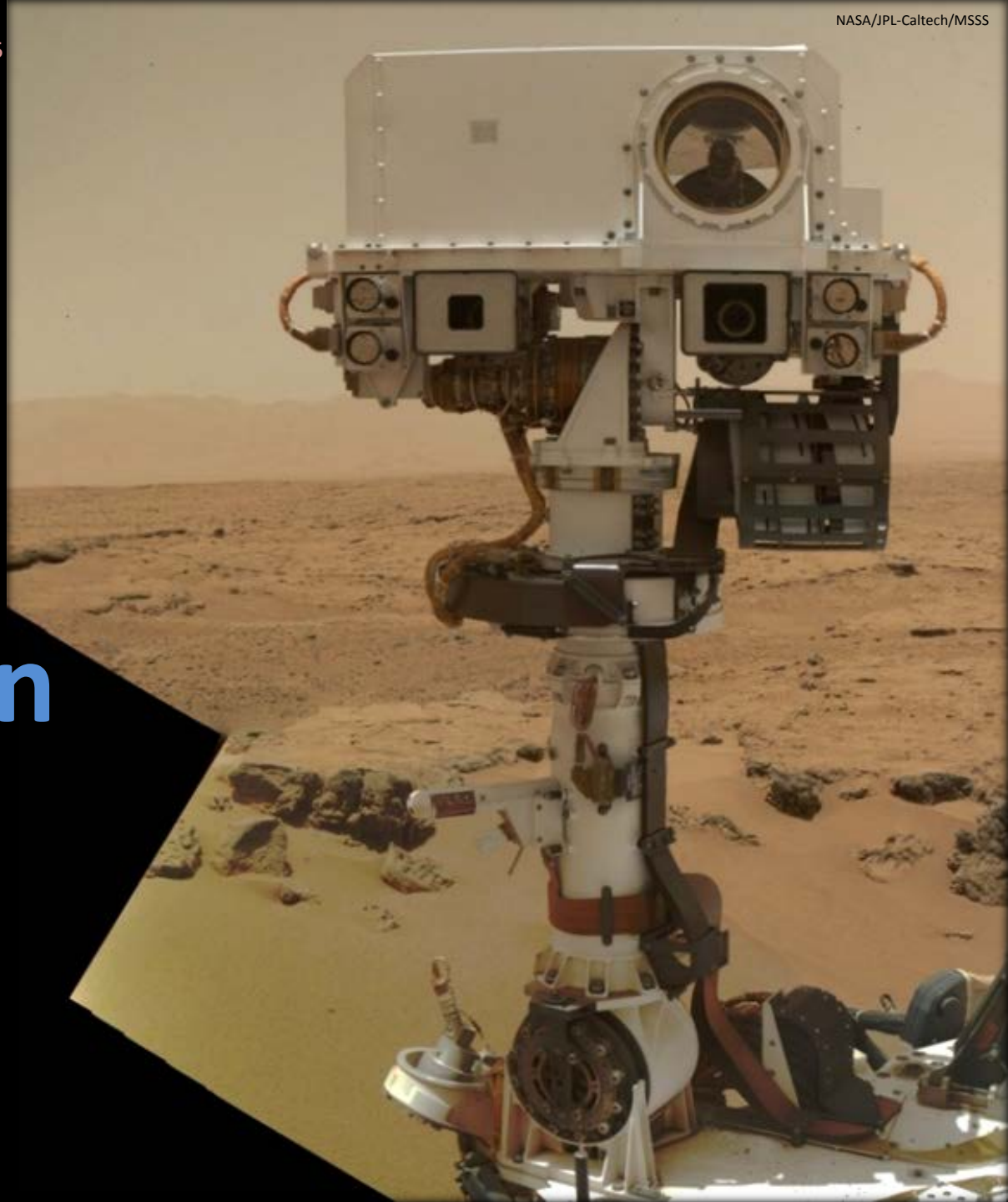
Lunar and Planetary Science Conference, March 18th, 2015

