DART

JOHNS HOPKINS APPLIED PHYSICS LABORATORY

NASA

DART Ejecta Plume Optical Depth Imaged by LICIACube Flyby

Kinetic Impactor Demonstration
Determination of β

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2-D Extension of Plume Model, Icarus 352,113989 (2020)

DART Mission: Asteroid Deflection Test

- DART kinetic impactor demonstration at Didymos binary asteroid, Sept. 30, 2022
- DART will hit the moon Dimorphos and change its orbit period; this change to be measured by Earth-based telescopes
- DART carries Italian cubesat LICIACube to image impact ejecta plume evolution
- Modeling of LICIACUBE ejecta images helps *determine momentum transfer efficiency* β

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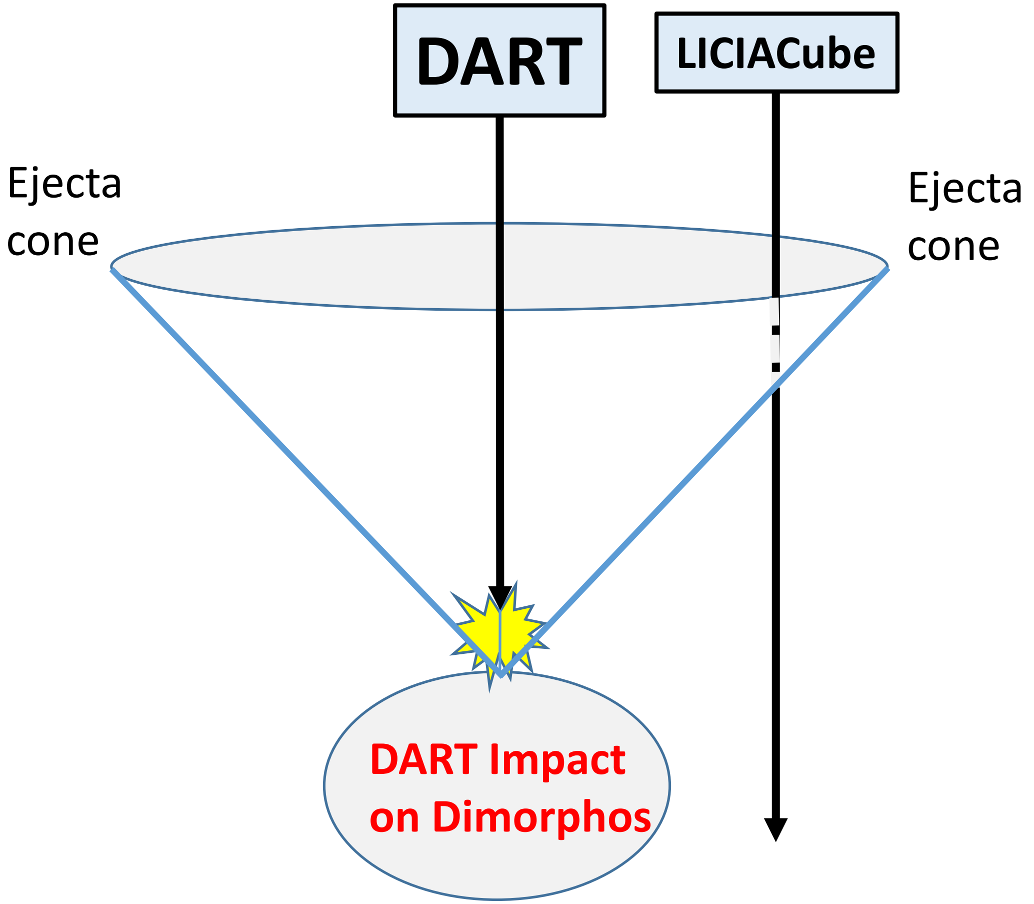


LICIACube will fly by Dimorphos after the DART impact and image DART impact ejecta

