# Probing He II reionization with GALEX-selected quasar sightlines

Gábor Worseck[1], J. Xavier Prochaska[1], Lutz Wisotzki[2], Aldo Dall'Aglio[2], Cora Fechner[3], Philipp Richter[3], Joseph F. Hennawi[4,5], Dieter Reimers[6]

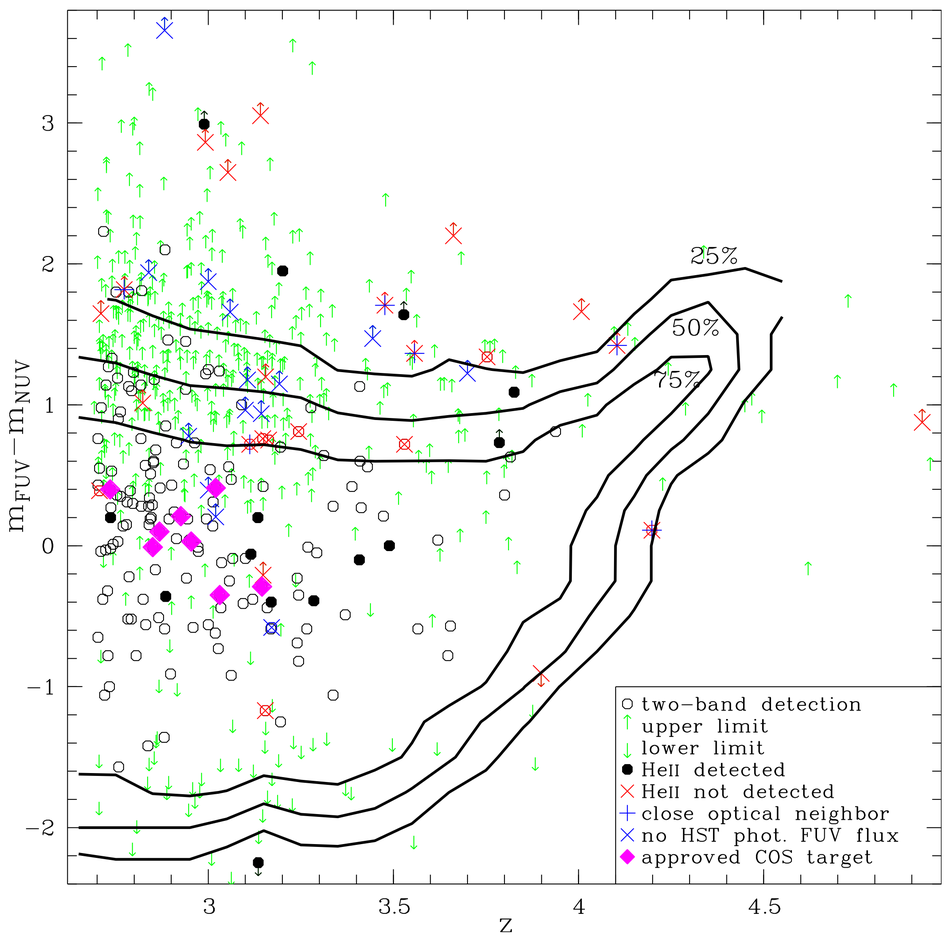
[1]UCO/Lick Observatory, [2]Astrophysikalisches Institut Potsdam, [3]Universität Potsdam, [4]University of California Berkeley, [5]Max Planck Institut für Astronomie Heidelberg, [6]Hamburger Sternwarte/Universität Hamburg

## The quest for intergalactic helium

Like hydrogen, intergalactic singly ionized helium can be probed by Ly$\alpha$ absorption spectra. However, observations of He II Ly$\alpha$ ($\lambda_0 = 303.78$Å) require far UV spectroscopy from space and are restricted to $z > 2$ due to the Galactic Lyman limit. Moreover, the far UV flux of most high-$z$ quasars is extinguished by optically thick intervening H I absorbers. Out of the 16 known transparent sightlines only 5 have been probed at scientifically useful spectral resolution. The strong redshift evolution of the He II absorption on these few sightlines provides the only direct evidence for a late reionization epoch of He II at $z \sim 3$. Moreover, a comparison between the He II absorption and the corresponding H I absorption yields a measure of the otherwise poorly constrained spectral shape of the UV background. Progress in this field clearly requires larger samples of He II sightlines.

