Working Group 1: Impact simulations

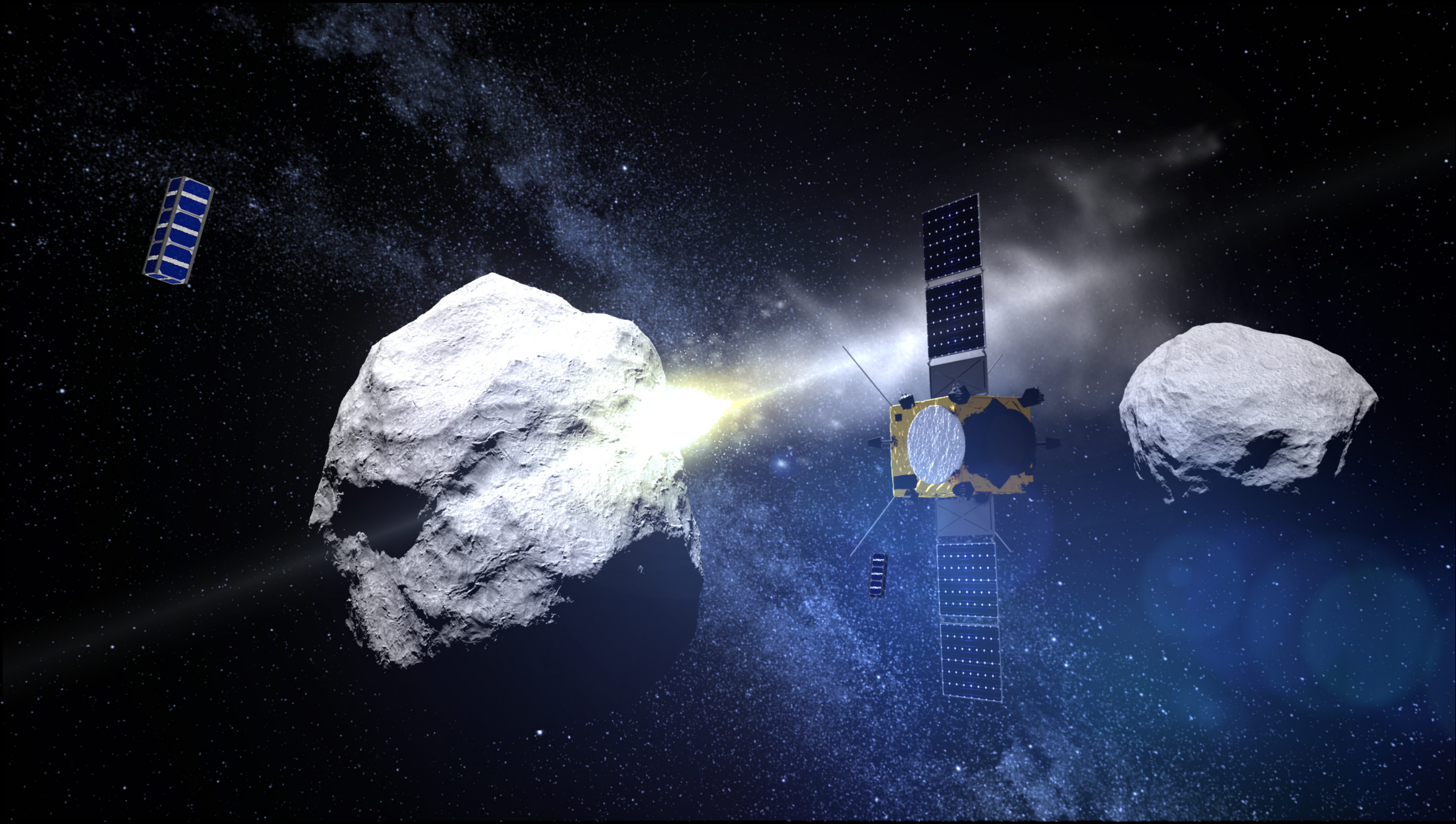


Image credit: ESA

Working Group 1: Impact simulations

Chairs: Kai Wünnemann / Martin Jutzi

Members of planetary science / astronomy community (cratering, collisions, small bodies, etc.)

