

# The Impact of Nonuniform Ionization and Return Current Losses on Hard X-Ray Spectra

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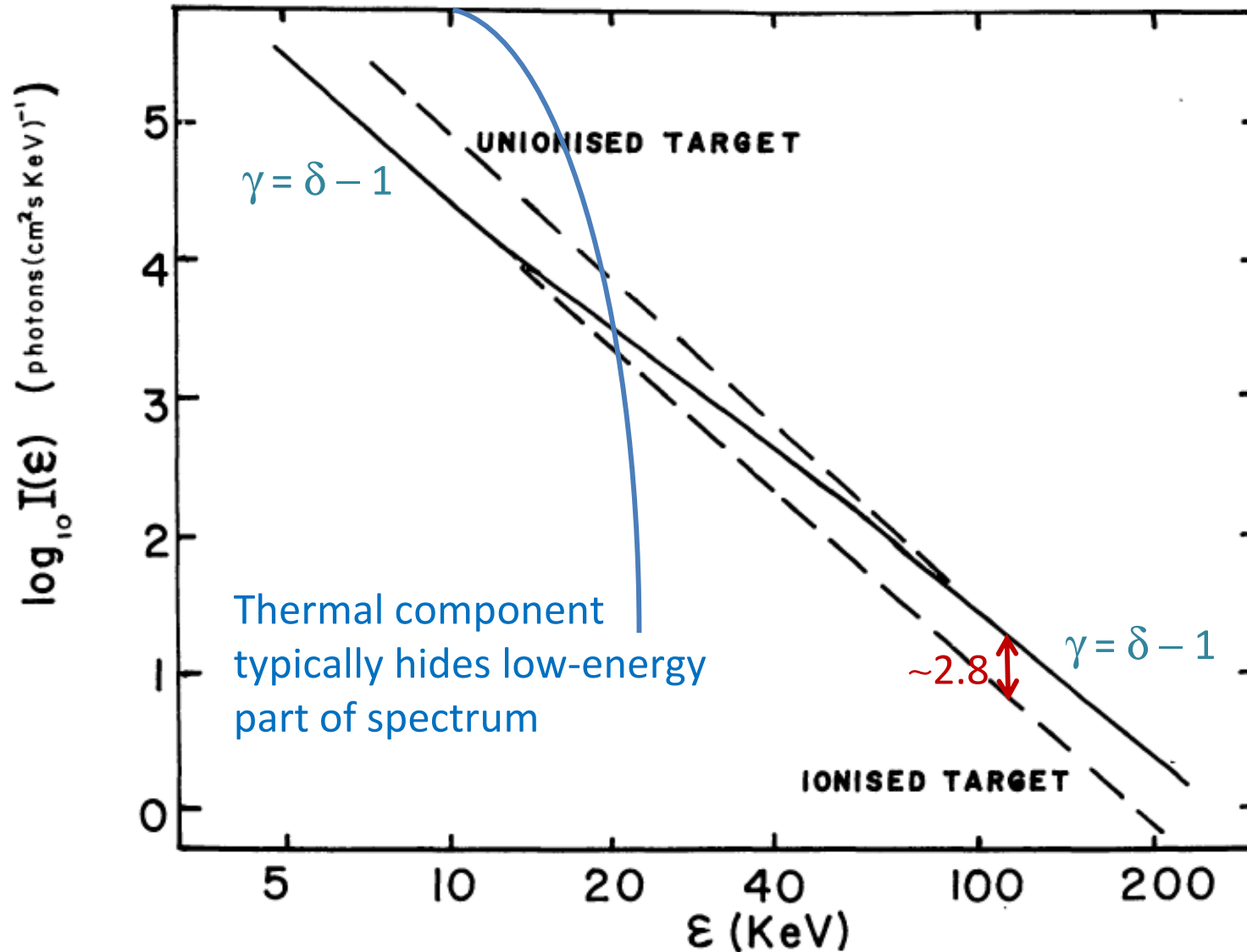
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Can we uniquely identify  
or rule out  
nonuniform ionization in the thick-  
target region  
or  
return-current-related energy losses  
as the cause of  
the break in a hard X-ray spectrum?

This presentation focuses on  
nonuniform ionization.

