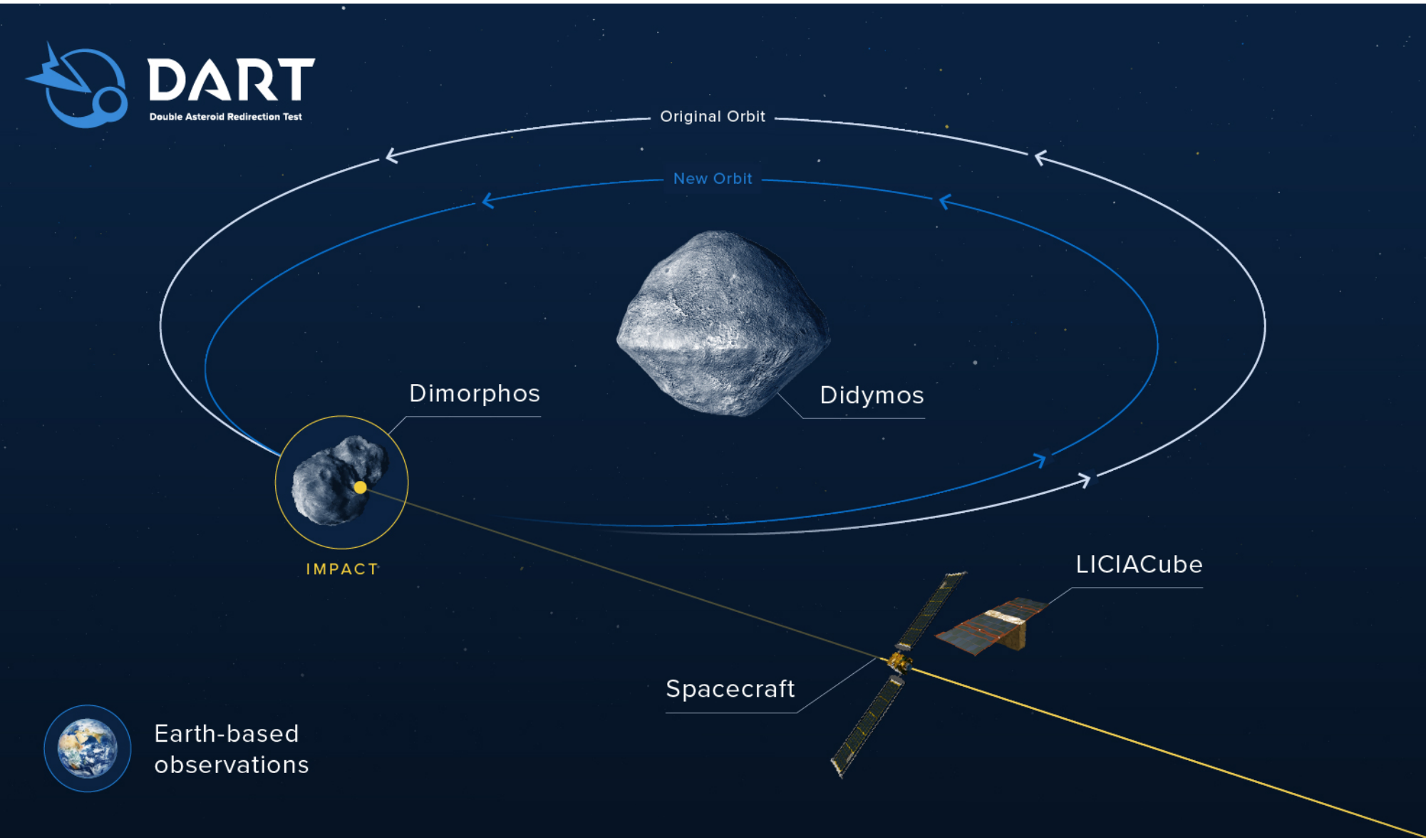
# SPH simulations for space defense

Maximilian Rutz

July 14, 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, 