COMMUNITY USER WORKSHOP ON PLANETARY LIBS (CHEMCAM) DATA

Introduction to LIBS

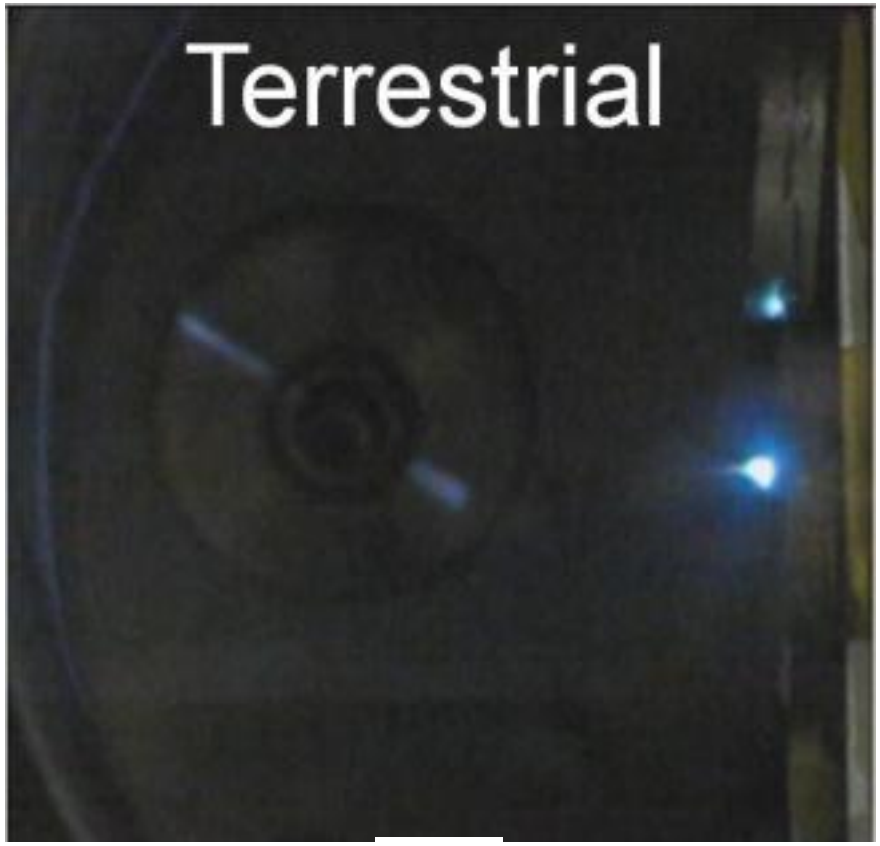
Sam Clegg

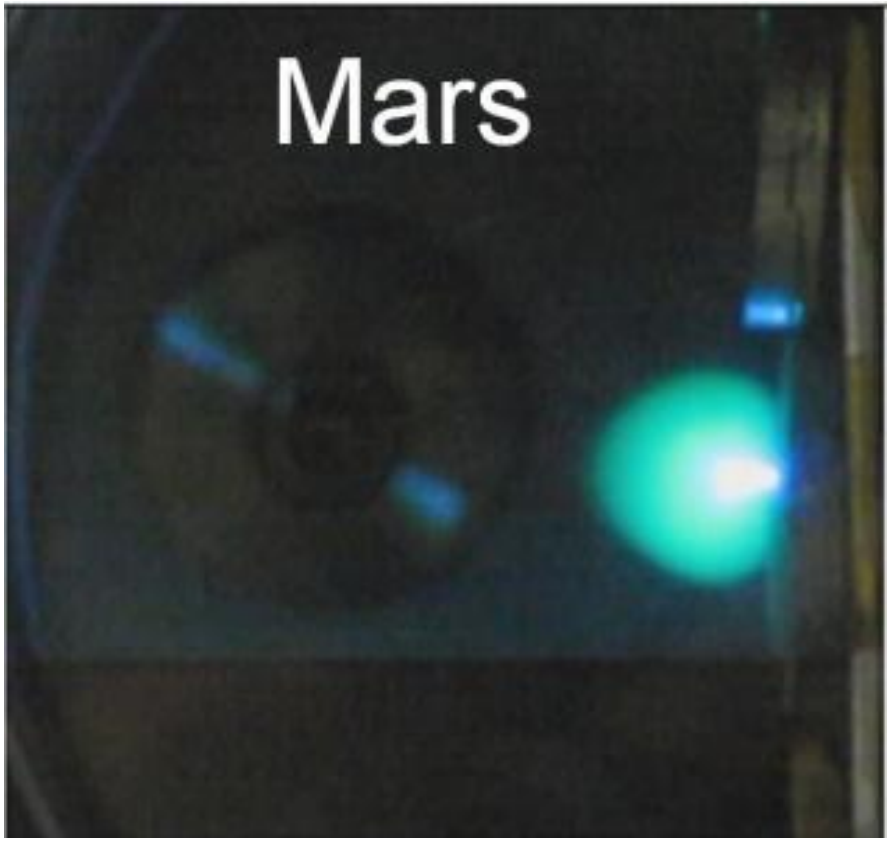
