APXS on Mars Science Laboratory – First Results From Post-landing Checkout

C. S. Dickinson[1], R. Gellert[2], P. Dietrich[1] and D. Hiemstra[1]

[1]MacDonald Dettwiler & Associates, [2]University of Guelph

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MSL APXS Background

- Payload contribution to MSL program by the Canadian Space Agency
- PI: Dr. Ralf Gellert, University of Guelph, Canada
- Prime contractor MacDonald Dettwiler & Associates (MDA)
- Scientific design and engineering support by University of Guelph, Canada
- Scientific design based on the successful MER design by Max-Plank Institute for Chemistry, Mainz, Germany

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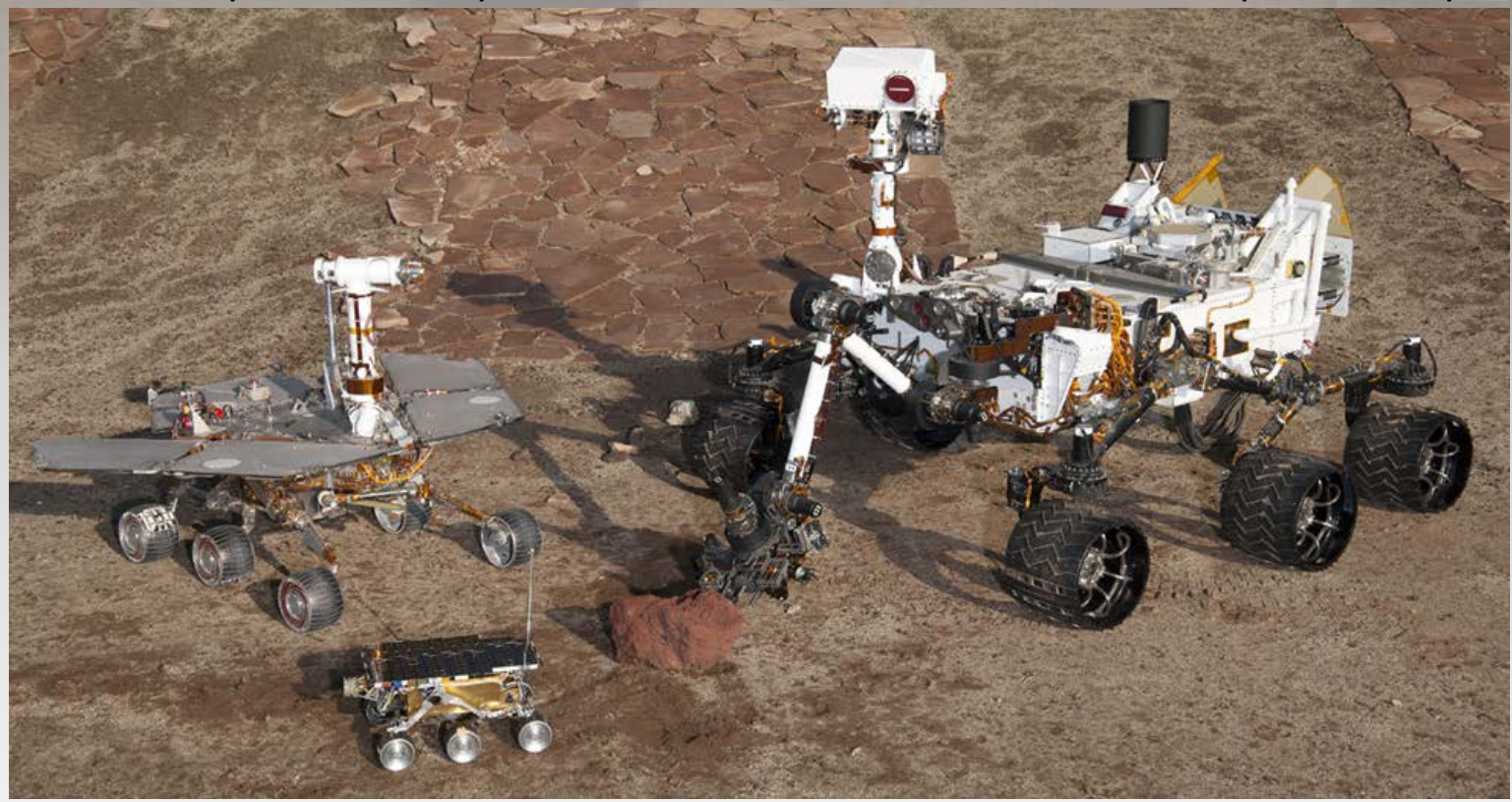
APXS Flight Lineage

Second generation:

Rover Spirit and Opportunity on MER Mission (2004 - now)

Third generation:

Rover Curiosity on MSL Mission (2012 - ??)



