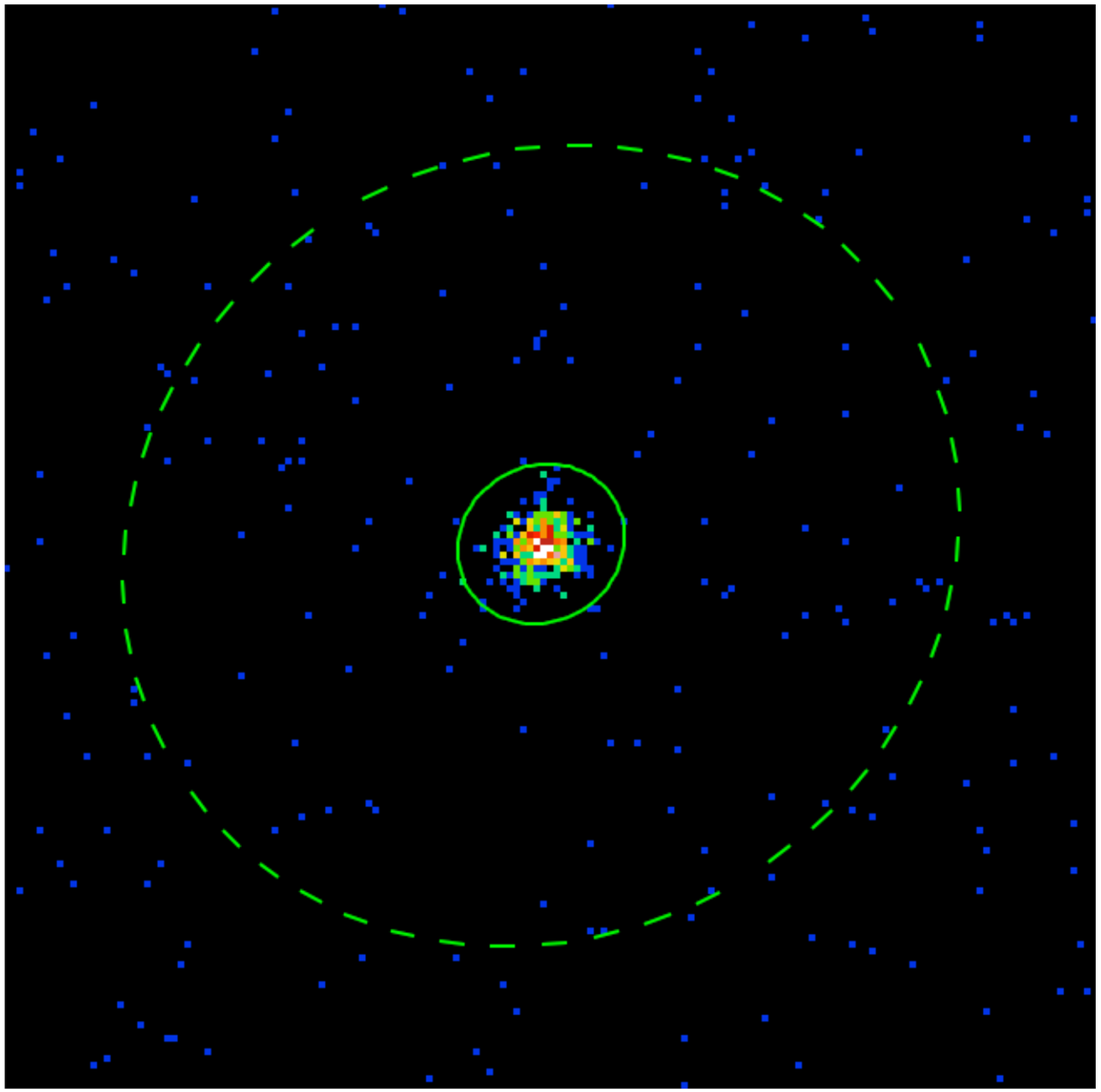
Computing Average Source Intensity for X-ray Sources Observed in Multiple X-ray Images

Using quantities measured in synthetic apertures in X-ray images, it's relatively easy to determine the posterior probability distribution for the intensity of an unresolved x-ray source in a single observation.

However, if the same source is observed in multiple observations, and one wishes to combine the data to determine a single average intensity, difficulties can ensue.

