Subaru/HSC による活動銀河核探査計画

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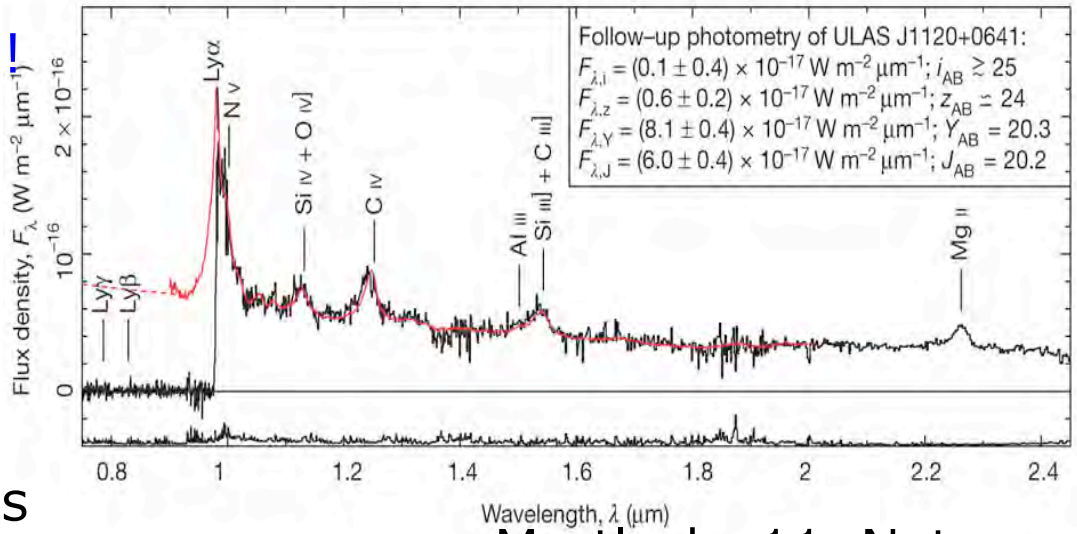
On behalf of
the HSC-AGN collaboration

ワークショップ「すばるHSCサーベイによるサイエンス」
国立天文台三鷹すばる棟大セミナー, 2012.9.26-28

Opt/NIR Results: z~7 quasar discovery

z=7.1 quasar has been found!!



Mortlock+11, Nature

GOOD:

~ Strong metallic lines
-- already enriched (!?)

~ M_{BH} ~2×10^9 M_{sun} at z=7.1
-- constraints on SMBH growth scenarios

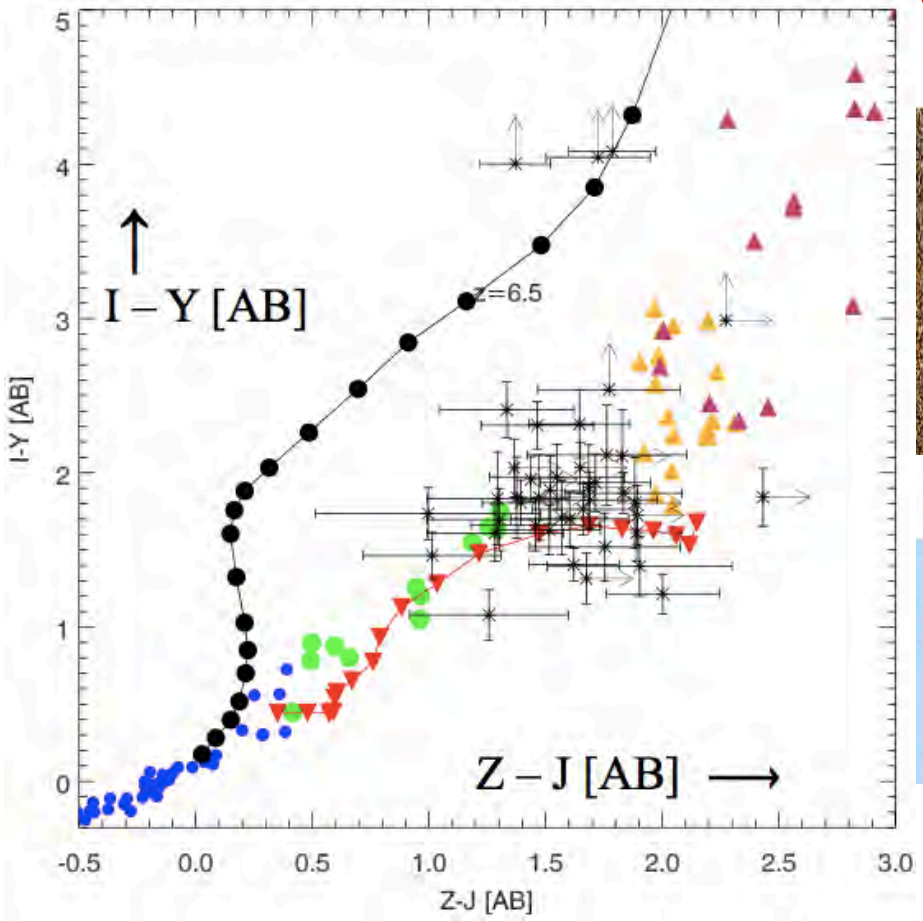
~ Neutral H frac: x15 higher than that at z~6
-- we are seeing "on-going" reionization phase

BAD:

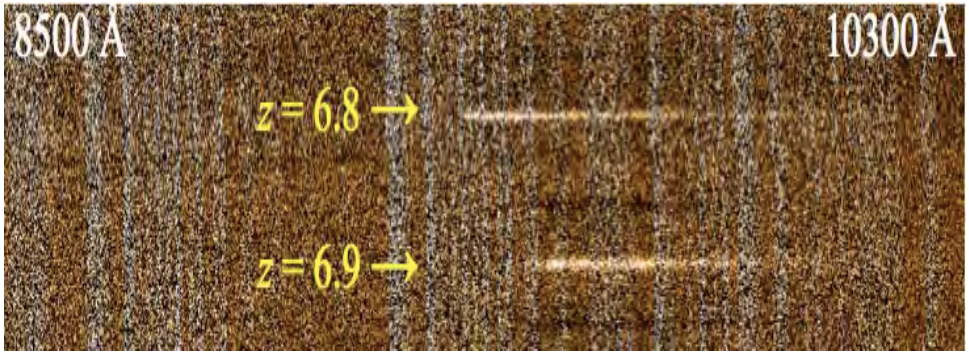
~ Only 1 quasar at z>6.5 published so far
-- how typical is this quasar?
-- how about statistical properties?

More sensitive surveys for z~7 quasars needed.

Opt/NIR Results: z~7 quasar discovery (contd.)



VISTA/VIKING also did it!!



~35 min VLT/FORS2, poor conditions (seeing ~1.4")

- 2 z>6.5 quasars in 180 square degrees

Y_{AB} ~ 21.2 and 21.3 → M_{1450} = -25.7

Another 3-4 candidates in a total area of 270 deg^2

Follow-up "optical" imaging with NTT for 45 "NIR" photometric candidates

→ Removing most contaminations

→ Further spectroscopy found 2 promising z~7 quasars!