First generation:

Sojourner rover on Mars Pathfinder Mission (1997)

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Principle of APXS

MSL APXS Detector

- Silicon drift detector (SDD) to detect x-rays induced by radioactive source
- ^{244}Cm source generating α particles and x-rays

Two modes

- PIXE: Particle induced x-ray emission
  - α particles eject inner shell electrons, resulting in characteristic x-ray emission
  - Best yield for low-Z elements
- XRF: X-ray induced fluorescence
  - X-rays (14 keV, 18 keV) eject inner shell electrons, resulting in characteristic x-ray emission
  - Best yield for high-Z elements

Application

- Elemental analysis of rocks, soils.
- Essential geological data

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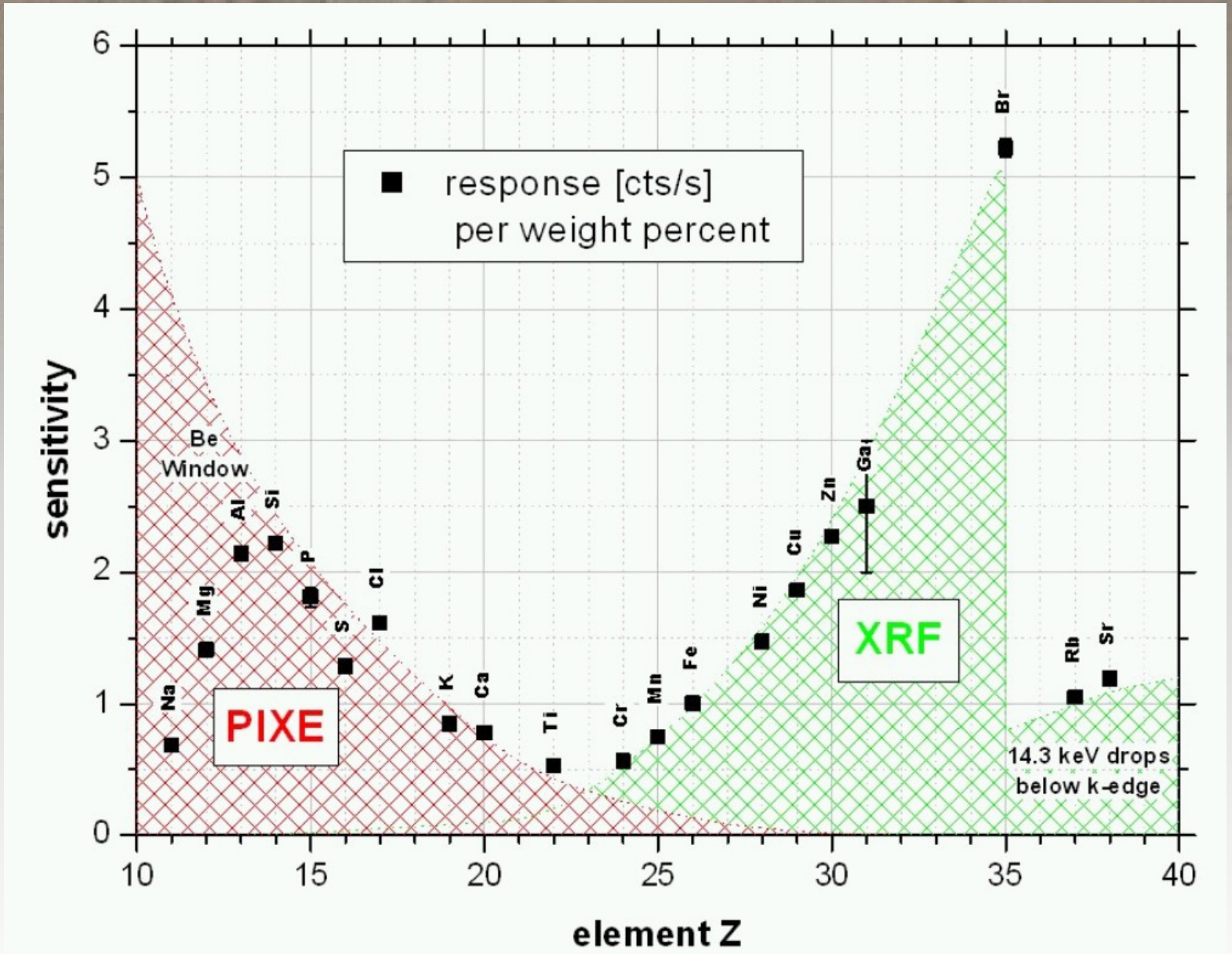
Sensitivity of PIXE and XRF Mode



MSL APXS Changes and Improvements

- Activated Peltier cooler for SDD ($\Delta T \sim -30C$)
  - Increased operating temperature up to -5° C (before -40° C)
  - Allows tactical daytime operation (before: only nighttime)
  - Improved resolution < 150 eV during night
- Shorter sample-detector distance
  - Possible by discarding alpha channel
  - Increased sensitivity by factor of 3
  - Decreased data acquisition by factor 5 (now 10 min to 2 hours)
- Added standard XRF ^{244}Cm sources
  - Increased sensitivity for high-Z elements by factor of 2
- On-board basaltic rock slab for calibration.
- Extended energy range to 25 keV (before 17 keV)
- Various SW enhancements, proximity mode, SW update,..

