

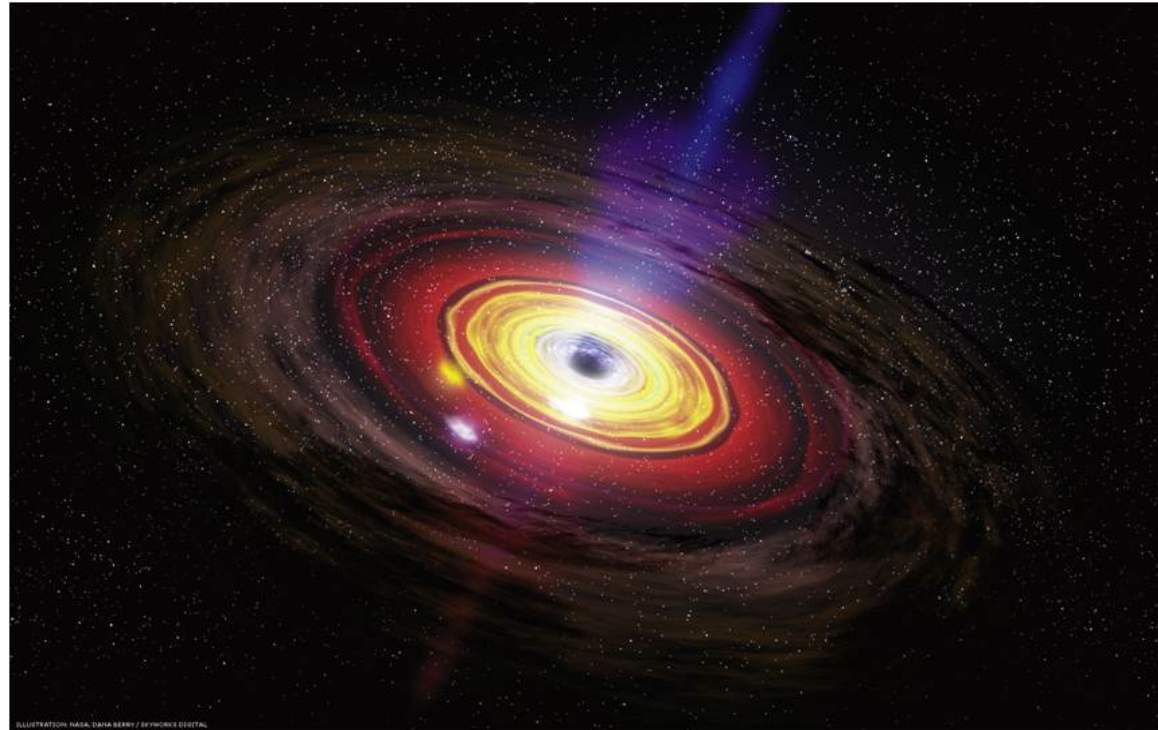


Observational Studies of AGNs through East-Asia Collaborations

Tohru Nagao
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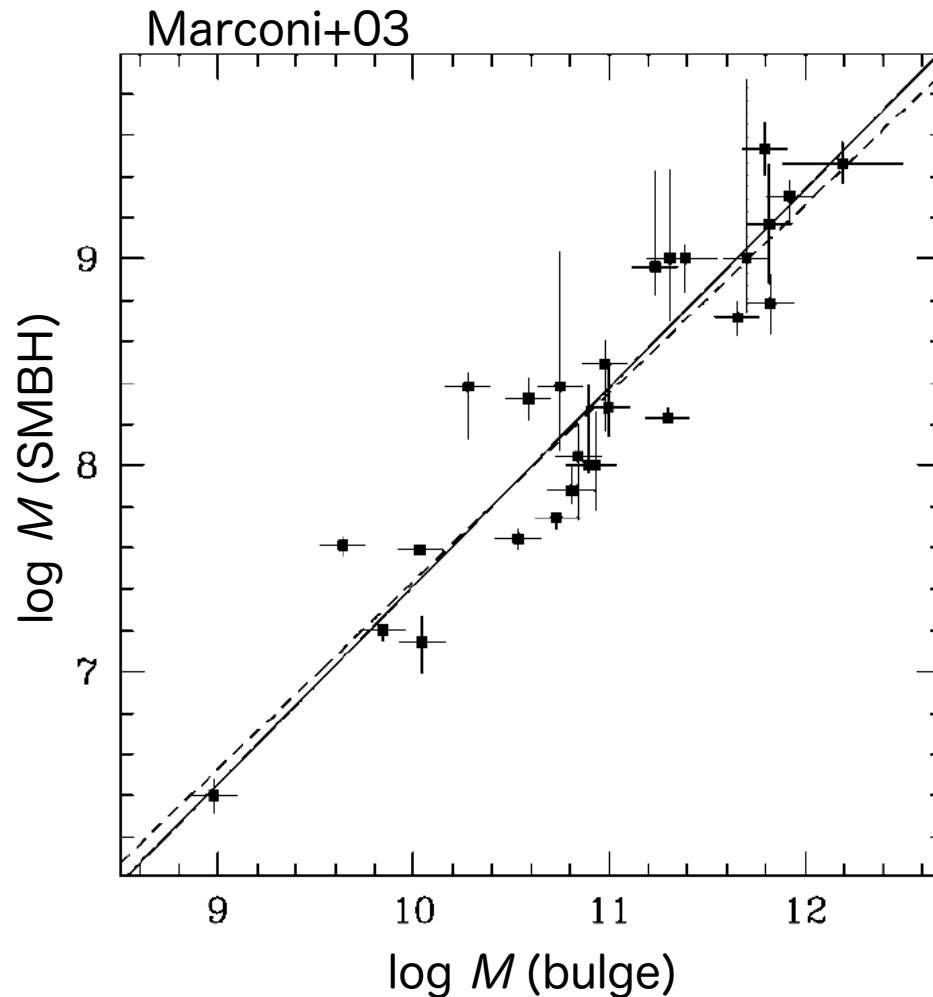
My science interests



AGNs are powered by supermassive black holes (SMBHs). The mass of SMBHs reaches up to $10^{10} M_{\text{sun}}$, but nobody knows **how** and **when** **SMBHs** **formed** **and** **evolved**.



My science interests (contd.)



