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The Power of `wavdetect`

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`wavdetect` is a hypothesis test!

A source is identified by asking "can the observed signal be ruled out as being produced as a fluctuation of the background at some probability?"

Type I Error:

False positives; probability of finding something that is not there. (*significance threshold* for source detection)

Type II Error:

False negatives; probability of not finding something that really is there.

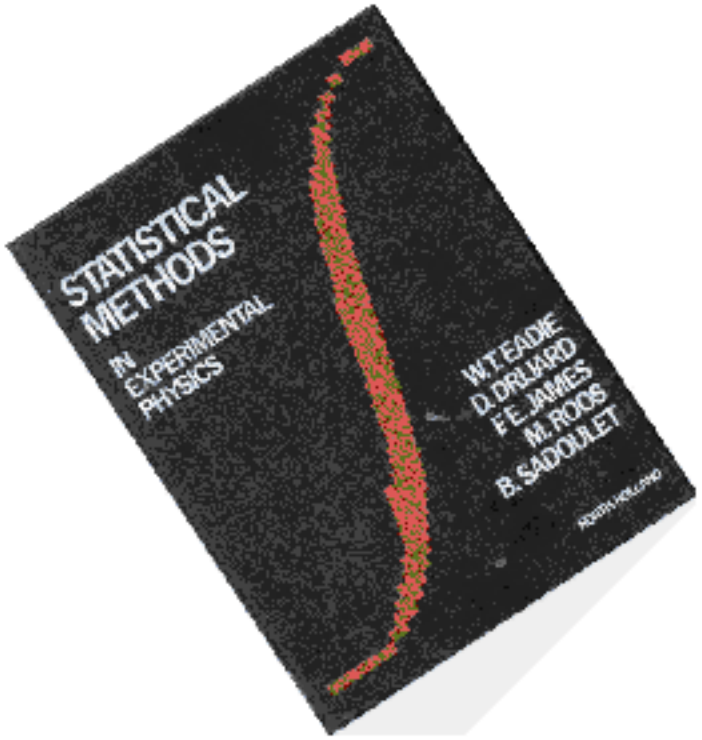
That is, α is the probability that H_0 would be rejected even if H_0 was indeed true.

The usefulness of a test depends on its ability to discriminate against the alternative hypothesis H_1. The measure of the usefulness is the power of the test, defined as the probability $1 - \beta$ of X falling into the critical region if H_1 is true:

$$P(X \in \omega | H_1) = 1 - \beta \,. \tag{10.2}$$

In other words, β is the probability that X will fall in the acceptance region if the alternative hypothesis is true:

$$P(X \in \bar{\omega} | H_1) = \beta \,.$$



Simulations

MARX simulations of postage stamp (256x256) images at different off-axis locations, with a wide variety of source and background strengths. `wavdetect` runs at different thresholds.

Off-axis angles of 0, 5, and 10 arcmin

Background intensities ranging from 1.5×10^{-4} to 0.17 ct pix^{-1}

Source strengths ranging from 3 to 4000 ct

Thresholds set to obtain 20, 10, 5, 2, 1, 0.5, and 0.1 per dataset

Obtain $\sim$ 40 simulated images for each case, and run `wavdetect` on each simulation at scales 1,2,4 `pix` for on-axis, 2,4,8,16 `pix` for off-axis locations.

Conclusions

Source Flux measurement: good to 3 counts (on average).

Source Locations: errors of ~ 2 pix for faint sources close to on-axis, ~ 7 pix at large off-axis; 2 pix systematic offset at large off-axis.

False Detection Rate: consistently better than the nominal rate.

False Negative Rate: first ever computation for a source detection algorithm; interpolate from tables.

