

Lessons Learned from Deep Impact (Programmatic Aspects of Observations in the Cruise Phase of a Mission)

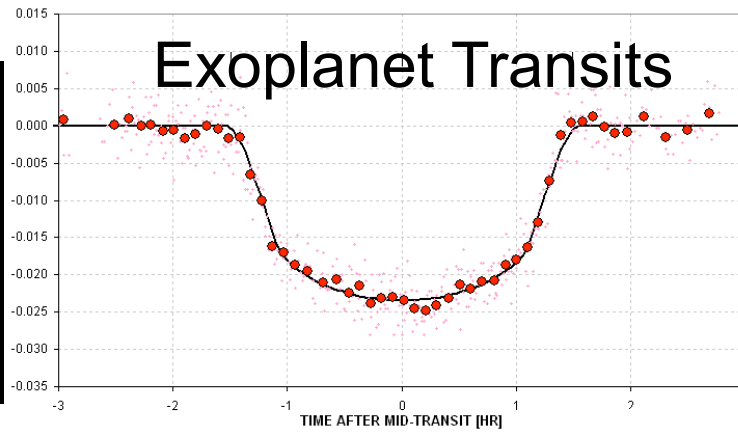
Nick Cowan (U of Washington)

The View from 5 AU

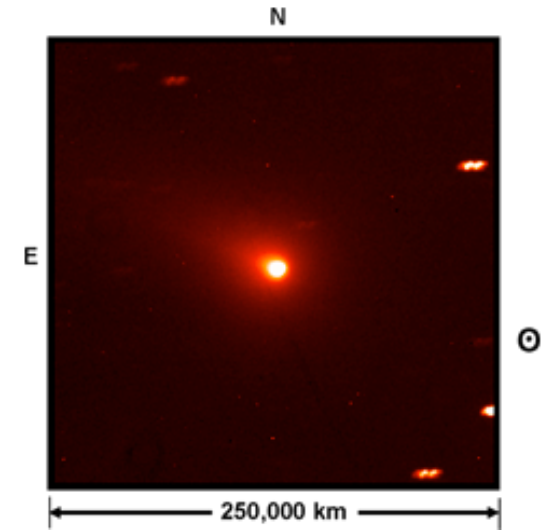
March 26, 2010

