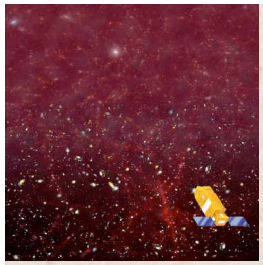
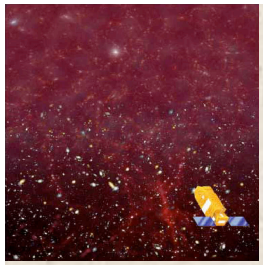
The Helium II Lyman Forest

Gerard Kriss
STScI



What We Can Learn from Observations of He II Absorption

- **Use the ratio of He II and H I column densities to ascertain the shape of the ionizing spectrum.**
  - Do stars or quasars dominate the radiation field at z=2-3?
- **Using the spectral shape in conjunction with proximity-effect measurements of the radiation field intensity,**
  - Set limits on the escape fraction of radiation from star-forming galaxies.
- **Trace the qualitative appearance of He II reionization.**
  - This may serve as a preview of what H I reionization looks like.
    - Look for a red damping wing on the G-P trough.
    - Look for absorption features on the damping wing indicative of infalling clouds.

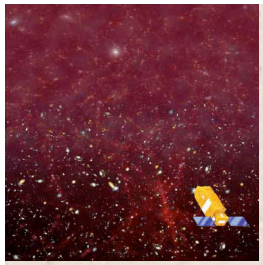


Observations of He II in the IGM

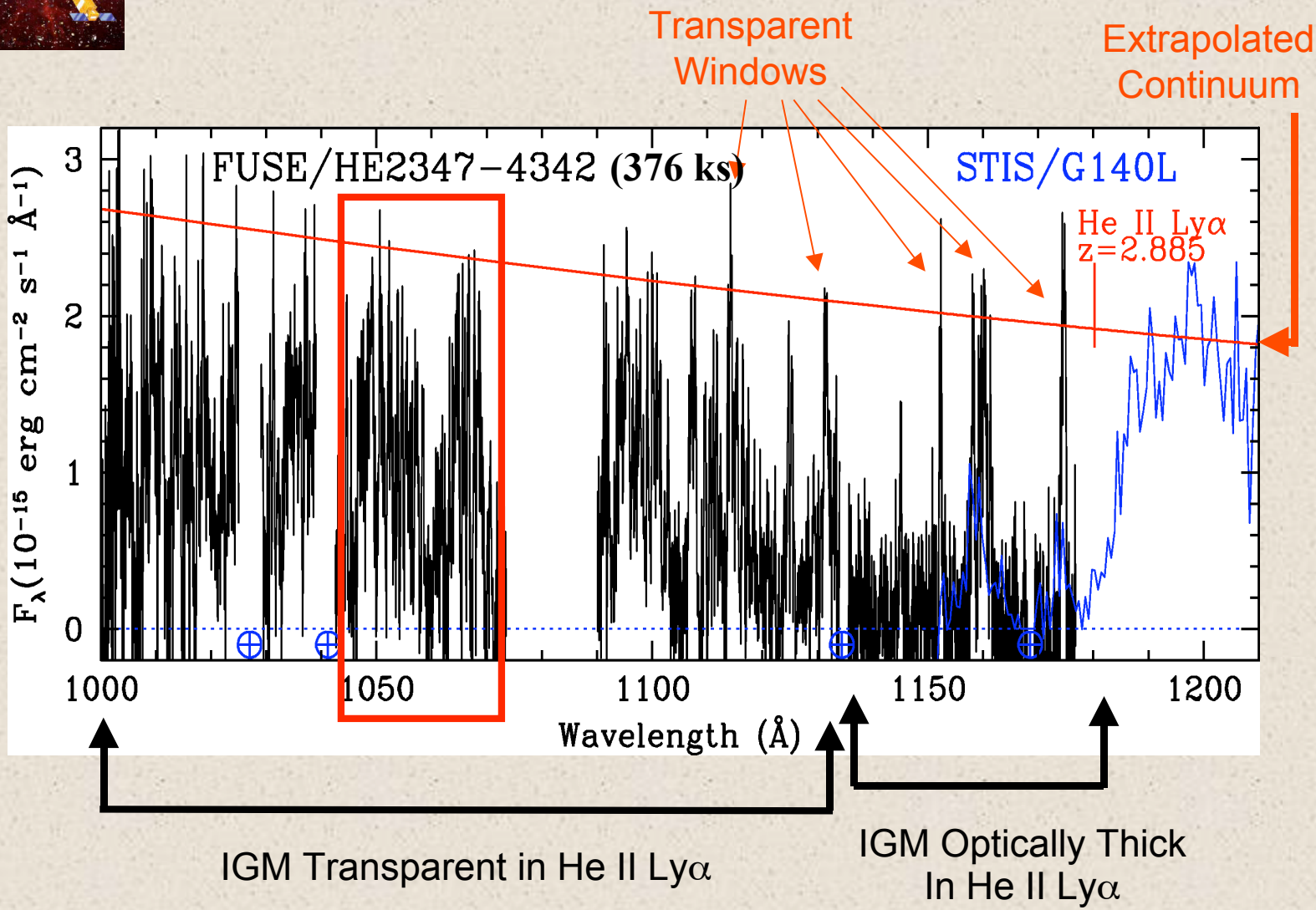
- ★ **Difficult to see—at z~3, only 15% of sightlines are free of LLSs**. There are only 7 known quasars with clear lines of sight.
- ★ **First detection of He II**: Q0302-003, Jakobsen et al. (1994).
- ★ **First measurement of finite He II optical depth**: HS1700+6416, Davidsen, Kriss & Zheng (1996).
- ★ **Observations of the end stages of He II reionization**: HE2347-4342, Reimers et al. (1997).

  Other indirect indicators of He II reionization:

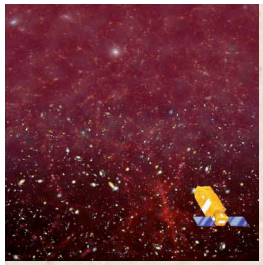
  - Si IV/C IV decreases at z~3: Songaila (1998).
  - HI line widths increase ⇒ IGM temperature increases at z~3.3: Theuns et al. (2002).
  - HI opacity decreases at z~3.3: Bernardi et al. (2003).
- ★ **FUSE observations resolve the He II Lyα forest:** Kriss et al. (2001).



