Origins Space Telescope (OST) MISC Instrument Presentation

Science and Technology Team Definition Team (STDT)

Face-to Face Meeting

March 21 – 22, 2017

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OST MISC Instrument team

ORIGINS Space Telescope

Mid-infrared Imager, Spectrometer, Coronagraph (MISC) Instrument Team Members

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MISC Instrument Team Members

List of MISC Instrument Team Members and Contact information (e-mail is suggested)

MISC Instrument Team Member, Role	Name/ Affiliation	E-mail Address
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Instrument Science Goals and Objectives

- Provide Mid-Infrared (6-38 μm) Capabilities to Address the Following Science Goals:
  - Transit spectroscopy of exoplanets to look for biogenic compounds (#14)
  - The rise of metals (#19)
  - Water content of Planet Forming Disks (#9)
  - The first dust (#27)
  - Connection between black hole growth and star formation over cosmic time (#21)
  - Birth of galaxies during cosmic dark ages (#26)
  - Galaxy feedback from SNe and AGN to Z~3 (#18)
  - Galaxy feedback mechanisms at z<1(#5)
  - Jupiter/Saturn Analogues (#16)

Instrument Science Requirements

- Science Observable and Measurement Requirement

  - Ten of the top fourteen science cases (#5, 9, 14, 15, 18, 19, 21, 22, 26, 27), for OST, plus the goal to provide a coronagraph to enable science case #16, require an instrument that covers < 40um. Of these cases, they can fall into a need for an imager (#14, 17), spectrometer R~few hundred (#14,16, 19, 21, 22, 26), spectrometer R~few thousand (#18) to R~few ten's thousand (#5, 9, 15) and transit spectrometer (#14).

  - Most of the science targets are point sources, with three cases (#19, 21, 22) in need of an instrument to map large areas of sky.

  - Science case #9 (Water content of planet-forming disks) and #15 (Direct detection of protoplanetary disk mass) requested R>25,000 for 25-200um.

  - Science case #5 (Galaxy feedback mechanisms at z<1) requested R=10,000 for 10-500um.

MIR Coronagraphy; 10^{-7}--10^{-8} contrast at 0.5" (~$2\lambda/D$ at 10µm)

Transit observations; stability better than 10 PPM on timescale of hours to days

Instrument Science Requirements

	Science Case	Mid-Infrared Imaging and Spectroscopy Channel	PIAACMC Coronagraph Channel (COR)	Transit Spectroscopy Channel (TRA)
#14	•Transit spectroscopy of exoplanets to look for biogenic compounds			X
#19	•The rise of metals	X		
#9	•Water content of Planet Forming Disks	X		
#27	•The first dust	X		
#21	•Connection between black hole growth and star formation over cosmic time	X		
#26	•Birth of galaxies during cosmic dark ages	X		
#18	•Galaxy feedback from SNe and AGN to Z~3	X		
#5	•Galaxy feedback mechanisms at z<1	X		
#6	•Jupiter/Saturn Analogues		X	

OST MISC Instrument Requirements

Technical Parameter	Technical Requirement
Wavelength Range (microns)	6um-38um
Detector Bandwidth	Si:As : 6-16.3µm, Si:Sb: 15.4-38µm
Angular Resolution	<0.25" at 10µm
Spectral Resolving Power	3-300 (6-38um), >1000 (20-38um), 10000-20000 (10-38um)
Spectral Line Sensitivity (5σ, 1 hr)	2×10^{-22} W/m-2
Continuum Point Source Sensitivity	1µJy (@6um, R=100) 10µJy (@30um, R=100)
Spectrometer Relative Calibration Accuracy	3%, but 10 ppm λ<10 µm, 50 ppm for λ>10µm for transits
Field of Regard (see note above)	4 pi
Field of View	Not set by science
Mapping Speed	Not set by science
Calibration / Gain stability [%]	1%

Technical Parameter	Technical Requirement
Photometric Accuracy −if available	N/A
Transit Monitoring Cadence	One measurement/10 minutes
Moving Target Tracking	Yes, up to 1"/second
Sensitivity to High Dynamic Range Targets	N/A for MISC science
Polarization Capabilities	No
Broadband, Wide-area Mapping	Yes, if 10 sq. deg is wide angle
Surface Brightness Sensitivity	N/A
Instantaneous Field of View	Not set by science
Coronagraphic Contrast	1e-7 at 0.5" at 10µm
Other	

Mid-Infrared Imager, Spectrometer and Coronagraph (MISC)

(1) Mid-Infrared Imaging and Spectroscopy Channel
- Wide Field Imager (WFI-S; 6-16um, WFI-L; 15-38um, R=3-10, R=100-300)
- Medium Resolution Spectrometer (MRS-S; 17-26um, MRS-L; 25-38um, R>1000)
- High Resolution Spectrometer (HRS-S; 12-18um, HRS-L; 25-38um)

Detectors; 3 1kx1k Si:As and 3 1kx1k Si:Sb

Mechanisms; 2 wave front correction systems (DM + TTM), 6 Filter Wheels

Others; IFU for MIR-S and MIR-L, sharing the same FOV,
WFI can be used as the slit viewer when doing spectroscopy

(2) PIAACMC Coronagraph Channel (COR)
- PIAACMC Coronagraph (COR-S; 6-16um, COR-L; 15-38um, R=3-10, R=100-300)

Detectors; 1 Si:As and 1 Si:Sb

Mechanisms; Deformable Mirror + Tip-tilt Mirror, 3 Filter Wheels

(3) Transit Spectroscopy Channel (TRA)
- densified pupil spectrometer (TRA-S; 6-16um, TRA-L; 15-38um, R~100 TBD)

Detectors; 1 Si:As and 1 Si:Sb

OST Instrument Optical Inputs Summary

(Detailed; OST/MISC Case A)

