Beyond Subaru 2

- we should start thinking about beyond Subaru 2 (Subaru 3) sooner than later

- "Subaru 2" (HSC+PFS+ULTIMATE-Subaru, 2022-2031) was actually bottom-up

- what about Subaru 3 (2032-)?
  Also bottom-up favored (?)

https://subarutelescope.org/en/subaru2/
https://subarutelescope.org/jp/subaru2/

Subaru Telescope
National Astronomical Observatory of Japan

For Researchers and Students | For Business Users | For the Media | Education

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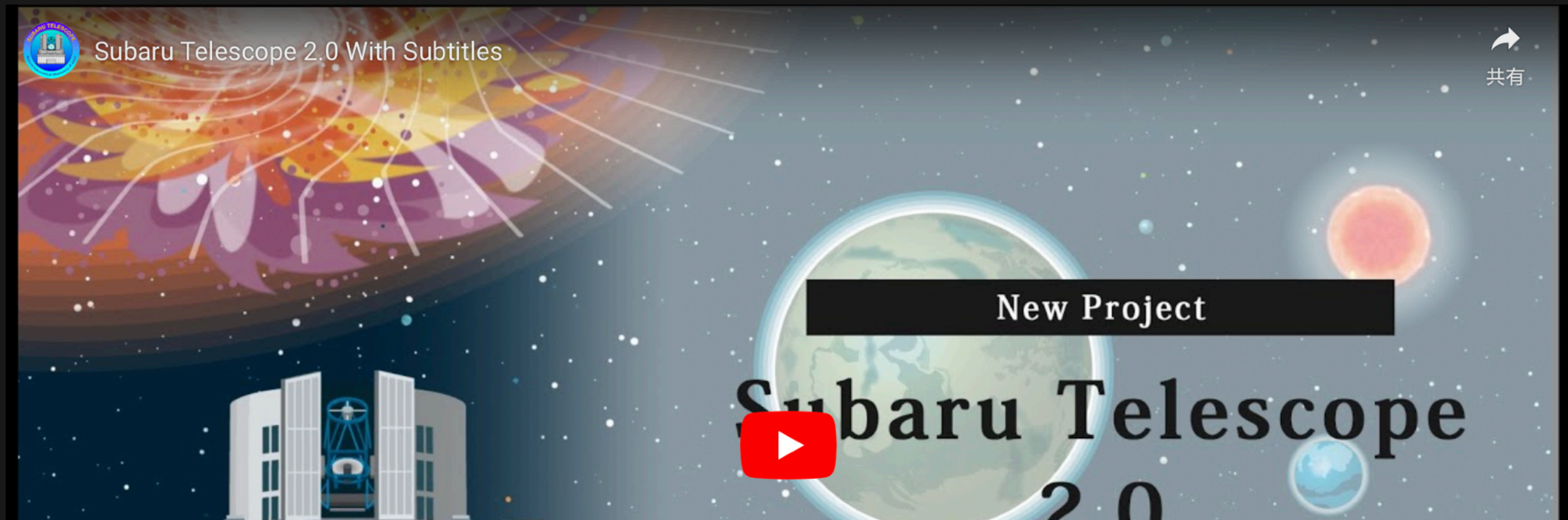
Visiting Subaru Telescope | Direction | Job Vacancy

Home | About the Subaru Telescope | The Universe Revealed by the Subaru Telescope | Science Results | Topics & Announcements | Subaru Telescope 2.0 | Activities of the Observatory | Subaru Gallery | Publications and Videos

Subaru Telescope 2.0 | Key Instruments | Science Goals | Collaborations

Subaru Telescope 2.0

— A New Era of the Subaru Telescope —



Some activities so far

- kick-off meeting in 2021 (voluntary)
  - various ideas/topics discussed
    - new instruments for exoplanets
    - instruments for multi-messenger astronomy
    - Gais follow-up
    - HSC/PFS upgrades

