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# Unveiling a Hidden Population of High Redshift Galaxies with the SKA

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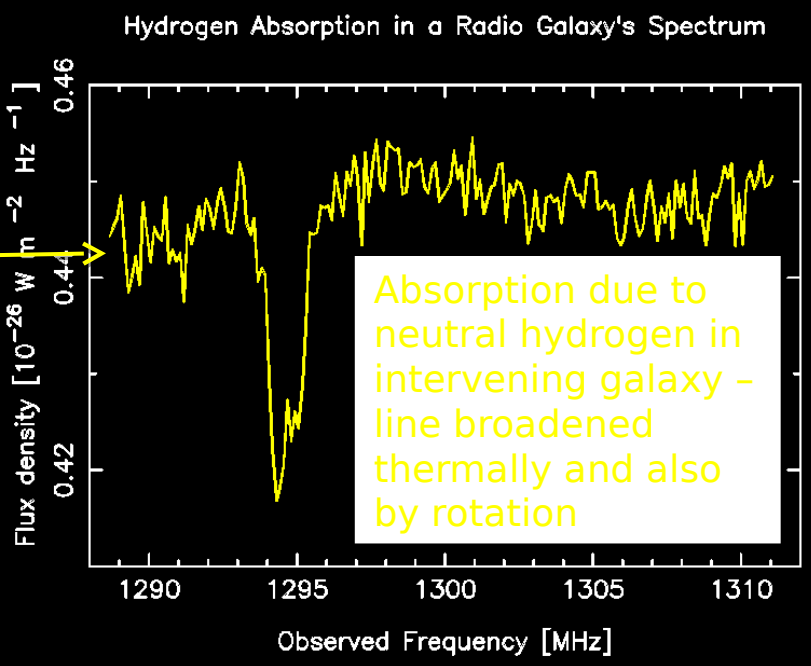
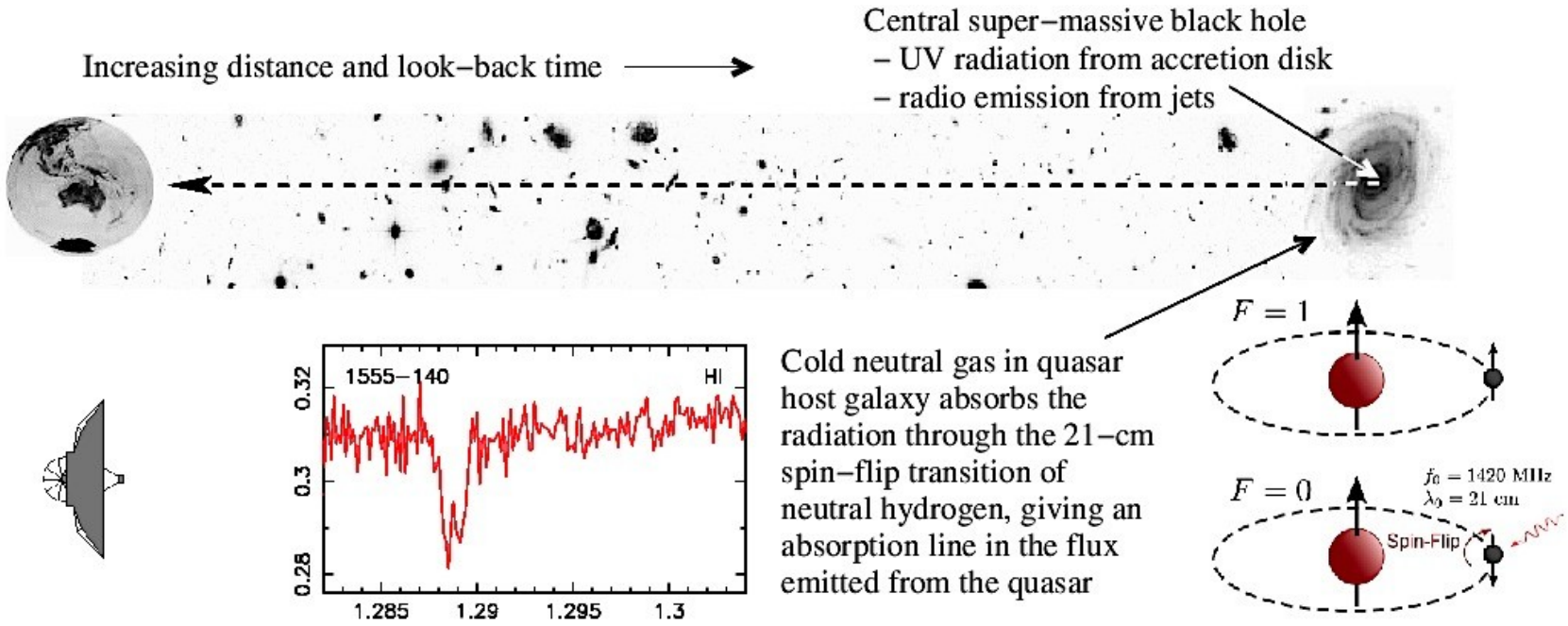
Line strength only dependent upon column density of absorbing gas and flux from background 1420 MHz continuum source (radio galaxy/quasar)

