ATCA 3 & 12mm Observations of High Redshift Objects

- **Highly Redshifted Molecular Absorption Systems**
- **Quasar Flux Measurements**

Steve Curran
School of Physics
University of New South Wales

Collaborators

Michael Murphy (UNSW)

John Webb (UNSW)

Lister Staveley-Smith (ATNF)

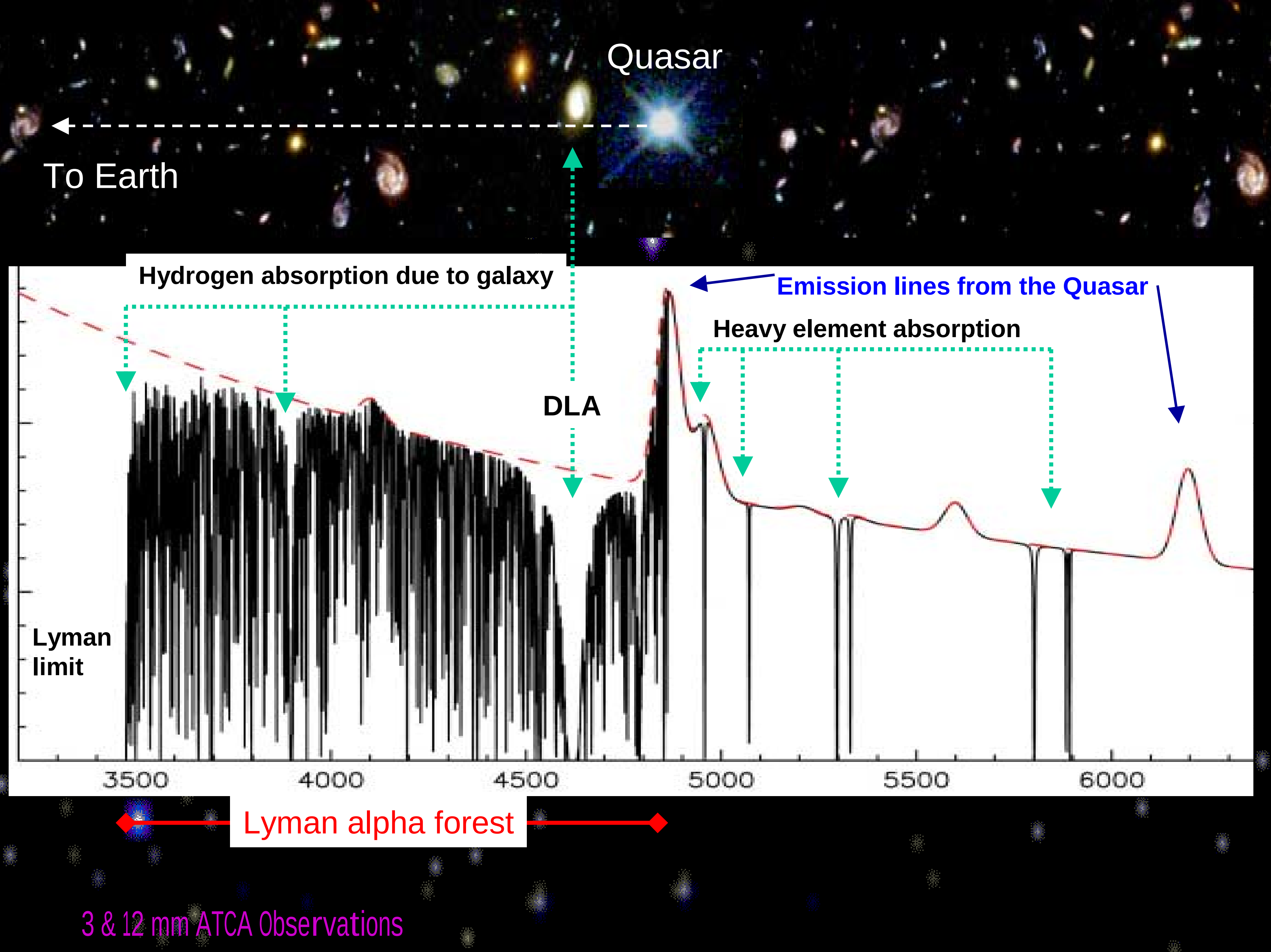
Fredrik Rantakyroe (ESO/Univeridad de Chile)

