MSL: 10 MONTHS OF OPERATIONS AT JPL AND FIMOC, THE FRENCH OPERATIONS CENTER FOR CHEMCAM AND SAM

Charles YANA (CNES)
Alain GABORIAUD (CNES)
Eric LORIGNY (CNES)
Olivier GASNAULT (IRAP)

SciOps Conference, September 11th 2013

AGENDA

- The MSL Mission and the ChemCam instrument
- Preparation of "90 sols" (commissioning)
- The 90 first sols of operations
- Operations at FIMOC
- Long-term monitoring of consumables

MARS SCIENCE LABORATORY

- **Mastcam** : 34 & 100 mm cameras
- **ChemCam** : Chemistry camera :
  - Laser-Induced Breakdown Spectrometer (LIBS)
  - Remote Micro-Imager (RMI)
- **APXS** : Alpha Particle X-ray Spectrometer
- **MAHLI** : Mars Hand Lens Imager
- **ChemMin** : Chemistry & Mineralogy
  - X-Ray Diffraction
  - X-Ray Fluorescence
- **SAM** : Sample Analysis at Mars
  - Quadrupole Mass Spectrometer (QMS)
  - Gas Chromatograph (GC)
  - Tunable Laser Spectrometer (TLS).
- **RAD** : Radiation Assessment Detector
- **REMS** : Rover Environmental Monitoring Station
- **DAN** : Dynamic Albedo of Neutrons
- **MARDI** : Mars Descent Imager

MARS SCIENCE LABORATORY

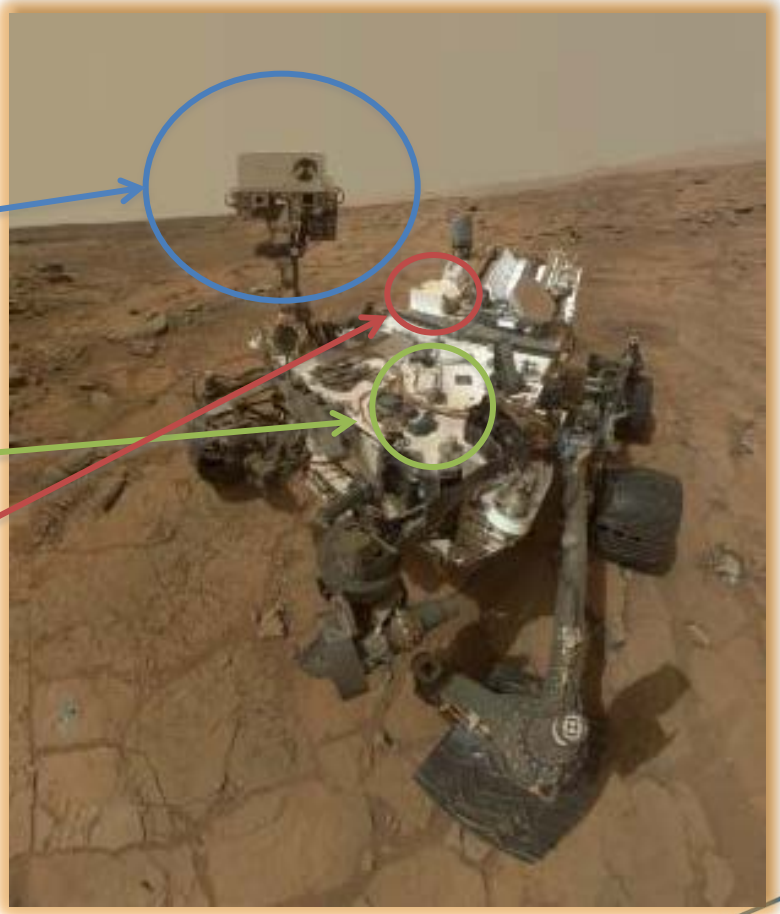
ChemCam : Chemistry camera :

- Laser-Induced Breakdown Spectrometer (LIBS)
- Remote Micro-Imager (RMI)

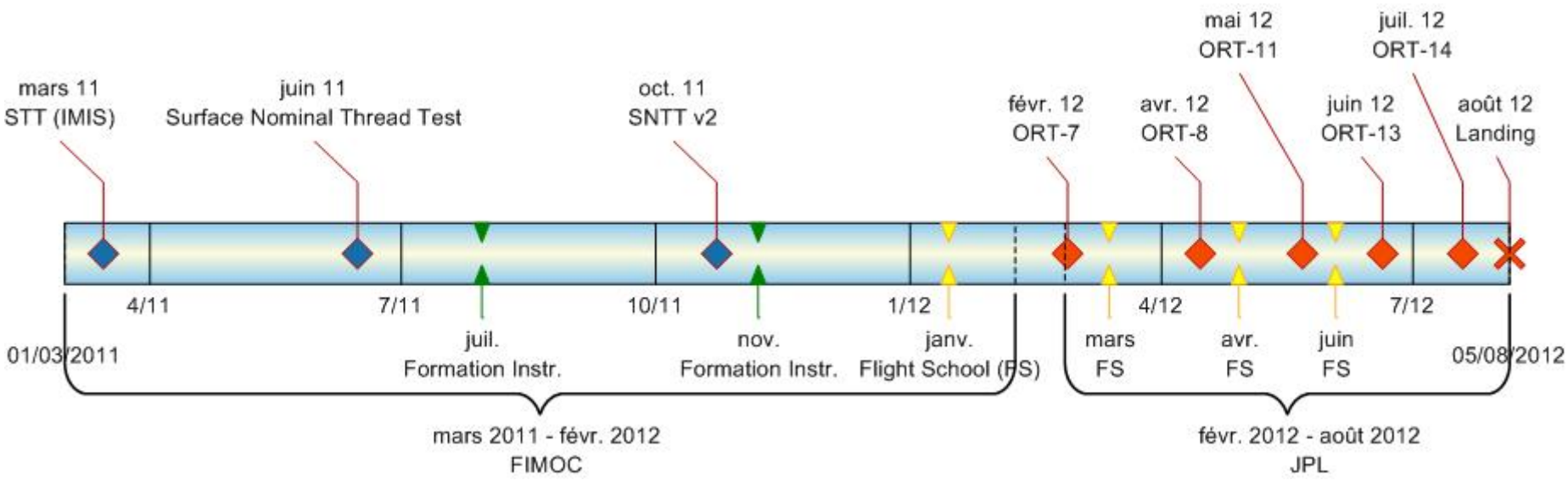
Mast Unit

Body Unit

Calibration targets



GETTING READY FOR 90 SOLS



- 2011: first remote tests
- Flight Schools in parallel with ORTs
- ORT-7, ORT-11 et ORT-14 very EDL-oriented (landing, CAP-1)
- ORT-8 and ORT-13: nominal training

