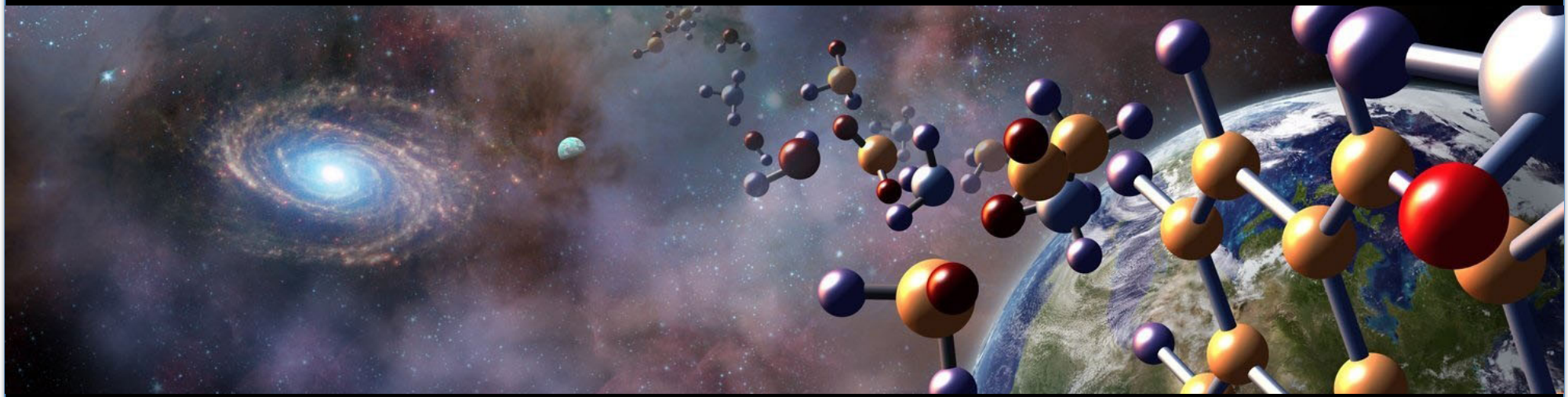
ORIGINS Space Telescope

From the Rise of Metals to Water for Habitable Worlds

Mid-Infrared Spectrometer and Camera (MISC) for the Origins Space Telescope (OST)



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Origins Space Telescope (OST) /MISC Team, OST STDT

ORIGINS Space Telescope

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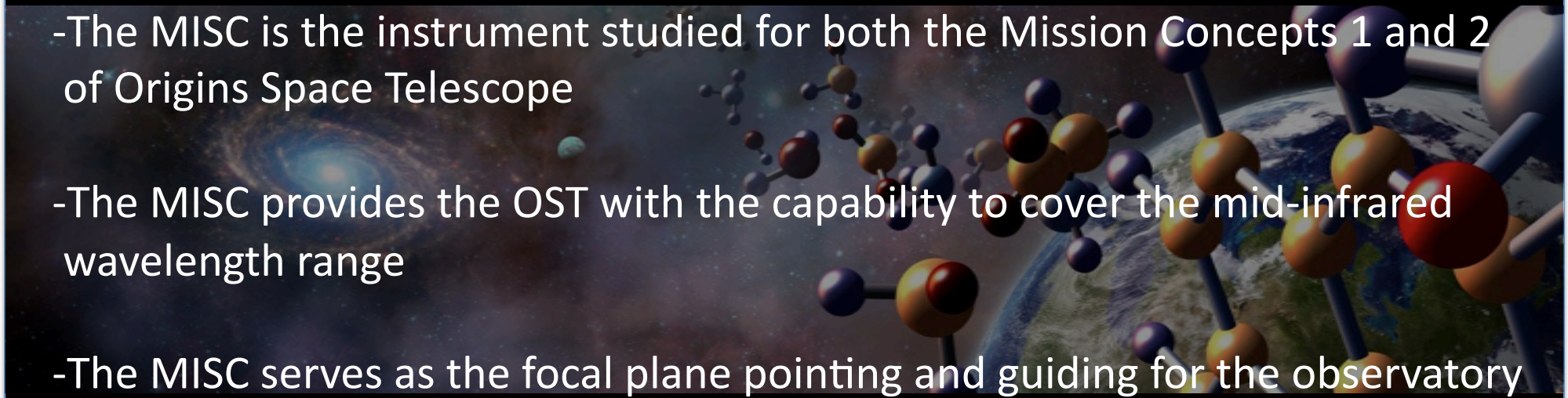
Mid-Infrared Spectrometer and Camera (MISC) for the Origins Space Telescope (OST)



-The MISC is the instrument studied for both the Mission Concepts 1 and 2 of Origins Space Telescope

-The MISC provides the OST with the capability to cover the mid-infrared wavelength range

-The MISC serves as the focal plane pointing and guiding for the observatory

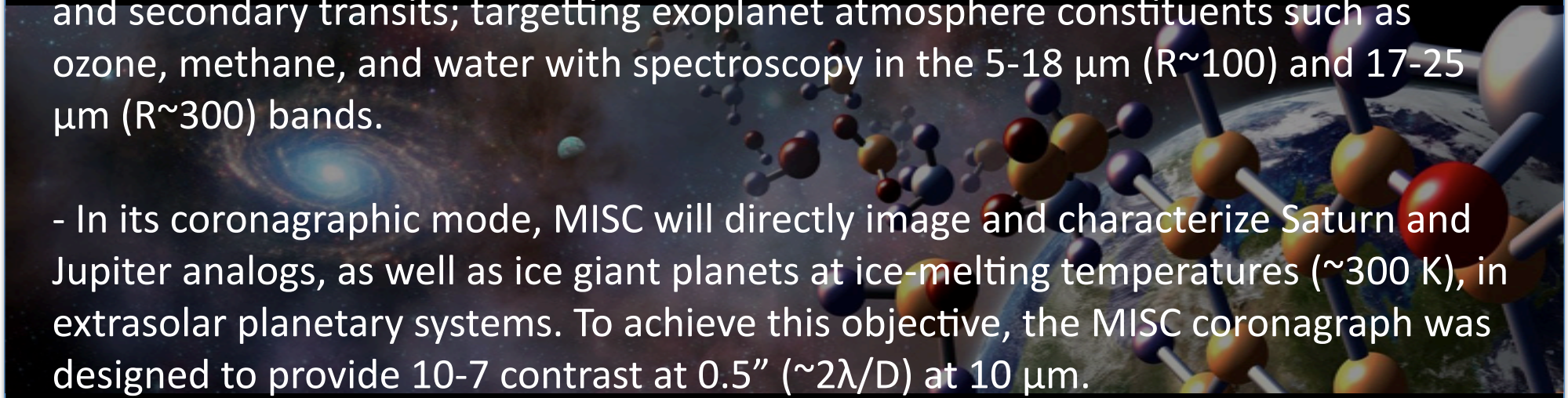
ORIGINS Space Telescope

From the Rise of Metals to Water for Habitable Worlds

NASA

MISC for the OST Mission Concept 1

-The MISC instrument for the OST Mission Concpet 1 is essential to the OST searching for biosignatures in the atmospheres of exoplanets via ultra-stable (<5 ppm on timescales of hours to days) spectro-photometric observations of primary and secondary transits; targetting exoplanet atmosphere constituents such as ozone, methane, and water with spectroscopy in the 5-18 µm (R~100) and 17-25 µm (R~300) bands.



- In its coronagraphic mode, MISC will directly image and characterize Saturn and Jupiter analogs, as well as ice giant planets at ice-melting temperatures (~300 K), in extrasolar planetary systems. To achieve this objective, the MISC coronagraph was designed to provide 10-7 contrast at 0.5" (~2λ/D) at 10 µm.

- MISC mid-IR imaging in the 5-40 µm band will be used to study episodic accretion in circumstellar debris disks, and to support the biosignature observations, while spectroscopy with resolving power ranging from ~10^2 to 10^4 in the MISC spectral range will support prioritized observing campaigns in all of OST's science themes.

A Fact Sheet of MISC for OST Mission Concept 1

(http://exoplanets.astron.s.u-tokyo.ac.jp/OST/MISC/index_misc_concept_1.html)