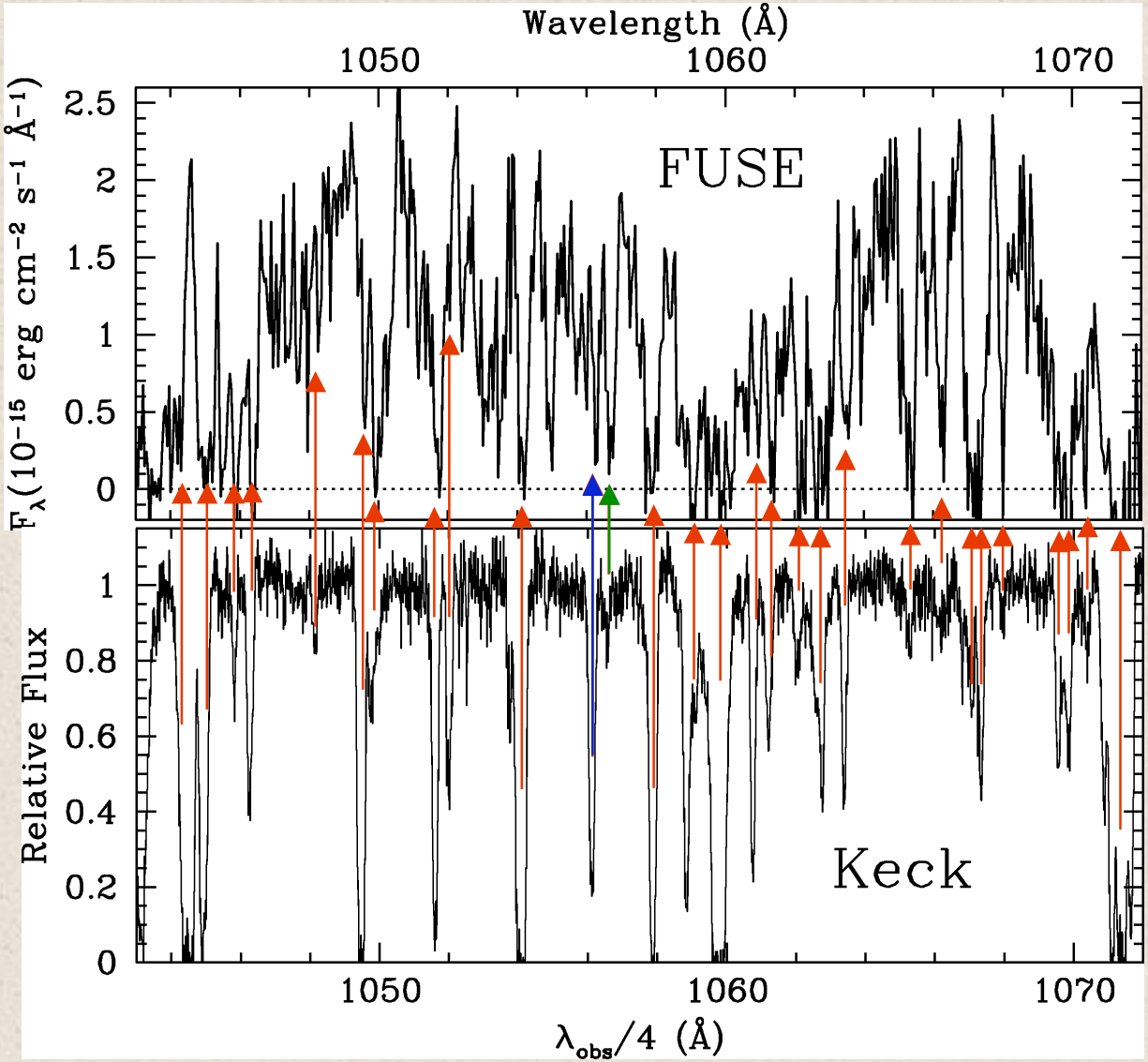
FUSE Spectrum of HE2347-4342



Kriss et al. 2001

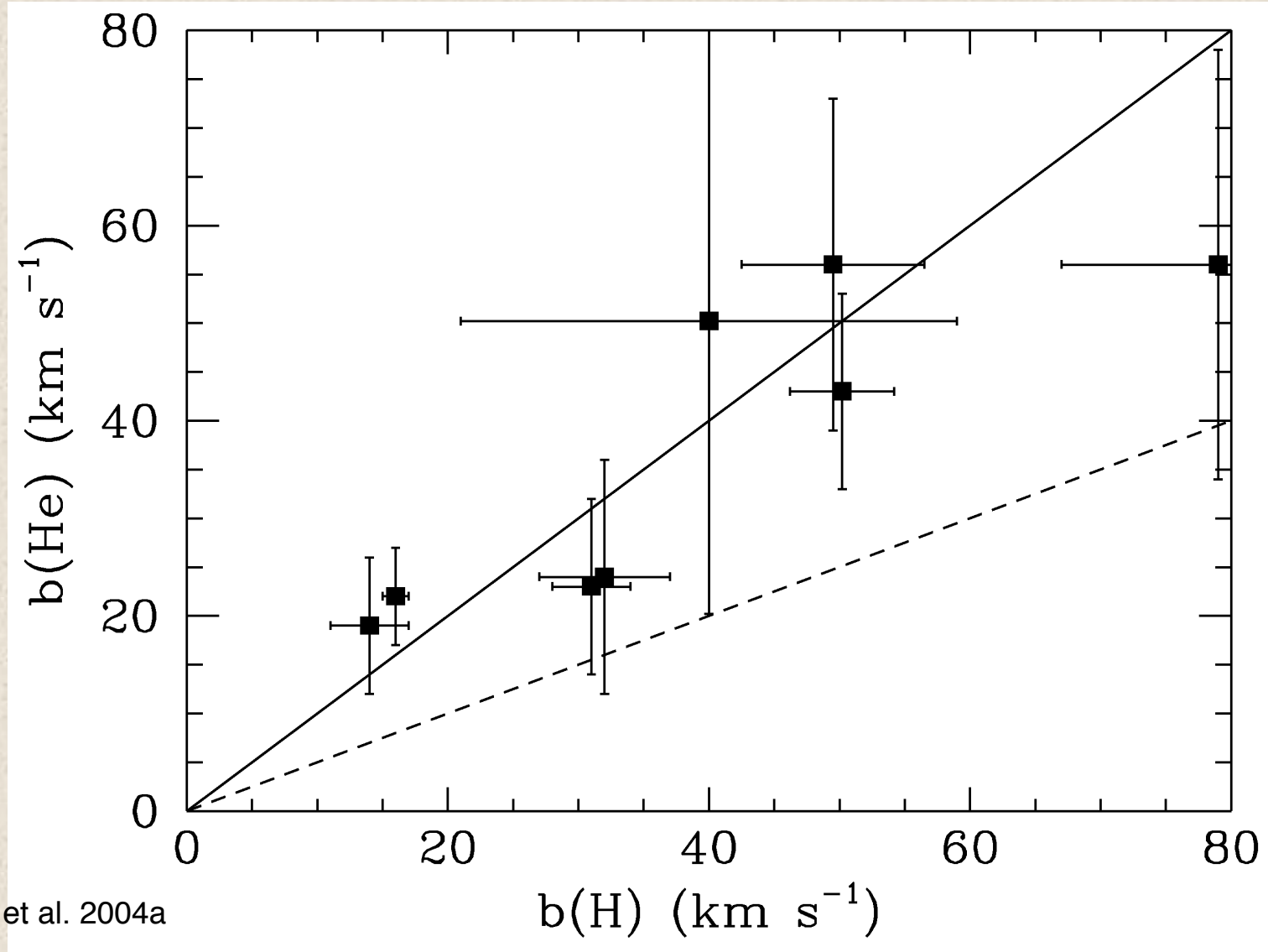


FUSE He II Absorption ⇔ Keck H I

