Asteroid explorer, Hayabusa2, reporter briefing

April 2, 2019

JAXA Hayabusa2 Project

Topics

Regarding Hayabusa2,

- Descent operation results
- Small Carry-on Impactor (SCI) operation

Contents

Overview of Hayabusa2

Objective

We will explore and sample the C-type asteroid Ryugu, which is a more primitive type than the S-type asteroid Itokawa that Hayabusa explored, and elucidate interactions between minerals, water, and organic matter in the primitive solar system. By doing so, we will learn about the origin and evolution of Earth, the oceans, and life, and maintain and develop the technologies for deep-space return exploration (as demonstrated with Hayabusa), a field in which Japan leads the world.

Expected results and effects

・By exploring a C-type asteroid, which is rich in water and organic materials, we will clarify interactions between the building blocks of Earth and the evolution of its oceans and life, thereby developing solar system science.

・ Japan will further its worldwide lead in this field by taking on the new challenge of obtaining samples from a crater produced by an impacting device.

・We will establish stable technologies for return exploration of solar-system bodies.

Features:

・World's first sample return mission to a C-type asteroid.

・World's first attempt at a rendezvous with an asteroid and performance of observation before and after projectile impact from an impactor.

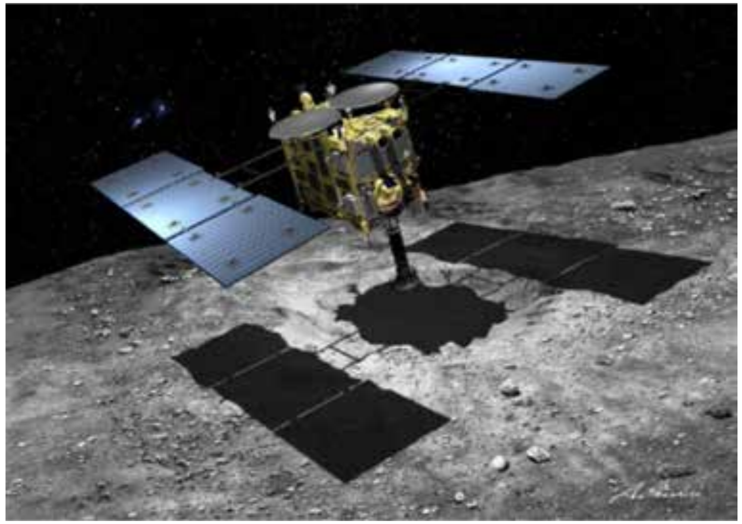
・Comparison with results from Hayabusa will allow deeper understanding of the distribution, origins, and evolution of materials in the solar system.

International positioning:

・Japan is a leader in the field of primitive body exploration, and visiting a type-C asteroid marks a new accomplishment.

・This mission builds on the originality and successes of the Hayabusa mission. In addition to developing planetary science and solar system exploration technologies in Japan, this mission develops new frontiers in exploration of primitive heavenly bodies.

・NASA too is conducting an asteroid sample return mission, OSIRIS-REx (launch: 2016; asteroid arrival: 2018; Earth return: 2023). We will exchange samples and otherwise promote scientific exchange, and expect further scientific findings through comparison and investigation of the results from both missions.



(Illustration: Akihiro Ikeshita)

Hayabusa 2 primary specifications

Mass	Approx. 609 kg
Launch	3 Dec 2014
Mission	Asteroid return
Arrival	27 June 2018
Earth return	2020
Stay at asteroid	Approx. 18 months
Target body	Near-Earth asteroid Ryugu

Primary instruments

Sampling mechanism, re-entry capsule, optical cameras, laser range-finder, scientific observation equipment (near-infrared, thermal infrared), impactor, miniature rovers.

Mission Flow

Launch

3 Dec 2014

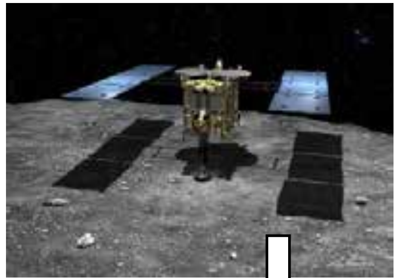
Earth swing-by

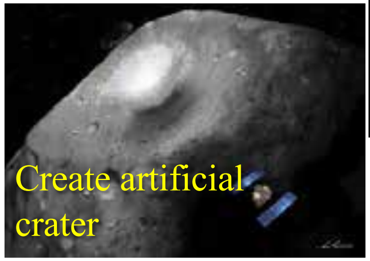
3 Dec 2015

Arrival at asteroid

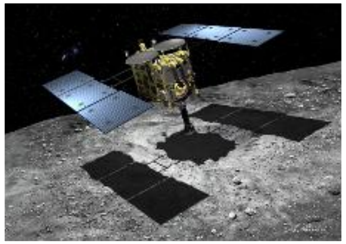
June 27, 2018

Examine the asteroid by remote sensing observations. Next, release a small lander and rover and also obtain samples from the surface.





Use an impactor to create an artificial crater on the asteroid's surface



After confirming safety, touchdown within the crater and obtain subsurface samples

Depart asteroid

Nov–Dec 2019

Earth return

late 2020

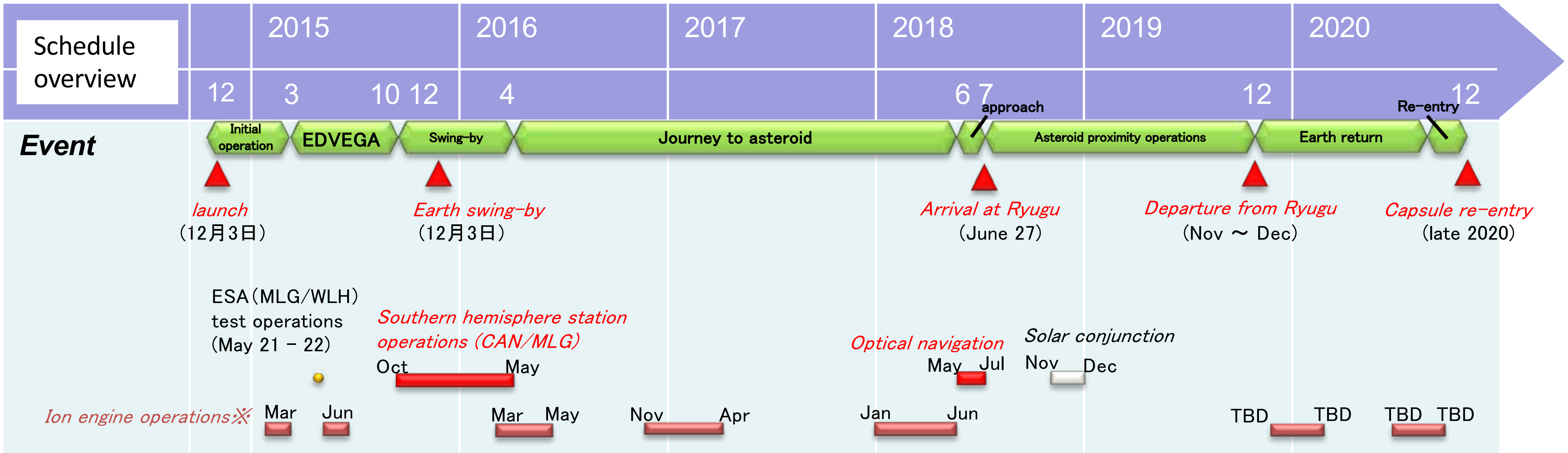
Sample analysis

(Illustrations: Akihiro Ikeshita)

