



H. Murayama (PI)



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# Subaru Prime Focus Spectrograph

## Galaxy evolution surveys

*Olivier Le Fèvre (LAM)*

*On behalf of the PFS Collaboration*



N. Tamura (PM)

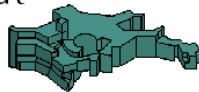


Caltech

Kavli IPMU is *leading* this international collaboration



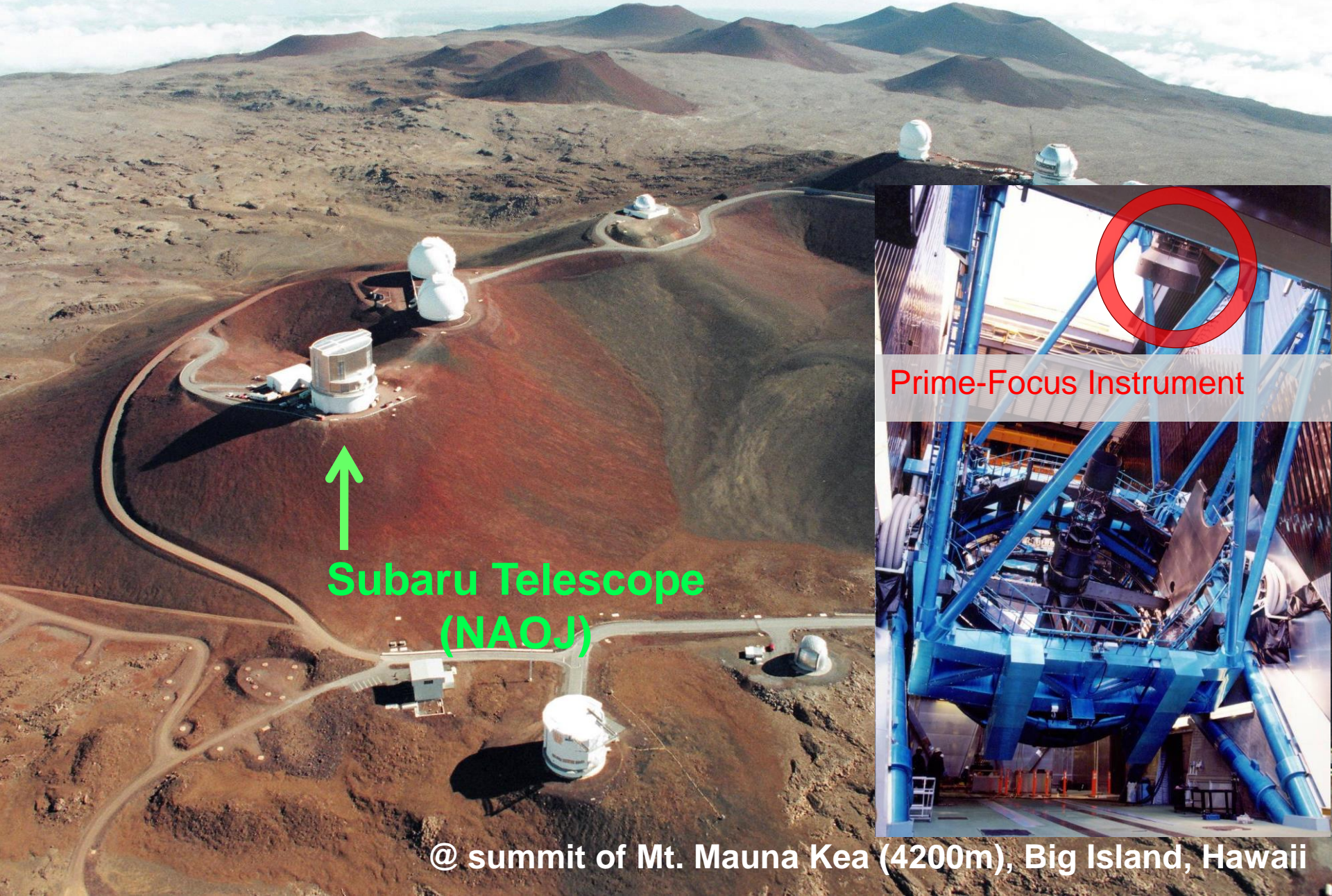
Max-Planck-Institut für Astrophysik



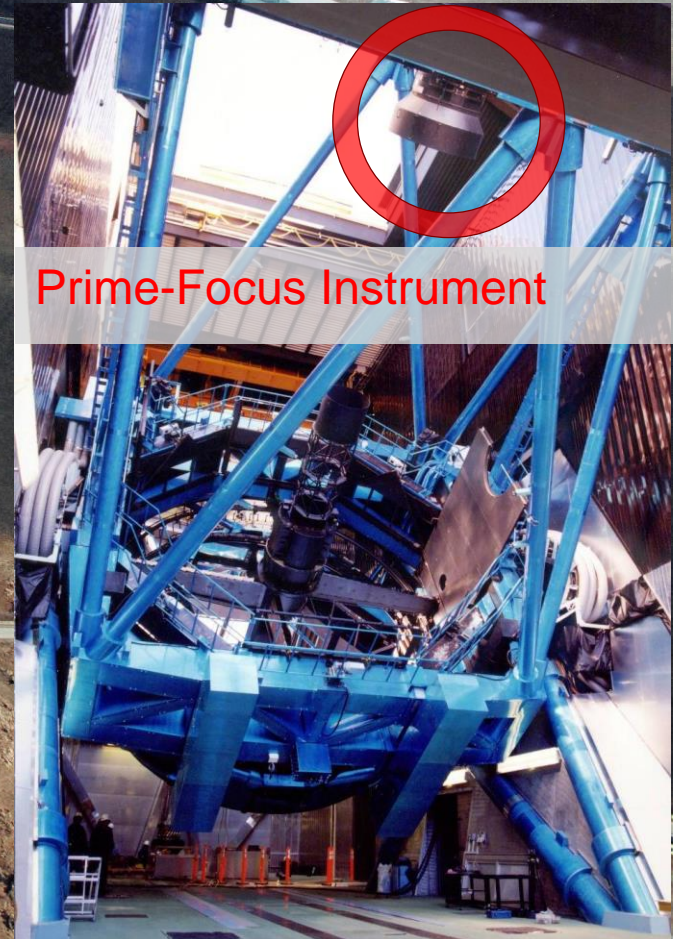
LNA LABORATÓRIO NACIONAL DE ASTROFÍSICA



# Subaru Telescope



Subaru Telescope  
(NAOJ)

