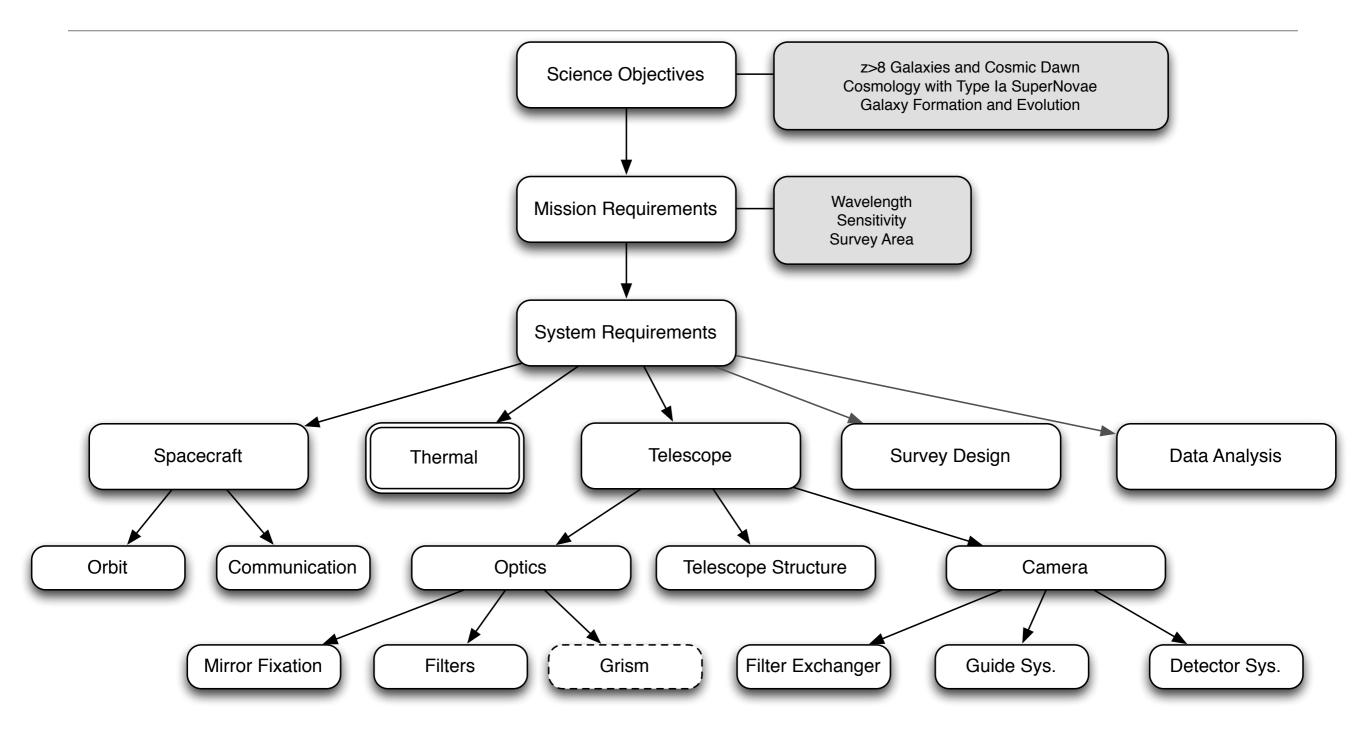
WISH Development Activities

2013/03/27 Ikuru Iwata (NAOJ)

WISH Design Flow

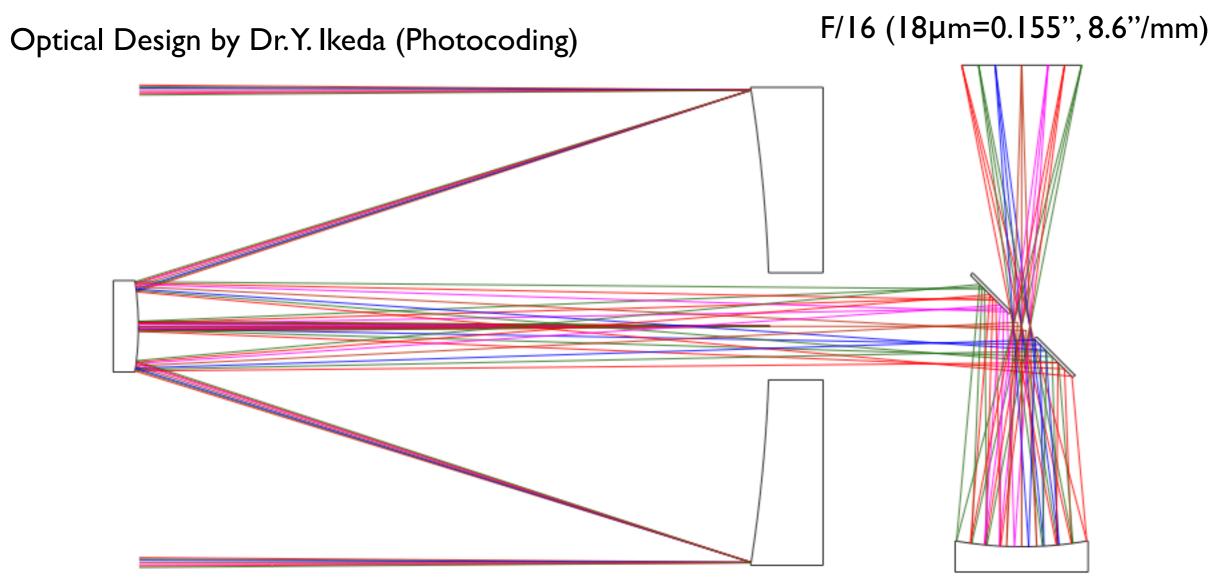


WISH Top-Level System Requirements

- Launcher: HIIA Dual Launch
- Orbit: Sun-Earth L2 Halo Orbit (TBC)
- Cooling: Mirrors < 100K, Detector < 40K
- Primary Mirror: > 1.5m
- Pixel Scale: ~ 0.15"
- Broad-band Filters
- Mission Lifetime: > 5 years
- Pointing Stability: <0.07" for 300 seconds
- Electricity
- Data Transfer Rate