and the ChemCam team



NASA/JPL-Caltech/MSSS

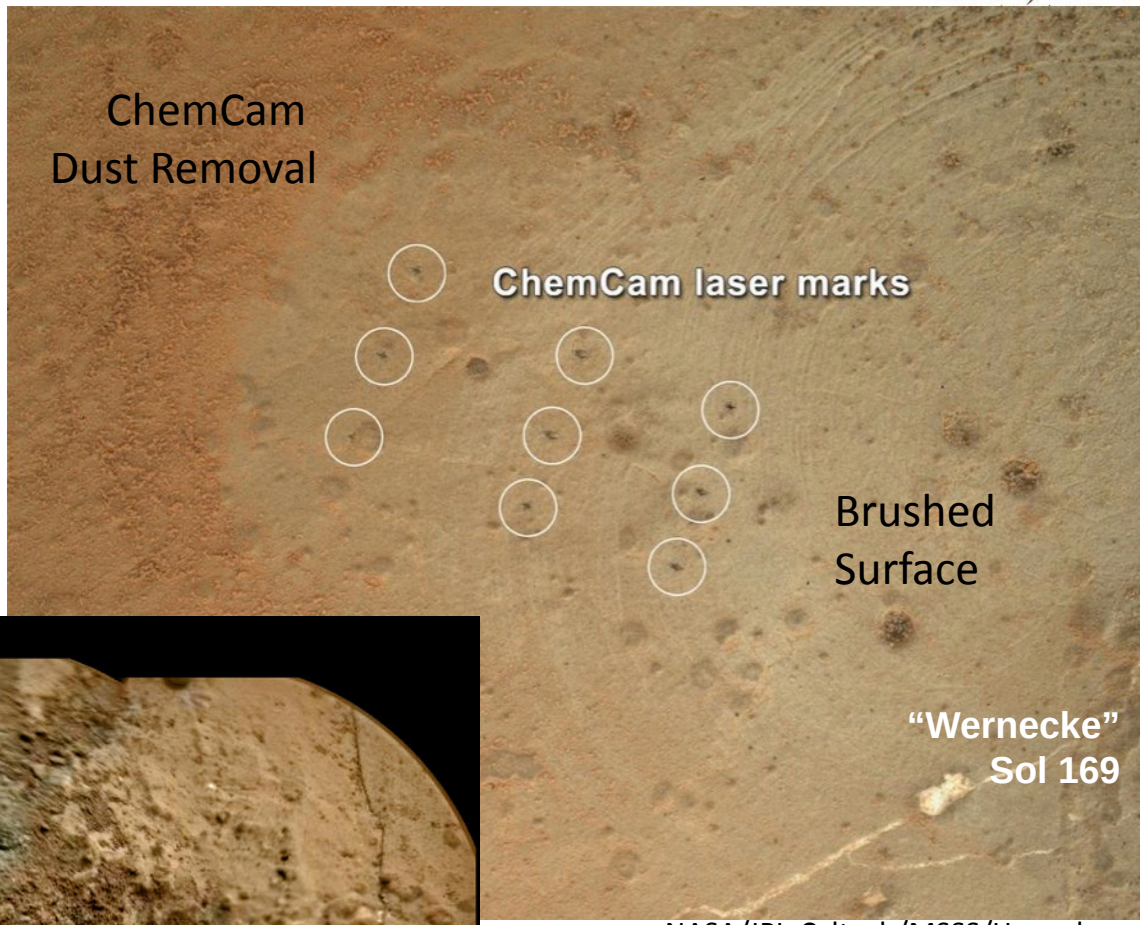
Creating LIBS Sparks



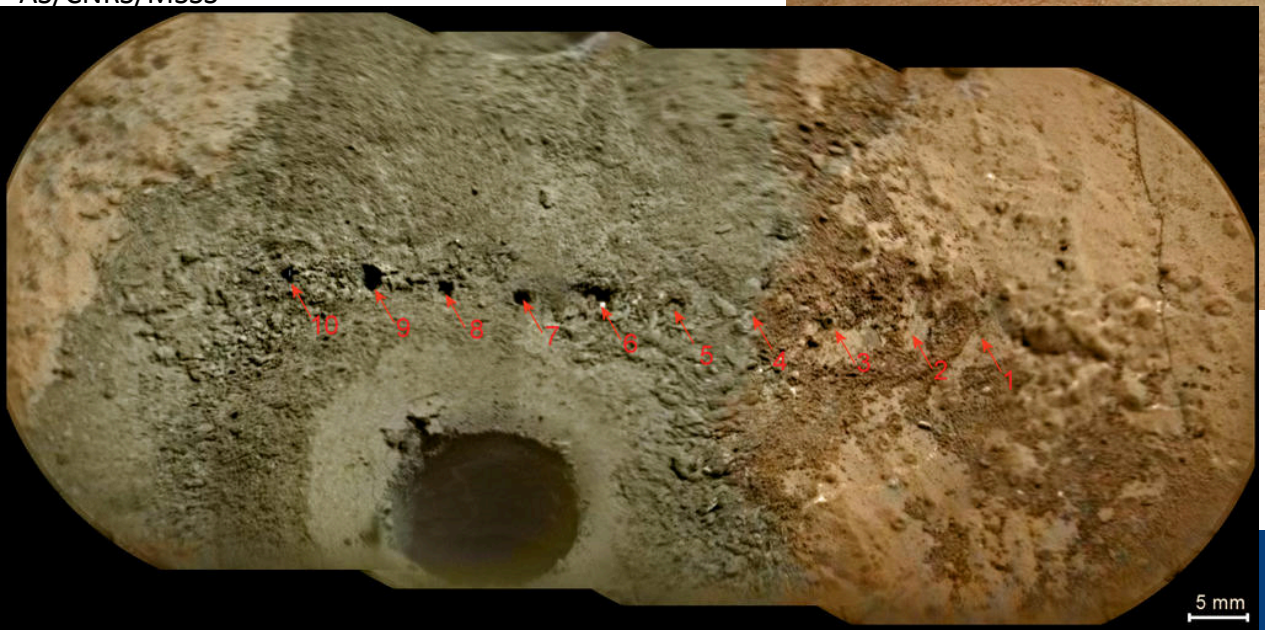


3”