Ylva Pihlstroem (NRAO)

Lars E. B. Johansson (Onsala Space Observatory)

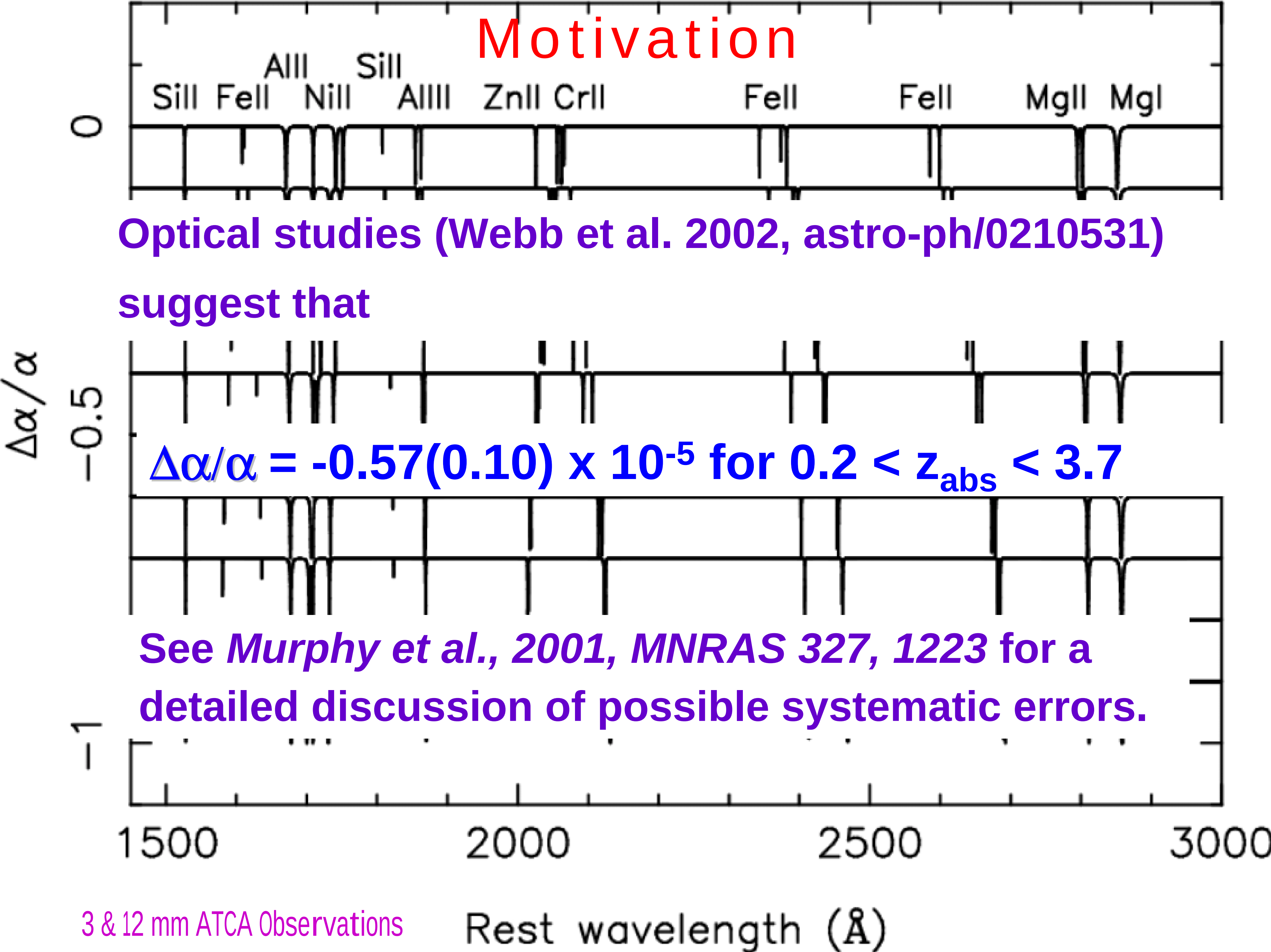
Silvana Nikolic (Onsala Space Observatory)