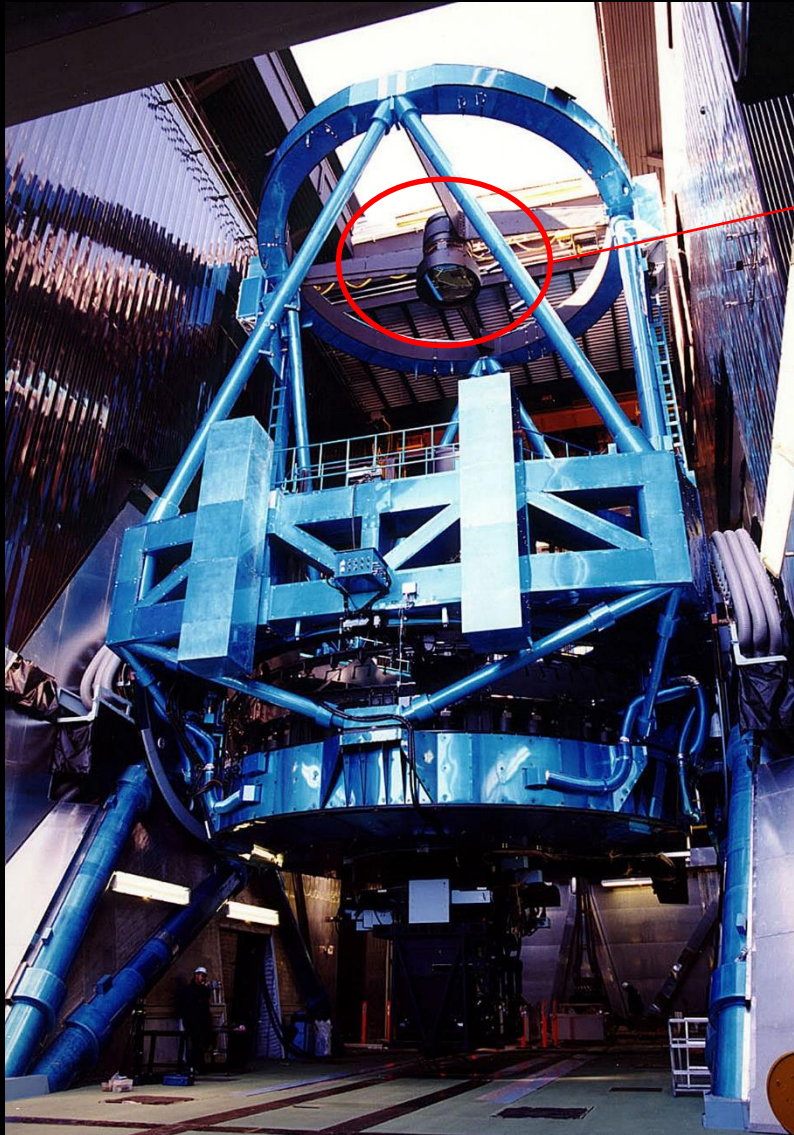


Prime-Focus Instrument

@ summit of Mt. Mauna Kea (4200m), Big Island, Hawaii



# Hyper Suprime-Cam



- largest camera
- 3m high
- weight 3 tons
- 104 CCDs (~0.9B pixels)