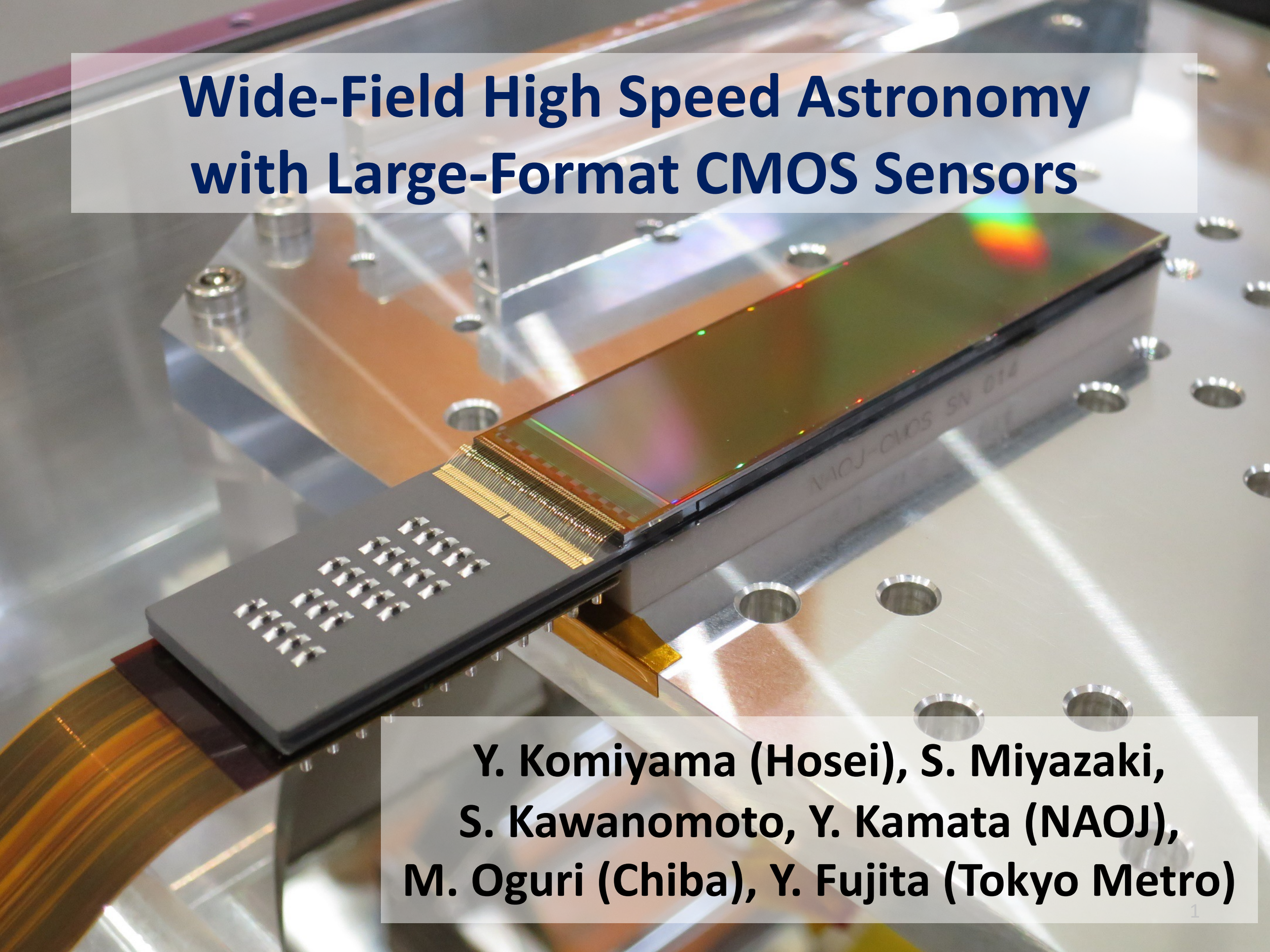
- talk by Takada-san in 2023 GOPIRA meeting
  - suggestion of having more discussions
  - apply for grants?

- not much beyond…

Comments

- comments from several people working on instruments
  - Kawahara-san
  - Kotani-san
  - Komiyama-san
  - Utsumi-san