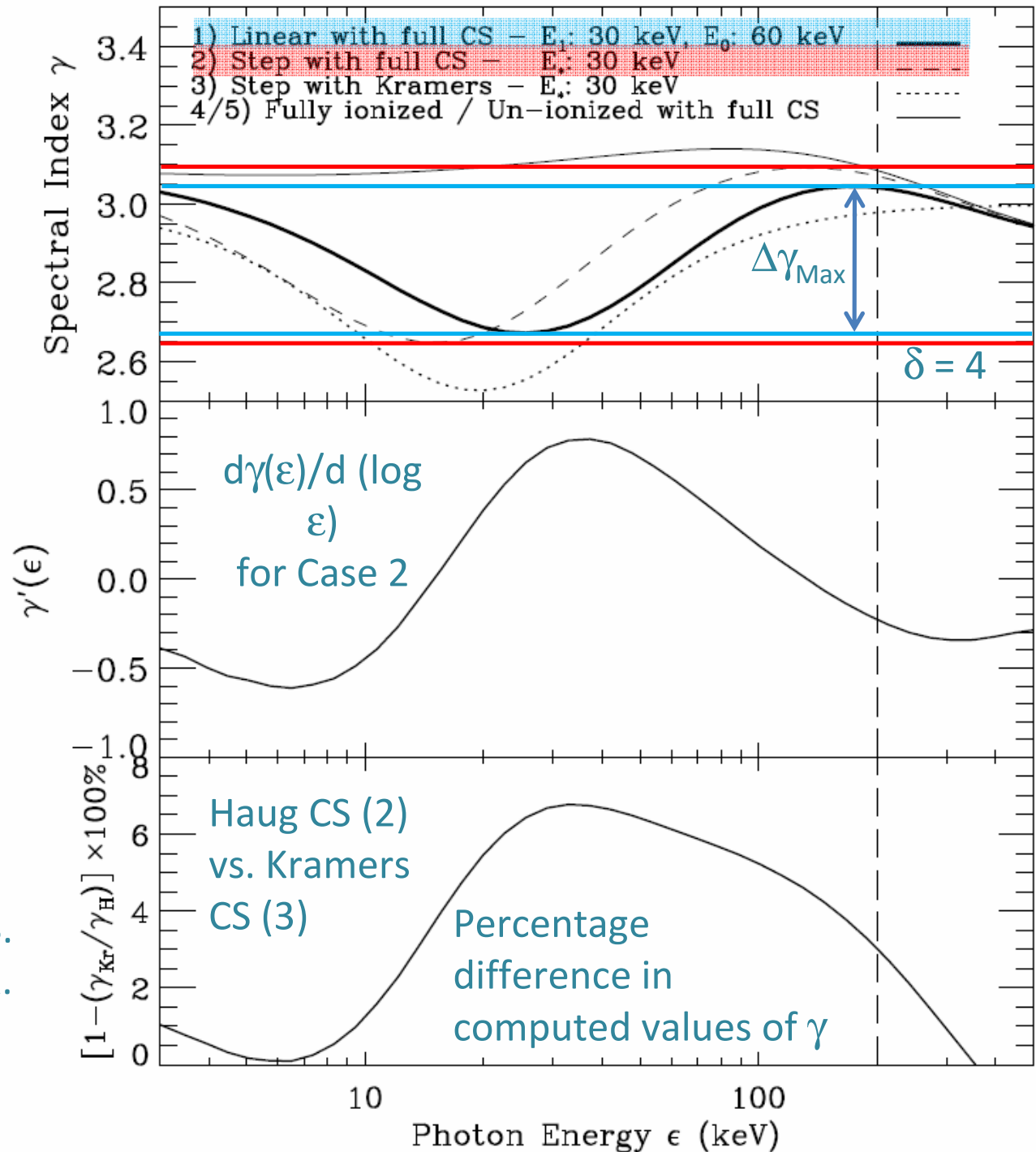
# Nonuniform Ionization in the Thick-Target X-Ray Emission Region



# Variation of Spectral Index with Photon Energy

Step-function ionization model gives the largest maximum spectral flattening,  $\Delta\gamma_{\text{Max}}$ .