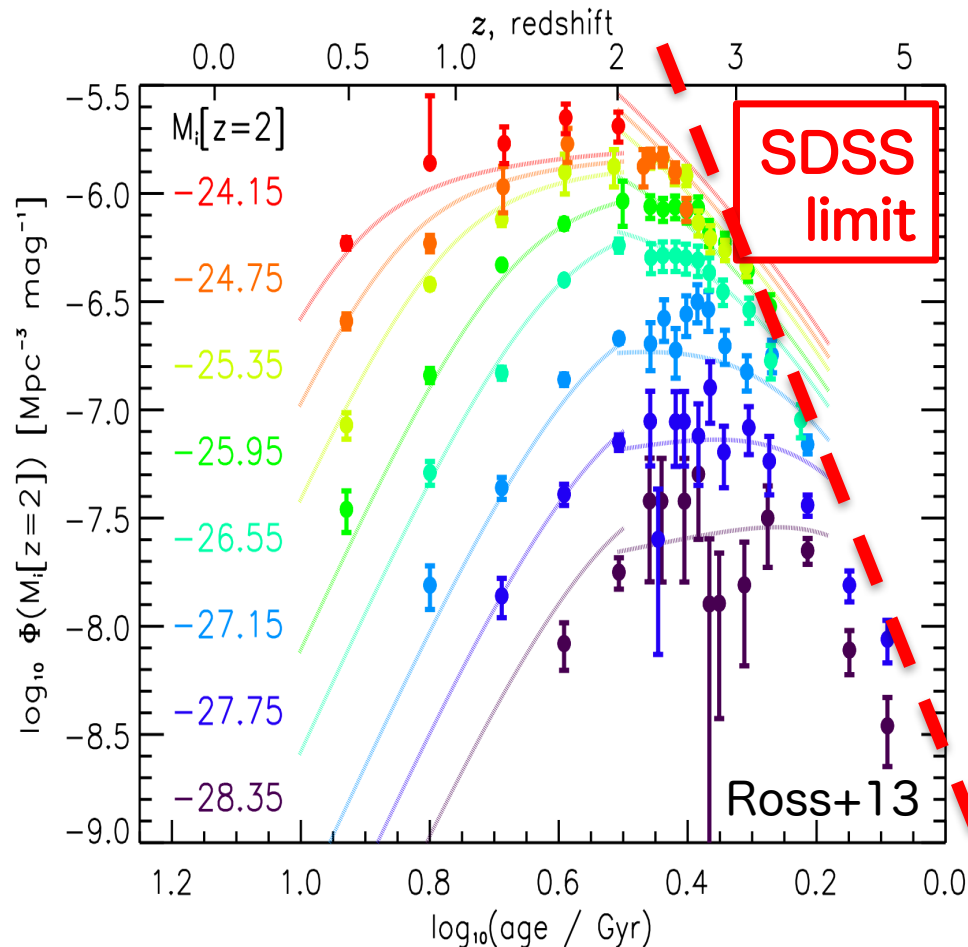
There is a tight correlation between the mass of SMBHs and their host galaxies, suggesting that there is **an evolutionary link between SMBHs and galaxies** (co-evolution).

Why? ...nobody knows.

Studies on the SMBH evolution is important, not only for AGNs/quasars but also for understanding the galaxy formation.



The luminosity-dependent density evolution?



Based on SDSS III (BOSS) data

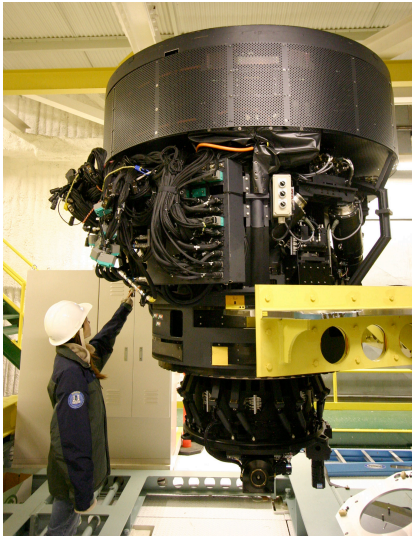
More luminous SDSS quasars show the peak of their number density evolution at higher redshifts.

Luminosity-dependent density evolution of quasars, that may be consistent to the picture of the so-called “downsizing” evolution.

Caveat: the number density is unclear at higher z & lower luminosity. Downsizing really holds also at higher z ?

