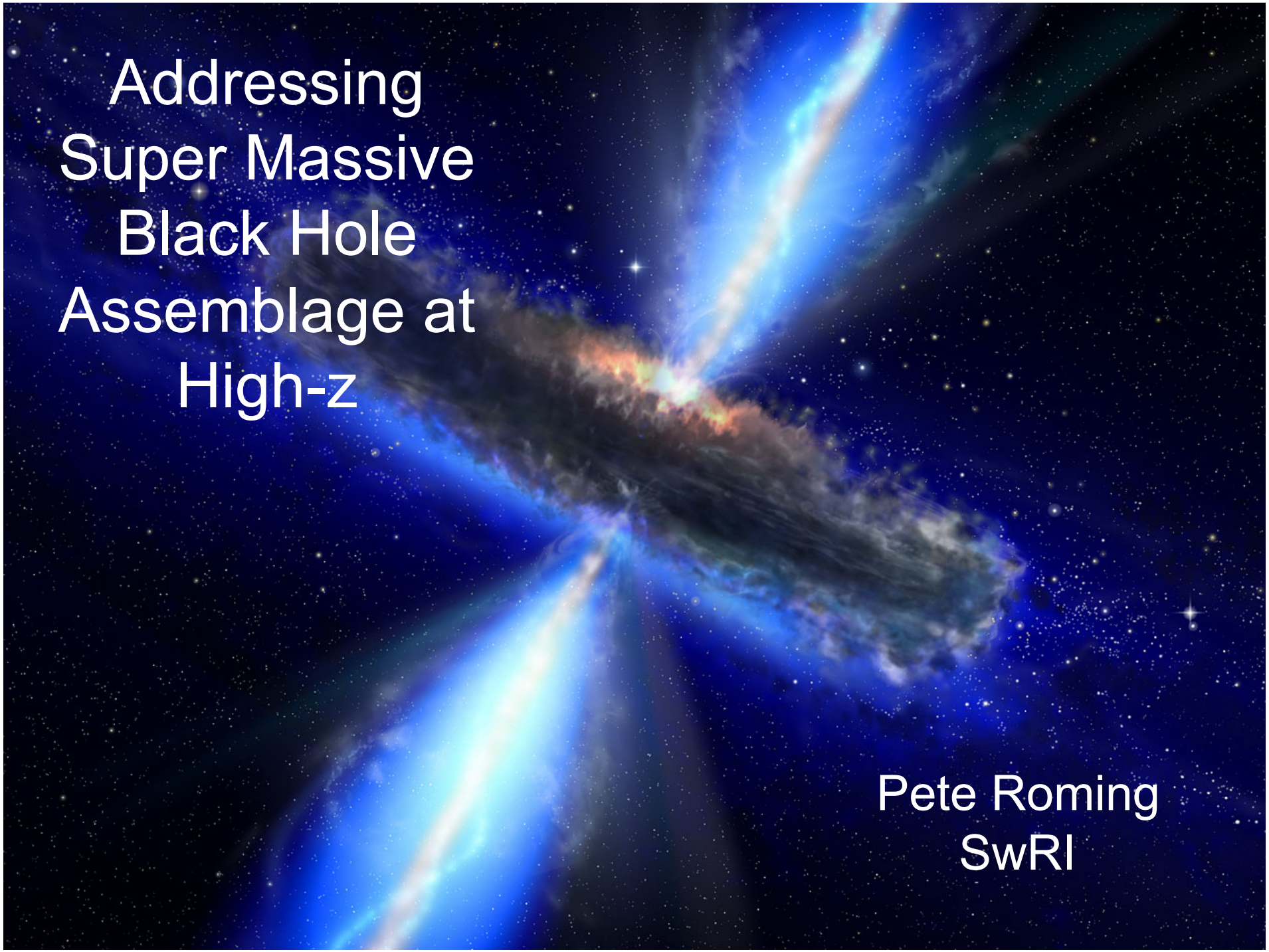
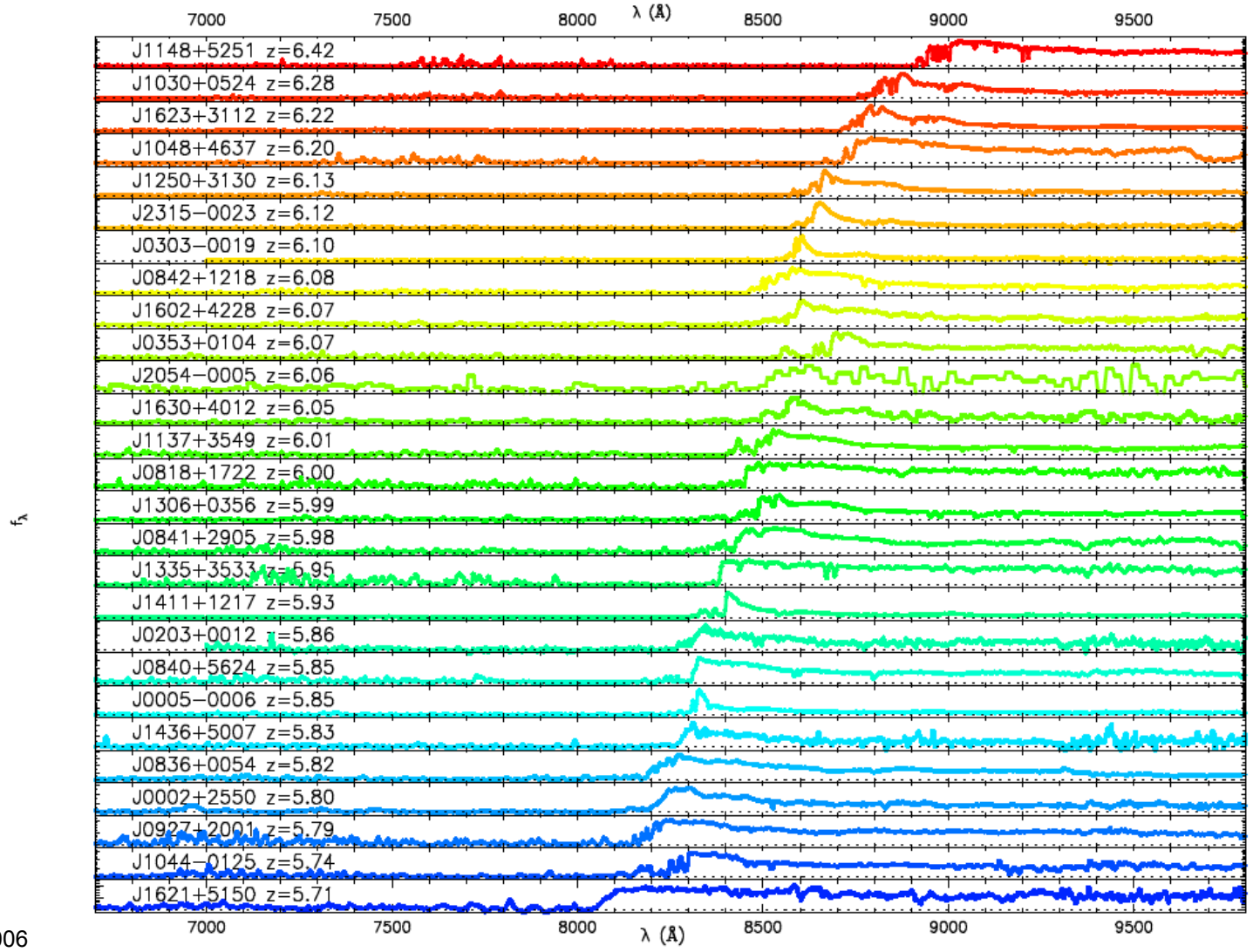
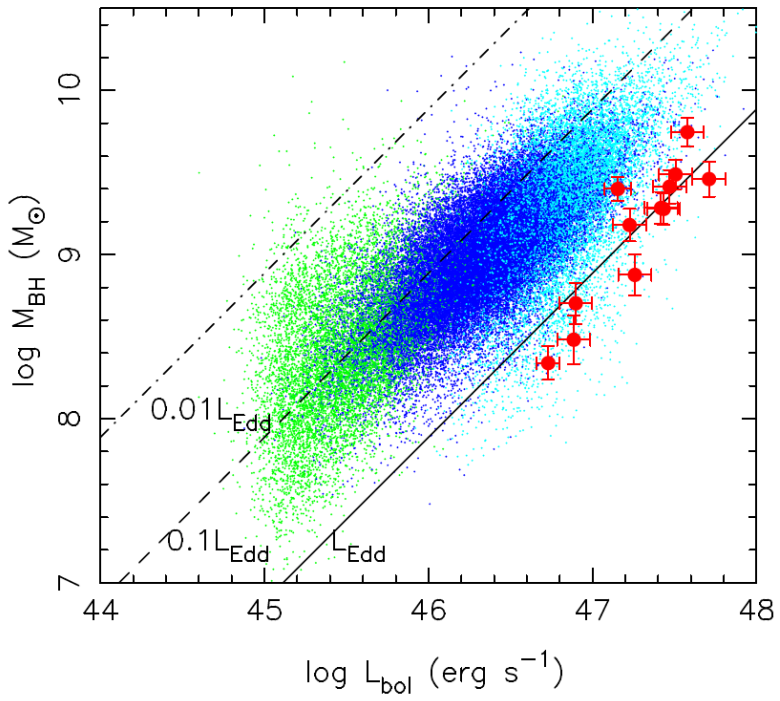

