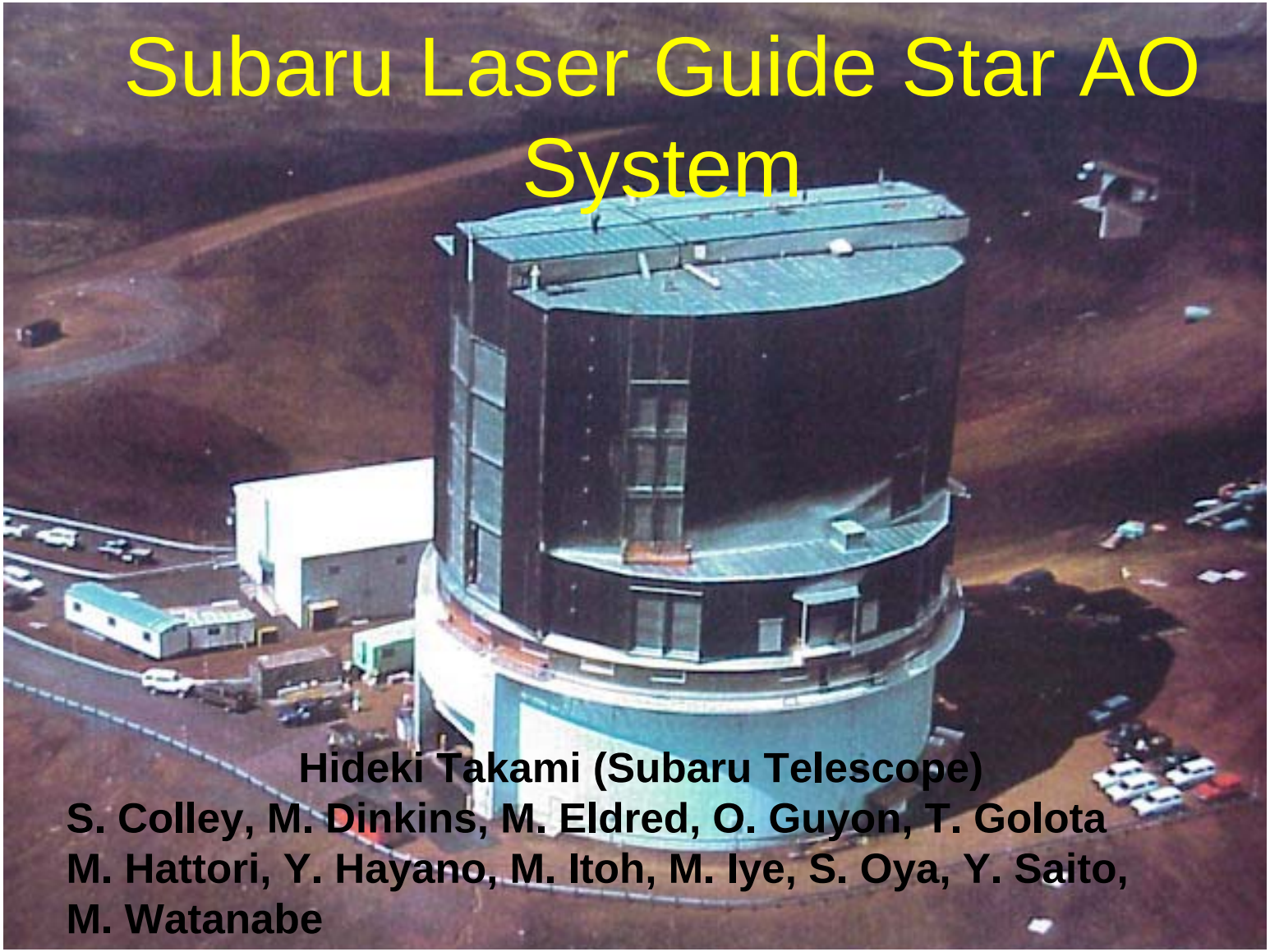
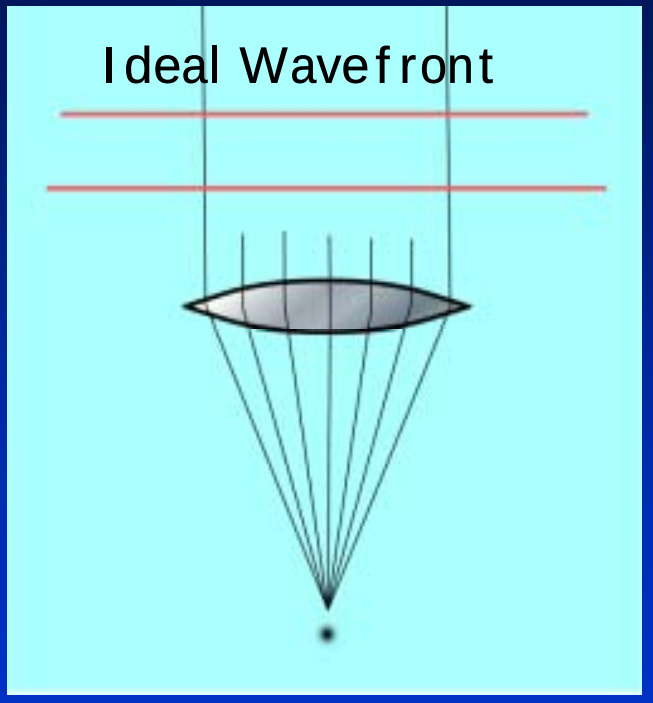
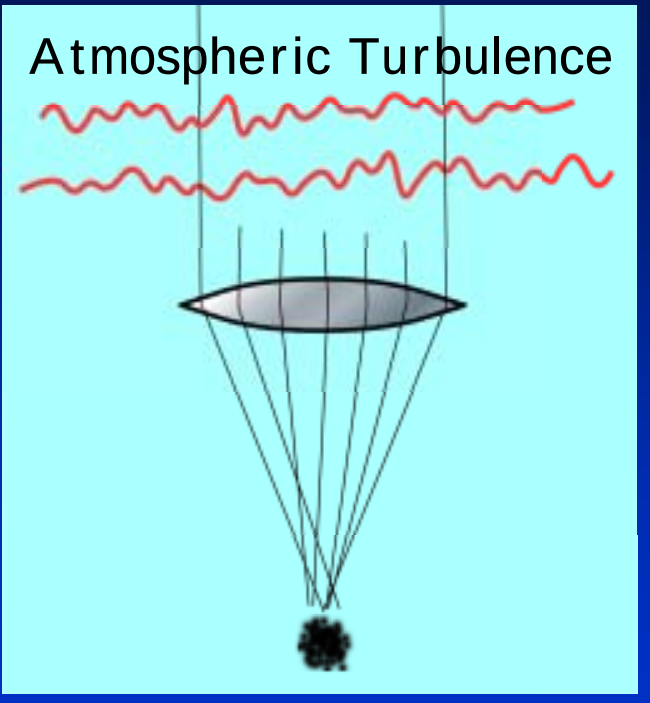
Subaru Laser Guide Star AO System



Hideki Takami (Subaru Telescope)
S. Colley, M. Dinkins, M. Eldred, O. Guyon, T. Golota
M. Hattori, Y. Hayano, M. Itoh, M. Iye, S. Oya, Y. Saito,
M. Watanabe