Module	Mid-IR Imager Spectrometer Channel			Transit Channel	Coronagraph Channel
	Imager/Low-Res Spec.	Medium-Res Spec.	High-Res Spec.	(Densified Pupil Spec.)	(PIAACMC)
	WFI-S/-L	MRS-S/-M/-L	HRS-S/-L	TRA-S/-M/-L	COR-S/-L
Bandpass (μm)	6-38	5-36	12-18, 25-38	5--26	6-38
Spectral Resolution	5-10 [Imager] 300 [Low-Res Spec.]	1000-1500	20,000-30,000	>100 (TRA-S, TRA-M) 300 (TRA-L)	300
Full FOV	3 arcmin x 3 arcmin [Imager]	3 arcsec x 5 arcsec [with IFU]		3 arcsec x 3 arcsec	5.5 arcsec x 5.5 arcsec
Slit for Spectroscopy	Length; 3 arcmin Width; 0.26 arcsec (WFI-SG1) 0.40 arcsec (WFI-SG2) 0.65 arcsec (WFI-LG1) 1.00 arcsec (WFI-LG2) [low-resolution Spec.]	Length; 3 arcsec (MRS-S/MRS-M/MRS-L) Width; 0.33 arcsec (MRS-S) 0.55 arcsec (MRS-M) 1.0 arcsec (MRS-L) Mum of Slices; 11 (MRS-S) 9 (MRS-M), 5 (MRS-L)	Length; 1.0 arcsec (HRS-S) 2.0 arcsec (HRS-L) Width; 0.5 arcsec (HRS-S) 1.0 arcsec (HRS-L)		Length; 1 arcmin Width; 0.26 arcsec (COR-SG1) 0.40 arcsec (COR-SG2) 0.65 arcsec (COR-LG1) 1.00 arcsec (COR-LG2)
Detectors	2kx2k Si:As (30μm/pix) [S] 2kx2k Si:Sb (18μm/pix) [L]	2kx2k Si:As (30μm/pix) [S] 2kx2k Si:As (30um/pix) [M] 1kx1k Si:Sb (18μm/pix) [L]	2kx2k Si:As (30μm/pix) [S] 1kx1k Si:Sb (18μm/pix) [L]	2kx2k Si:As (30μm/pix) [S] 2kx2k Si:As (30μm/pix) [M] 2kx2k Si:As (30um/pix) [L]	2kx2k Si:As (30μm/pix) [S] 1kx1k Si:Sb (18μm/pix) [L]
pixel scale	0.088 arcsec/pix	0.0615 arcsec/pix (MRS-S) 0.10 arcsec/pix (MRS-M) 0.15 arcsec/pix (MRS-L)	0.17 arcsec/pix [S] 0.34 arcsec/pix [L]	0.1 arcsec/pix	0.05 arcsec/pix (COR-S) 0.10 arcsec/pix (COR-L)
Specification (Sensitivity/ Stability/ Contrast)	**Sensitivity [Imager] ;** *1-hour 5σ Continuum Sens . for a Point Source* 0.027μJy@5μm, 0.16μJy@10μm, 0.26μJy@15μm, 0.37μJy@20μm, 0.55μJy@25μm, 0.63μJy@30μm, 0.7μJy@35μm **Sensitivity [Low-Res Spec.];** *1-hour 5s Continuum Sens. for a Point Source* (R=300) 0.6μJy@5μm, 1.3μJy@10μm, 4.0μJy@15μm, 5.0μJy@20μm, 8.8μJy@25μm, 11.2μJy@30μm, 37.5μJy@35μm	**Sensitivity;** *1-hour 5s Continuum Sens. for a Point Source (R~1200)* 3μJy@7μm, 10μJy@15μm, 30μJy@24μm,100μJy@32μm 1-hour 5s Line Sens. for a Point Source $1x10^{-21}$ W/m² @7μm, $2x10^{-21}$ W/m² @15μm, $3x10^{-21}$ W/m² @24μm, $1x10^{-20}$ W/m² @32μm	**Sensitivity;** 1-hour 5s Line Sens. for a Point Source $1x10^{-21}$ W/m² @15μm, $3x10^{-21}$ W/m² @30μm	**Photometric stability;** better than 10 ppm on timescales of hours to days (excluding the fluctuation of detector gain)	**Average contrast;** $7x10^{-6}$ for 10% band $1x10^{-6}$ for 4% band in 0.88-3.6λ/D

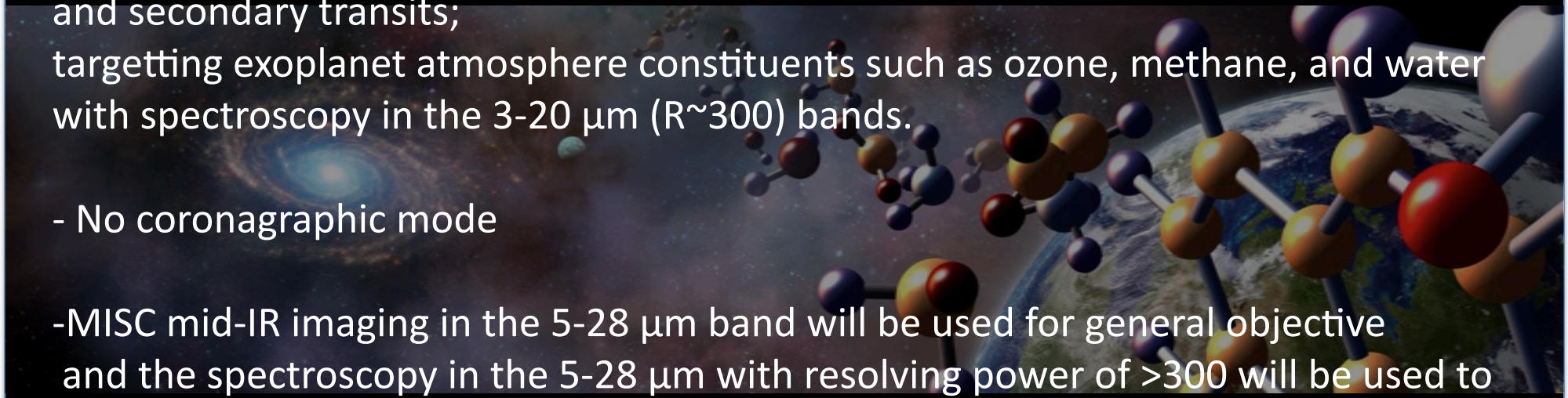
ORIGINS Space Telescope

From the Rise of Metals to Water for Habitable Worlds

NASA

MISC for the OST Mission Concept 2

-The MISC instrument for the OST Mission Concept 2 is still essential to the OST searching for biosignatures in the atmospheres of exoplanets via ultra-stable (<5 ppm on timescales of hours to days) spectro-photometric observations of primary and secondary transits;
targetting exoplanet atmosphere constituents such as ozone, methane, and water with spectroscopy in the 3-20 μm (R~300) bands.

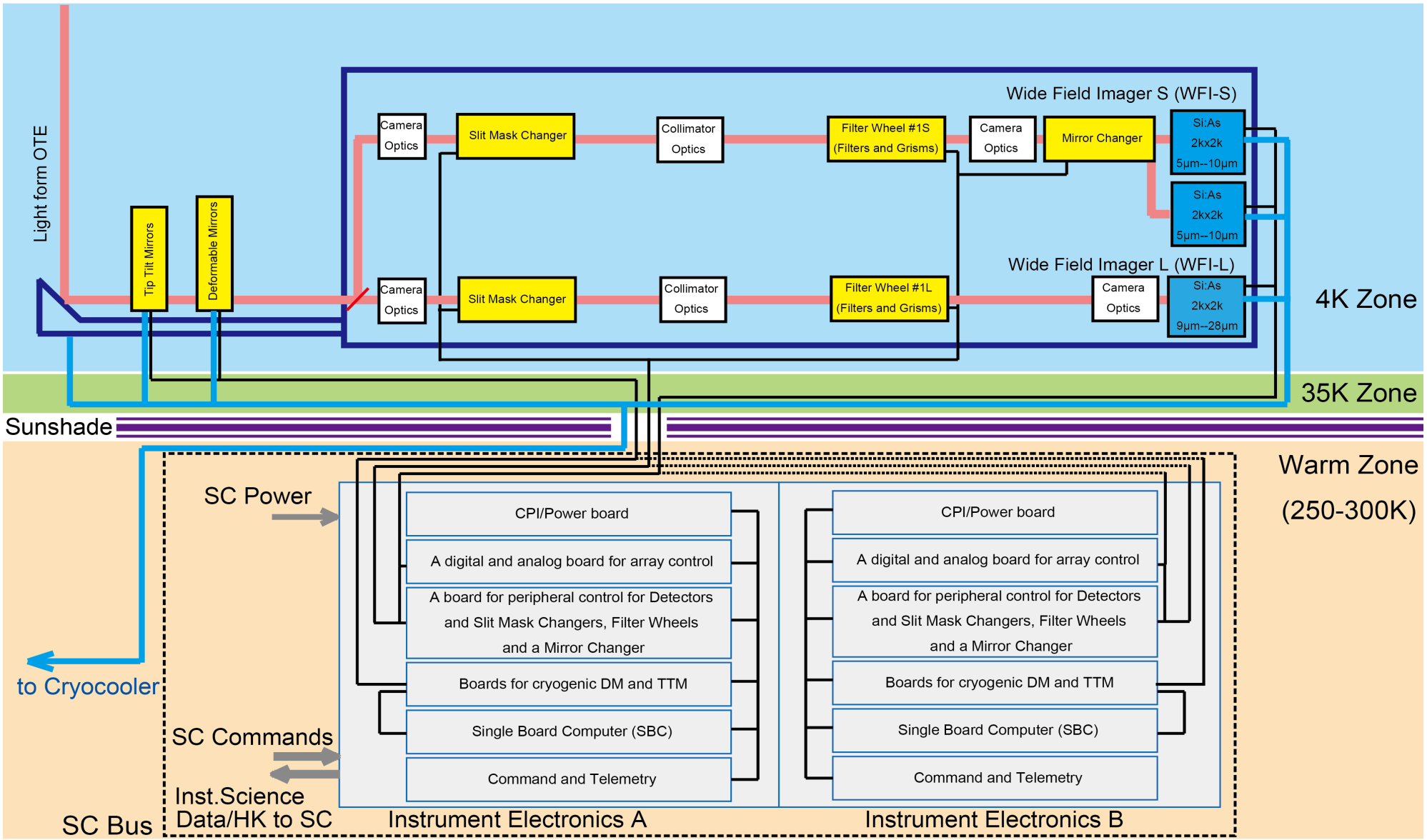


- No coronagraphic mode

-MISC mid-IR imaging in the 5-28 μm band will be used for general objective and the spectroscopy in the 5-28 μm with resolving power of >300 will be used to measure the mid-infrared dust features and ionic lines at z up to ~1 in Rise of Metals & Black Hole and Feedback programs.