1	Name	Mid-IR Imager Spectrometer			Transit Spec.	Coronagraph (PIAACMC)
		Imager/Low-Res Spec.	Medium-Res Spec.	High-Res Spec.		
2	Optical Design Form	relay/grism	crossed echelle grating	immersion grating		
3	Bandpass (um)	6-38 (*1)	17-38 (*1)	12-18, 25-38 (*1)	6-38	6-38 (*1)
4	Design Wavelength (um)		20 (*2)		N/A	20 (*2)
5	Spectral Resolution	300 (*3)	1000 (*4)	20,000-30,000 (*5)	100	300 (*3)
6	Telescope Aperture (m)	>9	>9	>9	>9	>9
7	Telescope Shape	N/A	N/A	N/A	N/A	circular aperture without obstruction by a secondary mirror nor support structures
8	sensitivity or PSF shape	N/A	N/A	N/A	N/A	PSF shape
9	Telescope F/#	N/A	N/A	N/A	N/A	N/A
10	On vs Off-axis pupil	N/A	N/A	N/A	N/A	Off-axis primary aperture is preferred
11	Full FOV	1.5 arcmin x 1.5 arcmin (*6) 3 arcmin x 3 arcmin (*7)	6 arcsec x 7.5 arcsec (*8)	1.0-2.0 arcsec length		
12	Pixel Sampling	Airy FWHM pans >2 pixels (*9)	Airy FWHM pans >2 pixels (*10)	Airy FWHM pans >2 pixels (*11)		Airy FWHM spans >4 pixels (*12)
13	Detector?	1kx1k Si:As(30μm/pix) 1kx1k Si:Sb(18μm/pix)	1kx1k Si:As(30μm/pix) 1kx1k Si:Sb(18μm/pix)	1kx1k Si:As(30μm/pix) 1kx1k Si:Sb(18μm/pix)	1kx1k Si:As(30μm/pix) 1kx1k Si:Sb(18μm/pix)	1kx1k Si:As (30μm/pix) 1kx1k Si:Sb (18μm/pix)
14	Scanning?	N/A	N/A	N/A	N/A	N/A
15	Image quality		diffraction limited at 20μm		N/A	Diffraction limited at 20μm
16	Sensitivity	yes	yes	yes	yes	yes
17	Stability	22 mas during pointing aided by internal TTM (*13)	36 mas during pointing aided by internal TTM (*14)	36mas during pointing aided by internal TTM (*15)	N/A	22 mas during pointing aided by internal TTM (*16) (*17)
18	Mechanisms?	DM, TTM, Filter Wheels	DM, TTM	DM, TTM, Filter Wheel	none	DM, TTM, Filter Wheels
19	Interface					
20	Special Consideration					
21	Detector driven beam steering?					
22	Anything Else?					

MISC plans to have Internal wave front correction System (DM + TTM)

- 8-OPM Coronagraph (case B) may request 4mas pointing stability
- PIAACMC Coronagraph (case A) requests 22mas pointing stability aided by internal TTM

OST Instrument Optical Inputs Summary
(notes)

(*1) The maximum value of 38μm is constrained by the longest wavelength covered by the Si:Sb detector.

(*2) The value is provided from the technical reason. The instrument requires the wavelength coverage down to 6μm (both for normal imager/spectrometer and coronagraph). Current MEMES-DM technology will be able to correct for the wave front error caused by the primary mirror with the diffraction-limited performance at <20 micron. Further study is needed to examine whether we can employ other DM technology that is able to ease this constraint.

(*3) The base line is R=300 with two grisms in a filter wheel. A R=1000 variant is possible with more grisms in a filter wheel.

(*4) The available detector array size invokes a trade-off between the resolution power and the IFU FOV size.

(*5) Immersion grating for 12-18μm is technically feasible using a heritage of SPICA. A feasiblity study of immersion grating for 25-38μm is needed.

(*6) The imaging FOV size for 6-16μm. The value is constrained by the size of the Si:As array, i.e., 1024 x 1024.

(*7) The imaging FOV size for 15-38μm. The value is constrained by the size of the Si:Sb array, i.e., 1024 x 1024.

(*8) The IFU FOV size. (4 arcsec length x 0.55 arcsec width x 9 slices for 17-26μm, 4 arcsec length x 0.7 arcsec width x 7 slices for 26-38μm)

(*9) 0.1 arcsec/pix for 6-16μm and 0.2 arcsec/pix for 15-38μm. The airy FWHM at 7μm (0.2 arcsec) and at 14μm (0.4 arcsec) spans 2pixels

(*10) 0.22 arcsec/pix for 17-26μm and 0.34 arcsec/pix for 25-38μm. The airy FWHM at 16μm (0.45 arcsec) and at 24μm (0.67 arcsec) spans 2pixels

(*11) 0.17 arcsec/pix for 12-18μm and 0.34 arcsec/pix for 25-38μm. The airy FWHM at 12μm (0.34 arcsec) and at 24μm (0.67 arcsec) spans 2pixels

(*12) 0.05 arcsec/pix for 7-16μm and 0.1 arcsec/pix for 15-38μm. The airy FWHM at 7μm (0.2 arcsec) and at 14μm (0.4 arcsec) spans 4pixels

(*13) The smallest slit width is 0.26 arcsec. The 3 sigma pointing stability per pointing is set to match with the 1/4 of the slit width. The 3 sigma pointing accuracy is set to match with the 1/2 of the slit width.

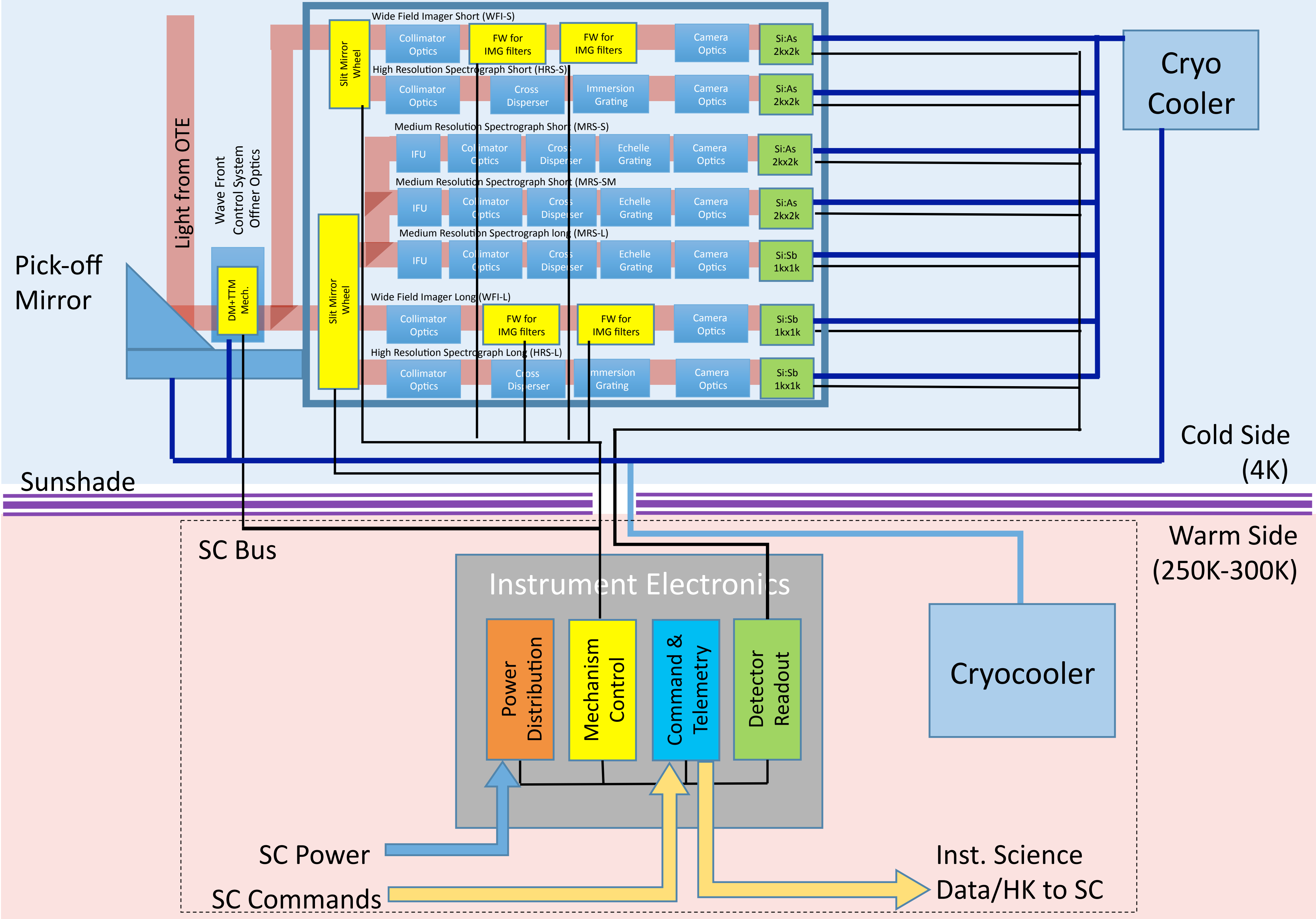
(*14) The smallest slit width is 0.80 arcsec. The 3 sigma pointing stability per pointing is set to match with the 1/4 of the slit width. No severe requirement on the poining accuracy because of the IFU.

