The Final Minute: Results from the LCROSS Solar Viewing NIR Spectrometer

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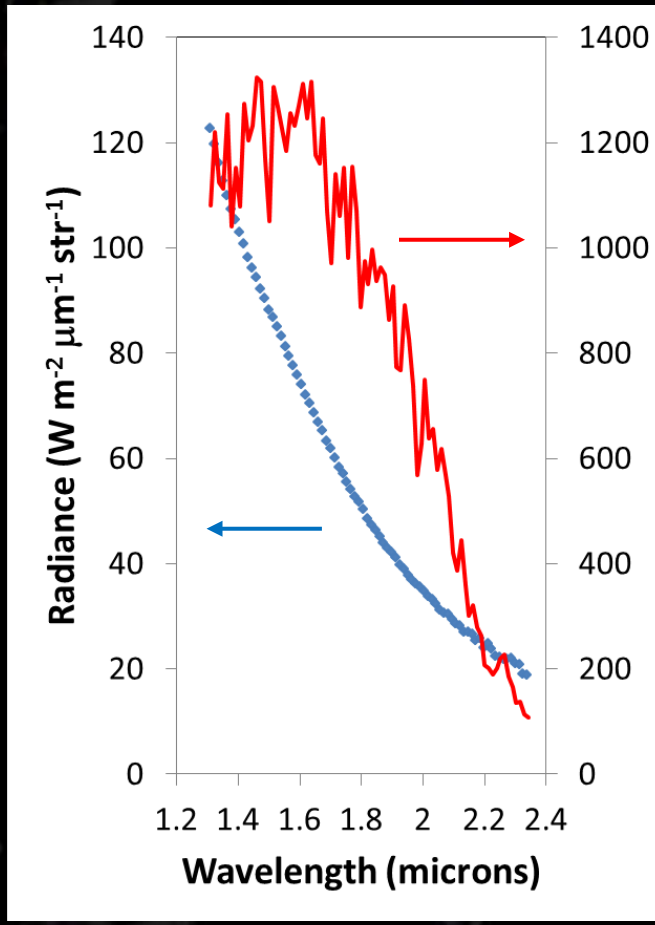
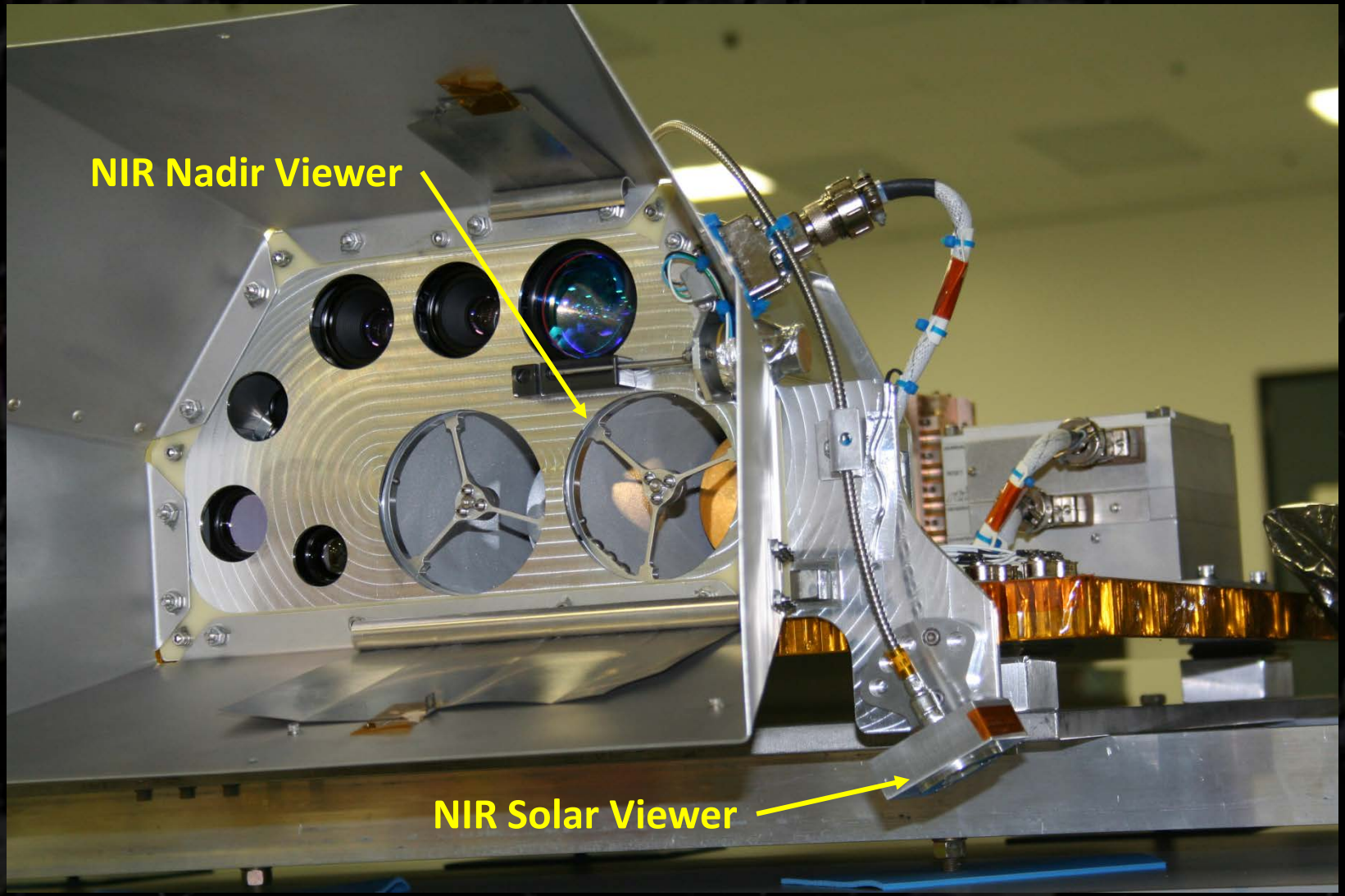
The Solar Viewing NIR Spectrometer