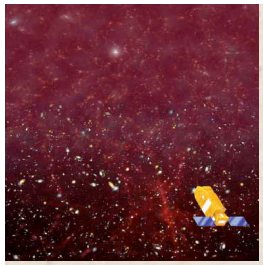


Kriss et al. 2001

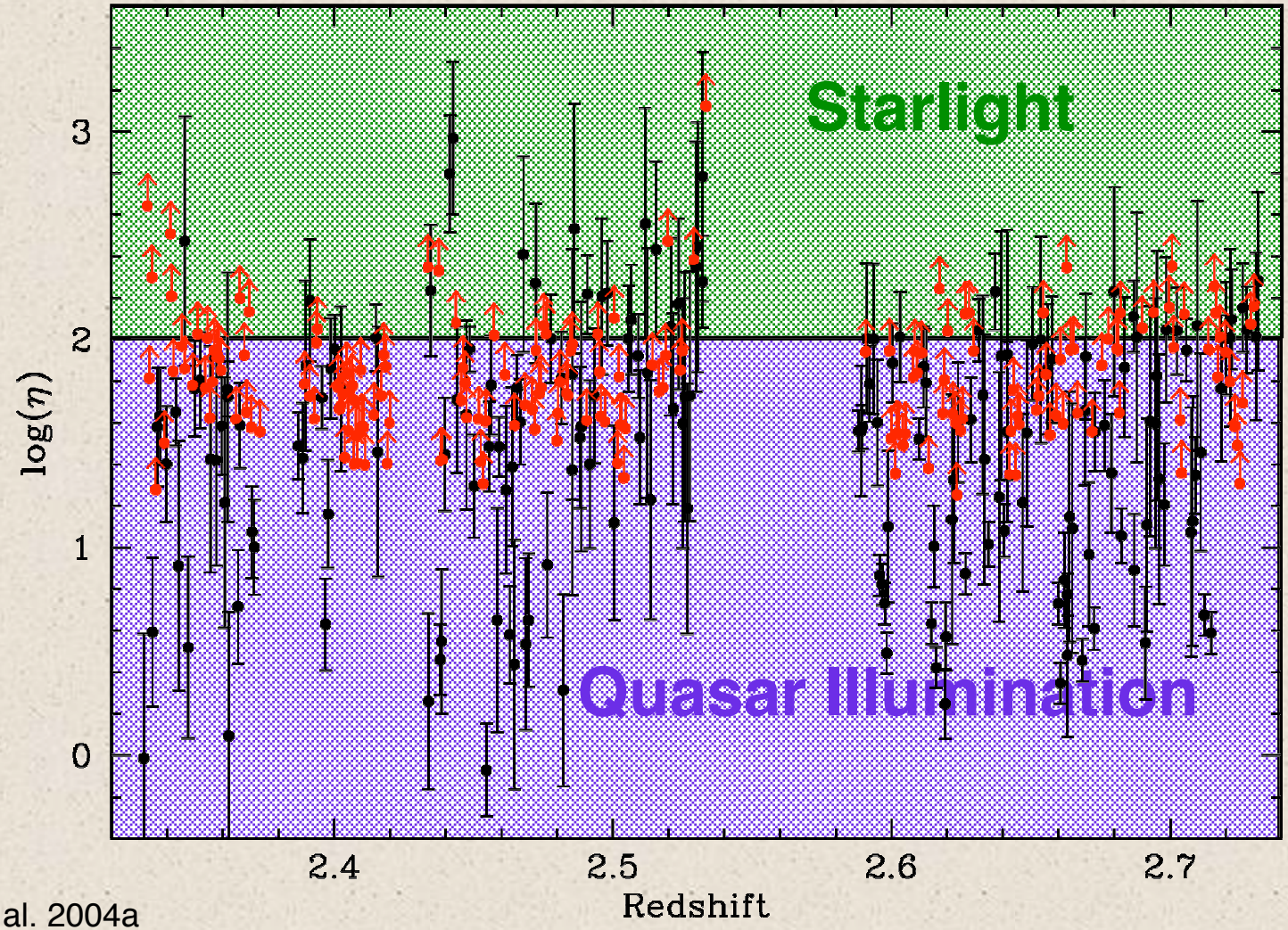
He II Lyman Lines are Turbulently Broadened



