

# Future Instrumentation at Subaru

Naruhisa Takato, Ikuru Iwata  
(Subaru Telescope)

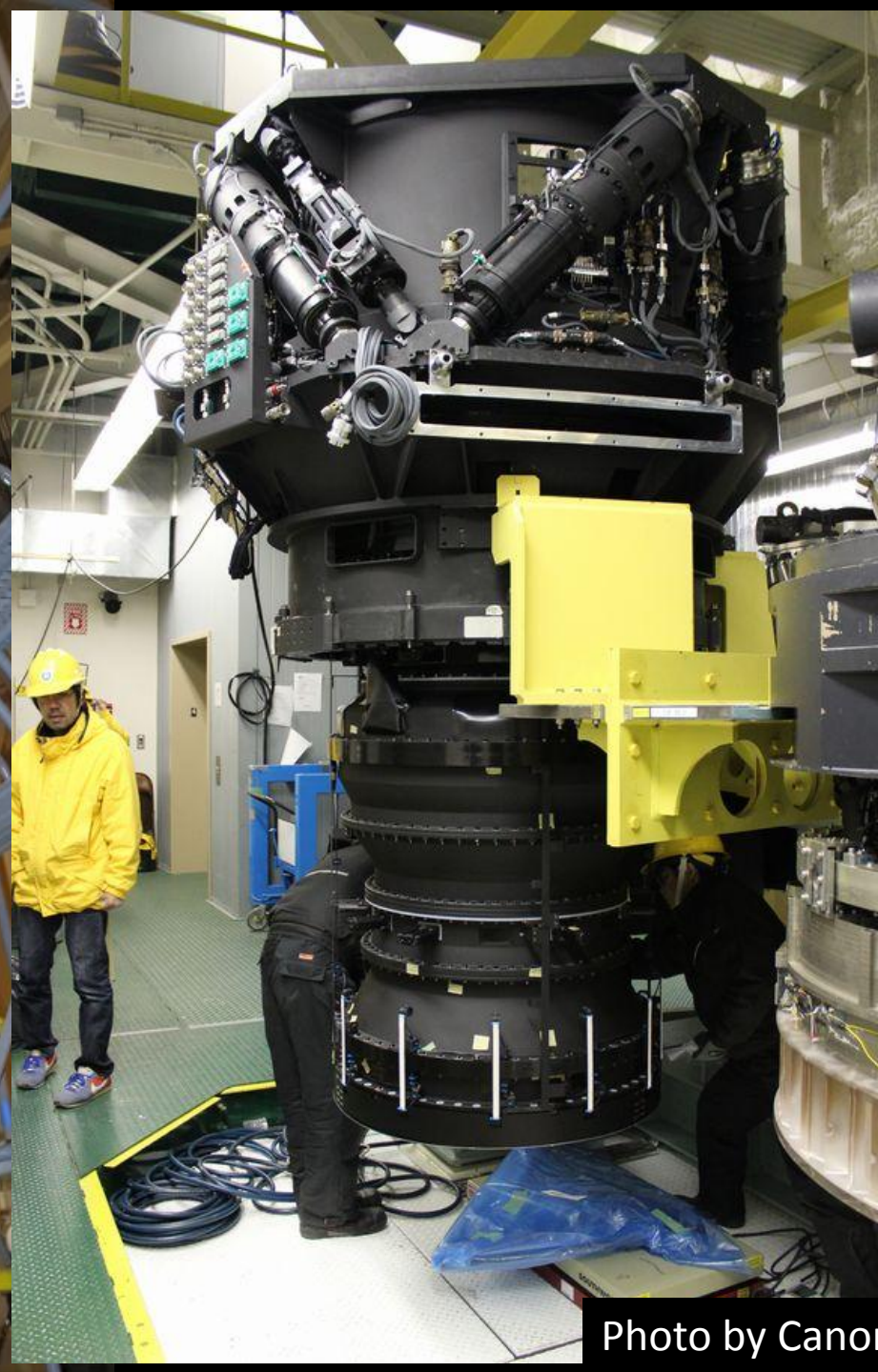
# Future Instrumentation at Subaru

1. Strengthen Subaru's advantage
  - wide-field capability
  - good image quality
    - \* Optical : **HSC + PFS**
    - \* NIR high Res. : **AO188 + SCExAO**
    - \* NIR wide-field: **GLAO**
2. Balance between **survey or specific-science** instruments and **general purpose** instruments.
3. Test-bed for future developments

# HSC

- $\Phi 1.5$  deg FoV
- Prime focus
- Commissioning run : 2012/08 ~
- Opne use (expected) : S13B or S14A