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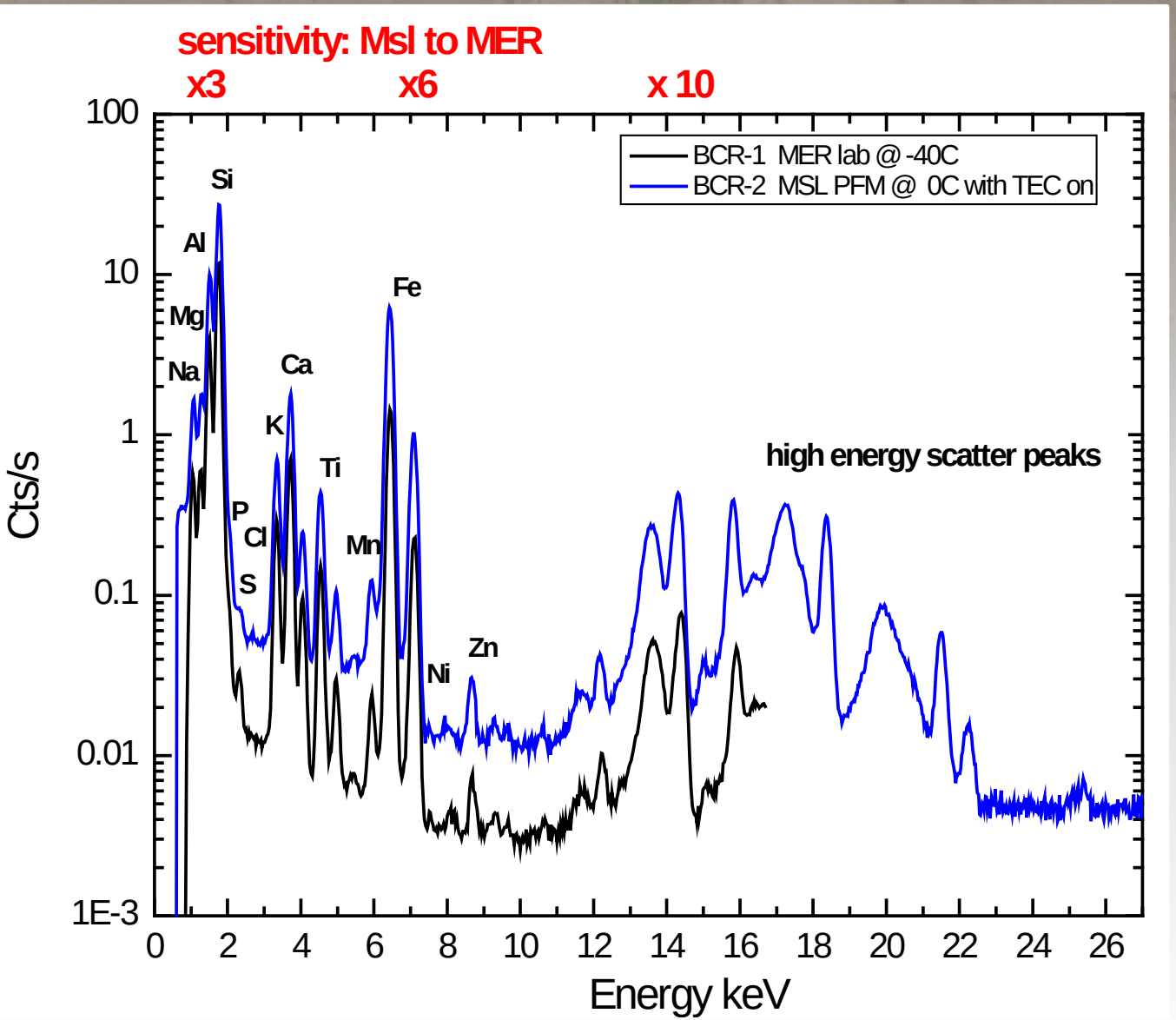
MER APXS versus MSL APXS



MSL APXS is ~ 6 times faster than MER

Able to measure at ~ 0 C during day ! MER needed -40C !

Additionally higher scatter peaks and extended energy

We are about 10 times faster than the MER APXS and can take good data during the day

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MSL APXS Calibration

Calibration approach similar to previous generation (MER)

- Calibration in laboratory using various basalts, minerals, sediments, well defined mixtures and chemical compounds
- Two independent analysis approaches (MER empirical and from first principles)
- On Mars re-calibration possible using the flight calibration target (basaltic rock slab)

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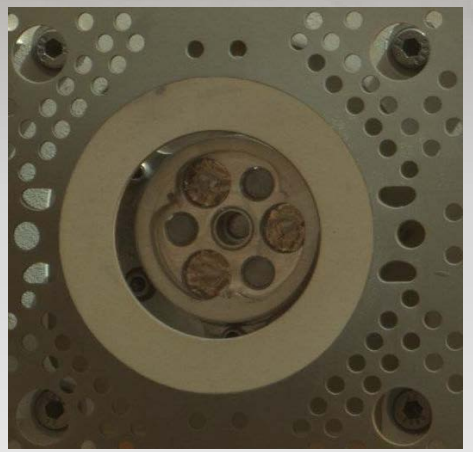
MSL APXS Specifications