Atmosphric turbulence



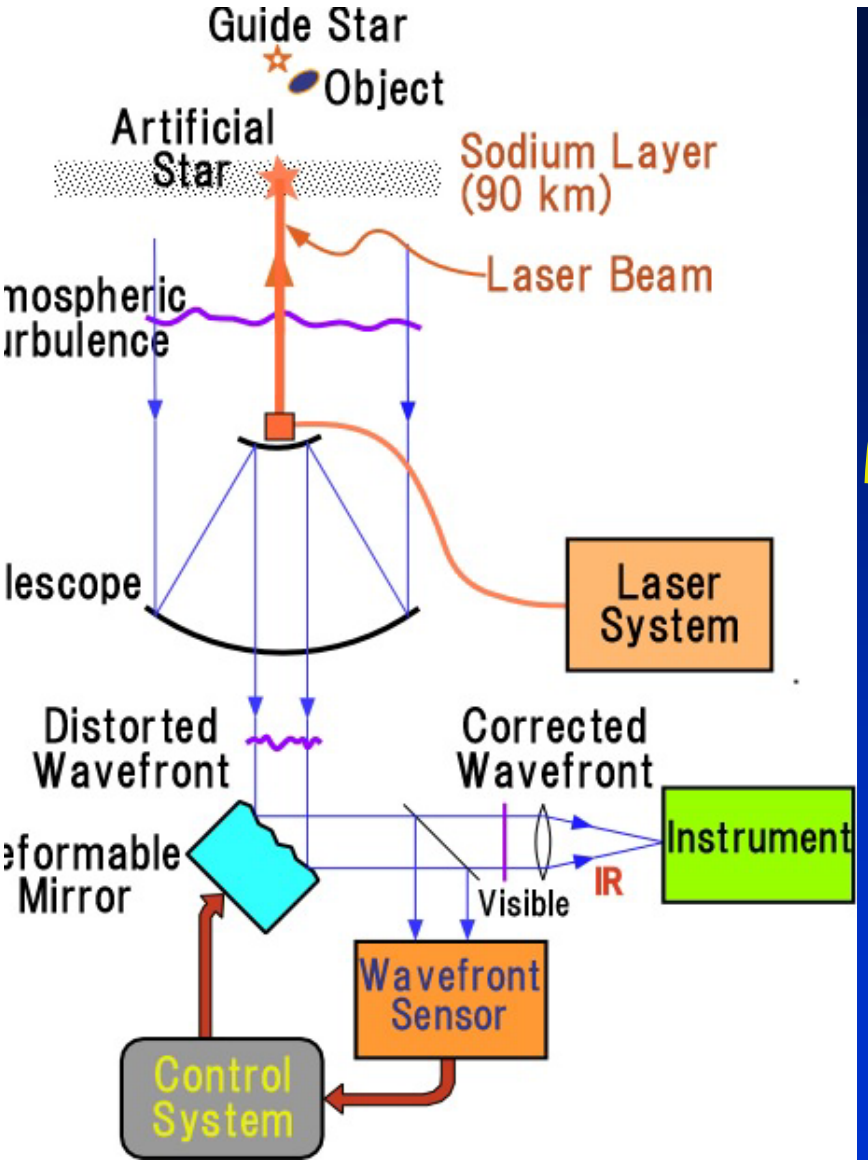


Space

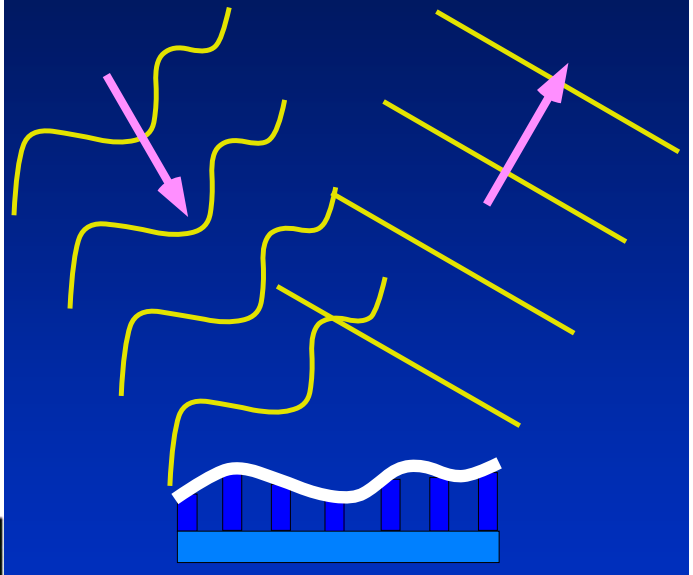
Subaru

Effect of Turbulence is serious for large telescope

Telescope size	Diffraction limit λ/D (@2.2μm)	Mauna Kea	Japan
2m	0.23″	0.6″	1-2″
8m	0.057″	0.6″	1-2″
30m	0.015″	0.6″	1-2″



Adaptive Optics



Deformable mirror

Compensate atmospheric turbulence

Real time image of AO

(Gemini observatory)

Subaru AO history

2000 AO36 first light
Cassegrain focus, K-band optimize

Low order, Small sky coverage

2002 Grant in Aid, 5 year project
Laser Guide Star AO
start (188 elements)

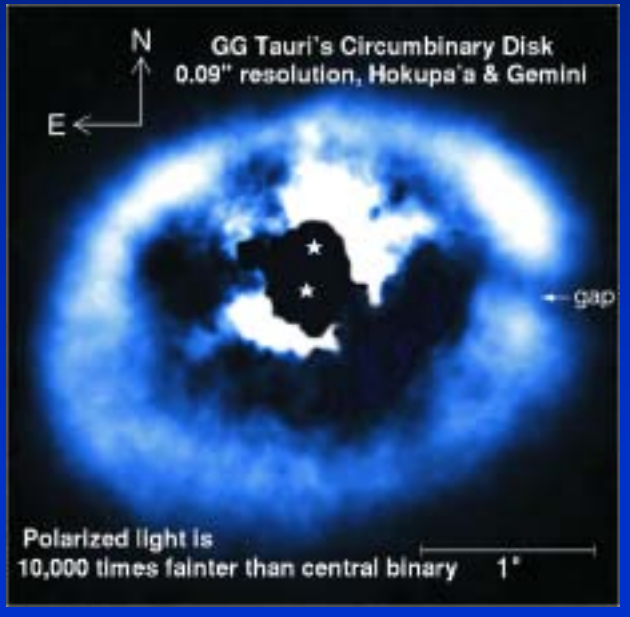
2006/10 First light
2008 Common use start

Science with current Subaru AO system

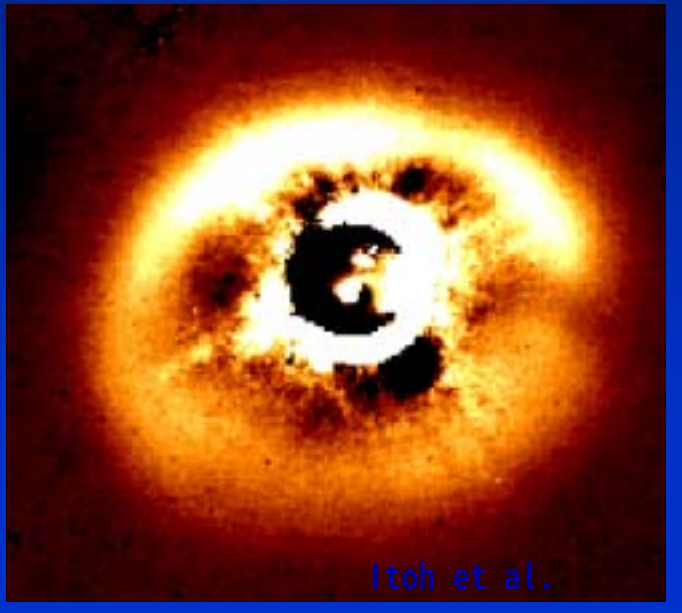
Conoragraph image of dust ring (Subaru AO+CIAO) Itoh et al. 2002