MISC for OST Mission Concept 2

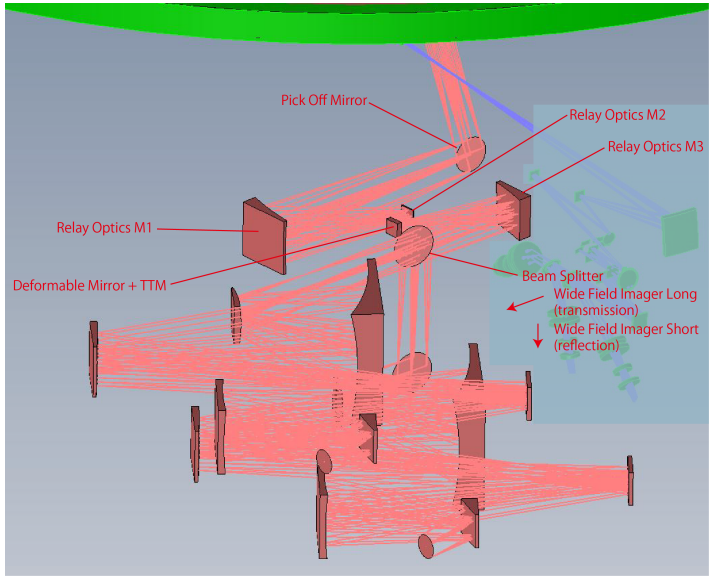
(1) MISC Wide Field Imager (WFI) Module

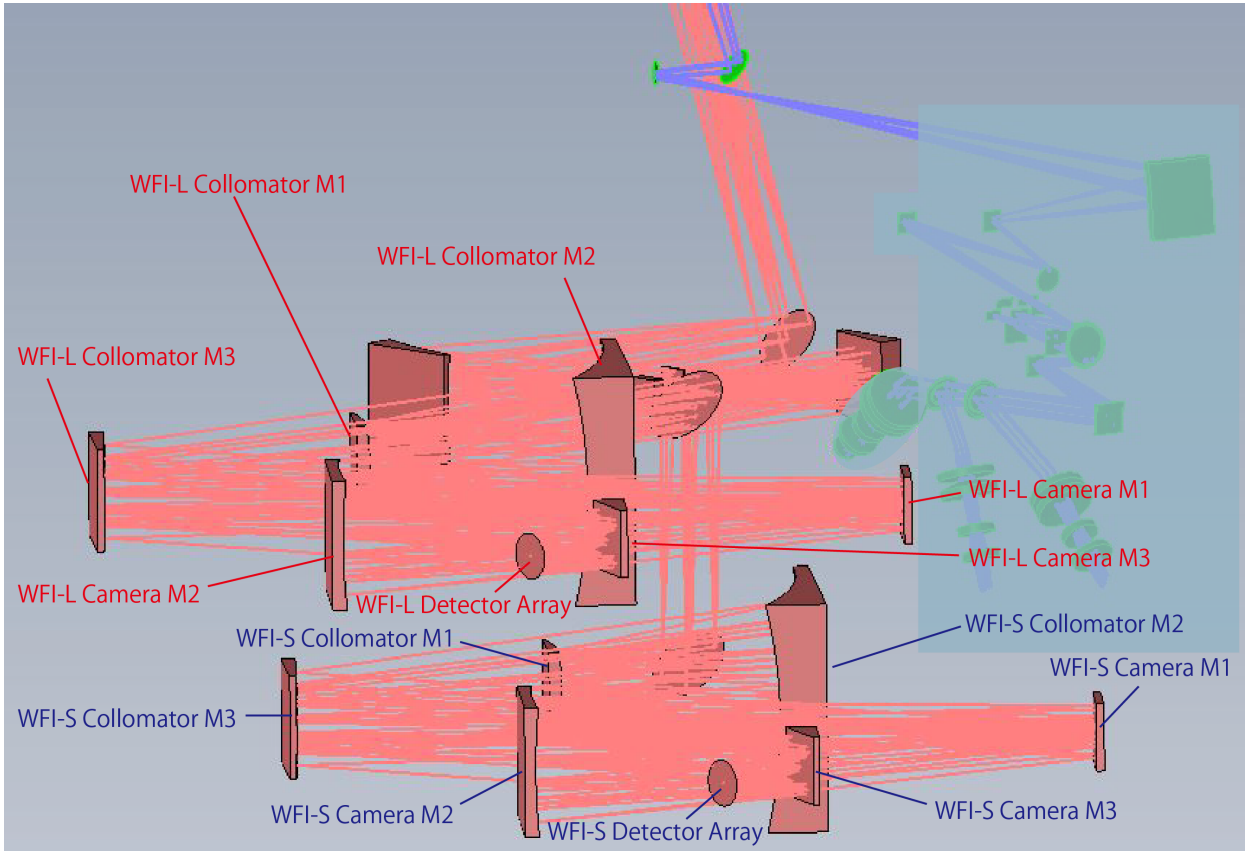


MISC for OST Mission Concept 2

(1) MISC Wide Field Imager (WFI) Module

Entire view of optical design of MISC Wide Field Imager Module for OST Mission Concept 2





Mechanisms

- Deformable Mirror
- Tip Tilt Mirror
- Filter Wheels (ϕ3inchx6 x triple wheels for WFI-S and WFI-L)
- Slit Mask Changers (ϕ4inchx2 for WFI-S, ϕ4inchx4 for WFI-L)
- Beam Changer (b/w WFI-S1 and S2)

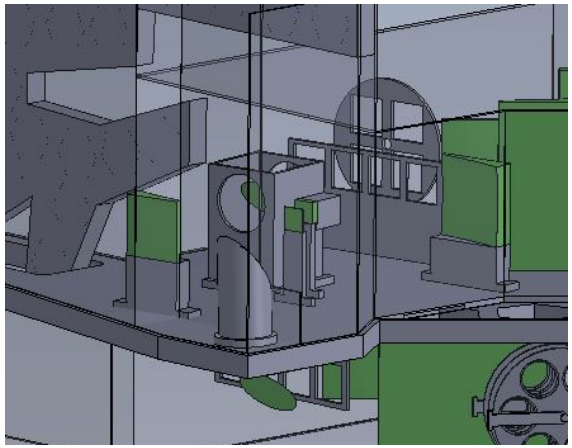
Cold Mass: 304.25kg(A6061-T6), 126.54kg(Be), 185.74kg(CO720)
Warm Mass: 36 kg (Inst. Electronics A &B, Harness)