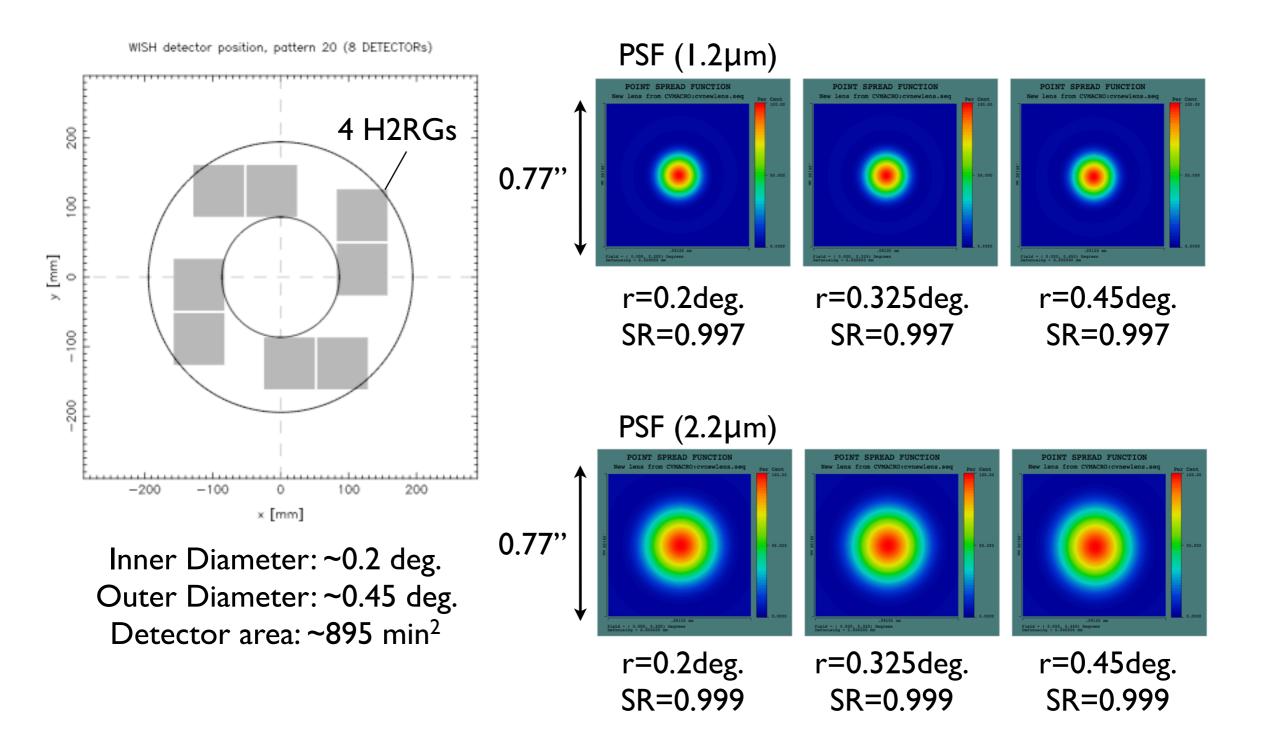
Telescope (Mission Payload)

Telescope Optics

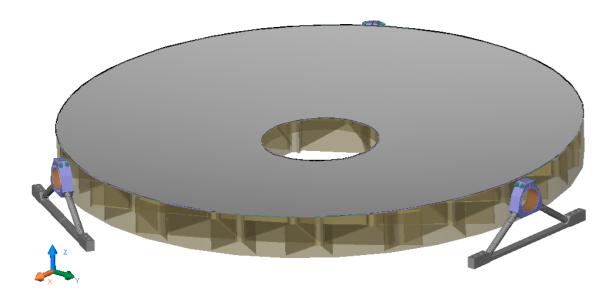


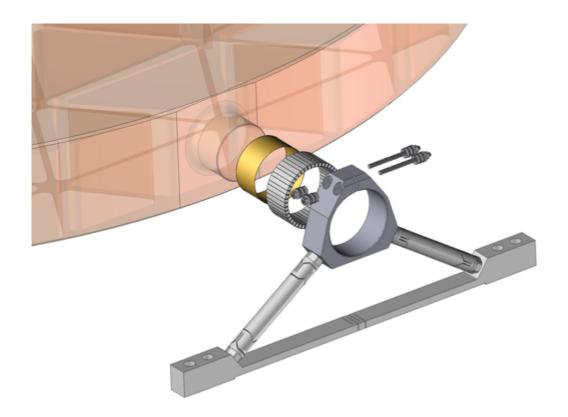
MI: I.5m Three Mirror Astigmatism

Telescope Optics: Focal Plane



Telescope Optics: Mirror Fixation





- Mirror Fixation and Preliminary MI Design by SAGEM / REOSC
- Tenon + Gold Sheet + Clamp to release stress
- Wavefront error analyses to quantify thermal effects, coating effects, load during the launch
- Mechanical load analyses
- Bare mirror weight: 143 kg

Telescope Optics: Mirror Fixation

SAFRAN Sagem WaRPP v 3.40

Date: 27/02/13 Heure: 13:49:12 MSE L = 1000.00 nm R = 763.000 mm Résol. : 200x200 Echelle Lin. : -26.551 nm à 6.213 nm 28620 points Min = -26.551 nm Max = 6.213 nm Moy = 0.000 nm P-V = 32.764 nm

