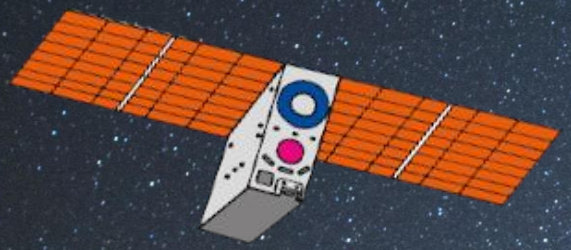
LICIA

Light Italian Cubesat for Imaging of Asteroids



# LICIACube
## the witness of the DART impact

Elisabetta Dotto (INAF – OAR)
on behalf of the LICIACube Team

DART
Double Asteroid Redirection Test

PDC 2023 – 3-7 April 2023

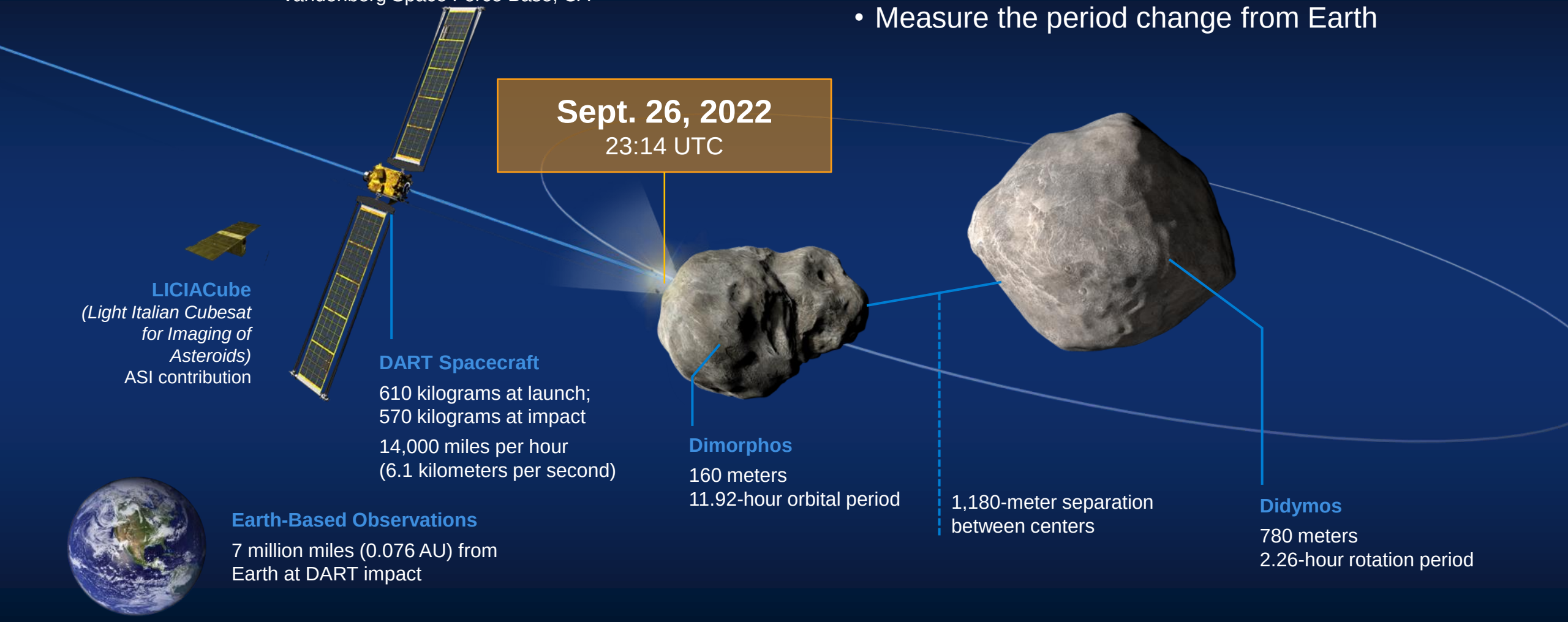
# Launch

Nov. 24, 2021
SpaceX Falcon 9
Vandenberg Space Force Base, CA

NASA's first test mission for planetary defense

- Target the binary asteroid Didymos system
- Impact Dimorphos and change its orbital period
- Measure the period change from Earth

**Sept. 26, 2022**
23:14 UTC



**LICIACube**
*(Light Italian Cubesat for Imaging of Asteroids)*
ASI contribution

**DART Spacecraft**
610 kilograms at launch;
570 kilograms at impact
14,000 miles per hour
(6.1 kilometers per second)

**Dimorphos**
160 meters
11.92-hour orbital period

1,180-meter separation between centers

**Didymos**
780 meters
2.26-hour rotation period

**Earth-Based Observations**
7 million miles (0.076 AU) from Earth at DART impact

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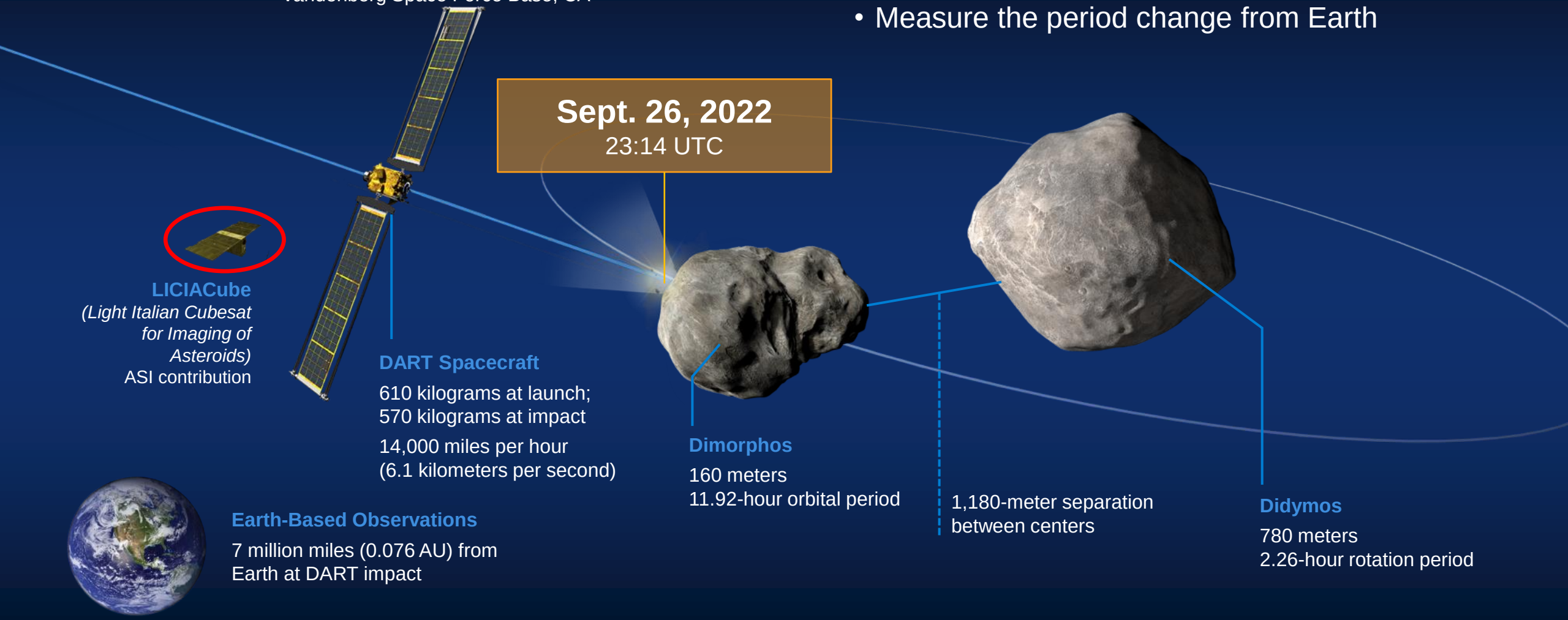

