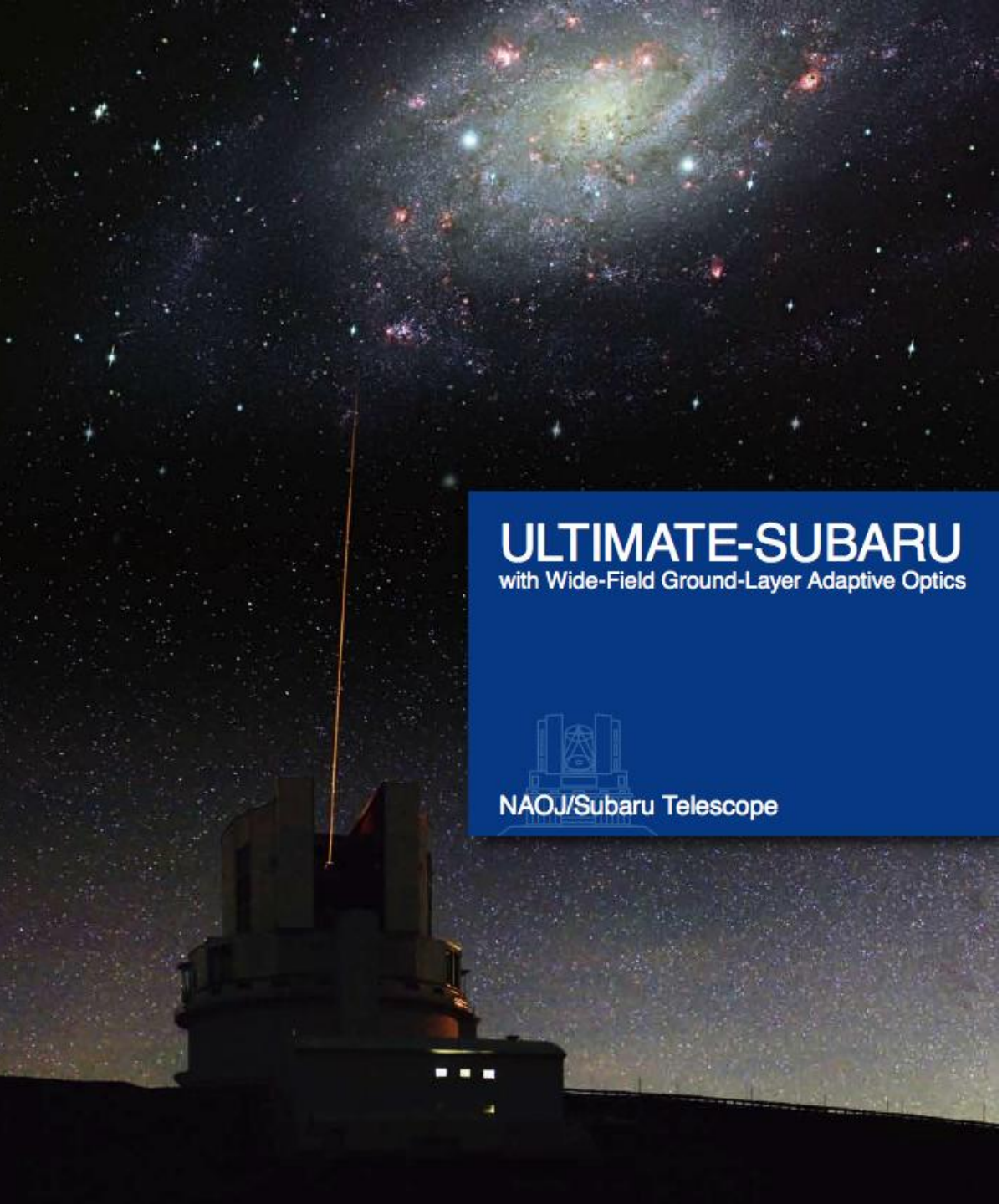
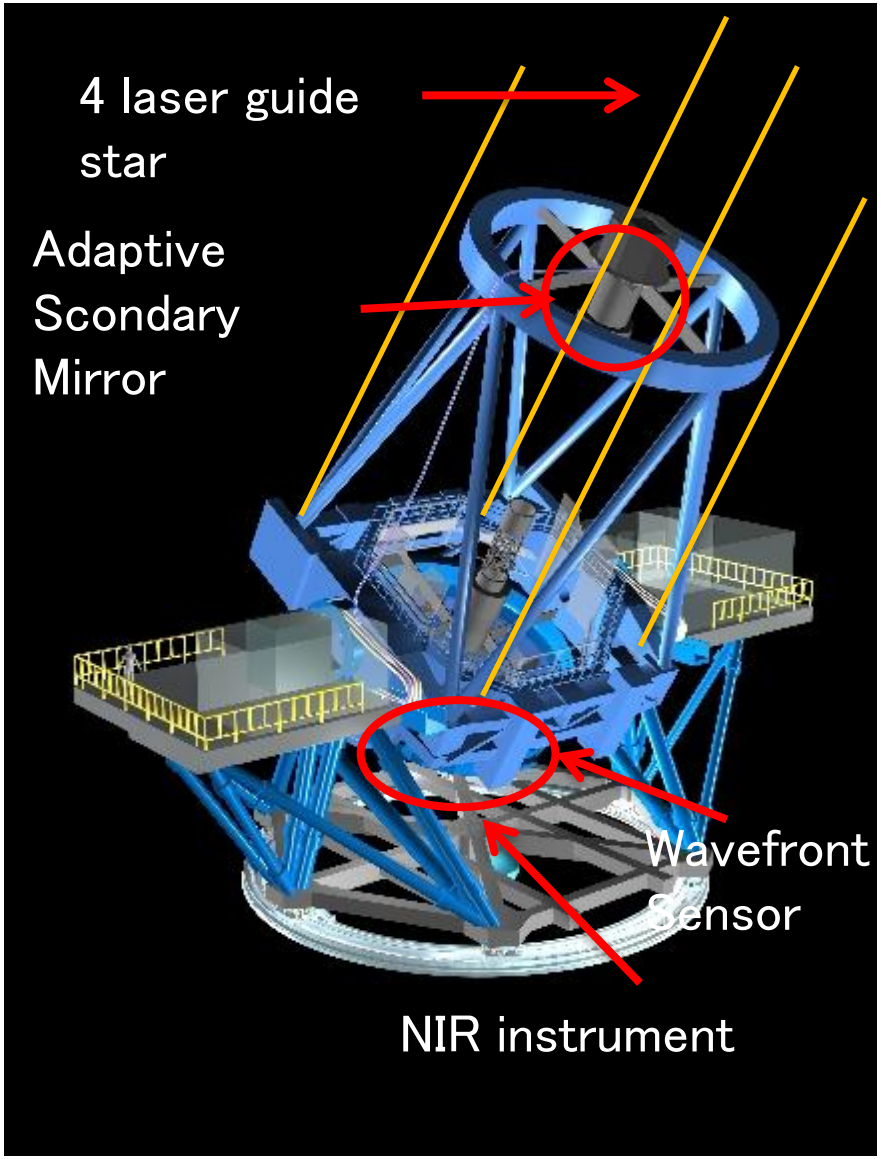
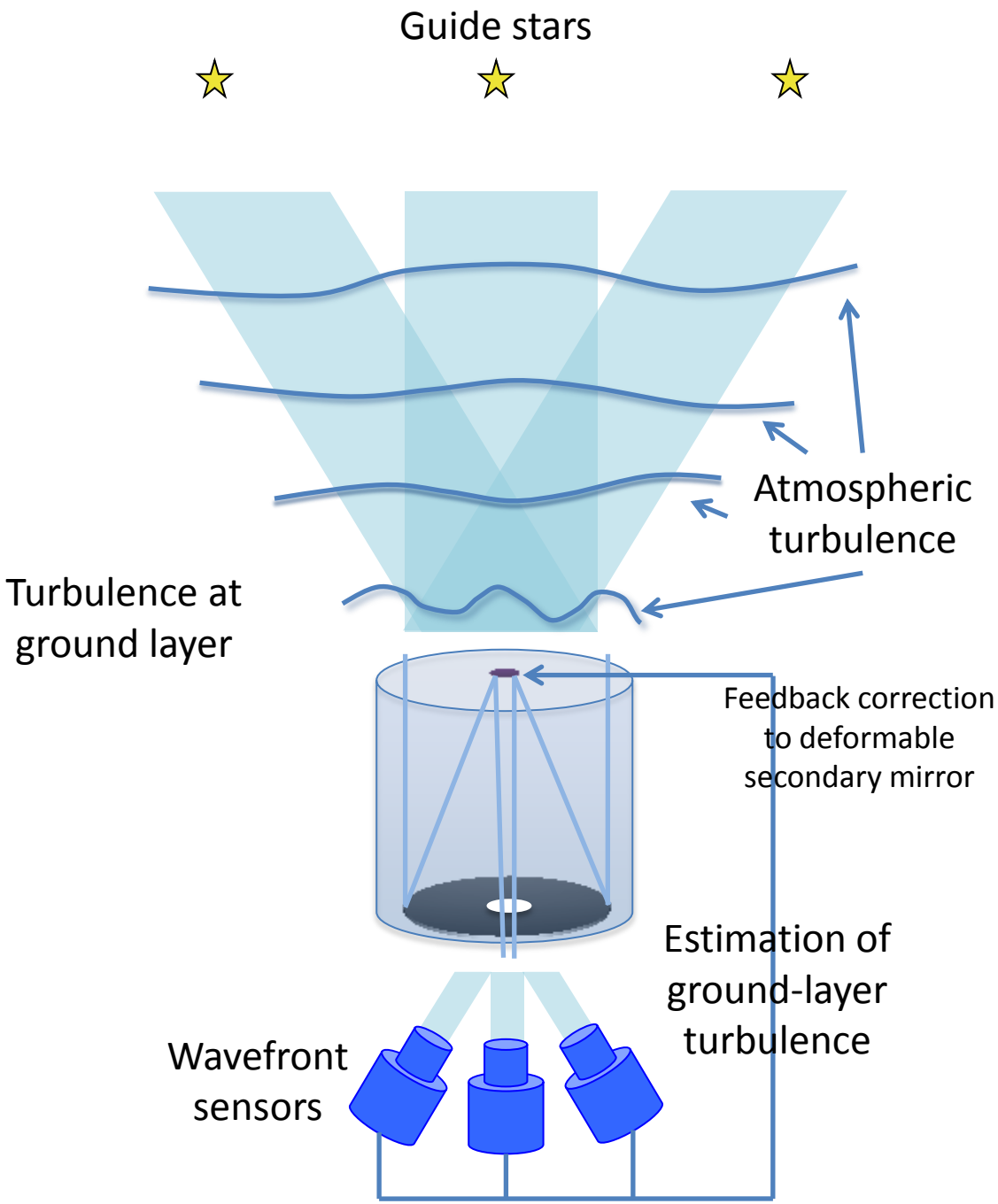


