Modeling the DART Impact

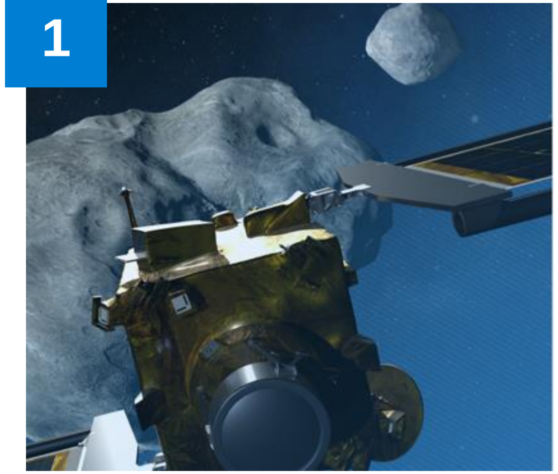
Effect of Surface Morphology and Rubble Pile Structure on Deflection Observables

Mallory DeCoster, Emma Rainey, Dawn Graninger, Angela Stickle, Katie Kumamoto, and Robert Luther

Mallory.DeCoster@jhuapl.edu

DART's Level 1 Requirements

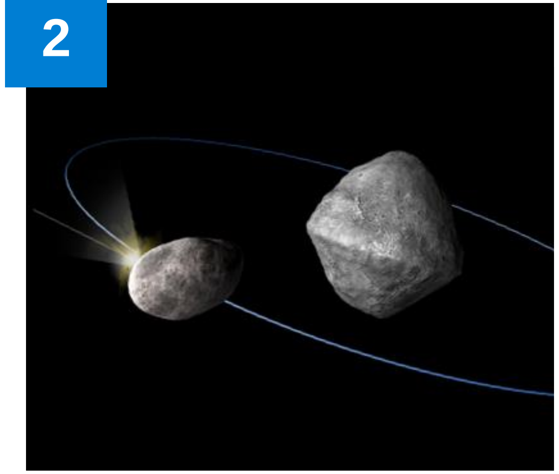
1



Impact Dimorphos

During its Sept/Oct 2022 close approach to Earth

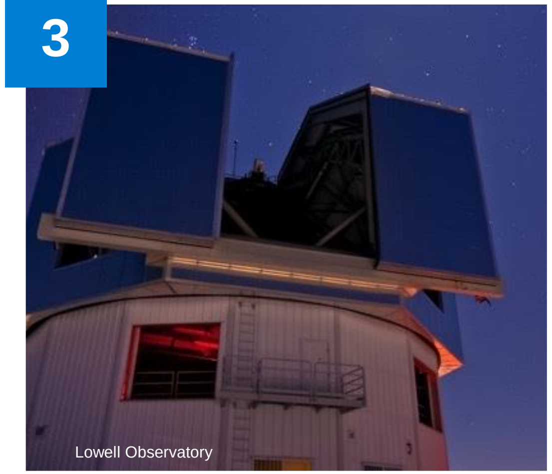
2