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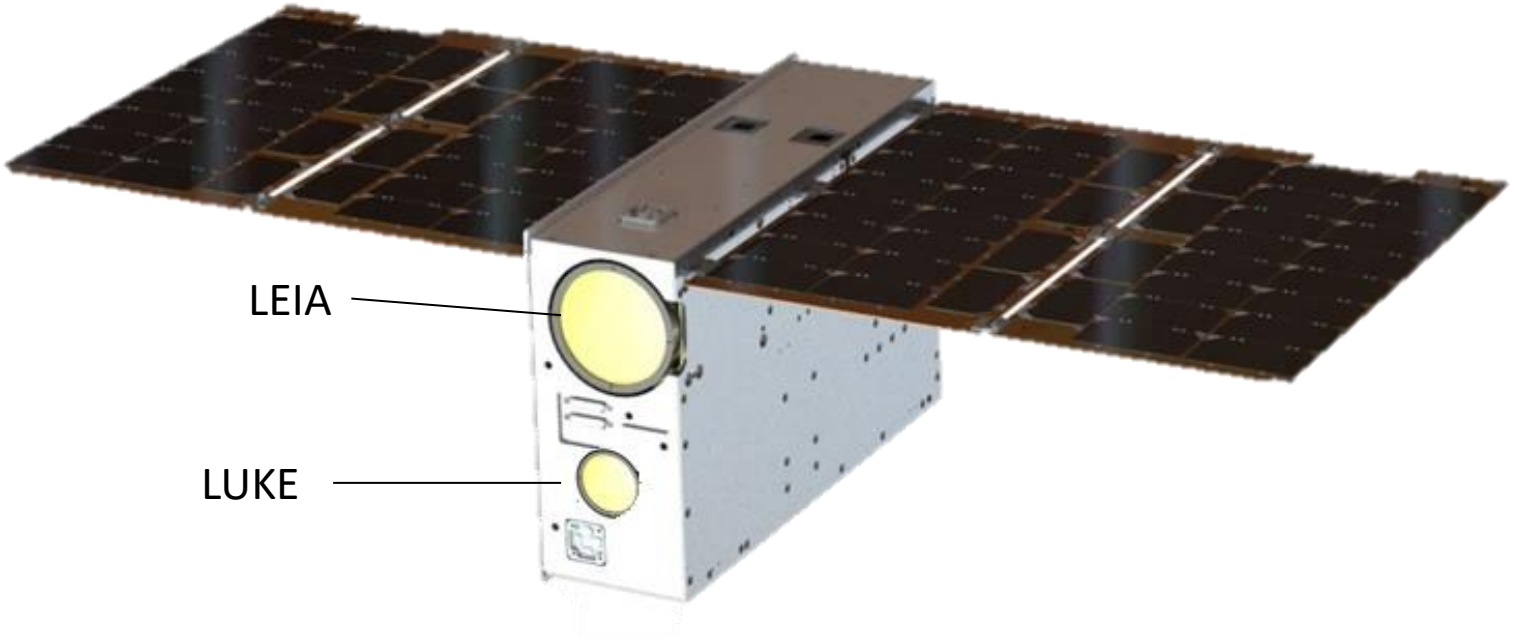
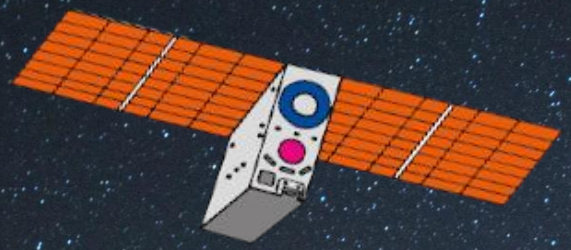
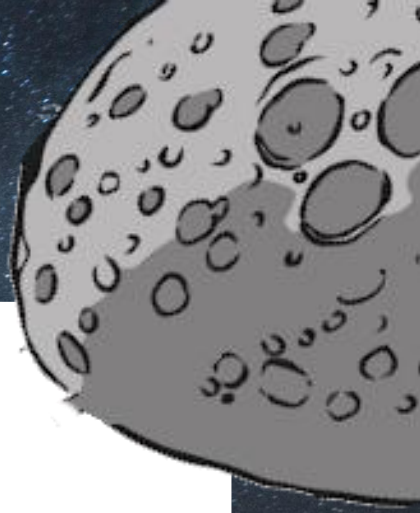
# LICIACube



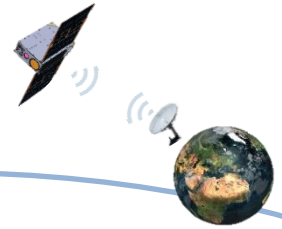

- CubeSat 6U managed by ASI and realized by Argotec
- Closest flyby of Dimorphos ~3 minutes after DART's kinetic impact
- Data downlinked for weeks after the encounter
- Two cameras: LEIA and LUKE (2 m/pixel best resolution from flyby images)

# LICIACube



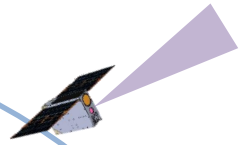


**LICIACUBE DEPLOYMENT**
DART S/C TRIGGERED THE LICIACUBE DEPLOYMENT 15 DAYS BEFORE THE IMPACT



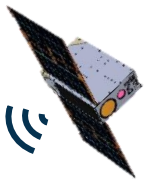
**PIGGYBACK CRUISE PHASE**
LICIACUBE IS CARRIED BY DART S/C

**APPROACHING PHASE**
LICIACUBE ESTABLISHES A LINK W/DSN TO PERFORM THE SATELLITE TRACKING AND THE ORBIT DETERMINATION

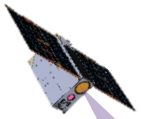


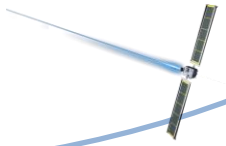
**APPROACHING PHASE**
LICIACUBE stars and planets acquisition for calibration

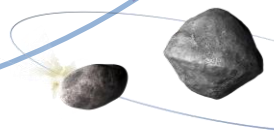
**LAUNCH**



**SCIENCE**
DOWNLINK OF ACQUIRED SCIENTIFIC DATA



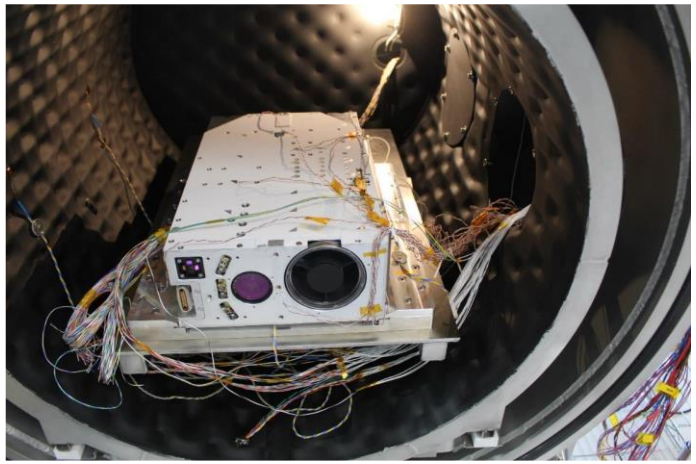


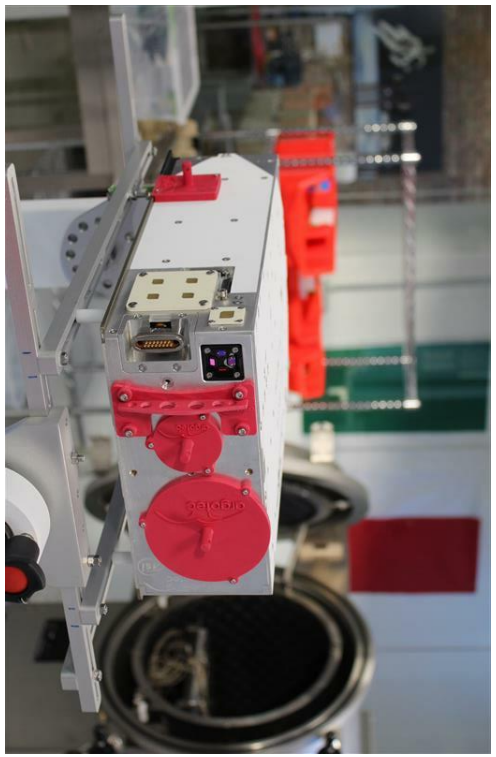


**SCIENCE**
LICIACUBE PERFORMS SEPARATION MAENUVERS AND ACQUIRES IMAGES OF DIDYMOS-DIMORPHOS AND PLUME GENERATED BY THE DART S/C IMPACT

