Venus Atmosphere Observation Mission by Venus Entry Probe and Water-Vapor Balloon

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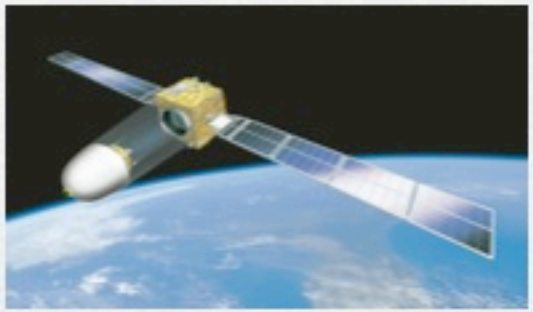
Imamura, T., Nakamura, M., and Venus Probe Study Group.

ISAS/JAXA

ISAS/JAXA Reentry Missions

Reentry Guys ISAS have been engaged in...



What's Next ?
we would answer
Planetary Entry !

USERS/REV

dedicated to μG Experiment
ISAS cooperate with USEF on Research Activities
Launched Sept/2002
Recovered May/2003

HAYABUSA

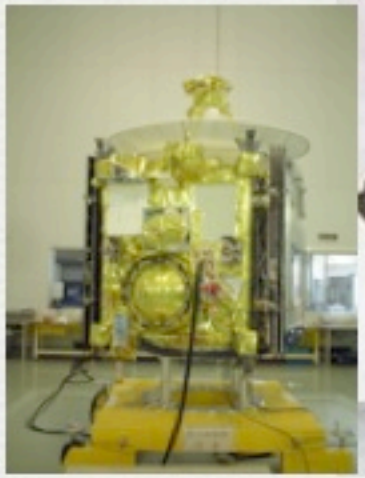
Asteroid Sample Return
Launched April/2003
Arrive at Asteroid Aug/2005
Return June/2007 => 2010

DASH

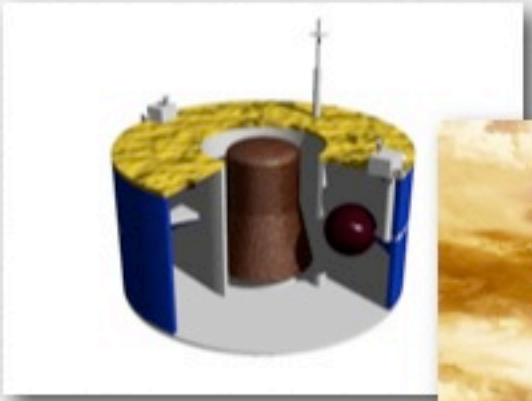
Launched Mar/2002
-Hyperbolic Velocity
-Precursor for M-C