Cheng AF et al. Icarus 352 (2020) 113989

Icarus 352 (2020) 113989

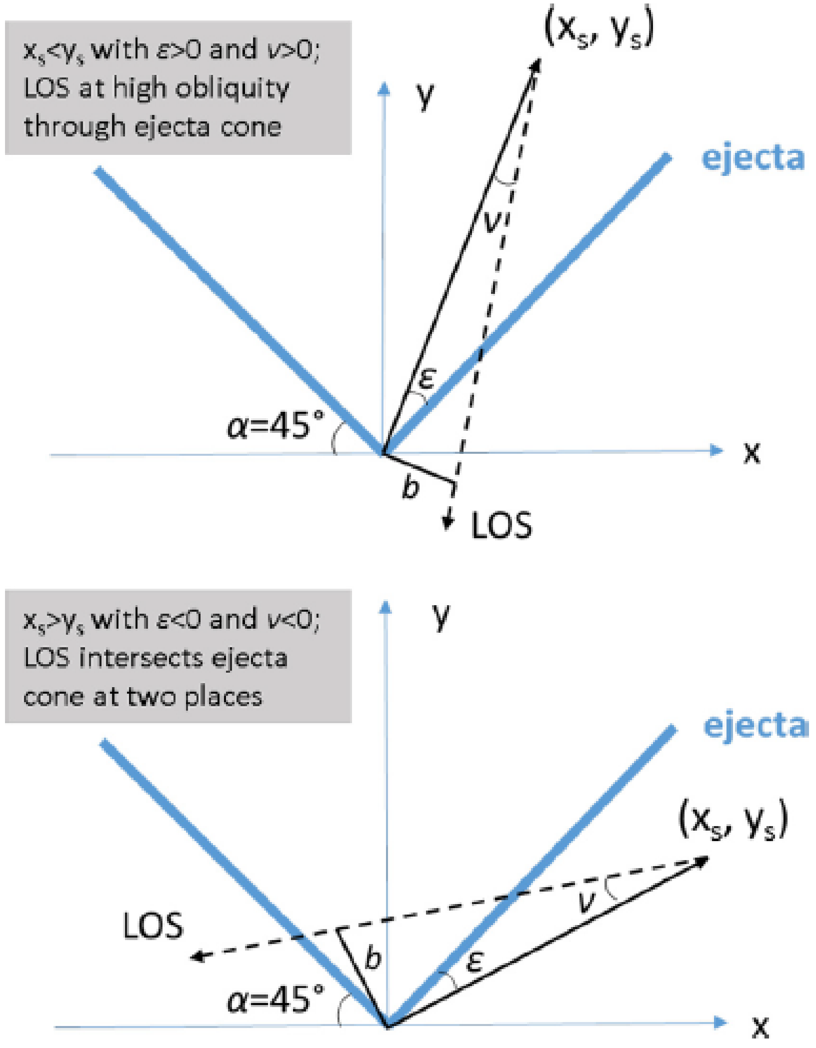
