SUNDAY

Coffee & Bagels			9:00
Student Analysis Updates			10:00
Moon	Cy for Morgan	15 min	
All Sky Survey	Cy for Kelin	15 min	
AGN	Gaurang for Scott	15 min	
"Revisiting GRB970417a"	Gaurang for Isabel	15 min	
Bursts	Joe	20 min	
BATSE+scalars+...	Miguel	15 min	
WIMPs	Lazar	15 min	
Lunch			12:00
Solar Proposal	Jim	15 min	1:30
Ops			
$$$$$	Jordan	15 min	
Running Status	Gus	30 min	
Air Conditioners	Gus		
Repairs	Gus		
Cal of New PMTs	Bussy	15 min	
Shifts	Cy	15 min	
Safety	Cy	15 min	
Compression	Miquel	5 min	
Archiver	Julie	15 min	
Database	Julie	15 min	
Break			4:00
Status of Trigger Upgrades	Erik Blaufuss	15 min	
Lower Trigger Threshold Memo	David Noyes/Liz Hays	15 min	
Intelligent Triggering	" "	15 min	
Upcoming Conferences	ALL (Gus)	15 min	
Institutional Reps Meeting			6:00

MONDAY

Coffee +			8:30
Milagrito Papers			9:00
Nov. 6 Paper	Abe	30 min	
Burst E & fluence Paper	Julie/David	20 min	
Other Papers	ALL (Cy)	30 min	
Milagrito Data Archive (how long do we hold on?)			
Crab			
Update	Andy	30 min	
Gamma-Hadron Rejection	Gus	20 min	
Crab & AGN search	Wystan	15 min	
"Compounding the Significances"	Roman	15 min	
Discussion	ALL(Jordan)	30 min	
Date of Next Collab. Meeting	ALL(Jordan)	15 min	

Lunch			12:30
MuonCand muon finder	David	20 min	2:00
Calibration	Gus	15 min	
Single Hadrons	Guaurang	20 min	
Software			
Computing at Site & LANL	Frank	15 min	
XTE proposal & Rapid Alerts	Brenda	15 min	
Offline v50	David W.	20 min	
DelCA	Joe	15 min	
Beyond v50	ALL (David W.)	30 min	
Break			4:00
Simulations past	Julie	15 min	
Milagro Sensitivity Calc.	Julie	15 min	
Simulations future	ALL (Julie)	30 min	
Moon over Milagro	Frank	30 min	
Collaboration Dinner			6:30

TUESDAY

Coffee +			8:30
Construction			9:00
WACT status & plans	Rob	15 min	
Outriggers	Tony	30 min	
Discussion	ALL (Tony)	2 hr	
who, when, where			
online reconstruction			
calibrations			
simulations needed			
Lunch			12:00
Local Dormant AGN's	David B.	20 min	1:30
Solar Events in Milagro	Abe	15 min	
Bursts in Milagro	Julie/Matt Wilson	15 min	
All Sky Analysis	Andy	30 min	

Other Analysis & Papers we should be doing ALL (Brenda)

Summarize ACTION ITEMS

WEDNESDAY WACT meeting but Milagro collab. is invited

SUNDAY

Coffee & Bagels			9:00
Student Analysis Updates			10:00
Moon	Cy for Morgan	15 min	
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Bursts	Joe	20 min	
BATSE+scalars+...	Miguel	15 min	
WIMPs	Lazar	15 min	
Lunch			12:00
Solar Proposal	Jim	15 min	1:30
Ops			
$$$$$	Jordan	15 min	
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Air Conditioners	Gus		
Repairs	Gus		
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Safety	Cy	15 min	
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Intelligent Triggering	" "	15 min	
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MONDAY

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Nov. 6 Paper	Abe	30 min	
Burst E & fluence Paper	Julie/David	20 min	
Other Papers	ALL (Cy)	30 min	
Milagrito Data Archive (how long do we hold on?)			
Crab			
Update	Andy	30 min	
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Crab & AGN search	Wystan	15 min	
"Compounding the Significances"	Roman	15 min	
Discussion	ALL(Jordan)	30 min	
Date of Next Collab. Meeting	ALL(Jordan)	15 min	

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MuonCand muon finder	David	20 min	2:00
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All Sky Analysis	Andy	30 min	
Other Analysis & Papers we should be doing	ALL (Brenda)		
Summarize ACTION ITEMS			

WEDNESDAY WACT meeting but Milagro collab. is invited

Table 6.3: Access bin ($\geq 3.7\sigma$) for Transient Search

Map Name	Significance	RA(bin)	Dec(bin)	RA(°)	Dec(°)	Events($\times 10^6$)
B2-No.1	4.0σ	39	9	89.69	19.44	81.5
A2-No.2	3.8σ	53	9	121.85	18.33	149.5
B2-No.3	3.8σ	77	17	212.66	37.22	243.8
A1-No.8	3.9σ	67	30	351.19	65.00	220.6
A1-No.8	3.8σ	28	-1	61.25	-3.89	220.6
B2-No.8	3.8σ	16	8	35.00	17.22	220.6
B1-No.9	4.4σ	118	1	261.22	1.67	228.0
B1-No.11	4.0σ	52	4	115.64	8.22	210.4
A1-No.13	3.9σ	56	22	182.12	47.22	276.4
B2-No.13	3.8σ	71	1	155.62	1.67	276.4
B2-No.13	3.7σ	53	9	122.67	19.44	276.4

Considering that each monthly search is independent, the probabilities for background fluctuation are:

$$P_{n\geq 1}(4.4\sigma) = 1 - e^{4319\times ln(0.99999459)} = 0.02309 \tag{6.15}$$

$$P_{n\geq 1}(4.0\sigma) = 1 - e^{4319\times ln(0.99996833)} = 0.1278 \tag{6.16}$$

$P_{n\geq 1}(3.9\sigma) = 0.1876$ as show in (5.20), and,

$$P_{n\geq 1}(3.8\sigma) = 1 - e^{4319\times ln(0.99992765)} = 0.2684 \tag{6.17}$$

Actually there happened to be 2 accesses more than 3.8σ (including a 3.9σ access) on map 71.56-No.8, so the probability of fluctuation is:

$$\begin{aligned} P_{n\geq 2}(3.8\sigma) &= 1 - [(1-p)^n + np(1-p)^{n-1}] \\ &= 1 - (1-p)^{n-1}[(1-p)(1-n) + n] \end{aligned} \tag{6.18}$$

Path of sources of various declination(δ) in ϑ and φ

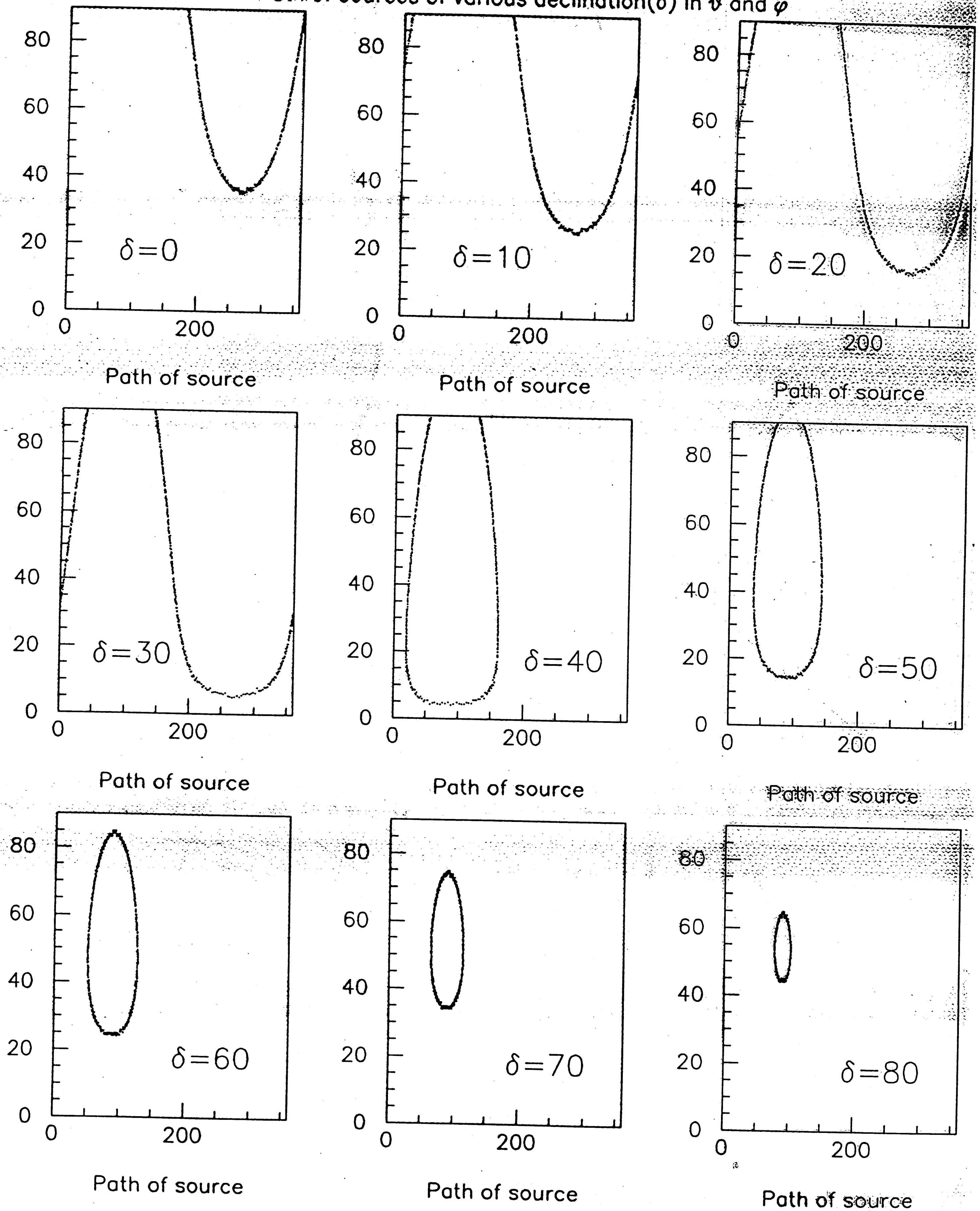


Table 6.4: Monthly Mornitoring for Mrk501.

Month No.	M.J.D.	Run No.	Events($\times10^6$)	Significance
1	487-517	1-25	81.5	0.47σ
2	518-547	26-99	149.5	0.75σ
3	548-577	100-202	243.8	0.77σ
4	578-607	205-284	225.4	-1.3σ
5	608-637	285-345	242.8	0.10σ
6	638-667	346-401	190.9	0.65σ
7	668-697	402-464	198.6	2.4σ
8	698-727	465-518	220.6	0.17σ
9	728-757	519-570	228.0	1.56σ
*10	758-787	571-603	164.3	0.18σ
*11	788-817	604-637	210.4	1.1σ
*12	818-847	638-673	274.3	0.60σ
13	848-877	674-749	276.4	0.44σ
14	878-907	750-828	363.2	2.3σ
15	908-940	829-896	361.2	0.45σ

6.2 Search for Steady Emission of All-northern sky

6.2.1 Four Independent Searches

An all-sky map consists of 162×34 bins of 2.2222° × 2.2222°. The starting coordinates of each map are listed in Table 5.1.

Table 6.1: Coordinates of the 4 all-sky maps

Map name	Max Dec(°)	Min Dec(°)	Start RA(°)
A1	70.5598	-4.9950	0.0030
A2	70.5598	-4.9950	1.1141
B1	71.6709	-3.8839	0.0030
B2	71.6709	-3.8839	1.1141

Since the number of bins change with Dec, the coordinate axises on the maps are not normal. It is more convenient to draw a map with axises of number of bins instead of the real RA and Dec. Figure 5.2-5.5 are the 2-dimensional maps for all

Table 6.2: Significance of known γ-ray sources

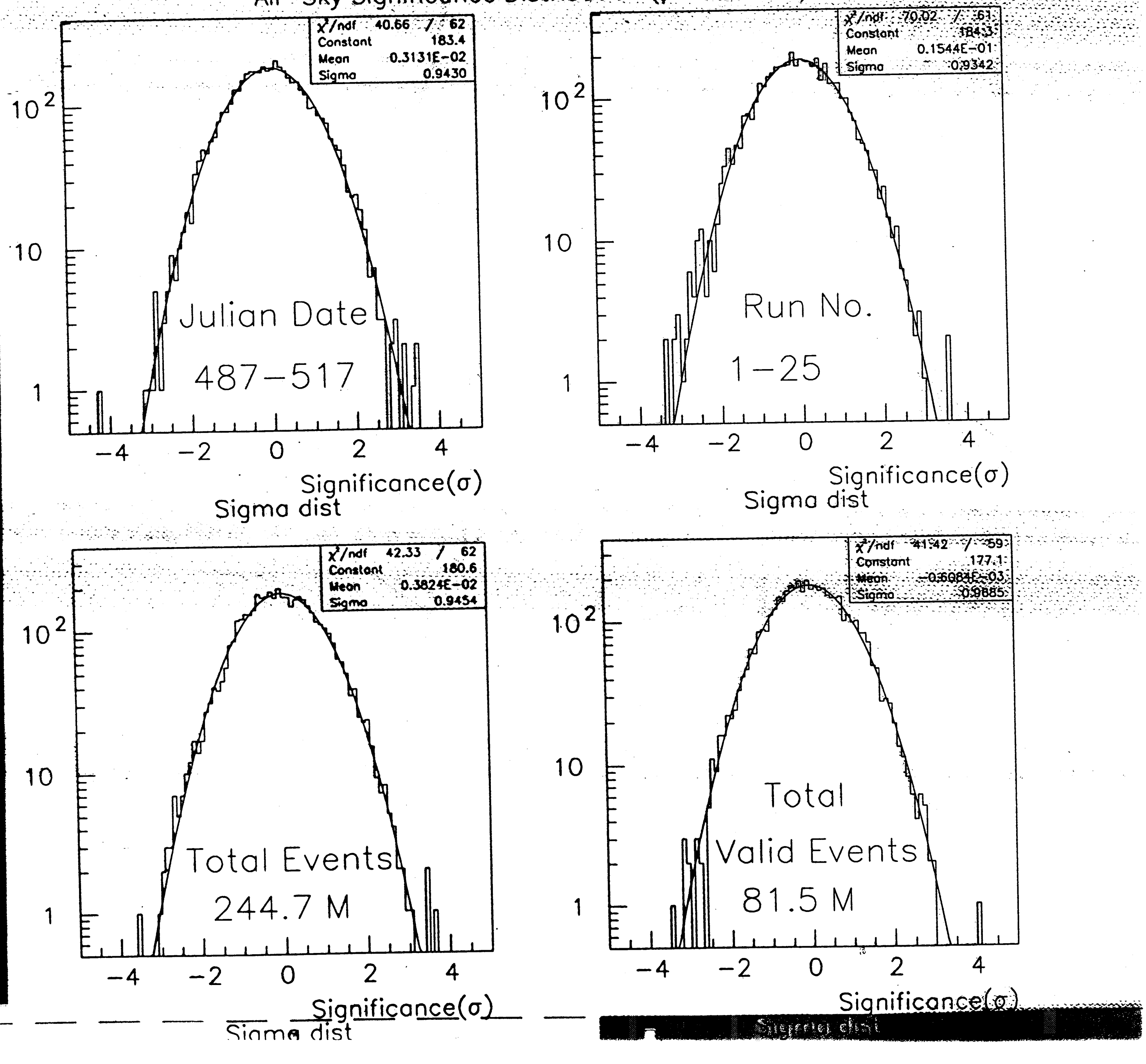
Source Name	RA(°)	Dec(°)	Map Name	RA(bin)	Dec(bin)	Signif.
Crab	83.63	22.01	B2	34.49	9.65	1.1σ
Mrk421	166.11	38.21	A1	58.73	17.44	-0.80σ
Mrk501	253.47	39.76	B1	87.68	17.64	2.8σ
1ES2344+514	356.15	51.43	A2	99.52	23.39	0.22σ

6.3 Search for Transient Emission of the Whole Northern Sky

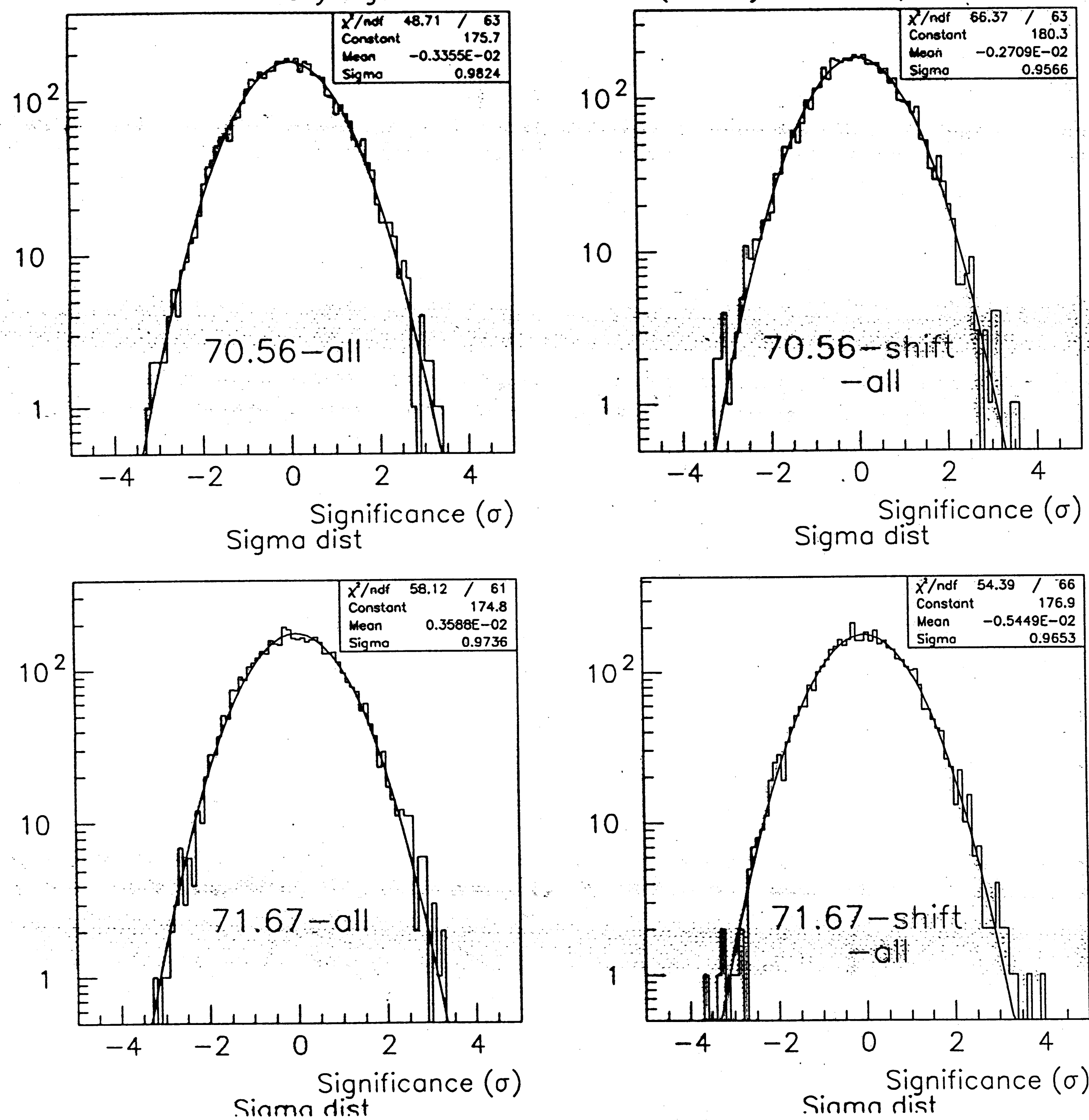
6.3.1 Monthly Accesses for Blind Searches

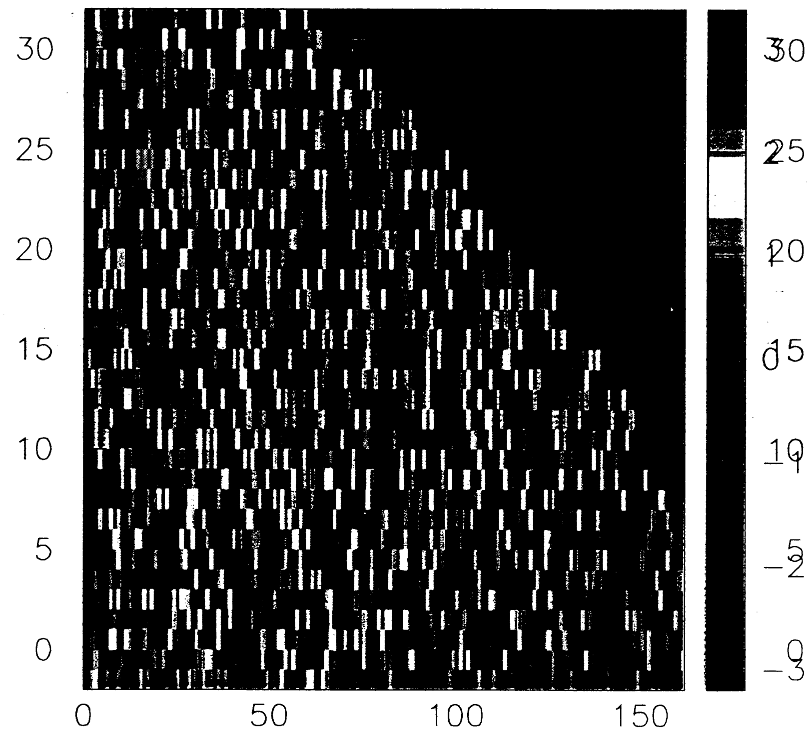
To study the transient emission of the whole northern sky, the whole Milagrito data sets are divided into 15 segments, each of which is a Julian Month except

All–Sky Significance Distribution (period No.1)

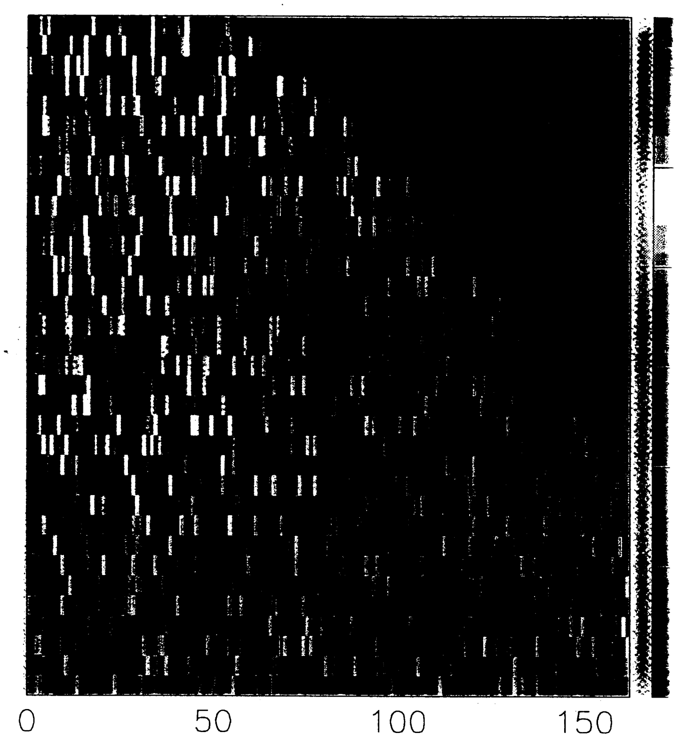


All-Sky Significance Distribution (whole year events)

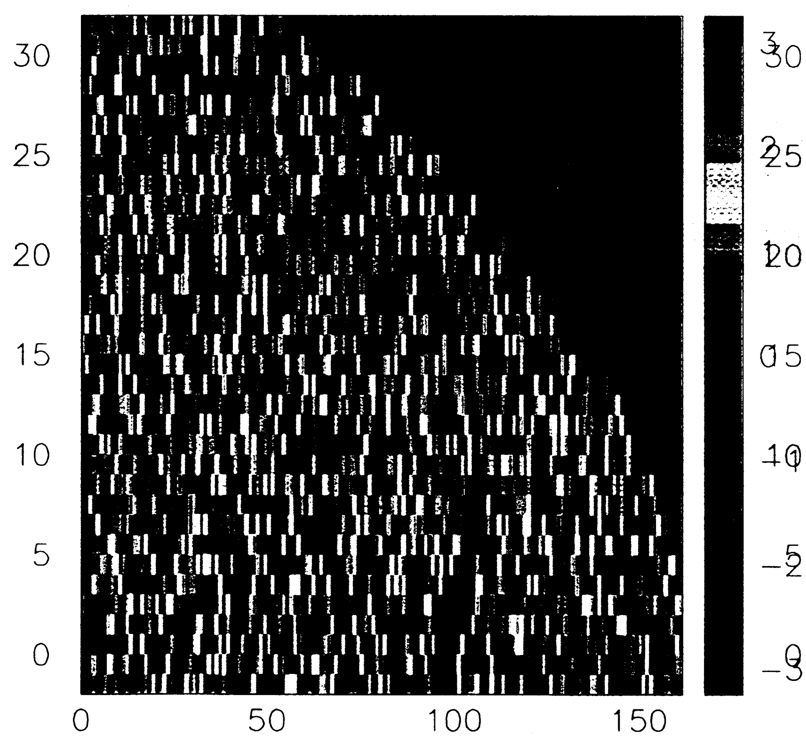




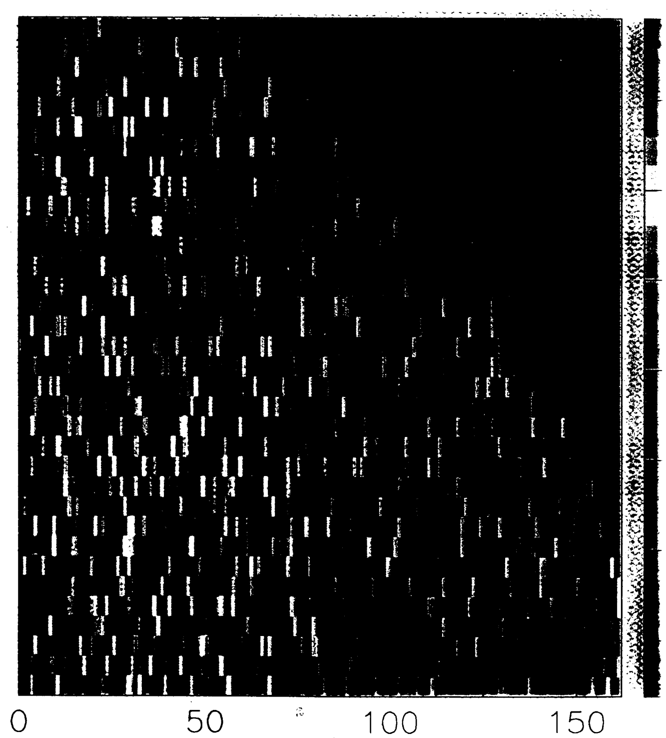
All−Sky Significance Map (in number)



All−Sky Significance Map (in number)



All−Sky Significance Map (in number)



All−Sky Significance Map (in number)

northern sky. In each figure the upper one is the map of total events distribution, and the lower one is the significance map. To find any position in RA and Dec on a map, the conversion of bin coordinates into RA and Dec are given below.

For map A1 and A2, suppose n_s is the bin number in Figure 5.1, the δ of the center of the bin is:

$$\delta = (n_s + 1) \times 2.2222 - 3.8889 \tag{6.1}$$

And, for map B1 and B2, the Dec is:

$$\delta = (n_s + 2) \times 2.2222 - 4.995 \tag{6.2}$$

For map A1 and B1, the RA is:

$$RA = \frac{n_s}{162 \times Cos\delta} \times 360 - \frac{10}{9 \times Cos\delta} \tag{6.3}$$

And, for map A2 and B2, the RA is:

$$RA = \frac{n_s}{162 \times Cos\delta} \times 360 - \frac{20}{9 \times Cos\delta} \tag{6.4}$$

For each map, the results show that the significance of each bin forms a perfect Gaussian which has a width of 1 and a center of zero. The Gaussian covers a range of $\sim \pm 3.4\sigma$. Of all the 4 maps, only map B2 has an access of 3.9σ, which has $RA = 29$, $\delta = 23$. By using formula (5.X) and (5.X), the position of this bin is: $RA = 78.23°$, $\delta = 50.56°$.

6.2.2 Probablity of Fluctuation for Multiple Accesses

Suppose there is a distinct access, what is the probability that it is within the fluctuation if there are n trials totally?

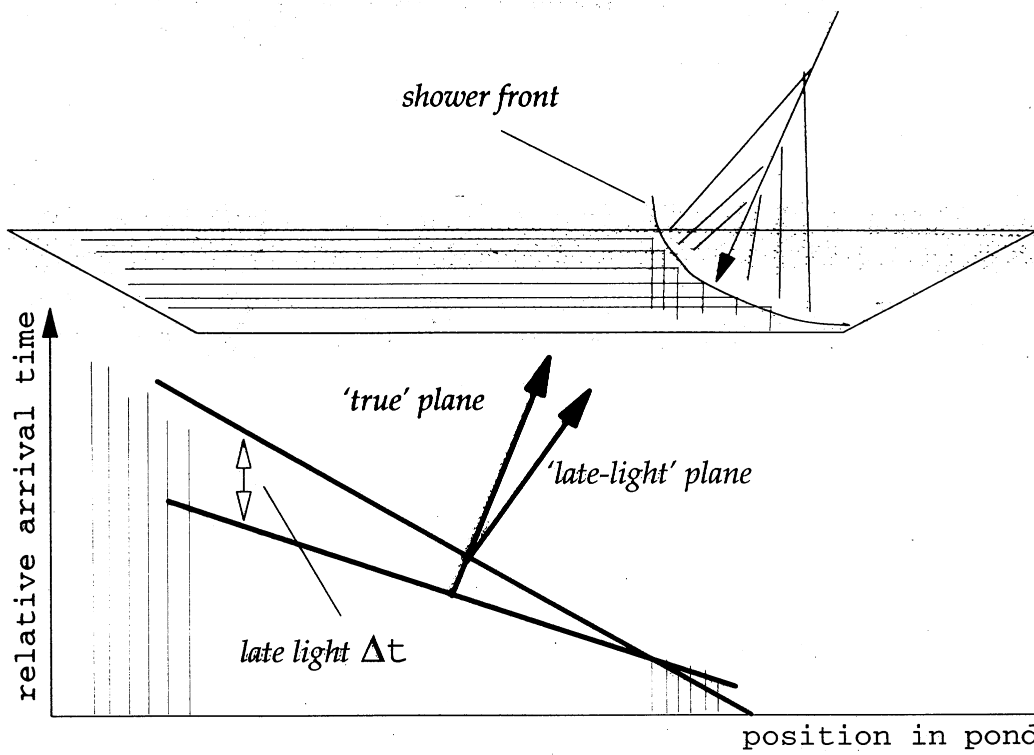
Morgan's Moon Shadow Analysis

by Jose Cyrus Hoffman

Utimate goals:

- To use the moon shadow to measure the absolute energy response of Milagrito.
- To measure the antiproton content of the CR flux.
- To learn how to type

Late light from the shower front leads to a systematic theta offset. This effect was studied with Monte Carlo and corrected in the data, event by event.



The correction works except for $nFit < 30$. Because of their crappy nature, these data are left out of the rest of the analysis.

In the geomagnetic deflection simulation, we can tweak the rigidity spectrum of the primaries.

Using this to simulate the moon shadow again, we can track the position of the shadow centroid as a function of rigidity.

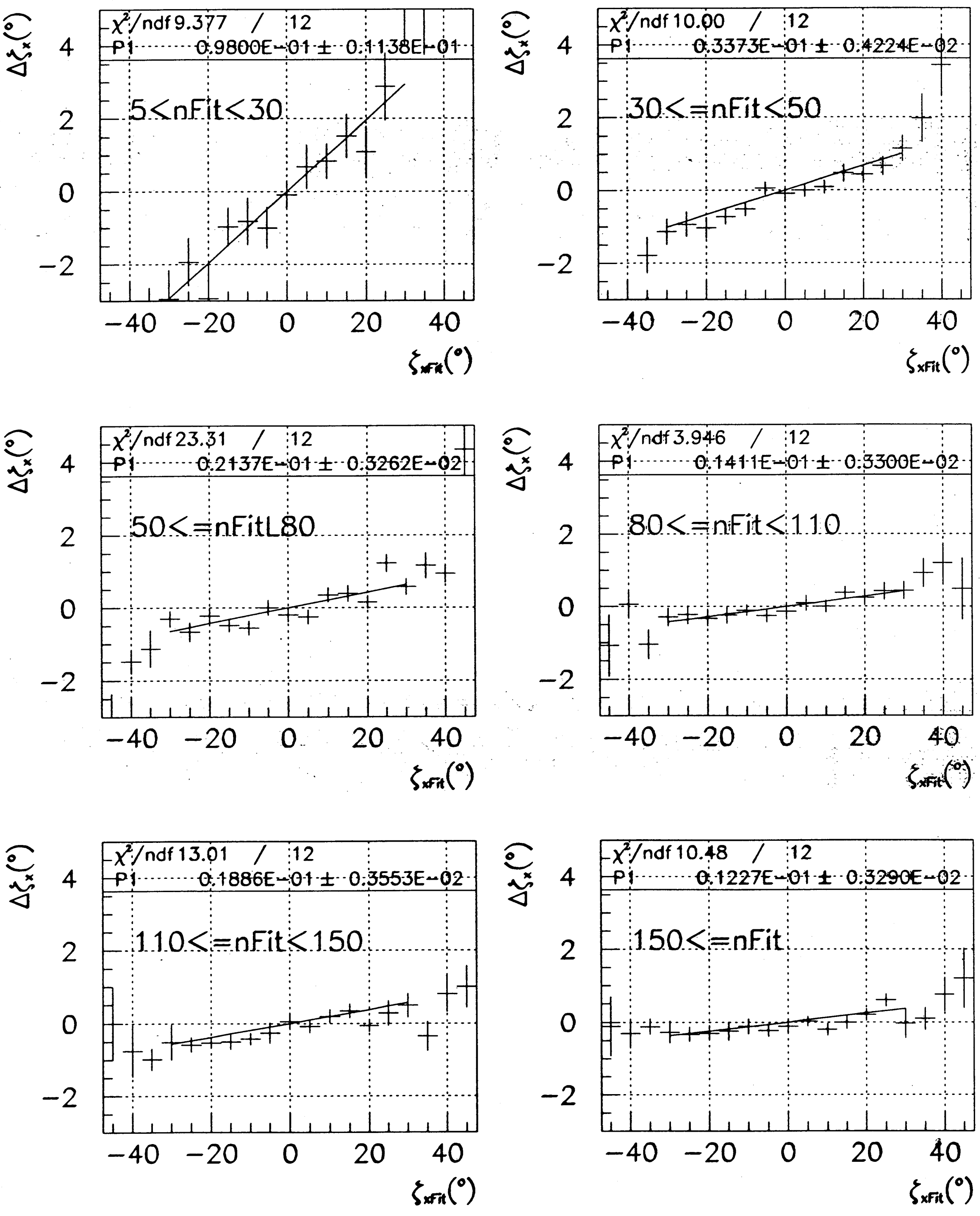
Comparing the simulation to the position of the centroid in the data should give us a true measurement of the median rigididty.

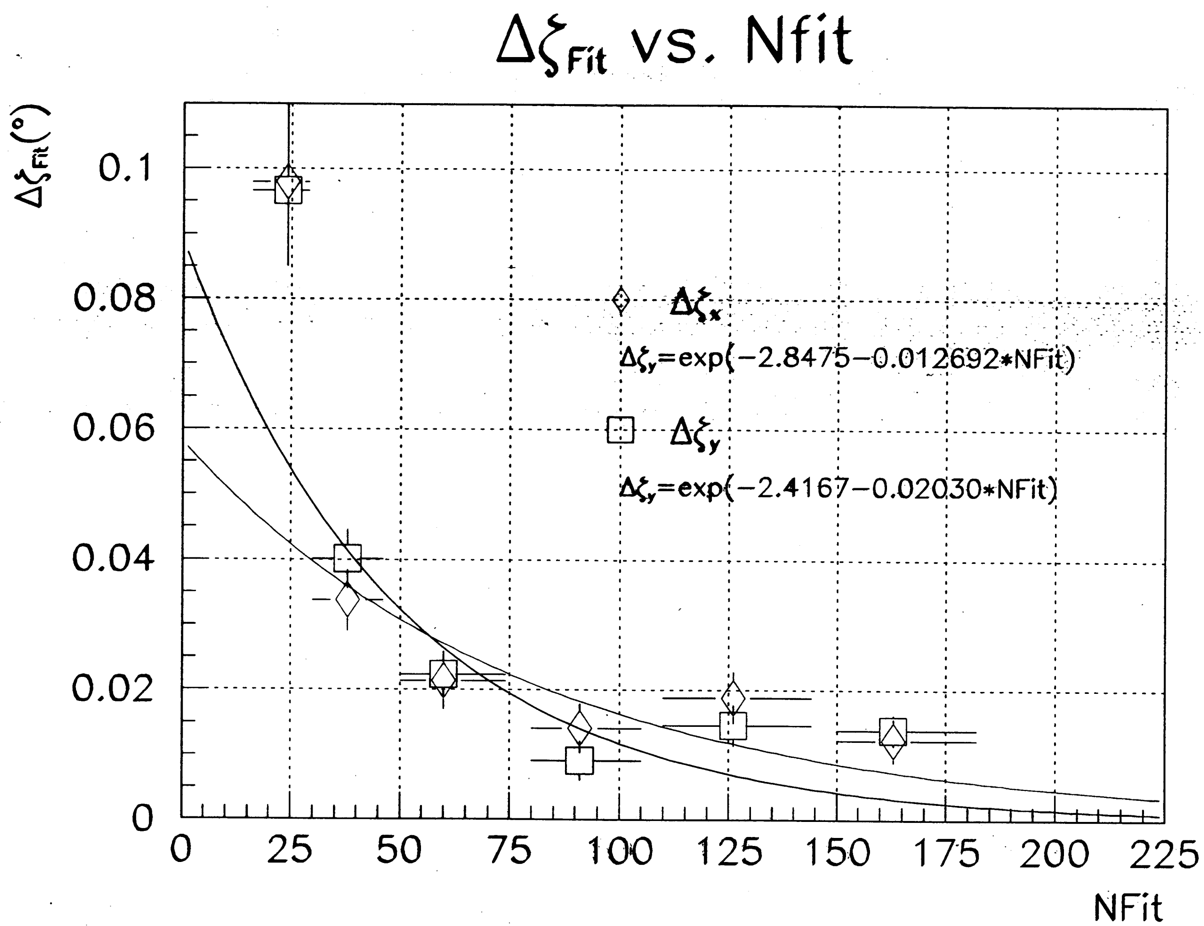
Late light from the shower front leads to a systematic theta offset.

2

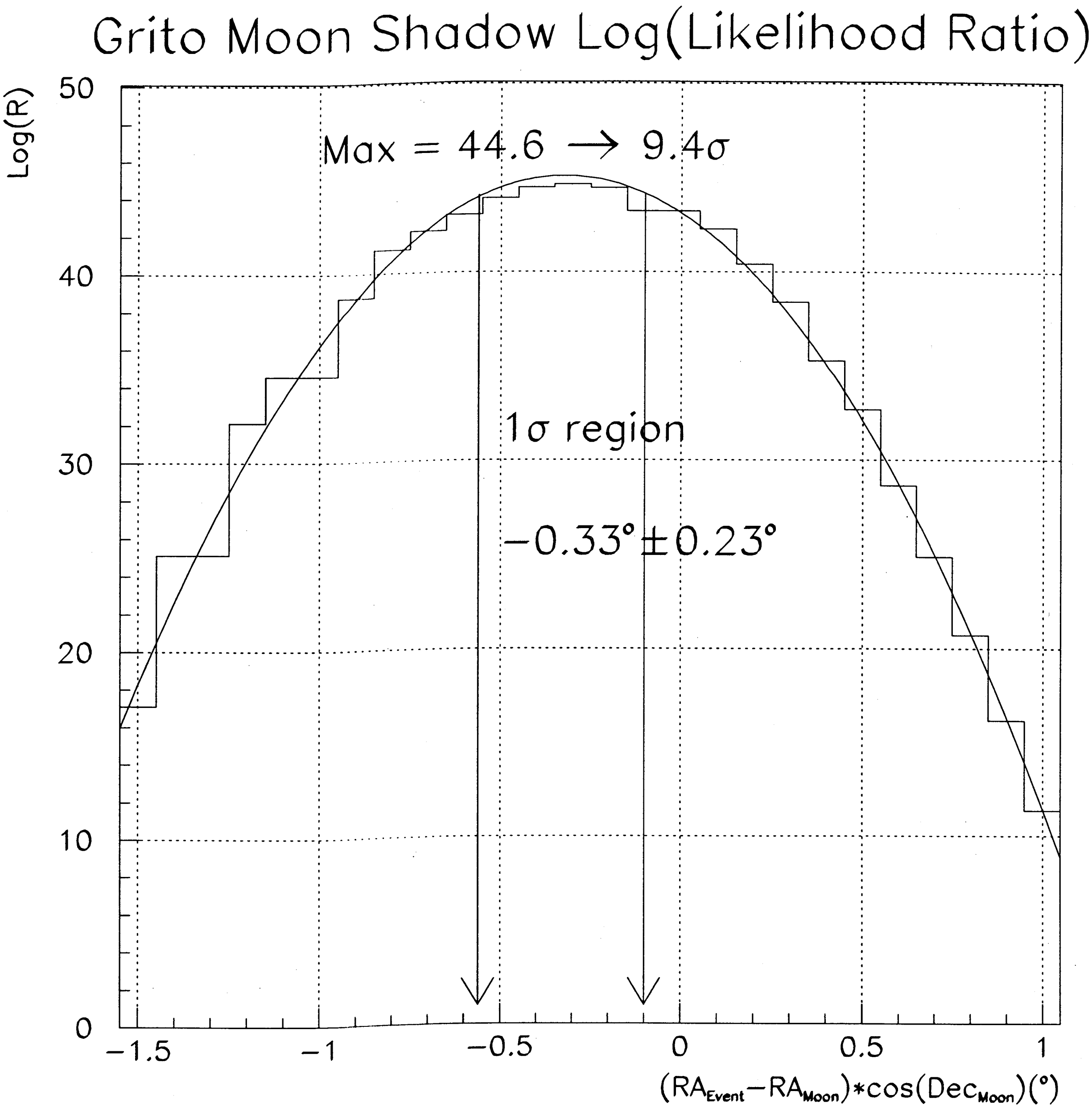
This effect was studied with Monte Carlo and corrected in the data, event by event. The correction is noticeable except for $nFit < 30$.

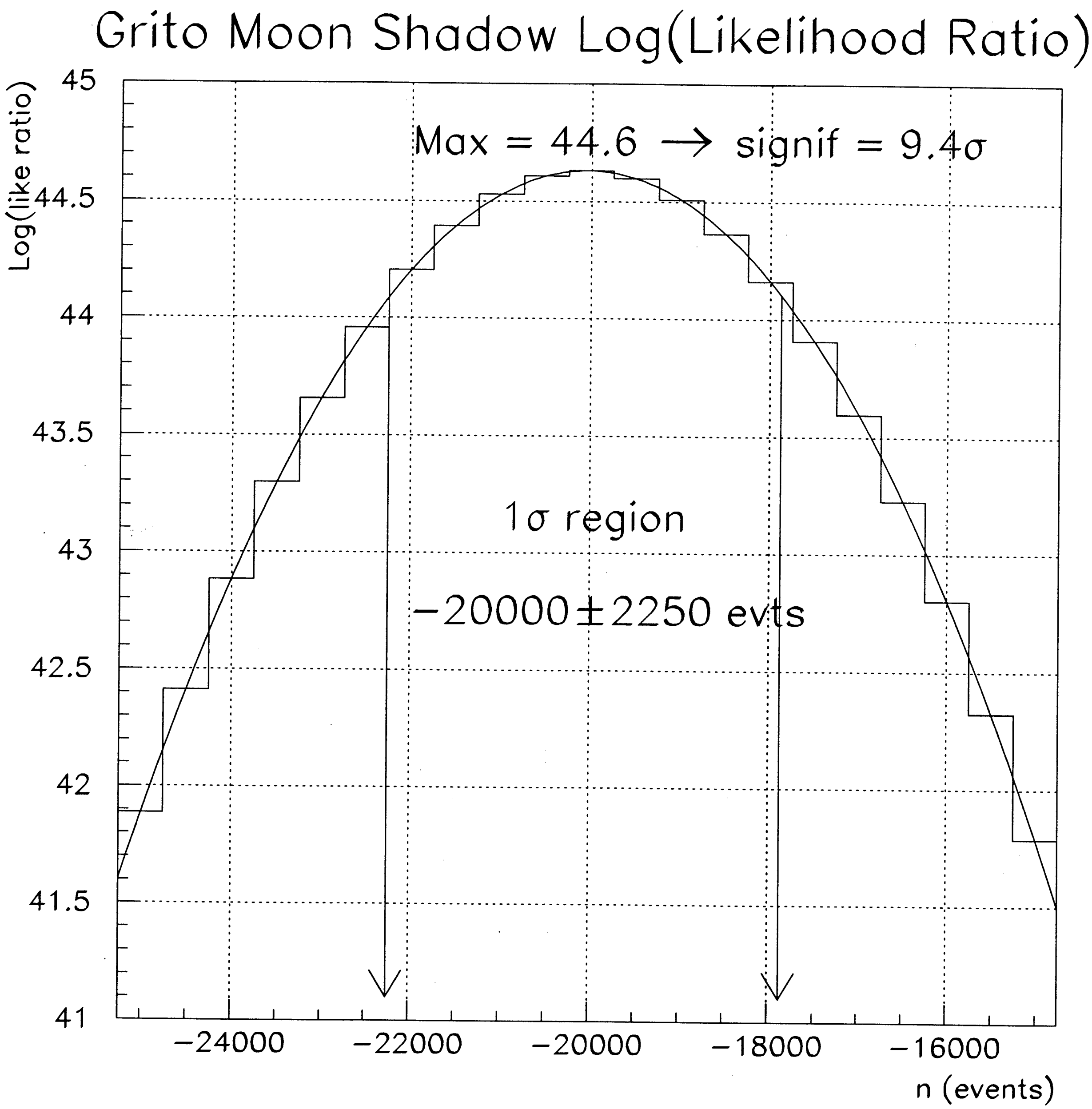
Milagrito MC: $\Delta\zeta_x$ vs. ζ_{xFit}

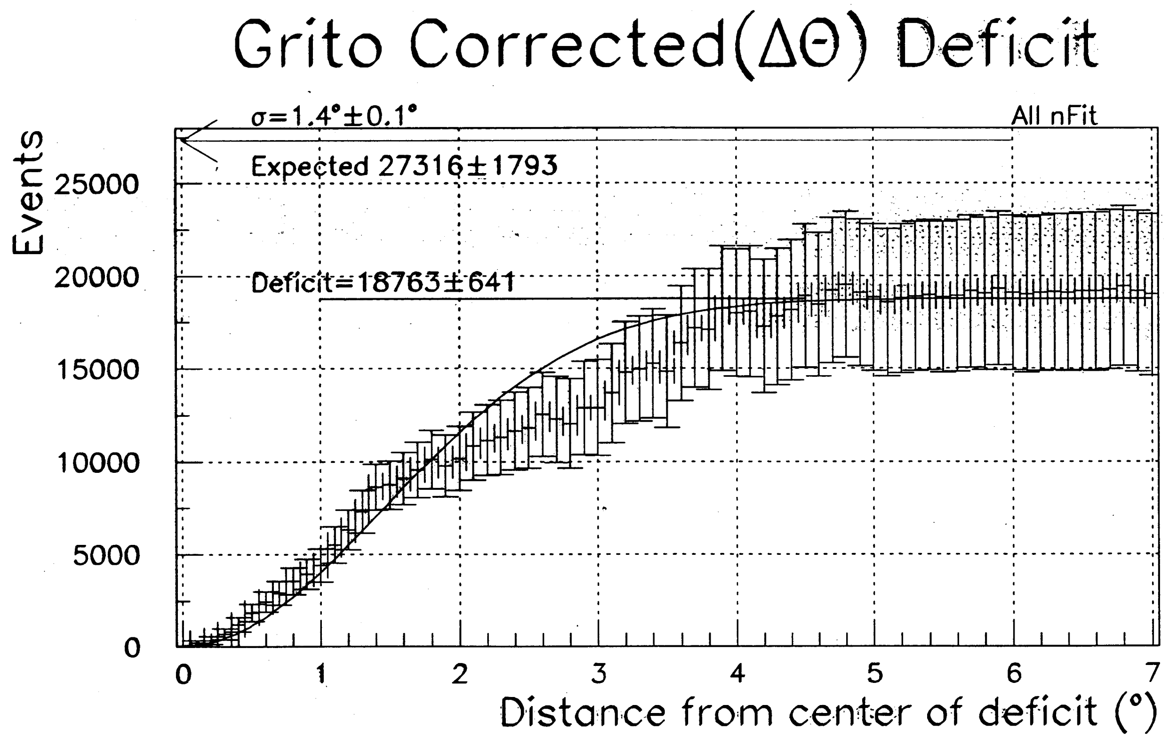




Δζ_Fit vs. Nfit
Δζ_Fit(°)
0.1
0.08
0.06
0.04
0.02
0
0
25
50
75
100
125
150
175
200
225
NFit
Δζ_x
Δζ_y=exp(−2.8475−0.012692*NFit)
Δζ_y
Δζ_y=exp(−2.4167−0.02030*NFit)


Grito Moon Shadow Log(Likelihood Ratio)
Log(R)
Max = 44.6 → 9.4σ
1σ region
−0.33°±0.23°
(RA_Event−RA_Moon)*cos(Dec_Moon)(°)
50
40
30
20
10
0
−1.5
−1
−0.5
0
0.5
1


Grito Moon Shadow Log(Likelihood Ratio)
Log(like ratio)
Max = 44.6 → signif = 9.4σ
1σ region
−20000±2250 evts
45
44.5
44
43.5
43
42.5
42
41.5
41
−24000
−22000
−20000
−18000
−16000
n (events)



Grito Corrected(ΔΘ) Deficit
σ=1.4°±0.1°
All nFit
Expected 27316±1793
Deficit=18763±641
Events
25000
20000
15000
10000
5000
0
0
1
2
3
4
5
6
7
Distance from center of deficit (°)

Assume there are 2 populations of events in the data: signal and background. Also let each event be a function of some "vector", such as

$$\vec{x_i} = (\alpha_i, \delta_i, nFit_i,).$$

The total number of events, N, is known and fixed. Let n be the number of signal events.

Let $Q(\vec{x_i})$ be the properly normalized probability distribution for the signal events, and $R(\vec{x_i})$ be the normalized probability distribution for the background events. The normalization condition requires the integral over the studied region, and NOT over all space, equal one.

The probability density per event is:

$$P(\vec{x_i}) = \frac{n}{N}Q(\vec{x_i}) + \frac{N-n}{N}R(\vec{x_i}).$$

The likelihood function is then given by:

$$\mathcal{L}(n, \vec{x_i}) \equiv \prod_{i=1}^{N} P(\vec{x_i})$$

$$= \prod_{i=1}^{N} \left(\frac{n}{N}Q(\vec{x_i}) + \frac{N-n}{N}R(\vec{x_i}) \right).$$

This is used to form the likelihood ratio function:

$$\mathcal{R}(n, \vec{x_i}) = \frac{\mathcal{L}(n, \vec{x_i})}{\mathcal{L}(0, \vec{x_i})}$$

$$= \prod_{i=1}^{N} \left\{ \frac{n}{N}\left(\frac{Q}{R} - 1\right) + 1 \right\},$$

For easier calculations, we use the logarithm of the likelihood ratio.

The log likelihood ratio yields the relative probability of two hypotheses:

Hypothesis 1 There are two populations: background and signal, defined by the distributions $Q(\vec{x_i})$ and $R(\vec{x_i})$. (Note that $n < 0$ for the moon shadow.)

Hypothesis 2 There is no signal. (n = 0)

The significance is then given by:

$$S = 2 \cdot \sqrt{\log \mathcal{R}}$$

$$= 2 \cdot \sqrt{\log \mathcal{L}(n, \vec{x_i}) - \log \mathcal{L}(0, \vec{x_i})}$$

This method can be used in a binned analysis very easily.

The probability functions for the two event populations can be calculated at the location of the center of each bin. Then the events are binned as usual, and we assume that a bin centered at $(\alpha_j,\ \delta_j)$ that contains n_j events is the same as n_j events located exactly at $(\alpha_j,\ \delta_j)$.

Applying this to the moon shadow is straightforward. $R(\vec{x_i})$ comes directly from the background calculation. And $Q(\vec{x_i})$ comes from the moon shadow simulation.

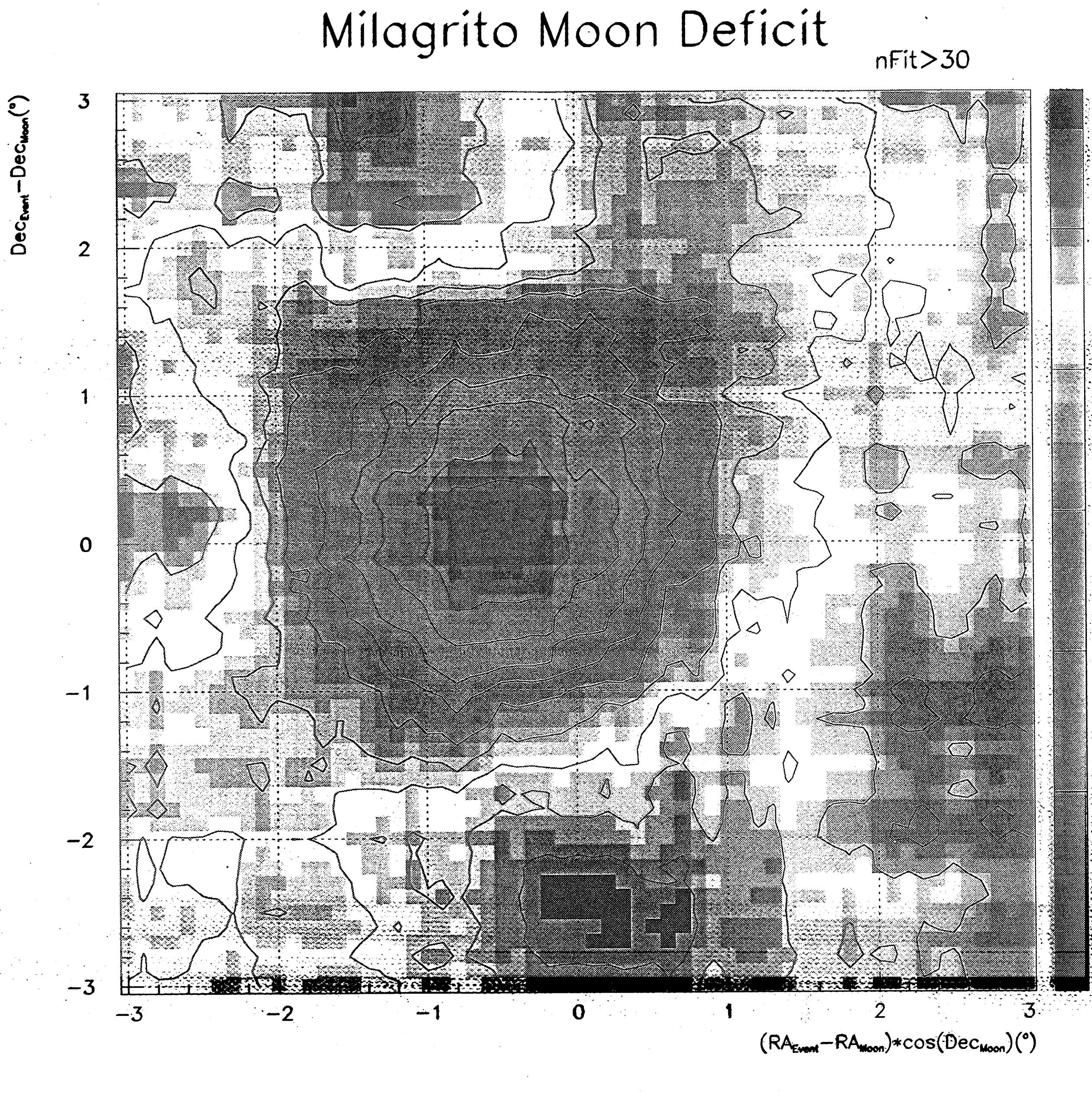
The Moon Shadow Simulation uses:

-A dipole field pointed at the “true” magnetic pole

-Protons, Helium, and CNO nuclei

-ΔAngle derived from Monte Carlo

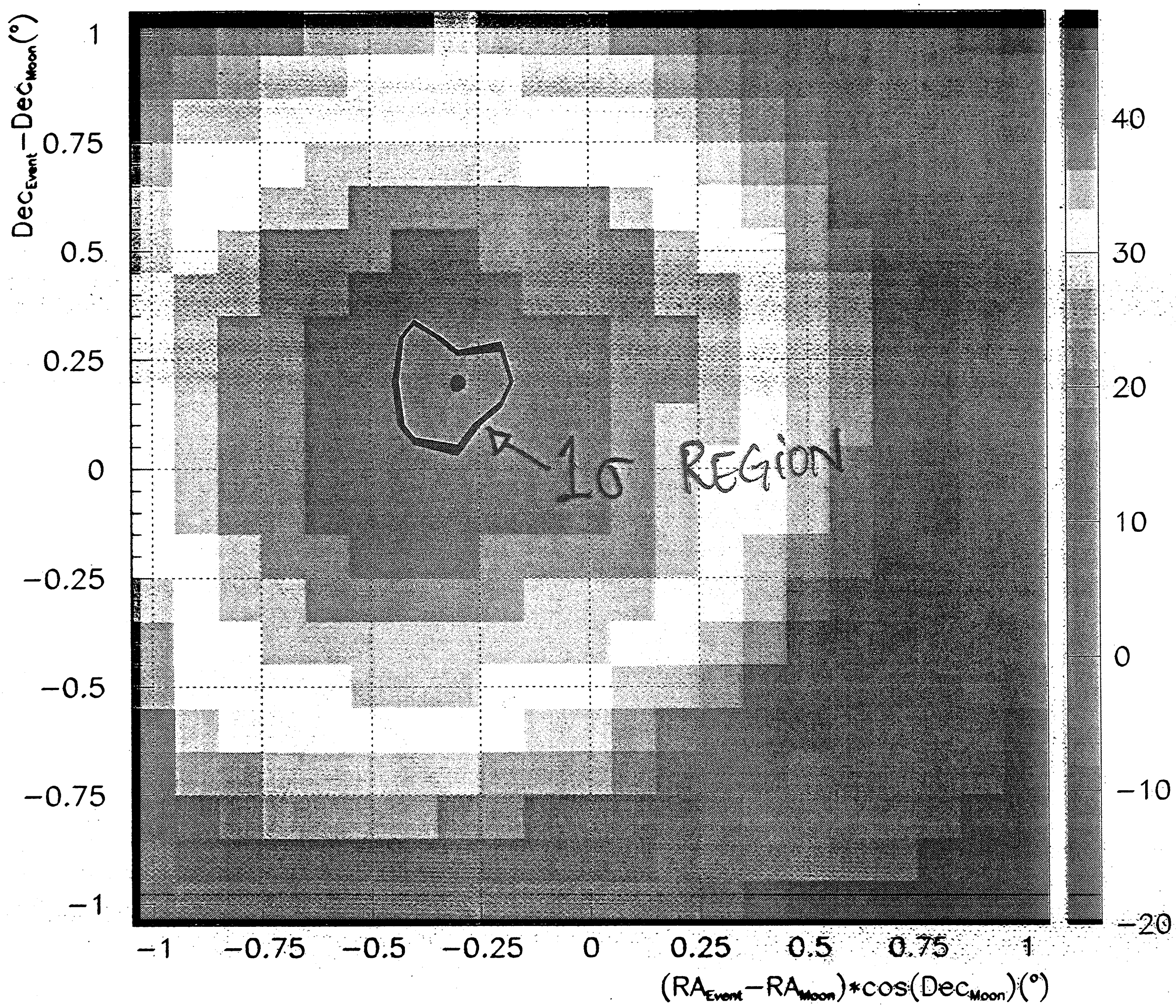
-$\Delta\theta$ corrections described in memo



expect 27,800 events

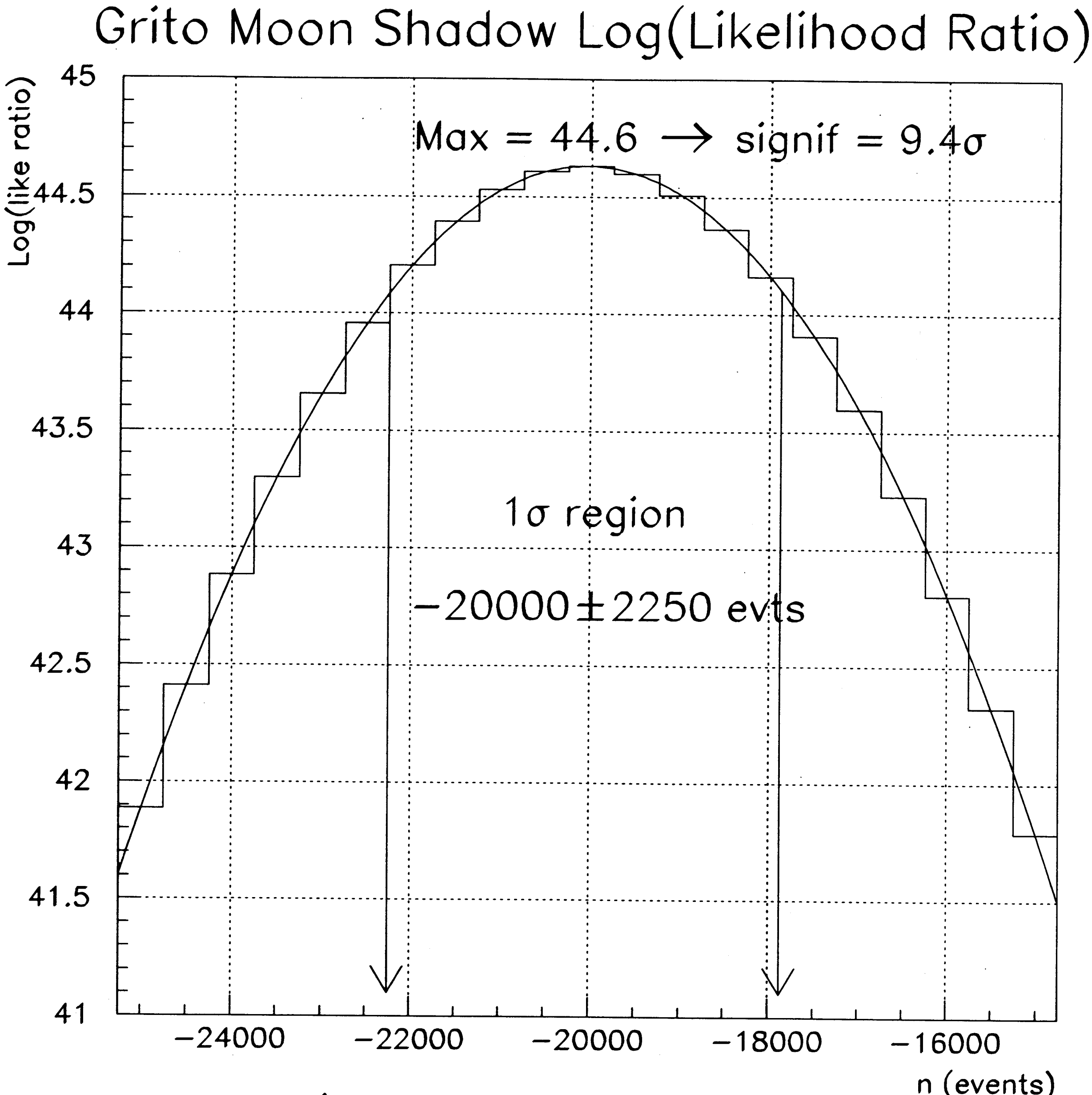
Max = 44.6 → 9.4σ

Grito Moon Log(Likelihood Ratio)



nFit ≥ 30

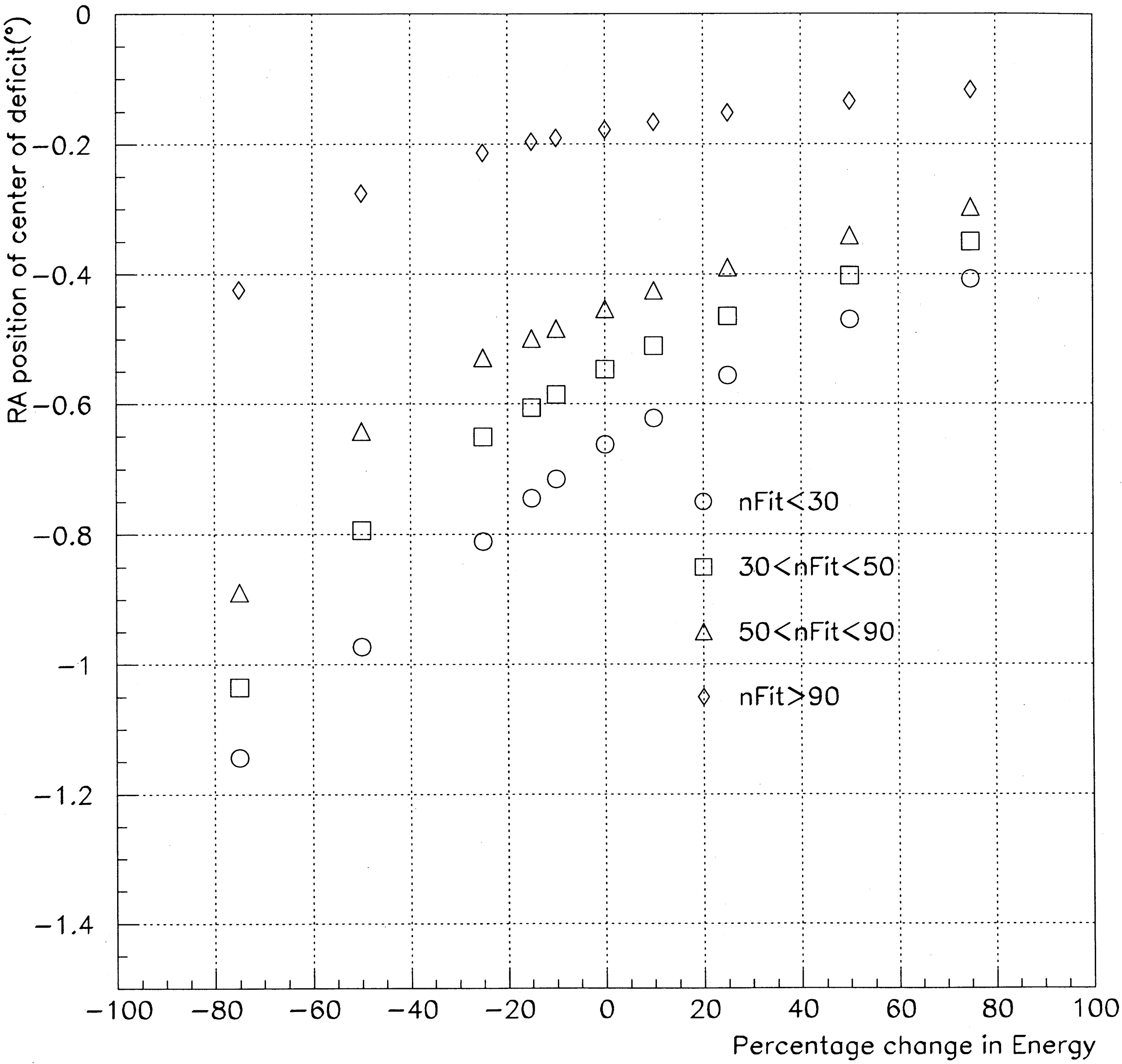
n= -20000 evts

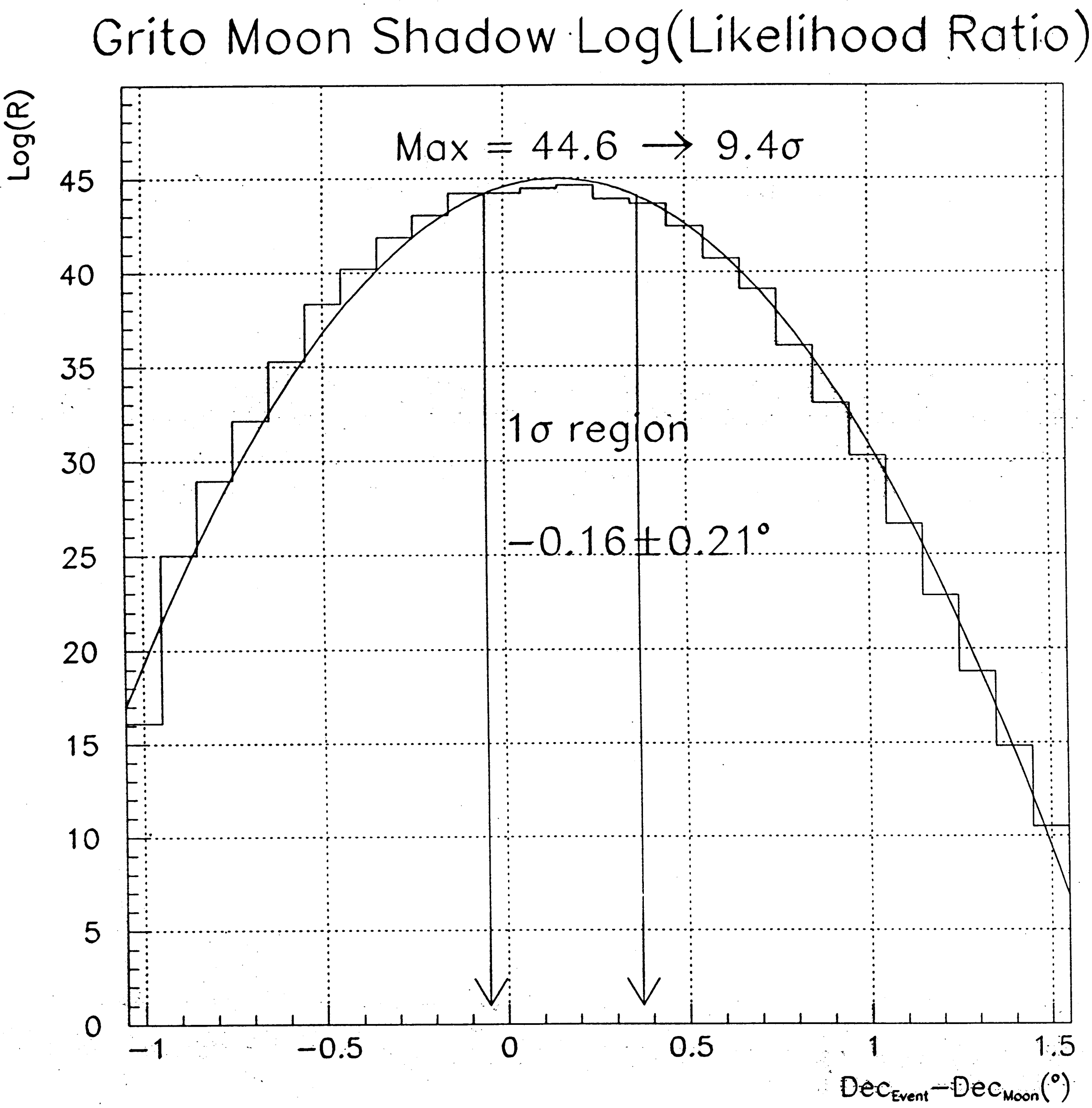


ALL nFit

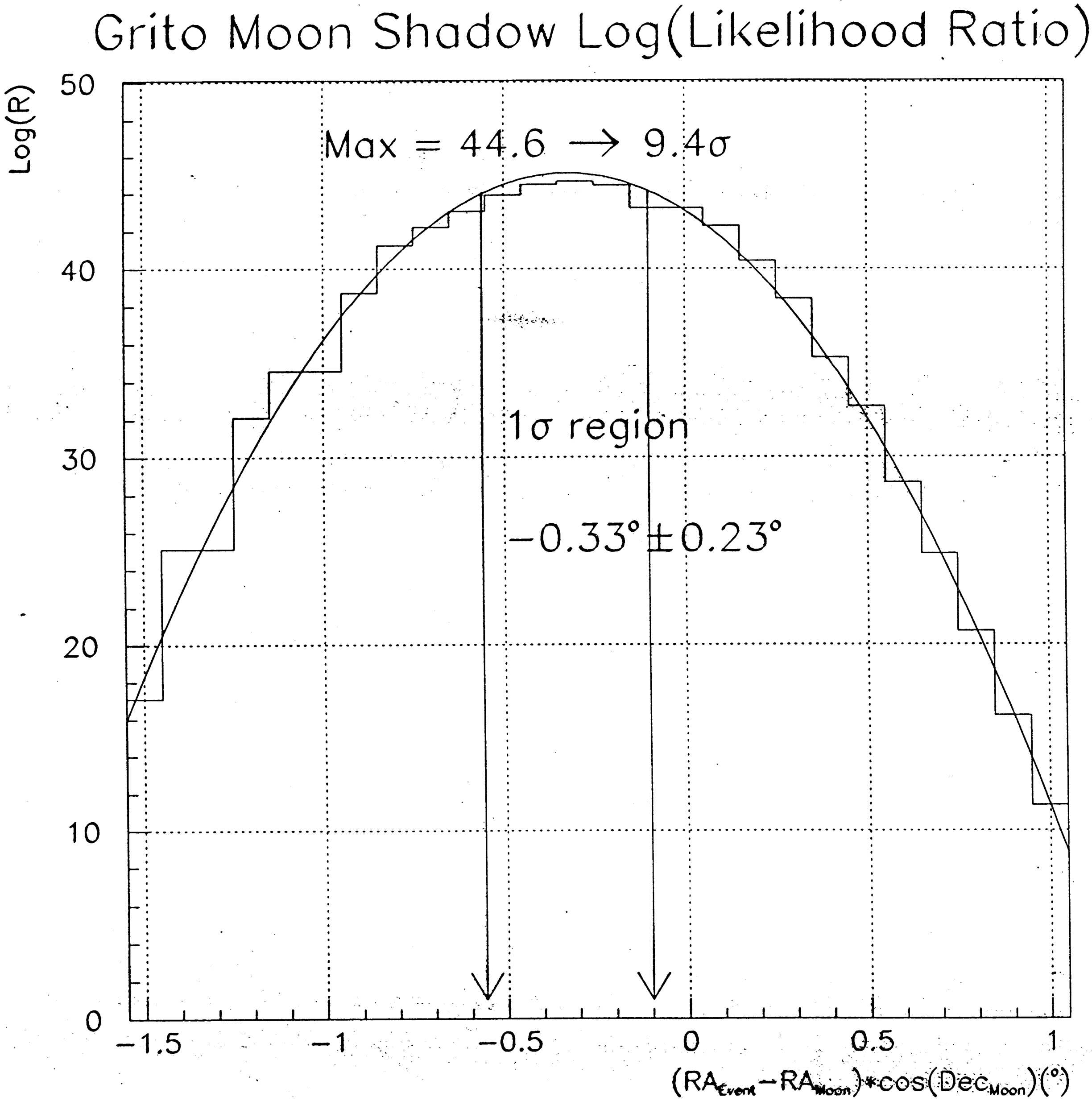
RA: −0.3°

Dec: +0.2°


RA position of center of deficit(°)
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−1.4
−100
−80
−60
−40
−20
0
20
40
60
80
100
Percentage change in Energy
nFit<30
30<nFit<50
50<nFit<90
nFit>90



Grito Moon Shadow Log(Likelihood Ratio)
Log(R)
Max = 44.6 → 9.4σ
1σ region
−0.16±0.21°
$Dec_{Event}-Dec_{Moon}$(°)



Grito Moon Shadow Log(Likelihood Ratio)
Log(R)
Max = 44.6 → 9.4σ
1σ region
−0.33°±0.23°
50
40
30
20
10
0
−1.5
−1
−0.5
0
0.5
1
(RA_Event − RA_Moon)*cos(Dec_Moon)(°)

In the geomagnetic deflection simulation, we can tweak the rigidity spectrum of the primaries.

Using this to simulate the moon shadow again, we can track the position of the shadow centroid as a function of rigidity.

Comparing the simulation to the position of the centroid in the data should give us a true measurement of the median rigididty.

Progress Report: AGN SEARCH

BY: SCOTT HUGENBERGER

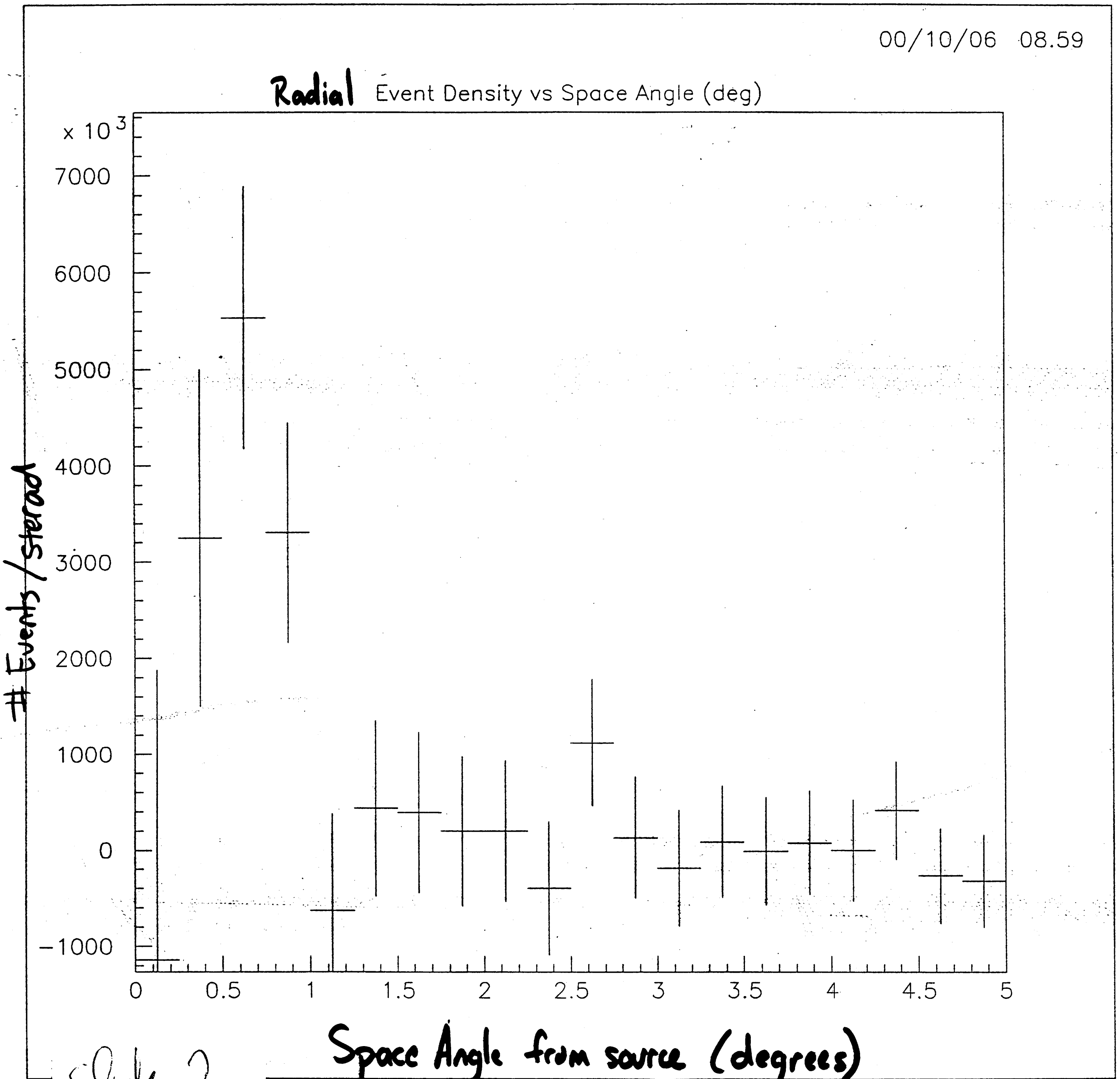
1. MRK 501 $\Delta DEC = 1.5^\circ$ all data
2. " radial plot $\Delta r = 0.25^\circ$
3. AGN sample
   VARIABLE TIME WINDOW SEARCH
   4 days, 12 days, 36 days
4. Search for successive days of Li Ma > 2
   Li Ma > 3
5. ~~Future~~ Currently working on Flux Limits

Right Ascension

Declin	247.64	249.60	251.55	253.50	255.45	257.40	259.36
42.80	645492	648006	649020	649552	648492	644901	643921
	646042	647720	648505	648747	648566	646465	643775
	-0.65	0.34	0.61	0.95	-0.09	-1.86	0.17
41.30	649785	650251	651819	651946	652294	650142	647860
	648951	651152	651528	651488	651225	649405	647160
	0.99	-1.06	0.34	0.54	1.26	0.87	0.83
39.80,	652188	652506	653398	656497	653138	652206	647716
	650643	652422	652939	653010	652808	650968	648705
	1.83	0.10	0.54	4.11	0.39	1.46	-1.17
38.30	651275	652658	652205	652818	652179	651668	647630
	650279	651455	652778	652819	651817	650481	648243
	1.18	1.42	-0.68	-0.00	0.43	1.40	-0.73
36.80	648386	649494	648908	650624	649612	647791	646844
	647754	649234	649548	649621	648950	647794	646102
	0.75	0.31	-0.76	1.19	0.78	-0.00	0.88

Slide 1

MRK 501



Slide 2

source name	z	RA	DEC	SB	Bckgrnd	LiMa
1ES 0145 + 138	.125	27.12	14.04	410830	411210	-0.56
1ES 0229 + 200	.139	38.2	20.29			
1ES 0323 + 022	.147	51.56	2.42			
1ES 0446 + 449	.203	72.53	45.05	630961	631422	-0.55
1ES 0927 + 500	.188	142.66	49.84	625038	625700	-0.80
1ES 1101 + 384	.031	166.11	38.20	668585	669719	-1.32
1ES 1118 + 424	.124	170.20	42.20	665935	666787	-0.99
1ES 1133 + 704	.046	174.11	70.16	329828	329932	-0.17
1ES 1212 + 078	.136	183.80	7.53	322331	322101	0.39
1ES 1239 + 069	.150	190.45	6.60	305189	305613	-0.73
1ES 1255 + 244	.141	194.38	24.21	571436	572525	-1.37
1ES 1440 + 122	.162	220.70	12.01	391563	392366	-1.22
1ES 1652 + 398	.034	253.50	39.80	656497	653010	4.11
1ES 1727 + 502	.055	262.08	50.22	604693	606088	-1.71
1ES 1741 + 196	.083	265.99	19.59	503198	502366	1.12
1ES 1959 + 650	.048	299.99	65.15	407704	407413	0.44
1ES 2321 + 419	.059	350.97	42.18	644587	645107	-0.62
1ES 2344 + 514	.044	356.77	51.70			

slide 3

	4 days		4 days		12 days		12 days		36 days		36 days	
	>2.	>3.	>2.	>3.	>2.	>3.	>2.	>3.	>2.	>3.	>2.	>3.
source												
0145+138	1	0	1	0	0	0	0	0	0	0	0	0
0229+200												
0323+022	1	0	1	0	0	0	1	0	0	0	0	0
0446+449	1	0	1	0	0	0	0	0	0	0	0	0
0927+500	1	0	1	0	1	0	0	0	0	0	0	0
1118+424			1	0	1	0	1	0	1	0	0	0
1133+704												
1212+078	1	0	0	0	1	0	0	0	0	0	0	0
1239+069	1	0	1	0	1	0	1	0	0	0	0	0
1255+244	1	0	1	0	0	0	0	0	0	0	0	0
1440+122	0	0	1	0	0	0	0	0	0	0	0	0
1652+398	1	1	2	1	1	0	1	0	1	1	1	0
1727+502	0	0	1	1	0	0	0	0	0	0	0	0
1741+196	1	0	1	0	1	0	0	0	1	0	0	0
1959+650	1	0	0	0	0	0	1	0	0	0	0	0
2321+419	1	0	1	0	1	1	1	0	0	0	0	0
2344+514												

Slide 4

Revisiting GRB 970417a

- lower limits on event energies
- distance scale
- limits on isotropic energy release

Isabel Leonor

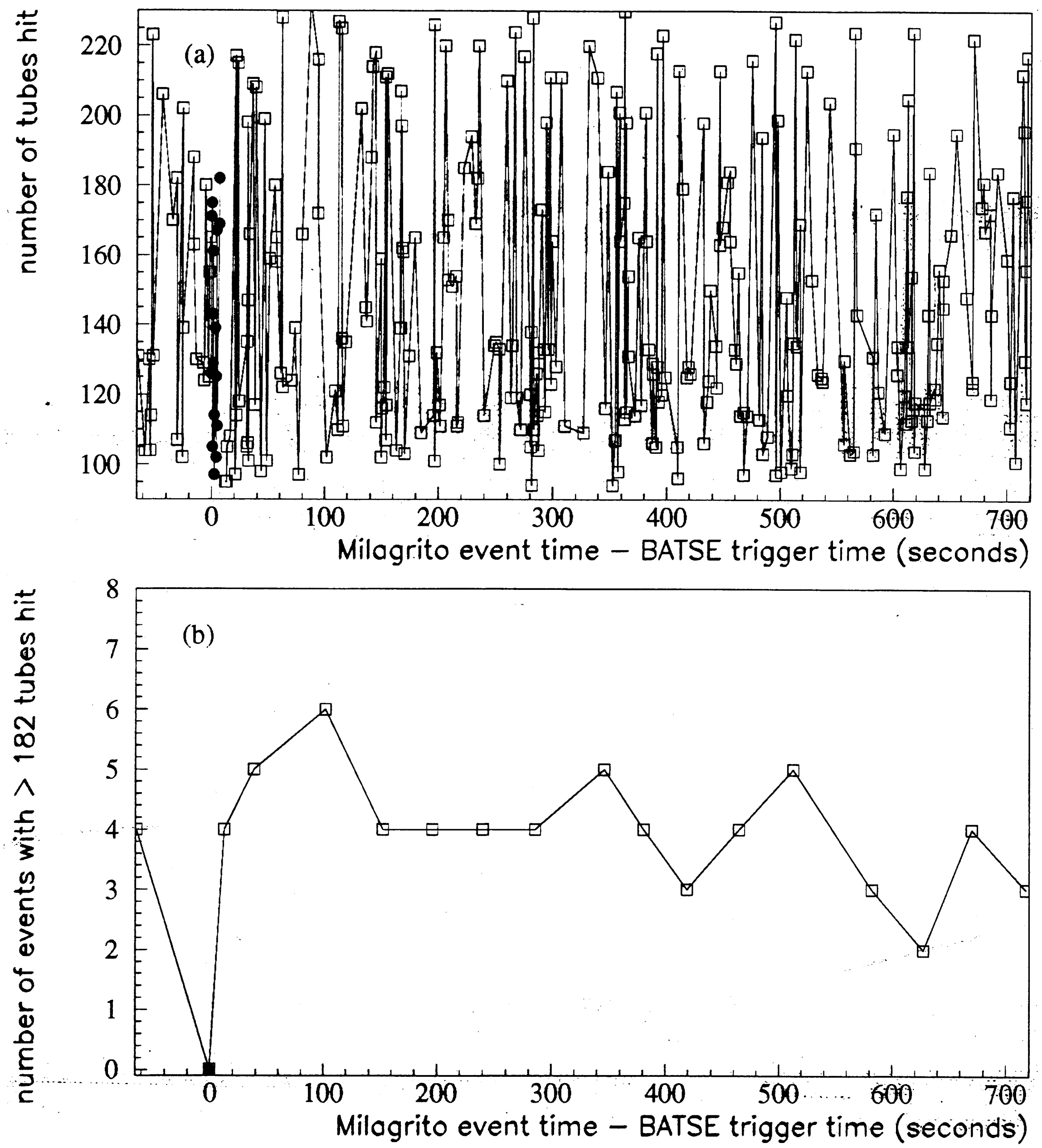


Figure 7.13: (a) Number of tubes hit as a result of air showers, with reconstructed directions falling in the local hot bin found in GRB 970417a's search area, triggering Milagrito, as a function of time relative to the BATSE trigger time for GRB 970417a. The 17 events which were detected during T90 are symbolized by dots, and can be found near relative time zero. (b) The number of detected air shower events for every 17 events which resulted in more than 182 tubes being hit. The relative absence of a large number of tubes being hit during T90 might be indicative of the relative absence of proton-initiated shower events during T90.

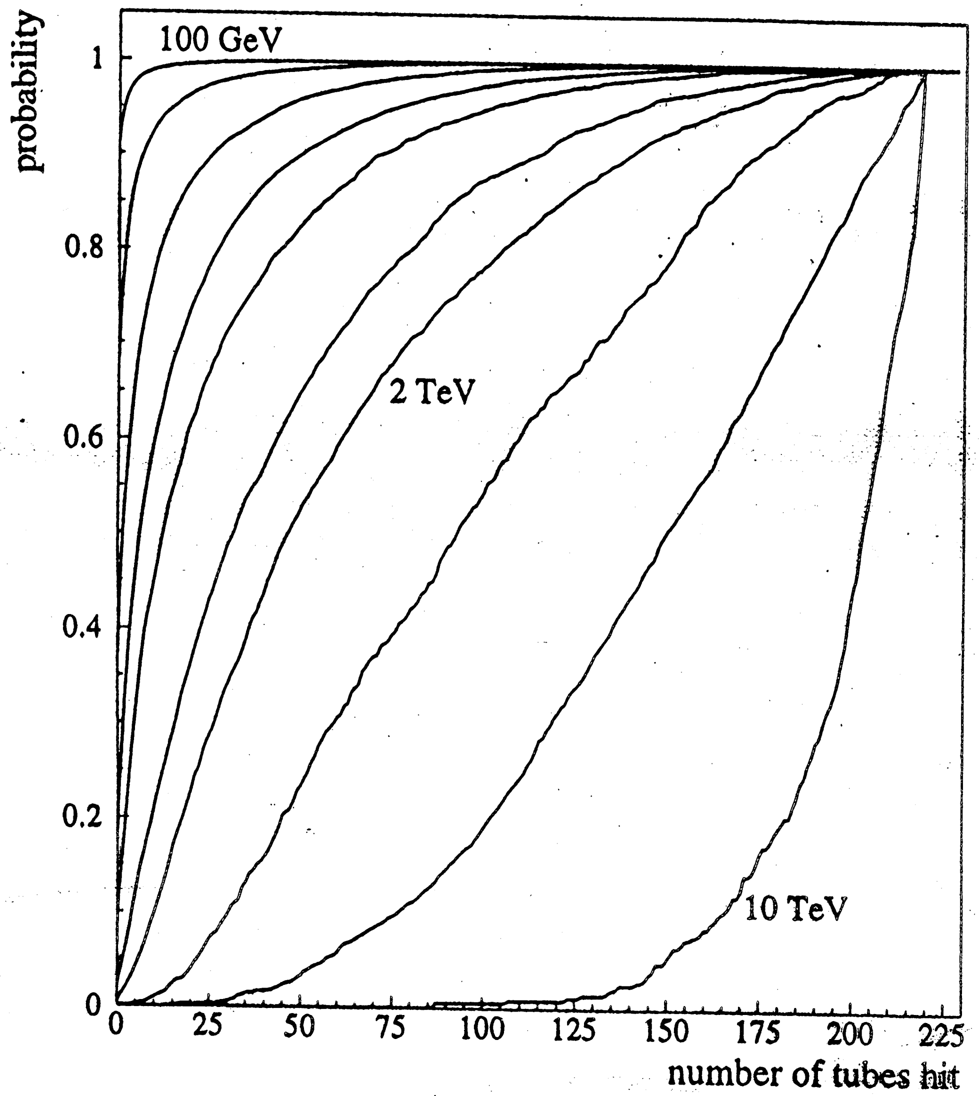


Figure 7.14: Integral distribution of number of tubes hit for different primary photon energies, valid for a source located at the center of the local hot bin found in GRB 970417a's search area, and for 1 meter of water above the PMTs. For a given primary photon energy and a given number of tubes, the corresponding curve gives the probability that an air shower produced by the primary, and whose core lands within the area delineated by the water surface, will result in that number of tubes or smaller being hit. From left to right, the curves correspond to the following primary photon energies: 100 GeV, 250 GeV, 500 GeV, 750 GeV, 1 TeV, 1.5 TeV, 2 TeV, 3 TeV, 5 TeV, and 10 TeV.

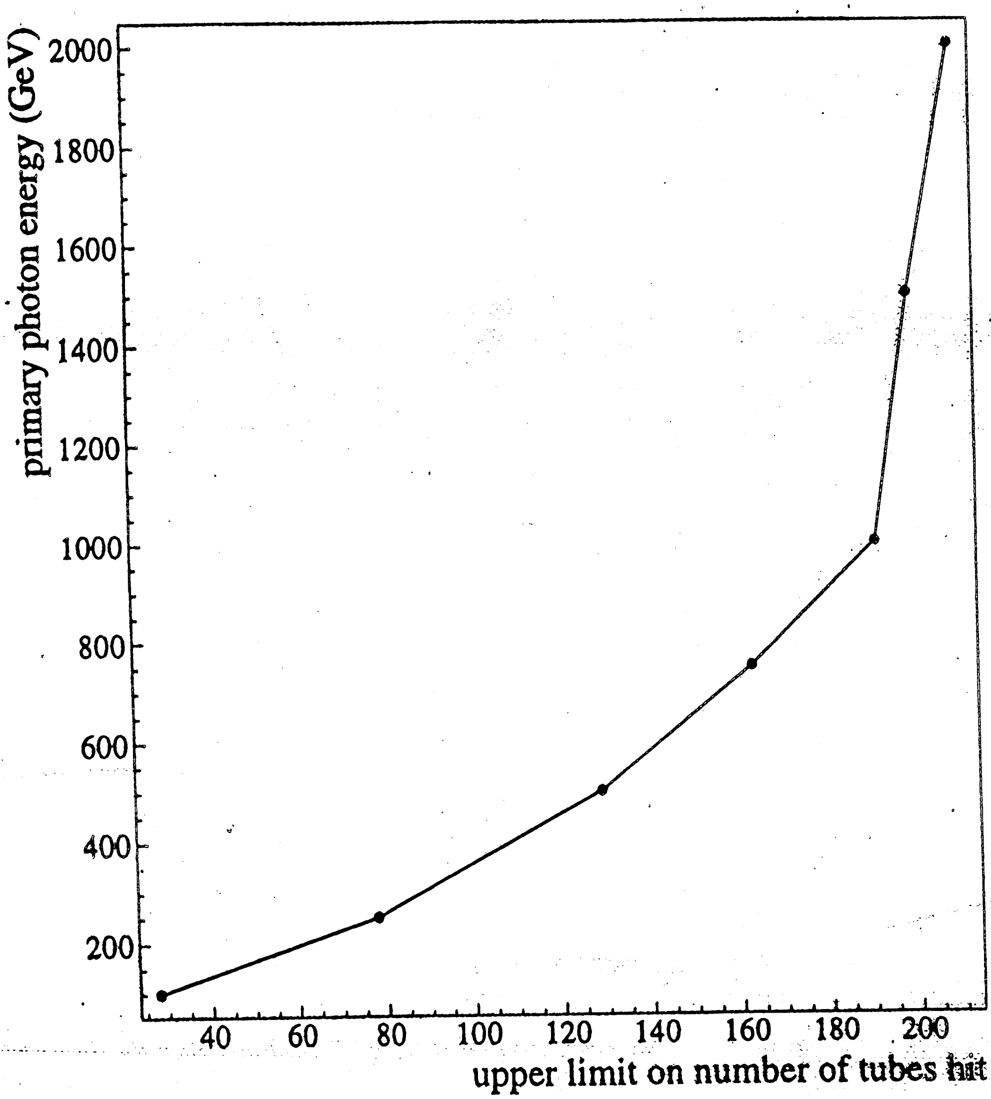


Figure 7.15: Plot of 3σ upper limit on the number of tubes hit for different primary photon energies, derived from Fig. 7.14. The same plot is used to determine a lower limit on the energy of each of the primary photons initiating the detected air shower events attributed to GRB 970417a, using the observed number of tubes hit for each event.

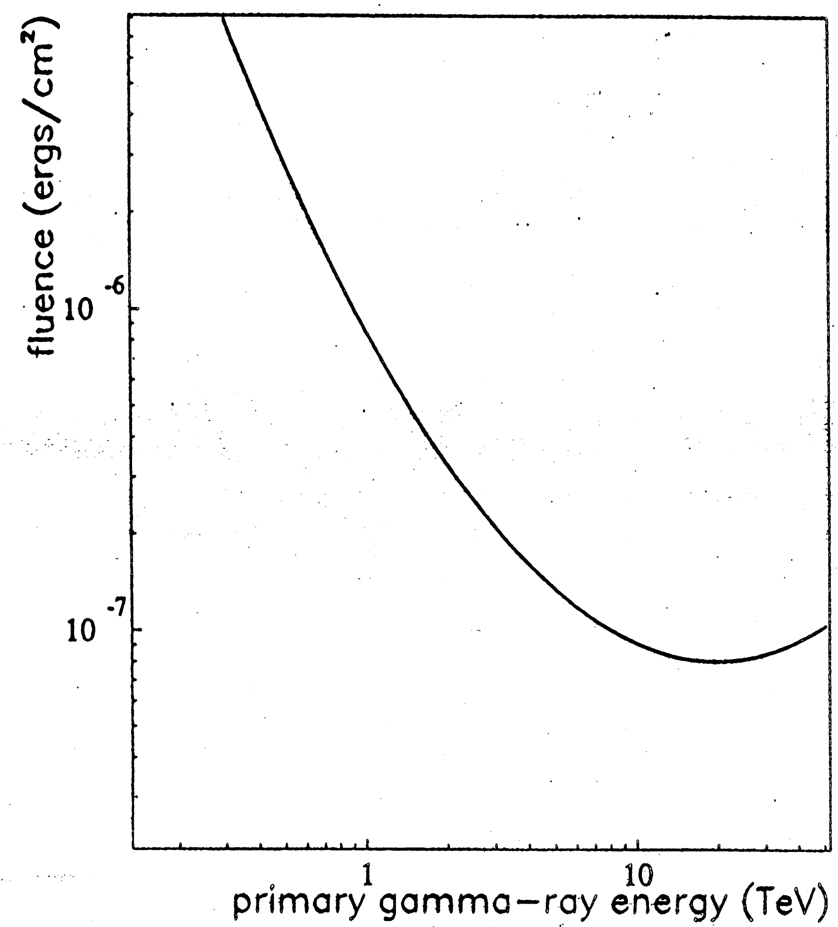


Figure 8.4: Fluence implied by the Milagrito detection of one primary gamma-ray particle of a certain energy, valid for gamma-ray primaries originating from the zenith angle at which the excess count attributed to GRB 970417a was found, and for a 1-meter layer of water above the PMTs.

Lower Limits on Event Energies and Upper Limit on Fluence

- **range of energy lower limits**

$\approx$ 340 GeV (97 tubes hit)

to

$\approx$ 920 GeV (182 tubes hit)

- **upper limit on fluence**

$$\Phi_{max} = \sum_{i=1}^{17} \mathbf{E}_{min,i}/\mathbf{A}_{eff,i}$$

$$\Phi_{max} \approx 4.7 \times 10^{-5}\ \mathrm{ergs/cm^2}$$

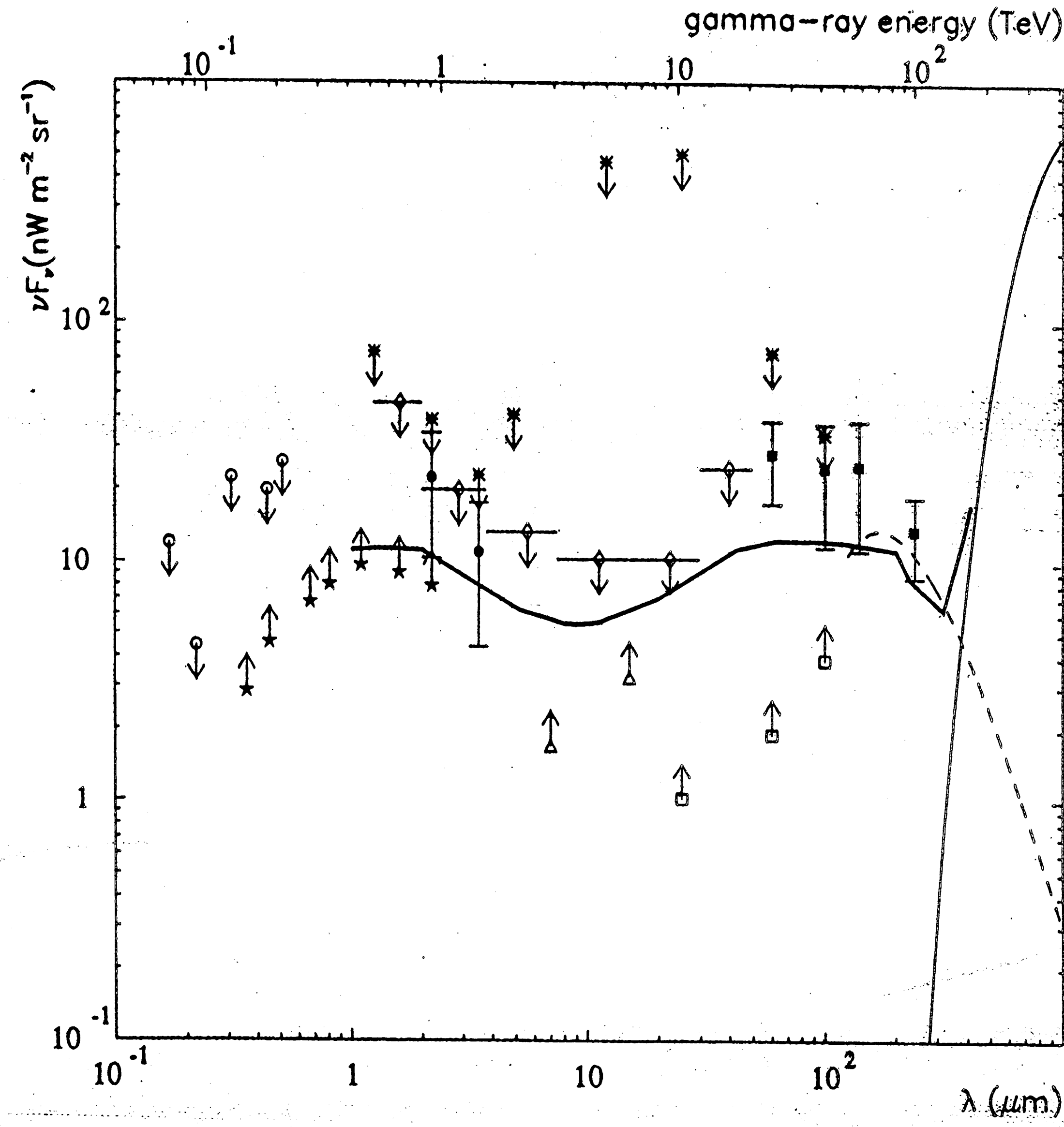


Figure 8.1: Limits on, and detections of, the EBL SED. • and ■ symbols are excesse found in DIRBE data, shown with 2σ error bars [6, 9, 10]; $*$ symbols are upper limits b DIRBE [9]; ◊ symbols are upper limits derived by Biller, et. al. from Mrk 421 and Mr 501 energy spectra [14]; ∘ symbols are upper limits from photometry measurements [1 19, 20]; ★ symbols are lower limits from Hubble Deep Field and ground-based galax counts [11]; △ symbols are lower limits by ISO [12]; □ symbols are lower limits by IRA [13]. The thin, dashed line is the average EBL SED measured by FIRAS [8], and the thi solid line is the CMB spectrum. The thick, solid line is the EBL model used by Stecker an de Jager 1997 [23] for calculating optical depths due to electron-positron pair production

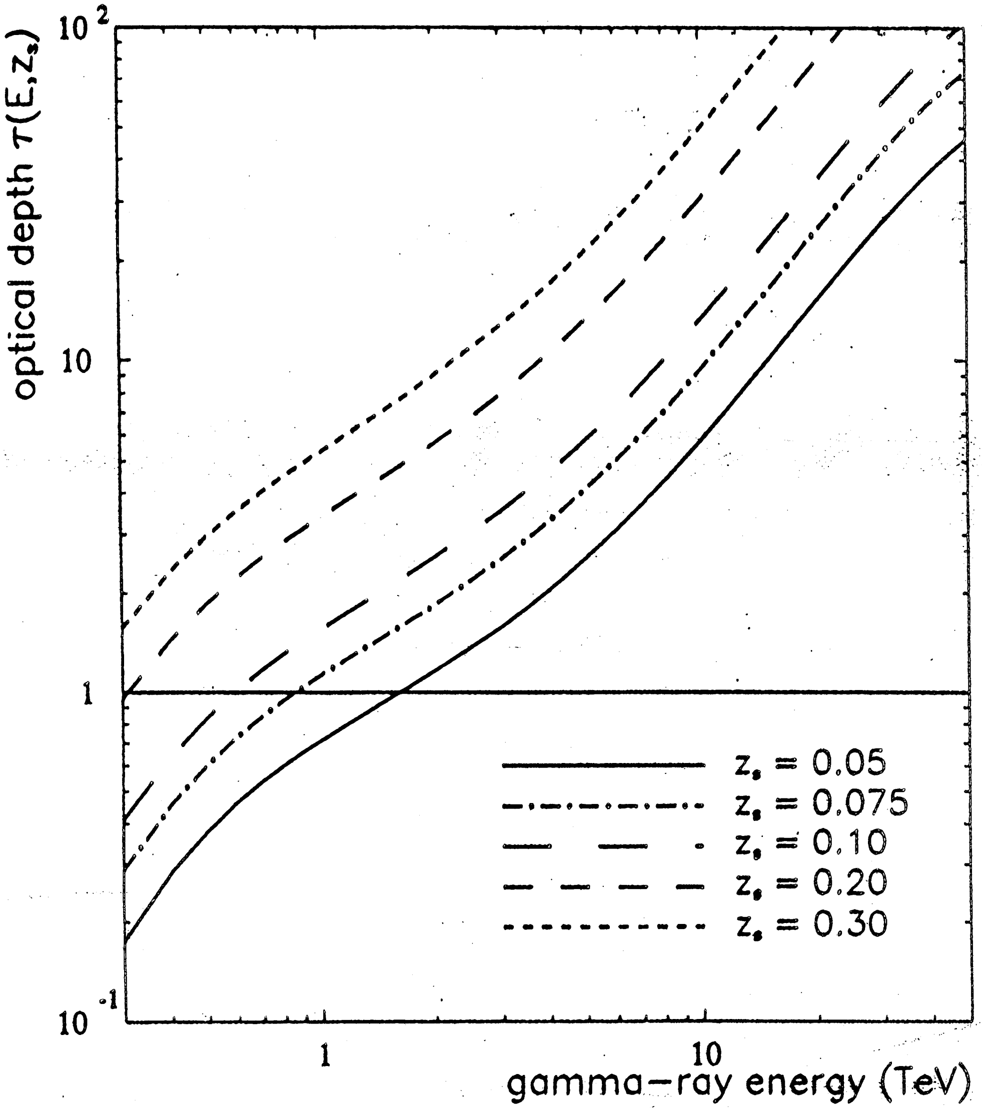


Figure 8.2: Optical depth, calculated by SJ97, due to EBL as a function of gamma-ray energy, for different redshifts.

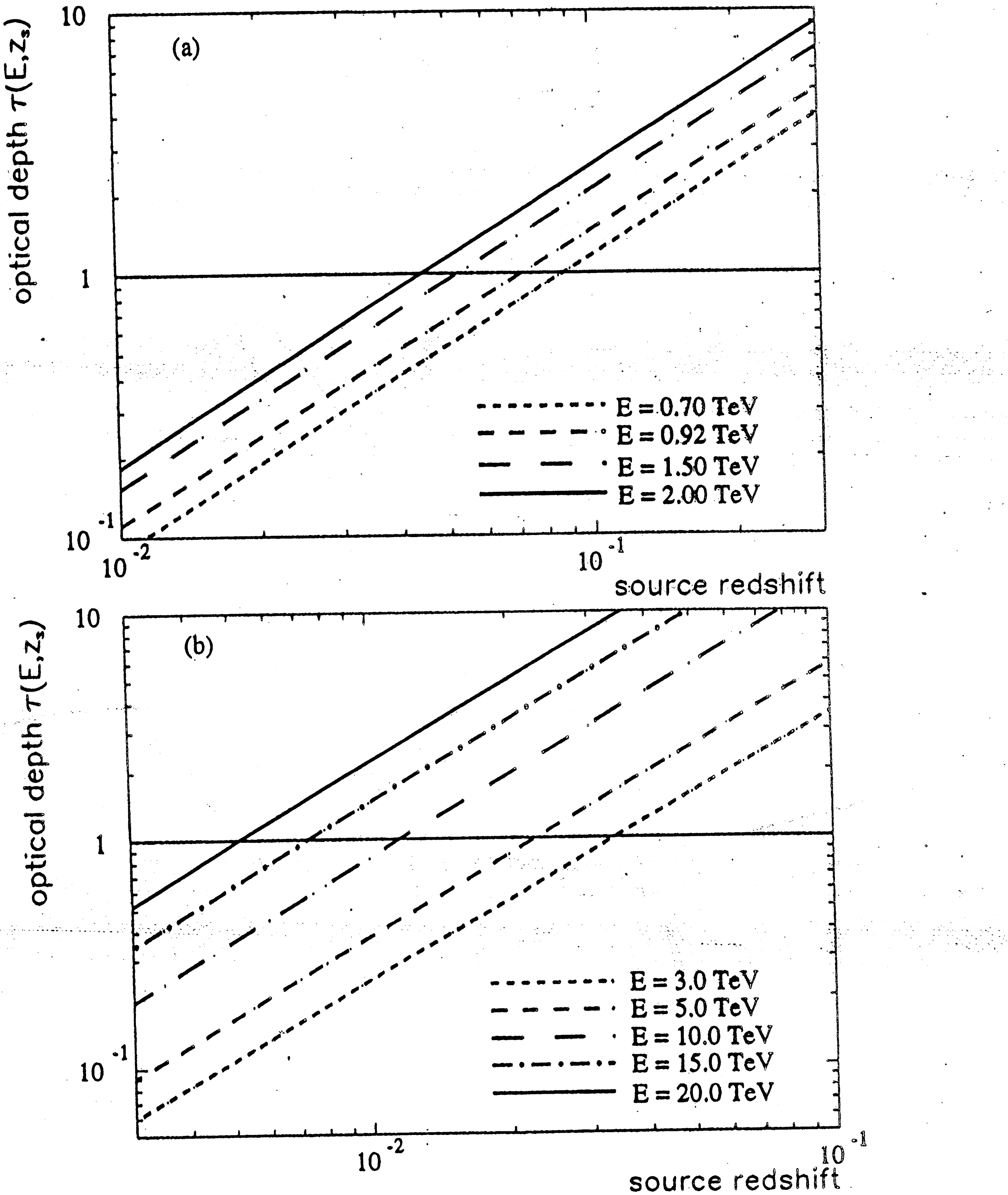


Figure 8.3: Optical depth by SJ97 due to EBL as a function of redshift, for different gamma ray energies.

Limits on Energy Release of GRB 970417a

$$\mathbf{E}_{\mathrm{iso}}(\mathbf{z}_s) = \frac{4\pi \mathbf{d}_L^2}{1+\mathbf{z}_s} \sum_{i=1}^{17} \left(\mathbf{E}_i / \mathbf{A}_{\mathrm{eff},i}\right) \exp\left(\tau\left(\mathbf{E}_i, \mathbf{z}_s\right)\right)$$

- **for upper limit on energy release,**

$$\mathbf{E}_i = \mathbf{E}_{\mathrm{min},i}$$

- **for lower limit on energy release,**

$$\tau\left(\mathbf{E}_i, \mathbf{z}_s\right) \approx 1$$

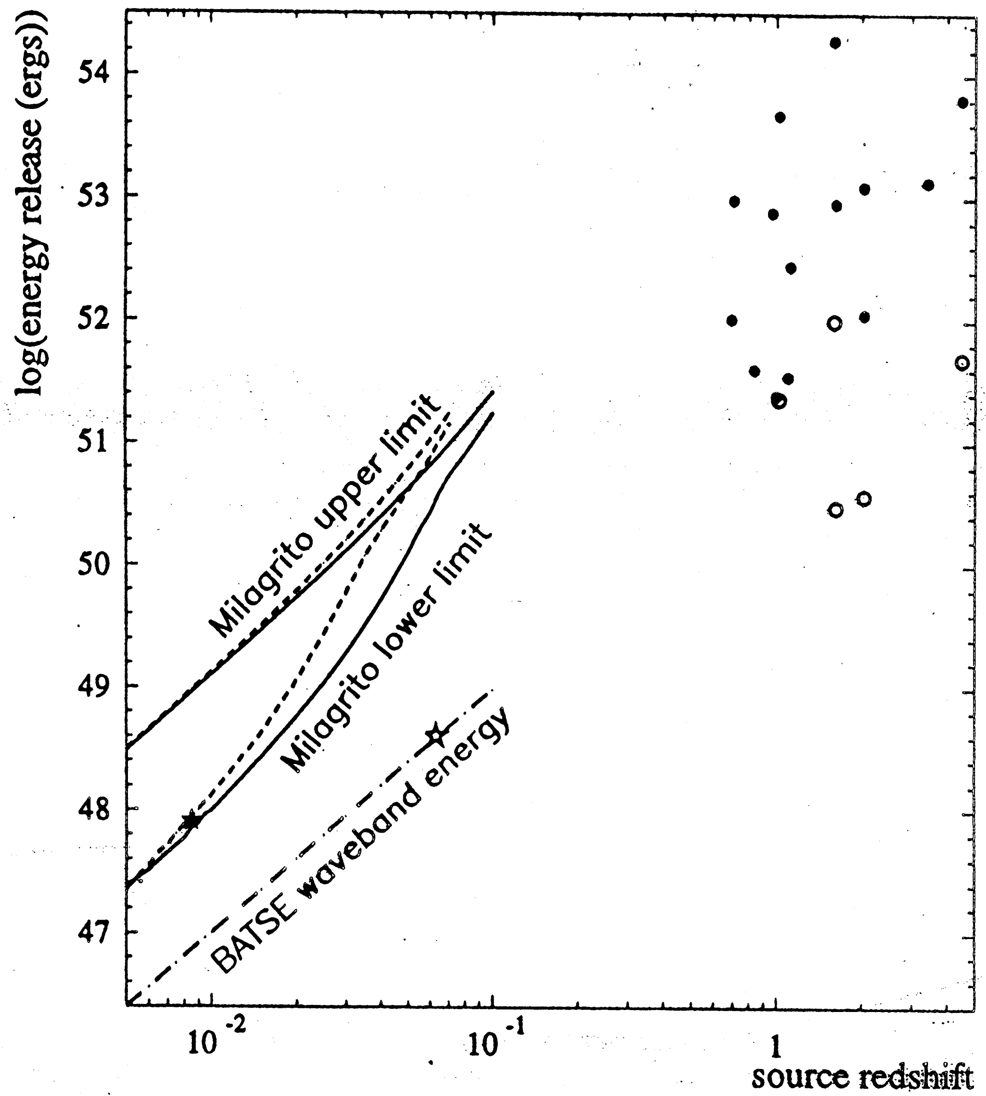
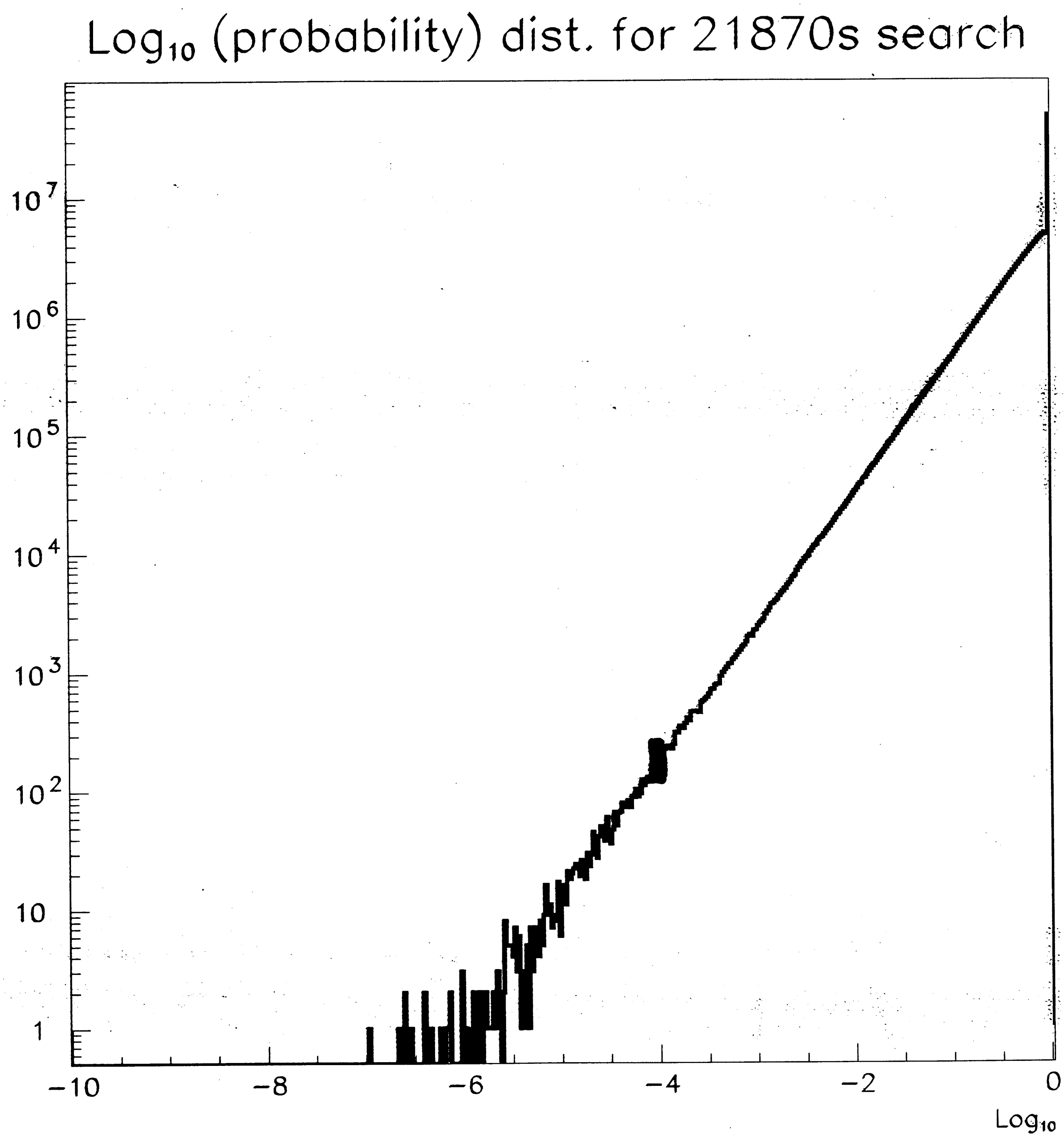


Figure 8.5: Upper and lower limits (thick, solid lines) on the isotropic energy release of GRB 970417a in the TeV waveband, as a function of redshift, using optical depths of SJ97. The short-dashed lines show the effect on the upper and lower limits of doubling the optical depths from that given by SJ97. The long-dashed line is the energy release of GRB 970417a in soft, keV-MeV gamma-rays, i.e. BATSE's waveband. Also shown are estimates of energy released in the soft gamma-rays by GRBs with known redshifts. The filled circles, filled star, and open star assume isotropic geometry. The open circles show the energy estimates for five of the GRBs when beaming is considered. The filled star is GRB 980425/SN 1997bw, and the open star is GRB 970514/SN 1997cy.