(*15) The smallest slit width is 0.43 arcsec. The 3 sigma pointing stability per pointing is set to match with the 1/4 of the slit width. The 3 sigma pointing accuracy is set to match with the 1/2 of the slit width.

(*16) The smallest slit width is 0.26 arcsec. The 3 sigma pointing stability per pointing is set to match with the 1/4 of the slit width. The 3 sigma pointing accuracy is set to match with the 1/2 of the slit width.

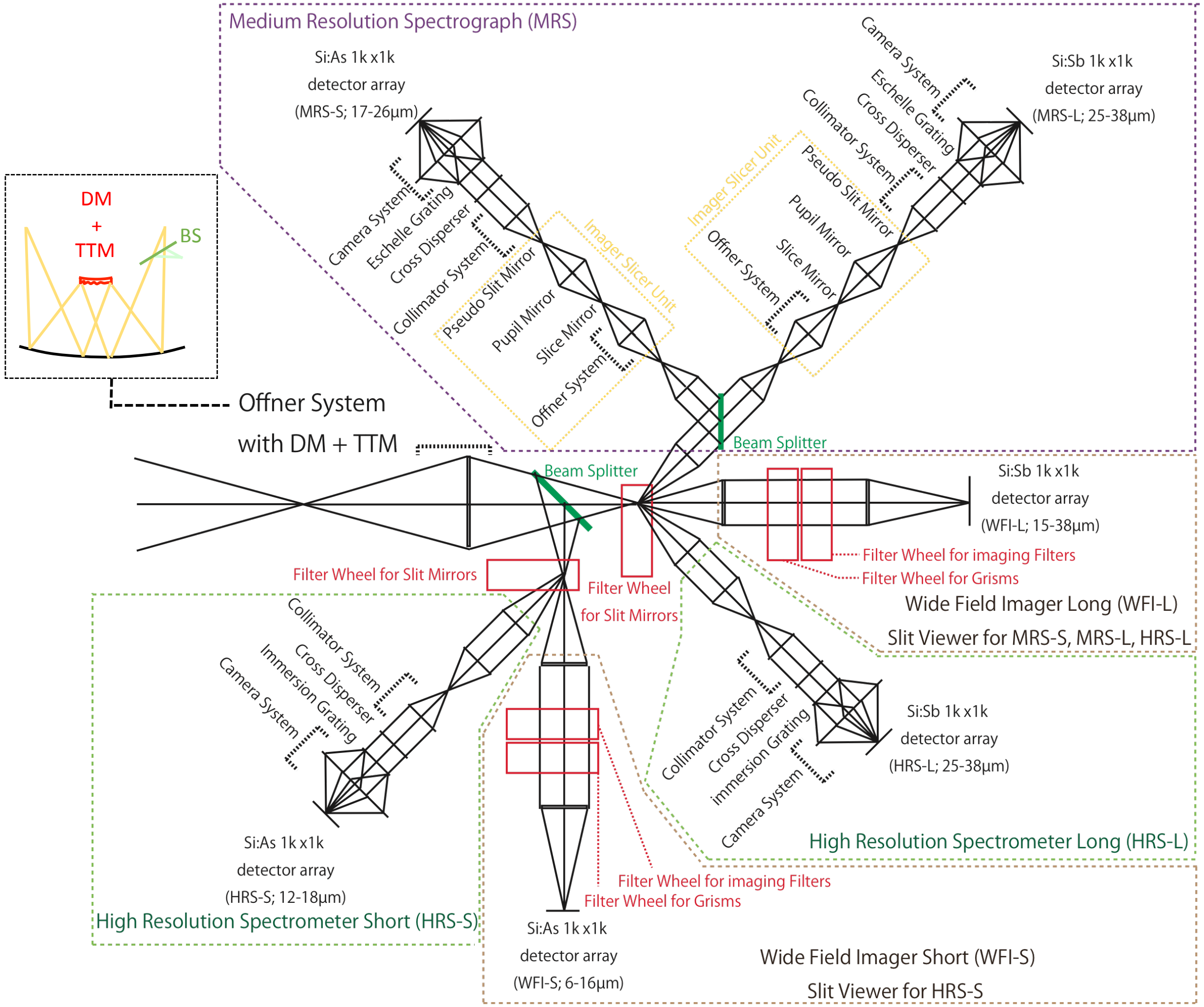
(*17) If the 8-Octa Phase Mask (8-OPM) Coronagraph is employed, the pointing stability of 3mas during an integration time is requested. If we aim to achieve 10-7 contrast, a jitter corresponding to <0.02 λ/D is allowed. Assuming λ/D=7um/9m~200mas, 0.02 λ/D becomes 4mas.