Next generation wide field AO (GLAO) and NIRMOS for Subaru Telescope.

Ultra-wide-field
Laser
Tomographic
Imager and
MOS with
AO for
Transcendent
Exploration
by
SUBARU telescope.

Adaptive Telescope




Guide stars
Atmospheric turbulence
Turbulence at ground layer
Feedback correction to deformable secondary mirror
Estimation of ground-layer turbulence
Wavefront sensors

GLAO - Specifications under Consideration

Guide stars	4 LGSs + 3 NGSs	
DM	Secondary mirror	~1000 actuators, modification of VLT ASM.
HO-WFS	> 8x8 SH	visible, EM-CCD(TBD)
TT(F)-WFS	2x2 SH or quad	visible
Laser	20 W CW	TOPTICA (589nm) (option: Rayleigh)
LGS constellation	15’ in diameter	
Laser Launch	~25cm dia. (TBD)	side launch

NIR Instrument - Specifications under Consideration

Wavelength	0.8-2.5μm	
Plate Scale	0.06-0.1”/pix	
FoV	approx.13‘x13’	Wider with Split FoVs?
Filters	Broad+Narrow	R?, I,z,J,H,K, NB
MOS	Multi Slit Mask	Alternatively Multi-IFU
λ Dispersion	2000(TBD)	Under Investigation

Comparison: Imaging

	Subaru MOIRCS	**Subaru GLAO**	TMT IRIS	HST WFC3/IR	JWST NIRCam
Telescope Aperture	8.2m	8.2m	30m	2.4m	6.5m
Wavelength Coverage	0.9-2.5μm	0.9-2.5μm	0.84-2.4μm	0.9-1.7μm	0.9-2.3μm / 2.4-5.0μm
Spatial Resolution	0.117”/pix 0.4”@2μm	~0.1”/pix 0.2”@2μm	4 mas 10mas@1μm	0.13”/pix FWHM~ 0.25”	32 mas / 64 mas
Field of View	28 □’	~180 □’	0.075 □’	4.65 □’	9.7 □’