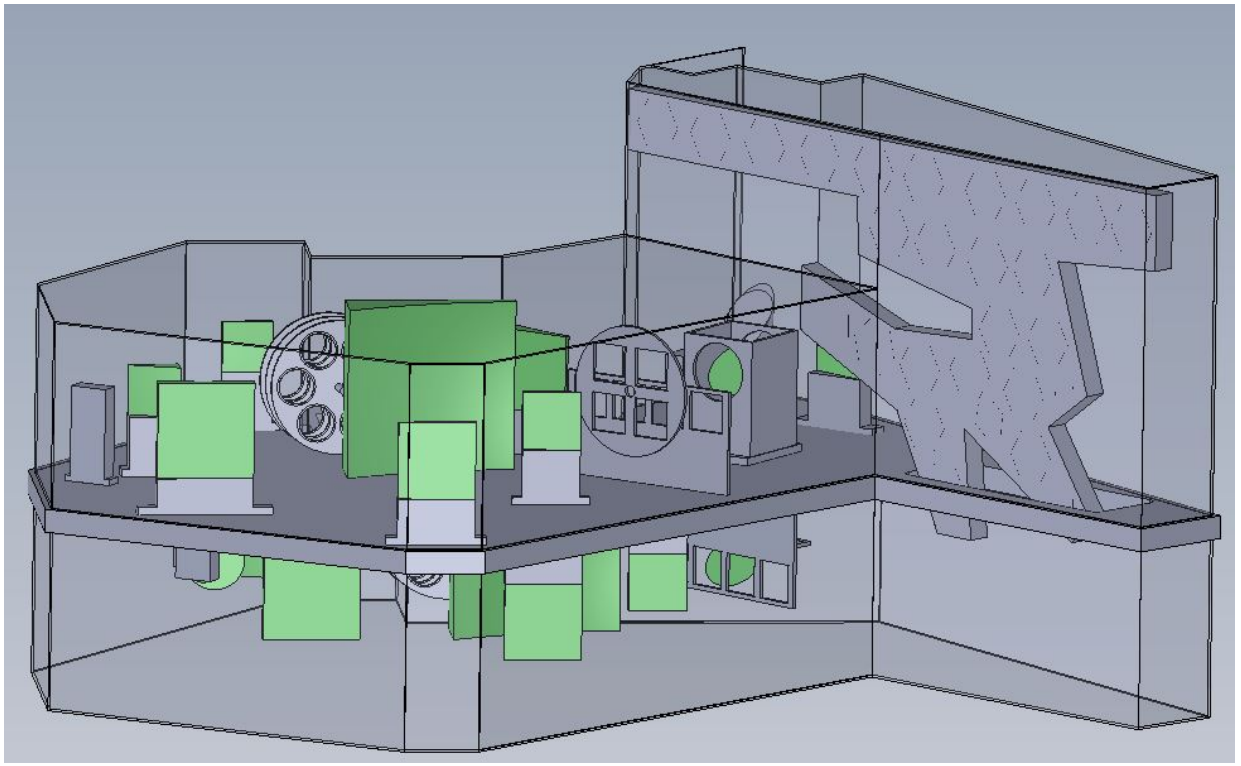
MISC for OST Mission Concept 2

(1) MISC Wide Field Imager (WFI) Module

Entire view of mechanical design of MISC WFI Module for OST Mission Concept 2

Wave front error correction system in the fore optics





Mechanisms

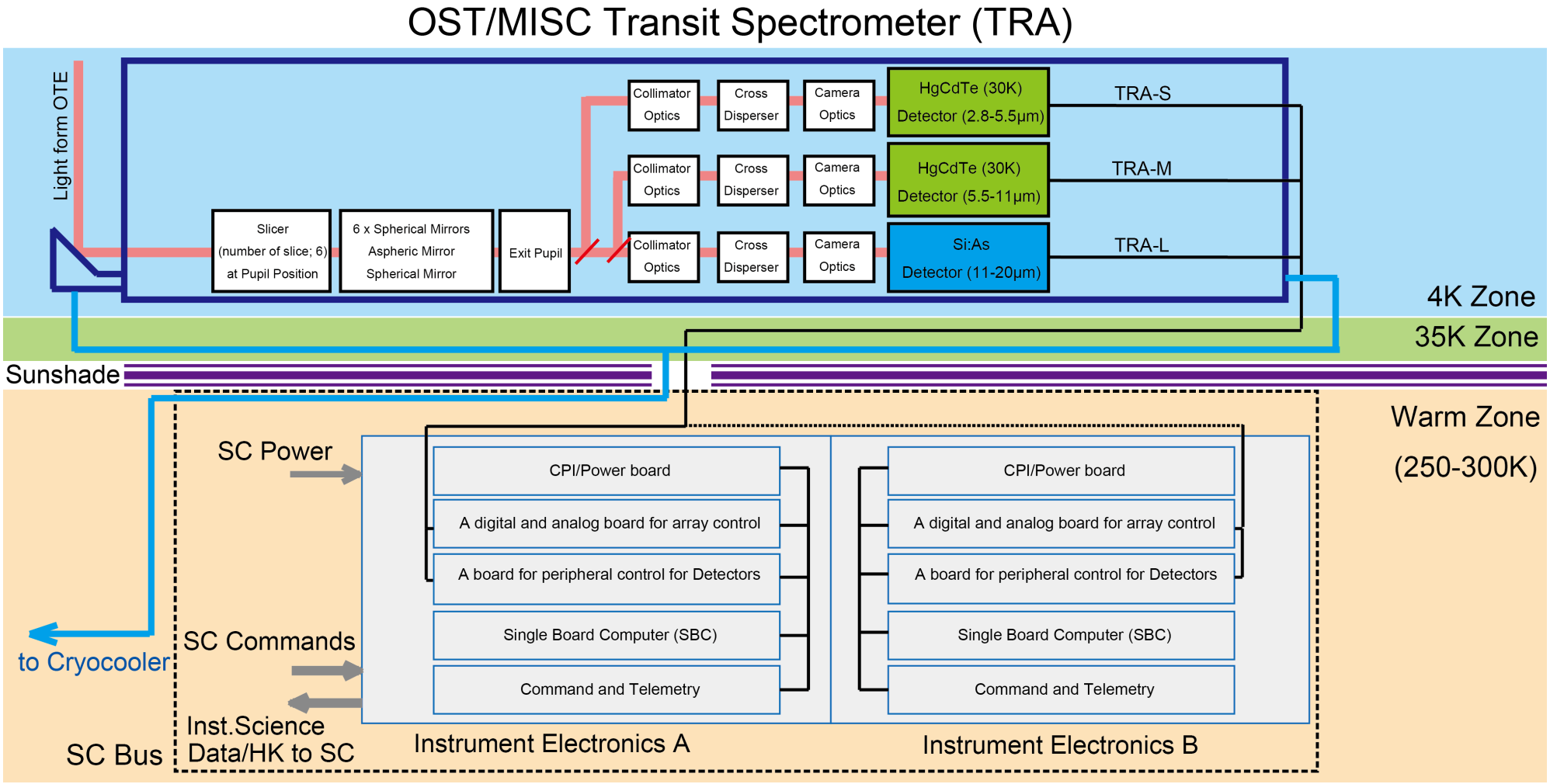
- Deformable Mirror
- Tip Tilt Mirror
- Filter Wheels (ϕ3inchx6 x triple wheels for WFI-S and WFI-L)
- Slit Mask Changers (ϕ4inchx2 for WFI-S, ϕ4inchx4 for WFI-L)
- Beam Changer (b/w WFI-S1 and S2)

Cold Mass: 304.25kg(A6061-T6), 126.54kg(Be), 185.74kg(CO720)
Warm Mass: 36 kg (Inst. Electronics A &B, Harness)

MISC for OST Mission Concept 2

(2) MISC Transit Spectrometer (TRA) Module

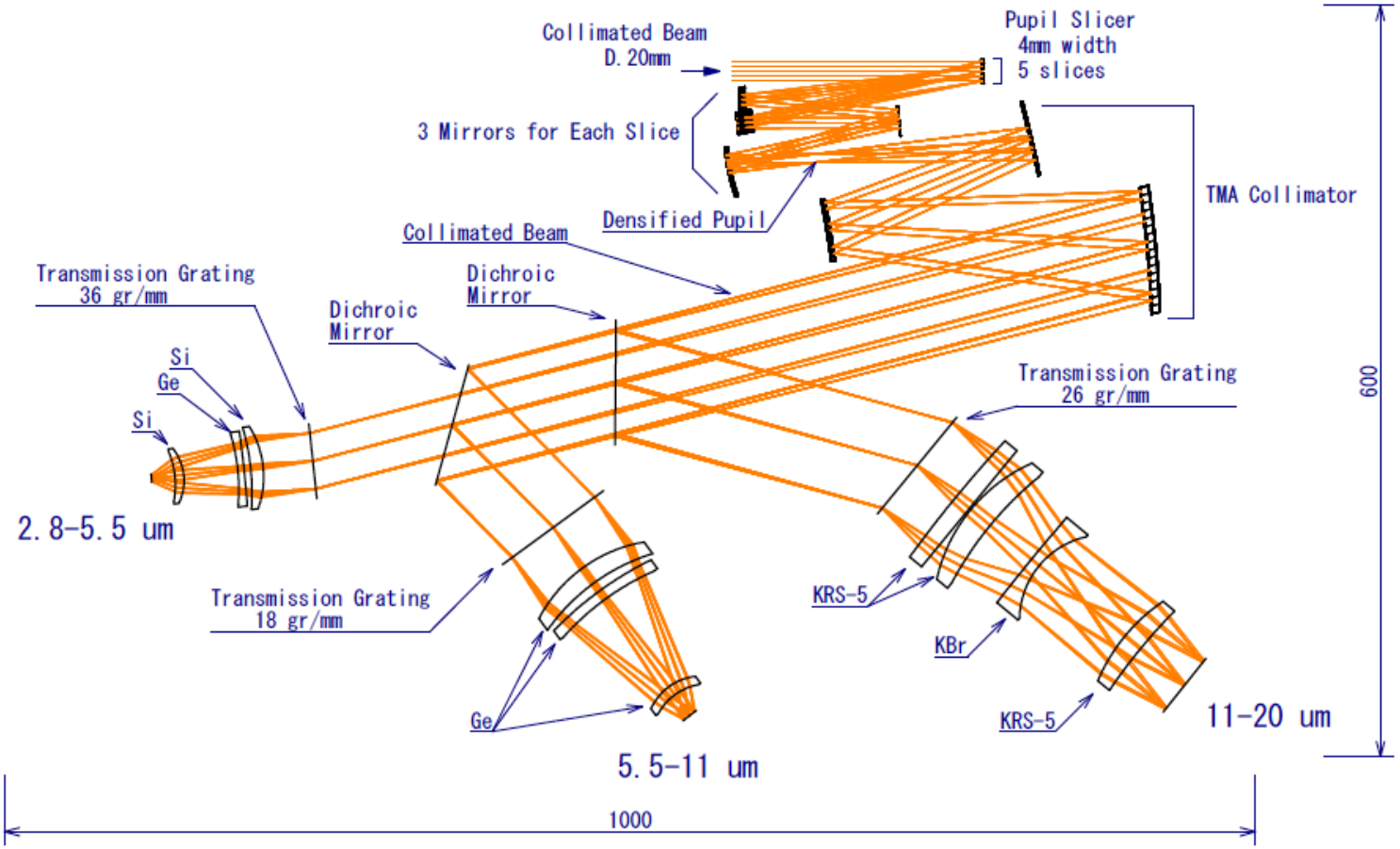
Densified pupil spectroscopy (Matsuo et al. 2016)



