

# Cold Gas at Intermediate and High-Redshifts: GMRT and GBT Survey of 21cm Absorption Using Strong MgII Systems and DLAs in SDSS.

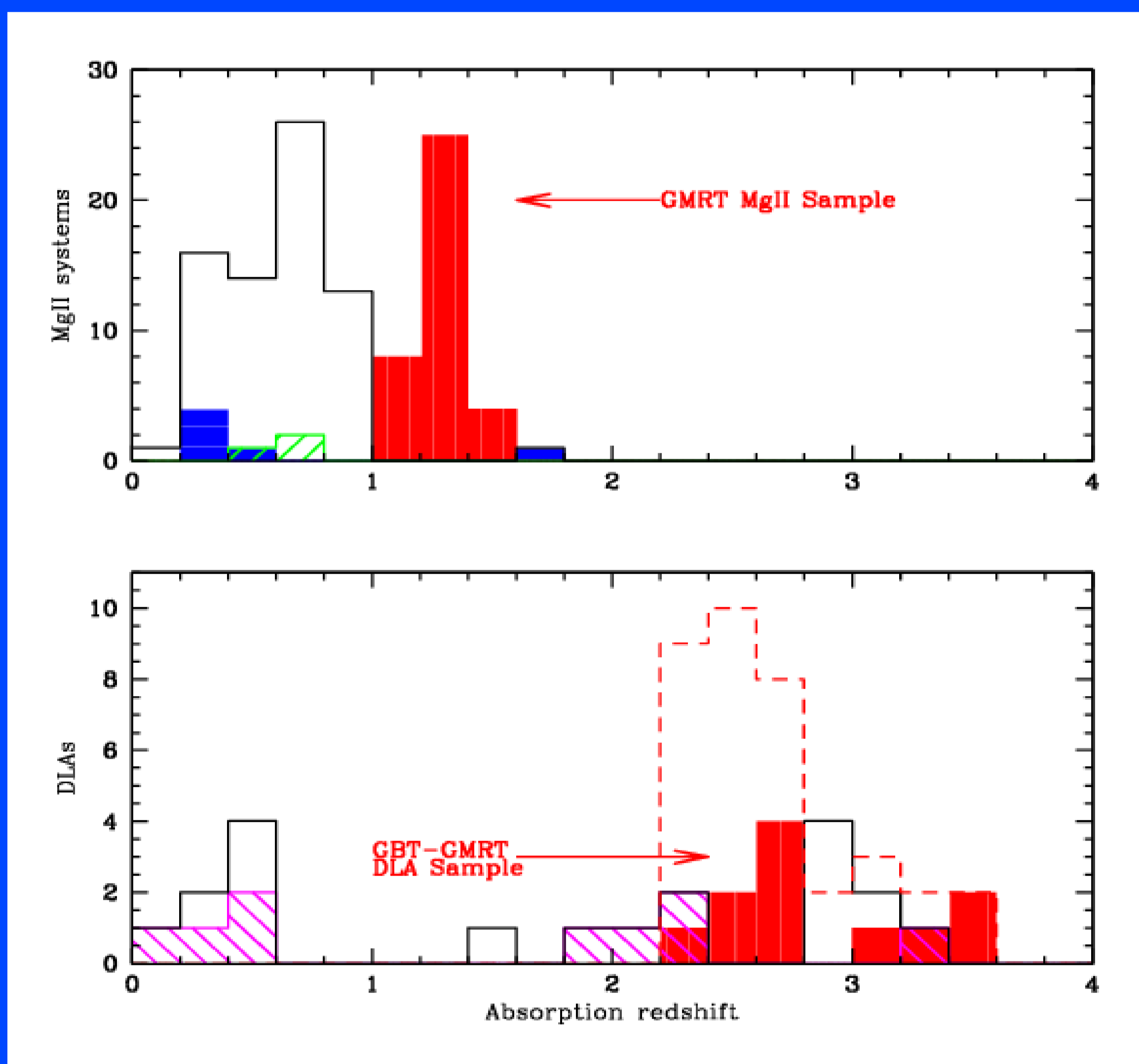
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## Introduction