Change the binary orbital period

Cause a ≥73-second change in the orbital period of Dimorphos

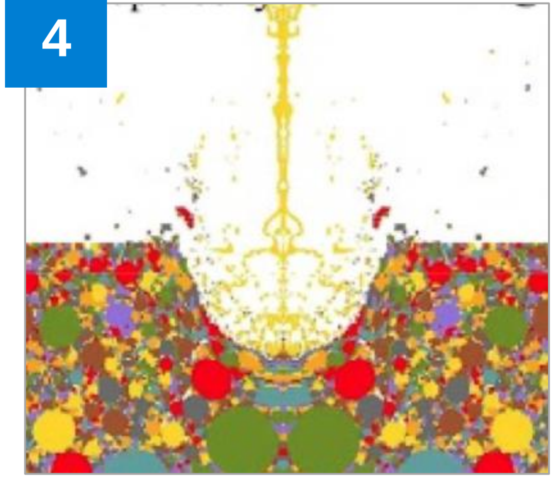
3



Measure the period change

To within 7.3 seconds, from ground-based observations before and after impact

4



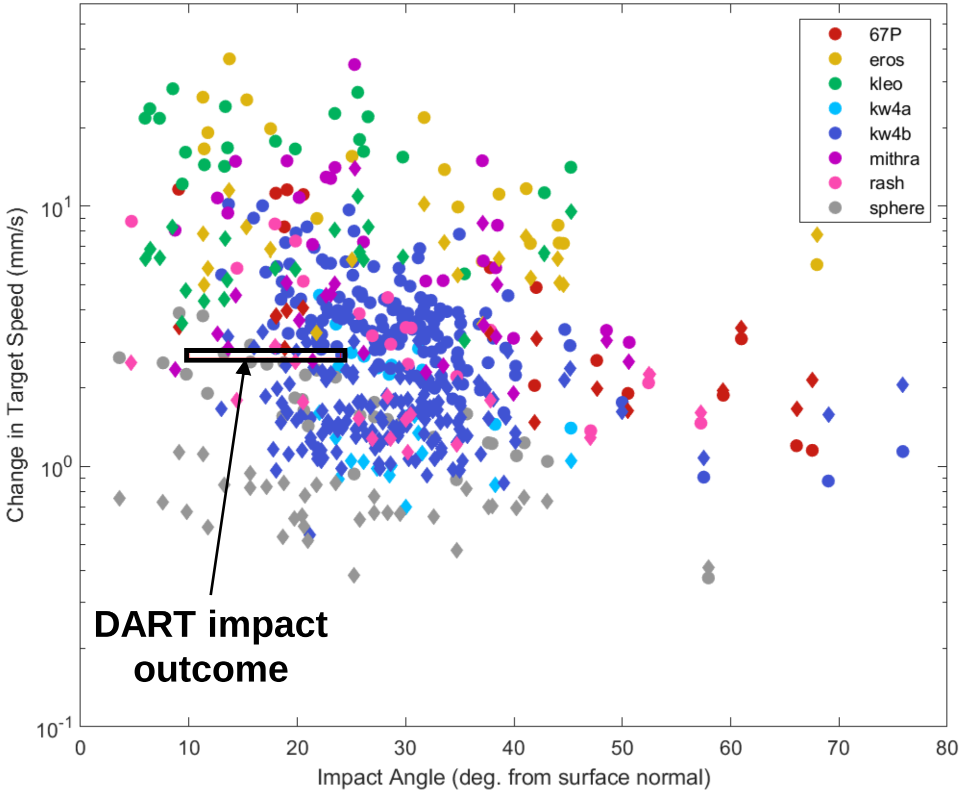
Measure "Beta" and characterize the impact site and dynamics

Beta = *the momentum enhancement factor*

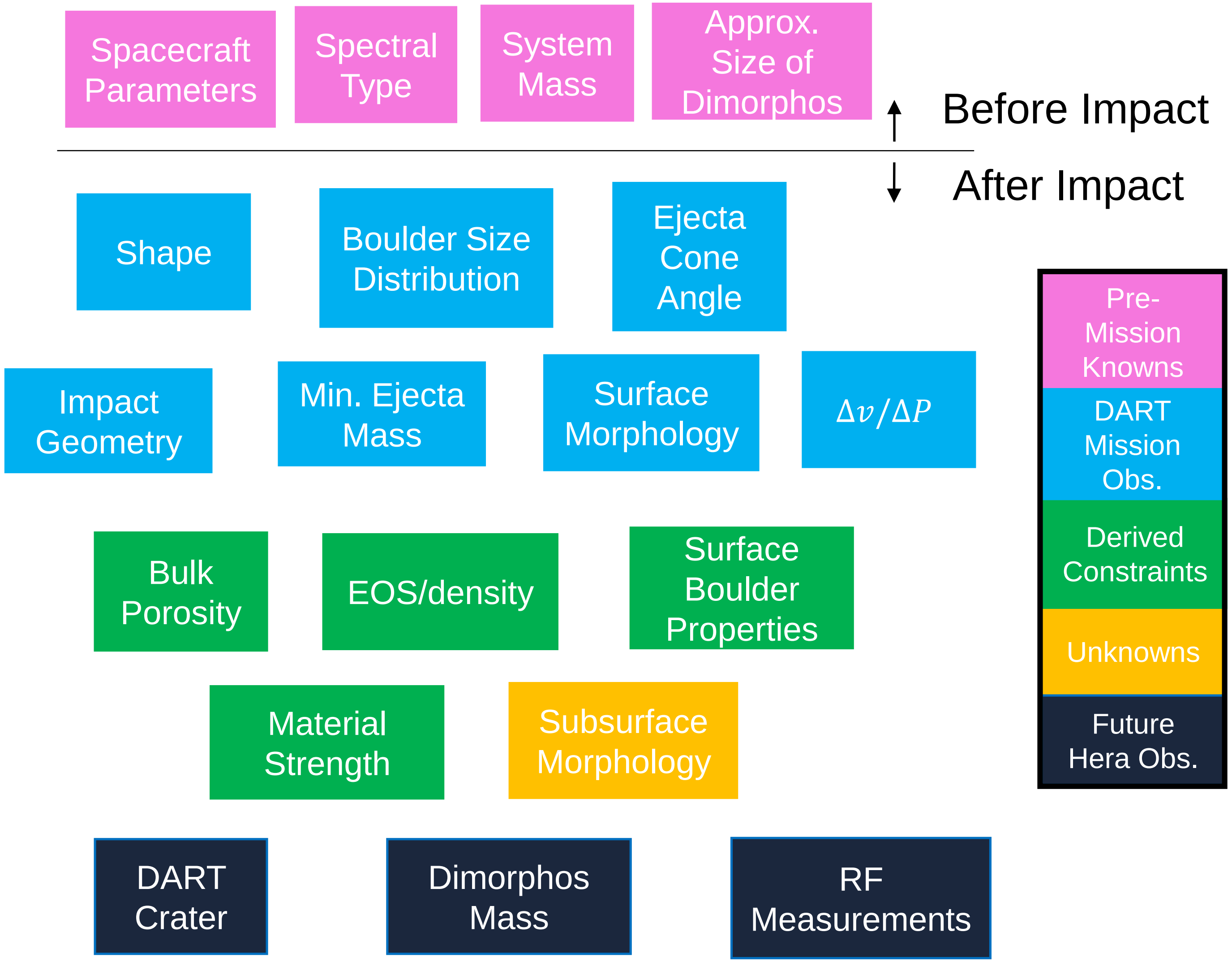
Defining the Mission's Planetary Defense Investigation

