CHEMCAM:

AN INSTRUMENT FOR STAND-OFF ANALYSIS OF PLANETARY SURFACE COMPOSITION.

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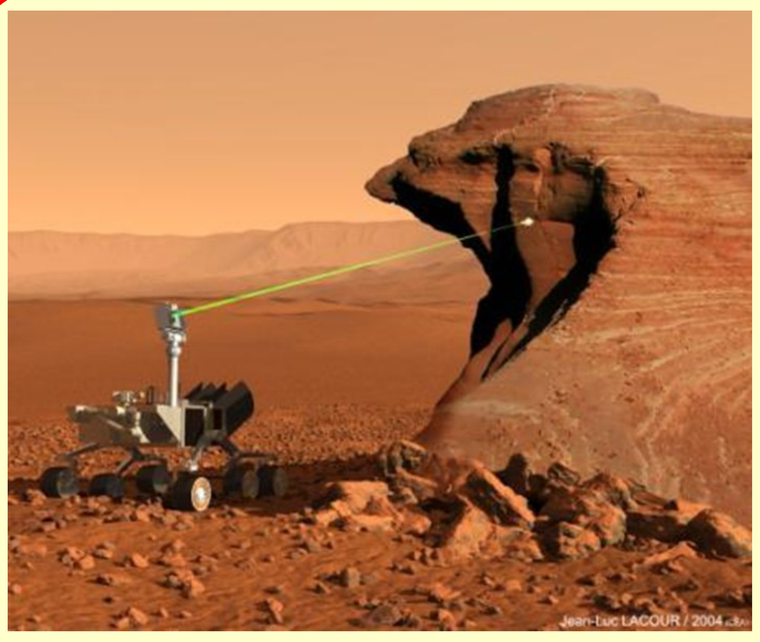


Applying LIBS method on Mars

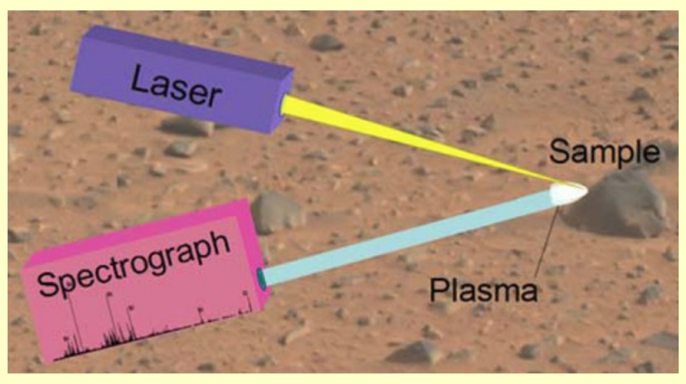
True exploration field geology of the solar system planetary bodies has already begun in the past recent years. To characterise the encountered geologic units, instruments have been developed to provide data on the composition of the surface materials and henceforth a glimpse at the history of the planetary body. Recently the Laser Induced Breakdown Spectroscopy (LIBS) method of observations has been proposed to investigate details of the Martian geochemistry; it capitalises on the development of laser devices which fit the space travel conditions and sustain the planetary surface environment.

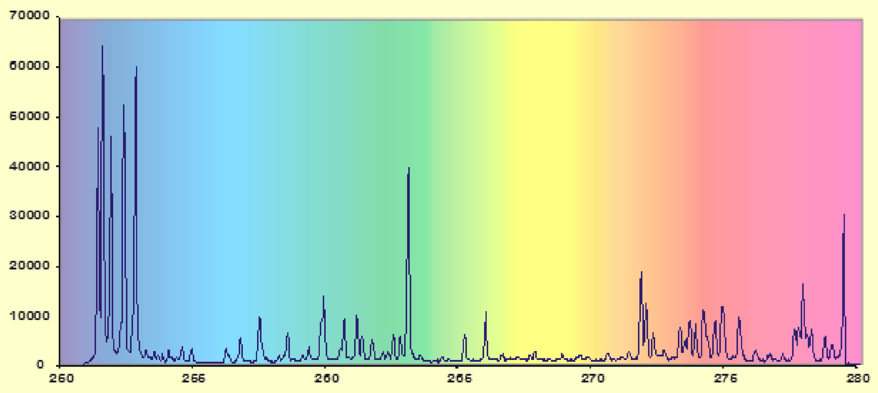
CHEMCAM (PI R. Wiens, Co-PI S. Maurice) is a remote sensing instrument suite that relies on **Laser-Induced Breakdown Spectroscopy (LIBS)** to provide elemental composition from 1.3 to 7 m, and a micro-camera to return context images from 2 m and beyond. This instrument was installed on board the rover Curiosity of Mars Science Laboratory (MSL) mission (Wiens et al., Maurice et al., Space Science Review, to appear 2012).