Parameter	Value
Sources	30 mCi of conventional sealed ^{244}Cm + 30 mCi of α emitting ^{244}Cm
Sample distance	~ 20 mm, standoff possible
Sample size in contact	17 mm ∅
Energy range	0.7 keV to 25 keV
Resolution (FWHM)	143 eV, T< -20° C
Operating temperature	-130° C to -5° C(*)
Power dissipation	8 W, incl. 3 W Peltier
Mass sensor head	362 g
Mass calibration target	114 g
Mass electronics	1166 g

(*) Up to 10°C with degraded resolution



JPL provided contact sensor

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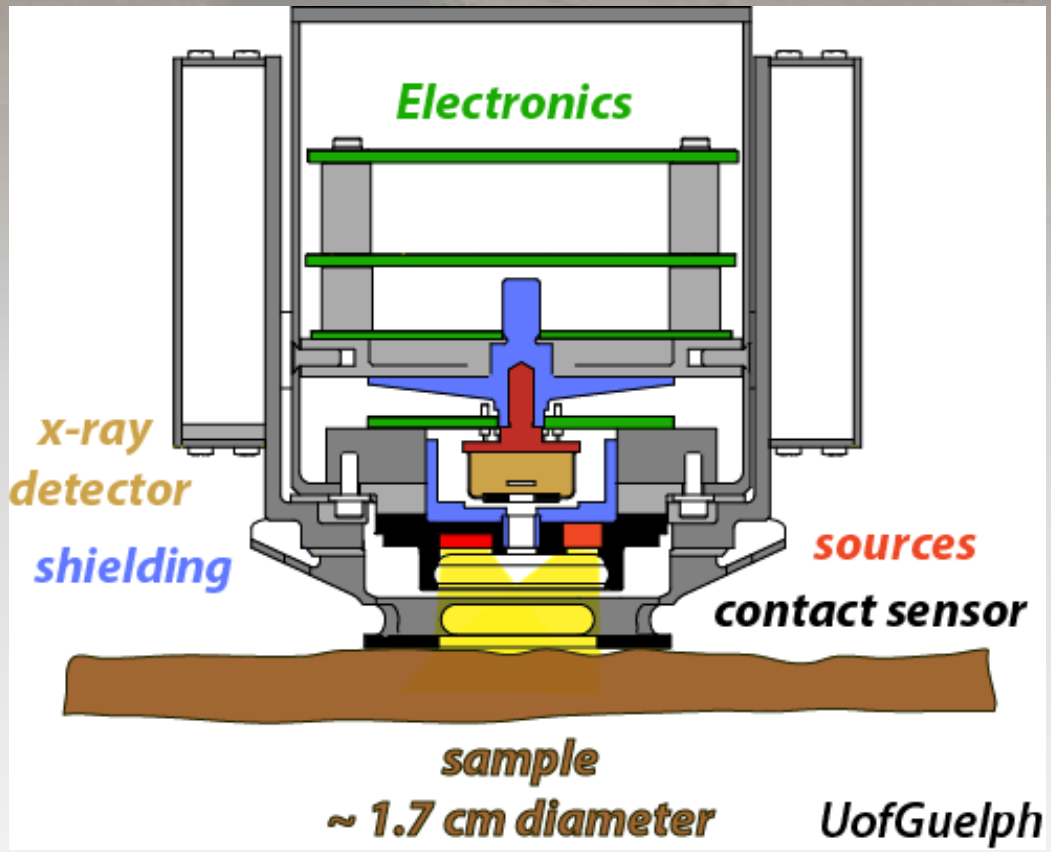
MSL APXS Design