Deep Impact Science

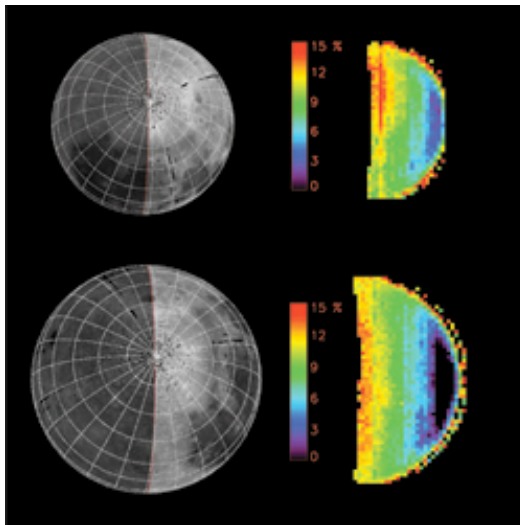
Tempel 1



Hartley 2

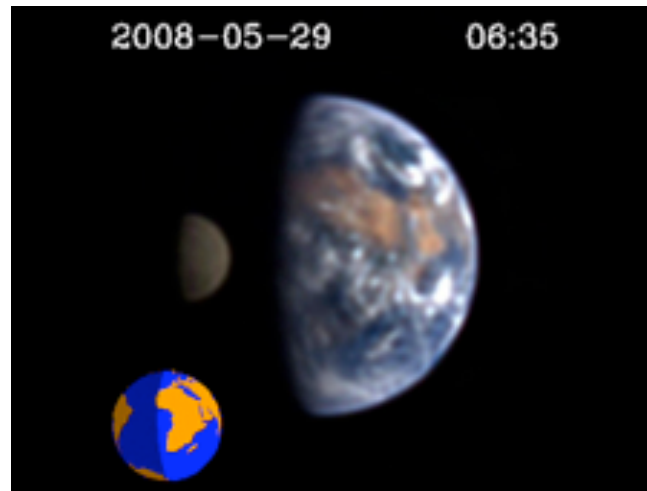


Lunar Ice

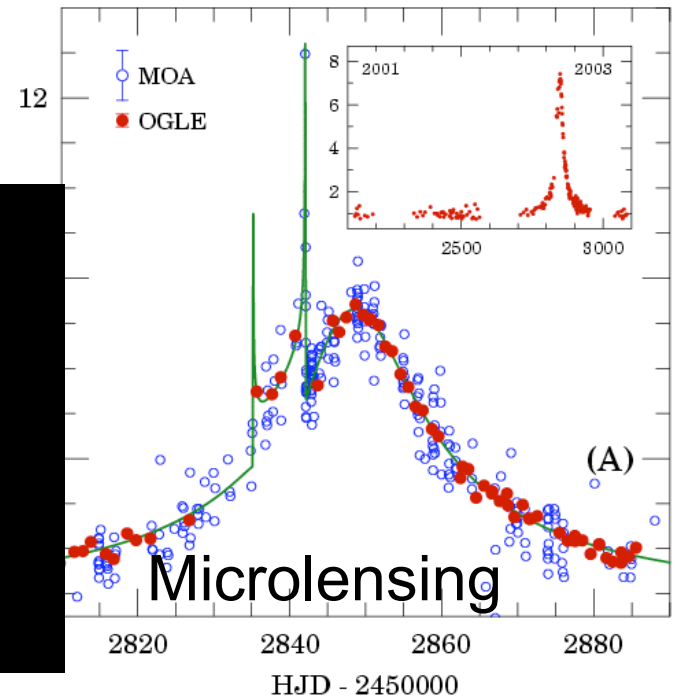


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Earth & Moon



Nick Cowan's talk at The View



