PitScan
Computer-Assisted Feature Detection

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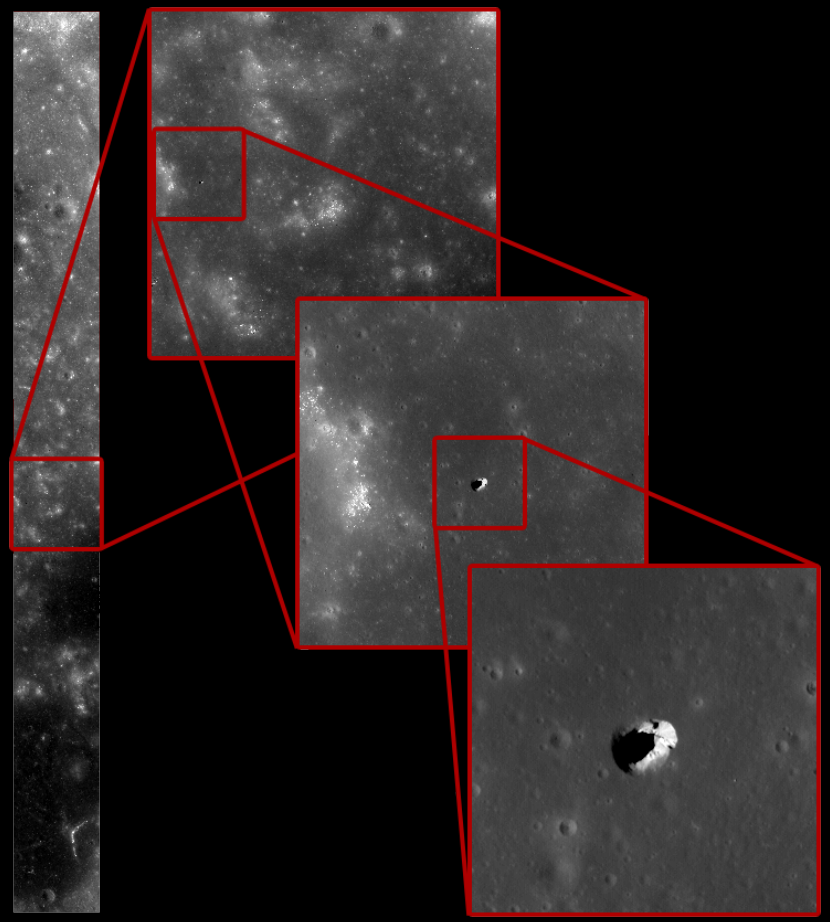
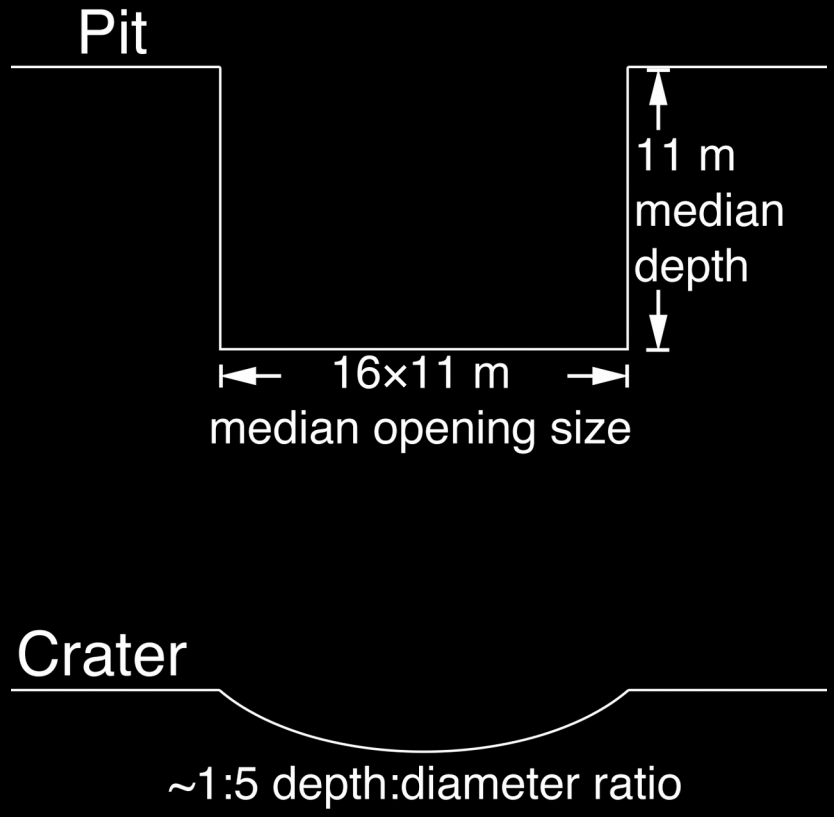
PitScan: What and Why

- PitScan: Automated program to detect potential collapse pits
- LROC NAC: Returns tens of gigapixels per day at 0.5 to 1.5 m/px



What is a pit? Why do we care?

- A “pit” on the Moon is a steep-walled collapse feature



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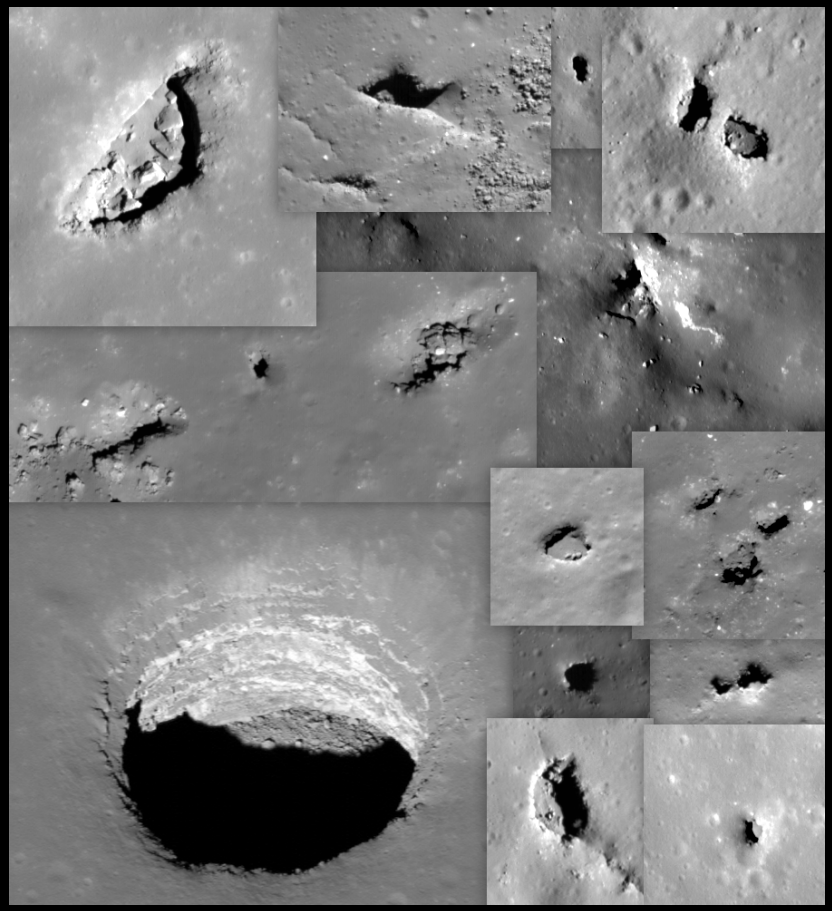
- A “pit” on the Moon is a steep-walled collapse feature
- We have found >300
  - <10 m to >150 m wide
  - Mostly in impact melt



