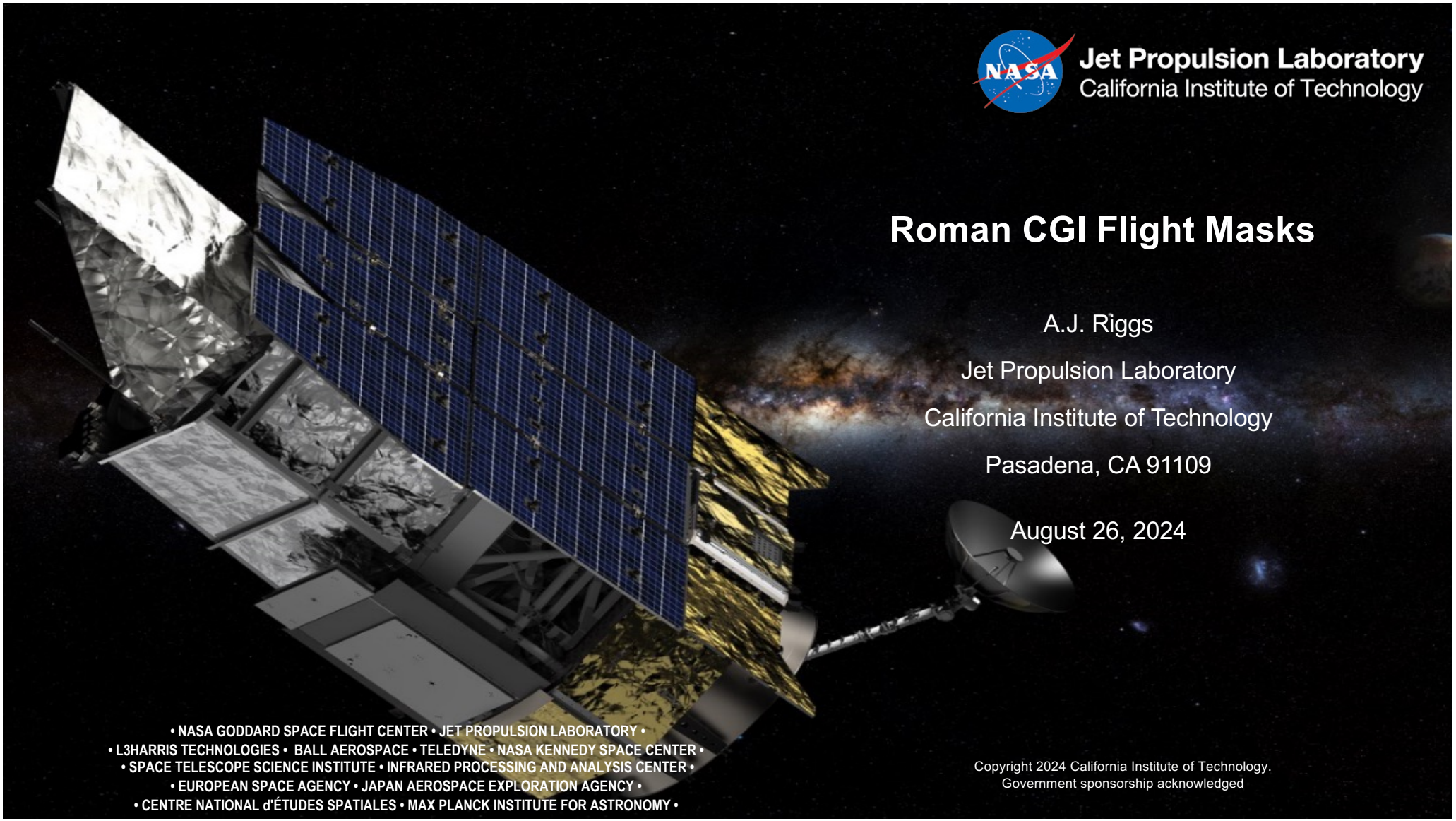

Roman CGI Flight Masks

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Outline

- Only 2 of the 12 possible high-contrast mask configurations within CGI were tested in TVAC.
  - The 2 tested were: **nfov_band1** and **wfov_band1**
  - But fortunately, 8 of the other ones are very similar to those two, so getting those working would follow the same steps.
  - The 2 for multi-star wavefront correction differ significantly and would require more software development by the CPP.
  - There are many field stops that could be used for each mask configuration. Some way will need to be determined to specify how different field stops would be used and positioned (e.g., where a slit should be located compared to the star).