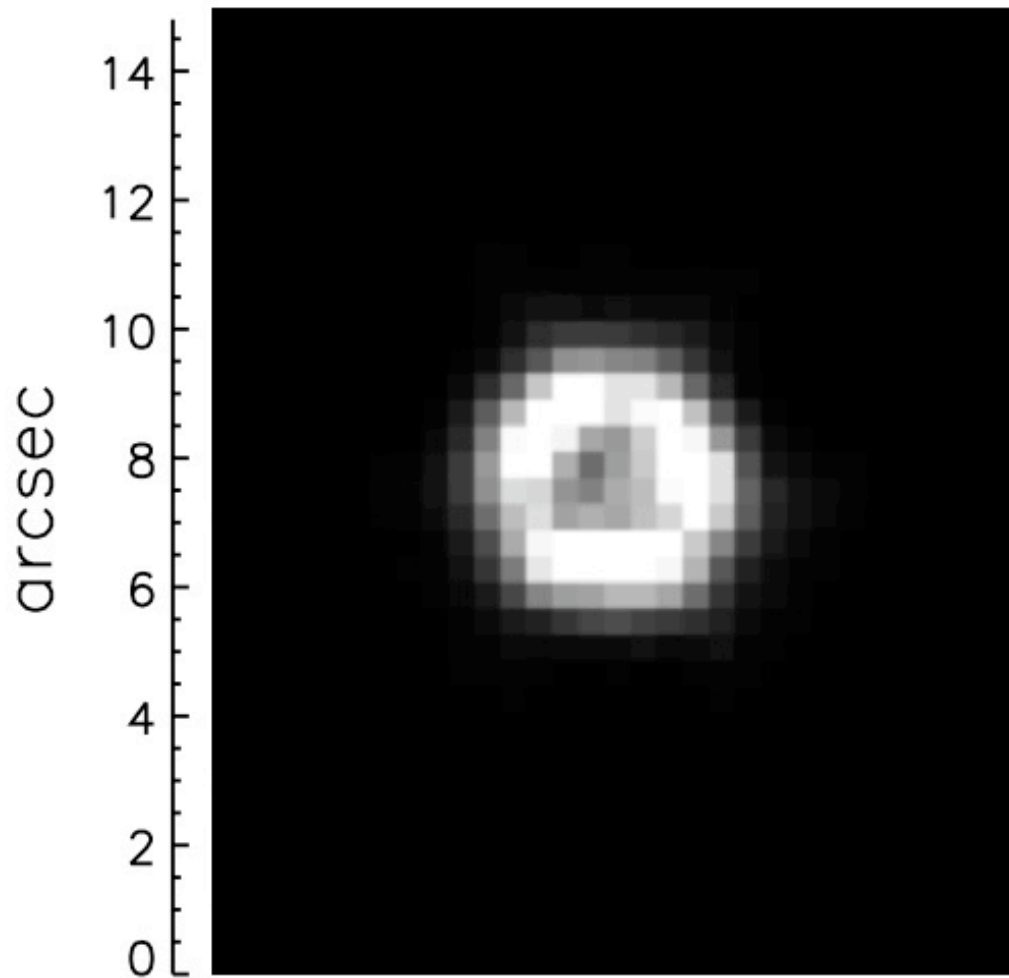
Microlensing

Deep Impact



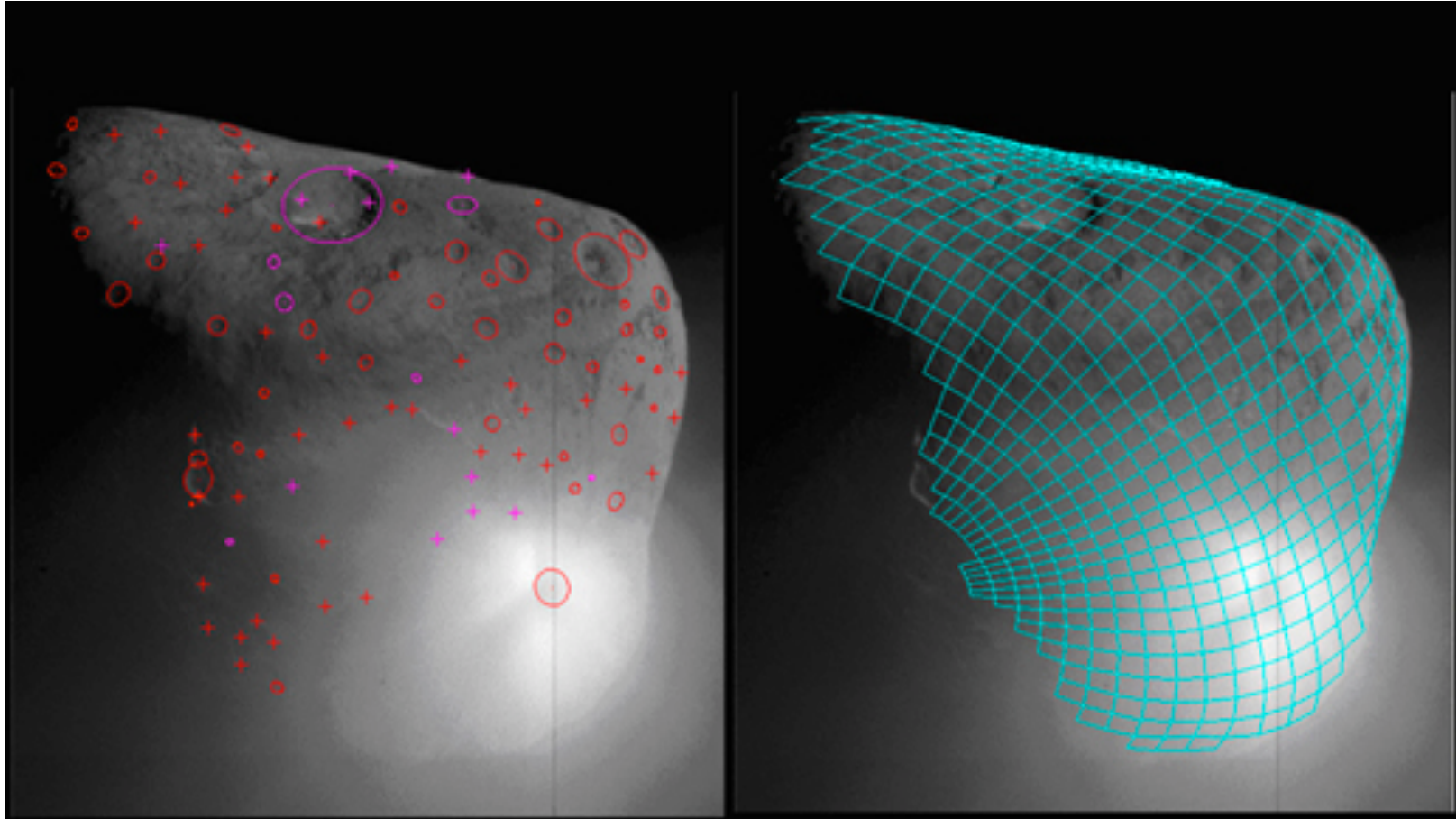
- PI: M. A'Hearn
- Target: Tempel 1
- Launch: Jan 12, 2005
- Impact: July 4, 2005
- Instruments: Smart Impactor, MRI, HRI (focus anomaly)

