Lunar and Planetary Science Conference, March 16th, 2014

COMMUNITY USER WORKSHOP ON PLANETARY LIBS (CHEMCAM) DATA

LIBS Data Processing Level-1

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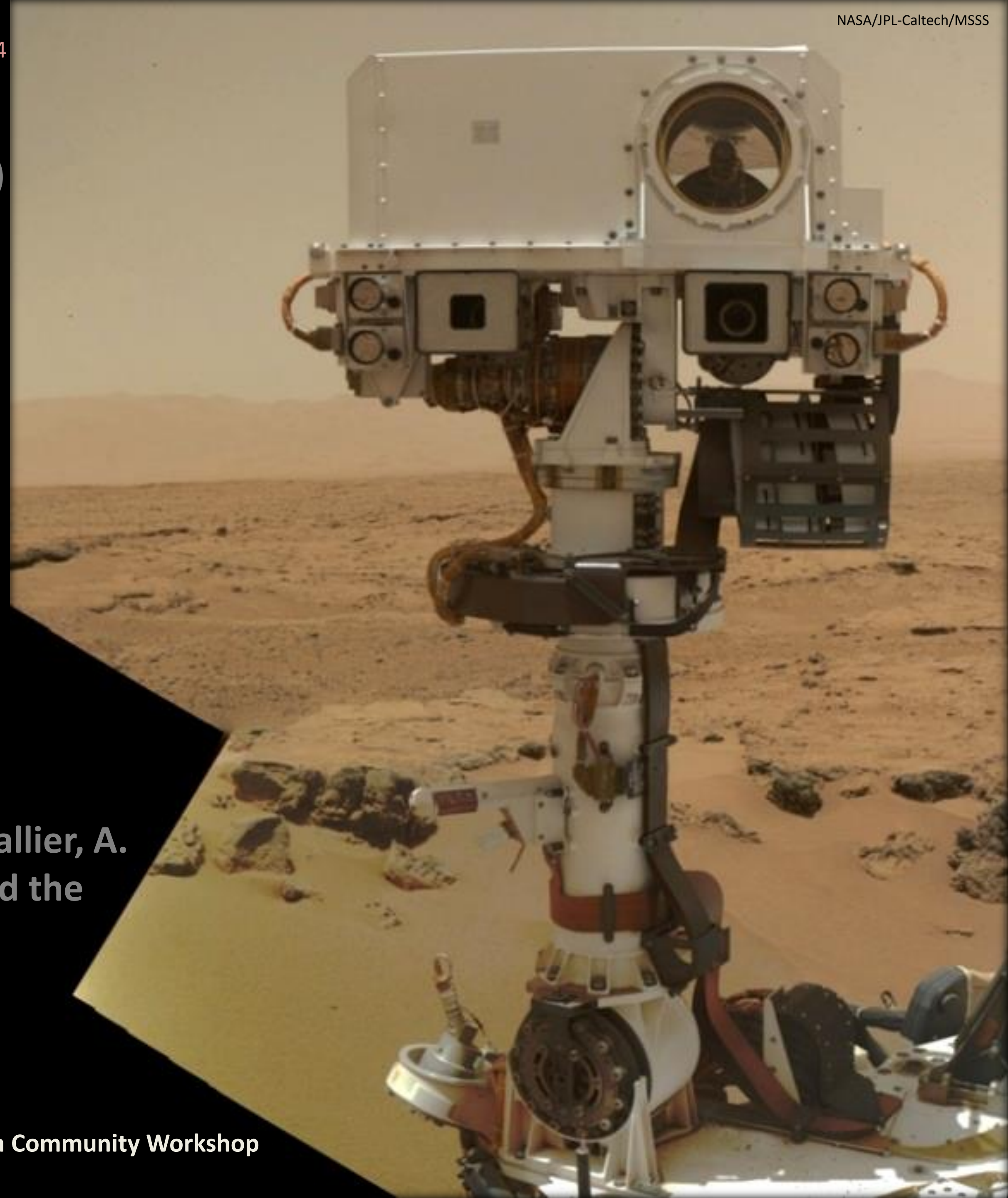