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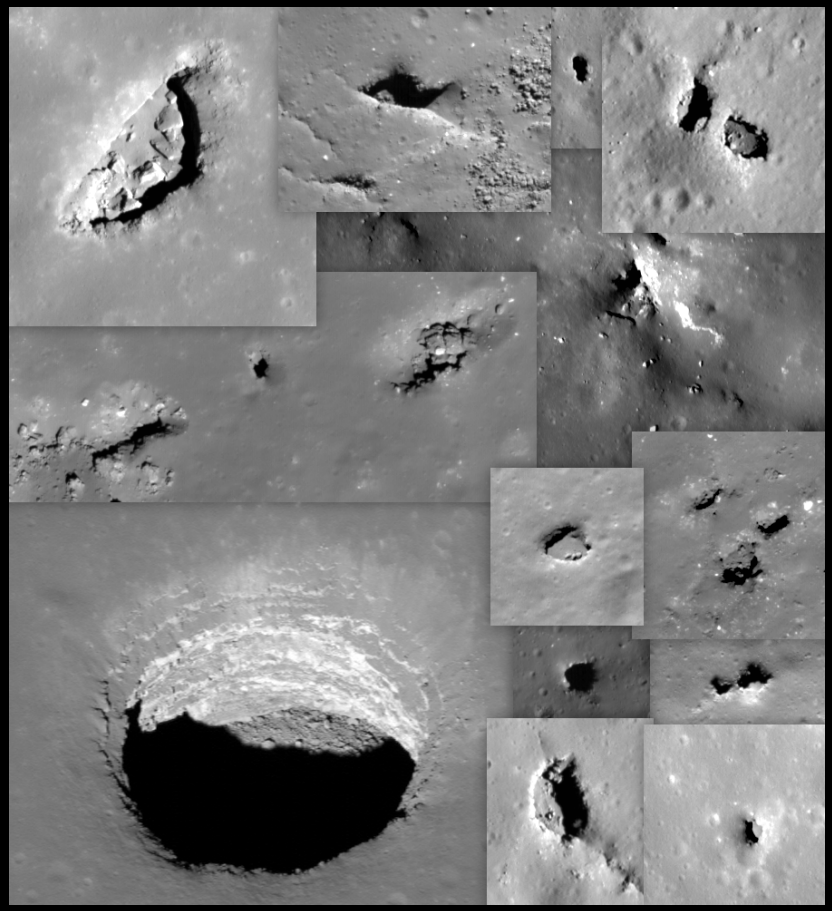
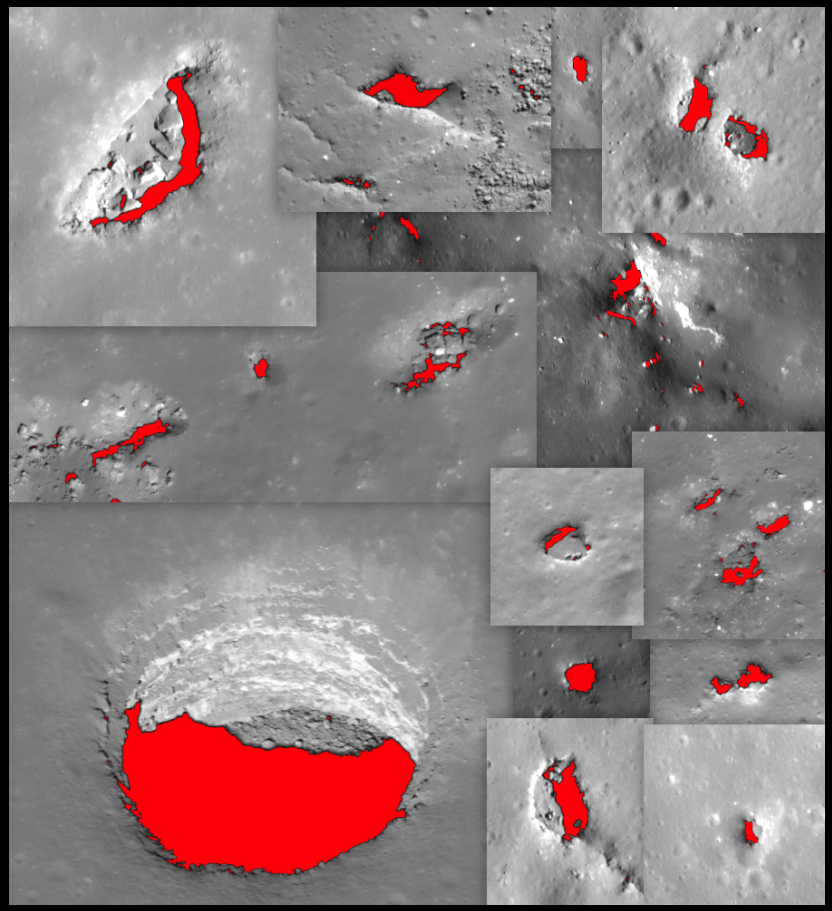
  - Mostly in impact melt
- Pits expose record of lava flows; could protect astronauts from radiation/meteorites

