QSO Studies with TAO

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The AGN study in the TAO era

(1) The Evolution of Supermassive Black Holes (SMBHs)

1a) Search for QSOs at z>6.5

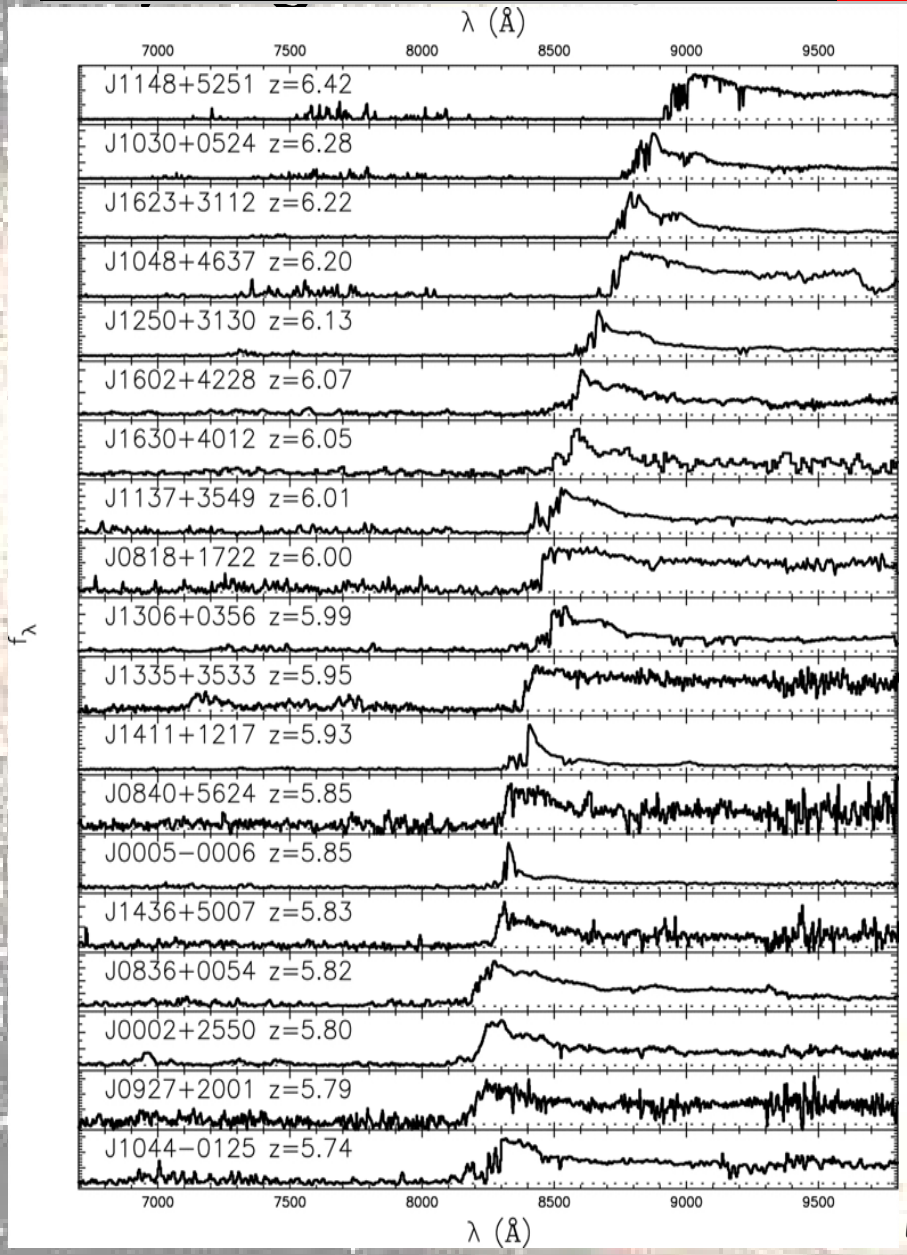
1b) QSO Luminosity Func. / SMBH Mass Func.

(2) The Co-Evolution of SMBHs and Galaxies

2a) QSO Host Galaxy Mass

2b) Chemical Properties (cf. next talk)

1a) Highest-z QSOs: SDSS View (1999-2006)



2 dozens of QSOs at 5.7<z<6.5

- ~ cosmic reionization
- ~ rapid growth of SMBHs
- ~ early metal enrichment
- ~ z>6.5 QSOs definitely needed

Maximum redshift: 6.5

- ~ limit of "i-drop" selection
- ~ "z-drop" QSOs ??
- ~ requires "wide" Y & NIR data

Fan et al. (2006)

