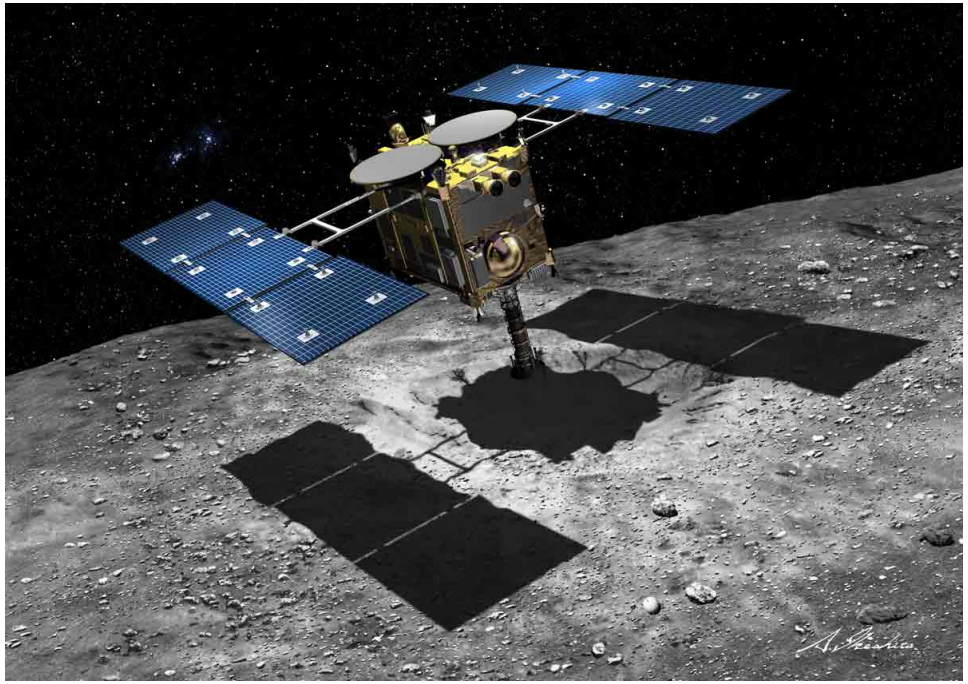
Hayabusa2



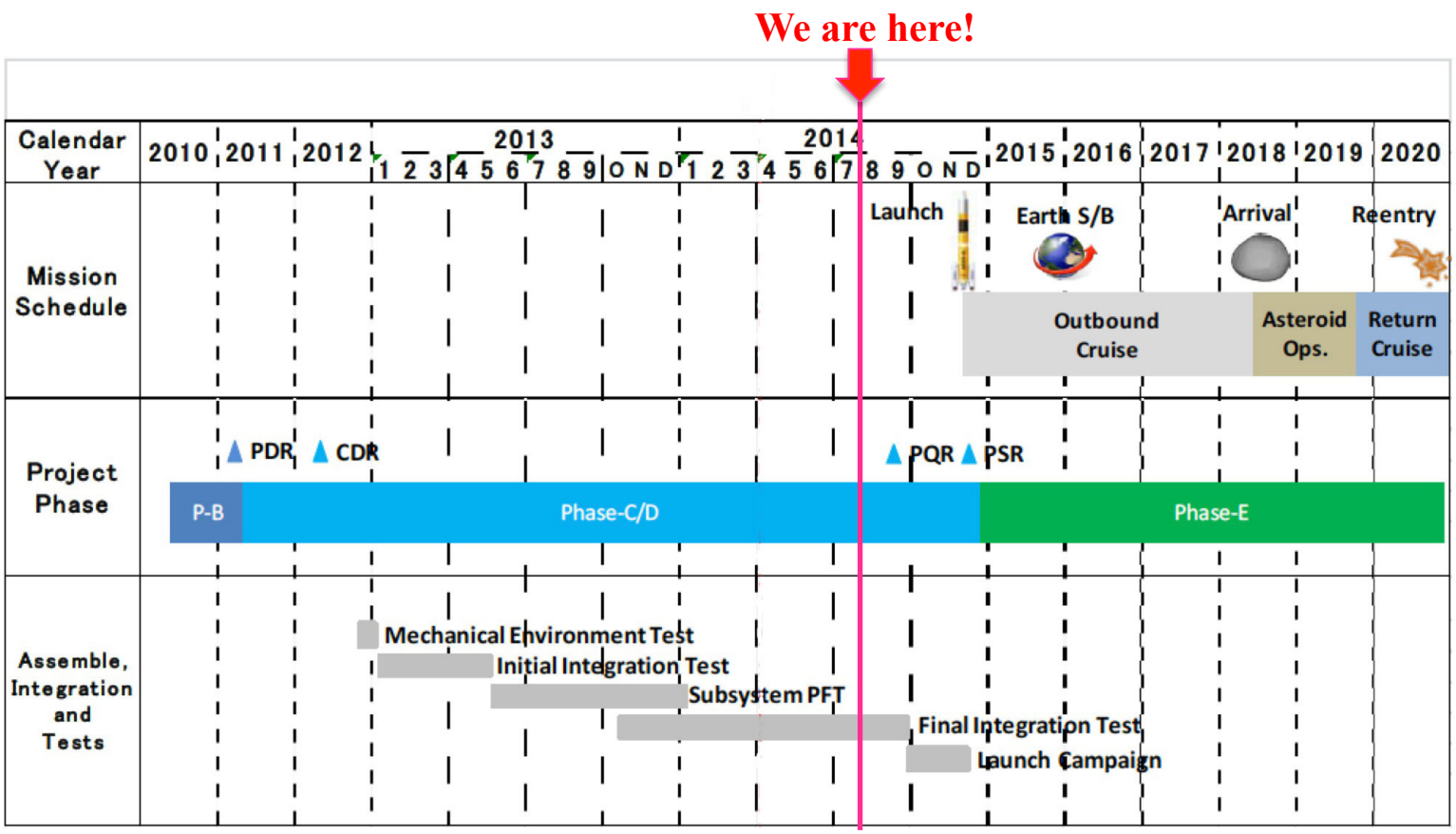
SBAG, Washington DC, USA
29 July 2014

Presented by Paul Abell

H. Kuninaka, N. Inaba, Y. Tsuda, M. Yoshikawa (JAXA)

Current Status

- We are now doing final integration test, which will be continued to September.
- Then the spacecraft is shipped to Tanegashima Space Center.
- The launch is scheduled in the winter of 2014.



Objectives : Hayabusa vs Hayabusa2

Hayabusa

Technological demonstrator

- Round-trip to asteroid
- Sample return

Engineering

- Ion engine
- Autonomous navigation
- Sample collection
- Reentry capsule

Science :

