

Lunar and Planetary Science Conference, March 16<sup>th</sup>, 2014

COMMUNITY USER WORKSHOP  
ON PLANETARY LIBS (CHEMCAM)  
DATA

# The ChemCam Remote Micro-Imager (RMI)

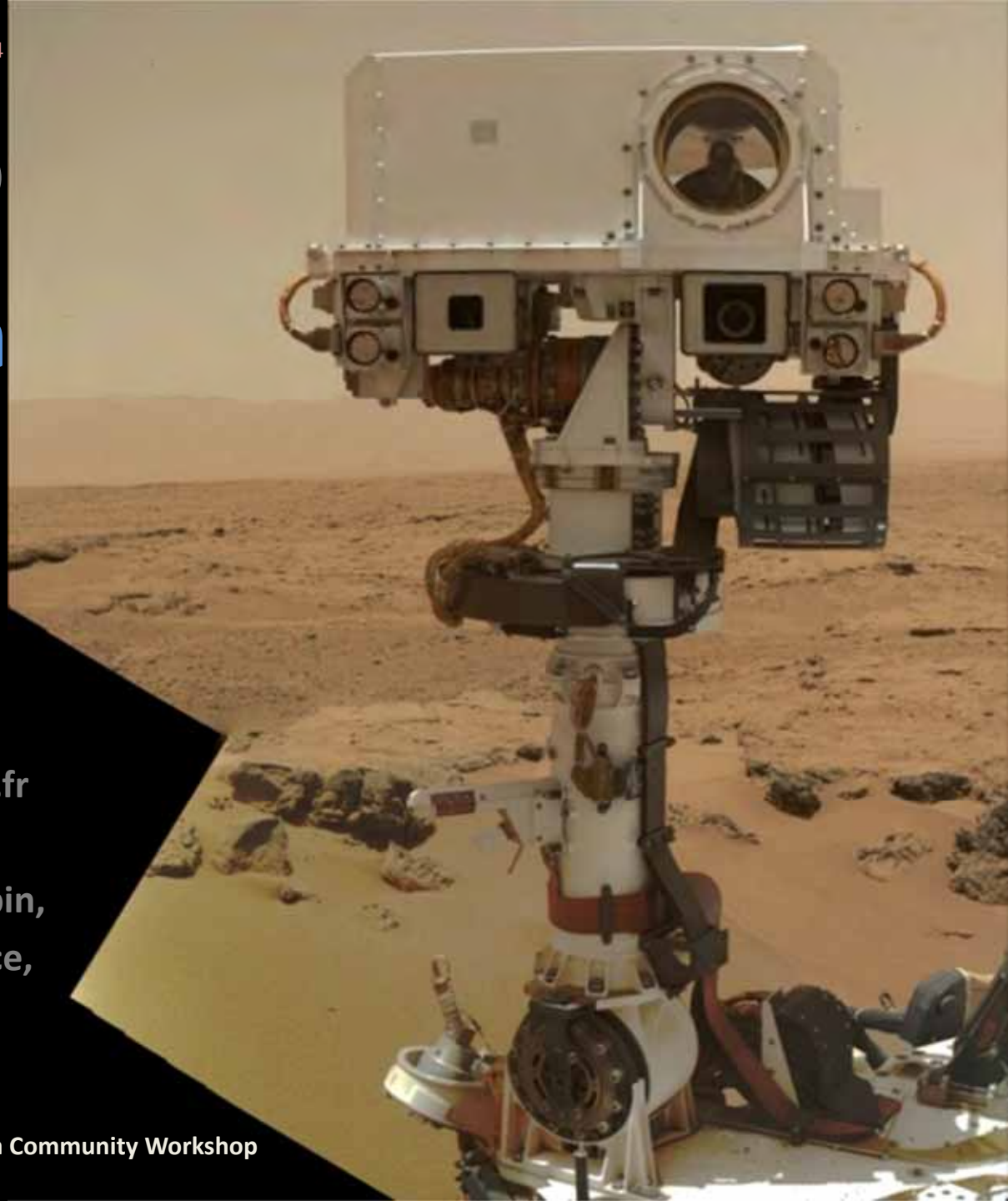
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and the ChemCam Team