EXPRESS

Launched Jan/1995
Reentry Tech. Acquisition

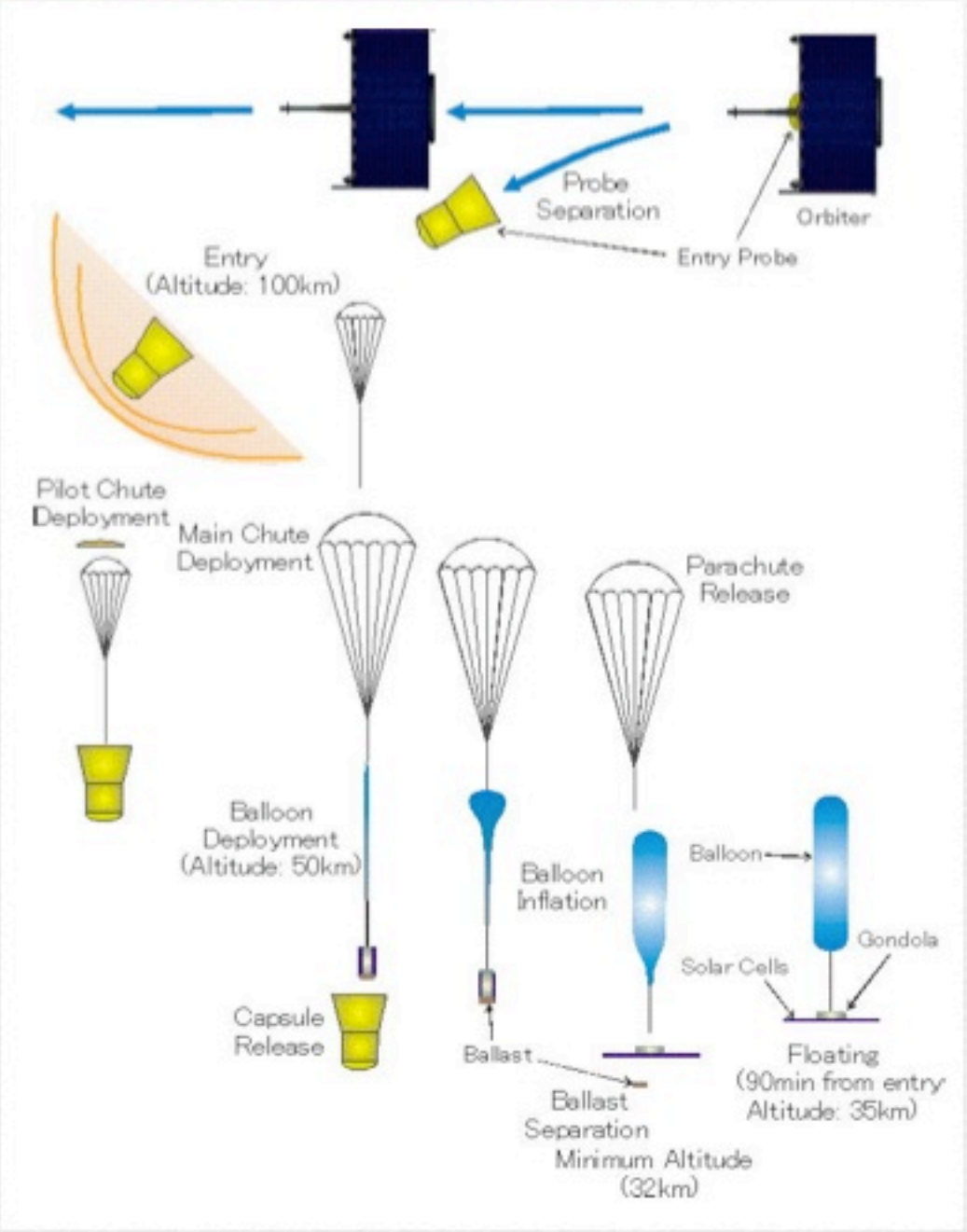


Venus Capsule and Balloon Missions

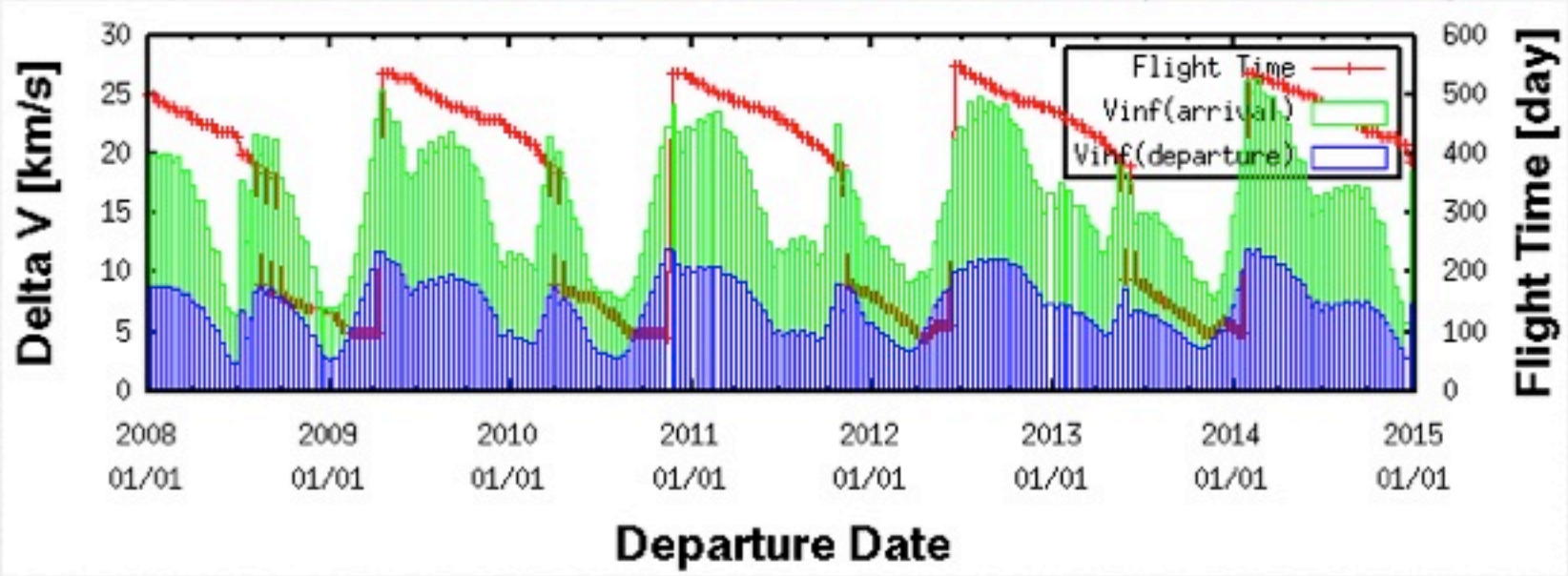


Mission Scenario

- Small Capsule enters Venusian Atmosphere directly from the interplanetary trans. orbit.
- The water-vapor Super-pressure Balloon released at H=45km.
- and is fully-expanded at H=35km under the Cloud.
- Long-term (over 2 weeks) Wind Observation is to be carried out by means of Precise VLBI Positioning from the Earth