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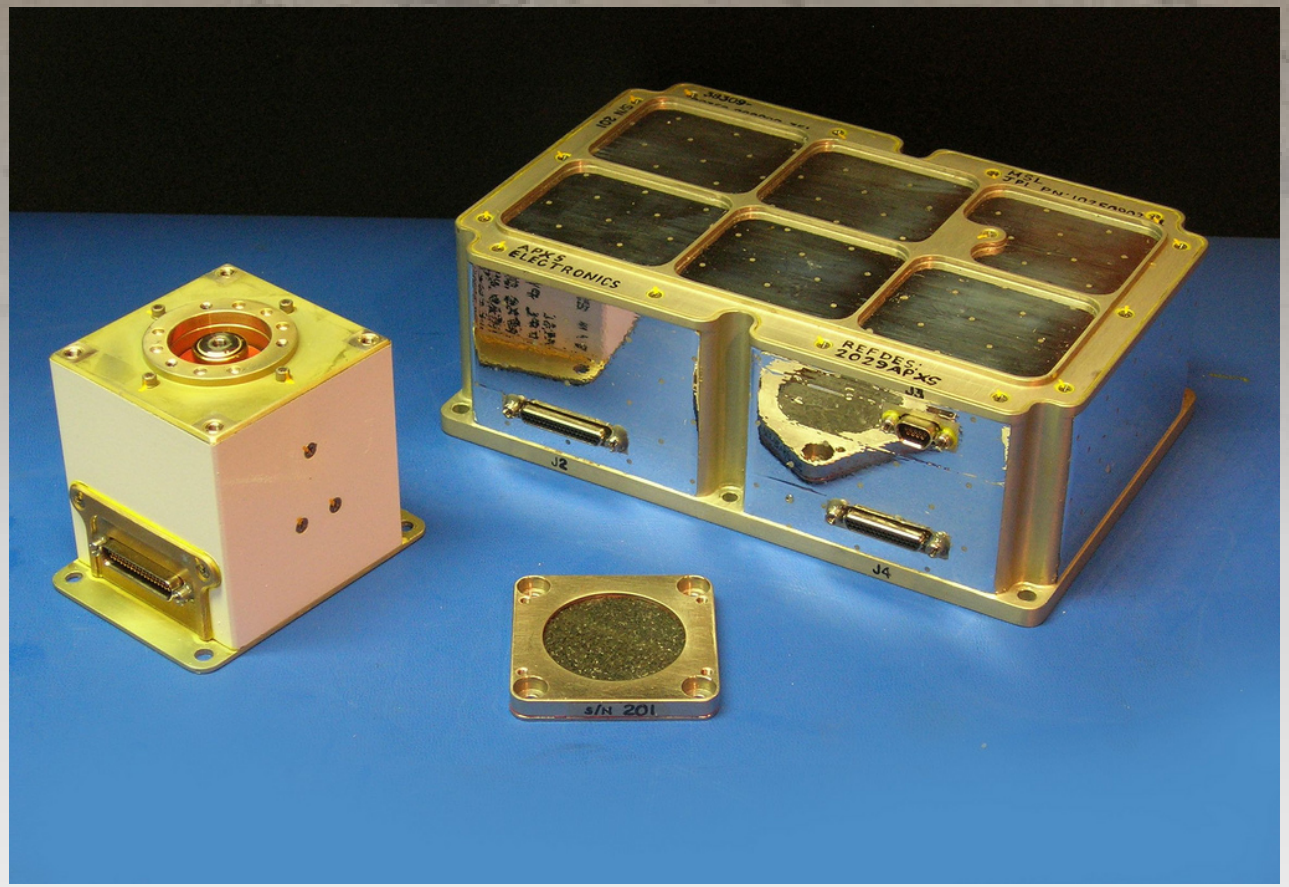
MSL APXS Flight Instrument



Sensor head

Electronics box

Calibration target (basaltic rock)

All deliverables underwent successful qualification, including 2x life PQV

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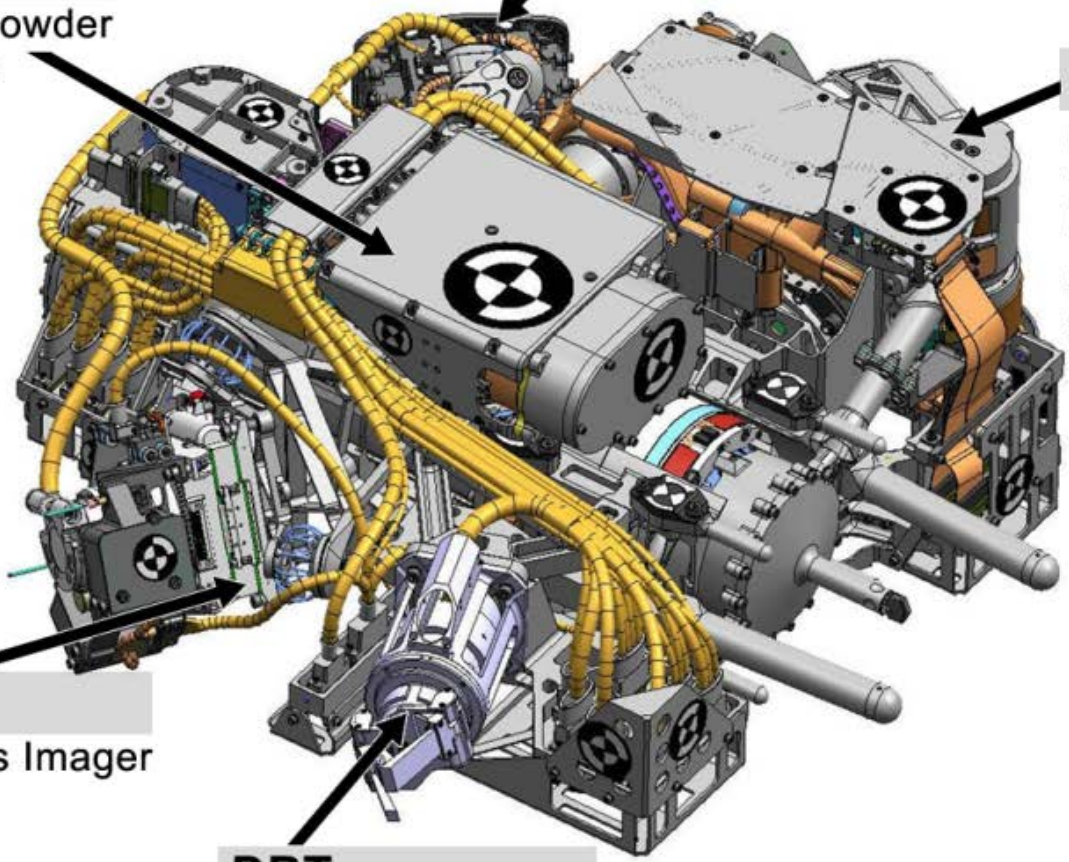
Curiosity Sampling Turret



