Instrument Systems Meeting on 6th June 2018

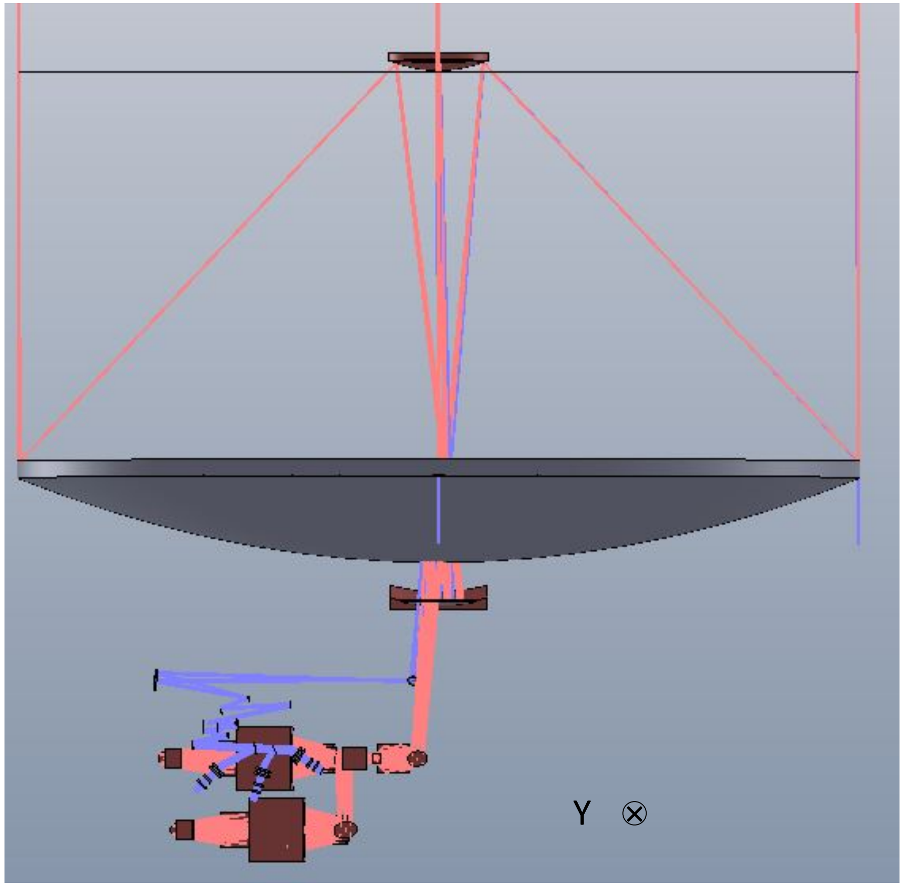
MISC for OST Concept 2

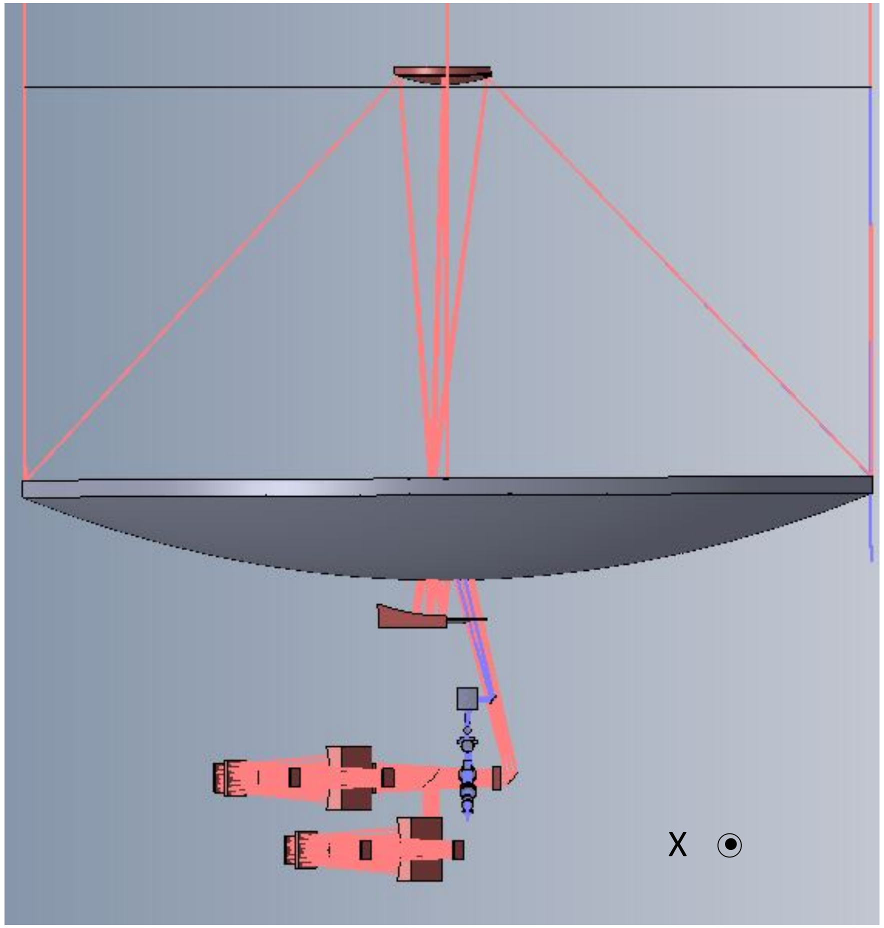
Latest information is available at the following web site on MISC Concept 2:
http://exoplanets.astron.s.u-tokyo.ac.jp/OST/MISC/index_misc_concept_2.html