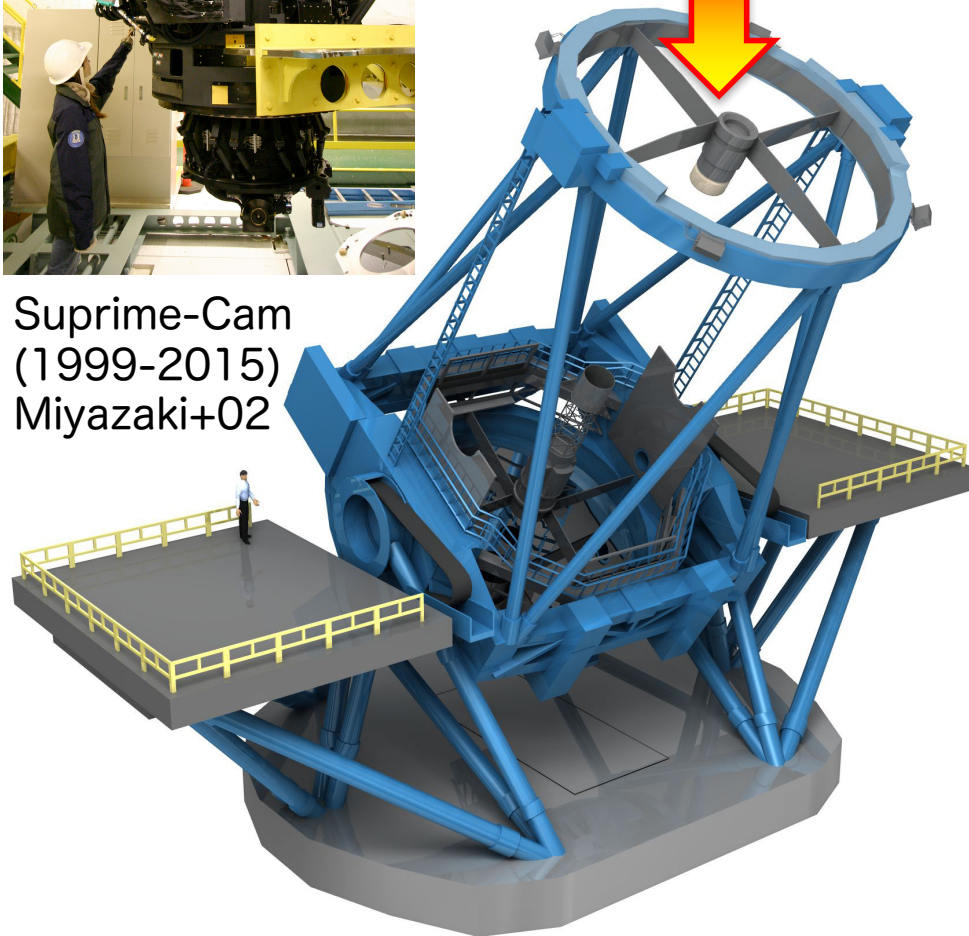


Subaru Suprime-Cam



Suprime-Cam
(1999-2015)
Miyazaki+02

Prime Focus



Suprime-Cam:
Prime-focus wide-field camera

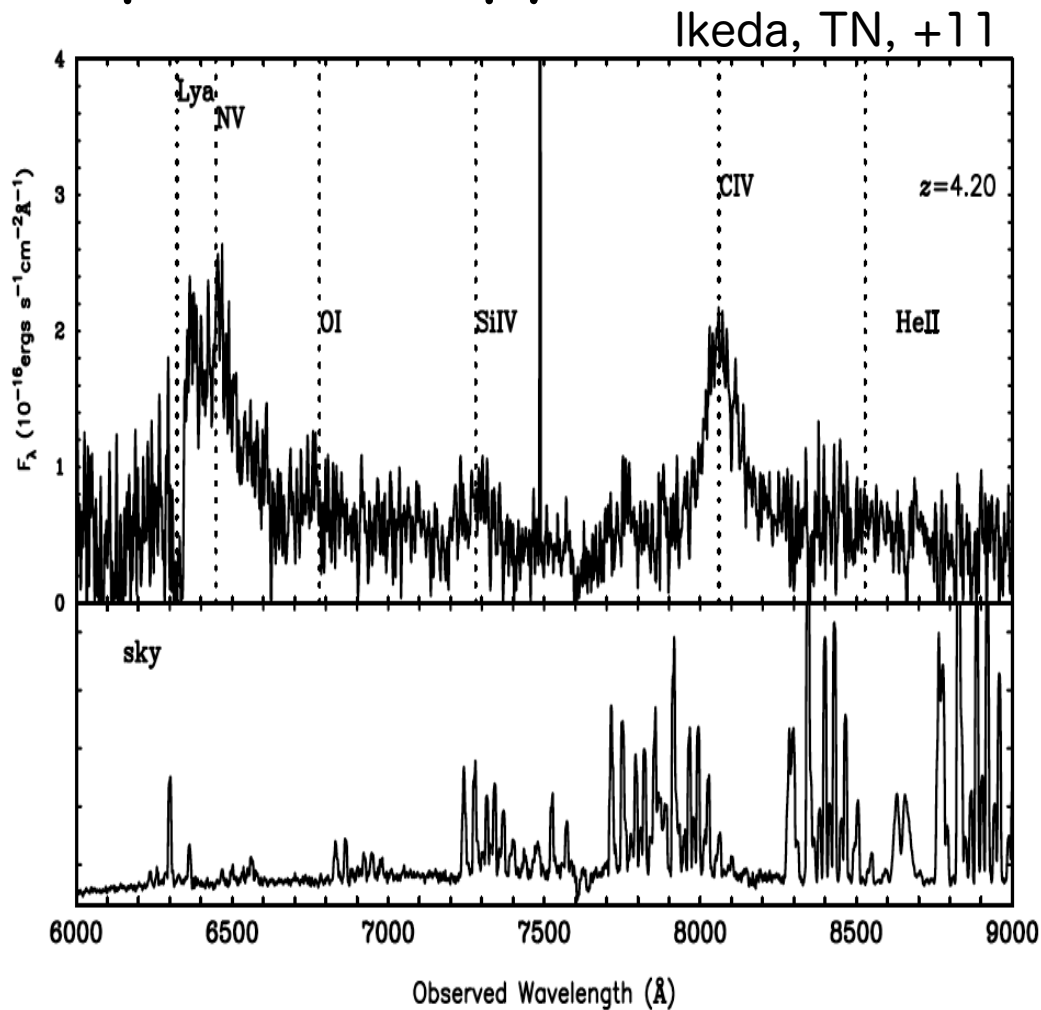
Field-of-view: 27'x34'

Good image quality:
instrumental degradation of
the image profile is negligible
for the whole of the FoV.

Extremely powerful in
searching for **rare and faint**
objects such as high-z
quasars.



Spectroscopy



FOCAS spectrum of a quasar at $z=4.20$ ($i=23.5$), with 0.5 hr exposures.

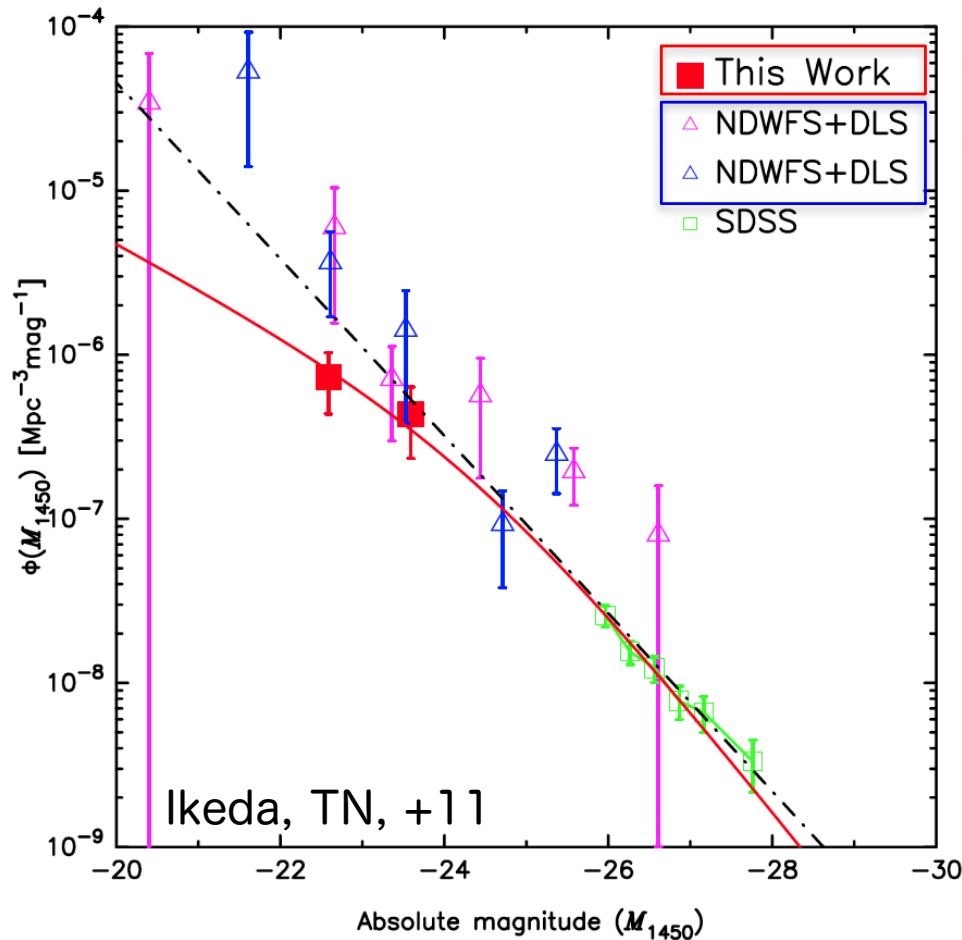
Spectra of 28 candidates of $z \sim 4$ quasars (among 31 candidates in the COSMOS field) were obtained with [Subaru/FOCAS](#).