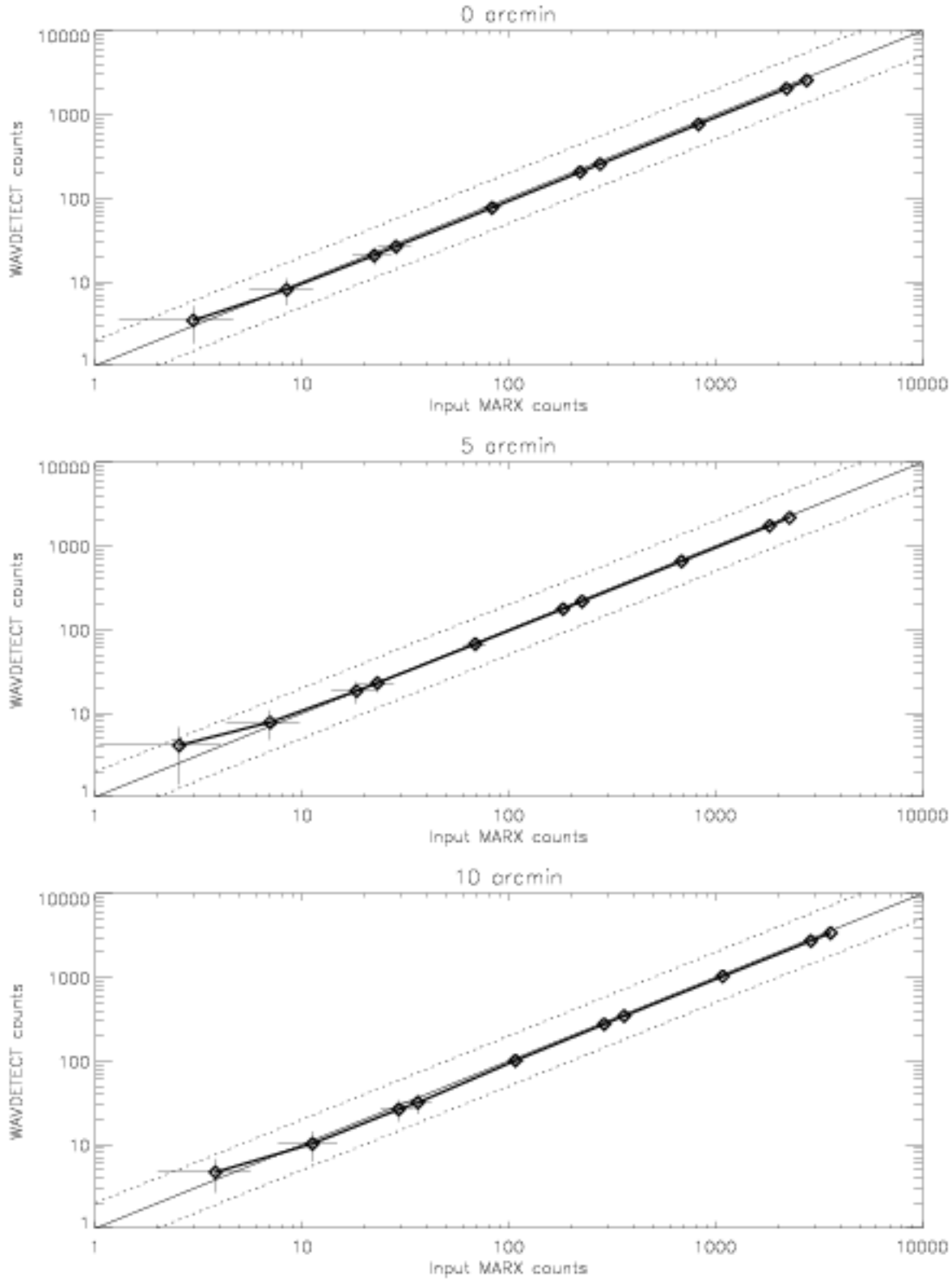


Fig. 1.— Comparison of input source flux and measured source flux