Origin and evolution of the solar system

- Remote sensing observation
- Sample analysis

S-type Asteroid

Hayabusa2

1. Science

- Origin and evolution of the solar system
- Organic matter, H_2O

2. Engineering

- Technology : more reliable and robust
- New challenge : ex) impactor

3. Exploration

- Extend the area that human can reach
- Spaceguard, Resources, Research for manned mission, etc.

C-type Asteroid

Hayabusa2 Mission Outline

Launch

2014

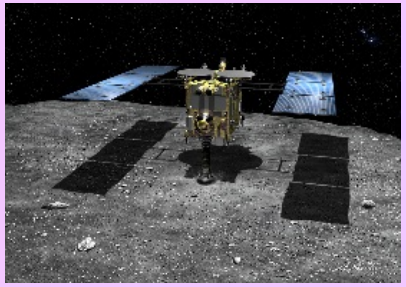
July 2018 : Arrival at 1999 JU3

Sample analysis

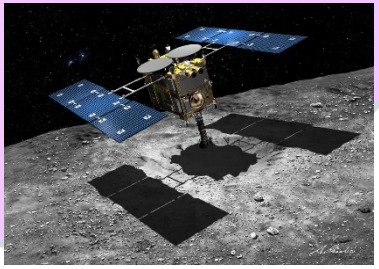
- *In-situ remote science*
- *Rovers deployment*
- *Surface Sampling*
- *Impact*

