Image Subtraction in Astrophysics

- adjust Point Spread Function for instrumental/atmospheric effects which otherwise mask physical changes in target of study

1) adjust PSF in images in different filter passbands* to allow inter-wavelength comparison (Ciardullo et al. 1990)

2) adjust PSF of images in time sequences to allow construction of light curves of variable sources (Tomaney & Crotts 1995)

*or polarization, or other variables for non-photons

Image 1

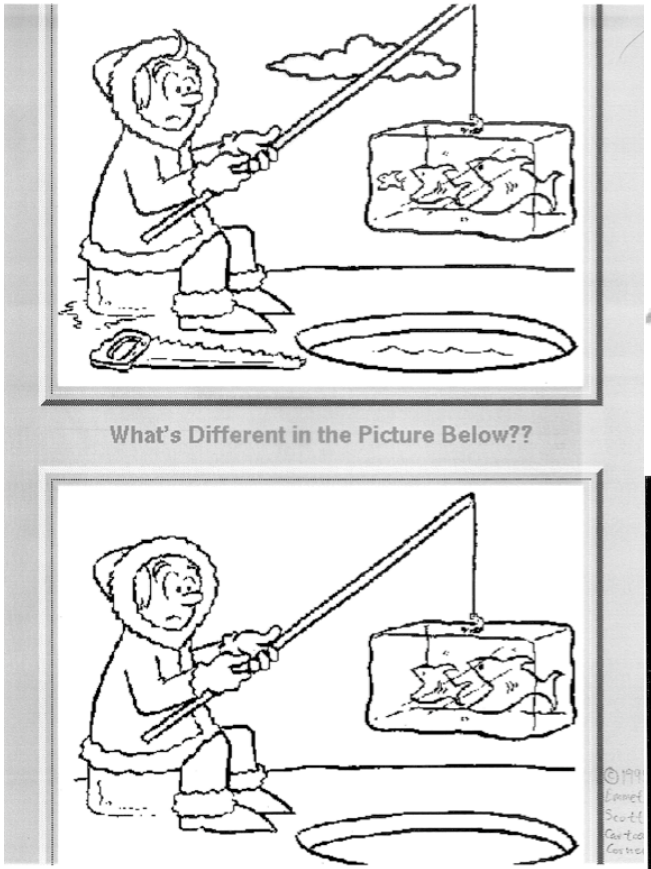
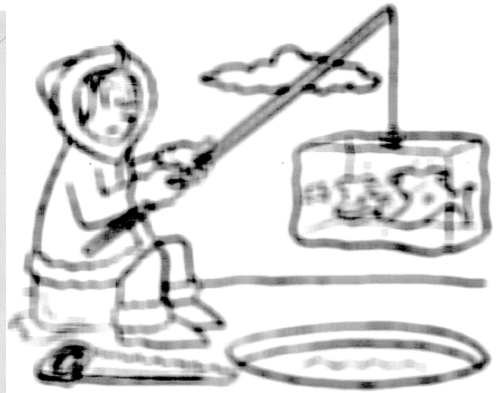