- LCROSS had two NIR spectrometers: a nadir viewing (NSP1) and a solar viewing (NSP2)
  - Had identical wavelength ranges and resolutions
  - Solar viewer used a diffusor to observe sun during the descent to the surface
- Diffusor was very lambertian so could support a range of angles to sun (since exact impact date was not constrained by LCROSS)
  - For the actual impact date the angle between sun and diffusor was relatively small (~ 14 deg) and constant during final moments (changed <3 deg)
- By viewing the sun the spectrometer had very high SNR (>1000)
- Intent was to look for any occultation of sunlight by ejecta cloud

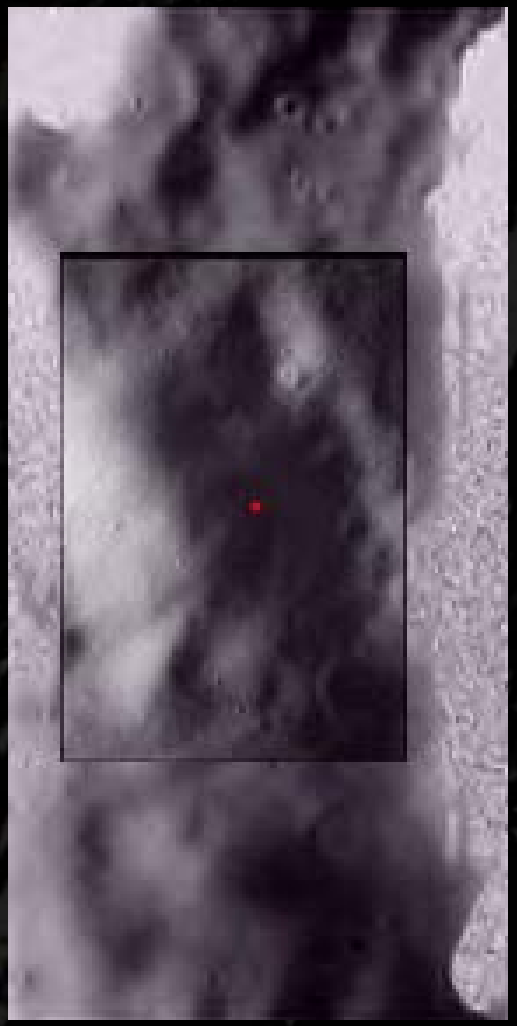


The Solar Viewing NIR Spectrometer

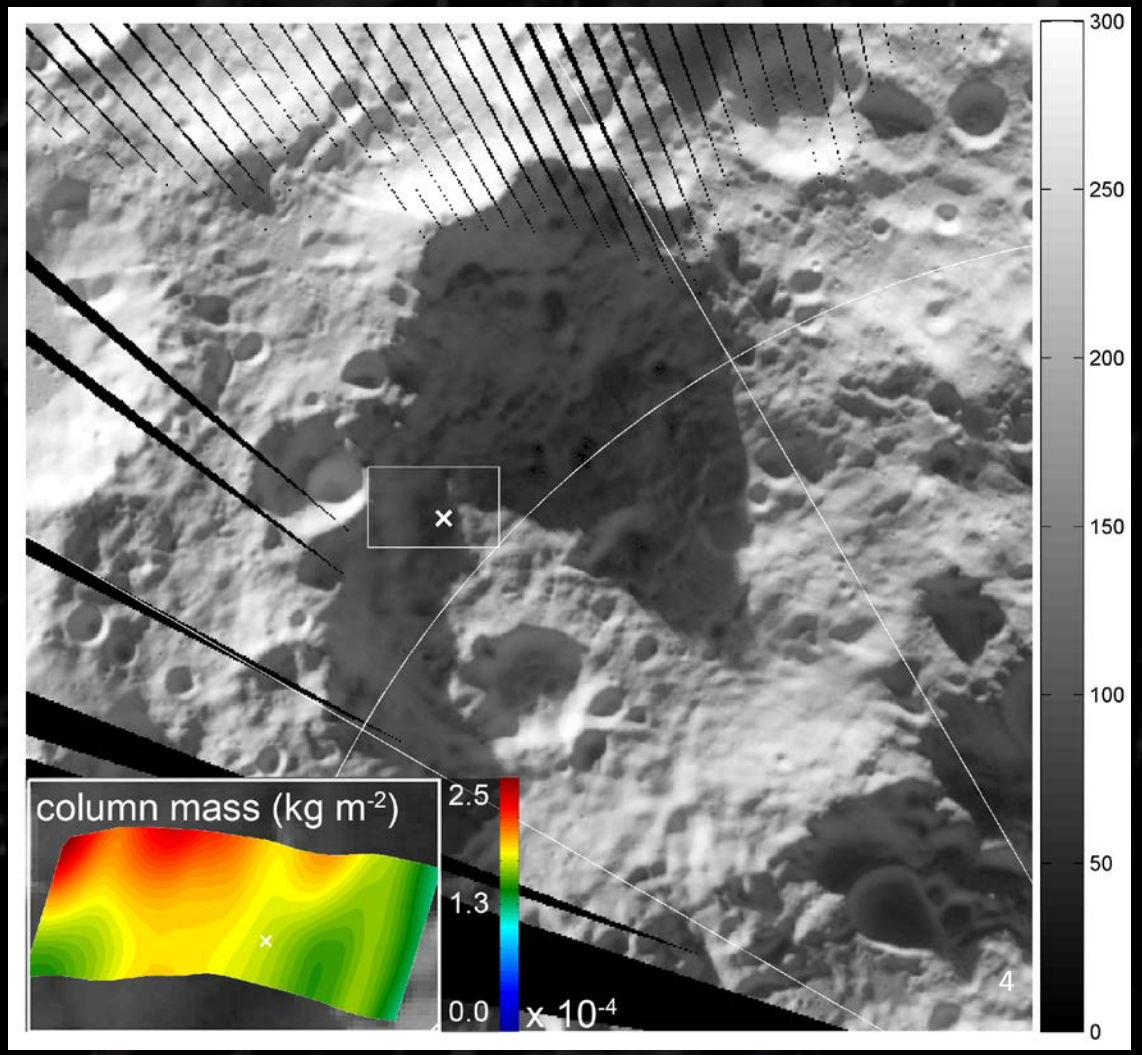


The LCROSS Impact Site

LCROSS NIR



Diviner Observations of Cabeus

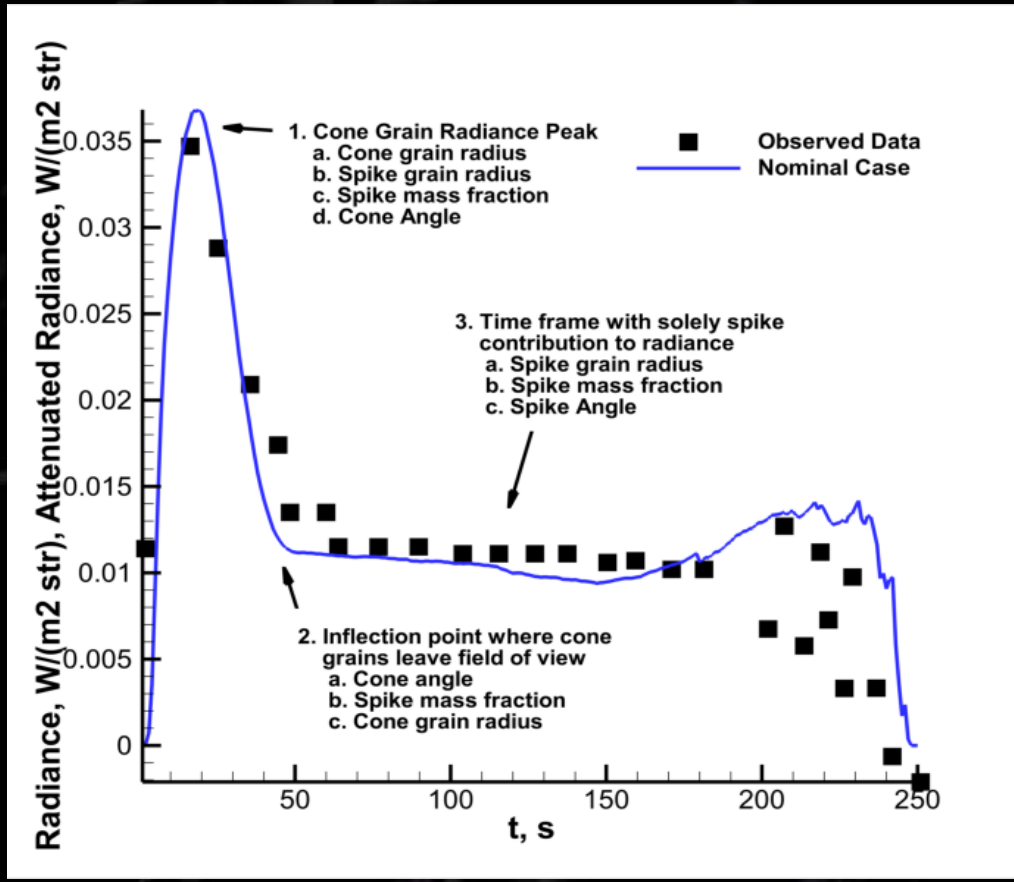


Hayne et al., 2010

The Impact Plume(s)