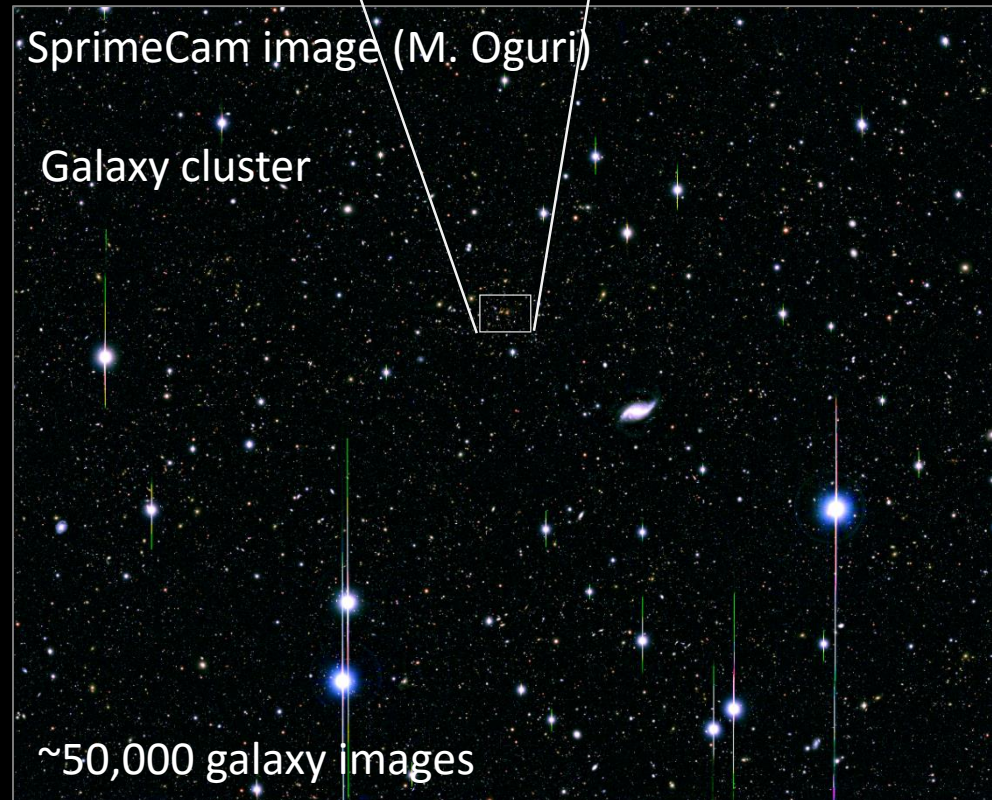


# Subaru Telescope: wide FoV & excellent image quality

- **Fast, Wide, Deep & Sharp**
- The PFS surveys needs these



HST



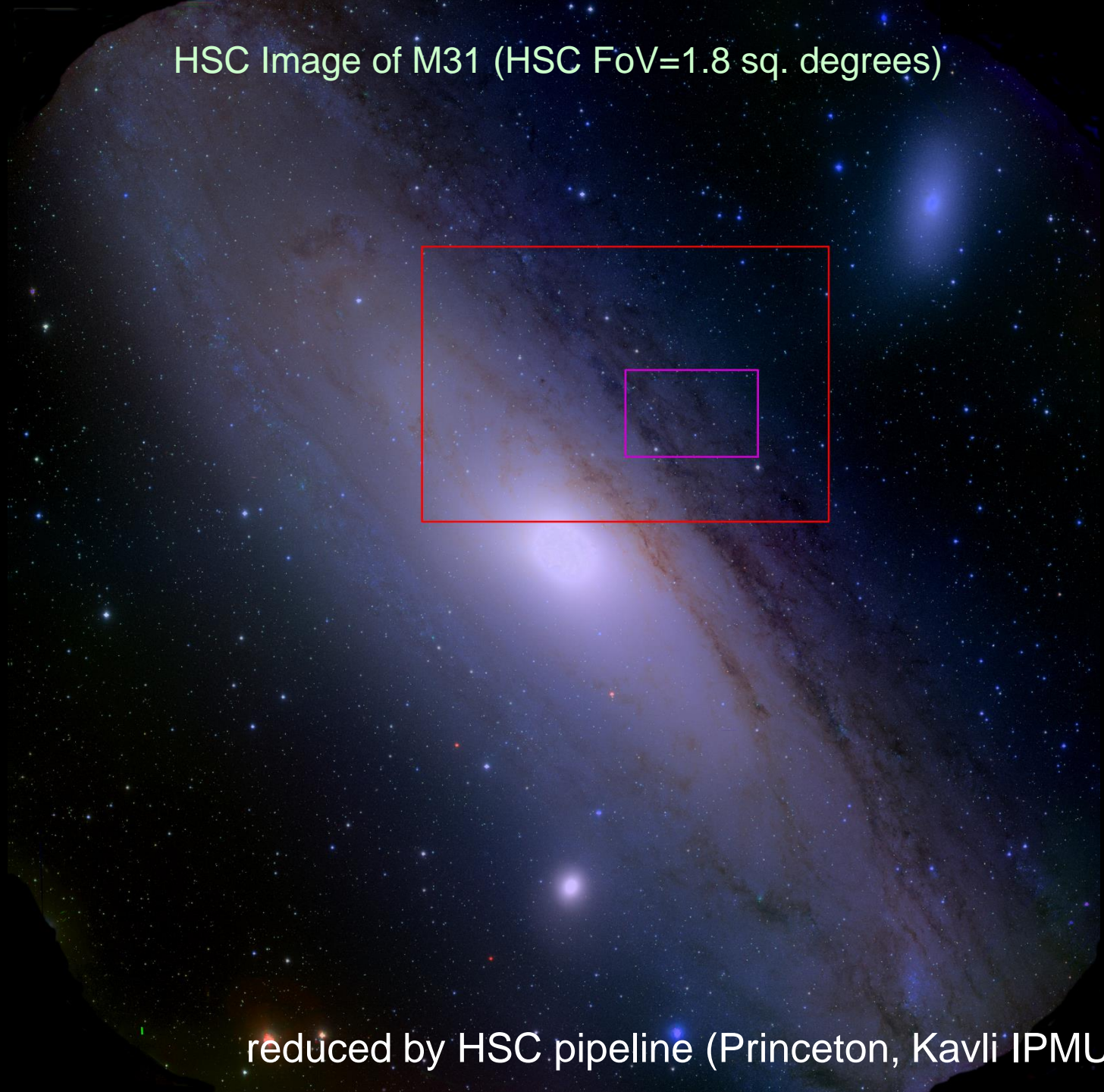
Suba  
wide

# Hyper Suprime-Cam FoV

- Fast,
- a cosm

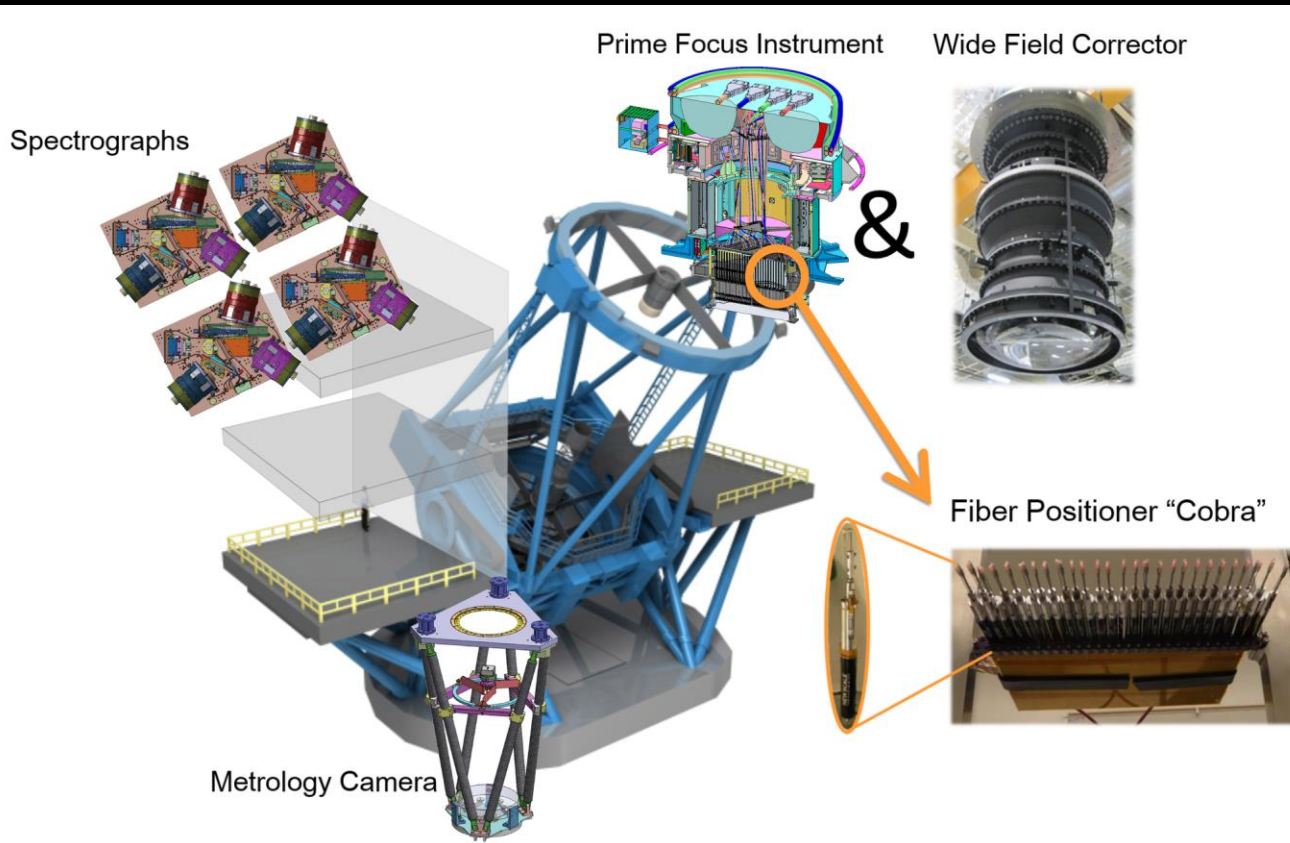


HSC Image of M31 (HSC FoV=1.8 sq. degrees)



reduced by HSC pipeline (Princeton, Kavli IPMU, NAOJ)