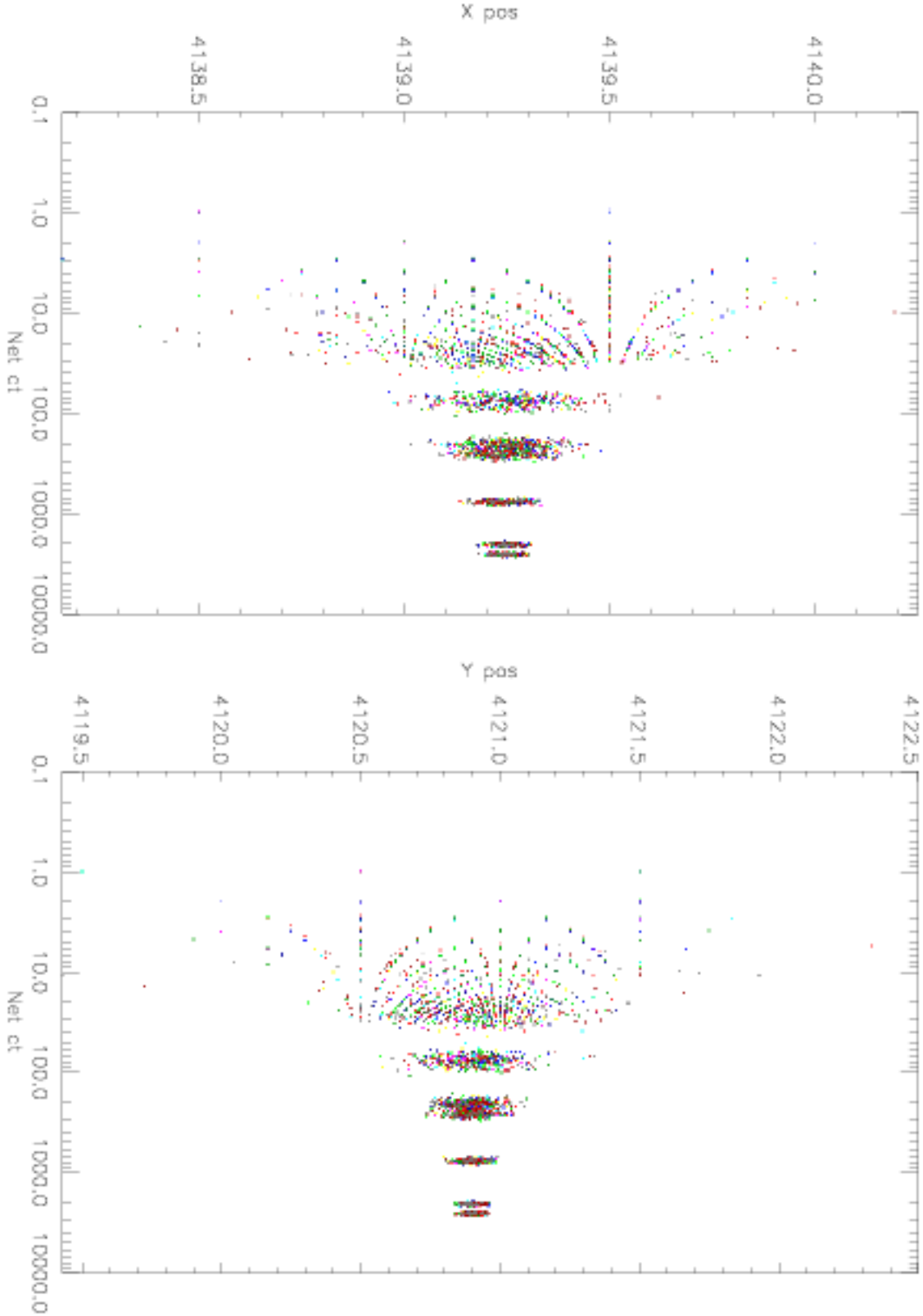


Fig. 2.— Detected source locations for on-axis sources; nominal source location is (4139,4121)