HRI Focus Anomaly



Deep Impact Science

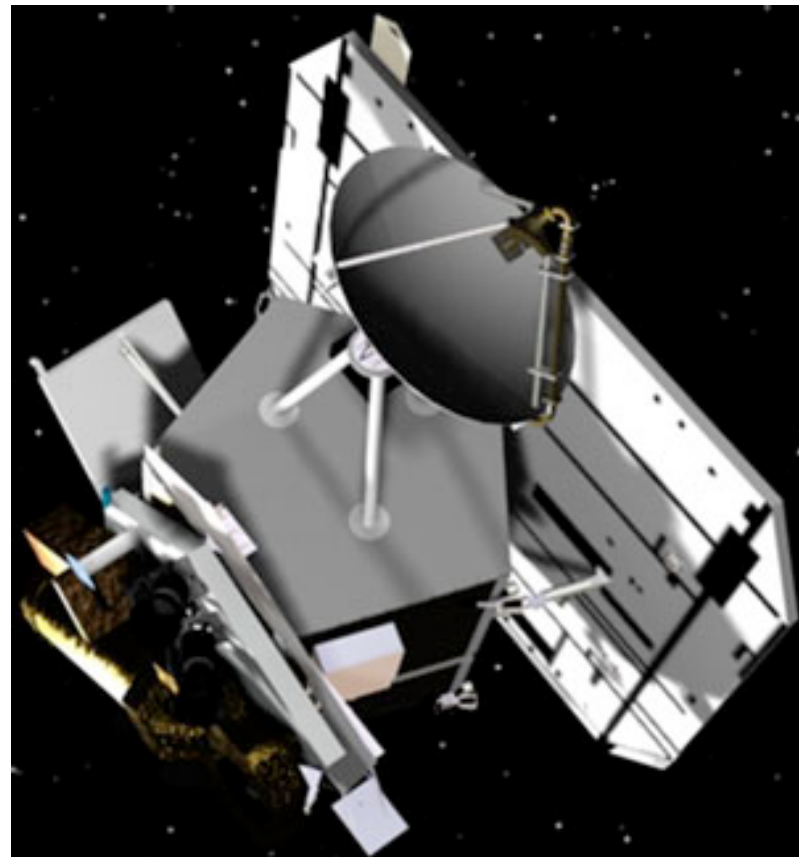
>10² refereed publications



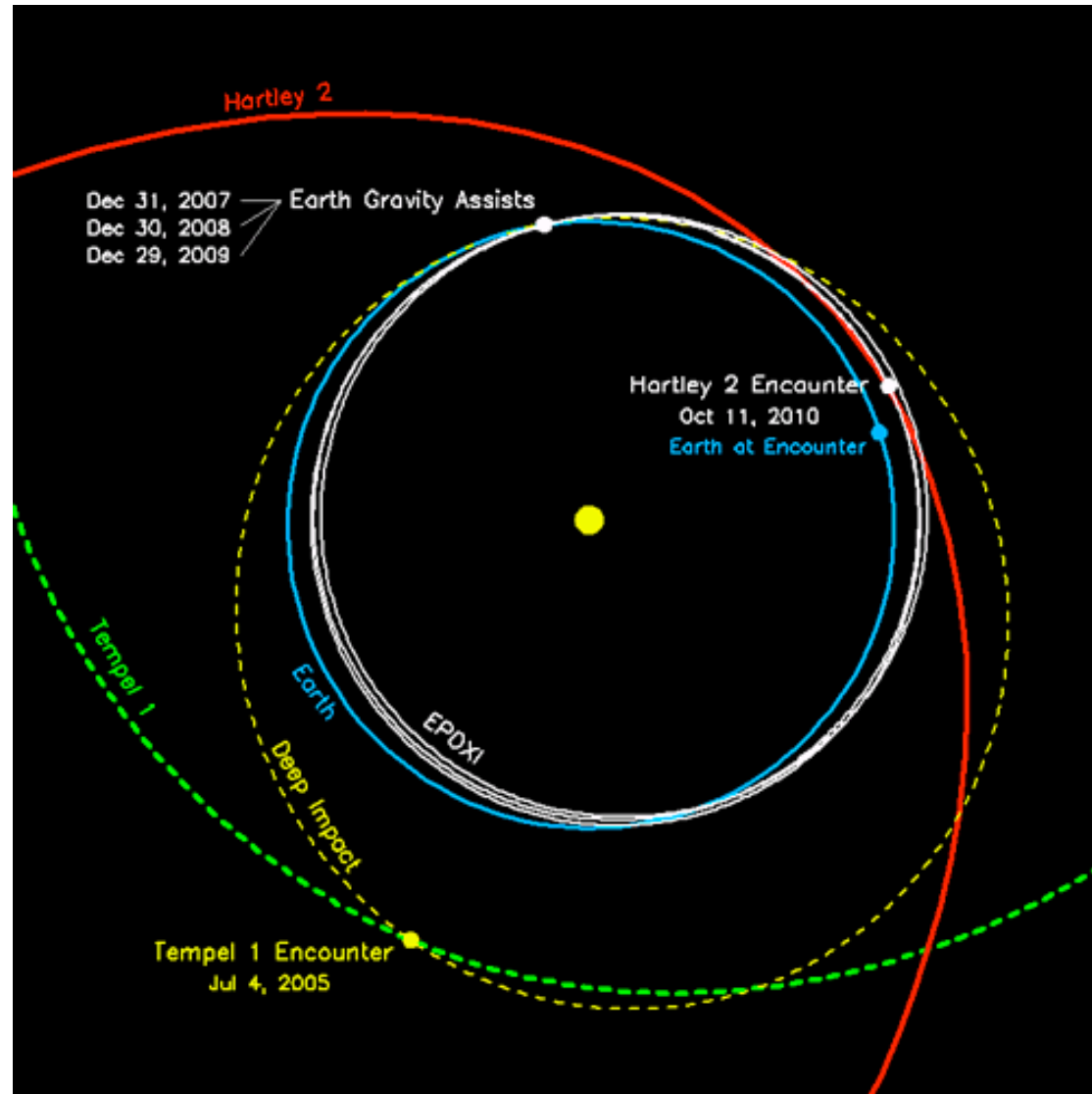
DIXI

(Deep Impact eXtended Investigation)

- PI: M. A'Hearn
- Target: 103P/Hartley 2
- Flyby: Nov 2010
- Instruments: MRI, HRI (focus anomaly)
- What to do until then?



