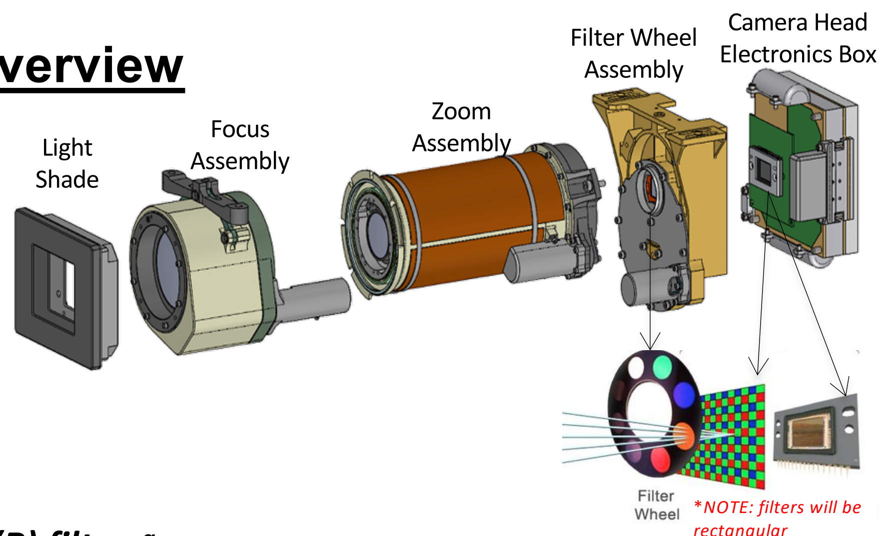
Multispectral Imaging Guidelines

WORKING DRAFT
Version 7
(July 2020)

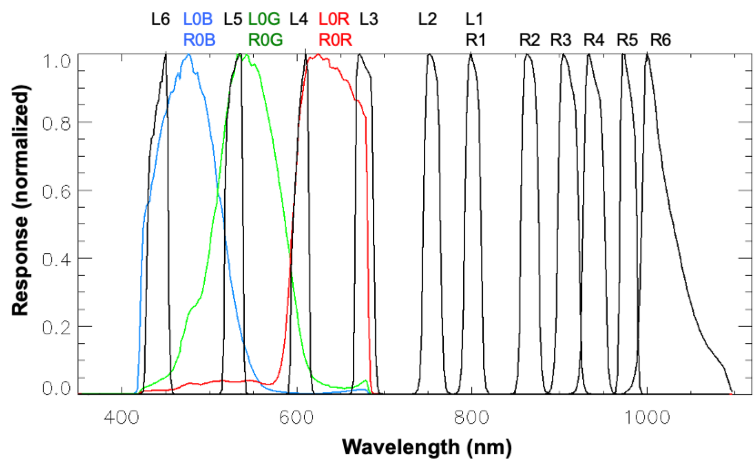
1. Mastcam-Z Filter Overview

Each Mastcam-Z takes images through a Bayer pattern of RGB microfilters bonded onto a 1600x1200 pixel CCD. Each Mastcam-Z also images through an 8-position filter wheel to take color images in "human-like" visible wavelengths in filter positions L0 and R0, as well as additional narrowband images through visible, near-IR, and solar neutral density filters in L7 and R7.



Mastcam-Z Left (L) and Right (R) filters[a]

Filter Number	$\lambda_{eff} \pm$ HWHM (nm)[b]	
L0/R0 (Red Bayer)	630 ± 43	631 ± 43
L0/R0 (Green Bayer)	544 ± 41	544 ± 42
L0/R0 (Blue Bayer)	480 ± 46	480 ± 46
L1 / R1	800 ± 9	800 ± 9
L2 / R2	754 ± 10	866 ± 10
L3 / R3	677 ± 11	910 ± 12
L4 / R4	605 ± 9	939 ± 12
L5 / R5	528 ± 11	978 ± 10
L6 / R6	442 ± 12	1022 ± 19
L7 / R7[c]	590 ± 88, ND6	880 ± 10, ND5



Above Left: [a] Red text means new performance compared to MSL/Mastcam; [b] effective band center wavelength with half-width of the bandpass at half-maximum for each filter; [c] Filters L7 and R7 are for direct imaging of the Sun using Neutral Density (ND) coatings that attenuate the flux by factors of 10^6 and 10^5, respectively. **Above Right:** Mastcam-Z filter transmission profiles as measured during calibration (see Hayes et al. submitted SSR paper for details).

Helpful Resources

Helpful Mastcam-Z Science Team Contacts:

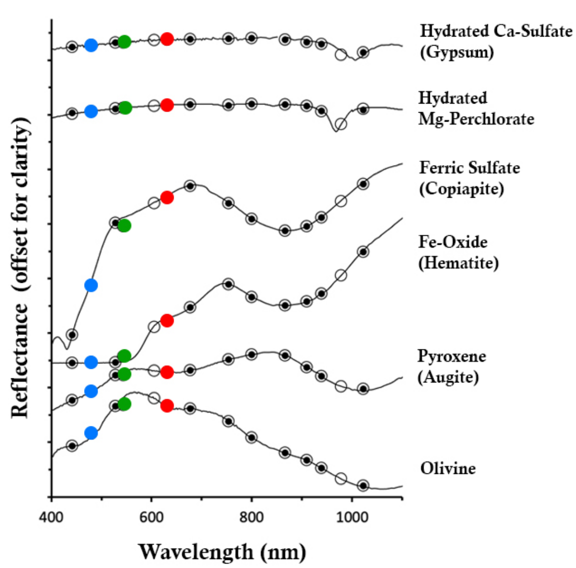
- Jim Bell (*Mastcam-Z PI*): Jim.Bell@asu.edu; (607) 227-6402
- Justin Maki (*Mastcam-Z Deputy PI*): justin.n.maki@jpl.nasa.gov; (818) 354-6227
- Melissa Rice (*Multispectral Co-Lead*): melissa.rice@wwu.edu; (626) 840-2521
- Jeff Johnson (*Multispectral Co-Lead*): Jeffrey.R.Johnson@jhuapl.edu; (443) 876-1718
- Alex Hayes (*Calibration Expert*): hayes@astro.cornell.edu; (607) 793-7531
- Kjartan Kinch (*Calibration Target Expert*): kinch@nbi.ku.dk; (+45) 28 96 32 86
- Elsa Jensen (Mastcam-Z Uplink Lead): jensen@msss.com; (858) 361-6940
- Kristen Paris (Mastcam-Z Downlink Lead): kparis@asu.edu; (716) 348-7979

