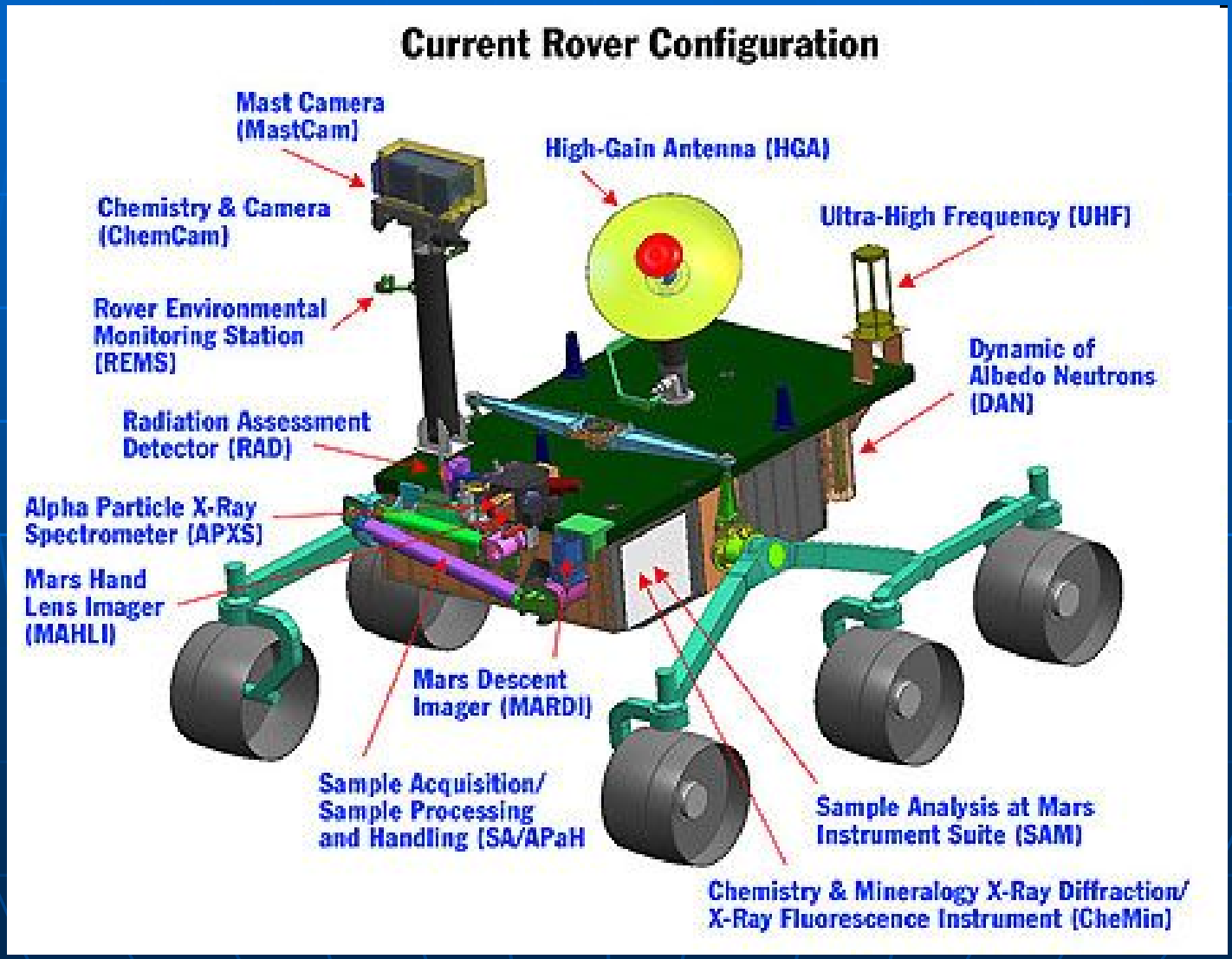
MSL – brief outline

- Very capable and complex rover
- Should run for many years
- Hosts a suite of instruments
- We (Canada) are involved with an instrument (APXS) and a number of participating scientists

