

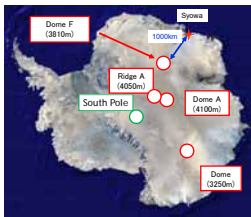
An optical design of the wide-field imaging and multi-object spectrograph for an Antarctic infrared telescope

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A design of the wide-field infrared camera (AIRC) for Antarctic 2.5m infrared telescope (AIRT) is presented. The off-axis design provides a 7.5'x7.5' field of view with 0.22"/pixel in the wavelength range of 1 to 5 μm for the simultaneous three-color bands using cooled optics and three 2Kx2K InSb focal plane arrays. To enjoy the stable atmosphere with extremely low perceptible water vapor (PWV), superb seeing quality, and the cadence of the polar winter at Dome Fuji on the Antarctic plateau, the camera will be dedicated to the transit observations of exoplanets. The function of multi-object spectroscopy with low resolution (R~50-100) will be added for the spectroscopic transit observation at 1-5 μm. The spectroscopic capability in the environment of extremely low PWV of Antarctica will be very effective for the study of the existence of water vapor in the atmosphere of super earths.

Infrared Telescope at Dome Fuji

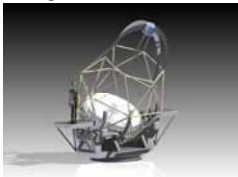


Dome Fuji station of National Institute of Polar Research Japan

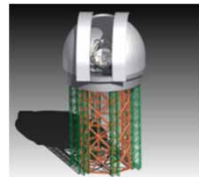


2.5m Antarctic InfraRed Telescope (AIRT)

mounted on an ultra-low weight structure



10m-high stage and styrene foams enclosure



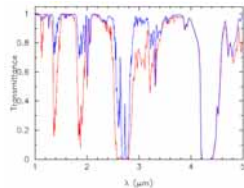
Telescope Specifications

effective aperture	2.5 m
focus	two Nasmyth foci (F/12)
Conic constant	-1 (primary) -1.96 (secondary)
focus scale	0".145 mm ⁻¹
Nasmyth stage	1 m x 1 m
Nasmyth load	≤ 500 kg for each

Why in Antarctica

- Cold atmosphere: dark infrared sky (50 – 100 times darker)
- Free-atmosphere seeing ~0.23" (at 0.47μm), the best for ground-based telescopes
- Dry atmosphere: <0.2 mm PWV in winter
- Stable transparency
- Thin atmospheric boundary layer (~11m high or lower)
- Cadence (continuous observation in polar winter)

Atmospheric transmission



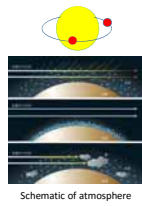
Site	Dome Fuji	South Pole	PWV
Altitude	3810m	4200m	0.2mm
Ref	Ichikawa et al.	Werner et al.	Werner et al.

Transit spectroscopy for exoplanets

water-dominated atmosphere on super-Earths

- The spectroscopic information on depth in the transit or eclipse provides important clues to atmospheric structure (e.g., thickness).
- Transit observations with low resolution spectrograph (λ/Δλ~100) for the detailed characterization of gas components in exoplanetary atmosphere

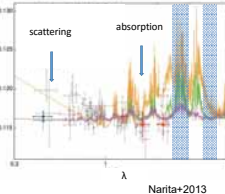
Transit and secondary eclipse



Narita 2013

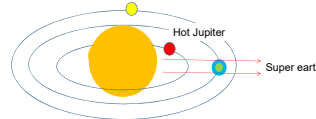
many molecular bands (H₂O, CO₂, CH₄, ...) in near-infrared

GJ 1214b

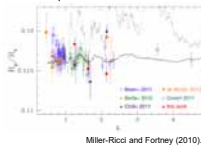


Narita+2013

Continuous observations of multiple systems

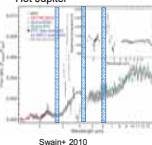


Super earth



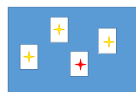
Miller-Ricci and Fortney (2010).

Hot Jupiter



Swain+ 2010

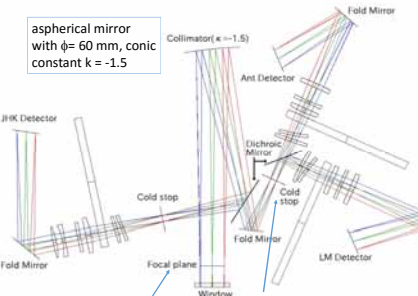
~10 reference stars in large slits to gain high accuracy in spectroscopic photometry



Wide filed infrared camera

Camera Specifications

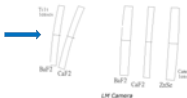
focal plane array	three 2Kx2K InSb	three color bands
pixel size	25μm x 25μm	
pixel scale	0".22 (F/9.32)	
field of view	7.5' x 7.5'	
wavelength coverage	0.6μm ~ 5μm	diffraction limit at ≥ 2μm
sensitivity for imaging	22.5 mag (0.54 μJy) at K _{max}	S/N = 5, 1 hour exposure
spectral resolution	50 ~ 100	
number of slits	~ 10	
slit size	~0.5 mm (width) x ~2 mm (length)	



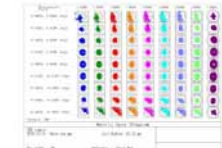
The square field stop with 33.5 mm x 33.5 mm

Φ=50 mm Cold stop: The maximum stray light of 5% of the sky emission (630 μm error in the pupil radius)

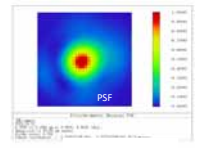
Two tilt lenses (left end) behind the cold stop to correct primary aberrations, making the optical system rotationally symmetric.



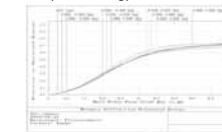
Spot diagram of the imaging mode.



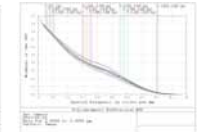
Strehl ration ~0.7



Ensquared energy



MTF



70% energy in 2x2pixels