Latest CAD data of MISC Concept 2 (updated based on the telescope model of ver. 14 May 2008) are available from the following links [version. 2018.06.06];
http://exoplanets.astron.s.u-tokyo.ac.jp/OST/MISC/OST2_misc-all_180606.IGS
http://exoplanets.astron.s.u-tokyo.ac.jp/OST/MISC/OST2_misc-all_180606.STEP
http://exoplanets.astron.s.u-tokyo.ac.jp/OST/MISC/OST2_misc-all_180606_64.exe

Itsuki Sakon (University of Tokyo), Tom Roellig (NASA Ames), Kimberly Ennico (NASA Ames)
MISC team

Latest Optical Design of Concept 2 MISC
(updated to match with the latest telescope model of version 14 May)





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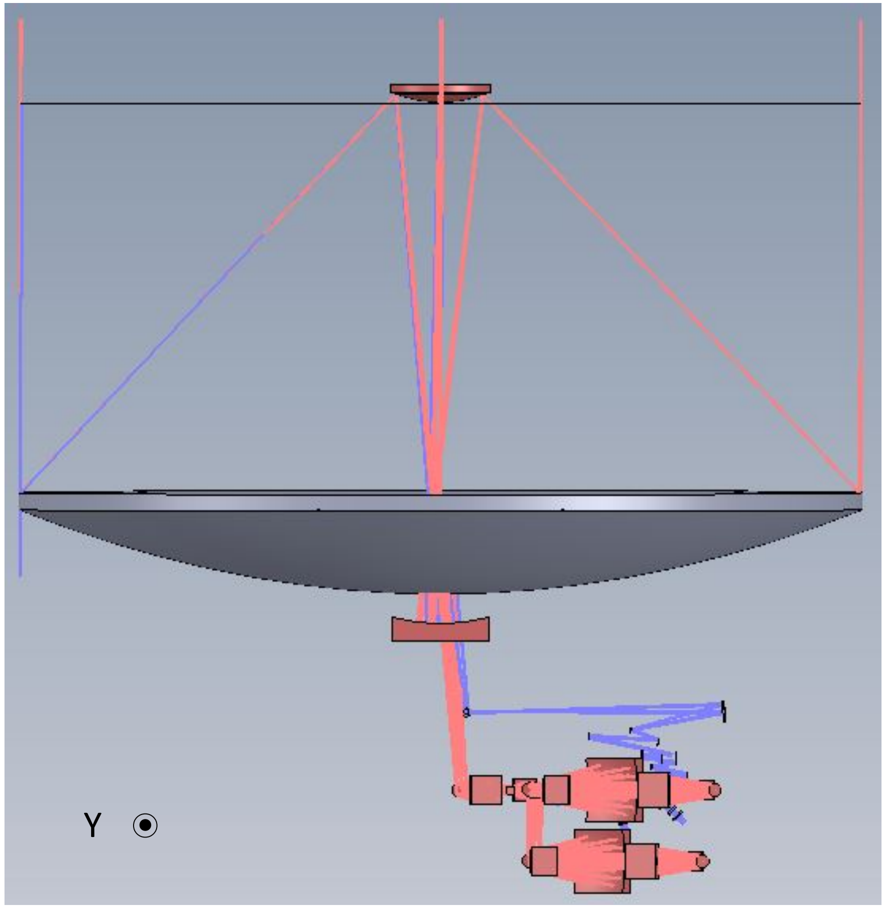
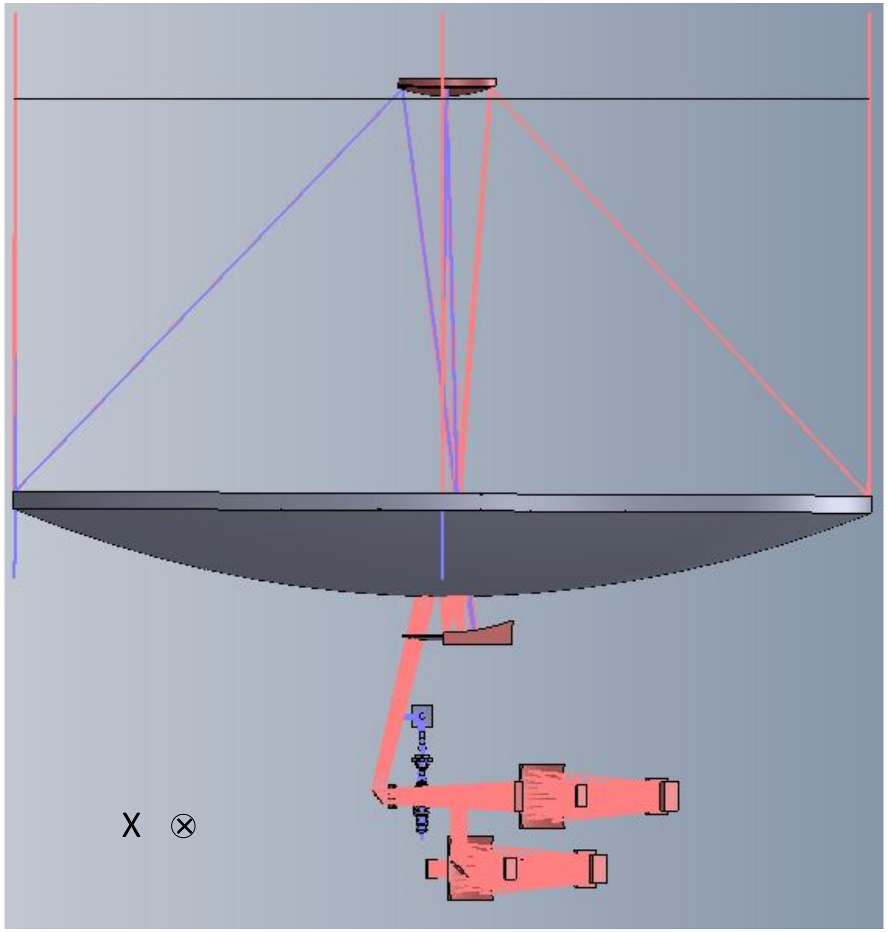