Comparison: Spectroscopy

	Subaru MOIRCS	**Subaru GLAO**	TMT IRIS	HST WFC3/IR	JWST NIRSpec
Wavelength Coverage	0.9-2.5μm	0.9-2.5μm	0.84-2.4μm	0.9-1.7μm	0.6-5μm
Spatial Resolution	0.117”/pix 0.4”@2μm	~0.1”/pix 0.2”@2μm	4 - 50 mas	0.13”/pix FWHM~ 0.25”	0.2”x0.45”
Field of View	~25 □’	~120 □’	0.2-10 □”	4.65 □’	12.24 □’(MSA) 3”x3”(IFS)
Functions	Single-Slit MOS IFS	MOS Multi-IFS?	IFS	Slitless	Slits Microshutters IFS
Spectral Resolution	600-3000	-2000?	4000-10000	TBW	100, 1000, 2700

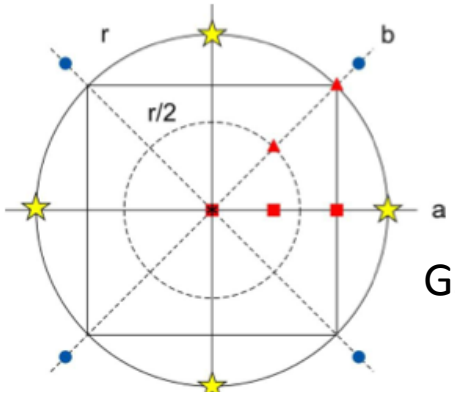
Perfoamance simulation

percentile seeing	25%-ile (good)	50%-ile (moderate)	75%-ile (bad)
height	fractional contribution		
0 km	0.4777	0.5507	0.5000
0.06 km	0.2055	0.1957	0.1872
0.5 km	0.0394	0.0605	0.0860
1 km	0.0137	0.0204	0.0359
2 km	0.1107	0.0234	0.0400
4 km	0.0488	0.0546	0.0518
8 km	0.0313	0.0429	0.0556
16 km	0.0731	0.0518	0.0435
$\int C_N^2 \times 10^{-13} \mathrm{m}^{1/3}$	3.5749	5.2736	8.1315
$r_0(0.5\mu\mathrm{m})$	14.9cm	11.8cm	9.1cm
fwhm(0.5μm)	0.56"	0.73"	0.97"
fwhm(AG)	0.49"	0.64"	0.84"

Turbulence profile

Add to match seeing statistics at Subaru.

TMT site test at 13N



★ : LGS (10mag)、●TTFGS (18mag)

GS asterism

FWHM

	R	J	H	K
Seeing	0.65"	0.51"	0.49"	0.44"
GLAO	0.41"	0.27"	0.23"	0.20"

Ensquared Energy (0.24"x0.24")

	R	J	H	K
Seeing	9%	12%	15%	17%
GLAO	16%	29%	36%	41%

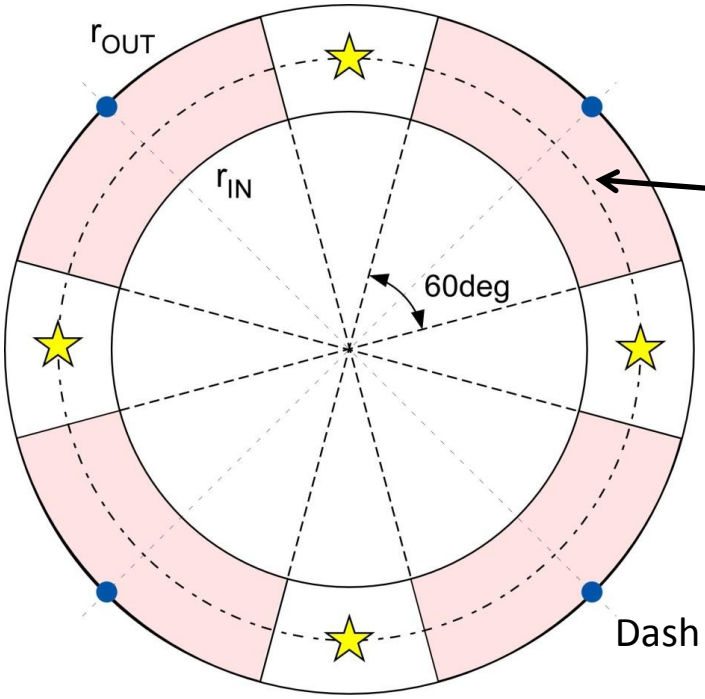
Zenith angle dependency

	0°	15°	30°	45°	60°
Seeing	0.44"	0.49"	0.52"	0.60"	0.76"
GLAO	0.20"	0.28"	0.31"	0.38"	0.55"

