More on NHIT and Energy for GRB970417a
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Abstract: I'm trying to find something useful about NHIT to put in our paper on the energetics of GRB970417a. I've used a K-S test to compare the NHIT distributions of the 18 events, purported to be from GRB970417a, with MC of fixed energy gamma-ray showers. The MC distribution depends on the cuts, such as the trigger and the angular reconstruction, and I've tried to make these the same as the data. For the cuts described below, these 18 events are consistent with 100 GeV (10 TeV) at a 0.5% (2%) confidence interval.

I've used the MC files that Julie has generated for Milagrito at fixed energies (100 GeV, 500 GeV, and 10 TeV) from the zenith angle (20-25 degrees) of this GRB. Rather than considering the individual nhit values, I wanted to compare the distribution of NHIT for these 18 events with a monoenergetic gamma-ray signal. The NHIT distribution for monoenergetic fluxes is not the same as Isabelle's because of different cuts on the data. The cuts used for this MC data follow.

- PMTs which were dead at that time--81, 96, 101, 105, 150, 194, 195, 207, 213-- were not used.
- The trigger was chosen to match the data by someone (I don't know who) with more knowledge of Milagrito than I, and the algorithm used is coded here.

```
trigger = 0;
rran = ran1(&iseed);
if (npmts >= 105) trigger = 1;
if (npmts >= 100 && npmts < 105 && rran < 0.8 ) trigger = 1;
if (npmts >=  95 && npmts < 100 && rran < 0.5 ) trigger = 1;
if (npmts >=  90 && npmts <  95 && rran < 0.05) trigger = 1;
```

- Cores were not restricted to the pond. However, the cores of the triggered events are in fact on the pond. Therefore, Isabelle's decision to throw only on the pond was not an approximation.
- The shower direction was reconstructed and required to be within 1.6 degrees -- the radius of the bin used in the GRB analysis -- of the true direction. I've included the K-S figures with and without this cut. In order to reconstruct the angle, one must also throw out the miscalibrated PMTs. Again someone more cognizant of Milagrito has written code to throw out a few PMTs. Note some events fall outside the angular bin, but others simply fail to reconstruct.

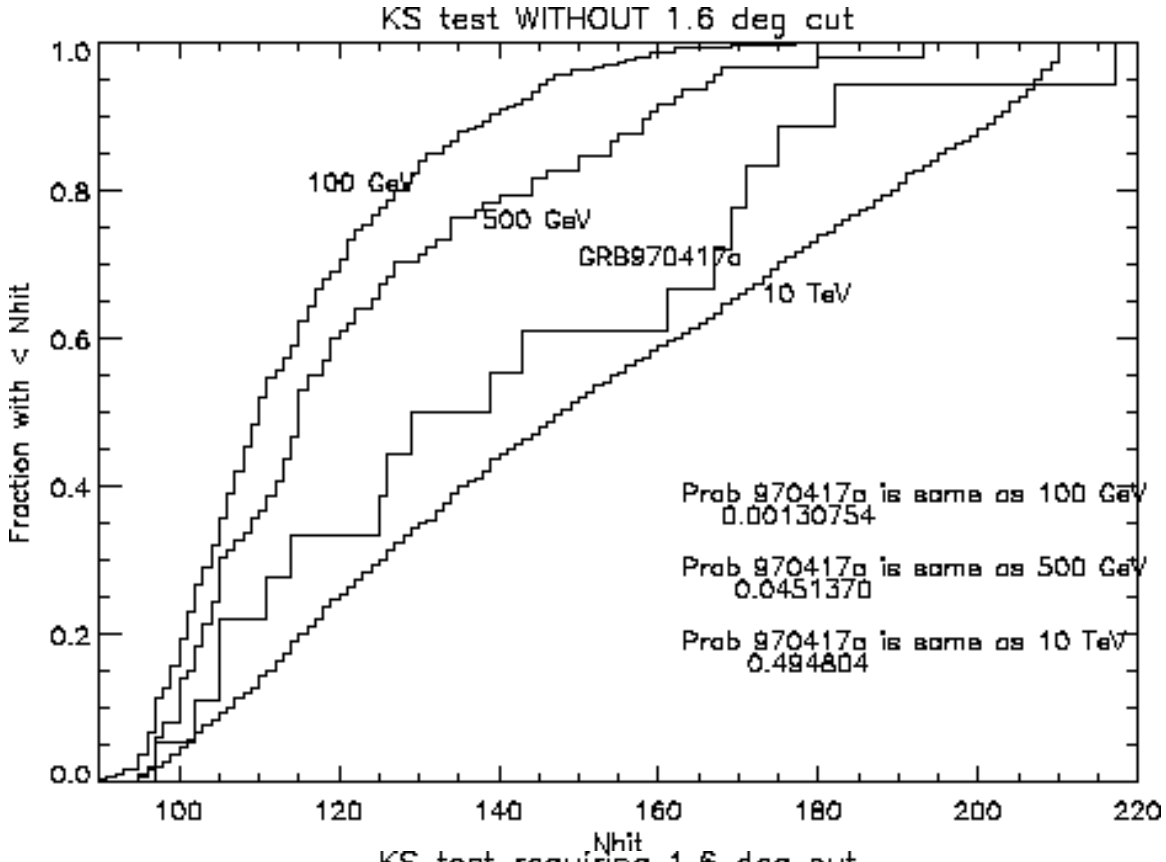
It is also not entirely clear what to use for NHIT in the data. NFIT is not NHIT because there are PMTs associated with the shower that we do not use in the fit. Also one can still include miscalibrated PMTs in NHIT, because they still participate in the trigger and tell us information about the extent of the shower. Julie's previous memo (of 6-11-01) used the number of calibrated PMTs, but Gus and Gaurang persuaded me to use all PMTs hit.

