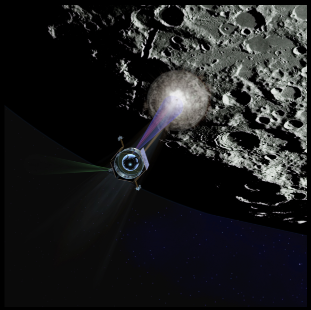

LCROSS Impact Update

K. Fisher canopus56@yahoo.com

Revised: 9-29-2009. This presentation is based on information available as of last revision date. Information or conclusions may deprecate based on other newly released information by LCROSS Team after 9-29.

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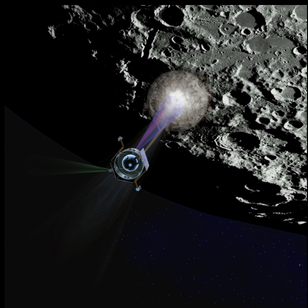
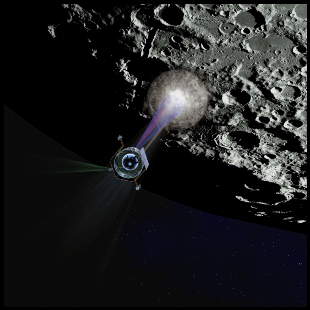
"From principles is derived probability, but truth or certainty is obtained only from facts." Tom Stoppard

"For my part I know nothing with any certainty, but the sight of the stars makes me dream." Vincent Van Gogh



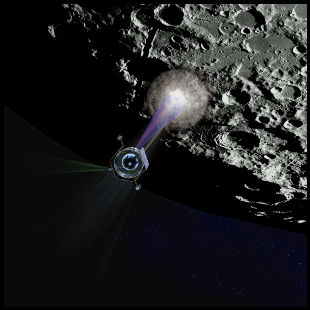
What

- 2200 kg spent Centaur Atlas booster impacts into the Moon at 2 kms.
- Makes a hole 20 meters in diameter and 3 meters deep.
- Throws several metric tons of dust into the air.
- Dust rises to 30km high in an ejecta plume and reflects sunlight. Heats up from -90 C to plus 200C.
- Light signal contains a spectra that may evidence water ice.



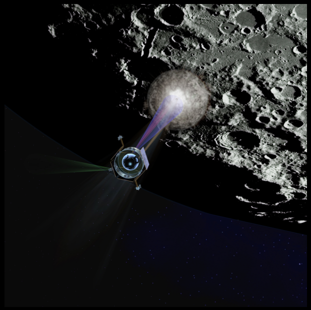
What

- Animations: Index list - see url - http://groups.google.com/group/lcross_observation/web/animations
  - KQUED broadcast url - http://www.kqed.org/quest/television/nasa-ames-rocket-to-the-moon
  - Pumice Test for Deep Impact – url: http://deepimpact.umd.edu/gallery/vid4.html
  - NASA LCROSS First-Steps Video – url: http://www.nasa.gov/mission_pages/LCROSS/multimedia/arc-LCROSS_First_Step.html



Why

- There is ice at the poles of Mercury, Earth and Mars. Then why not the Moon?
- It costs $15,000 to lift from the Earth and land on the Moon one ½ bottle liter of water.
- To see if there are any water ice layers trapped within the top 1 meter of the lunar regolith.
- The LCROSS experiment and current theories say nothing about water ice layers that may be trapped below a depth of 1 meter.



Why

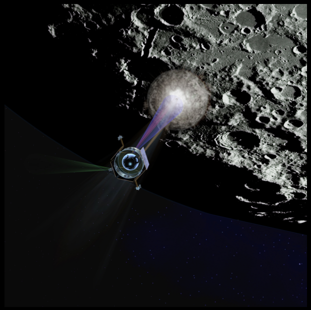
Image: NASA Earth Observatory

- Maximum estimated potential volume of water ice in the top 10 degrees from both poles and top 1 meter regolith layer in permanently shadowed regions (PSRs) may be equal to the volume of water in the Great Salt Lake – in theory.
- NASA LRO press conference of 9-15-2009 on early data release calls this estimate into question. More detailed LRO neutron mapping shows much of polar elemental hydrogen is not associated with cold PSR traps. Much hydrogen is beneath the "hot" surface of sunlit regolith; much is associated with PSR cold traps.
- But early LRO data release shows south polar PSR cold traps are the "coldest places in the solar system" and are good places to trap hydrogen-containing water ice. Impact crater shows 2% hydrogen content.
- An archived video of the 9-15-2009 LRO early results press conference can be viewed on YouTube.

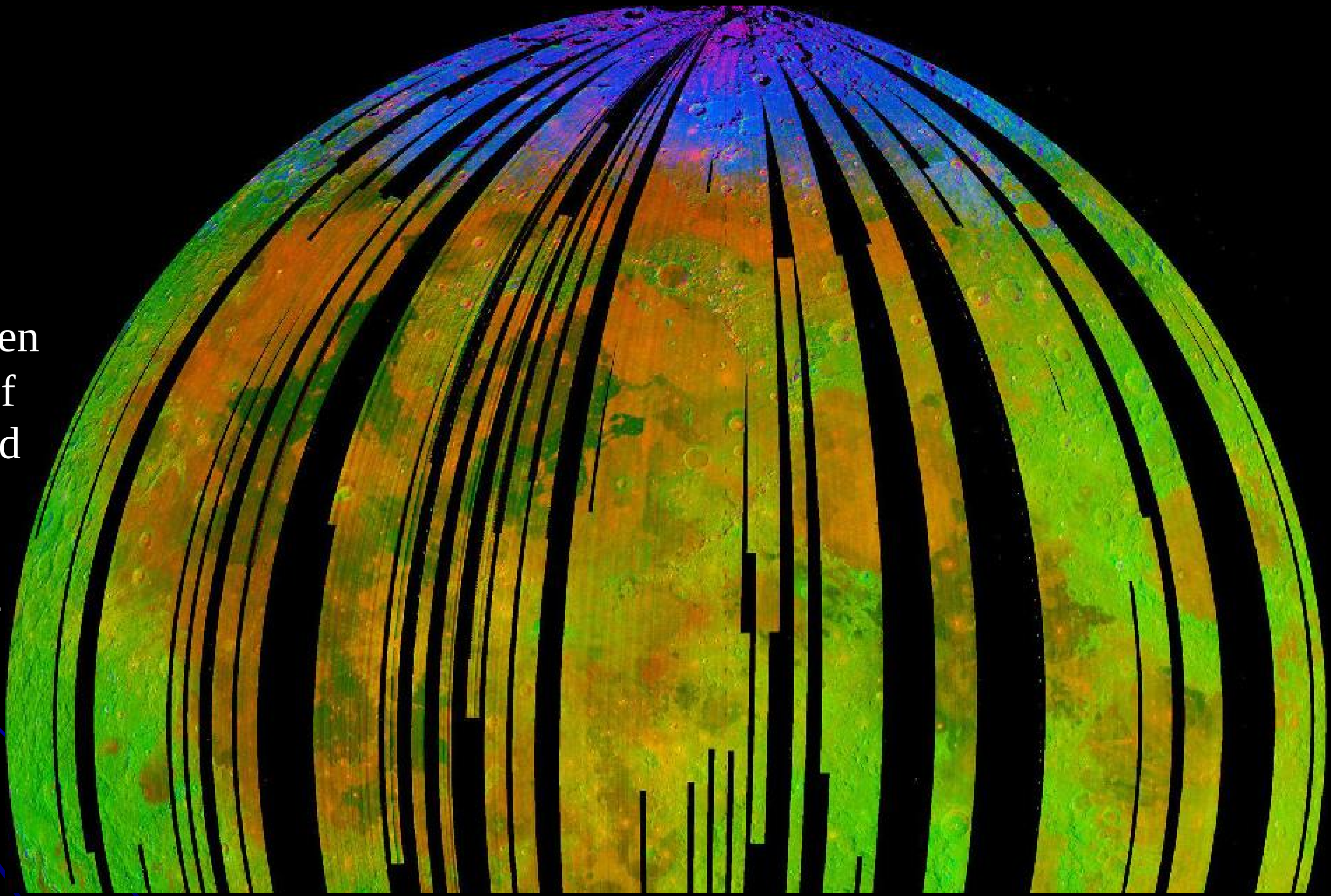
http://www.youtube.com/profile?v=59aaOW33aqs&user=NASAtelevision

Why

- Major new science results (9-24-2009) based on Chandrayaan-1, Cassini and Deep impact spectral imaging indicates widespread OH water ice signals at the poles. Hydroxyls (minerals bound to OH) are found extending to low lunar latitudes.
- These 9-24-2009 reports fundamentally change our understanding of water and the Moon.
- But these new remote sensing results need to be “ground truthed.”
- The LCROSS Team hopes to ground-truth this remote sensing by physically sampling the subsurface soil layer at the point of impact.
- Breaking science news links:
  - MM3 Press Conference 9-24-2009 on NASA YouTube **http://www.youtube.com/profile?v=je0FviGlBz8&user=NASAtelevision**
  - Science Express magazine articles. **http://www.sciencemag.org/sciencexpress/**

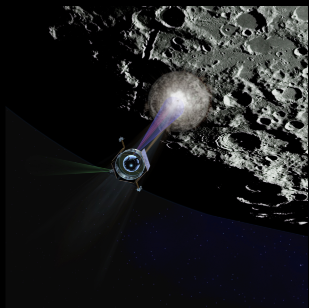


Why



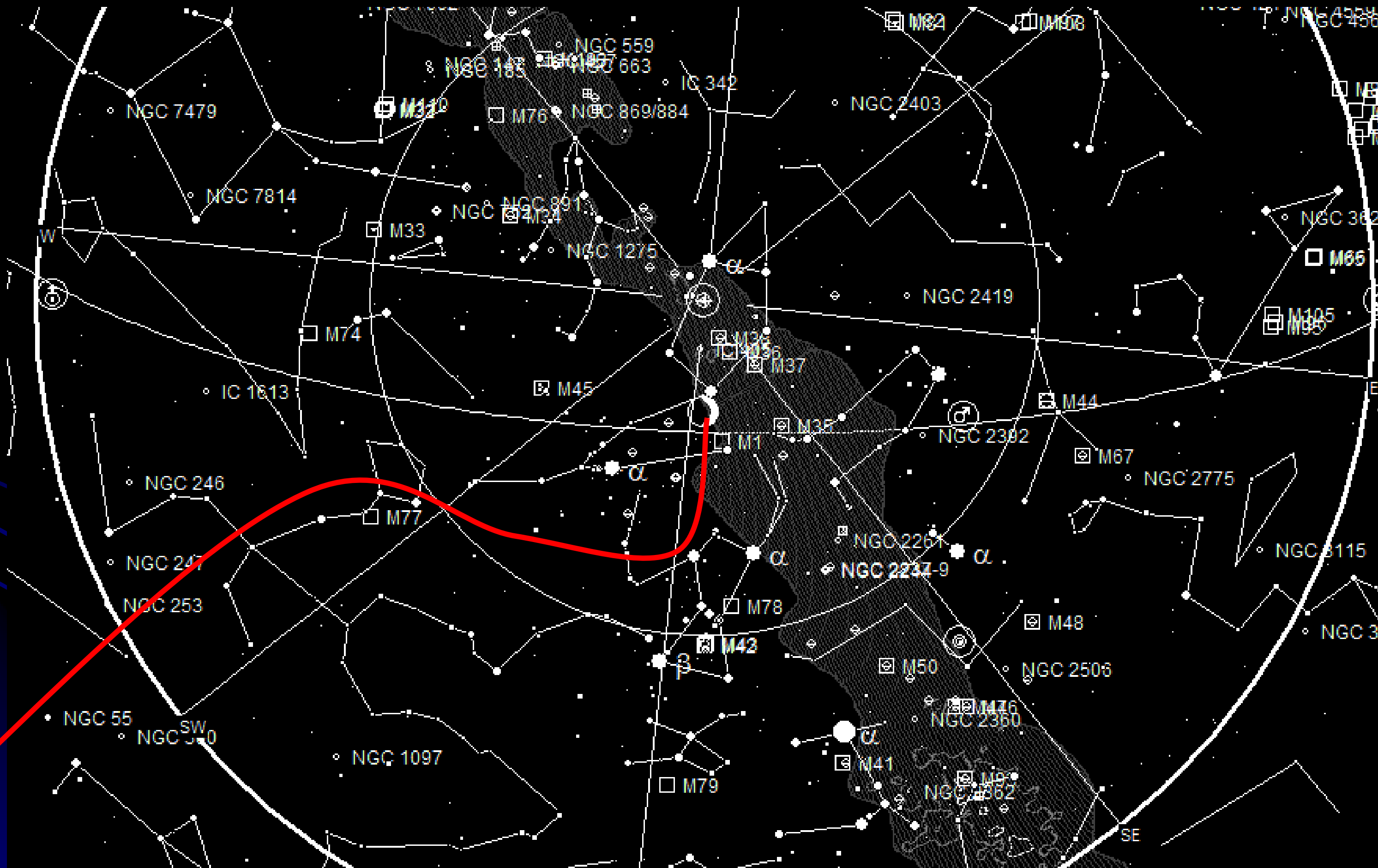
"Blue shows the signature of water, green shows the brightness of the surface as measured by reflected infrared radiation from the sun and red shows an iron-bearing mineral called pyroxene." 9-24-2009 NASA Press Conf.

Image Credit: ISRO/NASA/JPL-Caltech/Brown Univ./USGS
http://www.nasa.gov/multimedia/imagegallery/image_feature_1478.html

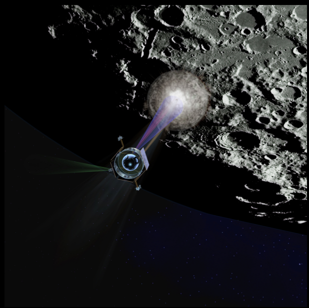


When

- October 9, 2009 11:30UT

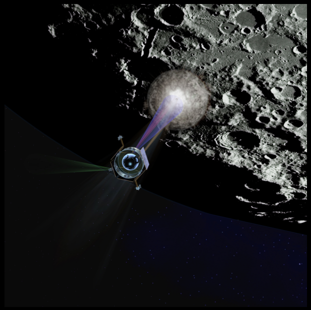


Alt-Az Horizon View – Salt Lake City 10-9-2009 5:30 MDT – South at bottom



Where

- The Moon will be about 1 degree from 1.7 mag bet Taurus (Alnath). between the Horn stars of Taurus at about 70 degrees altitude and at 71% illuminated fraction with lunar west illumination a few days after the full Moon.



Where

Lunar west of the southern lunar pole is a large crater – 100km diameter Cabeus. A small shadowed valley behind lunar mountain M1 is the target.

Coordinates for GOTO handboxes that offer automatic lunar crater targeting.

Cabeus 100km dia.
84.9°S 35.5° W

Image: Slooh widefield 9-10-2009

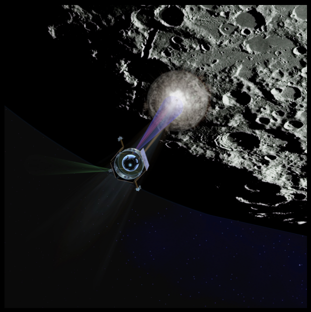
Estimated target coordinates.