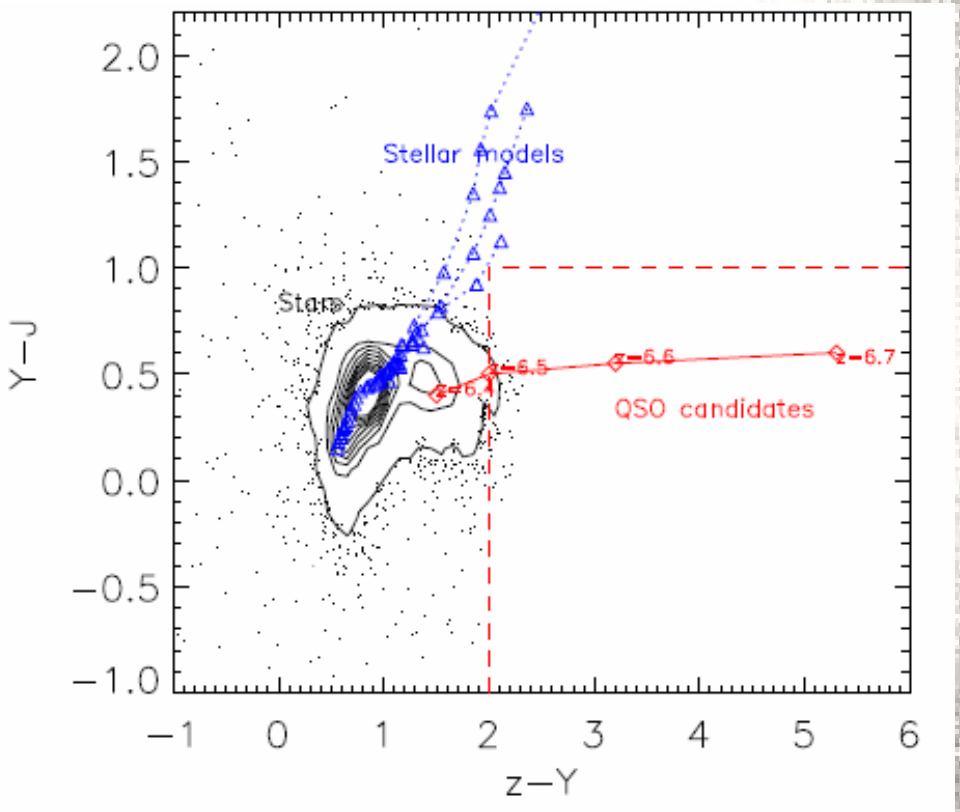
1a) Highest-z QSOs: SWANS View (2012-2016)

SWANS = Subaru Wide-Field AGN Survey

~ using Subaru/HSC (2011-)
~ 2000 sq.deg. ("HSC-wide")
~ 5 band (g, r, i, z, Y) imaging
~ JHK available data (UKIDSS)
~ observations: 2012-2016 (?)

Search for QSOs at z>6.5

~ "z-drop" for QSOs at z~7
~ 10-100 QSOs at z~7 expected
~ "Y-drop" for QSOs at z~8
~ a few QSOs at z~8 expected
~ cool dwarfs are contaminated
~ spectroscopic follow-up needed



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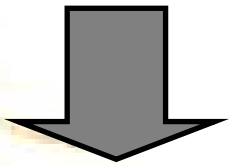
1a) Highest-z QSOs: TAO View (201x-)

Follow-Up Spectroscopy for High-z QSO Candidates

~ success rate: ~3% (300 targets for 10 true QSOs)
~ optical (incl. WFMOS): useless for QSOs at z>7 (Lya at >1micron)
~ FMOS: useless for rare objects (<1 targets for FMOS FoV)
~ 4m telescopes: useless for faint objects (J=20)
~ TAO: ~2 hours ok(?), 60/5 nights/yr for 300 targets (??)
~ requiring sensitivity down to 9000A for QSOs at z~6.5

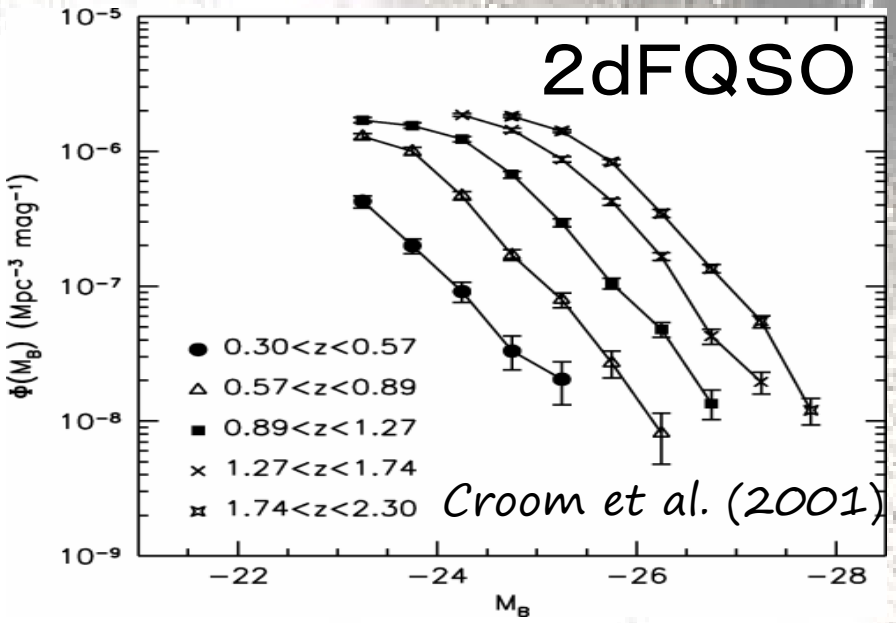
Moderately Large Aperture Size of TAO
Project-Oriented Operation of TAO
YJHK coverage of NIRCAM (especially Y)



Identifications of QSOs at z>7 with TAO !!