S. Oya

Sky coverage

★:LGS
●: TTFGS



Dash circle line: 7.5’ radius

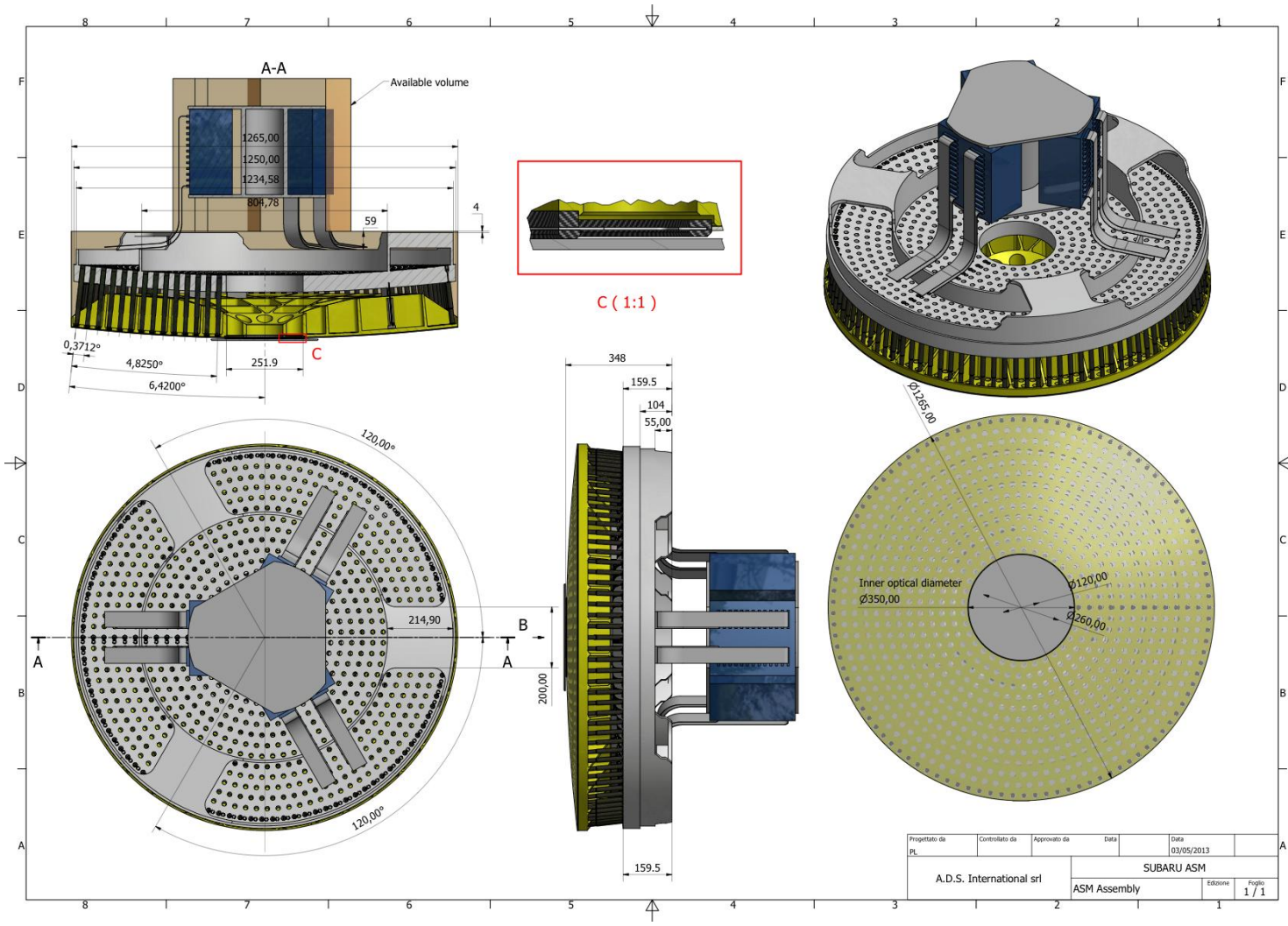
D. Simons, Gemini technical notes TN-PS-G0030, (1995).

r(in, out) = r_circ	TTFGS(R-band)	b: 10~20 deg	30~50 deg	60~90 deg	
(7' ,8') = 1.6'	< 18 mag	> 6.7	> 3.0	> 1.8	
	< 19 mag	> 10.7	> 4.8	> 2.8	1 mag fainter
(7', 8.5') = 2.0'	< 18mag	> 34.7	> 7.4	> 4.3	1‘ dia. wider

Conceptual study

- Performance simulation update
- Deformable secondary mirror
- Laser system
- Telescope interface and modification
- Optical design of NIR instrument

