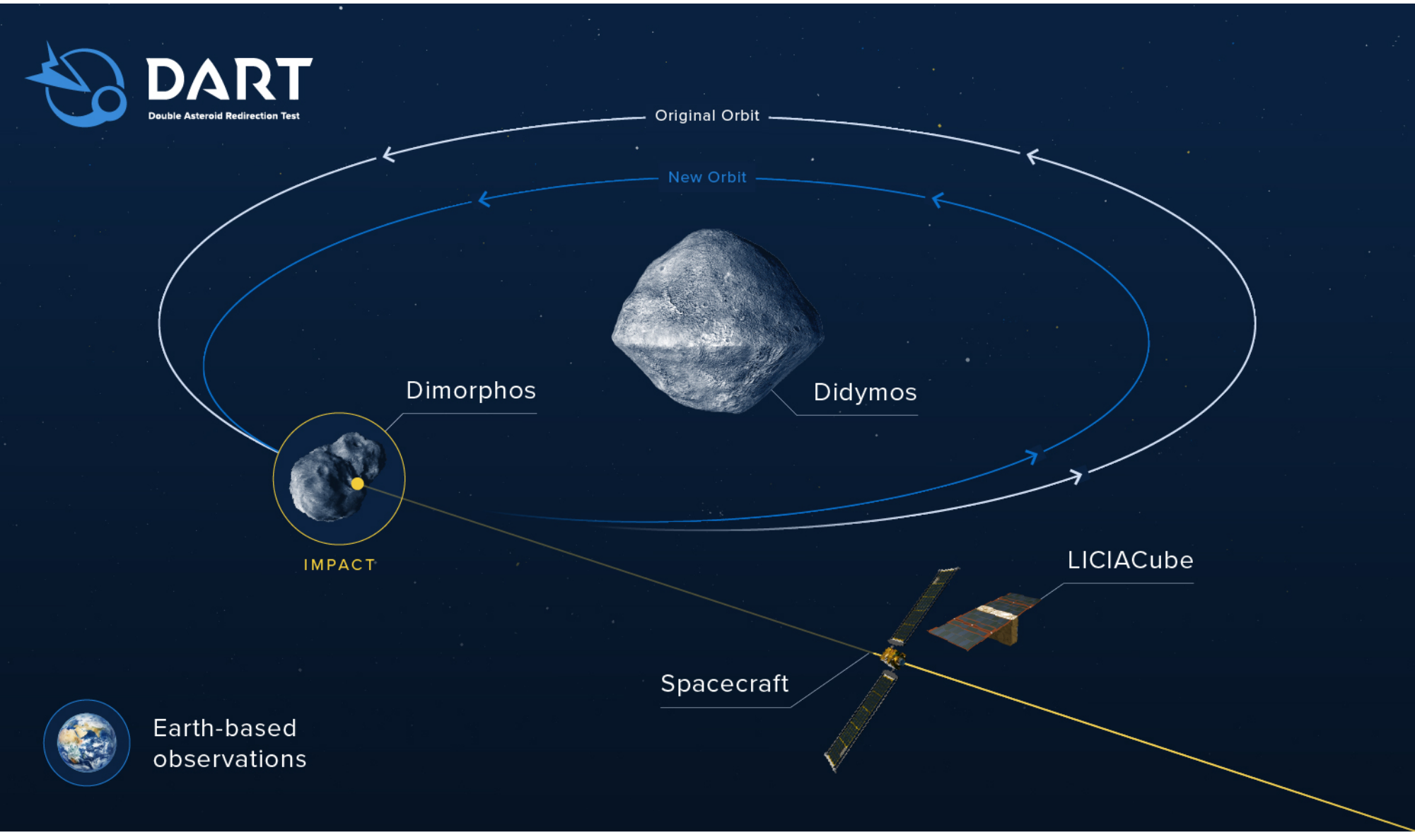
SPH simulations for space defense

Maximilian Rutz

July 15, 2020

Roadmap

1. Dart and Hera Missions
2. SPH setup
3. SPH results


DART
Double Asteroid Redirection Test
Original Orbit
New Orbit
Dimorphos
Didymos
IMPACT
LICIACube
Spacecraft
Earth-based
observations