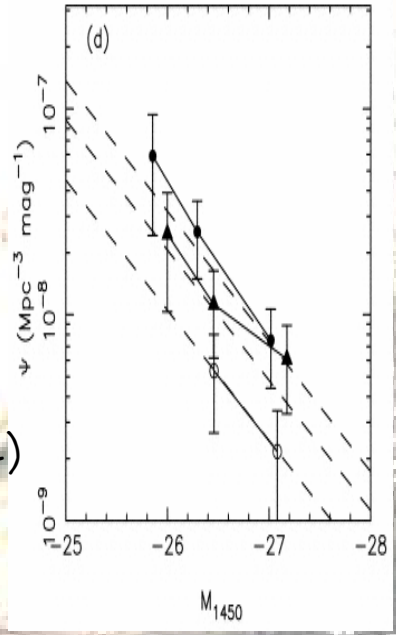
1b) QSO LF

~ QSO LF: double power-law
~ 0 < z < 3: well investigated
~ 4 < z < 6: still unknown
~ low-luminosity QSOs needed



SWANS + Optical Spectroscopy

●: 3.6 < z < 3.9
▲: 3.9 < z < 4.4
○: 4.4 < z < 5.0

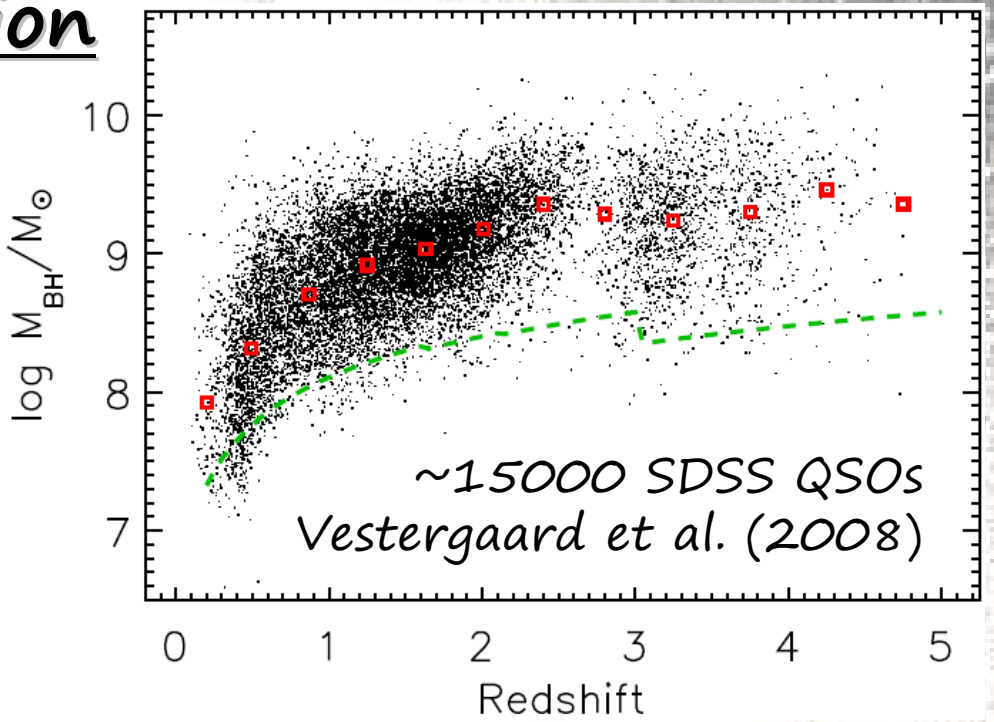


How about SMBH Mass Func?

SDSS
Fan et al. (2001)