# LICIACube

## Light Italian Cubesat for Imaging of Asteroids

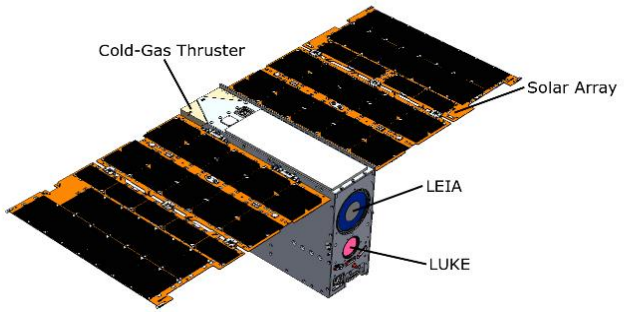


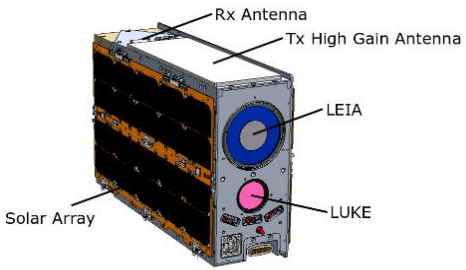


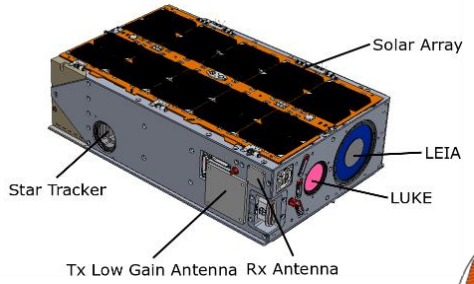
Mass: 13 kg

Dimension: 36.6 cm x 23.9 cm x 11.6 cm

91.2 cm x 36.6 cm x 23.9 cm



# LICIACube

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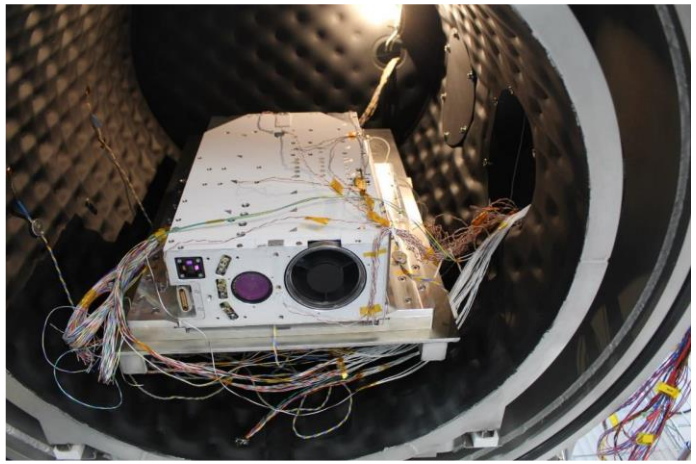
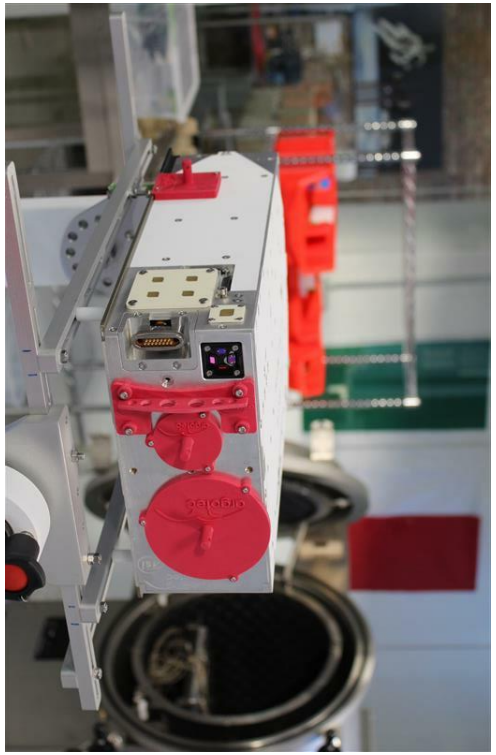
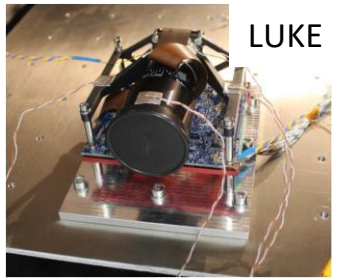
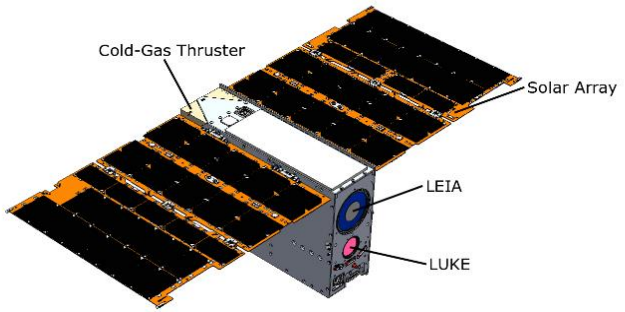


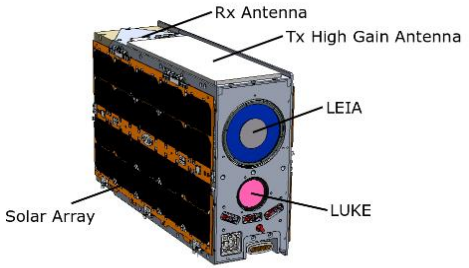


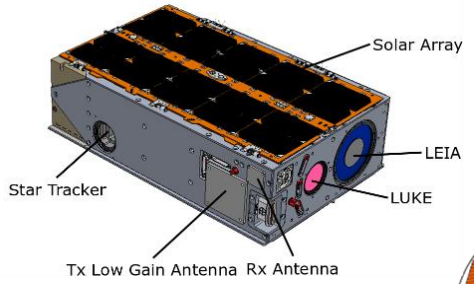


LUKE

LEIA



# LEIA

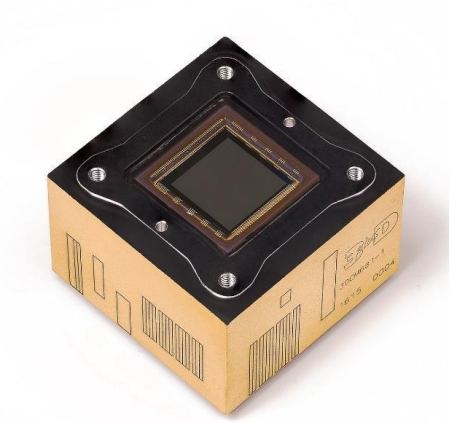
# (Liciacube Explorer Imaging for Asteroid)

- Panchromatic camera
- Detector 2048x2048 pixel
- Resolution up to 1.4 m/pixel at about 50 km

Dual functionality:

- Managing the cubesat operations/pointing:
  during the scientific phase, at regular intervals, it acquired images and processed them on-board, for keeping the target in the field-of-view

- Obtaining scientific images:
  starting from 71 seconds before the DART nominal impact, it acquired 3 images every 6 seconds to witness the impact and follow the evolution of its effects