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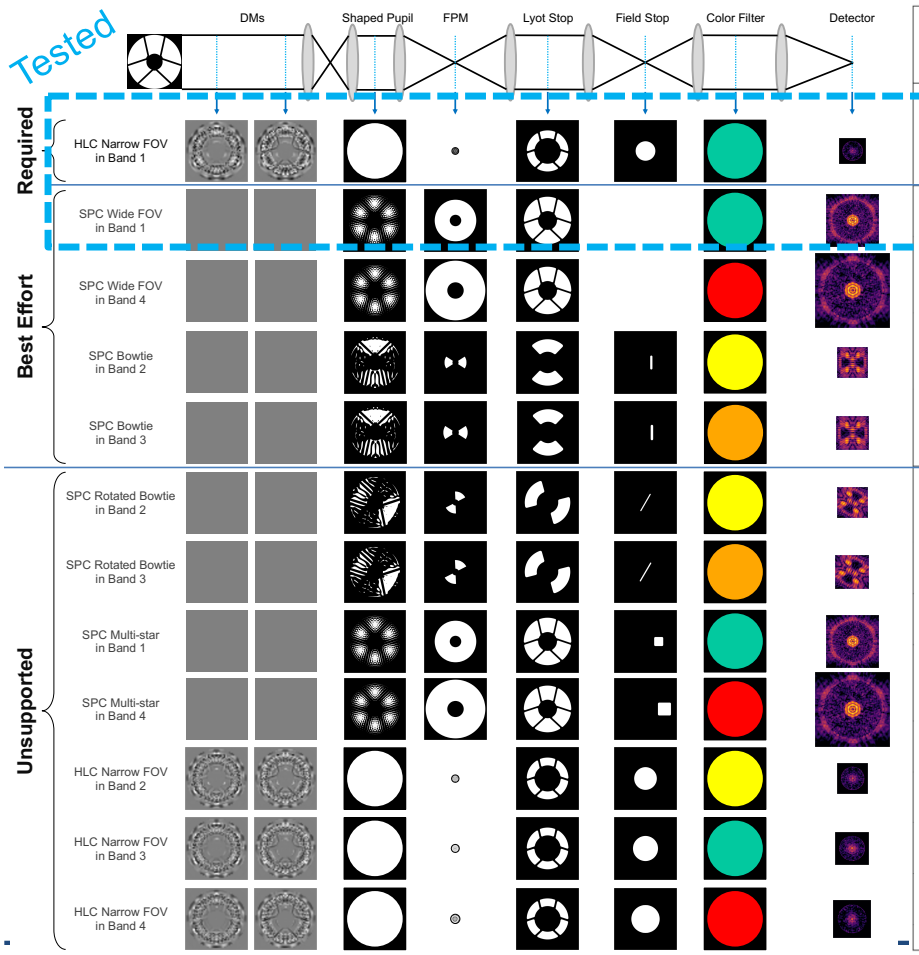
High-Contrast Mask Configurations

