02/29/2008
International review

MOIRCS

Takashi Ichikawa

Tohoku University


MOIRCS
Multi-Object Infrared Camera and Spectrograph
for Subaru
One of the most advanced and powerful instruments the
8-10 meter ground-based telescopes have at this time

Joint Project of Subaru Telescope and Tohoku University

Subaru/NAOJ (PI) T. Nishimura, K. Omata, T. Yamada,
Tohoku Univ. T. Ichikawa, R. Suzuki, C. Tokoku, Y. Uchimoto,
M. Konishi, T. Yoshikawa, I. Tanaka

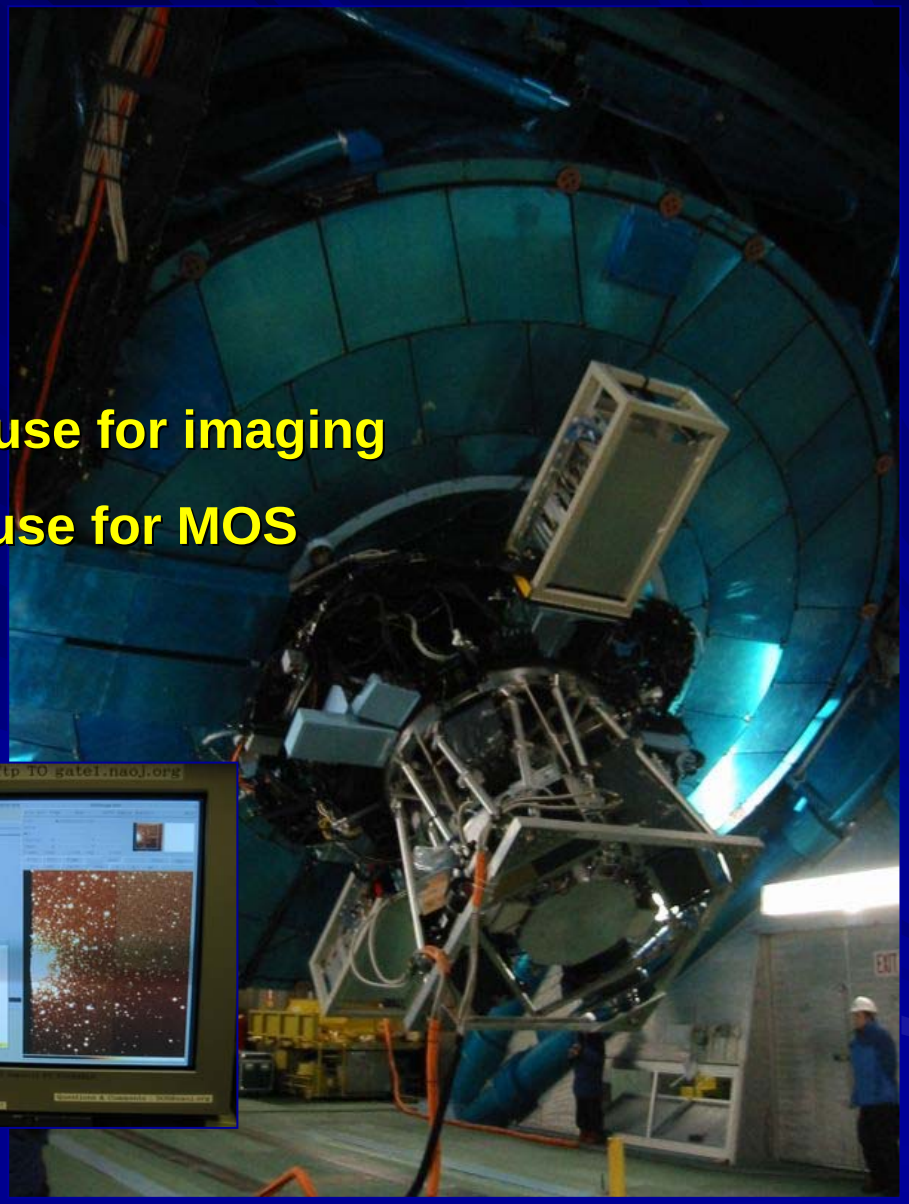
1999 R&D started

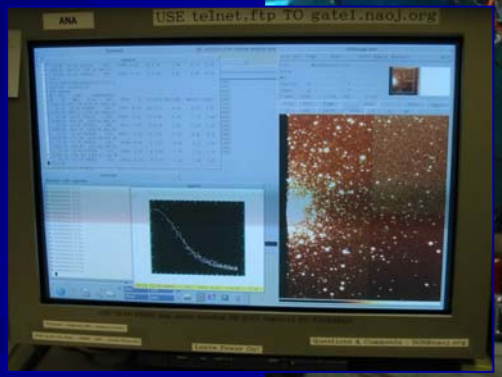
2000 Construction started

2004 Sep. first light

2006 Feb open to common use for imaging