Opt/NIR Results: z~6 quasar discoveries

Fan+06

Now 2 dozens of quasars have been identified at 5.7<z<6.5

GOOD:

~ Constraints on the reionization

~ M_{BH} ~10^9 M_{sun} even at z~6

BAD:

~ Only 1 quasar at z>6.5

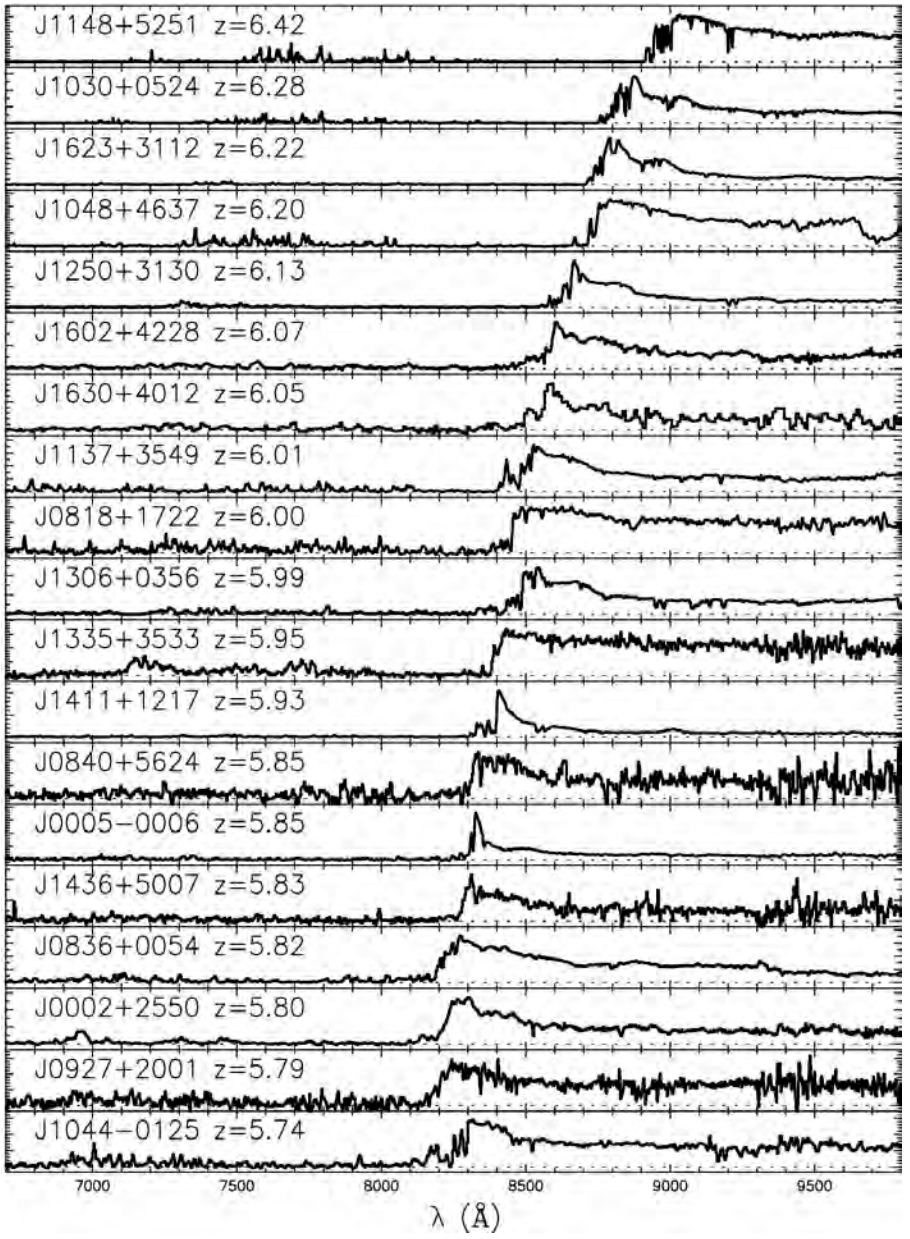
-- when massive BH formed?

~ Only few quasars at z~6

-- how "inhomogeneous" was the reionization?

~ Only too bright quasars at z~6

-- how about the whole shape of quasar luminosity func.?



Opt/NIR Results: z~4-5

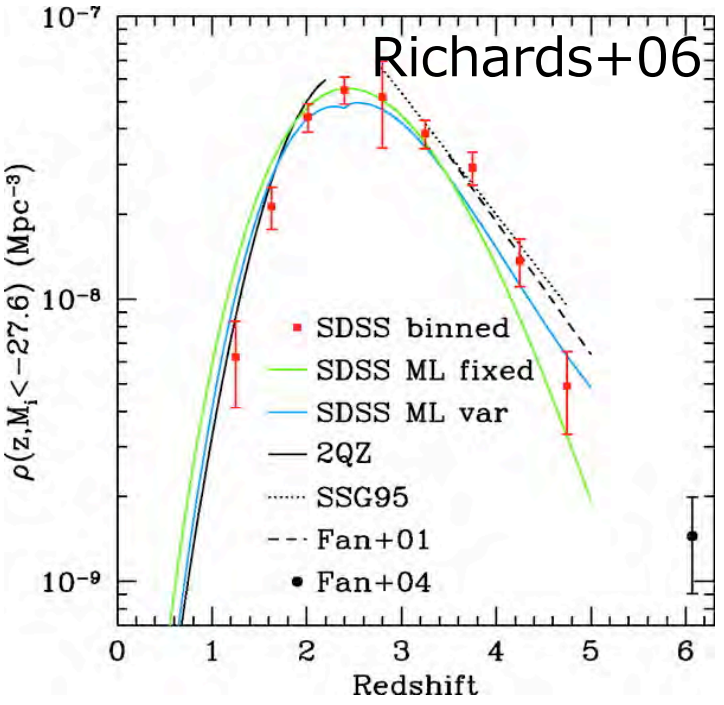
Now ~1000 quasars are found at z~4-5 in the SDSS DR7 database

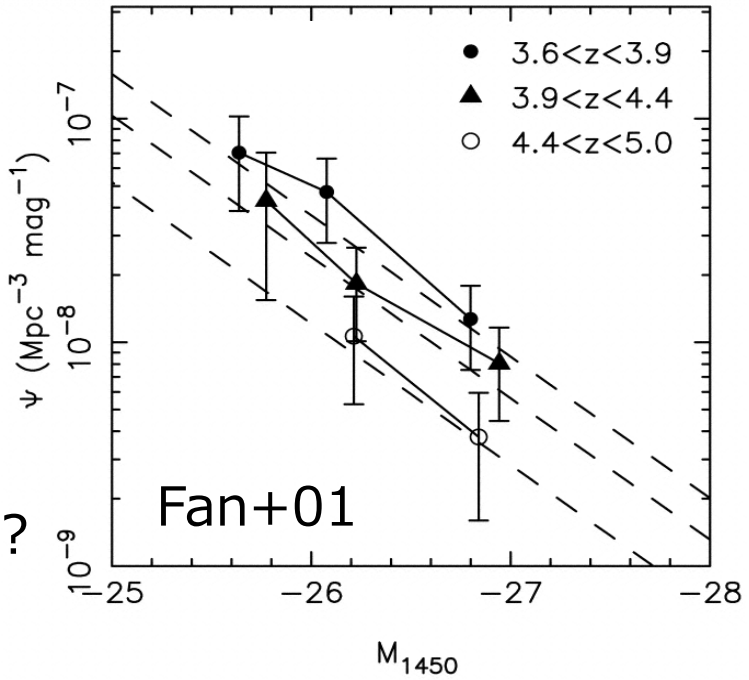
GOOD:

- ~ Evolution of the number density for high-luminosity quasars
- ~ Bright-end quasar luminosity func.
- ~ Super-solar metallicity at z>4

BAD:

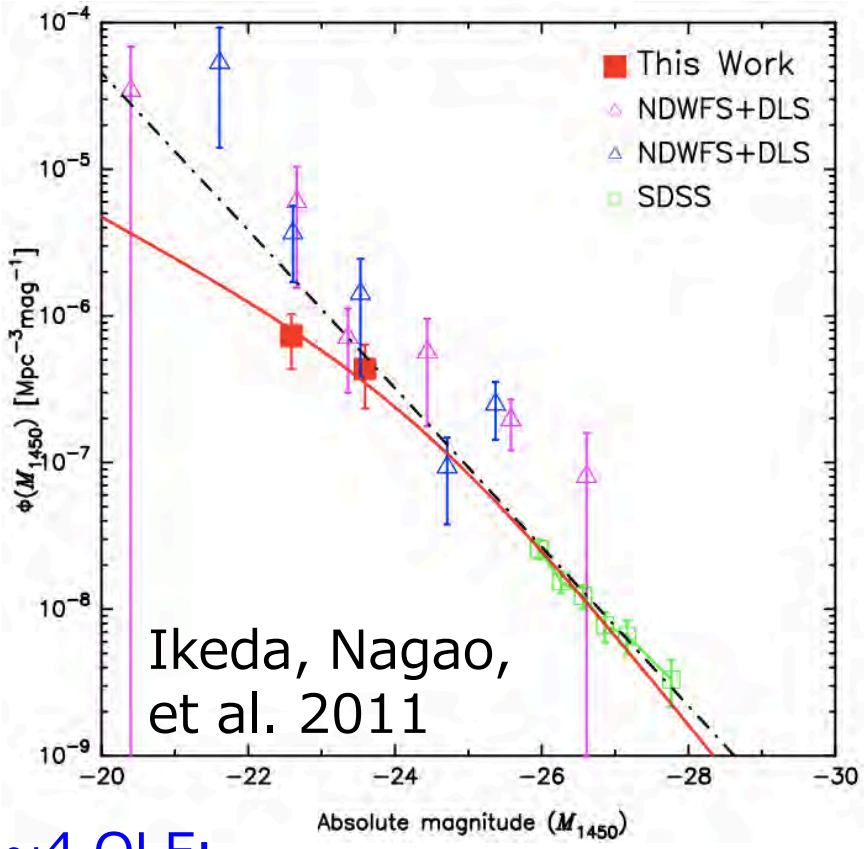
- ~ Only bright quasars are surveyed
  - -- whole shape of quasar LF?
  - -- cosmological evolution of quasars?
- ~ Bright → Low number density
  - -- quasar correlation function?
- ~ Galaxies around quasars are not seen
  - -- how about the quasar environment?
  - -- quasar-galaxy cross correlation?

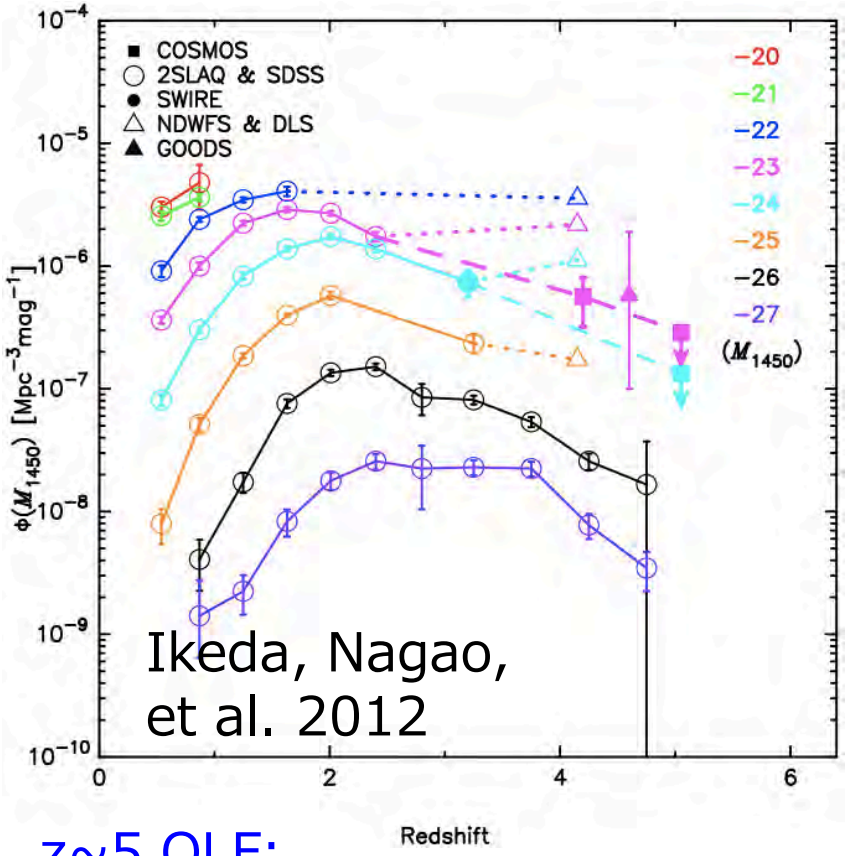




See Ikeda-san's poster!!

Opt/NIR Results: z~4-5: More Recently...





z~4 QLF:
1 order difference at the faint end among different surveys??

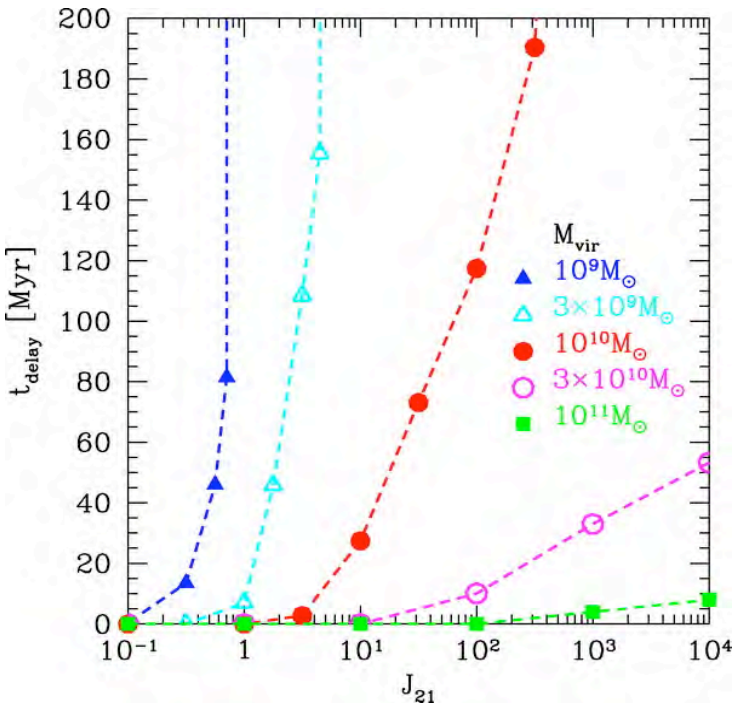
z~5 QLF:
Downsizing? Anti-downsizing??
Controversial results at z~4-5...

Need more statistics for low-L, even at z~4-5.