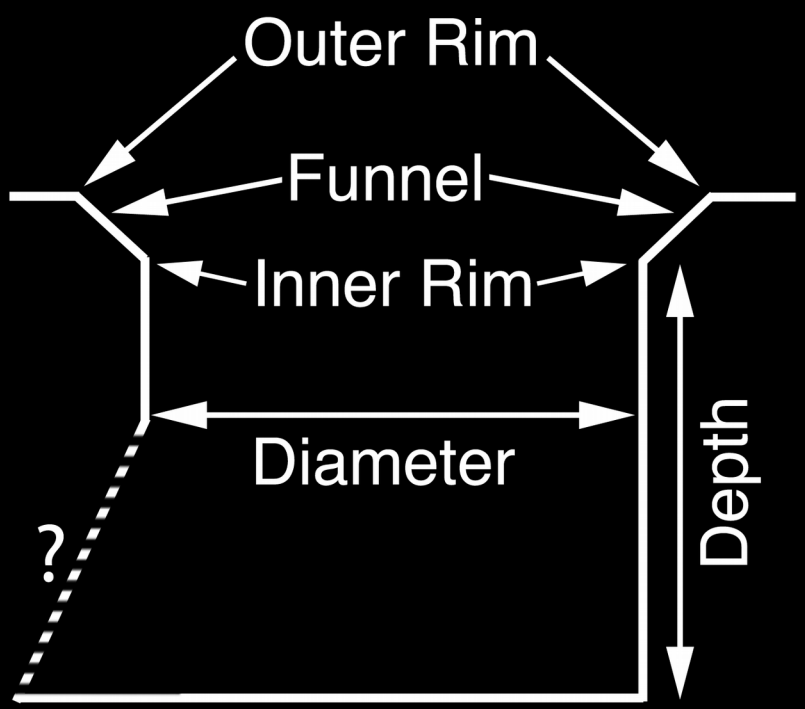


PitScan is fundamentally a shadow detector

- “Shadowed” value derived empirically from example pit images
- Based on image-wide mean pixel value
- Takes into account secondary illumination
- But other things cast shadows…

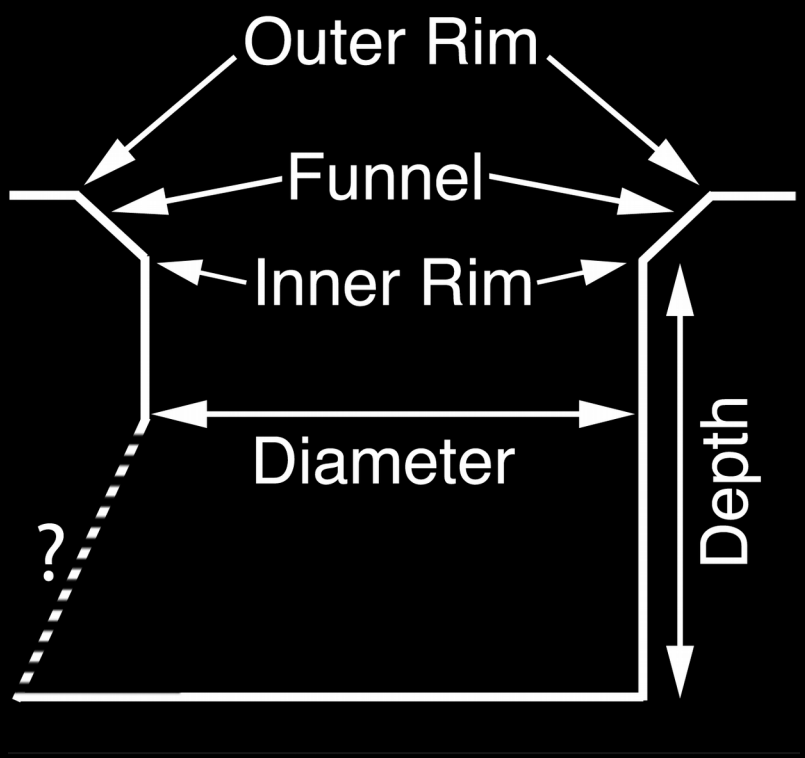


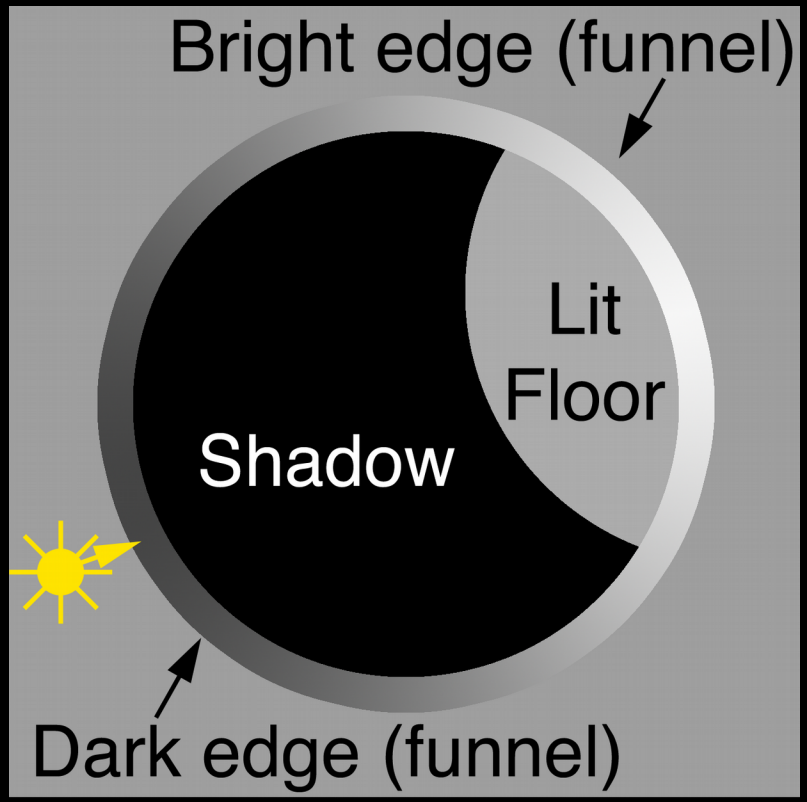
Pit Anatomy



- Central pit is surrounded by an inward-sloping funnel
- Floor is usually rocky, and younger/brighter than outside