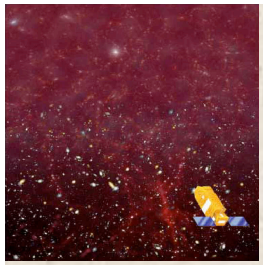
Zheng et al. 2004a



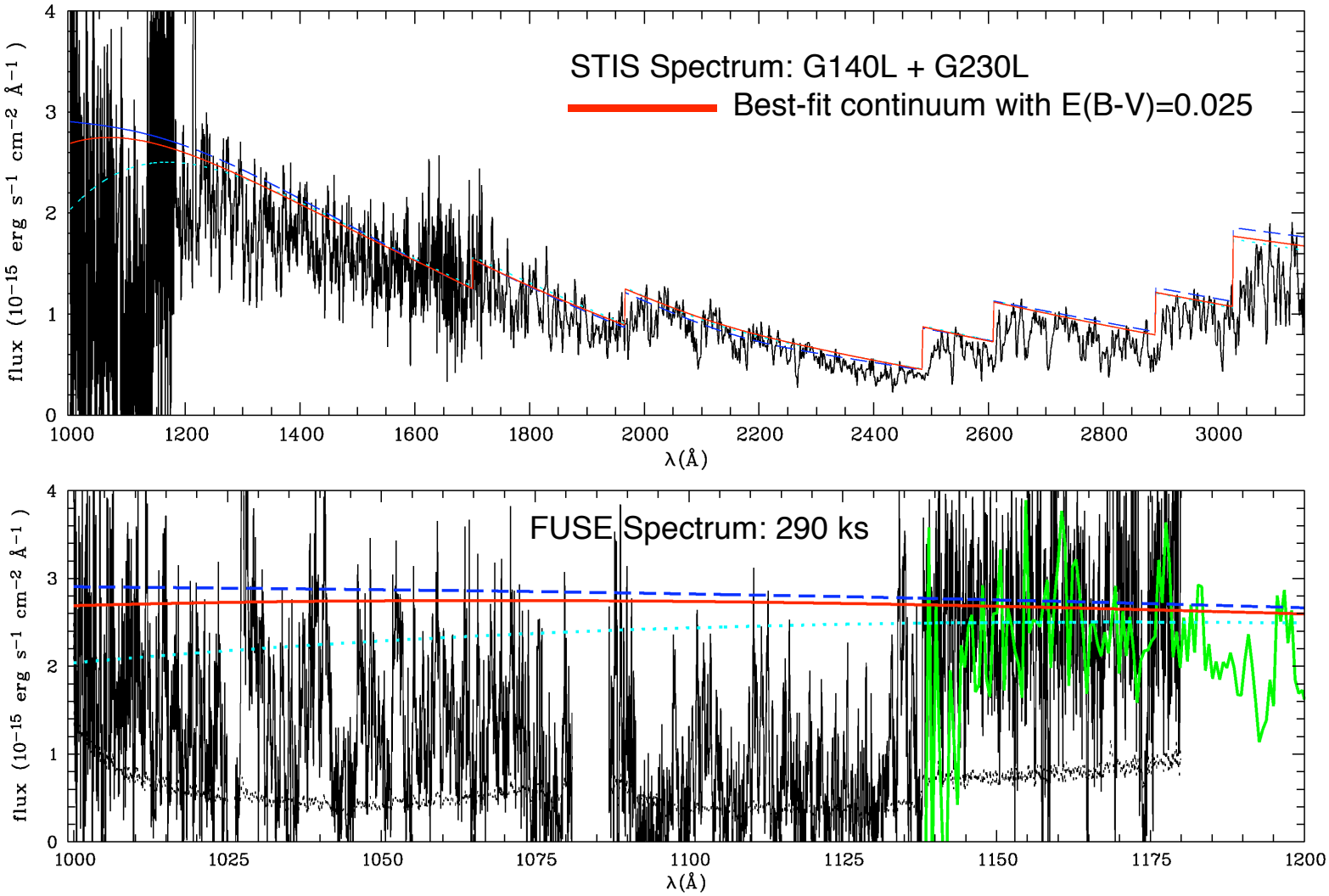
η (N_{HeII}/N_{HI}) vs. Redshift (z)