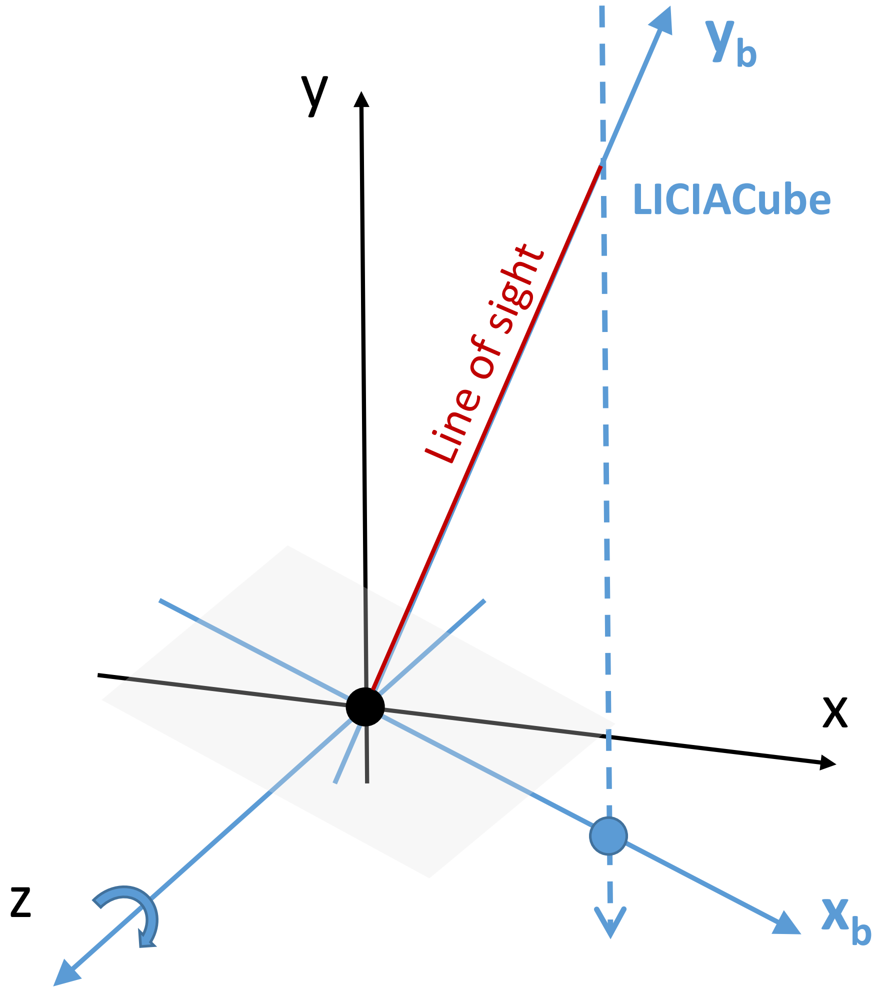
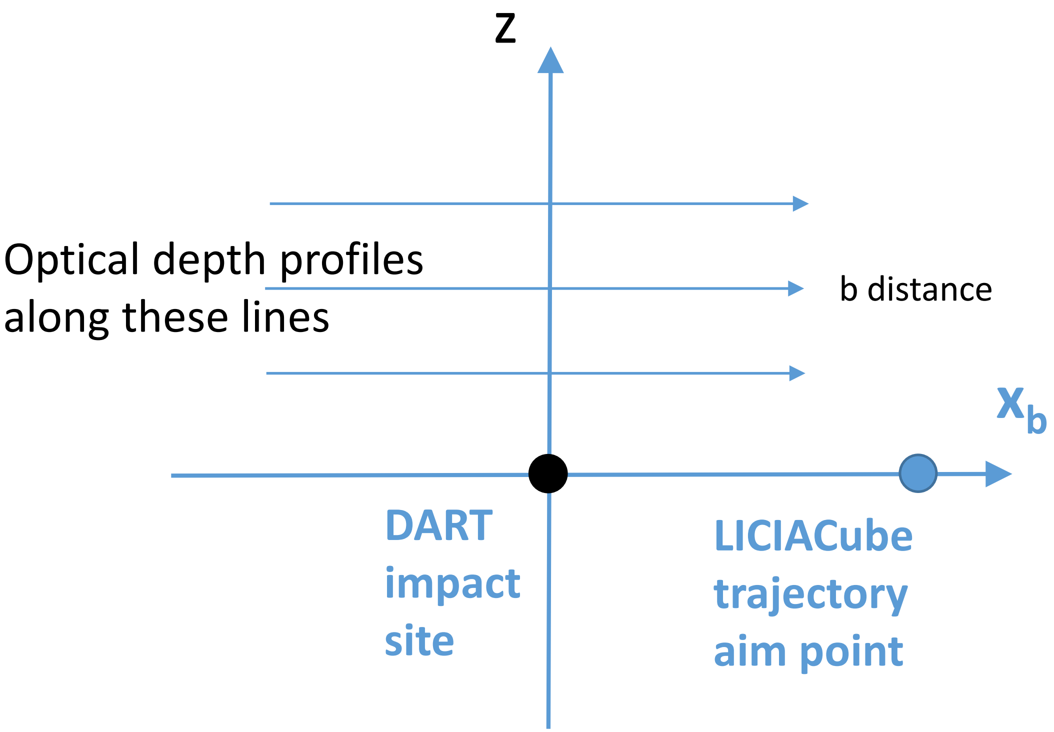