(A-2) MISC/MIR Imager and Spectrometer Channel Instrument Block Diagram



MISC Instrument Diagram or sketch
(MIR Imager and Spectrometer Channel)

Mid-Infrared Imager and Spectromter Channel



Cold side electronics portion

	volume [m3]	mass[kg]
WFI-S *	0.4 x 1.0 x 0.4	2.8 (optics) + 3.8 (FW)
WFI-L *	0.4 x 1.0 x 0.4	2.8 (optics) + 3.8 (FW)
MRS-S *	0.3 x 0.8 x 0.2	2.2(optics)
MRS-L *	0.3 x 0.8 x 0.2	2.2(optics)
HRS-S *	0.2 x 1.0 x 0.15	2.2(optics)
HRS-L *	0.2 x 1.0 x 0.15	2.2(optics)
WFC (DM+TTM) system (FOV 2'x2')	0.5 x 0.3 x 0.15	1.5 (offner optics, DM + TTM)
Alignment Panel *	(area: 1.7m^2)	11.1
Cover *	---	6.0

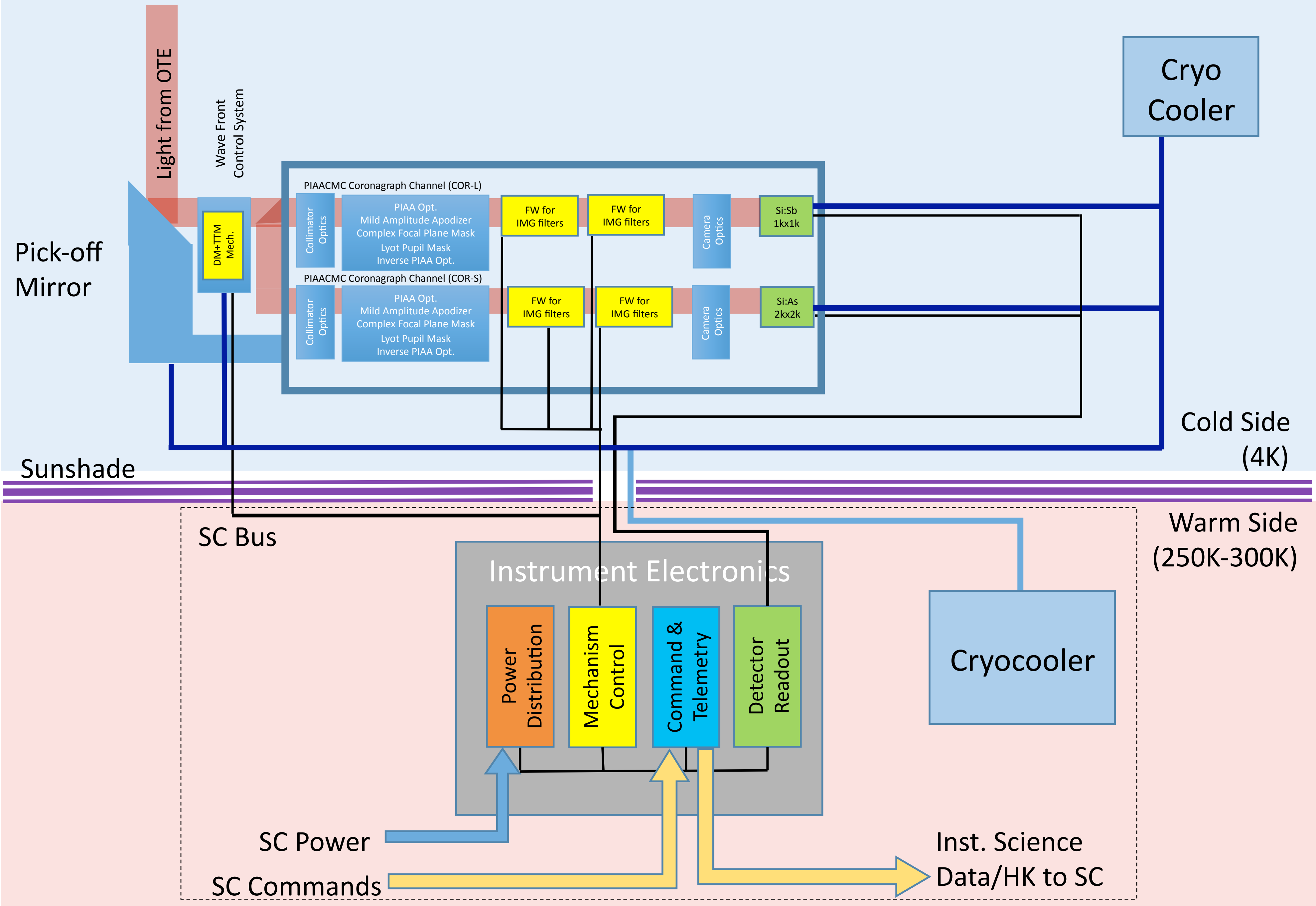
*Estimated from the results of SPICA/MSC study (MIRACLE, MIRMES and MIRHES; SPICA Focal Plane Instrument proposal). Values with higher accuracy will be obtained by June 2017 based on the results of optical designing and the design of optical mounting structures.

Warm side electronics portion

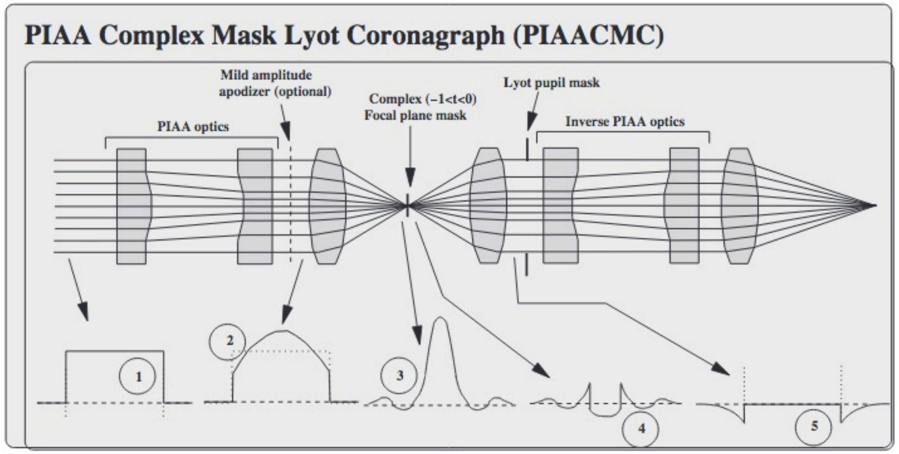
	volume [m3]	mass[kg]	power
WFI elec. *	0.4 x 0.3 x 0.15	6	9W
MRS elec.*	0.4 x 0.3 x 0.15	6	9W
HRS elec. *	0.4 x 0.3 x 0.15	6	9W
WFC elec.**	0.4x 0.3 x 0.10	4	60W(TTM) + 40W(DM)

*Estimated from the results of AKARI/IRC-E (operating 3 detectors and 3FW) with 4 boards includingCPI/Power board, a digital and analog board for array control, and a board for peripheral contrail (3 detectors + 3 FW). Each board has a size of 40cmx30cmx5cm, a mass of 2kg and a power of 3W.
In the case of AKARI/IRC-E, the mass was 8kg and the total power was 12W.
**Information of the WFC elec. Is estimated from the results of SPICA/SCI study.
For standby mode, 16W (TTM) +10W(DM; TBD) are needed

(A-1) MISC/PIAACMC Coronagraph Channel Instrument Block Diagram



MISC Instrument Diagram or sketch
(MIR PIAACMC Coronagraph Channel)



Inner Working Angle (IWA) (based on Guyon et al. 2014)
Obscured Circular Segmented pupils (GMT type);
- 0.72λ/D (aggressive design)
- 0.92λ/D (more conservative design)

