Early Redshift Surveys

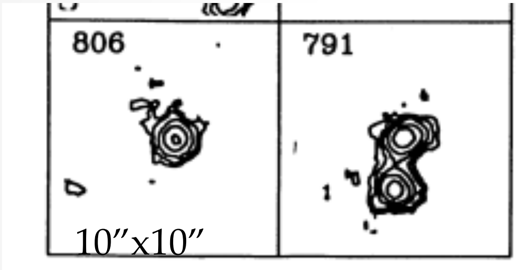
Xu Huang
Princeton, 2013 Spring

Outline

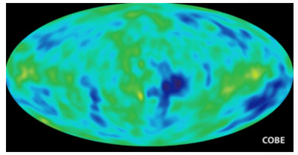
- Frontier of the 90^{th}
- Primeval Galaxies
- Observable properties of PGs
- Attempts to find PGs
- Reconsideration of Complications
- "Future" Strategies

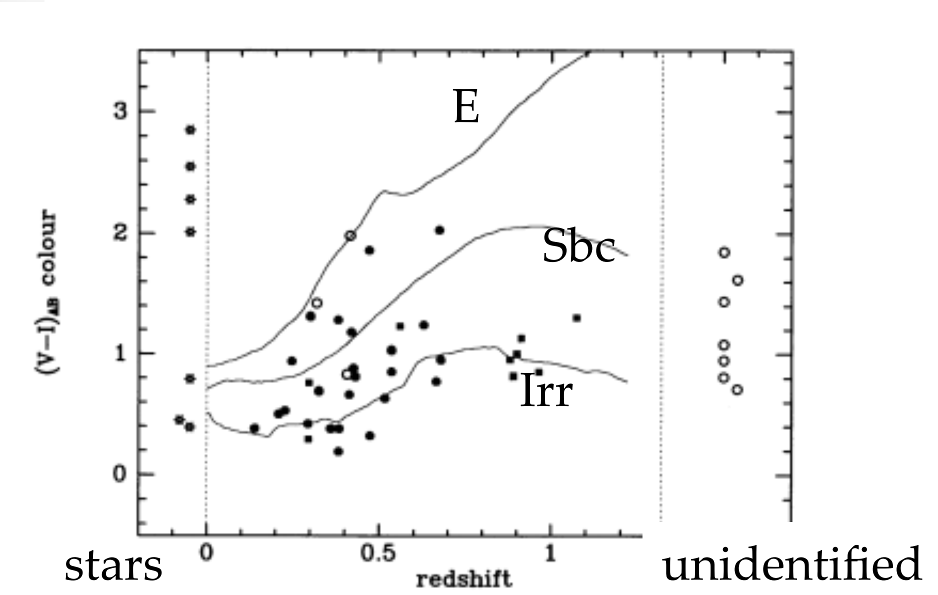
Frontier of the 90th

z<1 galaxies
Lyα absorbers
Quasar
CMB
z

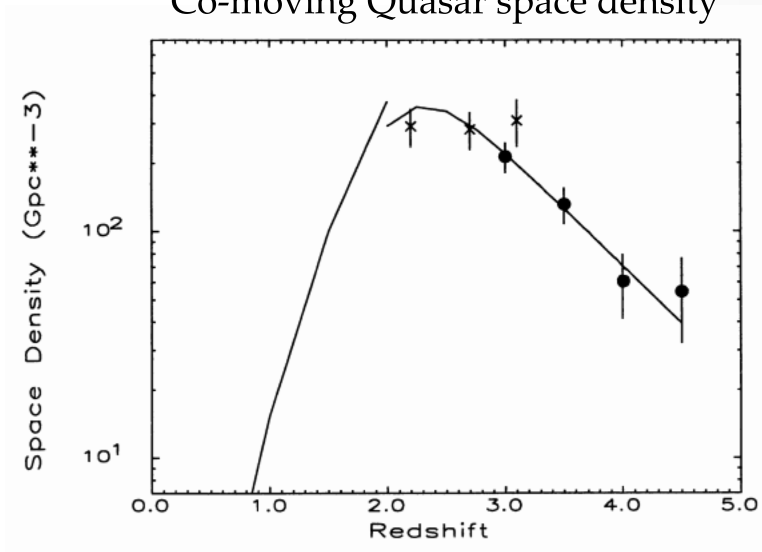


Lilly 1993





Co-moving Quasar space density



Schmidt, Schneider and Gunn 1991

Speculation of the existence of Primeval Galaxies

- Motivation:
- a) Early galaxy formation models – gravitational collapse from large hydrogen clouds
- b) Suggestion from early CDM (cold dark matter) simulations
- c) Accounts for the ionization photons in the early universe.
- Primeval Galaxies - Formation epoch of galaxies

Primeval Galaxies(PG)

- A galaxy at its peak luminosity (luminosity dominated by massive stars), undergo its first star bursts
- An definition from observer's point of view

observer's bias will be kept in this review: we will deal with the making of the wine, rather than of the bottles. The choice is driven by necessity: it is difficult to observe invisible matter of an unknown physical nature.