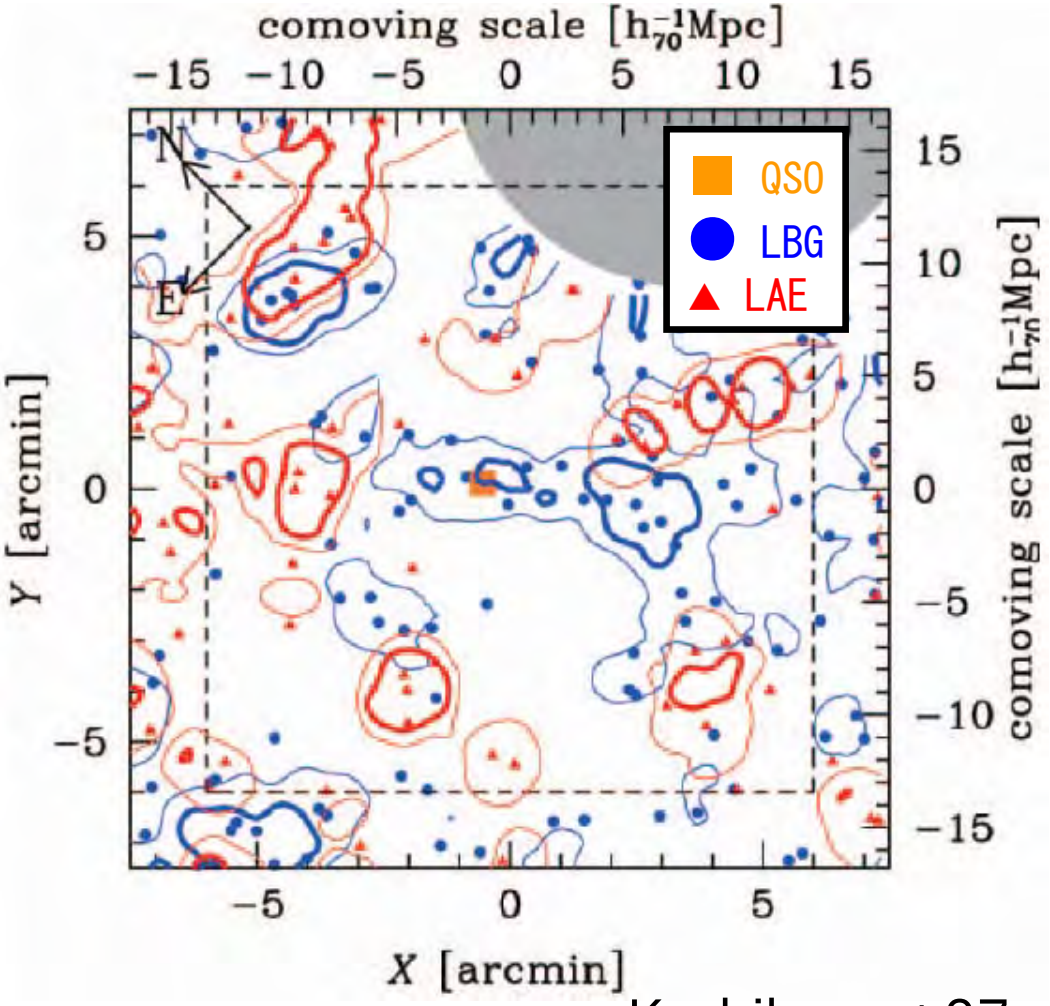
Opt/NIR Results: z~4-5: Quasar Environments

~ A case study for “quasar environment”
~ A quasar at z~4.9
~ V-drop LBGs at z~5
~ NB711 LAEs at z~4.9

~ Some LBGs around quasar
~ But no LAEs around quasar
~ “Negative Feedback” !?



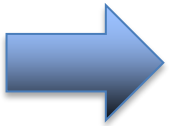
Kitayama+00,01



Kashikawa+07

Next Step?

~ More z~6-7 quasars
~ Lower-L z~4-6 quasars
~ Galaxies at similar-z



Wide & Deep Multi-Color Survey
with Multi-Wavelength Information

SWANS (Subaru Wide-Field AGN Survey)

~ with Hyper Suprime Cam (HSC) on Subaru
~ a legacy survey spending ~300 nights / 5 years
~ through the “Subaru Strategic Program” (SSP)
~ color, time-variability, and multi-wavelength selection
~ a few QSOs@z~7, ~200@z~6, ~2000@z~5 quasars
~ >30 participants
~ with many students & theoretical preparations
~ annual meetings from FY2009
(Matsuyama, Sendai, Kyoto, Matsuyama, ...)

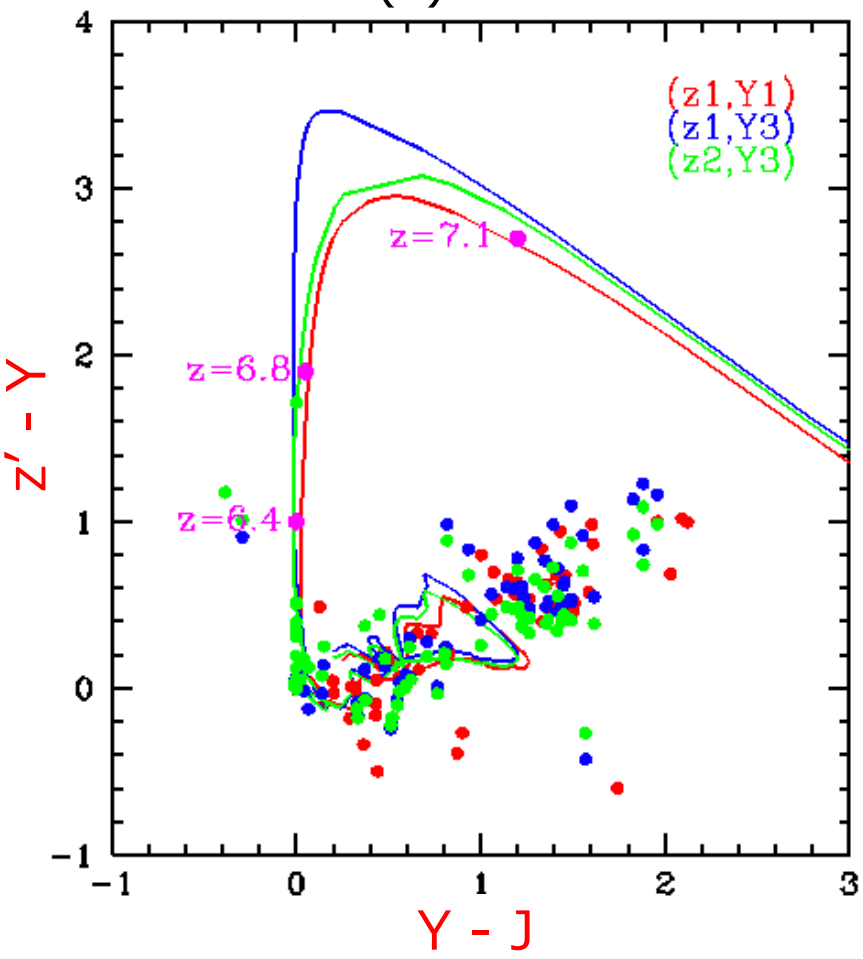
HSC at z~7

SWANS can find QSOs even at z~7,
thanks to the presence of Y-band
WHEN COMBINED WITH NIR DATA

HSC-wide: a few QSOs at 6.6<z<7.4
~ identifying bright-end QSOs
HSC-deep: a few QSOs at 6.6<z<7.4
~ identifying fainter-side QSOs

Our Pre-Studies
~ Thesis work by Ishizaki-san
with SCam & NIR data (w/Kashikawa-san
~ Selection criteria, completeness,
contamination, etc...
~ Number density estimates by
Imanishi-san et al.
~ HSC commissioning data would
help these pre-studies greatly

