TAO-MIR

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Mid infrared observations from the ground

Akari and Spitzer achieved excellent results in a number of astronomical fields

very high sensitivity / wide coverage of the sky

Groundbased observations at mid infrared are still important

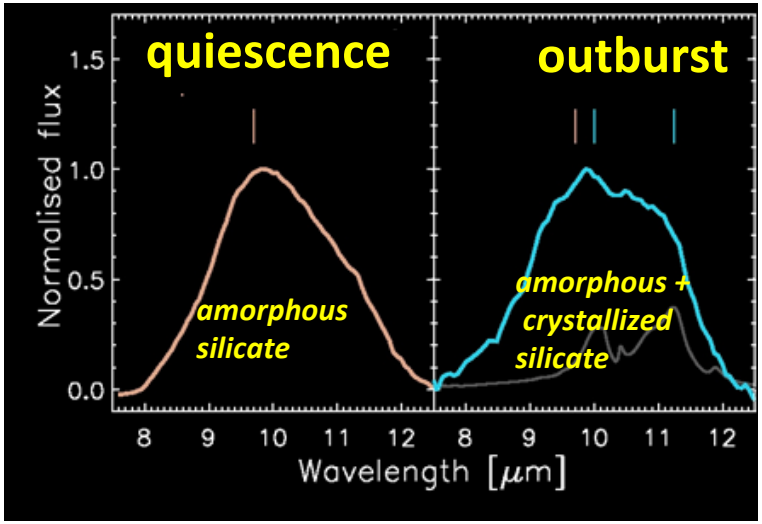
- high spatial resolution
- monitoring capability

Key concepts of the TAOMIR

Recently time variations at mid-infrared wavelengths have been reported

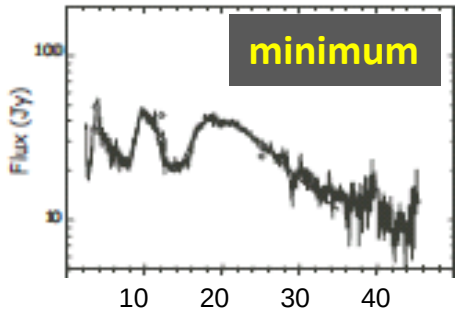
✓ T Tau stars, HAeBe

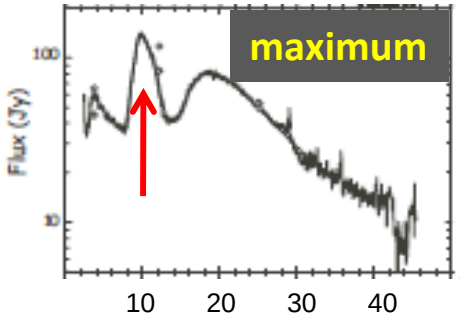
EX Lupi (FU Ori type, T Tauri star)



Abraham+ 2009

✓ AGB stars, Luminous Blue Variables, WR stars





Onaka+ 2002

✓ Comets....