Launch Window (2009-)



Launch	Type	Swing-by	Venus Arrival	C3	Arrival Velocity	Flight Time
2009/1/11	**Direct**	**-**	**2009/5/28**	**3.2km/s**	**5.3km/s**	**137day**
2009/2/25	**S-EGA**	**2010/2/25**	**2011/4/11**	**3.7km/s**	**6.3km/s**	**775day**
2009/7/25	**EGA**	**2010/7/25**	**2010/12/2**	**2.8km/s**	**5.1km/s**	**495day**
2010/7/23	**Direct**	**-**	**2010/11/27**	**2.9km/s**	**5.4km/s**	**127day**
2011/3/16	**EGA**	**2012/3/16**	**2012/7/14**	**3.4km/s**	**6.3km/s**	**475day**
2012/11/6	**EGA**	**2013/11/6**	**2014/2/14**	**3.8km/s**	**4.8km/s**	**465day**

2009年以降のDirect Ascentでの金星へのウィンドウは2回（$C3<16km^2/s^2$）.

それ以外の場合は1年周期軌道を経て地球スイングバイを行う必要がある. **One-circulation around the Sun**

Spacecraft Specification

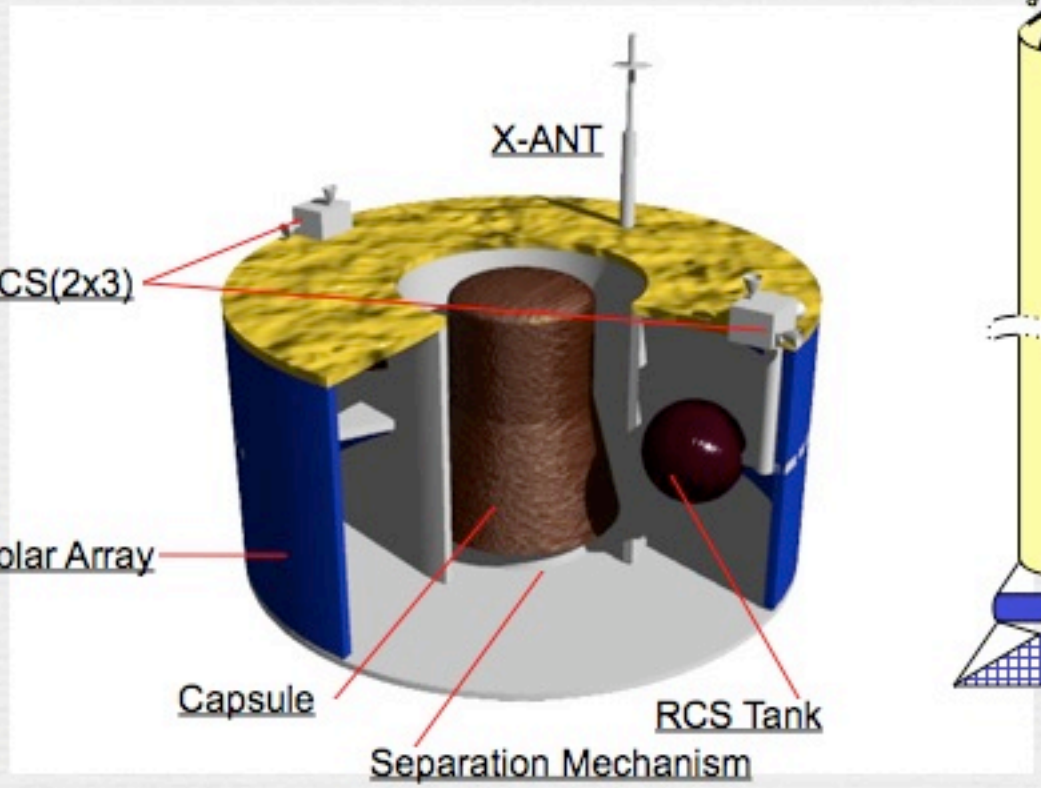
Spacecraft Size

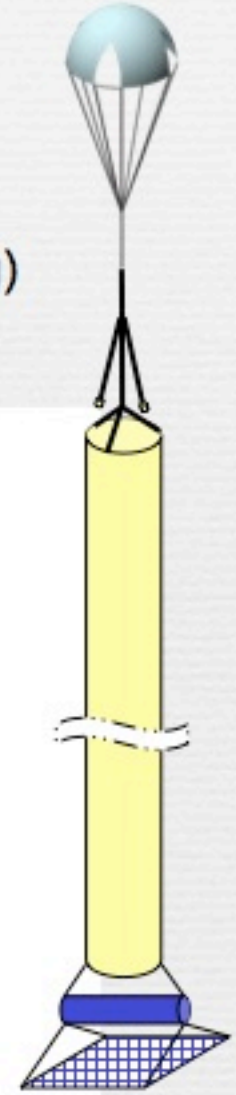
・Mothership : φ1.4m × H0.7m, total 150kg