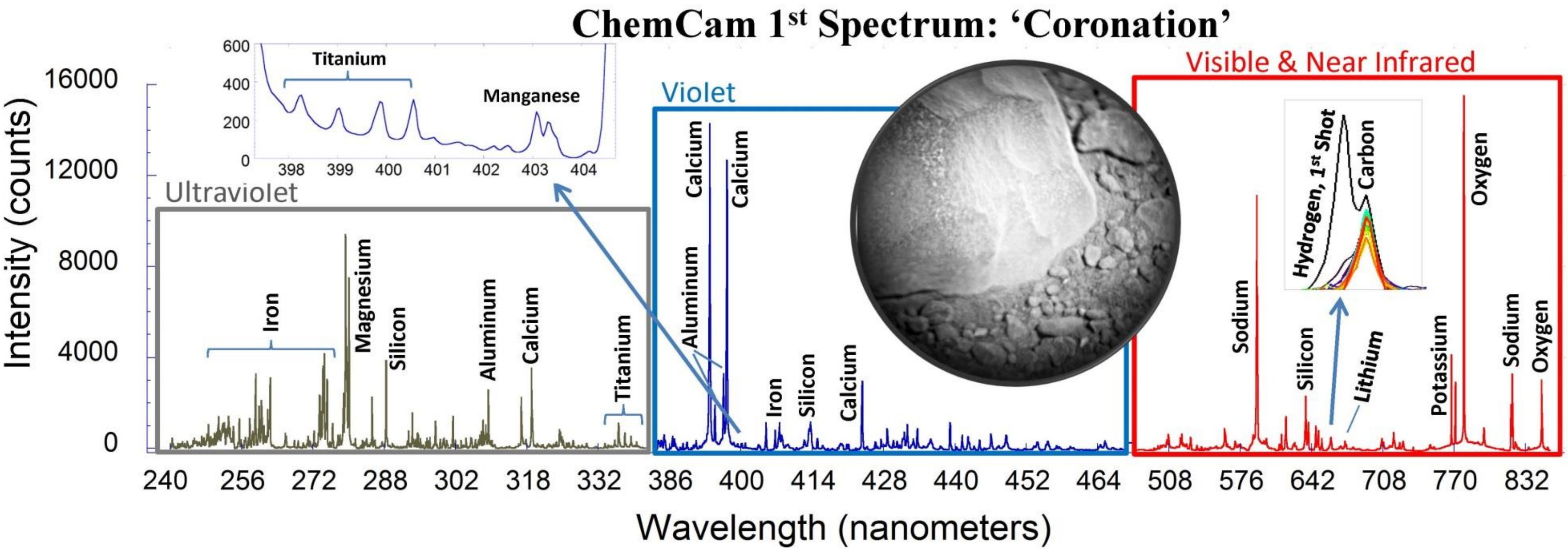
ChemCam Software - Level 1

- Steps in reduction
  - Dark removal
  - Noise removal
  - Wavelength calibration
  - Continuum extraction and subtraction
  - Conversion from counts to photons
  - Element line identification

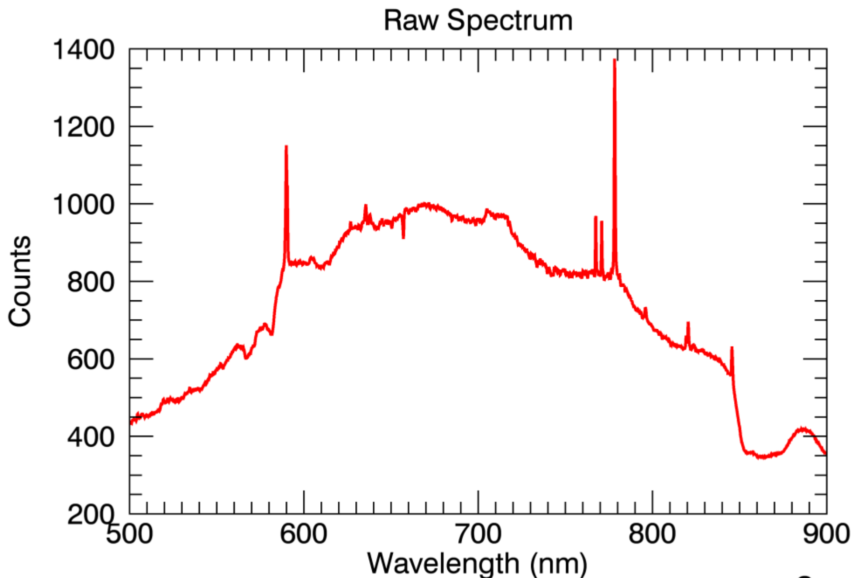
ChemCam Software – Level 2

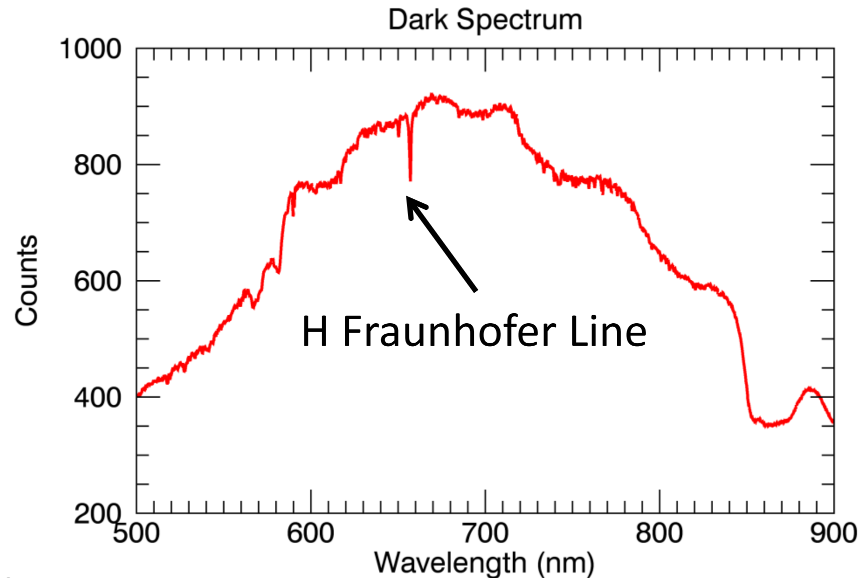
- Steps in analysis
  - Fit of lines
  - Quantitative estimation
    - Internal standard method
    - Calibration curve, PLS, …
    - Calibration free
    - Ratios of selected lines
  - Statistical Methods (PCA, ICA, …)
    - Assign spectrum to a reference library
    - Classification