- 0.3” binary (in mask) with circumbinary disk

Gemini H-band

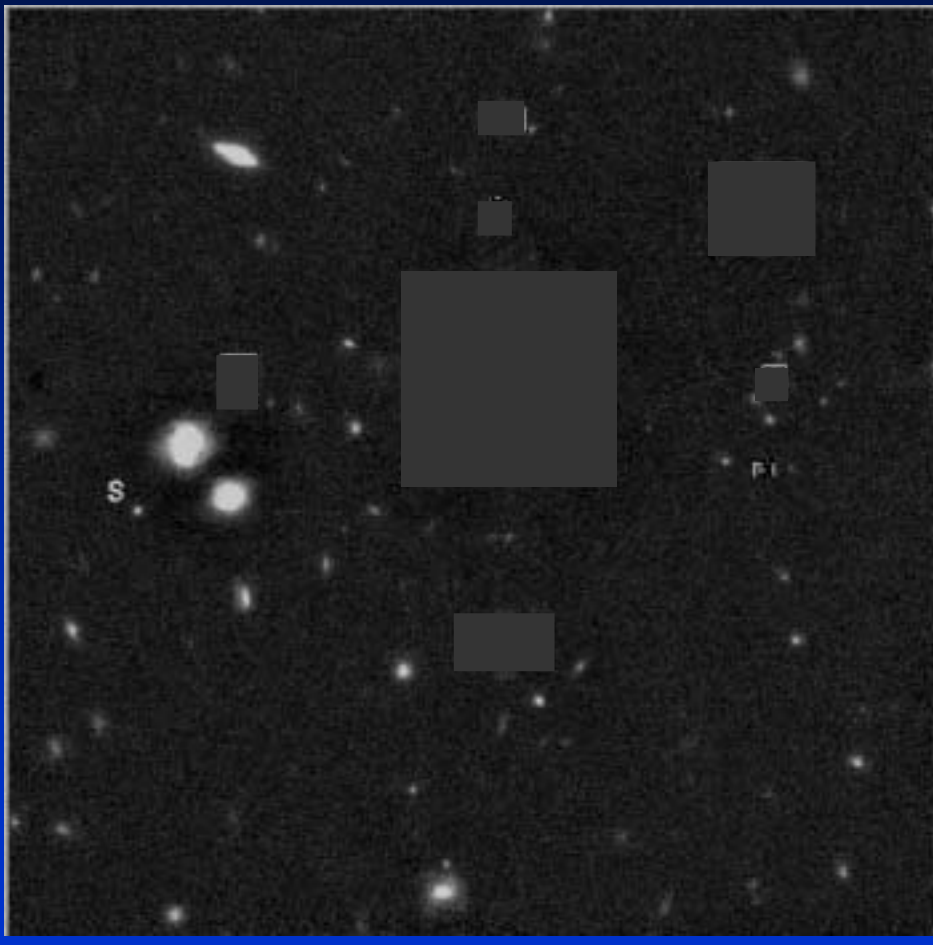


SUBARU+CIAO H-band



Super Subaru Deep Field by AO

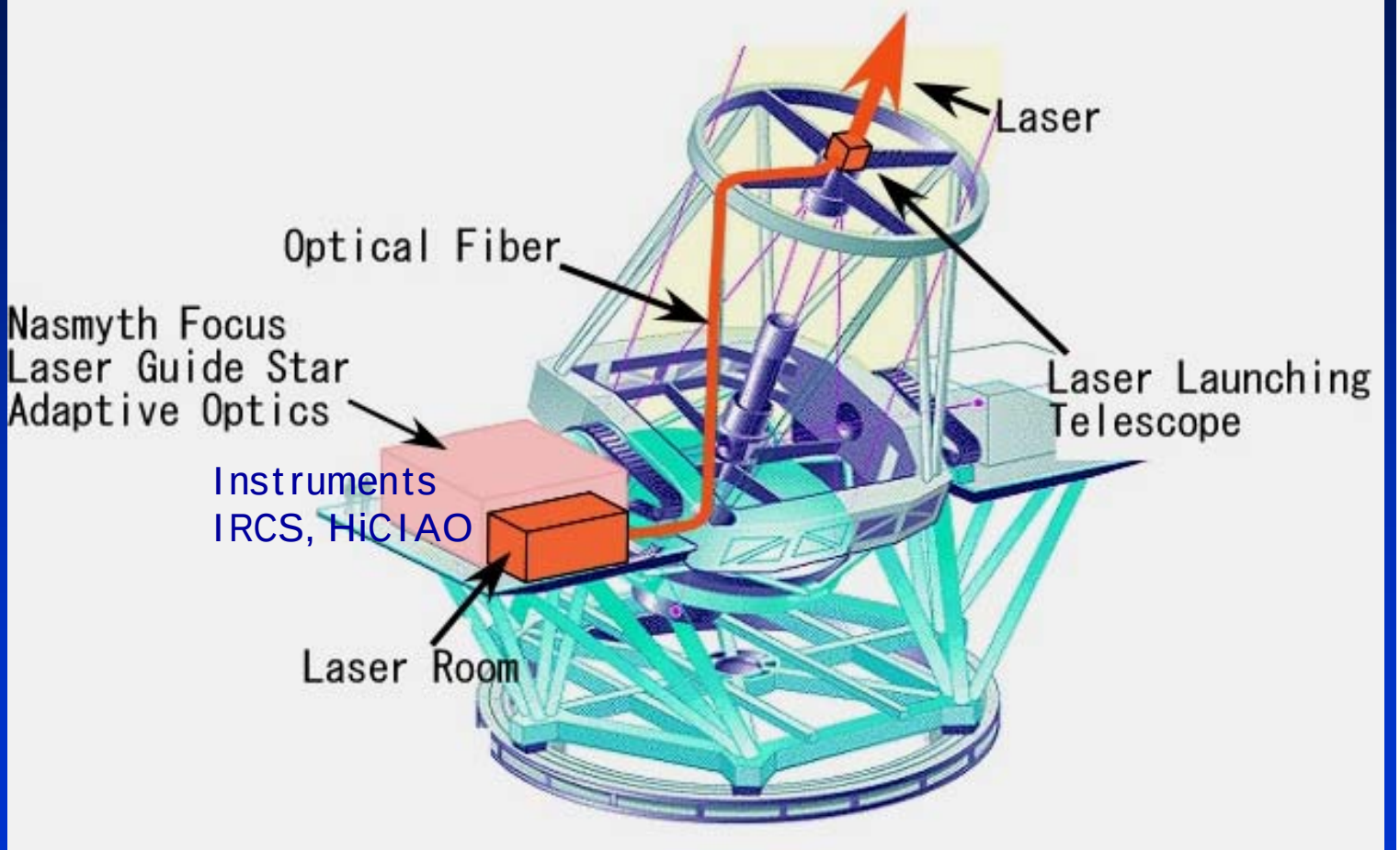
no AO	AO36
0“45	0“18
10hr	27hr
23.5 (mag)	24.7
Number counts	Morphology



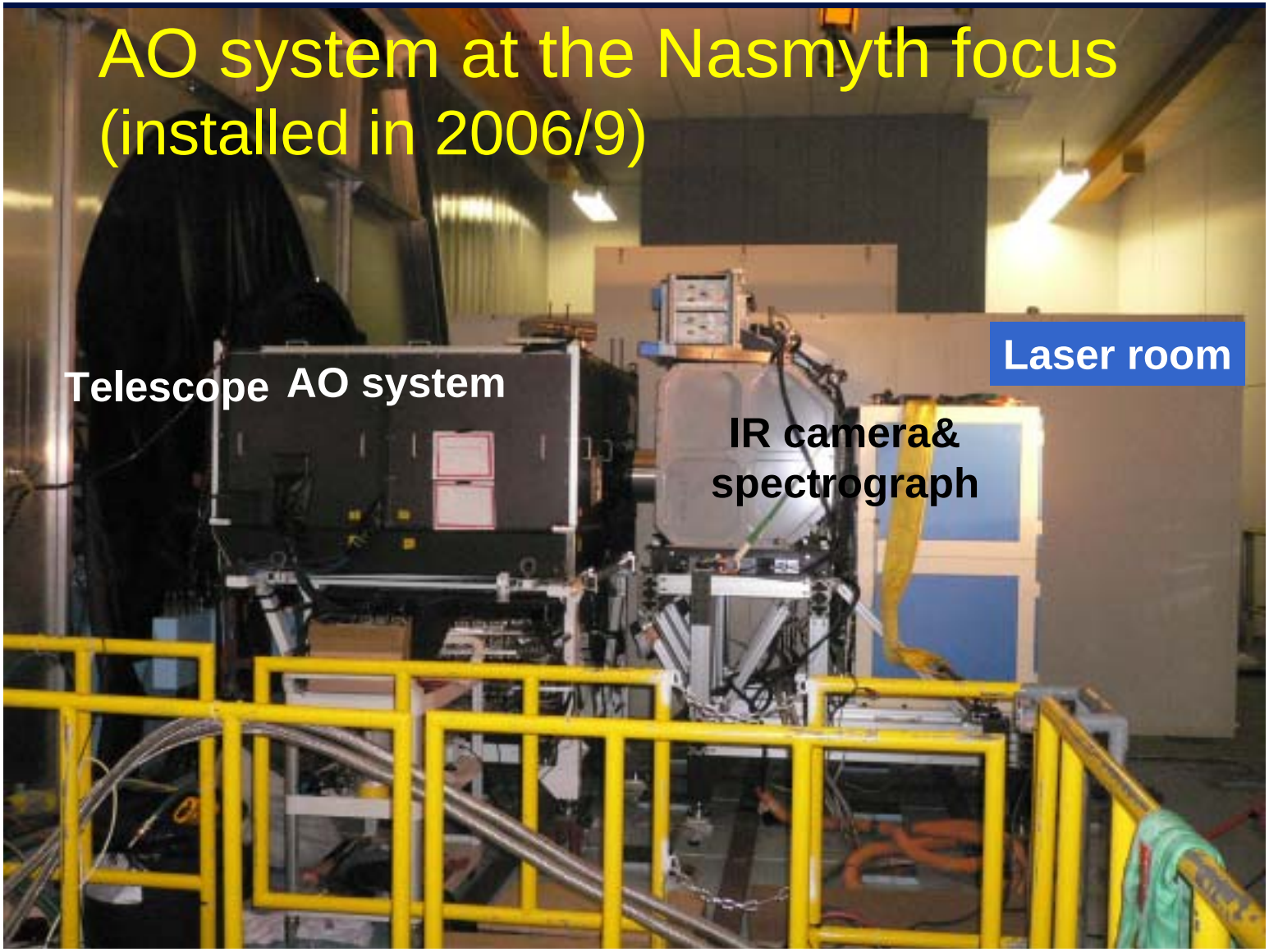
The most deep NIR imaging (Minowa el al)

Galaxy evolution

Subaru Laser guide star AO
(2nd generation)

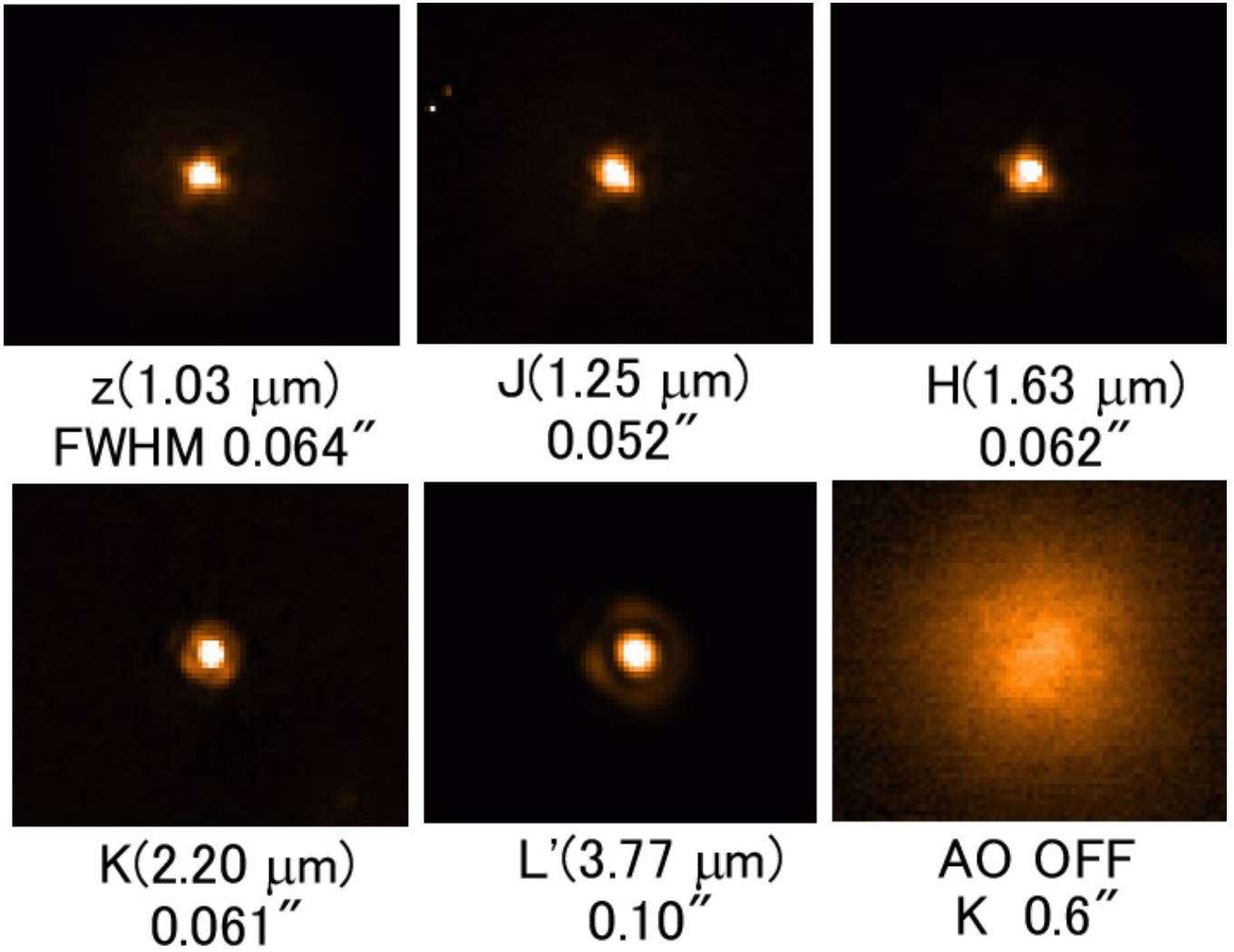


AO system at the Nasmyth focus (installed in 2006/9)