Dart Mission

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- Impact in fall 2022
- Impact at 0.07 au to Earth, 29x Earth-Moon, 1/5x Earth-Mars
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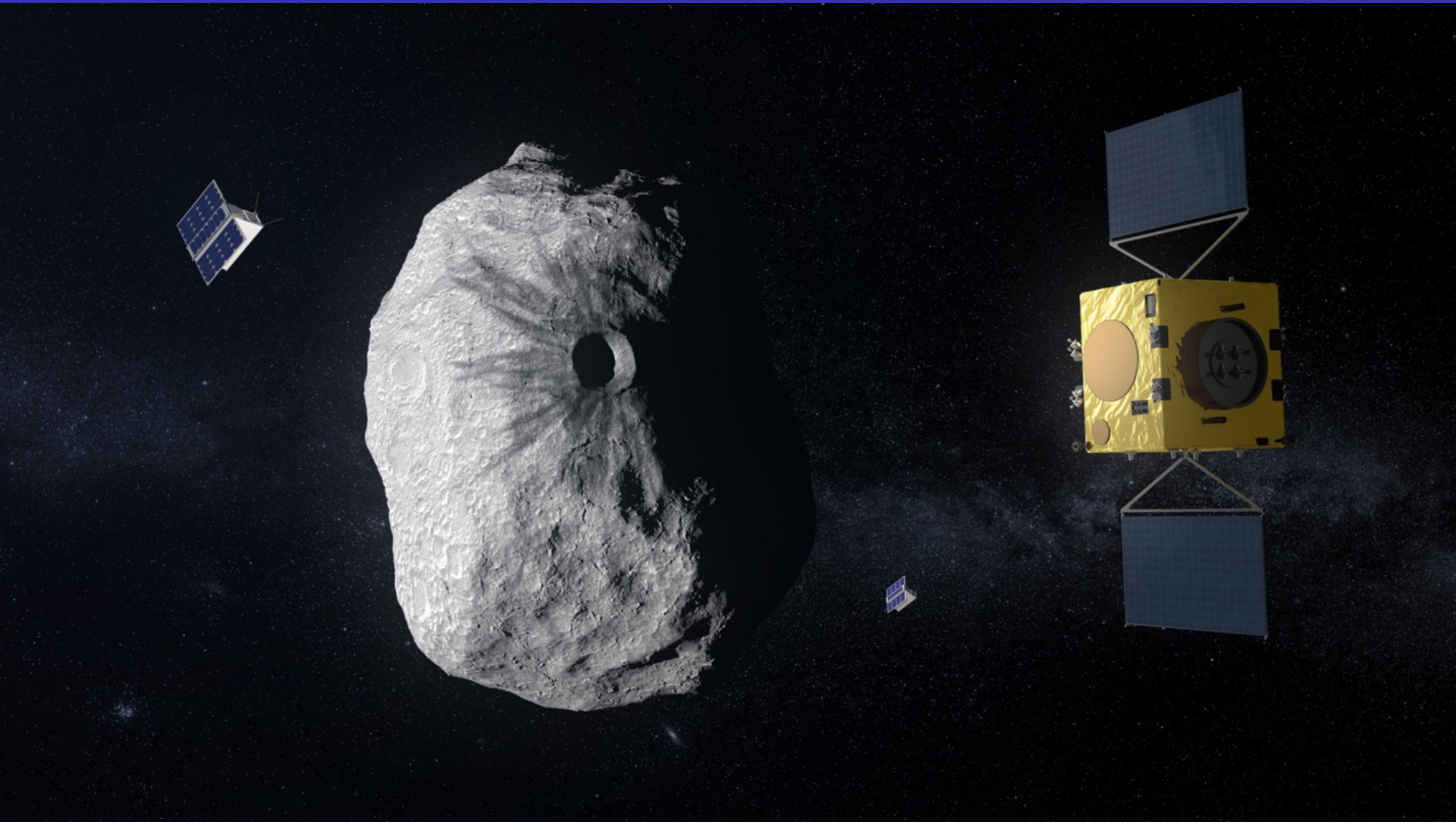
Hera Mission