- Modelling
  - Grid-based codes
  - SPH codes
  - Scaling-laws
- Experiments

Impact modeling + experiments by hypervelocity impact and engineering community

- Frauenhofer EMI
- SimChoc
- CEA

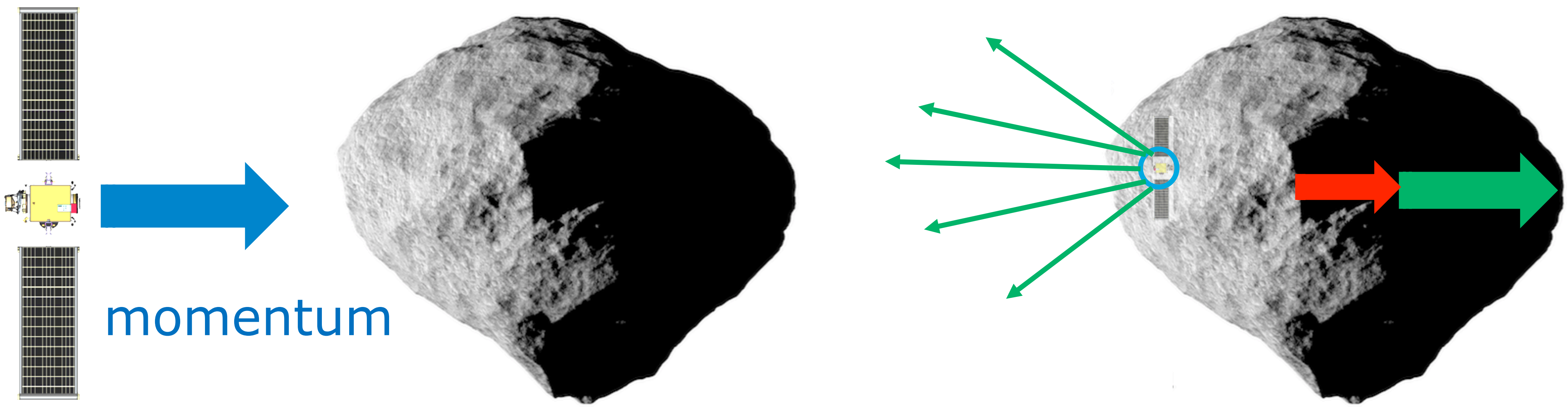
In collaboration with DART team

Goals of impact working group

Predict impact outcome

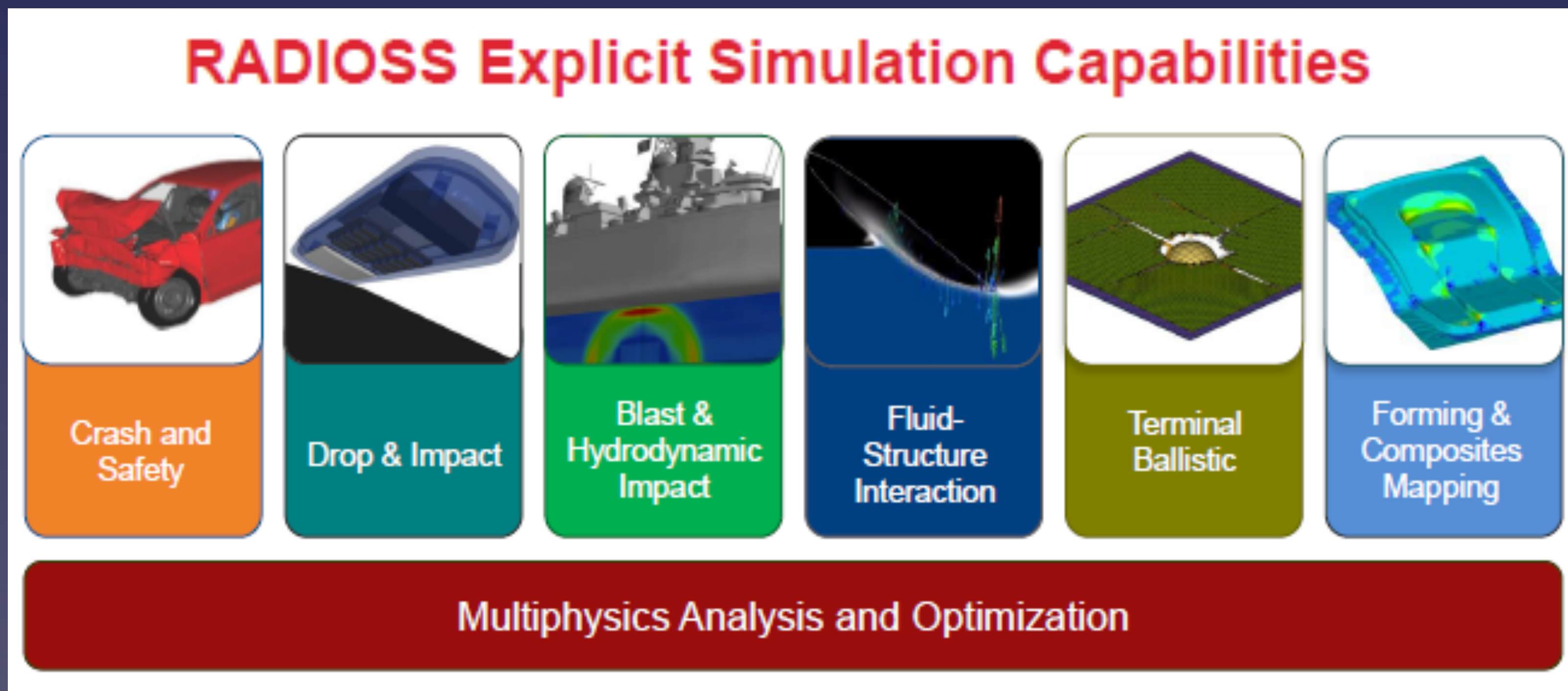
- Efficiency of momentum transfer
- Range of expected crater morphologies and properties of the surrounding surfaces

Complimentary to DART studies



$$\text{Efficiency } \boldsymbol{\beta} = \frac{\text{Didymoon mass } \mathbf{x}\ \Delta\mathbf{V}}{\text{momentum}}$$

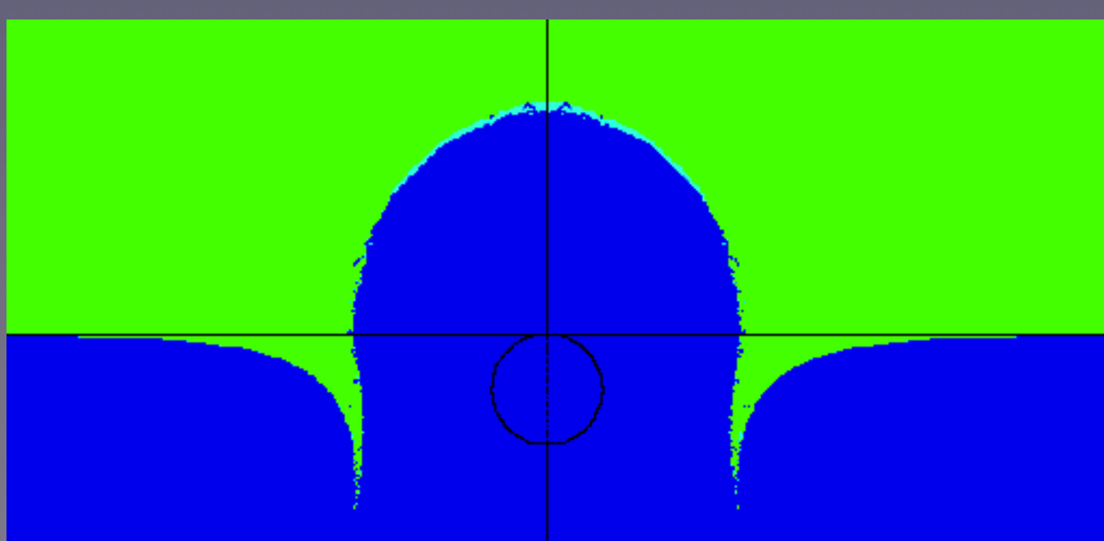
Examples of ongoing modeling & experiments