Djorgovski 1992

Most of the luminosity in young stars.

$$dN / d\log M \propto M^{-1.35}$$

$$L \propto M^{3}, (M < 100 M_{sun})$$

- A widespread population:

numerous $10^4 - 10^5$ /deg^2 and bright (+24 Magnitude)

Expected Observation Signatures

- Luminosity - Bright
- Size – large (5" -10")
- Spectrum
- Redshift – bulk of galaxy formation at $z<3.5$, some activity in higher redshifts

Luminosity of PGs

- Bright: high L/M

The metallicities argument : $L \sim 5\,L_{MW}$

$$L \simeq 6\times10^{44}\left(\frac{|\Delta X|}{0.01}\right)\left(\frac{M_{PG}}{10^{11}\ M_{\odot}}\right)\left(\frac{\Delta t_{PG}}{10^{9}\ \mathrm{yr}}\right)^{-1}\ \mathrm{erg\ s^{-1}},$$

Lily and Cowie 1987

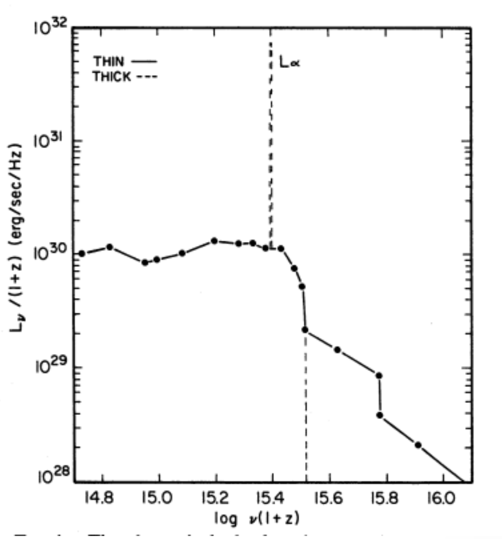
$$S = \frac{1}{4\pi}\,\epsilon_{\nu}(\rho Z)c$$
$$= 2.1\times10^{-25}\left(\frac{\rho Z}{10^{-43}\ \mathrm{g\ cm^{-3}}}\right)\mathrm{ergs\ cm^{-2}\ s^{-1}\ Hz^{-1}\ deg^{-2}}, \quad (1)$$

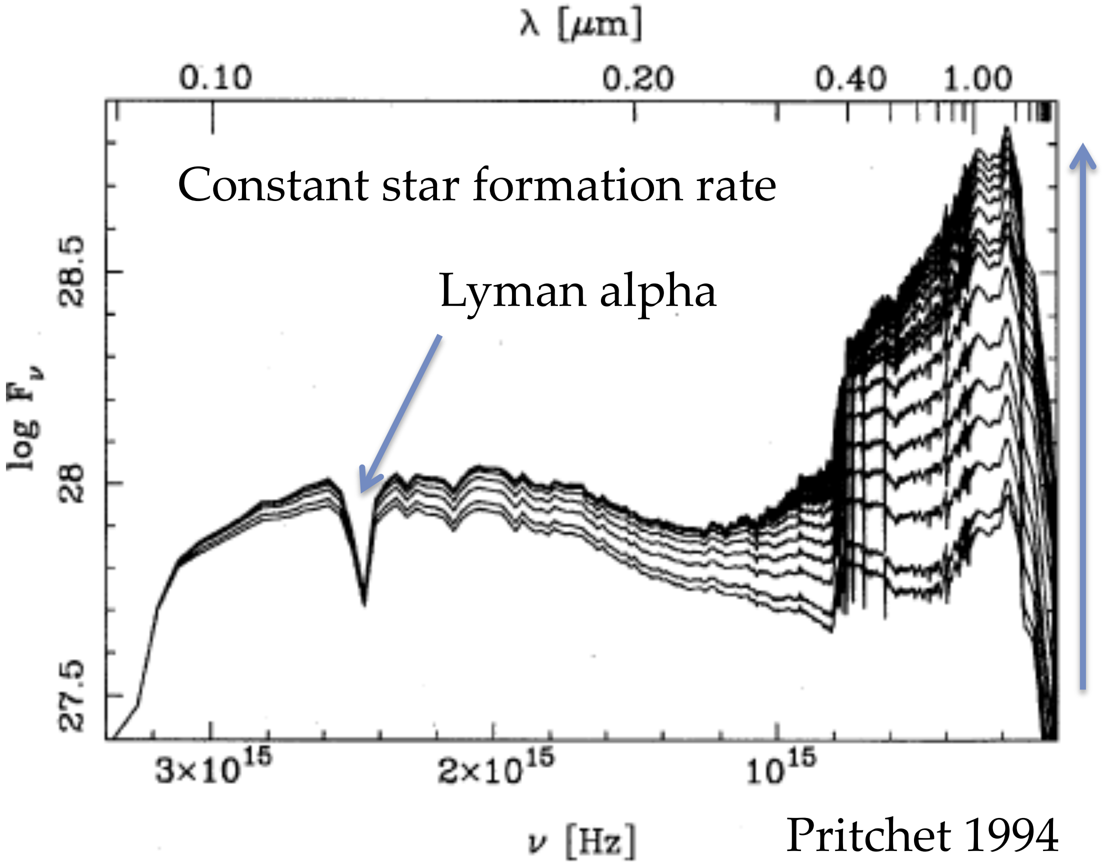
- Elliptical are young? (**Parpritge and Peebles 1967**)

Spectrum of PGs

Strong Ly α emission
due to UV heated ISM?