Burst Search Update

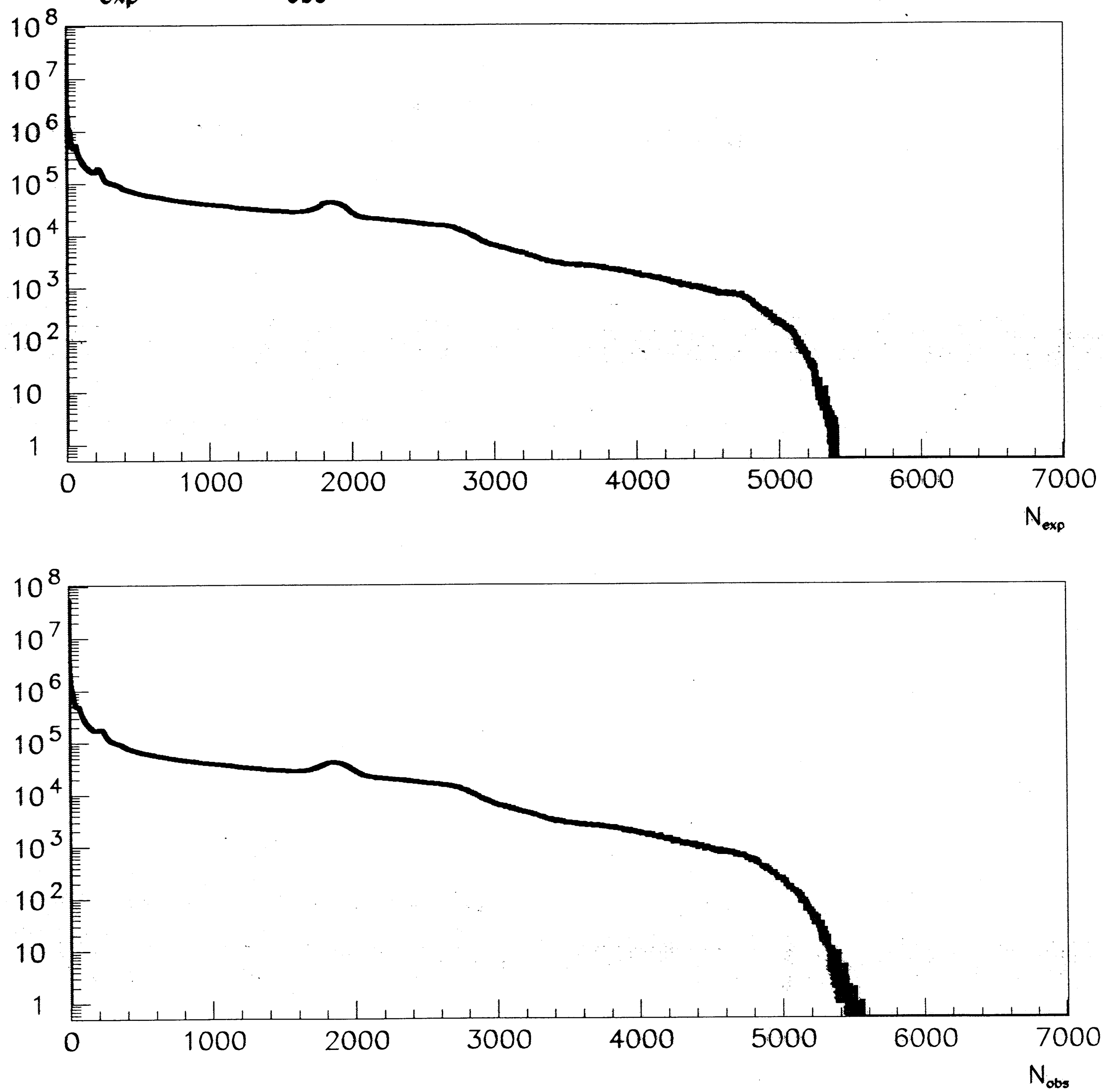
Untriggered

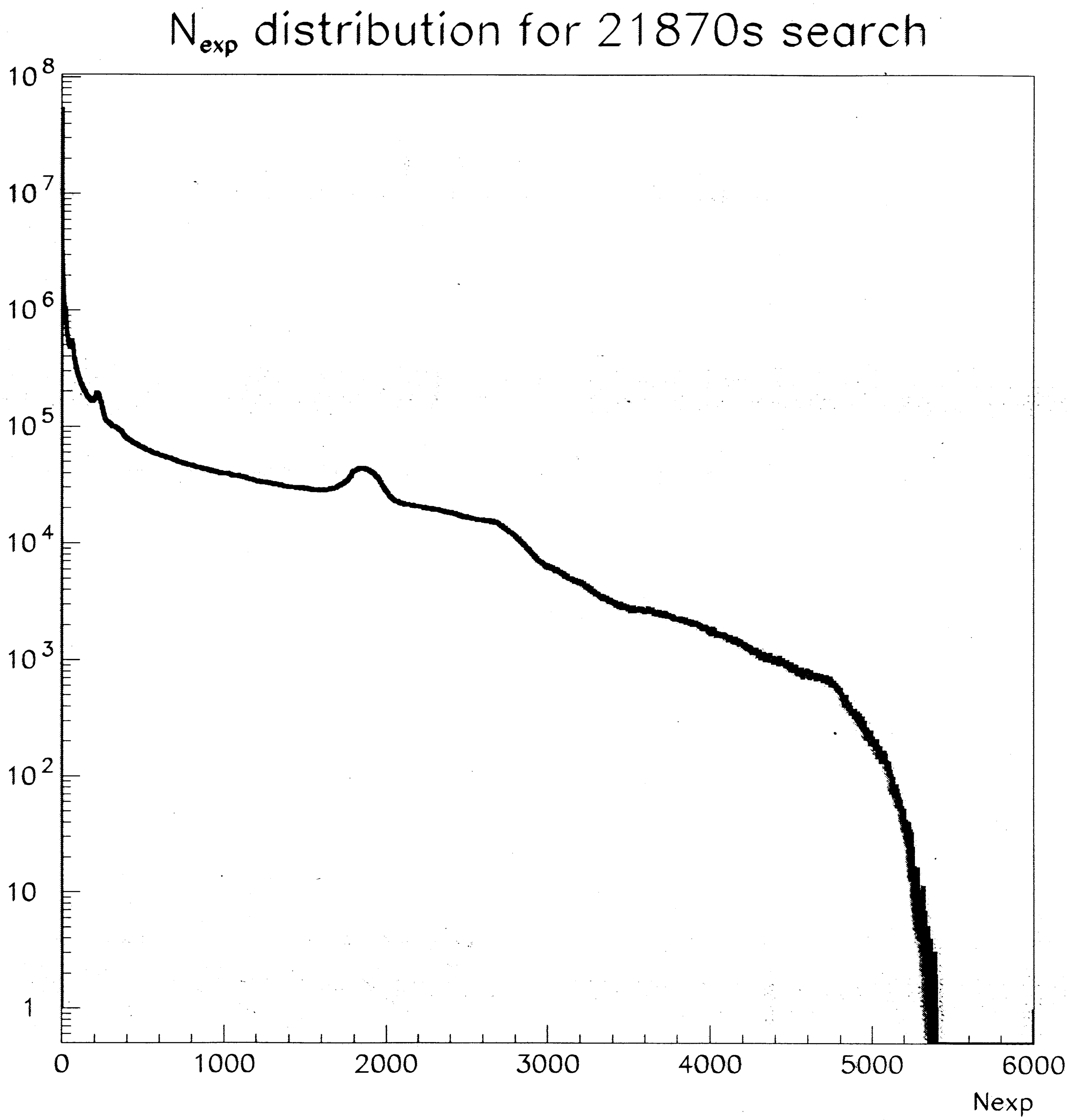
- 3, 10, 30, 90, 270, 810, 2430, 7290, & 21870 s searches done
- 1 s search
  - optimal binsize study done
  - speed up code
- figured out bumps in distributions



Log10 (probability) dist. for 21870s search
10^7
10^6
10^5
10^4
10^3
10^2
10
1
−10
−8
−6
−4
−2
0
Log10

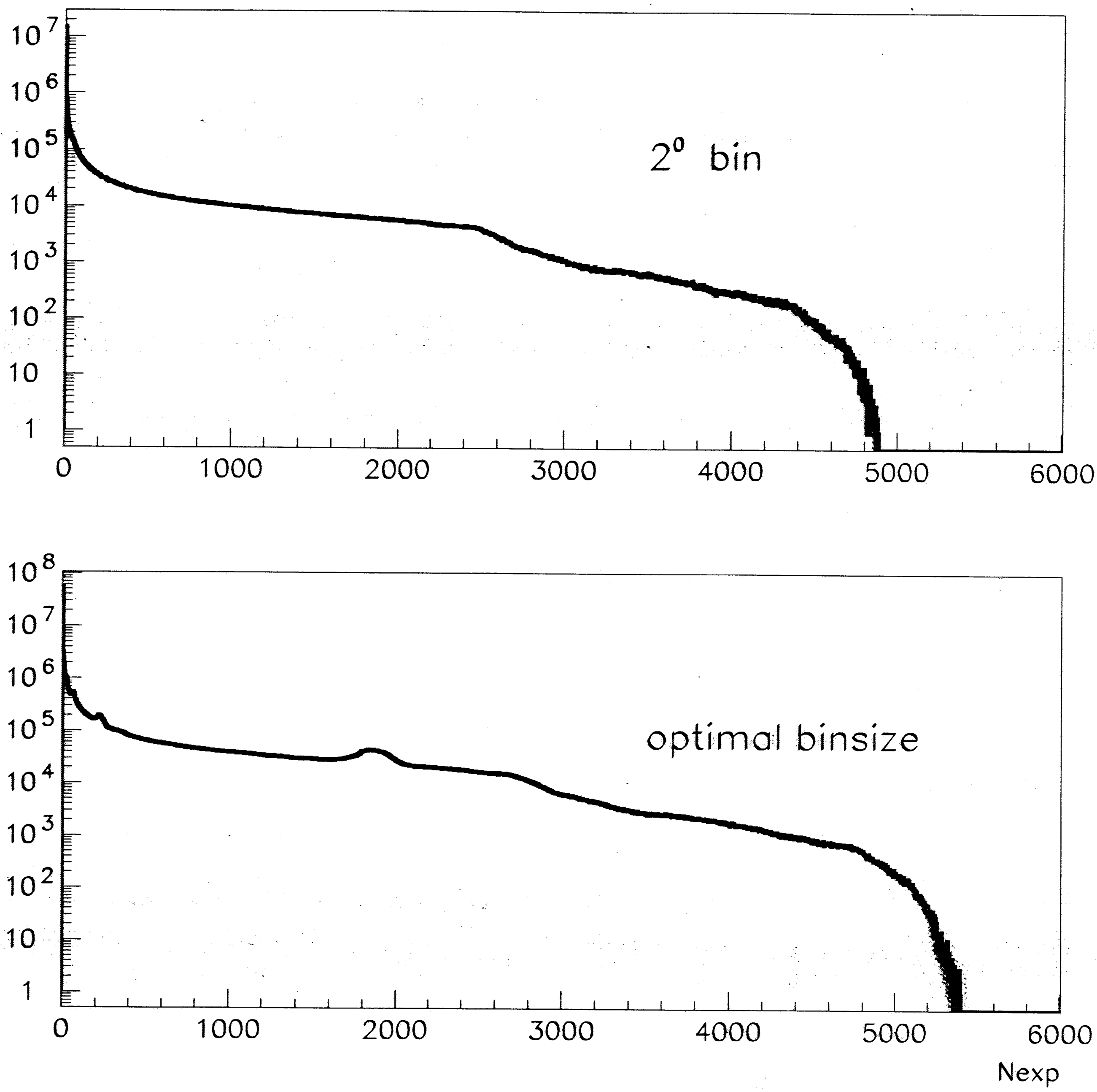
N_{exp} and N_{obs} distributions for 21870s search



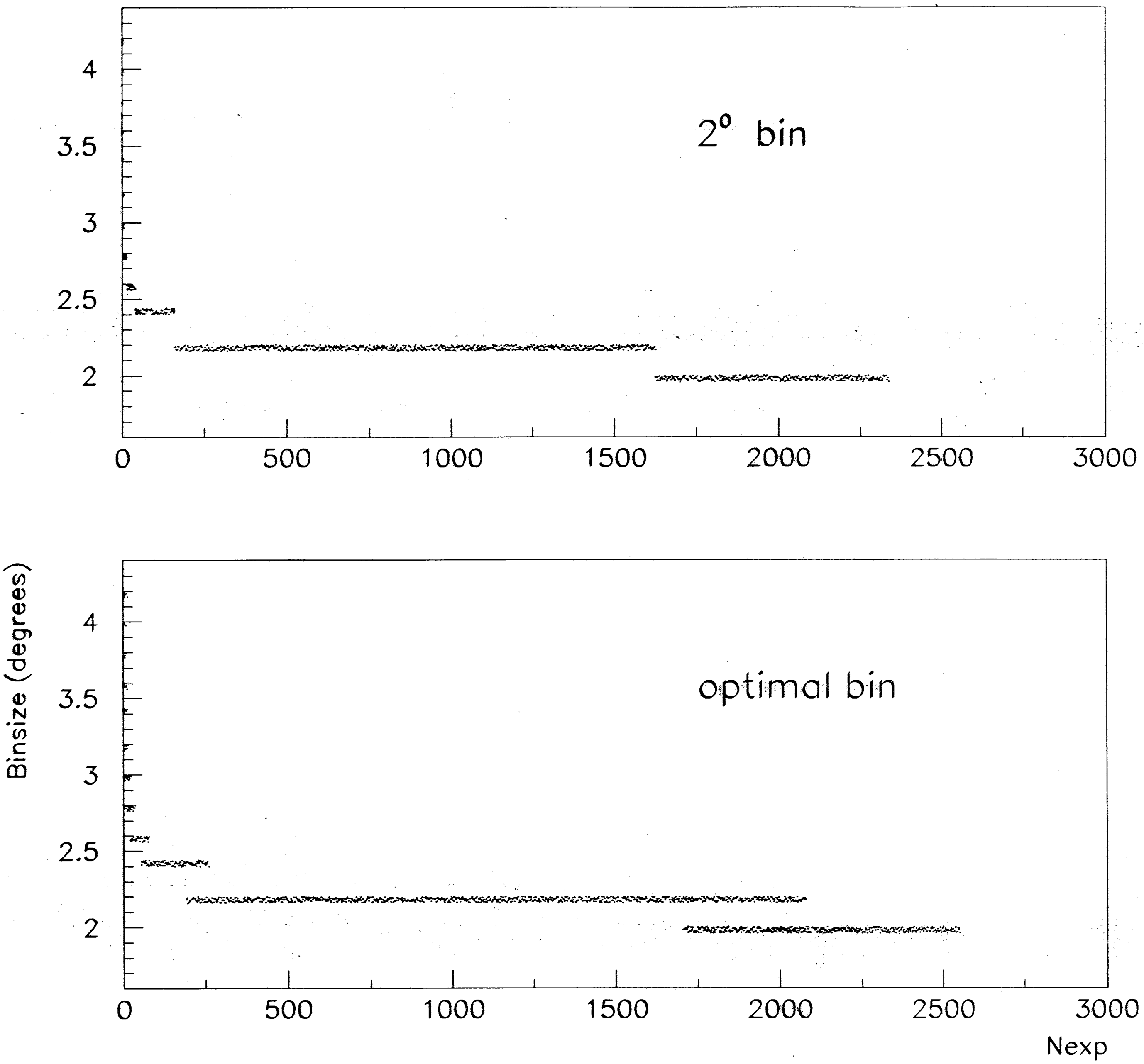


N_{exp} distribution for 21870s search
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10
1
0
1000
2000
3000
4000
5000
6000
Nexp

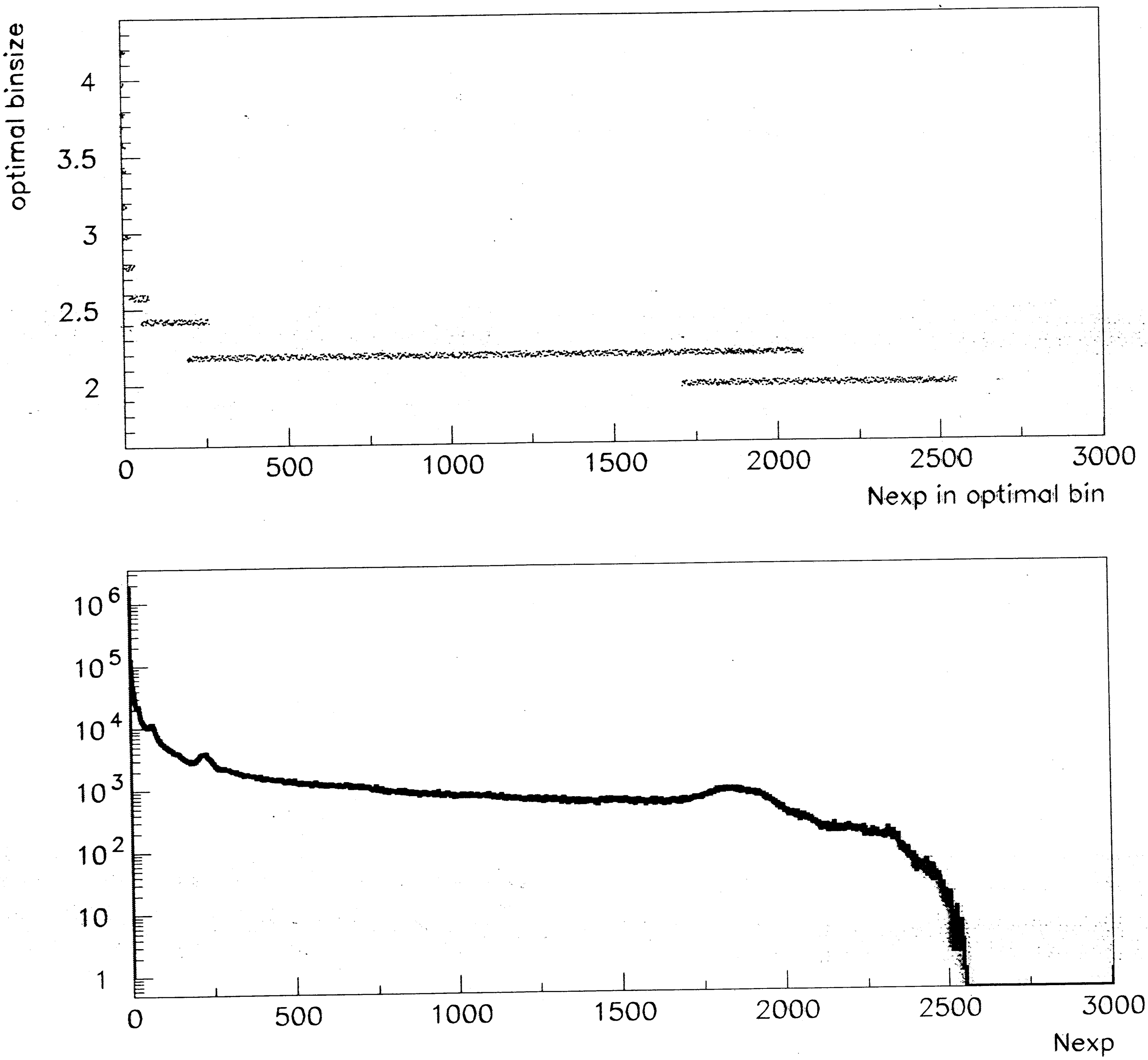
N_{exp} distributions for 21870s search



Optimal binsize vs. N_{exp} for 21870s search



50 runs from 21870s search



X-ray selected BL Lacs and Blazars (Perlman 1999)

Name	RA	Dec.
1ES0033+595	8.97	59.83
RGB0110+418	17.52	41.83
RGB0152+017	28.16	1.79
RGB0153+712	28.36	71.25
RGB0214+517	33.57	51.75
RGB0314+247	48.51	24.74
RGB0656+426	104.04	42.62
Mkn180	174.11	70.16
RGB1532+302	233.01	30.27
GBJ1610+671	242.51	67.17
1ES1727+502	262.08	50.22
1ES1741+196	265.99	19.59
1ES1959+650	300.00	65.15
1ES2321+419	350.97	42.18
RGB2322+346	350.68	34.60
III_Zw_2	2.63	10.97
B2_0138+398	25.49	39.39
B2_0321+33	51.17	34.18
RGB1413+436	213.43	43.66
PG2209+184	332.97	18.70
Crab	83.65	22.01
Mrk501	253.47	39.76
Mrk421	166.11	38.21
1ES2344+514	356.77	51.70

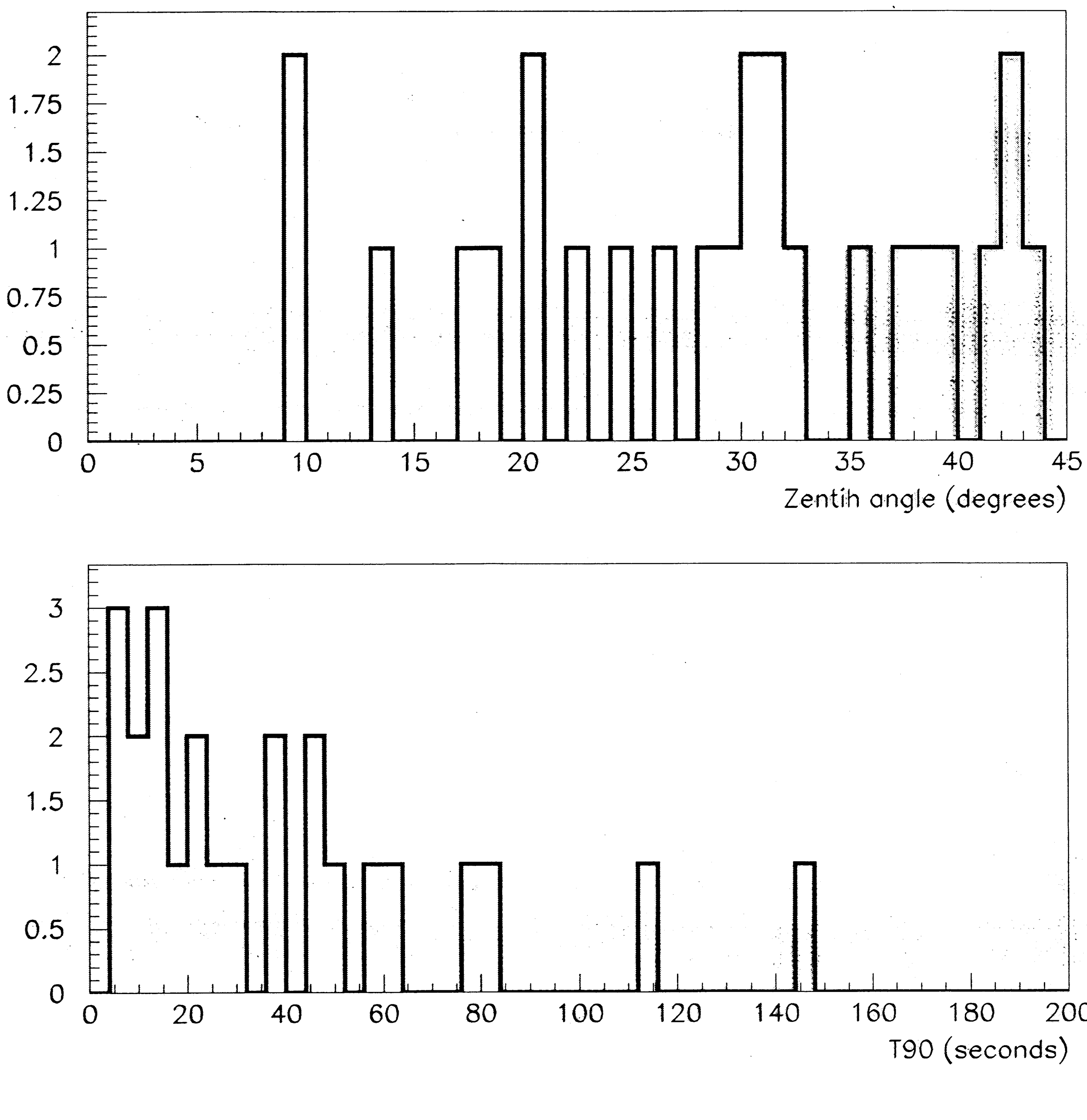
New Bursts from Stern et. al.

- offline scan of BATSE data
- found ~1000 new bursts
- 25 GRBs with zenith angles 0-45° for Milagrito

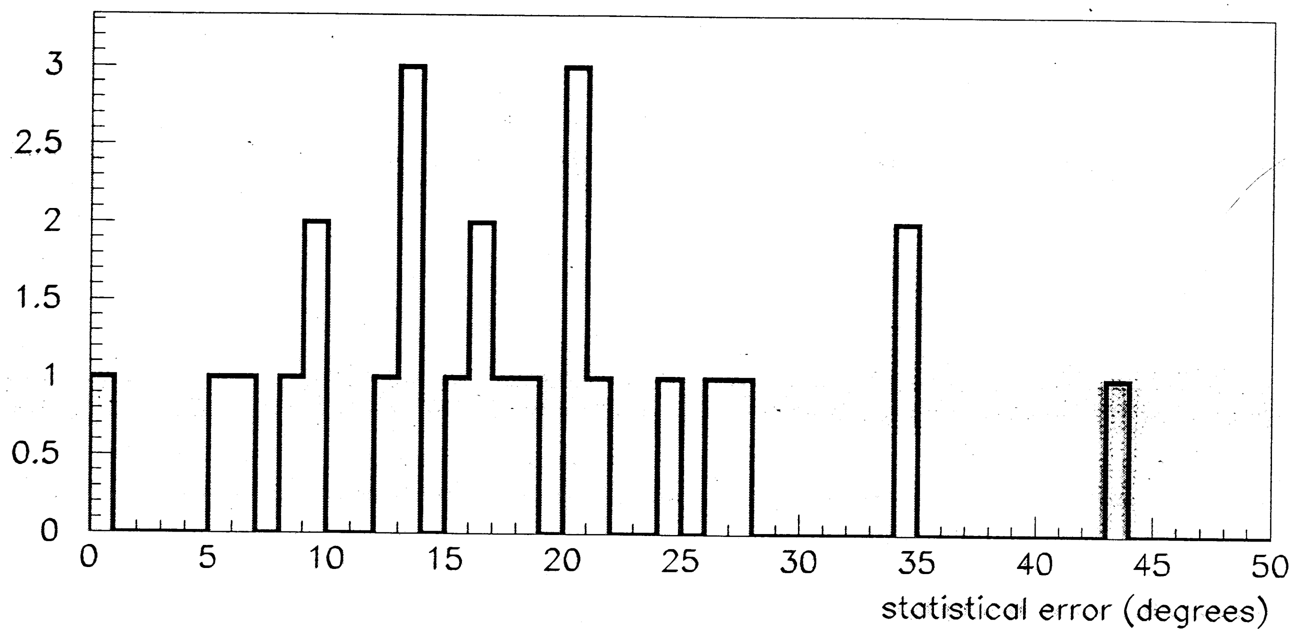
Search

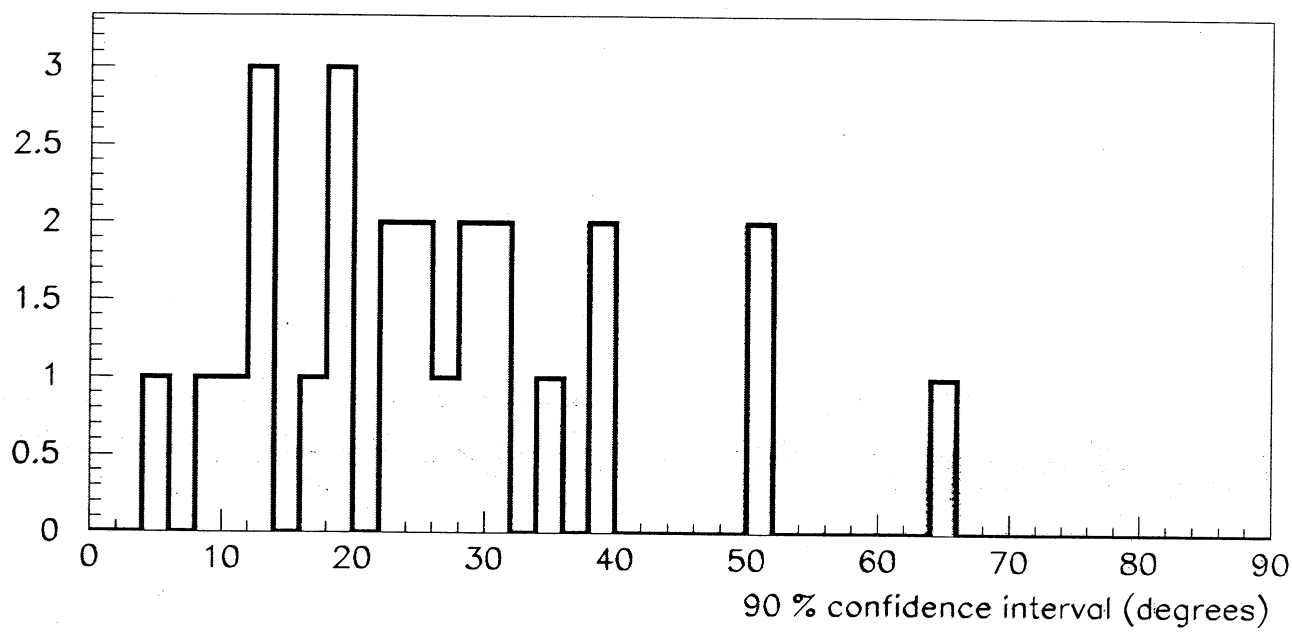
- nfit cut 30
- 90% confidence interval
- optimal binsize
- T90

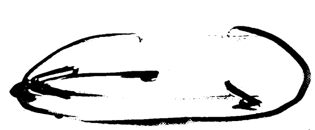
New BATSE GRBs from Stern et. al.



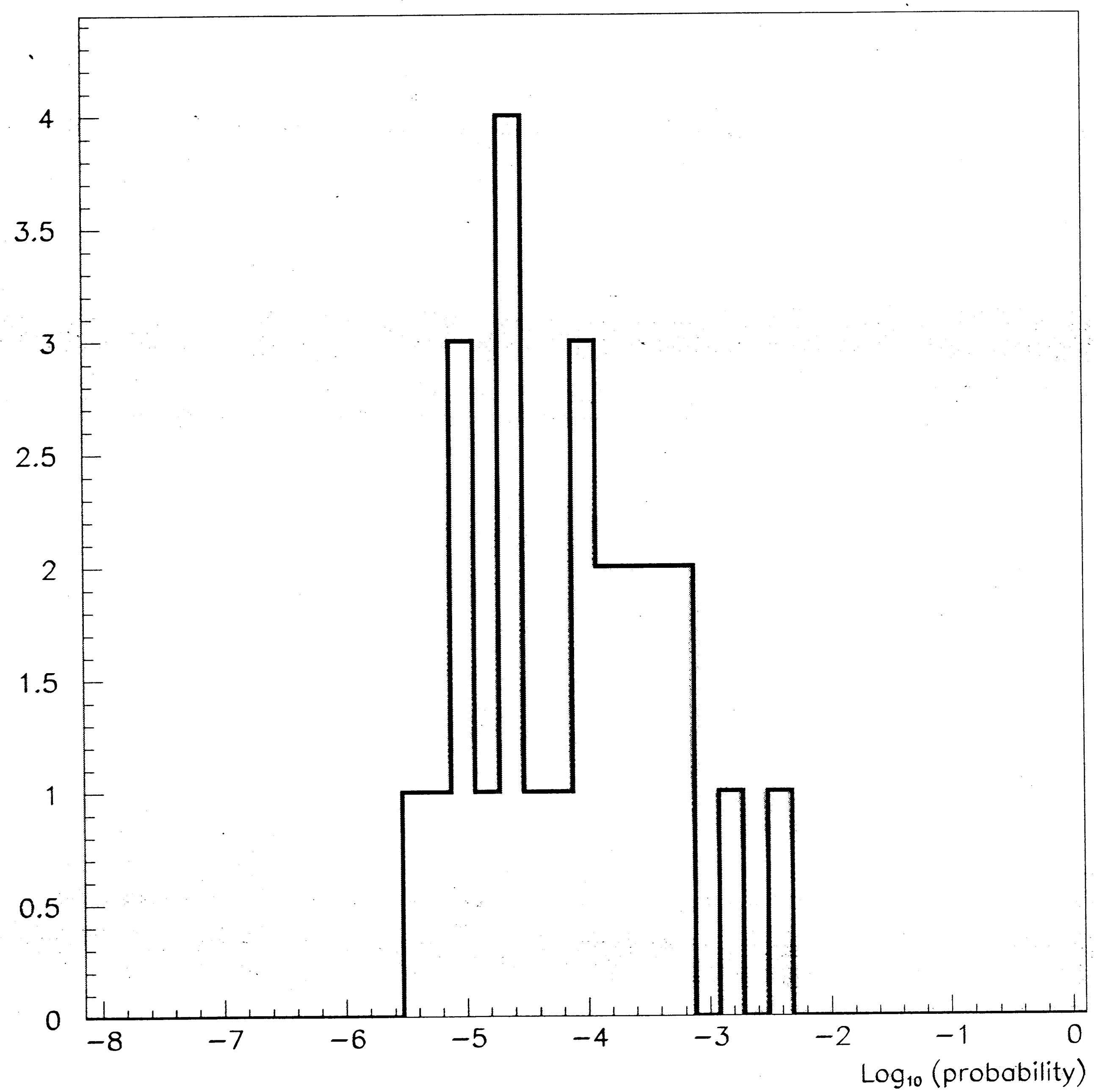
New BATSE GRBs from Stern et. al.







Most improbable bin from each GRB



GRB 970417a

	BATSE	STERN	
R.A.	295.66	290.20	
Dec.	55.77	54.20	
Stat. error	6.23°	16.80°	
90% interval	9.76°	24.33°	
T90	7.936	8.40	
start	50016.7135 −1.024	50016.458 ?	50016.45 −1.024

R.A.	290.30	290.12	290.12
Dec.	53.86	53.92	53.92
Binsize	2.83	2.81	2.81
Nexp	2.81	2.99	2.98
Nobs	17	16	18
Prob	8.55×10^{-9}	1.22×10^{-7}	3.19×10^{-9}
Distance	3.63°	0.28°	0.28°

SOLAR PROPOSAL STATUS

Submitted & reviewed by Atmospheric Sciences Division of NSF (Paul Evenson)

5 reviews 3 Very Good, 2 Good

All positive on scientific merit, cost effectiveness

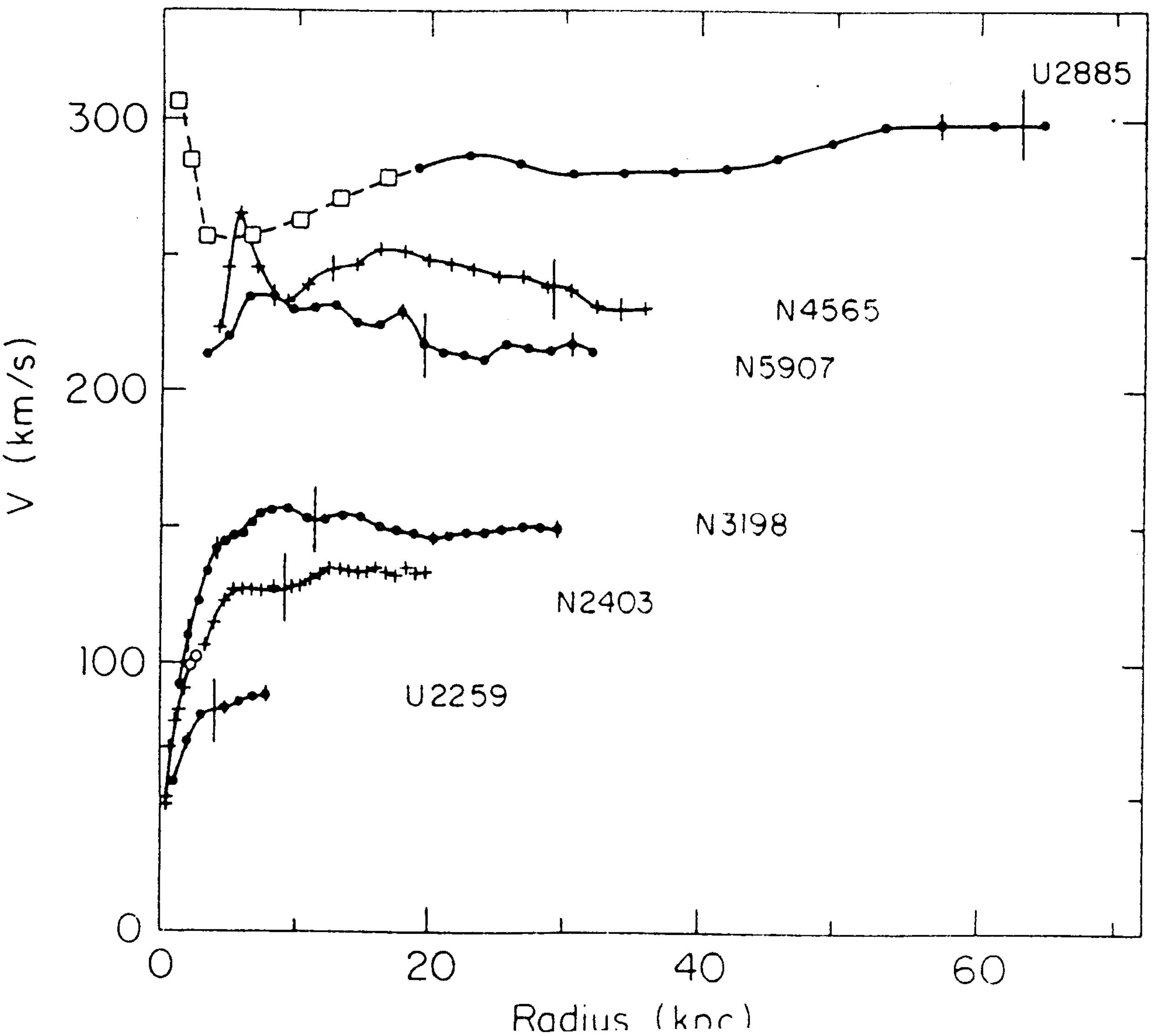
Misunderstanding about duration of observations

Valid criticism on preliminary 6 Nov 97 event.

Criticism on not having sufficient knowledge of instrument.

Paul Evenson — "I was looking for 5 excellents to fund at this level." Wants and expects a resubmission for less \$.

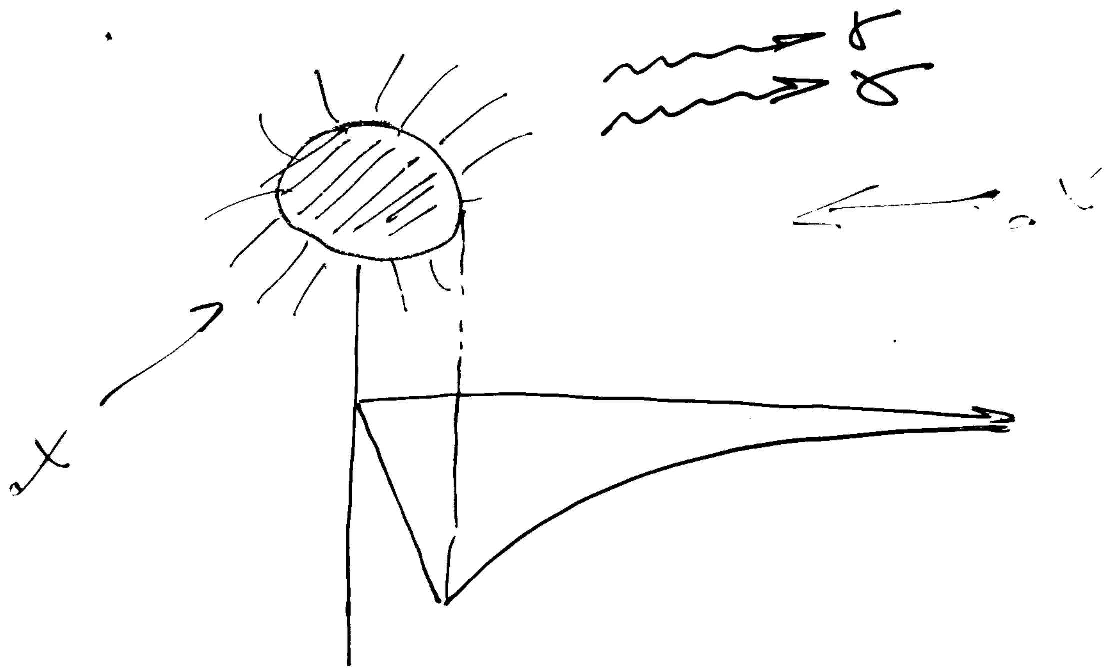
Reading between the lines — \$70K will fly. Hardware needs to come from elsewhere. (MRI?)



From: the Early Universe
E. Kolb
M. Turner

$\Omega_{lum} \sim 0.01$, $\Omega_{halo} \sim 0.1$, $\Omega_{cluster} \sim 0.3$

$\Omega_{beauty} = 1$ $\Omega_{baryon} < 0.15$



$0.1\ \mathrm{TeV} \lesssim M_\chi \lesssim 10\ \mathrm{TeV}$

$\chi\chi \to \gamma\gamma \quad ; \quad \chi\chi \to Z\gamma$

$E_\gamma = M_\chi \qquad E_\gamma = M_\chi \left(1 - \left(\frac{m_Z}{2M_\chi}\right)^2\right)$

predict annihilation rate (find $n(x)$)

Simulations

1) Backward in time: from annihilation $\to \infty$

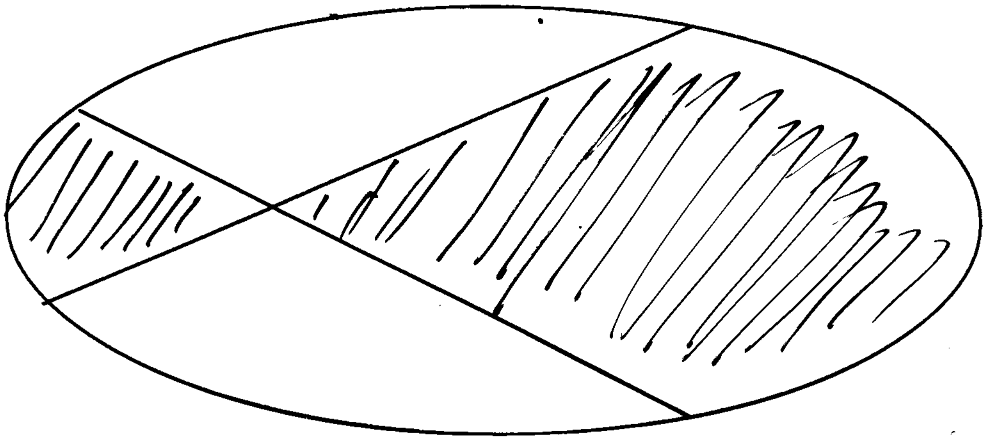
2) From ① and "Known" distribution of χ at $\infty \to n(\chi)$ near the Sun $\to$ rate $\sim n^2(\chi)$

Each scattering in the Sun $\to$ gain energy!

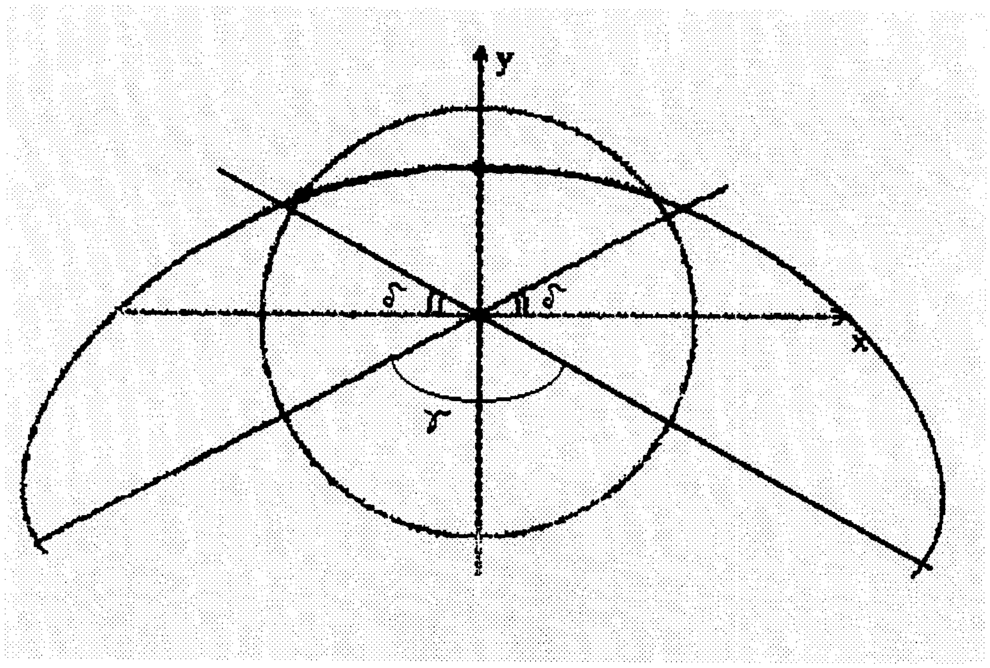
$$\text{Column density} = \int n_p \sigma_{p\chi}\, dl = n_p \langle \sigma V \rangle \int \frac{dl}{V} \sim T_{in}$$

Time is fundamental variable!

$$e^{-x/\lambda} \to e^{-t/\tau}$$



$$\Gamma = \frac{S}{2} = \frac{\pi A B}{T} = \text{const}!!!$$



$$\left.\begin{array}{l} U_{out} \sim \frac{1}{r} \\ U_{in} \sim r^2 \end{array}\right\} \Rightarrow \text{orbit is an ellipse}$$

Milagro Predictions *)

0.3° angular resolution

50% hadron rejection

100% γ - acceptance

50% Energy resolution

E (TeV)	hours (Sun)
0.35	10
1.0	100
3.5	10^4

26 ICRC HE 5.1.07, Steven Strausz

Milagro Budget Issues

- The Good News
  - The NSF groups (Md, UCSC, UCI) got funded this year at a workable level for the next three years
  - NSF (Gene Loh) has approved our proposal to
    - Operate Milagro ($266k/yr)
    - Build the outriggers
    - Provide computing support
- Other News
  - NSF is reviewing the Los Alamos Support and wants us to start paying them out of the Operations/Outrigger grant

What we requested

Summary	Year 1	Year 2	Year 3	Total
Operating	$242,500	$242,500	$242,500	$727,500
Outriggers	$261,812	$172,171	$0	$433,983
Computing	$132,540	$129,000	$69,000	$330,540
Indirect costs	$70,275	$70,925	$63,050	$204,250
Total Request	$707,127	$614,596	$374,550	$1,696,273
NSF Actual	$600,000	$545,000	$545,000	$1,690,000

Breakdown

Captial Equipment (Overhead Free)

	Year 1	Year 2	Year 3	Total
Operating				
Outriggers	$234,022	$141,881		$375,903
Computing	$132,540	$129,000	$69,000	$330,540
Equipment Totals	$366,562	$270,881	$69,000	$706,443

Labor

	Year 1	Year 2	Year 3	Total
Operating	$0	$0	$0	$0
Outriggers	$27,790	$30,290		$58,080
Computing				$0
Labor costs	$27,790	$30,290	$0	$58,080

Utilities and Expendables

	Year 1	Year 2	Year 3	Total
Operating	$242,500	$242,500	$242,500	$727,500
Outriggers				$0
Computing				$0
Util & Expend. costs	$242,500	$242,500	$242,500	$727,500

Total annual costs	$707,127	$614,596	$374,550	$1,696,273

Revised NSF Budget

Summary	Year 1	Year 2	Year 3	Total
Operating	$177,500	$266,250	$266,250	$710,000
Outriggers	$114,750	$172,422	$0	$287,172
Computing	$9,000	$29,227	$209,525	$247,752
Indirect costs	$48,750	$77,100	$69,225	$187,573
Subcontract	$250,000			
Total	$600,000	$545,000	$545,000	$1,690,000

Breakdown

Captial Equipment (Overhead Free)

	Year 1	Year 2	Year 3	Total
Operating				
Outriggers	$104,750	$142,132		$246,882
Computing	$9,000	$29,227	$209,525	$38,227
Equipment Totals	$113,750	$171,359	$209,525	$285,109

Labor

	Year 1	Year 2	Year 3	Total
Operating	$0	$0	$0	$0
Outriggers	$10,000	$30,290		$40,290
Computing				$0
Labor costs	$10,000	$30,290	$0	$40,290

Utilities and Expendables

	Year 1	Year 2	Year 3	Total
Operating	$177,500	$266,250	$266,250	$710,000
Outriggers				$0
Computing				$0
Util & Expend. costs	$177,500	$266,250	$266,250	$710,000

Los Alamos Sub	$250,000

Total annual costs	$600,000	$545,000	$545,000	$1,222,972

What we requested for Los Alamos

Item	Burdened FY2001 Cost
0,5 FTE Postdoctoral Associate	$36,002
Facility Management at Fenton Hill	$21,000
T1 Communications Line	$20,400
Telephones and pagers	$11,200
TA-53 Space charges + utilities	$90,450
GSA vehicle	$9,750
CRYPTOcards	$33,480
ADSM, Computer backup	$33,840
Total	$256,122

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Maryland College Park

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jordan A Goodman

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Jordan A Goodman - PI	0.00	0.00	0.00	$ 0	$
2. Donald G Coyne - Co-PI	0.00	0.00	0.00	0	
3. Brenda L Dingus - Co-PI	0.00	0.00	0.00	0	
4. Peter Nemethy - Co-PI	0.00	0.00	0.00	0	
5. Gaurang B Yodh - Co-PI	0.00	0.00	0.00	0	
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (5) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (1) OTHER				10,000	
TOTAL SALARIES AND WAGES (A + B)				10,000	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				10,000	

D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)

2-node PII 600 MHz Rackmount PC 7 @ $4,820	$ 9,000
Hardware at UCI,UCSC,NYU,UNH,Wisc 5 @$13,800 each	0
Material for Outriggers	104,750
Others (See Budget Comments Page...)	0

	Funds Requested By proposer	Funds granted by NSF (if different)
TOTAL EQUIPMENT	113,750	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)	0	
2. FOREIGN	0	

F. PARTICIPANT SUPPORT COSTS
1. STIPENDS $ 0
2. TRAVEL 0
3. SUBSISTENCE 0
4. OTHER 0

	Funds Requested By proposer	Funds granted by NSF (if different)
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS	0	
G. OTHER DIRECT COSTS		
1. MATERIALS AND SUPPLIES	0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION	0	
3. CONSULTANT SERVICES	0	
4. COMPUTER SERVICES	0	
5. SUBAWARDS	250,000	
6. OTHER	177,500	
TOTAL OTHER DIRECT COSTS	427,500	
H. TOTAL DIRECT COSTS (A THROUGH G)	551,250	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) % of MTDC (Rate: 26.0000, Base: 187500)		
TOTAL INDIRECT COSTS (F&A)	48,750	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)	600,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)	0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)	$ 600,000	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI / PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Jordan A Goodman		INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Of Rate Sheet	Initials - ORG

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Maryland College Park

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jordan A Goodman

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Jordan A Goodman - PI	0.00	0.00	0.00	$ 0	$
2. Donald G Coyne - Co-PI	0.00	0.00	0.00	0	
3. Brenda L Dingus - Co-PI	0.00	0.00	0.00	0	
4. Peter Nemethy - Co-PI	0.00	0.00	0.00	0	
5. Gaurang B Yodh - Co-PI	0.00	0.00	0.00	0	
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (5) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (1) OTHER				30,290	
TOTAL SALARIES AND WAGES (A + B)				30,290	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				30,290	

D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)

4-node Xeon 600MHz Rackmount PC 4 @ $20,000	$ 29,227
Hardware at UCI,UCSC,NYU,UNH,Wisc 5 @ $13,800	0
Material for Outriggers	142,131

	Funds Requested By proposer	Funds granted by NSF (if different)
TOTAL EQUIPMENT	171,358	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)	0	
2. FOREIGN	0	

F. PARTICIPANT SUPPORT COSTS

1. STIPENDS $ 0
2. TRAVEL 0
3. SUBSISTENCE 0
4. OTHER 0

	Funds Requested By proposer	Funds granted by NSF (if different)
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS	0	
G. OTHER DIRECT COSTS		
1. MATERIALS AND SUPPLIES	0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION	0	
3. CONSULTANT SERVICES	0	
4. COMPUTER SERVICES	0	
5. SUBAWARDS	0	
6. OTHER	266,252	
TOTAL OTHER DIRECT COSTS	266,252	
H. TOTAL DIRECT COSTS (A THROUGH G)	467,900	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) % of MTDC (Rate: 26.0000, Base: 296540)		
TOTAL INDIRECT COSTS (F&A)	77,100	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)	545,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)	0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)	$ 545,000	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI / PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Jordan A Goodman		INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Of Rate Sheet	Initials - ORG

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Maryland College Park

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jordan A Goodman

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Jordan A Goodman - PI	0.00	0.00	0.00	$ 0	$
2. Donald G Coyne - Co-PI	0.00	0.00	0.00	0	
3. Brenda L Dingus - Co-PI	0.00	0.00	0.00	0	
4. Peter Nemethy - Co-PI	0.00	0.00	0.00	0	
5. Gaurang B Yodh - Co-PI	0.00	0.00	0.00	0	
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (5) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	

D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)			
COmputer upgrade	$ 140,525		
Hardware at UCI,USCS,NYU,UNH,Wisc 5 @$13,800 each	69,000		
TOTAL EQUIPMENT		209,525	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)		0	
2. FOREIGN		0	

F. PARTICIPANT SUPPORT COSTS
1. STIPENDS $ 0
2. TRAVEL 0
3. SUBSISTENCE 0
4. OTHER 0

TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS	0	
G. OTHER DIRECT COSTS		
1. MATERIALS AND SUPPLIES	0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION	0	
3. CONSULTANT SERVICES	0	
4. COMPUTER SERVICES	0	
5. SUBAWARDS	0	
6. OTHER	266,250	
TOTAL OTHER DIRECT COSTS	266,250	
H. TOTAL DIRECT COSTS (A THROUGH G)	475,775	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) % of MTDC (Rate: 26.0000, Base: 266250)		
TOTAL INDIRECT COSTS (F&A)	69,225	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)	545,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)	0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)	$ 545,000	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI / PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Jordan A Goodman		INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Of Rate Sheet	Initials - ORG

NSF Form 1030 (10/99) Supersedes all previous editions

3 *SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B)

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Maryland College Park

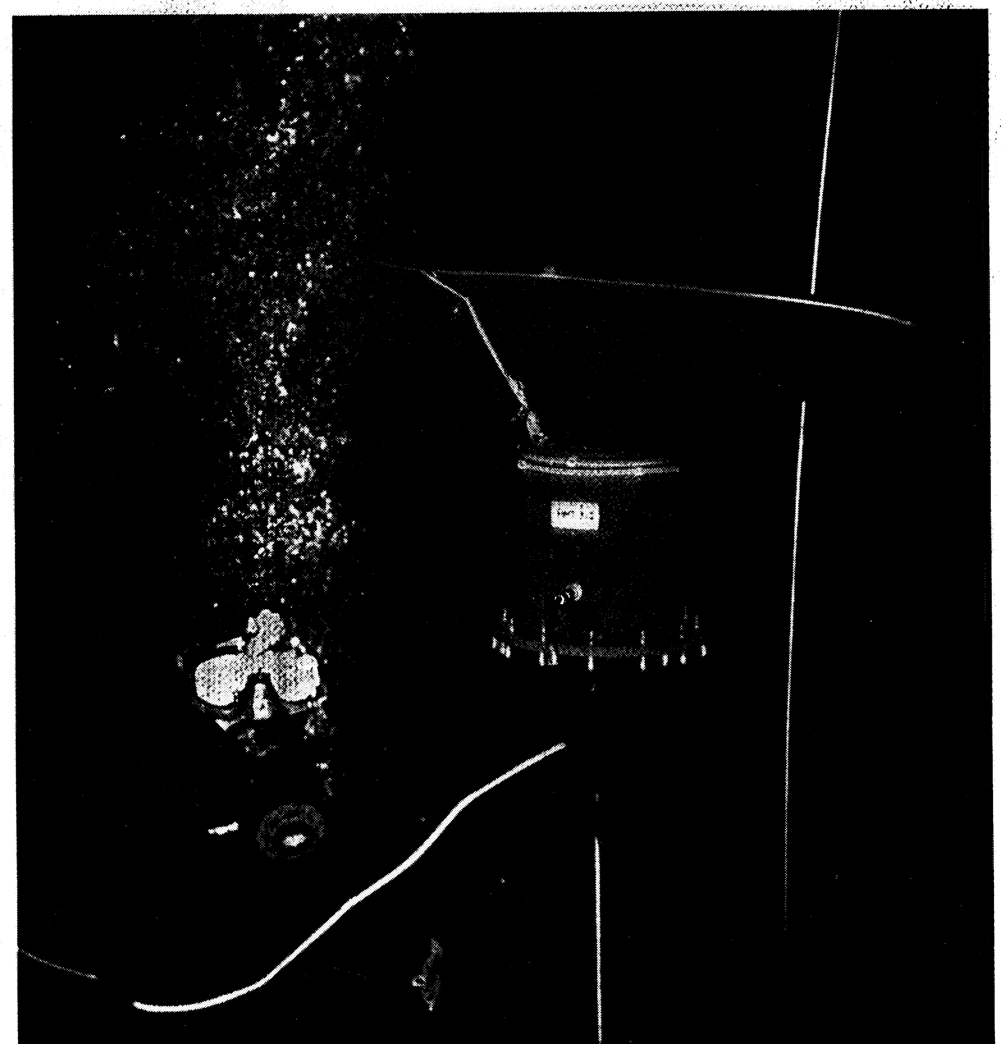
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jordan A Goodman

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Jordan A Goodman - PI	0.00	0.00	0.00	$ 0	$
2. Donald G Coyne - Co-PI	0.00	0.00	0.00	0	
3. Brenda L Dingus - Co-PI	0.00	0.00	0.00	0	
4. Peter Nemethy - Co-PI	0.00	0.00	0.00	0	
5. Gaurang B Yodh - Co-PI	0.00	0.00	0.00	0	
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (5) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (2) OTHER				40,290	
TOTAL SALARIES AND WAGES (A + B)				40,290	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				40,290	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 494,633					
TOTAL EQUIPMENT				494,633	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				250,000	
6. OTHER				710,002	
TOTAL OTHER DIRECT COSTS				960,002	
H. TOTAL DIRECT COSTS (A THROUGH G)				1,494,925	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				195,075	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				1,690,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 1,690,000	$

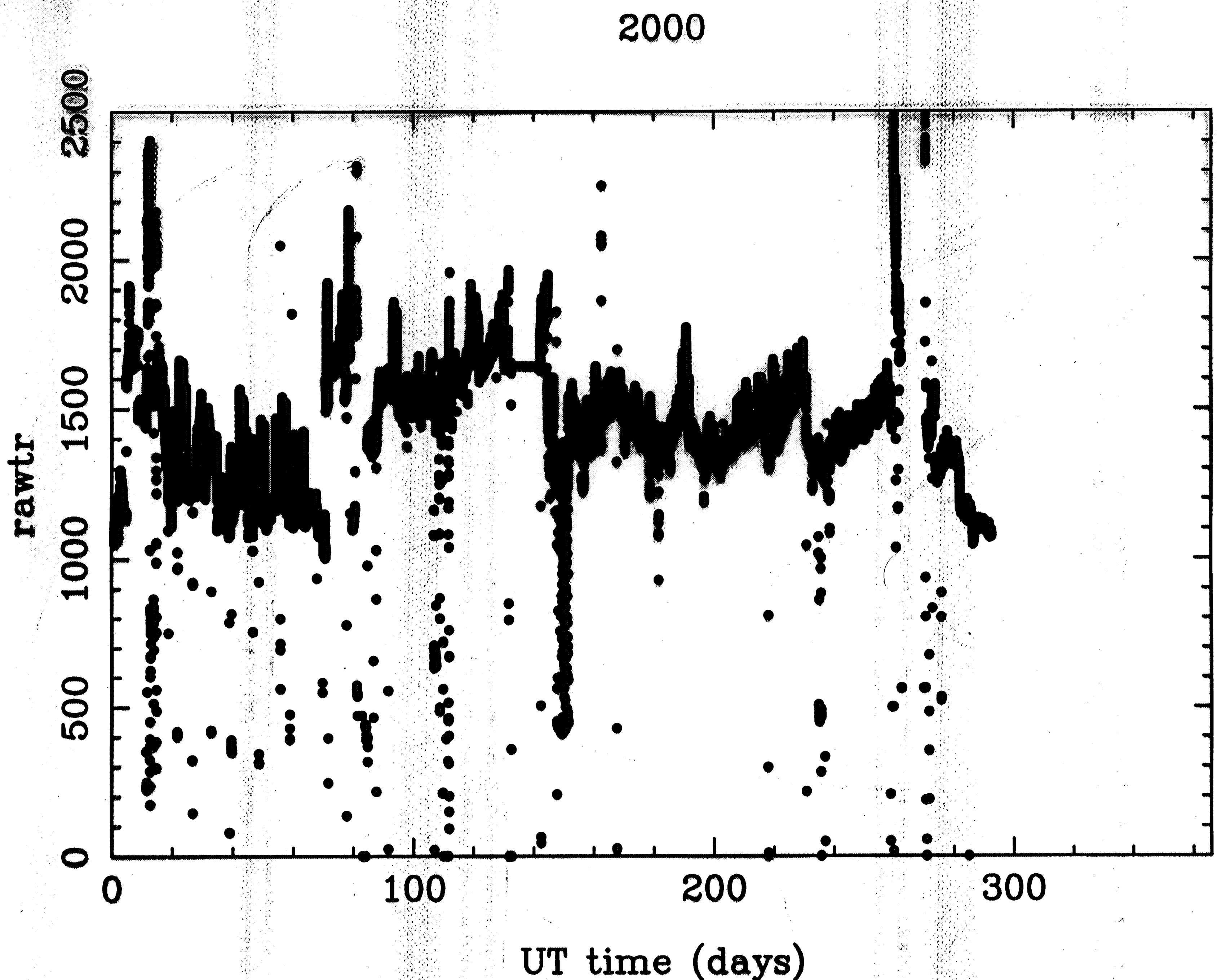
M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

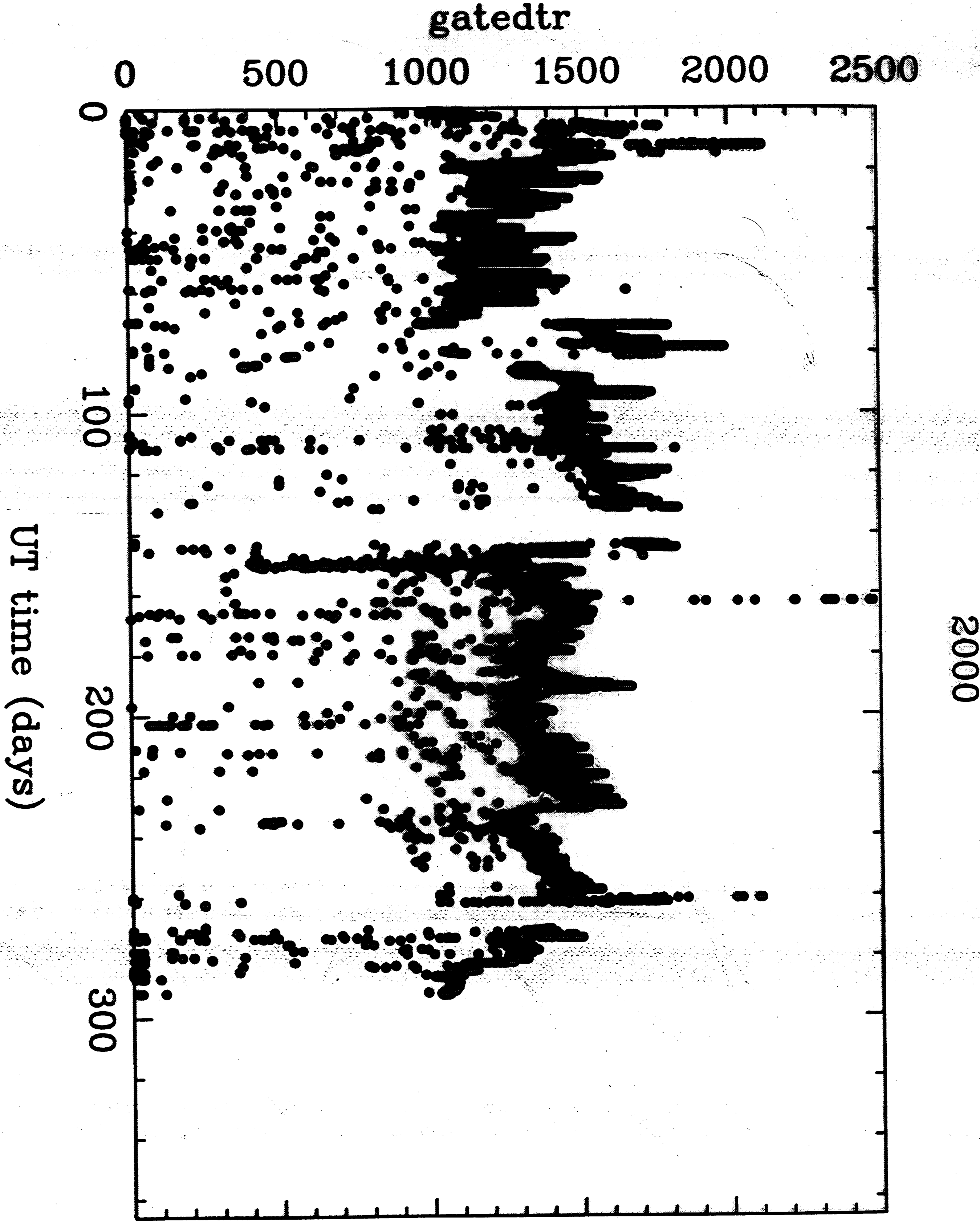
PI / PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Jordan A Goodman		INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Of Rate Sheet	Initials - ORG

Milagro Running Status and PMT Repairs



Gus Sinnis
Milagro Collaboration Meeting
10/22/2000


2000
rawtr
UT time (days)
0
500
1000
1500
2000
2500
0
100
200
300


gatedtr
0
500
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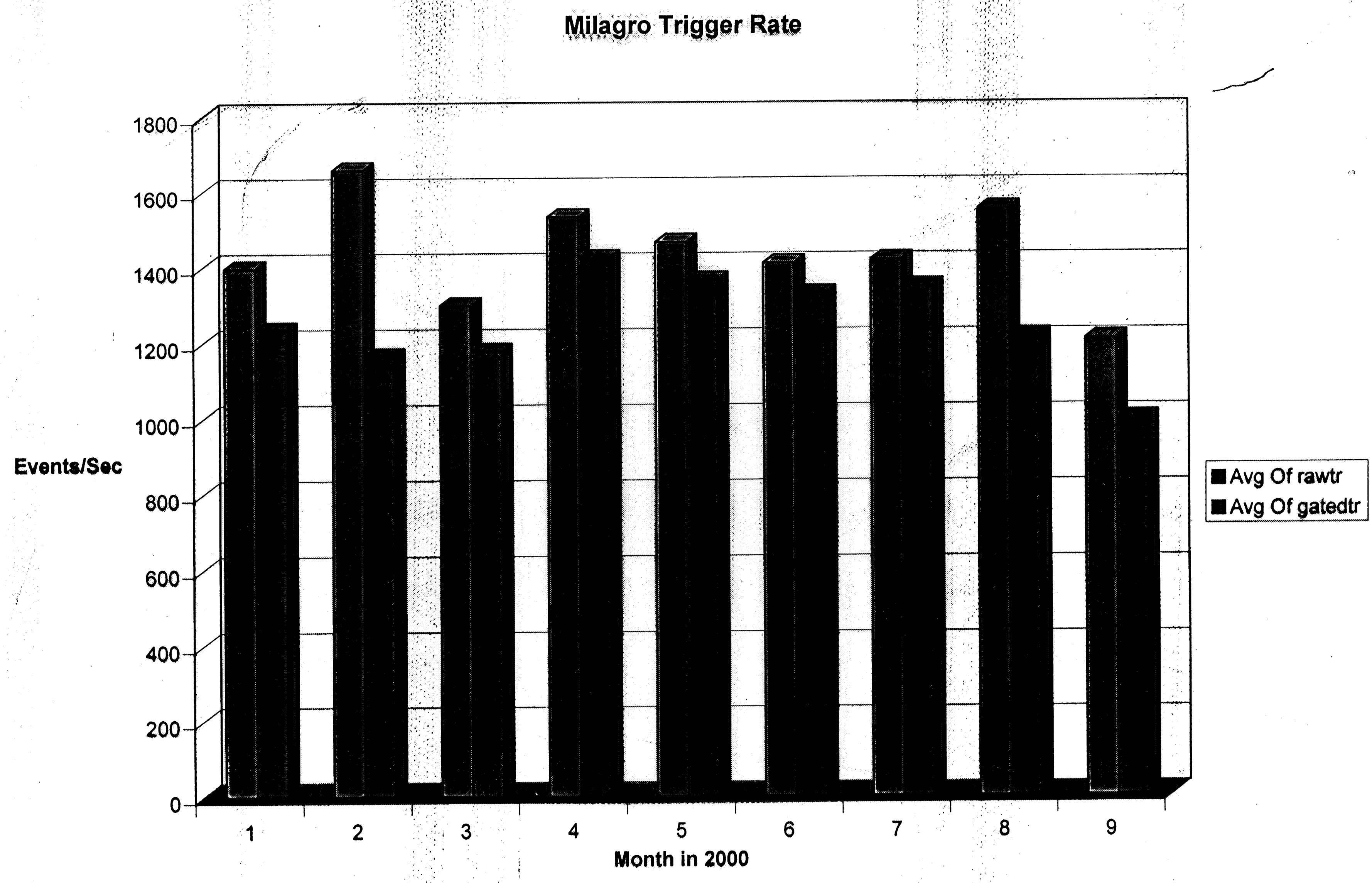
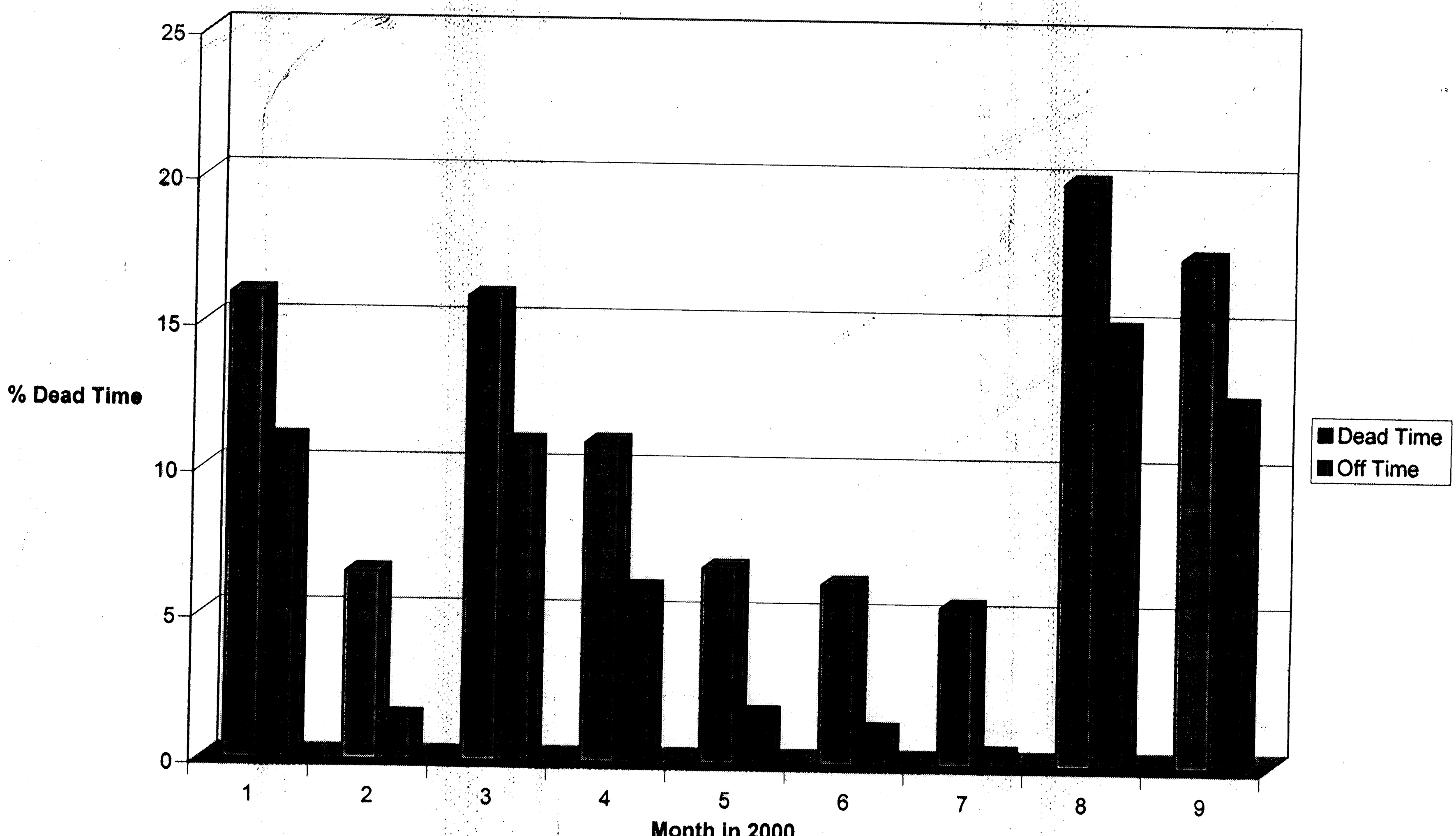
1500
2000
2500
UT time (days)
0
100
200
300
2000



1400 Hz
1251 Hz

Milagro Dead Time



11.6%
6.7% → 93.3% live time

Running Status

Excluding May (Database hosed?) (Fire)

Livetime – 93.3%

- Includes: Repairs 3%
- Calibrations: 2%

Detector is very stable

Causes of downtime:

- Fire (15 days)
- Repairs (9 days)
- Calibrations (6 days) Implement to concurrent mode
- Archiver Obtain more disk space
- Computer Hardware
- Low Voltage Power

DLT Tape Usage

Save Tapes:	~51/month
Sun/Moon:	~23/month
Crab Tapes:	~15/month
REC Tapes:	~5/month
GRB Tapes:	~3/month
Total:	~100/month (+ Mrk) ~budgeted amount

Shift

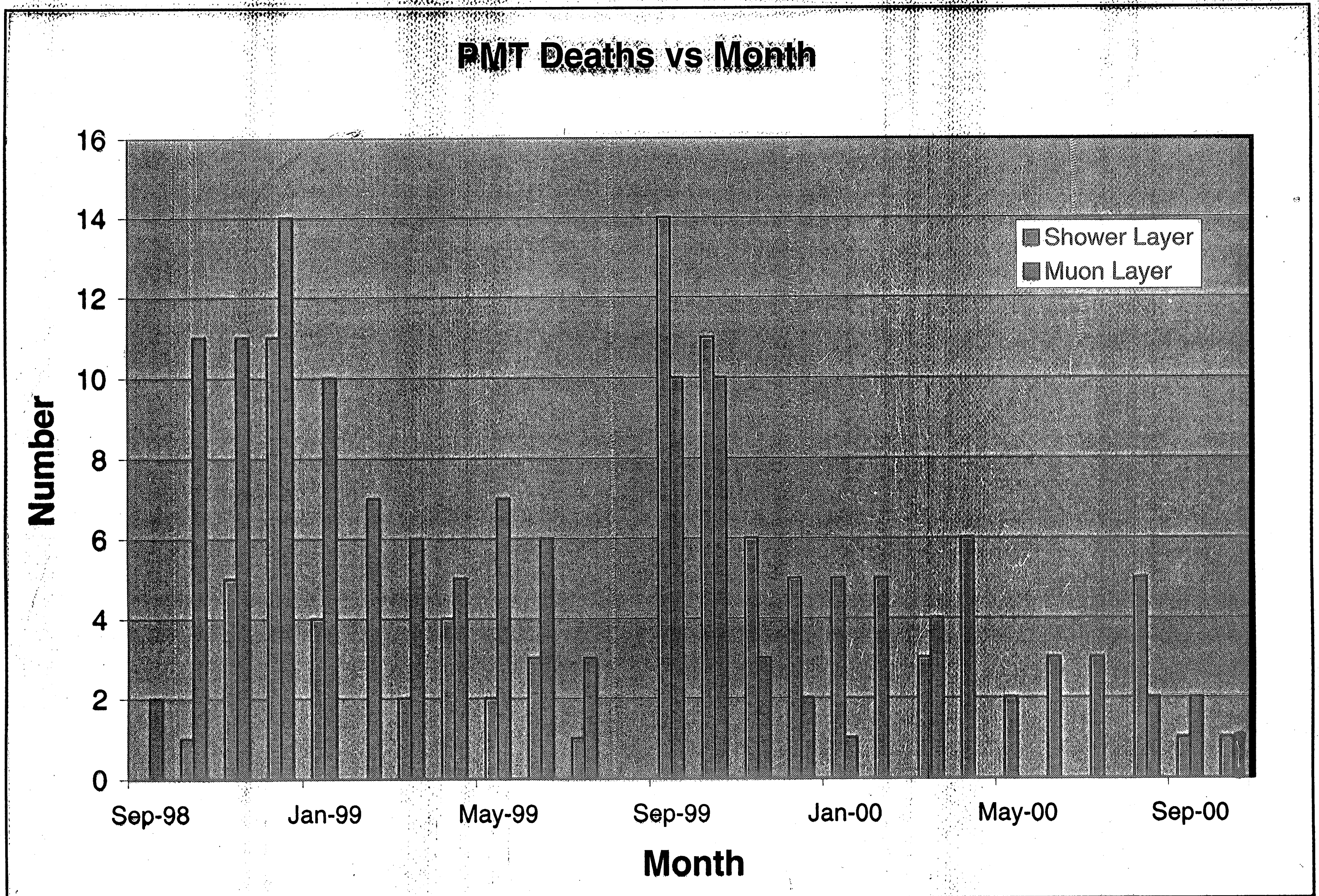
- Do your shift
  - Monitor Histograms
  - Report bad channels to Scott
  - Report anomalies to Gus
  - Do NOT ignore messages from Archiver
  - Write in the Logbook
- Go to site to restart if safety permits
  - Use your backup at night
- Keep live time high

PMT Repairs

9/15	Experiment down, seeded pond
9/16,17	Experiment up for weekend
9/18,19	Divers raised PMTs
9/19-21	PMTs repaired
9/22	Sabbath
9/25	Divers replace PMTs
9/26	Experiment up

PMT Status

- 1 PMT not repaired (115)
- 1 repaired PMT died (stressed during dive) (240)
- 2 PMTs died during repair (435, 526)
- 1 PMT has high rate (535)
- 1 PMT died after right after repair (540 9/26/00)
- 2 PMTs have died since (436 10/10/00 & 618 10/20/00)


PMT Deaths vs Month
Number
16
14
12
10
8
6
4
2
0
Sep-98
Jan-99
May-99
Sep-99
Jan-00
May-00
Sep-00
Month
Shower Layer
Muon Layer

Tape Usage 2

Month	Crab Tapes	GRB Tapes	Rec Tapes	Save Tapes
January 2000				
Summary for 'utdate' = 1/24/2000 11:28:08 PM (20 detail records)				
Min	67	1	9	357
February 2000				
Summary for 'utdate' = 2/28/2000 5:11:56 AM (165 detail records)				
Min	76	5	10	388
March 2000				
Summary for 'utdate' = 3/31/2000 11:55:38 PM (216 detail records)				
Min	91	10	13	438
April 2000				
Summary for 'utdate' = 4/24/2000 8:05:09 PM (72 detail records)				
Min	107	19	15	484
May 2000				
Summary for 'utdate' = 5/24/2000 1:47:09 AM (53 detail records)				
Min	126	25	18	535

Zarsky Water Chillers

mmarrone@waterchillers.com

Chillers Sales & Manufacturing · Pre-Owned Chillers & Refrigeration Equipment

Technical Specifications

Please choose a model from the following menu.

Choose your model..

Or click one of the following links on the left.

MODEL	TONNAGE ±5%	VOLTAGE/PHASE	PUMP HP	G.P.M @ HEAD	TANK GAL	COST
ACWC-24-D	2	208/230/1	1/2	37@20'	25	$3,916.00
ACWC-36-D	3	208/230/1	1/2	37@20'	25	$4,233.00
ACWC-60-D	5	208/230/460/3	1/2 / 3/4	37@20' / 48@20'	25	$4,887.00
ACWC-90-D	7.5	208/230/460/3	3/4	48@20'	41	$6,820.00
ACWC-120-D	10	208/230/460/3	1 1/2	86@20'	41	$8,420.00
ACWC-180-D	15	208/230/460/3	1 1/2	86@20'	82	$12,940.00
ACWC-240-D	20	208/230/460/3	2	150@20'	82	$15,250.00
ACWC-300-D	25	208/230/460/3	3	165@30'	82	$17,750.00
ACWC-360-D	30	208/230/460/3	5	200@50'	100	$20,700.00

V - (713) 462-2500 / F - (713) 462-2544
mmarrone@waterchillers.com

Milagro Shifts

Year 2 - Status and Plans
June, 2000 - May, 2001

Institution	# People	% Shifts Covered to Date
UC Irvine	2	65%
UC Riverside	2	22%
UC Santa Cruz	6.5	57%
LANL	5	13%
Maryland	8.5	31%
New Hampshire	3	0%
NYU	4	44%
Wisconsin	3	73%

Issues to discuss:

1) Do we want to continue backup shifts? Are they necessary or useful?

2) Some collaborators did not fulfill their shift responsibilities last year and some appear not to be doing so this year. Should we enforce our policy, or what should the policy be?

3) What is our shift policy for Milagrito students? Who are they?

4) I need shift requests for the 3rd quarter [December, 2000 - February, 2001].

Safety Issues

1. Safety IS IMPORTANT

   If we screw up - We could get shut dow

   Studies show that making things safe
   make things more efficient - Ask Dup

   Most Important - We don't want anyon
   to get hurt

2. LANL + DOE are in the midst of
   Safety + Security Frenzy

   They have many aspects of this wro

   Emphasis on mandatory training
   Many courses are bad, useless, etc
   Far too much paperwork
   Checkers checking checkers

3. We should strive to do WORK Safely
   and comply with lab requirements

   Good Example: Gus' planning for Dive

   a) Complete Required training (See list

   b) Let me &/or Mary Hockaday know
   about useless training - in writing
   make suggesti

   c) Truly think about safety - and act on it

10/17/00

Milagro Training Requirements

Name	General Plan	Course Number		Course Title
Atkins, Robert	Computer Security	1425		Computer Security refresher
	TA-53	11575		GERT
Coyne, Donald	Computer Security	1425		Computer Security refresher
		9369		Initial Computer security Training
	Lockout/Tagout	17571		Lock out/tagout Update
		17552		Lock out/tagout Refresher
	Non-energized electrical worker	16822		electrical elective
		16749		electrical injury mechanisms
		16750		LANL Electrical safety program
Delay, Scott	Gas Cylinders/low pressure systems	769		Pressure Safety
Dingus, Brenda	Computer Security	1425		Computer Security refresher
		9369		Initial Computer security Training
	TA-53	11575		GERT
Ellsworth, Robert	Computer Security	1425		Computer Security refresher
Fleysher, Lazar	Computer Security	1425		Computer Security refresher
		9369		Initial Computer security Training
	TA-53	11575		GERT
Fleysher, Roman	Computer Security	1425		Computer Security refresher
		9369		Initial Computer security Training
	TA-53	11575		GERT
Goodman, Jordan	Computer Security	1425		Computer Security refresher
	TA-53	11575		GERT
Haines, Todd	Non-energized electrical worker	16822		electrical elective
McCullough, Joe	Computer Security	1425		Computer Security refresher
		9369		Initial Computer security Training
	TA-53	11575		GERT
Nemethy, Peter	Non-energized electrical worker	16822		electrical elective
		16750		LANL Electrical safety program
	TA-53	11575		GERT
		9693		TA-53 site-specific
Samuelson, Frank	Substance abuse	7863		Substance abuse awareness
	Laser safety	15181		Laser safety orientation
		17817		Class 3b
	Non-energized electrical worker	16822		electrical elective
		16749		Electrical injury mechanisms
		16750		LANL Electrical safety program
Schneider, Michael	Computer Security	1425		Computer Security refresher
	Non-energized electrical worker	16822		electrical elective
		16749		electrical injury mechanisms
		16750		LANL Electrical safety program
	TA-53	11575		GERT
		9693		TA-53 site-specific
Shoup, Anthony	Computer Security	1425		Computer Security refresher
	TA-53	11575		GERT
Sinnis, Gus	Non-energized electrical worker	16822		electrical elective
		16750		LANL Electrical safety program
Sullivan, Greg	Computer Security	1425		Computer Security refresher
Wang, Kelin	Computer Security	1425		Computer Security refresher
		9369		Initial Computer security Training
	TA-53	11575		GERT
		9693		TA-53 Site-specific
Williams, David	Computer Security	1425		Computer Security refresher
If he ever comes back to LANL:				
Hugenberger, Scott				

Red = available on the Web.

```
APPEAL TO BUY A NEW LASER UNDER OPERATIONS BUDGET (Maryland?)
by Javier Busso'ns Gordo (22nd October 2000)
----------------------------------------------------------------

Cronology:

        August 99:     Peterson laser repaired
        October 99:    Pond repairs finished
        November 99:   First successful calibrations
        January 00:    Non-Petereson laser repaired
        March 00:      Timing calibration
                       Peterson becomes unstable
        July 00:       Take over from Fleyshers
        September 00:  Pond repairs finished
                       Polishing, alignment, etc wih Peterson
                       Toolkit is missing
        October 2-8:   Software, DAQ, fibers test with Peterson
                       Non-Peterson installed, adjusted and tested
                9-15:  23 balls worth of data before NP dies
               16-22:  Struggled to take data for remaining 7 balls
                       Laser company has vanished
                       Data analysis started

        Future:        Find usable part of this data and combine with former for now
                       BUY NEW LASER
                       Take another round of laser data
                       Prepare for outriggers
```

THE LASERS OF FENTON HILL,
a PAW-M by Javier Busso'ns Gordo (21st October 2000)

Last night as I lay dreaming
Of hard-working days gone by
Me mind being bent on rambling
I found in the laser shack ...

Not one but two wee lasers
For our PMTs to calibrate
By shining light inside the pond
At a nice and steady rate.

Right on, right on! - said Wystan
Such a piece of cake! - I said
For even if one of them goes awry
I will always have a spare!

And a toolkit for to fix them
And a Company for repairs
And the NYU behind me
That to fail should be so rare!

But before the work is ended
The fresh laser fails and flickers
And then dies and gets replacED
By a sick one ... that gets sicker.

And the toolkit goes a-missing
And the Company follows suit
While the whole Collaboration asks me
Do we have results en route?

You need a laser expert!
I hear the Fleyshers cry
Other people say it's the pressure
Or the chamber or the dye.

Put the blame on heavy tax cuts
Trigger locks or fuzzy math
But I've seen much better lasers
For ten dollars in Wal Mart.

If you thought that walking hard drives
were a case of misterY
You should've seen our laser toolkit
hiking its way to Wen Ho Lee's

Begod! - says I - let's face it
For these calibrations to be
We need to buy a laser
But a real one, indeed! ...

And when the cock crew in the morning
It crew but loud and shrill
Christ!, I have never seen such lasers
as the ones in Fenton Hill.

Milagro Trigger System Upgrade

Milagro Group Meeting– ~~Nov~~ Oct 2000

Erik Blaufuss– UMD

- The Idea:
  - Replace the discriminator in DAQ trigger with a VME module that allows for:
    - Additional trigger types
    - An event counter
    - Saving information about the PMT analog sum signal that generated the trigger
    - Ability to add "Smart Triggers" at a later time.

New Trigger Types

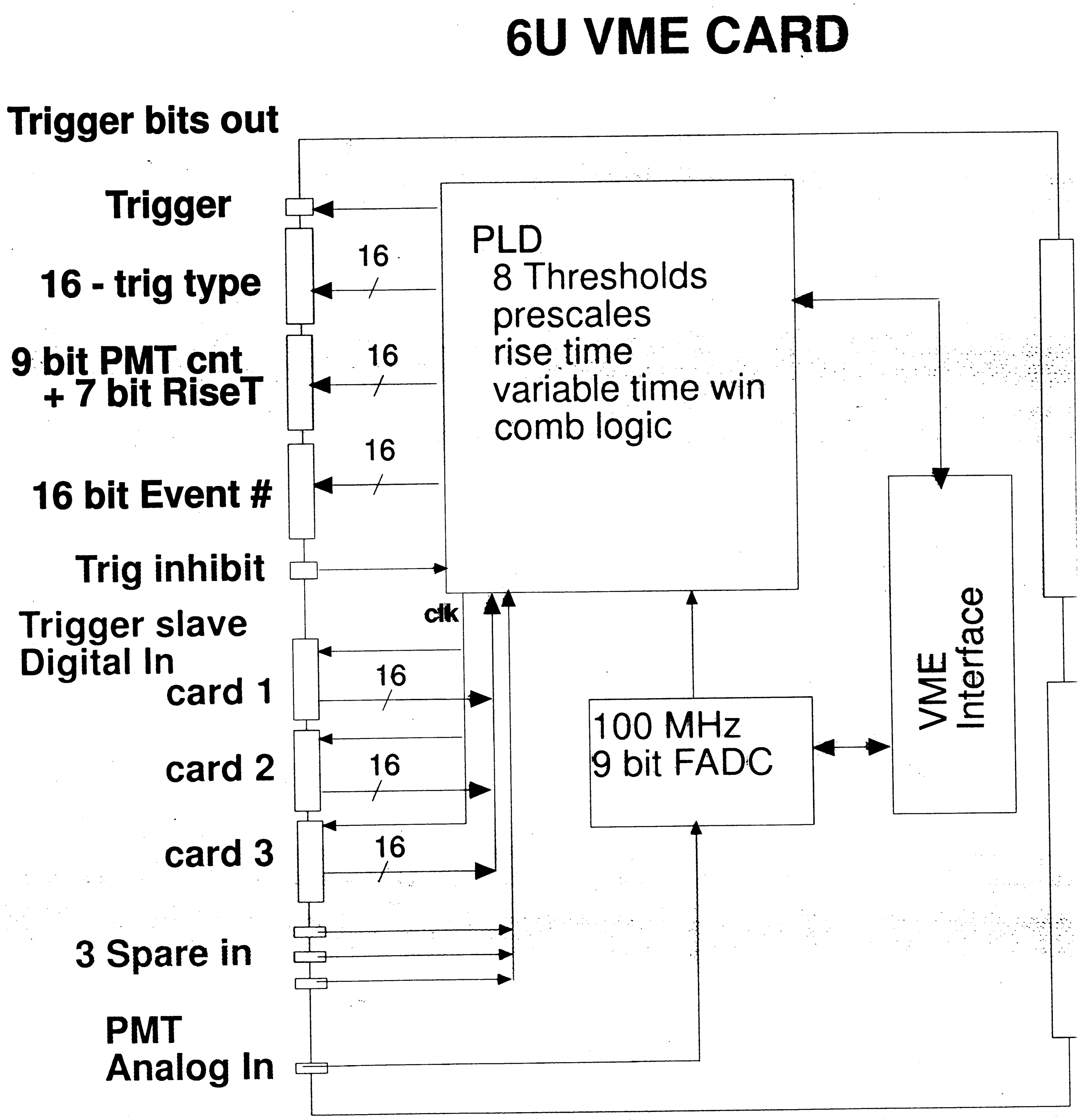
- Up to 8 trigger types possible based on the analog PMT sum signal
  - Triggers generated based on signal height and signal risetime
  - Prescaling of each trigger level possible
  - Threshold and prescale of each trigger type is settable by the VME bus at run start.
- 3 external trigger inputs
  - For calibration, outriggers, etc.
- Each trigger type has unique trigger ID
- Each event can have multiple trigger types.

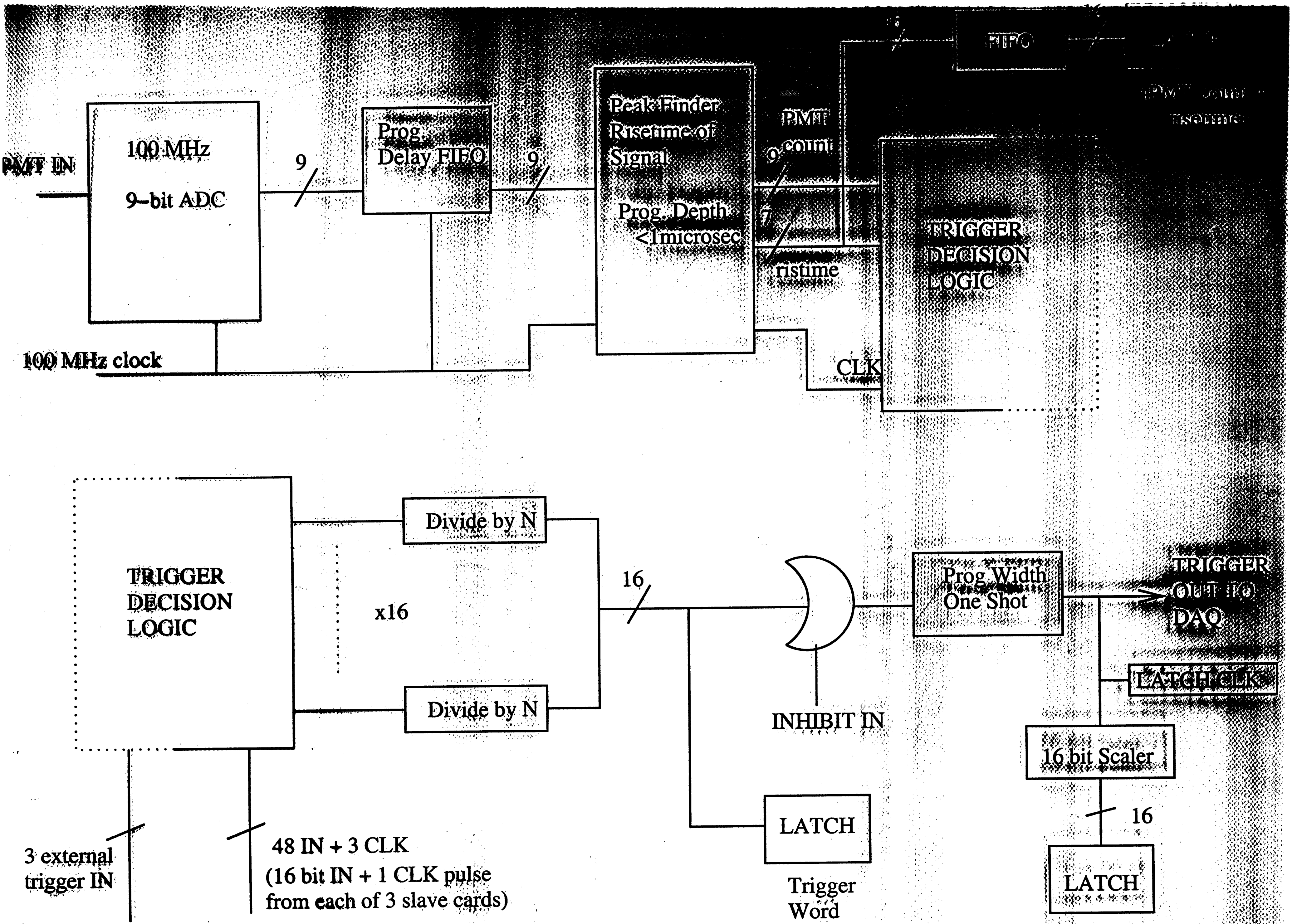
"Smart" Triggers

- 3 16–bit interfaces with CLK inputs are included to allow for the addition of smart trigger units.
- Smart trigger units are VME cards that will generate or reject triggers based on some combination of hits in the shower and muon layers.
- The design of smart trigger units are still under study.

Other Additions...

- A–D conversion of the peak height and risetime of PMT analog sum signal
  - 9 bits for trigger PMT count.
  - 7 bits for risetime of peak.
- 16 bit scaler for an event counter.
- 16 bit trigger word.
- This information is output to the latch to be included in data.


6U VME CARD
Trigger bits out
Trigger
16 - trig type
9 bit PMT cnt
+ 7 bit RiseT
16 bit Event #
Trig inhibit
Trigger slave
Digital In
card 1
card 2
card 3
3 Spare in
PMT
Analog In
16
16
16
16
16
16
clk
PLD
8 Thresholds
prescales
rise time
variable time win
comb logic
100 MHz
9 bit FADC
VME
Interface


PMT IN
100 MHz
9–bit ADC
9
Prog.
Delay FIFO
9
Peak Finder
Risetime of
Signal
Prog. Depth
<1microsec
PMT
count
9
7
ristime
FIFO
TRIGGER
DECISION
LOGIC
CLK
100 MHz clock
TRIGGER
DECISION
LOGIC
Divide by N
x16
Divide by N
16
INHIBIT IN
Prog Width
One Shot
TRIGGER
OUT TO
DAQ
LATCH CLK
16 bit Scaler
16
LATCH
LATCH
Trigger
Word
3 external
trigger IN
48 IN + 3 CLK
(16 bit IN + 1 CLK pulse
from each of 3 slave cards)

Schedule

- Engineering work has already started.
- Now ~ Dec – Design and construction of trigger VME card.
- Dec ~ Jan – Testing
- ~ Feb – Installation at site.
- Next Year – Design and construction of first "smart" trigger cards.

Motivation For Lowering Milagro's Trigger Threshold

Liz Hays and David Noyes

Wisconsin Collaboration Meeting 10/23/00

Lowering the Trigger Threshold

- To have a greater chance of seeing GRB's or AGN we should lower the trigger threshold.
- Lowering the trigger threshold will increase the effective area at low energies, and allow us to obtain more low energy events.
- Problem: Lowering the threshold increases the background rate as well.

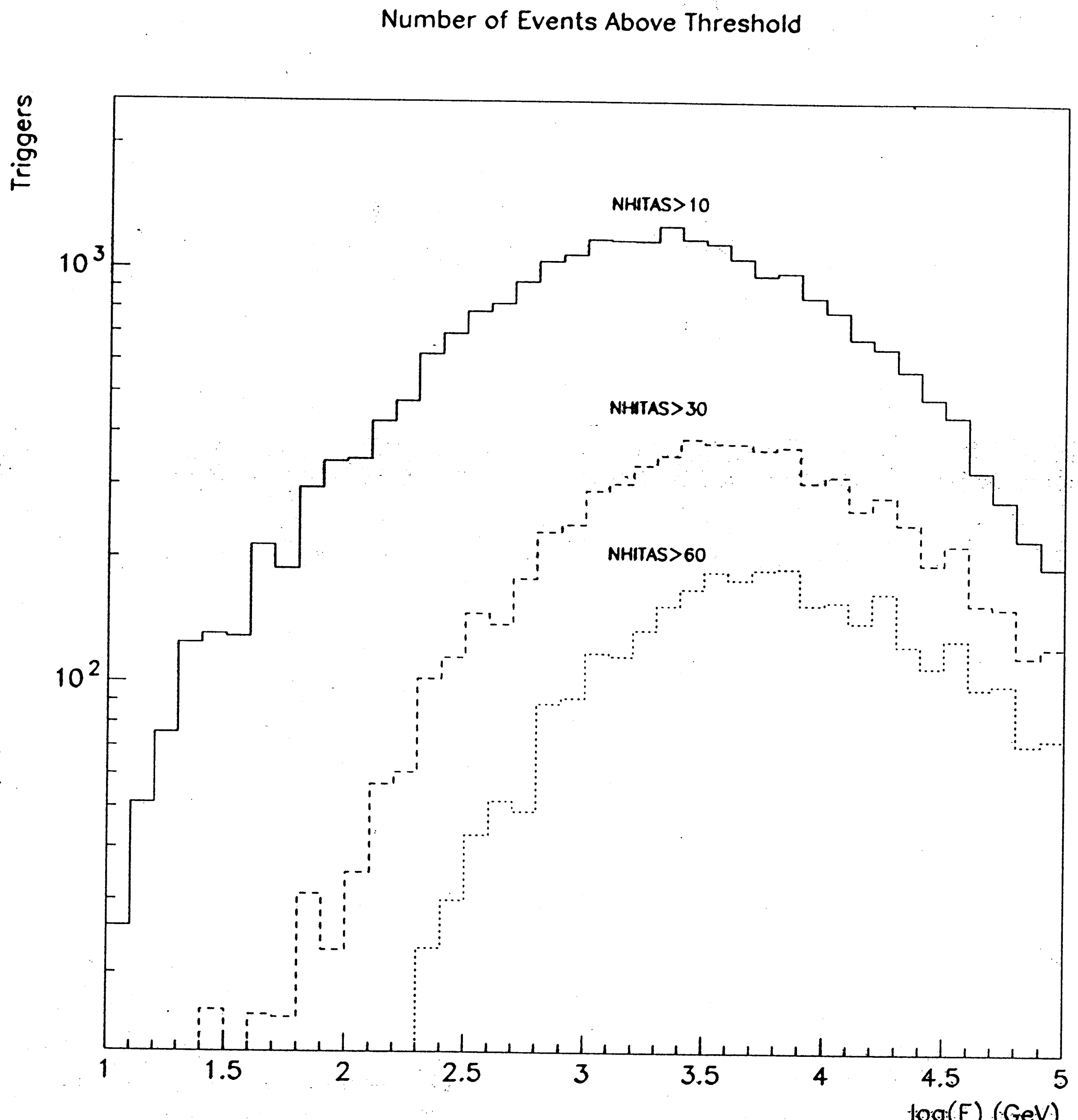


Figure 1: When the trigger threshold is lowered, the increase in gamma triggers is most pronounced at lower energies.

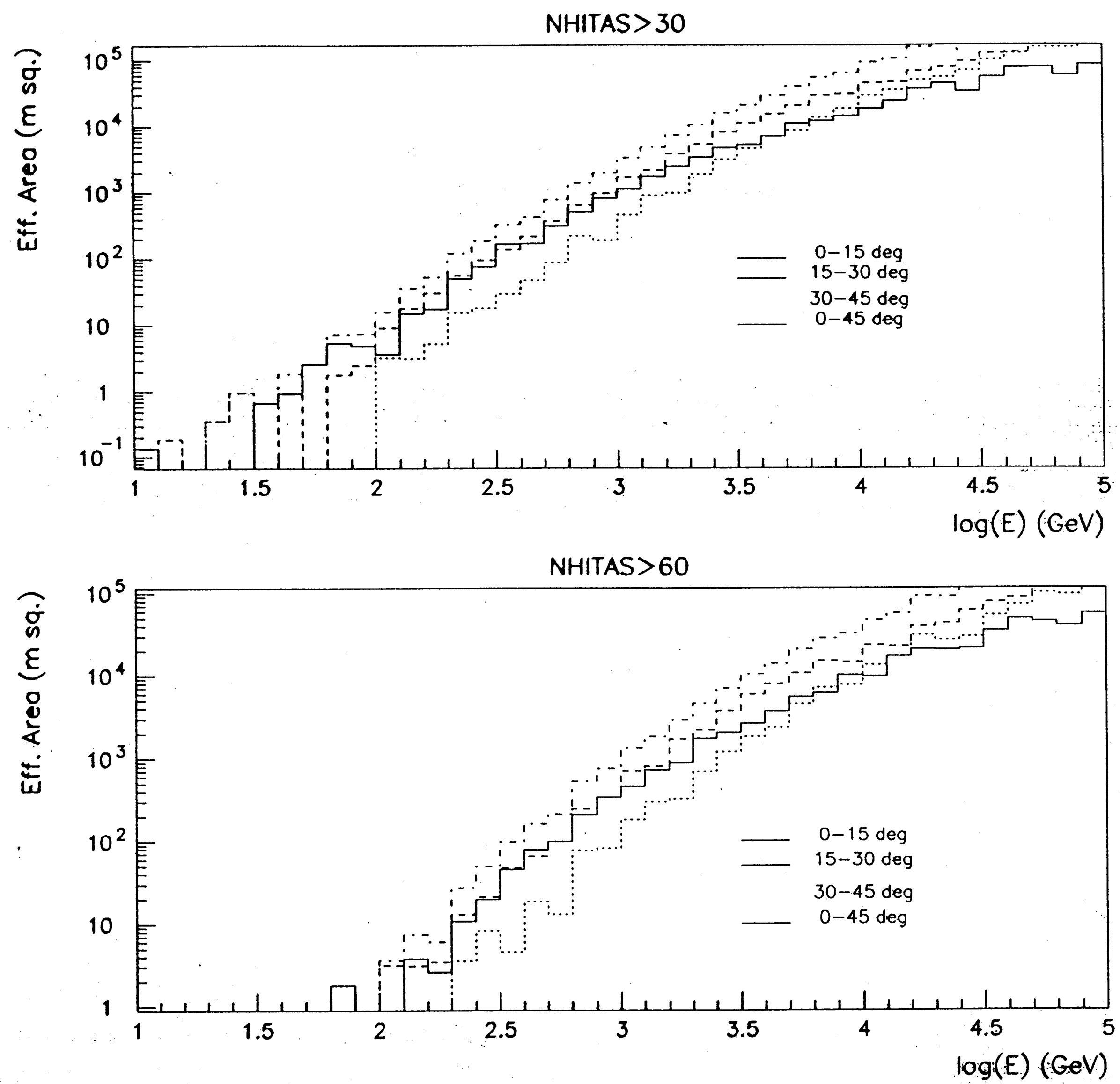


Figure 2: This shows the dependence of the effective area on zenith angle cut. Only events within 0-15 deg. of zenith were considered for our calculations.

MC Rate vs Threshold

- Absorption of extragalactic TeV photons by scattering with infared photons
- Survival Probability
- Event Rate = $\int_{10\,GeV}^{100\,TeV} dE\, Area_{eff}\; N_{trigger} \times \frac{dN}{dEdAdt} \times \mathrm{e}^{-\tau(E,z)}$

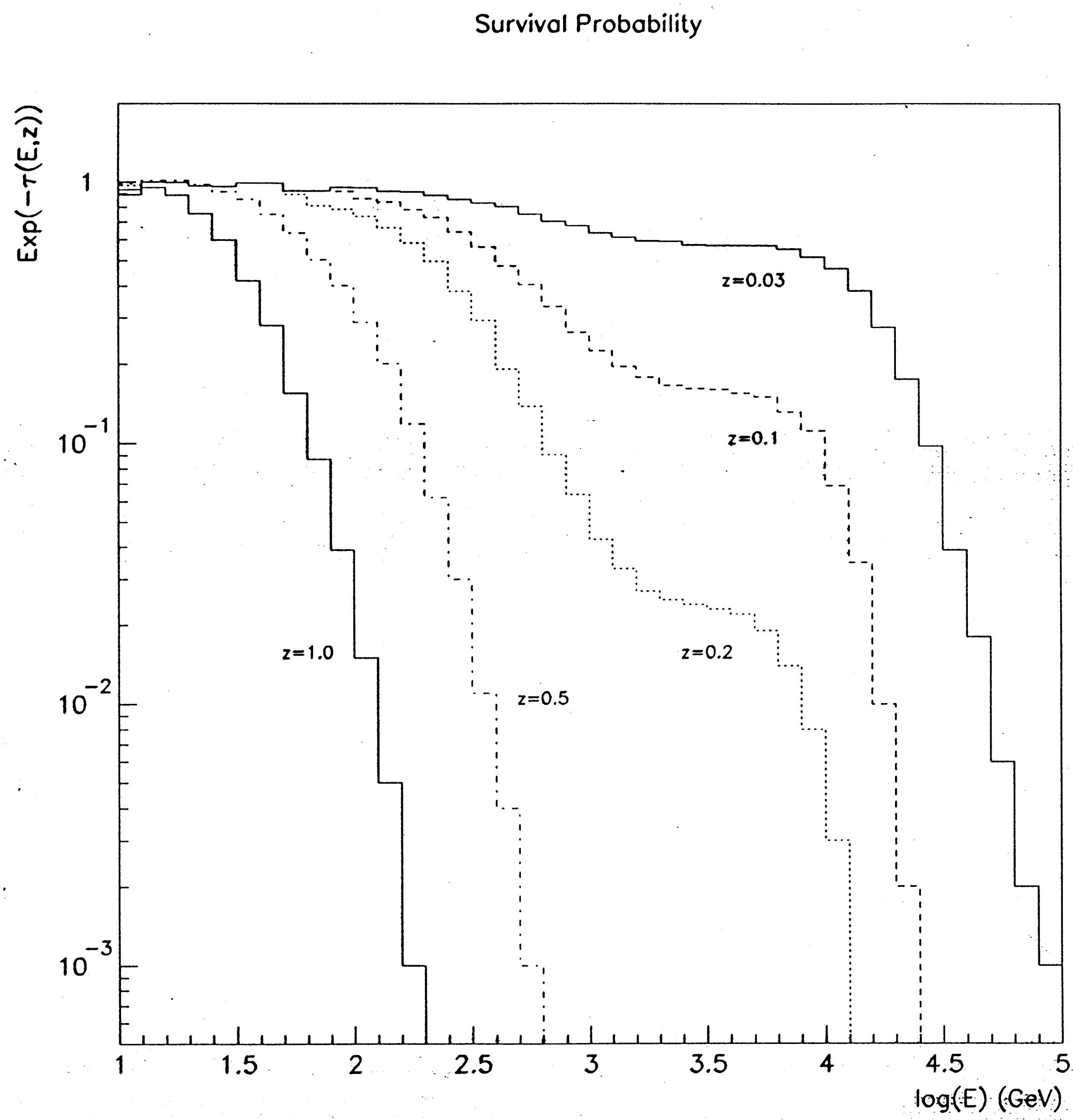


Figure 4: The survival probability as a function of redshift and photon energy is taken from James Bullock's thesis (UCSC, June 1999.)

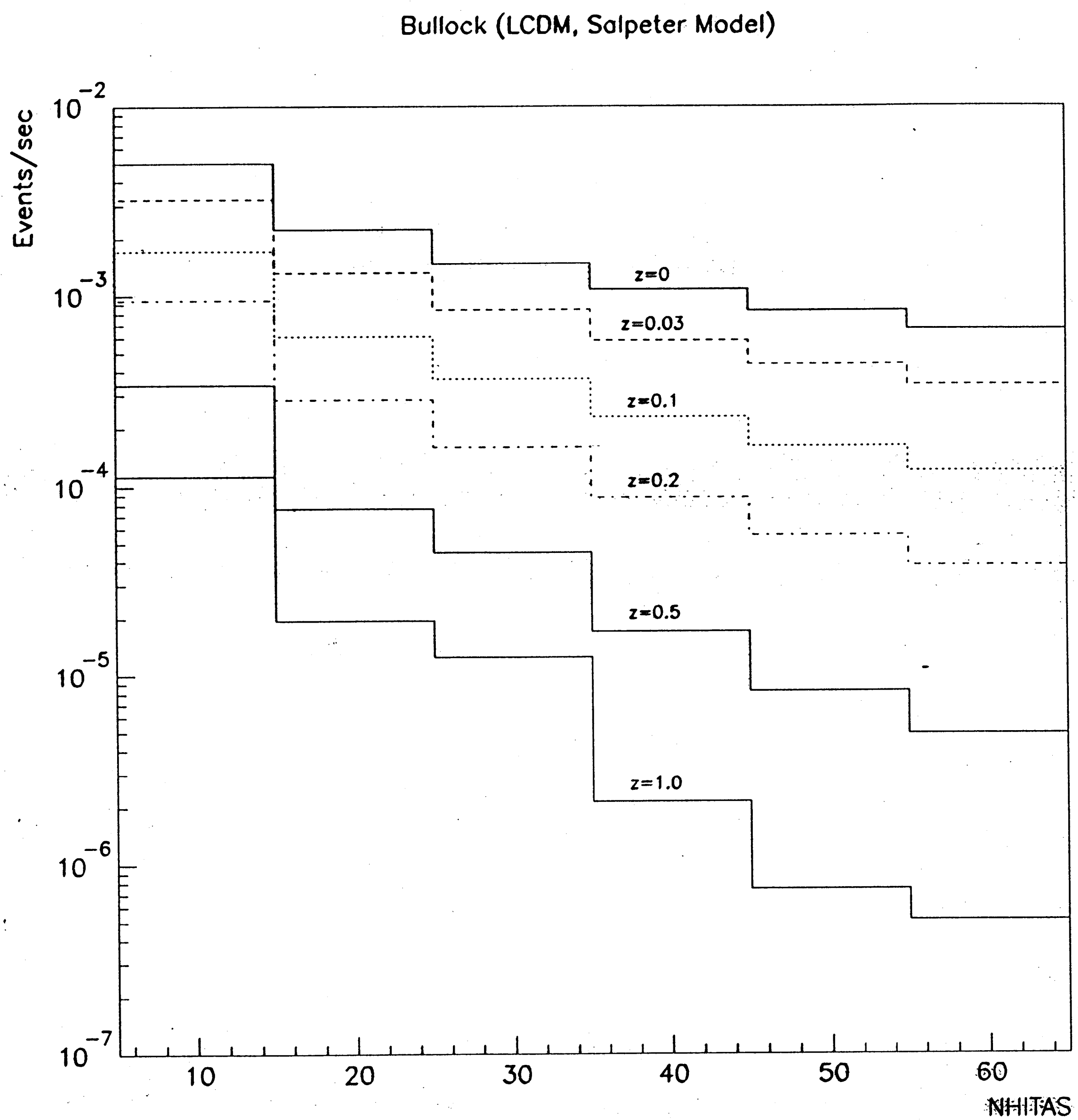


Figure 6: The gamma ray event rates for each z are shown at each threshold. Note that the rate increase for lowered trigger threshold is more dramatic at larger redshifts. Calculations were made for a 70 tube threshold as well but are not shown here as they are very similar to the 60 tube threshold.

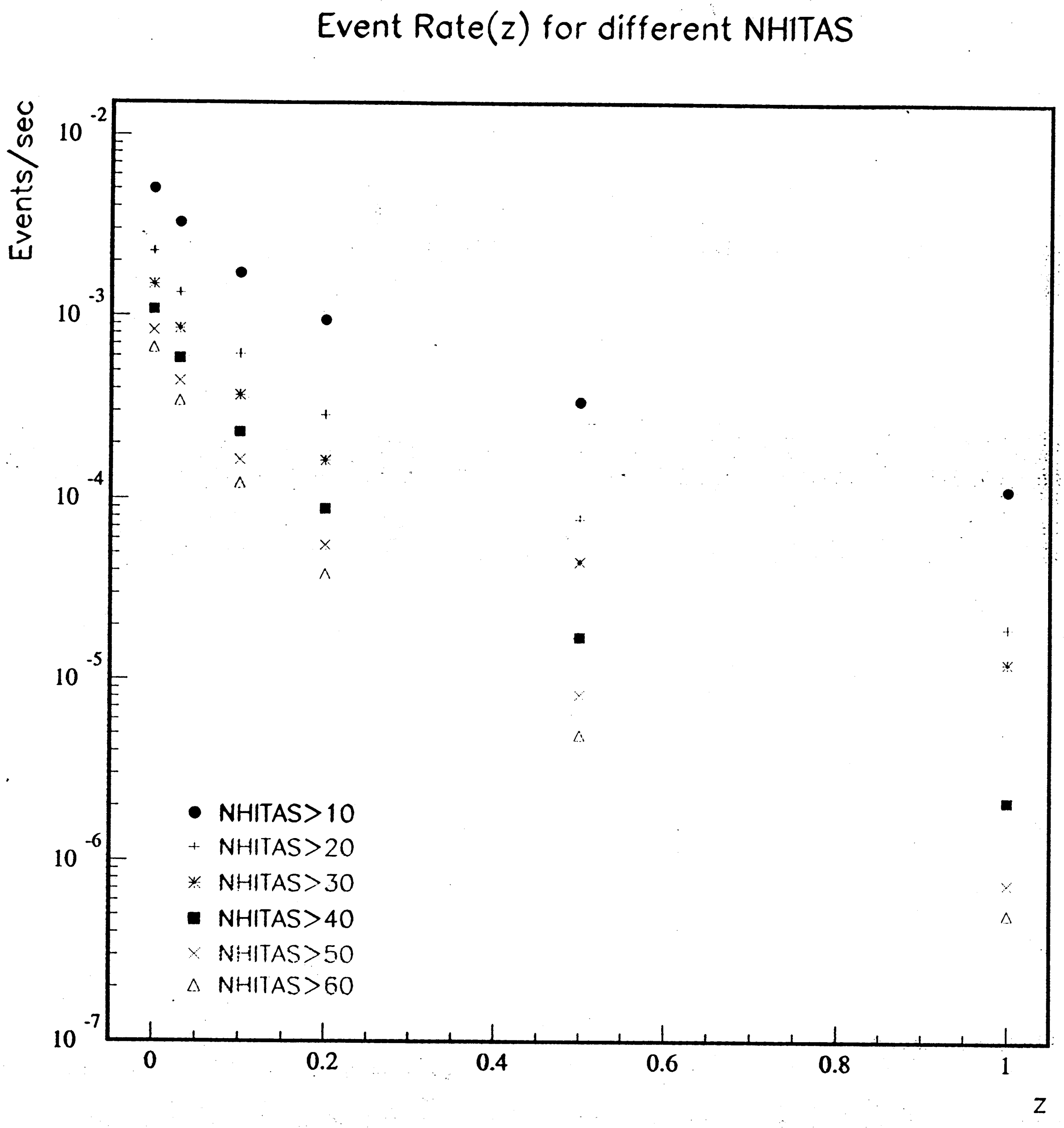


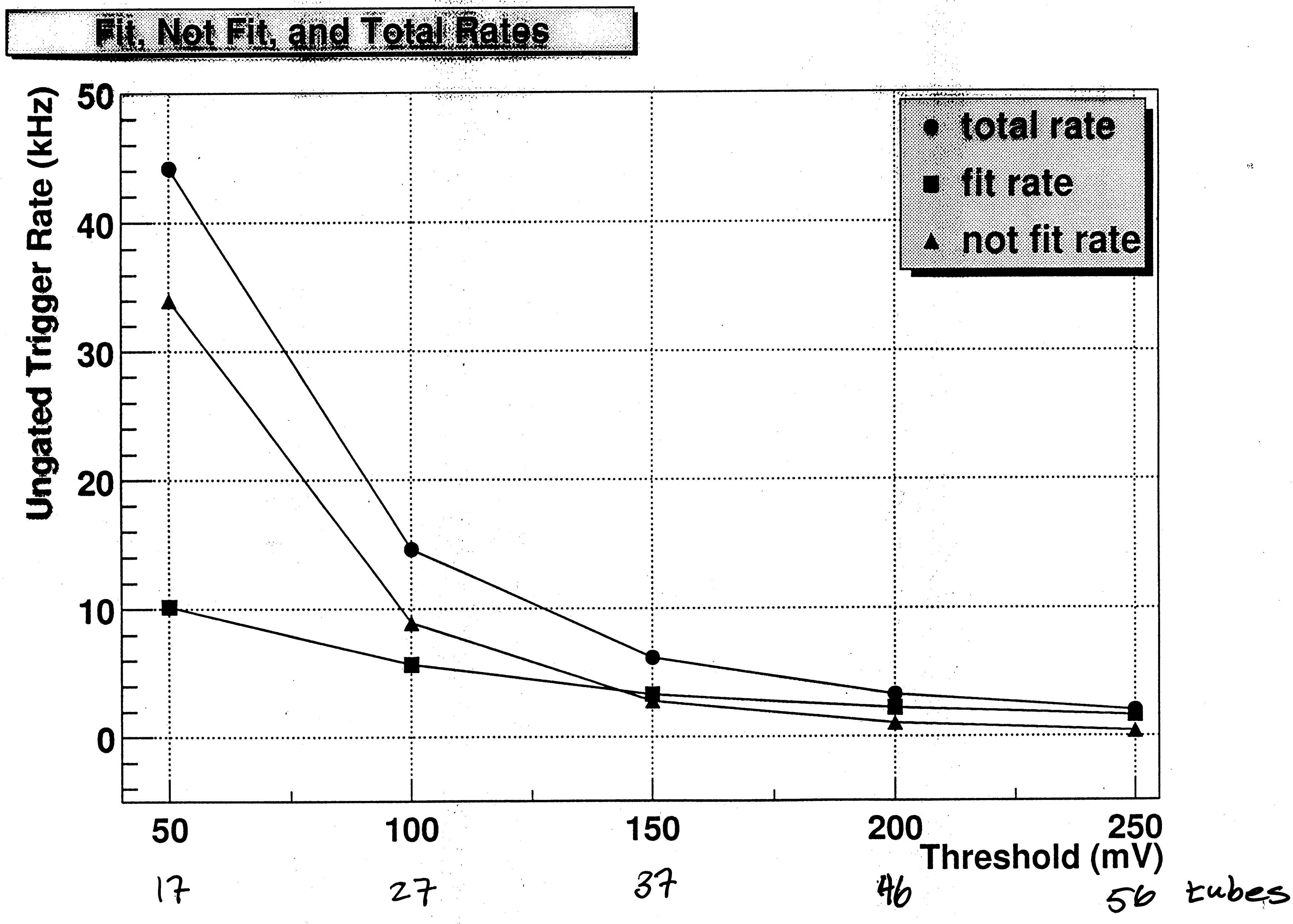
Figure 7: The gamma ray event rate for each trigger threshold is shown as a function of redshift.