16 Mar 2014

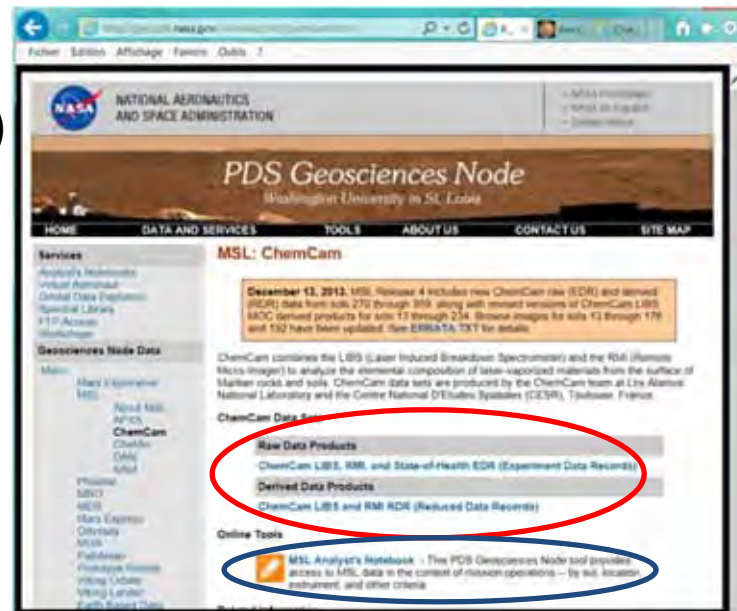
ChemCam Community Workshop



## Access to the RMI data

(see details in the presentation by N. Lanza)

- Raw image:
  - Filename: CRO\_\***EDR**\*.IMG
  - ASCII header and binary data
- Processed image:
  - Filenames: CRO\_\***PRC**\*.TIF and .LBL
  - TIFF image with separated labels  
(little endian, image scaled on unsigned 16-bit entities)
- Raw and Processed images are available on the PDS website and on the Analyst Notebook website
  - <http://pds-geosciences.wustl.edu/missions/msl/chemcam.htm>
  - <https://an.rsl.wustl.edu/msl/mslbrowser/default.asp>
- Image mosaics:
  - Filenames: CRM\_\*\_**Target\_Name**\*.PNG
  - Include annotations and pit localizations
  - Available on the ChemCam website at:  
<http://results.msl-chemcam.com>



- ~1600 raw full-frame images available up to Sol 449

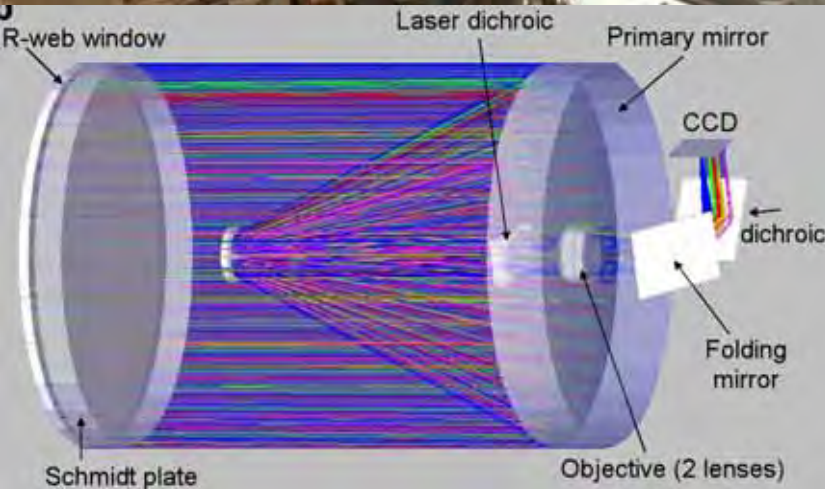
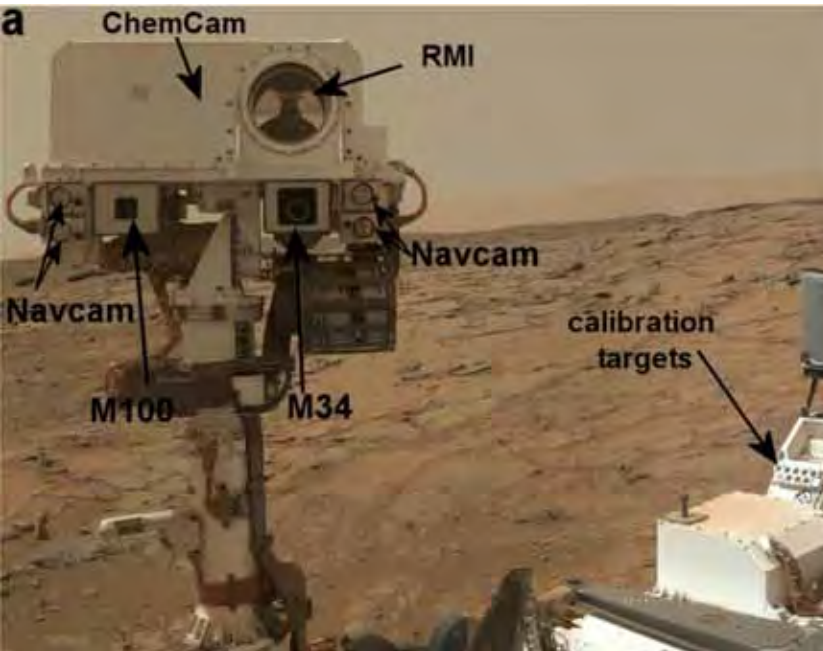