Obscured Circular Highly Segmented pupils (E-ELT type)
- 0.8λ/D (aggressive design)
- 1.0λ/D (more conservative design)

→ 0.75 – 0.95 λ/D for the IWA of OST/MISC
(for D=9m, λ=9μm, IWA is 0.15-0.20 arcsec)

Contrast at the IWA (based on Guyon et al. 2014)
Average contrast in 0.88-3.6 λ/D
→ 7.07×10^{-6} for 10% band, 1.16×10^{-6} for 4% band (@1.65um)

Cold side electronics portion

	volume [m3]	mass[kg]
COR-S *	0.4 x 1.0 x 0.4	2.8 (optics) + 3.8(FW)
COR-L *	0.4 x 1.0 x 0.4	2.8 (optics) + 3.8 (FW)
WFC (DM+TTM) system (FOV 1'x1')	0.5 x 0.3 x 0.15	1.5 (offner optics, DM + TTM)
Alignment Panel *	(area: 0.95m^2)	6.1
Cover *	---	3.5

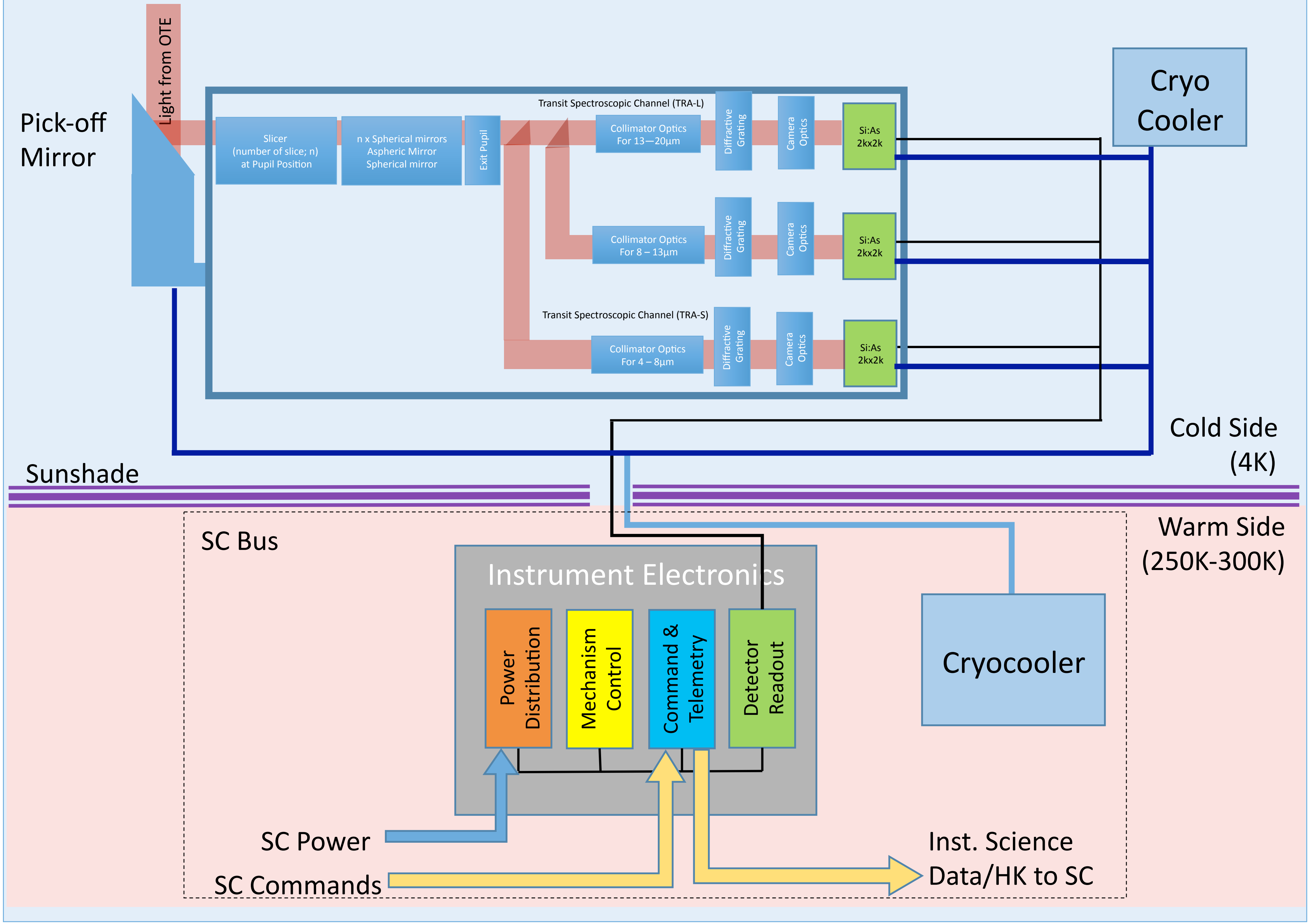
*Estimated from the results of SPICA/MSC study (MIRACLE, MIRMES and MIRHES; SPICA Focal Plane Instrument proposal). Values with higher accuracy will be obtained by June 2017 based on the results of optical designing and the design of optical mounting structures.

Warm side electronics portion

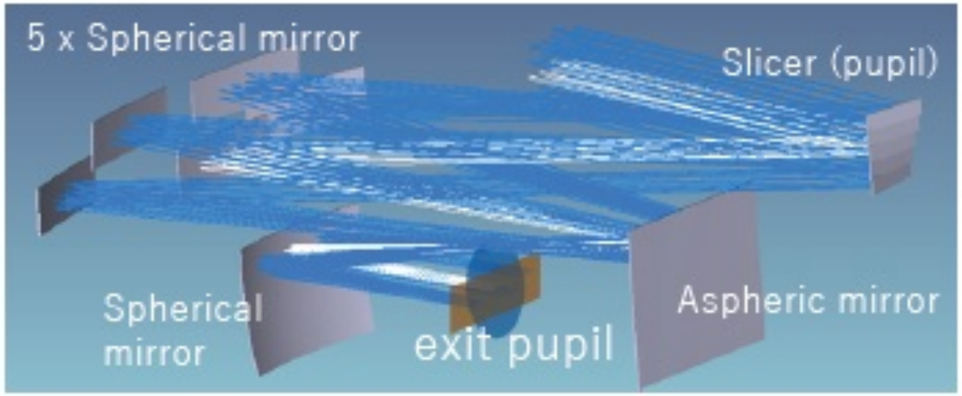
	volume [m3]	mass[kg]	power
COR elec. *	0.4 x 0.3 x 0.15	6	9W
WFC elec.**	0.4x 0.3 x 0.10	4	60W(TTM) + 40W(DM)