What have we learned from DART to inform our models?

Deflection Magnitudes From Pre-Mission Monte Carlo Simulations*

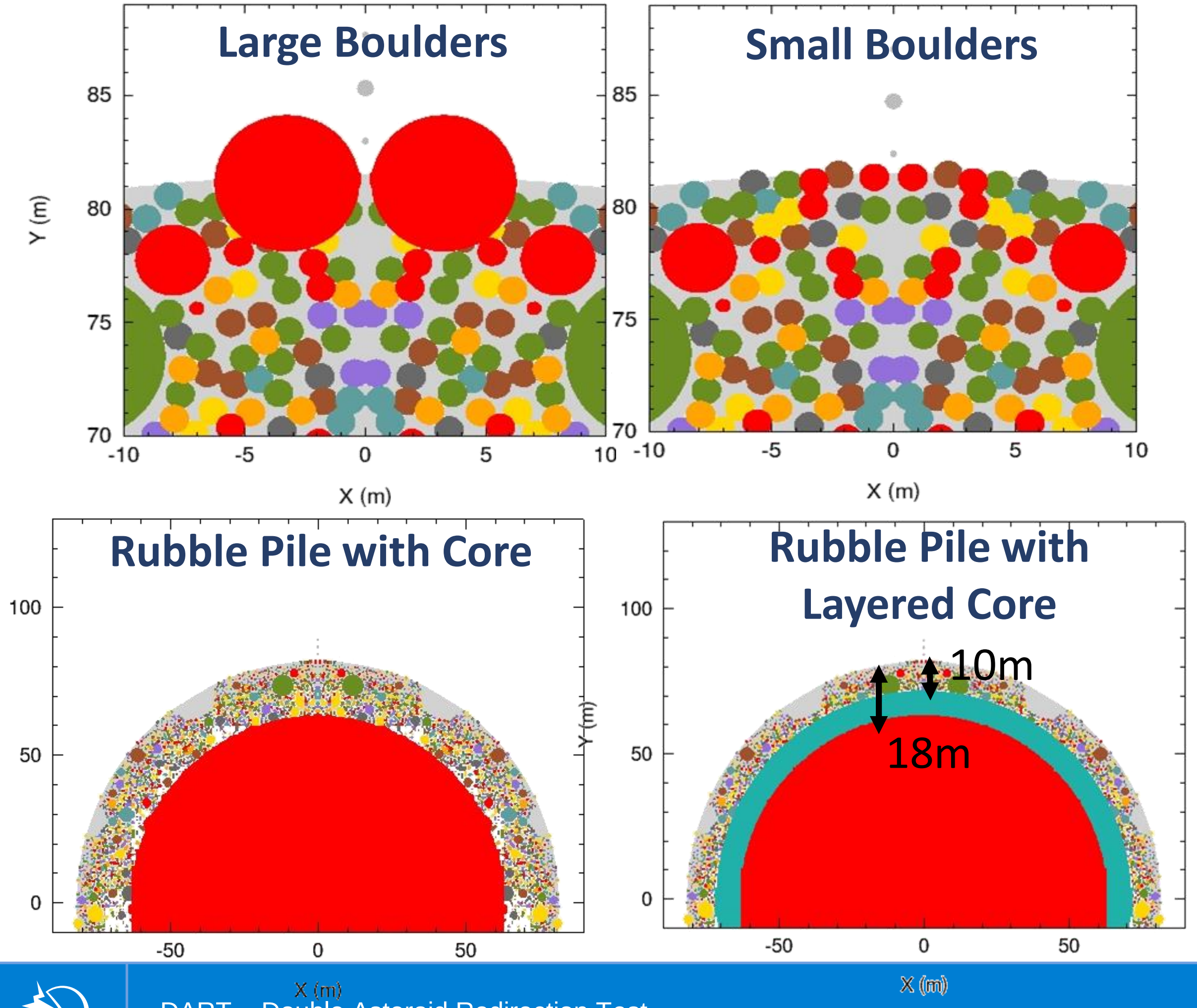


*Varying asteroid shape, size, material properties, and impact geometry

