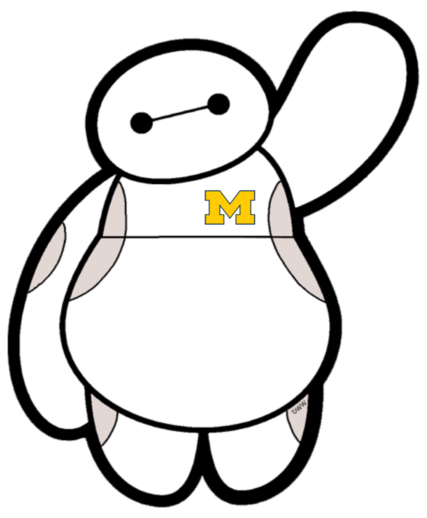

Quantifying the Rate of Dual-AGN with BAYMAX
(**B**ayesian **A**nal**Y**sis of **M**ultiple **A**GNs in **X**-rays)

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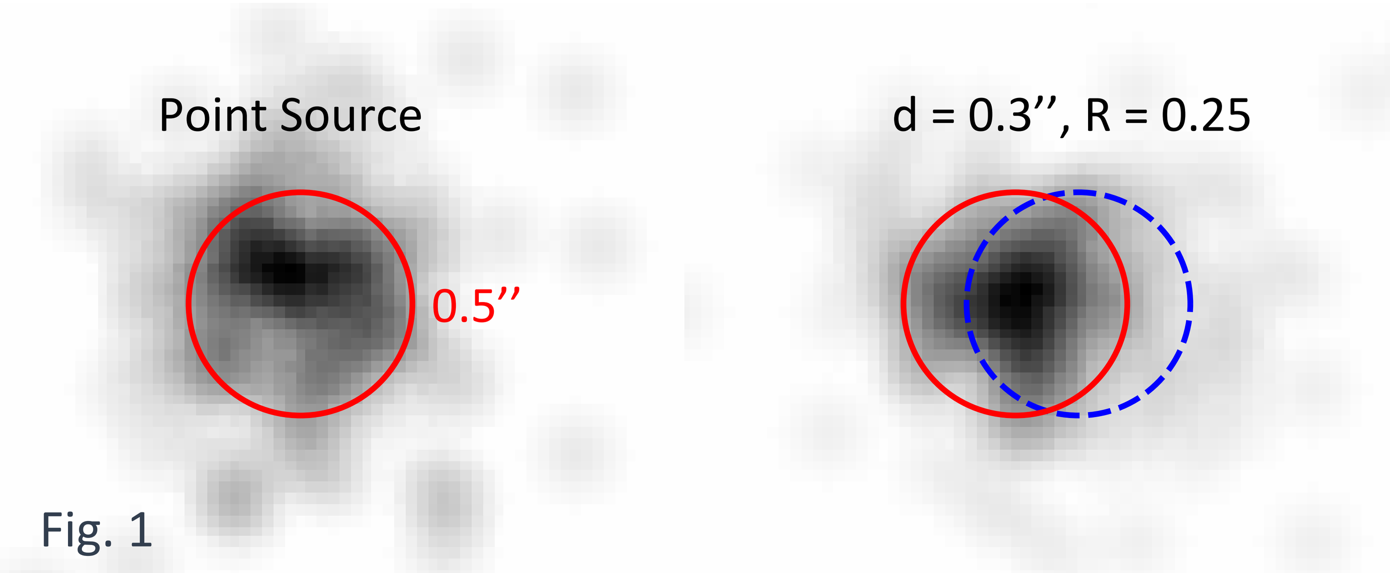
X-ray or radio observations are necessary for dual-AGN confirmation



Left: A simulated AGN as seen by *Chandra*. *Right:* Two simulated AGN, with angular separation of 0.3" and flux ratio of 0.25, as seen by *Chandra*. Both simulations have been processed with EDSER, a tool that improves the spatial resolution [1]. By eye, it is impossible to tell the difference between the two.

We can confirm dual-SMBHs observationally ***if they power dual-AGN and if you have the necessary resolution.*** Yet, resolving close (<1") dual-AGN becomes difficult even with *Chandra*'s superb resolution. Existing methods to improve spatial resolution [1] only allow for qualitative analyses for the presence of dual point sources, leading to false negative/positives in the low count regime and at small separations.