Results: Number of events expected assuming a GRB of flux 100 times the Crab and duration of 100 seconds

Trigger Threshold	10	20	30	40	50	60	70
Z =0	50	22	15	11	8	7	6
Z = 0.03	32	13	8	6	4	3	3
Z =0.1	17	6	4	2	2	1	1
Z = 0.2	10	3	2	1	0	0	0
Z = 0.5	3	2	1	0	0	0	0

Conclusion

- Lowering the trigger threshold increases the chance of seeing objects at greater redshift.
- Sensitivity to such events remains to be studied, however we are certain that the background rate is very large, and this suggests the need for intelligent triggering to reduce the background data rate.

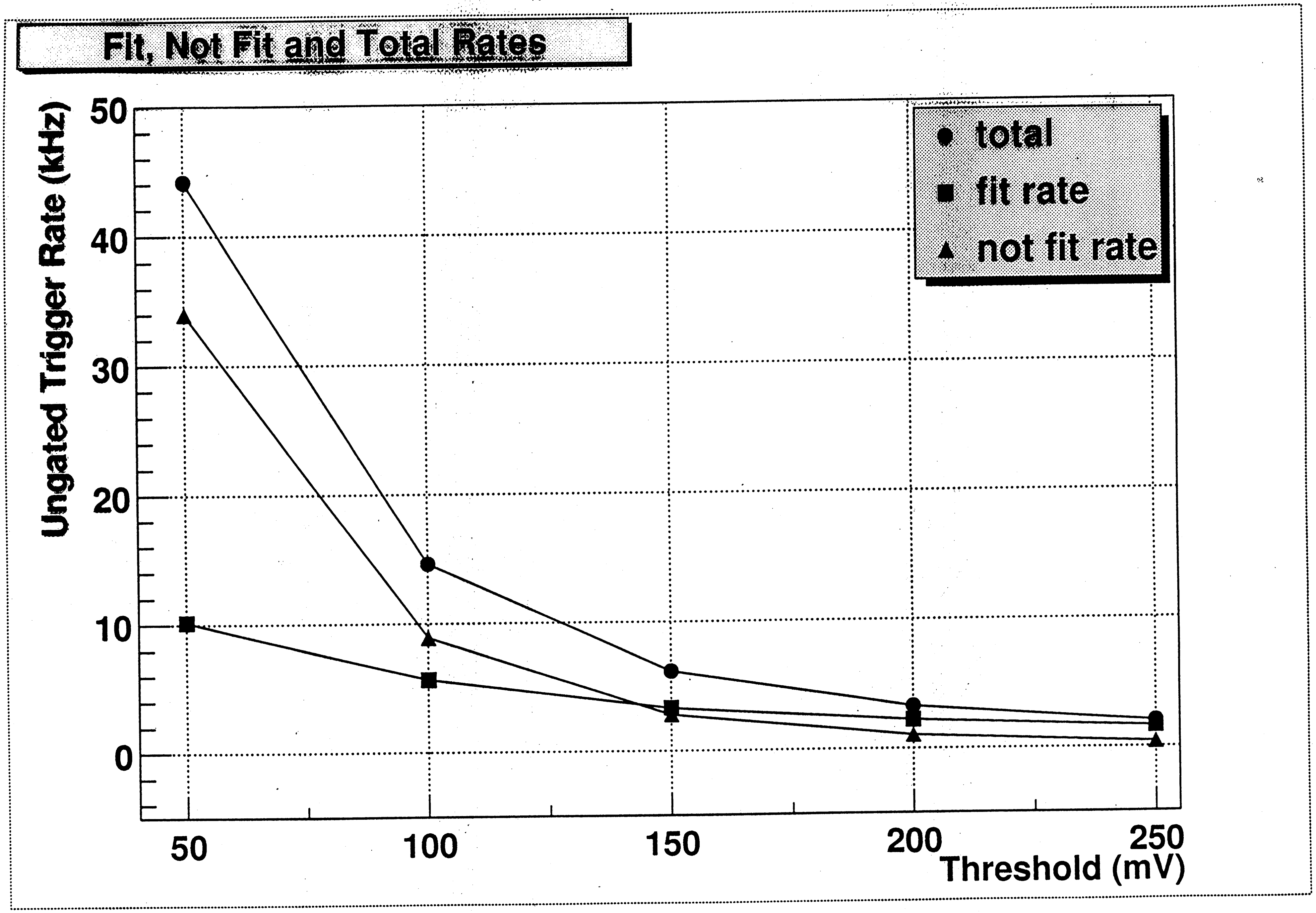

Fit, Not Fit, and Total Rates
Ungated Trigger Rate (kHz)
0
10
20
30
40
50
total rate
fit rate
not fit rate
50
100
150
200
250
Threshold (mV)
17
27
37
46
56 tubes

Intelligent Triggering

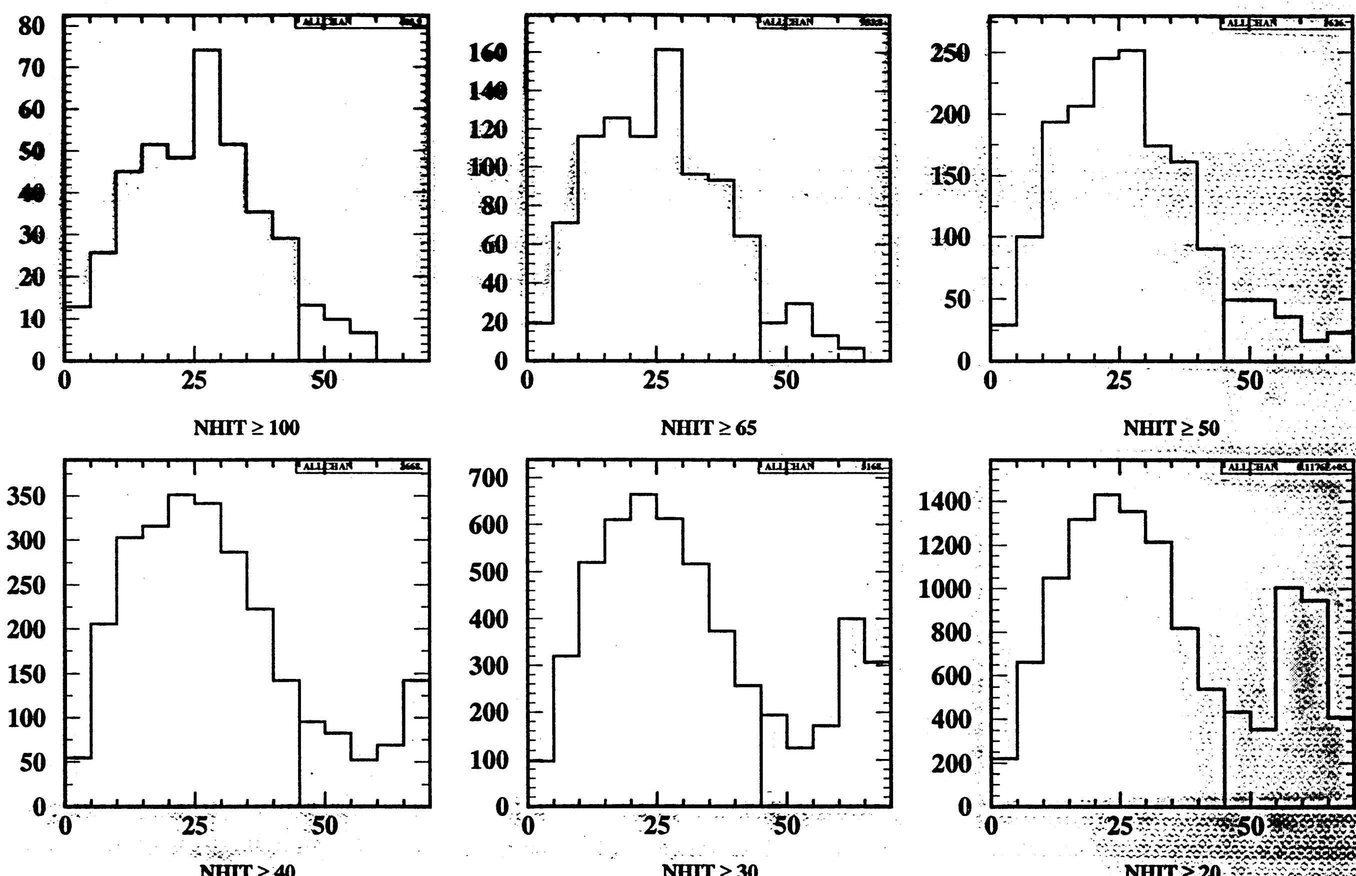
Elizabeth Hays and David Noyes

Problems

- High rates at lower trigger thresholds
- Large fraction of events that don't fit at lower trigger thresholds–at lower trigger thresholds high angle muons can cause a trigger.
- Some simple solution is needed to reduce rates at low trigger thresholds


Fit, Not Fit and Total Rates
Ungated Trigger Rate (kHz)
50
40
30
20
10
0
50
100
150
200
250
Threshold (mV)
total
fit rate
not fit rate

Zenith Angle dist. for 1s of MC data



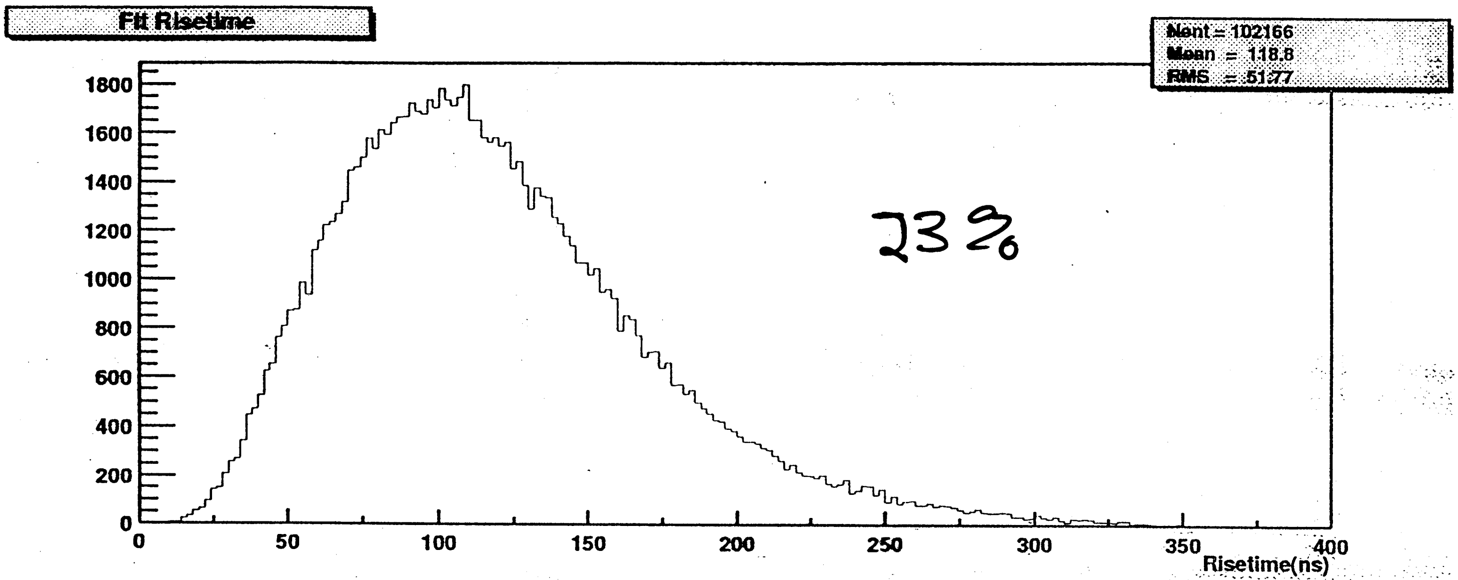
A Simple Solution

- Events that don't fit have a different time characteristic for shower development
- Particle shower velocities go like c
- Muons produce light showers so velocities go like c/n
- A timing cut can be done easily with the new trigger card

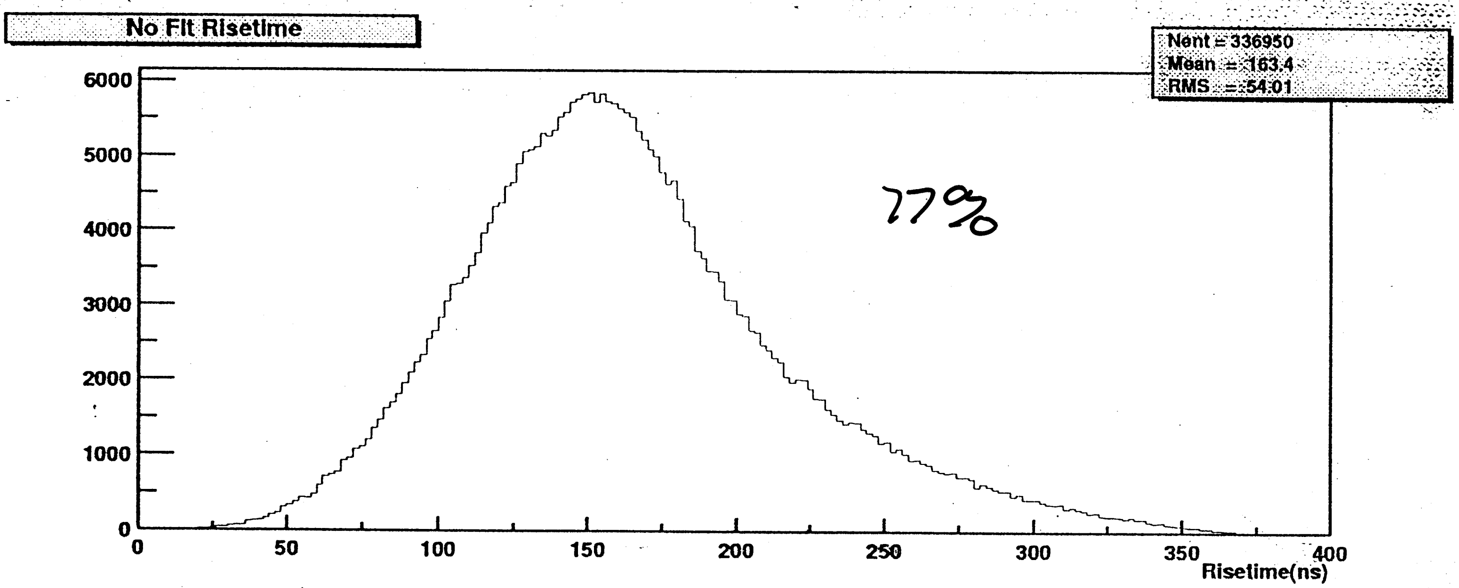
Some Definitions

- Risetime: the time difference from when 10% of the tubes in an event have been hit and when 90% have been hit
- Data refers to 5 raw data files taken at lower trigger thresholds
- Gamma MC results are for $10-10^5$ GeV, zenith angle<45

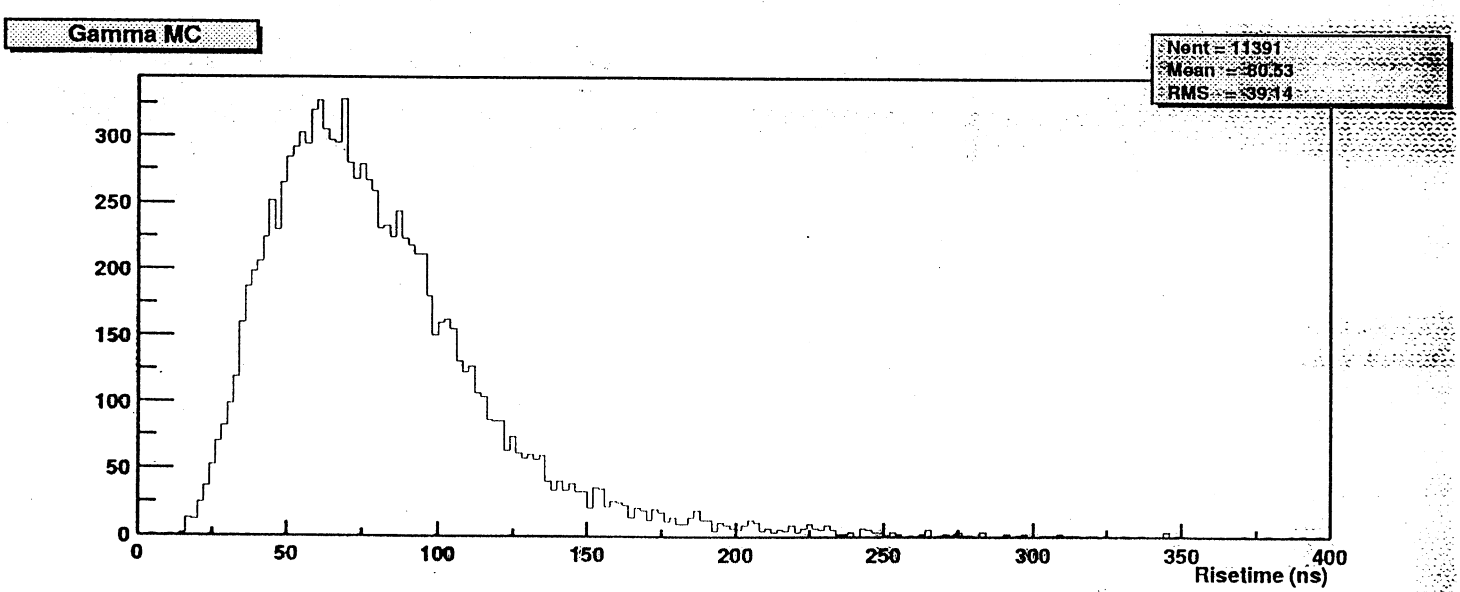
50 mV (17 PMT)



Fit Risetime
Nent = 102166
Mean = 118.8
RMS = 51.77
23%
Risetime(ns)

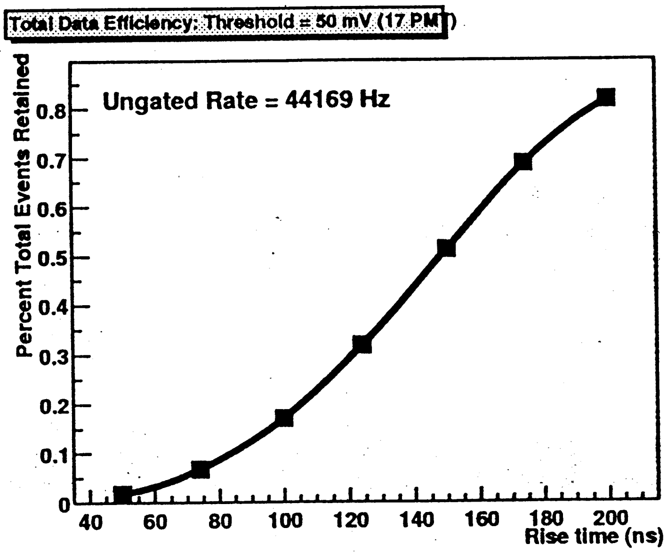


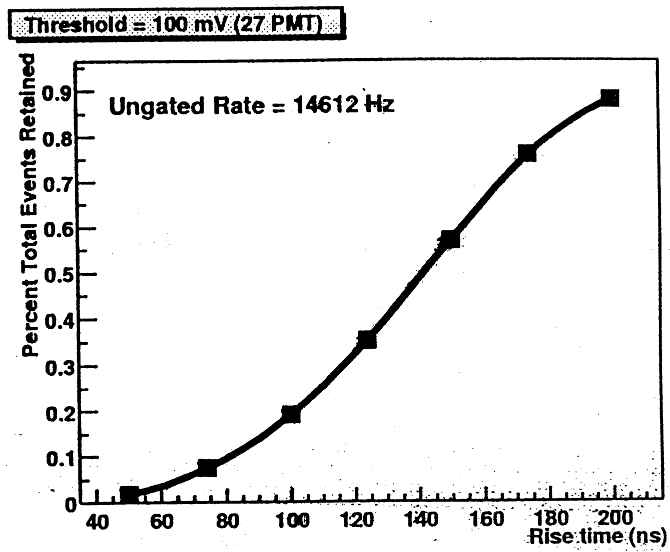
No Fit Risetime
Nent = 336950
Mean = 163.4
RMS = 54.01
77%
Risetime(ns)

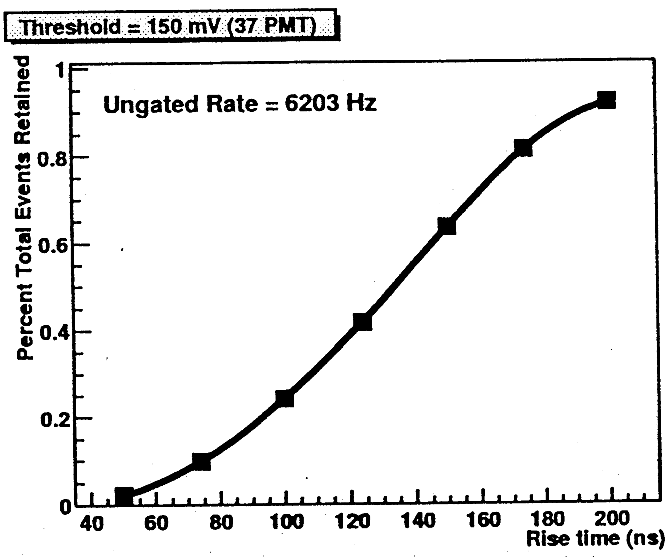


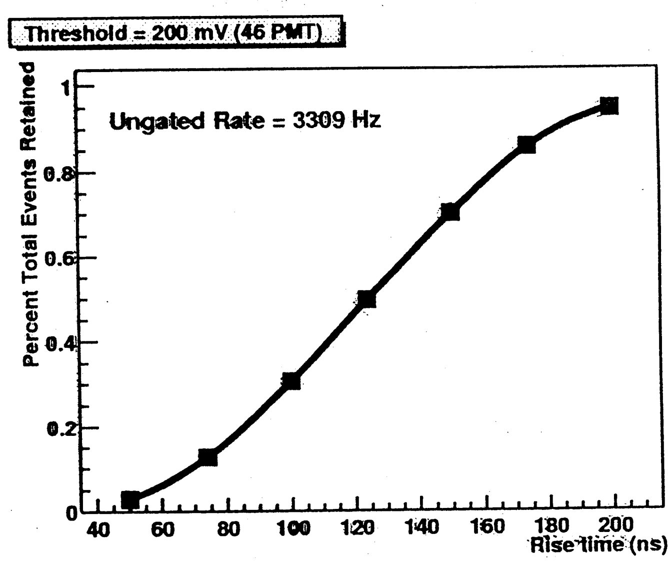
Gamma MC
Nent = 11391
Mean = 80.53
RMS = 39.14
Risetime (ns)

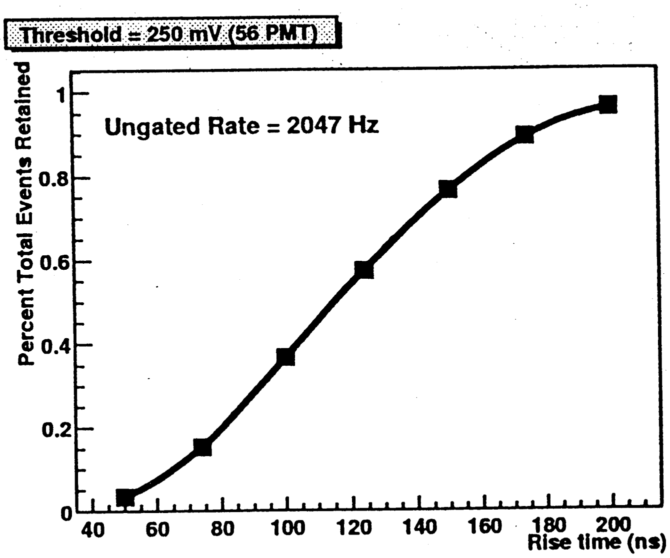
Total Data


Total Data Efficiency: Threshold = 50 mV (17 PMT)
Ungated Rate = 44169 Hz
Percent Total Events Retained
Rise time (ns)

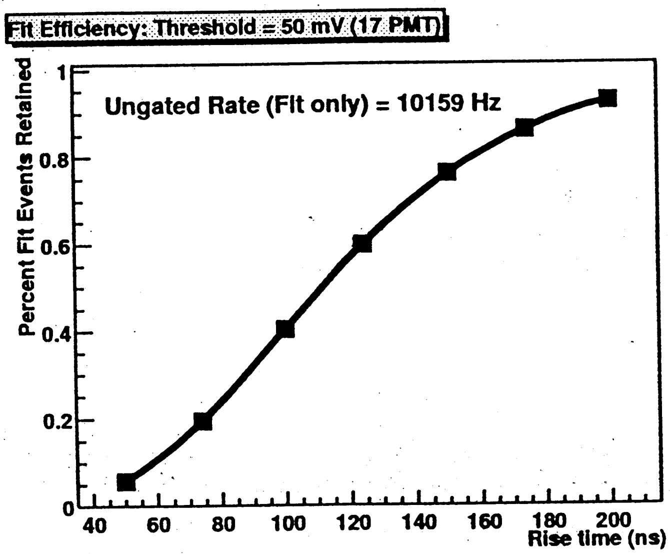

Threshold = 100 mV (27 PMT)
Ungated Rate = 14612 Hz
Percent Total Events Retained
Rise time (ns)

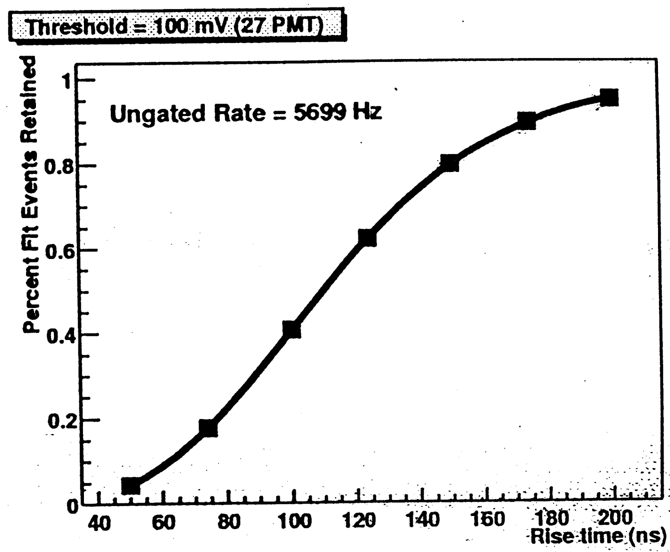

Threshold = 150 mV (37 PMT)
Ungated Rate = 6203 Hz
Percent Total Events Retained
Rise time (ns)

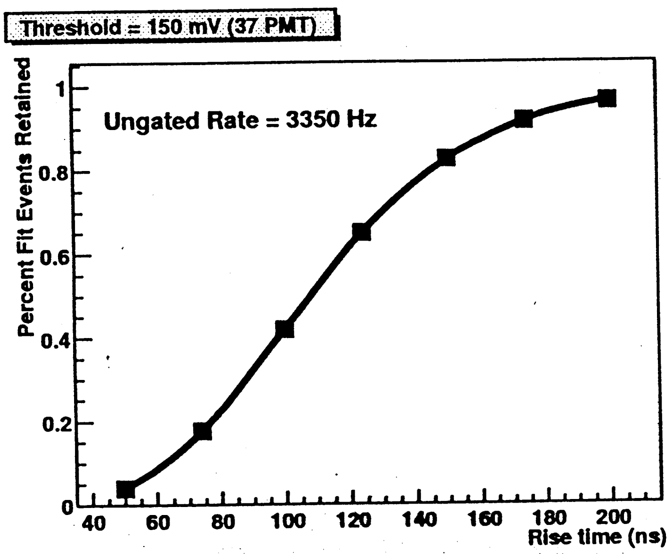

Threshold = 200 mV (46 PMT)
Ungated Rate = 3309 Hz
Percent Total Events Retained
Rise time (ns)

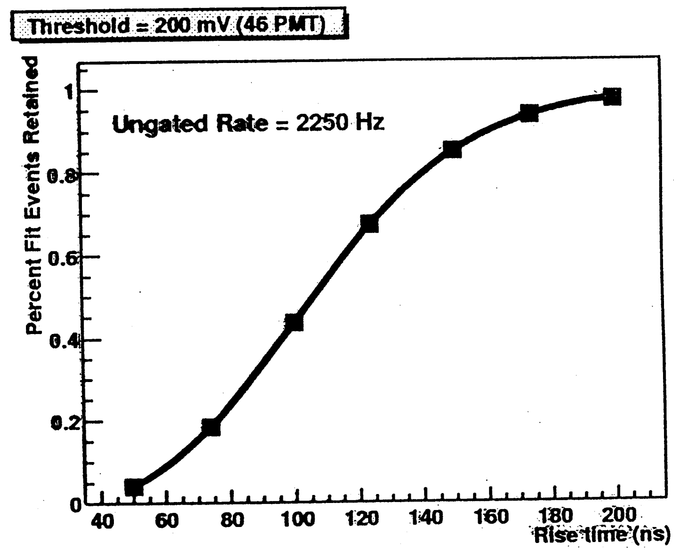

Threshold = 250 mV (56 PMT)
Ungated Rate = 2047 Hz
Percent Total Events Retained
Rise time (ns)

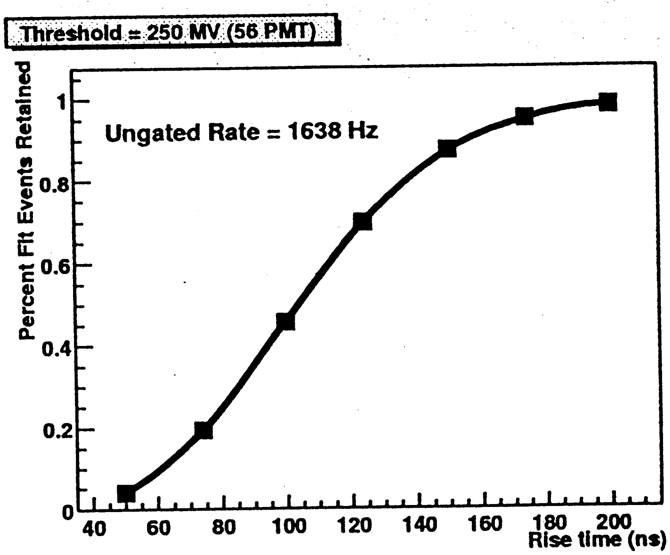
Fit Only


Fit Efficiency: Threshold = 50 mV (17 PMT)
Ungated Rate (Fit only) = 10159 Hz
Percent Fit Events Retained
Rise time (ns)

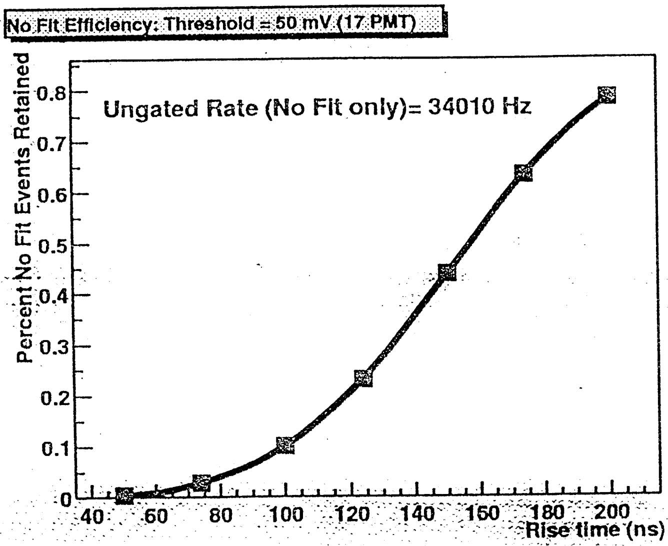

Threshold = 100 mV (27 PMT)
Ungated Rate = 5699 Hz
Percent Fit Events Retained
Rise time (ns)

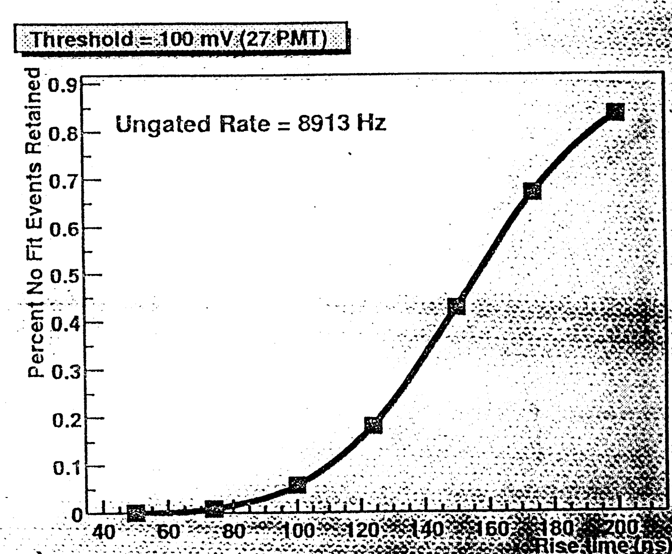

Threshold = 150 mV (37 PMT)
Ungated Rate = 3350 Hz
Percent Fit Events Retained
Rise time (ns)

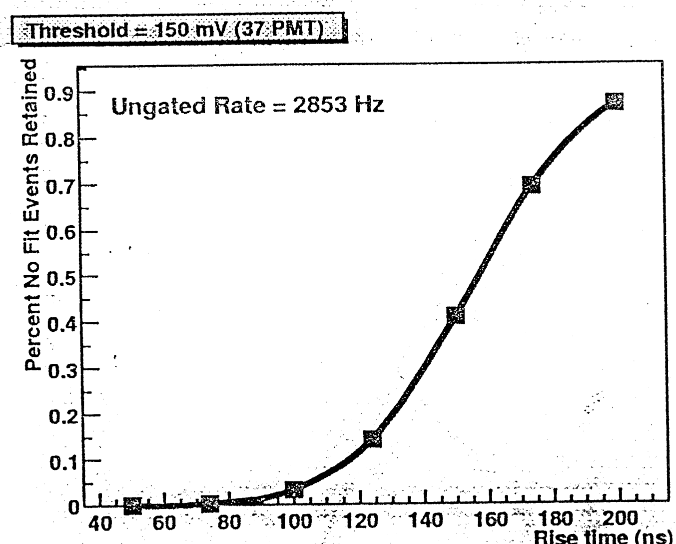

Threshold = 200 mV (46 PMT)
Ungated Rate = 2250 Hz
Percent Fit Events Retained
Rise time (ns)

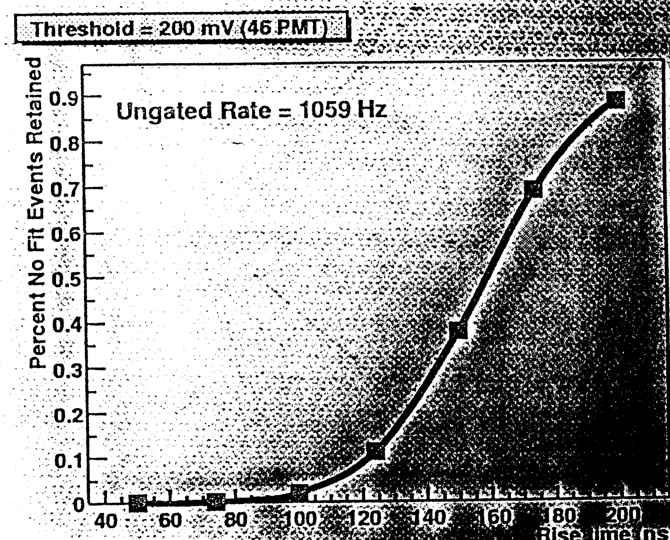

Threshold = 250 MV (56 PMT)
Ungated Rate = 1638 Hz
Percent Fit Events Retained
Rise time (ns)

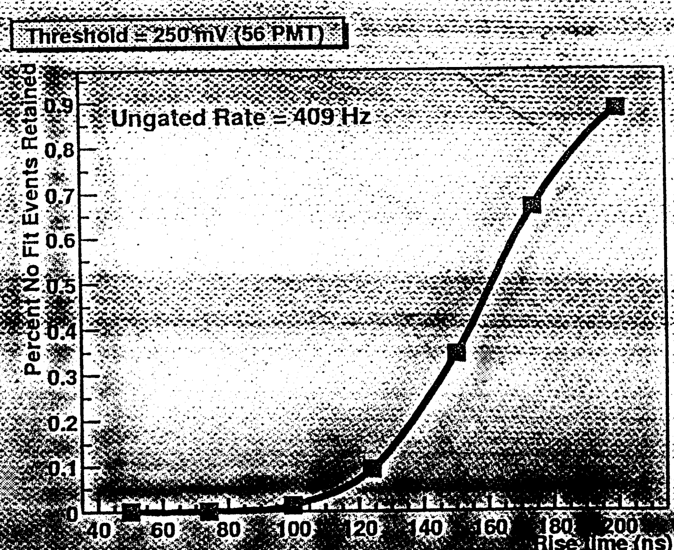
Not Fit Only

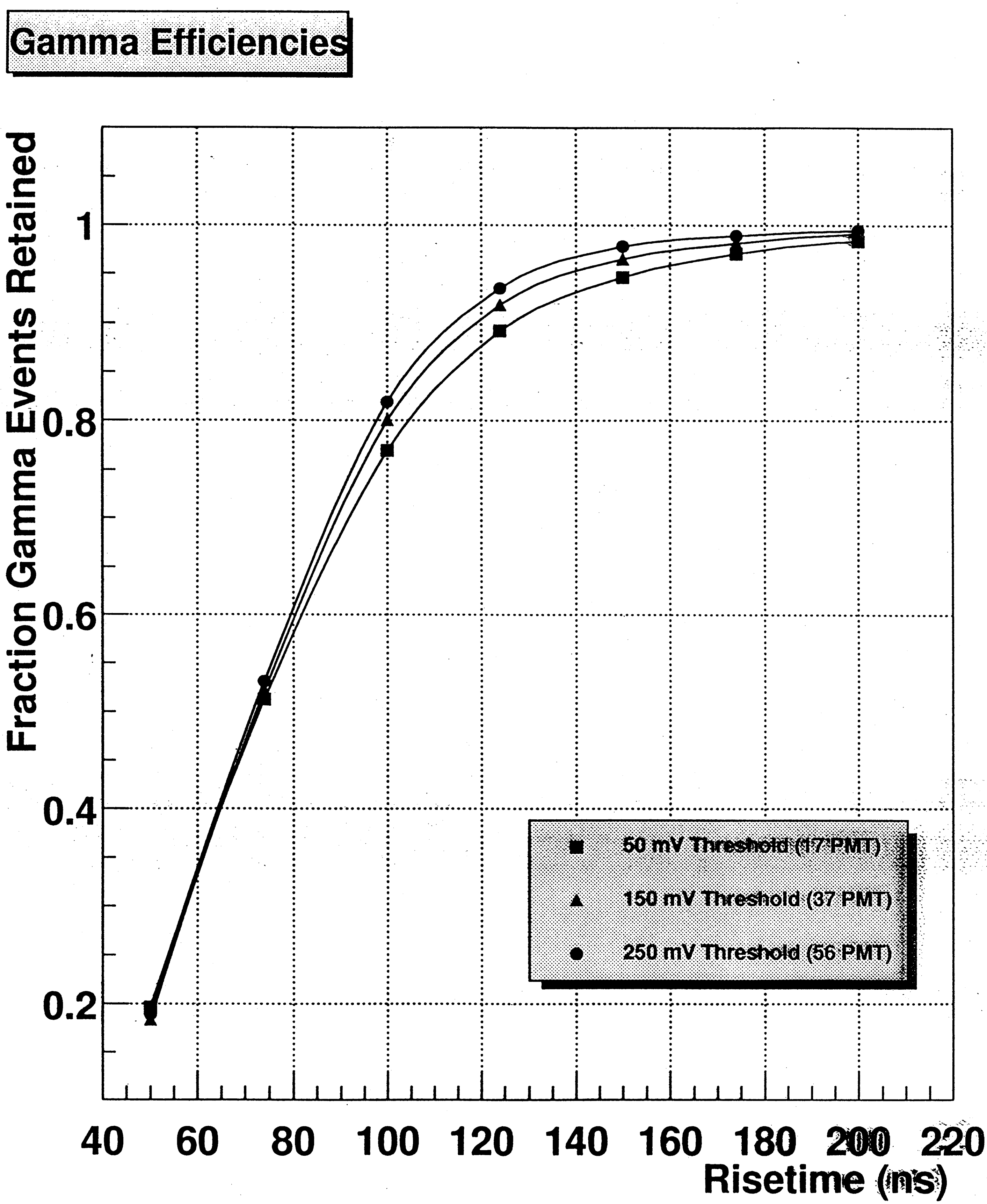

No Fit Efficiency: Threshold = 50 mV (17 PMT)
Ungated Rate (No Fit only)= 34010 Hz
Percent No Fit Events Retained
Rise time (ns)


Threshold = 100 mV (27 PMT)
Ungated Rate = 8913 Hz
Percent No Fit Events Retained
Rise time (ns)

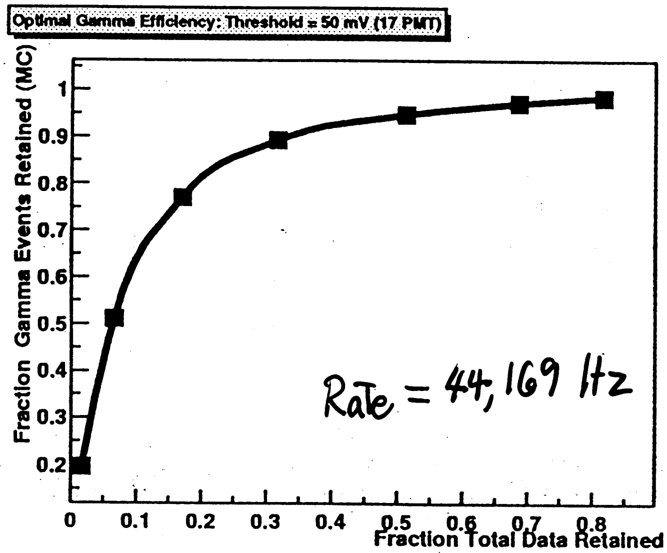

Threshold = 150 mV (37 PMT)
Ungated Rate = 2853 Hz
Percent No Fit Events Retained
Rise time (ns)

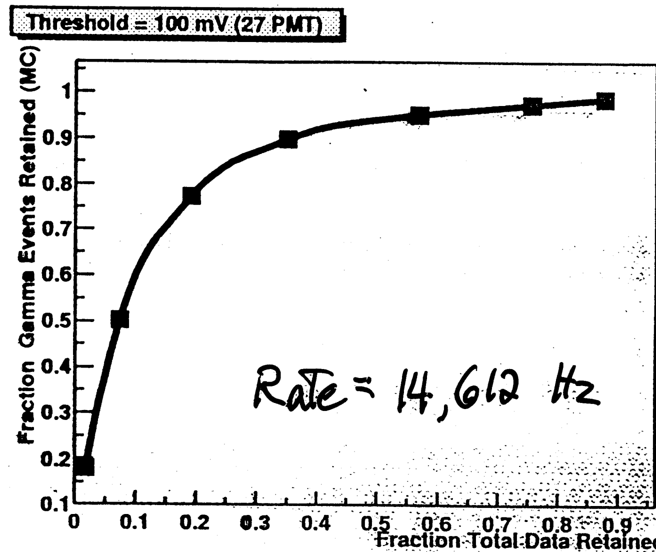

Threshold = 200 mV (46 PMT)
Ungated Rate = 1059 Hz
Percent No Fit Events Retained
Rise time (ns)

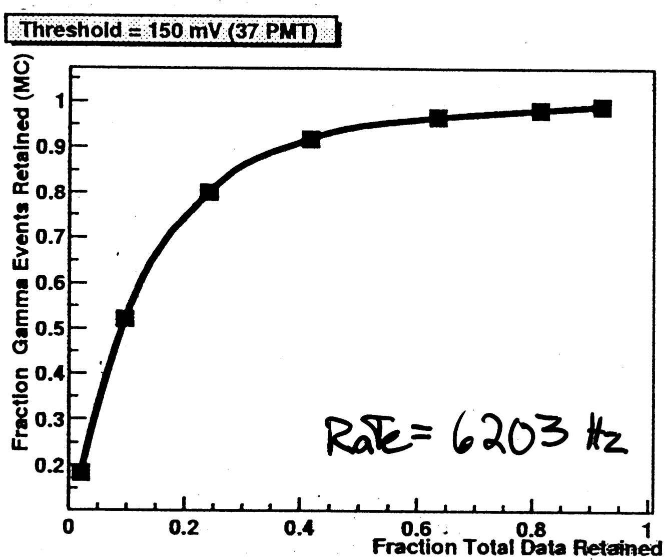

Threshold = 250 mV (56 PMT)
Ungated Rate = 409 Hz
Percent No Fit Events Retained
Rise time (ns)

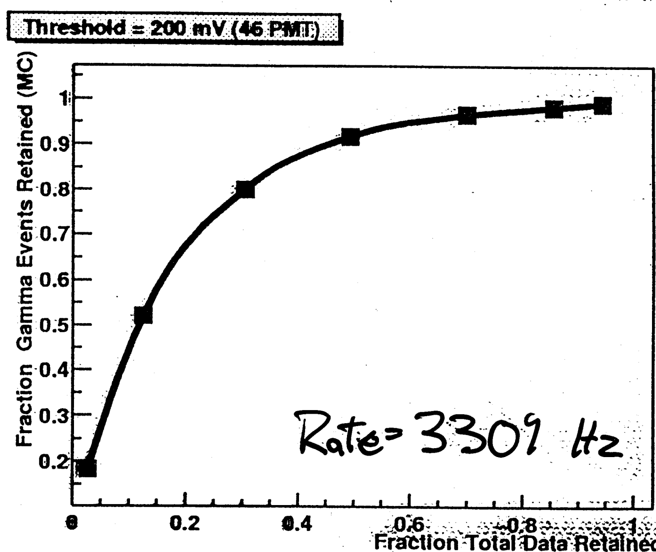


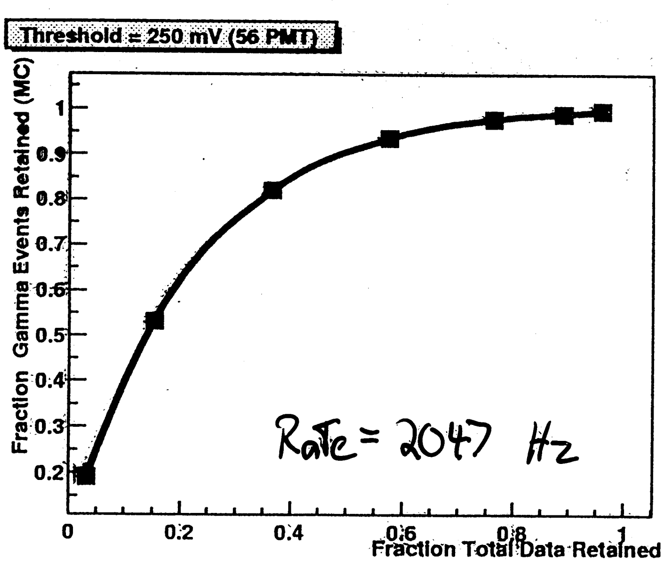
Gamma Efficiencies
Fraction Gamma Events Retained
1
0.8
0.6
0.4
0.2
40
60
80
100
120
140
160
180
200
220
Risetime (ns)
50 mV Threshold (17 PMT)
150 mV Threshold (37 PMT)
250 mV Threshold (56 PMT)

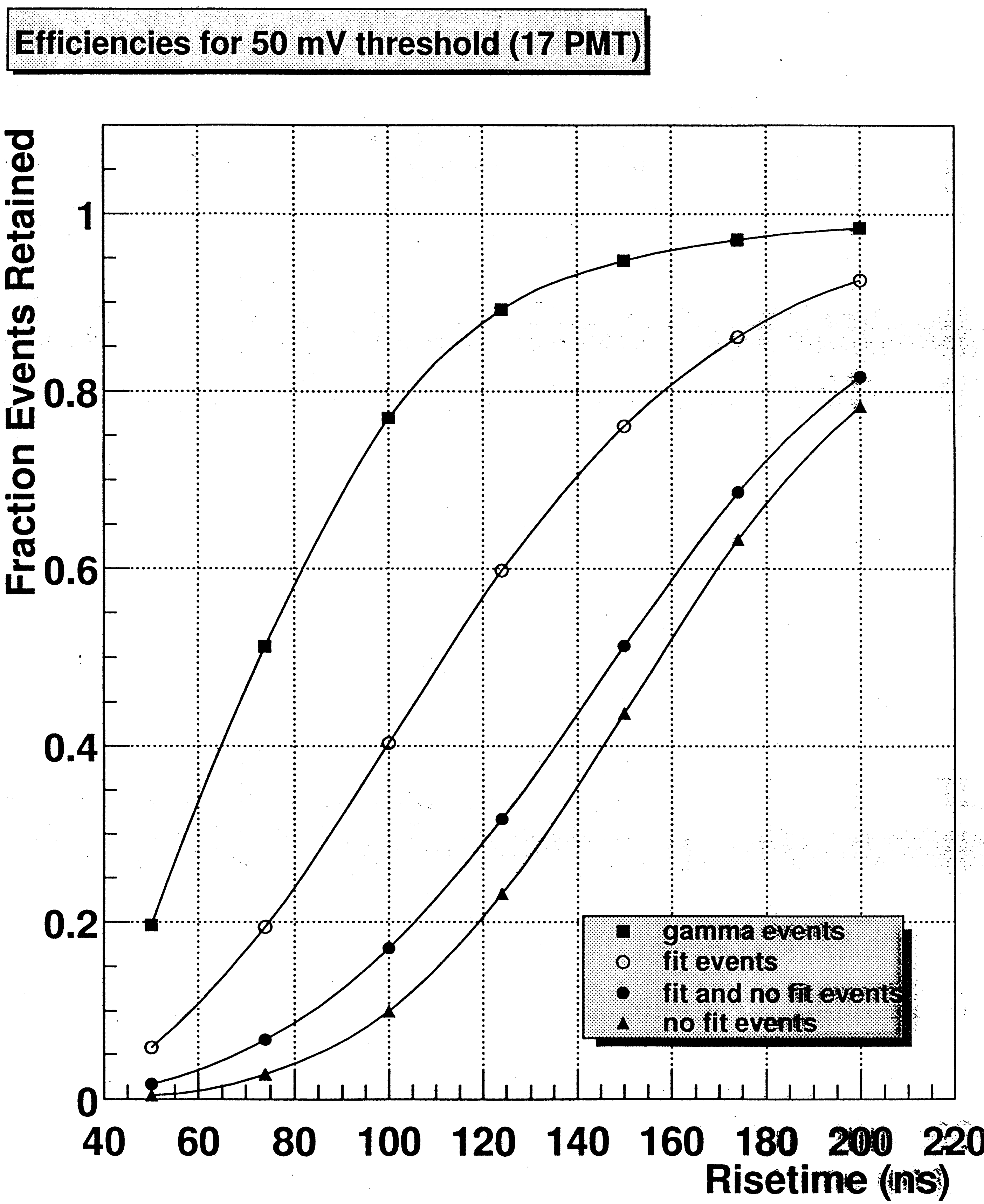

Optimal Gamma Efficiency: Threshold = 50 mV (17 PMT)
Fraction Gamma Events Retained (MC)
Fraction Total Data Retained
Rate = 44,169 Hz


Threshold = 100 mV (27 PMT)
Fraction Gamma Events Retained (MC)
Fraction Total Data Retained
Rate = 14,612 Hz

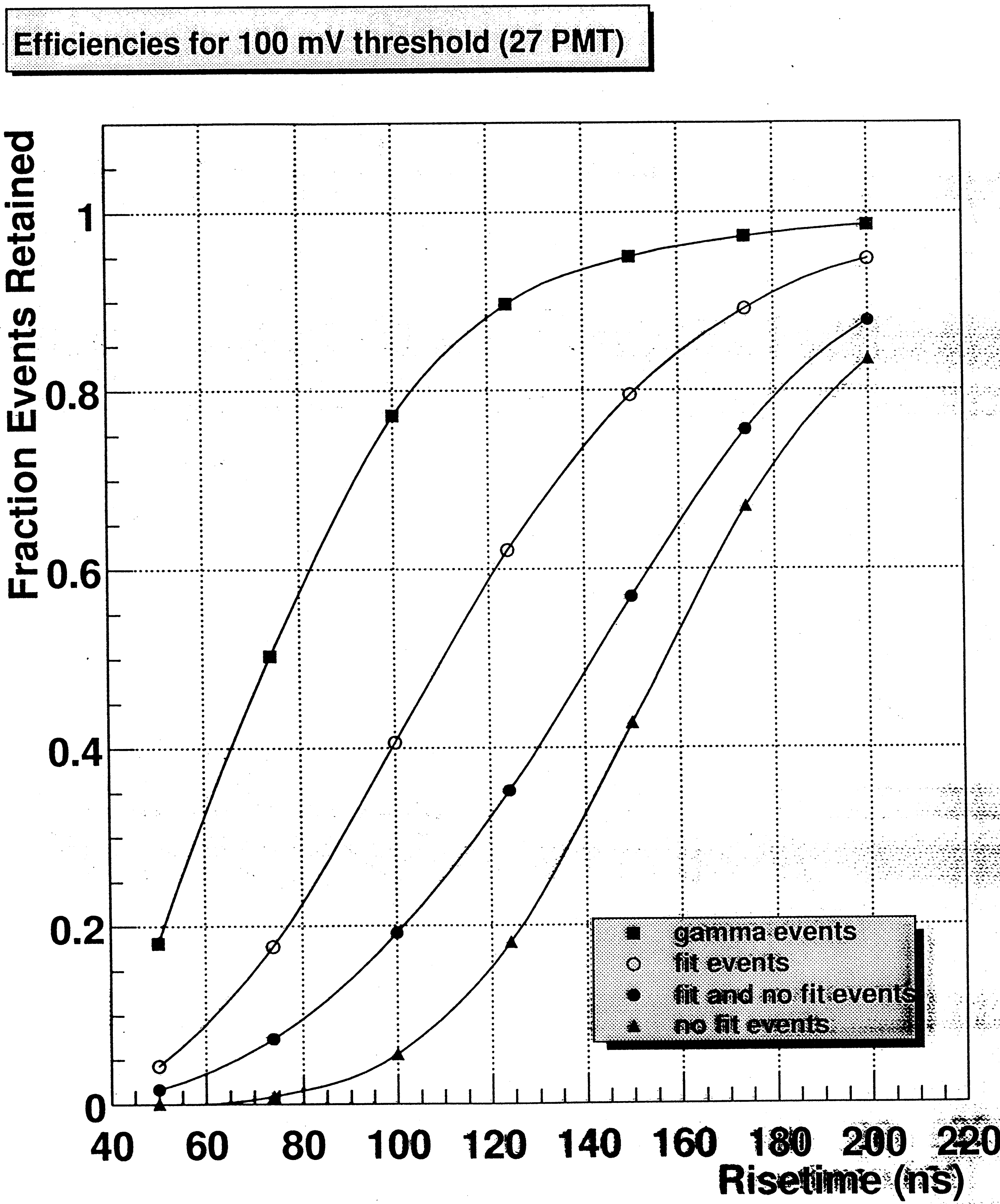

Threshold = 150 mV (37 PMT)
Fraction Gamma Events Retained (MC)
Fraction Total Data Retained
Rate = 6203 Hz


Threshold = 200 mV (46 PMT)
Fraction Gamma Events Retained (MC)
Fraction Total Data Retained
Rate = 3309 Hz


Threshold = 250 mV (56 PMT)
Fraction Gamma Events Retained (MC)
Fraction Total Data Retained
Rate = 2047 Hz



Efficiencies for 50 mV threshold (17 PMT)
Fraction Events Retained
0
0.2
0.4
0.6
0.8
1
40
60
80
100
120
140
160
180
200
220
Risetime (ns)
gamma events
fit events
fit and no fit events
no fit events



Efficiencies for 100 mV threshold (27 PMT)
Fraction Events Retained
0
0.2
0.4
0.6
0.8
1
40
60
80
100
120
140
160
180
200
220
Risetime (ns)
gamma events
fit events
fit and no fit events
no fit events

Risetime Cuts for 50 mV Threshold

Risetime Cut (ns)	Gammas Retained (%)	No Fits Rejected (%)	Total Rejected (%)	Rate (Hz)
50	20	99	98	883
75	51	97	94	2650
100	77	90	83	7509
125	89	77	68	14134
150	93	56	49	22526
175	96	36	32	30035
200	98	22	18	36218

Risetime Cuts for 100 mV Threshold

Risetime Cut (ns)	Gammas Retained (%)	No Fits Rejected (%)	Total Rejected (%)	Rate (Hz)
50	18	99.9	98	292
75	50	99	93	1023
100	77	94	81	2776
125	90	82	65	5114
150	95	58	43	8329
175	97	33	24	11105
200	99	17	12	12858

Risetime Cuts for 150 mV Threshold

Risetime (ns)	Gammas Retained (%)	No Fits Rejected (%)	Total Rejected (%)	Rate (Hz)
50	18	99.98	98	124
75	52	99.7	90	620
100	80	97	76	1489
125	92	86	58	2605
150	97	59	37	3908
175	98	31	19	5024
200	99	13	8	5706

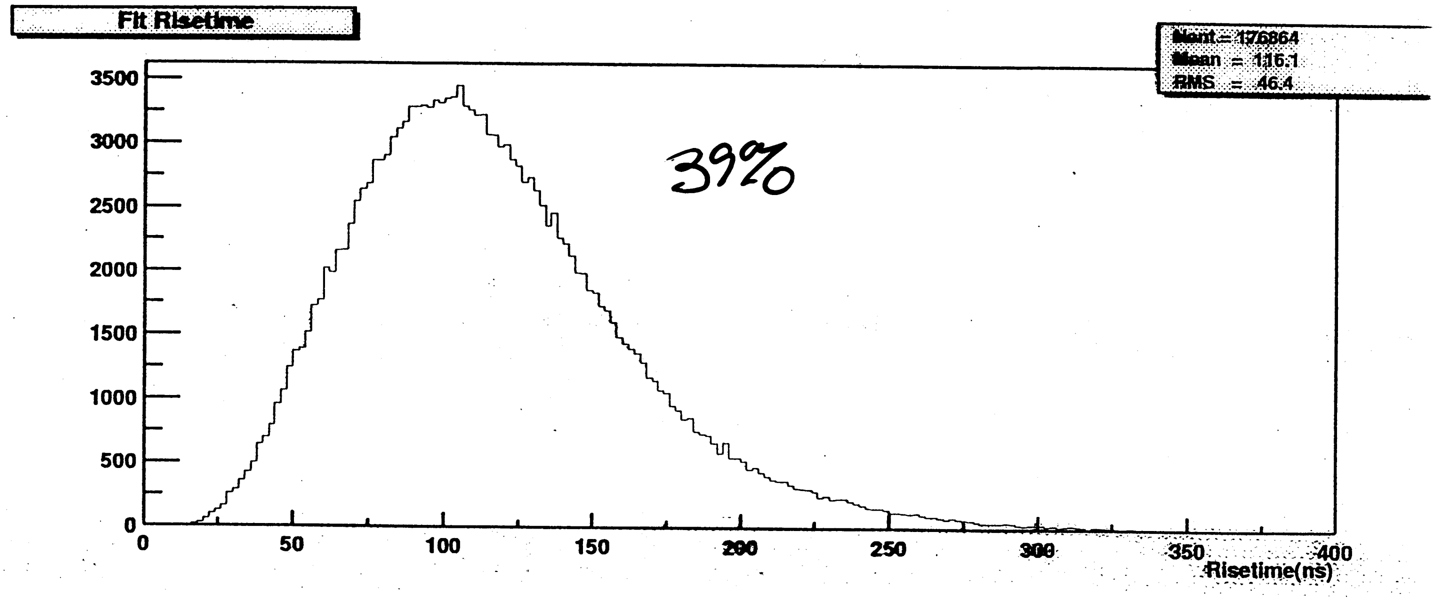
Risetime Cuts for 200 mV Threshold

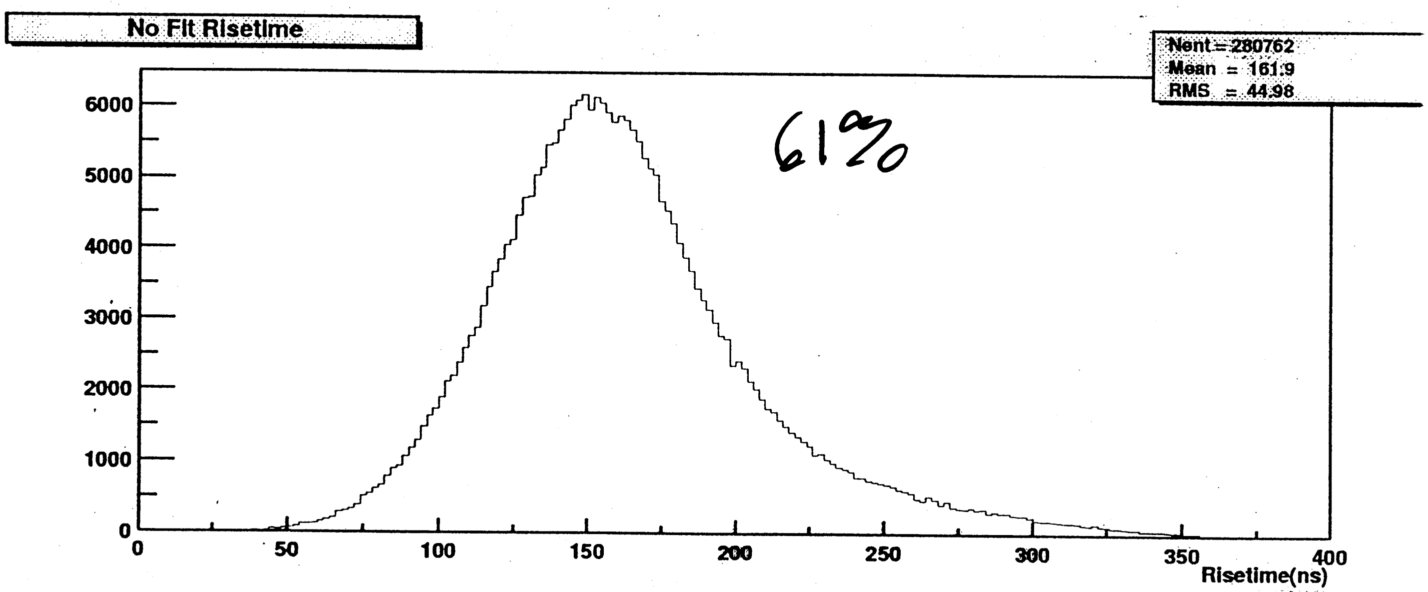
Risetime (ns)	Gammas Retained (%)	No Fits Rejected (%)	Total Rejected (%)	Rate (Hz)
50	18	99.99	97	99
75	52	99.99	87	430
100	80	98	70	993
125	92	89	50	1655
150	97	62	30	2316
175	98	31	14	2846
200	99	12	6	3110

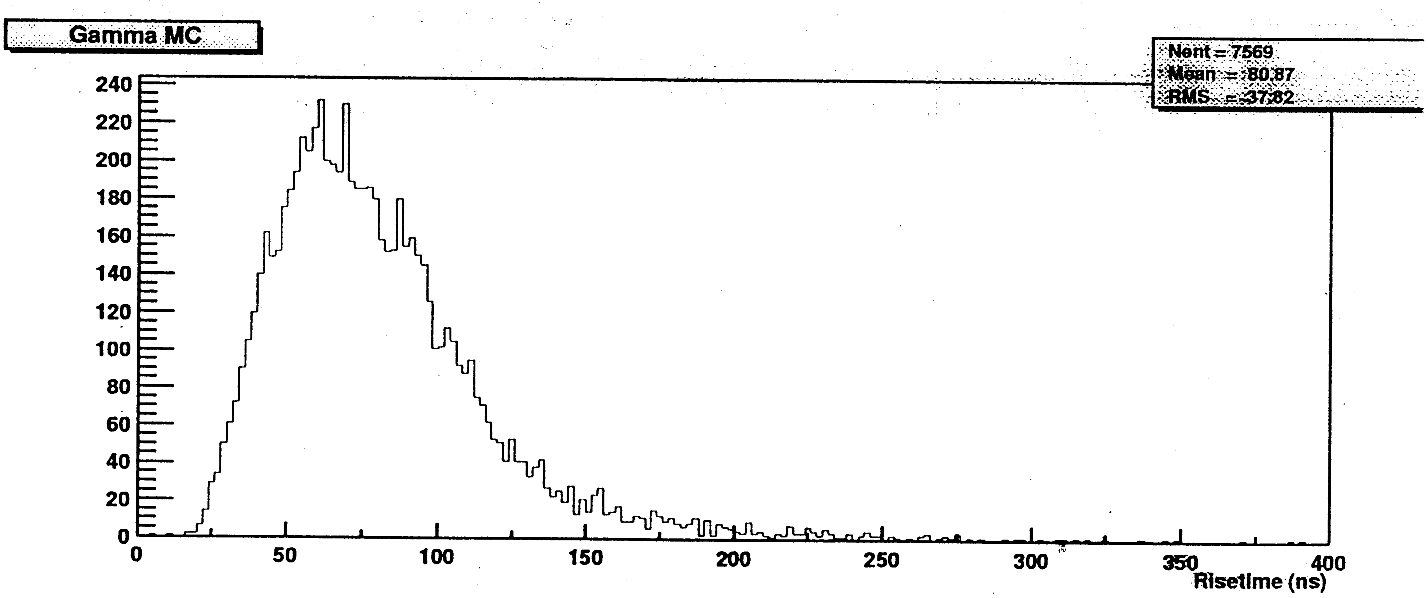
Risetime Cuts for 250 mV Threshold

Risetime (ns)	Gammas Retained (%)	No Fits Rejected (%)	Total Rejected (%)	Rate (Hz)
50	19	99.99	97	61
75	53	99.95	85	307
100	82	99	63	757
125	94	91	43	1167
150	98	66	24	1556
175	99	33	11	1822
200	99	12	4	1965

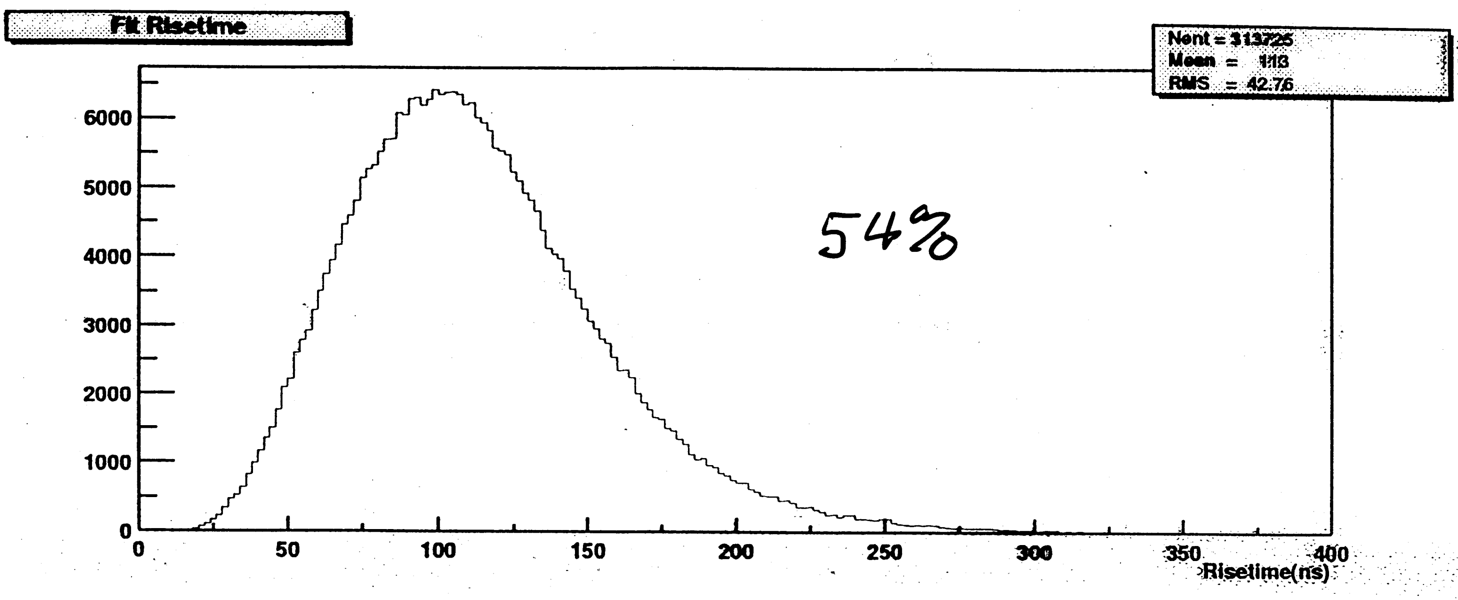
100 mV (27 PMT)


Fit Risetime
Nent = 176864
Mean = 116.1
RMS = 46.4
39%
0
500
1000
1500
2000
2500
3000
3500
0
50
100
150
200
250
300
350
400
Risetime(ns)

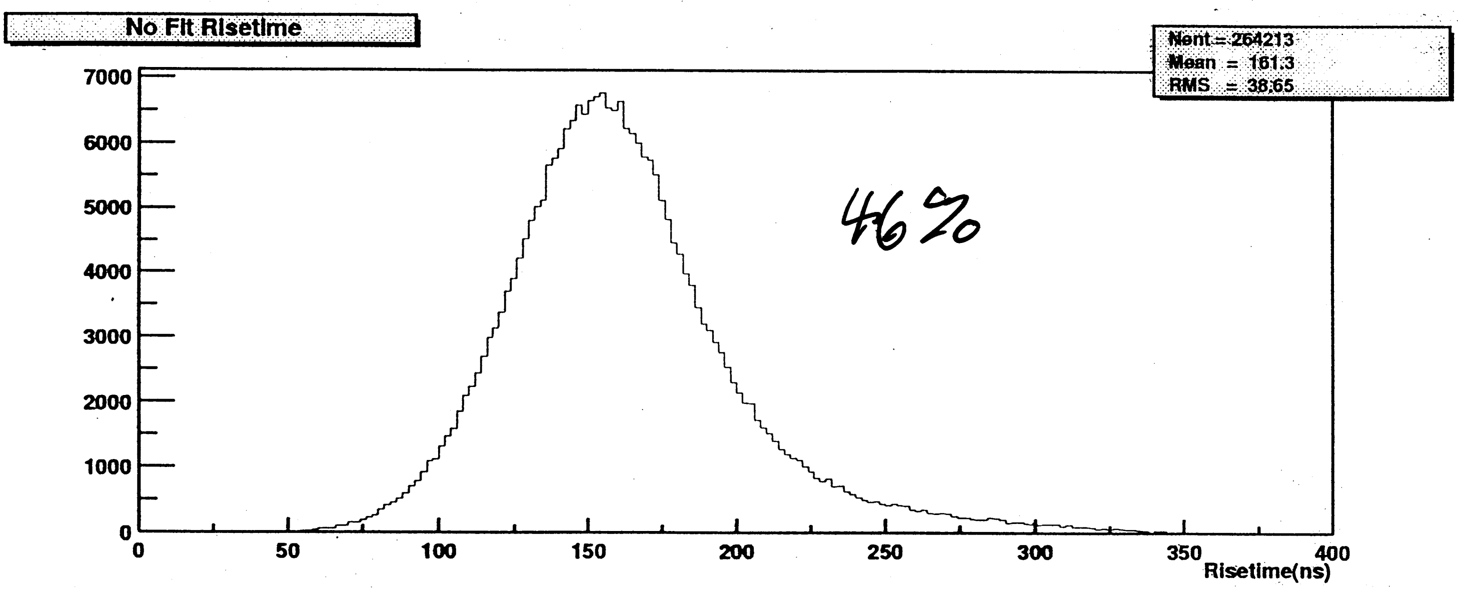

No Fit Risetime
Nent = 280762
Mean = 161.9
RMS = 44.98
61%
0
1000
2000
3000
4000
5000
6000
0
50
100
150
200
250
300
350
400
Risetime(ns)


Gamma MC
Nent = 7569
Mean = 80.87
RMS = 37.82
0
20
40
60
80
100
120
140
160
180
200
220
240
0
50
100
150
200
250
300
350
400
Risetime (ns)

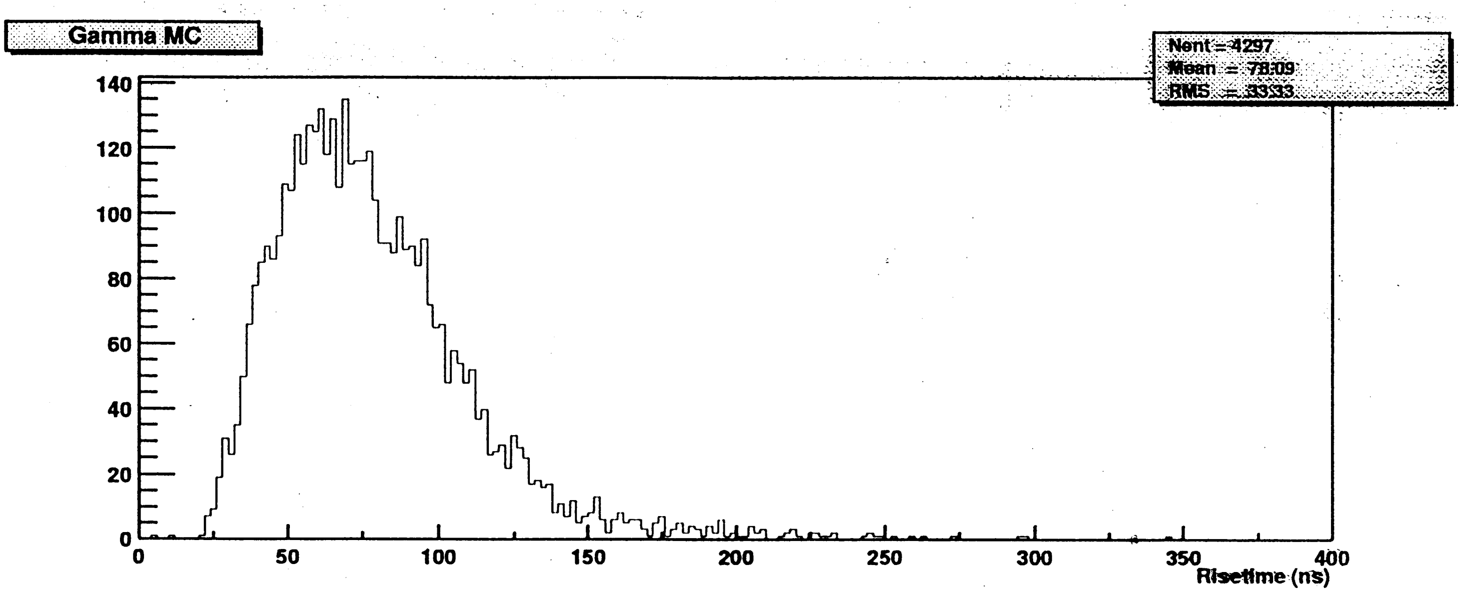
150 mV (37 PMT)



Fit Risetime
Nent = 313725
Mean = 113
RMS = 42.76
54%
Risetime(ns)

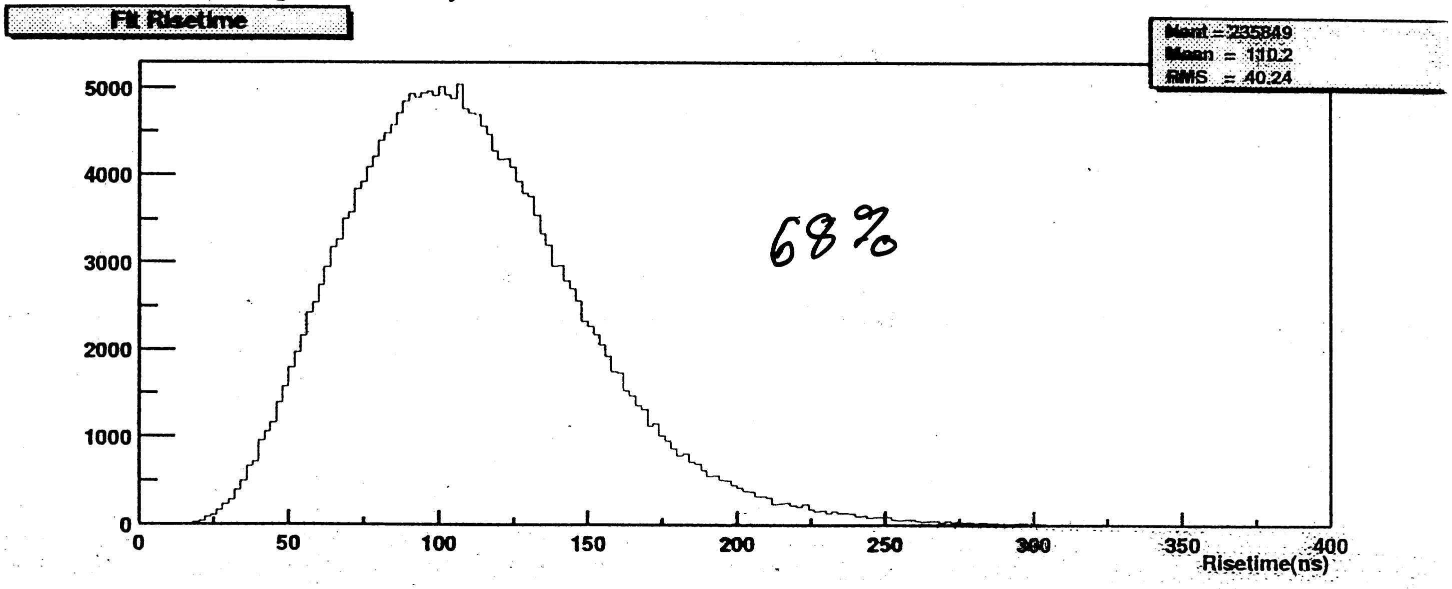


No Fit Risetime
Nent = 264213
Mean = 161.3
RMS = 38.65
46%
Risetime(ns)

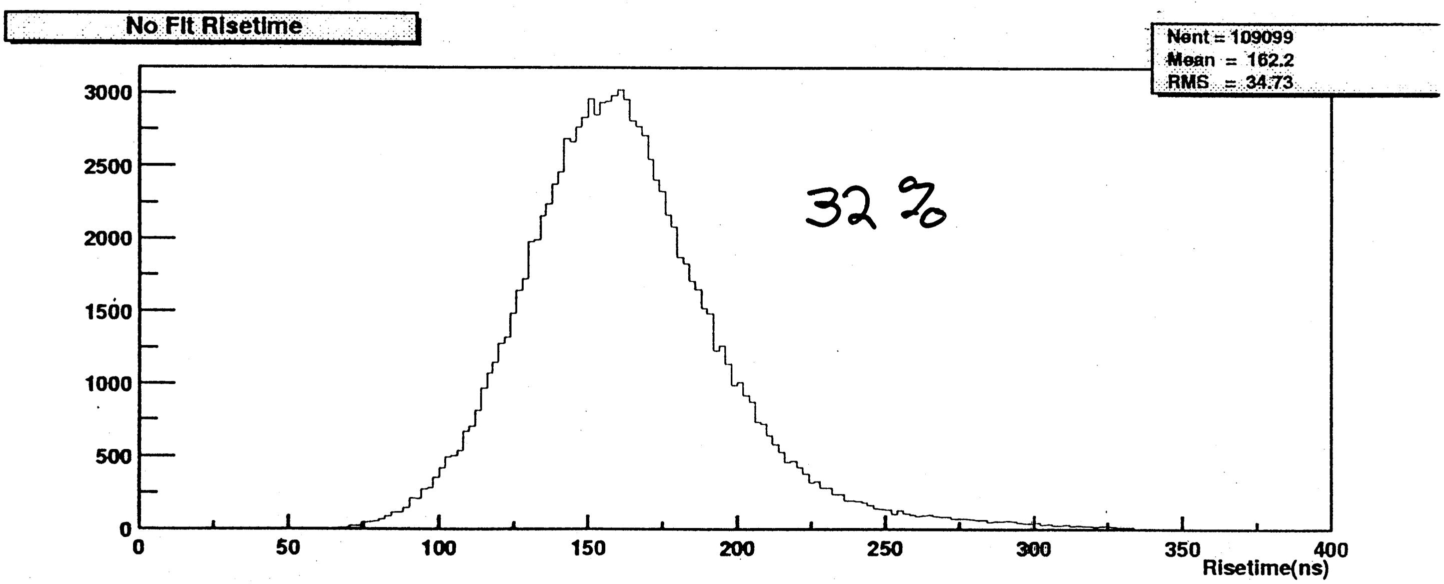


Gamma MC
Nent = 4297
Mean = 78.09
RMS = 33.33
Risetime (ns)

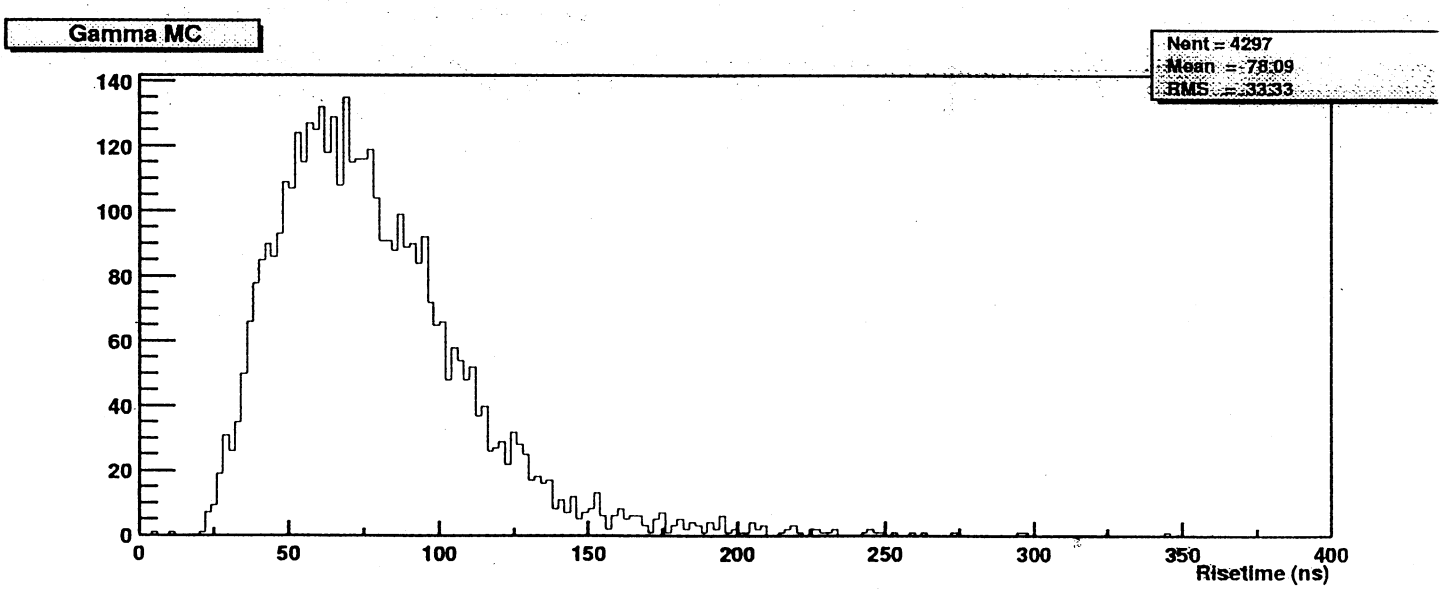
200 mV (46 PMT)



Fit Risetime
Nent = 235849
Mean = 110.2
RMS = 40.24
5000
4000
3000
2000
1000
0
0
50
100
150
200
250
300
350
400
Risetime(ns)
68%

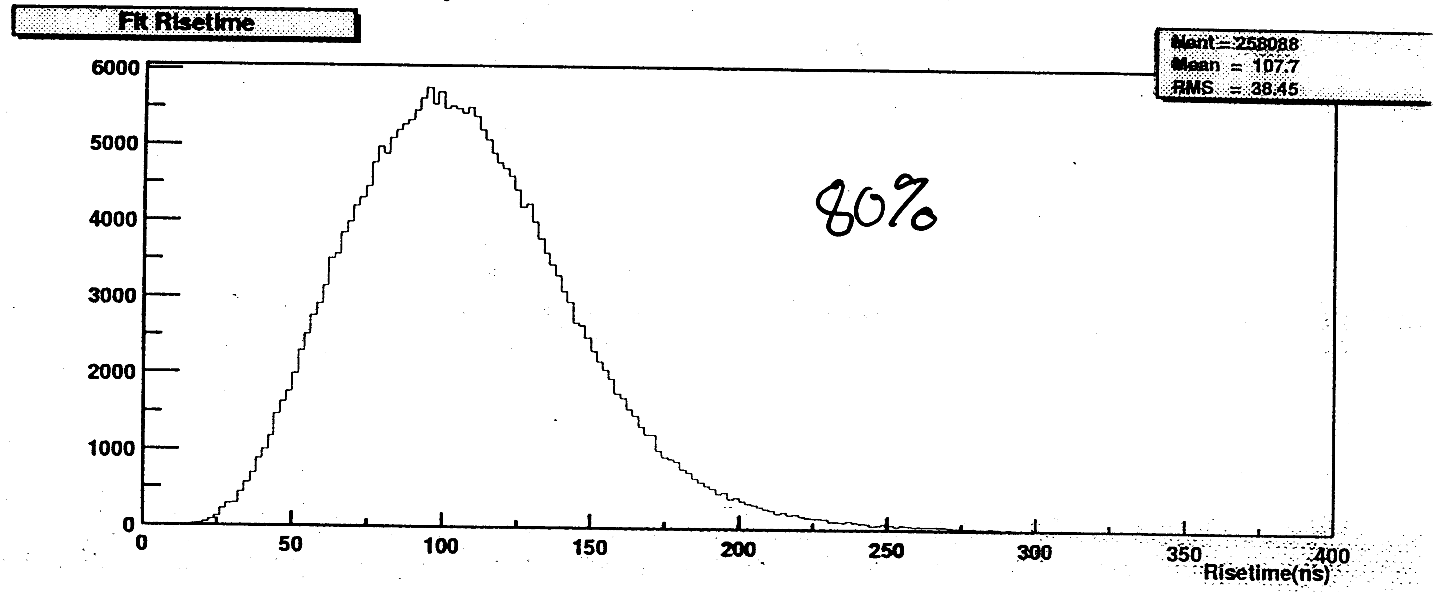


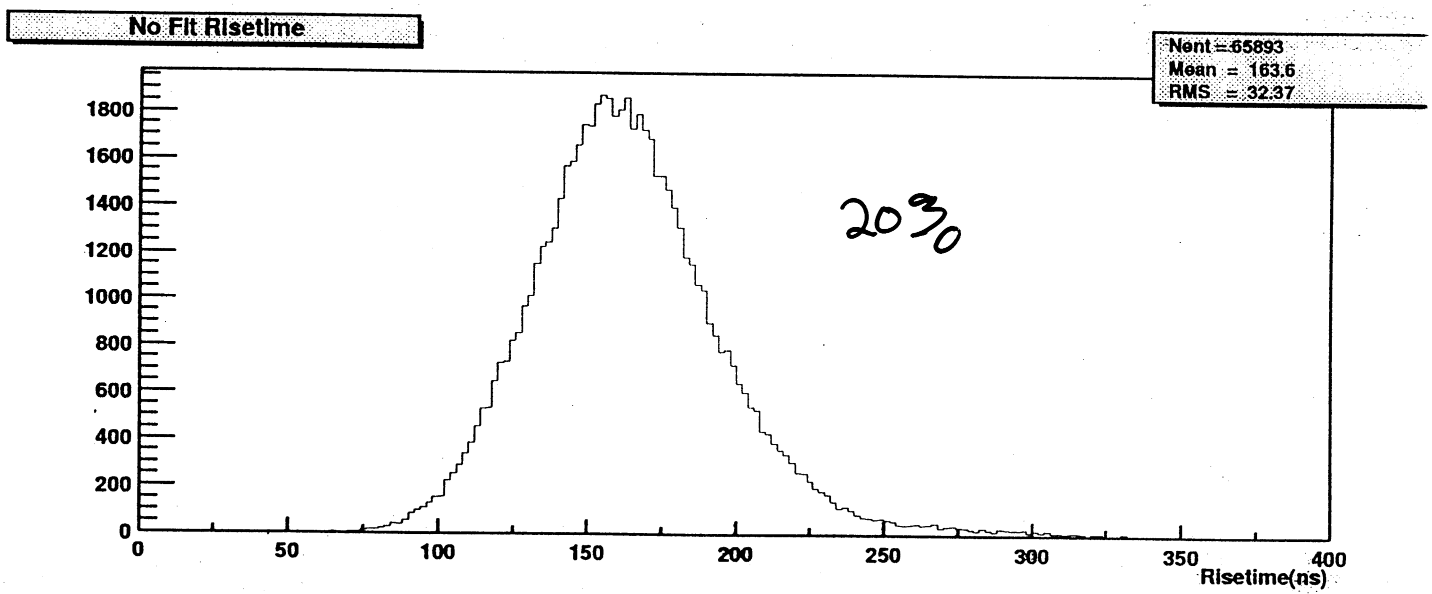
No Fit Risetime
Nent = 109099
Mean = 162.2
RMS = 34.73
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Risetime(ns)
32%

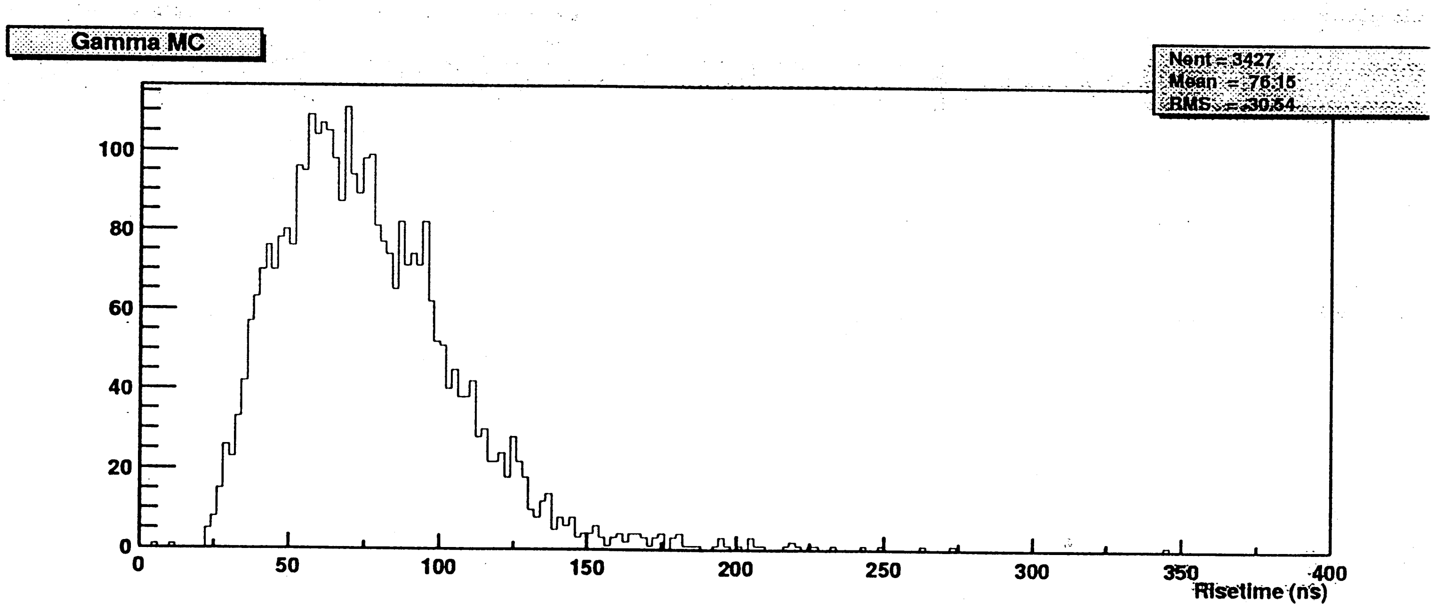


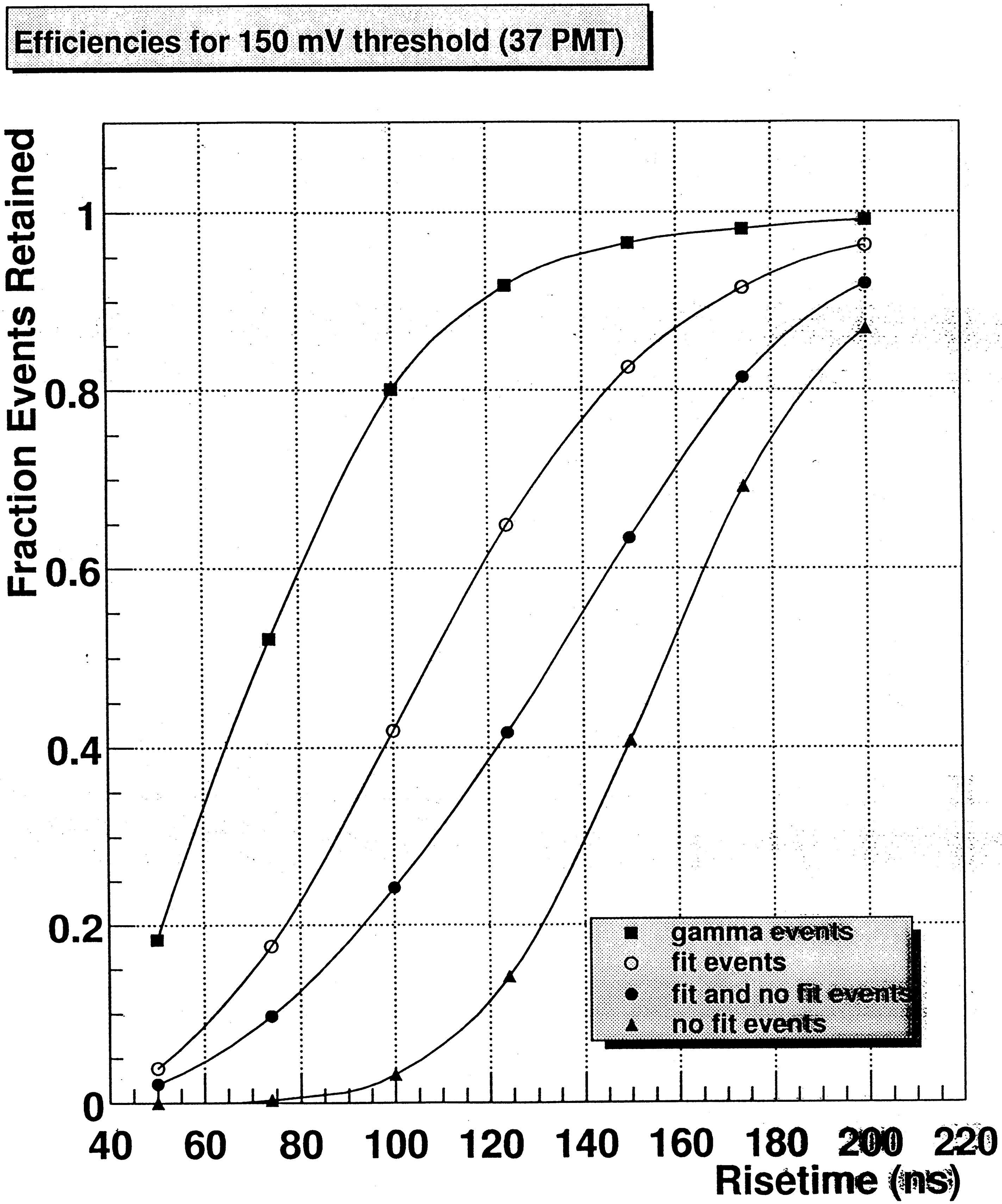
Gamma MC
Nent = 4297
Mean = 78.09
RMS = 33.33
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
400
Risetime (ns)

250 mV (56 PMT)

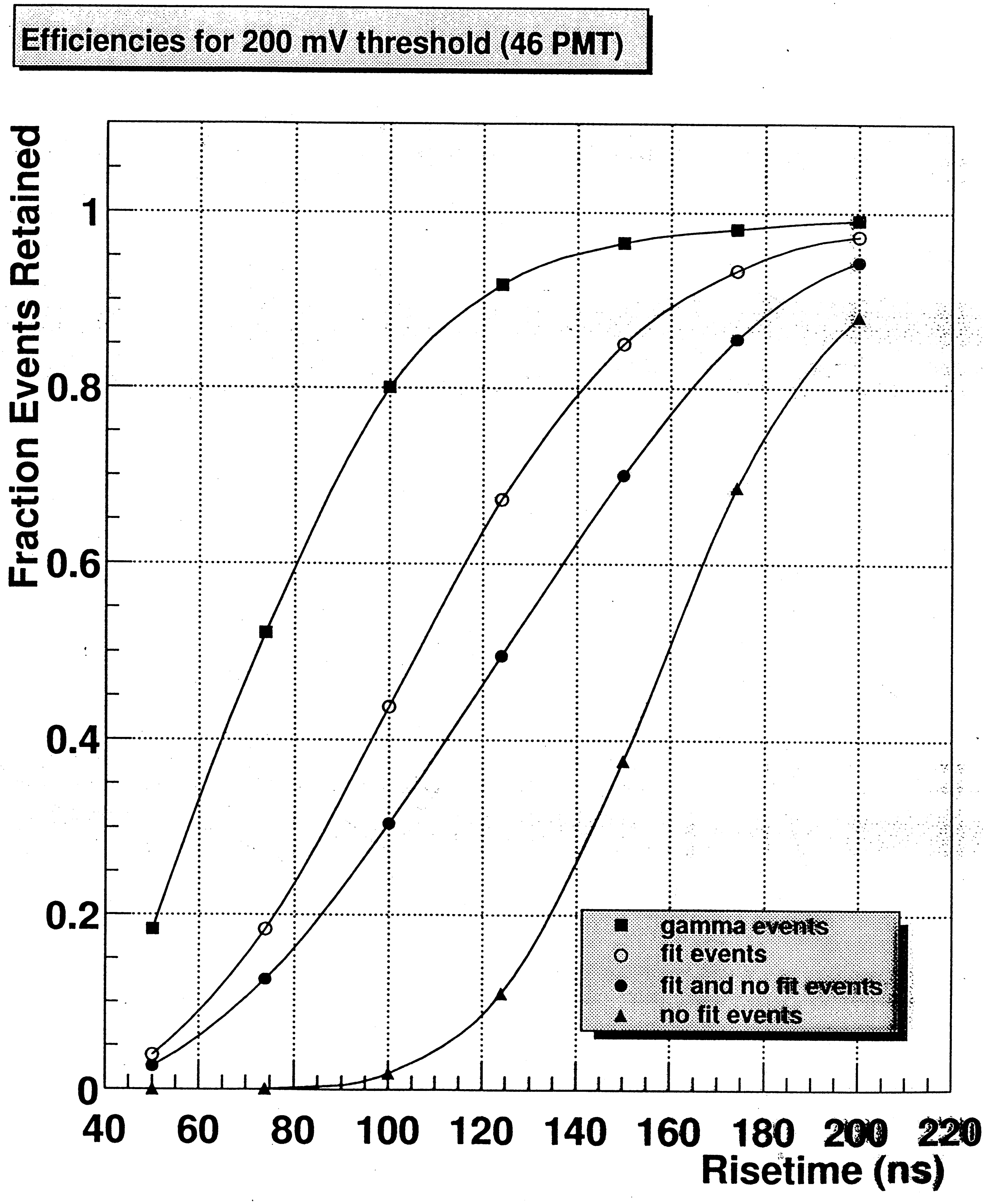

Fit Risetime
Nent = 258088
Mean = 107.7
RMS = 38.45
80%
0
1000
2000
3000
4000
5000
6000
0
50
100
150
200
250
300
350
400
Risetime(ns)


No Fit Risetime
Nent = 65893
Mean = 163.6
RMS = 32.37
20%
0
200
400
600
800
1000
1200
1400
1600
1800
0
50
100
150
200
250
300
350
400
Risetime(ns)

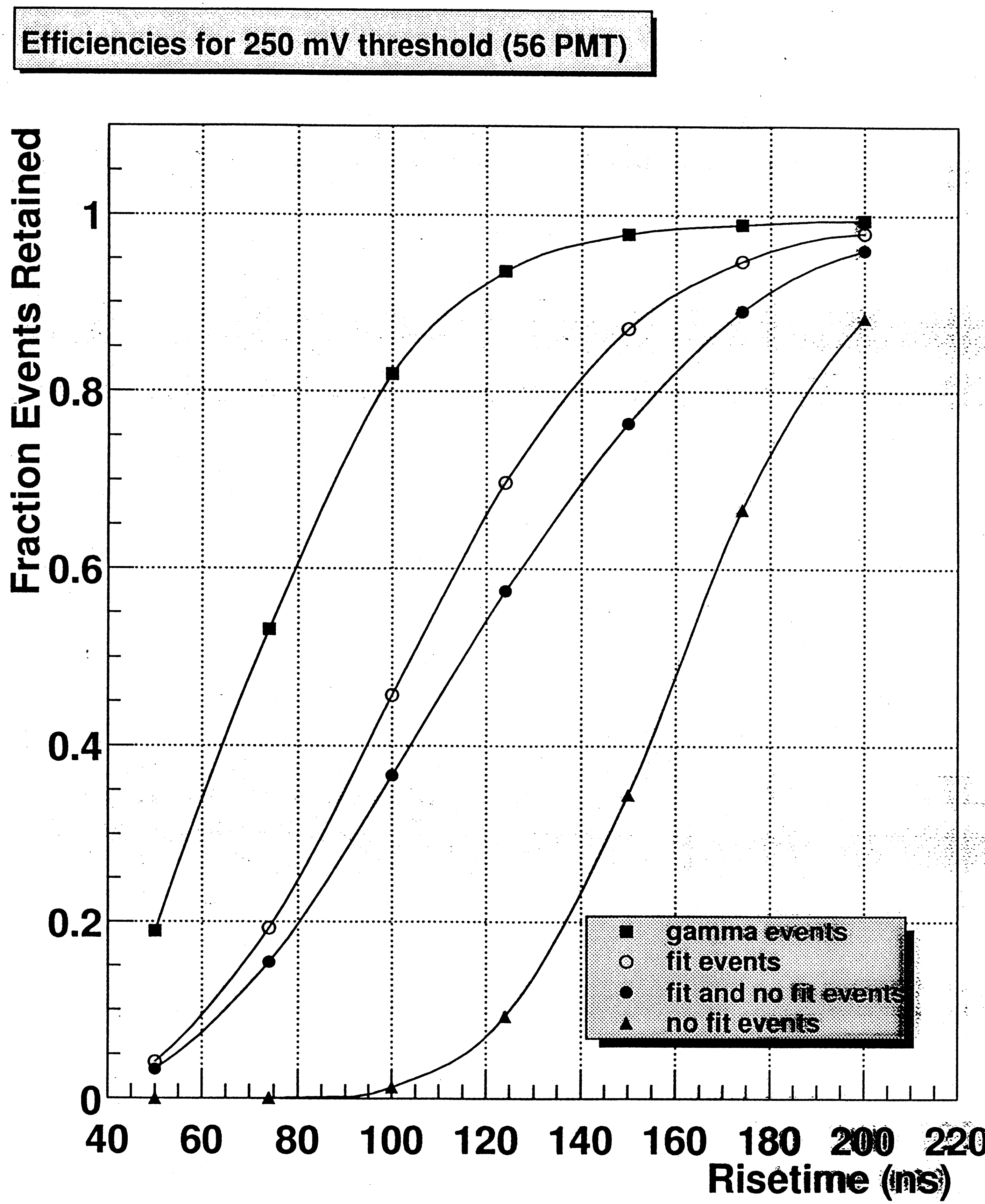

Gamma MC
Nent = 3427
Mean = 76.15
RMS = 30.54
0
20
40
60
80
100
0
50
100
150
200
250
300
350
400
Risetime (ns)



Efficiencies for 150 mV threshold (37 PMT)
Fraction Events Retained
0
0.2
0.4
0.6
0.8
1
40
60
80
100
120
140
160
180
200
220
Risetime (ns)
gamma events
fit events
fit and no fit events
no fit events



Efficiencies for 200 mV threshold (46 PMT)
Fraction Events Retained
0
0.2
0.4
0.6
0.8
1
40
60
80
100
120
140
160
180
200
220
Risetime (ns)
gamma events
fit events
fit and no fit events
no fit events



Efficiencies for 250 mV threshold (56 PMT)
Fraction Events Retained
0
0.2
0.4
0.6
0.8
1
40
60
80
100
120
140
160
180
200
220
Risetime (ns)
gamma events
fit events
fit and no fit events
no fit events

Upcoming Papers - Grito.

1. Solar CME - Abe - Nov.

2. GRB - Scalers - Julie, David
Energies

3. All-Sky - Kelin, Cy ; 3b. AGNs - Gary

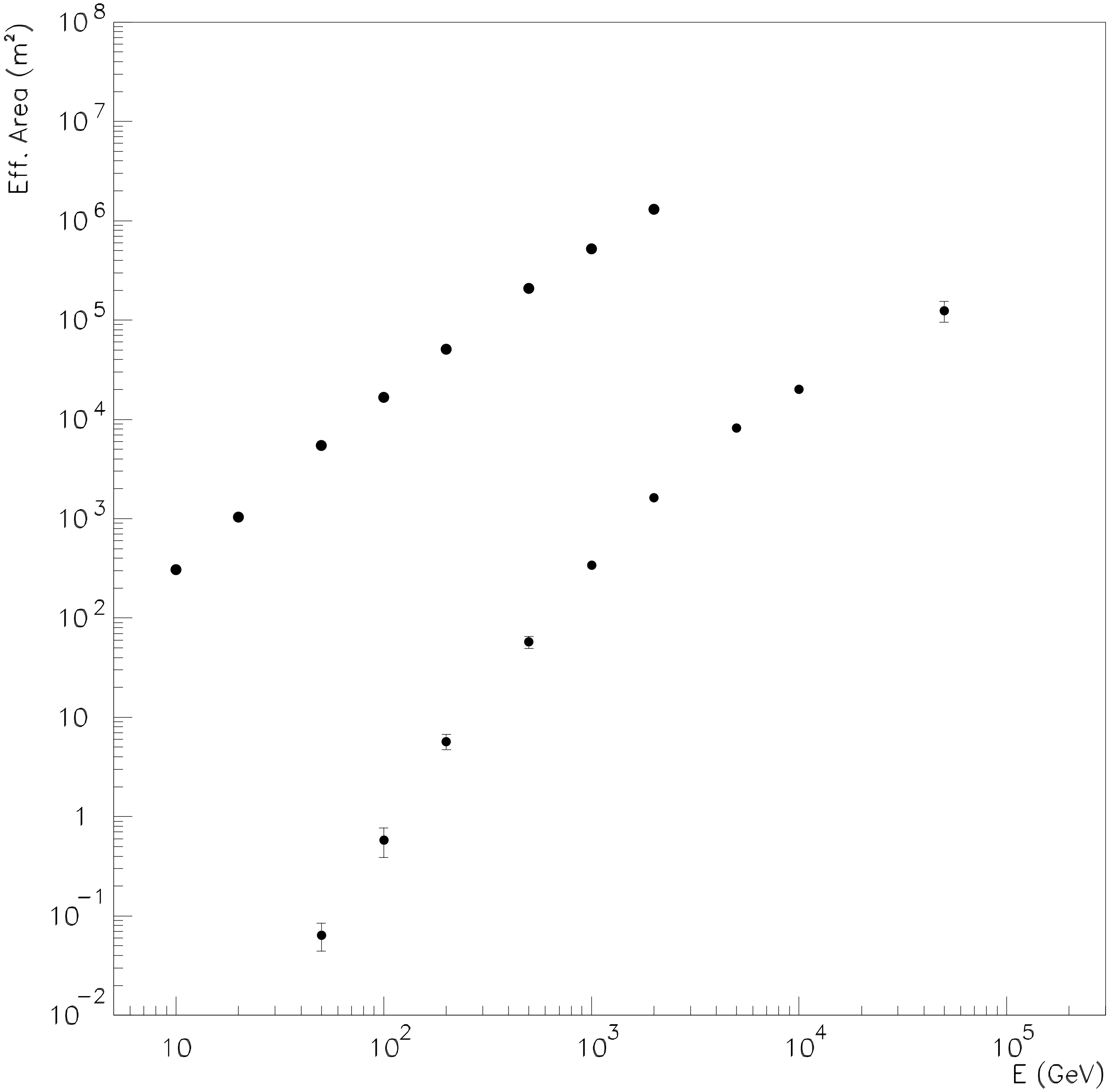
4. Untriggered Burst - Joe

5. Moon - $\bar{p}$'s Morgan
Escale

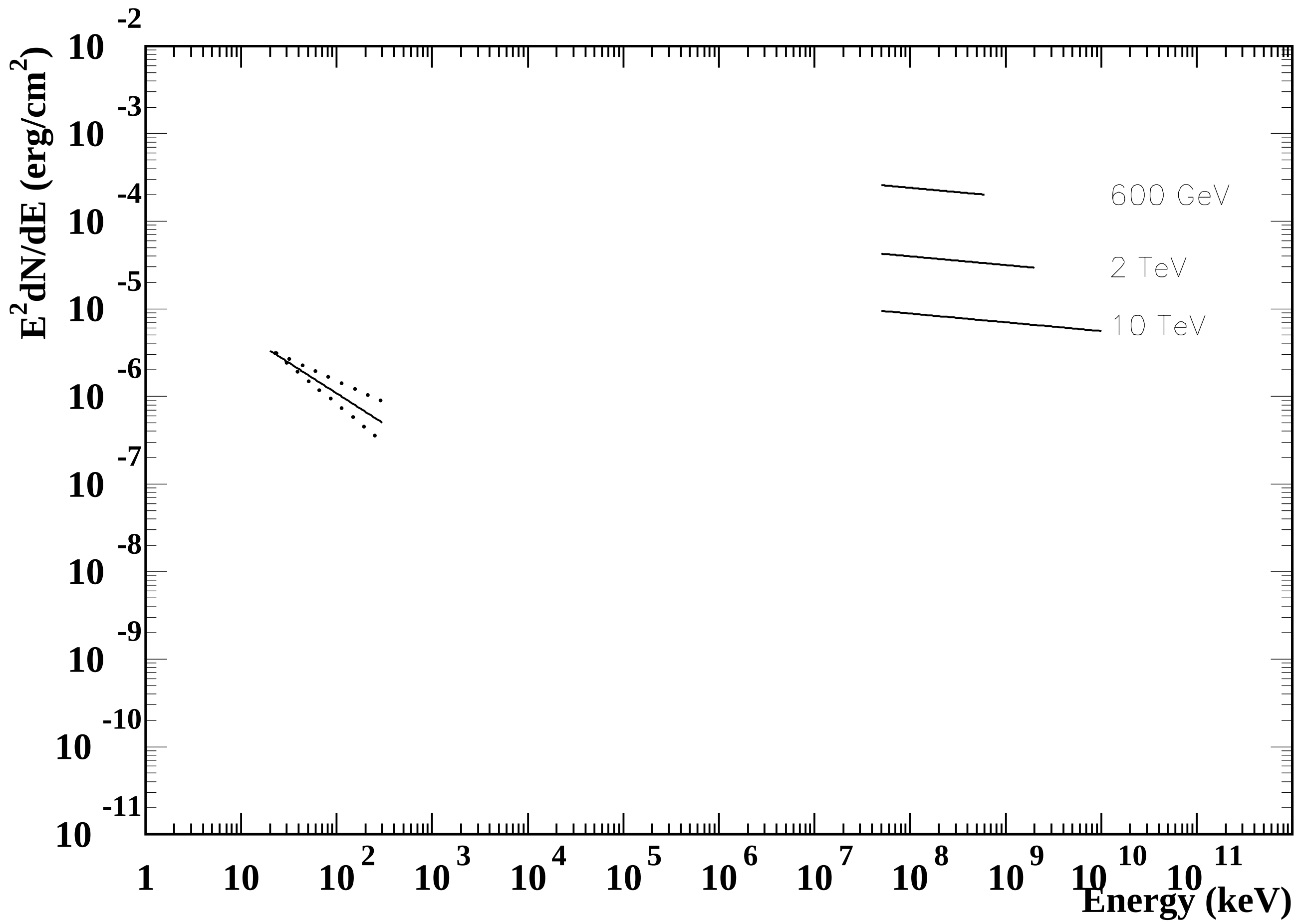
6 NIM Calibration paper - NYU

Overarching Publications Committee

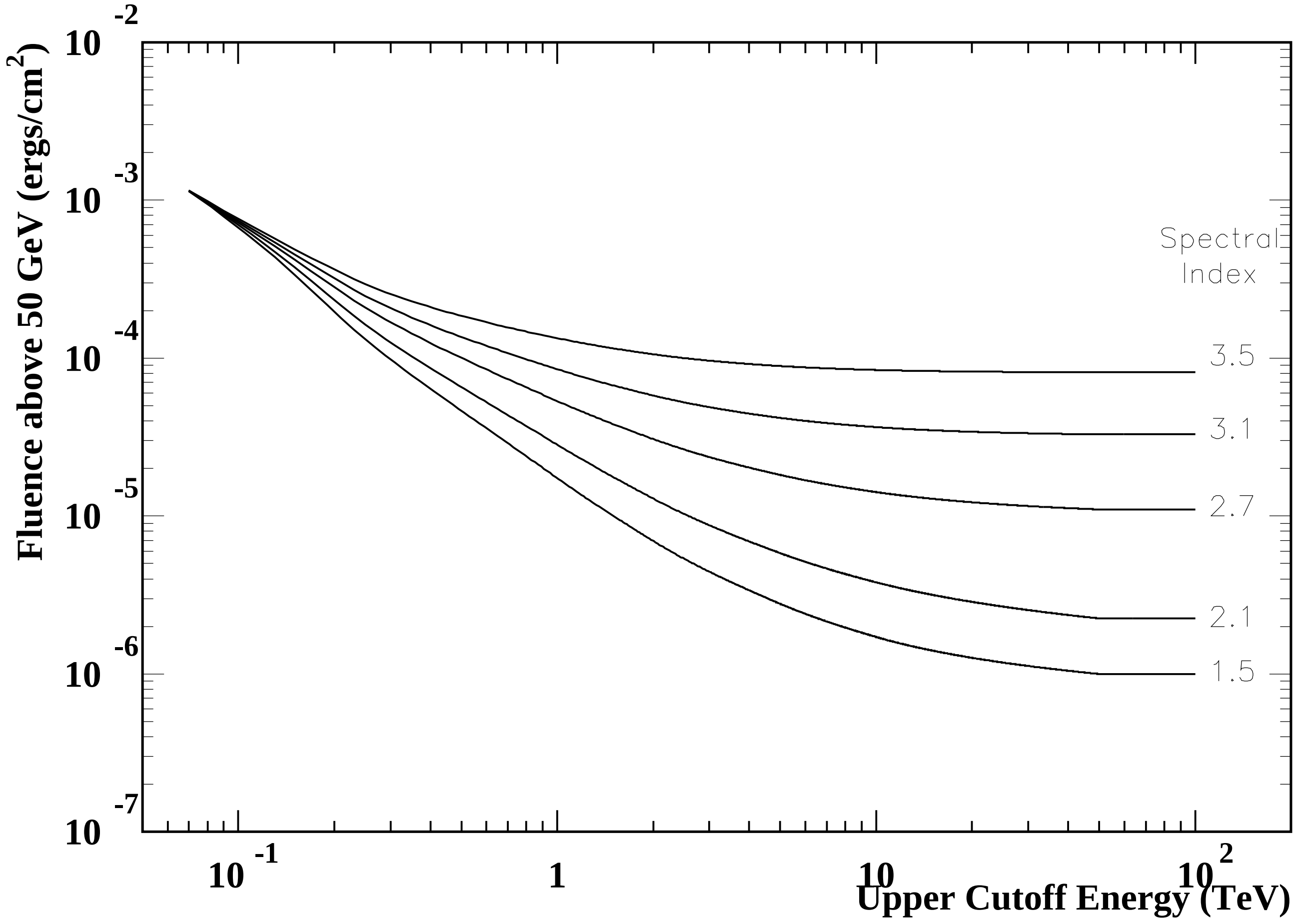
Effective Areas



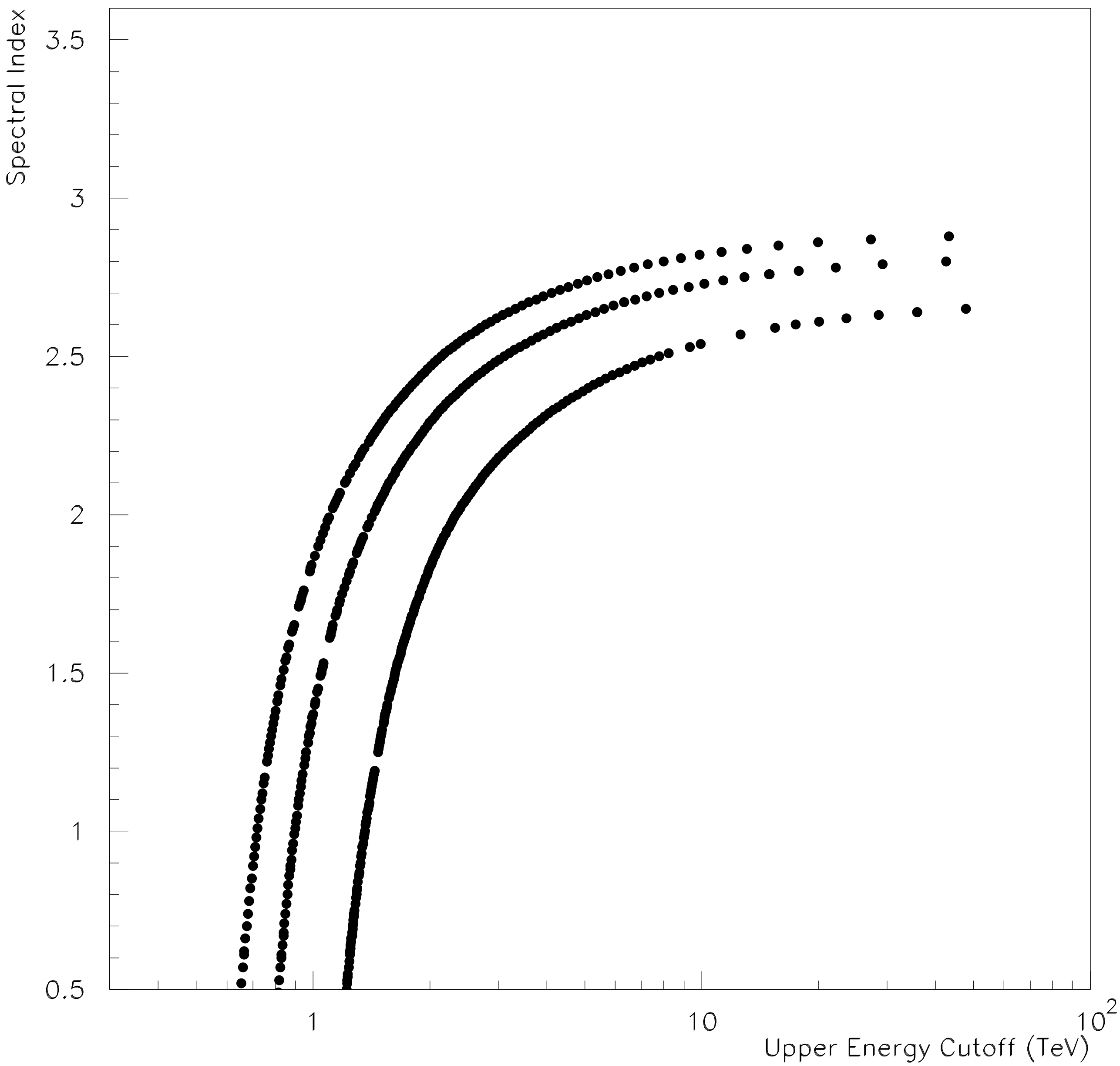
Spectral Energy Distribution



Implied Fluence



Limits from Scalers



6 Nov 1997 Event

by Abe Falcone

Overview:

- Effective Area to p^+s
- Validity of 100 PMT "signal"
- Present state of Analysis and Paper

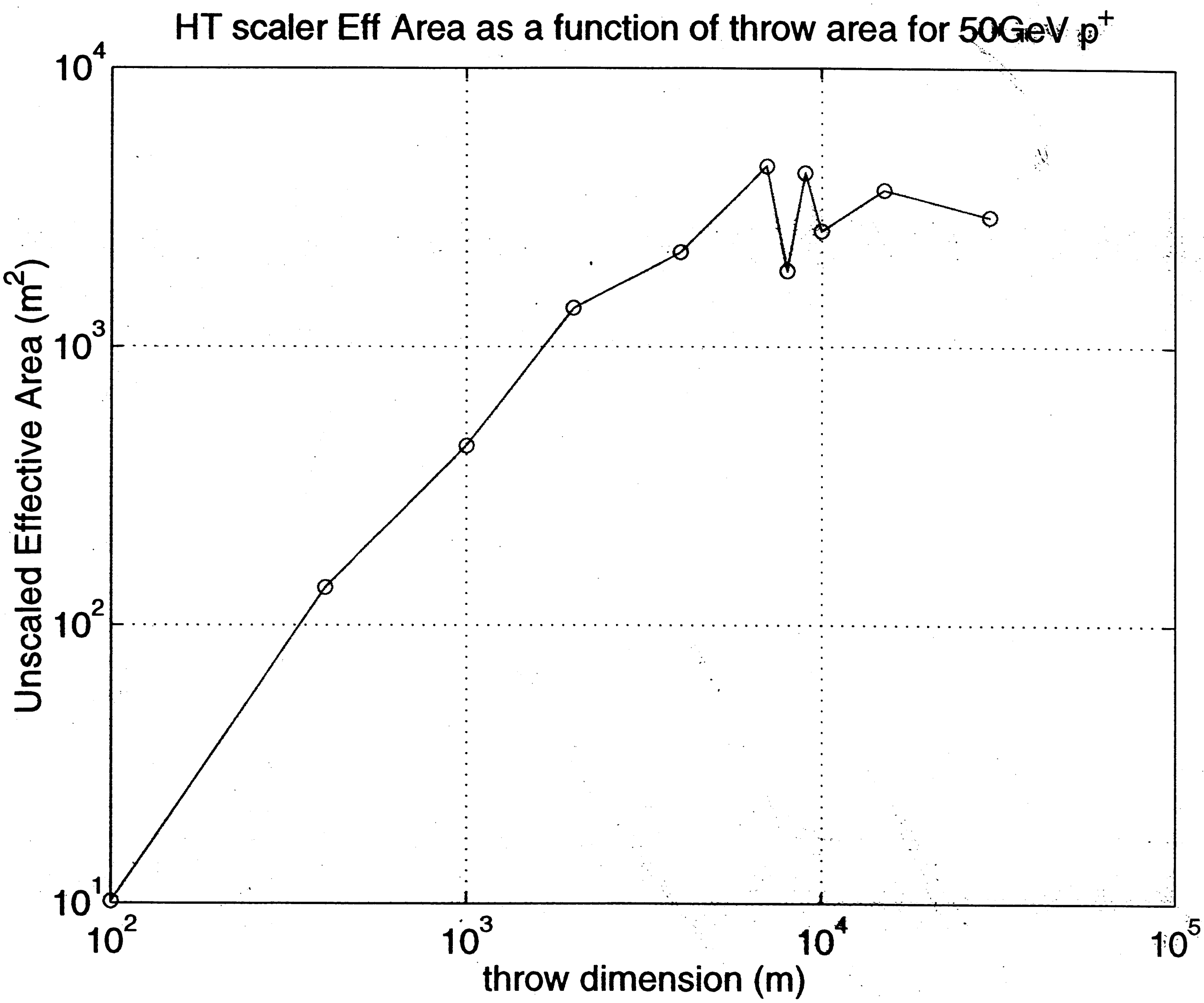
p^+ Effective Area Calculations

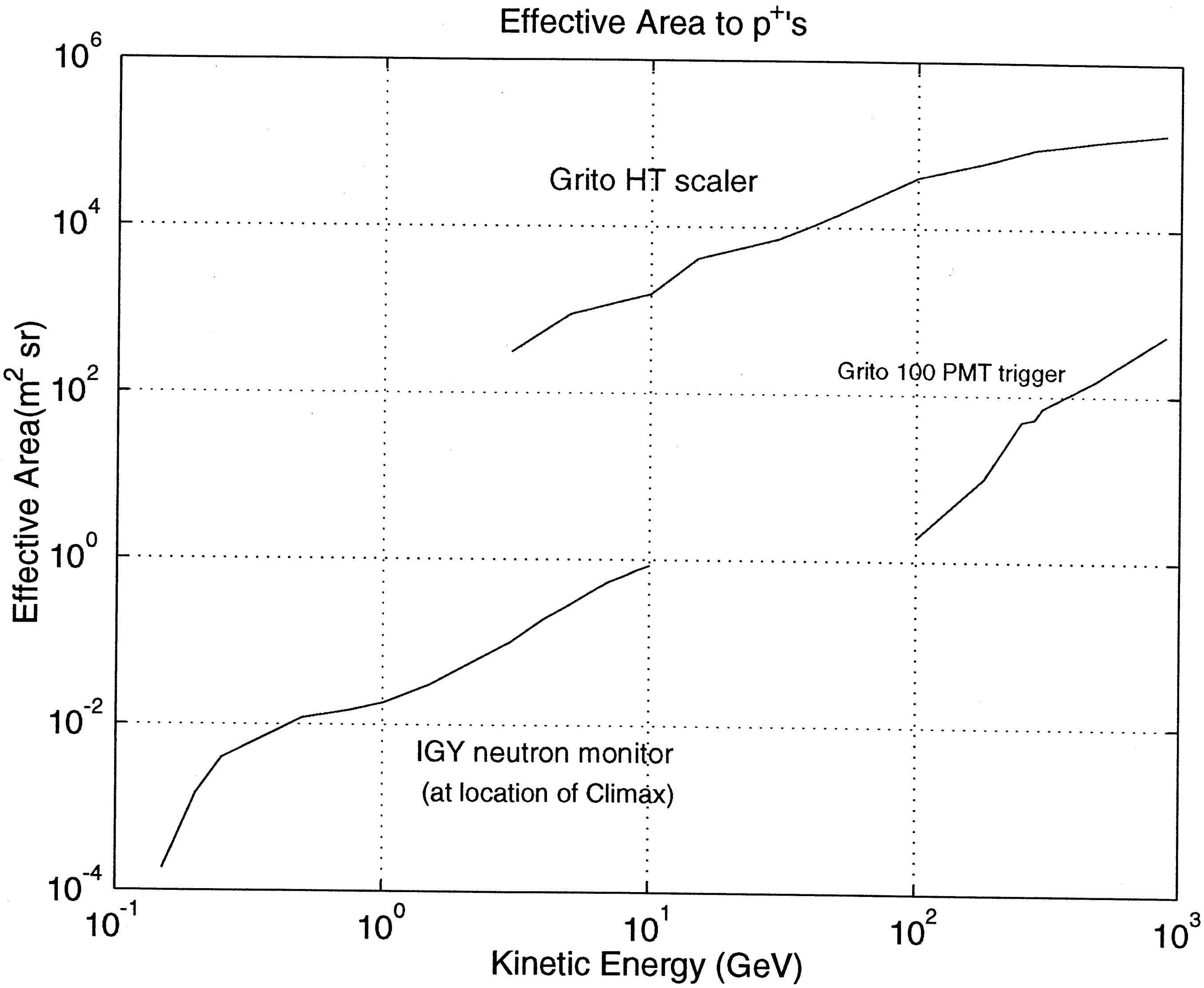
- Big Changes:
  - Improved threshold estimates
  - Corrected OR'd patch error
  - Throw range increased to 7000 m

* Increases Eff. area to protons by more than two orders of magnitude!