(c) Kashikawa-san



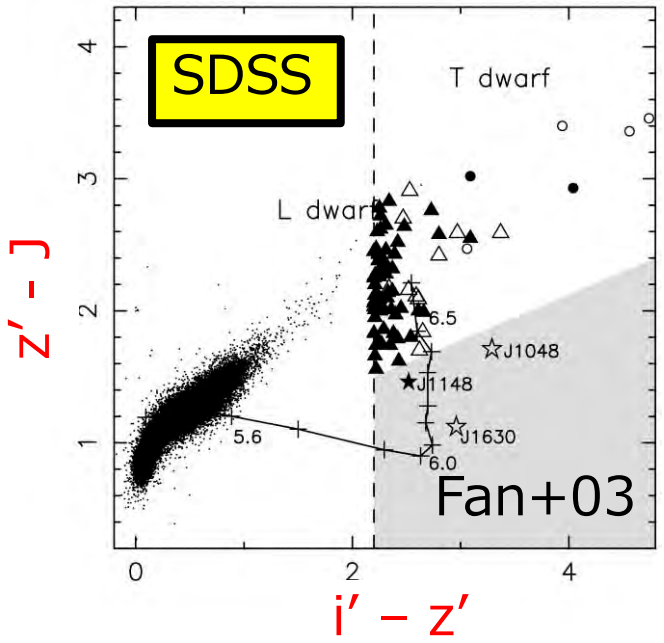
dots: Galactic brown dwarfs
lines: Quasar color tracks

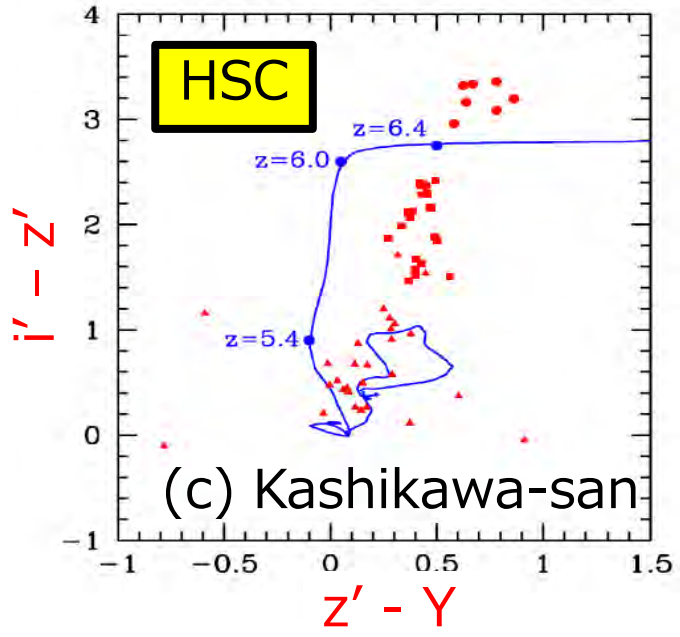
HSC at z~6

SWANS can find many QSOs at z~6 without NIR (i.e., only the HSC data) thanks to the presence of Y-band (but NIR data still useful)

Many z~6 QSOs (>300) enable us to:
- ~ study inhomogeneous reionization
- ~ QSO luminosity function at z~6
- ~ mass func., metallicity, ...

Our Pre-Studies
- ~ Master thesis work by Ishizaki-san
- ~ Goto-san identified a z=5.96 QSO (Goto 2006, w/NIR)
- ~ Matsuoka-san, Asami-san, et al.
  -- 1000 deg^2, z'_{lim}~21mag survey





HSC at z~5

LAE search in the HSC survey
HSC-D: z~2.2, 5.7, 6.5
HSC-UD: z~2.2, 3.3, 4.9, 5.7, 6.5, 7

~ A case study for “QSO environment”
~ A QSO at z~4.9
~ V-drop LBGs at z~5
~ NB711 LAEs at z~4.9