Earth Return

Dec. 2020



Dec. 2019 : Departure



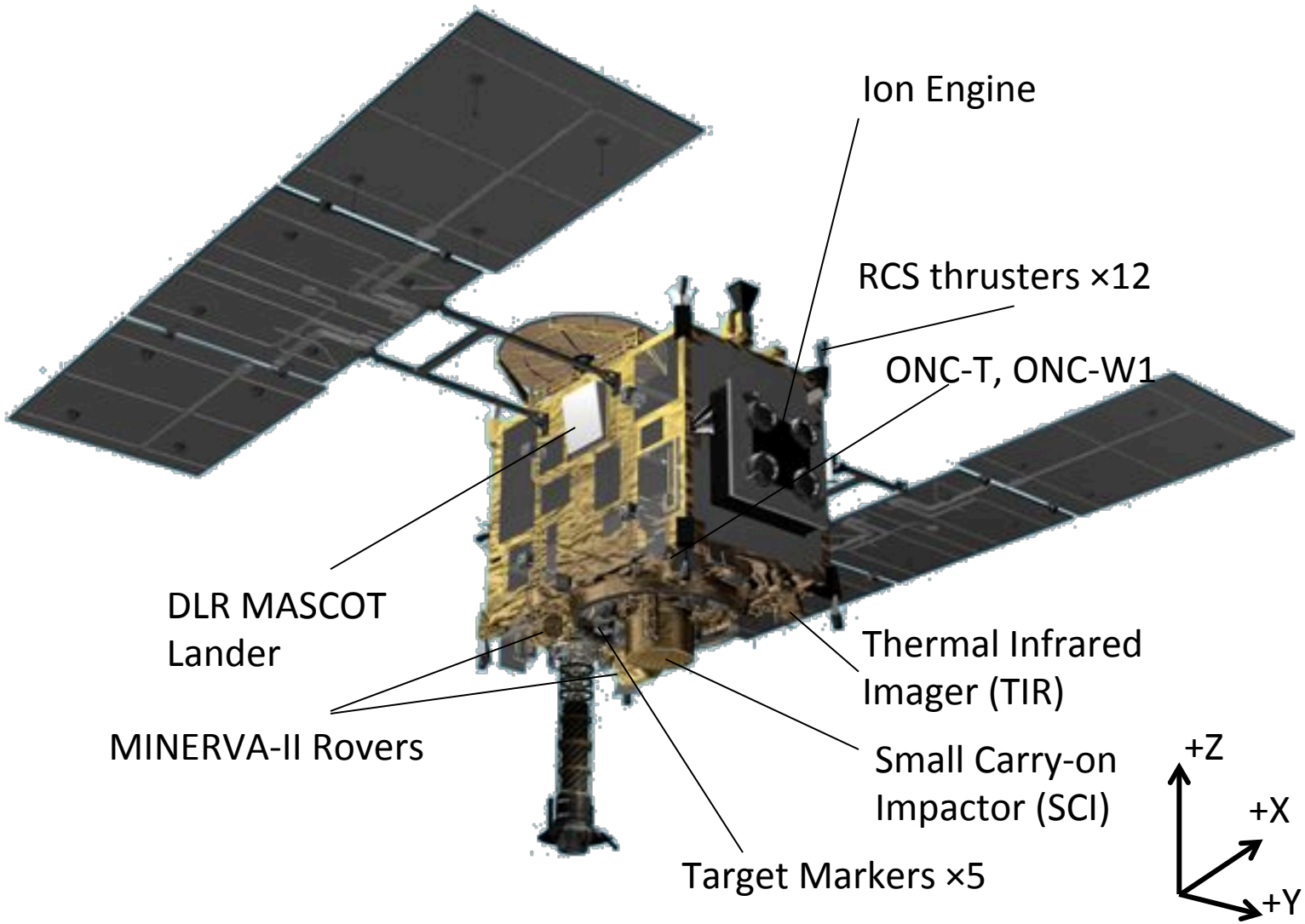
Summer 2018 – Winter

Hayabusa2 Mission CG

External View of Spacecraft (1/2)

Size : 1m×1.6m×1.25m (body)
Mass : 600kg (Wet)

External View of Spacecraft (2/2)



Spacecraft System Specifications

Structure	-1.6m × 1.0m × 1.4m(Height) box structure with two fixed SAPs -Mass 600kg(wet), 500kg(dry)
Data Handling System	-COSMO16 based DHU-PIM bus system -Onboard autonomous command generation feature -1Gbyte Data Recorder
Attitude and Orbit Control System	-HR5000S based processor, Double redundant. -4 Reaction Wheels, 2 IRUs, 2 Star Trackers (STT), 4 Coarse Sun Aspect Sensors (CSAS), 4 accelerometers (ACS). -Sensors for Proximity Operation LIDAR, LRF, 5 Target Makers (TM), Flash lamp (FLASH) -Optical Navigation Cameras (ONC) Wide: ONC-W1, ONC-W2 (FOV 54deg × 54deg, 1Mpix) Telescopic: ONC-T (FOV 5.4deg × 5.4deg, 1Mpix, 5 band filter)
Propulsion System	RCS -Bi-propellant hydrazine system - 20N thruster × 12. IES -Xe microwave discharge ion engine system -Maximum thrust 28mN, Isp=2800sec. -4 thruster heads on gimballed stage -3 operative at once (4/3 redundant)

Communication System	-Xband TT&C (Coherent Xup/Xdown), 8bps-32Kbps, Double redundant. -Kaband Telemetry (Coherent Xup/Ka-down), 8bps-32Kbps -Normal/Regenerative Ranging System -DDOR support -1 X-HGA, 1 Ka-HGA, 1 two-axis gimballed X-MGA, 3 X-LGA
Power System	SAP -1.4kW@1.4AU, 2.6kW@1AU. BAT -Li-ion Battery 13.2AH. Power Bus -Series Switching Regulator(SSR) System, 50V Bus.
Mission Payload	-Sampler Horn (SMP) -Small Carry-on Impactor(SCI) -Near Infrared Spectrometer(NIRS3) -Thermal Infrared Imager(TIR) -3 Rovers(MINERVA-II-1A/1B/2) -Lander(MASCOT) -Deployable Camera(DCAM3) -Reentry Capsule(CPSL)