1. Current project status & schedule overview

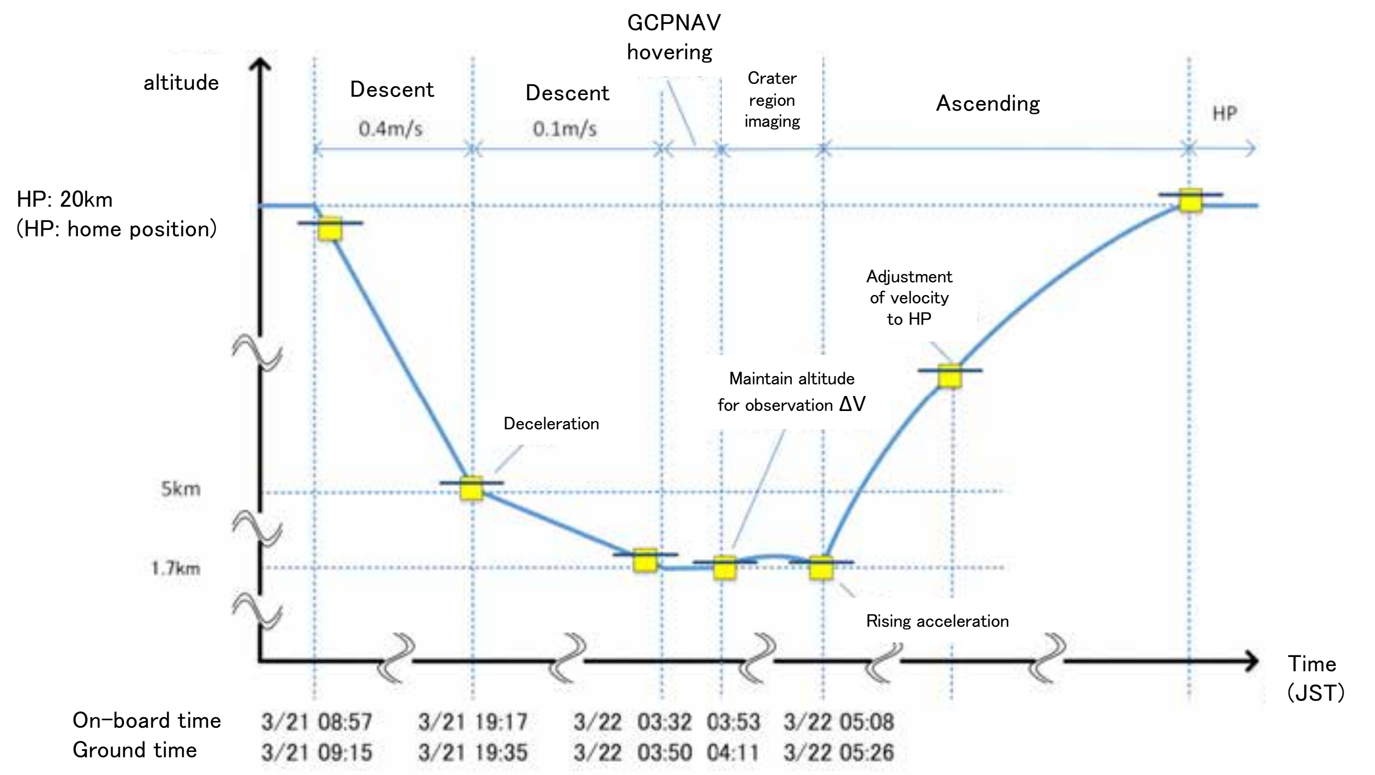
Current status:

- Three journal papers were published in ‘Science’ (March 20 JST)
- In preparation for the impactor experiment, the ‘Crater Search Operation (Pre-SCI)’ (CRA1) was performed from March 20 to 22 (altitude 1.7km).
- Preparation for the Small Carry-on Impactor (SCI) operation progressed.



2. Descent operation results

Results from the Crater Search Operation (Pre-SCI), CRA1



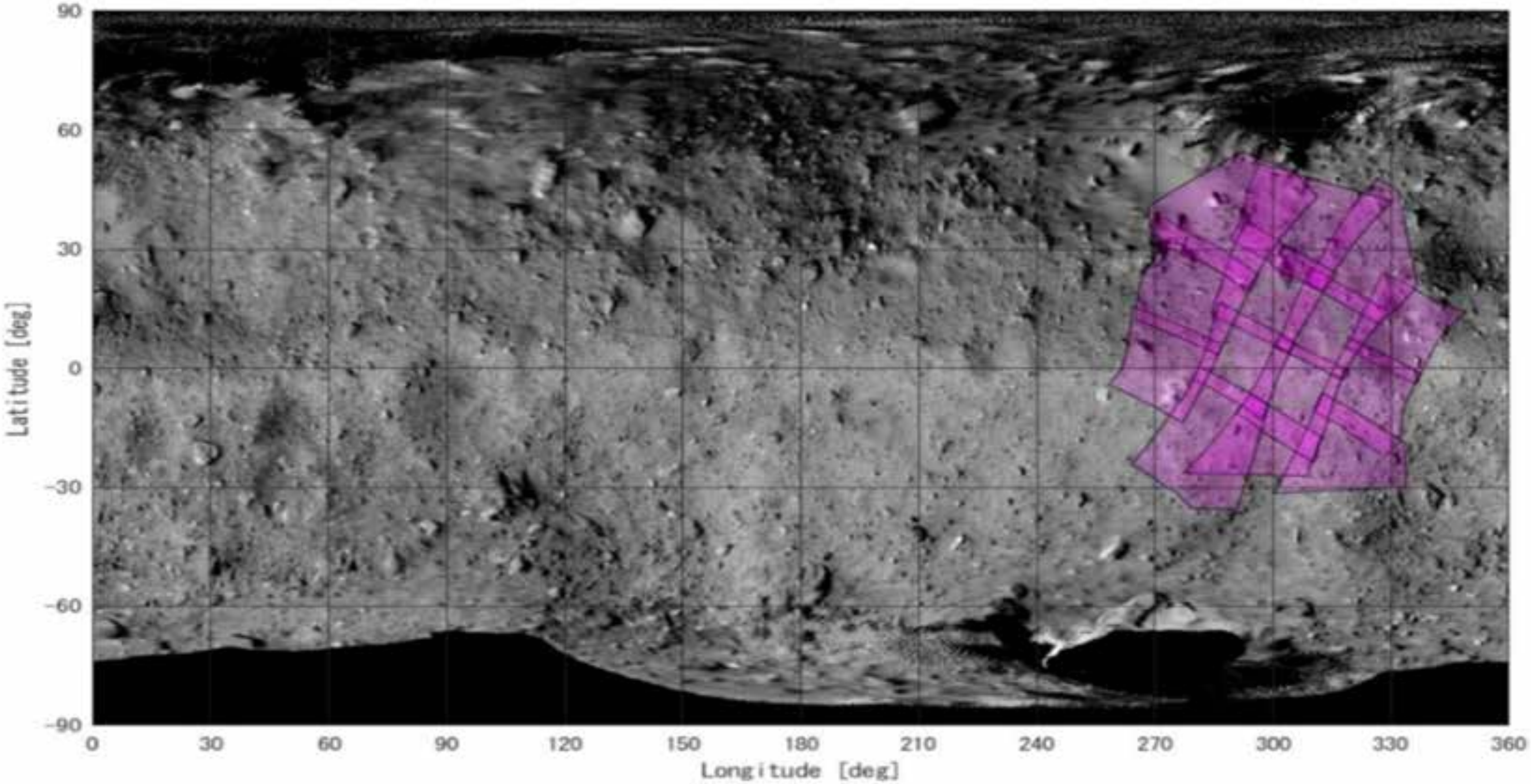
(Image credit : JAXA)

- Observations while maintaining an altitude of about 1.7km.
- Acquire detailed data in advance about the area where a crater will be generated with the small carry-on impactor (SCI).

↓

Observations were made as scheduled.

2. Descent operation results



Area observed by the CRA1 operation

（Image credit：JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute, Meiji University, University of Aizu, AIST.)

3. Small Carry-on Impactor operation

Outline and purpose of operation

- The impact device generates an artificial crater on the surface of Ryugu.
- Collect information about the interior of the asteroid by examining the crater formation and generated crater.
- At a later date, touchdown at or around the generated crater and try to collect subsurface material. However, if the condition of the surface of Ryugu is dangerous for touchdown, the touchdown will not be attempted.