~ Some LBGs around quasar
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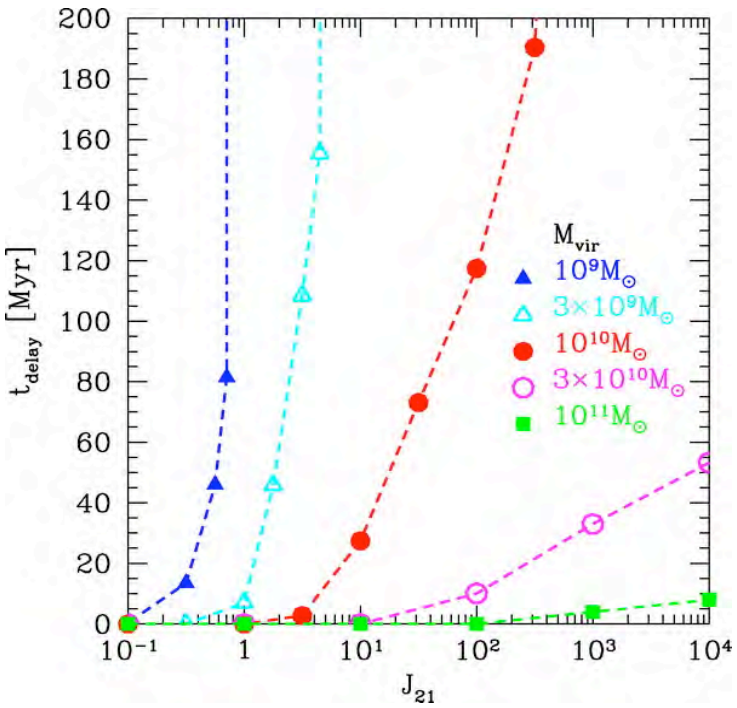
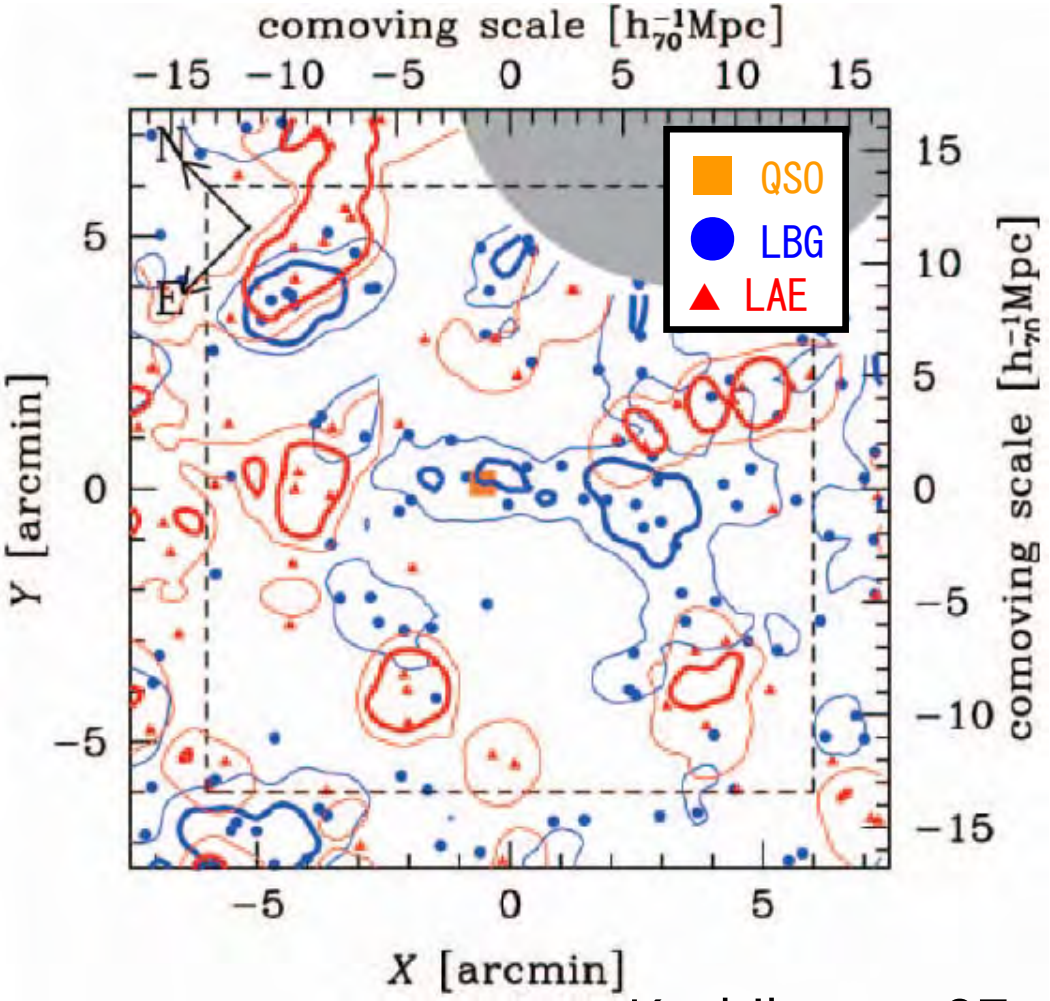
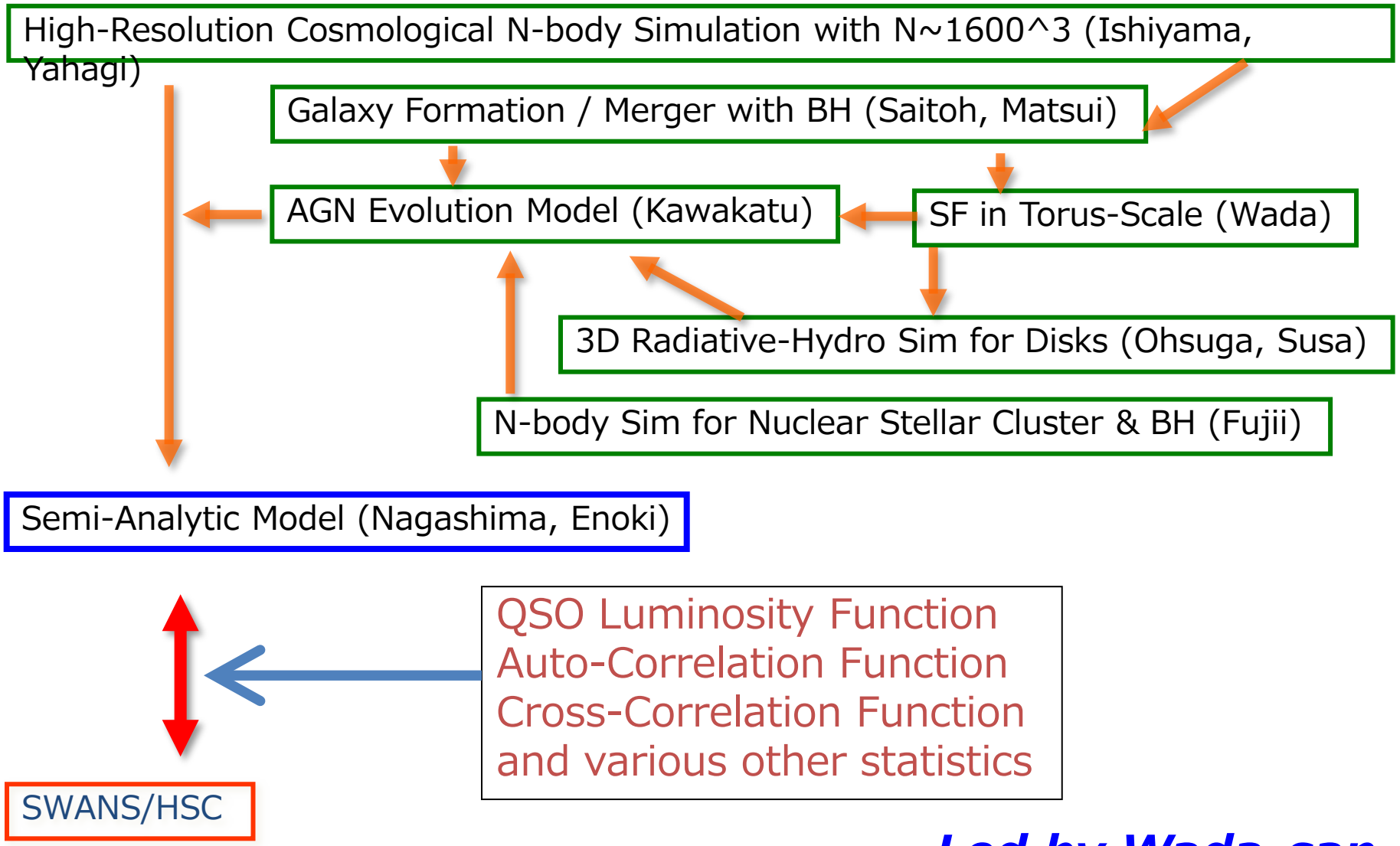


Kitayama+00,01



Kashikawa+07

Theoretical Preparations (with semi-analytic models)



Led by Wada-san

HSCと他のデータを組み合わせて何ができるか？

~ X-ray data (Chandra, XMM (and eROSITA?))
~ Deep and wide NIR data (UKIRT, VISTA)
~ All sky MIR data (WISE)
~ All sky radio data (FIRST (and ACT?))
~ ALMA

~ and PFS (2017-?)

~ それぞれのデータがavailableになる時期に注意

~ HSC後のプロジェクトに対してターゲット供給
-- Astro-H (2014-)
-- TAO (2018-?) ...PFSでは不可能なHK分光を
-- TMT (2022-?) ...deep spectroscopy
-- SPICA (2022-?) ...hot dust, PAH, SB-AGN relation
-- Athena的な何か

Synergy with X-ray (Terashima-san, Ueda-san, Akiyama-san, ...)

- interesting targets from HSC (e.g., z~7 quasars)
  - ~ Chandra and/or XMM proposals (DDT and/or open)
- XMM-LSS data + HSC
  - ~ X-ray selected sample, SED, ...
- eROSITA (2014 launch) all-sky survey data
  - ~ extending the XMMLSS-like sciences
  - ~ data availability unclear

25 deg^2 in CFHTLS-W1 2h23 -5d00

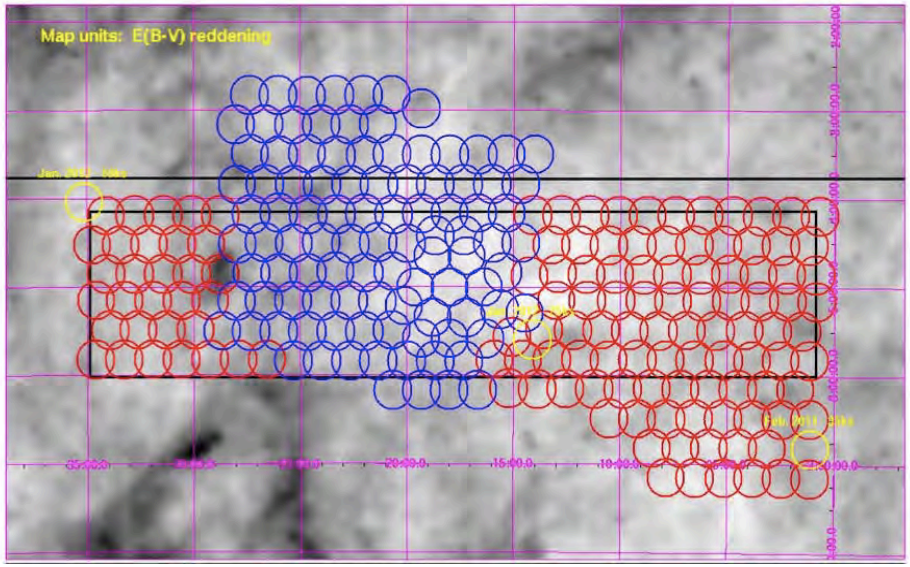
(extension of the XMM-LSS field)

blue: observed (11deg^2, XMMLSS)
~ catalog available for 5 deg^2

red: planned (25deg^2, XXL)
~ obs. will be completed in 2013.04
~ catalog-release timescale unclear