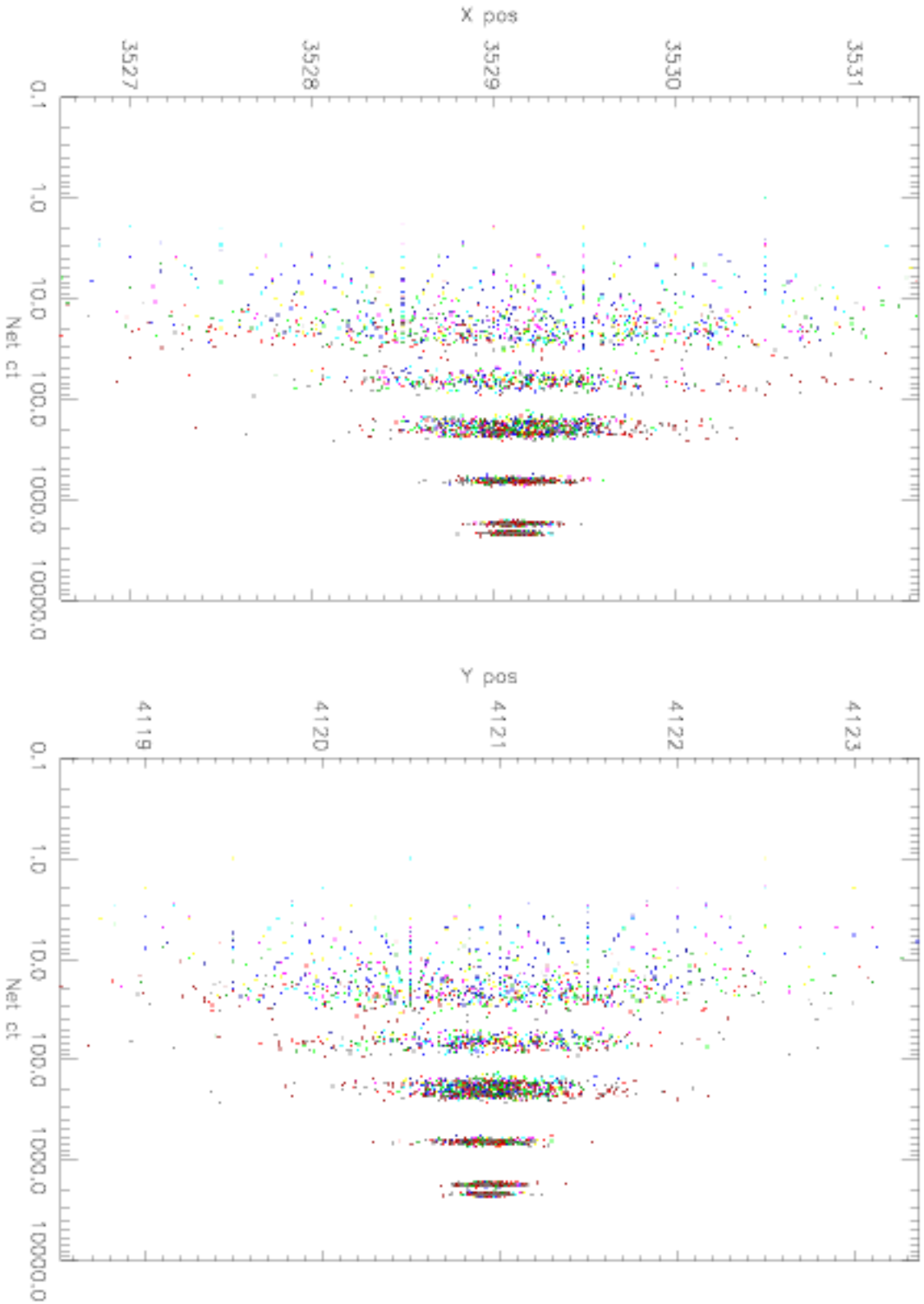


Fig. 3.— Detected source locations for sources at 5′ off-axis; nominal source location is (3529,4121)