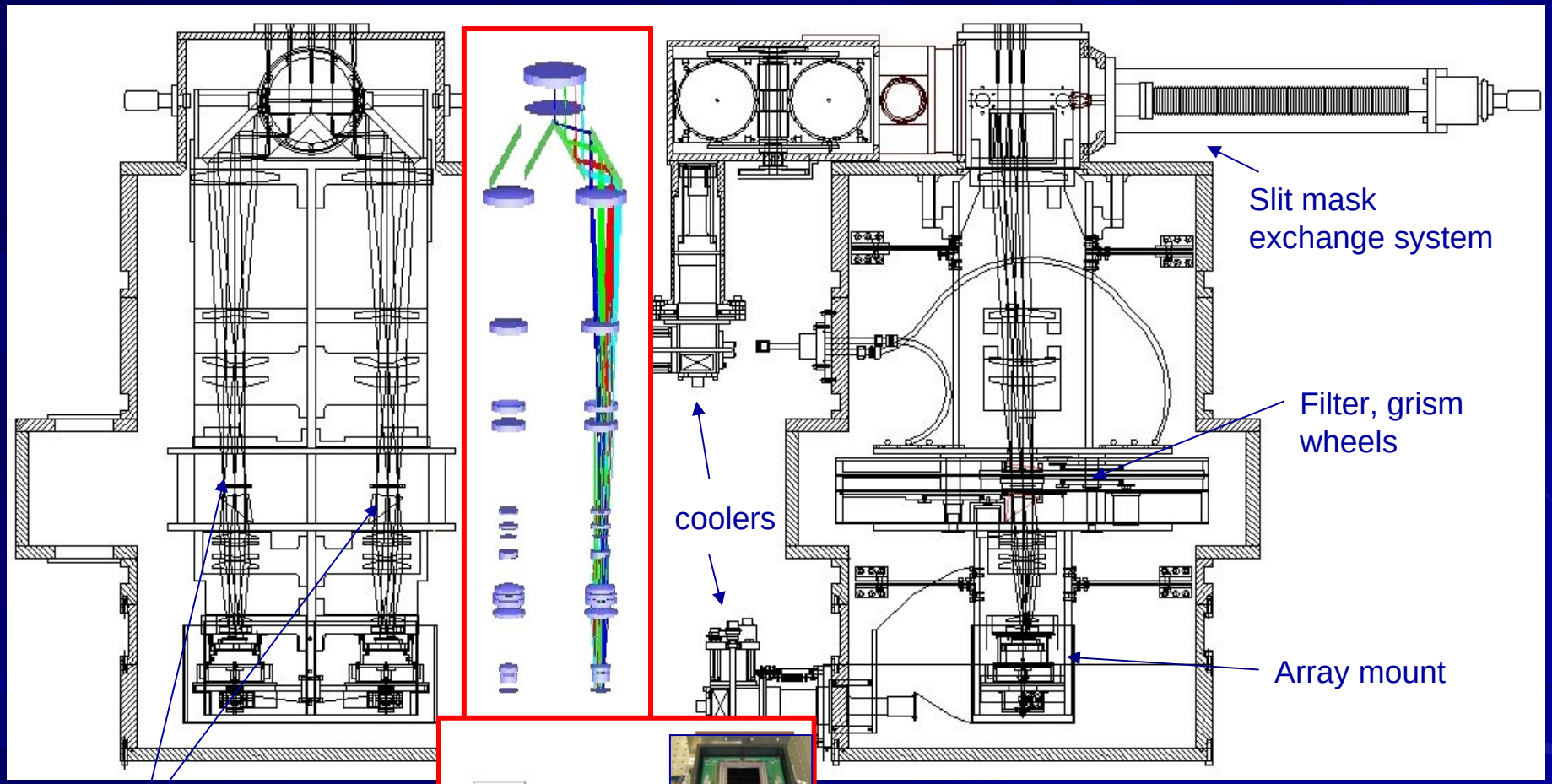
2006 Aug open to common use for MOS





The first light with students

MOIRCS Overview



Focus on two 2Kx2K HAWAII2 arrays

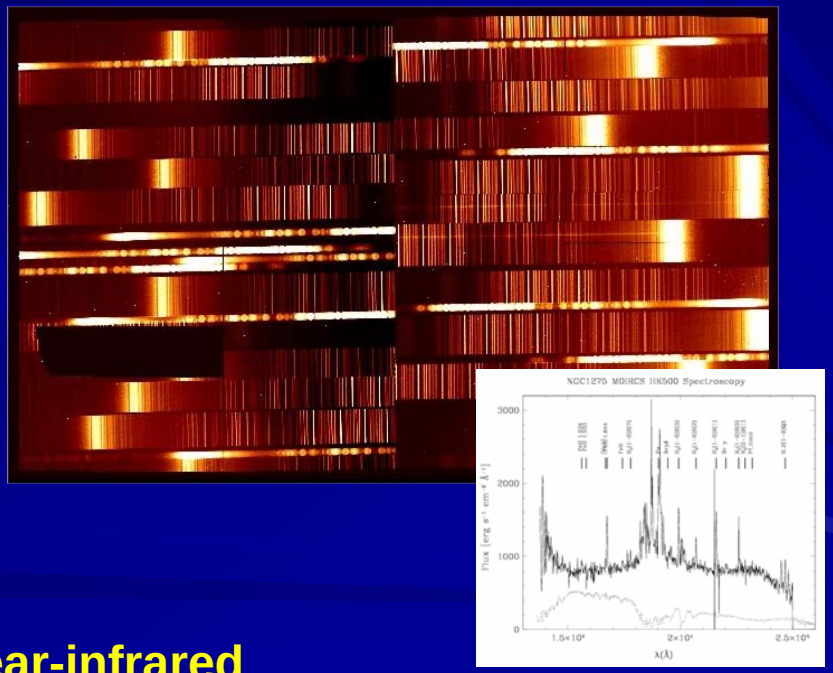
(A buttable array 4Kx4K was not available)

Two challenges of MOIRCS in 0.8 μm - 2.5 μm

Wide field of view, keeping high image quality in near infrared. Nearly ten times wider for the imagers of 8-10m telescopes

multi-object spectroscopy in near-infrared wavelength (to K band) with cooled slit masks, which was not available for current 8-10 m telescopes

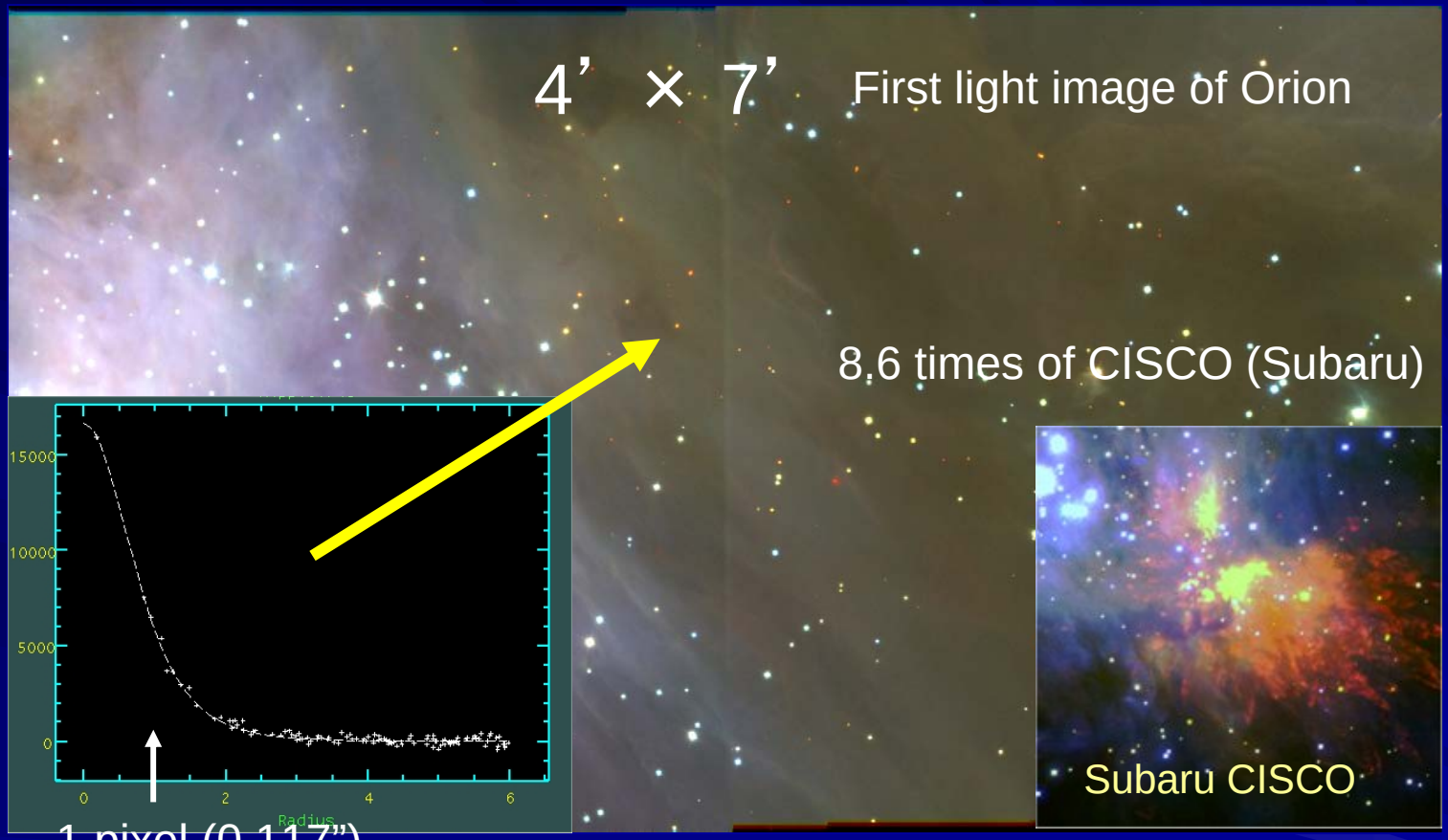
Near-infrared spectra of about 50 objects are obtained with one shot.