29 Earth-Moon, 1/5 Earth-Mars
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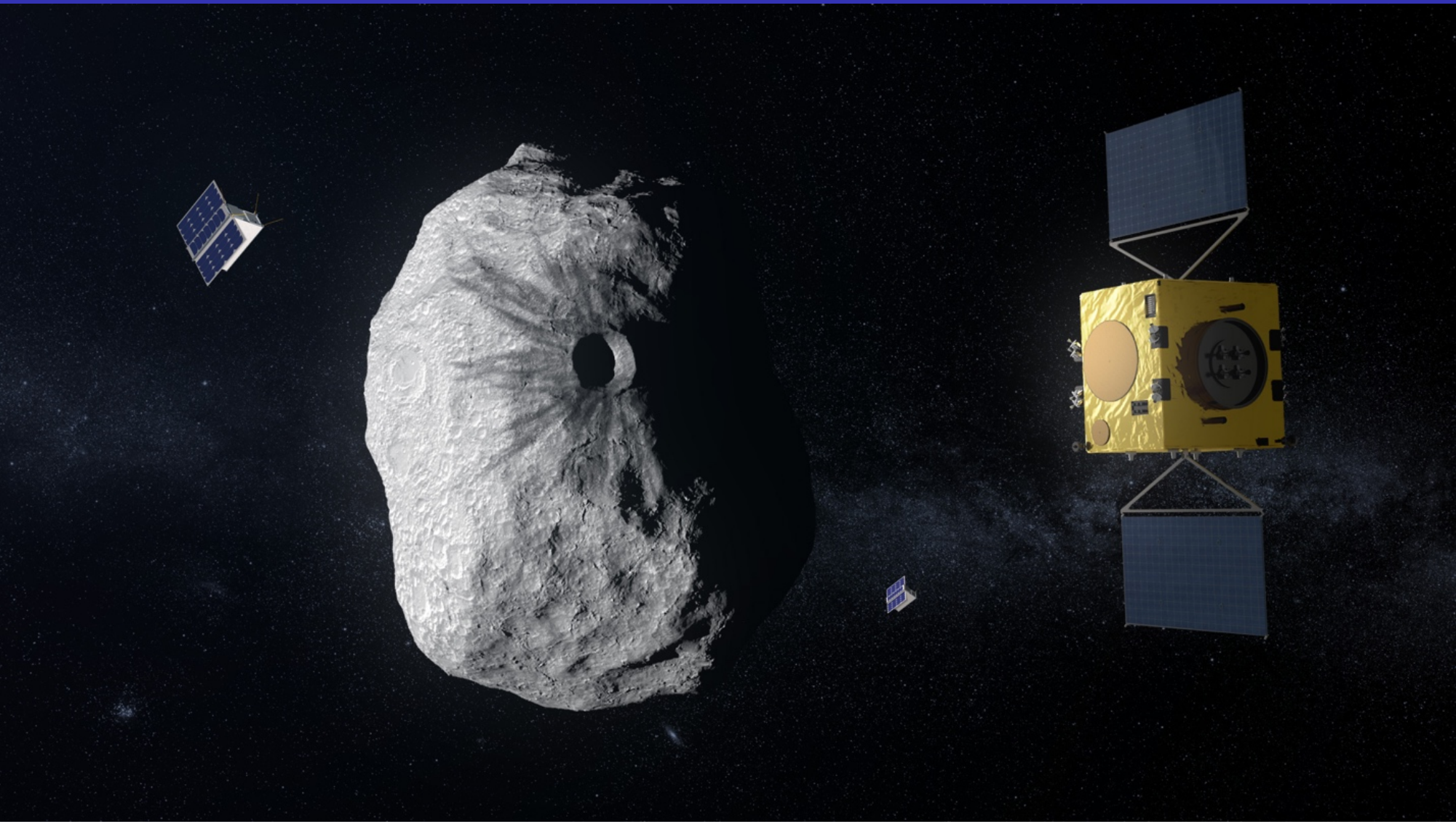