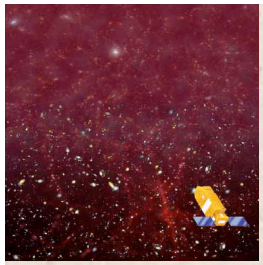
Zheng et al. 2004a



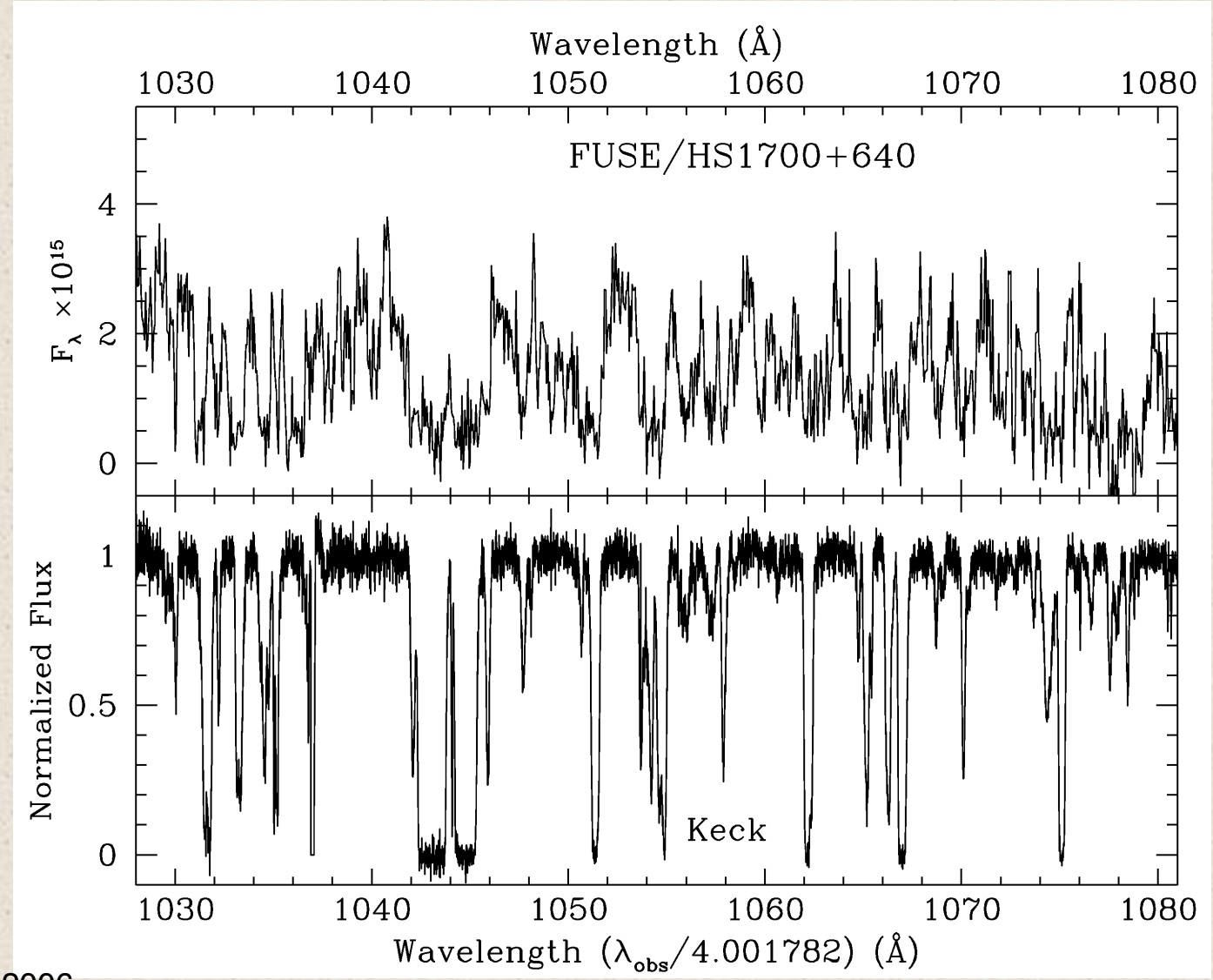
STIS & FUSE Spectra of HS1700+6416



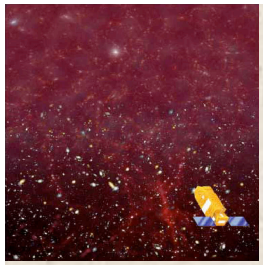
Fechner et al. 2006



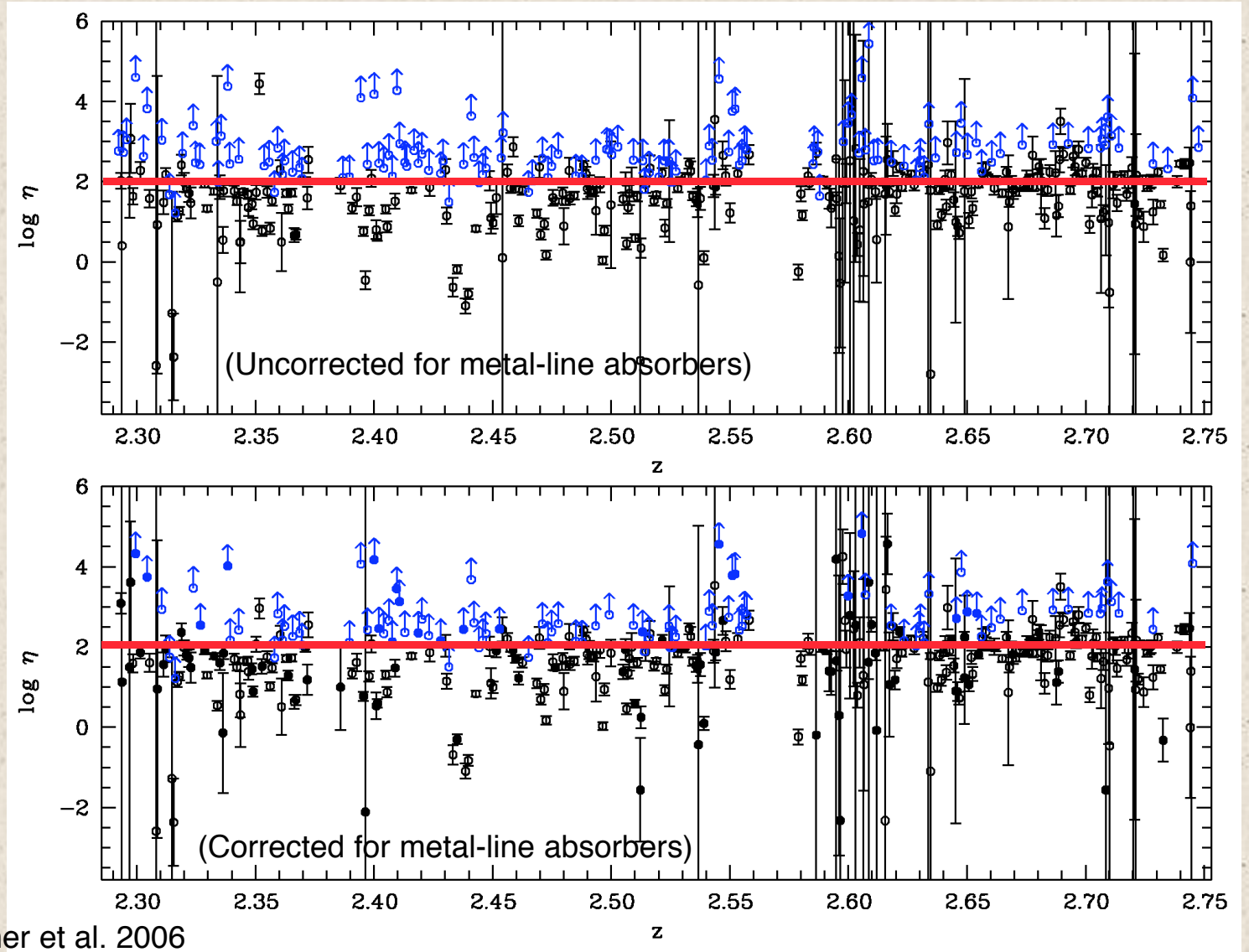
Comparison of FUSE and Keck Spectra of HS1700+6416