BAYMAX is the first framework to quantitatively analyze the likelihood that a given Chandra observation is due to one or two point sources.

BAYMAX will be important for many future observations, as an X-ray telescope with resolution better than *Chandra*'s is unlikely in the near future.

BAYMAX allows for statistical analyses on *Chandra* observations

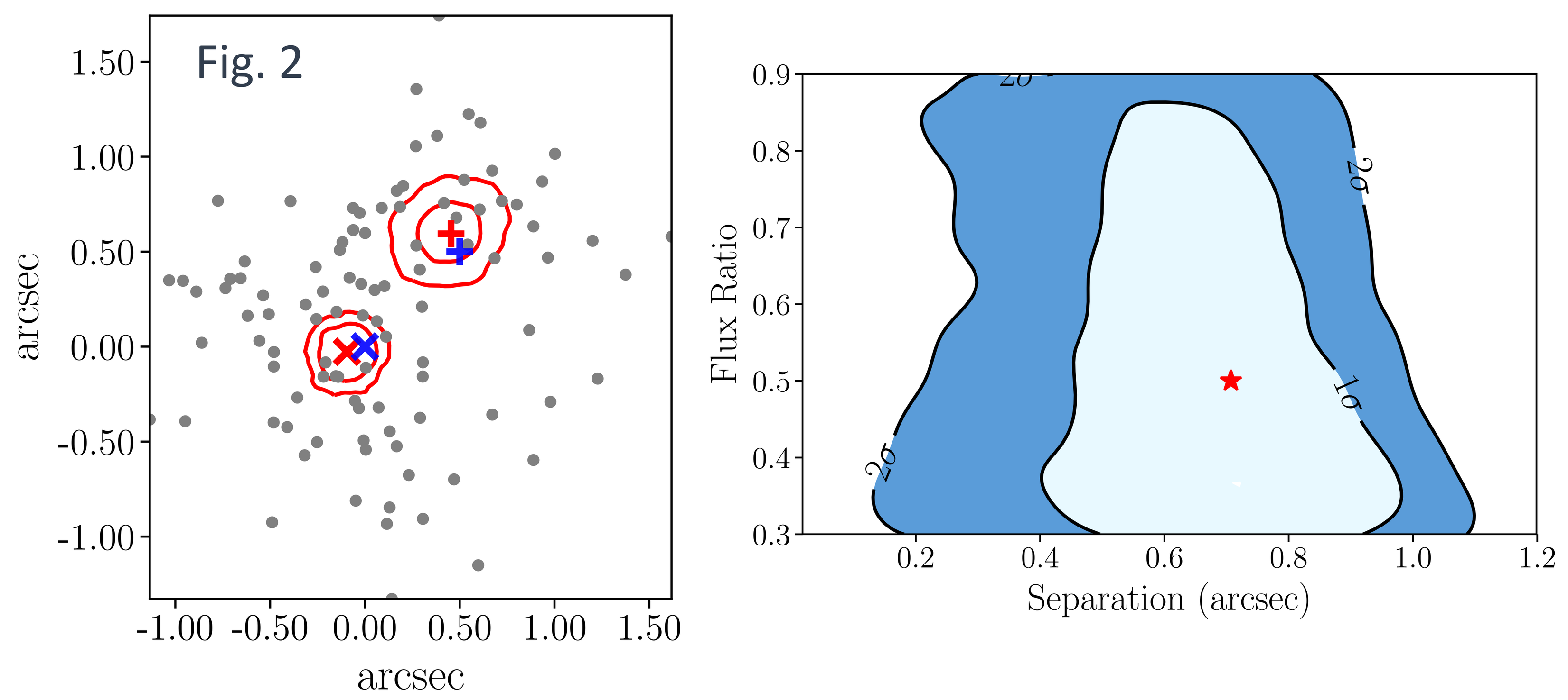
The main components of the code are:

1) Develop likelihood models for single and double point sources via MARX [2].
2) The Bayes factor, which represents the posterior odds or the degree to which we favor one hypothesis over the other, is used to evaluate the likelihood of a dual point source system:

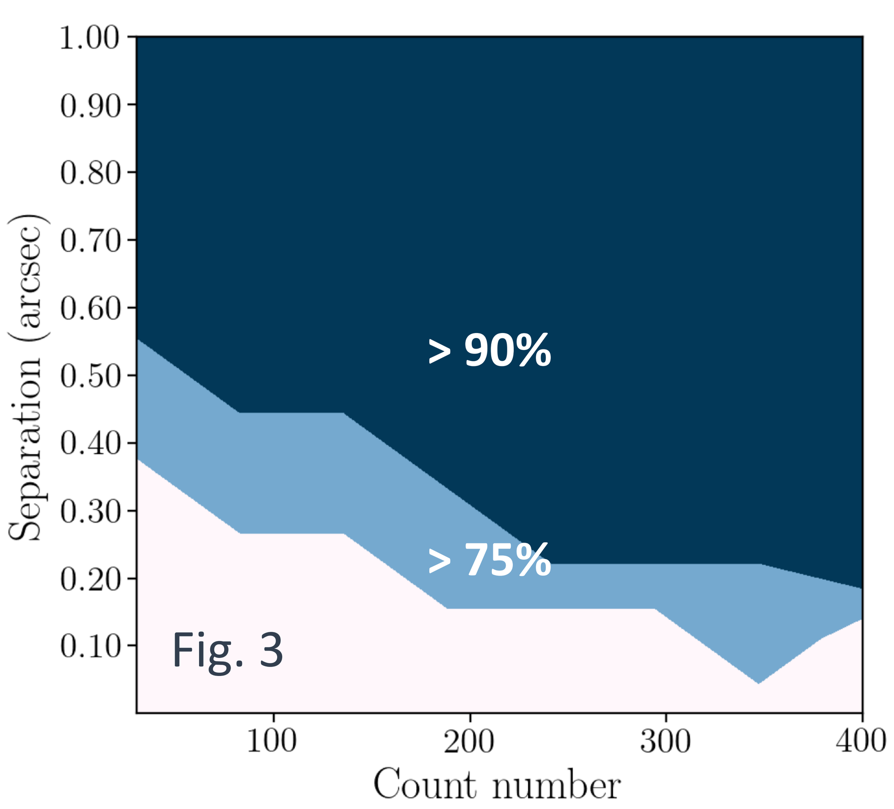
$$P(M|D) = \frac{\int P(D|\theta_1, M_1)P(\theta_1|M_1)d\theta_1}{\int P(D|\theta_2, M_2)P(\theta_2|M_2)d\theta_2}$$

3) Using emcee, the maximum likelihood of parameters such as the location of the point source on the chip, separation of dual point sources, and flux ratio F_2/F_1, as well as their uncertainties are estimated.

BAYMAX tests

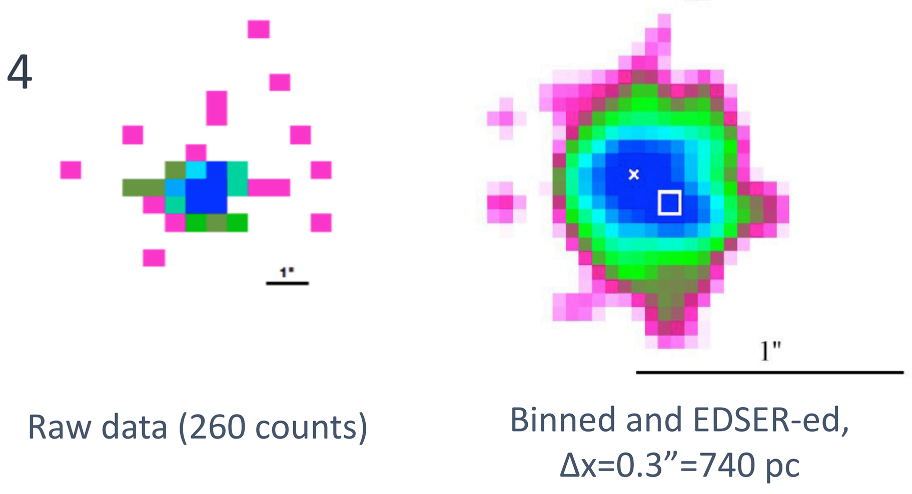


A simulation of two AGN, where the total number of counts is 100, the flux ratio $F_2/F_1 = 0.5$, and separation of 0.5" (true centers denoted by blue symbols "x" and "+"). No spectral information is included here. BAYMAX finds that a double point-source model is strongly favored and can locate the center of each AGN within 1σ (red "x" and "+").



