Neutral Hydrogen Gas in Star Forming Galaxies at z=0.24

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HI Survival Through Cosmic Times Conference

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Talk Outline

Star Forming Galaxies at z = 0.24

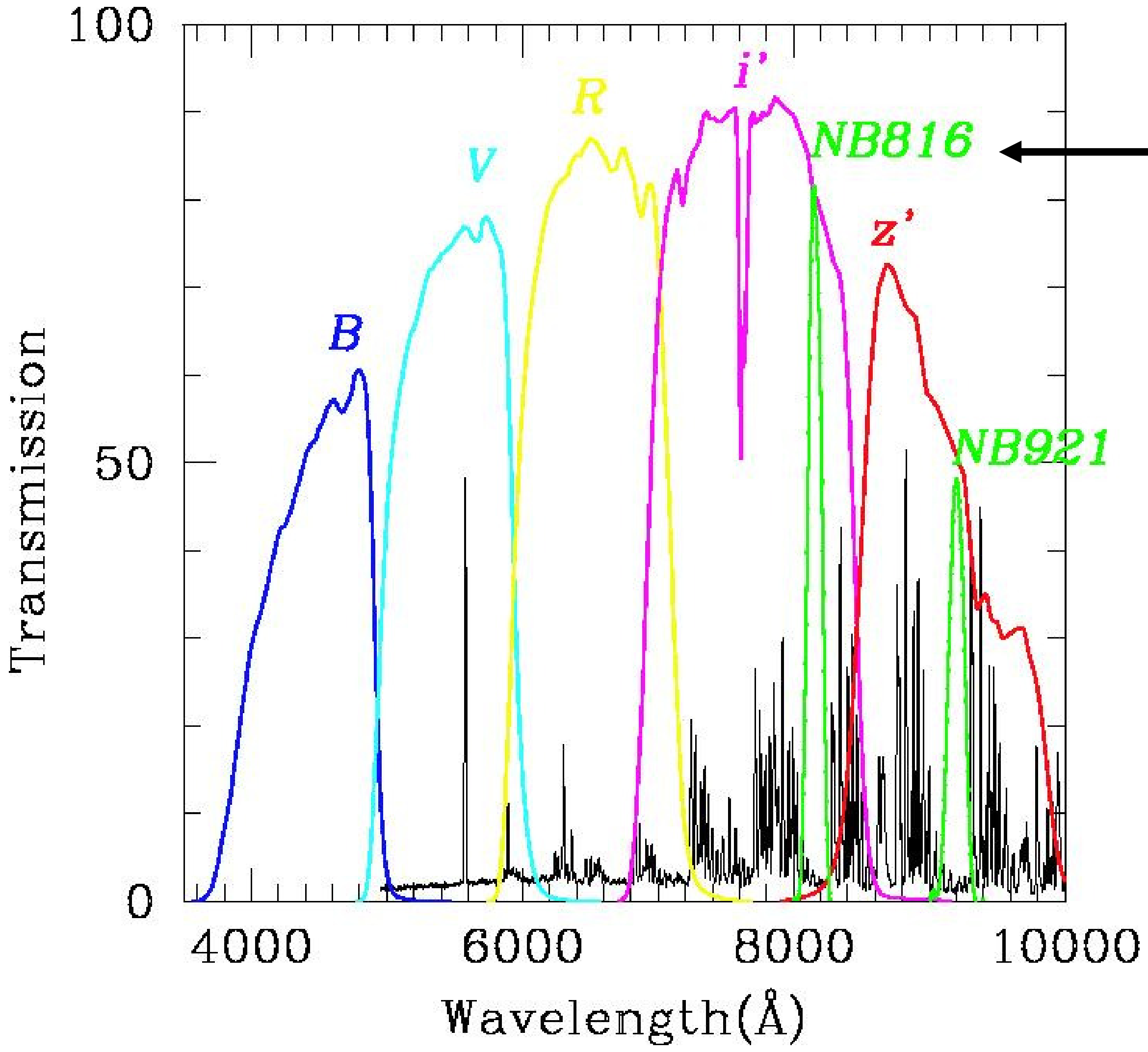
- ‘Fujita sample’ of star-forming galaxies
- HI mass content by ‘coadding’
- HI mass vs. star formation rate
- radio continuum at z = 0.24

HI in Abell 370, a galaxy cluster at z=0.37

The Fujita galaxies -
Hα emission galaxies

The Subaru Telescope

The Surprime-cam filters



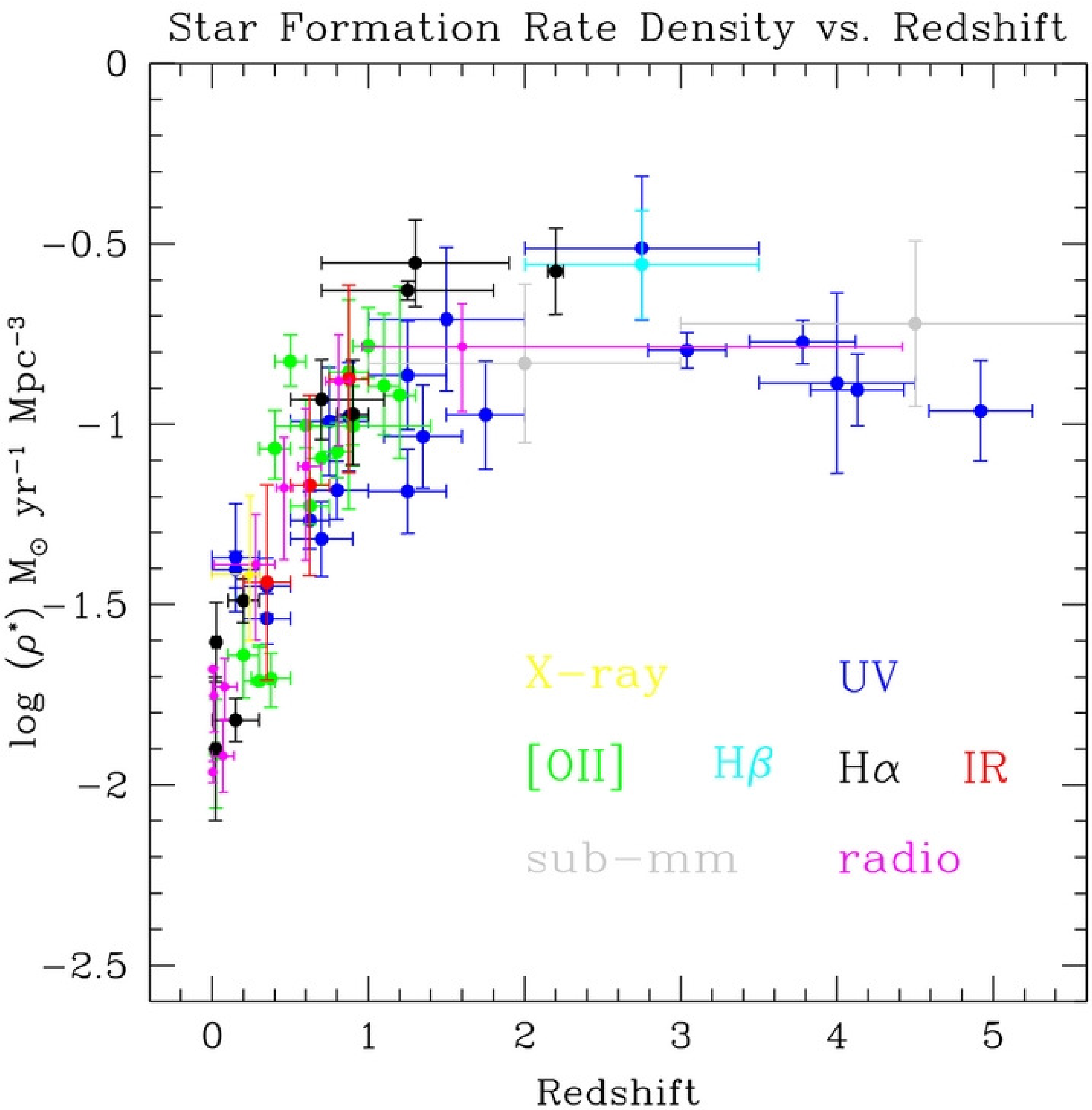
Hα at
z = 0.24

The Suprime-Cam Field

24’ × 30’

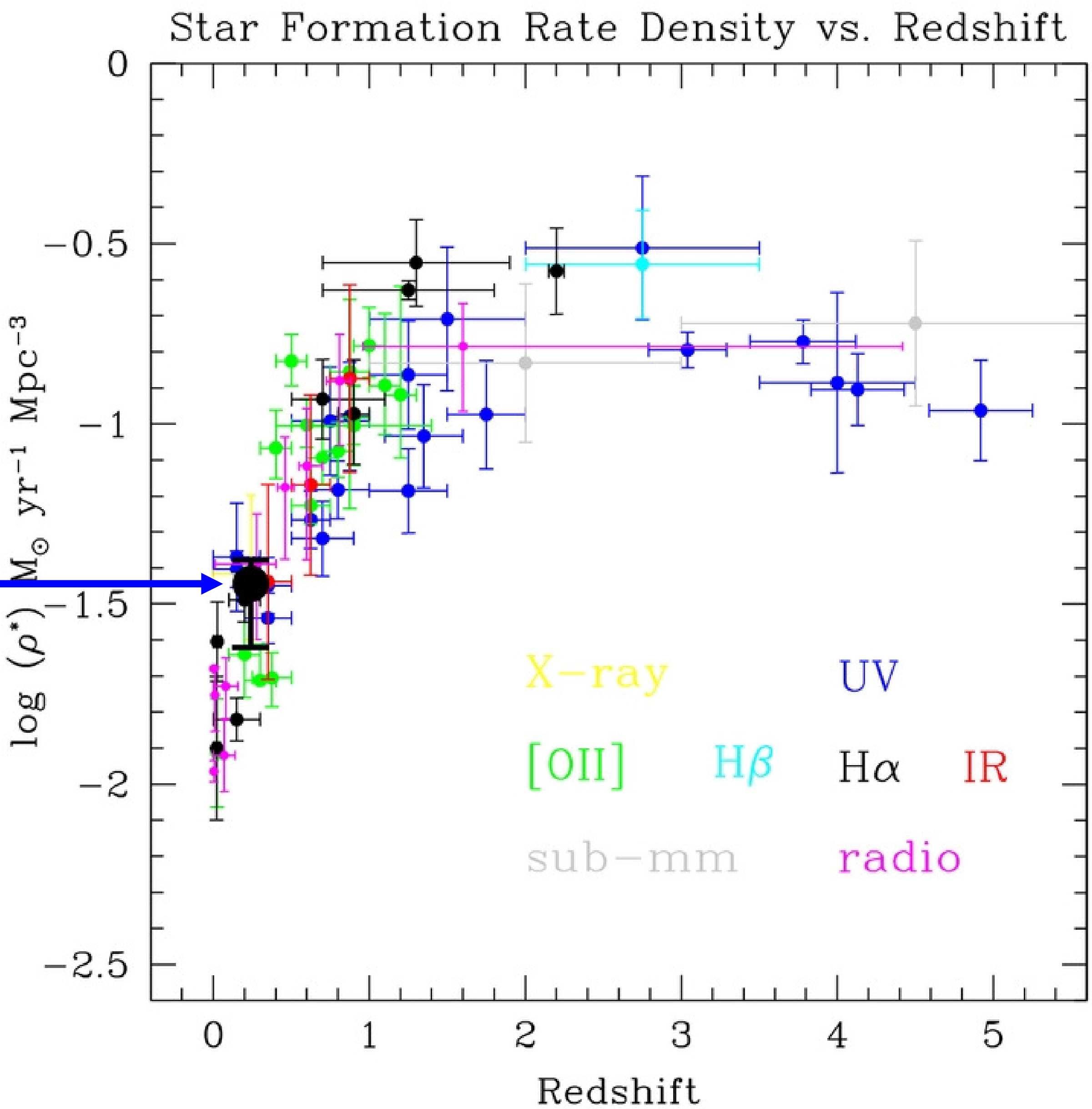
Fujita et al. 2003 narrow band imaging - Hα emission at z=0.24