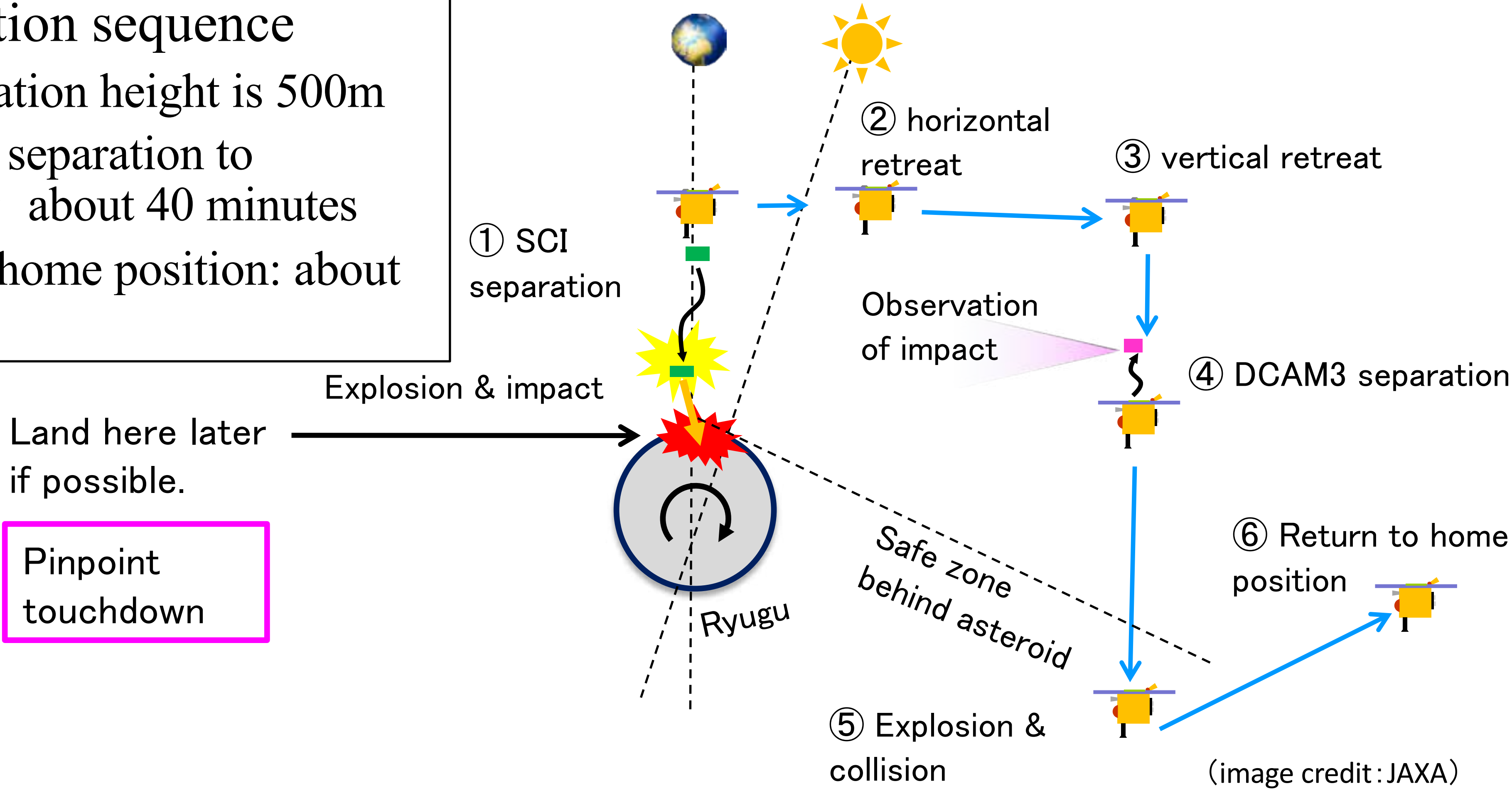
Operation schedule

- SCI operation：April 4〜6
- Crater generation date & time： April 5 at 11:36（onboard time, JST）.

3. Small Carry-on Impactor operation

SCI operation sequence

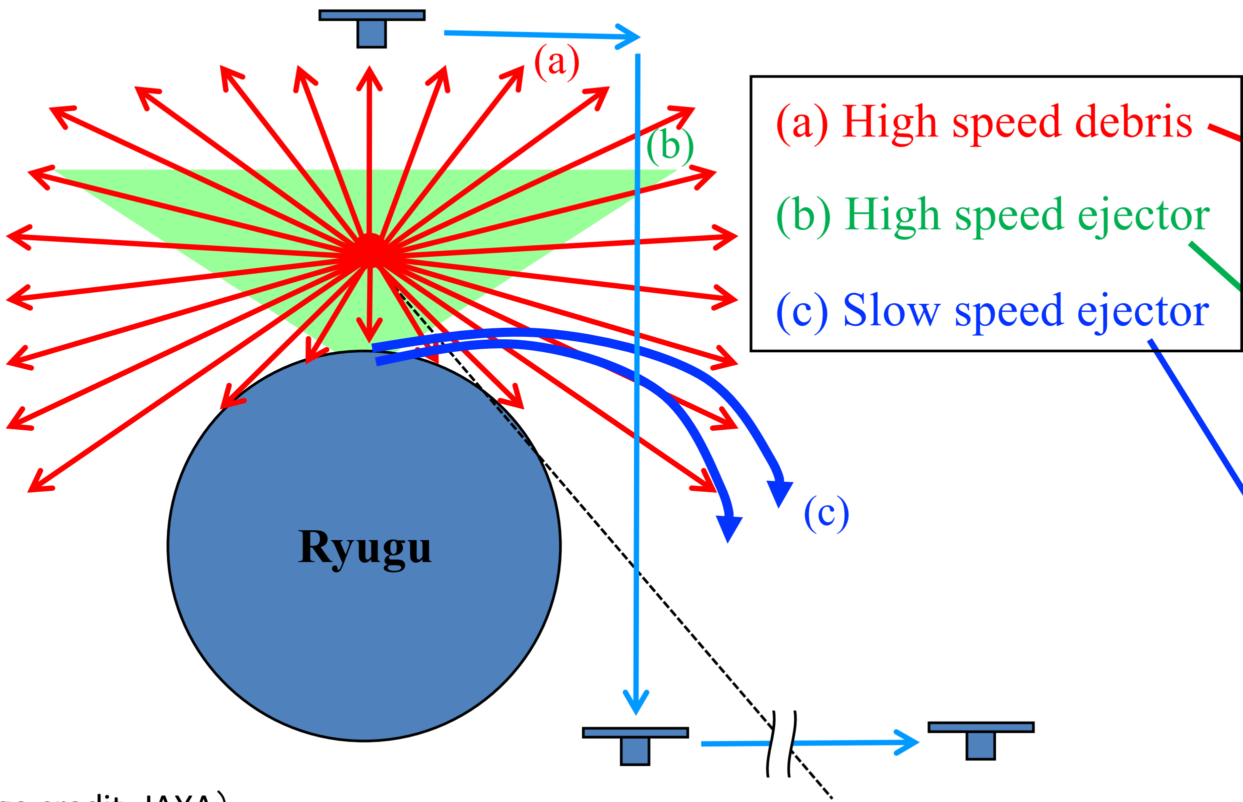
- SCI separation height is 500m
- From SCI separation to explosion: about 40 minutes
- Return to home position: about 2 weeks



(image credit：JAXA)

3. Small Carry-on Impactor operation

How to avoid debris and ejector



① Avoid debris
Debris that scatters during the detonation of the small carry-on impactor is avoided in the shadow of the asteroid.

② High-speed ejector avoidance
Collision with high speed ejector at the time of impact. Avoid in the shadow of the asteroid as with ①.

③ Slow ejector avoidance
Low speed ejector sent into an orbit trajectory is avoided by increasing the distance from the asteroid. The impact from collision is small as the speed of the slow ejector thrown to ultra-high altitudes is low and collision probability is small.

（image credit：JAXA）

3. Small Carry-on Impactor operation

Selection of impact target point and reason for choice

Constraint

Target point at a subearth latitude (~6°N) during the SCI collision (predicted collision area has a radius of about 200m = latitude / longitude ±30° in 3σ).