The High Angle Impact Plume

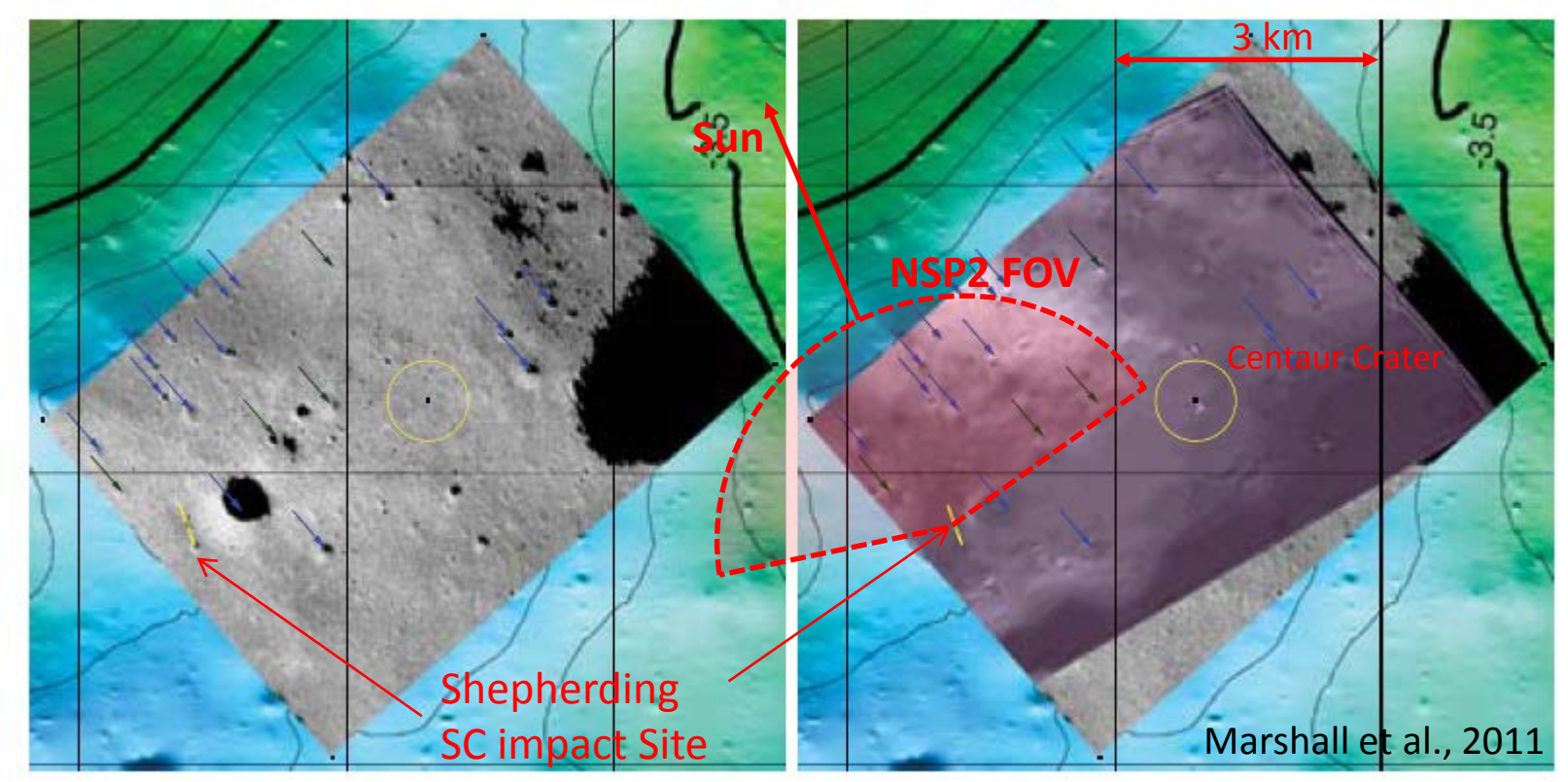
- Two curtains seen in UV/vis spectrometer (VSP)
- Dust seen at altitudes >4 km by observed by Apache Point Observatory (Strycker et al., 2012)
- Would have to have reach ~12 km to still be falling at Impact+4 min
- Possible dust clouds seen NIR camera images (Schultz et al., 2010)



