Source Detection by Count Excess

Tom Stephens/GSSC

Sept. 29, 2004

Outline

- ***Motivation***
- ***Method Description***
- ***Current Status & results***
- ***Future Directions***

Motivation

- ***Jim was looking for a list of potential targets to try Likelihood out on to generate the initial DC1 catalog and 1 week before the closeout meeting no one had responded***
- ***Simple and straight-forward***
- ***No* a priori *knowledge required***
- ***Envisioned as "first step" to locate potential targets, not determine their properties.***

Description

- ***Step 1: Determine Significance***
  - *Grid of points defined on the sky*
  - *Count excess and significance calculated at each point on the grid*
  - *Done in spherical coordinates*
- ***Step 2: Find local maxima***
  - *Excess data searched to find local maxima*
  - *Simply the highest excess within N grid points*

Determining Significance (1 of 2)

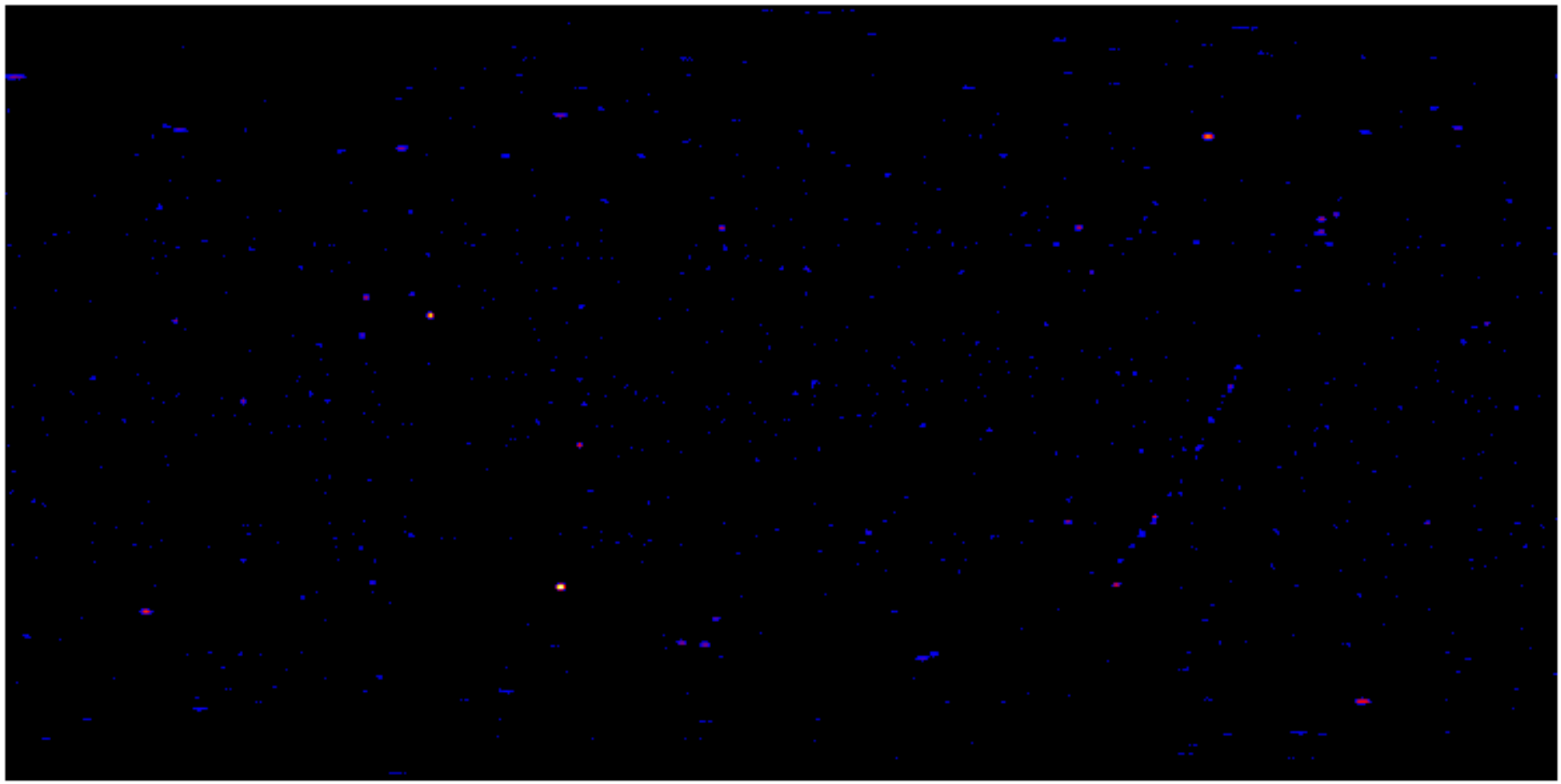
- ***Background counts***
  - *Sum all events within an annulus centered on the grid point*
    - *Inner radius of annulus fixed*
    - *Outer radius can either be fixed or allowed to increase with increasing galactic latitude*
  - *Divide total counts by area of annulus in degrees to get average counts per unit area*
  - *Background counts equal the area of the aperture (below) times the average background counts per unit area*