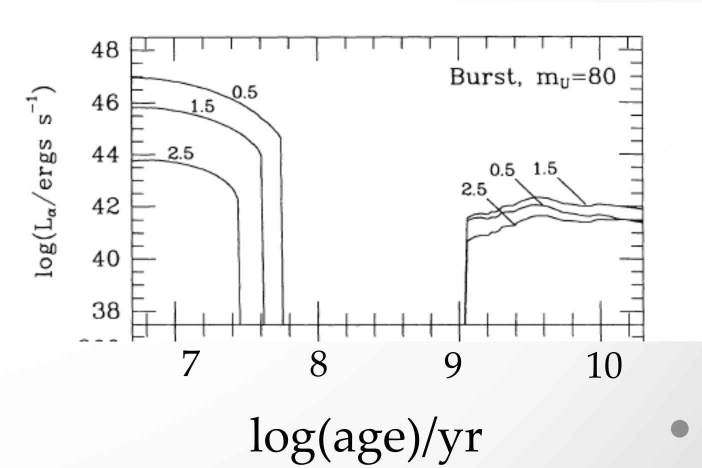
Meier 1976





age

Charlot and Fall 1993



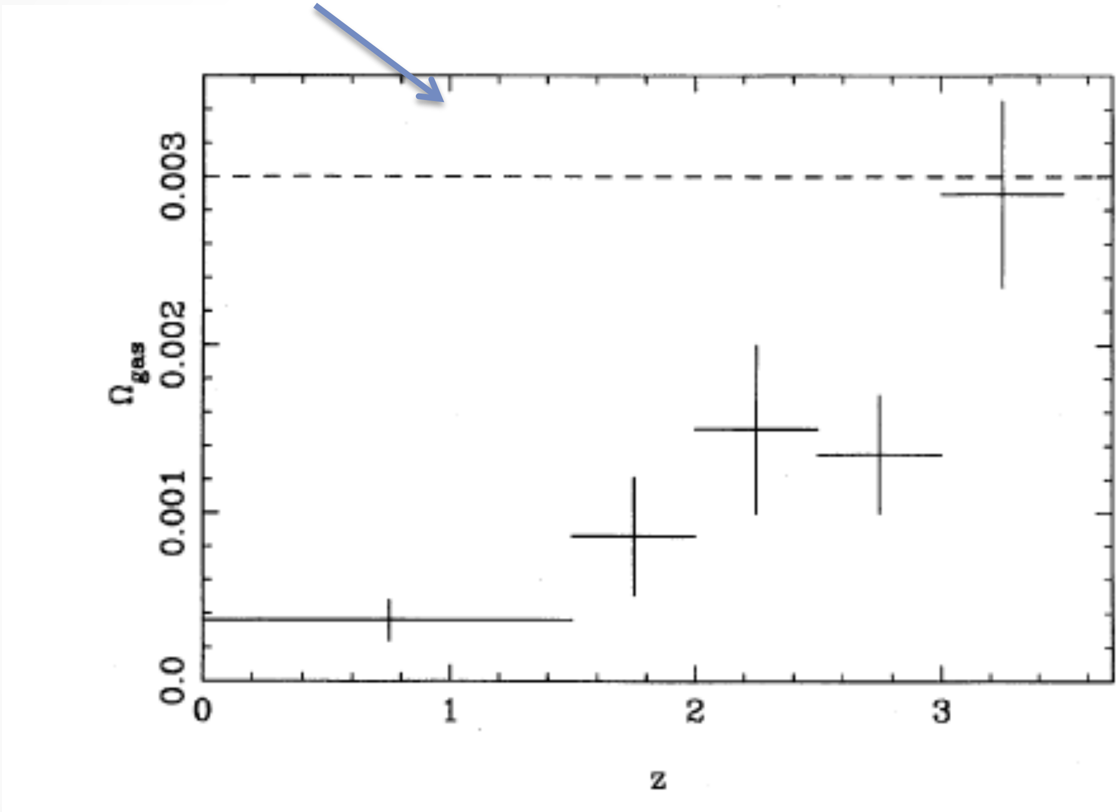
Pritchet 1994

Constrain the Redshift of PGs

- Evidences
  - Redshift Surveys (rule out $z \leq 1$)
  - CMB (lack of distortion from IR background, rule out $z>10$)
  - Cluster ellipticals (the scattering in CMD infer age)
  - Milky Way GC (3Gyr)
  - High redshift radio galaxies
  - Quasars (with peak density ~2-3)
  - Damped Lyman alpha absorbers