ROMAN CORONAGRAPH

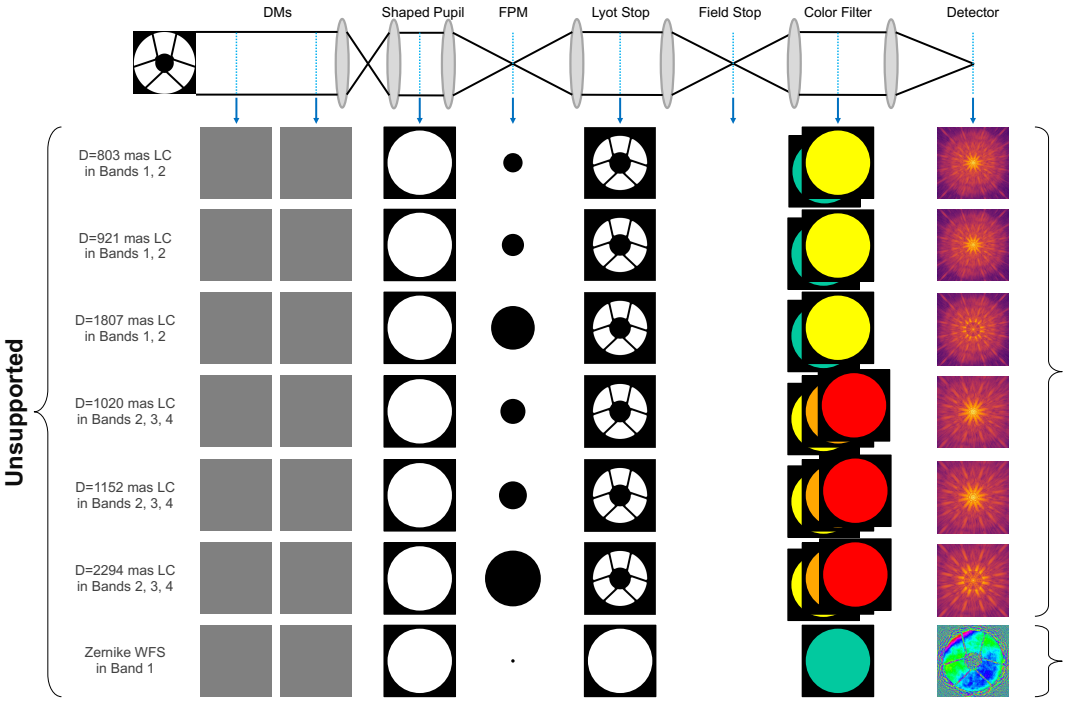
SPAM FPAM LSAM FSAM CFAM



Mask Config. Class	Coro. Type	Configuration Name	SPAM Pos'n	FPAM Pos'n	LSAM Pos'n	FSAM Pos'n	Azim. FOV (deg)	IWA (λ/D)	IWA (mas)	OWA (λ/D)	OWA (mas)
Required	HLC	nfov_band1	OPEN	4-C2R1:9, 4-C3R1:8, 4-C4R7:9	3	R1C1, (R1C3), (R6C6), R5C3, R5C4	360	3.0	150.6	9.7	486.8
Best Effort	SPC	wfov_band1	WFOV	2-R1C1:2, 2-R2C1	4	open, R1C5, R6C1, R6C2	360	5.9	296.1	20.1	1008.8
	SPC	wfov_band4	WFOV	6-R5C1, 6-R8C1, 6-R8C3	4	open, R1C5, R6C1, R6C2	360	5.9	424.9	20.1	1447.4
	SPC	spec_band2	SPEC	2-R3C2, 2-R4C2, 2-R4C4	5	open, R2C5, R3C1, R3C2, R6C5	130	3.0	172.8	9.1	524.2
	SPC	spec_band3	SPEC	6-R2C2, 6-R4C3, 6-R6C1	5	open, R1C2, R3C1, R3C2, R4C2, R4C6	130	3.0	191.2	9.1	579.8
Unsupported (High Contrast)	SPC	specrot_band2	SPECROT	2-R3C1, 2-R3C3, 2-R4C3	1	R4C3, R4C4	130	3.0	172.8	9.1	524.2
	SPC	specrot_band2	SPECROT	6-R2C3:4, 6-R4C2	1	R2C2, R4C2	130	3.0	191.2	9.1	579.8
	SPC	mswc_band1	MSWC	2-R1C1:2, 2-R2C1	4	R4C1	360	5.9	296.1	20.1	1008.8
	SPC	mswc_band4	MSWC	6-R5C1, 6-R8C1, 6-R8C3	4	R1C4, (R4C1)	360	5.9	424.9	20.1	1447.4
	HLC	nfov_band2	OPEN	3-R7C1:2, 3-R8C2:3	3	R3C3, R2C3	360	3.0	172.8	9.7	558.8
	HLC	nfov_alt_band2	OPEN	4-C4R1:6, 4-C5R1:8	3	R3C3, R2C3	360	3.0	172.8	9.7	558.8
	HLC	nfov_band3	OPEN	3-R5C1:3, 3-R6C1:3	3	R3C4, R4C5, R5C1, R5C2	360	3.0	191.2	9.7	618.1
	HLC	nfov_band4	OPEN	3-R3C1:3, 3-R4C1:3	3	R3C5	360	3.0	216.0	9.1	655.3
	HLC	nfov_alt_band4	OPEN	3-R2C1:3	3	R3C5	360	3.0	216.0	9.1	655.3

Note: Rows do not exactly line up for unsupported configs.