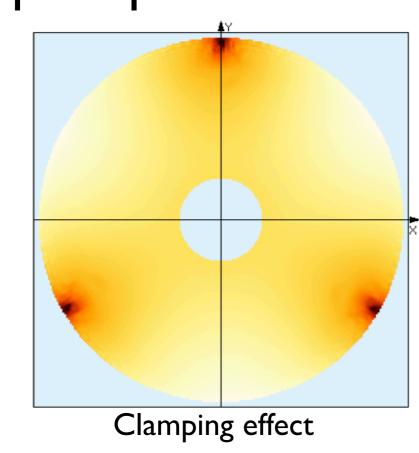
RMS = 3.372 nm



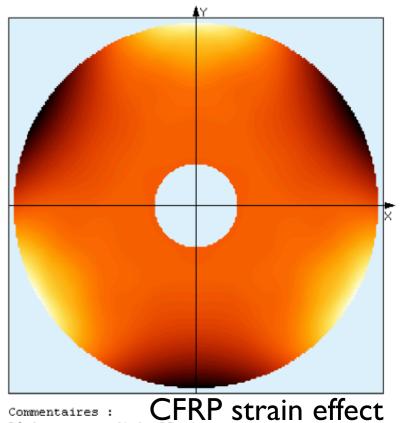
WaRPP v 3.40

WISH6_DT190K

Date: 27/02/13 Heure: 16:26:34 MSE L = 1000.00 nm R = 765.000 mm Résol. : 200x200 Echelle Lin. : -7.629 nm à 47.154 nm 28620 points Min = -7.629 nm Max = 47.154 nm Max = 47.154 nm Moy = 0.000 nm P-V = 54.783 nm RMS = 6.185 nm



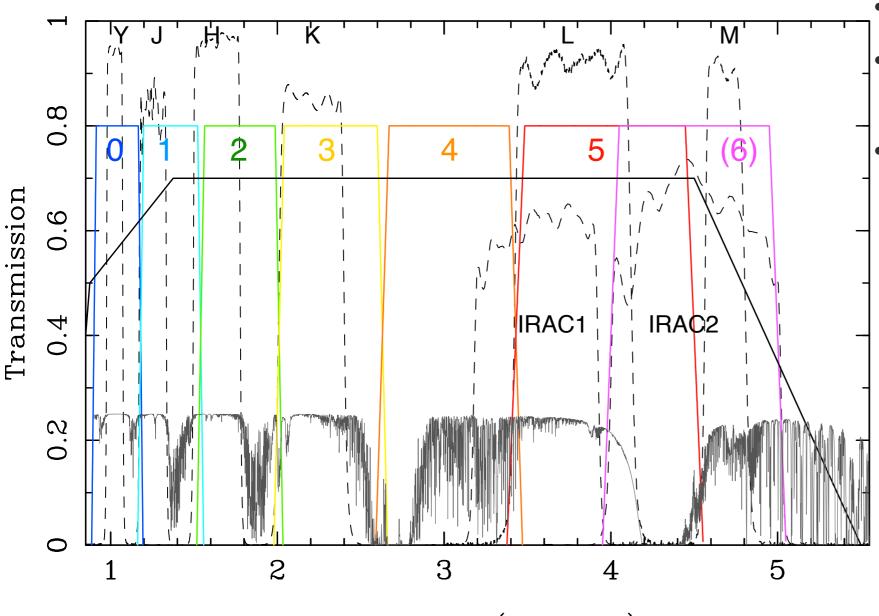
SAFRAN Sagem WaRPP v 3.40 WISH6_UR Date : 27/02/13 Heure : 15:31:25 MSE L = 1000.00 nmR = 765.000 mmRésol. : 200x200 Echelle Lin. : -3.854 nm à 5.409 nm 28620 points Min = -3.854 nmMax = 5.409 nmMoy = 0.000 nmP-V = 9.263 nmRMS = 1.359 nm



Commentaires : CFRP Strain effe Déplacement radial +30 microns. (Cas thermique sur base CFRP)

Coating effect

Telescope Optics: Filters



Wavelength (microns)

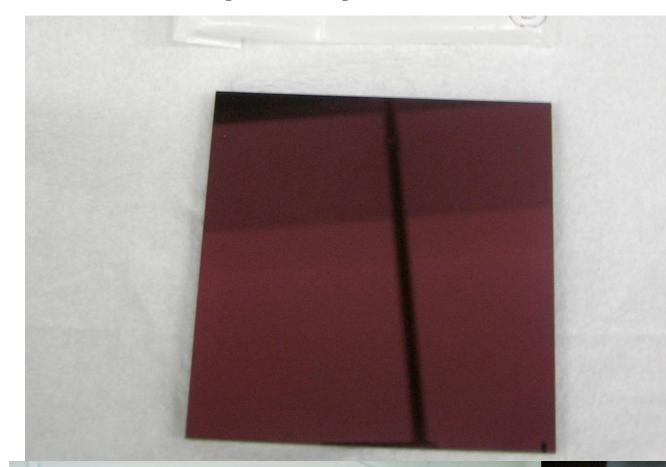
- Broad-band filters for WISH
- Logarithmic band widths along with wavelength
- Some similarity with standard broad-band filters for ground-based telescopes

Telescope Optics: Filters

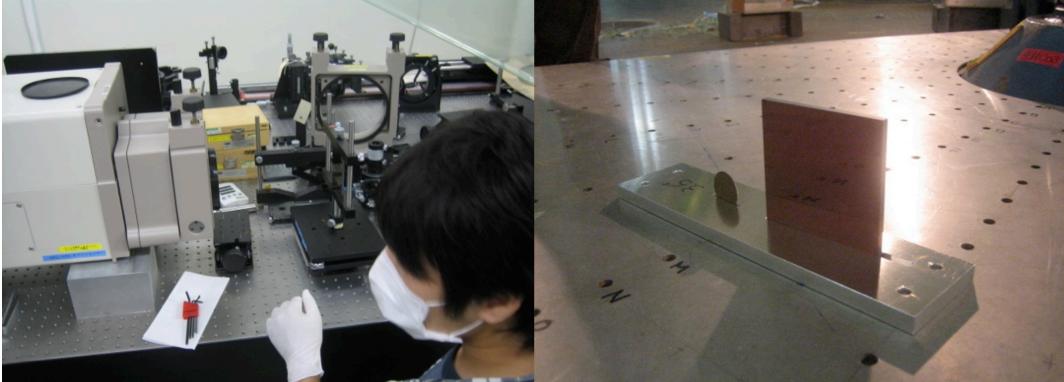
Name	$\lambda { m center}$	FWHM	w0	w1	R	Diff. Limit	Ref. Name	Notes
	$[\mu { m m}]$	$[\mu m]$	$[\mu m]$	$[\mu m]$		["]		
Filter 0	1.040	0.280	0.900	1.180	3.714	0.174	WBF0300_00	
Filter 1	1.360	0.360	1.180	1.540	3.778	0.228	WBF0300_01	
Filter 2	1.775	0.470	1.540	2.010	3.777	0.298	WBF0300_02	
Filter 3	2.320	0.620	2.010	2.630	3.742	0.389	WBF0300_03	
Filter 4	3.030	0.800	2.630	3.430	3.788	0.508	WBF0300_04	
Filter 5	3.965	1.070	3.430	4.500	3.706	0.665	WBF0300_05	
Filter 5e	4.215	1.570	3.430	5.000	2.685	0.707	WBF0301_05	オプション
Filter 6	4.500	1.000	4.000	5.000	4.500	0.755	WBF0302_06	オプション

