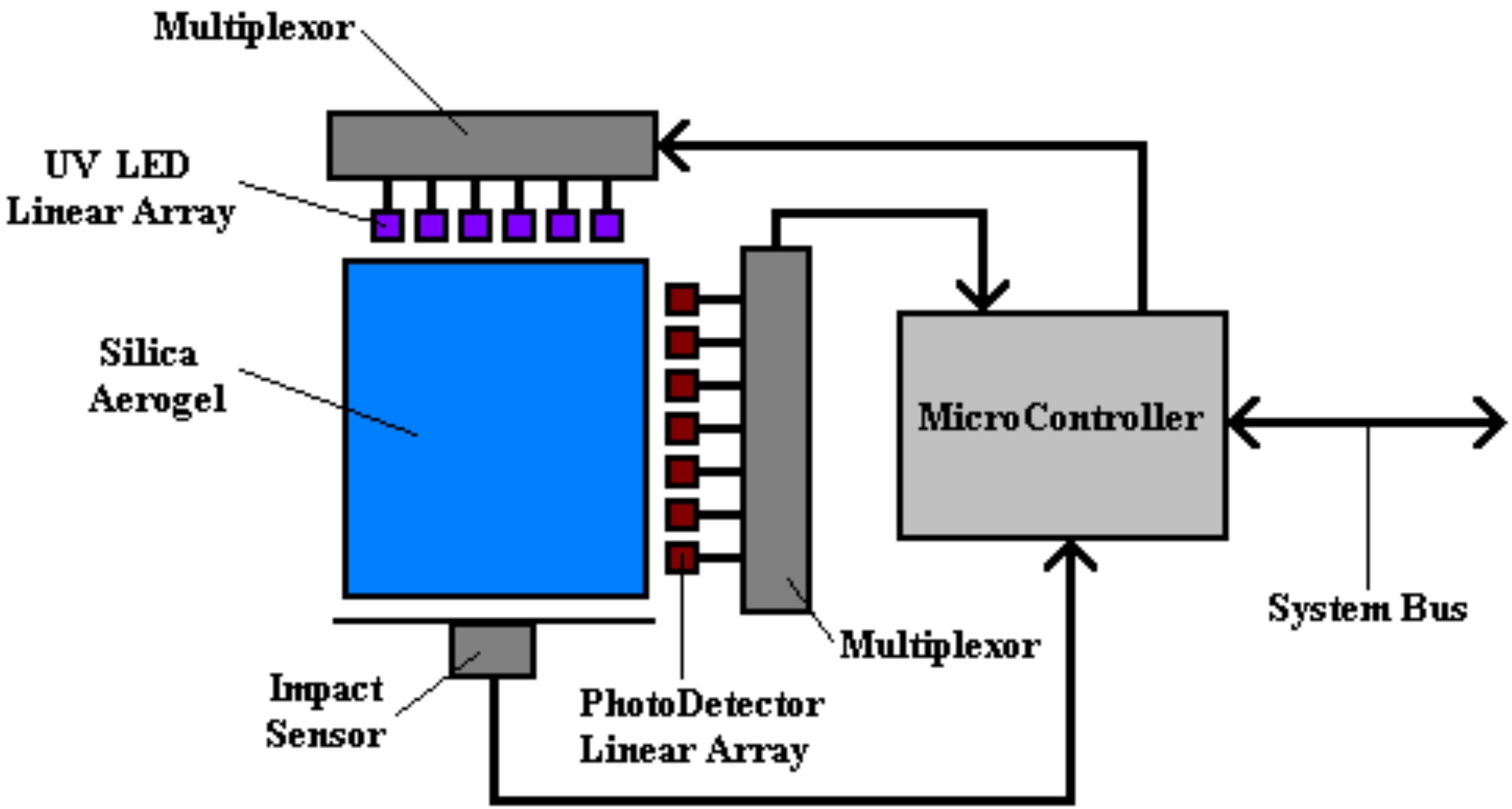
Particle Identification

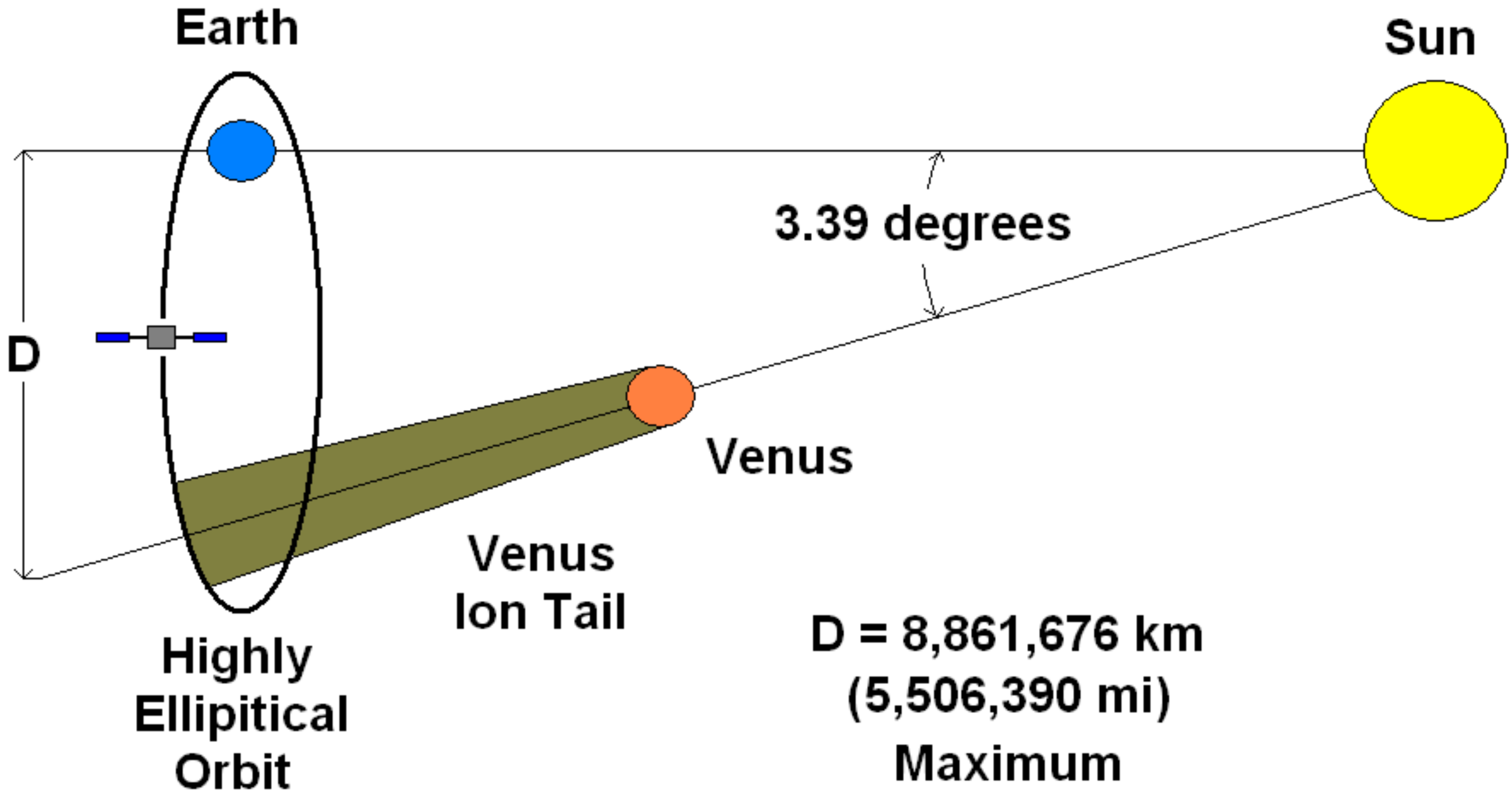
UV Induced Fluorescence

of Organic Compounds

Characteristic of Microbes

Particle Capture and Identification





Radial Alignment (Inferior Conjunction)

occurs about every 584 days

Potential Problems

Detection Non-Specific to Life

Possible Significant Background Signal (Carbonaceous Chondrites, Anthropogenic Sources)

Use of a Sampling Shutter

Conclusions

Solar Wind is eroding the upper Atmosphere of Venus, perhaps carrying away Indigenous Cloud-Life Microbes

Earth will next pass through the Venusian "Cometary Tail" during today's Transit

Conclusions - continued

It may be possible to Detect these putative Venusian Microbes from Earth Orbit

Due to the potentially High Arrival Velocity, Silica Aerogel is proposed as a Sample Collection Medium

Conclusions - continued

Ultraviolet Stimulated Fluorescence
is proposed to Identify Organic Components
in Samples collected by the Aerogel

It may be possible to Correlate
Fluorescence Signatures with a
Biotic Fingerprint

Conclusions - continued

The CubeSat Platform provides
a Low Cost, Fast Response approach
to test these concepts.