Simple X-ray Aperture Photometry Problem:

Determine source intensity s and errors for an unresolved (point) x-ray source



Know:

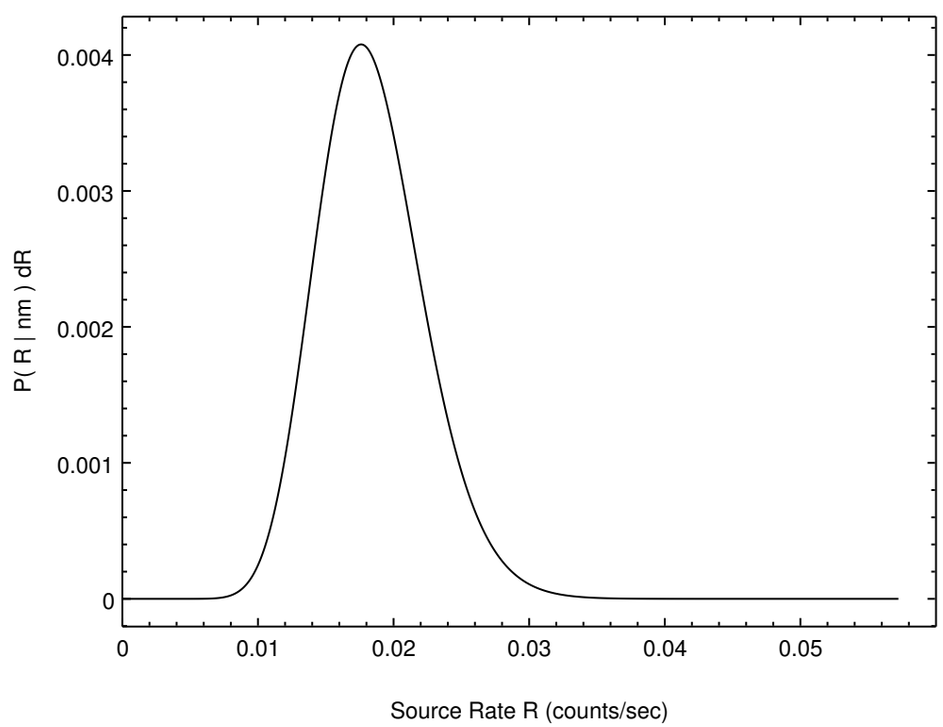
- Number of counts, C, in source aperture (solid green ellipse)
- Number of counts, B, in background aperture (dashed green elliptical annulus)
- Areas A_s and A_b of source and background apertures
- f = $\int$ psf(x,y)dx dy over source aperture
- g = $\int$ psf(x,y)dx dy over background aperture

Simple X-ray Aperture Photometry Problem Solution
(see http://cxc.cfa.harvard.edu/csc/memos/files/Kashyap_xraysrc.pdf for details)

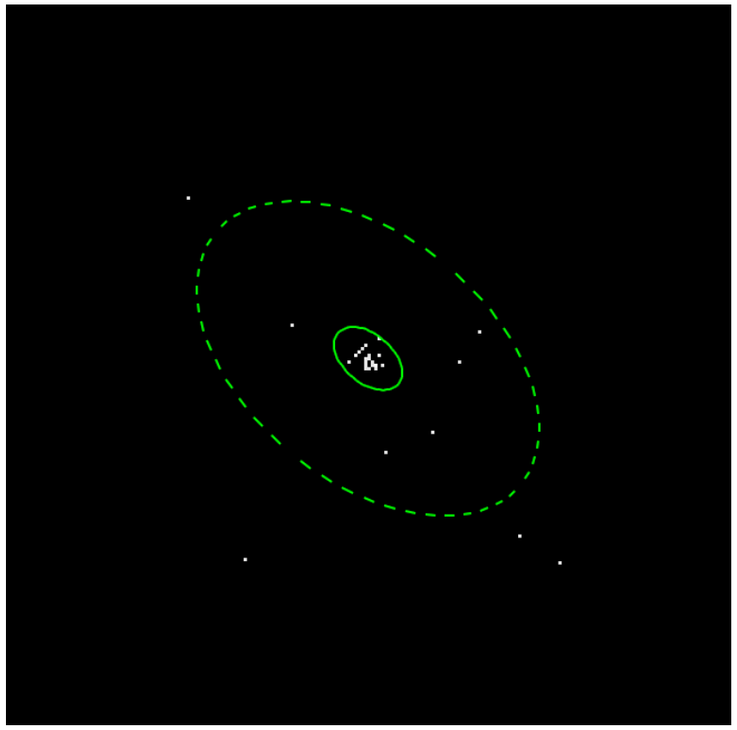
- Statistical Model: C ~ Pois(f s + b); B ~ Pois(g s + r b) where $r = A_b / A_s$