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- Arrival in 2026
- Why a second mission?
  - Dust cloud after impact
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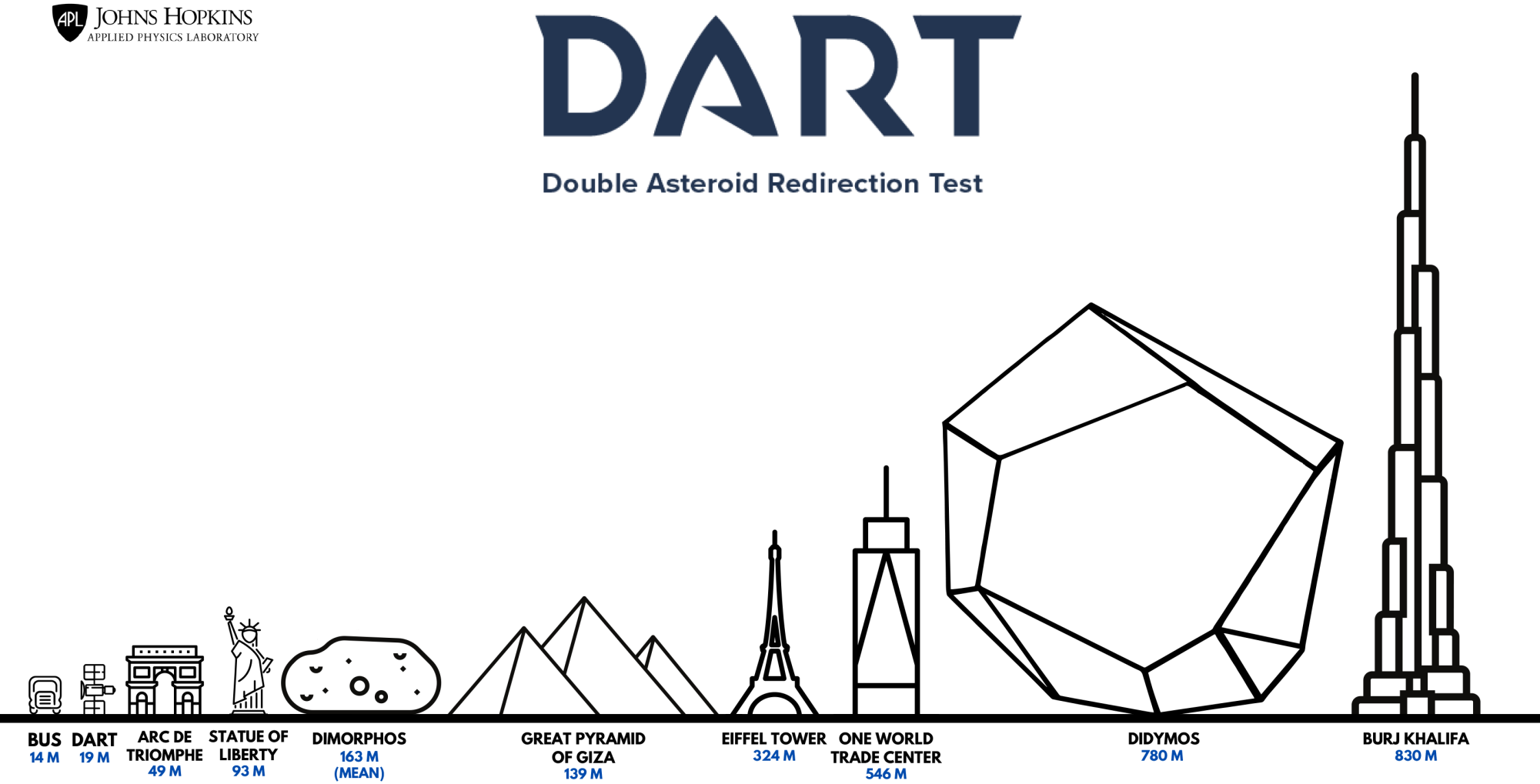
JOHNS HOPKINS
APPLIED PHYSICS LABORATORY
DART
Double Asteroid Redirection Test
BUS 14 M
DART 19 M
ARC DE TRIOMPHE 49 M
STATUE OF LIBERTY 93 M
DIMORPHOS 163 M (MEAN)
GREAT PYRAMID OF GIZA 139 M
EIFFEL TOWER 324 M
ONE WORLD TRADE CENTER 546 M
DIDYMOS 780 M
BURJ KHALIFA 830 M

# 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 1.2 $\times$ 1.3 $\times$ 1.3 meters

# SPH method

Smoothed particle hydrodynamics

# Miluphcuda

Smoothed particle hydrodynamics

# Miluphcuda setup

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- artifical viscosity
- Runge Kutta fourth order
- no self gravity
- p-$\alpha$ porosity - micro vs macroporosity