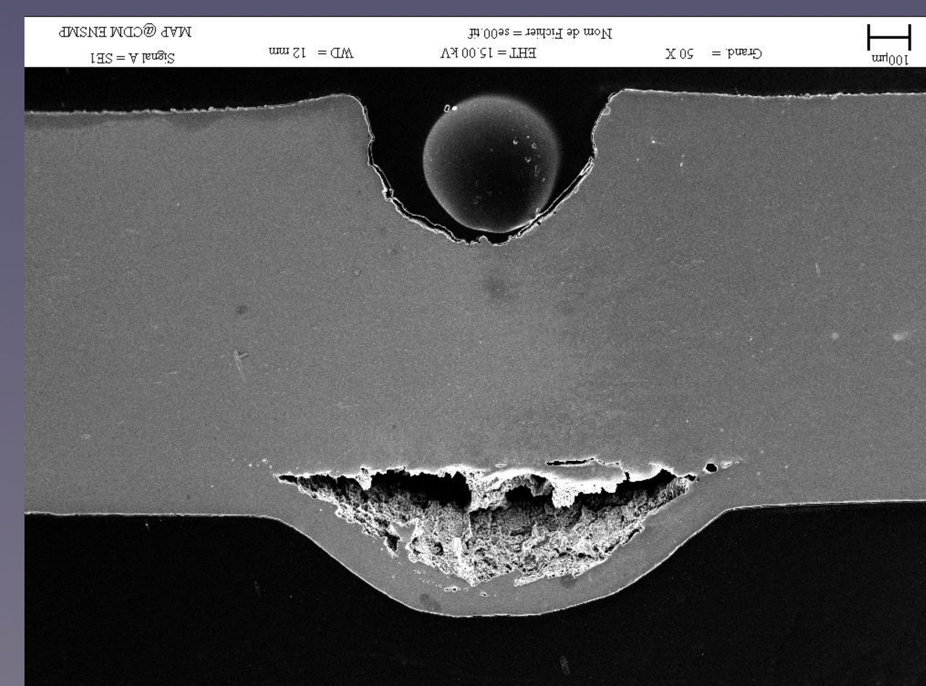


SimChoc

Laser

Al sphere on Al half space modelling
(Based on AIDA benchmark studies)





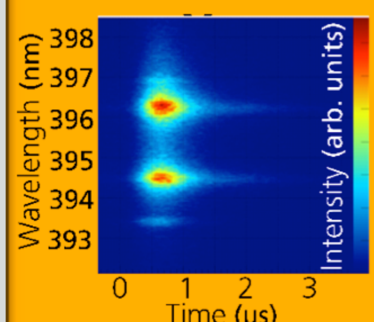
LULI2000 facility, 1.7 TW/cm^2 , 5ns at w irradiation focused onto 1mm thick Al target

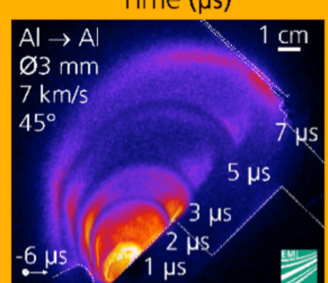
Examples of ongoing modeling & experiments

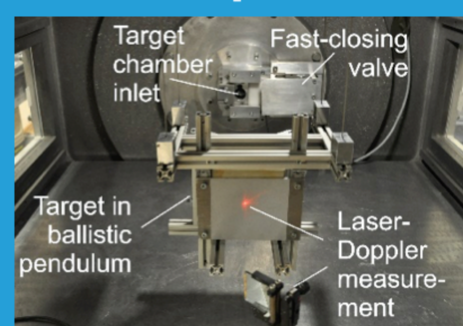
EXPERIMENTAL REPRODUCTION OF DART IMPACT

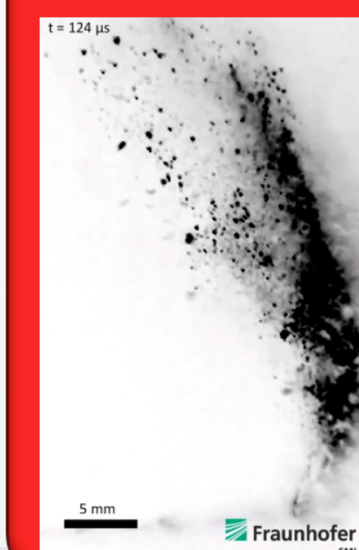
DIAGNOSTICS

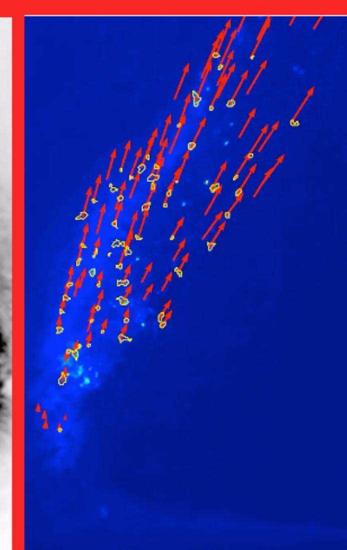
Feature	Impact flash	Momentum transfer	Impact ejecta	Cratering
	High-speed visualization			
In-situ	Emission spectroscop	Ballistic pendulum	*Advanced particle tracking*	*3D crater profilometry*
Post mortem		Weighing	Ejecta catcher, witness plates	3D scan