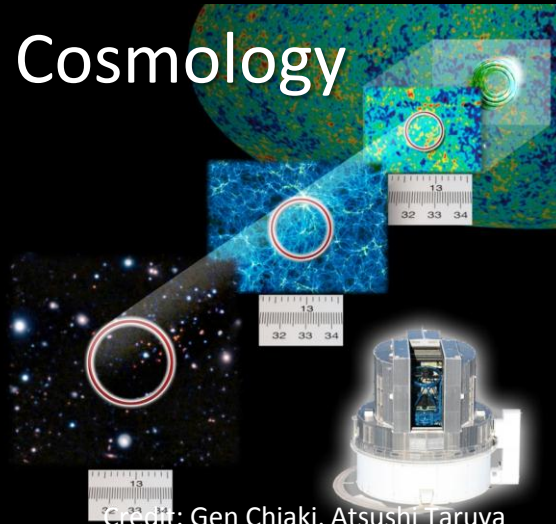
# Prime-Focus Spectrograph (PFS)

- Dark energy survey (BAO) +
- 2400 fibers
- $\phi 1.3^\circ$  patrol area
- 0.38 – 1.26  $\mu\text{m}$  simultaneously  
(4sets of 3 arms spectrograph)
- $R \sim 1400$  (blue) to  $R \sim 4800$  (NIR)
- cooled spectrograph optics ( $\sim < 5^\circ\text{C}$ )



# Science targets of PFS

## Cosmology



$9.3 \text{ h}^{-3} \text{ Gpc}^3$  in  $0.8 < z < 2.4$   
 $1400 \text{ deg}^2$

Credit: Gen Chiaki, Atsushi Taruya

Milky Way  $17 < V < 21.5$   $390 \text{ deg}^2$   
 M31 halo  $21.5 < V < 22.5$   $65 \text{ deg}^2$

## Galactic Archaeology

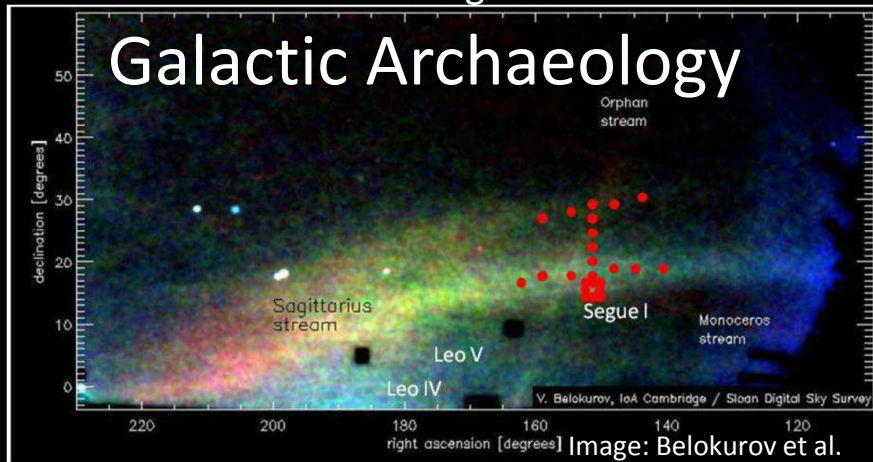
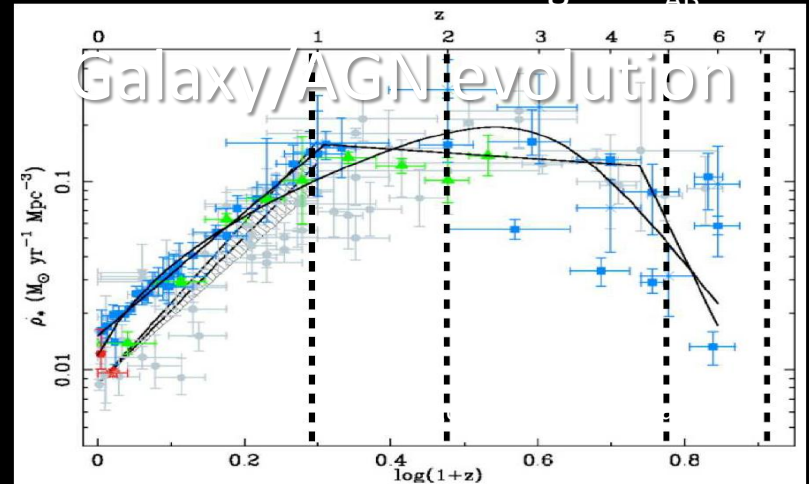


Image: Belokurov et al.