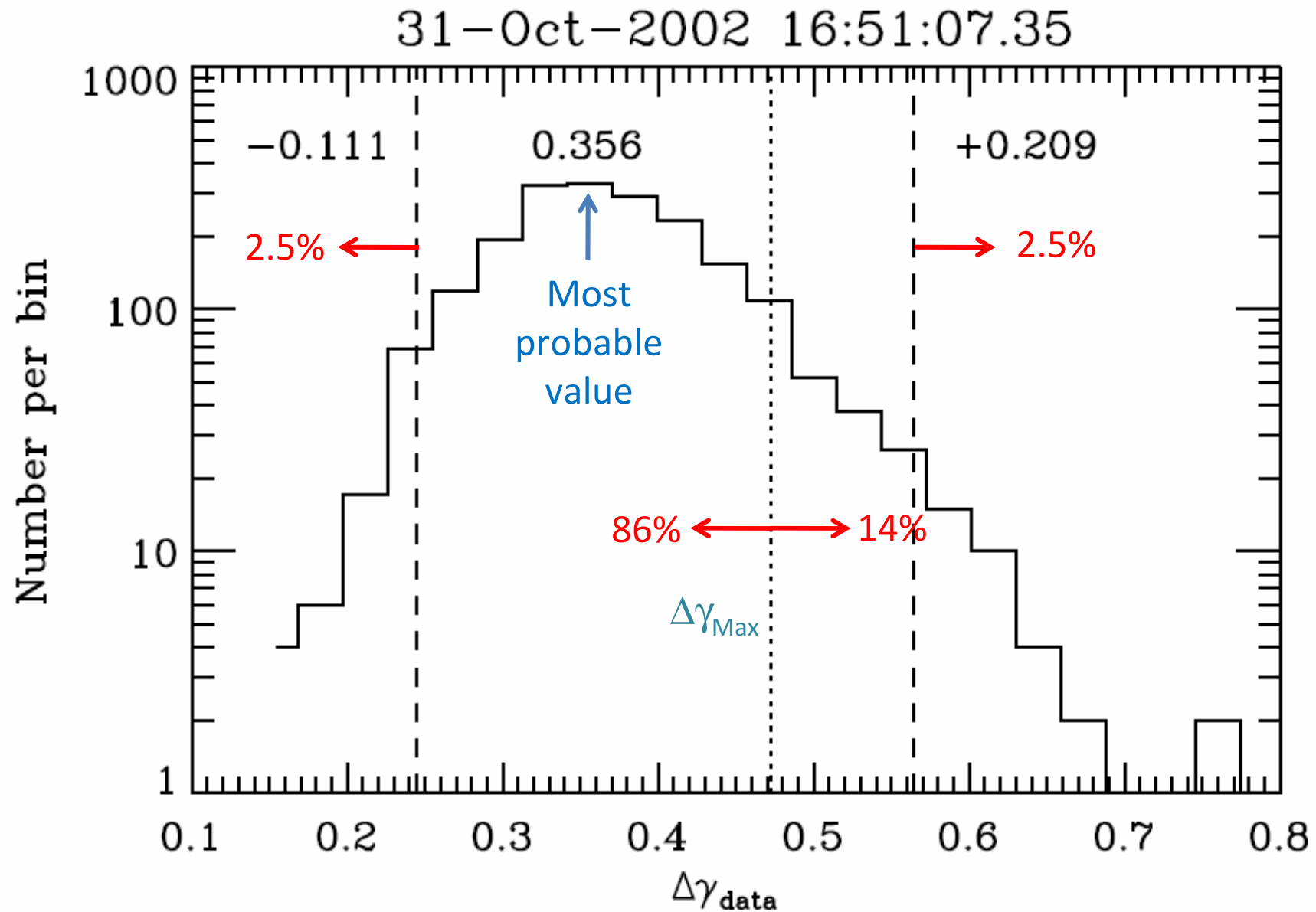
Su, Y., Holman, G. D., Dennis, B. R., Tolbert, A. K., & Schwartz, R. A. 2009, ApJ, submitted