Preliminary model for ASM



Mirror Dia: 1265mm

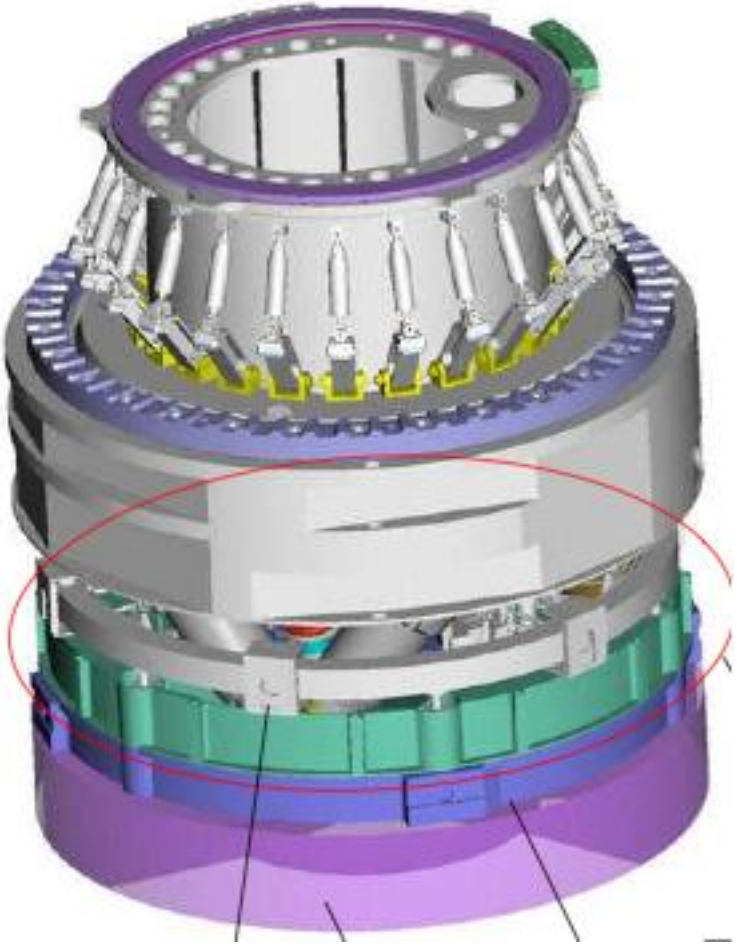
Actuators: 924
Spacing: ~ 35 mm

Center obscuration:
350mm

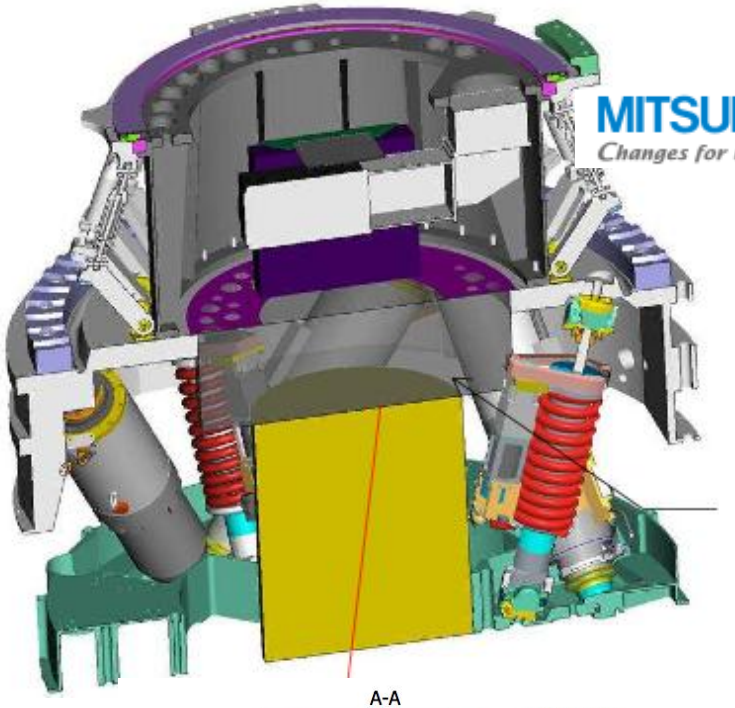
MICROGATE

ADS
A.D.S. International

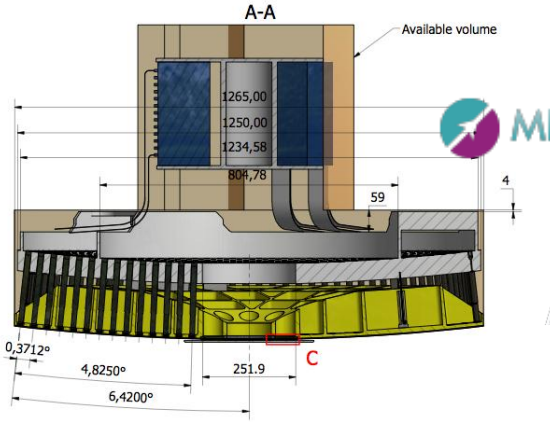
Interface to existing IR M2



MITSUBISHI
Changes for the Better



