Tracing the merger rate of the Universe with *Apertif* (and ASKAP)

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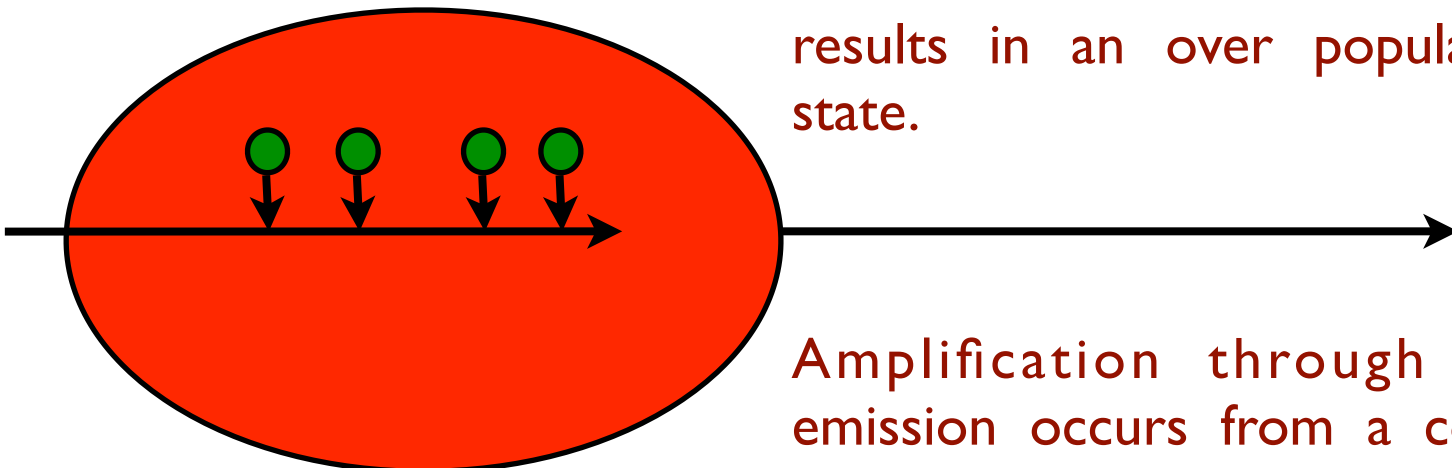
Outline

- ★ Brief introduction to OH masers
- ★ The merger rate of the Universe
- ★ *Apertif* and ASKAP
- ★ The local OH maser luminosity function
- ★ Model predictions and survey strategies
- ★ Current prospects at moderate and high redshifts

OH masers

Maser emission from hydroxyl is seen at 1.667 and 1.665 GHz (rest frame.)



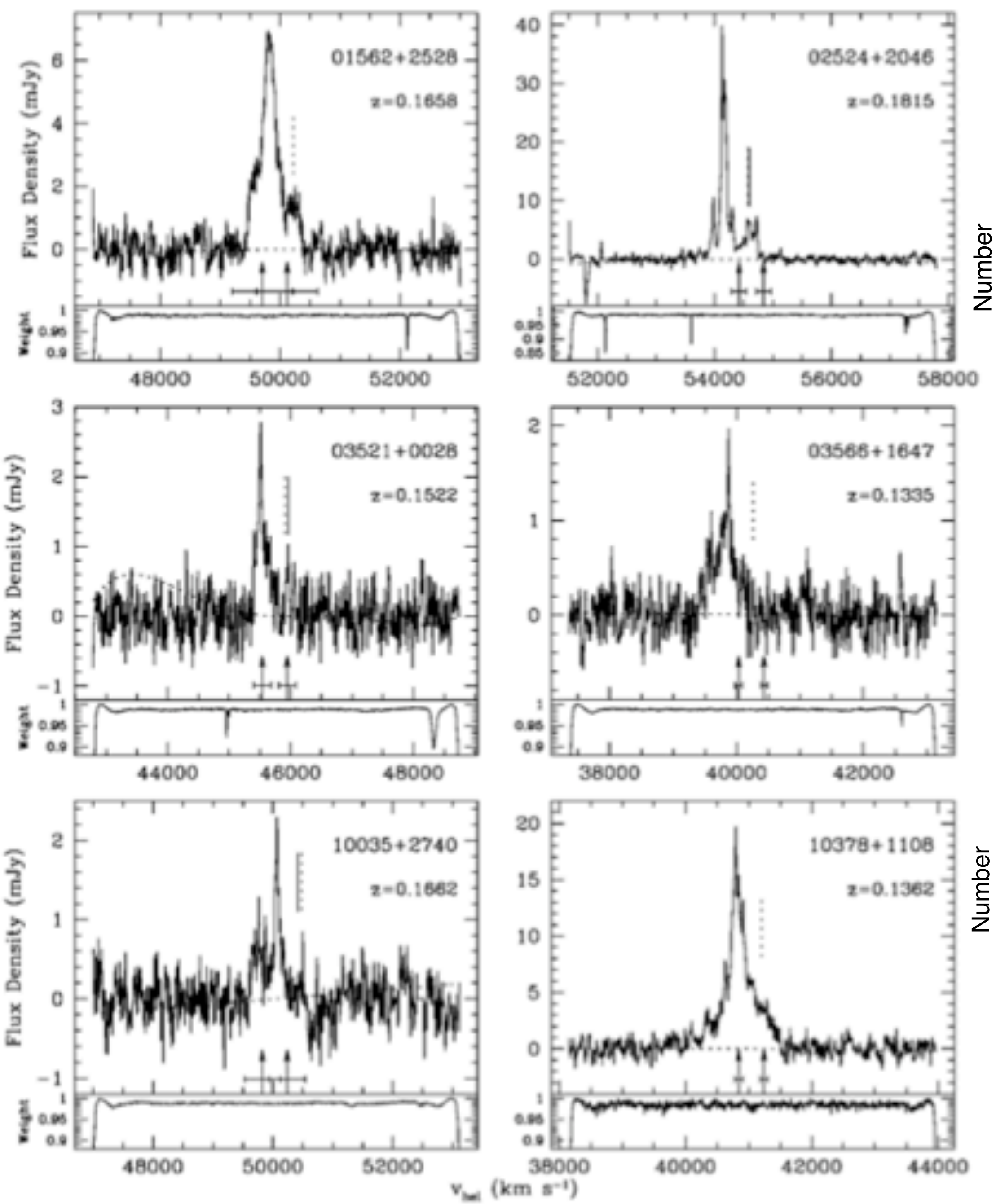
Radiative excitation from a strong infrared field and low de-excitation results in an over populated excited state.

Amplification through stimulated emission occurs from a coherent gain medium (a continuum source).