Addressing
Super Massive
Black Hole
Assemblage at
High-z
Pete Roming
SwRI

Earliest Quasars



Fan et al. 2006

Black Hole Growth



- z~6 quasars are on average close to or at the Eddington accretion

$$L_{Edd} = \frac{4\pi G c m_p}{\sigma_T} M_{BH} = \varepsilon\, M\, c^2$$

$$M_{BH} = M_{seed}\, e^{\frac{t}{t_{Edd}}}$$

$$t_{Edd} = 450\ Myr \frac{\varepsilon}{1-\varepsilon}$$

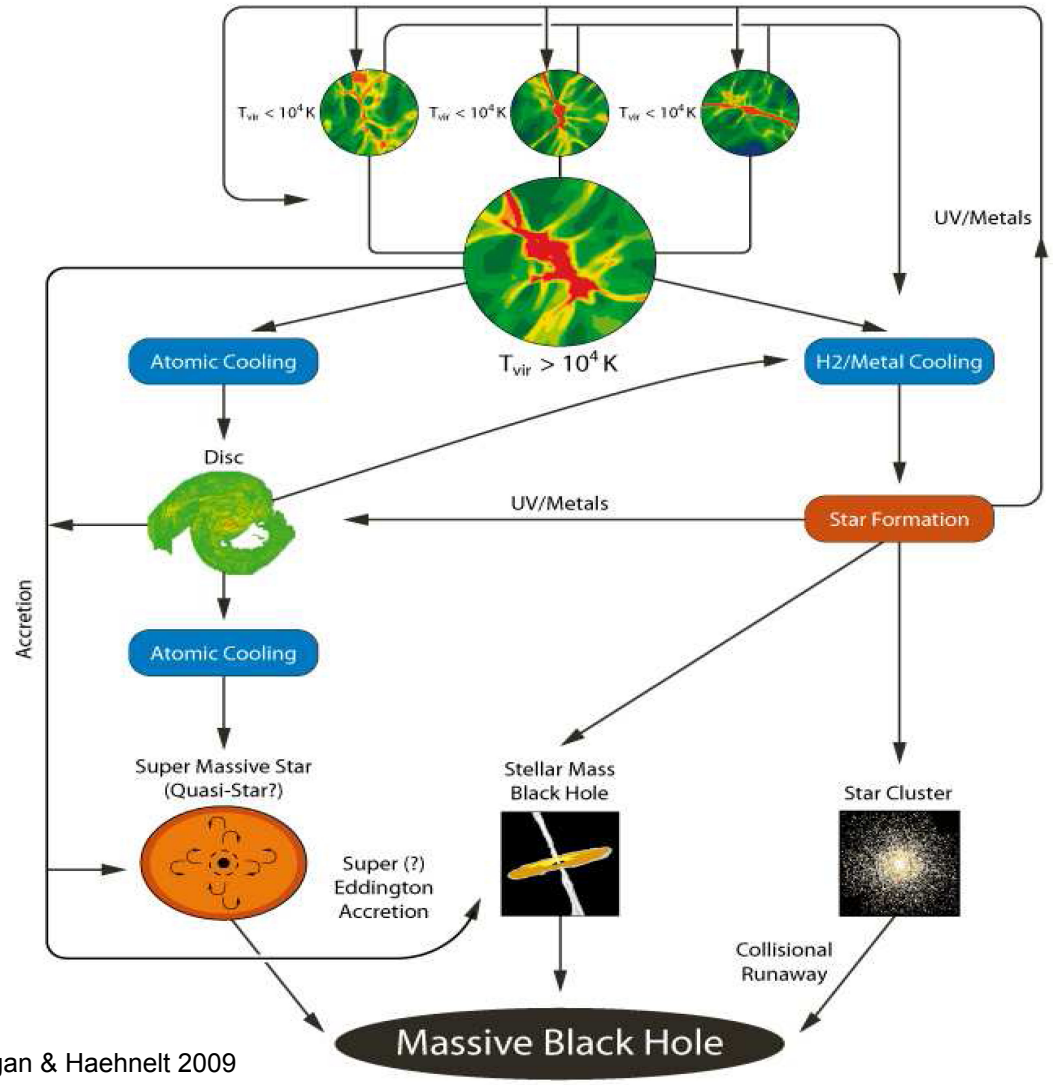
Fan 2010

Can We Get a SMBH in Time?

- Black Holes do not grow arbitrarily fast
  - Accretion onto BHs dictated by Eddington Limit
  - E-folding time of **maximum** SMBH growth: 40 Myr
  - At z=7 age of the universe is 800 Myr = **maximum** 20 e-folding
- Billion solar mass BH at z>7
  - *Non-stop, maximum accretion from 100 solar mass BHs at z=15 (collapse of first stars in the Universe)*
  - ***Theoretically difficult for formation of z>7 billion solar mass BHs by Eddington-limited accretion from stellar seeds***

