

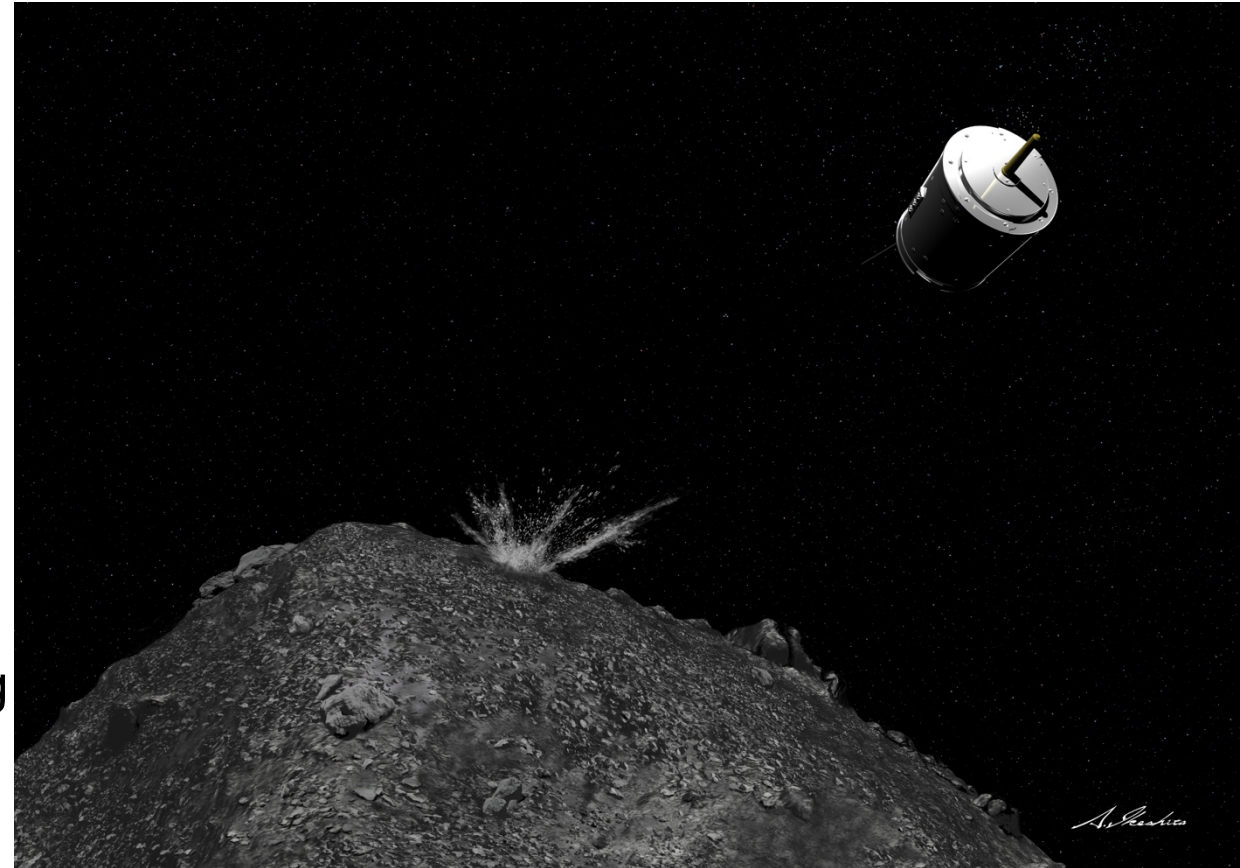
Artificial impact crater on Ryugu formed in the gravity dominated regime

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SCI Impact experiment on Ryugu

- **Artificial impact crater**
 - To excavate the subsurface and observe the asteroid interior.
- **Ejecta curtain**
 - Observed by **Deployable CAMera 3** to study the mechanical properties of the surface.
- **Scientific aspects**
 - Supported Hayabusa2 scientific observations by remote-sensing instruments and sampling at touchdown.
 1. Sample science
 2. Remote sensing science
 3. Science for Planetary impact process