LIBS Spots and Dust Removal

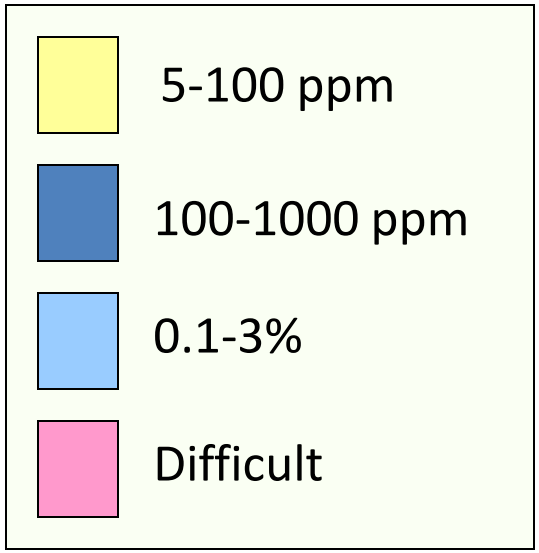


NASA/JPL-Caltech/LANL/IRAP/CNES/LPGNantes/IAS/CNRS/MSSS



NASA/JPL-Caltech/MSSS/Honeybee Robotics/LANL/CNES

LIBS Sensitivies, ChemCam Configuration

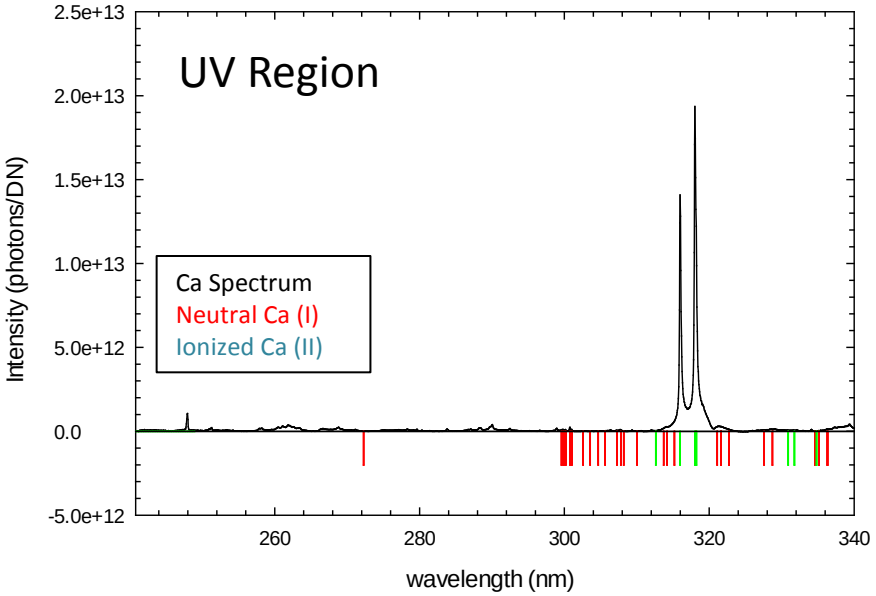


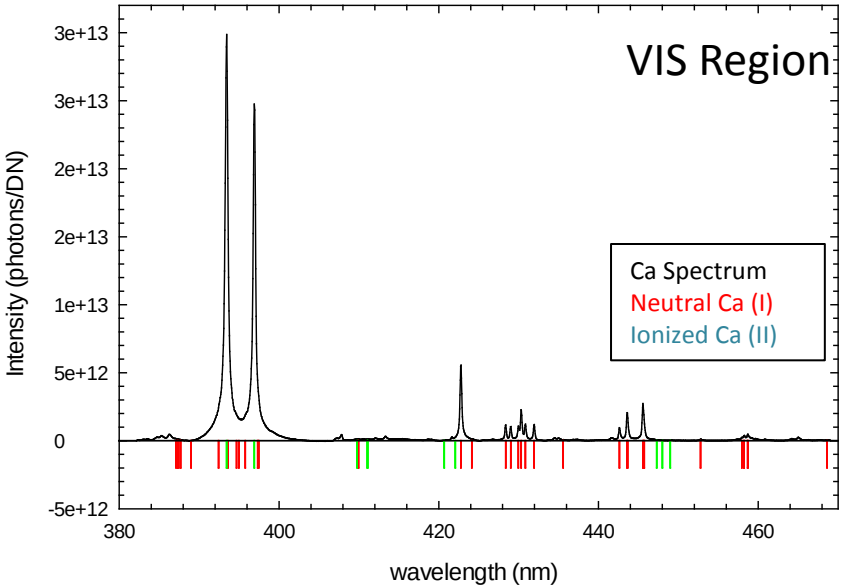
Approximate detection limits
at Mars atmospheric pressure

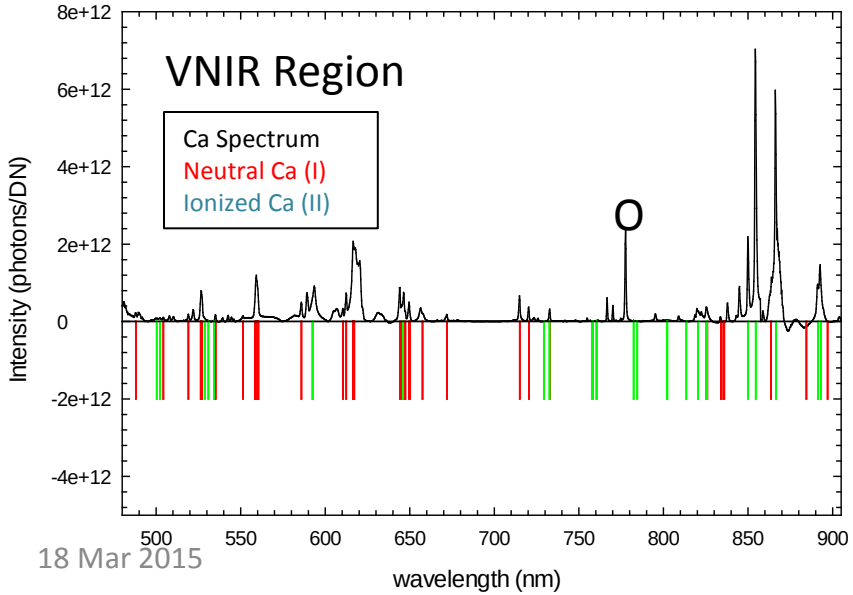
X* = Reported Oxides
X* = Reported in literature
X* = To be reported

H*																He
Li*	Be*										B*	C*	N*	O*	F*	Ne
Na*	Mg*										Al*	Si*	P*	S*	Cl*	Ar
K*	Ca*	Sc*	Ti*	V	Cr*	Mn*	Fe*	Co	Ni*	Cu*	Zn*	Ga	Ge	As*	Se	Br	Kr
Rb*	Sr*	Y	Zr	Nb	Mo		Ru	Rh	Pd	Ag	Cd*	In	Sn	Sb	Te	I	Xe
Cs	Ba*	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb*	Bi			