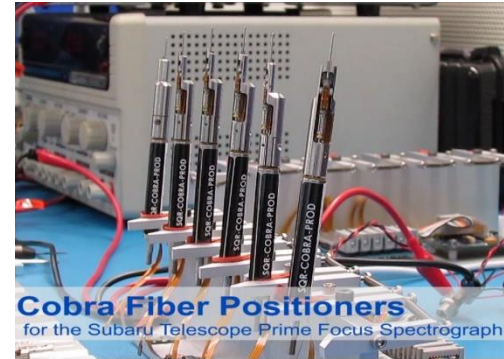
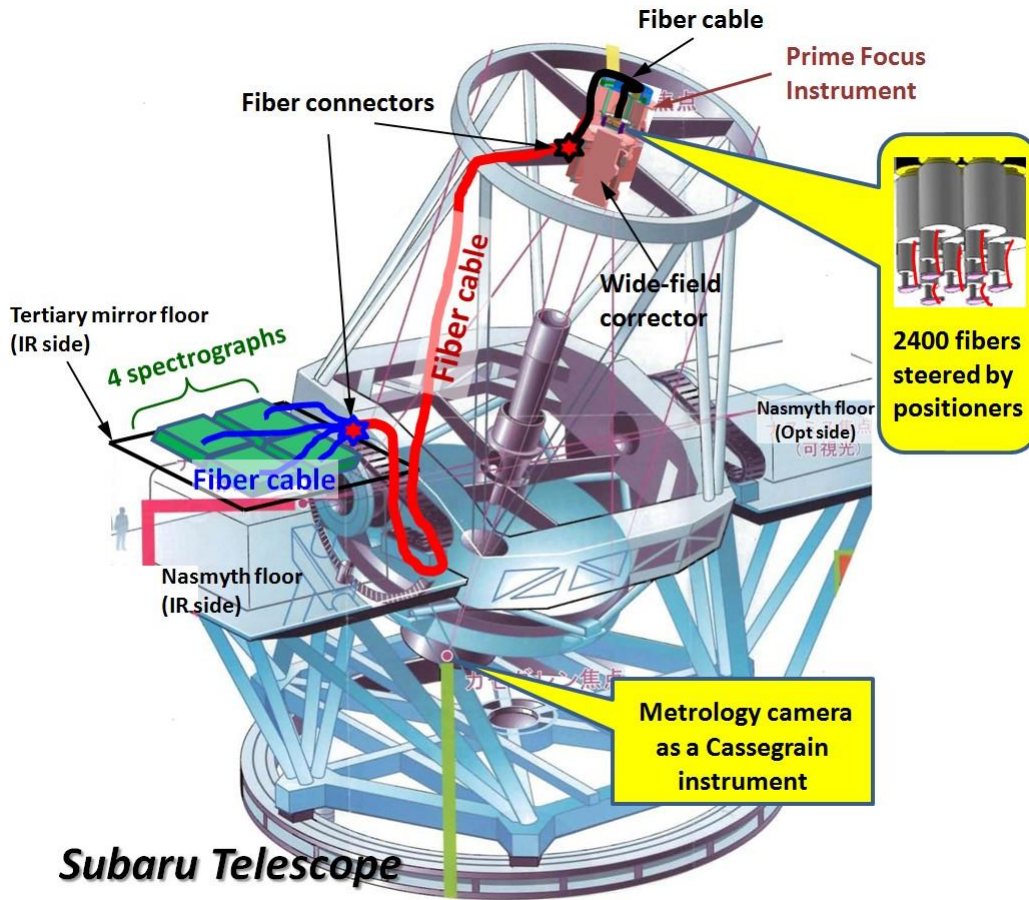
# Prime focus spectrograph



- largest multi-fiber spectrograph multiplex = 2400
- 3 bands covering 0.38 to 1.26  $\mu\text{m}$
- 12 cameras-spectrographs

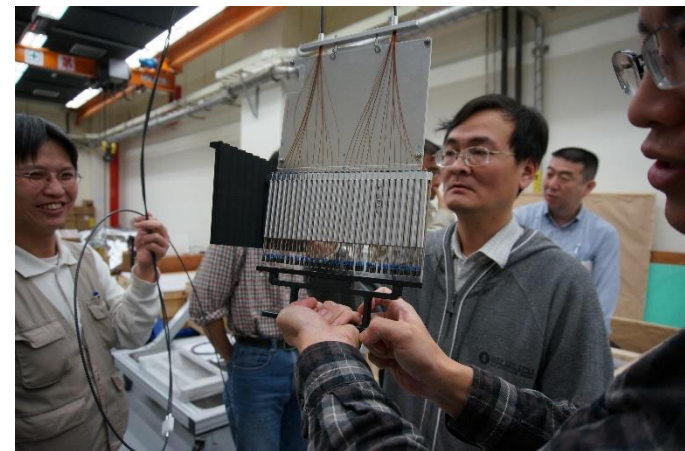


# Fiber positioner and fiber system

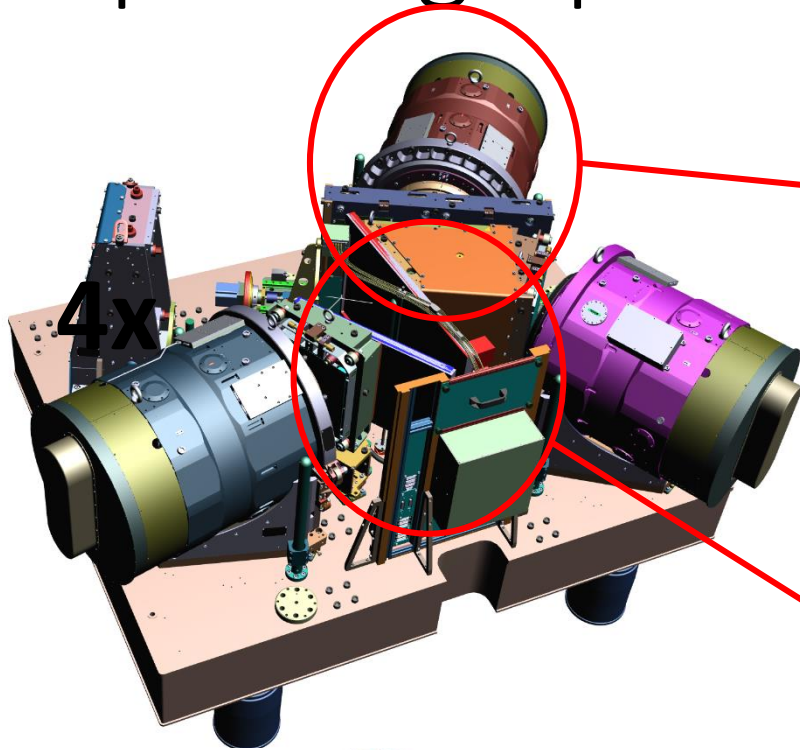


Cobra positioner & module development at JPL/Caltech/New Scale Tech.