$1 < z < 2$   $16 \text{ deg}^2$  to  $J_{AB} \sim 23.4$

## Galaxy/AGN evolution



See arXiv:1206.0737 “Extragalactic science and cosmology with Subaru PFS” Ellis et al. (2012)

Sugai et al

# International Collaboration

IPMU, NAOJ (Japan), ASIAA (Taiwan) , Caltech/JPL,  
Princeton, JHU (USA), LAM(France), LNA+ (Brazil)



2011/01: supported by Subaru UM

2012/03: CoDR

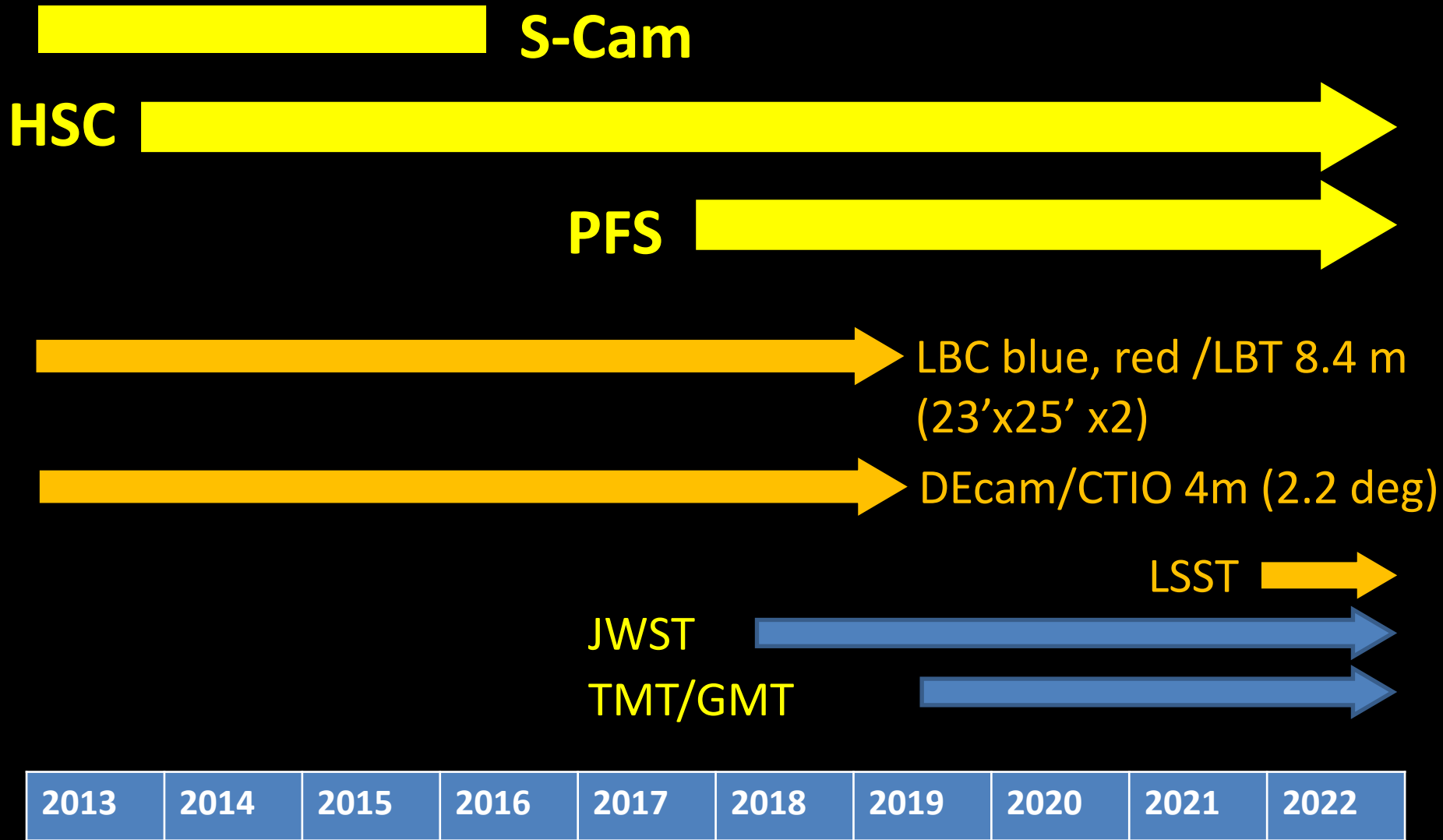
2013/02: PDR

2013/04: review by NAOJ

...