APXS
Alpha Particle X-Ray Spectrometer

Drill
Acquires powder from rocks

CHIMRA
Collection and Handling for Interior Martian Rock Analysis

Scoops regolith, sieves and portions

MAHLI
Mars Hand Lens Imager

DRT
Dust Removal Tool

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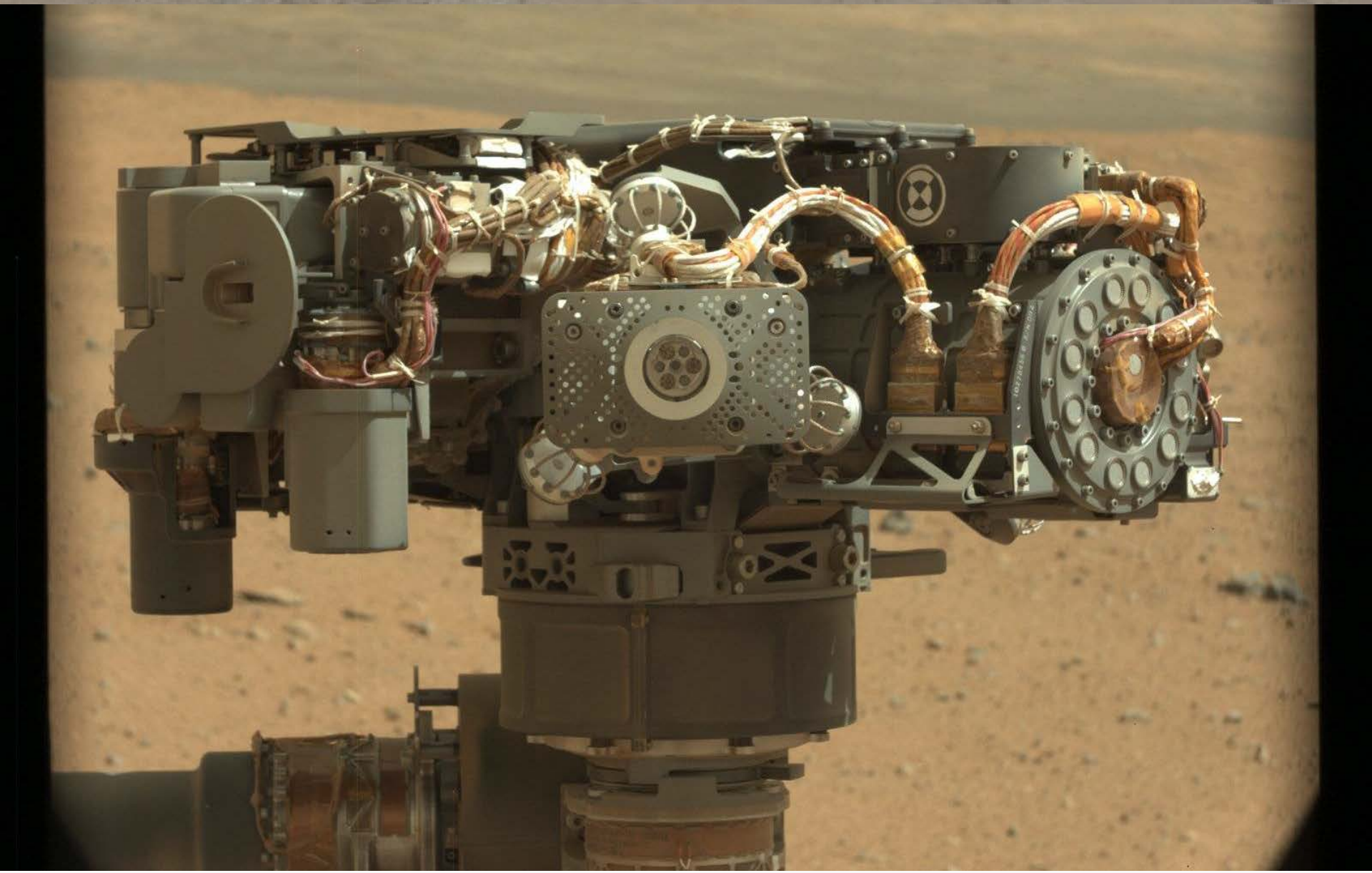
Curiosity Turret: APXS View