The use of LIBS method on Mars offers several advantages over other methods of chemical analysis : It doesn't need sample preparation; it is fast; it may analyse samples at distance therefore suppressing the need for close approach; repeated laser shots allow removing the sample dust cover and provides depth profiling ability . In addition the Mars atmosphere low pressure offers the best condition for the development of the LIBS signal.

What is LIBS ?

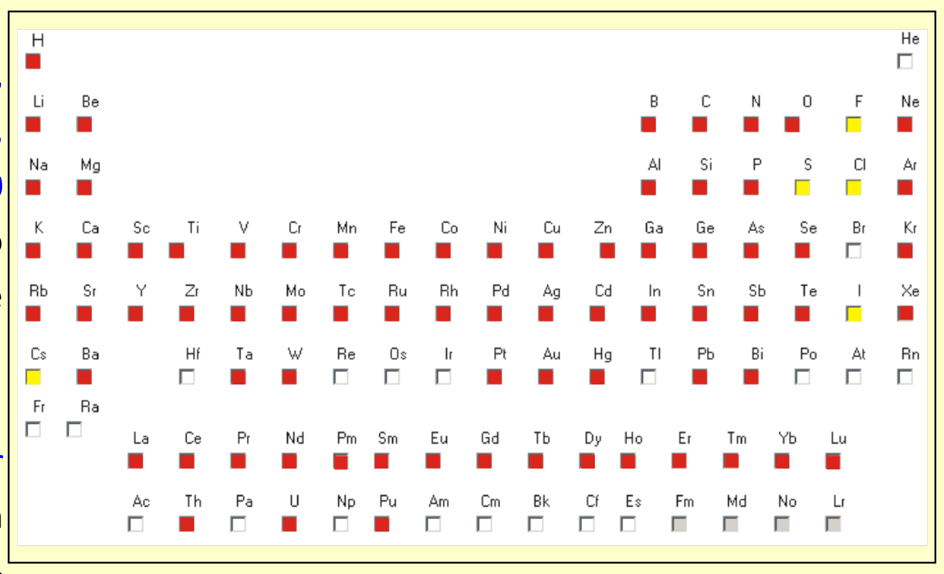
In the LIBS technique, brief but powerful laser pulses are focused on a target. The high photon flux results in ablation of atoms and atomic clusters in electronically excited states, typically with a temperature of ~104 K. As the ions and atoms decay to lower energy levels, photons are emitted at wavelengths that are unique to each element. The emitting plasma, lasts up to ~20 µs. The LIBS spectrum covers a range from the deep ultraviolet to the infrared; however, characteristic emission lines exist for essentially all of the elements within a range from the near UV (i.e., l > 240 nm) to the near IR (i.e., l < 900 nm).



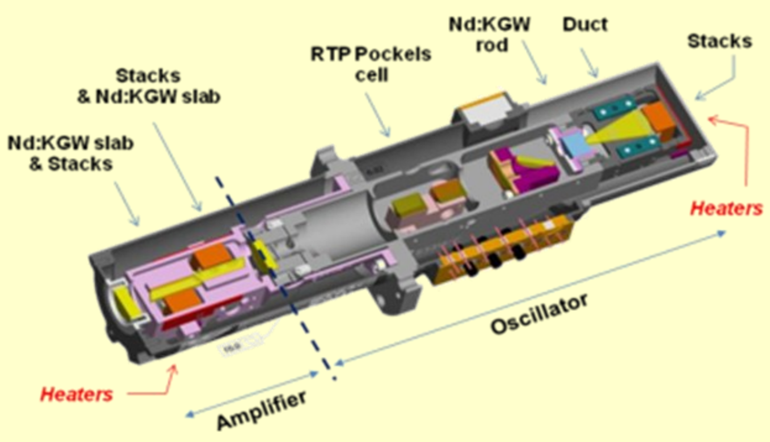


What elements may LIBS measure ?