~ 2017 : engineering first light

# Subaru leads Wide-Filed Survey





# Exoplanet Science Instruments

- HiCIAO

Coronagraphic imager (SDI, PDI)

Use with AO188, SCExAO

SEEDS program (120 nights) are on going

- SCExAO

extreme AO, speckle nulling

- CHARIS

integral-field unit , J + H (+ K),  $R \sim 40$ ,  $> 1.8'' \times 1.8''$

use with AO188, SCExAO

Led by Univ. Princeton

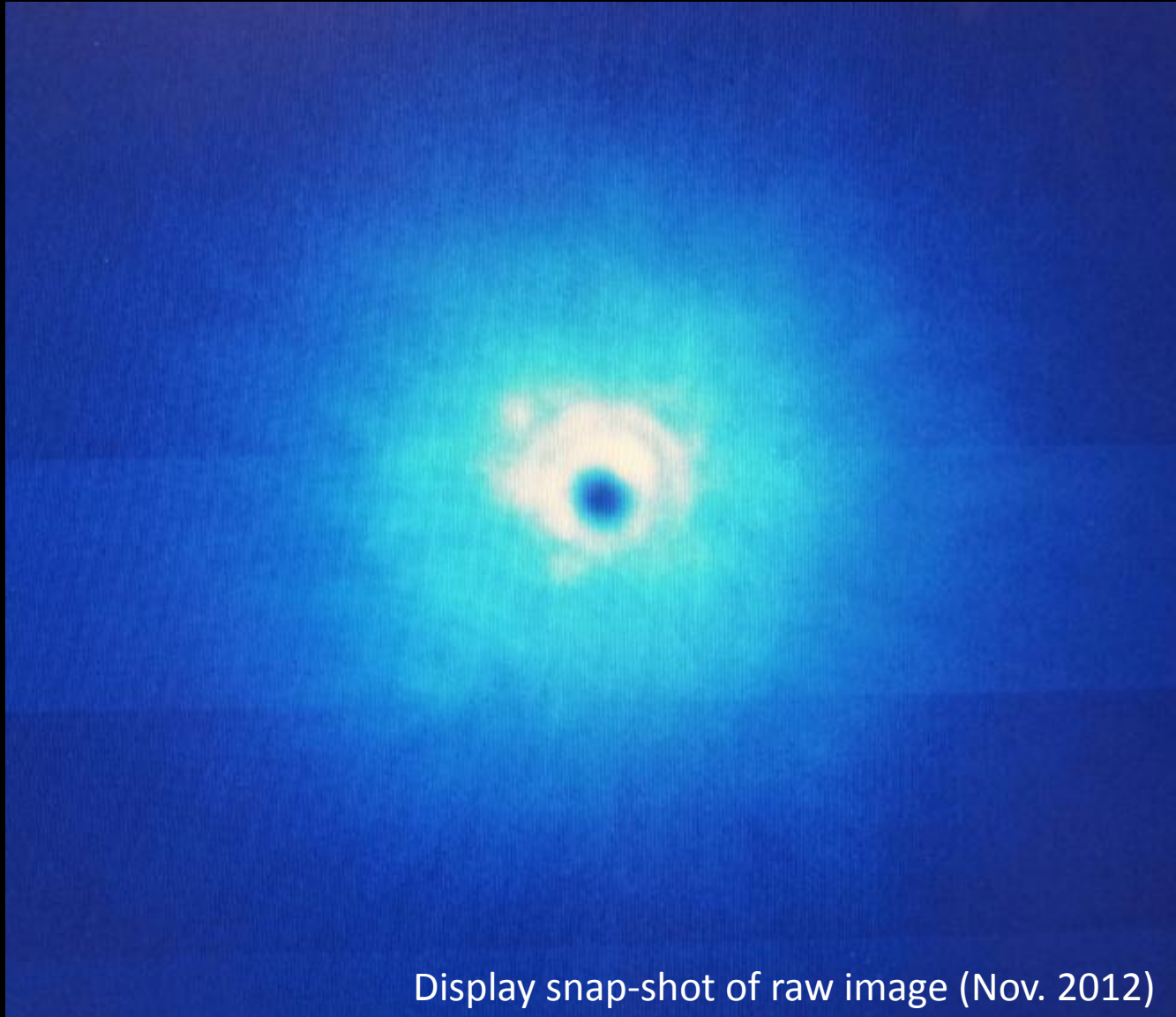
- IR Doppler instrument (IRD)

M-type star survey

$R=70,000$ , J+H, Optical Frequency Comb (OFC),  $< 1$  m/s

fiber feed from AO188

# SCExAO phase I (speckle nulling)



Display snap-shot of raw image (Nov. 2012)