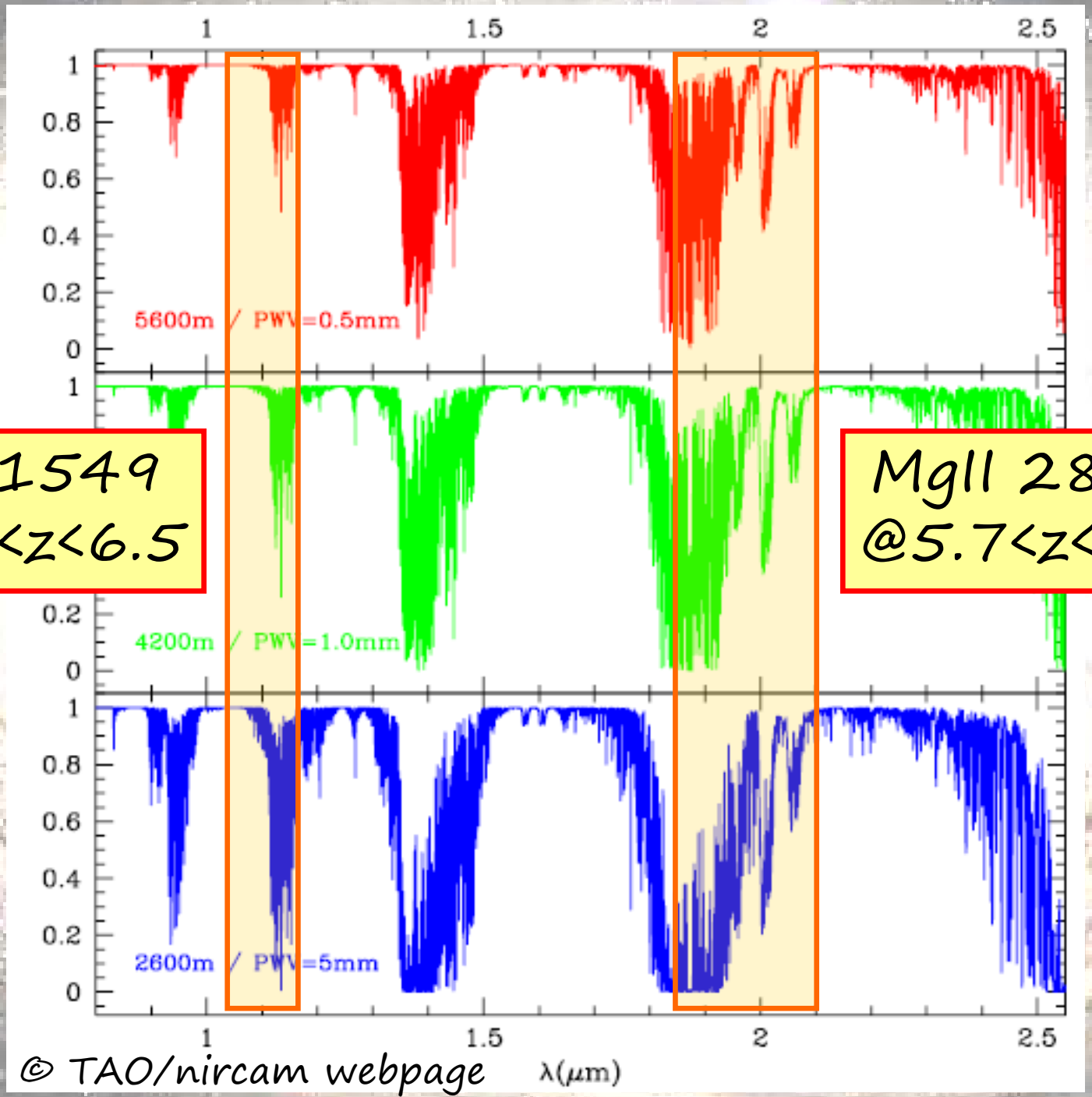
1b) SMBH Mass Function

~ with C IV @1549A (or Mg II)
~ SDSS MF: only at z<5
~ NIR spectra needed for z>5
~ Target QSO sample needed



SWANS + NIR Spectroscopy

~ 2000 sq.deg. → a few hundreds candidates @5.7<z<6.5
~ SWANS Y-band → less contamination by cool dwarf stars
~ TAO/NIRCAM → less affected by YJ-gap (important @z~6.2)
~ Simultaneous observation of C IV & Mg II (avoiding HK-gap)
→ Very accurate M_{BH} measurements !!
~ R~500 is enough?? Slit width should be variable...



CIV 1549
@5.7<z<6.5

MgII 2800
@5.7<z<6.5

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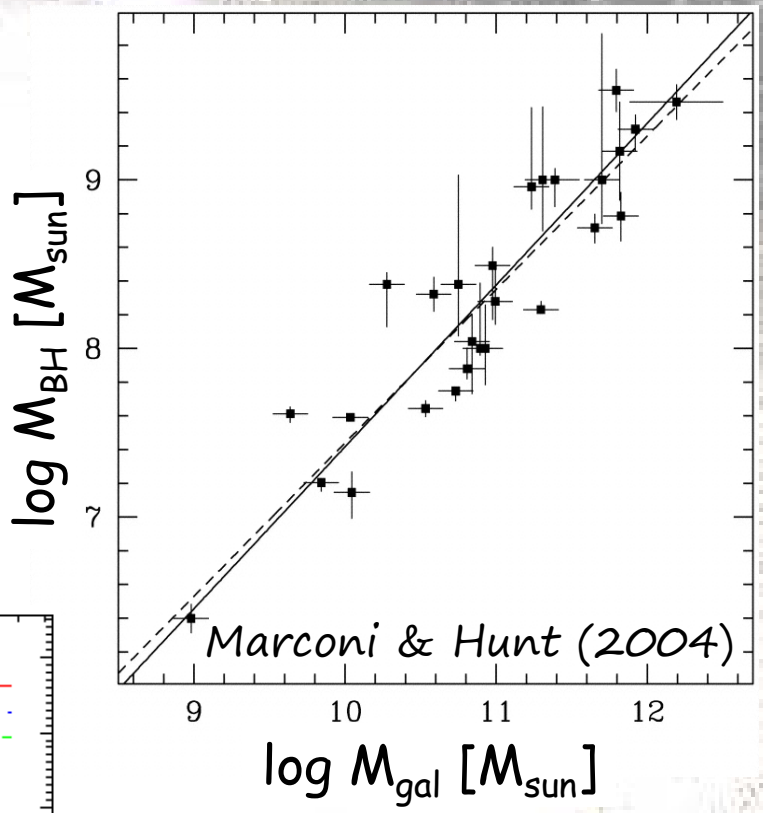
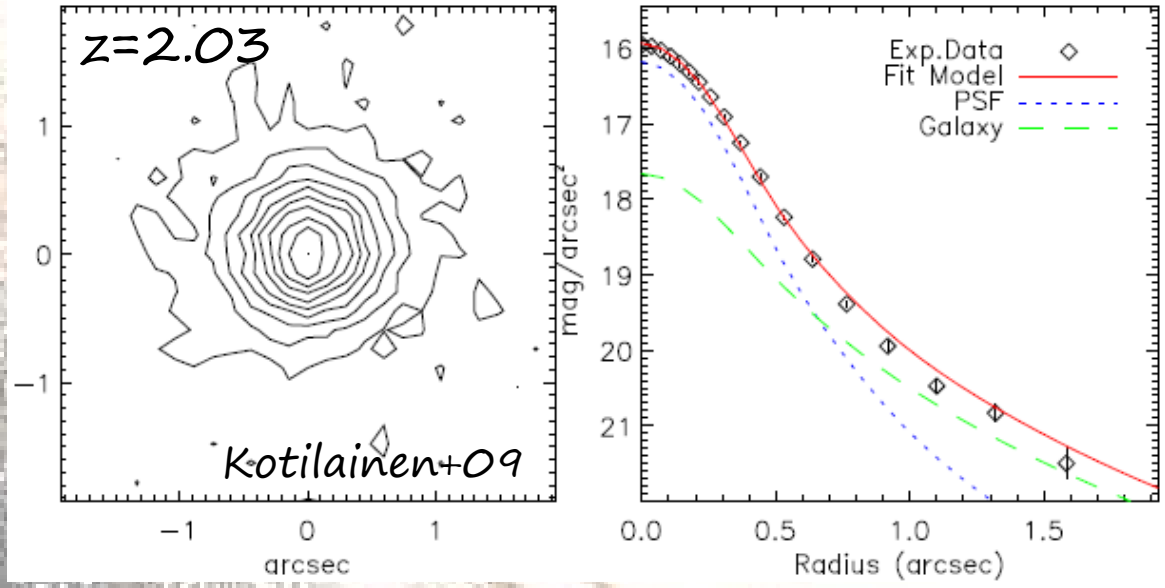
2a) Host Galaxy Mass