This a common technology in optical.

MOIRCS is the first and only one in near-infrared for 8-10m telescopes.

MOIRCS gives wide field and superb image quality



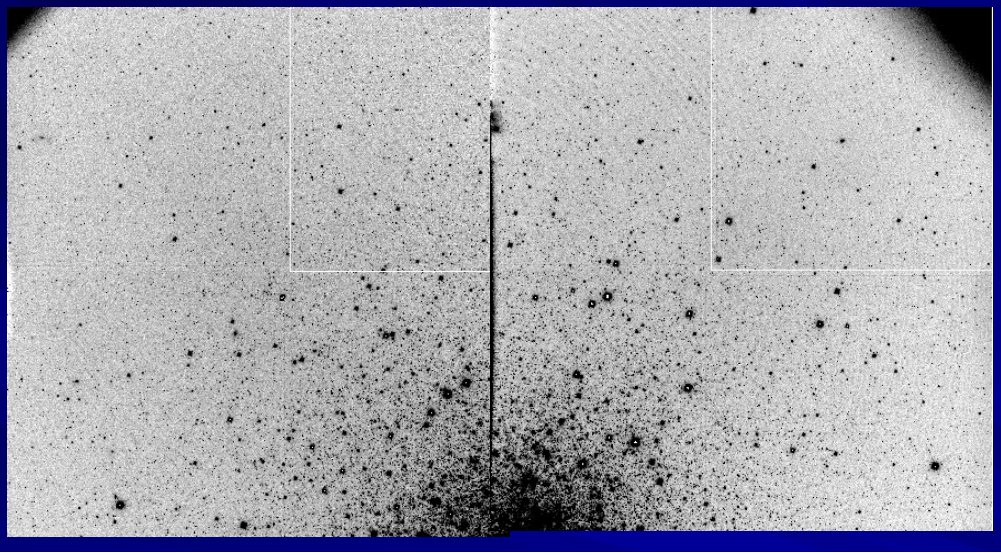
1 pixel (0.117”)

Best seeing: FWHM=0.18” (13s exposure, without adaptive optics)

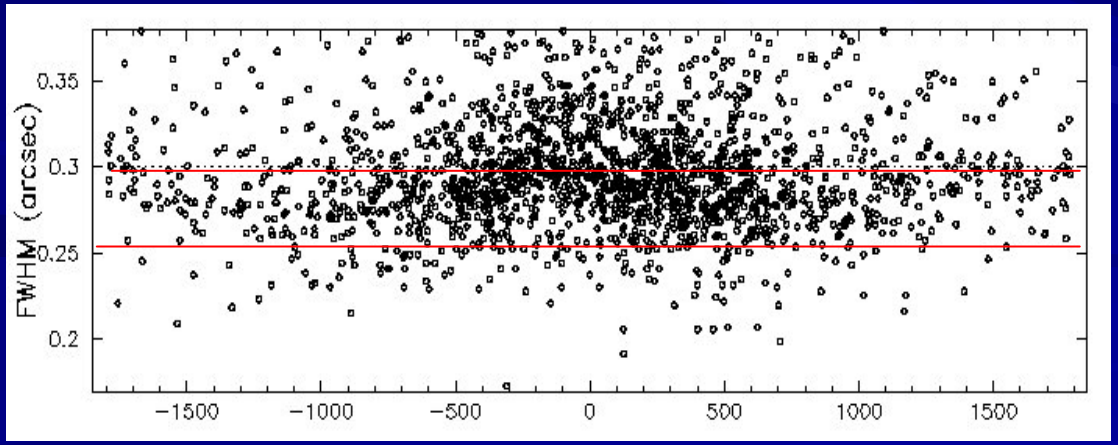
Good image quality (~0.2”-0.3”) is always available over the field under good seeing

An Image Quality Map

The average image size is FWHM=0.28” over full field of view without any perceptible degradation of image quality. PSF is very uniform.



M3

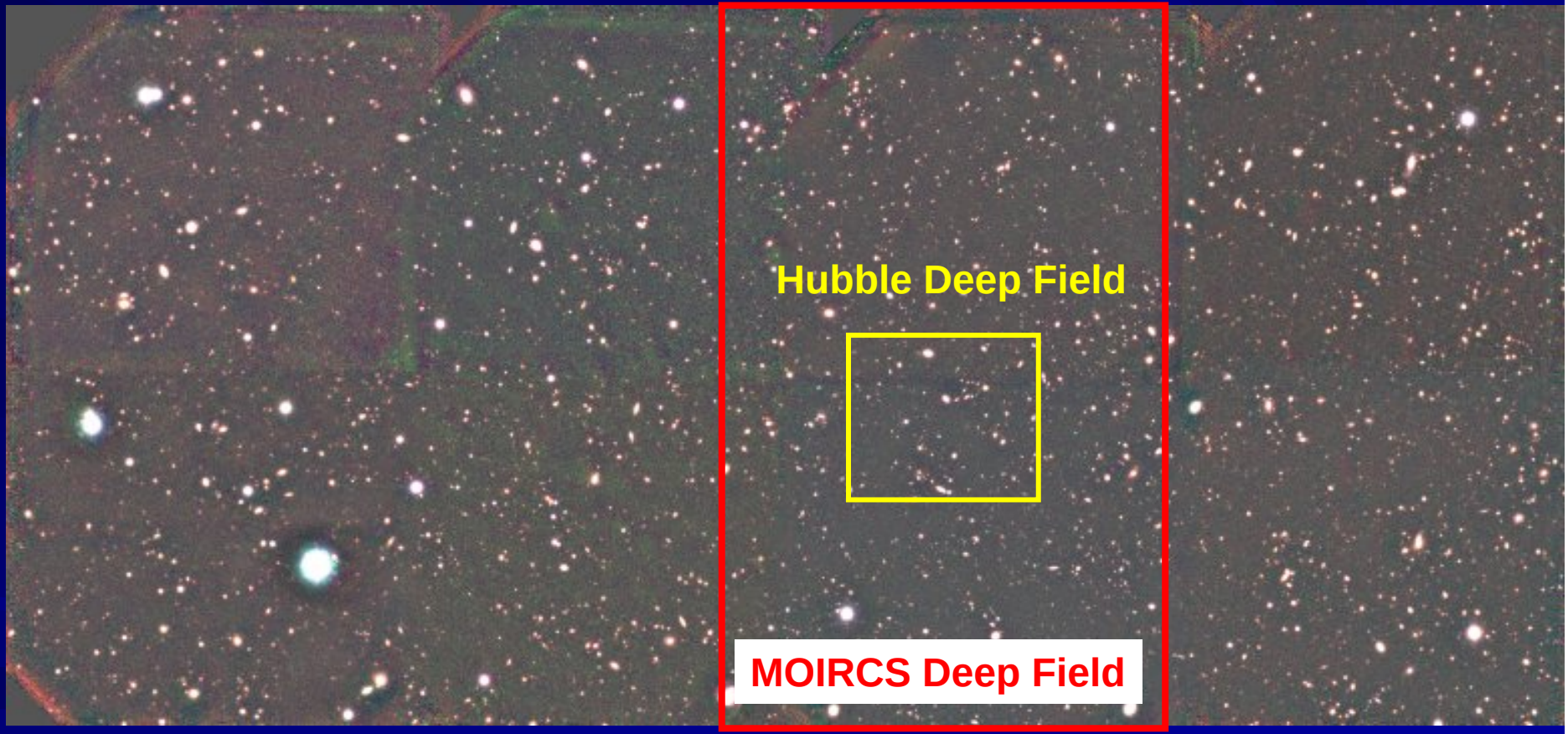


0.3”