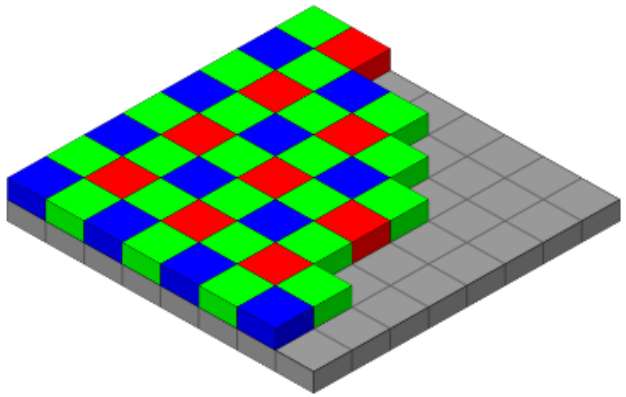


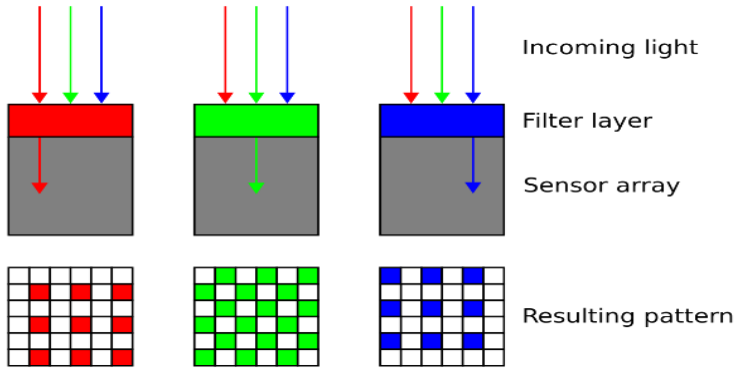
CMOS sensor
2048 x 2048 pixel

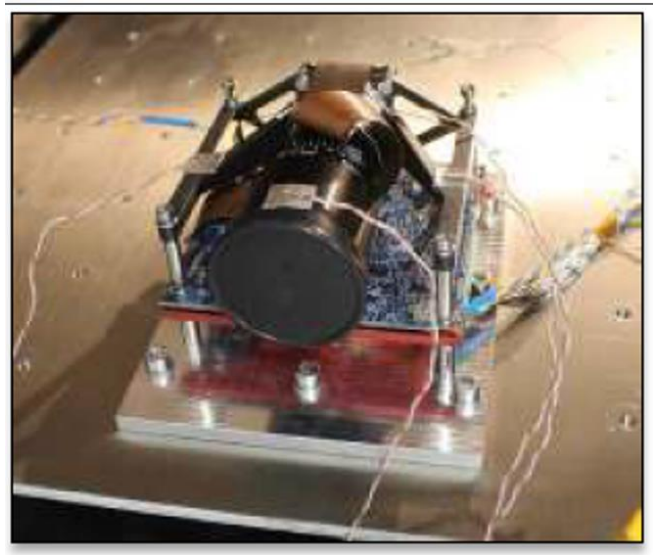
# LUKE
# (Liciacube Unit Key Explorer)

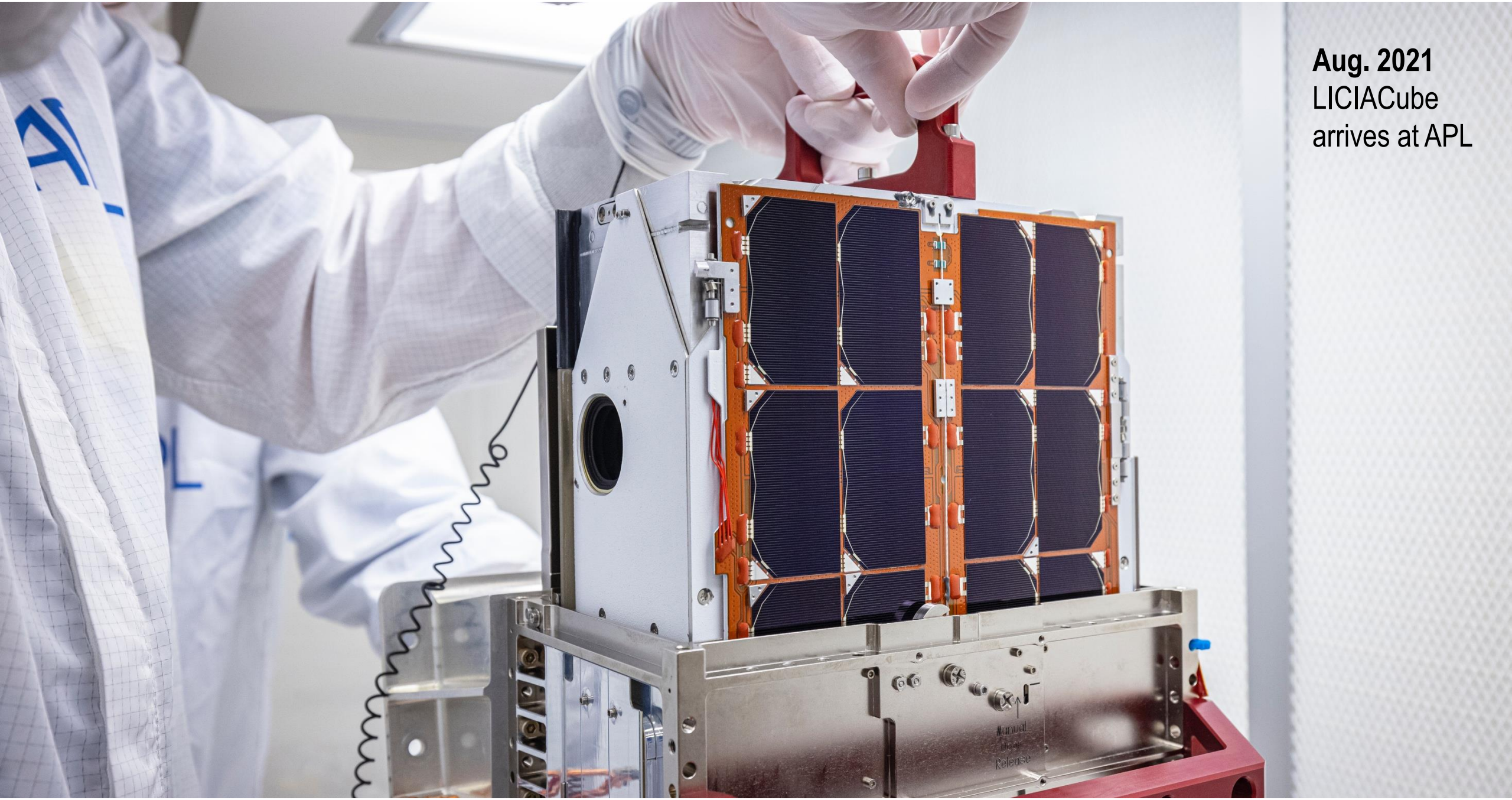
RGB Camera with a FoV of 10°
Bayer pattern filter:

- The three colors are acquired simultaneously according to a predetermined mosaic of filters on the detector
- Recomposing mosaics allows us to reconstruct 24-bit color images