DIXI Orbit



March 26, 2010

Nick Cowan's talk at The View from 5AU

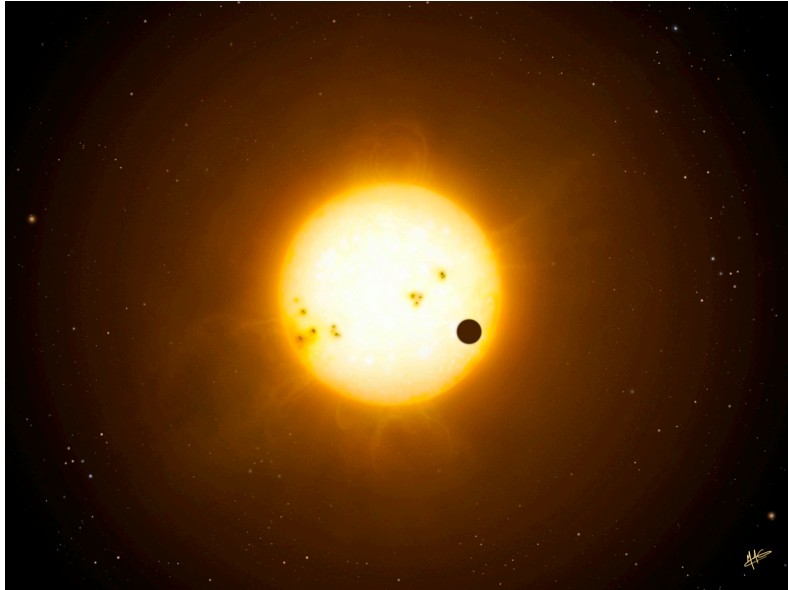
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Cruise Phase Observations

- Capitalize on HRI defocus
 - D. Deming worked closely with D. Wellnitz (in-depth knowledge of Deep Impact Spacecraft, Instruments, Operations)
- Encouraged to Propose
 - M. A'Hearn (DIXI PI) wanted to add high-profile cruise science
 - Still had to apply through official NASA channels

EPOCH

(Extrasolar Planet Observation and Characterization)



- PI: D. Deming
- Targets: transiting planets, Earth
- Turns HRI “focus anomaly” into asset
- Return DI to DIXI team in late 2008 (w/ plenty of fuel)

EPOCH Science Goals

Earth

- Time-Resolved, spatially resolved optical photometry
- Latitudinally resolved IR Spectroscopy
- Verify Earth Models

Exoplanets

- Accurate radii and ephemerides
- Transit Timing Variations
- Thermal/Reflected Secondary Eclipses
- Additional Transiting Planets
- Rings & Moons

EPOCH Instrument Requirements

Earth

- Time Resolution
- Spectral Resolution
- Distant Spacecraft
- IR Spectroscopy
- Multiband Optical Photometry
- Continuous Observing

Exoplanets

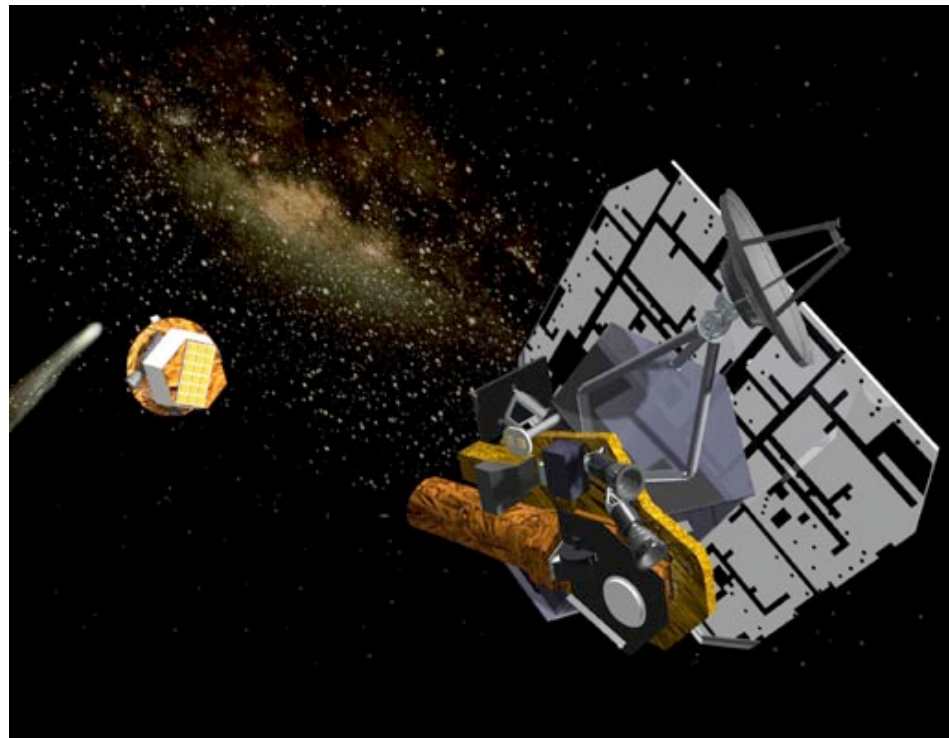
- Time Resolution
- Broad Filter
- Stable Photometry
- Defocused PSF
- Deep CCD well-capacity
- Continuous Observing