Density in damped Lyα absorbers .Verses. redshift

Present day density of luminous material



The rapid reduce of gas density between z = 1-3
is due to star formation

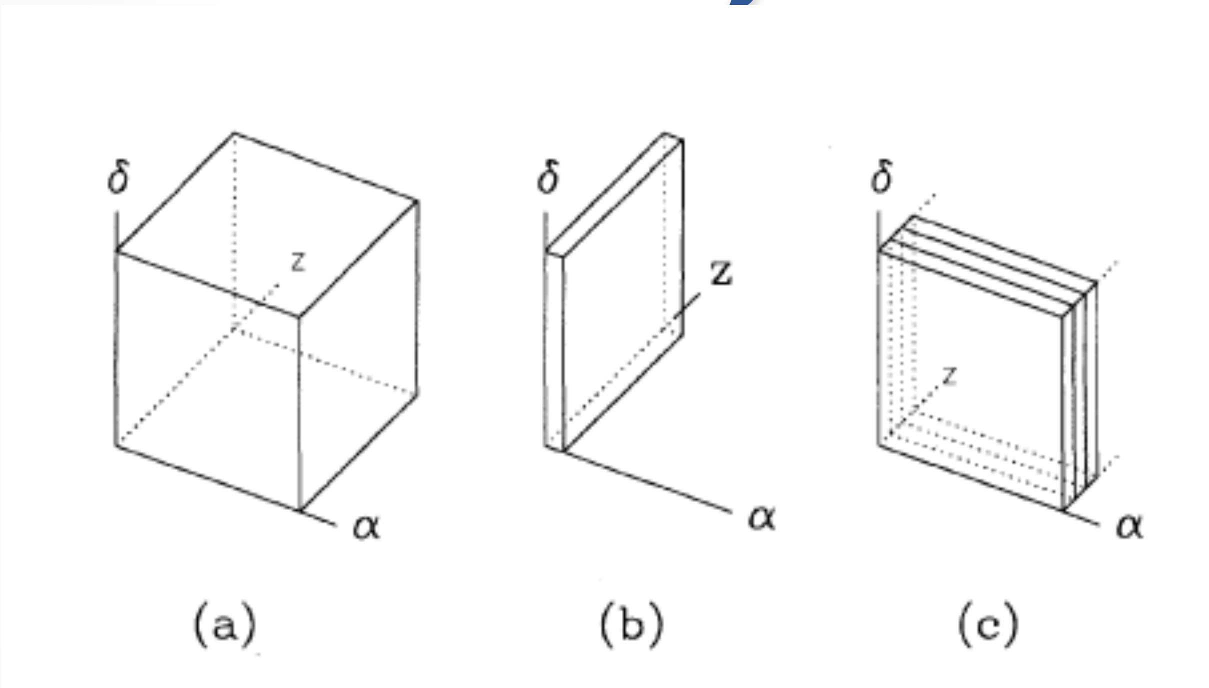
Pritchet 1994

Early Attempts

- Broad band- search for flux fluctuation on the background due to red shifted UV continuum

  Don't have good redshift indicators.
- Quasars
- Redshift surveys (related to Broad band search)
- 21cm (neutral hydrogen clouds before reionization, low sensitivity)
- UV-Optical Emission lines(such as Lyα)