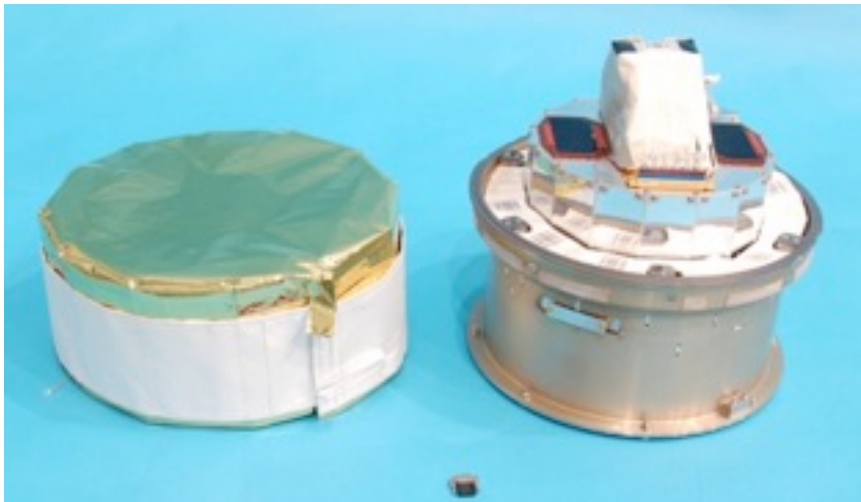


Instruments

SCI

Small Carry-on Impactor

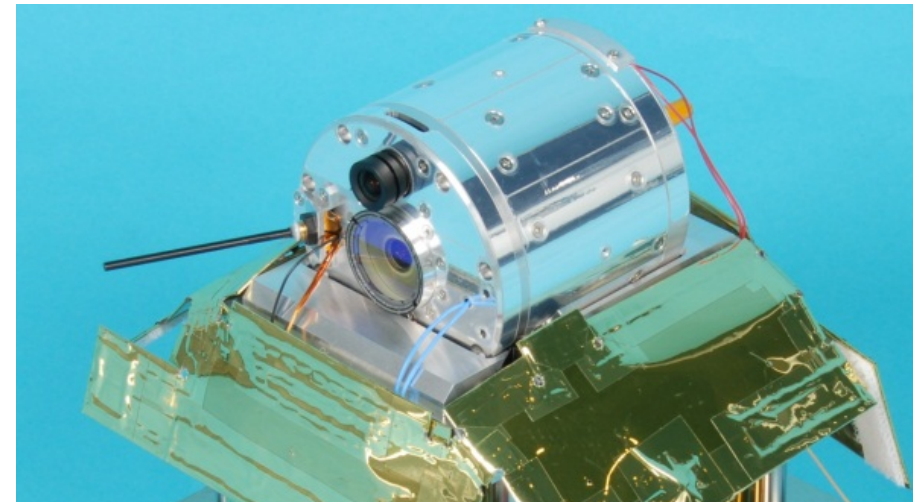
- Copper disk (30 cm) and explosive.
- Copper disk projectile (2 kg, ~ 2 km/s) deforms to a hollow spherical shell.
- First instrument to form artificial impact crater on asteroids.