Fig. 5. Viewing geometries from LICIACube along flyby trajectory: during early approach (upper panel) LICIACube is within the ejecta cone $x_s < y_s$ and LOS can intersect the ejecta cone at high obliquity as shown or at low obliquity; after crossing outside ejecta cone (lower panel) where $x_s > y_s$ a single LOS intersects the ejecta cone twice.

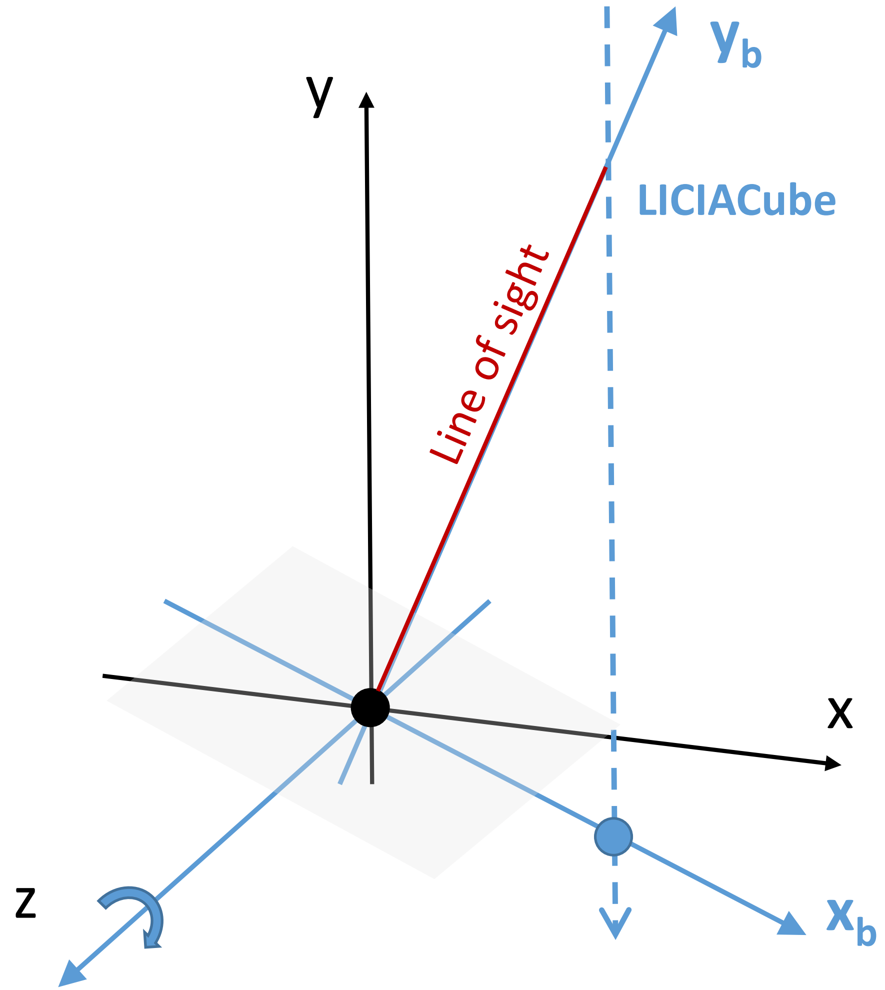


LICIACube trajectory is dashed blue line. Line of sight to Dimorphos impact site is red line defining y_b axis. The plane of sky at Dimorphos seen from LICIACube is x_b-z (shaded)

LICIACube images:
plane of sky at Dimorphos



Optical depth versus distance b is calculated along image lines z = z0 constant, where profiles at z = 0 were presented by Cheng et al. (2020).