Selection criteria for target points

1st priority: Area where a generated crater can be found.

2nd priority: Area which is suitable for landing.

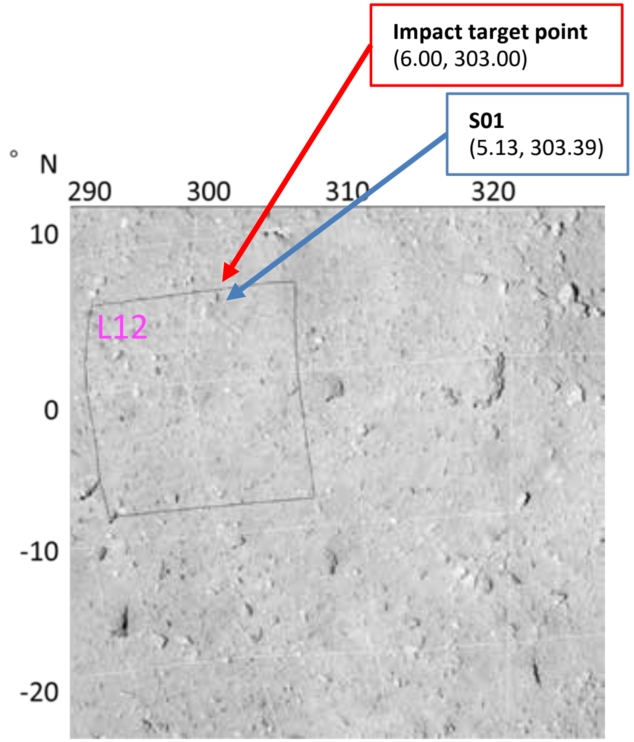
→ Flat areas with a layer of sand are desirable.

Collision target point latitude and longitude (6.00°, 303.00°)

Flat areas are scattered around the vicinity of the flat region L12 (where the next touchdown candidate, S01, is located).

Possibility to collect a sample from areas other than TD1 (Horai Fossa and the eastern hemisphere).

This is a geological area very similar to TD1 and the depth distribution of matter and structure can be discussed by comparing with the TD1 sample with an excavated sample.

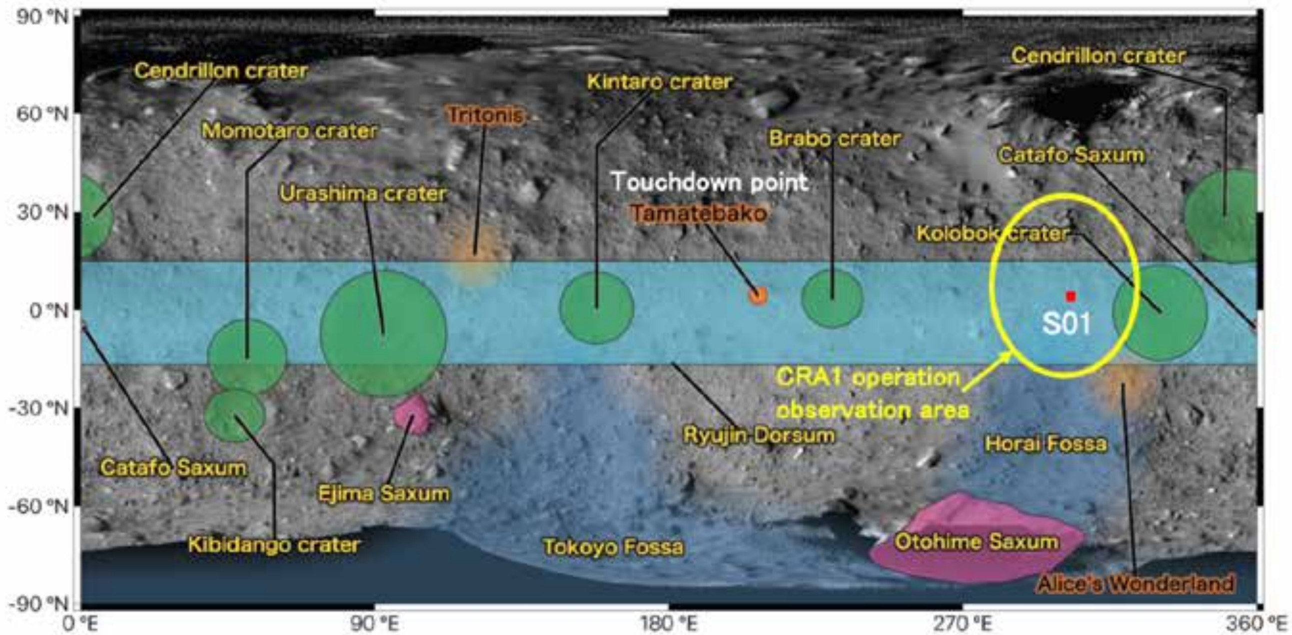


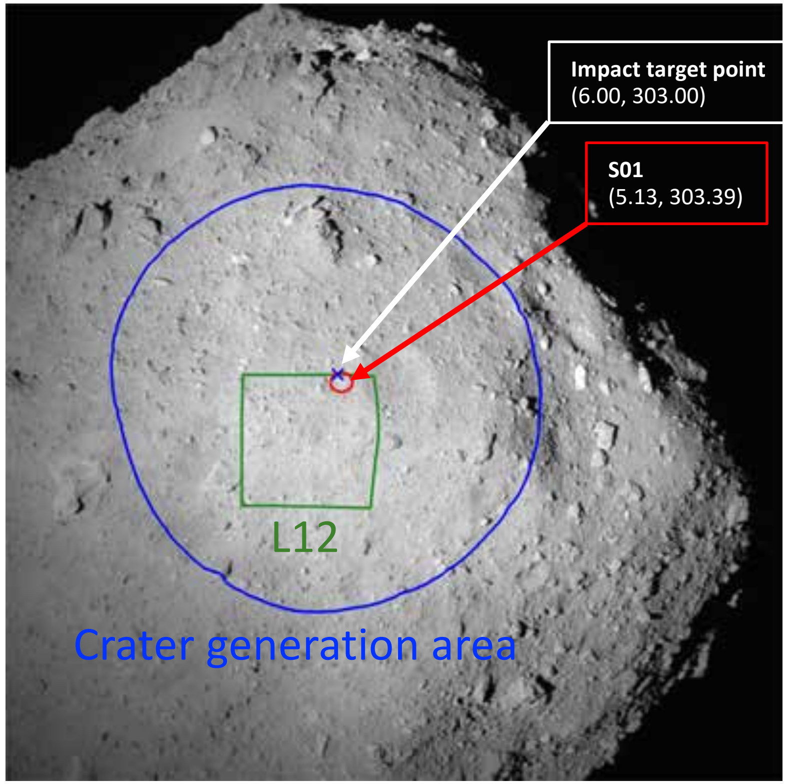
Captured by the ONC-T, hovering for MASCOT deployment (approximately 3km altitude)

(Image credit: JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute, Meiji University, University of Aizu, AIST.)