Typical exposure time:
0.5-2 hours for each targets

23 targets showed meaningful spectra, and [8 quasars were identified as quasars at \$z \sim 4\$](#) (the remaining objects were late-type stars).



Quasar luminosity function at $z \sim 4$



COSMOS results (Ikeda, TN, +11)

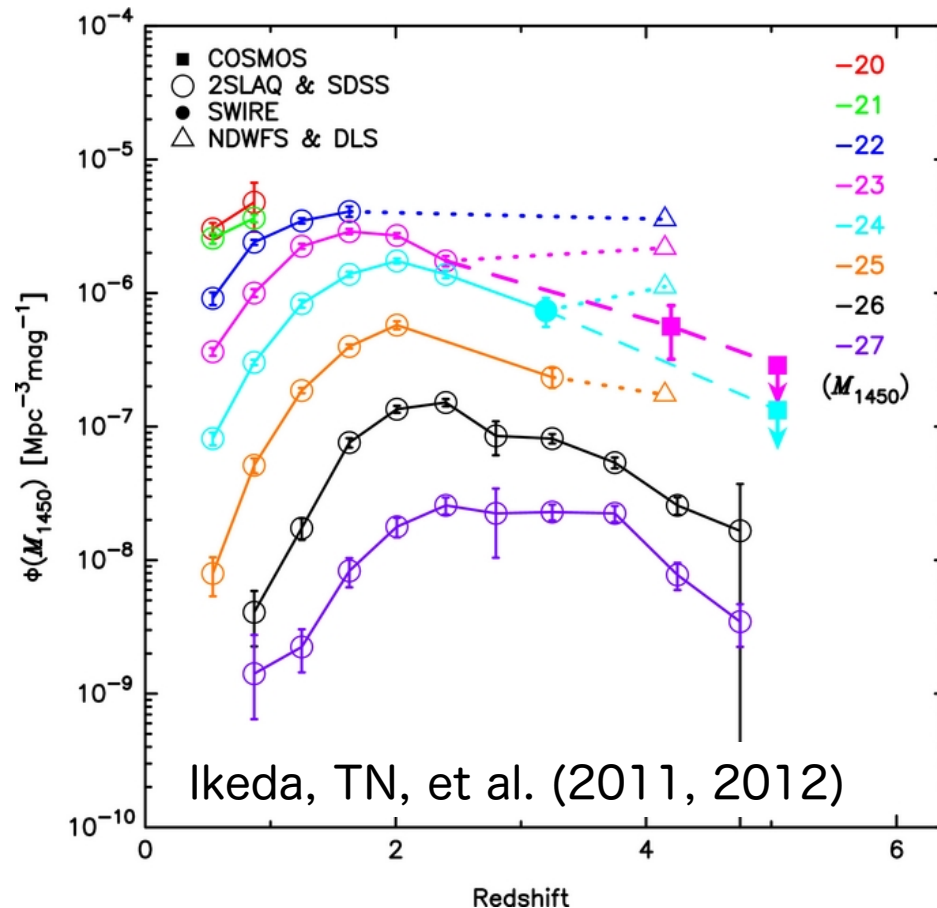
Results in NDWFS+DLS
(Glikman et al. 2010, 2011)

Derived QLF (+ SDSS QLF)
is consistent to double
power-law shape.

~0.5 dex lower than the
number density derived by
another quasar survey at
similar redshift...??



Luminosity dependence of the number density



NOTE: quasars at $z \sim 5$ were also searched in our COSMOS study but not identified (thus the upper limits are given at $z \sim 5$).

Our results are consistent to the extrapolation of the downsizing evolutionary trend at lower z , while another survey show a different picture...??

More intensive surveys for high- z low-luminosity quasars are needed !!

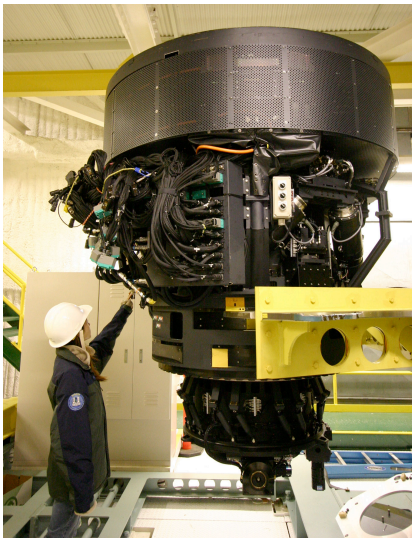


Hiroyuki
Ikeda

Ehime → ASIAA → NAOJ (HSC)