Image 2

Image 1 blurred



- Image 2

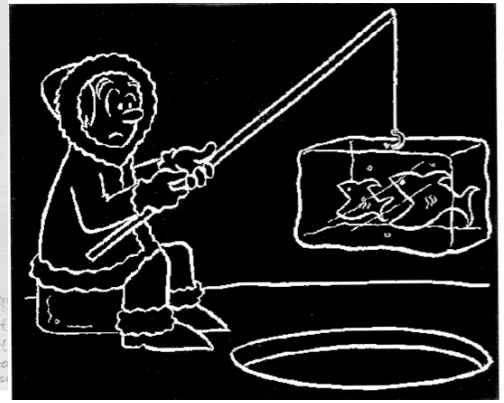


Image 1 blurred - Image 1

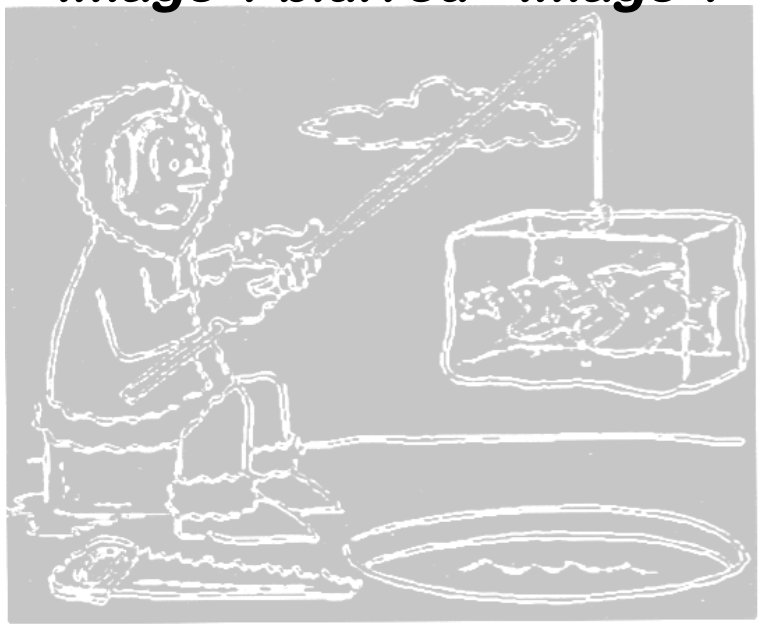


Image 1 blurred - Image 2

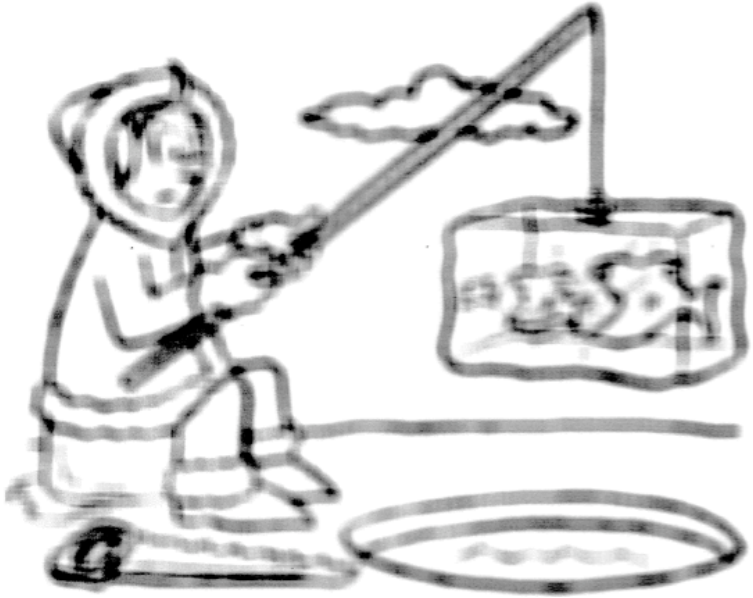
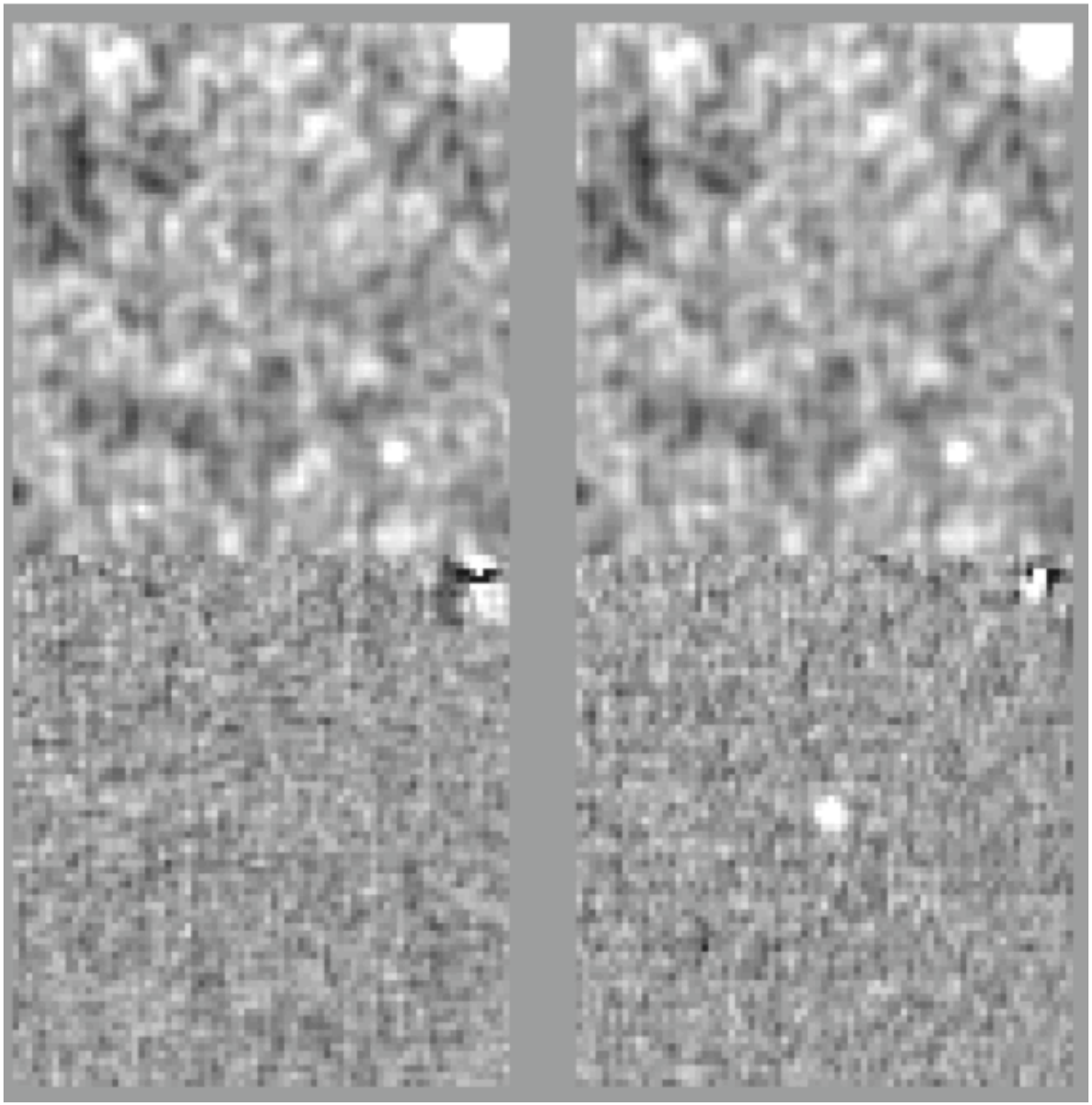