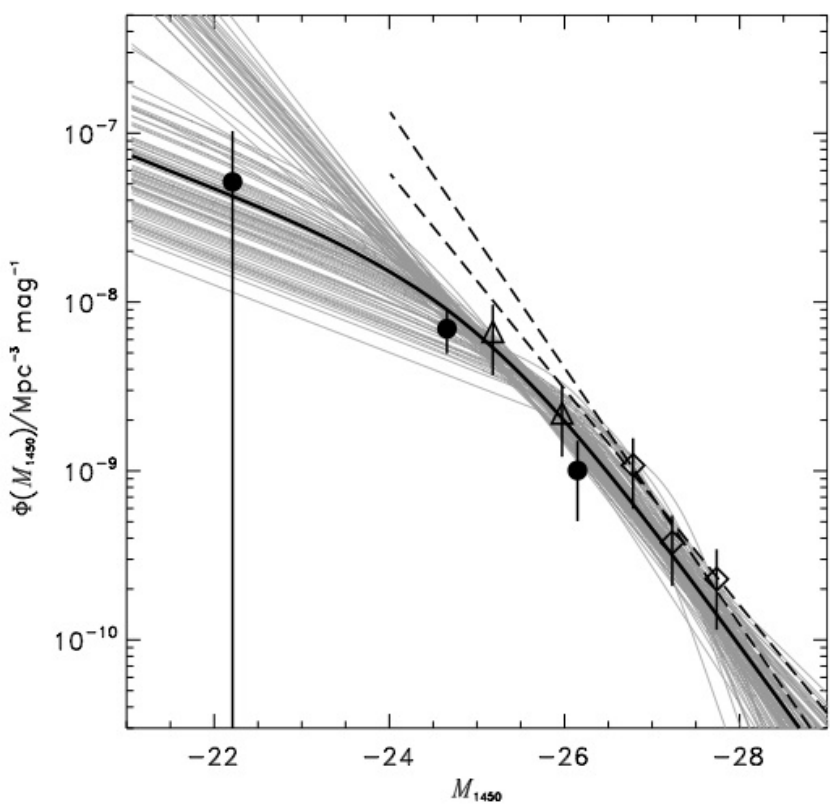
Fan 2010

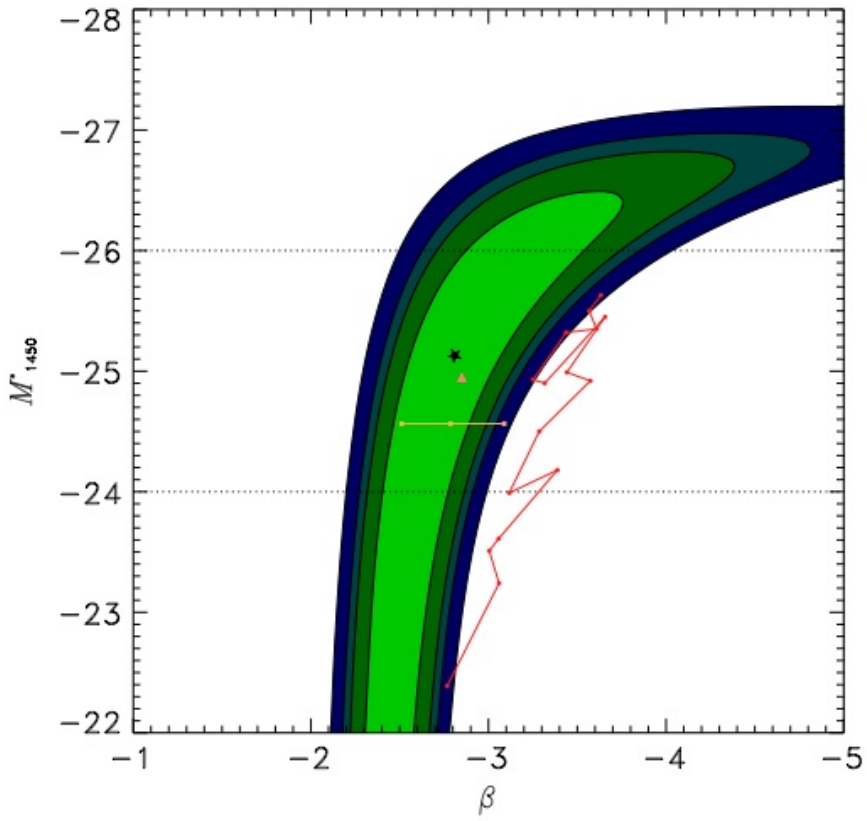
What If We Find Them?



