

# **SPiCA Near-Infrared Instrument FPC (Focal Plane Camera)**

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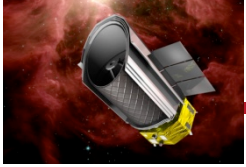
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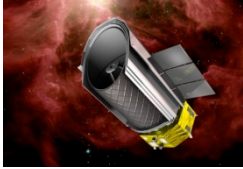
<sup>6</sup> *National Astronomical Observatory of Japan, Japan*



# FPC (Focal Plane Camera)

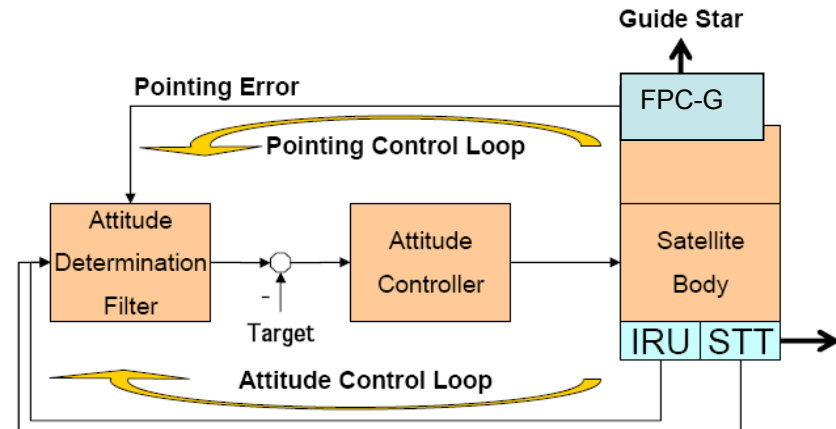
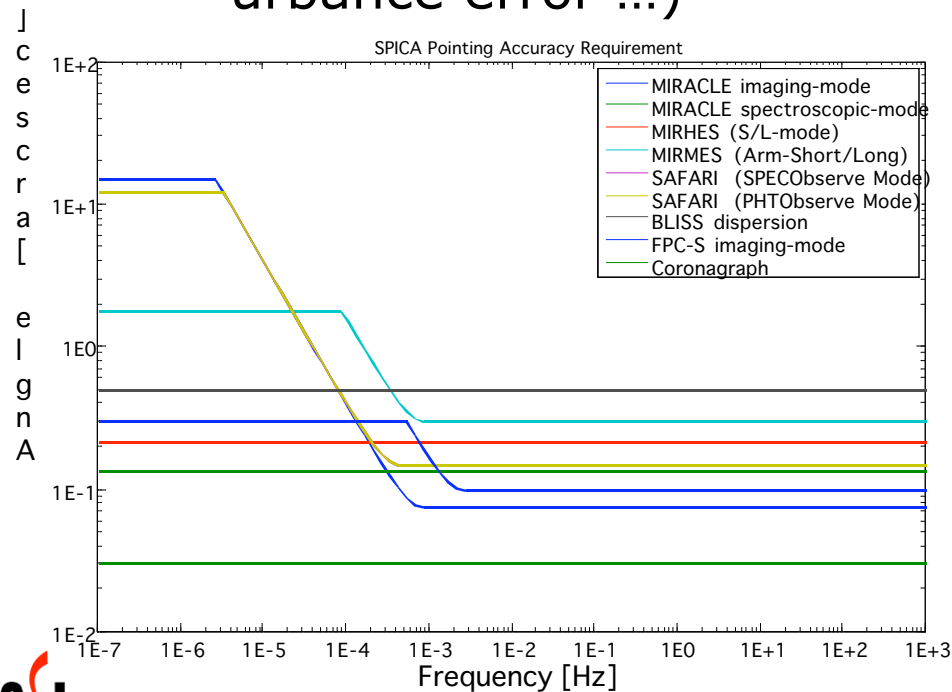
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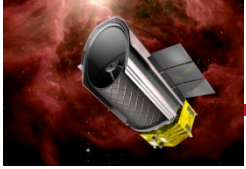
- **FPC-G (FPC Guidance)**: Fine guiding system
  - Positional information of identified star
- **FPC-S (FPC Science)**: Science purpose
  - Near-IR Imaging & Spectroscopy
  - Back-up Instrument of FPC-G



# Concept of FPC-G

- AOCS: pointing stability  $\sim 1$  arcsec
- Requirements of FPC-G
  - Fine guiding  $\sim 0.036$  arcsec ( $3\sigma$ , 0.5 Hz readout)
  - Use Guiding Star Catalogue II
  - Pointing error budget (alignment, attitude, internal disturbance error ...)