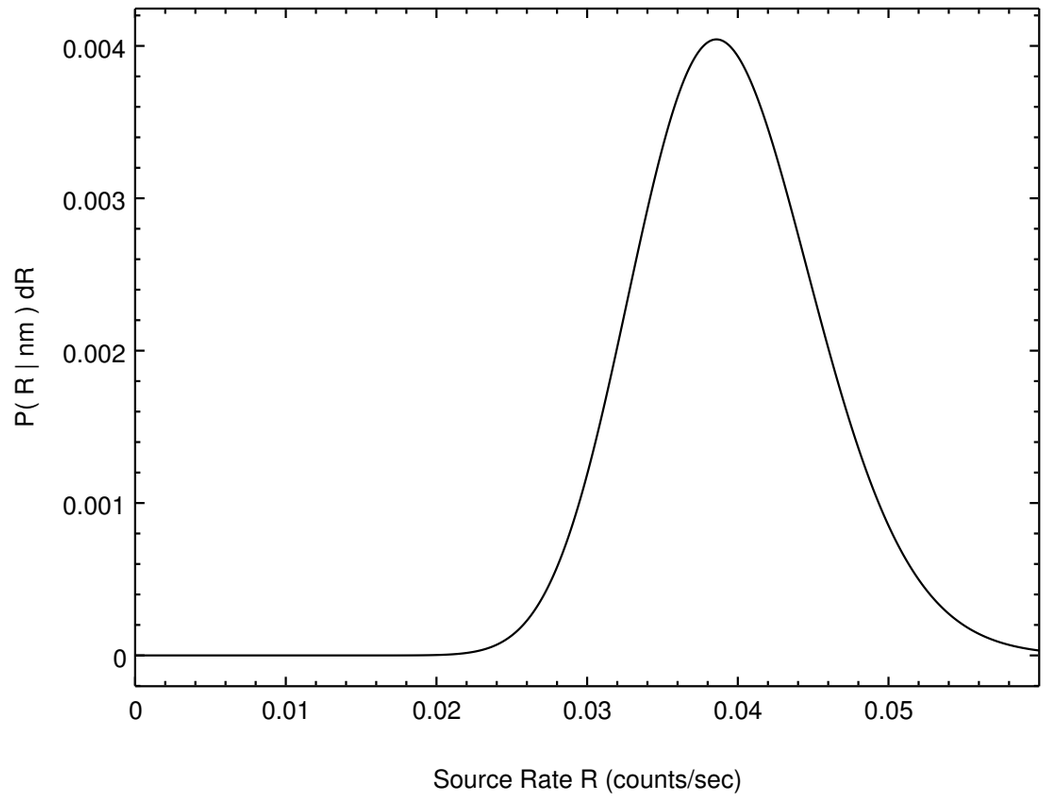
- Solution for non-informative priors:

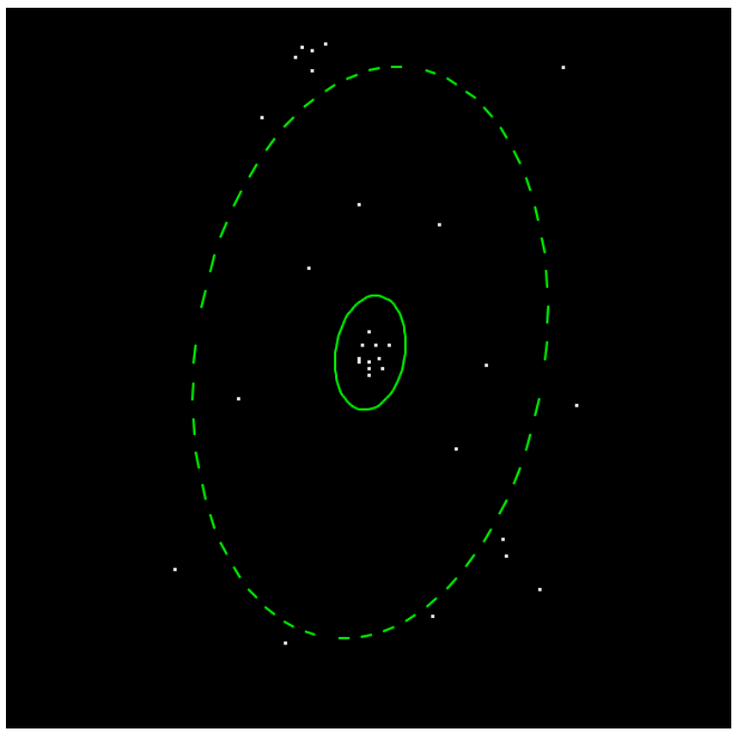
$$p(s|CB)ds = ds\ (rf - g)\frac{1}{\Gamma(C+1)\Gamma(B+1)} \times \sum_{k=0}^{C}\sum_{j=0}^{B}(f^k\ g^j\ r^{B\ \ j}\ s^{k+j}\ e^{\ s(f+g)} \times \frac{\Gamma(C+1)\Gamma(B+1)\Gamma(C+B-k-j+1)}{\Gamma(k+1)\Gamma(C-k+1)\Gamma(j+1)\Gamma(B-j+1)(1+r)^{C+B\ \ k\ \ j+1}}). \quad (26)$$