Other Unsupported Mask Configurations
(No HOWFSC Needed)

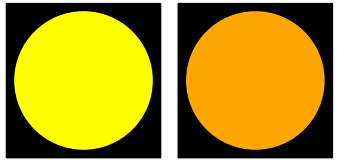


Mask Config. Class	Coro. Type	Configuration Name	Band No.	SPAM Pos'n	FPAM Pos'n	LSAM Pos'n	FSAM Pos'n	Az FOV (deg)	IWA (λ/D)	IWA (mas)	OWA (λ/D)	OWA (mas)
Unsupported (Low Contrast)	Lyot	0.281" occulter	1, 2	1	4-C2R1:9, 4-C3R1:8, 4-C4R7-9	3, 4	open, any	360	-	140.5	-	3600
	Lyot	0.322" occulter	1, 2	1	4-C4R1:6, 4-C5R1:8	3, 4	open, any	360	-	161.1	-	3600
	Lyot	0.803" occulter	1, 2	1	4-C1R3:4	3, 4	open, any	360	-	401.5	-	3600
	Lyot	0.921" occulter	1, 2	1	4-C1R2	3, 4	open, any	360	-	460.7	-	3600
	Lyot	1.807" occulter	1, 2	1	4-C1R1	3, 4	open, any	360	-	903.4	-	3600
	Lyot	0.357" occulter	2,3,4	1	3-R5C1:3, 3-R6C1:3, 3-R7C1:2, 3-R8C1	3, 4	open, any	360	-	178.6	-	3600
	Lyot	0.403" occulter	2,3,4	1	3-R2C1:3, 3-R3C1:3, 3-R4C1:3	3, 4	open, any	360	-	201.6	-	3600
	Lyot	1.020" occulter	2,3,4	1	3-R1C3	3, 4	open, any	360	-	509.8	-	3600
	Lyot	1.152" occulter	2,3,4	1	3-R1C1	3, 4	open, any	360	-	576.1	-	3600
	Lyot	2.294" occulter	2,3,4	1	3-R1C2	3, 4	open, any	360	-	1147.1	-	3600
Unsupported (Calibration)	ZWFS	transmissive and reflective	1	1	4-C7R2:8	2	open	N/A	N/A	N/A	N/A	N/A
	ZWFS	reflective only	N/A	1	2-R2C2:4, 6-R4C1, 6-R6C2, 6-R8C2	N/A	N/A	N/A	N/A	N/A	N/A	N/A

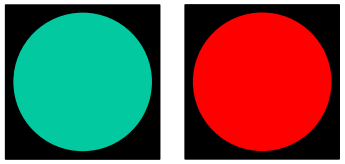
- The bigger the occulter, the better the Lyot coronagraph contrast (at least to a point).
- The occulting spot radii were chosen to mostly block out what the NFOV and WFOV dark holes would cover, except for 1 lambda/D overlap.
- Smaller occulters are already present for the high-contrast designs.

Imaging, Spectroscopy, Polarimetry

- Imaging can be done in all 4 bands and is the only way of doing HOWFSC.
- Spectroscopy and polarimetry can technically be used in all 4 bands, but:
  - Spectroscopy is only intended for Bands 2 & 3 due to linearity of the dispersion (higher res in Band 1, lower res in Band 4).



  - Polarimetry is only intended for Bands 1 & 4 (but determined by the coronagraph masks not by the Wollaston prisms).