Ca LIBS Spectrum-LANL Testbed

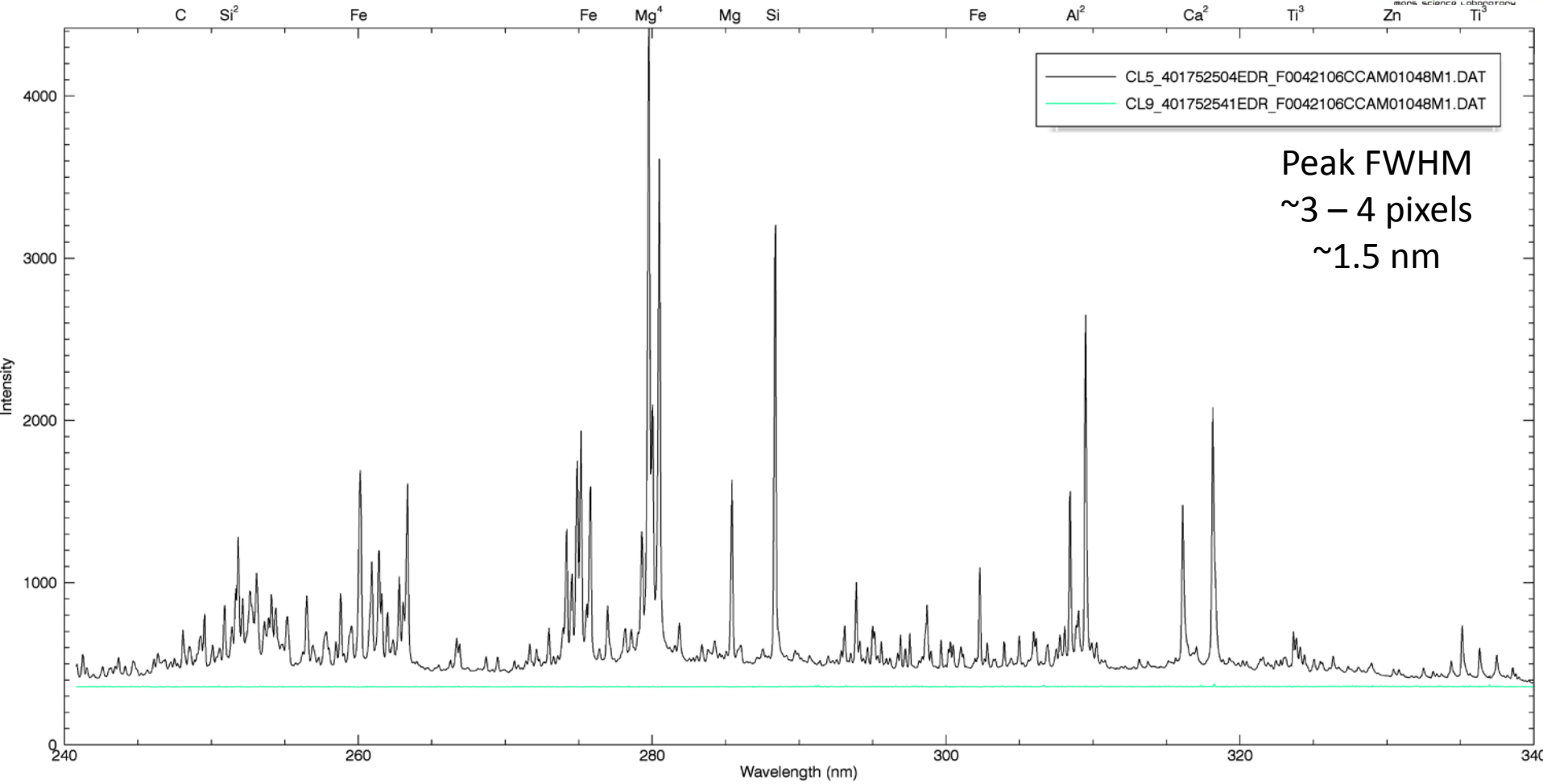




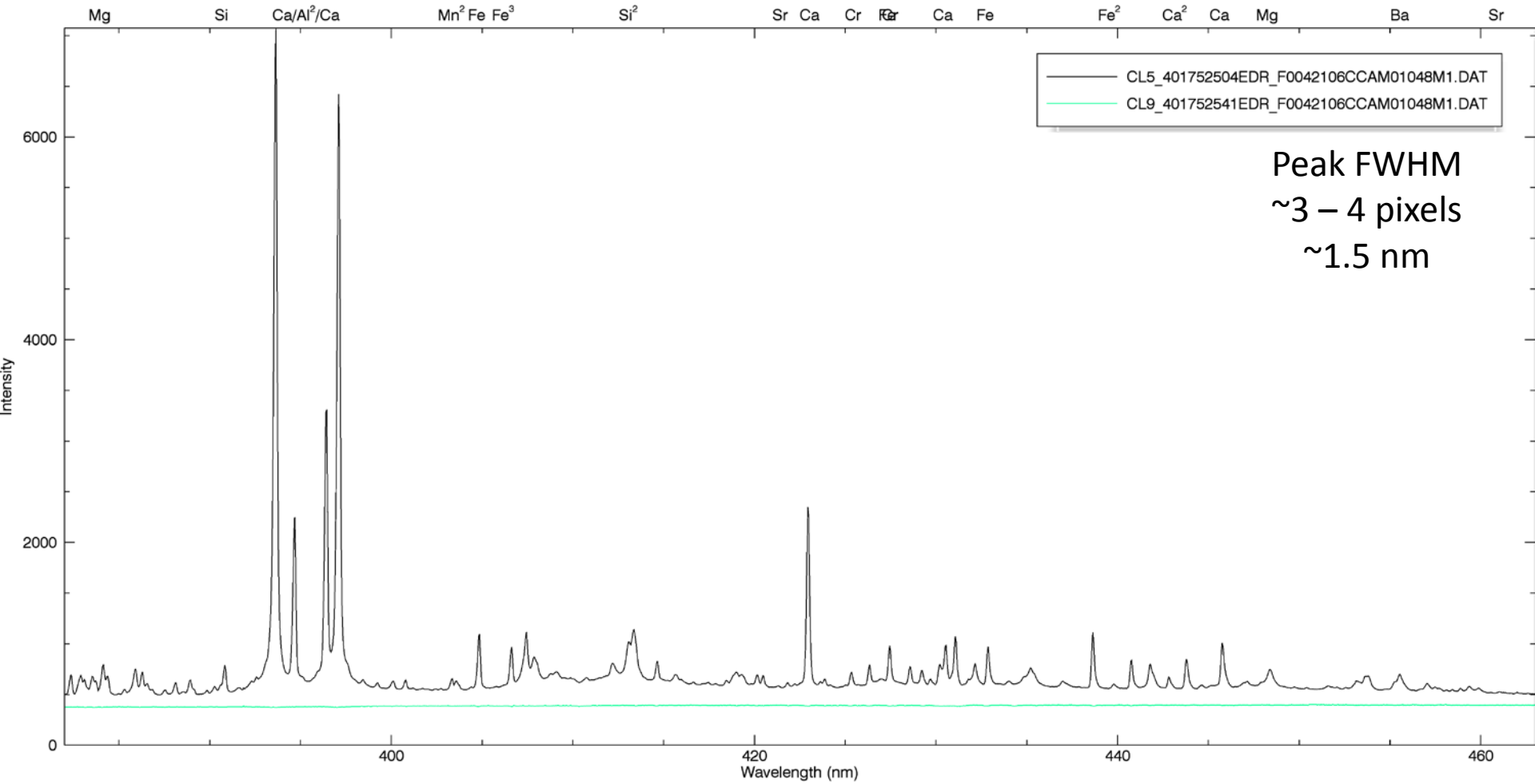


- Not every NIST emission line is observed in a LIBS spectrum.
  - http://physics.nist.gov/PhysRefData/ASD/lines_form.html
  - Every LIBS line must be found in NIST
  - Typically observe neutral and first ionized atoms, perhaps second ionization under ChemCam conditions.
- Must be Spectrally well calibrated!
  - Know the difference between vacuum vs. air (Earth or Mars) calibration
  - Closest NIST emission line is not good enough
- More details provided in the next few presentations