Determining Significance (2 of 2)

- ***Source counts***
  - *Determined by summing all events within a fixed circular aperture around the grid point*
  - *Subtract the calculated background counts for the aperture*

- ***Source significance***
  - *Compute the significance of the source counts above the background*
  - *Significance determined by dividing the source counts by the square root of the calculated background counts*

Significance Map



Aperture = 0.5º Annulus = 1º-2º Grid=0.25º Significance >=3

Finding Local Maxima

- ***Once the significance of the count excess has been determined at each point on the grid I search through the points to find the local maxima.***
- ***Finding the maxima***
  - *Scans over all grid points*
  - *Check to see if the grid point in question has the highest significance of all its neighbors within a box N by N pixels wide in RA and Dec.*
  - *If so, this is the local maximum and the coordinates and relevant data written to the output.*

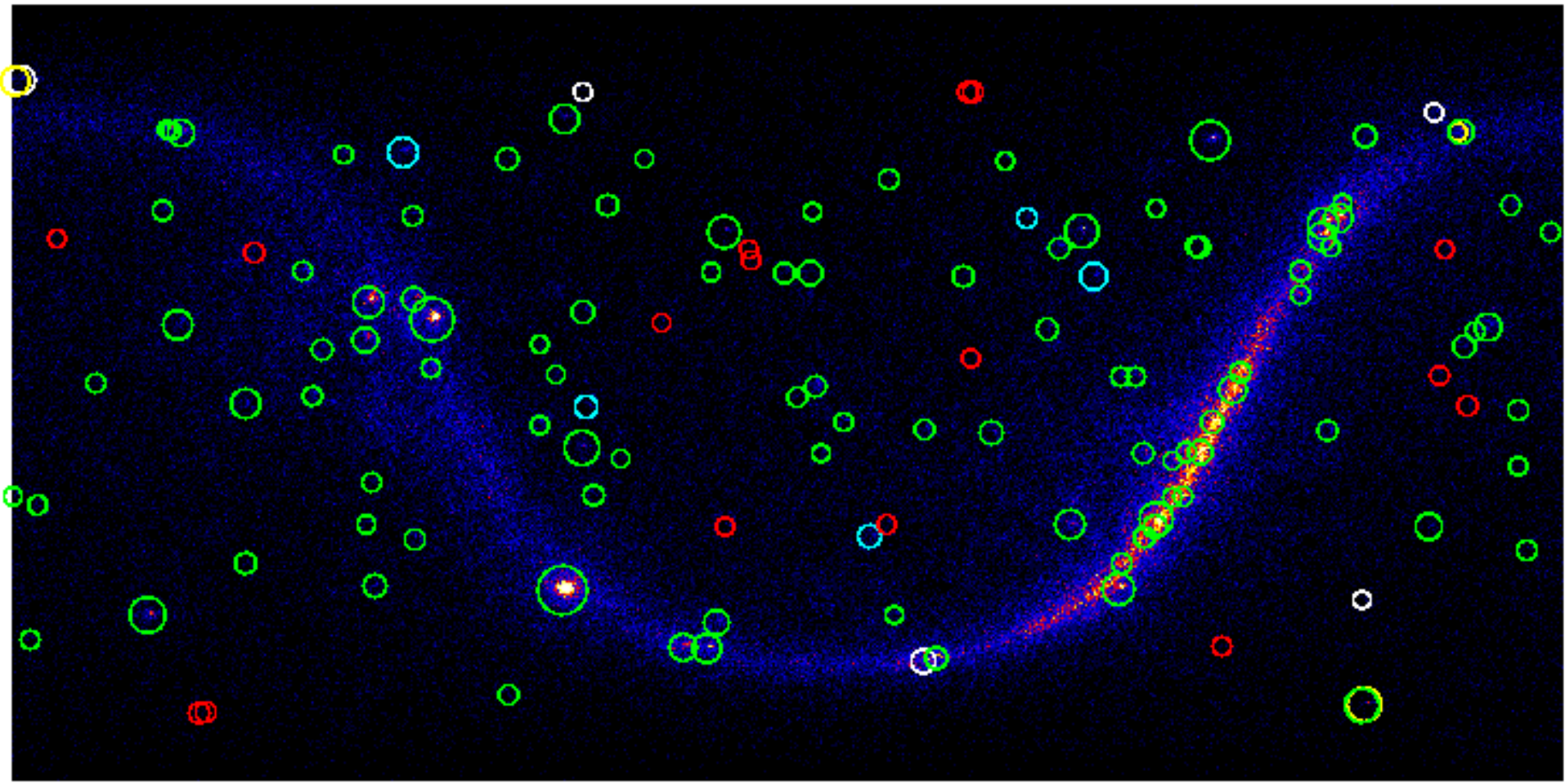
However…

- ***Grid treats RA & Dec as Cartesian system***
  - *More points at high Declinations that really necessary*
  - *Must account for this when doing the maxima search*

Initial DC1 Results

- ***Initial search parameters:***
  - *Aperture = 0.5°*
  - *Annulus*
    - *1° inner radius*
    - *2° outer radius (fixed)*
  - *Grid=0.25° steps in RA and Dec*
  - *Significance >= 3*
  - → ***1677 local maxima***
  - *363 matches in the truth data*
- ***126 detected sources in the 5.8 days of DC1 data with σ>=5***
  - *14 spurious detections (11%)*
  - *112 DC1 sources detected, 5 of which were GRBs.*

Detected Sources



- ***Green, white = real DC1 sources detected***
- ***Cyan = DC1 GRB's detected***
- ***Red = Spurious sources***