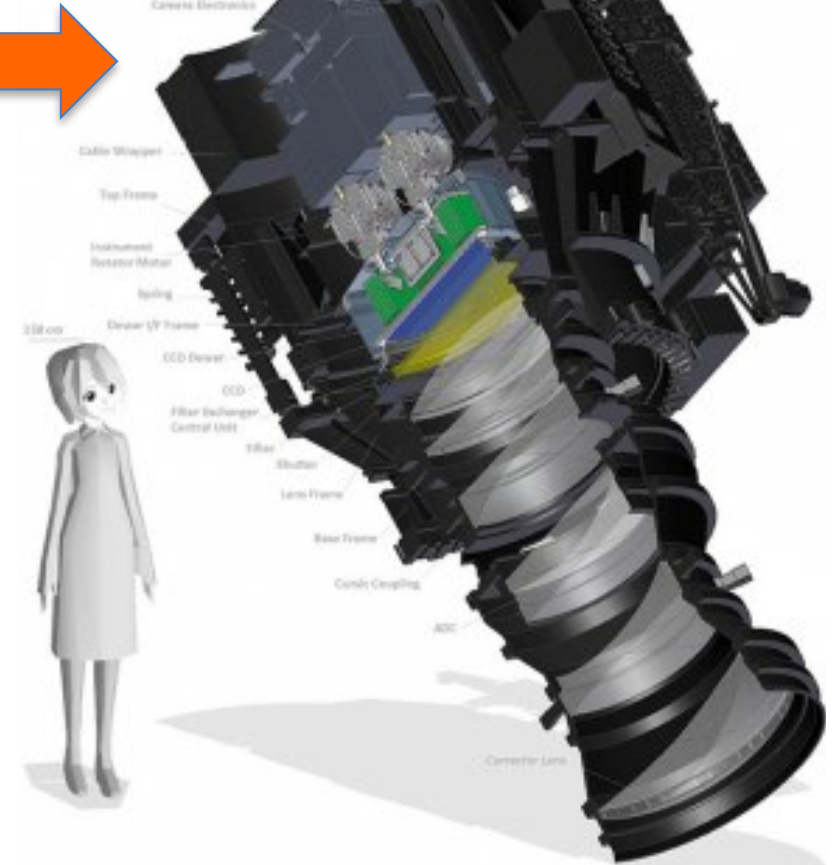
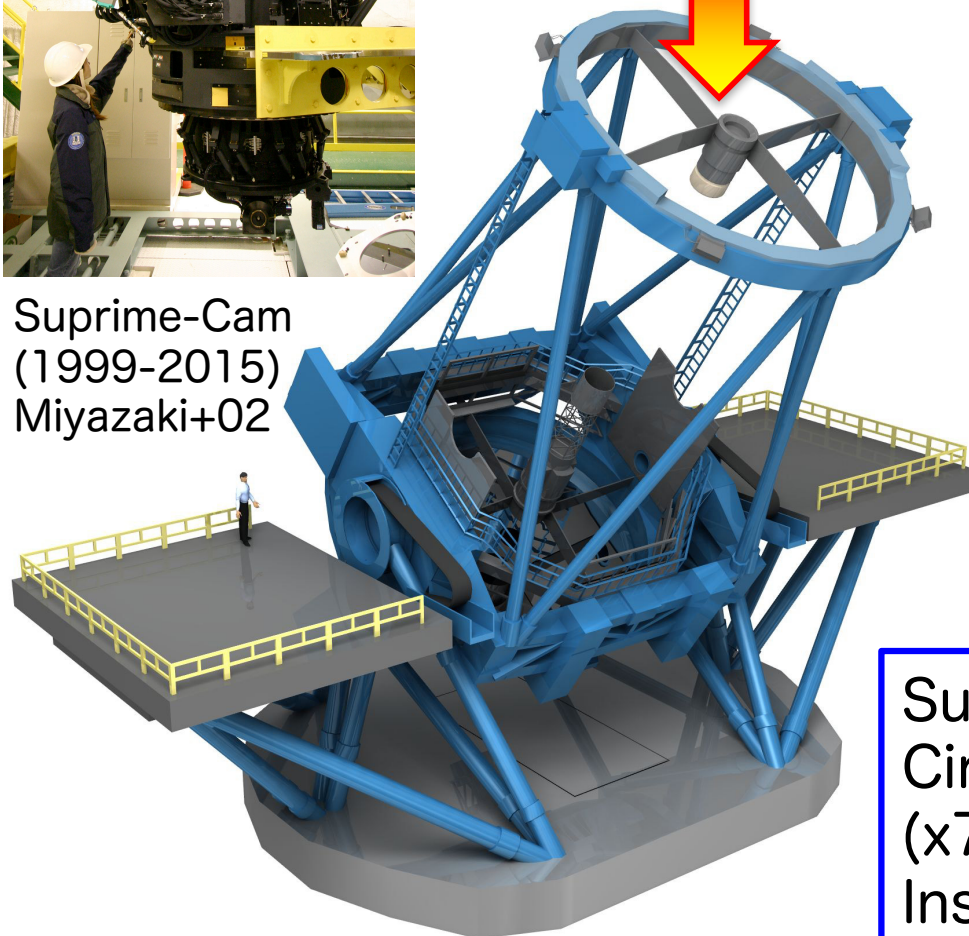


Subaru Hyper Suprime-Cam (HSC)



Suprime-Cam
(1999-2015)
Miyazaki+02

Prime Focus



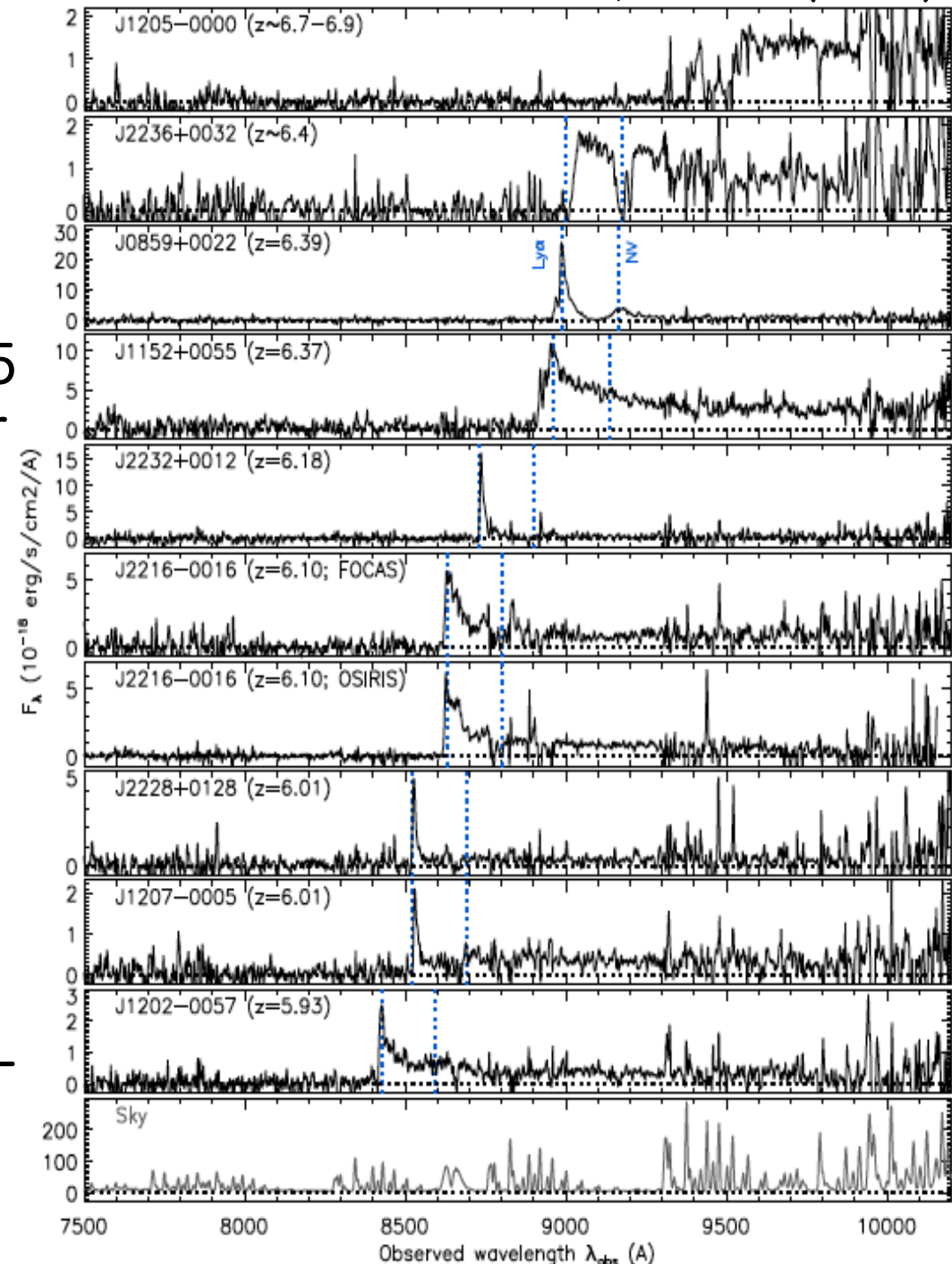
Subaru next-gen. wide-field camera
Circular FoV with a 1.5 deg diameter
(x7 wider FoV than Suprime-Cam)
Instrumental PSF: $<0.1''$ (for the whole FoV)
Red-sensitive detectors