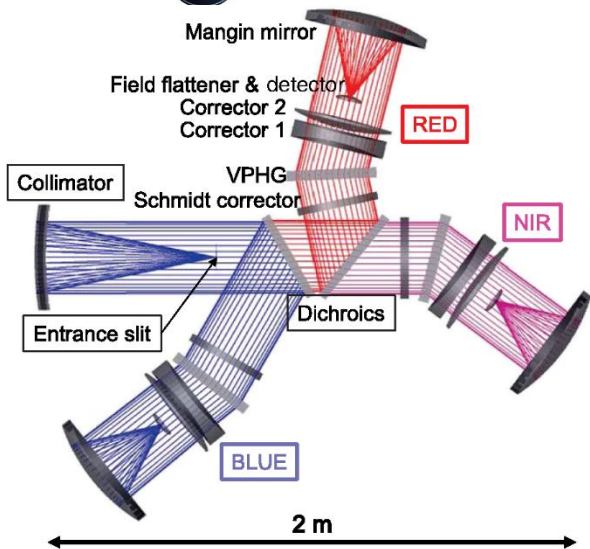
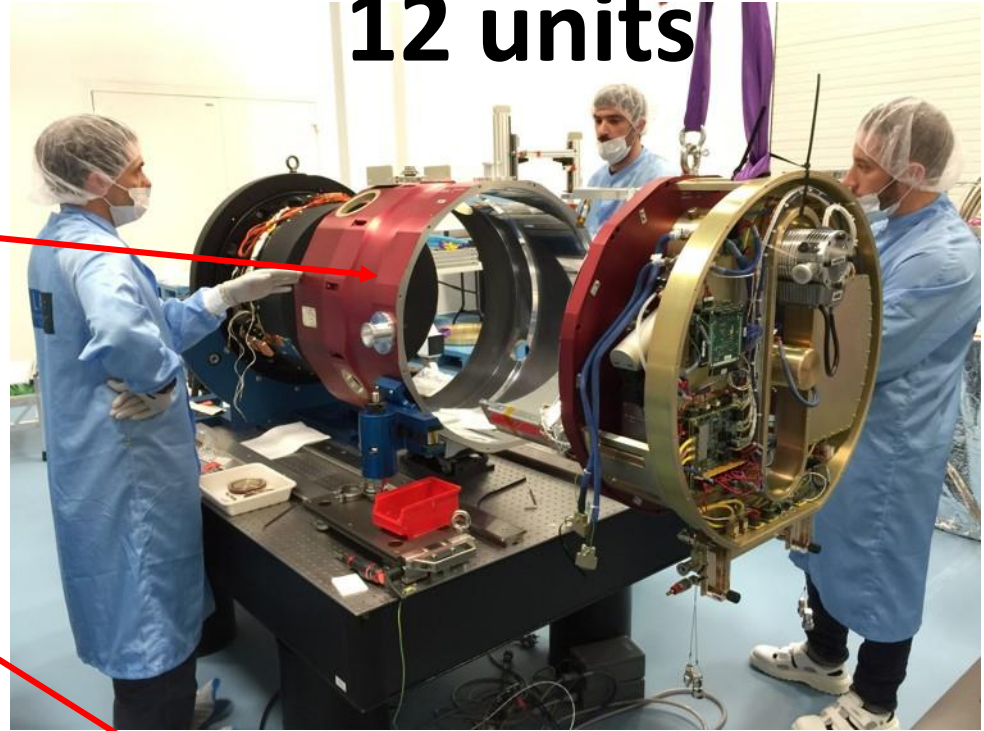
Assembly of Cobra modules at ASIAA