Radio continuum emission from background source – UV from matter accreted onto supermassive black hole. Radio from electrons accelerated along jets

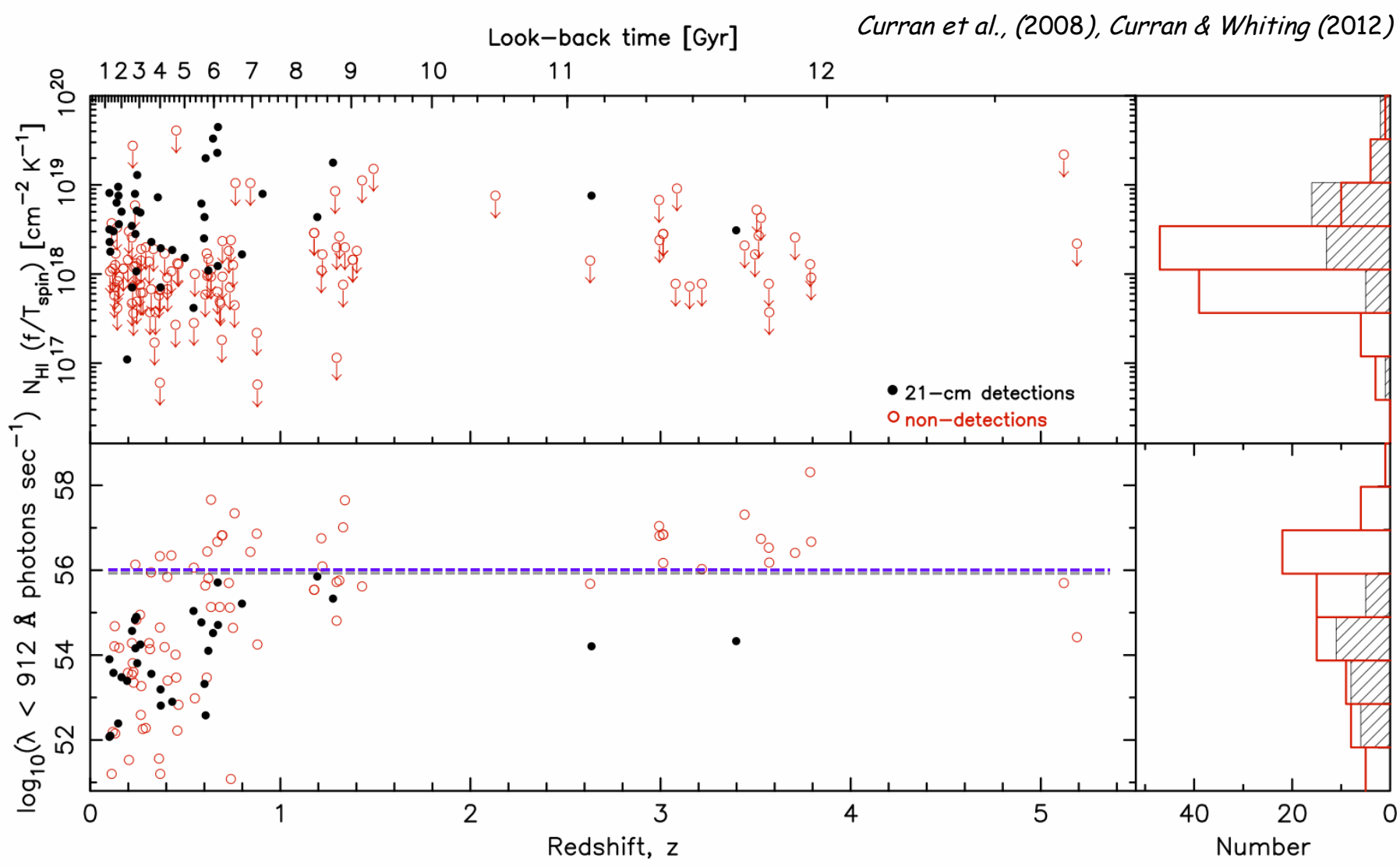



Absorption due to neutral hydrogen in intervening galaxy – line broadened thermally and also by rotation




In absorption, the 21-cm transition of neutral hydrogen (HI):

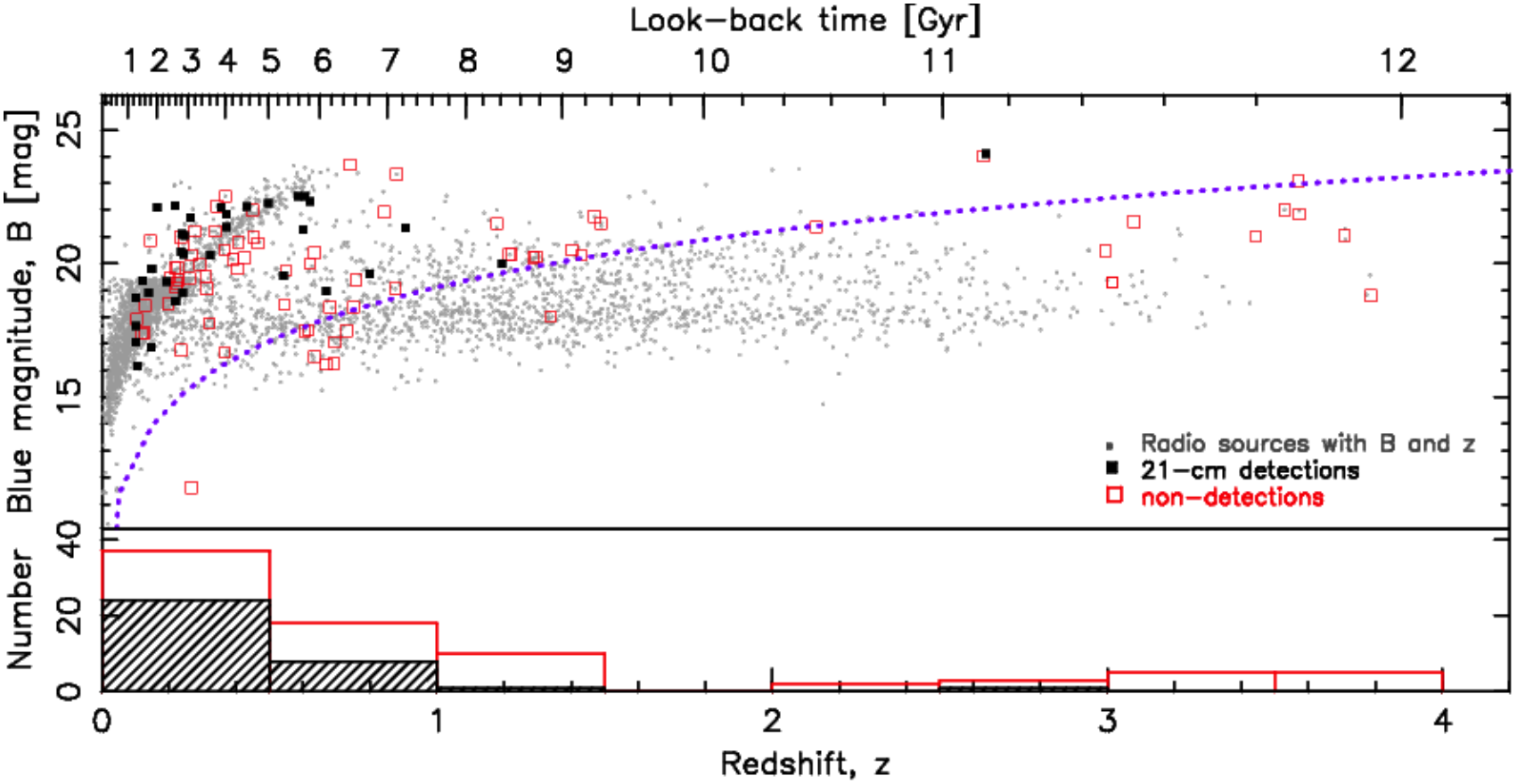
- Traces the *cool* component of the neutral gas. That is, the raw material for star formation, which in turn forms planets and all heavy elements.
- Unlike the Lyman-$\alpha$ transition of HI (which traces *all* of the neutral gas), can be observed at $z = 0$ by ground-based telescopes (cf. $z > 1.7$).
- Unlike 21-cm emission, can be readily detected at $z > 0.2$, since absorption strength only dependent upon column density and background flux.