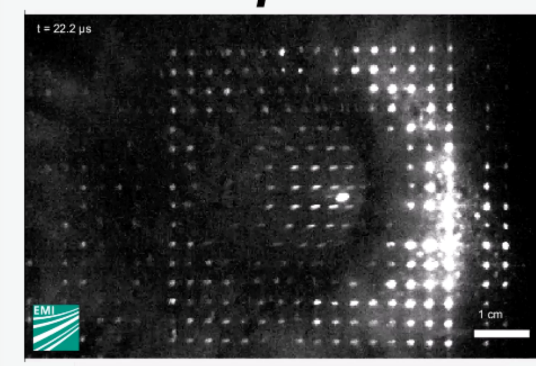


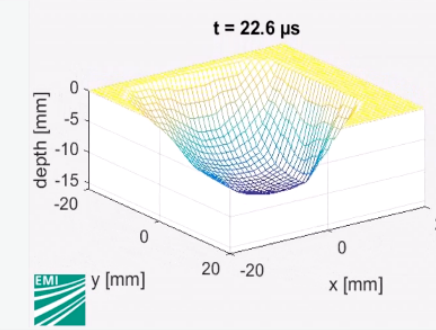


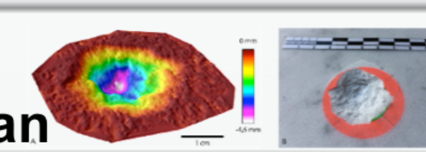












Initial impact modeling study

- Test case:
  - Target (Asteroid Didymos B):
    - Diameter ≈160m
    - other physical properties such as density, porosity or strength are not well constraint so far)
  - Impactor:
    - Impact velocity: 6 km/s
    - Impactor mass: 500 kg
    - Impact angle: head-on / 45° (3D models only)

Goal: illustrate differences due to different model approaches and assumptions <u>regarding material properties</u>

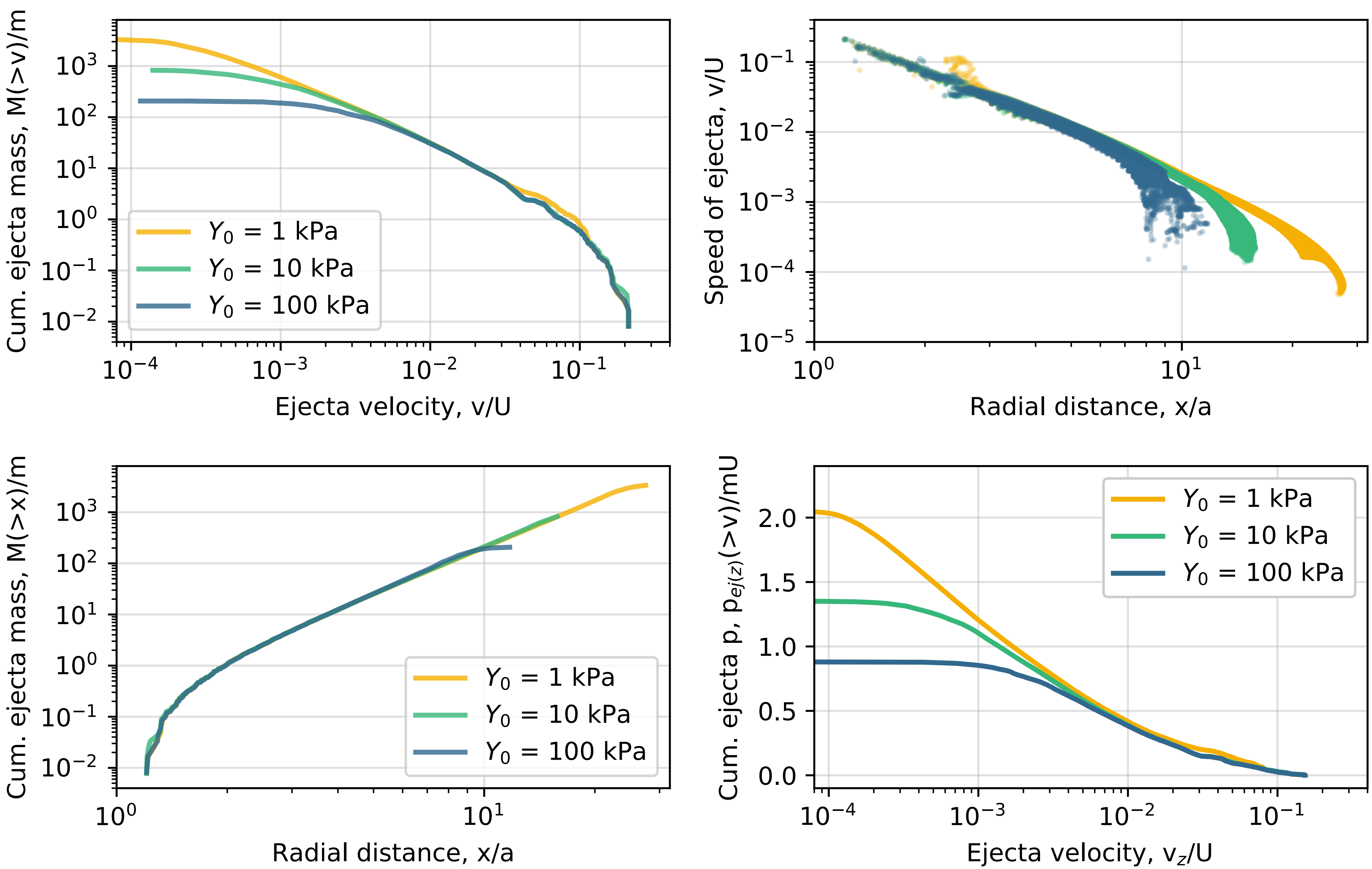
Initial impact modeling study

- Various groups using various methods
  - iSale shock physics code
    - Raducan et al.
    - Luther et al.
  - SPH shock physics codes
    - Maindl and Schäfer
    - Jutzi et al.