- 345 mosaics available up to Sol 349





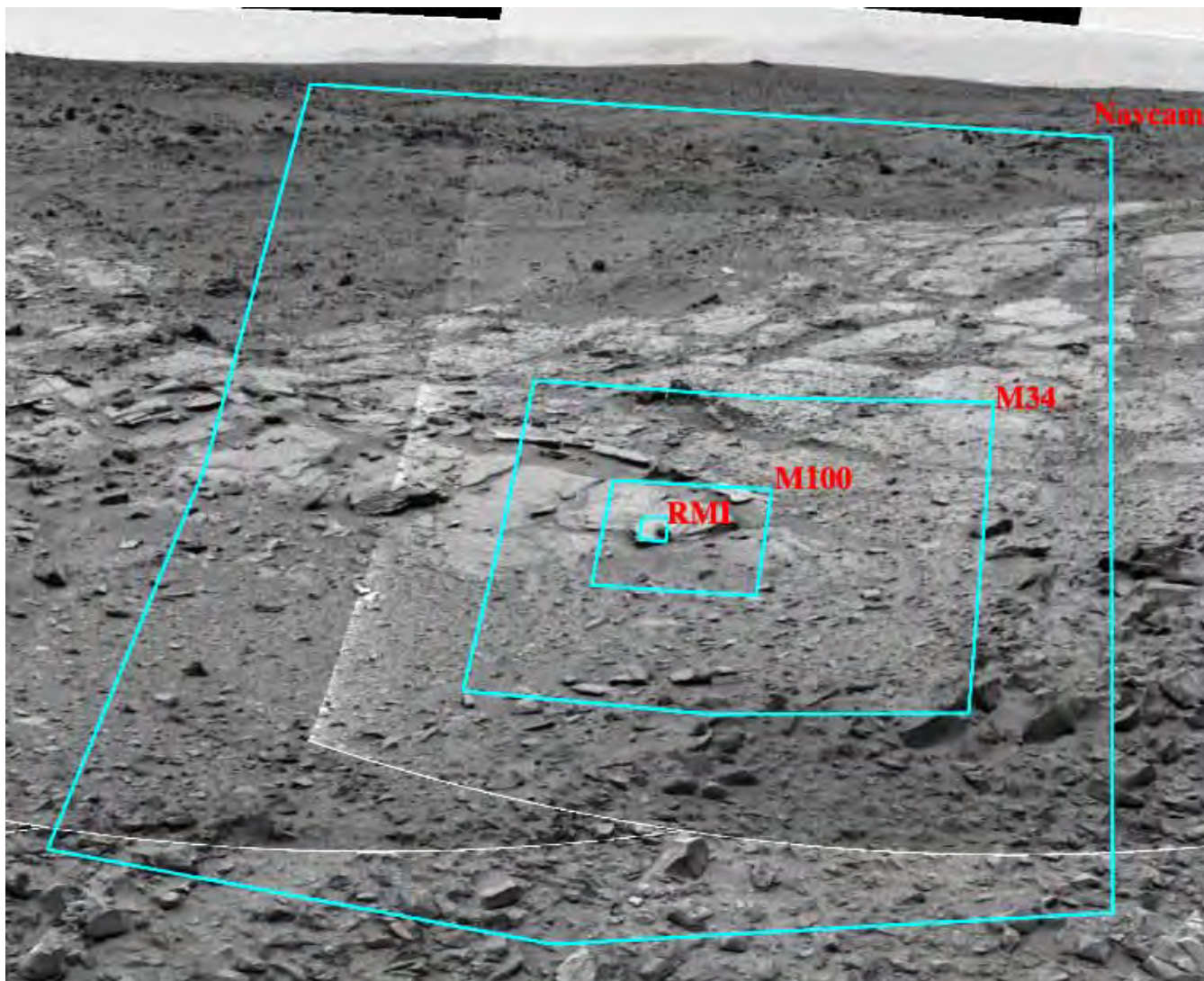
## RMI Description



- Co-aligned with the other mast-mounted cameras, though the point of view is slightly different.
- A Schmidt Cassegrain telescope dually used for laser and imaging (compromise design).
- Among the highest spatial resolution of the imagers on board.

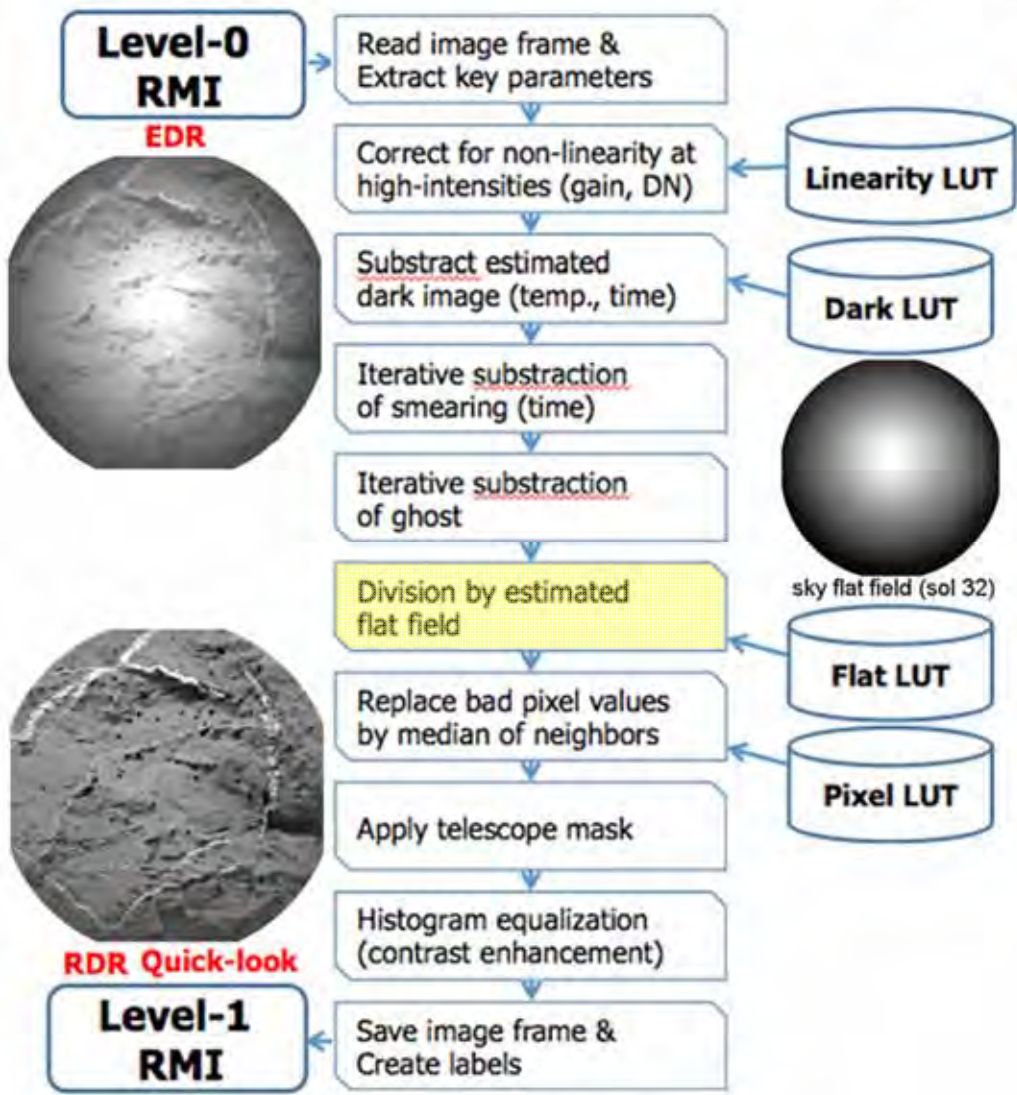
<b>Aperture</b>	110 mm
<b>f/</b>	4
<b>Focus Range</b>	1.2 m to infinity
<b>Detector size</b>	1024x1024 useful pixels of 14x14 $\mu\text{m}$
<b>Pixel scale and resolution</b>	19.6 $\mu\text{rad}/\text{pixel}$ (resolution of 2 pixels, i.e. $\sim 80 \mu\text{m}$ at 2 m, 4 mm at 100 m)
<b>Field of view</b>	20 mrad (1024x1024 useful pixels)
<b>Wavelength range</b>	240-900 nm (panchromatic)
<b>Exposure range</b>	2 ms – 65 s
<b>MTF at Nyquist</b>	0.10-0.44
<b>Radiometric precision</b>	10 bits/pixel
<b>Depth of field</b>	$\sim 2 \text{ mm}$ at 2 m; 1.2 cm at 7 m
<b>SNR</b>	$>200:1$ for well-exposed images