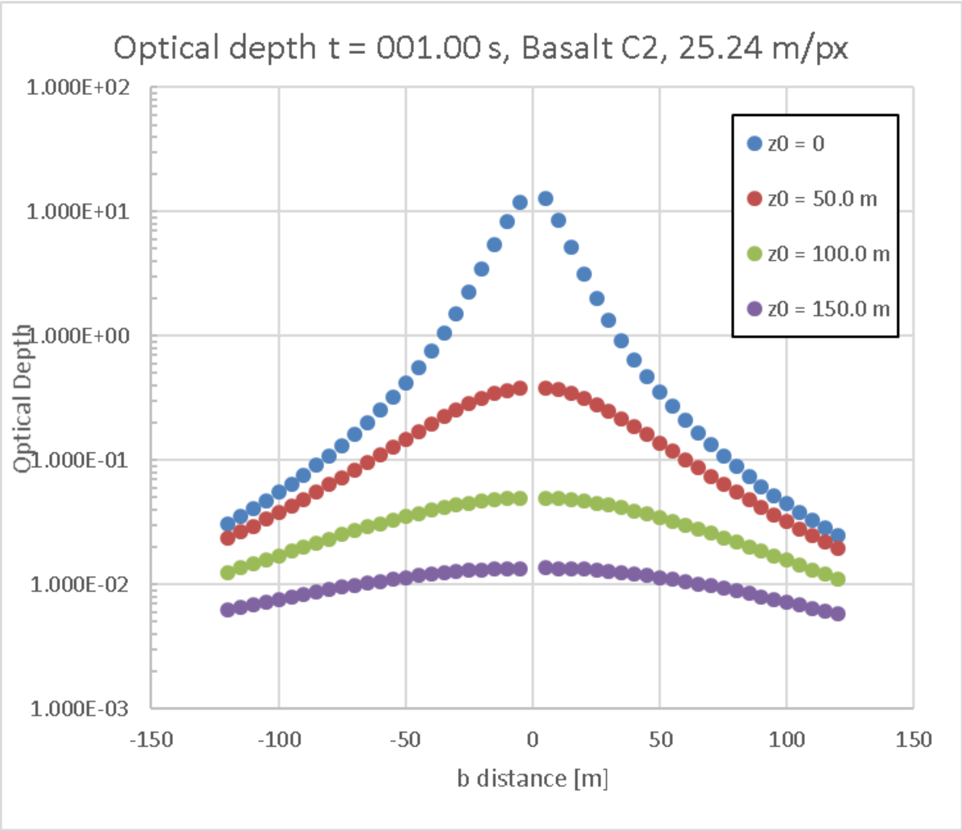
Ejecta plume axis is y-axis. Plume model is symmetric for ± z but asymmetric for ± x_b

