LICIACUBE OBSERVATION CAPABILITIES OF DUST PLUME EVOLUTION AFTER DART IMPACT

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OVERVIEW

LICIACube - Light Italian Cubesat for Imaging of Asteroids is a space mission of the Italian Space Agency, based on a 6U cubesat that will take part in the NASA DART mission, with the aim to enhance the information gained from the main probe impact and to allow dedicated scientific investigations.

LICIACube is an ASI project, whose design, integration and test has been assigned to the aerospace company Argotec. The scientific team is led by National Institute of Astrophysics and it is enriched by University of Bologna team, supporting the orbit determination and the satellite navigation, and Polytechnic of Milan, for mission analysis support and optimization.

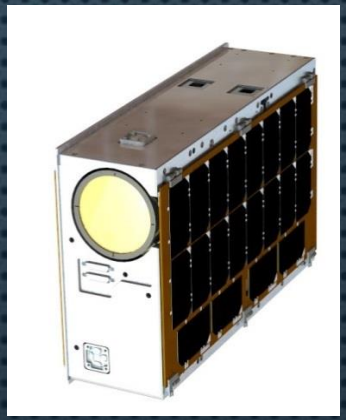
LICIACUBE OBJECTIVES

1. Multiple images of the ejecta plume taken over a span of time and phase angle to
   a) Allow measurement of the motion of the slow ejecta
   b) Allow estimation of the density structure of the plume

2. Multiple images of the DART impact site having sufficient resolution (< 2 m/pixel) to allow measurements of the size and morphology of the crater;

3. Multiple images of Didymos B showing the non-impact hemisphere,

LICIACUBE SPACECRAFT AND PAYLOADS



Mass:	14 kg
Volume:	228 mm x 100 mm x 363 mm (stowed)
	228 mm x 900 mm x 363 mm (deployed)
Downlink Data rate:	Up to 256 kbps
Lifetime:	16 months of cruise phase,
	6 months of operative phase
Propulsion:	Cold gas for attitude and orbital maneuvers
Primary Payload:	±2.05 deg (Diagonal FoV) Panchromatic (400-900 nm) camera (2048x2048)
Secondary Payload:	± 5 deg (Diagonal FoV) RGB (Bayer) camera (2048x1088)

PLUME EVOLUTION IMAGING

Present mission design foresees a release of the cubesat 10 days before the DART impact and a flyby of Didymos B with a close Approach distance of 55 km about 163 second after the DART impact .

The first part of the LICIAcube payloads scientific acquisition will be dedicated to the imaging of
the evolution of the produced dust plume

Most of the scientific phase of the mission will be dedicated to this task

Both payloads will acquire several images of the expanding plume during the about 140 s
Needed to reach the Close Approach phase and when the Payloads will focus acquisitions to
Didymos A and Dydimos B thanks to the higher resolution achievable

PLUME ACQUISITION SIMULATION 1/3

With the two fold aim of set the operative parameters for the Paylods and to understand the information retrievable by the images of the evolving plume we started an imaging simulation activities taking into account:

- LICIAcube mission design (Trajectory, Speed, illumination conditions
- Payloads optical design (F#, Aperture, filters)

The plume evolution was simplified assuming:

- Non colliding particles during the plume evolution;
- A speed distribution in the plume given by eq:

$$v = U C_1 [\, x/a \;\; (\rho/\delta)^{\nu}]^{-1/\mu} (1 - x/(n\_2\, R))^{p}, \qquad n_1\, a \le x \le n_2\, R.$$

- Where x is the distance from the impact point of the starting position of the particle and the other parameters have the following values:

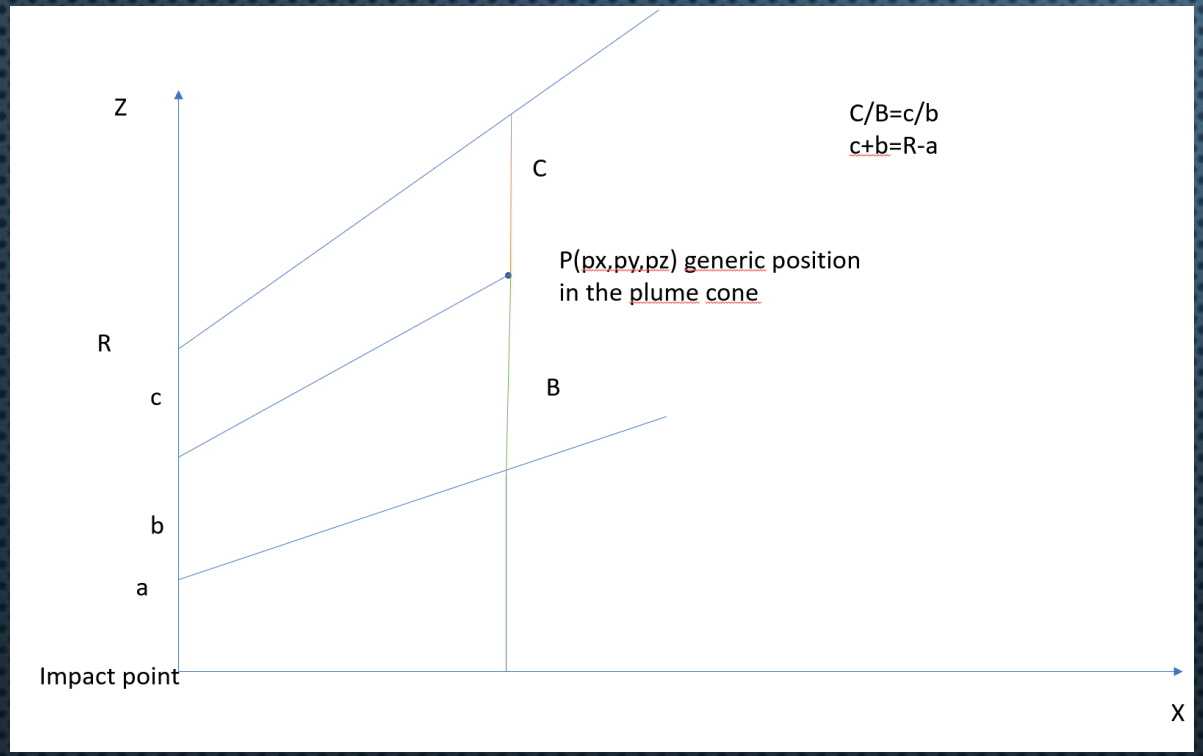
a (m)	R (m)	δ (g/cc)	ρ (g/cc)	μ	C_1	k	p	ν	n_1	n_2
0.5	10	0.57	2.6	0.46	0.18	0.3	0.3	0.4	1.2	1

- We considered the most representative 3 size bin for what concern the ejected mass the total number of particles are respectively:

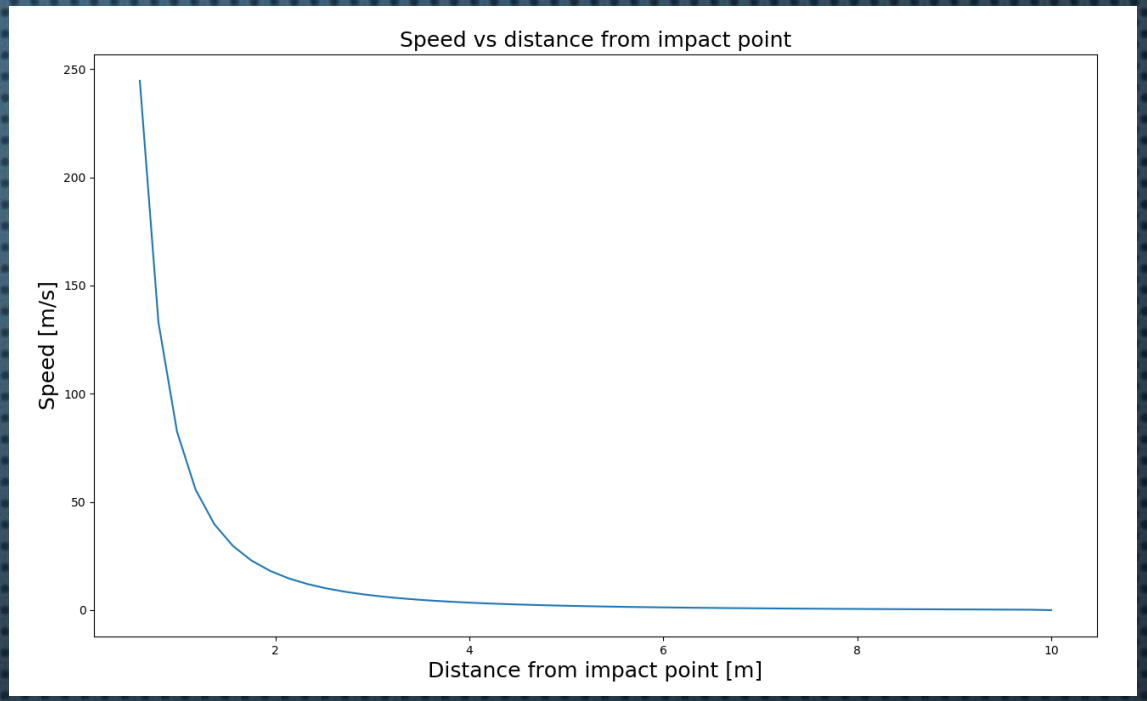
	Size range (m)	Total number
SR_1	$10^{-2} - 10^{-1}$	3.44×10^{7}
SR_2	$10^{-3} - 10^{-2}$	2.17×10^{10}
SR_3	$10^{-4} - 10^{-3}$	1.37×10^{13}

