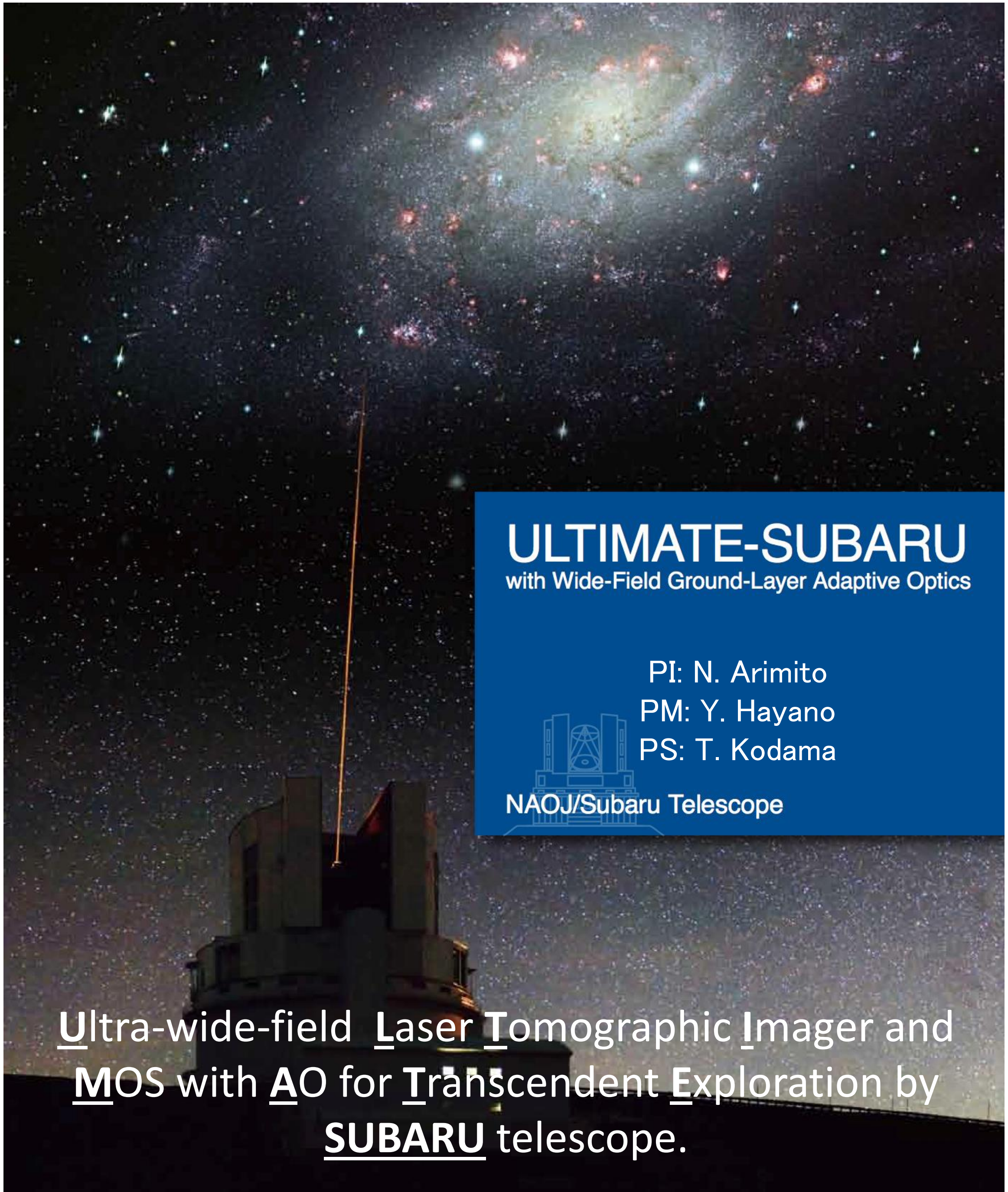
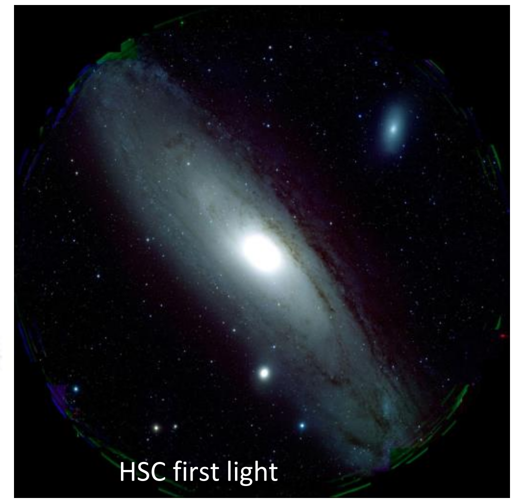
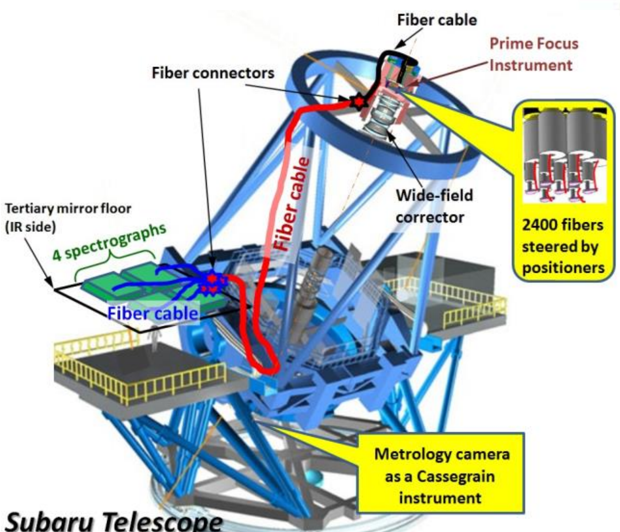

ULTIMATE-SUBARU
with Wide-Field Ground-Layer Adaptive Optics
PI: N. Arimito
PM: Y. Hayano
PS: T. Kodama
NAOJ/Subaru Telescope
Ultra-wide-field Laser Tomographic Imager and MOS with AO for Transcendent Exploration by SUBARU telescope.

Project overview

- Why we need ULTIMATE-SUBARU?
- GLAO System overview
- Seeing at Mauna Kea (next talk by Oya-san)
- GLAO simulation (next talk by Oya-san)
- Project organization
- Schedule and budget
- Technical studies
  - Adaptive secondary mirror study
  - Telescope modification study
  - Wide field imager

Key instruments at Subaru Telescope
鼎(...t)





HSC
(vis)

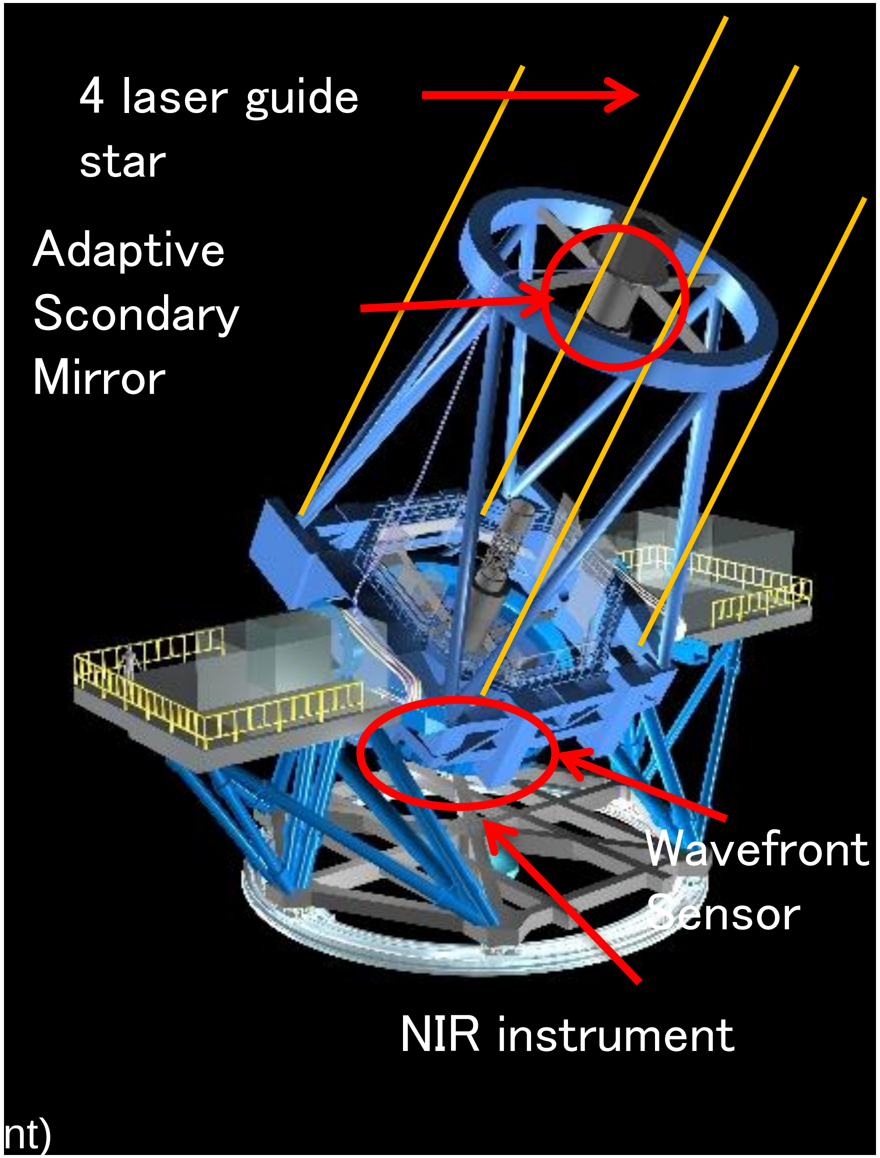
PFS
(vis)