## Field of view: the narrowest



(approximate relative sizes and locations of the mast cameras projected on a NavCam mosaic)

# Partial Radiometric Corrections (PRC)



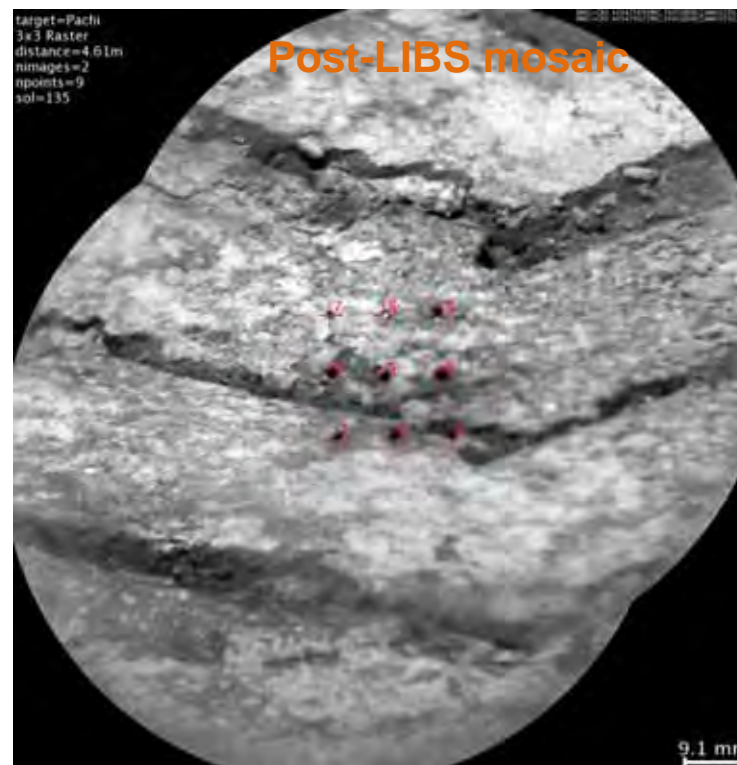
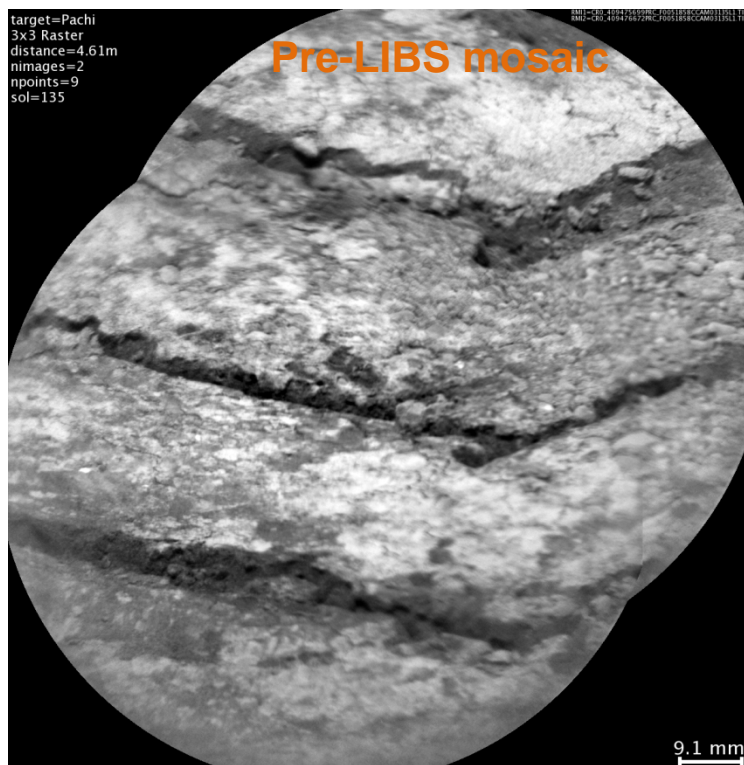
\*LUT: Lookup table