Accurate monitoring at MIR

Monitoring observations at MIR wavelength are difficult

Satellite telescopes → observing time is very competitive

Ground-based telescopes → accuracy of the photometry is a problem

× Unstable sky condition

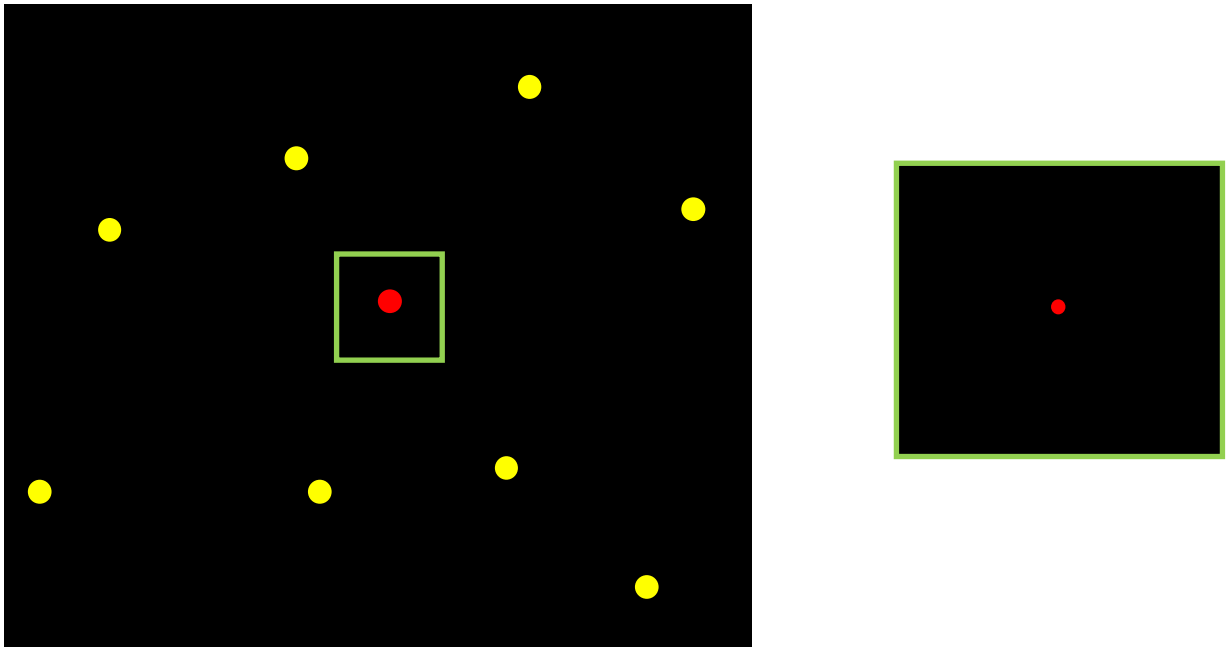
× Limited number of comparison stars
→ **Differential photometry** cannot be applied.

c.f. optical / NIR wavelengths….
a lot of stars + wide filed of view
→ Stars around a target object can be used as a standard of comparison

Concept of the Field Stacker

-Not many stars in MIR sky
-Filed of view of current MIR cameras : not so large (< 1arcmin)

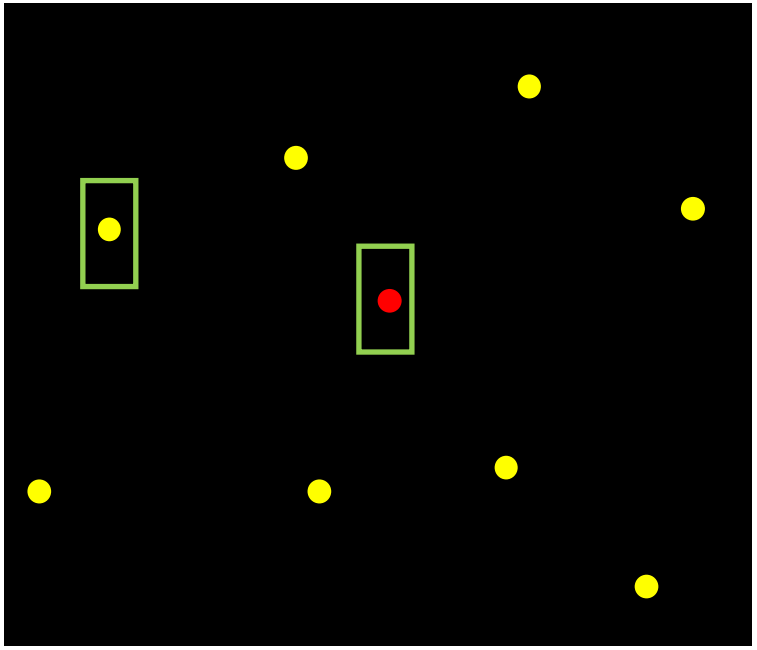
→ Only the target object is observed at once.

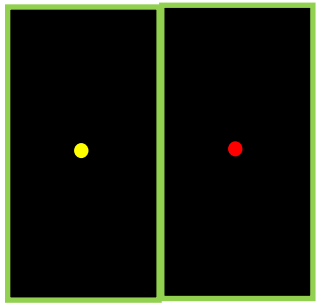


Schematics of the mid-infrared sky

Concept of the Field Stacker

If we can take two (or more) discrete fields simultaneously.....