*Estimated from the results of AKARI/IRC-E (operating 3 detectors and 3FW) with 4 boards includingCPI/Power board, a digital and analog board for array control, and a board for peripheral contrail (3 detectors + 3 FW). Each board has a size of 40cmx30cmx5cm, a mass of 2kg and a power of 3W.
In the case of AKARI/IRC-E, the mass was 8kg and the total power was 12W.
**Information of the WFC elec. Is estimated from the results of SPICA/SCI study. For standby mode, 16W (TTM) +10W(DM; TBD) are needed

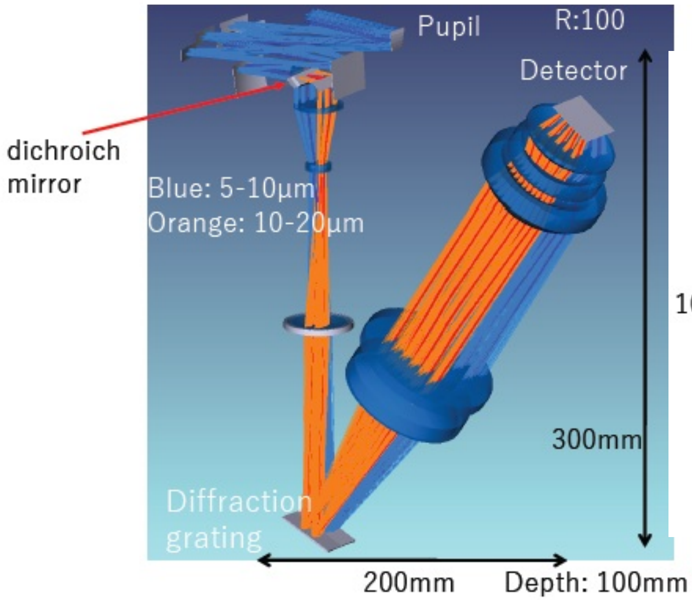
(A-3) MISC/Transit Spectroscopic Channel Instrument Block Diagram

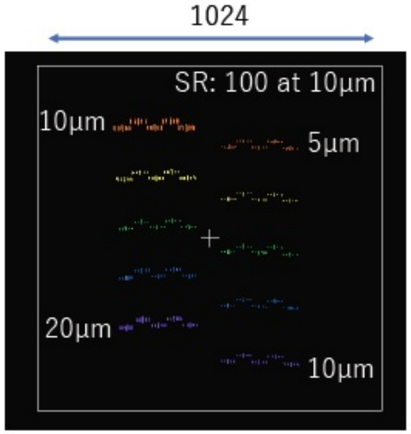


MISC Instrument Diagram or sketch
(Transit Spectroscopic Channel)



division and densification part





foot print on detector plane

Cold side electronics portion

	volume [m3]	mass[kg]
TRA-S *	0.3 x 0.4 x 0.1	2.2 (optics)
TRA-L *	0.3 x 0.4 x 0.1	2.2 (optics)
Alignment Panel *	(area: 0.24m^2)	1.6
Cover *	---	1.0

*Estimated from the results of SPICA/MSC study (MIRACLE, MIRMES and MIRHES; SPICA Focal Plane Instrument proposal). Values with higher accuracy will be obtained by June 2017 based on the results of optical designing and the design of optical mounting structures.

Warm side electronics portion

	volume [m3]	mass[kg]	power
TRA elec. *	0.4 x 0.3 x 0.10	4	6W

*Estimated from the results of AKARI/IRC-E (operating 3 detectors and 3FW) with 4 boards includingCPI/Power board, a digital and analog board for array control, and a board for peripheral contrail (3 detectors + 3 FW). Each board has a size of 40cmx30cmx5cm, a mass of 2kg and a power of 3W.
In the case of AKARI/IRC-E, the mass was 8kg and the total power was 12W.

Expected performance achieved by densified pupil spectrometer; ~ a few 10^{-6}

Systematic noise	Value
Movement of PSF on detector intra- and inter-pixel sensitivity variation by pointing jitter	4×10^{-7}
Movement of PSF on Field stop by pointing jitter	1×10^{-6}
Change of PSF width on detector intra- and inter-pixel sensitivity variation by deformation of primary mirror	5×10^{-7}
Fluctuation of detector gain	??

ORIGINS Space Telescope

Instrument Specifications, Accommodation and Interface Requirements (1)

Mid-Infrared Imager and Spectrometer Channel

Cold side portion

MIR Imager and Spectrometer	Dimensions (m3)	Mass (kg)
WFI-S	0.4 x 1.0 x 0.4	2.8(optics) + 3.8 (FWs)
WFI-L	0.4 x 1.0 x 0.4	2.8(optics) + 3.8 (FWs)
MRS-S	0.3 x 0.8 x 0.2	2.2(optics)
MRS-L	0.3 x 0.8 x 0.2	2.2(optics)
HRS-S	0.2 x 1.0 x 0.15	2.2(optics)
HRS-L	0.2 x 1.0 x 0.15	2.2(optics)
WFC(DM+TTM)	0.5 x 0.3 x 0.15	1.5
Alignment Panel	-	11.1
Cover	-	6.0
total		**40.6 kg**

Warm electronics portion

MIR Imager and Spectrometer	Dimension [m3]	Mass (kg)	Power (W)
WFI-Electronics	0.4 x 0.3 x 0.15	6	9
MRS-Electronics	0.4 x 0.3 x 0.15	6	9
HRS-Electronics	0.4 x 0.3 x 0.15	6	9
WFC(DM+TTM)-Electronics	0.4 x 0.3 x 0.10	4	60 (TTM) 40 (DM)
total		**22 kg**	127 W

Instrument Specifications, Accommodation and Interface Requirements (2)

Mid-Infrared PIAACMC Coronagraph Channel

Cold side portion

PIAACMC Coronagraph	Dimensions (m3)	Mass (kg)
COR-S	0.4 x 1.0 x 0.4	2.8(optics) + 3.8 (FWs)
COR-L	0.4 x 1.0 x 0.4	2.8(optics) + 3.8 (FWs)
WFC(DM+TTM)	0.5 x 0.3 x 0.15	1.5
Alignment Panel	-	6.1
Cover	-	3.5
total		**24.3 kg**

Warm electronics portion

PIAACMC Coronagraph	Dimension [m3]	Mass (kg)	Power (W)
COR-Electronics	0.4 x 0.3 x 0.15	6	9
WFC(DM+TTM)-Electronics	0.4 x 0.3 x 0.10	4	60 (TTM) 40 (DM)
total		**10 kg**	109 W

Mid-Infrared Transit Spectrometer Channel

Cold side portion

PIAACMC Coronagraph	Dimensions (m3)	Mass (kg)
TRA-S	0.3 x 0.4 x 0.1	2.2(optics)
TRA-L	0.3 x 0.4 x 0.1	2.2(optics)
Alignment Panel	-	1.6
Cover	-	1.0
total		7.0 kg

Warm electronics portion

PIAACMC Coronagraph	Dimension [m3]	Mass (kg)	Power (W)
TRA-Electronics	0.4 x 0.3 x 0.10	4	6
total		4 kg	6 W

Instrument Specifications, Accommodation and Interface Requirements (3)

MISC
- Mid-Infrared Imager and Spectrometer Channel
- PIAACMC Coronagraph Channel
- Transit Spectroscopic Channel

Total;
Dimension: [L] 2m x [W] 1.6m x [D] (0.1-0.4) m
(total volume; 0.85 m^3)
Cold Mass: 40.6+ 24.3+7 =71.9 kg
Warm Mass: 22 + 10 + 4 = 36 kg

Power (Warm Electronics): 127 W + 109 W + 6 W = 242 W

→***More accurate estimate will be made by June 2017***
based on the optical design analyses of MISC's three channels

Instrument Specifications, Accommodation and Interface Requirements (4)

- Operational Modes.