Damped Lyman-alpha absorbers (DLAs) seen in the spectra of QSOs allow us to probe the physical conditions in the interstellar medium of galaxies at high redshifts. Our understanding of physical conditions in DLAs at high- $z$  is primarily based on the absorption lines of molecular Hydrogen and fine structure transitions. Another important way of probing the thermal state of interstellar medium in these high- $z$  galaxies is by studying the 21cm absorption. In fact, in the absence of UV-based spectrograph in space, 21cm absorption is the unique way of probing the neutral hydrogen content of the Universe at  $z < 2$ . There have been several searches of 21cm absorption in the DLAs undertaken by various groups (Briggs & Wolfe 1983; Lane 2000; Kanekar & Chengalur 2003) but have yielded limited success. As can be seen from the figure below, the redshift coverage is sparse and 21cm absorption measurements are available only for a handful of systems at  $z > 1$ . In particular, only six 21cm absorbers are known at  $z > 1$ .



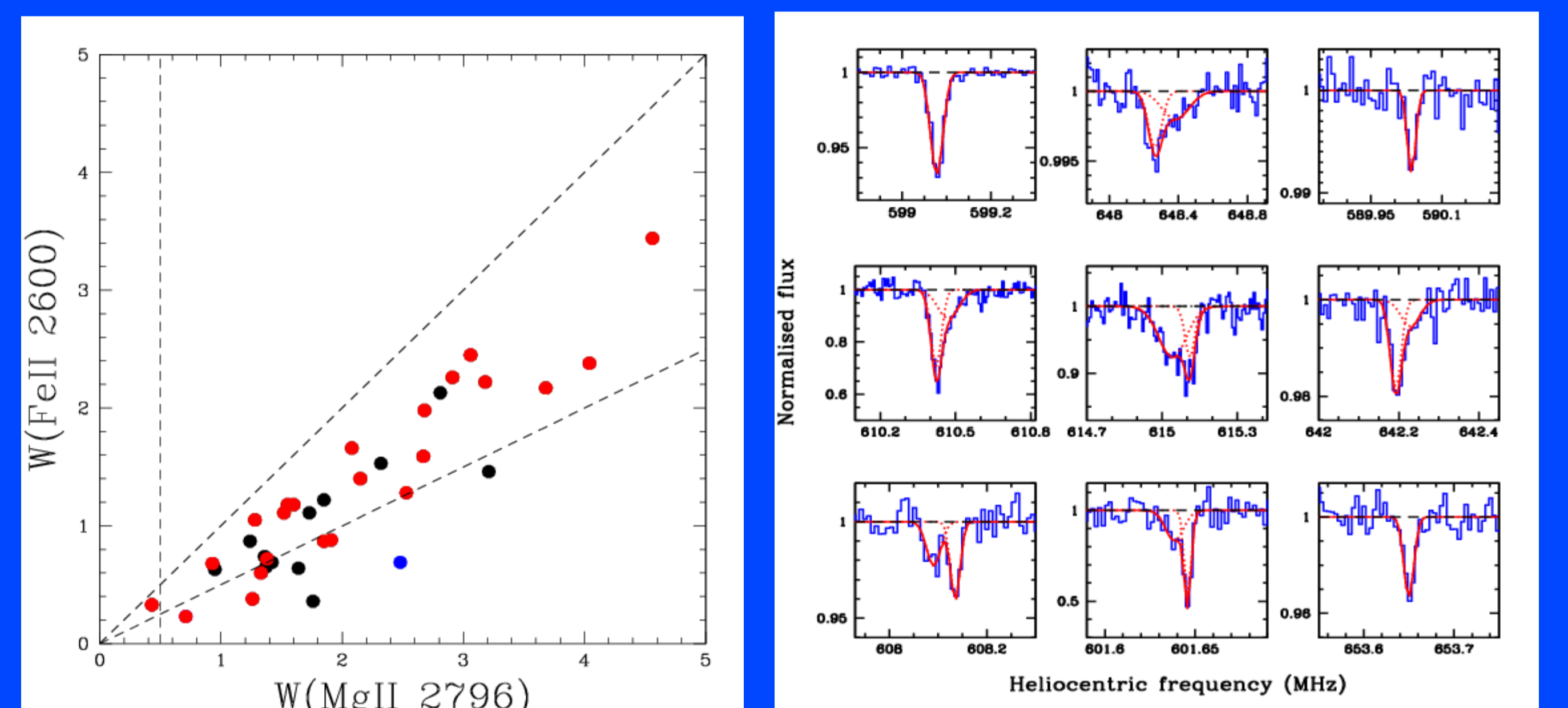
The redshift distribution of MgII systems (top panel) and DLAs (bottom panel) that have been searched for 21cm absorption is shown in the figure above. Top panel: line histogram and solid histogram (blue) mark, respectively, MgII systems searched for 21cm absorption and 21cm absorption detections from the literature. 21cm absorption detections from blind surveys have been marked as histogram (green) with hatched lines. Bottom panel: line histogram and histogram (magenta) with hatched lines mark, respectively, DLAs searched for 21cm absorption and 21cm absorption detections from the literature. In both the panels, distribution for our MgII systems and DLA samples to search for 21cm absorption has been marked as solid (red) histogram.