MISC for OST Mission Concept 2

(2) MISC Transit Spectrometer (TRA) Module

Entire view of optical design of MISC/TRA for OST Mission Concept 2



Mechanisms

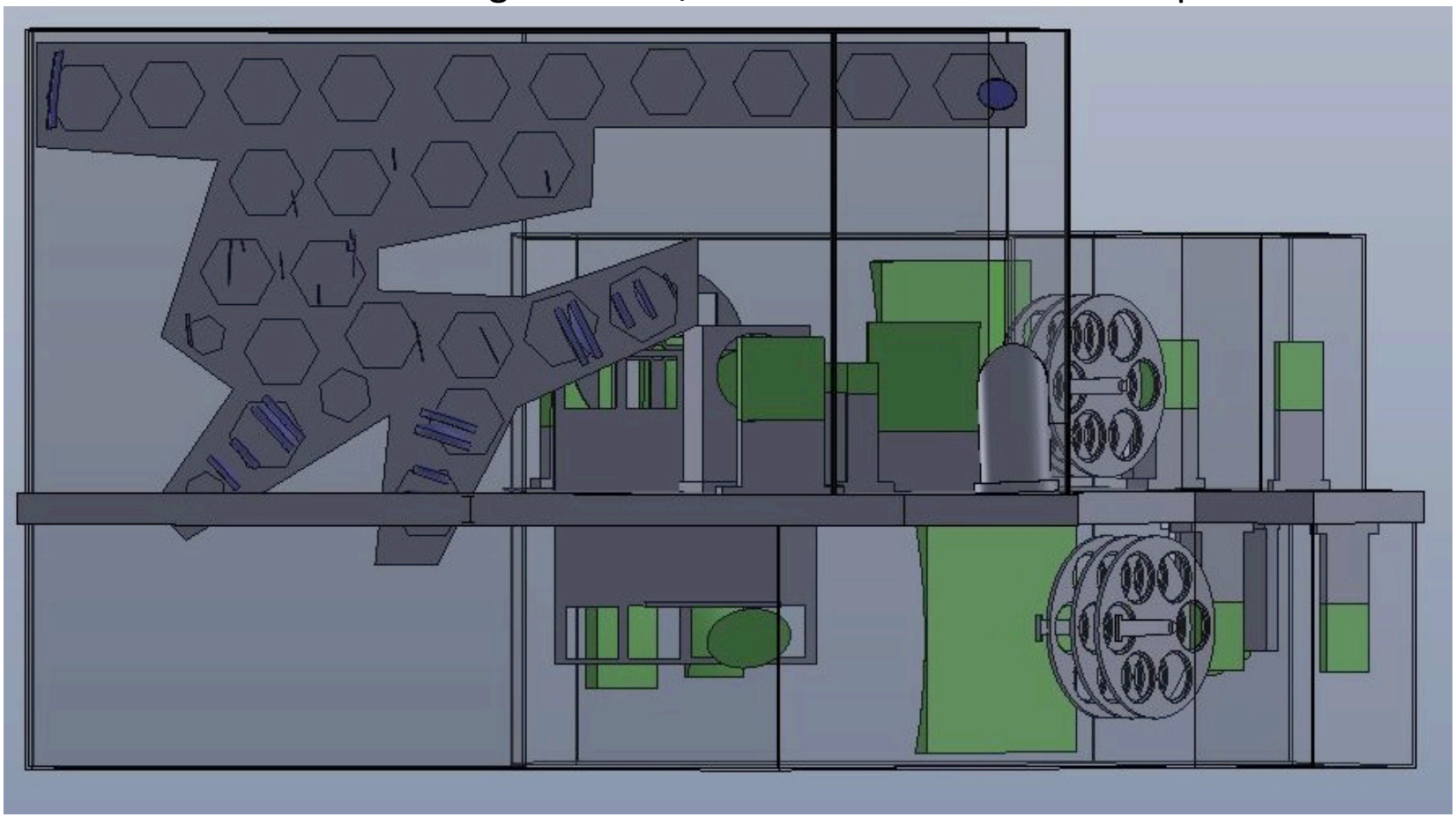
・no moving part

Cold Mass: 98.40kg(A6061-T6), 58.47kg(Be), 71.78kg(CO720)

Warm Mass: 22 kg (Inst. Electronics A & B, Harness)

MISC for OST Mission Concept 2
(2) MISC Transit Spectrometer (TRA) Module

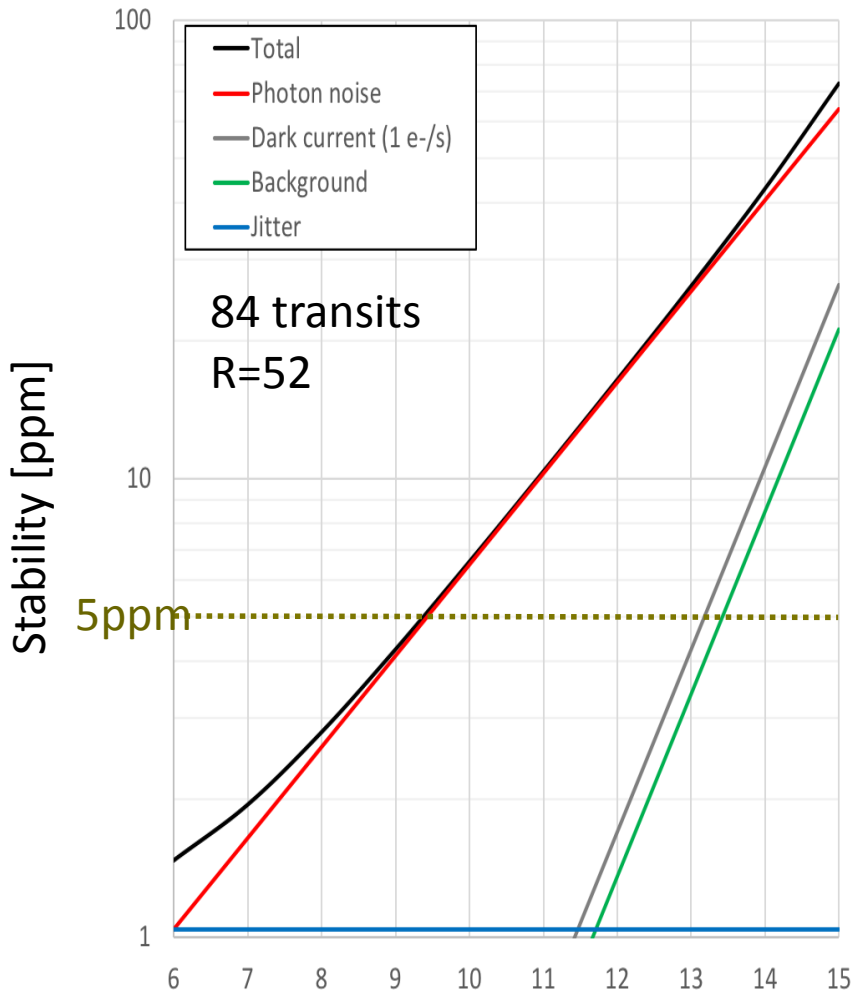
Entire view of mechanical design of MISC/TRA for OST Mission Concept 2



Mechanisms
・no moving part

Cold Mass: 98.40kg(A6061-T6), 58.47kg(Be), 71.78kg(CO720)
Warm Mass: 22 kg (Inst. Electronics A & B, Harness)

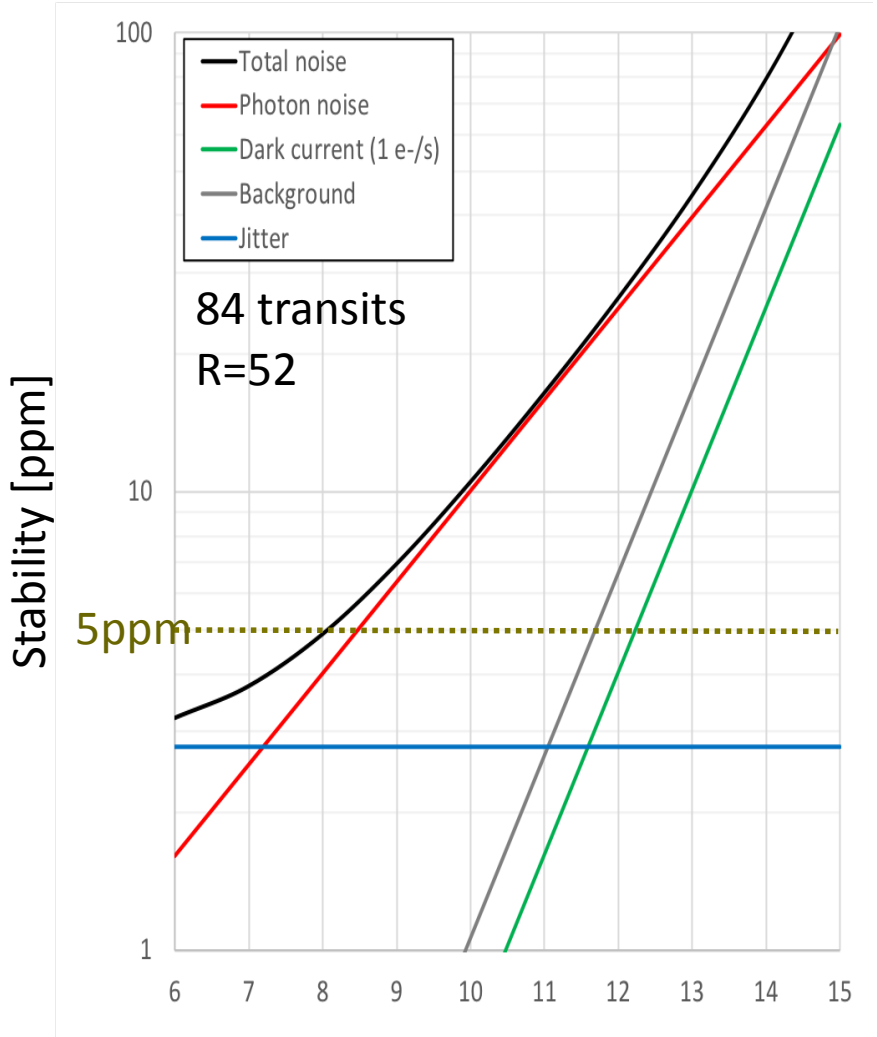
OST MISC/TRA noise performance at 3µm



K (mag)	M8 (pc)	M5 (pc)	M1 (pc)
6	1.3	2.7	7.8
7	2.1	4.2	12.4
8	3.3	6.7	19.6
9	5.2	10.6	30.9
10	8.2	16.8	48.9
11	13.0	26.5	77.3
12	20.5	41.9	122.2
13	32.4	66.2	193.2
14	51.3	104.7	305.5
15	81.0	165.5	483

* The results do not strongly depend on the spectral type of a host star.