LIBS analyses yield elemental compositions typically for **H, Li, Be, B, C, N, O, F, Na, Mg, Al, Si, P, Cl, K, Ca, Ti, V, Cr, Fe, Ni, Zr, Rb, Sr, As, Ba, and Pb** in general with detection limit from 100 to 1000 ppm. LIBS is particularly sensitive to the alkali and alkali earth elements, with some detection limits down to ~1 ppm at close range. On the other hand, remote LIBS is poorly sensitive to halogens, with detection limits for F, Cl, S, and P in the range of several wt.%. In the martian environment, C, N, and O abundances have interferences from atmospheric constituents, raising the C detection limit to ~2 wt. %.



Laser

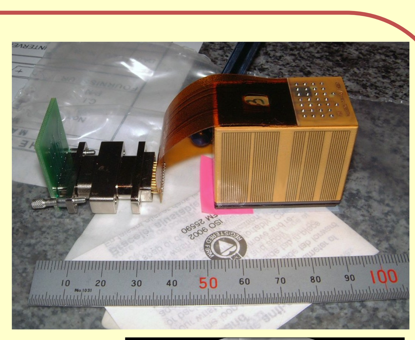


Wavelength

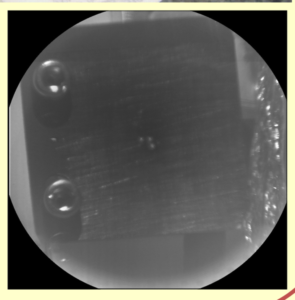
1067 nm

Energy > 24 mJ [-20°C,+20°C],	Repetition rate 1 Hz – 10 Hz
> 30 mJ for one T	Functional T range [-30°C, +30°C]
Stability Shot to shot ≤ 2% rms	Beam diameter 2.5 ≤ Ø ≤ 3.5 mm
Pulse duration ≤ 8 nsec	Overall mass ≤ 600 g
Beam quality M² < 3	Volume Ø < 60 mm, L < 220 mm

RMI



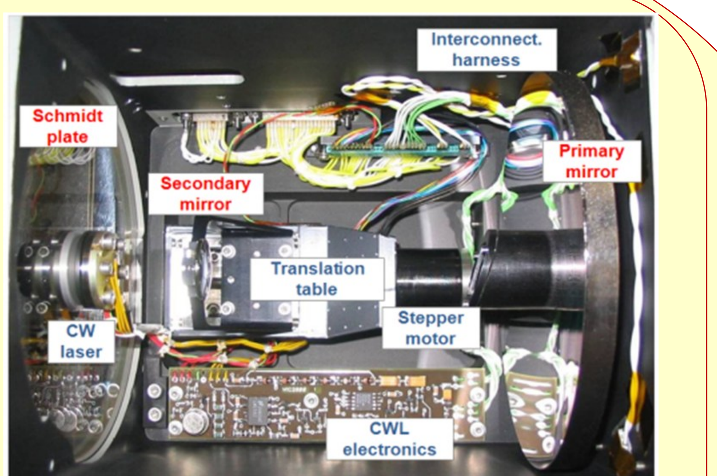
The Remote Micro-Imager places the LIBS analyzes in their geomorphological context by imaging small details.



At 10 m, the field-of-view = 10 cm; resolution = 1 mm (0.2 mm just in front of the rover);

Imaging range: 1.16m to infinity .