MSL - technology

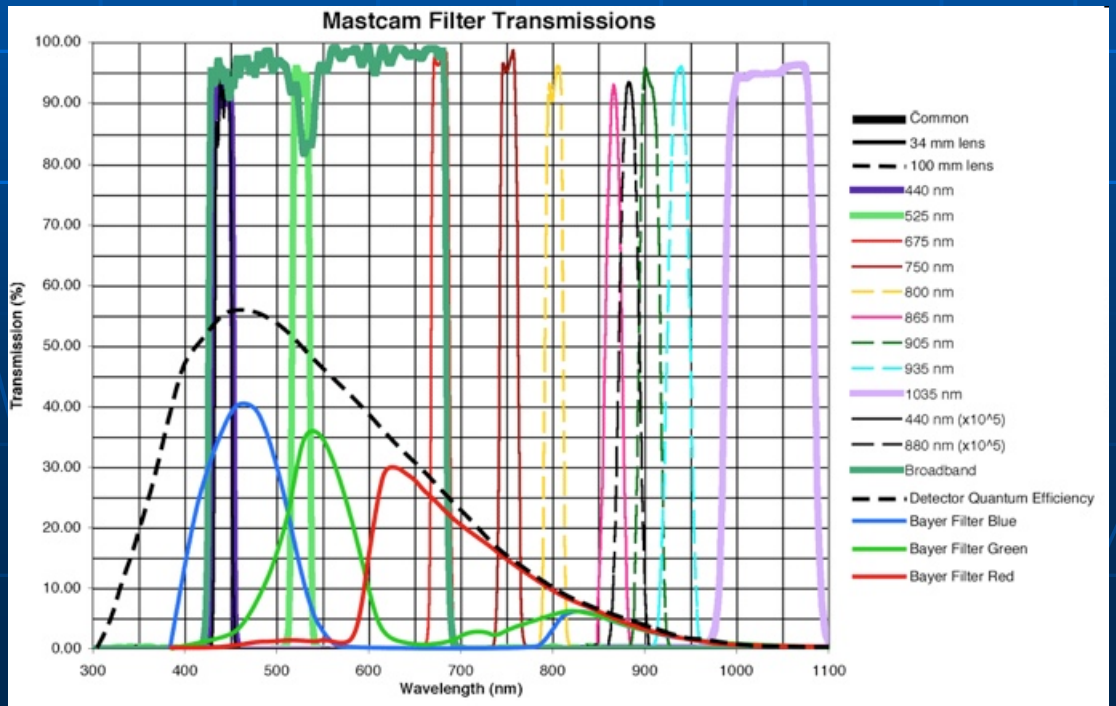


1. DAN

- Dynamic Albedo of Neutrons (DAN) is an active/passive neutron spectrometer that measures the abundance and depth distribution of H- and OH-bearing materials (e.g., adsorbed water, hydrated minerals) in a shallow layer (~1 m) of Mars' subsurface along the path of the MSL rover. In active mode, DAN measures the time decay curve (the "dynamic albedo") of the neutron flux from the subsurface induced by its pulsing 14 MeV neutron source.

MastCam

- The Mast Camera is a two-instrument suite of imaging systems mounted on the MSL rover's Remote Sensing Mast
- 14 filter positions for scientific multispectral studies



REMS

- REMS has been designed to record six atmospheric parameters: wind speed/direction, pressure, relative humidity, air temperature, ground temperature, and ultraviolet radiation. All sensors are located around three elements: two booms attached to the rover Remote Sensing Mast (RSM), the Ultraviolet Sensor (UVS) assembly located on the rover top deck, and the Instrument Control Unit (ICU) inside the rover body.

RAD

- The Radiation Assessment Detector (RAD) is an energetic particle analyzer designed to characterize the full spectrum of energetic particle radiation at the surface of Mars, including galactic cosmic rays (GCRs), solar energetic particles (SEPs), secondary neutrons and other particles created both in the atmosphere and in the Martian regolith.

MAHLI

- The Mars Hand Lens Imager (MAHLI) is a focusable color camera located on the turret at the end of the MSL robotic arm. The instrument acquires images of up to 1600 by 1200 pixels with a color quality equivalent to that of consumer digital cameras.