GLAO

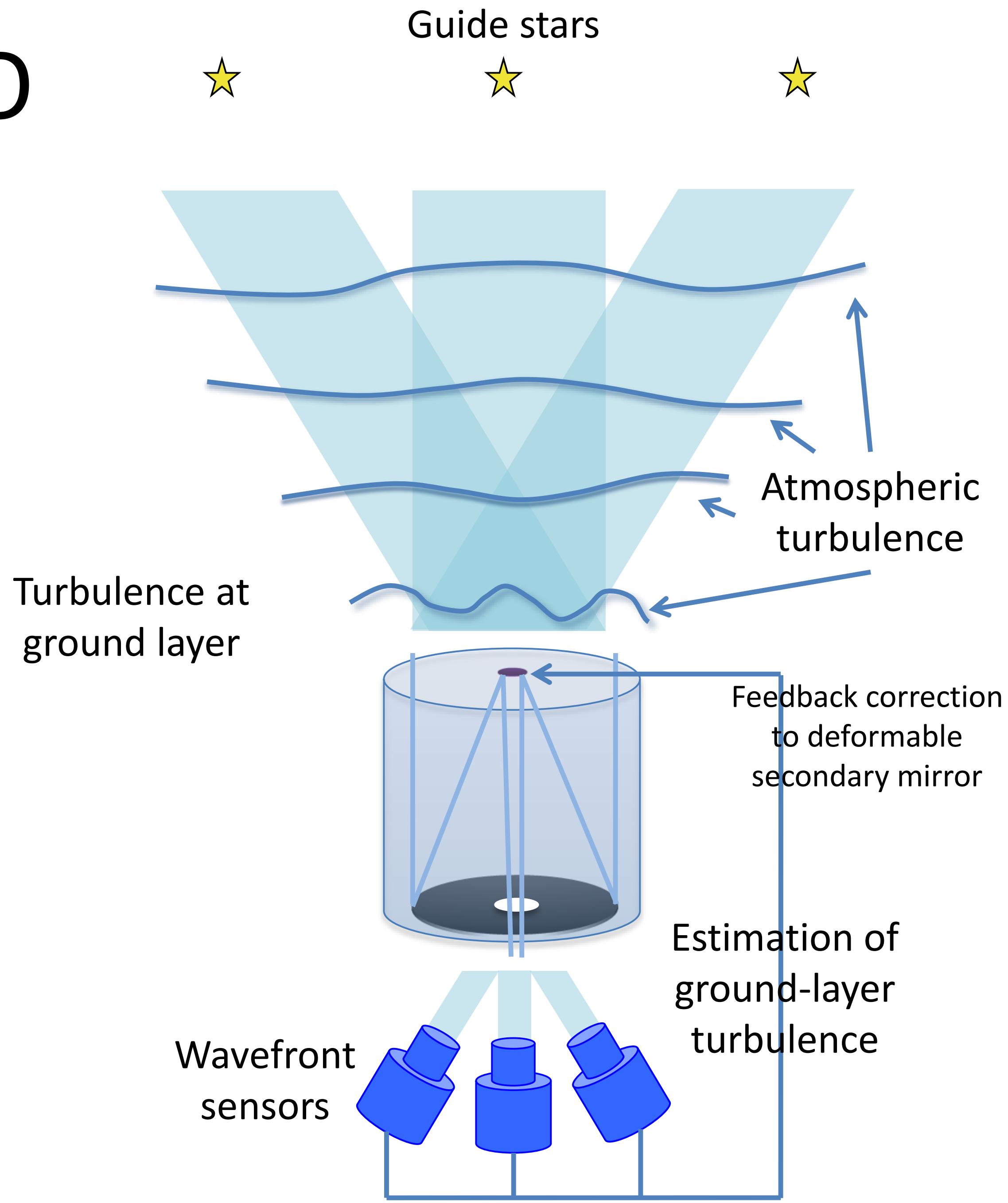
NIR instrument

System Overview

1. **Ground Layer AO with Adaptive Secondary Mirror (4 LGSs)**



GLAO


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

System Overview

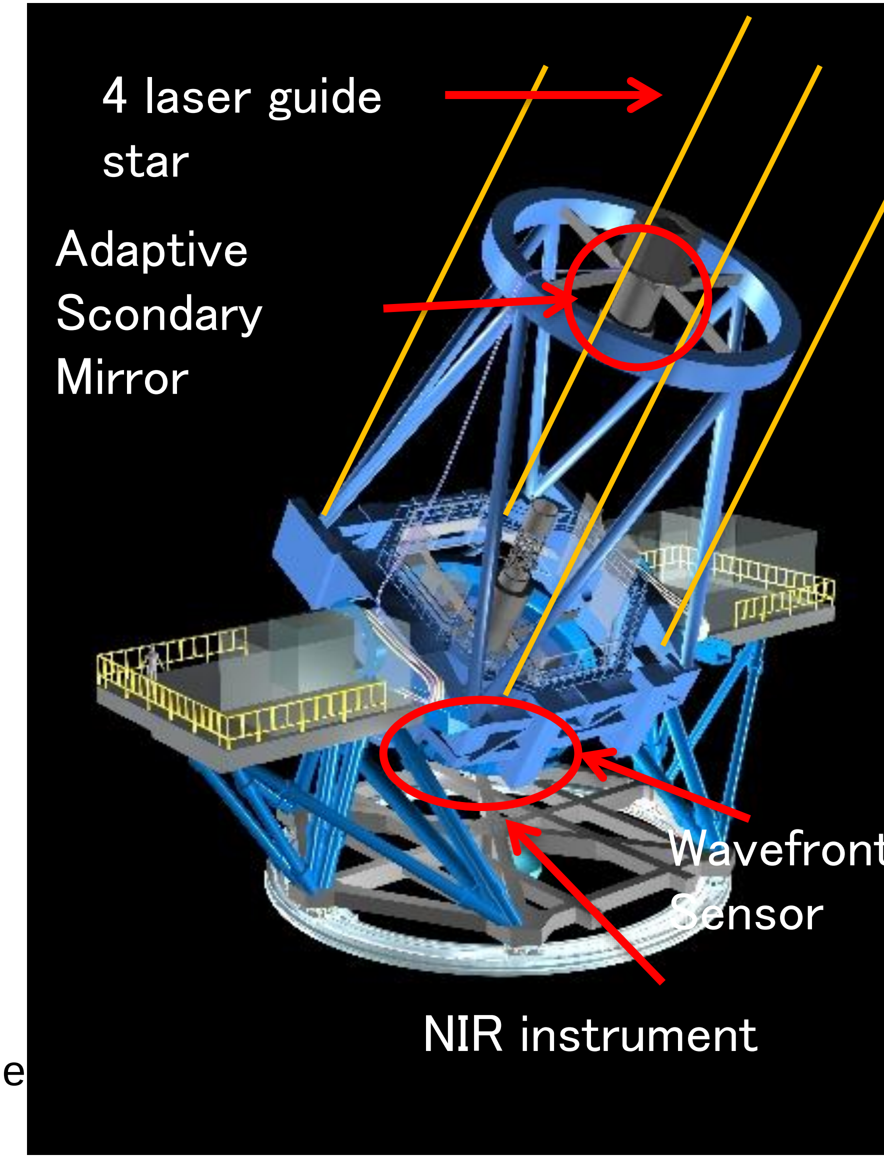
1. **Ground Layer AO with Adaptive Secondary Mirror (4 LGSs)**

1. **Wide-field Near-IR Instrument (Imager + MOS or M-IFU)**

→ Seeing improvement (FWHM 0.4”→0.2”) over FOV ~15’

- **Higher sensitivity equivalent to 2x telescope aperture*1**
- **6 times wider FOV*2**
  - **~200 times wider FOV compared with AO188/LGS+IRCS**

*1 For point sources.
*2 Relative to MOIRCS (seeing limited NIR instrume



GLAO - Specifications under Consideration

Guide stars	4 LGSs + 3 NGSs	
DM	Secondary mirror	~1000 actuators, modification of VLT ASM.
High-order WFS	> 8x8 SH	visible, EM-CCD(TBD)
Tip-tilt-focus 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

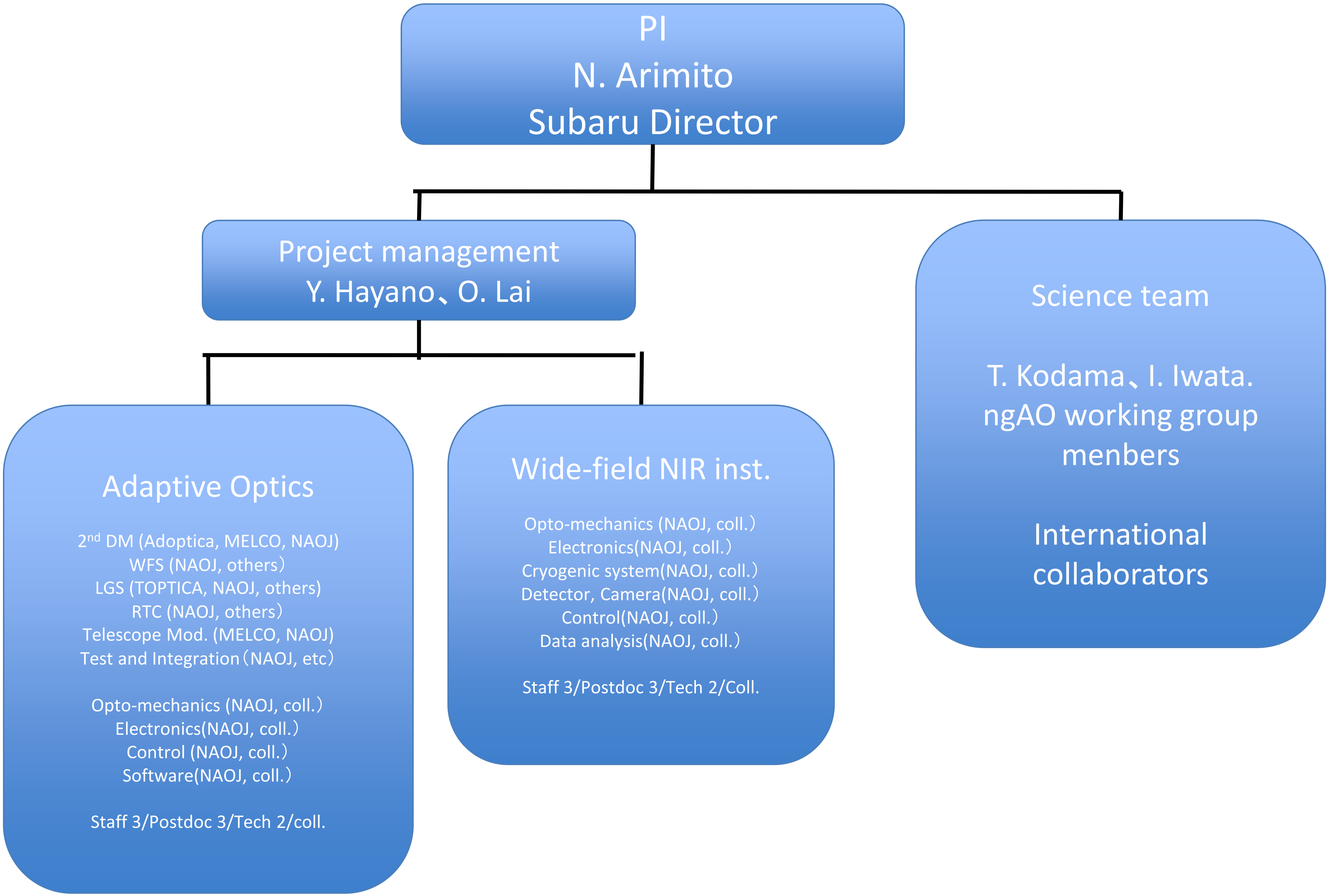
Main Science Targets

- “Anatomy” of galaxies at z=1 – 3
  - *What are the key parameters to drive the galaxy evolution?*
  - *What determines morphologies of the galaxies?*
  - Large-Scale Near-IR Surveys (Imaging and spectroscopy) of about 5000 galaxies

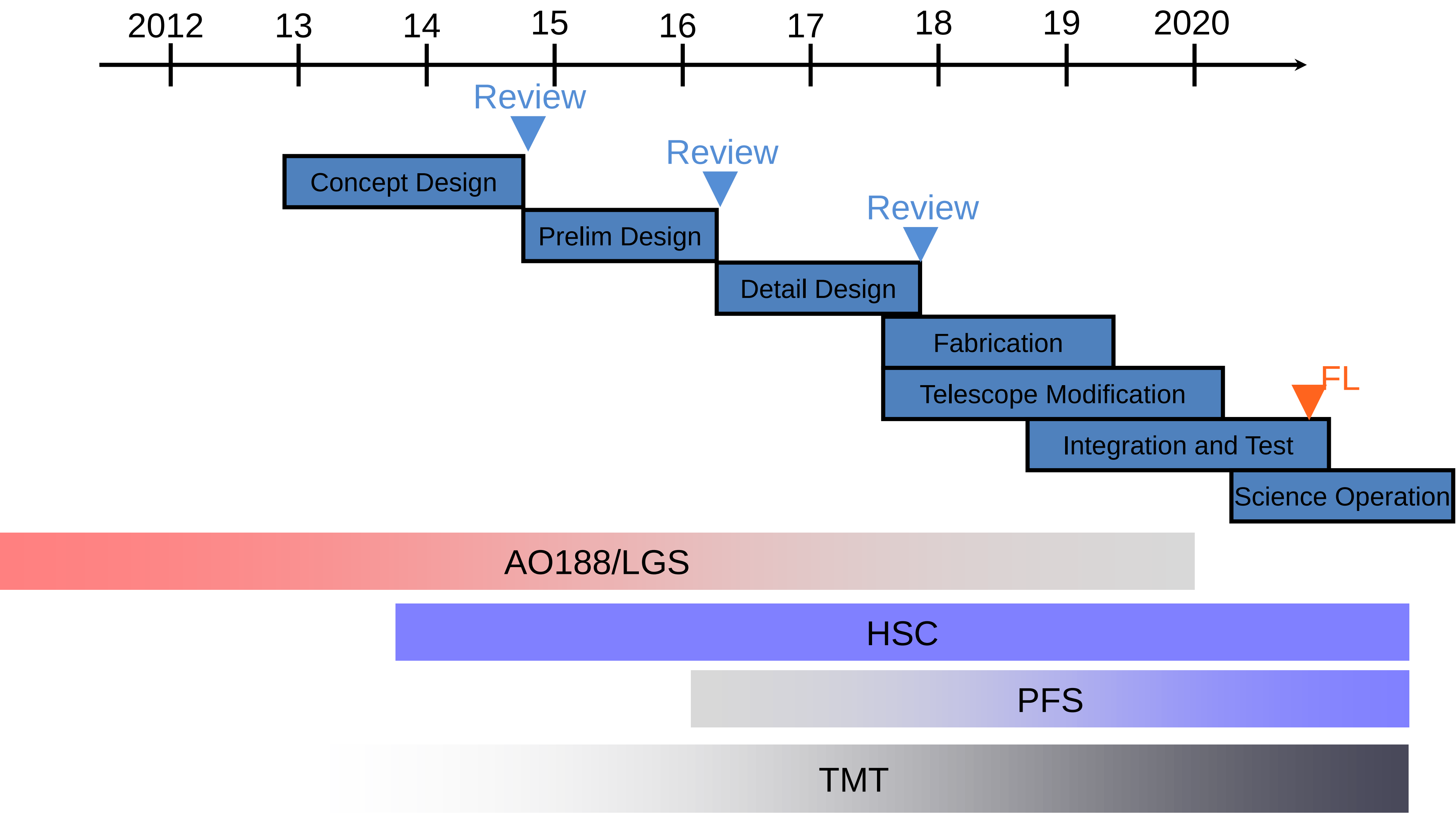
- Discovery of the Most Distant Galaxies at z>7.5
  - Understand of the Cosmic Reionization
  - NBF imaging survey (～180 $arcmin^2$), 100 galaxies.