Heldmann et al. 2015

NSP2 Observation Geometry

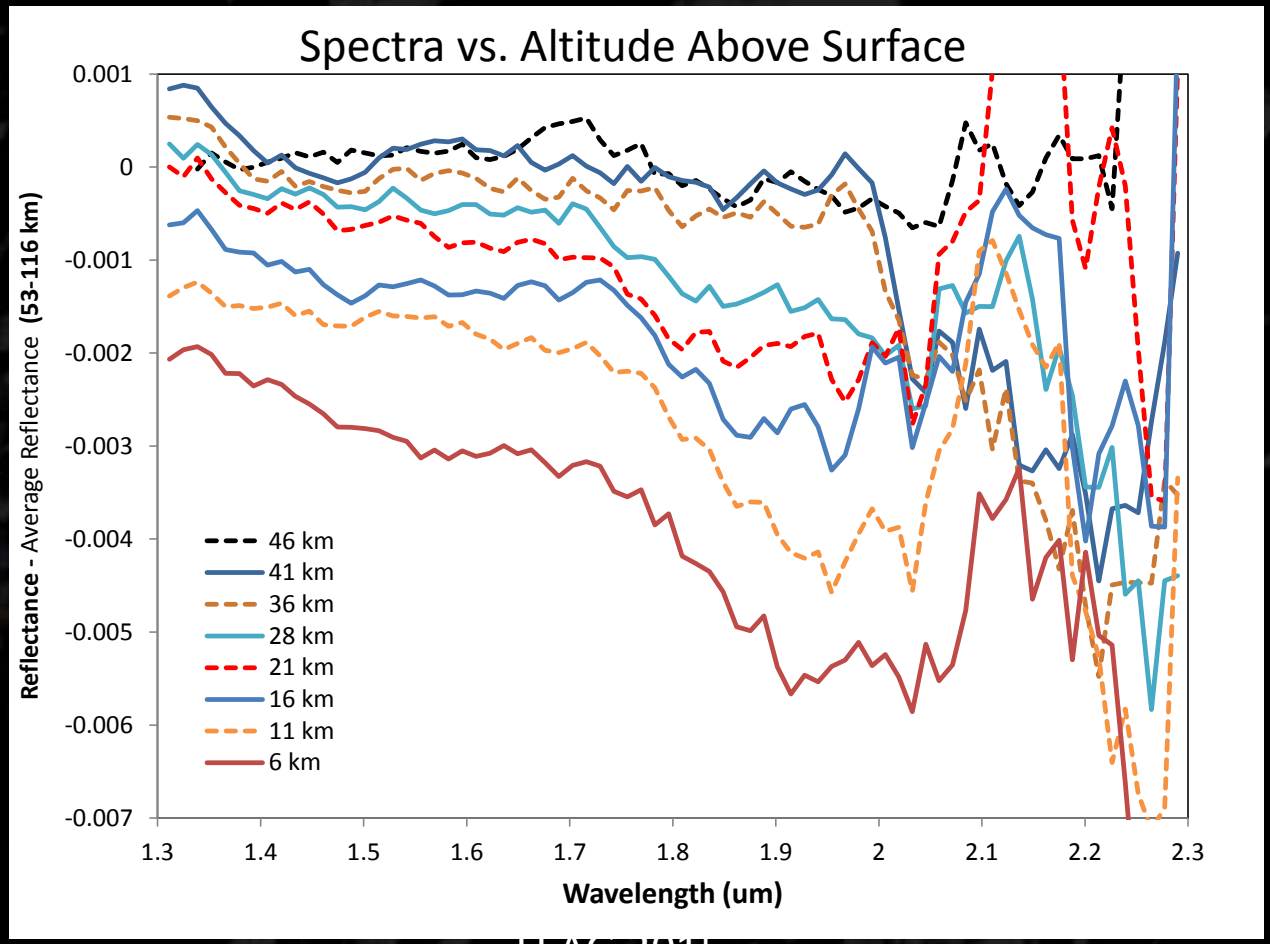
- Shepherding SC came down ~3km from Centaur impact site
- Sampled spectra once every 0.6 seconds



NSP2 Observations

The final moments

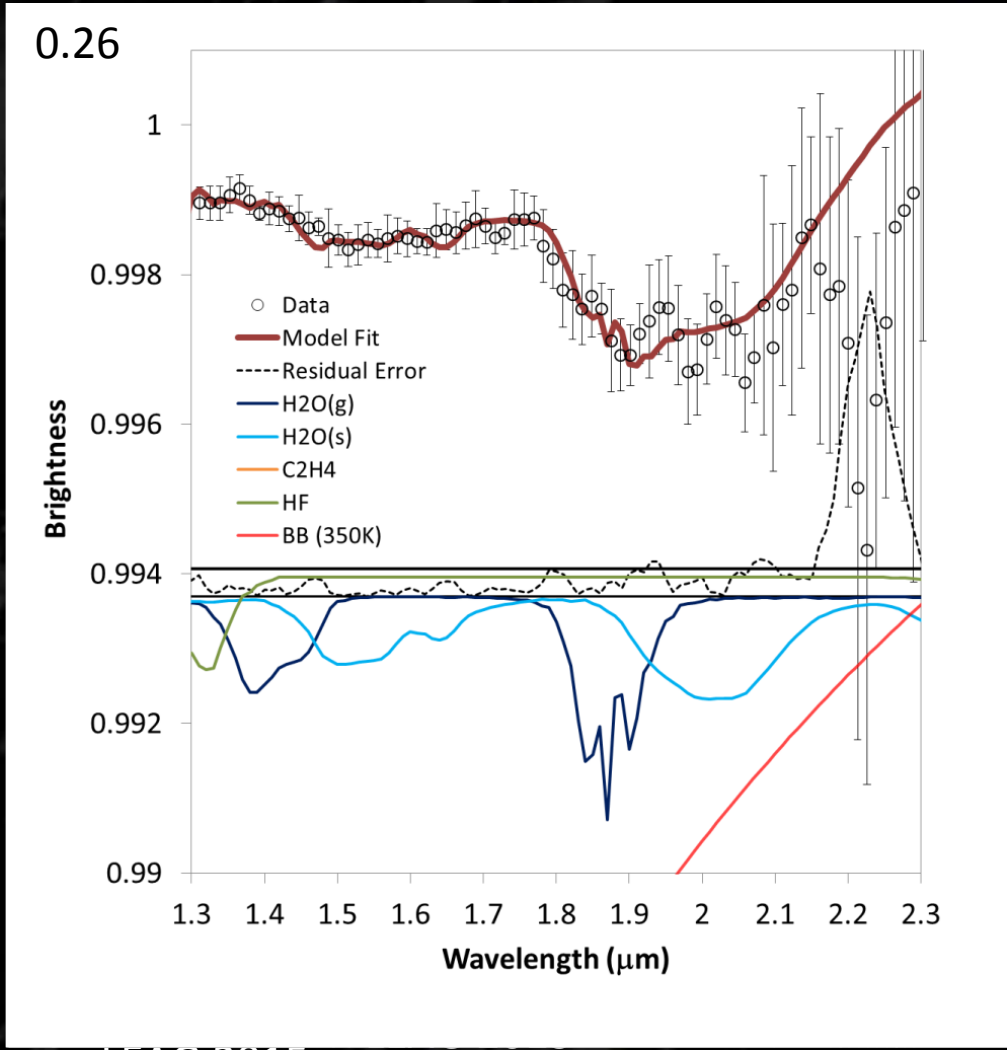
- Averaged 5 scans tin time and across 11 pixels (moving average) to build SNR
- Ratioed averaged scans to “reference” scan made from spectra taken about 30-40 sec prior to impact