- The first objective of these products is the provide **high-resolution context images** of the laser pit localizations;
  - But the quality of each image make it a science product by itself. ←
- The default processing does not apply a full radiometric calibration, and does not necessarily preserve the original dynamic of the raw image.
- The current processing uses a flat field estimate derived for a focus position at 2m;
  - The team is working on getting more flight data to correct this effect more accurately.
- **This processing pipeline will improve in the future. Check for updates!**

## Before/After: Localization of laser pits and mosaics

- Context for LIBS shots, with images taken **before and after** laser shots
  - Default activity: RMI image, LIBS spectra (raster), RMI image;
  - The spacing between two successive images is chosen to cover the LIBS area in both images.
- LIBS and RMI are boresighted (same optics), therefore the laser position in the image is known.
- Custom mosaics can be computed using a stitching software such as **Hugin** (free), **Image Composite Editor** (free), **Photoshop**, or **Ptgui**, or they can be directly found in **ChemCam's website**
  - <http://results.msl-chemcam.com> (after LIBS annotated mosaics, scaled at 75% for the website).

Target  
"Pachi"  
(soil in  
rover  
tracks)

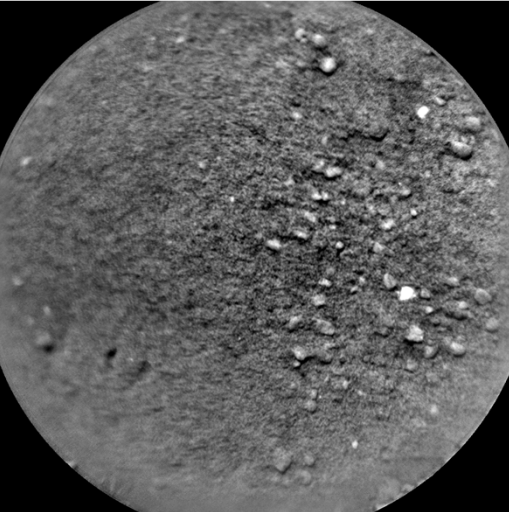




# Other RMI Special Products (for publications or presentations)

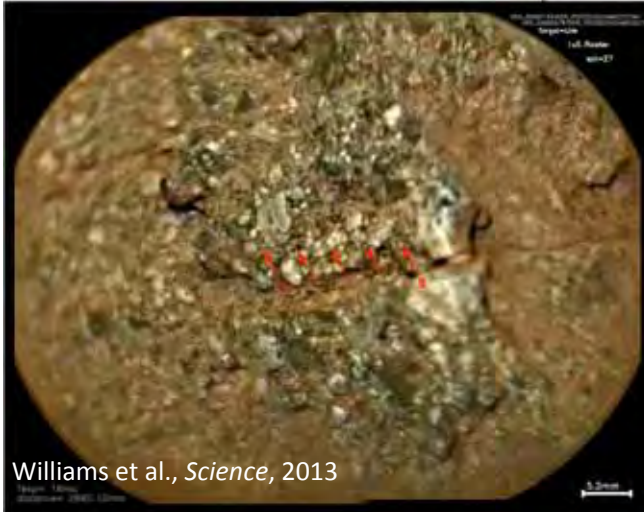
## • Time lapse animation

- Example: Sutton\_Inlier, Sol 271 (series of 16 images interspersed with 100 laser shots)
- <http://mars.jpl.nasa.gov/msl/multimedia/images/?ImageID=5364>



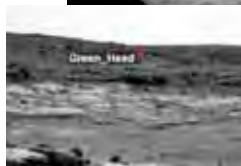
## • Color merges

- Example: Link Sol 27 (Black and white RMI is merged with the color of Mascam acquired at a lower spatial resolution)



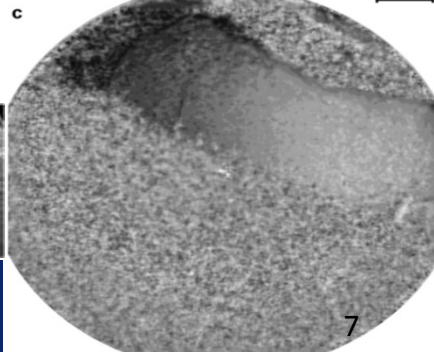
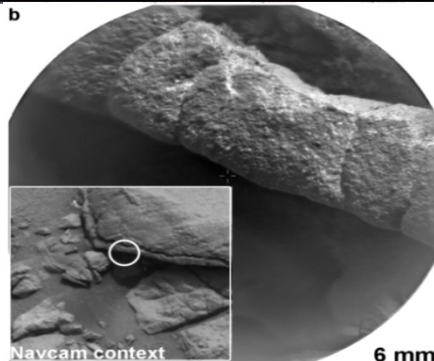
## • Imaging up to infinity

- Example: Green\_Head, Sol 284 (thanks to its high spatial resolution, RMI can be used as a reconnaissance tool)