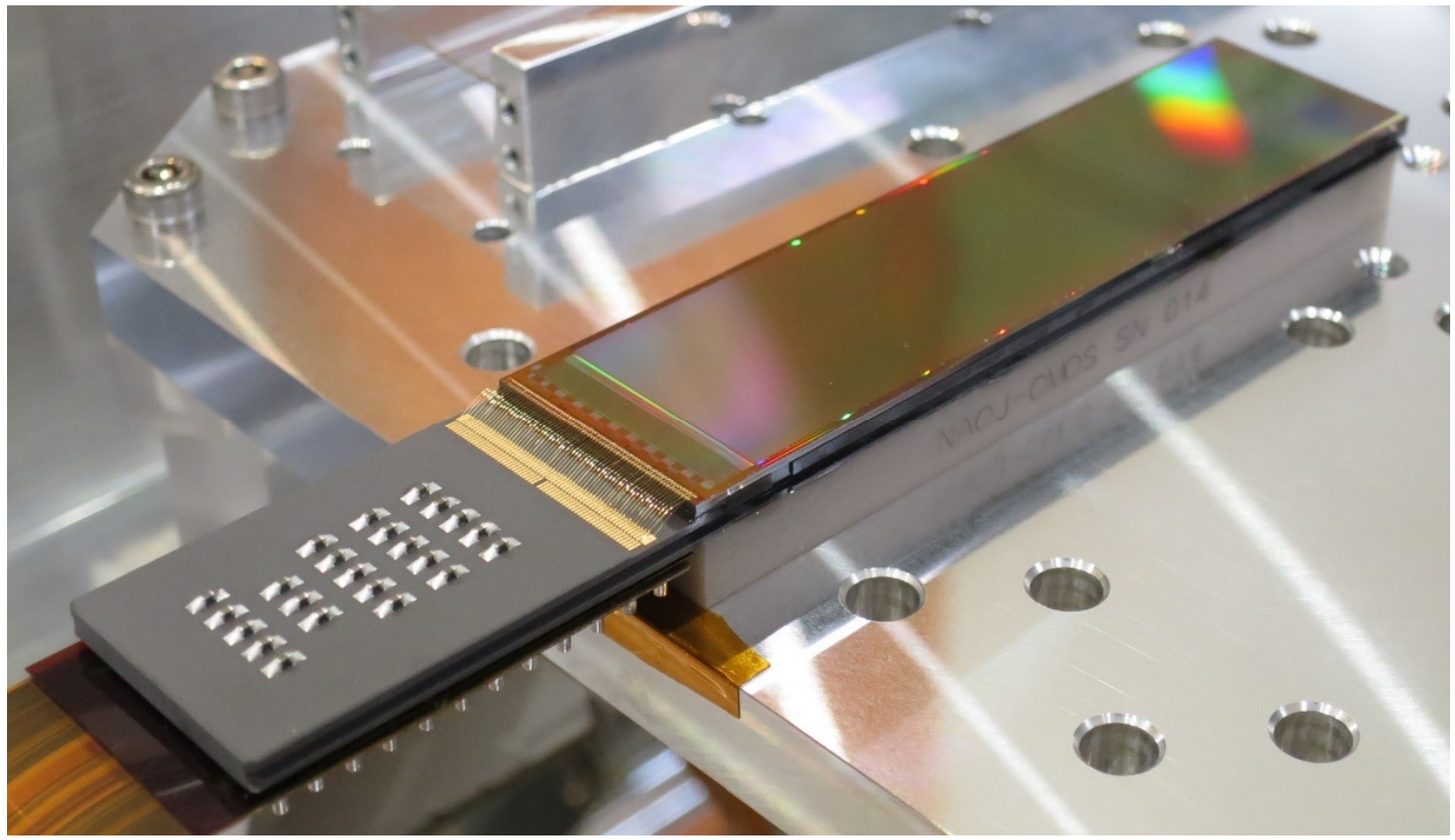
Wide-Field High Speed Astronomy with Large-Format CMOS Sensors



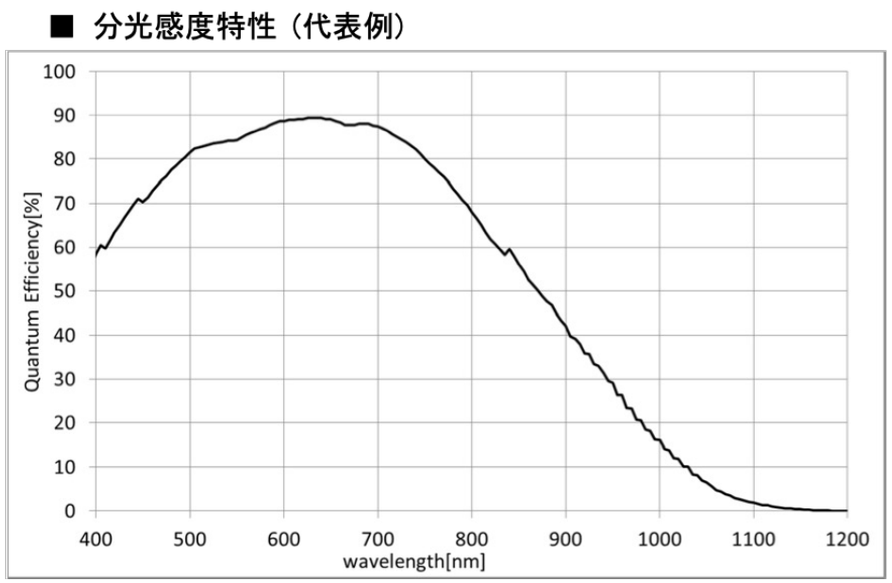
Y. Komiyama (Hosei), S. Miyazaki,
S. Kawanomoto, Y. Kamata (NAOJ),
M. Oguri (Chiba), Y. Fujita (Tokyo Metro)

Development of Large Format CMOS Sensor

- Collaborative Development by NAOJ and Hamamatsu
- Back illuminated
- 2,560 x 10,000 pixels
- 7.5 μm square pixel
- 3-side buttable
- Full well ~ 30,000 e
- Readout noise ~ 2 e
- Dark: 90 e/s/pix @ 300 K
- Readout speed: 10 Hz
- (partial readout→1000Hz)



Covers wide focal plane with minimum gaps between sensors
（Design philosophy taken from Subaru prime focus cameras）
→ **Wide-Field High Speed Astronomy**