EPOXI = EPOCH + DIXI

PI: **M. A'Hearn**

EPOCH Deputy PI: **D. Deming**

DIXI Deputy PI: **J. Sunshine**



Instrument Modifications?

- Deep Impact already in space... no physical modifications possible!
- Modifying flight *software* would have been great:
 - 300 Mb memory \Rightarrow Use subarray mode
 - Bad Pointing \Rightarrow Target drifts off subarray
 - Bright Targets, Blank Background \Rightarrow Lossless Compression
- But would have nixed mission (spacecraft flight software is sacred to engineers)
- Built observing sequences from flight-proven commands (and still tested them on spacecraft simulator at JPL)

Logistics

- Dealing with poor pointing
 - Stars drifting off CCD
 - Sensitivity variations
- Time-Stamp Confusion (matters for TTV)
- Worked closely with original Deep Impact team.
 - Critical to leave plenty of time and consumables for DIXI

EPOCH Science

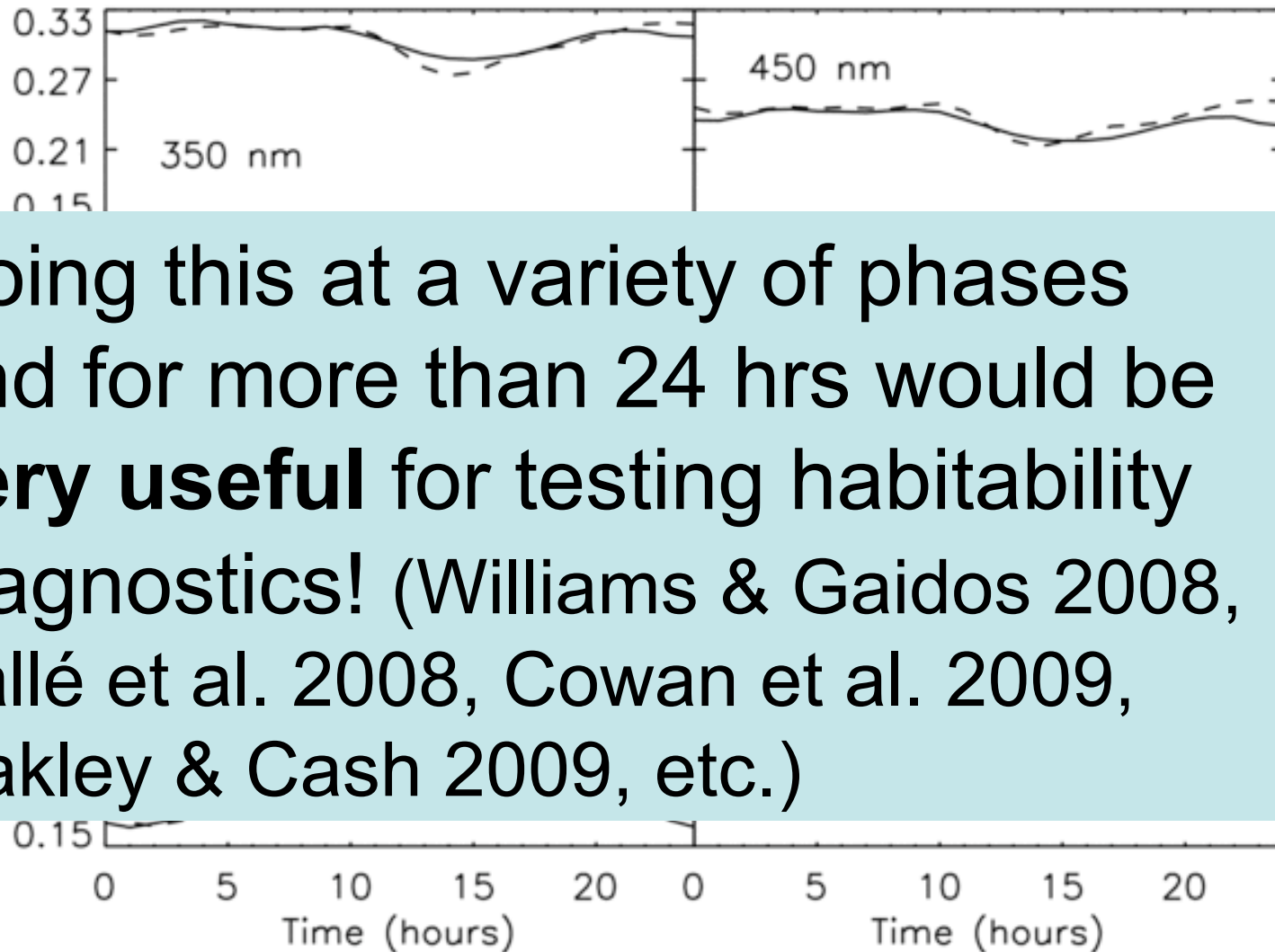
- Earth Observations: Cowan et al. (2009), Robinson et al. (2010), Livengood et al. (2010), etc.
- Exoplanet Observations: Christiansen et al. (2009, 2010), Ballard et al. (2010)