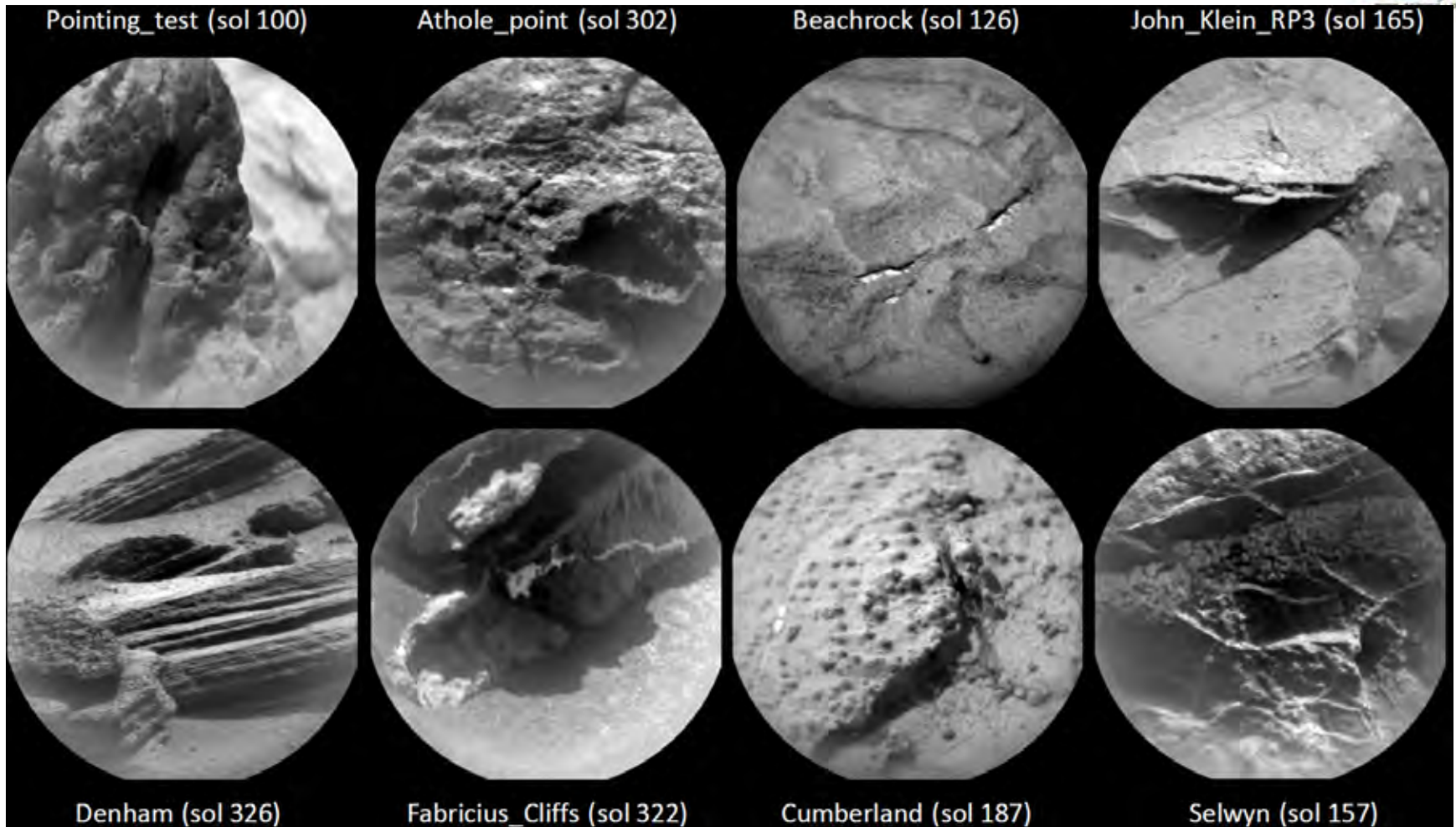
## • 3D information using Z-stack

- Example: Tindir\_1, Sol 159 (Series of RMIs acquired with varying focus distance to increase the depth of field and retrieve the 3D shape)





## RMI for standalone textural analysis



**RMI reveals the diversity of textures and morphologies of martian soils and rocks at Gale crater.**





## More Information...

- Posters:
  - **Determination of the first level Image processing of the ChemCam RMI instrument for MSL**, *Dufour et al.*, International Conference on Space Optics, 2010
    - [http://www.msl-chemcam.com/doc/documents/585/Dufour2010\\_poster.pdf](http://www.msl-chemcam.com/doc/documents/585/Dufour2010_poster.pdf)
  - **Mars imaging by the ChemCam Remote Microscopic Imager (RMI) onboard Curiosity: The first three months**, *Le Mouélic et al.*, Lunar and Planet. Sci. Conf. 44th, 1213, 2013