GETTING READY FOR 90 SOLS

- Required a lot of testing on the Engineering Model, especially for interactions between the different subsystems (ressources, laser collisions, etc.)
- A simulator of the instrument is onboard the EM rover
- Preparation of instrument procedures and training packages

THE FIRST 90 SOLS

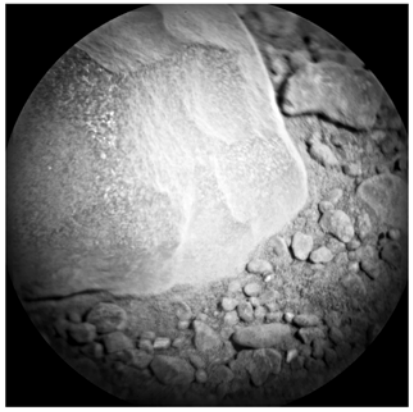
First 4 sols (= days) activities, **prior to any science observation**:

- Turn on ChemCam few minutes after landing, first measurements with Mast stowed (sequences already onboard)
- Check the health of the instrument
- Provide a Go to mission for Mast deployment, by checking pyros firing
- First calibration activities
- Strong mission priority on outreach activities (Panoramas)

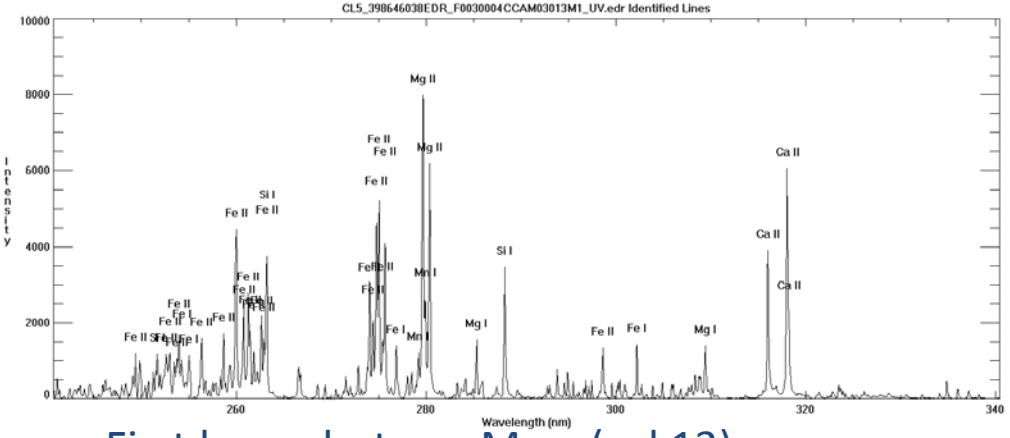
THE FIRST 90 SOLS

1 sol = 1 day on Mars

First sols happened to be very close to ORTs => excellent training

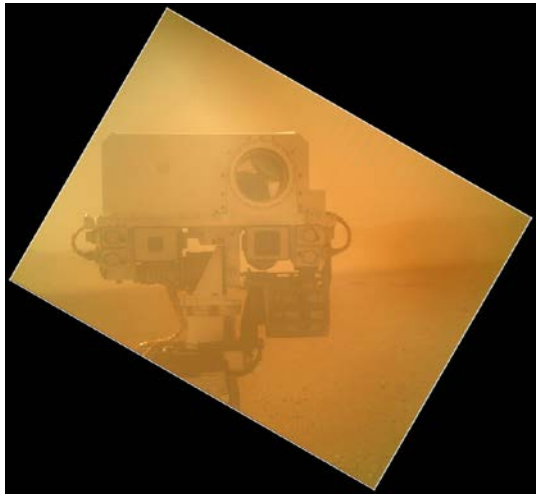


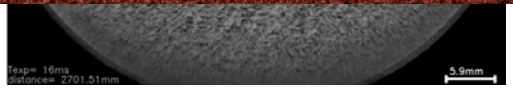
First RMI on Mars (sol 12)



First laser shots on Mars (sol 13)

What does a laser shoot look like?