  → Target sample for TMT.

ULTIMATE-SUBARU organization



Schedule


2012
13
14
15
16
17
18
19
2020
Review
Review
Review
Concept Design
Prelim Design
Detail Design
Fabrication
Telescope Modification
FL
Integration and Test
Science Operation
AO188/LGS
HSC
PFS
TMT

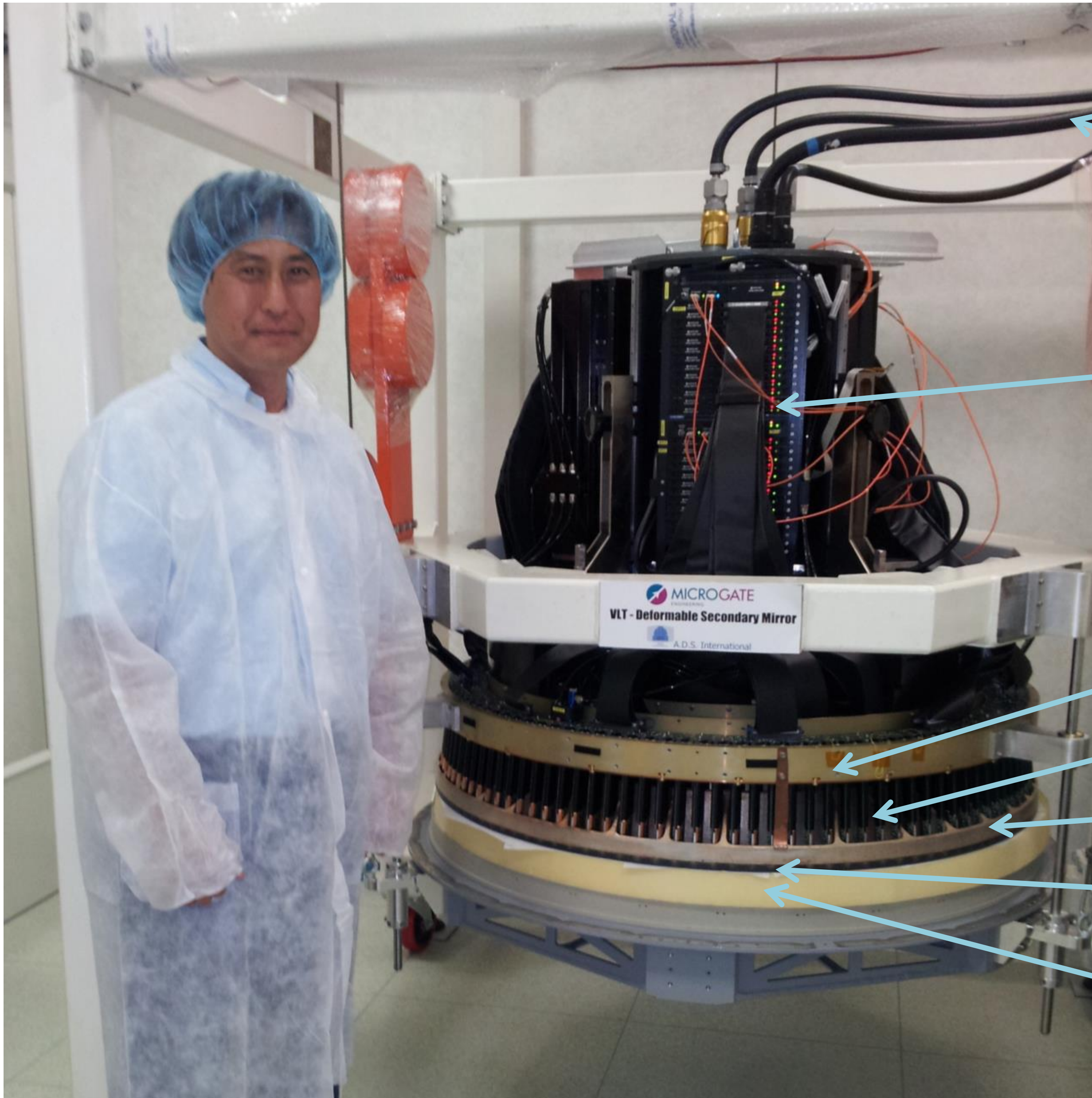
Cost estimation, budget

Items	Cost	Budget
ASM system	6 M	**Grant-in-aid Scientific Research, etc.**
Laser system	0.5 – 4 M	**Grant-in-aid Scientific Research, etc.** **(if Rayleight LGSs, cost is 1/10)**
Wavefront sensor unit	1 M	Grant-in-aid Scientific Research (International collaboration)
Realtime controller	0.5 M	Grant-in-aid Scientific Research, etc. (International collaboration)
Telescope modification	5 – 8 M	NAOJ budget
NIR instrument	0 – 10 M	Existing instrument at first. (MOIRCS or MOIRCS upgrade etc.)
Manpower	2 M	NAOJ budget and Grant-in-aid Scientific Research
Contingency	5 M	
Total	20 – 36.5 M	

1. Grant-in-Aid for Scientific Research on Innovative Areas, 2015-2019
2. Grant-in-Aid for Specially Promoted Research, 2016-2020
3. Grant-in-Aid for Scientific Research (Category S), 2020-2024

Technical studies

Adaptive Secondary mirror for VLT



Interface cables
(Power, Network, coolant)

Control electronics

Hexapods will be located around control electronics.