0.25”

MOIRCS Deep Survey (MODS) Project In GOODS-North region

MOIRCS builder and science team



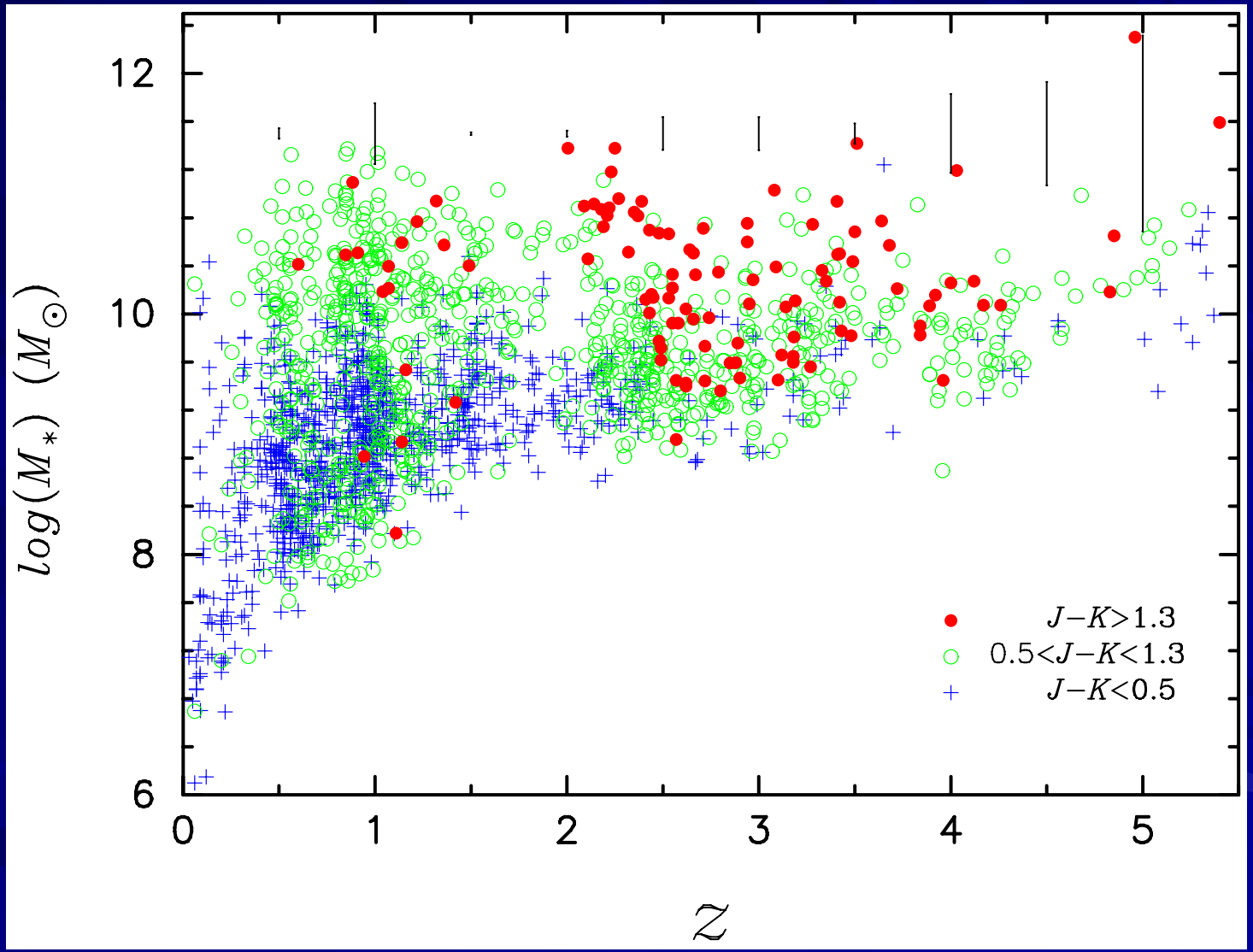
Ks band image

FWHM =0.40 "

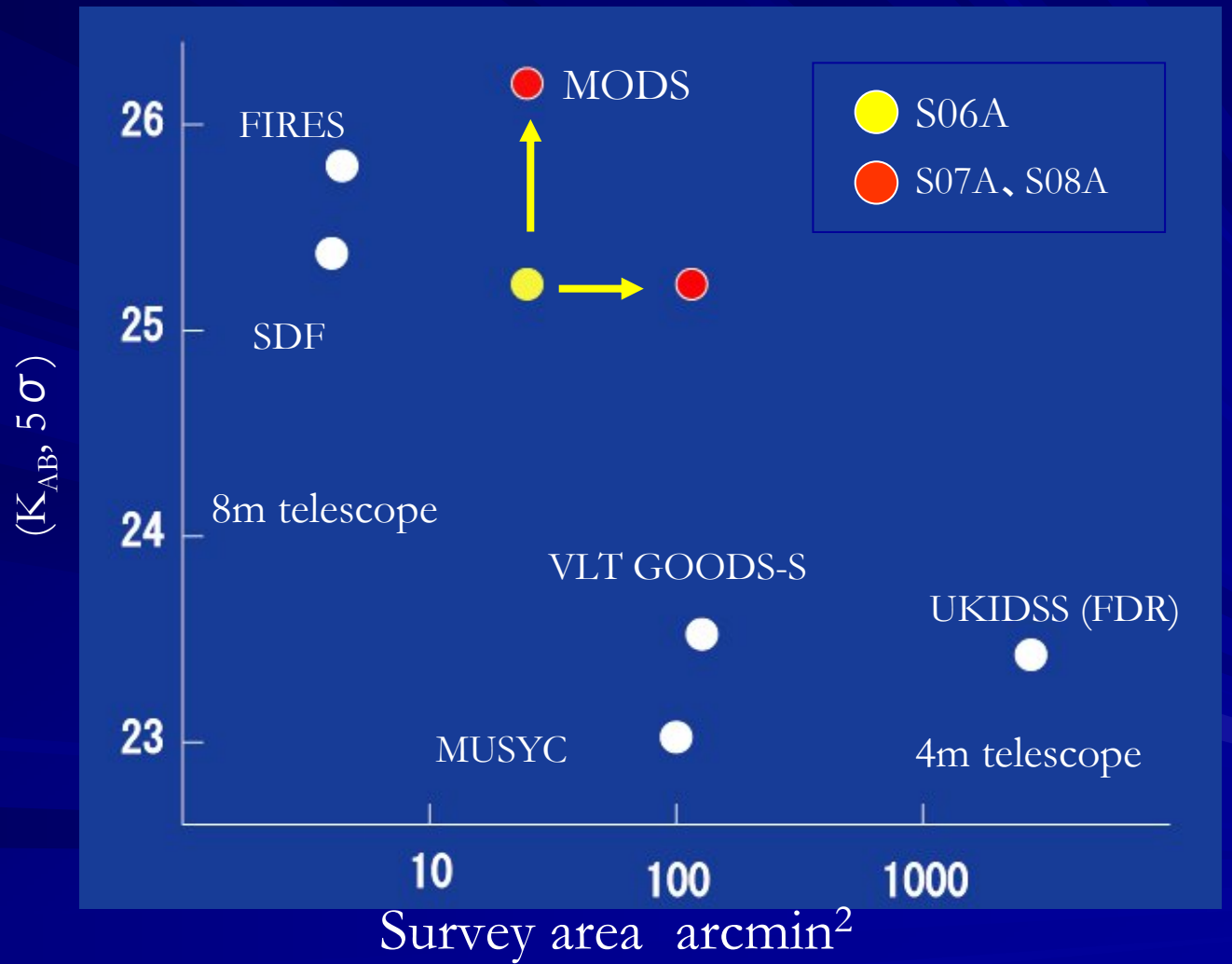
(12 hour integration)