EPOXI Earth Video

Lunar Transit of Earth
NASA's EPOXI Spacecraft

Range to Earth = 31 million miles
Infrared-Green-Blue Color Composite

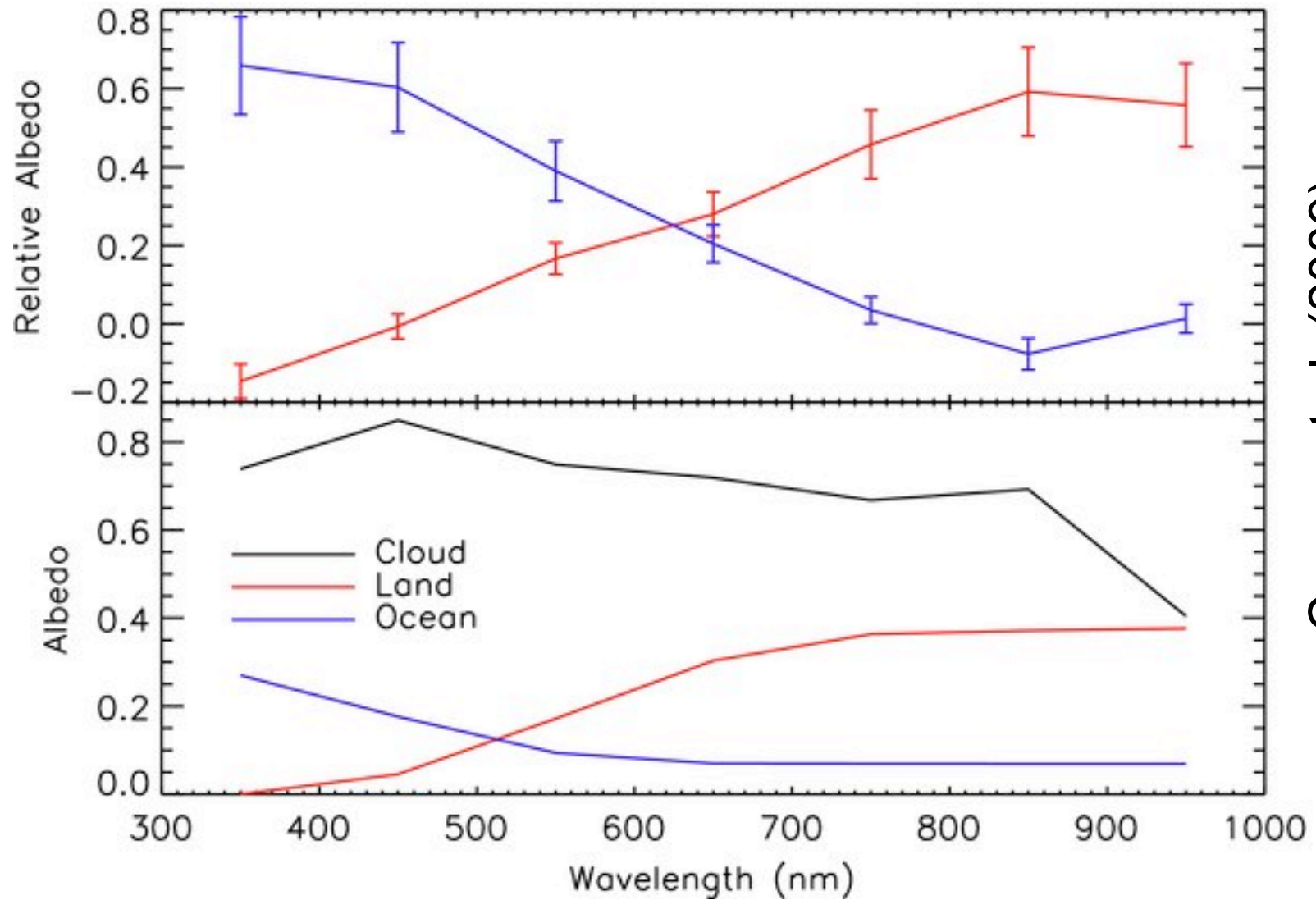
EPOXI Light Curves



Doing this at a variety of phases and for more than 24 hrs would be **very useful** for testing habitability diagnostics! (Williams & Gaidos 2008, Pallé et al. 2008, Cowan et al. 2009, Oakley & Cash 2009, etc.)

