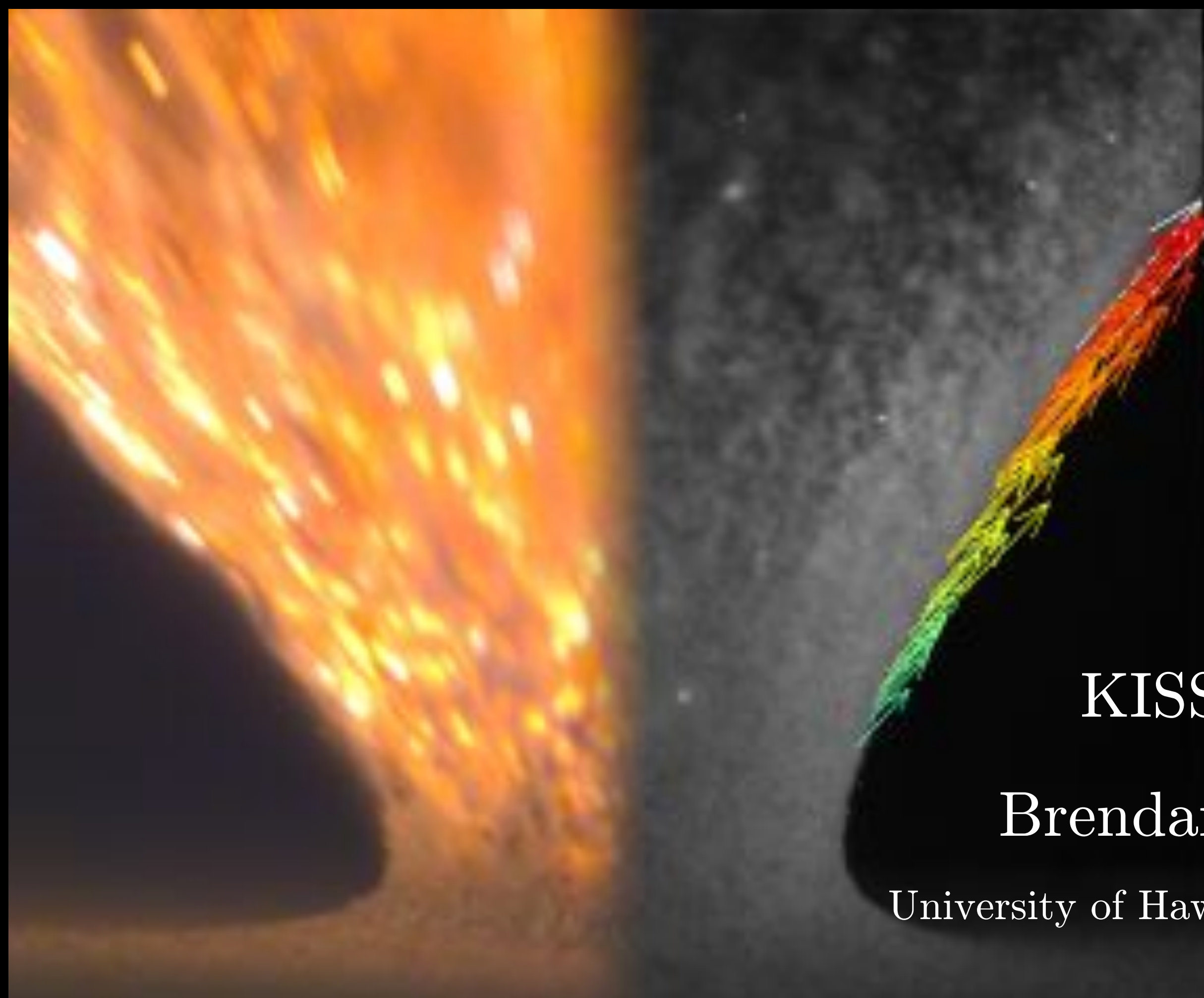
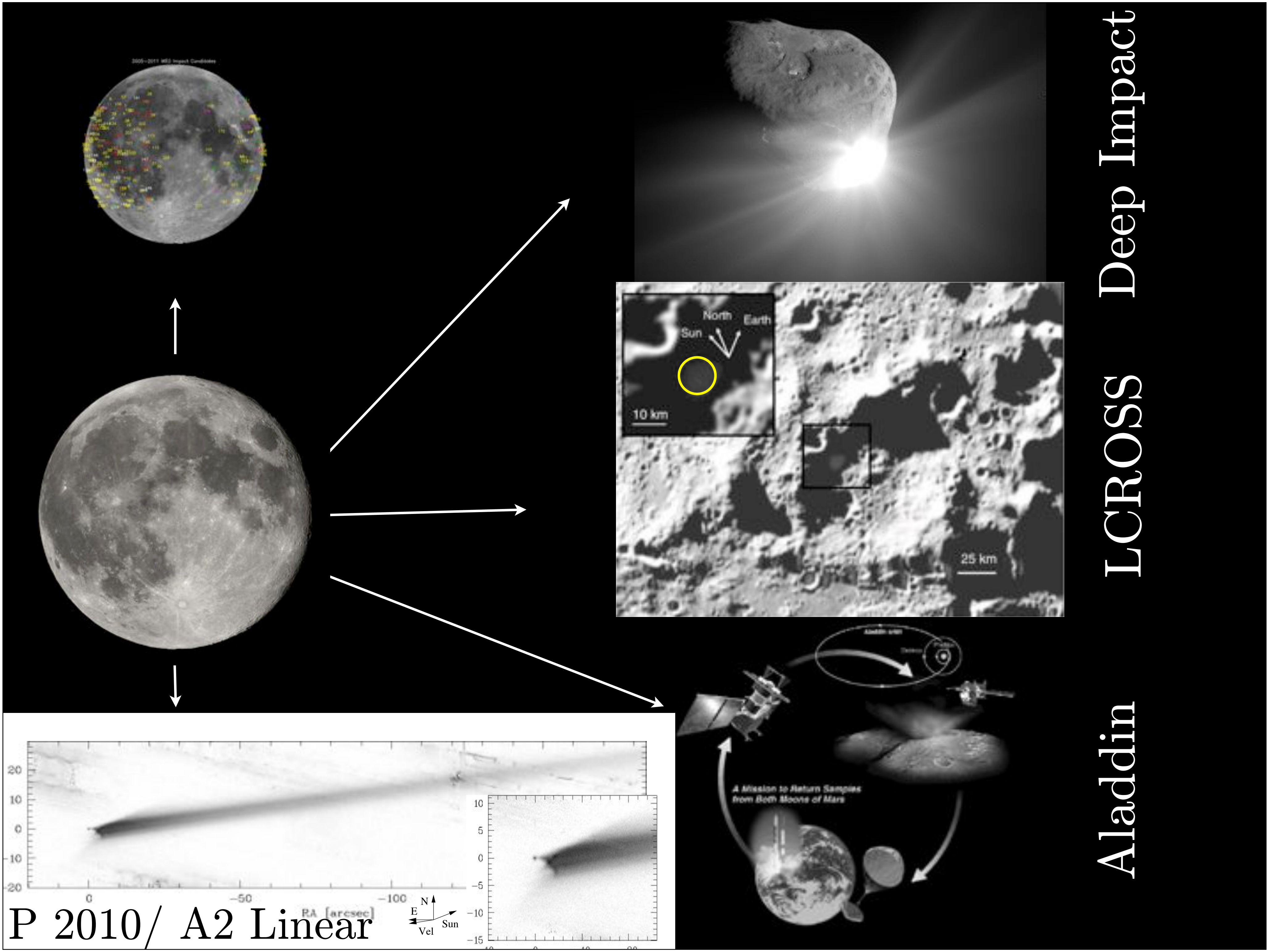
Impacts



KISS Workshop
7/23/13
Brendan Hermalyn

University of Hawaii, Honolulu, HI


Deep Impact
LCROSS
North
Sun
Earth
10 km
25 km
Aladdin
A Mission to Return Samples from Both Moons of Mars
P 2010/ A2 Linear
R.A. [arcsec]
N
E
Vel
Sun

Artificial Lunar Impacts

	V (km/s)	Mass (kg)	Angle	Crater Size
Ranger 7	2.62	365.6	64°	14
Ranger 8	2.65	369.7	42°	13x14
Ranger 9	2.67	369.7	-	16
Apollo 13	2.58	13925	76°	41
Apollo 14	2.54	14916	69°	39
LCROSS	2.5	2200	>85°	25
Grail	1.6	200	~2°	5

