Behavior of stellar coronal spectral lines during flare onset

Vinay Kashyap (CfA)
Jeremy Drake (SAO), Thomas Lee (UCI), Raymond Wong (ISU)

Wide Band Spectral and Timing Studies of Cosmic X-ray Sources, Jan 10-13 2017, TIFR-Mumbai

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X-ray jets from distant quasars

Vinay Kashyap (CfA)
Aneta Siemiginowska (CfA), Katy McKeough (Harvard), Teddy Cheung (NRL)
David van Dyk (Imperial), Nathan Stein (UPenn), Vasileios Stampoulis (Imperial)

McKeough et al. 2016, ApJ 833, 123

Wideband Spectral and Timing Studies from Cosmic X-ray sources, TIFR Mumbai, 9-13 Jan 2017

kpc scale Jets

- 11 quasars at z>2 with known kpc-scale radio jets have been observed with Chandra

- Q: are these jets detectable in X-ray?

  Strong central source and weak jet emission, PSF~1/2”

  a priori unknown shapes and sizes → how to tell when a feature becomes detectable?

- Q: can we say anything about the emission mechanism at high redshift?

  If present, and whether different from low redshift cases

  Inverse Compton off CMB, or synchrotron?

Digression: LIRA

Low-counts Image Reconstruction and Analysis

- Bayesian multi-scale MCMC image reconstruction algorithm
  - Given a known baseline, models residuals in a counts image as a multi-scale component
  - Produces a series of images of the multi-scale residuals drawn from the posterior density distribution
  - Esch et al. 2004 ApJ, Connors & van Dyk 2007 SCMA IV, Connors et al. 2011 ADASS, Stein et al. 2015 ApJ
  - http://github.com/astrostat/LIRA/

Digression: LIRA

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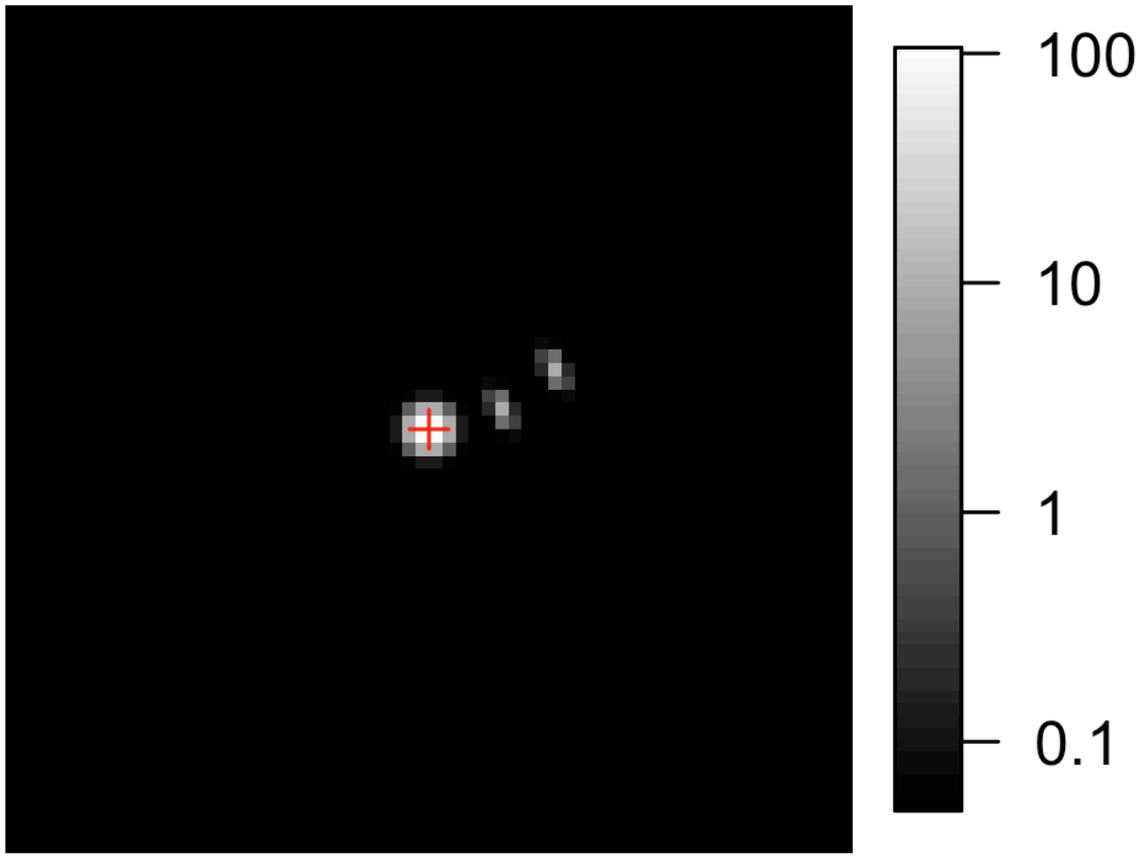

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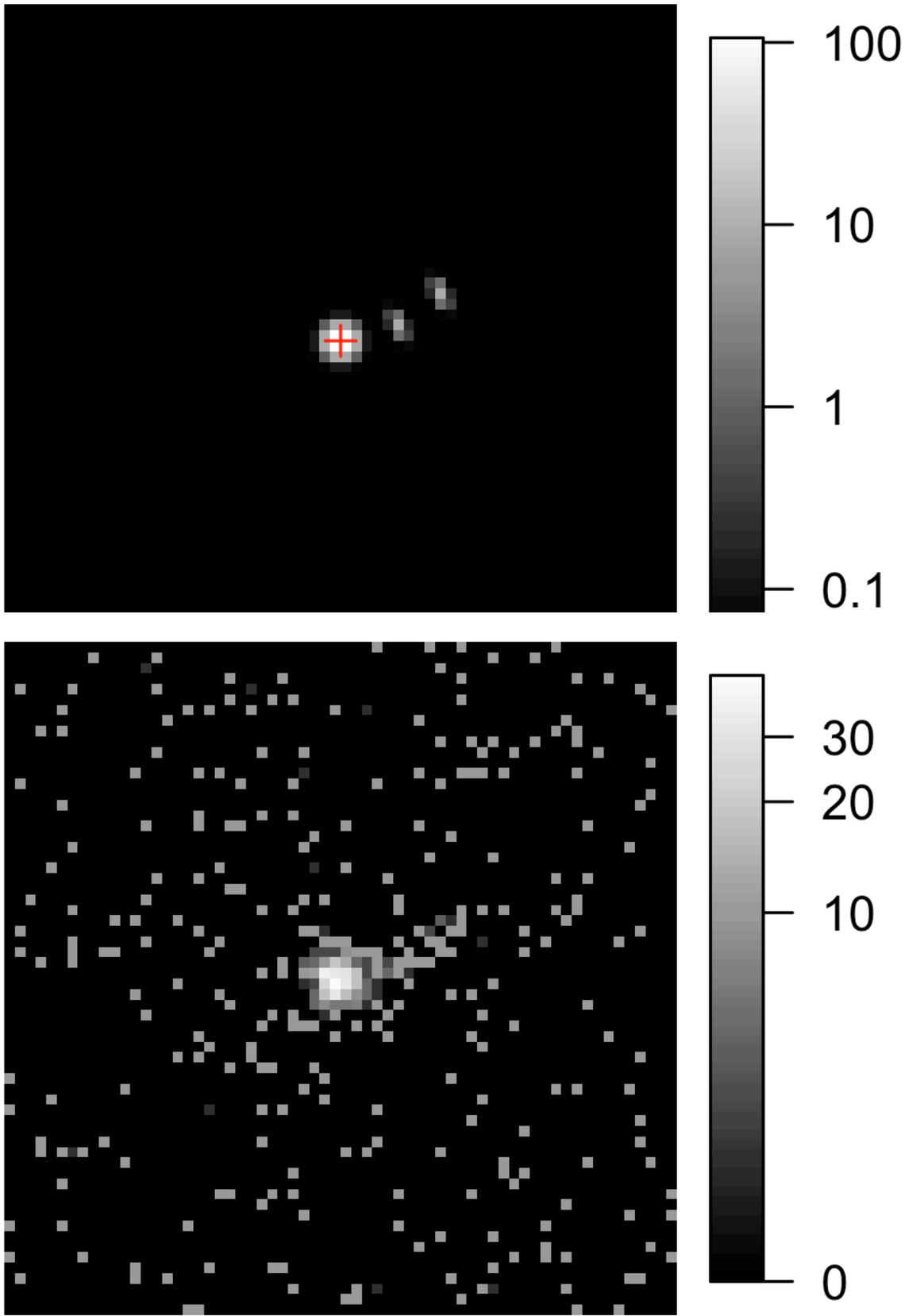