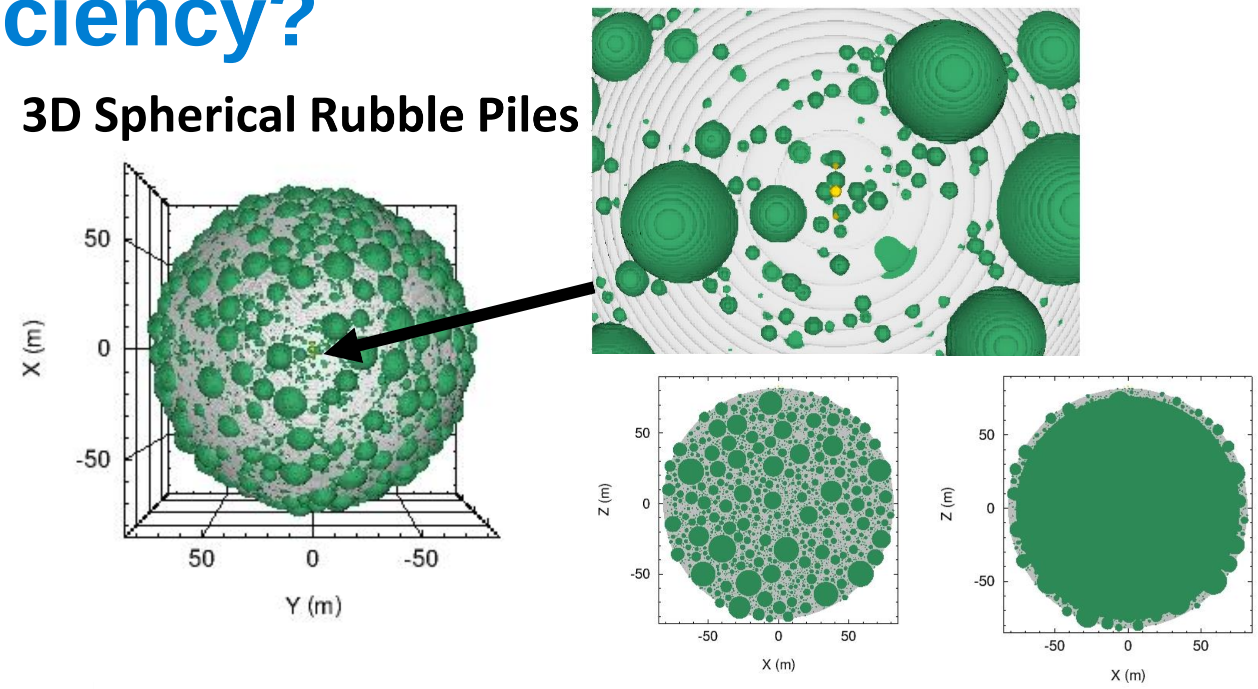


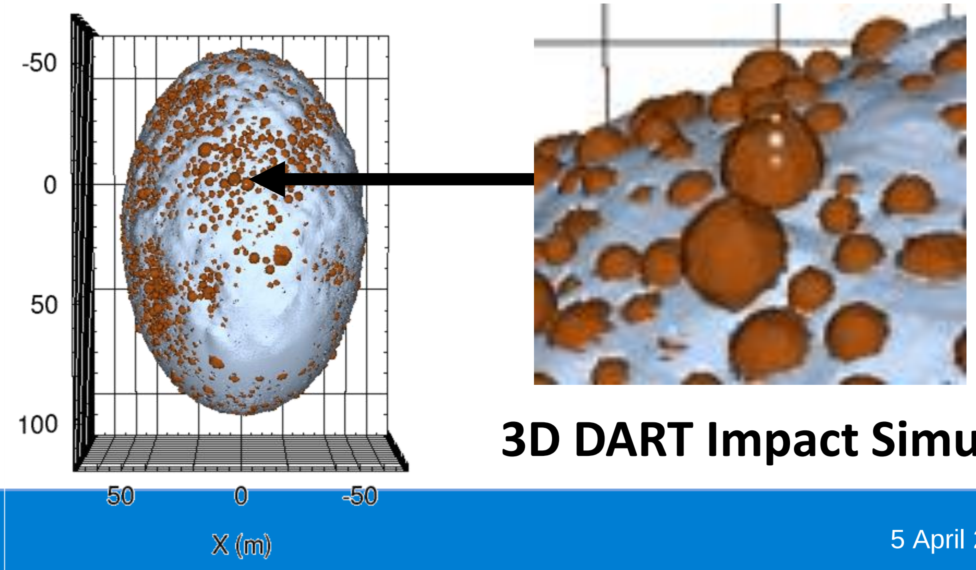
What are the relative effects of surface and subsurface morphology on deflection efficiency?