*Curran et al., (2008), Curran & Whiting (2012)*

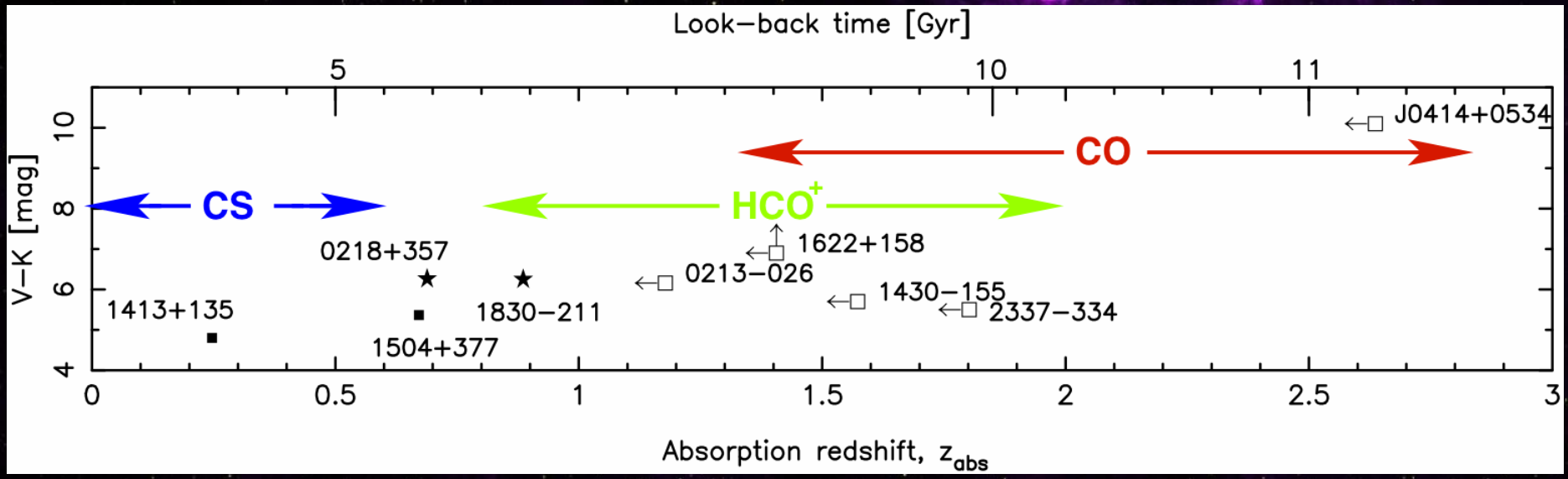
High redshift selection biases towards most UV luminous ($L_{UV} > 10^{23}$ W $Hz^{-1}$) objects, in which gas is completely ionised (confirmed through a similar dearth in associated MgII absorption around $L_{UV} > 10^{23}$ W $Hz^{-1}$ QSOs, *Curran, Whiting, Allison, Glowacki, et al.*, submitted).