Special thanks to Tony Wong & Bob Sault



Quasar
To Earth
Hydrogen absorption due to galaxy
Emission lines from the Quasar
Heavy element absorption
DLA
Lyman limit
3500
4000
4500
5000
5500
6000
Lyman alpha forest
3 & 12 mm ATCA Observations

Motivation



Optical studies (Webb et al. 2002, astro-ph/0210531) suggest that

$\Delta\alpha/\alpha$ = -0.57(0.10) x 10^{-5} for 0.2 < z_{abs} < 3.7

See *Murphy et al., 2001, MNRAS 327, 1223* for a detailed discussion of possible systematic errors.

Using Radio Observations

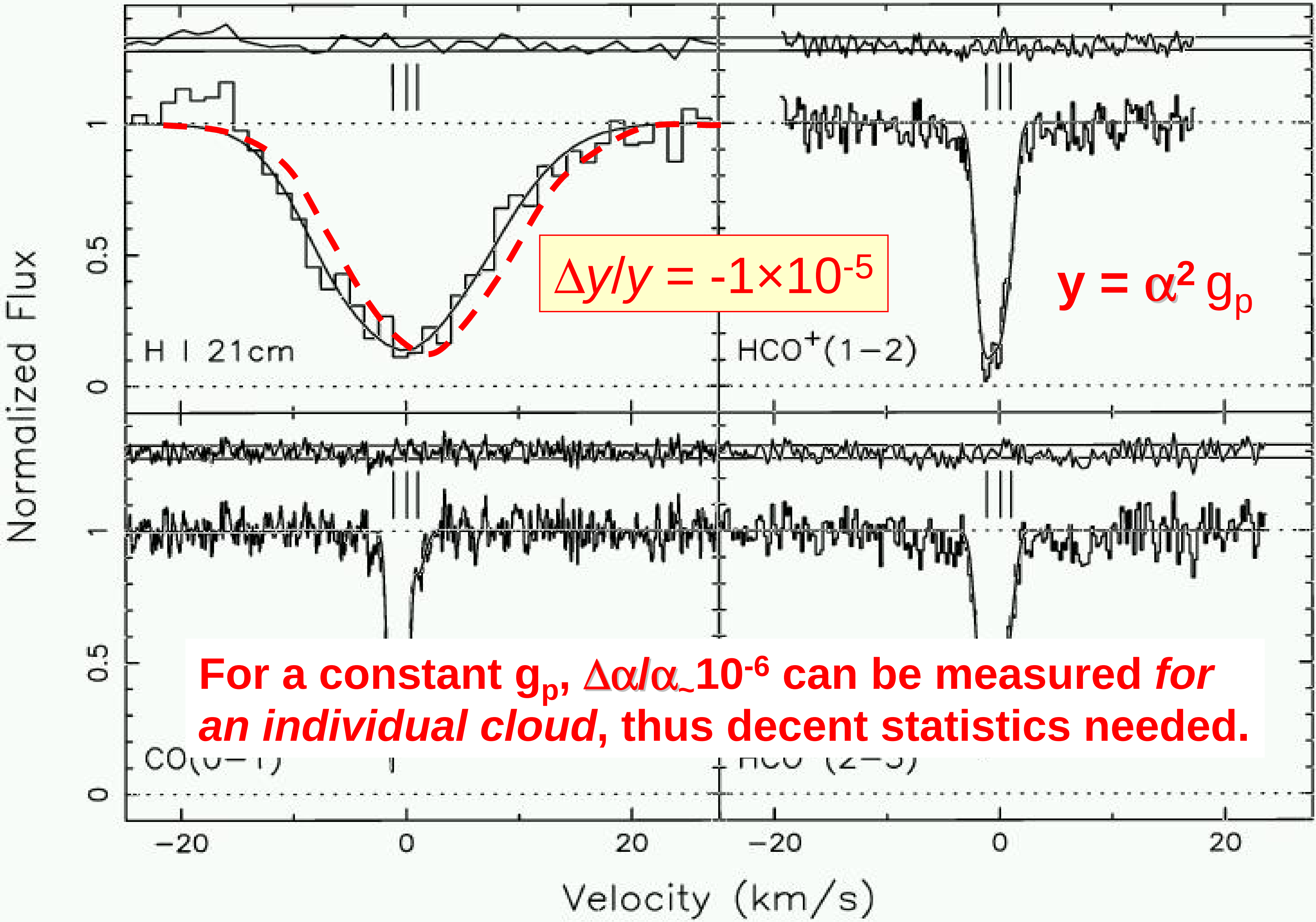
Two Different Optical Transitions

Difference in α due to relativistic correction of the energy levels (around 10% of the levels).