MARDI

- The Mars Descent Imager (MARDI) is a fixed-focus color camera fixed-body-mounted to the fore-port-side of the MSL rover, even with the bottom of the rover chassis. The optical axis points in the +Z direction (toward the ground in the rover coordinate system).

APXS

- The MSL APXS takes advantage of a combination of the terrestrial standard methods Particle-Induced X-ray Emission (PIXE) and X-ray Fluorescence (XRF) to determine elemental chemistry.
- Determine the abundance of major elements down to trace elements from sodium to bromine and beyond.
- The sampled area is about 1.7 cm in diameter when the instrument is in contact with the sample.

ChemCam

- The ChemCam instrument package consists of two remote sensing instruments: the first planetary science Laser-Induced Breakdown Spectrometer (LIBS) and a Remote Micro-Imager (RMI). The LIBS provides elemental compositions, while the RMI places the LIBS analyses in their geomorphologic context.
- The LIBS instrument uses powerful laser pulses, focused on a small spot on target rock and soil samples within 7 m of the rover
- Typical rock and soil analyses yield detectable quantities of Na, Mg, Al, Si, Ca, K, Ti, Mn, Fe, H, C, O, Li, Sr, and Ba. Other elements often seen in soils and rocks on Earth include S, N, P, Be, Ni, Zr, Zn, Cu, Rb, and Cs.

CheMin

- CheMin, short for “Chemistry and Mineralogy,” is a powder X-ray Diffraction (XRD) instrument that also has X-ray Fluorescence (XRF) capabilities.
- CheMin will analyze as many as 74 samples delivered by the SA/SPaH system during the nominal prime mission, but is capable of analyzing many more because its sample cells can be reused for additional analyses.

SAM

- The Sample Analysis at Mars (SAM) Suite Investigation in the MSL Analytical Laboratory is designed to address the present and past habitability of Mars by exploring molecular and elemental chemistry relevant to life. SAM addresses carbon chemistry through a search for organic compounds, the chemical state of light elements other than carbon, and isotopic tracers of planetary change