- Broad-band filters for WISH
- Logarithmic band widths along with wavelength
- Some similarity with standard broad-band filters for ground-based telescopes

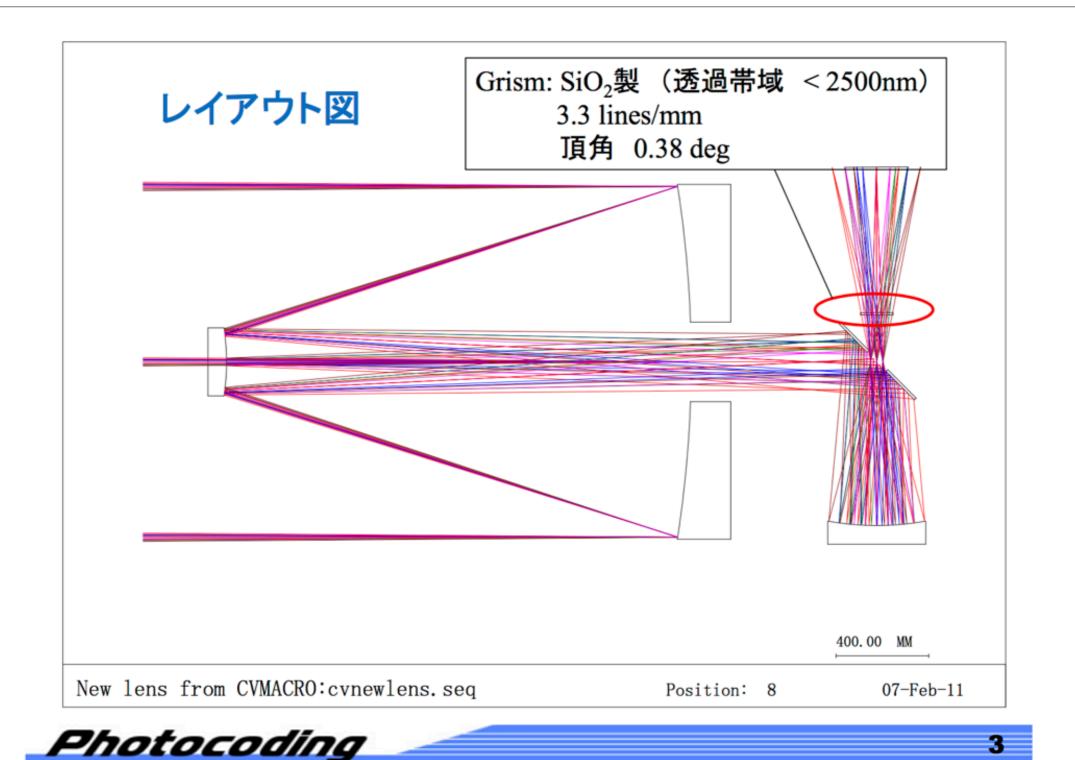
Telescope Optics: Filters



- Test fabrication of large infrared filters in 2009
- Si 80mm x 80mm 3.2µm BPF
- Radiation test passed
- Cryogenic test Throughput measurements



Telescope Optics: Possibility of Slitless Grism Spectroscopy



Telescope Optics: Possibility of Slitless Grism Spectroscopy

FIELD POSITION 0. 71, -0. 71 0. 318, -0. 32 DG 0. 51, -0. 51 0. 230, -0. 23 DG 0. 31, -0. 31 0. 141, -0. 14 DG 0. 71, 0. 71 0. 318, 0. 318 DG	- 100% RMS 100% RMS 100% RMS 100% RMS	% = 0.024047 = 0.005938 % = 0.012798 = 0.017409	FIELD POSITION 0. 71, -0. 71 0. 318, -0. 32 DG 0. 51, -0. 51 0. 230, -0. 23 DG 0. 31, -0. 31 0. 141, -0. 14 DG 0. 71, 0. 71 0. 318, 0. 318 DG	-		BMS-Feb-20 100% = RMS = 100% = RMS = 100% = RMS = 100% =	0.040143 0.013915 0.028017 0.006808 0.015703 0.019363
0. 51, 0. 51 0. 230, 0. 230 DG 0. 31, 0. 31 0. 141, 0. 141 DG	100% RMS 100% RMS 100% RMS	% = 0.021106 = 0.009820 % = 0.015751	0. 51, 0. 51 0. 230, 0. 230 DG 0. 31, 0. 31 0. 141, 0. 141 DG	-	2	100% = RMS = 100% = RMS = 100% = RMS =	0. 030559 0. 014929 0. 022459 0. 011241 0. 016080 0. 026689
0. 00, 1. 00 0. 000, 0. 450 DG 0. 00, 0. 72 0. 000, 0. 325 DG 0. 00, 0. 44 0. 000, 0. 200 DG		% = 0.033793 = 0.015042 % = 0.025095 = 0.011194	0.00, 1.00 0.000, 0.450 DG 0.00, 0.72 0.000, 0.325 DG 0.00, 0.44	- 2	- -	100% = RMS = 100% = RMS =	0.042165 0.020276 0.030366 0.014501
1. 00, 0. 00 0. 450, 0. 000 DG 0. 72, 0. 00 0. 325, 0. 000 DG	 100% RMS 100% RMS 100% RMS 100% RMS 	% = 0.023499 = 0.009791 % = 0.015650	0. 000, 0. 200 DG 1. 00, 0. 00 0. 450, 0. 000 DG 0. 72, 0. 00 0. 325, 0. 000 DG	- •		100% = RMS = 100% = RMS = 100% = RMS =	0.020597 0.007121 0.015123 0.005133 0.009894 0.004329
0. 44, 0. 00 0. 200, 0. 000 DG 0. 00, -1. 00 0. 000, -0. 45 DG 0. 00, -0. 72 0. 000, -0. 32 DG	 100% RMS 100% RMS 100% 100% 	= 0.017714 % = 0.040115 = 0.012152	0. 44, 0. 00 0. 200, 0. 000 DG 0. 00, -1. 00 0. 000, -0. 45 DG 0. 00, -0. 72 0. 000, -0. 32 DG	- L		100% = RMS = 100% = RMS = 100% =	0. 006788 0. 028609 0. 050347 0. 019227 0. 035644
0. 00, -0. 44 0. 000, -0. 20 DG	100 MM RMS 000000 100%	= 0.006208	0.00, -0.44 0.000, -0.20 DG DEFOCUSING		0	RMS = 100% =	0. 009868 0. 020304