2D Axisymmetric Simulations



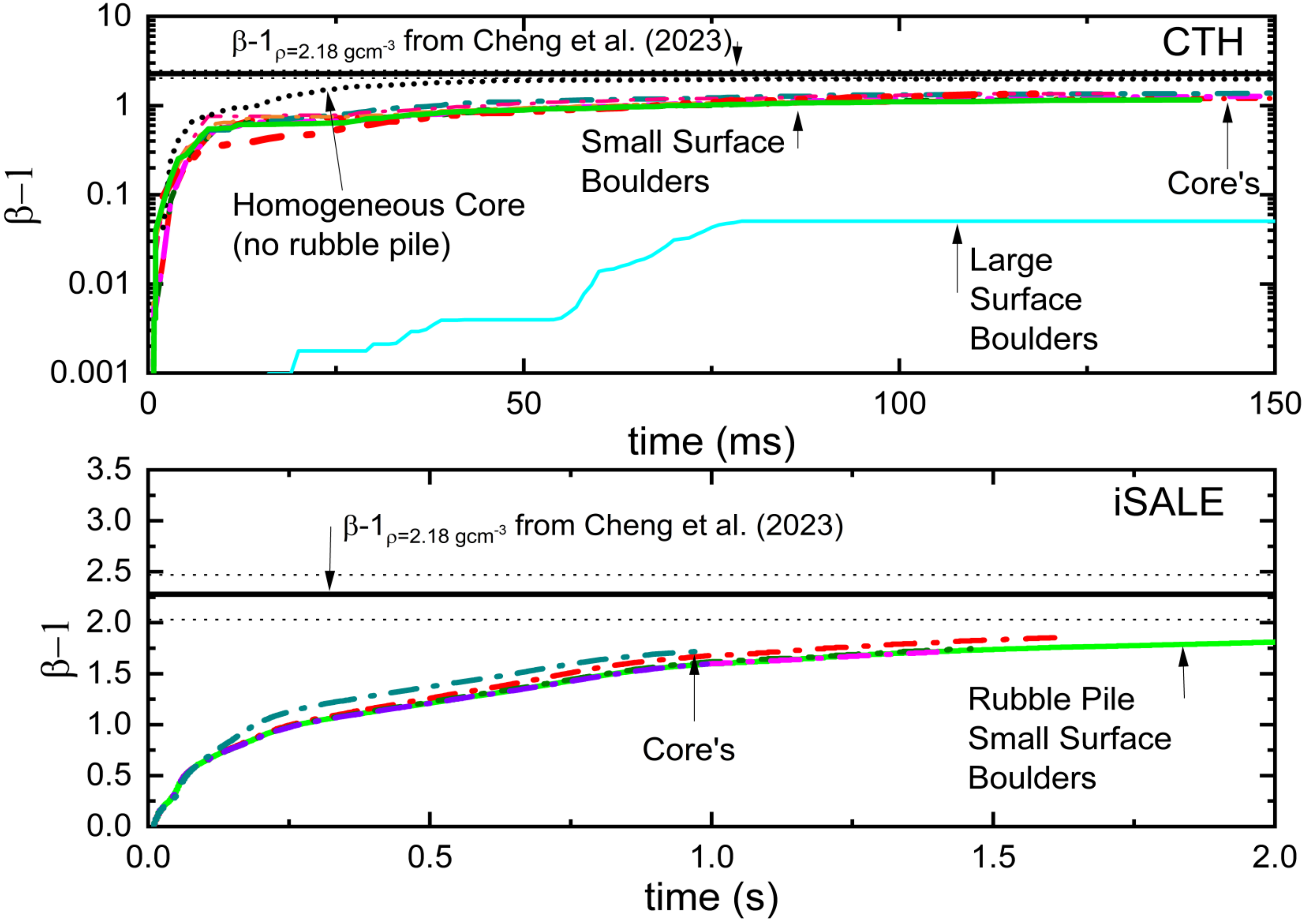
3D Spherical Rubble Piles





3D DART Impact Simulation

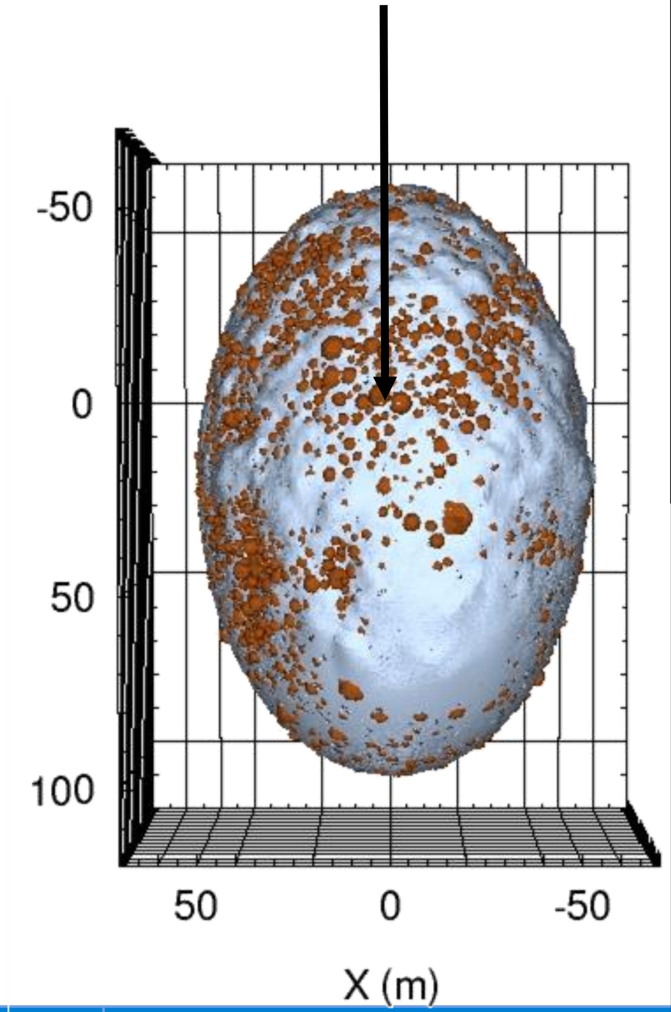
Surface Effects Dominate Subsurface Effects