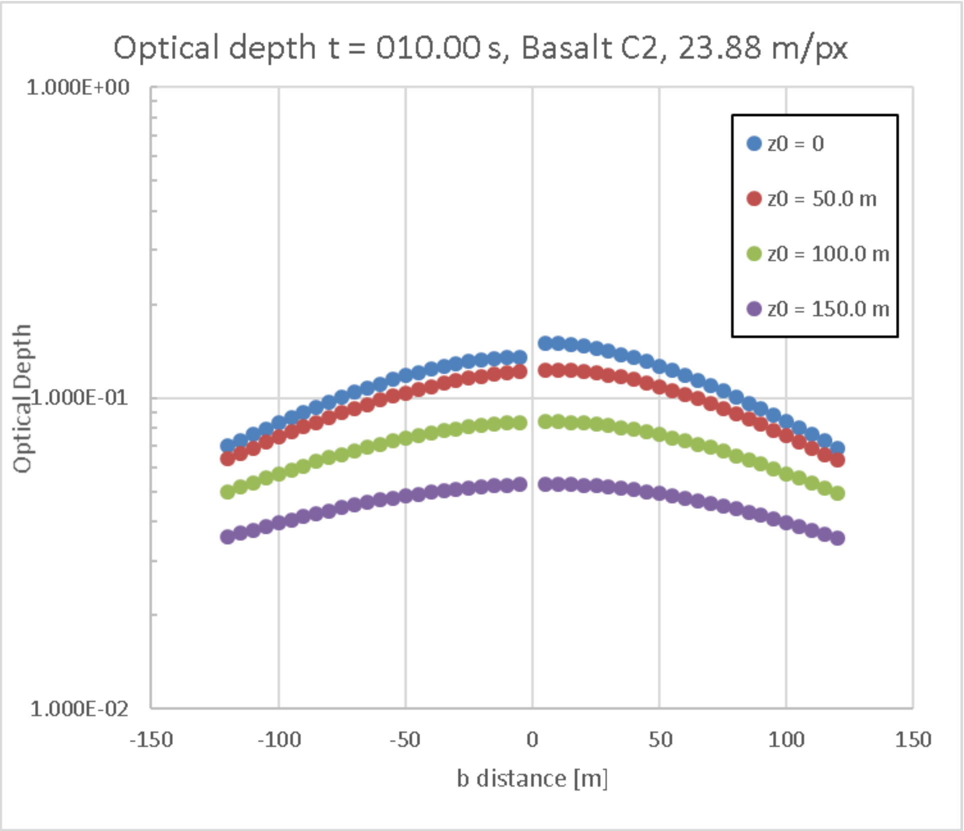
Plume evolution: basalt target, fast evolution

Basalt Target:
Strength 30 MPa
Density 3.0 g/cc

DART 610 kg
Impact speed 6.15 km/s
Crater radius 4.9 m

LICIACube c/a distance 51.2 km from Didymos
LICIACube c/a delay time 167 s from DART impact