West shadow hole of Cabeus at
84.4°S 45.0° W

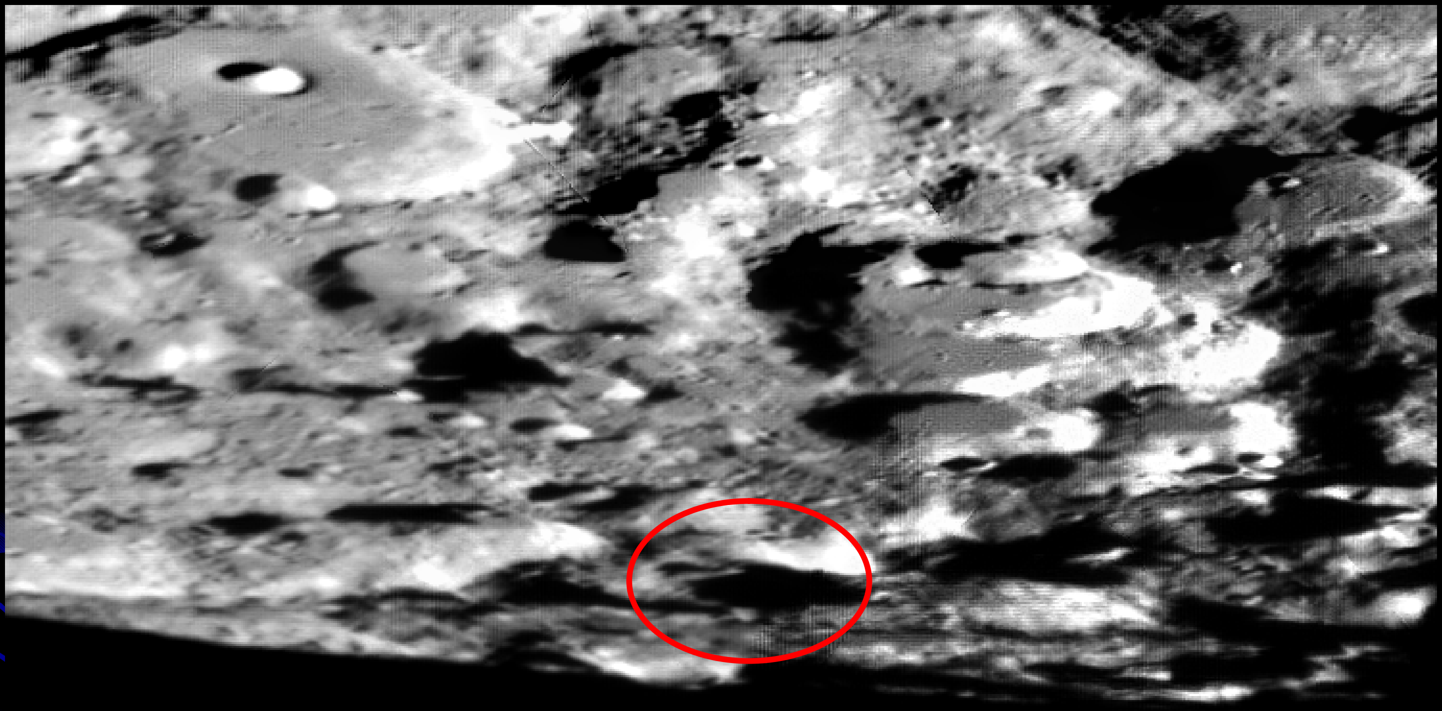
No official target coordinates have been released as of 9-29-2009.

Where

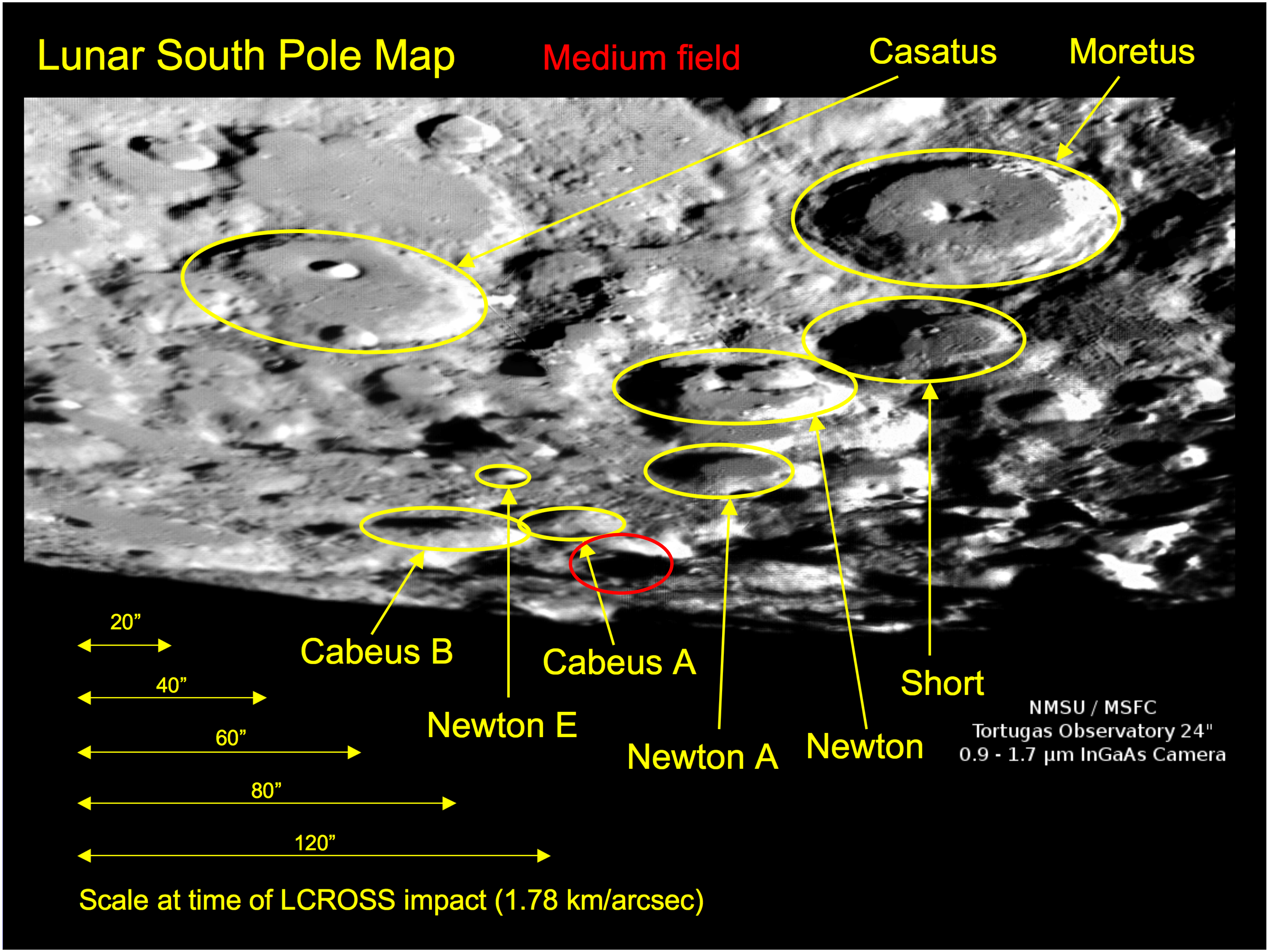
Image credit: Stefan Lammel 9-9-2009 Used with permission.



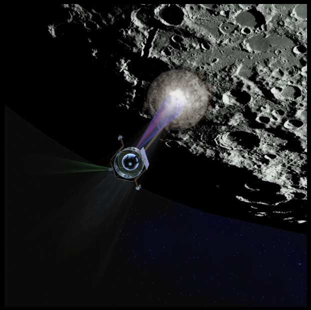
Where



NMSU / MSFC
Tortugas Observatory 24"
0.9 - 1.7 µm InGaAs Camera



Lunar South Pole Map
Medium field
Casatus
Moretus
Cabeus B
Newton E
Cabeus A
Newton A
Newton
Short
20”
40”
60”
80”
120”
NMSU / MSFC
Tortugas Observatory 24"
0.9 - 1.7 μm InGaAs Camera
Scale at time of LCROSS impact (1.78 km/arcsec)



Where

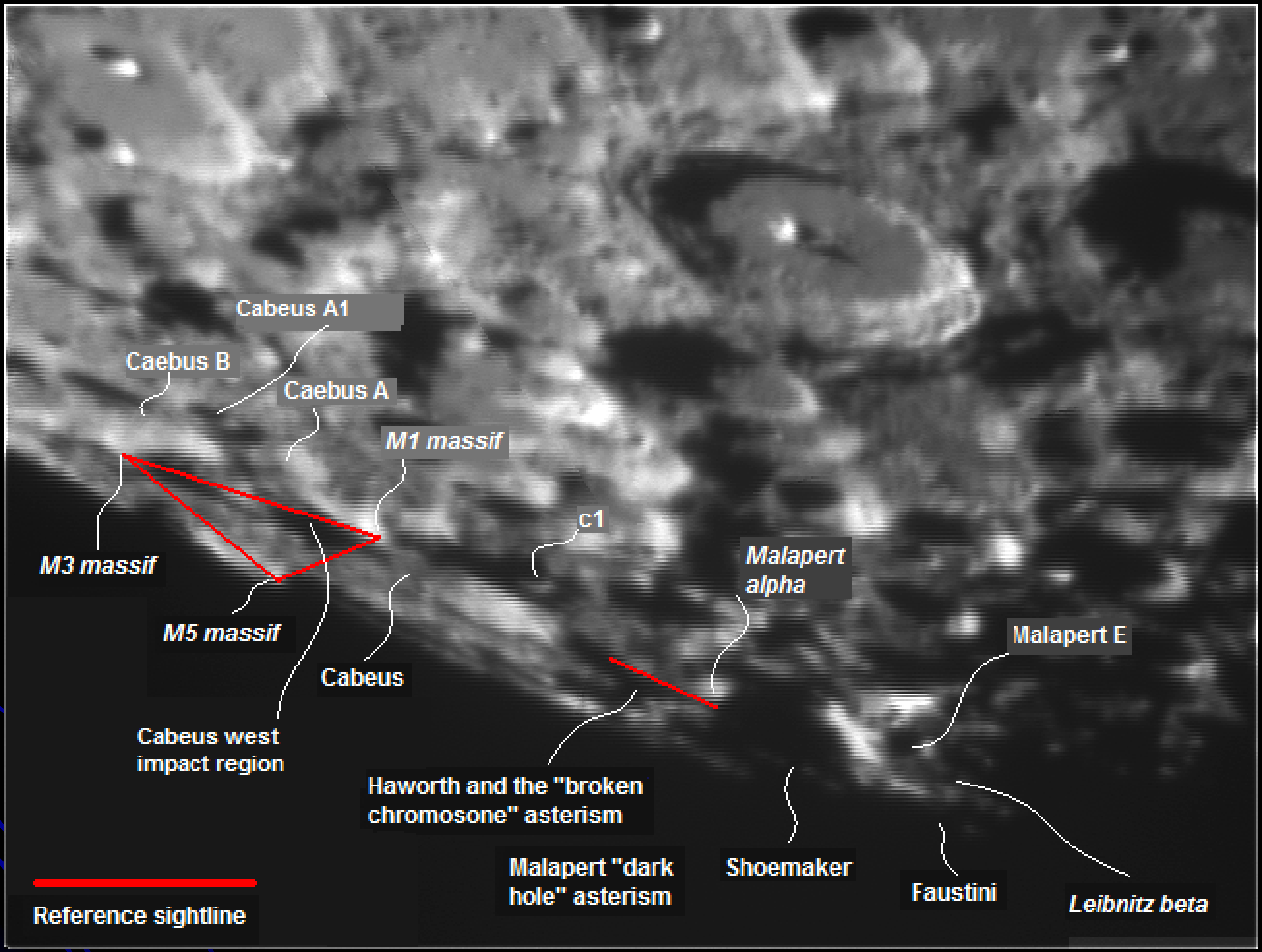
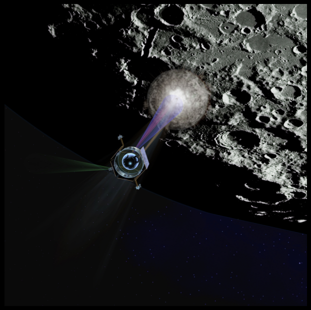


Image: K. Fisher 9-10-2009



Where

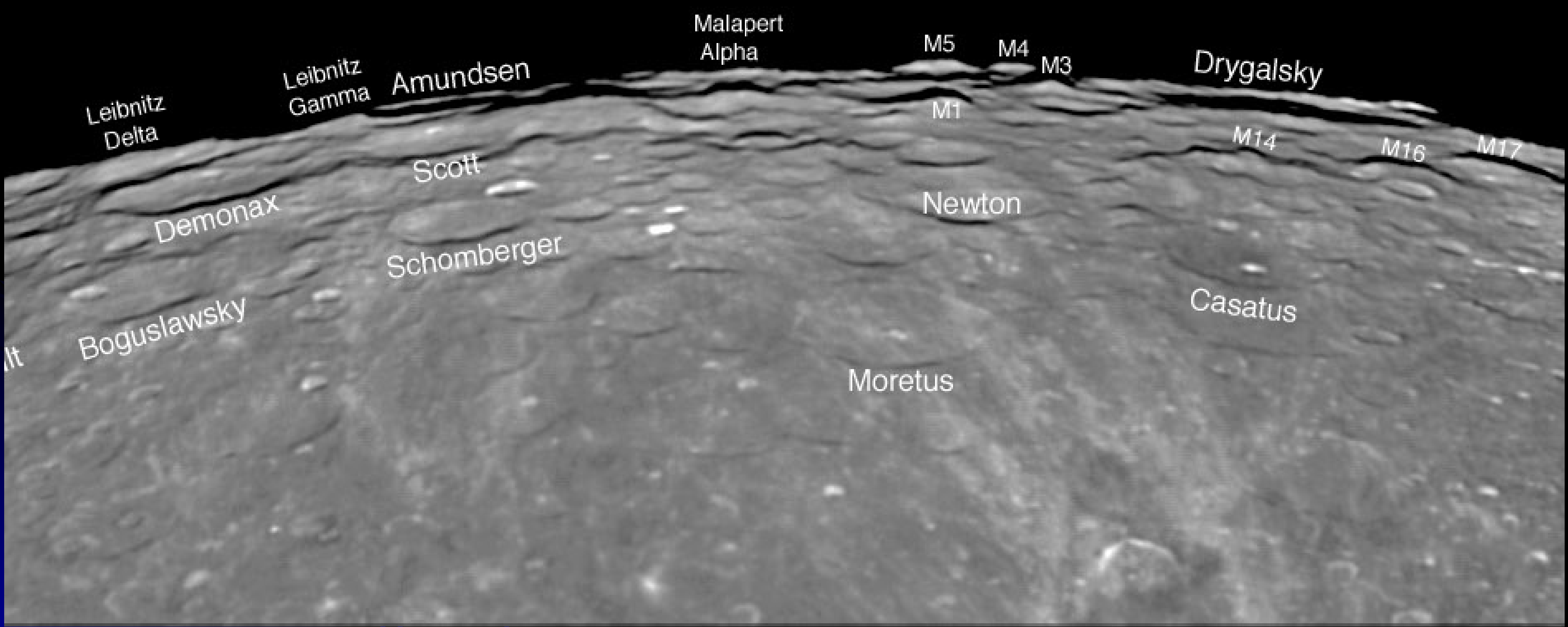


Image: Tom Bash. Used with permission.

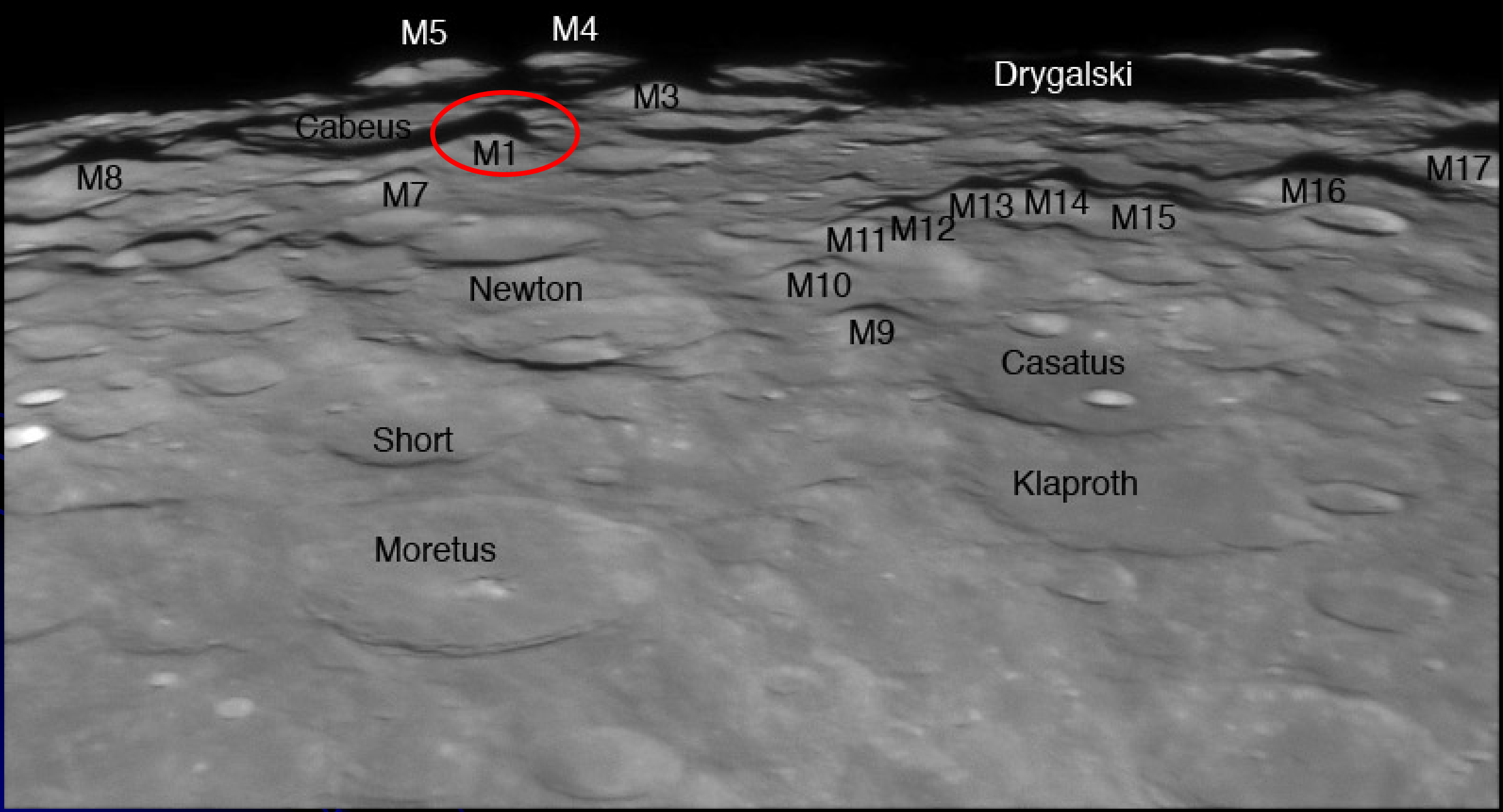
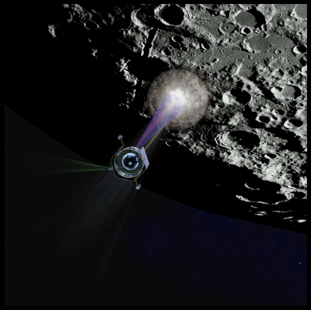


Image: Tom Bash. Used with permission.