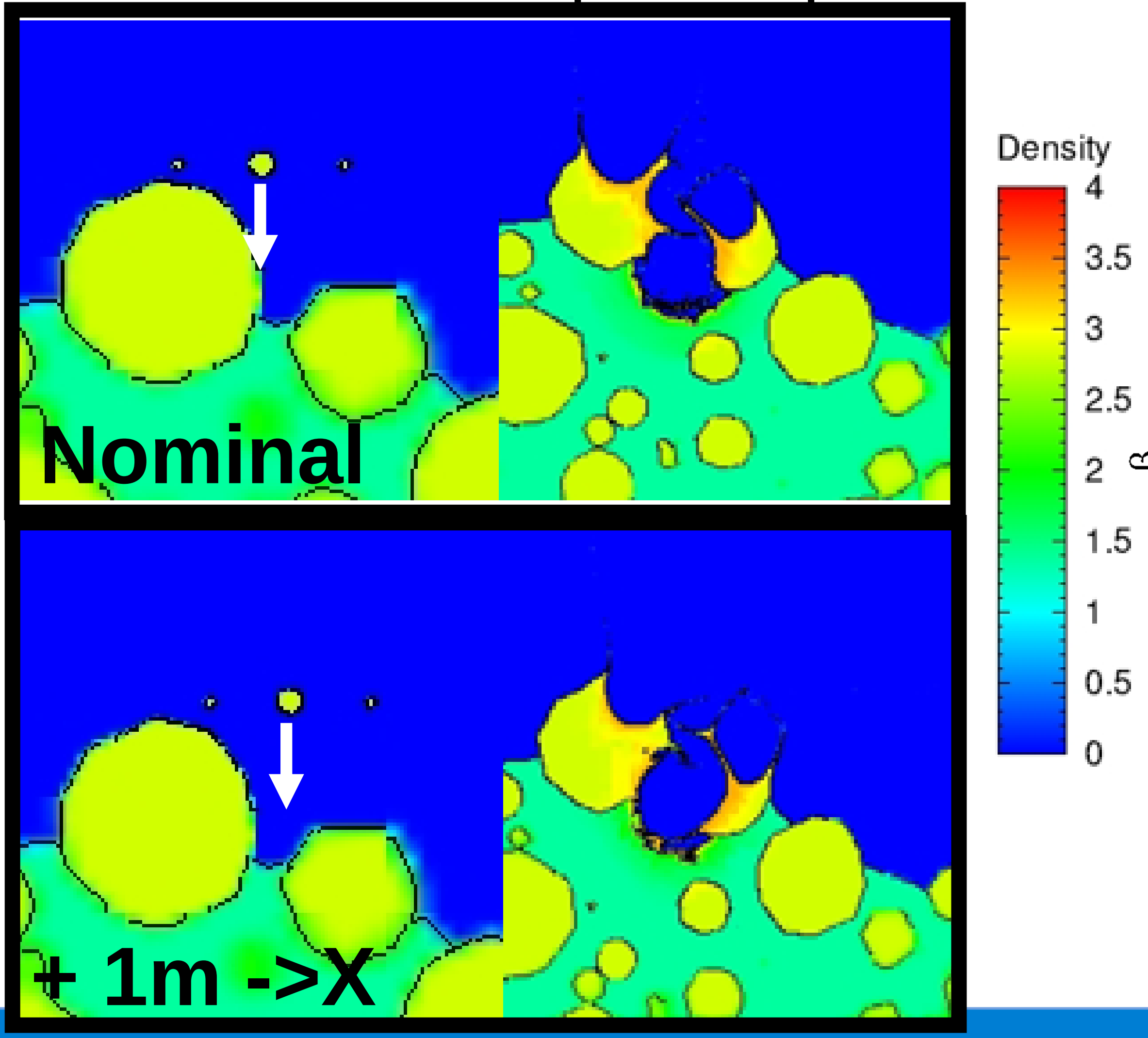
- **Momentum Enhancement Factor (β-1):**
- Simulations from CTH and iSALE show similar trends.
- Large surface boulders reduce β-1 by >90%.
- A competent core close (1m) to the surface enhances β-1 by 17%.