SAM

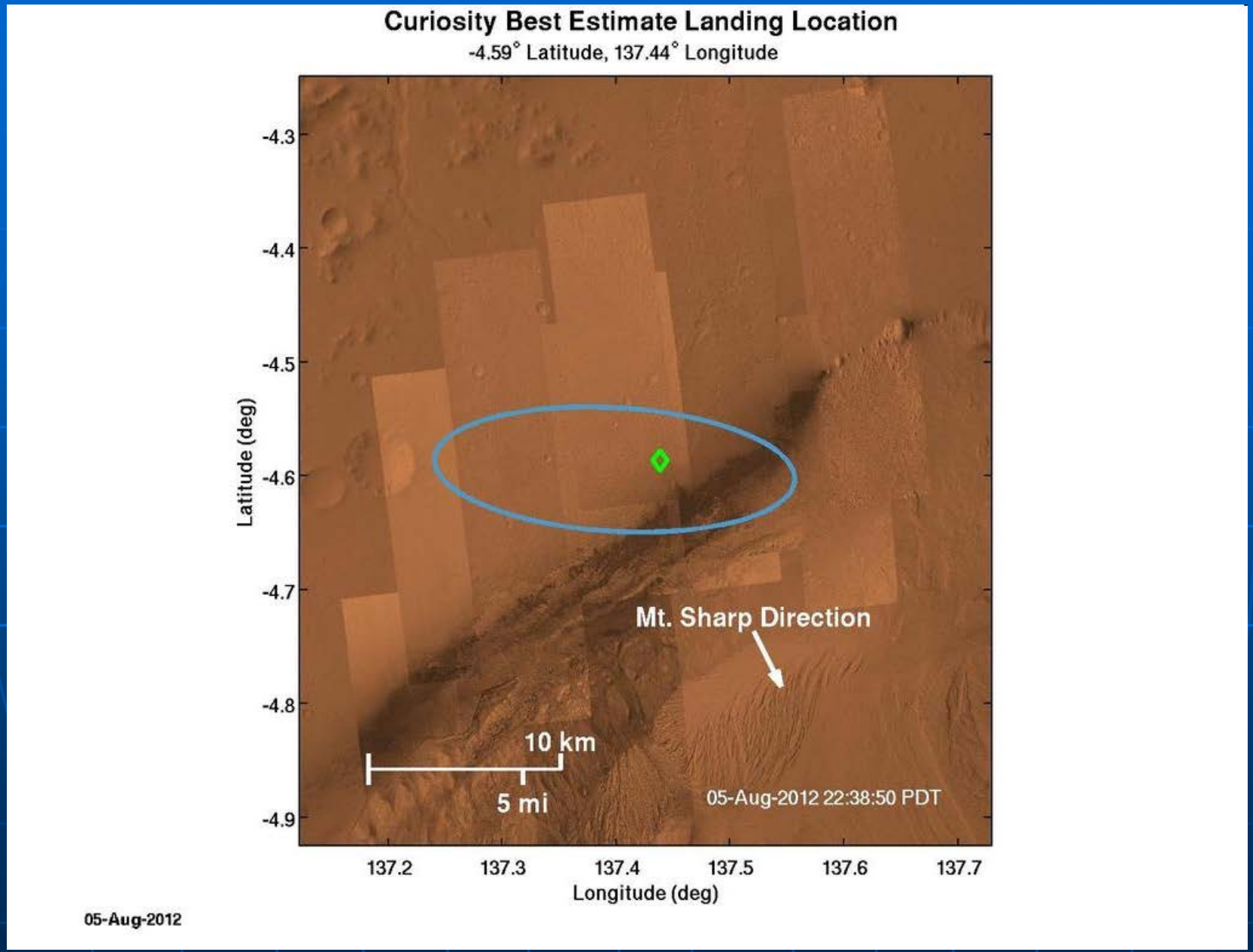
- SAM is a suite of three instruments, a Quadrupole Mass Spectrometer (QMS), a Gas Chromatograph (GC), and a Tunable Laser Spectrometer (TLS). The QMS and the GC can operate together in a GCMS mode for separation (GC) and definitive identification (QMS) of organic compounds. The TLS obtains precise isotope ratios for C and O in carbon dioxide and measures trace levels of methane and its carbon isotope.

Quadrupole Mass Spectrometer			Tunable Laser Spectrometer	
Summary: QMS analyzes the atmosphere, gases thermally evolved from solid phase samples to sub ppb sensitivity. QMS is the primary detector for the GC and can operate in static or dynamic mode			**Summary:** Two-channel Herriott cell design spectrometer that provides high sensitivity, unambiguous detection of targeted species (CH_4, H_2O, and CO_2) and selected isotope ratios. One channel is at a wavelength of 3.27 µm for CH_4, and the second is at 2.78 µm for CO_2 and H_2O.	
Mass range	2-535 Dalton (Da)		sensitivity	Methane: 2 ppb direct Water: 2 ppm direct CSPL enrichment improves by ~100x
Detector dynamic range	$>10^{10}$ with pulse counting and Faraday Cup		Isotopes	$^{13}C/^{12}C$ in methane; $^{13}C/^{12}C$ in CO_2; $^{18}O/^{16}O$ in CO_2 ; $^{17}O/^{16}O$ in CO_2
Crosstalk	$<10^6$ adjacent unit mass channels (below 150 Da)		Isotope precision	Typically < 10 per mil