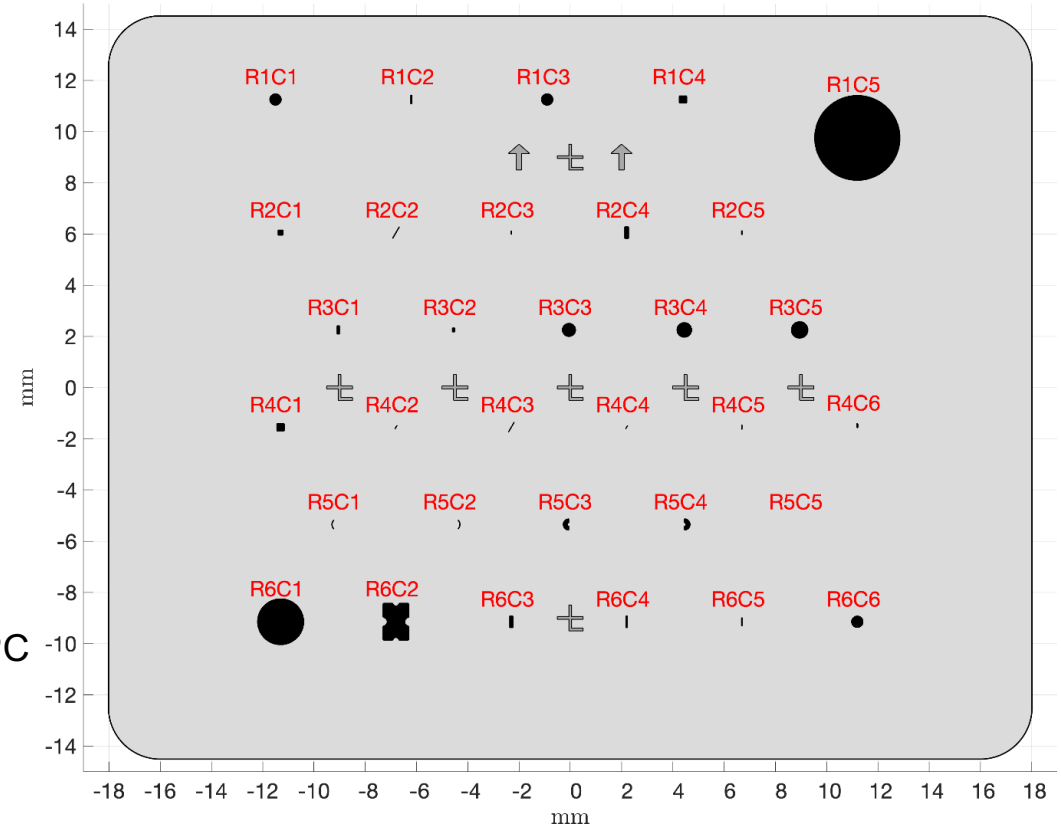


Field Stops

- Field stops are not diffractive, so there are usually many that could be used with a given mask configuration.
  - Caveat: Too many possible combos, so must prioritize.
  - SPCs block most of the light before FSAM, so any field stop or no field stop could be used.
  - HLCs still have ~10% of all the starlight reaching the FSAM, so a field stop MUST be used and must be <= the dark hole size.

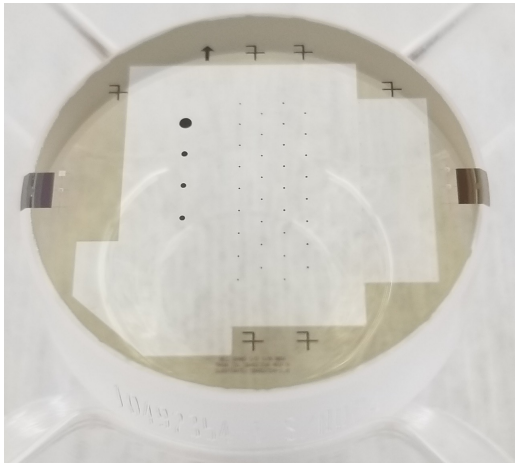
<u>Rough Overview of Shapes and Their Usages:</u>
(full table in backup slides)

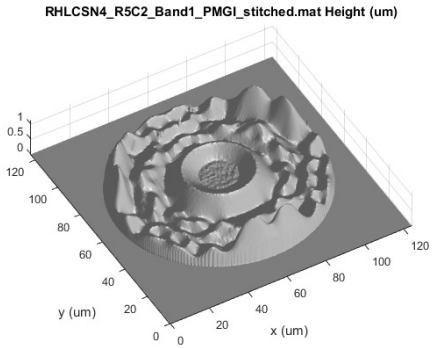
- 2 large circles are for WFOV polarimetry
- 6 small circles are for HLC NFOV full dark holes
- Vertical slits are for spectroscopy
- 4 rotated slits for for SPC rotated spectroscopy
- 3 squares are for multi-star WFC (MSWC) / or half SPC spectroscopy dark holes
- Thick C-shapes are for HLC half-dark holes
- Thin C-shapes are curved slits for HLC spectroscopy
- 1 Jigsaw puzzle piece is for half WFOV dark hole