Science Instruments

●Newly developed for HYB2

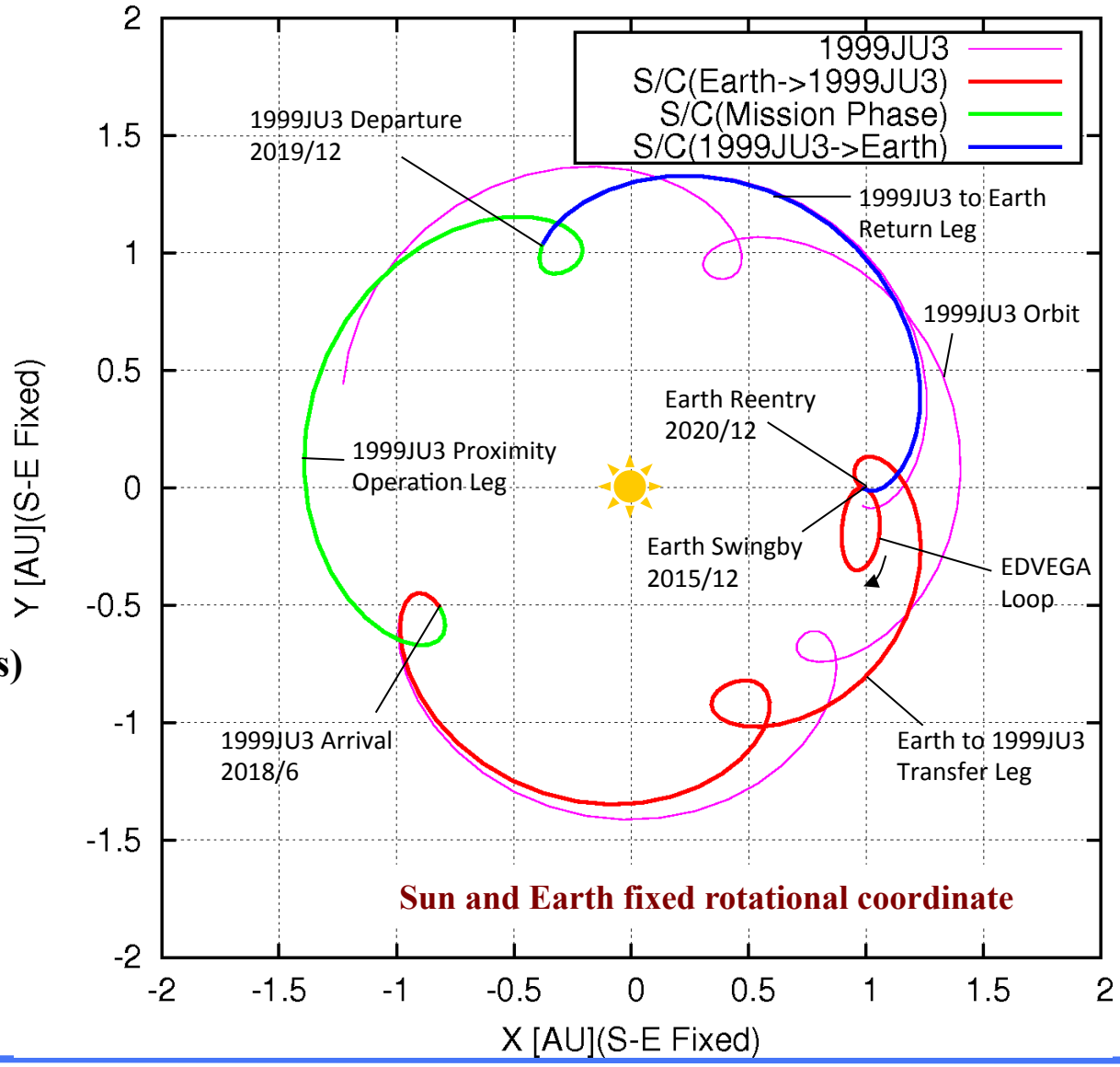
- **Sampler Horn**
  - Increased sample container rooms (2→3 rooms)
  - Metal seal adopted for gas-sealing performance
  - Several improvements in mechanical design to increase yield performance
- **NIRS3（Near Infrared Spectrometer）●**
  - Newly developed for HYB2
  - Observation wavelength 1.7-3.4μm. (Water)
  - Passive cooling
- **TIR（Thermal Infrared Imager）**
  - Planet-C (AKATSUKI)-derived component
  - Observation wavelength 7-14μm. (Thermal distribution, Hydrated minerals distribution)
- **Lander（MASCOT）●**
  - Developed and provided by DLR
  - 10kg surface exploration lander
  - Detail observation of local surface（MARA，MicrOmega，MAG，CAM）
- **Rover（MINERVA-II 1A / 1B / 2）●**
  - Developed by JAXA and a Japanese university consortium
  - Three 1.5kg class surface exploration rovers
- **Optical Navigation Cameras（W1/W2/T），LIDAR**
  - Multipurpose components both for bus and scientific operation
  - ONC：Global mapping/asteroid relative navigation，LIDAR：altimeter/gravity determination
- **Small Carry-on Impactor（SCI）●，Deployable Camera(DCAM) ●**
  - 18kg kinetic impact system (detonator+Cu liner+Electronics), 2kg impact mass at 2km/s impact speed.
  - Impact observation by IKAROS-derived DCAM(remote camera)