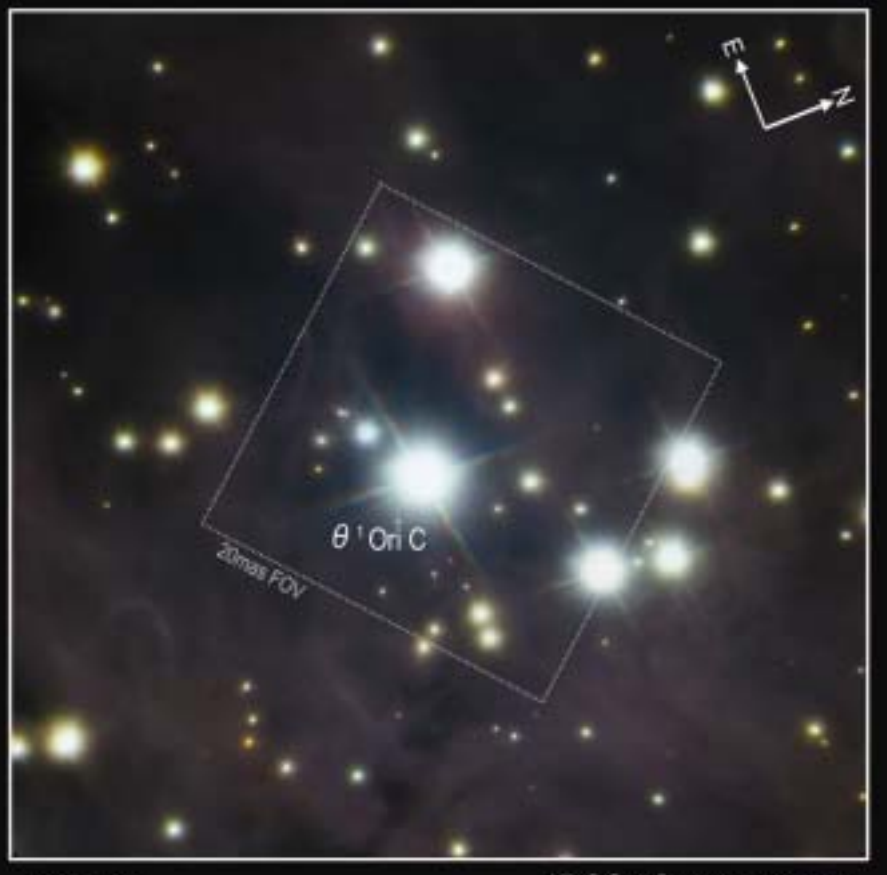


First Light of New AO system

First Light Images of New AO (2006/10)



AO188 first light image (2006/10)
Orion Trapezium, Infrared image



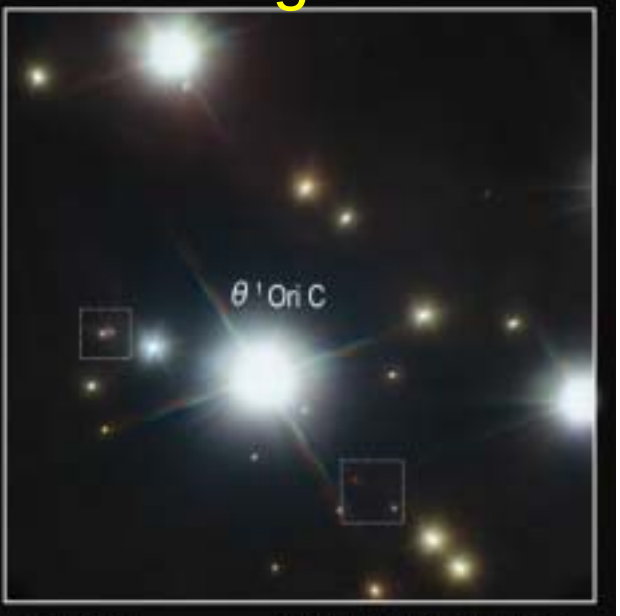
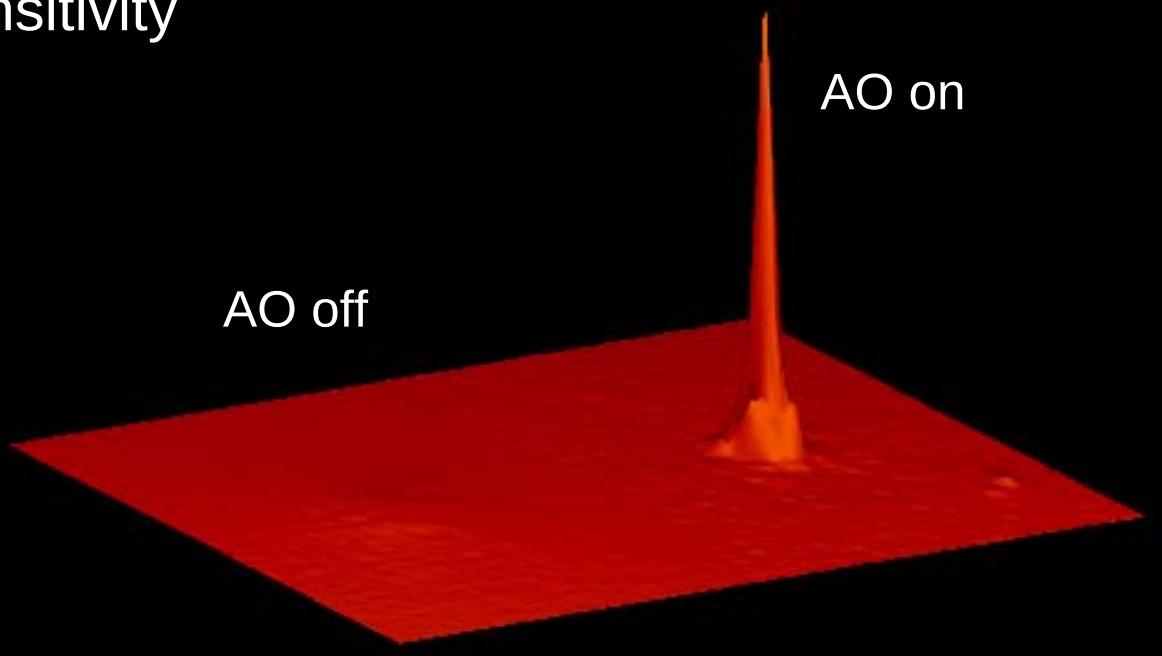


Image by Adaptive Optics

It improves spatial resolution
and sensitivity



Key technologies of AO

1) Deformable mirror

2) Wavefront sensor

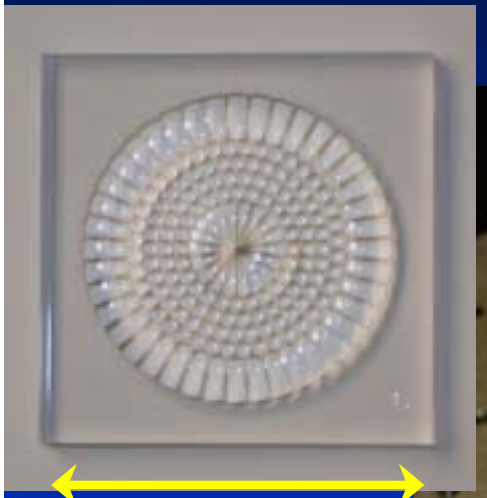
3) Laser guide star

Bimorph deformable mirror

Number:	188
Effective:	90 mm
Blank Size:	130 mm
Manufacture:	CILAS

DM bends by piezoelectric effect of the material

Wavefront sensor:188 element lenslet array



32 mm

Diamond machined plastic mold lens
(Nalux, Co.)