Fechner et al. 2006



η (N_{HeII}/N_{HI}) vs. Redshift in HS1700+6416



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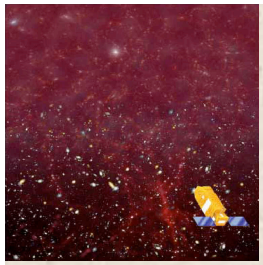
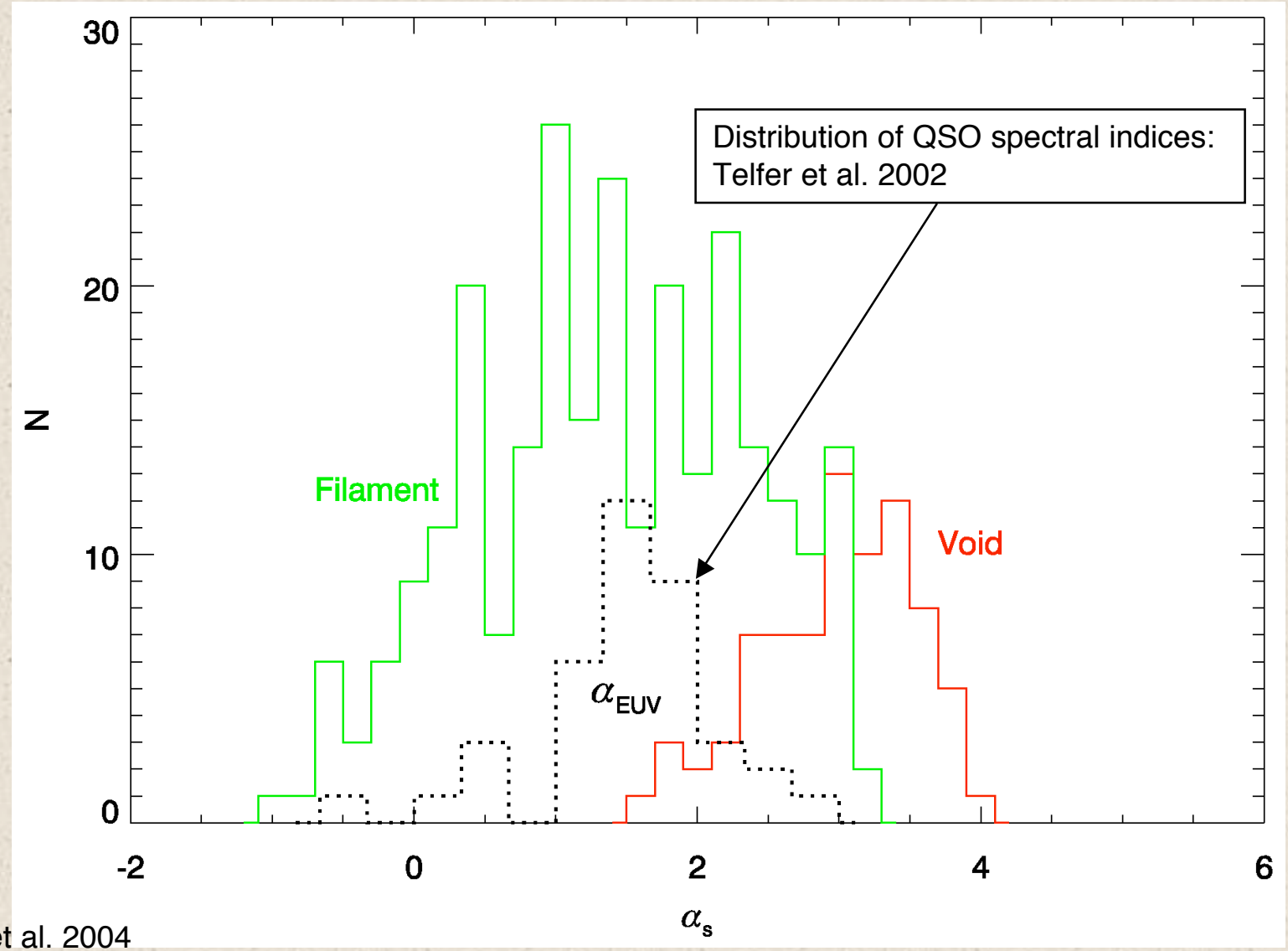
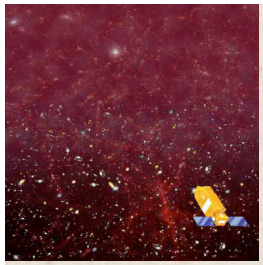


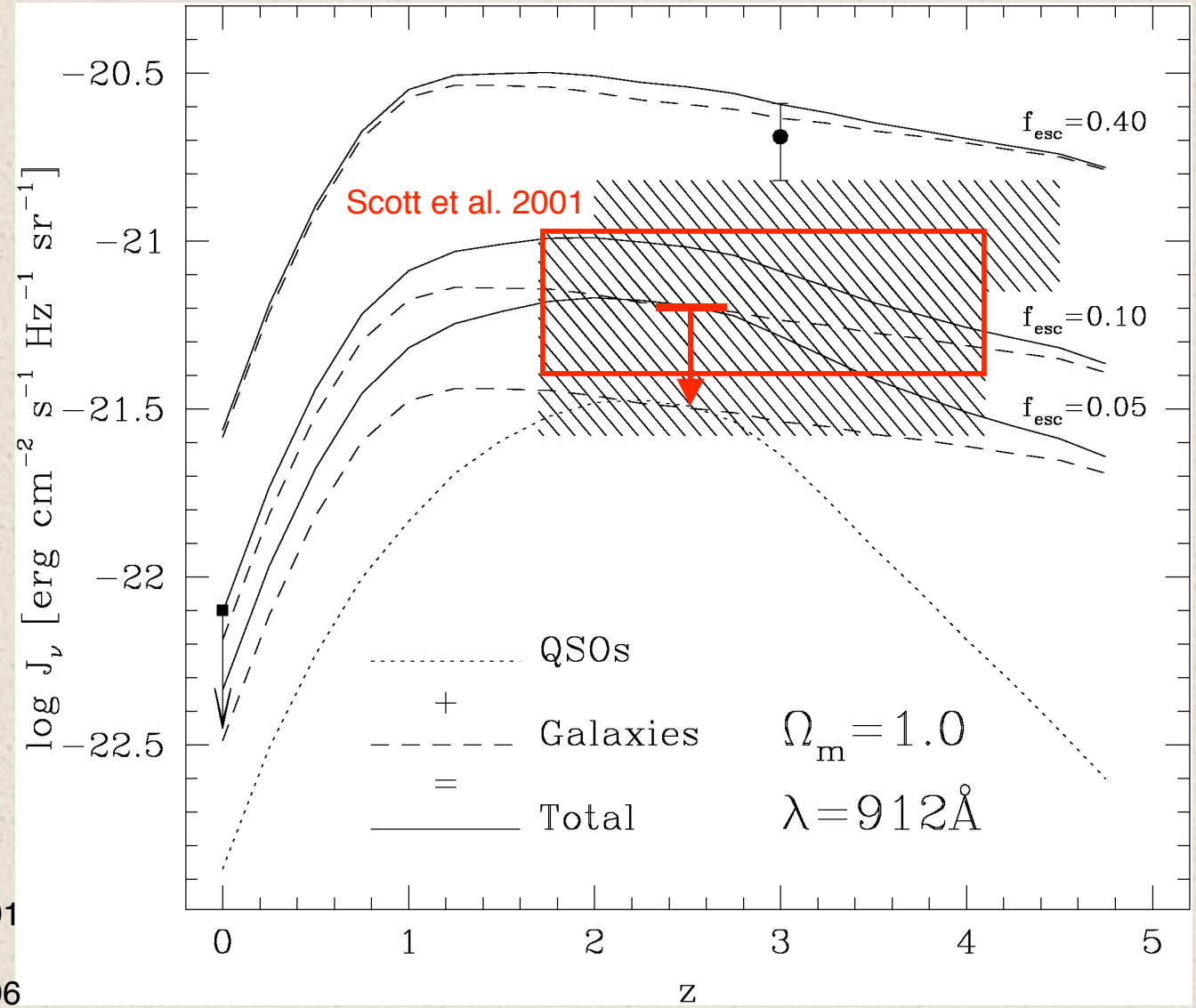
Inferred Spectral Indices Compared to QSOs