Trajectory Design

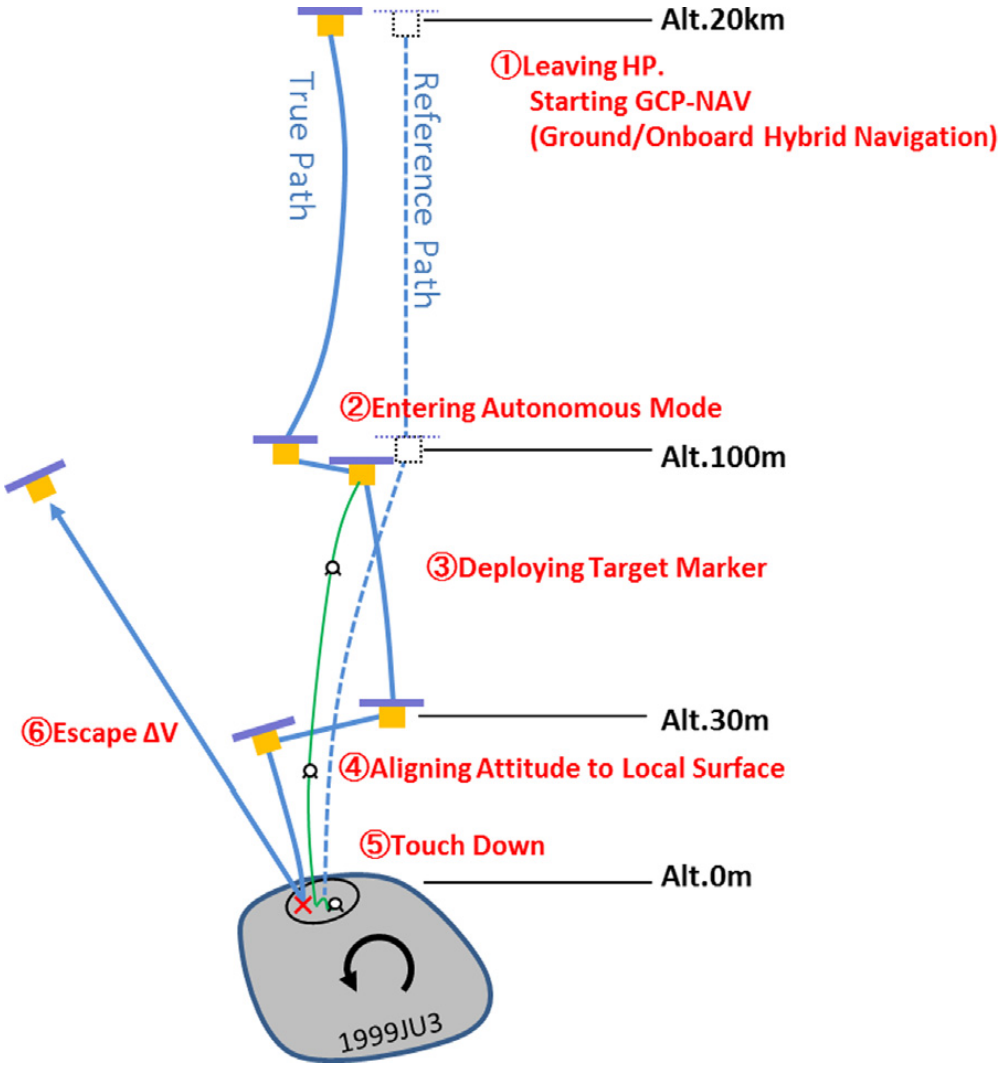
Earth Departure: 2014
Earth Swing-by: 2015/12
1999JU3 Arrival: 2018/7
1999JU3 Dep.: 2019/12
Earth Reentry: 2020/12

Departure C3=21km^2/s^2
IES Total Impulse=2km/s
Reentry Speed=11.6km/s

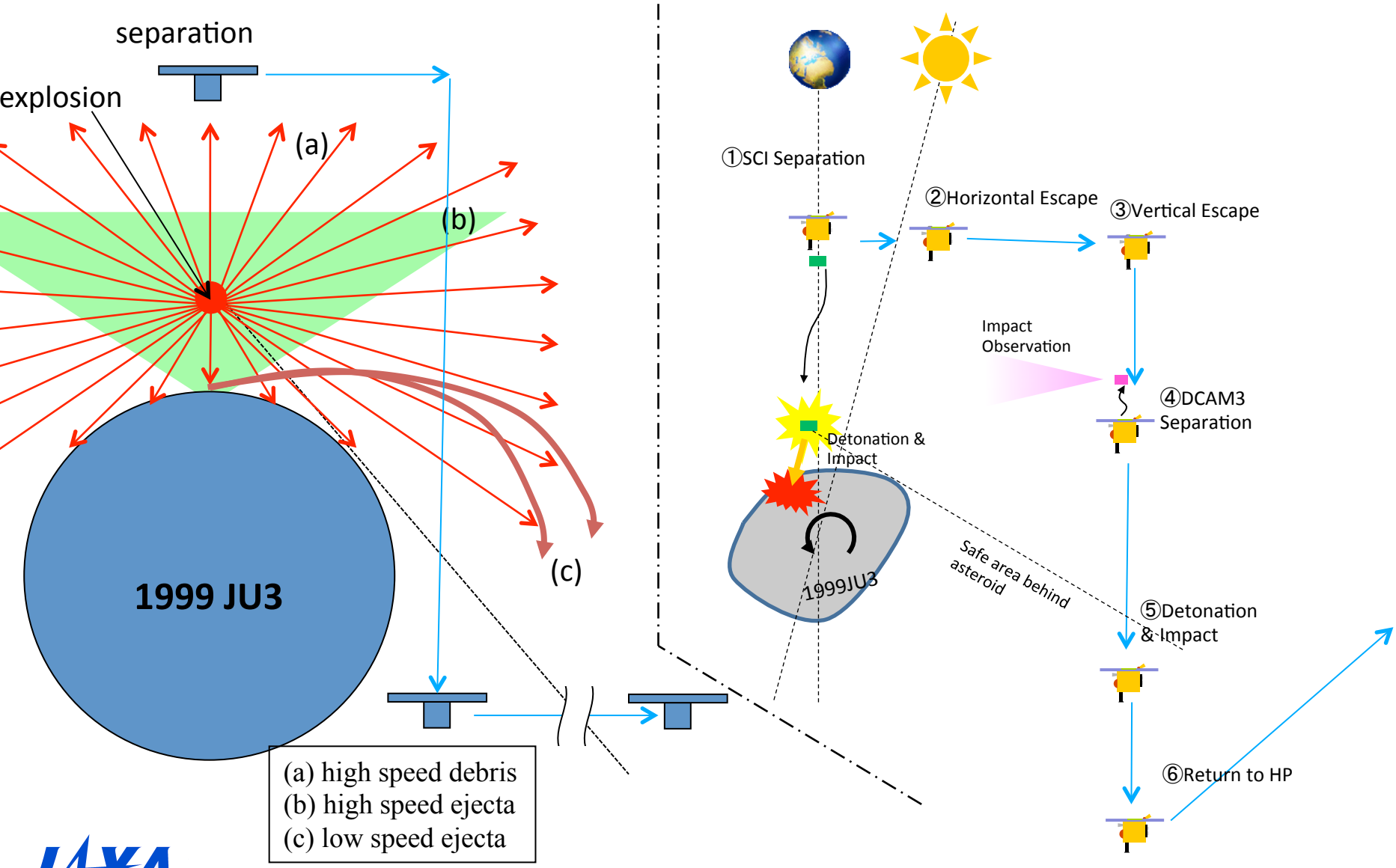
Total Flight Time=6yr
(Cruising 4.5yrs)
Total Powered Flight Time
=1.5yr