Plume evolution: sand target, slow evolution

Sand Target:
Strength 100 Pa
Density 1.51 g/cc

DART 610 kg
Impact speed 6.15 km/s
Crater radius 22.4 m

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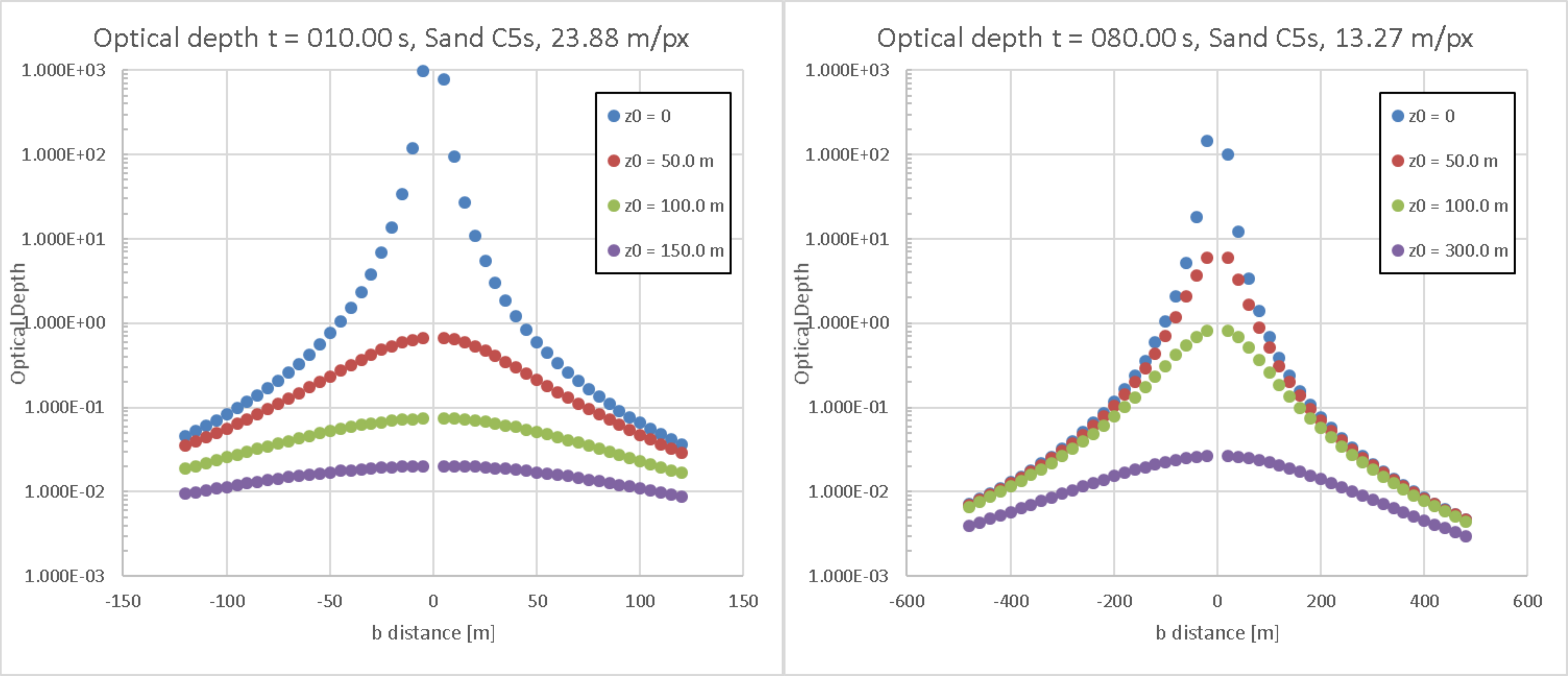
LICIACube c/a delay time 167 s from DART impact



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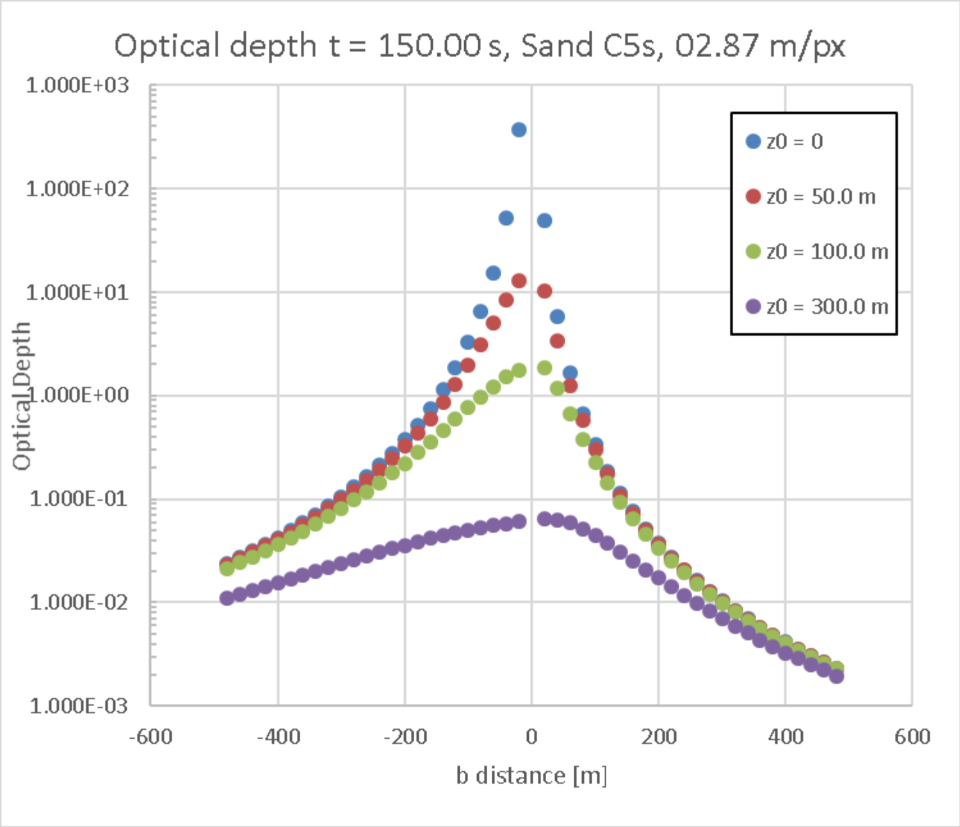