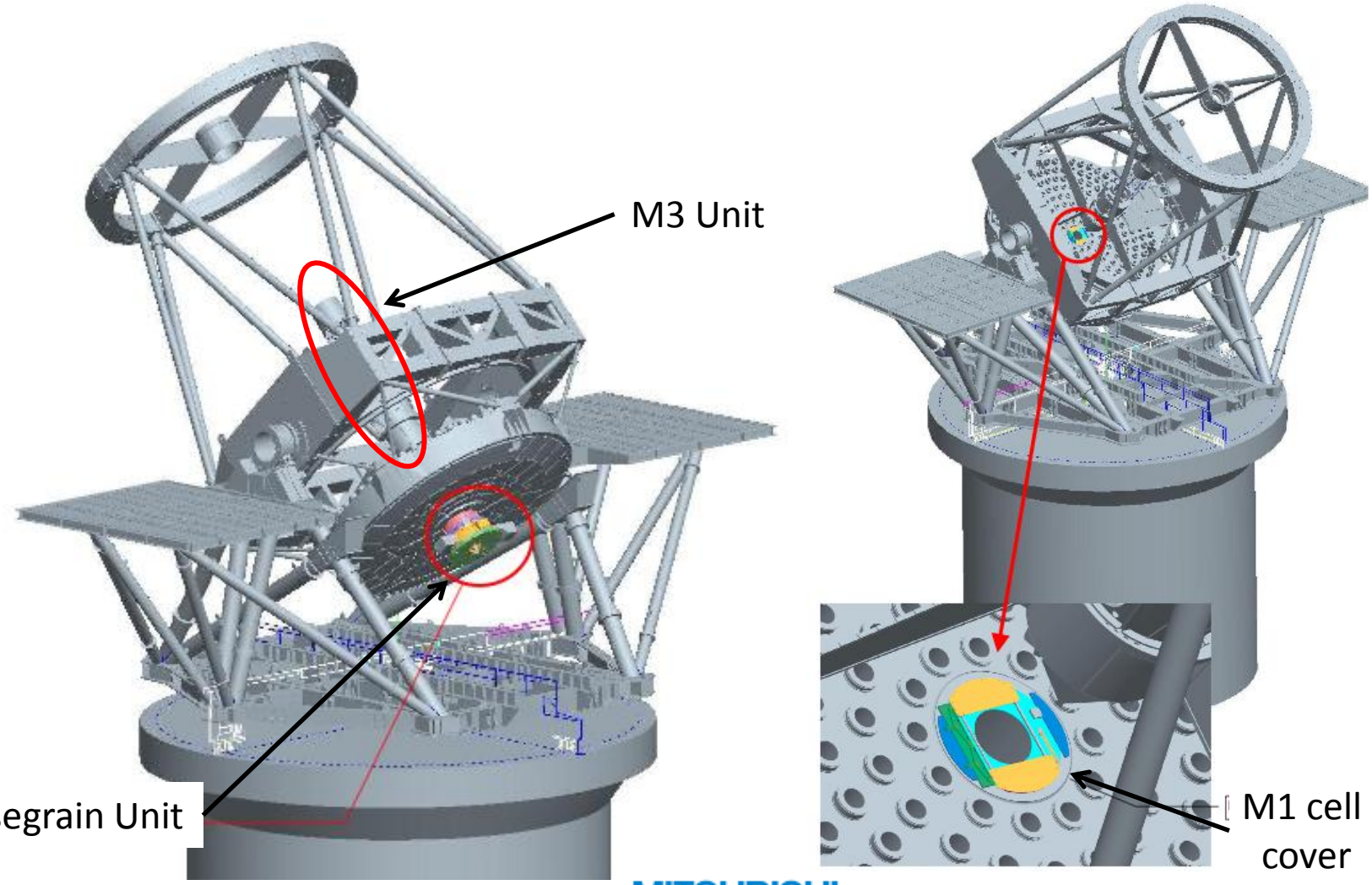
MITSUBISHI
Changes for the Better



MICROGATE

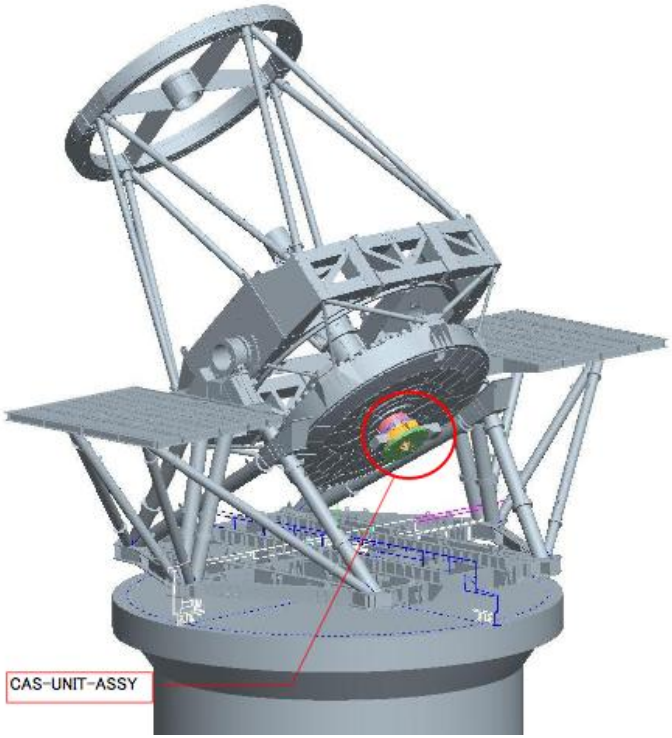
ADS
A.D.S. International

Vignetting by telescope structures

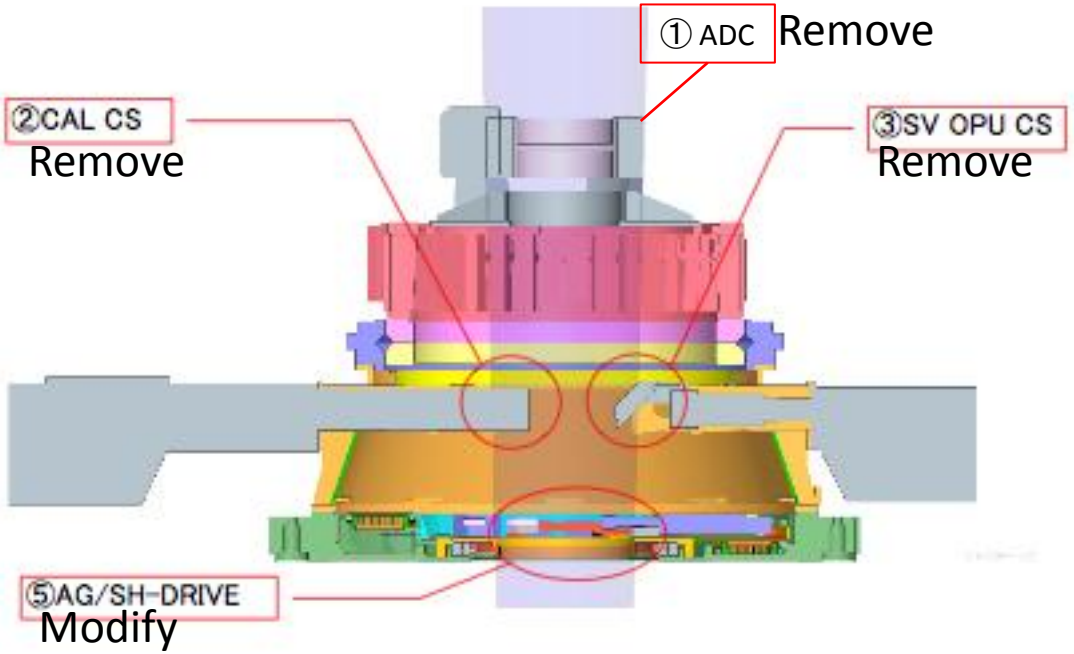


MITSUBISHI
Changes for the Better

Cassegrain Unit



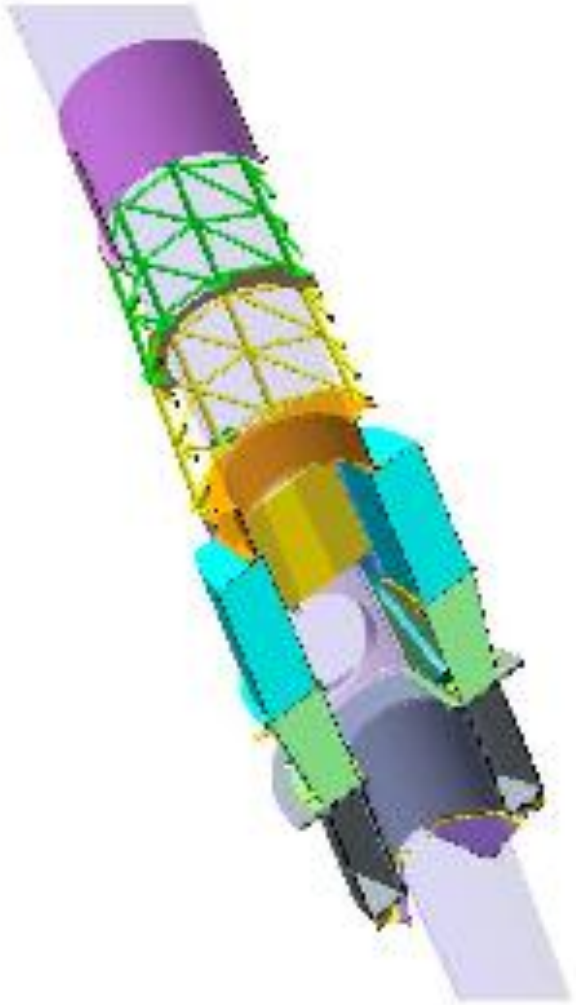