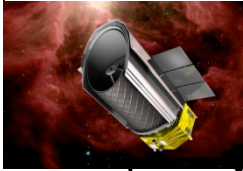




# Specification of FPC-G

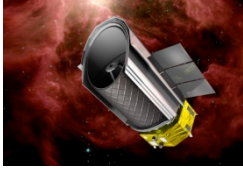
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- Pixel scale = 0.3'' (diffraction limit @ 5 $\mu$ m, telescope limit)
- Band: **I band** (0.8 $\mu$ m) (z or H) + diffuser
- Pointing stability ( $3\sigma$ ) < 0.05'' (requirement, 1Hz)  
(c.f. Pointing stability ( $3\sigma$ ) < **0.036''** @ 0.5Hz)
- QE & optical efficiency = 0.5 (assumed)
- Readout noise = 20 electrons
- Detector array = InSb 1k x 1k
- FoV = 5 arcmin x 5 arcmin



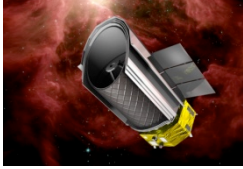
# Specification of FPC-S

Parameter	Specification	Remarks
Instrument type	Imaging and Low Resolution Spectroscopy	LVF (Linear Variable Filter) for spectroscopy
Wavelength range	0.7 ~ 5.2 $\mu\text{m}$	capability of backup of FPC-G
Detector	InSb 1K x 1K array	The same as FPC-G
Instrument Field of View	5 arcmin. x 5 arcmin.	
Pixel resolution	0.3 arcsec	
Spectral resolution	Photometric Imaging: R ~ 5 Low Res. Spectroscopy: R ~ 20	
Sensitivity (3 $\sigma$ - 600 sec)	Wide band filter: 27.3 AB mag LVF: 26.3 AB mag	No consideration of confusion
Filter positions	10	1 blank, 1 backup of FPC-G (diffuser + I band), 3 LVFs, 5 Wide band filters
Heat dissipation load (Cold)	< 1 mW	
Heat dissipation load (Warm)	< 12 W	
Mass (Cold)	< 6 kg	
Mass (Warm)	< 10 kg	
Operation modes	OFF, ON, FuncCheck, Imaging, Step Scan, Slow Scan, Parallel mode, Backup of FPC-G	Operation concepts



# Filter Spec

Filter position	Filter
F1	blank (cold shutter)
F2	diffuser + I (0.8 $\mu\text{m}$ ) (back up of FPC-G)
F3	Linear Variable Filter, LVF-1, (0.8 ~ 1.6 $\mu\text{m}$ )
F4	Linear Variable Filter, LVF-2, (1.4 ~ 2.8 $\mu\text{m}$ )
F5	Linear Variable Filter, LVF-3, (2.6 ~ 5.2 $\mu\text{m}$ )
F6	J (1.2 $\mu\text{m}$ )
F7	H (1.6 $\mu\text{m}$ )
F8	K (2.2 $\mu\text{m}$ )
F9	L (3.5 $\mu\text{m}$ )
F10	M (5.0 $\mu\text{m}$ )



# Summary of Sensitivities

- **3 $\sigma$  detection limit (100 sec integration, R $\sim$ 5)**

26.3mag(AB) for point sources

$1.62 \cdot 10^3 \cdot \lambda^{-1} \cdot t^{-1} \text{ nW} \cdot \text{m}^{-2} \cdot \text{sr}^{-1}$  for extended sources

Vega magnitude

J(1.25 $\mu\text{m}$ ) H(1.6 $\mu\text{m}$ ) K(2.2 $\mu\text{m}$ ) L(3.5 $\mu\text{m}$ ) M(5.0 $\mu\text{m}$ )

25.6

25.2

24.2

24.5

22.4

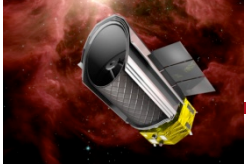
\* Photon noise becomes dominant for integration time >  $\sim$ 100 sec

- **3 $\sigma$  detection limit in LVF mode, R $\sim$ 20, integration time t**

Point sources,  $F_\lambda = 1.36 \times 10^{-16} \cdot \lambda^{-2} \cdot t^{-1} \text{ W} \cdot \text{m}^{-2} \cdot \mu\text{m}^{-1}$

Extended source,  $\lambda \cdot F_\lambda = 3.64 \times 10^4 \cdot \lambda^{-1} \cdot t^{-1} \text{ nW} \cdot \text{m}^{-2} \cdot \text{sr}^{-1}$