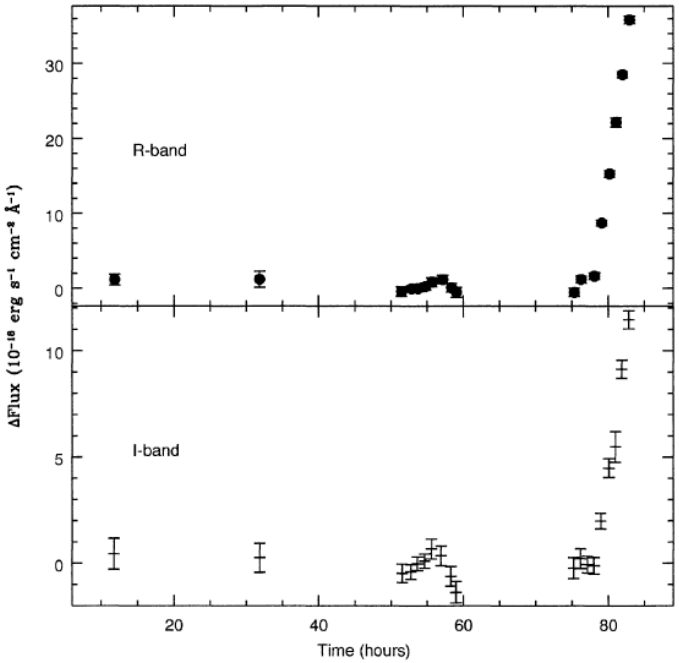
Image Subtraction Algorithms

First: register 2 images to same coordinate system and adjust photometric scaling so net photon counts equal

- ***Fourier quotient technique: construct convolution kernel by dividing transforms of 2 PSFs in fourier space and transform back to image space (Phillips 1990; difimphot - Tomaney & Crotts 1995)***
- ***Simultaneous least-squares fit: set of simultaneous equations relating pixel values in 2 images, plus convolution kernel. Solve for convolution kernel. (ISIS - Alard & Lupton 1998, …)***

