

Overview of Collisional-Threat-Mitigation Activities at Lawrence Livermore National Laboratory

2013 Planetary Defense Conference, Flagstaff, Arizona

6 April 2013

Dr. Paul Miller



LLNL-PRES-634473

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344, and partially funded by the Laboratory Directed Research and Development Program at LLNL under tracking code 12-ERD-005. Lawrence Livermore National Security, LLC



Current and past LLNL project participants

Tarabay Antoun

David Dearborn

James Elliott

Seran Gibbard

Eric Herbold

Kirsten Howley

Brian Kaplinger (summer)

Ilya Lomov

Robert Managan

Aaron Miles

Paul Miller

Michael Owen

Jared Rovny (summer)

William Schill (summer)

Joseph Wasem

Blue: attending this meeting

What are our options?



As everything else had failed, it was the human race's last hope that paper really did beat rock.

<http://wumocomicstrip.com/stip/2010/08/16/>

Courtesy of Dennis Højlund.

Used with permission.

Nuclear explosives provide an effective option for many threat scenarios

§ The energy and effects are quite substantial



Castle Bravo explosion



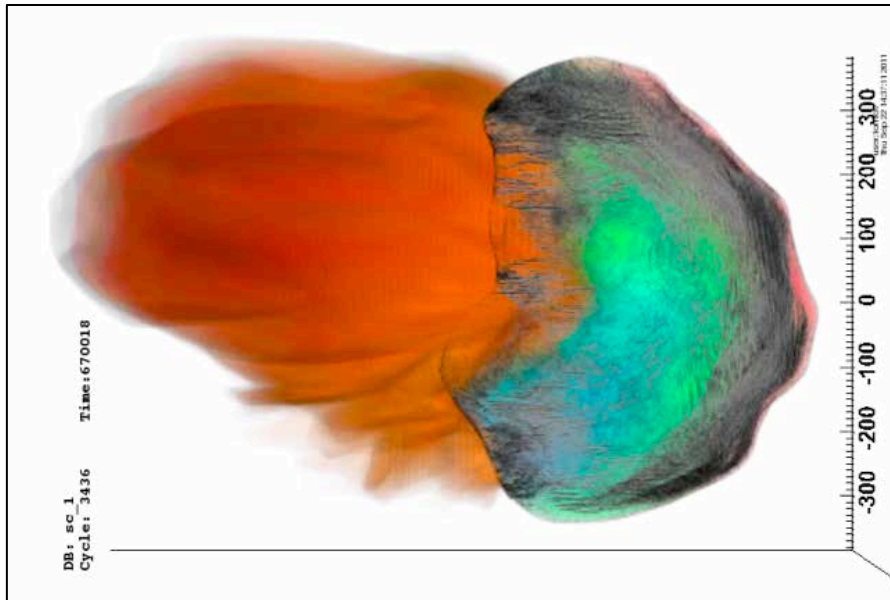
Castle Bravo crater

We address a range of topics related to nuclear-driven deflection and disruption

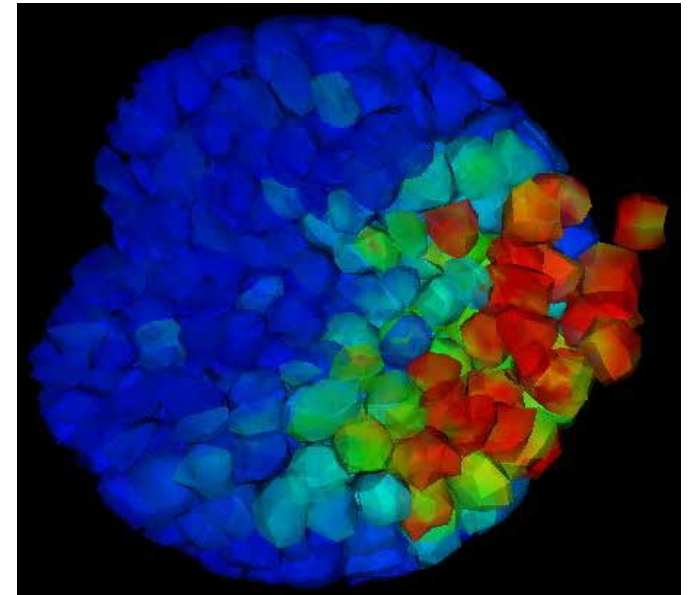
- § Realistic threat scenarios
- § Method development
- § Verification of methods
- § **Energy coupling (Kirsten Howley)**
- § **Uncertainty effects (Joe Wasem)**
- § **Deflection modeling**
- § **Disruption modeling**
- § **Dispersal and deposition**
- § Assessment of US capabilities
- § **Validation of methods**