Primary Science Drivers of MISC for Concept 2 OST

Science Objectives	Value of MISC Measurements
(1) Transit spectroscopy of exoplanets	Measurement of biogenic CH_4 7.6μm, CO_2 15μm, O_3 9.6μm, N_2O 17.6μm, and H_2O 17+ μm absorption lines achieving 5ppm (1ppm with a goal) utlra-high sensitivity with R~100 (<15μm) and R~300 (>15μm)
(2) Measurements of mid-infrared lines in Rise of Metals & Black Hole and Feedback programs	Measurement of dust features and [NeII] 12.8μm, [NeIII] 15.6μm, [SIII] 18.7μm, and [SIV]10.5μm lines at z up to ~1 (de-scoped from z~2, lose ability to detect 28 μm H_2 line at any z) with R>300
(3) Engineering objective: provide focal plane pointing and guiding function for observatory by observing star fields	
(4) General objective: Mid-infrared Imaging (not specifically tied to any program but generally agreed that we need it)	

MISC for Concept 2 OST

Configuration:
[1] MISC Wide Field Imager (WFI-S1, WFI-S2, WFI-L)
[2] MISC Transit Spectrometer (TRA)

Detectors:
[1] Si:As (TBD)
Three 2kx2k Detector Arrays [30μm/pix] for WFI-S1, WFI-S2 and WFI-L
[2] super-conducting nano wire detector (TBD)
Twelve 5(spatial) x 140(dispersion) Detector Arrays for TRA

Observing Modes of MISC for OST Concept 2

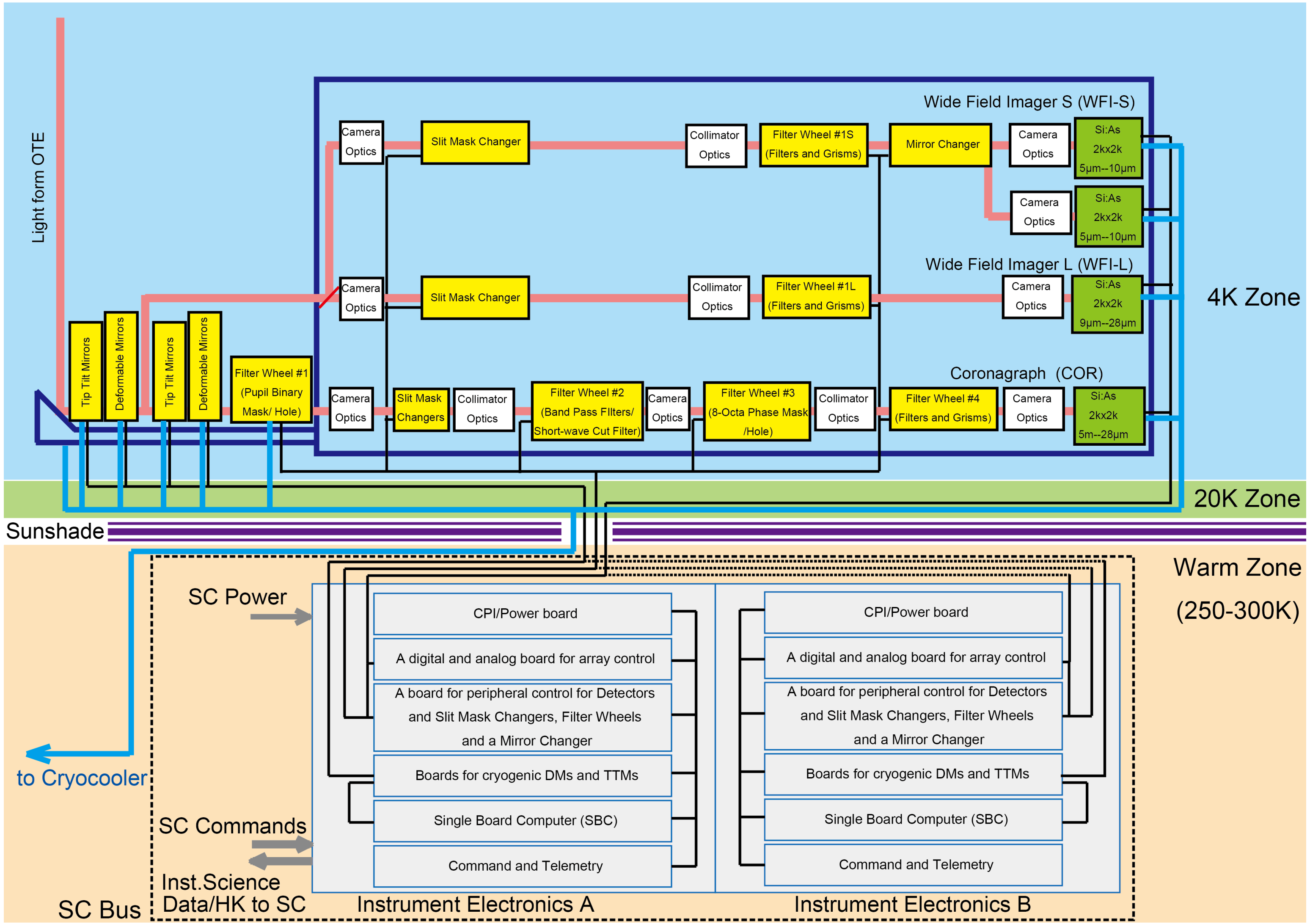
(1) MIR Imaging [WFI-S, WFI-L]
(2) MIR Low-Resolution Spectroscopy (slit) [WFI-S, WFI-L]
(3) MIR Low-Resolution Spectroscopy (slitless) [WFI-S, WFI-L]
(4) MIR Scan [WFI-S, WFI-L]
(5) MIR Ultra Stable Spectroscopy [TRA]