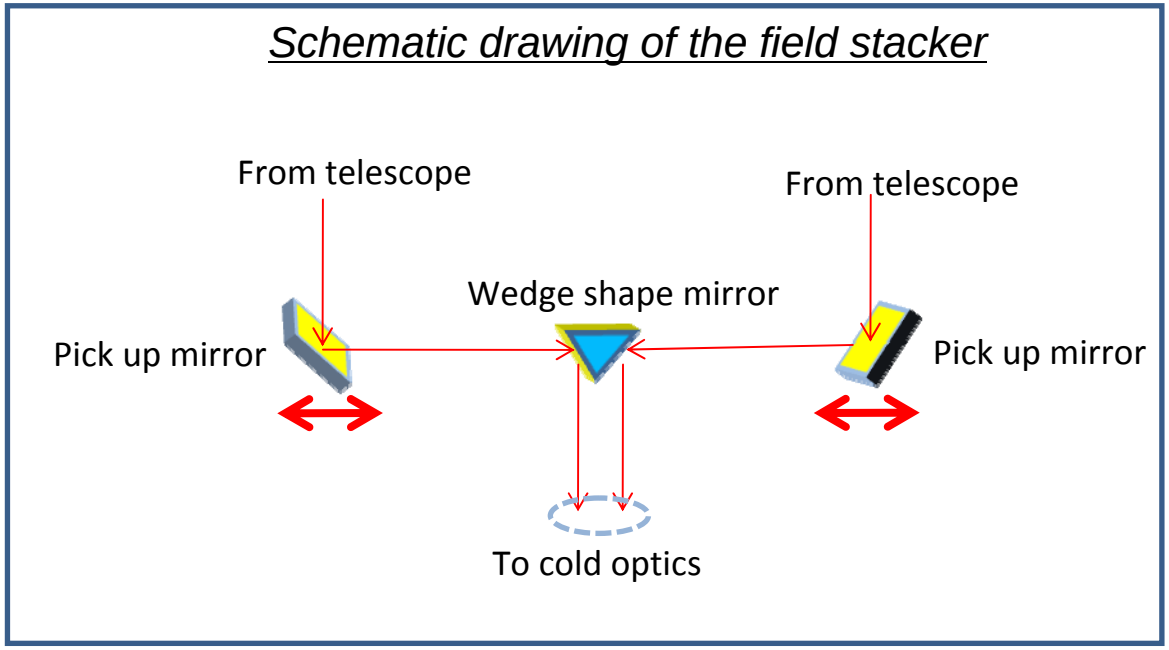




Differential photometric method can be applied
→ improve precision and reliability dramatically

Concept of the Field Stacker

Field Stacker



-- consists of two movable pick-up mirrors and a wedge shape mirror
-- picks up two discrete fields of the sky
-- brings into the instrument field of view

➔ Simultaneous observation of two (or more) stars

Conceptual studies of the Field Stacker

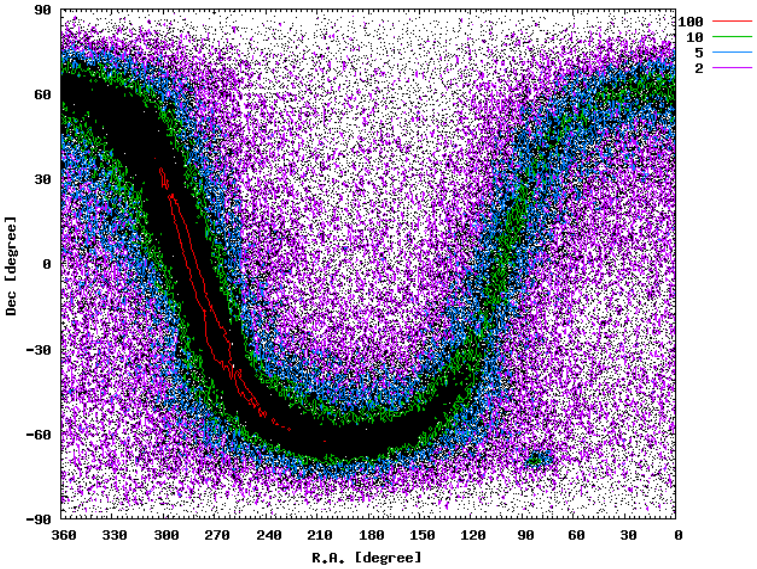
There are enough number of stars ??

We counted # of MIR objects of Akari 9um survey data.
-- Akari 9um survey : ~7M objects with > 50mJy
(~ 1sig1sec sensitivity of the TAOMIR)

Fraction of two or more objects in a field

Field of VIew	> 50mJy	> 300mJy
ϕ 25’	55%	51%
ϕ 12.5’	48%	39%
ϕ 2.5’	23%	13%

You can use the Field Stacker
for ~ 30% of Akari 9um sources



Conceptual studies of the Field Stacker

There are enough number of stars ??