3. Small Carry-on Impactor operation

S01・CRA1・crater generation area



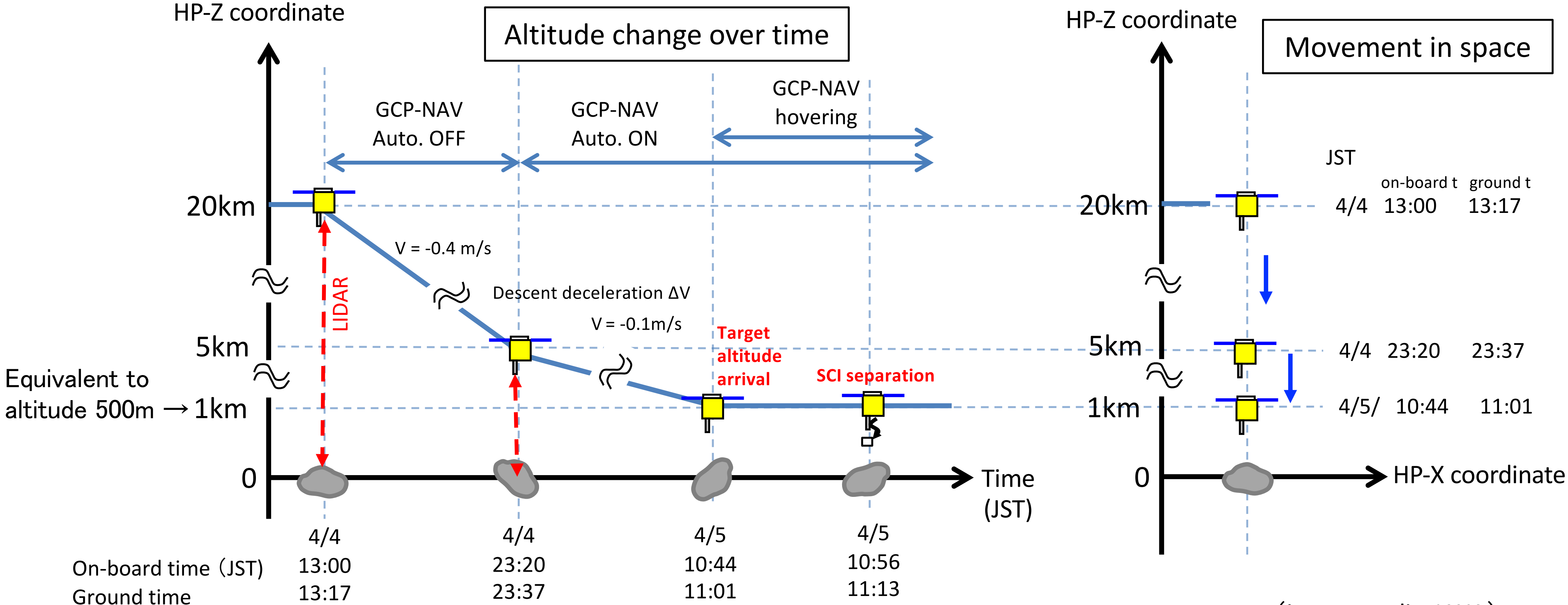


Note: The observation area for the CRA1 operation is the same as that of the crater generation area with the SCI.

（Image credit：JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute, Meiji University, University of Aizu, AIST.)

3. Small Carry-on Impactor operation

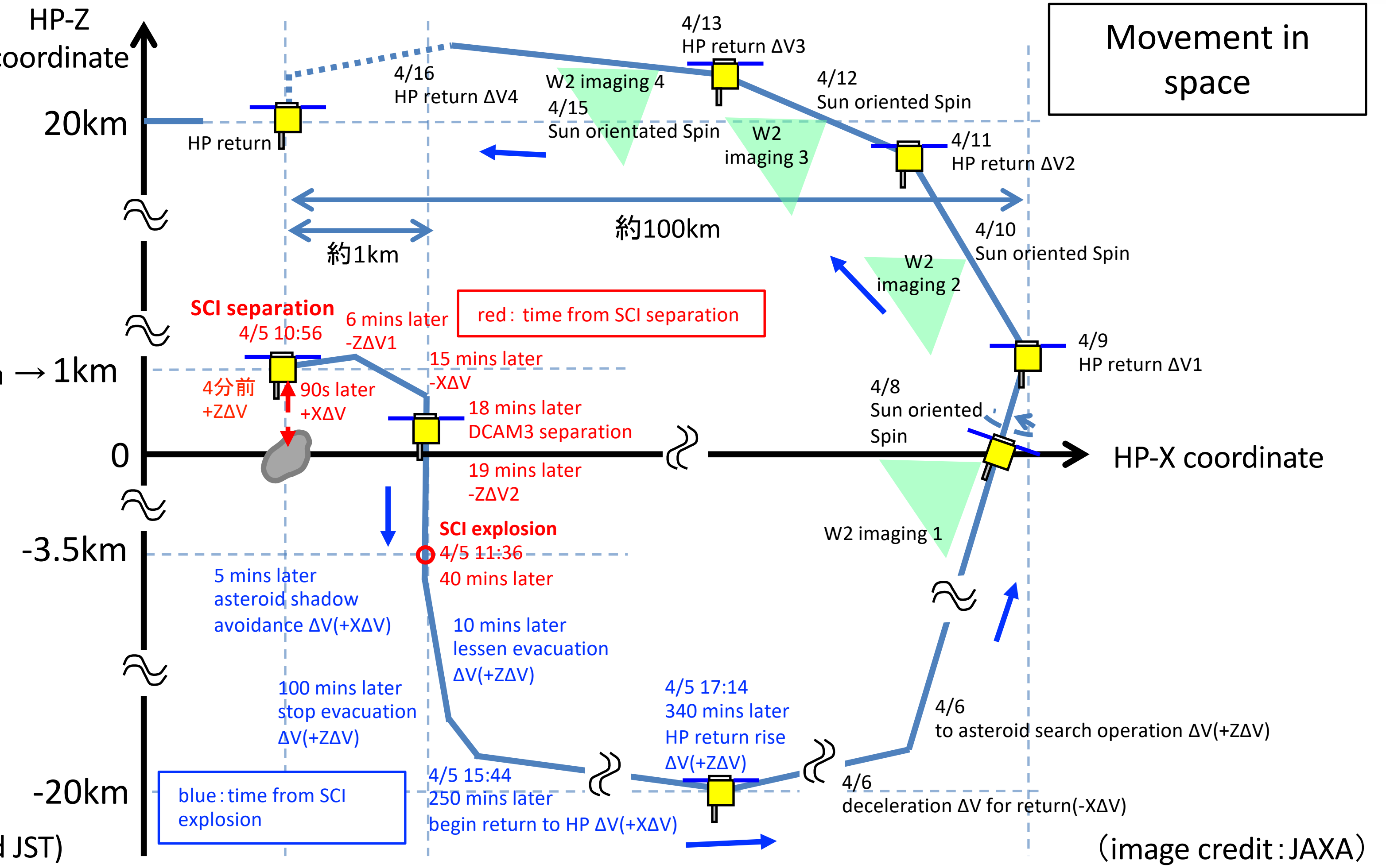
From home position to separation of the SCI