Pre-nova Activity in M31

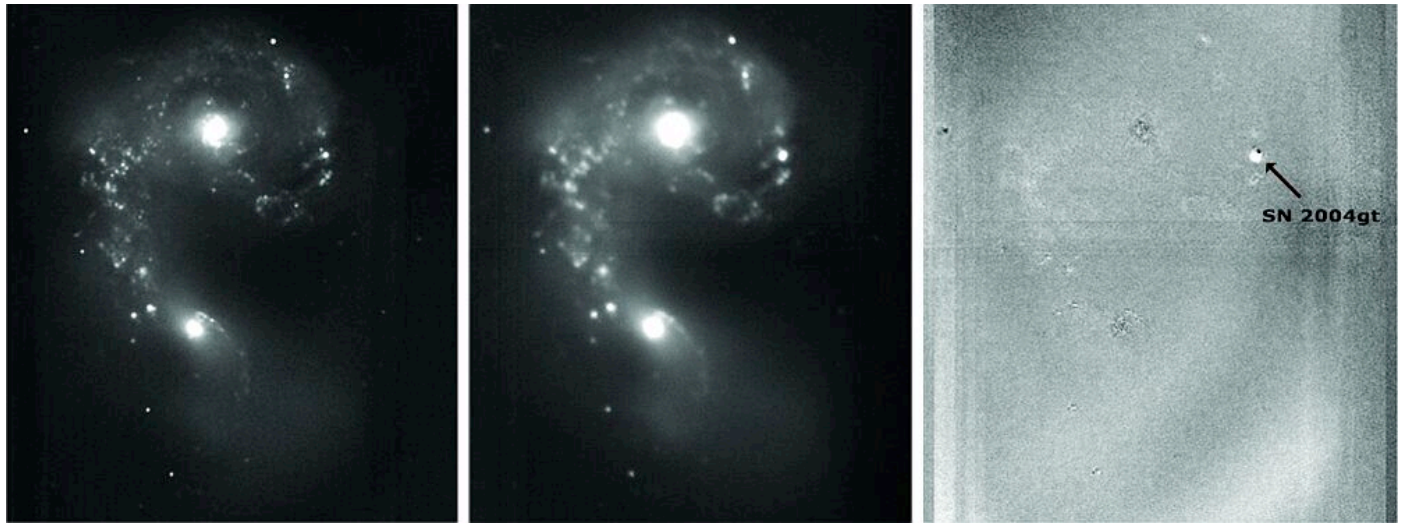


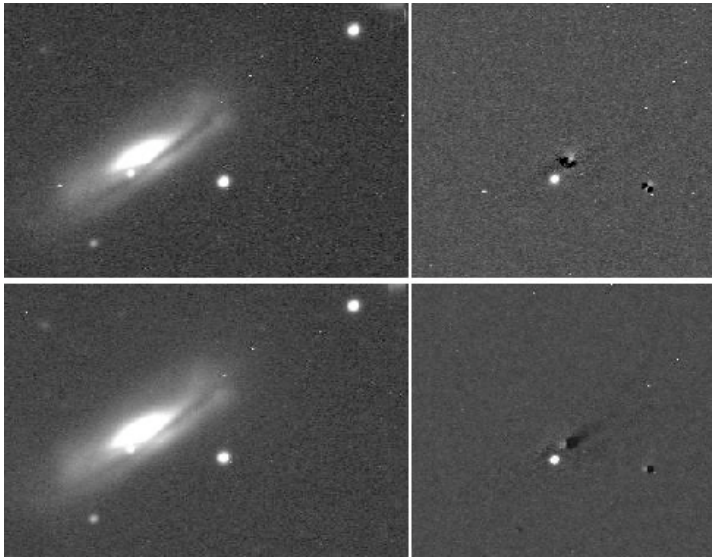


Time-series Image Subtraction (17 orders of magnitude distance)

- ***Supernovae & gamma-ray bursts***
- ***Light Echoes (transient reflection nebulae)***
- ***Gravitational microlensing***
- ***Variable stars***
- ***Planetary surfaces e.g., Moon, Mercury***
- ***(also can be used for measuring small proper motions via positional shifts)***