(1) MISC Camera/Imager for OST Concept 2

- Wide Field Imager-Short 1
- Wide Field Imager-Short 2
- Wide Field Imager-Long

Yuji Ikeda (Photocoding); Optical and structural designing of MISC Camera/Coronagraph
Takehiko Wada (ISAS/JAXA); Detector technology, studies on observing mode 'MISC Scan'
Aoi Takahashi (ISAS/JAXA); Deformable mirror
Itsuki Sakon (U Tokyo), Tom Roellig (NASA Ames), Kimberly Ennico (NASA Ames),
MISC Wide Field Imager team

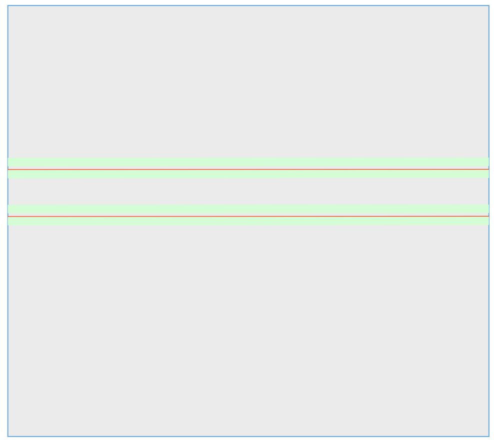
OST/MISC Camera - with coronagraph channel



MISC Scan (1)

The scan speed for MIR scan is estimated based on the scheme adopted for AKARI/IRC All Sky Survey (Ishihara et al. 2008, SPIE, 7010, 70100B)

- using double lines (2 x 1 pix x 2048 pix) for the purpose of mili-sec confirmation
- reading neighboring 4 lines to avoid unstable behavior of the detector
- Concequently 2 x (4+1+4) = 18 lines are read
- 2lines are downlinked and other 16 lines are discarded
- assuming 4 sec for full readout (2048 lines)
- 4 x 18 / 2048 = 35 msec per double lines
- pixel scale; 0.09 arcsec
- Aopting the nyxist rate of twice for the purpose of imaging reconstruction, the scan speed is 0.09 arcsec / 2 / 35msec ~ 1.5 [arcsec/s].



MISC Scan (2)

There is an alternate way of doing scanning with MISC for imaging or slit-less grism spectroscopy, which is to use the tip-tilt mirror in the front of the MISC imager moving in a "freeze-frame". Sawtooth pattern.

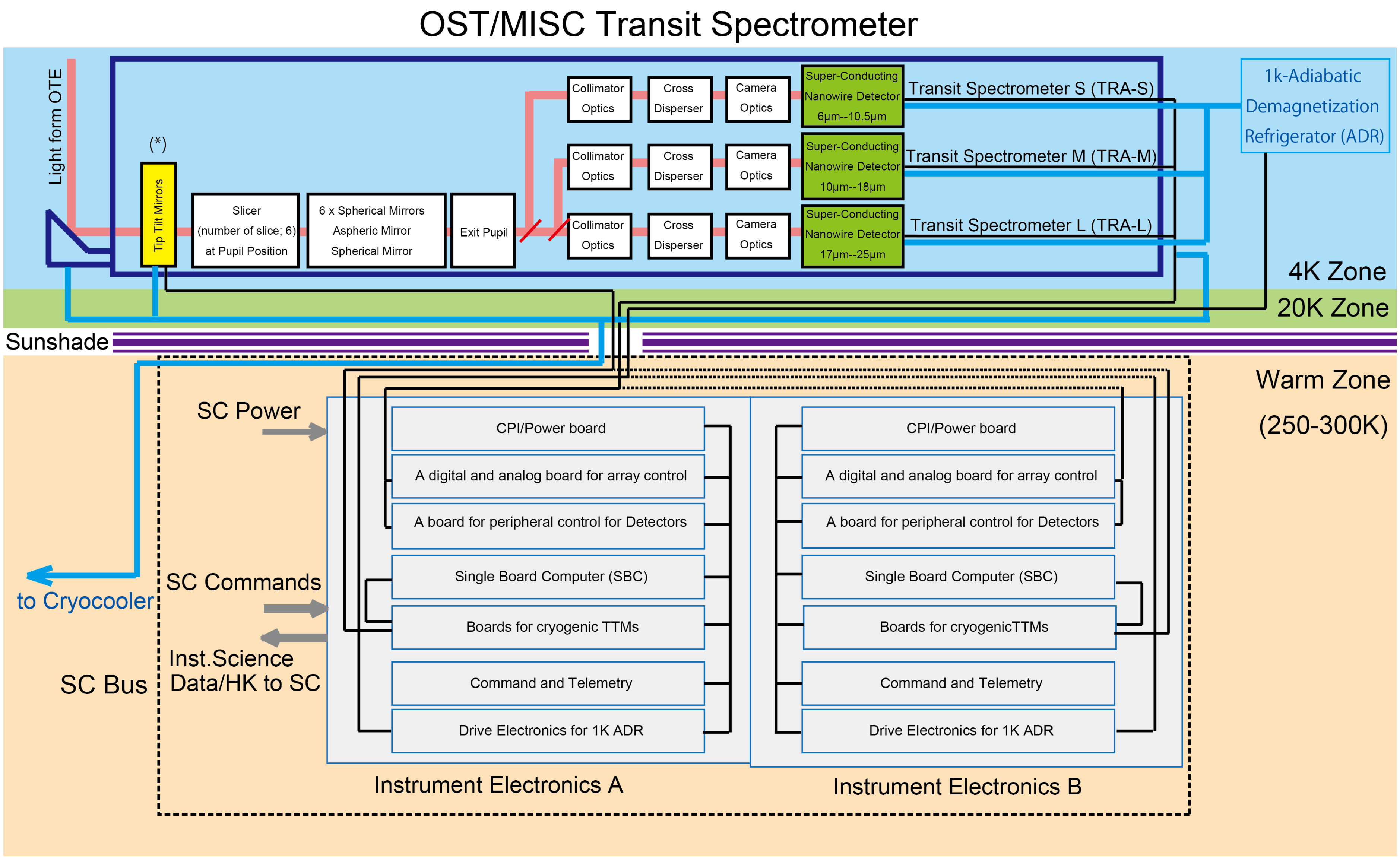
This has the advantage of achieving higher sensitivity, but limits the maximum scan rate.