Where

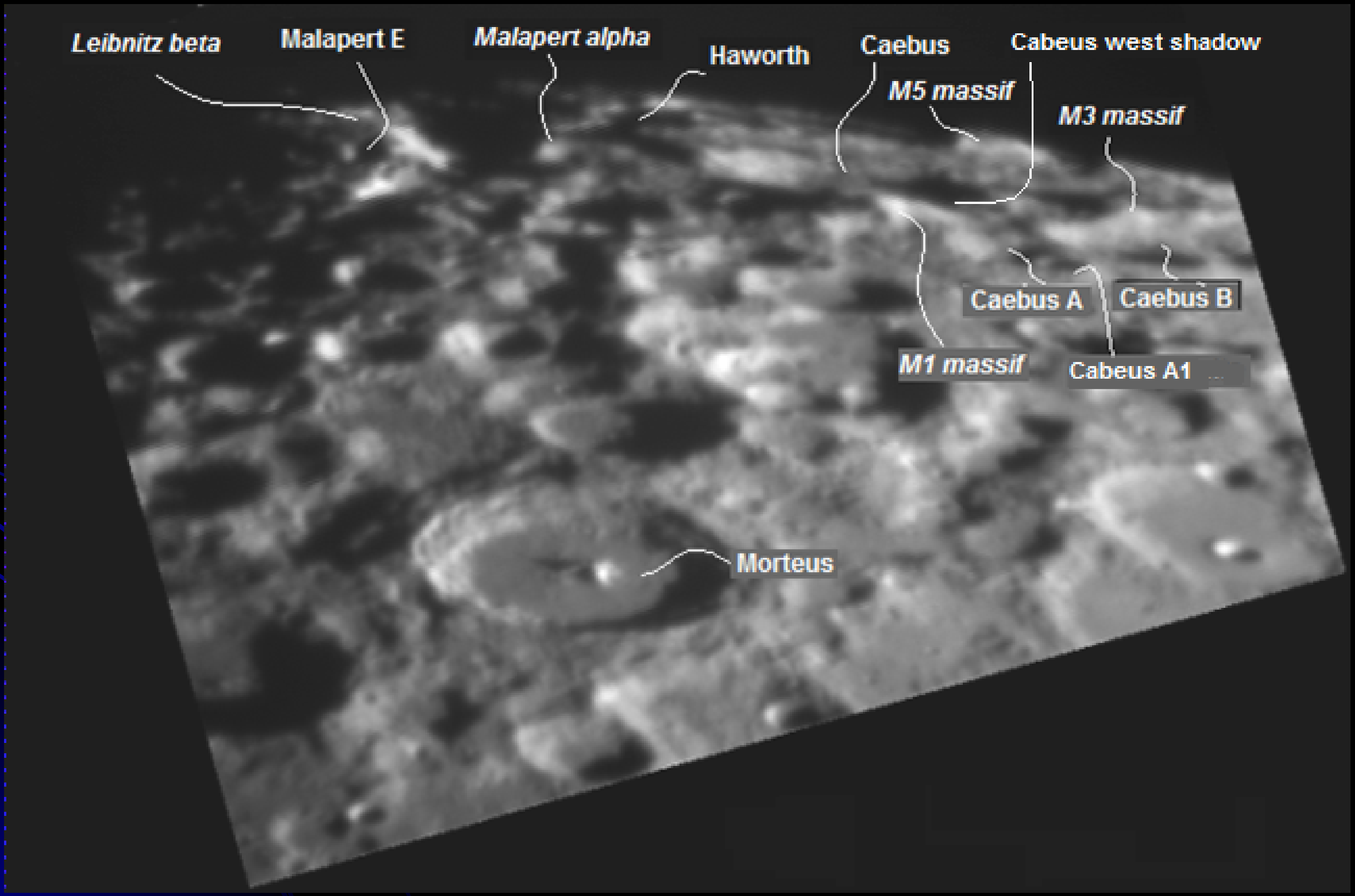
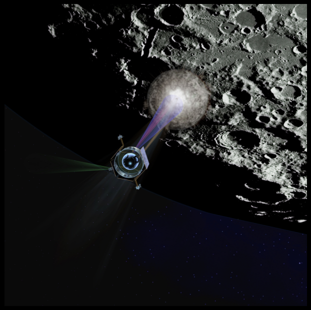


Image: K. Fisher 9-10-2009



Where

Sightline –

Morteus through center of Newton A

Newton A to M1
M1 to M5

Target is between
M1 and M5

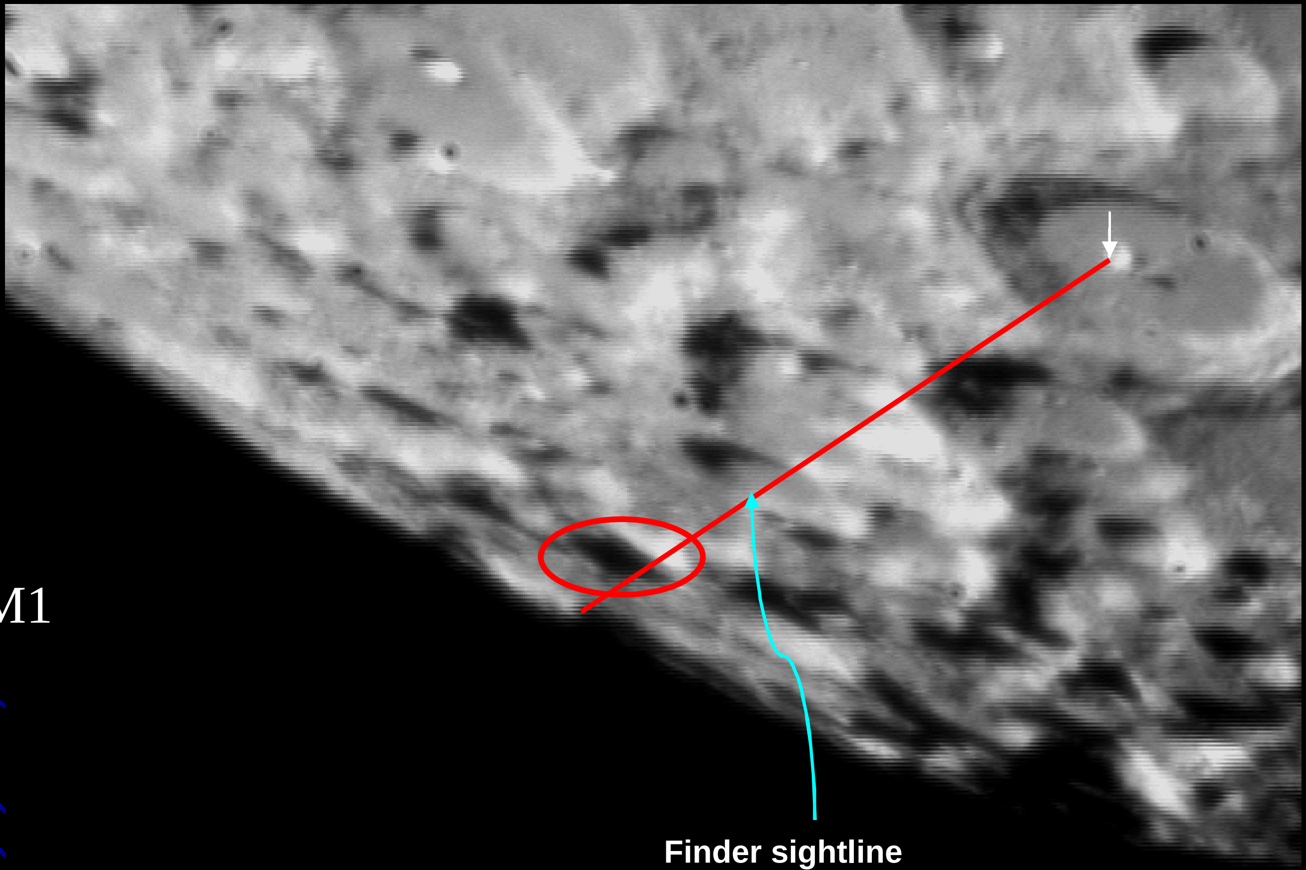
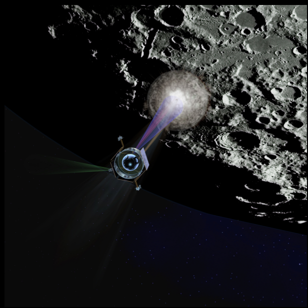
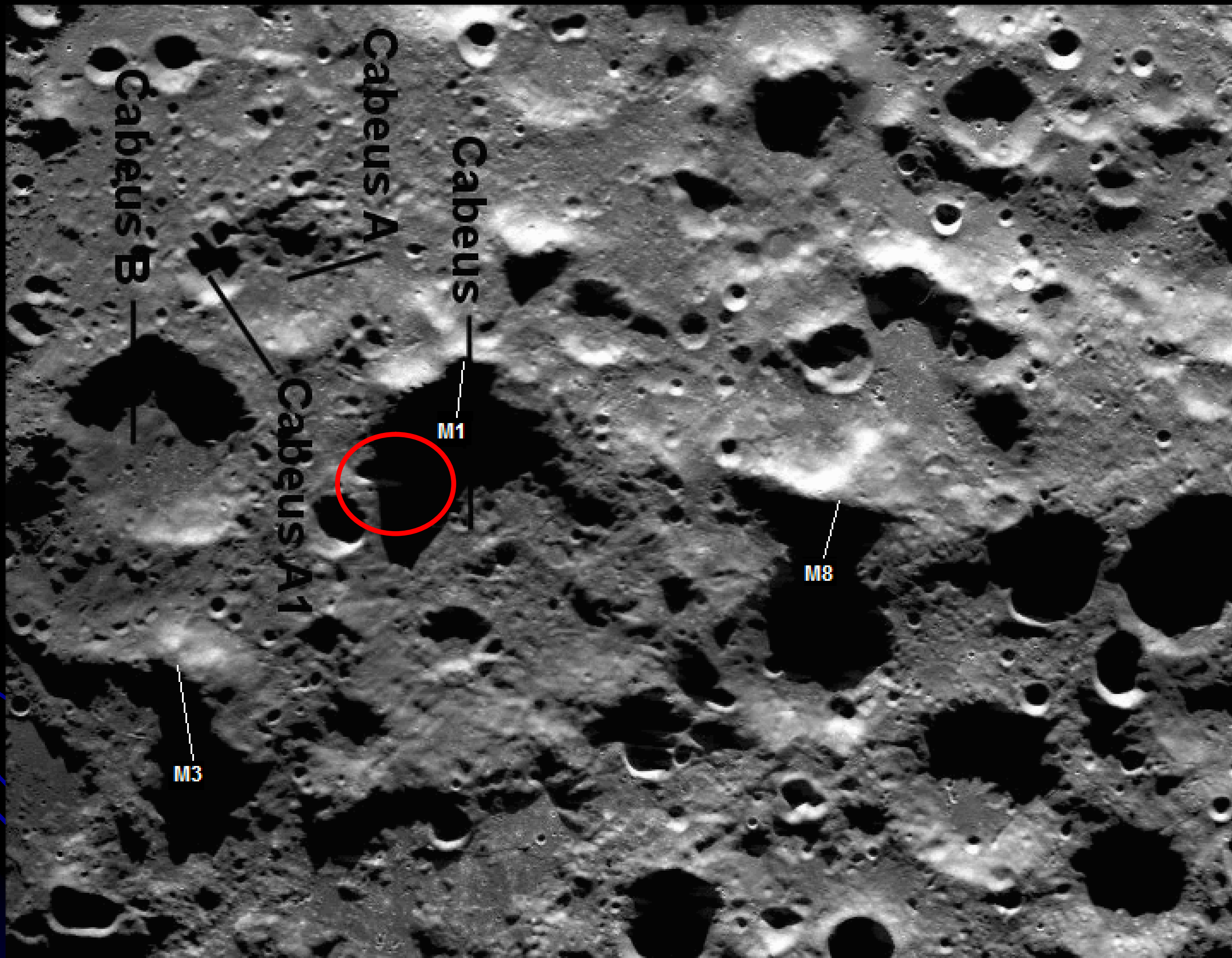


Image: K. Fisher 9-10-2009

Where





Illumination does not correspond to Oct. 9. Solar illumination will come from 331 degs az at impact. See red sun az angle arrow.

Image: NASA/JPL

Where

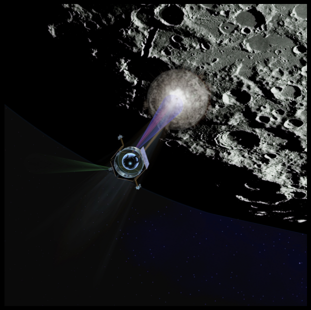
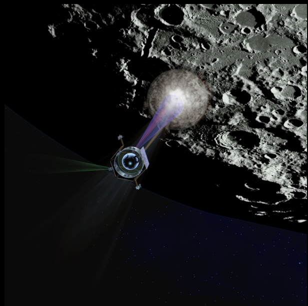


Image: NASA/JPL (Base topo map only)

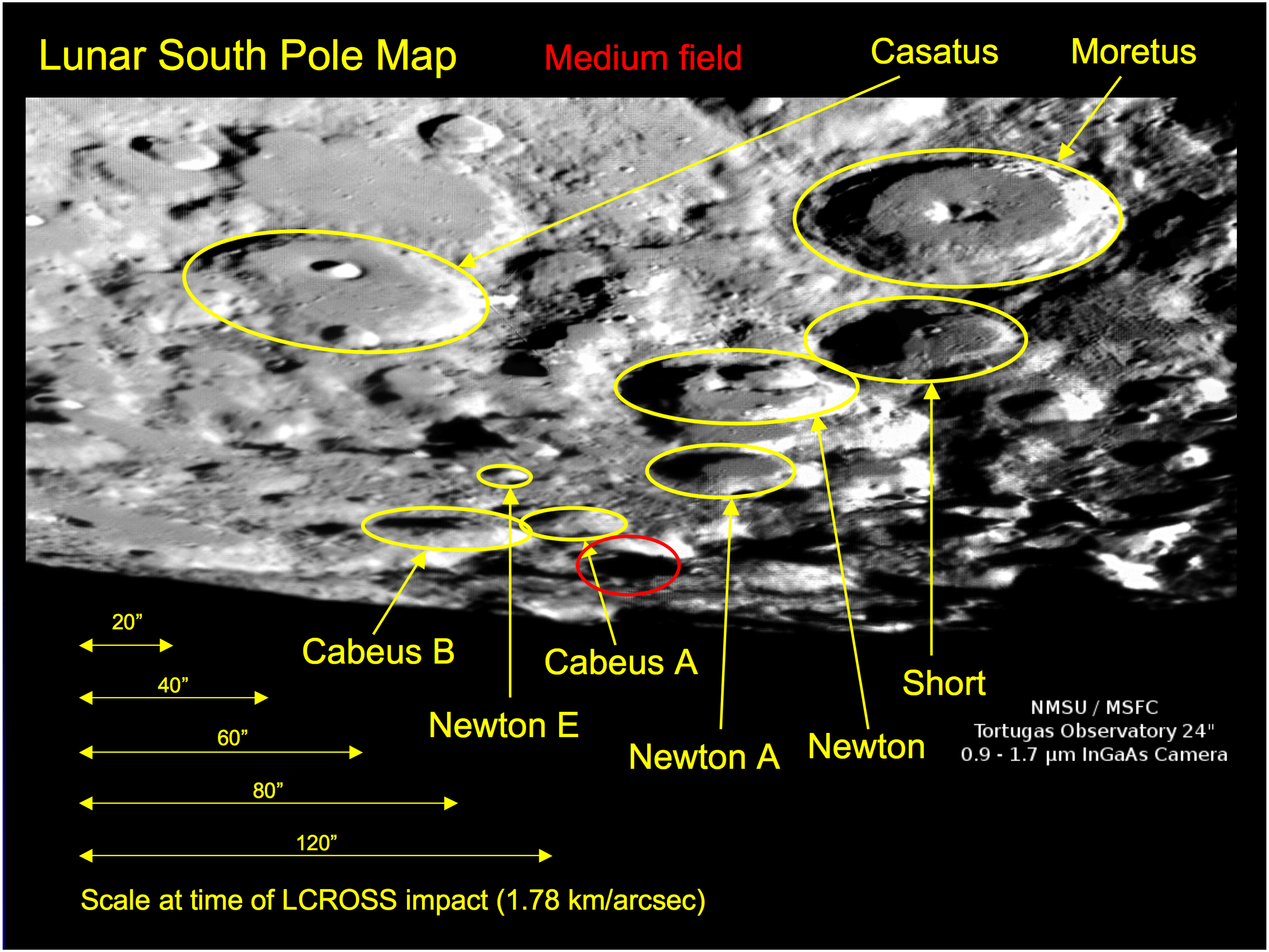


How big

- Working values: 10km wide (5.6 arcsecs) by 5km (~3 arcsecs) with 3km (1.7 arcsecs) sticking above the rim.