λ=2100nm

λ=1800nm

Spot diagrams simulated by Dr.Y. Ikeda (Photocoding)

Telescope Optics: Possibility of Slitless Grism Spectroscopy

FIELD POSITION - \bigcirc 0. 318, -0. 32 DG - \bigcirc 0. 318, -0. 32 DG - \bigcirc 0. 230, -0. 23 DG - \bigcirc 0. 31, -0. 31 - \bigcirc 0. 31, -0. 31 - \bigcirc 0. 31, -0. 31 - \bigcirc 0. 318, 0. 318 DG - \bigcirc 0. 51, 0. 51 - \bigcirc 0. 318, 0. 318 DG - \bigcirc 0. 51, 0. 51 - \bigcirc 0. 31, 0. 31 - \bigcirc 0. 31, 0. 31 - \bigcirc 0. 31, 0. 31 - \bigcirc 0. 00, 0. 450 DG - \bigcirc 0. 00, 0. 72 - \bigcirc 0. 00, 0. 450 DG - \bigcirc 0. 00, 0. 200 DG - \bigcirc 1. 00, 0. 00 - \bigcirc 0. 450, 0. 000 DG - \bigcirc 0. 72, 0. 00 - \bigcirc	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	FIELD POSITION 0. 71, -0. 71	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$
0. 00, 0. 44 0. 000, 0. 200 DG 1. 00, 0. 00	$\begin{bmatrix} RMS &= & 0.018107 \\ 100\% &= & 0.037874 \\ RMS &= & 0.032600 \end{bmatrix}$	0. 00, 0. 44 0. 000, 0. 200 DG 1. 00, 0. 00	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
0. 323, 0. 000 DG 0. 44, 0. 00 0. 200, 0. 000 DG 0. 00, -1. 00 0. 000, -0. 45 DG 0. 00, -0. 72 0. 000, -0. 32 DG	RMS = 0.014439 $100% = 0.023095$ $RMS = 0.039179$ $100% = 0.072009$ $RMS = 0.028321$ $100% = 0.051700$	0. 325, 0. 000 DG 0. 44, 0. 00 0. 200, 0. 000 DG 0. 00, -1. 00 0. 000, -0. 45 DG 0. 00, -0. 72 0. 000, -0. 32 DG	RMS = 0.008720 $100% = 0.014755$ $RMS = 0.017710$ $100% = 0.035392$ $RMS = 0.013122$ $100% = 0.025428$
0.00, -0.44 0.000, -0.20 DG DEFOCUSING 0.00000 New lens from CVMACRO:cvnewlens.seq POSITION 6	RMS = 0.018057 $100% = 0.031766$	0.00,-0.44 0.000,-0.20 DG DEFOCUSING 0.0000 New lens from CVMACR0:cvnewlens, see POSITION 7	100% = 0.014762

λ=1500nm

λ=1200nm

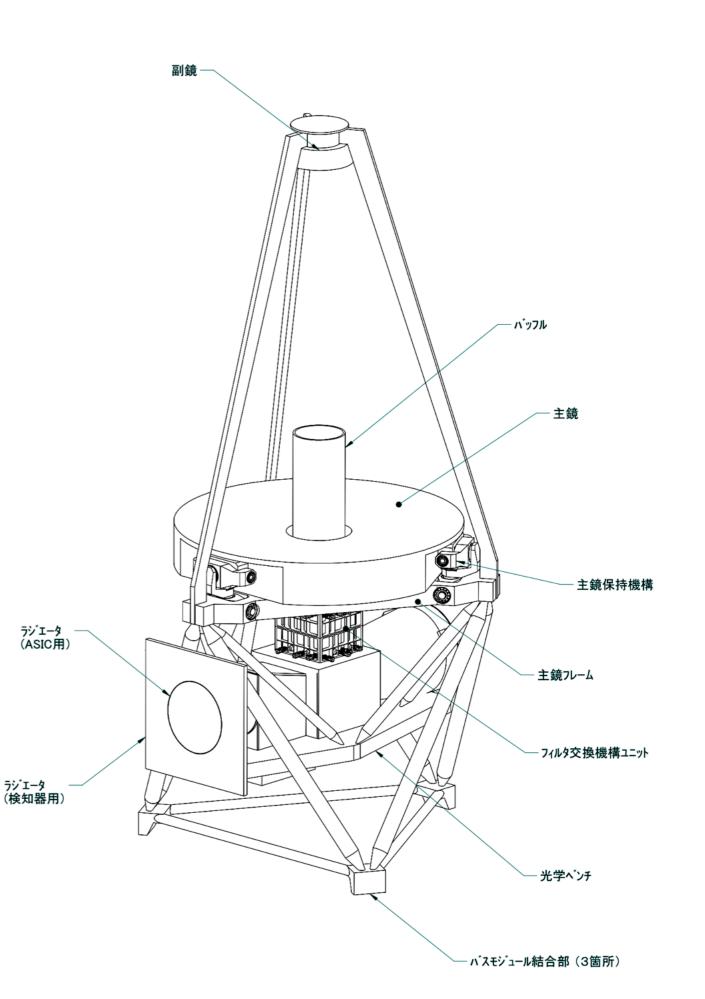
Spot diagrams simulated by Dr.Y. Ikeda (Photocoding)

Telescope Structure

- Basic investigation of properties of CFRP as telescope structure material
 - CTE
 - Degradation of strength with thermal cycles
 - Swelling
- CTEs of materials Low-expansion glass (Ohara CLEAECERAM-Z) and invar
- Properties of adhesive
 - CTE
 - Degradation of strength with thermal cycles
- Telescope structure study is still in preliminary stage (investigation of basic properties of materials). Design study of telescope structure and interface with mirrors are important items for us.