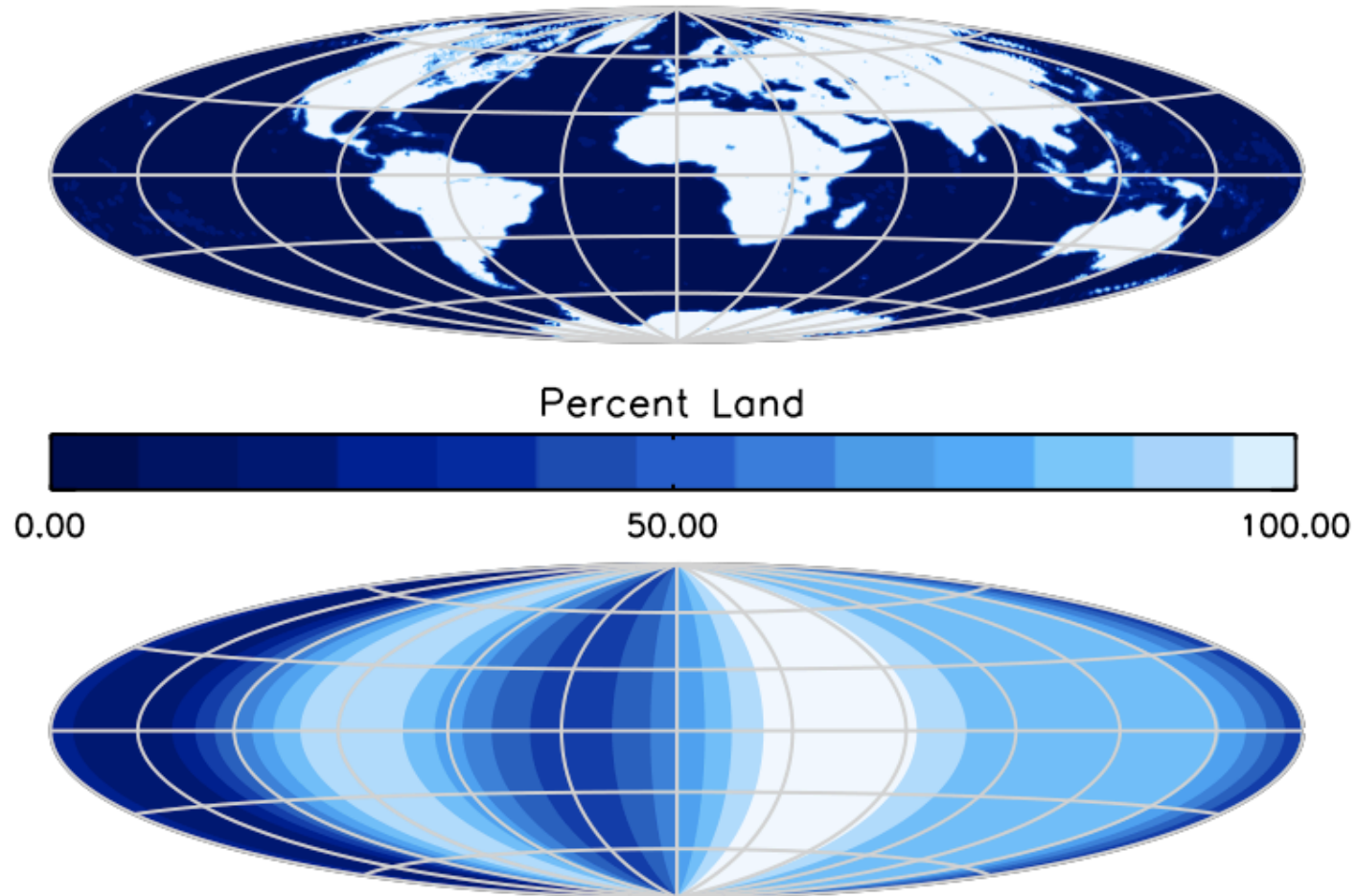
Cowan et al. (2009)

Eigencolors



Cowan et al. (2009)

Longitudinal Map



Cowan et al. (2009)

Summary

- Invited *after* primary mission
- Used existing hardware and software
- Capitalized on existing hardware flaw
- Returned spacecraft in working condition for tertiary mission
- Had cute acronym
- Awarded NASA Group Achievement Award
- OBSERVE EARTH FROM 5AU!