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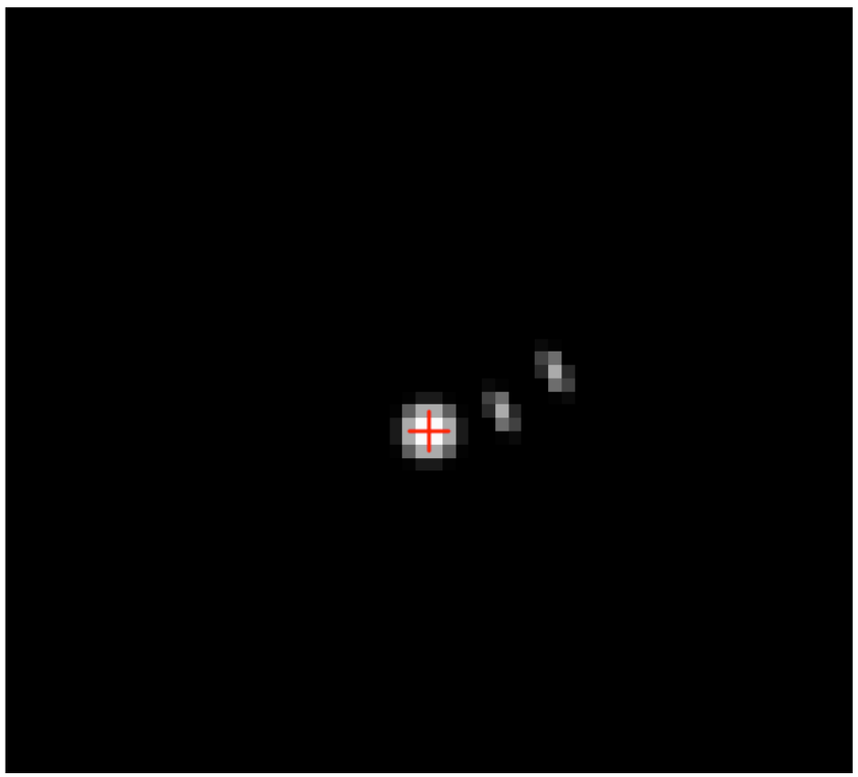
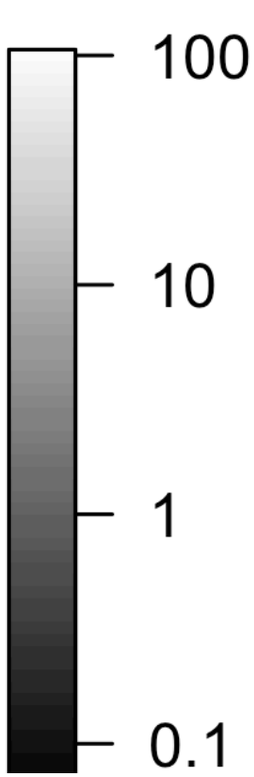
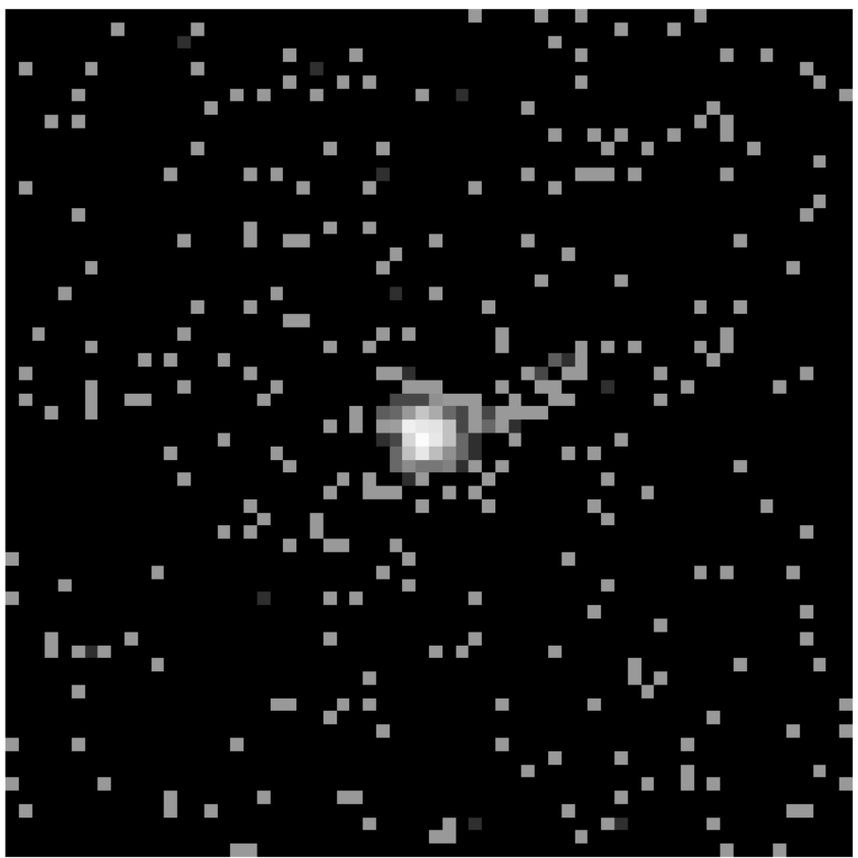
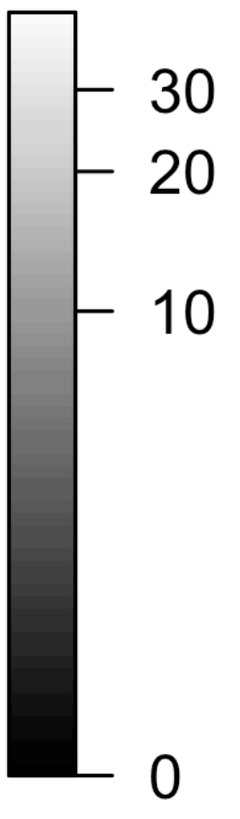
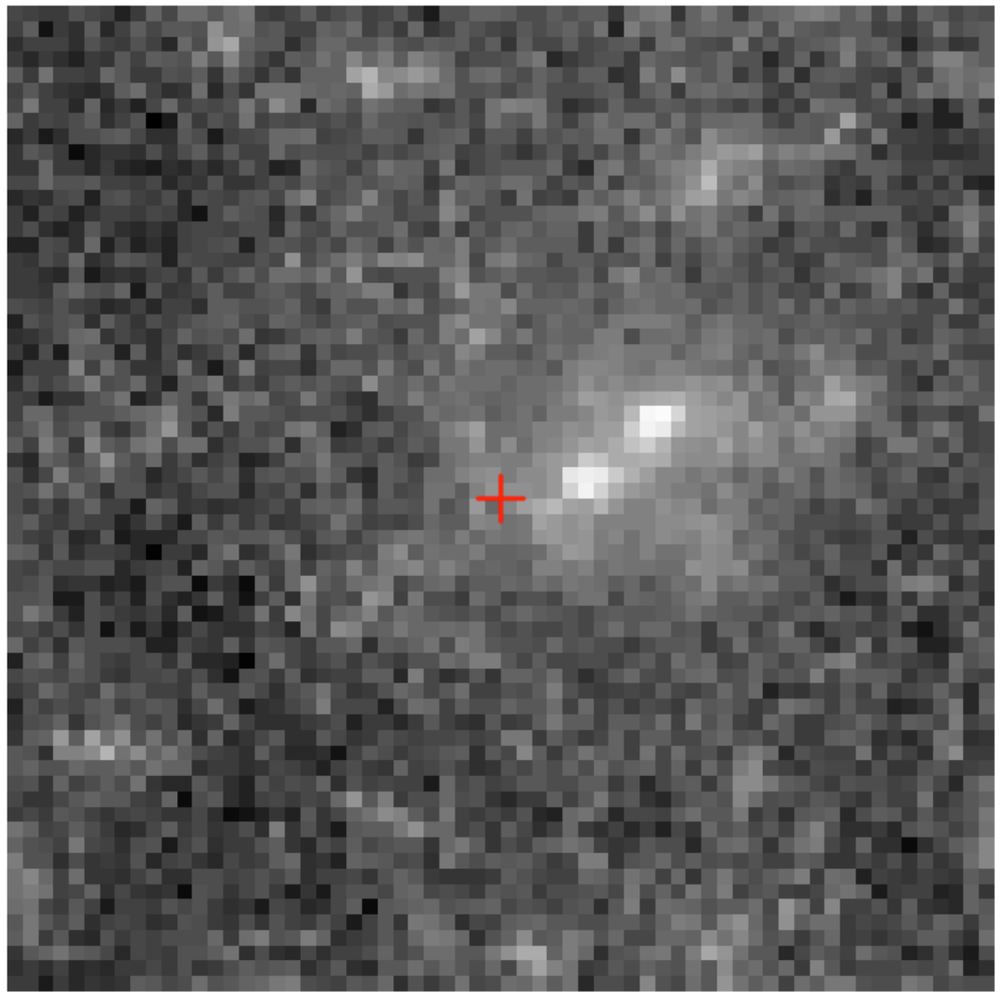
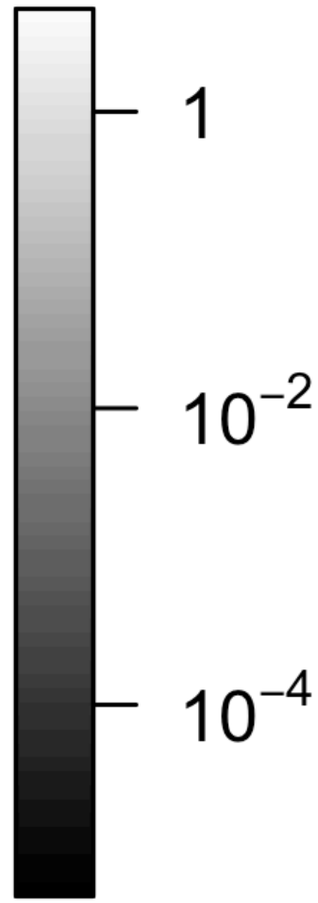