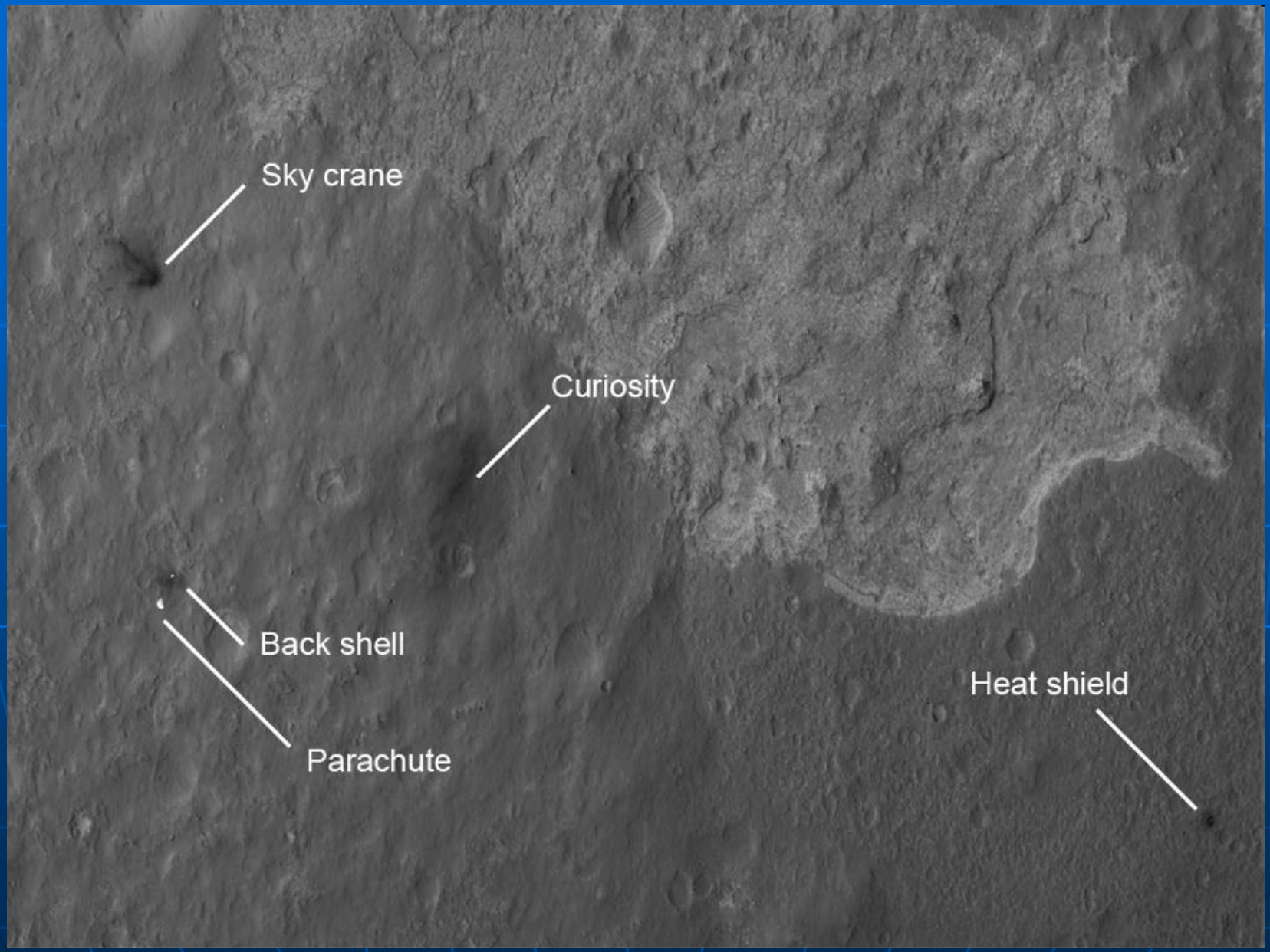
Gas Chromatograph	
Summary: GC separates complex mixtures of organic compounds into molecular components for QMS and GC stand alone analysis. Helium carrier gas is utilized.	
Injection	Injection from traps in the SAM manifold or from 3 GC injection traps incorporated into the GC subsystem
6 GC Columns	GC1; w/o trap; w/o TCD; MXT20 (C5-C15 organics) GC2; w/o trap; TCD; MXT5 (> C15 organics) GC3; trap; TCD; Carbobond (permanent gases) GC4; trap; TCD; ChirasilDex (chiral compound separation) GC5; trap; TCD; MXT CLP (C5-C15 organics) GC6; trap; TCD; MXTQ (C1-C4 organics/N/S compounds)
Detection Limit	10^{-11} mole