16 March 2007

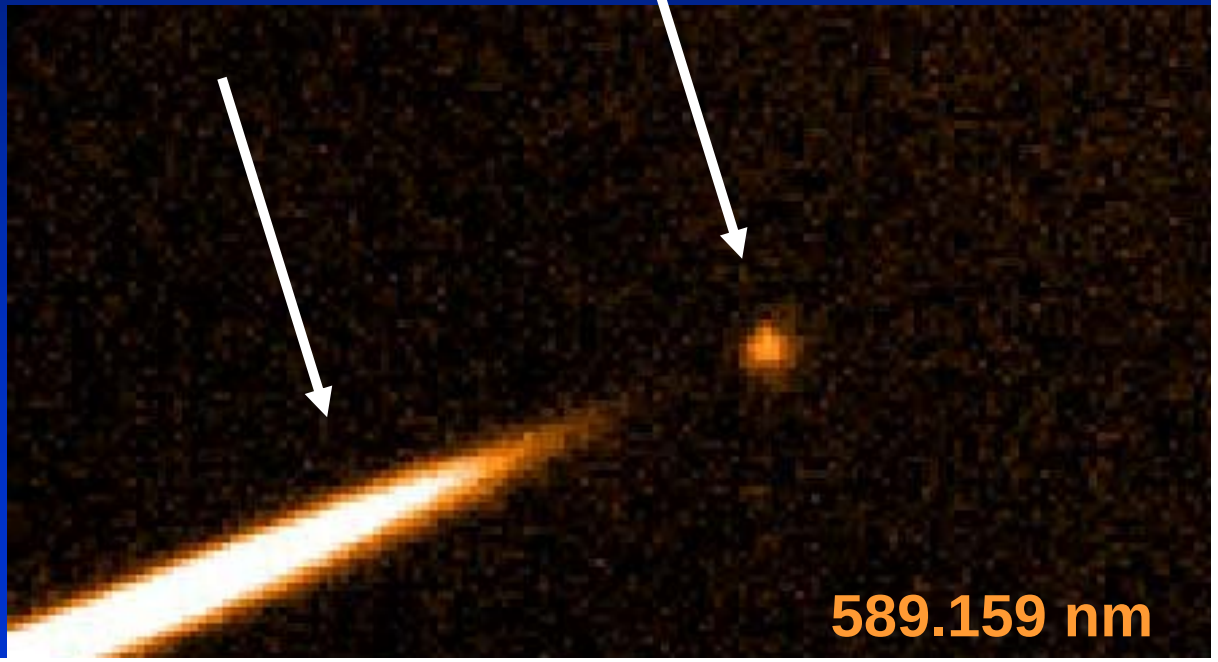
Chance we have guide star is small

=> Create guide stars by Laser

Sodium Laser Guide Star

90 km sodium layer

Rayleigh Scattering

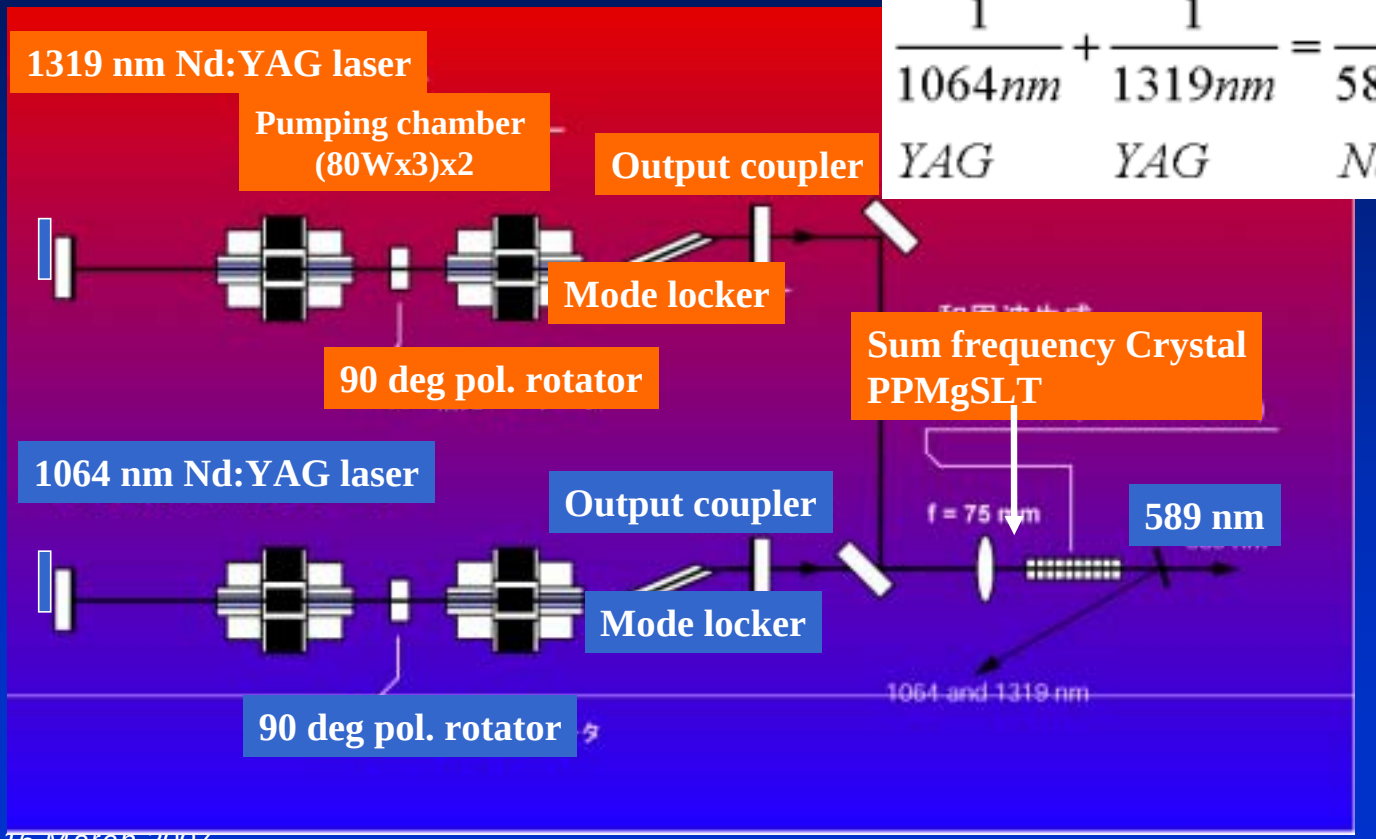


16 March 2007

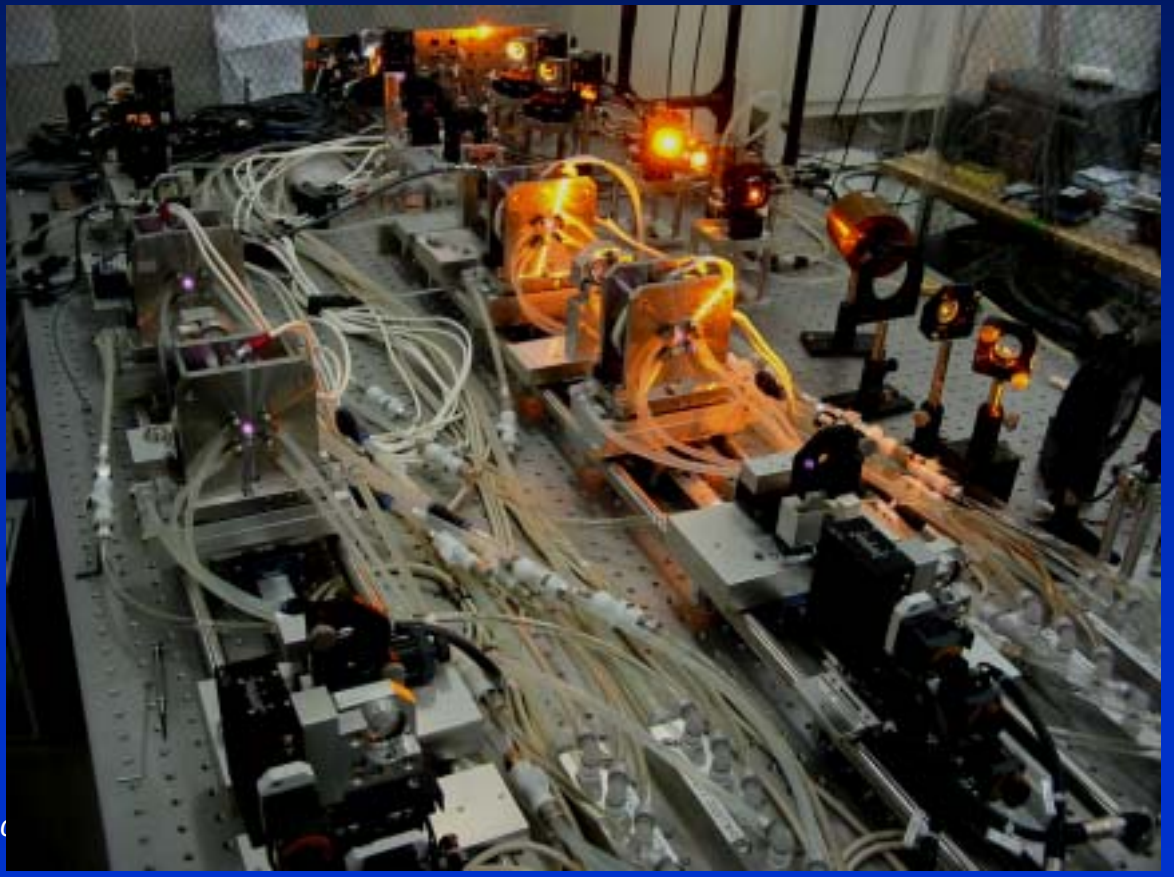
Sum frequency 589 nm laser (Megaopt Co., RIKEN, NAOJ)