Liner Fitting of Spectra

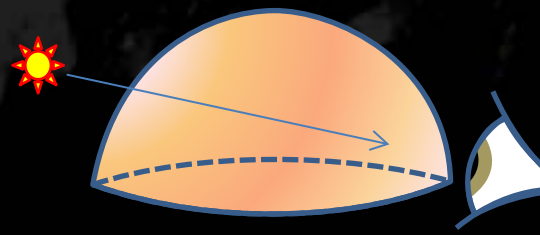
First cut at identifying composition of plume

- Linear fit (optically thin cloud) of last 10 spectra
- Used Chi-Square analysis to assess goodness of fit
- Water ice and vapor are principle components of spectrum

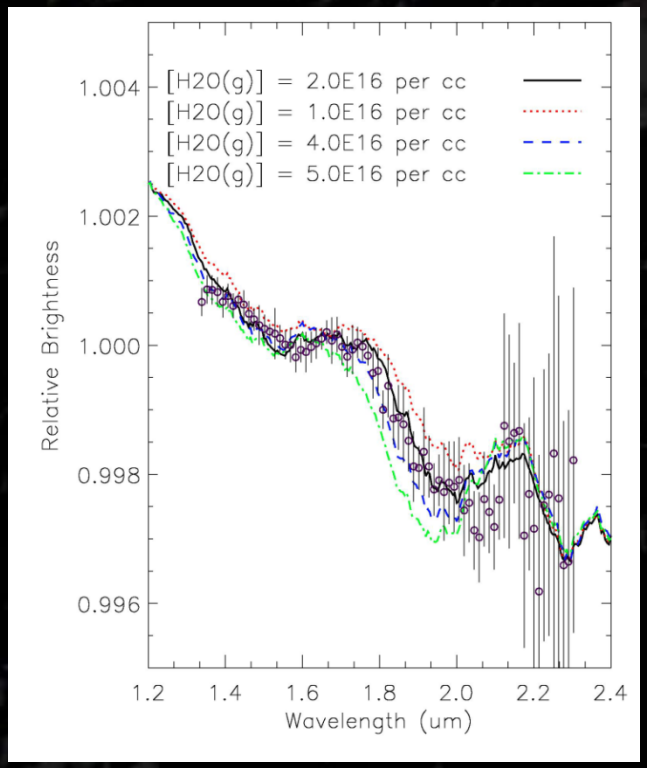


NSP2 Modeling

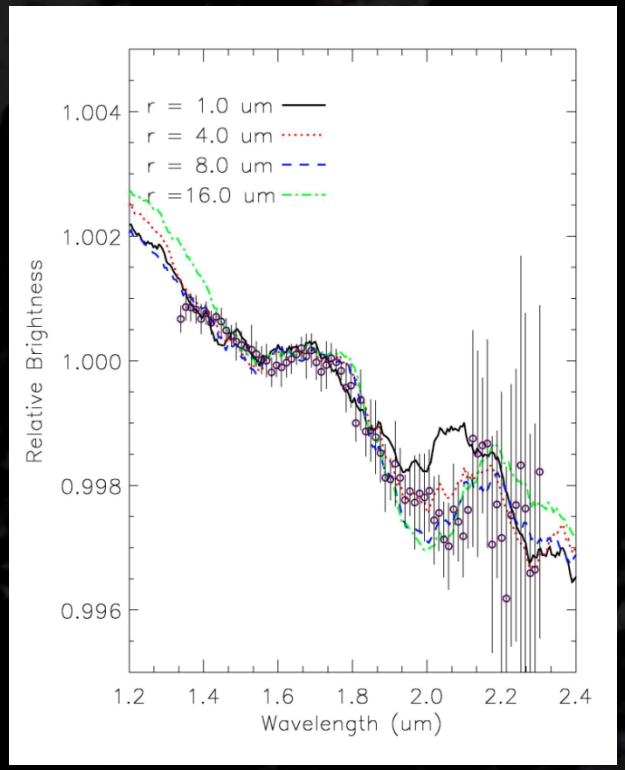
- Monte Carlo Simulations of Solar Viewing NIR Observations
- Modeled hemispherical cloud of dust, water ice and water vapor