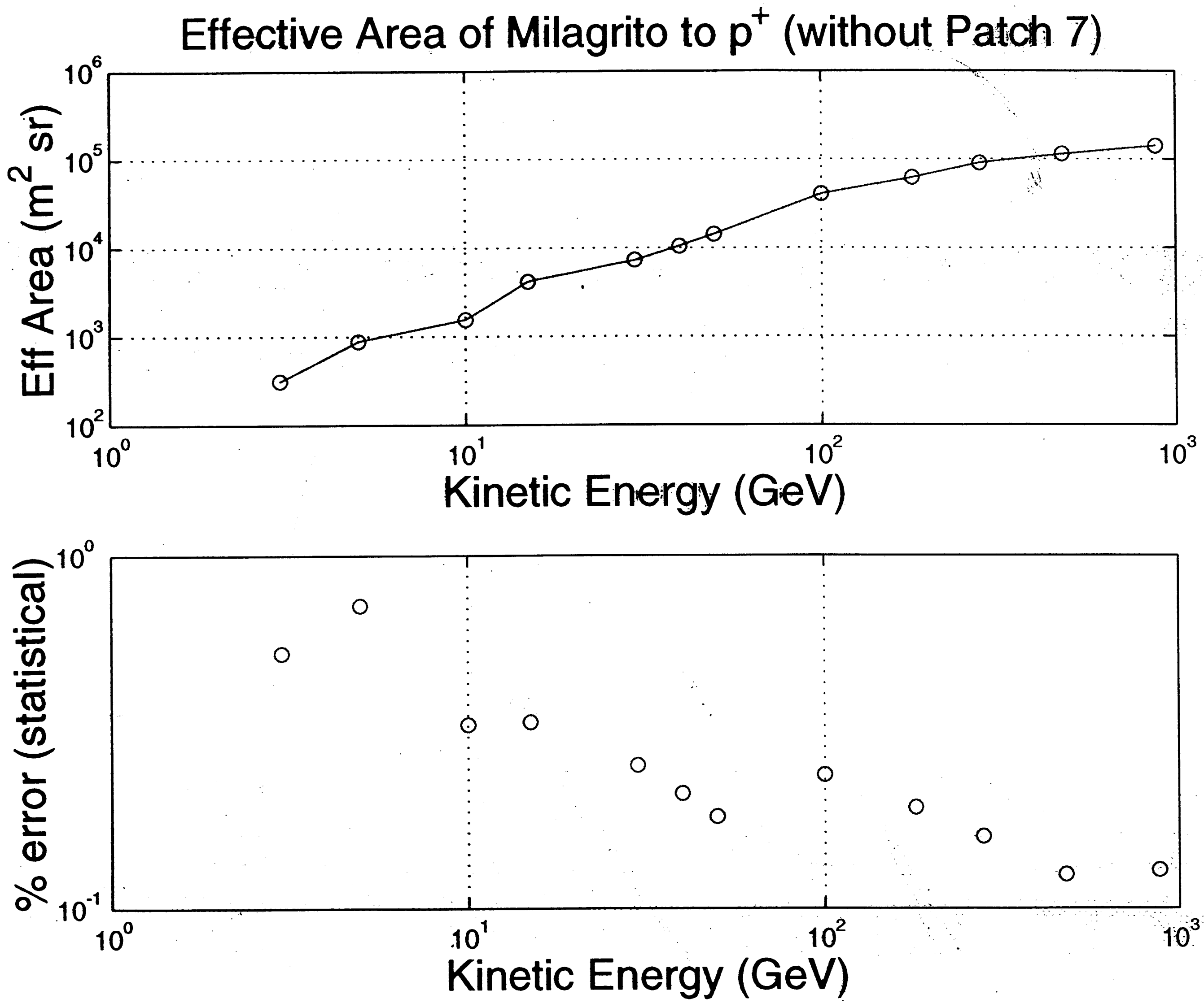
⇒ Major impact on Solar Event spectrum calculations (to be discussed)

- The new effective area curves predict Cosmic Ray background rate within a factor of ≈3

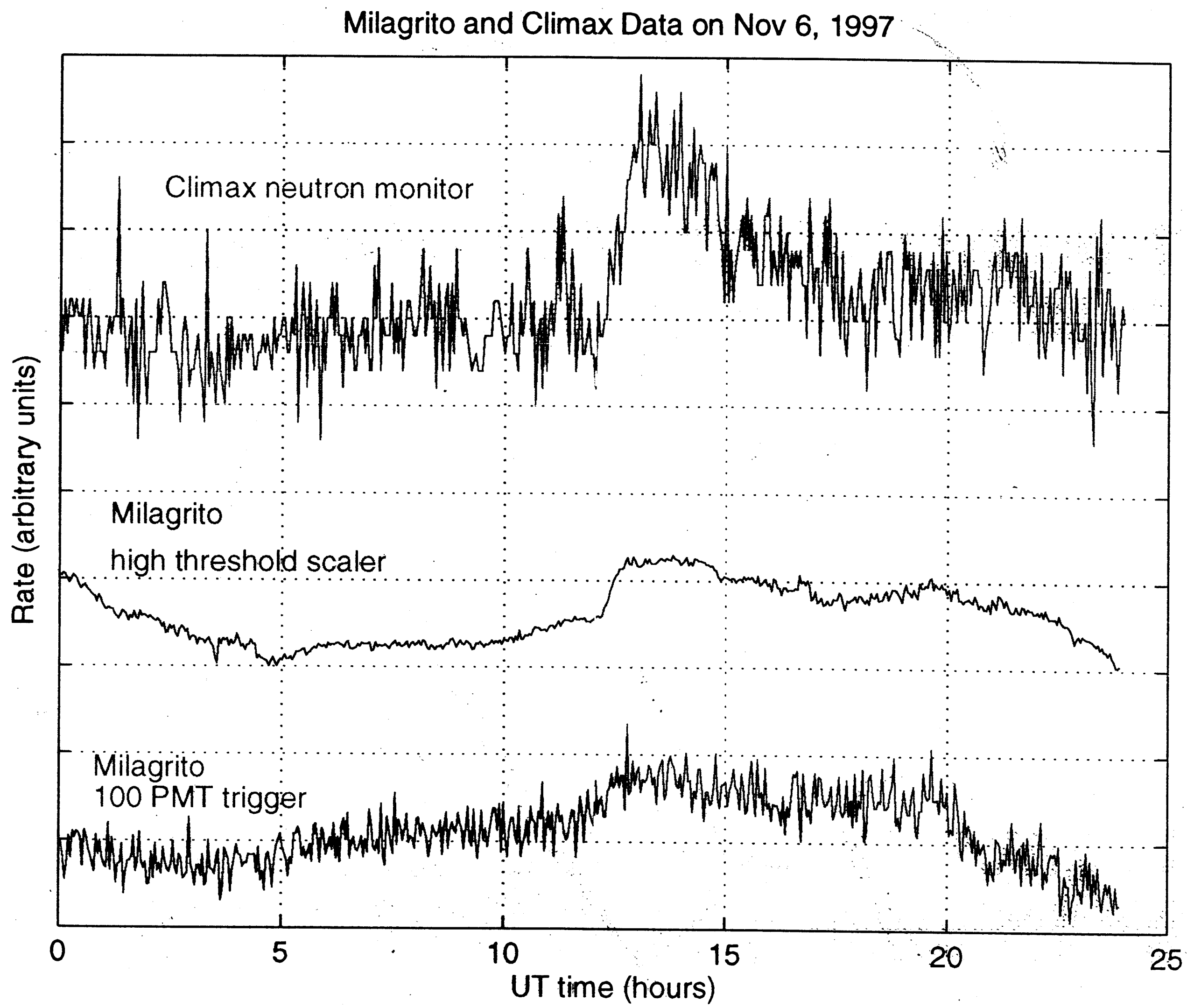

HT scaler Eff Area as a function of throw area for 50GeV p+
Unscaled Effective Area (m2)
throw dimension (m)
10^1
10^2
10^3
10^4
10^5



From LA Astro Talk



Effective Area of Milagrito to p+ (without Patch 7)
Eff Area (m2 sr)
Kinetic Energy (GeV)
% error (statistical)
Kinetic Energy (GeV)



Milagrito and Climax Data on Nov 6, 1997
Climax neutron monitor
Milagrito
high threshold scaler
Milagrito
100 PMT trigger
Rate (arbitrary units)
0
5
10
15
20
25
UT time (hours)

100 PMT "Signal": A few Facts

- ~2x RMS increase $\left(\frac{\text{peak}}{\text{backgrnd}}\right.$ with 2.5 min bins$\left.\right)$

- starts at ≈ 11:40 ± 15 min UT

- isotropic in both θ & ϕ

- $\frac{\text{NoFit}}{\text{Fit}}$ ratio increases as event progresse

- χ^2 does not change significantly throughou

- "signal" goes away for Nfit ≥ 40

- Isotropic p^+'s would need to have $\sim p^{-2.5}$ spectrum to explain "signal." $\boxed{(\approx 90\% \text{ of } p^+\text{'s} > 200 \text{ Ge}}$

⟹ Inconsistent with other observations
(satellites, neutron monitors ($p^{-5.2}$), HT ($p^{-6.6}$))

- There are other mechanisms that can trigger 100 PMT "signal"

Possible Sources of 100 PMT "Signal"

1) isotropic protons

2) "flashers"
   a) high rate flashers
   b) high PE, low Nfit flashers
   c) high PE, high Nfit flashers

3) High θ muons

4) high Z ions

5) multiple muons

6) Corsika inadequacies

7) Other suggestions?

1) Isotropic protons?

pro: - There is a "bump"

cons: - starts early ($\simeq$ 11:40 UT) $\pm$ 15 min

- requires $\sim p^{-2.5}$ spectrum

$\Rightarrow$ inconsistencies

- NoFits increase as event progresses

other: - θ & ϕ isotropic at all times

- χ^2 constant throughout event

- same eff. area used here predicts CR rate with factor of ~ 3

2) Flashers

a) high rate flashers:

- going on at ≈13:30 & ≈ 14:40 BUT NOT at onset time of event

b) High PE, low Nfit Flashers:

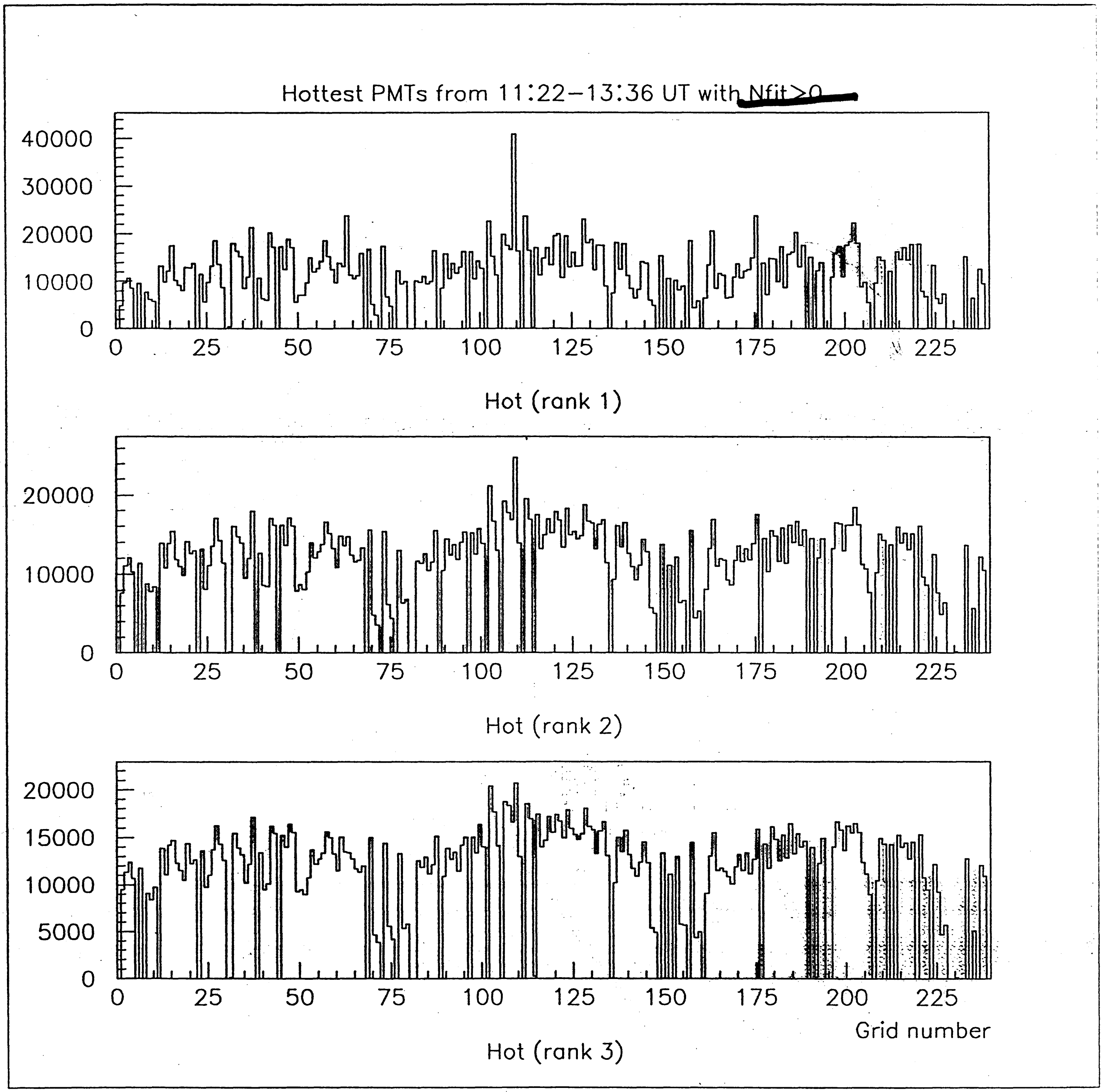
- could theoretically add to 100 PMT rate without adding significantly to HT scaler ra
- None seem to be present
  ⇒ Certainly not transient near event ons

(evaluated using Joe & Rick's flasher ID technique)

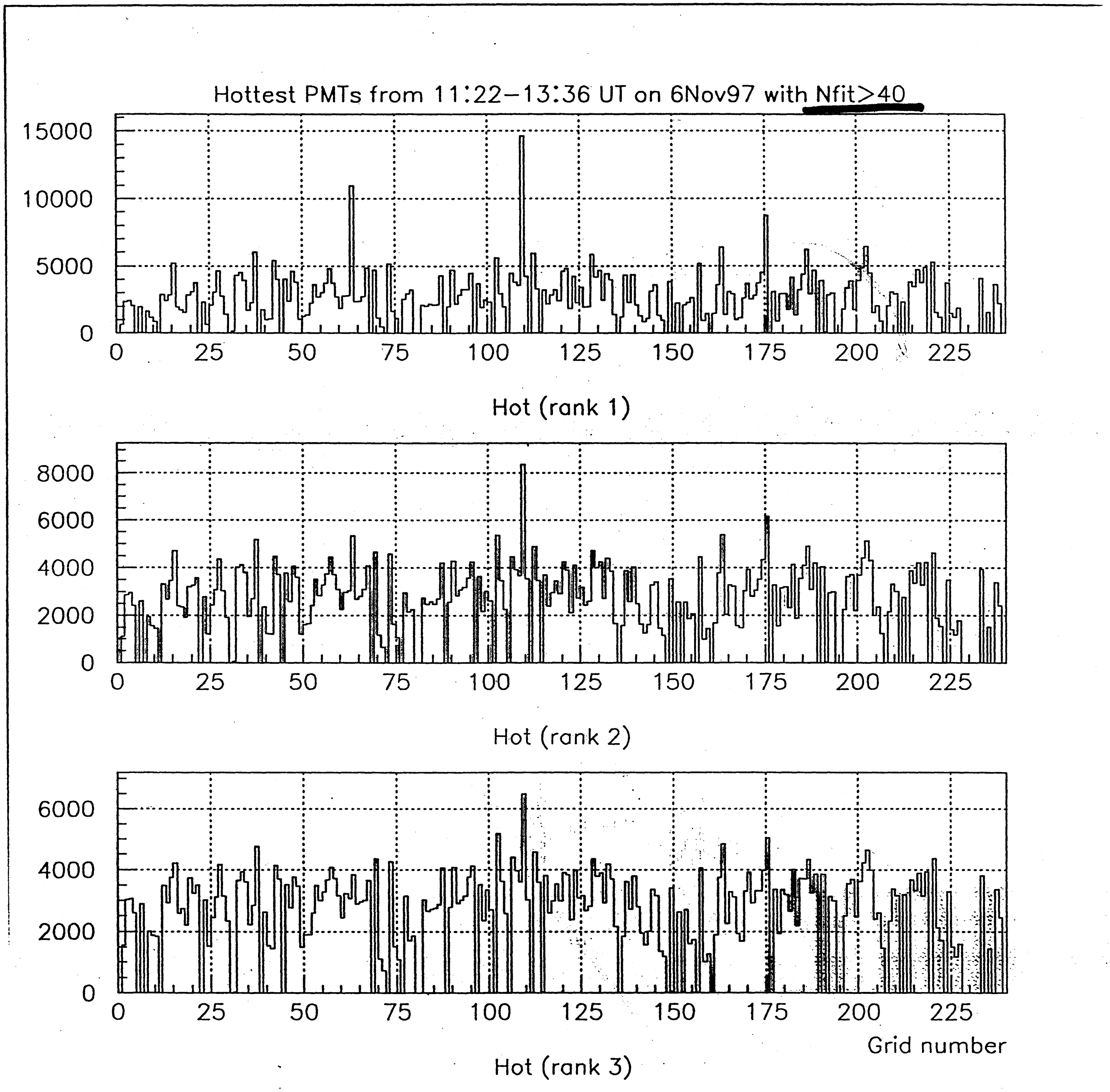
c) High PE, High Nfit Flashers:

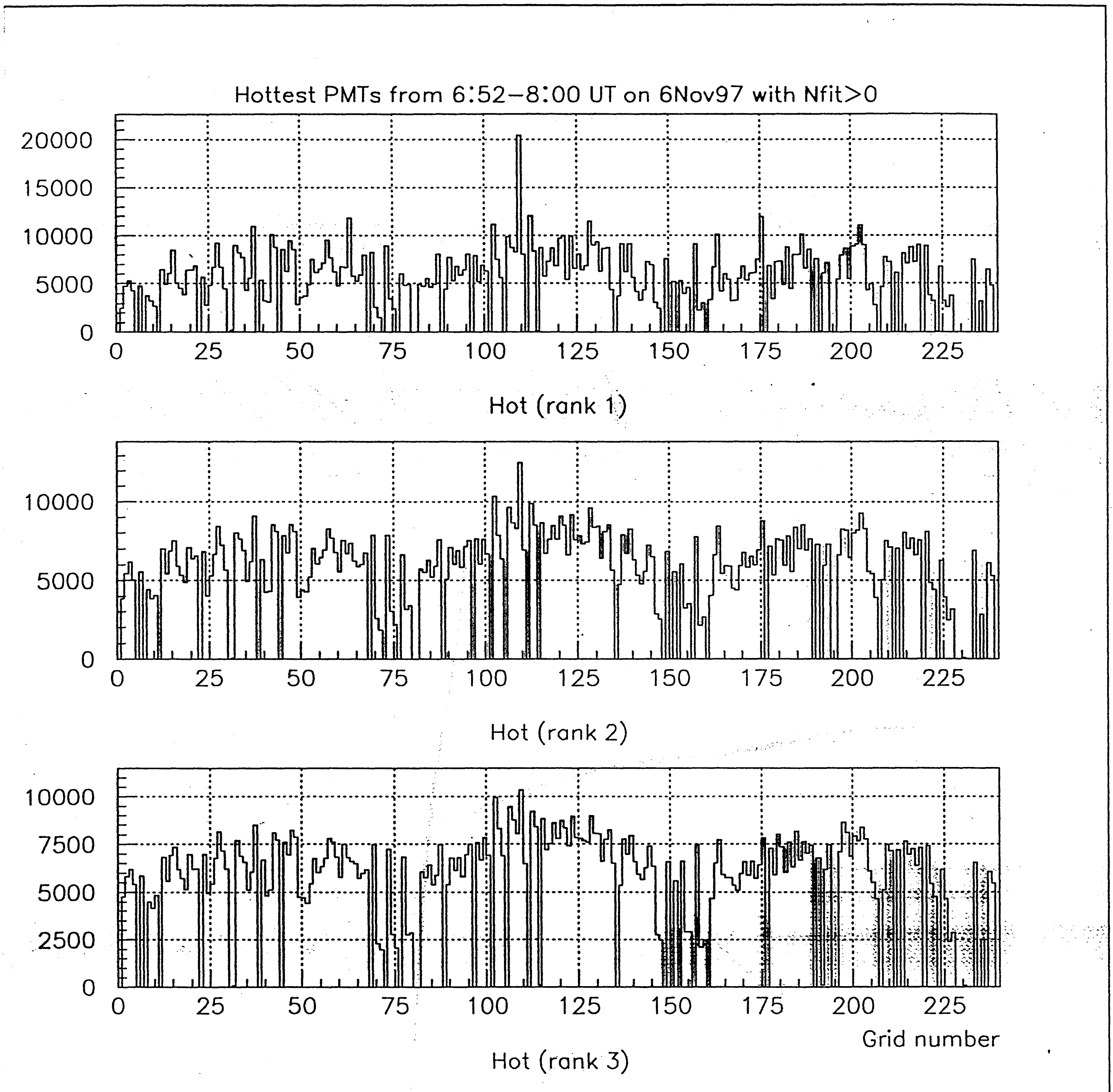
- Definetely present during event!
- Patch 7, and surrounding patches, see most!
- BUT: No change before, during, or after eve
  (i.e. hot tubes don't get hot with higher frequency during event)
  - Also, solar event goes away for Nfit ≥ 4(
    while these flashers become more pronounc

⇒ Probably Not flashers

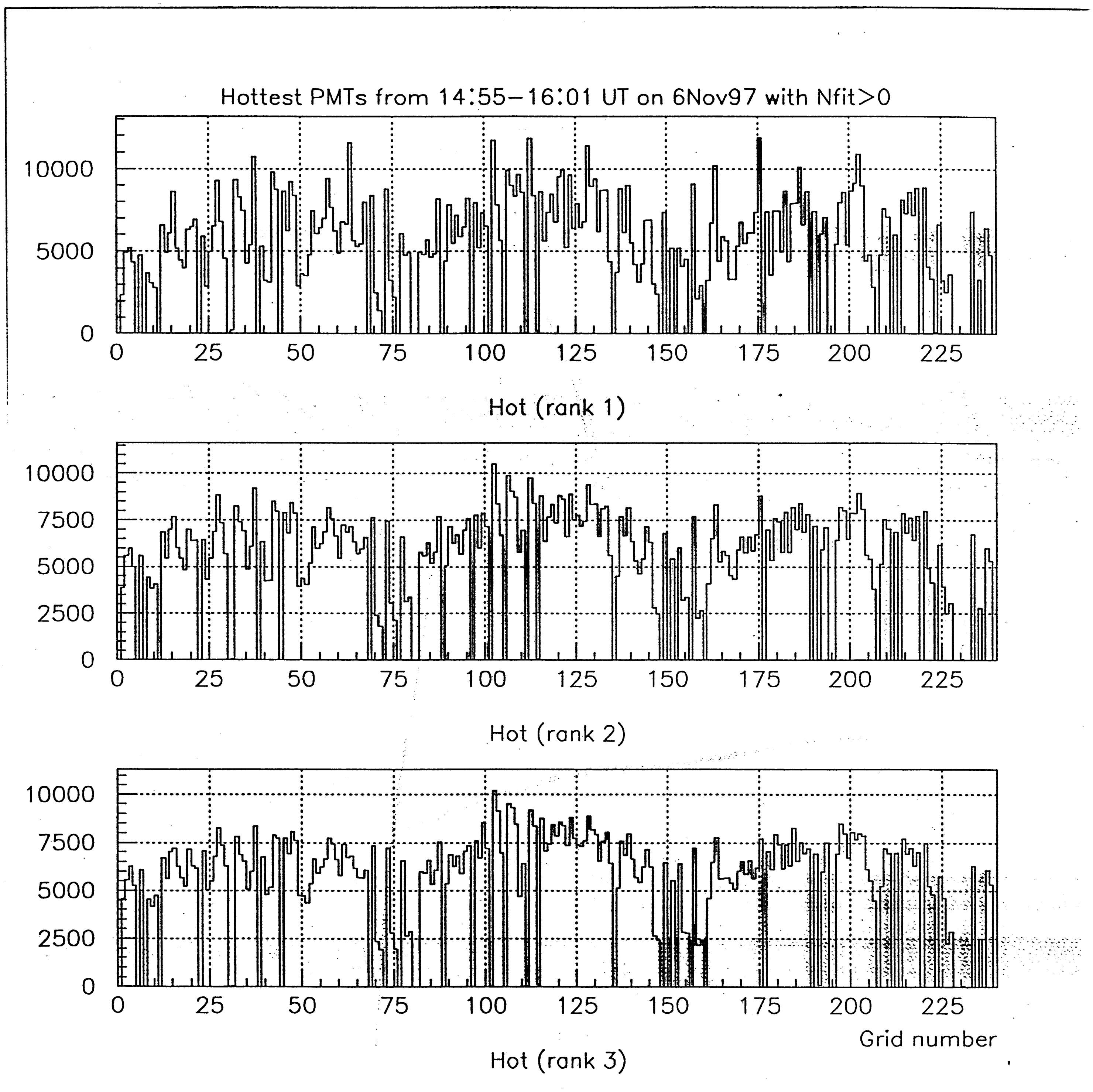


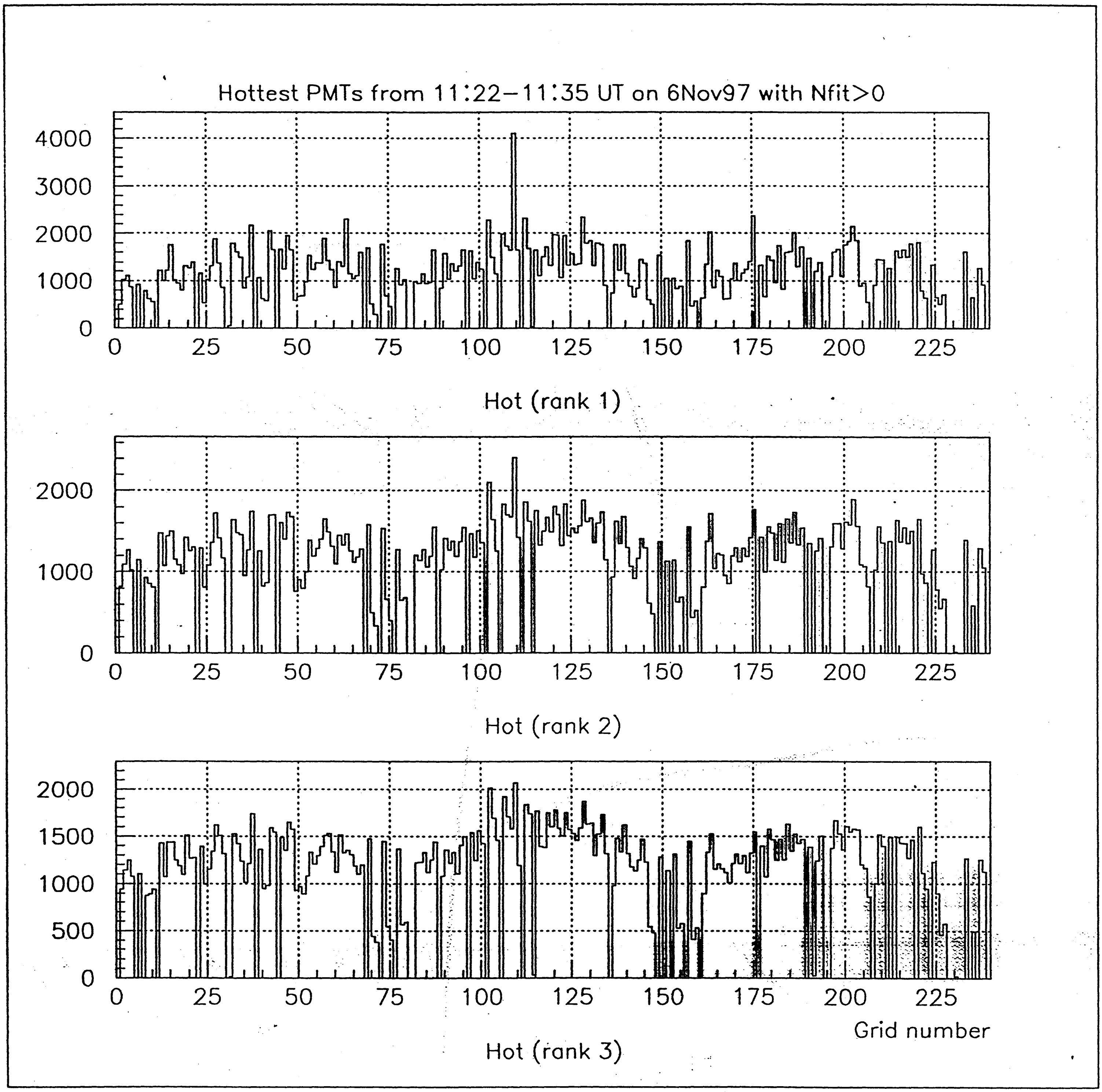
Hottest PMTs from 11:22–13:36 UT with Nfit>0
40000
30000
20000
10000
0
0 25 50 75 100 125 150 175 200 225
Hot (rank 1)
20000
10000
0
0 25 50 75 100 125 150 175 200 225
Hot (rank 2)
20000
15000
10000
5000
0
0 25 50 75 100 125 150 175 200 225
Grid number
Hot (rank 3)

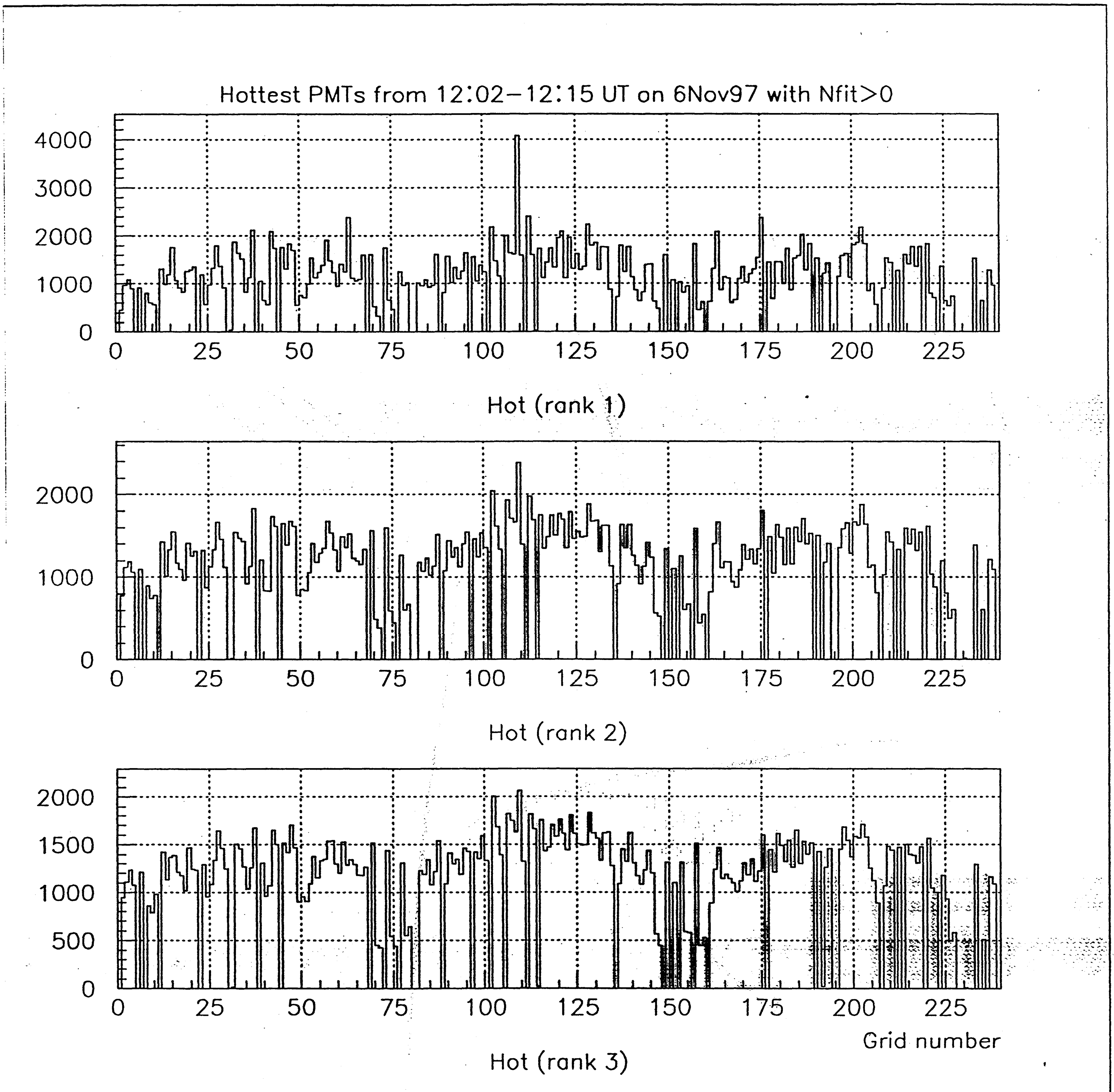

Hottest PMTs from 11:22-13:36 UT on 6Nov97 with Nfit>40
Hot (rank 1)
Hot (rank 2)
Hot (rank 3)
Grid number
0
5000
10000
15000
2000
4000
6000
8000
0
25
50
75
100
125
150
175
200
225

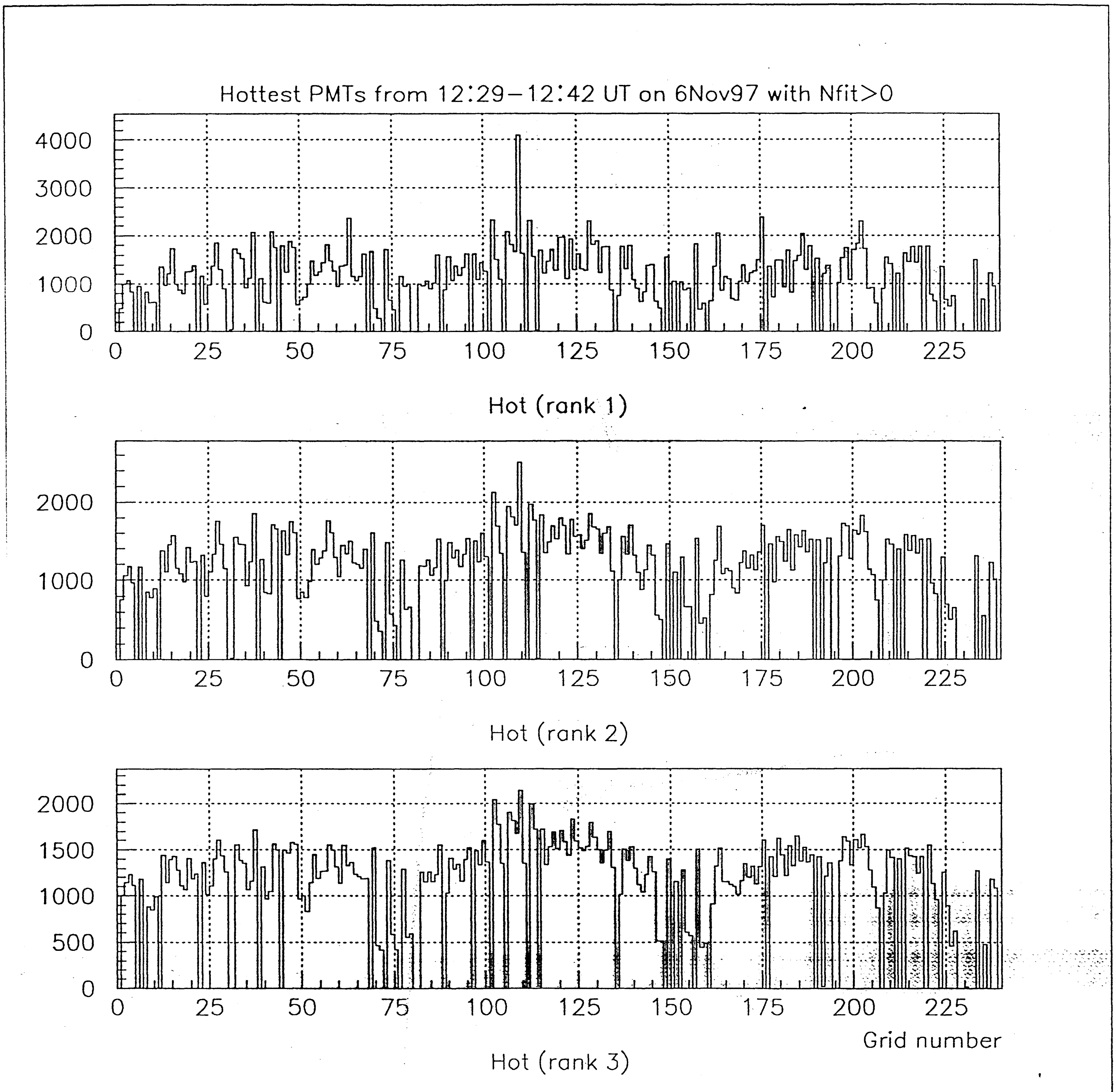


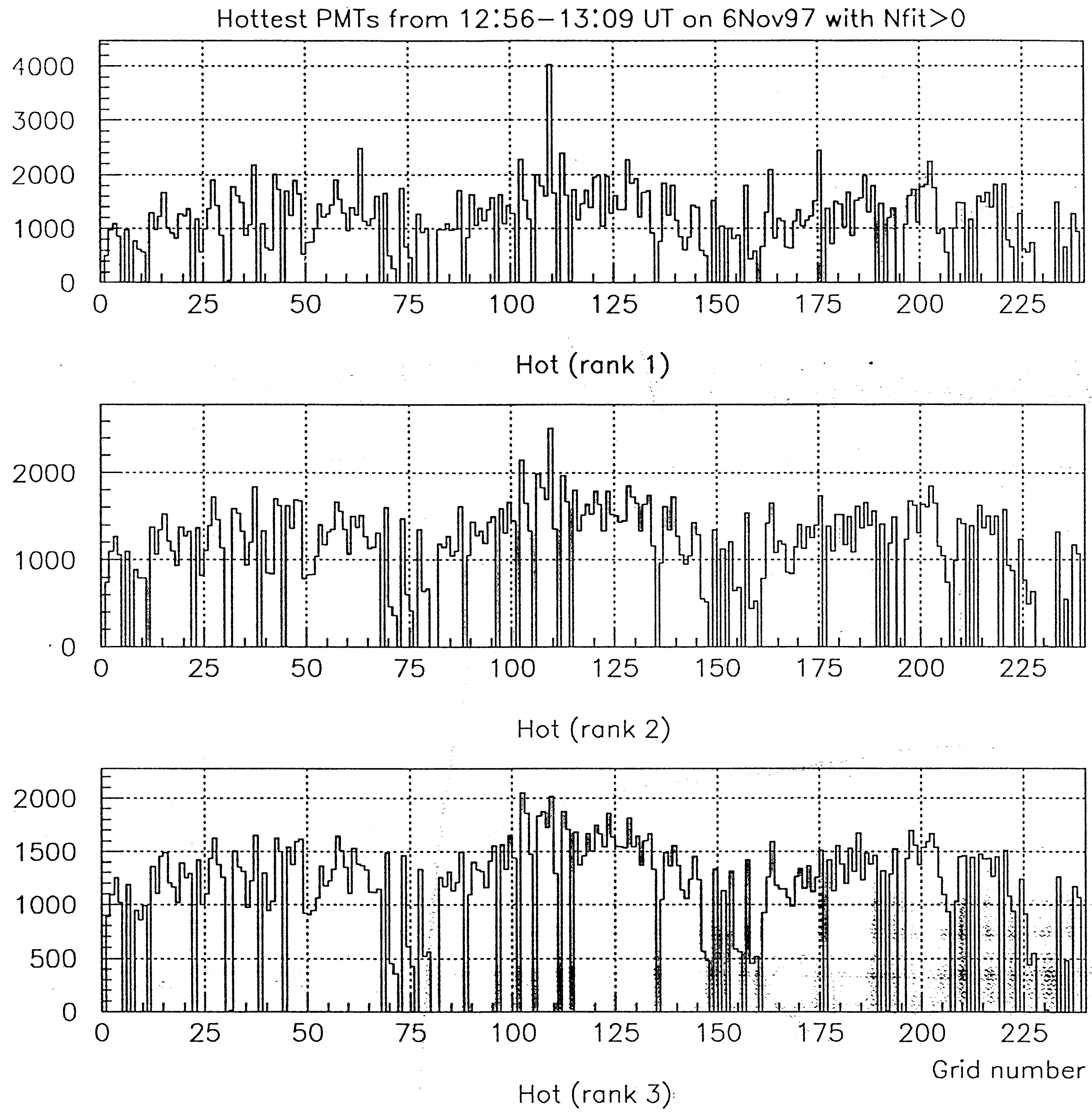
Hottest PMTs from 6:52–8:00 UT on 6Nov97 with Nfit>0
20000
15000
10000
5000
0
0 25 50 75 100 125 150 175 200 225
Hot (rank 1)
10000
5000
0
0 25 50 75 100 125 150 175 200 225
Hot (rank 2)
10000
7500
5000
2500
0
0 25 50 75 100 125 150 175 200 225
Grid number
Hot (rank 3)


Hottest PMTs from 14:55-16:01 UT on 6Nov97 with Nfit>0
Hot (rank 1)
Hot (rank 2)
Hot (rank 3)
Grid number

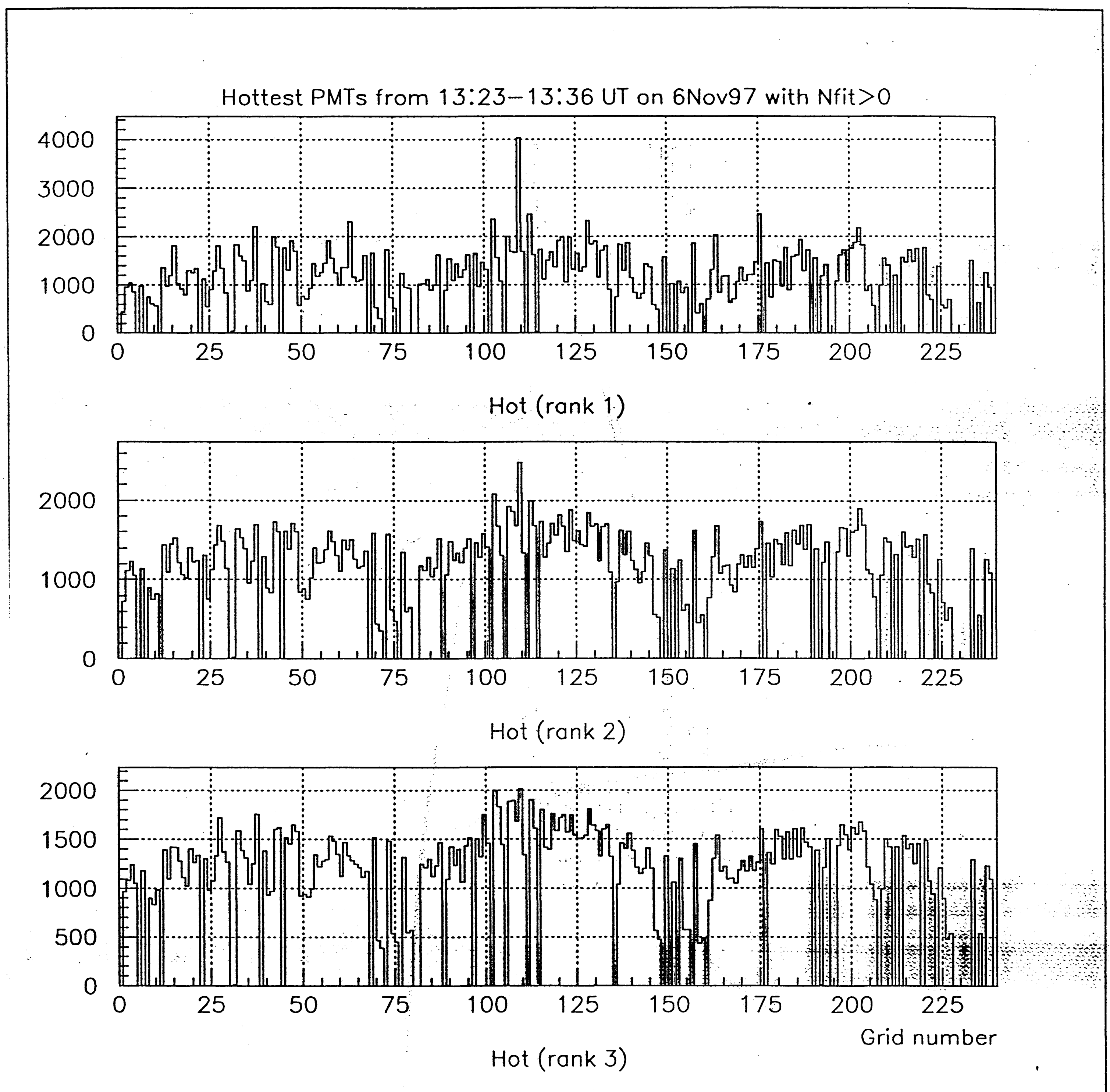

Hottest PMTs from 11:22–11:35 UT on 6Nov97 with Nfit>0
4000
3000
2000
1000
0
0
25
50
75
100
125
150
175
200
225
Hot (rank 1)
2000
1000
0
0
25
50
75
100
125
150
175
200
225
Hot (rank 2)
2000
1500
1000
500
0
0
25
50
75
100
125
150
175
200
225
Grid number
Hot (rank 3)


Hottest PMTs from 12:02–12:15 UT on 6Nov97 with Nfit>0
0
1000
2000
3000
4000
0 25 50 75 100 125 150 175 200 225
Hot (rank 1)
0
1000
2000
0 25 50 75 100 125 150 175 200 225
Hot (rank 2)
0
500
1000
1500
2000
0 25 50 75 100 125 150 175 200 225
Grid number
Hot (rank 3)


Hottest PMTs from 12:29–12:42 UT on 6Nov97 with Nfit>0
4000
3000
2000
1000
0
0
25
50
75
100
125
150
175
200
225
Hot (rank 1)
2000
1000
0
0
25
50
75
100
125
150
175
200
225
Hot (rank 2)
2000
1500
1000
500
0
0
25
50
75
100
125
150
175
200
225
Grid number
Hot (rank 3)



Hottest PMTs from 12:56–13:09 UT on 6Nov97 with Nfit>0
Hot (rank 1)
Hot (rank 2)
Grid number
Hot (rank 3)


Hottest PMTs from 13:23–13:36 UT on 6Nov97 with Nfit>0
4000
3000
2000
1000
0
0
25
50
75
100
125
150
175
200
225
Hot (rank 1)
2000
1000
0
0
25
50
75
100
125
150
175
200
225
Hot (rank 2)
2000
1500
1000
500
0
0
25
50
75
100
125
150
175
200
225
Grid number
Hot (rank 3)

3) High Zenith Angle Muons

- $\frac{\text{Nofit}}{\text{Fit}}$ ratio increases as event progresses

  ⇒ Support for presence of ~horizontal μ's ($\gtrsim 83°$)

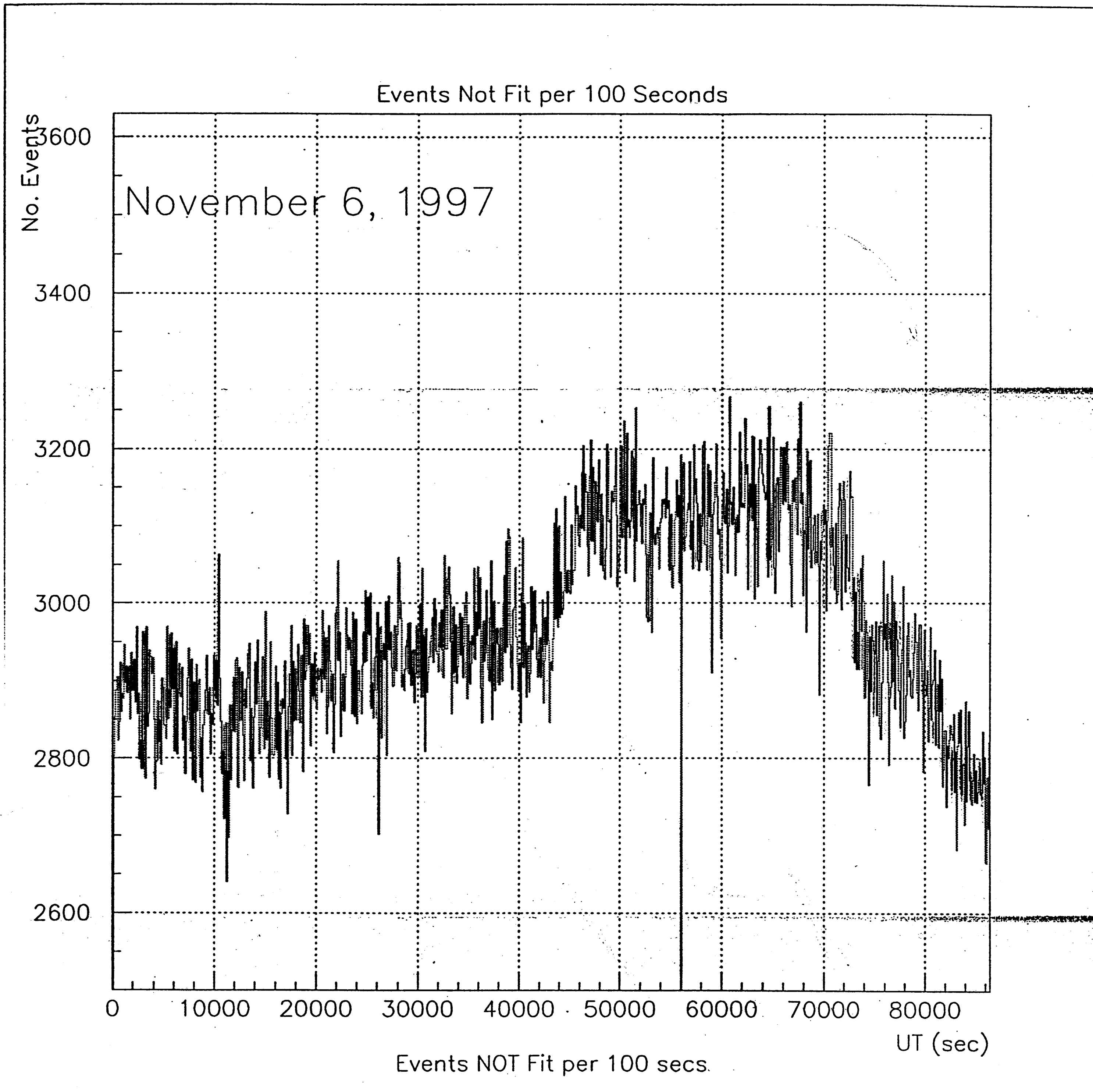
- But, there are still some fit events

- The increase is not present for $Nfit \geq 40$

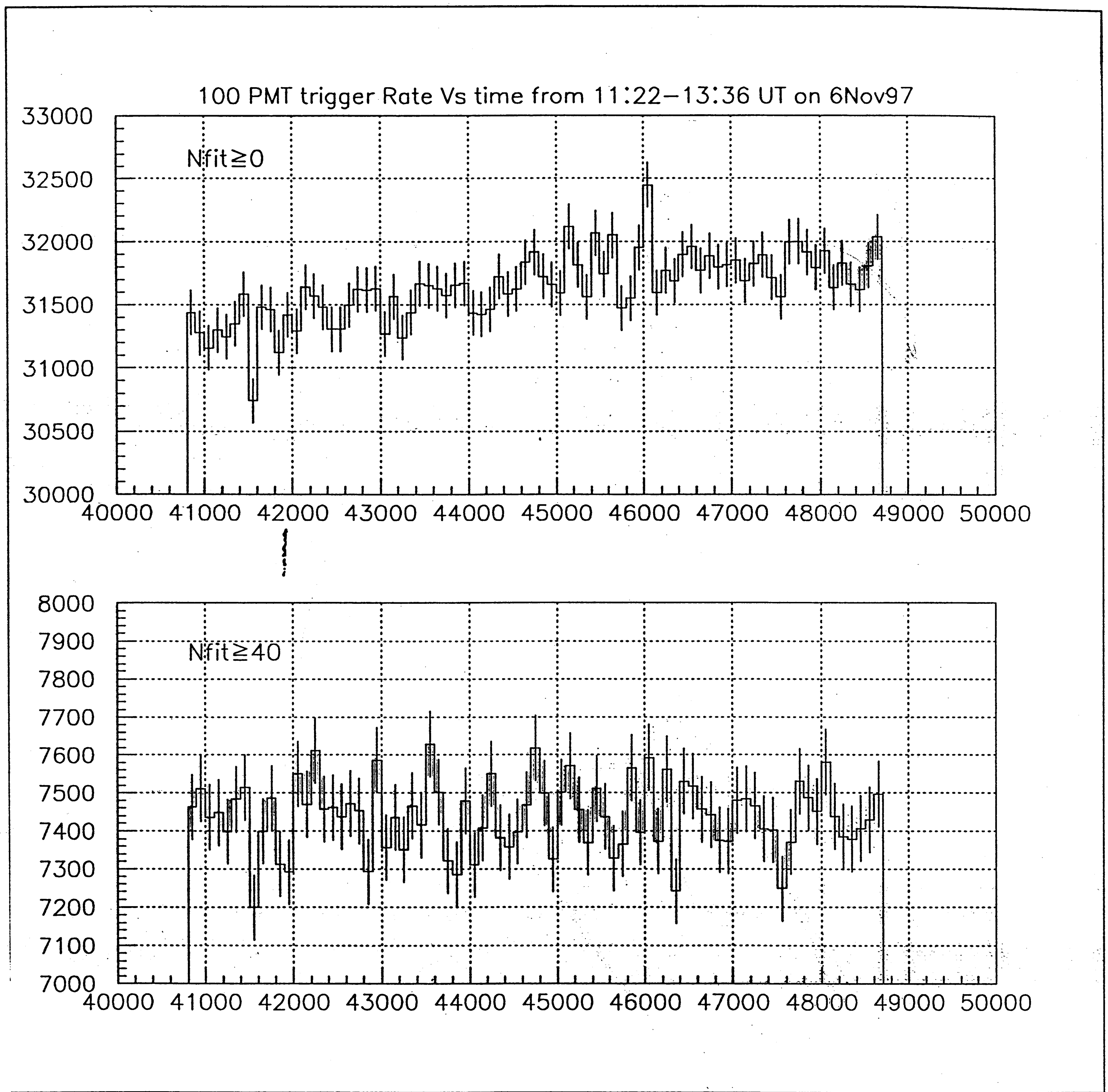
  ⇒ Even the fit events are "poor quality" (although χ^2 does not increase significantly)

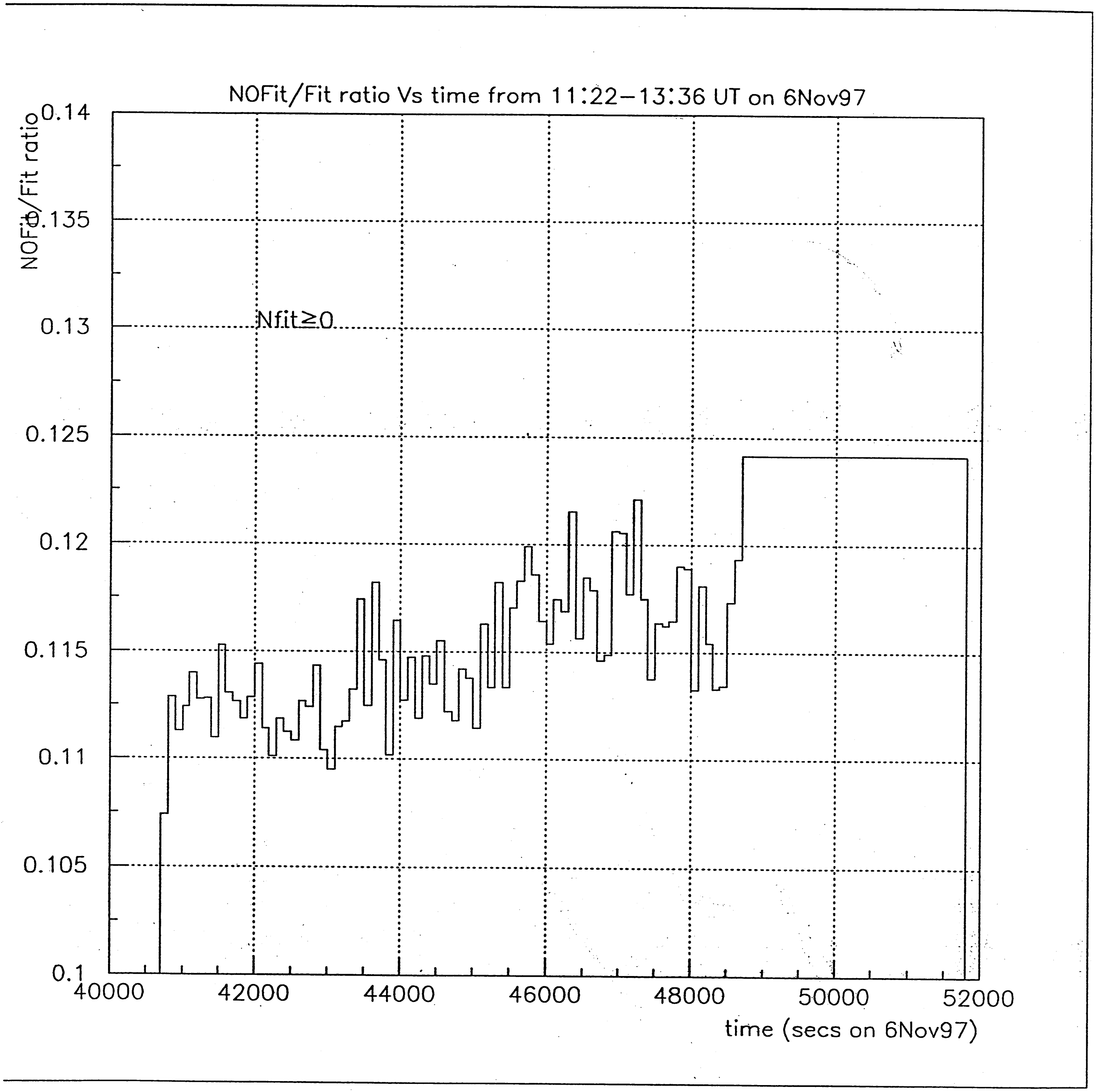
- These $Nfit < 40$ events could be muons between $60° - 83°$, which must certainly accompany $\theta > 83°$ muons

  (These would not have been in MC)

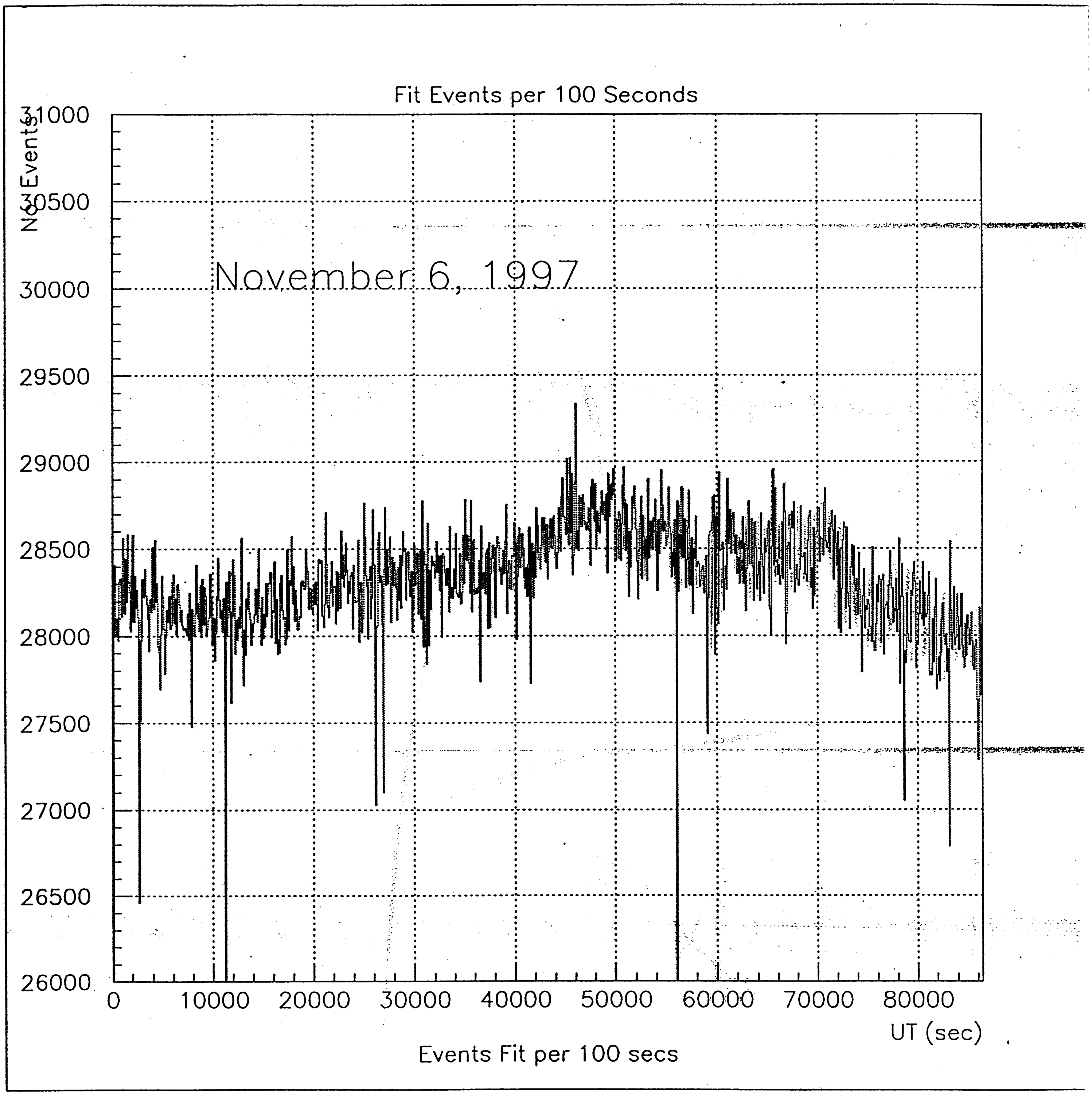


Events Not Fit per 100 Seconds
No. Events
November 6, 1997
3600
3400
3200
3000
2800
2600
0
10000
20000
30000
40000
50000
60000
70000
80000
UT (sec)
Events NOT Fit per 100 secs.


100 PMT trigger Rate Vs time from 11:22–13:36 UT on 6Nov97
Nfit≧0
33000
32500
32000
31500
31000
30500
30000
40000
41000
42000
43000
44000
45000
46000
47000
48000
49000
50000
Nfit≧40
8000
7900
7800
7700
7600
7500
7400
7300
7200
7100
7000
40000
41000
42000
43000
44000
45000
46000
47000
48000
49000
50000



NOFit/Fit ratio Vs time from 11:22-13:36 UT on 6Nov97
NOFit/Fit ratio
0.14
0.135
0.13
0.125
0.12
0.115
0.11
0.105
0.1
Nfit≥0
40000
42000
44000
46000
48000
50000
52000
time (secs on 6Nov97)



Fit Events per 100 Seconds
No. Events
31000
30500
30000
29500
29000
28500
28000
27500
27000
26500
26000
November 6, 1997
0
10000
20000
30000
40000
50000
60000
70000
80000
UT (sec)
Events Fit per 100 secs

4) High Z ions

- Spectral flux decreases with Z faster than eff. area increases

5) multipe muons

- Corsika includes these

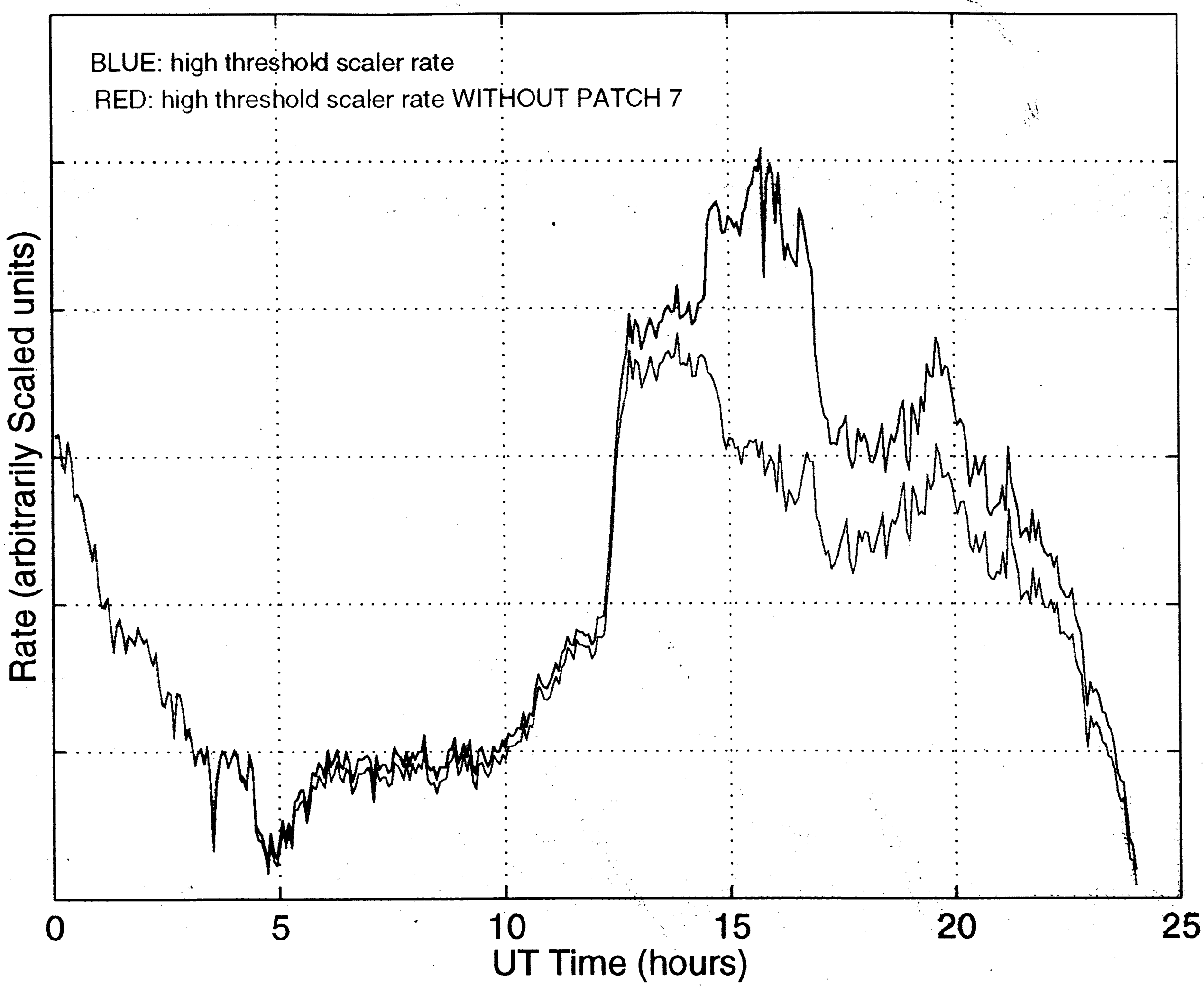
6) Miscalculation of Eff. Area by Corsika

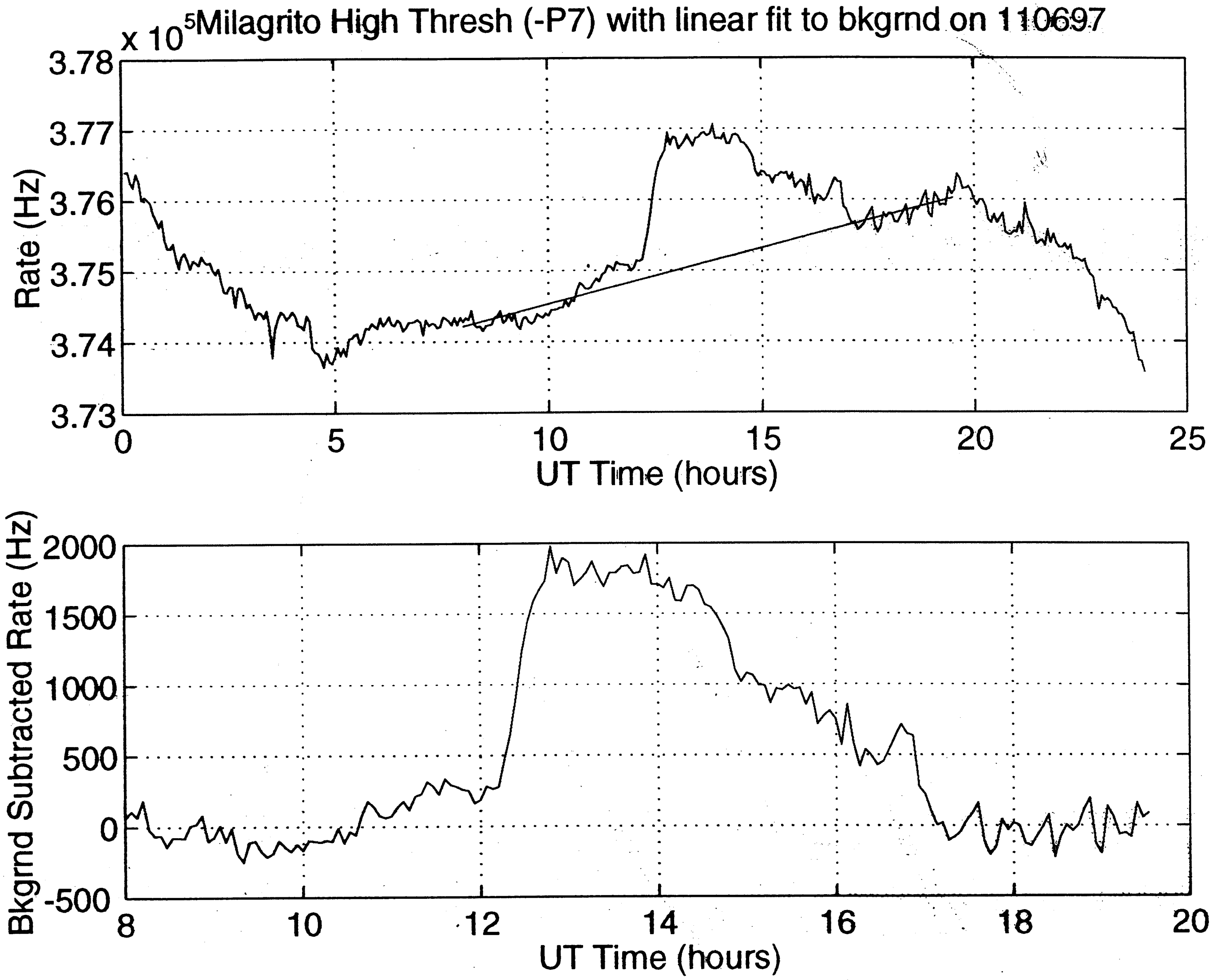
- Corsika does have problems at low energy
- BUT: a) This would affect HT also

  b) Both HT scaler & 100 PMT eff. areas reproduce measured background rate fairly well

7) Suggestions?

Milagrito High Threshold Scaler Rate w/wo Patch 7 on 110697




x 10^5 Milagrito High Thresh (-P7) with linear fit to bkgrnd on 110697
3.78
3.77
3.76
3.75
3.74
3.73
Rate (Hz)
0
5
10
15
20
25
UT Time (hours)
2000
1500
1000
500
0
-500
Bkgrnd Subtracted Rate (Hz)
8
10
12
14
16
18
20
UT Time (hours)

Proton Spectrum

- Assume $P^{-\alpha}$ spectrum

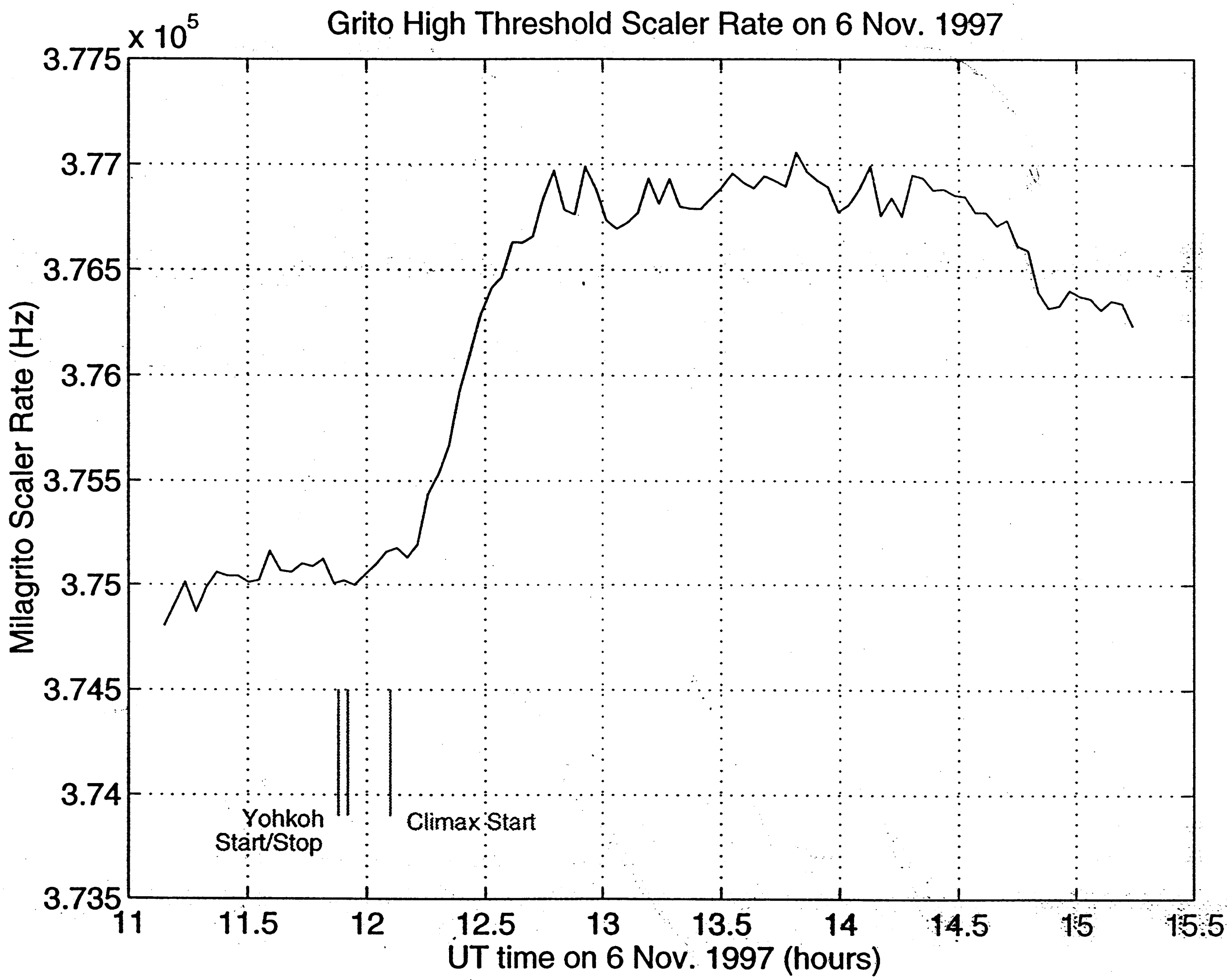
- Require continuity of Grito derived spectr with neutron monitor derived spectrum

- Use new eff. area curve

$$\Rightarrow \quad \underline{\alpha \simeq 6.6 \pm 1.4}$$

- This result is consistent with NMs & satellites, and it is self consistent

- This implies a spectrum which rolls over as energy increases



Grito High Threshold Scaler Rate on 6 Nov. 1997
x 10^5
3.775
3.77
3.765
3.76
3.755
3.75
3.745
3.74
3.735
Milagrito Scaler Rate (Hz)
Yohkoh
Start/Stop
Climax Start
11
11.5
12
12.5
13
13.5
14
14.5
15
15.5
UT time on 6 Nov. 1997 (hours)

Event Timing and Acceleration Time

- gamma ray line flare from 11:52 – 11:55

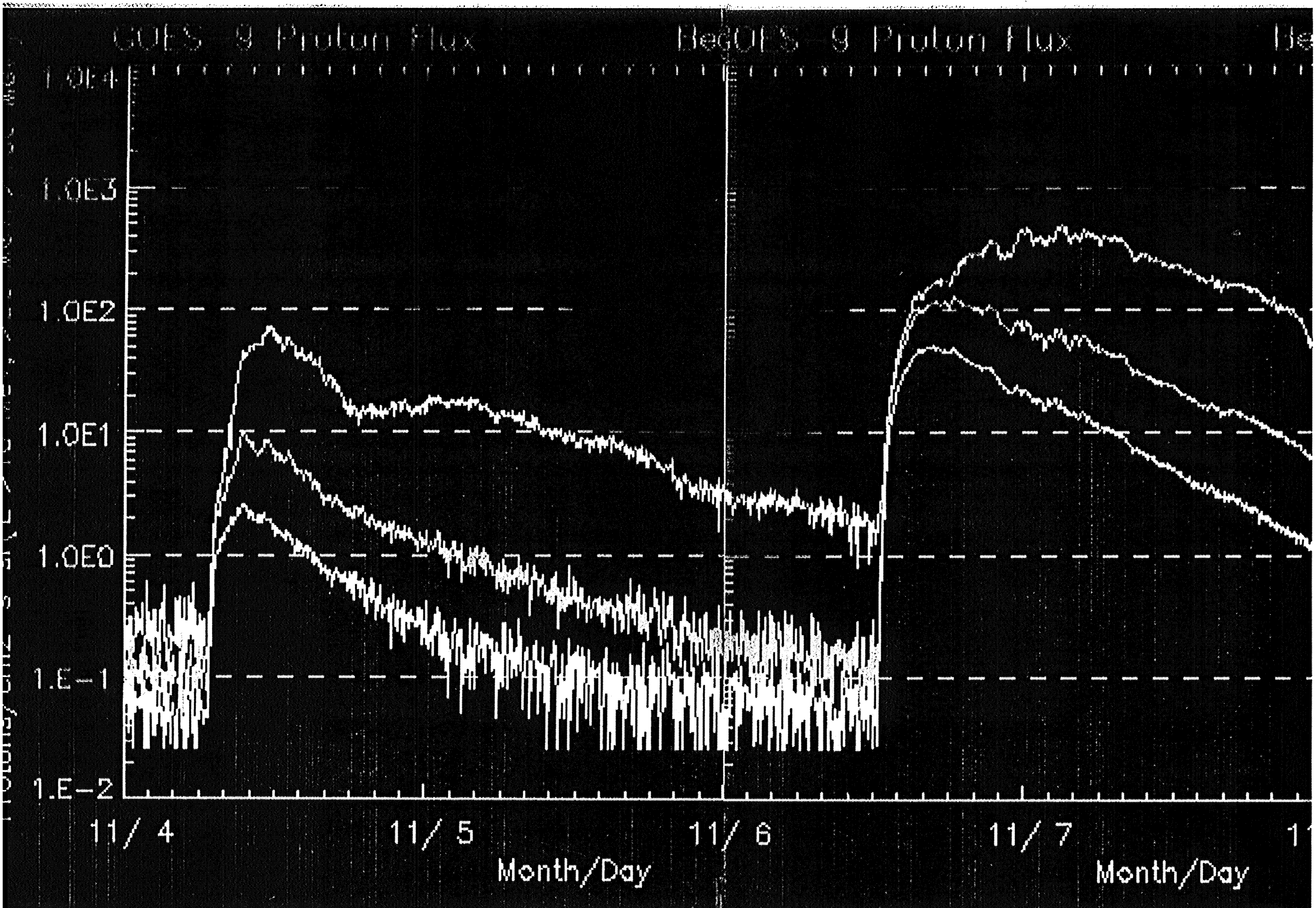
- HT scaler rate increase starts at $\simeq$ 12:07 UT

$\Rightarrow$ 1) Acceleration of long duration SEPs probably not at flare site; probably due to CME driven shock

2) Taking shock speed to be $\gtrsim$ 2000 km/s, the acceleration begins in low corona at ~2 $R_\odot$.

- The acceleration time of $\simeq$ 10 min is consistent with shock acceleration models, given injection energies exceeding 10 MeV!

- The ambient medium is filled with >10 MeV p^+'s due to previous solar event on 4 Nov.


GOES-9 Proton Flux
GOES-9 Proton Flux
1.0E4
1.0E3
1.0E2
1.0E1
1.0E0
1.E-1
1.E-2
11/ 4
11/ 5
11/ 6
11/ 7
Month/Day
Month/Day

Conclusions

- New effective areas are good to within factor of ≈ 3

- 100 PMT "signal" is inconclusive, while HT signal is on solid ground

- HT Scaler signal analysis says:

  - $p^{-6.6}$ spectrum above ≈ 5 GeV
    $\Rightarrow$ rollover implied

  - low corona ($\approx 2 R_\odot$) SEP origin
    probably CME driven shock acceleratio
    with high injection energies

  - HT is consistent with other instrum
    (neutron monitors & satellites)

How Many Days

- The the time between events for the crab data for event separations <0.1s is 76 days.
  - Crab data is collected for 6.7hr/day

  $76 * 24/6.7 = 275$ days

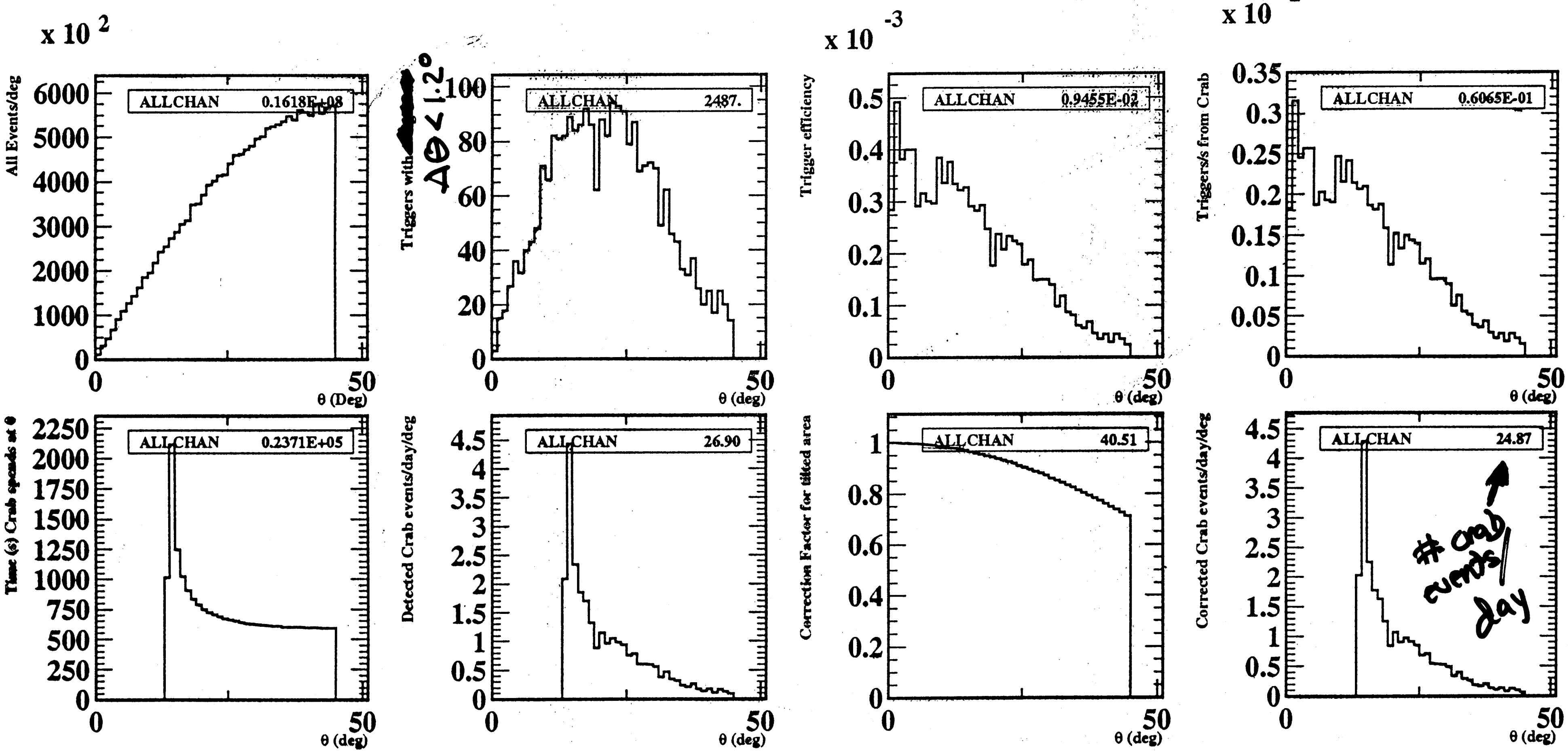
- The total background in the NFIT>20 2.1 deg bin is 3,350,000. The expected daily background for 1 day is 23,600. Dividing the 2 numbers gives:

  3,350,000 events /(23,600 events/day)
  = 200 days

The difference is due to extended periods of running at a higher threshold (lower rate) than used to estimate the daily background. A reasonable estimate of the exposure is [redacted] years or ~240 days.

2/3

Crab Sensi: NFIT≥65, NFIT≥20, 1.2 deg round bin



Prediction for Crab Signal

- MC gammas thrown from 100 GeV to 100 Tev with an E**−2.4 spectrum. The throw area was 1000m x 1000m for all energies.

- PMTs known to be dead were eliminated from the reconstruction and triggering of the detector.

- Crab Spectrum used: (recent Whipple)

  3.3 10**−7 E**−2.45 gammas/s/TeV/m**2

- Trigger threshold assumed to be 65 PMTs. This corresponds to ~300 mV in recent a recent measurement. This Threshold gives roughly a 1400−1500Hz data rate.

Reconstruction

- Events collected when the RA of the crab was more than 50 deg from the RA of zenith were excluded from the reconstruction. This represents a zenith angle cut of ~45 deg, and reduces the data set by a factor of 5/8.

- The data were reconstructed with a standard v44 offline with 2 changes:

  GS Core Fitter, curv corr increased to 0.07ns/m

  v44 includes:

  Laser timing calibrations with extrapolation for low LO and high HI TOT.

  Laser based PE−TOT calibration

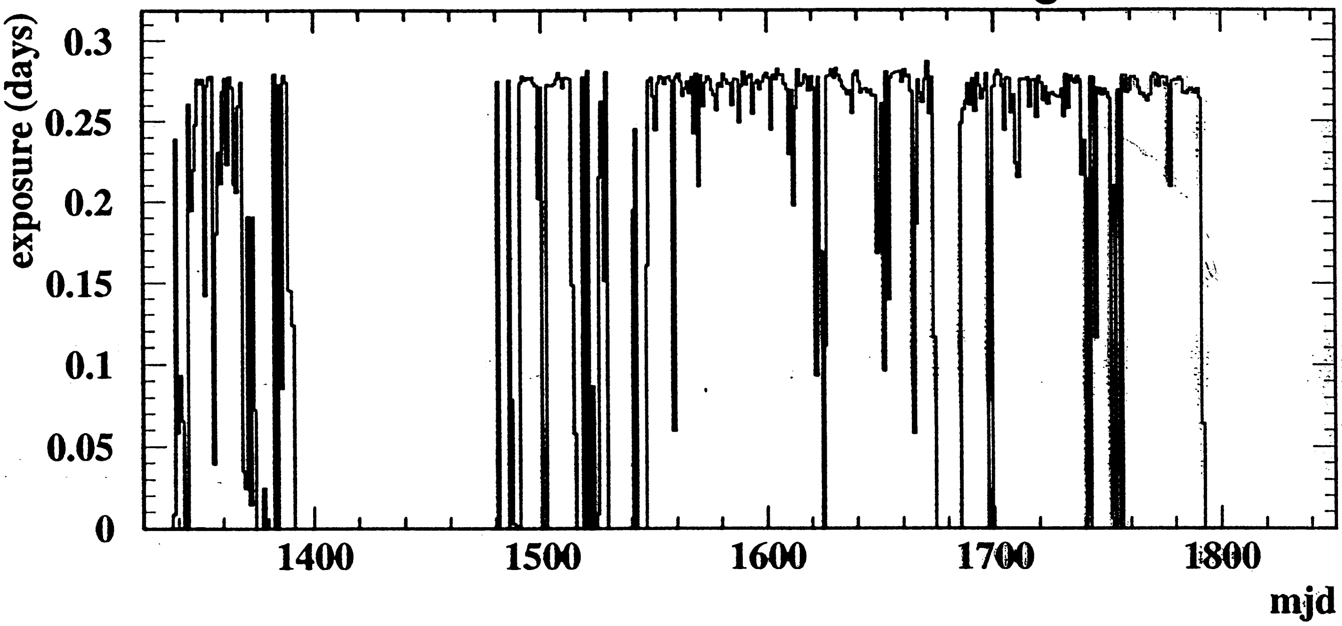
  Chi**2 angle fitter with v44

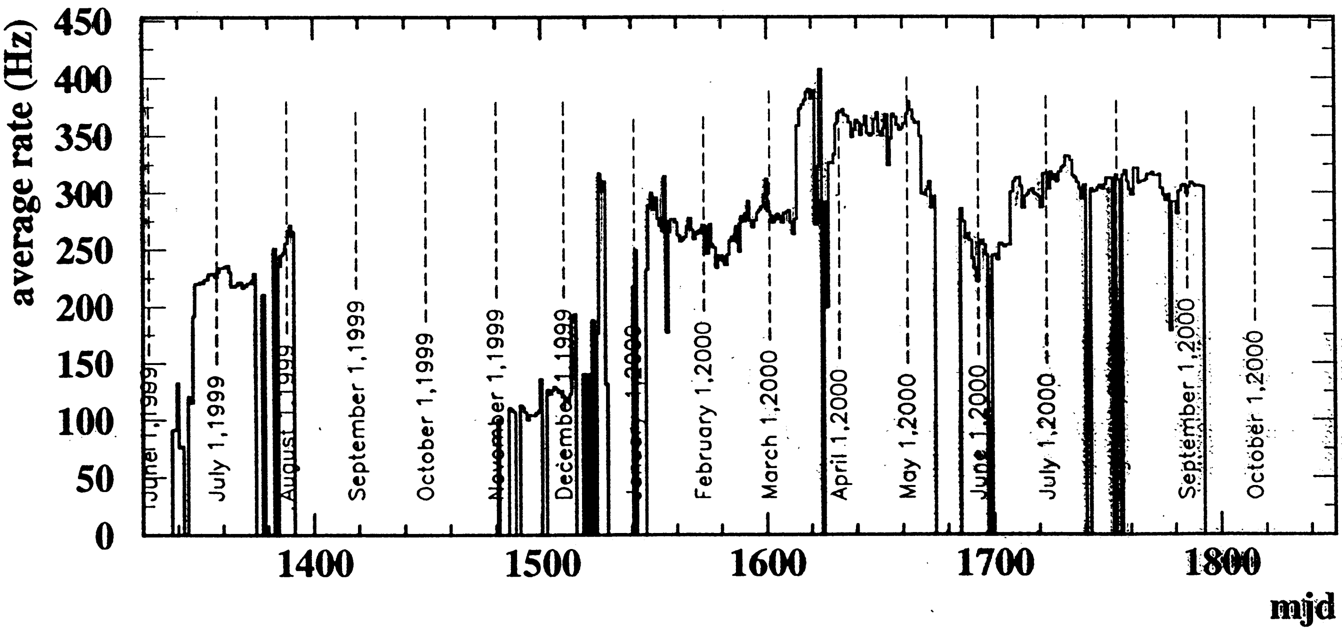
- The events were logged with the Max Muon in the bottom layer and Nbottom gh cut data.

Nbottom
Nbottom 2pe+

~~1.8B~~ events
75.8 days

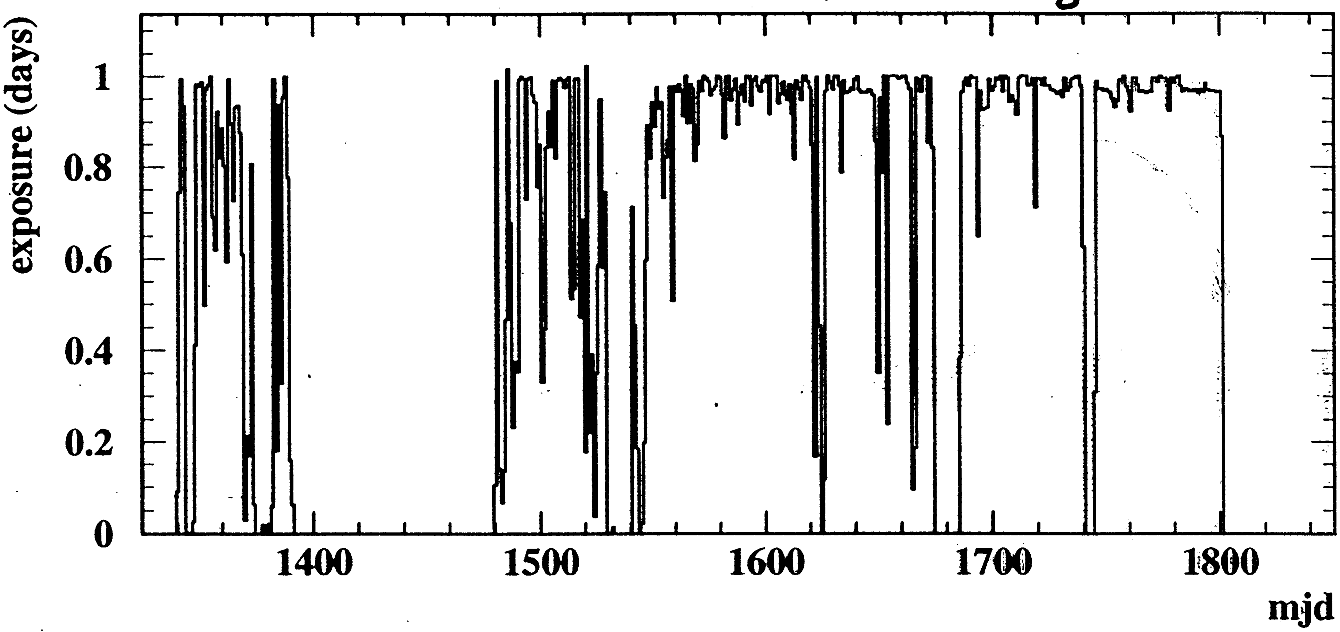
Crab Data Set 1.8B events
75.8 days

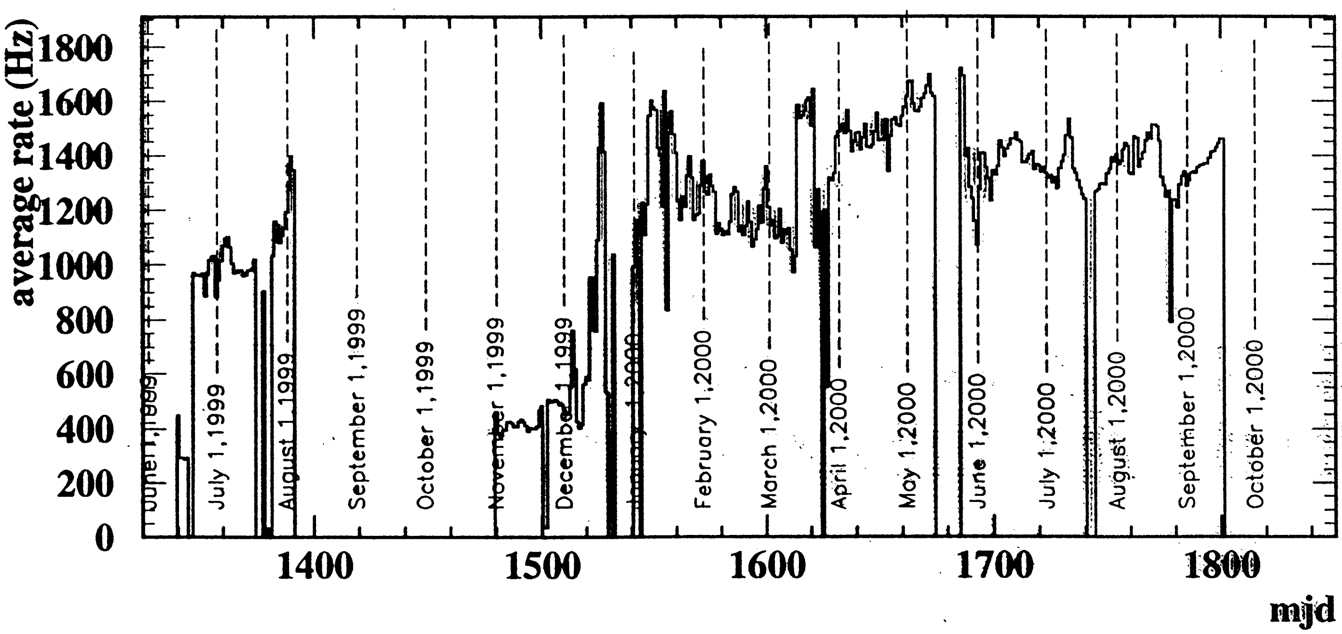




30.3B events
288 days

All Milagro Data Prior to Repairs
30.3B events, 288 Days





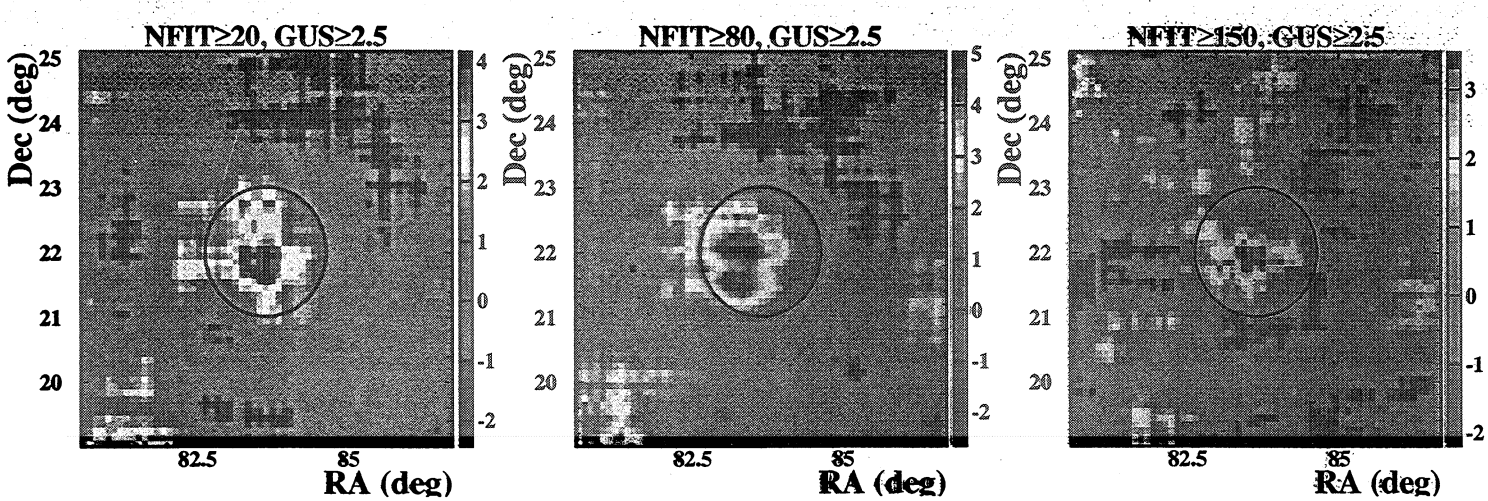
The Crab Data

- Crab data are recorded when the RA of the zenith zenith is within 80 deg of the Crab RA. (10.7h/day)

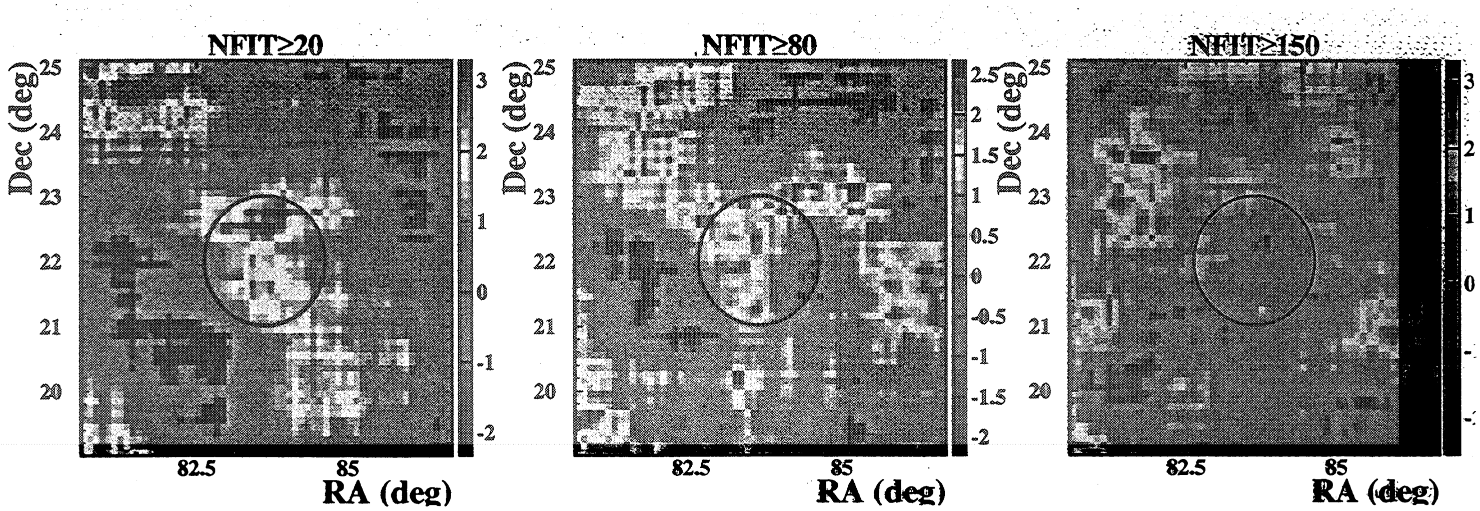
- All events with reconstructed declinations within 10 deg of the declination of the Crab are saved during this period.

- We currently write ~0.5 crab tapes/day and have written ~180 tapes to date.

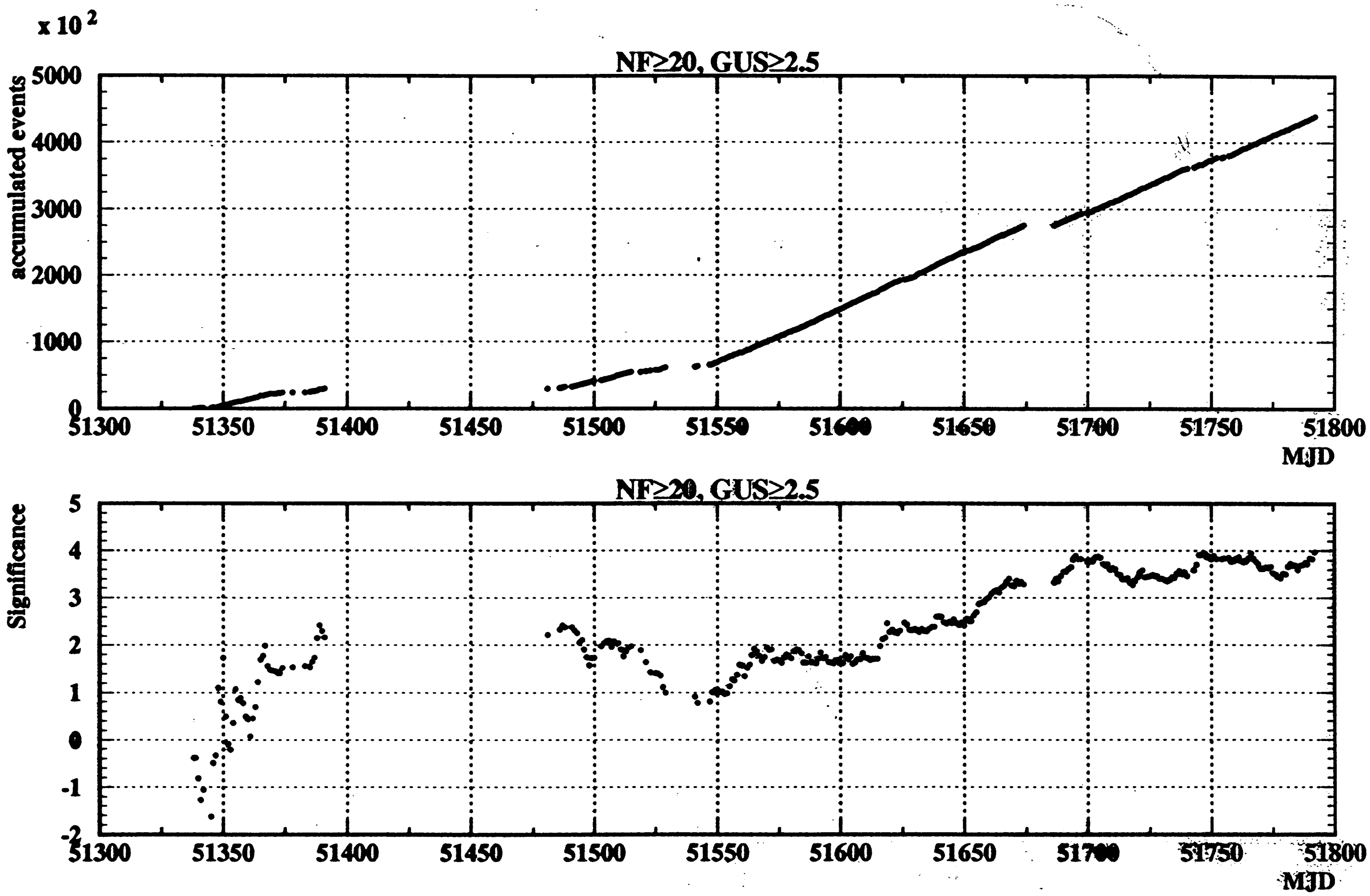
- The current Crab data set is more than half the size of the entire milagrito data set.