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- Arrival in 2026
- Why a second mission?
  - Dust cloud after impact
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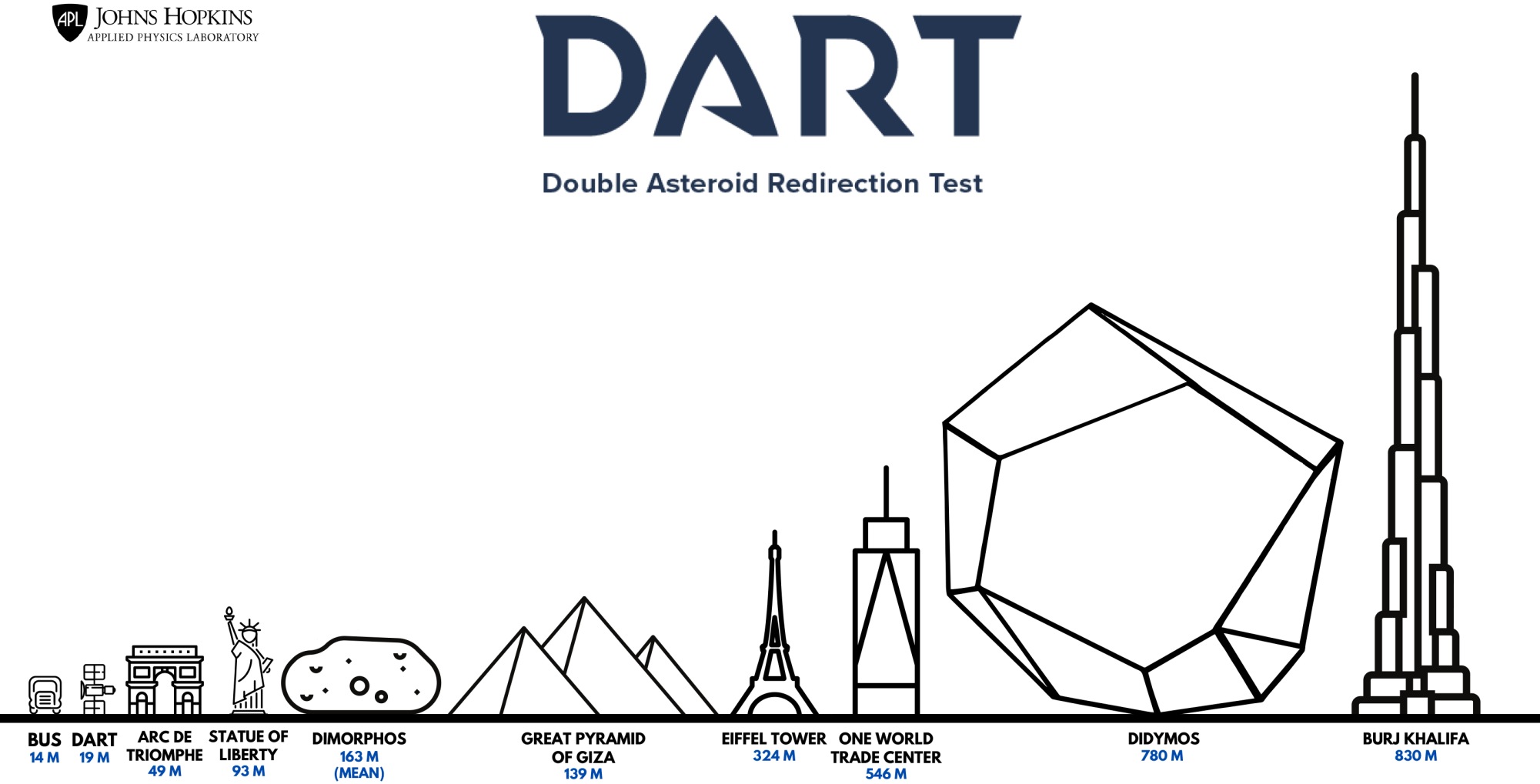
APL JOHNS HOPKINS
APPLIED PHYSICS LABORATORY
DART
Double Asteroid Redirection Test
BUS 14 M
DART 19 M
ARC DE TRIOMPHE 49 M
STATUE OF LIBERTY 93 M
DIMORPHOS 163 M (MEAN)
GREAT PYRAMID OF GIZA 139 M
EIFFEL TOWER 324 M
ONE WORLD TRADE CENTER 546 M
DIDYMOS 780 M
BURJ KHALIFA 830 M

Target

https://www.nasa.gov/planetarydefense/dart
Dimorphos orbiting Didymos
https://dart.jhuapl.edu/Gallery/media/graphics/lg/DART

Impactor

https://dart.jhuapl.edu/Mission/Impactor-Spacecraft.php

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SPH method

Smoothed particle hydrodynamics

Miluphcuda

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- Runge Kutta fourth order
- no self gravity
- p-α porosity - micro vs macroporosity

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smoothing length

- how can resolution be locally increased with SPH method (different radii and sml) - limit of sml -¿ 0 is normal hydrodynamics??