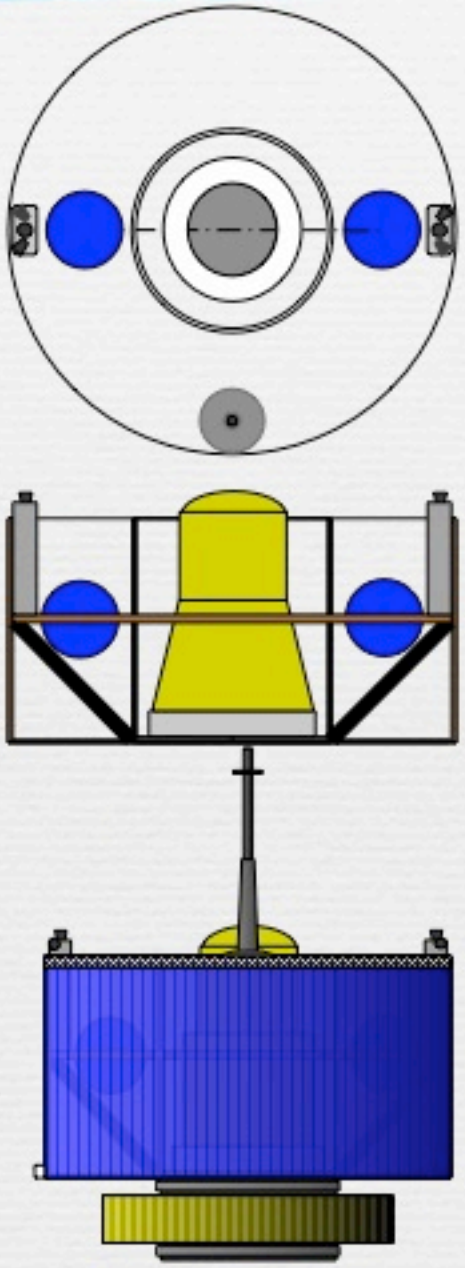
includes

・Carrier/Aerocap : φ1.0m × H0.2m

・Capsule : φ0.5m × H0.6m, 35kg+SEP(5kg)