External link to NASA First Step Video. Impact simulation is at minute 1:39.

NASA LCROSS First-Steps Video
url: http://www.nasa.gov/mission_pages/LCROSS/multimedia/arc-LCROSS_First_Step.html



Lunar South Pole Map
Medium field
Casatus
Moretus
Cabeus B
Newton E
Cabeus A
Newton A
Newton
Short
NMSU / MSFC
Tortugas Observatory 24"
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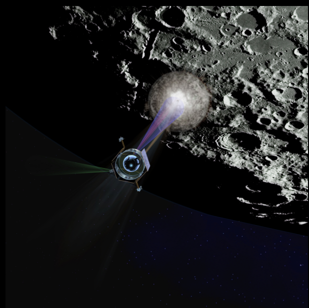
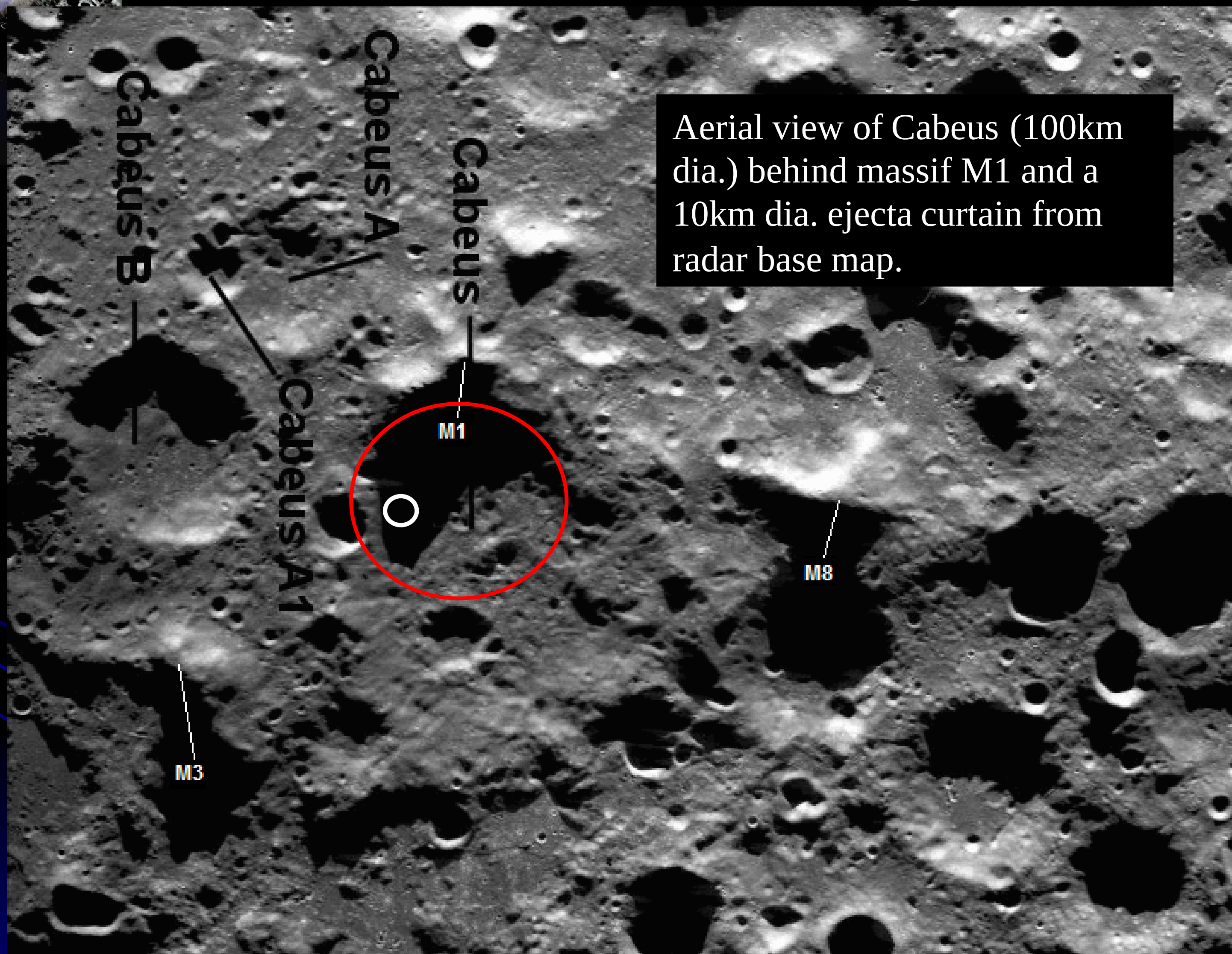
Scale at time of LCROSS impact (1.78 km/arcsec)



How big

Image: K. Fisher 9-8-2009

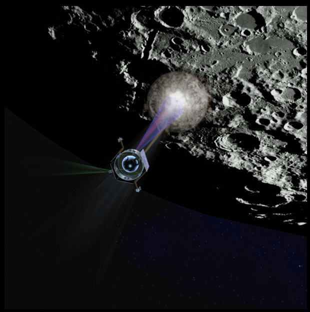
How big



Aerial view of Cabeus (100km dia.) behind massif M1 and a 10km dia. ejecta curtain from radar base map.

Illumination does not correspond to Oct. 9. Solar illumination will come from 331 degs az at impact. See red sun az angle arrow.

Image: NASA/JPL 9-11 press release



How big

3D graphic suggesting the relative size of Cabeus (98 km dia. - grey) and ejecta plume (10km dia. - red). The sun angle plane on Oct. 9 (yellow) is shown. Angle of presentation and position of plume are arbitrary.

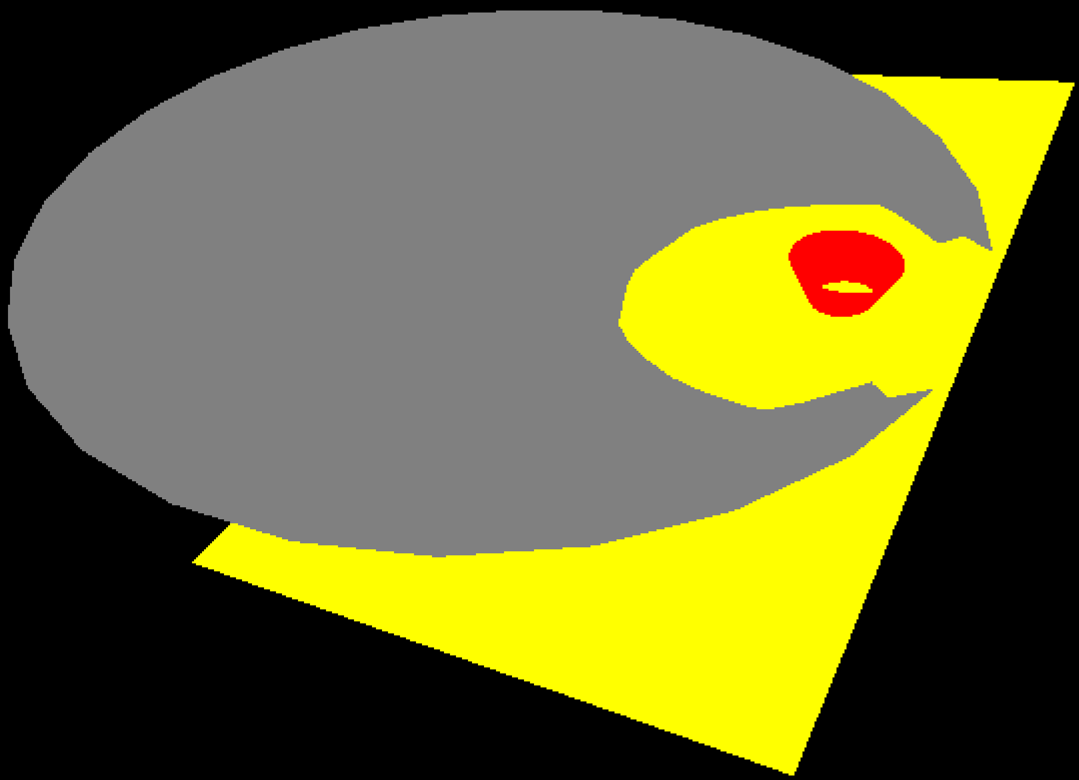


Image: K. Fisher graphic

How tall

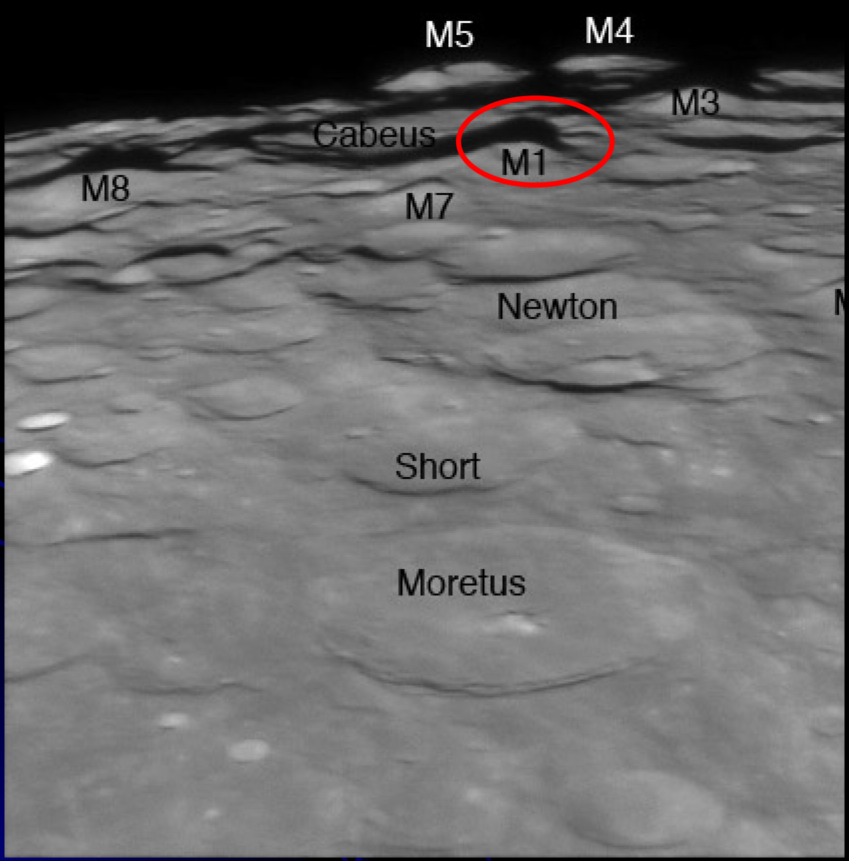
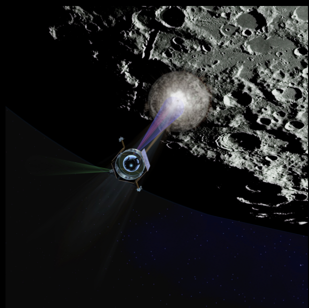


Image: Tom Bash. Used with permission.

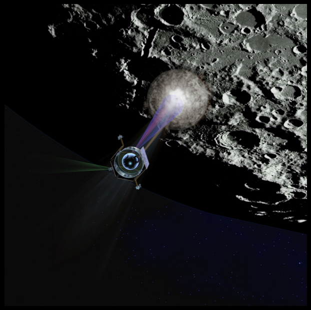
Tom Bash's image at high libration gives a sense of vertical scale. Combined with the elevation information from the NASA/JPL color-coded topo map slide, above, massifs M1 and M3 both rise about 6 kilometers above the surrounding plain. The LCROSS lampshade model at its brightest is 5km tall, with 3km appearing above the target crater's rim. At the extreme southwest lunar pole, length and width distances are distorted by foreshortening while the vertical dimension has almost no foreshortening.



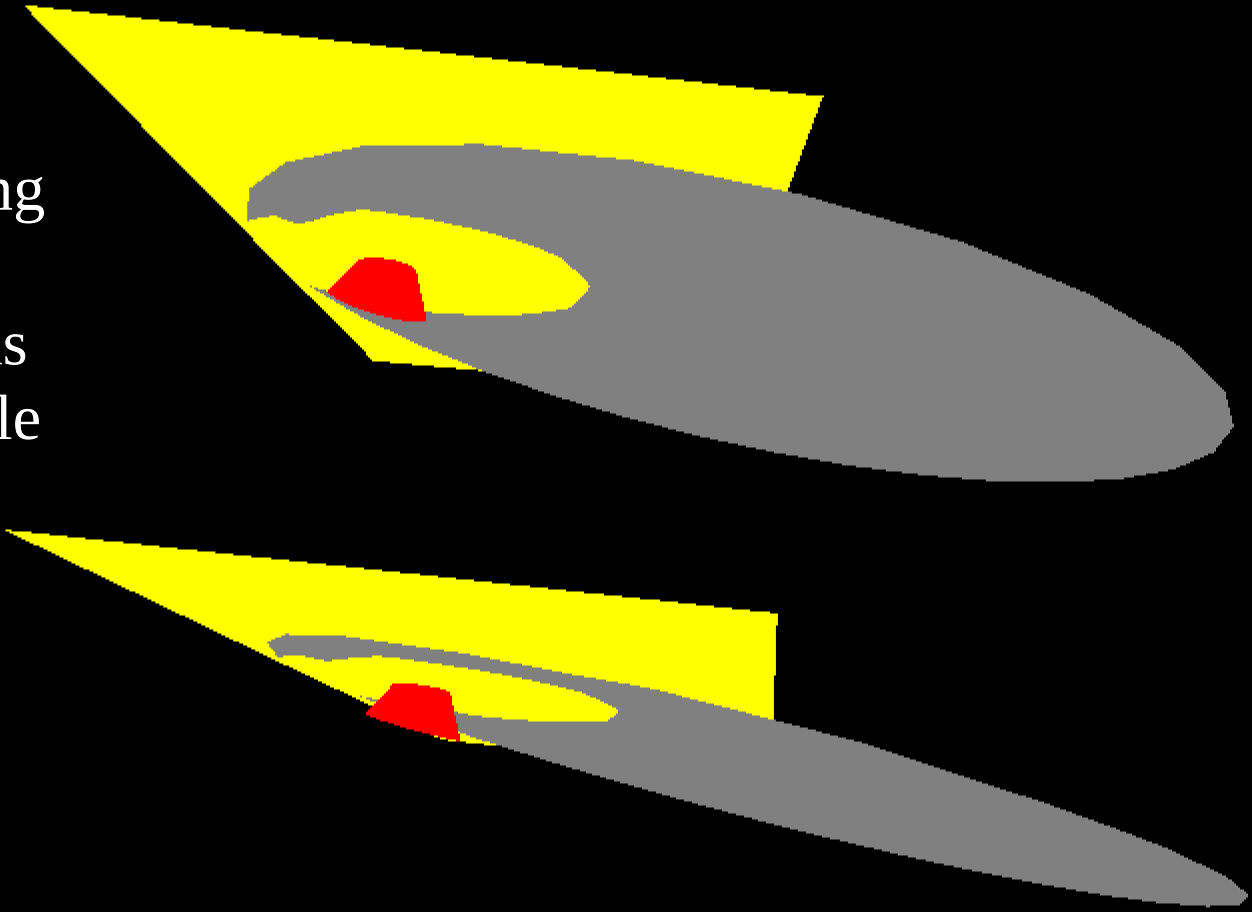
How tilted

- Libration changes between 9-10-2009 and the 10-9-2009 impact will make Cabeus look more linear than in the above images. Cabeus will look more vertically “squished”.   The crater will appear closer to the southern lunar limb.
  - Libration in latitude on 9-10 ~ -5 degs
  - Libration in latitude on 10-9 ~ -3 degs