Final HLC Flight Masks

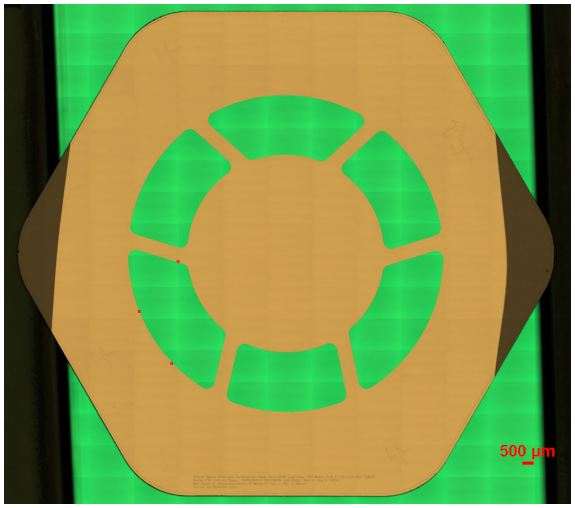
2. FPM Array: SN 004





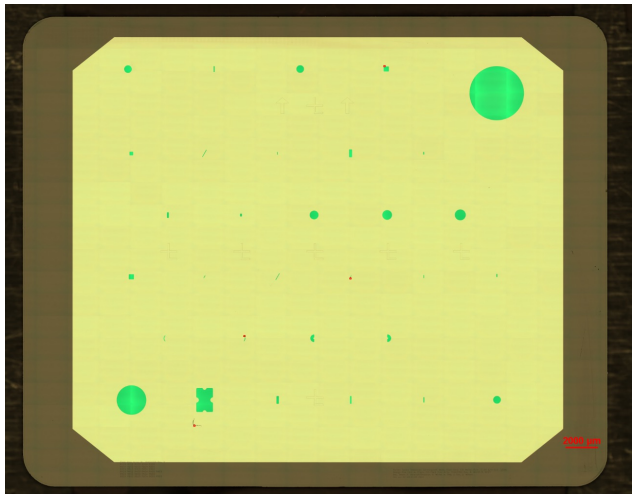
C2R5: used in TVAC

3. HLC Lyot Stop: Wafer 6-11145, SN 2, #3



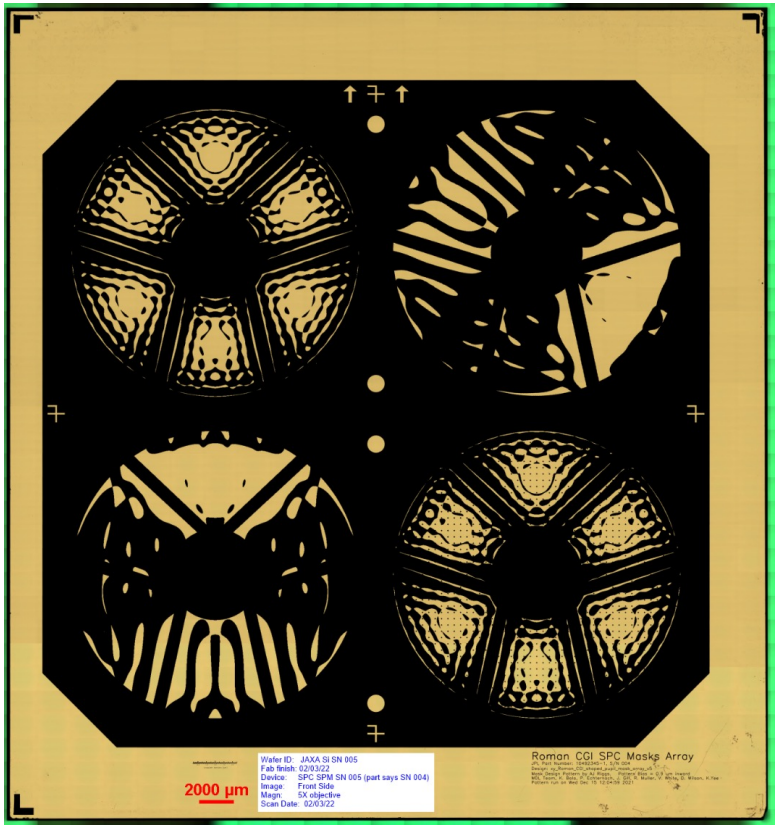
- 25nm bias error in PMGI
- 0 P-V error in PMGI