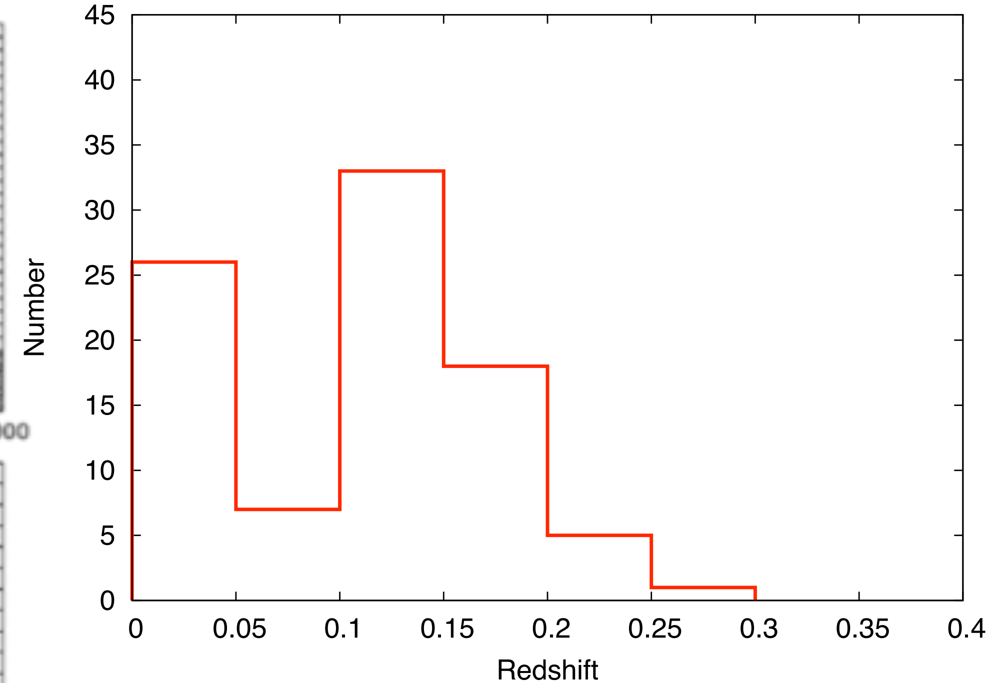
Radiation has a very high surface brightness and is beamed to the observer.

Found in regions of hot (~160 K), dense gas (<10^7 cm^{-3}) => most luminous termed OH mega-masers (> 10 $L_\odot$) and are typically associated with regions of intense star-formation.

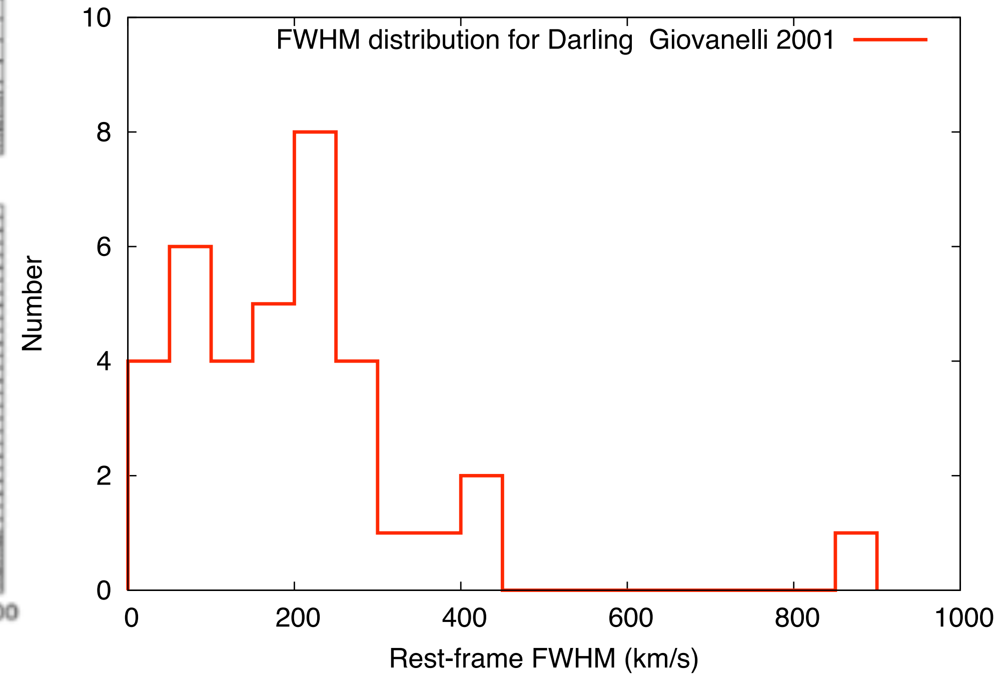
OH masers



01562+2528
z=0.1658
02524+2046
z=0.1815
03521+0028
z=0.1522
03566+1647
z=0.1335
10035+2740
z=0.1662
10378+1108
z=0.1362
Flux Density (mJy)
Weight
48000
50000
52000
54000
56000
58000
44000
46000
38000
40000
42000



Number
Redshift
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4



FWHM distribution for Darling Giovanelli 2001
Number
Rest-frame FWHM (km/s)
0
200
400
600
800
1000

OH masers

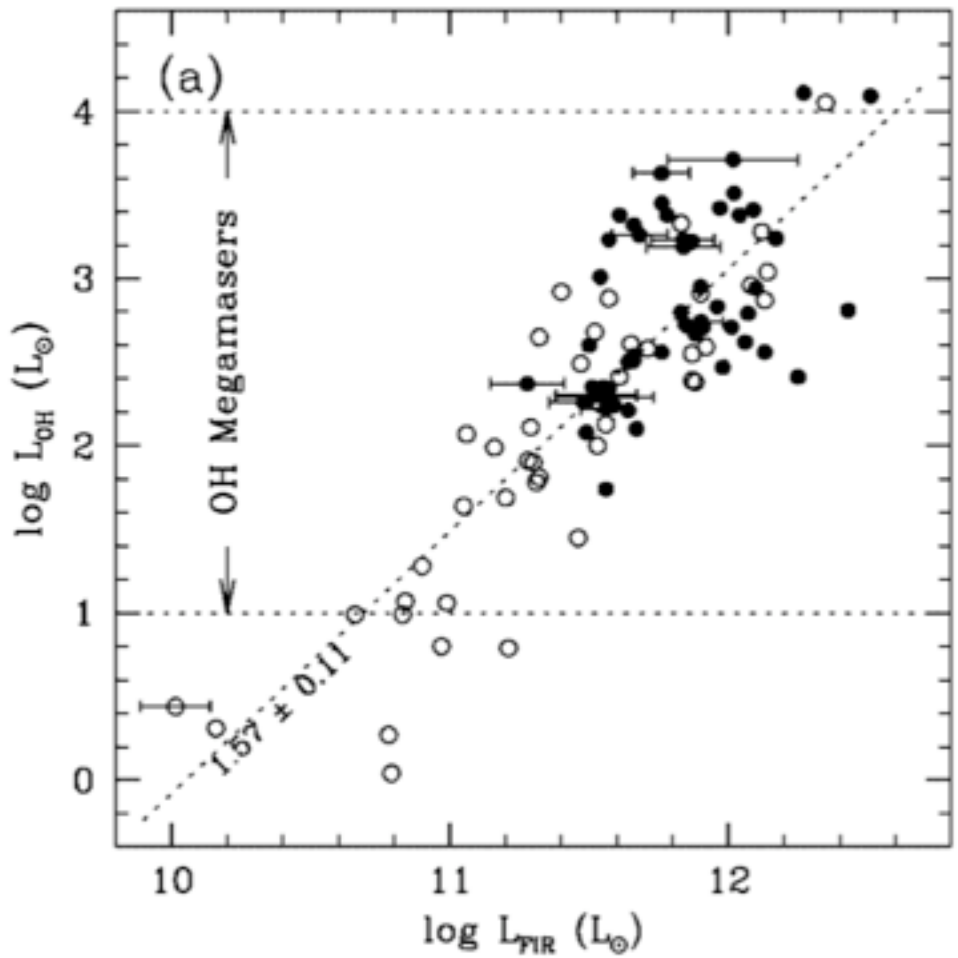
Simple model for maser emission requires a pumping field and stimulating photons.