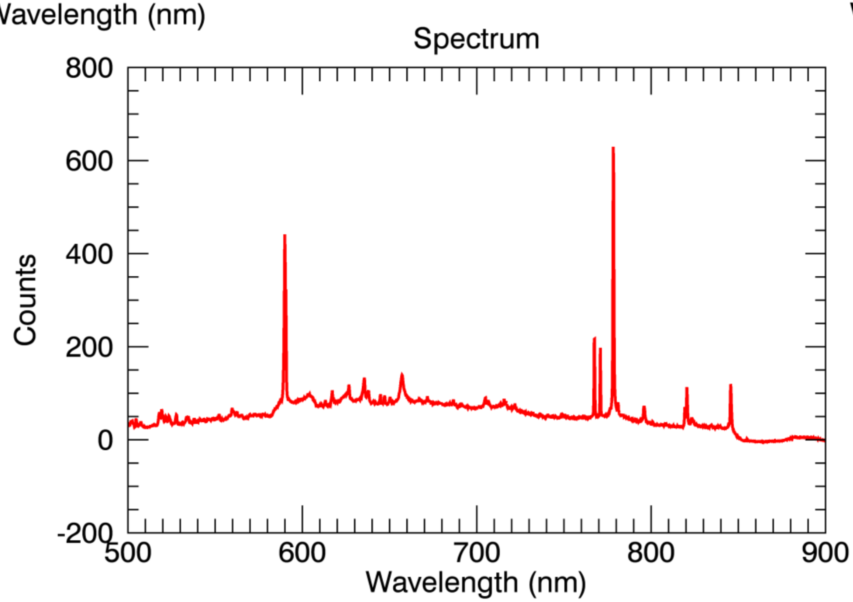
Coronation (Sol 14)



Coronation (Sol 14)