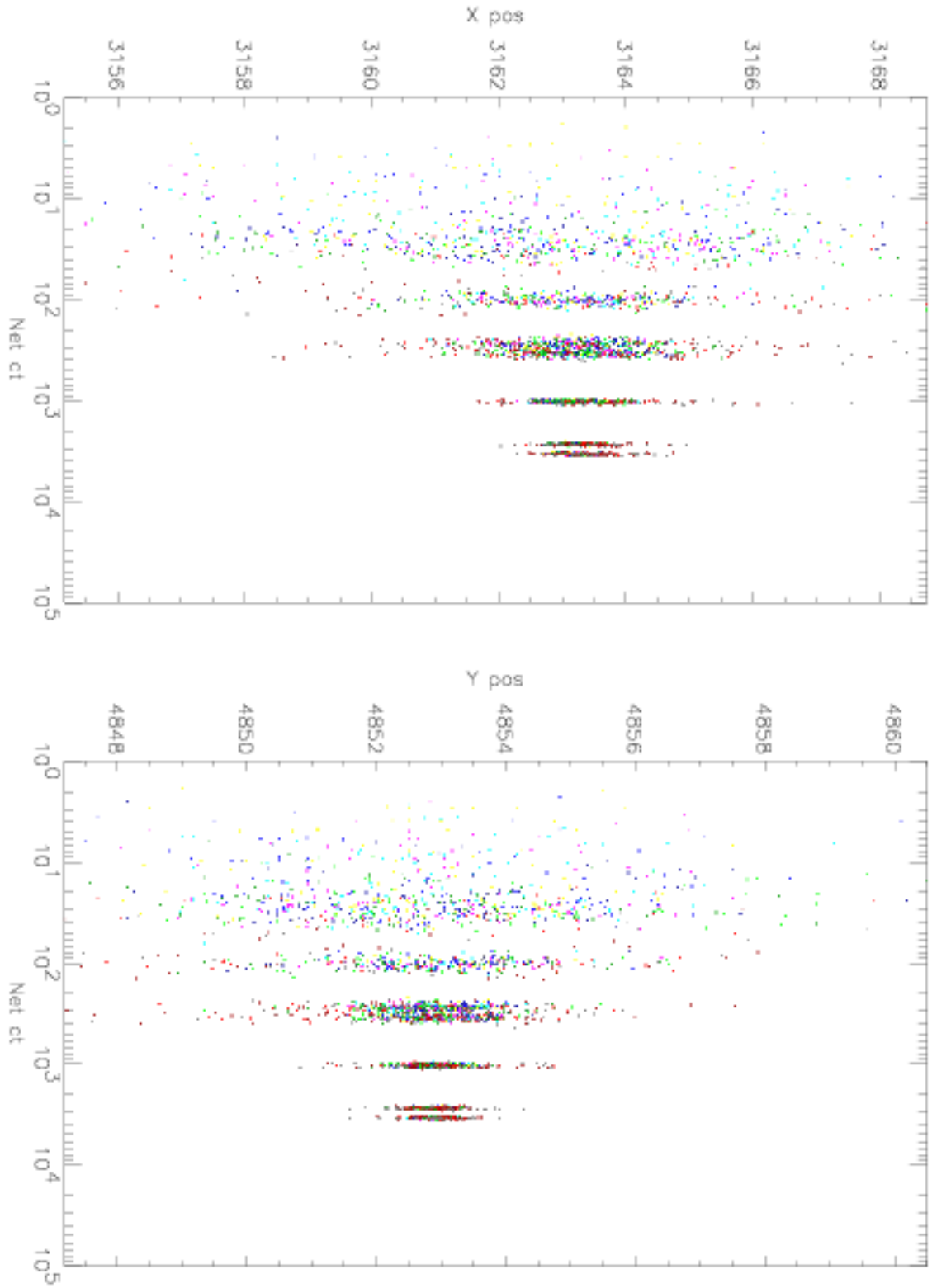


Fig. 4.— Detected source locations for on-axis sources; nominal source location is (3162,4854)