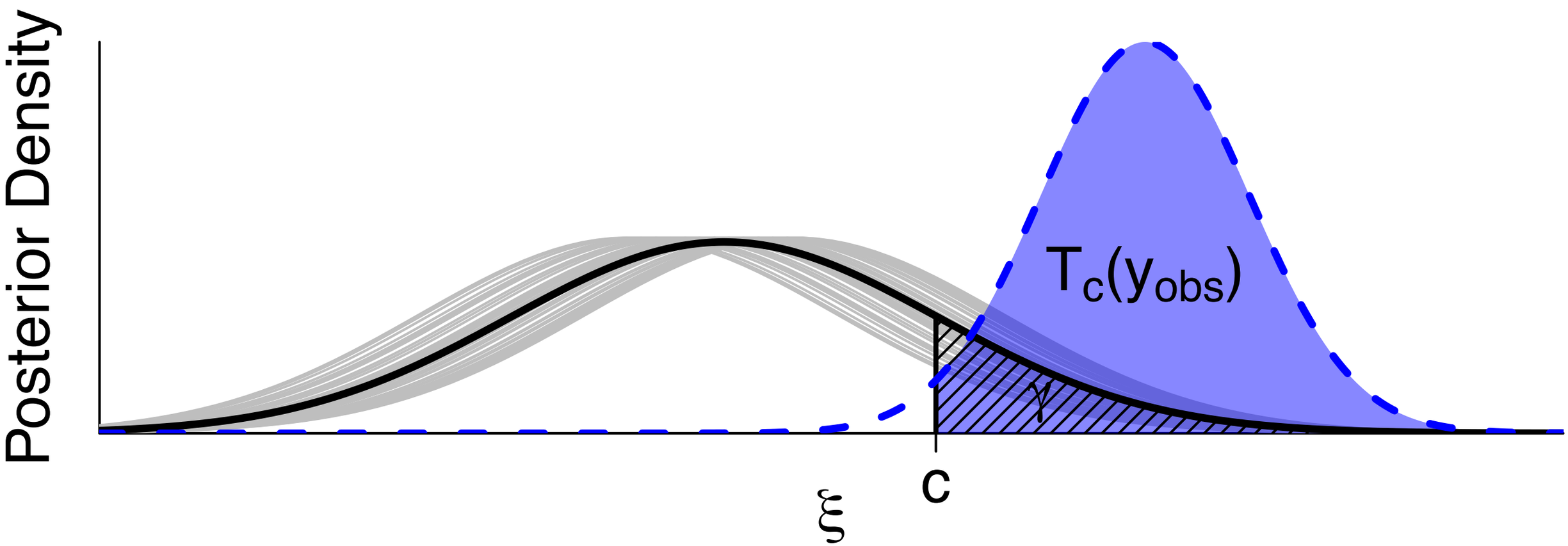








Digression: significance of arbitrarily shaped feature



Stein et al. 2015 ApJ 813, 66

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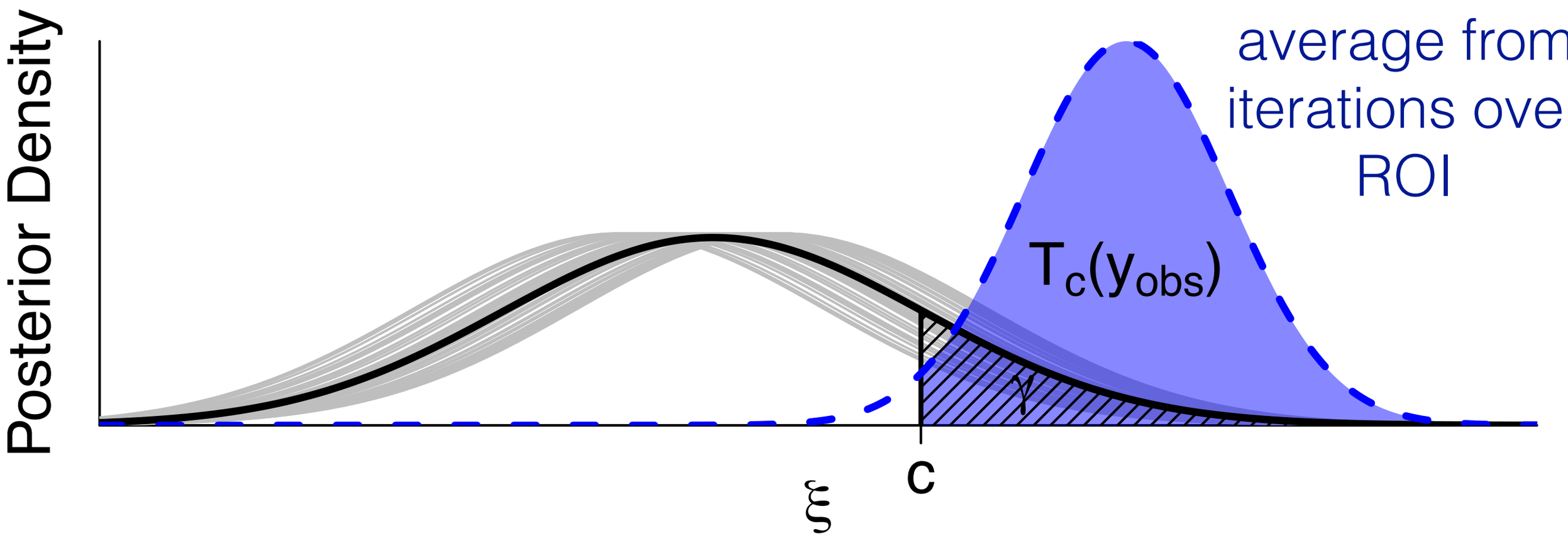
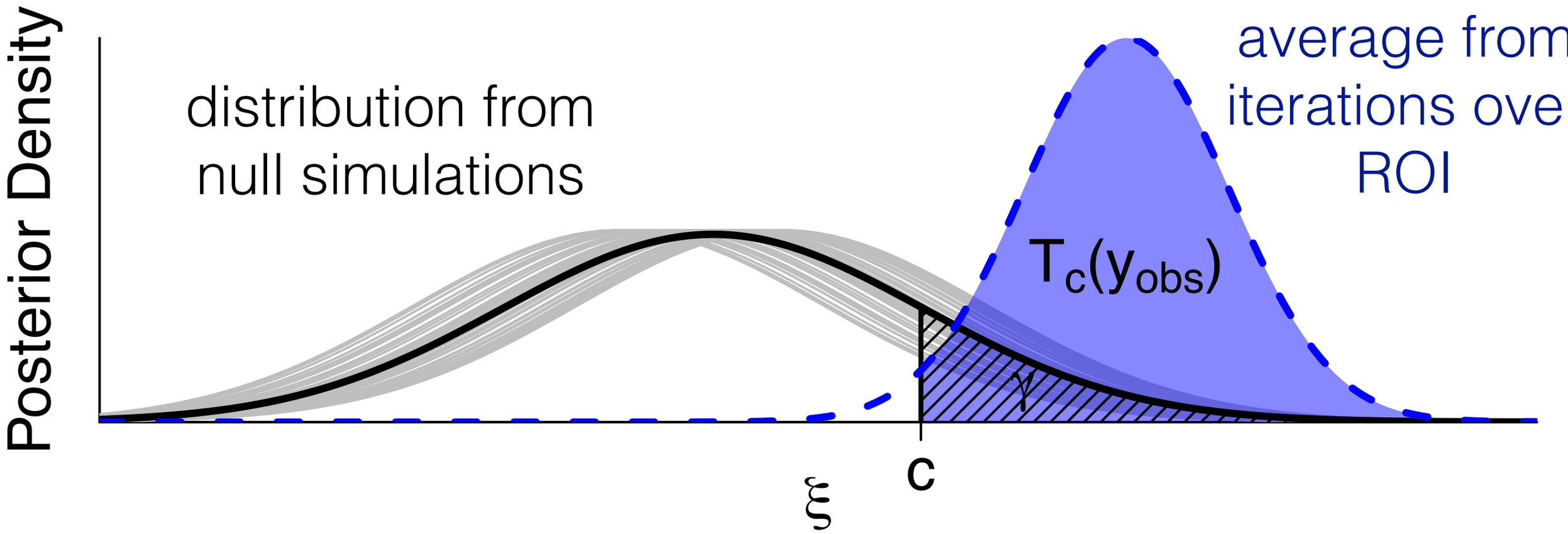


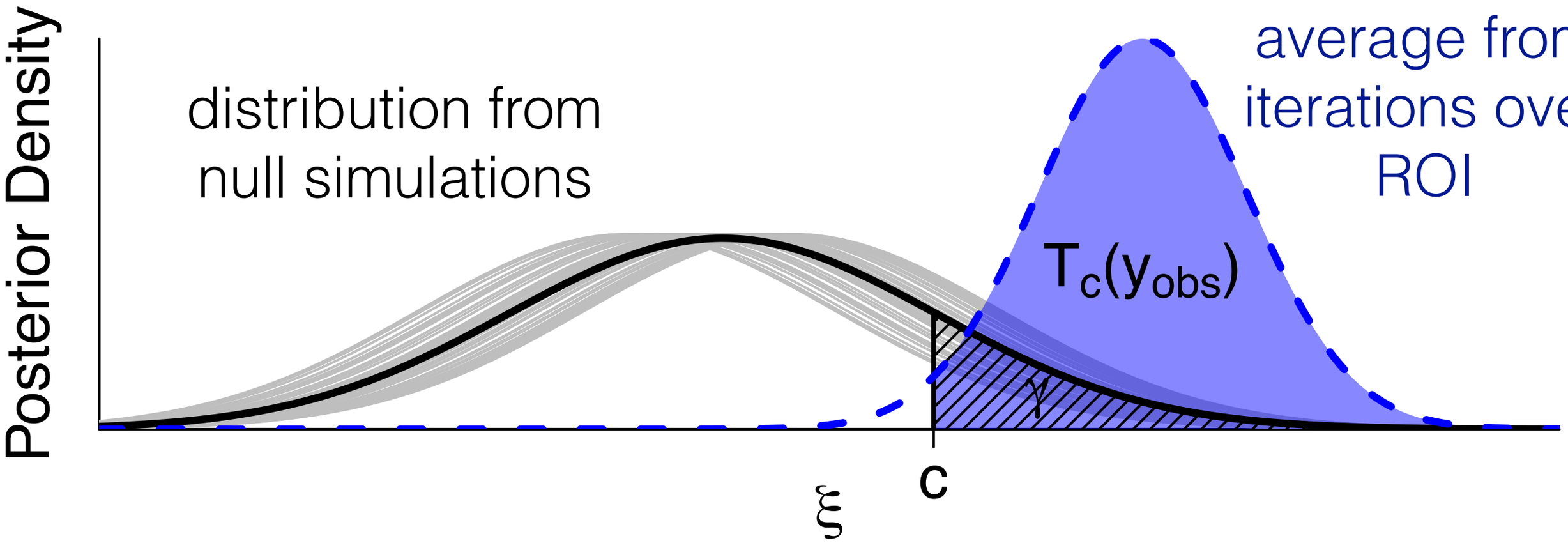
Stein et al. 2015 ApJ 813, 66

Digression: significance of arbitrarily shaped feature



Stein et al. 2015 ApJ 813, 66

Digression: significance of arbitrarily shaped feature



set threshold based on desired p-value

compute upper bound on p-value by checking fraction of signal beyond threshold

Stein et al. 2015 ApJ 813, 66

Process

- Define regions of interest covering jet features based on VLA radio images *before* looking at X-ray analysis images

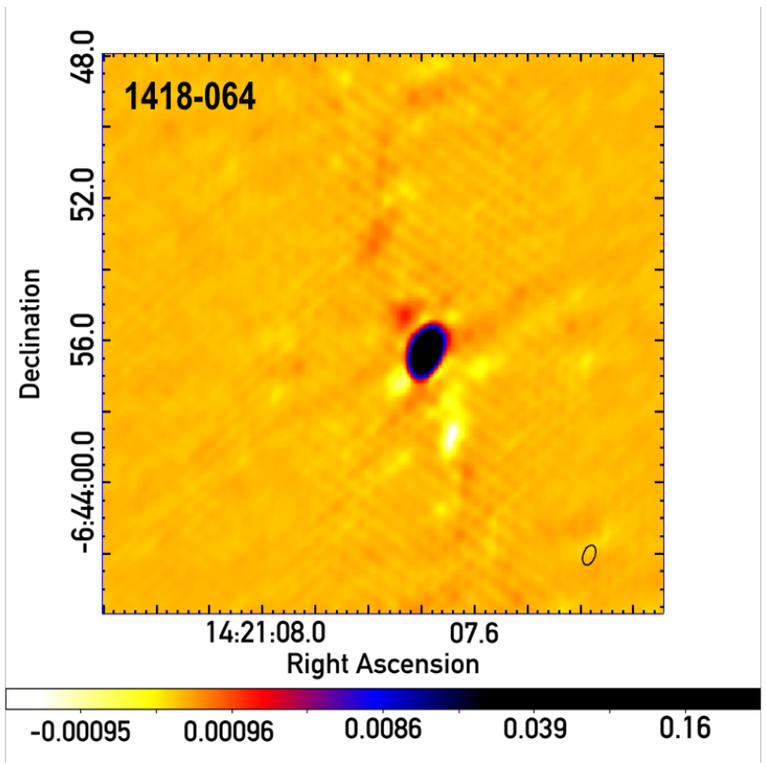
- Apply LIRA to Chandra/ACIS-S X-ray images, with baseline as central quasar modeled as a 2D Gaussian and a flat background

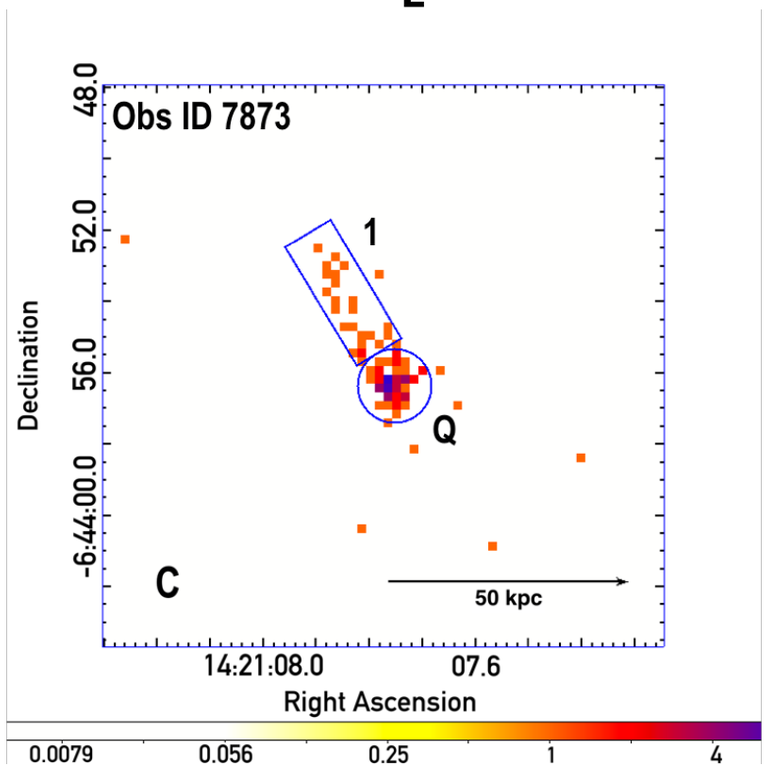
- Also apply LIRA to 50 simulated nulls that contain only the baseline model