Sept. 9 Oct . 9



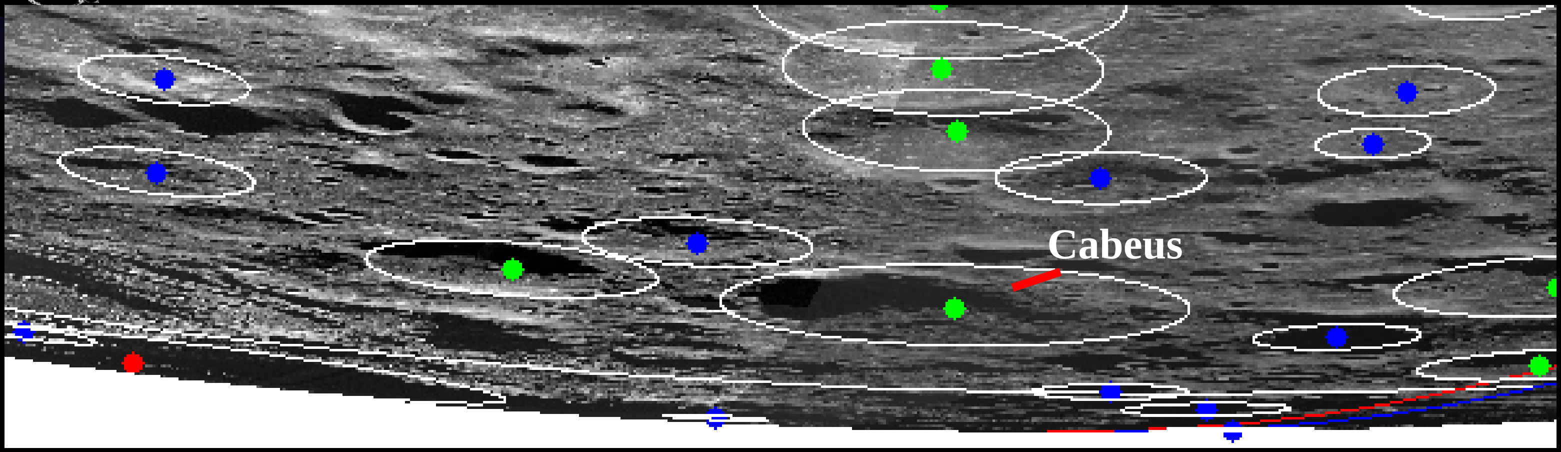
How tilted?



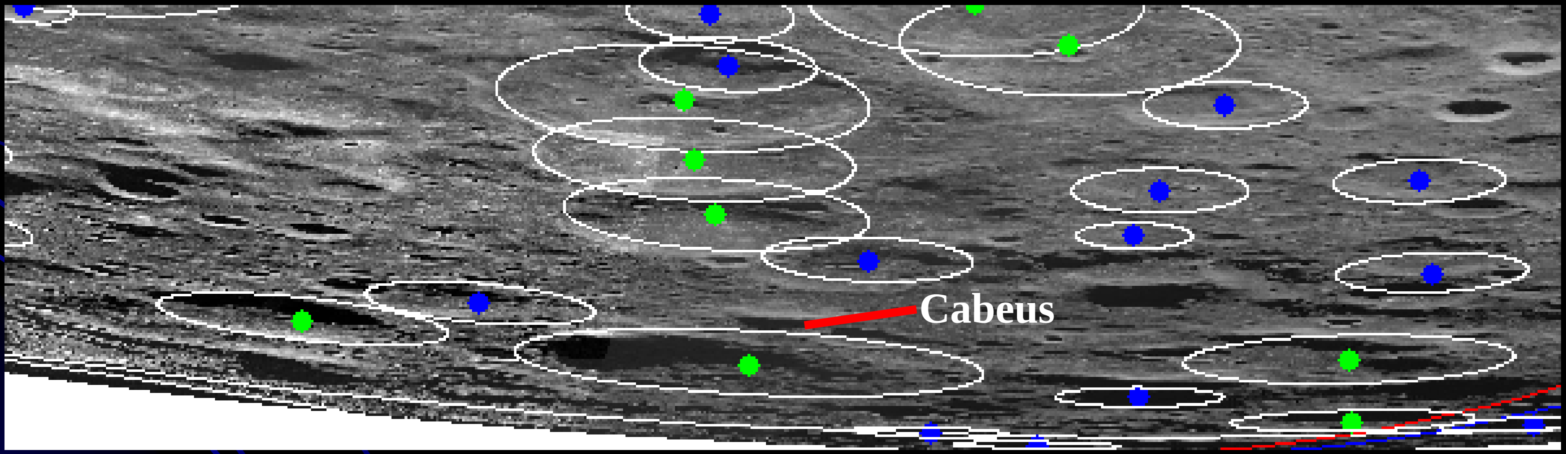
3D graphics suggesting the effect of libration in latitude on plume as seen from Earth. Angle of presentations and position of plume are chosen arbitrarily.

Image: K. Fisher graphic

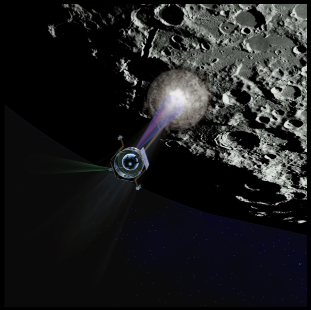
How tilted



South polar libration on Sept. 9 (above) compared to Oct. 9 (below)

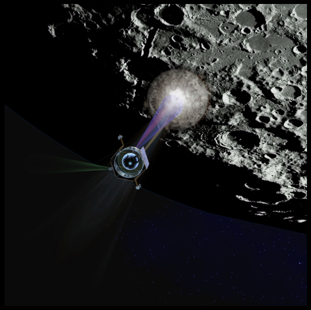


Images: Simulated lunar views generated using LTVT. http://ltvt.wikispaces.com/LTVT Base image is 2005 Cornell 20mm radar map. Courtesy Cornell University/Smithsonian Institution. http://www.nasm.si.edu/ceps/research/moon/radar_south_images.cfm and http://arecibo.tc.cornell.edu/lunarimages/default.aspx .



How bright

- The ejecta curtain will become its brightest at 30 secs after impact reaching 4.0 mpsas (2.5 stellar magnitudes).
- The average large scale surface brightness of the Moon varies between 4 and 6 mpsas.
- The NASA-JPL Horizon ephemeris system models the average surface brightness of the sunlit porition of the Moon at 4.8 mpsas.
- Amateur reduction of an image from the ROLO lunar image archive indicates that the site-specific mpsas is 3.8.
- The dark shadowed portion of Cabeus near the impact should become as bright as the surface brightness of the surrounding terrain.



Bright enough?

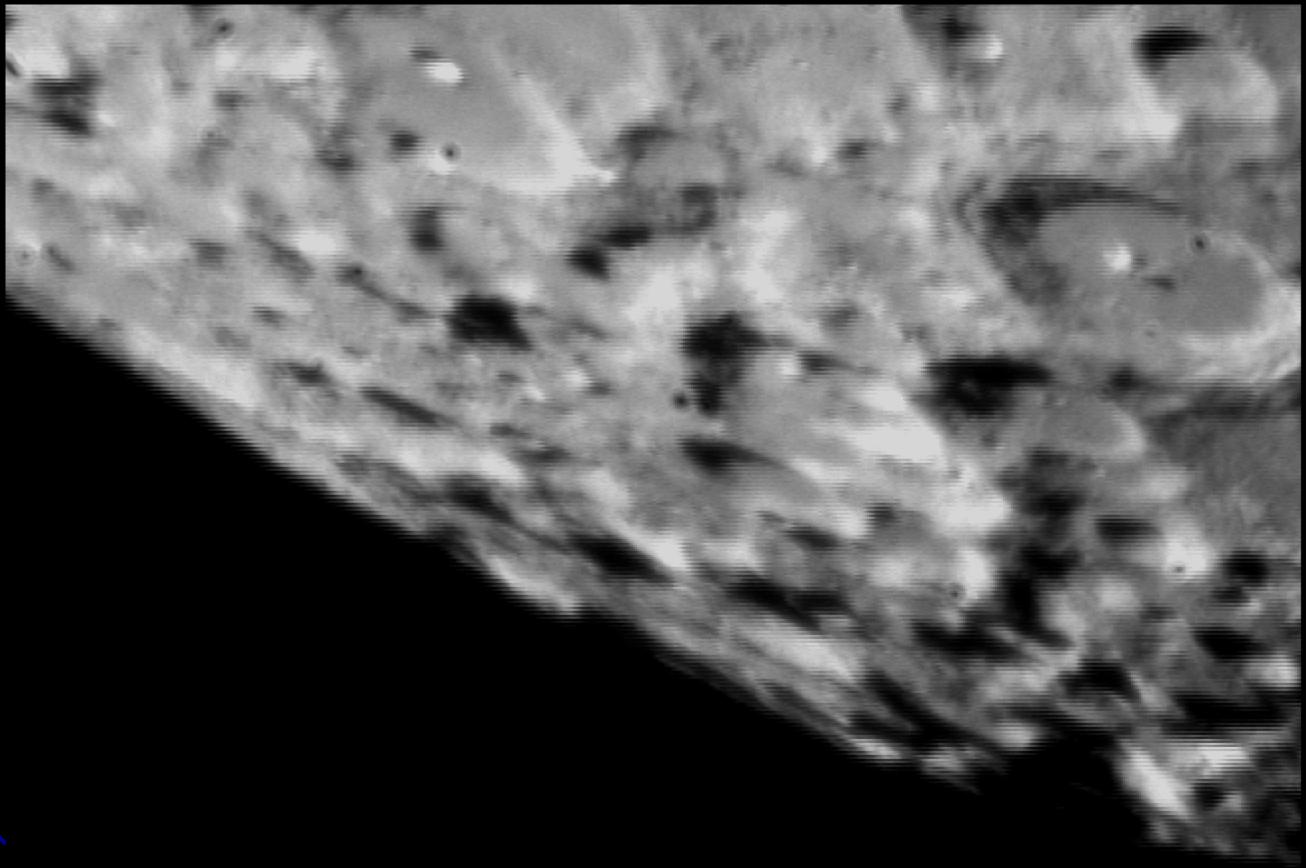
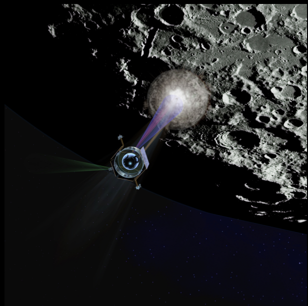


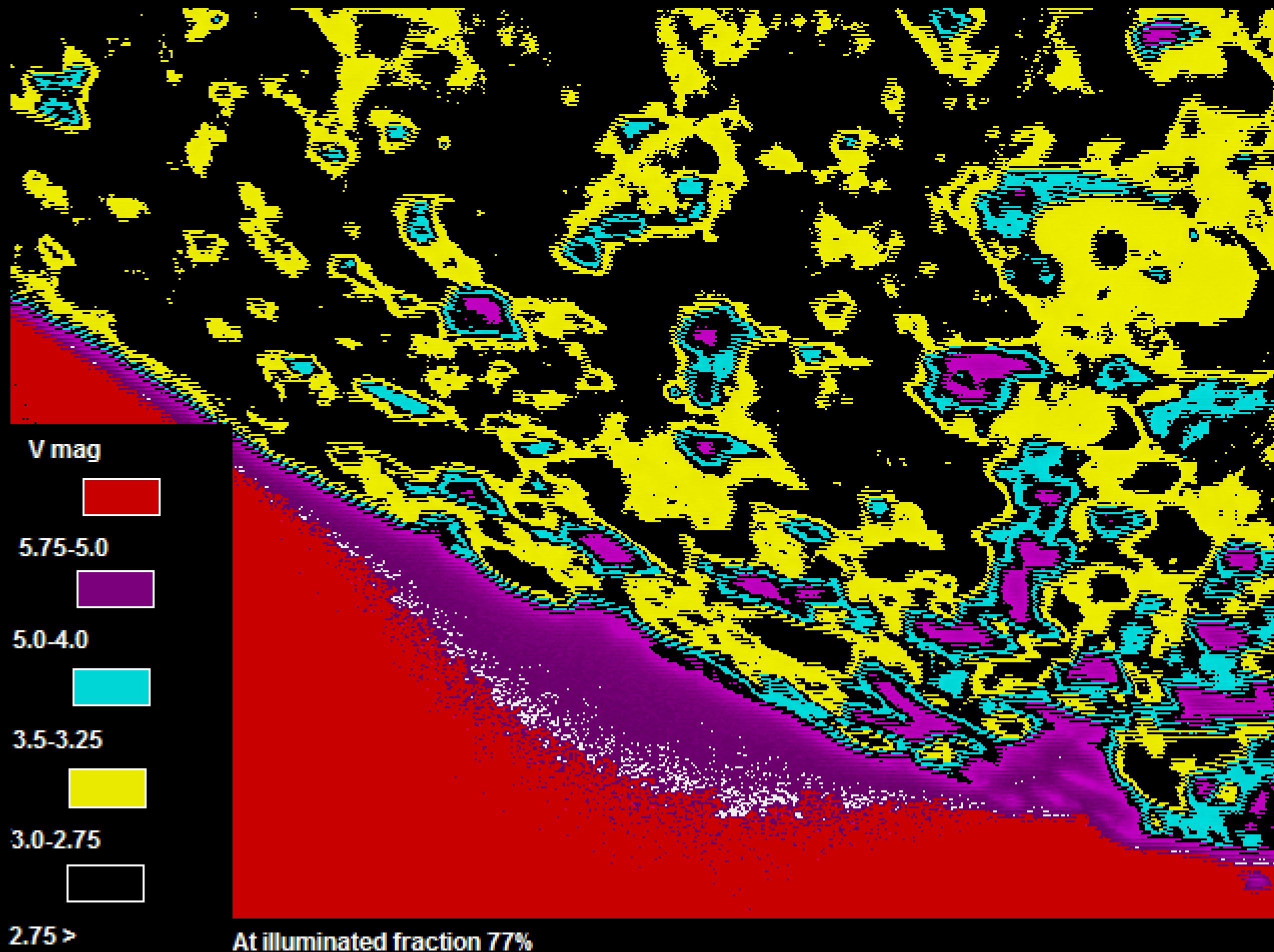
Image: K. Fisher 9-10-2009

The site-specific absolute and differential magnitude between the shadow within Cabeus and the surrounding terrain has not been characterized. Is the shadowed portion of Cabeus brighter than 4.0 mpsas?

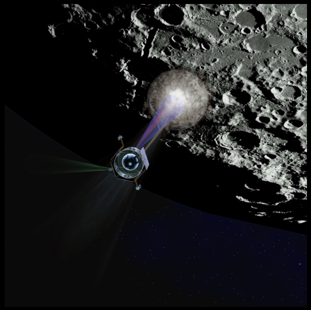


Bright enough?

Image: K. Fisher 9-10-2009

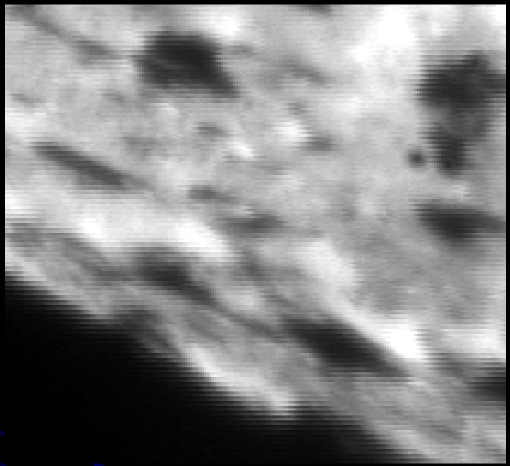


Differential magnitude experiment with amateur CCD camera. Absolute magnitudes are not scientifically valid. Is there a 1.5 magnitude difference between the surrounding surface and the dark shadow within Cabeus?