Dark removal

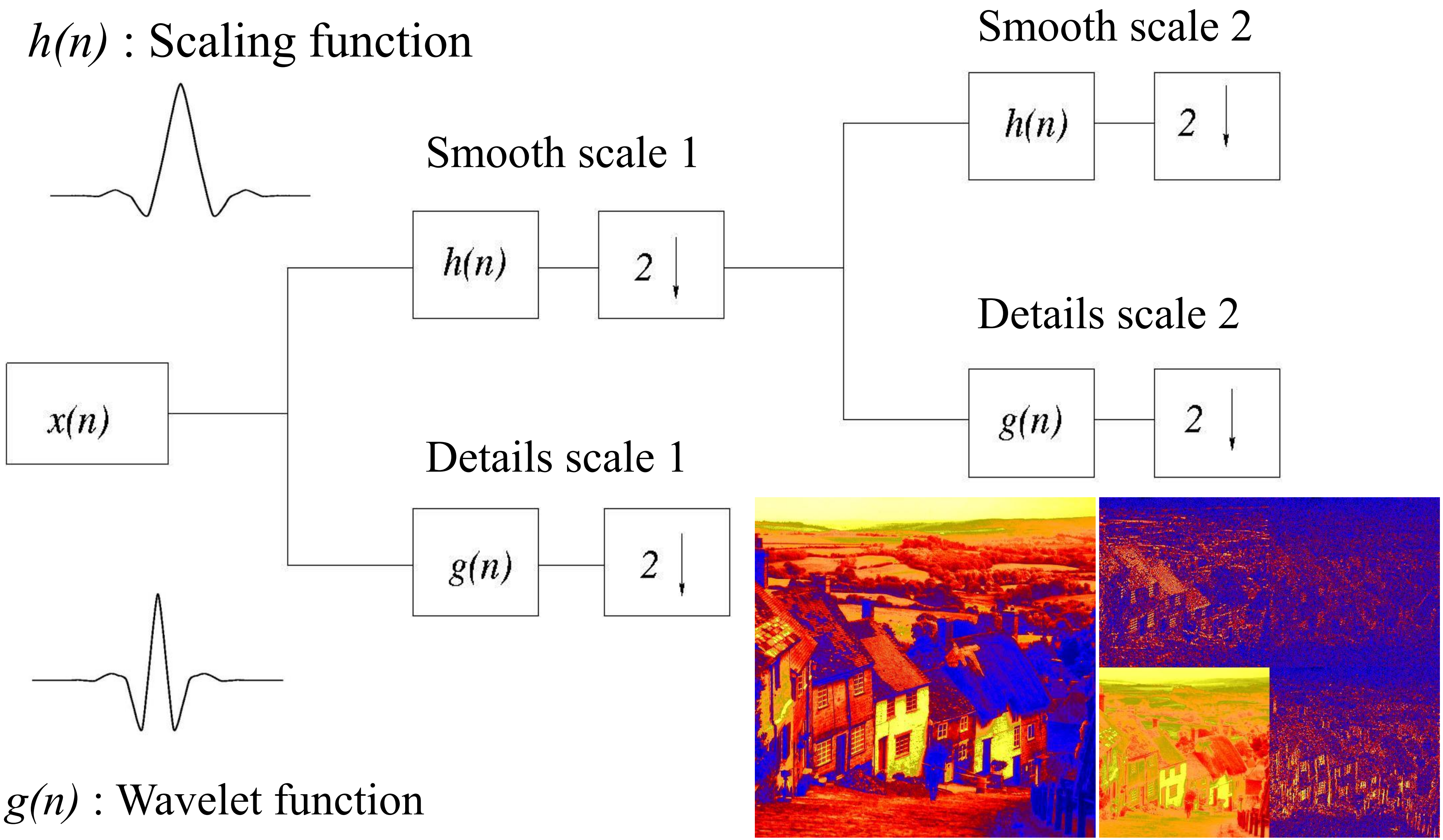
Noise Estimation and Removal

– Undecimated wavelet transform
– Noise estimation at each wavelet scale
– Hard thresholding at sigma for each scale
– Sum of thresholded wavelet scales

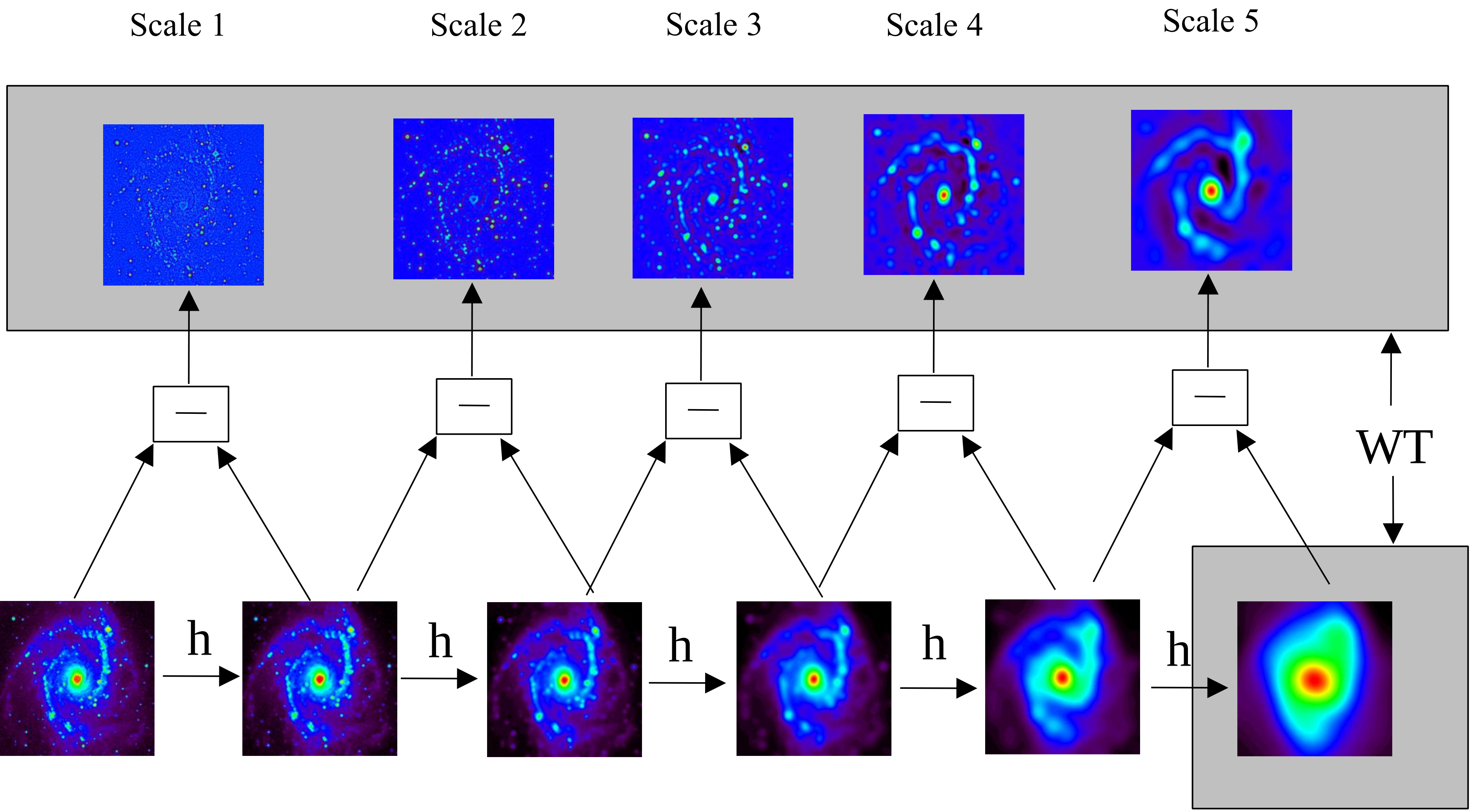
Continuum Estimation

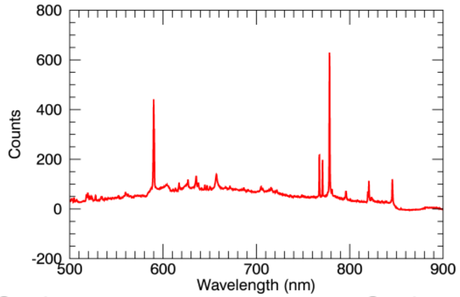
- Undecimated wavelet transform
- All scales above threshold level
- Identification of local minima
- Cubic spline interpolation