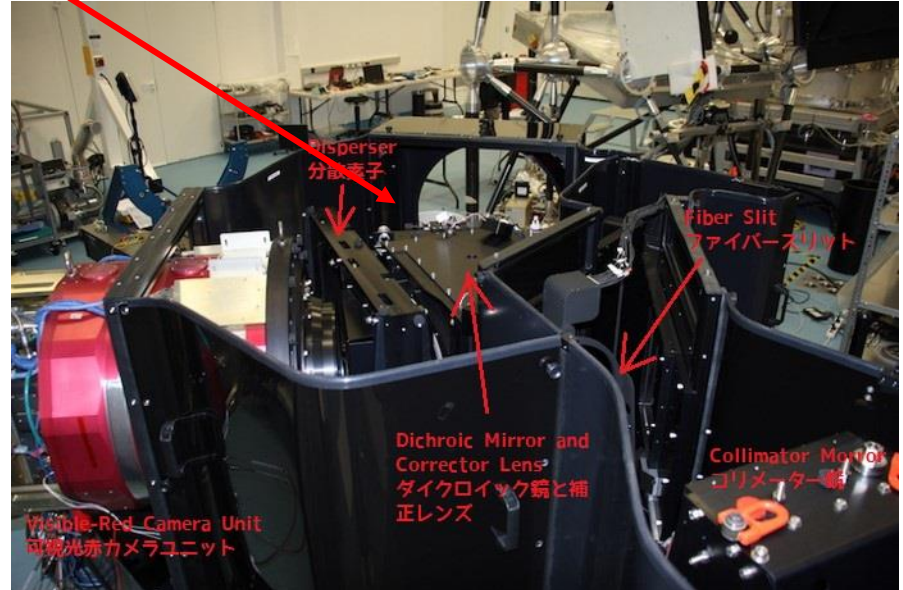
# Spectrographs



12 units



Integration  
at LAM



# PFS Scientific drivers: Three Pillars

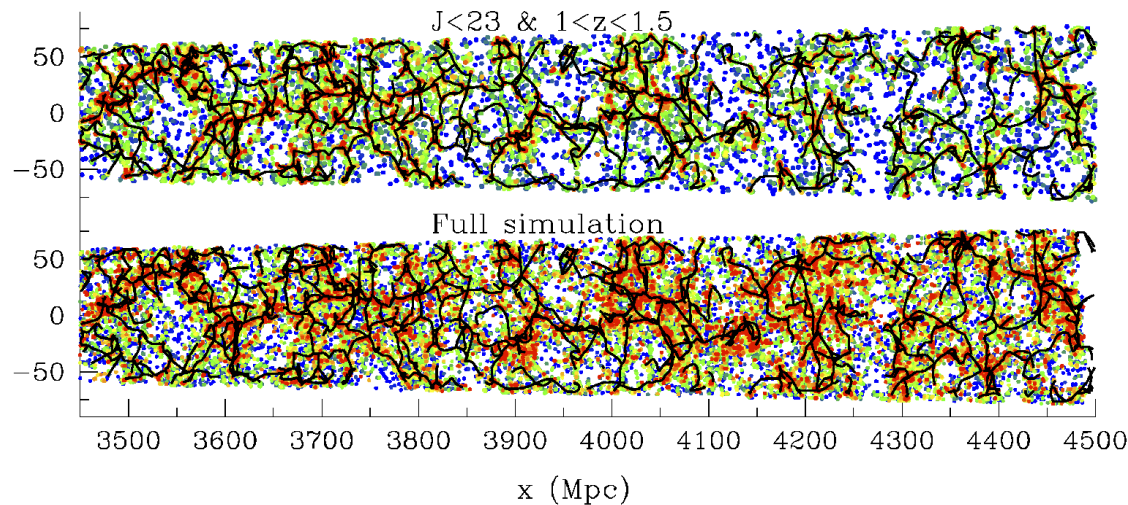
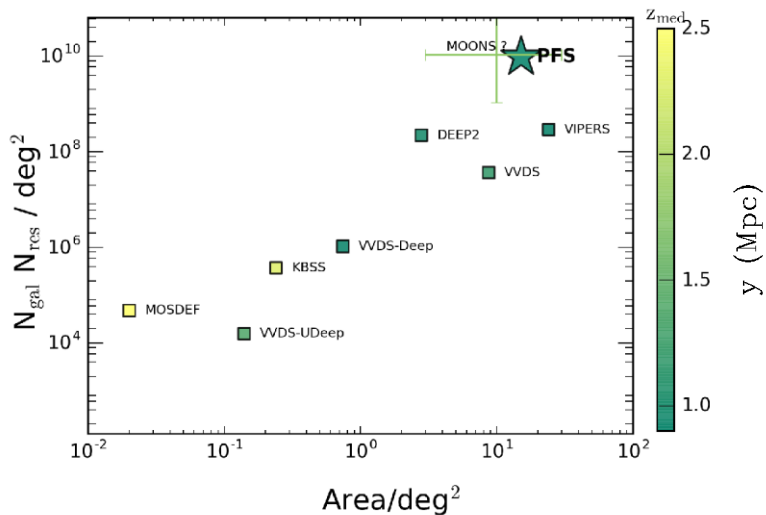
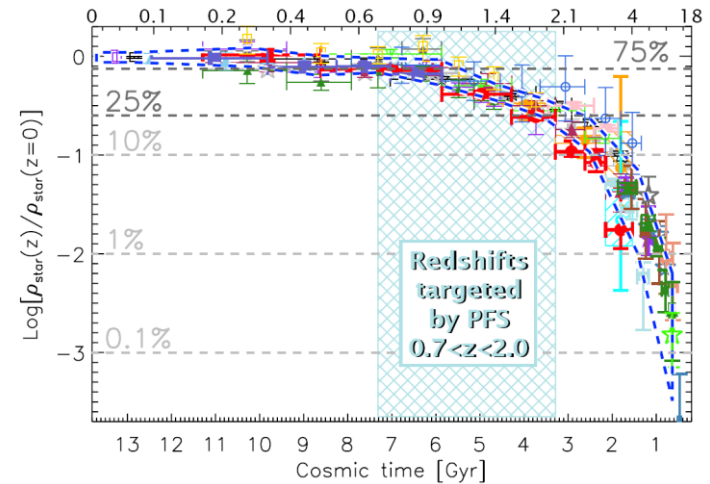
*All science cases are based on a spectroscopic follow-up of objects taken from the HSC imaging data*

- Cosmology (~100 nights): 1400 sq. degrees
  - ~4M redshifts of emission-line galaxies
  - BAO at each of 6 redshift bins over  $0.8 < z < 2.4$
  - Cosmology with the joint experiment of WL and galaxy clustering (HSC/PFS)
- Galaxy Evolution (~100 nights): ~20 deg<sup>2</sup>
  - A unique sample of galaxies (~0.3M) up to  $z \sim 2$ , “SDSS at  $z \sim 1.5$ ”
  - Dense sampling of faint galaxies (also many pairs of foreground/background gals)
  - Studying galaxy assembly and cosmic reionization with >50000 LAEs, LBGs  $2 < z < 7$
- Galactic Archaeology (~100 nights): Milky Way/M31/dSphs
  - ~1M star spectra for measuring their radial velocities
  - Use the 6D phase-space structure, in combination with GAIA in order to study the origin of Milky Way (also use the M31 survey)
  - Use a medium-resolution-mode survey of ~0.1M stars to study the chemo-dynamical evolution of stars in Milky Way

# Mass assembly within the cosmic web at the peak in star formation

Jenny Greene et al.

