

# LIRA: Low-count Image Reconstruction and Analysis

Nathan M. Stein

Department of Statistics, Harvard University

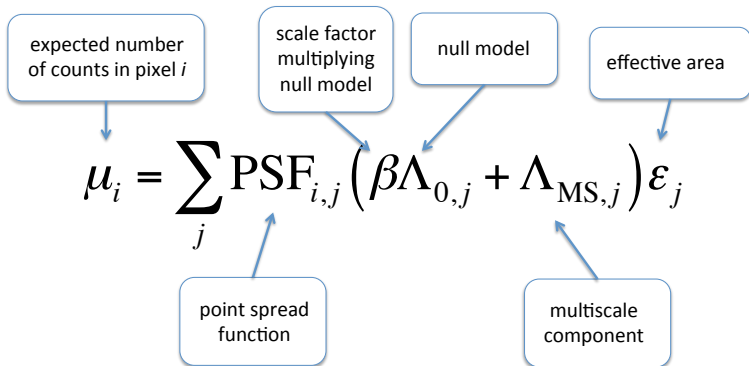
April 8, 2013

# Overview

- LIRA is a software package for the R statistical computing language
- A main focus for Alanna Connors in recent years
- Multiscale non-parametric image analysis for use in high energy astrophysics
- Based on Poisson model suitable for images with low counts
- Fully Bayesian analysis using Markov chain Monte Carlo
- Allows for quantification of uncertainty of fitted image and evaluation of goodness-of-fit of a proposed 2D model

# Statistical Model

- Observations are modeled as independent Poisson( $\mu_i$ )



# Multiscale Component

- $\Lambda_{MS,i} = G \prod_{k=1}^K D_{klm}$
- $D_{klm} =$  split proportion at scale  $k$
- Smoothing prior on  $D_{kl}$

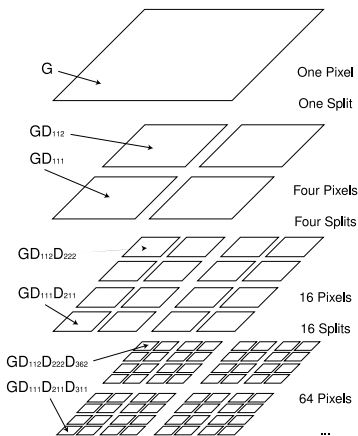
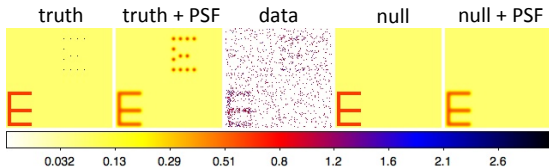


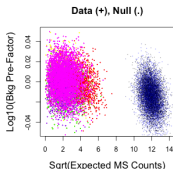
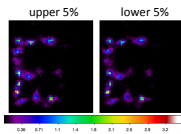
Figure: Esch et al. (2004)

# Evaluating the Goodness-of-Fit of a Proposed Model



Given a proposed physical null model:

- Simulate multiple datasets under this model
- Use LIRA to analyze simulated and observed data
- Compare structure in multiscale “residual” from analyses of simulated vs observed data
- Compare posterior distributions of model parameters



## For more information. . .

- Software available at: [github.com/vkashyap/LIRA](https://github.com/vkashyap/LIRA)
- A. Connors and D. A. van Dyk. (2007) Statistical Challenges in Modern Astronomy IV
- D. N. Esch, A. Connors, M. Karovska, and D. A. van Dyk. (2004) ApJ 610:1213–1227