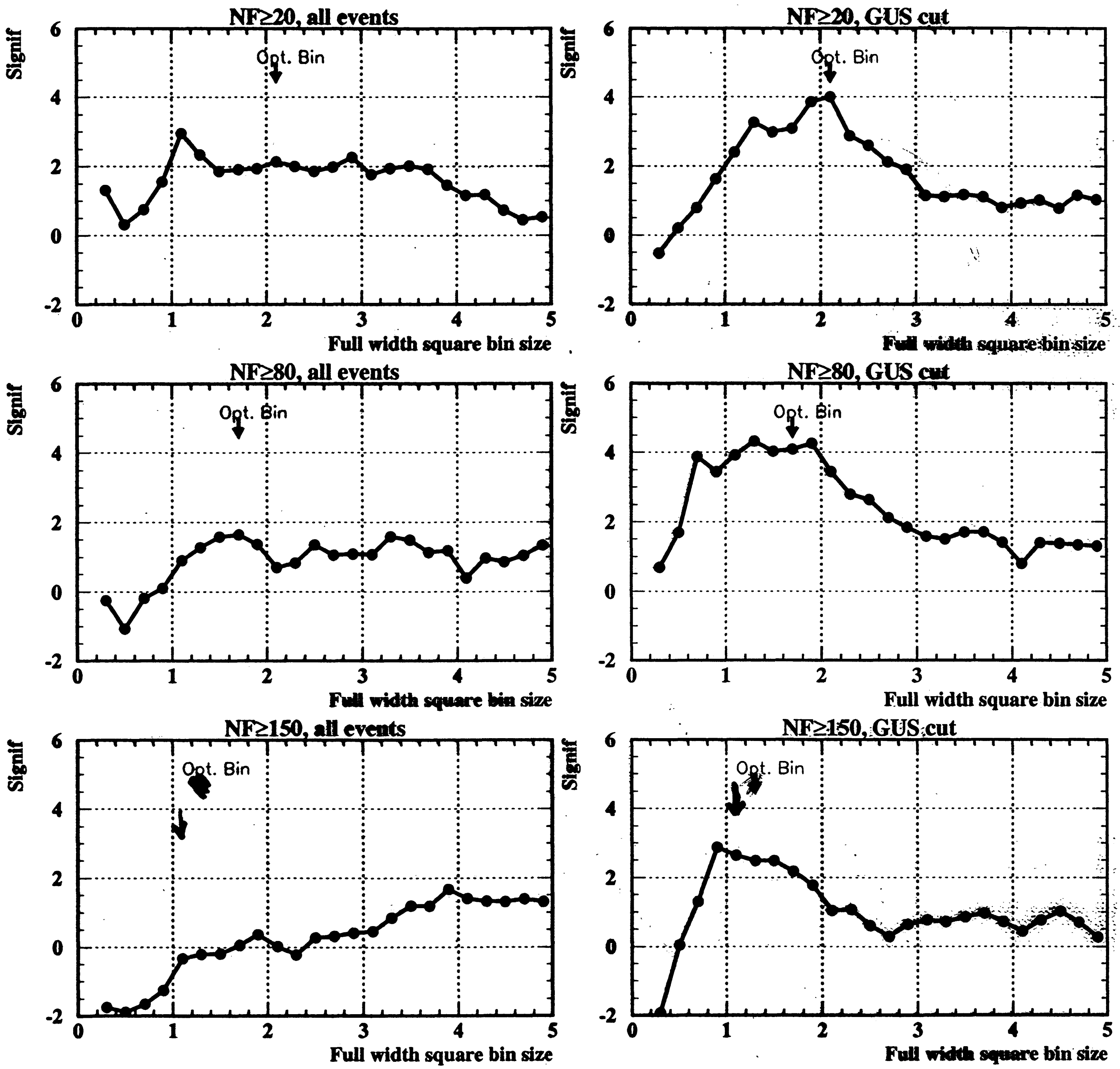


NFIT≥20, GUS≥2.5
NFIT≥80, GUS≥2.5
NFIT≥150, GUS≥2.5
Dec (deg)
RA (deg)
82.5
85



NFIT≥20
NFIT≥80
NFIT≥150
Dec (deg)
25
24
23
22
21
20
82.5
85
RA (deg)
3
2
1
0
-1
-2
2.5
1.5
0.5
-0.5
-1.5


x 10^2
NF≥20, GUS≥2.5
accumulated events
5000
4000
3000
2000
1000
0
51300
51350
51400
51450
51500
51550
51600
51650
51700
51750
51800
MJD
NF≥20, GUS≥2.5
Significance
5
4
3
2
1
0
-1
-2
51300
51350
51400
51450
51500
51550
51600
51650
51700
51750
51800
MJD



Bin sizes used:

NF>20 2.1°

NF>80 1.7°

NF>150 1.1°

square bin width

Crab Sensitvity

Cuts	Optimal round bin	Optimal square bin	Signal	2.1 deg background	opt bin background	sigmas 1/day	1/y
NF>20	1.2	2.1	24.9	23600	23600	.16	3.1
NF>80	1.0	1.7	12.1	5300	3550	.20	3.9
NF>150	0.6	1.1	3.7	1760	440	.18	3.4

Quality Factor for g/h cuts: see other talks

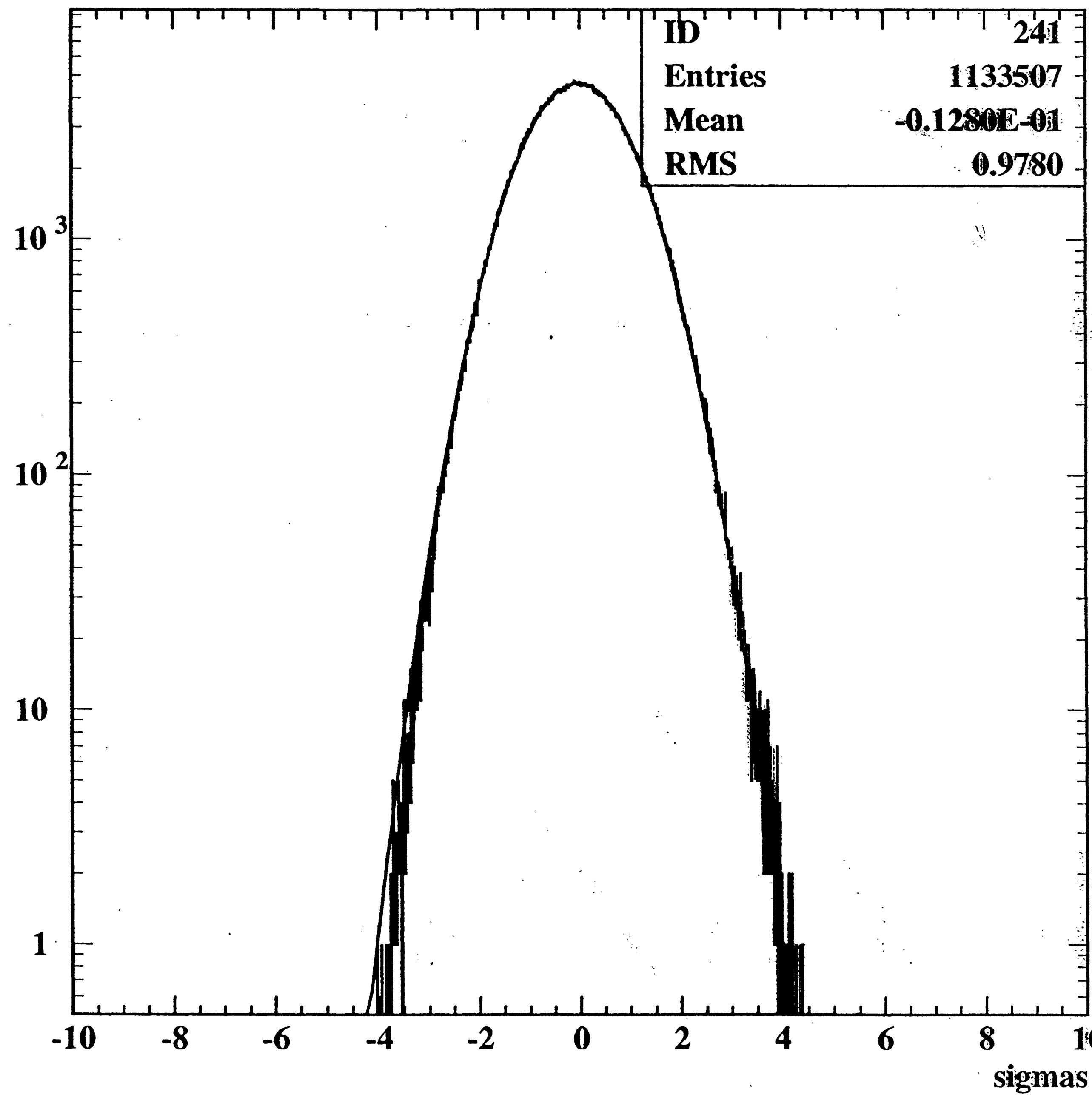
Hegra Flux: $2.8\ E^{-2.6}\ \gamma/s/m^2/TeV \Rightarrow$ 30% less

Tibet Flux: $8.2\ E^{-2.6}\ \gamma/s/m^2/TeV \Rightarrow$ 70% more

Crab Data

Cuts	Optimal round bin	Optimal square bin	On Crab	background	excess	measured sigmas	expected sigmas
NF>20	1.2	2.1	4729560	4725078	4481	2.1	2.5
NF>80	1.0	1.7	851877	850404	1472	1.6	3.1
NF>150	0.6	1.1	104880	104982	−103	−0.3	2.7
GUS x > 2.5 NF>20	1.2	2.1	439245	436698	2546	4.0	
GUS x > 2.5 NF>80	1.0	1.7	107888	106589	1298	4.1	
GUS x > 2.5 NF>150	0.6	1.1	6916	6702	213	2.6	

Crab Data with NF≥20, GUS cut



Gamma/Hadron Separation

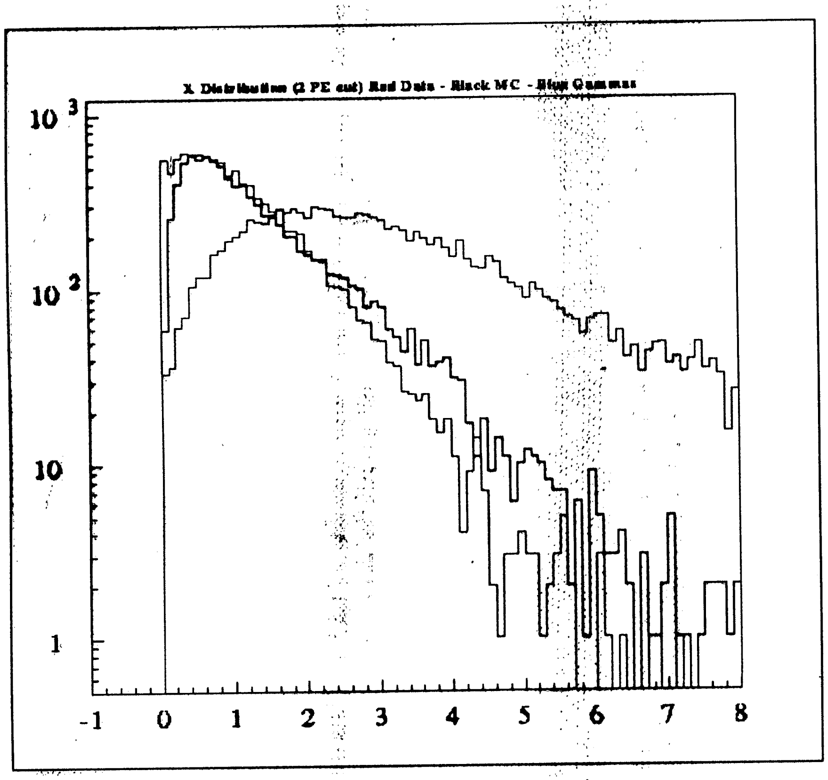
- NB2/PEMAX (X_2 Distribution)
- Extension of Direct Integration
- ON and OFF source X_2 distributions
- Maximum likelihood analysis of X_2
- Outstanding issues

Gus Sinnis

Milagro Collaboration Meeting

Madison, WI (10/22/00)

NB2/PEMAX



Data, MC Protons, MC Gammas

$Q = N_\Gamma/\mathrm{sqrt}(N_{Back})$

<u>MC protons/MC gammas</u>

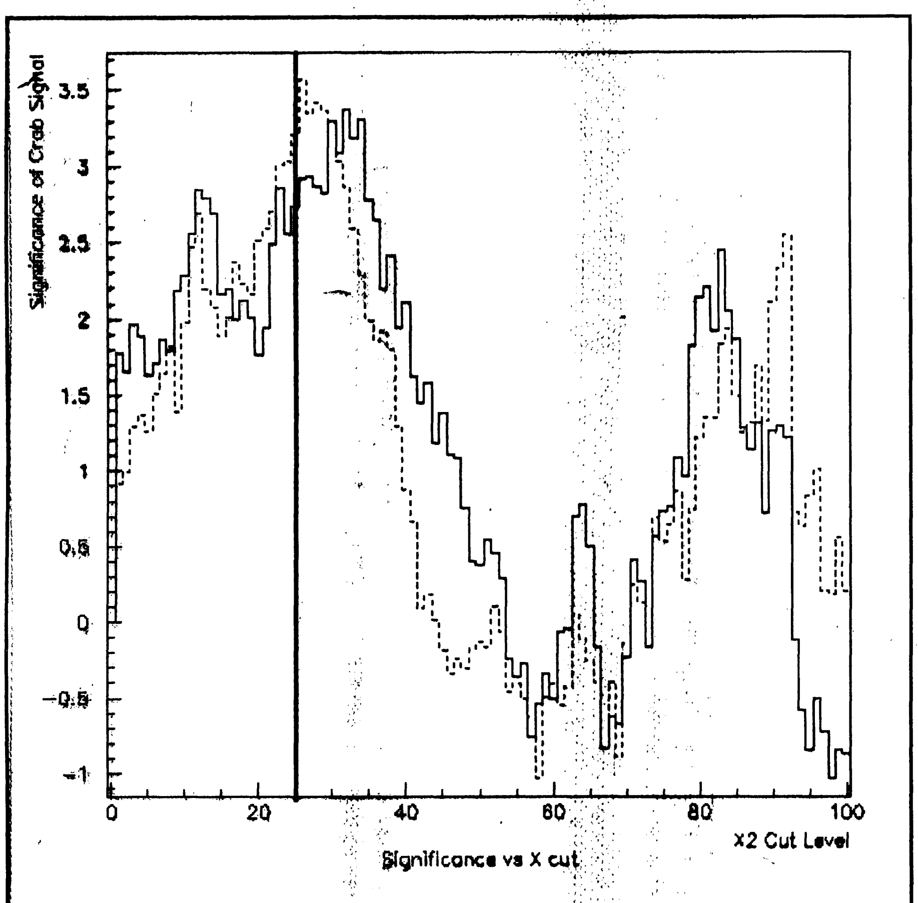
$X_2>2.5$ Q=1.7

<u>Data/MC gammas</u>

$X_2>7$ Q=8

NB2/PEMAX: Crab Results

Significance vs. Cut Level



Crab Analysis

Runs 1121 – 2451

DC Analysis (No Cuts)

NFIT>20:

ON 4,529,268

OFF 4,525,489

Excess: 3378 (1.8 σ)

NFIT>80:

ON 731,345

OFF 730,560

Excess: 784 (0.9 σ)

Compare ON & OFF Source X_2 Distributions

How to derive "OFF" source X distribution?

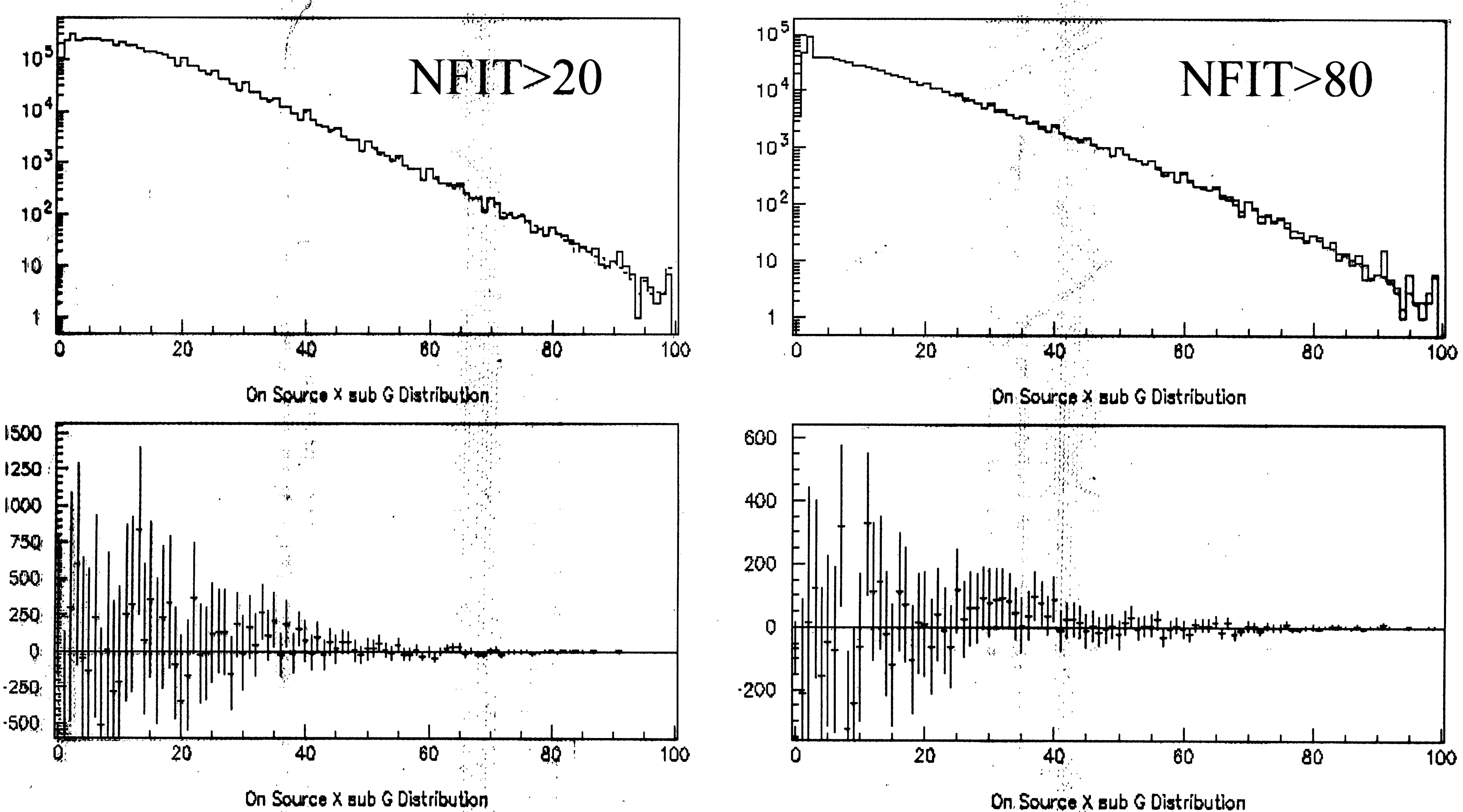
Direct Integration:

$$Off[RA][DEC][X] = \iint E(HA, DEC, X)\mathbb{R}(t)\delta(f(HA,t) - RA)d\Omega$$

Then:

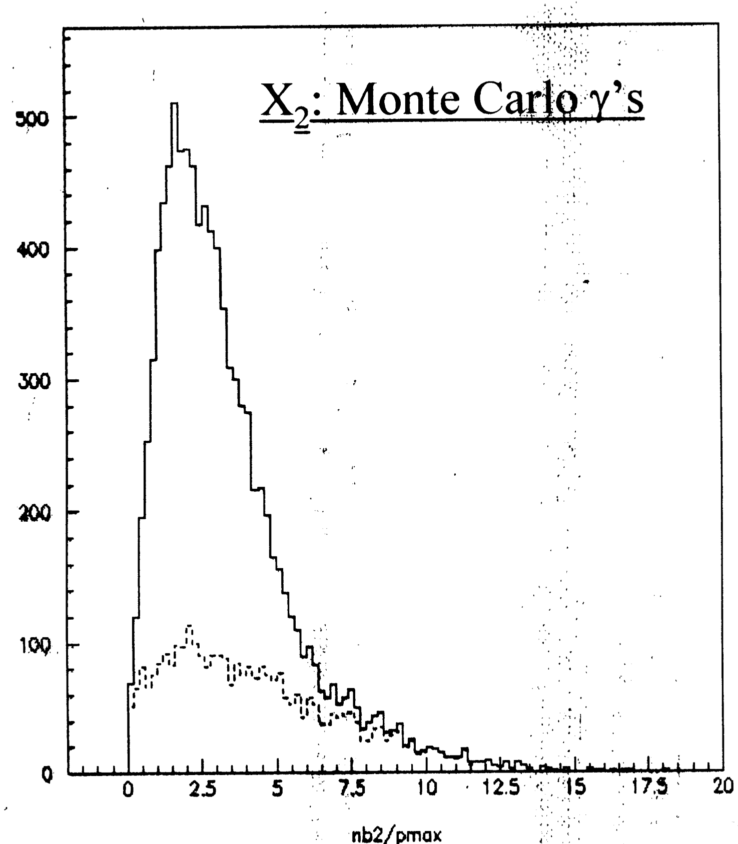
$$Off[X] = \iint_{Crab\ bin} Off[ra][dec][X]d(ra)d(dec)$$

X_2 Distributions: Results



Likelihood Ratio Method

$$\mathcal{L}(N_S, N_{Obs} - N_S) = \prod_{i=1}^{100} P(ON_i \mid N_S\Gamma_i + (N_{Obs} - N_S)OFF_i)$$



ON_i = # On Source events in i^{th} x bin

OFF_i = Fraction of Off source evts in i^{th} x bin

Γ_i = Fraction of MC γ evts in i^{th} x bin

If

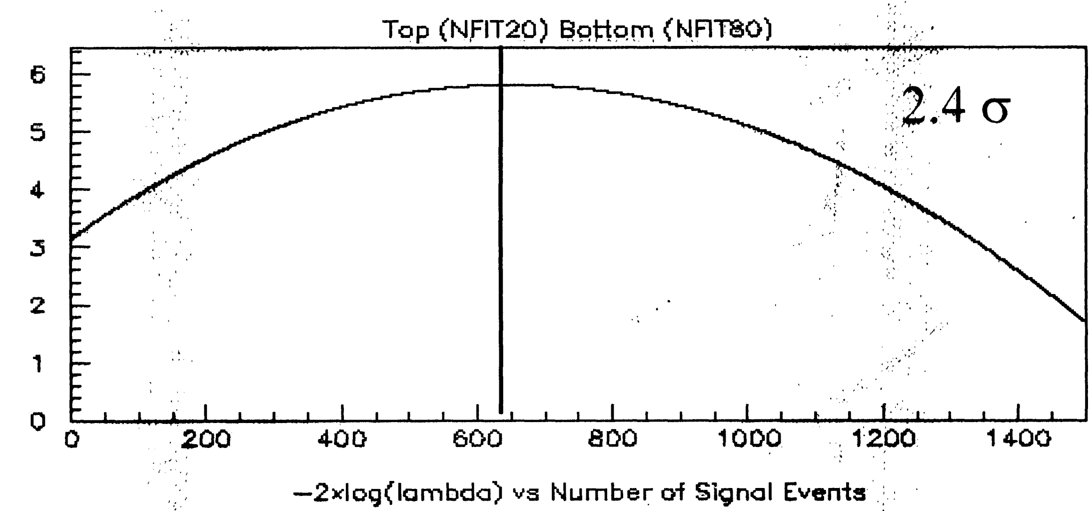
$$\lambda = \frac{\mathcal{L}(0, N_{Obs})}{\max_{N_S} \mathcal{L}(N_S, N_{Obs} - N_S)}$$

Then

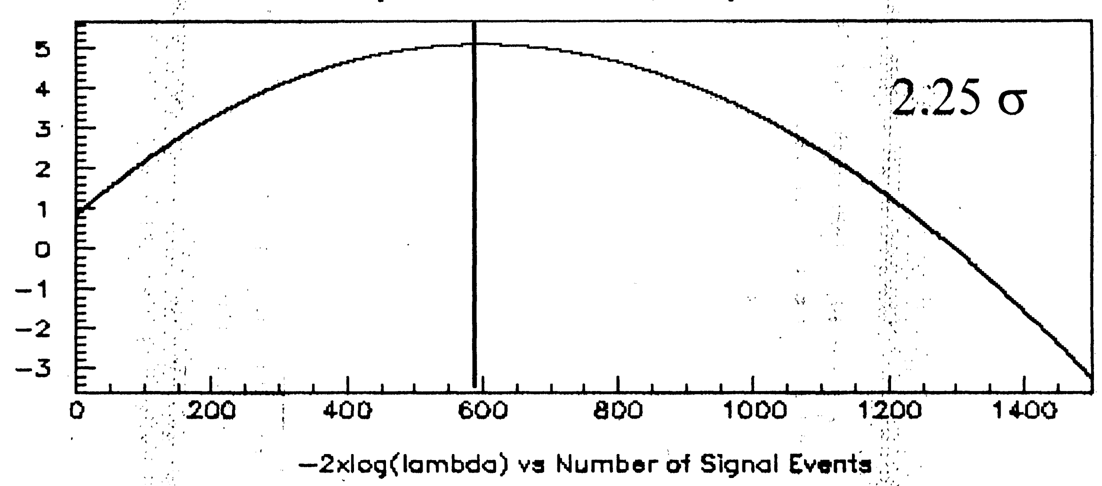
-2ln(λ) is distributed as $\chi^2(1)$

Likelihood Ratio: Results

NFIT>20



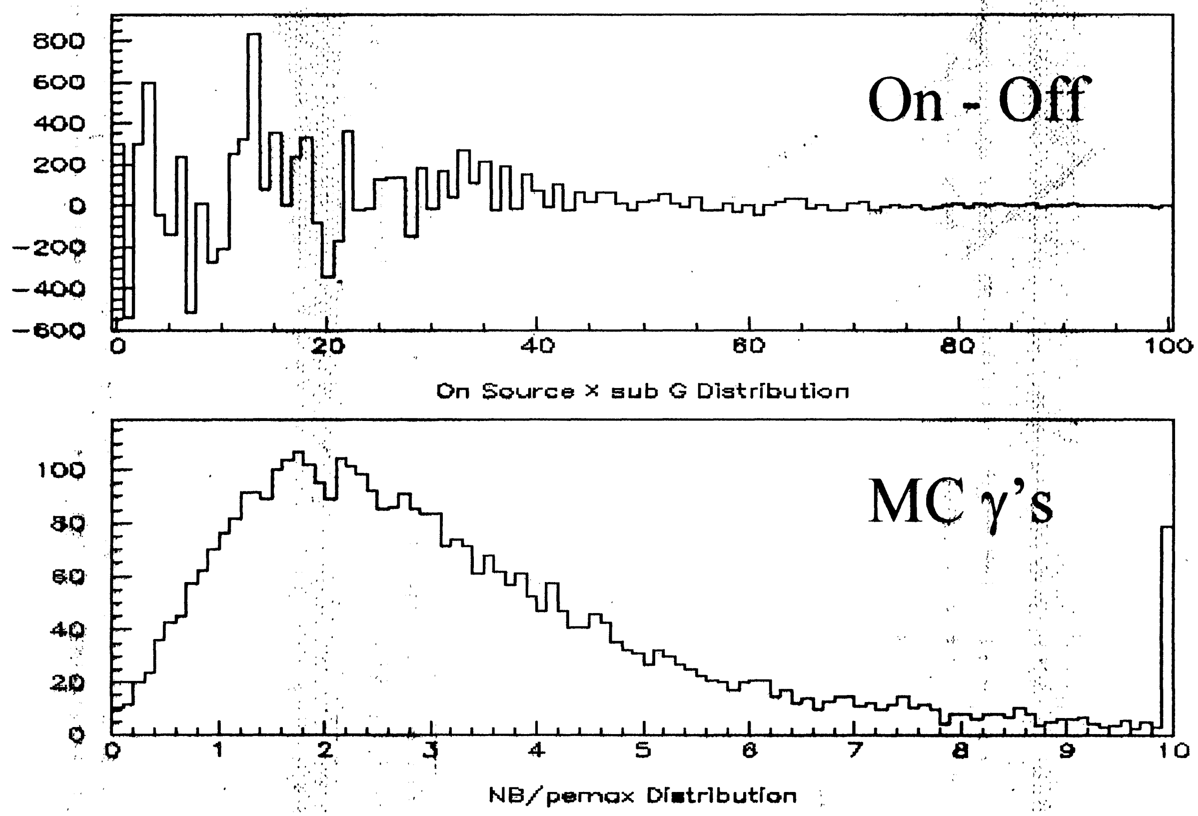
NFIT>80



What's Wrong?

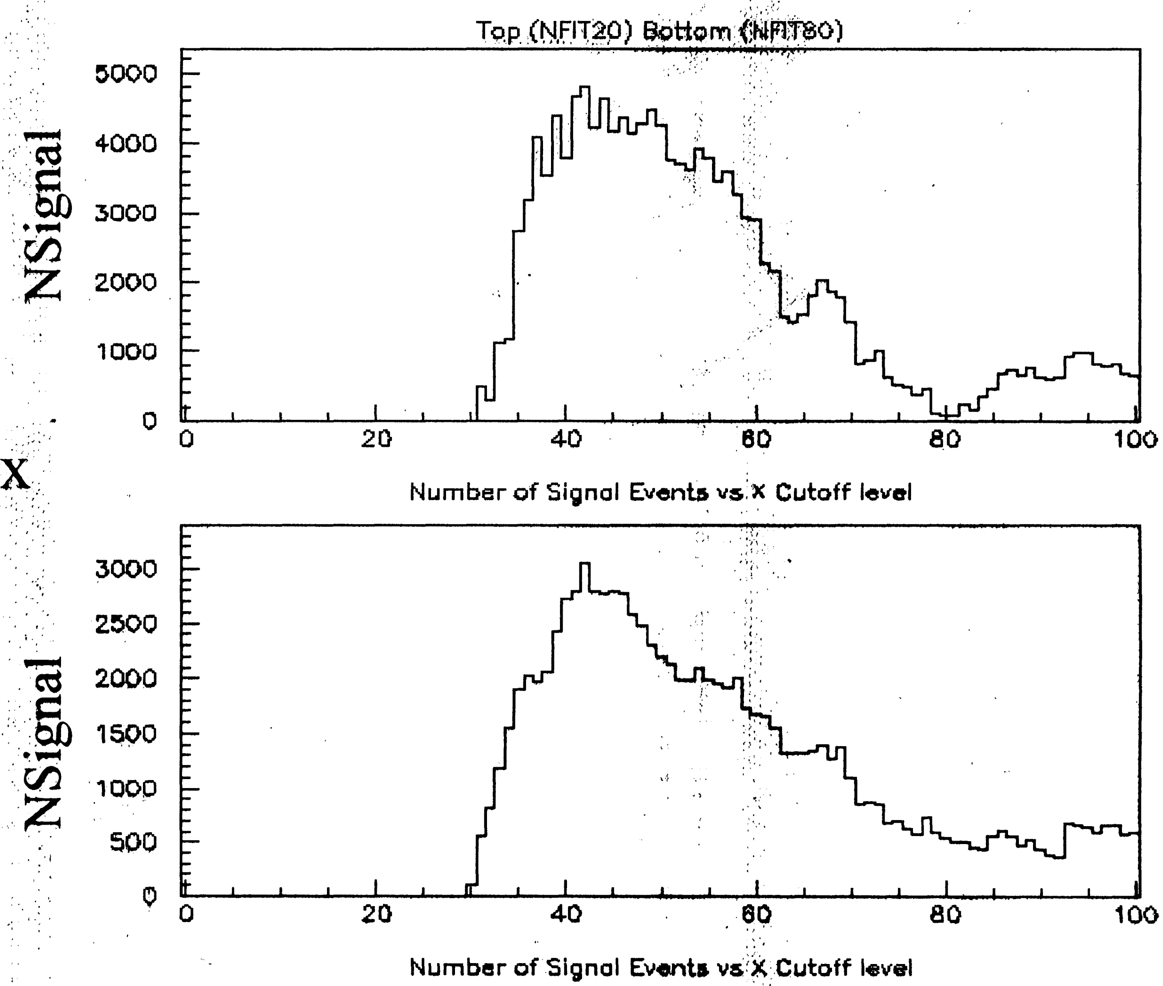
Postulate:

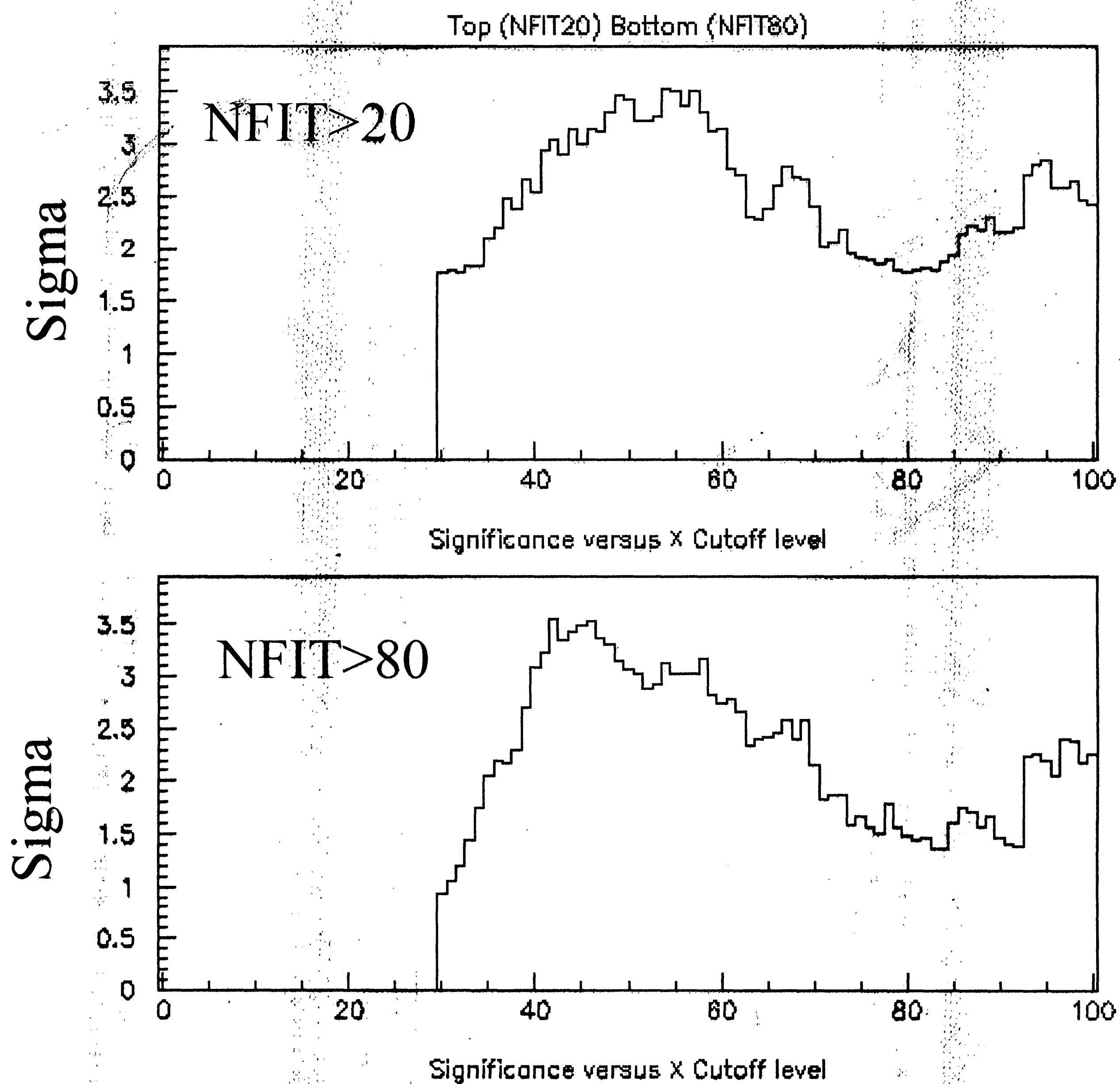
As with protons, Monte Carlo over produces γ's at large X_2.



Truncate Monte Carlo X_2 Distribution

$\Gamma_i = 0$ for all $I > X_2 max$




Top (NFIT20) Bottom (NFIT80)
NFIT>20
Sigma
Significance versus X Cutoff level
NFIT>80
Sigma
Significance versus X Cutoff level

Conclusions

- General extension of direct integration allows for binned likelihood analysis of Milagro data
- Likelihood analysis of X_2 distribution has promise
- Can detect sources purely on shape of X2 distribution
- Problems with Monte Carlo and w/ Calibrations limit usefulness of technique
- See later talk

Compounding significances.

Motivation:

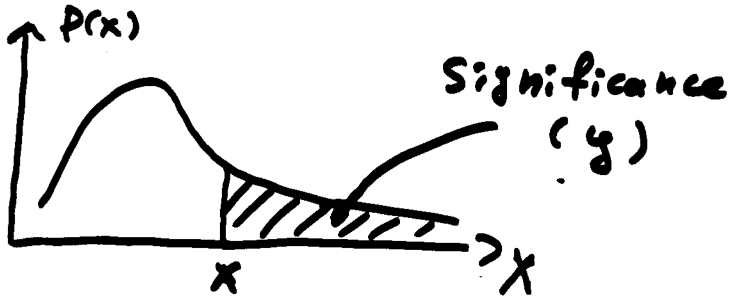
"When a number of quite independent tests of significance have been made, it sometimes happens that although few or none of them can be claimed individually as significant, yet the aggregate gives an impression that the probabilities are on the whole lower than would often have been obtained by chance...."

Ronald A. Fisher

Significance.

$H_0: \; X \sim p(x)$

$$y = \int_x^{\infty} p(x)\,dx$$



$$X \sim p(x) \iff y \text{ is uniform } [0, 1]$$

Combination

- independent samples.
- independent tests on the same sample.

$$y_i = \int_{x_i}^{\infty} p_i(x)\,dx$$

Combined test:

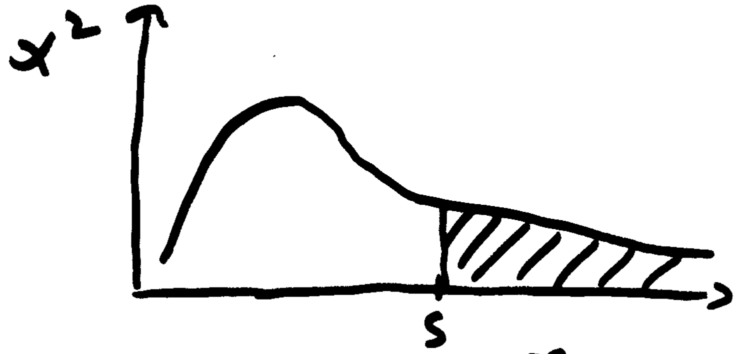
$$\left\{ \begin{array}{l} H_0^{(1)}: \; X_1 \sim p_1(x) \\ H_0^{(2)}: \; X_2 \sim p_2(x) \\ \dots \quad \dots \\ H_0^{(n)}: \; X_n \sim p_n(x) \end{array} \right| \iff \left\{ \begin{array}{l} y_1, y_2, \dots y_n \text{ are} \\ \text{uniform on } [0, 1] \end{array} \right.$$

Fisher's Method

y - uniform on $[0,1]$ $\Rightarrow$

$-2 \ln y \sim \chi^2$ with 2 degrees of freedom.

$S = -2 \sum_{i=1}^{n} \ln y_i \sim \chi^2$ with $2n$ degrees of freedom

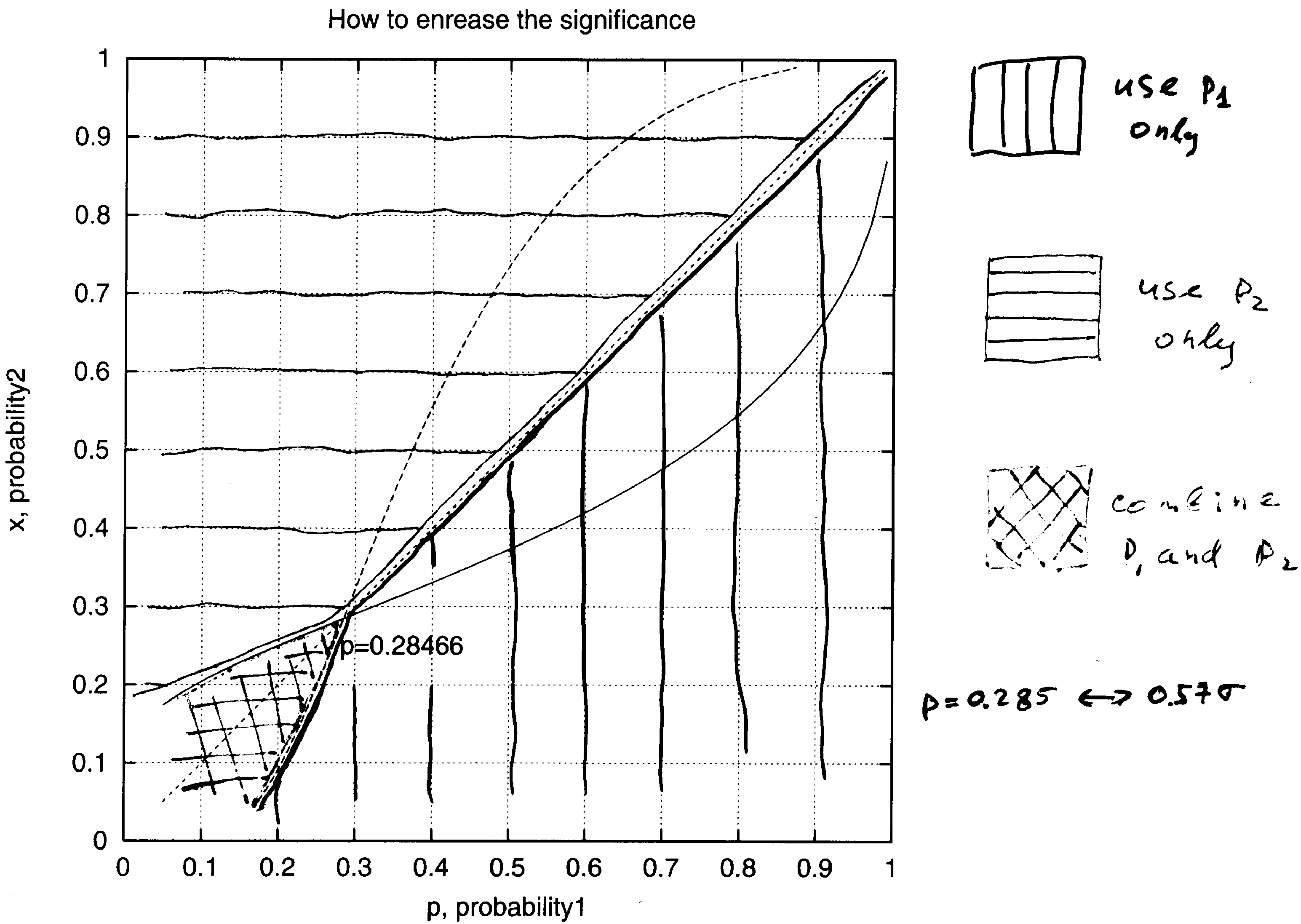


$$\text{Significance} = \int_S^{\infty} \chi^2_{2n}(s)\,ds =$$

$$= y \sum_{m=0}^{n-1} \frac{(-\ln y)^m}{m!}, \text{ where } y = y_1 \cdot y_2 \cdot \ldots \cdot y_n$$

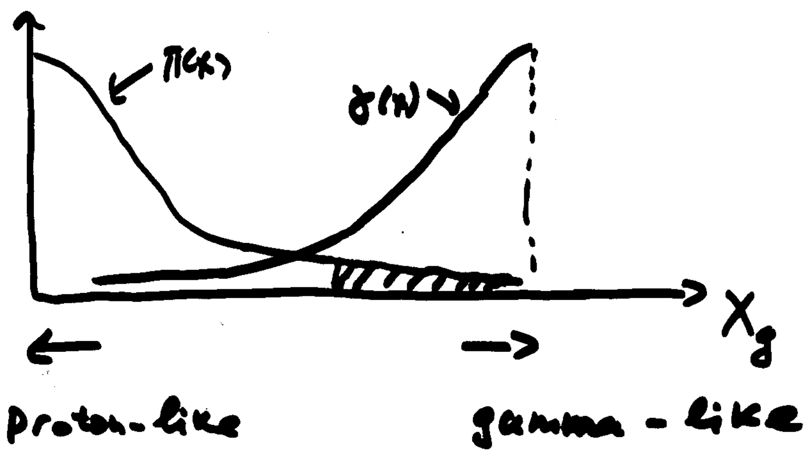
Same as in Eadie.

Ex: $n=2$; $\text{signif} = p_1 \cdot p_2 (1 - \ln p_1 \cdot p_2)$



$p = 0.285 \longleftrightarrow 0.57\sigma$

γ/p separation.



$X \sim \pi(x)$ if primary is proton

$X \sim \gamma(x)$ if primary is gamma

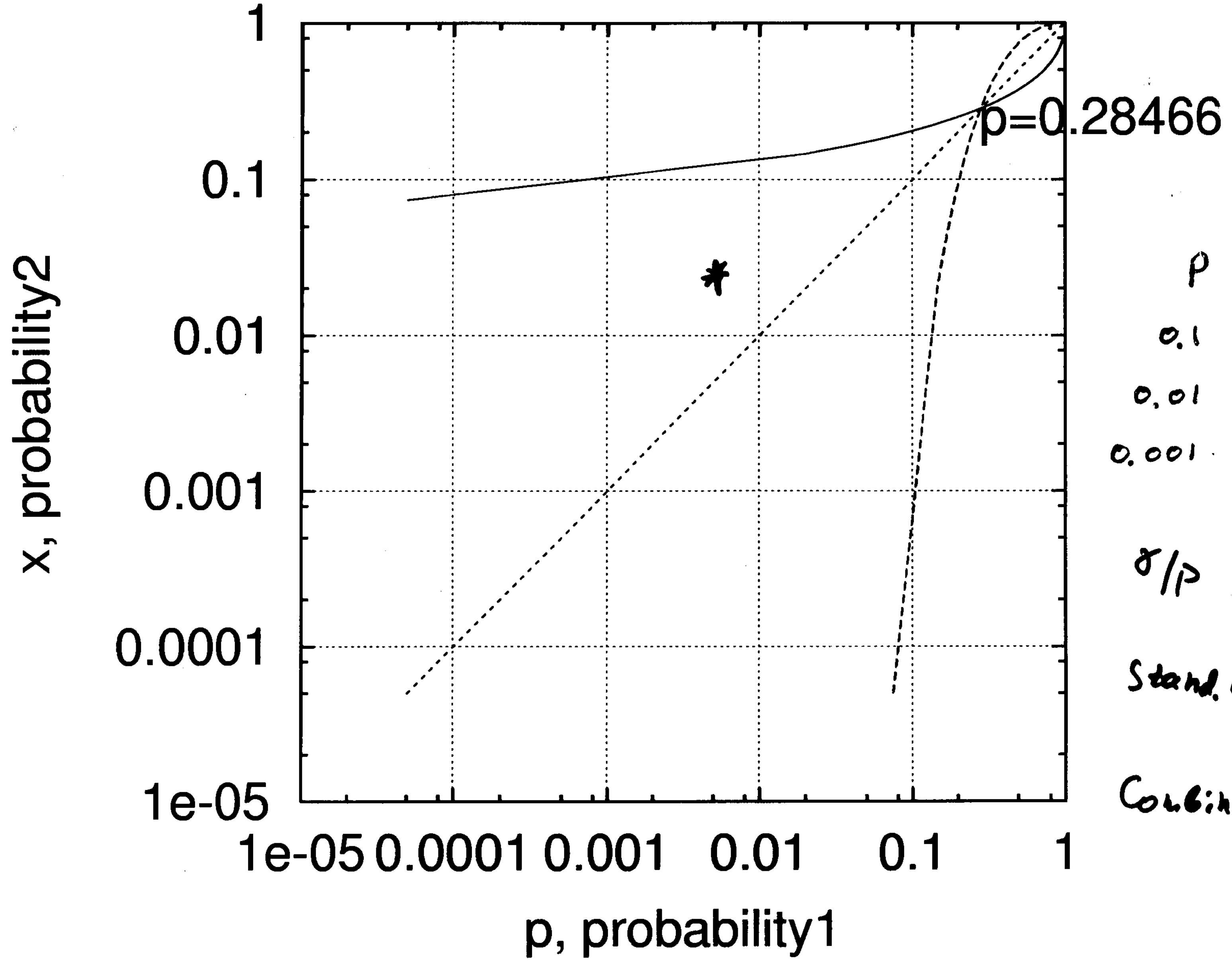
$$y_i = \int_{x_i}^{\infty} \pi(x)\,dx$$

$$S = -2 \sum_{i=1}^{n} \ln y_i$$

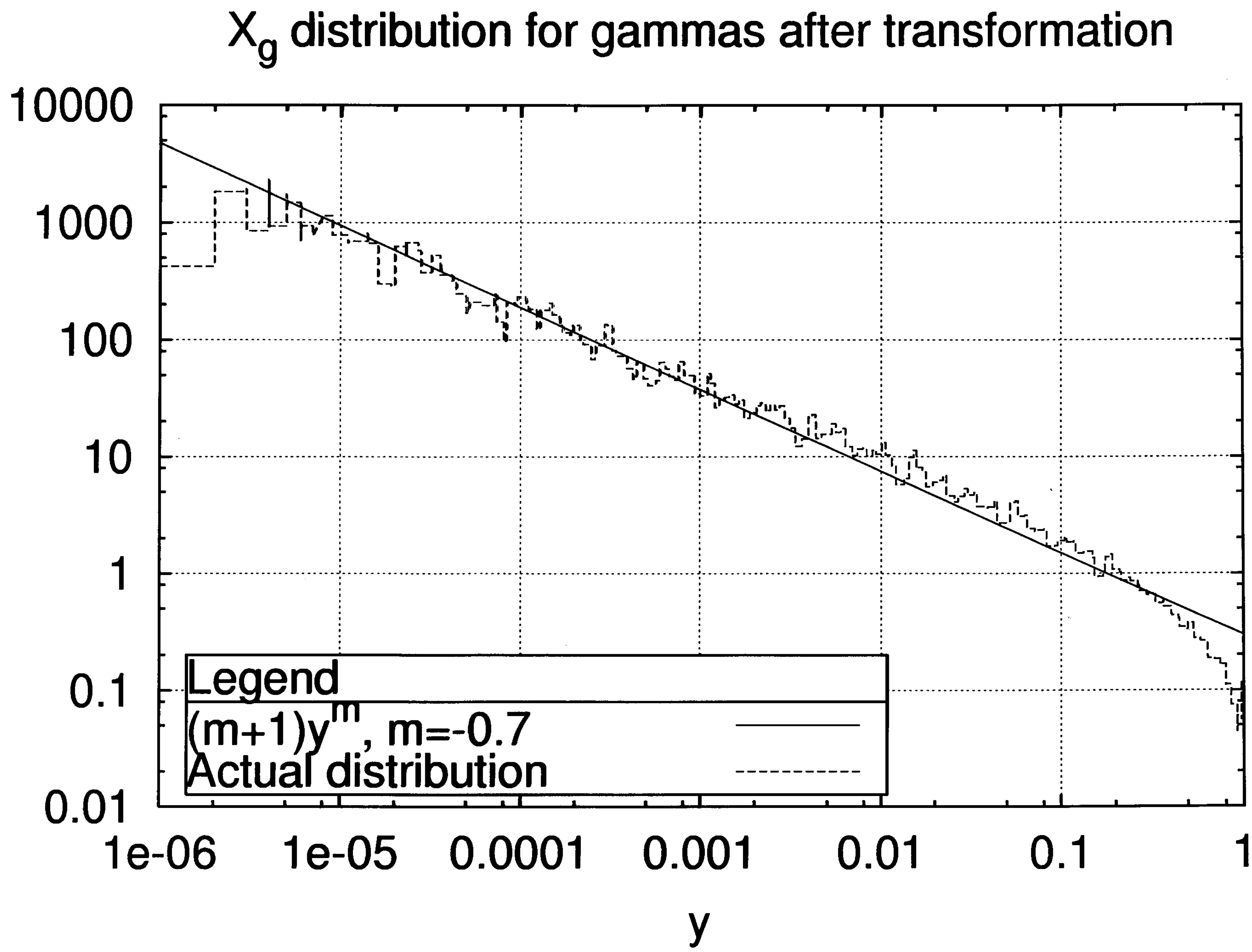
For $n \gg 1$

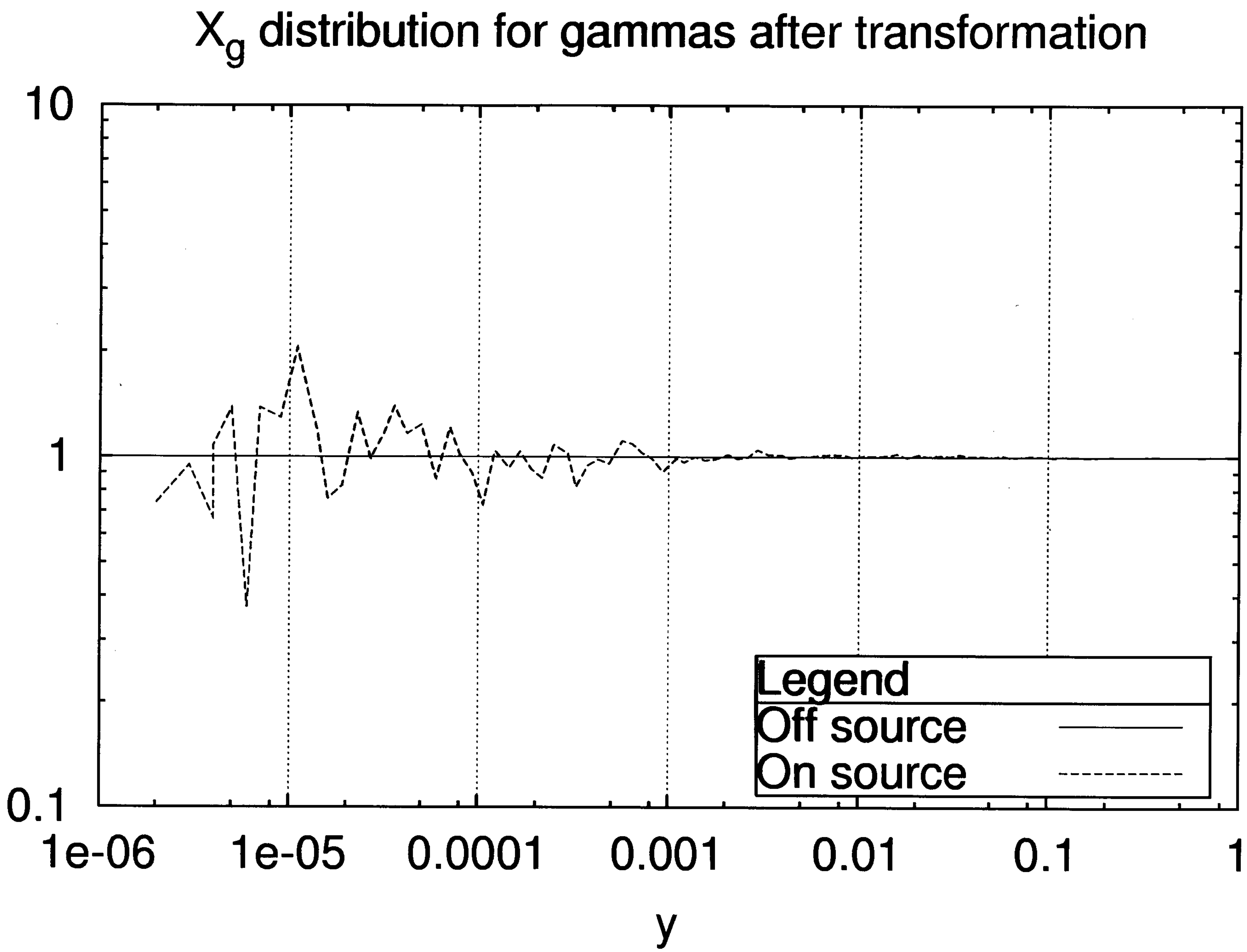
$$u \approx 2\sqrt{n}\left(\sqrt{\frac{S}{2n}} - 1\right)$$ - significance in the units of standard deviations.

How to enrease the significance

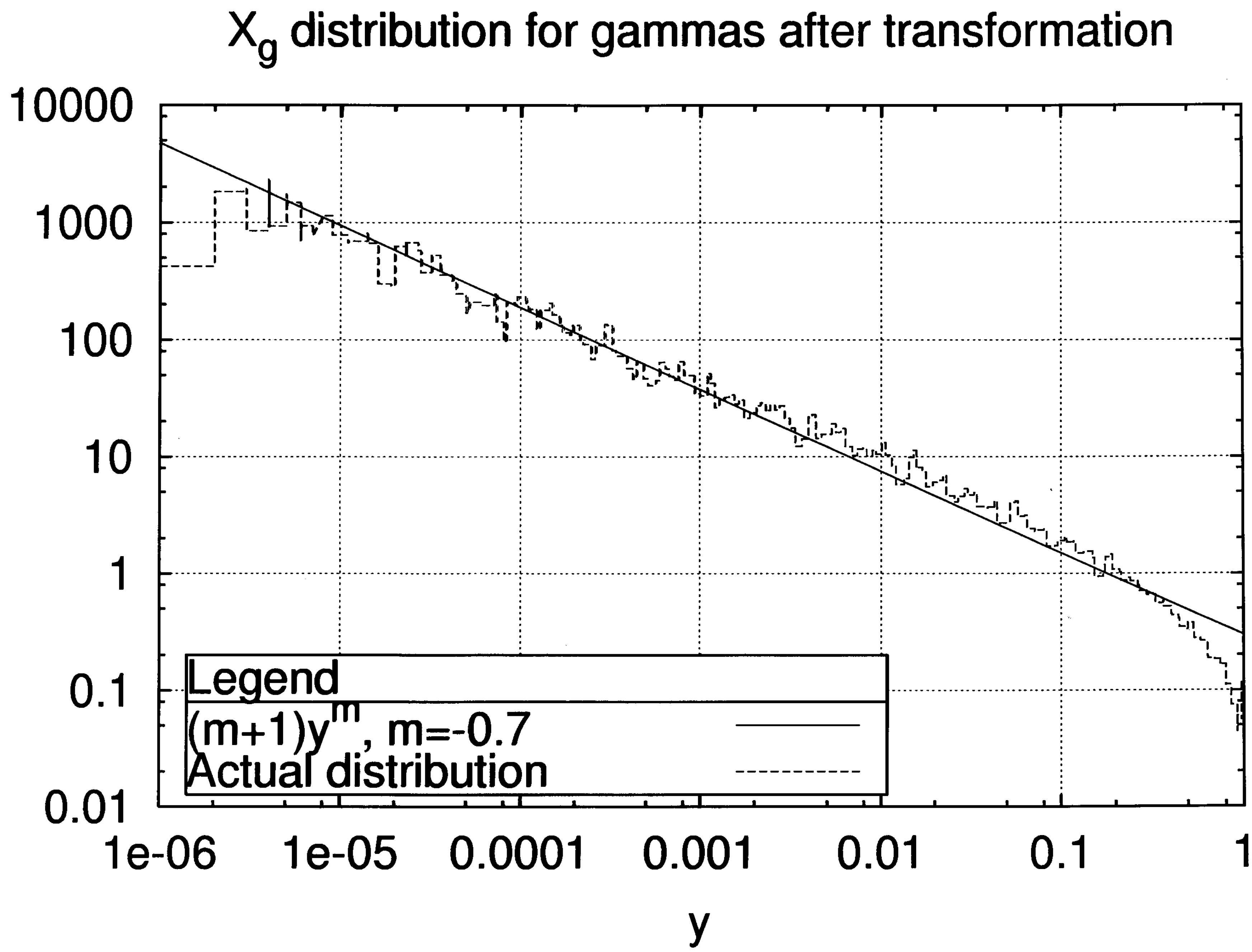


p	σ
0.1	1.29
0.01	2.33
0.001	3.09
γ/p	2.4σ
Stand. meth.	2.2σ
Combined	3.3σ


X_g distribution for gammas after transformation
10000
1000
100
10
1
0.1
0.01
1e-06
1e-05
0.0001
0.001
0.01
0.1
1
y
Legend
(m+1)y^m, m=-0.7
Actual distribution



X_g distribution for gammas after transformation
10
1
0.1
1e-06
1e-05
0.0001
0.001
0.01
0.1
1
y
Legend
Off source
On source



X_g distribution for gammas after transformation
10000
1000
100
10
1
0.1
0.01
1e-06
1e-05
0.0001
0.001
0.01
0.1
1
y
Legend
(m+1)y^m, m=-0.7
Actual distribution

Wystan's Thesis

"Observations of the Crab
& 26 AGN w/ Milagro"

Crab: What do we expect?
What is optimal analysis?
Explore Background Rejection
What do we see? Is it consistent?
Energy / Spectrum / Flux ??????

AGN: Search for Emission on
Various Timescales

How AGN Selected

$Z < .1$: minimize effects of IR Absorption

$0^\circ < Dec < 70^\circ$: - Milagro Field of View

- more time at low zenith angles where resolution is better

X-ray Selected Blazars

- most likely candidates (theory) (all TeV det. are X-ray Selected)

Not Exclusive

Useful Papers: - Perlman (astro-ph/9910321)

- Buckley, Astroparticle Physics 11 (1999) 119-1
  ⇒ Whipple Results

- Mukherjee, Astrophysical Journal, 490: 116-135, 11/2
  ⇒ Egret

Selected AGN Details

- 18 X-ray Selected Blazars
- 3 Radio Selected Blazars
- 5 FSRQ

} 26 Total

List: – 3 AGN det. by Whipple

- Mrk 501, Mrk 421, 1ES 2344+514
  (X-ray Sel.)

- All EGRET AGN that meet conditions
  - W Comae, BL Lac

- 3C371 ← (Radio Sel.)

- Perlman: (X ray sel.) 1ES 0033+595, RGB 0110+418, RGB 0152+017, RGB 0153+712, RGB 0214+517, RGB 0314+247, RGB 0656+426, Mrk 180, RGB 1532+302, RGBJ 1610+671, 1ES 1727+502, 1ES 1741+196, 1ES 1959+650, 1ES 2321+419, RGB 2322+346

(FSRQ) III Zw 2, B2 0138+398, B2 0321+33, RGB 1413+436, PG 2209+184

Analysis

- Standard Binned, nFit Analysis
- Lima Sig.
- Round Bins
- Background Estimation by Time Sloshing
  (2 hr pool, 30 events from pool for each event in Pool)
- Incorporates Background Rejection if desired

Future: -Use Direct Integration for Background

- Max Likelihood

Optimal Bin Size & Cuts

Pure Deko Analysis: ⇒ .7° radius, nFit > 20

- Too Small!
- IGNORES systematics

⇒ Used Bin of same area & cuts as found in Andy's Crab Memo

2.1° square ⇒ 1.2° radius ; nFit > 20

Data Set

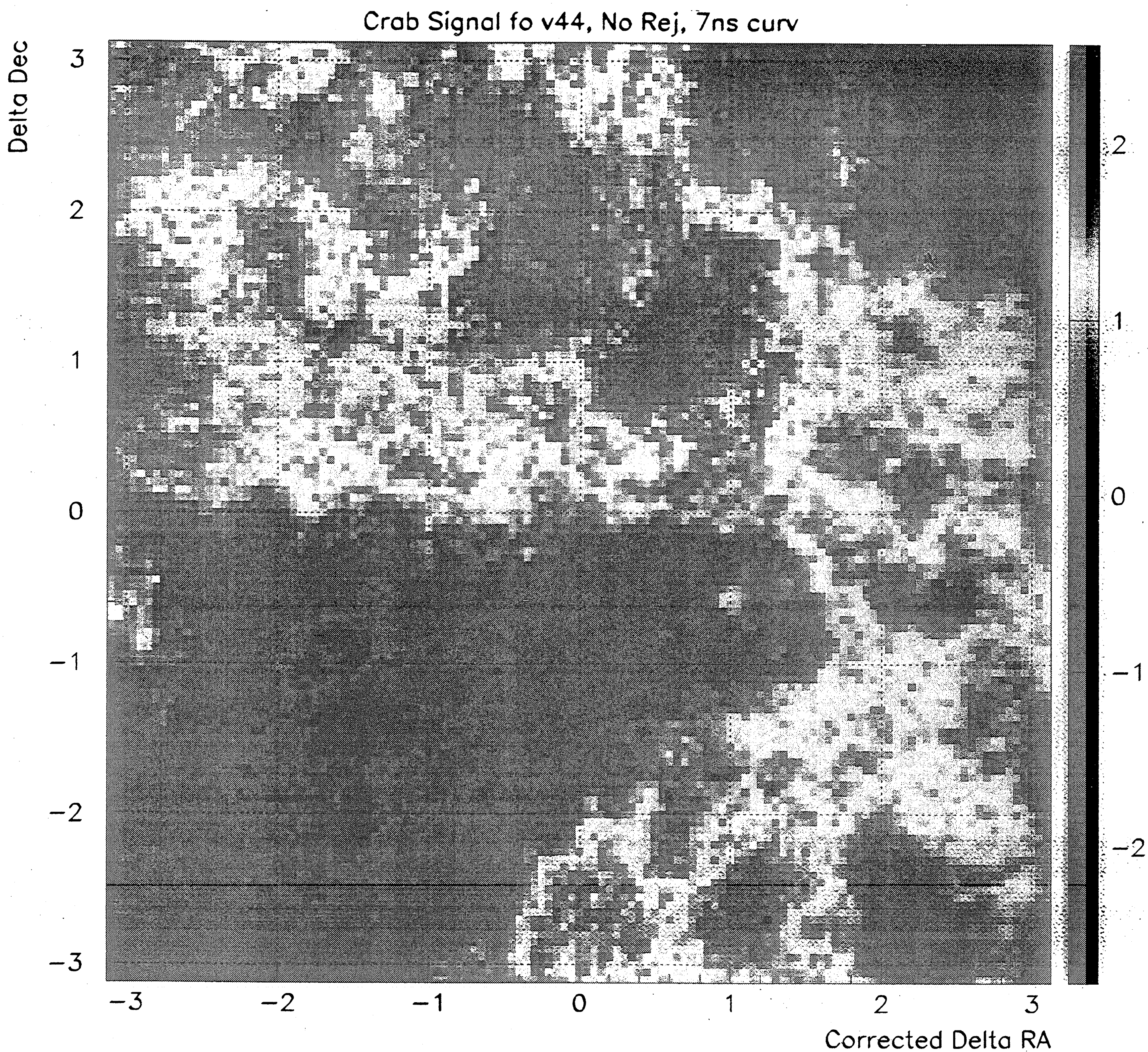
A. Standard v44 (July → Tube Repair) w/wo Rejection

B. re-Reconstructed 44a: std. w/ 7ns curv.
(all Data)

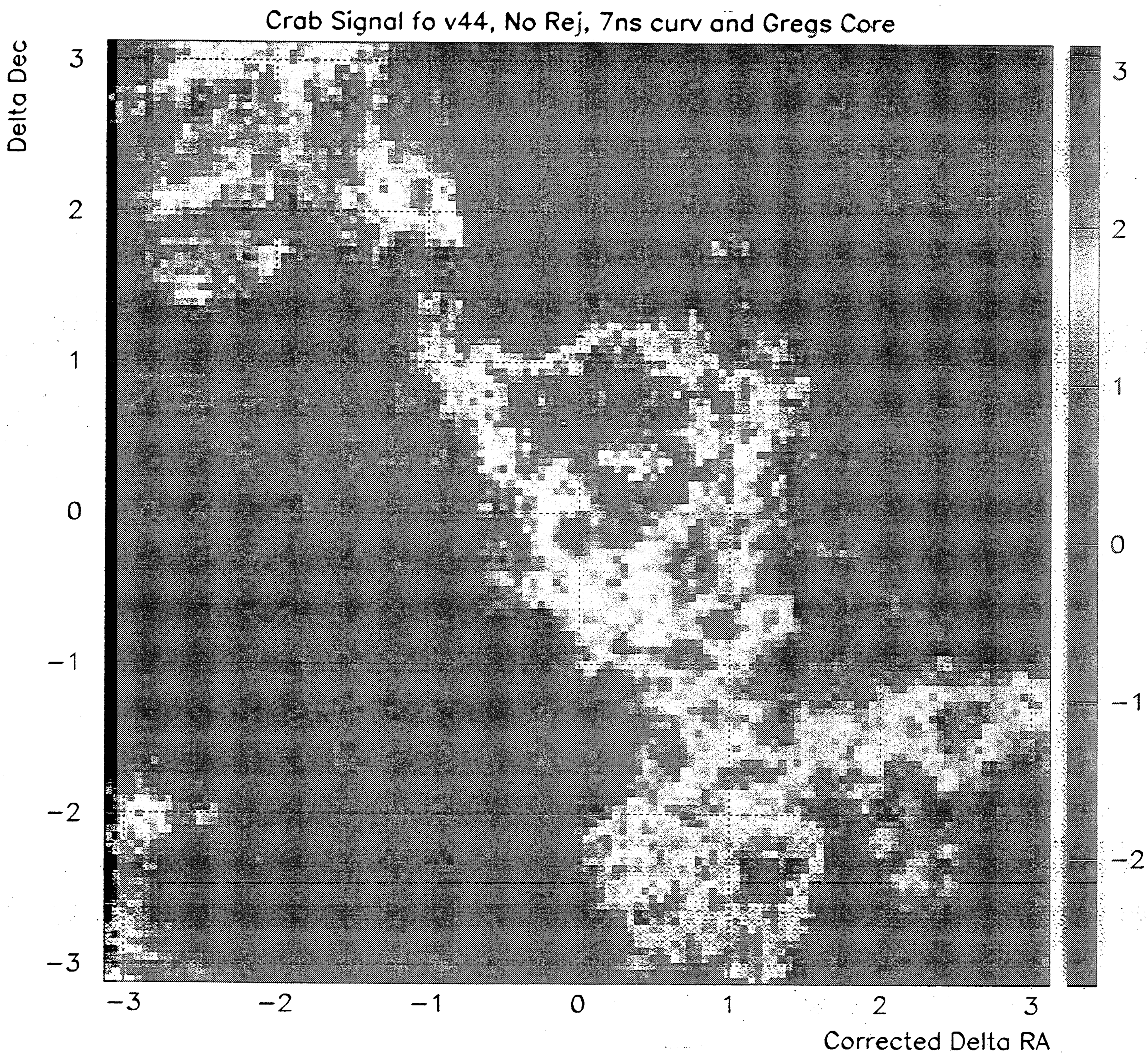
C. re-Reconstructed 44b: Std. w/ 7ns curv
Greg's Core, 3 Rej Methods,
(all Data)

→ Andy's re-Reconstruction

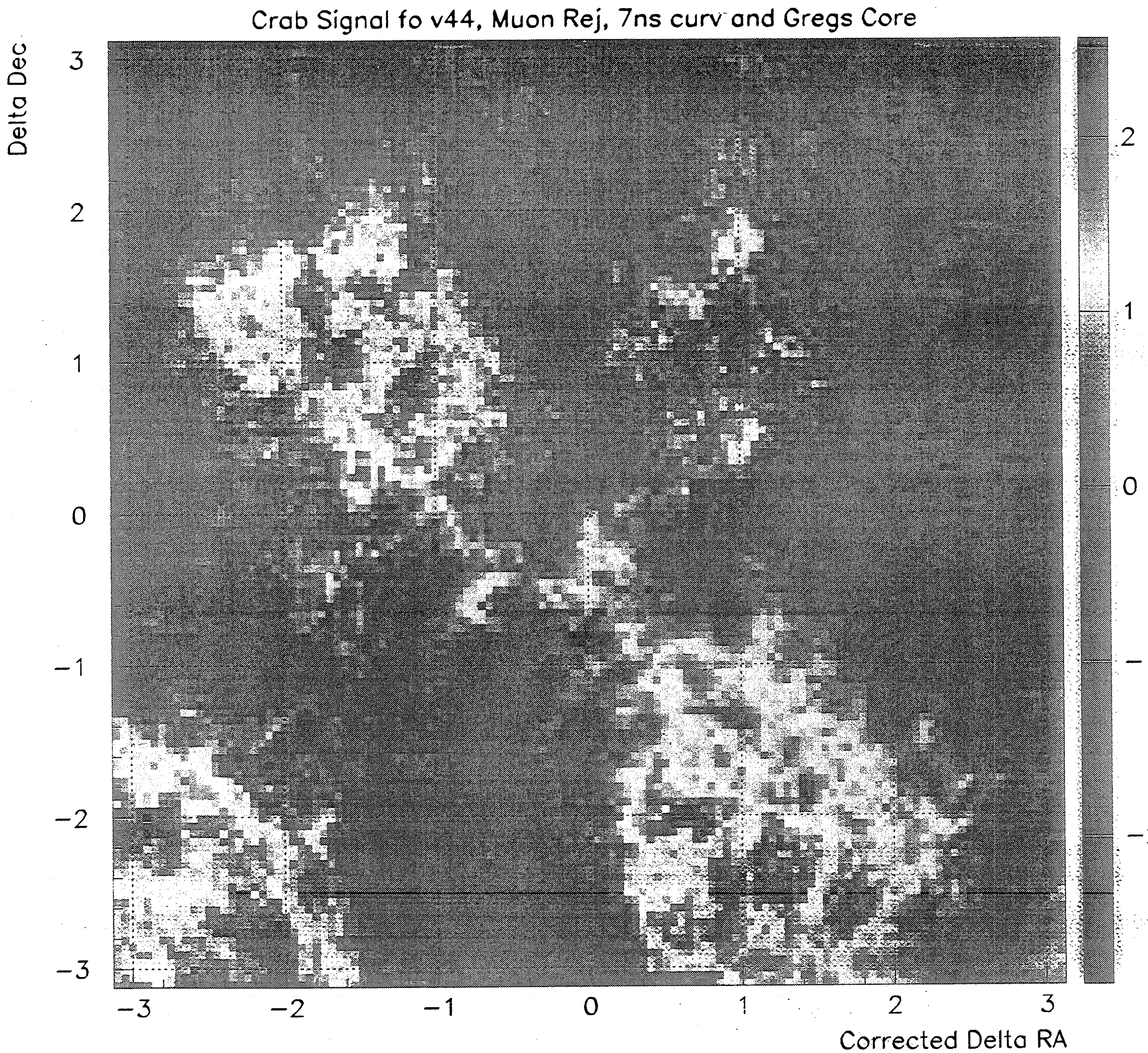
Look for Crab in A, B, C & AGN in A

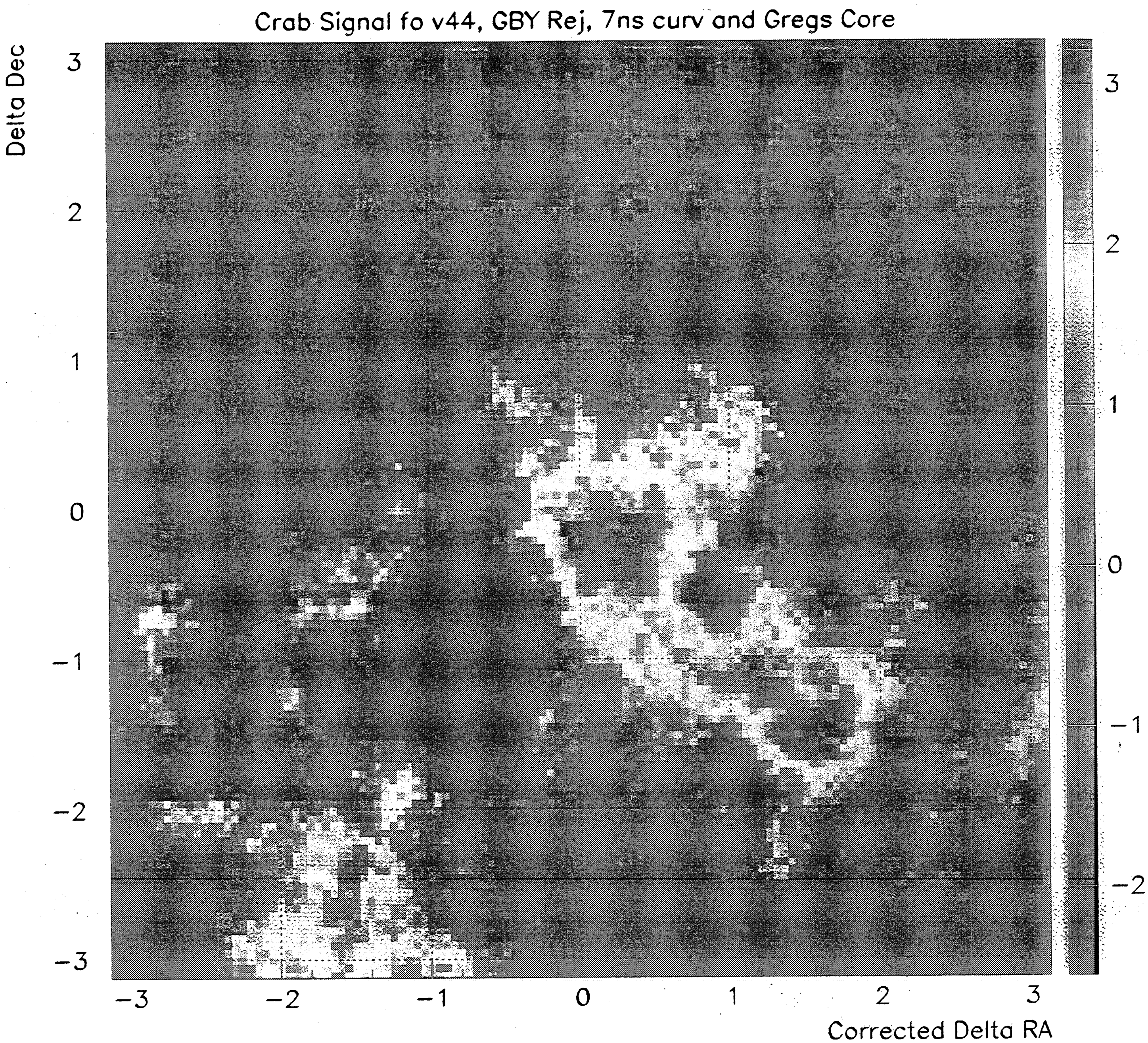


Crab Signal fo v44, No Rej, 7ns curv
Delta Dec
3
2
1
0
−1
−2
−3
−3
−2
−1
0
1
2
3
Corrected Delta RA
2
1
0
−1
−2

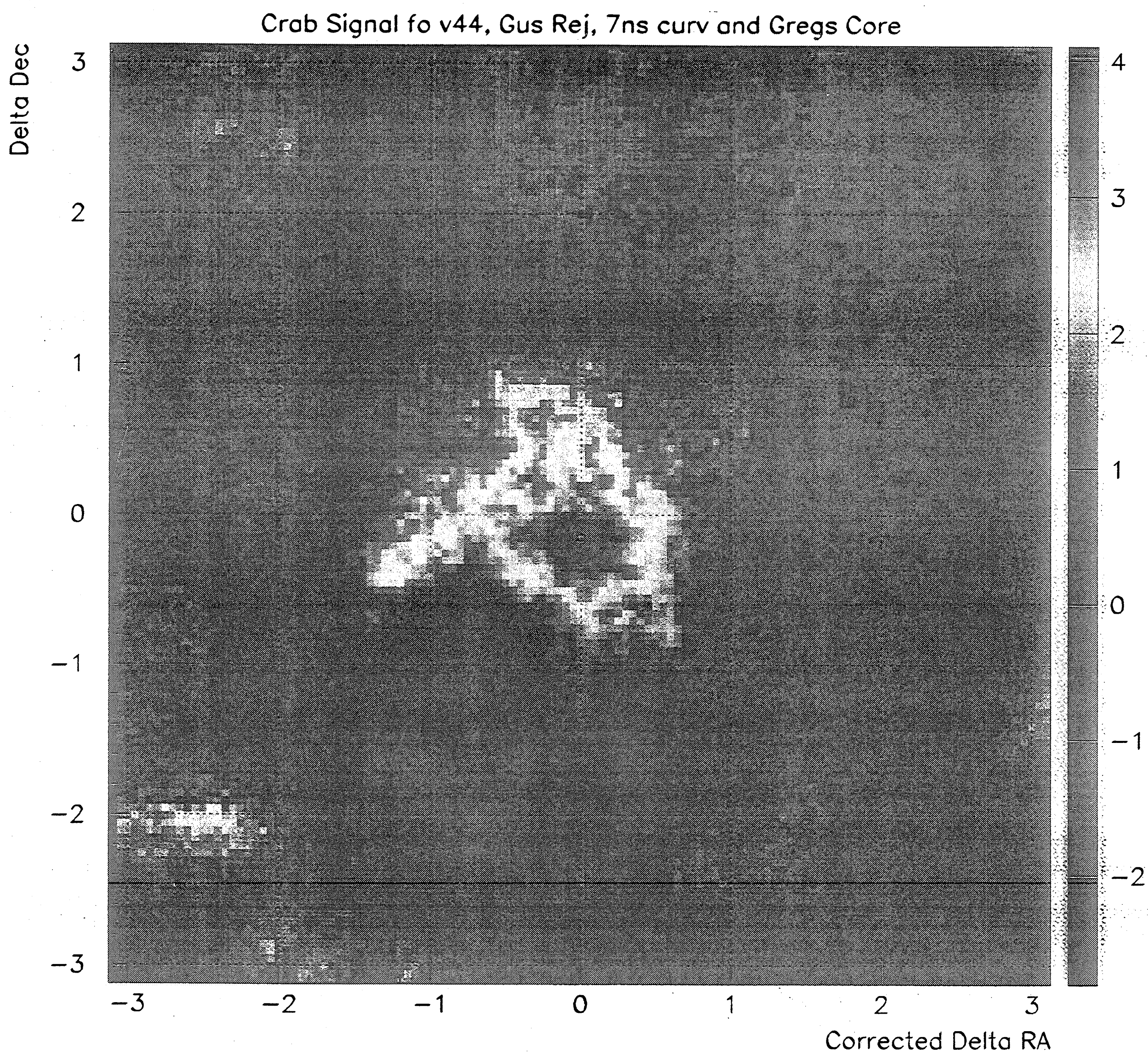


Crab Signal fo v44, No Rej, 7ns curv and Gregs Core
Delta Dec
Corrected Delta RA
3
2
1
0
−1
−2
−3


Crab Signal fo v44, Muon Rej, 7ns curv and Gregs Core
Delta Dec
Corrected Delta RA
3
2
1
0
−1
−2
−3
−3
−2
−1
0
1
2
3
2
1
0
−1
−2



Crab Signal fo v44, GBY Rej, 7ns curv and Gregs Core
Delta Dec
3
2
1
0
−1
−2
−3
−3
−2
−1
0
1
2
3
Corrected Delta RA
3
2
1
0
−1
−2



Crab Signal fo v44, Gus Rej, 7ns curv and Gregs Core
Delta Dec
Corrected Delta RA
3
2
1
0
−1
−2
−3
4

Crab Results

Analysis:	Significance .7° radius NFit > 20	1.2° radius nFit > 20	Andy (2.1° sqr, nFit≥
44a	1.09	.65	NA
44b no Rej	2.53	2.12	2.21 (93
44b (Muon rej.)	.08	.71 (34%)	.45 (31.1
44b (GBY > 5)	1.27	2.00 (10.6%)	2.23 (10
44b (Gus > 2.5)	2.63	3.13 (8.6%)	3.47 (8.1
44 (July → Sept) No Rej.			NA
44 (July → Sept) Gus > 2.5			NA

% is fraction of data kept.

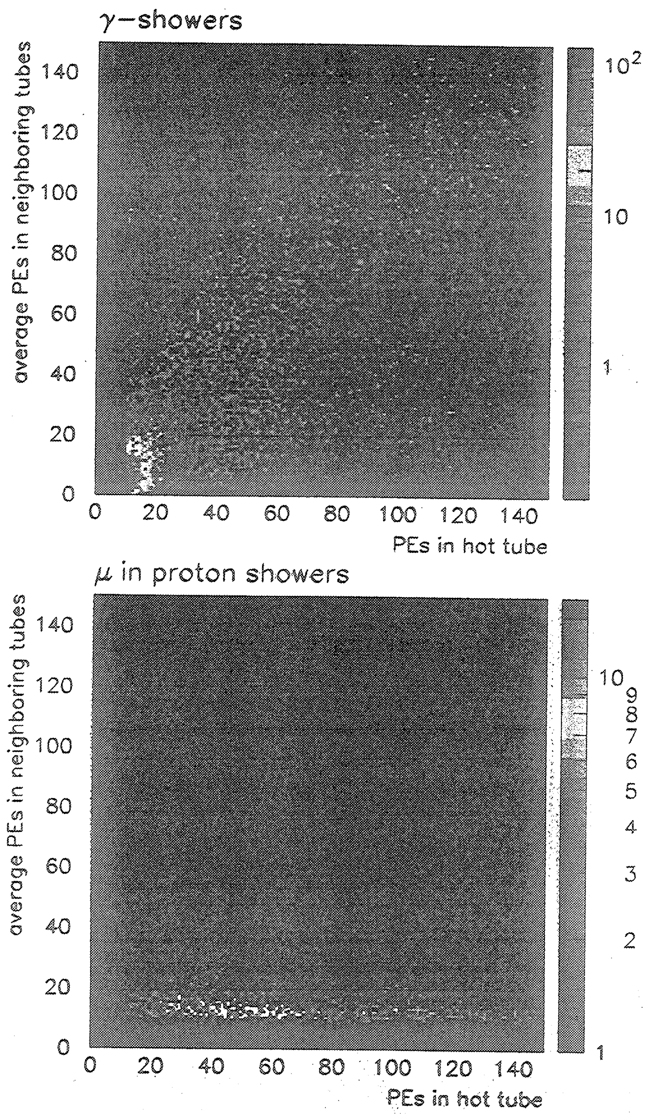
Agree w/ Andy ⇒ Code "works"

AGN Results

- Nothing Significant found for 26
  AGN w/ wo Gus > 2.5 rejection
  (only v44 std. from July → Tube Repair)
- A few plots "look" neat, but likely
  just statistical fluctuations

Note: We Don't See the Crab during
this time period.

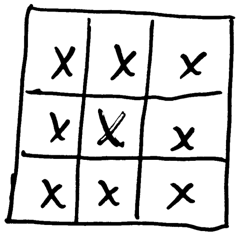
From Miller, Westerhoff & Williams memo on Igloo Performance



muon Cand.c

Figure 5: PE level of "hot" tubes (≥ 10) vs. the average PE level of their 8 neighboring tubes for γ showers and (true) muons in proton showers.

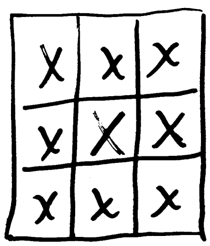
Original muon Cand



Local Maximum >

Average of 8 Neighbors < 20

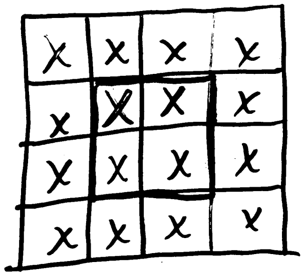
"Fancy" muon Candidates



Sum of Local Maximum +
Second Highest Tube

Average of 7 Neighbors

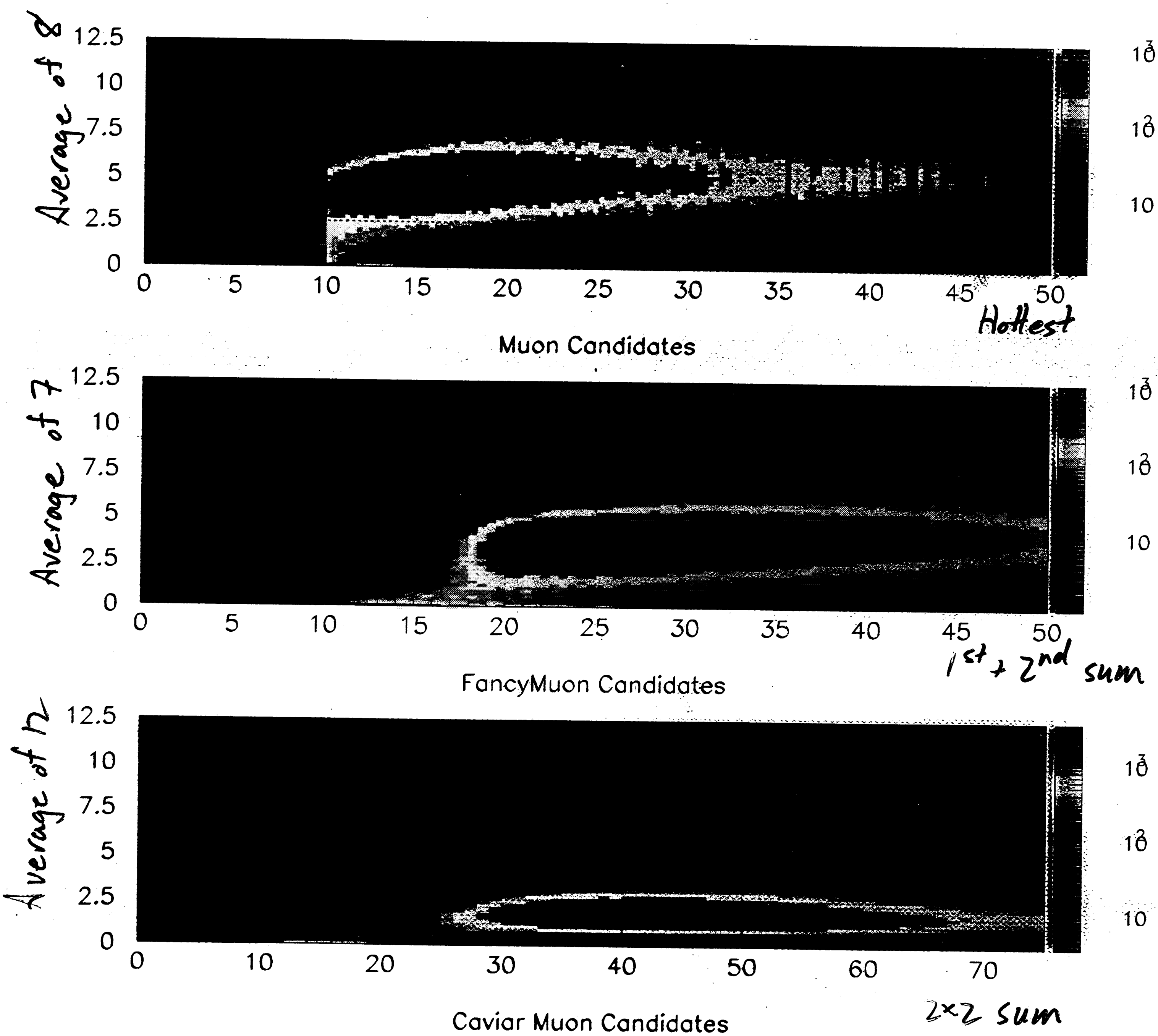
"Caviar" or "4/12" muon Candidates



Largest 2x2 sum Containing
Local Maximum

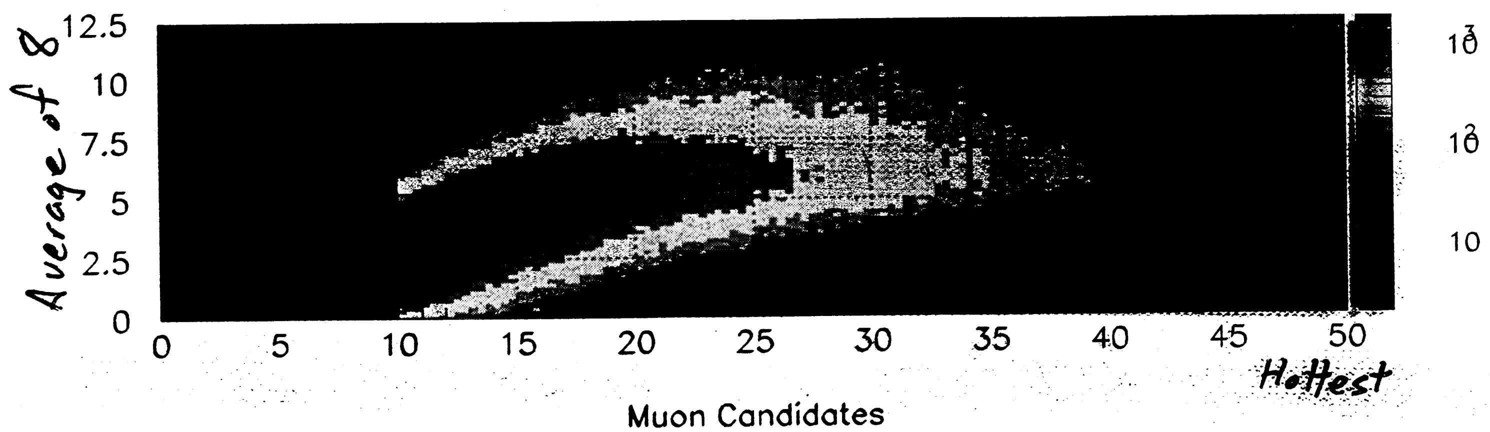
Average of 12 Neighbors

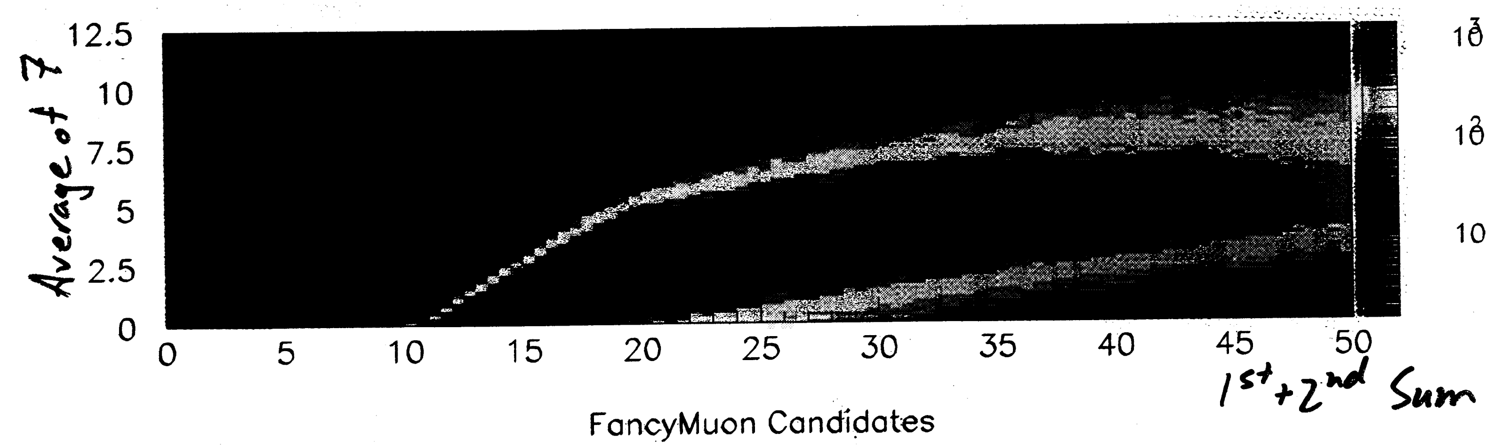
Igloo Triggers

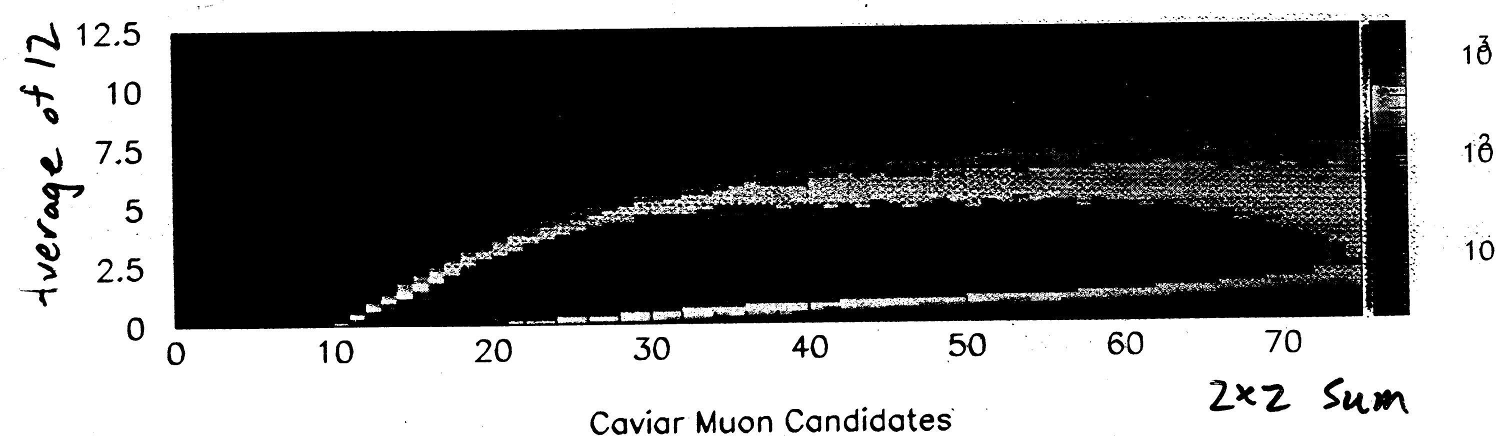


Spectrum PE Calibration

Normal
Data



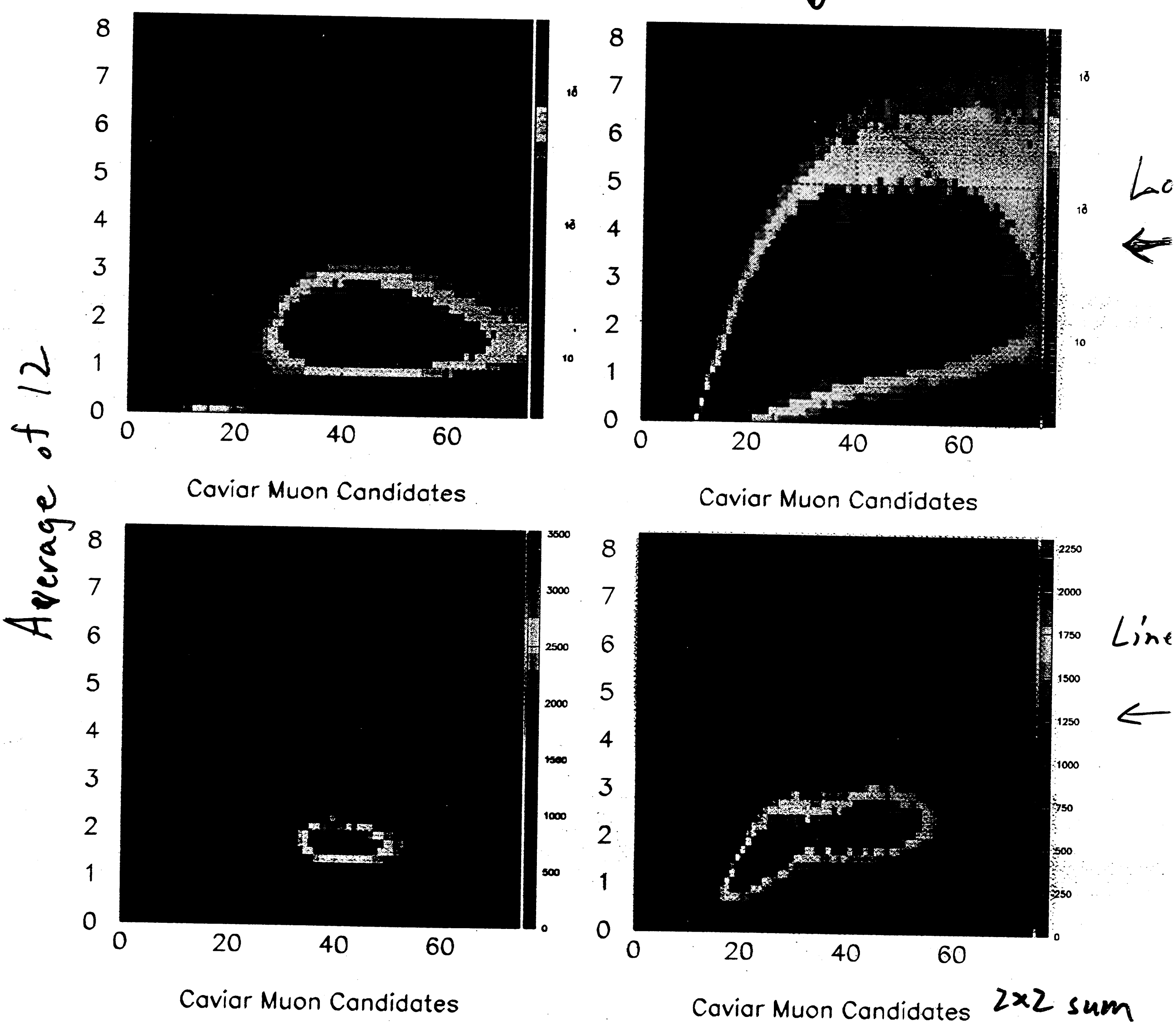




Spectrum PE Calibration

Igloo Triggers

Normal Data



Spectrum PE Calibration

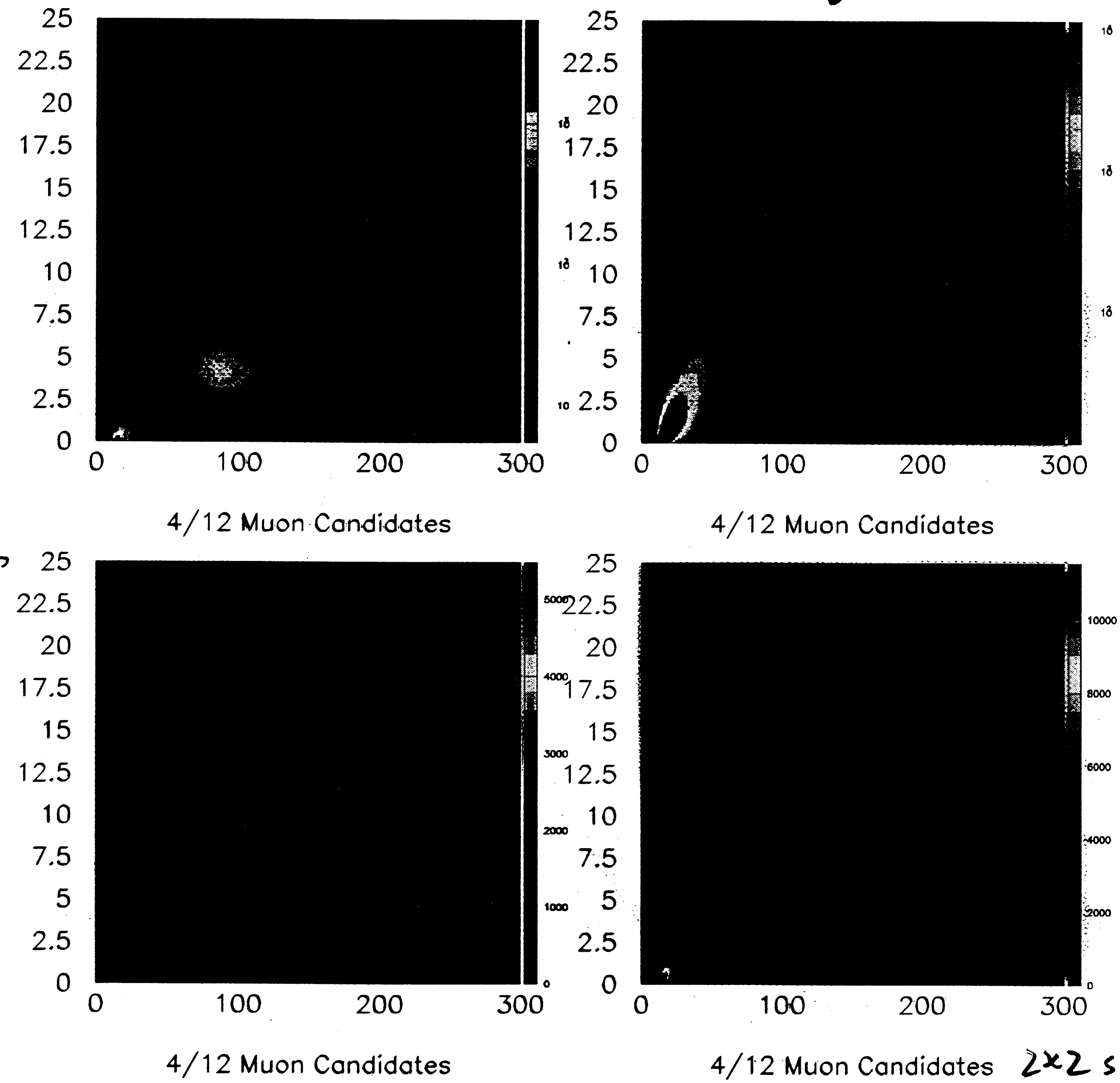
Igloo Triggers

Normal Data

Average of 12

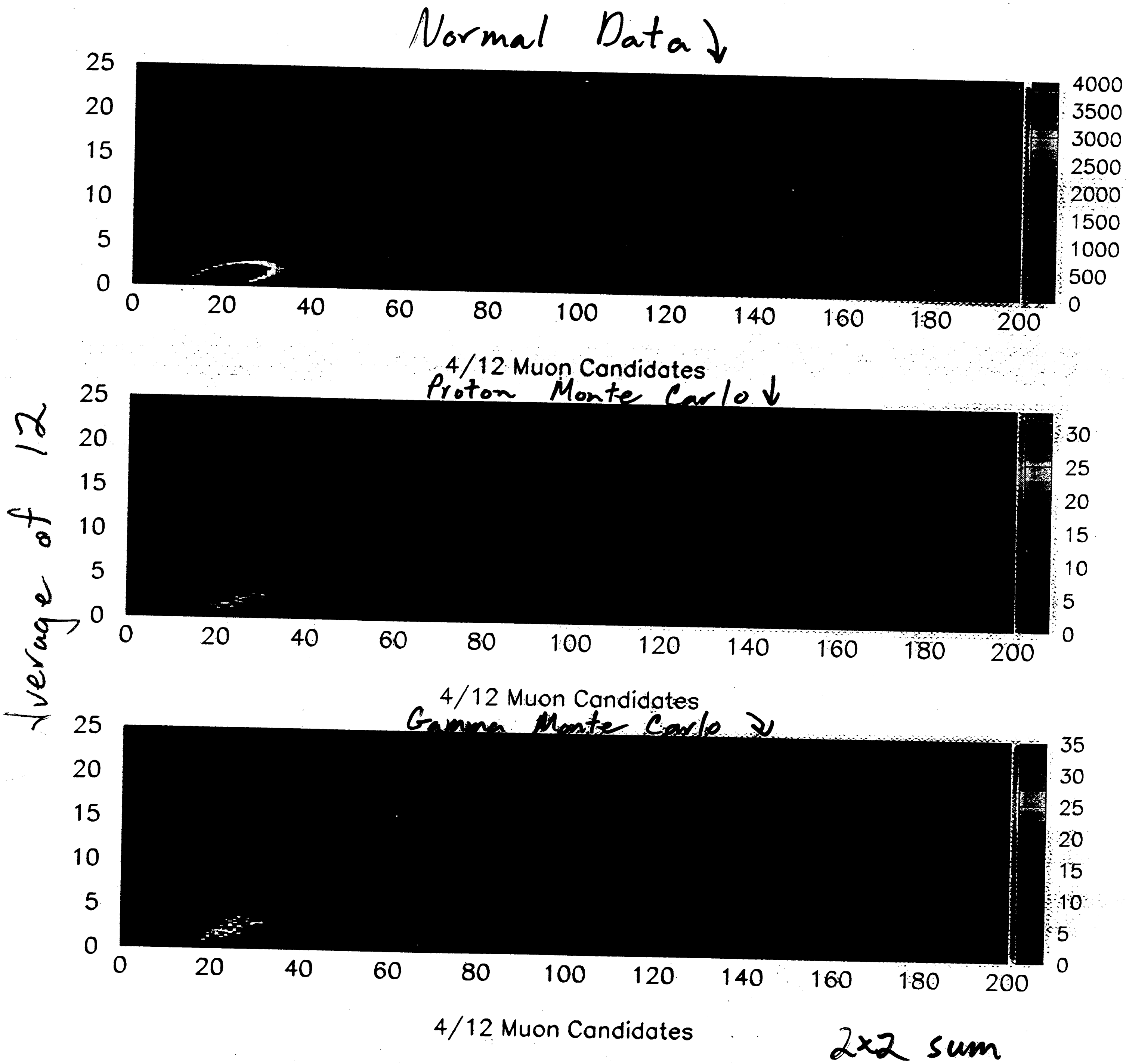
lo

line



2x2 sum

Laser PE Calibration


Normal Data
4/12 Muon Candidates
Proton Monte Carlo
4/12 Muon Candidates
Gamma Monte Carlo
4/12 Muon Candidates
Average of 12
2x2 sum

Revised muon Cand

$$\left.\begin{array}{c}\text{2x2 sum} > 50 \\ \text{and} \\ \text{Average of 12} < 7.5\end{array}\right\} \equiv \text{muon}$$

Sample of 82405 events with > 30 p.e. in Igloo

78255	have	≥1 muon	95%
4150	have	no muon	5%

Sample of 100001 normal events

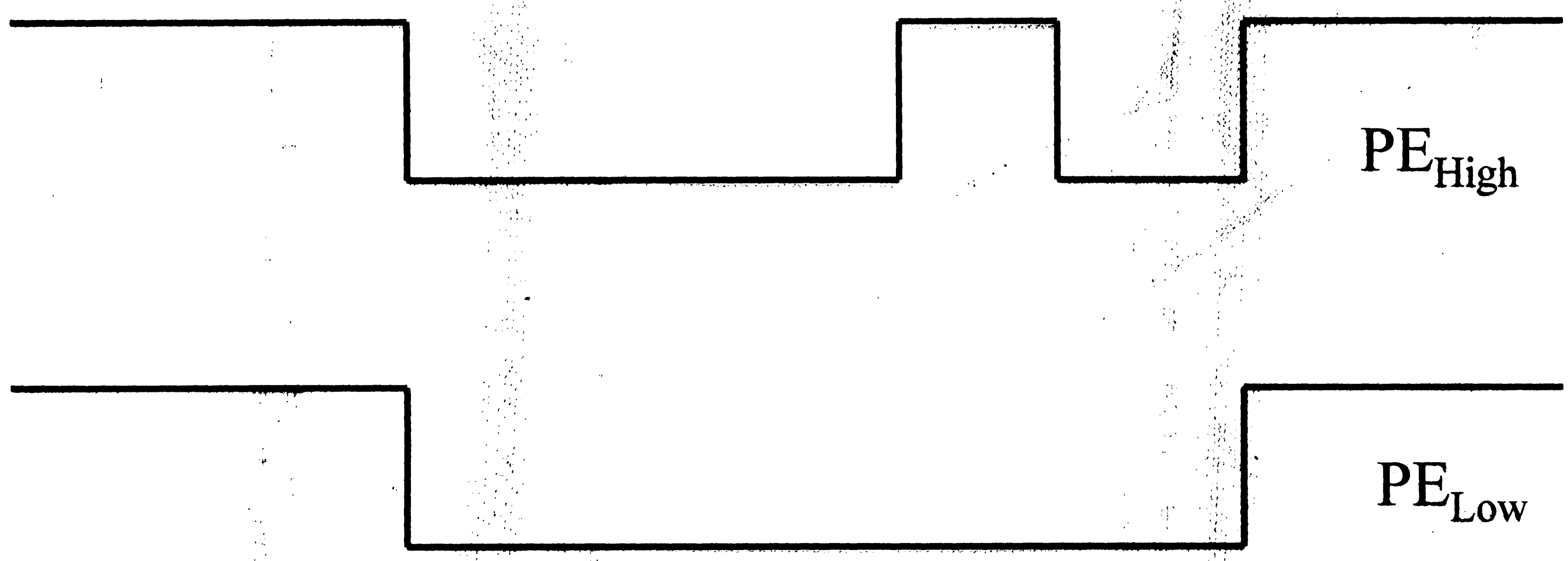
68693	have	≥1 muon	69%
31308	have	no muon	31%

TOT-PE Calibration Issues

- Problems Near High Threshold
- Incident Photons vs. PEs at Electronics

Gus Sinnis
Milagro Collaboration Meeting
Madison, WI (10/22/00)

The Transition Region



Can get $PE_{Low} > PE_{High}$

Partial Fix (in TOTPE_OCC4)

Impose Condition

$PE_{Low} <= PE_{High}(TOT=HiStart)$

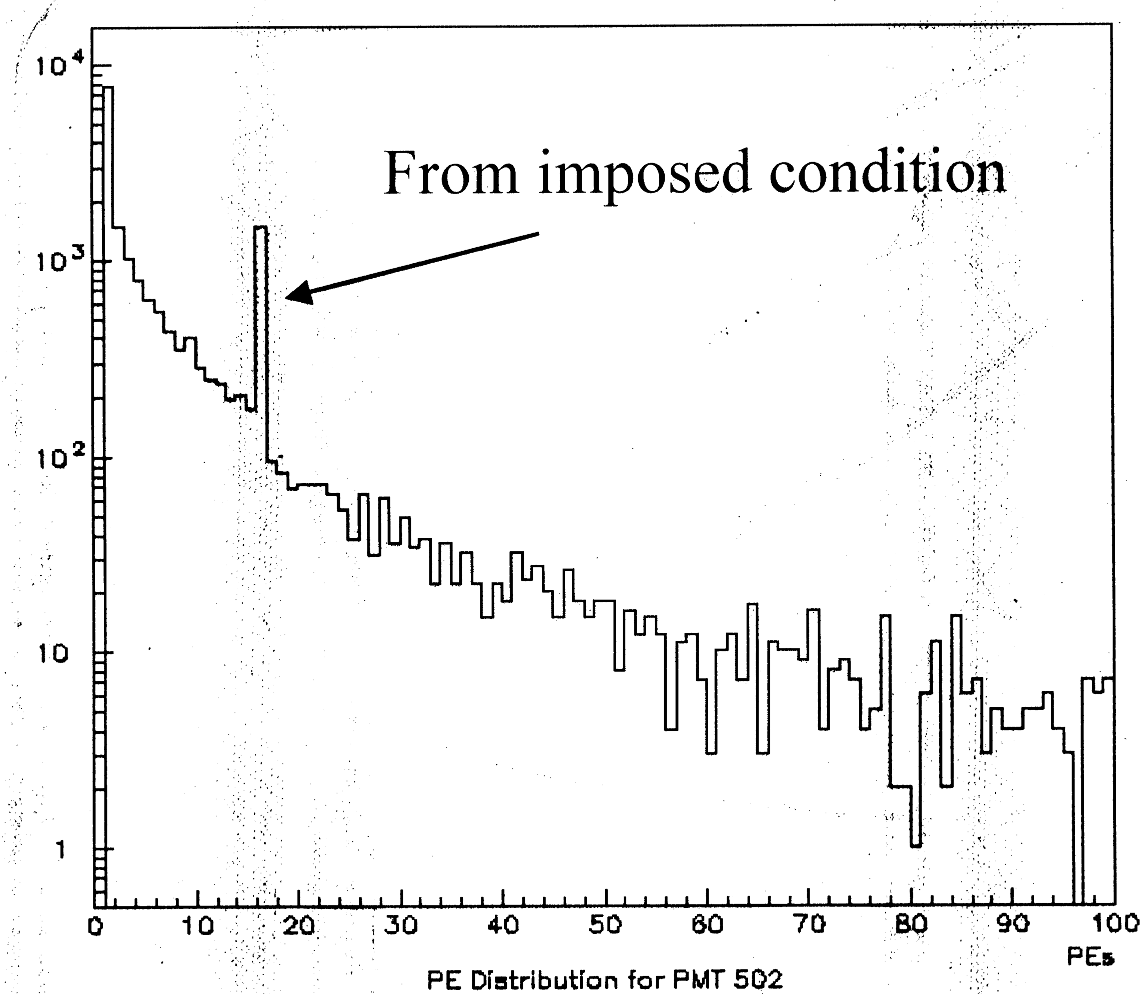
But

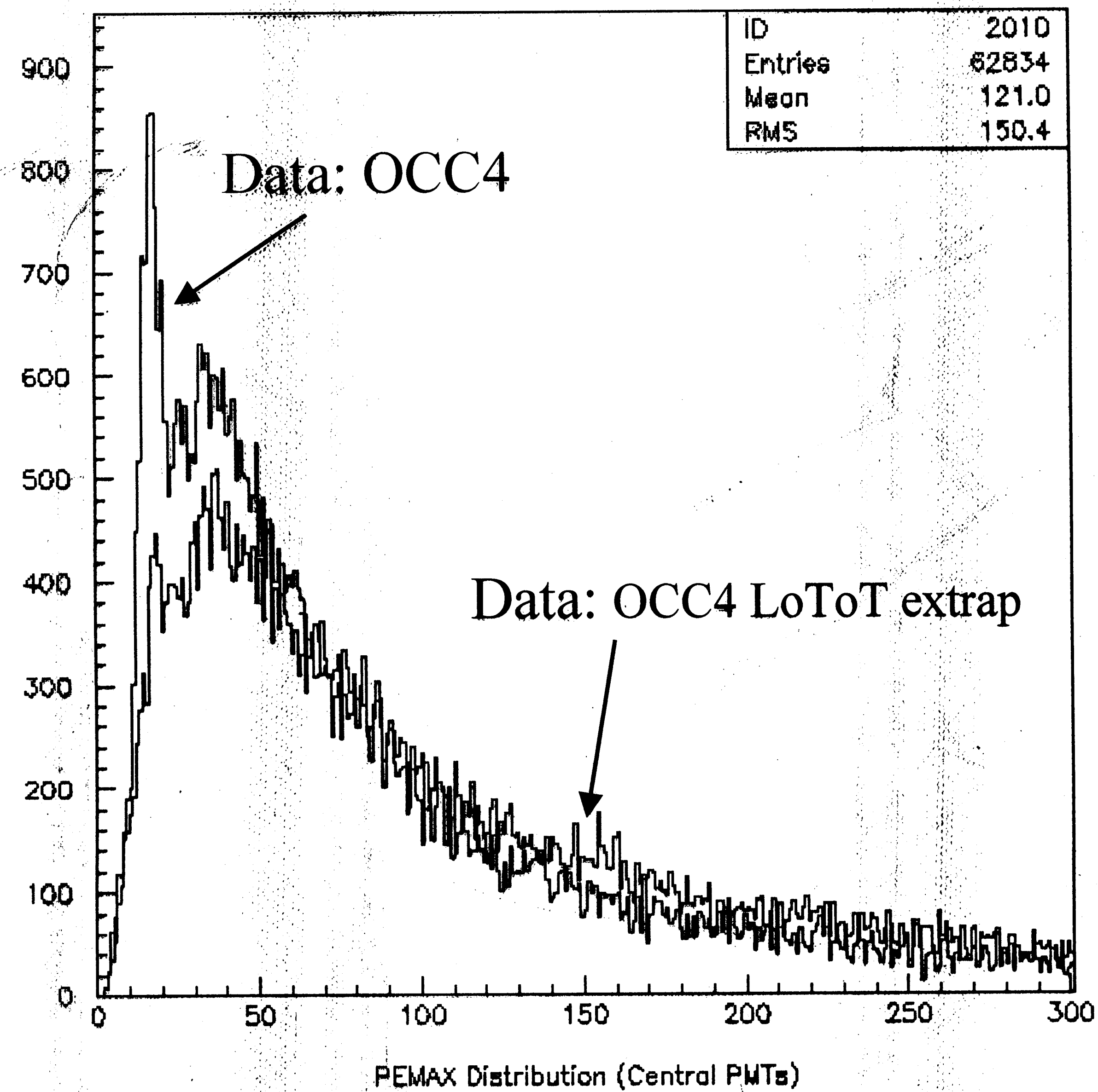
TOT=HiStart ~200-300 counts

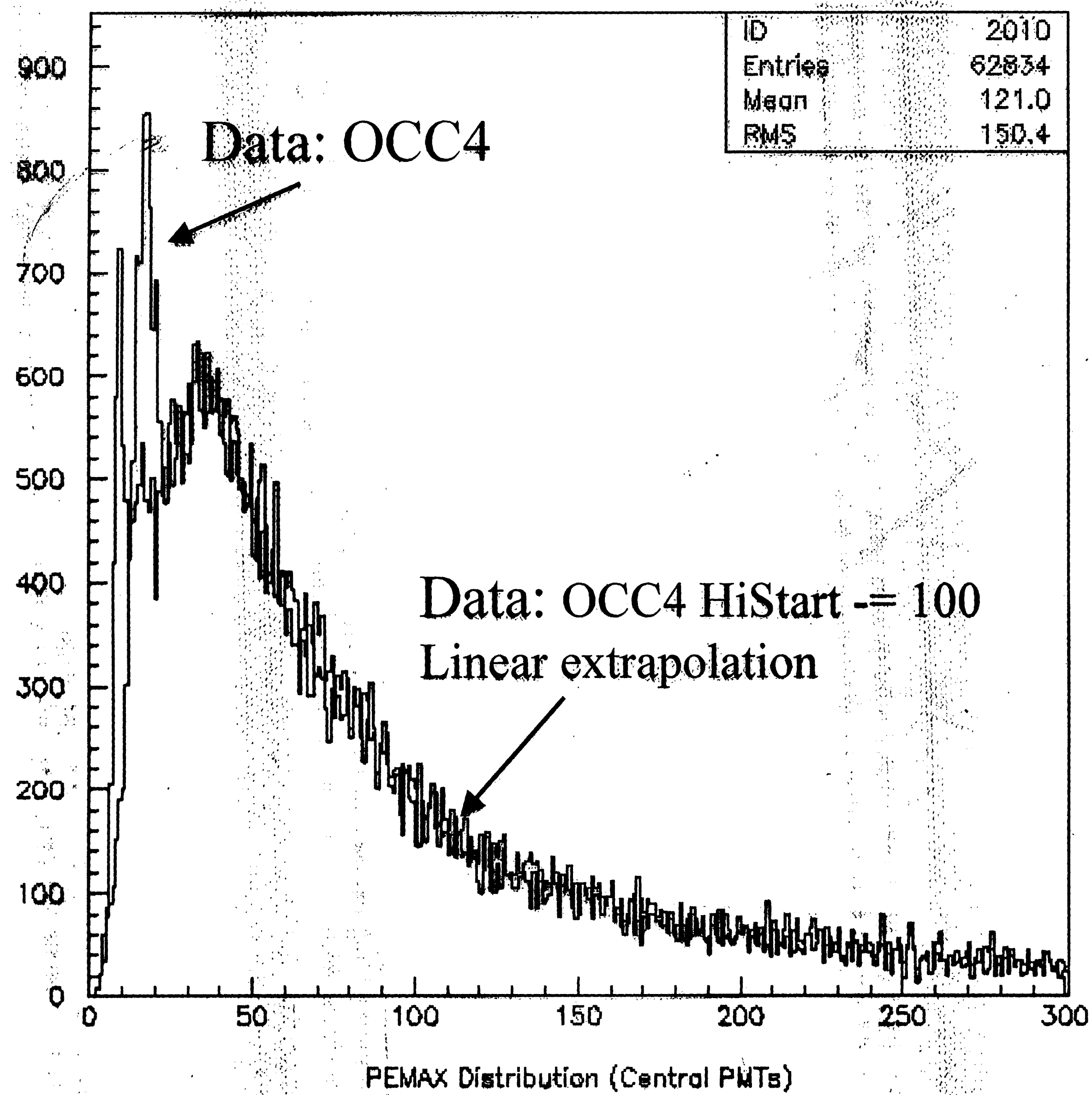
While

High Threshold ~100 counts

Typical PE Distribution

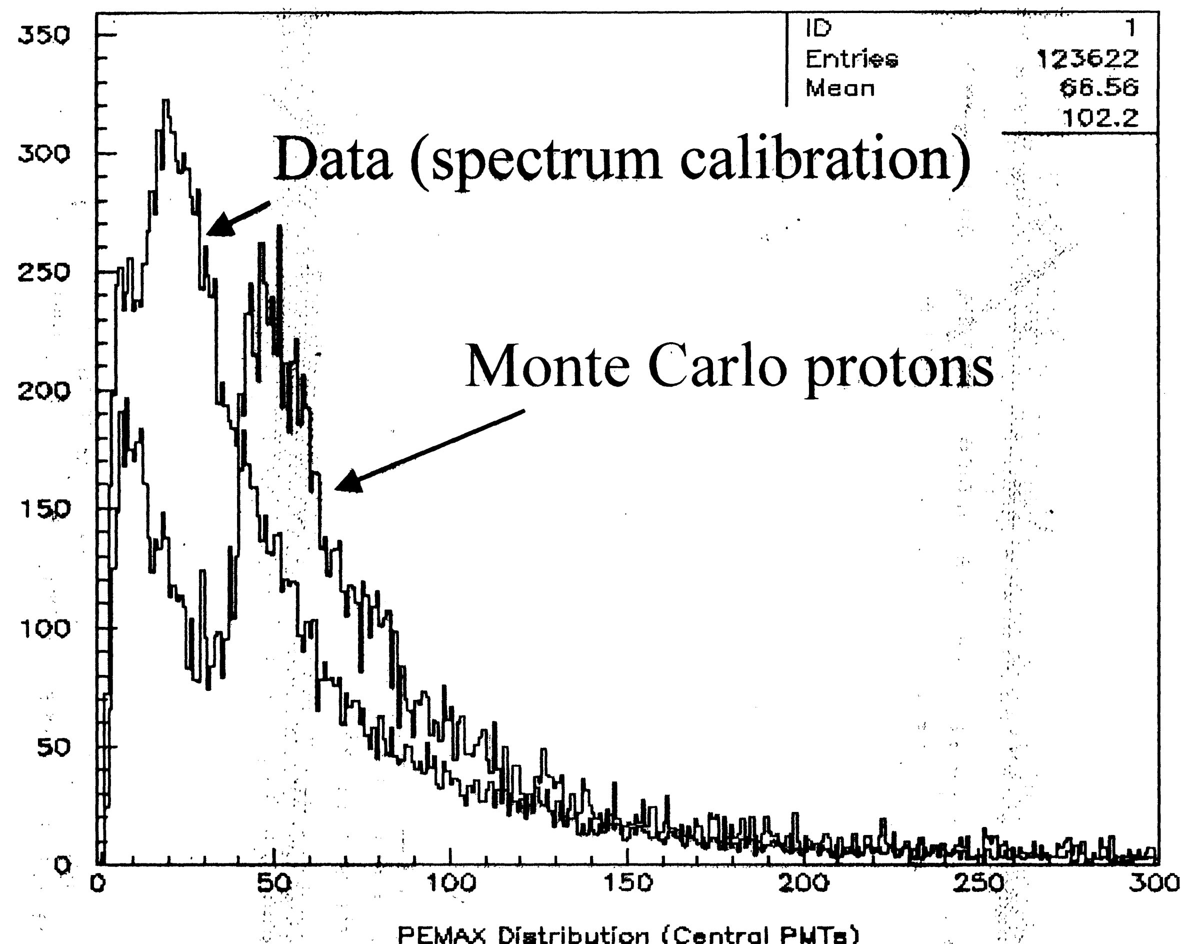



ID 2010
Entries 62834
Mean 121.0
RMS 150.4
Data: OCC4
Data: OCC4 LoToT extrap
0
100
200
300
400
500
600
700
800
900
0
50
100
150
200
250
300
PEMAX Distribution (Central PMTs)