Green: this talk
Blue: other PDC talks
Black: not covered here

Both deflection and disruption (breakup) results are achievable with nuclear explosives

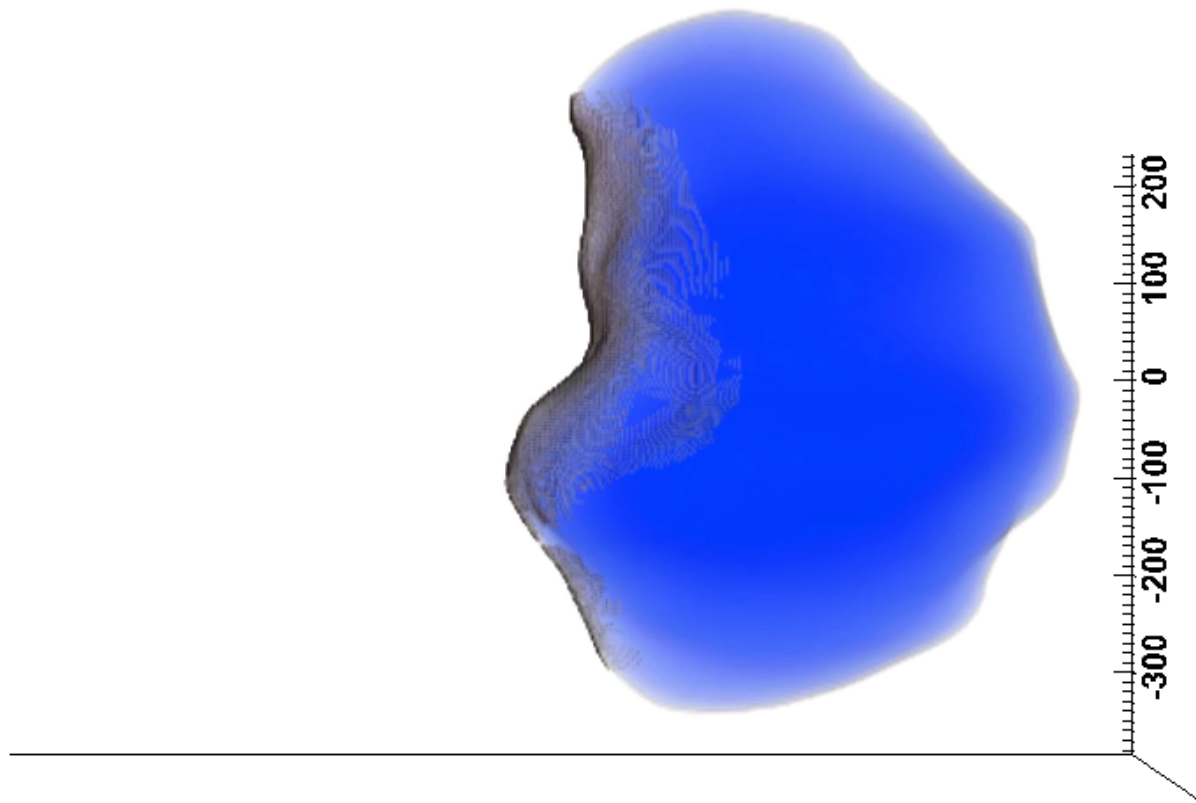


Deflection



Disruption

Nuclear explosives deflect by depositing energy and blowing off material



Disruption is an option for smaller objects when there is little warning time

- § Disrupt (break up) object
- § Let cloud of debris expand

Avoid “tight spread”