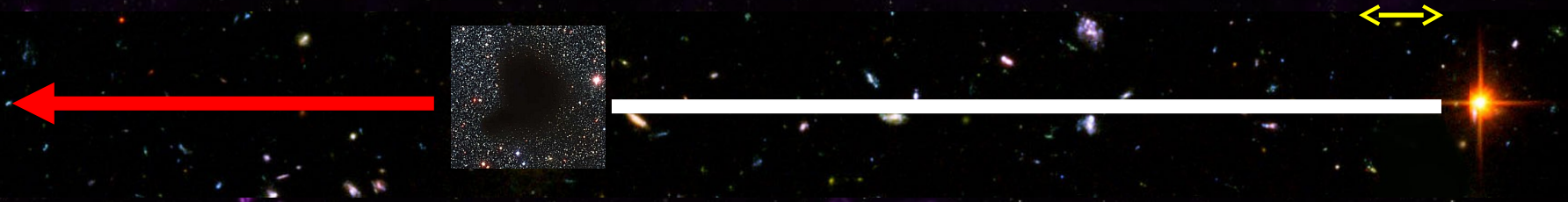
Traditional optical selection biases towards object in which gas is completely ionised even faint objects ($B \approx 23$) at $z > 3$ yields objects extremely UV luminous in the rest-frame ($L_{UV} \approx 10^{23}$ W Hz$^{-1}$) -> target optically faint, radio-loud, sources at high-z. However…