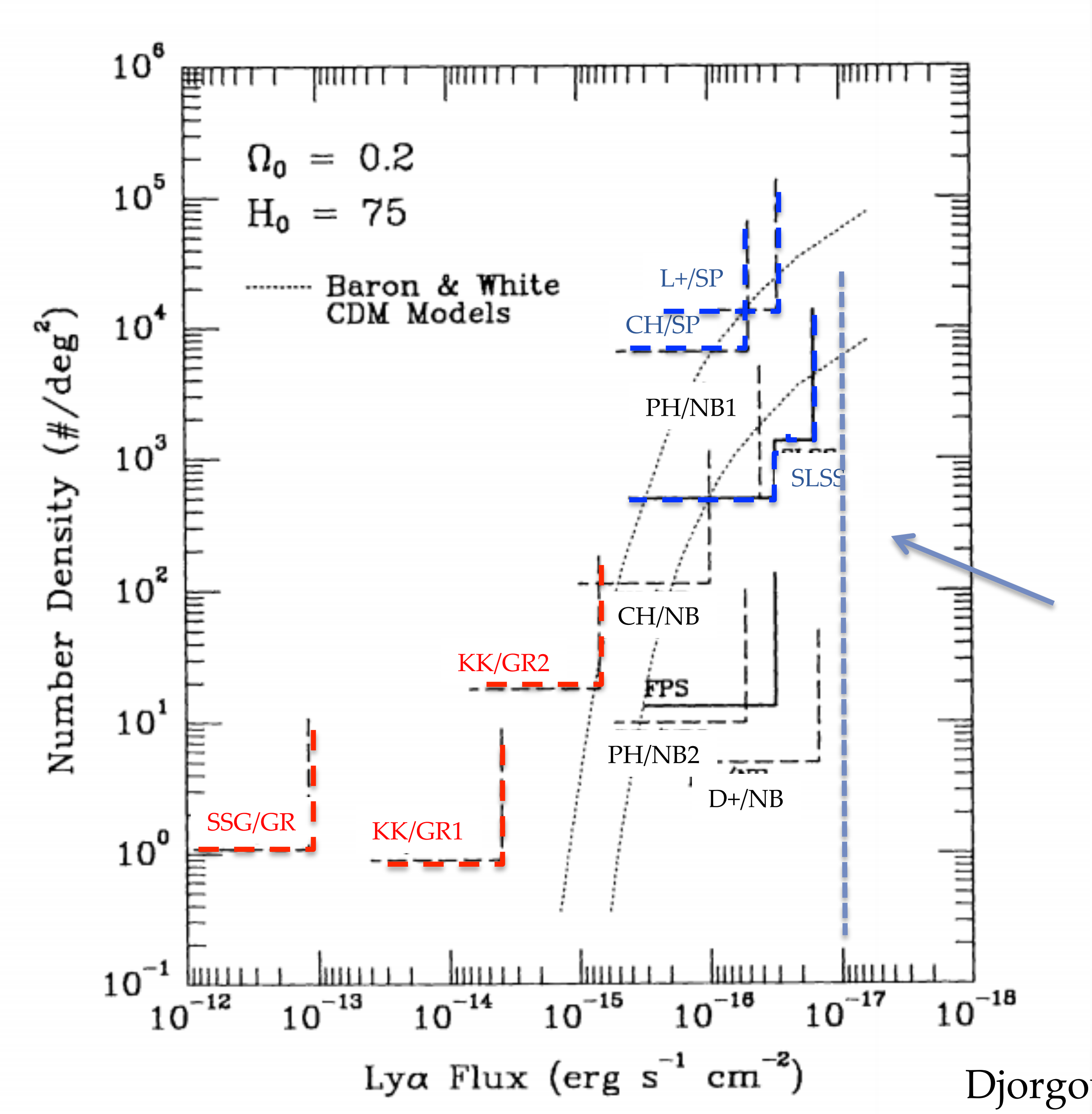
Search for Lyα emission



(a) slitless
large volume,
high flux limit

(b) long slit
low sky background
small volume

(c) narrow band imaging
large sky coverage
small redshift coverage



GR-slitless
SP – long slit
NB – narrow band

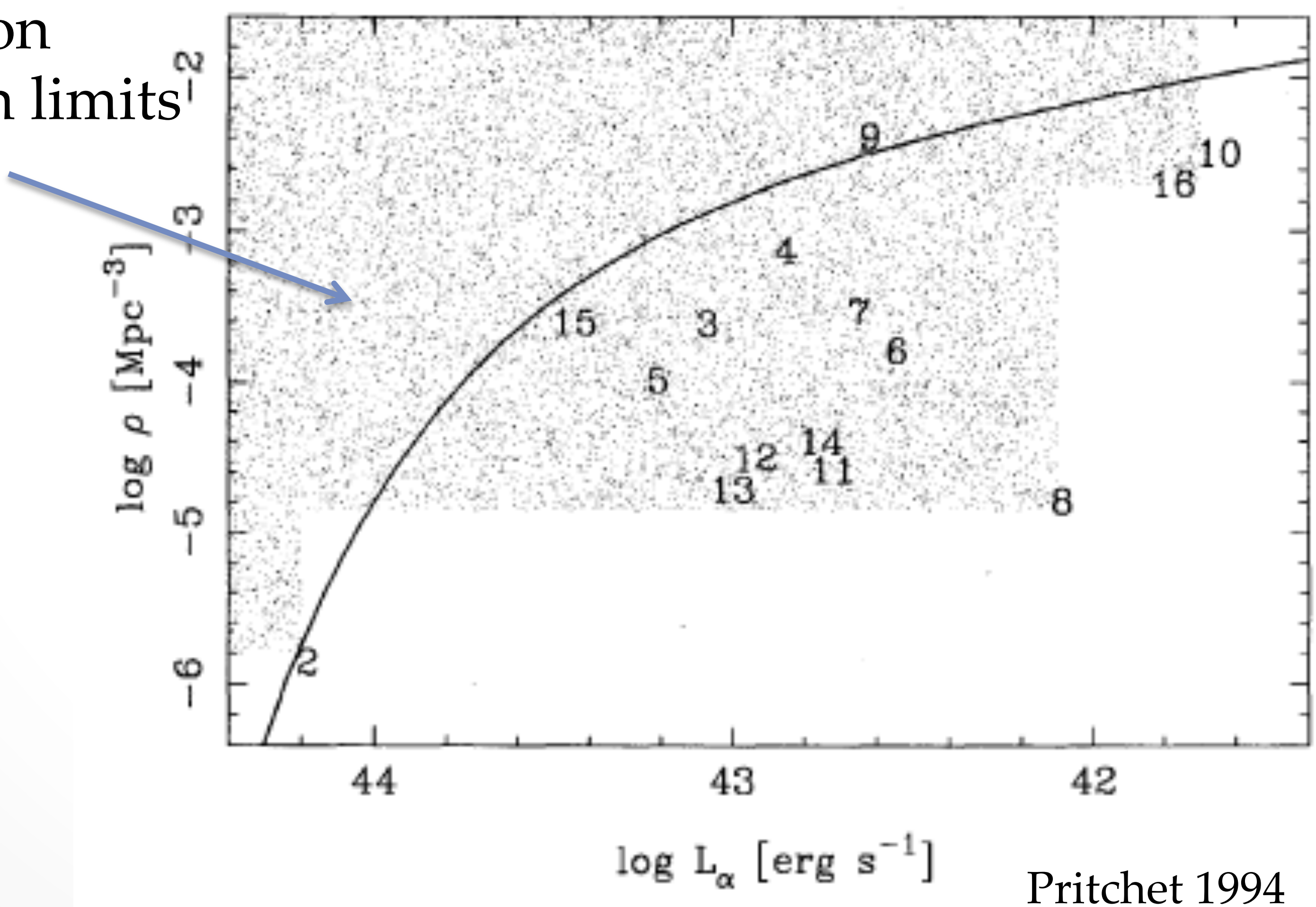
Typical flux limit for ground based survey today.
Malho and Rhoads 2004

Djorgovski and Thompson 1992

Null Results!