348 galaxies



Hopkins 2004

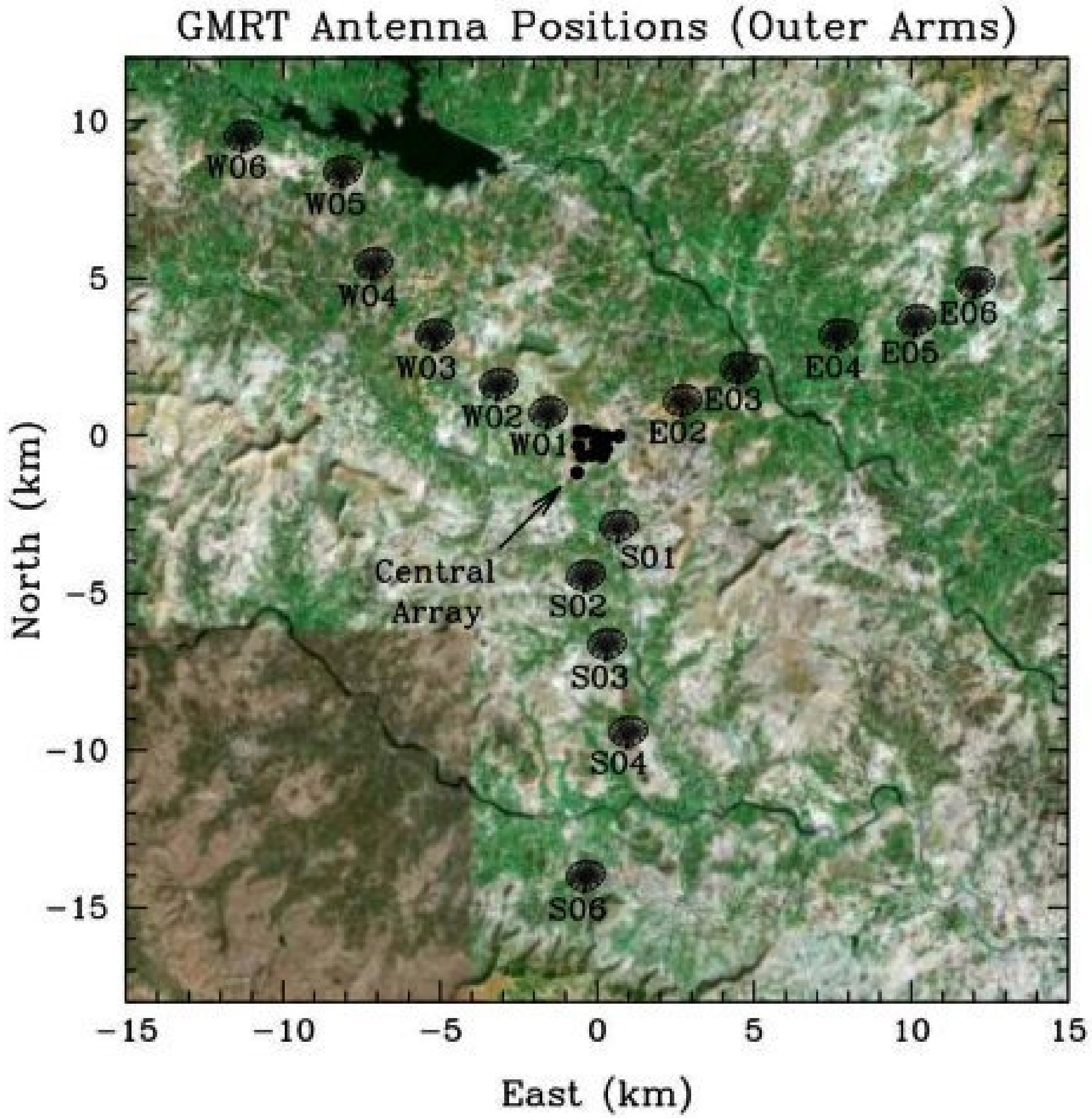
Fujita et al. 2003

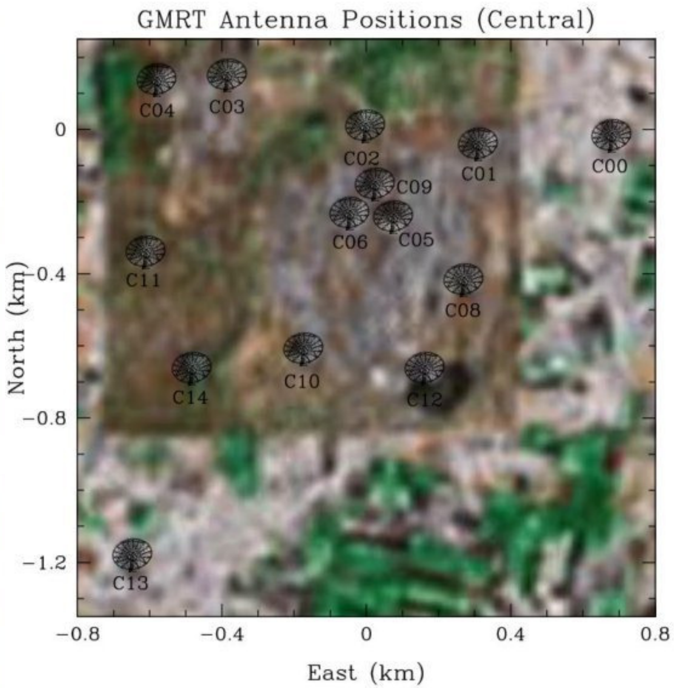


Hopkins 2004

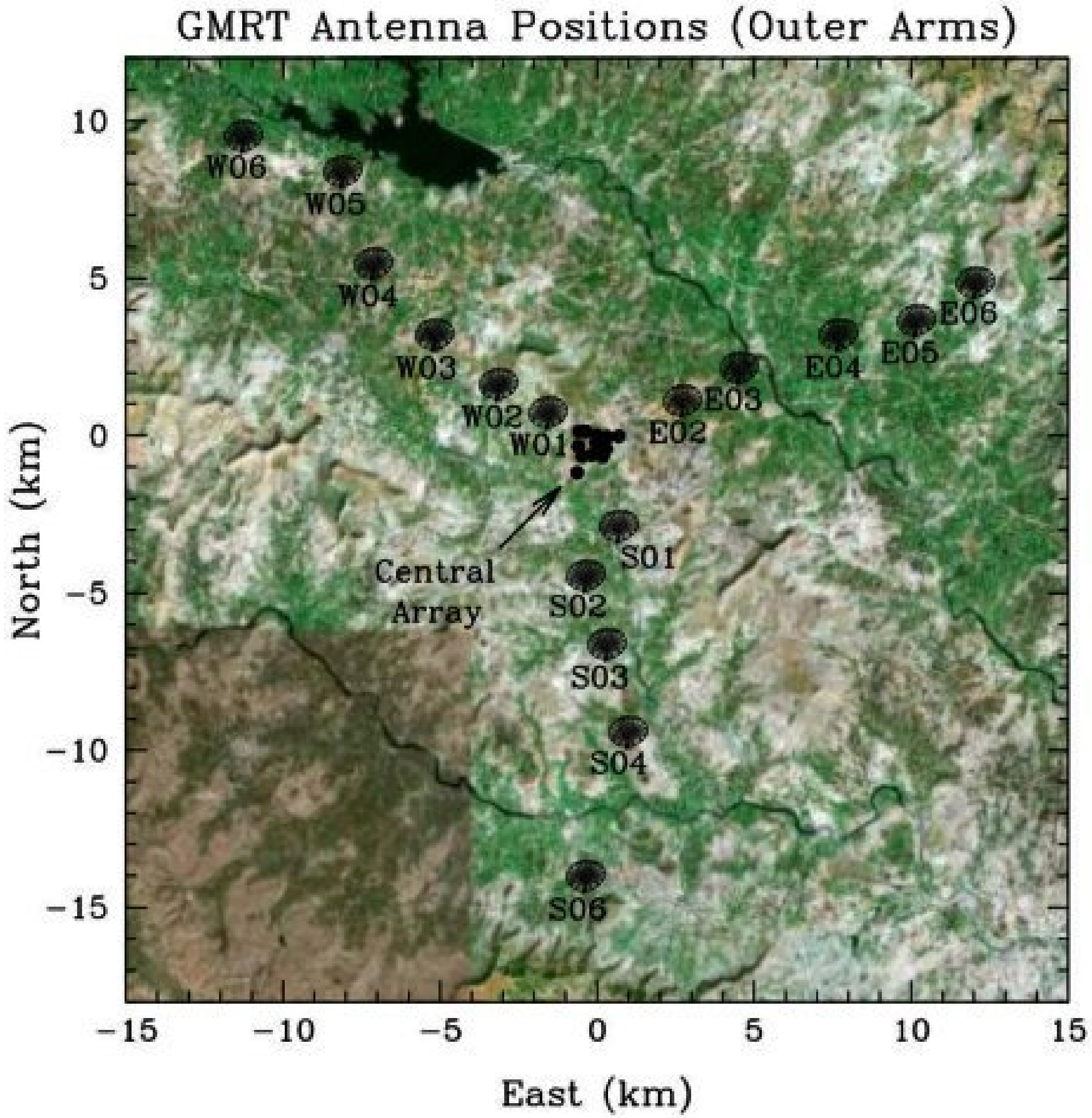
HI in the Fujita Galaxies

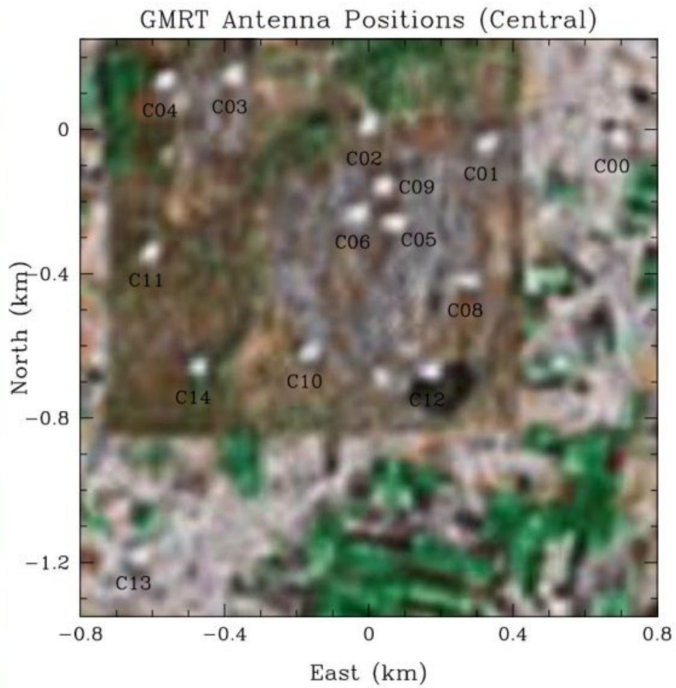
Giant Metrewave Radio Telescope





Giant Metrewave Radio Telescope





GMRT data for the field

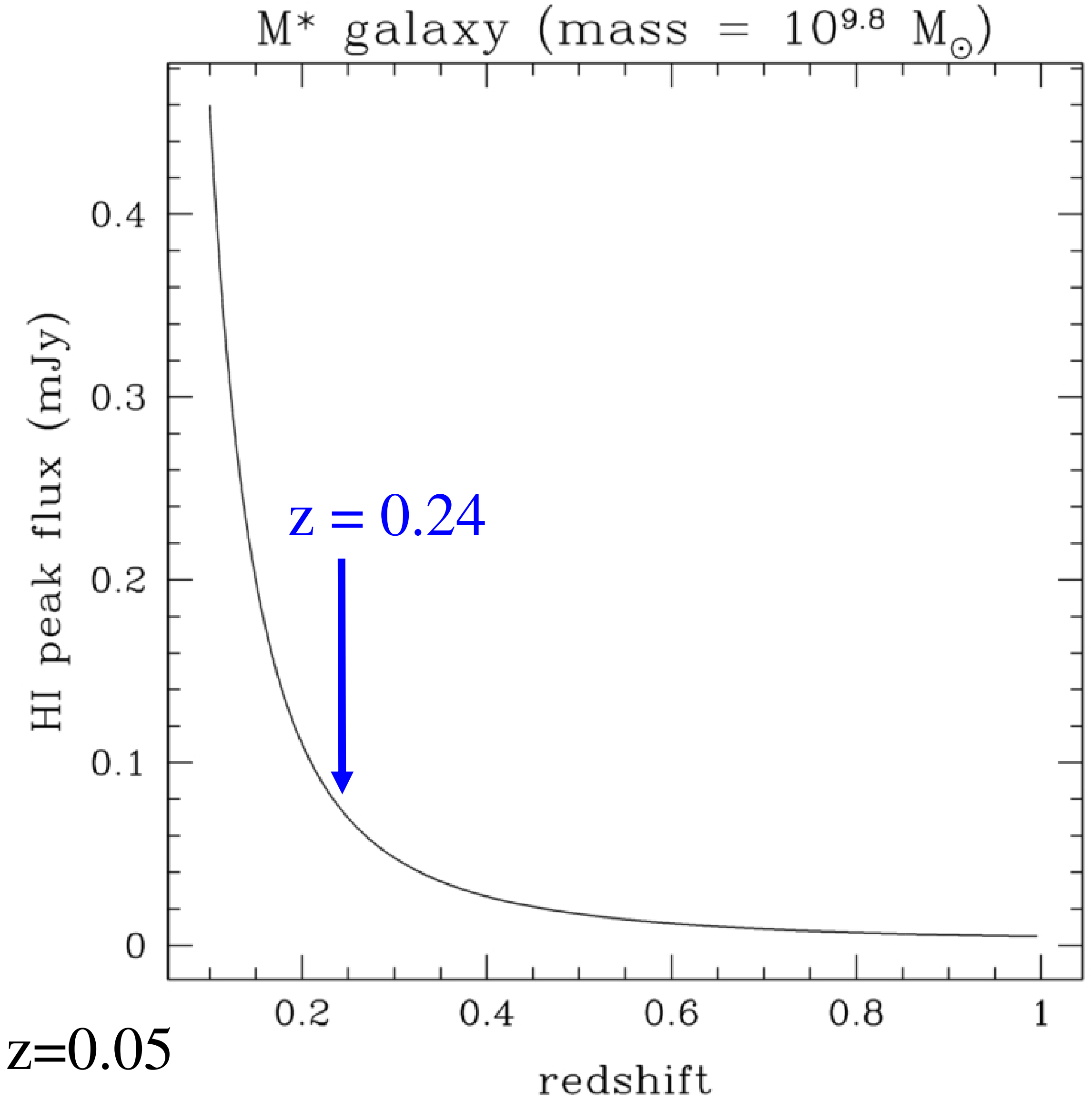
Observing Frequency	HI Redshift
1150 MHz	0.24

Time on Field
~44 hours

Primary Beam Size	Synthesis Beam Size
~29’	~2.9’’

RMS per channel
~0.13 mJy

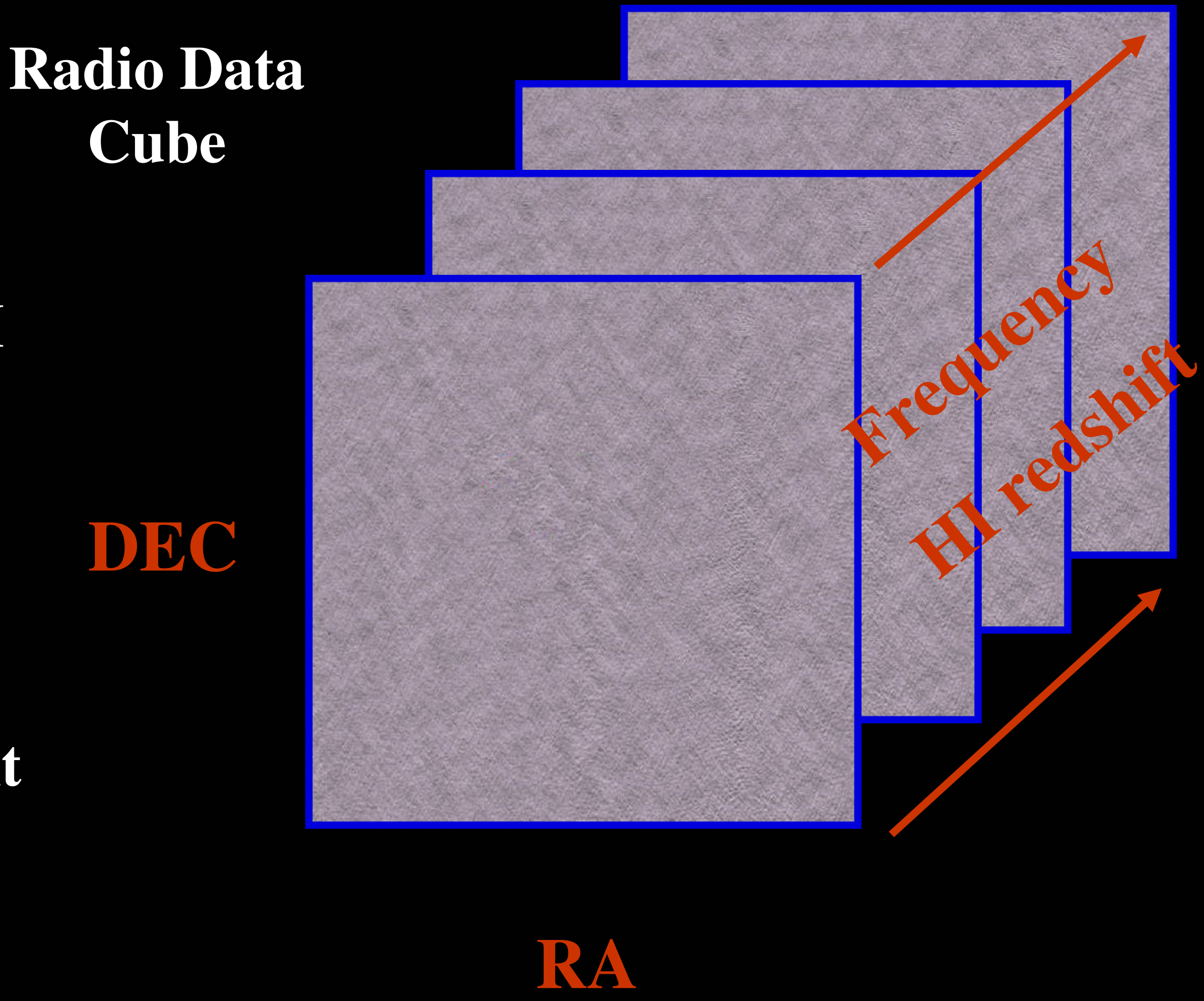
Why HI detection is hard



Coadding of HI Signals

• pick out the HI signal using optical redshifts

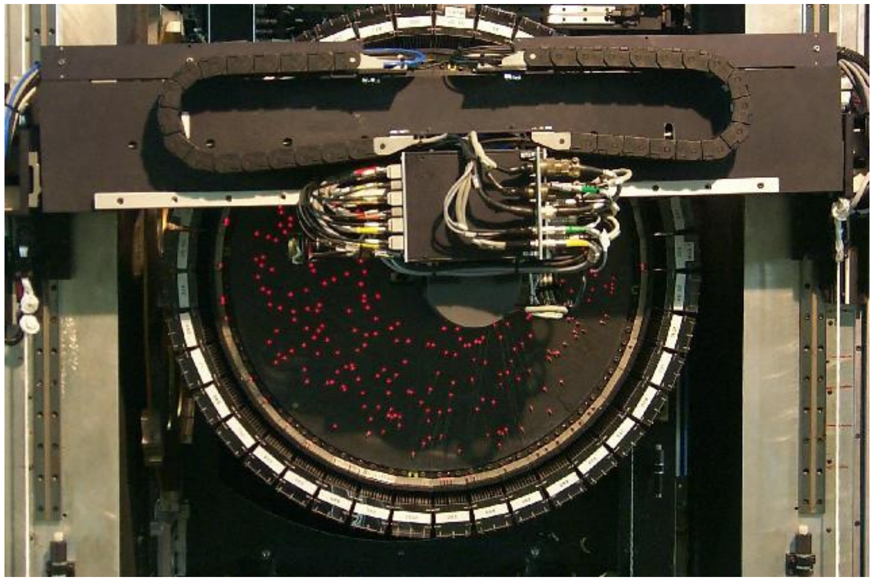
• coadd faint signals to make the measurement