**Aug. 2021**
LICIACube
arrives at APL

**Sept. 2021**
LICIACube
Integration

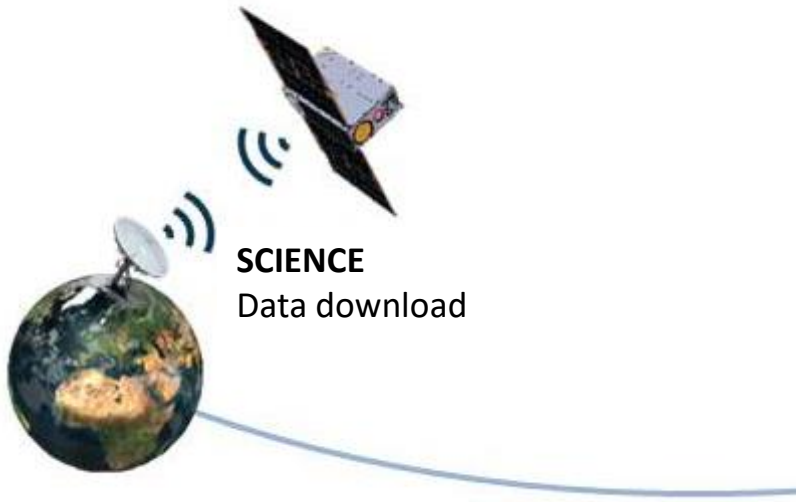
**Sept. 2021**
Pre-ship inspection

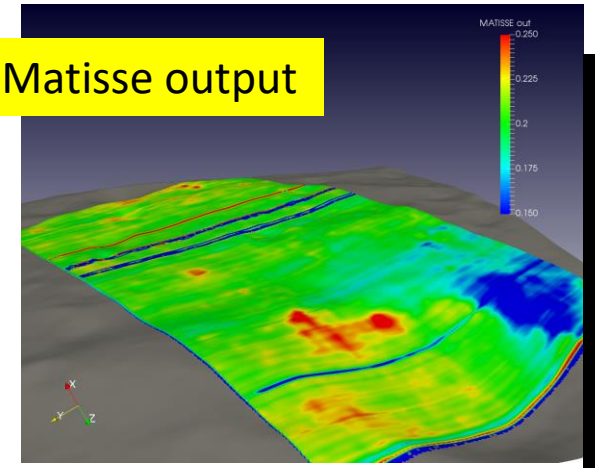

**Sept 2021**
Lift to the container

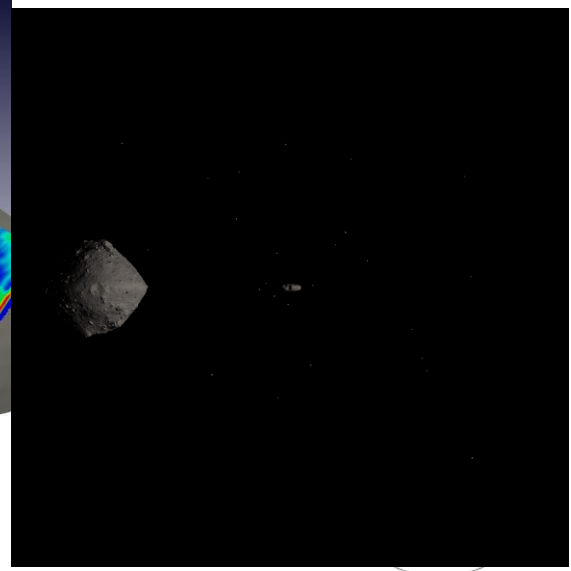
# Ground Segment

The mission Ground Segment architecture includes DSN  antennas and the two main elements located in Italy:

- Mission Control Center (MCC): @ Argotec (Turin)
- Science Control Center (SOC): @ ASI SSDC (Rome) https://www.ssdc.asi.it/liciacube/



# LICIACube

# Scientific Objectives

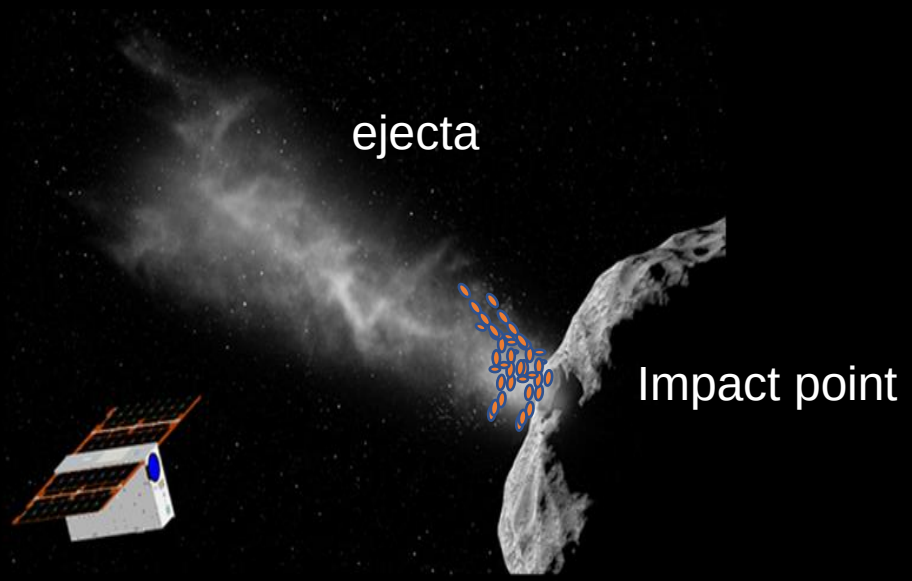
- To witness  the DART impact

- To obtain images of the ejecta plume taken over a span of time and phase angle, that can allow:
    * the measurement of the motion of the ejecta;
    * the estimation on the structure of the plume, by measuring the evolution of the dust distribution;

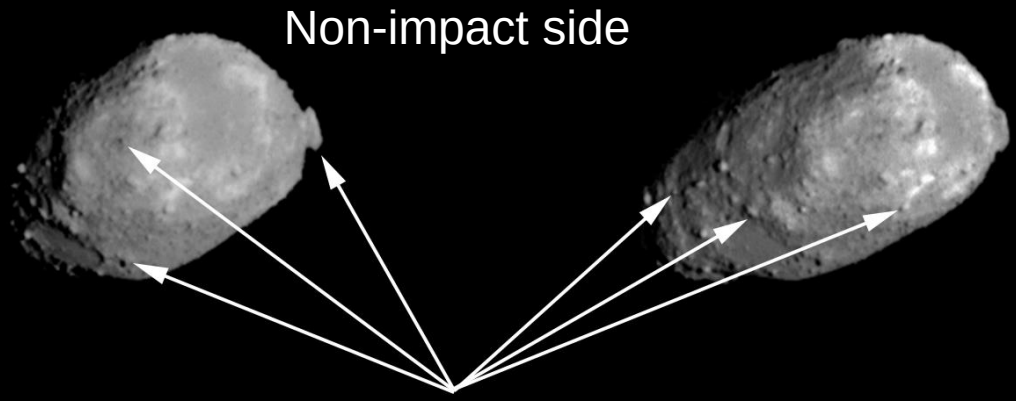
- To obtain images of the DART impact site to see (if visible) the crater;

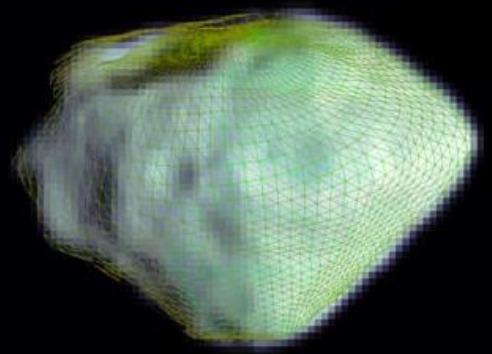
- To obtain images of Dimorphos showing the non-impact hemisphere, hence increasing the accuracy of the shape and volume determination of the whole system.