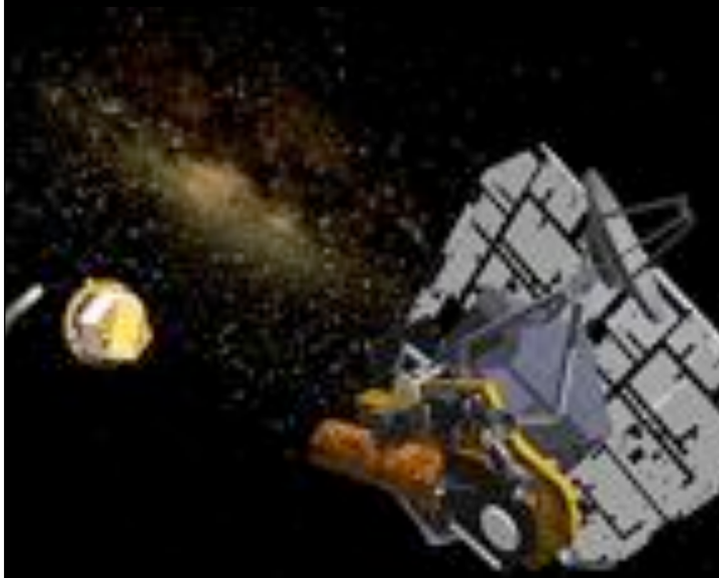
Baldwin (1967), Moore (1968,1971), Whitaker (1971)

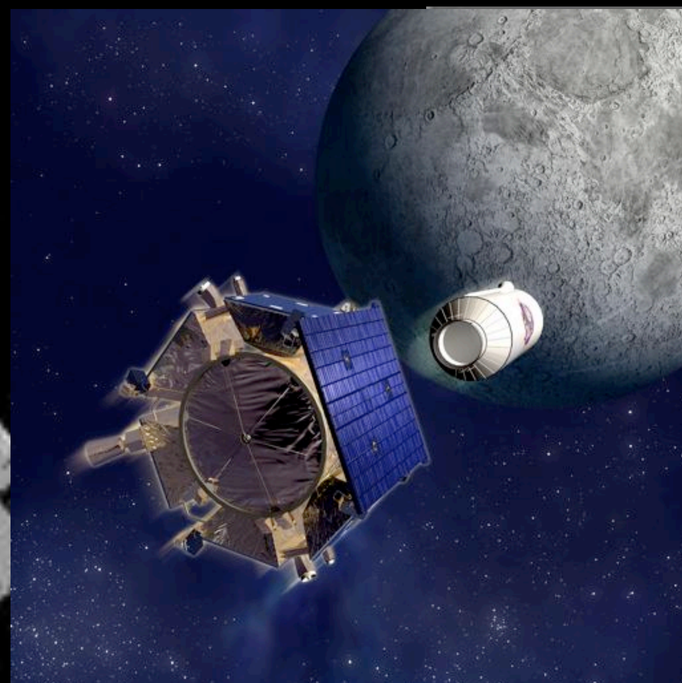
Overview:

- Why use impacts?
- New experimental methods and data enabling novel missions
- Why we care:
  - Cratering as a sensing tool

Examination of Subsurface

- Spectrometers?
  - Limited depth (~70cm) and resolving abilities (is it water or H?)
- Lander?
  - Expensive
  - Difficult to land and excavate on small bodies
  - Excavator depth is limited
  - Unknown surface properties can negate methodology
- Impactor?
  - Allows examination of subsurface and material properties (what's down there? Grain size? Etc.,)
  - Excellent for initial survey
  - Cheap