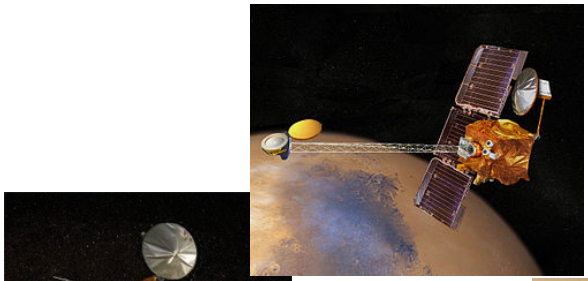


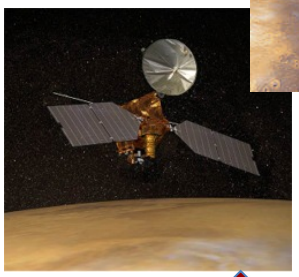
THE ORGANISATION OF OPERATIONS

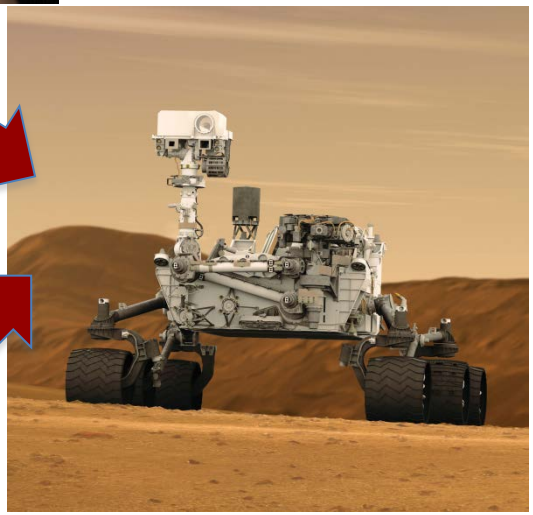
Remote Science Operations

MSL Operations

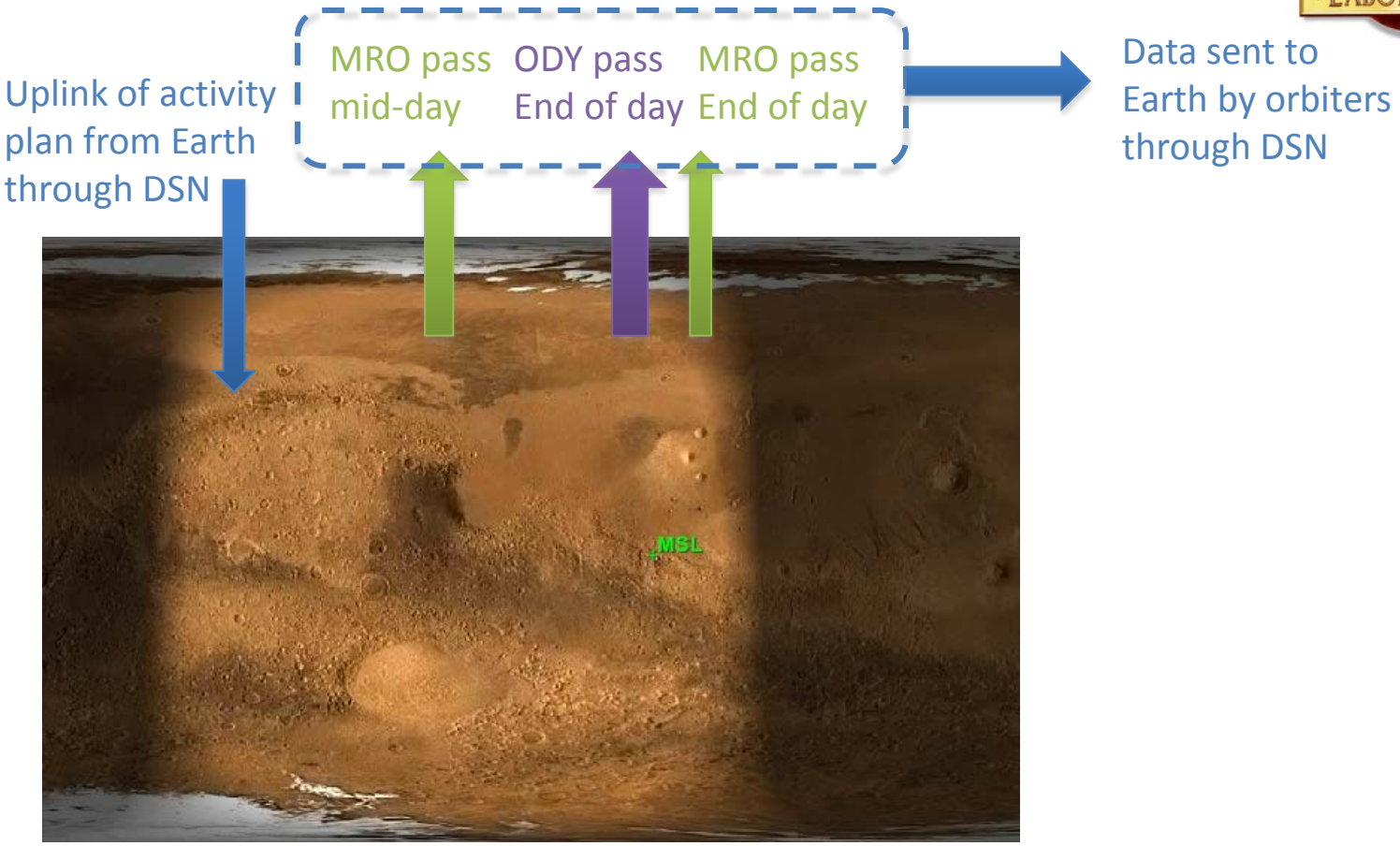
Local Science Operations (90 sols)





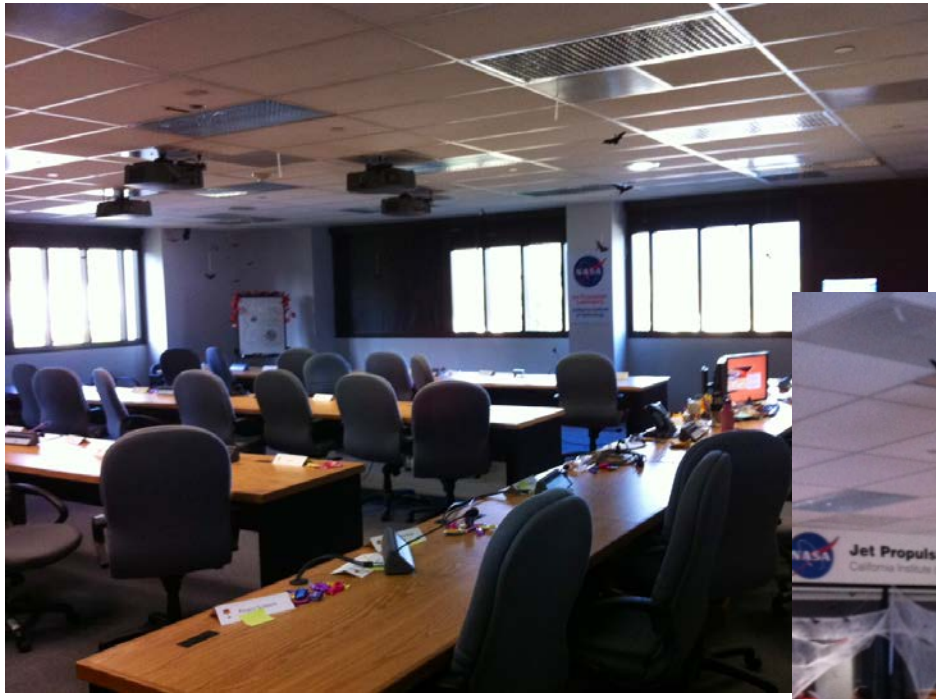


THE ORGANISATION OF OPERATIONS



- One uplink of activity plan per martian day
- 1 to 3 uplink opportunities from rover to orbiter (MRO, Odyssey)
- Roughly 400Mbits of available downlink per sol

THE JPL MEETING ROOM



REMOTE OPERATIONS AT FIMOC

- First remote operational shift on MSL by ChemCam ePDL from FIMOC at sol 75
- Transition from working 7/7 on martian time to 5/7 on US time (5pm to 4am in France)
- Share of operations with LANL, one week each
- Handover telecons on Mondays
- Mixing Engineers and Scientists (users) at FIMOC

OPERATIONAL PROCESS: DOWNLINK

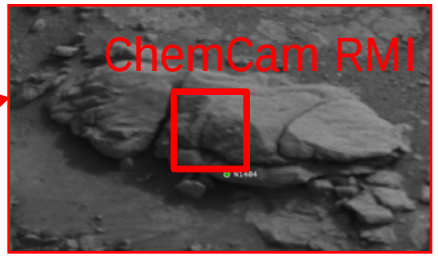
- Tactical
  - Downloading and analysis of ChemCam data
  - Must provide an assessment of instrument health
  - A non-nominal state prevents from using the instrument