$$L_{OH} \propto L_{FIR} L_{RAD}^{\Upsilon-1} \propto L_{FIR}^{\Upsilon}$$

$1 < \Upsilon < 2$ (Baan 1989)

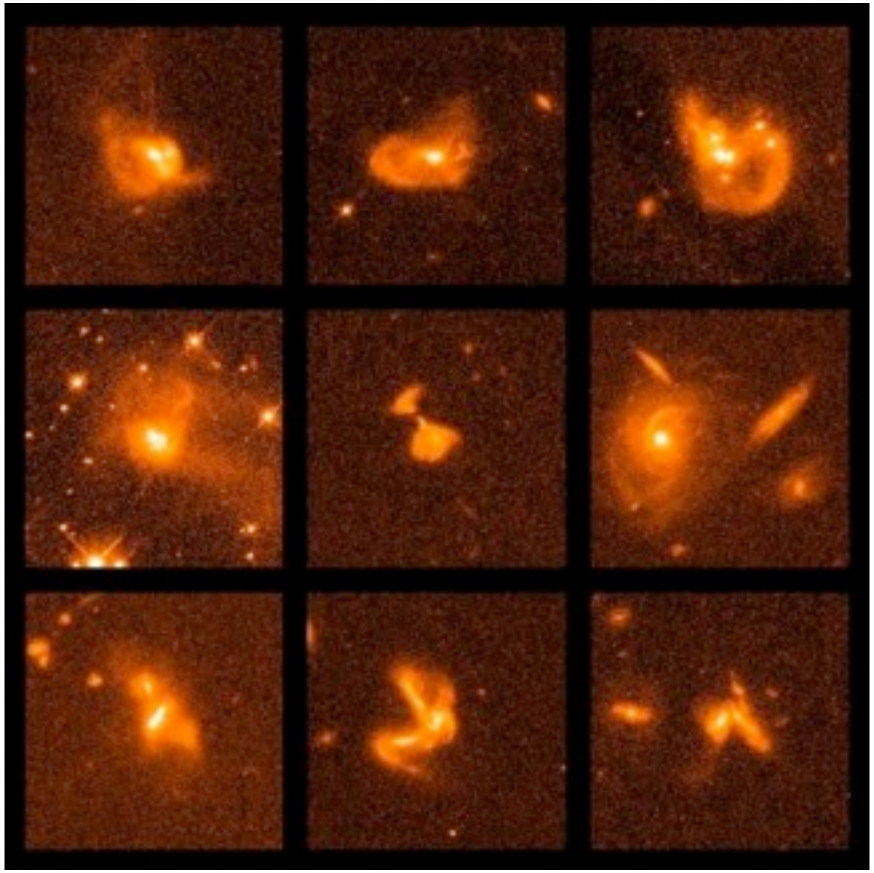
Need to find low L_{OH} and L_{FIR} masers to investigate Υ.

Target strong IR sources with radio emission to find OH masers.



(Darling & Giovanelli 2002)

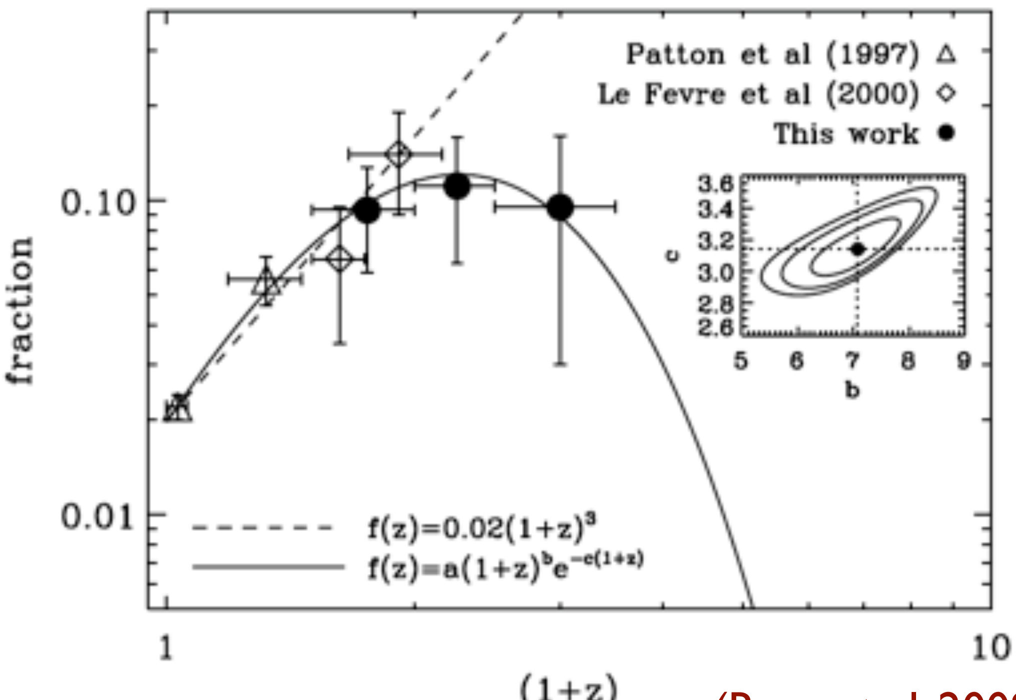
The merger rate



(U)LIRGS ($L_{FIR} > 10^{11}\ L_{\odot}$) are thought to be caused by galaxy mergers.

Targeted searches find 2--15 per cent of ULIRGS have OH megamasers (e.g. Staveley-Smith et al. 1992; Darling & Giovanelli et al. 2002)

Observations of galaxy pairs in HDF and HUDF show mergers increase with z.



Merger rate turnover at z = 1.3?