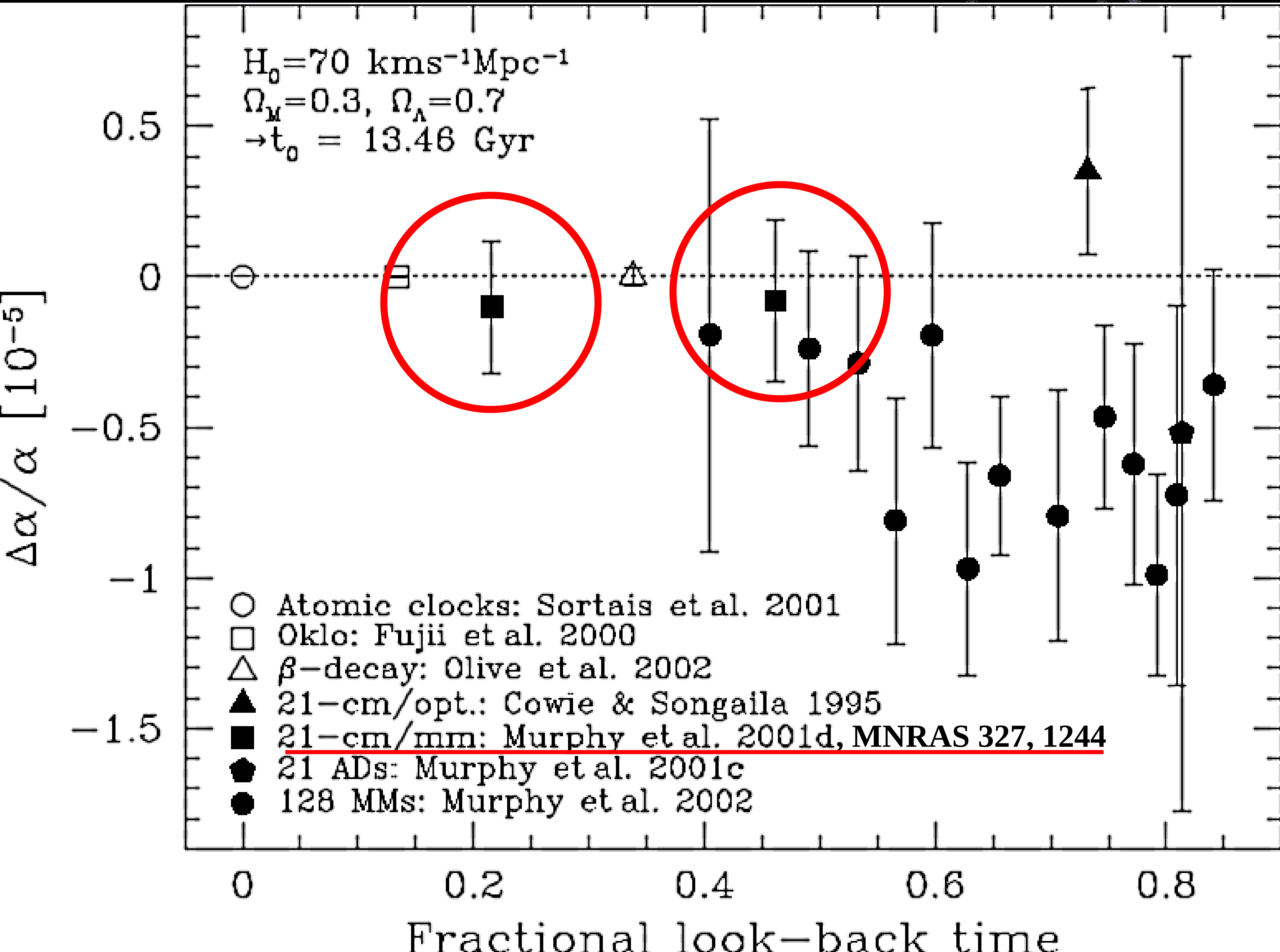
Hyperfine (HI) c.f. Rotational Line Transition

Difference observed arises from actual energy levels. Ratio of $\Delta\nu$ `s is proportional to $\alpha^2 g_p$.