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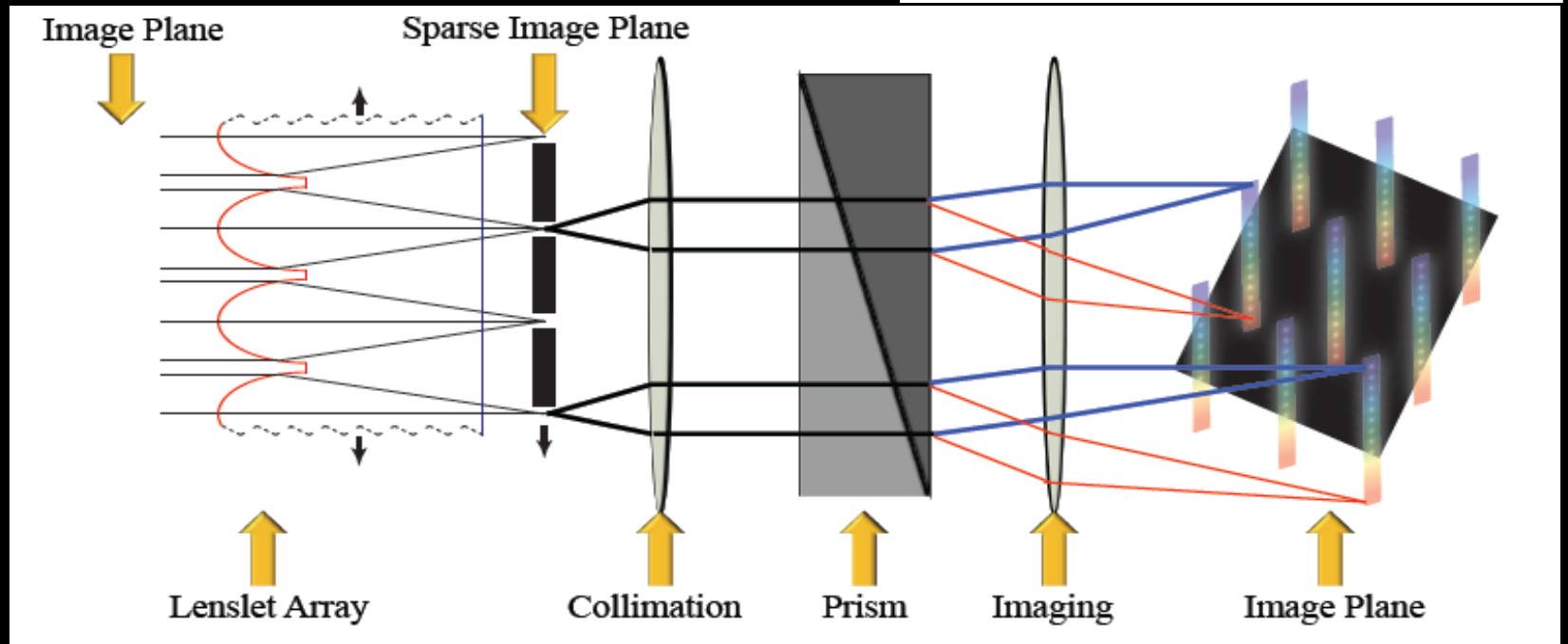
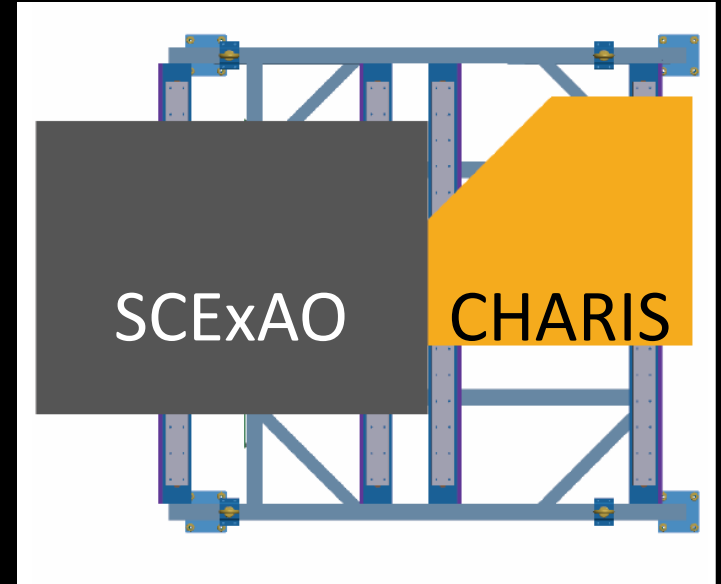