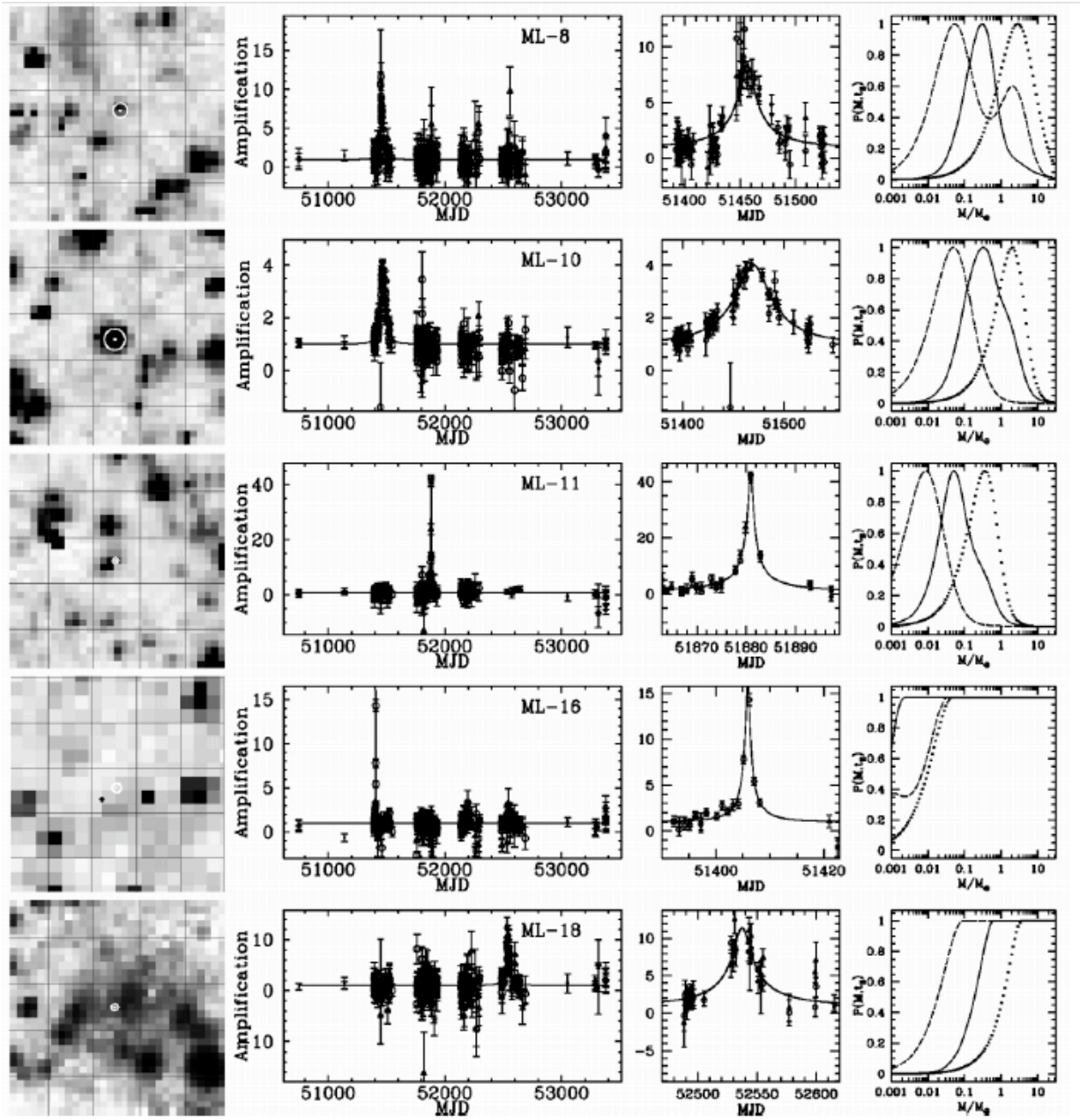
Distant Supernova Photometry





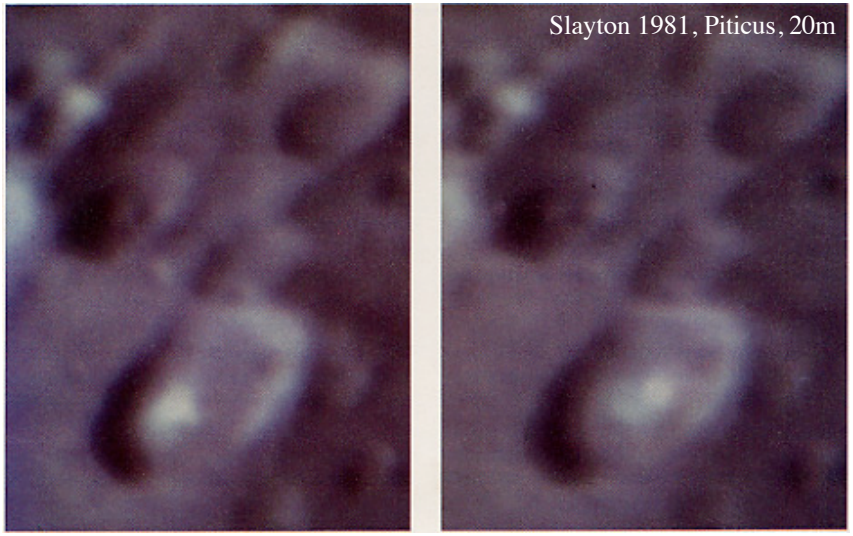
SN 2002bo