Parameter space where BAYMAX favors the correct model (BF > 1) for simulated dual-AGN systems. Preliminary tests show that with ~100 counts, BAYMAX is capable of correctly identifying dual-AGN down to separations of 0.3".

The lowest-mass dual-AGN candidate: SDSS J0914+0853



What:

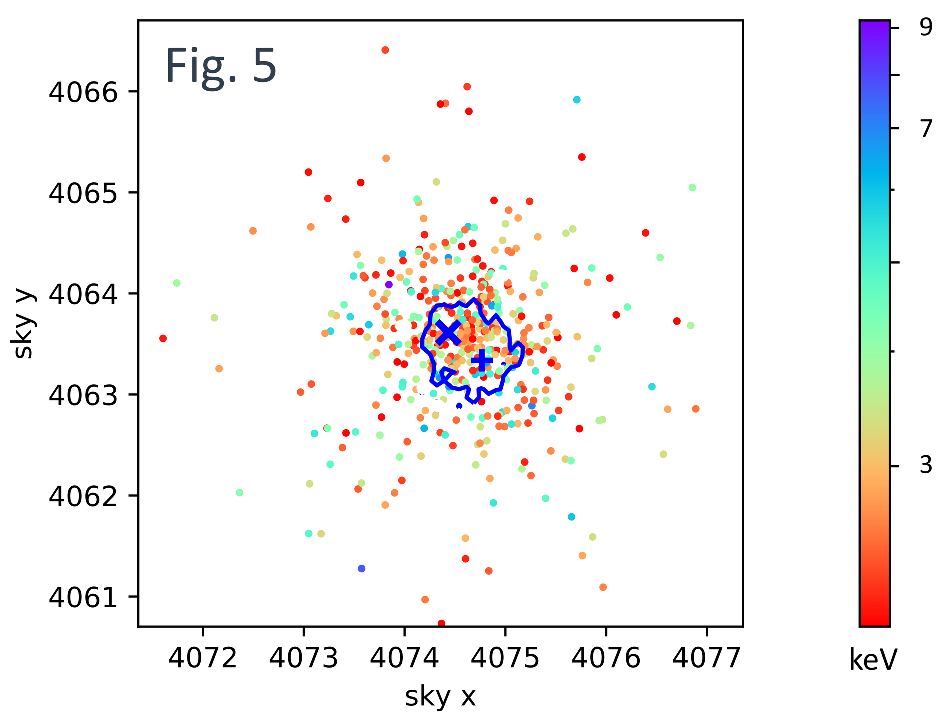
SDSS J0914+0853 is a low-mass ($M_{BH} = 10^6$ M [3]), low-luminosity dual-AGN candidate based on archival shallow *Chandra* imaging. The archival Chandra exposure shows a possible "secondary" source 0.3" away with $F_{3\text{-}7\,keV} = 5 \times 10^{42}$ erg s^{-1} (see Fig. 4). We received a new *Chandra* observation (50 ks; PI: Gültekin) for analysis with BAYMAX.

Why:

It has been argued that mergers can trigger high-luminosity AGN but not low-luminosity AGN, which are triggered by stochastic processes [4]. A competing hypothesis is that there is no correlation between AGN luminosity and mergers [5]. The presence of a low-luminosity dual-AGN in SDSS J0914+0853 would show that ***low luminosity AGNs can arise from mergers.***

Preliminary BAYMAX analysis:

BAYMAX finds a dual-point source most likely, with Bayes factor >> 10. The best-fit position of the primary (blue "x") and secondary (blue "+") are shown in Figure 5 (with 2σ error contour), corresponding to a separation of 0.25" ± 0.1" [6]. Future work includes varying the spectrum of each candidate AGN.



Scan me

(●—●) BAYMAX

Please feel free to contact me!

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References:

[1] Liu, X. et al. 2013, ApJ, 762, 110, [2] Davis, J. E. et al. 2012, SPIE, 8443 [3] Greene, J. E. & Ho L. C. 2007, ApJ, 670, 92, [4] Hopkins, P. F. & Hernquist, L. 2009, ApJ, 698, 150, [5] Treister, E. et al. 2012, ApJ, 758, 39, [6] Foord, A. et al. 2018 (in prep.)