3 σ limit
25.3 mag (Vega)

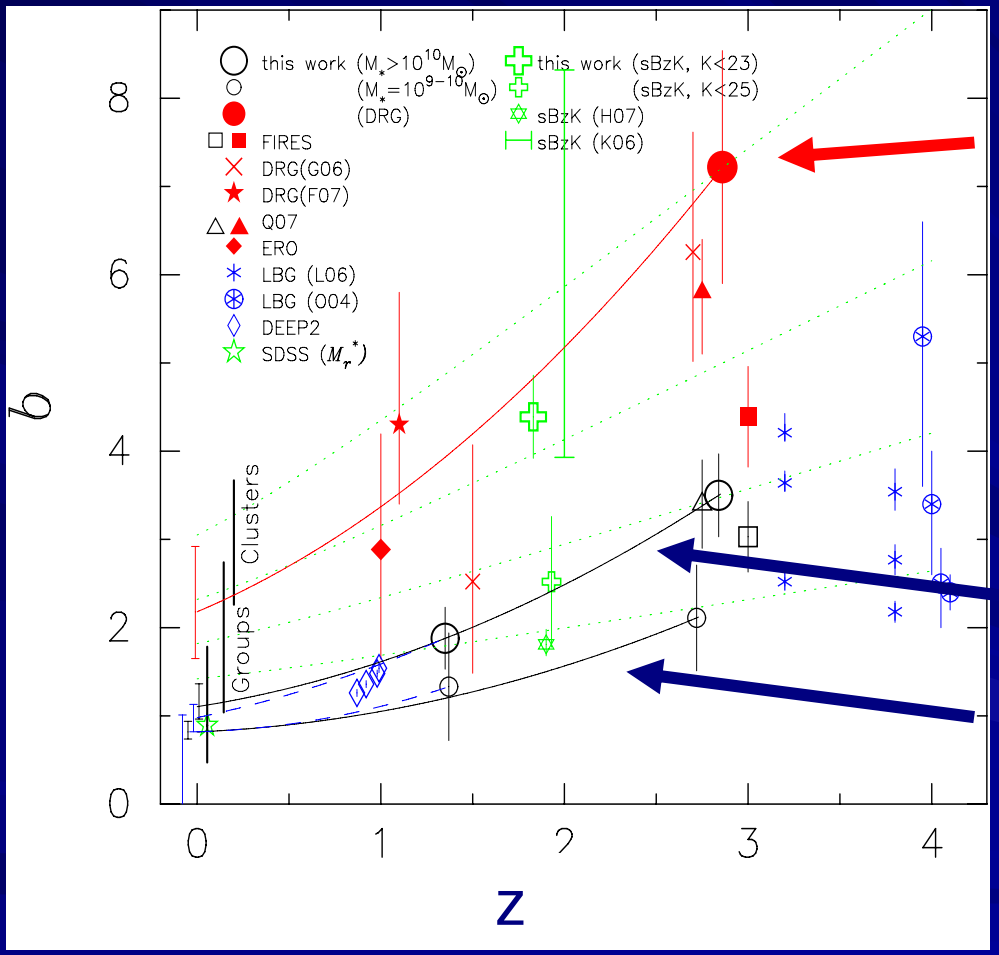
Stellar masses as a function of redshift in MODS



MOIRCS is in the forefront of near-Infrared astronomy



Clustering analysis shows that less massive galaxies (stellar mass ~ $10^{9\text{-}10}$ Msun) evolve into normal galaxies in local universe.



Bias parameter against CMD

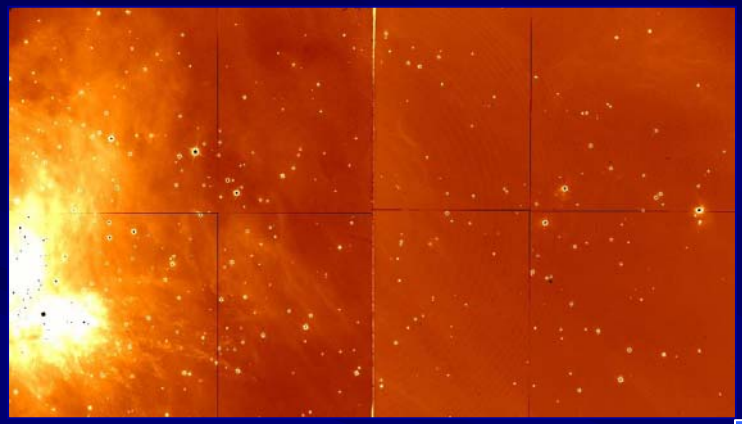
DRG

Massive galaxies ($M_*>10^{10}$ Msun)

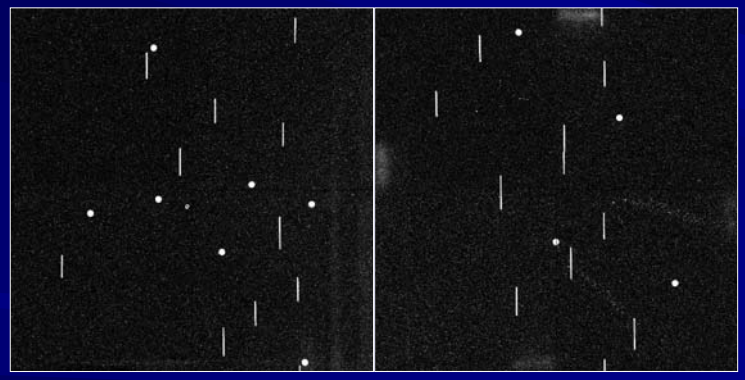
Less massive galaxies ($M_*\sim10^{9\text{-}10}$ Msun)

Ichikawa + (2007)