Objective is a cloud much larger than Earth, small pieces



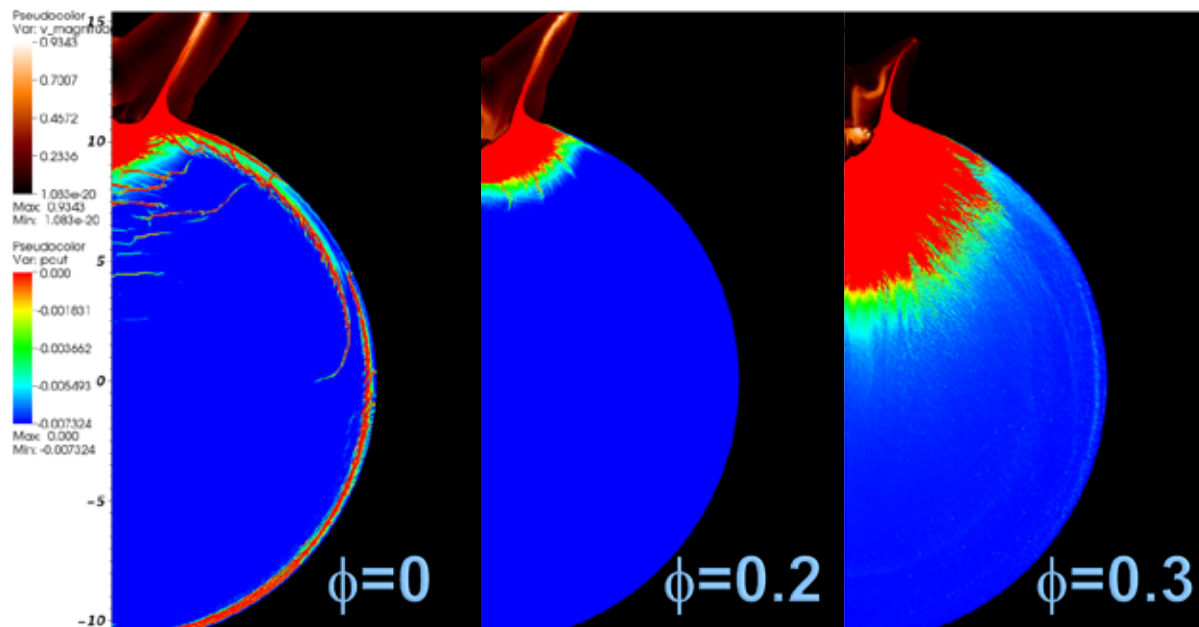
Porosity acts to dampen shocks and change the response of the object