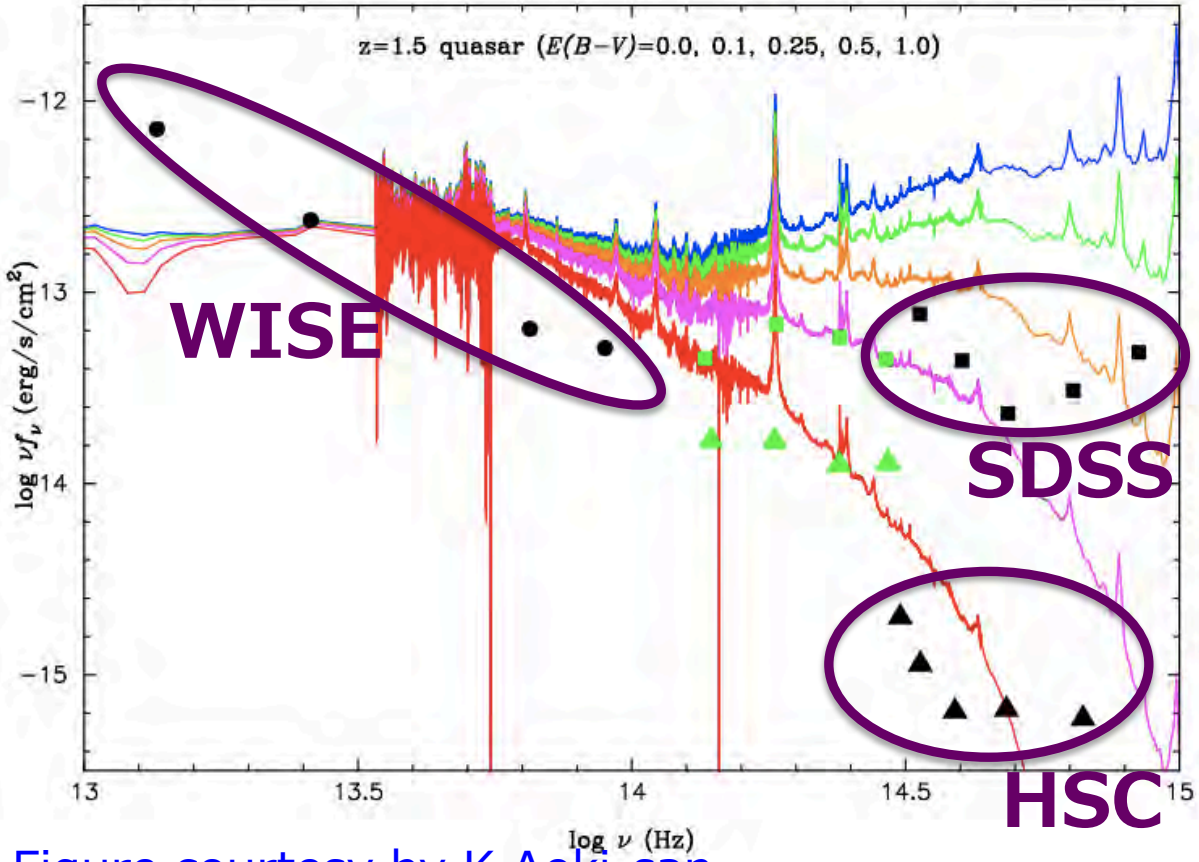
mostly covered with HSC-W/D

from M. Pierre's PPT
(and Terashima-san's study)



Synergy with MIR (WISE) (K.Aoki-san)

- identifying red quasars with HSC & WISE
  - ~ WISE all-sky data have been already released
  - ~ Dusty quasars (in interesting evolutionary phases?)
  - ~ Type 2 AGNs (cannot be sampled only with HSC)



z=1.5 quasar spectrum with various E(B-V)

Red WISE-detected quasars cannot be detected in SDSS

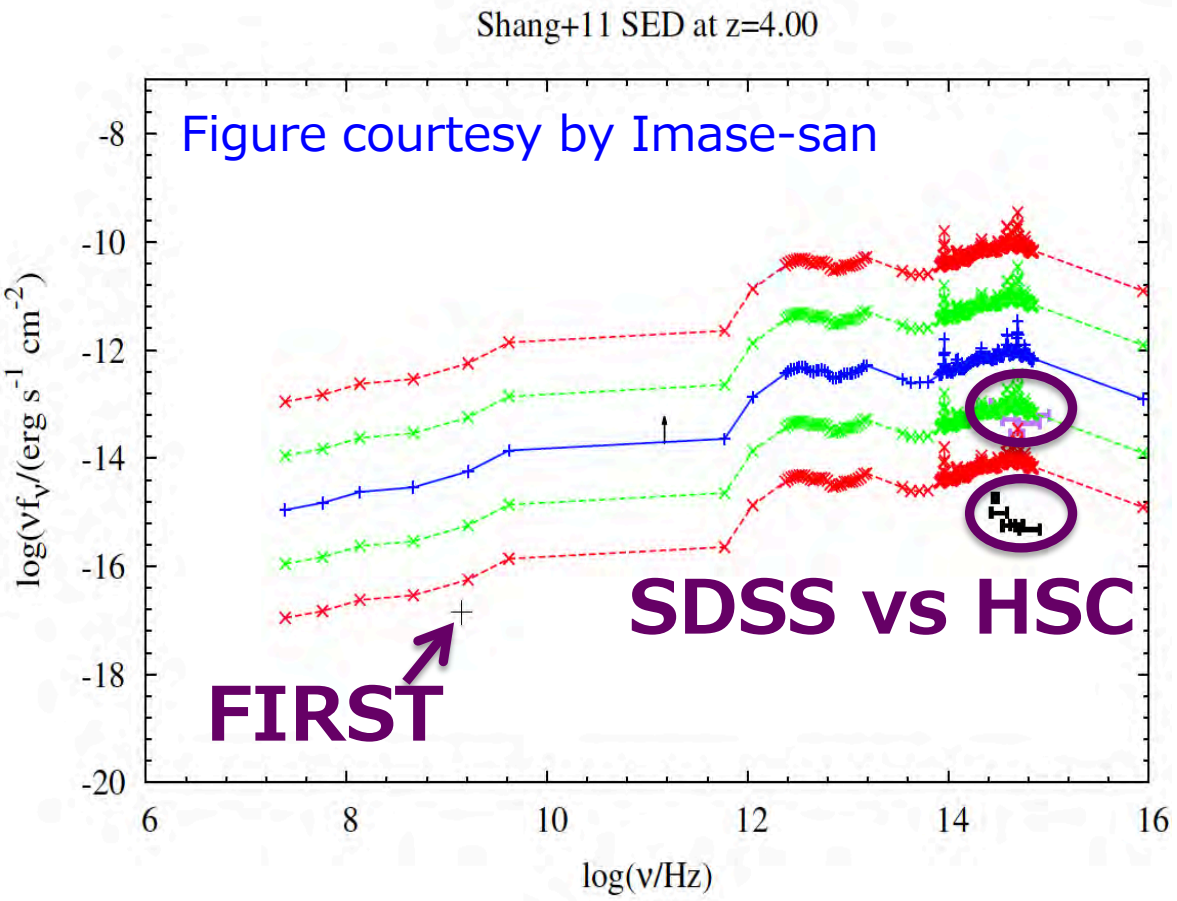
HSC is deep enough to detect them!