(Ryan et al. 2008)

Apertif and ASKAP

Telescope: 12 x 25 m

Beam-size: 15 arcsec

Fov: 8 deg^2 (FPA)

Bandwidth: 300 MHz

Frequency range: 900 -- 1700 MHz ($z < 0.85$)

line sensitivity (150 kms^{-1}): 0.15 mJy/beam (12 hr)

(1σ) 0.52 mJy/beam (1 hr)

Telescope: 36 x 12 m

Beam-size: 10 arcsec

Fov: 30 deg^2 (FPA)

Bandwidth: 300 MHz

Frequency range: 700 -- 1700 MHz ($z < 1.38$)

line sensitivity (150 kms^{-1}): 0.21 mJy/beam (12 hr)

(1σ) 0.73 mJy/beam (1 hr)

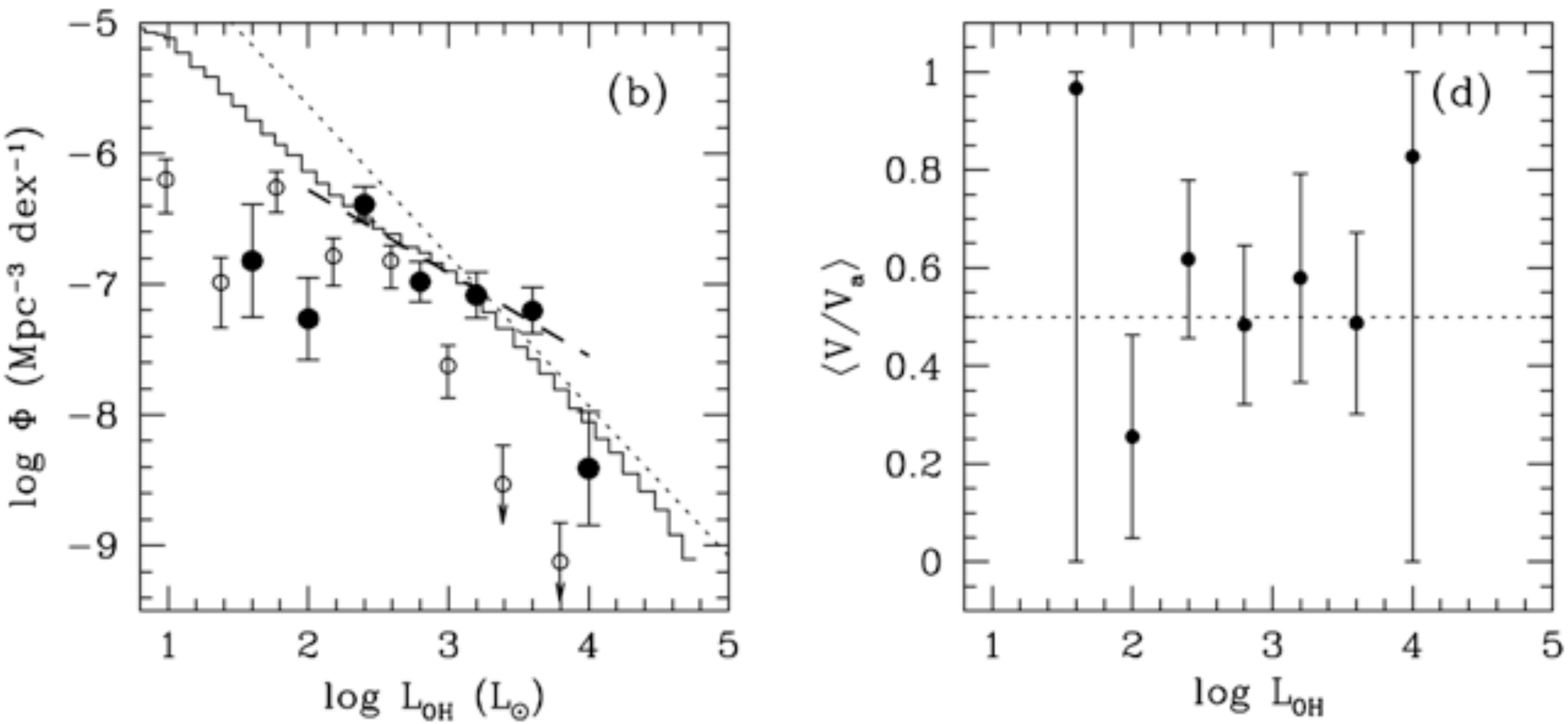
Luminosity function I. DG02

Pointed survey with Arecibo of a complete sample of 311 ULIRGS (redshifts and FIR flux-density limited).

53 OH maser galaxies between redshifts 0.1 -- 0.23 (0.63 Gpc^3)

$$\Phi(L) \propto L_{OH}^{-0.64 \pm 0.21}\ \mathrm{Mpc^{-3}\ dex^{-1}}$$

Darling & Giovanelli 2002



Luminosity function II. K03

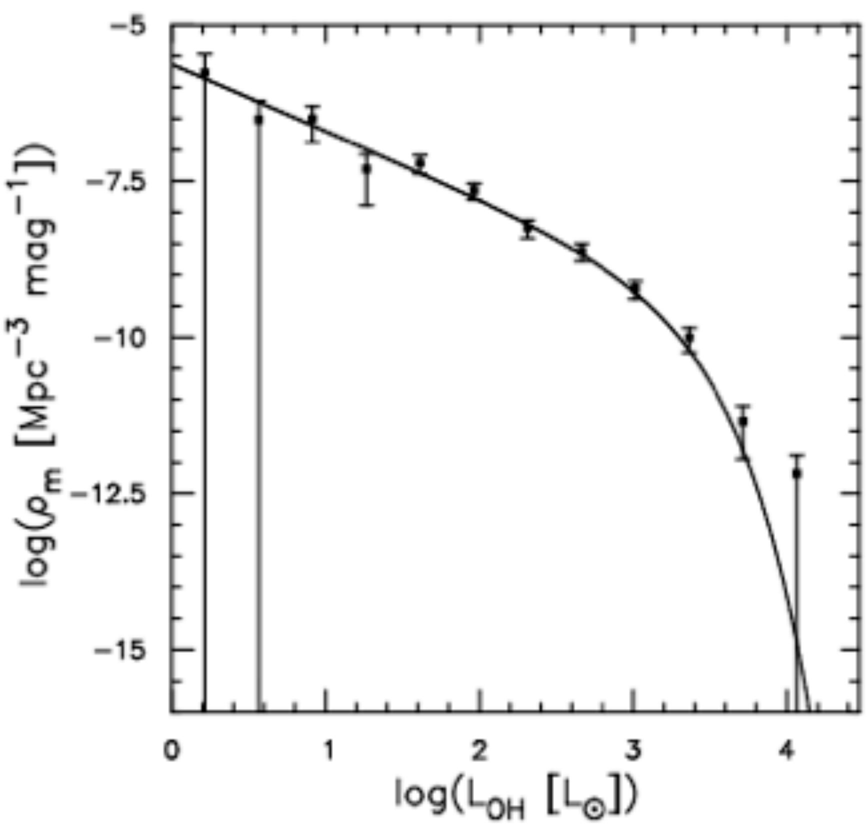
Sample of 74 known OH maser galaxies considered to be reliable (includes DG02 sample).