Development in progress (slowly) by (old) HSC builders

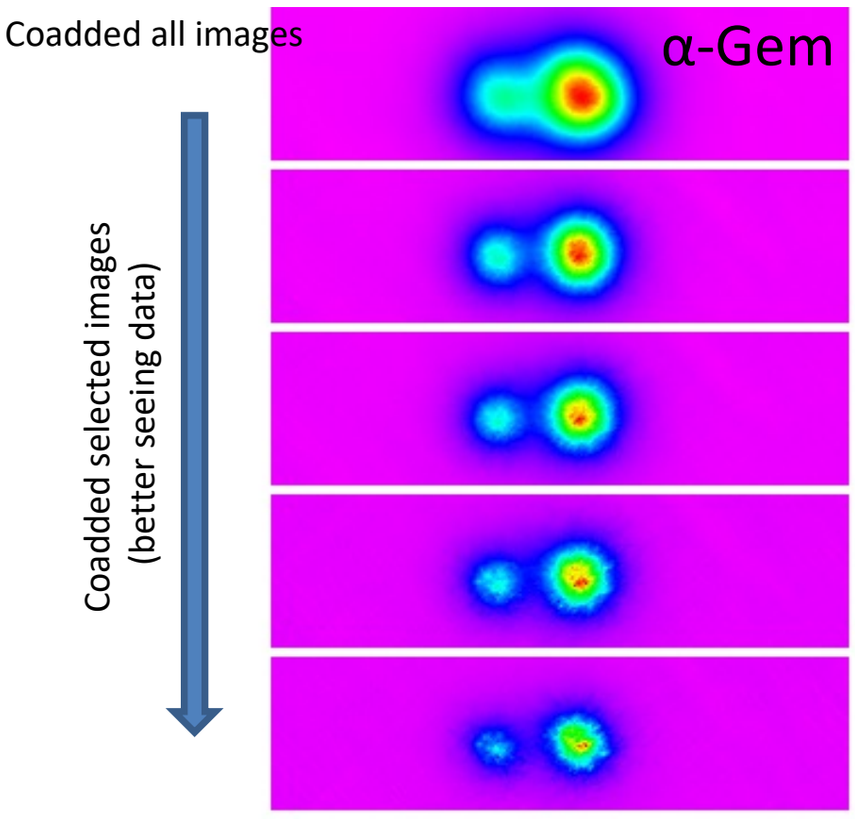
Wide-Field High Speed Astronomy

- Fast radio burst, Gamma-ray burst
- Pulsar, Black Hole binary, Flare stars
- Solar system small bodies
  - Near-Earth Objects
  - Impact on Moon/Planet surface
  - Eclipse by Kuiper Belt/Oort Cloud objects
- Lucky Imaging
- Unknown high speed variable

Various science cases are possible by 1 instrument

New astronomical phenomena can be observed

	Tomo-e Gozen	**TAOS II**	**Subaru CMOS**
Tel. Aperture	1.05 m	1.3 m	**8.2 m**
Field of View	20 deg^2	2.3 deg^2	0.25 deg^2
Frame Rate	2 sec^{-1} (20 for part)	20 sec^{-1}	**10 sec^{-1}**
Limiting Mag.	~17 mag	~18 mag	~21 mag
Sensor Format	2000x1128 (19um/pix)	1920x4608 (16um/pix)	2560x10000 (7.5um/pix)
# of Sensors	84	10	12
Vendor	Canon	e2v	Hamamatsu
Site	Kiso	Mexico	**Maunakea**



Current Status

Test Observation at Kanata Telescope

（2019 Sep + 2020 Mar）

1 sensor: Fundamental data were obtained

Development of Sensor/Readout Electronics

(FY 2022) SPMU002: High-speed readout + data transfer by 10GbE

Screening of CMOS sensors

Development of Camera with multiple sensors (FY2023)

Chance to observe at Arizona Univ. Telescope

Focal Plane Layout of CMOS sensors

Dewar Design, I/F Design

Electronics Design (Distribution board, etc)