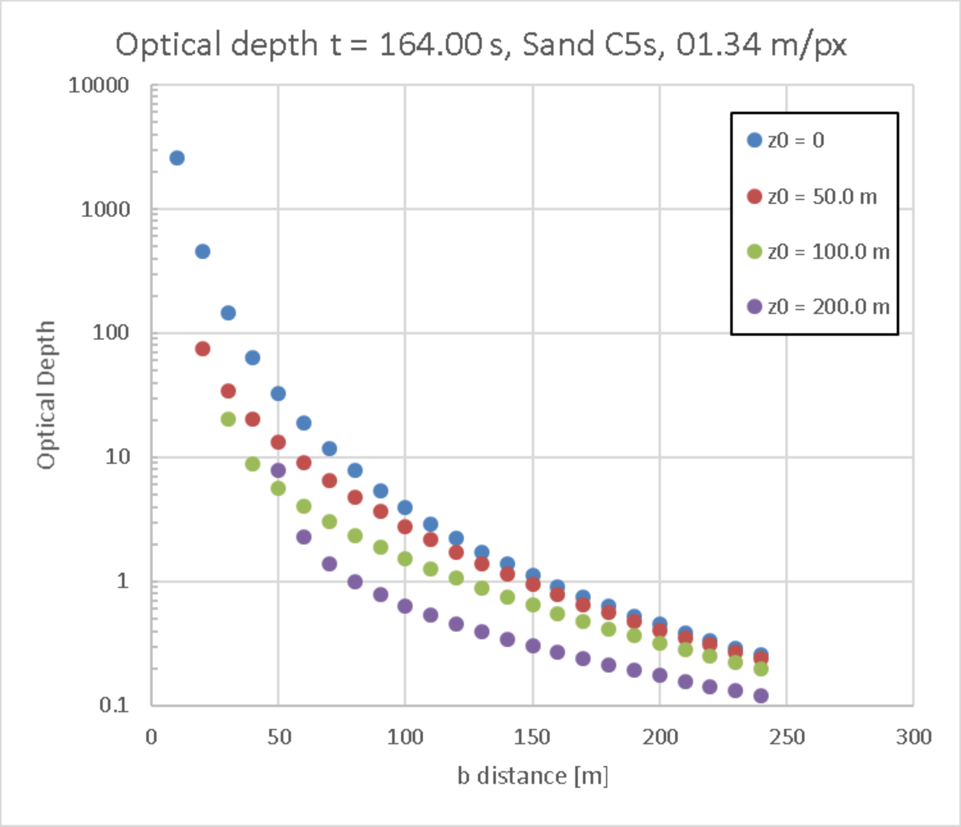

LICIACube Plume Images and Determination of β

- Images of plume evolution characterize the ejecta mass vs. velocity distribution: at a given time, how much mass has climbed how high
- Plume evolution distinguishes target properties, and distinguishes strength-controlled from gravity-controlled impacts
  - Rapid evolution, short clearing time (or plume separation) for strong targets
  - Slow evolution for weak targets
- Plume geometry (axis direction, asymmetry) constrains direction of ejecta momentum; plume images also constrain ejection angle
- If one limb of target body is visible through plume prior to c/a
  - Limb observations can determine optical depth and particle sizes