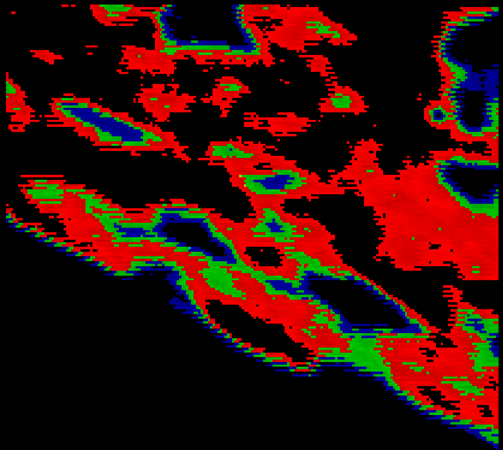


Bright enough?

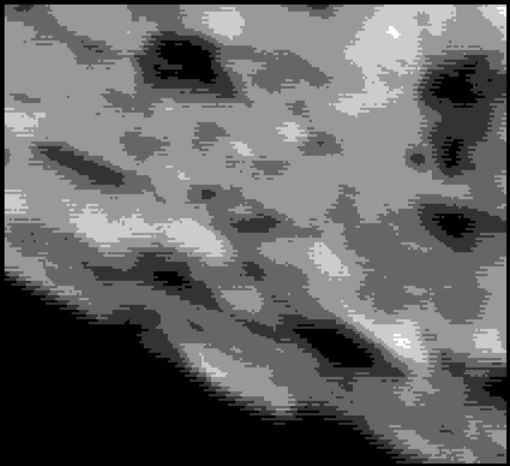
Raw



Colorgram slice



10 level quantized

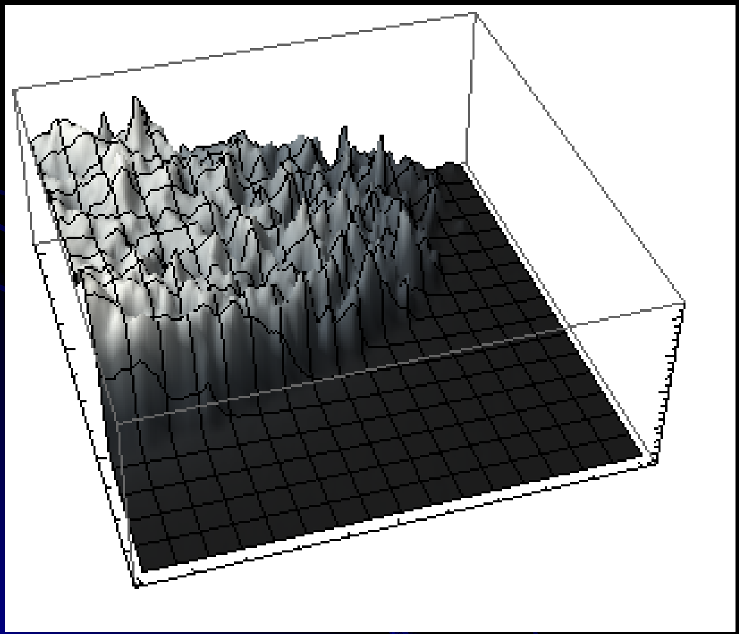


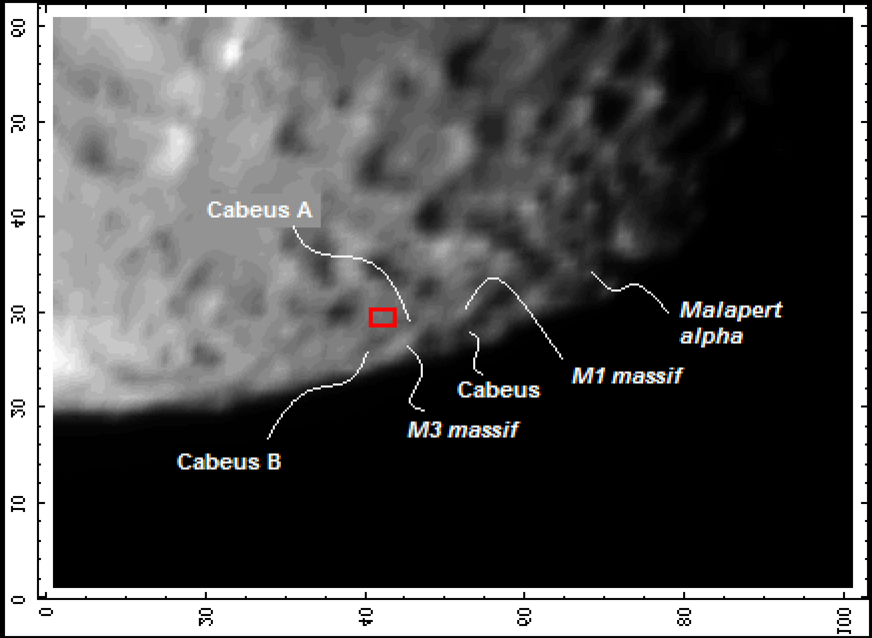
Images: K. Fisher 9-10-2009

Differential magnitude experiment with amateur CCD camera. Absolute magnitudes are not scientifically valid. Is there a 1.5 magnitude difference between the surrounding surface and the dark shadow within Cabeus?

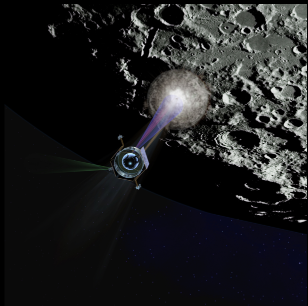
Bright enough?

- This author's amateur analysis of USGS ROLO lunar image archive radiance data at a 68% illuminated fraction estimates the surface brightness near Cabeus A at 3.8 mpsas.





Images: K. Fisher 9-27-2009 generated from USGS ROLO lunar radiance archive data provided courtesy of USGG. url: http://www.moon-cal.org/

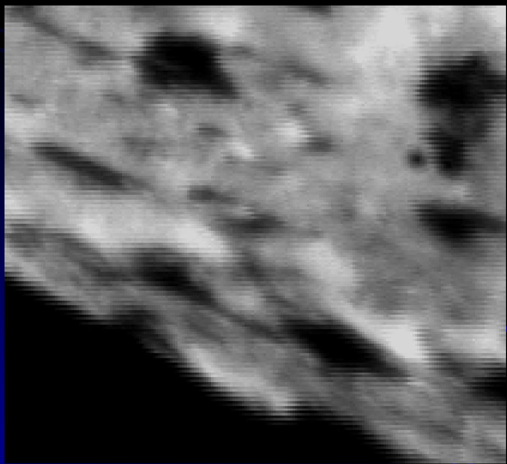


Bright enough?

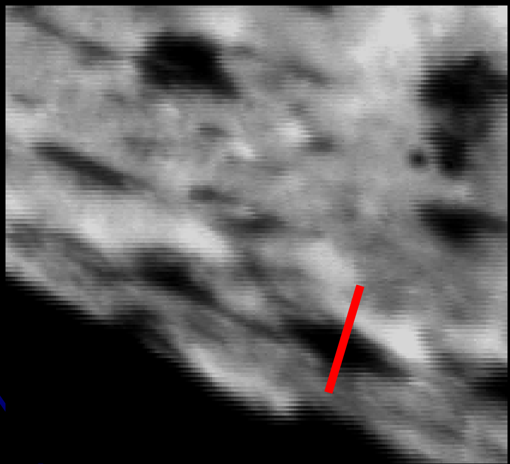
- A pixel value line profile on an amateur image that crosses Cabeus suggests about an 0.75 to 1.25 stellar magnitude difference between the shadowed portion of Cabeus and its brighter rim.

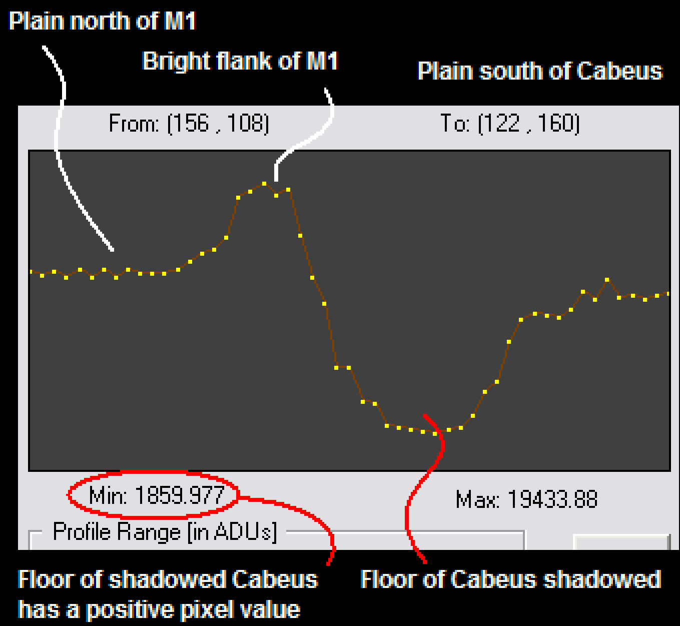
Histogram on single dark subtracted test frame created with Line Profile Tool

Raw

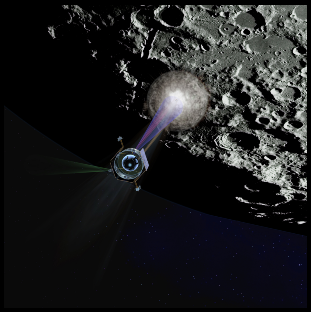


Raw with Line Profile Tool



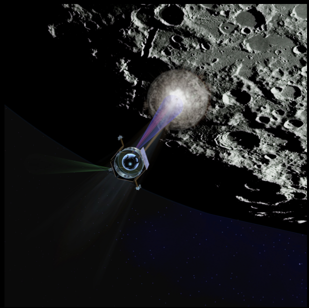


Images: K. Fisher 9-10-2009



What will I see

- Basically a contrast effect.   As the ejecta plume brightens to match the apparent brightness of the surrounding terrain and obscures the dark shadowed portion of Cabeus, the crater will appear to partially fill-in.
- Where ejecta curtain crosses with a background of the sunlit lunar surface, it will seem to disappear because there will be no contrast between the curtain and the background terrain.
- The west dark lobe of Cabeus may take on a flat-top shape, a raised muffin shape, or disappear altogether for about 20 seconds.



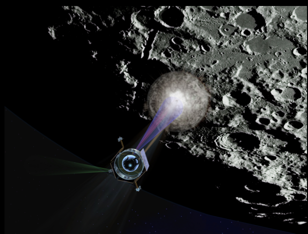
What will I see

Author's hypothetical simulated impact image emphasizing a contrast effect theory.

Before impact | Impact +30 secs | Impact +30 secs scaled plume

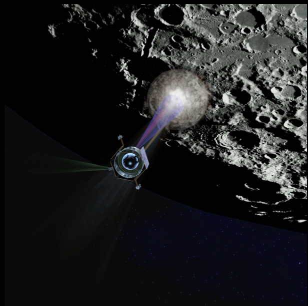
Base image credit: Stefan Lammel 9-9-2009 Used with permission.

- but anybody's guess is a good as mine!



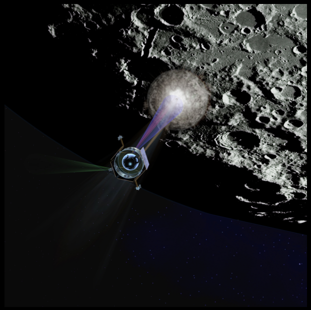
Uncertainty – Plume 4-6 mpsas

- LCROSS is a unique, novel experiment. Novel experiments involve systematic uncertainty flowing from the design and the unknown nature of independent variables.
- Uncontrollable risks:
  - The predicted 4-6 mpsas plume brightness is a best modeled value. Experimental unknowns that may result in an unobservable low plume brightness include:
    - Plume model is wrong: The plume prediction model may be wrong.
  - Soil different than assumed in the model: The lunar soil at the point of impact may have different characteristics than that assume in plume brightness models.
    - Surface different than assumed in the model: The impactor may strike an angled small hill or crater side. The angled surface will disperse the impact energy. The modeled plume assumes striking a flat surface.
    - Bad guiding: Guidance fails on the shepherding satellite and the impactor hits the wrong spot.
    - Impact model is wrong: In 2008, Russian scientists criticized that modeling of the impact erred because NASA LCROSS had used a solid, instead of hollow, impactor modeling. In early 2009, the LCROSS Team reran their computations for a hollow impactor and retested in the Ames high-velocity impact gun using a hollow sphere.
    - Since there is no way to really measure site specific grain size at Cabeus except by driving an impactor into it – well, know you get the inherent experimental or systematic uncertainty problem.
  - Weather.
  - It's an experiment. Sometimes experiments have unexpected results or fail.



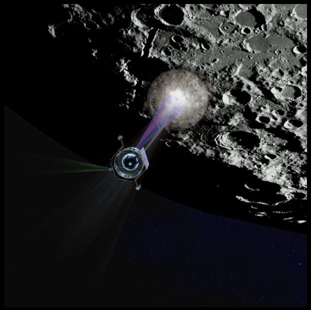
Uncertainty – Plume 4-6 mpsas

- Controllable risks:
  - No good site specific data on the apparent brightness in mpsas of the shadowed portion of Cabeus or the apparent brightness in mpsas of the surrounding lunar surface has been collected. Solution: collect photometry.
  - Personal skill with your own telescope-camera system.



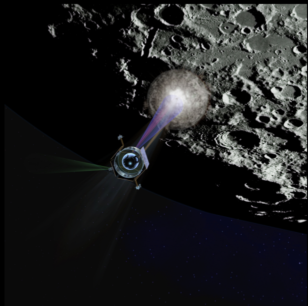
How to visually observe it

- Scope: 5 inches of aperture and above. At 5 inches of aperture there is no light grasp safety margin. If the plume does not reach the modeled maximum brightness, 5 inches of aperture may be insufficient. The NASA LCROSS Team recommendation for 10 inches of aperture. 10 inches of aperture gives a better light grasp margin against a fainter plume.
- Eyepiece: A good planetary 4mm – 6mm
- Visual observing will be at a high magnification, so lunar glare should not be a problem.
- No filters. If lunar glare still is a problem at high-magnification, add one-half of a polarizing Moon filter to your eyepiece to polarize the light.



Stops and masks

- Aperture stops and apodizing masks
  - Aperture stopping or apodizing masks will reduce the amount of light coming off the faint ejecta plume, possibly preventing you from seeing it.
  - If used at all, filters should be applied minimally in order to maintain a light grasp safety margin against a plume that is fainter than predicted.



How to visually observe it

- Magnification: lunar planetary detail magnification suitable for your scope.
  - Knisley’s useful magnification guideline:

    Used For: Specific planetary lunar detail

    Useful Mag Description: Very high

    Low Mag Per Inch of Aperture: 30.0

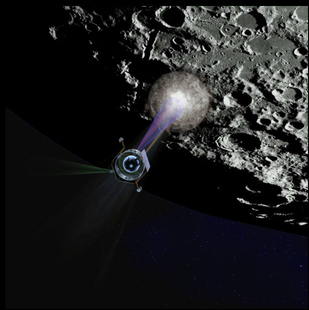
    High Mag Per Inch of Aperture: 41.9

    Low Exit Pupil mm: 0.7

    High Exit Pupil mm: 0.6
- For a 10" aperture scope, the guidance magnification range is 300 to 410 power.

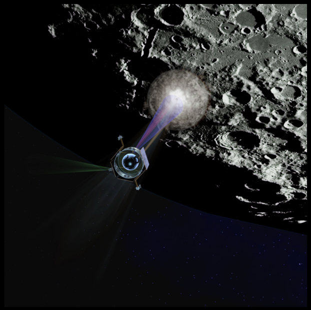
How to visually observe it

- Tracking
  - Because of the high magnification, tracking is necessary. High magnification may present a problem for box mounted Dobs.
  - Alt Az GOTO scope users may want to switch to equatorial mode.
    - With a Meade ETX 125, Alt Az tracking was do-able but needed bothersome adjustments at 300x even with training.
    - The Meade ETX 125 with polar equatorial tracked smoothly and needed minor adjustments.