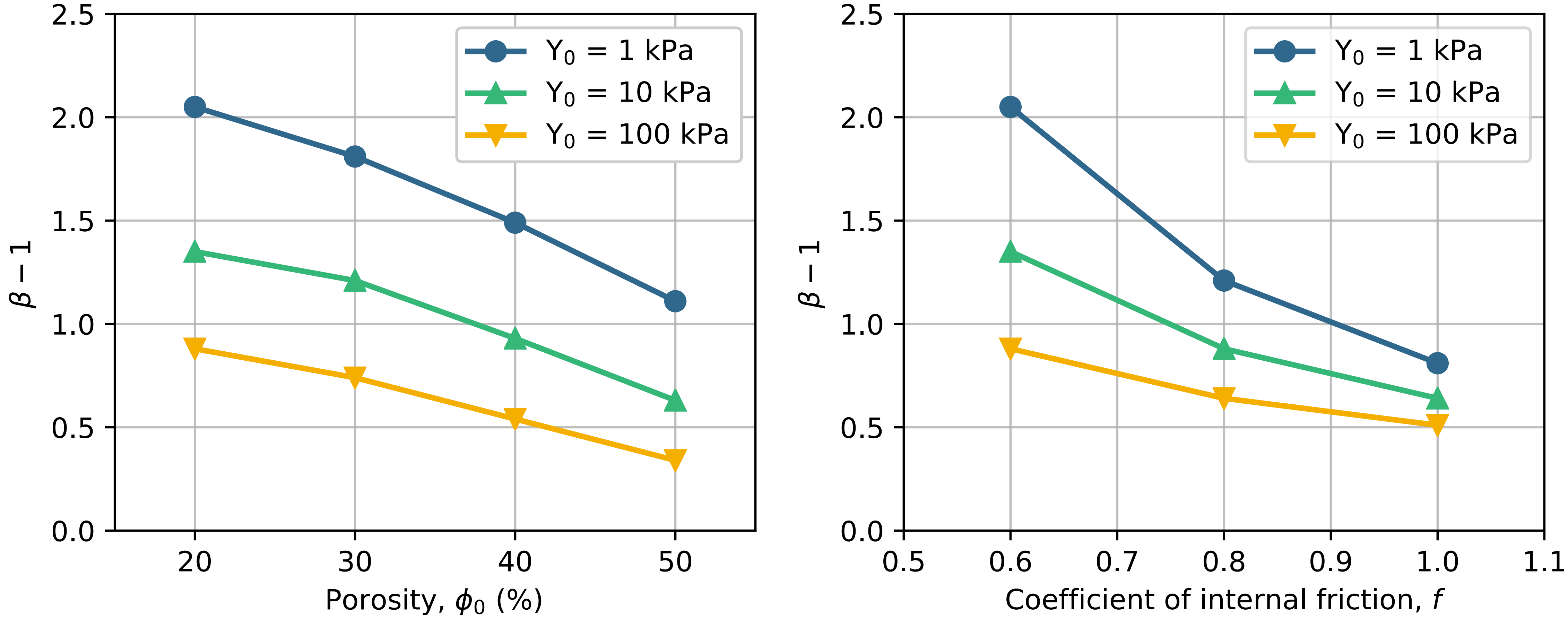
Initial results

iSale modeling by Raducan et al.

Results: Ejecta distribution for Y_0 = 1 - 100 kPa, ϕ_0 = 20% and f = 0.6



Initial results



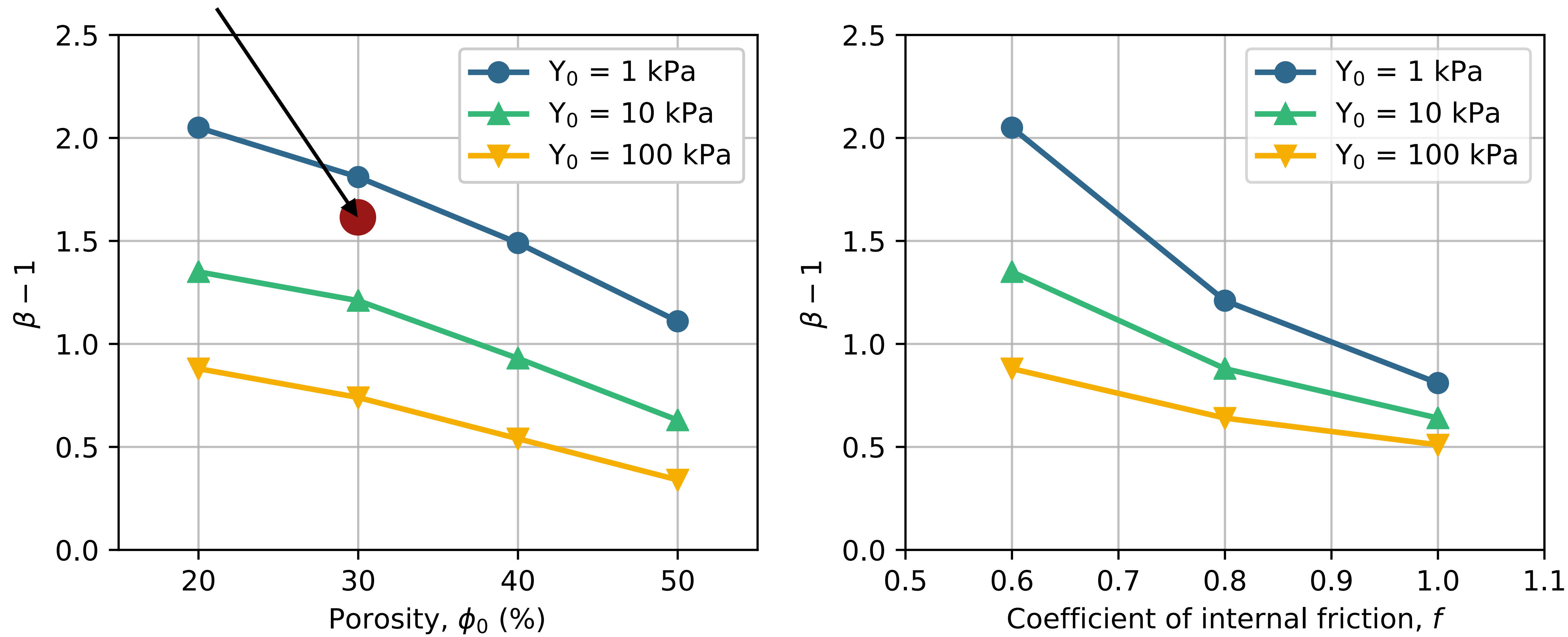
iSale modeling by Raducan et al.