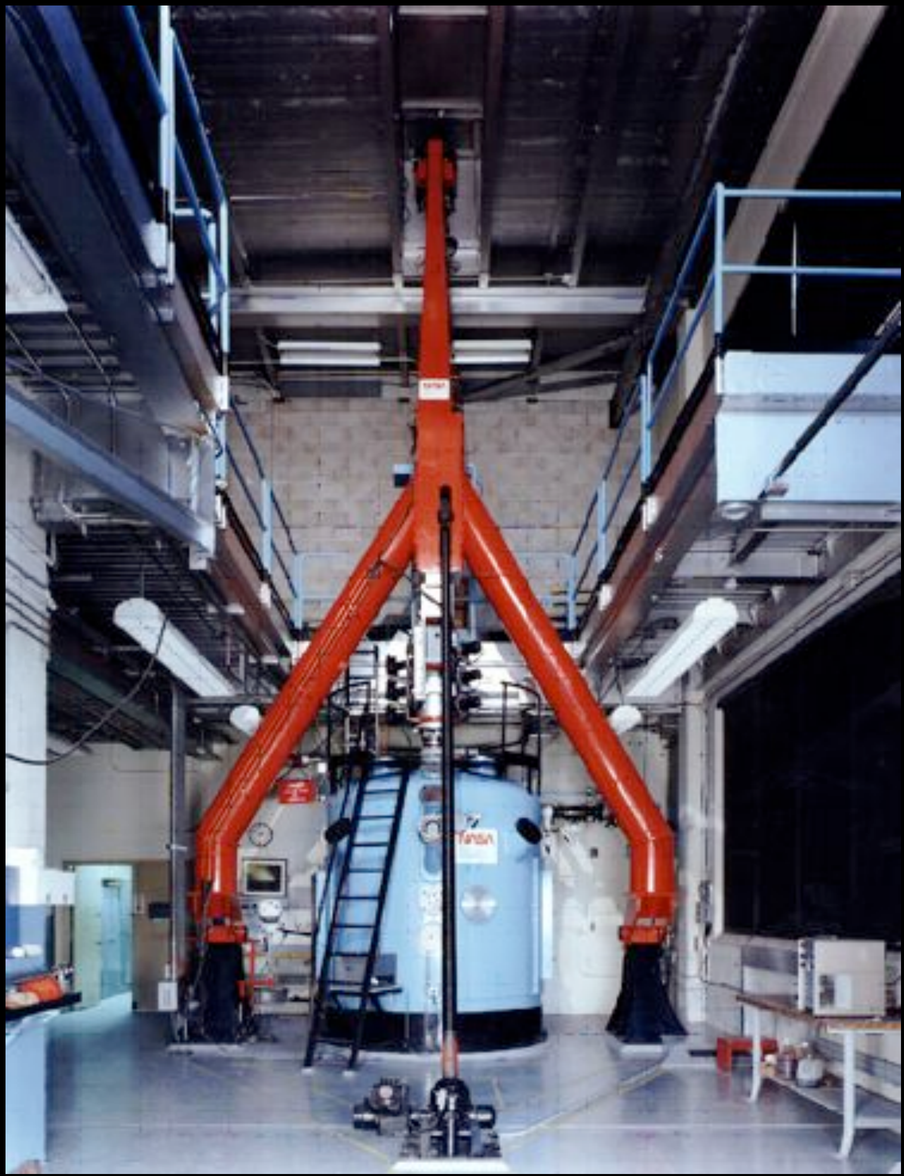


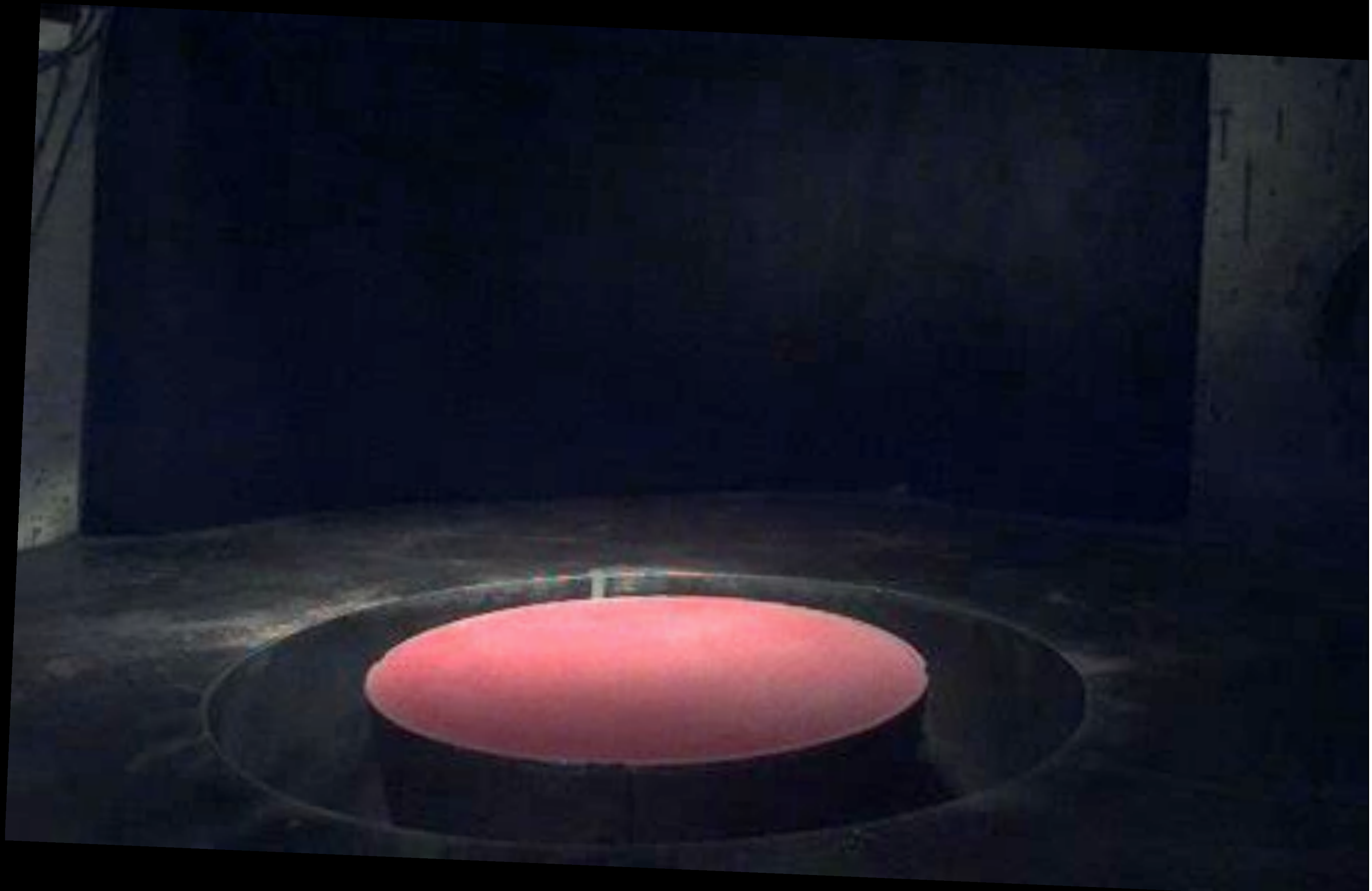
DI: $330M

LCROSS: $79M

<$.1M-$10sM

NASA Ames Vertical Gun Range

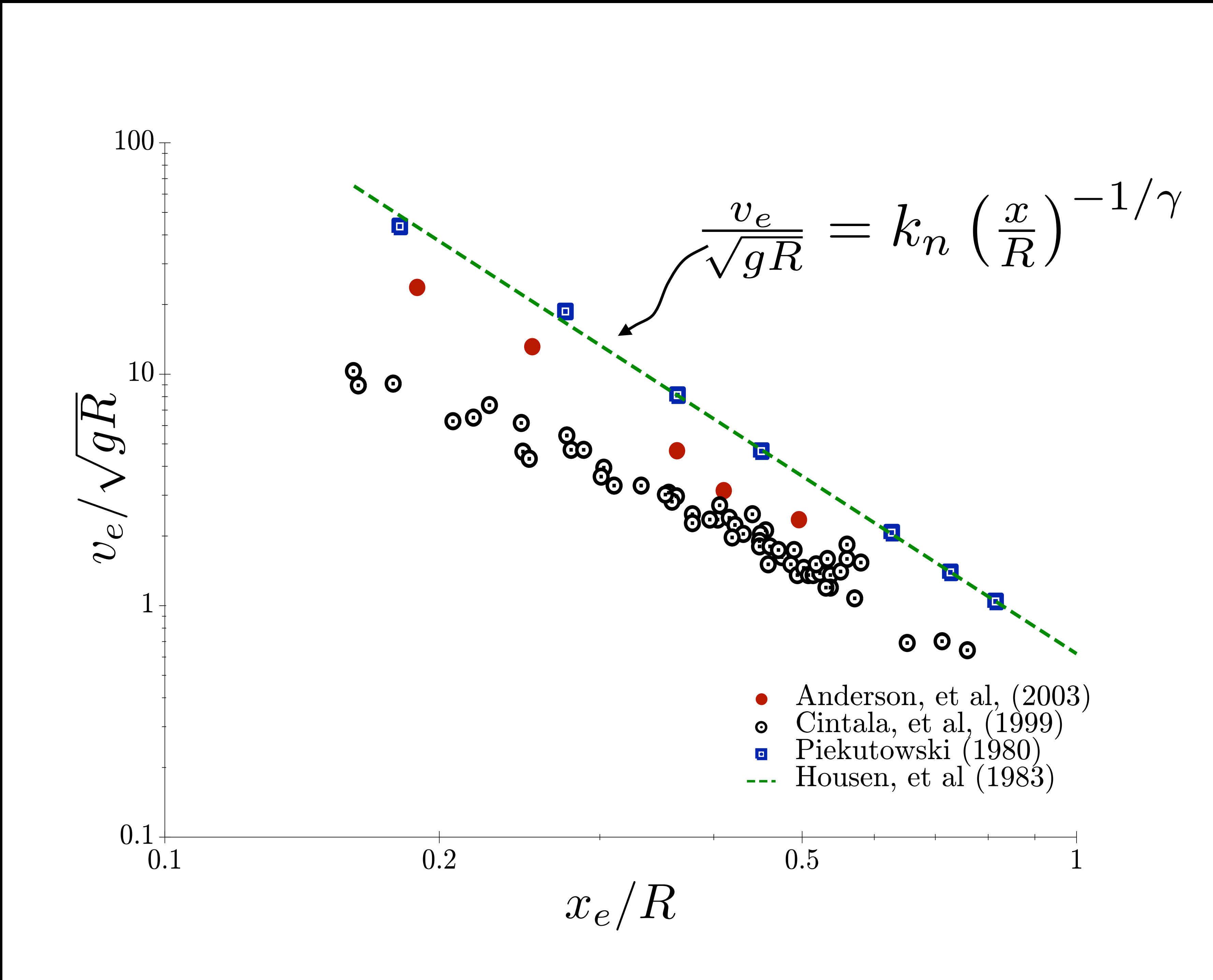




Impact Relevance

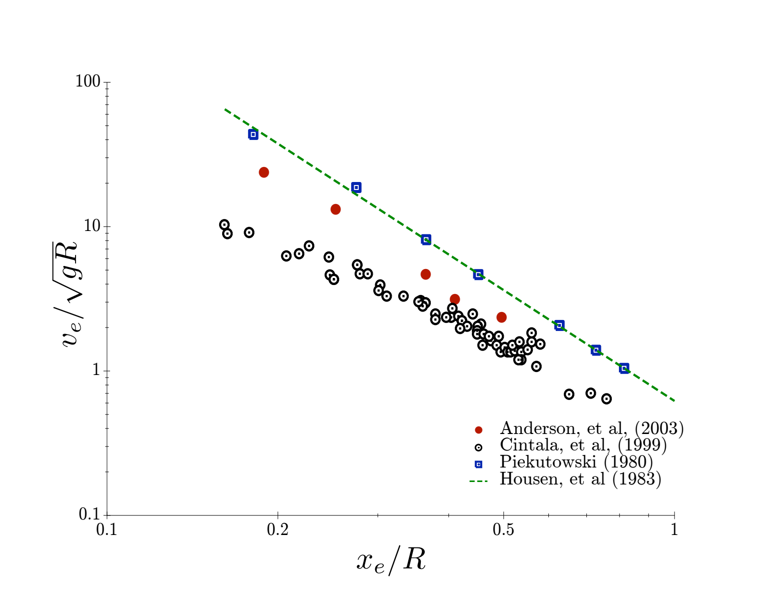
- Ejecta:
  - Where does it go?
  - Where does it come from?
- Volatile Release:
  - Heating during impact
  - Heating in sunlight
  - Ejecta return scouring and heating

- What can the ejecta tell you about the subsurface?
  - Strength
  - Density
  - Homogeneity/Layering
  - Materials
  - Etc.
- How can a small impacts guide future investigations? (ISRU, excavator design)



$\frac{v_e}{\sqrt{gR}} = k_n \left(\frac{x}{R}\right)^{-1/\gamma}$
$v_e/\sqrt{gR}$
x_e/R
100
10
1
0.1
0.1
0.2
0.5
1
Anderson, et al, (2003)
Cintala, et al, (1999)
Piekutowski (1980)
Housen, et al (1983)

Main-stage Scaling
(vertical impacts)



Position:

$$\frac{v_e}{\sqrt{gR}} = k_n \left(\frac{x}{R}\right)^{-1/\gamma}$$

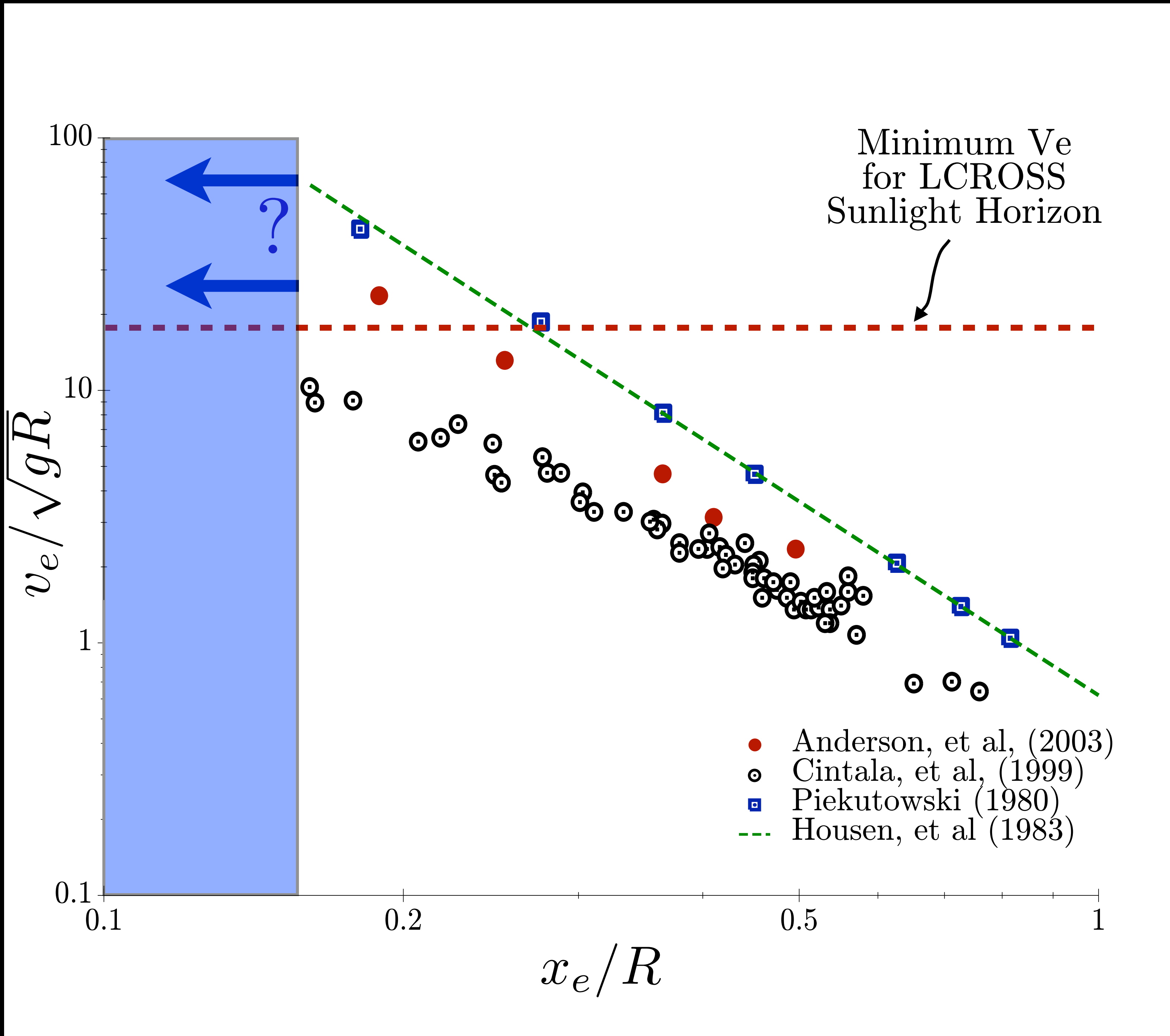
Time:

$$\frac{v_e}{\sqrt{gR_c}} = k_1 \left(t_{launch}\sqrt{\frac{g}{R_c}}\right)^{(\alpha-3)/(\alpha+3)}$$

Relies on Coupling Parameter:

$$C = aV_i^{\mu}\delta^{\nu}\left(\frac{\delta_p^{\nu}V_i^{\mu}}{\delta_t^{\nu}c^{\mu}}\right)$$

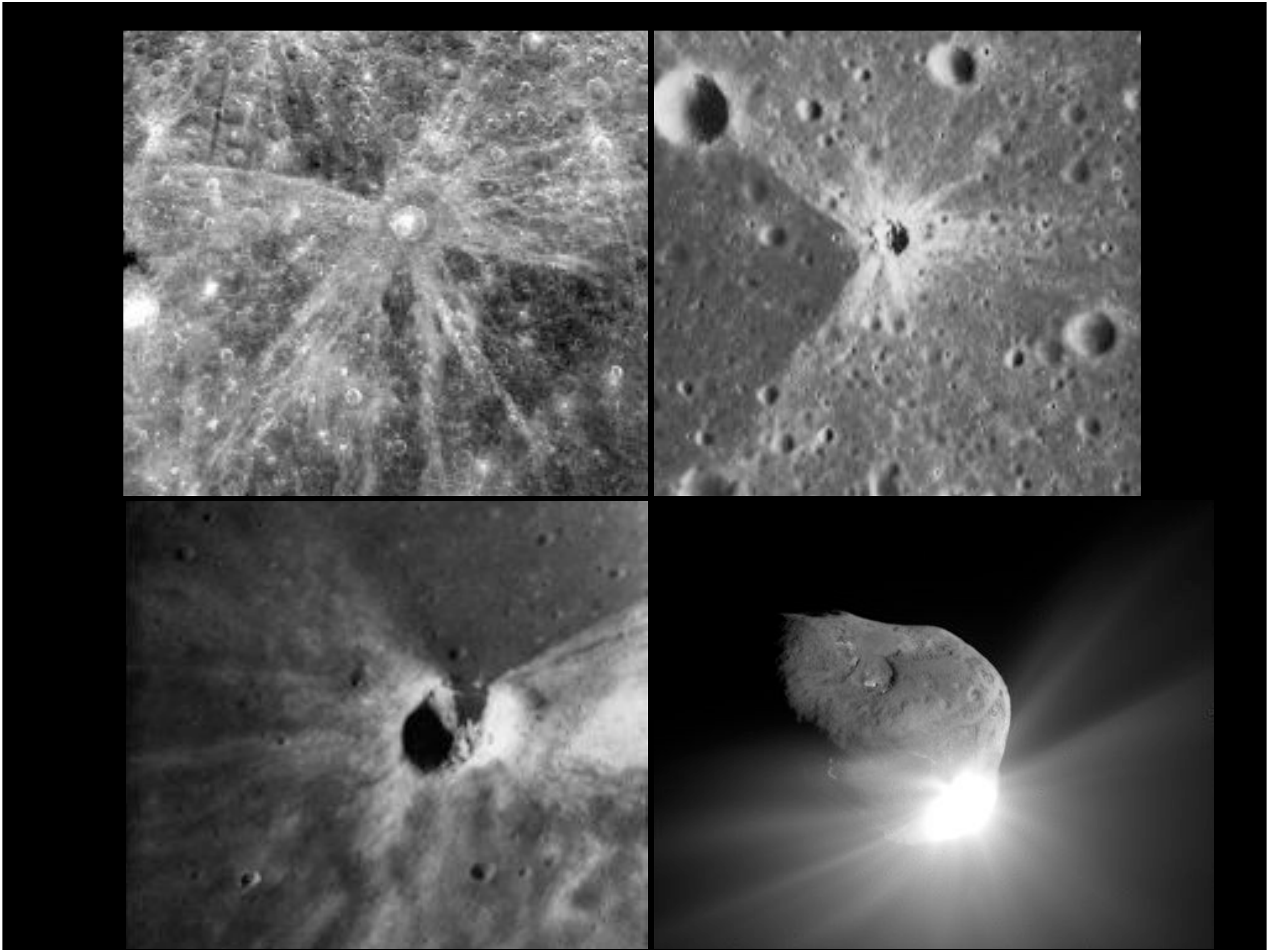
[Housen, et al 1983]