DCAM3

Deployable Camera in 3rd generation

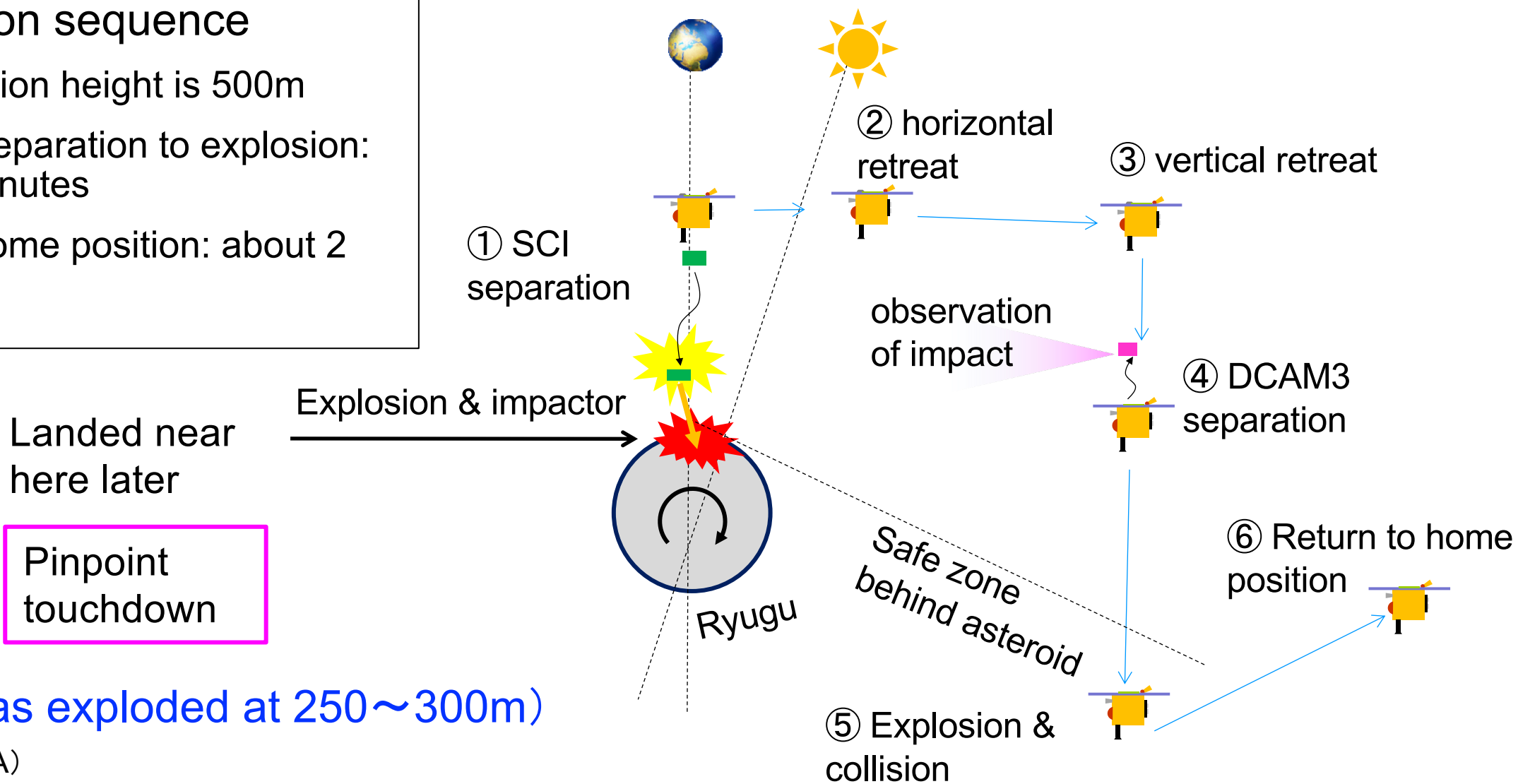
- A tiny satellite composed of optics, sensor, transmitter, and battery.
- Specifications: < 1 m/pixel, 1 frame/sec, 74°x74° FOV.
- **In-situ observation of SCI impact on the surface of Ryugu.**