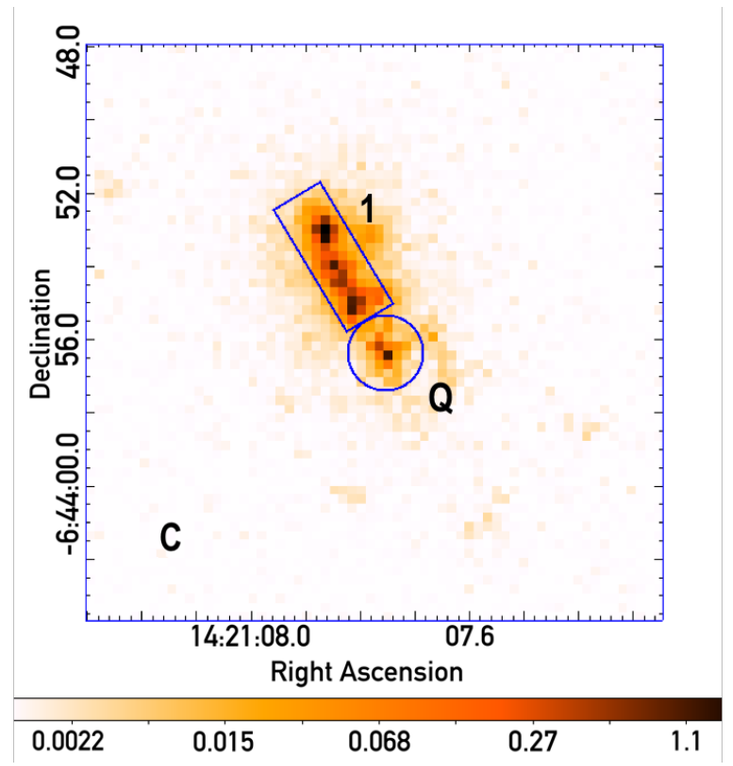
- Compare distribution of intensities in multi-scale residual summed over ROI for observed vs null

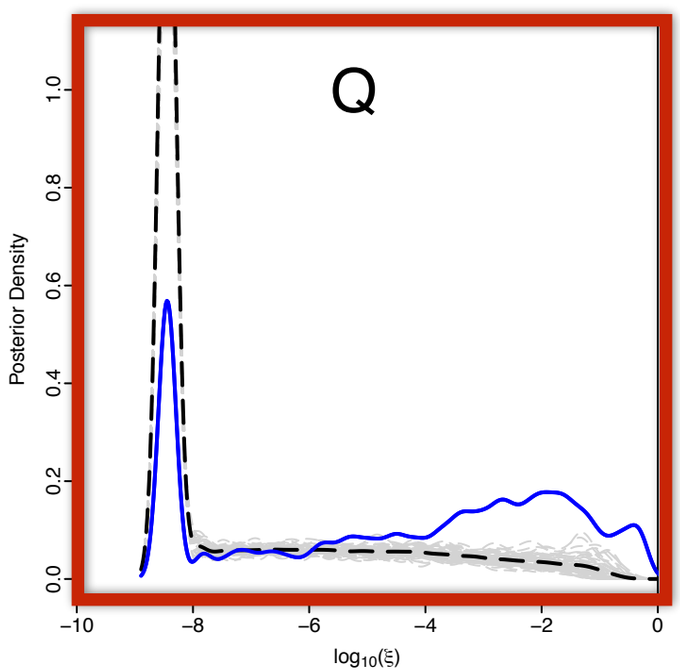
- Consider the jet feature detected if $p<0.01$ and look at the ratio of X-ray and radio fluxes

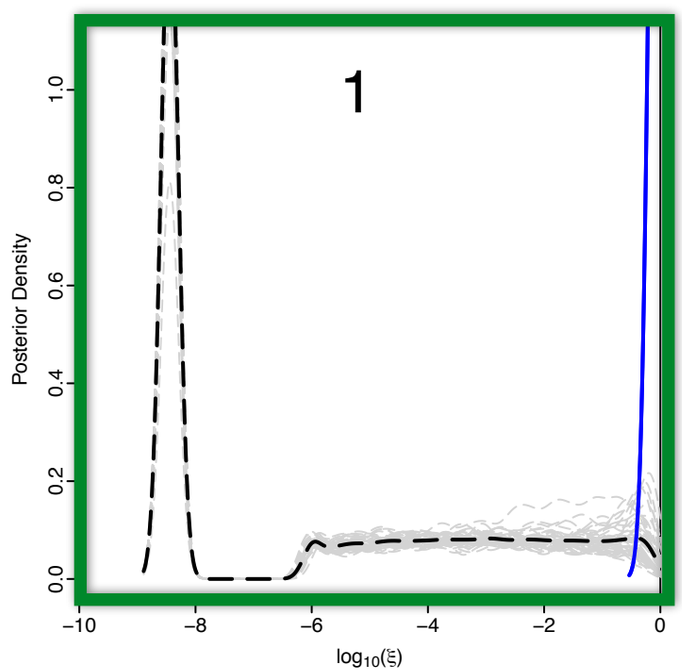
1418-064 [z=3.689]