MSL – the mission

- Gale crater
- 5 km pile of sediments
- Can/will run for many years

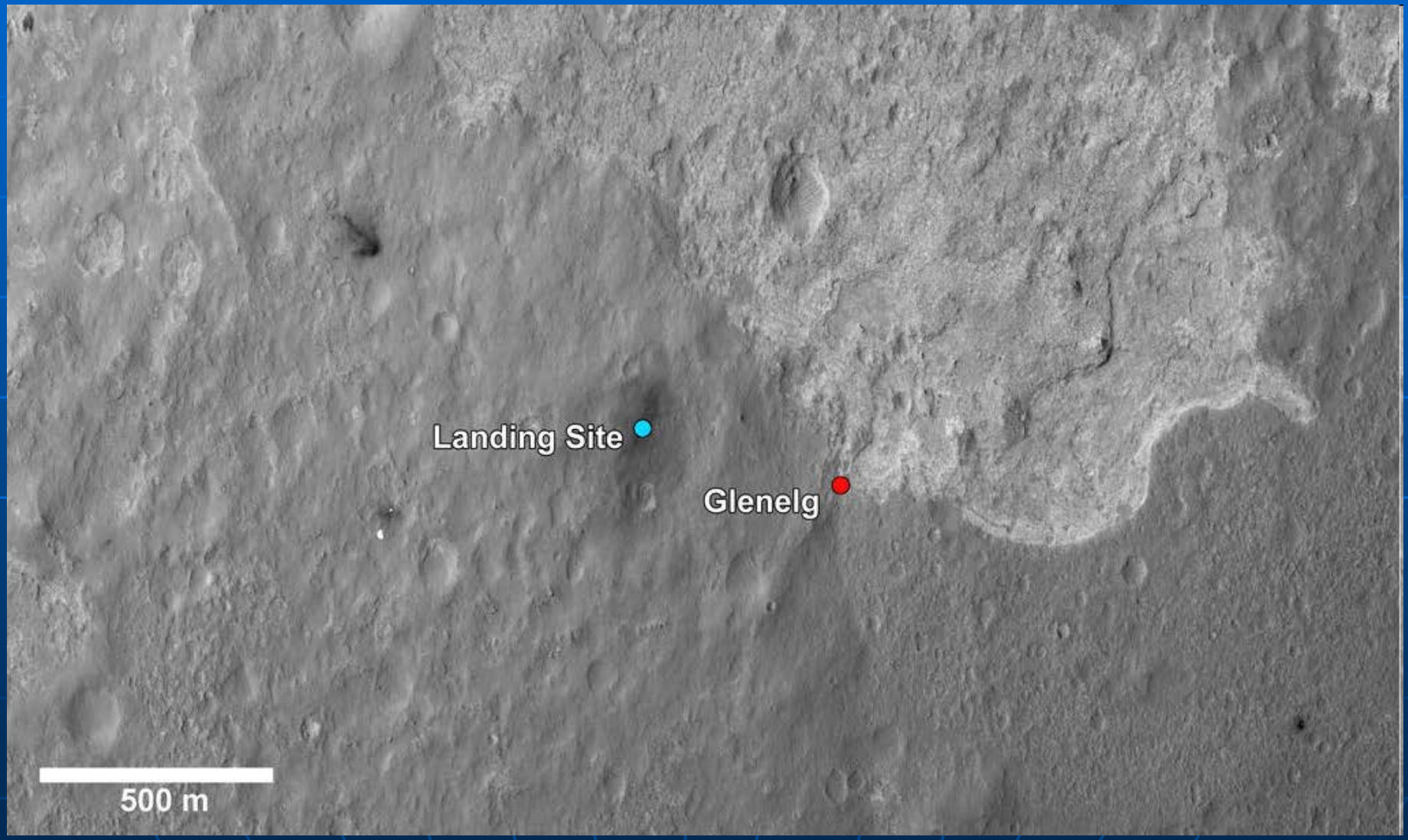

Curiosity Best Estimate Landing Location
-4.59° Latitude, 137.44° Longitude
-4.3
-4.4
-4.5
-4.6
-4.7
-4.8
-4.9
Latitude (deg)
Mt. Sharp Direction
10 km
5 mi
05-Aug-2012 22:38:50 PDT
137.2
137.3
137.4
137.5
137.6
137.7
Longitude (deg)
05-Aug-2012