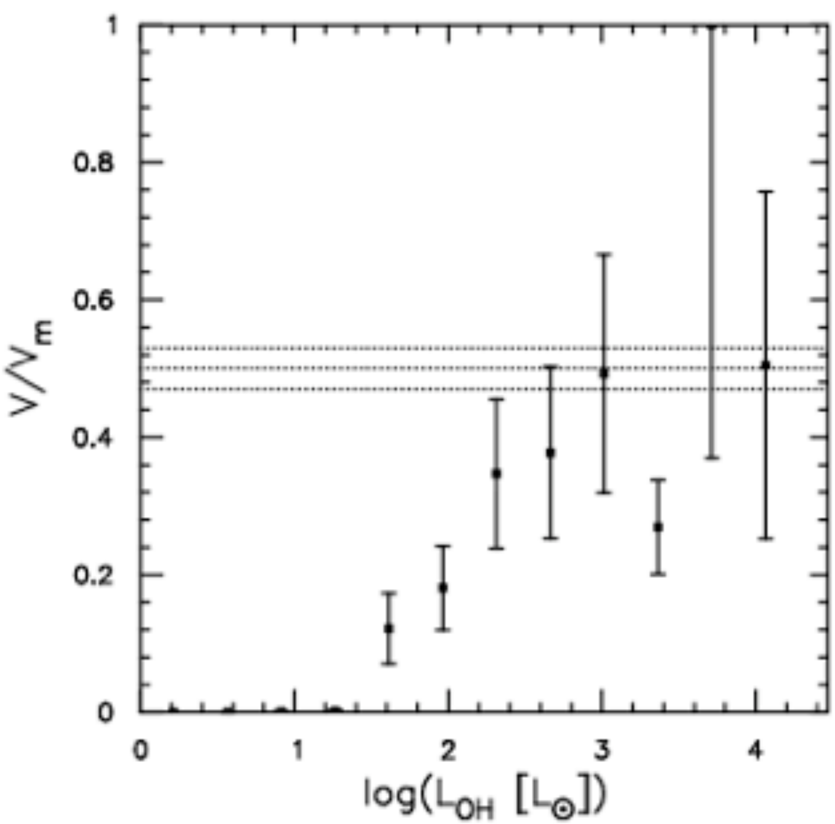
Represented by a Schechter function instead of a power-law.

Exponential cut-off heavily decreases high luminosity objects.

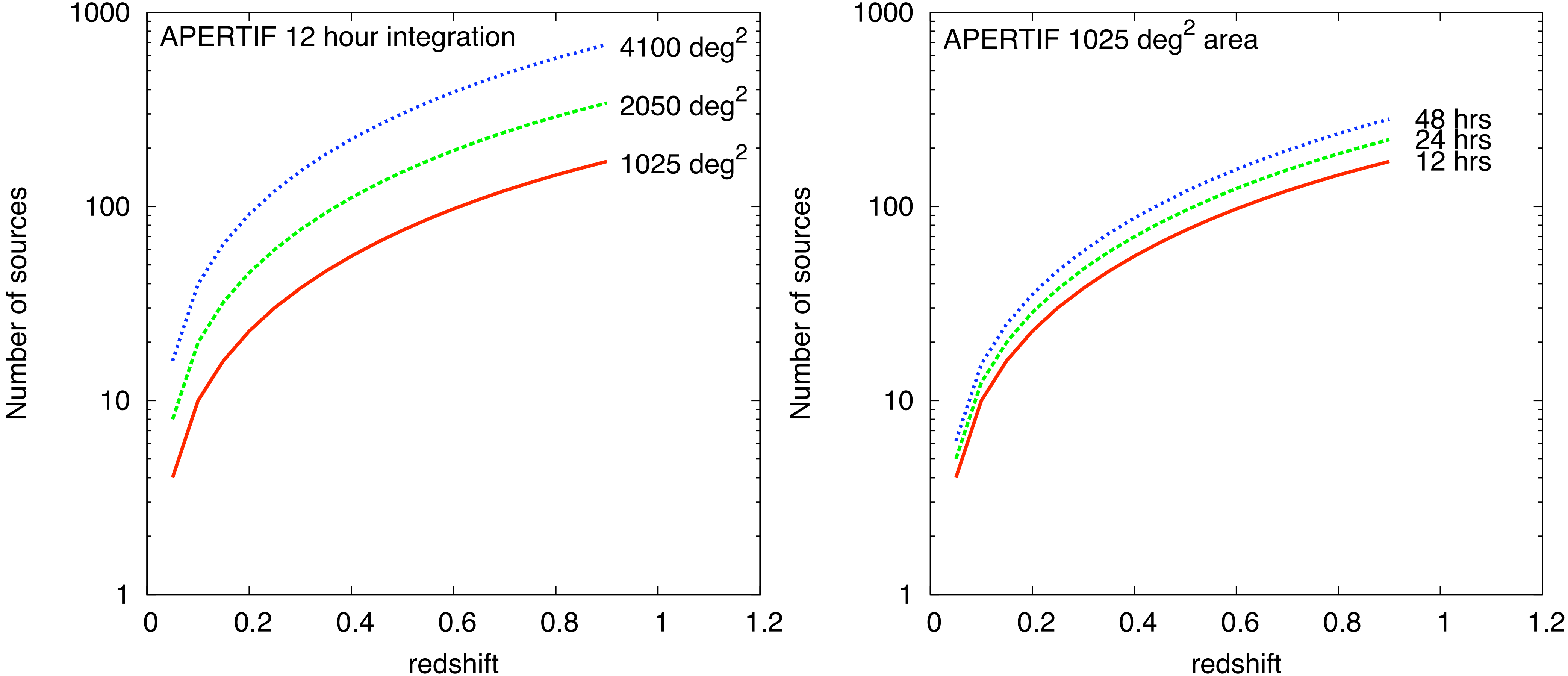
Effects LF at high z.