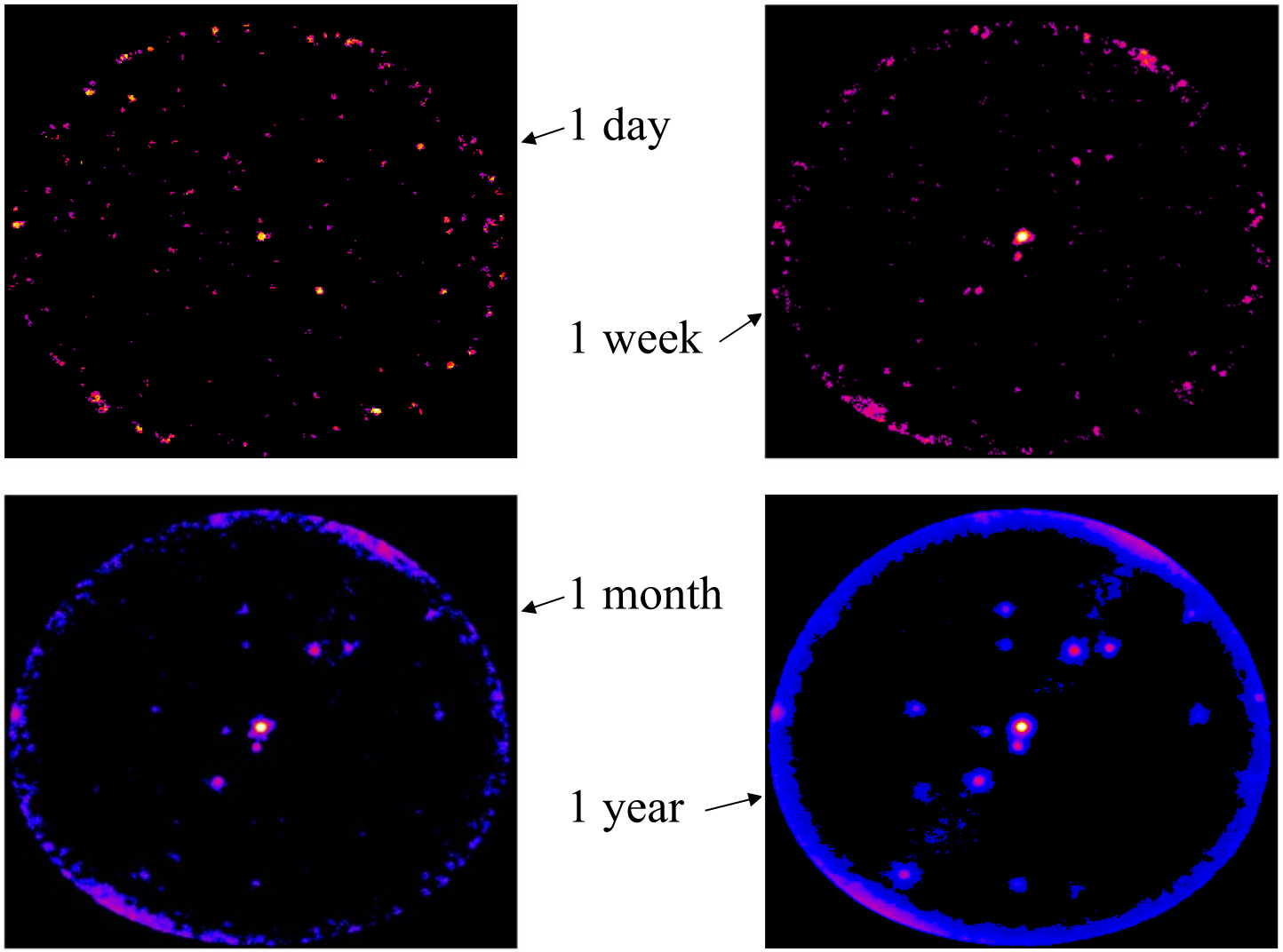
Effects of Data Volume

- ***I had a years worth of data from Jim that I have been using to test the database system that contains just the galactic diffuse emission, extra-galactic diffuse emission, and (I believe) all the 3rd Egret Catalog sources.***
- ***Wanted to see what the effects of more/less data was on the detection thresholds and fraction of spurious results***
- ***Looked a 1 day, 1 week, 1 month, 3 months and 1 year data sets of 15º radius regions centered on the Crab pulsar and the Galactic center.***
  - *Looked for sources within 10º of the image center to avoid "edge effects" from the way I computed background counts*
  - *6 Egret sources in the Crab field*
  - *10 sources in the Galactic Center field*