- Surface properties (boulder properties) have a much stronger effect than subsurface layers.

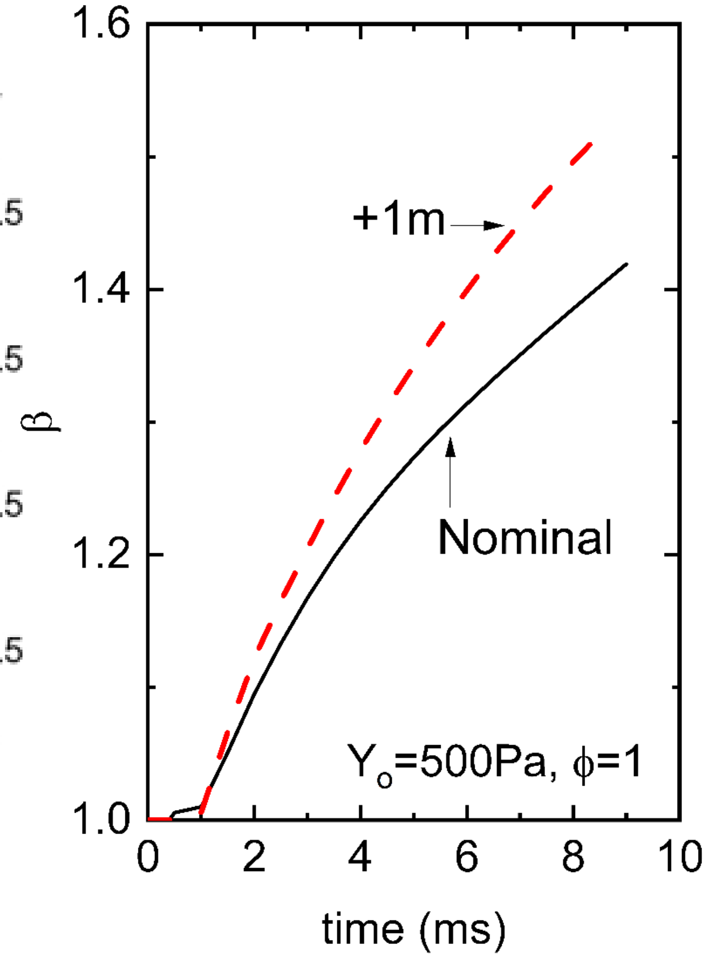
Boulder Effects Due to Uncertainty in Impact Location