References: Bell et al.(2014): http://ssed.gsfc.nasa.gov/IPM/PDF/1151.pdf

SSR papers: Bell et al., Hayes et al., and Kinch et al. (links to be added when in press)

Online Spectral Database: Laboratory spectra compiled from multiple databases are available to view, plot interactively, and download for comparison to Mastcam-Z data: http://spectro.geol.wwu.edu/

Example mineral spectra convolved to Mastcam-Z bandpasses



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2. Planning Multispectral Observations

MSL Mastcam enhanced color example of an iron meteorite multispectral target

MSL Mastcam enhanced color example of a rock target broken by MSL's wheels, with a "fresh," dust-free surface exposed

2.1 Target Considerations

Indications of a promising multispectral target may include (but are not limited to):

- **Color variations** in previously acquired imaging (such as RGB or orbital imaging)
- **Unusual morphologies**, including small scale (but resolvable) features that may indicate alteration or diagenesis
- Significant **differences in chemistry** relative to a previous site or within the present site, especially variations in Fe or Mn abundance
- Potential for **diverse lithologies** within the field-of-view, including conglomerate rocks, unit contacts, and long-distance observations of different units.
- **"Fresh" surfaces** created by the rover (e.g., brushed/broken rocks, drill fines)
- **Sample caching targets** should be well-documented in all filters.

Low-dust surfaces are always preferred.

When possible, the frame should also include **targets of other instruments** as well, to facilitate comparisons with other data.

2.2 Lighting and Geometry

- Targets need to be as fully illuminated as possible. **Minimize shadows**, either from rocks or other topographic elements, or rover components.
- For horizontal surfaces, the best results are at low emission angles (when Mastcam is looking as straight down as possible at the target).
- For vertical surfaces, the best results are when the surface is directly illuminated, which may be late afternoon or early morning. Consult with a Mastcam-Z PUL to model shadowing at different times of day.

2.3 Time of Day Restrictions

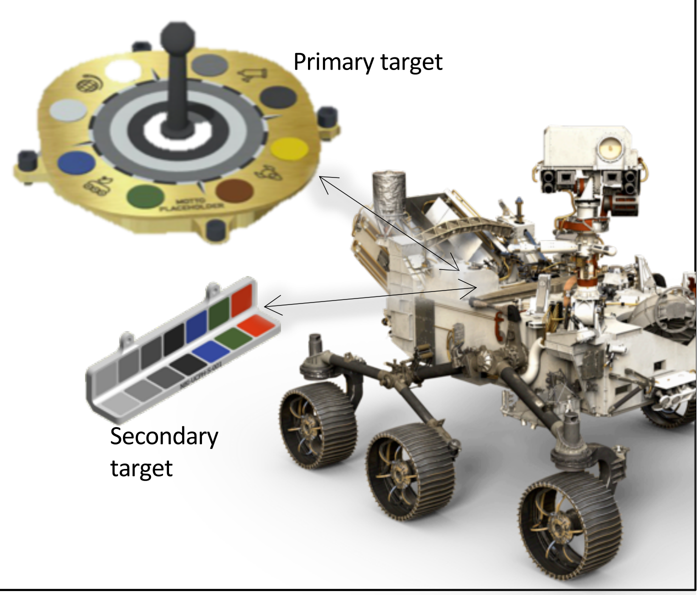
- Best results come from measurements taken as close to 12:00 LTST as possible (minimizes shadows; also, assumptions used in the cal target calibration procedure break down when the Sun is low).
- Restrict multispectral observations to **after ~10:30 LTST and before ~13:30 LTST.**
- Exceptions can be made to these timing restrictions for vertical surfaces that require other times of day for direct illumination (see 2.2 above).

2.4 Exposure Times

- Bright elements in the field of view (e.g., glints from rover hardware, light-toned veins, and other high-albedo materials) can lead to image saturation in one or more filters. To avoid saturation, work with a Mastcam-Z PUL to check the exposure time.
- In downlinked raw data, check the bright portions of each image for saturation (DN > 3000; ask a Mastcam-Z team member)

2.5 Calibration Target Imaging

- For any multispectral sequence that requires calibration to radiance factor (I/F), associated images of the primary target must be acquired at the **same approximate local time of sol (within 20 min)** and with the **same filter set** as the to-be-calibrated multispectral sequence.
- Images of the secondary target will be taken periodically, but do not need to be associated with every multispectral sequence.
- Calibration sequences are available at several zoom settings. Work with a Mastcam-Z PUL to select the best sequence.



Coming Soon!

- Zoom, resolution and compression guidelines
- Recommended filter subsets for iron oxides, hydration, etc.
- Links to calibrated IOF Mastcam-Z data and "quicklook" products
- Mastcam-Z SIS