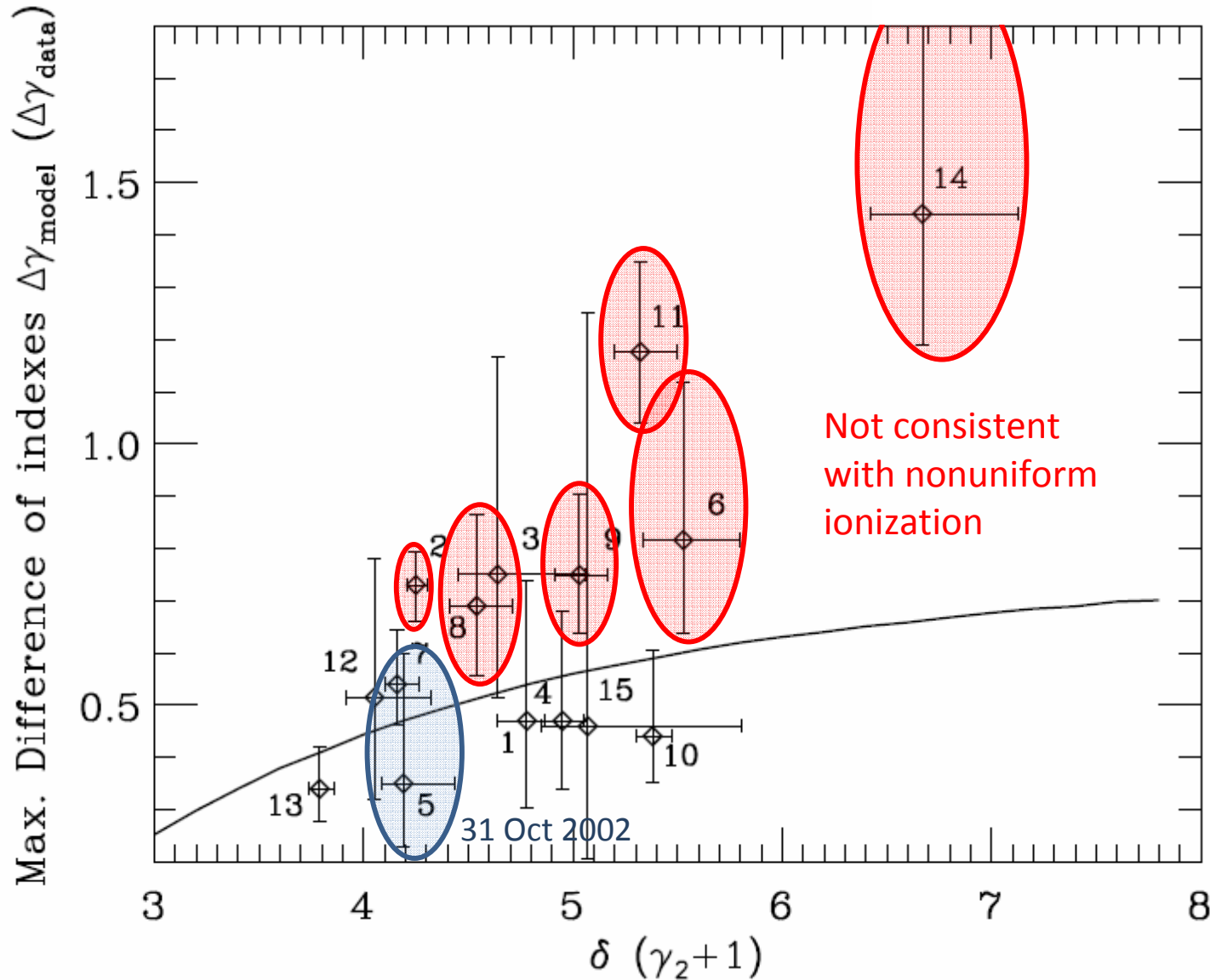
# Flare Sample for Comparison of Measured Spectral Breaks with $\Delta\gamma_{\text{Max}}$

1. Flares observed from 12 Feb 2002 to 31 Dec 2004 (7815)
2. 12 – 25 keV count rate  $> 300$  counts  $s^{-1}$  detector $^{-1}$  & 50 – 100 keV count rate  $> 3\sigma$  above background (83)
3. Radial distance from disk center  $> 927''$  (22)
4. Livetime  $> 90\%$  (20)
5. Fitted one 4 s time interval at the peak of each flare

# Monte Carlo Determination of the Uncertainty in $\Delta\gamma_{\text{data}}$



# Comparison of $\Delta\gamma_{\text{Data}}$ with $\Delta\gamma_{\text{Max}}$



# Summary

- 15 out of 20 flare spectra showed significant flattening at low energies
- 6 out of the 15 spectral breaks were not consistent with nonuniform ionization (< 2.5% probability of  $\Delta\gamma_{\text{Data}}$  being  $\leq \Delta\gamma_{\text{Max}}$ )
- Conclusion: we can rule out many spectral breaks as being explained by nonuniform ionization alone