- Strategic
  - Long-term assessment of key parameters: temperatures, voltages, optical power, etc...
  - Long-term assessment of consumables: number of laser shots, autofocuses, motor steps,...
  - Instrument anomalies analysis

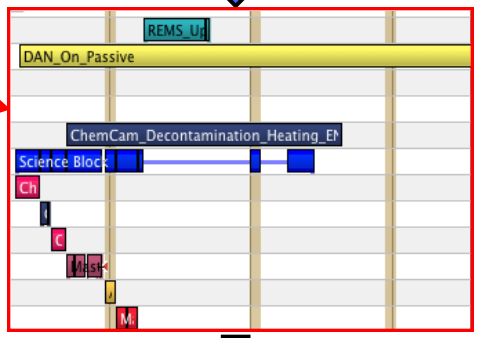
OPERATIONAL PROCESS: UPLINK

ChemCam used for **remote science**, allowing to **save time and ressources** for contact science

Starting time (CET)	Meeting name	Objective
16:00-19:00	Science Theme Groups (STG)	Propose observations for next sol : CCAM LIBS, MastCam mosaics, APXS contact science…
18:00-21:00	Science Operations Working Group (SOWG)	Build next sol plan from proposed observations by STGs
21:00-00:00	Activity Plan Approval Meeting (APAM)	Confirm next sol plan : durations, power, data volume and other constraints must be fulfilled
01:30-04:30	Sequence Report Walkthrough	Validation of next sol sequences