（image credit：JAXA）

3. Small Carry-on Impactor operation

From SCI separation to home position



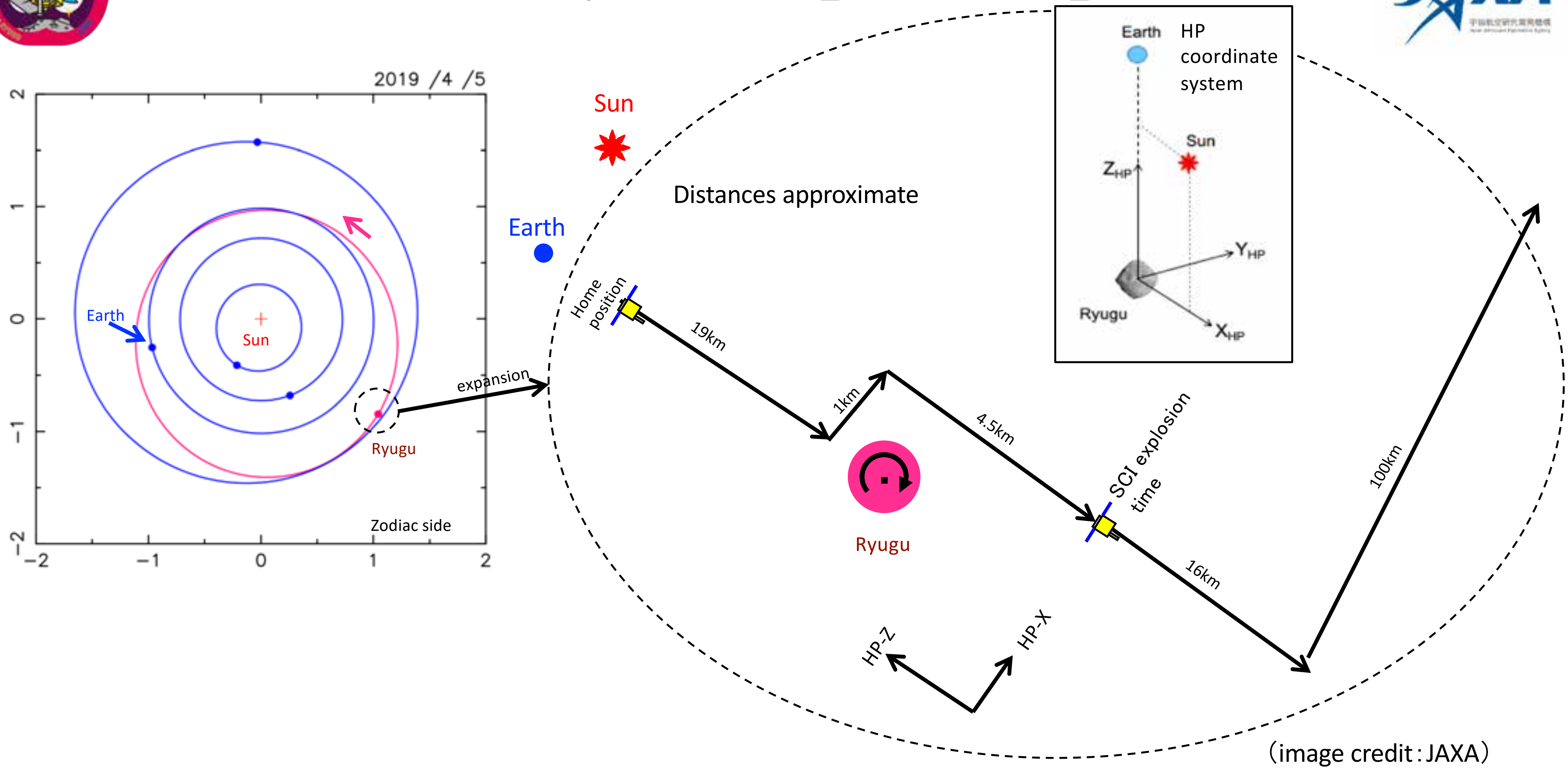
At SCI separation：
- spacecraft rises at 14cm/s
- SCI separation speed (downward) is 20cm/s

At DCAM3 separation：
- spacecraft descends at 64cm/s
- DCAM3 separation speed is 70cm/s (upward)

(time：on-board JST)

(image credit：JAXA)

3.Small Carry-on Impactor operation



（image credit：JAXA）

3. Small Carry-on Impactor operation

Decision points during operation

item	Ground time: JST ()on-board time	判断項目
Gate 1	4/4 12:00	Begin judgement to begin descent (@20km)
Gate 2	4/4 23:37	Begin judgement as to whether to continue descent (@5km)
Gate 3	4/5 09:44	Begin final separation judgement(GO/NOGO judgement)
SCI separation	4/5 11:13 (10:56)	SCI separation
DCAM3 separation	4/5 11:31 (11:14)	DCAM3 separation
SCI operation	4/5 11:53 (11:36)	SCI explosion time
Gate 5	4/5 13:32	Spacecraft status check
Gate 6	4/5 14:52	Spacecraft status check

Transmission of information

Gate 1 – Gate 3: Spacecraft altitude, operation status, etc.

SCI separation – Gate 6: Status of spacecraft etc.

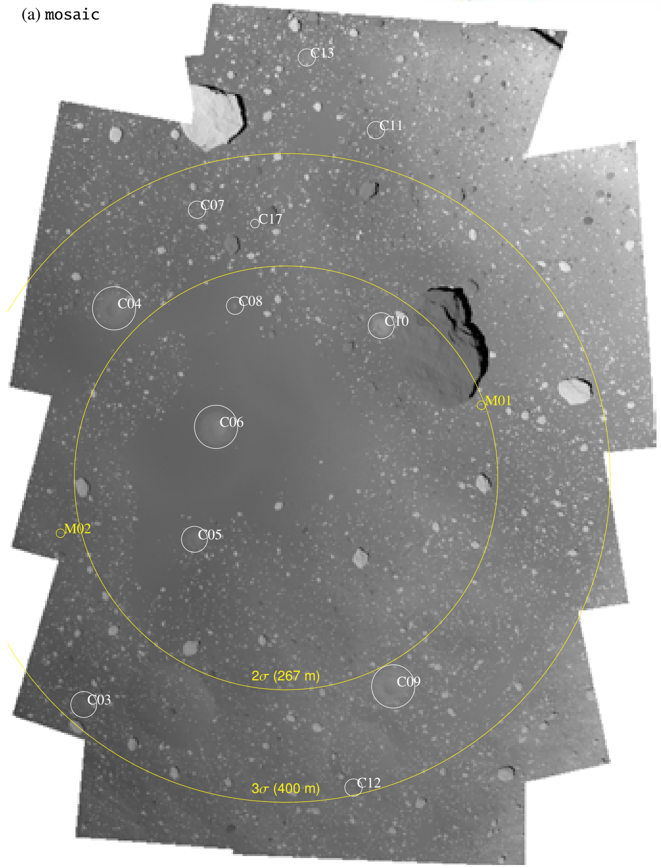
Note: Gate 4 not defined.

※ Time shown are not fixed and are subject to change depending on the final plan and situation on the day of operation.
The time stated on the Gate is the time to begin judgement. It may take some time before the judgement result is decided.

3. Small Carry-on Impactor operation

Crater search：basically, search by eye

- DCAM3 imaging → estimate impact position
- Comparison with pre/post low altitude ONC & TIR imaging (CRA1,2) → impact position, crater identification.
  - Low altitude image scan of predicted impact area two weeks prior and three weeks after impact.
    - ONC-T resolution：~17cm/pix@ altitude 1.7km
    - TIR resolution：~1.7m/pix@ altitude 1.7km
- Image of SCI separation with ONC-W1 etc. → SCI separation confirmation, explosion location estimations.
- In addition, dust observations after SCI impact with TIR and LIDAR → Collision confirmation



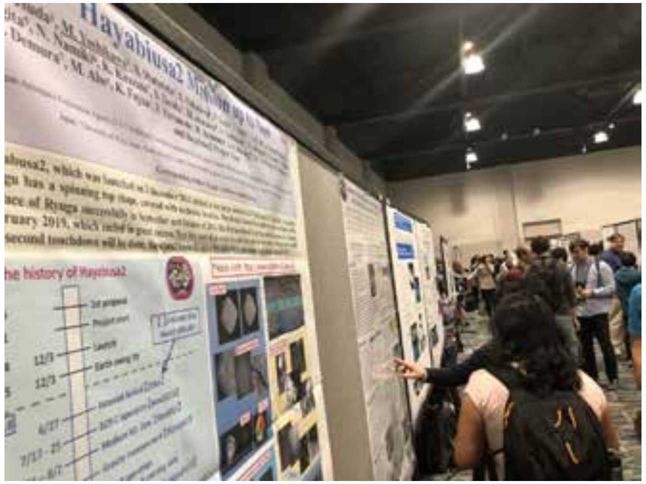
From crater exploratory training (ONC-T image mosaic)

4. Other topics

■Overseas presentations

- At the 50th Lunar and Planetary Science Conference (LPSC) --a research conference in the US– there was both a special session (oral 3/19, poster 3/20) and local media briefing (3/19).

- Date & place: March 18 – 22, The Woodlands, Texas, USA.
- Hayabusa2 special session: 13 oral presentations (3/19), 28 poster presentations (3/20).
- Several additional announcements regarding Hayabusa2 were also in other sessions.
- Science team meeting (3/20, 3/21)



Top：Hayabusa2 special session (3/19)

Left：Hayabusa2 poster presentation corner (3/20)

（Photo credit：Hayabusa2 Project）

4. Other topics

Group photograph of the Hayabusa2 Joint Science Team (HJST) meeting held at LPSC (March 21, 2019). (Photo credit: Hayabusa2 Project.)