If we assume that we can read out one of the MISC 2k x 2k arrays at 0.25 Hz, and we further assume that we only can read out a maximum of half the imager FOV (because otherwise we would need to increase the 3' x 3' FOV), then we could handle a maximum scan rate of roughly 22.5 [arcsec/sec].

(2) MISC Transit Spectrometer for OST Concept 2

- Densified Pupil Spectrometer

Taro Matsuo (Osaka University); Studies of densified pupil spectrometer for MISC Concept 2
Tomoyasu Yamamuro (Photocoding); Optical designing of MISC Transit Spectrometer
Itsuki Sakon (U Tokyo), Tom Roellig (NASA Ames), Kimberly Ennico (NASA Ames)
MISC Transit Spectrometer Team


OST/MISC Transit Spectrometer
Light form OTE
(*)
Tip Tilt Mirrors
Slicer (number of slice; 6) at Pupil Position
6 x Spherical Mirrors Aspheric Mirror Spherical Mirror
Exit Pupil
Collimator Optics
Cross Disperser
Camera Optics
Super-Conducting Nanowire Detector 6μm--10.5μm
Transit Spectrometer S (TRA-S)
Super-Conducting Nanowire Detector 10μm--18μm
Transit Spectrometer M (TRA-M)
Super-Conducting Nanowire Detector 17μm--25μm
Transit Spectrometer L (TRA-L)
1k-Adiabatic Demagnetization Refrigerator (ADR)
4K Zone
20K Zone
Sunshade
Warm Zone (250-300K)
SC Power
SC Commands
Inst.Science Data/HK to SC
SC Bus
to Cryocooler
CPI/Power board
A digital and analog board for array control
A board for peripheral control for Detectors
Single Board Computer (SBC)
Boards for cryogenic TTMs
Command and Telemetry
Drive Electronics for 1K ADR
Instrument Electronics A
Boards for cryogenicTTMs
Instrument Electronics B

Policy of optical design for Concept 2

- Transit spectrograph is mainly composed of two parts:

  1. Pupil relay system

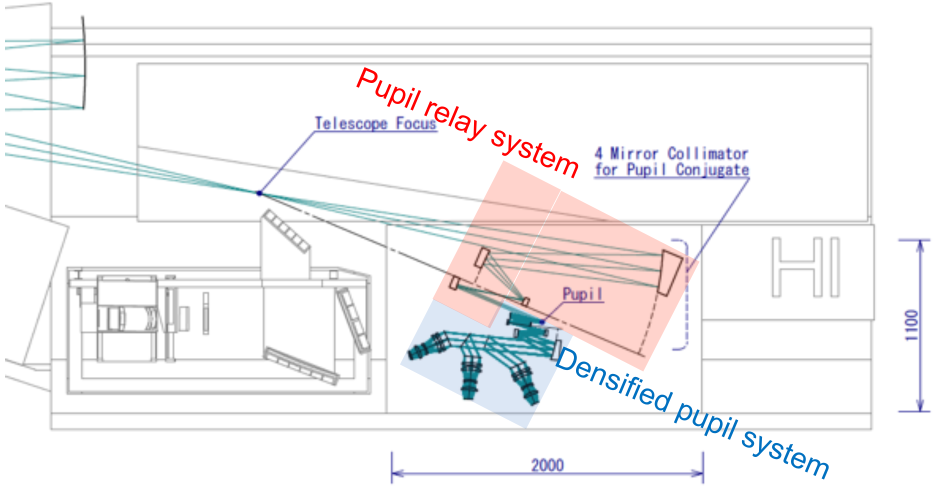
     - Four mirror assembly (FMA) for correction of pupil aberration

  2. Densified pupil spectrograph

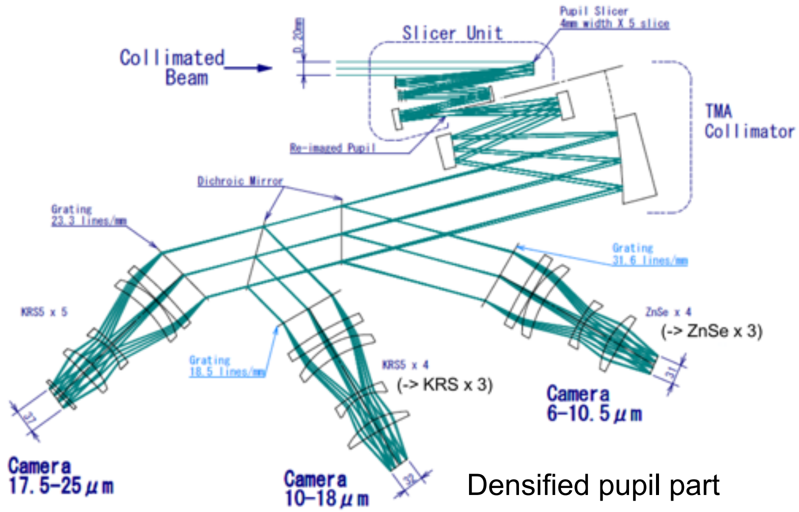
     - pupil division and densification
     - spectrograph

- The performance of the transit spectrograph (# of spectra, spectral resolution, etc) is mainly determined by the parameters of the densified pupil spectrograph.