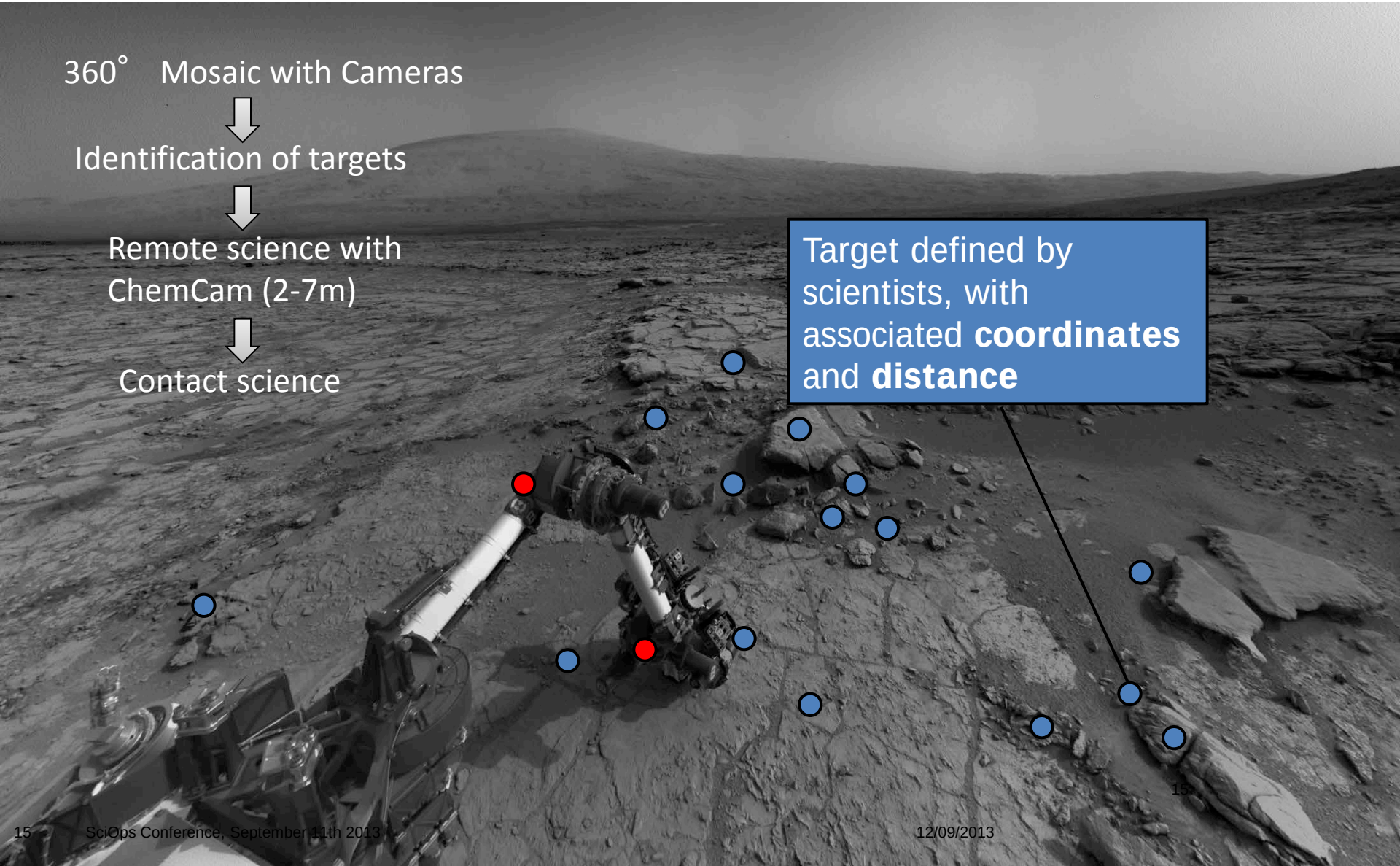


Activity plan building



Sequences development

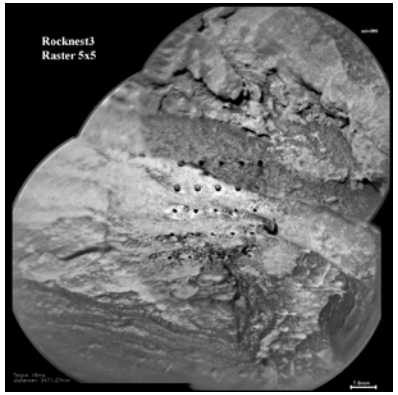
SCIENCE ACTIVITIES

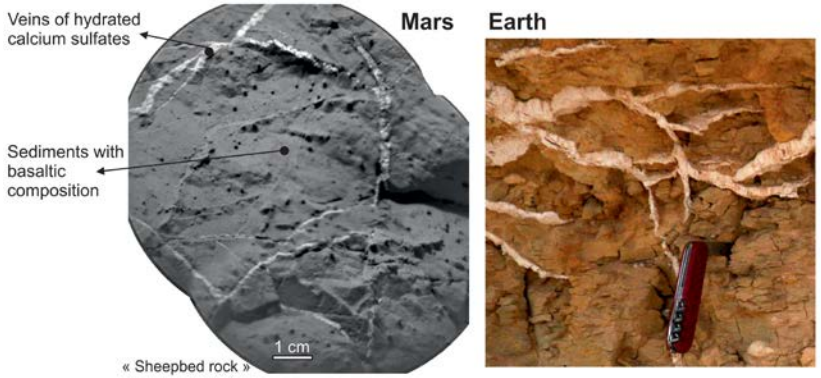


CHEMCAM ACTIVITIES

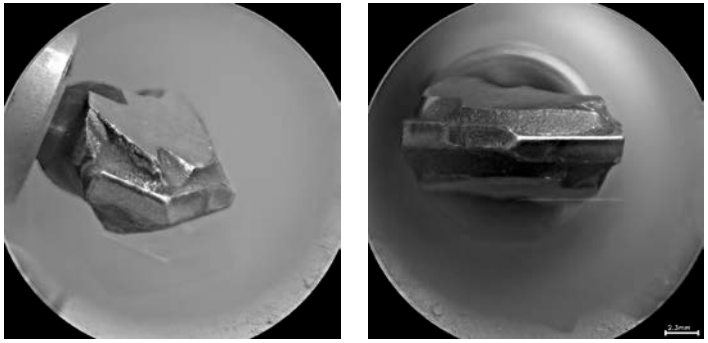
So what do we REALLY do with our laser on Mars?

We do some rasters (1x5, 1x10, 3x3, etc.), trying to hit calcium veins

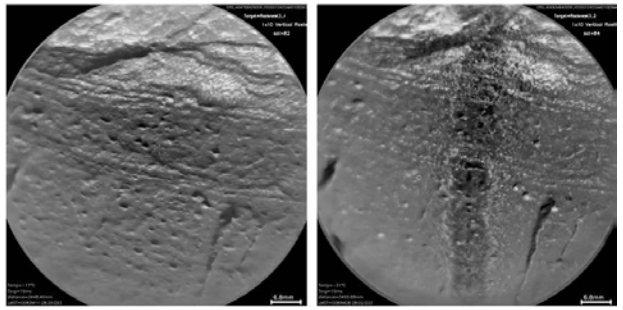




We take hi-resolution images of drill bit, cal target, rover parts

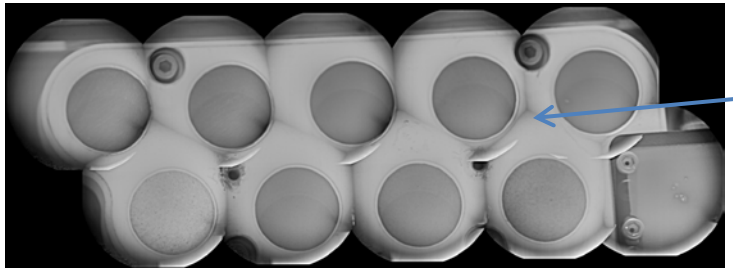


We clean dust



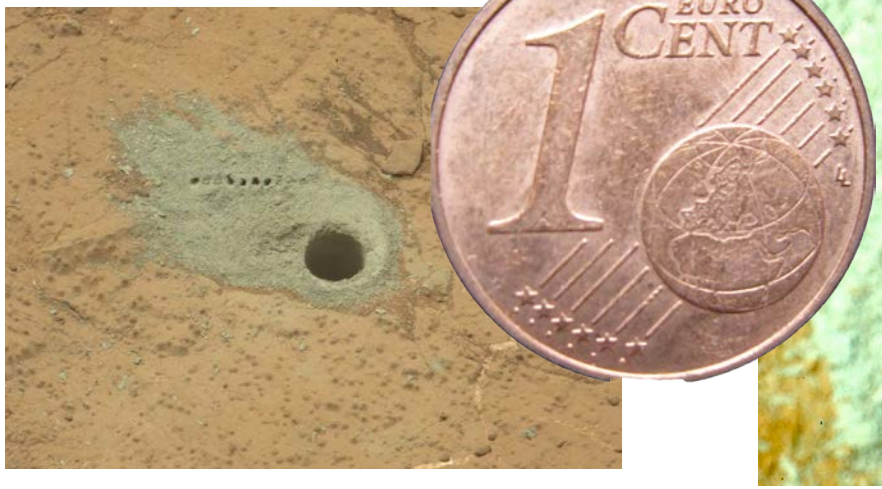
CHEMCAM ACTIVITIES

We shoot at calibration targets...



... and do passive observations of the paint

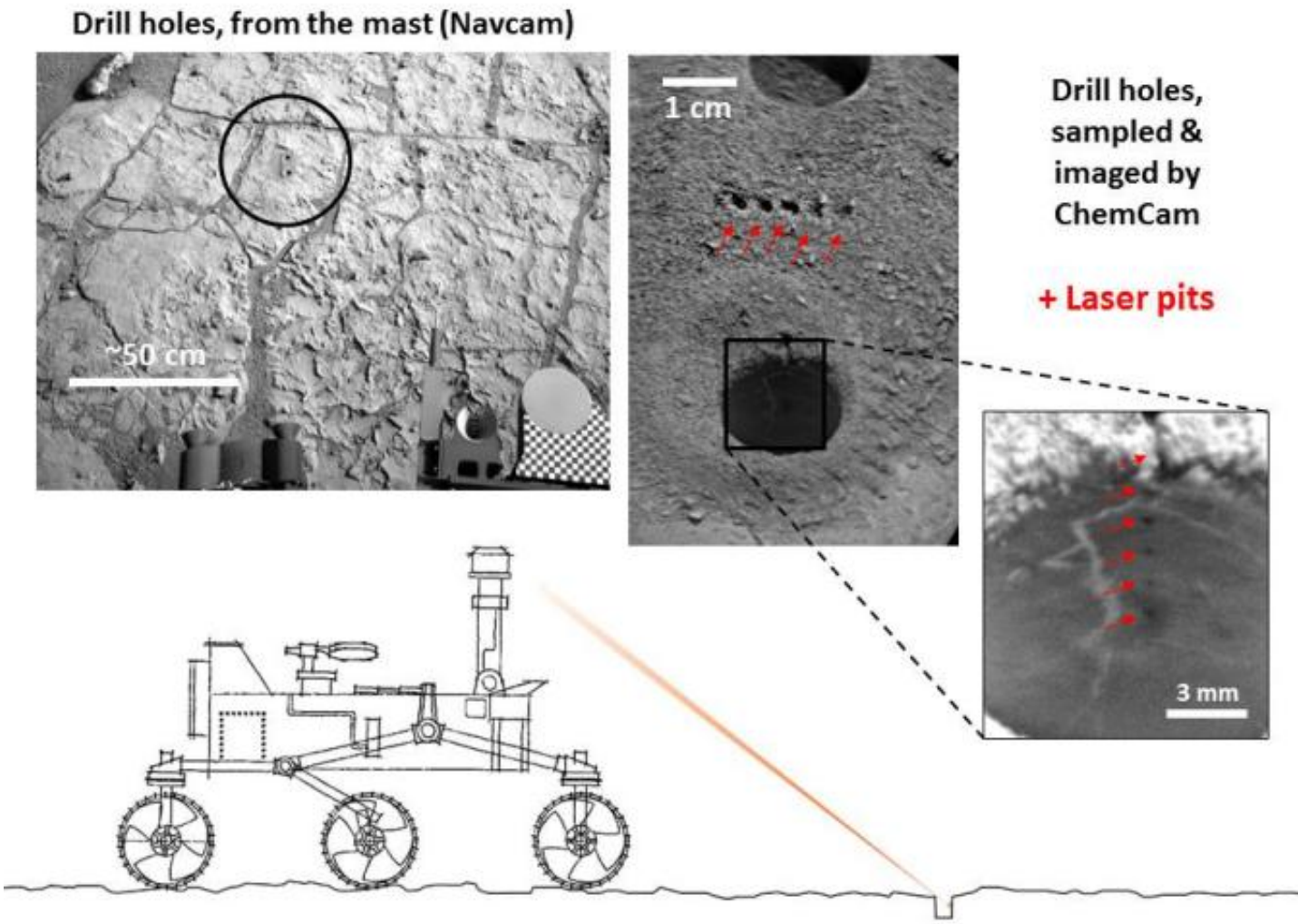
And we can shoot inside the drill holes!