~ M_{gal}/M_{BH} = 0.002 at z~0
~ most direct evidence for co-evolution
~ at high-z: crucial to constrain models

~ HST useless at z>2 (small aperture size)
~ ground-based telescopes requires AO
~ hosts of low-L QSOs without AO??



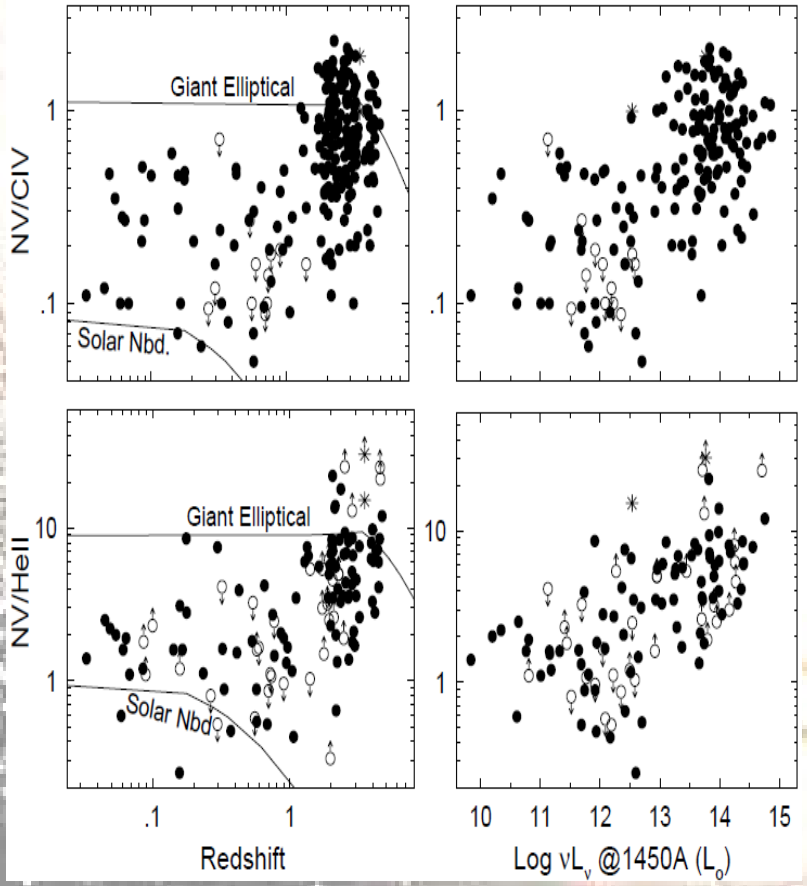


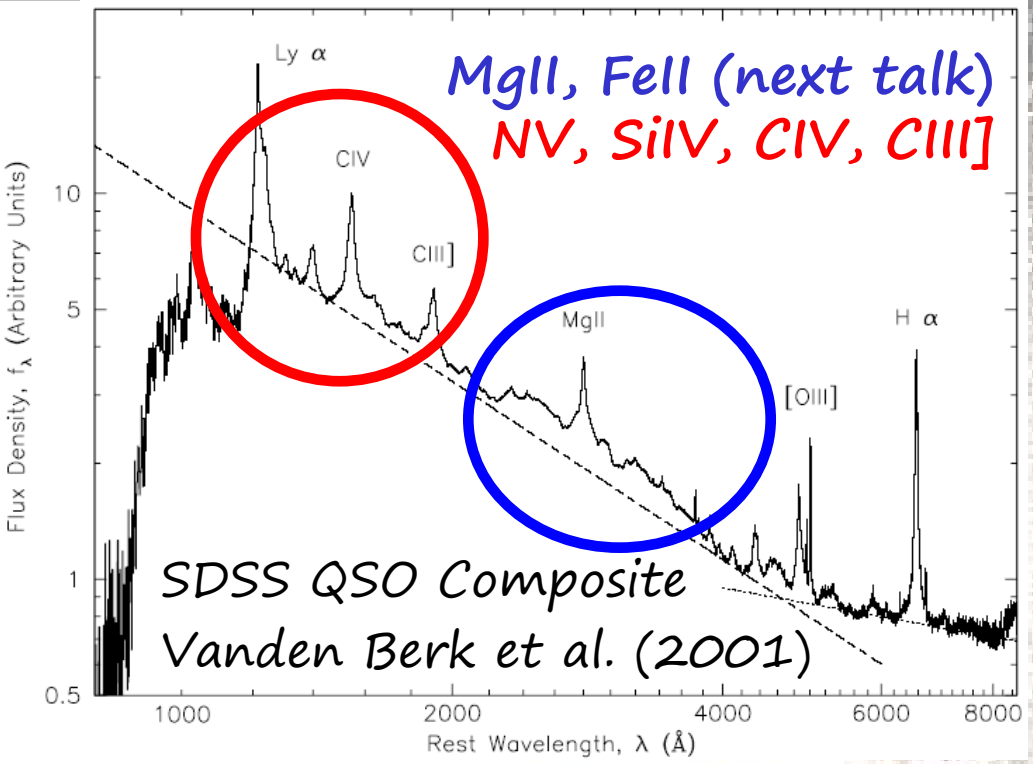
VLT/ISAAC without AO
seeing size: ~0.5 arcsec
typically 1-2 hours