ID 2010
Entries 62834
Mean 121.0
RMS 150.4
Data: OCC4
Data: OCC4 HiStart -= 100
Linear extrapolation
900
800
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
PEMAX Distribution (Central PMTs)

Effect on Gamma Hadron Separation



Comments

Need reality based calibrations of HiTOT

Need to begin HiStart at smaller TOT values

Monte Carlo only qualitatively correct

Positions of peaks depends on efficiency and water quality

Relative Efficiency of PMTs

Want number of photons incident on "PMT"

Measure number of PEs at electronics

Must correct for:

- Quantum/collection efficiency
- Baffle efficiency (reflectivity and geometry)

PMT PE Distributions

PMTs with similar geometry should have similar PE distributions

Monte Carlo predicts 3 classes of PMTs:

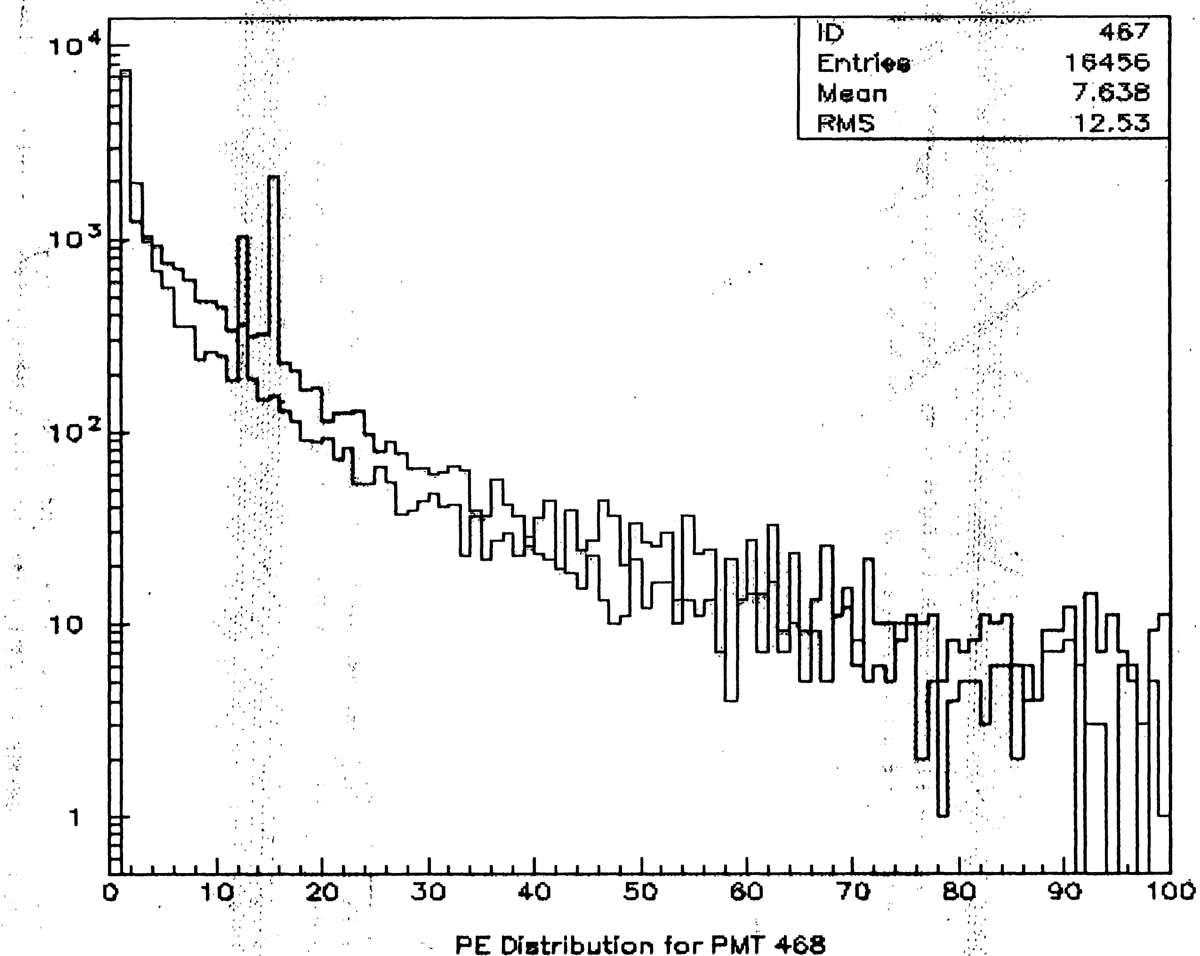
- Central
- Edge
- Corner

Make all PE distributions within class identical

Use average PE value to adjust relative efficiency

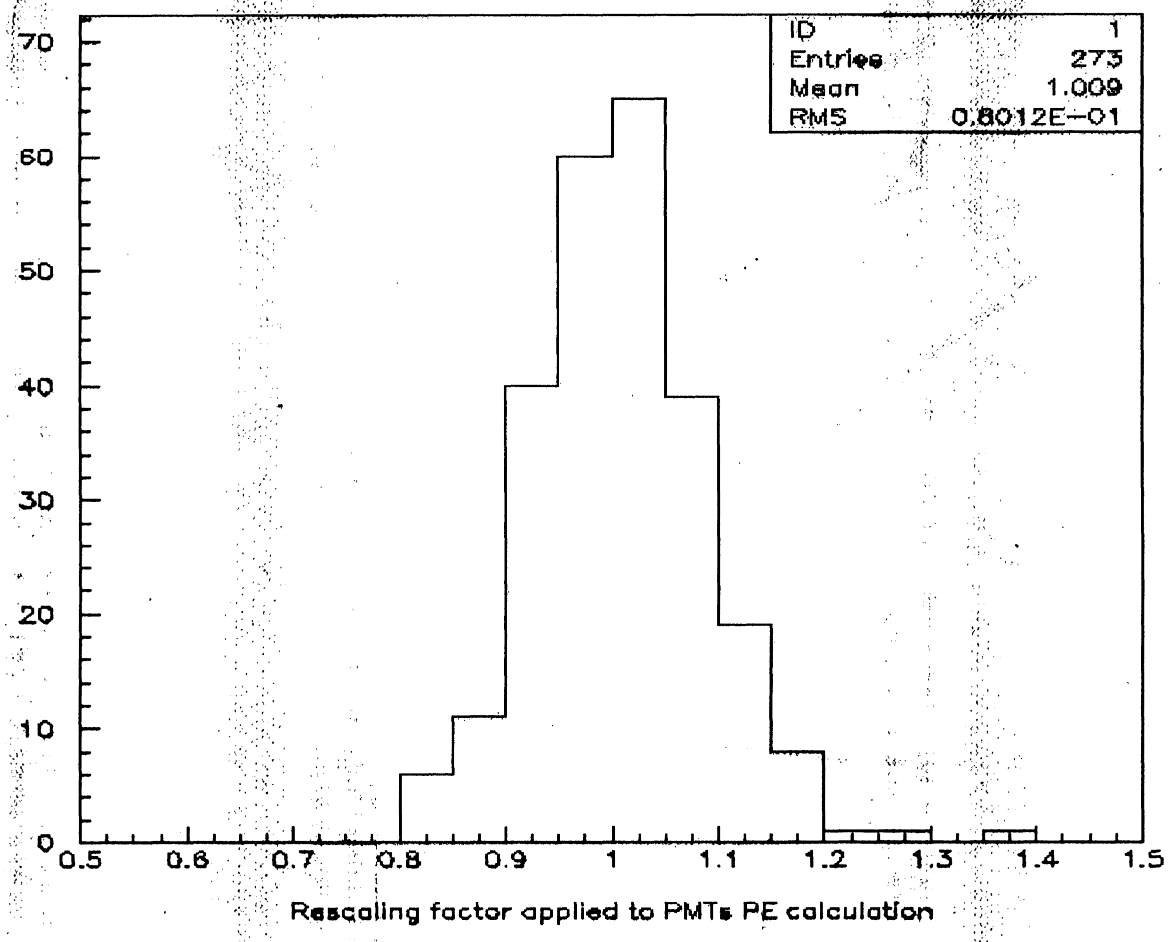
Use frequency distribution of PEMAX to check results

Before

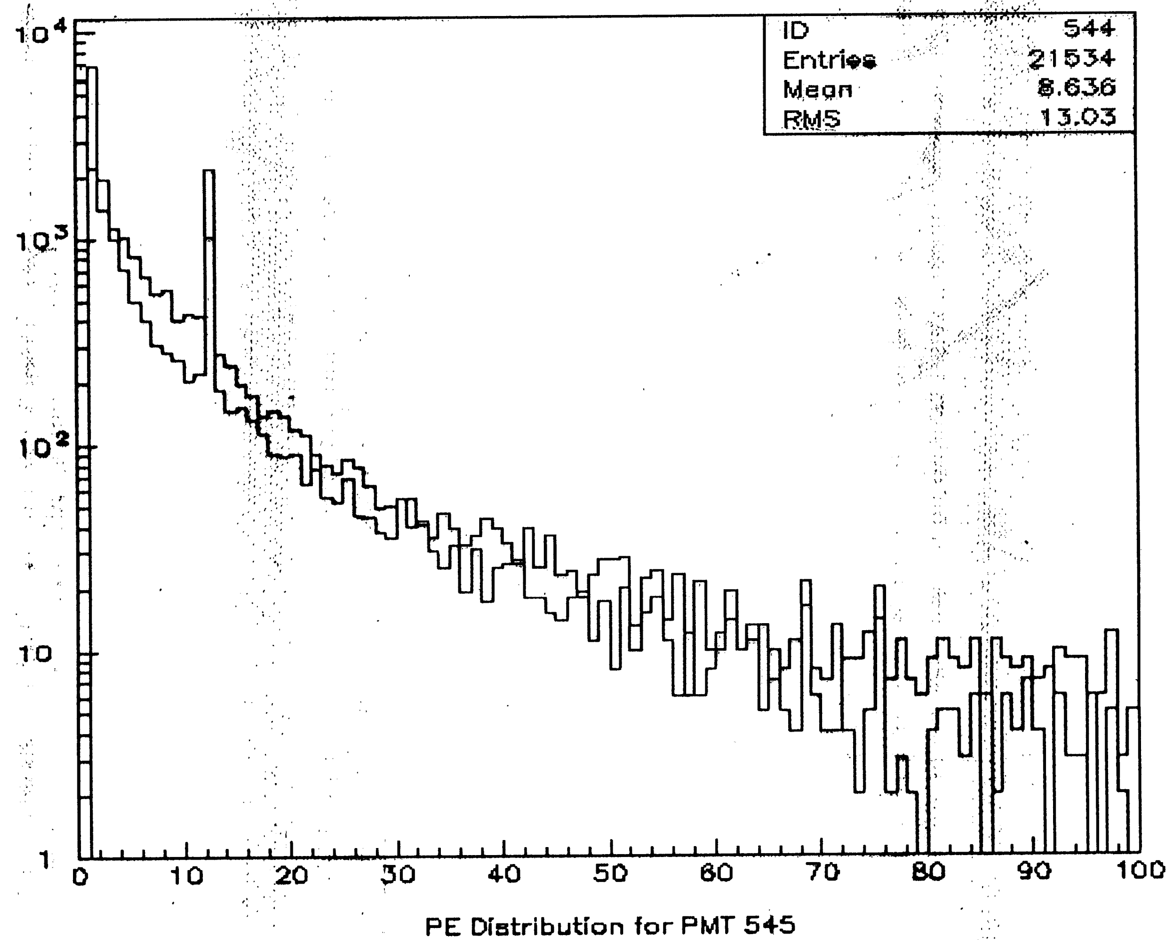


ID 467
Entries 16456
Mean 7.638
RMS 12.53
10^4
10^3
10^2
10
1
0
10
20
30
40
50
60
70
80
90
100
PE Distribution for PMT 468

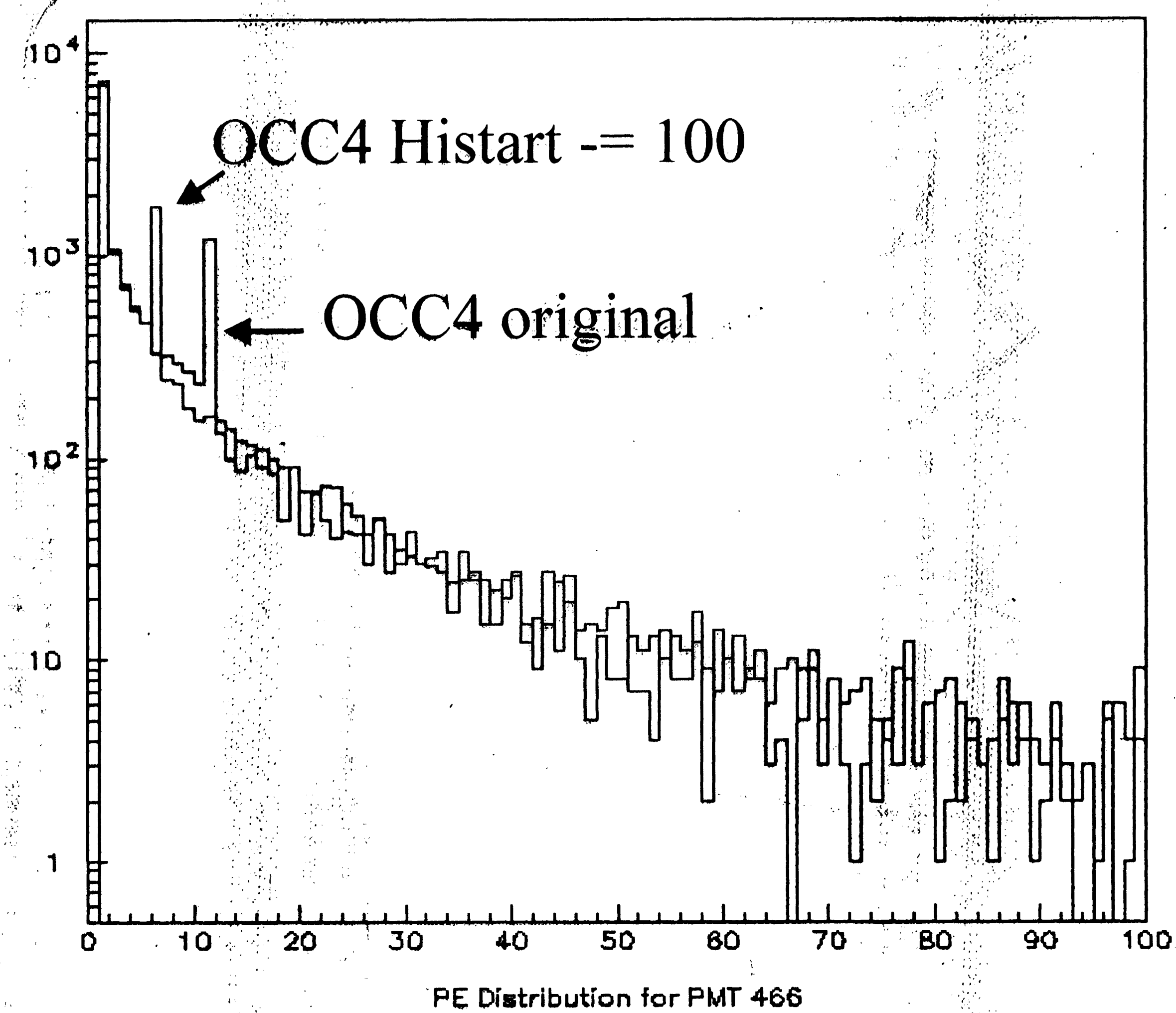
Correction Factors



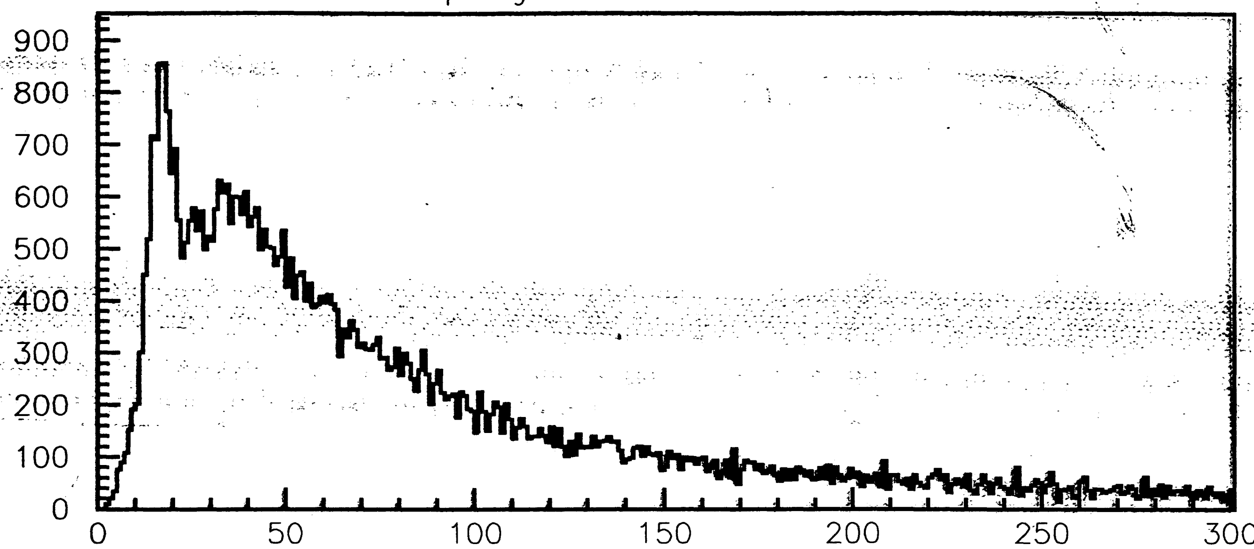
After


ID 544
Entries 21534
Mean 8.636
RMS 13.03
10^4
10^3
10^2
10
1
0
10
20
30
40
50
60
70
80
90
100
PE Distribution for PMT 545

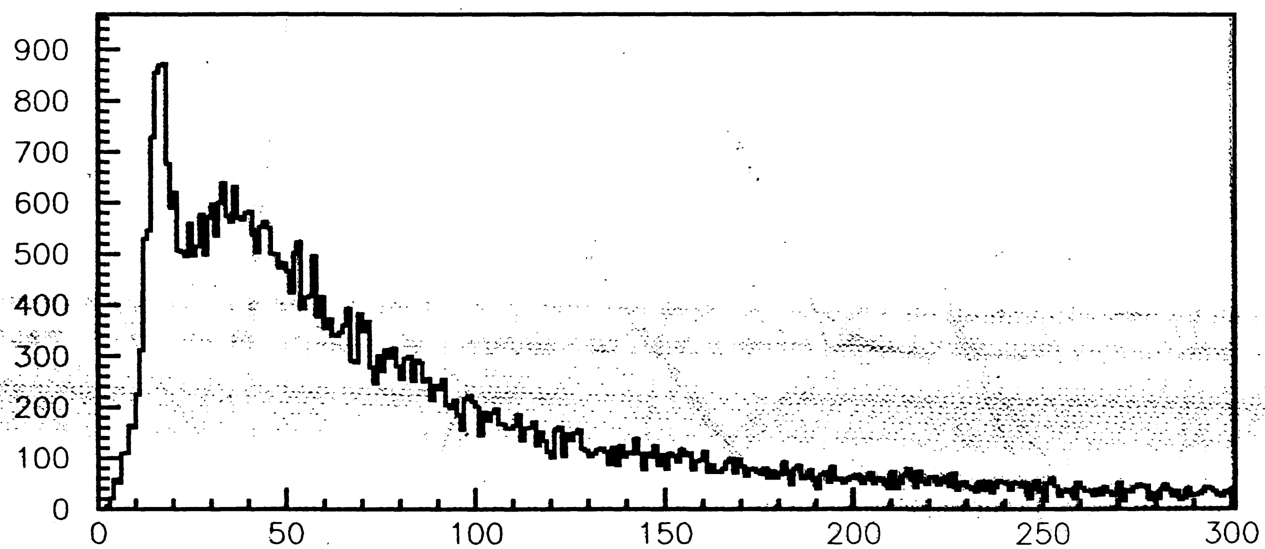
Effect of HiStart -= 100



Top original. Bottom rescaled PEs.

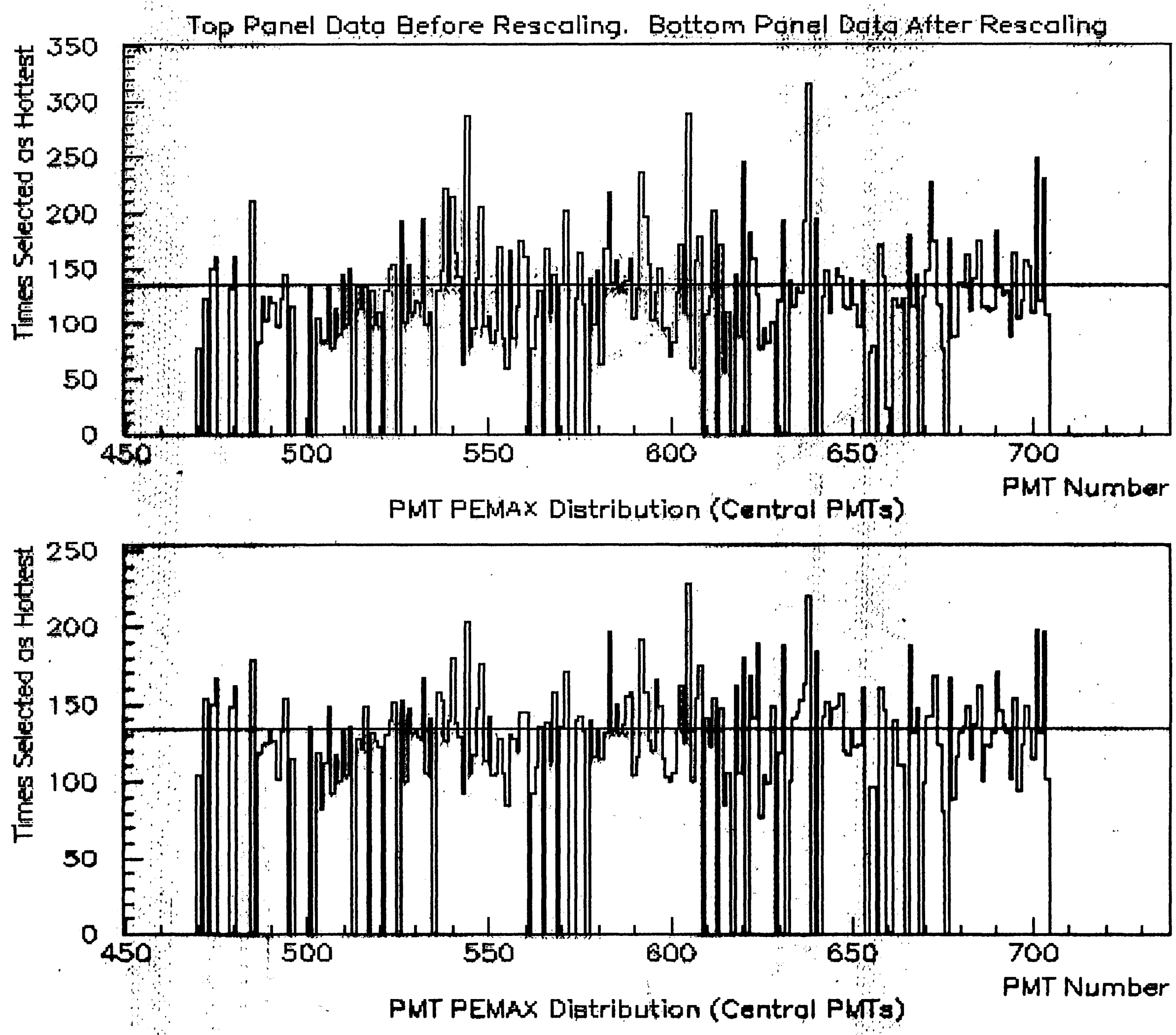


PEMAX Distribution (Central PMTs)



PEMAX Distribution (Central PMTs)

Frequency of PEMAX



Data Before

$\chi^2 = 16/\text{dof}$

Data After

$\chi^2 = 5.5/\text{dof}$

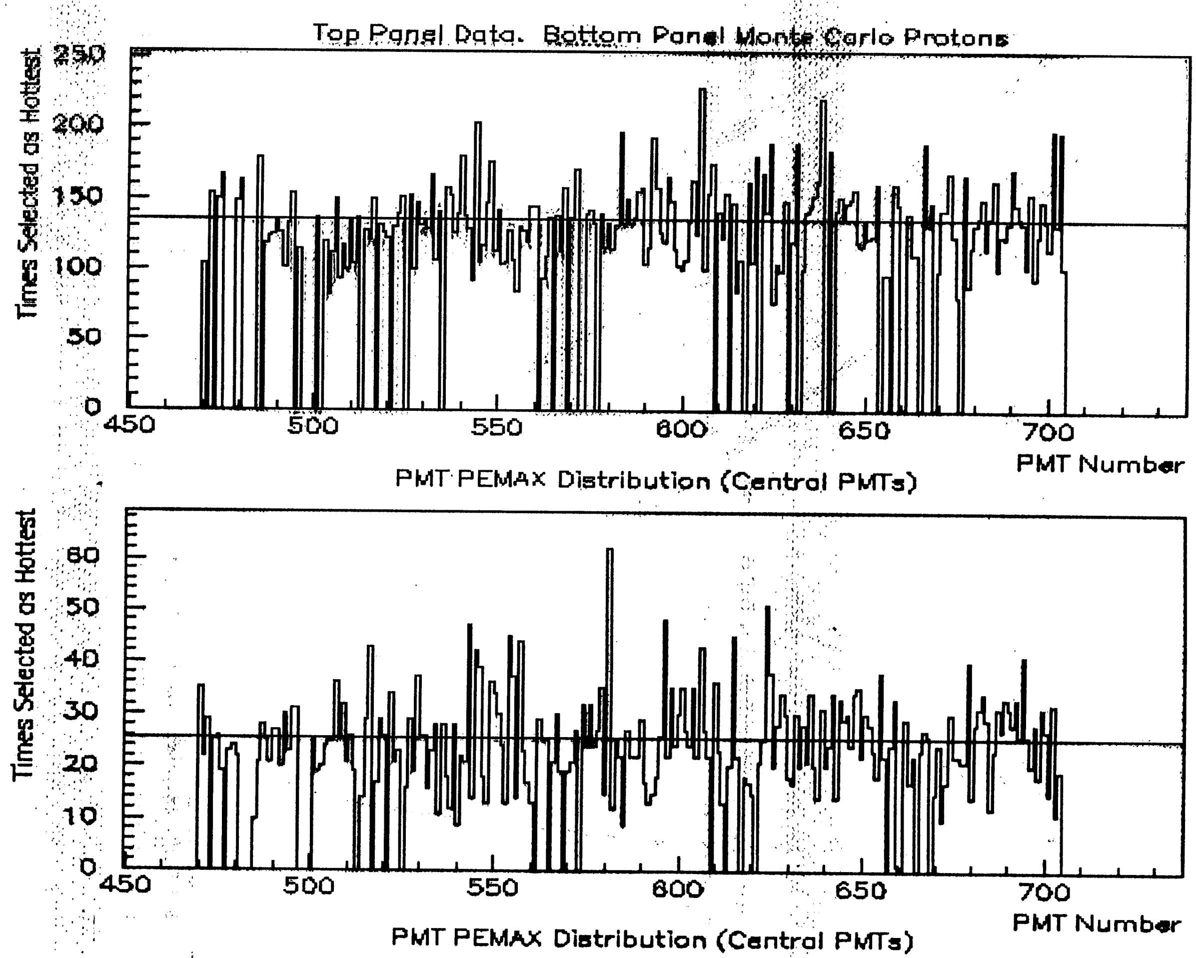
Frequency After Correction

<u>Data</u>

$\chi^2 = 5.5$/dof (3.5/dof w/o outliers, 17 PMTs)

<u>Monte Carlo</u>

$\chi^2 = 3.3$/dof



Conclusions

Calibrations can be improved in 2 ways

1. Calibrate HiTOT to lower values
2. Correct for differing PMT efficiencies

Improve our gamma hadron separation

WISCONSIN

G B Yodh

SH selection of Data Events

Procedure:

(1) FIND MAXPE TUBE IN TOP & BOTTOM LAYERS INDEPENDENTLY

(2) Require, in top layer that fraction of PMT's ALONG SPEED OF LIGHT IN WATER > 80% of all hits. (~~[illegible]~~

$t_i - t_{max} > -15 + 4.5\,(r_{i;\,max})$

This procedure retains ~ ~~[illegible]~~ 0.6% of all events.

Typical results: Selected events

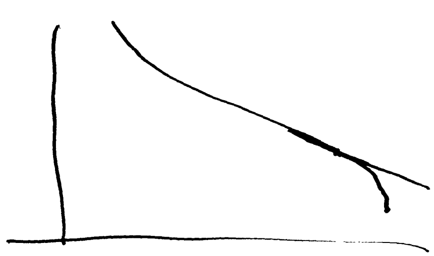
(1) t vs r top layer

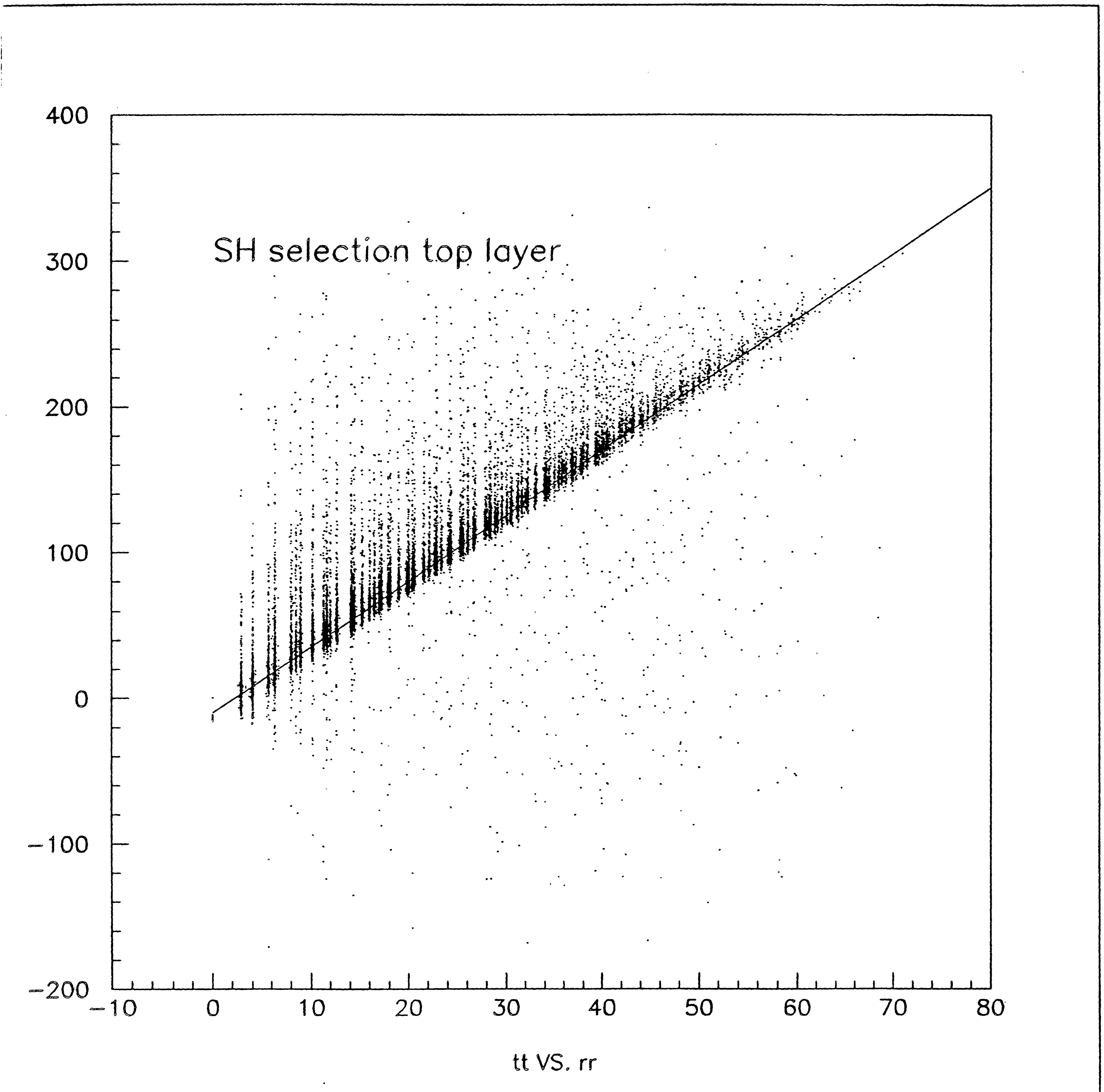
(2) t vs r bottom layer

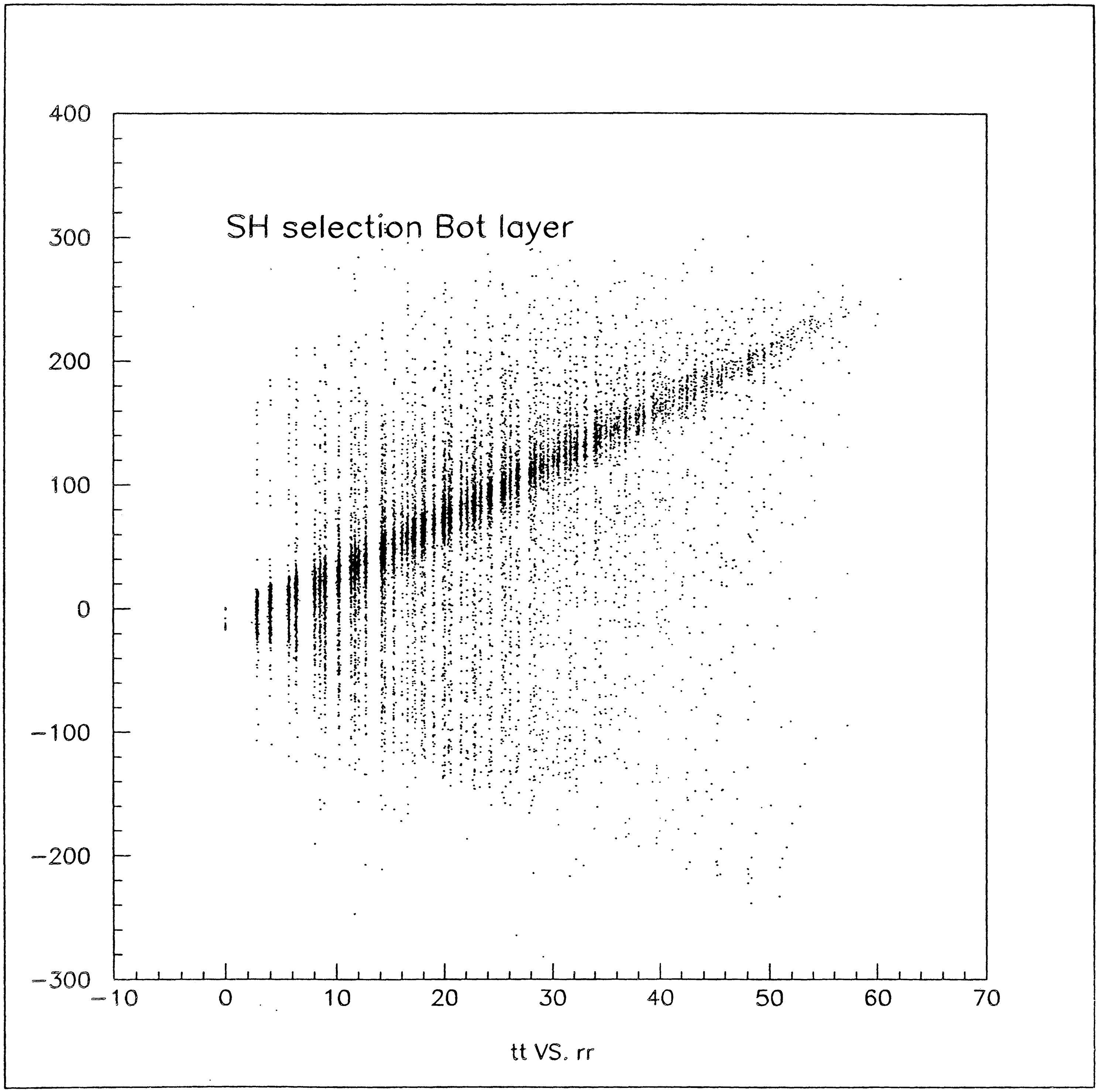
(3) $\log_{10}$ (pesum bot)

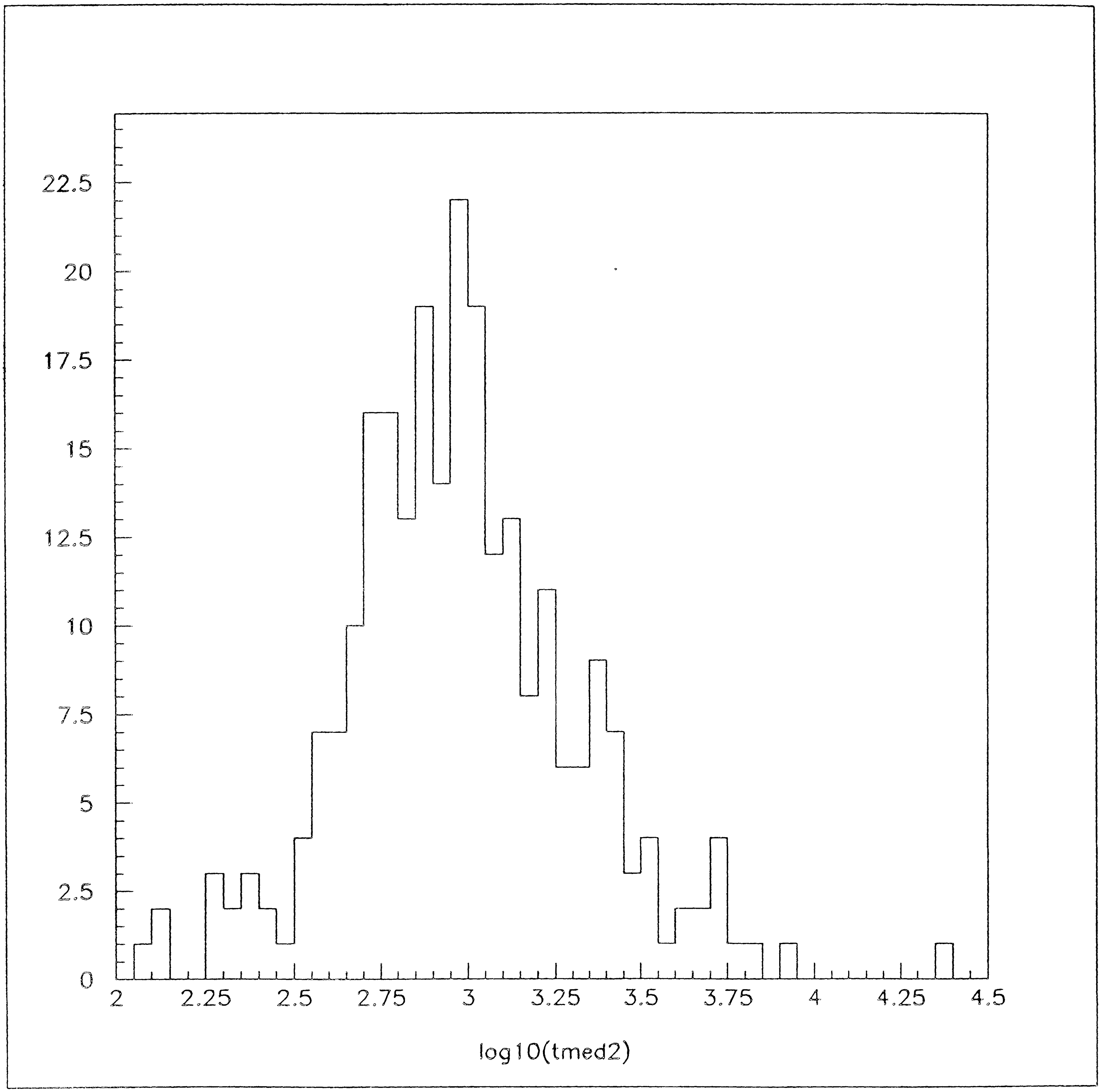
(4) Examples of selected events

$J_{SH}(E) > J_{sur}(E) = J_{Prot}\, e^{-x/\lambda}$

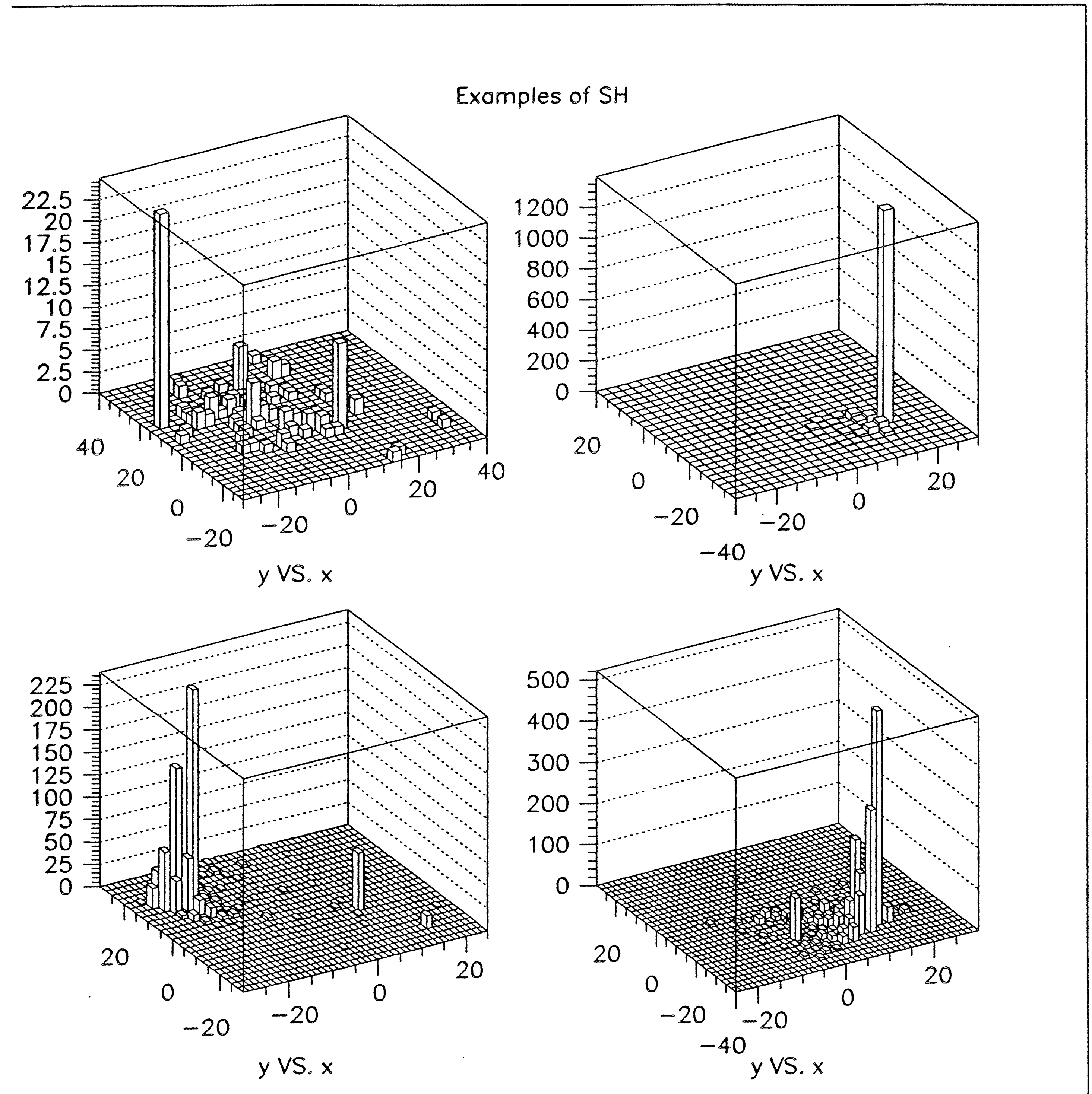



SH selection top layer
400
300
200
100
0
−100
−200
−10
0
10
20
30
40
50
60
70
80
tt VS. rr

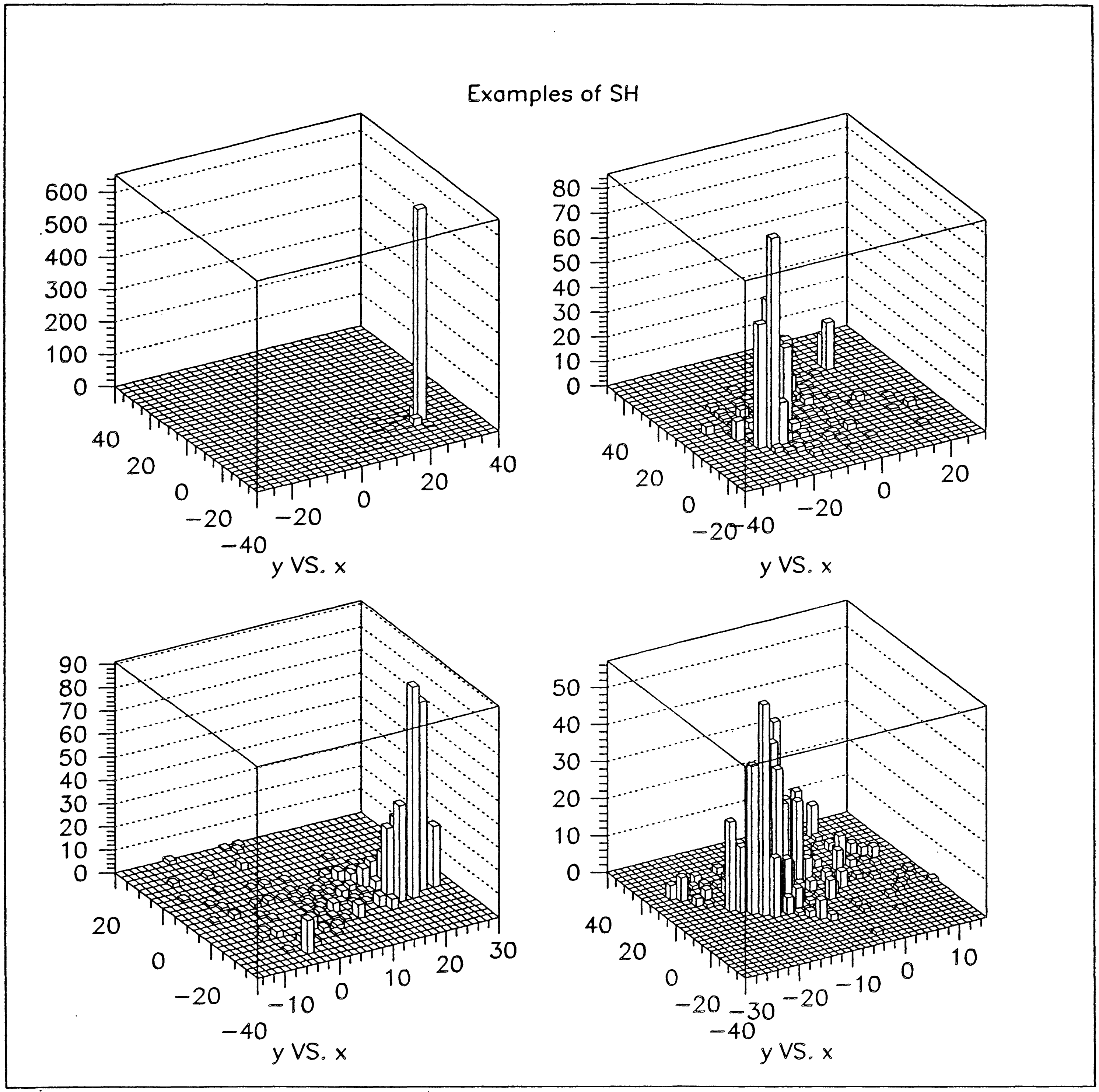

SH selection Bot layer
400
300
200
100
0
−100
−200
−300
−10
0
10
20
30
40
50
60
70
tt VS. rr

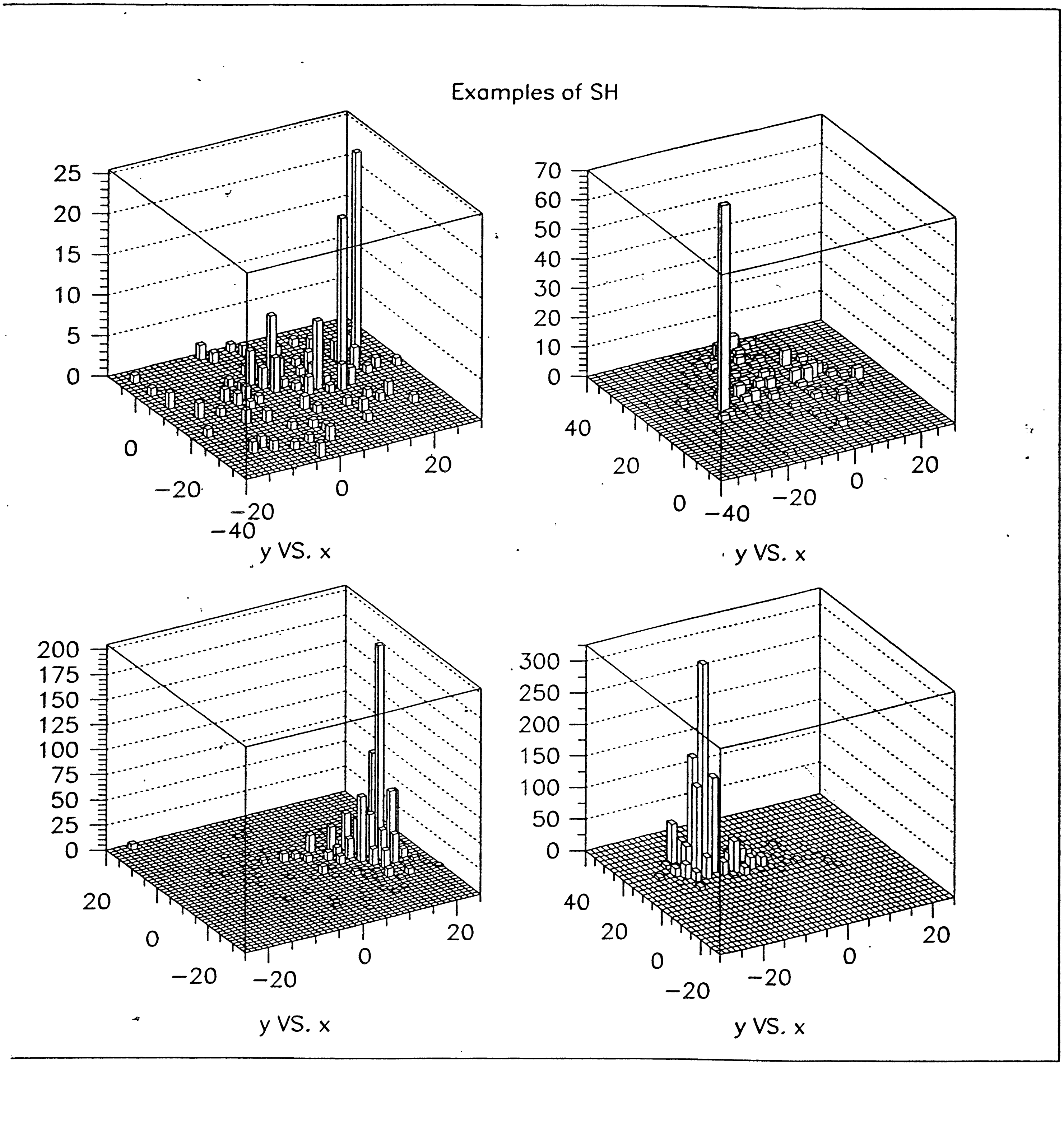


22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
2
2.25
2.5
2.75
3
3.25
3.5
3.75
4
4.25
4.5
log10(tmed2)

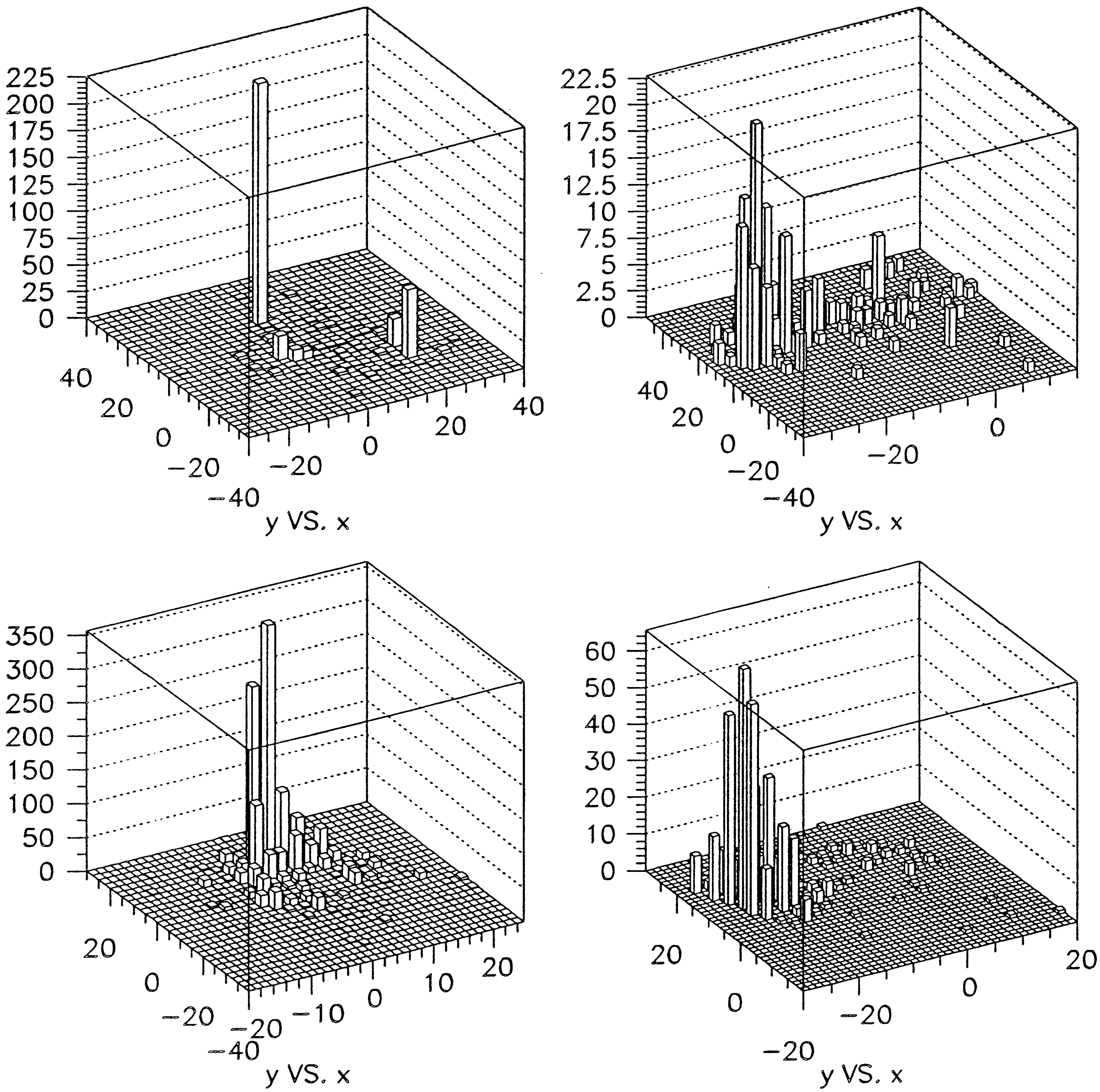


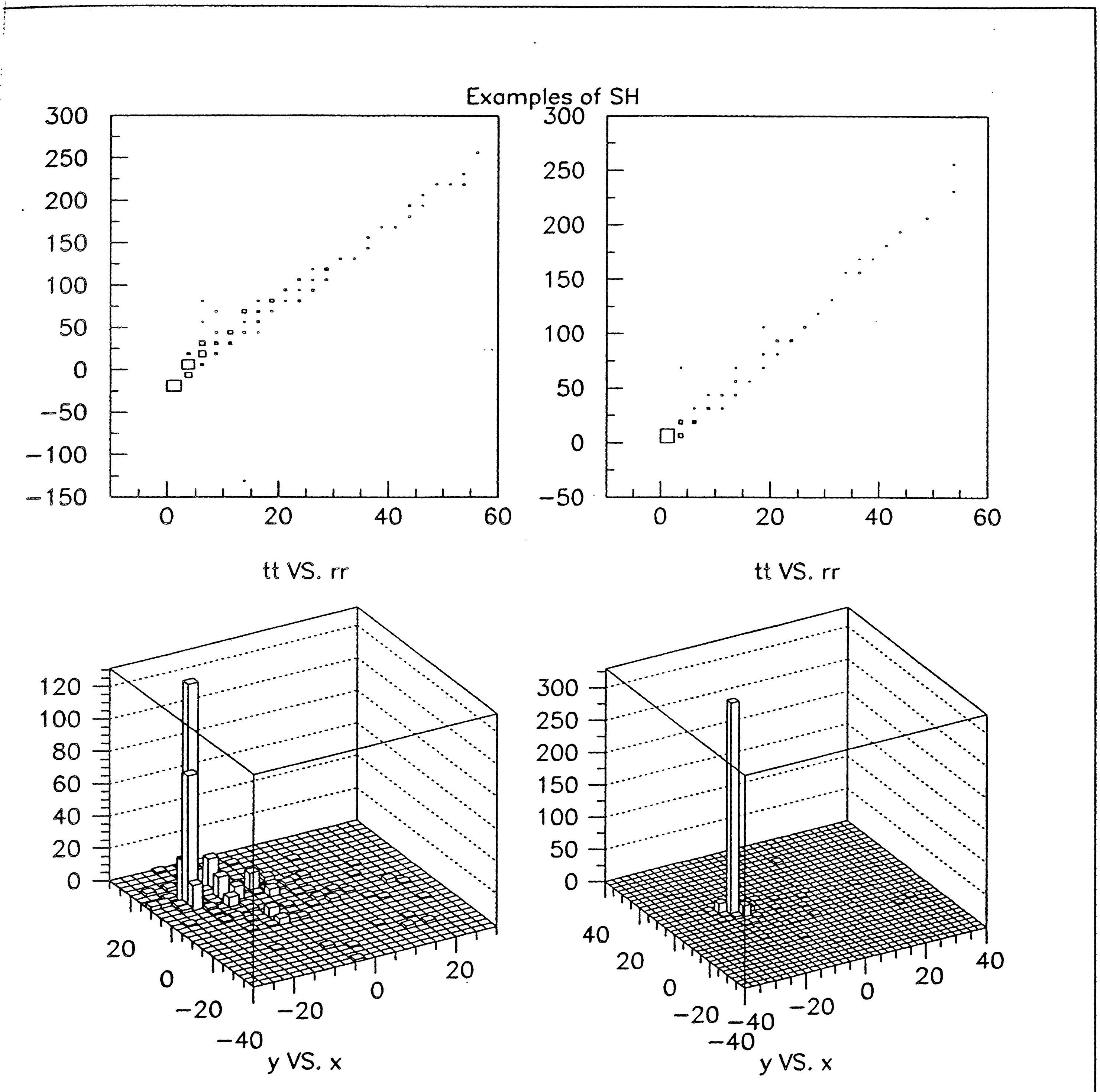
Examples of SH
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
40
20
0
−20
−20
0
20
40
y VS. x
1200
1000
800
600
400
200
0
20
0
−20
−40
−20
0
20
y VS. x
225
200
175
150
125
100
75
50
25
0
20
0
−20
−20
0
20
y VS. x
500
400
300
200
100
0
20
0
−20
−40
−20
0
20
y VS. x

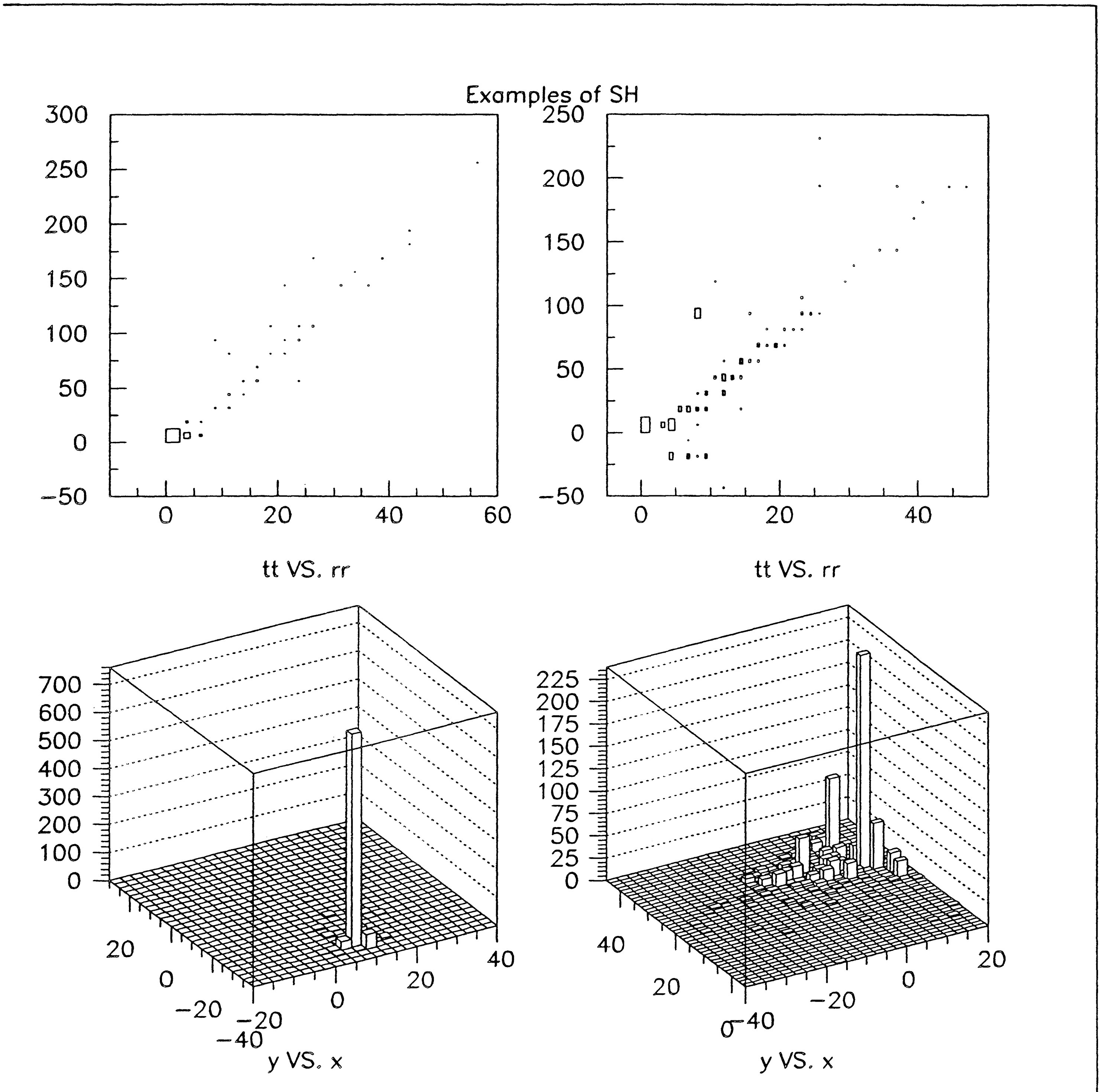

Examples of SH
600
500
400
300
200
100
0
40
20
0
−20
−40
−20
0
20
40
y VS. x
80
70
60
50
40
30
20
10
0
40
20
0
−20
−40
−20
0
20
y VS. x
90
80
70
60
50
40
30
20
10
0
20
0
−20
−40
−10
0
10
20
30
y VS. x
50
40
30
20
10
0
40
20
0
−20
−40
−30
−20
−10
0
10
y VS. x


Examples of SH
y VS. x
y VS. x
y VS. x
y VS. x

Examples of SH




Examples of SH
tt VS. rr
tt VS. rr
y VS. x
y VS. x



Examples of SH
tt VS. rr
tt VS. rr
y VS. x
y VS. x

Some characteristics of

Triggers of Milagro

Proton Simulation - All $e^{\pm}, \gamma$ down to 5 MeV

TRIGGER nhit > 50 ;

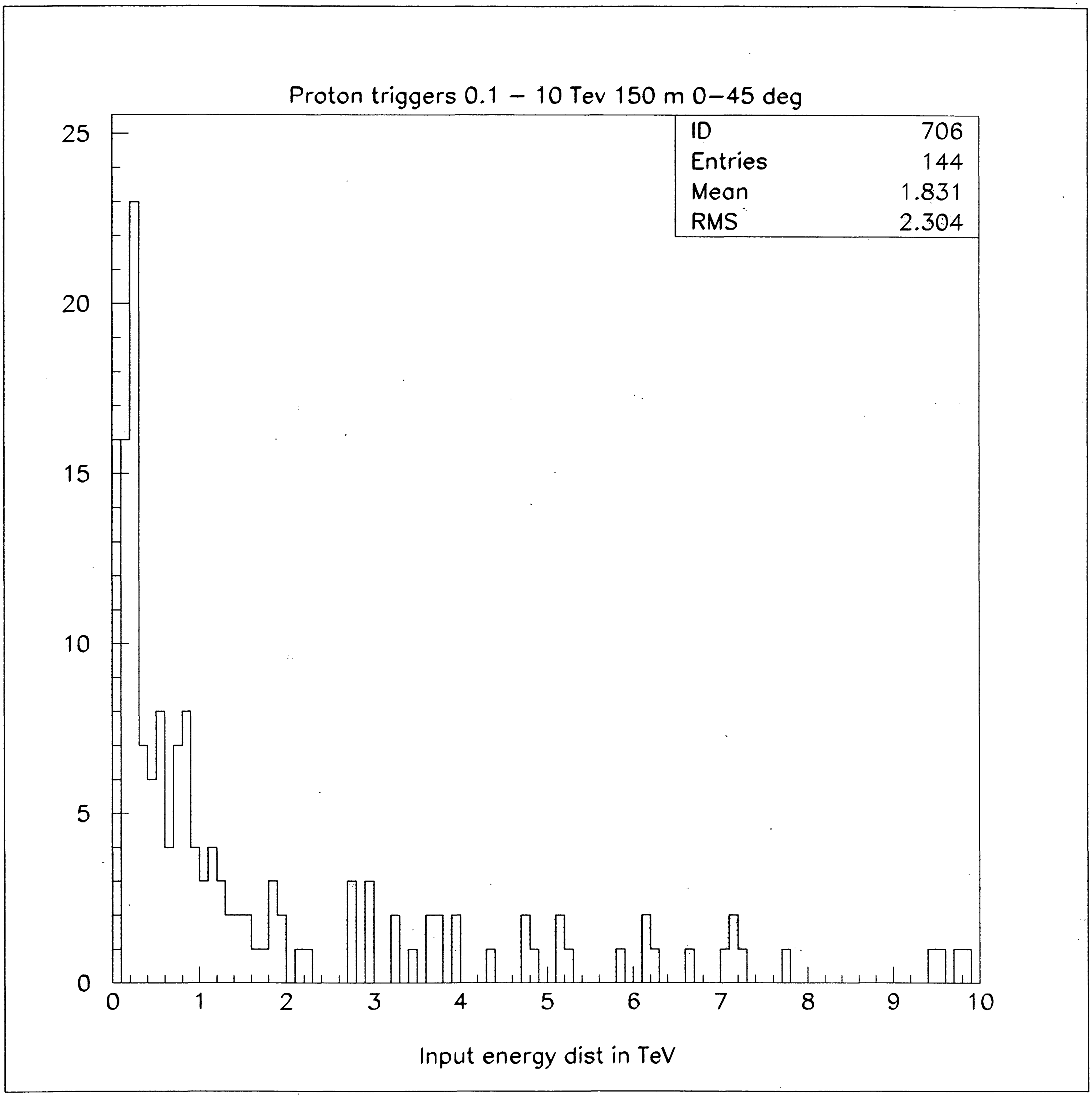
(1) PMT HITS / SHOWER PARTICLE

(2) MeV / pe

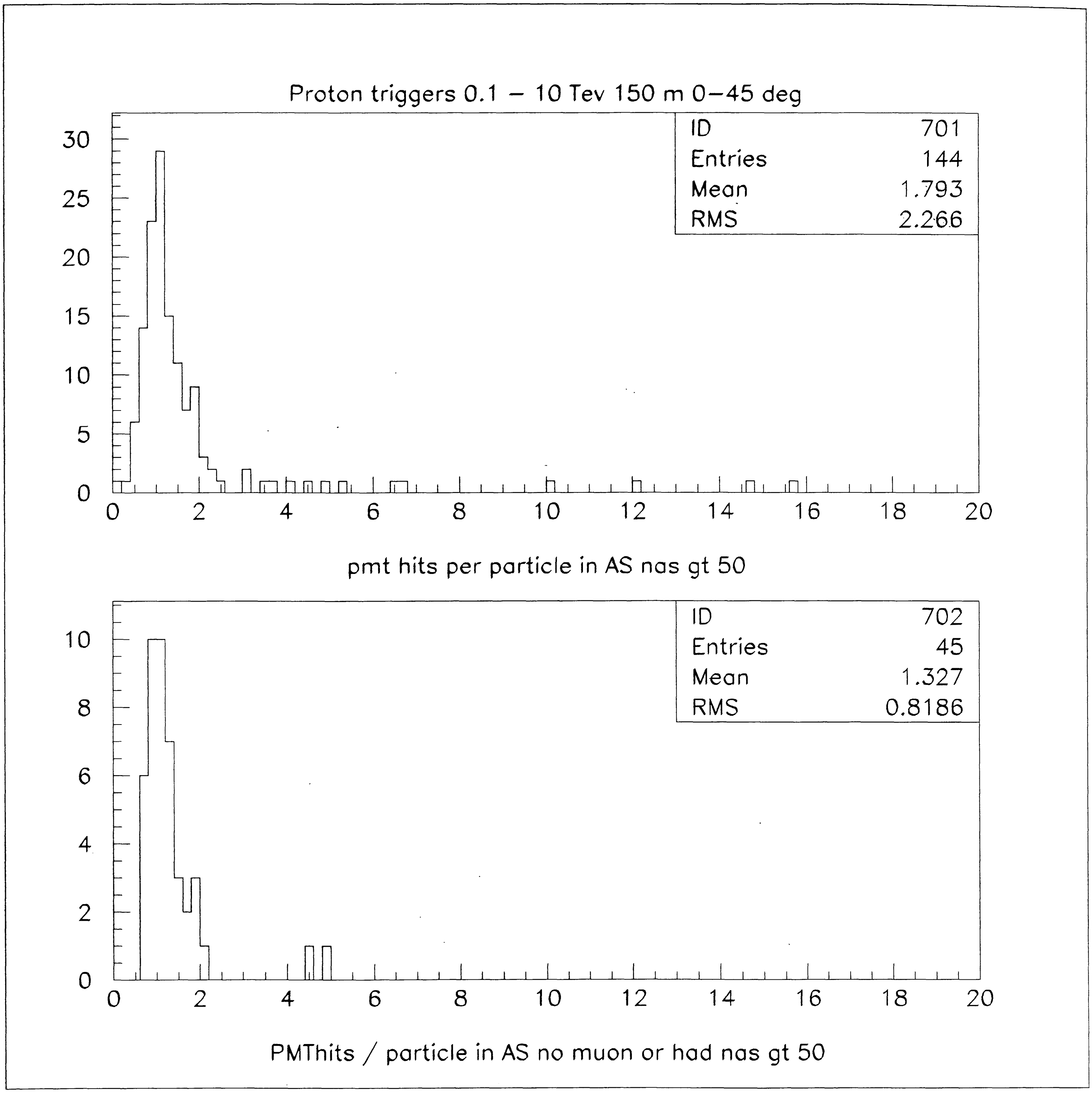
(3) Energy dist of $e^{\pm}$

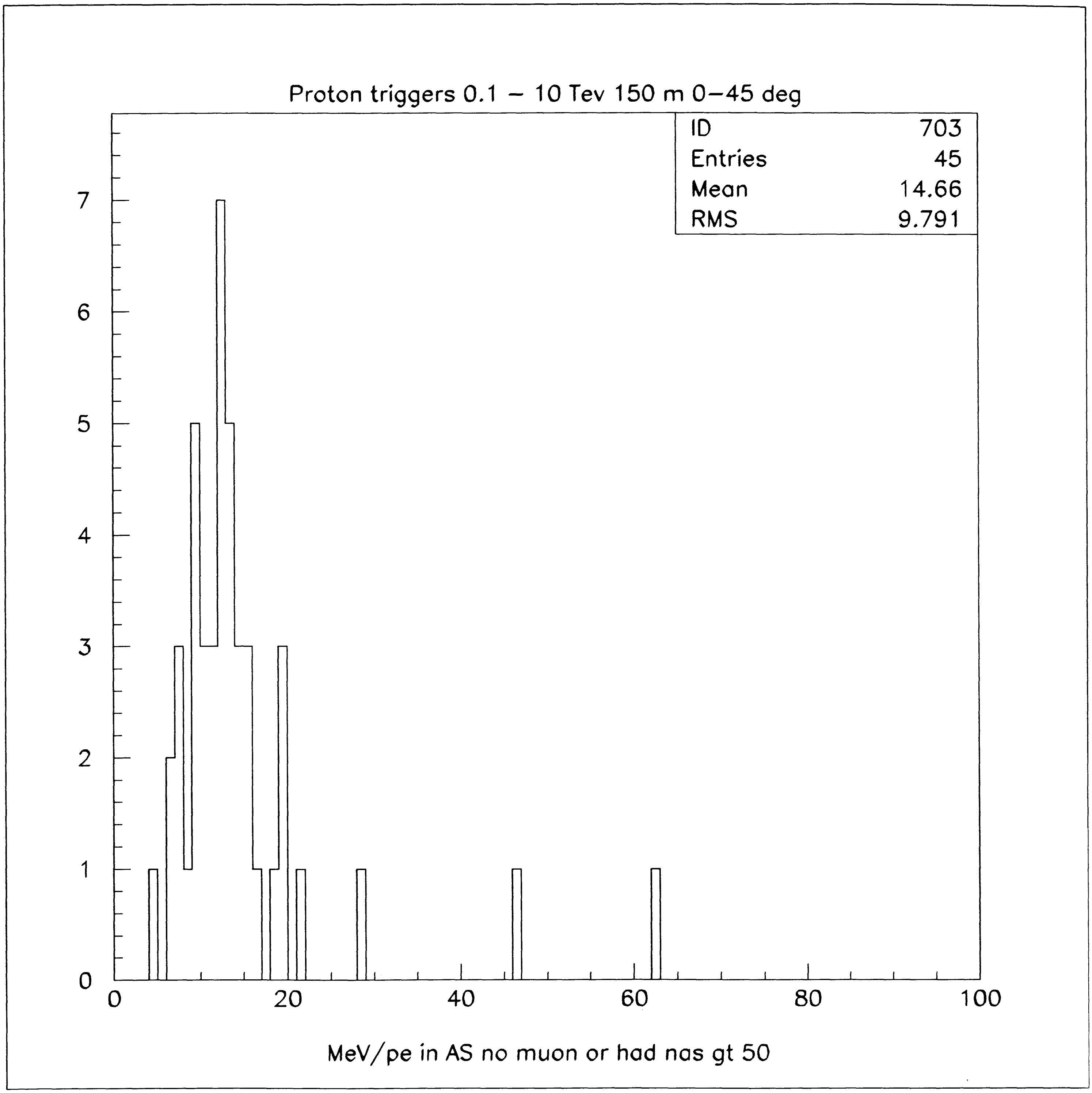
(4) " " " photons

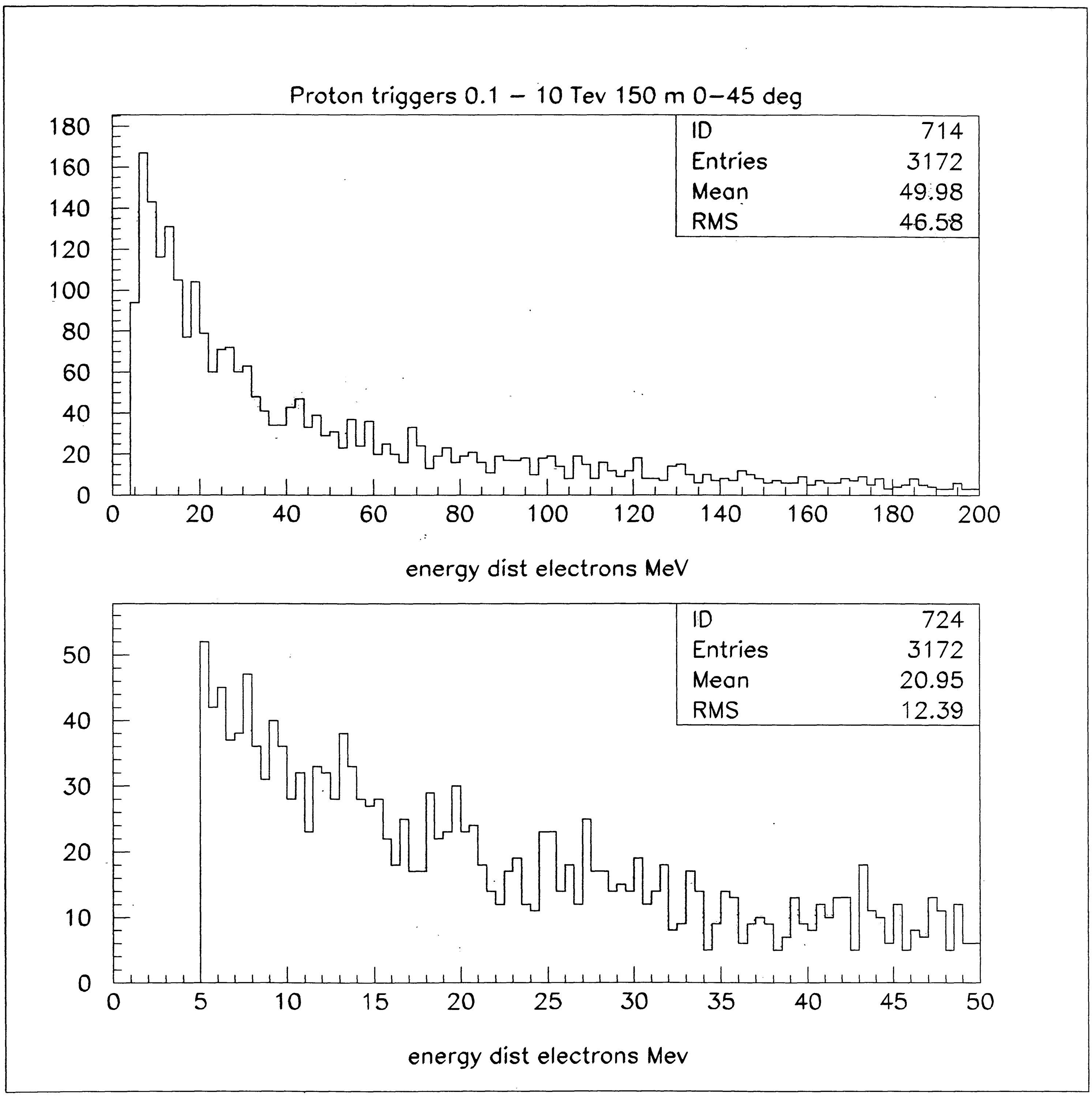
(5) Core dist of trigger showers.



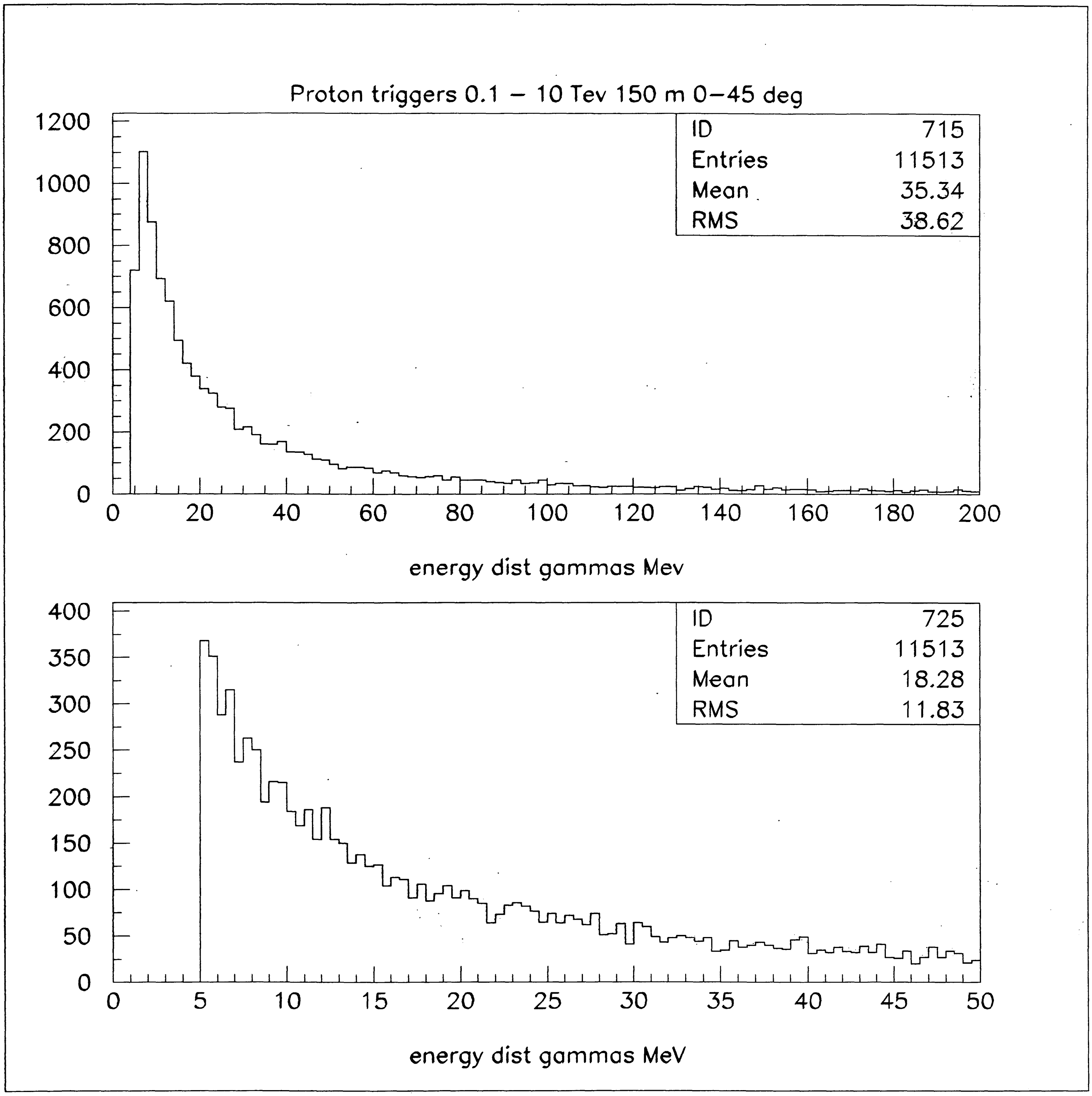
Proton triggers 0.1 – 10 Tev 150 m 0–45 deg
ID 706
Entries 144
Mean 1.831
RMS 2.304
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
Input energy dist in TeV

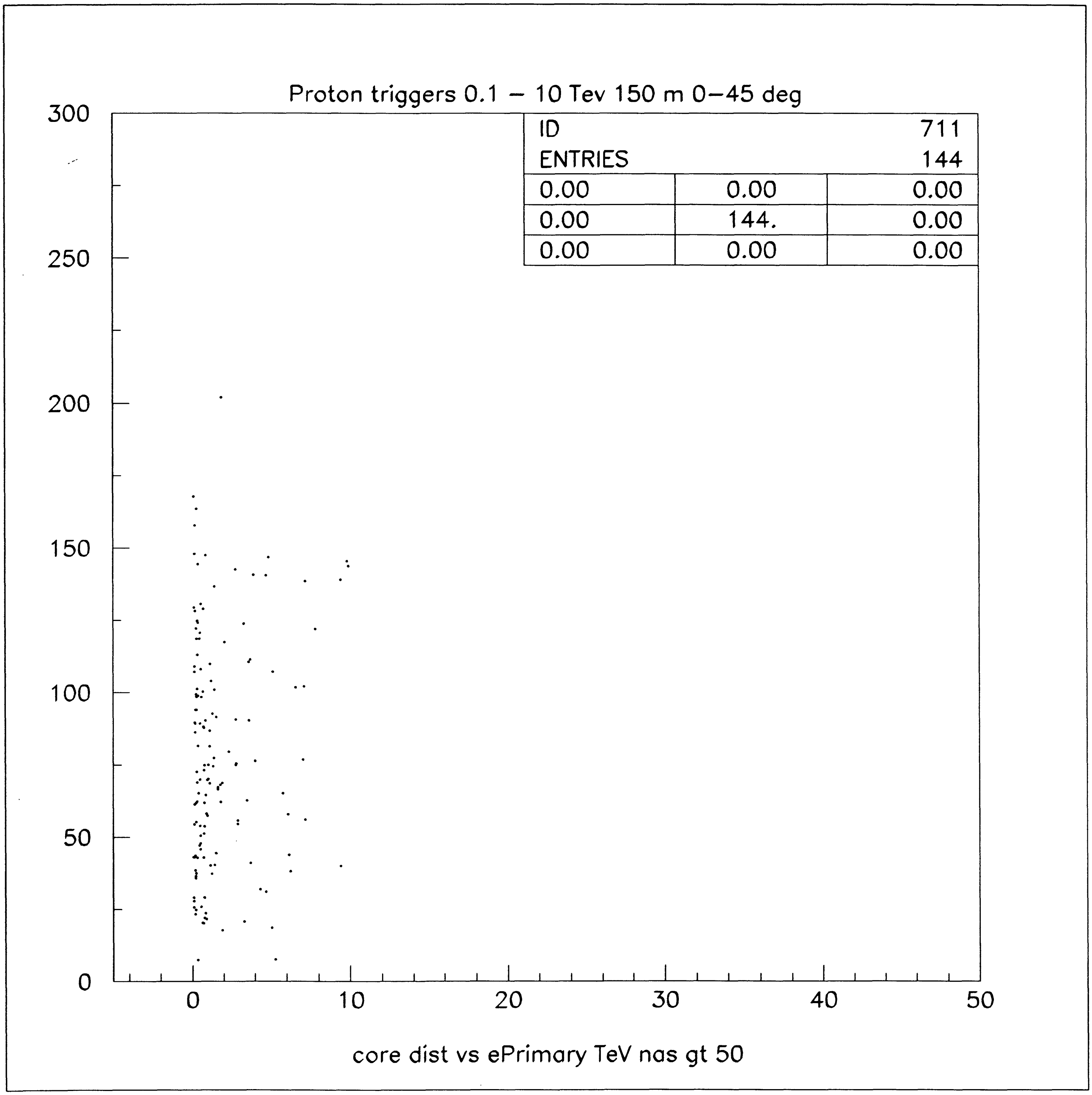

Proton triggers 0.1 – 10 Tev 150 m 0–45 deg
ID 701
Entries 144
Mean 1.793
RMS 2.266
0 5 10 15 20 25 30
0 2 4 6 8 10 12 14 16 18 20
pmt hits per particle in AS nas gt 50
ID 702
Entries 45
Mean 1.327
RMS 0.8186
0 2 4 6 8 10
0 2 4 6 8 10 12 14 16 18 20
PMThits / particle in AS no muon or had nas gt 50


Proton triggers 0.1 – 10 Tev 150 m 0–45 deg
ID 703
Entries 45
Mean 14.66
RMS 9.791
0
1
2
3
4
5
6
7
0
20
40
60
80
100
MeV/pe in AS no muon or had nas gt 50

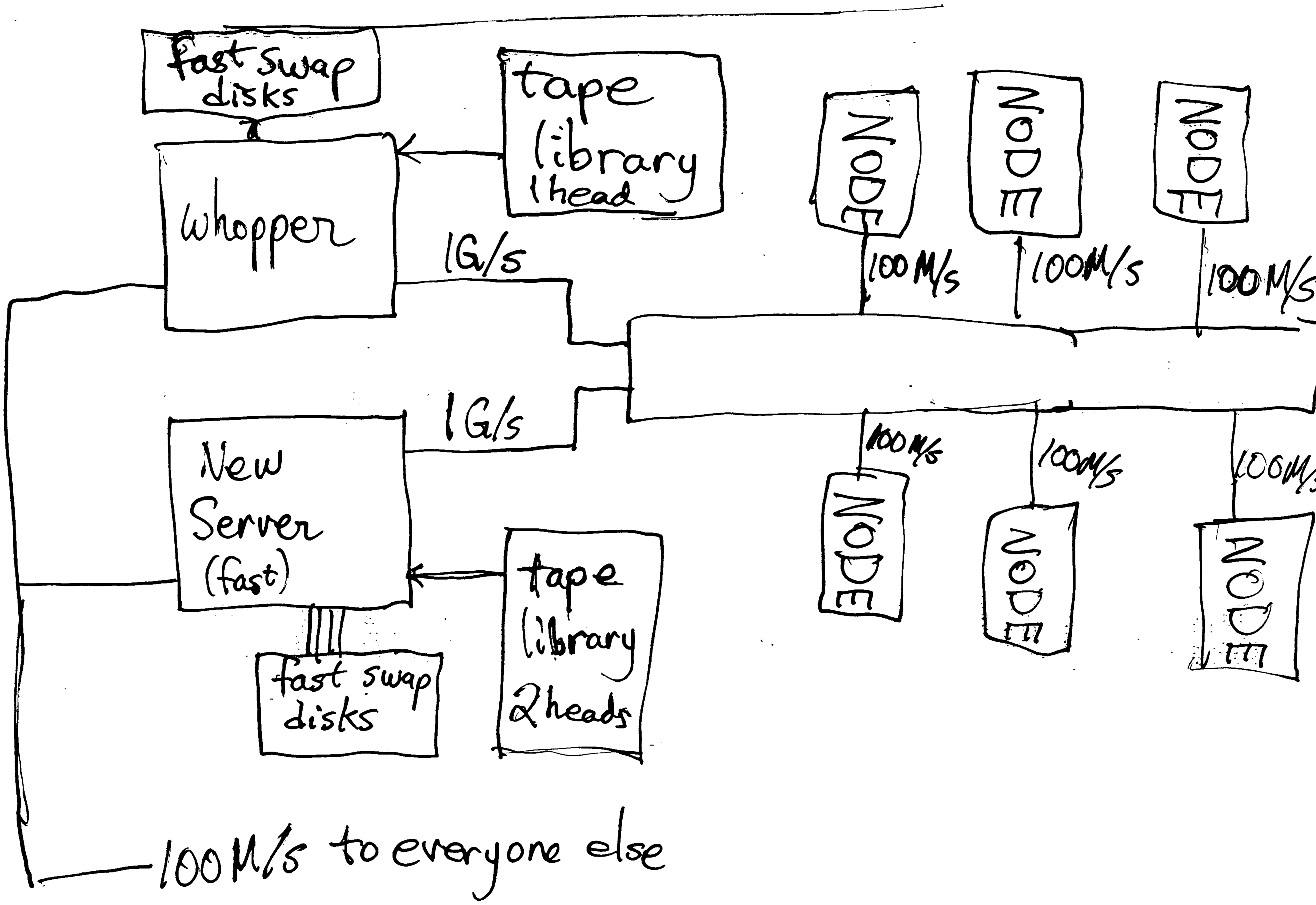


Proton triggers 0.1 – 10 Tev 150 m 0–45 deg
ID 714
Entries 3172
Mean 49.98
RMS 46.58
energy dist electrons MeV
ID 724
Entries 3172
Mean 20.95
RMS 12.39
energy dist electrons Mev


Proton triggers 0.1 – 10 Tev 150 m 0–45 deg
ID 715
Entries 11513
Mean 35.34
RMS 38.62
1200
1000
800
600
400
200
0
0 20 40 60 80 100 120 140 160 180 200
energy dist gammas Mev
ID 725
Entries 11513
Mean 18.28
RMS 11.83
400
350
300
250
200
150
100
50
0
0 5 10 15 20 25 30 35 40 45 50
energy dist gammas MeV


Proton triggers 0.1 – 10 Tev 150 m 0–45 deg
ID 711
ENTRIES 144
0.00 0.00 0.00
0.00 144. 0.00
0.00 0.00 0.00
300
250
200
150
100
50
0
0
10
20
30
40
50
core dist vs ePrimary TeV nas gt 50

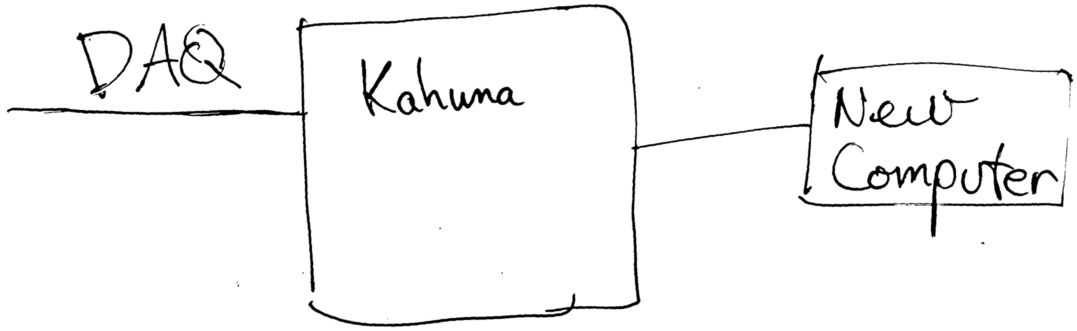
at LANL



⇒ Speedy Rereconstruction

Develop better reconstruction/analysis
& Implement it.

The Site



Online Analysis with Reconstructed Data

* Andy's Burst Search
* Regular Moon Analysis to verify data integrity.
* Your project here

Milagro & Transient Notification

- Not just good idea, SAGENAP insists
- Need to practice by notifying collaboration
- New computers at site allow several analysis to run in real time
- Need Automatically Updated Web pages with

  - Untrig burst search in ___ time intervals (Plots of # vs P, Table with α, δ, t of best few)

  - All Sky Maps for 1 day, 4 day, 2 weeks, 2 months,...

  - Moon Shadow for recent data

X-ray Afterglows from TeV GRBs

Gamma-ray bursts have been a mystery since their discovery in the early 1970's. In the last 10 years great progress has been made in furthering our understanding of GRBs. Much of this recent progress is due to the the observation of x-ray afterglows of GRBs by the BeppoSax satellite. This has allowed follow-up observations at other wavelengths, which have been crucial in determining the distance to GRBs and measuring the properties of the expanding fireball.

Here we propose to use GRBs observed in the TeV energy band with the Milagro detector to trigger up to 3 ToOs for RXTE. Milagro can localize the position of burst to better than 0.5 degrees and may see a few GRBs/year. Observation of x-ray afterglows would be confirmation of the Milagro identification. RXTE would also be able to localize the GRB to a few arcmin, allowing further observations in the optical and radio bands. These follow-up observations – the x-ray flux and decay as well the longer wavelength measurements – are critical in determining the true nature of these "TeV selected" GRBs.

Milagro: A TeV Observatory for GRBs

Milagro is a new type of TeV gamma-ray observatory. Most TeV observatories detect the Cherenkov light created by the shower of particles in the atmosphere, but this technique is not well suited to detecting rapid transients due to the field of view of a few square degrees and the requirement for dark, moonless night time observing. A large field of view and continuous observation are possible if the particles in the shower that reach the ground are detected. However, in the past this technique has had too high an energy threshold to detect TeV gamma-rays. Milagro, a large covered pond of water filled with photomultiplier tubes and located at high altitude, is an air shower detector with a threshold below a TeV. The water Cherenkov technology provides a dense sampling of the particles (electrons, positrons, and gammas) in the air shower. Milagro has a large field-of-view (~ 2 sr) and a high duty factor ($> 90\%$). For each air shower the direction of the primary particle or gamma ray is determined to ~ 0.8 degrees. In addition, Milagro measures the penetrating component of hadron induced air showers, and that information is used to reduce the large background of cosmic ray events.

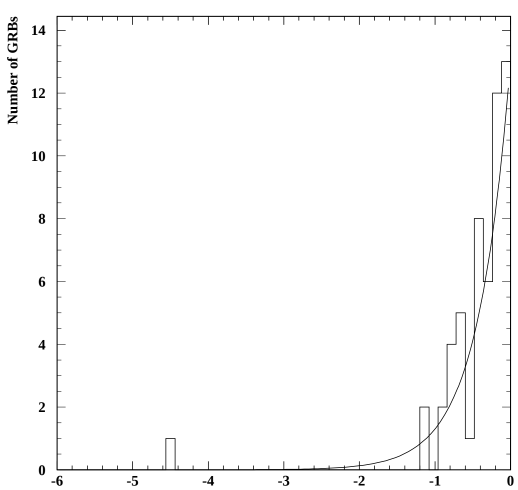


Figure 1: The probability that the observed excess at the candidate TeV position was a background fluctuation, for each of the 54 bursts. The curve indicates the expected distribution of the background. The entry at -4.5 corresponds to GRB 970417a.

The combination of high duty factor and large field-of-view make Milagro ideally suited to search for transient phenomena such as GRBs. In fact a prototype detector, Milagrito, observed evidence for a TeV counterpart to a BATSE GRB [1]. Evidence for TeV emission from GRB 970417a was obtained in a search for TeV emission from the 54 BATSE triggered GRBs within Milagrito's field-of-view during its 15 months of operation. Figure 1 shows the probability of the Milagrito observation being due to a background fluctuation for these 54 BATSE bursts. GRB 970417a, showed a large (4.2 σ) excess above background (the entry with small probability in the figure). The distribution of probabilities for the remaining 53 GRBs is in agreement with that expected from a sample drawn from background (indicated by the solid curve).

If the observed excess of events in Milagrito was indeed associated with GRB 970417a, then it represents the highest energy photons ever detected from a GRB. The energies of these photons must have extended up to at least 700 GeV. The TeV fluence implied by this observation depends on the energy spectrum and upper energy cutoff of the emission, both of which were difficult to determine from

Milagrito data. However, regardless of the spectral shape, the luminosity of this burst at TeV energies must have been brighter than that at sub-MeV energies.

Milagro has improved sensitivity over Milagrito. First, the energy threshold is reduced (yielding a trigger rate $\sim$ 5 times greater than that in Milagrito) which allows one to view a larger volume of space. Second, the imaging capabilities of the bottom layer of PMTs allows us to determine the nature (gamma ray or hadronic particle) of the primary particles. This improved sensitivity will allow Milagro to search for GRBs of similar TeV flux to GRB970417a even without trigger from BATSE. While a few bursts identified by satellites will still be in Milagro's field of view, we will rely solely on the Milagro data to identify "untriggered" potential GRBs.

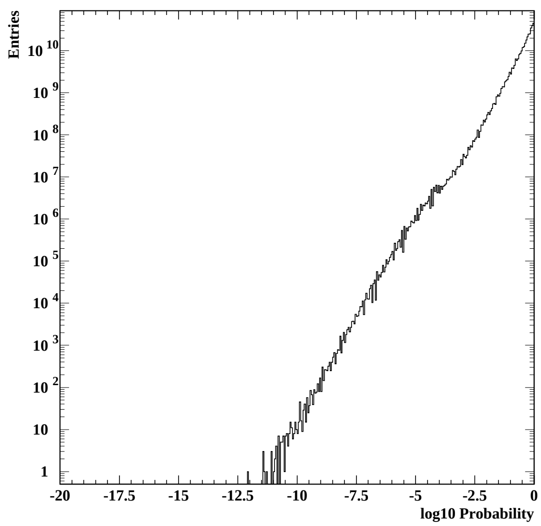


Figure 2: A search of all directions and 10 sec time intervals for the first 6 months of Milagro data.

A preliminary search for GRBs in the first 6 months of Milagro data has been performed. In this search 27 durations were searched from $250\mu s$ to $40s$. Figure 2 is a plot of the probability distribution for the search for GRBs with a 10s duration. The plot shows no evidence of a burst signal. If a GRB identical to 970417a was observed by Milagro 90 events would be detected over an expected background of 17.5 or yielding a probability of $1.5x10^{-34}$. Such a signal is clearly distinguishable from the background even in the absence of a coincidence with the BATSE detector or another experiment. Additionally, Milagro will be able to distinguish gamma and proton induced showers by both muon identification and pattern recognition, further reducing the background (and producing a positive identification of the primary particle) with only a minimal reduction in the signal.

While such a detection would be statistically significant, since it would be the first ever "TeV selected" GRB one will not know how or if it is related to other GRBs. An XTE ToO will help solve this problem. More than 90% of all GRBs have x-ray afterglows, and XTE is sensitive enough to observe them if the observation begins within a few hours [2]. Observing such an afterglow would give confidence that the Milagro detection was truly a GRB, and would also allow this GRB to placed in the context of other GRBs with measured x-ray afterglows. Also, with an RXTE scan around the Milagro position, a better position can be determined so that optical and radio observations can be performed.

The exact number of GRBs Milagro will detect is difficult to determine. EGRET has detected GRBs up to 20 GeV [3] and many GRB models predict emission of TeV gamma rays from the source. However, absorption of TeV photons via interactions with the intergalactic infrared radiation (IGIR) field will limit the distance at which a GRB will be visible to a TeV telescope. While the spectrum of the IGIR has not been measured, current models [4, 5], predict that the gamma-ray horizon of Milagro is at z$\sim$ 0.2. Using the distance distribution to GRBs of Schmidt [6] one would expect to observe 0.3 GRBs/year in Milagro. Using the distance distribution given by Dermer [7] one expects to observe roughly 10 times more GRBs in Milagro. This assumes that Milagro is sensitive enough to detect the TeV emission. Milagro's sensitivity is nearly the same as BATSE's in units of $ergs/cm^2$. If the spectral energy distribution is flat, Milagro will be able to detect essentially all of the nearby GRBs that BATSE would have detected. These nearby GRBs are an interesting subset of GRBs–for example, evidence of supernova charactistics should be observable in the optical light curve.

Technical Feasability

The raw data from the Milagro detector consists of the measurements of the relative arrival times and pulse heights in each of the 723 PMTs. This data is processed in real time on a 10-CPU SGI Power Challenge. An event is processed within roughly 0.1 seconds after it triggers the pond. The direction of the event is determined to ~ 0.8 degree accuracy. The reconstructed information is written to disk for later analysis. This detector has been operational since January 2000 recording data at over 1000 air showers each second. The Milagro collaboration is currently constructing a farm of computers to perform the physics analysis to seach for sources in real-time. The algorithms described below have been tested on archival data and are fast and robust enough to allow Milagro to generate alerts when an interesting phenomenon is observed.

Since the response of the detector depends only on local coordinates (zenith angle and azimuth, or hour angle and declination), one can form an efficiency map for the detector in local coordinates. This map is then integrated over the source transit (using the actual event times as the integration grid) to arrive at an expected number of background events for each bin in the sky. This technique ensures that any global fluctuations in the event rate of the detector (due to changing atmospheric conditions) are properly accounted for. In practice the map of the detector efficiency is made using 2 hours of data taken just prior to the interval in question. This ensures that the statistical uncertainty in the background estimate is negligibly small and that any systematic effects due to a changing instrument response over time are minimized.

We have developed efficient algorithms that will enable us to simultaneously search the entire sky over 10 timescales (covering 1 second to 128 seconds) with the planned computer cluster. This cluster will be operational by February 2001. Given the number of searches performed the chance probability of an observation will be set below $\sim 10^{-14}$ to ensure that the false alarm rate will be below 0.1/year. Milagro will also search for TeV emission from satellite-detected GRBs, which due to the known direction and time interval have a higher probability threshold to prevent false detections. When a TeV GRB candidate is found an alert will be sent to the Milagro scientist who is on shift and carries a pager. The scientist will ensure that the detector was operating properly during the time period of interest, run an additional analysis to verify and localize the burst. The burst coordinates will be sent to RXTE and the GCN, the email network used by all gamma-ray burst multiwavelength observers, in < 1 hour of the GRB.

RXTE's observation will follow the procedure which has been developed to observe afterglow from GRBs identified by satellites, i.e. BATSE, SAX, HETE. Frank Marshall, a coinvestigator on this project and an XTE scientist at GSFC, will insure that the appropriate commands are given to the satellite as soon as possible. The Milagro localization of < 0.5 degrees (95% confidence) is sufficient to point the satellite, but a scan of the position will be necessary to improve the localization for optical and radio observers. RXTE has been able to make these observations within 2-3 hours of a GRB notification in the past and with the assistance of Frank Marshall should be able to continue this procedure.

The x-ray flux measured by SAX for 6 GRBs is shown in Figure 3 [2]. Variations in flux by an order of magnitude are observed and are not correlated with the gamma-ray intensity. However, BATSE had a much larger direction error, and 3 bursts were detected by RXTE [8][9]. Based on these measurements, an RXTE ToO will be requested if the observation is possible within 5 hours of the GRB detection.

The afterglow of the x-ray flux is also interesting. The multiwavelength afterglow spectrum has been used successfully to constrain the physics of expanding fireball[10]. Three subsequent observations are requested. These should take place over the next few days because past GRB observations show a rapid power law decay. The timing of these observations is less critical. However, if no emission is detected in the first and second observation, the third and fourth will not be requested.

The expected number of ToO requests is a few per year. Given that RXTE is only capable of ToOs from 8am-midnight and that only one of the two antenna are operational, approximately half the requests will not be able to be observed. Therefore, a maximum of 3 ToOs are proposed.

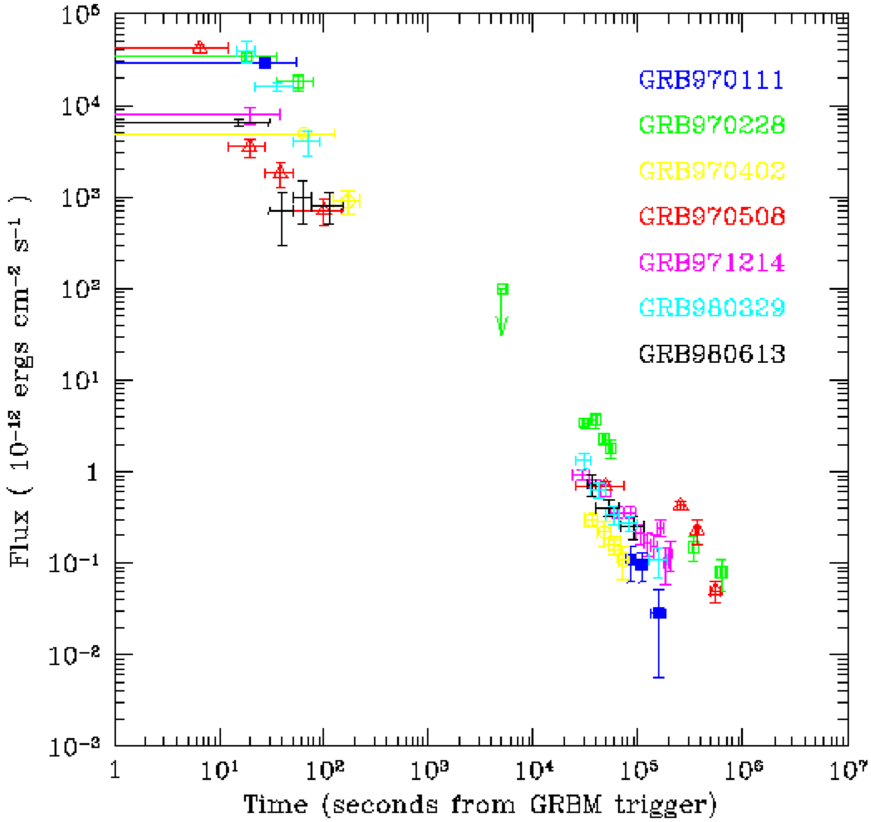


Figure 3: X-ray flux decay of 6 GRBs as observed by BeppoSAX.[2]

References

[1] Atkins, R., *et al.*, ApJ Lett, **533**, 119, 2000.

[2] Costa, E. for the BeppoSAX team, A & A Supp, **138**, 425, 1999

[3] Hurley, K., *et al.*, Nature, **372**, 652, 1994

[4] Primack, J.R., Bullock, J.S., Sommerville, R.S., MacMinn, D., Astropart. Ph. **11** 93, 1999

[5] Stecker, F.W. & deJager, O.C. A & A Lett, **334**, L85, 1998

[6] Schmidt, M., ApJ Lett, **523** 117, 1999

[7] Bottcher, M. & Dermer, C.D. ApJ **529** 635, 2000

[8] Marshall, F. E. *et al.*, Nuc. Phys. B (Proc. Suppl.) **69** 640 1998.