4. Field Stop Array: SN003 #4
(same device for all modes)

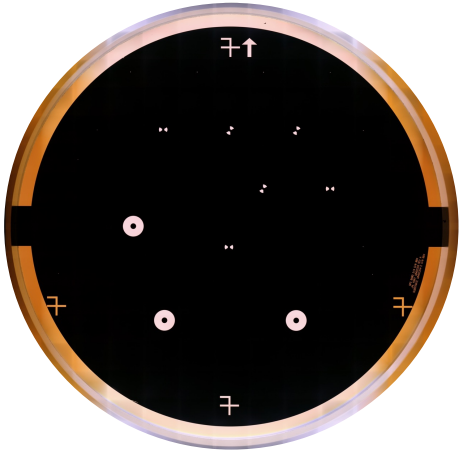


Final SPC Flight Masks

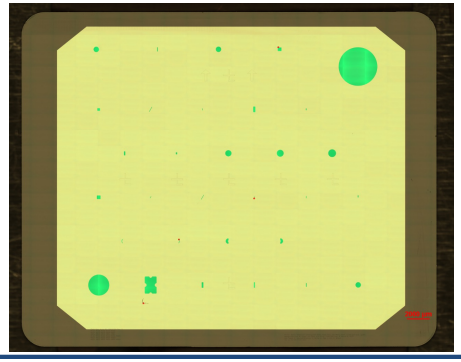
1. SPM Array: SN013



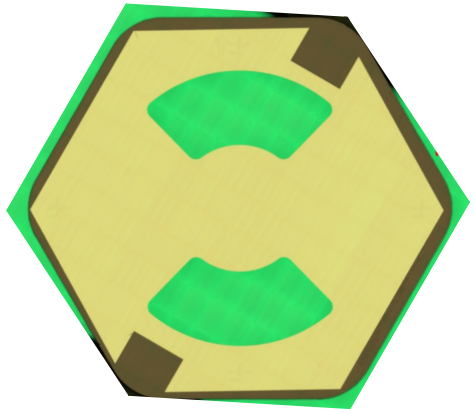
2. FPM Array: SN4



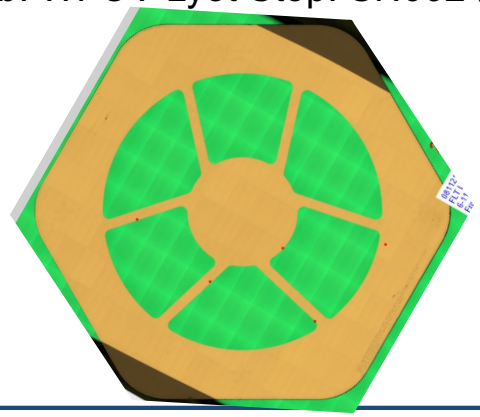
4. Field Stop Array: SN003 #4



3a. Spec Lyot Stop: SN002 #3



3b. WFOV Lyot Stop: SN002 #1



Summary

- Only 2 of the 12 possible high-contrast mask configurations within CGI were tested in TVAC.
  - Any not tested during IOC will need the full set of calibrations before HOWFSC can be done with them.
  - The unsupported mask configurations could be commissioned and used if the instrument is approved for operations after its initial tech demo phase.

- There are many field stops that could be used for each mask configuration. Some way will need to be determined to specify how different field stops would be used and positioned (e.g., where a slit should be located compared to the star).

- The as-fabricated masks from JPL's Microdevices Laboratory were all made well within tolerances.