TAOでもやれるかも。
でもTAOじゃなくても
Subaru+AO188とかで
やればいいような…？

2b) Chemical Properties

~ Z_{QSO} ⇔ past SF in hosts
~ Z_{QSO} @high-z
→ SH history, forming epoch





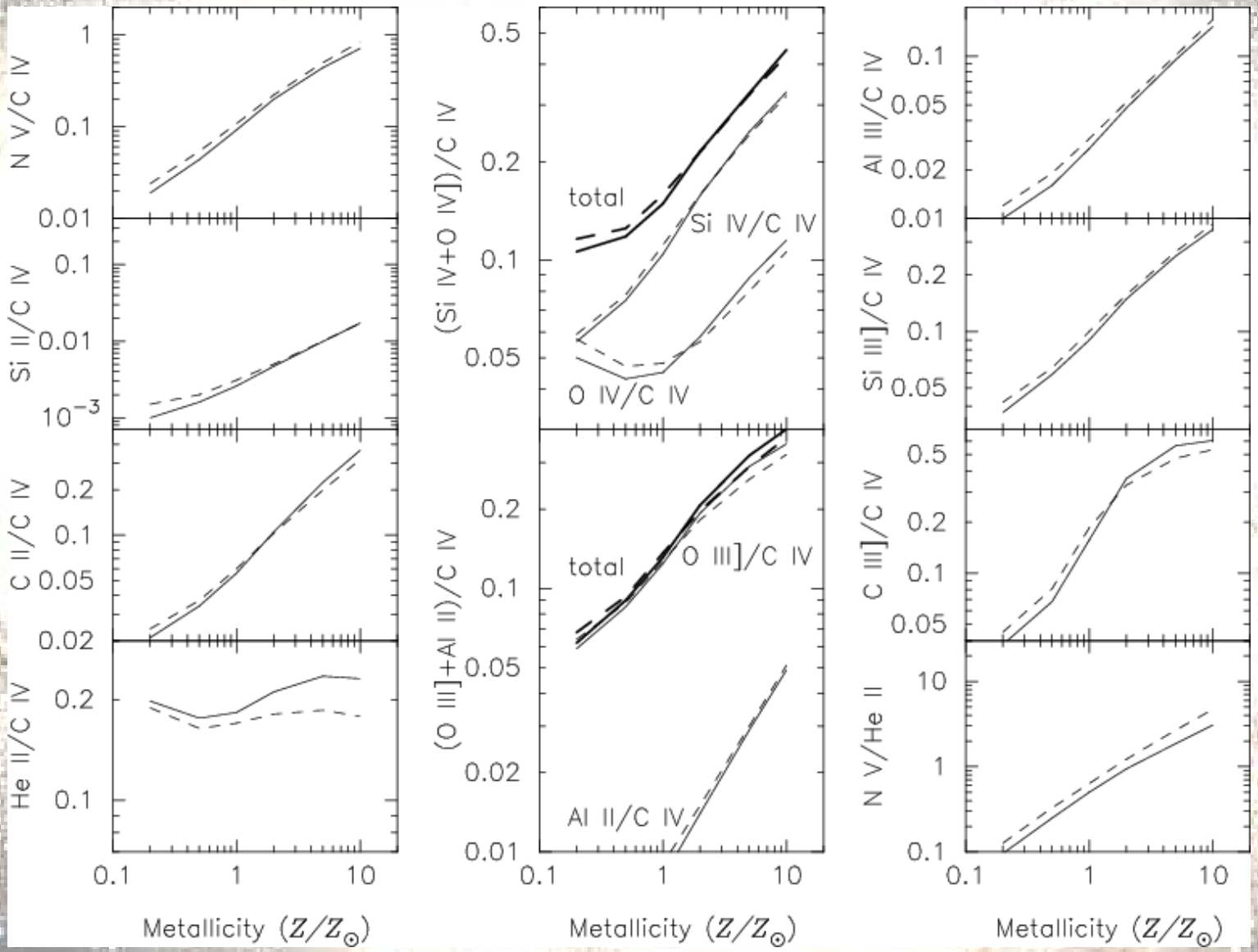
MgII, FeII (next talk)
NV, SiIV, CIV, CIII]

~ high metallicity ⇔ high redshift
~ high metallicity ⇔ high luminosity
~ which is important ?
~ nitrogen effects ???