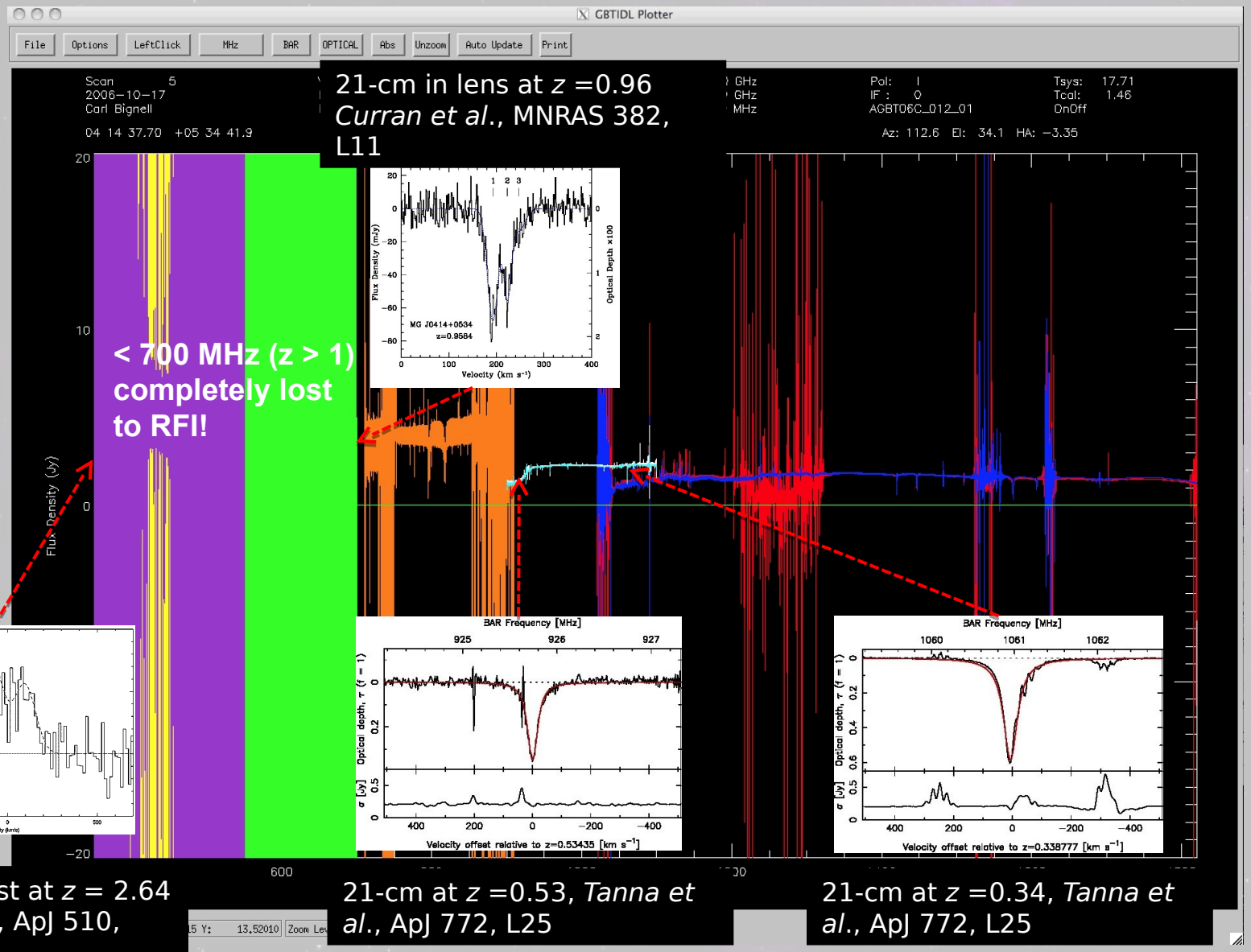

Since gas completely ionised (*Curran & Whiting*, 2012) even SKA won't be able to detect 21-cm absorption in $z > 3$ radio sources of known (optical) redshift!

No optical spectrum - could be anywhere at $z_{abs} \leq z_{QSO} \Rightarrow$ ***SPECTRAL SCAN***

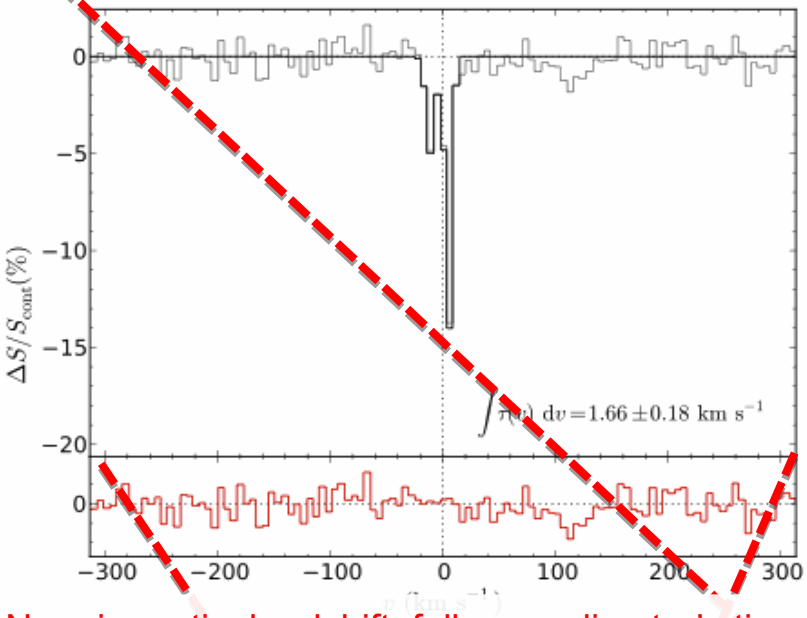


# Spectral scan towards a very red (V – K = 10.26) quasar with the Green Bank Telescope



ASKAP BETA array 1015 – 700 MHz (z = 0.4 – 1.0, LBT = 4.2 – 7.7 Gyr) spectral scan towards PKS 1740-517 (*Allison, ACES team et al.* arXiv:1503.0126.)




No prior optical redshift, follow up director's time on Gemini => z = 0.44 => associated