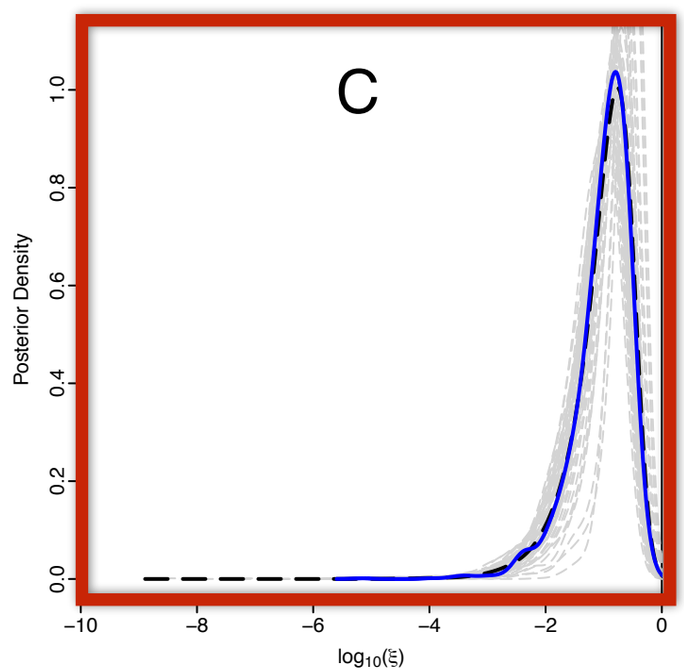






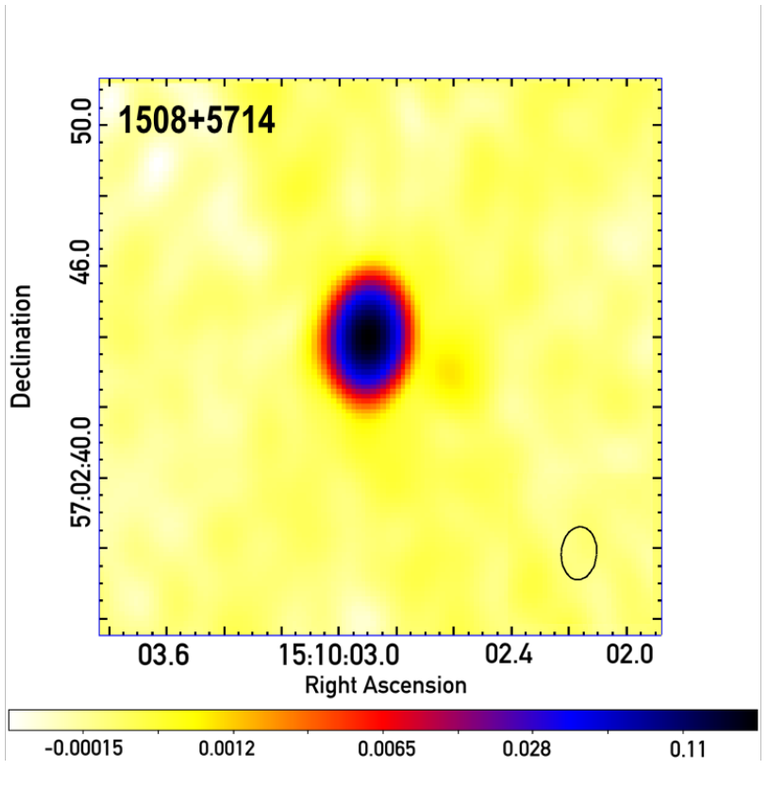


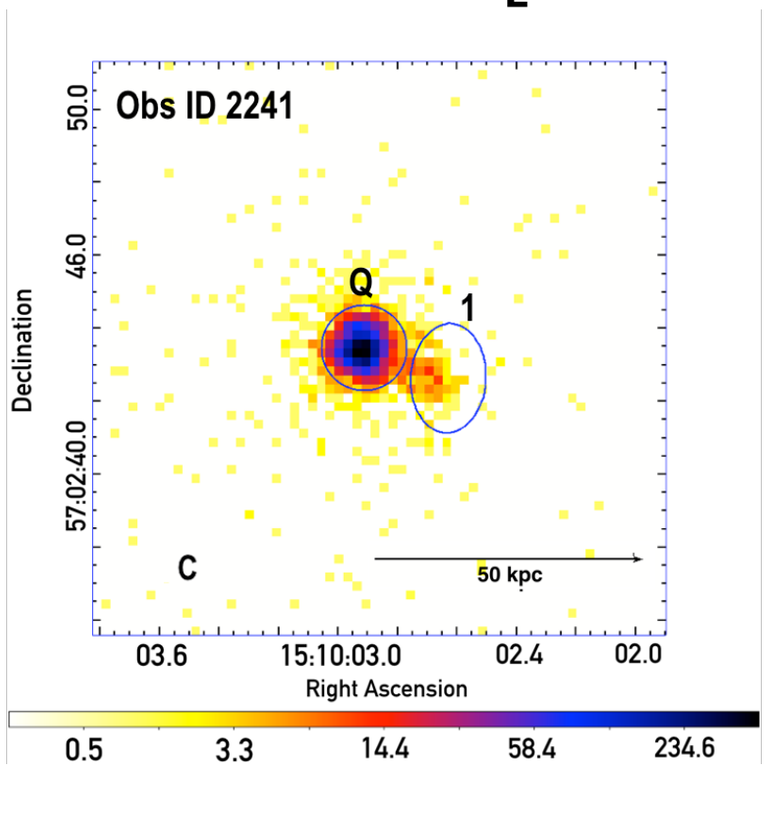


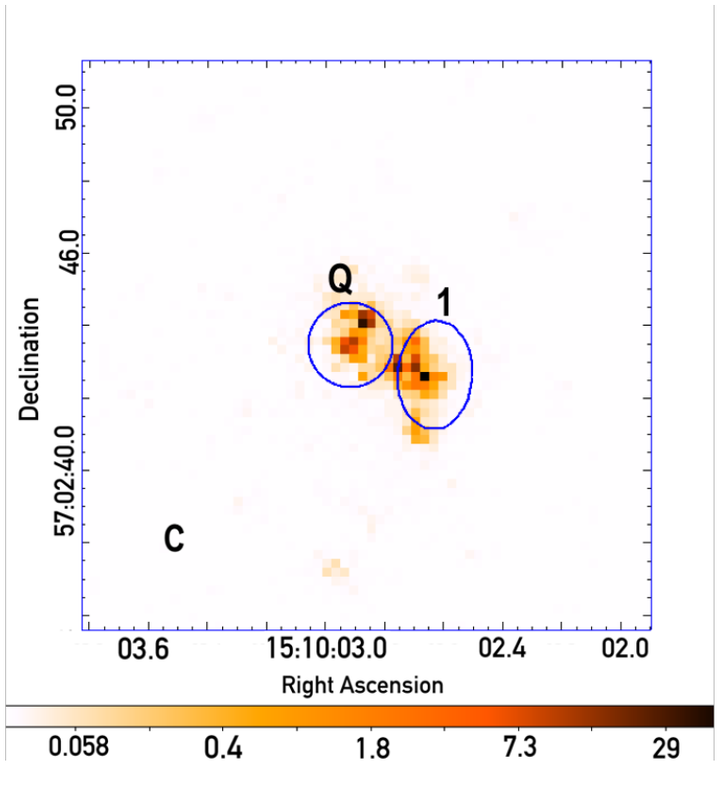


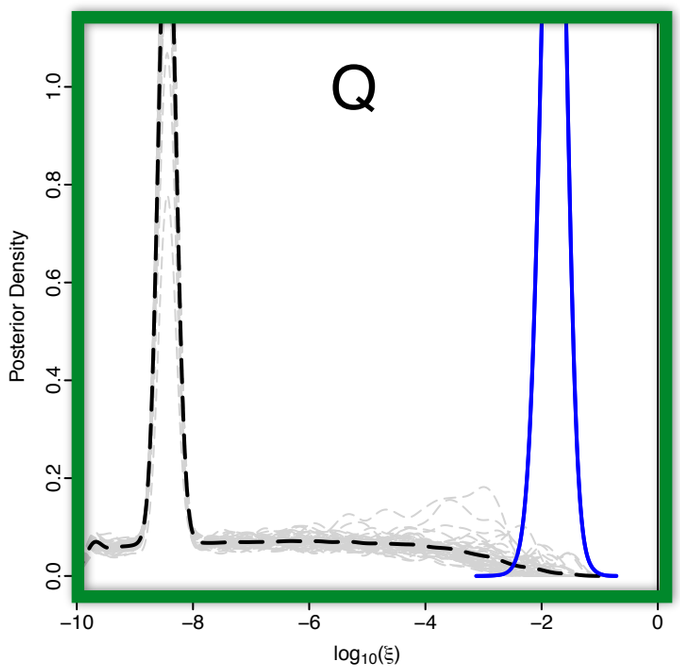
McKeough et al. 2016

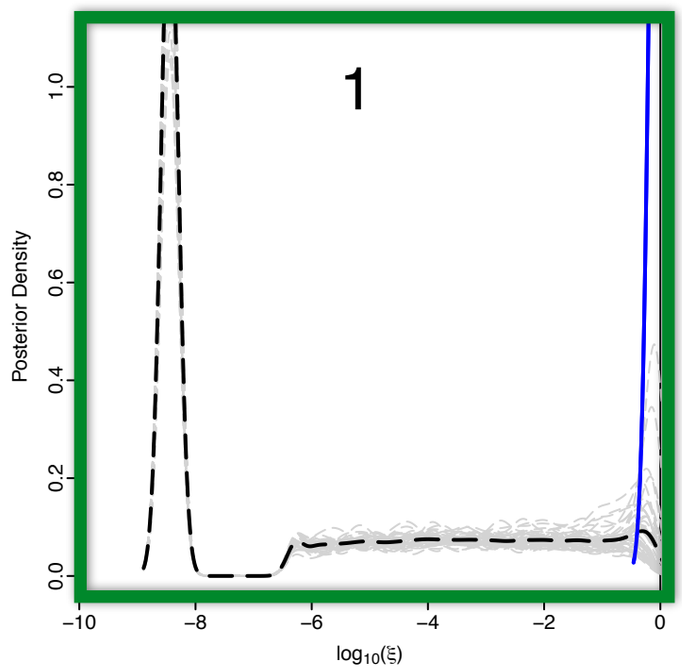
1502+5714 [z=4.3]

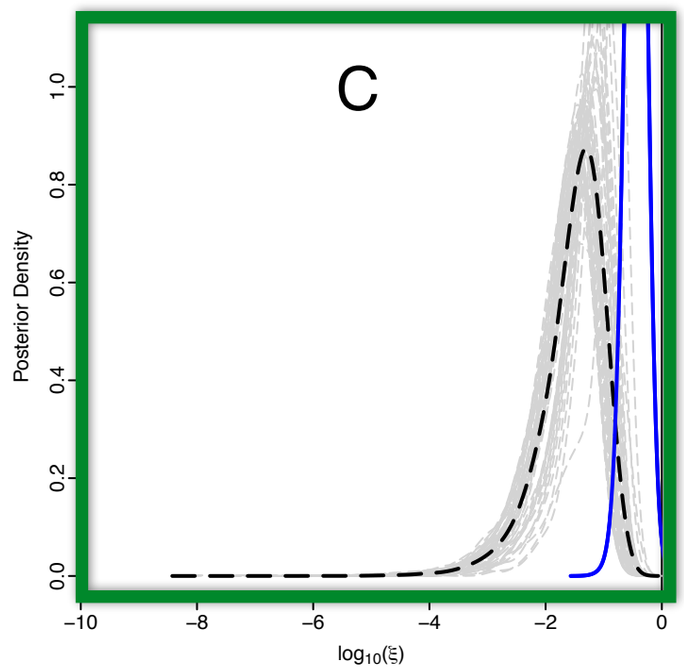












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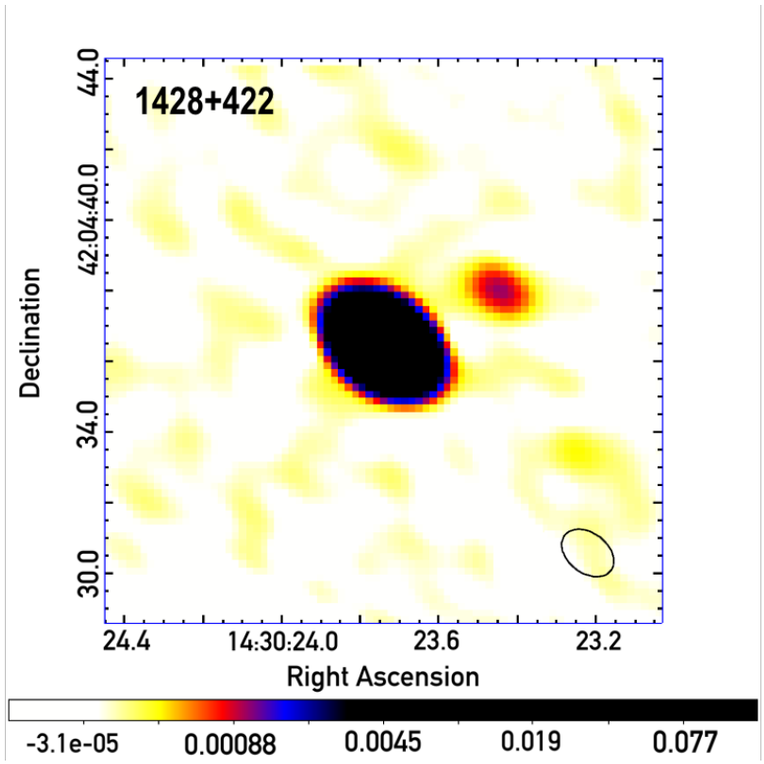
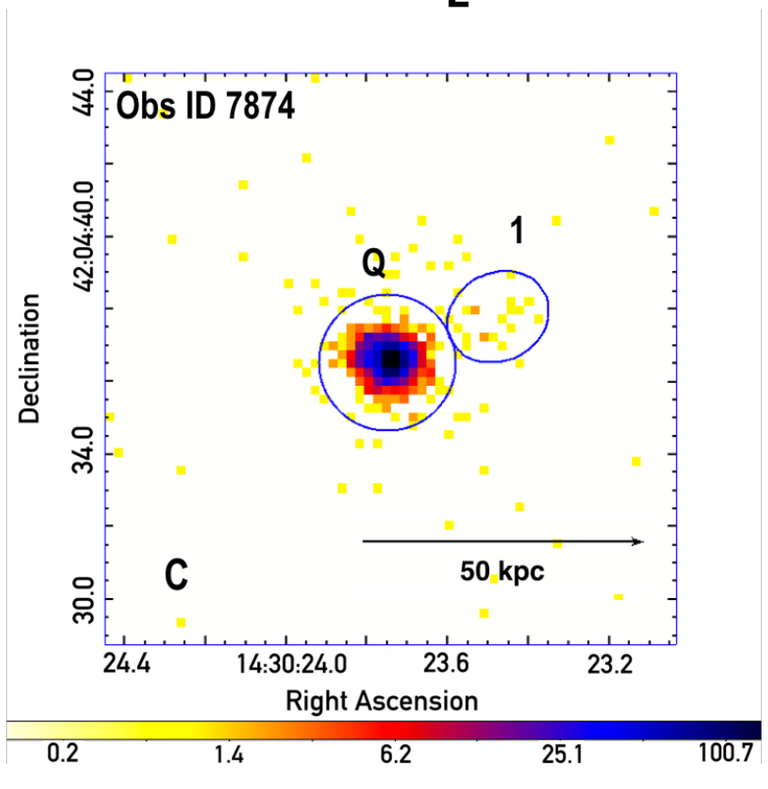
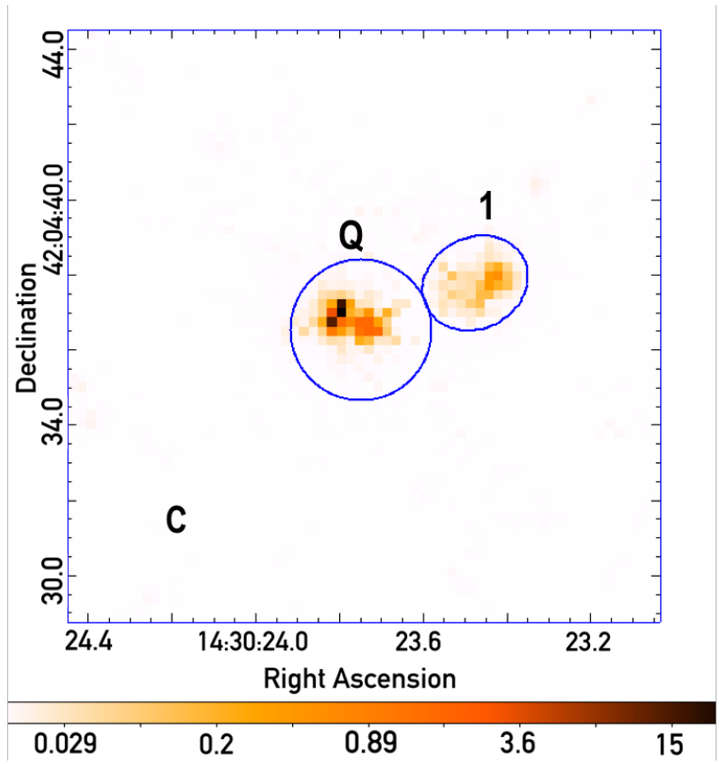
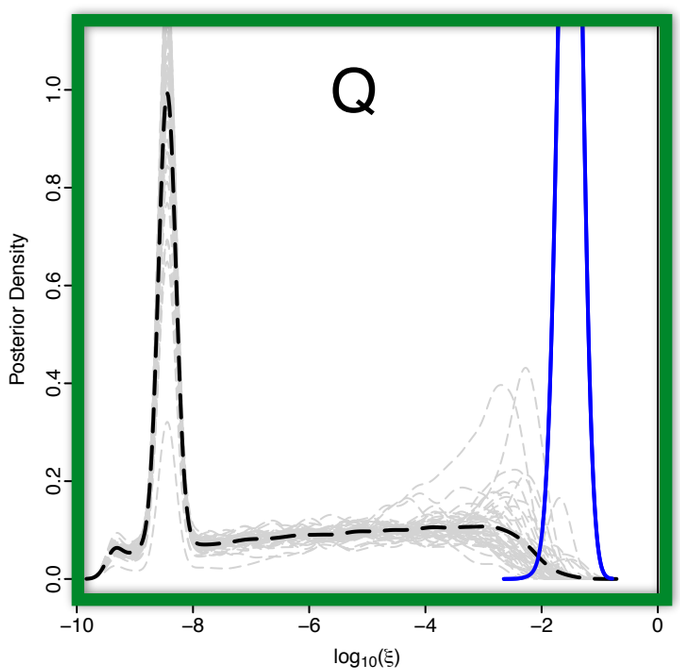
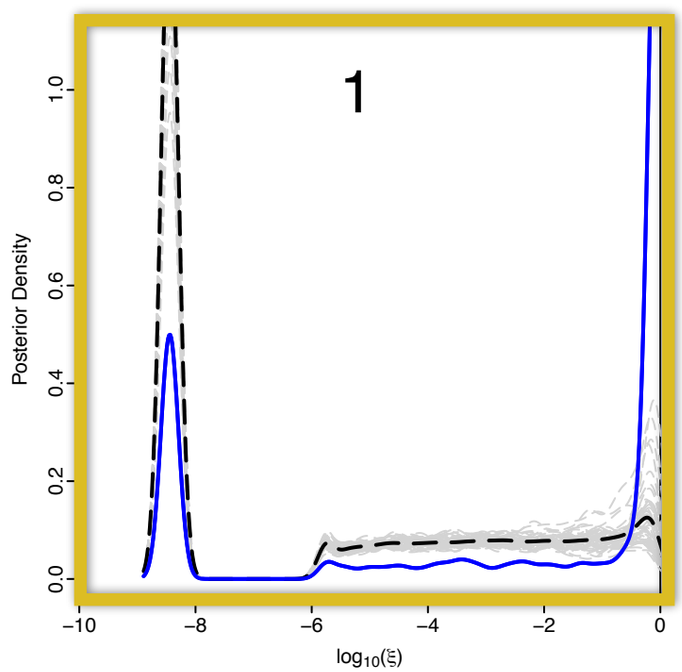
1428+422 [z=4.72]