Basic Theory: Pits have distinctive brightness pattern due to shape





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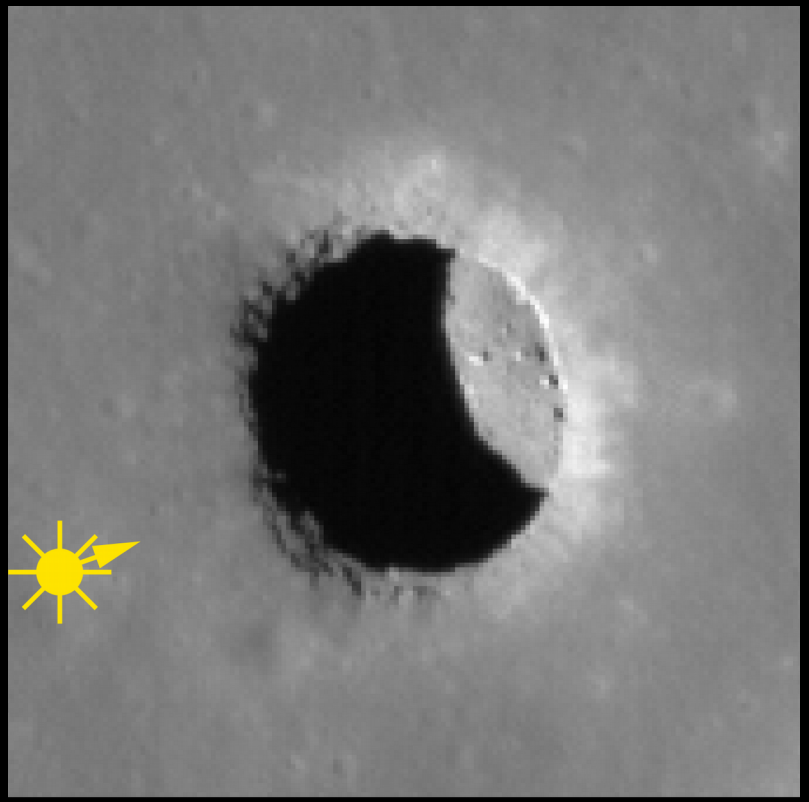
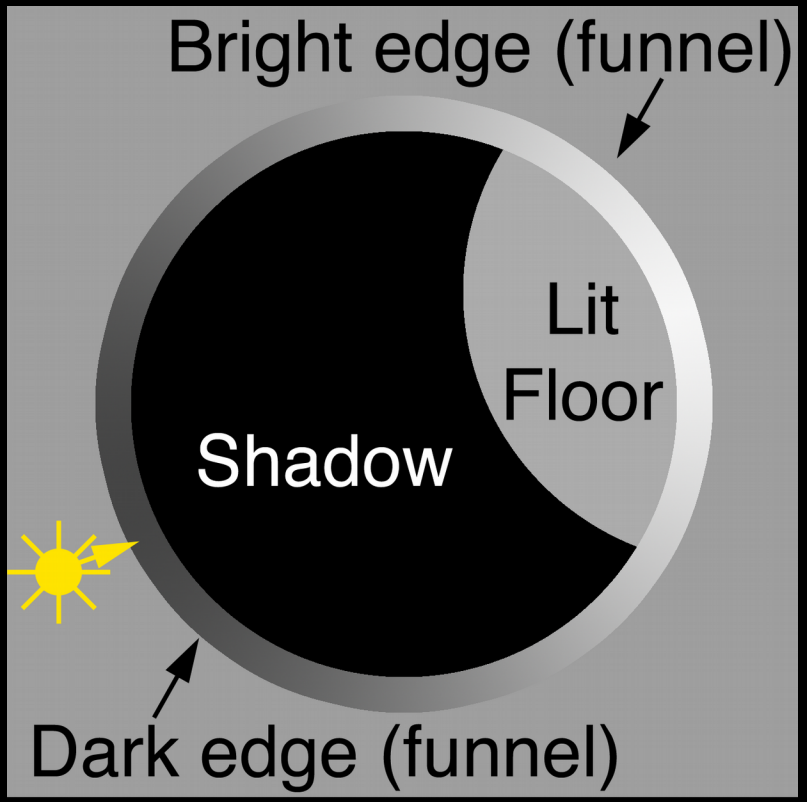
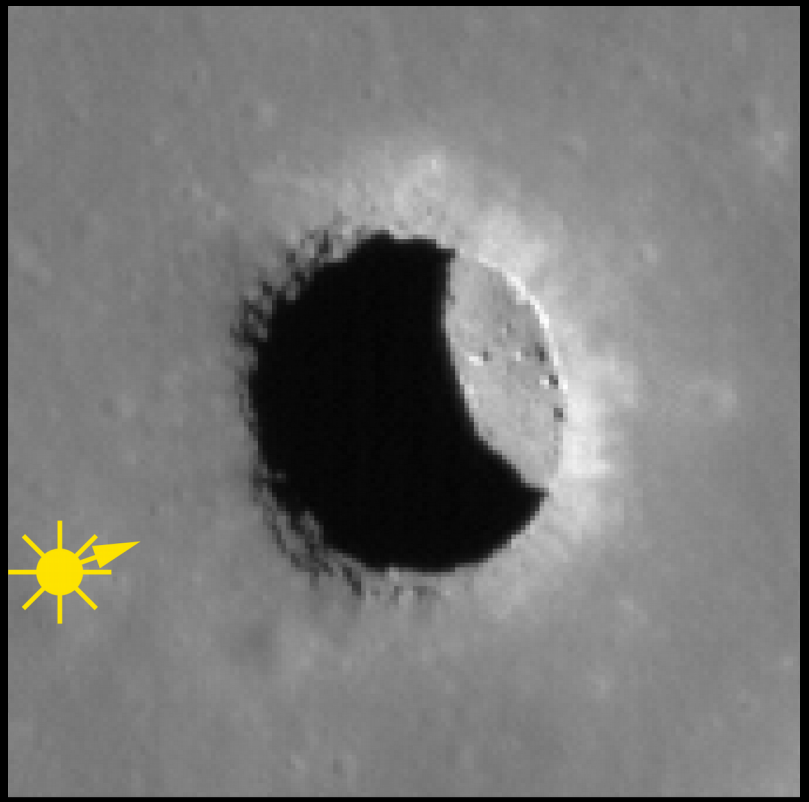
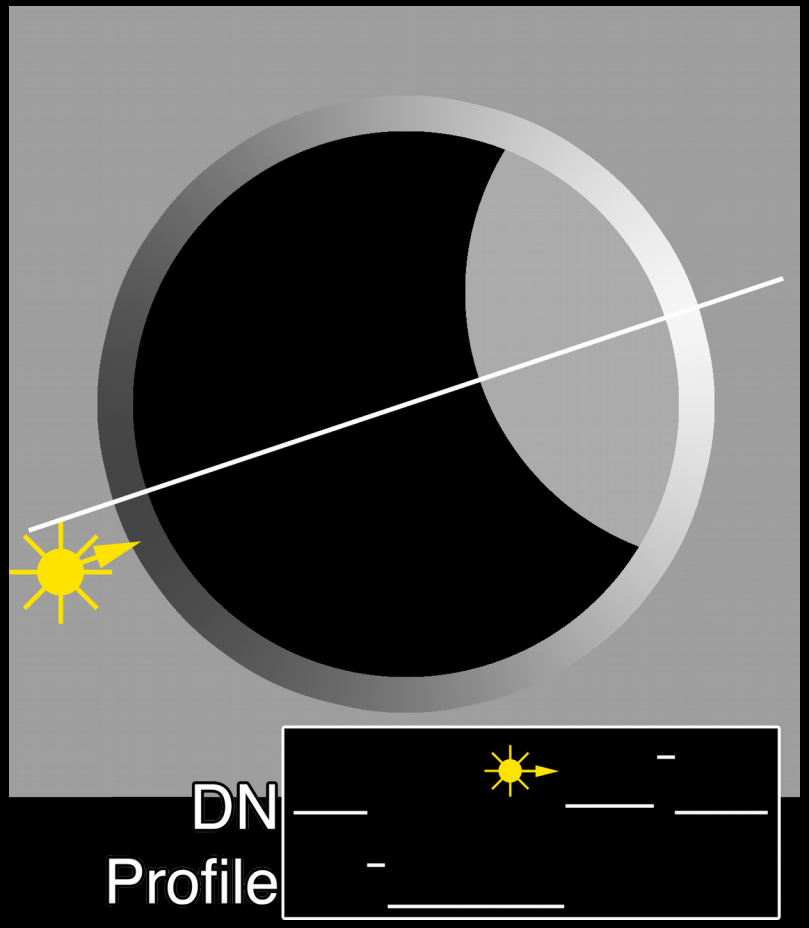