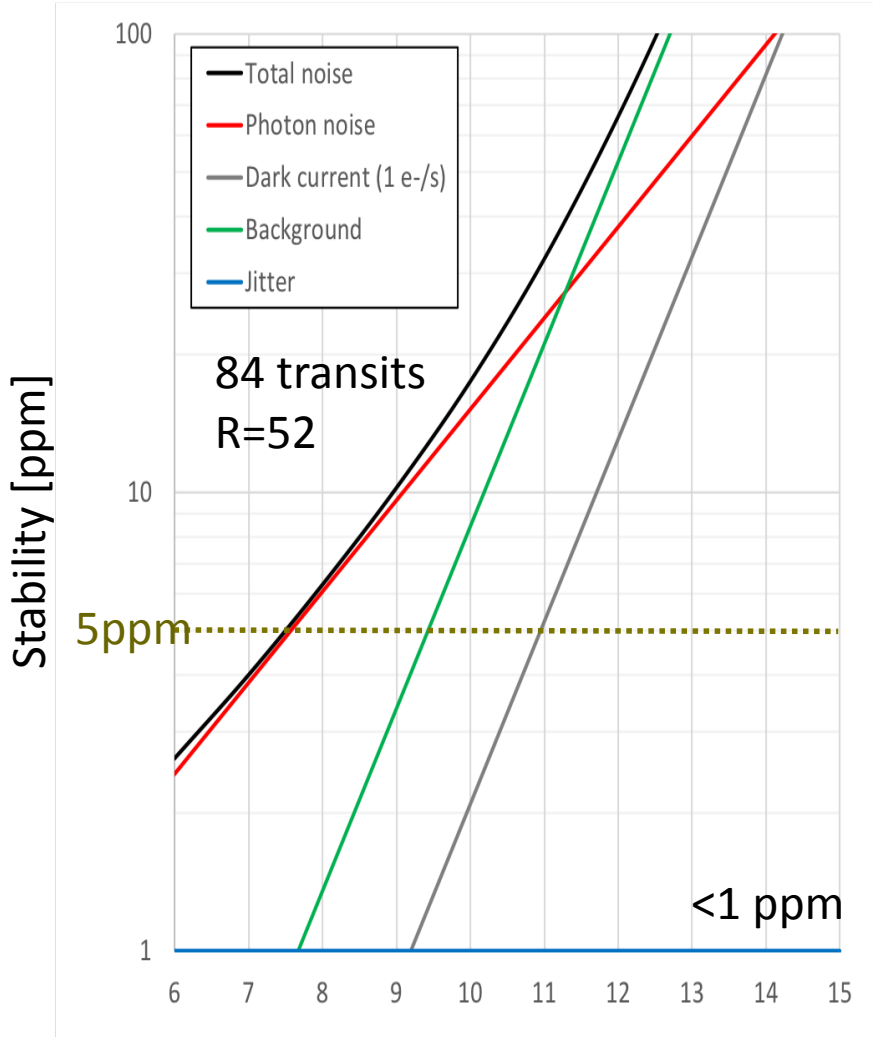
OST MISC/TRA noise performance at 5µm



K (mag)	M8 (pc)	M5 (pc)	M1 (pc)
6	1.3	2.7	7.8
7	2.1	4.2	12.4
8	3.3	6.7	19.6
9	5.2	10.6	30.9
10	8.2	16.8	48.9
11	13.0	26.5	77.3
12	20.5	41.9	122.2
13	32.4	66.2	193.2
14	51.3	104.7	305.5
15	81.0	165.5	483

* The results do not strongly depend on the spectral type of a host star.

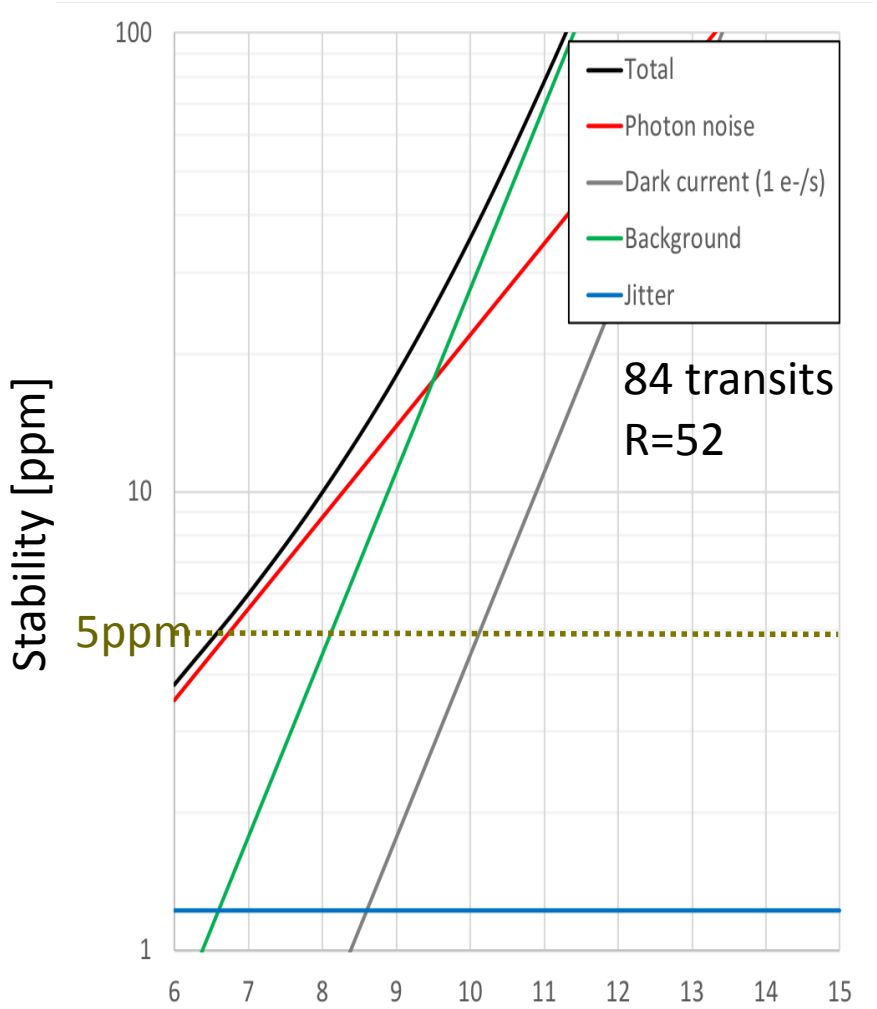
OST MISC/TRA noise performance at 8µm



K (mag)	M8 (pc)	M5 (pc)	M1 (pc)
6	1.3	2.7	7.8
7	2.1	4.2	12.4
8	3.3	6.7	19.6
9	5.2	10.6	30.9
10	8.2	16.8	48.9
11	13.0	26.5	77.3
12	20.5	41.9	122.2
13	32.4	66.2	193.2
14	51.3	104.7	305.5
15	81.0	165.5	483

* The results do not strongly depend on the spectral type of a host star.

OST MISC/TRA noise performance at 10µm



K (mag)	M8 (pc)	M5 (pc)	M1 (pc)
6	1.3	2.7	7.8
7	2.1	4.2	12.4
8	3.3	6.7	19.6
9	5.2	10.6	30.9
10	8.2	16.8	48.9
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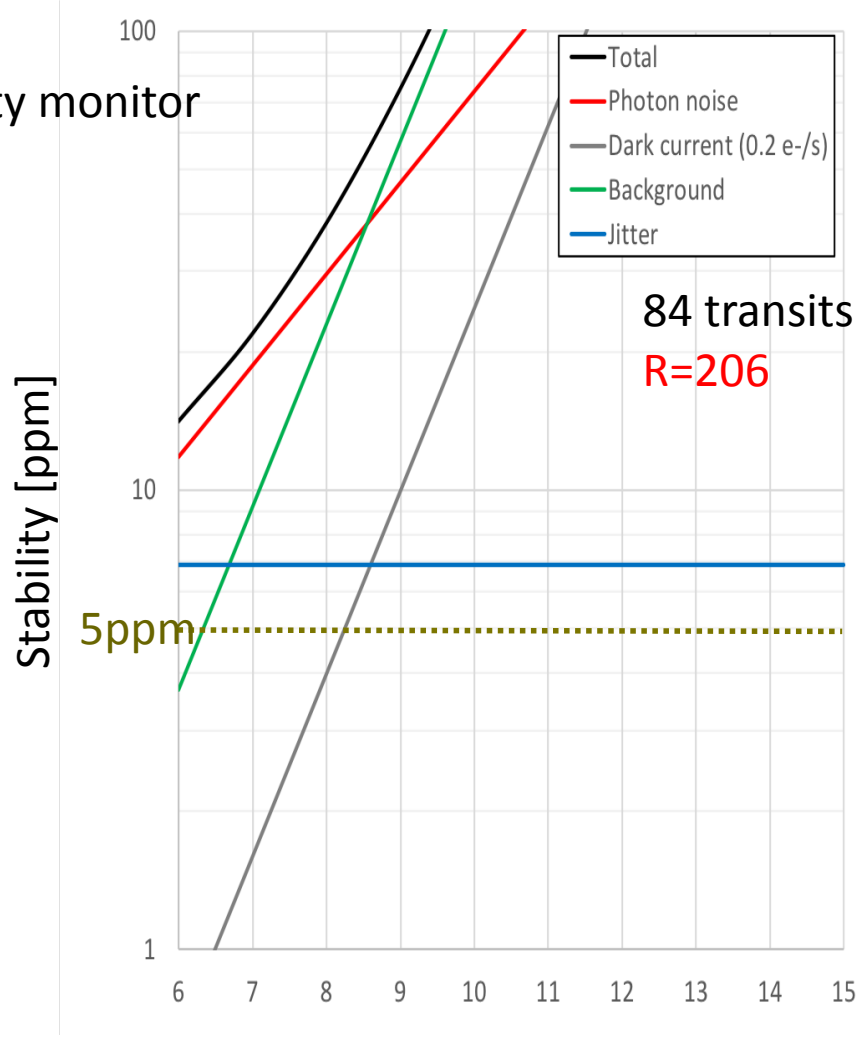
13	32.4	66.2	193.2
14	51.3	104.7	305.5
15	81.0	165.5	483

* The results do not strongly depend on the spectral type of a host star.