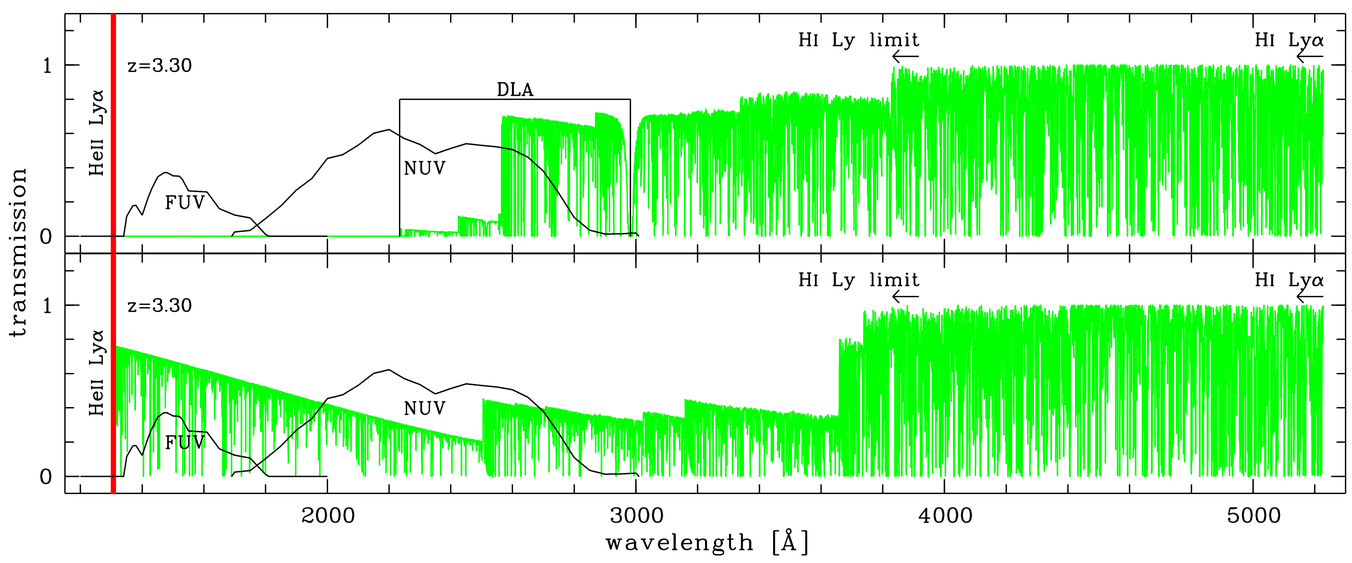
## New promising sightlines to find He II

We correlated the source list of GALEX GR4 ($\sim 25000$ deg$^2$) with verified $z > 2.7$ quasars and flagged likely cases of source confusion due to the large GALEX PSF (5″ FWHM). The figure below shows the UV colors of the 784 detected quasars as a function of redshift. By performing GALEX photometry on Monte Carlo simulated UV quasar spectra with appropriate H I forest and Lyman continuum absorption we estimated the probability to select transparent sightlines (contours). Besides confirming the UV color range of known (in)transparent quasar sightlines, our simulations indicate that most quasars detected in both GALEX bands likely show flux at the He II edge.