ϕ16 arcmin

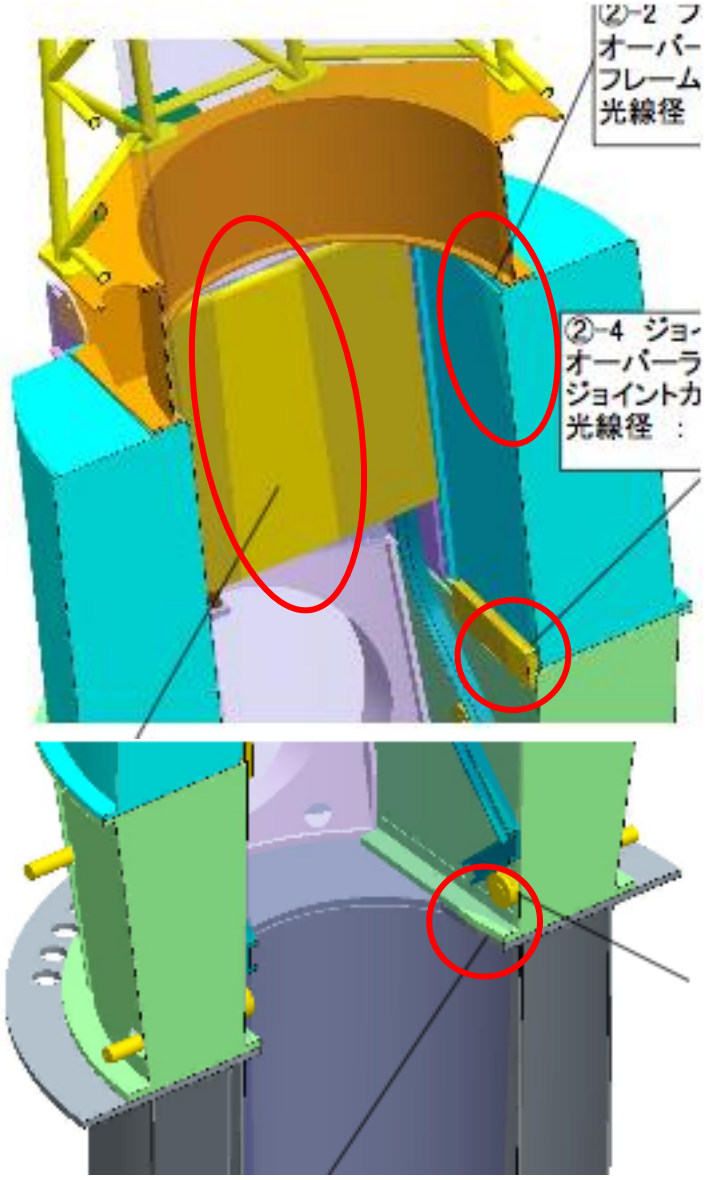


MITSUBISHI
Changes for the Better

M3 unit

ϕ16 arcmin

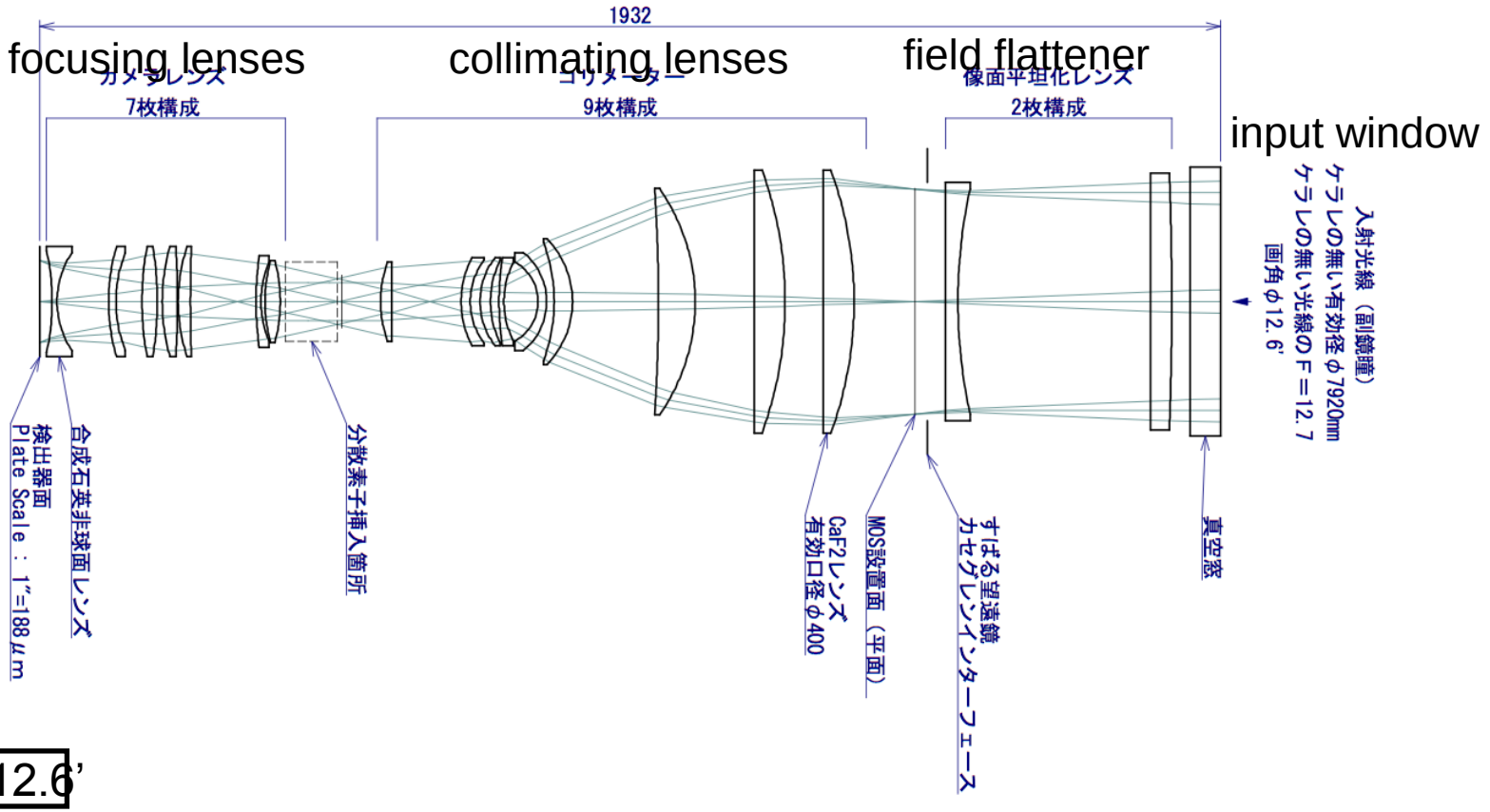




MITSUBISHI
Changes for the Better

Wide-Field NIR Imager+Multi-Object Spectrograph (A case without FoV splitting)

- Optical Design by Dr. Yamamuro (Optcraft)