That is, radio measurements are an order of magnitude more sensitive than the optical.
See *Drinkwater et al., 1998, MNRAS 295, 457.*



3 & 12 mm ATCA Observations



H0=70 kms-1Mpc-1
ΩM=0.3, ΩΛ=0.7
→t0 = 13.46 Gyr
0.5
0
−0.5
−1
−1.5
Δα/α [10−5]
Atomic clocks: Sortais et al. 2001
Oklo: Fujii et al. 2000
β−decay: Olive et al. 2002
21−cm/opt.: Cowie & Songaila 1995
21−cm/mm: Murphy et al. 2001d, MNRAS 327, 1244
21 ADs: Murphy et al. 2001c
128 MMs: Murphy et al. 2002
0
0.2
0.4
0.6
0.8
Fractional look−back time

High Redshift Molecular Absorption Systems, can also be used for…

1. Check the Big Bang model prediction that $T_{CMB}(z) = 2.7(1 + z)$ K.

2. Time delay studies of gravitational lenses giving a value of H_0.

3. Constrain temporal variations of proton and neutron masses.

4. … and of course, chemistry, physics and molecular cloud properties in the high redshift Universe.

See *Wiklind & Combes, 1997, A&A 328, 48*

A Systematic Search for New Absorption Systems

Compiled a catalogue of damped Lyman-alpha absorbers (DLAs) along with the radio fluxes of the background quasars (*Curran et al. 2002, PASA 19, 455*)

Online version can be accessed from
http://www.phys.unsw.edu.au/~sjc/dla/

That is, we have a sample of absorption systems of known redshifts and $N_{HI} > 10^{20}$ cm^{-2} from which to short-list those illuminated by quasars emitting strongly at centimetre and millimetre wavelengths.

ATCA Observations Towards DLAs

Although the 3 & 12 mm bands are still very limited, the ATCA has been used for 2 main projects…

1. **Searching for new molecular absorption systems (z~3)**

HCO^+ 0-1 absorption in DLAs (12 mm)

Molecular (CO 2-3 and HCO^+ 3-4) absorption in host QSO (3 mm)