\* Photon noise becomes dominant for integration time >  $\sim$ 600 sec

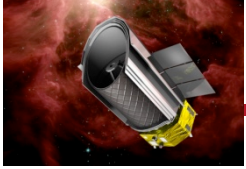


# FPC-S Scientific Targets

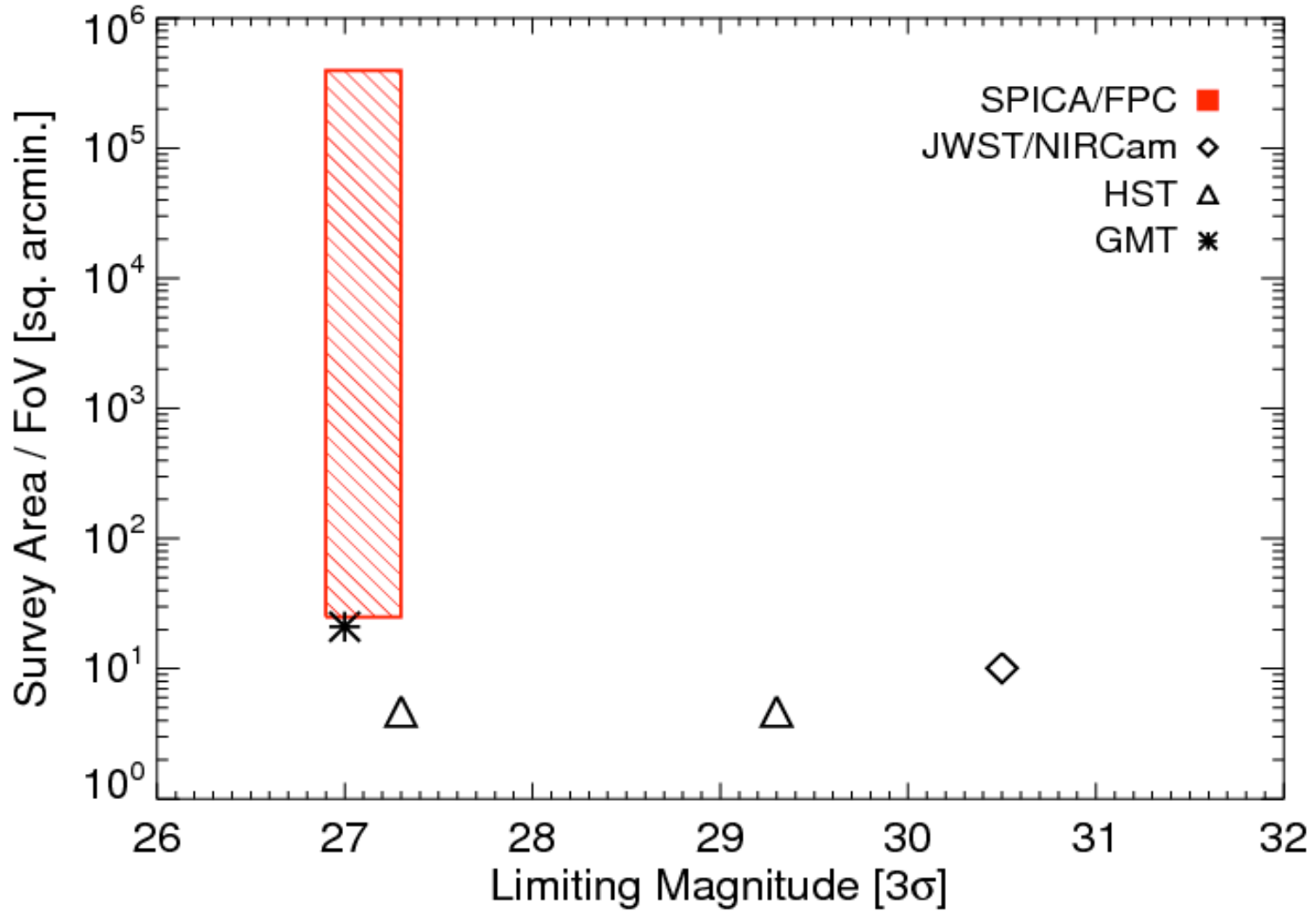
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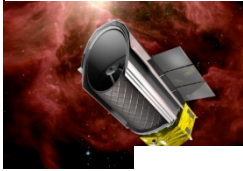
- Legacy Programs
  - NIRSS: Near-Infrared Spectroscopic Survey with FPC for Cosmic IR Background and Extragalactic Sciences
  - Parallel Imaging Survey for Extragalactic Sciences
- Target of Opportunities
  - Comet Observations
  - Gamma-ray bursts