First Multi-object spectra in Orion



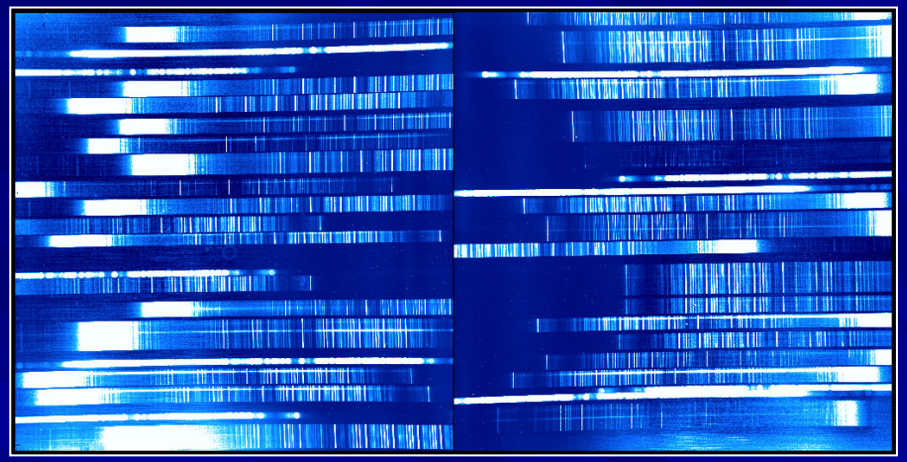
+

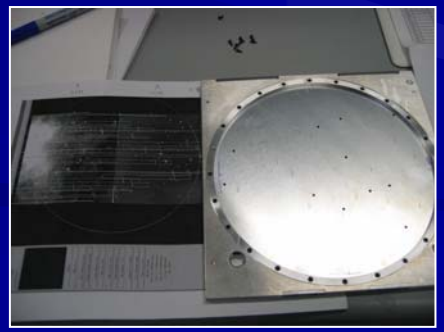


Slits or hole cut on the targets at the calculated position on shrink aluminum plate

The spectra of about 30 stars can be seen on the slit.

No single star is escaped from the slit.

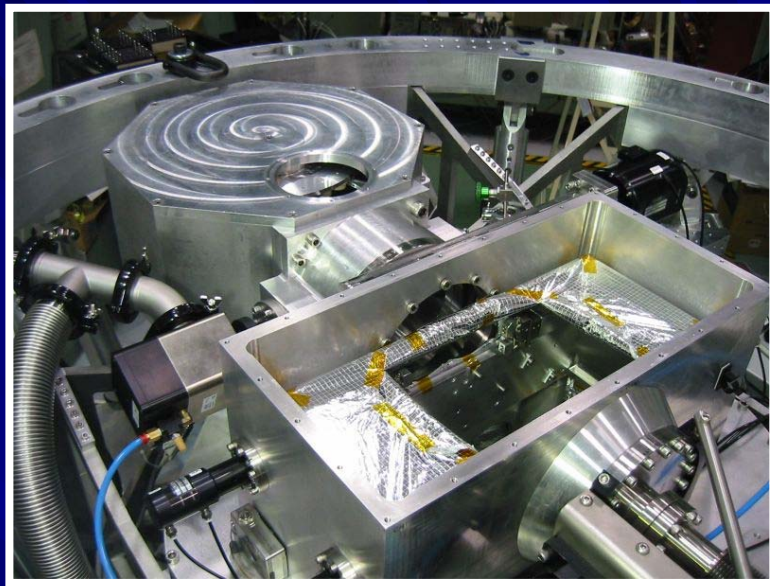


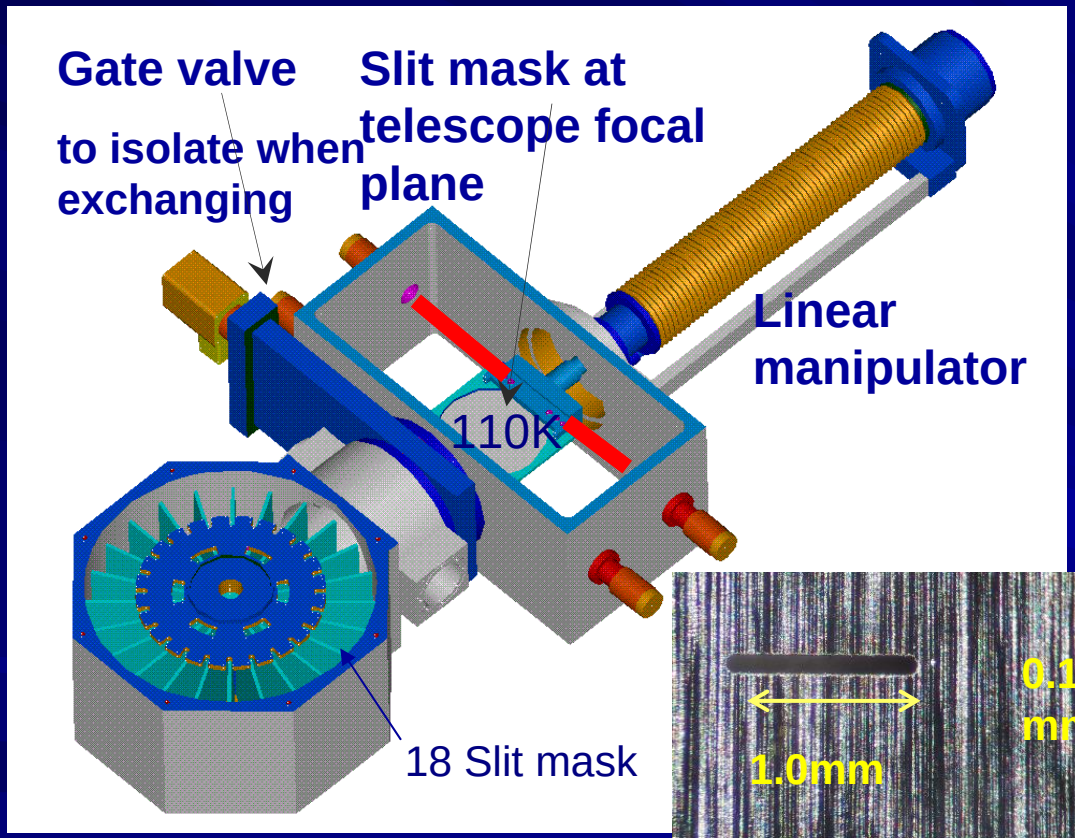


Slit Mask Exchange System

a jukebox technology in vacuum

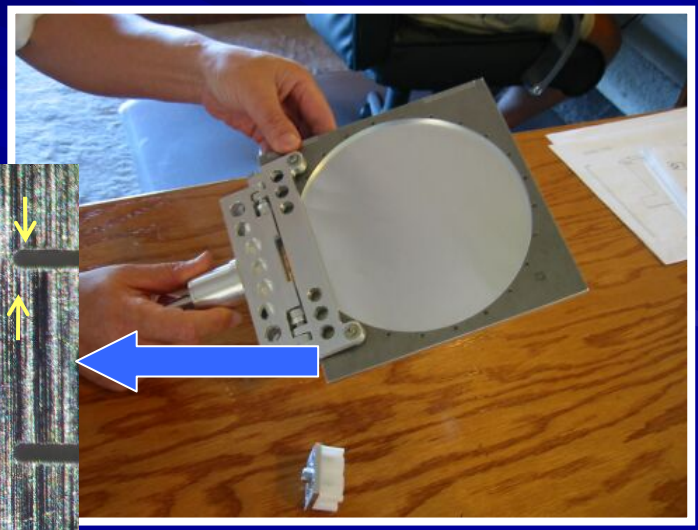
to keep slit masks at ~110 K





Mask Dewar (Carrousel)