# Scientific Objectives



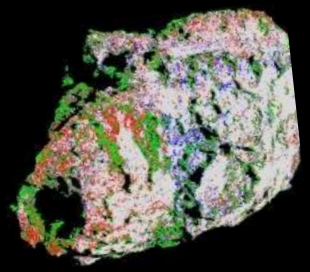

Geological and morphological analysis



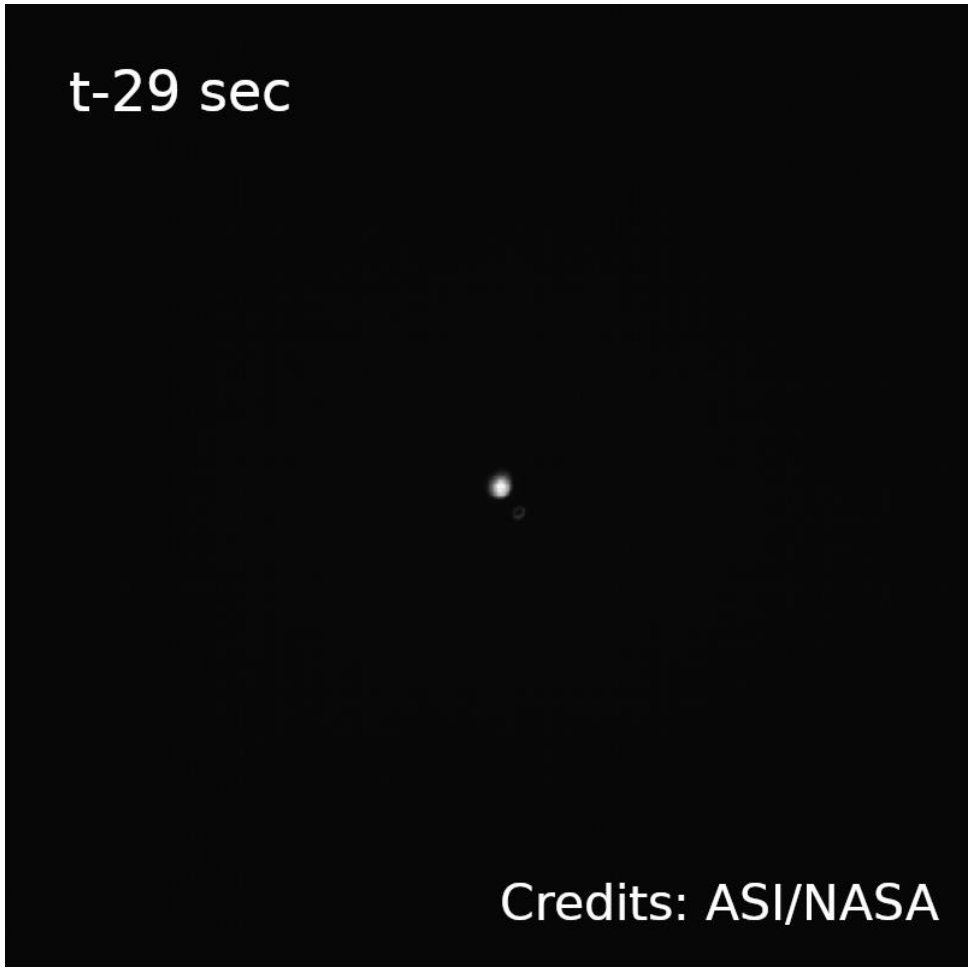



Shape and structure

Colours and composition



# LICIACube
# Witness of the DART impact



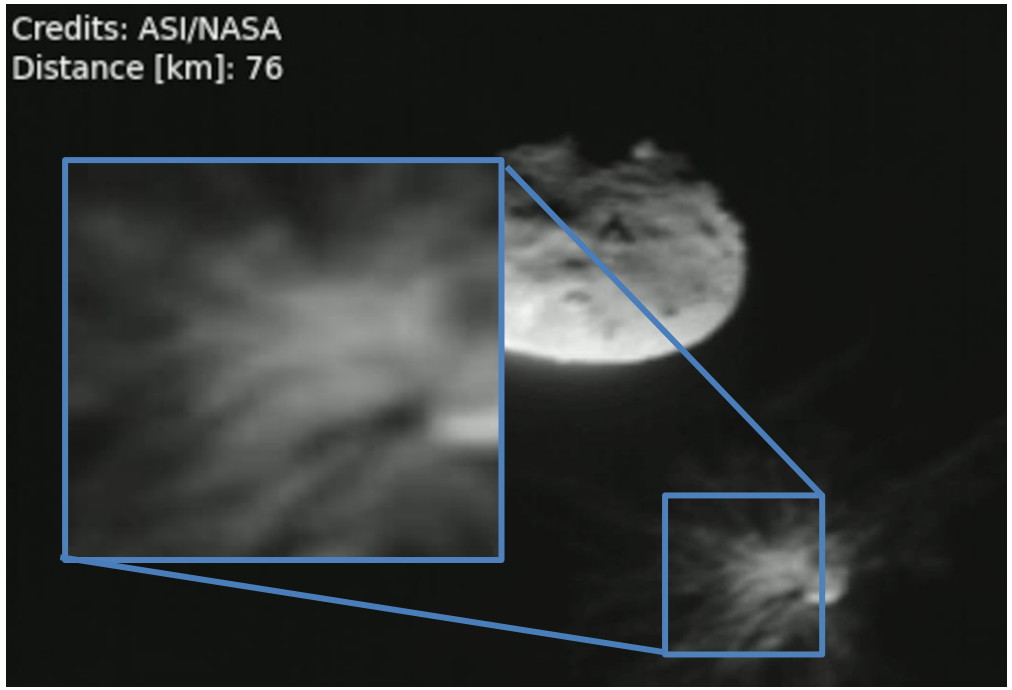
# The LICIACube Flyby

LICIACube LUKE
Roughly 3 minutes
after DART's impact

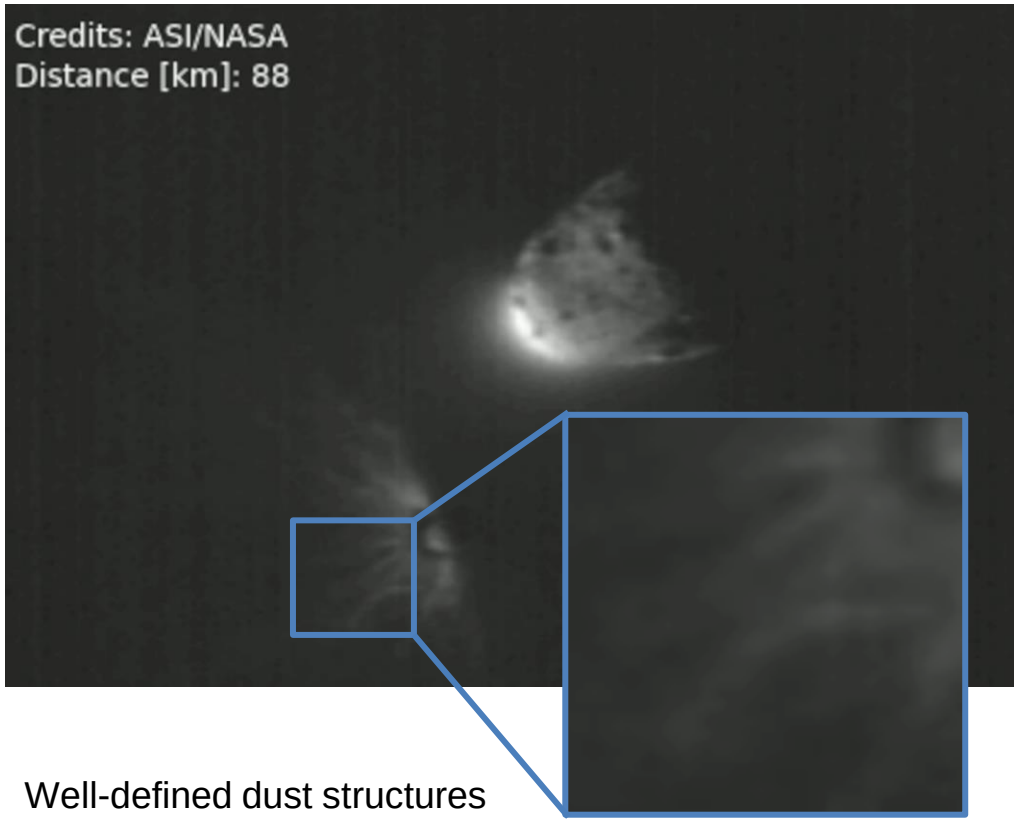
(LICIACube-Dimorphos
distance ~ 70 km)