Kloekner 2003





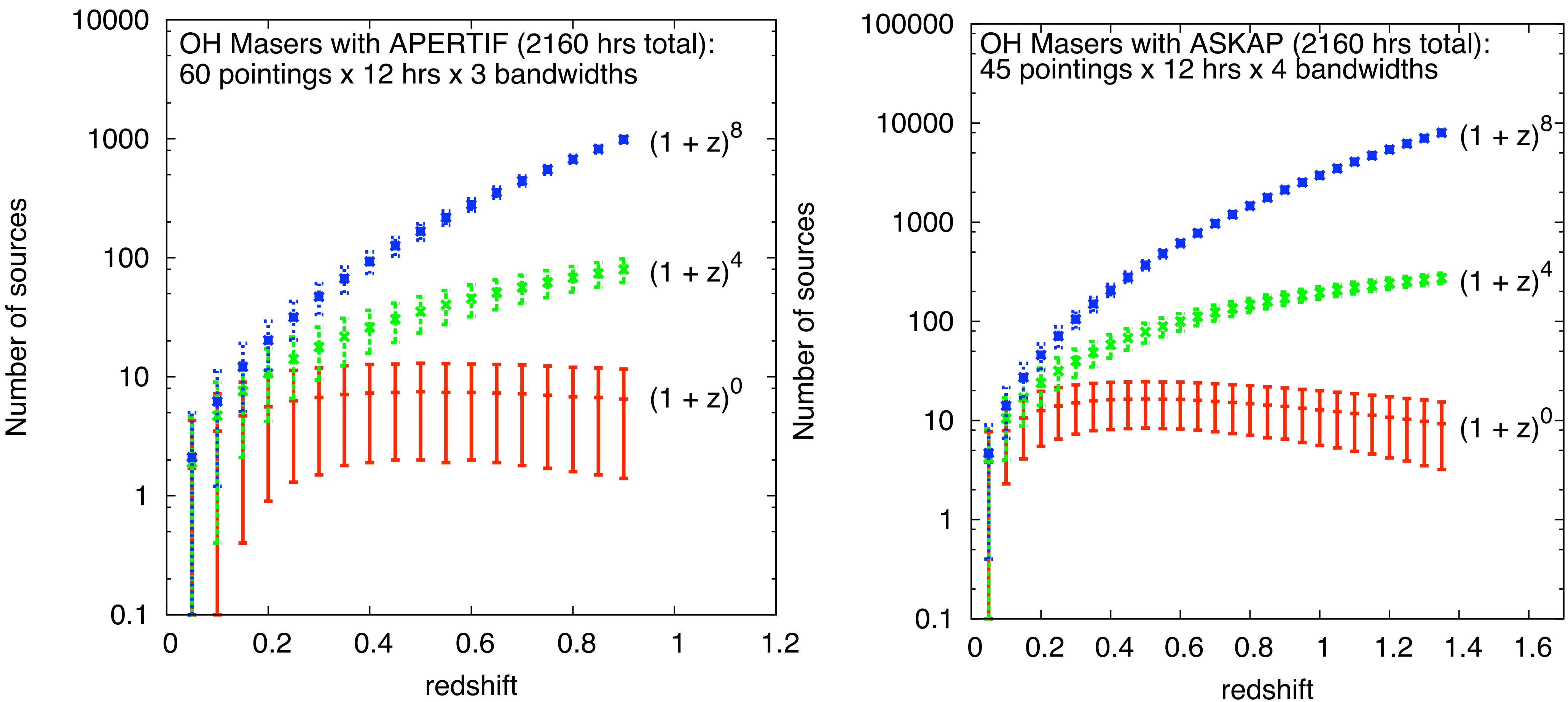
Survey strategies - Area v Depth



The shallow slope of the luminosity function results in more sources found over larger area surveys.

Density evolution

To characterize the evolution, we need to cleanly differentiate between merger models.

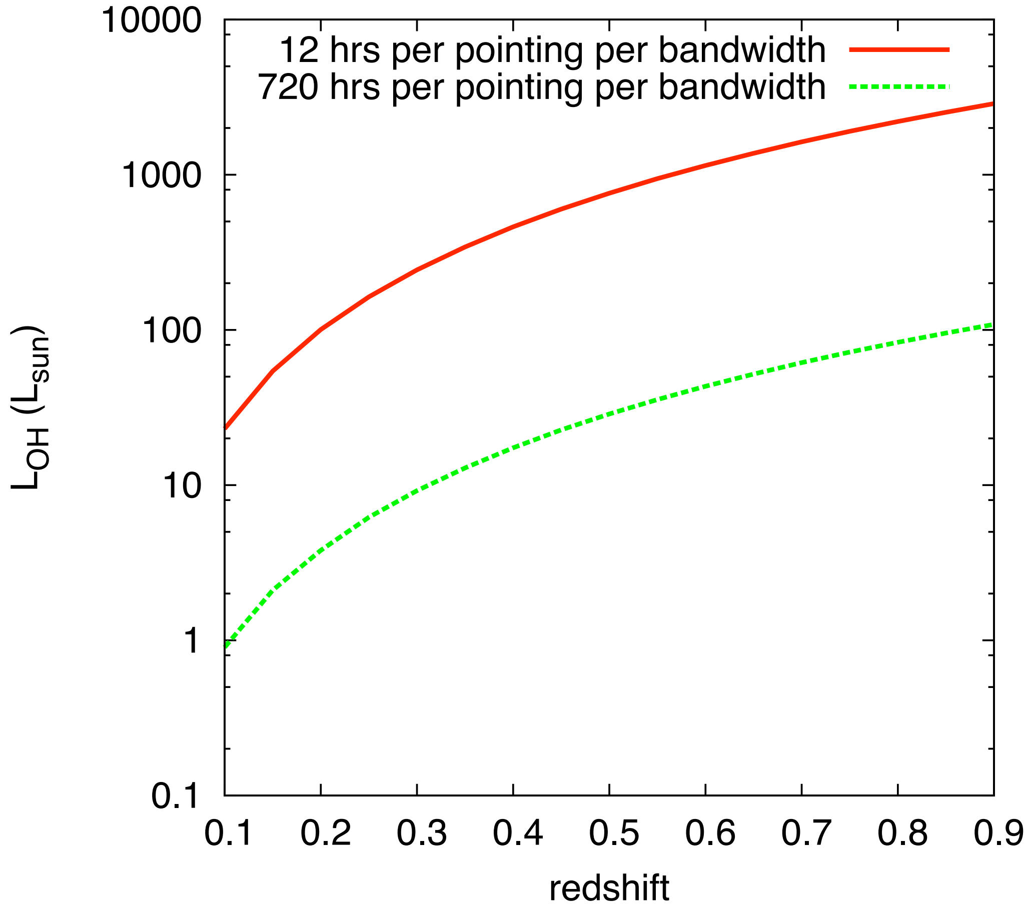


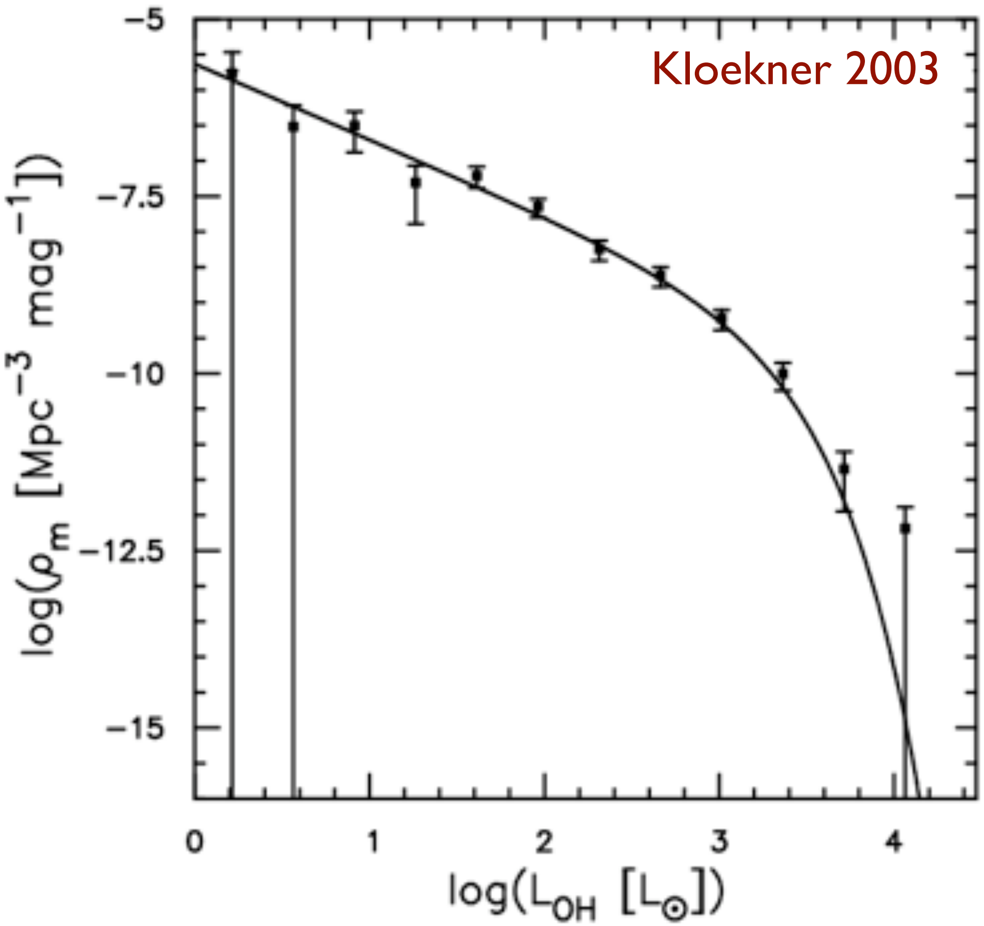
Modest surveys of 3 months observations in total look good.