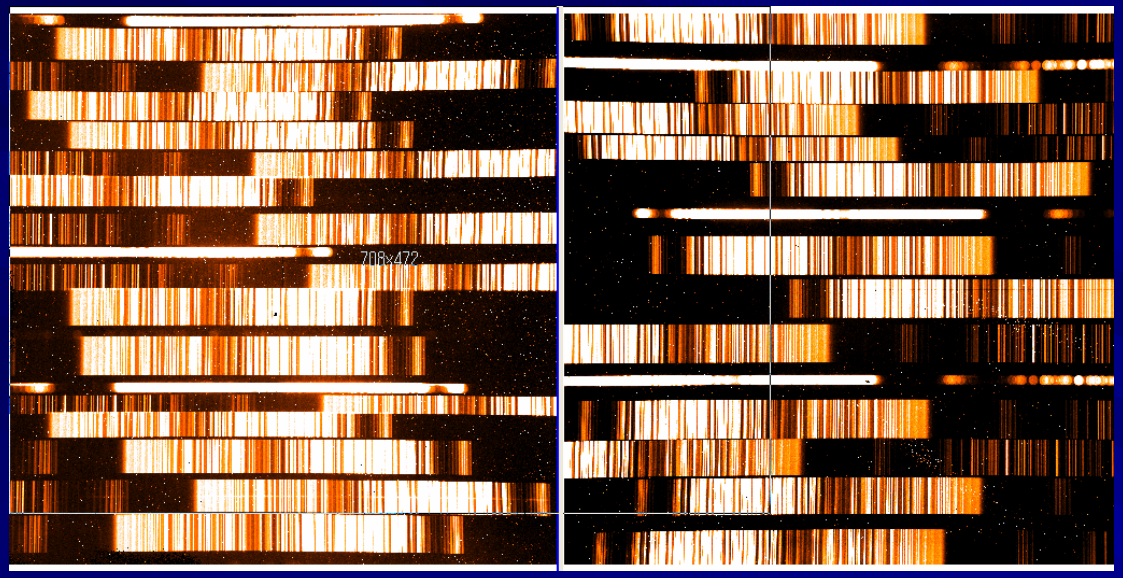
Cut by Laser



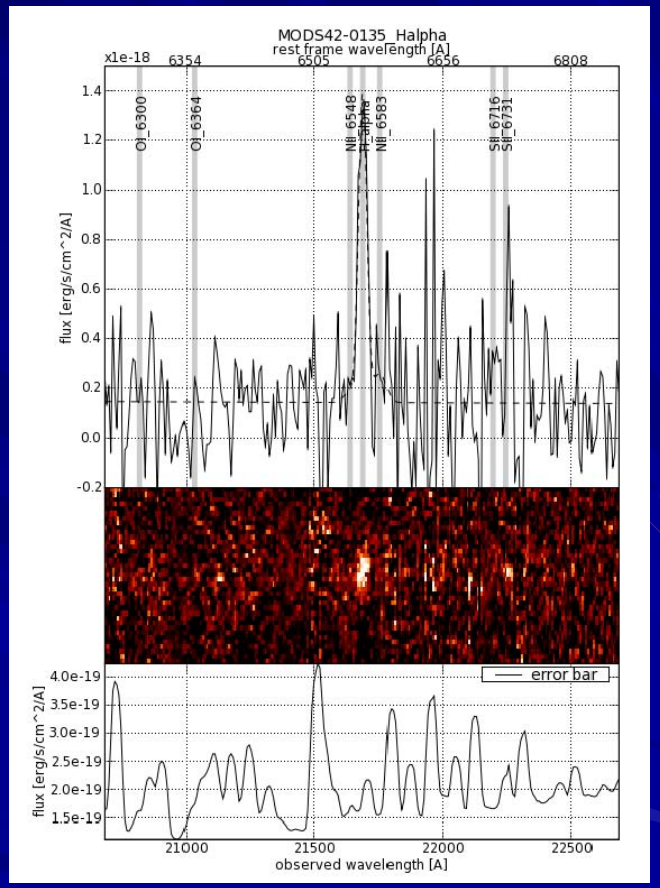
Aluminum slit mask

Multi object spectroscopy in MODS project

Star formation activity in massive galaxies at z~2-3
(Yoshikawa et al. in preparation)



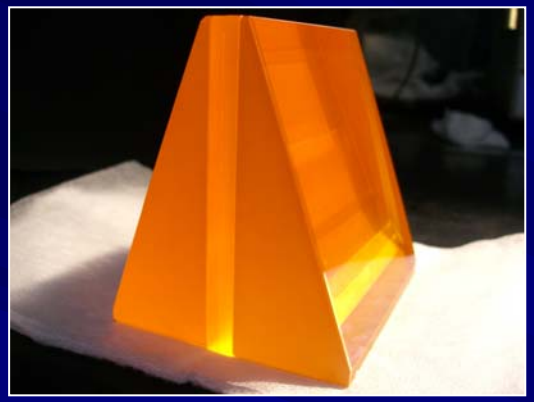
R=500



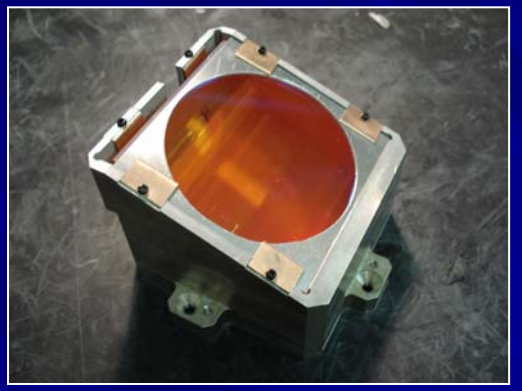
R～1300 and 500 are now In common use

Hα emission at z=2.305

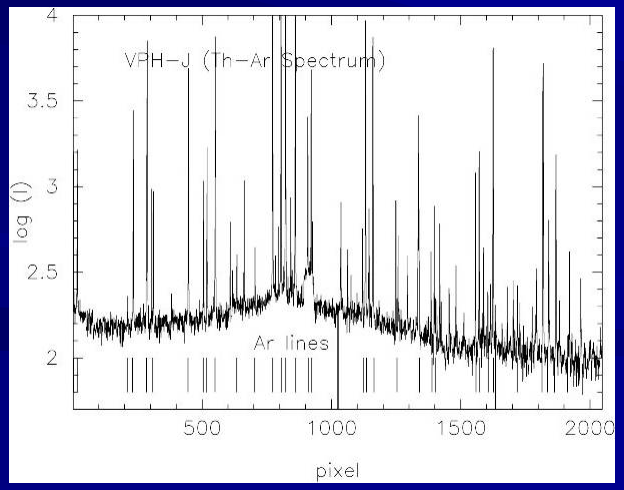
Cryogenic VPH grisms with higher dispersion (R~3000) are now under commissioning. For J and H bands, they are open to common use from S08b. The grism in Y-band (1.0 μm) and K band (2.2 μm) will follow soon.