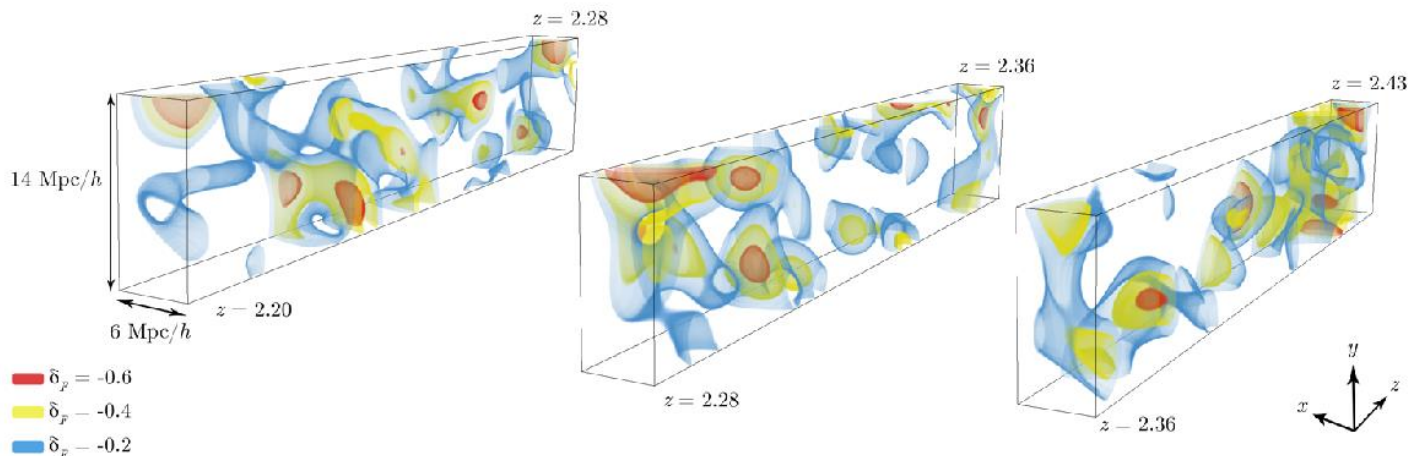
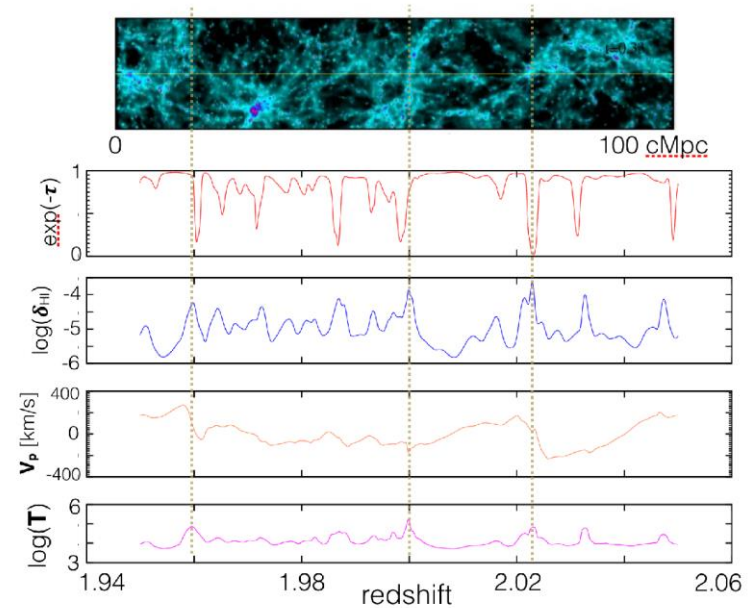
- $0.7 < z < 2$ ,  $J \leq 23$
- 300,000 galaxies,  $0.15 \text{ Gpc}^3$
- $14 \text{ deg}^2$



# IGM tomographic mapping $2 < z < 3$

Nao Suzuki, John Silverman et al.

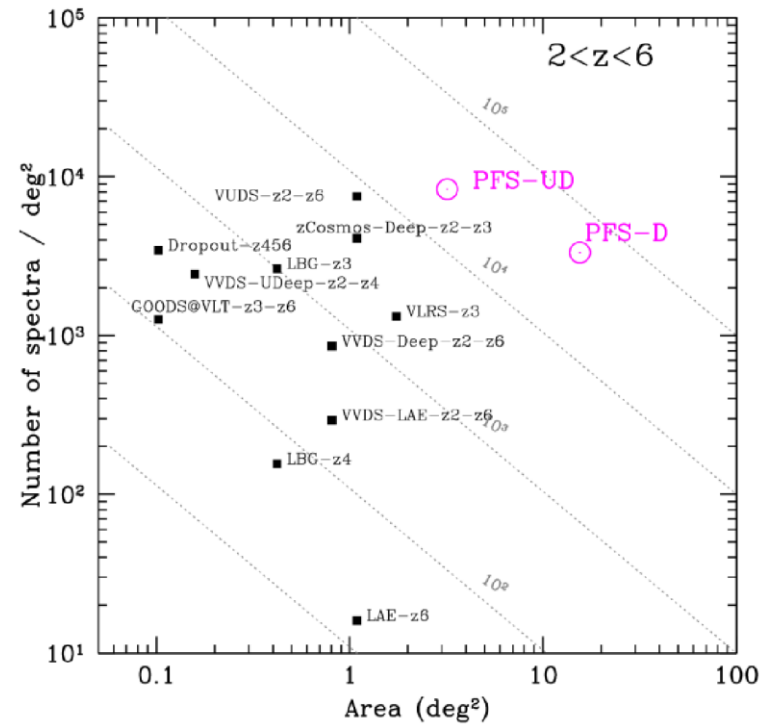
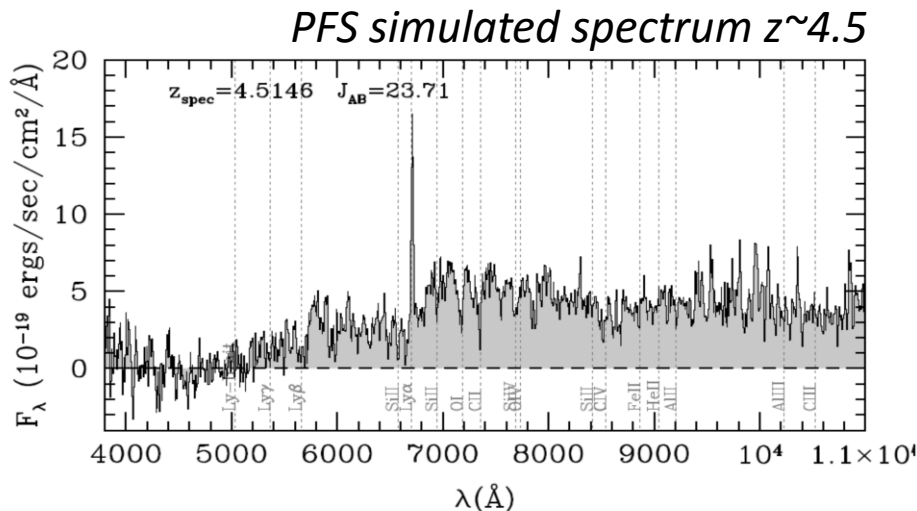
- 3D HI map over a volume of  $265 \times 265 \times 1650$  cMpc
- $2.1 < z < 2.5$
- $g \leq 24.7$  high S/N
- $15 \text{ deg}^2$
- 24,000 galaxies / lines of sight



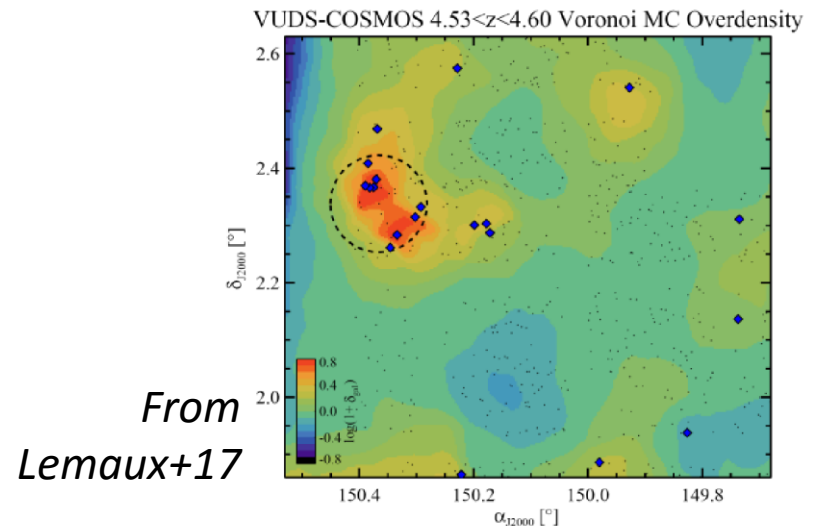
# The rise of massive galaxies in the seeds of large-scale structures

Olivier Le Fèvre et al.