cf. Takada-san's talk

HSC quasars at $z > 6$

- ~30 quasars at $z \sim 6$ -7 newly identified from HSC-SSP
- including a quasar at $z \sim 6.85$ (the 3rd most distant quasar identified so far)
- mostly [Subaru/FOCAS](#) is used for spectroscopy (but also GTC/OSIRIS for some cases)
- observations still on-going
- $z \sim 4$ -5 also on-going (by Akiyama-san, He-san, Niida-san, etc...)

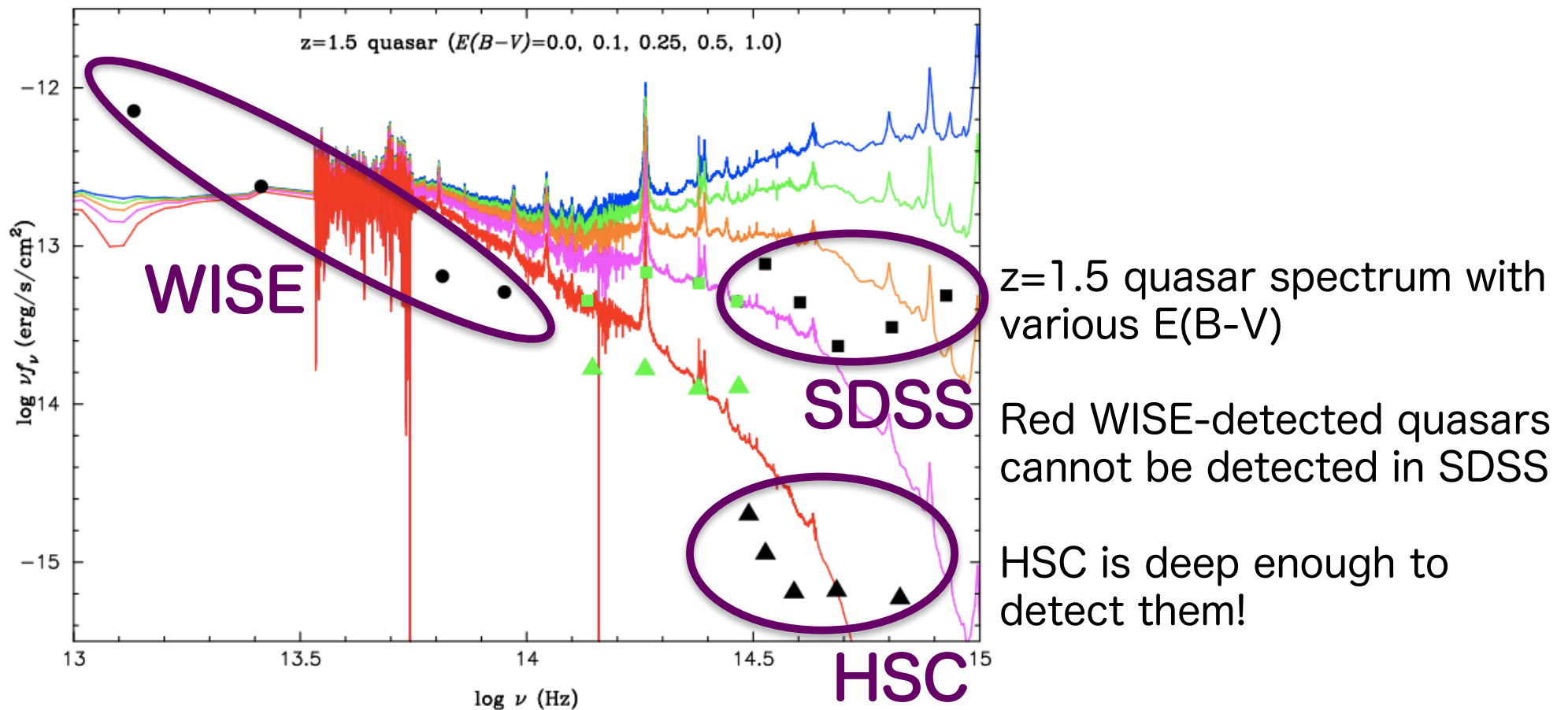
Matsuoka et al., incl. TN (2016)