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Compare numerical results with observations to:

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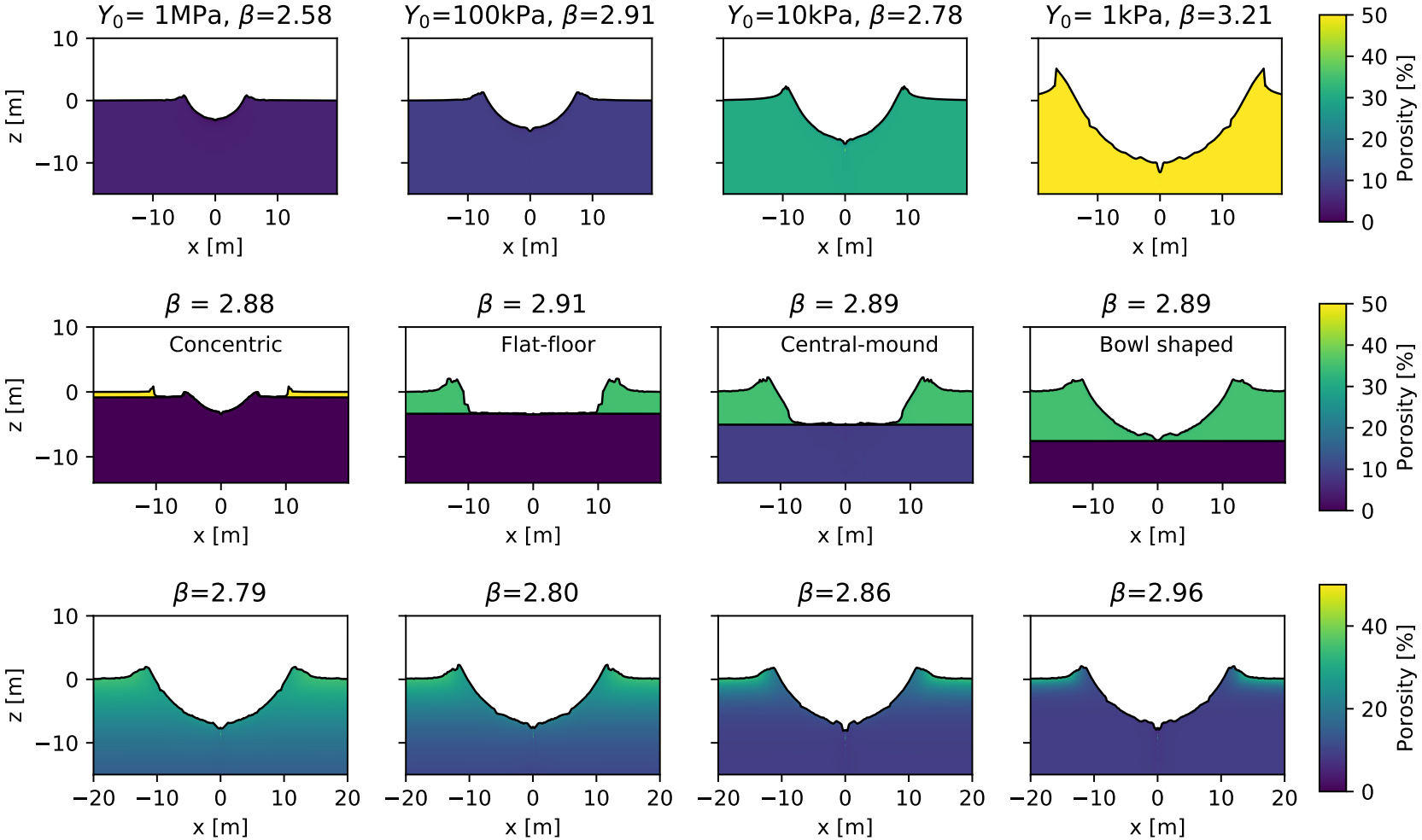
The DART impact into different targets can produce the same β, but different craters.

Measurements of **both** β and crater size/morphology **together** can be diagnostic of target properties.



Raducan et al. (2020), PSS

Impact angle

Not seen in 2d grid codes Raducan

Personal observations about SPH

- A lot of individual physics implementable
- Many different codes available
- Many parameters needed to reproduce results of others