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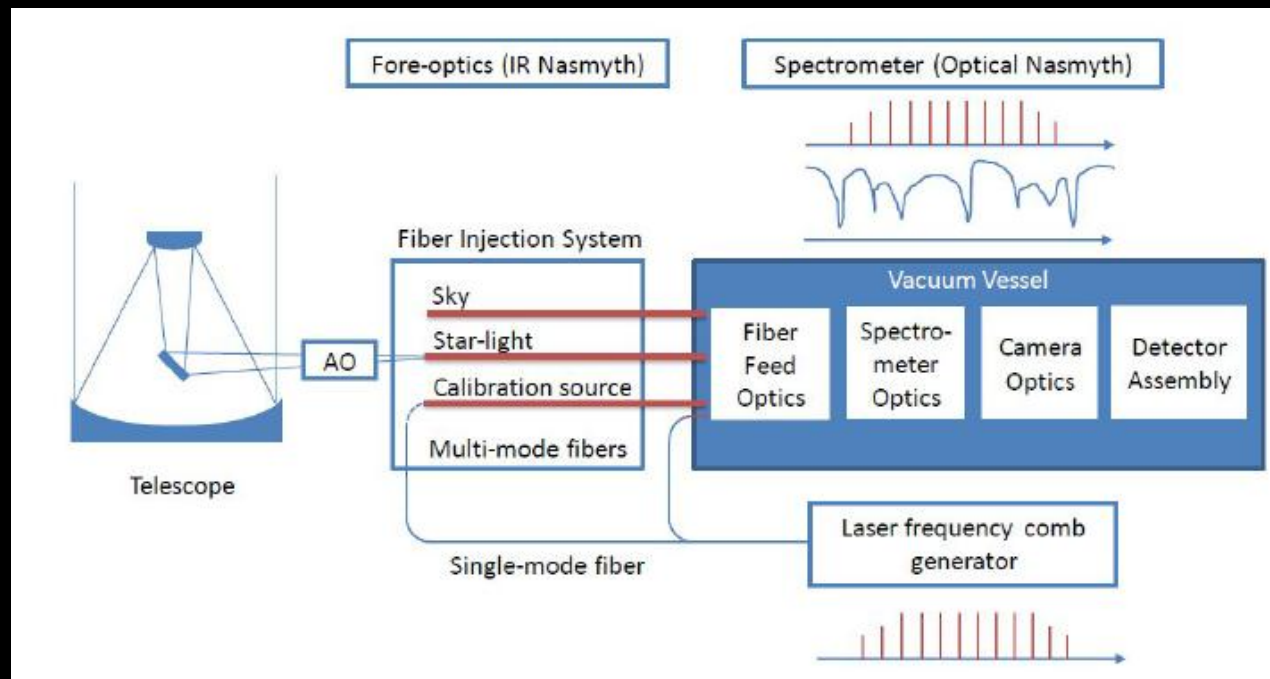
M-type star survey