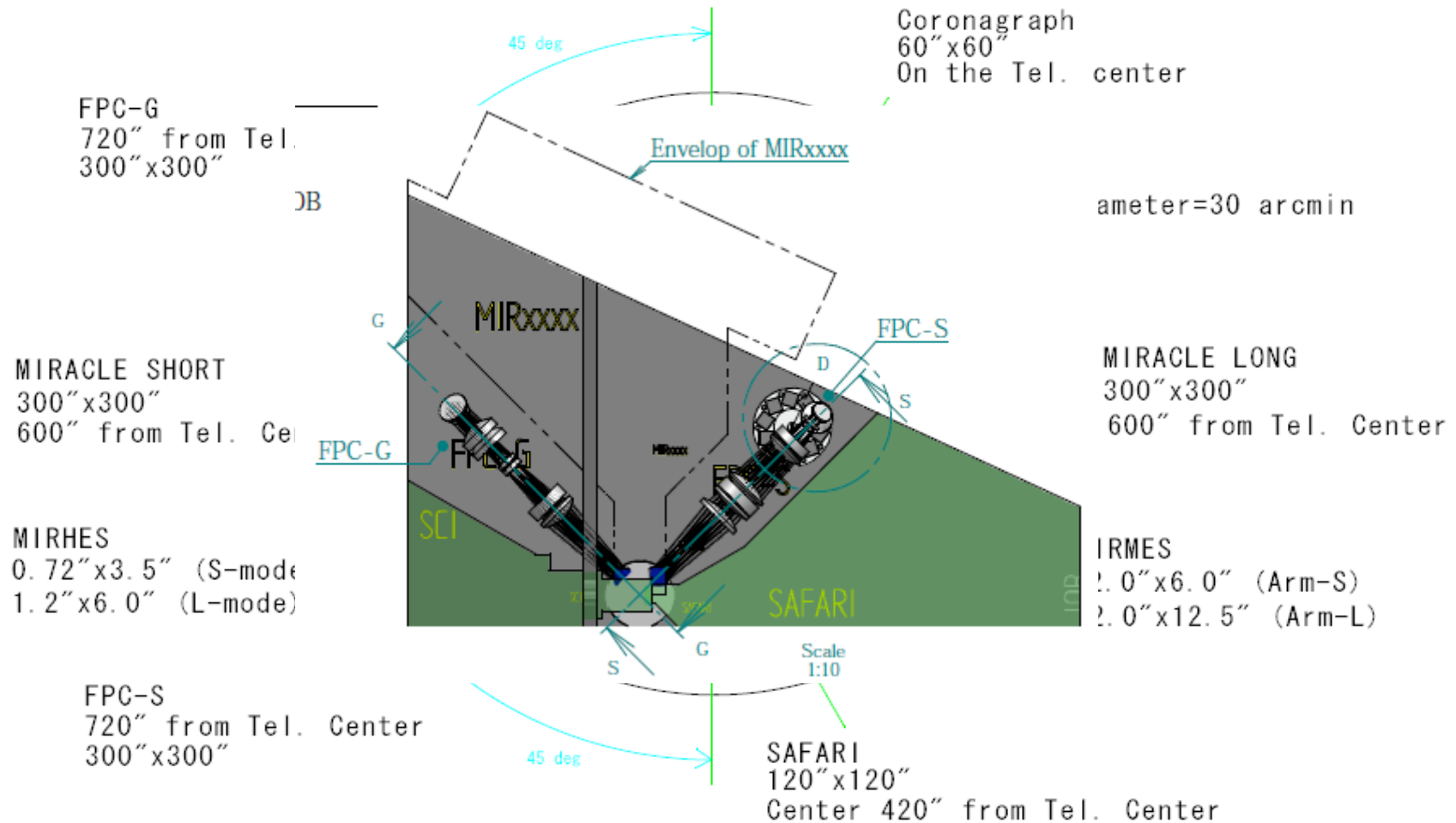


# Comparison with others

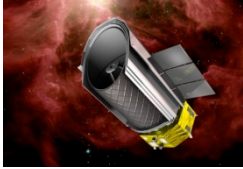




# Focal Plane Allocation



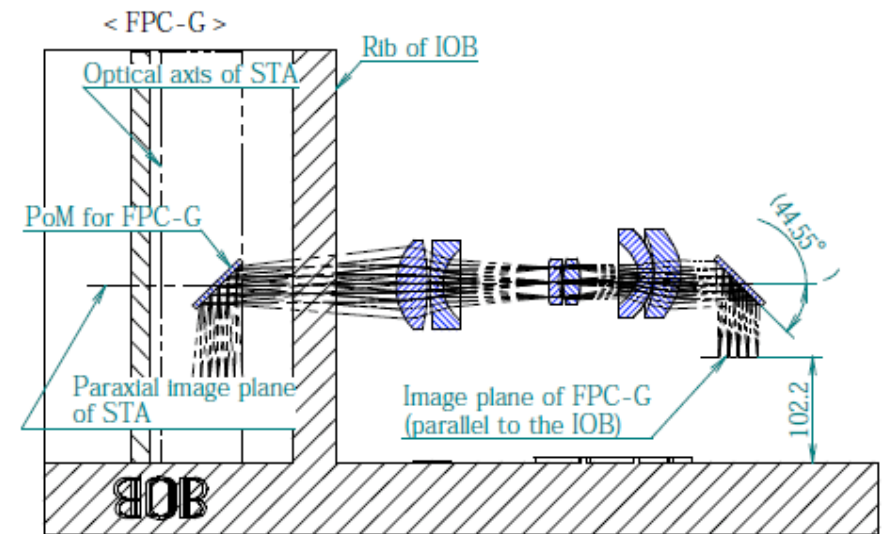
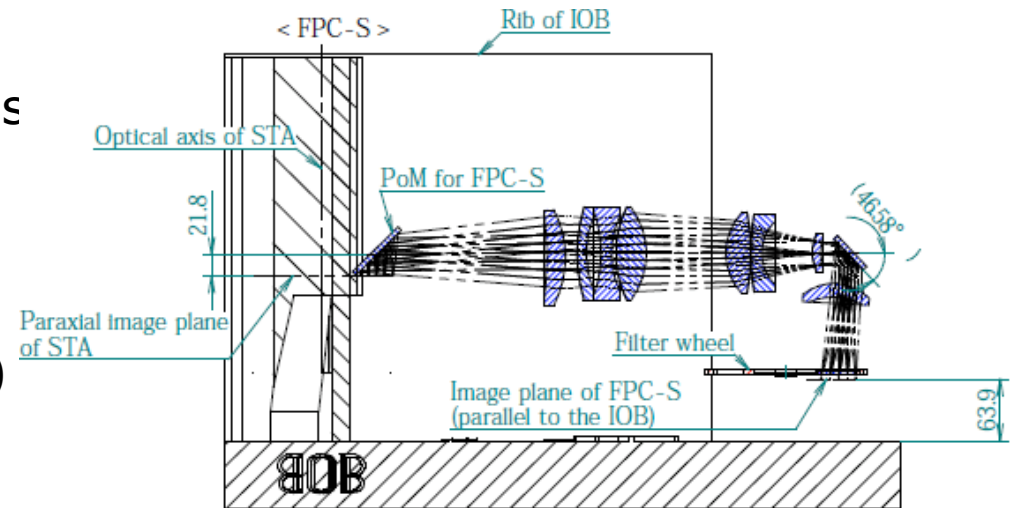
Seen from a telescope side

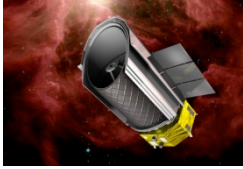


# Concept Design (1/2)

- Optical design

- 8 lenses with 4 aspherical surfaces
- Minimize distortion
- 10 filter positions
- LVF (Linear Variable Filter)
- Optical elements: C9754, ZnS, LiF and CaF<sub>2</sub>
- Back-up of FPC-G  
Diffuser (glass with sand blasted surface) + I band
- PSF (Point Spread Function) < pixel scale
- Position of filter wheel → ghost effect? Not so serious due to **fairly black surface of InSb** (Raytheon)





# Concept Design (2/2)

- Detector

- InSb 1k x 1k (Raytheon)
- Pixel pitch: 25 $\mu$ m
- Spectral response: 0.4 ~ 5.3 $\mu$ m
- Readout noise: 20e-1 (0.4Hz readout)
- Operating temperature > 10k

- Structural design

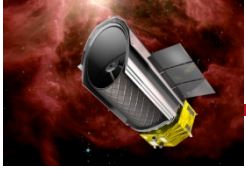
- Weight of FPC-S & -G: ~6kg, 4kg
- Total weight: ~10kg

- Thermal design

- Thermally isolated from telescope (use of heater on FPA)
- Heat load to IOB < 1 mW
- Stabilization of performance: several hours (after power-on)

## Estimated weight

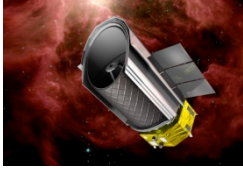
Part	Weight
Lens	2,200
Barrel	2,850
Motor	50
Filters & filter wheel	300
FPA	300
Supporting structure	300
<b>Total</b>	<b>6,000</b>