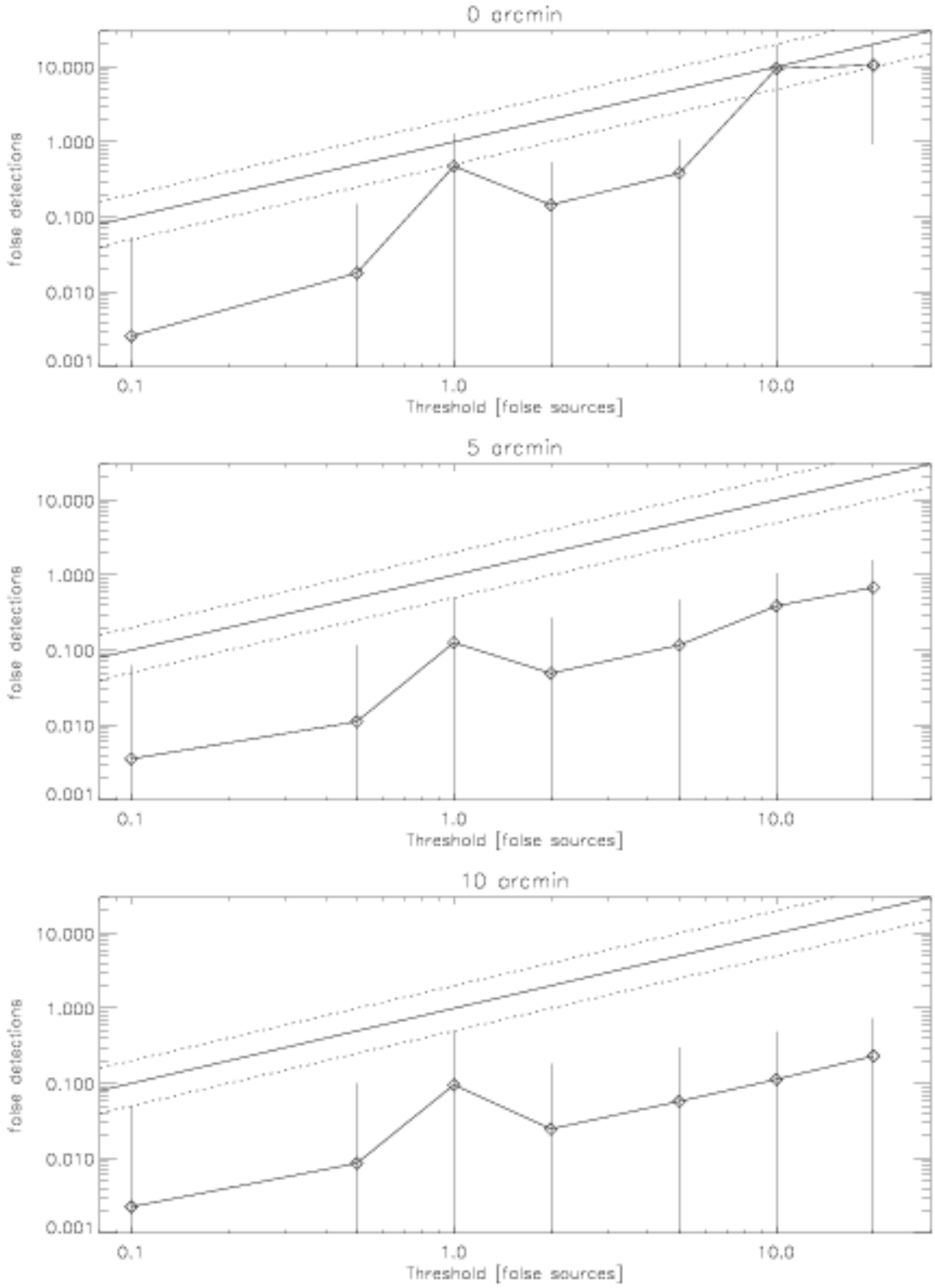


Fig. 5.— WAVDETECT Type I error, the number of false detections for different detection thresholds