Sampling Operation Sequence

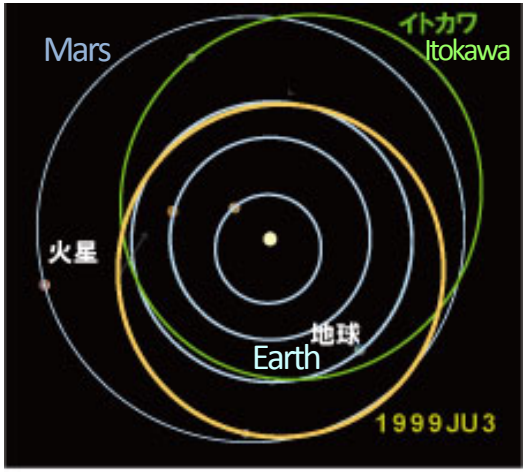


Artificial Crater Generation Operation



Target : (162173) 1999 JU_3

- C-type near-Earth asteroid
- Diameter: 0.9 km (nearly spherical?)
- Hydrated minerals, organic matter ?
- Origin: inner MB, ν_6 secular resonance Erigone Family (~300Ma) ?

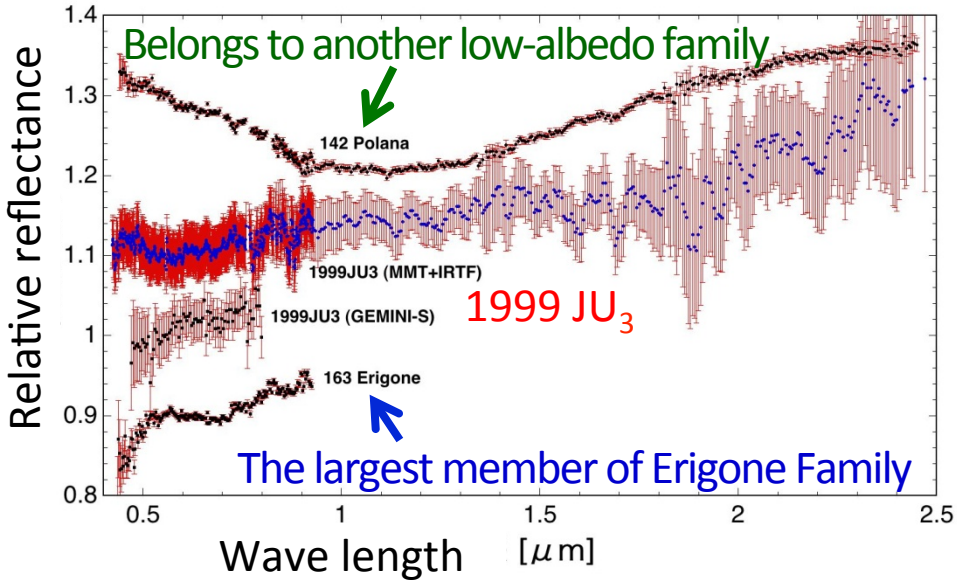


a = 1.19 AU, T = 1.30 yr
q = 0.96 AU, Q = 1.42 AU
e = 0.19, i = 5.88˚

P. Michel and M. Delbo 2010

H. Campins, et al. 2012

origin of 1999 JU3
92% ν_6
8% 3:1



Data from Vilas 2008, Sugita+ 2012, Abe+ 2008

Physical Properties of 1999 JU3

Observation results : by M. Ishiguro & D. Kuroda

(As of 2014 July)