- Particles contained within the volume comprised in two Cones with small difference in the vertex angle

PLUME ACQUISITION SIMULATION 2/3



Particle trajectories within the plume volume

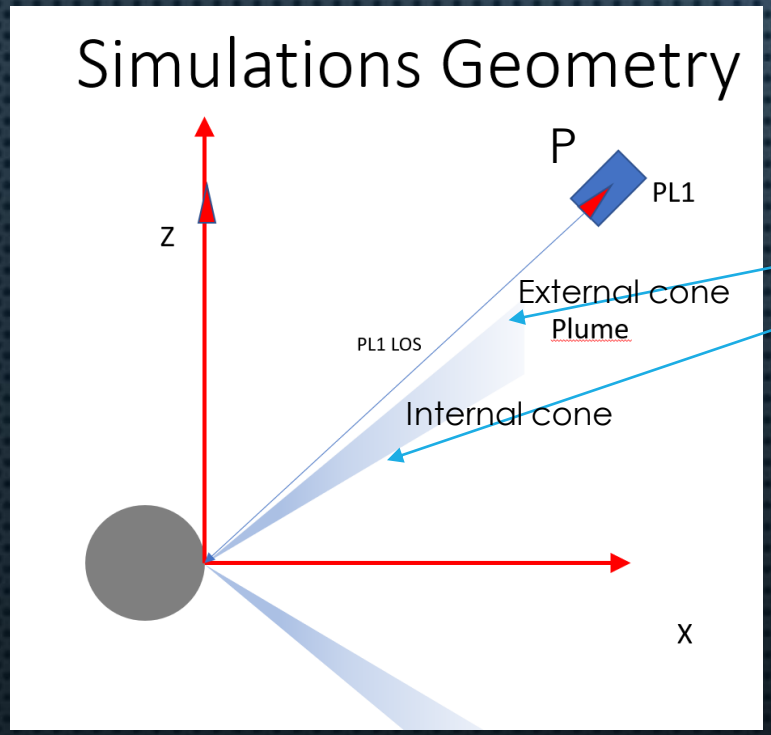


The expression of the speed give the reported trend for the particles speeds in function of the Distance from the impacting point

PLUME ACQUISITION SIMULATION 3/3

The initial plume images were simulated considering the axis of the evolution on the plume along the X axis represented and:

a) single position along the trajectory: the position 50 s before Close Approach
b) 1 plume evolution cone
c) 2 different retards in the plume evolution starting time