§ Model for a hypervelocity impact

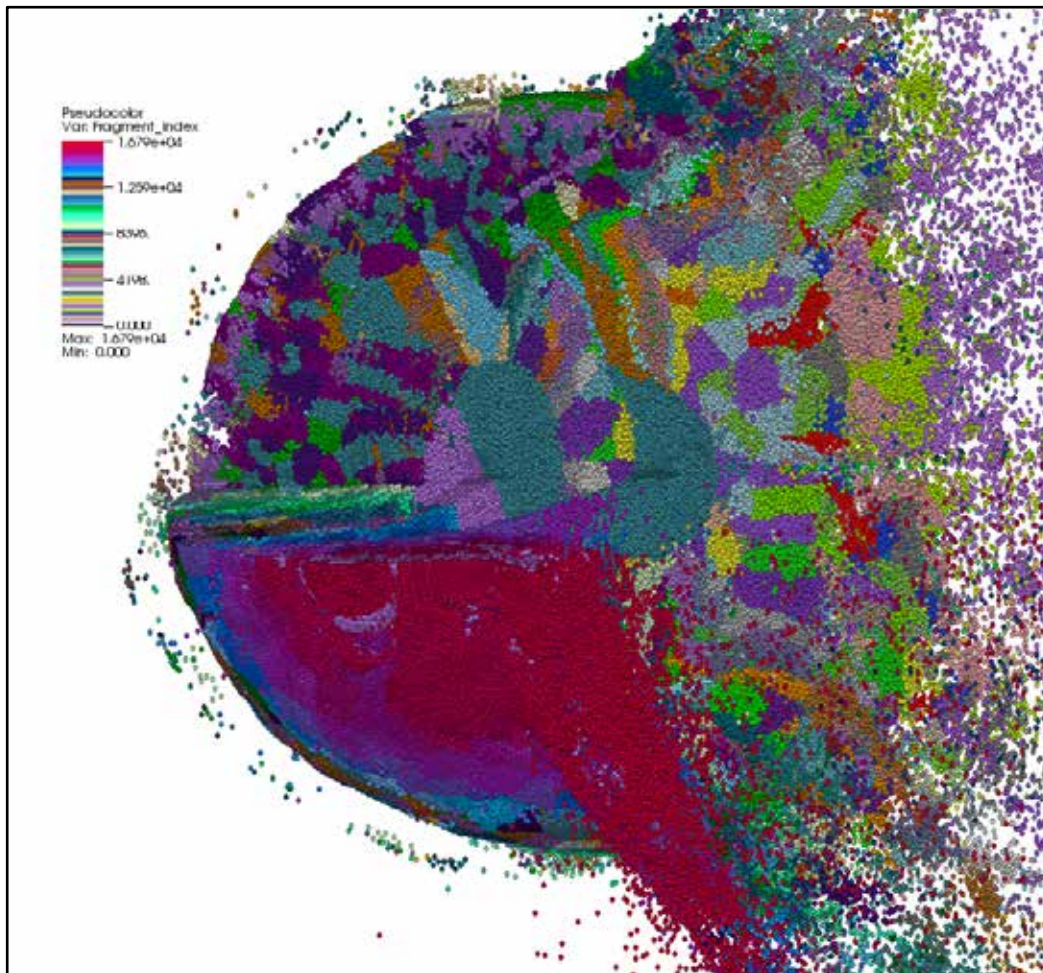
§ Porosities of 0, 20%, and 30%

§ Strength decreases with increasing porosity

Extent of damage (plotted) varies.