HIGH PRECISION POINTING

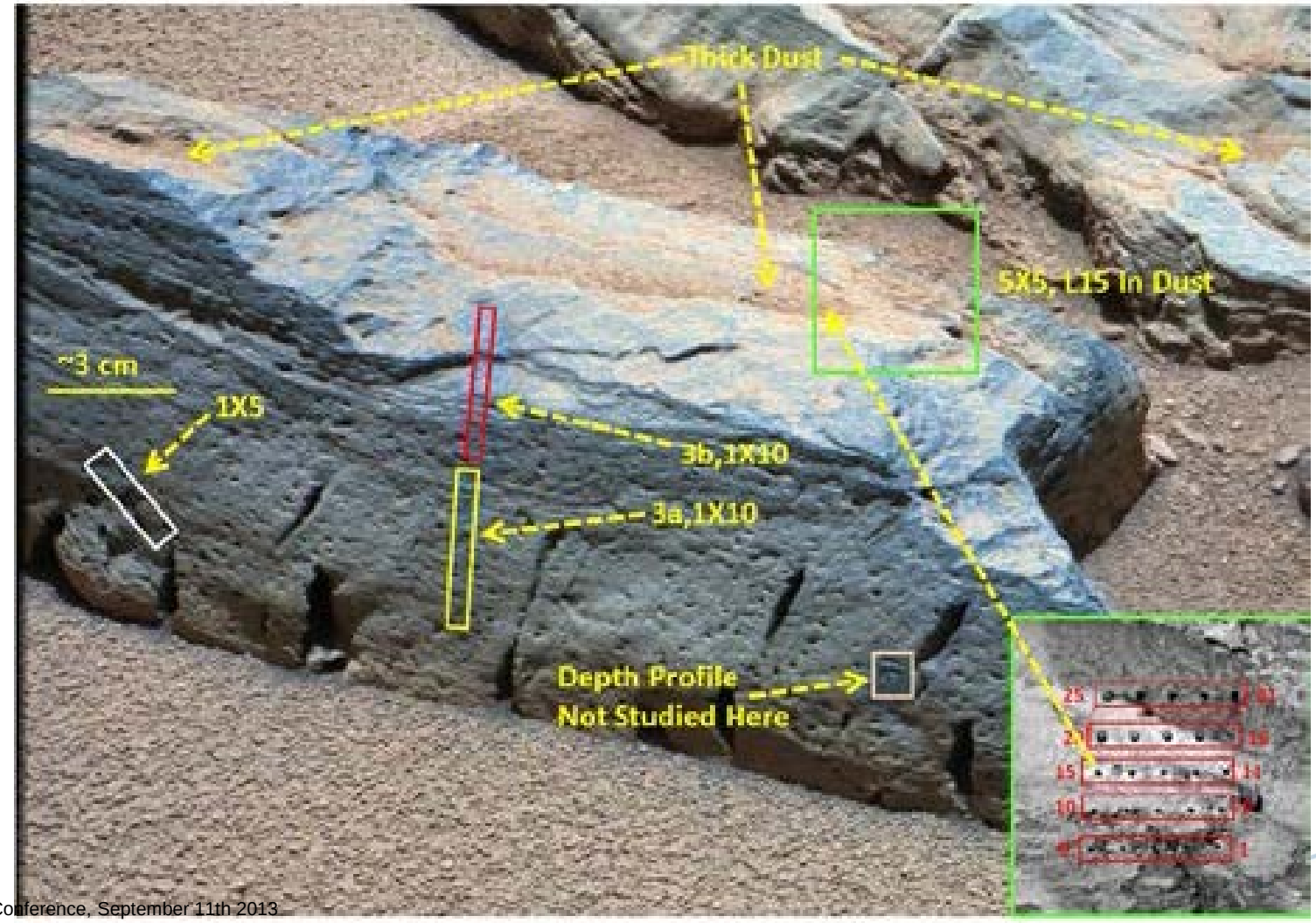
Pointing is the most complex part of the job, very high precision is needed