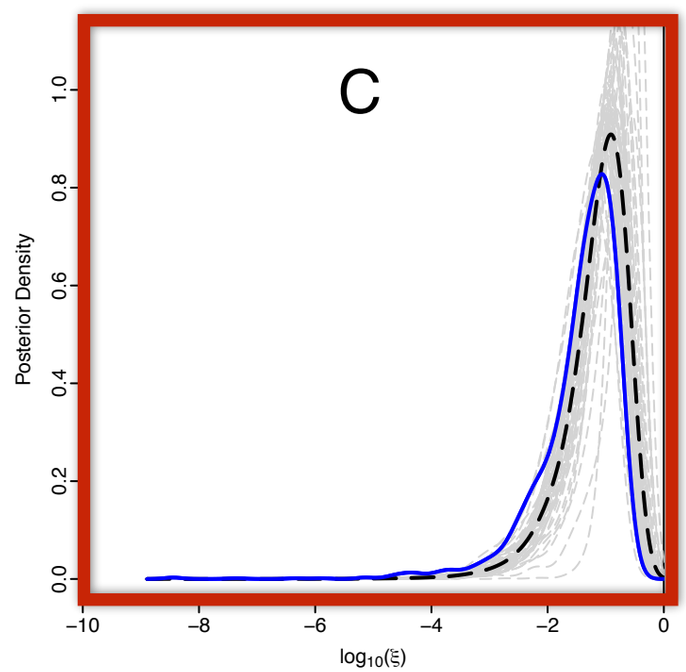












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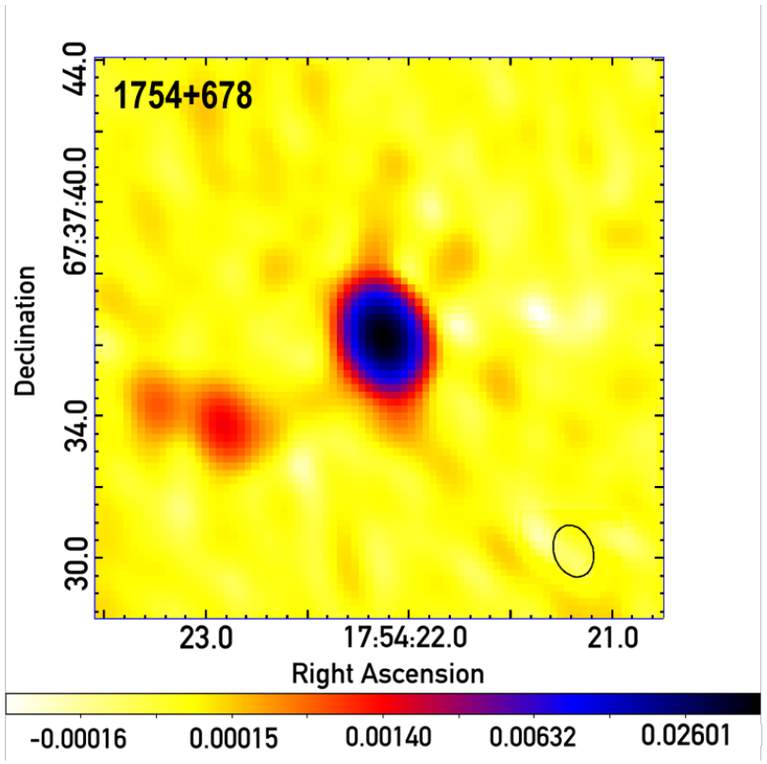
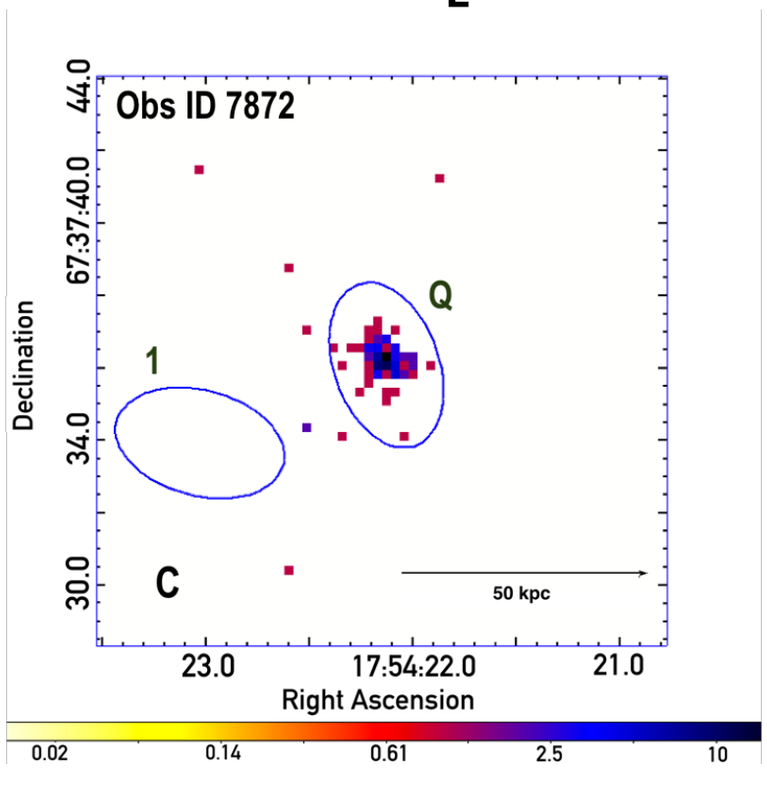
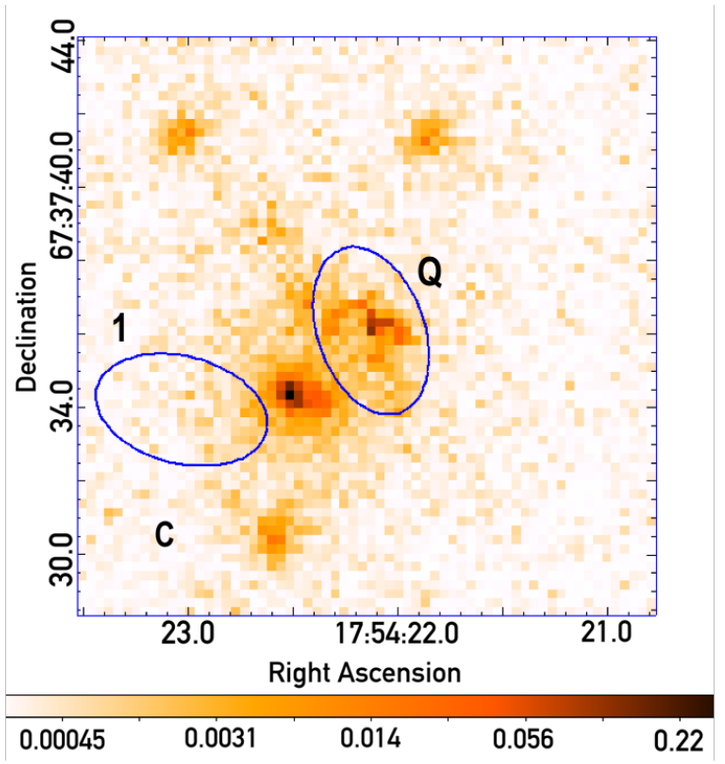
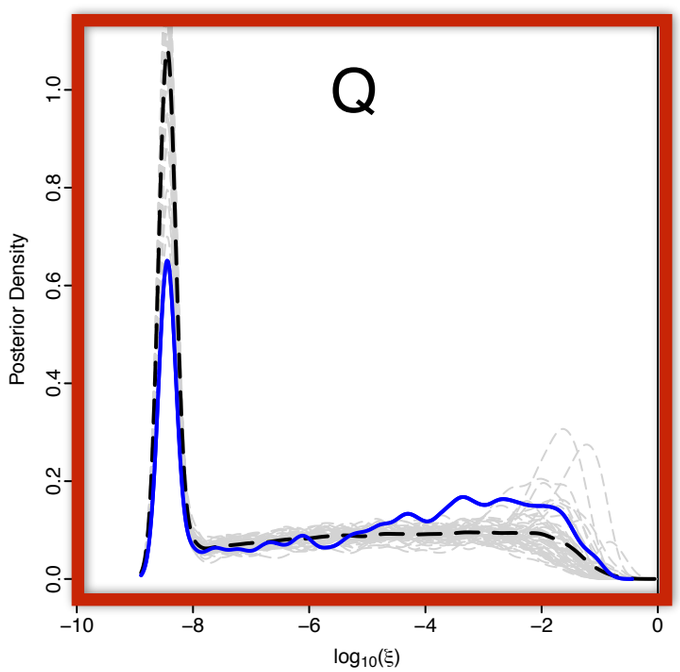
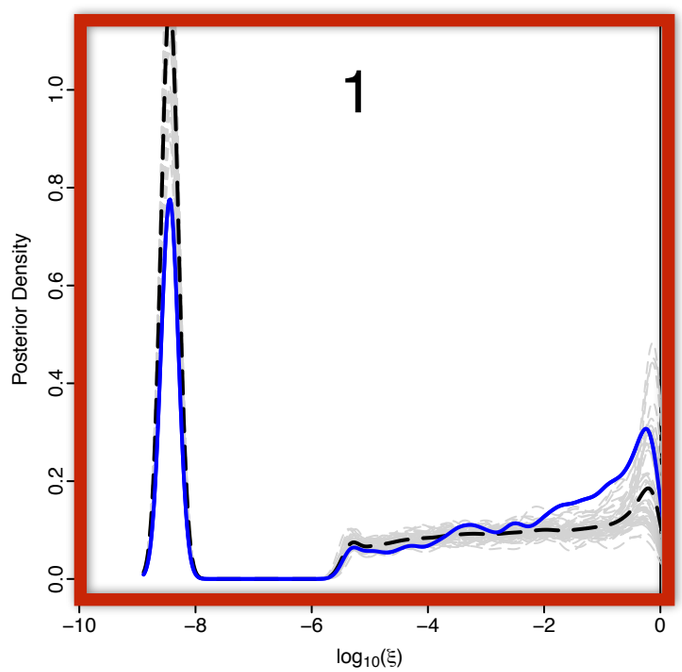
1754+676 [z=3.60]