Dispersal example: 50-meter object and near-proximity megaton explosion



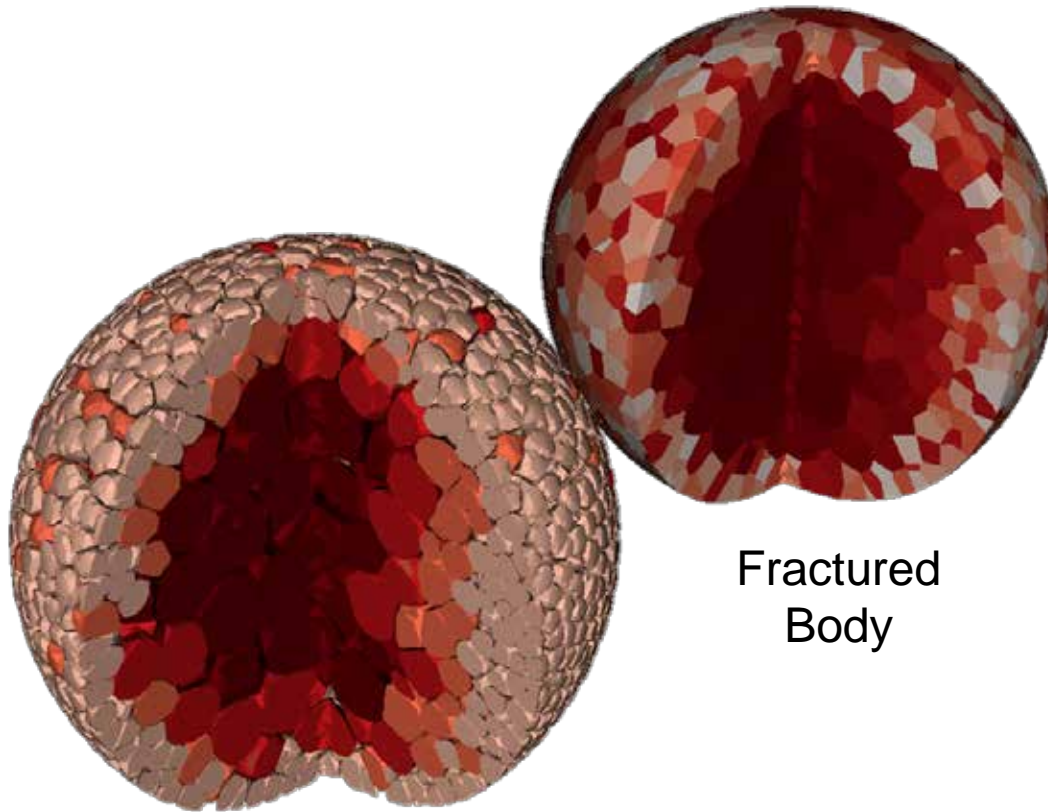
§ Time = 0.08 s

§ Porosity = 5%

§ Colors represent fragments

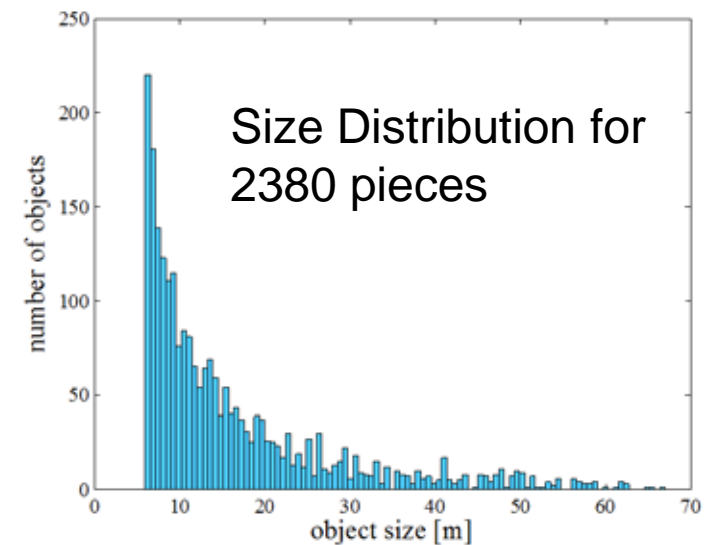
§ Largest fragments less than 3 meters in diameter

We can model fractured bodies and gravitational aggregates (rubble piles)



Fractured
Body

Gravitational Aggregate



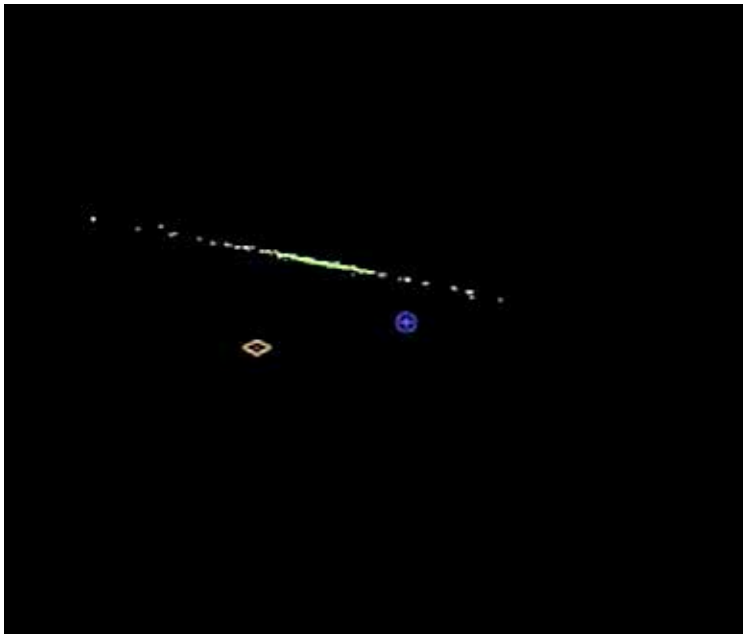
Cf. description by J.E. Richardson Jr, H.J. Melosh, R.J. Greenberg, D.P. O'Brien, *Icarus*, **179**, 325 (2005) and size distribution from J. Saito, et al, "Detailed Images of Asteroid 25143 Itokawa from Hayabusa", *Science* **312**, 1341 (2006).