Strong dependence of momentum transfer efficiency on material properties (strength, porosity)!

Initial results

iSale modeling by Luther et al. (Y_0 = 1kPa; same conditions)

Overall good agreement, small difference due to different analysis of simulation data

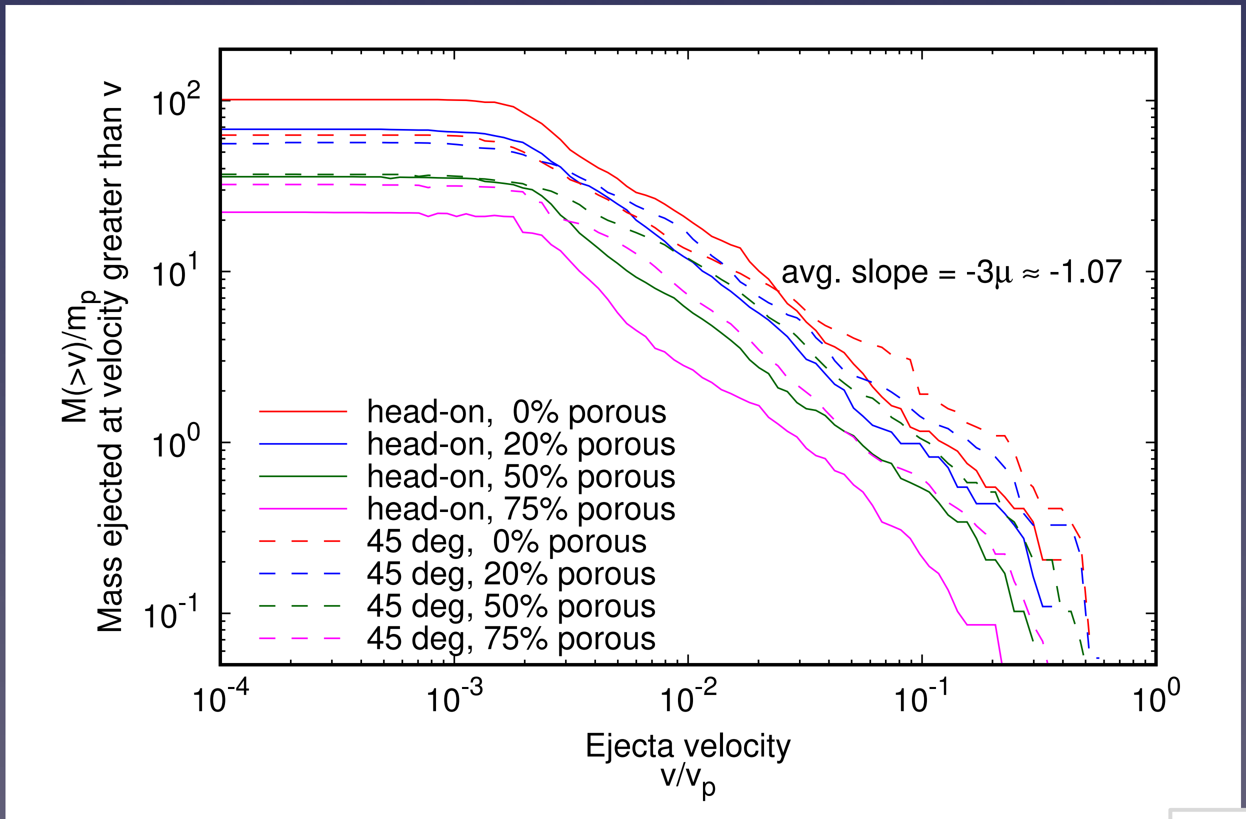


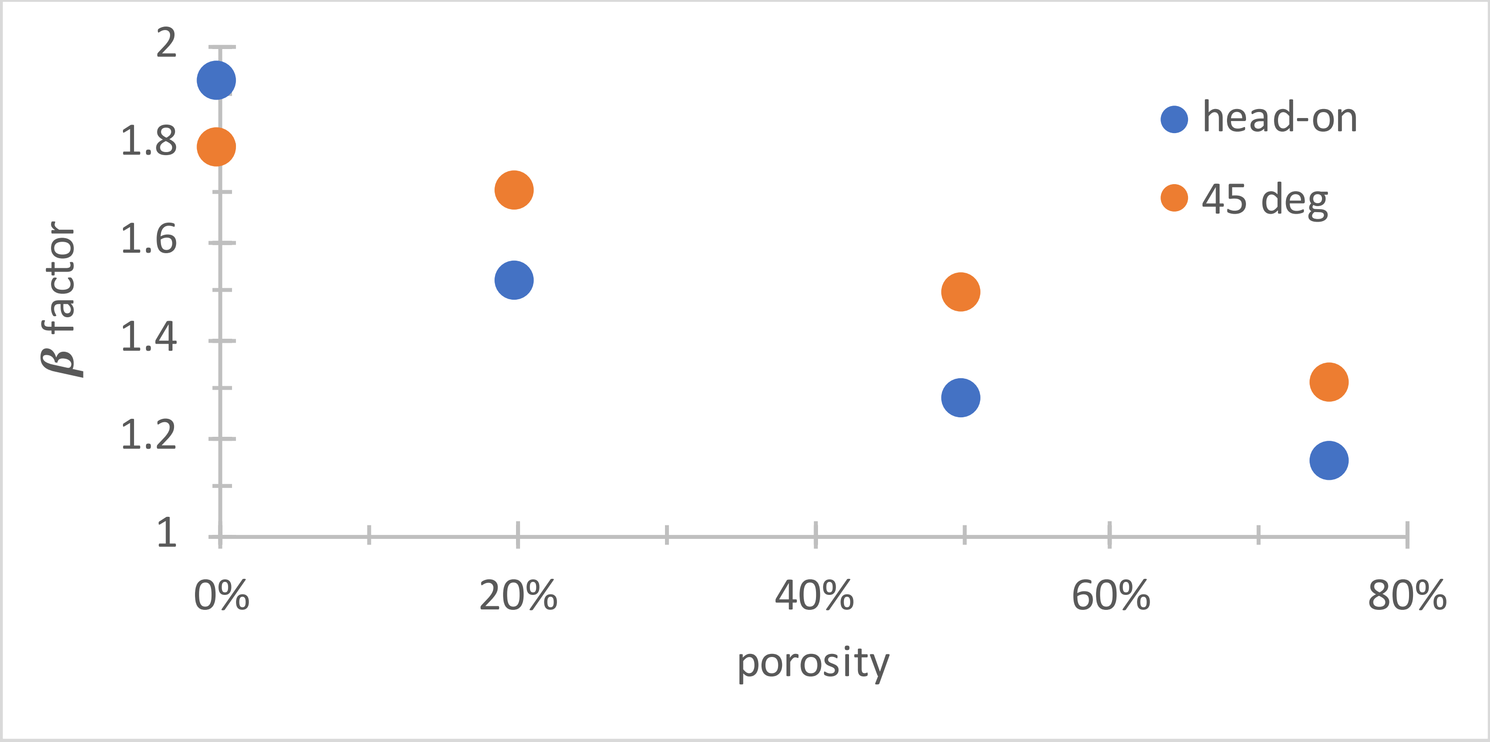
iSale modeling by Raducan et al.

Strong dependence of momentum transfer efficiency on material properties (strength, porosity)!