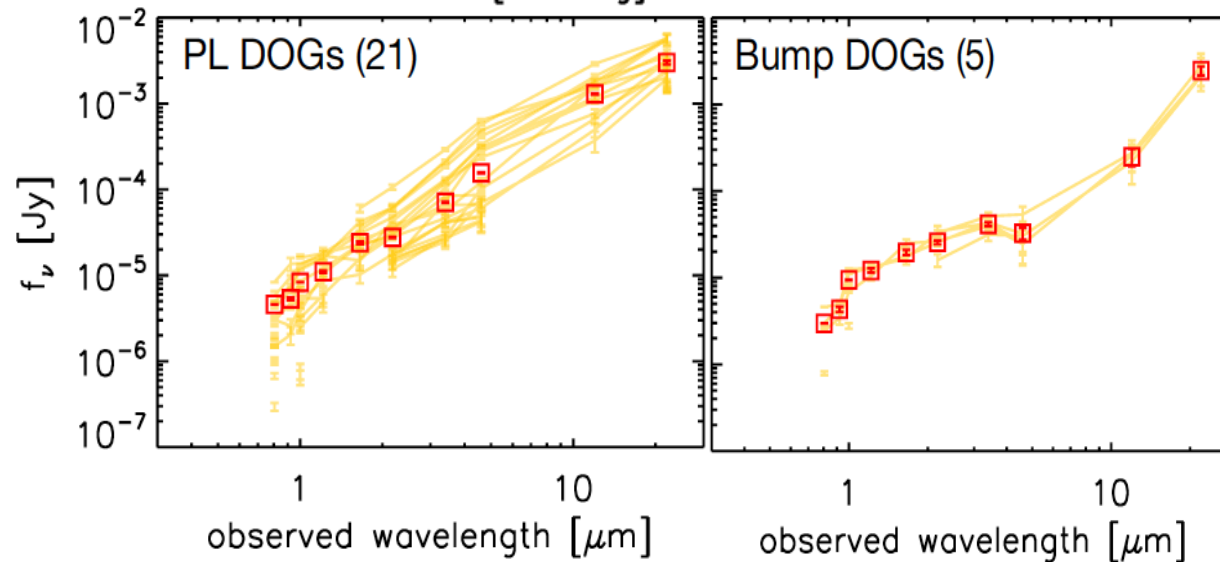
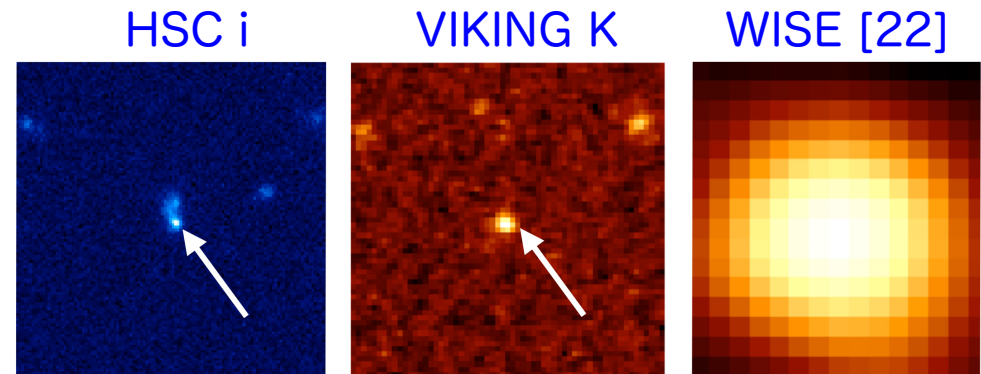
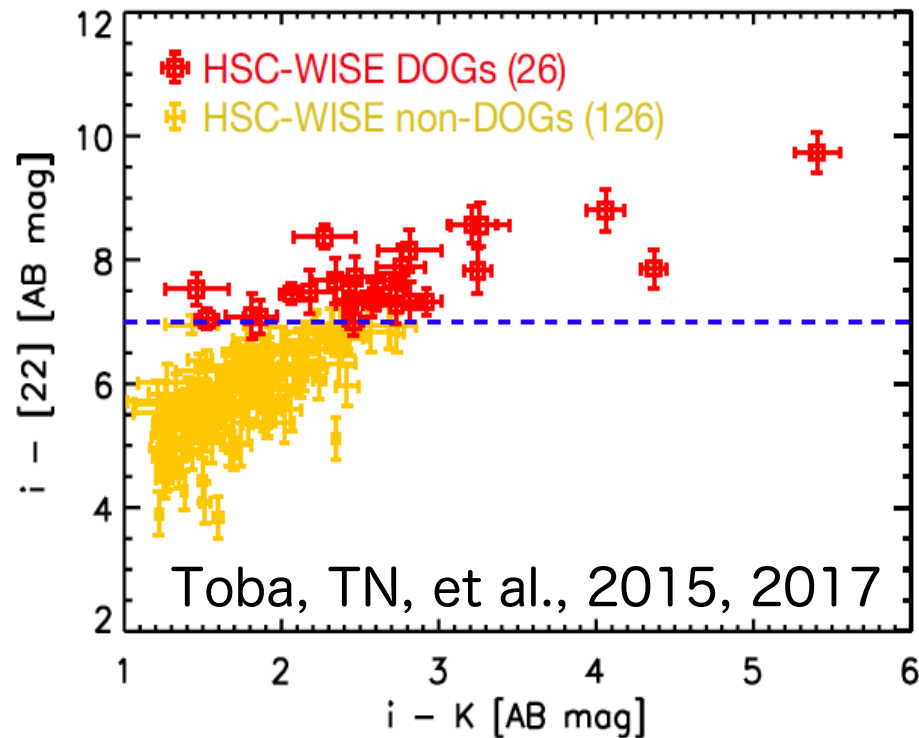
Dusty AGNs with HSC

- identifying red quasars with HSC & MIR all-sky data

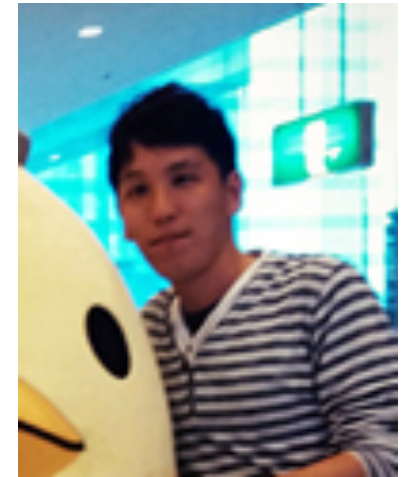




Results of HSC "Dusty Obscured Galaxies"



Yoshiki
Toba



ISAS \rightarrow Ehime \rightarrow ASIAA

\downarrow
Follow-up obs. with
SMA, ALMA, ...



For further understandings of AGN/SMBH...

- Characterization is needed (in addition to surveys)
- Need multi-wavelength approaches
 - ~ cross-match with wide-field data of radio, IR, Xray, ...
 - ~ sensitive follow-up with various instruments
- Need expertise for various specific analysis
 - ~ dynamical analysis for modeling the AGN outflow
 - ~ SED analysis (template, spectral fitting, ...)
 - ~ multi-wavelength experiences
 - ~ theoretical models (photoionization, N-body, MHD, ...)
- A solution: East-Asia AGN collaboration
 - ~ collaborating with neighboring friends
 - ~ series of workshops for fostering such collaborations