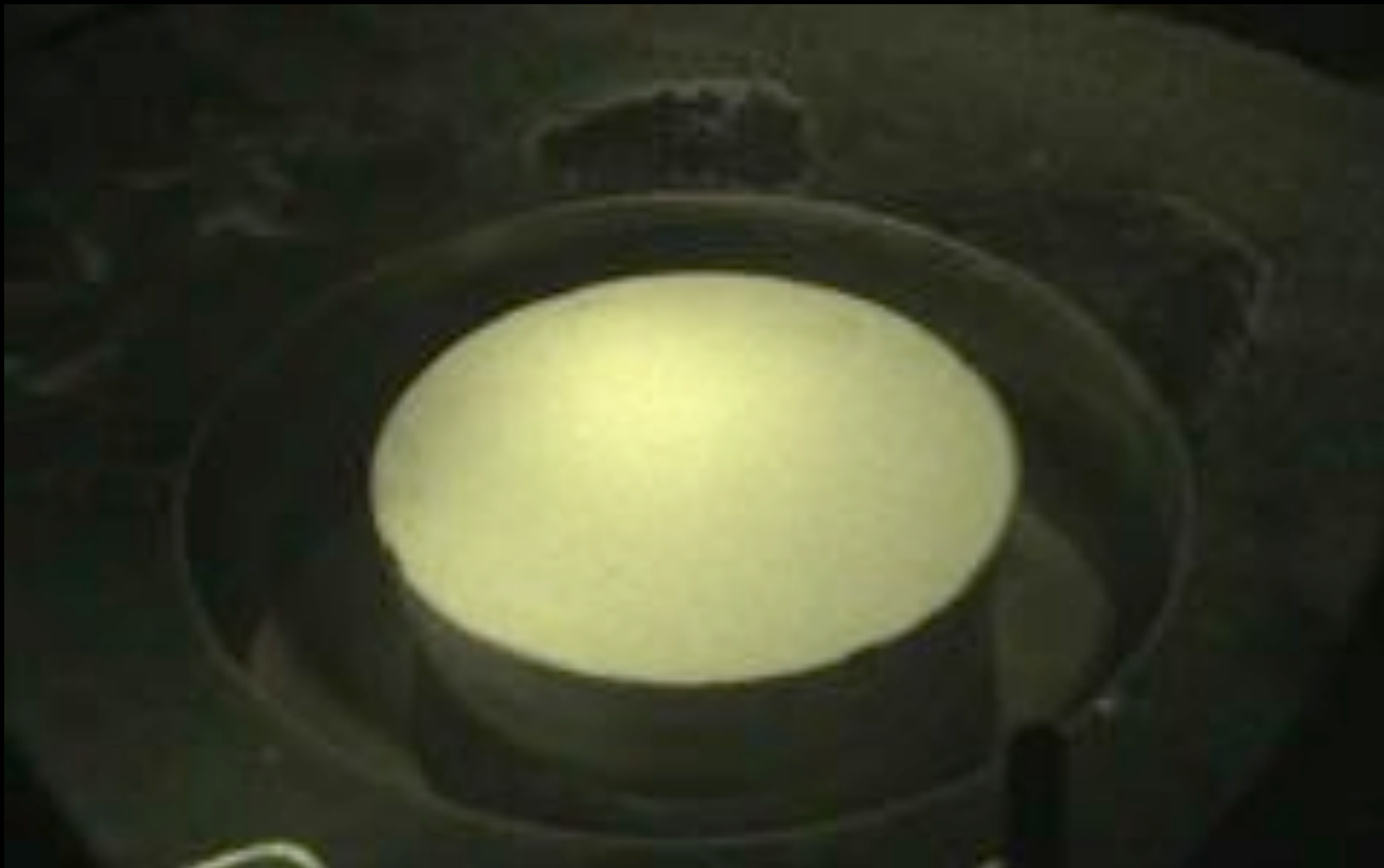


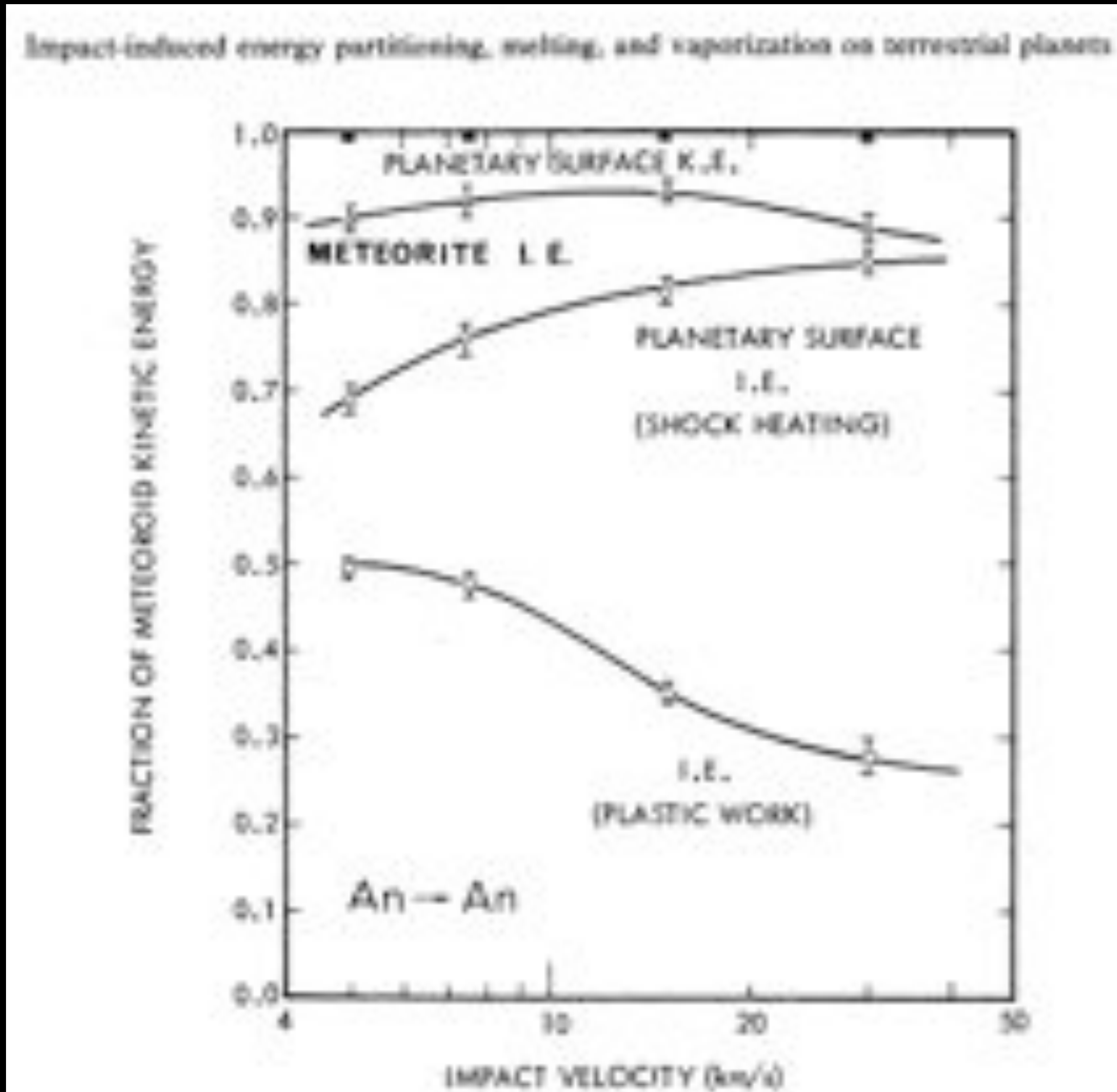
Minimum Ve
for LCROSS
Sunlight Horizon
?
100
10
1
0.1
0.1
0.2
0.5
1
$v_e/\sqrt{gR}$
x_e/R
Anderson, et al, (2003)
Cintala, et al, (1999)
Piekutowski (1980)
Housen, et al (1983)

Planned Impacts

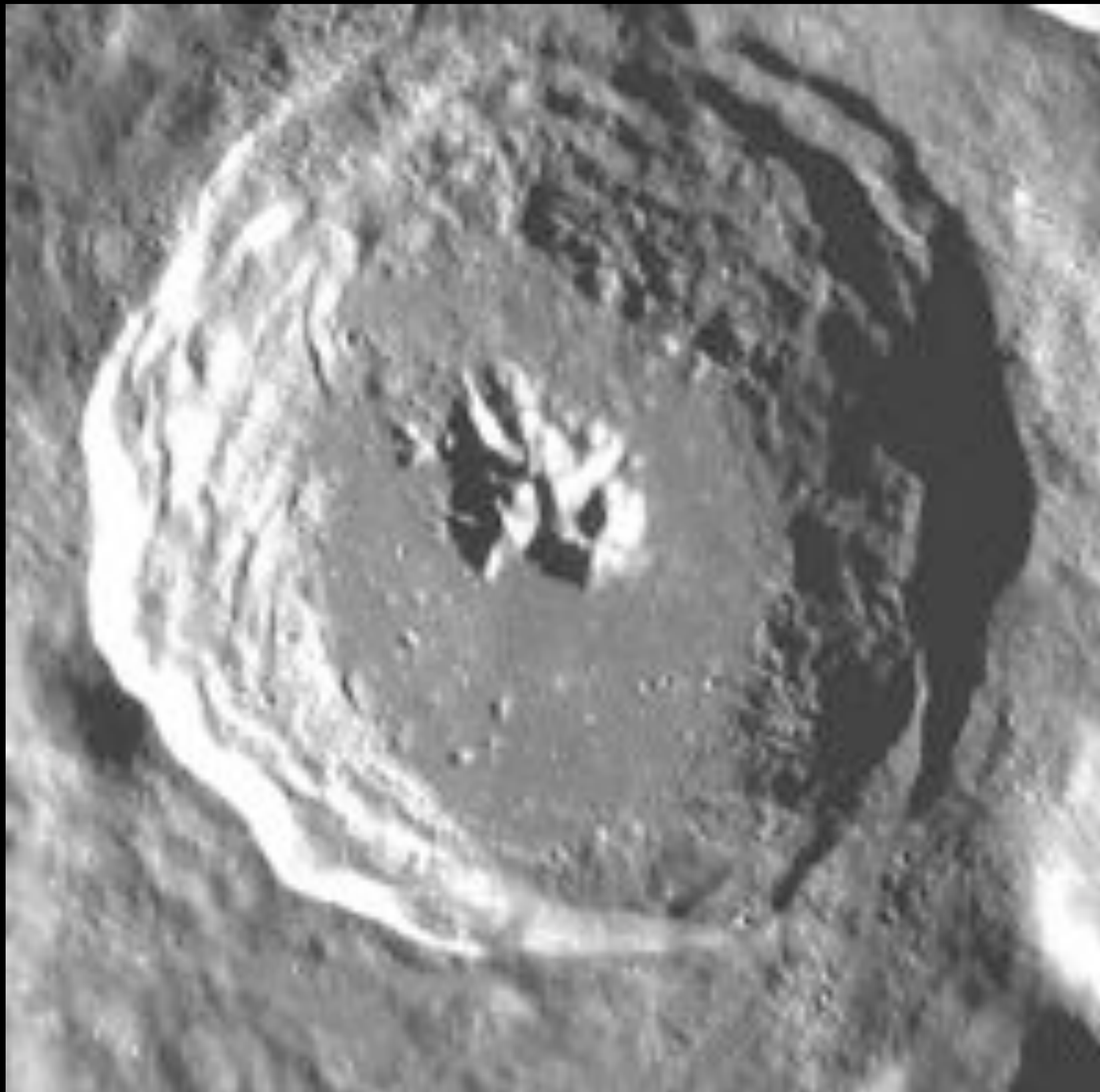
Standard	Impact Mission
Solid Spheres / flyer plates	Hollow, Low-density, Irregular Shape
5 km/s and up	2.5 km/s
Sand or Solid Material	? Unconsolidated, compressible regolith
Shock Heating	Low Peak Pressure
20-70 degrees	Almost vertical (90 degrees) to grazing