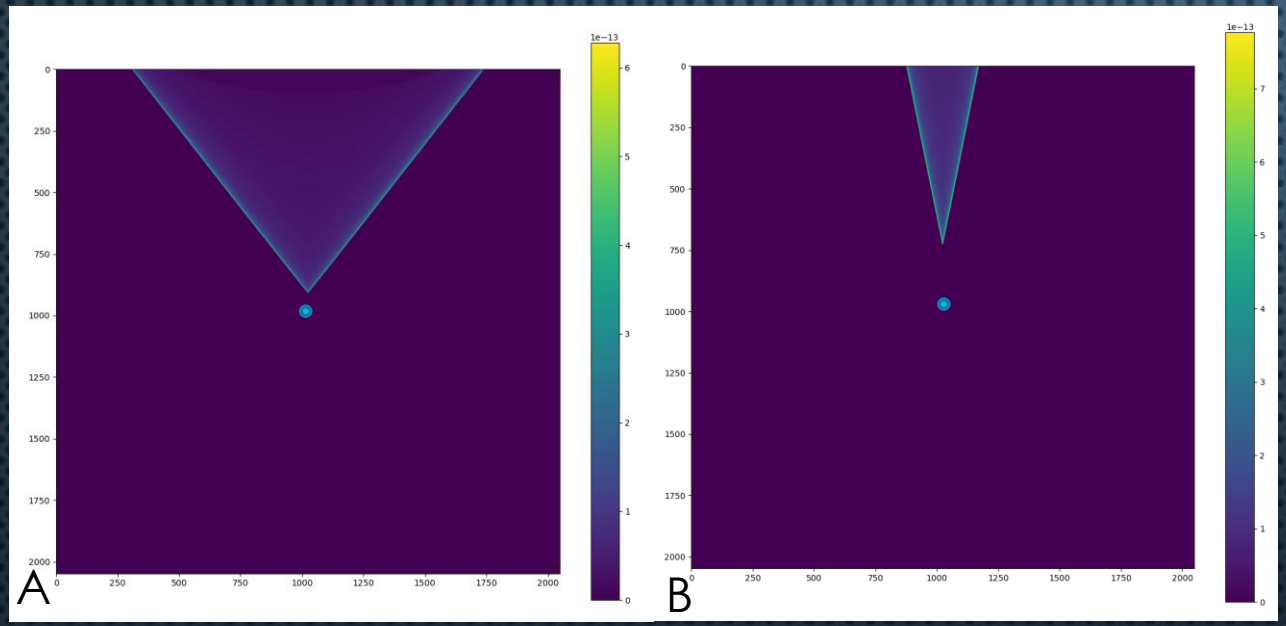


- LICIAcube Position in the used reference frame centered at impact point P[316440,0,232955] [m]
- Cone angles:
  1. 50 external 40 internal
- Plume evolution Retards from the impact:
  1. 0 s
  2. 60 s

Simulations have been performed anly for the Panchromatic camera. The results obtained can be scaled to the RGB camera

RESULTS 1/3

- Using the description of the plume and the optical parameters of the payload have been computed for the pixels of the camera the dust column density along its Line of Sight for each particle size bin.
- A preliminary rough evaluation of the Irradiance has been computed



In the images are reported de values of irradiance for each pixel in the in the case of the starting plume evolution just after the impact, but considering two different angles (A 50&40; B 20&10) for the cones in which the plume evolved. The values of radiance are similar but the extension of the plume is different (as expected)

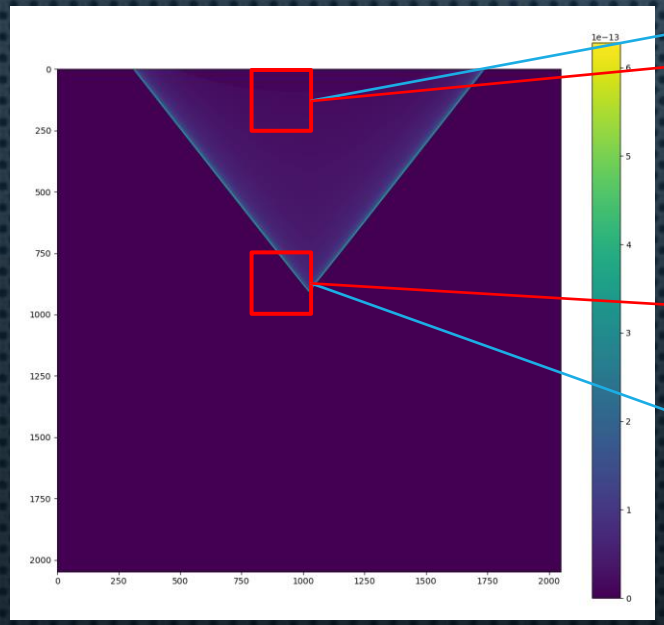
When the evolution is narrower the plume in images is more detached form the body represented by the small circle in the middle of the images