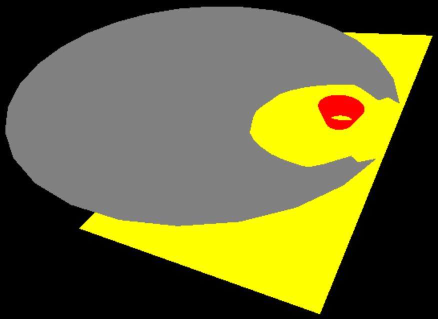
Visual workflow checklist

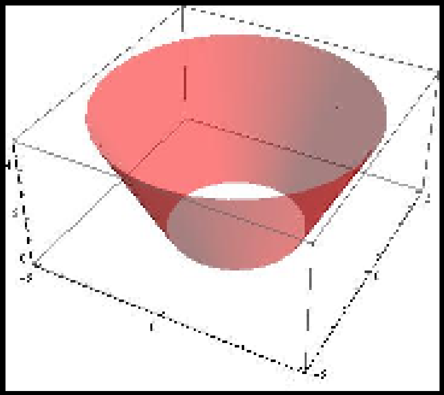
Activity	Duration	Timeline
Arrive at site locate observing stall	10 minutes	T-85 mins
Setup and polar align scope	30 minutes	T-75
Target and focus on Cabeus	15 minutes	T-45
Retarget Cabeus. Sleep scope and camera	5 minutes	T-30
Break	20 minutes	T-25
Restart scope, retarget.	15 minutes	T-10



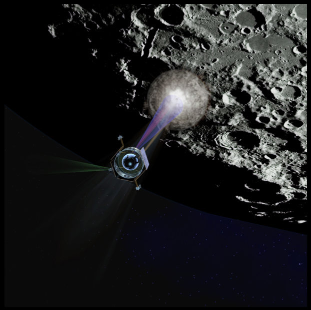
Follow-up observing

- Geometry of the ejecta plume and the size of Cabeus suggests that some of the ejecta plume will settle outside the rim of the crater.
- A speculative observing idea is to look again on the morning following the impact to see if the curtain remnants can be detected on the surface next to Cabeus.



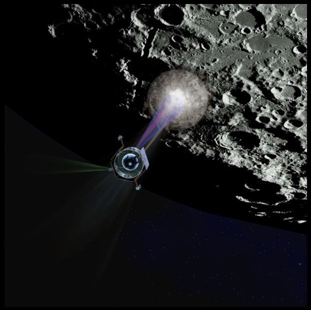


Images: K. Fisher graphics



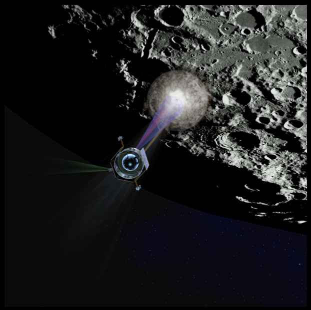
How to image it

- Equipment:
  - Match camera pixel size and equipment focal length.
  - See Sinnott's Effective Focal Length to Pixel Size nomogram, url - **http://media.skyandtelescope.com/images/Linked.gif**
  - Apply a “lucky imaging” strategy favored by lunar imagers, discussed below.



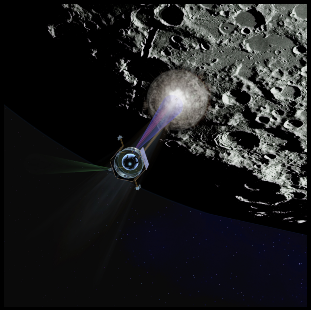
How to image it

- Cleaning your optics
  - DSO imagers may not realize how much dust you have in your secondary optical train (camera, filters, etc.)
  - DSO imagers capture dark background images.
  - Many dust particles can hide in the dark background of DSO pics.
  - DOS imagers may find when they train their cameras on the bright Moon that you have a screen covered dust donuts in what you thought was a clean optical train.
- Recommendation:
  - Give yourself some extra time to clean your optics and camera.
  - Slightly defocusing on the brightest part of the sunlit portion of the Moon will give a good pseudo white flat for testing how clean you got your optics.
  - Remember to bring gear needed to clean your optics.



How to image it

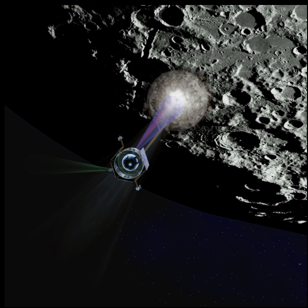
- LCROSS Team imaging guidance
  - Current official guidance can be found at url:
  - LCROSS Team Citizen Science About Page http://apps.nasa.gov/lcross/about/ (9-15)



How to image it

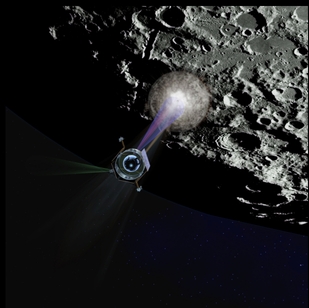
- LCROSS Team imaging guidance – filters
  - "However, observations are not trivial as the dust cloud may have a brightly lit Moon surface behind it, depending on the exact impact site selected, making it more difficult to see the dust cloud due to the poor contrast; bright dust against a bright Moon surface. The dust will polarize the scattered light but using polarimetery can help with the observation."
  - Translation: Put one-half of a variable Moon filter into your optical train.

Source: LCROSS Team Citizen Science About Page http://apps.nasa.gov/lcross/about/ (9-15)

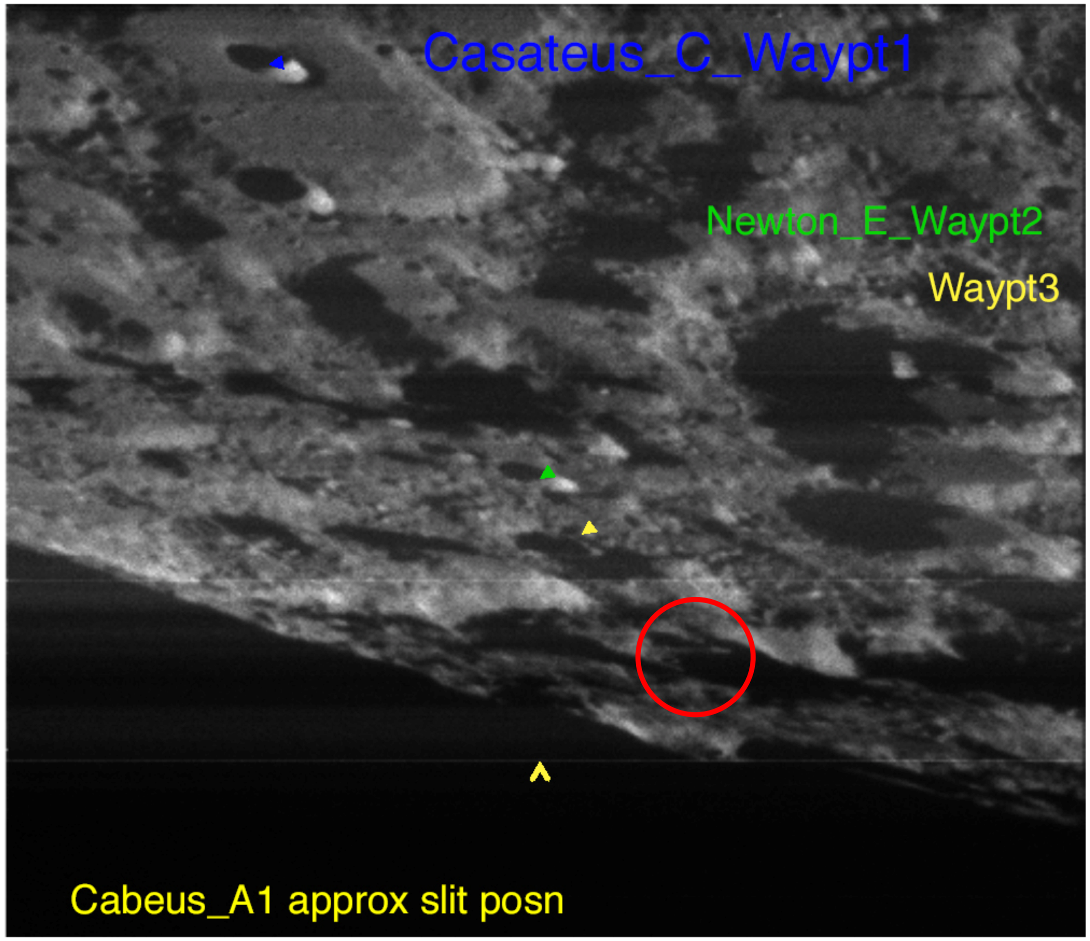


How to image it

- Other LCROSS Team related filter tip
  - When making the Gemini North targeting image made for spectroscopy, the investigator used a V-block filter “in two formats, at G-band (398-552 nm)+ RG610 (blue blocking) to avoid saturation.” (See next slide for image.)
  - This might be a filter strategy for amateurs to explore.

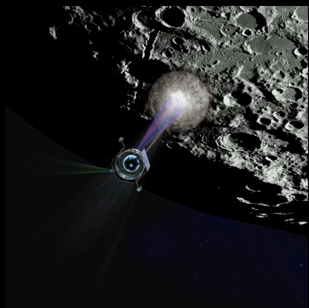


How to image it



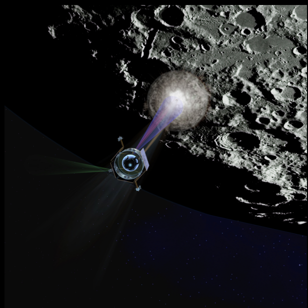
2009-sep 11 13:12UT Gemini-N Acquisition Camera

LCROSS GBOC Mauna Kea Spectroscopy Team including
Wooden, Woodward, Lucey, Harker, Young, Kelley, Geballe, Stephens, Roth, et al.



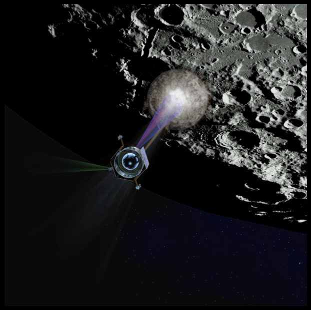
How to image it

- This author’s alternative imaging protocol
  - Apply the “lucky imaging” strategy favored by lunar imagers.
  - Small pixel (5 micron sq) mid- to high-end LPI cameras are used to capture 15 or 30 frames per second.
  - With an event duration of 40 seconds and assuming still seeing air windows at 3 second intervals with one-tenth second duration (a total crisp capture interval of 1.2 secs), means 18 to 36 crisp frames might be captured out of 600 to 1,200 frames.



How to image it

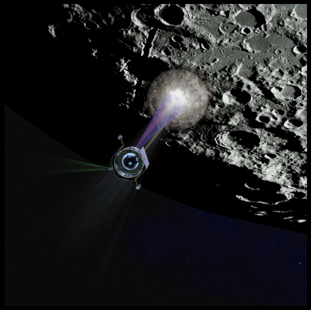
- This author's alternative imaging protocol
  - High focal length imaging is preferred in order to minimize the percent of the sunlit lunar disk captured in a frame.
  - High focal lengths dictate that large pixel DSLR cameras and CCD cameras are disfavored relative to small pixel sized fast moderate and high-end lunar imaging cameras.
  - Typical exposures are at elfs above 3000mm per Sinnott's nomogram or f/20 to f/30. Empircal exposures on a Meade DSI and Meade ETX 125 were at 0.01. An 0.06 second exposure was used through a Johnson V filter.



How to image it

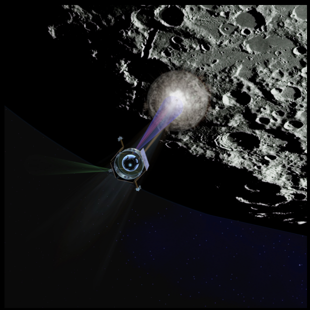
- This author's alternative imaging protocol
  - High effective focal length imaging is indicated by the need to minimize lunar glare.
  - Lunar glare is proportional to the fraction of the Moon's disk that appears in your image frame.
  - A higher fraction of Moon in your image, the higher the lowest pixel value you can capture on a feature the is partially illuminated in low-light. This effects your ability to see changes in the shadowed portion of Cabeus.
  - Higher efls mean a lower fraction of the Moon will appear in an image frame.

Image: Slooh widefield 9-10-2009



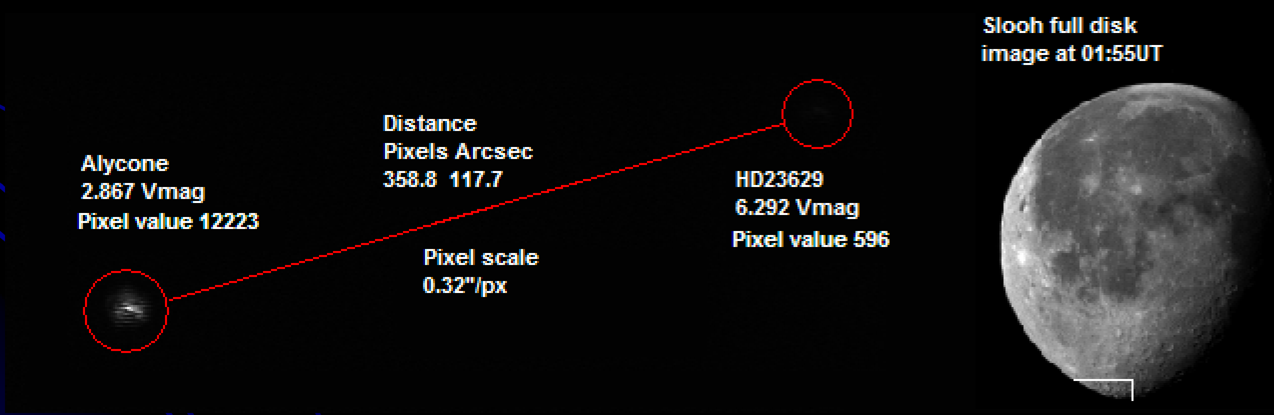
How to image it

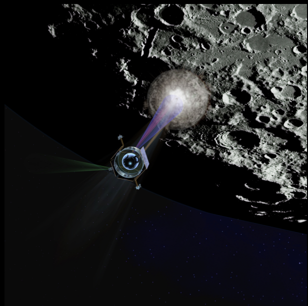
- This author’s alternative imaging protocol
  - The goals of this exposure calibration protocol are a) to set the pixel value of the brightest edge of the rim of Cabeus to 75% of your camera's well capacity in ADUs and b) optionally to record the image scale of the frame in arcsecs.
- Optional image scale and exposure calibration to a 2.5 mag star
  - Calibrate an exposure to a 2.5 mag A-O-B star.
  - Exposure calibration stars: theta Auriga 2.6 mags; zeta Per 2.8mags B0.5V, delta Orion 2.2 mags O9.5II, gamma Gem 1.9 mags AOIV, beta Auriga 1.9 mags A2IV.
  - The stellar calibration frame can also be used to measure the image scale of your camera.



How to image it

- Optional image scale and exposure calibration to star
  - Store 10 to 20 reference images of your calibration star with a close by star in order to compute the image scale and ADUs of your lunar image after the impact.

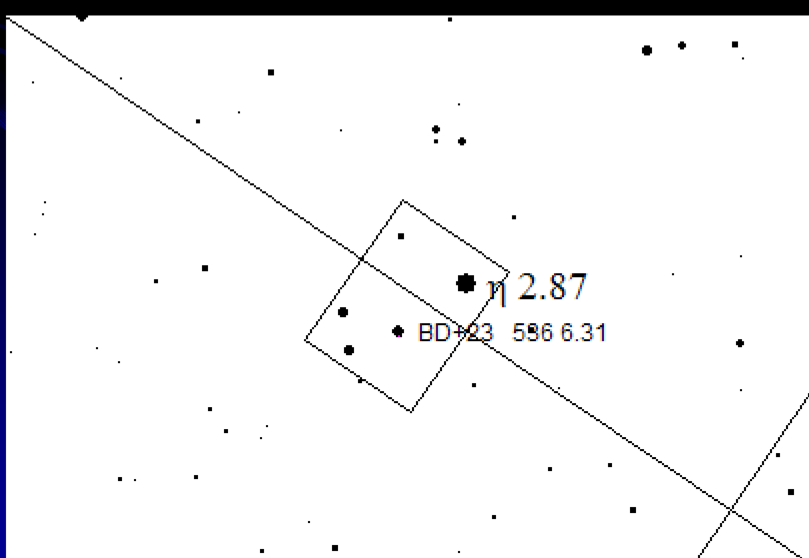




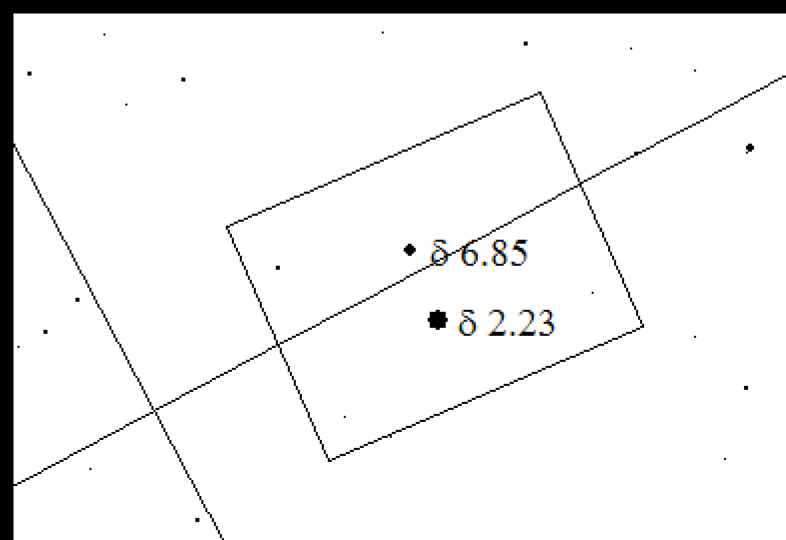
How to image it

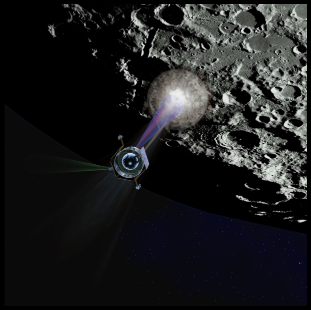
- Optional imaging scaling exposure – delta Ori (Mintaka to SAO132221 - 53”) and eta Tau (Alcyone to SAO 76192 - 117.7” sep) have a bright and fainter star that lay within a 3’ x 4’ high efl CCD frame. Pre-impact imaging these stars without changing focus, efl or exposure time will provide an image scale for your lunar photographs.