At 18 micron

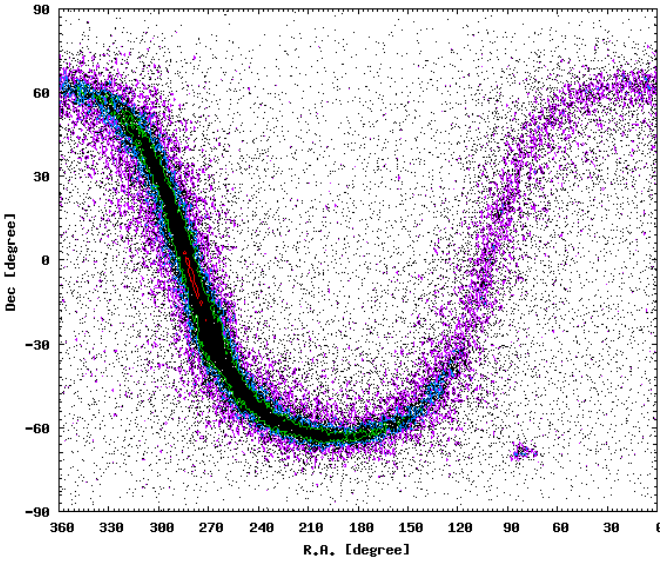
-- Akari 18um survey : ~1.6M objects with > 130mJy

(~ 1sig1sec sensitivity of the TAOMIR)

Fraction of two or more objects in a field

Field of VIew	> 130mJy	> 1000mJy
ϕ 25’	50%	41%
ϕ 12.5’	41%	35%
ϕ 2.5’	15%	0.3%

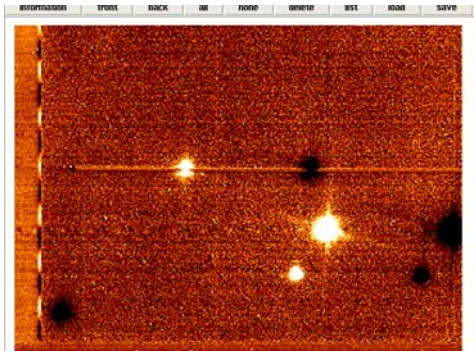
You can use the Field Stacker
for ~20% of Akari 18um sources

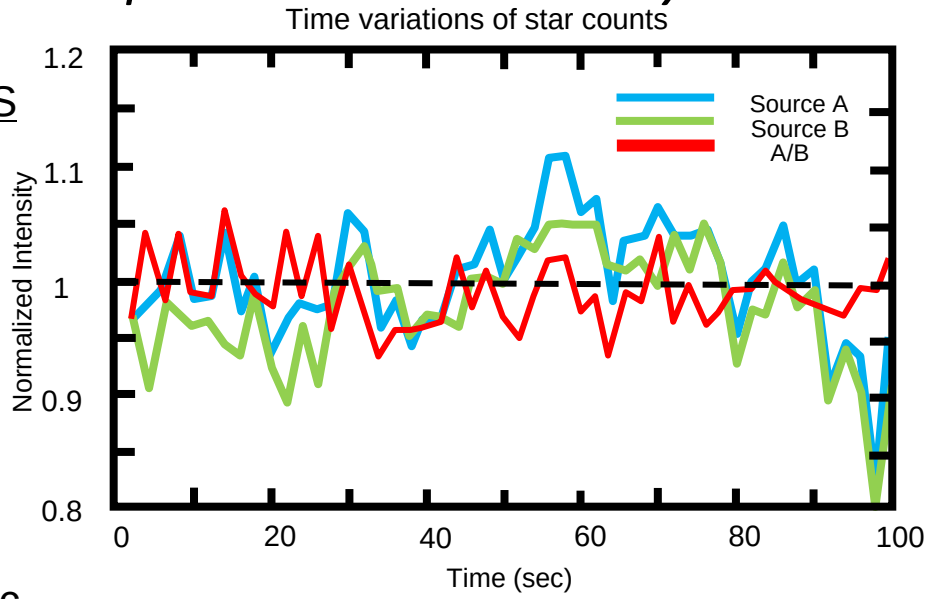


Conceptual studies of the Field Stacker

Simultaneous observation improves the photometric accuracy?