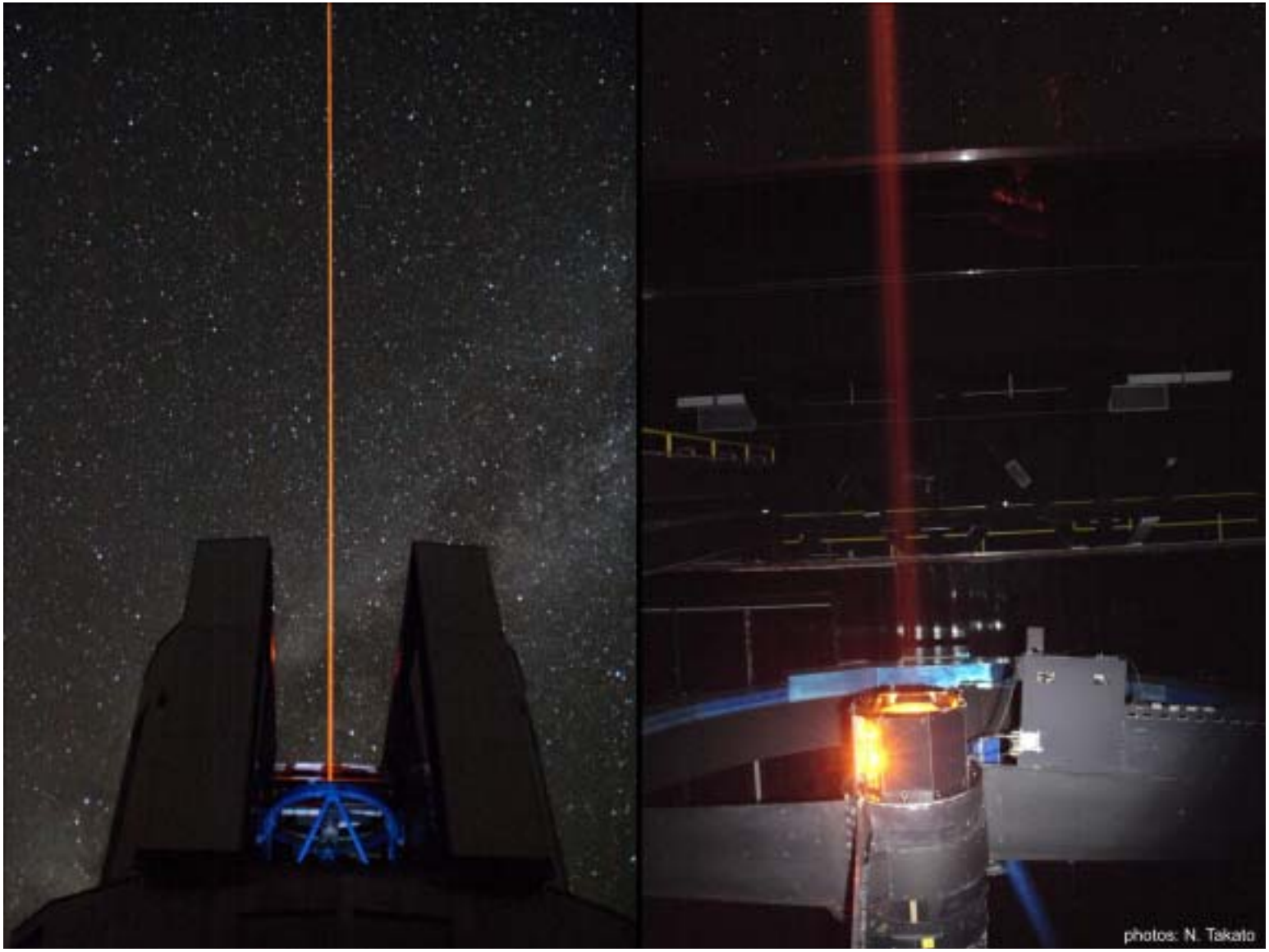
$$\frac{1}{1064nm}+\frac{1}{1319nm}=\frac{1}{589nm}$$

YAG YAG NaD

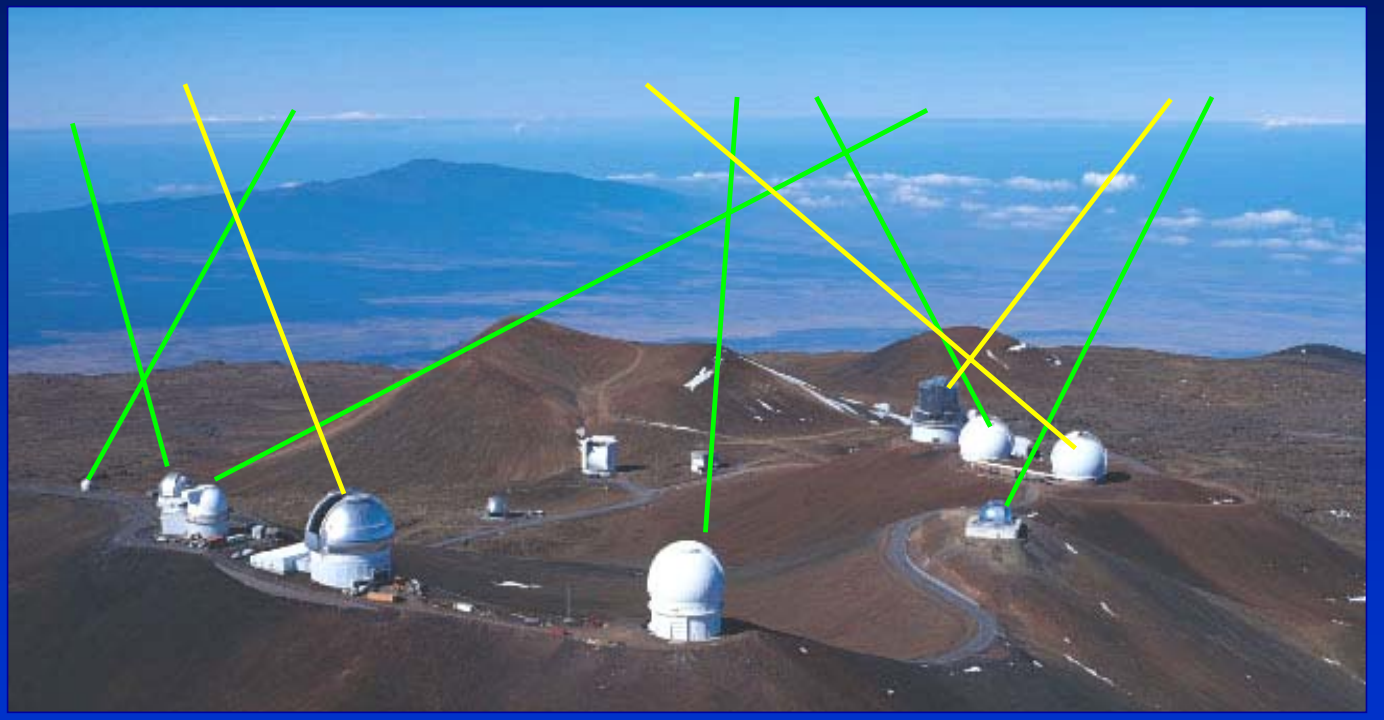


Sum Frequency Laser (inside view) now shipping to Hilo



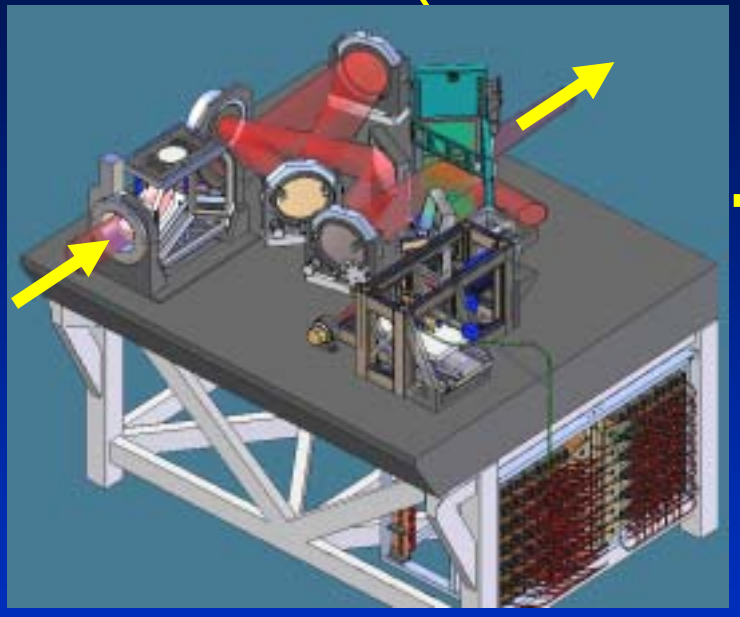

photos: N. Takato

Laser Traffic Control System

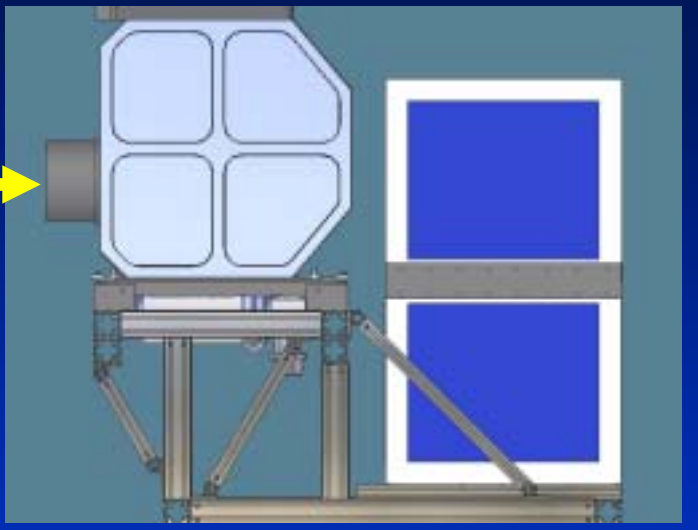


Instrument with AO188

AO+IRCS
(IR camera & spectrograph)