No emission line PG is found

excluded region
by observation limits

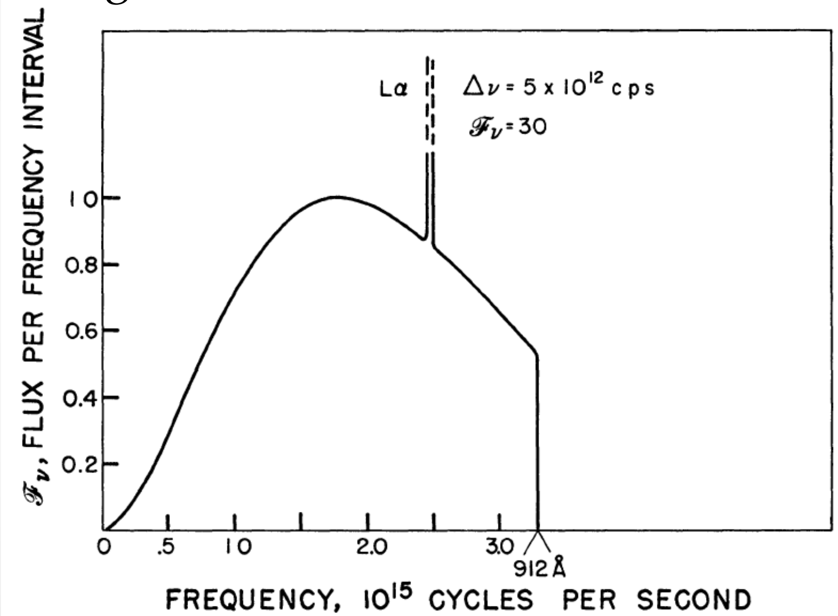


Pritchet 1994

Complications - Dust

- If without dust…

Pratridge and Peebles 1967

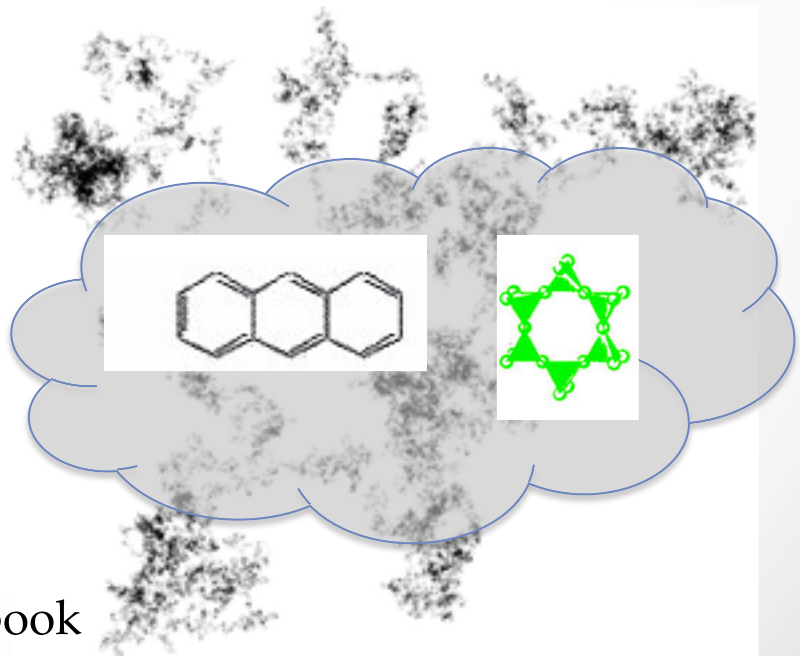


$$f_{esc} \approx 0.17\exp(-\tau_{d0})$$

- Escape of Ly α in H II region

Random walk in

- Frequency space
- Real space



Bruce's book

Complications

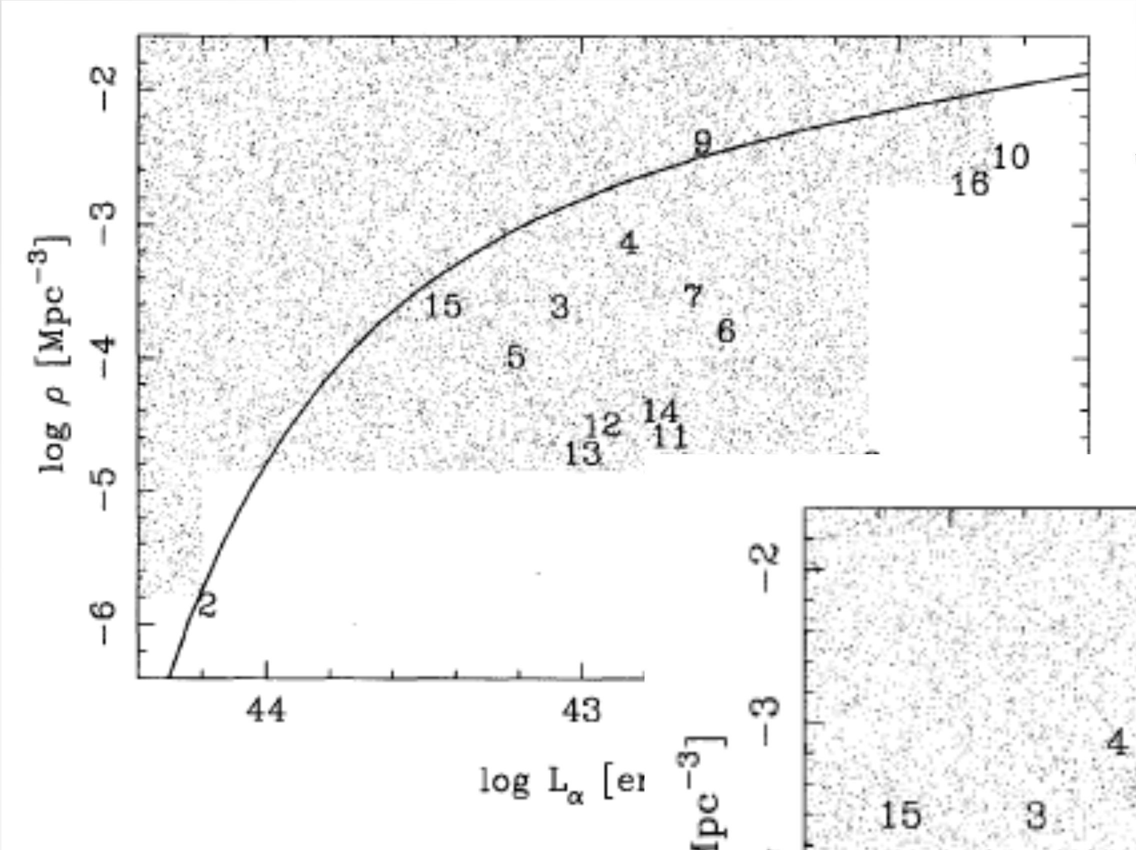
- angular size