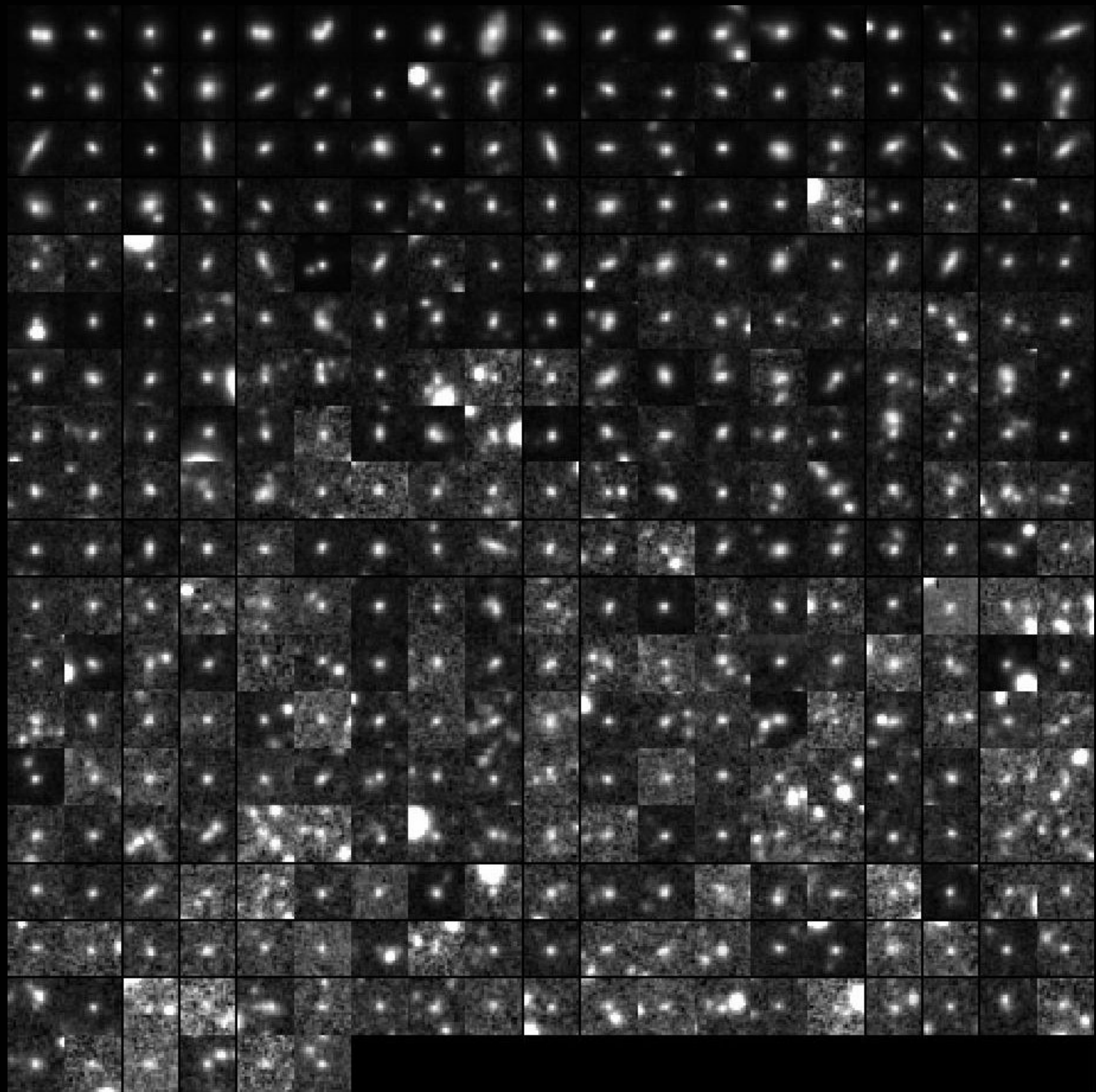
Anglo-Australian Telescope

2dF instrument

multi-object, fibre fed spectrograph



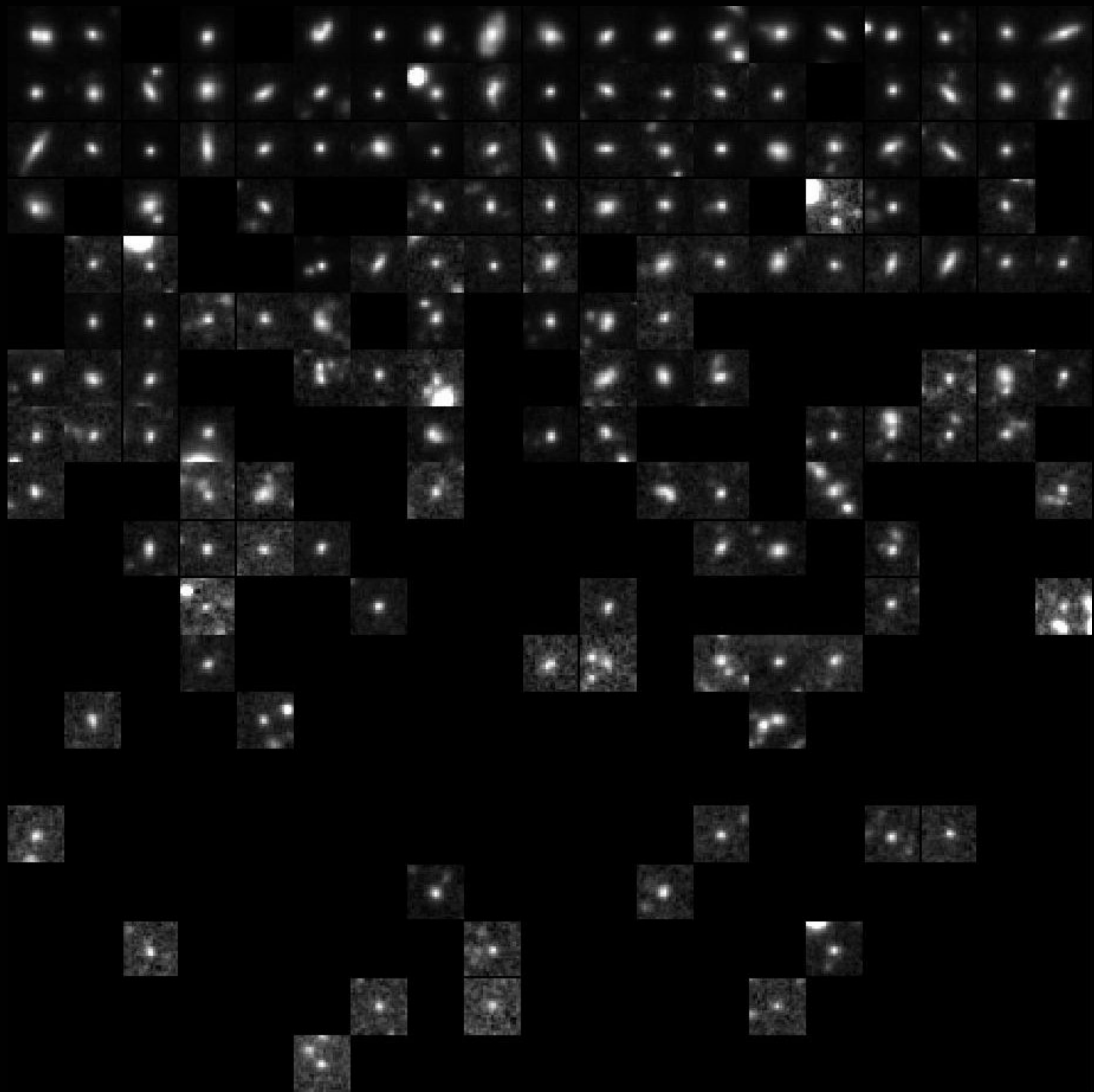
Fujita galaxies - B filter



thumbnails
10 arcsec ×
10 arcsec

ordered by
increasing
Hα
luminosity

Fujita galaxies – 2dF redshifts



154
redshifts

121
useful

thumbnails
10 arcsec ×
10 arcsec

ordered by
increasing
Hα
luminosity

Galaxy Sizes

To coadd the signal I need the galaxies to be unresolved. This allows me take the value in the radio data cube at the position and redshift of galaxy as the total HI flux.

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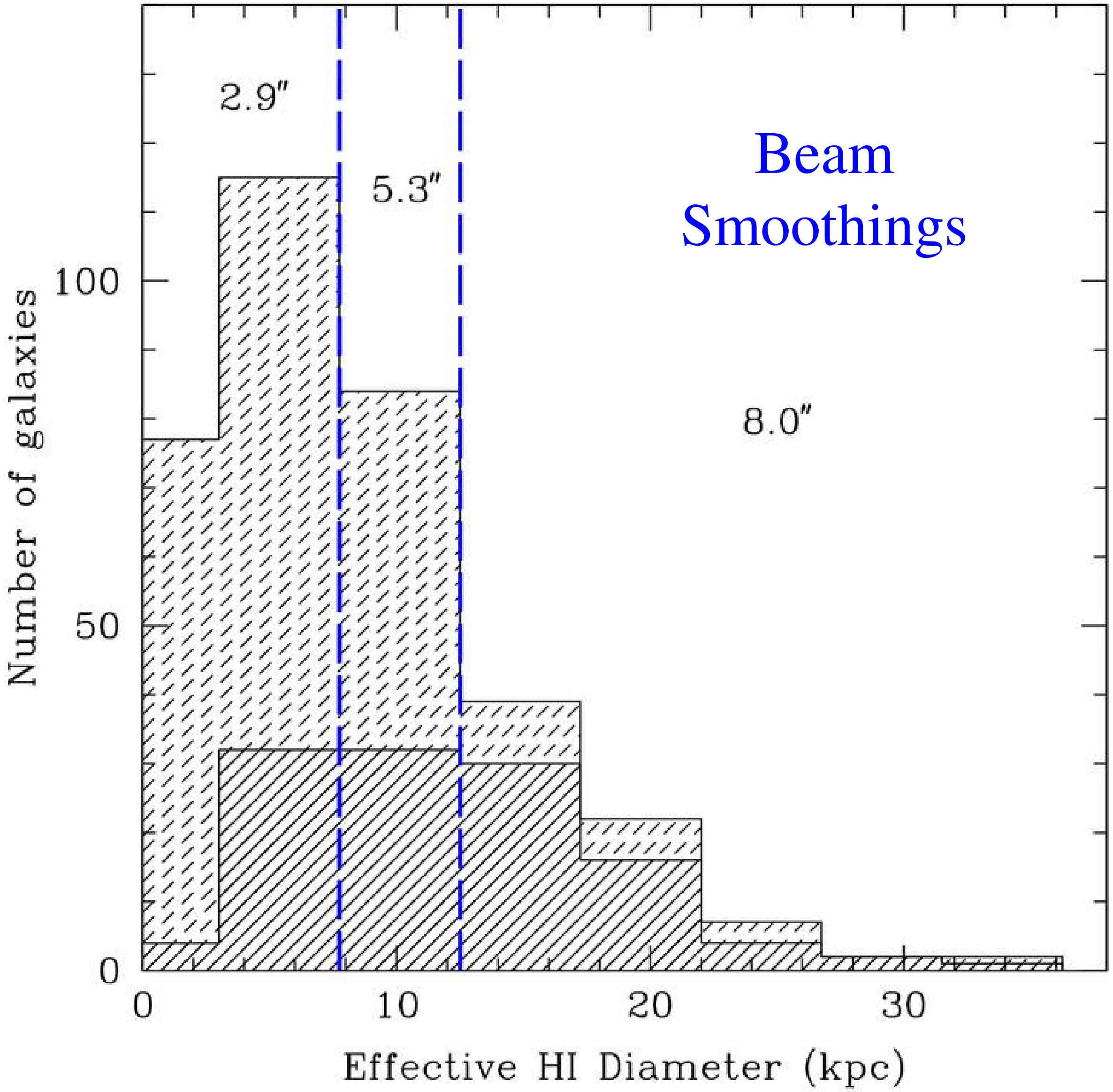
Complication!!

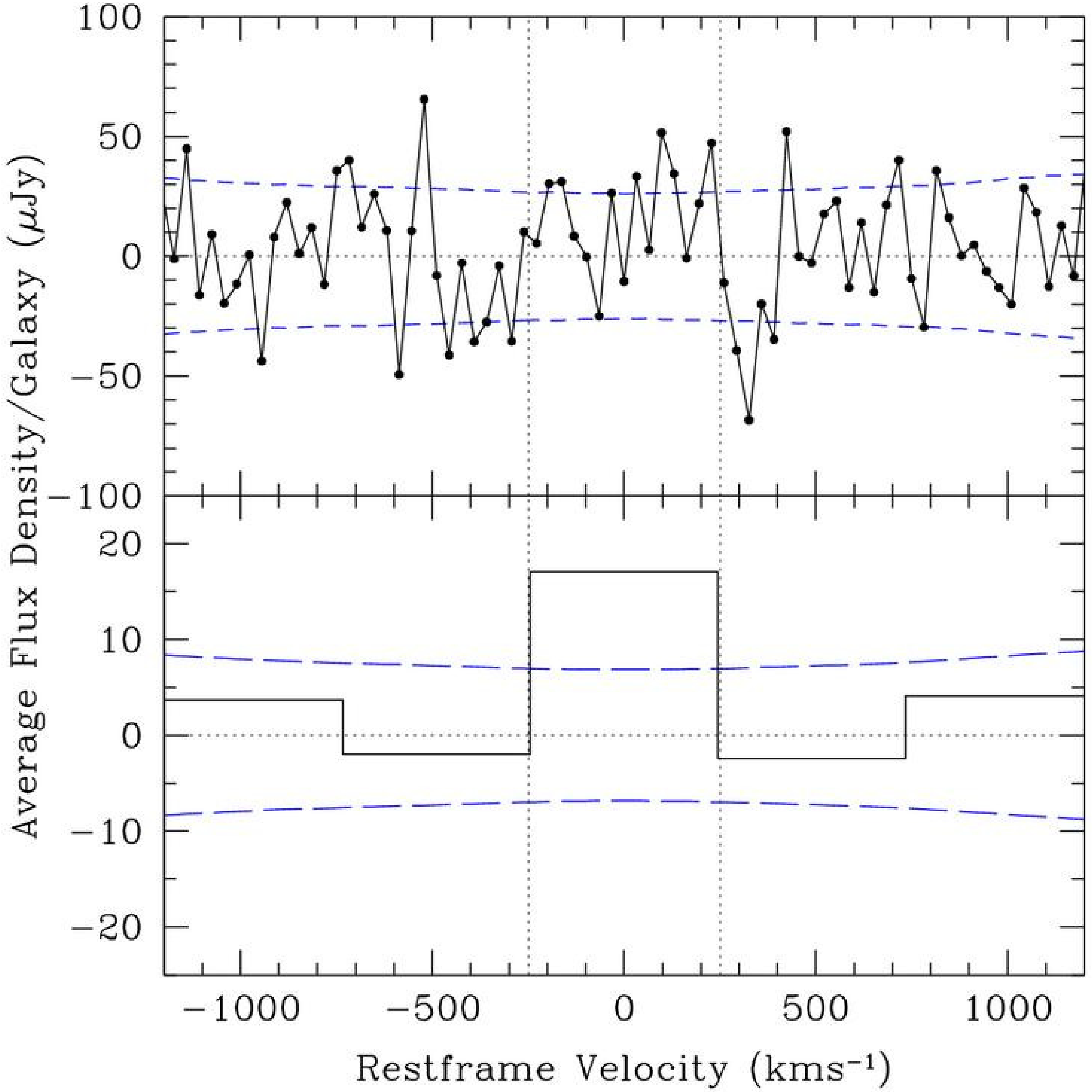
Many of the galaxies are larger than GMRT 2.9’’ synthesis beam.