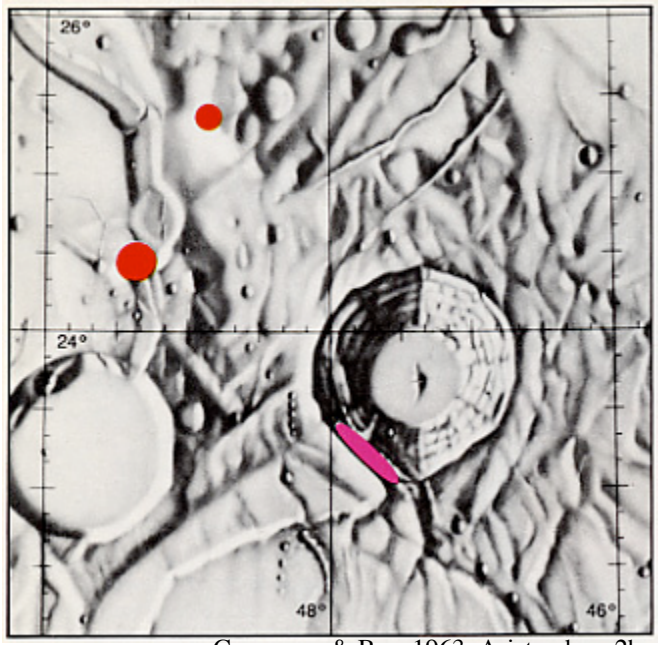
M31 (Halo?) Microlensing



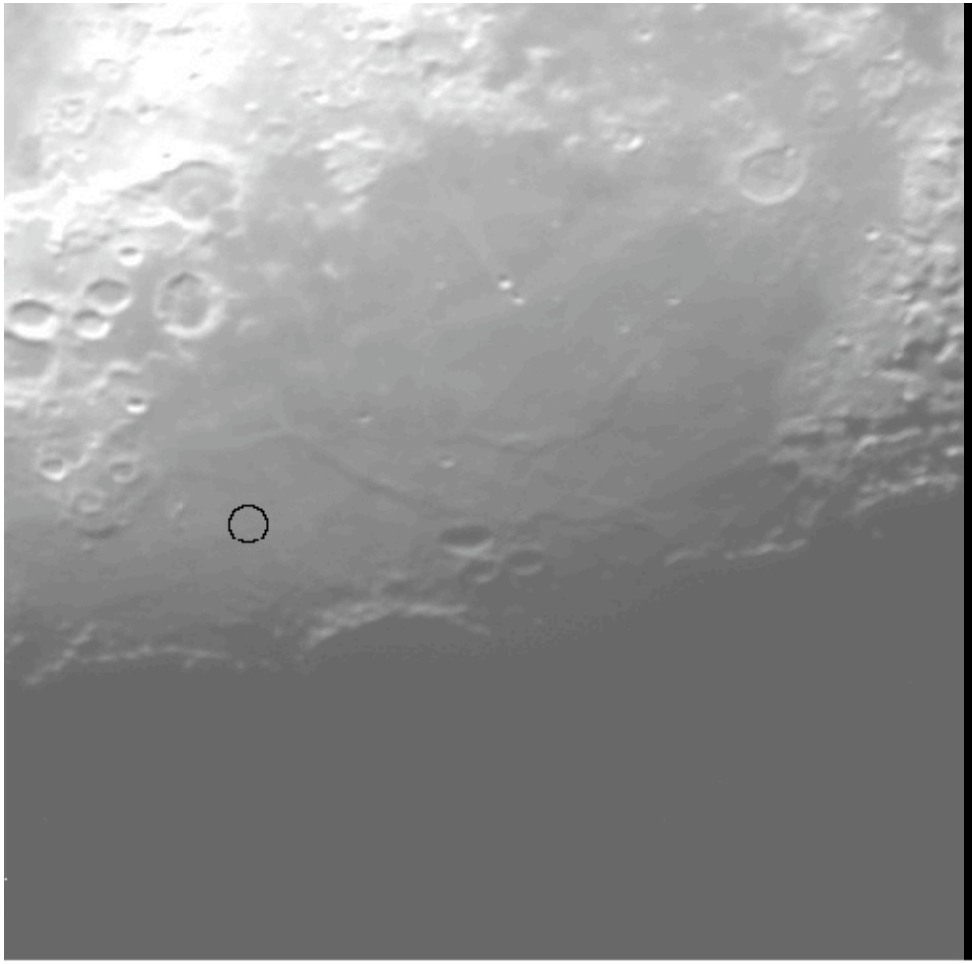
Transient Lunar Phenomena (TLPs)