# The LICIACube Flyby

# In more details: plume




Globally inhomogeneous and uncollimated dust distribution

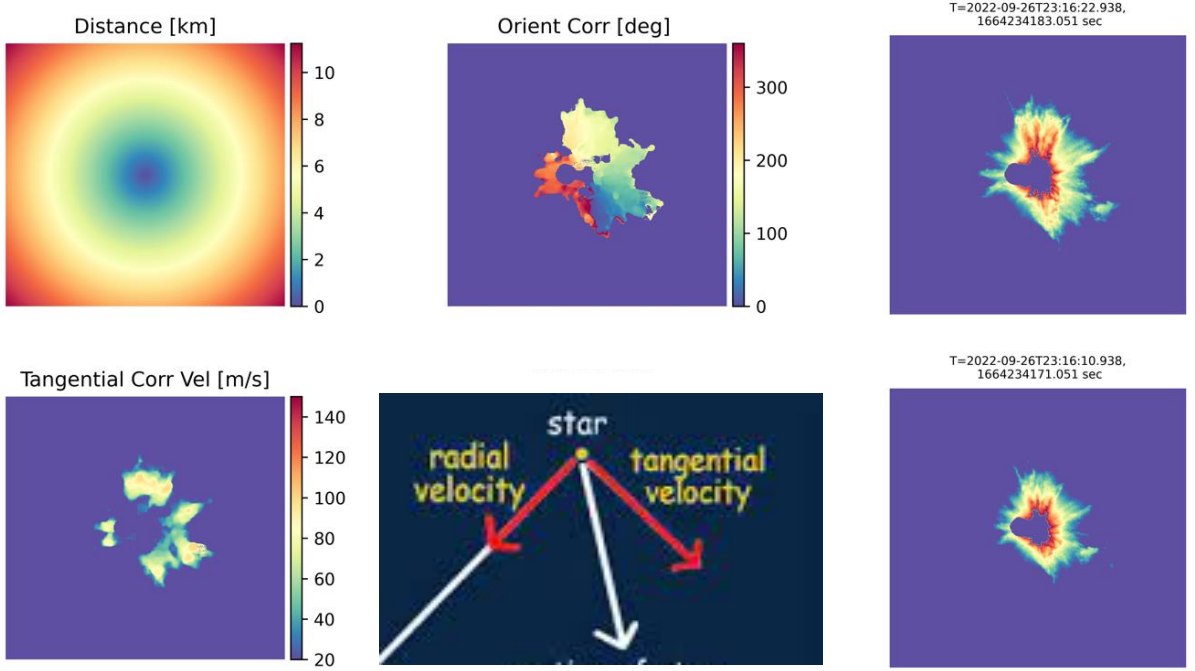



Well-defined dust structures also in the vicinity of Dimorphos

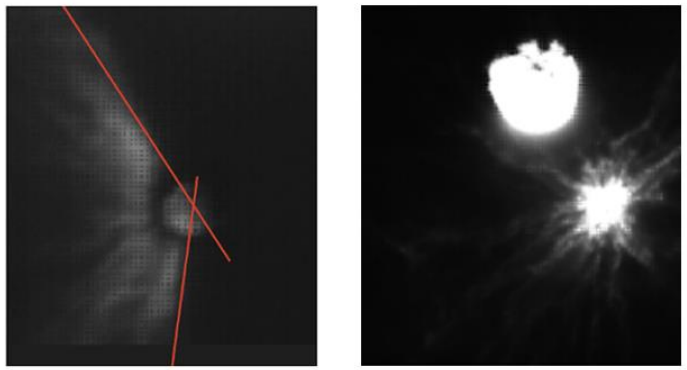
# Dynamics of the plume

- Particle velocities

Differential tangential velocities from automatic Optical Flow algorithm: detailed distribution of velocity for many structures in the plume.



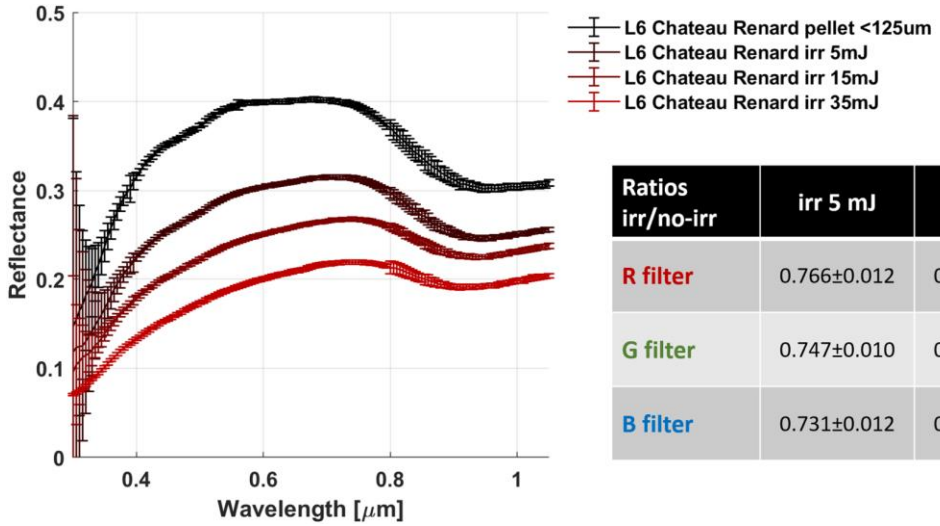

- Direction, density and structure of the ejecta cone



# Colours of the surface and of plume

Using LUKE data we obtain the color distribution of surfaces and plume.

A large database is pivotal to properly interpret color data from the system and in general from planetary bodies.




| Ratios irr/no-irr | irr 5 mJ | irr 15 mJ | irr 35 mJ |
|---|---|---|---|
| R filter | 0.766±0.012 | 0.636±0.009 | 0.509±0.009 |
| G filter | 0.747±0.010 | 0.609±0.008 | 0.480±0.008 |
| B filter | 0.731±0.012 | 0.588±0.009 | 0.453±0.008 |