Landing Site
Glenelg
Base of Mount Sharp
Lower Reaches of Mount Sharp
MND
EOL
Kilometers
0 0.5 1 2 3 4 5


Sky crane
Curiosity
Back shell
Parachute
Heat shield


Curiosity

1st target

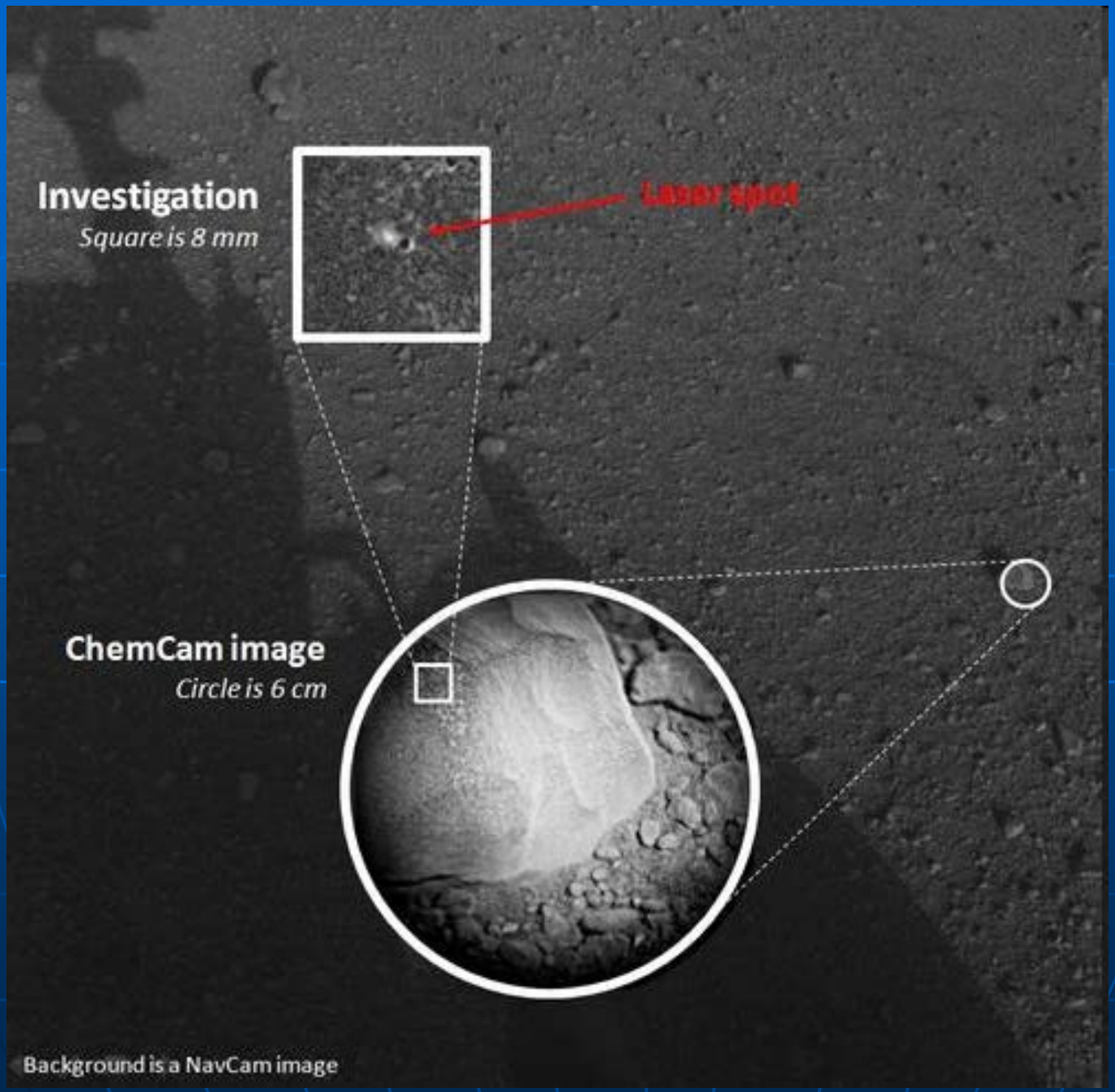



Landing Site
Glenelg
Base of Mount Sharp
Lower Reaches of Mount Sharp
MND
EOL
Kilometers
0 0.5 1 2 3 4 5