Regan & Haehnelt 2009

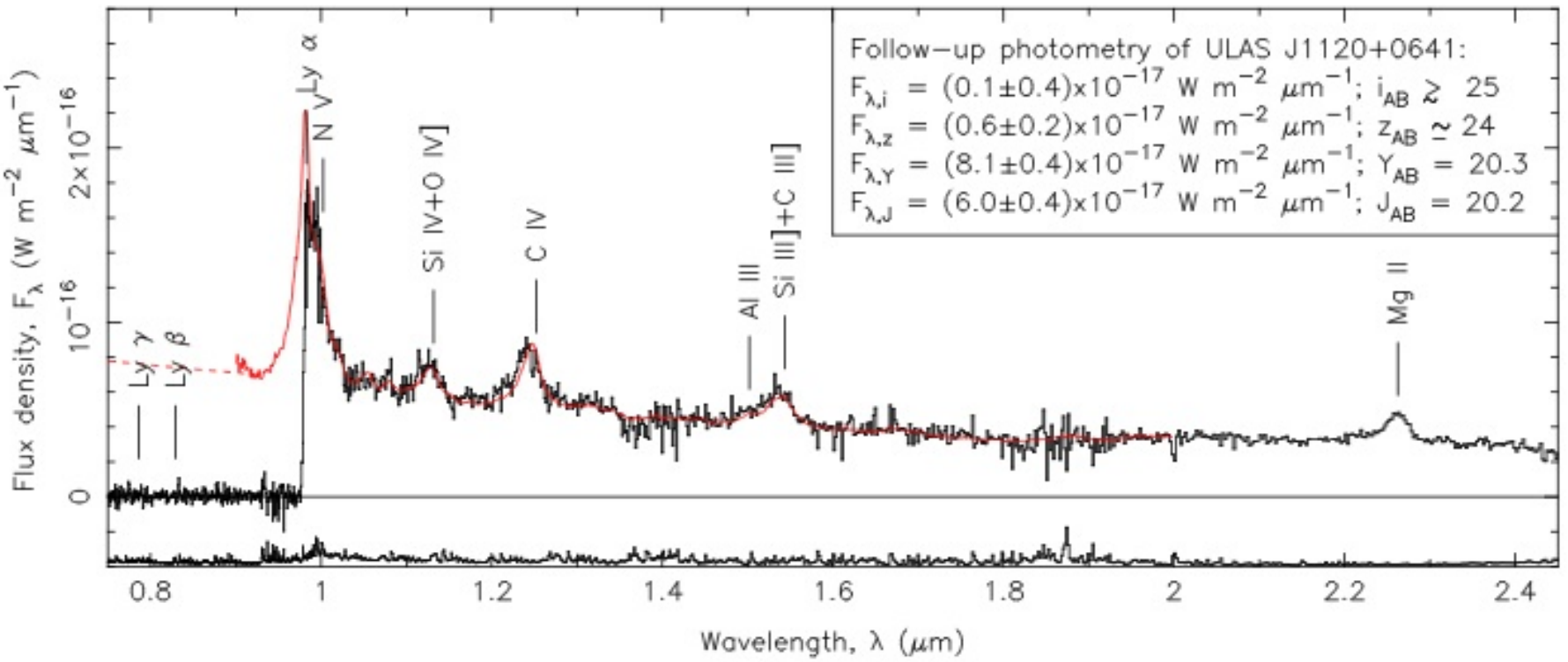
SMBHs Are Dropping Off





Willott et al. 2010

ULAS J1120+0641 (z=7.1) Quasar