OST MISC/TRA noise performance at 14µm

Stellar activity monitor



K (mag)	M8 (pc)	M5 (pc)	M1 (pc)
6	1.3	2.7	7.8
7	2.1	4.2	12.4
8	3.3	6.7	19.6
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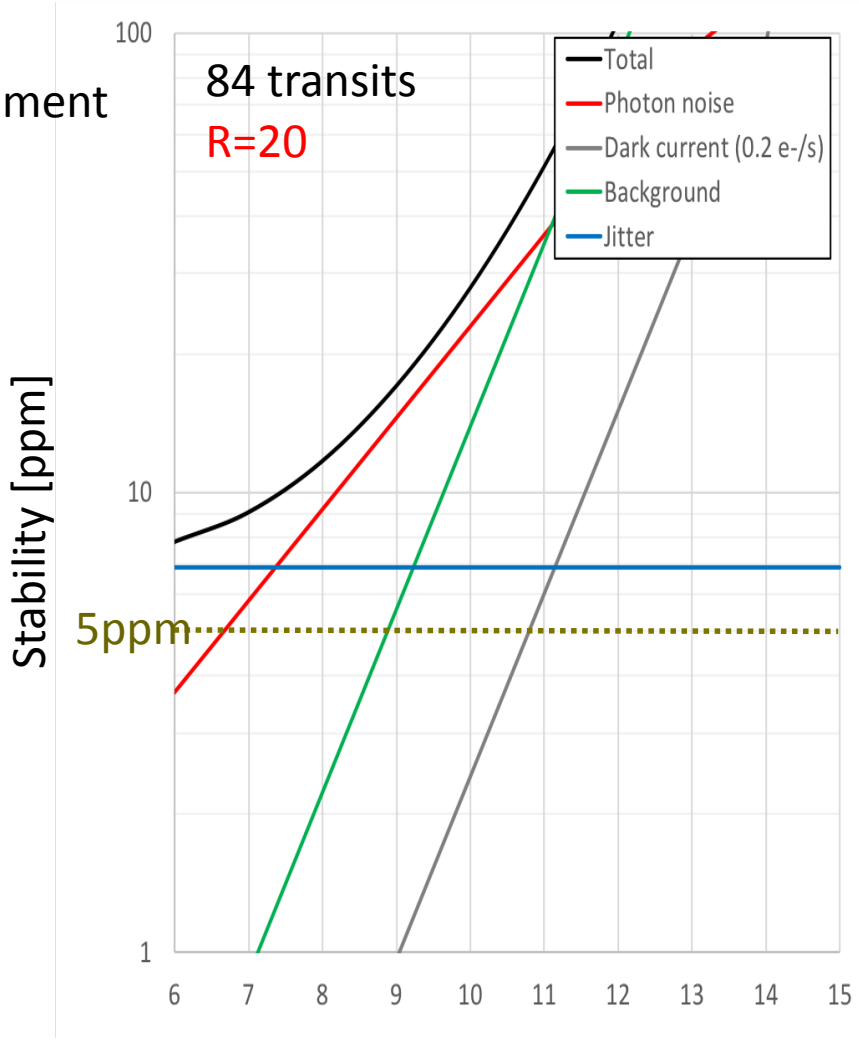
13	32.4	66.2	193.2
14	51.3	104.7	305.5
15	81.0	165.5	483

* The results do not strongly depend on the spectral type of a host star.

OST MISC/TRA noise performance at 14µm

SED measurement



K (mag)	M8 (pc)	M5 (pc)	M1 (pc)
6	1.3	2.7	7.8
7	2.1	4.2	12.4
8	3.3	6.7	19.6
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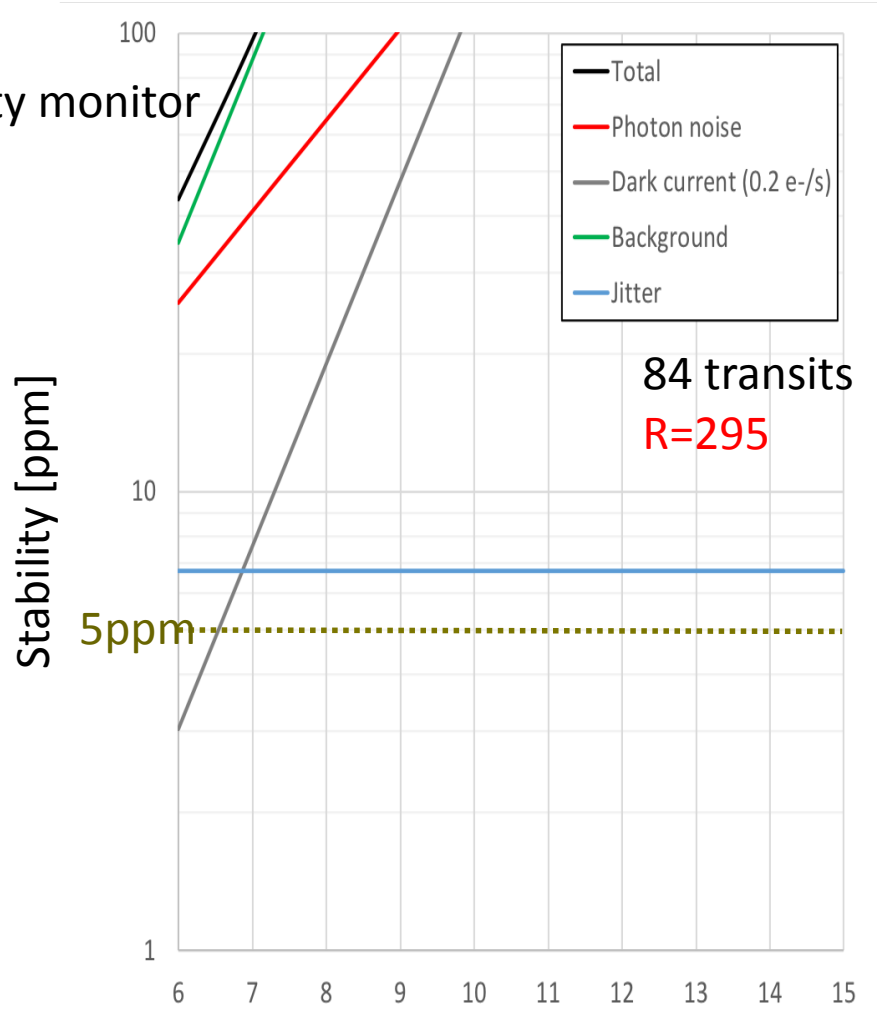
13	32.4	66.2	193.2
14	51.3	104.7	305.5
15	81.0	165.5	483

* The results do not strongly depend on the spectral type of a host star.

OST MISC/TRA noise performance at 20µm

Stellar activity monitor

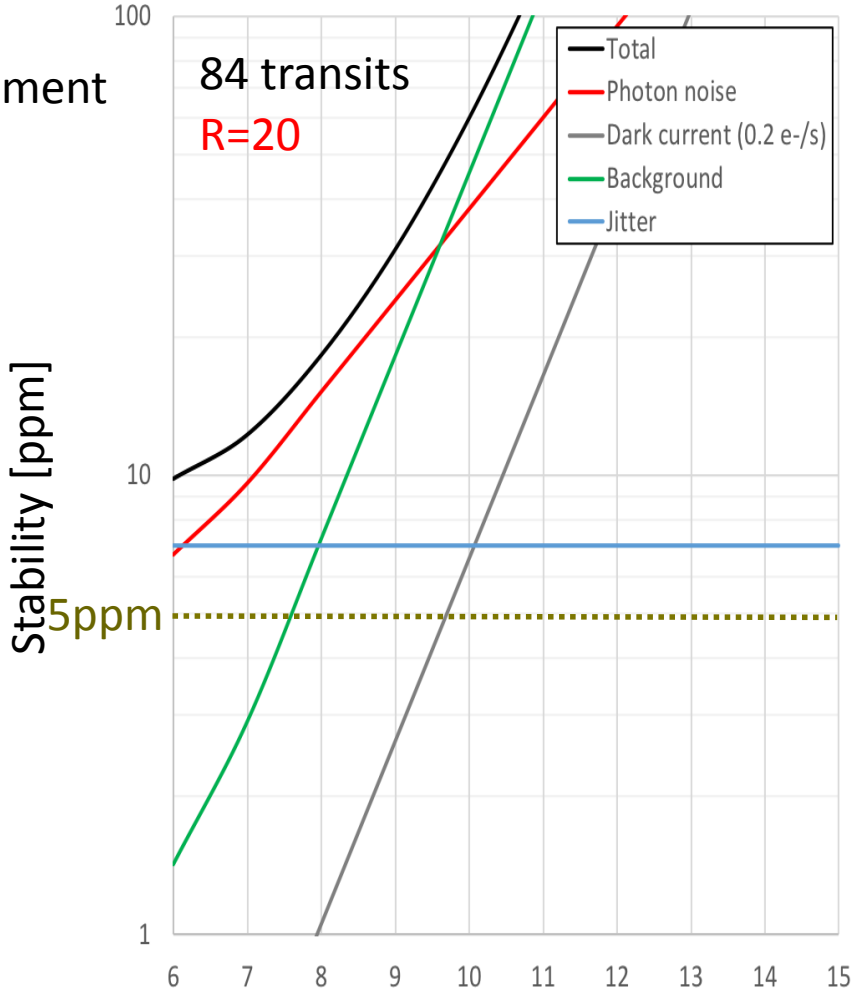


K (mag)	M8 (pc)	M5 (pc)	M1 (pc)
6	1.3	2.7	7.8
7	2.1	4.2	12.4
8	3.3	6.7	19.6
9	5.2	10.6	30.9
10	8.2	16.8	48.9
11	13.0	26.5	77.3
12	20.5	41.9	122.2
13	32.4	66.2	193.2
14	51.3	104.7	305.5
15	81.0	165.5	483

* The results do not strongly depend on the spectral type of a host star.