2. **Millimetre flux measurements of quasars illuminating DLAs**

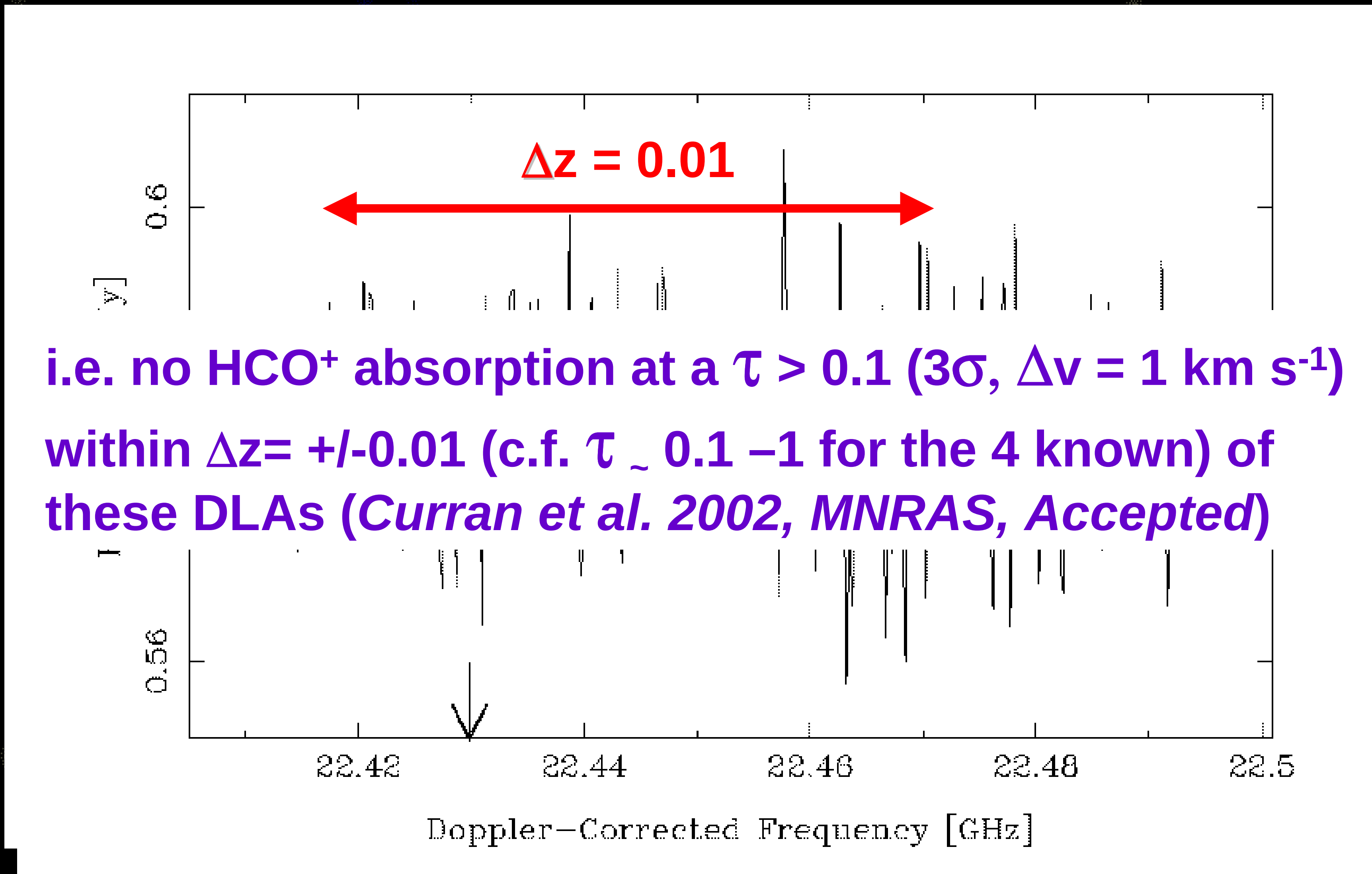
HCO^+ 0-1 Absorption at z~3 in DLAs

Last June observed the 3* DLAs, illuminated by 12 mm-loud quasars at $\delta < 30^0$.

Quasar	z_{abs}	ν_{obs}(GHz)	V	S_{22}(Jy)
0201+113	3.3869	20.331	19.5	0.59
0336-017	3.0619	21.958	18.8	0.15
0537-286	2.976	22.43	19.0	0.58

*If the full 16-22.5 GHz were available there are 12 DLAs known to occult mm-loud quasars which have at least one commonly detected transition (CO, HCO+, HCN) falling into this band.

Had to sacrifice a polarisation and splice 2x64 MHz in order to cover the redshift uncertainty while retaining $\Delta v = 3.4$ km s^{-1}



i.e. no HCO^+ absorption at a $\tau > 0.1$ (3σ, $\Delta v = 1$ km s^{-1}) within $\Delta z = +/-0.01$ (c.f. $\tau \sim 0.1 - 1$ for the 4 known) of these DLAs (*Curran et al. 2002, MNRAS, Accepted*)

Quasar Millimetre Flux Measurements

1. **By measuring the mm fluxes of the DLAs occulting radio-loud quasars (S_{5GHz} > 0.1 Jy) we can select further candidates in which to look for absorption.**

2. **Combining the ATCA 20 & 90 GHz fluxes (Aug '02) with SIMBA 250 GHz (observed 3 weeks ago), for > 50 quasars:**

Can obtain SEDs for this sample which spans a wide range of redshifts.

→ Spectral type of each source and possible dust excess.