# FPC-S Requirement (1/2)

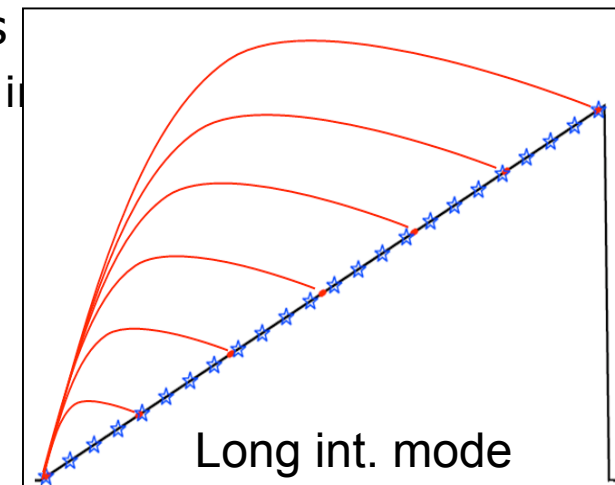
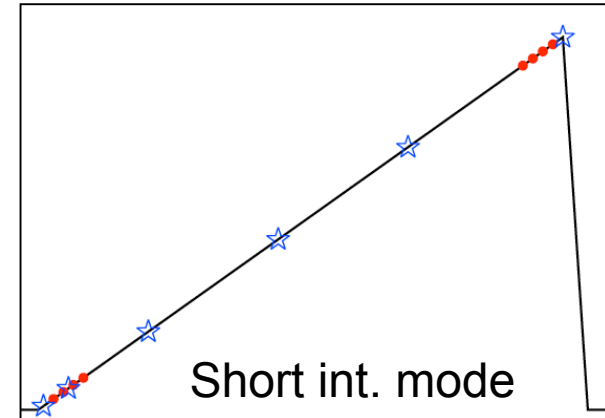
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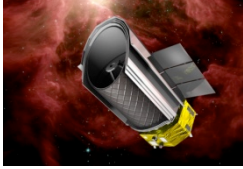
- Field of View (FoV)
  - Large area survey
  - Enough number of guiding stars as a back-up of FPC-G
  - 5 arcmin x 5 arcmin
- Thermal requirements
  - Temperature of IOB:  $\sim 5$  K
  - 12 or 20K stage buffer amplifier
- Attitude control accuracy: imaging & step scan mode (pointing accuracy, pointing stability)
  - Imaging mode: 0.3 arcsec, 0.1 arcsec
  - Step scan mode (LVF): 0.1 arcsec, 0.1 arcsec



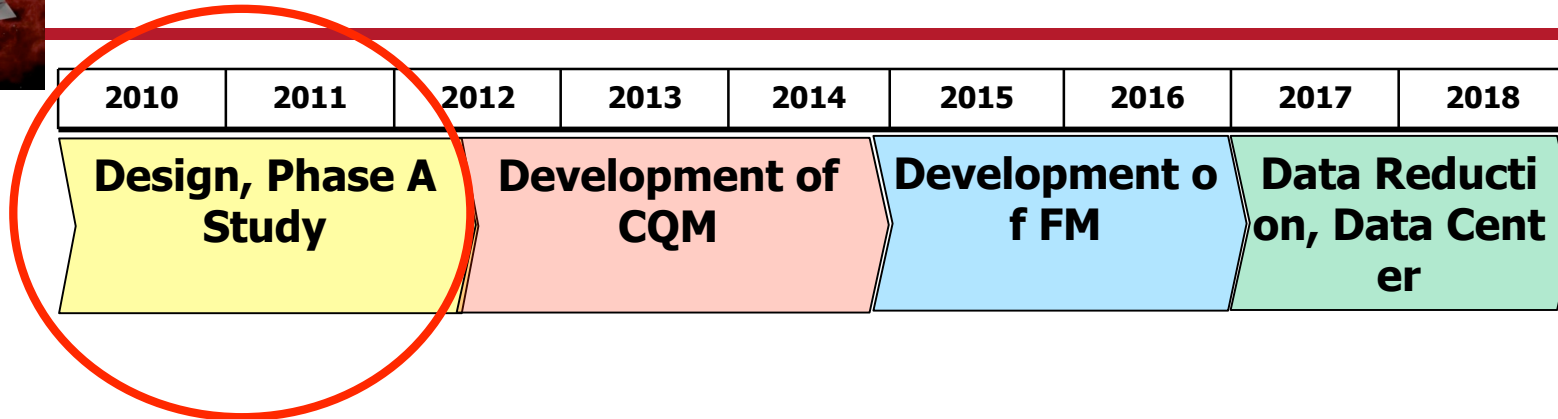
# FPC-S Requirement (2/2)