Actuator plate

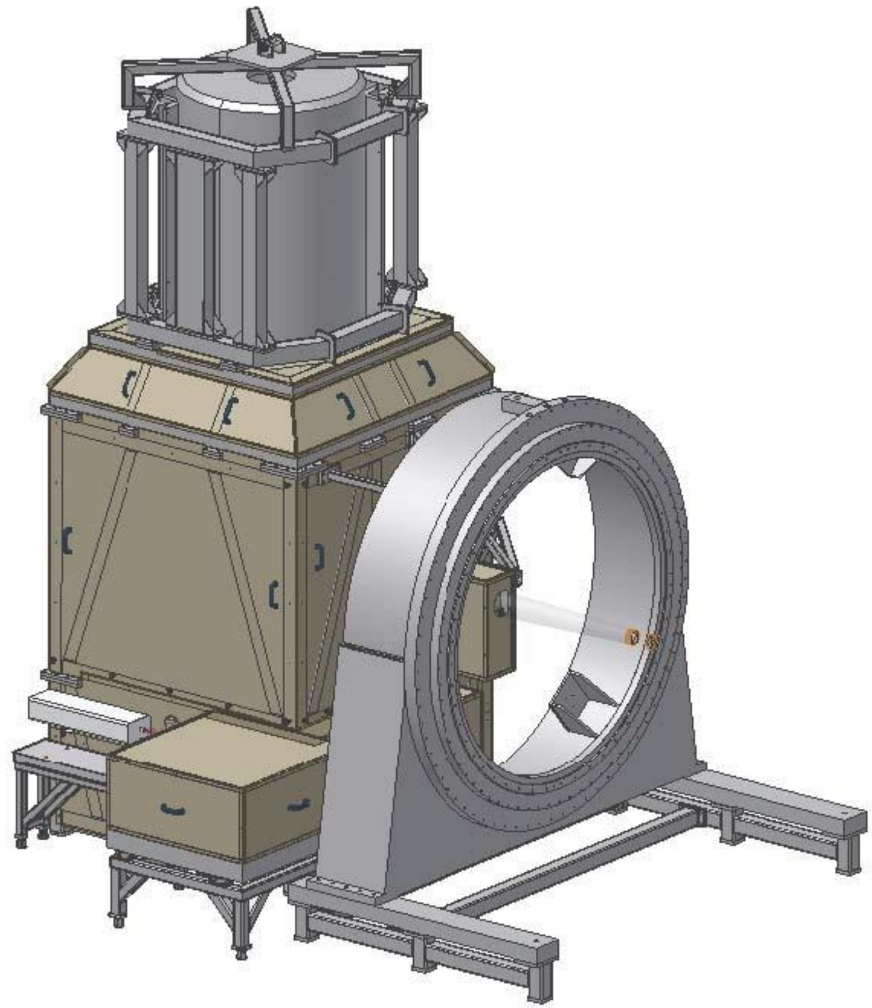
Actuators

Reference plate

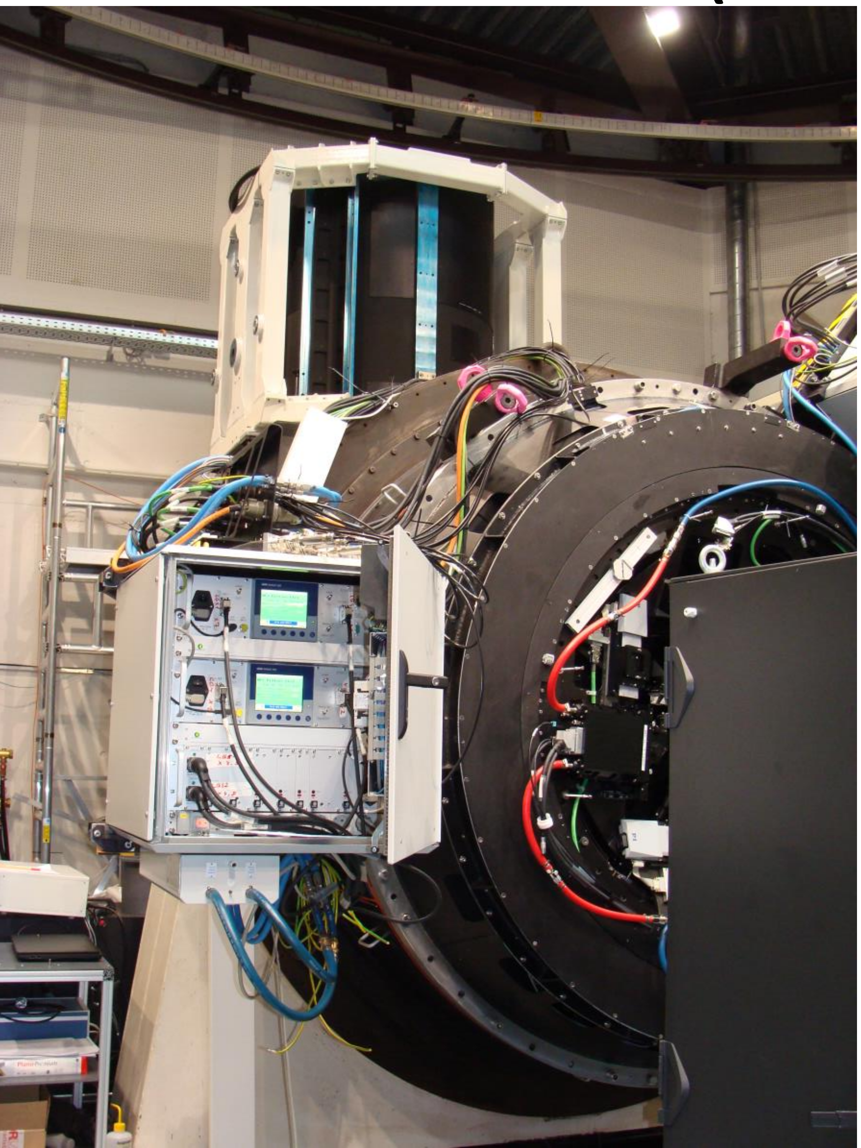
Thin shell mirror

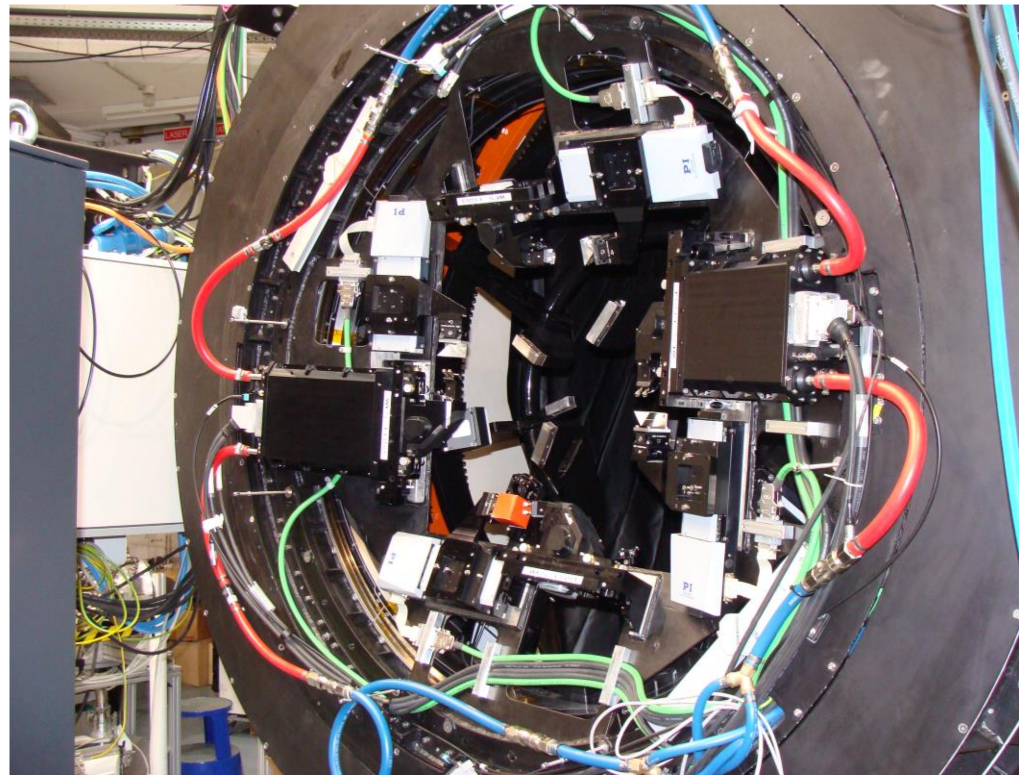
Thin shell supporting foam

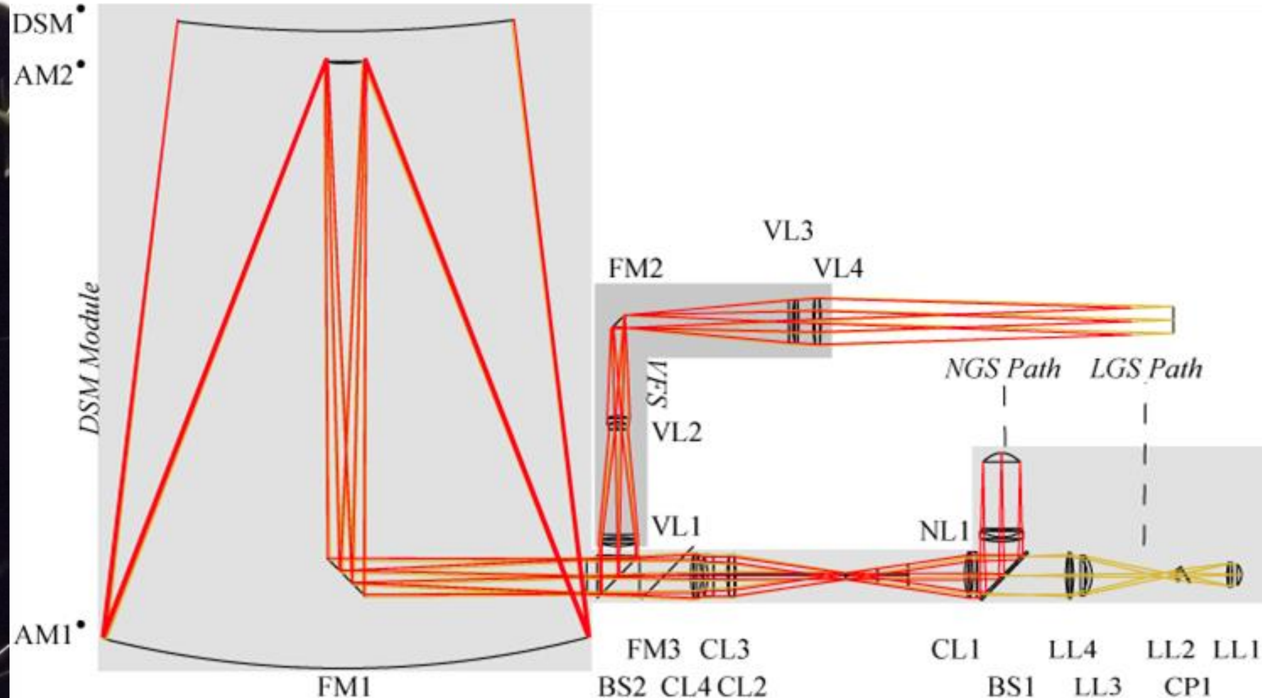
ASM test unit at ESO (ASSIST) (2012/11/13)



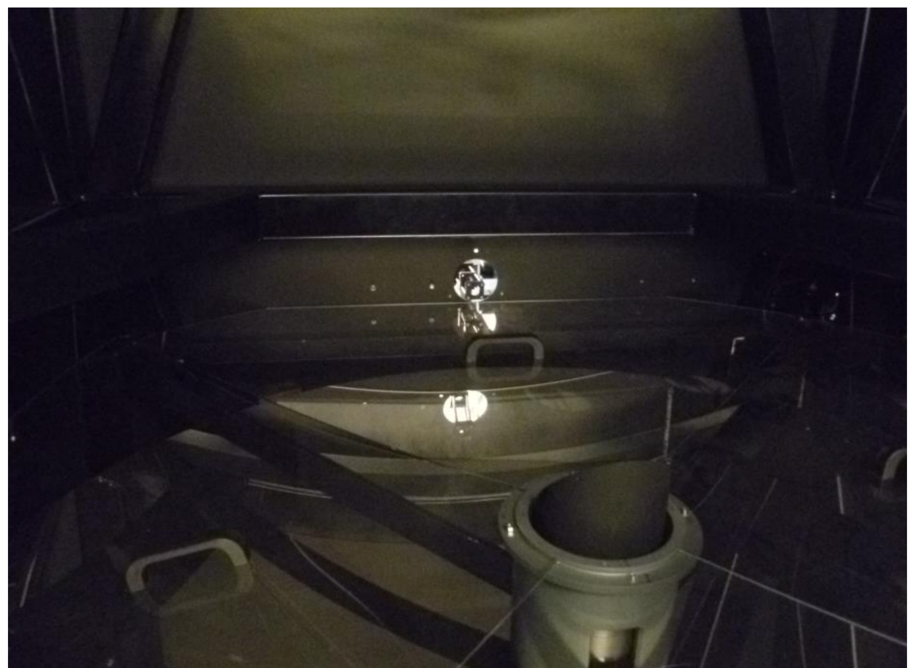
ASM test at ESO with GRALL (2013/3/27)