Estimate of Galaxy HI Diameter



Used relationship between optical size and HI size from Broeils & Rhee 1997

Coadded
HI
Spectrum



neutral hydrogen gas measurement

using 121 redshifts - weighted average

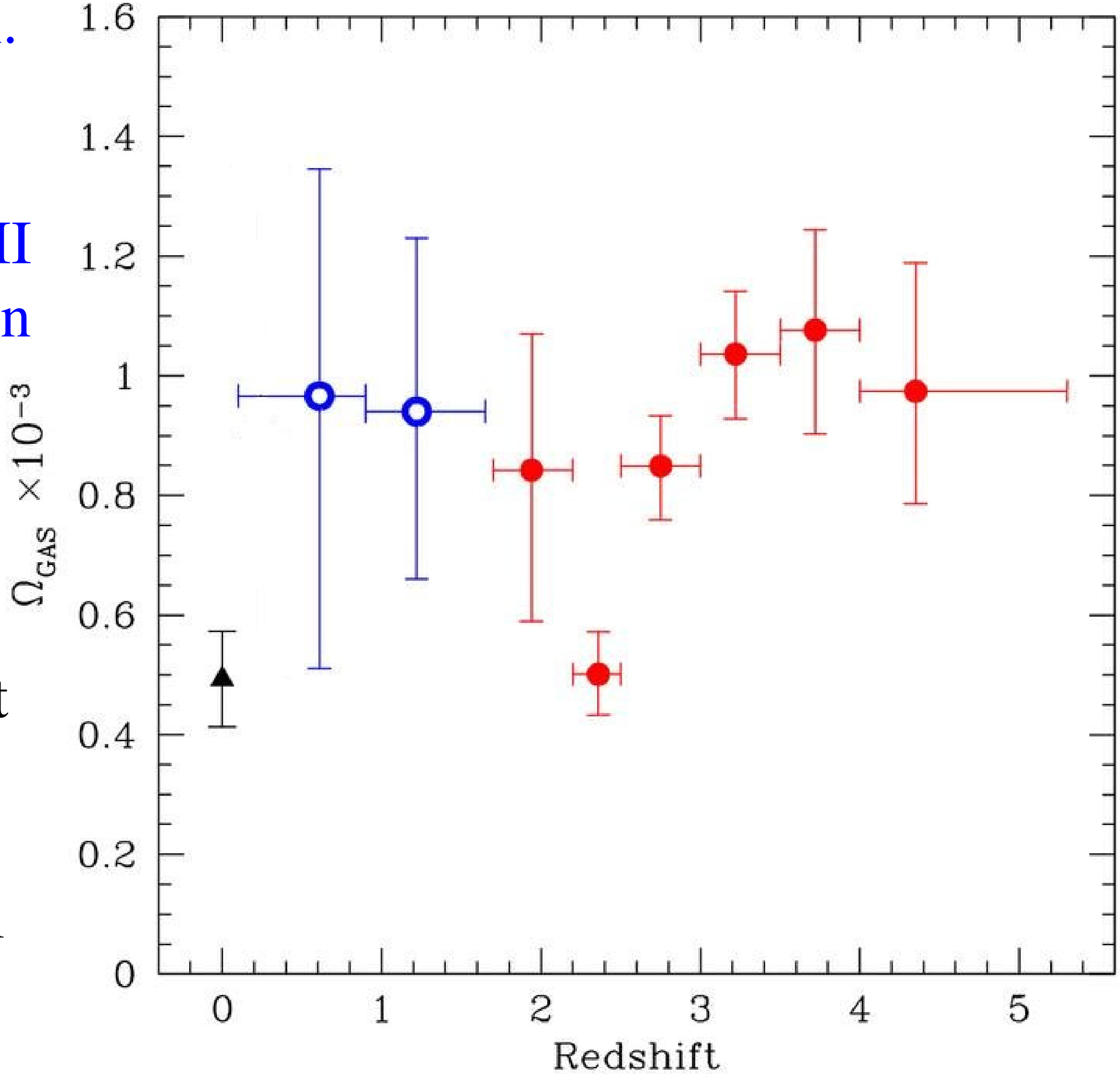
$M_{HI} = (2.26 \pm 0.90) \times 10^{9}\ M_{\odot}$