Flux limit is quoted for point source(not a problem from point of view now.)

- Clustering

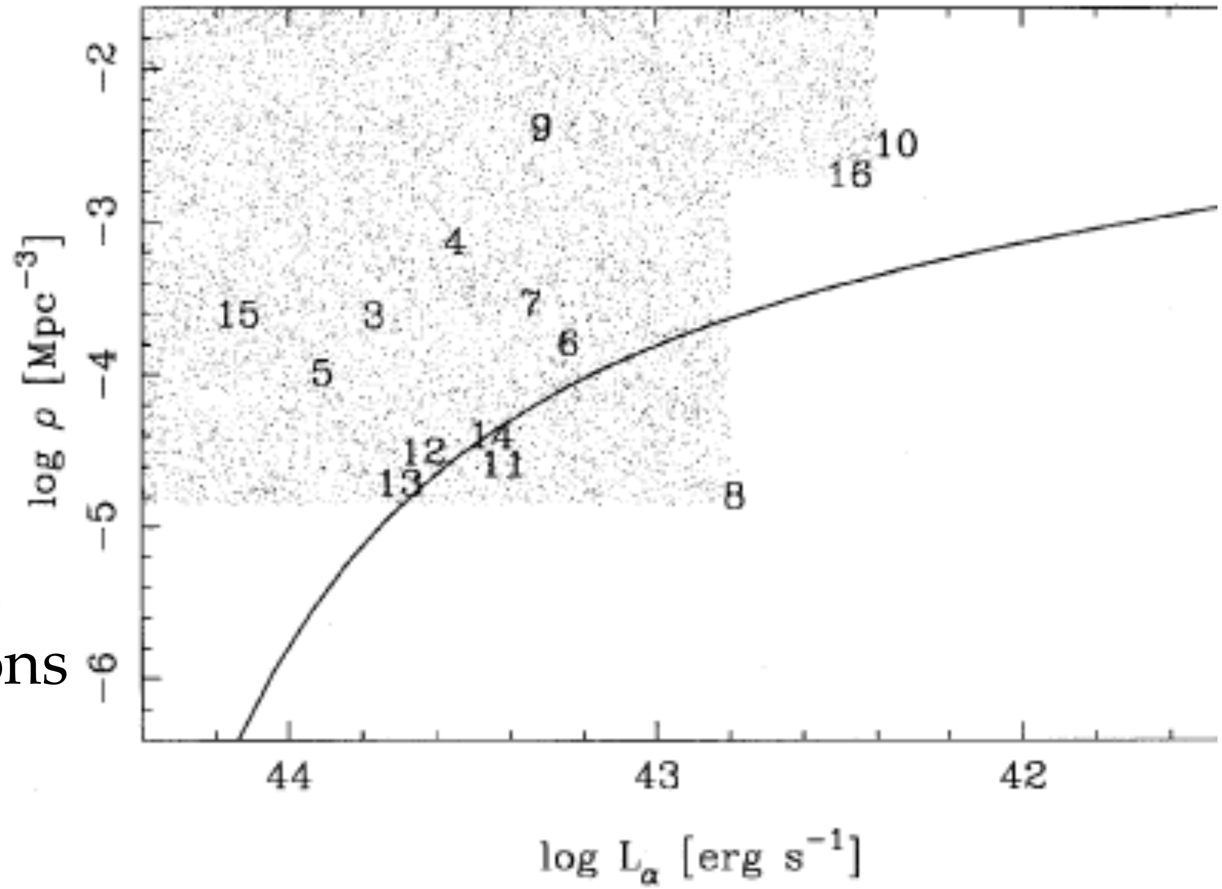
Lead to smaller filling factor

- PGs might appear as AGNs
- A different IMF



Before

Pritchet 1994



Revised comparison
account the complications

Preview of "Future" Strategies

Go deeper and wider

a) Improve flux limit to be able to get fainter objects.
b) Use mosaics of CCDs to increase solid angle coverage.
c) Focus on fields near QSOs.