Standoff Explosion Disruption Simulation

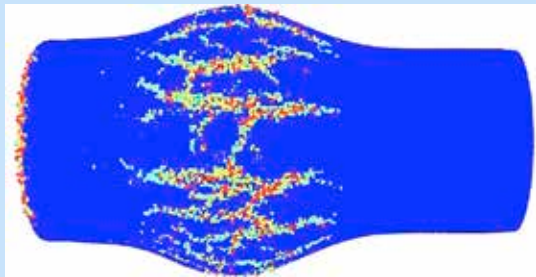
**Lawrence Livermore National Laboratory
2013**

We propagate the remnant core and pieces for 1.5 years until they pass Earth

- § Deflection of central core enough to miss
- § The debris cloud elongates and spreads
- § Earth perturbs the cloud as it passes



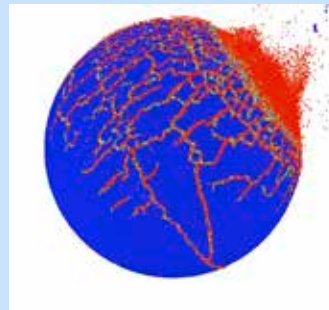
We use multiple codes, analytic test problems, and data to constrain our modeling



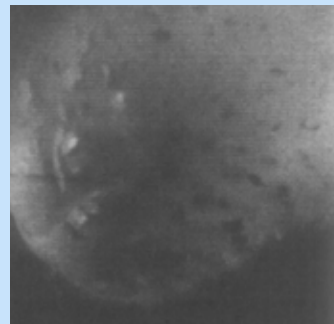
(LLNL Spheral simulation)



(Vogler et al. 2003)



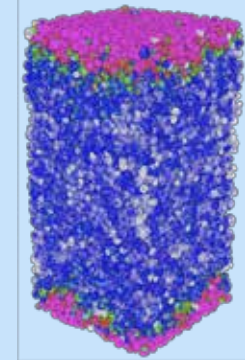
(LLNL Spheral simulation)



Nakamura & Fujiwara (1991)