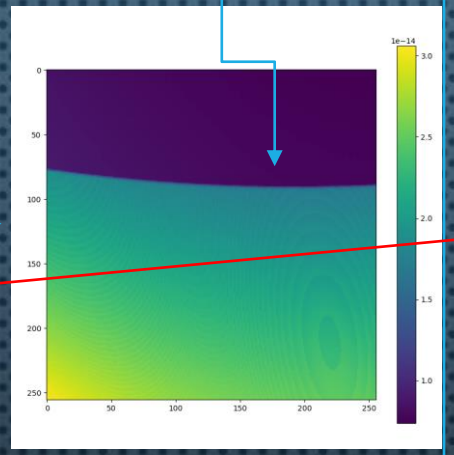
RESULTS 2/3

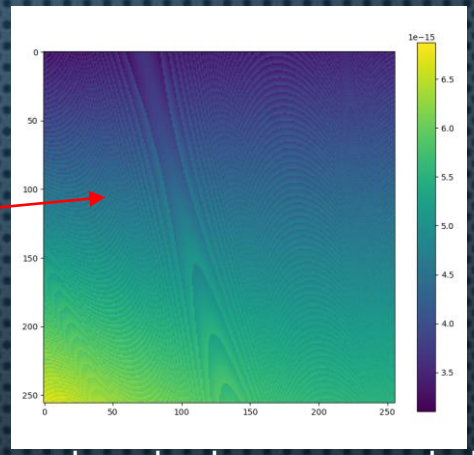
To detect ''structures'' in the plume acquisitions need to cover about 2 order of magnitude

When a retard of 60s is considered in the evolution of the plume, the irradiances evaluated seem become different only in the part of the plume far from the object

Zoom of the image with plume evolution started just after impact:

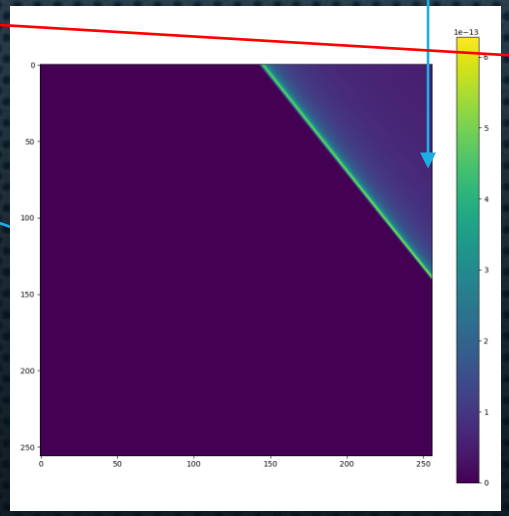


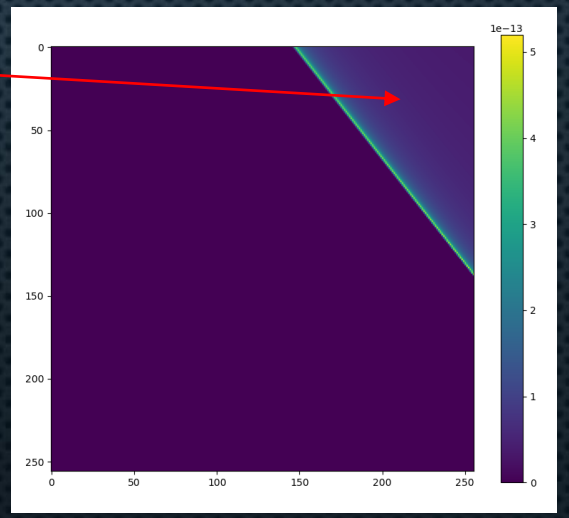




60s retard plume evolution

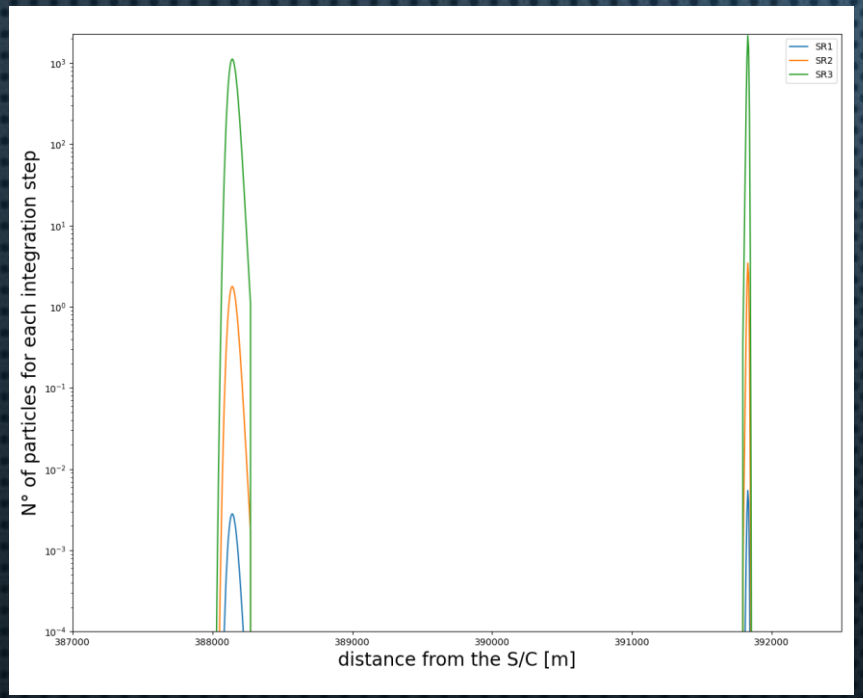
0s retard plume evolution

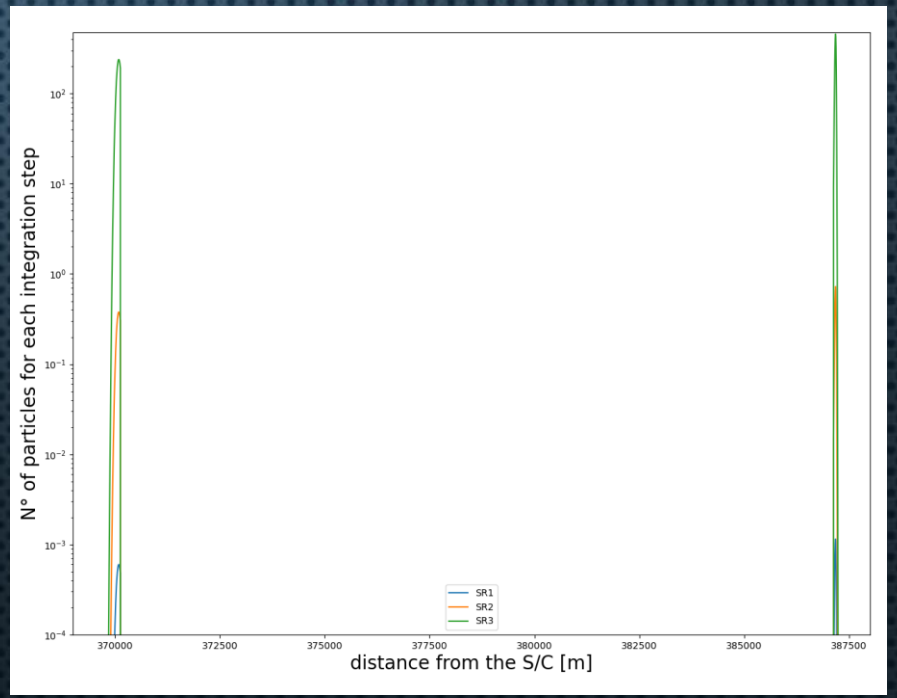




RESULTS 3/3

Line of sight column densities:
Considering a single image and plotting the values of the dust column densities w.r.t the distance for two different pixels, not only the values for each size bin are different but also the ratio between this values corresponding to istantaneous different size distributions.





CONCLUSIONS & FUTURE WORK

The simulations of the possible plume images that can be collected by the payloads of LICIAcube show several critical points that will be investigated in the future:

- Very wide range in terms of irradiance for the plume images, this aspect need to be addressed by an appropriate observation strategy
- Also simple modifications in the parameters of the plume evolution strongly affect the resulting images
- Colour analyses of the images probably will give information on the relative instantaneous particles size distribution