East-Asia AGN Workshops

Next EAAGN workshop:
4-6 Dec. 2017 @ Kagoshima, JP



12-14 Sep. 2012 @ Jeju, Korea



20-23 Aug. 2013 @ Sapporo, Japan

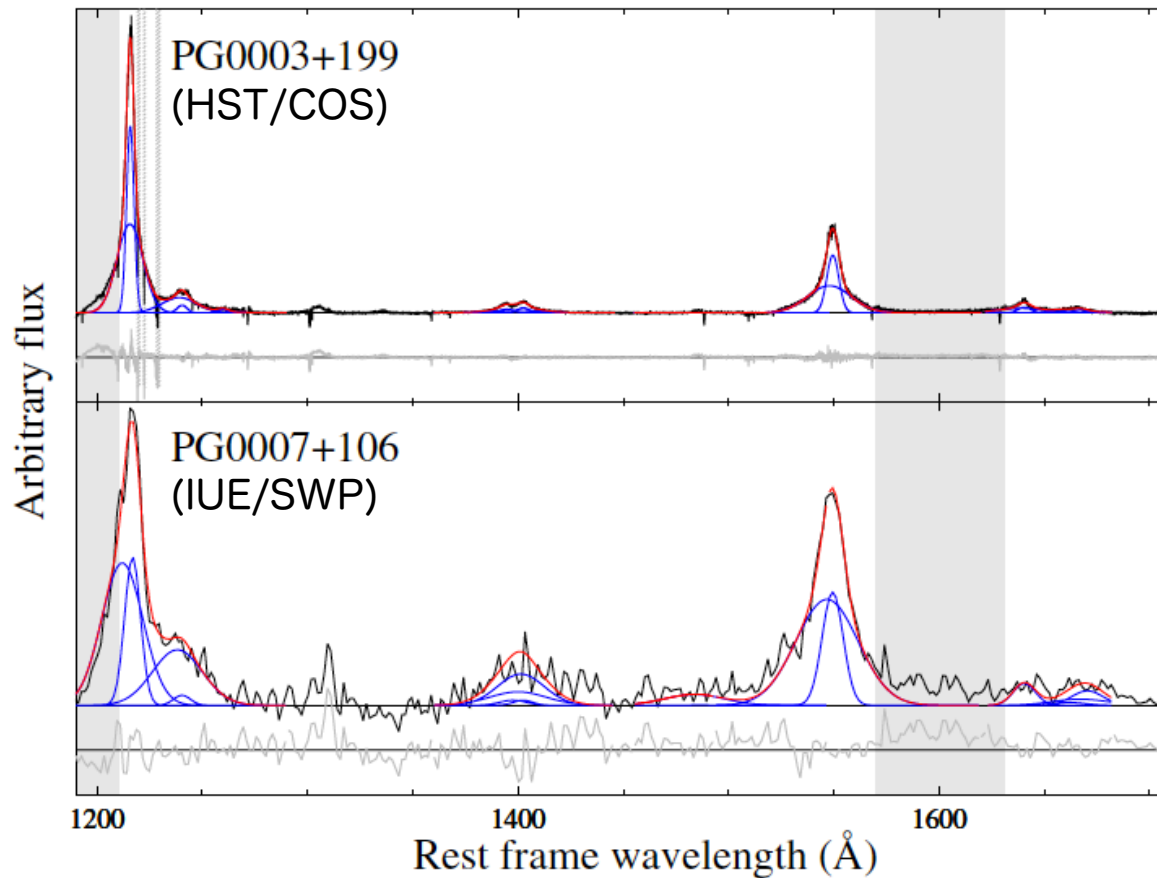


14-16 Jul. 2015 @ Changchun, China



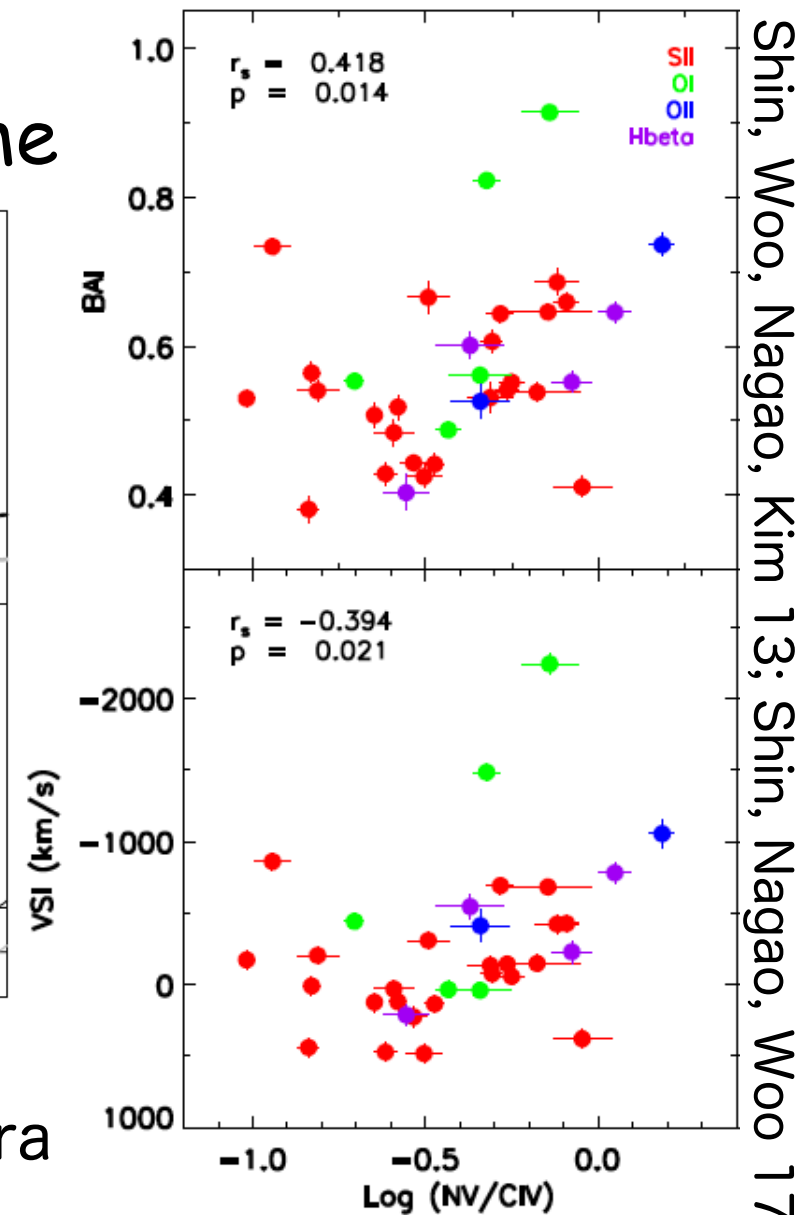
22-24 Sep. 2016 @ Seoul, Korea

An example of EAAGN outcome



Velocity profile analysis of UV spectra
for nearby AGNs

- Positive correlation between metallicity and outflow
- Requiring more studies for high- z low-metallicity quasars
- Joint Subaru/MOIRCS proposal in S17B



Shin, Woo, Nagao, Kim 13; Shin, Nagao, Woo 17



Summary

- Subaru is super-powerful for surveys
 - ~ Suprime-Cam → HSC (→ PFS & ULTIMATE)
 - ~ combination with multi-wavelength data also powerful

- Need characterization
 - ~ various follow-up (IFU, multi-wavelength, ...) needed
 - ~ various expertise (analysis, modeling, ...) needed

- International collaboration is also super-powerful
 - ~ current effort: “East-Asia AGN collaboration”
 - ~ annual workshops as a “bottom-up” approach
 - ~ continuous communication is crucial for outcomes
 - ~ next step: expanding the efforts to the Subaru friends