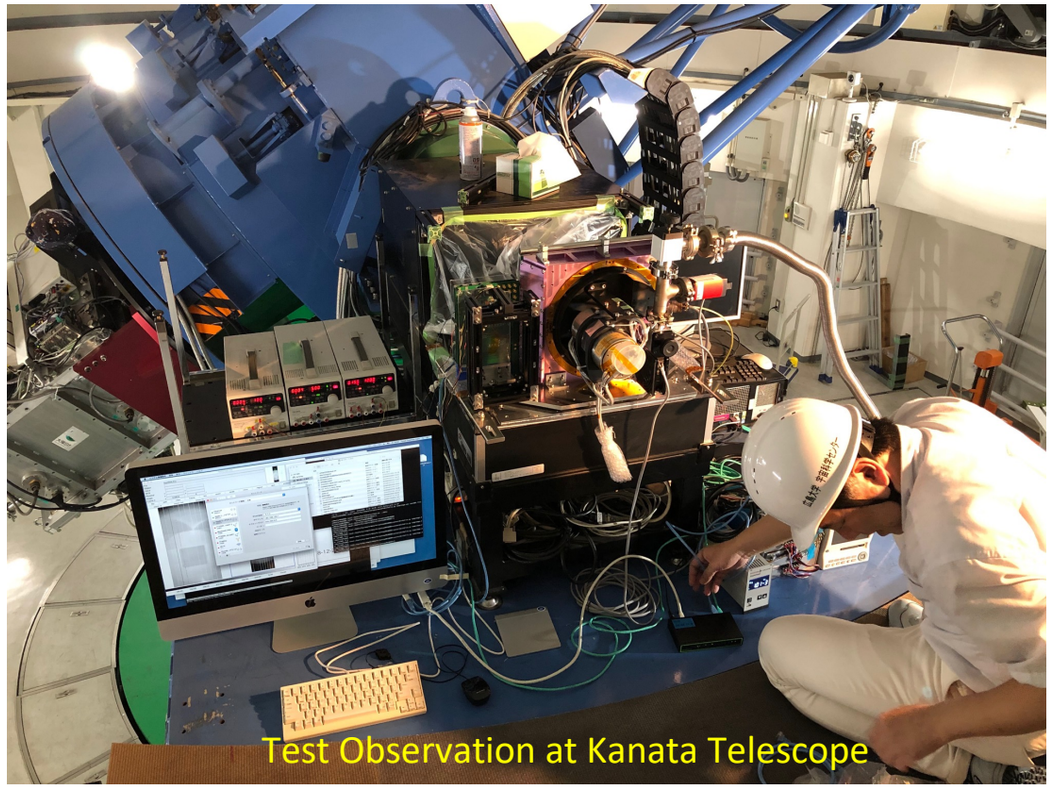
Graduation Research by B4 students：

Screening of CMOS sensors, Heat exhaust design of readout electronics

For the test observation (FY2024)