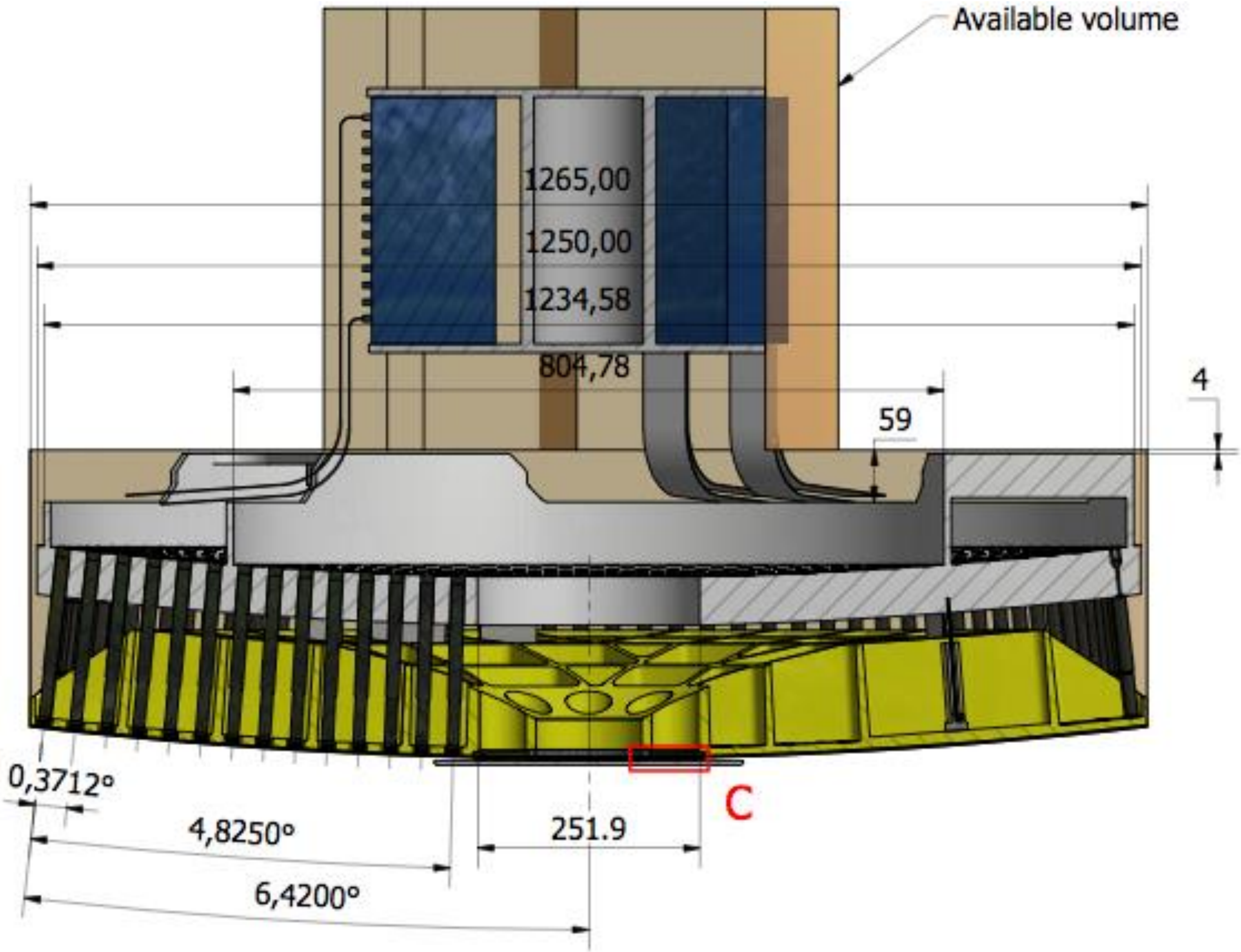


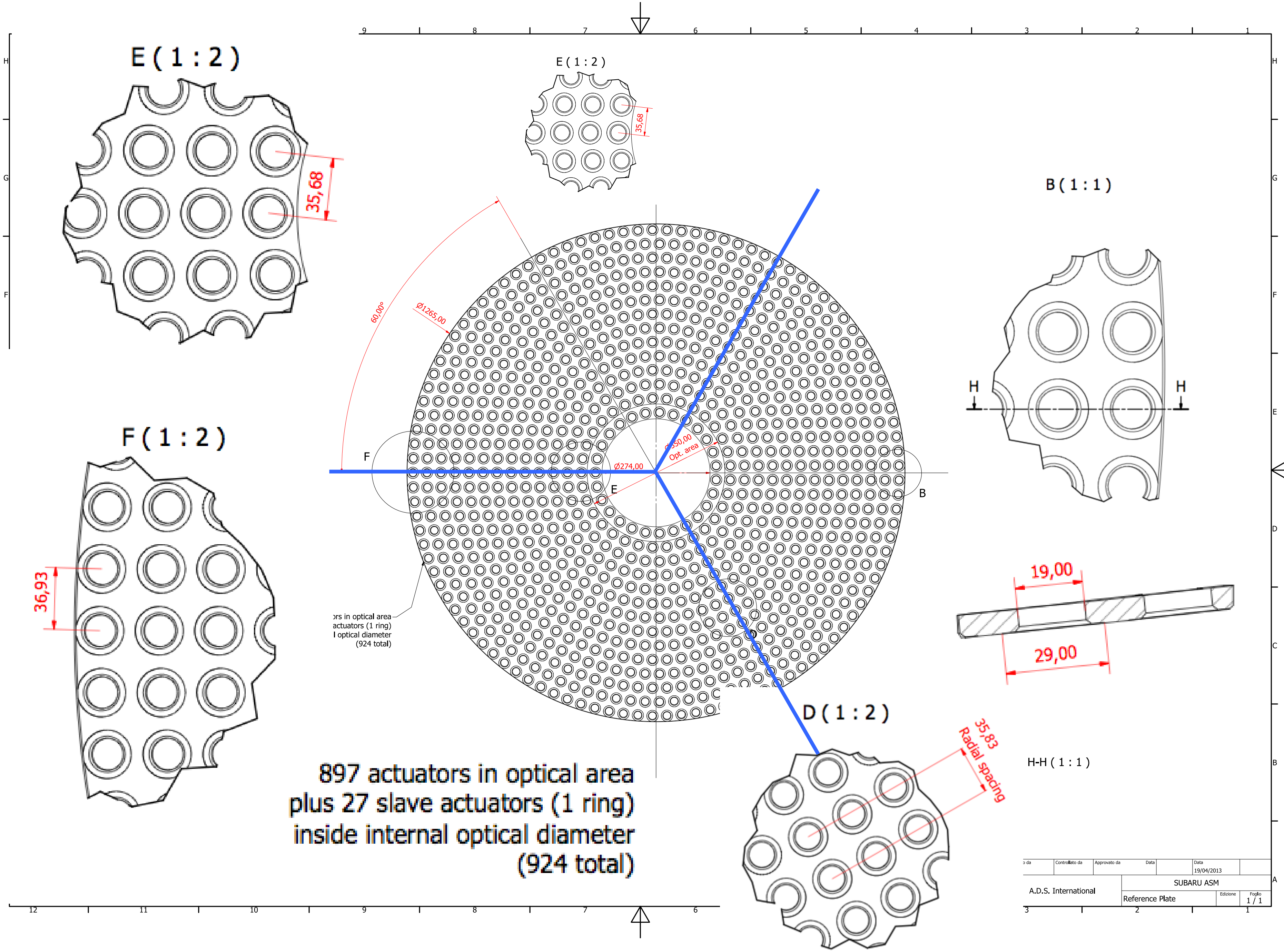


DSM
AM2
DSM Module
AM1
FM1
FM2
VL3
VL4
VFS
VL2
VL1
NGS Path
LGS Path
SSTG
NL1
FM3
CL3
CL1
LL4
LL2
LL1
BS2
CL4
CL2
BS1
LL3
CP1

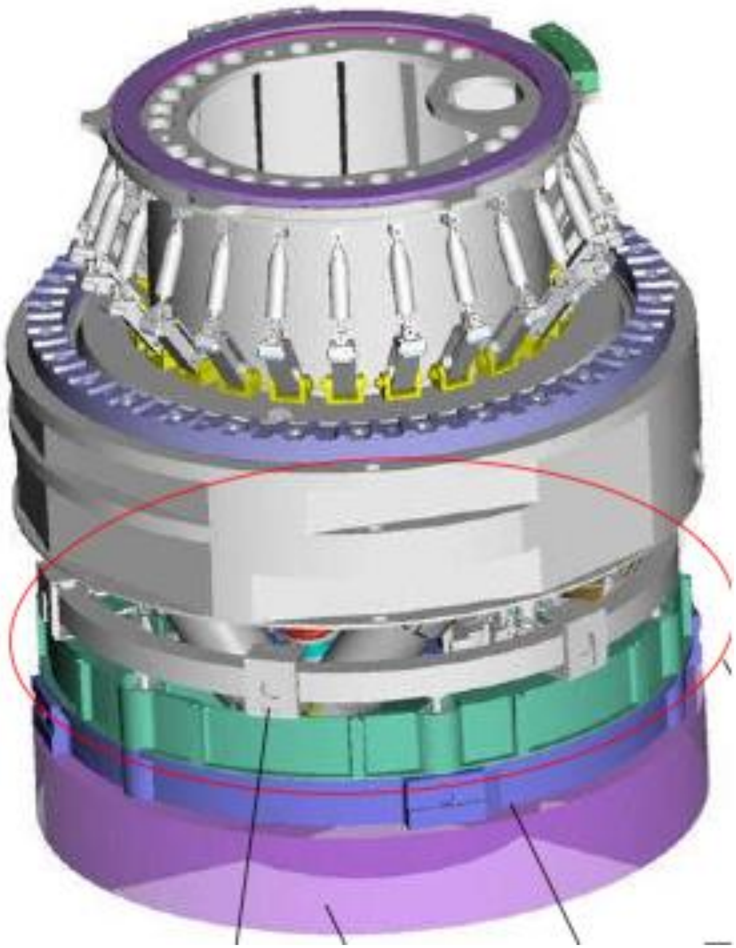


Subaru ASM model

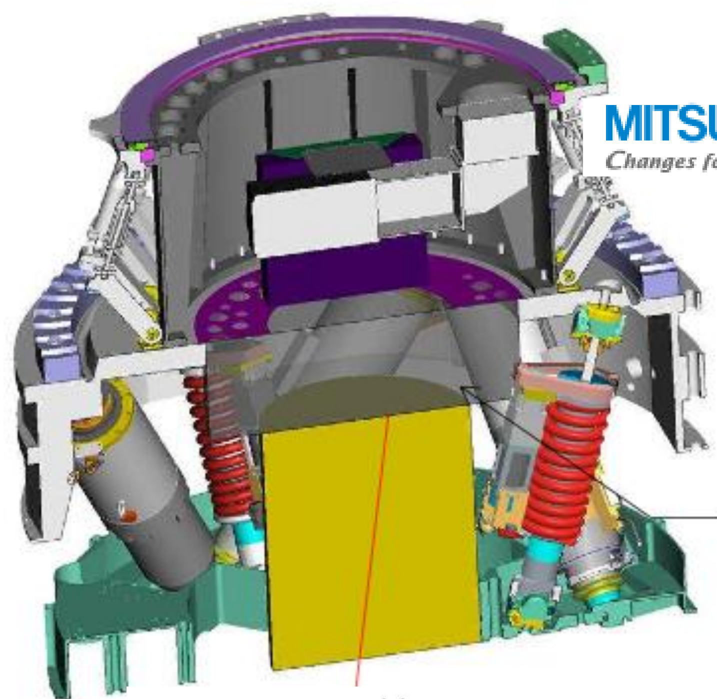



E (1 : 2)
35,68
E (1 : 2)
35,68
B (1 : 1)
H
H
60,00°
Ø1265,00
F
Ø274,00
Ø350,00
Opt. area
E
B
F (1 : 2)
36,93
19,00
29,00
D (1 : 2)
35,83
Radial spacing
H-H (1 : 1)
897 actuators in optical area
plus 27 slave actuators (1 ring)
inside internal optical diameter
(924 total)
Controllato da
Approvato da
Data
Data
19/04/2013
SUBARU ASM
A.D.S. International
Reference Plate
Edizione
Foglio
1 / 1