3 & 12 mm ATCA Observations

Summary and Future Projects

In searching for new high redshift molecular absorption systems:

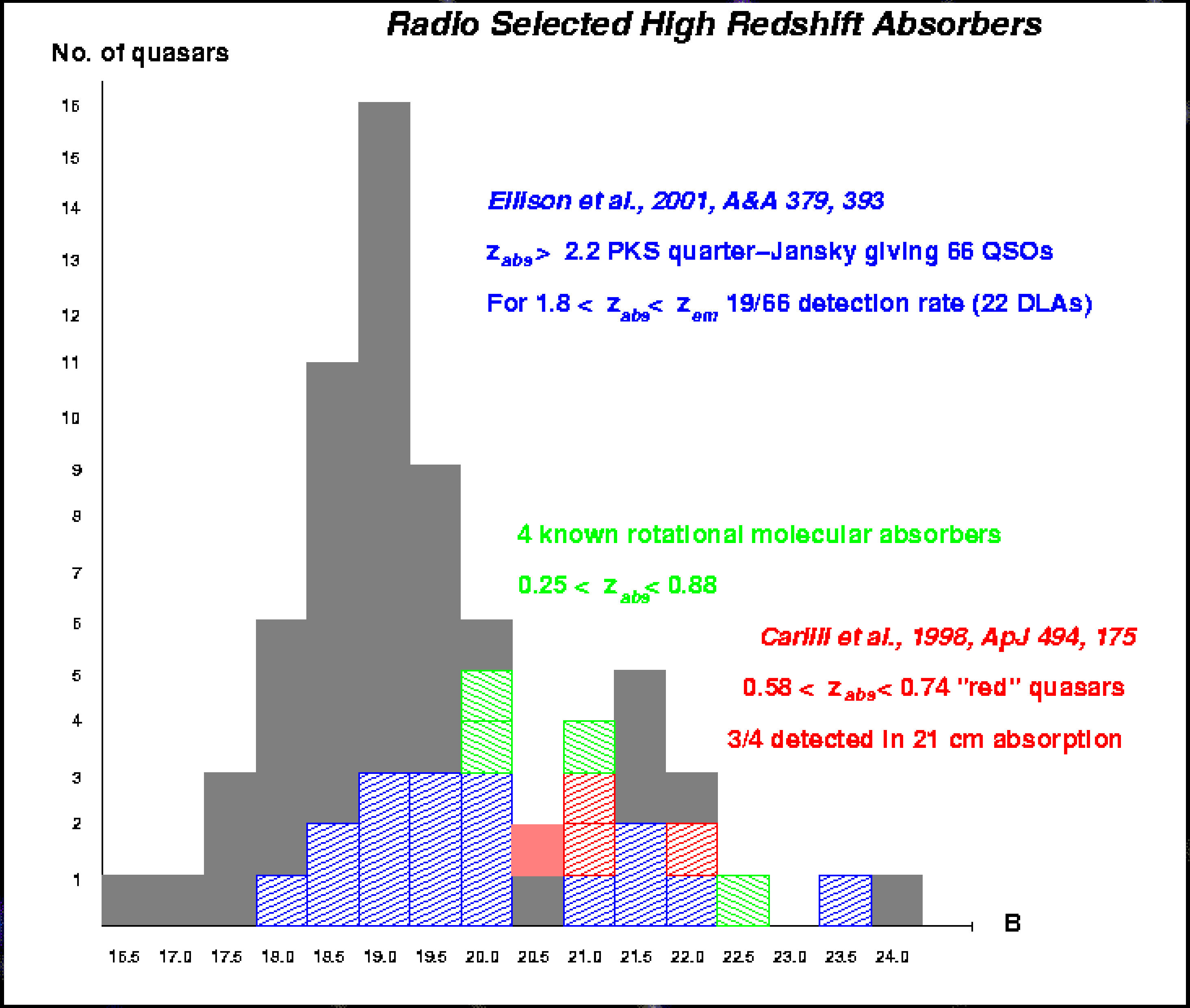
For the 3 DLAs (V = 18.8 – 19.5) searched at 12 mm no molecular absorption found.

Still to analyse 3 mm search at emission redshift of 2 mm-loud QSOs occulted by DLAs (V = 18.8 & 19.0).

These targets have been dictated by the currently limited tuning range of the ATCA. Once increased…

Strong MgII absorbers (V~20) which fall into the range.

With a 2 GHz band and 5 antennae, ATCA will be ideal for scanning towards optically unidentified (V > 20) quasars for new systems of unknown redshift.



3 & 12 mm ATCA Observations