Back-up charts

Table of Field Stops

#	Position	x (mm)	y (mm)	Description	shape	wavelength	width (micron)	width (lam/D)	width (mas)	height (micron)	height (lam/D)	height (mas)	Fillet radii (micron)	baseline
1	R1C1	-11.5	11.25	HLC 9.7 lam/D band 1 circular field stop	circle	575	464.34	19.4	974	464.34	19.4	974	N/A	y
2	R1C2	-6.2	11.25	SPC major-FWHM vertical slit band 3; tall	rect	730	60.77	2	127	364.84	12	765	30.39	y
3	R1C3	-0.9	11.25	HLC 9.7 lam/D band 1 circular field stop; spare	circle	575	464.34	19.4	974	464.34	19.4	974	N/A	y
4	R1C4	4.4	11.25	MSWC square field stop band 4	square	825	309.07	9	648	309.07	9	648	30	n
5	R1C5	11.2	9.75	3.5" radius circular polarimetry field stop	circle	n/a	3338.28	n/a	7000	3338.28	n/a	7000	N/A	y
6	R2C1	-11.3	6.05	MSWC square field stop band 1	square	575	215.41	9	452	215.41	9	452	30	n
7	R2C2	-6.8	6.05	SPC minor-FWHM rotated slit band 3; tall	rect	730	30.39	1	64	516.58	17	1083	15.19	n
8	R2C3	-2.3	6.05	HLC FWHM vertical slit Band 2	rect	660	30.22	1.1	63	164.84	6	346	15.11	n
9	R2C4	2.2	6.05	starshade slit #3	rect	n/a	171.68	n/a	360	476.90	n/a	1000	30	y*
10	R2C5	6.7	6.05	SPC major-FWHM vertical slit band 2; short	rect	660	54.95	2	115	164.84	6	346	27.47	y*
11	R3C1	-9.05	2.25	SPC ~1st null vertical slit; tall	rect	695	115.72	4	243	347.16	12	728	30	y
12	R3C2	-4.55	2.25	SPC ~1st null vertical slit; short	rect	695	115.72	4	243	173.58	6	364	30	y
13	R3C3	-0.05	2.25	HLC 9.7 lam/D band 2 circular field stop	circle	660	532.98	19.4	1118	532.98	19.4	1118	N/A	n
14	R3C4	4.45	2.25	HLC 9.7 lam/D band 3 circular field stop	circle	730	589.51	19.4	1236	589.51	19.4	1236	N/A	n
15	R3C5	8.95	2.25	HLC 9.7 lam/D band 4 circular field stop	circle	825	666.22	19.4	1397	666.22	19.4	1397	N/A	n
16	R4C1	-11.3	-1.55	MSWC square field stop band 4; spare	square	825	309.07	9	648	309.07	9	648	30	n
17	R4C2	-6.8	-1.55	SPC minor-FWHM rotated slit band 3; short	rect	730	30.39	1	64	182.32	6	382	15.19	n
18	R4C3	-2.3	-1.55	SPC minor-FWHM rotated slit band 2; tall	rect	660	27.47	1	58	467.04	17	979	13.74	n
19	R4C4	2.2	-1.55	SPC minor-FWHM rotated slit band 2; short	rect	660	27.47	1	58	164.84	6	346	13.74	n
20	R4C5	6.7	-1.55	HLC FWHM vertical slit Band 3	rect	730	33.43	1.1	70	182.32	6	382	16.71	n
21	R4C6	11.2	-1.4866	SPC major-FWHM vertical slit band 3; short	rect	730	60.77	2	127	182.32	6	382	30.39	y
22	R5C1	-9.05	-5.35	HLC FWHM curved slit band 3	arc	730	33.43	1.1	70	n/a	+/- 45 dgr	n/a	16.71	n
23	R5C2	-4.55	-5.35	HLC FWHM curved band 3 (reversed)	arc	730	33.43	1.1	70	n/a	+/- 45 dgr	n/a	16.71	n
24	R5C3	-0.05	-5.35	Left half HLC band 1	C	575	232.17	9.7	487	464.34	19.4	974	30	y*
25	R5C4	4.45	-5.35	Right half HLC Band 1	C	575	232.17	9.7	487	464.34	19.4	974	30	y*
26	R5C5	8.95	-5.35	[empty] / dark	n/a	n/a	0.00	0	0	0.00	0	0	N/A	y
27	R6C1	-11.3	-9.15	1.9" radius circular polarimetry field stop	circle	n/a	1812.21	n/a	3800	1812.21	n/a	3800	N/A	y
28	R6C2	-6.8	-9.15	Half SPC wide FOV box	indented rect	575w, 825h	1024.42	42.8	2148	1469.81	42.8	3082	60	y*
29	R6C3	-2.3	-9.15	starshade slit #2	rect	n/a	143.07	n/a	300	476.90	n/a	1000	30	y*
30	R6C4	2.2	-9.15	starshade slit #1	rect	n/a	85.84	n/a	180	476.90	n/a	1000	30	y*
31	R6C5	6.7	-9.15	SPC major-FWHM vertical slit band 2; tall	rect	660	54.95	2	115	329.68	12	691	27.47	y*
32	R6C6	11.2	-9.15	HLC 9.7 lam/D band 1 circular field stop; spare	circle	575	464.34	19.4	974	464.34	19.4	974	N/A	y

NOTE 1: All widths are effective widths (as seen by the beam). The widths on the substrate are actually stretched by 1/cos(5.0 degrees) because the substrate is mounted with an angle of incidence of 5.0 degrees.
Note 2: The (x,y) coordinates are: a) the star location for circles and C shapes or b) the center of rectangular openings. See next slide for position R4C6.

Refer to https://doi.org/10.1117/12.2598599, but note that an updated version will be in a JATIS paper later this year.