Luminosity evolution

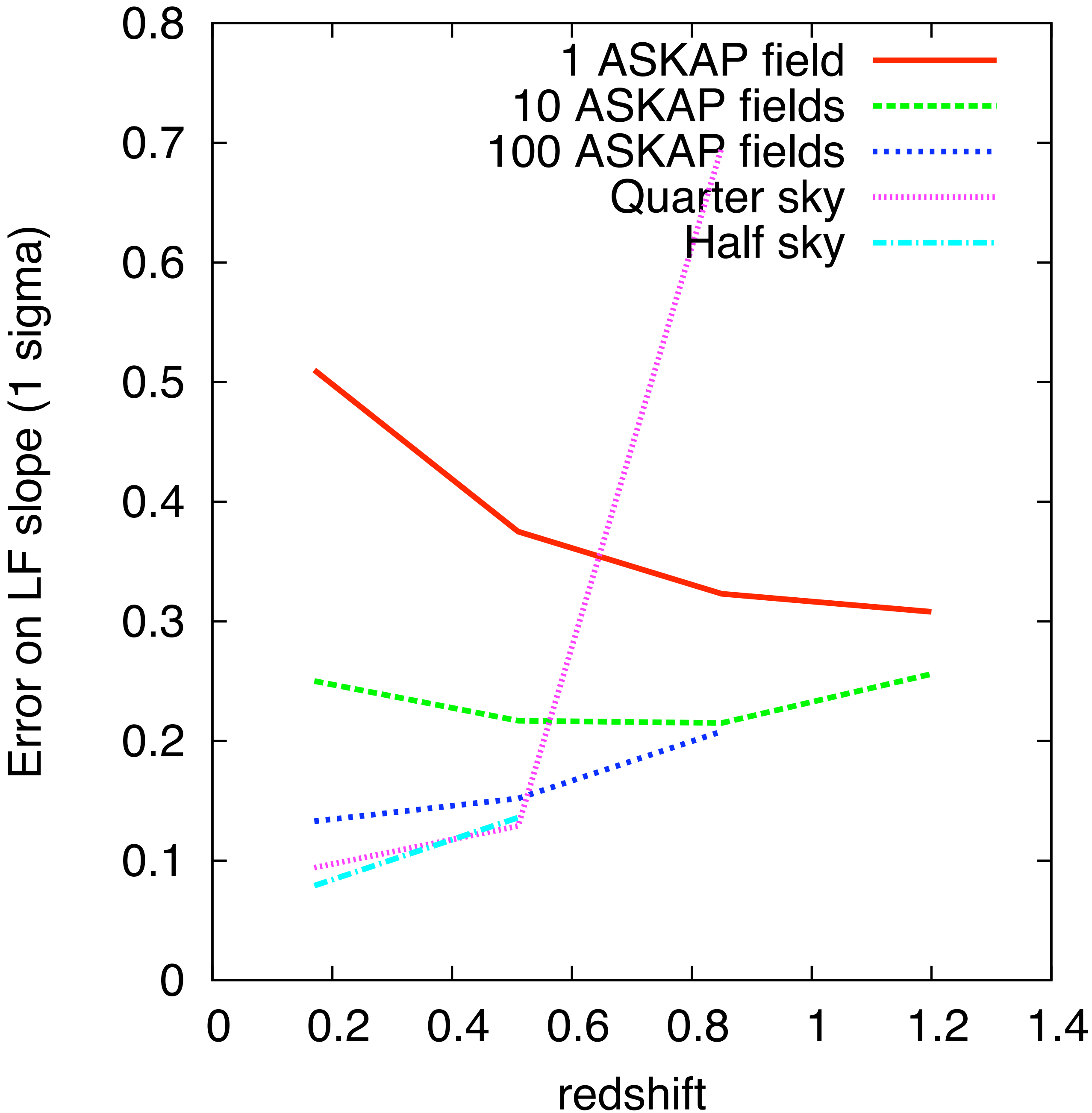
Given the changing nature of galaxies (dusty at higher z, increased SFR), there is likely to be luminosity evolution of the OH maser luminosity function.

$$L_{OH} \propto L_{FIR}^{\gamma} \qquad \gamma = 1 \text{ -- } 2$$





Uncertainty on the LF slope



For a fixed survey time of 2100 hours.