Dewar Assembly, install 6 CMOS sensors

Preparation for the observation



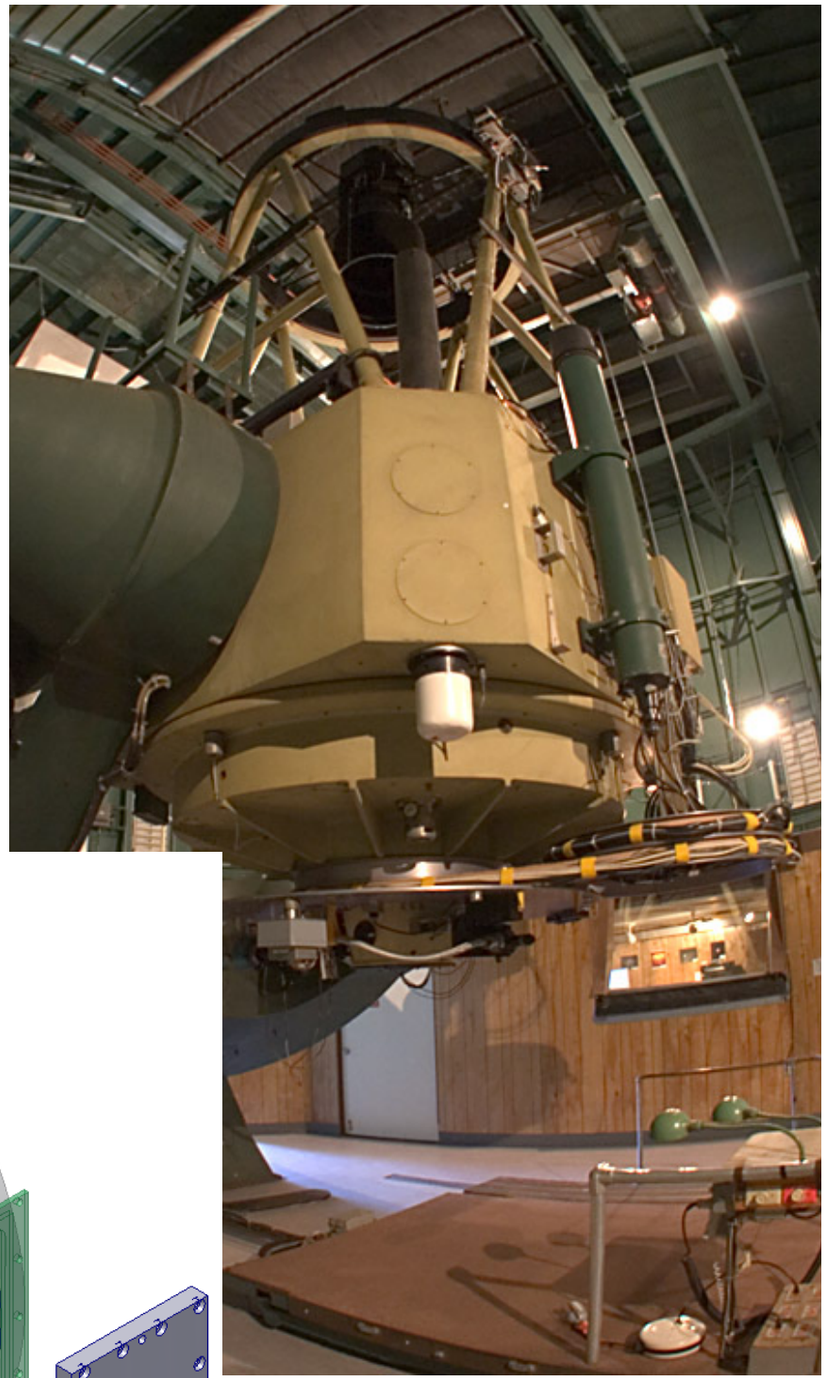
Test Observation at Kanata Telescope

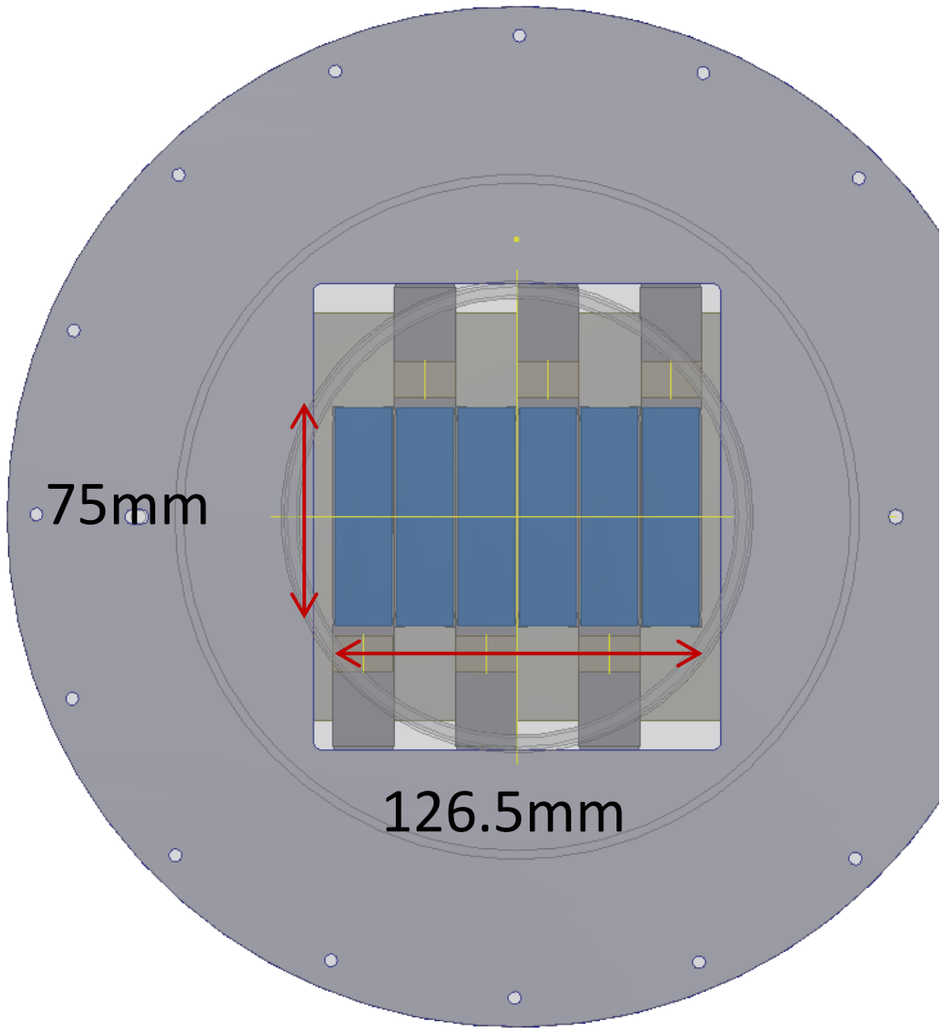
Heat Exhaust Test

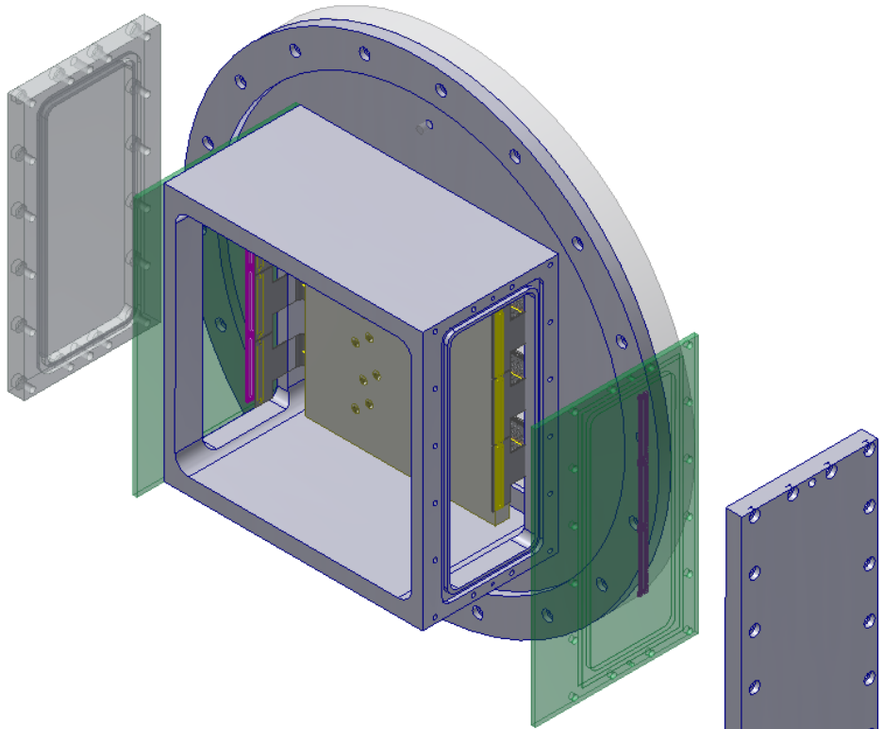
SPMU02

Development for Arizona 90inch Telescope

- Development of 6 sensor camera
  - Focal plane : 126.5mmx75mm
    → 1.06 x 0.63 deg^2 (0.23 arcsec/pix)