-> The optical design of the densified pupil spectrograph is kept in MC2

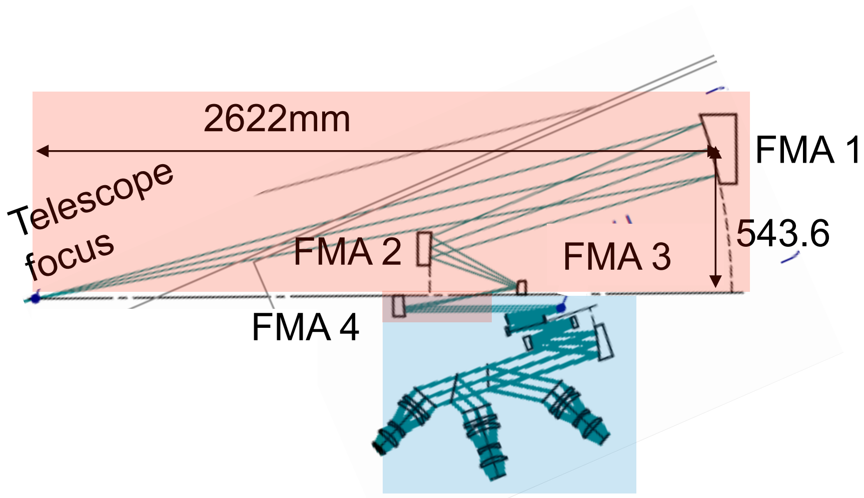


Entire view of transit spectrograph in MC1



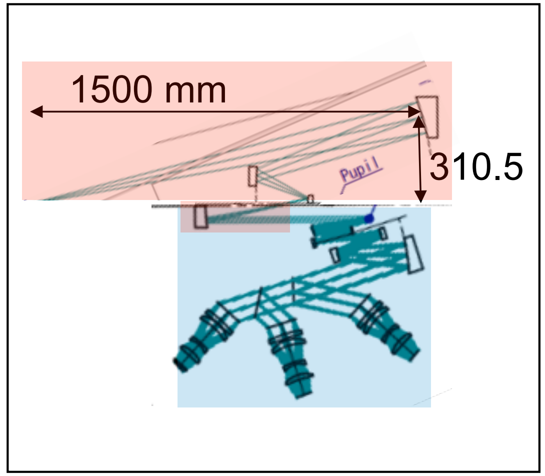
Densified pupil part

Optimization of relay system



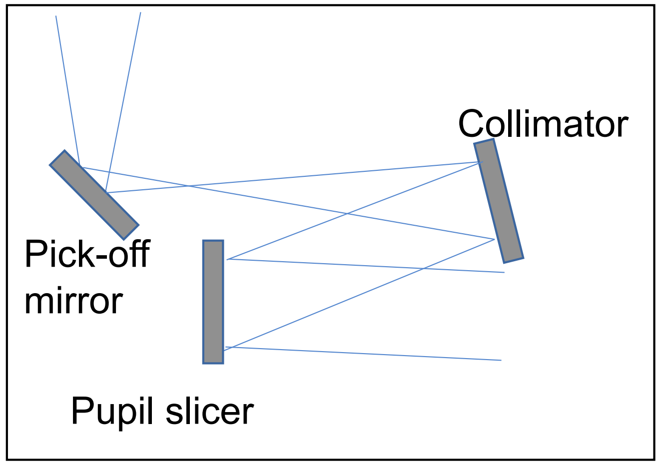
Original FMA (Concept 1)

Optimization of FMA



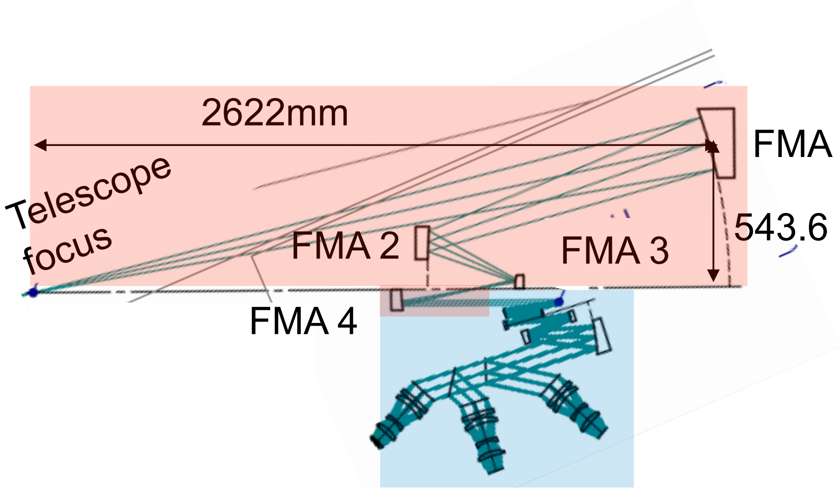
Option 1

Simplification of FMA



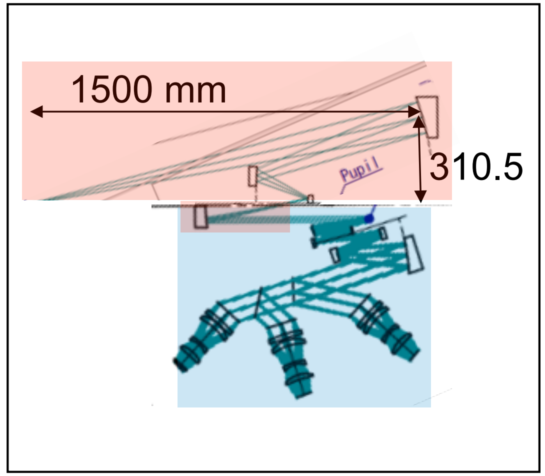
Option 2

Optimization of relay system



Original FMA (Concept 1)