Overview of SCI, DCAM3 operation

SCI operation sequence

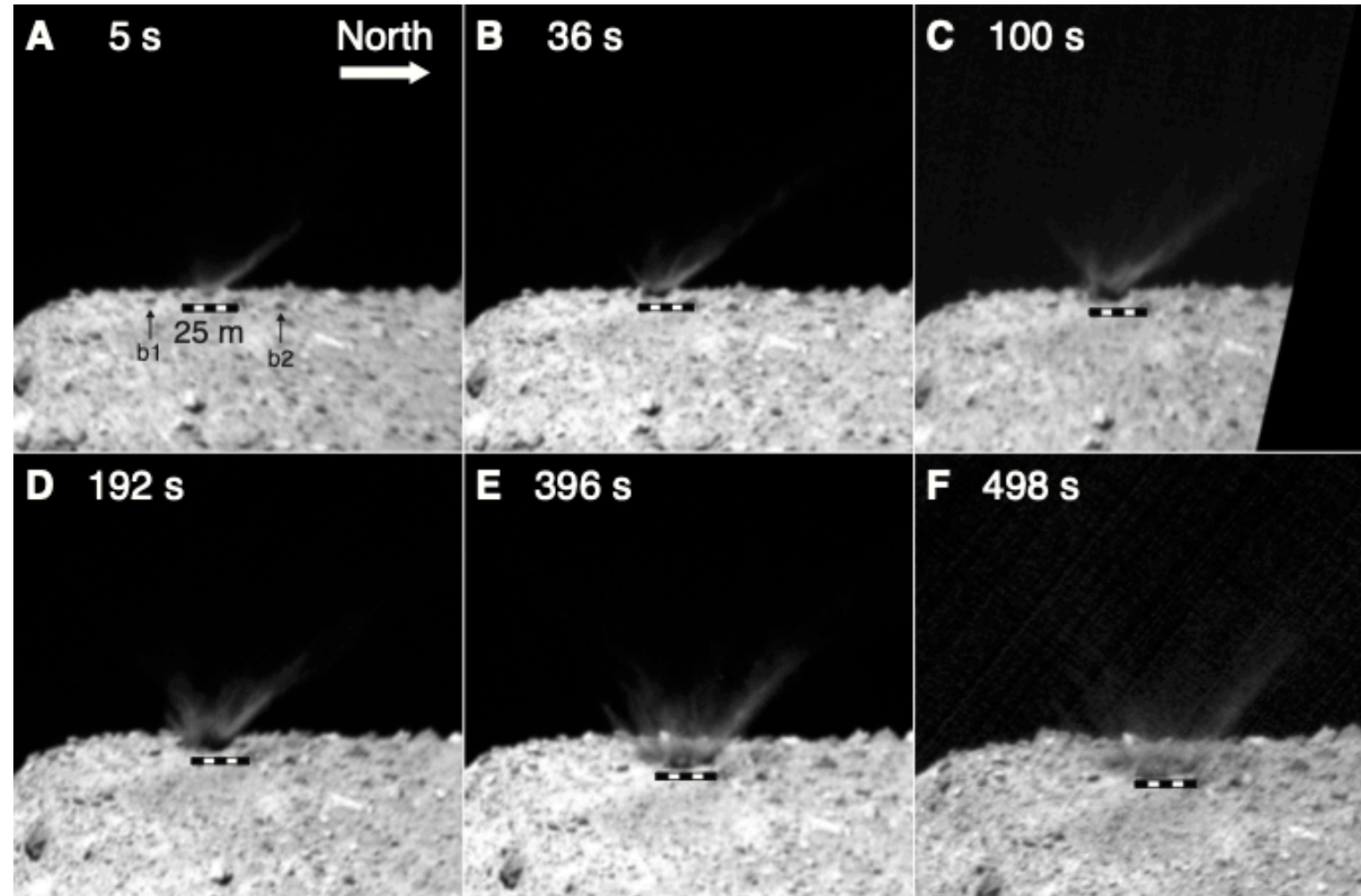
- SCI separation height is 500m
- From SCI separation to explosion: about 40 minutes
- Return to home position: about 2 weeks



(image credit: JAXA)