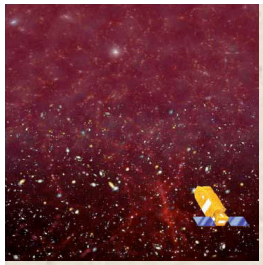
Shull et al. 2004



Constraining F_{esc} for Star-forming Galaxies

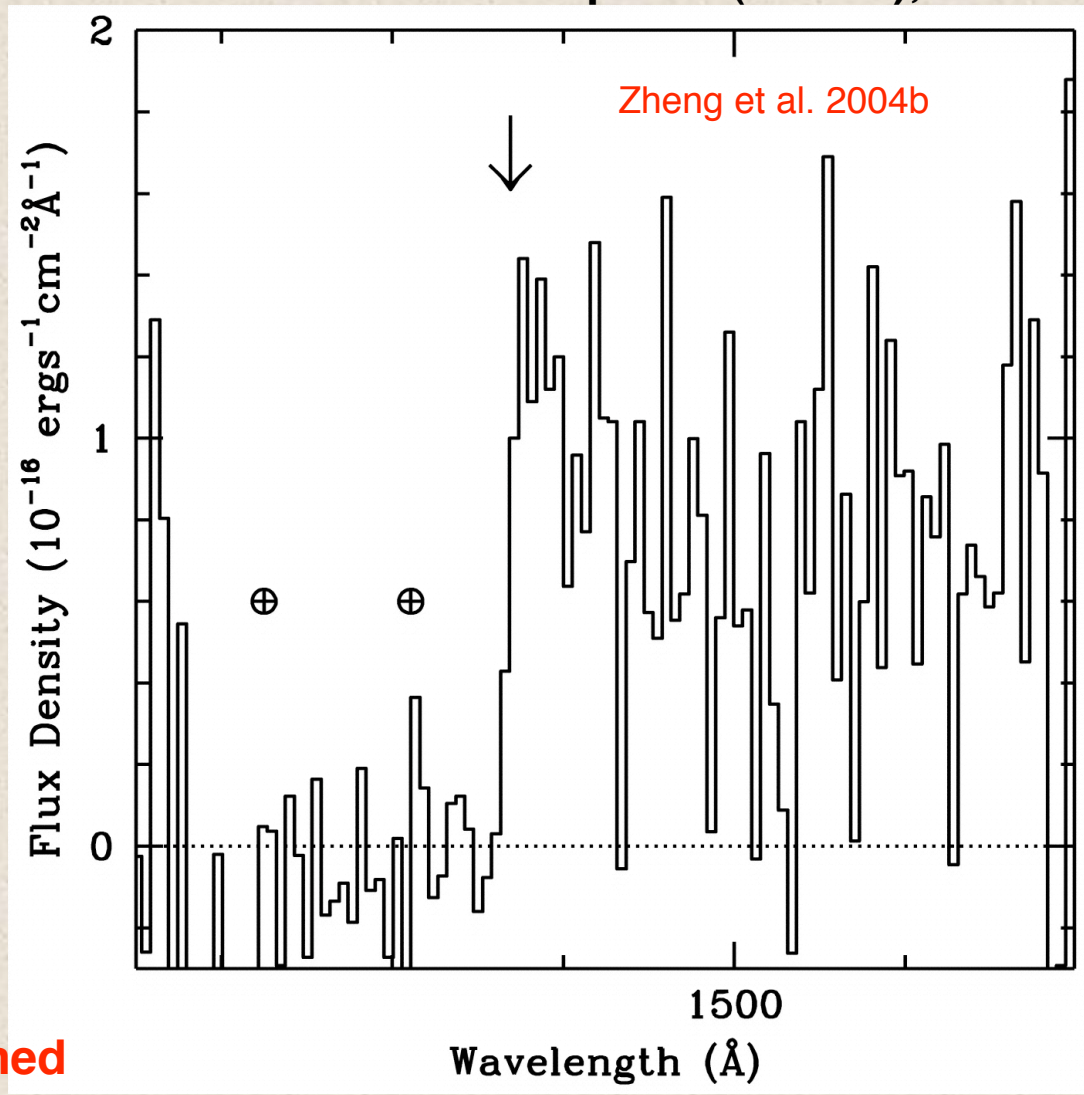


Bianchi et al. 2001
Scott et al. 2001
Kriss & Scott 2006

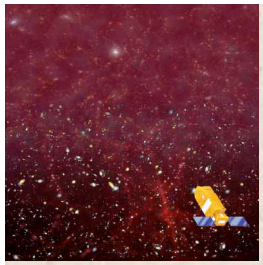


He II Absorption at z=3.5 in SDSS J2346-0016

STIS Low-resolution snapshot (G140L), 600 s



A 40 ks ACS/SBC Prism spectrum was just obtained this fall. Stay Tuned!



Conclusions

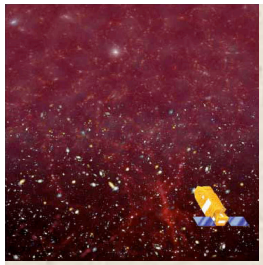
★ FUSE observations of both HE2347–4342 and HS1700+6416 resolve the He II Lyα forest in each object.

↔ For absorption with both He II and H I measurements (more than 90% of the observed He II features), the ratio η=N(He II)/N(H I) lies between 1 and 400, consistent with photoionization by a hard, quasar-like spectrum.

