SOURCE DETECTION AND ANALYSIS

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Overview: Why source detection?

How to detect sources

- In Theory
- In Practice

Dealing with detected sources

- Hardness Ratios
- $\log N - \log S$

Upper limits

Source Detection in the Real World: Snares and Traps

1. The Starter Kit
   - Aspect dither
   - Bad pixels
   - Exposure maps
2. Here be Hippogrif
   - Point Spread Functions
   - Varying background
   - Extended Sources
   - Overlapping Sources
3. What, me worry?
   - Source Position and plate scale
   - Source spectrum and ExpMaps and PSFs
   - Pileup
   - Detection Sensitivity (Type I Errors)
   - Detection Probability (Type II Errors)

Hardness Ratios

Useful with large samples and when spectral fits are unfeasible

Types of hardness ratios:

- $R = \frac{S}{H}$,
  $\sigma_R = R\sqrt{\left(\frac{\sigma_S}{S}\right)^2 + \left(\frac{\sigma_H}{H}\right)^2}$
- $C = \log_a(S) - \log_a(H)$,
  $\sigma_C = \log(a)\sqrt{\left(\frac{\sigma_S}{S}\right)^2 + \left(\frac{\sigma_H}{H}\right)^2}$
- $HR = \frac{H-S}{H+S}$,
  $\sigma_{HR} = \frac{2}{(H+S)^2}\sqrt{H^2\sigma_S^2 + S^2\sigma_H^2}$

Caveats

- Mathematical obstinacy
- Poisson statistics
- Background
- Upper limits

$\log N - \log S$

Say $n(r) = n_0$, $f(L_x) = \delta(L_x - L_{x0})$, $S = \frac{L_{x0}}{4\pi r^2}$. Number of sources within r, $N(< r) = \frac{4\pi}{3} r^3 n_0$, or $N(> S) = n_0 \frac{4\pi}{3} \left(\frac{L_{x0}}{4\pi S}\right)^{\frac{3}{2}}$, i.e., $N(> S) \propto S^{-\frac{3}{2}}$. In general,

$$N(> S, l, b) = d\Omega \int_0^\infty dL_x \int_0^\infty dL'_x f(L'_x) \sigma(L_x, L'_x) \int_0^{r'} n(r, l, b) r^2 dr$$

where r' is implicitly defined by $S = \frac{L'_x}{4\pi r'^2} e^{-\tau(r')}$.

Biases:

- Source confusion
- False sources (false positives)
- Lost sources (false negatives)
- Malmquist Bias
- Faint source fluctuations
- Eddington Bias

Construction:

- Sky coverage
- Modeling