The Cosmic Neutral Gas Density

Cosmic Neutral Gas Density vs. Redshift

Rao et al. 2006 DLAs from MgII absorption

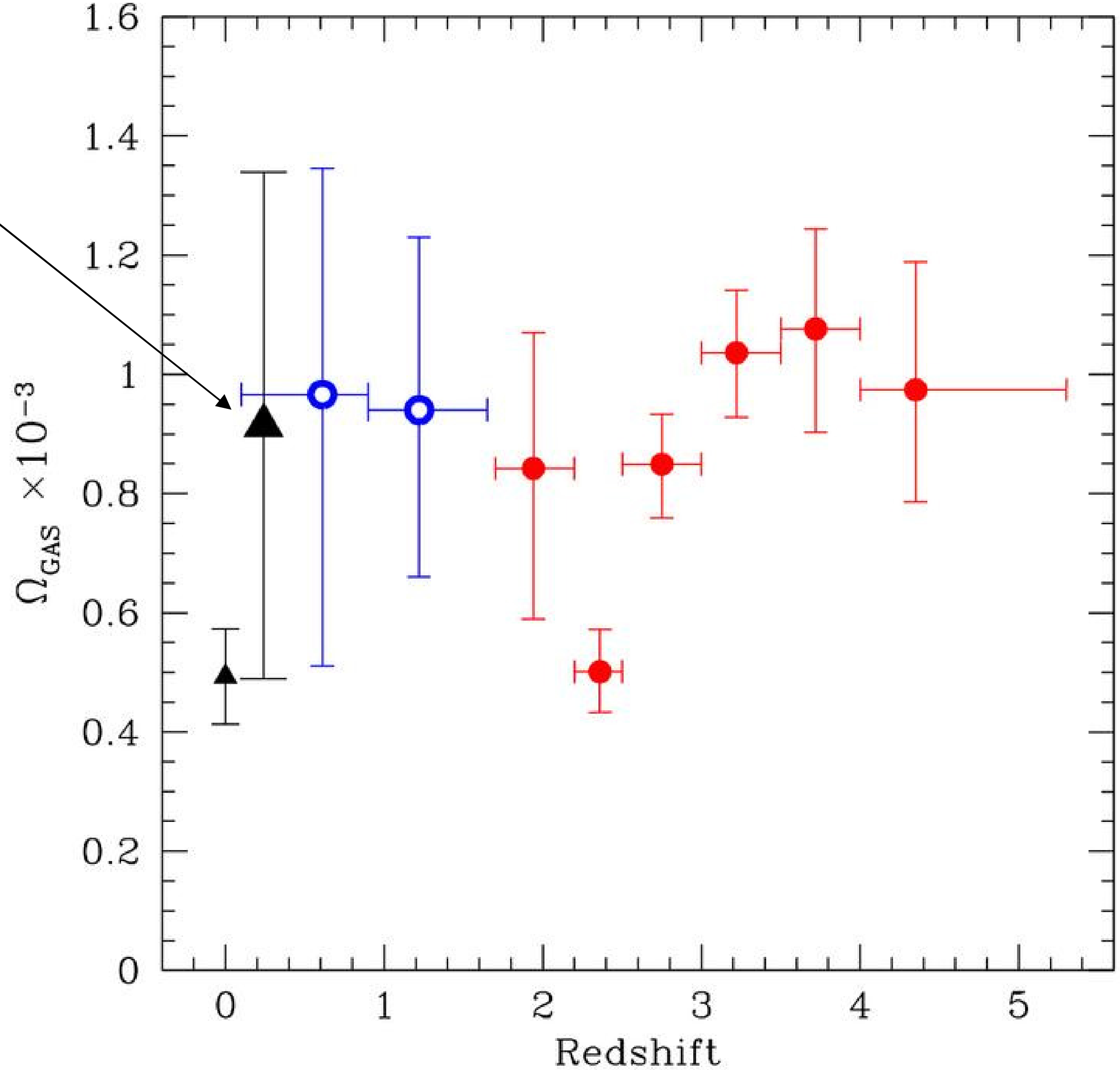
Zwaan et al. 2005 HIPASS HI 21cm



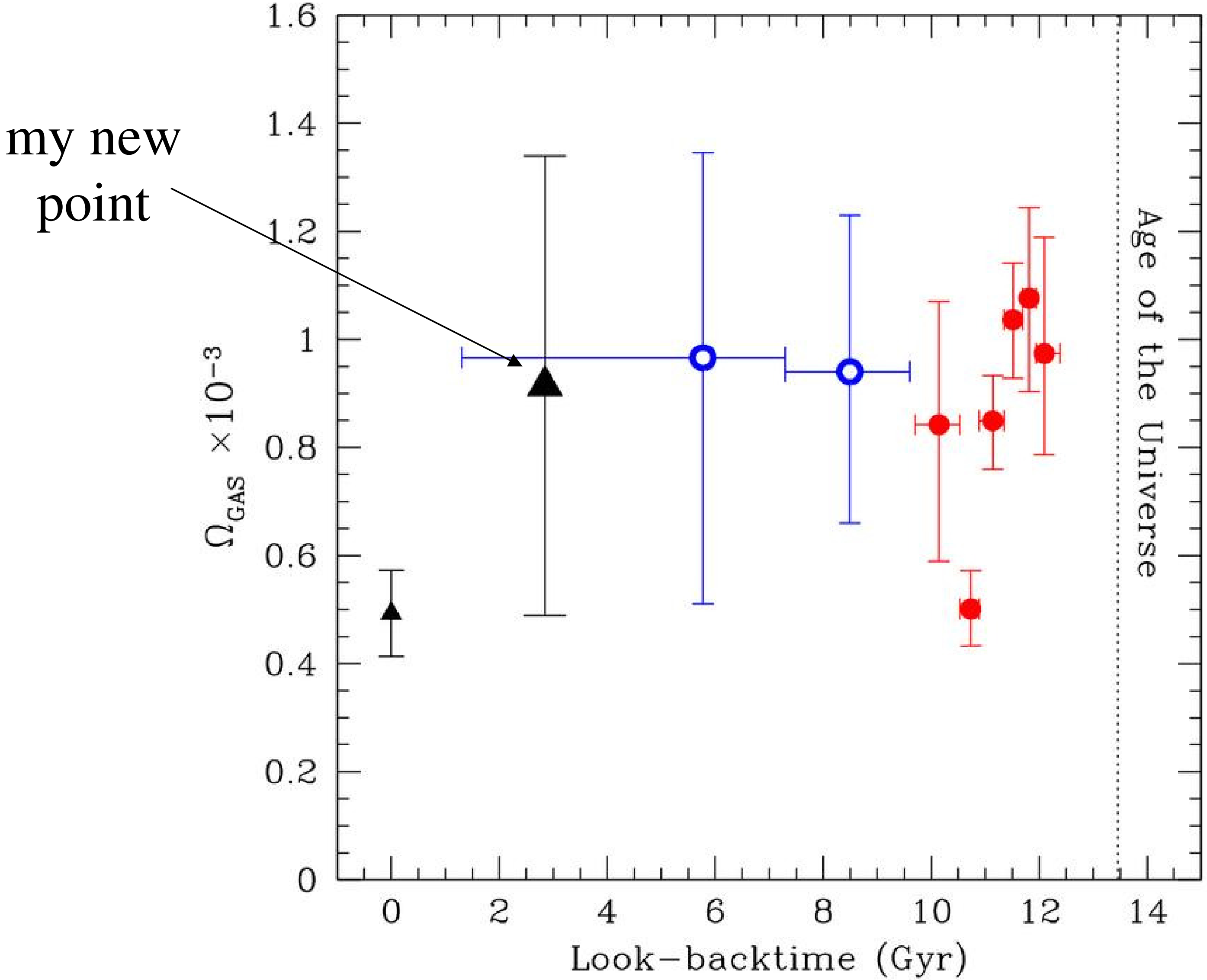
Prochaska et al. 2005 DLAs

Cosmic Neutral Gas Density vs. Redshift

my new point

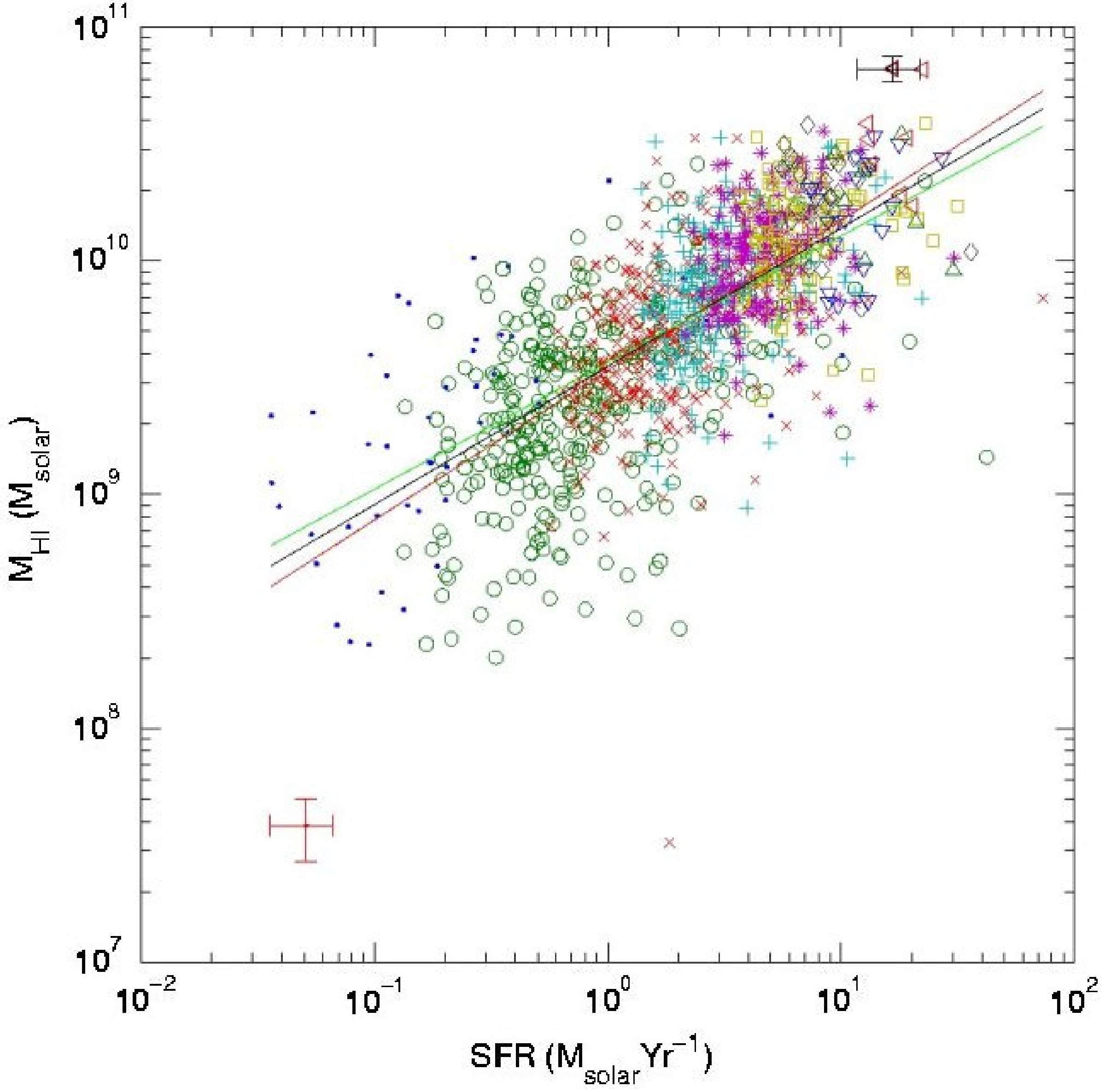


Cosmic Neutral Gas Density vs. Time



Star Formation Rate
&
HI mass

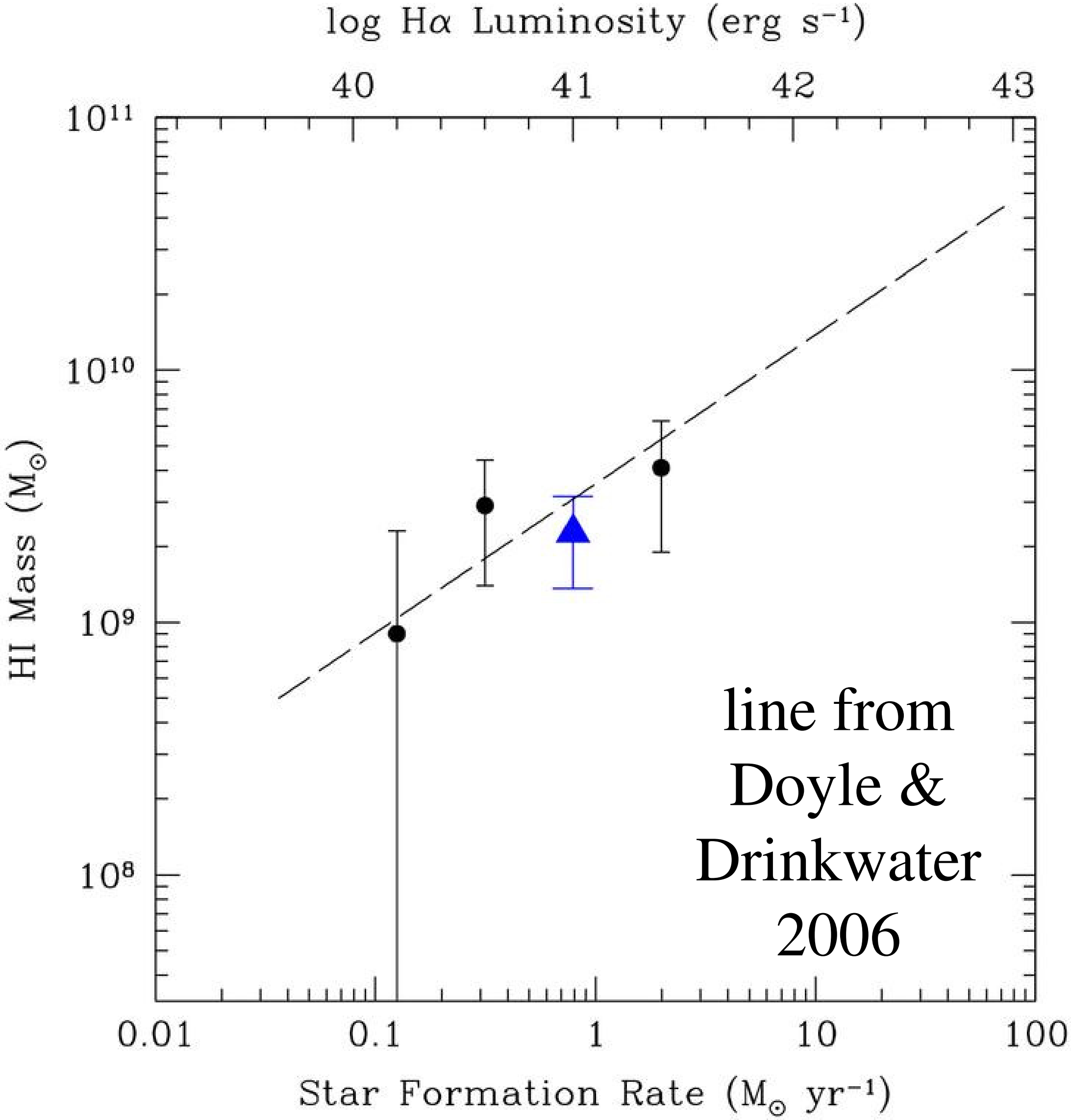
Galaxy HI Mass vs Star Formation Rate



HIPASS
&
IRAS
data
z ~ 0

Doyle &
Drinkwater
2006

HI Mass vs Star Formation Rate at z = 0.24

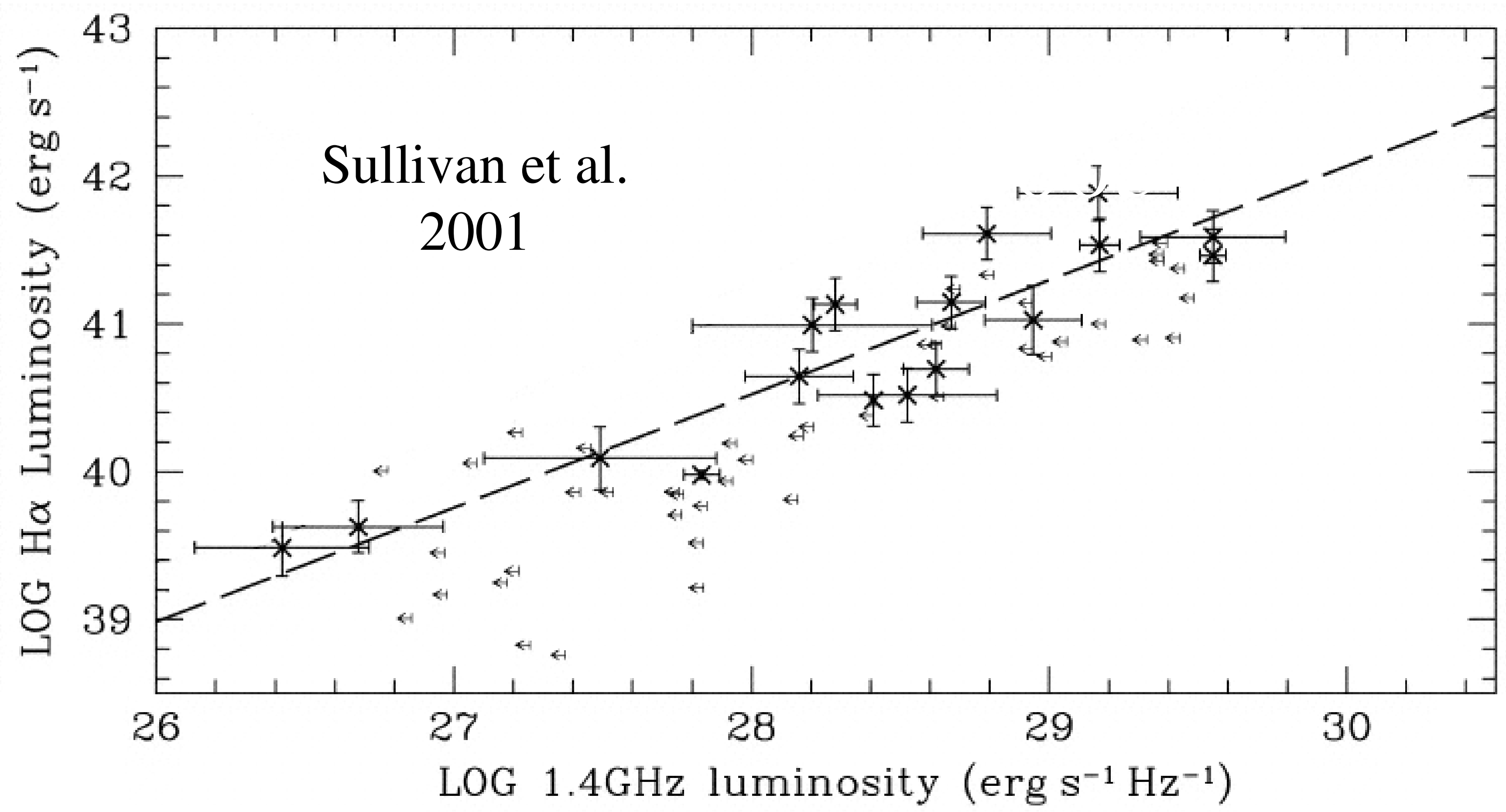


Problem at High Redshift

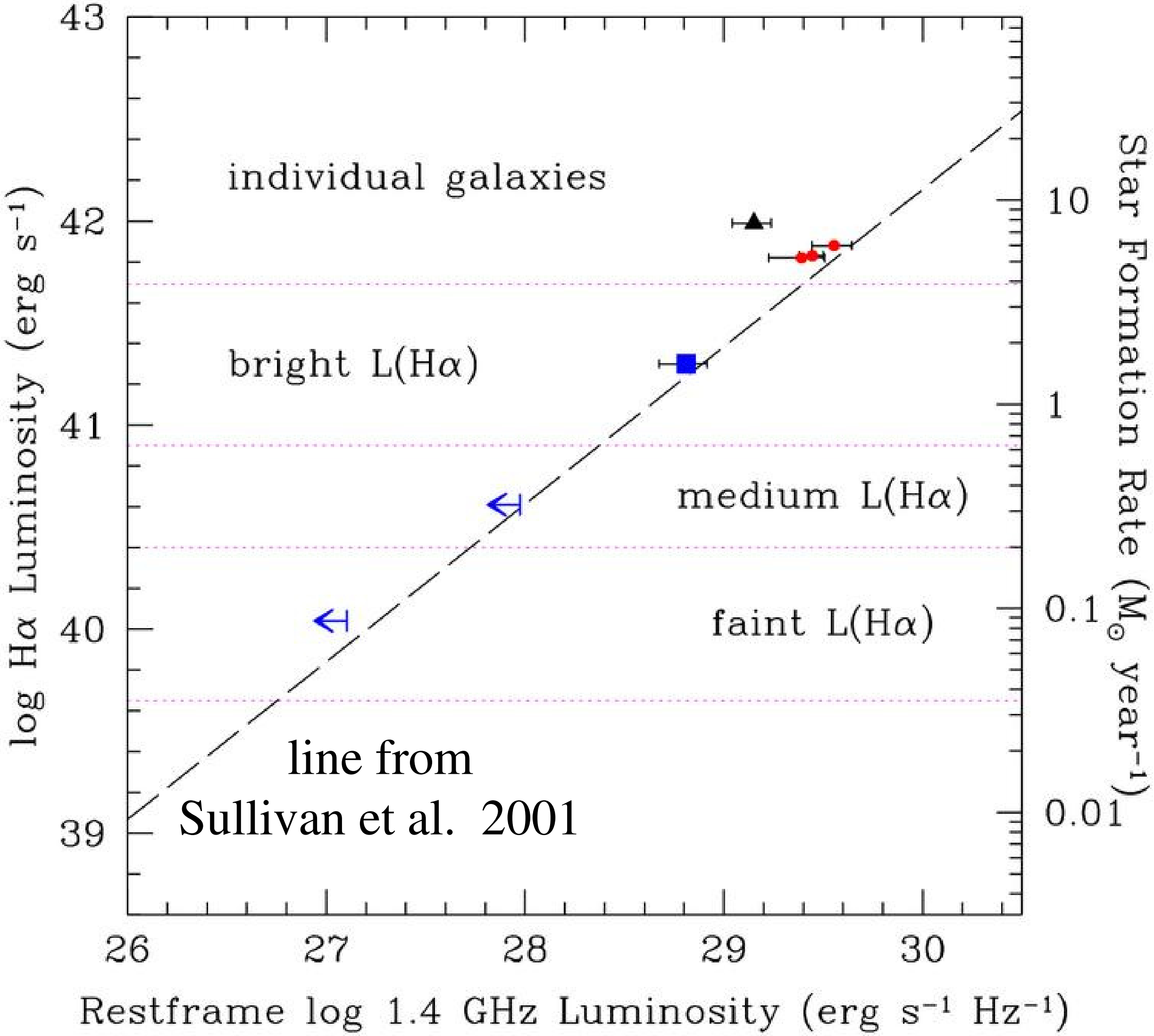
- at z > 1 factor ~10 increase in cosmic star formation rate density
- if the SFR-HI mass relation holds true would lead to factor of ~4 increase in cosmic neutral gas density
- from damped Lyα systems see only a factor ~2 increase at high redshift (Prochaska et al. 2005)
- change in star formation mechanism – efficiency increased by a factor ~2

Radio Continuum from Star Forming Galaxies

Comparison of Star Formation Indicators at z ≈ 0



Comparison at z = 0.24



using all
348 gals

45 gals

55 gals

236 gals

HI in Abell 370, a galaxy cluster at z = 0.37

Galaxy Clusters

Butcher-Oemler effect (1978)