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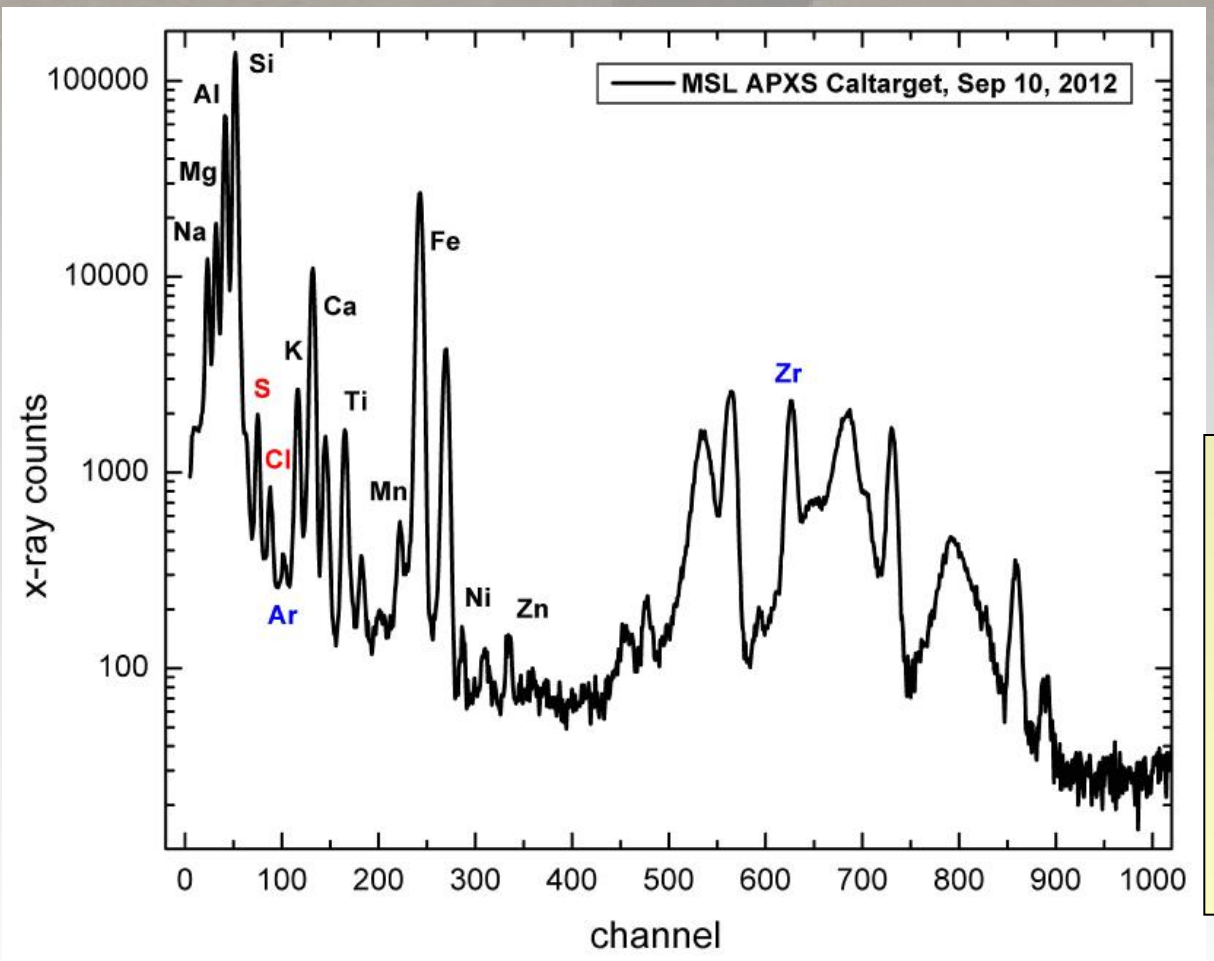
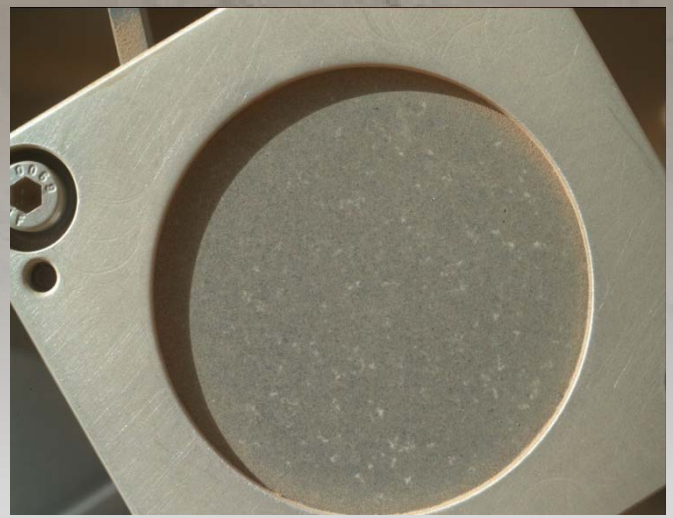
First Data from Mars