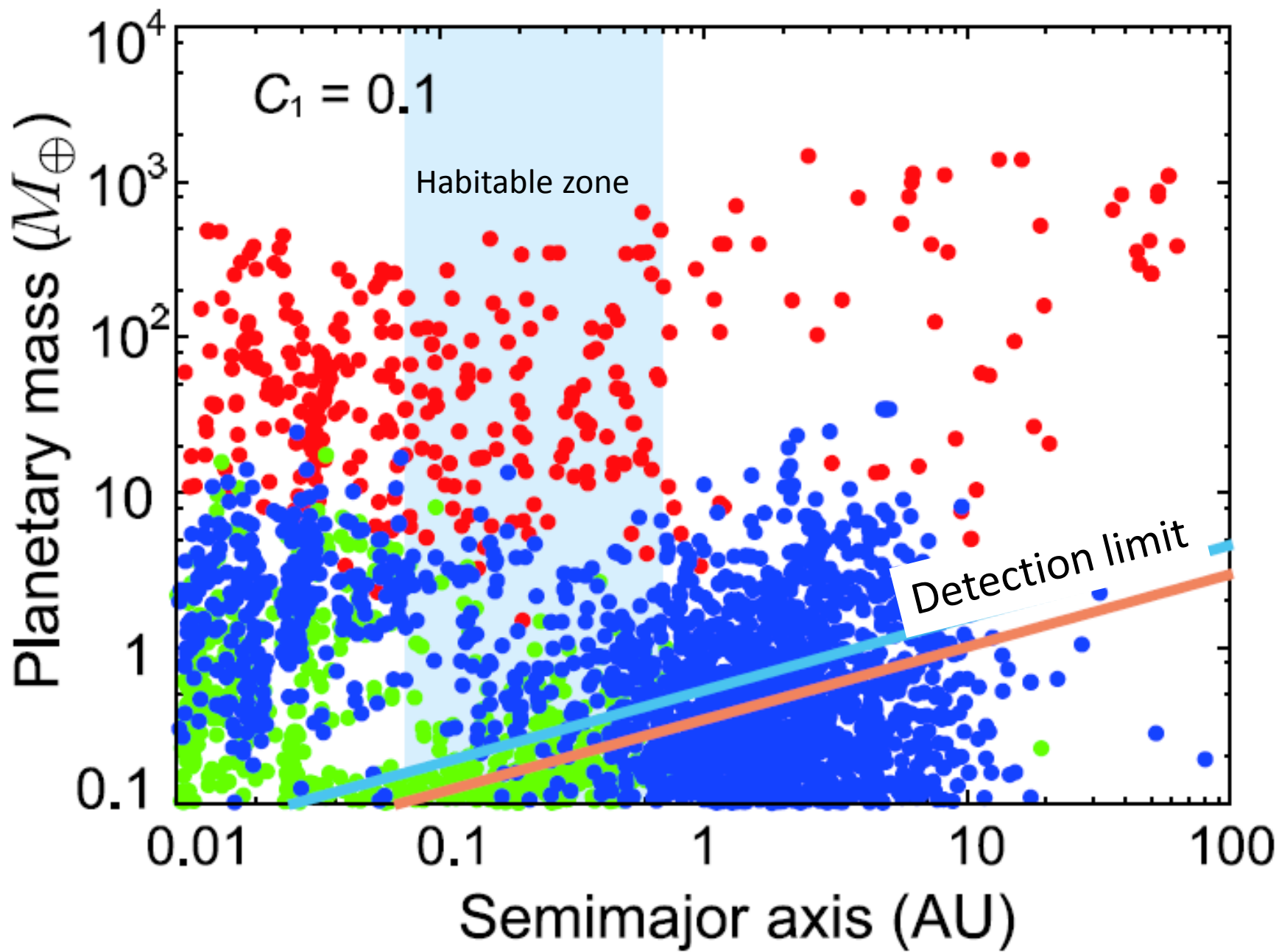
$R=70,000$ , J+H, Optical Frequency Comb (OFC),  $< 1$  m/s