Bi-orthogonal Wavelet Transform

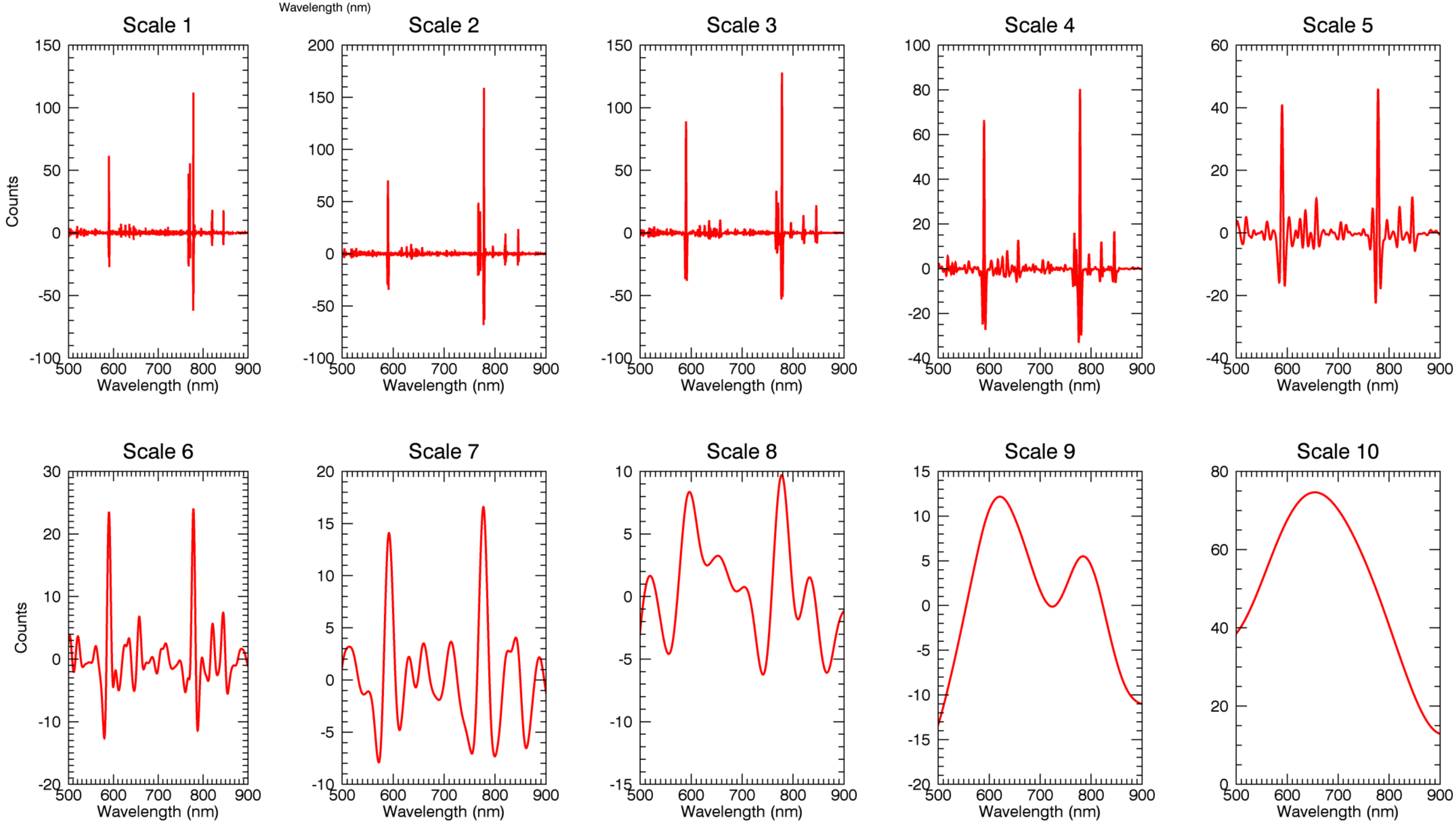


Undecimated Isotropic Wavelet Transform



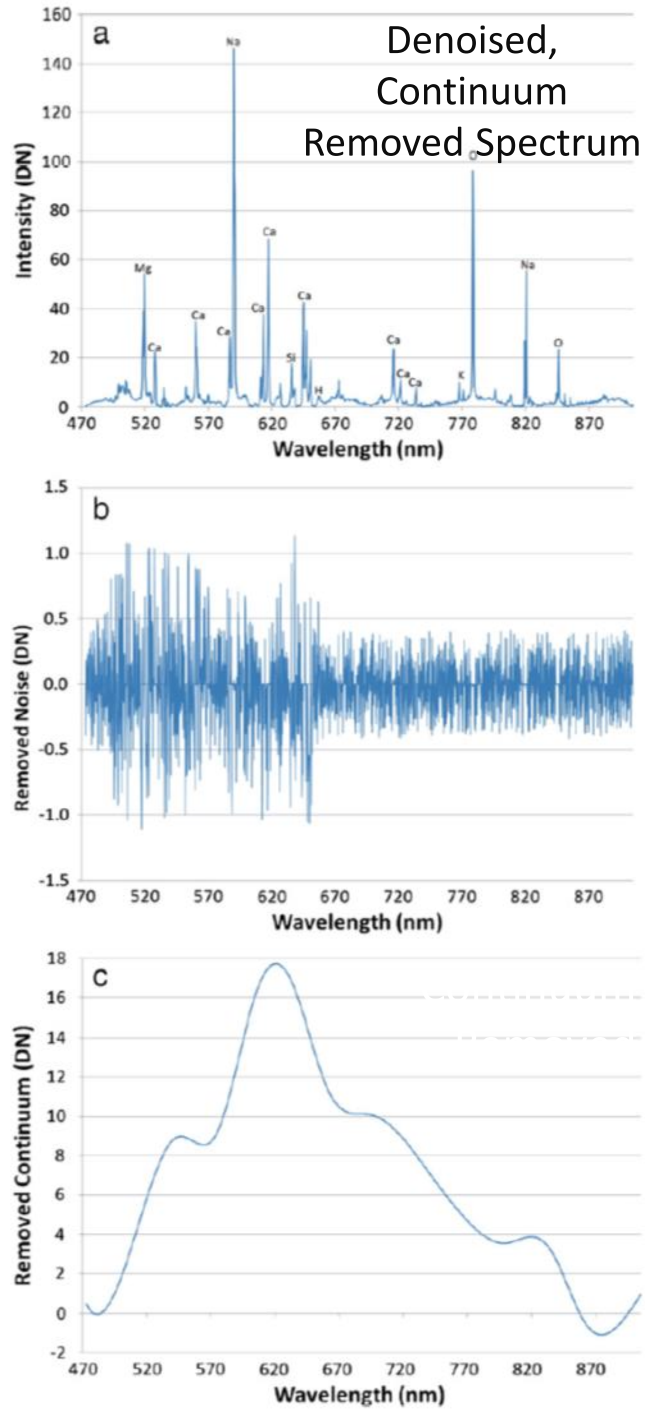


$$I(x,y) = c_J(x,y) + \sum_{j=1}^{J} w(j,x,y)$$



Dark Subtraction, Noise Removal, Continuum Removal

- “Dark” spectrum (no-laser) is subtracted from the LIBS spectrum.
- Noise removed using wavelet transform
- Continuum signal caused by Bremsstrahlung and ion-electron recombination needs to be removed:
  - Continuum defined by wavelet decomposition and fitting a spline to local minima in wavelet space.
- Background signal is distance-dependent, so removal partially corrects for distance.



Wiens et al., 2013

Conversion From Counts to Photons

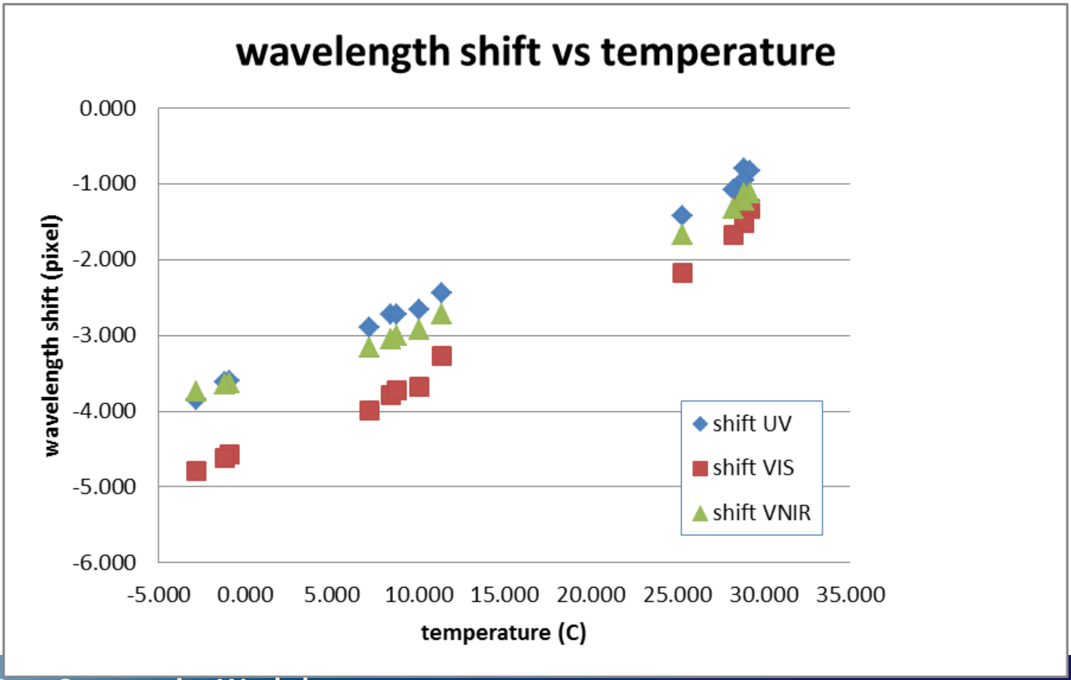
$$DN = L \times A \times \Omega \times \Delta\lambda \times \Delta t \times \sigma + Off$$