Alcyone in M45



delta Ori

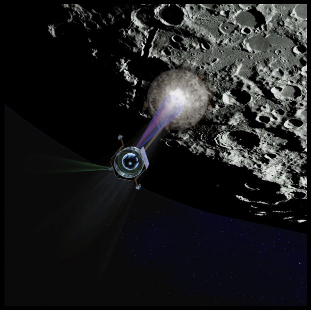




How to image it

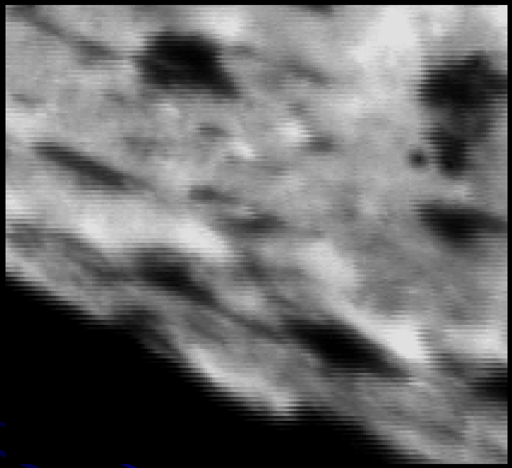
- Exposure calibration to crater line profile measurement
  - Slew and target Cabeus. Make focus adjustment.
  - Take test frames.
  - Open test frames in your image processing software and take a profile measurement across Cabeus, covering the bright rim, the sunlit crater floor, the shadowed crater floor and the opposite bright rim.
  - Adjust exposure time until test frames are such that the Cabeus bright crater rim is between 50%-75% of your ADU well capacity.
  - Check that the pixel values that cover the range for the dark shadowed portion of Cabeus are somewhere above 25% of the your ADU well capacity.

How to image it

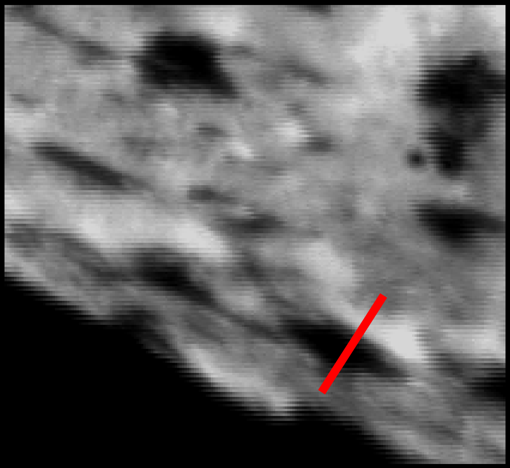


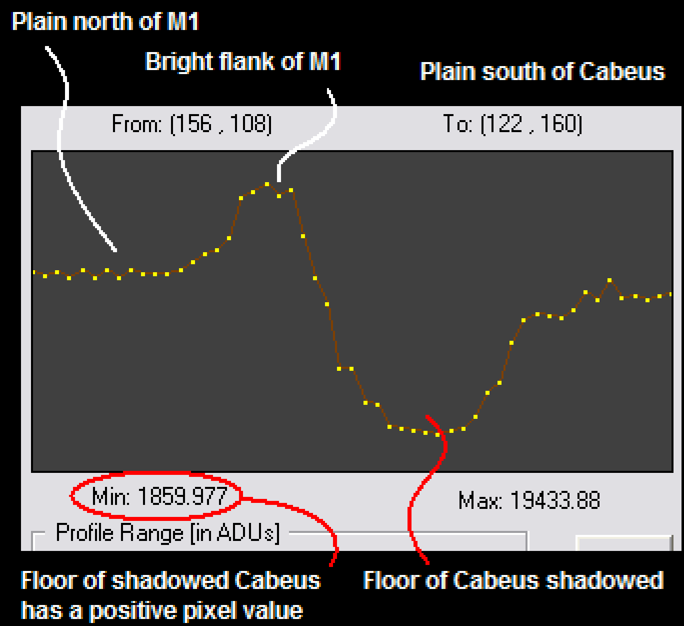
Histogram on single dark subtracted test frame created with Line Profile Tool

Raw



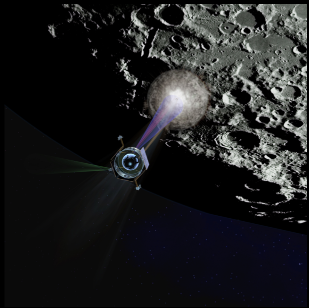
Raw with Line Profile Tool





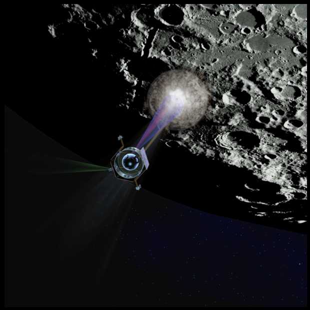
Images: K. Fisher 9-10-2009

Example of pre-impact exposure calibration using the Line Profile Tool in AIP4WIN across Cabeus. Calibrate image exposure time so that all pixels in the pixel value range between the bright rim of Cabeus and the dark shadow portion of the crater are between about 50% and 75% of your well capacity in ADUs. Tweak adjustment so the brightest parts of lunar surface in the image frame are not overexposed, while still preserving exposure of key Cabeus pixel value range. You may want to elect to overexpose the brightest parts of the image frame in order to best match the Cabeus region-of-interest to your well ADU capacity.



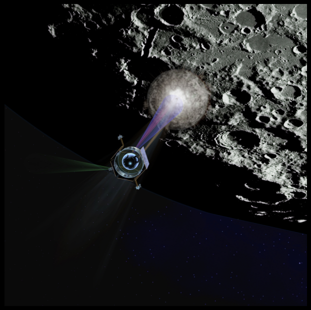
How to image it

- This author’s alternative imaging protocol
  - Finish by making your white flats with a white light box and taking your darks.
  - Re-target Cabeus and sleep your scope until about 15 minutes before the impact.



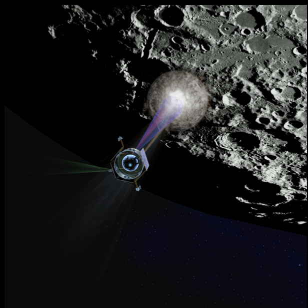
Timing when to look or image

- Group observing with a portable dish TV receiver as a central component is recommended.
- NASA TV will be broadcasting the impact live – Ranger 9 style.
- With a portable dish setup, a group of observers will have a time certain to start and stop their imaging cameras.
- Alternatively, one club member can monitor the NASA TV website and run a cell phone tree notifying remote observers and imagers.
- Group observing allows supports sharing of white light boxes for making white flats.



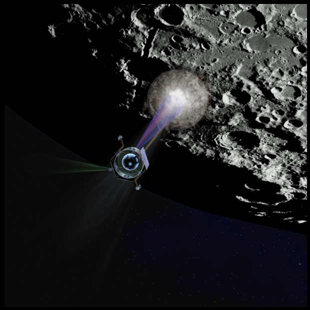
Imaging workflow checklist

Activity	Duration	Timeline
Arrive at site locate observing stall	10 minutes	T-150 mins
Setup and polar align scope	30 minutes	T-140
Image calibration star	20 minutes	T-110
Defocus on bright Moon and clean optics	15 minutes	T-90
Target and focus on Cabeus	15 minutes	T-75
Make dark and white flats	20 minutes	T-60
Retarget Cabeus. Sleep scope and camera	5 minutes	T-40
Break	20 minutes	T-35
Restart scope, retarget and warm-up camera before impact	15 minutes	T-15



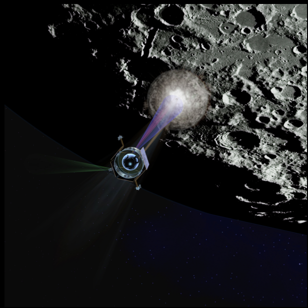
How to watch it live on a feed from the sat cam

- NASA TV on the internet
  - http://www.nasa.gov/multimedia/nasatv/index.html
- NASA TV on your local cable or dish provider
- LCROSS Team shepherding satellite cam internet feed
  - To be announced. See http://www.nasa.gov/mission_pages/LCROSS/news/index.html
- LRO will fly over the impact site “a few minutes” after the impact. Plans for LRO to contribute to the live LCROSS broadcast feed are not known.



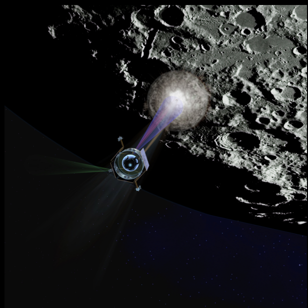
Kinematics

- During first 30 seconds, the ejecta curtain will vertically rise 5000 meters as it reaches maximum brightness.
- Vertical average speed:
  - 167 meters sec-1
  - 610 kilometers hour-1
  - 547 feet sec-1
  - 373 miles hour-1
- For period Impact +12 seconds to Impact + 30 seconds, the ejecta curtain will rise for 3000 meters above the crater rim.



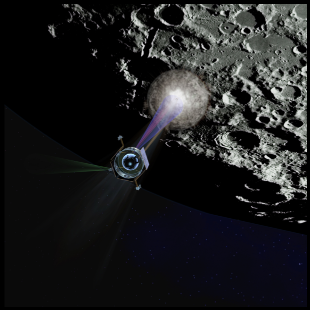
Kinematics

- A lunar occultation recording setup might be used to capture a video and audio time-stamped AVI file at 1/60 to 1/30 frames per second.
- Post impact the video recording can be analyzed by plotting time against the average pixel value for the area within Cabeus’s rim.



Kinematics

- Equipment – a very basic video with audio time stamp recording setup
  - LPI camera (Celestron NexStar LPI)
  - Laptop for video-audio recording
  - USB Audio-digital converter (Belkin)
  - Audio time signal source
    - Digital metronome (Ibanez)
    - Short-wave radio tuned to NIST WWW time signal (Radio Shack)



Practice imaging

- Exposure calibration can be practiced on any small crater near a limb and about 20 selenographic degrees from the terminator.
- Your objective is to take an image at high effective focal lengths and make sure a line profile across the bright surface going through the shadowed portion of a small crater is sufficient that your well capacity will pick up any changes in the shadowed portion of the crater.
- Be sure to open stored images and run a line profile. Do not rely on just eyeballing the preview window.
- The crater shadow portion of the line profile should be higher from the 0 well capacity point. That way, if anything happens in the crater shadow during the impact, you will pick it up.
- Any small crater near the limb and 20 selenographic degrees in longitude from the terminator will suffice. Since you are during a photometric exposure test, seeing and sharp resolution do not matter. Remember although the Moon is low now (Sept. 28) on the morning of the impact, it will be at about 70 deg alt for most of North America.

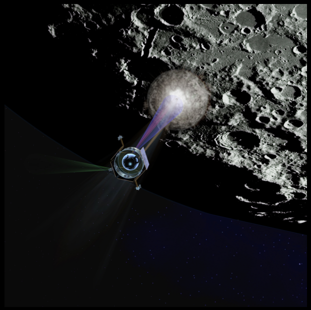
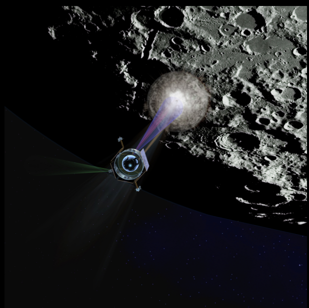


Image processing

- Image processing programs that support region-of-interest masking will probably be favored, e.g. Photoshop.
- That way a few selected crisp frames can be stacked, but the bright lunar surface and the shadowed portion of Cabeus can be gamma stretched separately.
- Note that Registax processing, by design, erases any changes between a series of registered images. E.g. – Registax "erases" dust donuts that drift across the stationary lunar surface background of a registered AVI recording.
- Registax also might digitally erase the ejecta curtain – a moving object – when processing an AVI file.
- A better strategy might be to hand review images and manually collect two or three crisp images that are within single second time frames.
- Stack and process those groups of two or three frames.
- Then assemble the result into an animated gif or in one time-series image using transparent layers.
- Difference image processing, which is normally applied to comets, might be a processing strategy to explore in this context.



Sharing your images

- The NASA LCROSS Citizen Science page is intended as a public gallery on which images from the global amateur community can be posted.

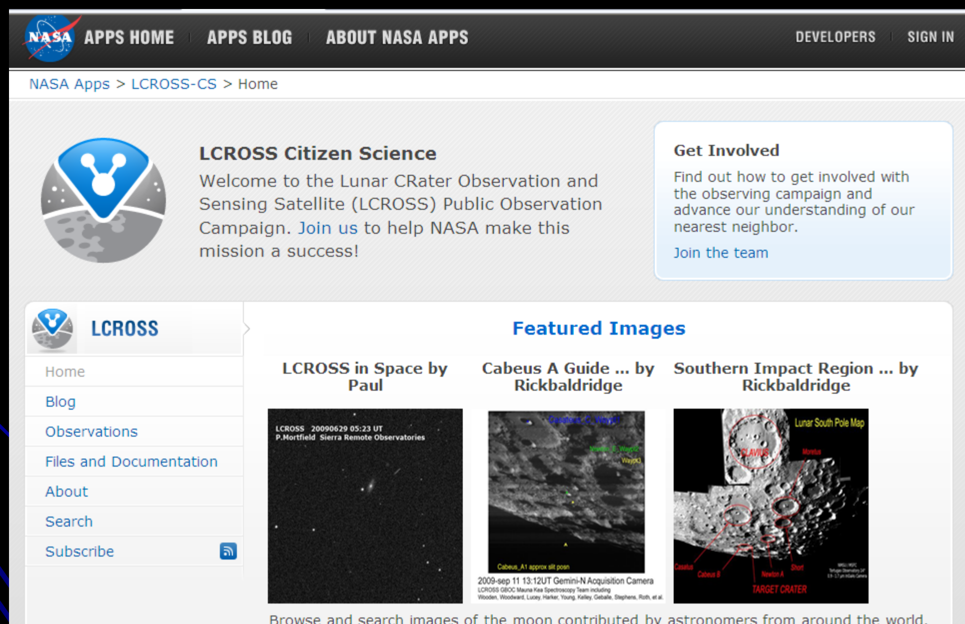
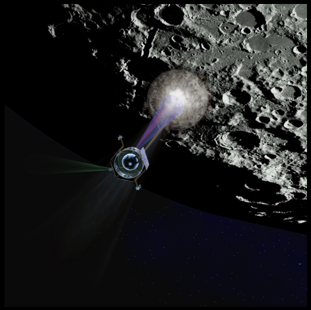


Image: LCROSS Team Citizen Science Page http://apps.nasa.gov/lcross/ (9-15)



Web links

- LCROSS Observation Group Finders page
  - http://groups.google.com/group/lcross_observation/web/finders
- Jim Mosher's LCROSS Impact Wiki Page
  - http://ltvt.wikispaces.com/LCROSS+Impact
- New Mexico State Univ. Tortugas Observatory LCROSS Site Finders (9-2009)
  - http://astronomy.nmsu.edu/rthamilt/LCROSS/media.shtml
- NASA LCROSS Citizen Science Site (9-2009)
  - http://apps.nasa.gov/lcross/
- LCROSS Team Observation Campaign Page
  - http://lcross.arc.nasa.gov/observation.htm
- Selenology Today No. 15 (Sept. 2009)
  - http://digilander.libero.it/glrgroup/selenologytoday15.pdf
- NASA LCROSS News and Info Page
  - http://www.nasa.gov/mission_pages/LCROSS/news/index.html