Off, Standby, Coronagraphic spectral imaging, filter imaging, low-res spectroscopy, med-res spectroscopy, high-res spectroscopy, Transit spectroscopy

- Electrical Interface

TBD VDC

- Command and Telemetry Interface

TBD

- Mechanical Interface

Details TBD

- Mechanisms

2 deformable mirror, 2 tip-tilt mirror, 10 filter/pupil wheels, all internal to the MISC

- Thermal Interface

4.2K only, with the exception of thermally anchoring the MISC cabling from the warm electronics

- Optical Interface:

See slides 10--15

- Requested Spacecraft Provided Services

TBD

Guidance and Attitude Assumptions (1 of 4)

- Are there any Observing Limitations with respect to the following sources: sun, moon, bright stars, target object, background light, extended sources?

  Detector reconditioning required after observations of bright sources in the FOV

- Is image stability required?
  - Is an active or passive approach anticipated?

  Wave Front Error Correction (DM operation) on orbit is made periodically

  TTM operation on orbit is made before the pointed observation and during the observation (TBD)

  - What is the stability requirement? *(e.g., arc seconds over time in seconds)*

  It should be stable within the TTM range of motion (1 arcmin, TBR)

- Is "tracking" of the target required?
  - What is the required pointing stability during an observation? *(e.g., arc seconds over time in seconds)*

  ~20mas aided by TTM (Case A; 1/12 of slit width at 6um)

  ~4mas aided by TTM (Case B; requirement from 8-OPM Coronagraph)

Guidance and Attitude Assumptions (2 of 4)

- Is attitude knowledge required?
  - What is the required accuracy and precision of the knowledge? *(e.g., arc seconds)*

  Slit position can be identified with an accuracy better than 0.1 arcsec

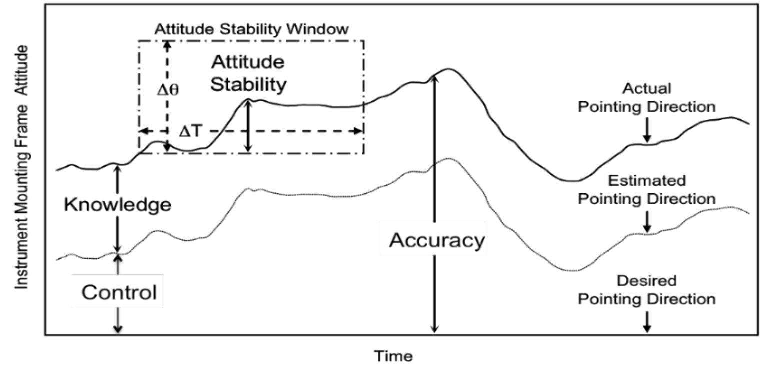
  via the slit viewer image obtained by the MISC imager

- Are there any assumptions about the exchange of guidance and attitude knowledge between the instrument and the observatory?

  The shortest wavelength band image of Mid-Infrared Imager and Spectrometer (~6um based on current setting) can provide the positional information with an accuracy better than 0.1 arcsecond. The FOV size of the imager is 1.5arcmin by 1.5 arcmin if 1k x 1k Si:As detector is used and 3 arcmin by 3 arcmin if 2k x 2k Si:As detector is used.

Guidance and Attitude Assumptions (3 of 4)

Instrument Pointing Requirements*	Baseline Configuration	Alternate Configuration**
Pointing Accuracy Requirement	40mas	
Pointing Knowledge Requirement	Obtained by slit viewer images. Simultaneous operation of MISC imager detectors (WFI-S and WFI-L) with other detectors in concern are required	
Jitter Requirement	20mas RMS	
Stability Requirement	20mas per exposure	
Any instrument generated jitter?	None	

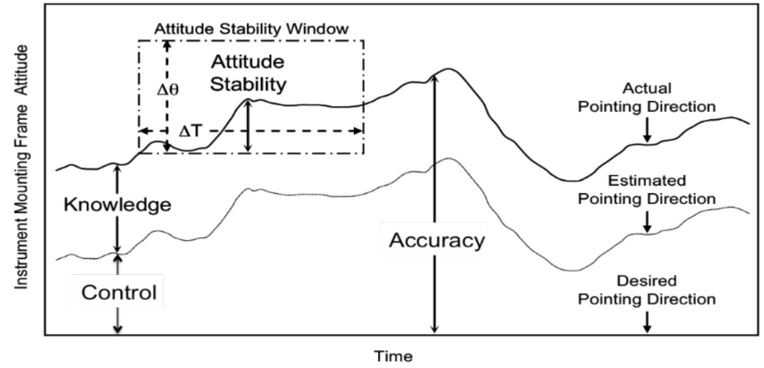


This figure illustrates the definition of attitude control, knowledge and jitter (stability)

Notes:
(*) As needed to be provided by the Observatory
(**) Relaxed requirements to meet minimum objectives, i.e., what can you live with?

Guidance and Attitude Assumptions (4 of 4)

Pointing Avoidance Requirement	Baseline Configuration	Alternate Configuration**
Any pointing avoidance requirements?	N/A	
Avoidance Requirements (degrees) – Sun, Moon, Earth, glint, other?	N/A	
Transient exposure acceptable? Required slew rate	N/A	



This figure illustrates the definition of attitude control, knowledge and jitter (stability)

Notes:
(*) As needed to be provided by the Observatory
(**) Relaxed requirements to meet minimum objectives, i.e., what can you live with?

Initial Concept of Operations (ConOps)

- Initial Concept of your instrument Operation in flight and the data collection plan

DM adjustment is operated periodically.

TTM operation is made before and during the observation.

We plan to use MISC imager as a slit viewer for spectroscopy.

→ Simultaneous operation between imager and spectrometer is requested.