LGSAO 188 element (2006)

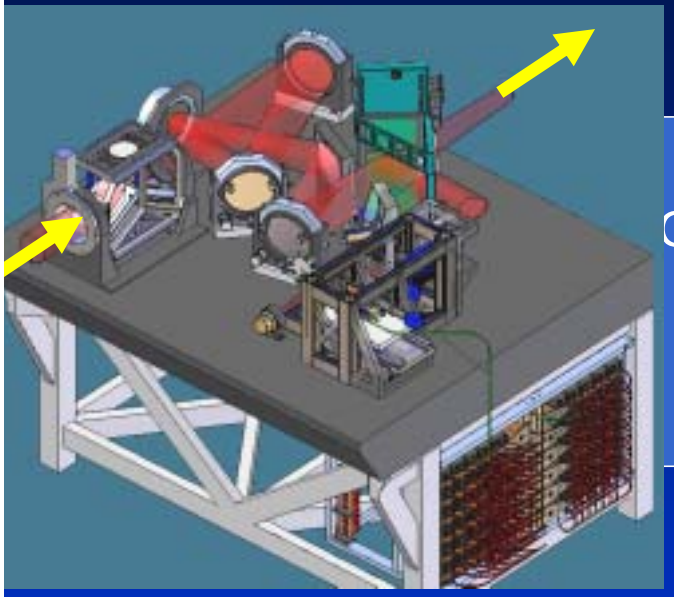


IRCS modification (2005 end)

1024x1024 InSb array
12, 18, 47mas/pix 1-5um
Grism R=1000
Echell R<20000
Low dispersion R=100@3um
1.5-5um simultaneously

AO+HiCIAO

Search for exosolar planets



AO188 (2006)

Advanced Coronagraph +AO1000

2007 – 2012

HiCIAO (2007)

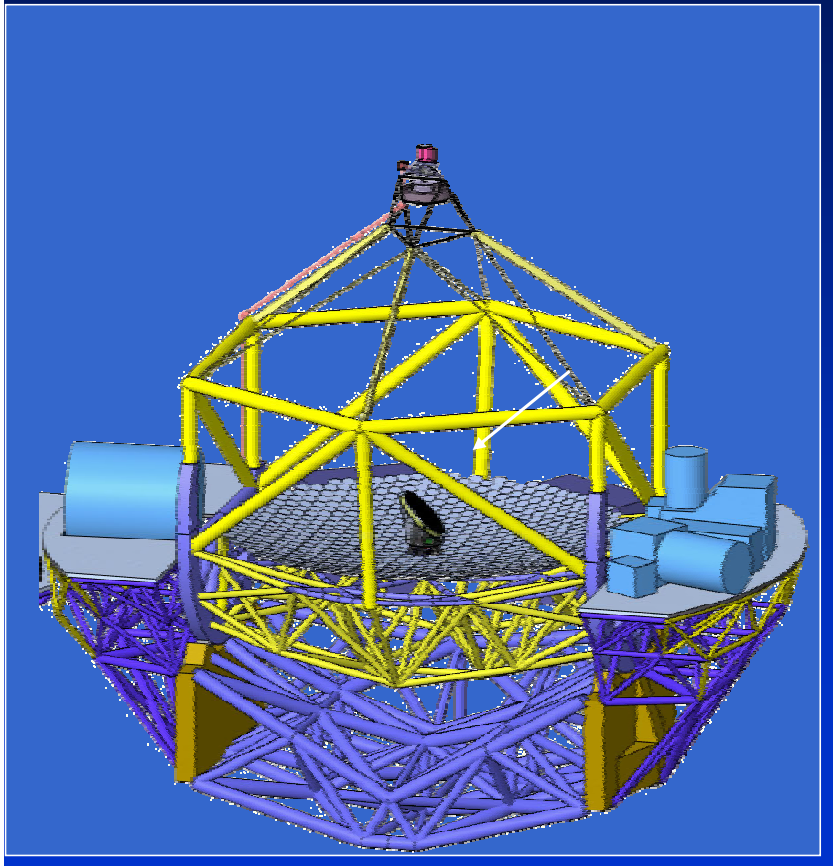
2048x2048 Hawaii array
Warm optics, SDI mode,
Coronagraph, Easy upgrade
Contrast 10^4@0.1" 10^6@1"