Optimization of FMA



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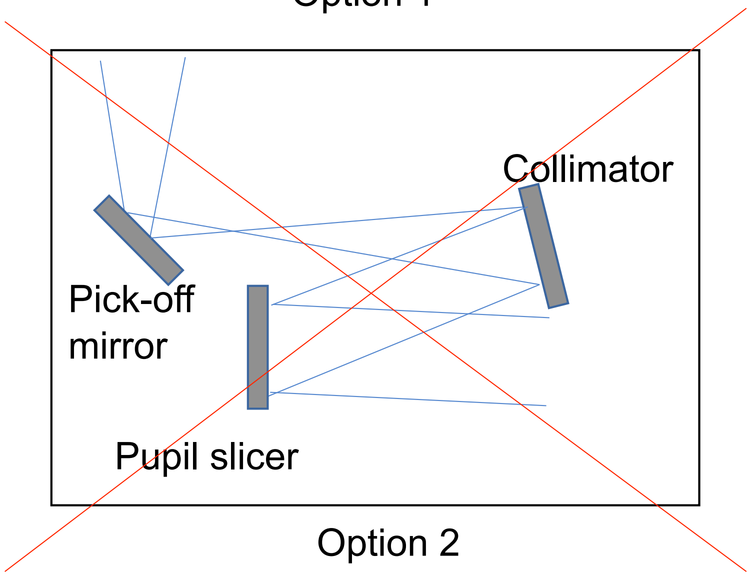
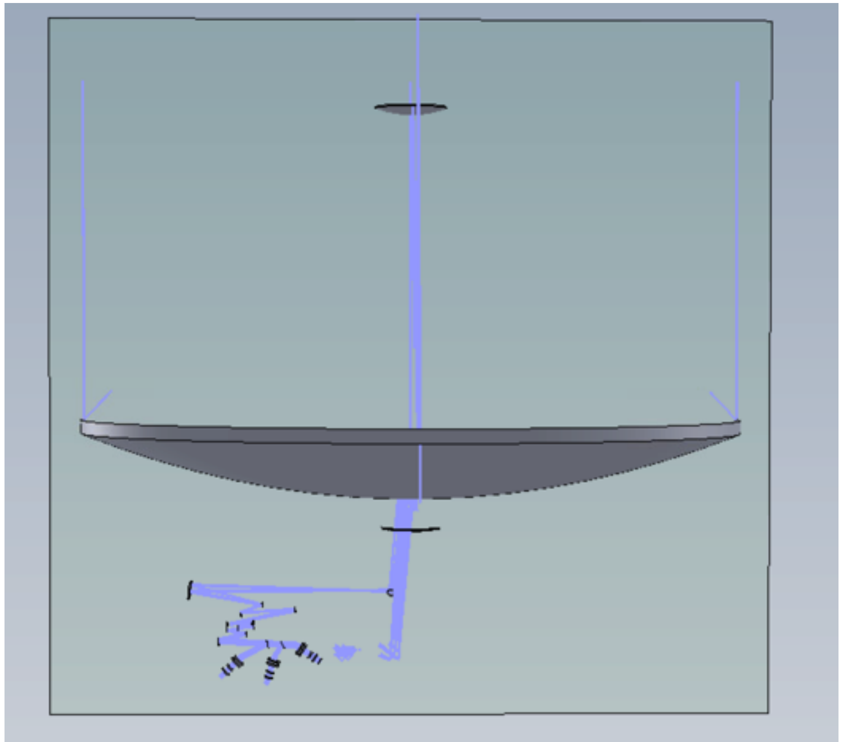
Simplification of FMA



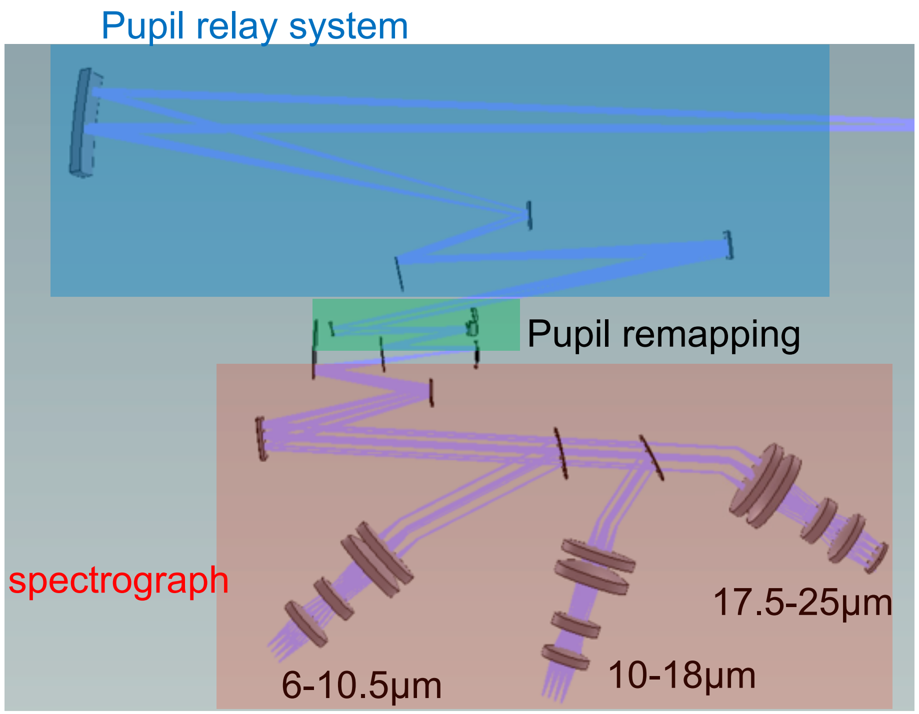
Option 2

The optical quality for one collimator (pupil aberration and PSF) is not sufficient for transit spectrograph.
-> We selected to optimize FMA.