OST MISC/TRA noise performance at 20µm

SED measurement



K (mag)	M8 (pc)	M5 (pc)	M1 (pc)
6	1.3	2.7	7.8
7	2.1	4.2	12.4
8	3.3	6.7	19.6
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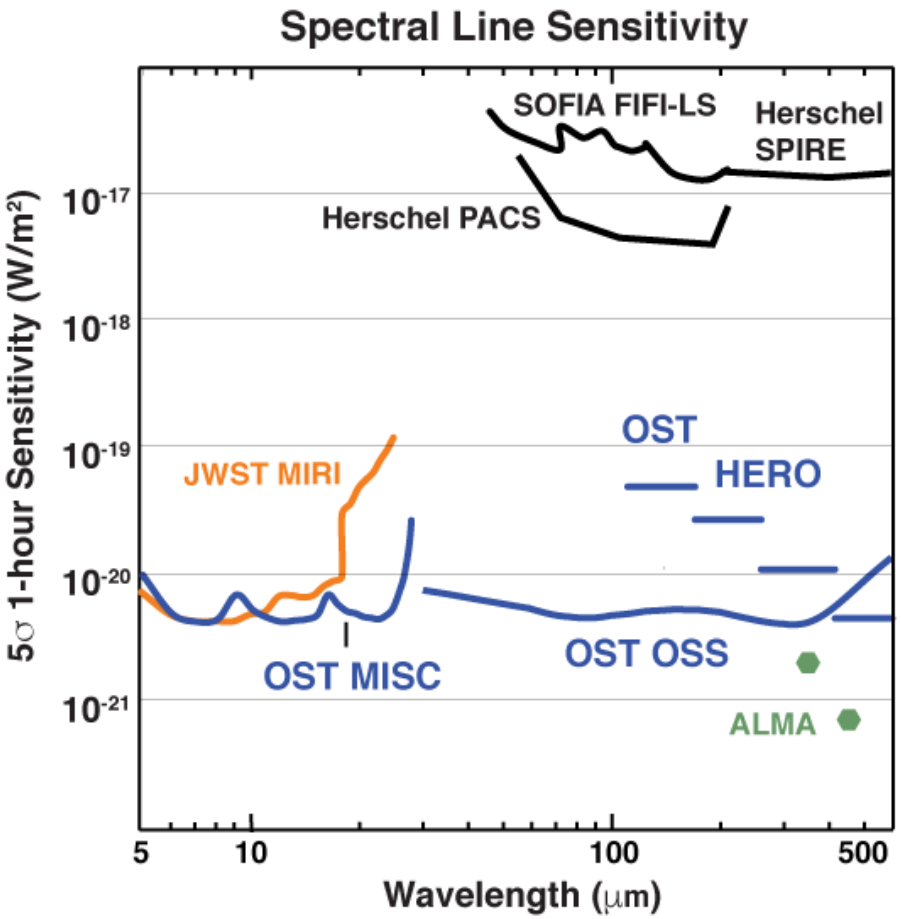
13	32.4	66.2	193.2
14	51.3	104.7	305.5
15	81.0	165.5	483

* The results do not strongly depend on the spectral type of a host star.

A Fact Sheet of MISC for OST Mission Concept 2

(http://exoplanets.astron.s.u-tokyo.ac.jp/OST/MISC/index_misc_concept_2.html)

Module	MISC Wide Field Imager	MISC Transit Spectrometer
	Imaging / Low-Res Spectroscopy	Densified Pupil Spectroscopy
	WFI-S1, S2/WFI-L	TRA-S/-M/-L
Operating Modes	[1] MIR Imaging [2] MIR Low-Res. Spectroscopy (slit) [3] MIR Low-Res. Spectroscopy (slitless) [4] MIR Scan Mapping	[5] MIR Super Stable Spectroscopy
Bandpass (μm)	6--28	2.8--20
Angular Resolution	0.21 arcsec @5 μm, 0.38 arcsec @9 μm, 0.68 arcsec @16 μm, 0.98 arcsec @23 μm, 1.18 arcsec @27.6 μm	Angular resolution is not important
Spectral Resolution	5-10 for MIR Imaging 300 for MIR Low-Resolution Spectroscopy	TRA-S, TRA-M; 300 (degrared to ~50) TRA-L; 300 for stellar activity monitoring (degraded to 20 for SED measurement)
Full FOV	3 arcmin x 3 arcmin [Imager]	3 arcsec x 3 arcsec
Slit for Spectroscopy	Length; 3 arcmin Width; 0.38 arcsec (WFI-SG1), 0.68 arcsec (WFI-LG1), 1.18 arcsec (WFI-LG2)	N/A
Detectors	three 2kx2k Si:As arrays - two for WFI-S - one for WFI-L	TRA-S (2.8-5.5μm); HgCdTe array with calibration source TRA-M (5.5-11.0μm); HgCdTe array with calibration source TRA-L (11-22μm); Si:As IBC array with calibration source
Pixel Scale	0.088 arcsec/pix	0.1 arcsec/pix
Scanning Speed	MIR Scan (width; 180 arcsec) Maximum 1.5 [arcsec/sec] -- 22.5 [arcsec/sec]	N/A
Specification (Sensitivity/ Stability)	**Sensitivity [Imager] ;** *1-hour 5σ Cont. Sensitivity for a Point Source* 0.06 μJy @5 μm, 0.25 μJy @9 μm, 0.64 μJy@16 μm, 0.96 μJy @23 μm, 1.93 μJy @25 μm **Sensitivity [Low-Res Spec.];** *1-hour 5s Line Sensitivity for a Point Source* (R=300) 5.0E-21 W/m2 @6μm, 4.5E-21 W/m2 @8μm, 5.3E-21 W/m2 @10μm, 4.3E-21 W/m2 @12μm,	**Photometric stability;** 5 ppm with a goal of 1 ppm on timescales of hours to days



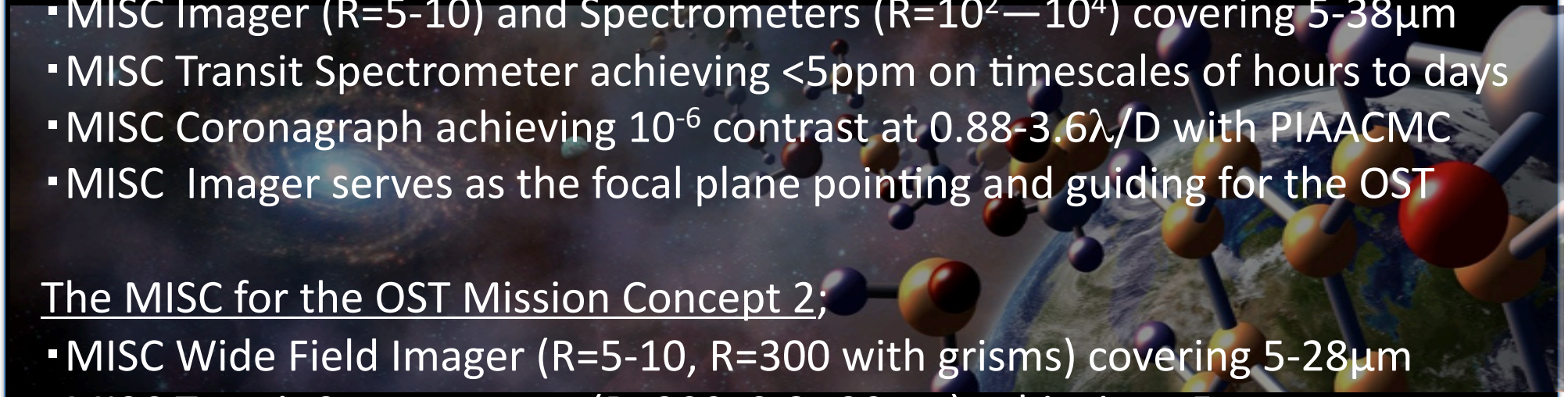
ORIGINS Space Telescope

From the Rise of Metals to Water for Habitable Worlds

NASA

Summary

The MISC is the instrument studied for both the OST Mission Concepts 1 & 2



The MISC for the OST Mission Concept 1;

- MISC Imager (R=5-10) and Spectrometers (R=10^2—10^4) covering 5-38μm
- MISC Transit Spectrometer achieving <5ppm on timescales of hours to days
- MISC Coronagraph achieving 10^{-6} contrast at 0.88-3.6λ/D with PIAACMC
- MISC Imager serves as the focal plane pointing and guiding for the OST

The MISC for the OST Mission Concept 2;

- MISC Wide Field Imager (R=5-10, R=300 with grisms) covering 5-28μm
- MISC Transit Spectrometer (R=300, 2.8--20μm) achieving <5ppm on timescales of hours to days
- No Coronagraph capability
- MISC Imager serves as the focal plane pointing and guiding for the OST