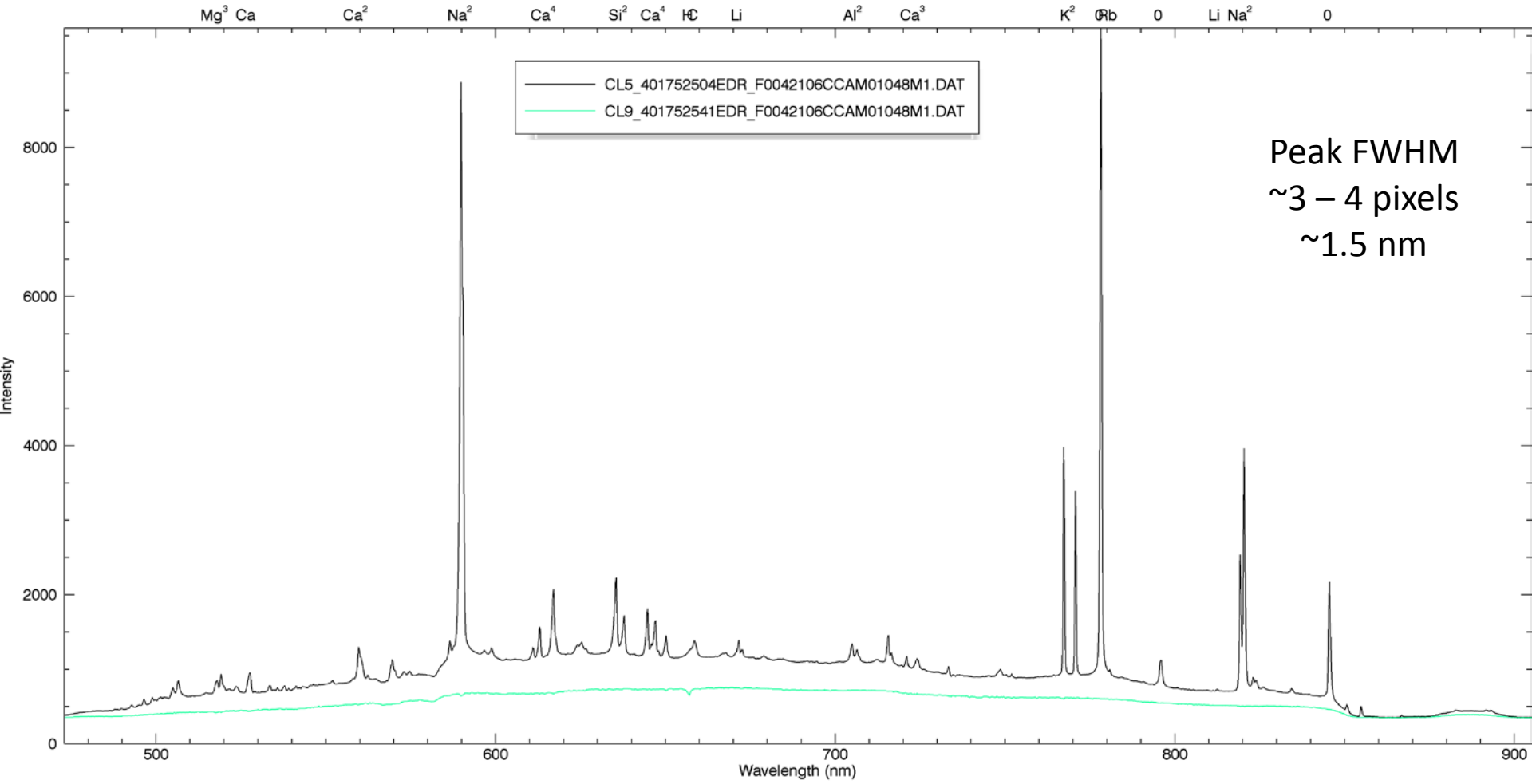
Raw ChemCam Spectrum – Jake_1



Raw ChemCam Spectrum – Jake_1



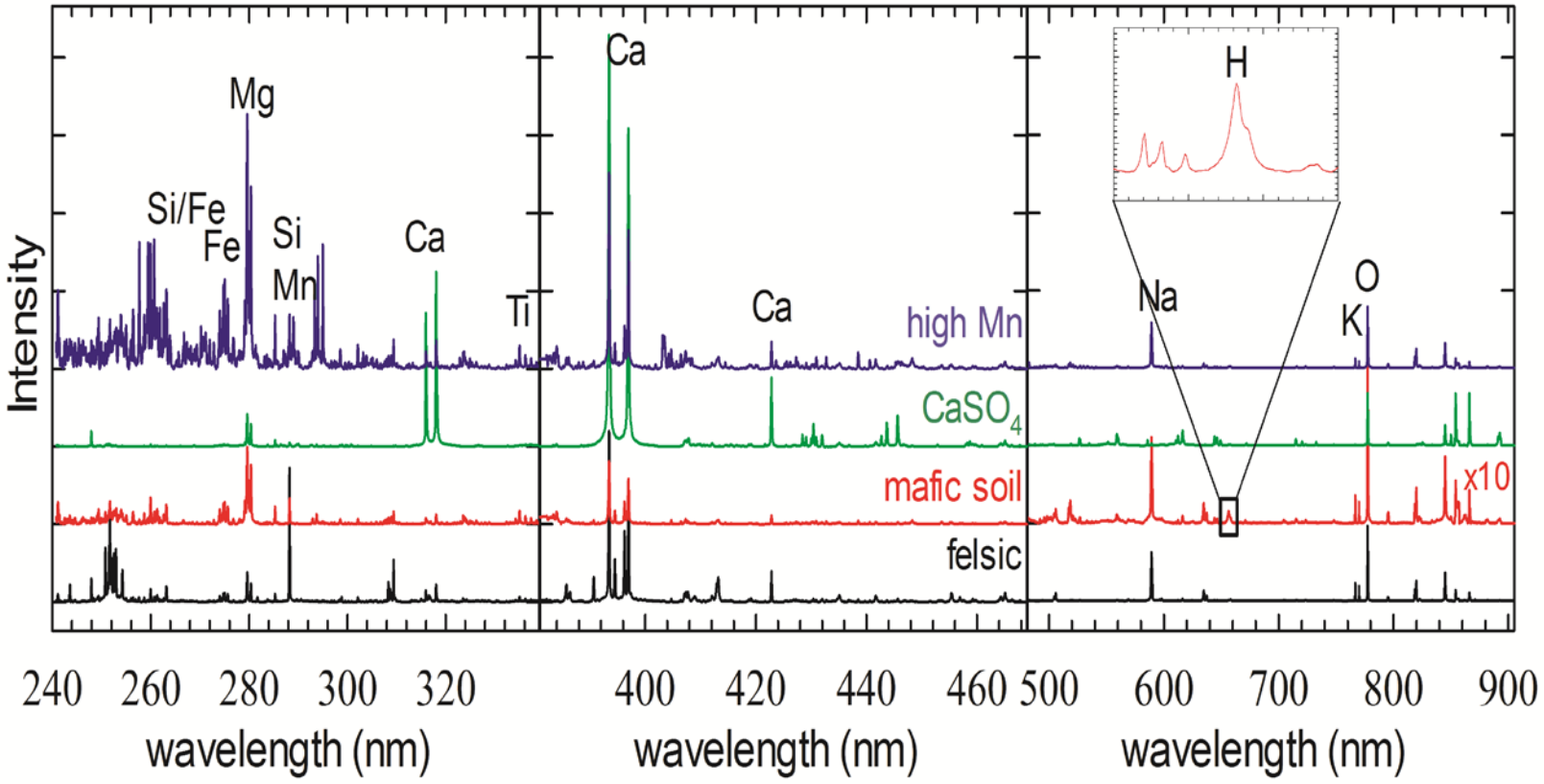
Raw ChemCam Spectrum – Jake_1



Peak FWHM