Optical design for Concept 2



Entire view of optical design for MC2



Enlarged view of transit spectrograph

Cold Mass Estimate for Concept 2 MISC Transit Spectrometer (TRA)

Part No.	Part Name	Material	Quantity	Total mass (kg) Material; Al (Concept 1)	Total mass (kg) Material; Al (Concept 2)	Total mass (kg) Material; Be (Concept 2)	Total mass (kg) Material; CO720 (Concept 2)
1	Body	A6061-T6/Be/CO720	1	56.00	52.00	13.00	21.67
2	Plane Mirror 1	A6061-T6/Be/CO720	1	4.70	2.00	0.40	0.67
3	Plane Mirror 2	A6061-T6/Be/CO720	1	4.70	2.00	0.40	0.67
4	Collimator 1	A6061-T6/Be/CO720	1	13.80	6.00	1.20	2.00
5	Collimator 2	A6061-T6/Be/CO720	1	1.70	1.00	0.20	0.33
6	Collimator 3	A6061-T6/Be/CO720	1	0.60	0.50	0.10	0.16
7	Collimator 4	A6061-T6/Be/CO720	1	0.60	0.50	0.10	0.16
8	Pupil Slicer	A6061-T6/Be/CO720	1	2.00	2.00	0.40	2.00
9	TMA 1	A6061-T6/Be/CO720	1	0.60	0.60	0.12	0.20
10	TMA 2	A6061-T6/Be/CO720	1	0.60	0.60	0.12	0.20
11	TMA 3	A6061-T6/Be/CO720	1	1.90	1.90	0.38	0.63
12	Dichloic Beam Splitter 1	CdTe	1	1.00	1.00	1.00	1.00
13	Dichroic Beam Splitter 2	CdTe/Si	1	1.00	1.00	1.00	1.00
14	Grisms	Other	3	3.00	3.00	3.00	3.00
15	Camera Lens (Short)	KRS-5	1	6.00	6.00	6.00	6.00
16	Camera Lens (Middle)	ZnSe	1	7.20	7.20	7.20	7.20
17	Camera Lens (Long)	ZnSe	1	7.20	7.20	7.20	7.20
18	Detector	A6061-T6	3	4.50	4.50	4.50	4.50
19	Light Shield	CFRP	1	3.10	3.10	3.10	3.10
			Total	120.20	102.10	49.42	61.69

Fact Sheet of MISC for Concept 2 OST

Parameter	MISC Imager	MISC Transit Spectrometer
Operating modes	MIR Imaging MIR Low-Resolution Spectroscopy (slit) MIR Low-Resolution spectroscopy (slitless) MIR Scan	MIR Ultra Stable Spectrpscopy
Sensitivity (5σ, 1 hr)	1h5σ continuum sensitivity for a point source - MIR Imaging (R=5): 0.06 μJy @5.0 μm 0.25 μJy @9.0 μm 0.64 μJy @16.0 μm 0.96 μJy @23.0 μm 1.93 μJy @27.6 μm 1h5σ line sensitivity for a point source - MIR Low-resolution Spectroscopy (Slit, 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 5.2E-21 W/m2 @18μm 5.4E-21 W/m2 @24μm 1.1E-20 W/m2 @26μm 5.4E-19 W/m2 @28μm	Sensitivity is not as important as a few ppm stability

Fact Sheet of MISC for Concept 2 OST

Parameter	MISC Imager	MISC Transit Spectrometer
Resolving power	R=5-10 for MIR Imaging R=300 For MIR Low-Resolution Spectroscopy	R=100 in 6-17 μm R=300 in 17-25 μm
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 range	5 - 28 μm	6 - 25 μm
Field of View (instantaneous)	3 x 3 arcmin	N/A

Fact Sheet of MISC for Concept 2 OST

Parameter	MISC Imager	MISC Transit Spectrometer
Saturation limit	Saturation limit for a point source - MIR Imaging (R=5): 100 mJy @ 5μm 200 mJy @ 10μm 500 mJy @ 20μm 1Jy @25μm - MIR Low-Resolution Spectroscopy (R=300): 4 Jy @ 5μm 8 Jy @ 10μm 20 Jy @ 20μm 50 Jy @25μm	N/A
Scanning speed (survey mode)	MIR Scan (width; 180 arcsec) Maximum 1.5 [arcsec/sec] -- 22.5 [arcsec/sec]	N/A
Detectors	three 2kx2k Si:As arrays - two for WFI-S - one for WFI-L	tweleve super-conducting nanowire detector arrays (a single array size; 5pix x 140 pix) - four 5 pix x 140 pix arrays for TRA-S - four 5 pix x 140 pix arrays for TRA-M - four 5 pix x 140 pix arrays for TRA-L
Detector NEP	N/A	N/A
Detector cold readout	MUX	MUX (TBD)
Photometric stability	N/A	5 ppm with a goal of 1 ppm on a timescale of hours to days