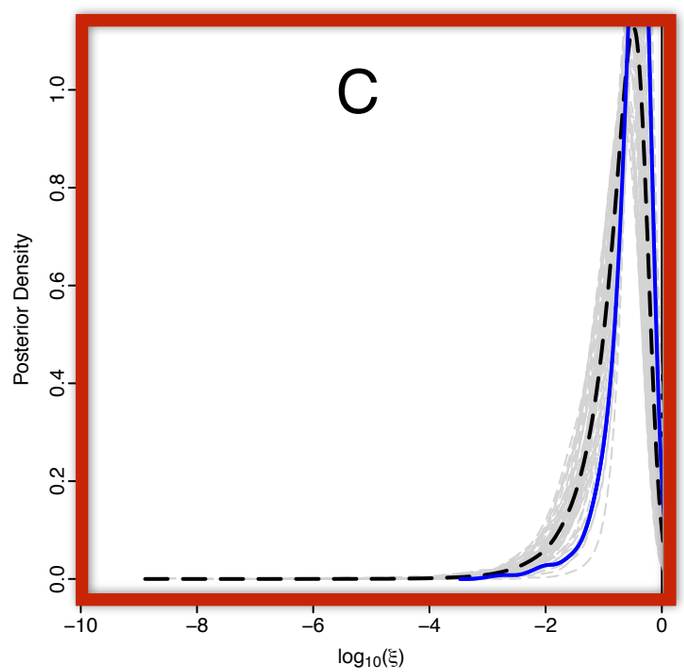












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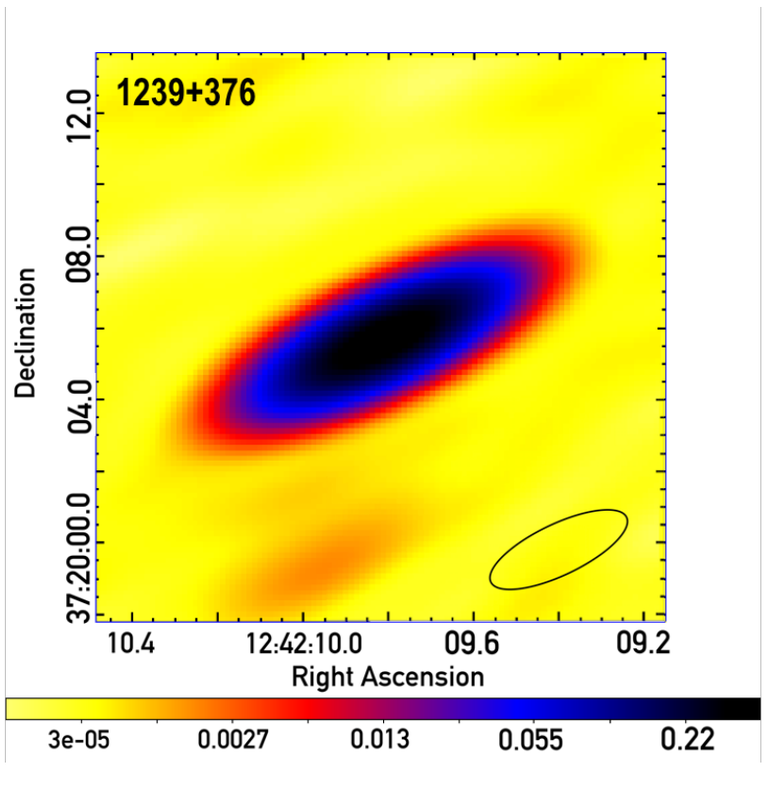
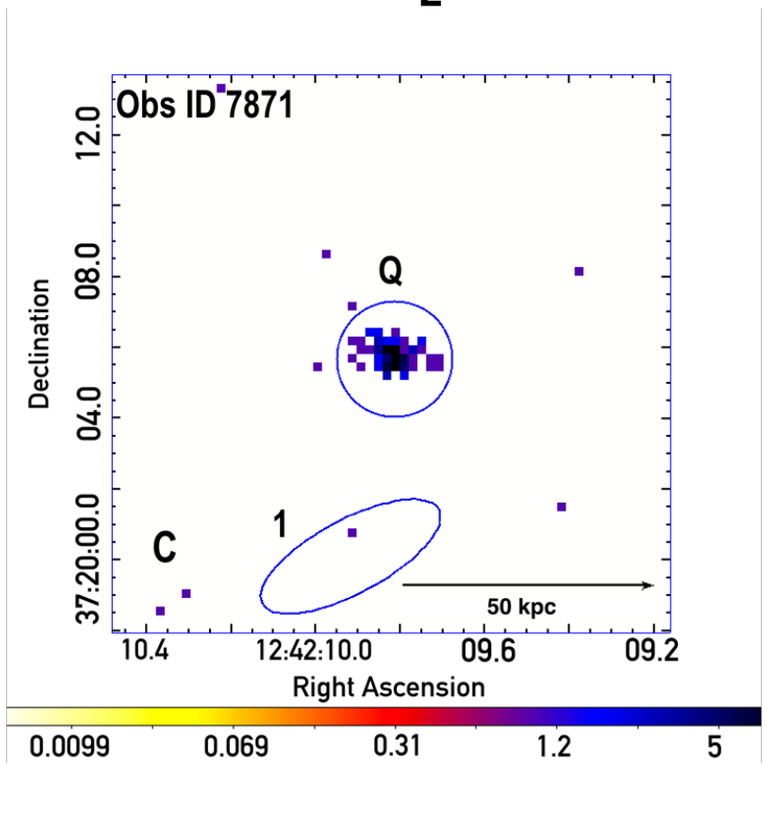
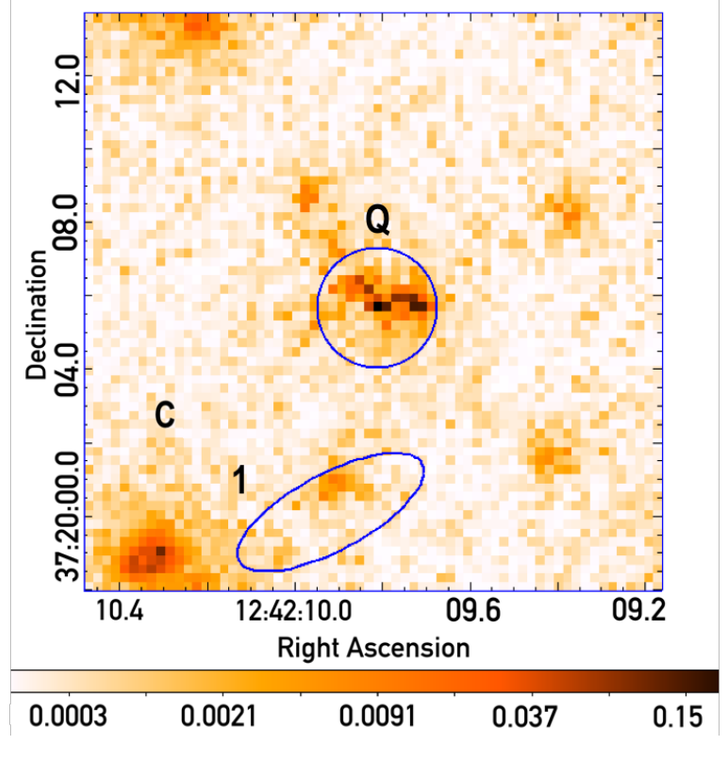
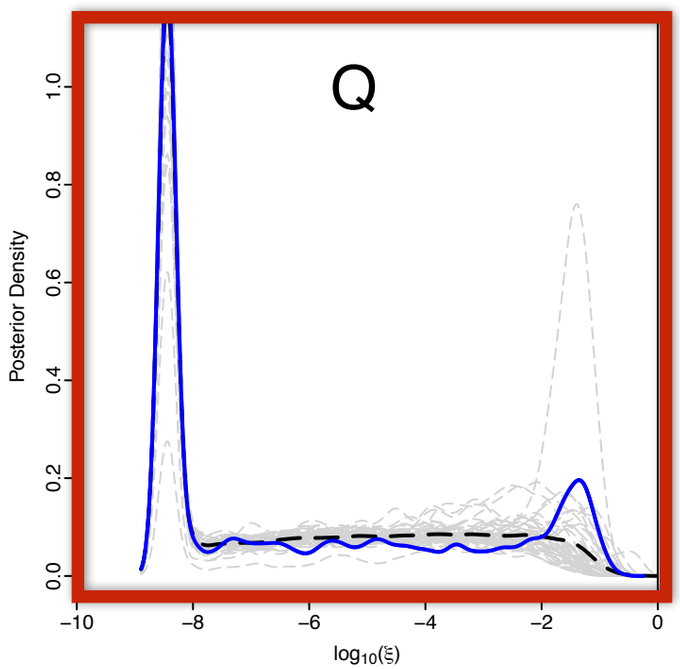
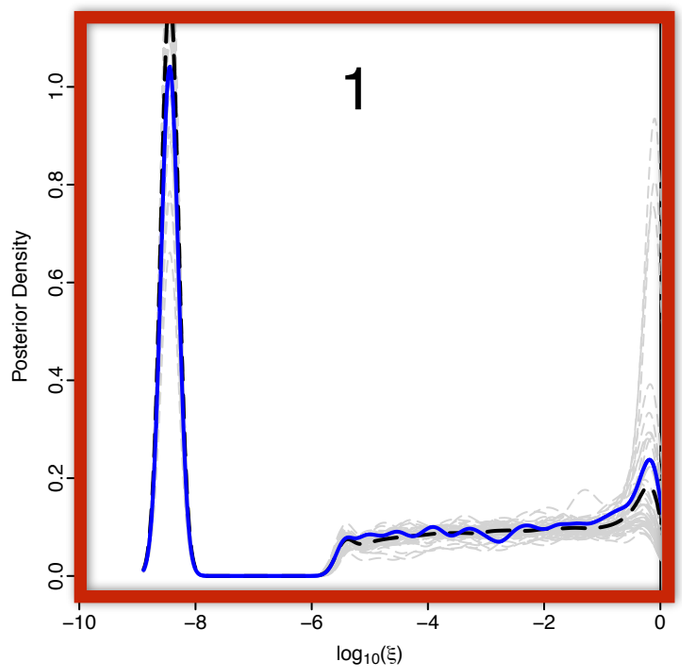
1239+376 [z=3.818]