- Data rate
  - Short integration mode: 1.232 Mbps
    - ✓ e.g, 100 sec integration
    - ✓ 5 images & slope information
  - Long integration mode: 0.76 Mbps
    - ✓ e.g., 600 sec integration
  - Parallel observation mode: 0.528 Mbps
    - ✓ 2 images at the beginning & the end of integration
  
- Operation mode
  - Imaging observation
  - Step scan observation
  - Slow scan observation
  - Parallel observation
  - Back-up of FPC-G

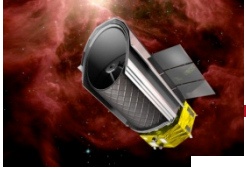




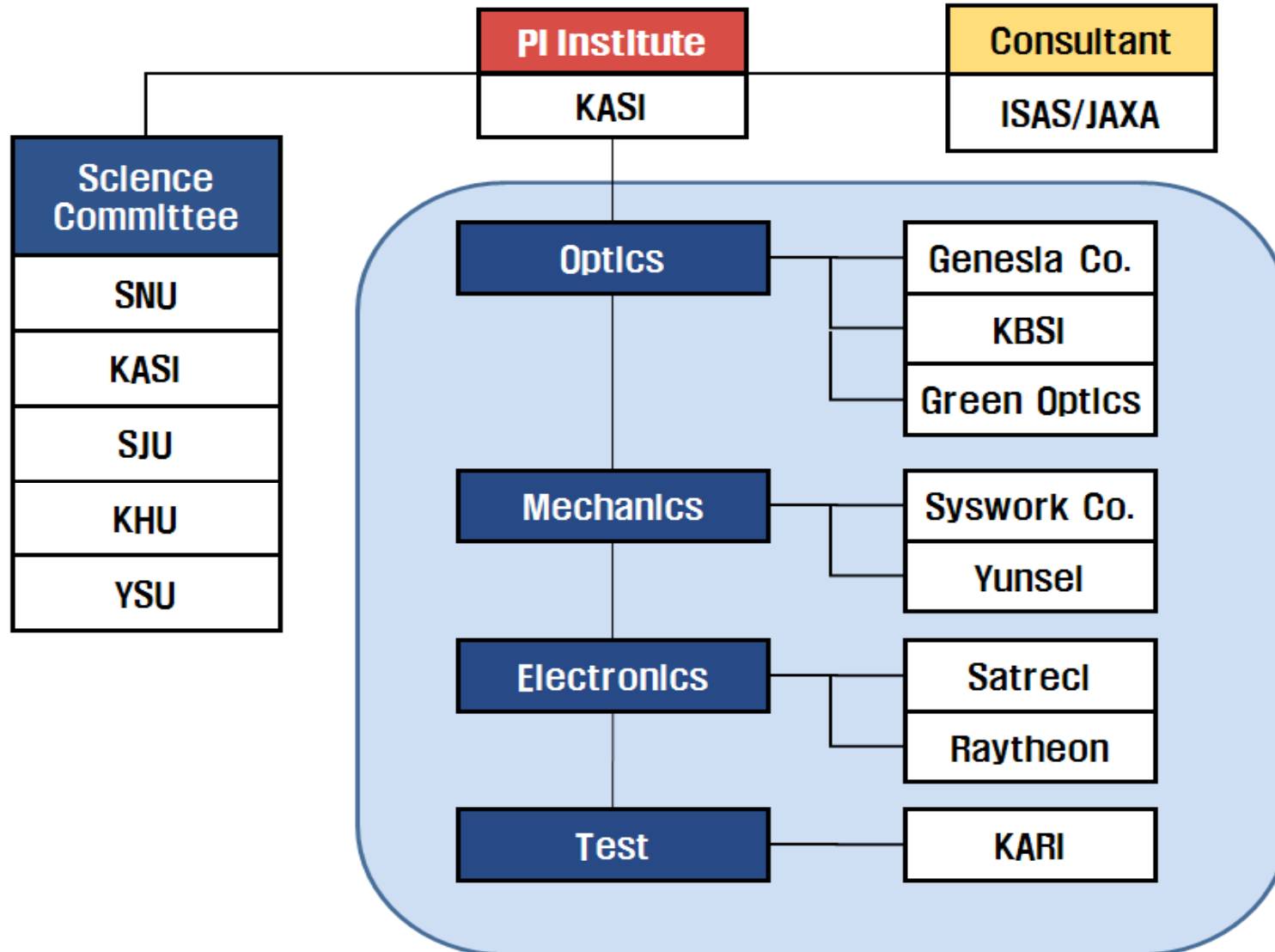
# Current Situation



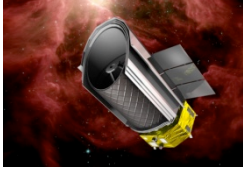
- Phase A study was approved inside KASI.
  - Preparation for internal report to persuade government
  - Project review was successfully passed at KASI (11/22)  
=> Selected as one of new KASI's R&D project
  - LoI signed by the president of KASI and delivered to ISAS (2010. 9.)
- Selected as a top priority in astronomy for the [National Large Research Facility Roadmap](#)
- 3<sup>rd</sup> FPC proposal is submitted and is under review process