Solar Sail Carrier

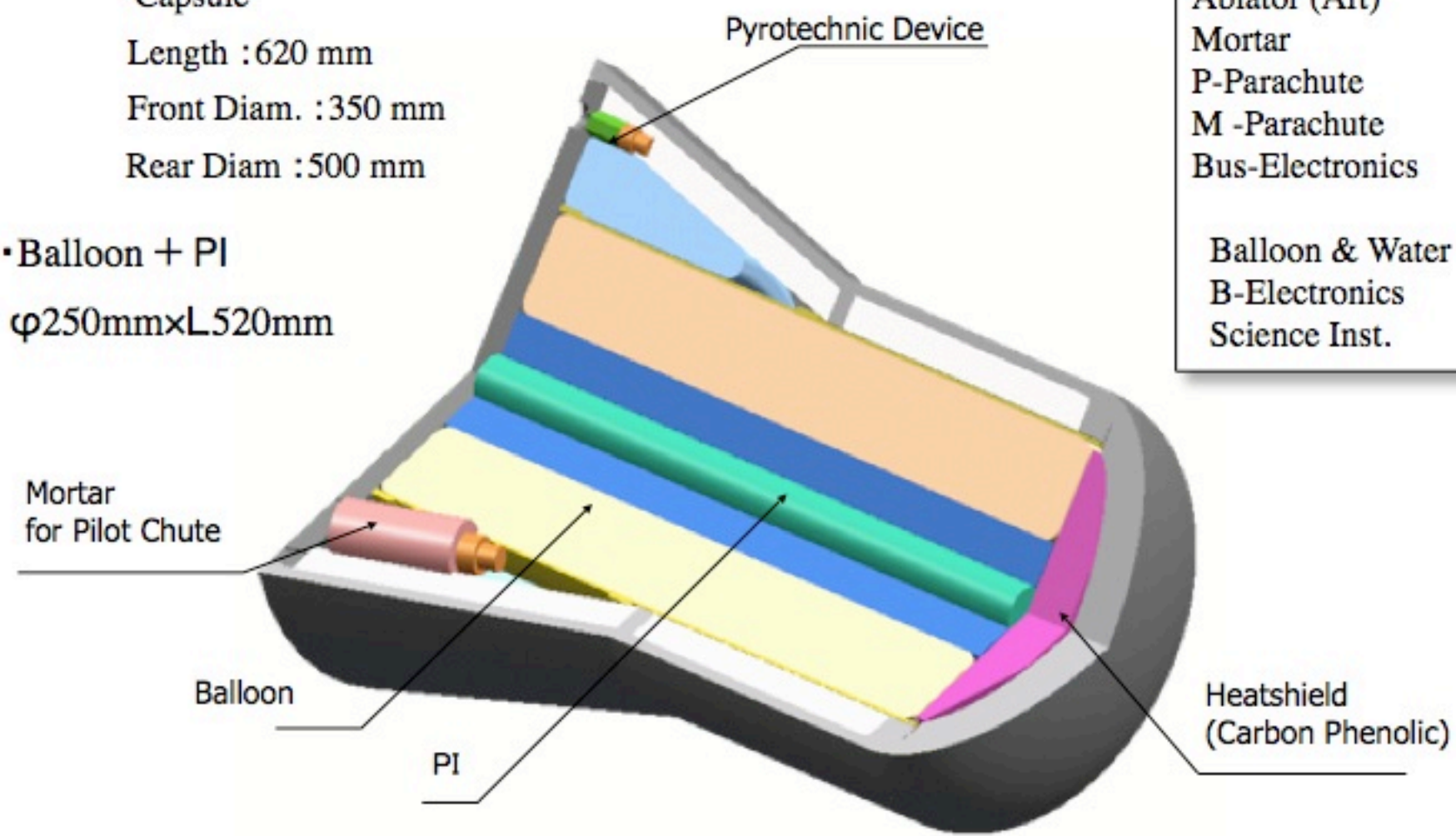
Venus Entry Capsule

Fast Descending Request
BALN accommodation => Hi-β CPSL

- Capsule
  Length : 620 mm
  Front Diam. : 350 mm
  Rear Diam : 500 mm

- Balloon + PI
  φ250mm×L520mm

Total Weight	**35 kg**
Ablator (Front)	17 kg
Ablator (Aft)	4.5 kg
Mortar	0.6 kg
P-Parachute	0.3 kg
M -Parachute	0.7 kg
Bus-Electronics	1.9 kg
Balloon & Water	8 kg
B-Electronics	1 kg
Science Inst.	1 kg



Spacecraft Weight Allocation

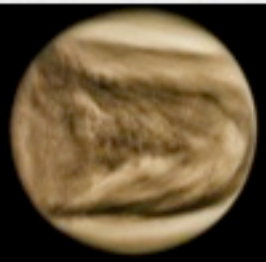
Power Supply Unit :	9.5 kg
Communications :	8.5 kg
DHU:	4.5 kg
AOCS:	15.7kg
Electric Instrument:	4.0 kg
Structure:	24.0 kg
Thermal Control:	6.0 kg
Capsule (w/SEP mecha):	40.0 kg
Solar Sail Carrier (Aerocapture Devce)	38.1 kg
Total	150.3 kg

Key Development Issues

- Venus Entry Probe transports the water-vapor Super-pressure Balloon at H=45km.
- Balloon floating at H=35km conducts Venusian Atmosphere

- T=460°C, P=90atm (Surface
- T=200°C (@H=35km)
- H2SO4 Cloud (H47-70km)

※Significant Long-term Observation at Low Altitude

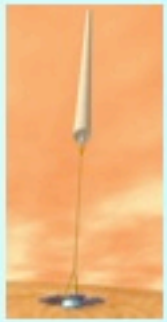


●Venus Entry Probe

- Entry to the CO_2 Atmosphere
  - Flight Environment Estimation
  - Aerothermal Design of the System
- Development of Heatshield
  - Development of High Enthalpy CO_2 Generator
- Descent System <= Ref) Hayabusa Capsule

●Water-vapor Balloon System

- Long-term Observation up to 2weeks
- Multi-layered Balloon Films (Gas Barrier, Light-weight, Strong)
- Efficient Heat-exchange Expansion



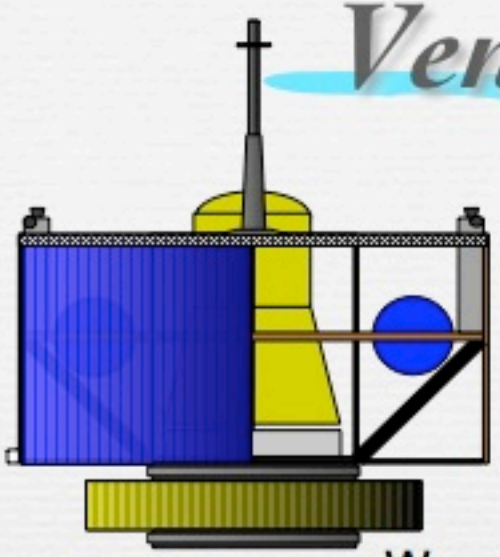
●Positioning of the Balloon Probe

- Narrow-band VLBI at Hight Temperature Environment
  => Higher Stability of the Oscilator

●High Temperature Electronics

- Operable in 200°C Environment (Solar Cell, Batteries, Transmitter with High Stability Oscillator, other SOI Devices)