Figure courtesy by K.Aoki-san

See Imase-san's poster!!

Synergy with Radio (FIRST)

- Optical counterparts of FIRST wide-sky survey sources
  - ~ FIRST catalog contains 10^7 radio sources
  - ~ 40% of FIRST sources have no SDSS optical counterparts
  - ~ many missing radio-loud populations? HSC can address this!



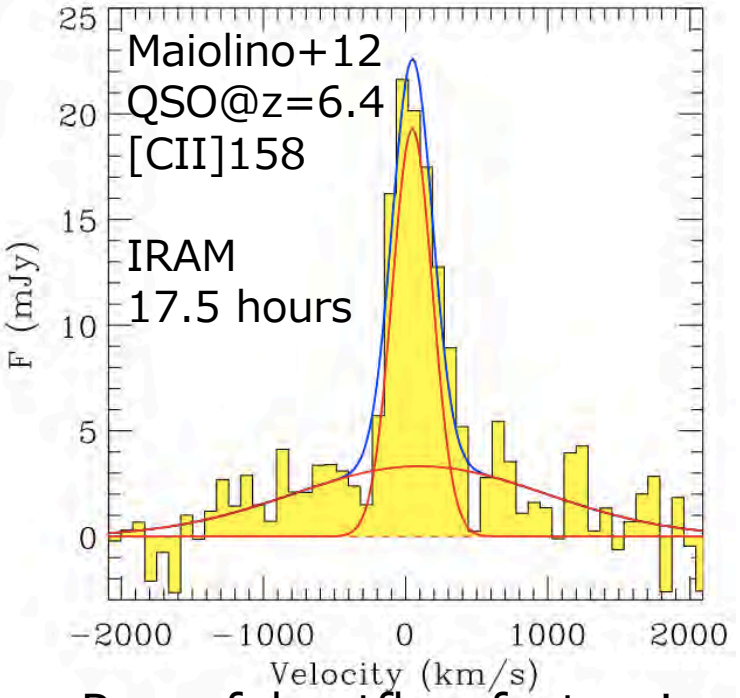
z=4 radio-loud quasar spectrum with various luminosity

High-z low-L radio-loud quasars are detected in the FIRST data but not in the SDSS data!

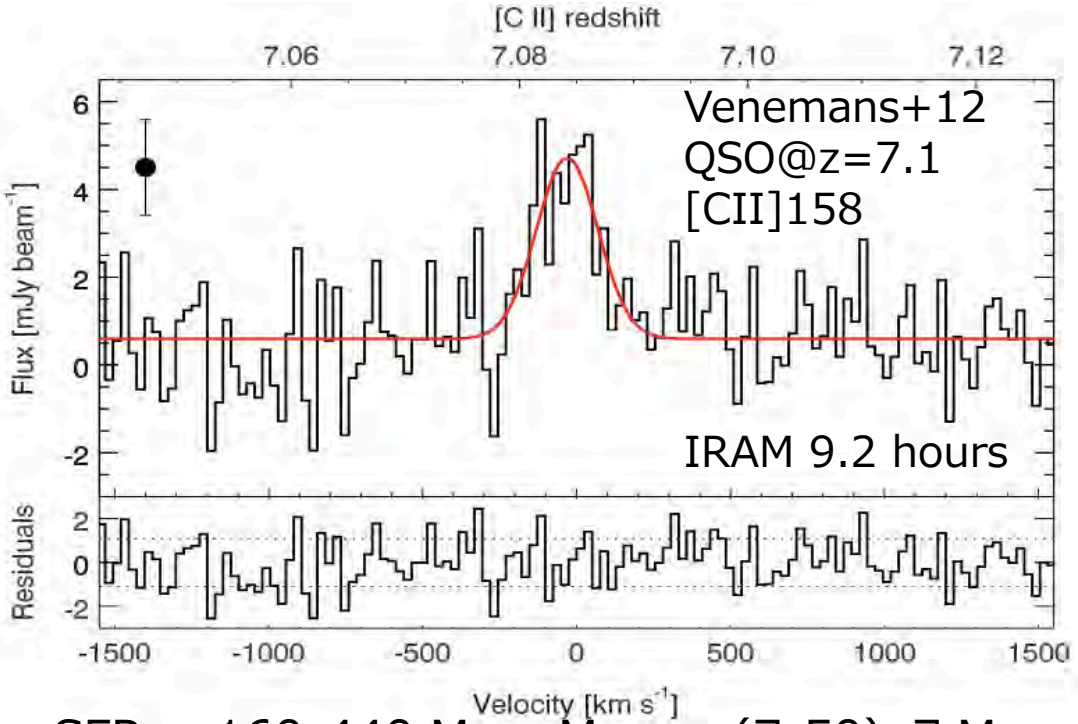
HSC is deep enough to detect them!!

Synergy with Sub-mm (ALMA)

- Sub-mm spectroscopy for HSC z~5-7 quasars
  - ~ dust, SFR, dynamics, stellar mass, feedback, ...
  - ~ note: lower-L quasars could be in a younger phase
  - ~ HSC fields are mostly accessible from ALMA



Powerful outflow feature!
Extended up to 16kpc, and
dM/dt > 3500 Msun/yr !!



SFR ~ 160-440 M_{sun}, M_{dust} ~ (7-50)e7 M_{sun}
sigma([CII]) ~ 100 +/- 15 km/s (narrow!)
M_{dyn} < 4e10 $(\sin i)^{-2}$ M_{sun} → large M_{BH}/M_{dyn} !

Synergy with PFS

~ “Prime Focus Spectrograph (PFS)” on the Subaru Tel.
~ Under world-wide international collaboration
~ Gigantic Spectrograph with the same FoV as HSC
~ Covering 0.38 – 1.25 um, with multiplicity of ~2200
~ Main Science Driver: Cosmology (Dark Energy)
~ Another “All-Japan” Survey through SSP
~ First Light in 2017?, Survey start in 2018?

~ Now discussing a systematic follow-up of HSC-QSOs
~ QLF, QMF, ERDF, ACF, CCF, chemistry, abs. lines, ...
~ PFS-AGN WG Chairs: Nagao & Strauss

~ last collaboration meeting in Aug. 2012 at Pasadena
~ next collaboration meeting in Mar. 2013 at Tokyo

Summary

- Subaru Wide-Field AGN Survey (SWANS)

  ~ 広視野HSCデータを軸としたquasarサーベイ
  -- color / variability / multi-wavelength selection
  -- z~7 QSOs, numerous z~4-6 QSOs, z<3 faint AGNs
  -- luminosity func., correlation func., environment, ...
  -- SMBH evolution, QSO triggering mechanism, ...
  ~ 統計データの解釈を目的とした準解析的モデルも準備中
  ~ 多波長データと組み合わせて様々なサイエンス
  -- X-ray, WISE, FIRST, ALMA
  ~ 将来の大型計画へのターゲット供給
  -- Astro-H, TAO, TMT, SPICA, etc...
  ~ 大規模PFS分光サーベイも視野に入れながら
  ~ ML上＆face-to-face会議などで議論を継続中
  -- 新規参加は大歓迎！ D論のテーマにも良さそう

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