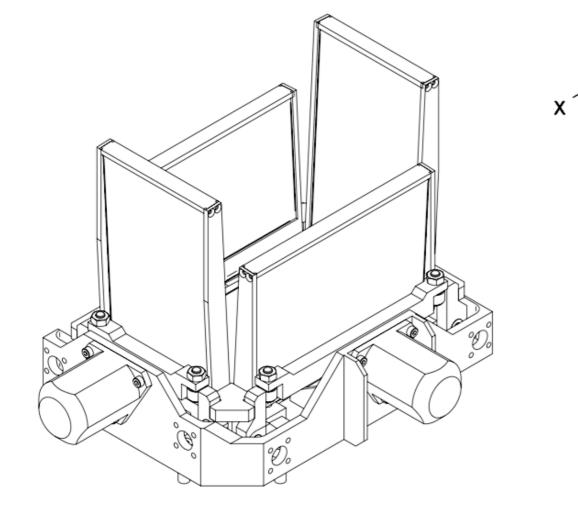
Camera System

- 'Optical Bench'
- Filter Exchanger Assembly
- Detector System
 - H2RG + ASIC
 - Read-out Electronics

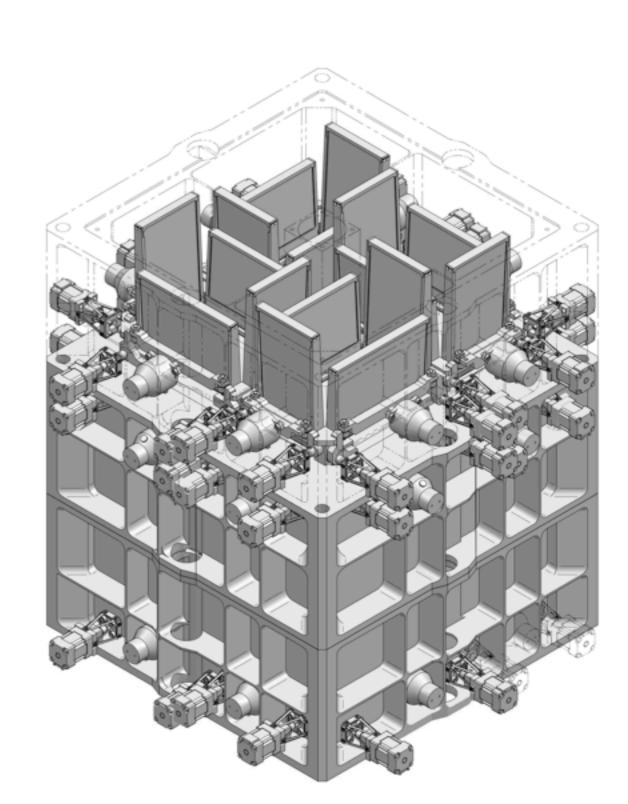


Camera System: Filter Exchanger

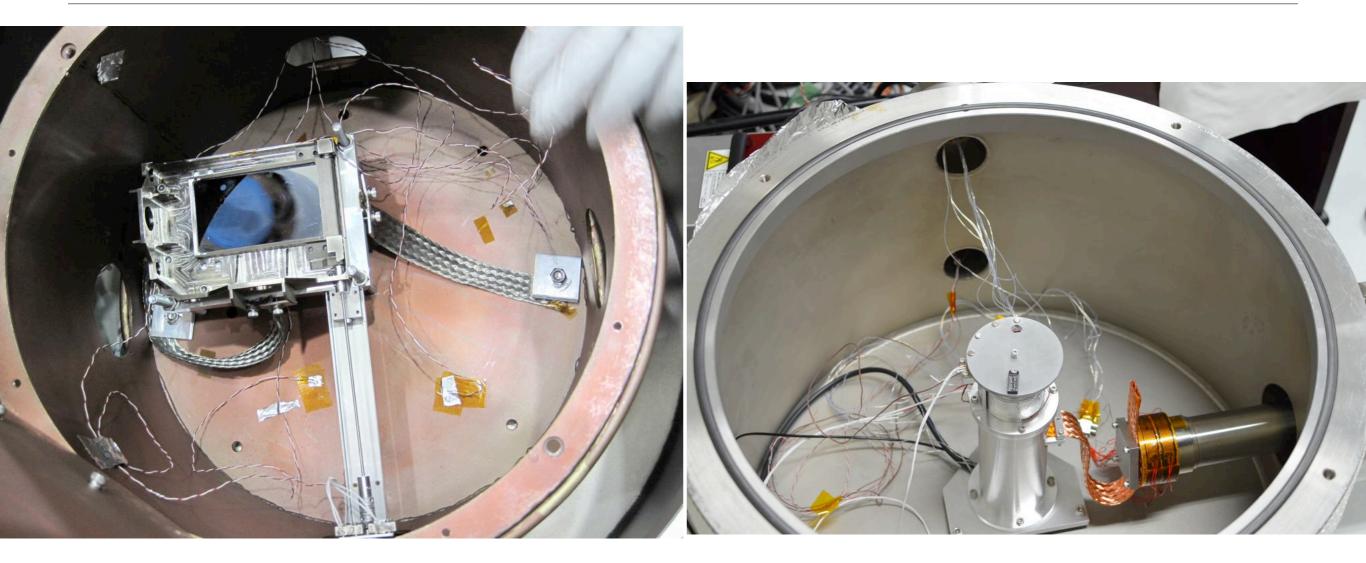
Z



Each 160mm x 80mm filter covers 8 H2RGs



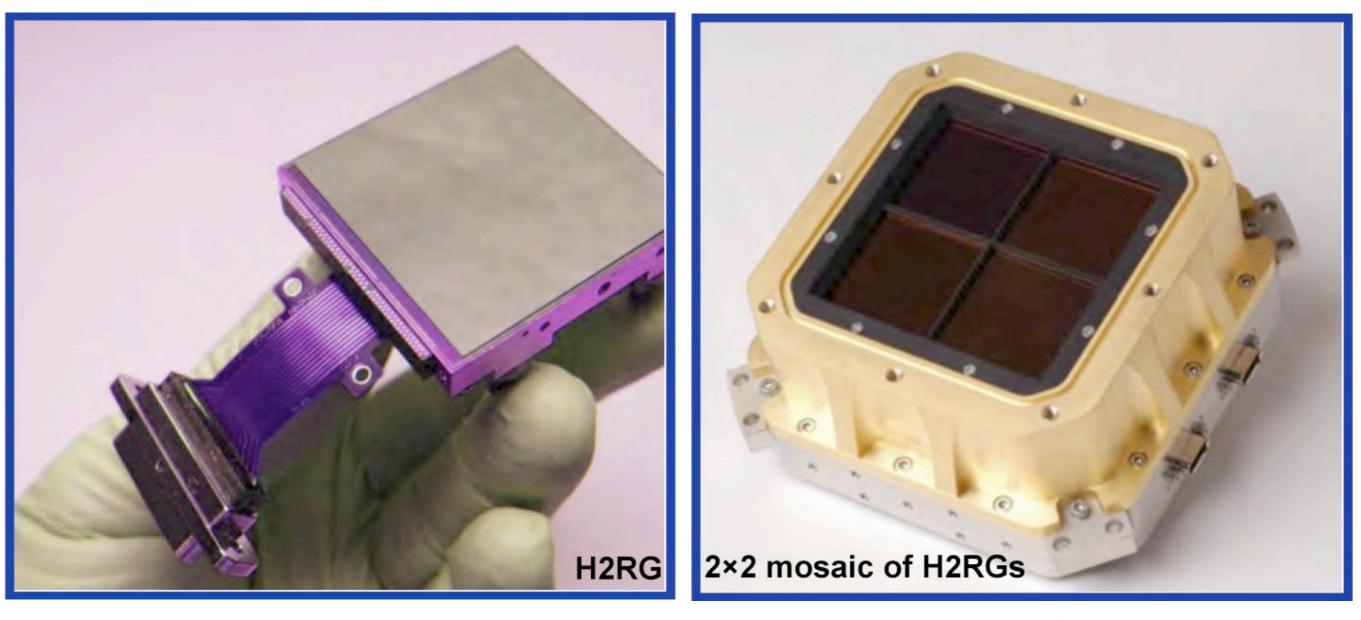
Camera System: Filter Exchanger



Mechanical reliability test under cold environment

Cryogenic motor test

Camera System: Detector System

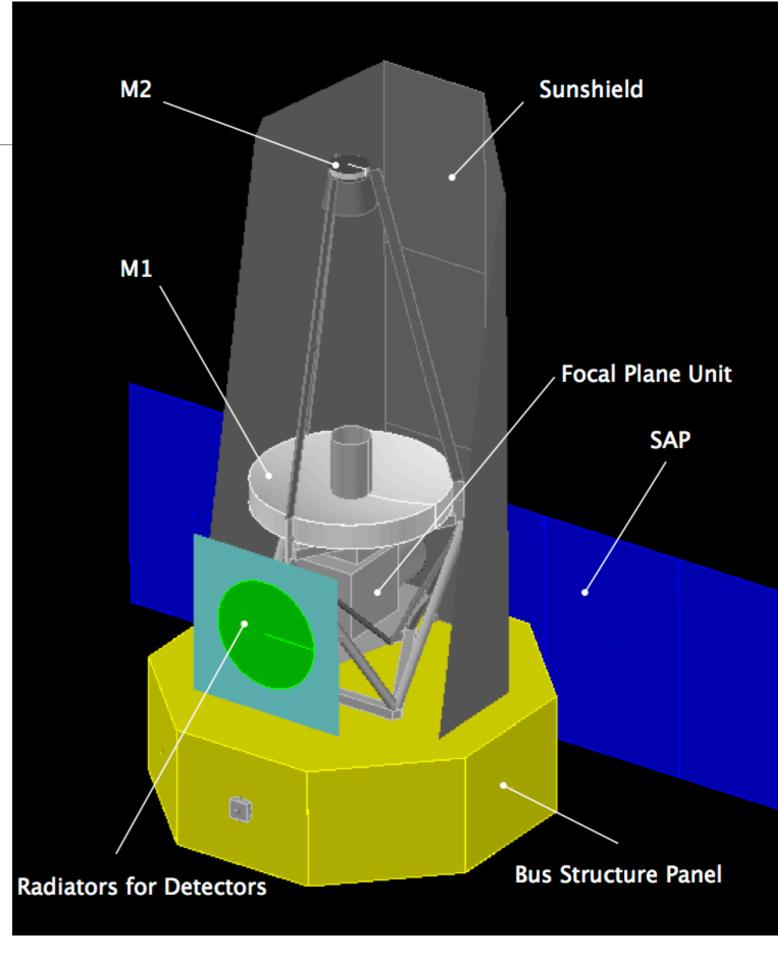




Thermal Design and Analyses

Thermal Model

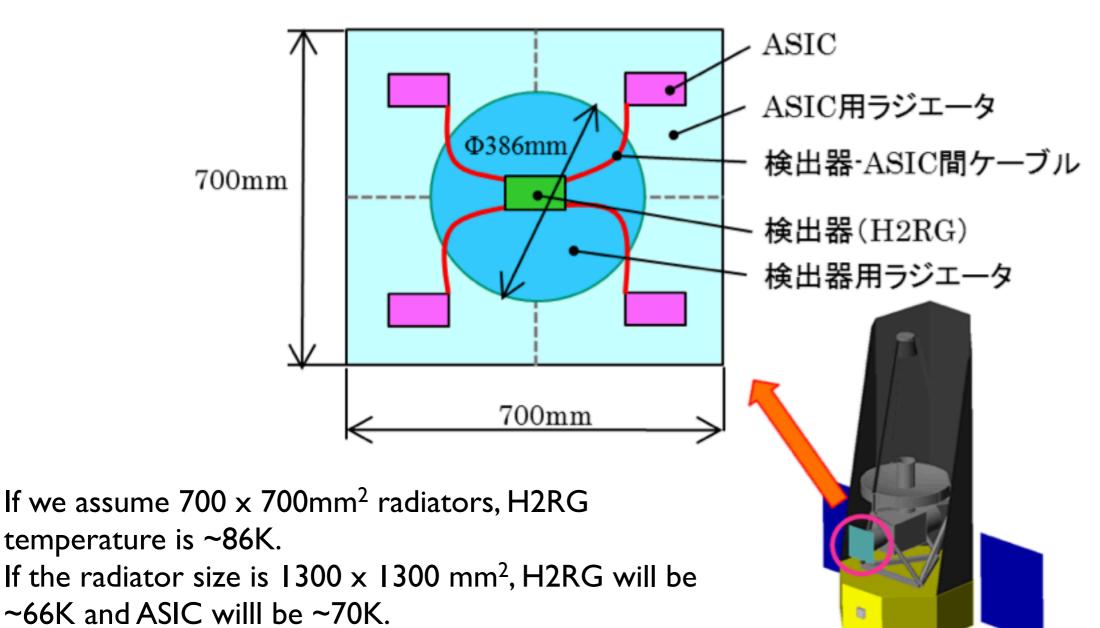