Basic Theory: Take profile of pixels in down-Sun direction





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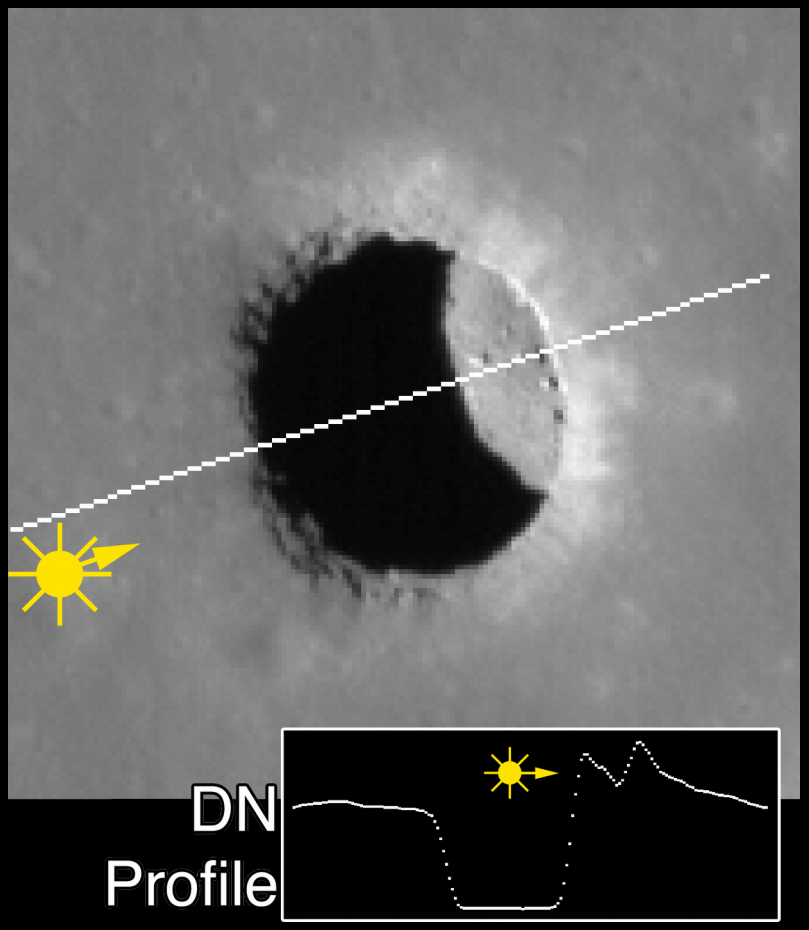