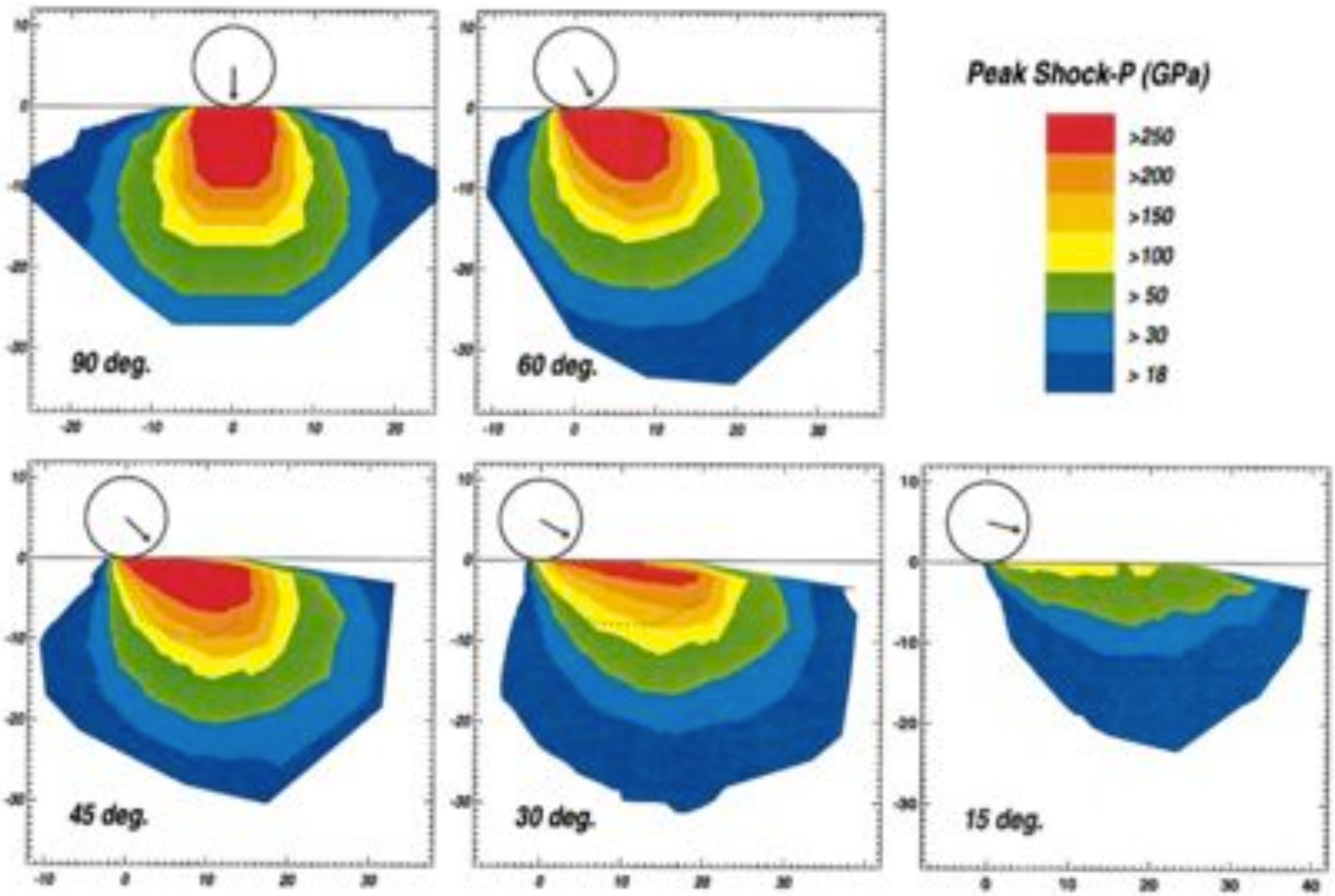


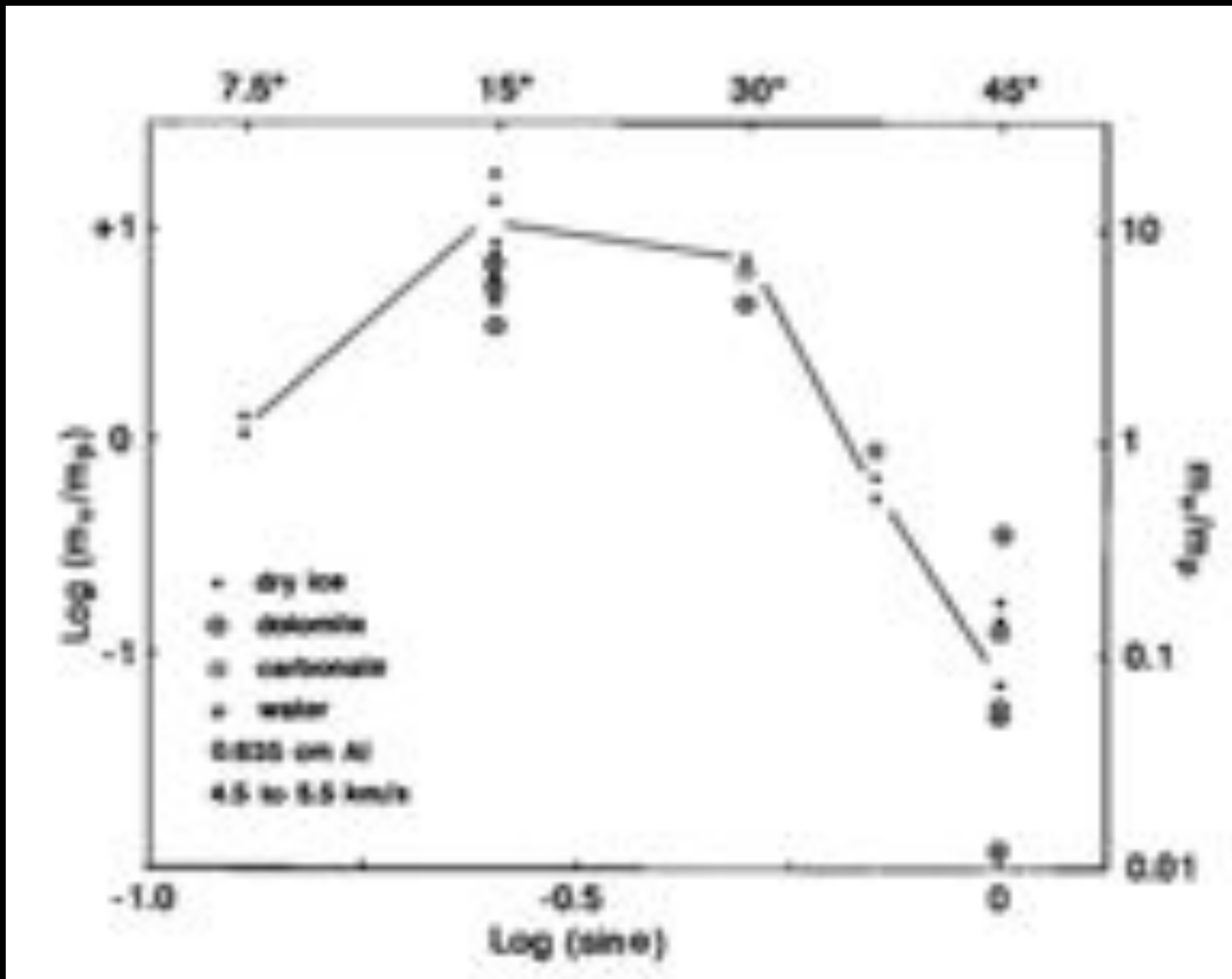




Okeefe, J. D. & Ahrens, T. J. 1977

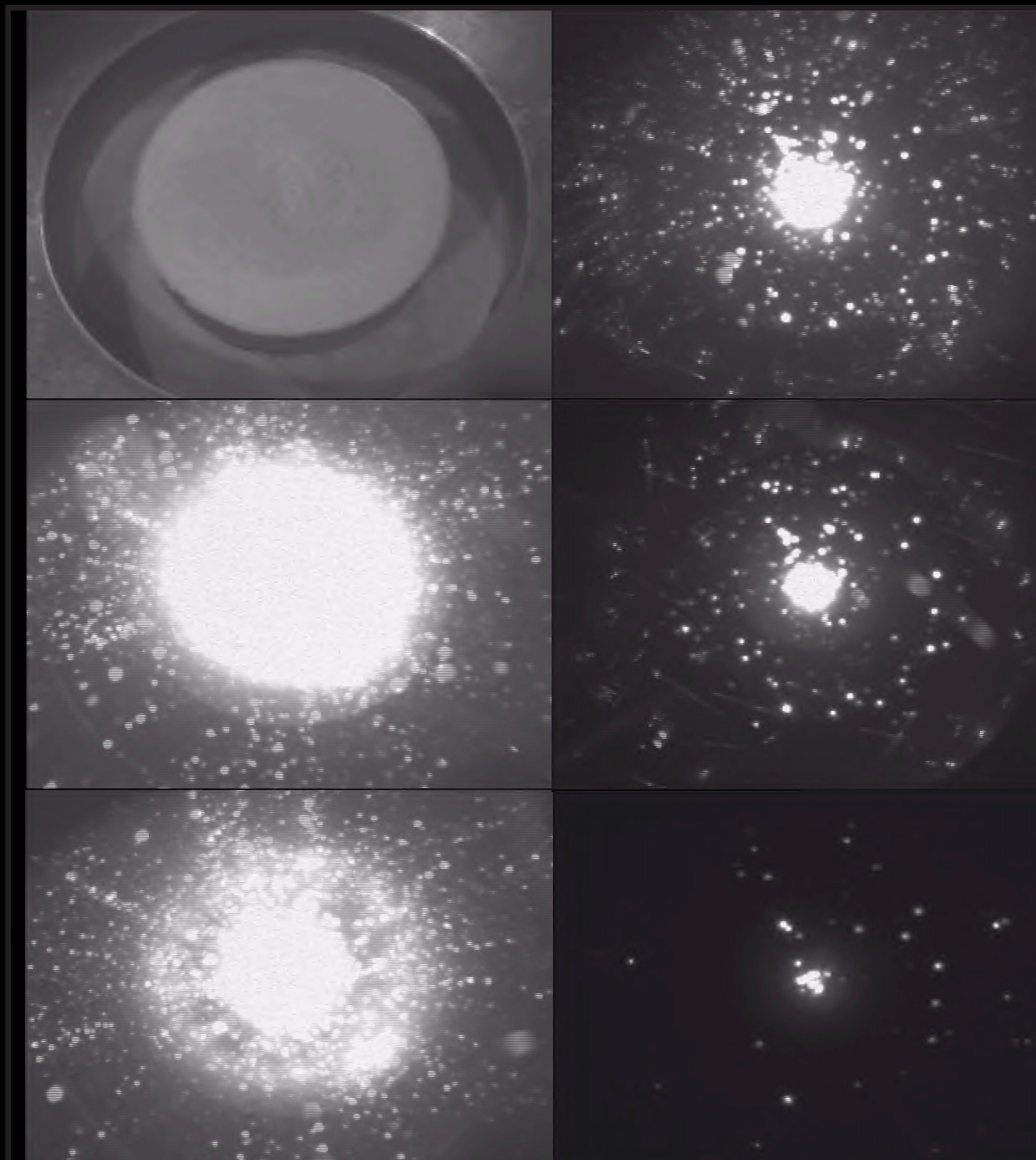



Peak Shock-P (GPa)
>250
>200
>150
>100
> 50
> 30
> 18
90 deg.
60 deg.
45 deg.
30 deg.
15 deg.