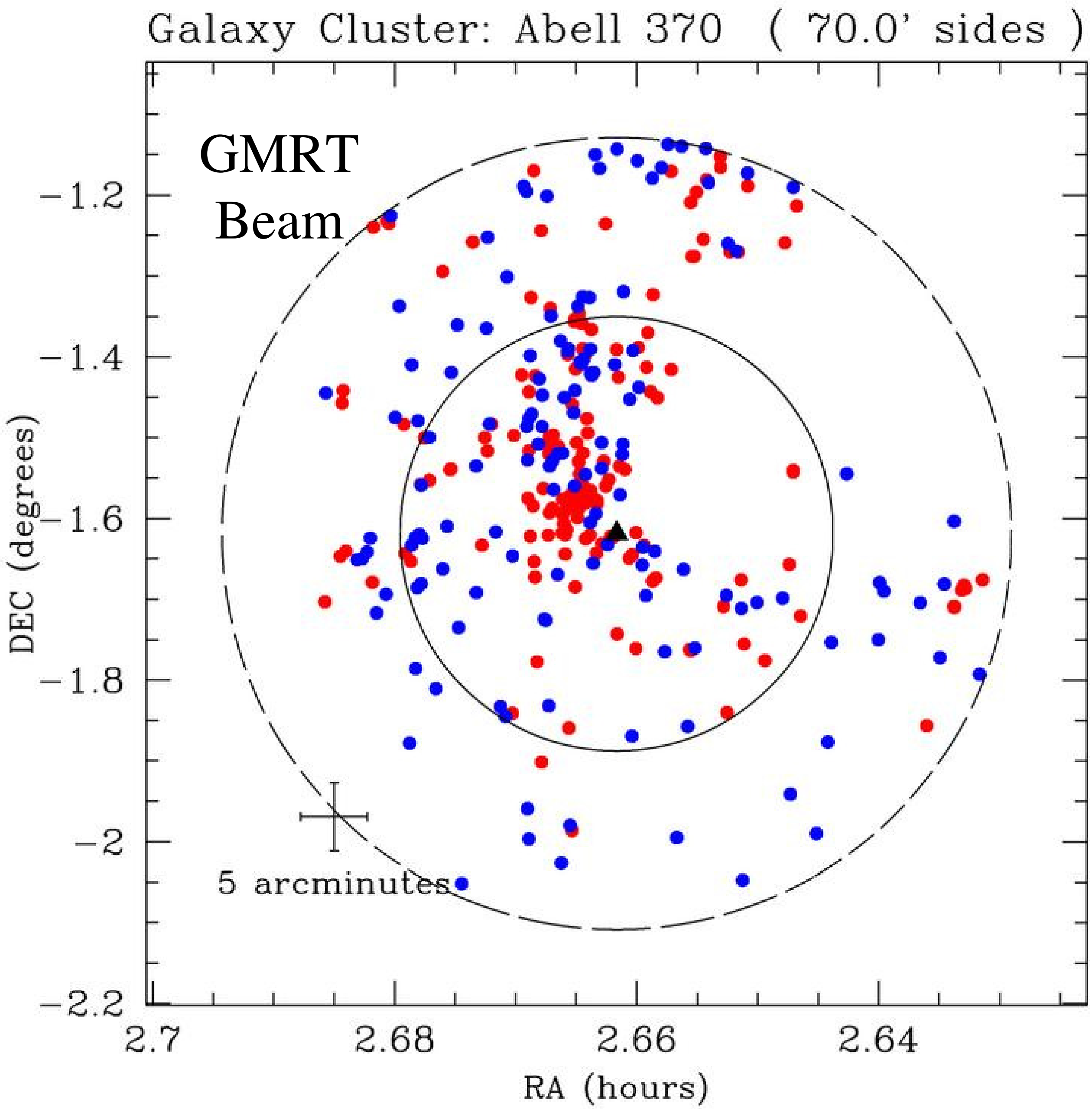
• with increasing redshift galaxy clusters show a higher fraction of optically blue galaxies (mostly bright spirals & irregulars)

• effect noticeable from $z \approx 0.1$

• strong effect by $z=0.4$

Abell 370 Observations

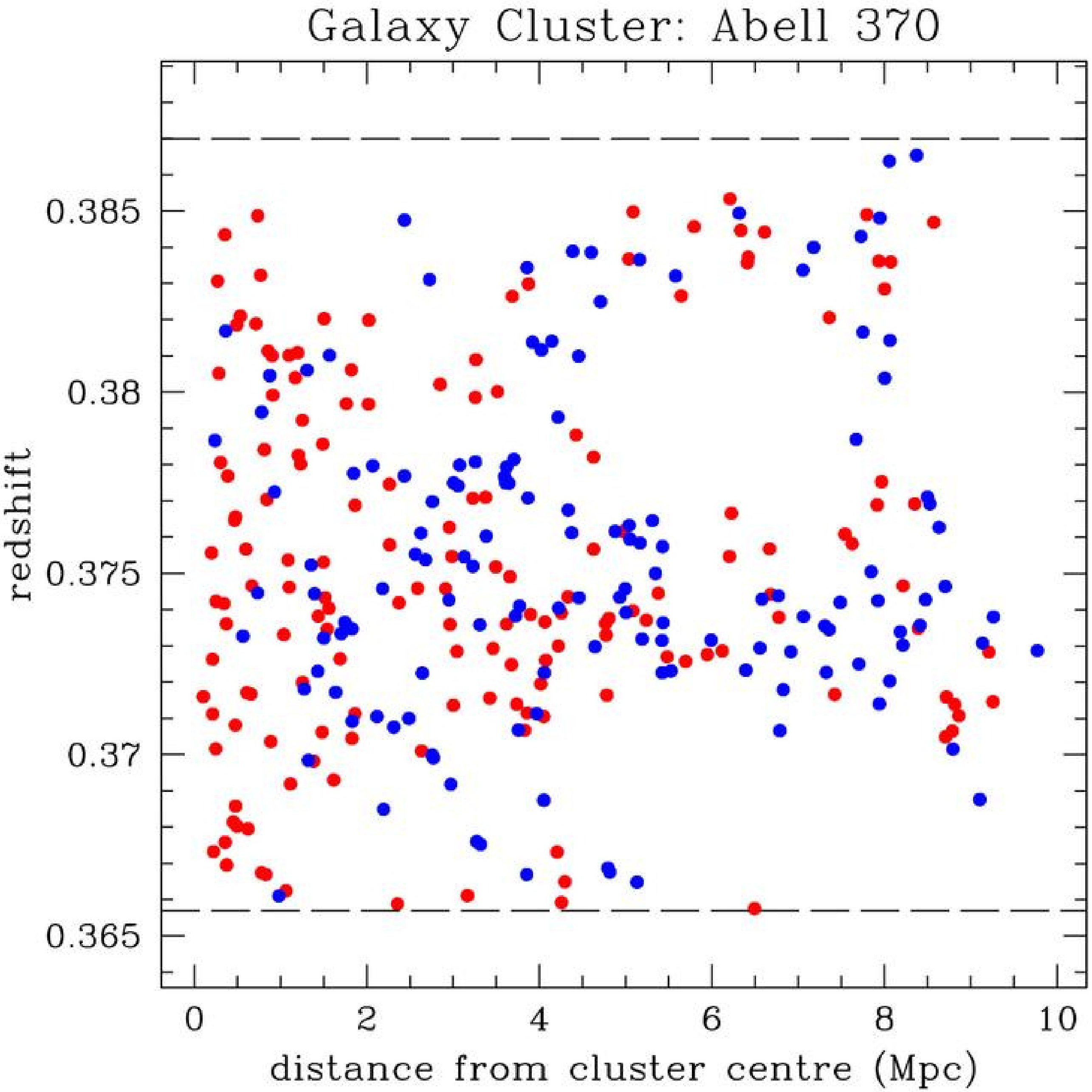
- radio observations with the GMRT of the galaxy cluster totalling ~34 hours at 1040 MHz (HI 21 cm at z = 0.37)
- V, R & I band optical imaging using the SSO 40 inch telescope
- spectroscopic follow-up using AAOmega on the Anglo-Australian Telescope for 4 nights for optical redshifts



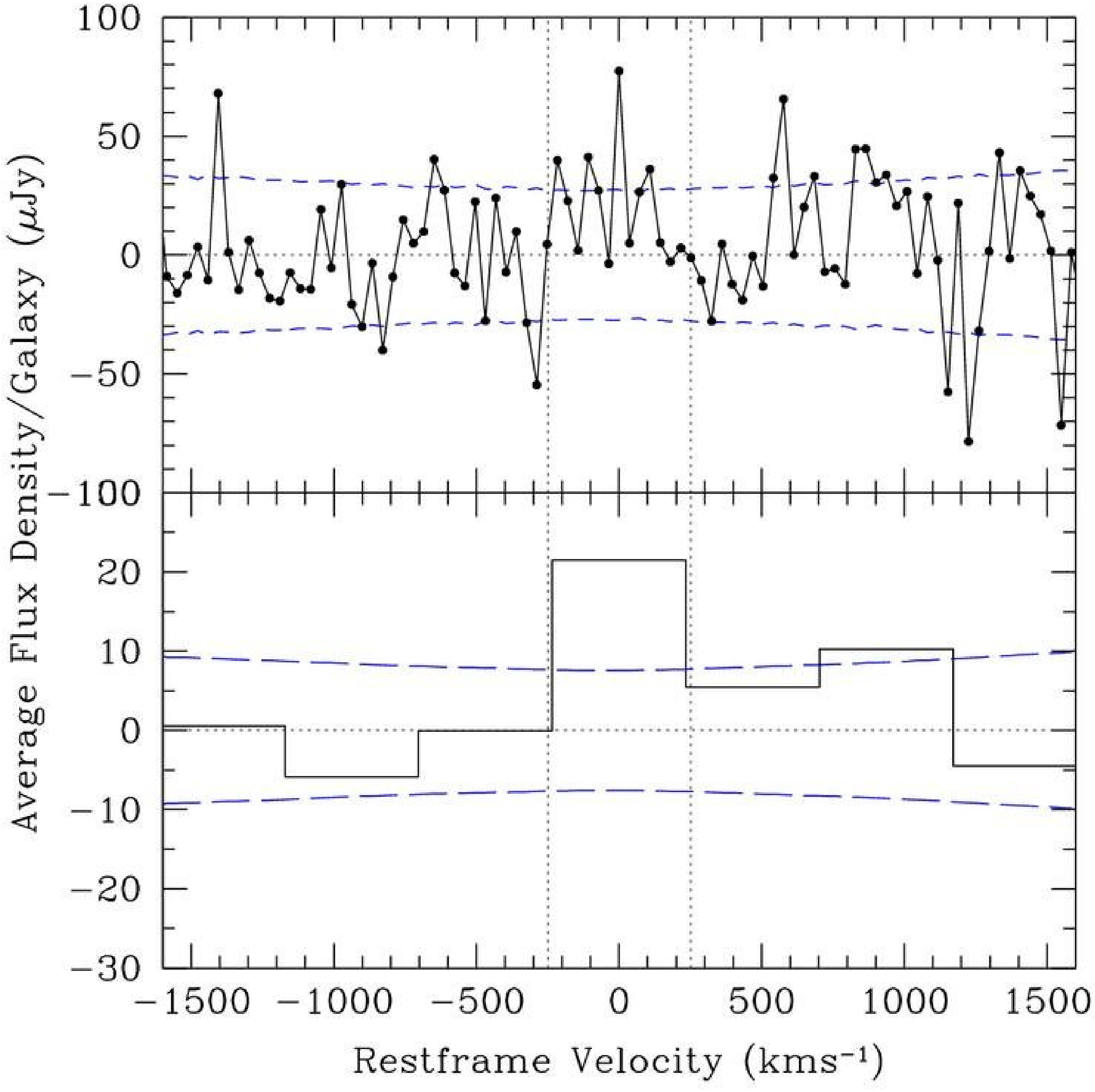
Blue
V-I colour ≤ 0.9

Red
V-I colour > 0.9

the galaxies are large - luminosities L^* or greater



Galaxy Cluster: Abell 370
redshift
0.385
0.38
0.375
0.37
0.365
0
2
4
6
8
10
distance from cluster centre (Mpc)



HI gas measurement

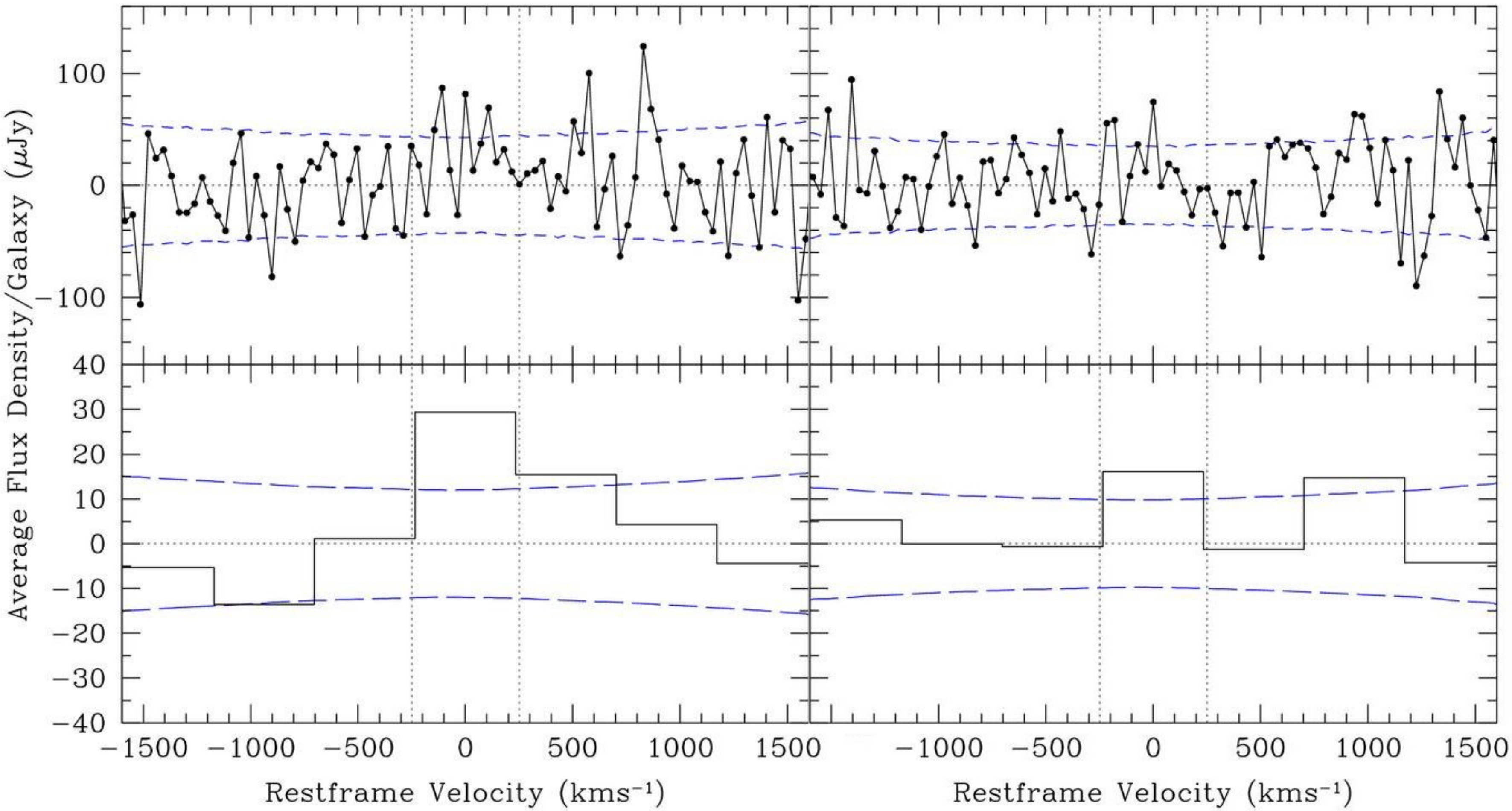
278 redshifts

M_{HI} = $(7.4 \pm 2.6) \times 10^9 M_\odot$

Signal to Noise = 2.8

Blue Galaxies
128 redshifts
$M_{HI} = (10.1 \pm 4.1) \times 10^9 \, M_\odot$
Signal to Noise = 2.5

Red Galaxies
150 redshifts
$M_{HI} = (5.5 \pm 3.4) \times 10^9 \, M_\odot$
Signal to Noise = 1.6