    - [http://www.msl-chemcam.com/doc/documents/586/Poster\\_LPSC2013\\_Lemouelic\\_ChemCamRMI.pdf](http://www.msl-chemcam.com/doc/documents/586/Poster_LPSC2013_Lemouelic_ChemCamRMI.pdf)
    - and visit the new poster Tuesday (#1361).
- References:
  - **The ChemCam instrument suite on the Mars Science Laboratory (MSL) rover: body unit and combined systems**, *Wiens et al.*, Space Sci. Rev., 170 :167-227, 2012
    - <http://dx.doi.org/10.1007/s11214-012-9902-4>
  - **The ChemCam instrument suite on the Mars Science Laboratory (MSL) rover : Science objectives and mast unit description**, *Maurice et al.*, Space Sci. Rev., 170 :95-166, 2012
    - <http://dx.doi.org/10.1007/s11214-012-9912-2>
  - **The ChemCam Remote Micro-Imager at Gale crater: Review of the first year on Mars**, *Le Mouélic et al.*, submitted to Icarus
    - [http://www.msl-chemcam.com/doc/documents/574/Le%20Mouelic\\_RMI%20submitted.pdf](http://www.msl-chemcam.com/doc/documents/574/Le%20Mouelic_RMI%20submitted.pdf) (preprint)

Visit the ChemCam website : <http://msl-chemcam.com/>

# Thank You!