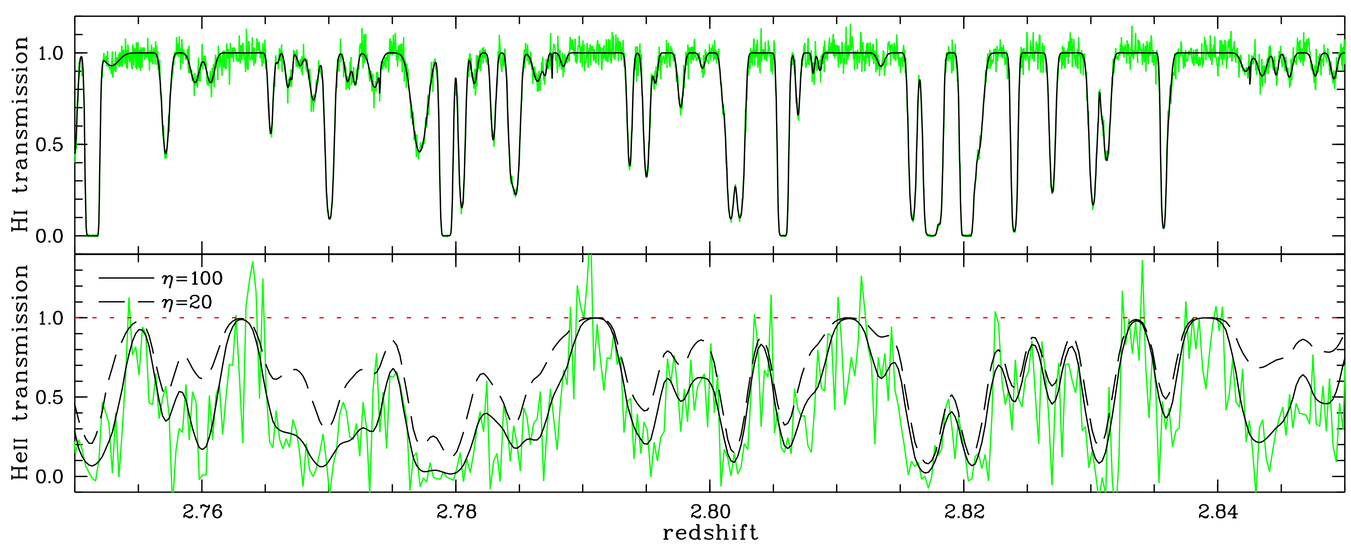

## Our GALEX UV color selection technique

The almost completed first wide-field UV imaging survey by the GALEX satellite provides the so far unknown UV fluxes of most high-$z$ quasars, thus allowing an efficent selection of potential He II sightlines. The figure below shows two simulated H I sightlines, the two GALEX bandpasses and the onset of the He II absorption. Recently, Syphers et al. (2009) detected He II absorption towards 9/24 targets primarily selected from GALEX near UV (NUV) photometry. However, at least for $z \lesssim 3.5$ quasars significant far UV (FUV) flux is required as low-$z$ Lyman limit systems will truncate the spectra in the NUV. Consequently, blue (red) UV colors $m_{FUV} - m_{NUV}$ indicate transparent (opaque) sightlines.




## Our UV+optical spectroscopic follow-up campaign

Eight UV-bright ($m_{FUV} \lesssim 21.5$) quasars are scheduled for follow-up FUV spectroscopy with HST/COS in Cycle 17. All of them are highly promising ($\gg 50\%$ He II detection probability, see left figure). We have also been awarded complementary optical spectroscopy of the H I Ly$\alpha$ forests of our targets with Keck/HIRES and VLT/UVES. The figure below displays simulated spectra illustrating the expected data quality (in green). In the UV the S/N$\sim 6$ at COS resolution ($R \sim 2400$) will be sufficient to confirm the He II Ly$\alpha$ absorption *and* to enable a quantitative analysis. We will match the fitted H I column densities to the observed He II absorption in order to estimate the column density ratio $\eta =$He II/H I (the He II spectrum below assumes $\eta = 100$). The column density ratio $\eta$ quantifies the spectral shape of the UV radiation field, with values $\lesssim 100$ ($\gtrsim 100$) corresponding to a UV background (less) dominated by quasars.




## Science Goal: New insights into the He II reionization epoch

Our first comprehensive sample of new He II sightlines probing similar redshifts will provide *direct* insights into the elusive He II reionization epoch:

- Our targets at $2.73 < z < 3.15$ straddle the suspected epoch of He II reionization at $z \sim 3$. HST/COS provides the spectral resolution to investigate the fluctuating He II absorption of low-opacity voids and He II Gunn-Peterson troughs.
- By comparing the He II absorption on different sightlines we will be able to characterize cosmic variance in the He II absorption, thereby constraining He II reionization scenarios. In addition, we will study the He III proximity zones of the background quasars and potential foreground quasars.
- With the co-spatial Ly$\alpha$ absorption of H I and He II we will constrain the spectral energy distribution of the UV background and its redshift evolution that probes the population of ionizing sources (hard quasars and soft star-forming galaxies).
- A delayed reionization of helium compared to hydrogen implies a significant hardening of the UV background. We will measure the expected fluctuations in the spectral shape of the UV background created by quasars at the epoch of He II reionization.

http://www.ucolick.org/~gworseck/ gworseck@ucolick.org