Hamann & Ferland (1999)

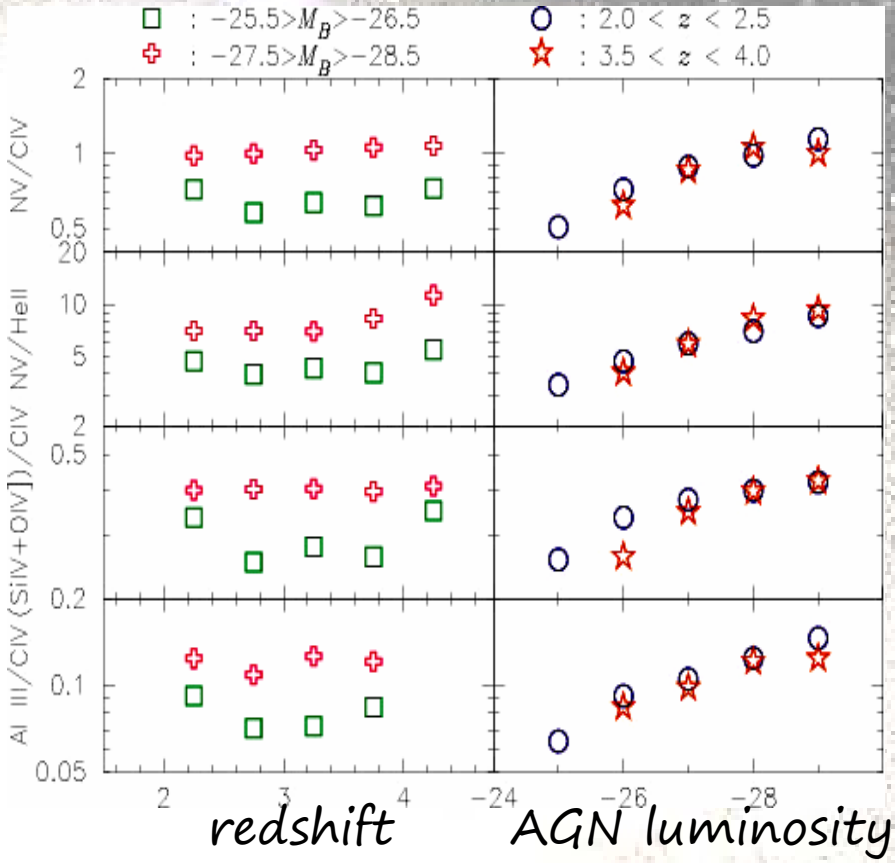
2b) Chemical Properties

TN, Marconi, & Maiolino (2006)



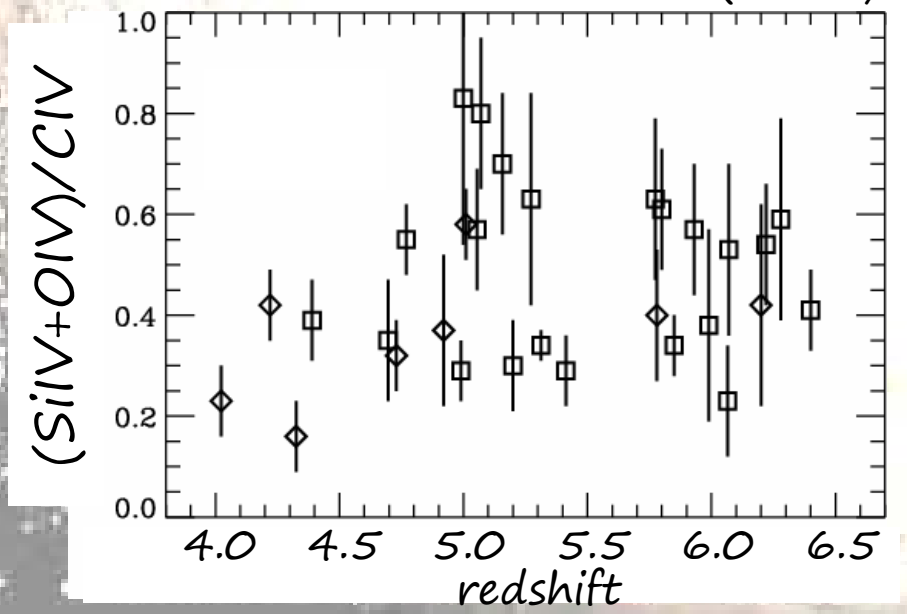
2b) Chemical Properties

Nagao+06



~ SDSS stacking analysis
using 5000 SDSS spectra
~ tight luminosity-metallicity rel.
~ no evolution up to z~5

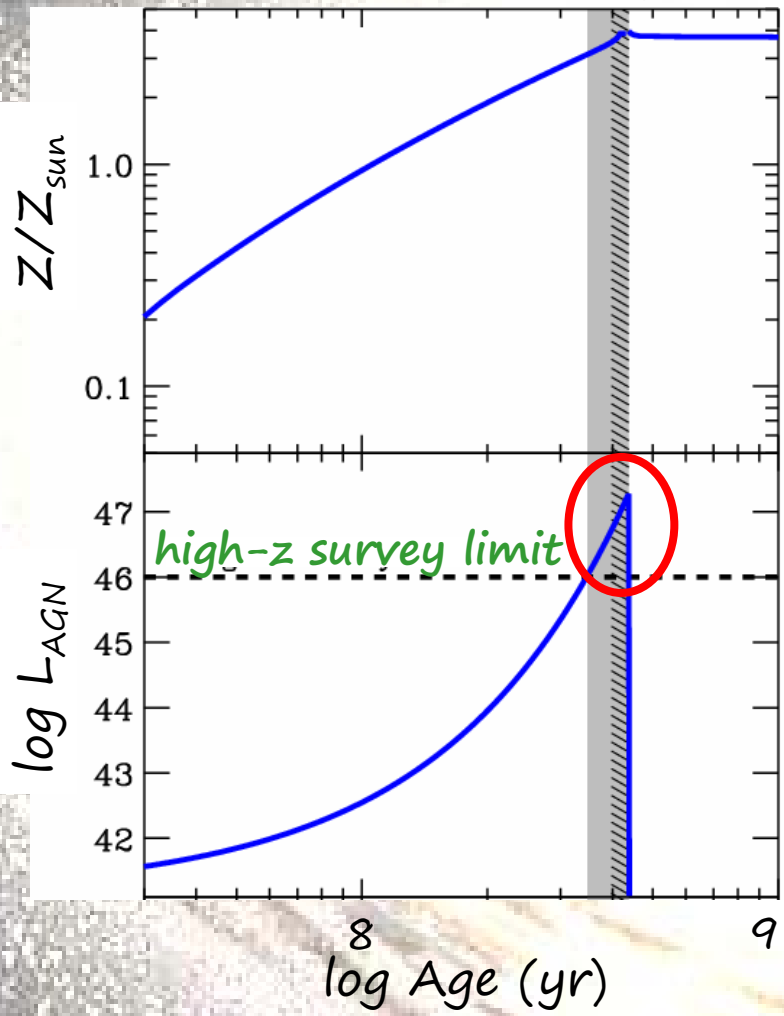
Juarez, Maiolino, TN, et al. (2009)