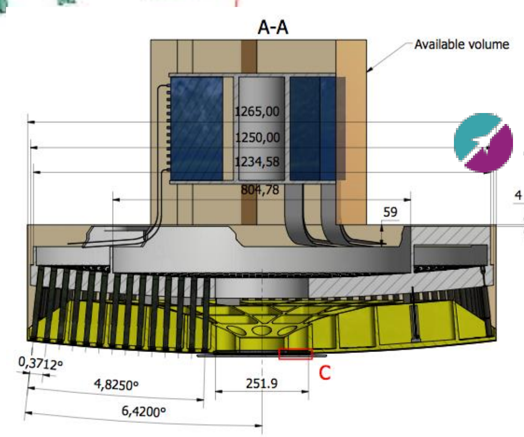
Interface to existing IR M2



MITSUBISHI
Changes for the Better



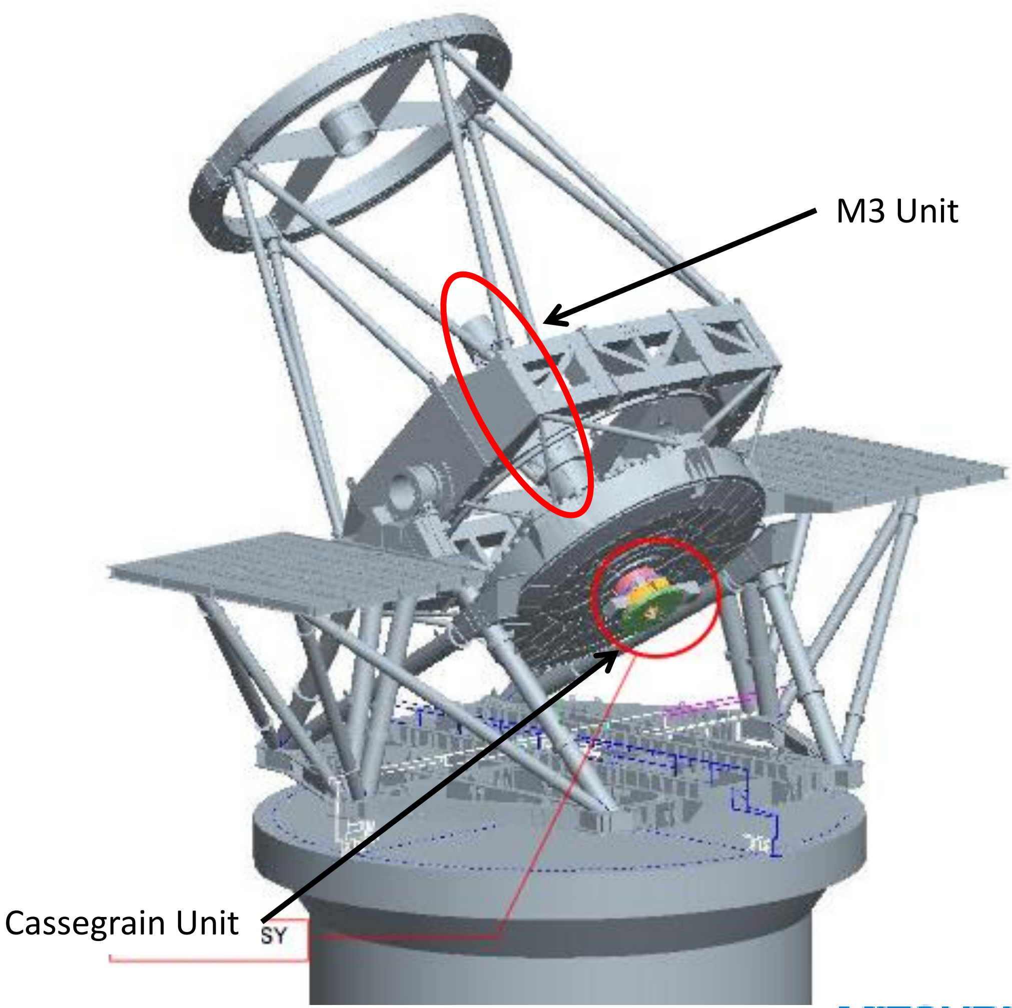
MITSUBISHI
Changes for the Better

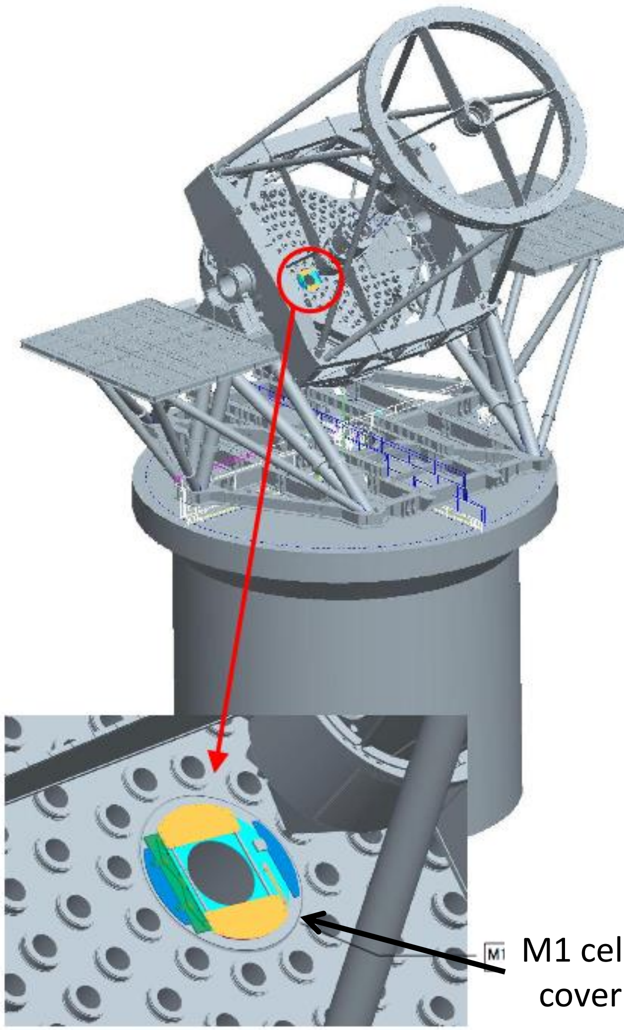


MICROGATE

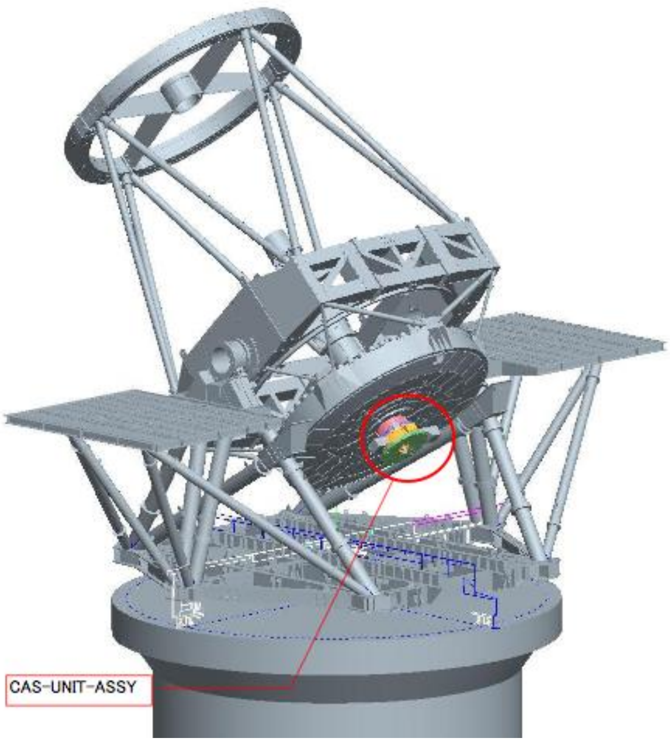
ADS
A.D.S. International

Vignetting by telescope structures

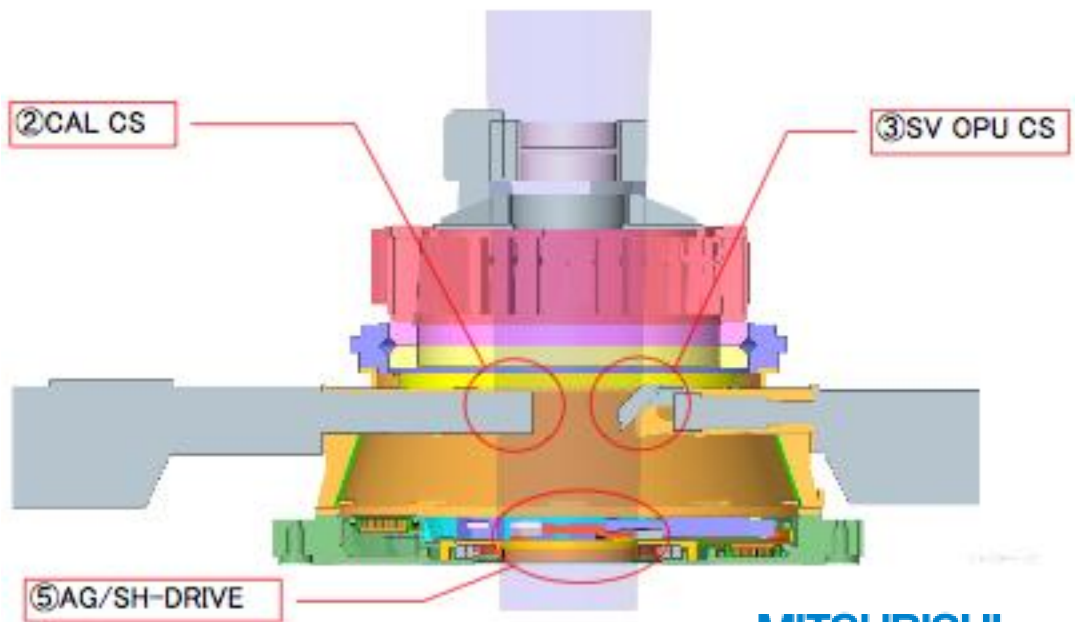




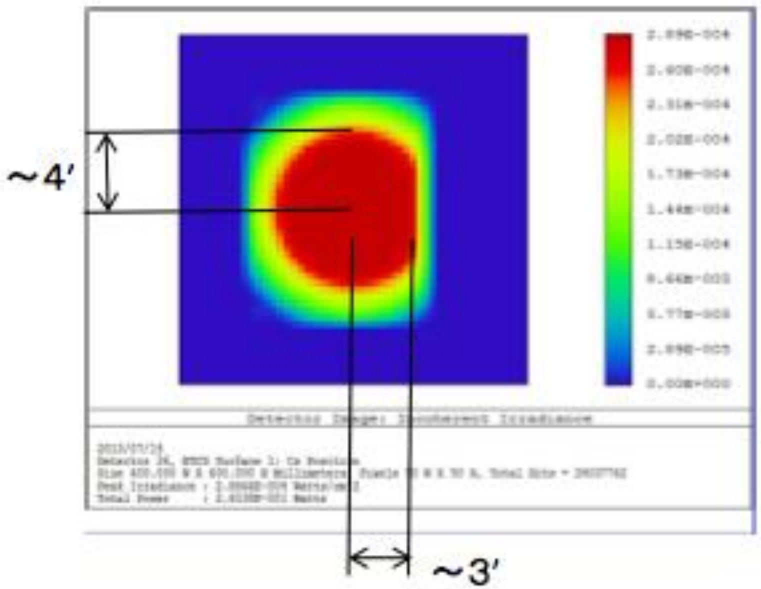
Cassegrain Unit

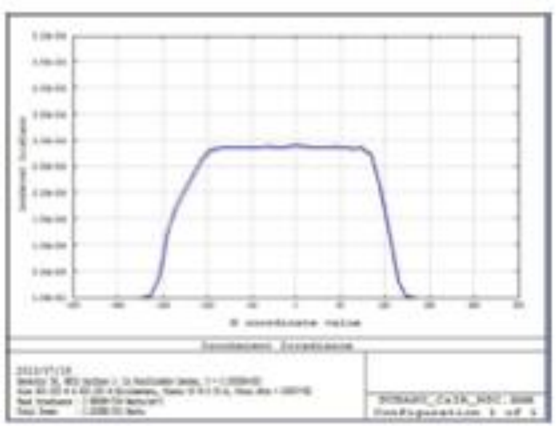


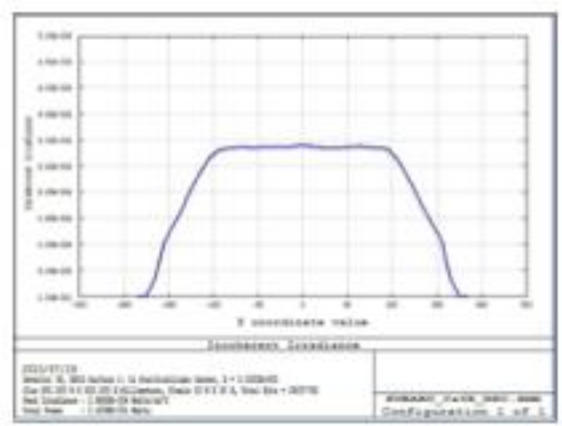
ϕ16 arcmin



FOV at Cassegrain (current)