Successive images of ejecta curtain growth observed by DCAM3

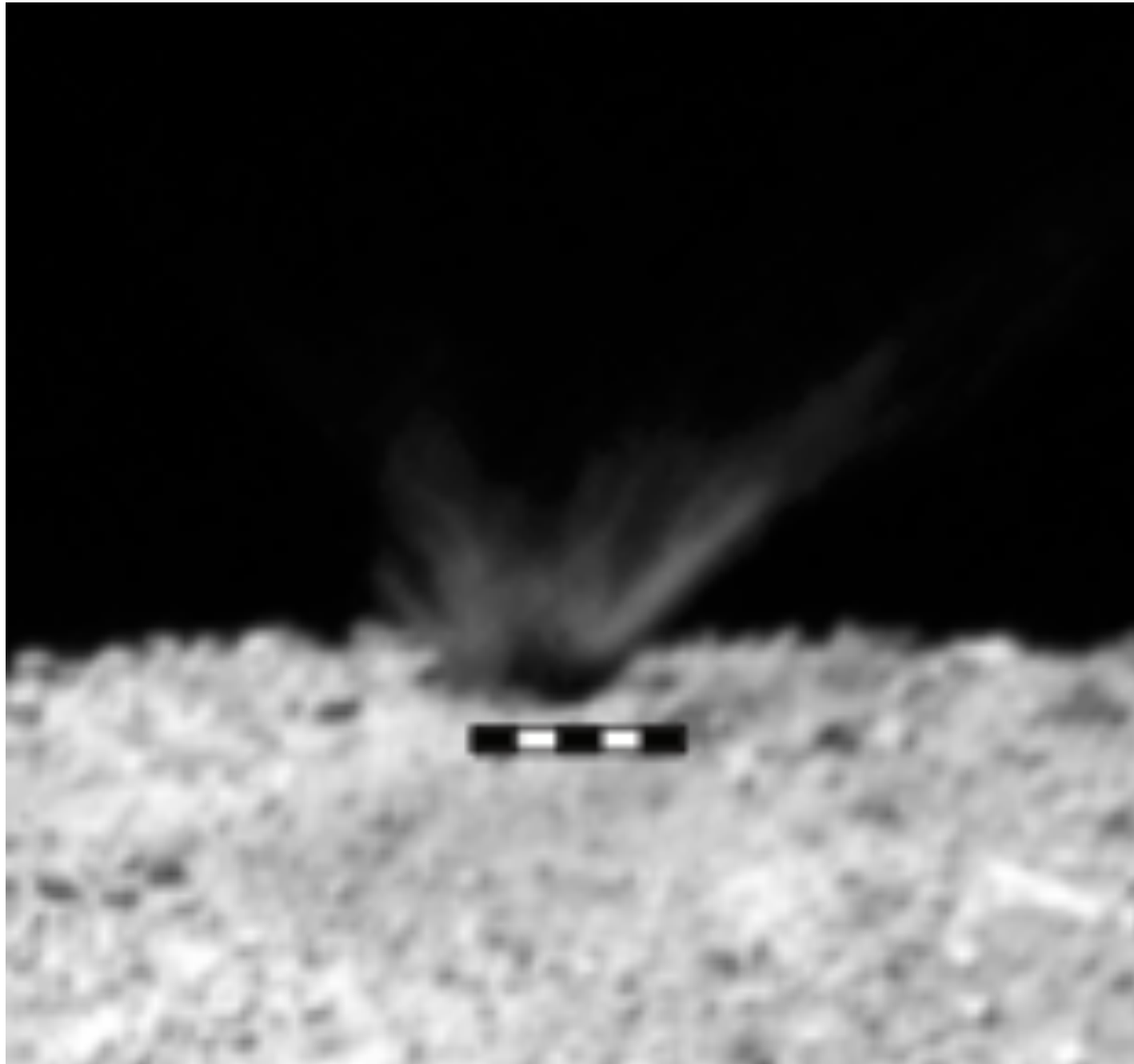
- Ejecta generated in the collision initially spray northward.
- Crater formation, excavation and **deposition** process, lasts for 500 seconds.
- **No separation between the ejecta curtain and ground surface** is observed.
- For the first **200 seconds**, the **crater appears to be growing**. After this, the ejecta deposition is occurring.
- **SCI crater could be formed in the gravity dominated regime**