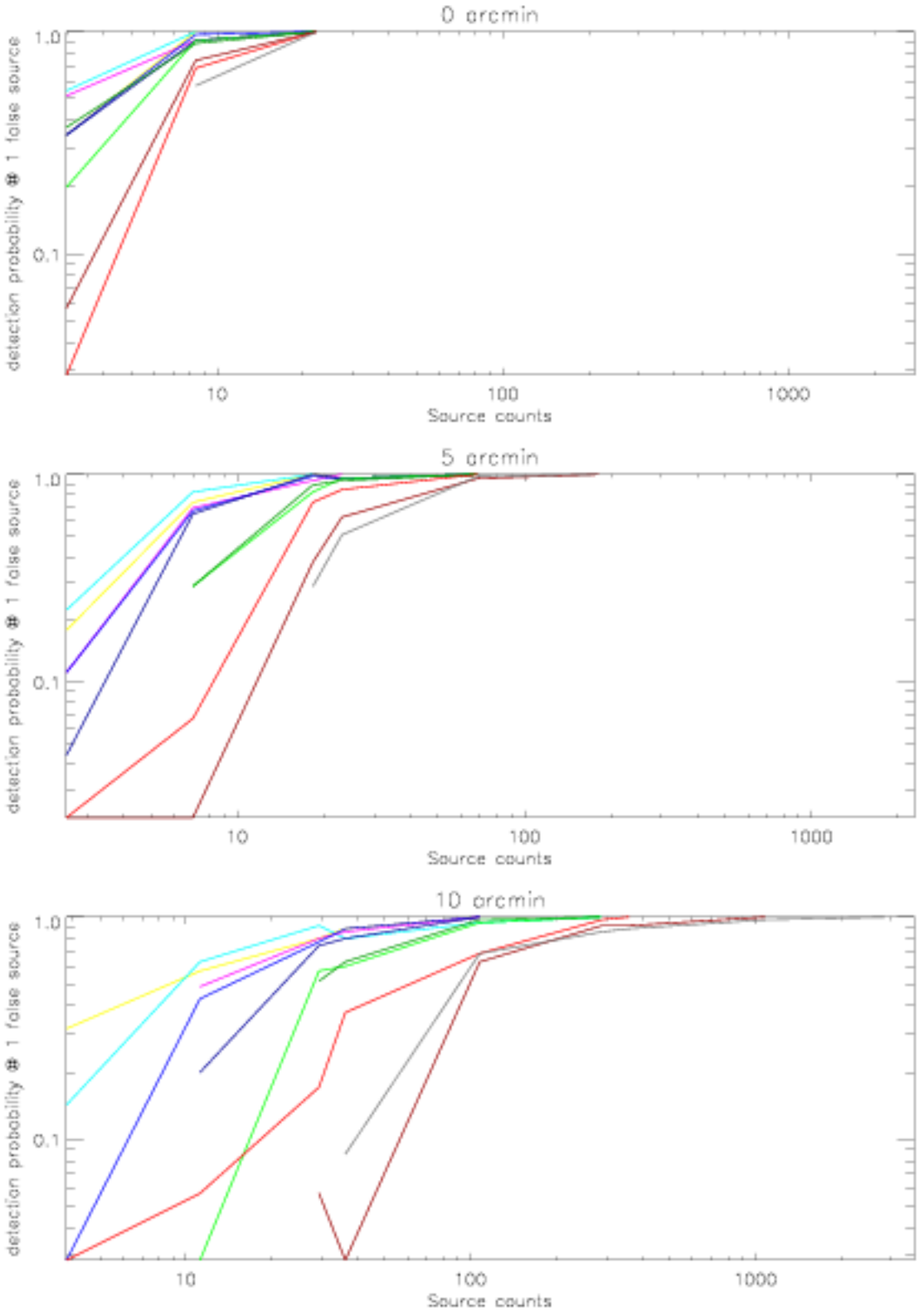


Fig. 6.— WAVDETECT Type II error, the probability of detecting a source of given strength, for various background values.

CONCLUSIONS

wavdetect is workin' pretty good.