5. Future plans

■Operation plans

- April 4～6：Small Carry-on Impactor (SCI) operation
- Week of April 22：Crater Search Operation (Post-SCI) (CRA2)

■Press and Media Briefings

- April 5, 8:30～ Press Center opens @ JAXA Sagamihara Campus

Hayabusa2 Small Carry-on Impactor (SCI) control room live broadcast（4/5 around 10:15～12:15）

JAXATV http://fanfun.jaxa.jp/jaxatv/detail/14343.html

YouTube https://www.youtube.com/watch?v=bv2ykuJDcBo

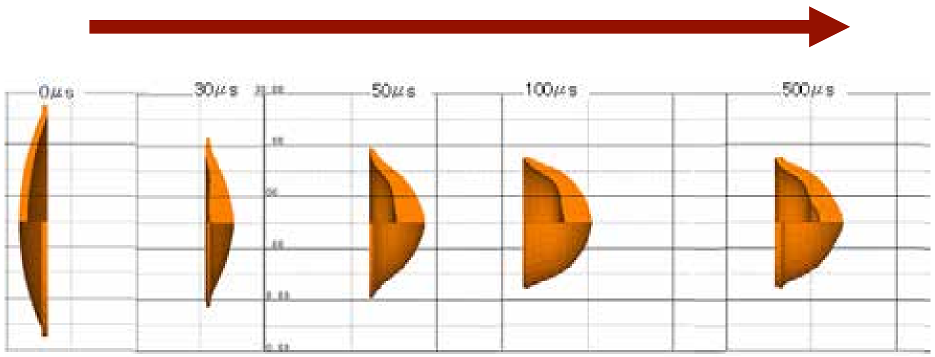
English https://youtu.be/Lh4iFyMRWZg

Reference material

Small Carry-on Impactor

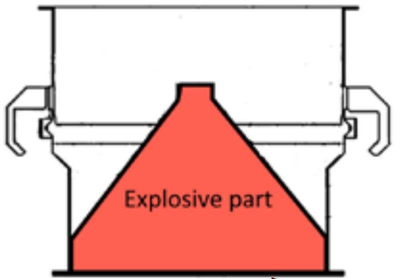
SCI：Small Carry-on Impactor

- Shape: conical (diameter 300mm、weight 14kg, explosive: ~9.5kg)
- Liner (impactor part): Pure copper (2kg), thickness ~5mm
- Explosive: HMX based PBX (Plastic bonded explosive)
- Explosive accelerates liner to 2 km/s in about 1/1000 seconds.



Copper plate (liner) that deforms as it flies

Cross section



Explosive part

（Image credit：JAXA）

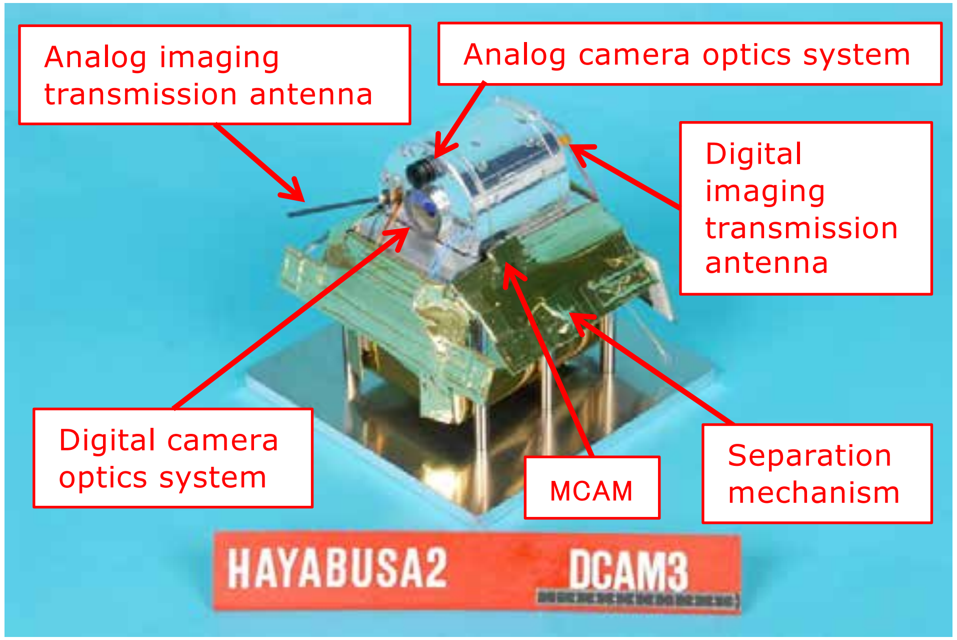
Copper plate

Deployable camera

Outline of the deployable camera (DCAM3)

- Deployable camera has a cylindrical Φ80 mm × 78 mm shape, excluding the protruding lens and antenna.
- There are two built-in cameras; one analog camera that can transmit images in low resolution but in real time, and one digital camera for digital communication of high resolution images.
- There is also an analog and a digital transmitting antenna for sending images.
- The battery enables imaging and wireless data transmission for up to 3 hours (depending on conditions).
- Images can be transmitted to the mothership wirelessly even at distances of 10km or more.
- A small monitor camera (MCAM) is mounted on the separation mechanism to try and capture images of how DCAM3 separates and leaves.

DCAM3 = Deployable Camera 3
Successor to DCAM 1 and 2, mounted on the solar sail IKAROS

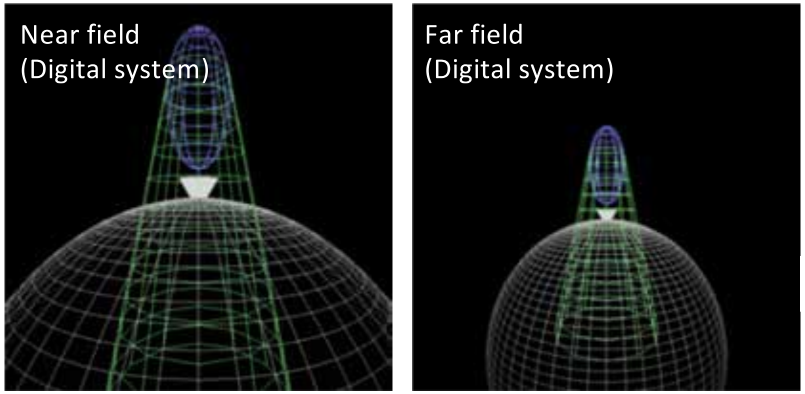


(Image credit：JAXA)

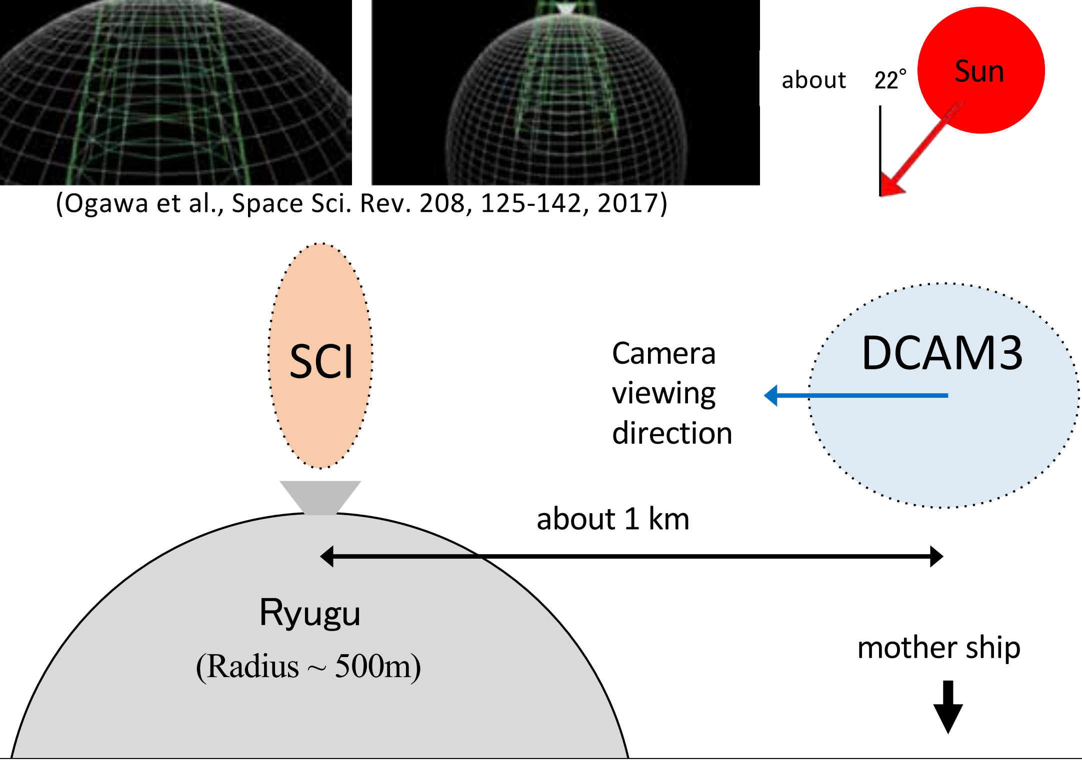
Deployable camera

Outline of observations from deployable camera (DCAM3)