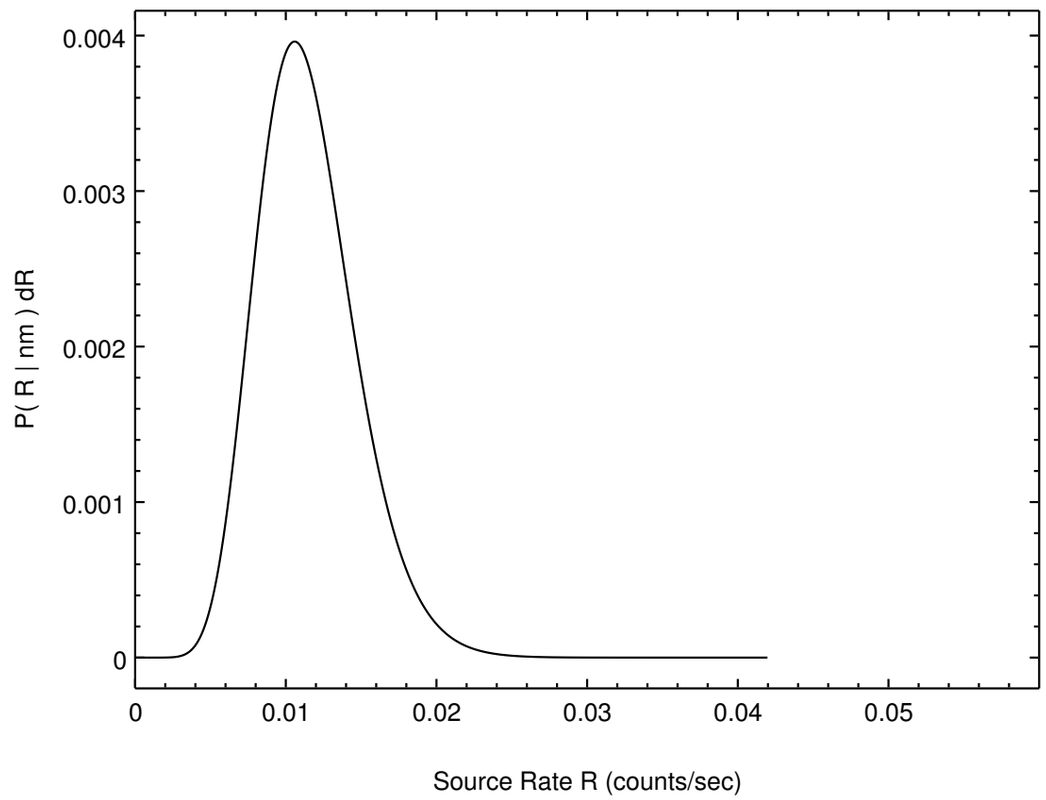


A more complicated problem:
Combining data from the same source, observed at different times, with distinct pdf's









Questions about multi-observation problem:

- Can the pdf from one observation be used as a prior for a second? What happens if the single observation pdf's are distinct?

- What if there are more than two observations? Need a robust solution that's insensitive to the order in which the data are analyzed, i.e., if observation 1 pdf is used as prior to observation 2, should get the same solution as observation 2 pdf used as prior to observation 1, etc.

- At what point does it make no sense to combine the data? Is there a quantitative measure that can be used to decide when to keep observations separate?

- In the limit of large counts, solution should approach that using Gaussian statistics, i.e., error-weighted mean of individual intensities.