  - Readout by 6 set of SPMU002
    - Synchronized readout





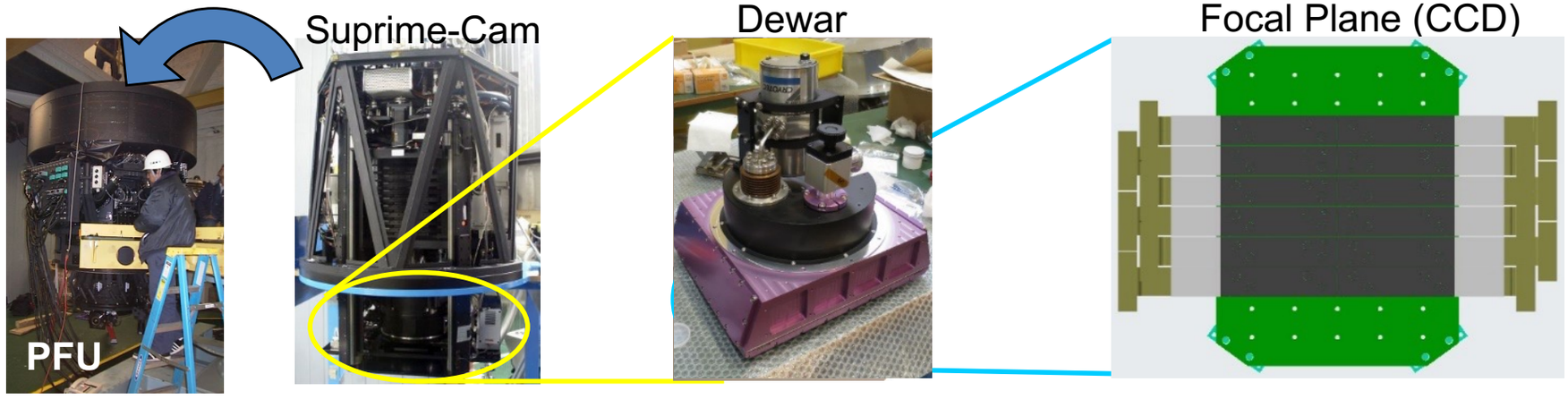


For Subaru Prime Focus

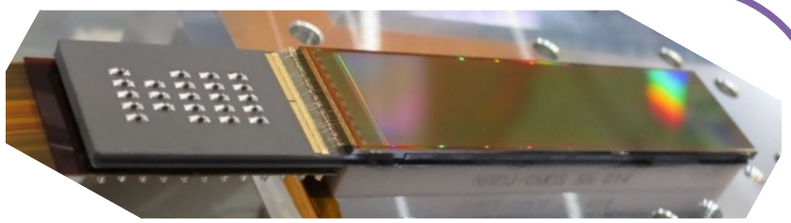
Taken over Suprime-Cam ?

34’x27’ focal plane will be covered by 12 CMOS sensors

Resources of Suprime-Cam (PFU/Interface frame/filters) can be used

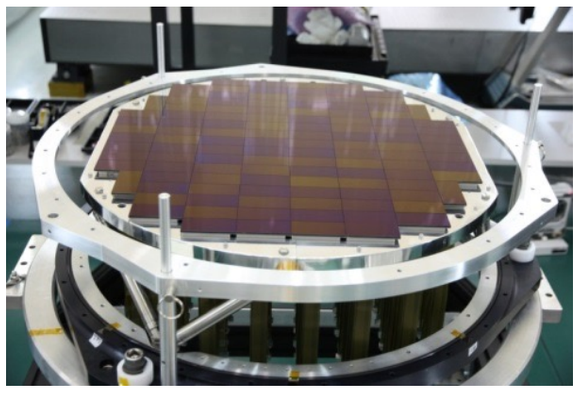


Taken over HSC ?