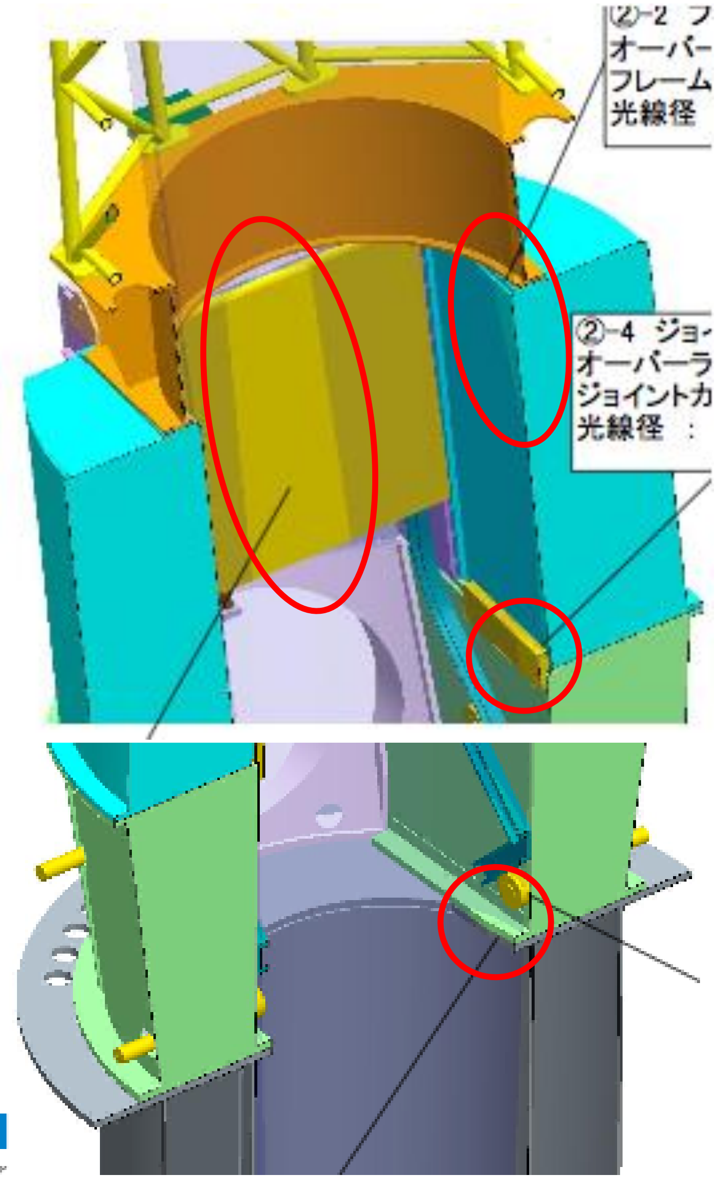






M3 unit

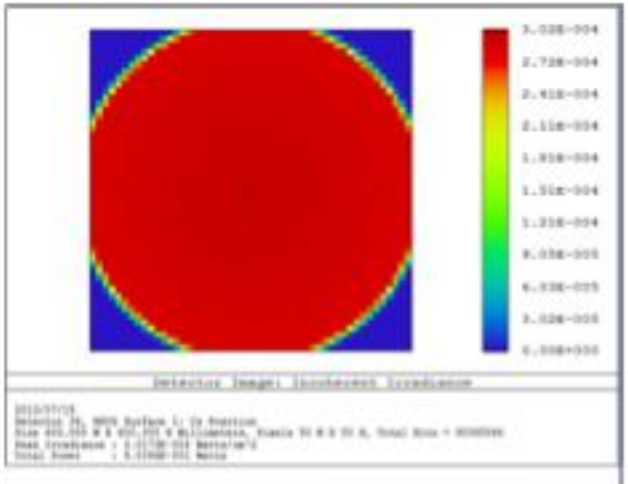
ϕ16 arcmin

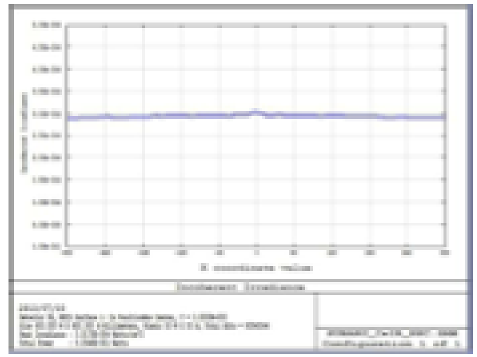


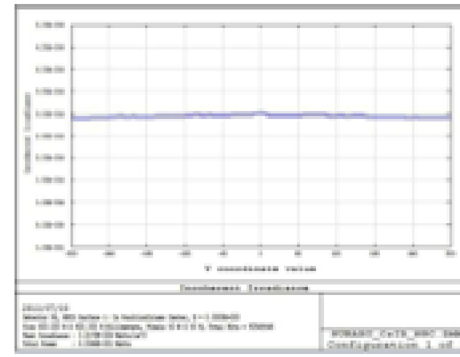
MITSUBISHI
Changes for the Better

Expandable FoV at Cassegrain

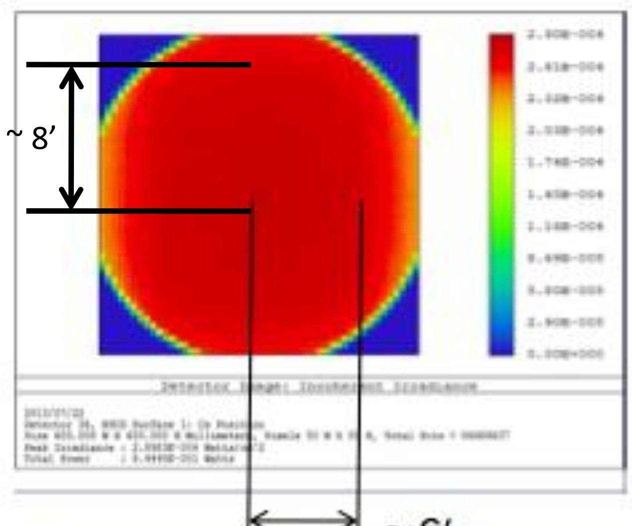
Only M1, M2

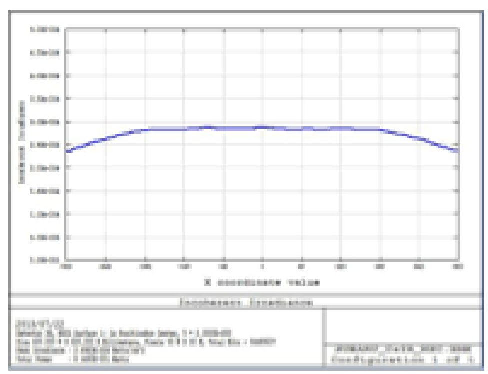


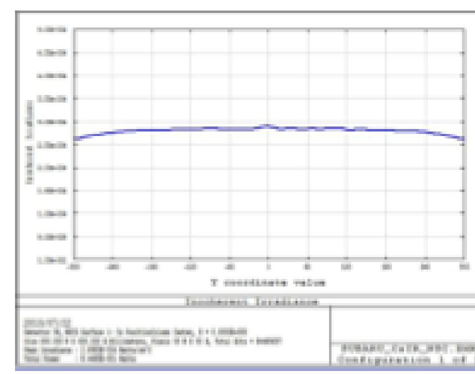




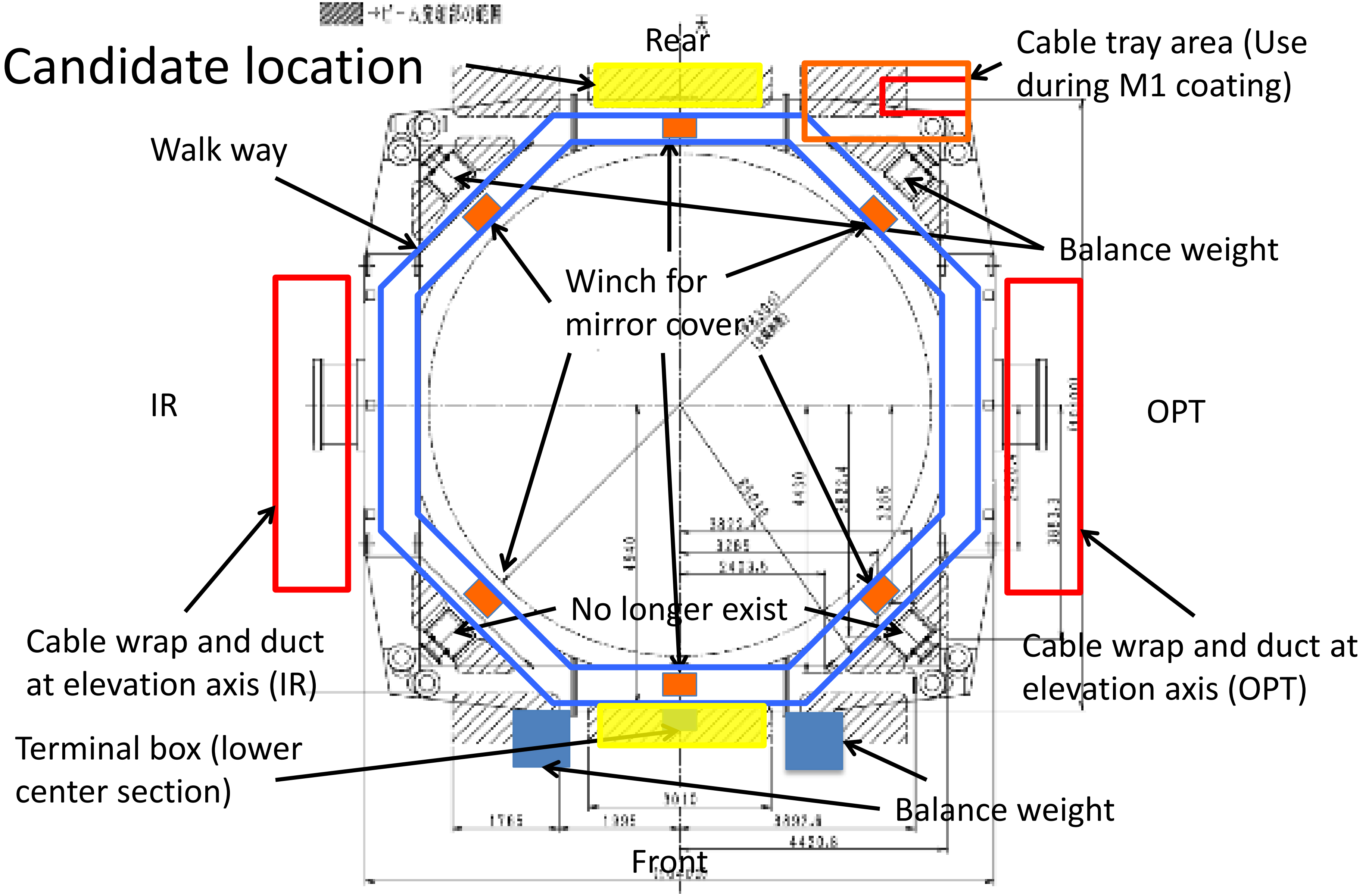
With M3 unit



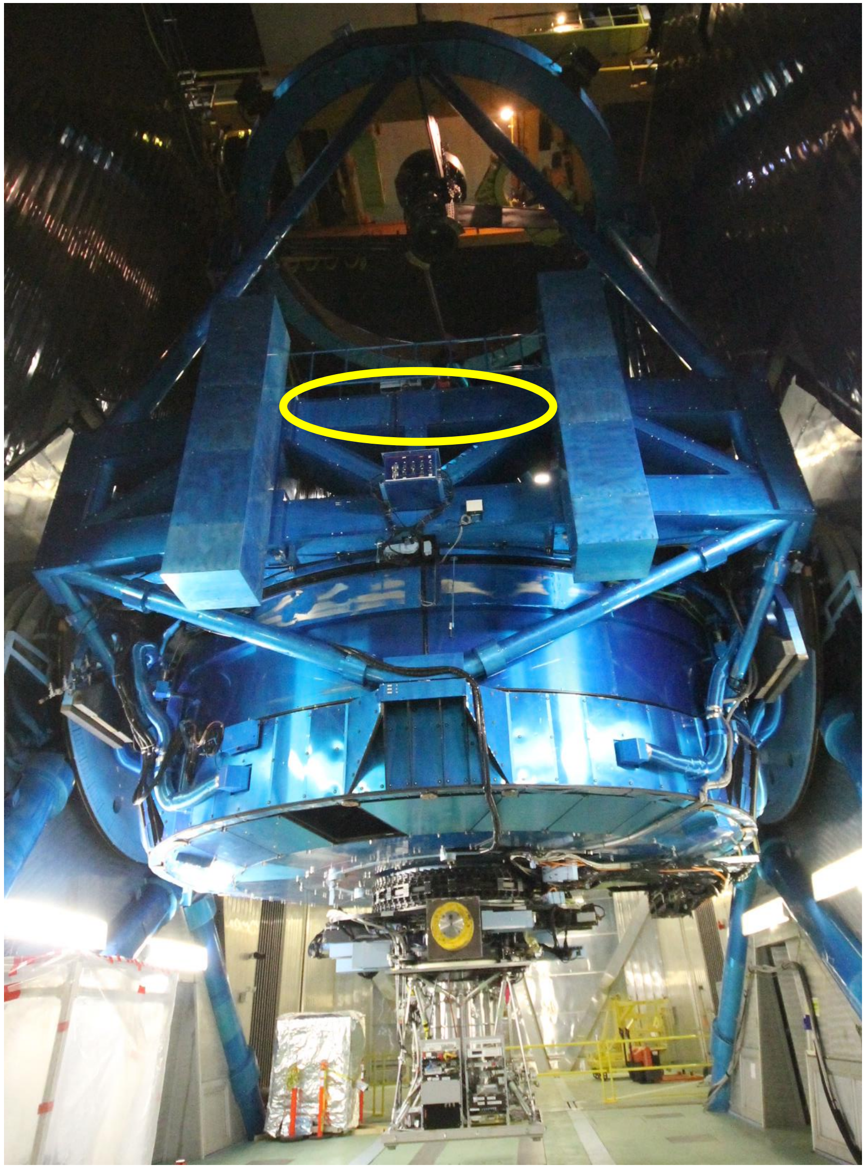


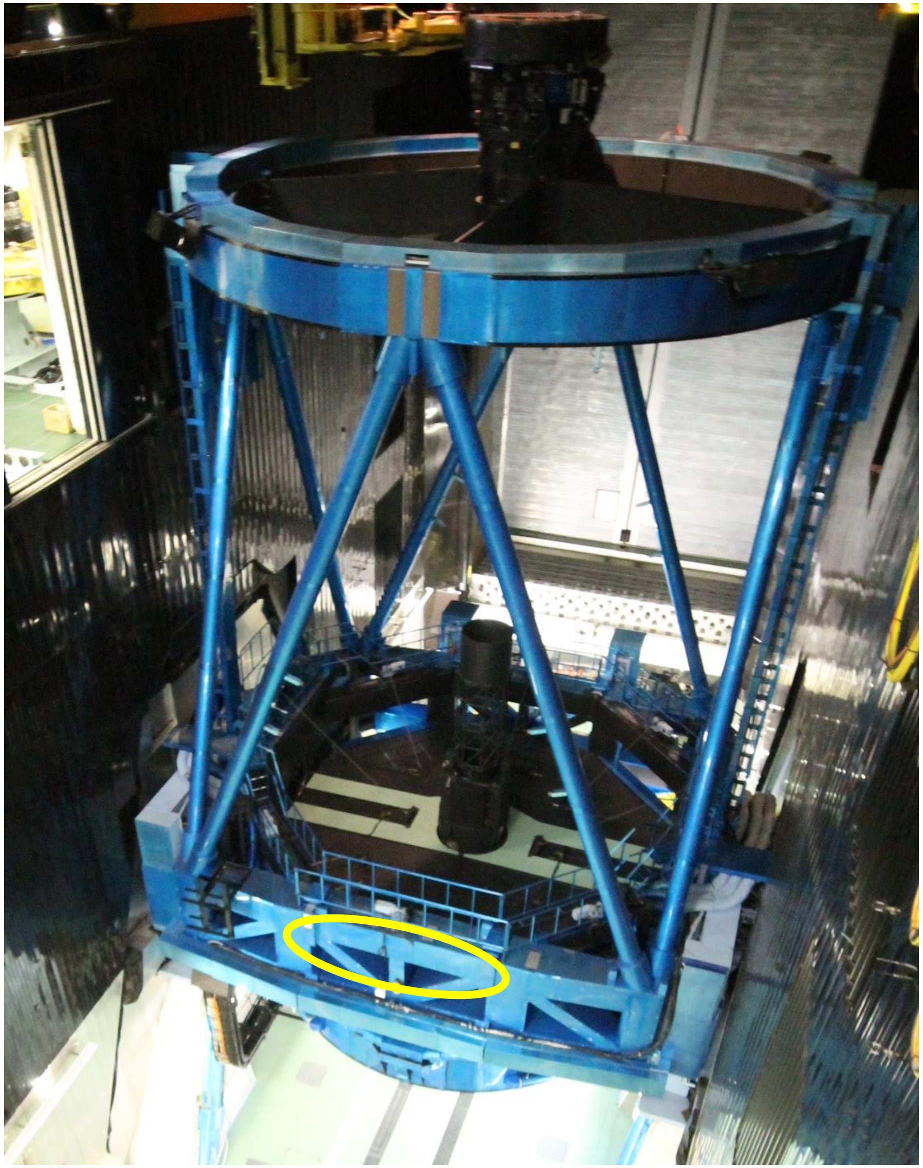


Location of LLT and laser head

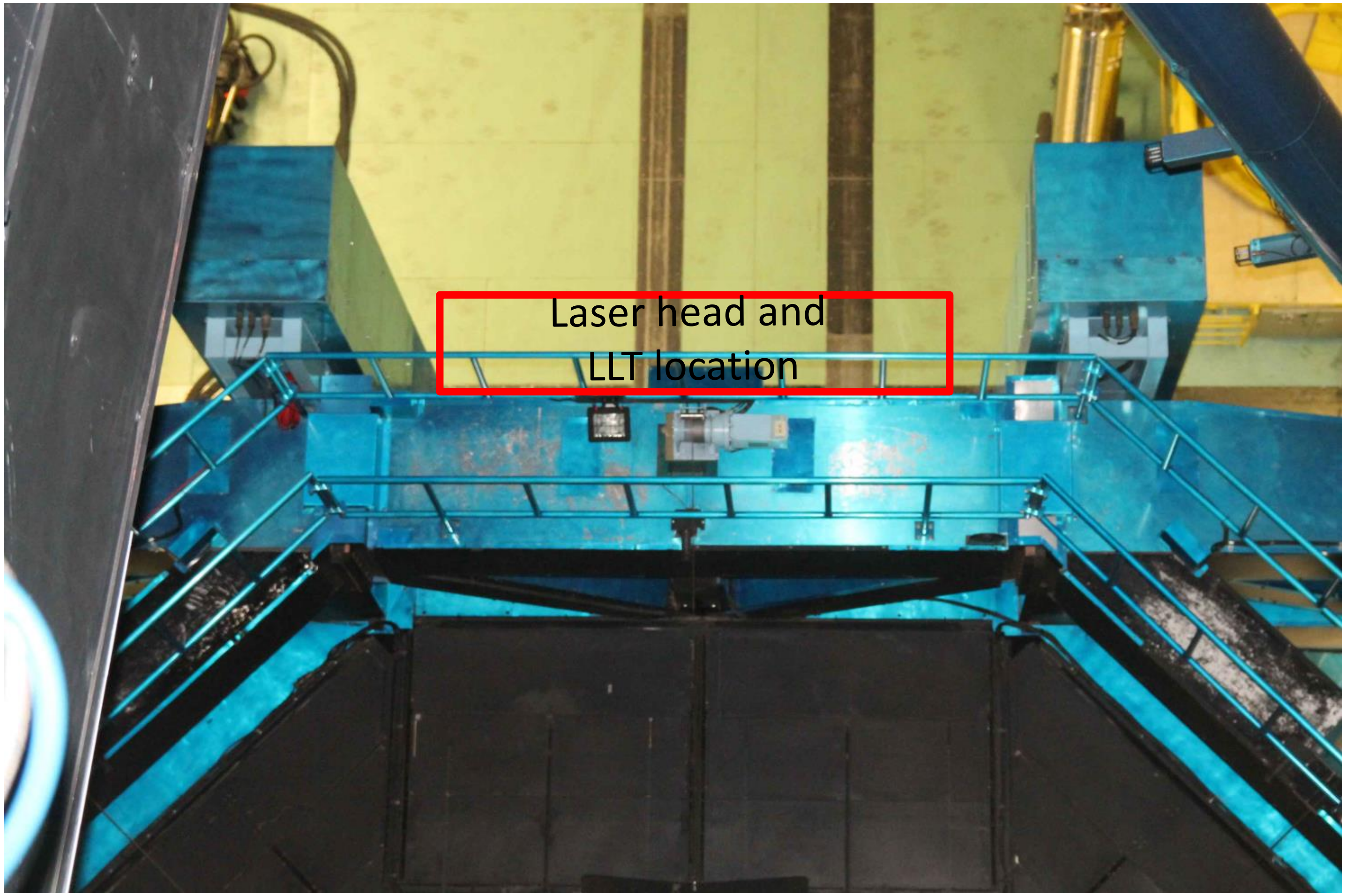


Candidate location for LLT

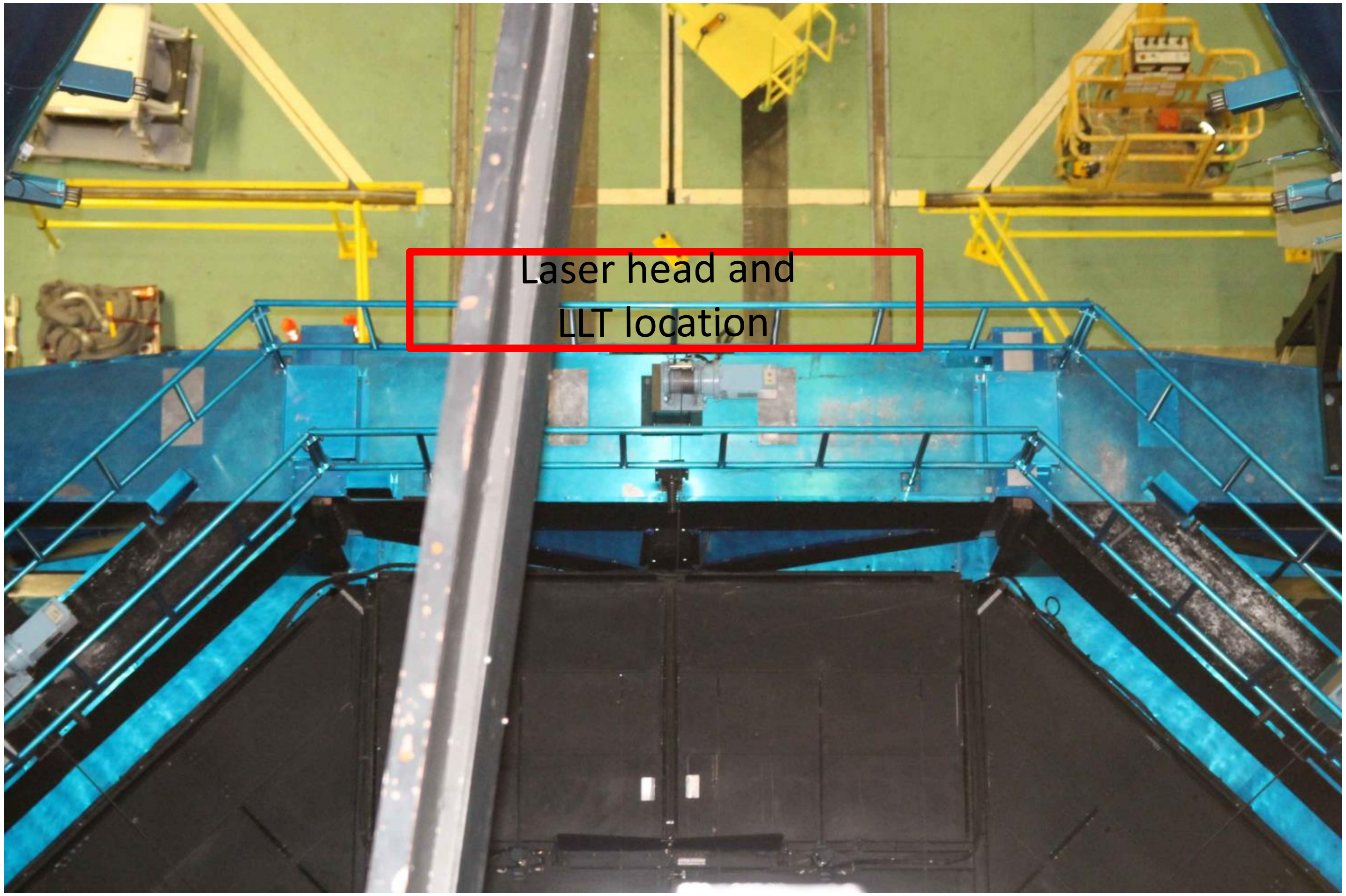