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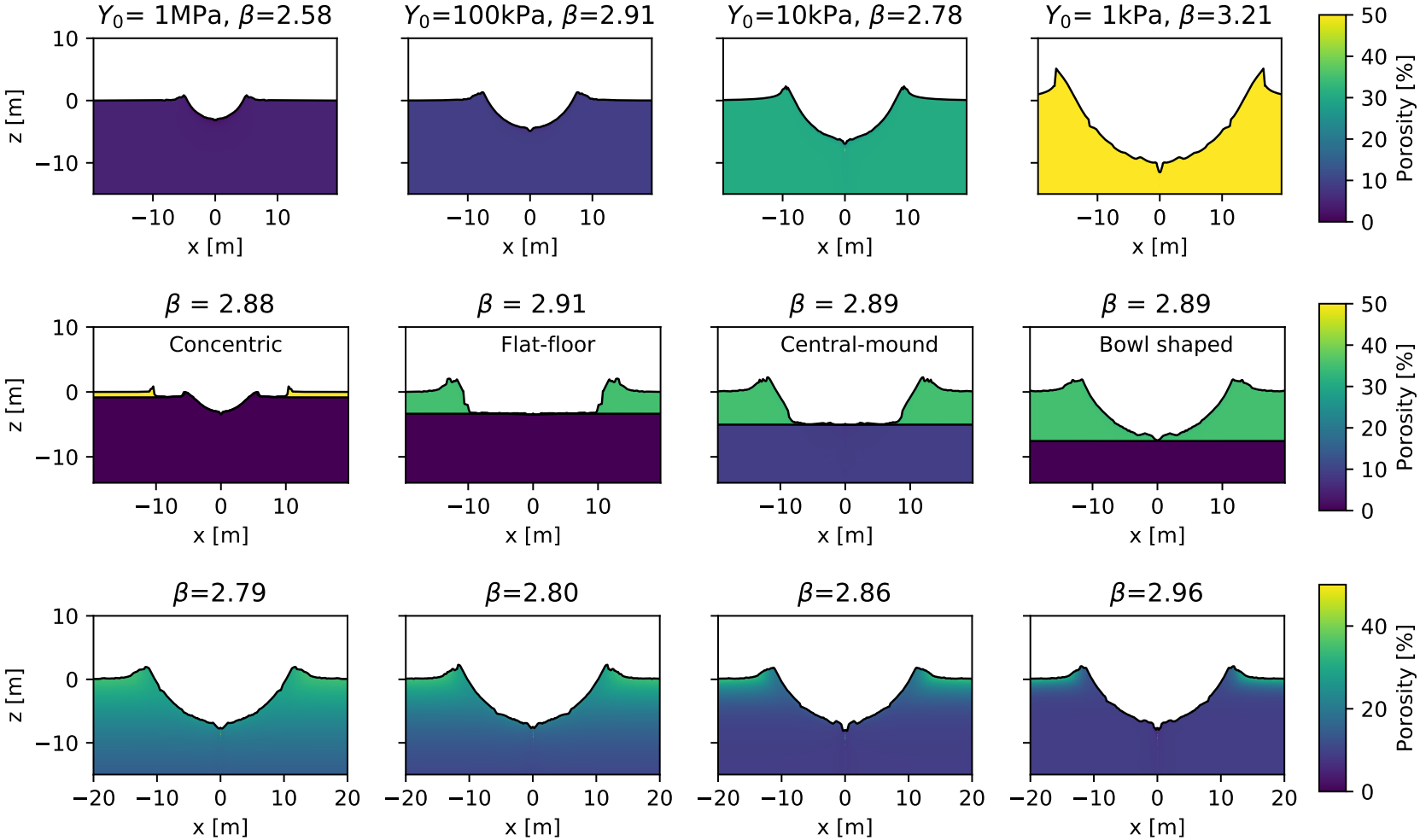
# smoothing length

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

# Beta factor

# The DART impact into different targets can produce the same $\beta$, but different craters.

Measurements of **both** $\beta$ 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

# Conclusion