**Several factors can induce color variation**

**Space Weathering**

FRESH — Albedo → OLD

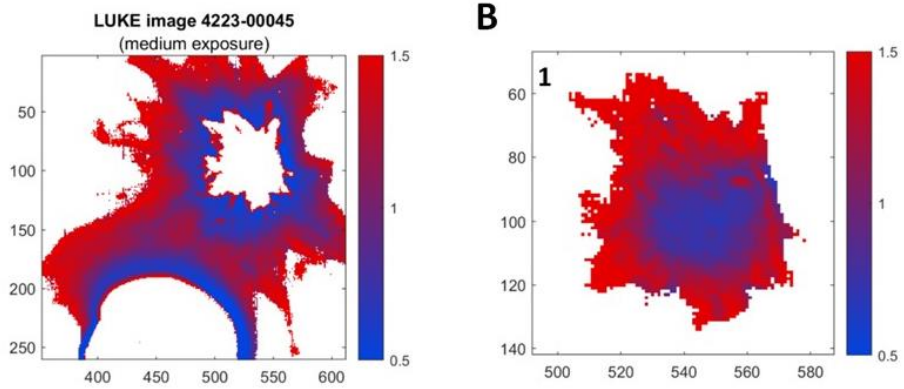
Slope

**Grain size**

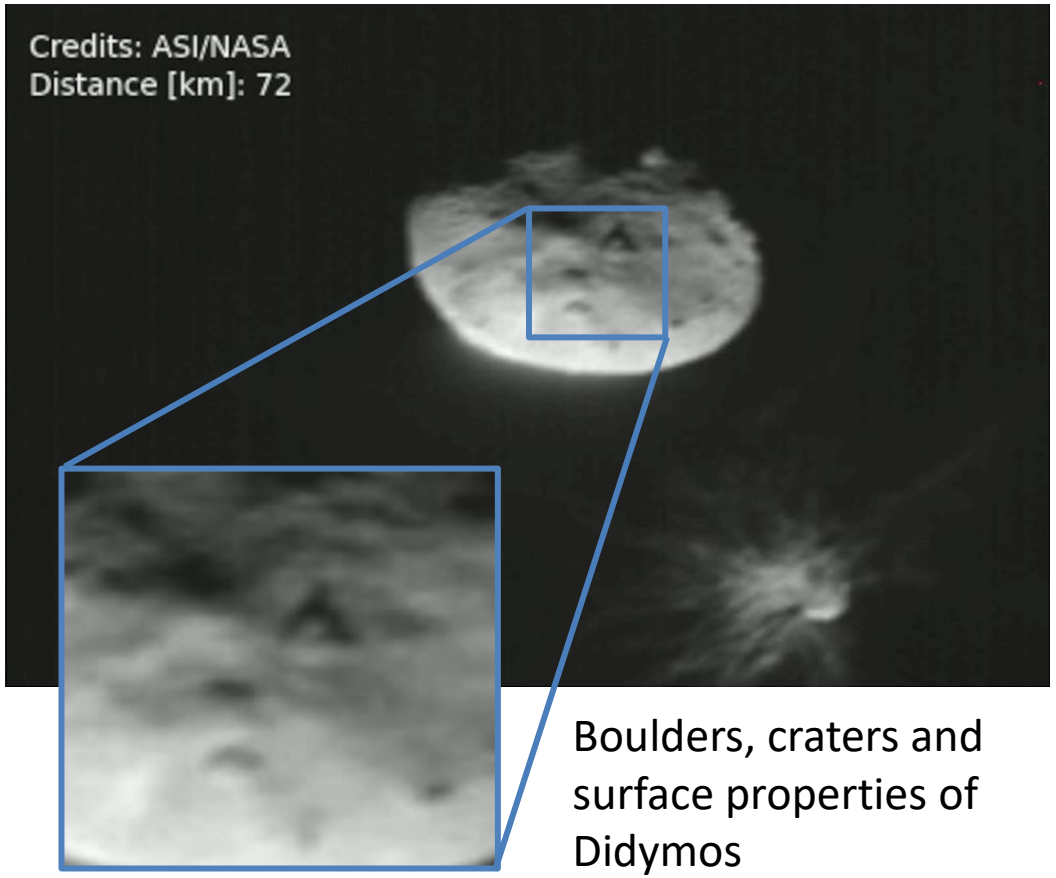
ROCKS — Albedo → DUST

Slope

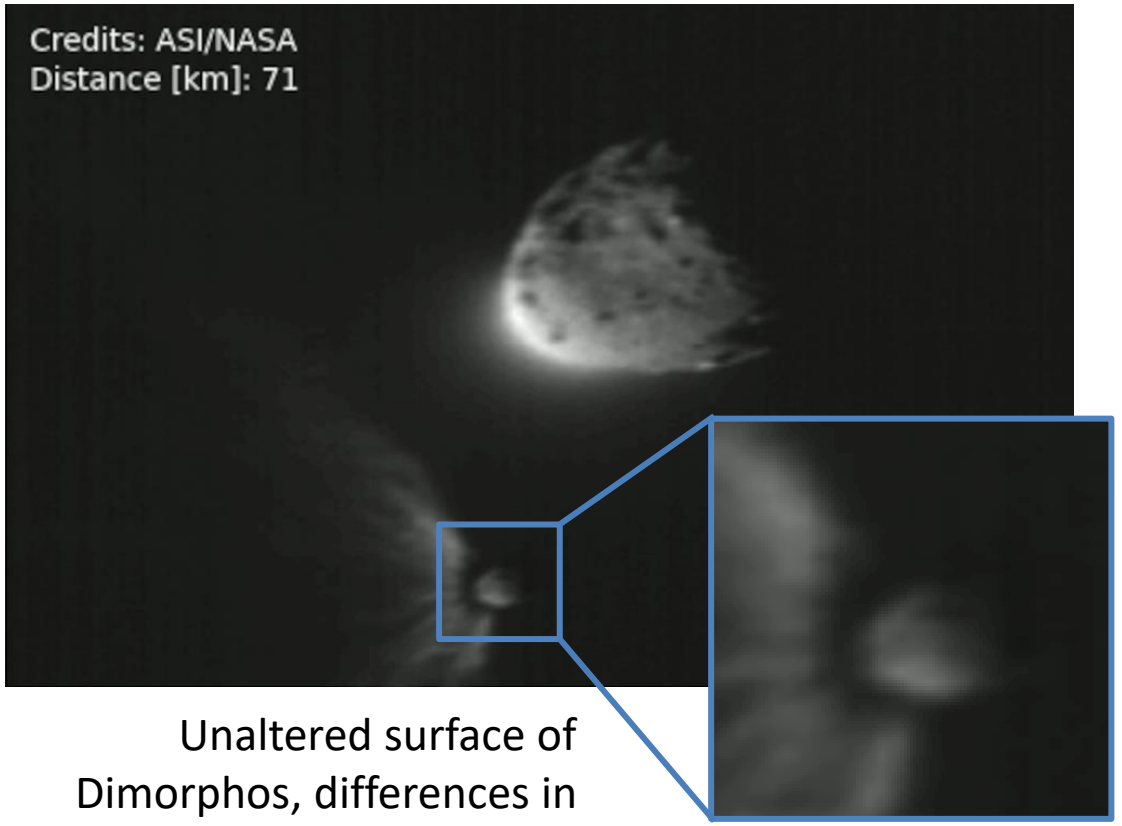
How plume color variation can be linked with surface and subsurface differences?



# In more details: surfaces




Boulders, craters and surface properties of Didymos




Unaltered surface of Dimorphos, differences in composition?

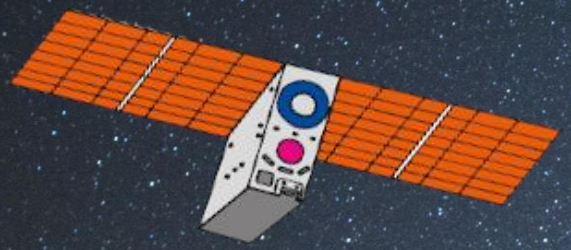
# The LICIACube team:

| | |
|---|---|
| **ASI:** | S. Pirrotta *(Program Manager)*, M. Amoroso *(Interface Manager)*, G. Impresario (*PA Manager*) |
| **ASI SSDC:** | A. Zinzi *(SOC Lead)* |
| **INAF:** | E. Dotto *(Science Team Lead)*<br>V. Della Corte *(Instrument Team Lead)*<br>E. Mazzotta Epifani *(WP Observations Lead)*, S. Ieva,<br>D. Perna, P. Deshapriya, P. Hasselmann, M. Dall'Ora<br>J.R. Brucato *(WP Laboratory experiments Lead)*, G. Poggiali, S. Caporali<br>S.L. Ivanovski *(WP Ejecta Lead)*<br>A. Lucchetti *(WP Impact Simulation Lead)*, G. Cremonese, M. Pajola, F. Tusberti |
| **IFAC-CNR:** | A. Rossi *(WP Dynamics Lead)* |
| **Univ. Parthenope:** | P. Palumbo, I. Bertini |
| **Politec. Milano:** | M. Lavagna *(WP Mission Analysis Lead)*, A. Capannolo, G. Zanotti, M. Ceresoli |
| **Univ. Bologna:** | M. Zannoni *(WP Orbit determination Lead)*, I. Gai, P. Tortora, D. Modenini. E. Gramigna,<br>M. Lombardo, R. Lasagni Manghi, L. Gomez Casajus |
| **@LICIACube:** | E. Nichelli, E. Mazzotta Epifani, A. Zinzi, F. Cruci, E. Perozzi, E. Dotto |

@LICIACube

LICIA

Light Italian Cubesat for Imaging of Asteroids



# LICIACube

## the witness of the DART impact

Thank you!

DART

Double Asteroid Redirection Test

PDC 2023 – 3-7 April 2023