Future of AO

1) For Extream Large Telescope

2) Other field, Vision science

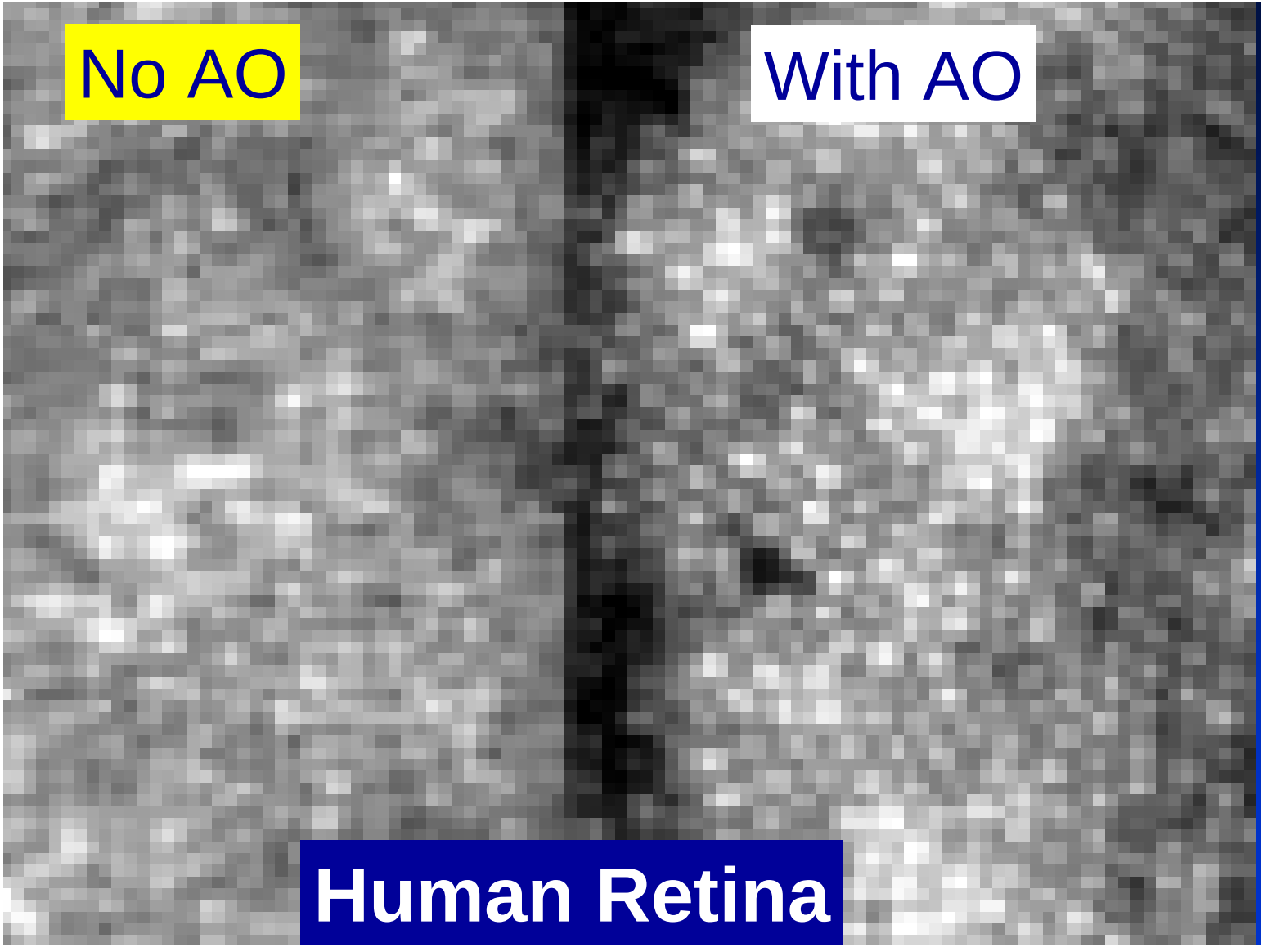
Extreme Large Telescope



TMT
(Thirty Meter Telescope)
First Light 2016

With AO,
4 times spatial resolution
16 times sensitivity

Key technology for ELT

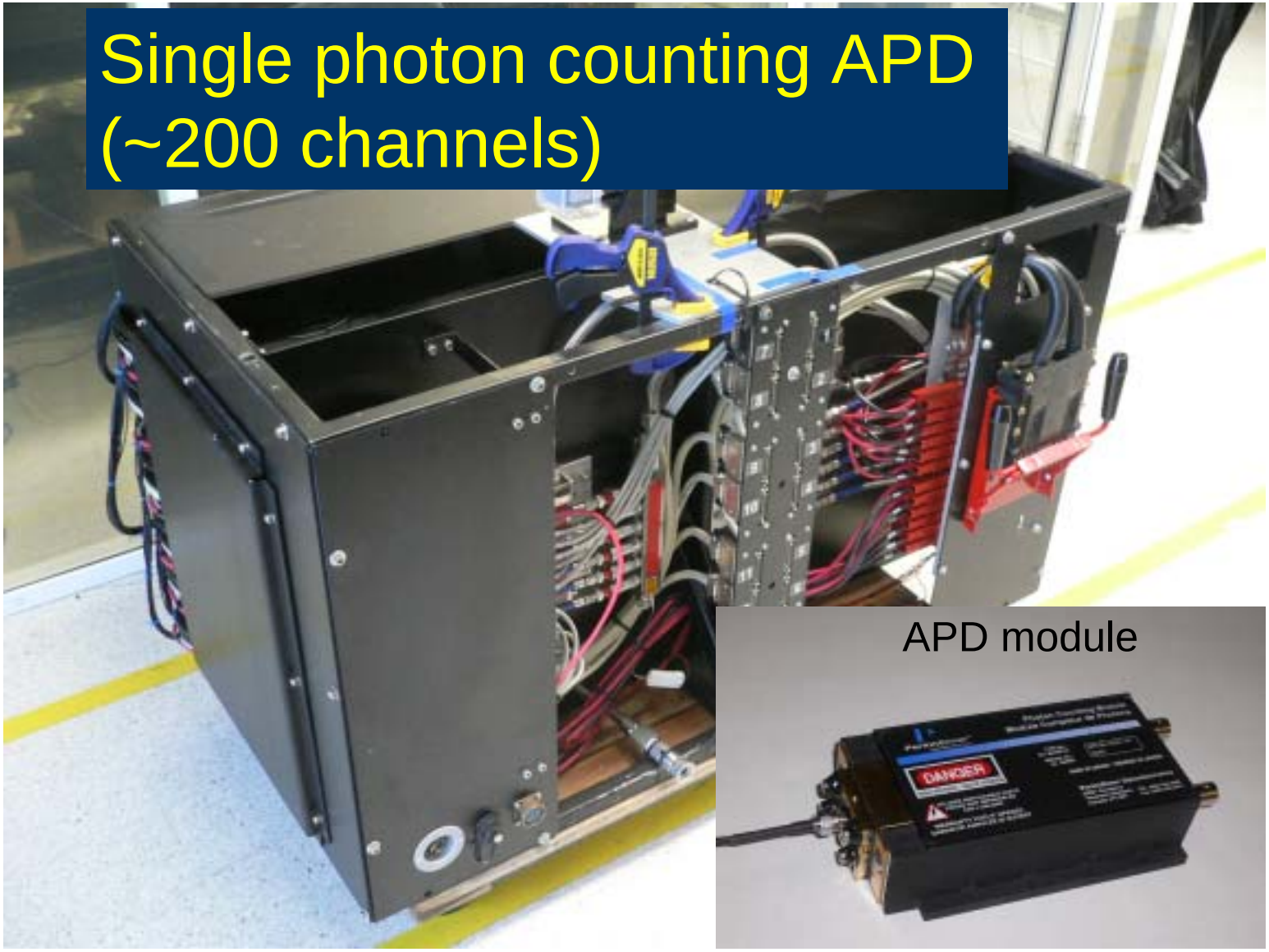

No AO
With AO
Human Retina


SUBARU

スケジュール

2006/10	**初観測**
2007/6	**本格試験観測開始**
2008/1	**自然ガイド星AO共同利用開始**
2008/6 (TBD)	**レーザーガイド星AO共同利用開始**

Single photon counting APD (~200 channels)

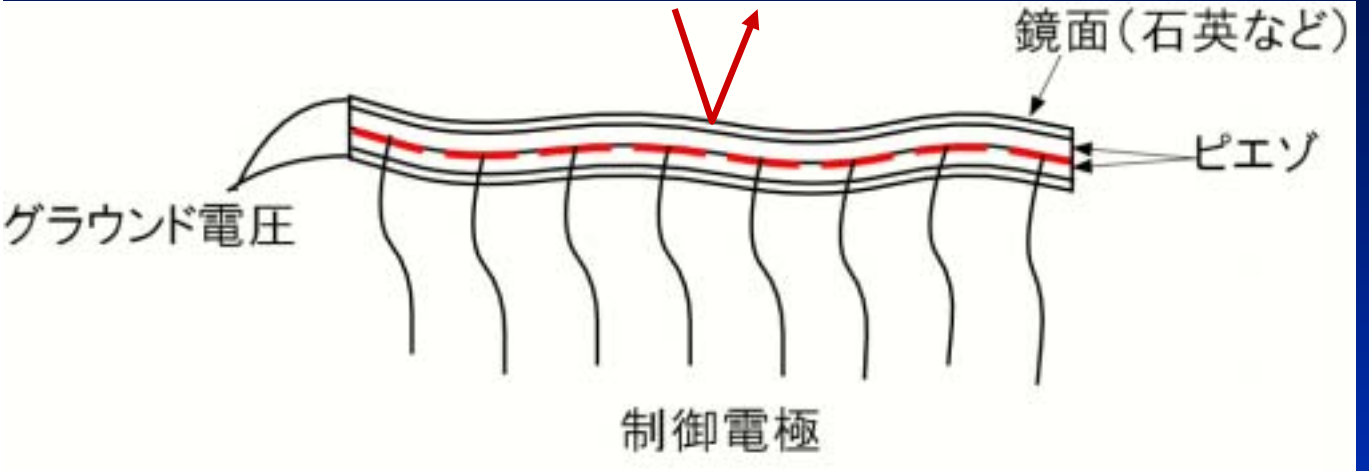


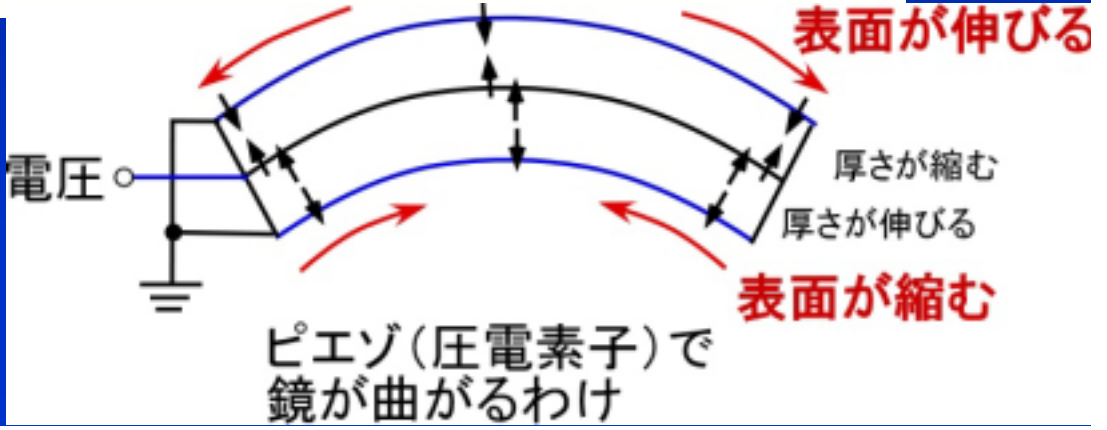
APD module

Control Electronics (> 1000 correction/sec)

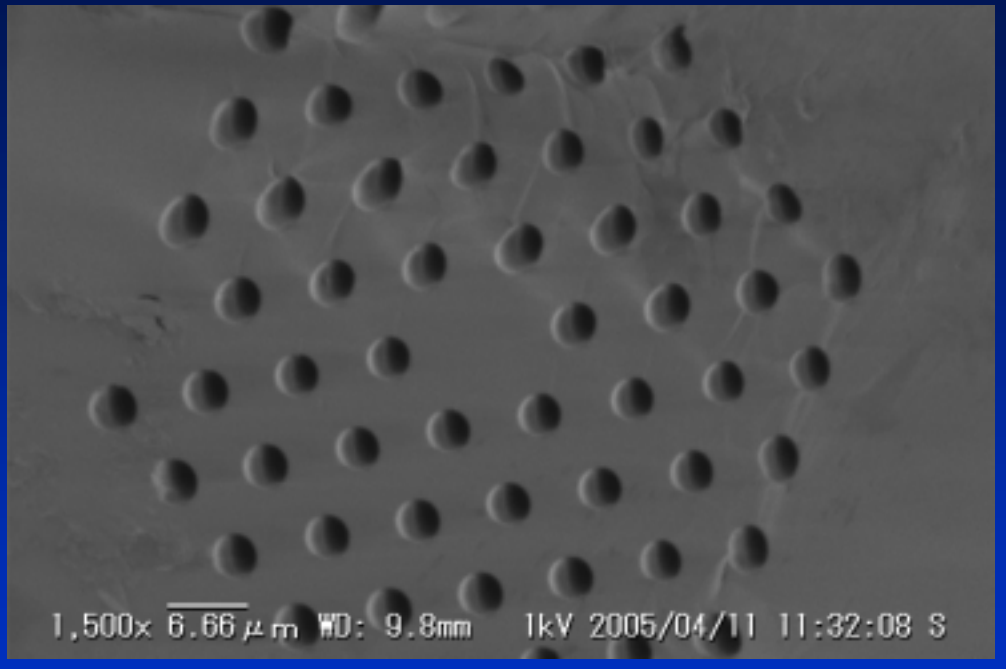
Left: Wavefront sensor, Right：Deformable mirror

How to deform the surface of mirror





Photonic Crystal Fiber (PCF)



Larger core diameter 14 um than SI fiber 5um
=> low power density

PCF experiment

Beam input experiment

Output Beam