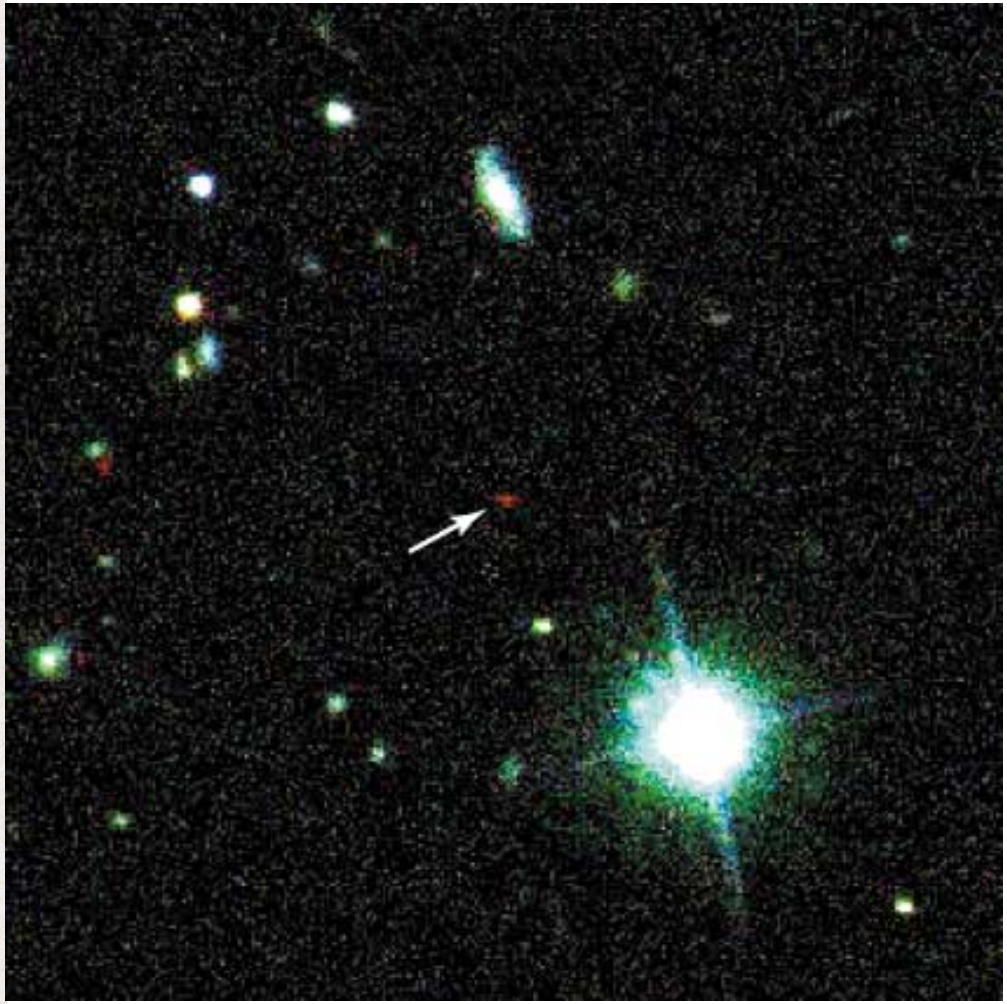


Mortlock et al. 2011

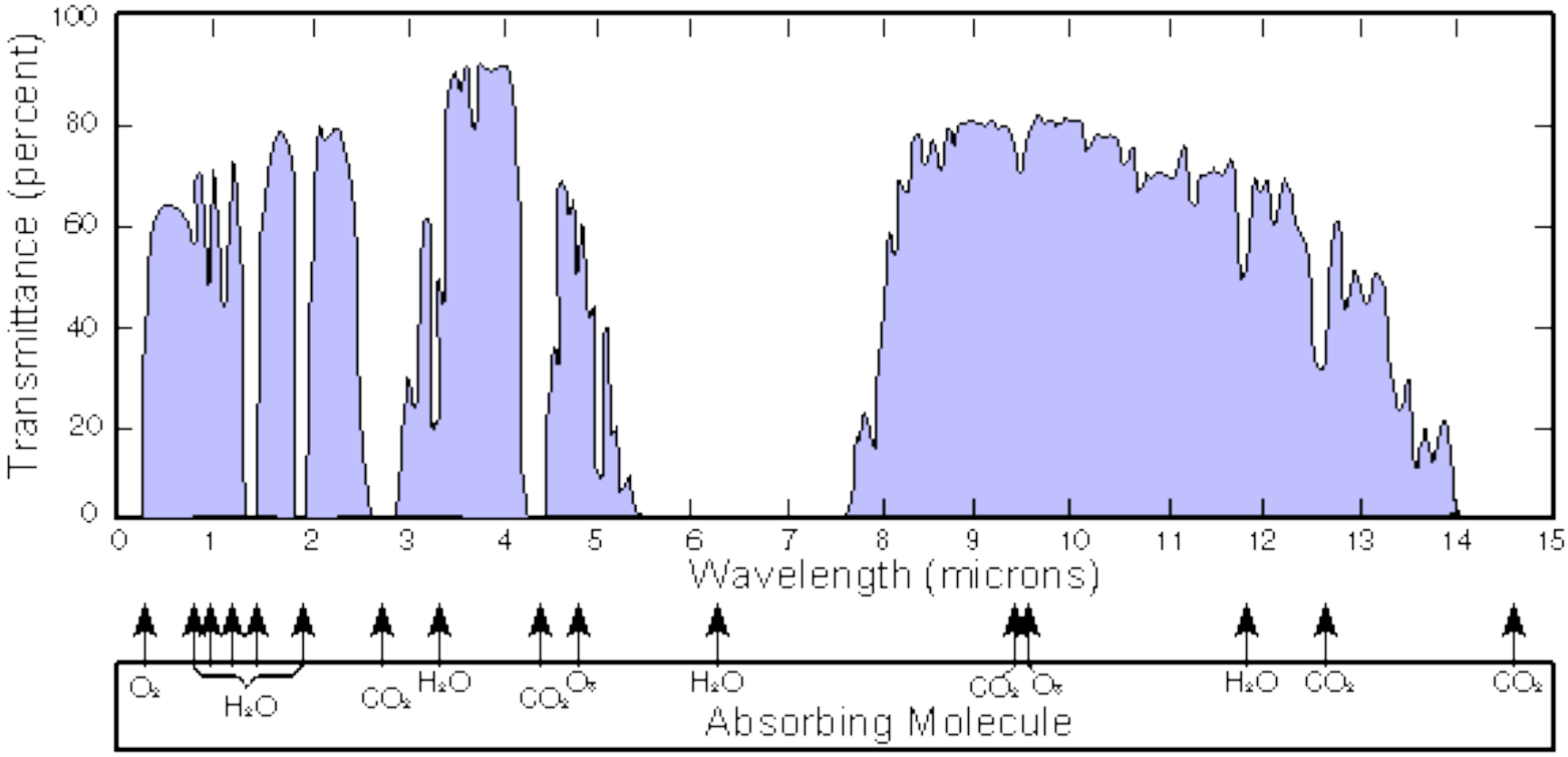
Why Not From the Ground?