- DN is the digital number (intensity in counts)
- L is the photon spectral radiance in photons/second/cm2/sr/μm wavelength
- A is the source area imaged, in cm2
- Ω is the solid viewing angle in sr
- Δλ is the detector wavelength bin width in μm
- Δt is the integration time in seconds
- σ is the amplified conversion gain in DN/photon
- Off is the offset provided in the analog-to-digital conversion electronics
- L and Ω are inversely dependent upon the distance from the ChemCam telescope to the target while A is increasingly dependent on distance

Wavelength Calibration

- Ti spectrum used as reference because emission lines are present in UV, VIS, and VNIR spectral ranges.
  - Establishes baseline channel-wavelength calibration
- Ti calibration target on Mars provides flight data for wavelength calibration
- Channel wavelength shifts as a linear function of spectrometer temperature
  - Varies from -2C to 30C, depending upon time of day on Mars and season

- For each pixel, find relationship between wavelength and temperature
- Apply shift and interpolate to get calibrated spectrum.

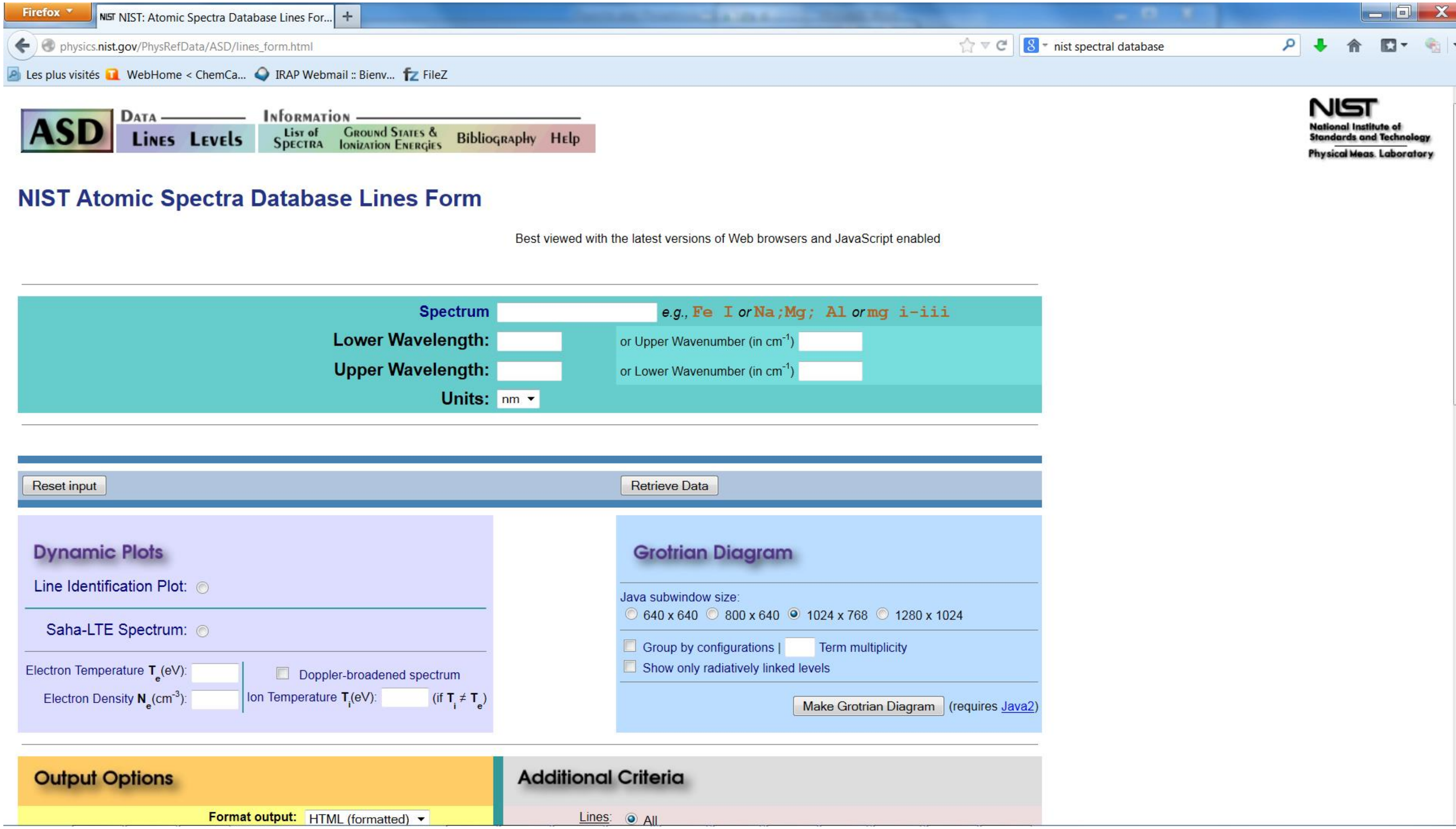


Line Identification

- Spectrum to database
  - Localisation of individual peaks
  - Search in library
- Database to spectrum
  - Correlation of region of spectrum (multiple lines) with elemental synthetic spectrum
  - Identification of multiple set of lines