Use Different techniques for different objects

- UV, optical and IR for red shifted UV. (Ben)
- mm and submm survey for dusty galaxies (Prachi)
- Dust free Lyman emitters (Chirs)

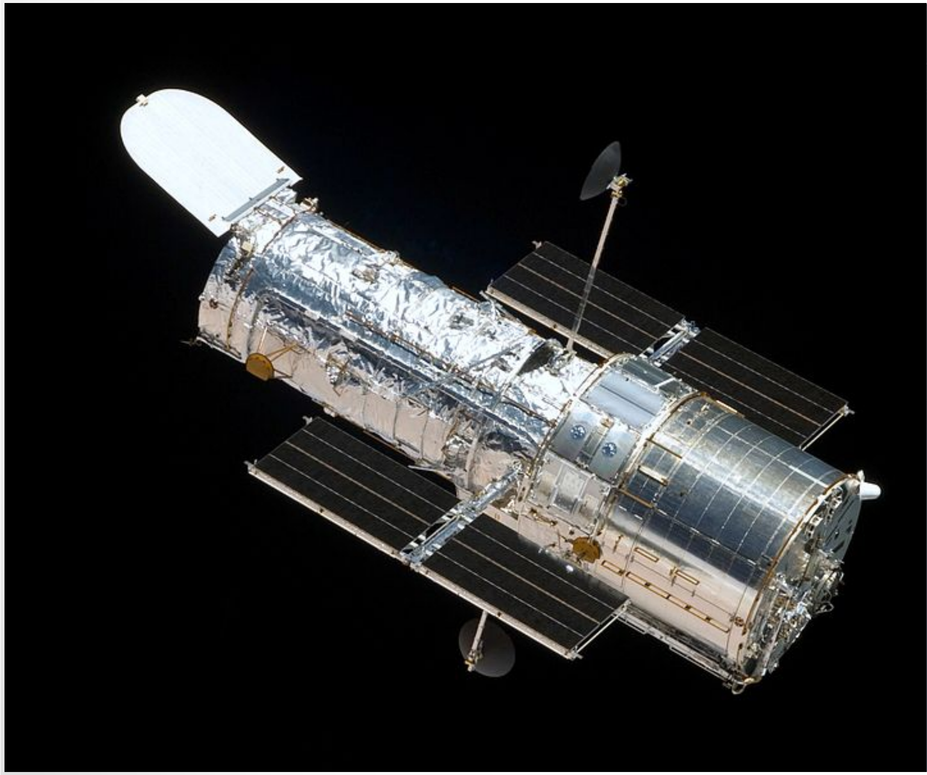
Summary

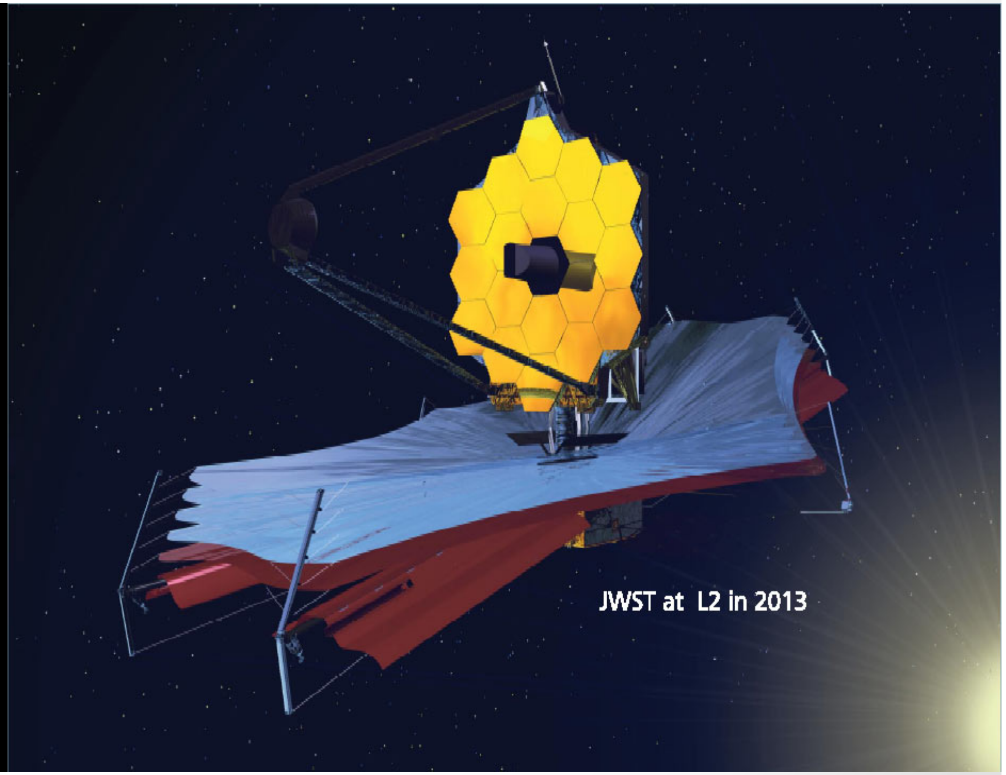
Barely reaching the flux limits and volumes needed to detect ~10^0 objects.

Pritchet 1994

They were waiting for Hubble

We are waiting for JWST





References

- S. J. Lilly 1993 ApJ 411, 501L
- Lilly, S. J. and Cowie, L. L. 1987, in Infrared Astronomy with Arrays, ed C. G. Wynn-Williams and E. E. Becklin (Honolulu, Univ. of Hawaii), p. 473
- M. Schmidt, D. P. Schneider and J. E. Gunn 1991 ASPC 21,109S
- S. Djorgovski 1992 ASPC 24, 73D
- S. Djorgovski and D. J. Thompson 1992 IAUS 149 337D
- R. B. Parpritge and P. J. E. Peebles 1967ApJ 147,868
- D. L. Meier 1976 ApJ 207,343
- S. Charlot and S. M. Fall 1993 ApJ 415, 580C
- C. J. Pritchet, 1994 PASP,106,1052P