Hunts Needle in a Haystack

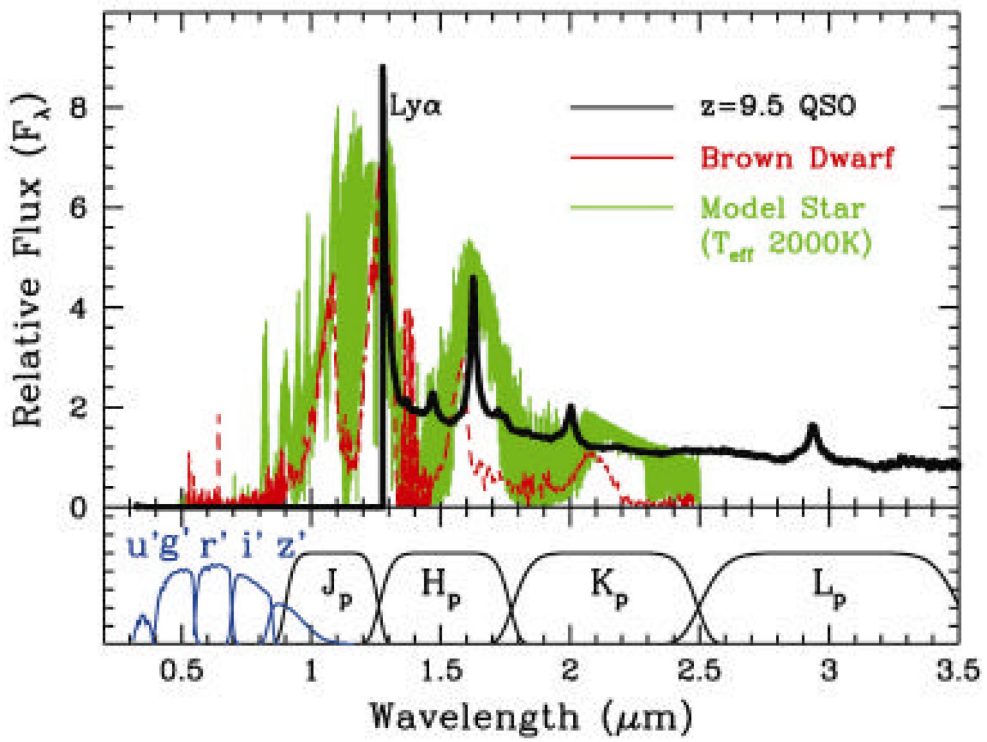
HOW LONG does it take to find a needle in a haystack? Jim Moran, Washington, D. C., publicity man, recently dropped a needle into a convenient pile of hay, hopped in after it, and began an intensive search for (a) some publicity and (b) the needle. Having found the former, Moran abandoned the needle hunt.