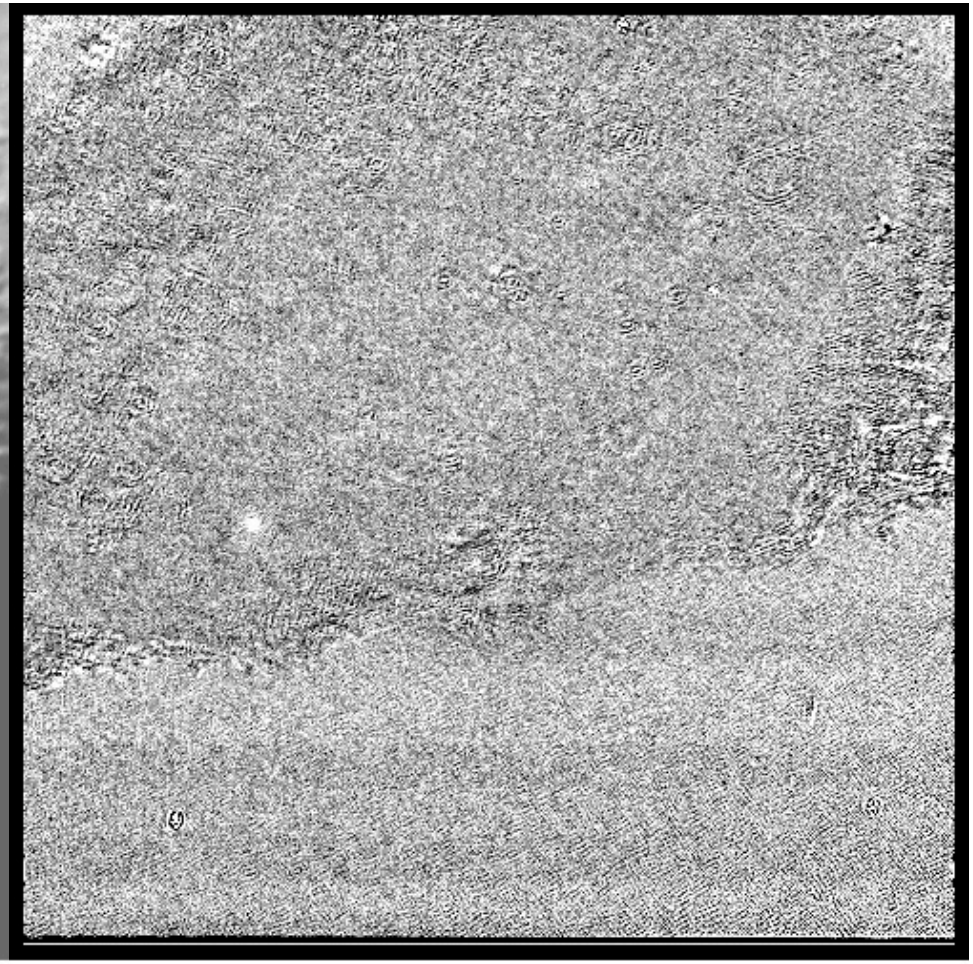
< 1 km to ~100 km across
~10 - 10000s duration
"brightening" "color change"
"obscuration" "darkening"
~1700 events (Middlehurst 1977, Cameron 1978, 2006)