Venus Entry Conditions



W : 160 kg
Size : φ1.4 x H0.7 m
Cap (BALN,PI) : 35kg

Direct Entry

Entry Condition

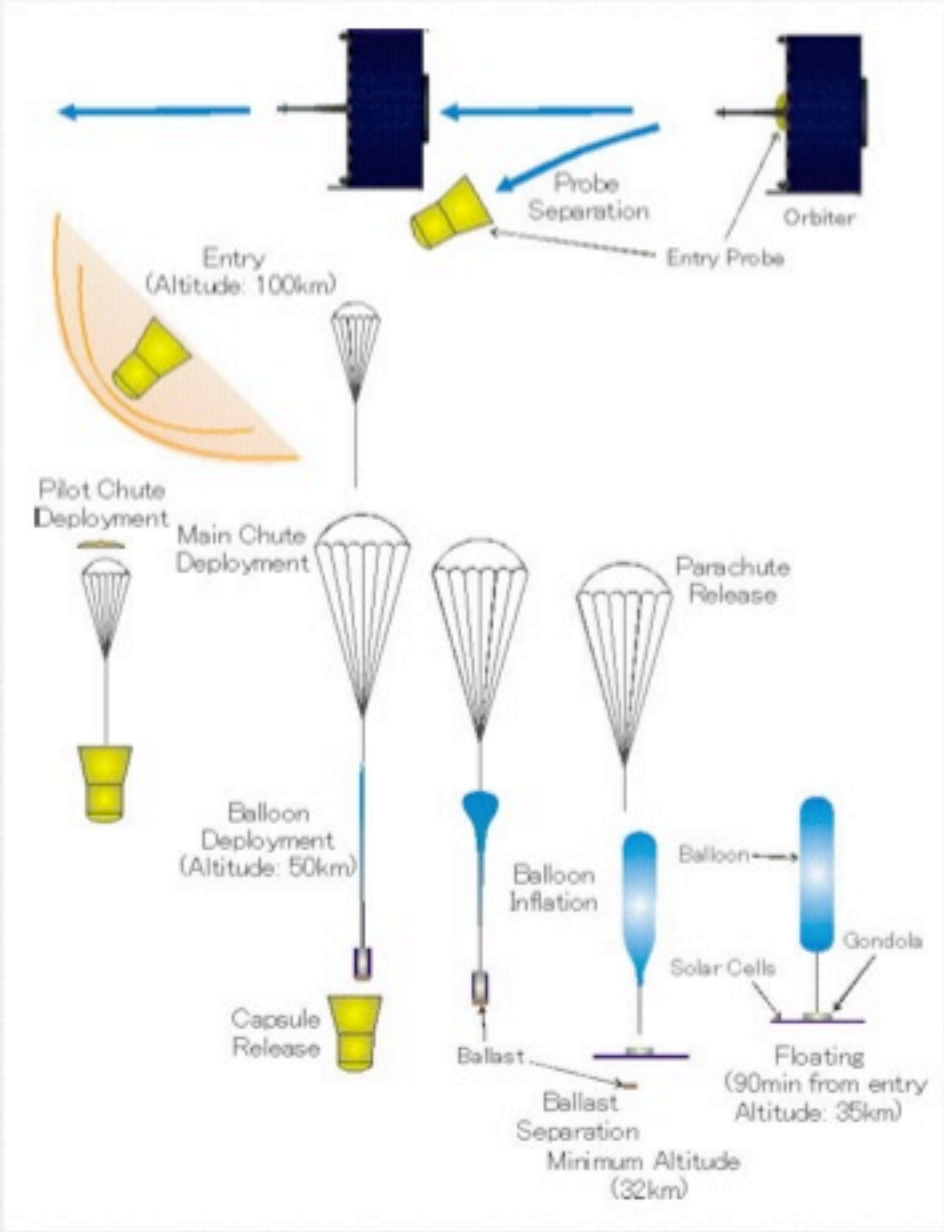
V0=11.5 km/s, γ ~ 15 deg

VLBI Positioning Resolution: ~1μrad

→ ~100 km @1x10^8 km

※Entry Point Control Accuracy

: 50 ~ 100 km

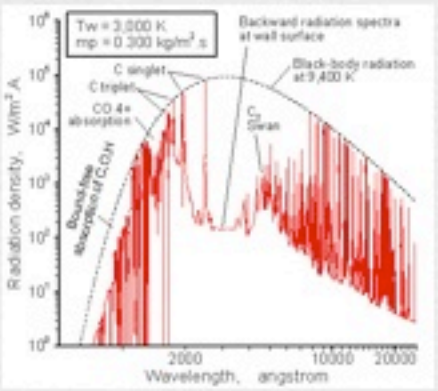


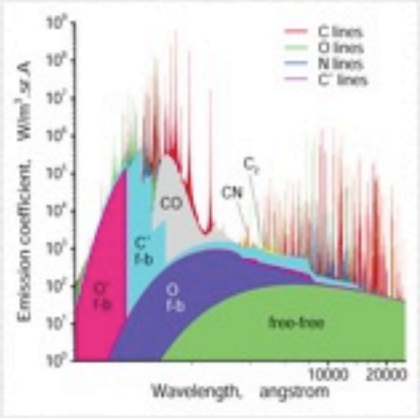
Aerothermal Studies on VEP

High Speed Entry into CO_2 Atmosphere
- Estimation of the Flight Environment

飛行環境予測
- Development of CO2 CFD Code
  - –23 species,53 reactions
  - – with Radiation–coupled Analysis
- Spectroscopic Code Varidation