[9] Takeshmia, T. *et al.*, presented at Rossi 2000: Astrophysics with RXTE

[10] Sari, R., Piran, T., Narayan, R. ApJ Lett, **497** 17, 1998

Offline v. 50

Structural Changes to Code

- Use Pointers to Functions instead of switches
- Initialize Calibration Data Arrays Outside Calibrai Routines
- Read gzipped data

Functional Changes to Code

- Add Greg's Core Finder
- Add "Hit Cleaning"
- Add more muon gamma/hadron separation
- Abandon MCASCII & MCASCII2
- Default curvature is 0.07 ns/m
- Single Hadron Selection

DelCA

⇒ deleo/2 is **not** our angular resolution

want some "deleo-like" function that can be combined with deleo to better represent our angular resolution

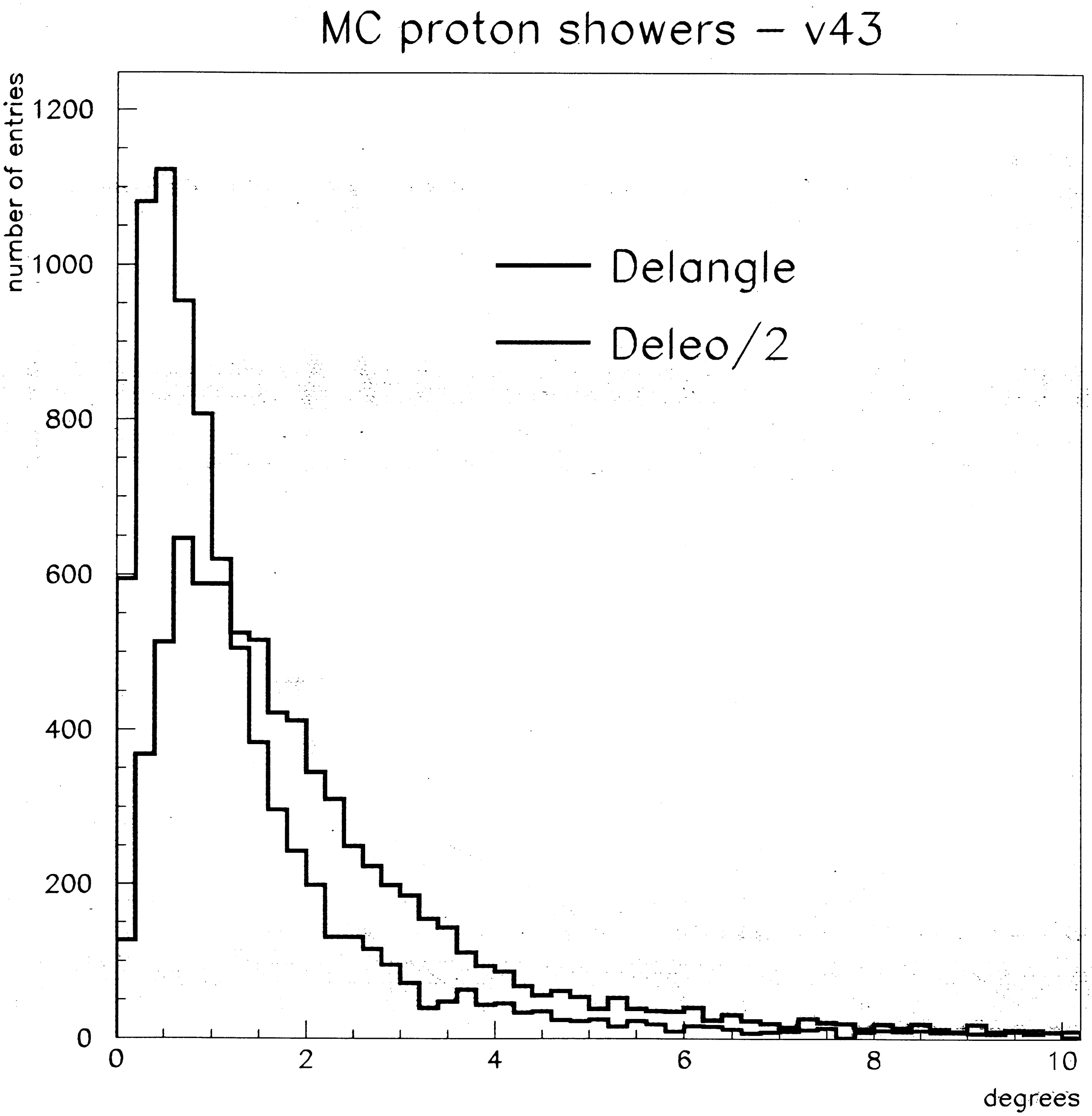
Side benefits:

delCA is sensitive to curvature

- get curvature from data
- possible core fitter

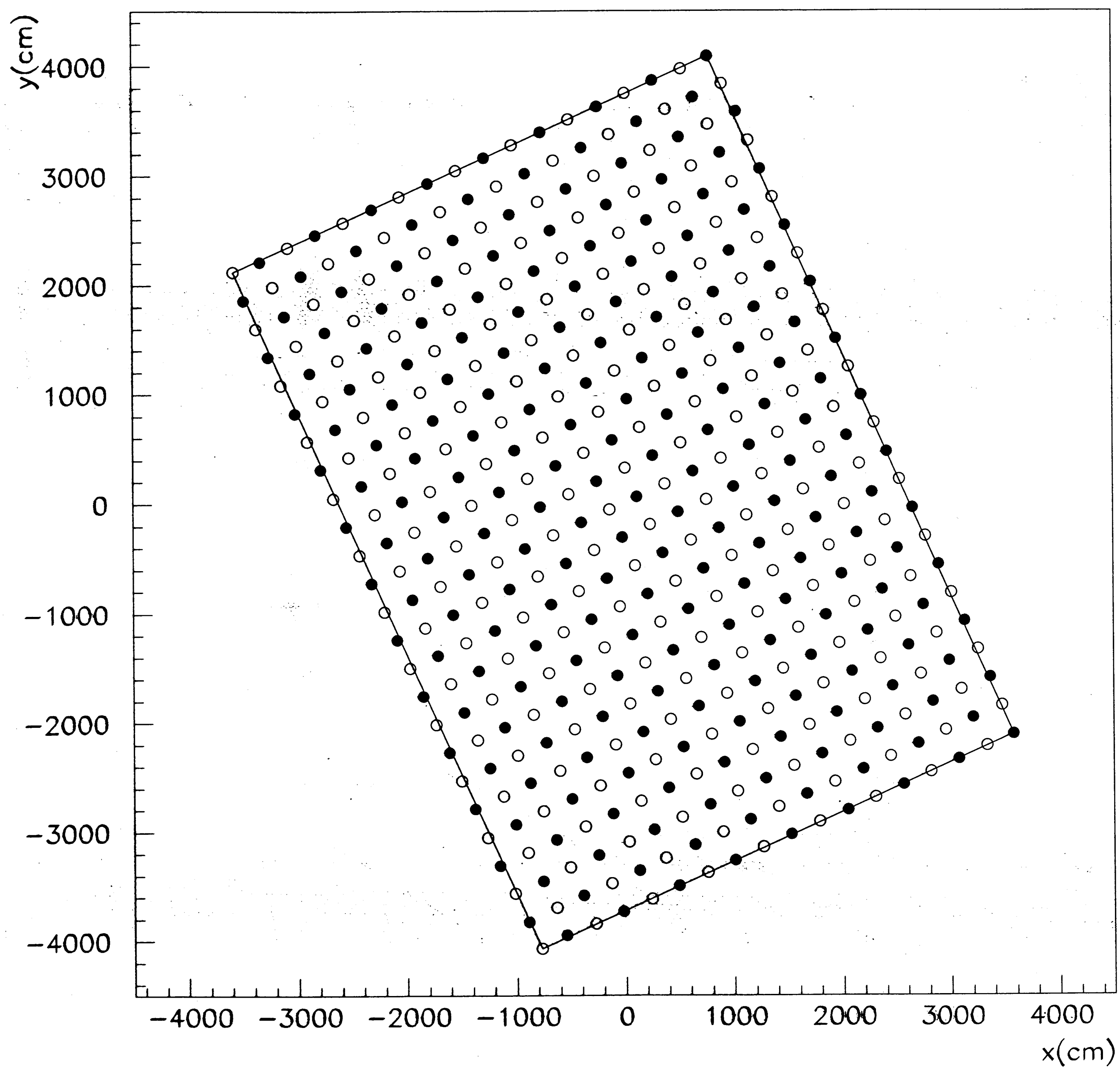
Results using Milagro MC:

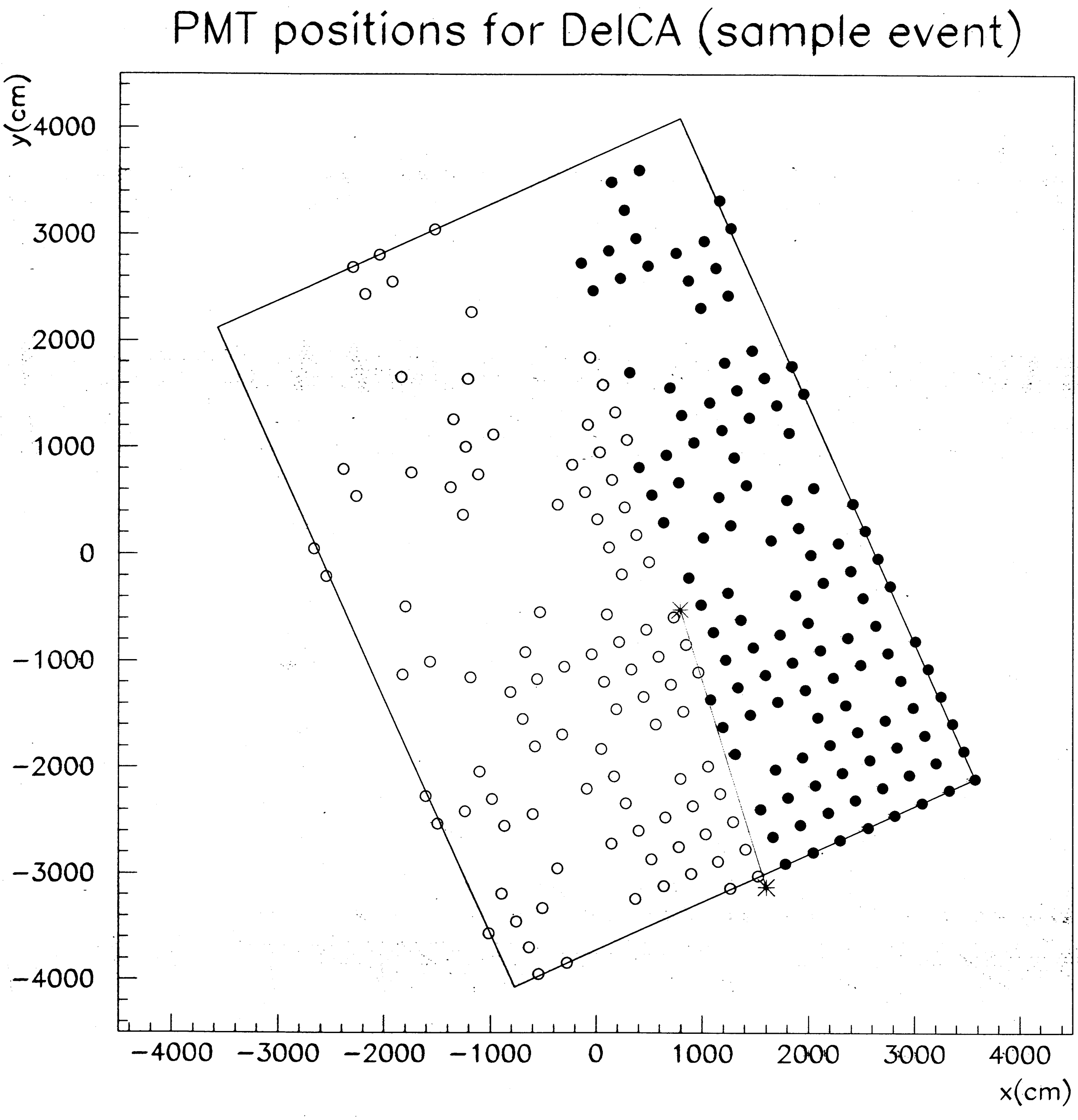
v43 offline
v22 MC

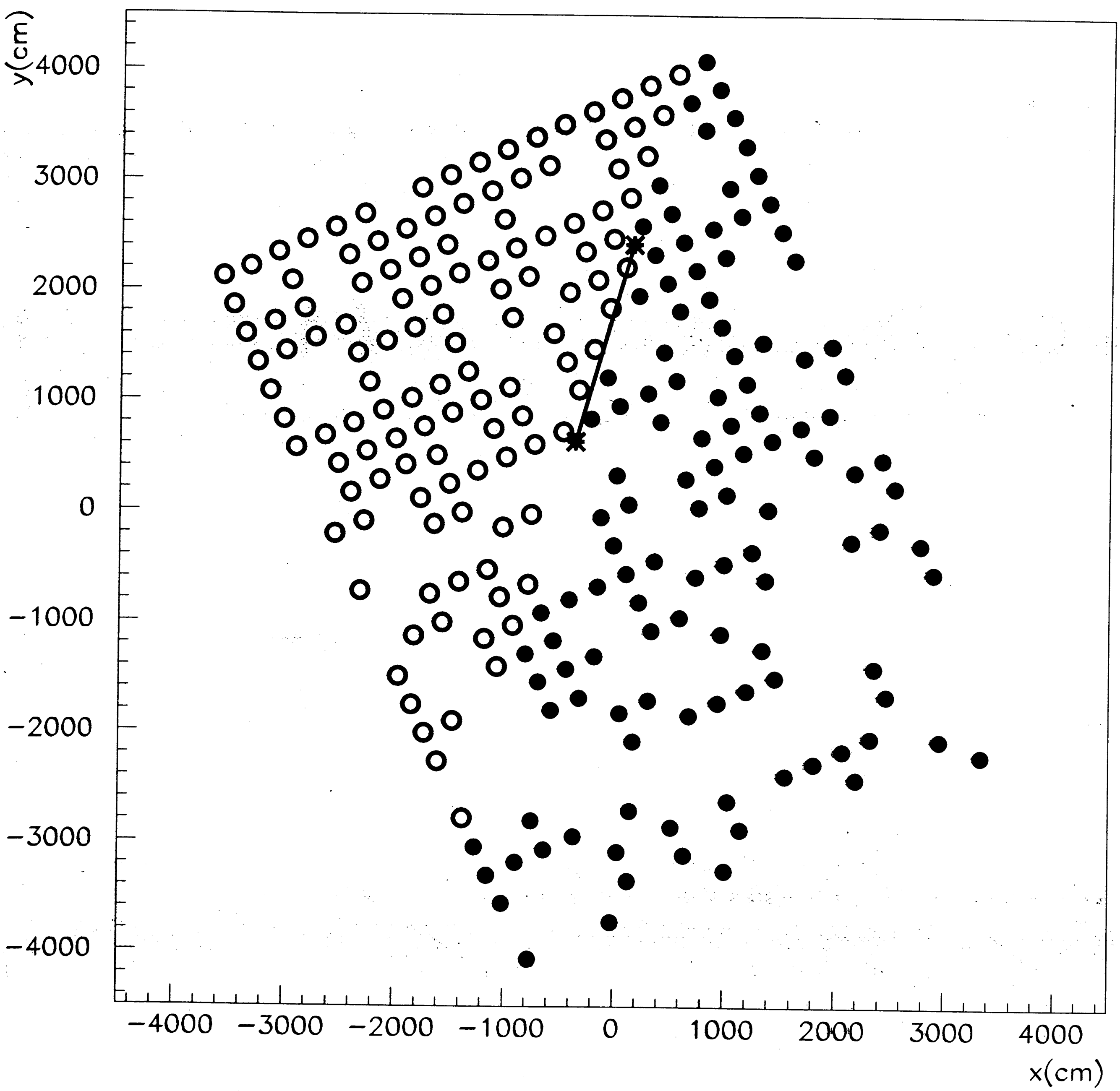


MC proton showers – v43
number of entries
1200
1000
800
600
400
200
0
0
2
4
6
8
10
degrees
Delangle
Deleo/2

PMT positions for Deleo

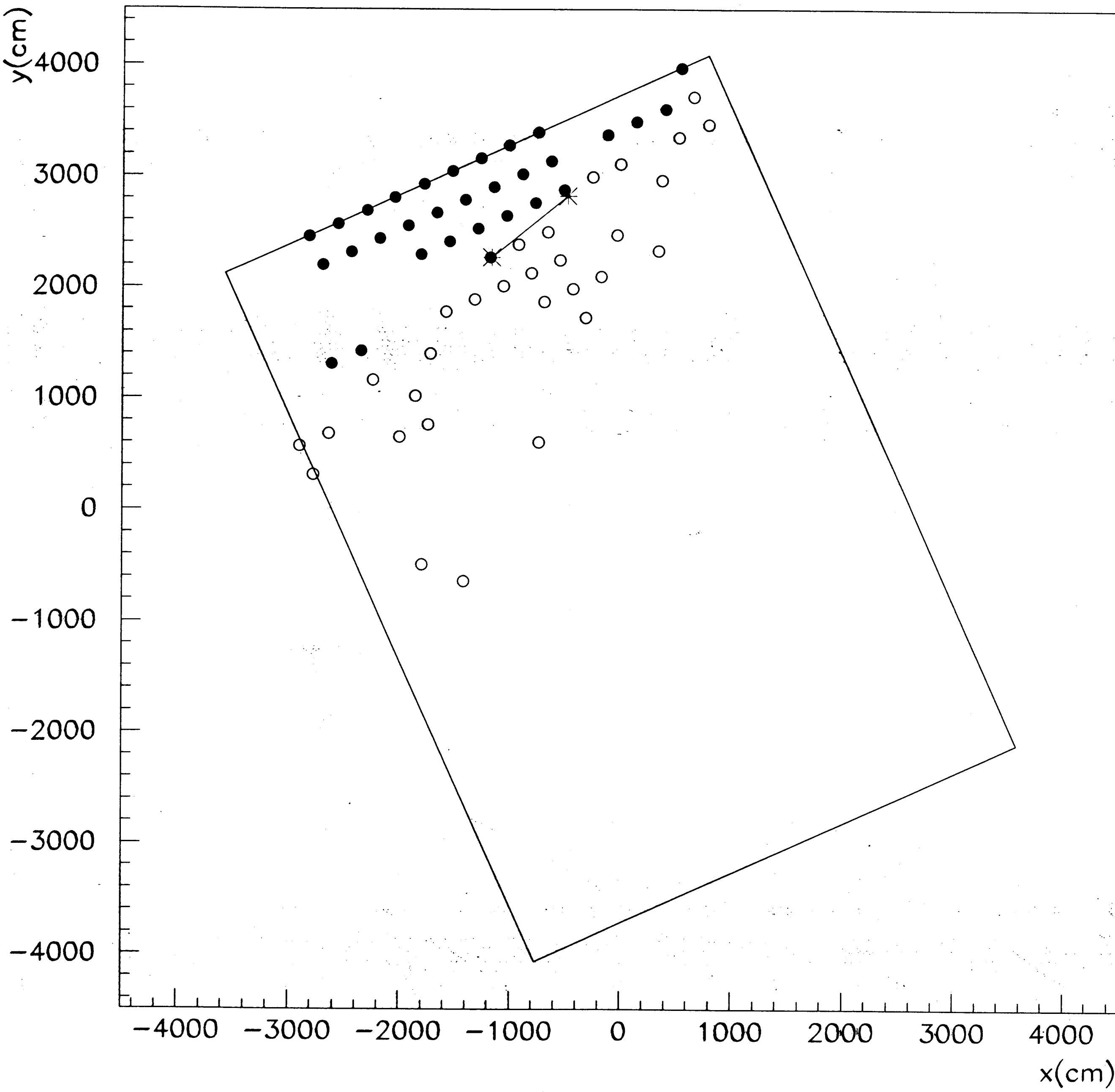


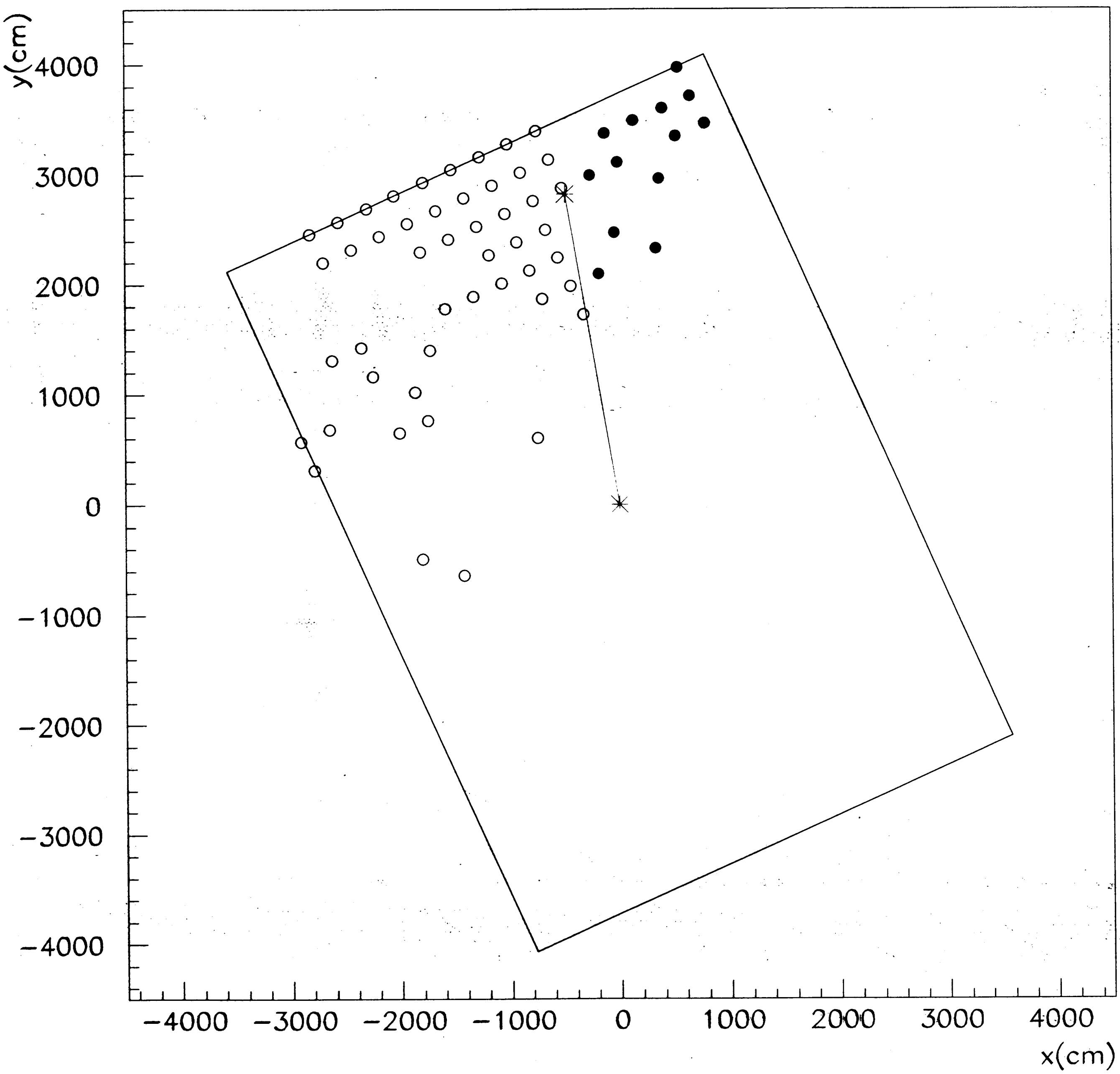

PMT positions for DelCA (sample event)
y(cm)
4000
3000
2000
1000
0
−1000
−2000
−3000
−4000
−4000 −3000 −2000 −1000 0 1000 2000 3000 4000
x(cm)



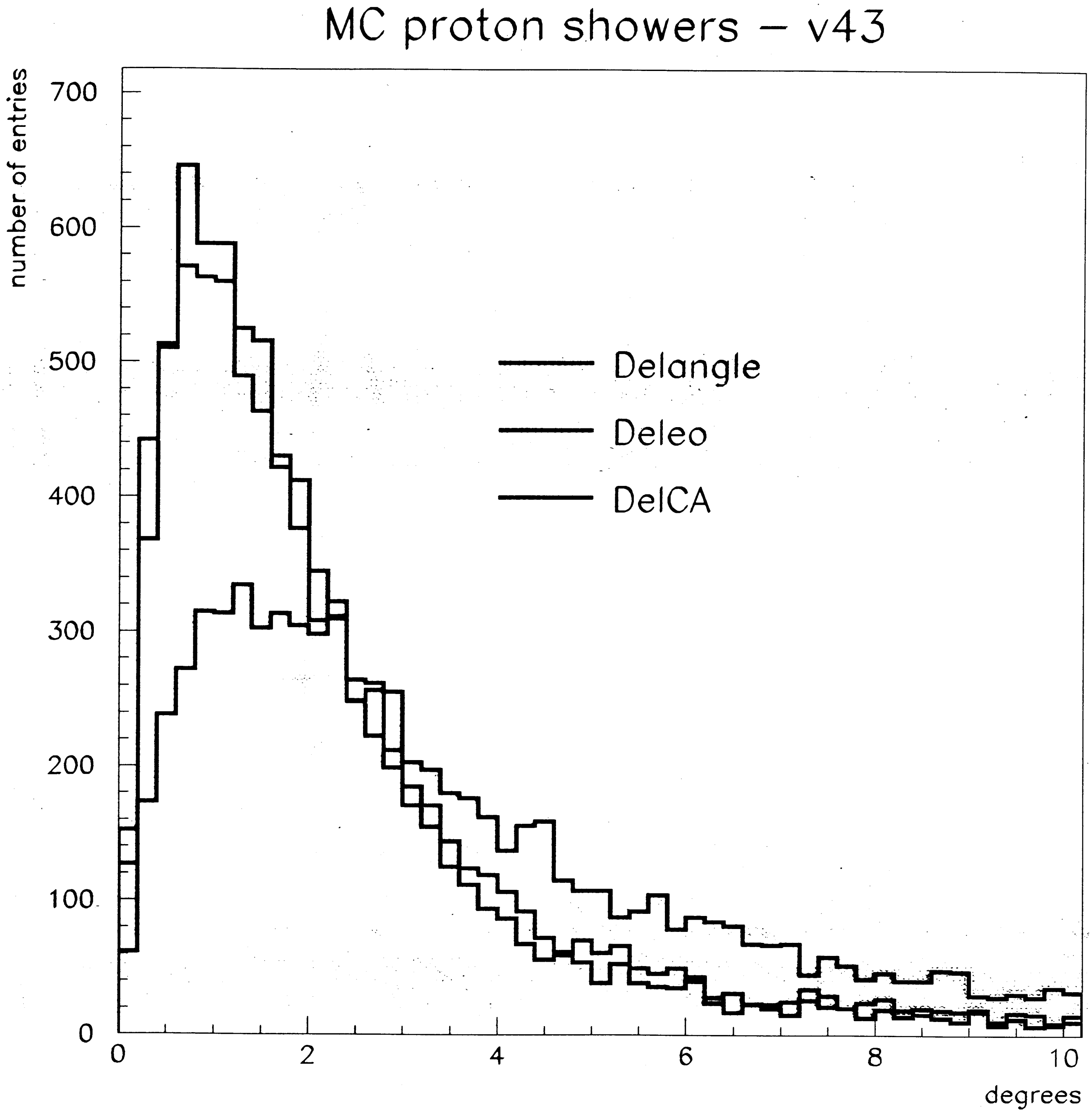
y(cm)
4000
3000
2000
1000
0
−1000
−2000
−3000
−4000
−4000 −3000 −2000 −1000 0 1000 2000 3000 4000
x(cm)

PMT positions for DelCA (sample event)

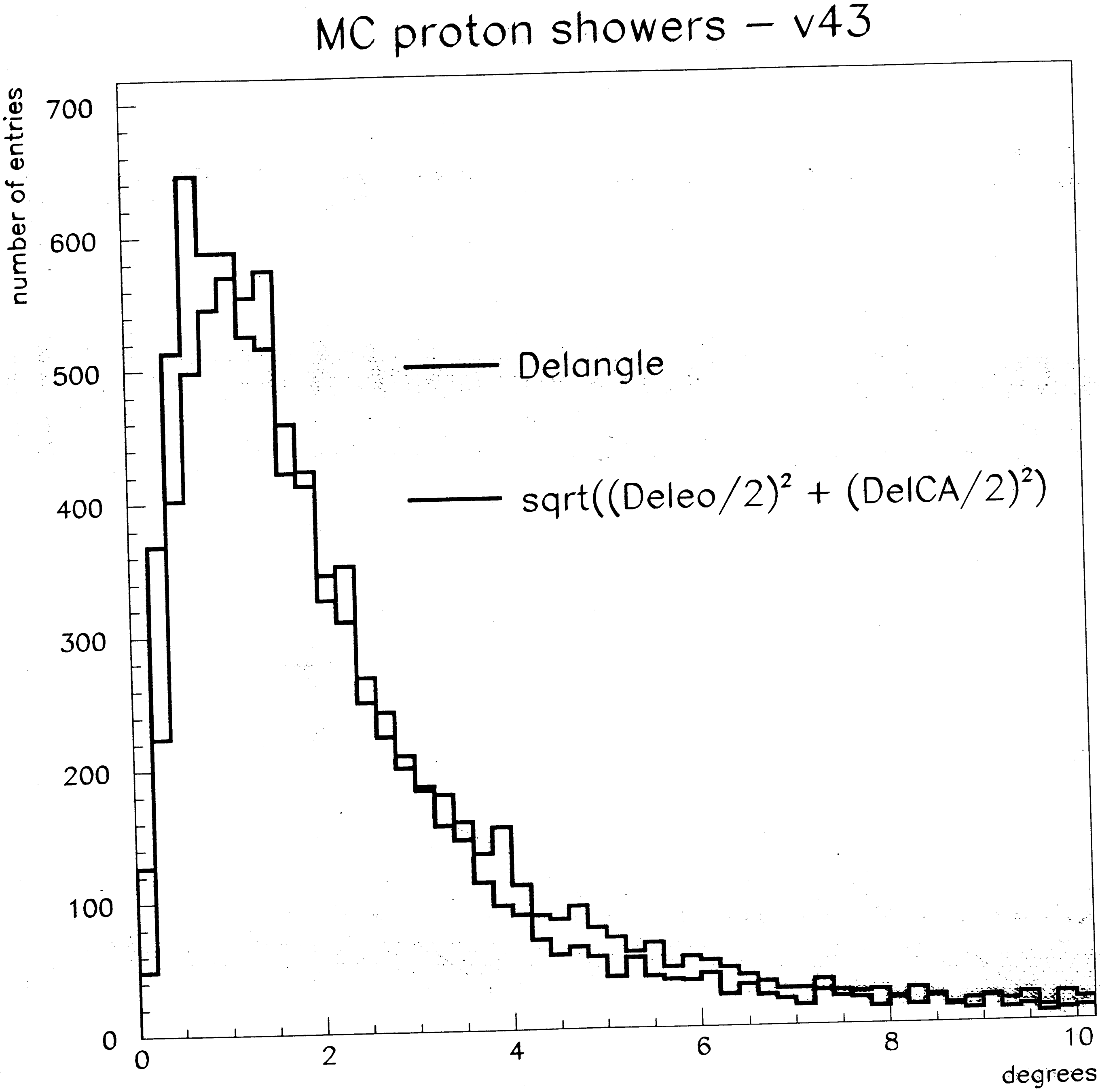




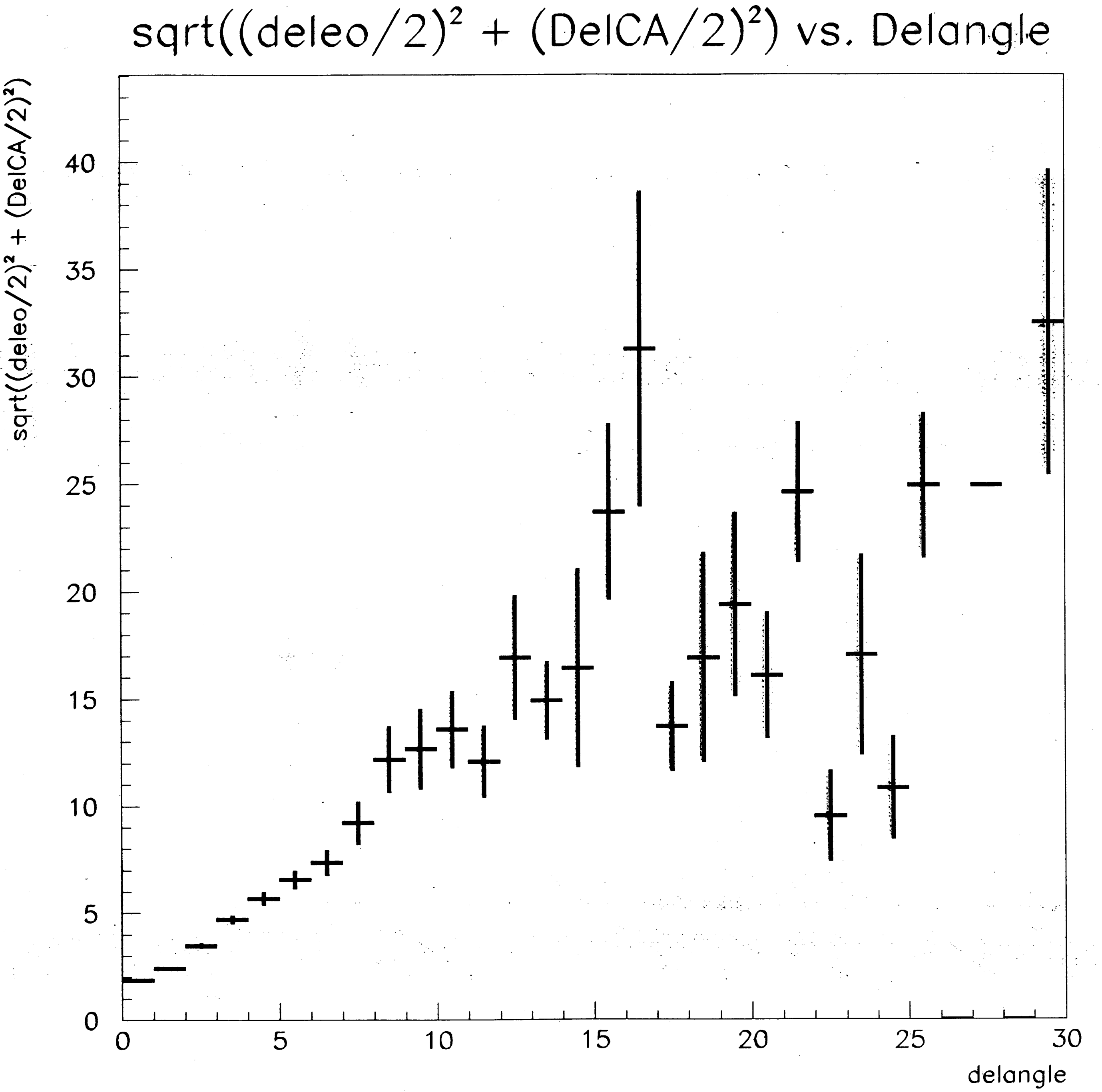
y(cm)
4000
3000
2000
1000
0
−1000
−2000
−3000
−4000
−4000
−3000
−2000
−1000
0
1000
2000
3000
4000
x(cm)



MC proton showers – v43
number of entries
700
600
500
400
300
200
100
0
0
2
4
6
8
10
degrees
Delangle
Deleo
DelCA

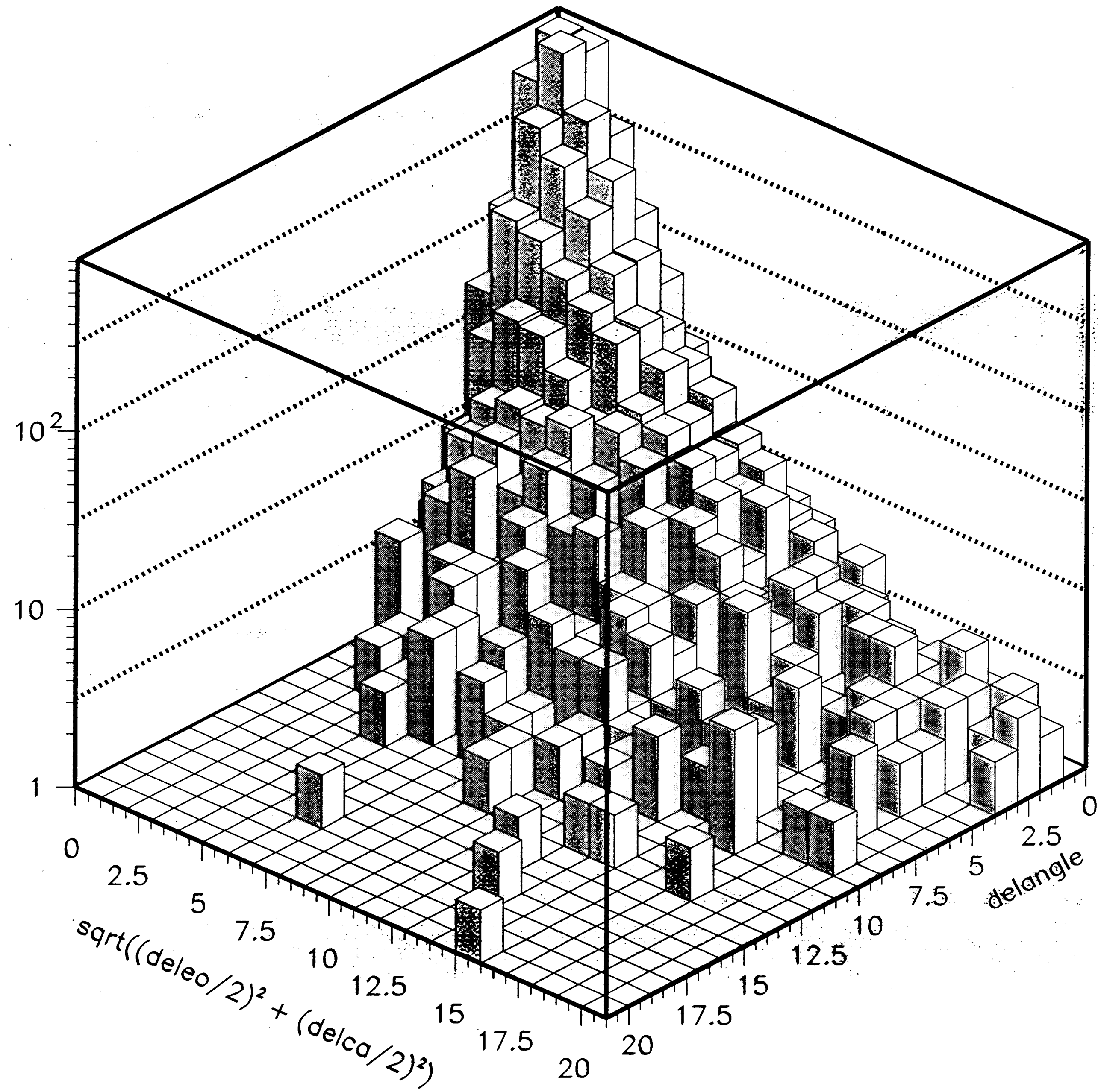


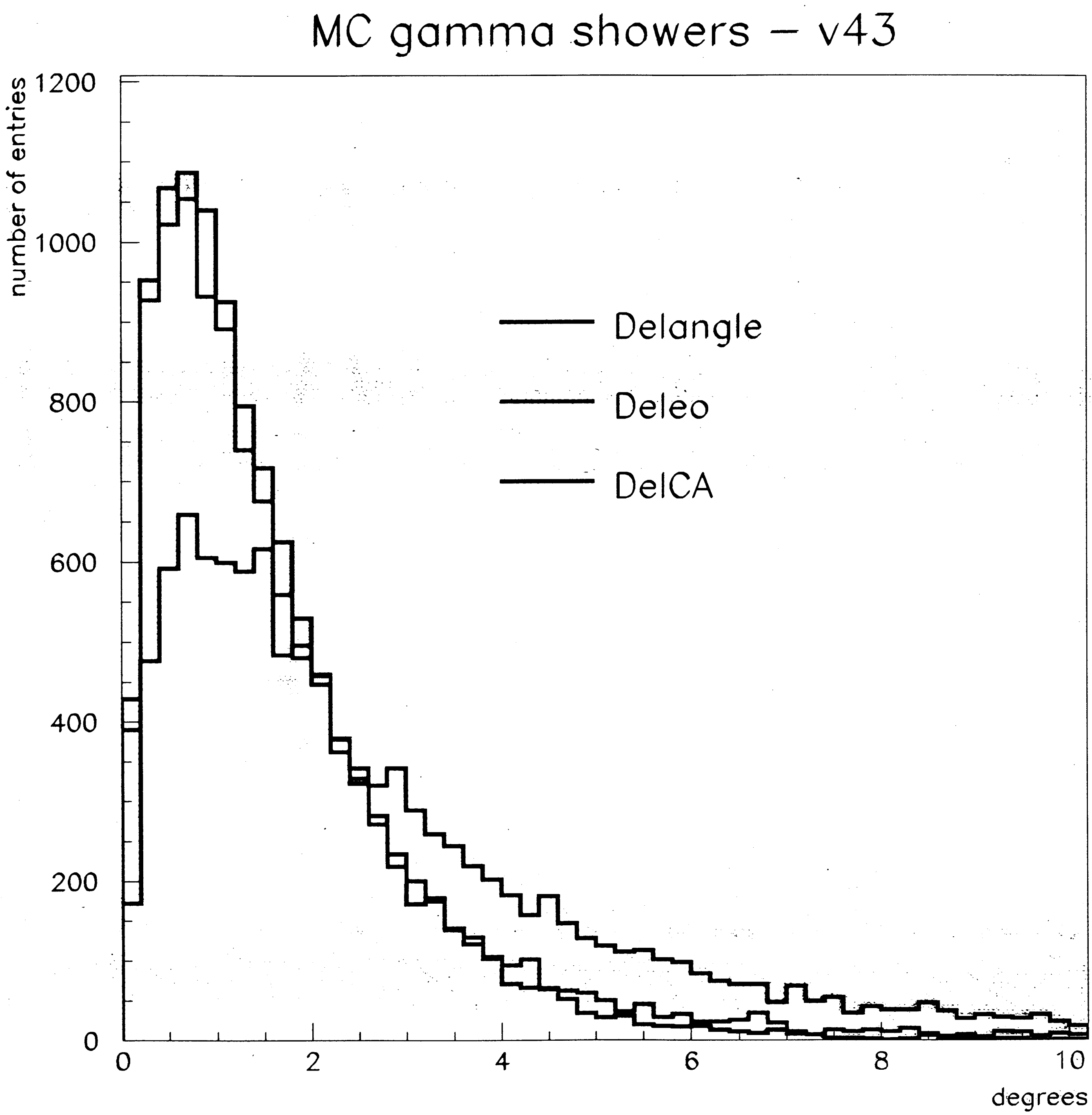
MC proton showers – v43
number of entries
700
600
500
400
300
200
100
0
0
2
4
6
8
10
degrees
Delangle
sqrt((Deleo/2)² + (DelCA/2)²)



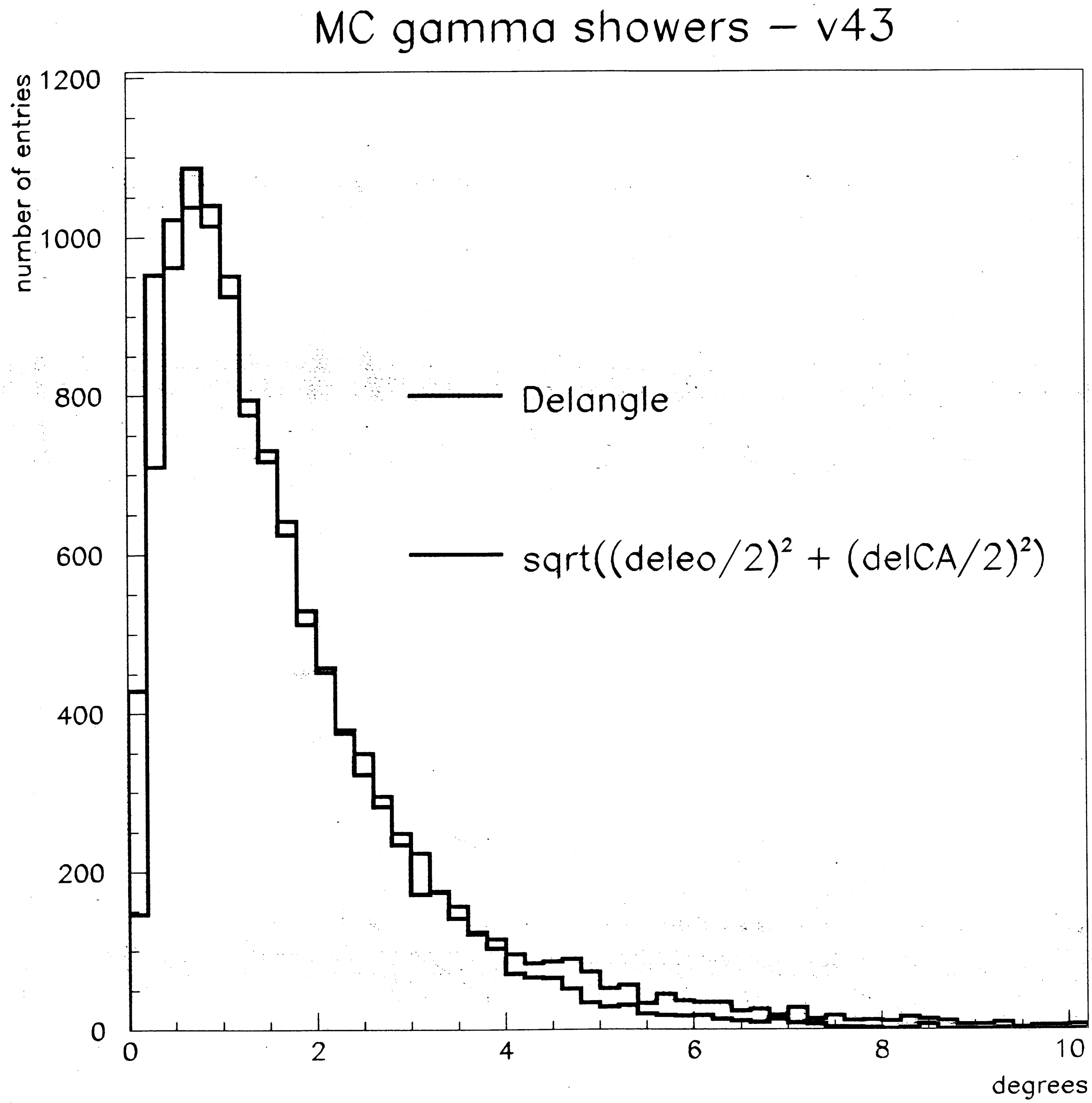
sqrt((deleo/2)² + (DelCA/2)²) vs. Delangle
sqrt((deleo/2)² + (DelCA/2)²)
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
delangle

sqrt((deleo/2)² + (delca/2)²) vs. delangle



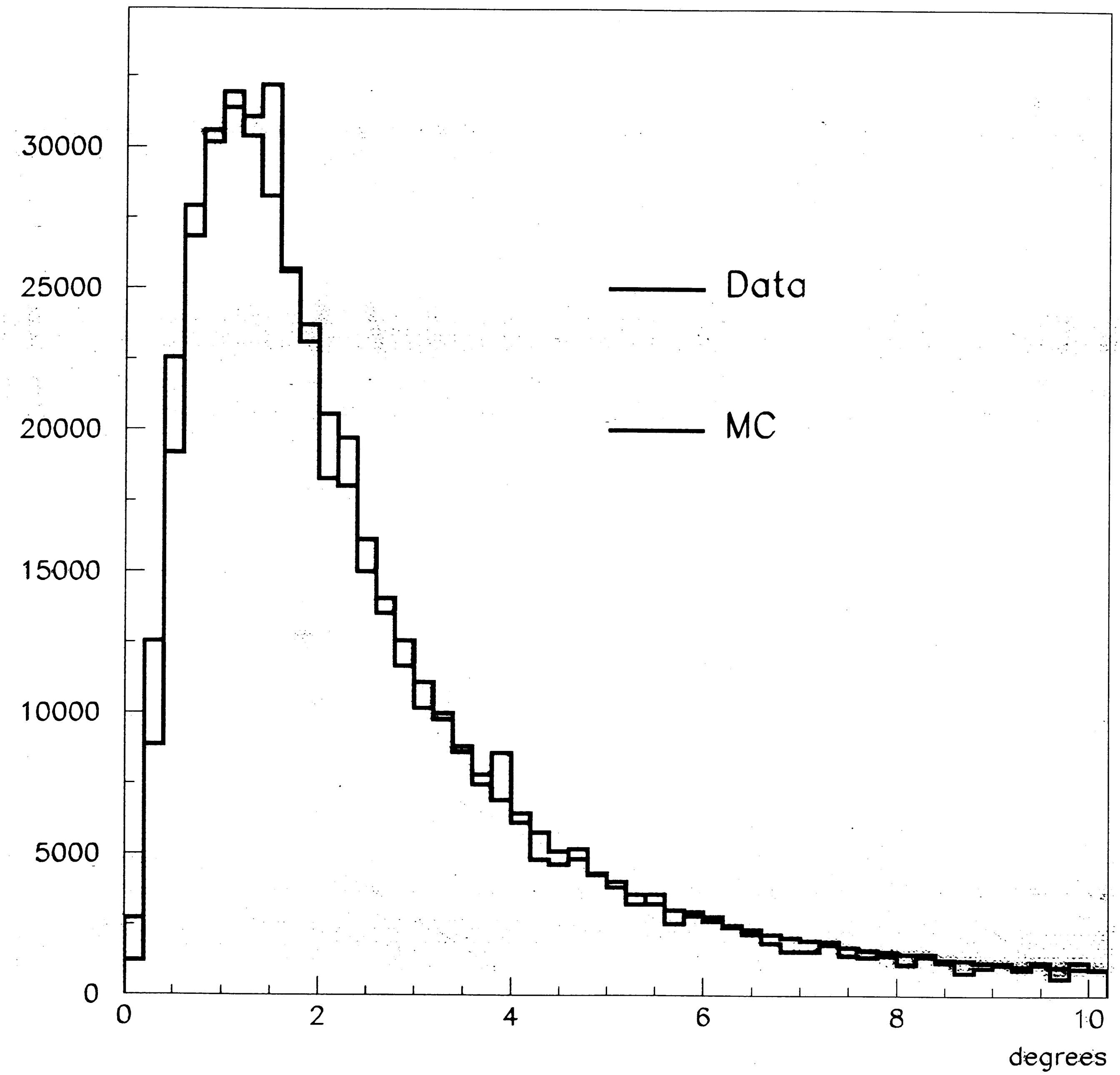


MC gamma showers – v43
number of entries
1200
1000
800
600
400
200
0
0
2
4
6
8
10
degrees
Delangle
Deleo
DelCA



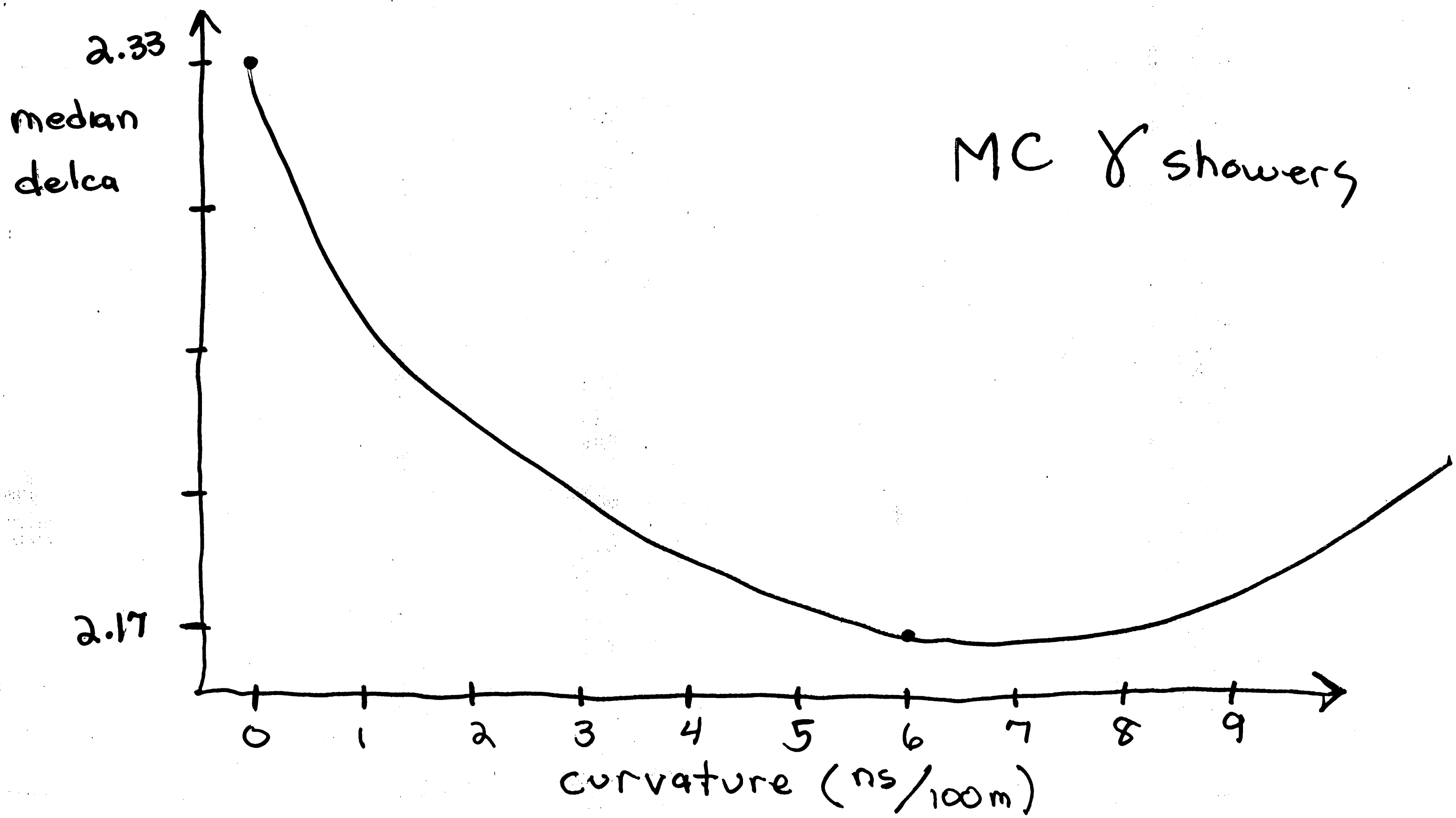
MC gamma showers – v43
number of entries
1200
1000
800
600
400
200
0
Delangle
sqrt((deleo/2)² + (delCA/2)²)
0
2
4
6
8
10
degrees

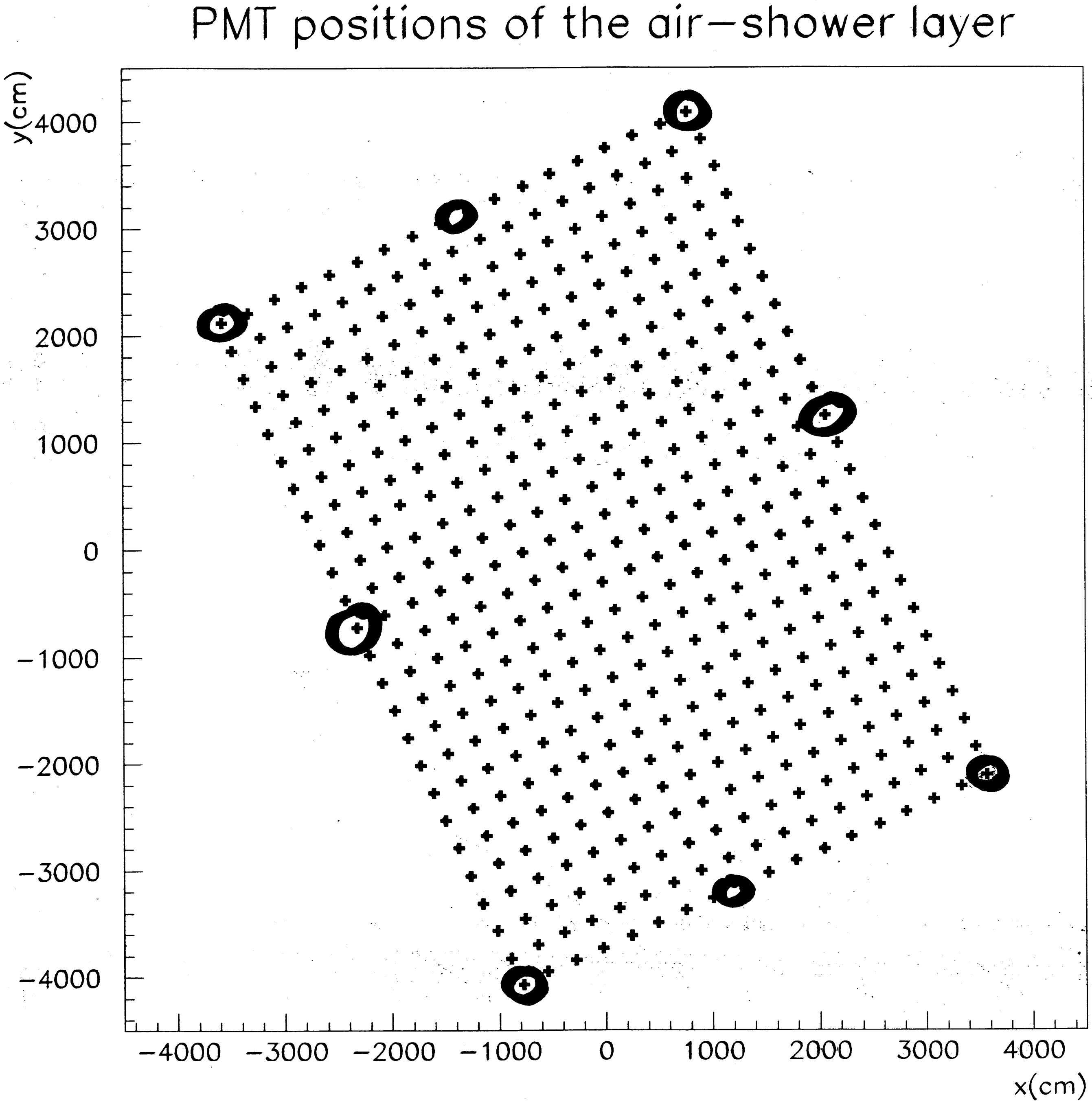
Deleo DelCA combo for data and MC



delCA is sensitive to curvature!

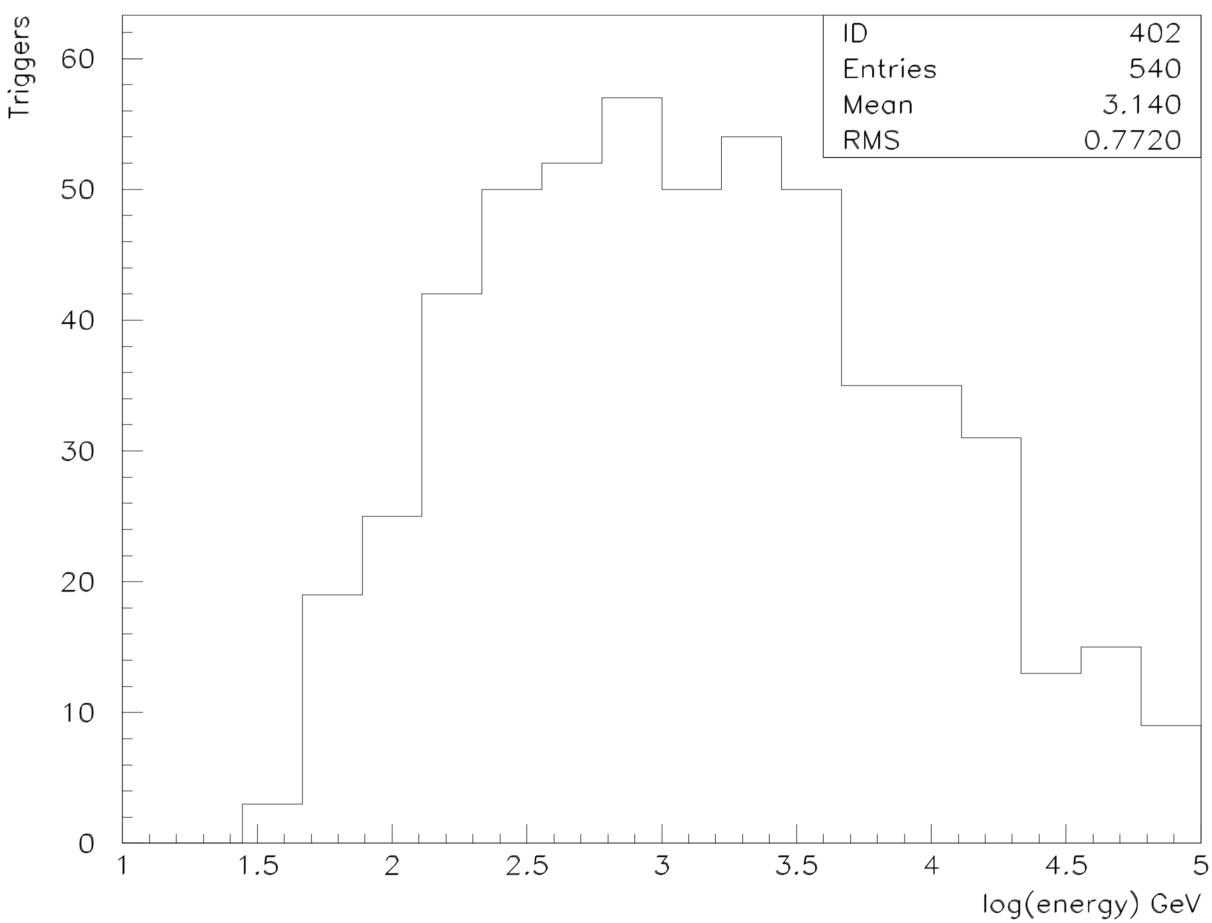
- get curvature from data
- core fitter




PMT positions of the air-shower layer
y(cm)
4000
3000
2000
1000
0
−1000
−2000
−3000
−4000
−4000
−3000
−2000
−1000
0
1000
2000
3000
4000
x(cm)

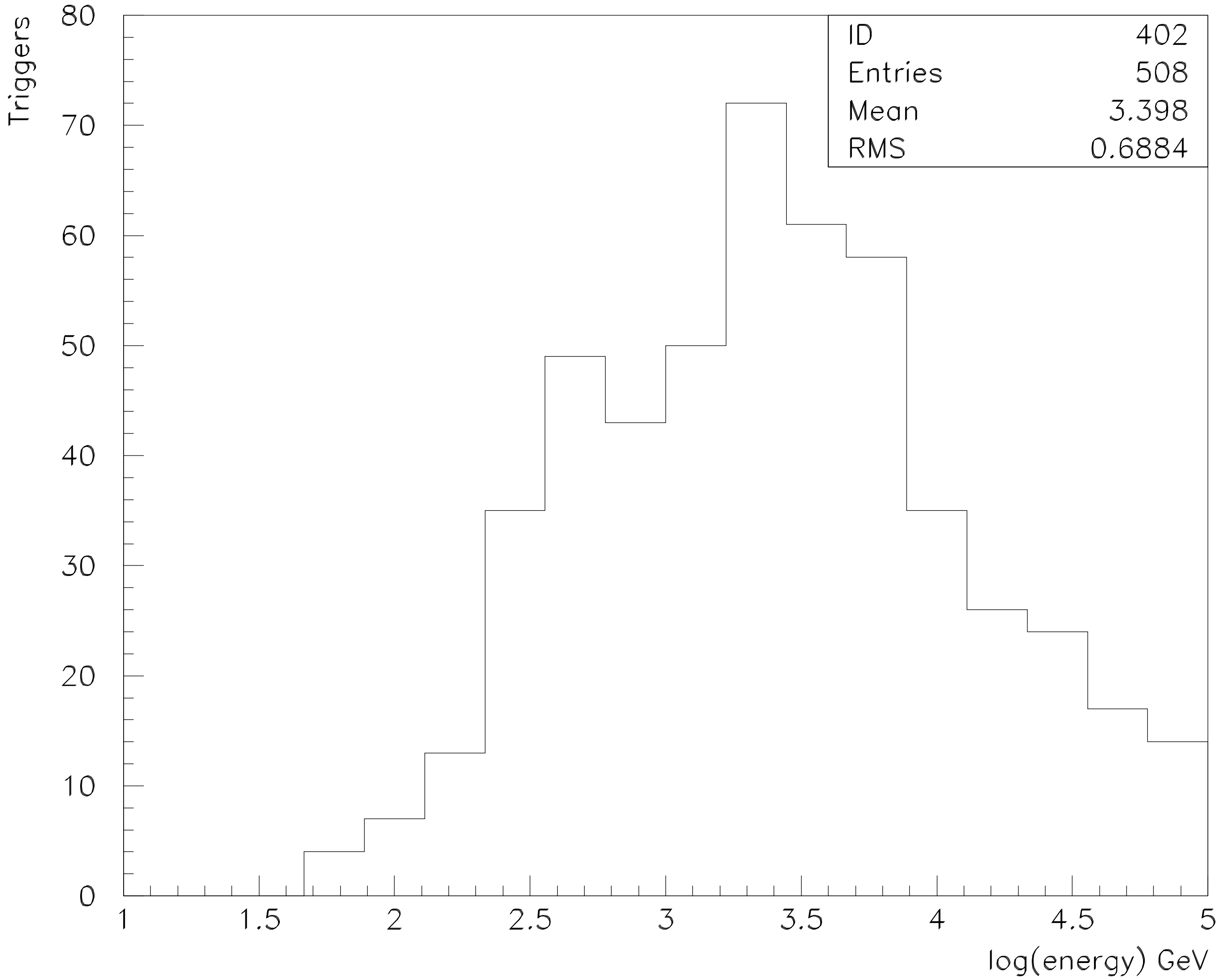
Proton Simulations

- 1.3 x 10^8 throws between 10 GeV and 100 TeV
- ~500 triggers above 65 tubes
- Includes layer of air between cover and water



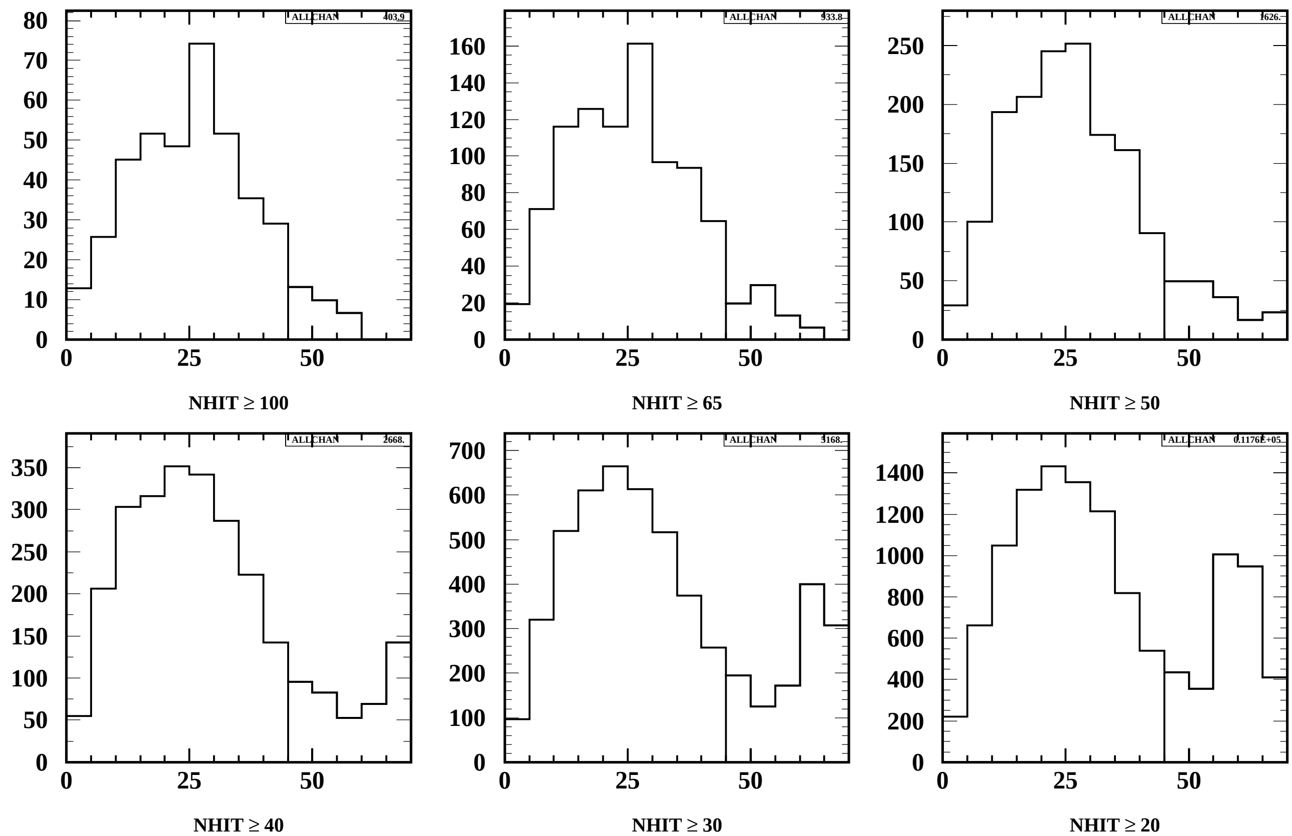
Proton Simulations

- 1.5 x 10^7 throws between 50 GeV and 100 TeV
- ~500 triggers above 65 tubes
- No air between water and cover



Trigger Rate

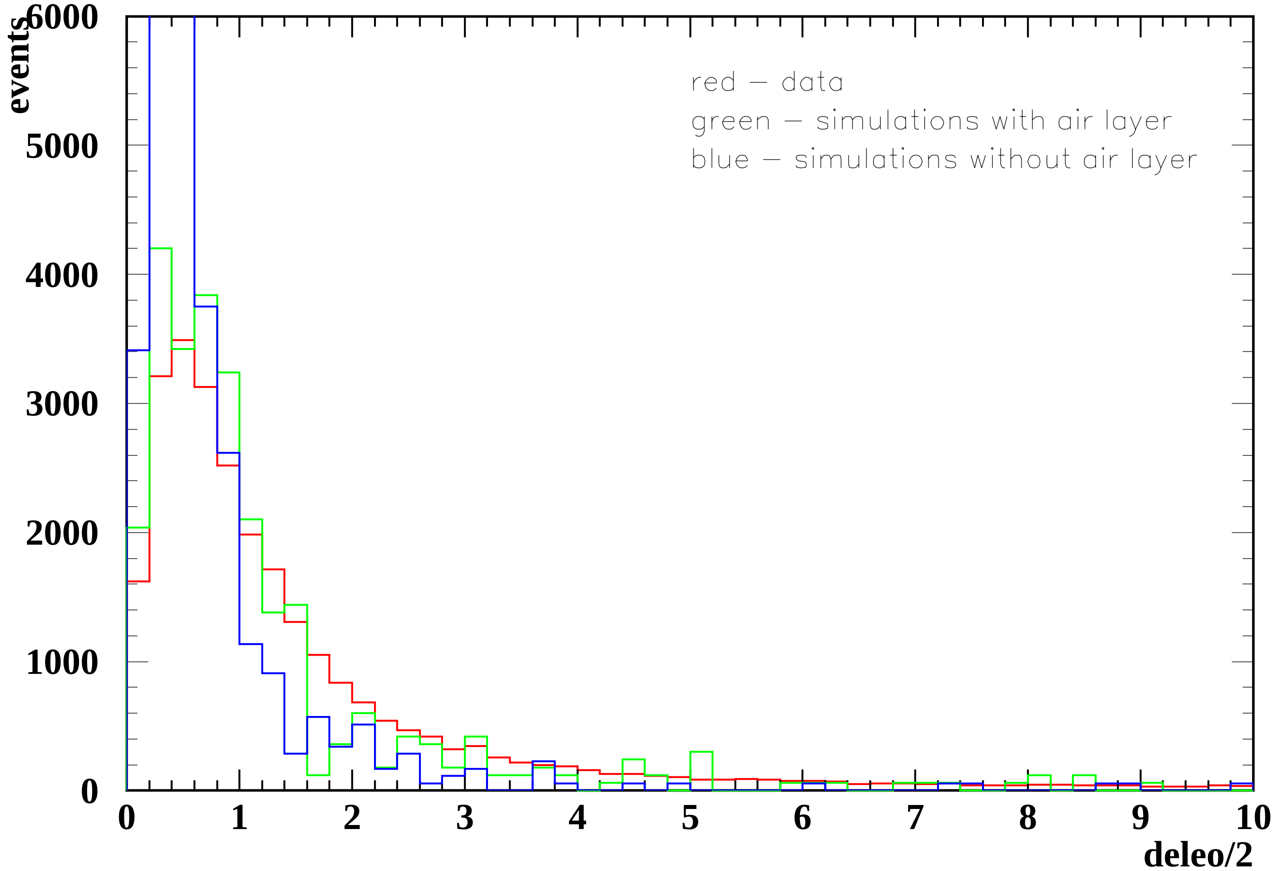
Zenith Angle dist. for 1s of MC data



Predicted trigger rate from protons for a 65 tube trigger is 934 Hz.

For no air layer, this drops by a factor of 1.76

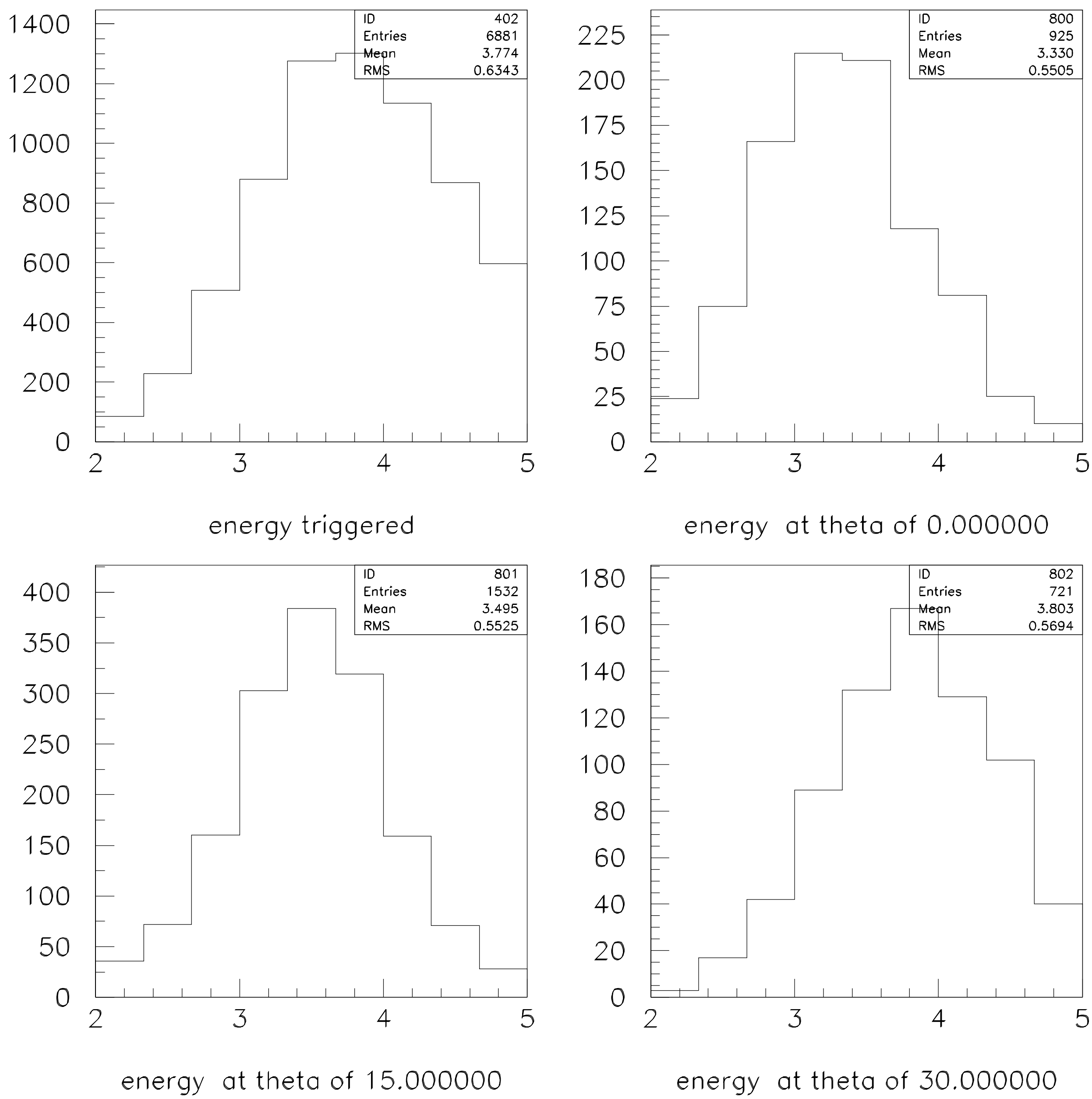
Deleo



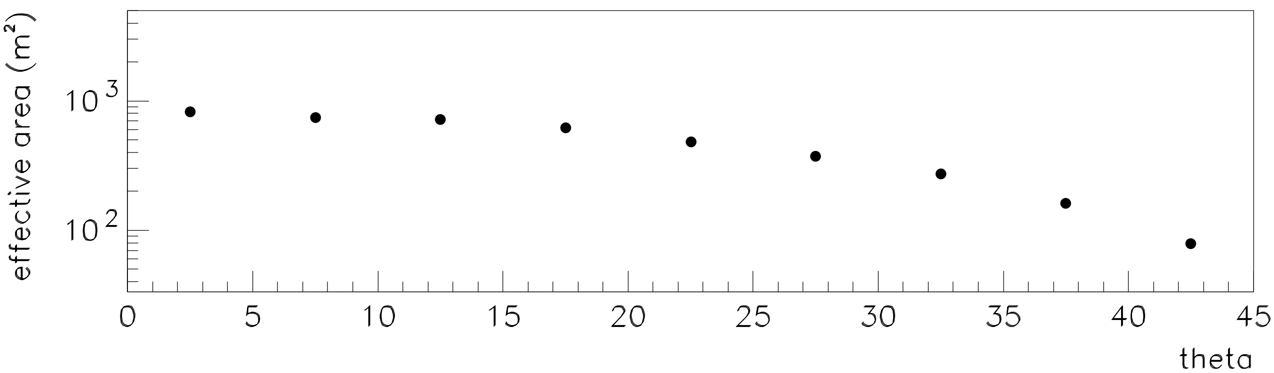
The simulated showers with no layer of air, seem to fit too well.

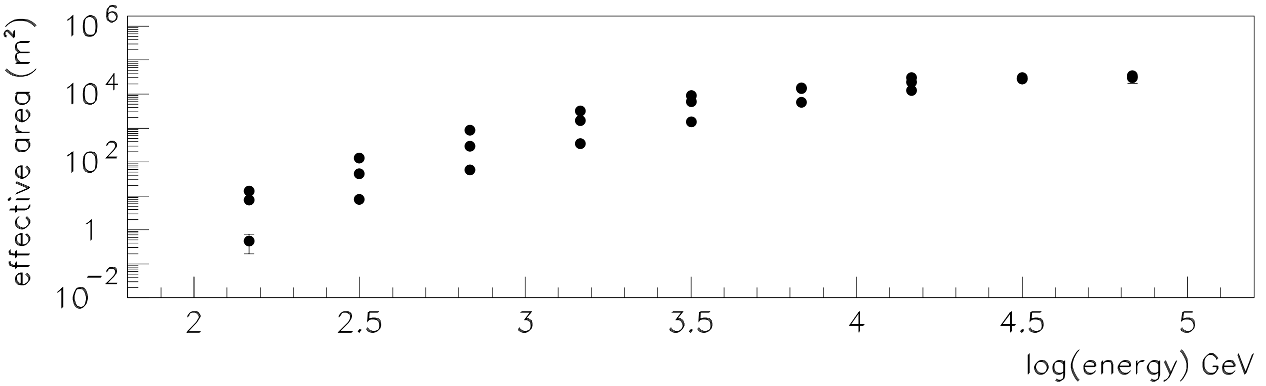
Gamma−Ray Simulations

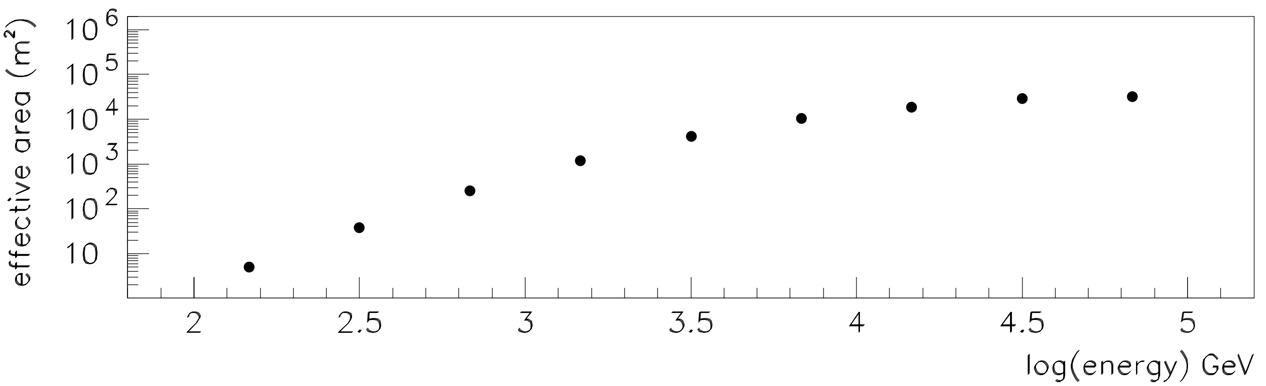
- 2 x10^7 throws from 100 GeV to 100 TeV
- ~7000 triggers >65 tubes



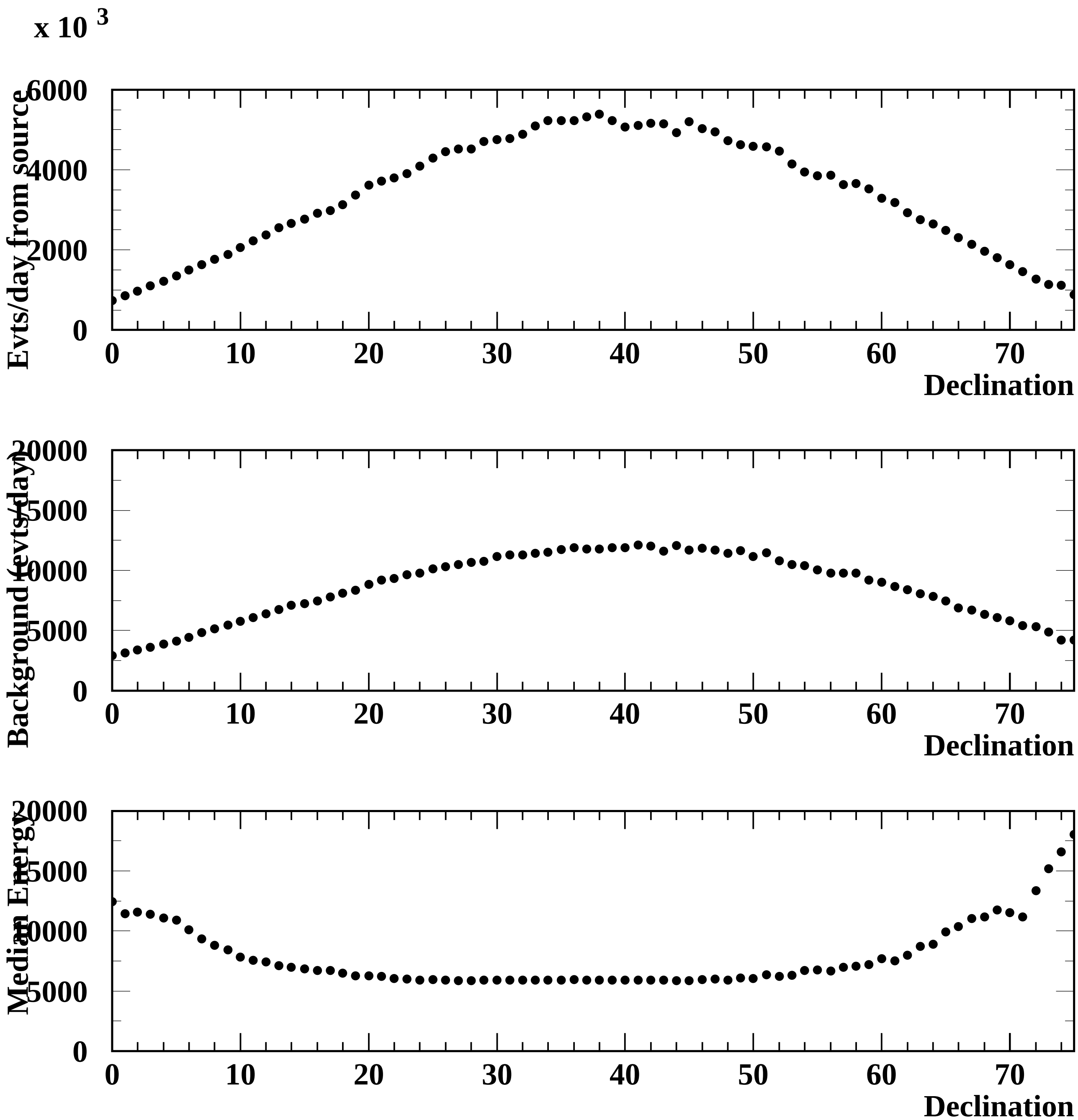
Effective Area



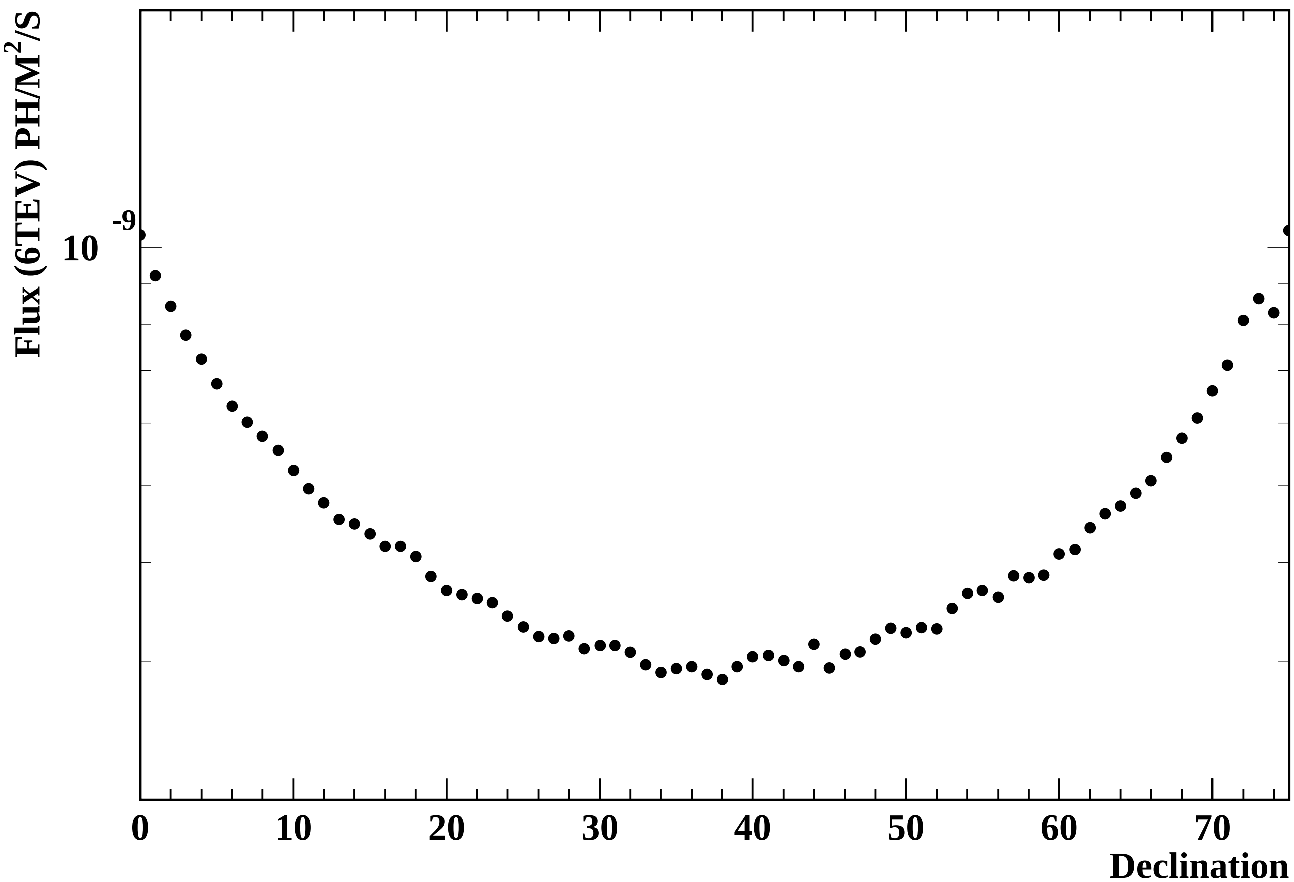




Sensitivity vs. Declination

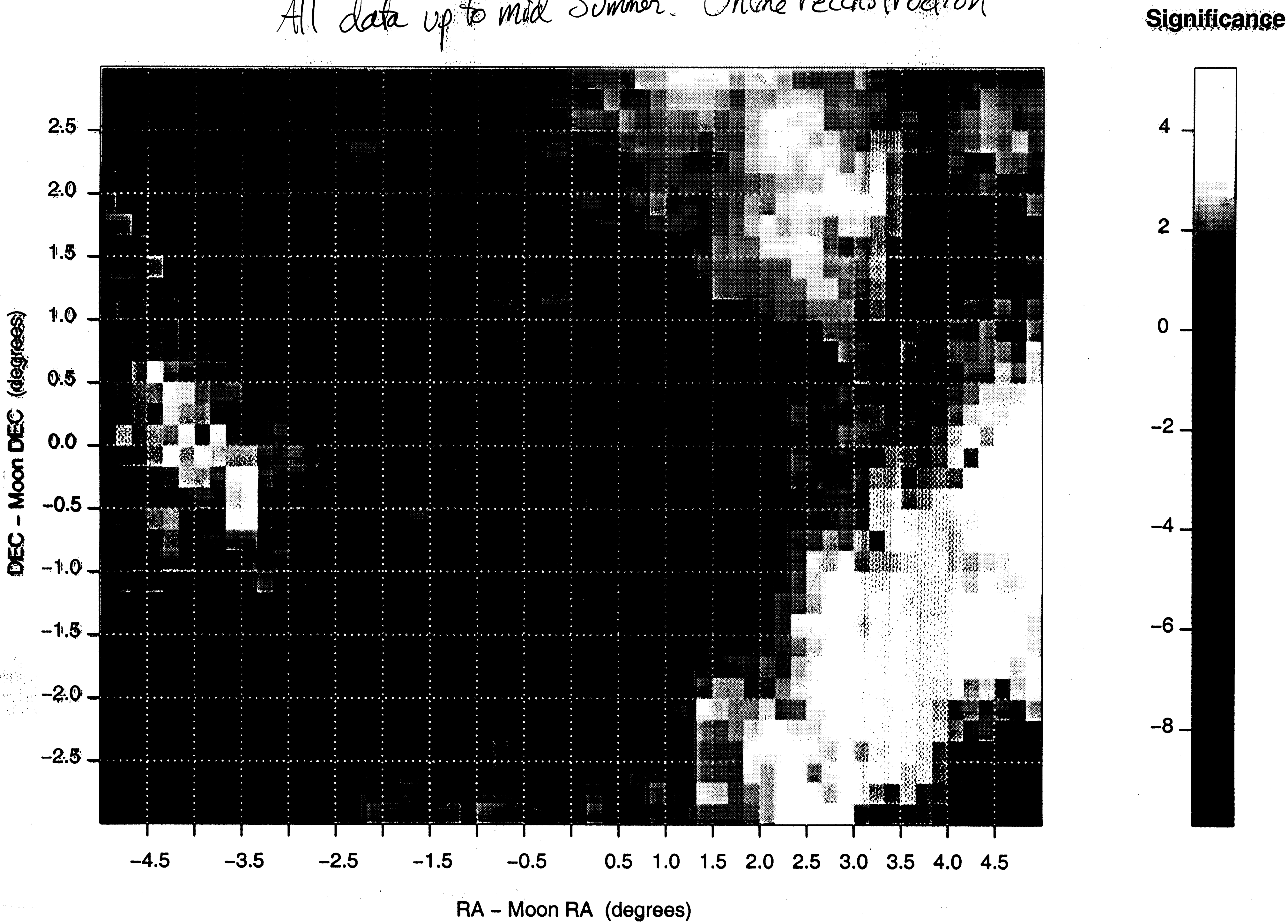


Flux vs. Declination



Sensitivity vs. Zenith Angle

All data up to mid Summer. Online reconstruction



WACJ

Update

Wisc 2000

- what did we do
- how did we do it
- who helped us do it
-

- People to thank.

Julie
Frank
Wystan

couldnt have ~~c~~ done anything without them.

- also thank

Jordan
(Matt + Andy) undergrads
Greg
David Berley
Alan Mincer
David Noyes
Liz
(Devon + Mike) ~~OC~~ UMD Jemez spr
Stephen Bracht
4 students from LANL
Scott

_onclusion

- We worked really really hard.

- Still a great deal of things to do

- ~~Cabeling~~
  Cabling - done
  buildings - done
  trenching - done - 10 ft.
  rails + wheels - done
  mirrors + frames - done - 1 mirror

- electronics
  camera
  bases
  alignment

Outrigger Status and Plans

Anthony Shoup, UCI

Introduction

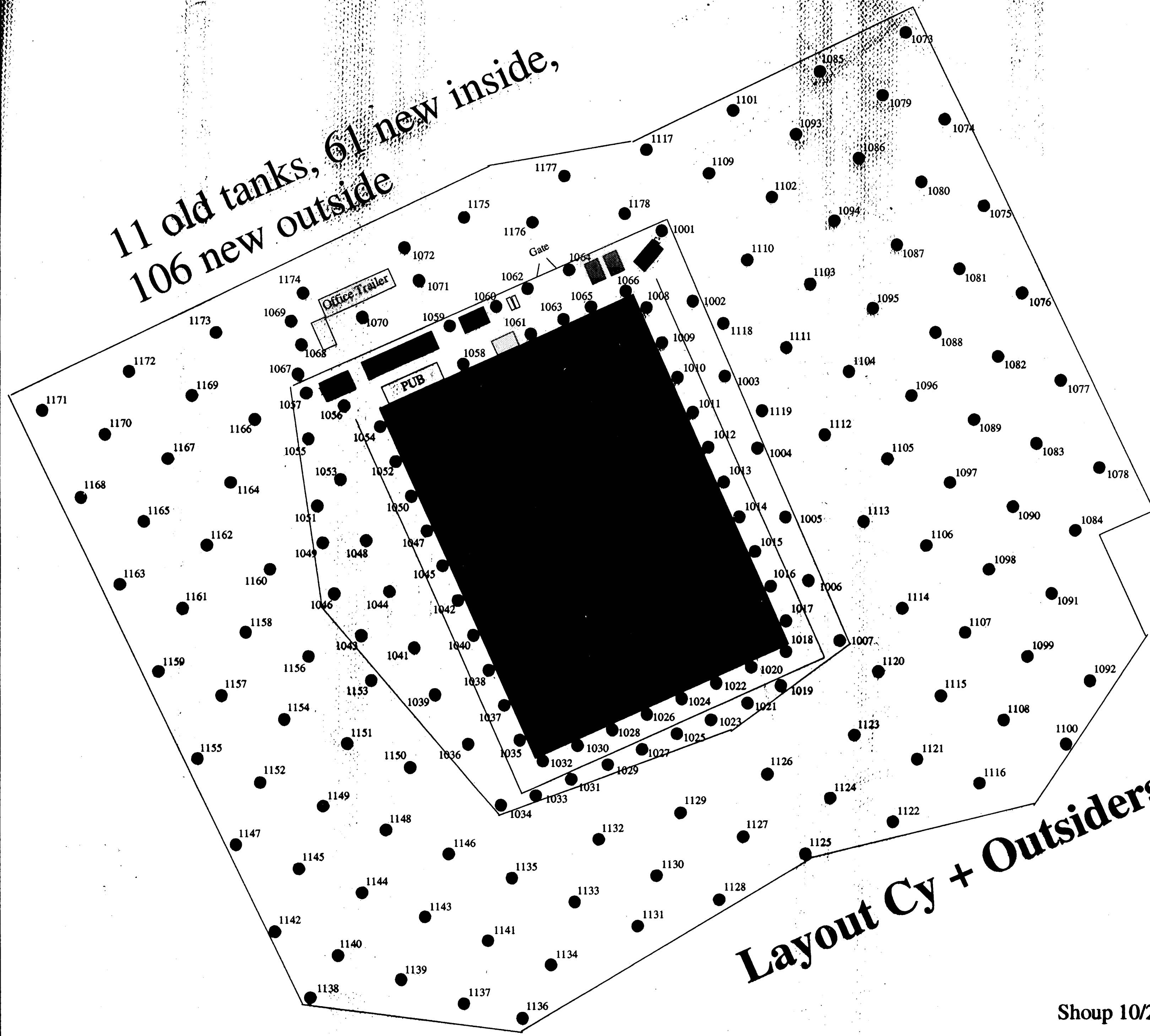
- Current design
  - Overall layout
  - Detector design
  - Interface to daq & calibration system
- Summary of work done to date
  - At site
  - elsewhere
- Summary of work needed to finish
  - Inner array
  - Outer array
- Schedule

Design: Overall Layout

- 178 Outriggers covers full outer fence area (see diagram)
  - 66 inners with 8 m to 15 m spacing (5 old, 61 new)
  - 112 outers with 15m spacing (6 old, 106 new)
  - 8' dia., water tanks, 2.5' deep water, Tyvek lined (see design below)
- Lightning protection for outer array only (see Don Coyne's email)
- Each outrigger calibrated using laser light

Layout Cy + Outsiders

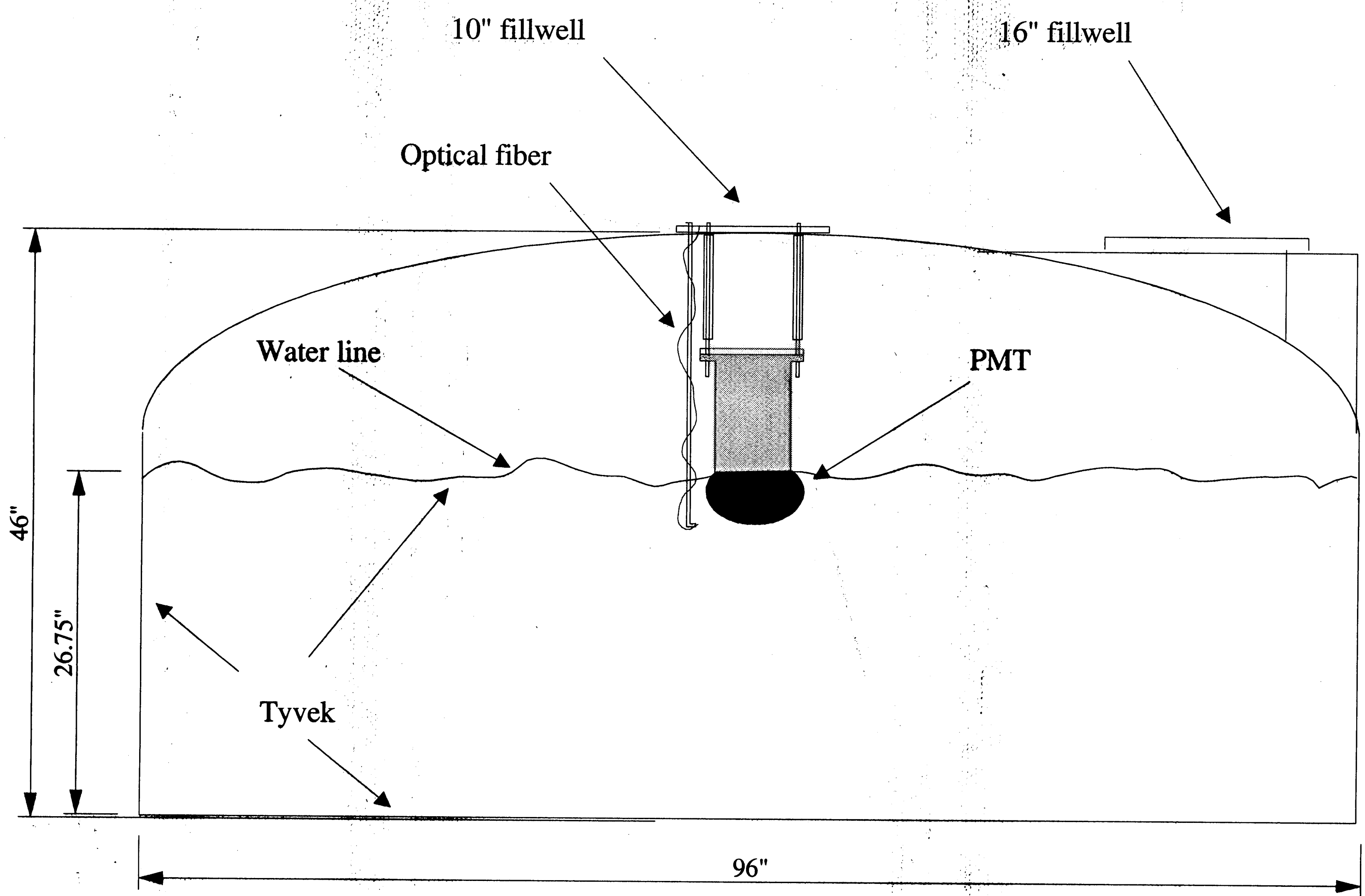
11 old tanks, 61 new inside,
106 new outside



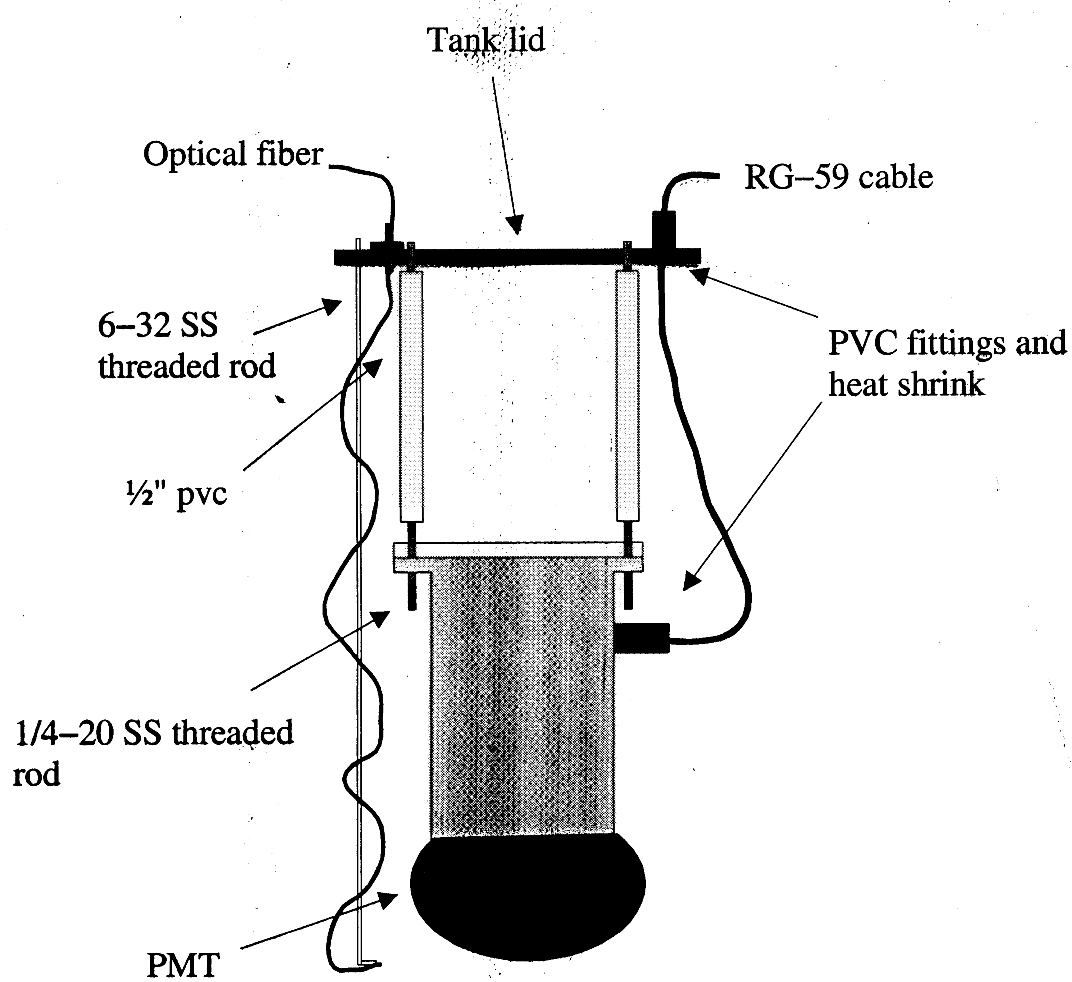
Design: Detector

- Based upon Abe's prototype design
- 8' dia. by 2.5' deep water tank lined with Tyvek and housing one 8" pmt
- Feedthru for RG–59 using 2 pvc fittings (same as new pond repair)
- Feedthru for optical fiber using ST style fiber connectors (modular)

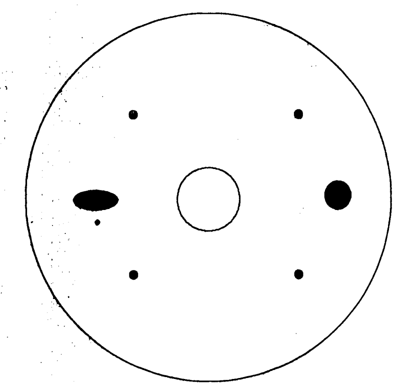
Tank Overview



PMT Support

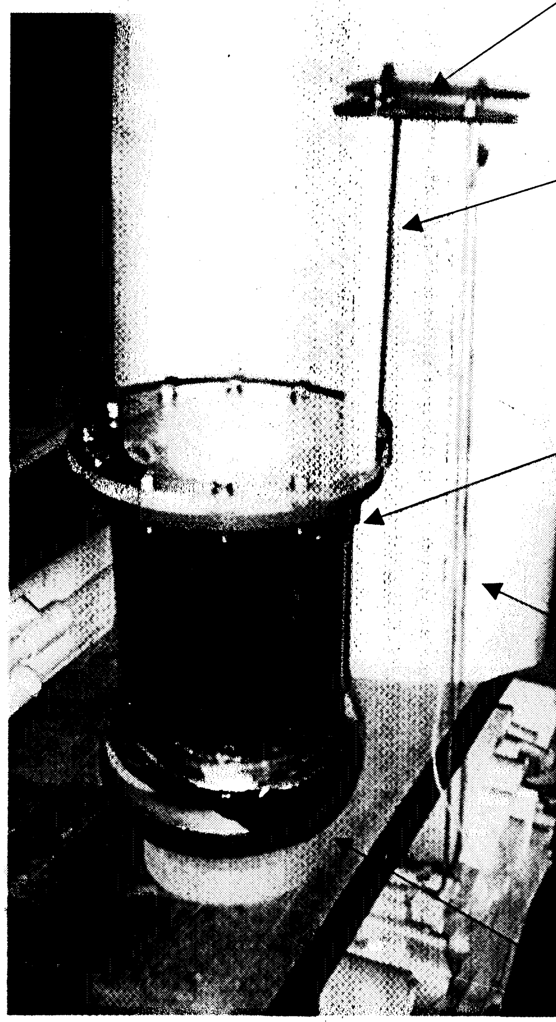


Side View

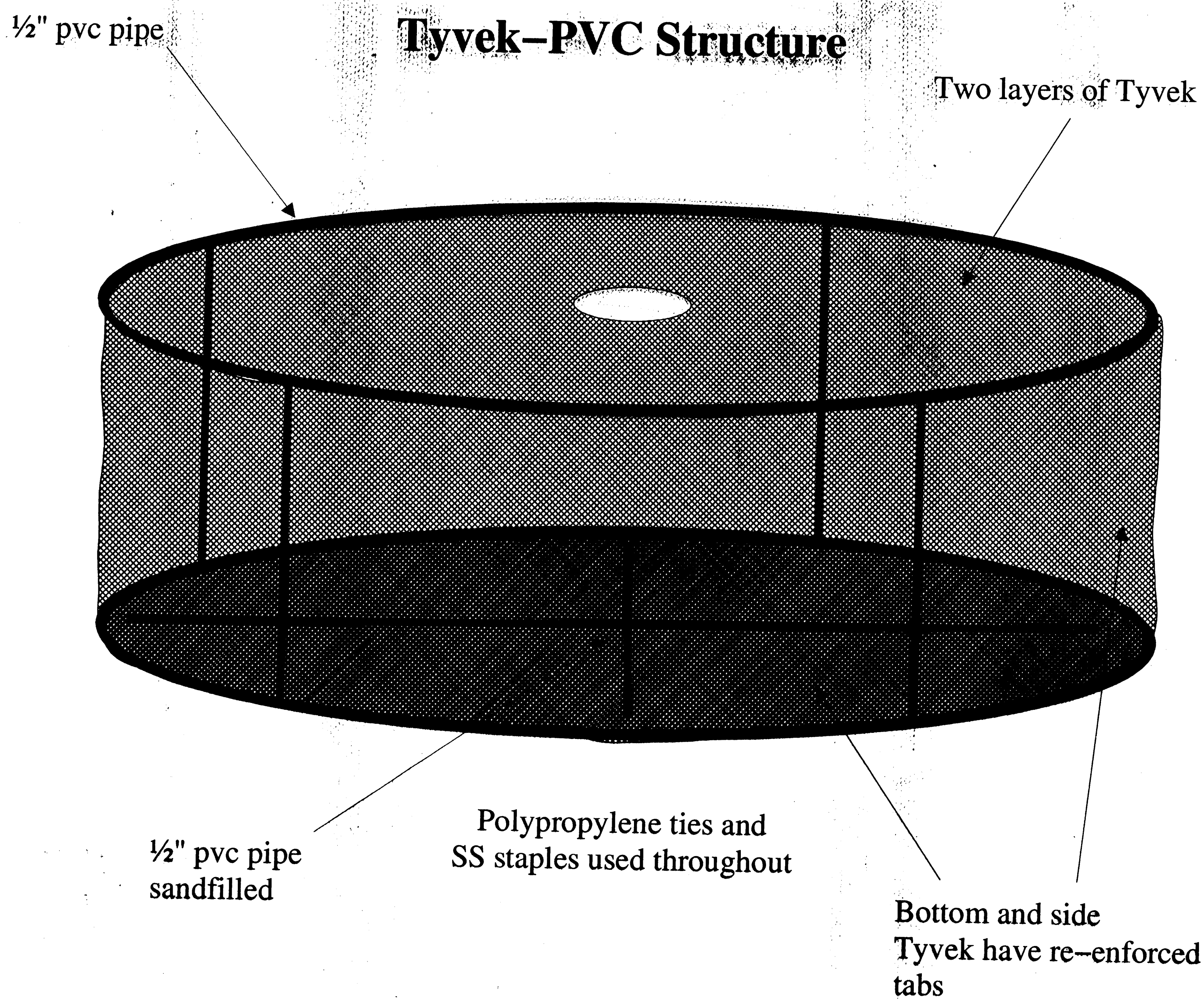


Top View

PMT Support Model



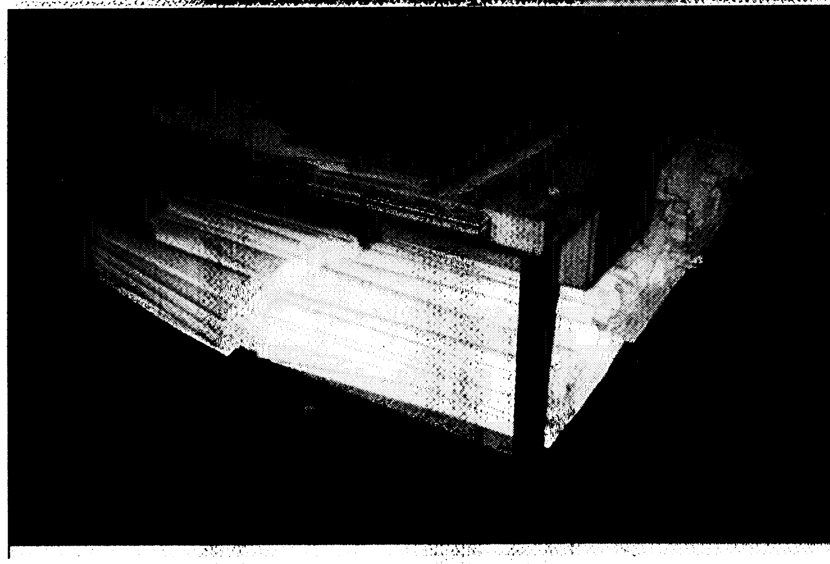
Tyvek–PVC Structure



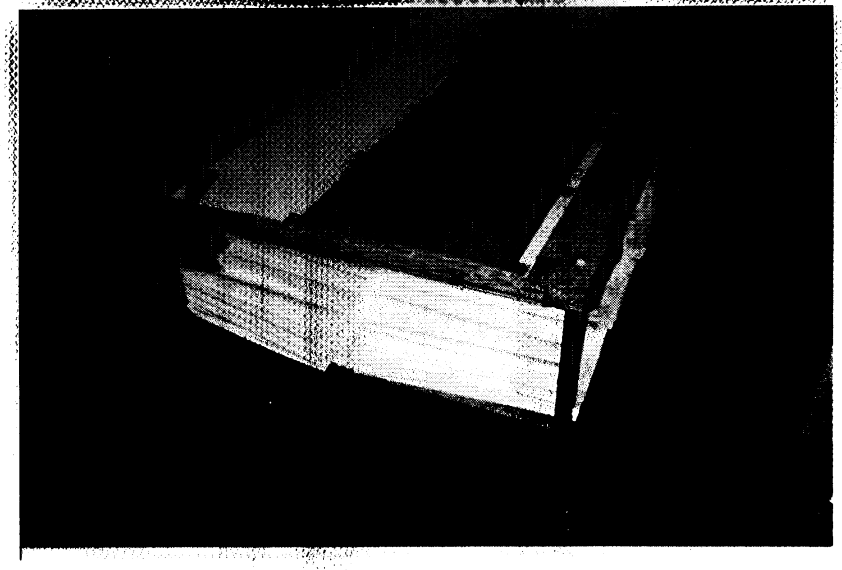
Tyvek – PVC Set

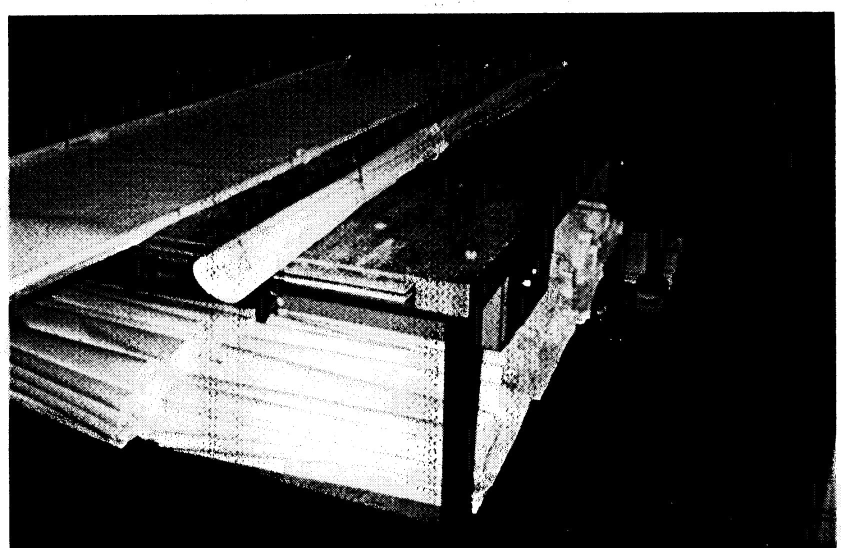
- Contents
  - 2 Tyvek sides (12' x 26") with 12' pvc pipe
  - 1 Tyvek bottom (7' 10" dia.)
  - 1 Tyvek top (7' 10" dia., 10" center hole)
  - 4 sand filled cross pieces (44") with pvc cross fitting
  - 4 26 ¾" upright pvc pieces

Bottom/Top Pattern

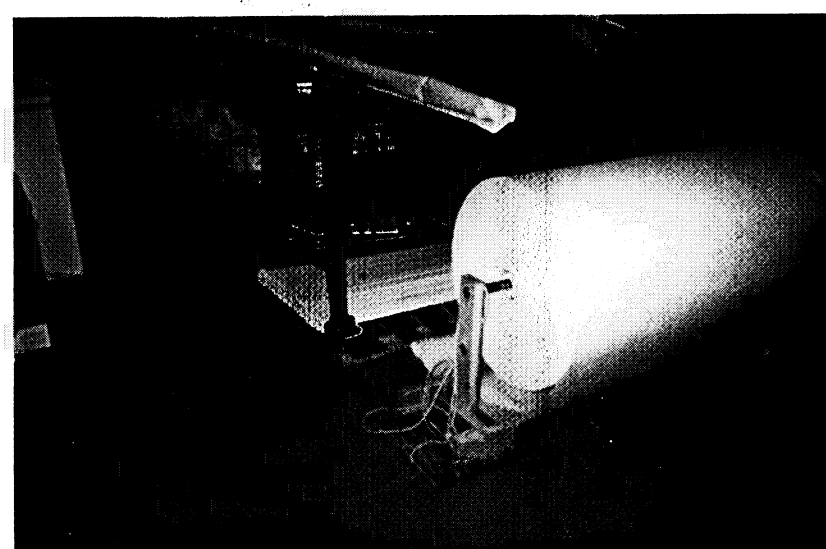


Side Pattern





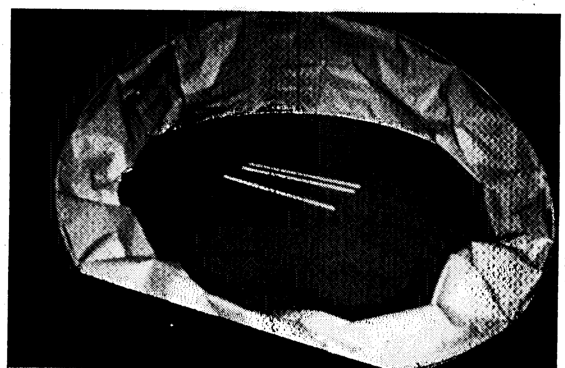
Side is folded for tank insertion



Tyvek roll (about half used)

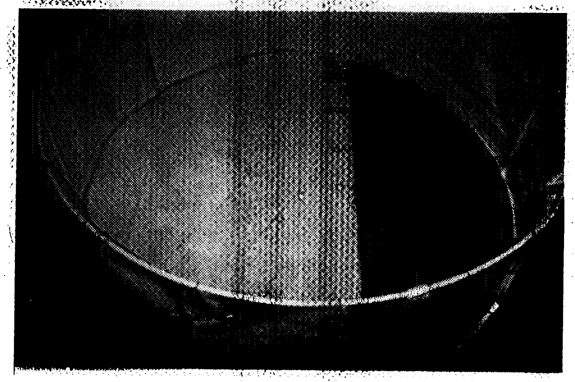
Tyvek–PVC Installation

(1) Insert Side

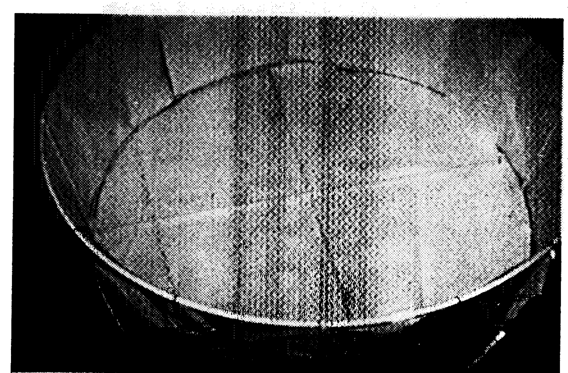


(2) Install Side Supports

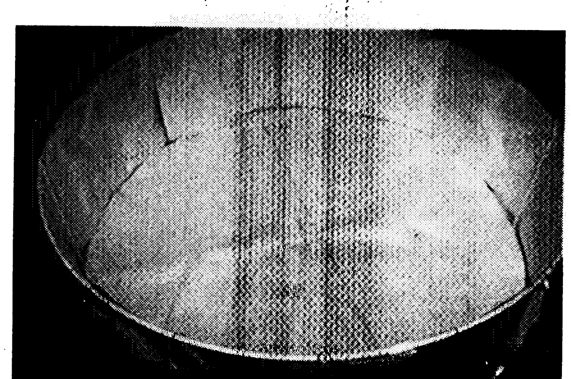
(3) Completed Side



(4) Insert, unfold, and "tie" bottom



(5) Install sand–filled cross.



(6) Finished

Progress to Date

- At UMD
  - RG–59 cable ordered and received for inner array, delivered to site
  - Optical fiber cables ordered (and received?) for inner array
  - Fiber connectors, feedthrus and internal tank fibers ordered and soon to be received for inner array

- At Site
  - Trenching & cable laying done for inner array from outrigger sites into electronic racks
  - Trenching & cable laying done for outer array from under counting house to inner fence
  - Trenching & conduit laying for optical fibers for inner array done
  - Optical fibers layed for outer array from near laser shack to inner fence
  - 70 tanks ordered and received
  - Electronics re–arranged
    - Crate and power supplies installed for FE–boards
    - HV Pod in Caen supply
    - Installed new CAMAC crate for expansion of scalar system

- At UCI
  - Tyvek–PVC Structure
    - Design finished
    - Materials ordered and received
    - Pre–assembly of 60 sets ~ 85% done
  - Design of pmt support and feedthrus done
    - Materials ordered and received (except fiber stuff which is on order)
    - Will use pmts currently at site (from pond repair)

To Finish Inner Array

- Action items to finish deployment of inner array:
  - At UCI
    - Complete Tyvek–PVC structures
    - Drive all parts (minus pmts) for 60 outriggers to site
  - At Site
    - Lay fiber cables
    - Deploy tanks
      - Position tank at each site
      - Install Tyvek
      - Assemble pmt, pmt support & feedthrus
      - Install pmt–support assemble in tank & connect RG–59 and fiber cable
      - Fill with pond water
      - Make light–tight and install tarp ?
    - Connectorize RG–59 cable in counting house
    - "Connect fibers in laser shack???"