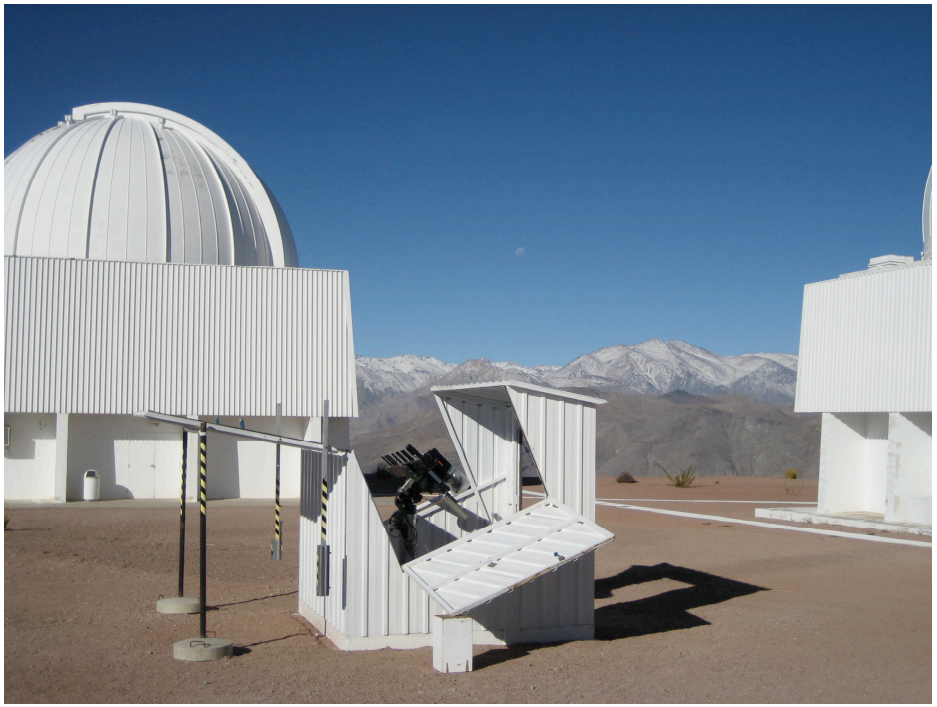




Greenacre & Barr 1963, Aristarchus, 2h



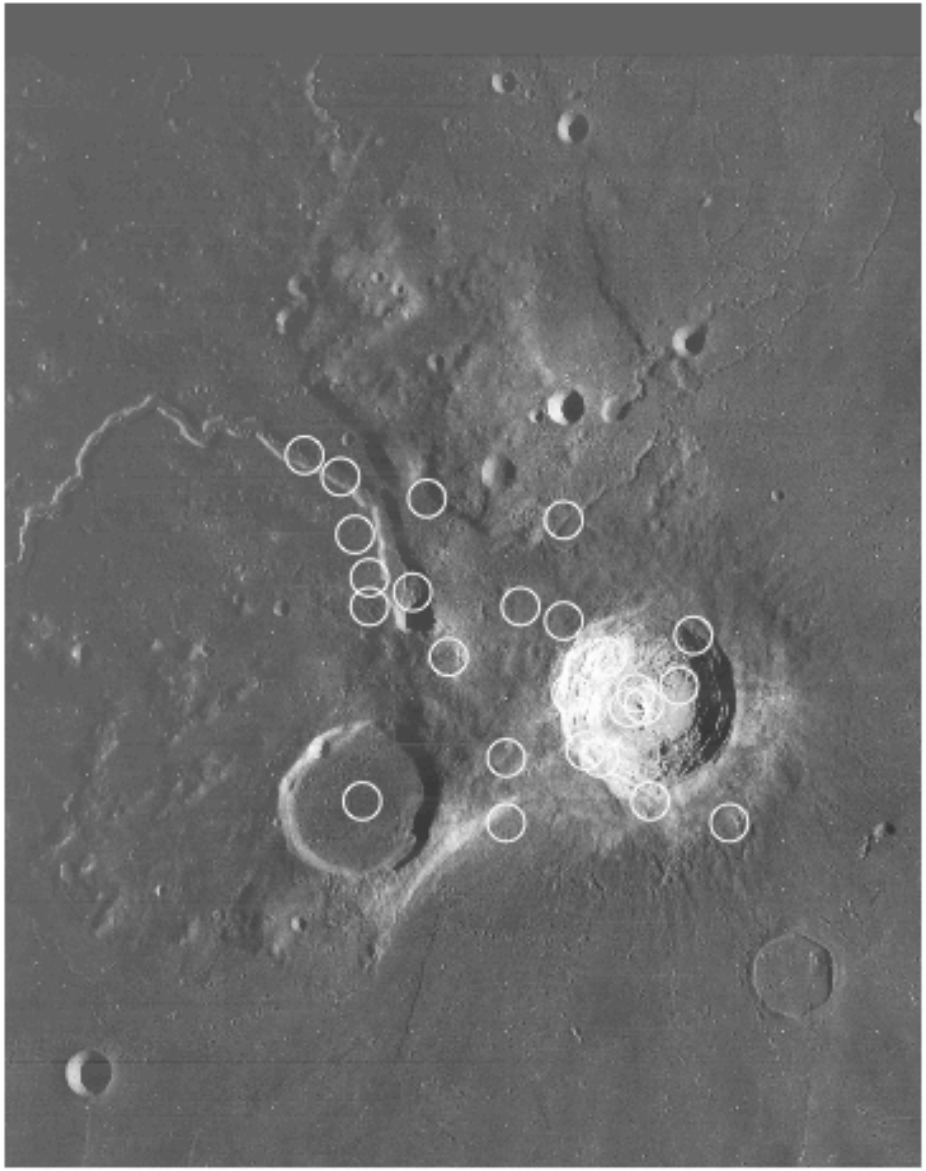




MEADE

5000
10000
15000
20000
25000

-400
-200
0
200
400
600



Current/Future Surveys using Image Subtraction

- ***Current microlensing/supernova surveys are producing << 1 Tbyte/night (SDSS II, III; MEGA,…)***
- ***Future surveys >> 1 Tbyte/night (DES, LSST, ALPACA,…)***
- ***Strong need for real-time processing for alerts on variable events to trigger followup studies***