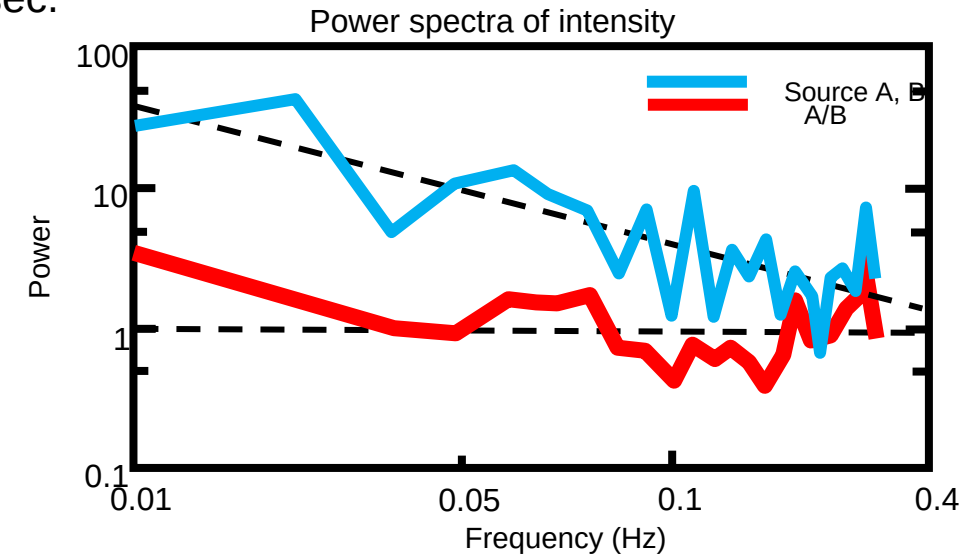
MIR images of two or more stars taken by COMICS





✓Variation of the intensity : 10% within 100 sec.
✓ Variations of two stars are synchronized

Simultaneous observations are effective
(at least within 1 arcmin)

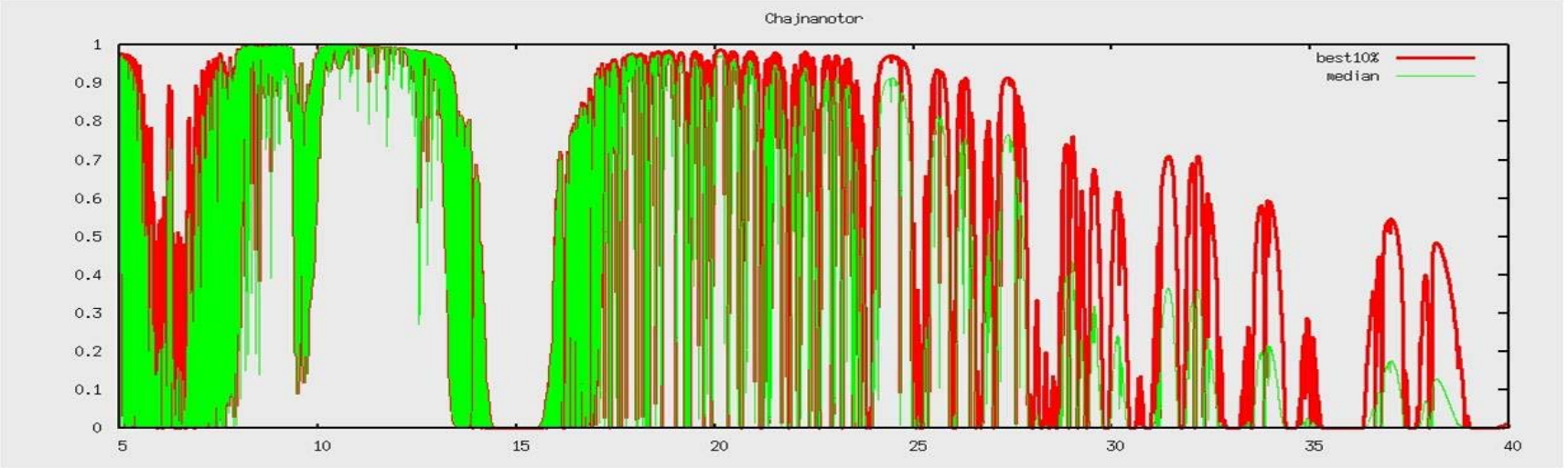


Field stacker for spectroscopy

The field stacker is also useful for spectroscopic observations.

Simultaneous observation enable us
accurate calibration of the atmospheric absorptions

especially for
around the ozone absorption band at 10 micron
Q-band or longer wavelength ranges



Key concepts of the TAOMIR

✓ Wide wavelength coverage

Covers 2-38 micron wavelength region (over 4 octaves!)