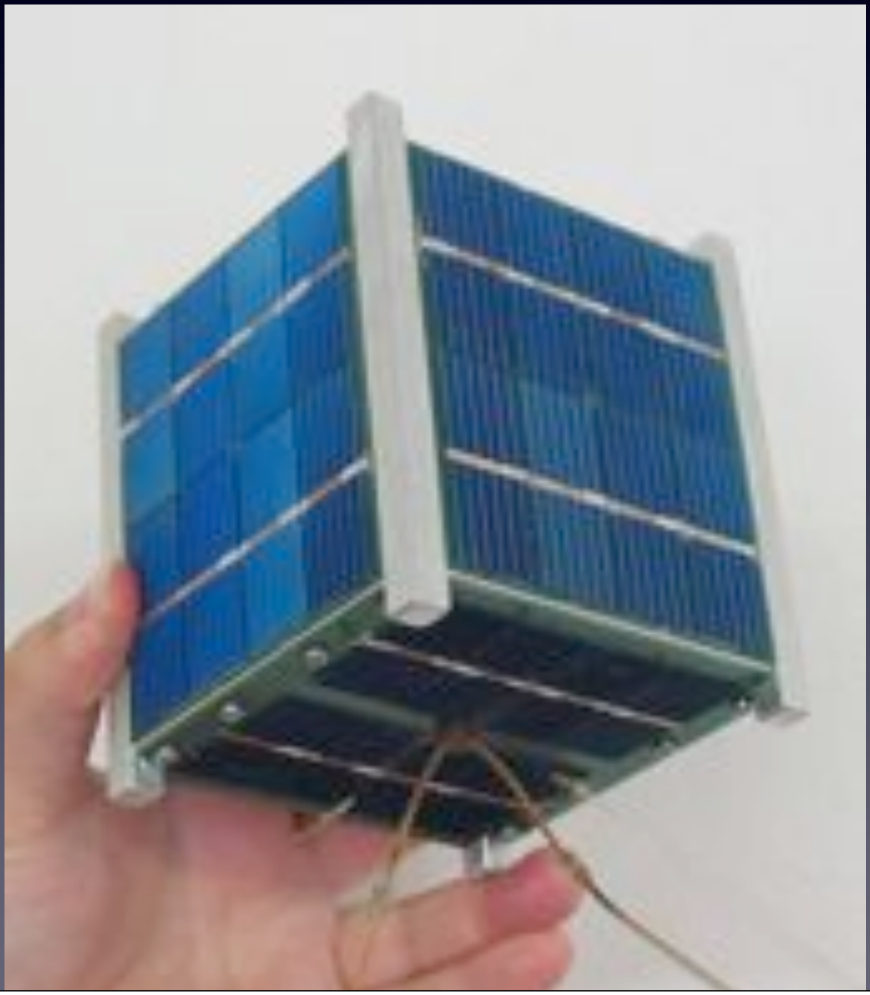


Schultz 1996

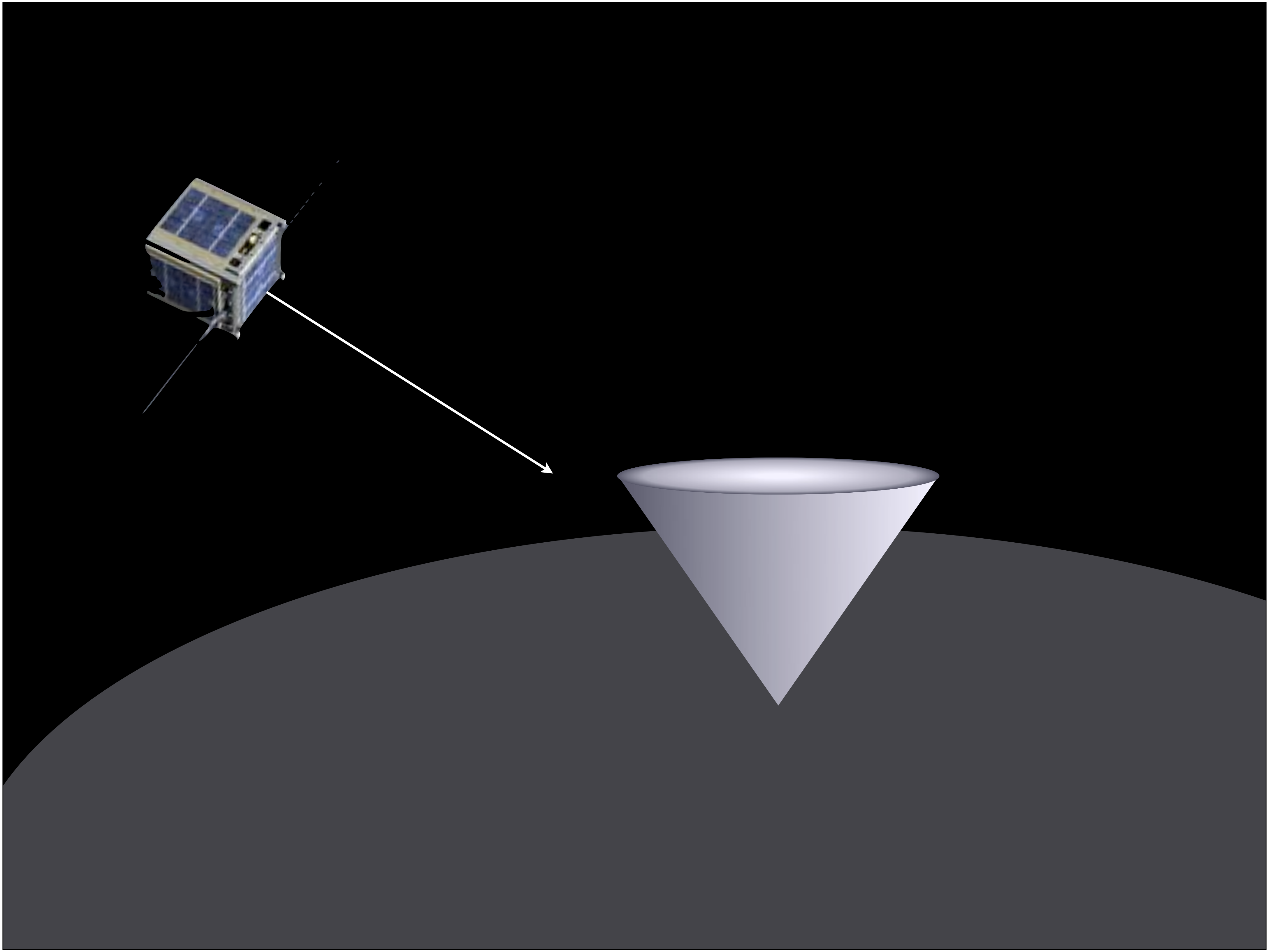
LCROSS IR Camera



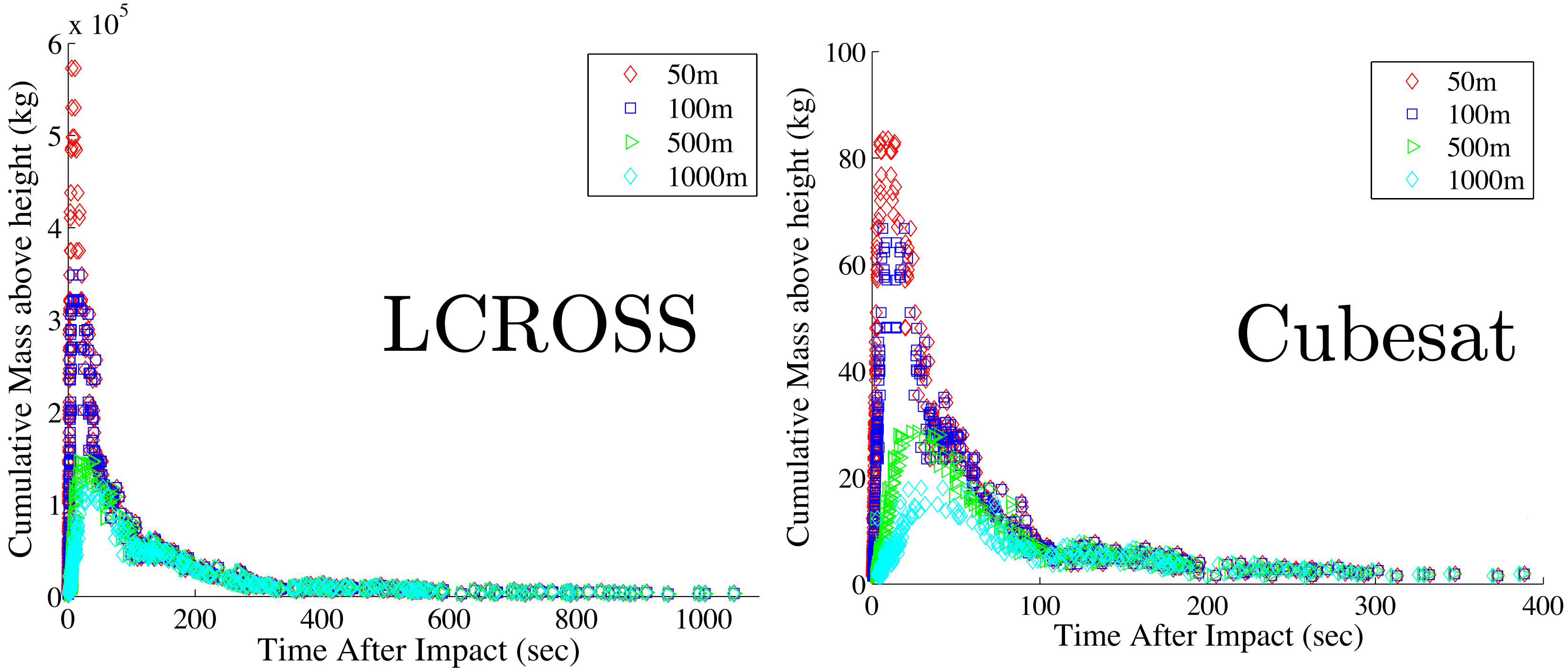
Hypothetical Case: Cubesat Mission