- Observe the impact from about 1km distance:
  - Ryugu
  - Scattered material generated during the collision
  - High speed debris (digital only)
  - Low speed dust (digital only)
  - SCI main body before explosion (digital only)
- Analog system: color, viewing angle 71ºx53º, 720x526 pixels, resolution about 10m.
  Digital system: Monochrome, viewing angle 74ºx74º, 2000x2000 pixel, resolution about 1m.
- Analog system can send data to the mother ship in real time. Digital system is delayed before sending.



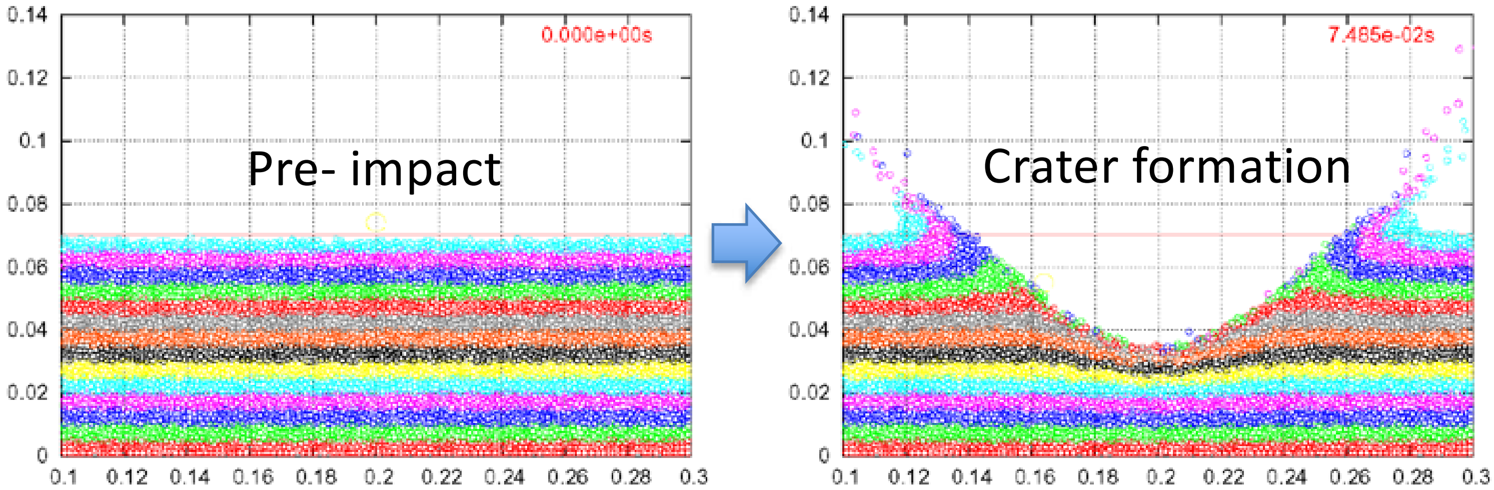
(Ogawa et al., Space Sci. Rev. 208, 125-142, 2017)



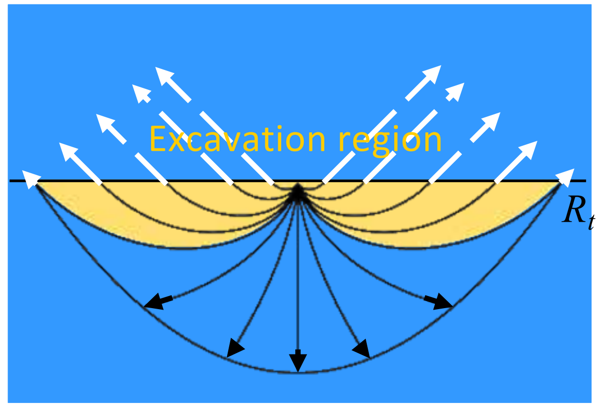
(Image credit : Kobe Univ.)

Crater excavation depth

- Depth of the excavation region is about 1/10 of the crater diameter.



An example of numerical simulations of crater formation impacts on a granular layer (sand). Color corresponds to the depth prior to collision. (Provided by Koji Wada)



Excavation model

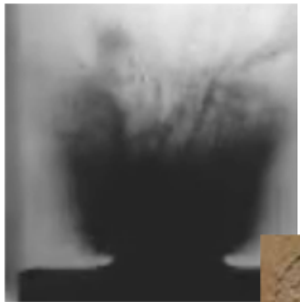
(Image credit：Chiba Institute of Technology)

Ejector seen during collision experiments

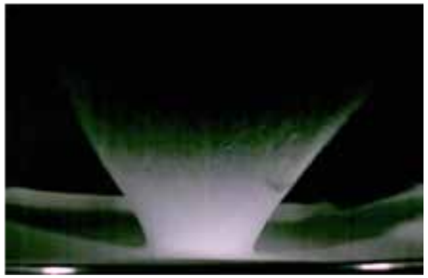
Large blocks | Granular (sand) layer | Powder layer


Basalt: P=0%

↕ strength




Mortar: P=20%
Impact speed: 4km/s
Φ7mm, nylon

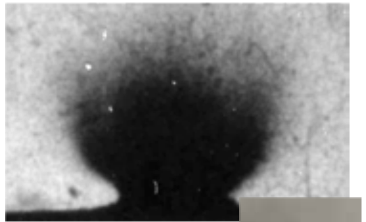
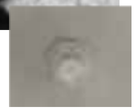


Glass beads (100μm): P=40%

↕ Porosity

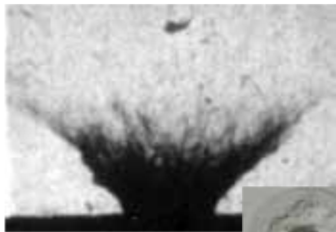
Perlite (3mm): P=80%

Impact speed: 90 m/s
Φ3mm, aluminum

Plaster: P=50%

↕ Strength




Porous silica dust: P=65%

Impact speed: 3.2km/s
Φ2mm, nylon

P: Porosity
φ : Projectile diameter

Courtesy of Kobe University Arakawa Laboratory

Impactor Experiment Science

To understand the repeated collisional growth and destruction of celestial body evolution

- What kind of impact crater can / cannot form on the surface of Ryugu?
  - Observation of the crater formation process and measurements of the formed crater size and shape.
    - Construction of a impact physics model (scaling laws) based on the impact experiment in real asteroid material and environment.
    - Construction of scaling rules for Ryugu's collisional history on the surface and surface age estimation (crater chronology)

Scaling law: a universal equation connecting impact conditions and the properties of the formed crater.

- What's going on below Ryugu's surface?
  - Exposure and collection of subsurface material via crater formation → Assessment of the impact of space weathering and surface flow.
  - In-situ observation of ejecta motion → Estimate subsurface conditions (porosity, particle size distribution etc.)

principal role of DCAM3

- Does Ryugu's surface move easily?
  - Measurement of terrain changes caused by the impact → Understand the effect of impact vibrations, the presence of few small craters.
- In case we hit a boulder…
  - Crater on boulder measurement or measurement of fragments from boulder destruction → Estimate strength of asteroid material