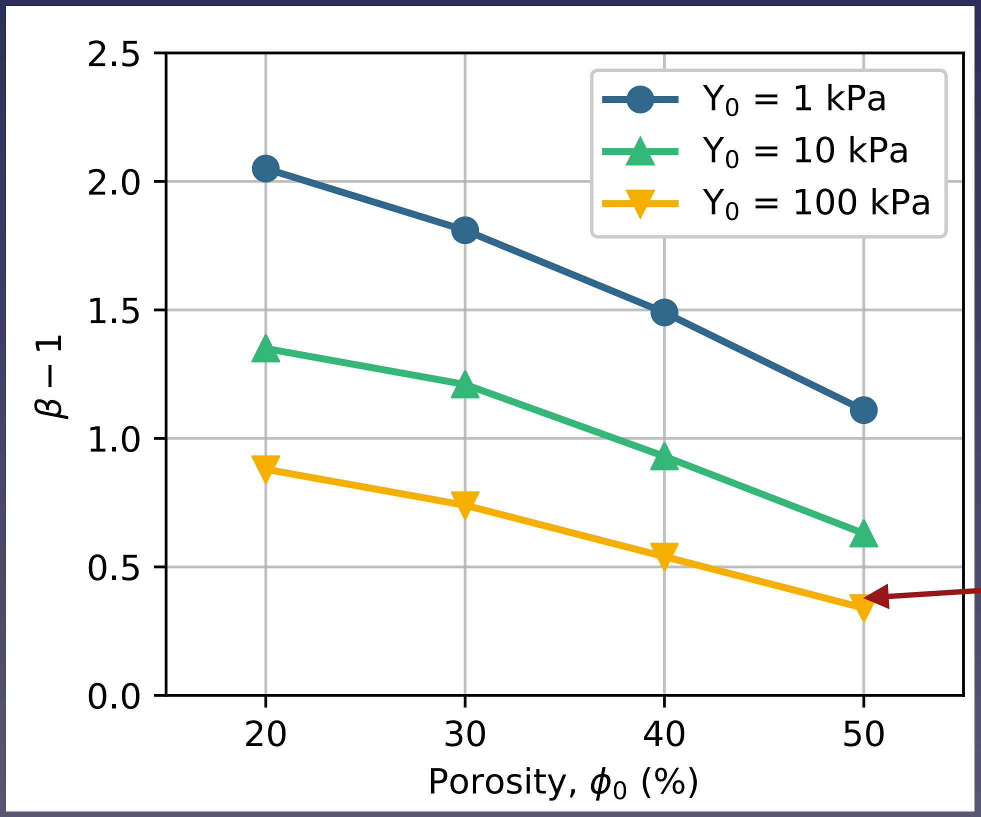
Initial results

SPH modeling by Maindl and Schäfer





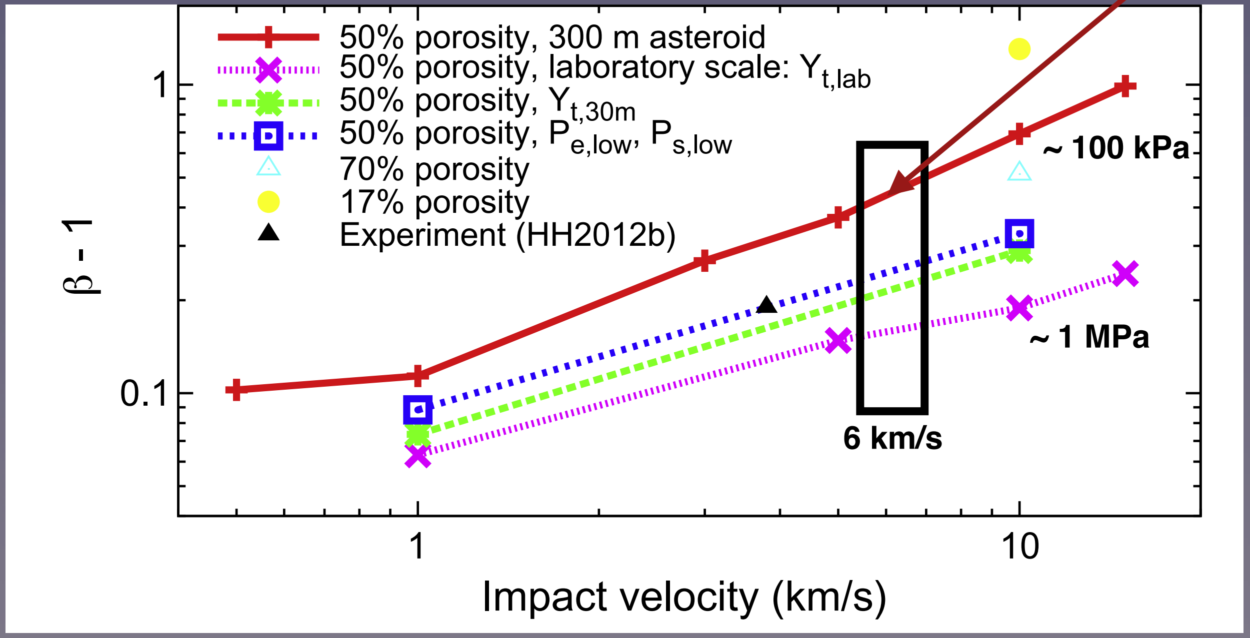
iSale vs. SPH comparison of initial results



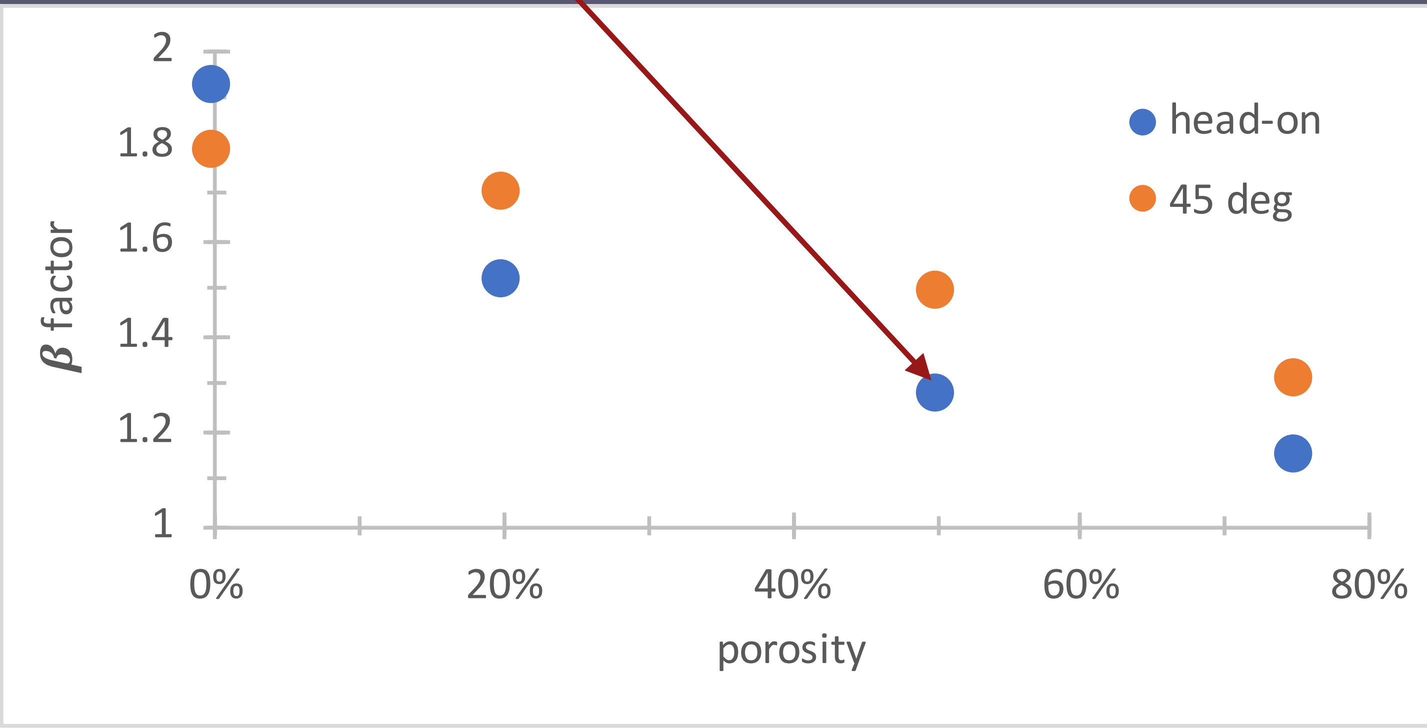
Raducan et al., this study

Both methods show similar dependence on porosity and strength

For ~ 100 kPa, ~ 50 % porosity, head-on impact:
(Beta - 1) ~ 0.3-0.5
-> good agreement



Jutzi and Michel, 2014



Maindl and Schäfer, this study

Conclusions of initial modeling study

- Preliminary results indicate an overall good agreement between iSale and SPH calculations
- Results (beta factor, crater etc.) *are very strongly depended on material properties*
  - strength is most important
  - porosity and friction properties play also a role
- These properties need to be better constraint
  - Laboratory experiments
  - In-situ measurements at the actual scale!

Next steps

- Predict the impact outcome as function of material properties and impact conditions
  - momentum transfer efficiency
  - range of expected crater morphologies and properties of the surrounding surfaces
- Study of more complex effects
  - shape, local topography, rotation etc.
- Connect in-situ observations with properties of subsurface
  - improve understanding of impact processes