輻射の波長分布例



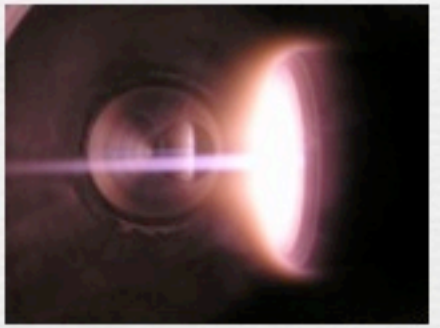


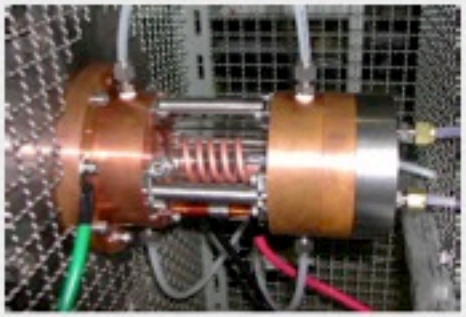
qc: 8MW/m², qr: 12MW/m² (Rn=0.4m)

Further Issues
Obtain More Spectroscopic Data

Characterization of the ICPG
- Generation of High Enthalpy CO_2

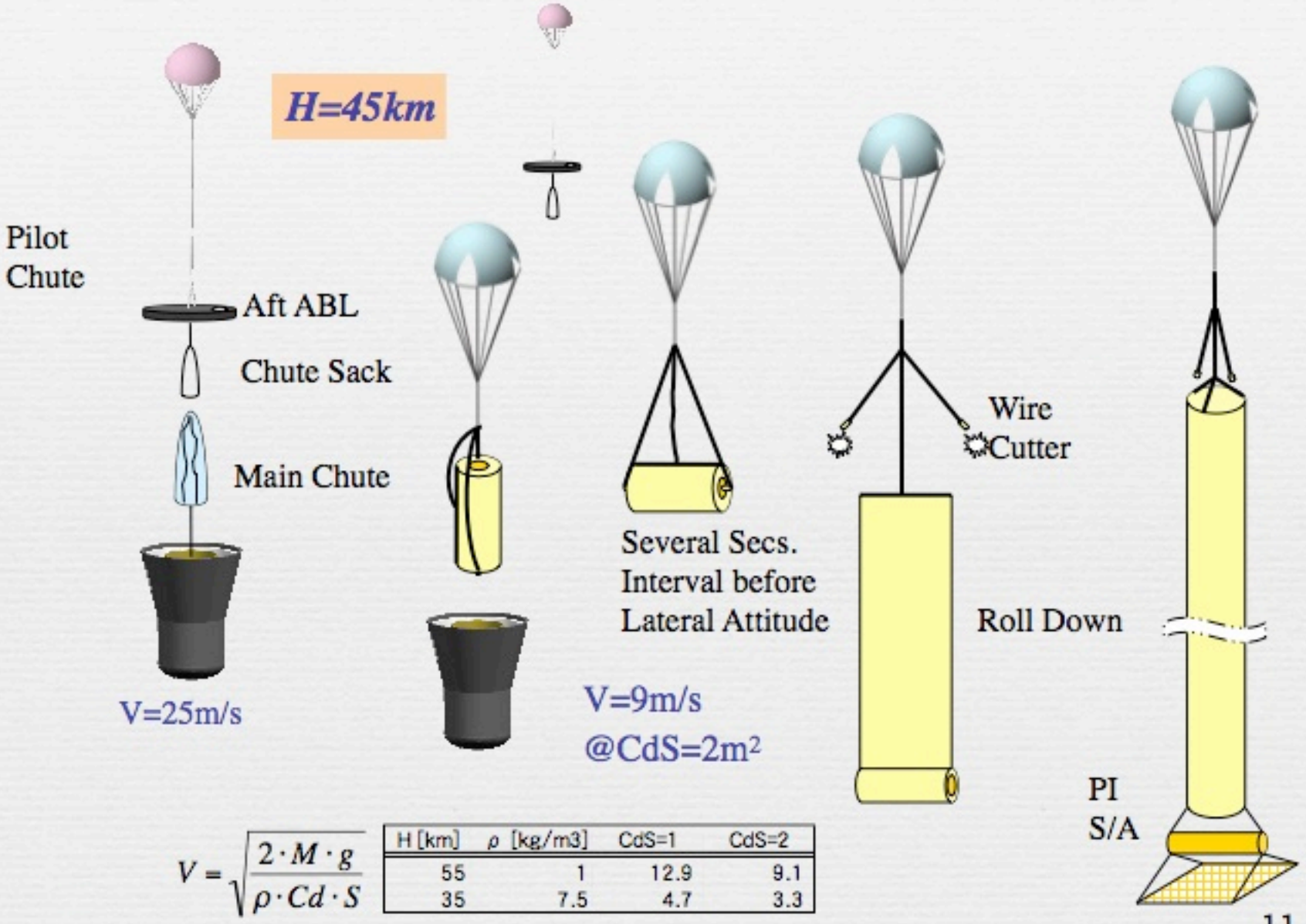
13.56MHz Induction–coupled Plasma Generator
- CO2 : Enthalpy up to 30MJ/kg accomplished
- High Pressure Operation :
  Plenum Pressure up to 30kPa