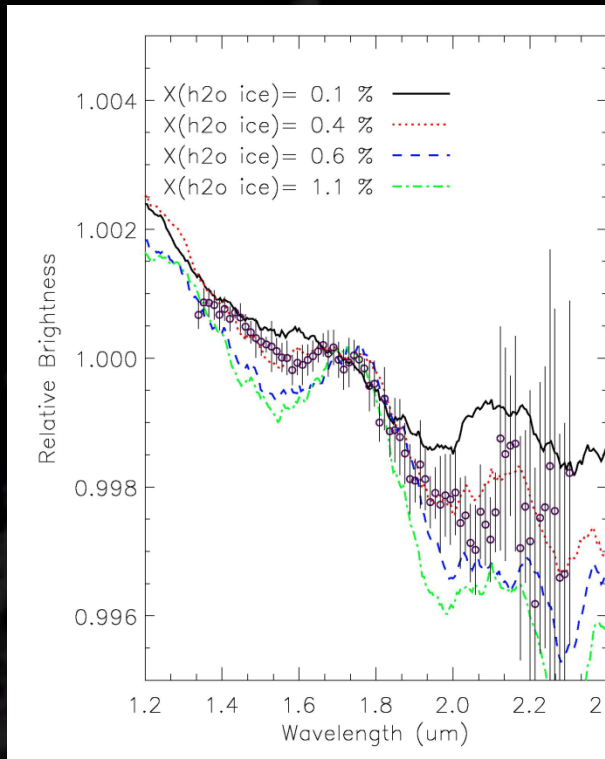
Fit against water gas column



Fit against ice grain radius



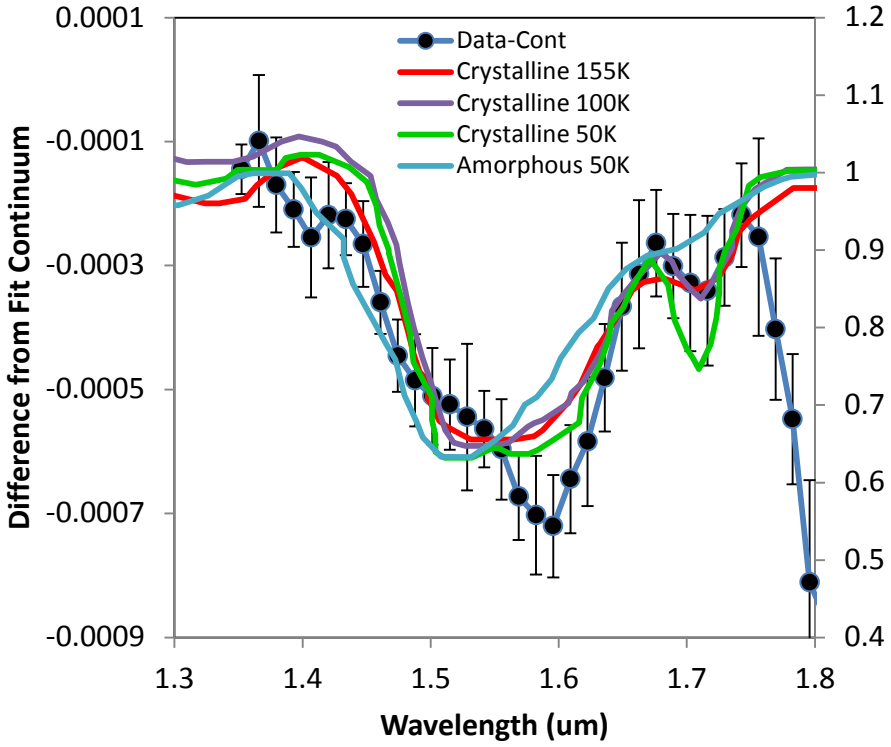
Fit against water ice OD

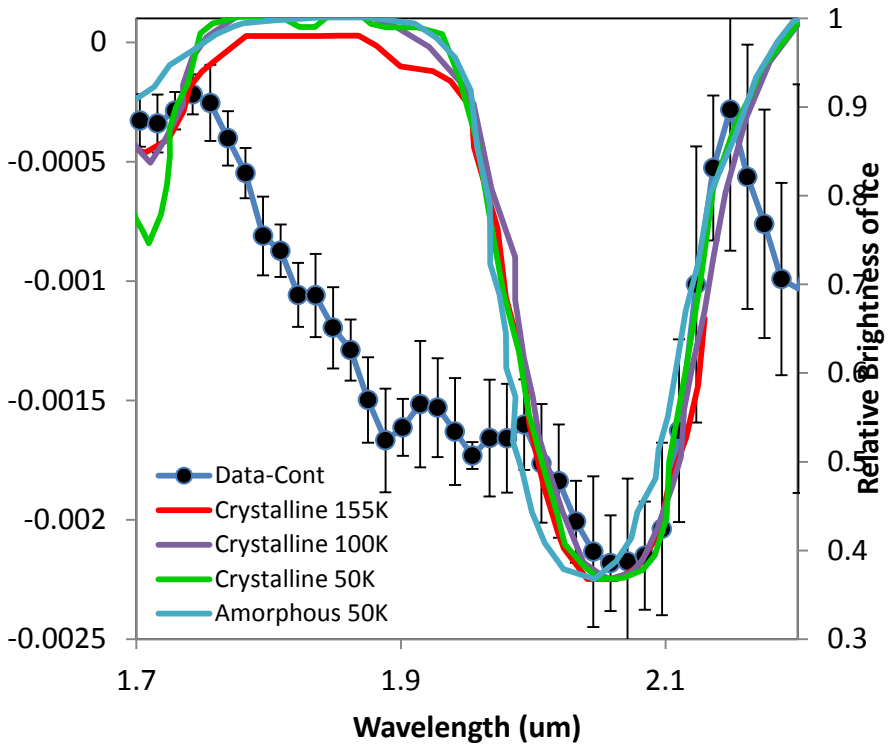


A look at the 1.5 μm Ice Band

Comparing the last 5 seconds of data to low temperature crystalline and amorphous ice