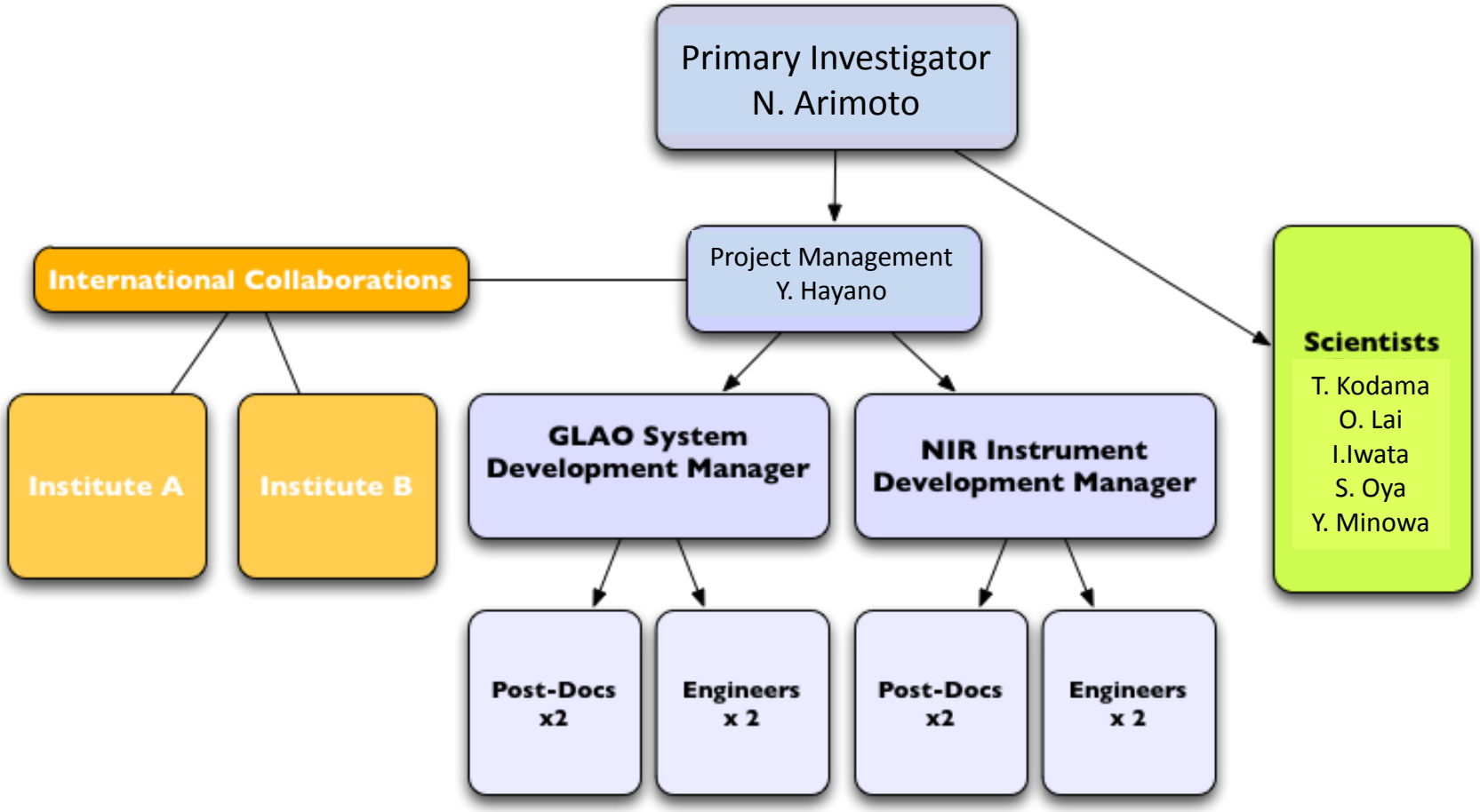
FoV 12.6’

Project preparation

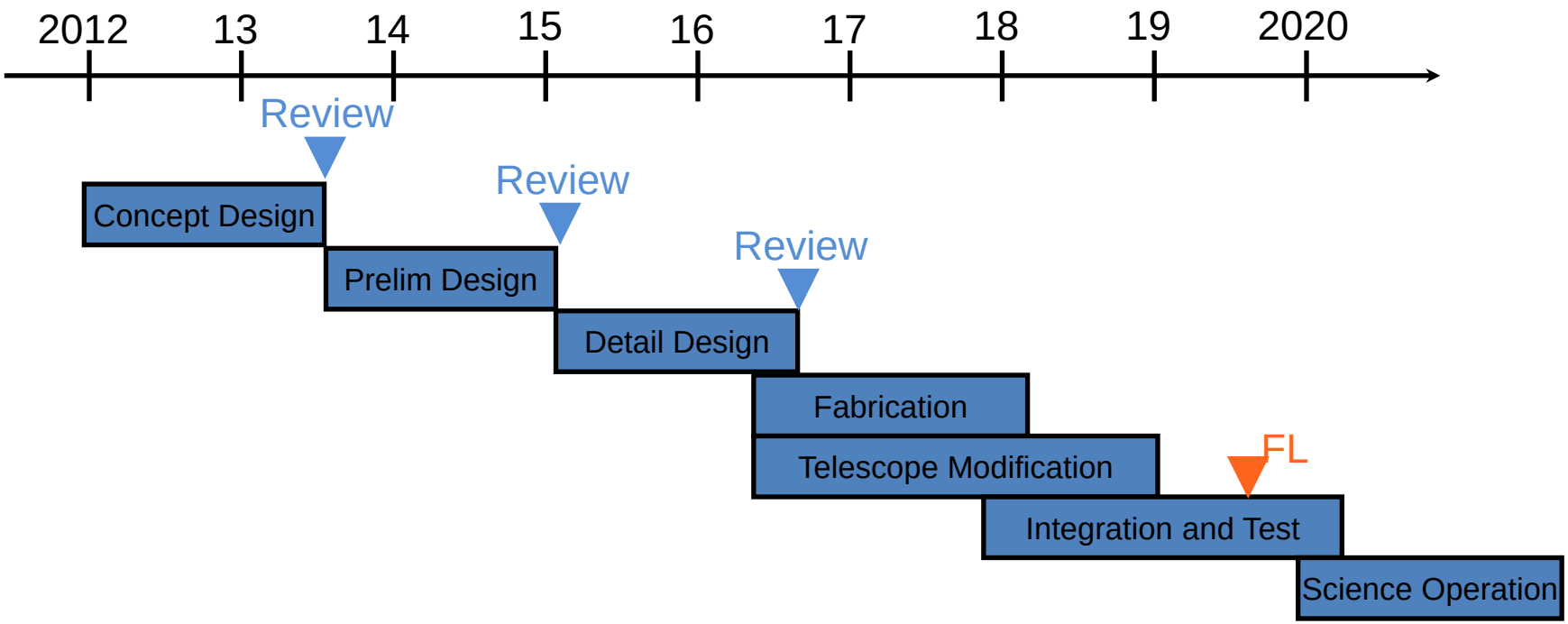
- Project organization
  - PI (Nobuo Arimoto, Director of Subaru Telescope.)
  - Project management (Hayano)
  - Project AO scientist (Oya, Lai)
  - Project scientist (Kodama, Iwata, Minowa)

- International collaborators
  - Gemini, HIA, ASIAA etc.

Project organization



Schedule



AO188/LGS

HSC

PFS

TMT

Feasible schedule (plan)

- Upgrade to Adaptive Telescope
  - Adaptive Secondary Mirror.
    - Grant-in-Aid, Specially Promoted Research, (Tokubetu-shuishin), 2014 or 2015, 5 years,
  - Wavefront sensor and lasers.
    - Grant-in-Aid, New research field, (Shin-gakujutu), 2014 or 2015, 5 years.
    - Collaboration with biology researcher.
  - GLAO + Nu MOIRCS

- NIR wide field instrument.
  - Imager, MOS or M-IFS.
  - International collaboration or other Grant-in-Aid.

Cost Estimation

Item	Cost (USD)
Adaptive Secondary Mirror	5-10M
Laser System	4-8M
Wavefront Sensor System	~3.5M
Computers	~0.2M
Telescope Modifications	15-20M
Instruments	5-20M
(Additional) Human Resources	~2M
Total	35-60M