Further Issues
- Measurement Accuracy
- Simulated Environment Characterization

Balloon Extraction Sequence



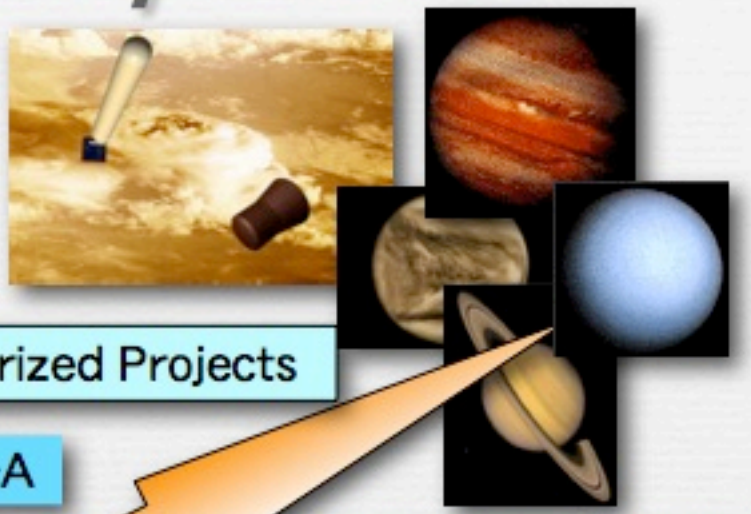
$$V = \sqrt{\frac{2 \cdot M \cdot g}{\rho \cdot Cd \cdot S}}$$

H [km]	ρ [kg/m3]	CdS=1	CdS=2
55	1	12.9	9.1
35	7.5	4.7	3.3

Venus Balloon Development

Planetary Probe Technology to be learned

- Entry Environment Estimation and Heatshield
- Heat-exchange expansion Balloon
- Deceleration System at High Atmos. Altitude
- High Temperature Electronics
- Precise Positioning of Small Probes (VLBI etc.)



Authorized Projects

Phase-A

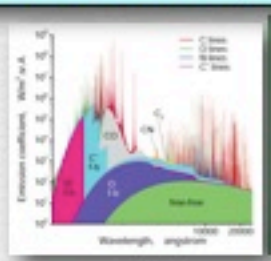
WG Proposal

WG

Project:
Planetary Probe

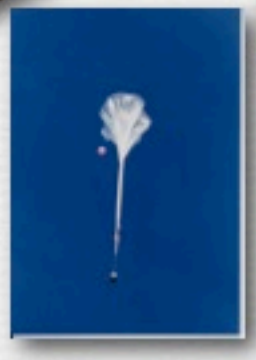
07FY

Pre-WG Study Group

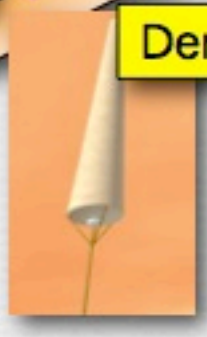


06FY

Demonstration

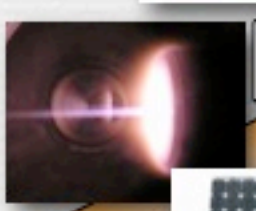


Drop Test:
Balloon Expansion



Scaled Model
Ground Expansion Simulation

05FY



Basic Study

M-V to Next Solid Propellant Rocket

- M-V (LEO:1.8t) ceased with M-V-7 Solar Observation Sat. 'Hinode' on Sept. 23, 2006.

- 'M-V Successor'

  Solid Propellant Rocket Tech.

  will be succeeded by the next solid propellant rocket.

- Japanese Launch vehicle Lineup

  is planned to change to

  H-IIa, GX, and M-V successor ?!

Last M-V (#7) Launched on Sep.23 , 2006