fiber feed from AO188

# IRD

- M-type star survey
- R=70,000, J+H, high stability
- Optical Frequency Comb (OFC)
- $< \sim 1$  m/s
- fiber feed from AO188





# Competitor of planet finders

HiCIAO

+

SCEXAO

+

CHARIS

≡

GPI (Gemini-S)

+

SPHERE (VLT)

-

(spectro-polar mode)

(spectro-polar mode)

IRD (NIR)

↔

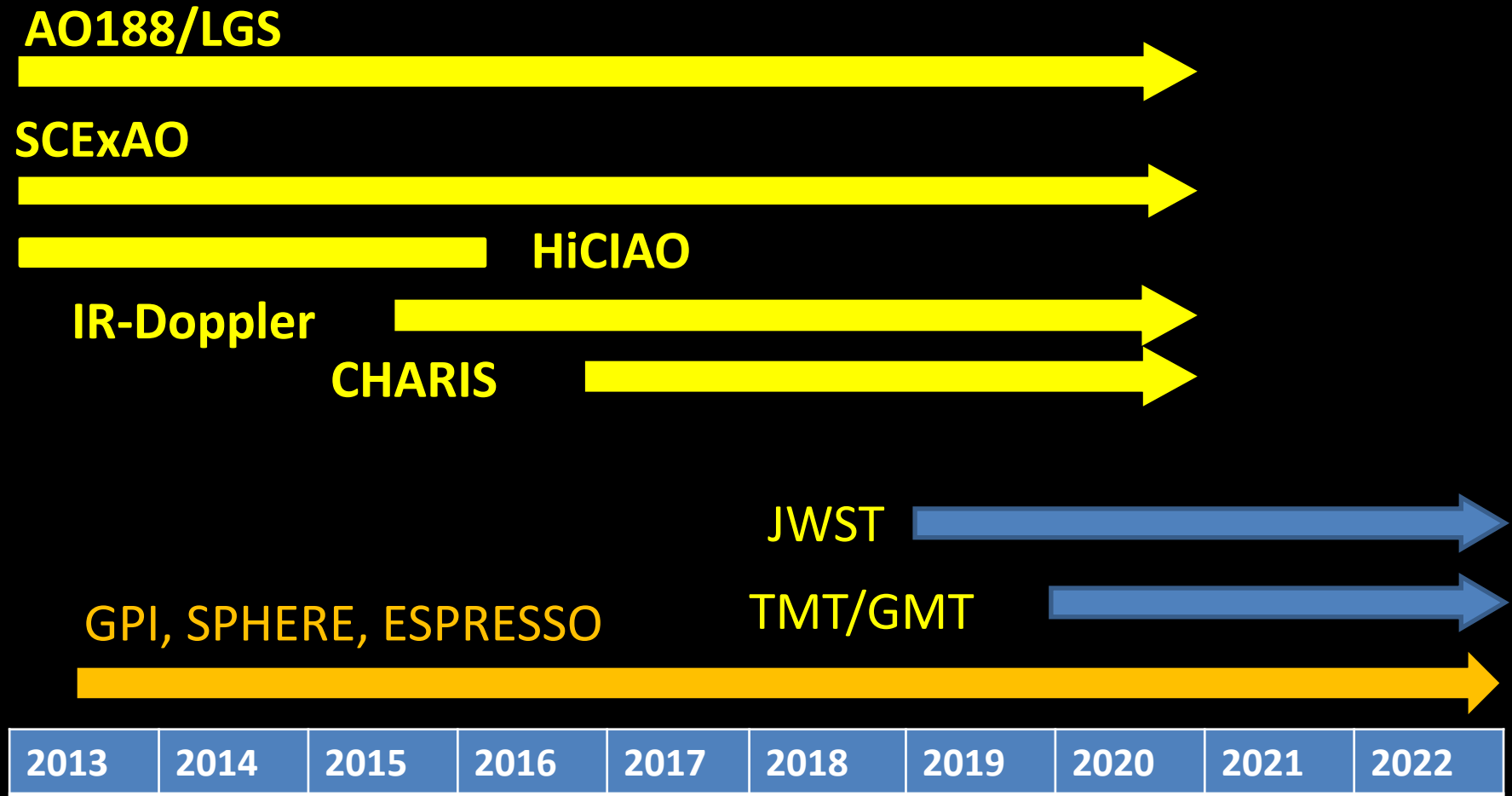
ESPRESSO (Optical)

Small-scale , PI-type instruments

➔ **Short turn-around time**, use latest technology



# Subaru is competitive in Exo-planet science



# PI-type instruments

- Non-facility instruments
- Less supported by Subaru
- Complementary to facility instruments
- Short turn-around time
- Provide opportunities for developing human resources, especially for students  
(Investment for the future)

# PI-type instruments on the waiting list

- RAVEN (UVic)
- CHARIS (Princeton U.)
- IR Doppler (NAOJ/Tamura)
- MIMIZUKU (U. Tokyo/Miyata)
  
- SWIMS (U. Tokyo/Motohara)
- GIGMICS (U. Nagoya/Hirahara)

Acceptance schedule have to be commensurate with the manpower of Subaru

		2013	2014	2015	2016	2017	2018	2019
P	S-Cam							
	FMOS							
	HSC							
	PFS							
Cs	FOCAS							
	MOIRCS							
	COMICS							
	* K3DII							
	* SWIMS							
	* MIMIZUKU							
	GLAO							
NsOpt	HDS							
NsIR	*IRD							
	AO188							
	IRCS							
	* HiCIAO							
	* SCExAO							
	*CHARIS							
	* K3DII							
	* RAVEN							
	* GIGMICS							



# Next facility instrument ?

High resolution Wide-Field instrument ?

- GLAO + wide-field NIR spectrograph/camera
- MOAO + spectrograph (w/IFU)

Working group discussion from 2010

Sep. 2010: Subaru Future Instrumentation Workshop

Sep. 2011: Subaru Next-Generation AO Workshop

- Gemini/VLT have been developing MCAO/GLAO for long time.
- How can we make a competitive instrument in this field?
- competitive with/complementary to TMT ?

# Summary

- HSC commissioning run have started. Open use is expected to be S13B or S14A.
- PFS passed CoDR. PDR and NAOJ review will be Feb. and Mar. 2013.
- Subaru can lead wide-field survey next 5-10 yrs
- Planet finding instruments are lining up (they are all visiting instruments)
- Subaru should be competitive in exo-planet science
- GLAO + wide-field NIR instrument is a possible future facility instruments

For PIs who want to use there PI-type instruments for open-use science time:

A **fact sheet** and **performance tables** must be provided to Subaru(\*) by the dead-line date of call for proposal of the open-use observations.

This enables referees to make reliable judgment by providing sufficient information of the instruments.

(\*) notify the URL of the instrument web-site where the fact sheet and performance tables are provided