## Our 21cm Absorption Searches

We have been doing systematic searches of 21cm absorption using Giant Metrewave Radio Telescope (GMRT) and Green Bank Telescope (GBT). Our 21cm absorption searches are based on the following complete samples of strong MgII absorption line systems and DLAs drawn from SDSS :

For  $1.10 < z < 1.45$ :

At  $z < 2$ , where it is virtually impossible to obtain a new sample of DLAs, we have based our search on the sample of strong MgII systems. Rao et al. (2006) showed that DLAs can be preselected on the basis of equivalent widths of MgII, MgI and FeII absorption lines. Motivated by this we have constructed a complete sample of 38 DLA candidates from the sample of  $\sim 3000$  MgII systems in SDSS DR5. In the figure below, we plot MgII and FeII equivalent widths for our sample. As marked by the dashed lines in the figure, for  $\sim 75\%$  of the MgII systems in our sample:  $1 < W(\text{MgII})/W(\text{FeII}) < 2$ . Thus more than  $2/3$  of the MgII systems in our sample have metal absorption line properties consistent with bonafide DLAs (cf. Rao et al. 2006).



We have systematically searched for 21cm absorption in this complete sample of DLA candidates using 400hrs of GMRT time. This survey is recently completed and has resulted in discovery of 9 new 21cm absorbers. Prior to our survey only one 21cm absorber was known in the redshift range:  $0.7 < z < 2$ . This is by far the largest number of intervening 21cm absorbers detected from any single survey. Results from the first phase of our survey are published as Gupta et al. (2007).

For  $z > 2$ :

Our DLA sample at  $z > 2$  is based on  $\sim 1200$  DLAs at  $z > 2$  detected by us in SDSS DR6. Of these only 11 DLAs, which form our complete sample, are in front of quasars with 1.4GHz flux density greater than 100mJy. This survey is currently in progress at GMRT and GBT. Complete observations of this sample of 11 DLAs will double the number of DLAs that have been searched for 21cm absorption.

## Conclusions and Future Prospects

We have discovered 9 new 21cm absorbers from our systematic survey of DLA candidates at  $1.10 < z < 1.45$ . Prior to our survey only one 21cm absorber was known in the redshift range:  $0.7 < z < 2$ . Our systematic surveys based on SDSS provide us the complete samples of 21cm absorbers that are being used in combination with various follow up observations to:

- constrain the evolution of number density per unit redshift range of 21cm absorbers,
- investigate the detectability 21cm absorption in MgII systems and DLAs and its relationship to metallicity and dust content,
- investigate the physical conditions in the absorbing gas using spin temperature, and
- probe the time evolution of fundamental constants using 21cm absorption line in conjunction with the metal absorption lines.