Auto-focus

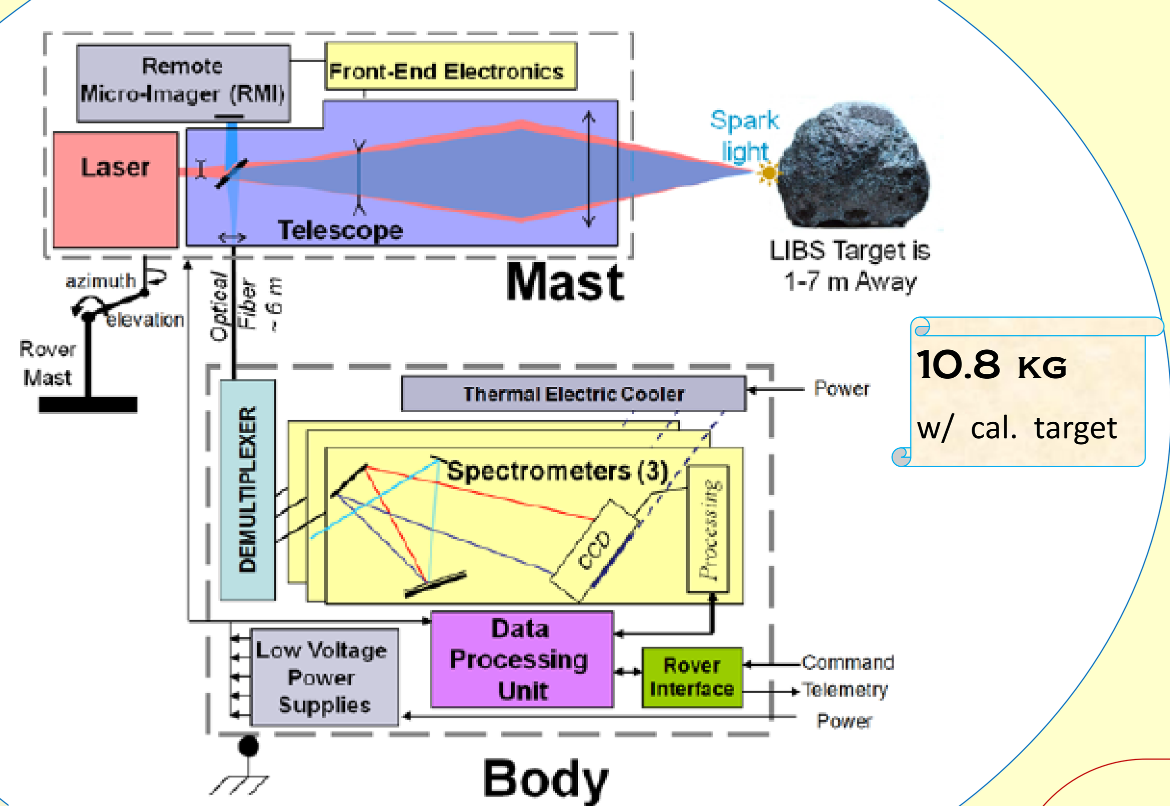


Focusing from 1.16m to 20m by moving the secondary mirror

A continuous wavelength laser pointer, in the center of the Schmidt window, is turned on, illuminating the target with monochromatic light.

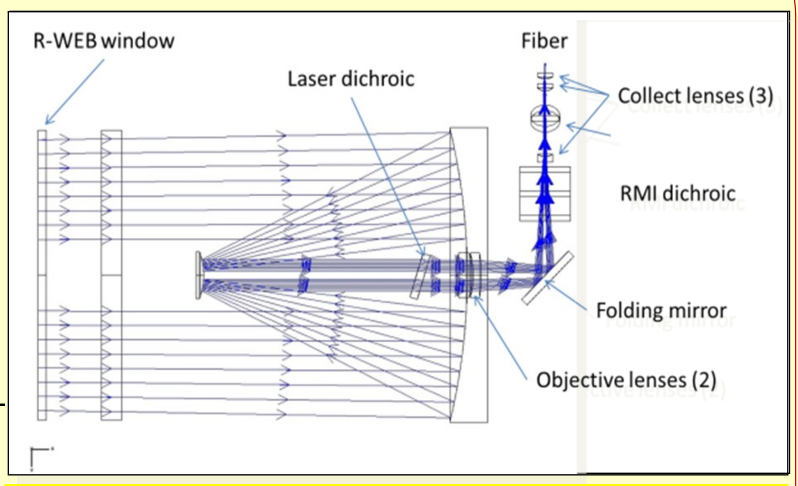
The focus stage is scanned while the returned signal is monitored at the correct wavelength by a detector. The focus position is determined by the maximum in the fitted returned intensity.

System architecture



Telescope : Schmidt-Cassegrain type

- Focus laser to achieve 1 GW/cm^2 on the target spot.
- Collect light for spectral analysis between 240 and 800 nm; link to the spectrometer by optical fiber.