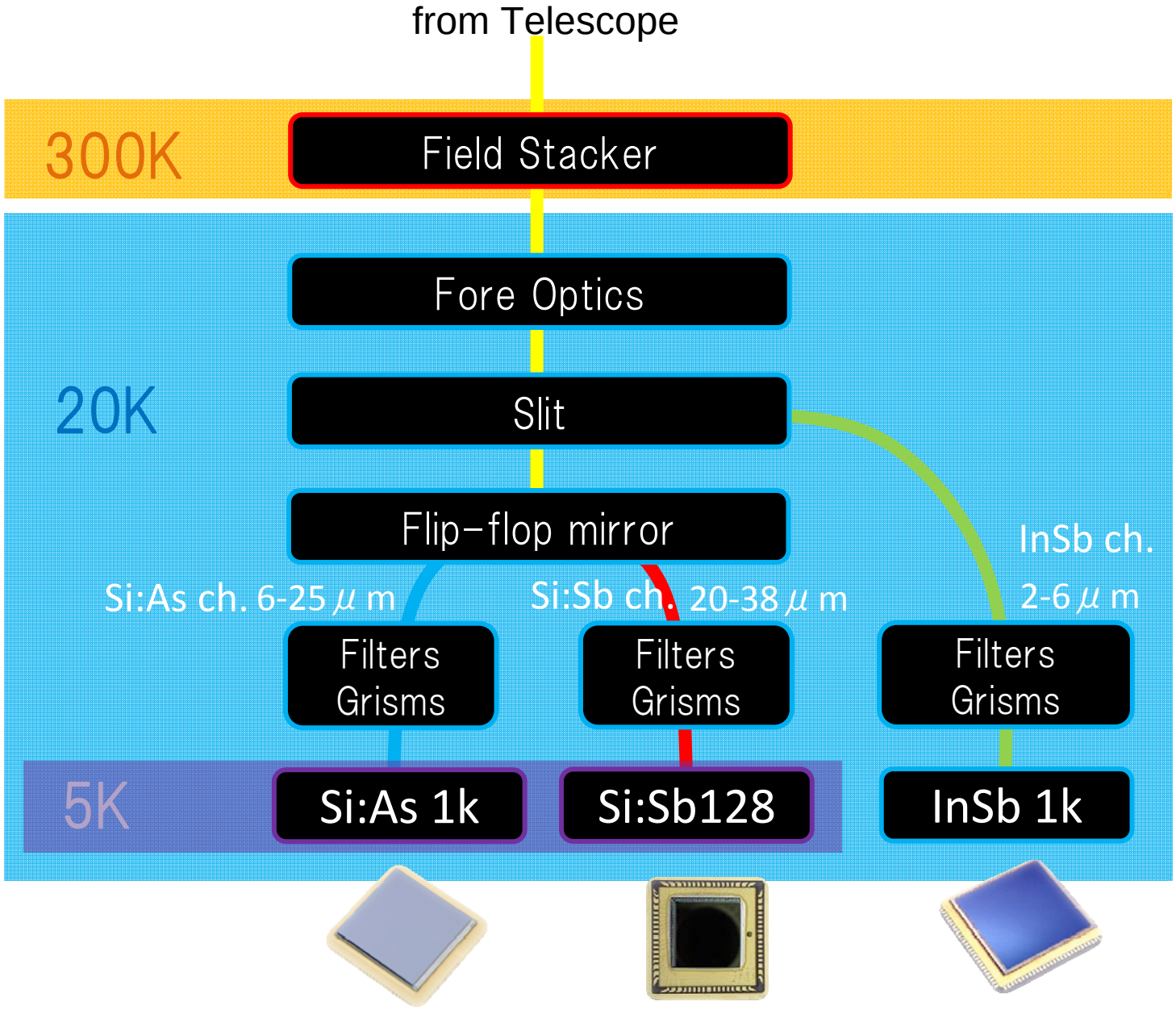
✓ High spatial resolution

Achieves diffraction limited spatial resolution

✓ Accurate monitoring

with the Field stacker

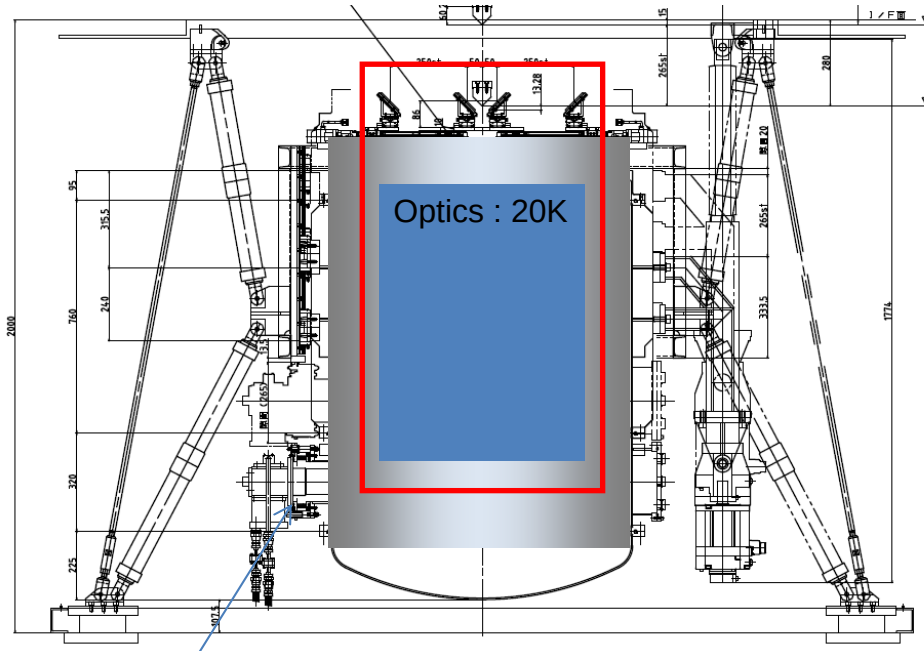
Desgin of the TAOMIR



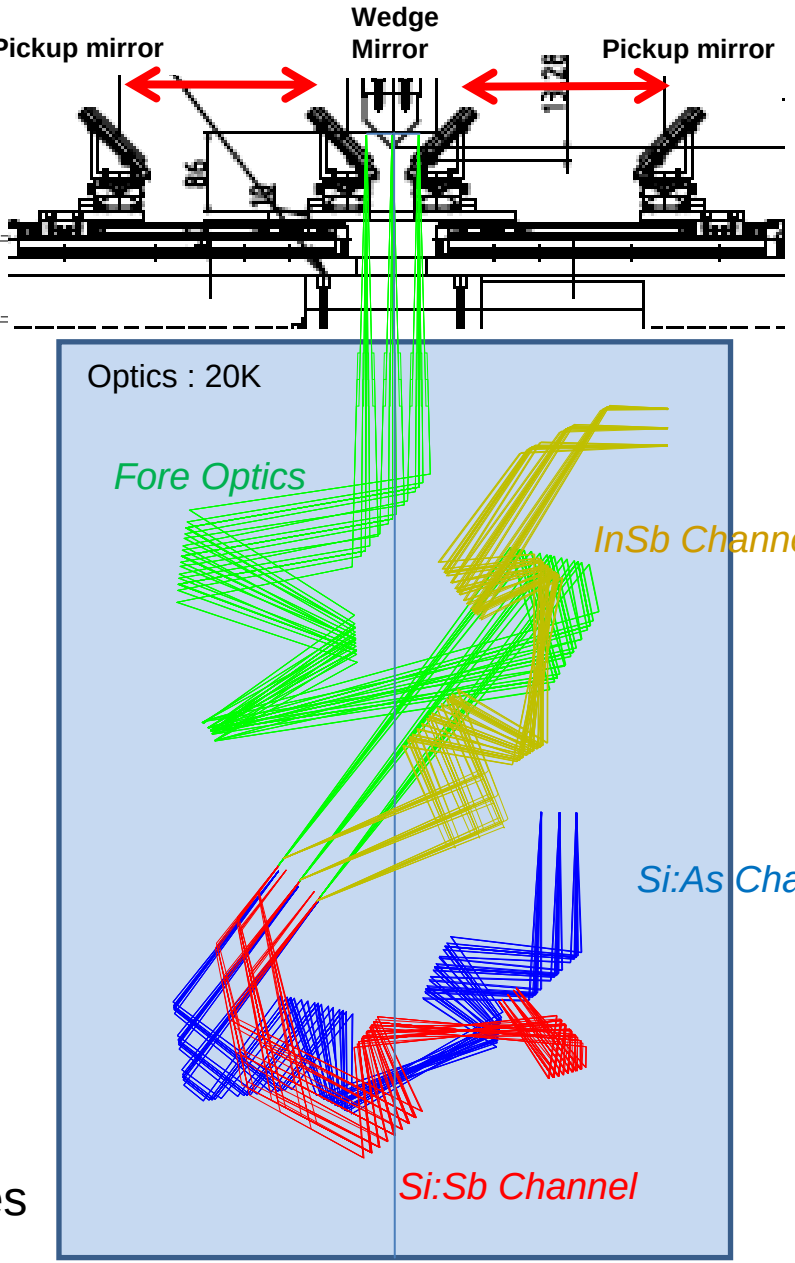
Desgin of the TAOMIR

TAOMIR

↑ **Cassegrain Focus**



two 4K cryocoolers (SHI)



All optics are reflective
→ achieves good performances

TAOMIR : Specifications

Parameters	Values			Notes
# of channels	3 (Si:As / Si:Sb / InSb)			
Detectors	Si:As 1k x 1k	Si:Sb 128 x 128	InSb 1k x 1k	
Wavelength coverage	6-25um	20-38um	2-6um	
Pixel scale	0.1”/pix	0.4”/pix	0.1”/pix	@SUBARU telescope
Field of view	2’ x 2’ or 1’x2’ x 2fields	1’ x 1’ or 0.5’x1’ x 2fields	2’ x 2’ or 1’x2’ x 2fields	@SUBARU telescope
Filters	max 16 filtes (6-25um)	max 16 filtes (20-38um)	max 16 filtes (2-6um)	