Initial Concept of Operations (ConOps)

Operational Modes, for example:

	COR-S	COR-L	WFI-S	WFI-L	MRS-S	MRS-L	HRS-S	HRS-L	TRA-S	TRA-L
	6-16um	15-38um	6-16um	15-38um	17-26um	25-38um	12-18um	25-38um	6-16um	25-38um
Coronagraph Imaging	**ON**		**Standby**		**Standby**		**Standby**		**Standby**	
Coronagraph Imaging (option 1)	ON		ON		ON		ON	Standby	Standby	
Coronagraph Imaging (option 2)	ON		ON		Standby		Standby	ON	Standby	
Coronagraph Spectroscopy	**ON**		**Standby**		**Standby**		**Standby**		**Standby**	
Coronagraph Spectroscopy (option 1)	ON		ON		ON		ON	Standby	Standby	
Coronagraph Spectroscopy (option 2)	ON		ON		Stanby		Standby	ON	Standby	
MIR imaging	**Standby**		**ON**		**Standby**		**Standby**		**Standby**	
MIR imaging (option 1)	Standby		ON		ON		ON	Standby	Standby	
MIR imaging (option 2)	Standby		ON		Standby		Standby	ON	Standby	
MIR low res spectroscopy	**Standby**		**ON**		**Standby**		**Standby**		**Standby**	
MIR low res spectroscopy (option 1)	Standby		ON		ON		ON	Standby	Standby	
MIR low res spectroscopy (option 2)	Standby		ON		Standby		Standby	ON	Standby	
MIR med res spectroscopy	**Standby**		**ON**		**ON**		**Standby**		**Standby**	
MIR med res spectroscopy (option 1)	Standby		ON		ON		ON	Standby	Standby	
MIR high res spectroscopy	**Standby**		**ON**		**Standby**		**ON**		**Standby**	
Transit spectroscopy	**Standby**		**Standby**		**Standby**		**Standby**		**ON**	
Transit Spectroscopy (option 1)	Standby		ON		ON		ON	Standby	ON	
Transit Spectroscopy (option 2)	Standby		ON		Standby		Standby	ON	ON	

Instrument TRL's and Heritage

Description	Subsystem/ Component	TRL	Heritage
Deformable Mirror	Component	4	SPICA/SCI
Tip Tilt Mirror	Component	4	SPICA/SCI, JWST/NIRCAM
2K x 2K Si:As	Component	2	
PIAACMC Coronagraph	Subsystem	3	
8-Octa Phase Mask for MIR(8-36um)	Component	2	
Binary Pupil Mask Coronagraph	Component	4	SPICA/SCI
Beam Splitter, Band-pass Filters (Multi-Layer Interference Filter)	Component	4	SPICA/MCS
Image Slicer	Subsystem	4	SPICA/MCS, TMT/MICHI
Immersion grating (12-18µm)	Component	4	SPICA/MCS
Immersion grating (25-38µm)	Component	2	
Densified pupil spectrometer	Subsystem	3	

Issues and Concerns

- What is the OST policy on redundancy within the science instruments?
- Concern about the wire count and the parasitic heat load from all the instruments
- Will all instruments be on at the same time? Will they need to take data at the same time?
- Field of view – will it include enough reference stars for the transit spectroscopy program? Will it include enough bright stars if the MISC is going to provide focal plane guidance for the observatory?
- Thermal stability needed for coronagraph?

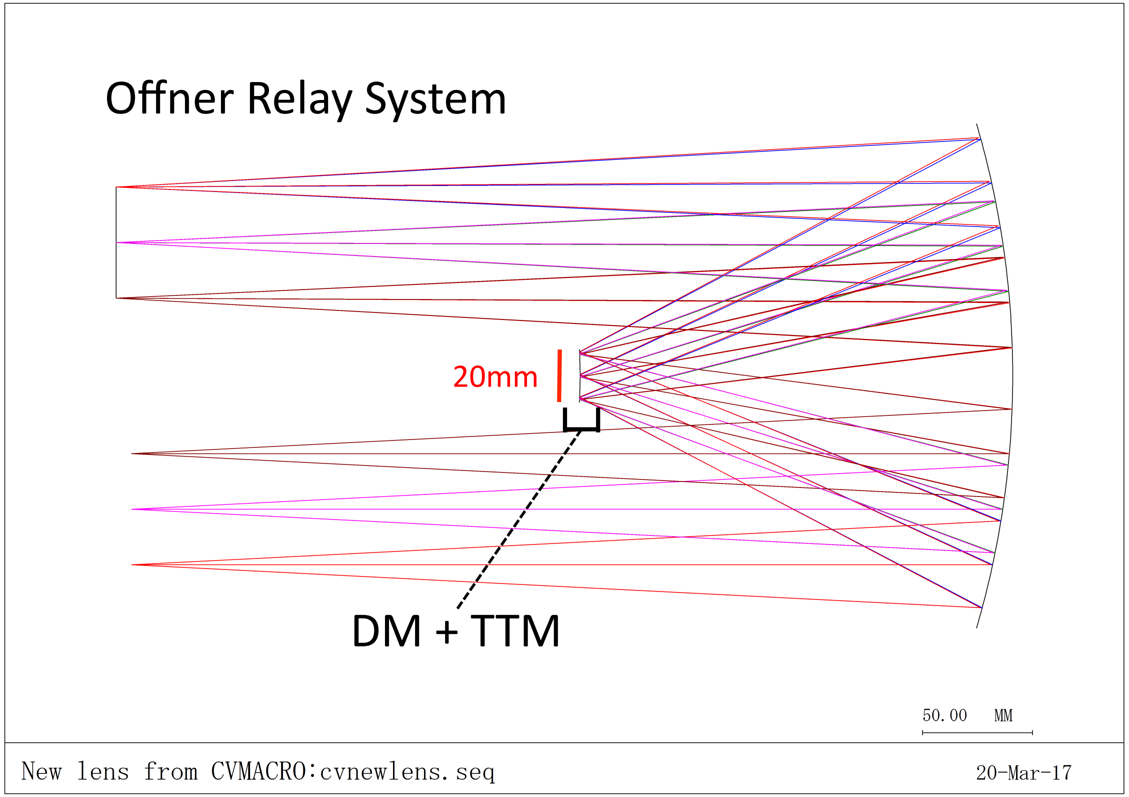
Back-up Slides (if any)

ORIGINS Space Telescope

Wave Front Control System

MEMS Deformable mirror; 32 actuators x 32 actuators (0.3mm between actuators)
Size of DM; 10mm x 10mm → 20mm x 20mm is needed to achieve 2'x 2' FOV

Assumption:
Primary mirror diameter; D=9m
Beam from the telescope; f/10
→2' x 2' FOV corresponds to 50mm x 50mm on focal plane



Power dissipation

Power dissipation from a 1Kx1K detector array

Power dissipation from unit cell source follower amplifier and output source follower amplifier is dominant

Power dissipation from unit cell source follower amplifier; 0.72mW

Power dissipation from output source follower amplifier; 0.28mW

In total, 1 mW per detector array

Power dissipation from a DM mechanism

TBA (in operation/standby/off)

Power dissipation from a TTM mechanism

TBA (in operation/standby/off)

Power dissipation from a FW mechanism

TBA (in operation/standby/off)