A Weighting Analysis of Crab Data

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Introduction

It has for a long time been observed by many people that the significance of the excess from the Crab is almost independent of the cuts applied. When compared to "standard" cuts (NFIT>=20, X2>2.5), similar significance is typically obtained for harder cuts cuts are applied, even when the number of events passing the cuts is reduced by a factor of 1000x more more. This phenomenon indicate that the significance of the excess can be substantially increased by combining the independent result of from the "soft" and "hard" cuts form a single result of higher significance.

Presented here is an analysis of recently reconstructed Crab data by weighting the events in by a factor proportional to the probability that they are gamma rays from the a point source. Both gamma/hadron based weighting and Gaussian weighting to account for the differences in angular resolution are applied. The result is that the significance of the Crab significance from 1.5 years of data is 9.5 sigma compared to 4.8 sigma for the standard cuts.

Data Set

The data set used in this analysis is the "tped" reconstruction recently produced by Curtis. This data set includes ~1.54 years of data collected between Sept. 2003 and May 2005. You can find the data in /data/sources02/milagro/crab71_tped/final on the computer cluster at UMD.

Independent Data Sets

A standard analysis is performed on the data only cutting on X2 and NFIT. The cuts are progressively increased. The separate analysese are not independent. To make them independent, the results signal map from the next harder set of cuts are subtracted. The table below shows the cuts for each of the 7 independent data sets. These cuts were not optimized, but were chosen base on the general understanding that harder X2 cuts work better for harder X2 cuts. The cuts used in each independent "slice" are shown in table 1 along with the weight assigned to each slice.

Slice	***Cuts***	***Expected No of gammas***	***Measured bkg total(x10**6)***	***Weight***
1	(NF>=20 &&X2>2.5) && !(NF>=50 && x2>3.0)	1933	265	1
2	(NF>=50 &&X2>3.0) && !(NF>=75 && x2>3.5)	951	87	1.5
3	(NF>=75 &&X2>3.5) && !(NF>=100 && x2>4.0)	550	30	2.51
4	(NF>=100 &&X2>4.0) && !(NF>=125 && x2>4.5)	366	11.4	4.4
5	(NF>=125 &&X2>4.5) && !(NF>=150 && x2>5.0)	263	4.39	8.2
6	(NF>=150 &&X2>5.0) && !(NF>=175 && x2>5.5)	194	1.71	15.6
7	(NF>=175 &&X2>5.5)	145	0.9	22.1

Table 1List of cuts for the 7 independent data sets. The weight is the ratio of the expected number of signal events to the number of background events passing the cuts. Note that the weight is relative so I define the weight for slice 1 to be 1.0 and the other weights are computed relative to it.

Angular Resolution

The gamma-ray signals from each slice are expected to have different angular resolutions. I found from the simulation that the angular resolution gradually improves with slice number. In this analysis, the angular resolution for each slice is assumed to be a Gaussian characterized only by width. A more generalized analysis could use the known PSF. Table 2 shows the angular resolution used in each slice in this analysis.
For each of the 7 slices, the signal and background maps are smoothed with a 2D Gaussian with width determined by the angular resolution for that map.

Slice	***Angular Resolution***
1	1.25
2	1.00
3	0.60
4	0.50
5	0.40
6	0.30
7	0.30

<u>Putting it all together</u>

After each map has been smoothed, the maps are combined into a single map where the weight assigned to the each map is given in table 1. The significance is computed in a manner that properly takes into account the weight assigned to each event. This is handled automatically by the standard map class as described at the January Maryland collaboration meeting. Figure 1 shows the significance distribution for the vicinity of the Crab for final map. Figure 2 shows the sigma distribution for the same map. A 9.5 sigma excess is found at the position of the Crab. The highest excess in the map is 9.8 sigma located 0.2 deg away from the Crab position. The "standard" analysis (x2>2.5,nf>=20, binsize=2.1 deg) yields a Crab significance of 4.8 sigma for this same data set. A fit of the sigma distribution to a Gaussian yields a width of 0.987.

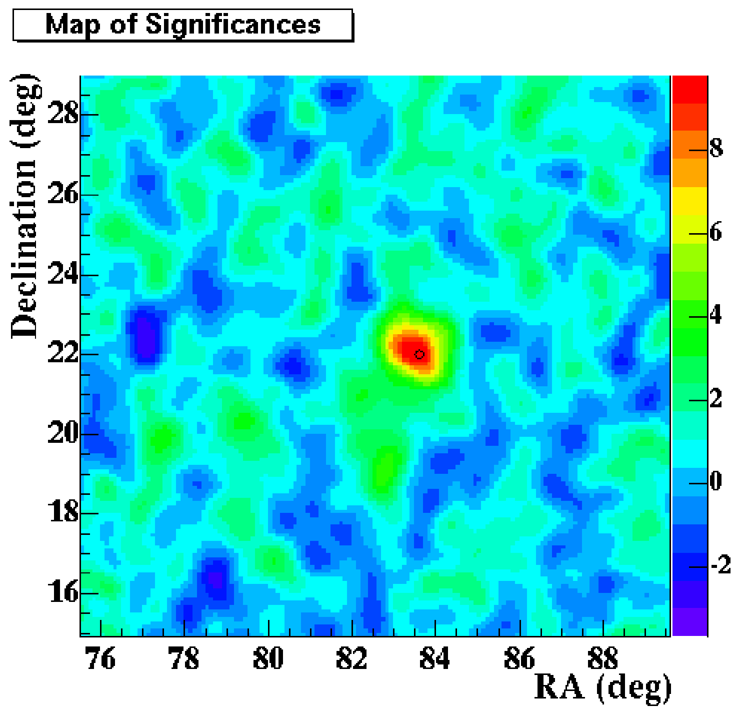

Illustration 1Significance map in the vicinity of the Crab.