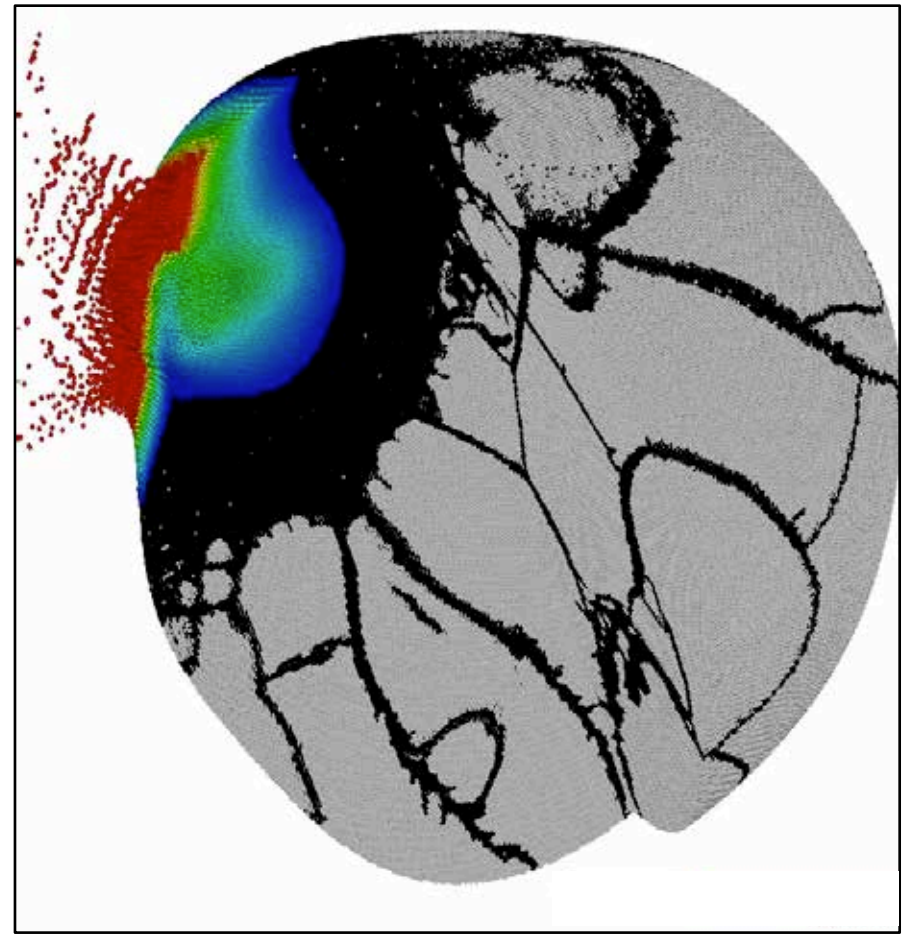


(LLNL GEODYN simulation)

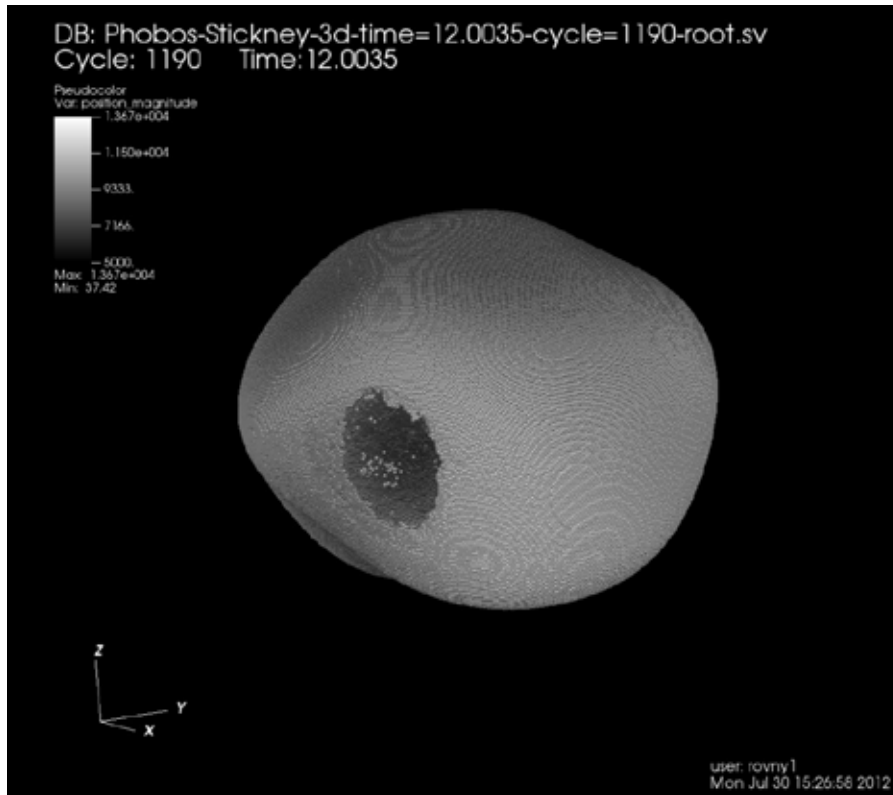


(LLNL GEODYN-L simulation)

We simulate the formation of Stickney Crater on Phobos as an integrated test problem



The Stickney problem brings together many modeling elements



Conclusion

- § Our work is in progress, as we continue to develop, refine, and validate our modeling
- § We solicit interactions with others who are addressing related problems