- 2.5km/s
- 1.3kg
- 10cm^3
- Into the moon

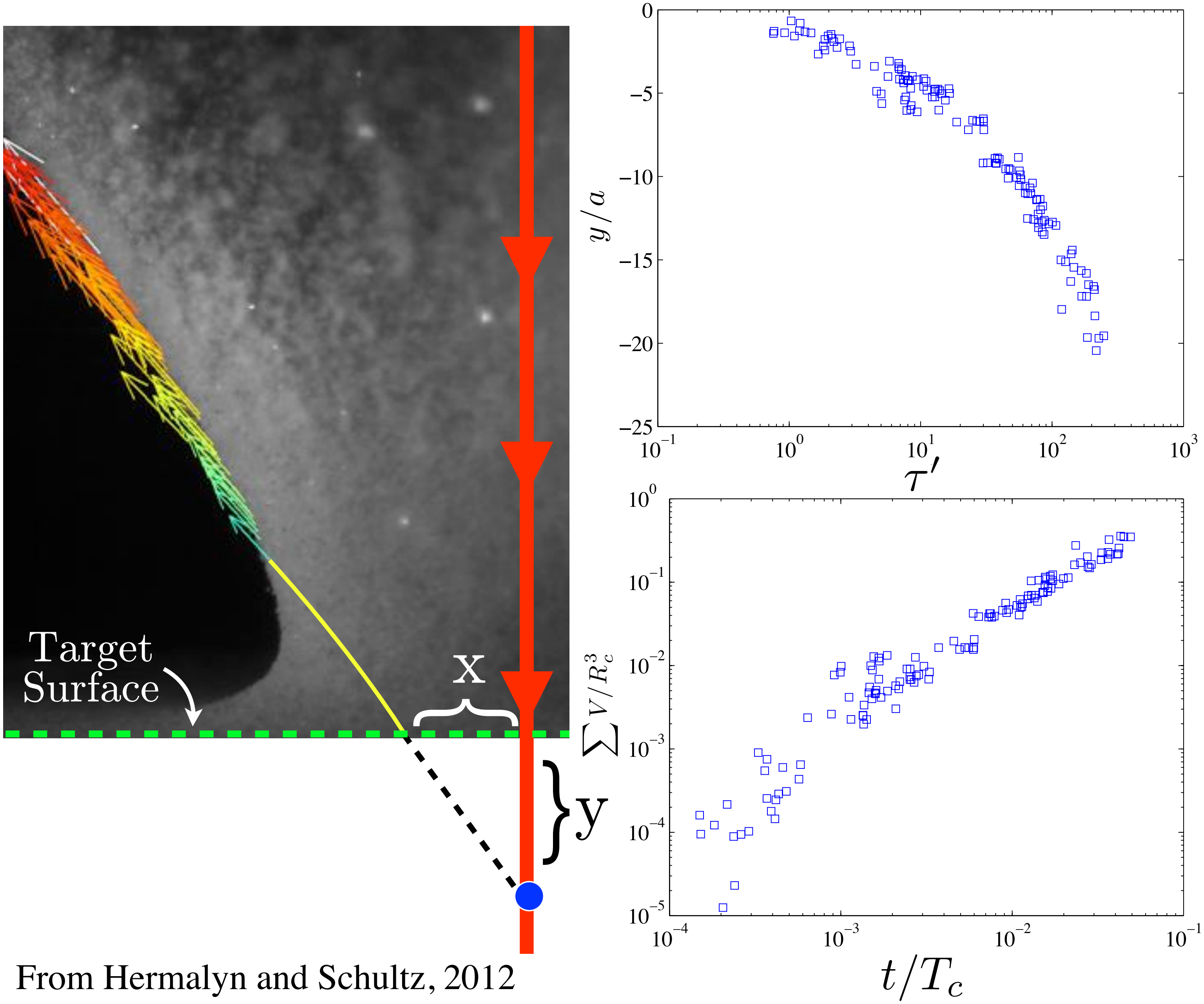


How Much?



From Hermalyn and Schultz, 2012

From Where?



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