NIST Data Base

http://physics.nist.gov/PhysRefData/ASD/lines_form.html

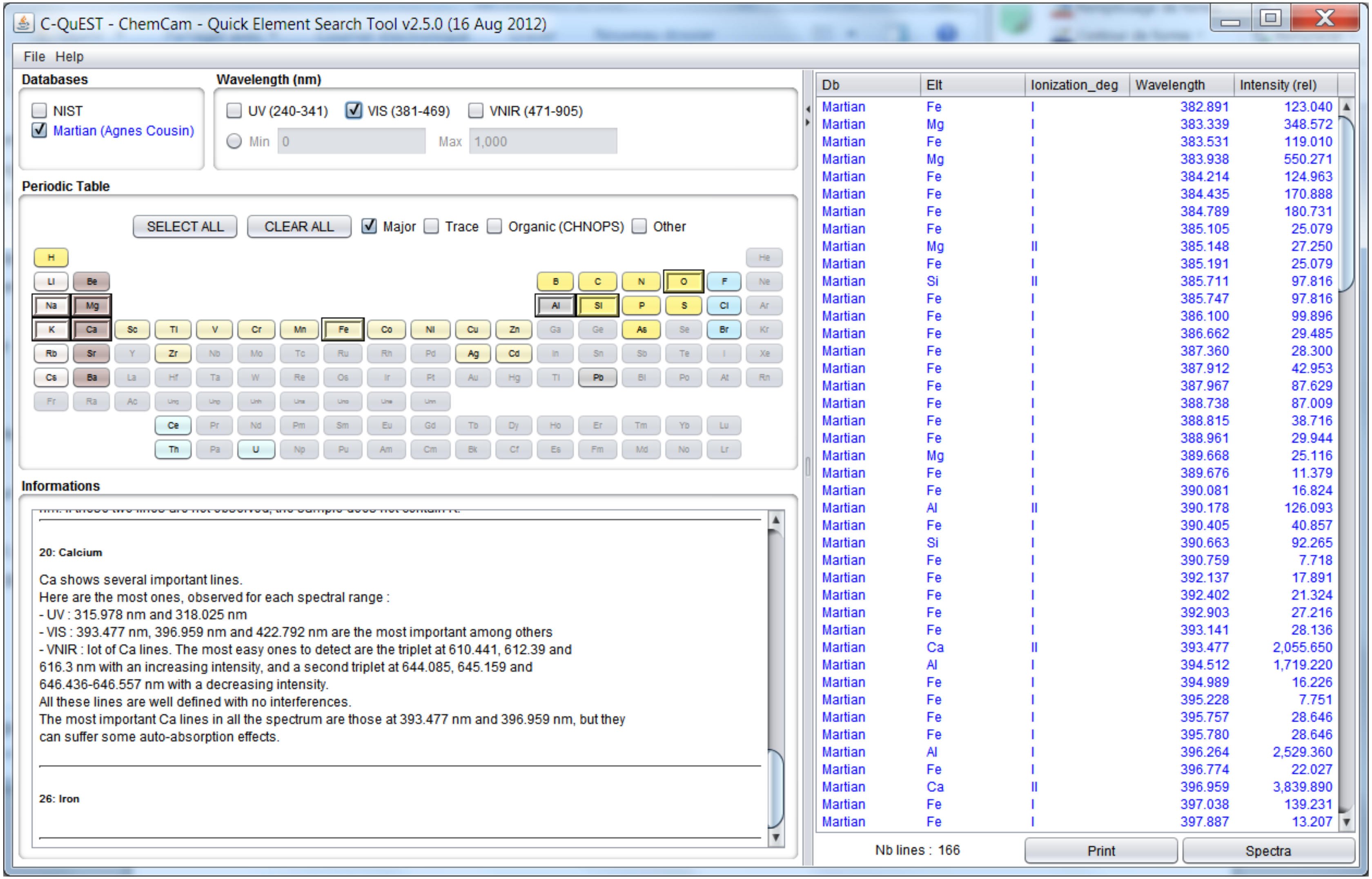


NIST Database

http://physics.nist.gov/PhysRefData/ASD/lines_form.html

Ca I	395.002	15	3.34e+06	C	
Ca I	395.817	17	9.8e+06	C	
Ca II	396.959	220	1.4e+08	C	
Ca I	397.369	8			
Ca I	397.483	18	1.75e+07	C	
Ca II	409.826	50	9.9e+06	D	
Ca I	409.969	15	1.3e+07	D	
Ca I	409.973	15	1.5e+06	D	
Ca II	411.098	60	1.2e+07	D	
Ca II	411.144	30	1.9e+06	D	
Ca II	420.736	40	4.3e+06	D	
Ca II	422.126	50	8.5e+06	D	
Ca I	422.792	50	2.18e+08	B+	

C-Quest



Agnes presentation

To be continued with level 2

Thank you