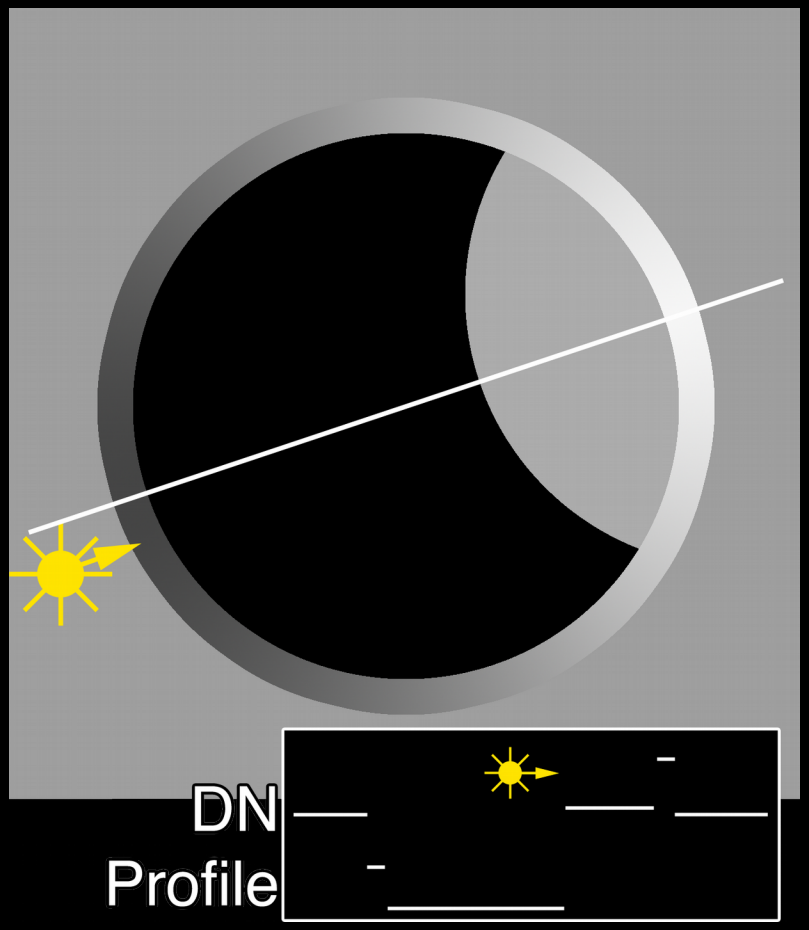
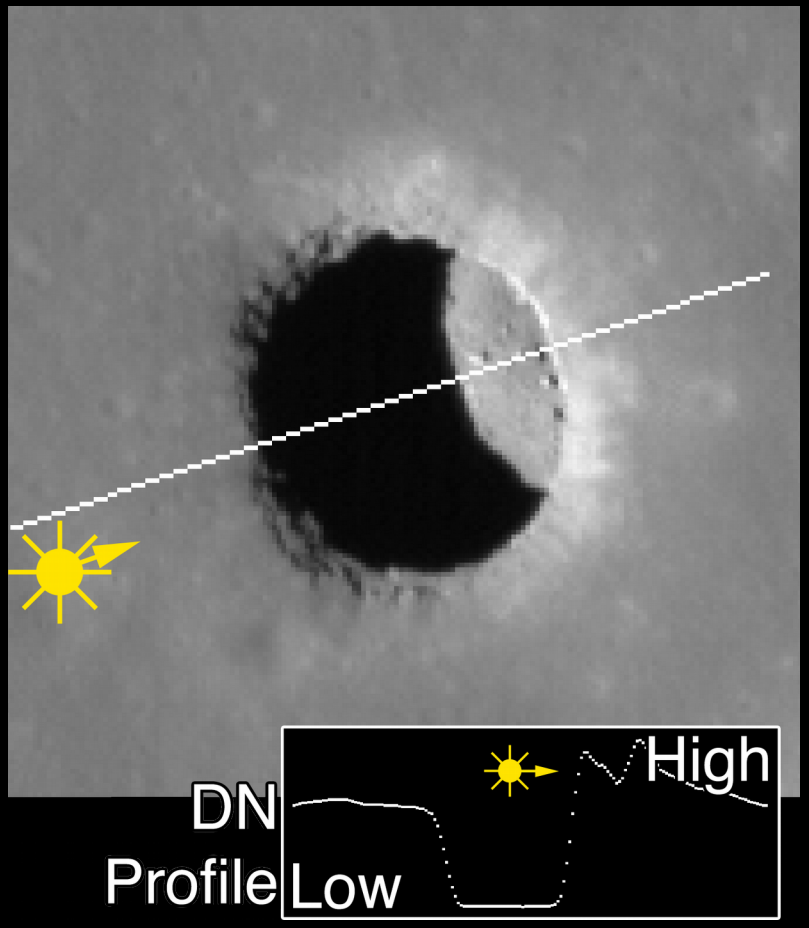
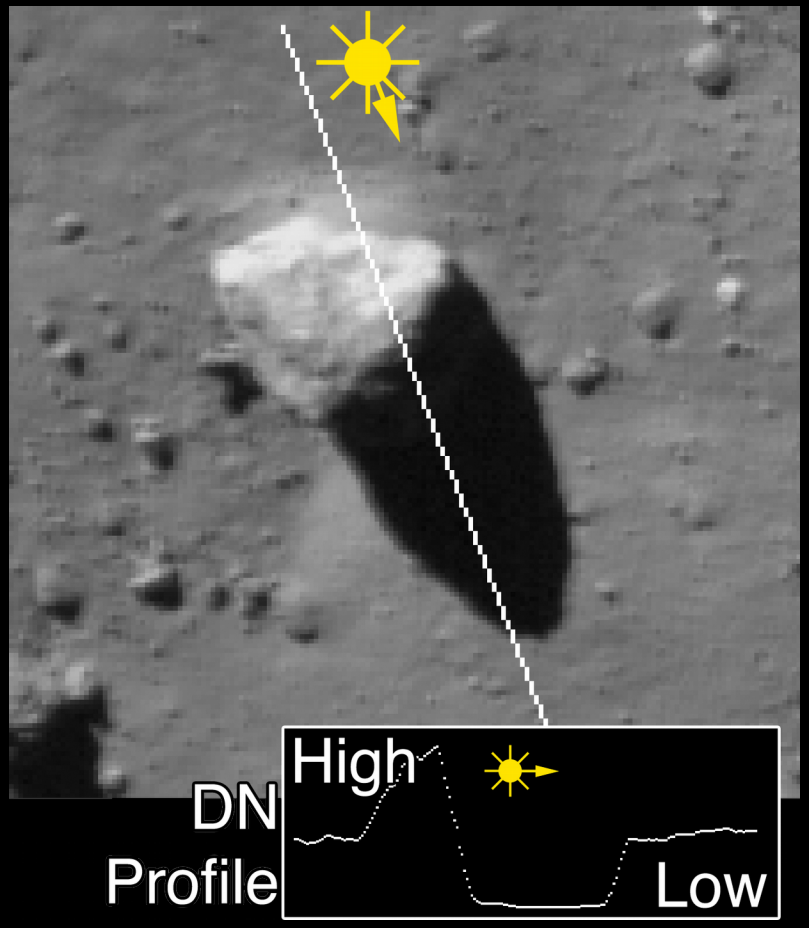