Arakawa et al., 2020

**Ejecta curtain
growth**

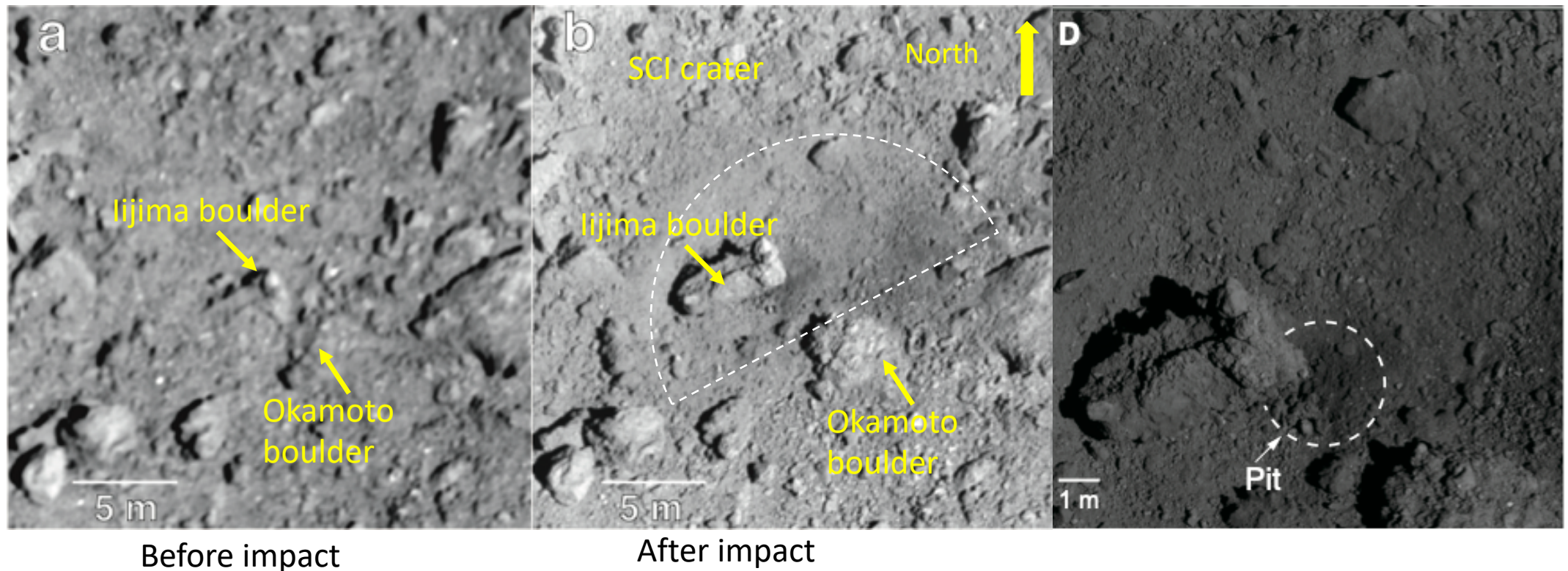
Close up images



 **North**

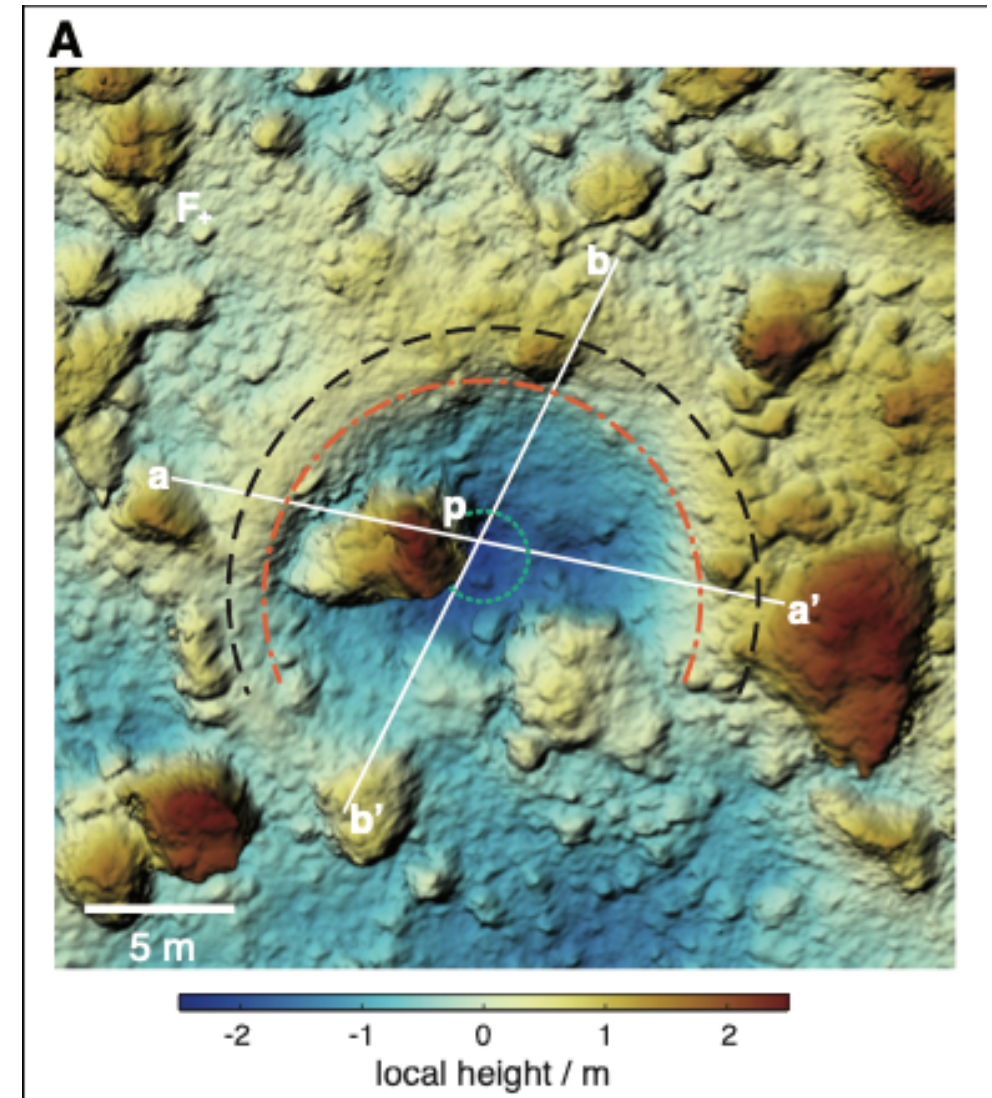
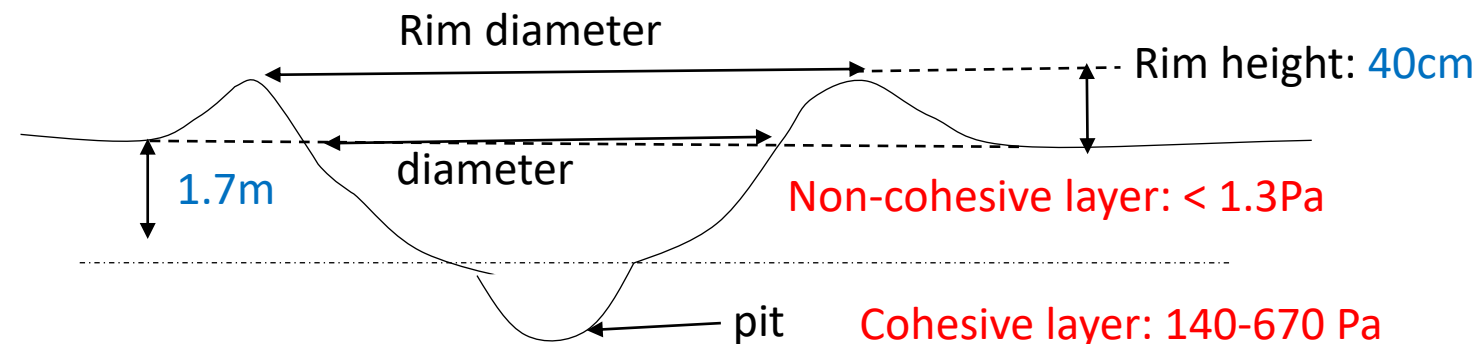
SCI (Omusubi-Kororin) crater

- The crater is **semi-circular**. Southern growth was inhibited by the Okamoto boulder.
- Large boulder (Iijima boulder) moved 3m northwest.
- A pit about 3m in diameter was seen at the eastern end of the Iijima boulder.