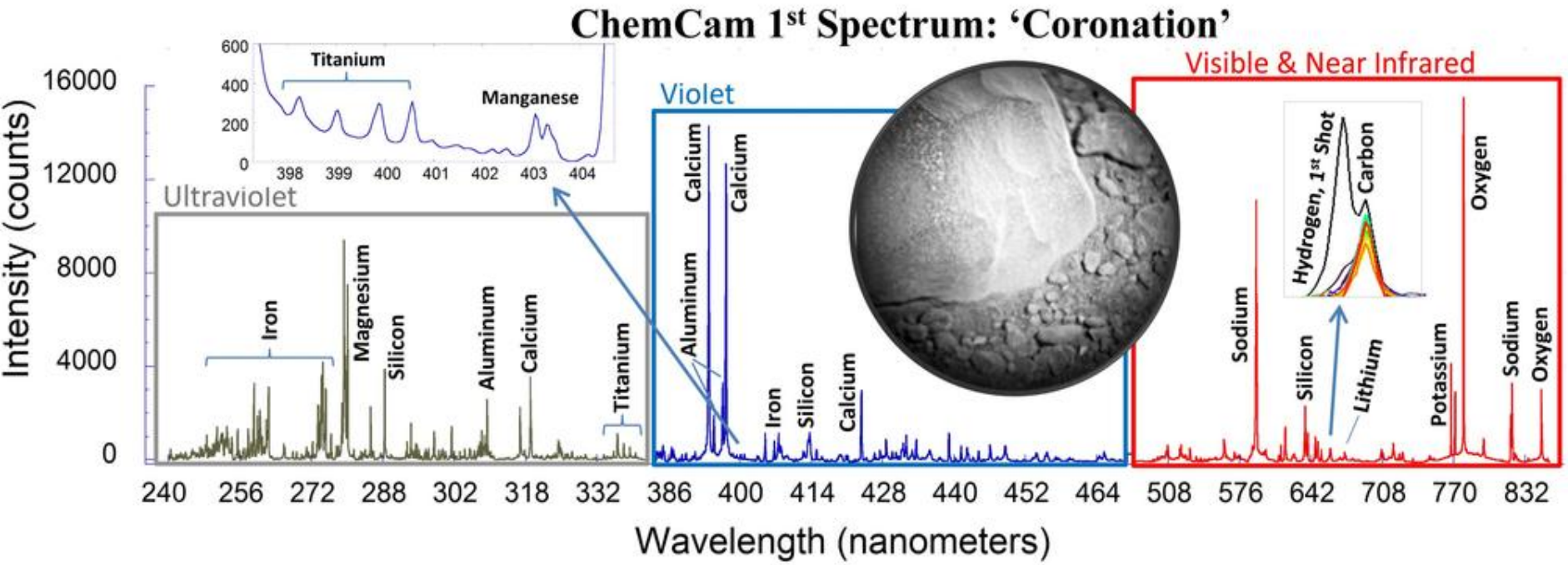

100 m

Early results

- Instruments getting checked out
- First target for LIBS


Investigation
Square is 8 mm
Laser spot
ChemCam image
Circle is 6 cm
Background is a NavCam image


pour Corinne


ChemCam 1st Spectrum: 'Coronation'
Intensity (counts)
16000
12000
8000
4000
0
Ultraviolet
Iron
Magnesium
Silicon
Aluminum
Calcium
Titanium
600
400
200
0
398 399 400 401 402 403 404
Titanium
Manganese
Violet
Calcium
Calcium
Aluminum
Iron
Silicon
Calcium
Visible & Near Infrared
Hydrogen, 1st Shot
Carbon
Oxygen
Sodium
Silicon
Lithium
Potassium
Sodium
Oxygen
240 256 272 288 302 318 332 386 400 414 428 440 452 464 508 576 642 708 770 832
Wavelength (nanometers)