Basic Theory : Exclude rocks using up-Sun and down-Sun averages

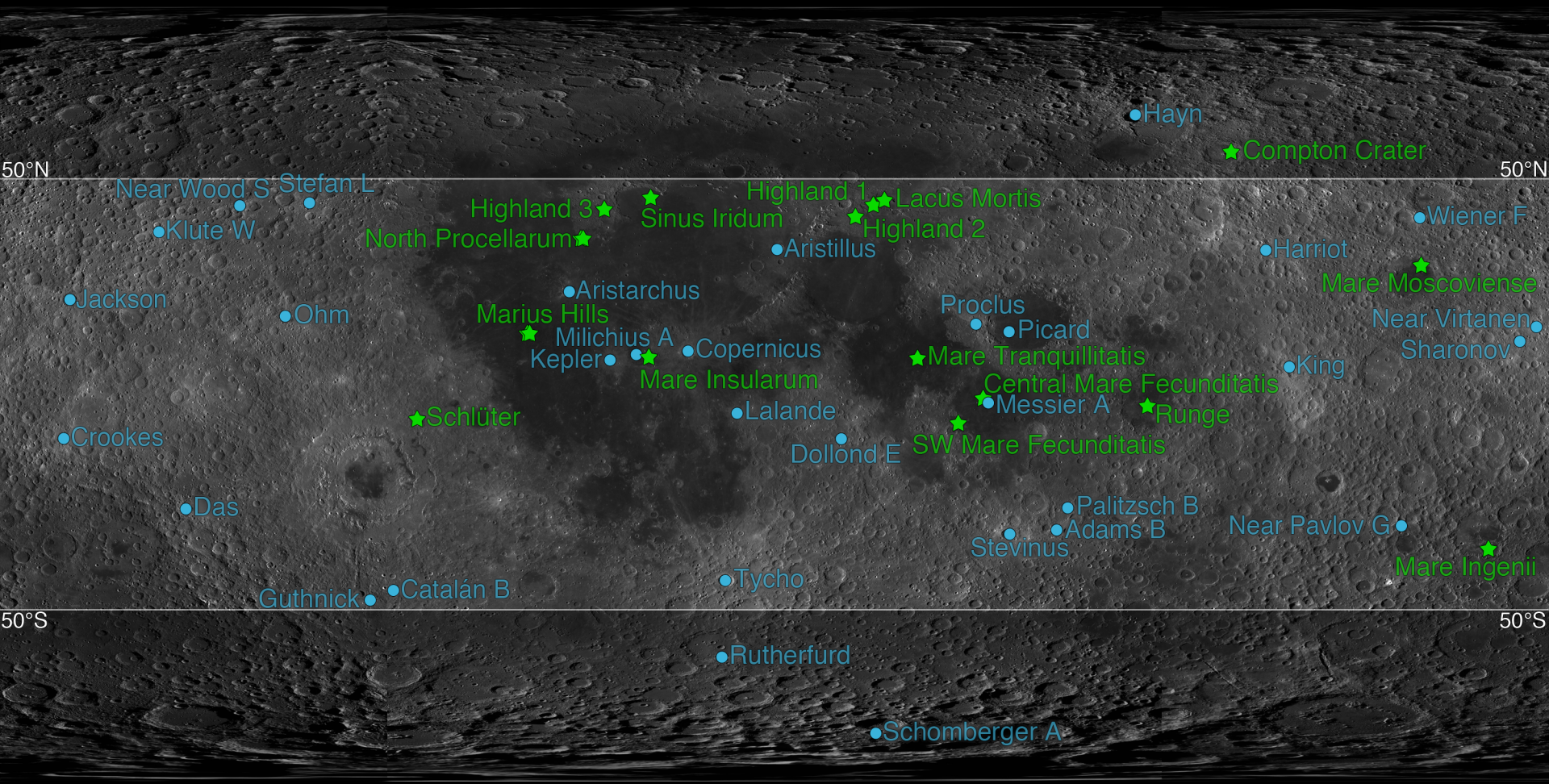




Restrictions and coverage

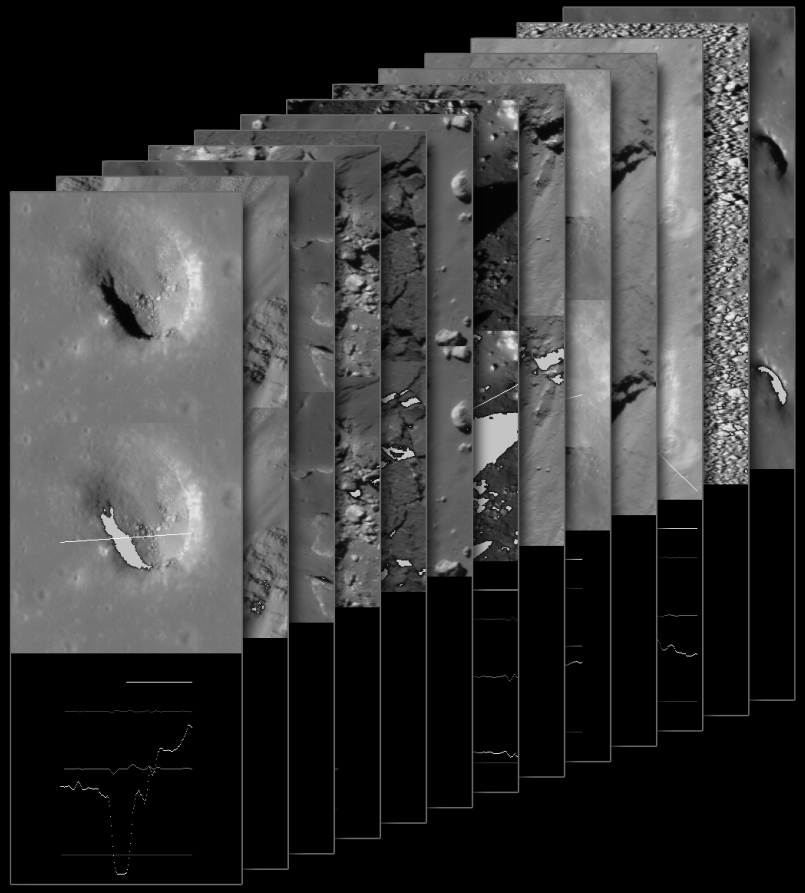
- Only works with sun >40° above horizon
- Searched ~23 million km^2
  - 61.3% of entire Moon
  - 79.6% of equatorial Moon (lat. < 50°)
  - >339,000 images
  - >73 trillion pixels

Results


Hayn
Compton Crater
50°N
50°N
Near Wood S
Stefan L
Highland 3
Sinus Iridum
Highland 1
Lacus Mortis
Highland 2
Wiener F
Klute W
North Procellarum
Aristillus
Harriot
Mare Moscoviense
Jackson
Aristarchus
Ohm
Marius Hills
Proclus
Picard
Near Virtanen
Milichius A
Kepler
Copernicus
Mare Tranquillitatis
Sharonov
King
Mare Insularum
Central Mare Fecunditatis
Messier A
Runge
Schlüter
Lalande
Crookes
SW Mare Fecunditatis
Dollond E
Das
Palitzsch B
Adams B
Near Pavlov G
Stevinus
Mare Ingenii
Tycho
Guthnick
Catalán B
50°S
50°S
Rutherfurd
Schomberger A

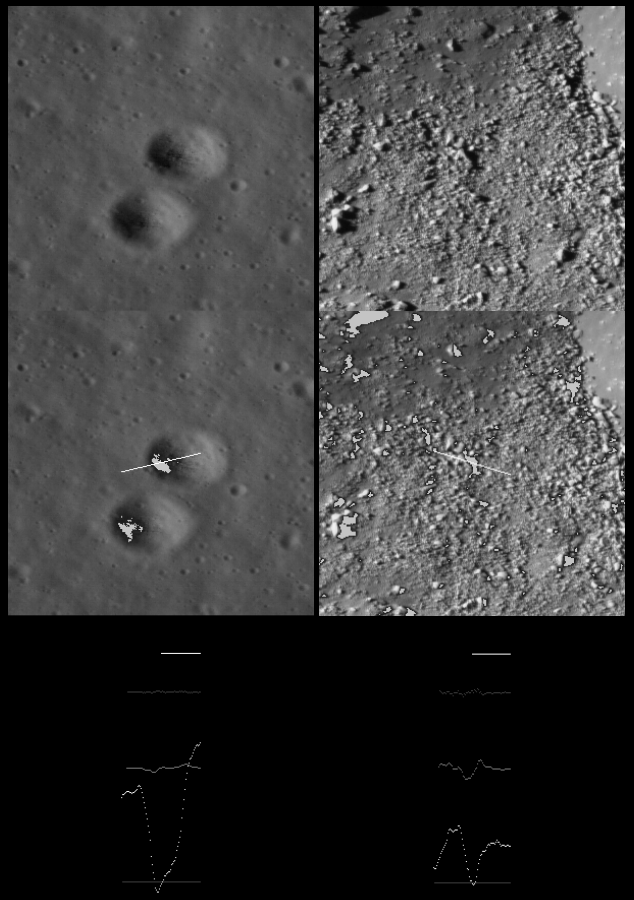
Time Taken

- Takes ~200 s/image
  - Including radiometric calibration, congested filesystem access
- On 600-core cluster, takes a few hours for 6 months of images
- Human takes a couple hours to sort output