~3 – 4 pixels
~1.5 nm

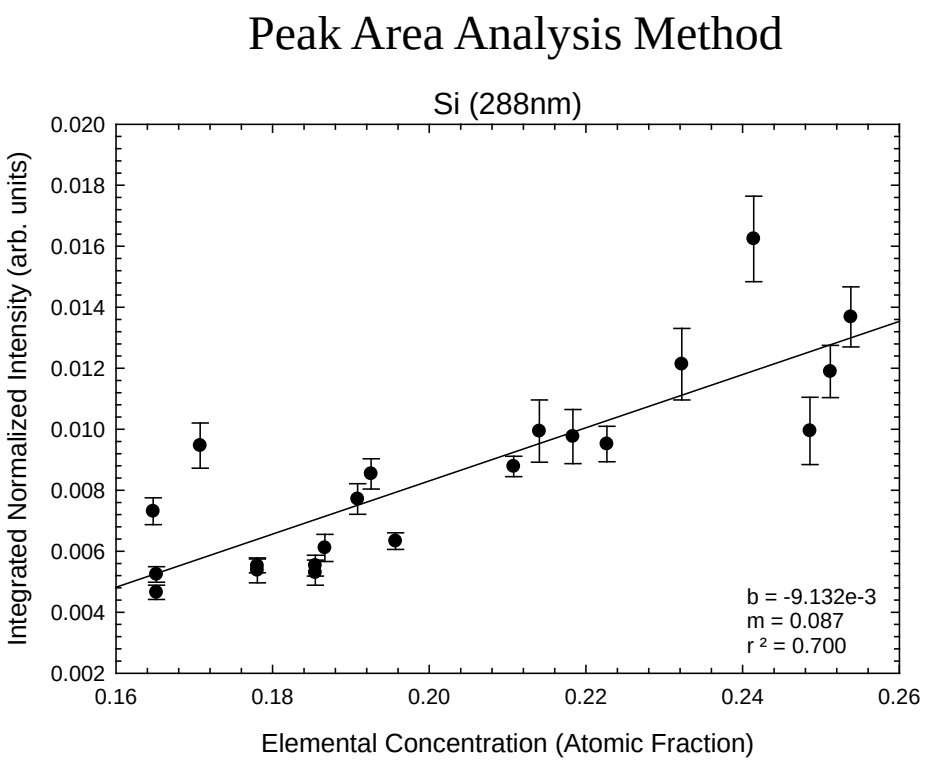
Carefully Processed Spectra Lead to Quantitative Analysis
Continuum Removal, Spectral Calibration, Distance Correction are Critical