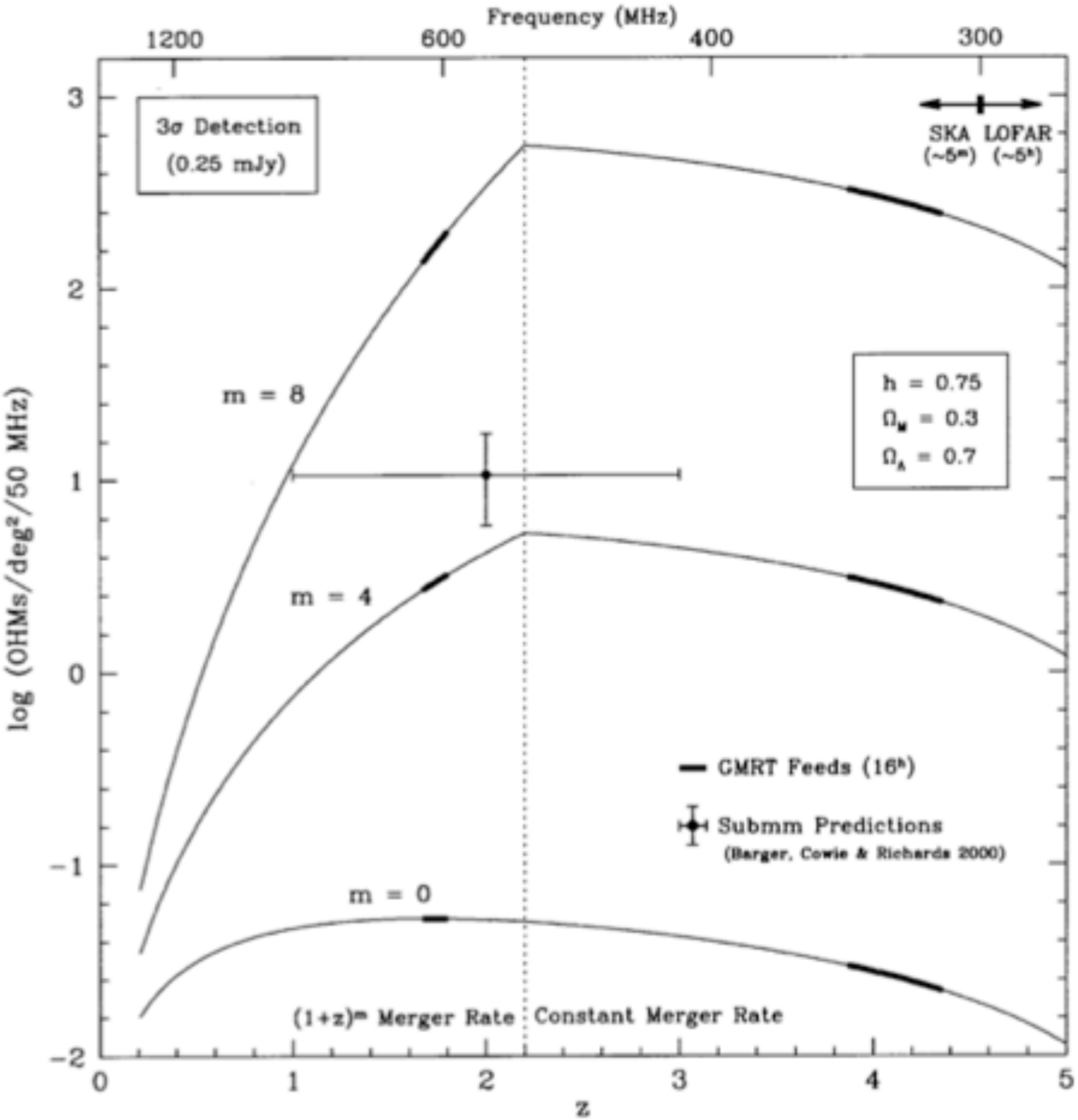
One ASKAP field is not so useful.

10 ASKAP fields provide good coverage of LF over all redshifts

100 ASKAP fields give good constraints at low-z.

Quarter and half sky surveys provide similar results.

Current prospects



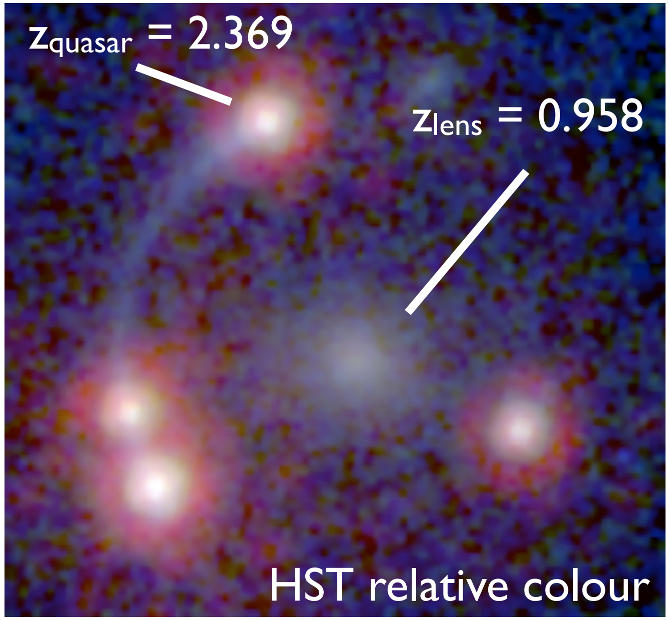
Blind (16 hr) observation of a single field with e.g. the GMRT.

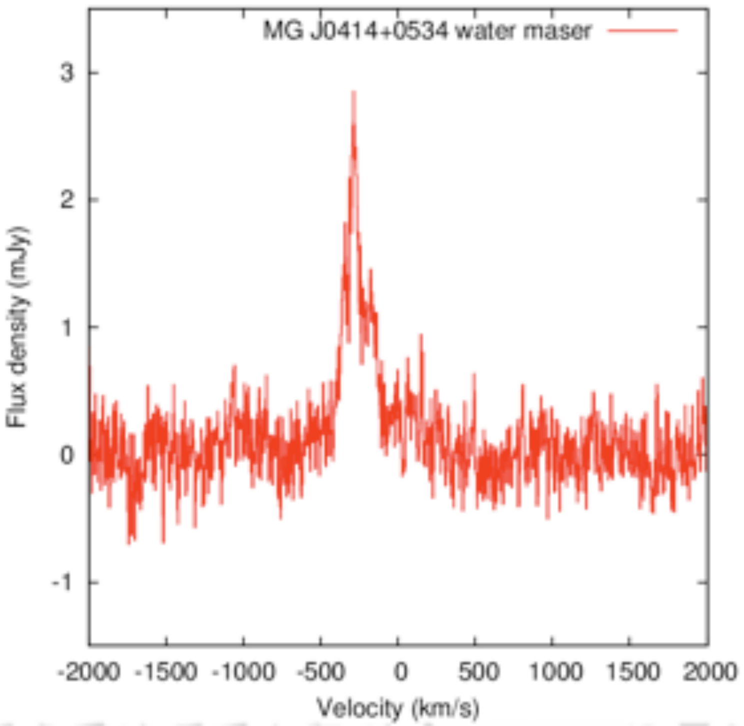
Can differentiate between evolutionary models.

Non-detections still a constraint!

Darling & Giovanelli 2002

OH in the high redshift Universe





Gravitational lensing can be used to magnify distant OH maser galaxies to be detected with current telescopes (e.g. GMRT, VLA, WSRT)

Finding even a single lensed OH maser system can place a useful constraint on the evolution parameter *m*.

This technique found the most distant water maser known at z = 2.64 (Impellizzeri et al., Nature, 2008).

Summary and issues

- ★ Surveys with *Apertif* and ASKAP have the potential to find 10000s of OH megamaser galaxies with modest integration times.
- ★ These OH maser galaxies can be used to investigate the merger rate of the Universe - providing luminosity evolution can be accounted for.
- ★ Much of this work can be done in tandem with wide/deep HI surveys that are planned.
- ★ The uncertainty in the luminosity function makes any solid predictions difficult to make.
- ★ Identifying the OH maser galaxies in optical/IR/FIR fields could be an issue.
- ★ Interested? - join the extragalactic OH maser projects (see Alan Roy for ASKAP).