We're aiming at a 1cm hole, 3m away

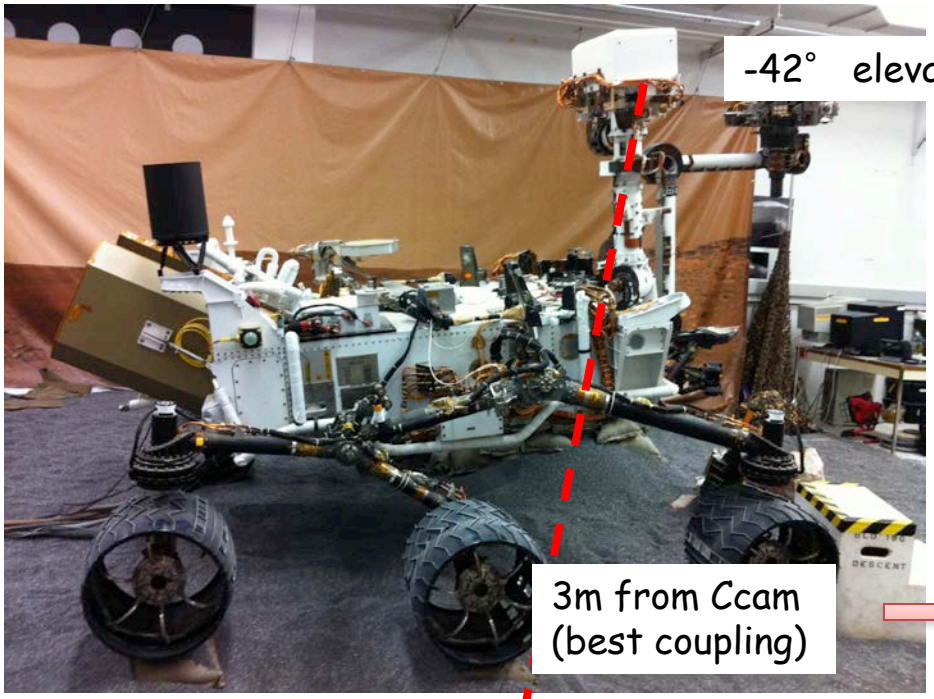


CHEMCAM ACTIVITIES

When we really like a rock



BLIND TARGETING

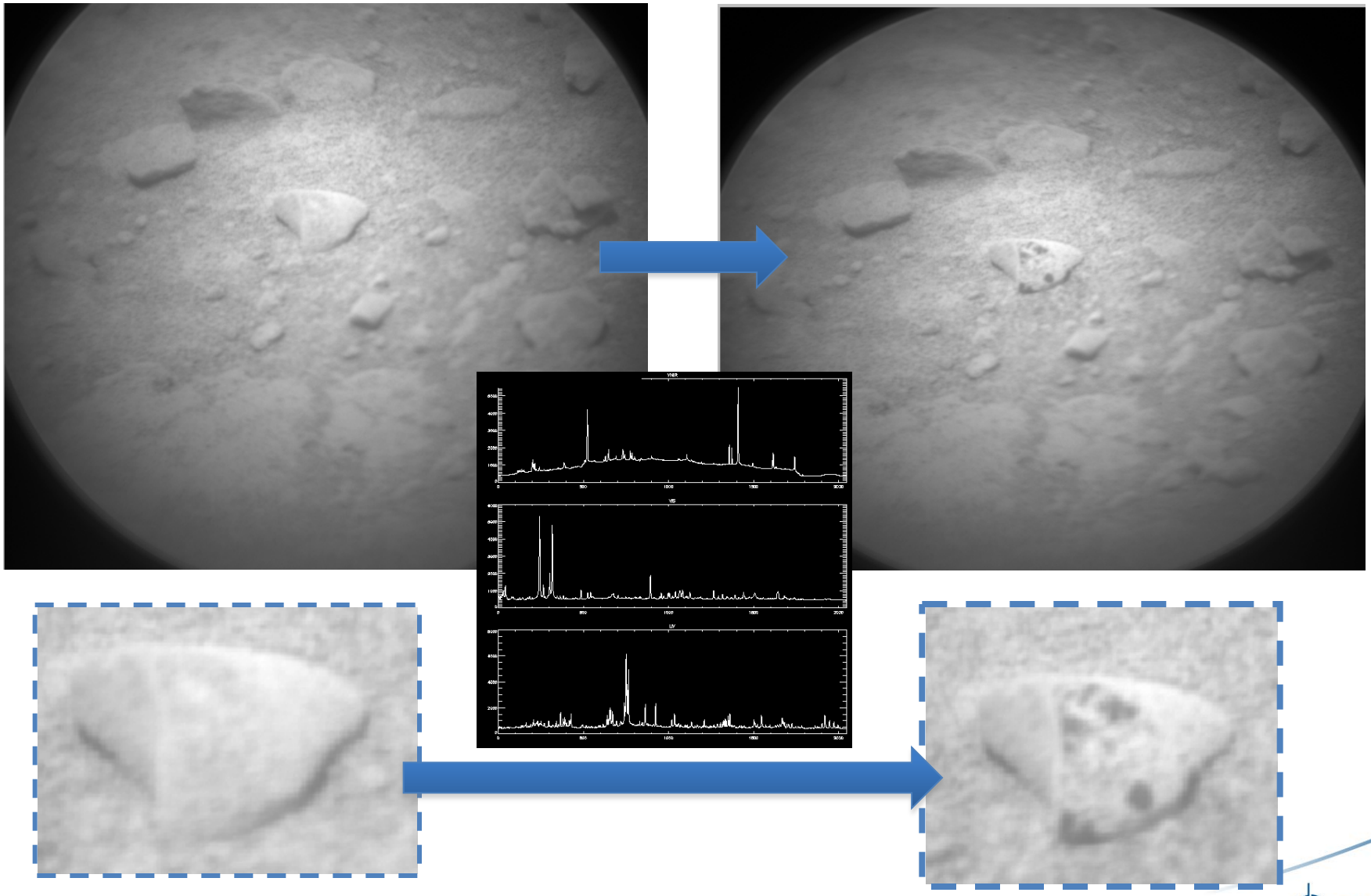


-42° elevation → **Sunsafety**

3m from Ccam (best coupling) → **Collision**

Target, assumption of flat ground → **Focus**

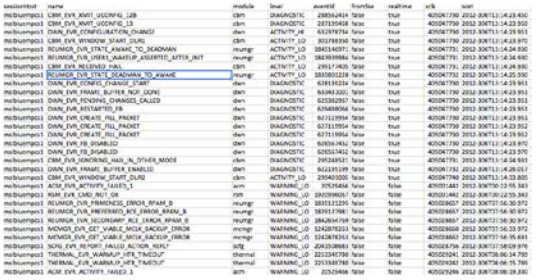
BLIND TARGETING (SINGLE POINT)

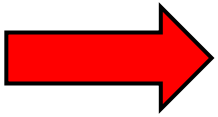


TOOLS INTERNAL DEVELOPMENT

ARC *(ruby + shell)* :