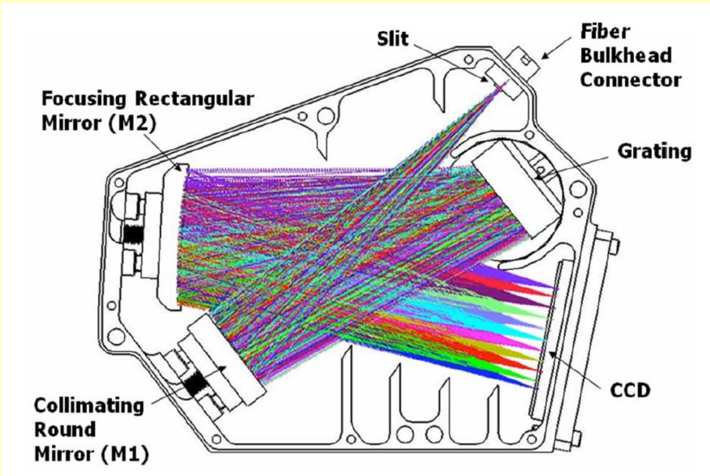


Optical schematic of plasma light within the telescope

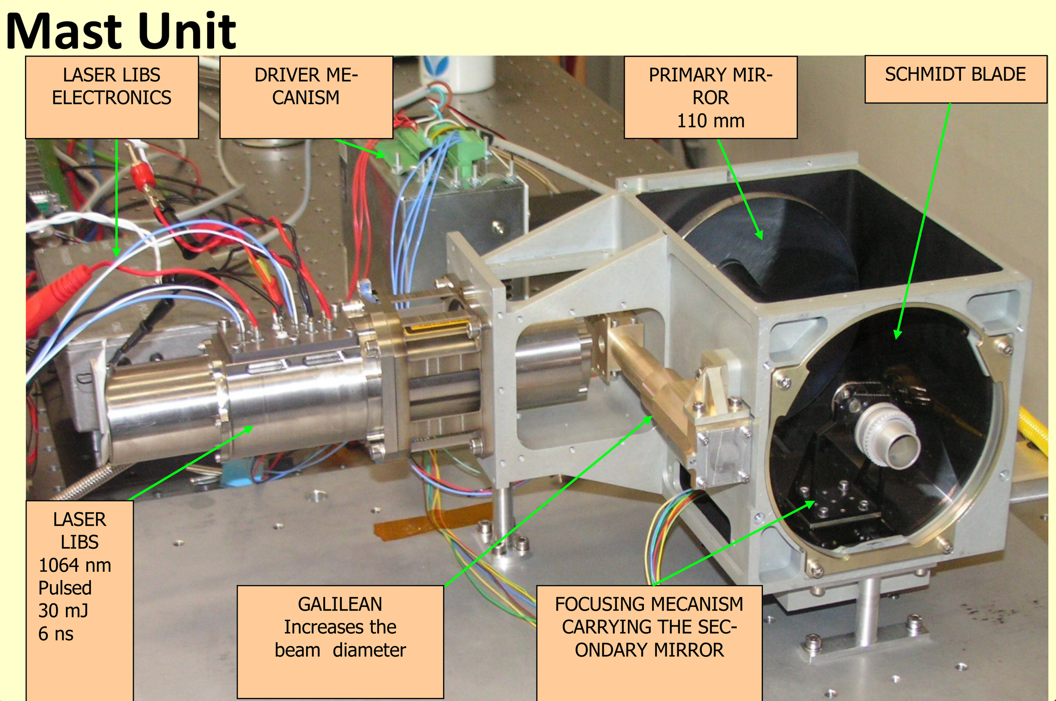
- Collect light for imaging around 750 nm by the RMI.