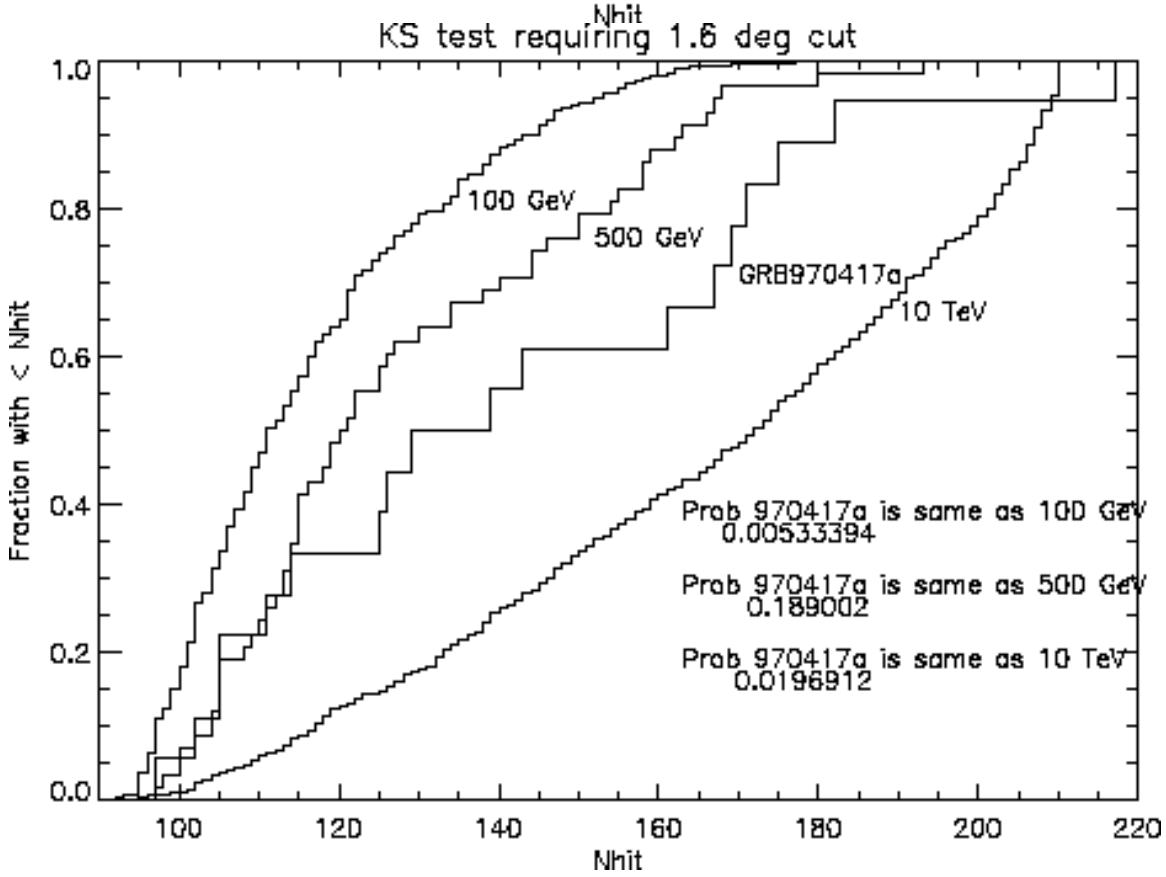
The K-S test is shown on the next two pages --first without the angular reconstruction and then requiring the direction to be within 1.6 degrees. The 1.6 degree cut makes a

significant difference and is necessary since the 18 events are required to be in a 1.6 degree bin. However, it's still not perfect because the MC doesn't have noise hits which the data does, but the data is required to be in a 500ns gate. Assuming 200 PMTs at 15KHz each, we only expect 1.5 noise hits per event, so that doesn't effect these plots significantly. Also, 3-5 of the 18 events are background so we should add a certain fraction of events drawn from the data as well. This will tend to make the low and high energy MC more similar, but as it stands this plot is all ready sufficient to tell us that NHIT is not a sensitive measure of energy when we only have 18 events, or at least not as sensitive as the scalars.

Therefore, my conclusion is NHIT tells us with 2-2.5 sigma confidence that our events, if they are due to a monoenergetic beam, are between 100 GeV and 10 TeV whereas the scalars tell us the energy is greater than 700 GeV with 3 sigma confidence (Julie and Andy's memo of 2-24-00) for either a monoenergetic beam and a wide variety of power law spectra. I propose we include the second plot in the paper to give the reader an idea of how NHIT is correlated with energy, but not use this information to calculate flux or fluence.

Also since a true gamma-ray burst flux is very unlikely to be monoenergetic, we can't use the NHIT distribution to get our maximum energy either. The maximum energy would be an interesting number, because it constrains the burst distance and the minimum fluence we've detected. (Remember minimum fluence comes from the maximum energy because our area increases with energy faster than the energy.) In our first paper we gave the fluence for a reasonable selection of power law spectra, but in this next paper we can give the effective area for the scalars and the air showers and describe how to calculate the fluence for any spectrum a theorist might have.


KS test WITHOUT 1.6 deg cut
Fraction with < Nhit
Nhit
100 GeV
500 GeV
GRB970417a
10 TeV
Prob 970417a is same as 100 GeV
0.00130754
Prob 970417a is same as 500 GeV
0.0451370
Prob 970417a is same as 10 TeV
0.494804


KS test requiring 1.6 deg cut
Fraction with < Nhit
Nhit
100 GeV
500 GeV
GRB970417a
10 TeV
Prob 970417a is same as 100 GeV
0.00533394
Prob 970417a is same as 500 GeV
0.189002
Prob 970417a is same as 10 TeV
0.0196912