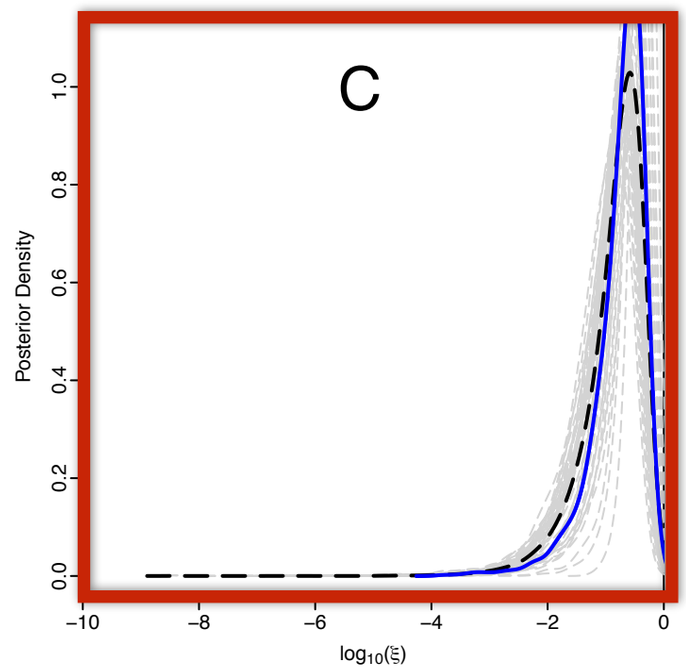












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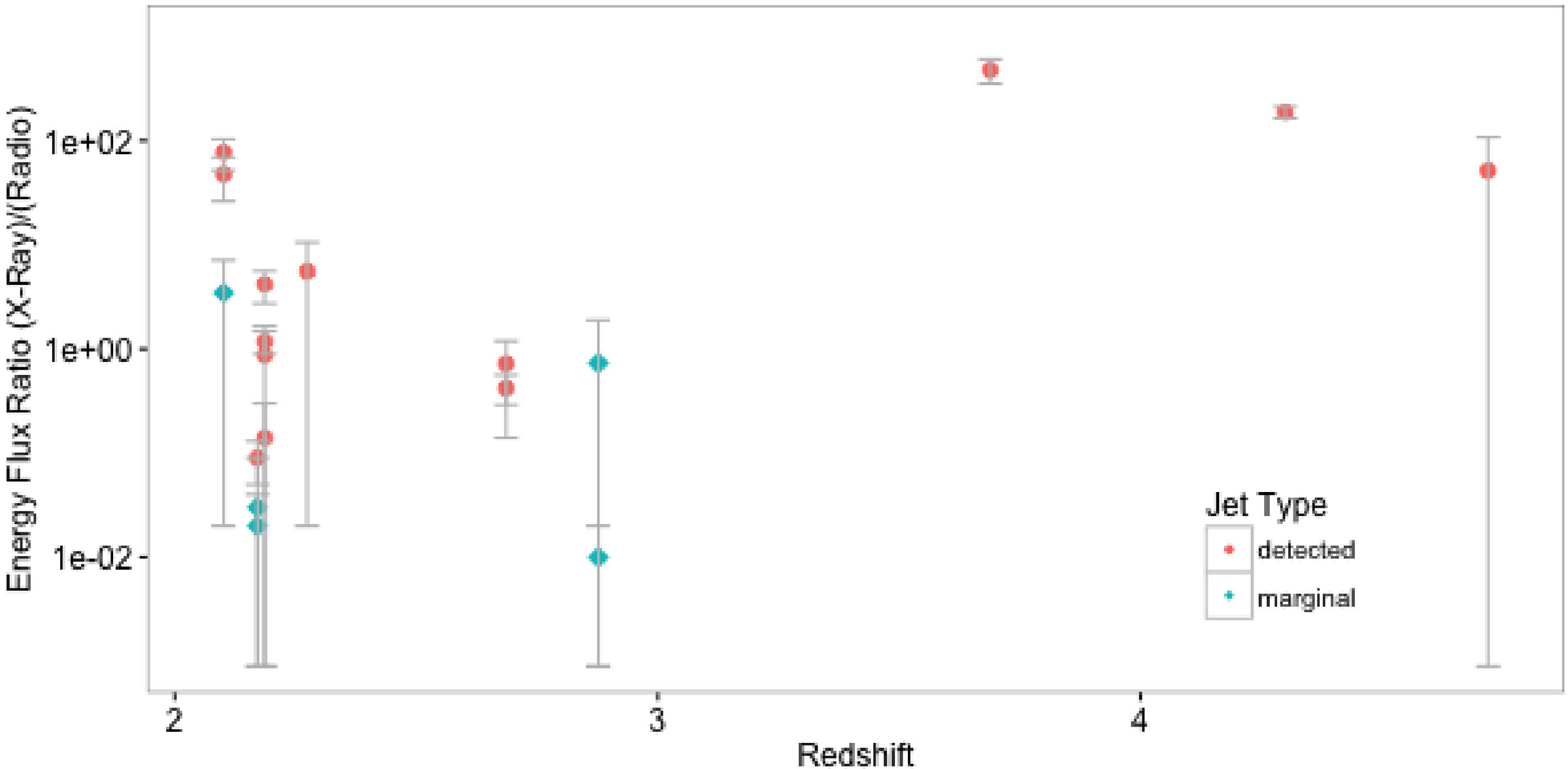
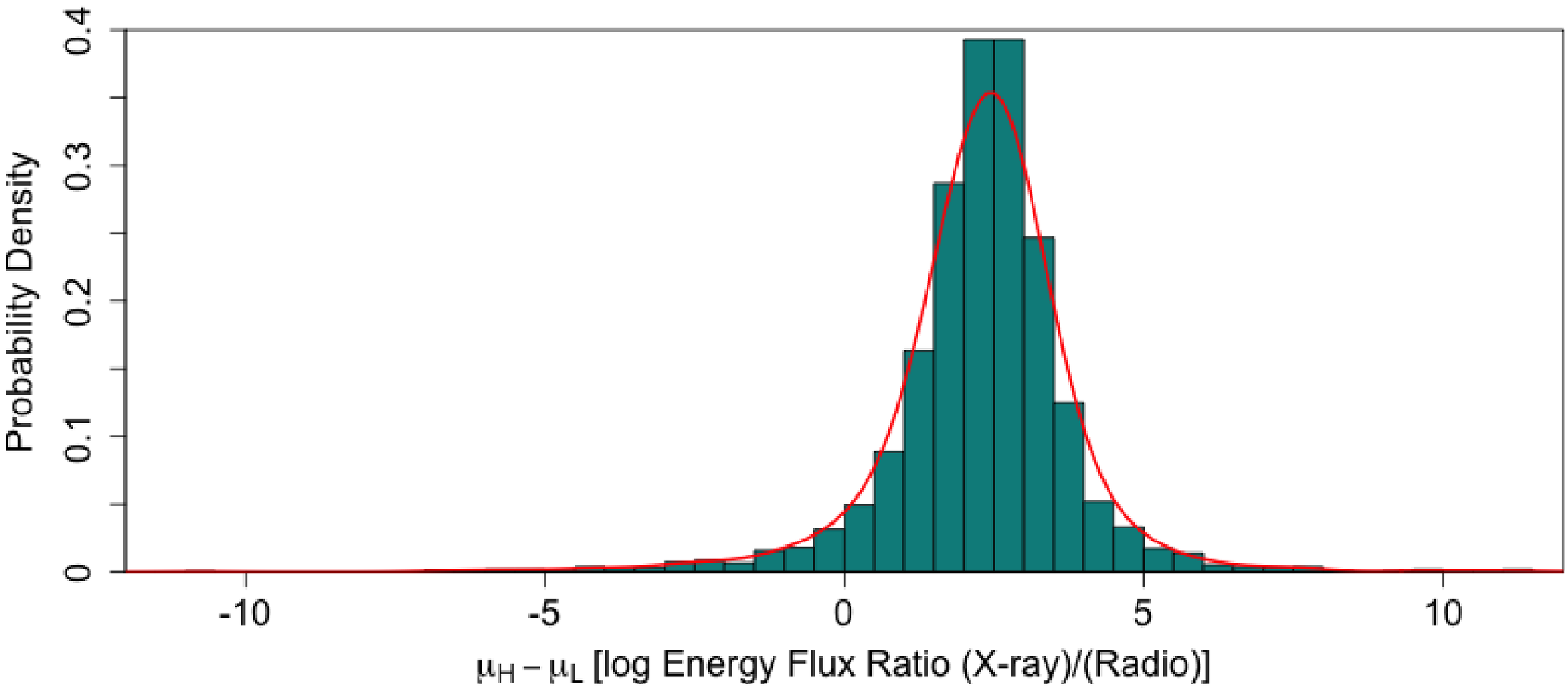
Emission at high redshift



Emission at high redshift



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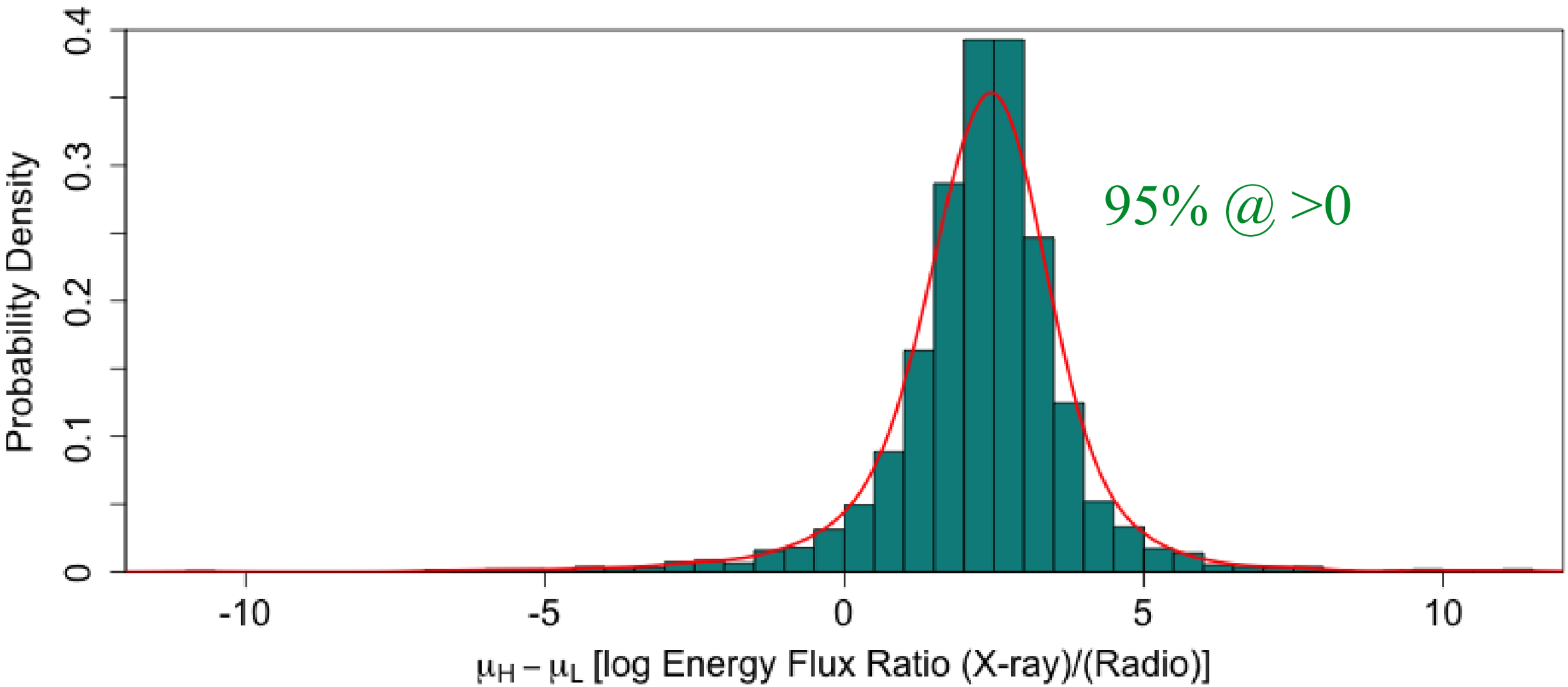
Emission at high redshift



McKeough et al. 2016

Summary

- 12 of 25 radio jet features in 11 Quasars at z>2 have detectable X-ray counterparts

- LIRA: http://github.com/astrostat/LIRA

- Some evidence for higher X-ray luminosities relative to radio at large redshifts -- not definitive