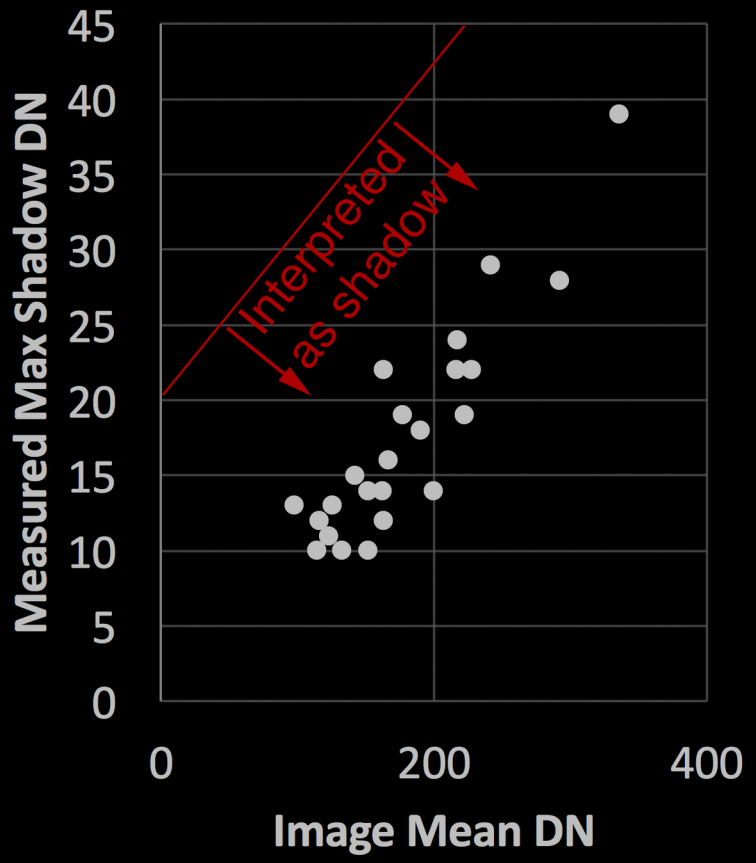
Some issues with accuracy

- >150 false positives per actual pit identification
  - Mostly craters
  - Mostly at lowest down-Sun/up-Sun ratios
- 55% false negative rate
  - Only found 45% of pits that should have been above pixel size cutoff
  - Did not control for incidence/shadow size



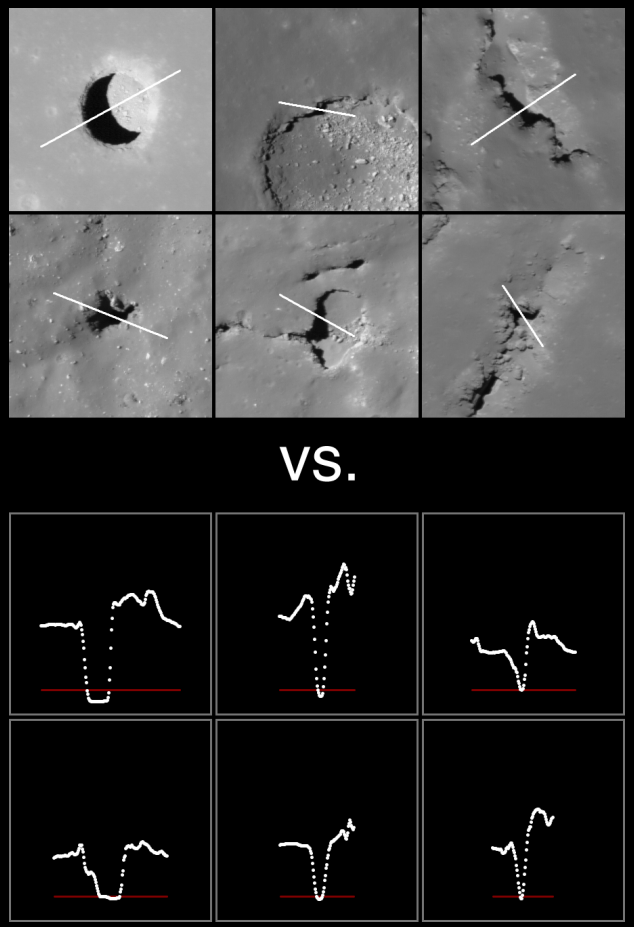
Future Work: Improved Shadow Identification

- Missed shadows seems to be main cause of false negatives
- Current method is equation based on mean image DN
  - Found no relation between shadow cutoff and phase/incidence…
- Machine learning?



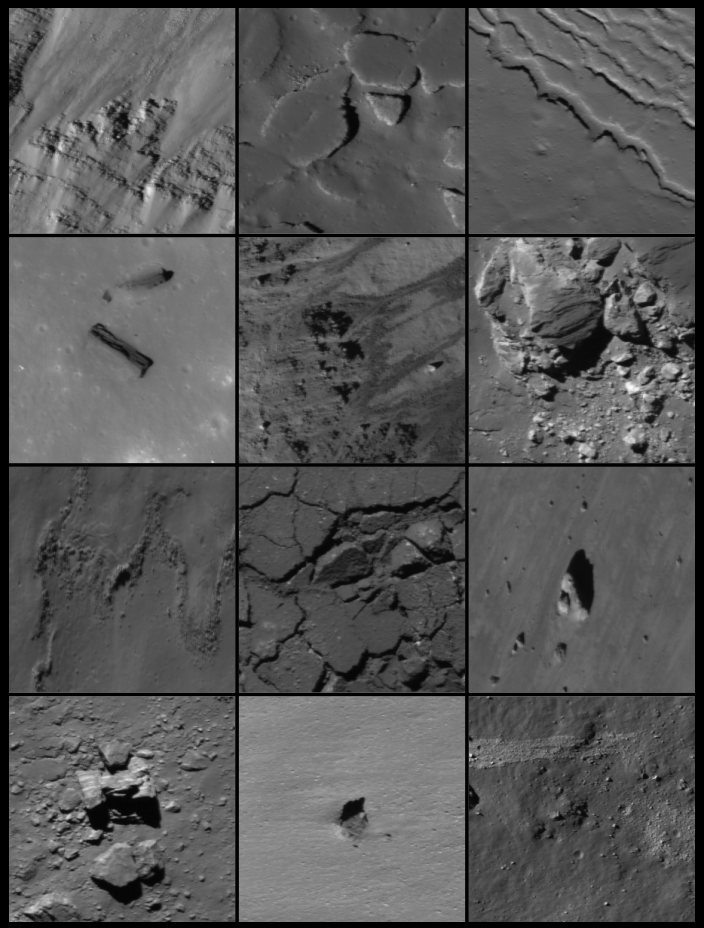
Future Work: Machine learning on DN profiles

- Profiles provide well-constrained input data
  - Wide variation in pit morphology might make direct vision-based ID hard



Benefits of high false positive rate

- Many non-pit results are still interesting
  - In last run, 1 in 30
- Perhaps best to focus primarily on reducing false negatives



Conclusions

- PitScan has worked well over the past ~7 years
- Simple filtering algorithm is effective
- Needs some improvements to avoid missing pits