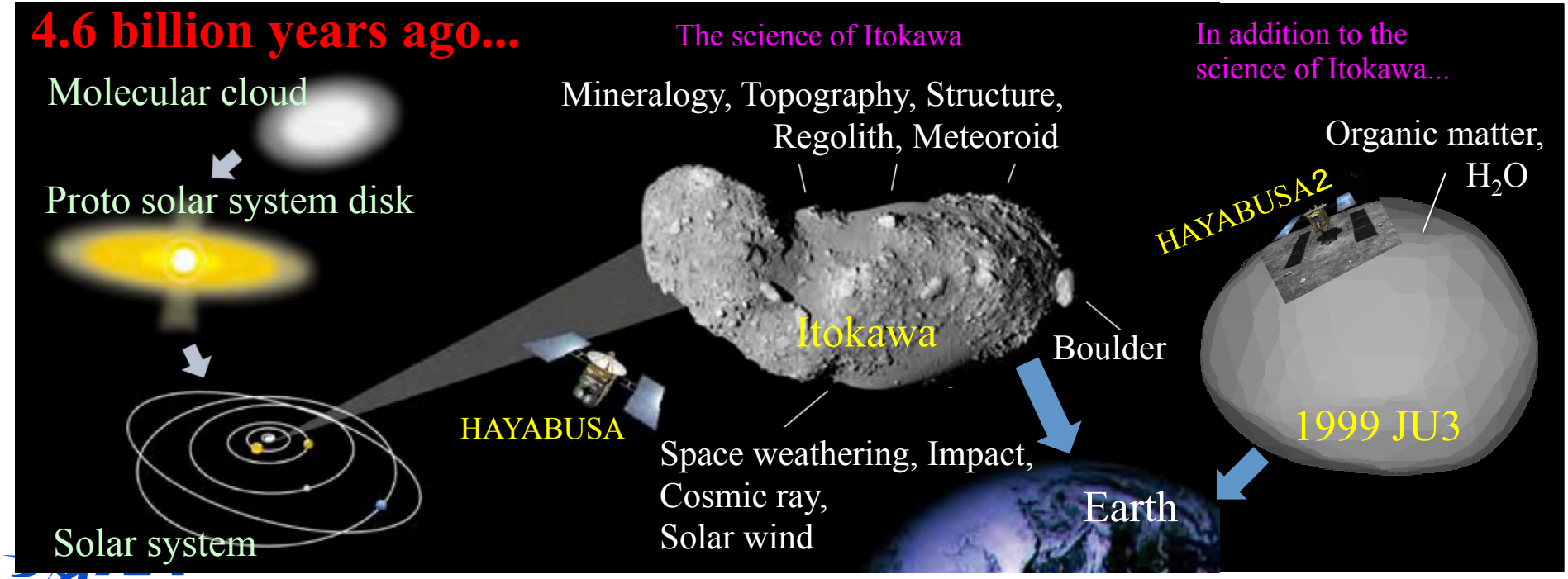
- Photometric Properties
  - Rotational period: 7.6312 ± 0.0010 hr (*1)
  - H_0 in V-band: 19.25 ± 0.03 (*2)
  - G parameter (α<30°): 0.13 ± 0.02 (*2)
  - Geometric albedo: 0.047 ± 0.003 (*1-2)
- Spectroscopic Properties
  - Spectral type: C-type (*3-6)
  - Absorption around 0.7 μm (*4)
  - Rotational variability: Not obvious (*5-6)
- Thermal Properties (*1)
  - Effective diameter: 875 ± 15 m
  - Thermal inertia: 250 ± 50 J m^{-2} $s^{-0.5}$ K^{-1}
  - Pole orientation: Probably retrograde (ongoing)

[1] Mueller et al. ACM 2014 [1] Ishiguro et al submitted [3] Binzel et al. 2001, Icarus 151, 139
[4] Vilas 2008, AJ 135, 1191 [5] Lazzaro et al. 2013, A&A 549, L2 [6] Moskovitz et al. 2013, Icarus 224, 23,

Science of Hayabusa and Hayabusa2

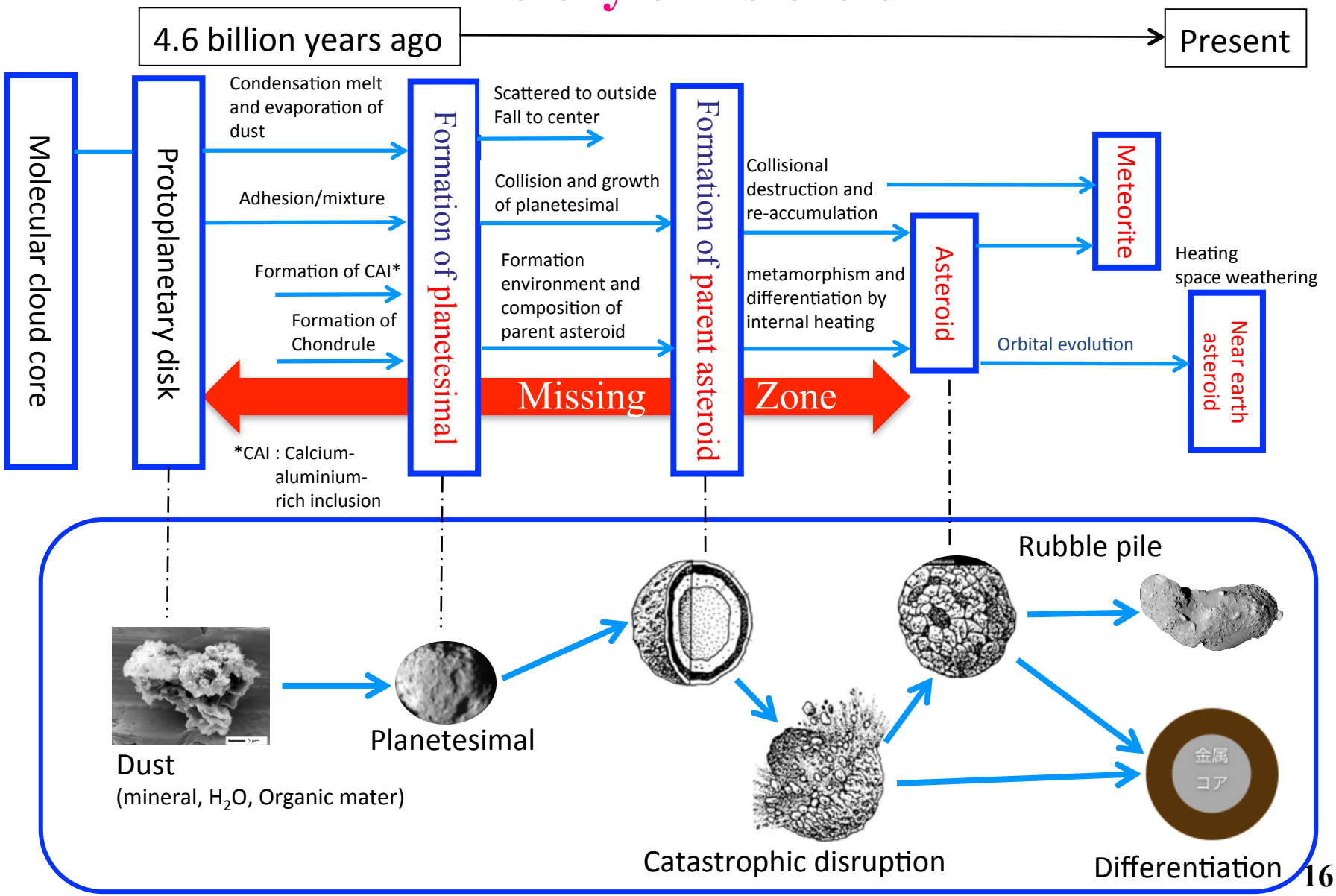
Study of the origin and evolution of the solar system