- Suggests cold, crystalline ice





Summary of Observations and Modeling

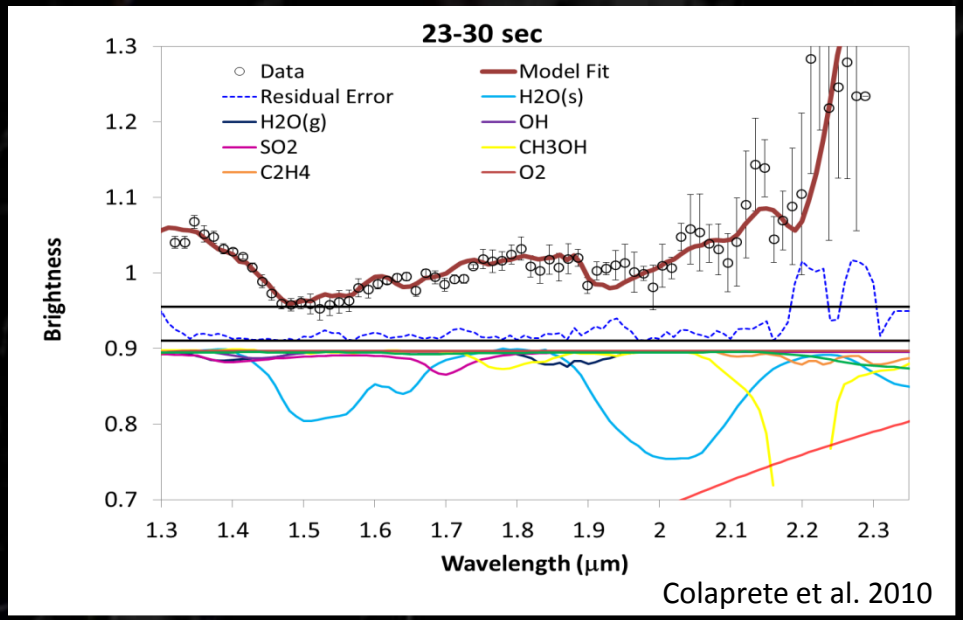
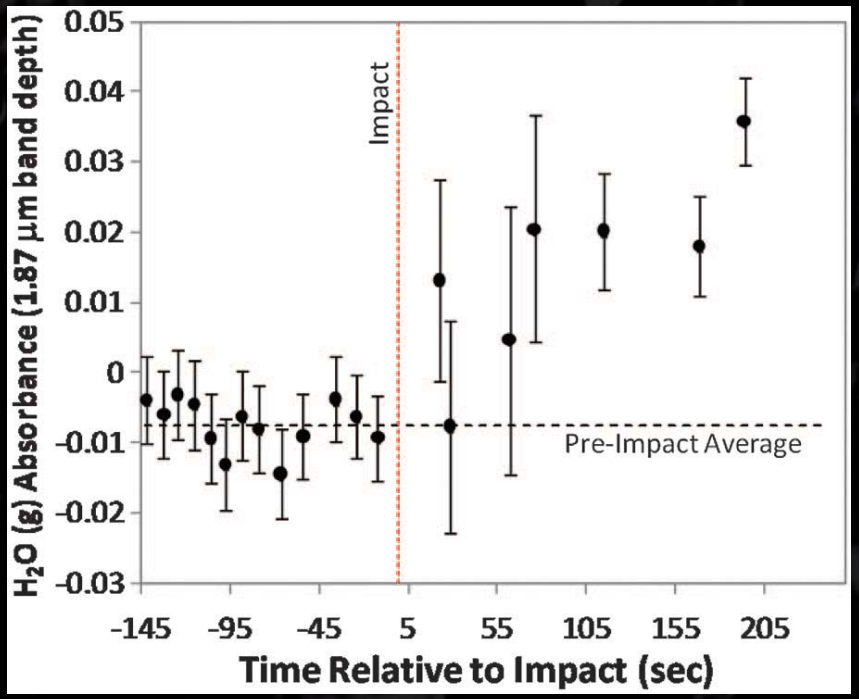
- NSP2 Observed dust + water (ice and gas) cloud in final ~20 seconds of its descent
- Linear and Monte Carlo fits identify water ice and vapor and constrain grain size to > 1 μm
- Water ice grains are relatively pure (ice-to-dust ratio) to persist ~4 min in sunlight
- Total water gas measurements consistent with nadir measurements: A persistent surface source, maybe sublimation from exposed ice?
- The high angle plume likely consisted of material closer to the surface (top 1-2 meters?) compared to low angle plume

Thank You!

LCROSS Observations

3 sec ≤ Impact ≤ 180 sec

- Curtain expansion and peak of visible radiance: A tale of two plumes
- Peaking brightness marked by bluing of spectra
- Early water ice detection
- Continued evolution of volatiles, water vapor band begins to strengthen



Colaprete et al. 2010