- Sun Shield: 30 layer MLI
- MLI for top-surface of Bus Structure
- CFRP truss
- Step I: thermal model of detector, FEE and radiators
- Step2: thermal model of the entire space craft and calculate static thermal flow



Requirements on Temperature of WISH Components

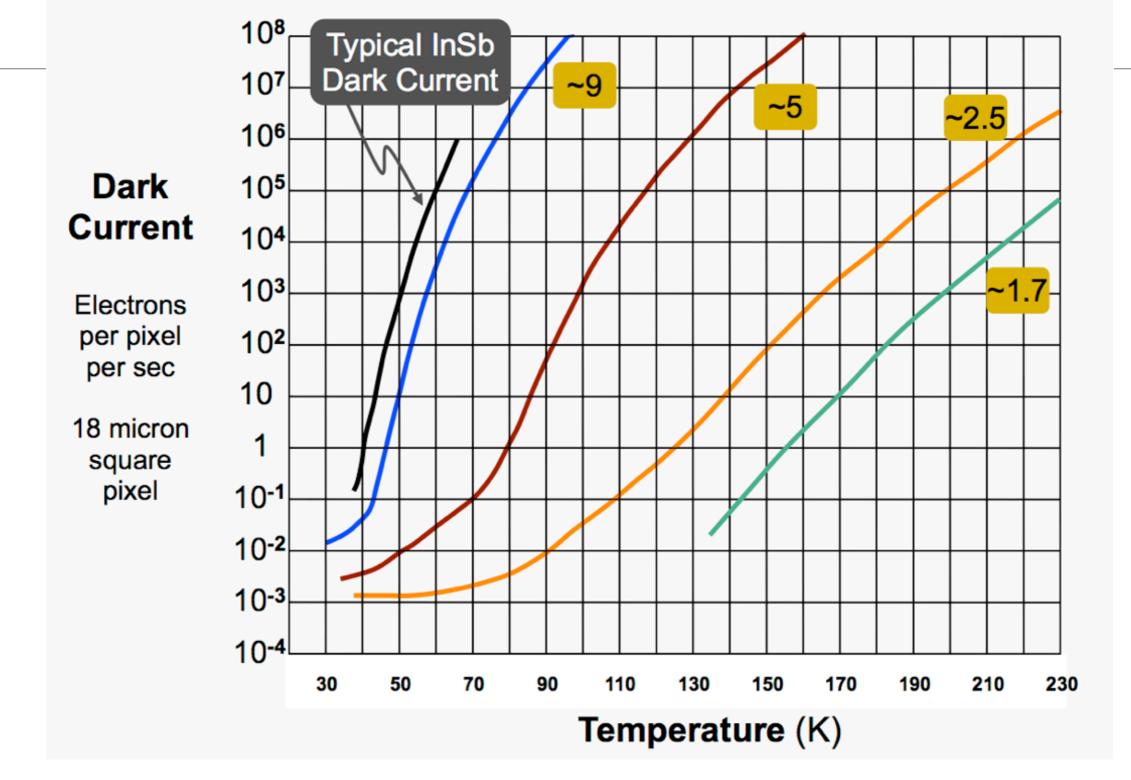
Components	Requirements	
Mirrors (MI, M2, Flat, M3)	100K	
Spiders	100K	
Filters	80K	
Focal Plane Unit	80K	
Detectors	40K (Goal)	

Detector, ASIC (FEE) and Radiators



Need to reduce thermal conductance from ASIC and effective cooling to achieve <50K

Cutoff Wavelengths and Dark Current - from Teledyne



We assume 0.05e-/pix/s for sensitivity calculations.

Current Results of Thermal Analysis by the JAXA Thermal Group

Components	Requirements	Current Results	
Mirrors (MI, M2, Flat, M3)	100K	50-70K	
Spiders	100K	40-70K	
Filters	80K	100K	
Focal Plane Unit	80K	70-100K	
Detectors	40K (Goal)	65K	

Spacecraft (Uncompleted)

- Data Rate: 3- 30 Mbps. 30 120 GB / day
- Dry Weight: I.3t Tandem launch with H2A
- Electricity: ~I200W
- Orbit: Need to consider possibilities other than S-E L2?

Development of WISH: Primary Issues

- Telescope Structure
- Mirror fixation
- Thermal studies
 - Dynamic study (pointing, stabilization, exposure ..)
- Data analysis and Data archive