Sensor: 3-side buttable → 4-side buttable

~100 sensors can cover HSC’s FoV (if sensors are available)



Heritage of HSC development

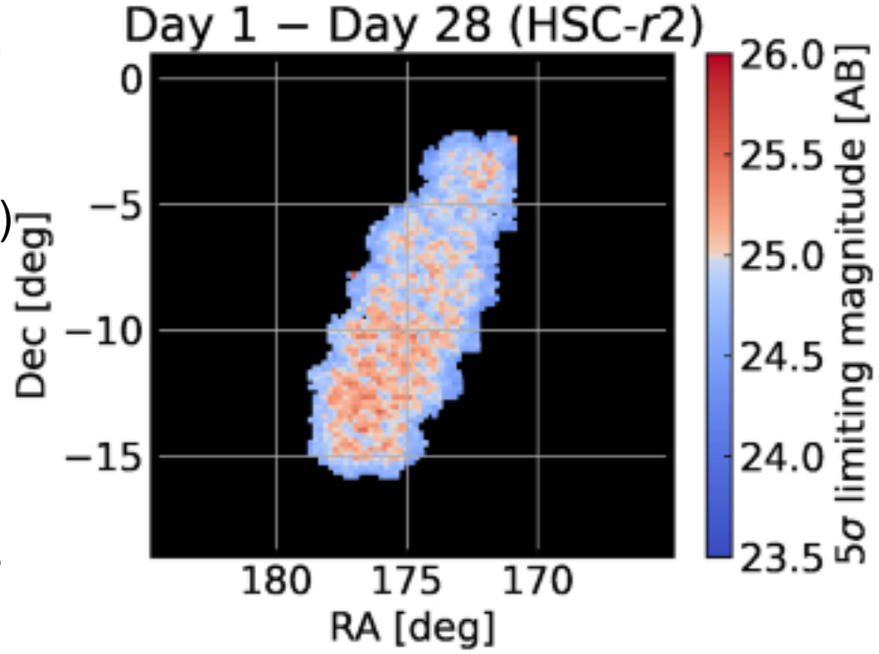
Challenges： Enormous data Transfer/Analysis/Archive…

Wide field imaging survey - Utsumi

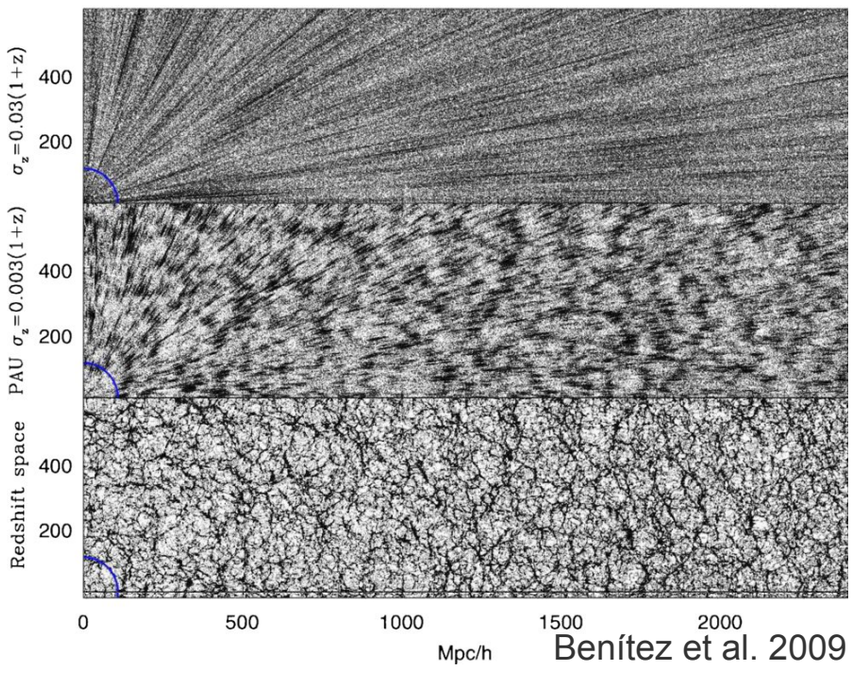
- Subaru is great because of not only the **aperture size** but also **“image quality”**:

$$\frac{S}{N} \propto \frac{\sqrt{Qt/R_{\rm sky}}}{\sigma_{\rm PSF}}$$ (O’Connor et al. 2006)

- HSC “2”
  - **Ultra wide** with **shorter** exposures
    - **Enabling HSC’s fast readout** 18s->10s (Nakaya et al., 2012)
      - read noise (12e-; Kamata et al., 2012), X talk, thermal performance need to be investigated
      - off loading fits writing 12s -> ~0s?
      - ~50?% gain for 30sec exposure
- **Narrow band survey** (e.g. PAU, LSST“2”?)
  - Maximize the unique performance of low noise



57deg²/half a night with a mode depth of **25th** by 2x30sec exposure (Ohgami et al.; 2023)



Benítez et al. 2009

Discussions

- more ideas?
- how to proceed?
  - meeting?
  - grant?
  - bottom-up or top-down?