Front side



Rear side

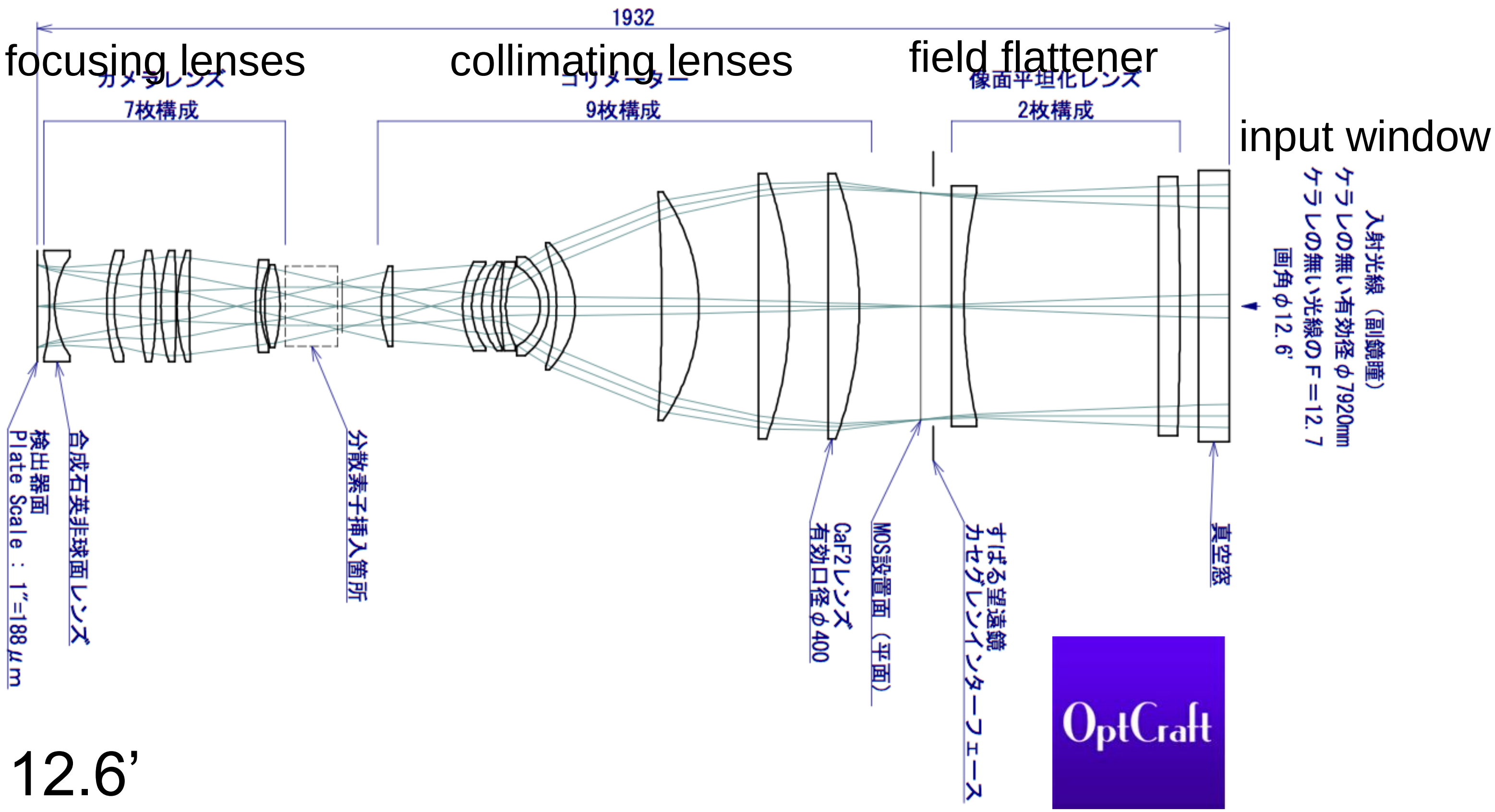


Feasibility study for NIR instrument

- Optical design
  - w/wo field splitting
  - Change telescope optical parameters or not.
  - Optical components (CaF_2) < 400mm
  - Goal FWHM <0.15” over FoV and 0.8-2.5μm

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

Example of Optical Design



FoV 12.6'

Next step

- Conceptual design review
- International Collaboration
  - AAO、NRC, etc.
- Adaptive secondary mirror
  - Interface to IR M2 unit.
  - Further design study with ADS, Microgate.
- Fiber laser (TOPTICA/MPBC) upgrade
- Budget application
  - Grant-in-Aid for Scientific Research on Innovative Areas, 2015-2019.