Impact point



~9.5 ms post impact



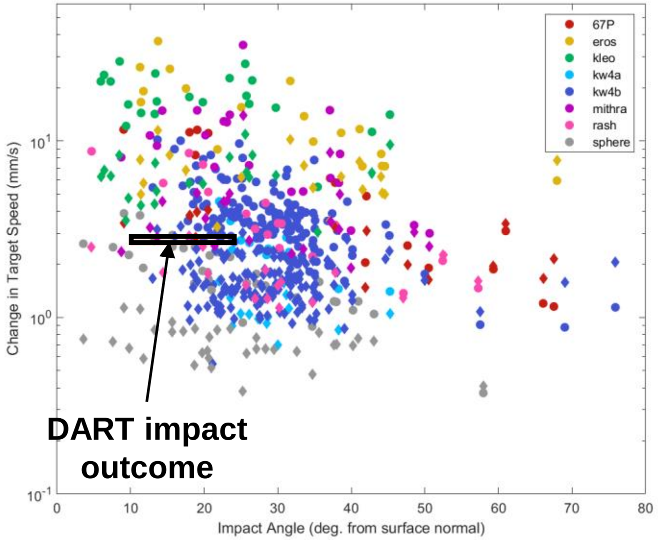


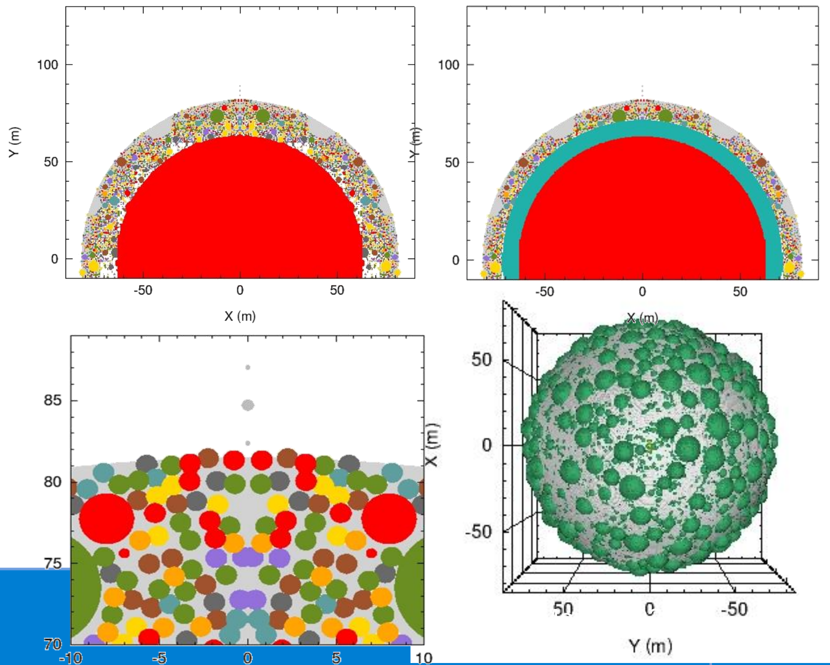
Summary: DART Modeling Implications

- Observations from the DART mission have enabled the impact modeling community to validate our models and provide additional constraints on the properties of Dimorphos.

- We investigated how uncertainty in the Dimorphos subsurface and uncertainty in the impact site affect DART impact observables.
  - Surface effects (boulder size) are more significant than subsurface effects, even when layers are close to the surface.
  - Impact location relative to large boulders at the impact site can affect ejecta mass and β by ~10% at early times.

- DART observables do not provide significant constraints on the subsurface structure of Dimorphos.





DART

Double Asteroid Redirection Test