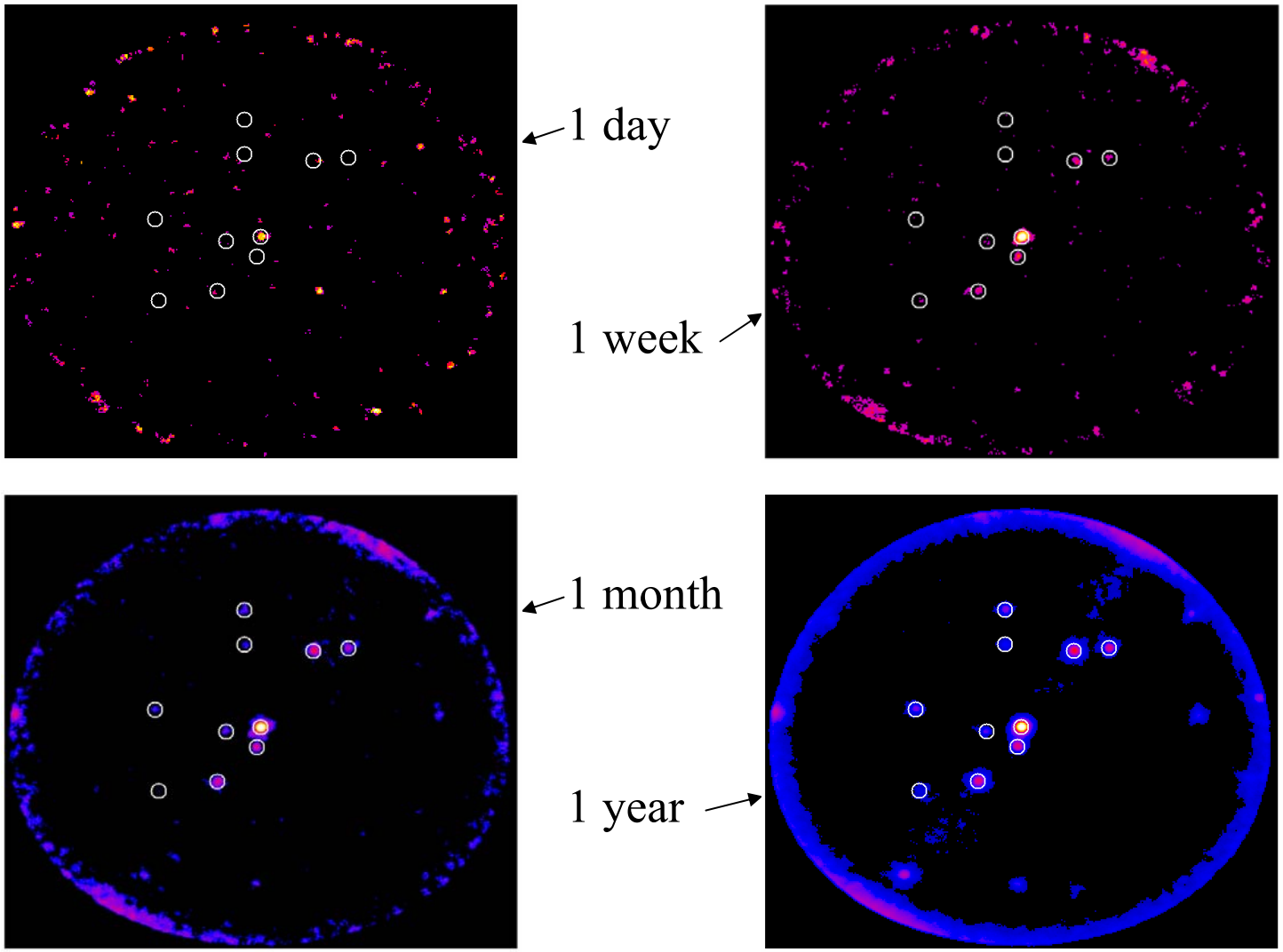
Data Volume Results

Field	*Exposure Time*	*# of 5σ Detections*	*<0.5º 3EG matches*	*Spurious Detections*	*Missed Sources*
Crab	*1 day*	*7*	*2*	*5*	*4*
	1 week	*2*	*2*	*0*	*4*
	1 month	*3*	*3*	*0*	*3*
	3 months	*4*	*4*	*0*	*2*
	1 year	*6*	*6*	*0*	*0*
G. Center	*1 day*	*3*	*1*	*2*	*10*
	1 week	*4*	*4*	*0*	*6*
	1 month	*7*	*7*	*0*	*3*
	3 months	*10*	*10*	*0*	*0*
	1 year	*12*	*10*	*2*	*0*

Galactic Center Significance Map



Galactic Center Significance Map



Effects of Background Levels

- ***Wanted to see the effect of varying amount of background on detection results***
- ***Ran obsSim and created a year's worth of data that contains the galactic diffuse emission doubled, extra-galactic diffuse emission tripled, and all the 3rd Egret Catalog sources***
- ***As before, I looked at 1 day, 1 week, 1 month, 3 months and 1 year data sets of 15º radius regions centered on the Crab pulsar and the Galactic center.***
- ***Strangely, the faint sources had a lot more counts than expected (by a factor of 3), almost as if they are in the flux map used for the background model.***

Background Results

Field	*Exposure Time*	*# of 5σ Detections*	*<0.5º 3EG matches*	*Spurious Detections*	*Missed Sources*
Crab	*1 day*	*6*	*4*	*2*	*2*
	1 week	*4*	*4*	*0*	*2*
	1 month	*5*	*5*	*0*	*1*
	3 months	*6*	*6*	*0*	*0*
	1 year	*7*	*6*	*1*	*0*
G. Center	*1 day*	*7*	*3*	*4*	*7*
	1 week	*13*	*9*	*4*	*1*
	1 month	*20*	*10*	*10*	*0*
	3 months	*16*	*10*	*6*	*0*
	1 year	*15*	*10*	*5*	*0*

Future Directions

- ***Aperture Size***
  - *Optimize fixed aperture size*
  - *Use energy dependent aperture to account for PSF*
- ***Background***
  - *Optimize annulus size for various parts of sky (i.e. on/off galactic plane, crowded field, etc.)*
  - *Possibly use a background model to fit the background*
- ***Detection threshold***
- ***Source localization***
- ***Test in field of crowded, faint objects***
- ***Work on sensitivity limits***