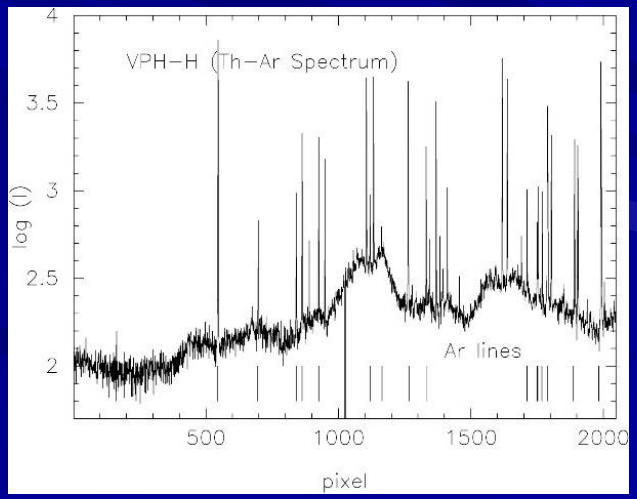
J (0.125 μm)



H (0.164 μm)



R=3050



R=2940

Near-infrared instruments for 8-10 m telescopes,

- wide filed imaging with high image quality in near-infrared

  MOIRCS has been two years ahead

  Cf. HAWK-I (VLT) with 7.5'x7.5' will be open in coming March.

- multi-object spectroscopy in near-infrared

  MOIRCS is still a unique instrument.

  Cf. A rival instrument FLAMINGOS2 Is still under construction.

Another important aspect in MOIRCS project

MOIRCS project greatly helped graduate students on the education in astronomical instrumentation and following research.

It is a great educational side product

From MOIRCS builder team, 4 Ph.D.s so far, and one more following closely. All have greatly contributed to MOIRCS construction.

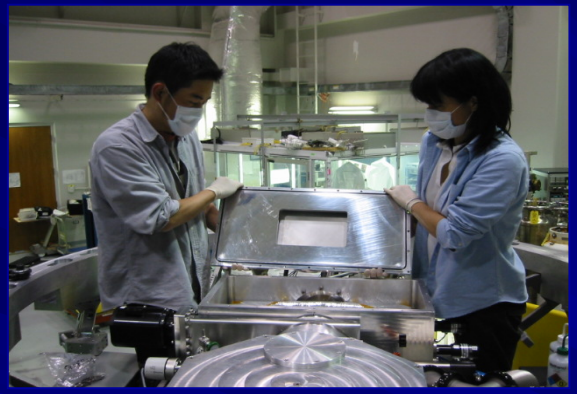
In general, common instruments for such a big telescope like Subaru are built by experts in astronomical instrumentation. However, while the education in universities is quite important, it would be very encouraging for student if they have a chance for the contribution to Subaru instruments.

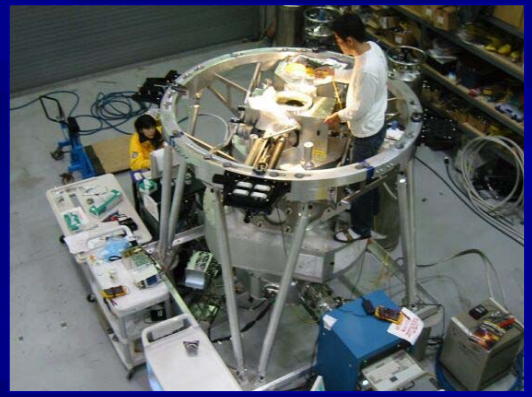
Subaru Telescope has a unique R&D, and education base in Hilo

Thanks to thoughtful consideration and help of Subaru members, many students were able to join in MOIRCS project and enjoyed the whole process of astronomical instrumentation from designing.
Without their help, students could never play important roles in the construction.

MOIRCS fully assembled at Hilo

An instrument made-in Hawaii, made-in Hilo


We used things off the shelf or self-making and self–designing components as many as possible to avoid expensive custom-made products.

A the result, the construction cost was much cheaper than those with same size.

Construction cost 3 Million US$

(without permanent staff salary)

2.7 Million US$ from Subaru telescope
0.3 Million US$ from Tohoku University

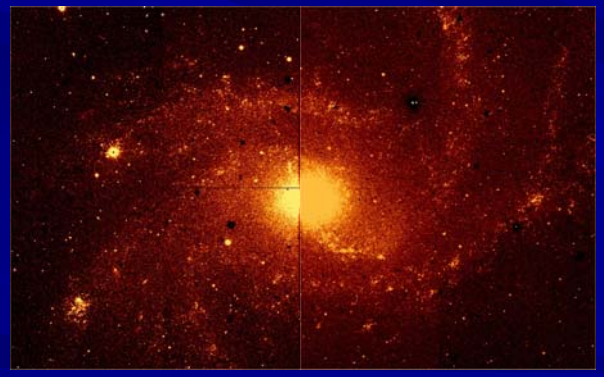
MOIRCS will usher in a new era in near-infrared astronomy from local universe to high-redshift.

In photometric and spectroscopic ways with MOIRCS

star formation in local nebulae

Orion nebula

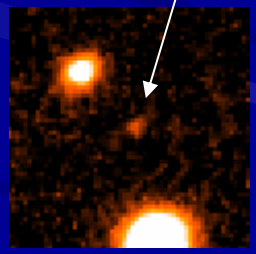
Star evolution in local galaxies



NGC6946

15M light-years

Galaxies beyond 10 billion years ago



DRG

Since the common use was started in Feb. 2006, MOIRCS has been one of the most popular instruments among Subaru instruments

For example, in the last semester (S07B),

- 37% of common use time was allocated to MOIRCS
- 46% of UH time was allocated to MOIRCS

In addition,

- MOIRCS is provided for the exchange program of observation time among Keck, Gemini, and Subaru telescopes

S08A March

24 days in March are allocated to MOIRCS observations.

Gemini use

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						Mar 01
						UH-13A Kartaltepe MOIRCS
Mar 02	Mar 03	Mar 04	Mar 05	Mar 06 ●	Mar 07	Mar 08
S08A-082 Koekemoer MOIRCS	Keck Brown SCam		UH-28B Jewitt SCam		S08A-018 Aoki HDS	S08A-021 Narita HDS
Mar 09	Mar 10	Mar 11	Mar 12	Mar 13 ◐	Mar 14	Mar 15
S08A-018 Aoki HDS	UH-54A Le Floch MOIRCS		Gemini Shanks MOIRCS	Gemini Bunker MOIRCS	UH-37A Henry MOIRCS	
Mar 16	Mar 17	Mar 18	Mar 19	Mar 20	Mar 21 ○	Mar 22
UH-37A Henry MOIRCS	S08A-083 Watson MOIRCS	S07A-010 Ichikawa MOIRCS				
Mar 23	Mar 24	Mar 25	Mar 26	Mar 27	Mar 28 ◑	Mar 29
S07A-010 Ichikawa MOIRCS	S08A-024 Tokoku MOIRCS		UH-51B Kewley MOIRCS	UH-25B Cowie MOIRCS		
Mar 30	Mar 31					
S08A-094 Ouchi MOIRCS						

Many scientific results will be expected soon.

Finally,

Tohoku University acknowledges, not only educational, but also financial support of Subaru Telescope to integrate infrastructure for astronomical instrumentation, which was very limited in our astronomical department before MOIRCS collaboration was started.