Spectroscopy	R ~250 @Nband R~250 @Qband	R~100 @30um	R~300 @Lband (TBD)	w/ grism
Sensitivity (Img.) 1sig1sec	40mJy @10um 130mJy @20um	*(400mJy @30um?)*		for point sources
Instrument size	2m x 2m x 2m , < 2ton			
Others	- A cold chopping unit is installed in fore-optics			

TAOMIR : Specifications

MIR performances compared with COMICS

	TAO-MIR	COMICS
Sensitivity	~40mJy @10um 1s1s	~30mJy @10um 1s1s
Spatial resolution	diffraction limited	diffraction limited
Filed of view	120” x 120” or 60”x120” x2filed	~ 40”x30”
Spectral resolution	R~250 @N-band R~250 @Q-band	R~250/2,500/10,000 @N-band R~2,500/5,000 @Q-band
Monitoring Accuracy	Good (w/ Field Stacker)	---

COMICS has advantages of

slightly higher sensitivity (because TAOMIR has warm optics)

med/high resolution spectroscopic capabilities

TAOMIR will add an unique function of

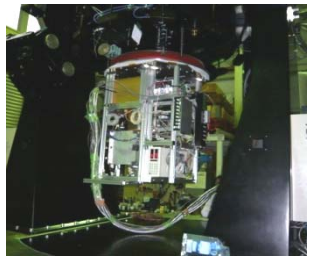
MIR monitoring observations to the SUBARU telescope

TAOMIR : Schedule

2010 **2011** **2012** **2013** **2014……**

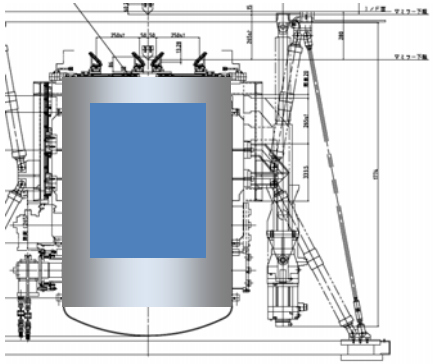
Prototype instrument

MAX38



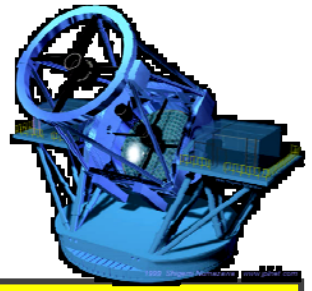
Atacama 1m telescope

TAO-MIR



Desgin and Development

Tests @ Mitaka



Observations
@ SUBARU

Observations
@ TAO

TAO-MIR
first light

Summary of this talk

✓ TAOMIR is a new mid-infrared instrument
- wide wavelength coverage
- high spatial resolution
- accurate monitoring capabilities

✓ TAOMIR employs the field stacker system,
which picks up two discrete field
and brings them into the instrument filed.

➔ improves the precision and reliability

➔ accurate monitoring / spectroscopic observations

a new function to the SUBARU MIR observations!