Automatisation of Downlink reports

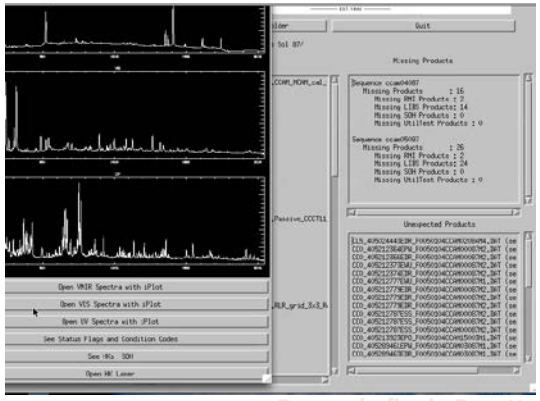


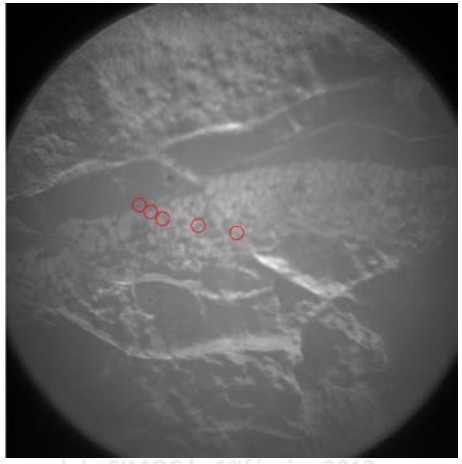


CCAM Product Viewer *(IDL)* :

Analysis and visualization of received products

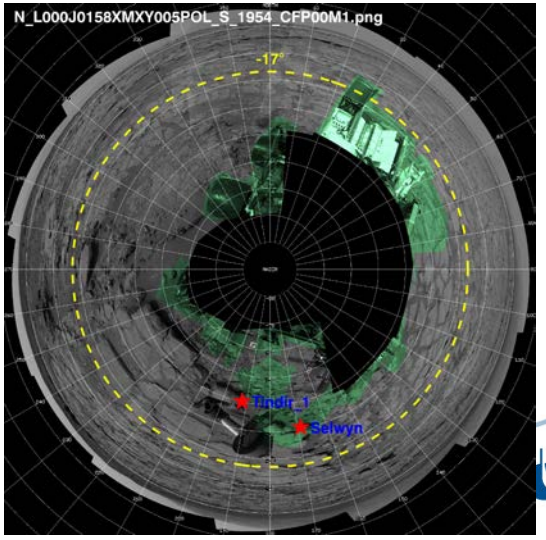
Generation of html lists of expected, received and missing products





ChemCam Mosaic Viewer (IDL) :

Check the collision zone for all ChemCam laser shots

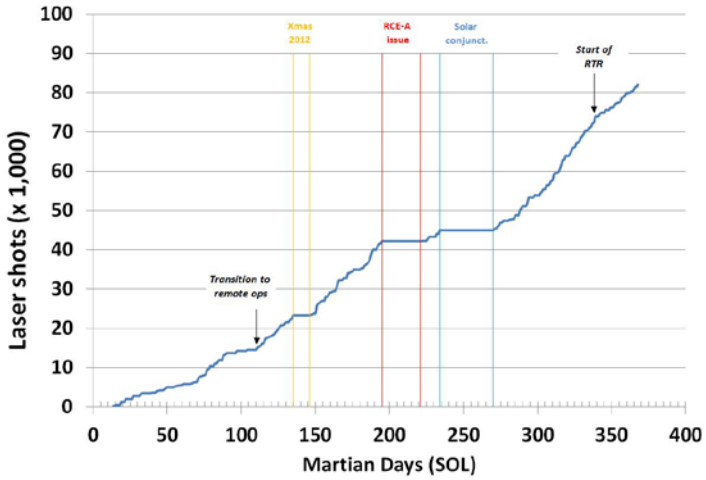


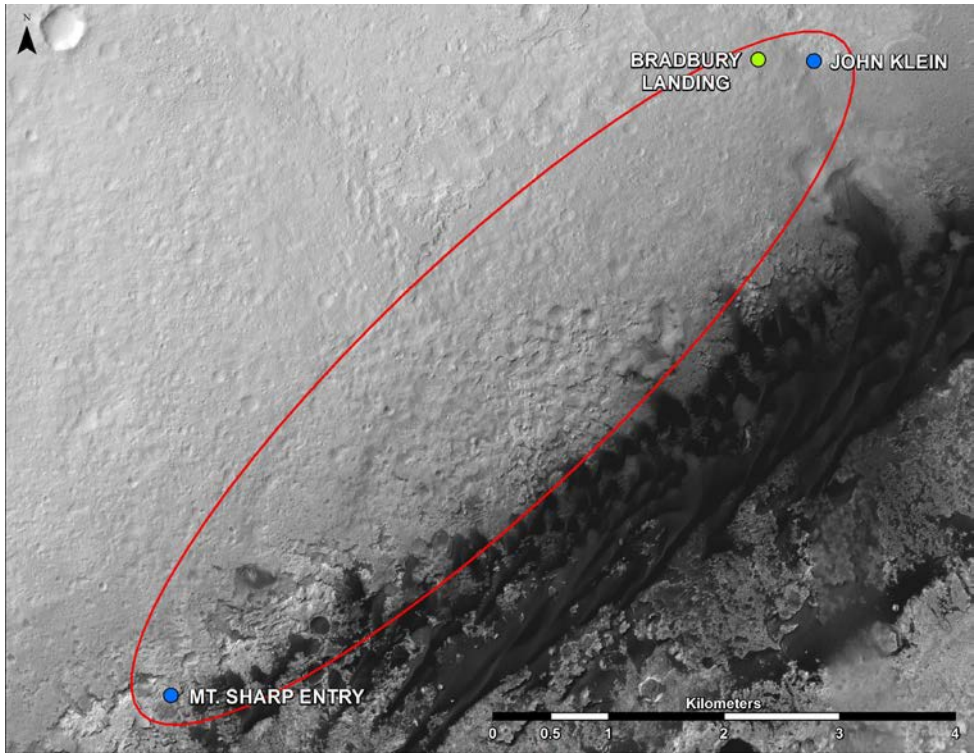
Revue de fin de Recette en vol du FIMOC le 1er février 2013

LONG-TERM MONITORING OF CONSUMABLES

Parameters	Requirements	Up to Sol 368	% of lifetime
Number of hours ON for CCMU FM	1h/day for 2 years	44min/day	
Number of laser shots	3 millions	88250 Mean of 404 shots/day when Ccam is used	3%
Number of autofocuses	14000	936 Mean of 66sec/autofocus	6%
CWL diode (ON/OFF)	14000	940	6%
Number of shots in restricted zone	100000	0	
Total # of motor steps	N/A	15818227	

ChemCam used 60% of times => very useful instrument for remote science



CONCLUSION

- Successful local operations at JPL during the commissioning phase
- Remote operations at night since november, alternating every week with LANL
- Various activities allowed by ChemCam, very useful instrument
- Long driving period ongoing