ChemCam Spectra



Fully Processed Spectra Ready for Quantitative Analysis
Much can be Qualitatively Observed

Chemical Matrix Effects Complicate Quantitative Analysis



- Conventional Elemental Analysis
  - Peak Area or Height vs. Concentration
  - Each Peak is Analyzed Independently
- Sample Elemental and Molecular Composition Influences:
  - Laser-to-Sample Coupling Efficiency
  - Chemical Reactions within the Plasma
  - Collisional Quenching
- Chemical Matrix Effects
  - Increase Scatter and Uncertainty
- Chemical Matrix Effects Compensation
  - Cal-Free LIBS
  - Various Normalization

Multivariate analyses are used to compensate for these matrix effects

Quantitative Calibration

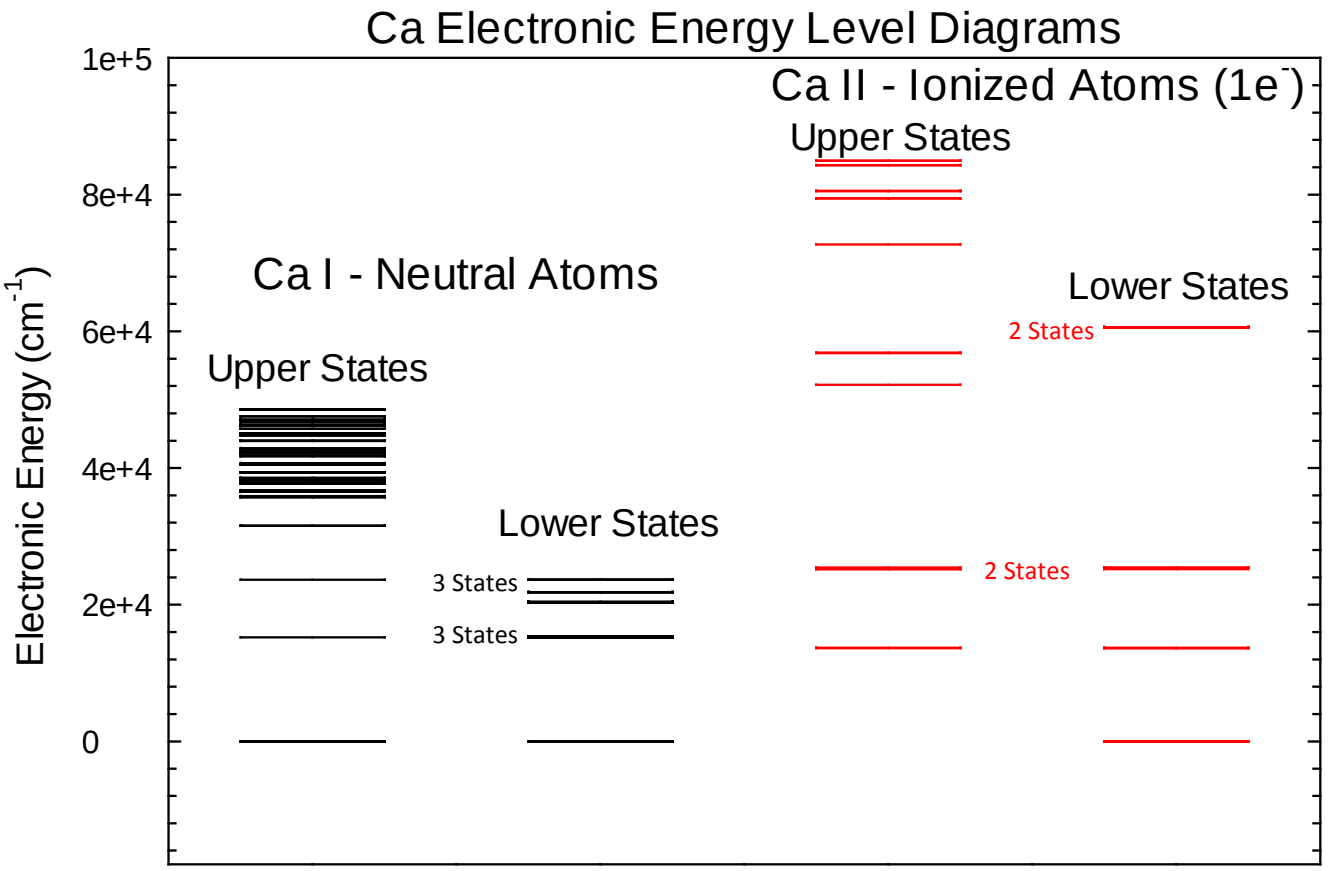
3 m standoff distance			
BHVO-2	DH 4912	Norite	Swy-2
GBW 07105	JR-1	GYP A	SGR-1
NBS688	GBW 07113	GYP C	VS MO7
BIR-1	Ultramafic*	GYP D	UNS ZK
BCR-2	Umph*	MHC1356*	GUW GNA
JA-1	Cadillac*	MHC2319*	M6 Haggerty*
Ja2	VH-1*	VZO106	GYP B
Ja3	MSHA*	VZO114	MHC3828*
MO12	Moppin*	NAu2-Hi-S	UNS AK
MO14	BK-2	NAu2-Med-S	GBW 07313
JB-2	BWQC1*	NAu2-Lo-S	GBW 07316
GSR-2	Trond*	KGa2-Med-S	SARM51
BE-N	WMG*	NBS-88b	STSD-1
AGV-2	VH-49*	JDo-1	STSD-3
JB-3	Grano Dike*	GBW 07108	STSD-4
BT-2	Macusanite	NBS 97a	
GBW 07110	Picrite	NBS 98a	
GBW07104	Shergottite	NAu2	

	Igneous
	Sedimentary
	Sulfur-rich
	Rover cal

* = from Dyar lab, all others from commercial sources

backup

Ca Electronic Energy Level Diagram



Emission lines are produced as atoms relax from upper state to lower state.
Lower state is not always the ground state.