Conclusions

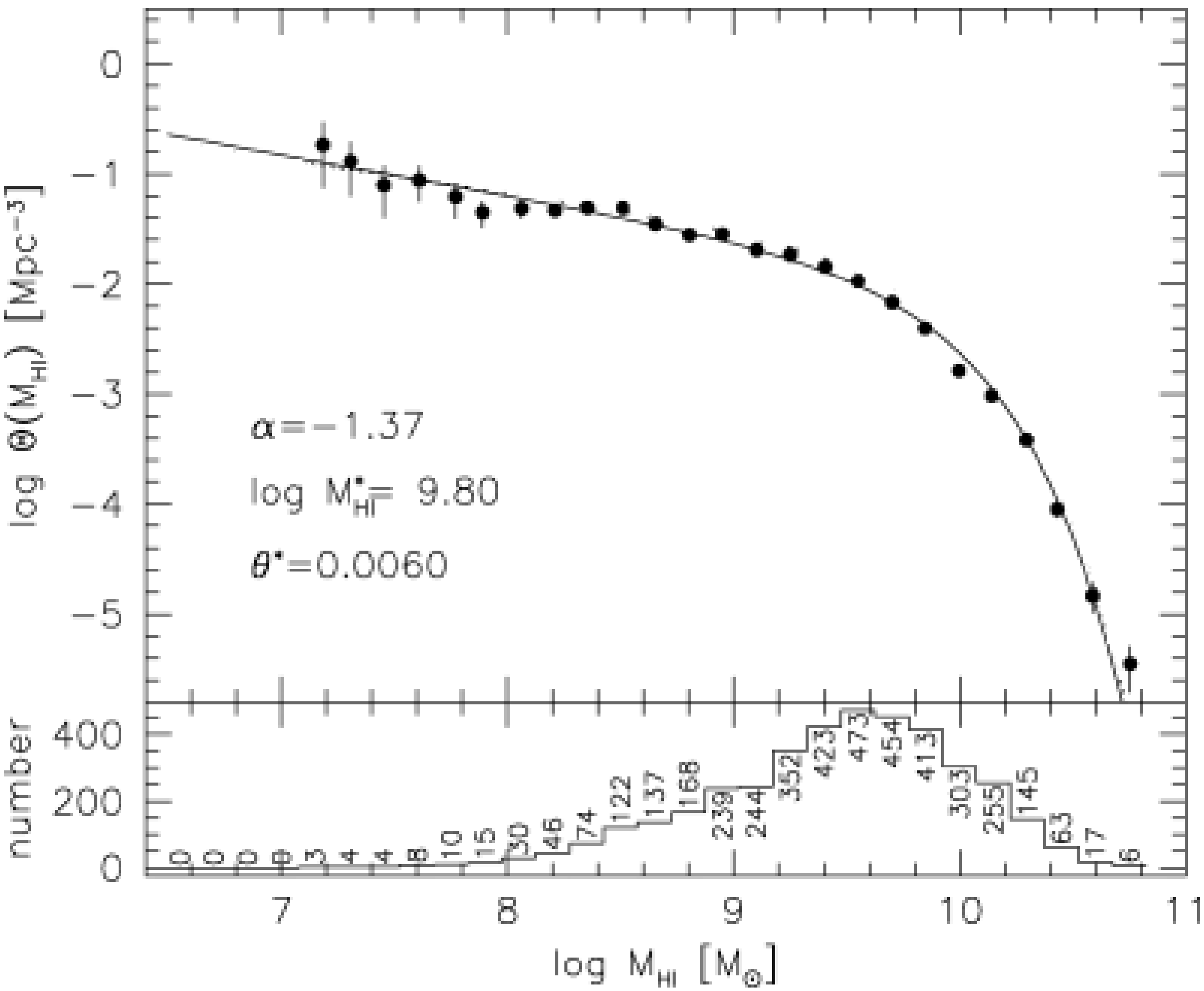
Conclusions

- HI 21cm emission is observable at moderate redshifts using the coadding technique
- the measured cosmic neutral gas density at z=0.24 is consistent with that from damped Lyα
- the radio continuum-Hα & SFR-HI mass correlations both hold at z=0.24 ⇒ suggests that the process of star formation in field galaxies is not significantly different ~3 Gyr ago
- there is large amounts of HI gas at z=0.37 in galaxies within clusters and the gas is concentrated in the blue galaxies

[redacted]

Additional Slides

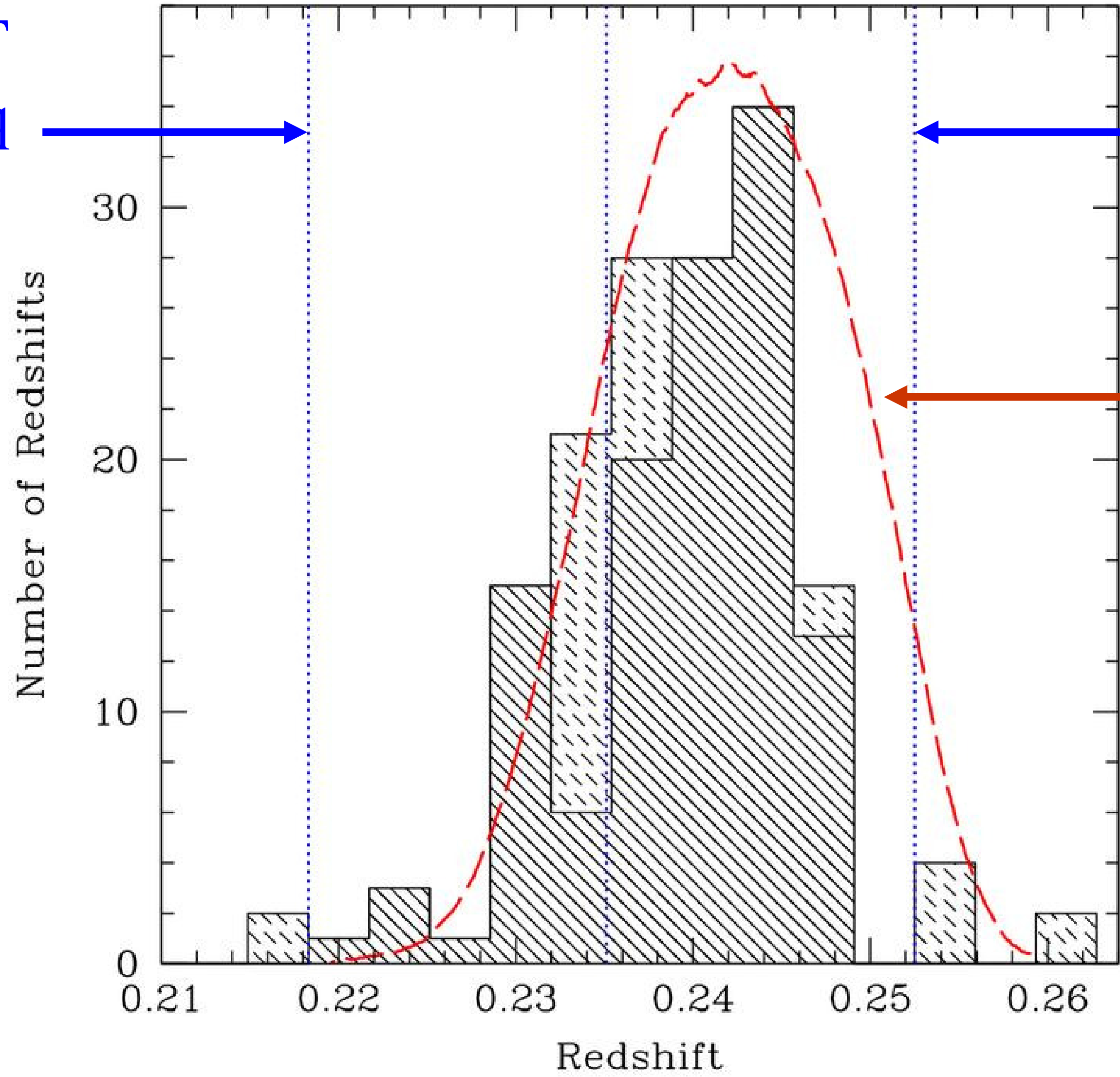
HI mass function



HIPASS
out to
z~0.042
Zwaan et al.
2005

Histogram of Redshifts

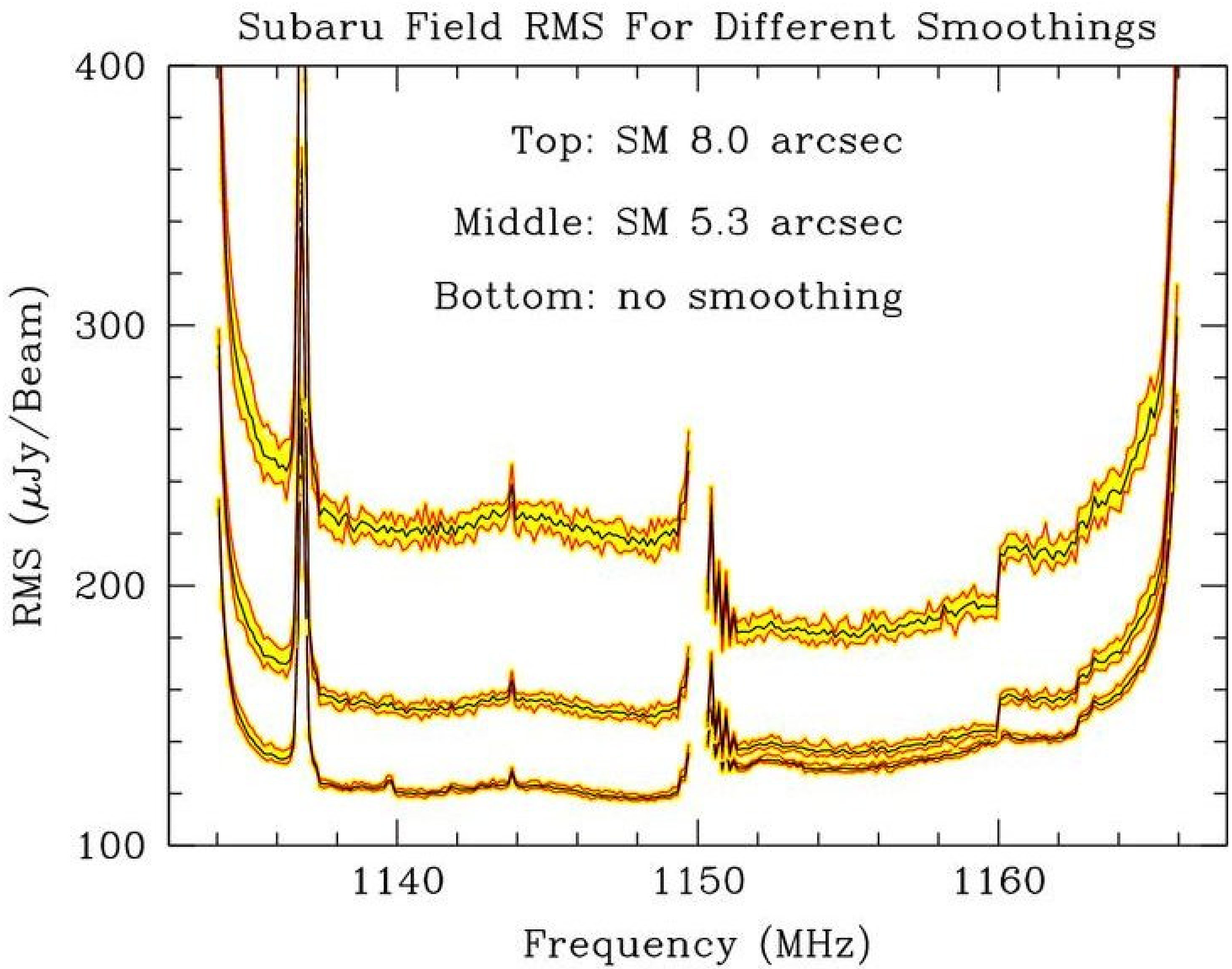
GMRT HI freq range



Subaru Narrow Band Filter

154 redshifts

121 useful



Subaru Field RMS For Different Smoothings
Top: SM 8.0 arcsec
Middle: SM 5.3 arcsec
Bottom: no smoothing
RMS (μJy/Beam)
Frequency (MHz)
400
300
200
100
1140
1150
1160

Why use GMRT?

- GMRT collecting area
  - ⇨ 21 × ATCA
  - ⇨ 6.9 × WSRT
  - ⇨ 3.6 × VLA
- frequency coverage & bandwidth
- angular resolution
- position at low latitude

GMRT data for the field

GMRT Observation Time	Time on Field
80.5 hours	~44 hours

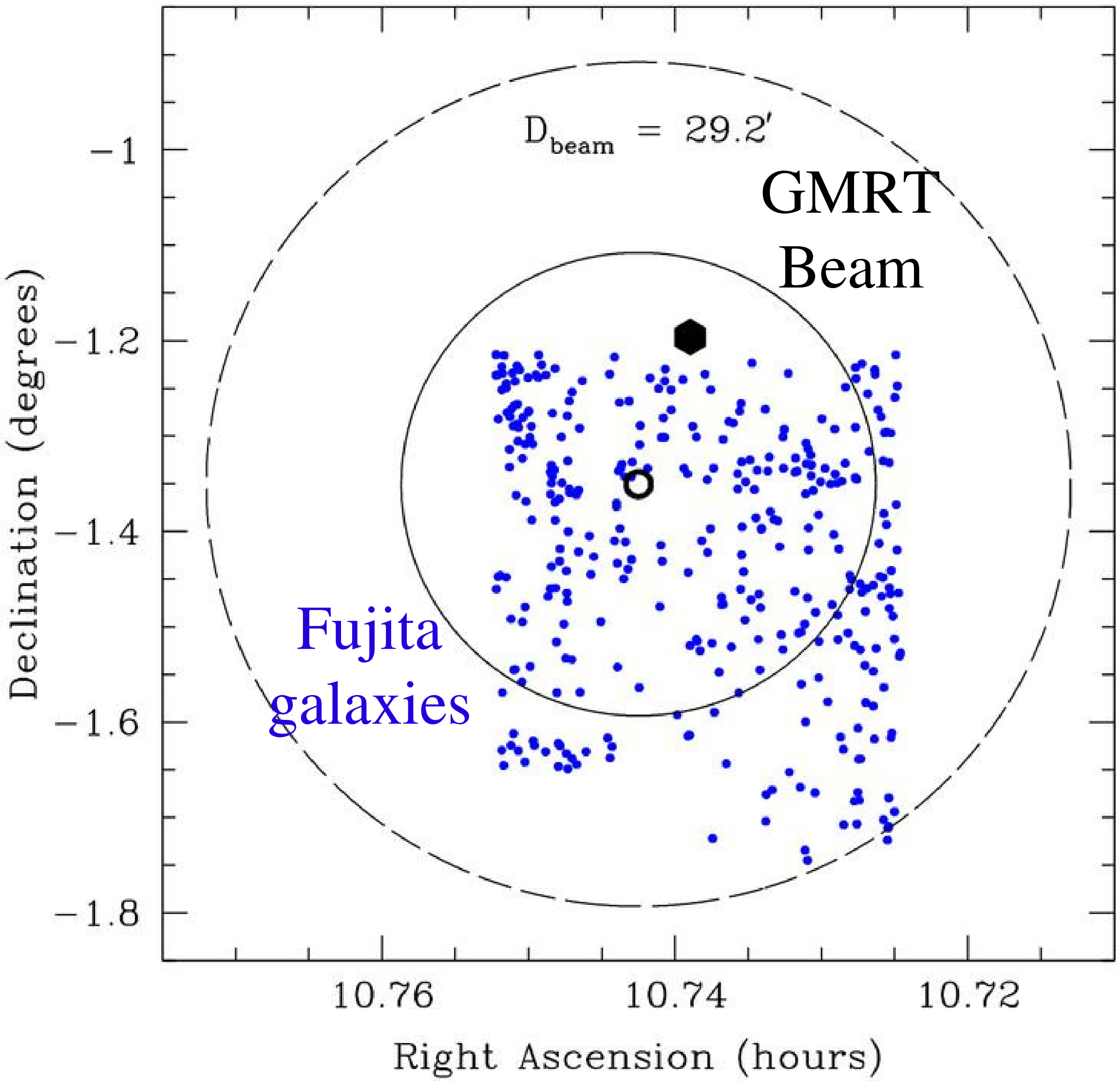
Observing Frequency	HI Redshift
1150 MHz	0.24

Instantaneous Bandwidth	Number of Channels	Channel Bandwidth	Channel Width
32 MHz	2×128	125 kHz	32.6 kms^{-1}