- Planetesimal formation : Destruction and accumulation
- Thermal evolution from planetesimal to near earth asteroid
- Diversification of organics through interactions with minerals and water on planetesimal
- Material circulation in the early solar system



Hayabusa2 will solve the "Missing Zone"

History of Asteroid



International Collaboration Structure

JAPAN

To NASA

- Membership of Hayabusa2 scientific committee
- Asteroid sample provision
- Accommodation of appointed personnel on mission ops.

and so on

LOA
↓
MOU

USA

To JAXA

- Heat shield test
- Deep Space Network support
- Radiometric navigation support
- Airborne Observation
- Cooperation with OSIRIS-REx

and so on

Australia

- Landing authorization

Europe

- Small Lander "MASCOT"
- ESTRACK tracking support

Hayabusa2 Joint Science Team (HJST) Meeting

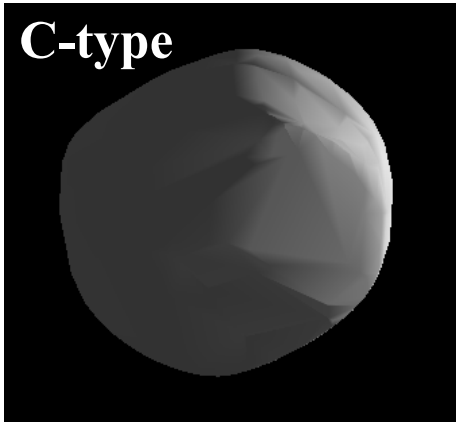
1st : November 26-27, 2012

2nd : September 19-20, 2013

3rd : March 18, 2014

Collaboration with OSIRIS-REx Team

Hayabusa2

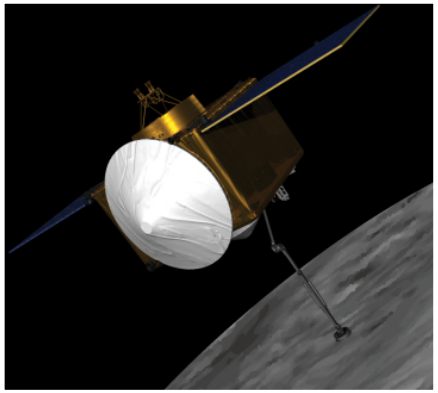


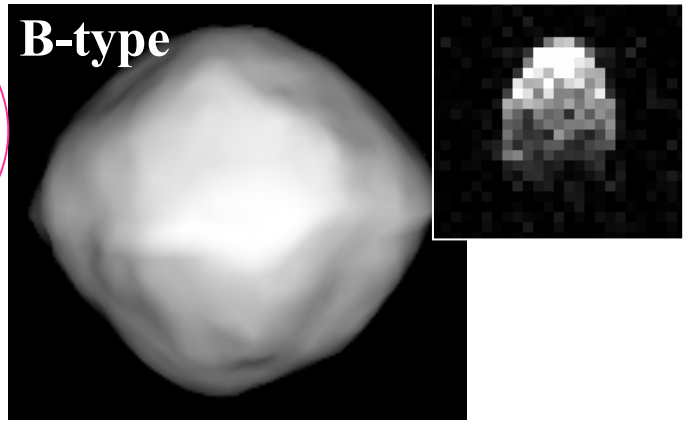
(162173) 1999 JU3

Collaborations

Science
Education
Outreach
...

OSIRIS-REx





(101955) Bennu

Summary

- Hayabusa2 is the modified spacecraft based on the lessons learned of Hayabusa, and it will aim for much more advance science to understand the origin and evolution of the solar system.
- We are now in the final stage in the integration of the spacecraft, and it will be launched in the winter of 2014.

Thank you!