~ no evolution up to z~6.5 !?
~ Z_{QSO} for lower-L / higher-z needed

TAO/NIRCAM + SWANS

2b) Chemical Properties



We see only brightest QSOs at high-z

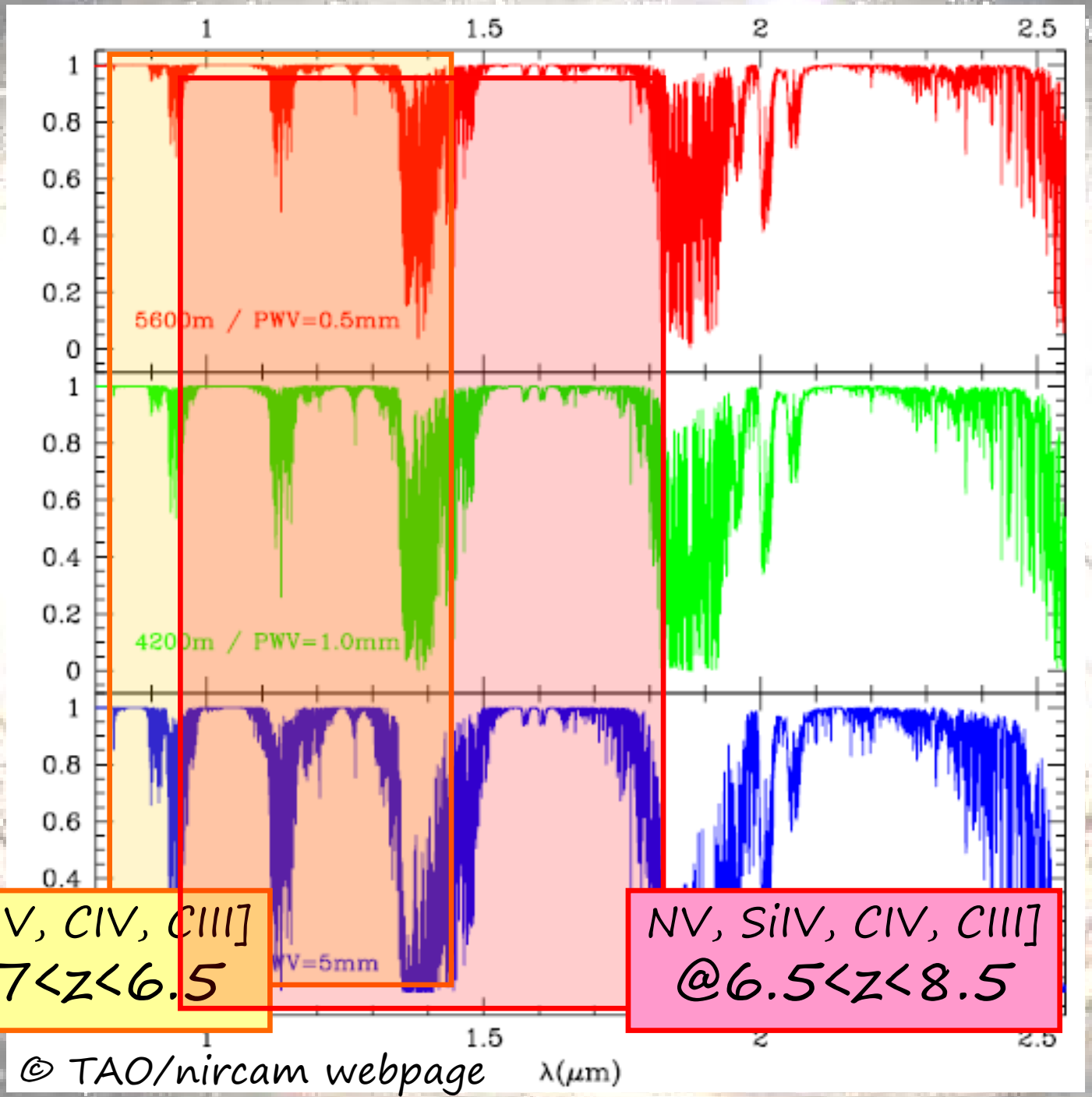
Sampling only "well-evolved" guys

"No-evolution" due to selection effects

NEXT STEP: Higher-z & Lower-L

TAO/NIRCAM + SWANS

Kawakatu et al. (2003)
Granato et al. (2004)
Juarez, Maiolino, TN, et al. (2009)



NV, SiIV, CIV, CIII]
@5.7<z<6.5

NV, SiIV, CIV, CIII]
@6.5<z<8.5

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SWANS (2012-) in the TAO era

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Requests to TAO/NIRCAM

~ variable slit width
~ spectral coverage down to ~8200A
~ project-oriented operation