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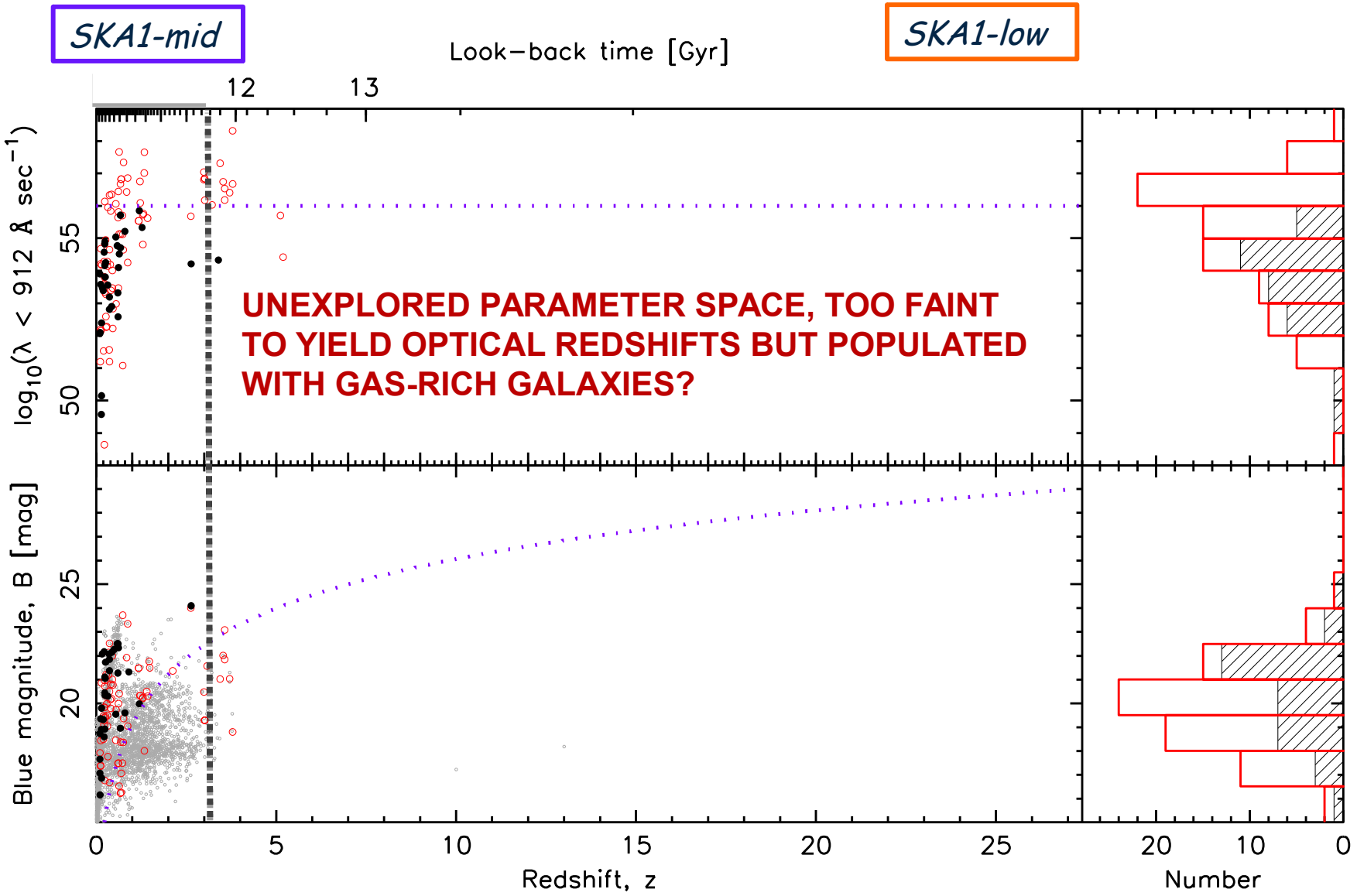
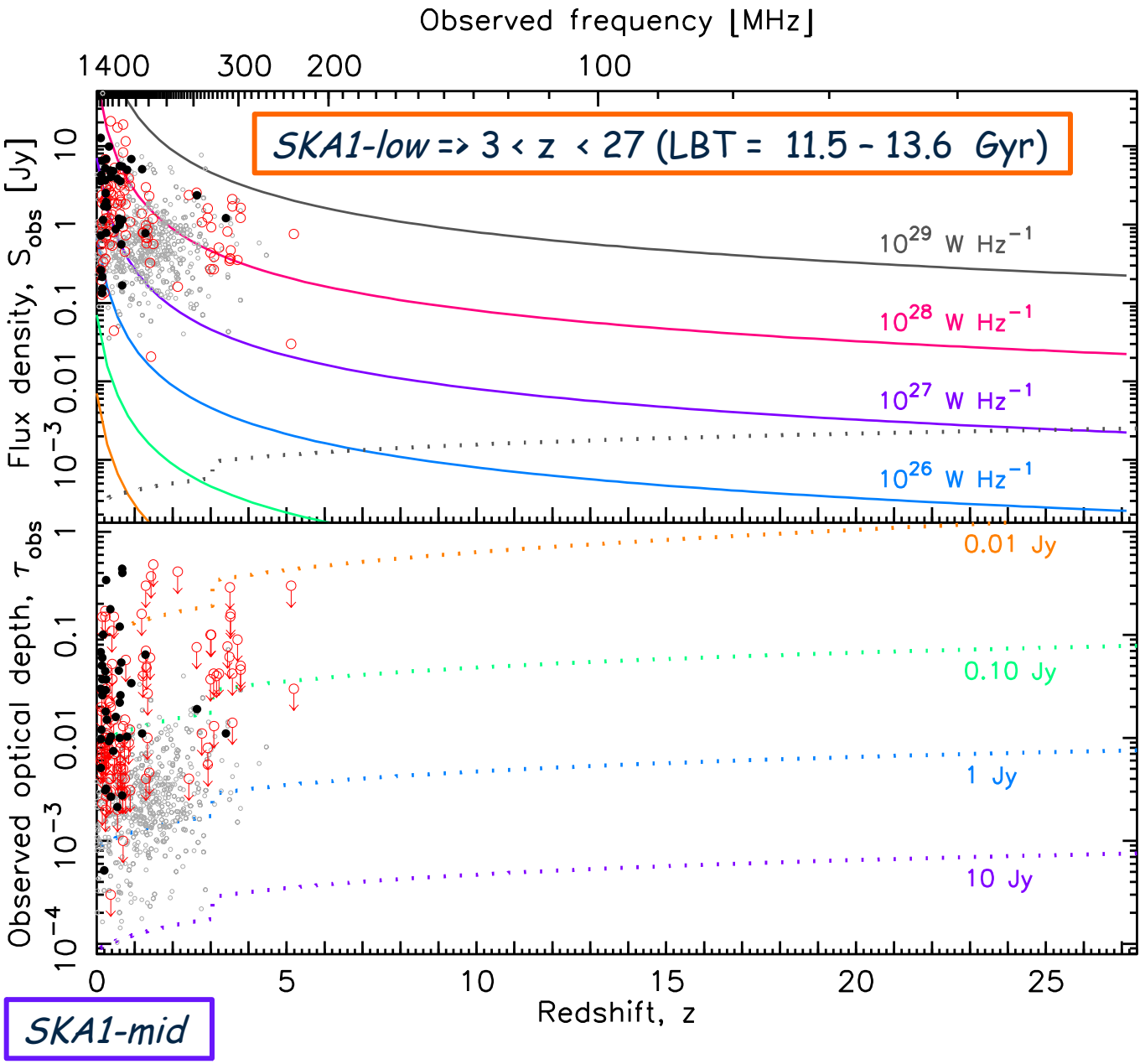