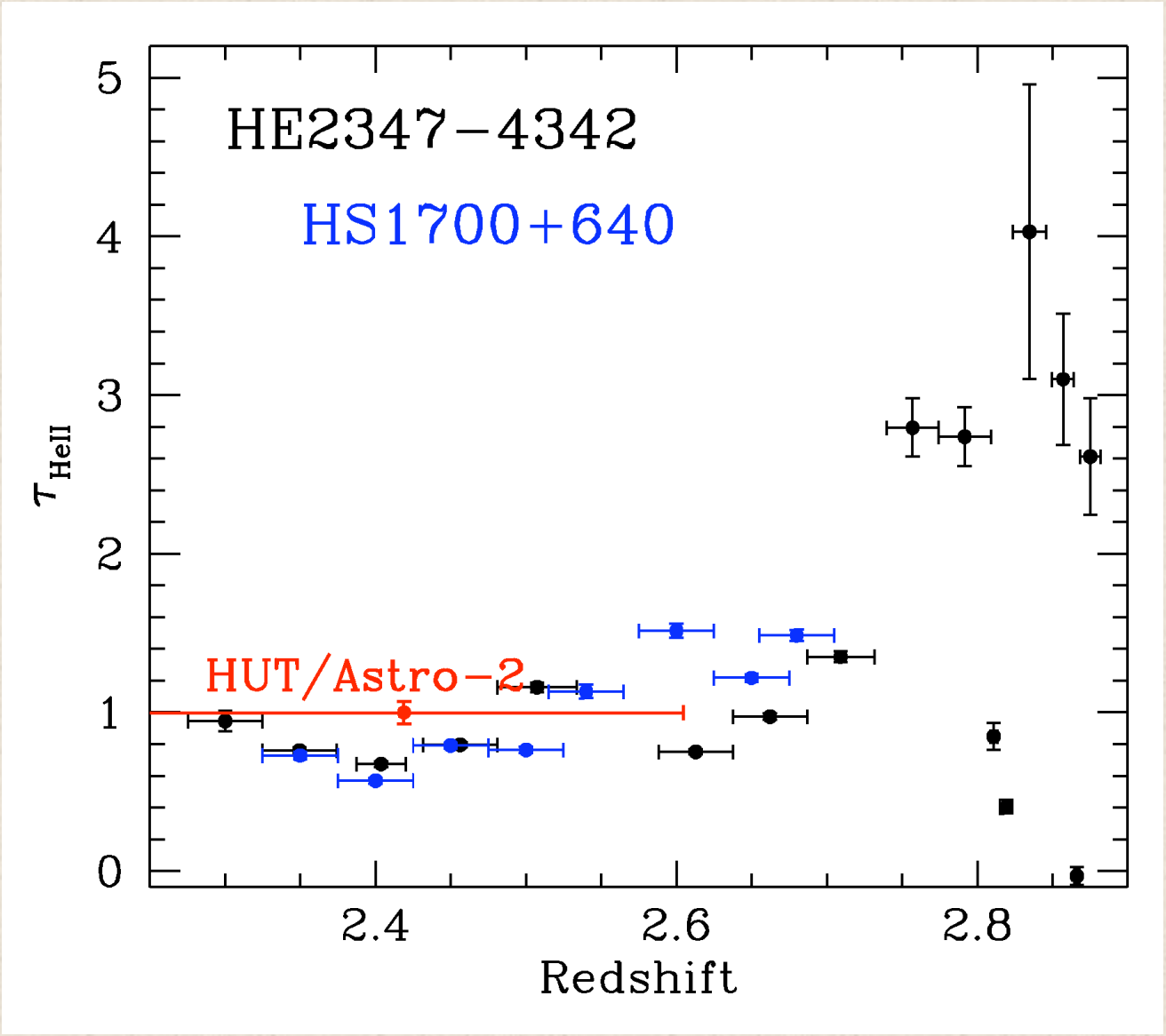
↔ If AGN contribute more than 50% of the ionizing UV flux at z=2.5, the escape fraction for radiation from star-forming galaxies must be less than 5%.

↔ There is considerable scatter in the value of η across the spectrum. This implies that the metagalactic ionizing radiation field is not at all uniform—the nearest sources of UV flux probably play a dominant role at any given location.

↔ The wide distribution of η is consistent with the observed spread in the spectral indices of AGN.



He II Optical Depth vs. Redshift



Kriss et al. 2001
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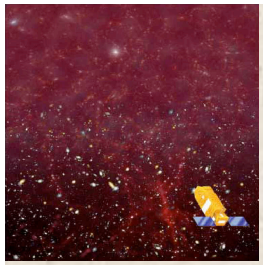

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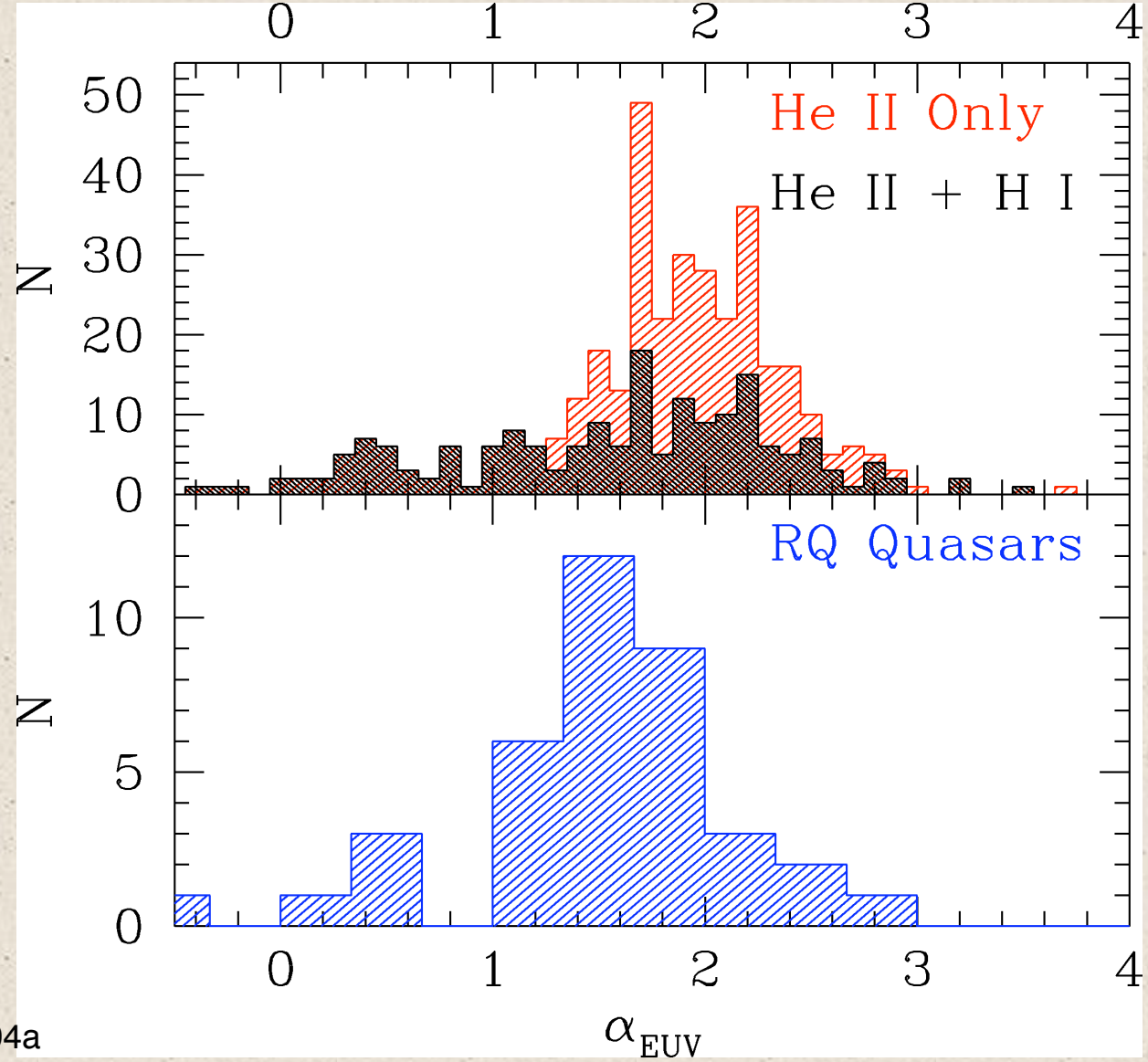

Zheng et al. 2004a