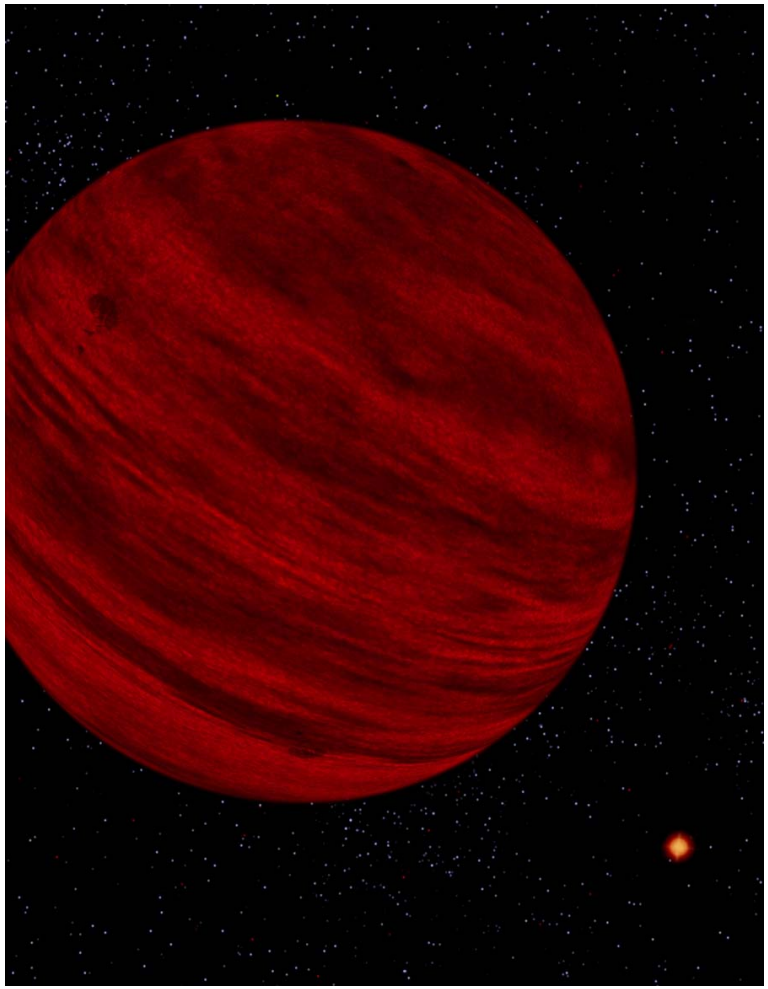


Water Vapor Is the Primary Enemy



Brown Dwarf Interlopers

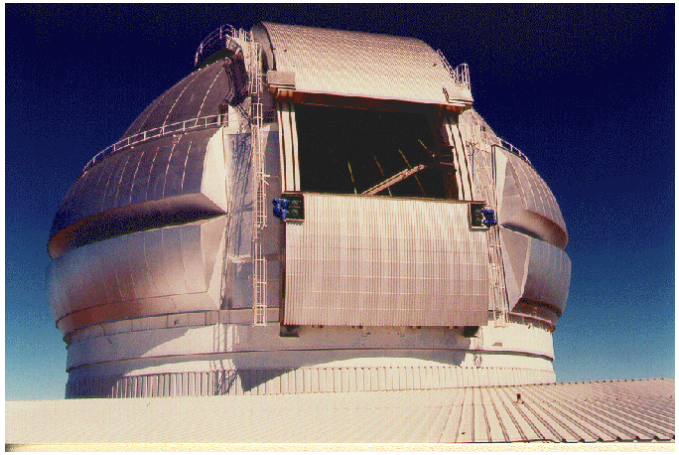




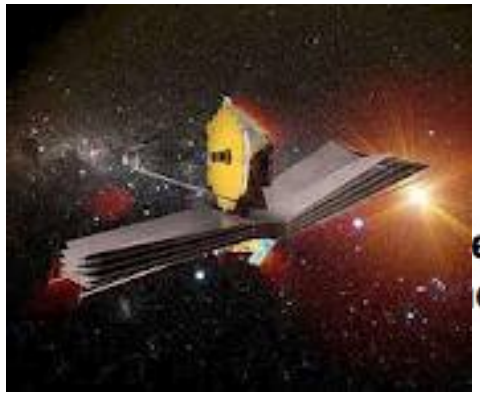
Large Contamination Rate

Contamination Rate = ~30:1

Expensive



How Can WFIRST Fit In?