R.M.S. noise level and 3σ optical depth limits at 1 km $s^{-1}$ resolution after one hour integration for SKA1-mid & low (*Morganti, Sadler, Curran et al., 2015,* arXiv:1501.01091)



# Summary

Non-detection of associated HI 21-cm at high-z explained by UV luminosities of $L_{UV} > 10^{23}$ W $Hz^{-1}$ ionising/exciting the neutral gas (*Curran et al*,. 2008). Has been confirmed by *Grasha & Darling* (2011) & *Allison et al*. (2012).

The non-detection of HI 21-cm in these objects is *not* a sensitivity issue, but a consequence of *all of the gas being ionised* (as demonstrated by the model of *Curran & Whiting,* 2012, and lack of MgII absorption at $Q_{MgII} > 10^{56}$ $sec^{-1}$ ).

So even the SKA is unlikely to detect 21-cm absorption in the currently known (optically selected) z > 3 radio galaxies and quasars.

Spectral scans towards radio-loud, optically-faint objects are required in order to detect missing star-forming gas in high-z radio galaxies and quasars.

With its wide instantaneous bandwidth (700 MHz for SKA1-mid & 250 MHz for SKA1-low) and high sensitivity, the SKA will be ideal in performing such scans for HI 21-cm out to stupidly high redshifts!