Calibration target on Curiosity (sol34)

- Red lines (S, Cl) are from dust on calibration target
- Ar line is from atmosphere, Zr from collimator
- Black lines are known calibration target lines





At night FWHM ~ 145eV.
During day FWHM 180-250eV
→
acceptable and good science in 20 minutes during day

All science design goals verified

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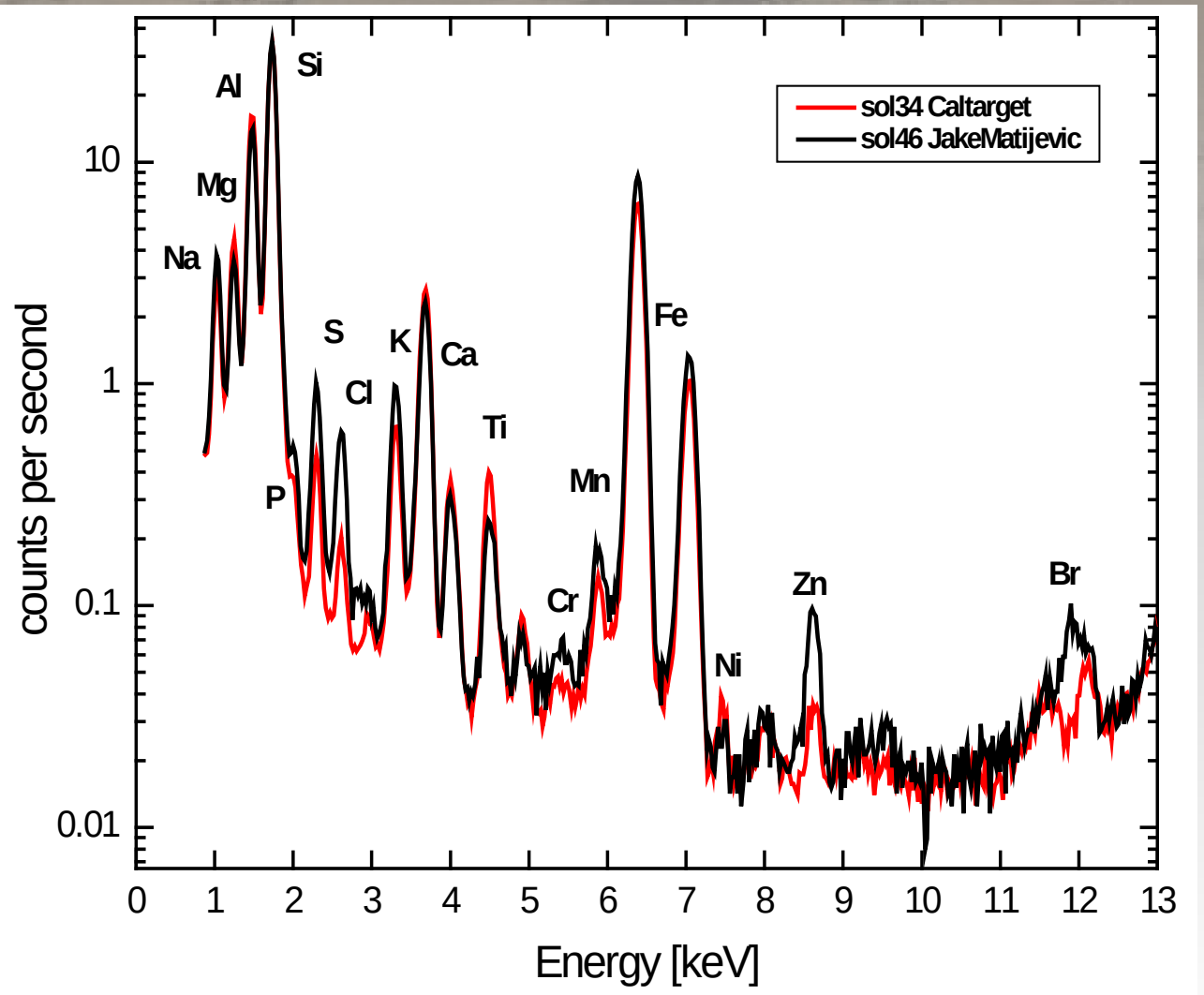
And More Data from Mars

APXS spectrum of rock Jake Matijevic (sol46)



Jake Matijevic compared to calibration target:

- Low in Mg, Fe
- High in Na, Al, Si, K
- Very low in Ni
- S, Cl, Br are likely from soil or dust on surface of rock
- Quite different from basalts measured with MER Spirit APXS in Gusev Crater

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Acknowledgements

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