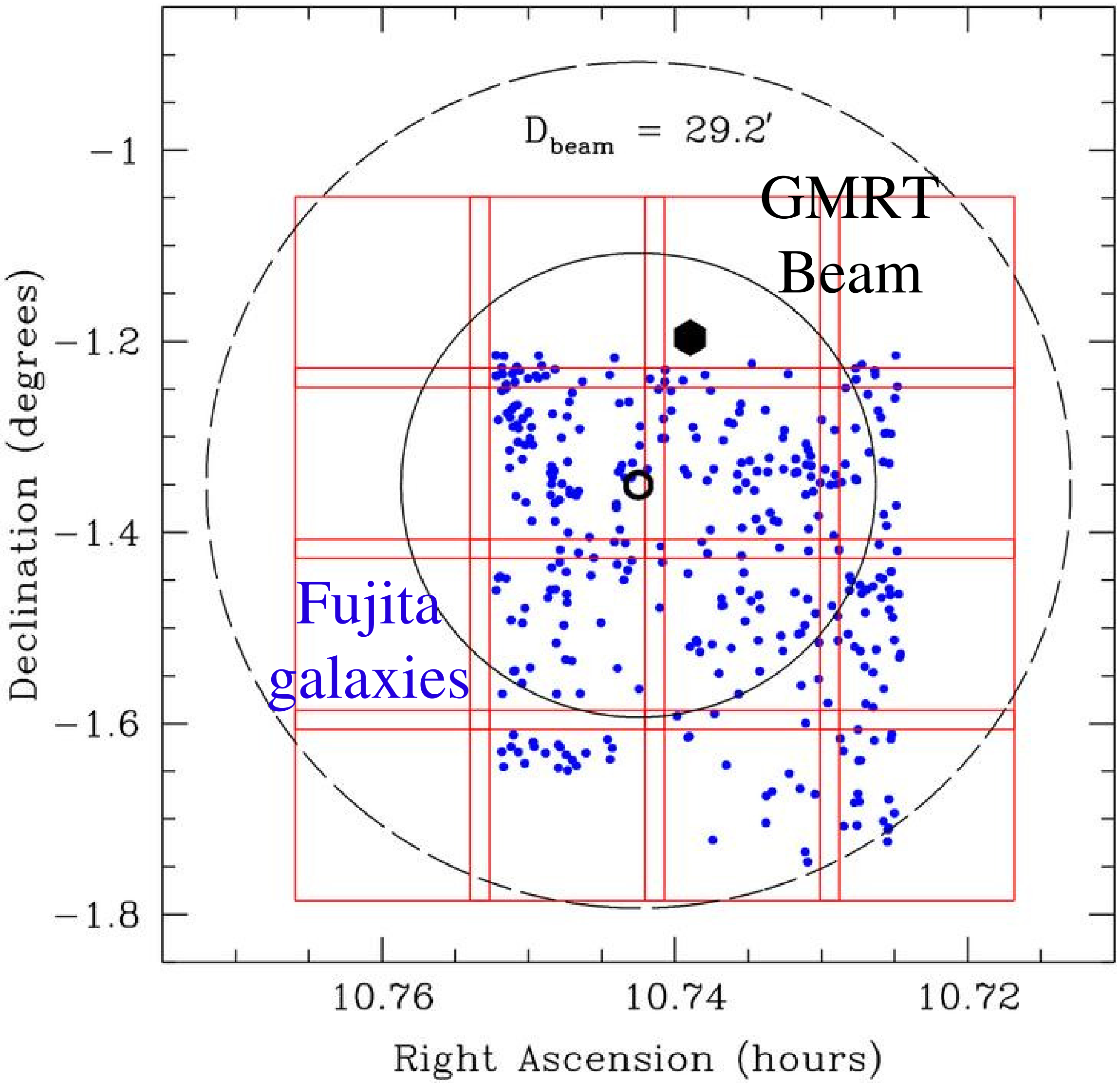
Primary Beam Size	Synthesis Beam Size
~29’	~2.9”

RMS per channel	Continuum RMS
~130 μJy	15 μJy

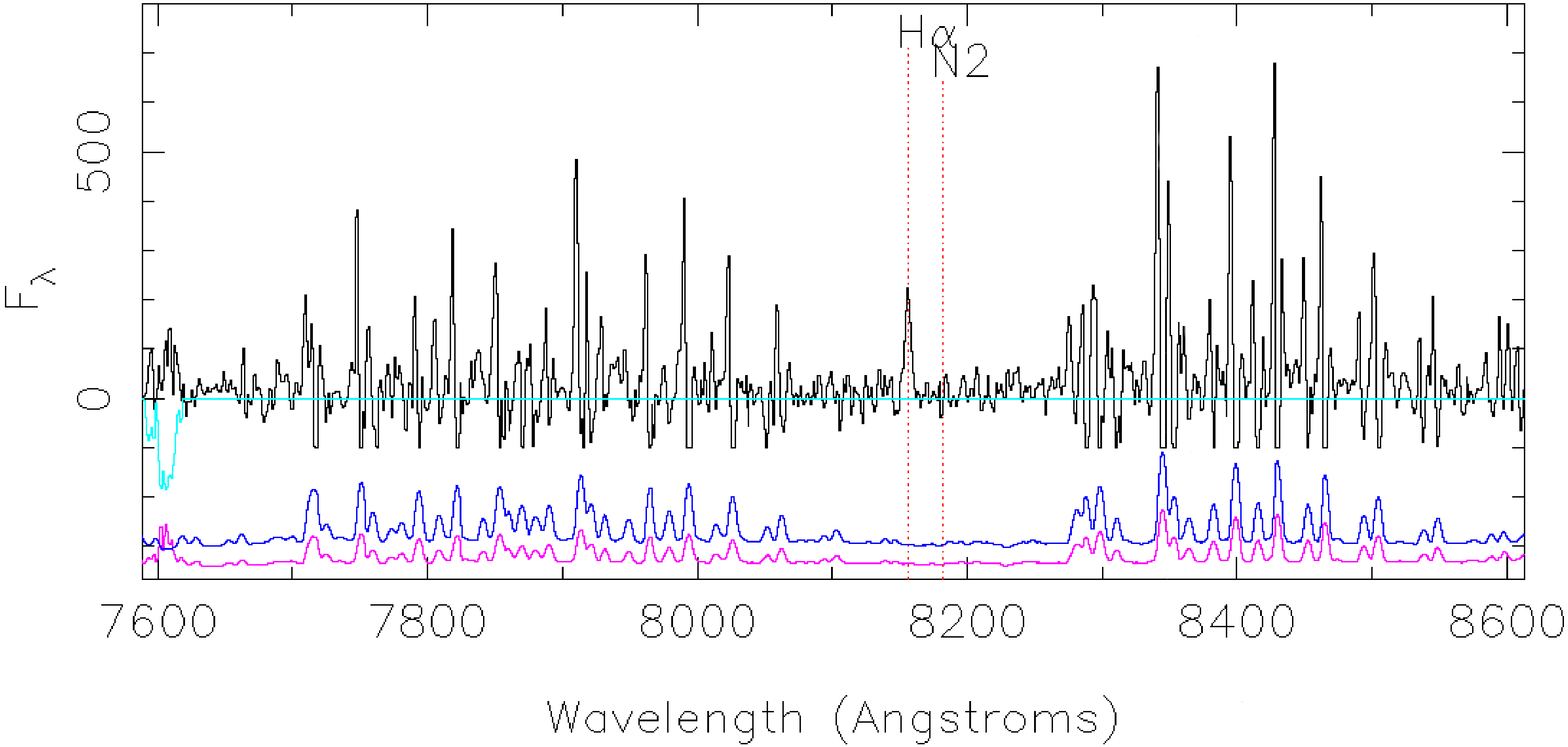
The Galaxy Positions



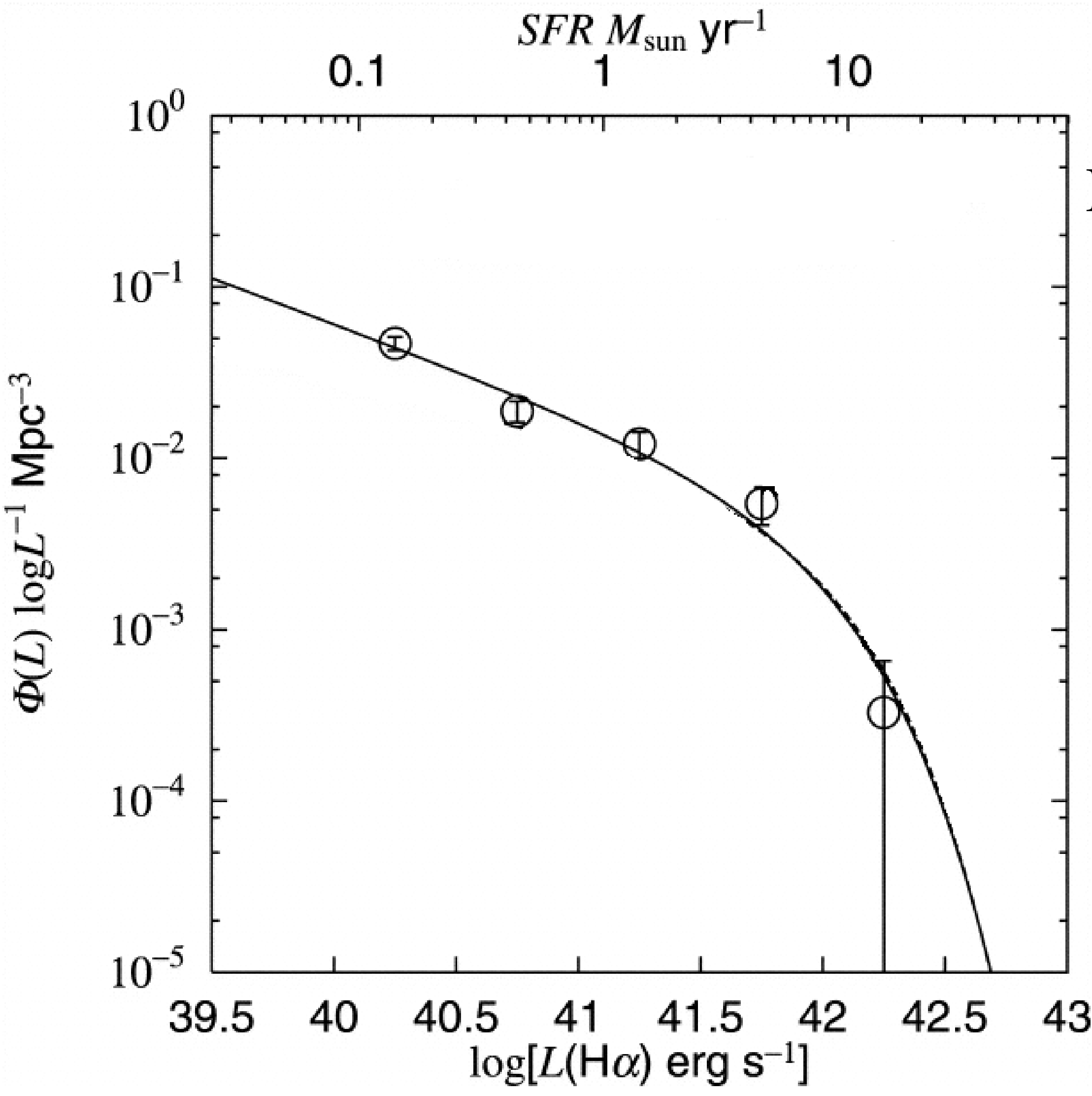
The Galaxy Positions



Narrowband Filter: Hα detection

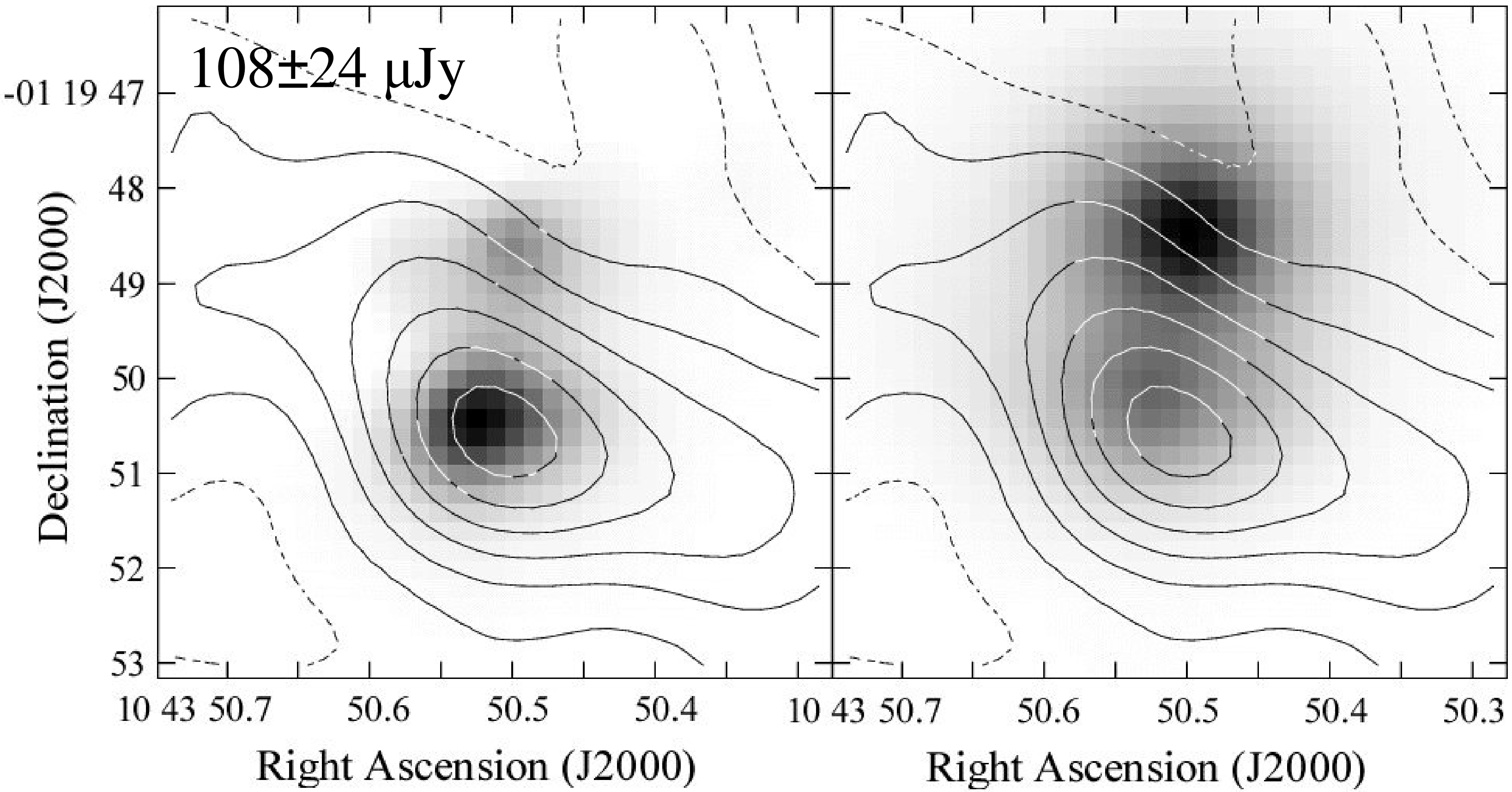


Hα Luminosity Function



Fujita et al. 2003

Merging/Interacting System



Contours - radio continuum
Greyscale - Hα emission
- 5 times brighter in Hα

Contours- radio continuum
Greyscale - optical continuum
- 0.6 times as bright in z' filter

The End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UCOMICS.COM