SCI crater shape : Digital Elevation Map

- **Diameter: $14.5 \pm 0.8\text{m}$**
 - Crater diameter at 0m height.
- Rim diameter: $17.6 \pm 0.7\text{m}$
 - Distance between rim tops
- Pit diameter about 3m, depth 60cm
 - **140 – 670 Pa layer at bottom**

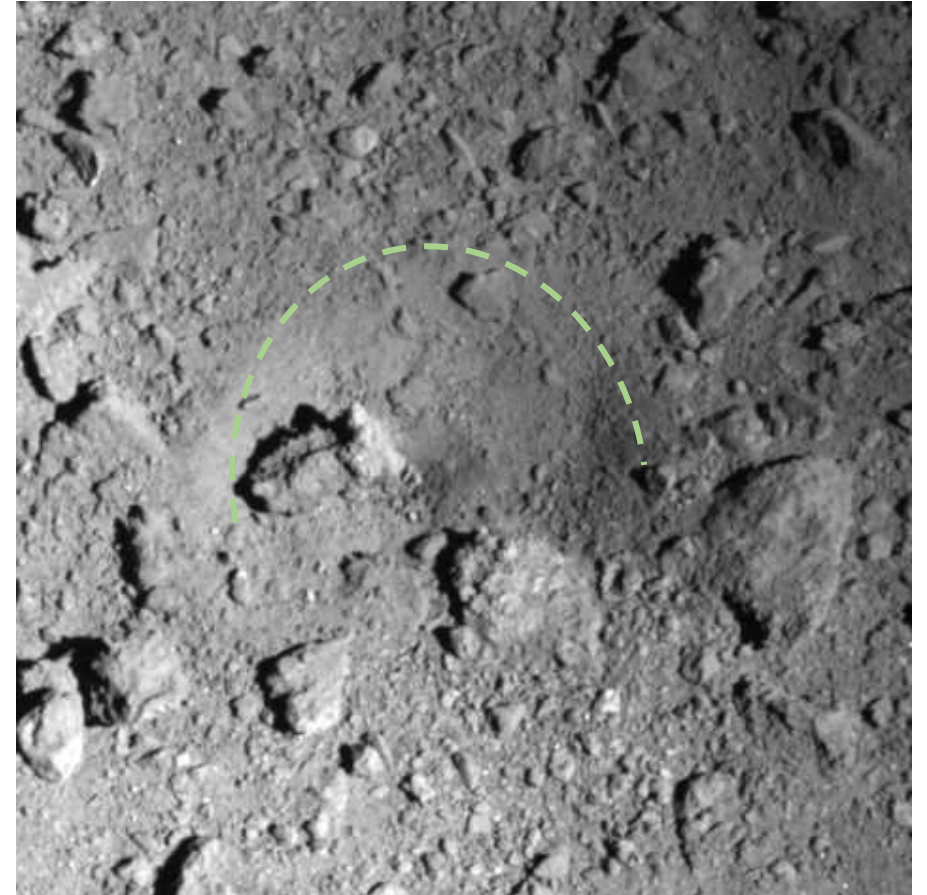


Comparison with ground experiments

- Artificial crater was formed by ground tests of the SCI. **The size was about 2m.**
- The SCI crater was **about 7 times** larger than that formed on Earth because of small gravity, **10^{-5} G.**
- SCI crater diameter of 14.5 m is explained by the surface covered **with sand-like regolith without cohesion.**



(image credit : JAXA)



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

Summary

- Hayabusa2 Small Carry-on Impactor (SCI) formed an artificial impact crater (SCI crater) on the surface of asteroid Ryugu.
- The SCI crater is a semi-circle with the diameter of 14.5 m, and has a elevated rim. Ejecta curtain growth observed by Deployable CAMera 3 (DCAM3) showed the crater formation time longer than 200 s.
- These evidences show that the SCI crater was formed in the gravity-dominated regime, and the crater diameter was almost similar to that estimated from the scaling law for dry-sand.
- The surface boulder layer behaves like non-cohesive sand.
- The central pit was discovered and it may show the slightly cohesive subsurface layer with the strength of 140 – 670 Pa.