# Framework of Development

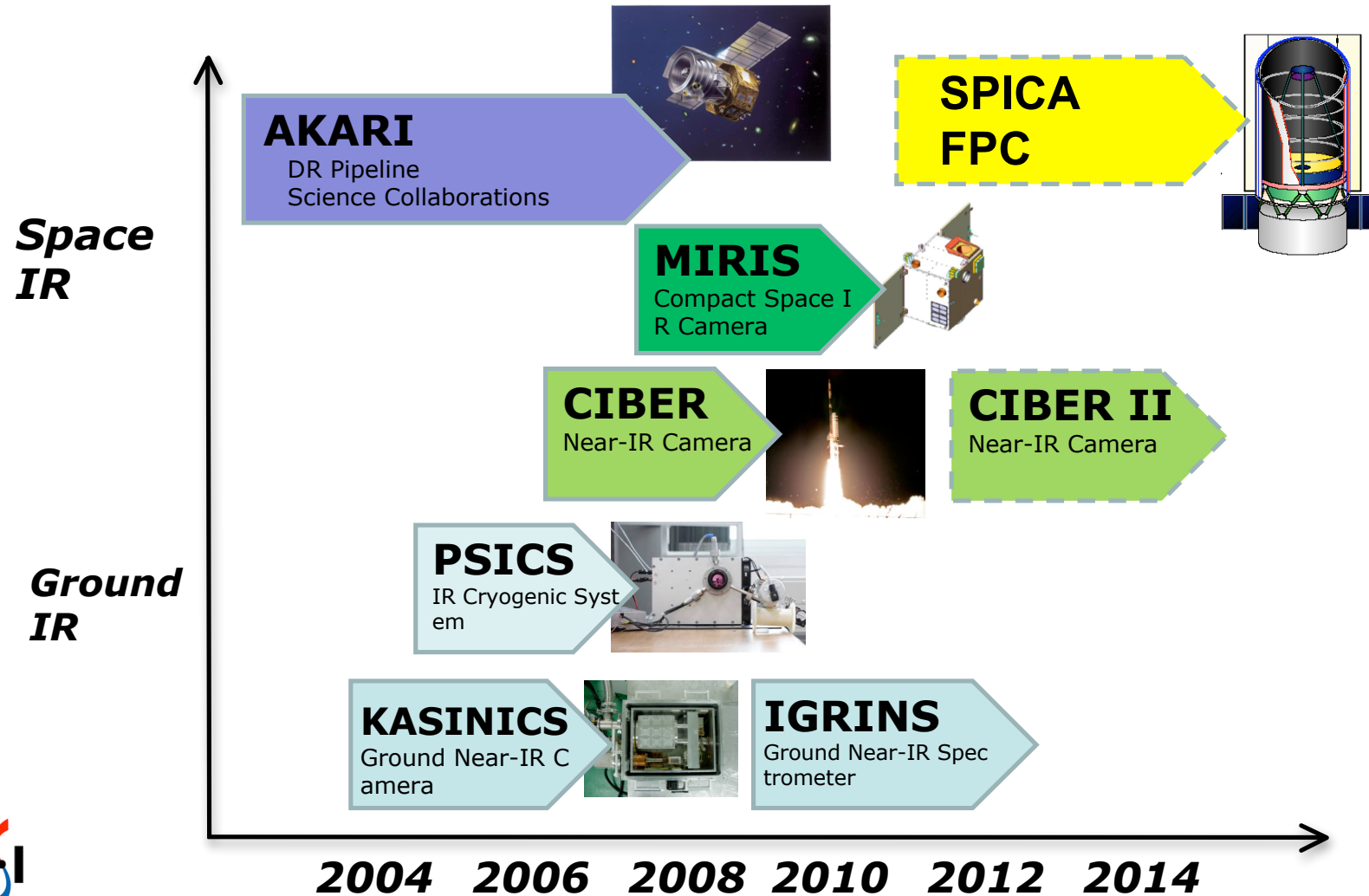


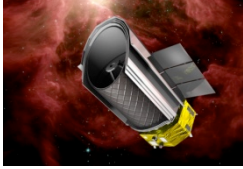




# KASI's IR Projects

- Experience in the near-IR space instrument
- Data analysis & scientific research in IR range





# Comparison with others