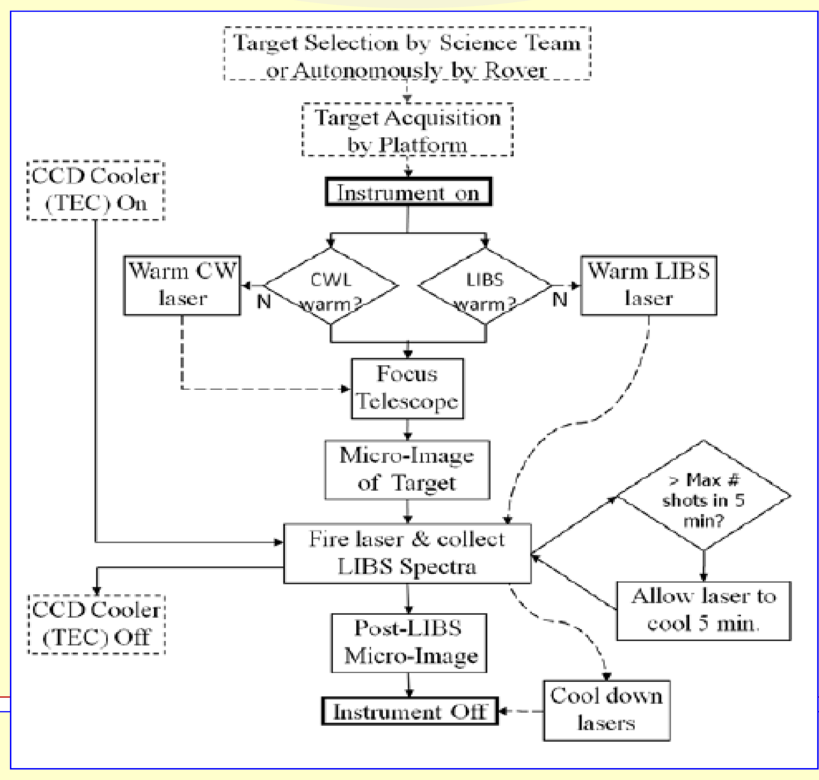
PARAMETER	UV	Violet (VIO)	VNIR
Spectrometer range (nm)	240.1 – 342.2	382.1 – 469.3	474.0 – 906.5
Spectral resolution (FWHM)	0.15nm	0.20nm	0.61nm

Spectrometer

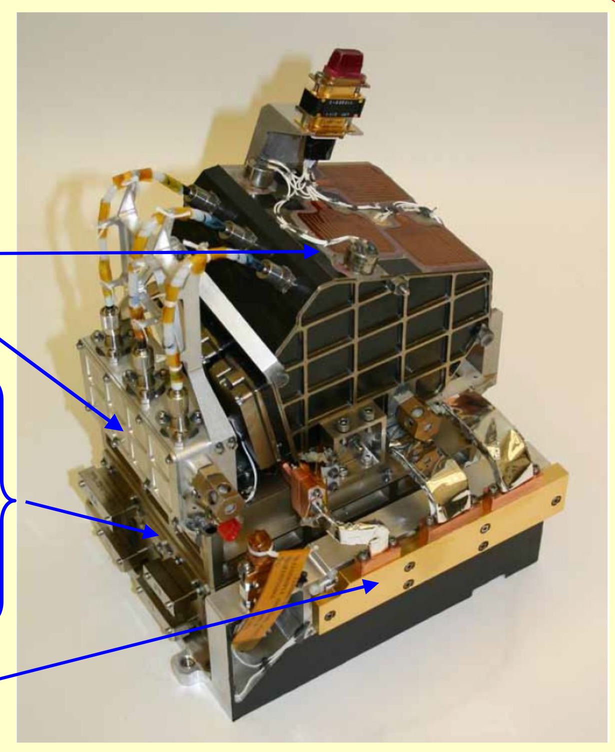


Mast Unit





Body Unit



Within the main rover body,

It contains :

- The 3 spectrometers
- The optical demultiplexer
- Electronic box
  - The data processing unit
  - The low voltage power supplies
  - Interface circuit
- The thermoelectric coolers (TECs) for CCDs (x3)

Operation modes

CHEMCAM provides an energy of 14 mJ per pulse on the target; this allows injection of > 1GW.cm-2 per pulse at a frequency of up to 10 Hz, in the target at distance between 2 m and 7 m. Typical spot size on a target is ~350µm in diameter. In combination with a co-aligned high resolution micro-imager (RMI), the knowledge of the exact position of this spot allows identifying the mineral context of the measurement. To explore a rock composition that results from some mineral assemblage, line series or raster of spots may be commanded. A set of calibrated target minerals is placed on the rover upper deck to periodically check the instrument performances

Spectrum obtained under the Martian atmosphere with the Chemcam flight model at a distance of 3 meters.