- From the end of reionization  $z \sim 6$  to the peak in SFRD  $z \sim 2$
- Connect galaxy properties to local environment
- 50,000 galaxies
- $15 \text{ deg}^2$   $Y=24.3$
- $3 \text{ deg}^2$   $J=25$
- $\sim 50$  proto-clusters and environment from galaxy density field



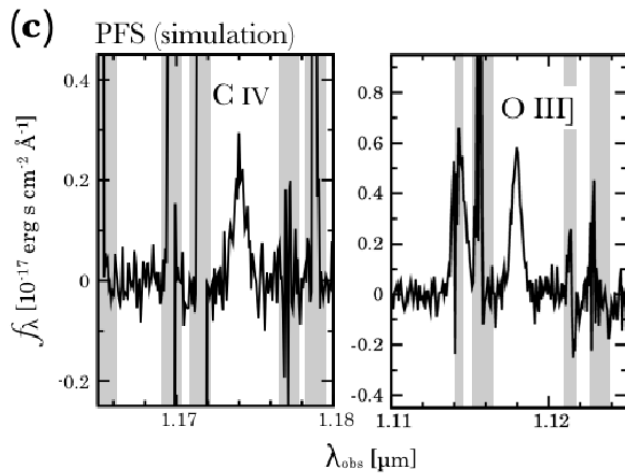
*Reconstructing the density field: spectro-z + photo-z*



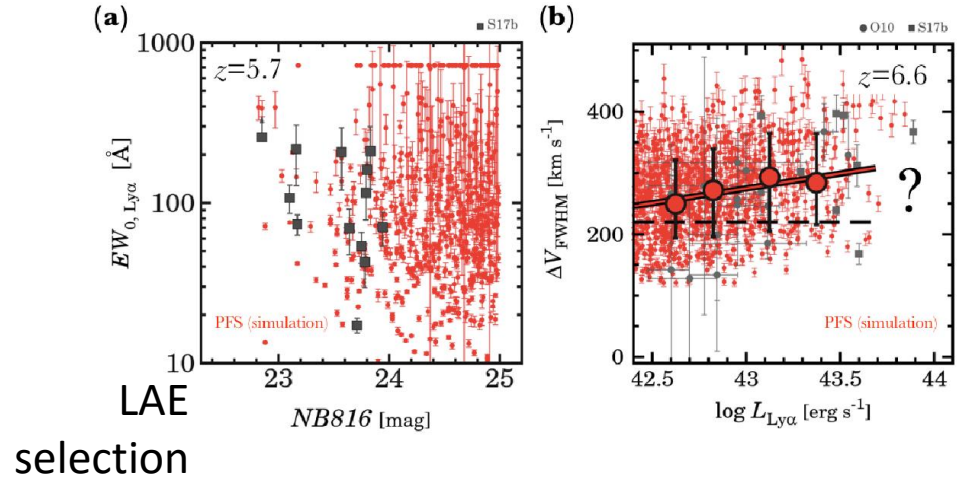
# Reionization and early galaxy formation

Masami Ouchi et al.

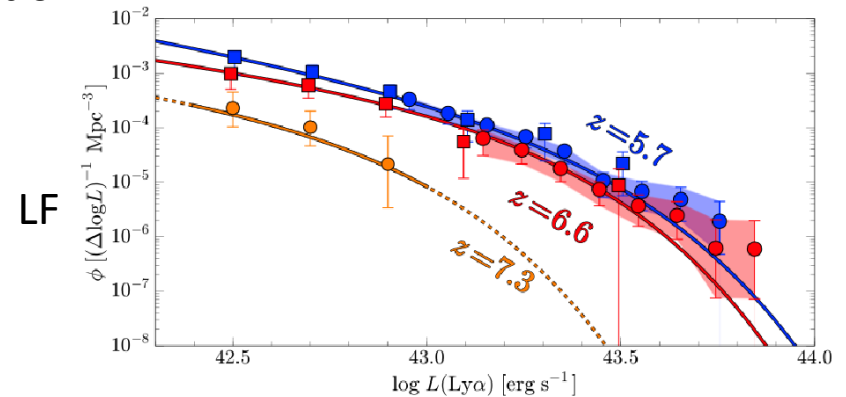
- LAEs at  $z \sim 6-7$  and  $z \sim 2$  selected from HSC narrow band survey
- 20,000 galaxies
- $15 \text{ deg}^2$



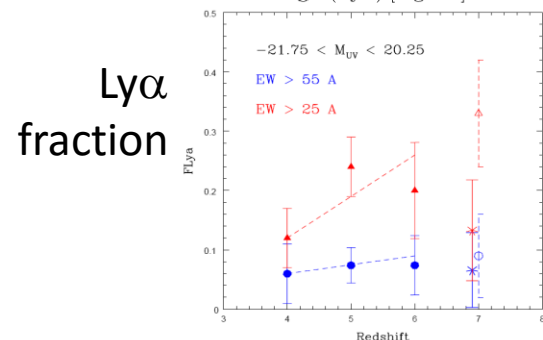
PFS simulation



LAE selection



LF



Ly $\alpha$  fraction

# Subaru Prime Focus Spectrograph (PFS) galaxy surveys

- PFS is one of the key, strategic instruments of Subaru
- PFS first light 2020
- Unique capability: 1.3deg FoV, 2394 fibers,  $\lambda=380 - 1260\text{nm}$ ,  $R\sim 2000$  (blue), 3000 (red), 4000 (NIR)
- Subaru will switch to a survey-type operation in 2020 era
- PFS science drivers: cosmology, galaxy, GA:  $\sim 300$  Subaru nights
- Ambitious spectroscopic galaxy surveys being designed
  - $0.7 < z < 2$ : 300,000 galaxies in  $15 \text{ deg}^2$
  - $2 < z < 3$ : tomography survey from 24,000 galaxies and LOS
  - $2 < z < 6$ : 50,000 galaxies in  $15 \text{ deg}^2$
  - $z \sim 6-7$ : 20,000 galaxies in  $15 \text{ deg}^2$