Solar Array Structure and Thermal Shroud

Spectrometer Channel A

Telescope

Spectrometer Channel B

FPA Radiators

er

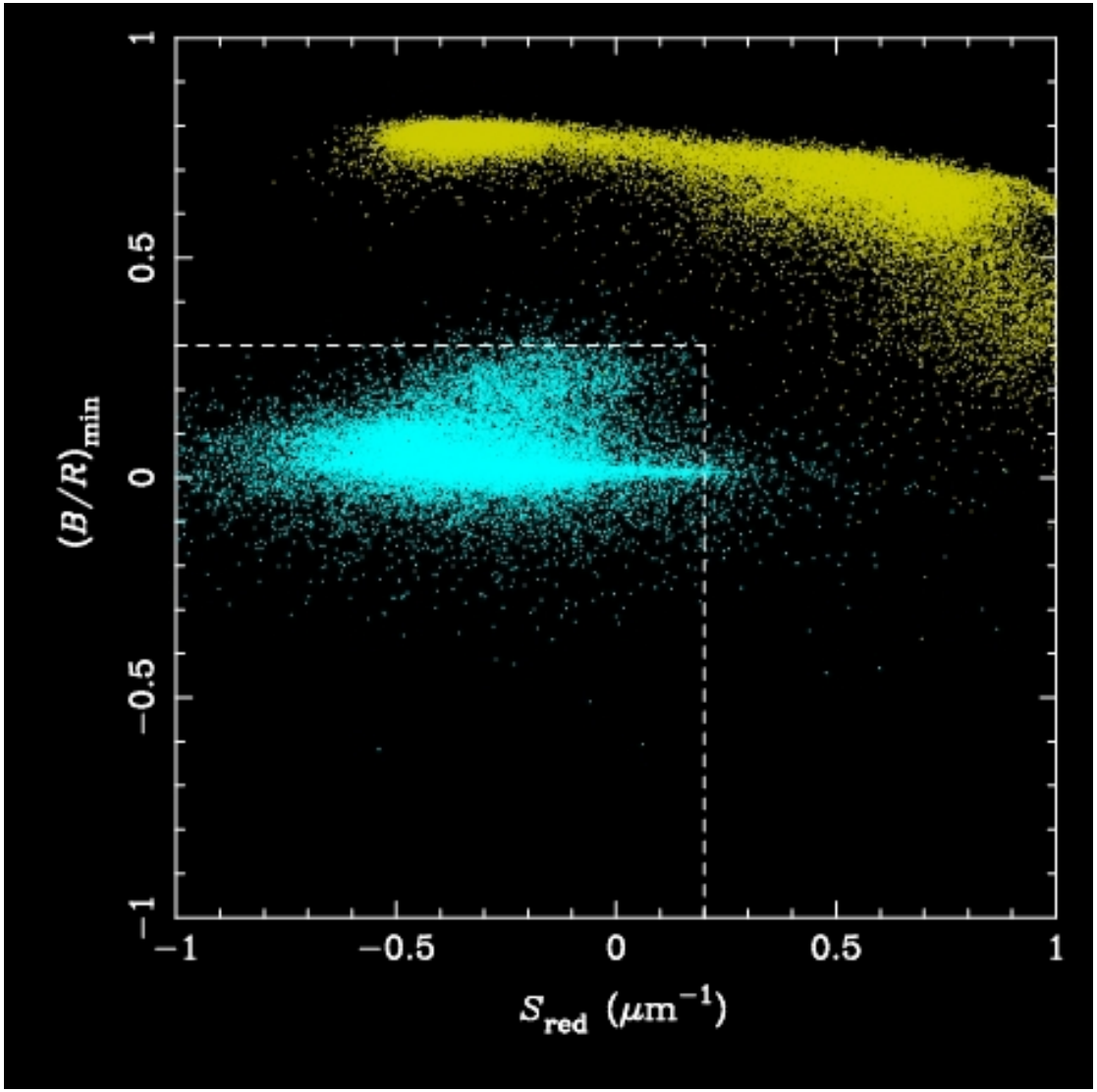
el

Spacecraft Bus

High-z Quasar Survey Needs

- Large field-of-view instruments
  - Finds large number of high-z quasars
  - Breadth is more important than depth in this case
  - Although a deeper survey can also be done
- Reducing contamination
  - Near-IR quasar survey unaffected by atmosphere
  - High-*z* quasar spectra highly distinctive even at R≈14
- Good imaging can reduce the contamination rate further

Contamination Rate Much Better from Space

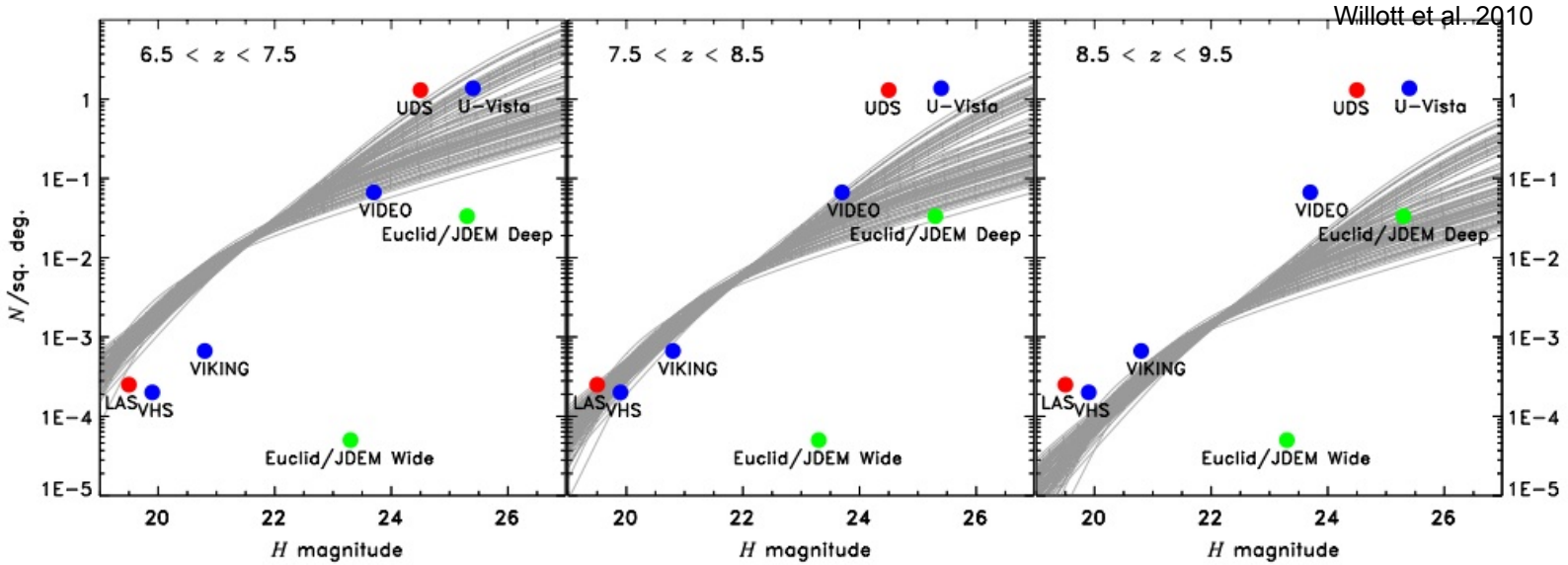


Contamination ratio ellipticals:quasars is <5:1

Stars, brown dwarfs, irregulars galaxies are eliminated

Conclusions

- Reduction in the contamination rate is crucial
  - Optimize large ground-based telescope use
- Large field-of-view space-based instruments
  - Could find >100's SMBHs at z>7 (>1000 6<z<7)
  - Probe the less massive SMBHs



- Help distinguish between competing models