Schedule to Complete Deployment of Inner Outriggers

Task	Responsible party	Labor Need	Start Date	Completion Date
Complete Tyvek Structures	UCI	3 man–days	10/26/00	10/30/00
Deliver Tyvek sets to Site	UCI	2 man–days	10/31/00	11/1/00
Lay fiber cable	UCI (Scott)	7–14 man–days	10/23/00	11/6/00
Deploy at "no prep" (~40) sites	UCI	15 man–days	11/1/00	11/14/00
Connectorize RG–59 in cnt house	UCI (Scott)	2 man–days	11/15/00	11/17/00
"Connect fibers in laser shack"	LANL, UMD?	?????	????	????
Prep remaining inner 'rigger sites	UCI (Scott)	5 man–days	4/2/01	4/6/01
Deploy at remaining sites	UCI	7 man–days	4/9/01	4/18/01

- Action items to "make useful" the inner 'array
  - Hardware
    - Survey site positions
    - Install outrigger electronics (FE–boards, HV Pod, TDC, support, etc.
    - Calibrate inner array: tpeds, slewing, pulseheights
    - Other hardware?
  - Software
    - Update Calibration software for use with outriggers?
    - Design/Test incorporation of outriggers into event reconstruction
      - Angle, Core, Energy, Background rejection, etc.
    - Design/Test incorporation of outriggers into event "monitoring"
    - Other software?

Schedule to Make Inner Outriggers Useful

Task	Responsible party	Labor Need	Start Date	Completion Date
Survey site positions	LANL	3 man-days??	4/19/01	4/20/01
Finish electronics installation	UCSC	7 man-days??	????	????
Update Calibration software	UMD	?????	????	????
Acquire outrigger calibration data	UMD	?????	????	????
Update Event recon for outriggers	????	?????	????	????
Update other online/offline code?	????	?????	????	????

To Finish Outer Array

- Action items to finish deployment of outer array:
  - At UCI
    - Drive Jordan's purchasing office mad by ordering more parts
    - Complete *ANOTHER* 107 Tyvek–PVC structures
    - Complete another set of 107 pmt supports
    - Drive all parts (plus pmts) for 107 outriggers to site
  - At UCSC
    - Lightning protection for outer outriggers
      - Finish design & have Jordan order components
      - Do any pre–assembly at UCSC
      - Ship to Site
    - DAQ Electronics
      - Finish remaining FE–Boards
      - Have Jordan order additional components

- At UMD
  - Order
    - RG–59 cables and SHV connectors
    - ~~107~~ 94 more water tanks
    - Everything else people require
  - Assemble/Test outer array's RG–59 cables (from inner fence to each site)
  - Finalize design to thermally insulate outer array's RG–59 cables without trenching
- At Site
  - Prepare outer array sites (leveling, clearing, etc)
  - Install "lightning protection system" (including patch panels)
  - Layout outer array cables, RG–59 and fiber
  - Deploy tanks
    - Position tank at each site
    - Install Tyvek
    - Assemble pmt, pmt support & feedthrus
    - Install pmt–support assemble in tank & connect RG–59 and fiber cable
    - Fill with pond water
    - Make light–tight and install tarp

- At Site (cont)
  - Connectorize RG–59 cables, both inside inner fence and outside (at patch panel)
  - Laser shack upgrade
    - Start/Finish design of laser shack upgrade to efficiently handle calibrations of all outriggers
    - Have Jordan order all necessary parts
    - Install in new/old laser shack
  - Connectorize outer array fibers
  - Survey all outrigger positions
  - Acquire set of outrigger calibration data and extract:
    - tpeds, slewing, pulseheight –> pe parameters
  - Everything else I forgot

Schedule to Complete Outer Array

Task	Responsible party	Labor Need	Start Date	Completion Date
Complete Tyvek–PVC structures	UCI	27 M-DAY		
Prepare PMTs and supports	UCI	7 M-DAY		
Finish design of lightning protect. *	UCSC			
Order remaining ~~95~~ tanks 94	UMD			
Pre–assembly of lightning protect	UCSC			
Install lightning protect at site	UCSC			
Finish remaining FE–boards	UCSC			
Order remaining DAQ support stuff	UCSC			
Acquire/Test RG–59 cables	UMD			
Finalize outer cable layout *	UMD			
Prep outer array sites	LNAL & Scott			
Layout outer array cables *	UMD & Scott			
Deploy tanks	UCI & Scott	45-M-DAY		
Connectorize cables in cnt. House	UMD & Scott			
Upgrade laser shack *	LNAL			
Connectorize fiber cables in shack	LNAL & Scott			
Survey all outrigger positions	LNAL			
Acquire outrigger calibration data	UMD & LANL			

Particle Event			CME	Flare & [illegible]			
START	Max	p^+ flux		flare max (Day/time UT)	Xray/opt	Loc.	Region#
1997							
Nov 04/0830	Nov 04/1120	72	W/04 0610	Nov 04/0558	X2/2B	S14W33	8100
Nov 06/1305	Nov 07/0255	490	W/06 >1300	Nov 06/1155	X9/2B	S18W63	8100
1998							
Apr 20/1400	Apr 21/1205	1700	W/20 1007	Apr 20/1021	M1/EPL	S43W90	8194
May 02/1420	May 02/1650	150	Halo/02 1406	May 02/1342	X1/3B	S15W15	8210
May 06/0845	May 06/0945	210	W/06 0829	May 06/0809	X2/1N	S11W65	8210
Aug 24/2355	Aug 26/1055	670	NA	Aug 24/2212	X1/3B	N30E07	8307
Sep 25/0010	Sep 25/0130	44	NA	Sep 23/0713	M7/3B	N18E09	8340
Sep 30/1520	Oct 01/0025	1200	NA	Sep 30/1350	M2/2N	N23W81	8340
Nov 08/0245	Nov 08/0300	11	?				
Nov 14/0810	Nov 14/1240	310	NA	Nov 14/0518	C1/BSL	N28W90	8375?
1999							
Jan 23/1105	Jan 23/1135	14	NA	Jan 20/2004	M5	N27E90	
Apr 24/1804	Apr 25/0055	32	Halo/24 1331			NW limb	8517?
May 05/1820	May 05/1955	14	Halo/ 03 0606	May 03/0602	M4/2N	N15E32	8525
Jun 02/0245	Jun 02/1010	48	Halo/ 01 <1937	Jun 01/~1930			
Jun 04/0925	Jun 04/1055	64	NW/ 04 0726	Jun 04/0703	M3/2B	N17W69	8552
2000							
Feb 18/1130	Feb 18/1215	13	W/ 18 0954	Feb 17/2035	M1/2N	S29E07	8872
Apr 04/2055	Apr 05/0930	55	W/ 04 1632	Apr 04/1541	C9/2F	N16W66	8933
Jun 07/1335	Jun 08/0940	84	Halo/06 1554	Jun 06/1525	X2/3B	N20E18	9026
Jun 10/1805	Jun 10/2045	46	Halo/10 1708	Jun 10/1702	M5/3B	N22W38	9026
Jul 14/1045	Jul 15/1230	24000	Halo/14 1054	Jul 14/1024	X5/3B	N22W07	9077
Jul 22/1320	Jul 22/1405	17	NW/22 1230	Jul 22/1134	M3/2N	N14W56	9085

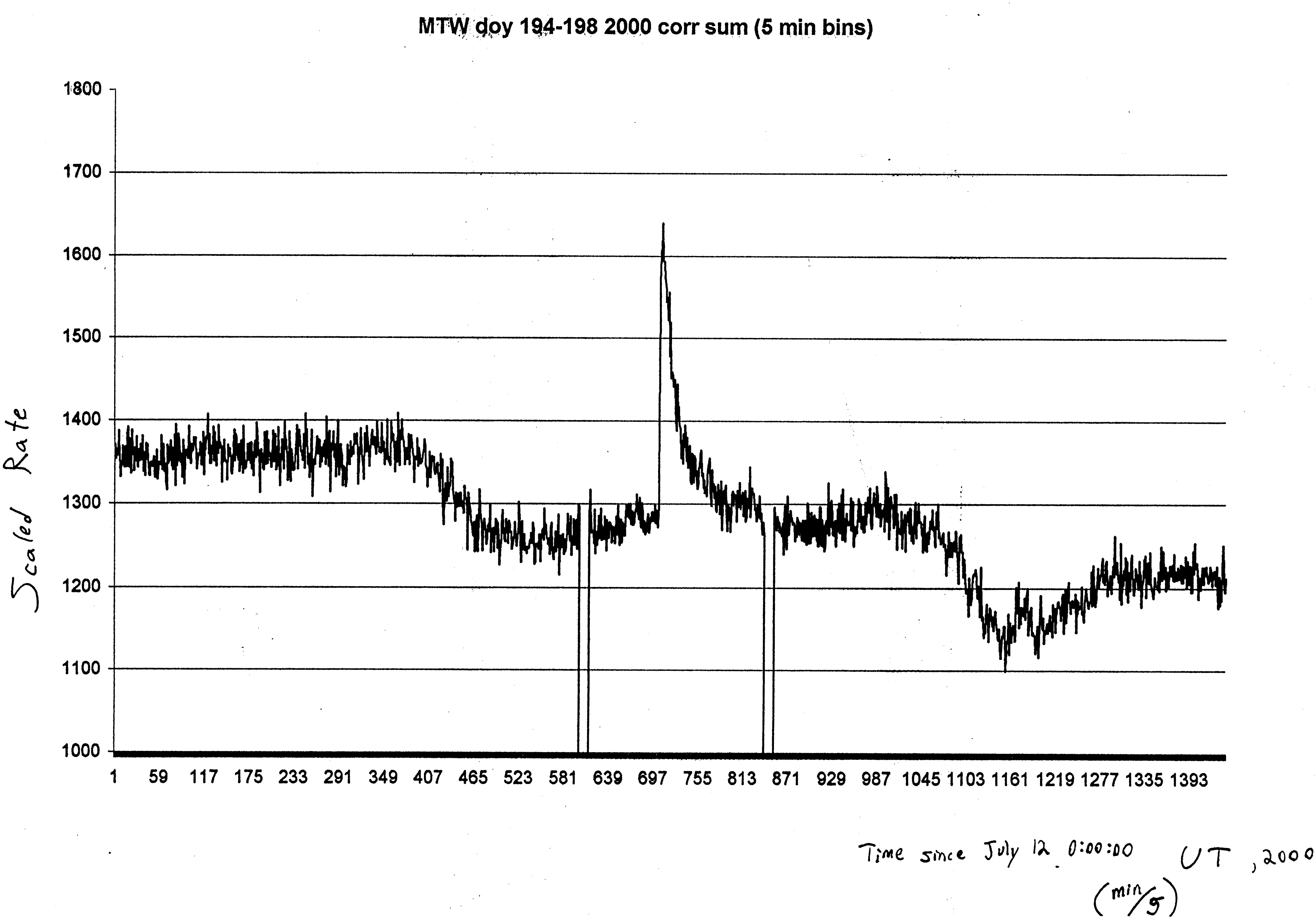
associated GLE

Please Note: Proton fluxes are integral 5-minute averages for energies > 10 MeV, given in Particle Flux Units (pfu), measured by GOES spacecraft at Geosynchronous orbit: 1 pfu = 1 p/sq. cm-s-sr. SWO defines the start of a proton event to be the first of 3 consecutive data points with fluxes greater than or equal to 10 pfu. The end of an event is the last time the flux was greater than or equal to 10 pfu. This definition, motivated by SWO customer needs, allows multiple proton flares and/or interplanetary shock proton increases to occur within one SWO proton event. Additional data may be necessary to more completely resolve any individual proton event.

Different detectors, onboard various GOES spacecraft, have taken the data since 1976. These proton data were processed using various algorithms. To date, no attempt has been made to cross-normalize the resulting proton fluxes.

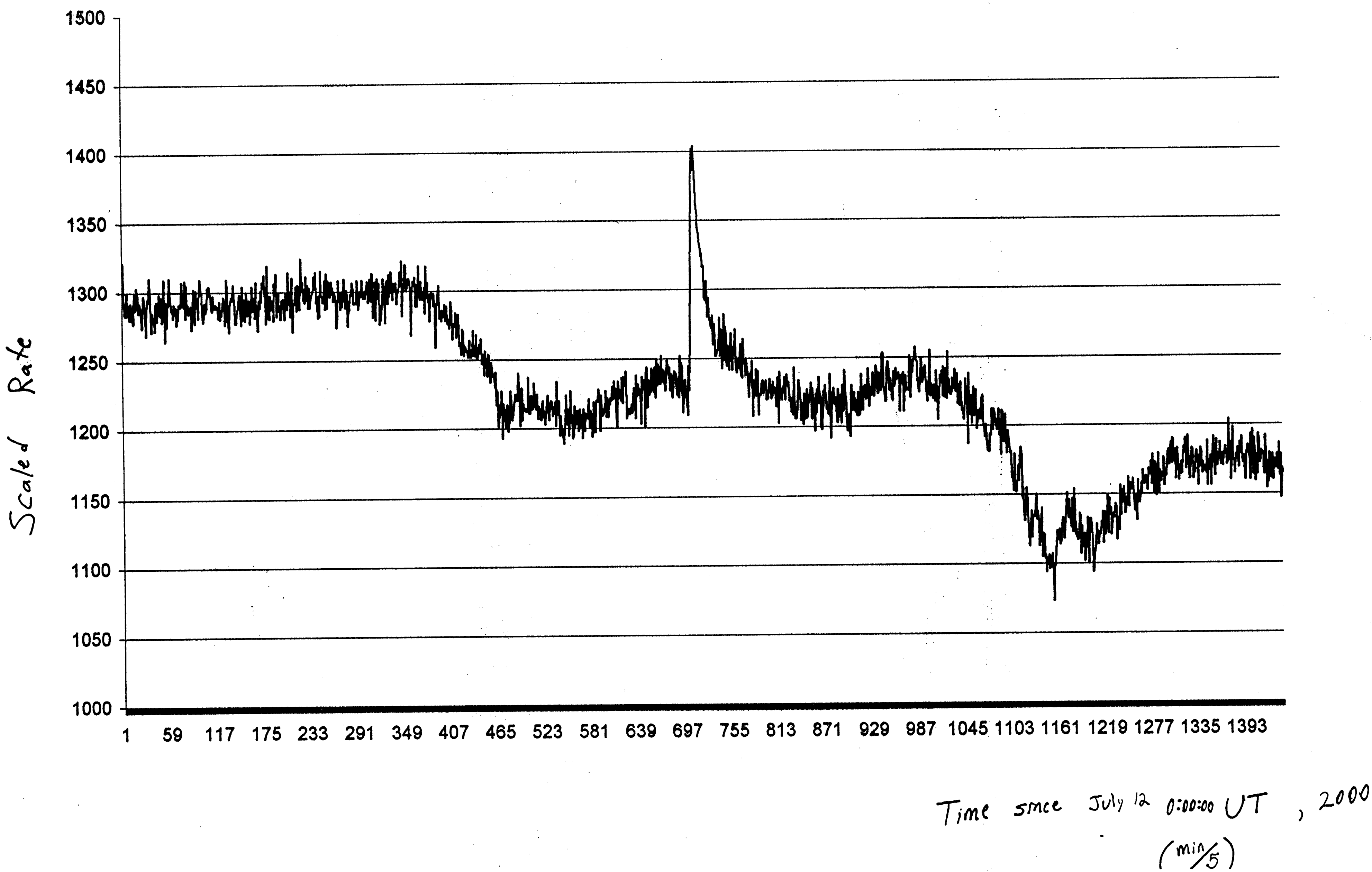
(From Space Environment Center)

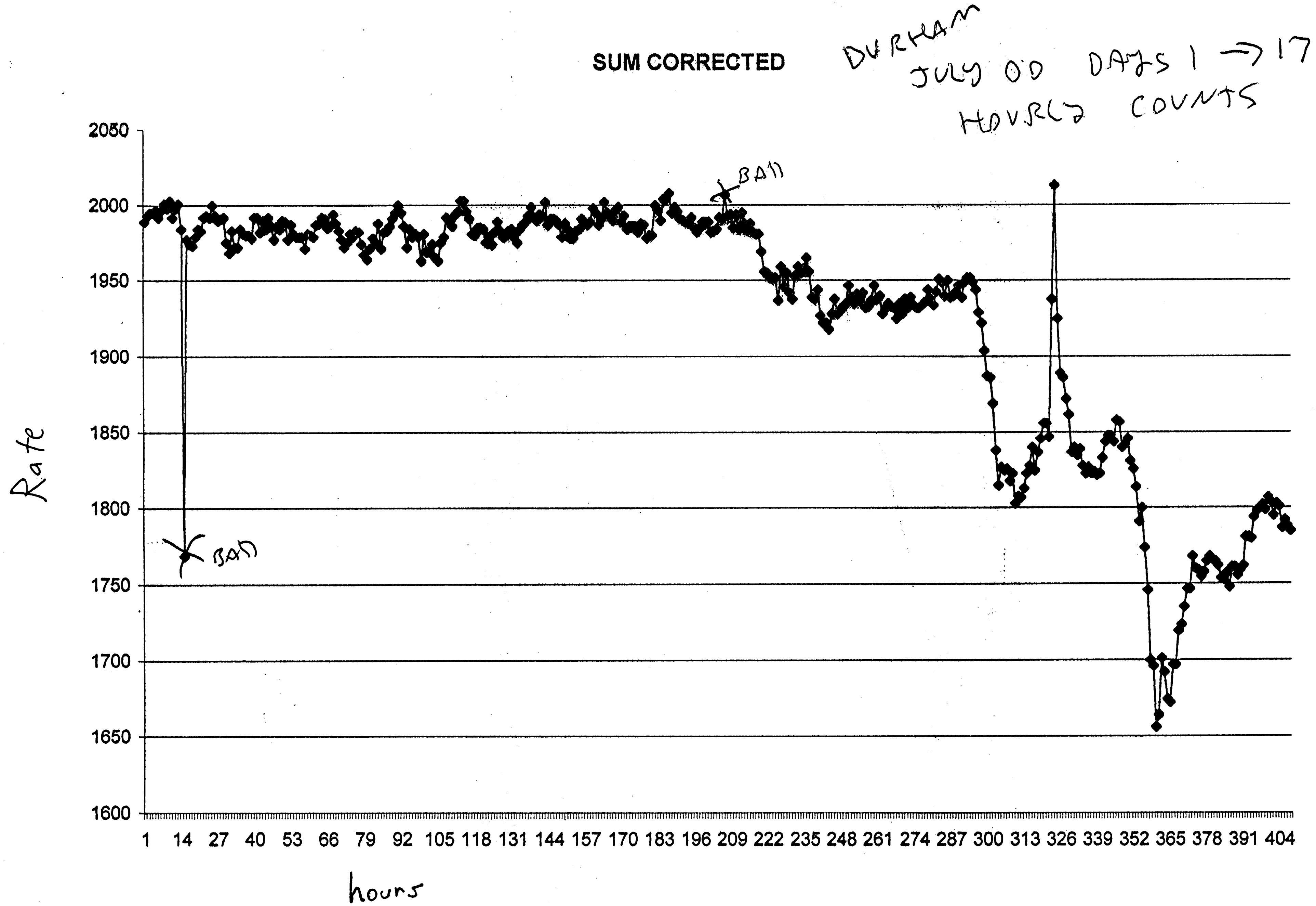
pressure corrected



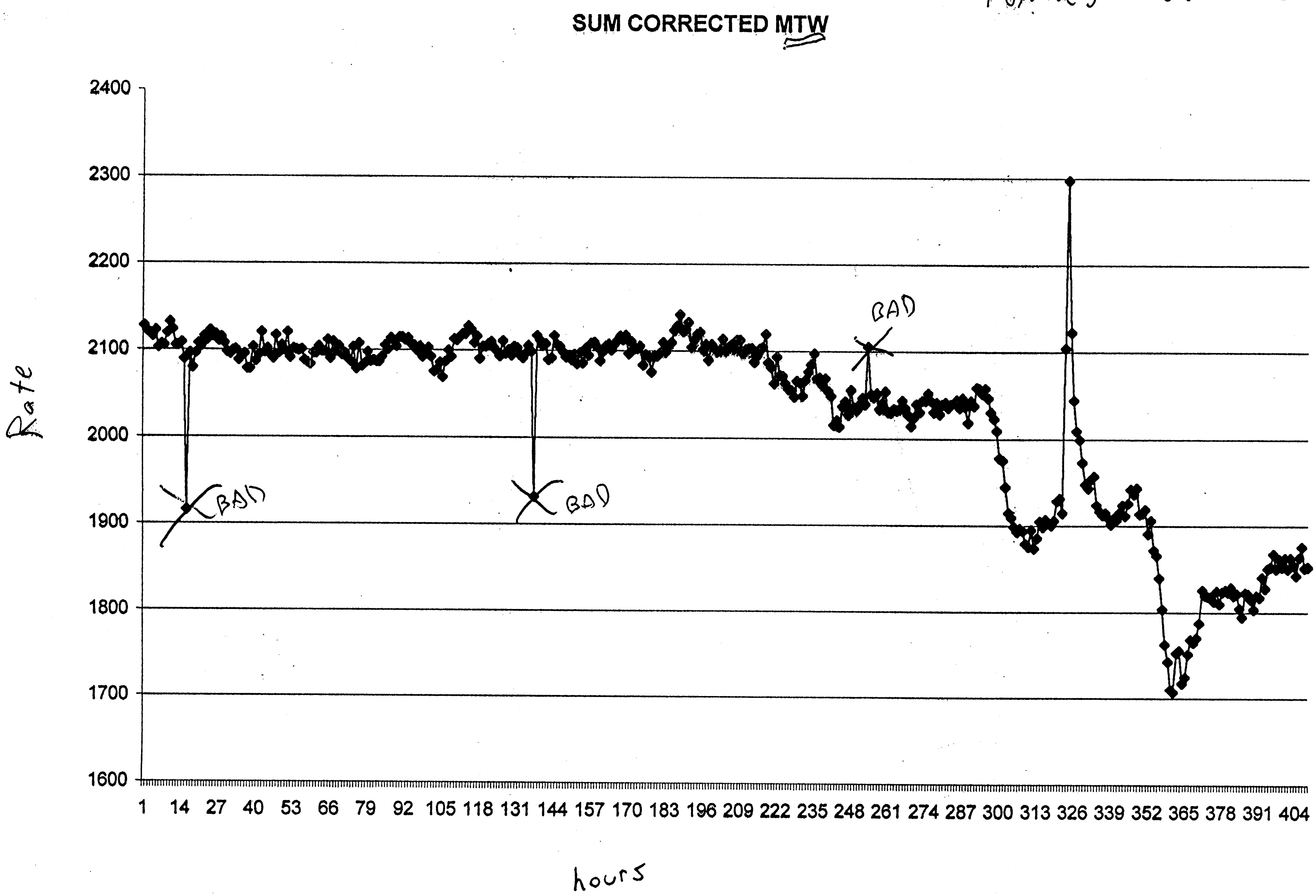
pressure corrected

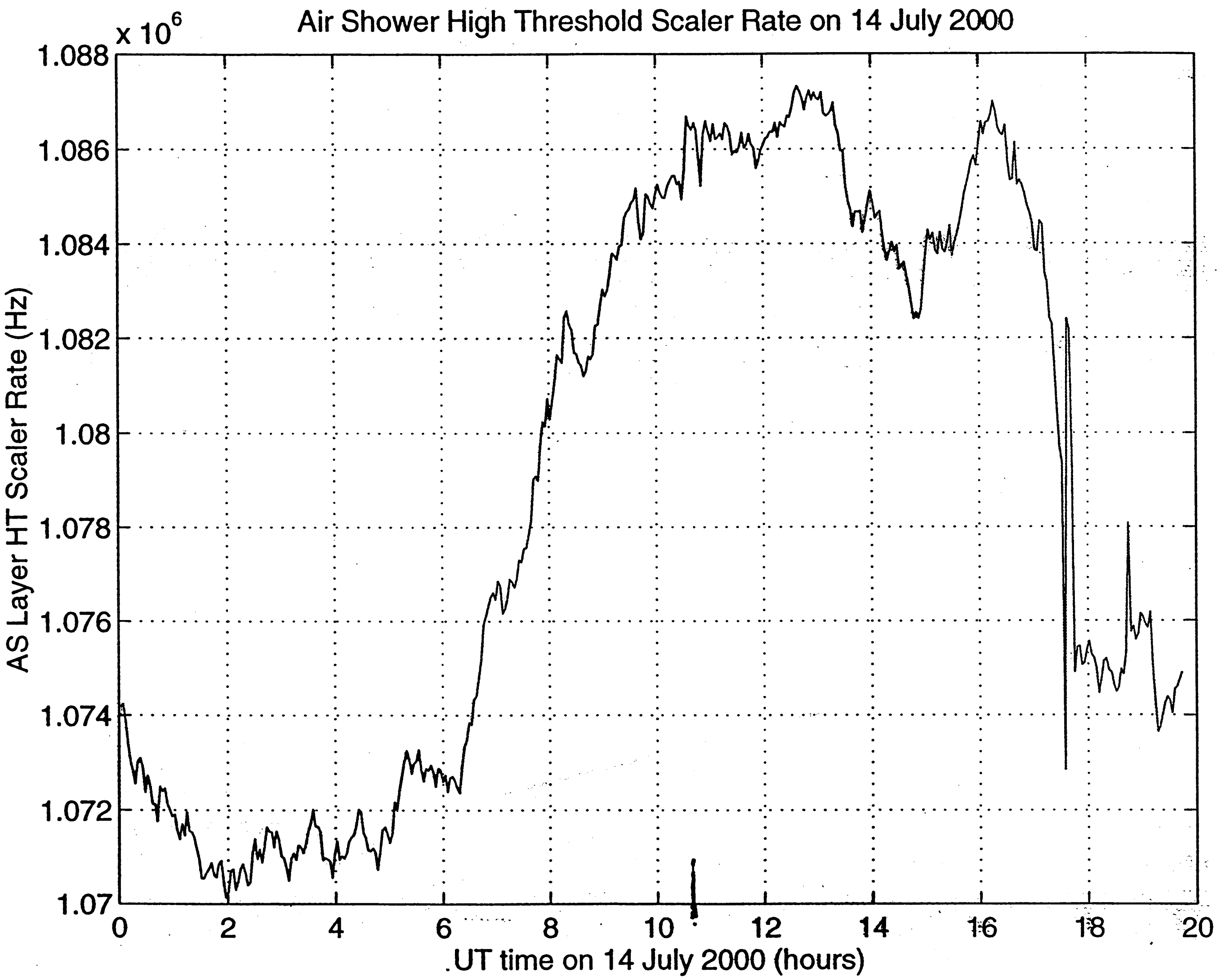
DUR doy 194-198 2000 corr sum (5 min bins)

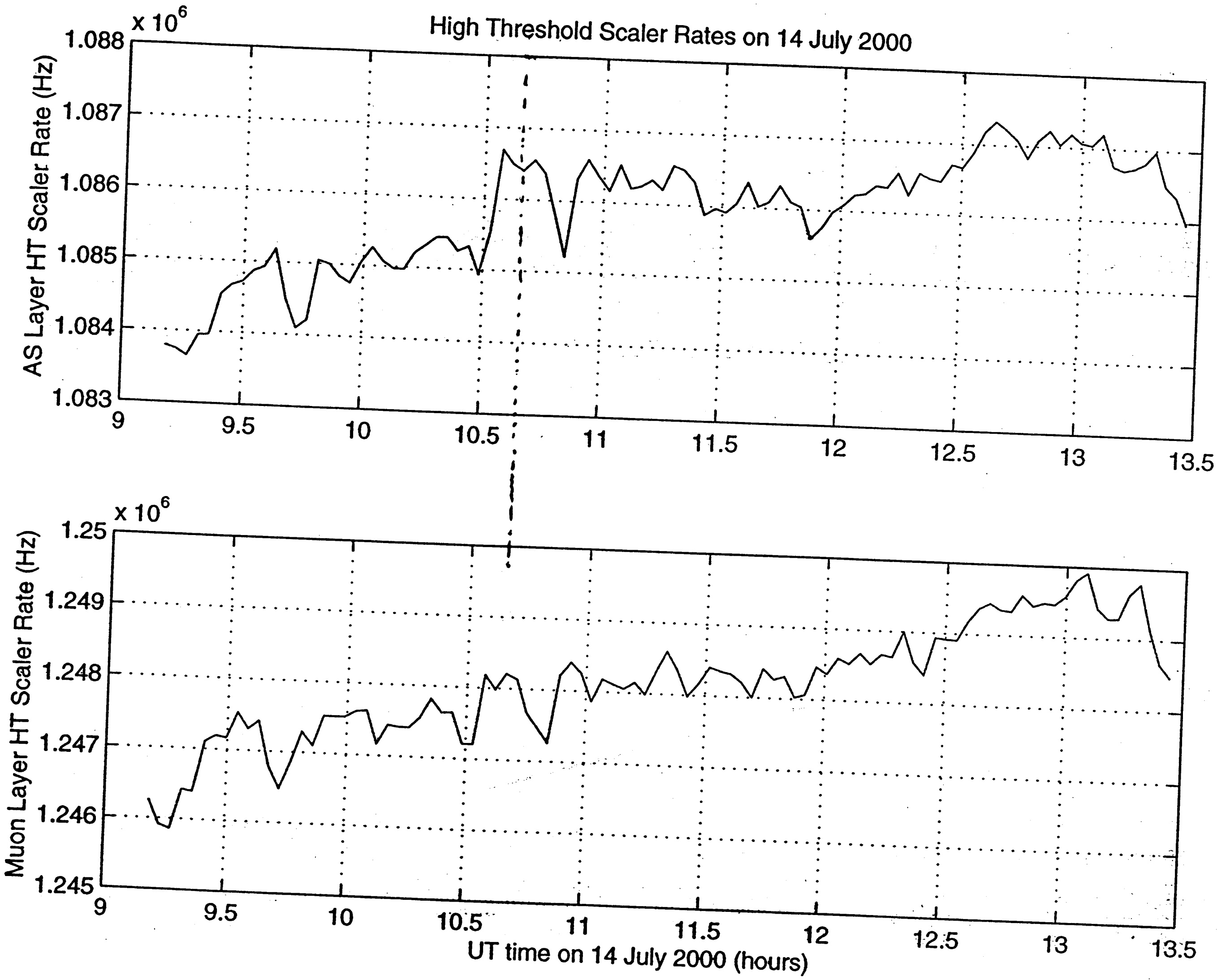



SUM CORRECTED
DURHAM
JULY 00 DAYS 1 → 17
HOURLY COUNTS
BAD
BAD
Rate
hours
2050
2000
1950
1900
1850
1800
1750
1700
1650
1600
1 14 27 40 53 66 79 92 105 118 131 144 157 170 183 196 209 222 235 248 261 274 287 300 313 326 339 352 365 378 391 404

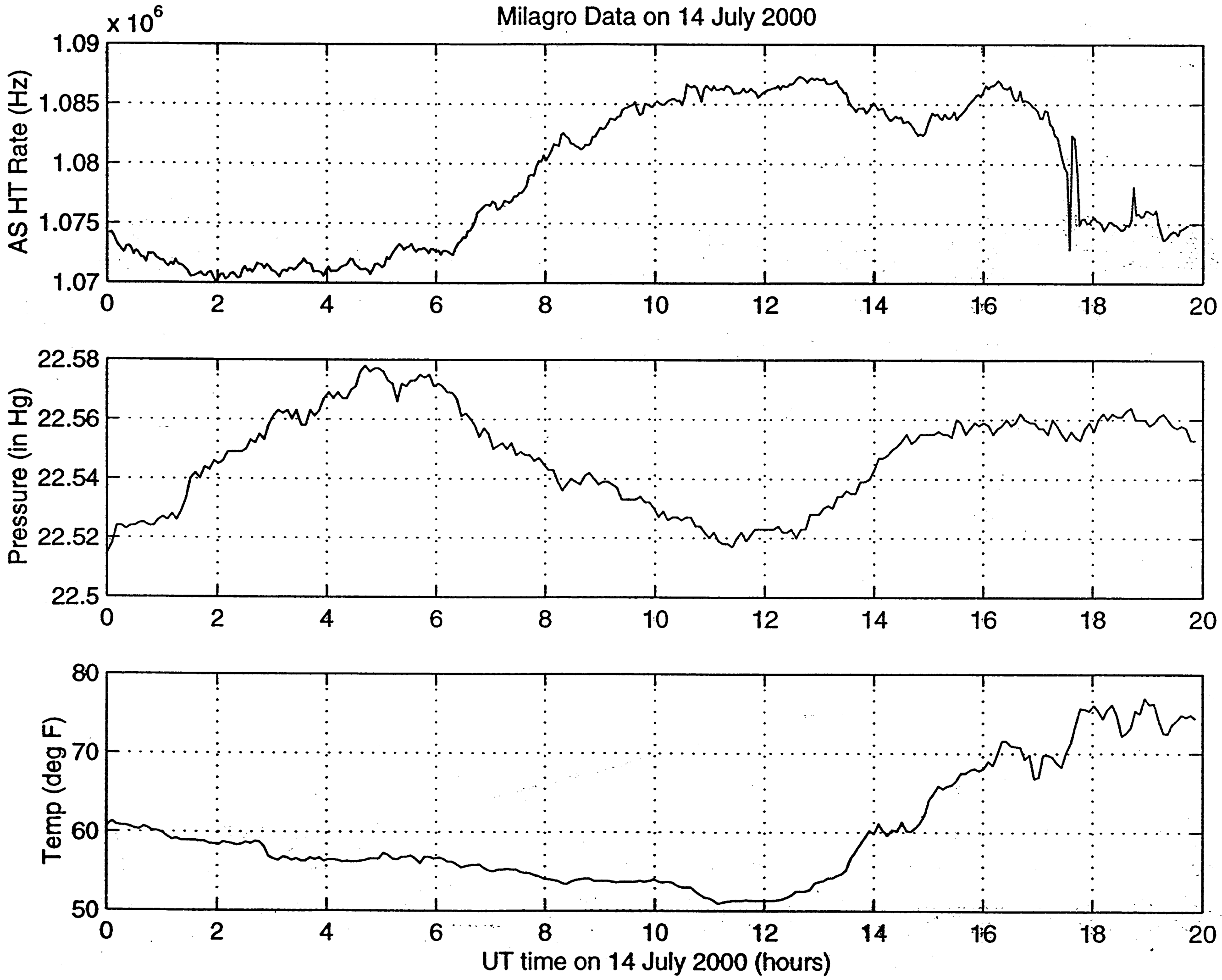
JULY 00 DAYS 1 → 17
HOURLY COUNTS

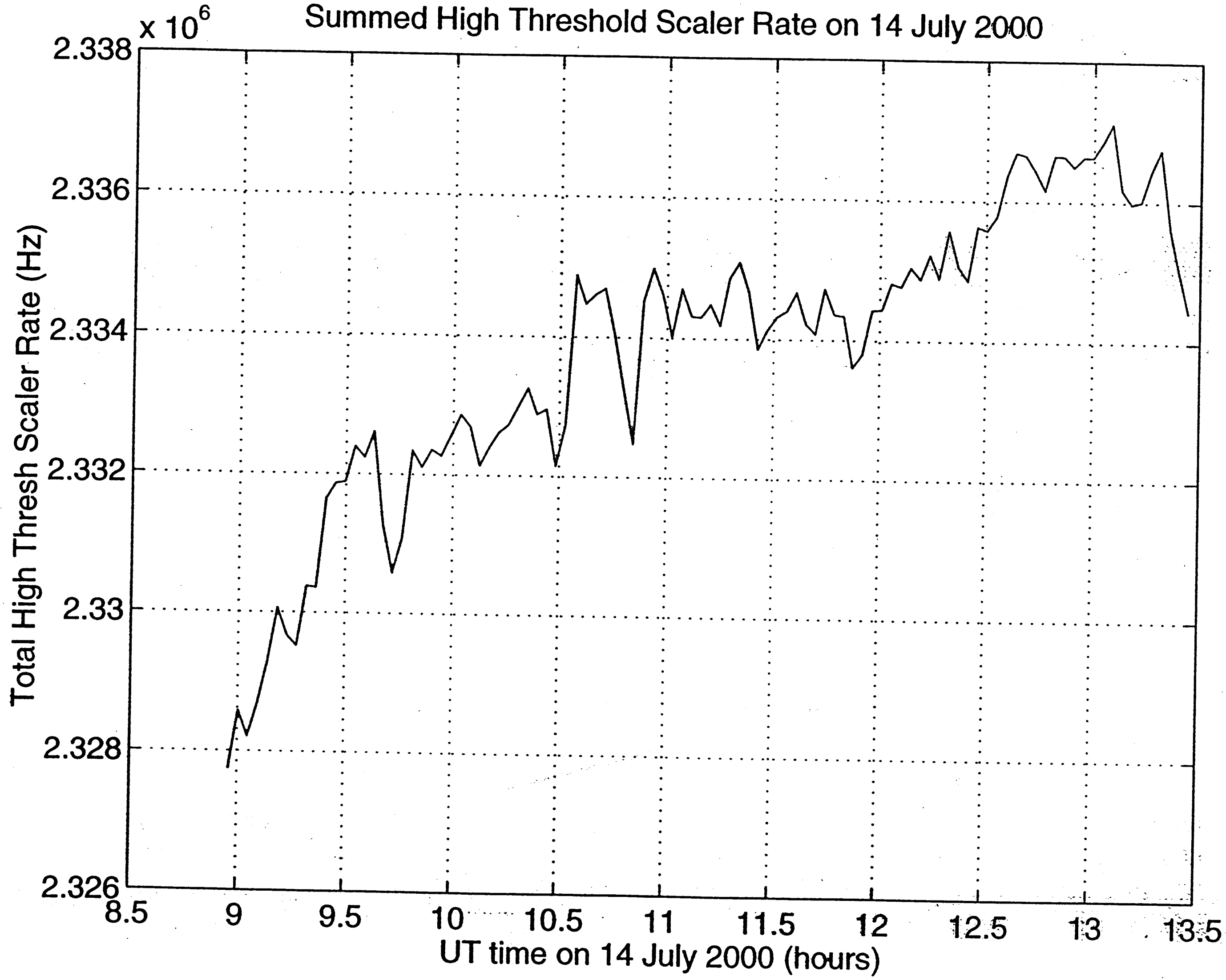



Air Shower High Threshold Scaler Rate on 14 July 2000
x 10^6
1.088
1.086
1.084
1.082
1.08
1.078
1.076
1.074
1.072
1.07
AS Layer HT Scaler Rate (Hz)
0
2
4
6
8
10
12
14
16
18
20
UT time on 14 July 2000 (hours)

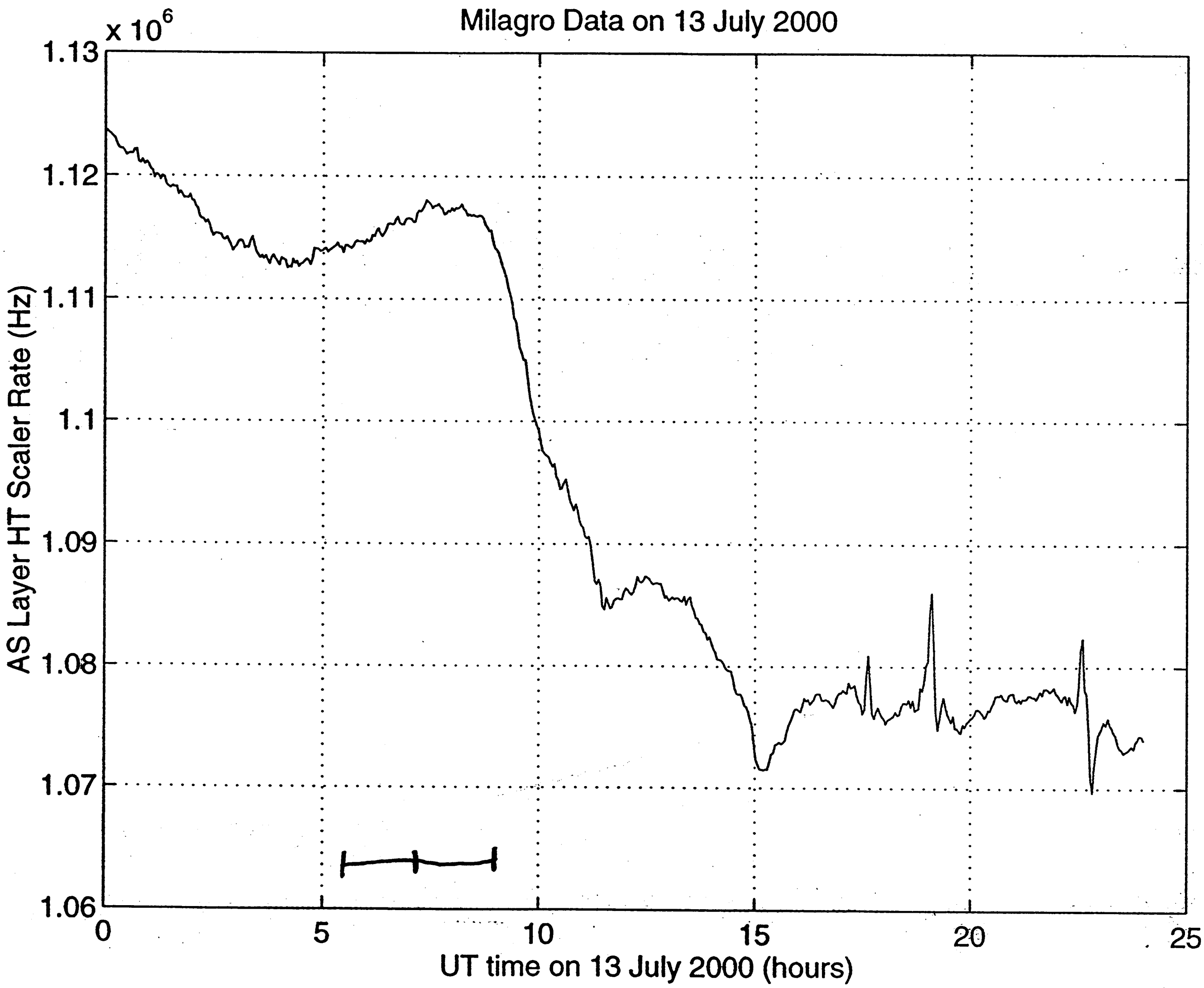


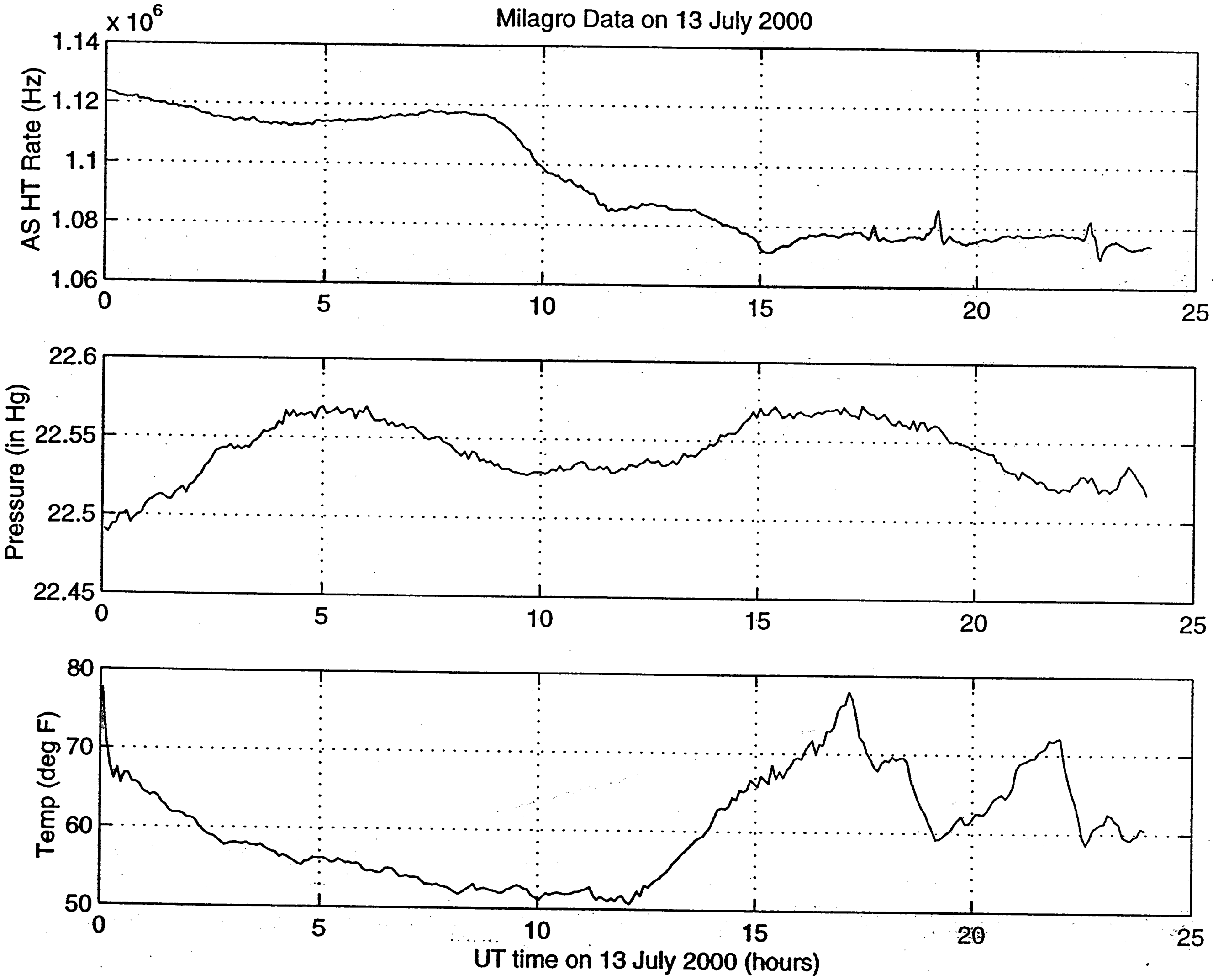
High Threshold Scaler Rates on 14 July 2000
x 10^6
1.088
1.087
1.086
1.085
1.084
1.083
AS Layer HT Scaler Rate (Hz)
9
9.5
10
10.5
11
11.5
12
12.5
13
13.5
x 10^6
1.25
1.249
1.248
1.247
1.246
1.245
Muon Layer HT Scaler Rate (Hz)
9
9.5
10
10.5
11
11.5
12
12.5
13
13.5
UT time on 14 July 2000 (hours)


Milagro Data on 14 July 2000
x 10^6
AS HT Rate (Hz)
1.09
1.085
1.08
1.075
1.07
Pressure (in Hg)
22.58
22.56
22.54
22.52
22.5
Temp (deg F)
80
70
60
50
0
2
4
6
8
10
12
14
16
18
20
UT time on 14 July 2000 (hours)

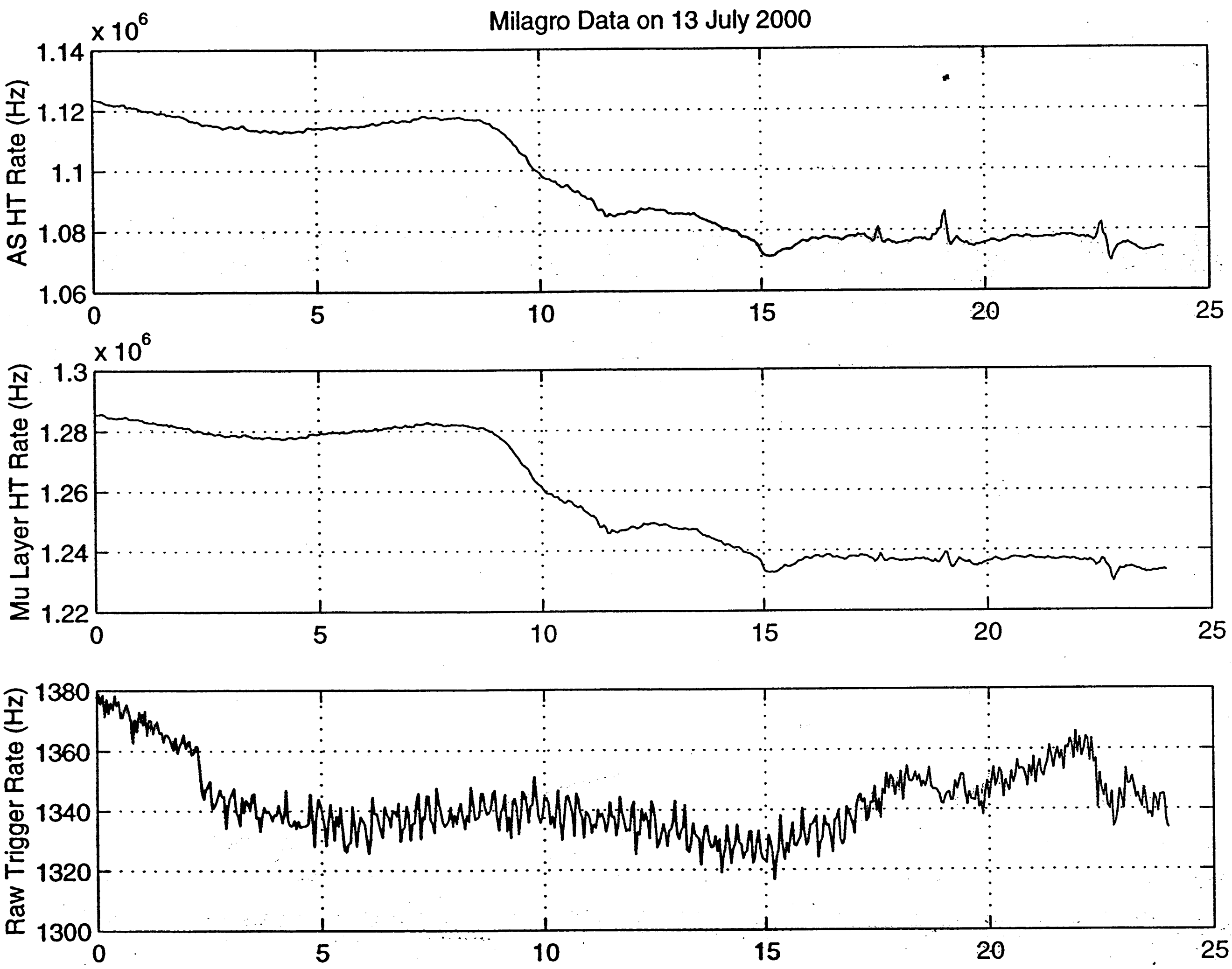


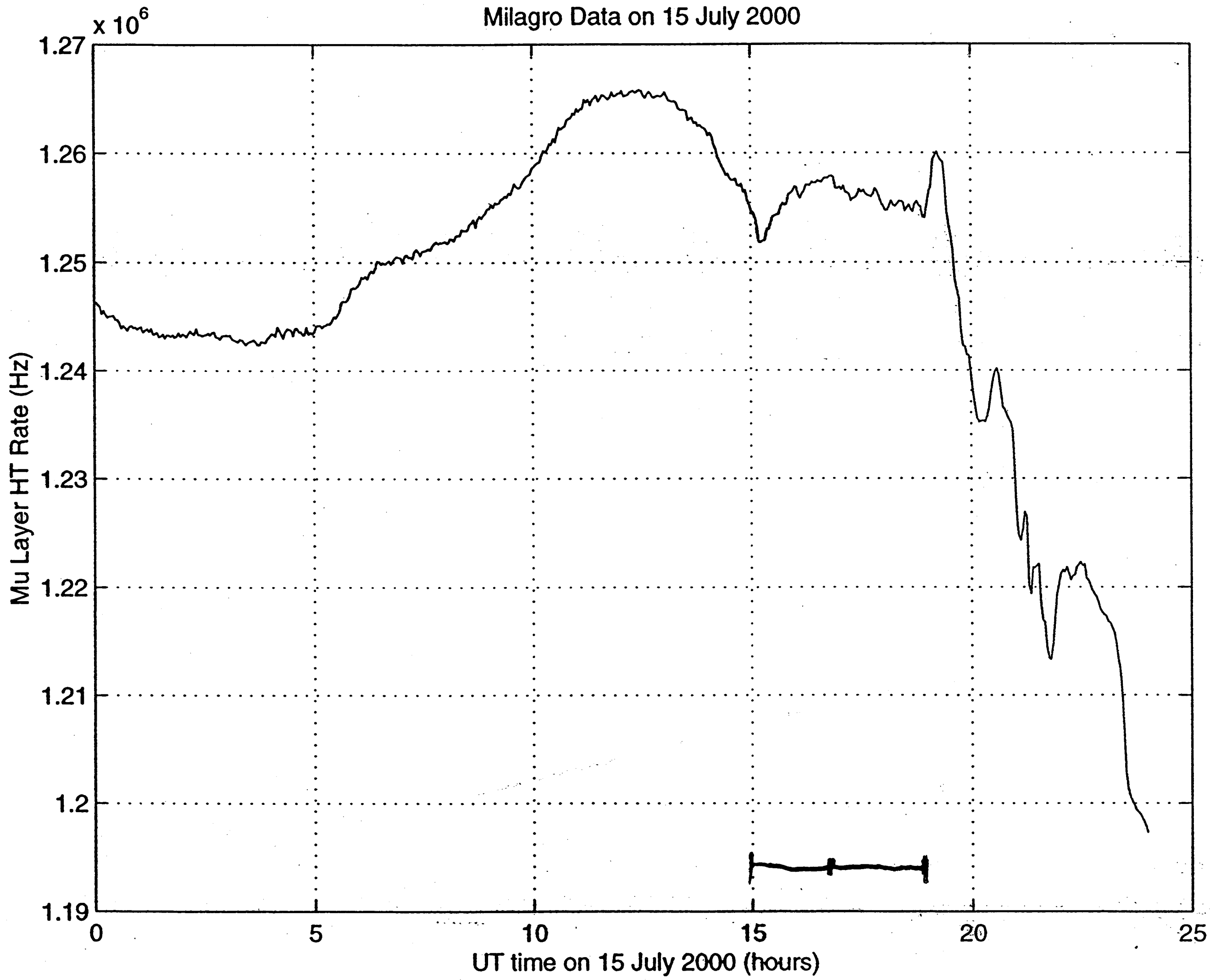
Summed High Threshold Scaler Rate on 14 July 2000
x 10^6
2.338
2.336
2.334
2.332
2.33
2.328
2.326
Total High Thresh Scaler Rate (Hz)
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
13.5
UT time on 14 July 2000 (hours)

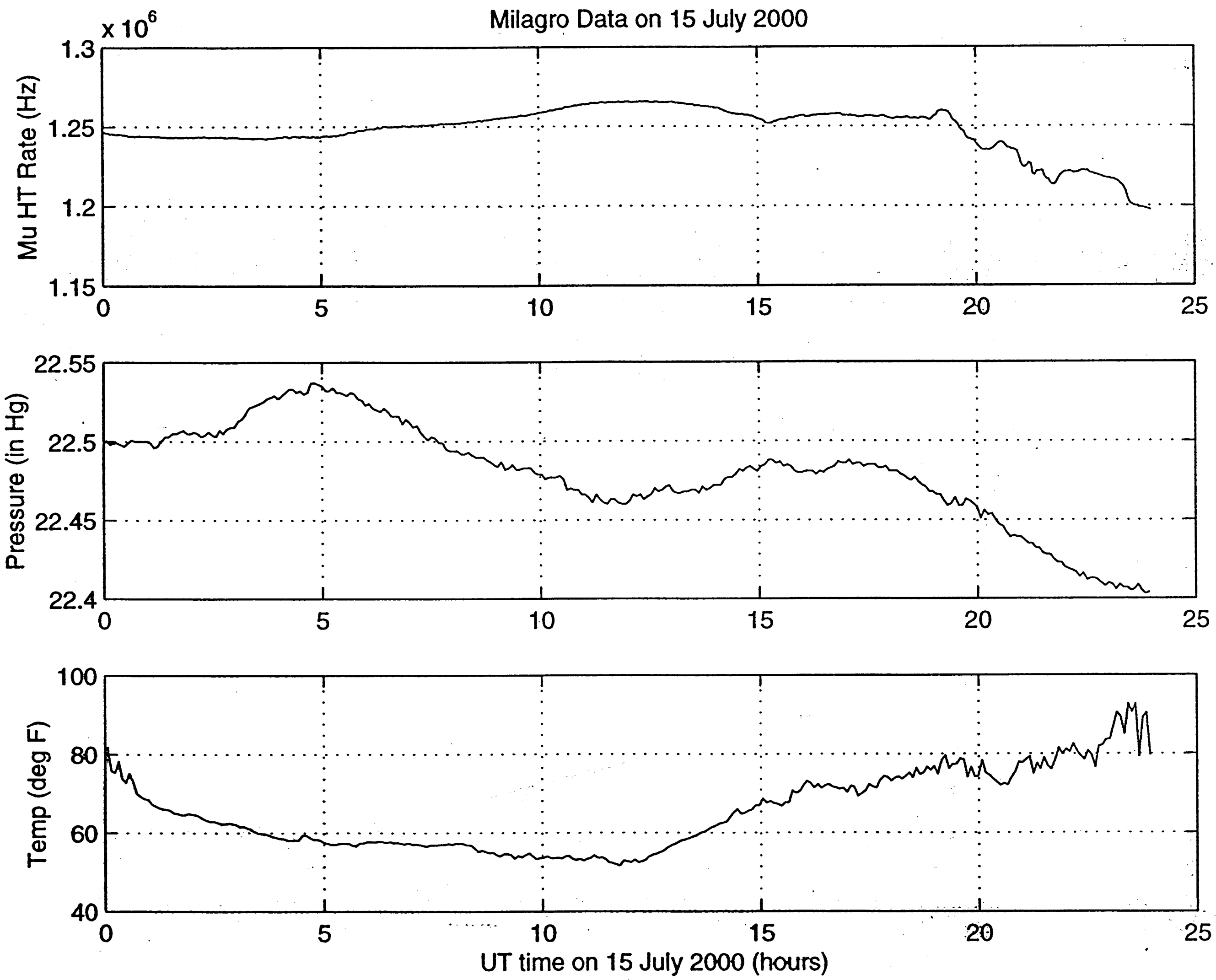

Milagro Data on 13 July 2000
x 10^6
1.13
1.12
1.11
1.1
1.09
1.08
1.07
1.06
AS Layer HT Scaler Rate (Hz)
0
5
10
15
20
25
UT time on 13 July 2000 (hours)



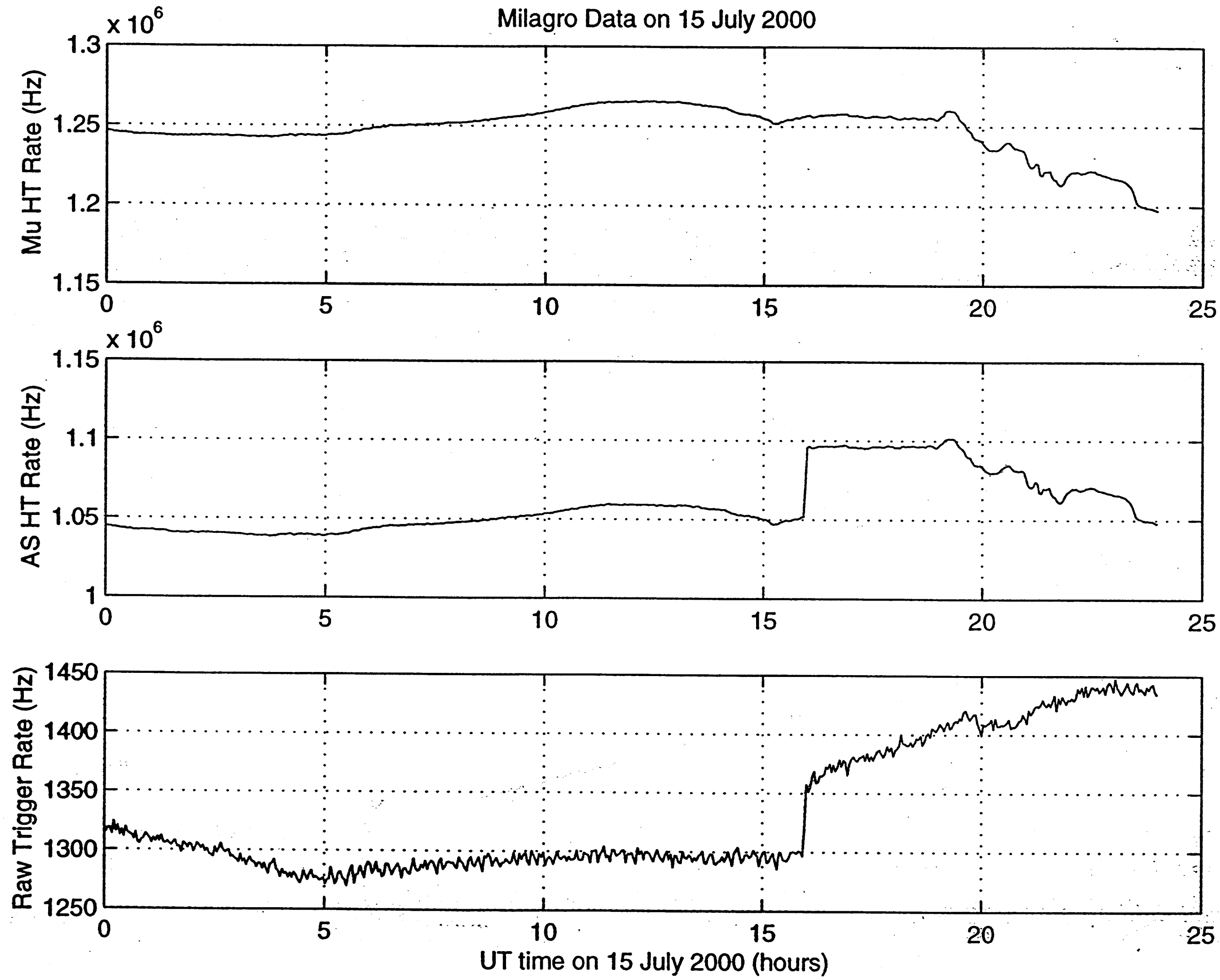
Milagro Data on 13 July 2000
x 10^6
AS HT Rate (Hz)
1.14
1.12
1.1
1.08
1.06
0
5
10
15
20
25
Pressure (in Hg)
22.6
22.55
22.5
22.45
Temp (deg F)
80
70
60
50
UT time on 13 July 2000 (hours)


Milagro Data on 13 July 2000
x 10^6
AS HT Rate (Hz)
1.14
1.12
1.1
1.08
1.06
0
5
10
15
20
25
x 10^6
Mu Layer HT Rate (Hz)
1.3
1.28
1.26
1.24
1.22
Raw Trigger Rate (Hz)
1380
1360
1340
1320
1300

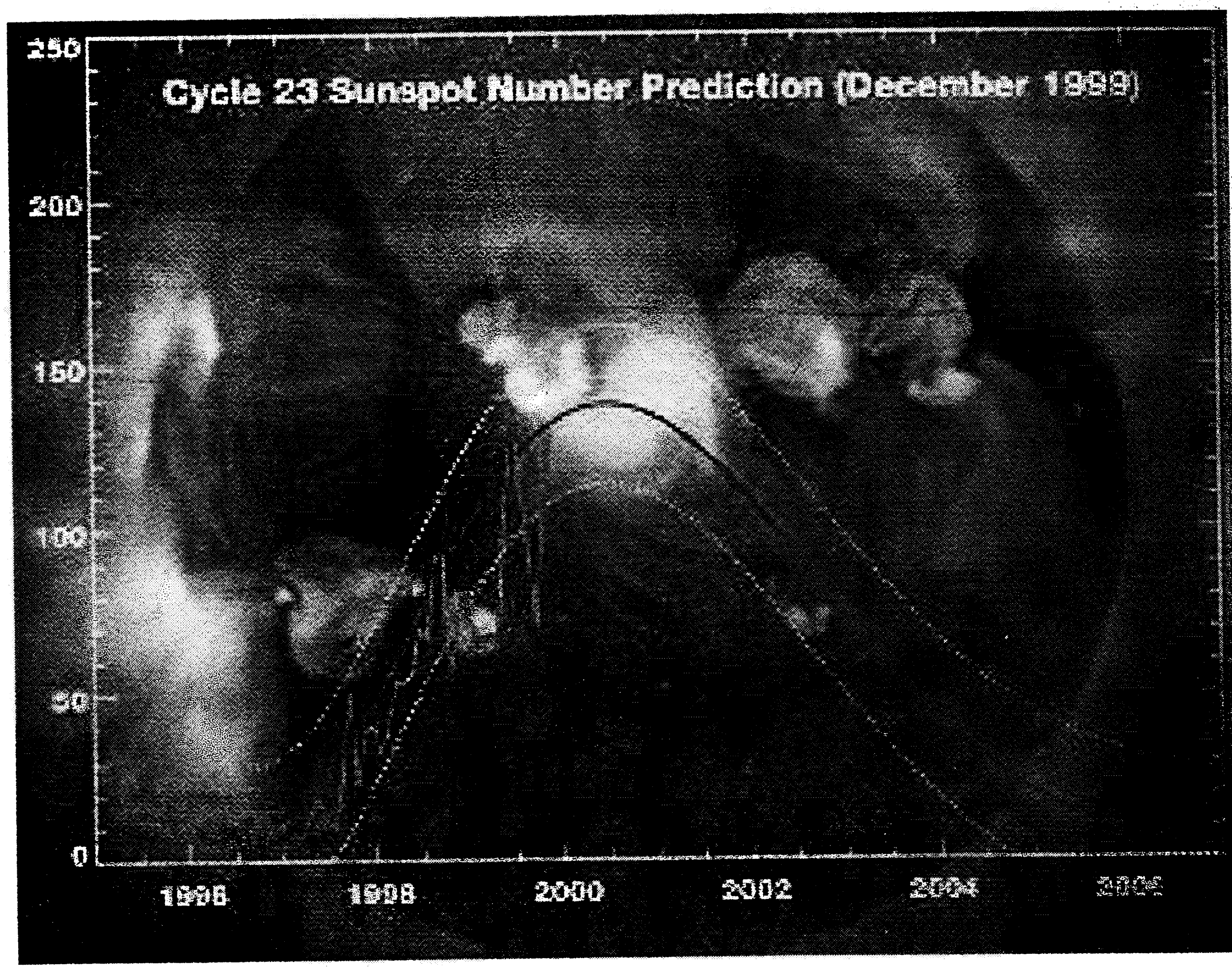

Milagro Data on 15 July 2000
x 10^6
1.27
1.26
1.25
1.24
1.23
1.22
1.21
1.2
1.19
Mu Layer HT Rate (Hz)
0
5
10
15
20
25
UT time on 15 July 2000 (hours)



Milagro Data on 15 July 2000
x 10^6
1.3
1.25
1.2
1.15
Mu HT Rate (Hz)
0
5
10
15
20
25
22.55
22.5
22.45
22.4
Pressure (in Hg)
0
5
10
15
20
25
100
80
60
40
Temp (deg F)
0
5
10
15
20
25
UT time on 15 July 2000 (hours)



Milagro Data on 15 July 2000
x 10^6
Mu HT Rate (Hz)
1.3
1.25
1.2
1.15
0
5
10
15
20
25
x 10^6
AS HT Rate (Hz)
1.15
1.1
1.05
1
0
5
10
15
20
25
Raw Trigger Rate (Hz)
1450
1400
1350
1300
1250
0
5
10
15
20
25
UT time on 15 July 2000 (hours)


Cycle 23 Sunspot Number Prediction (December 1999)
250
200
150
100
50
0
1996
1998
2000
2002
2004
2006

IPN Bursts:

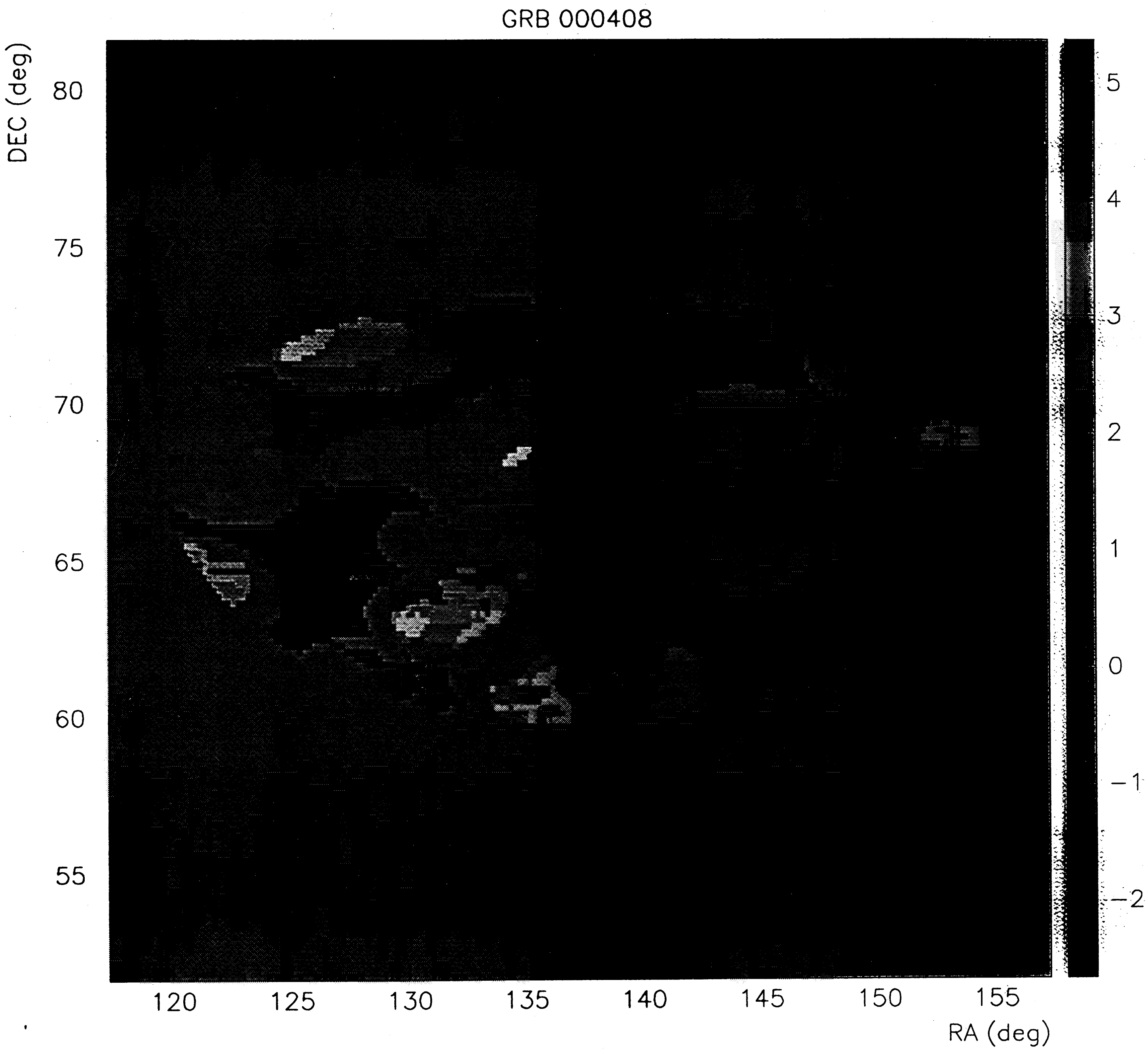
Preliminary search only

Used all bursts with a zenith < 45 degrees.

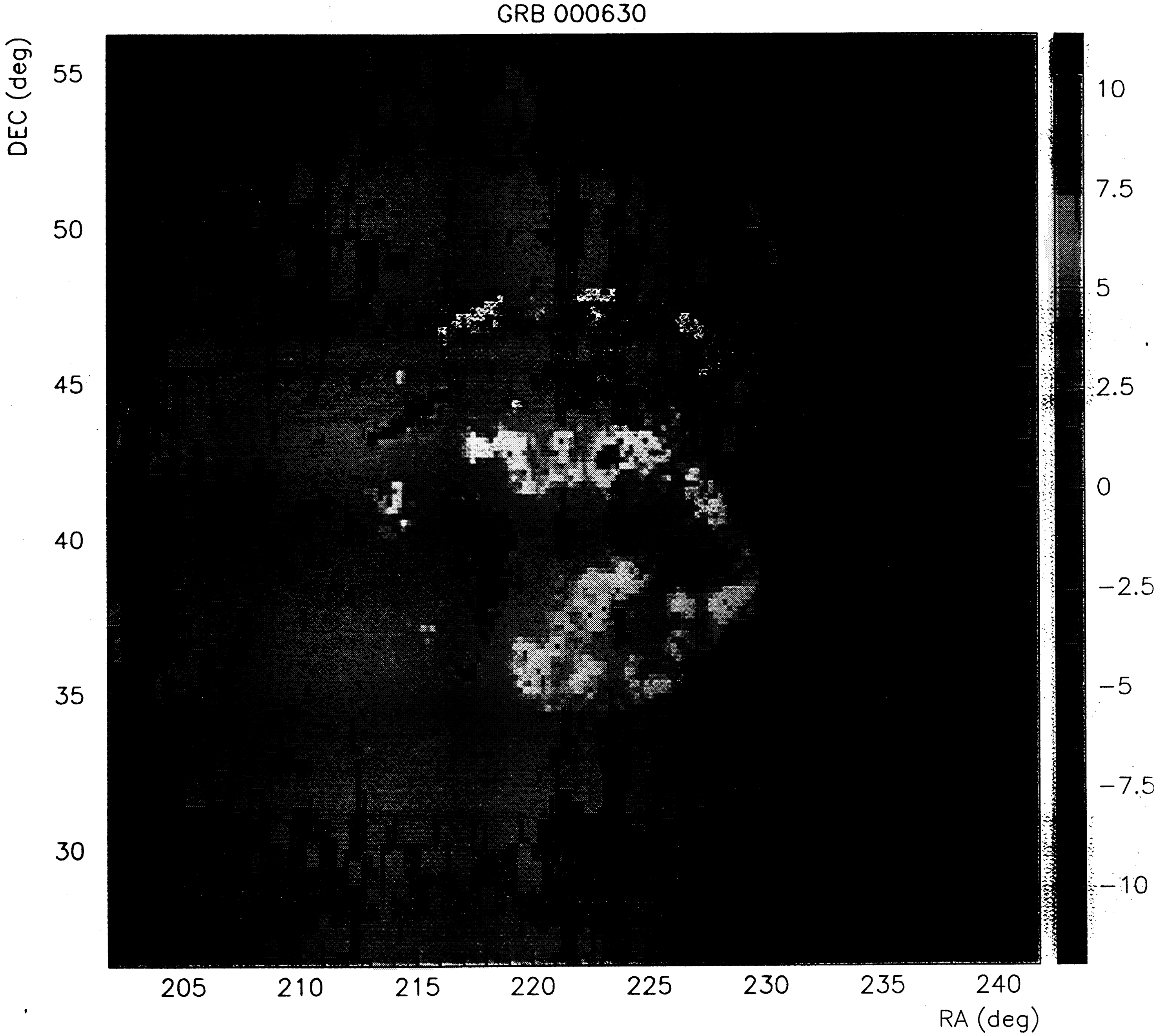
Found ~10 bursts that met this condition.

Burst 000408 has BATSE ID# 8069.

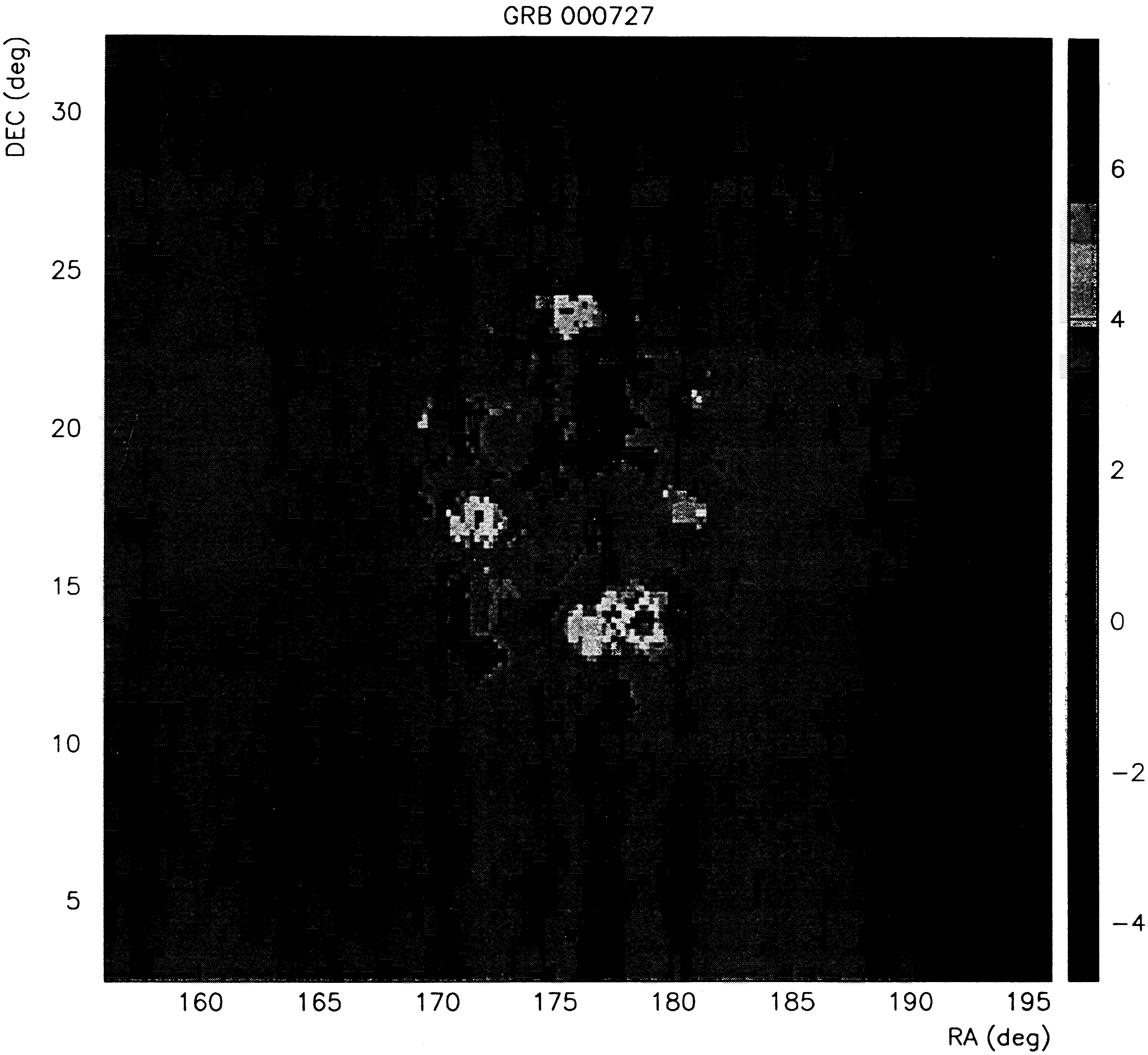
Burst 000323 has BATSE ID# 8049.

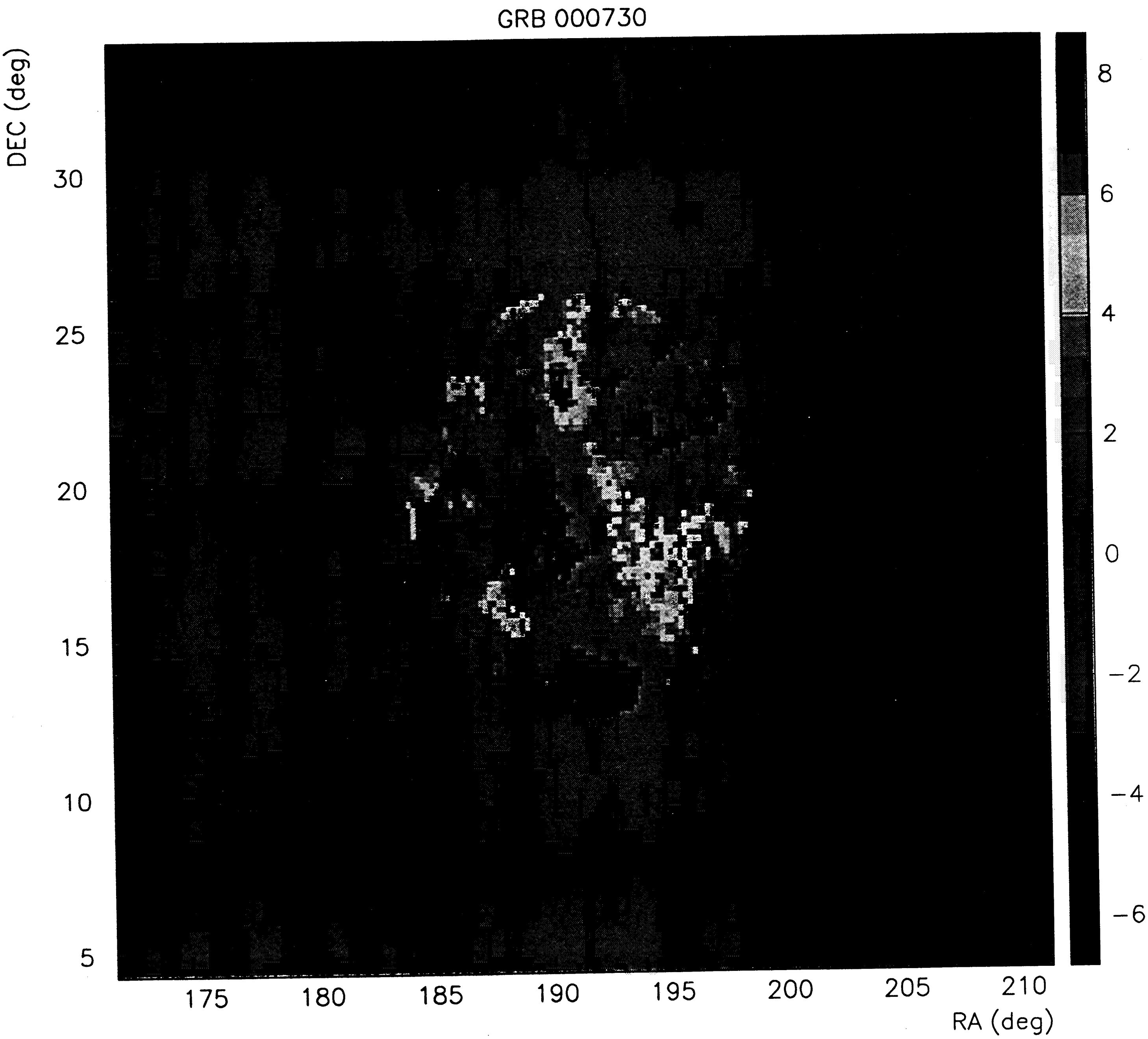


BATSE ID # 8069



GRB 000630
DEC (deg)
55
50
45
40
35
30
205
210
215
220
225
230
235
240
RA (deg)
10
7.5
5
2.5
0
−2.5
−5
−7.5
−10

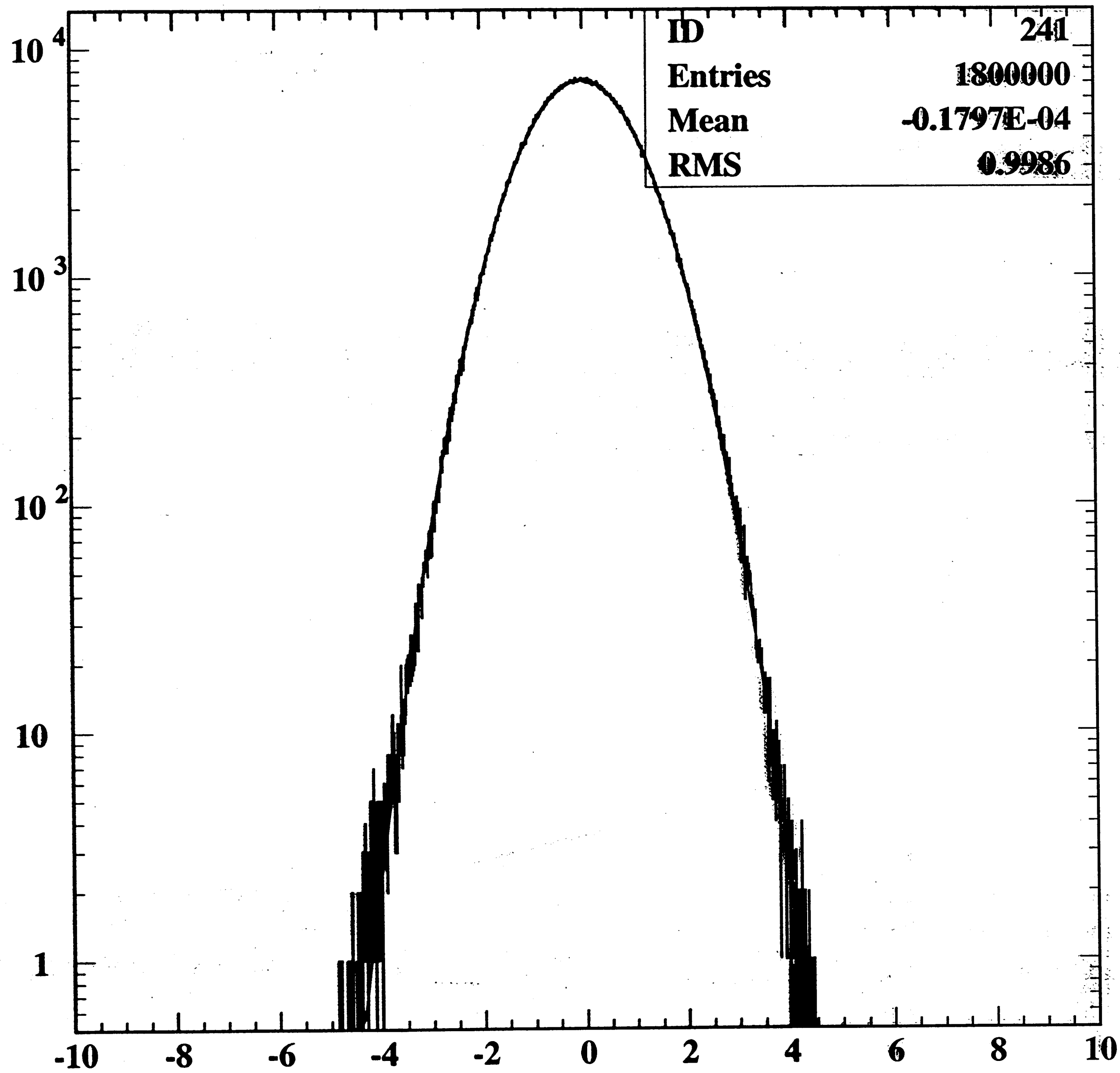

GRB 000727
DEC (deg)
30
25
20
15
10
5
160
165
170
175
180
185
190
195
RA (deg)
6
4
2
0
−2
−4



GRB 000730
DEC (deg)
30
25
20
15
10
5
175
180
185
190
195
200
205
210
RA (deg)
8
6
4
2
0
−2
−4
−6

DC - 30B events

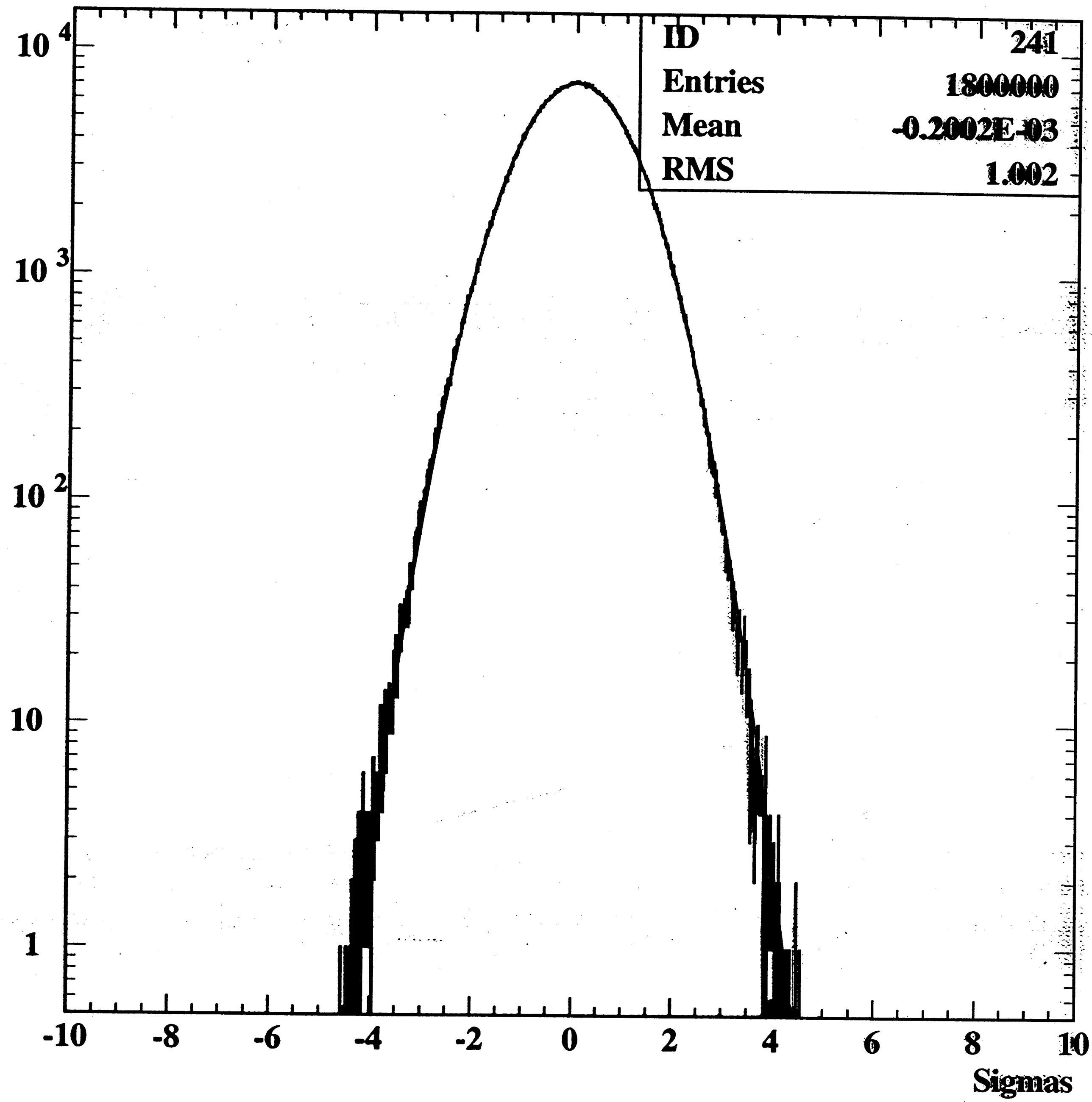
Allsky - All Milagro Data: NFIT≥20, 2.1 deg square bin



$10^\circ \le \delta \le 60^\circ$

DC - 30B events

Allsky - All Milagro Data: NFIT≥80, 1.7 deg square bin



$10^\circ \leq \delta \leq 60^\circ$

Searching for GRBs in Milagro Data

- The death of CGRO makes it clear that "blind" GRB searches are our only hope of seeing another GRB.

- To date, only a few timescales have been searched in Grito data. The searches have been computationally costly.

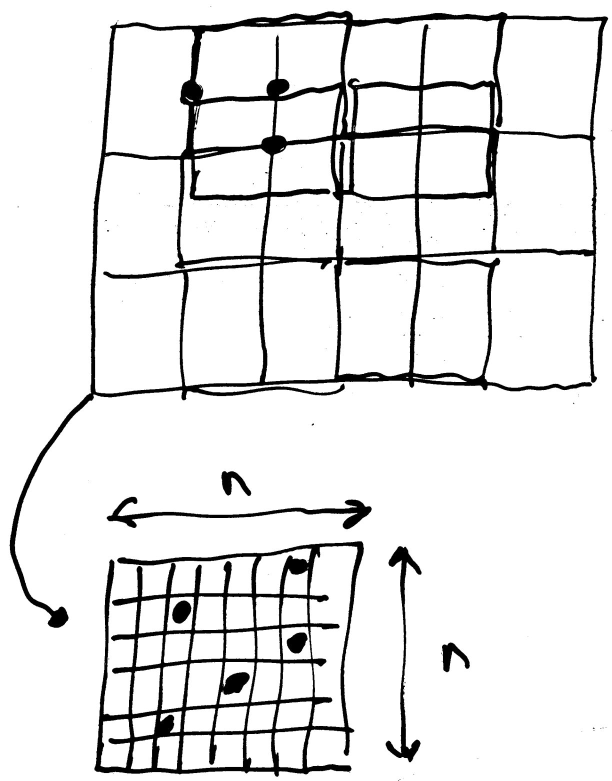
- Gus's estimation of the sensitivity of the 10s search to bursts of unknown start time and location showed substantial loss due to the coursness of the search.

  => "The undersampling of the oversampling..."

- This presentation arises from some ideas I've had on how to increase the speed of searching for excesses. The method (excess over a poison distributed background) is the same as in previous work by Joe and Gus.

Prior Searches

- 50% over sampling in time and space:



Search A candidate posit

At each position, add up nxn small bins.

Single time slice calculation:

$$A \cdot (n \times n)$$

For T timescales: TAn^2

Doing the Search

- Create the Background map:
  - –Compile all events in local coordinate map B(HA,dec).
  - –Normalize the map to the number of events collected in the entire sky for the search duration.

  => really easy and fast.

- Create the Signal map:
  - –Add events collected during presumed GRB duration to fine map (0.2x0.2 deg)
  - –Add up all the small bins in the vicinity of the candidate in signal and background map.

- Searching the Signal map/Background map:
  - –Calculate Poisson prob of getting signal S with background B.

Adding Events to the Signal Map

- Old Method:

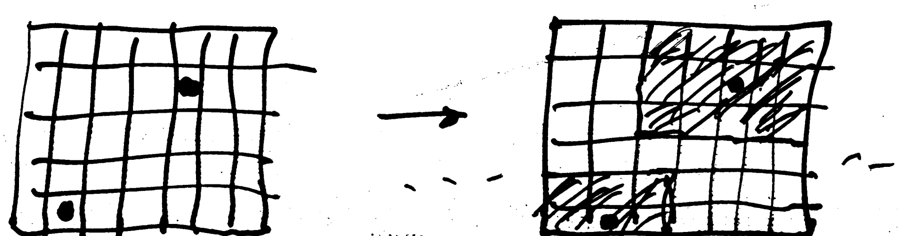
TA (n×n)

Optimal when event density is >1 event/small bin

- My Method:

time scale>.3s: Binned Search:

Add each event to signal map



N = total # event

Summing entire signal map $\propto N n^2$

time scale <.3s: Follow the events (table):

As data added to summed map keep track of all positions with ≥ 2 hits:

>2 hit table

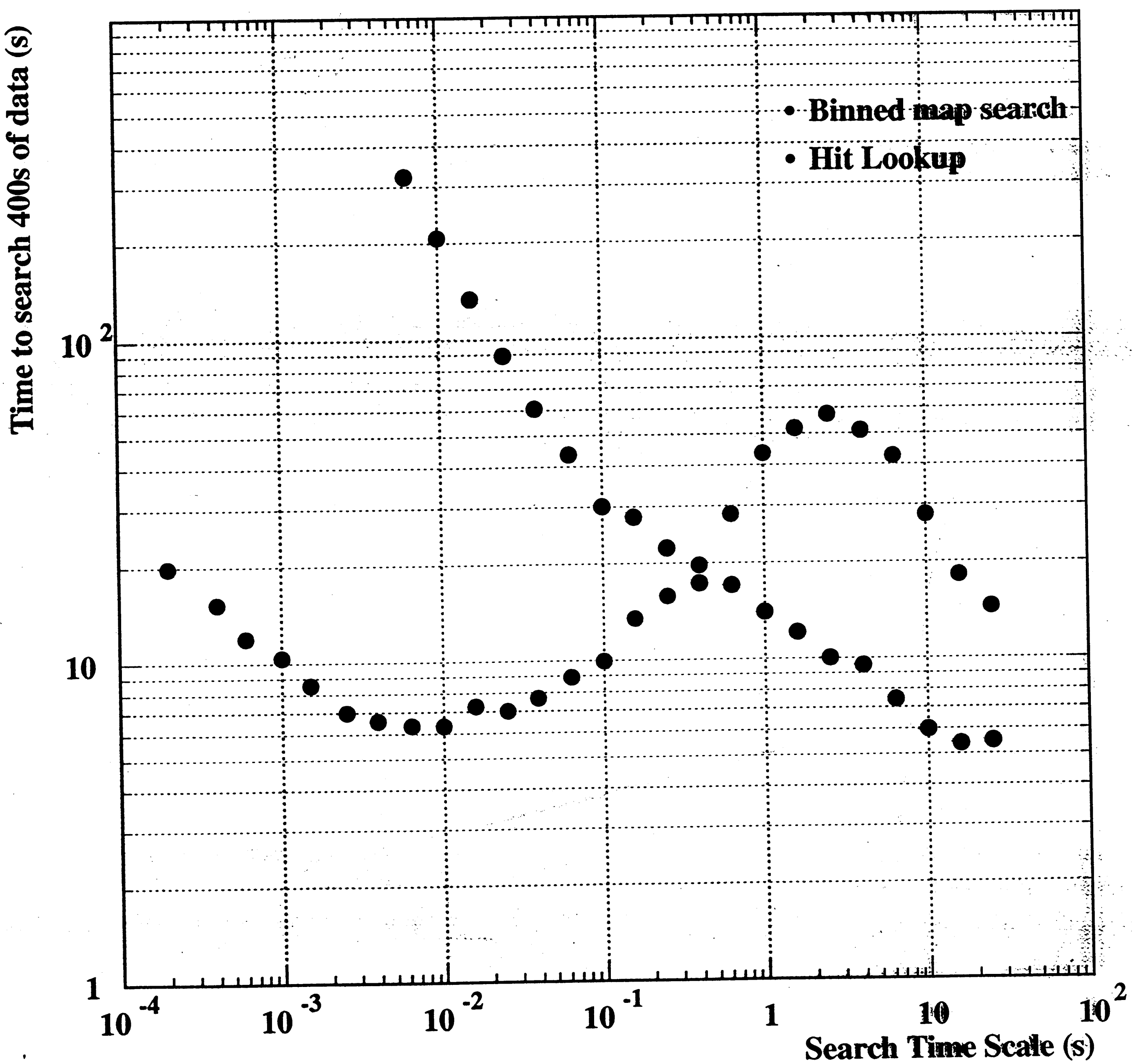
$(i,j)_1$

$(i,j)_2$

⋮

Increasing the Speed

- Look up tables for Poision prob.
- Background converted to integer.
- Copious use of incremented pointers for array searches
- Limit search to zenith angles from 0–45 deg
- Load events into memory and calculate background map and signal map with a single pass.
- Background normalization estimated from allsky rate for 10s centered at the burst time, or the burst duration, whichever is longer.



Binned map search
Hit Lookup
Time to search 400s of data (s)
Search Time Scale (s)
1
10
10^{2}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^{2}

Getting Rid of Bad Events

- End search buffer when a 0.1s time gap or a time reversal is encountered.
- These simple cuts get rid of a host of problems.

A Search of the Milagro Data

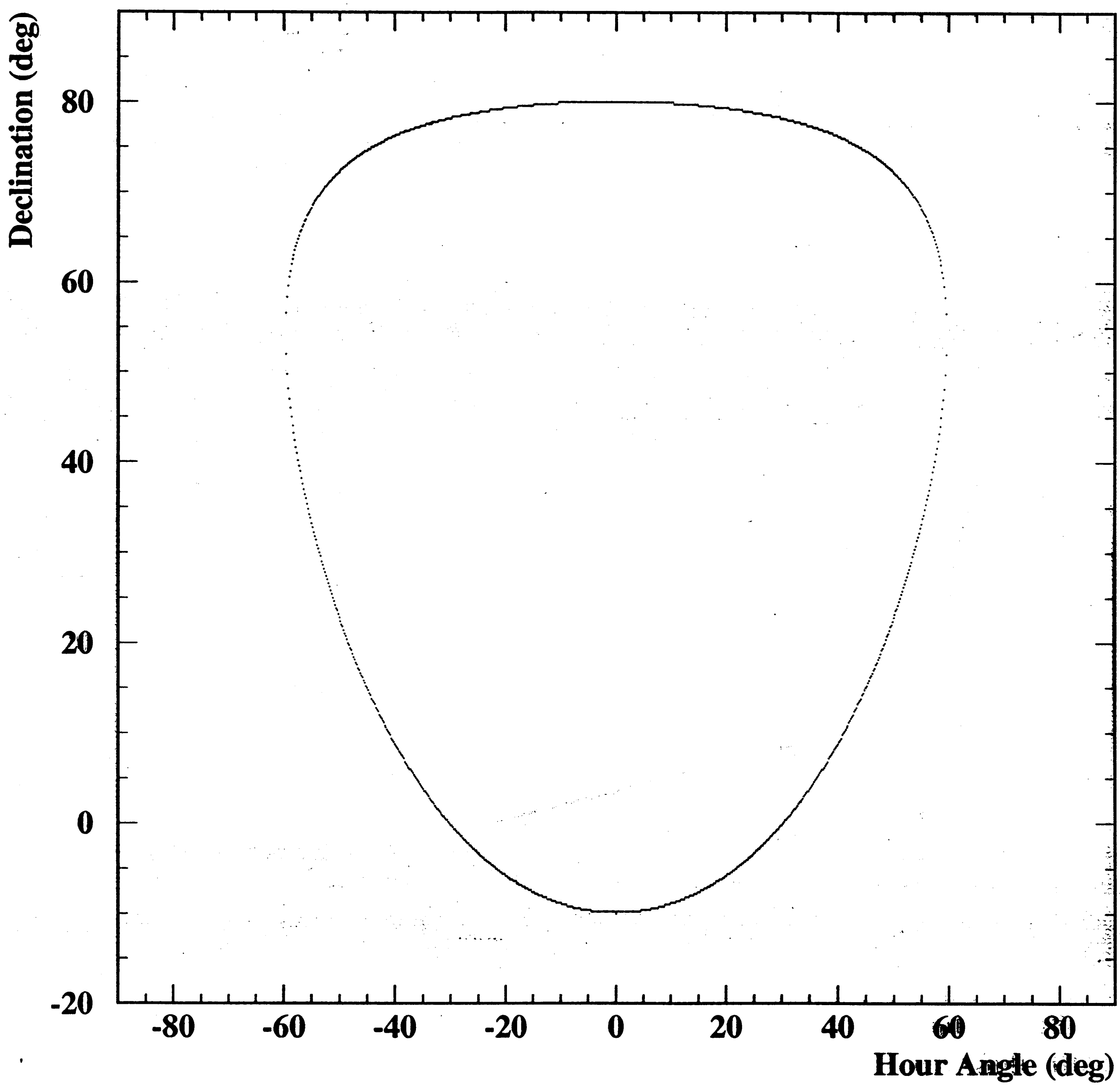
The availible Milagro data (reconstructed online) was searched for GRBs.

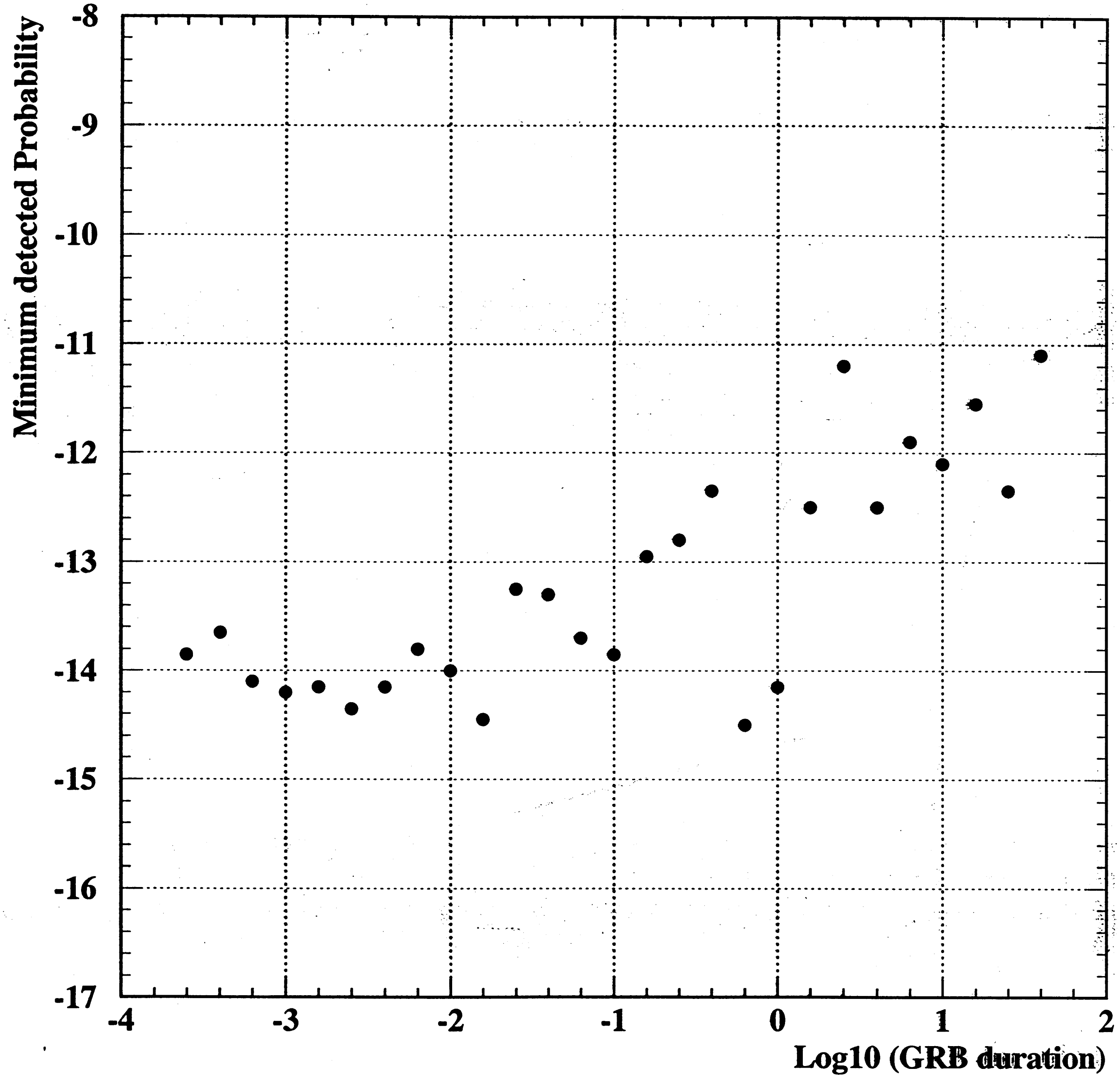
27 time scales from 250us to 39.8s were searched.

–For times < 250us,
number of trials >~ 10**15
~>5 events needed for a signal
readout deadtime for 5 events ~= 150us

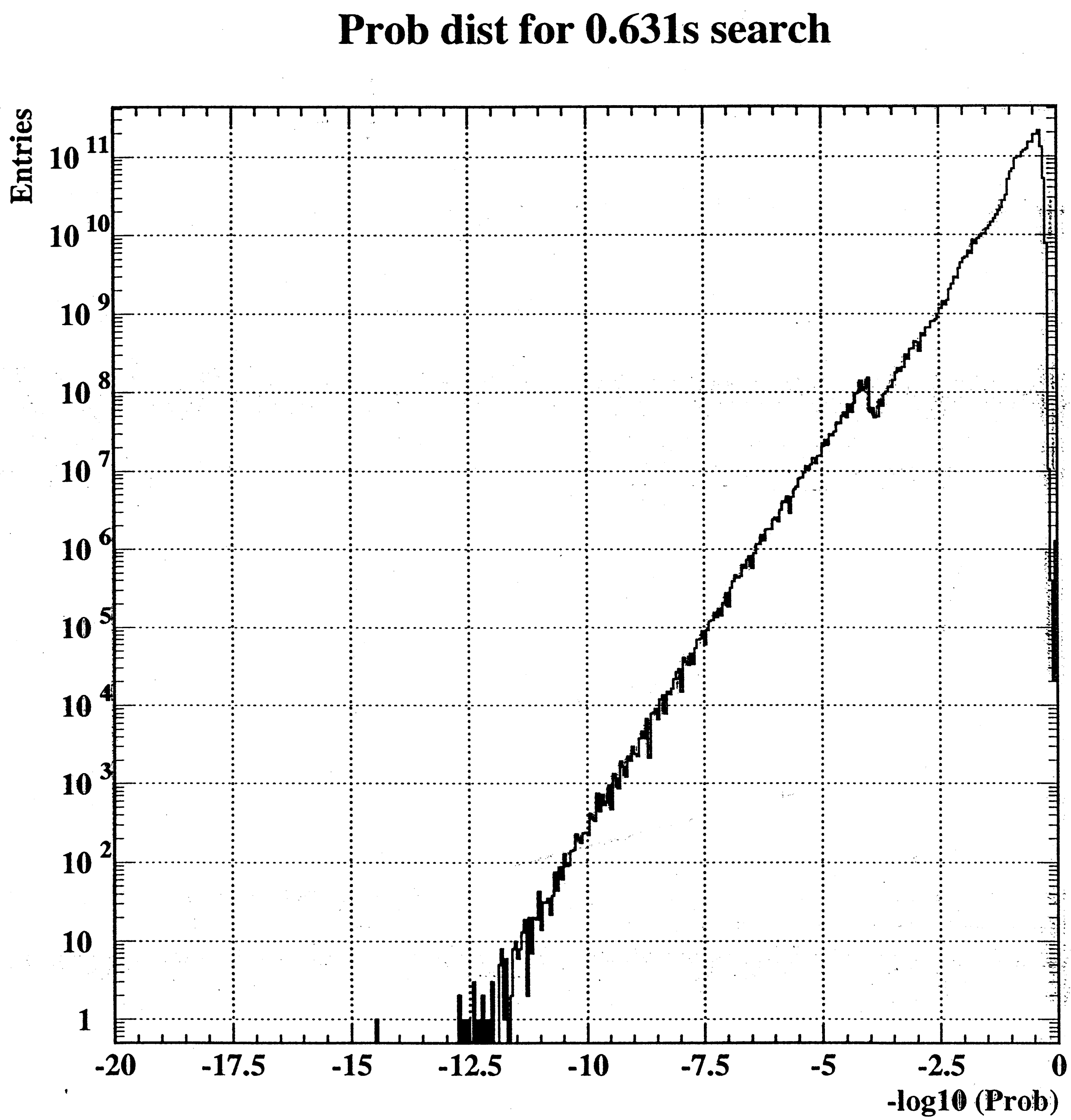
–For times >40s,
The rotation of the earth is important,
so candidate source positions need to
be tracked in (RA,dec).

- The spatial bin separation was 0.2 deg (about 10% of the bin size = 1.8 deg square)
- Temporal oversampling was 10%.
- Total number of sky positions searchded for 250us GRB duration = 200*86400*4000.*10*220000
  = 1.5 x 10**18 trials


Declination (deg)
80
60
40
20
0
-20
-80
-60
-40
-20
0
20
40
60
80
Hour Angle (deg)



Minimum detected Probability
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-4
-3
-2
-1
0
1
2
Log10 (GRB duration)



Prob dist for 0.631s search
Entries
10 11
10 10
10 9
10 8
10 7
10 6
10 5
10 4
10 3
10 2
10
1
-20
-17.5
-15
-12.5
-10
-7.5
-5
-2.5
0
-log10 (Prob)

GRB "Candidate"

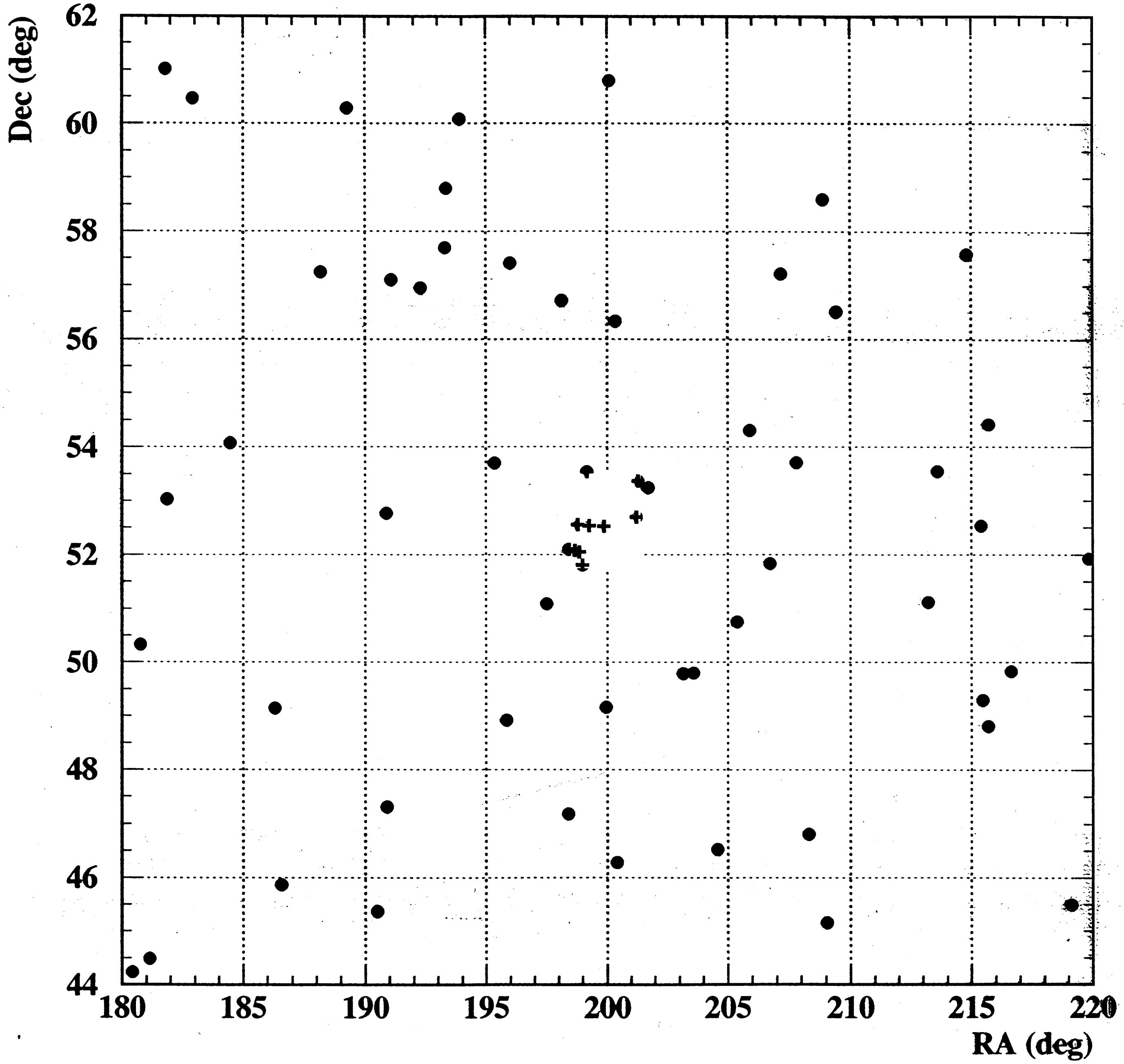
$HA = -9.2^\circ$ $RA = 199.9$

$\delta = 52.6$

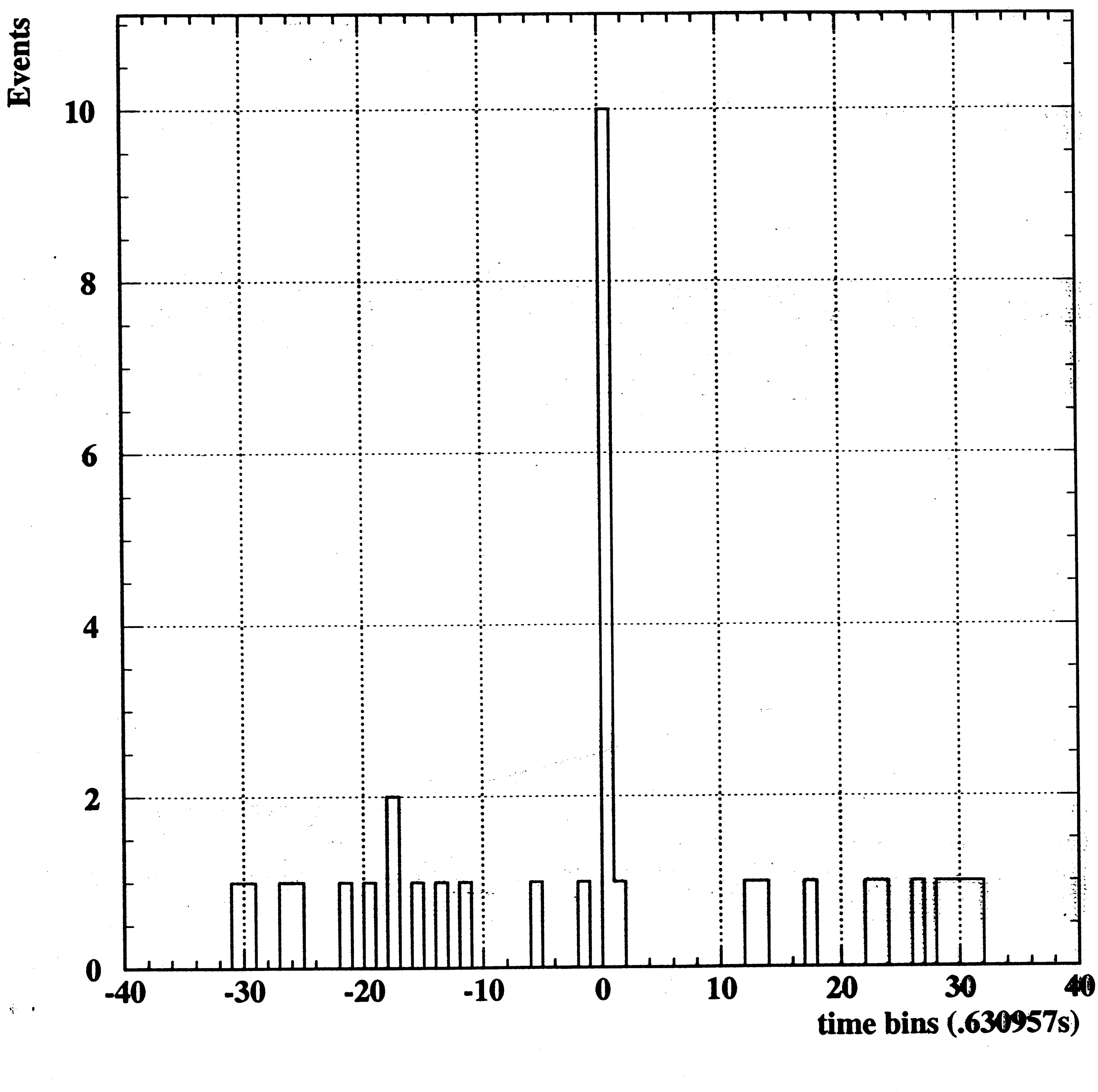
time = 16700.548 MJD = 1692

$\Delta T = 0.630957s$

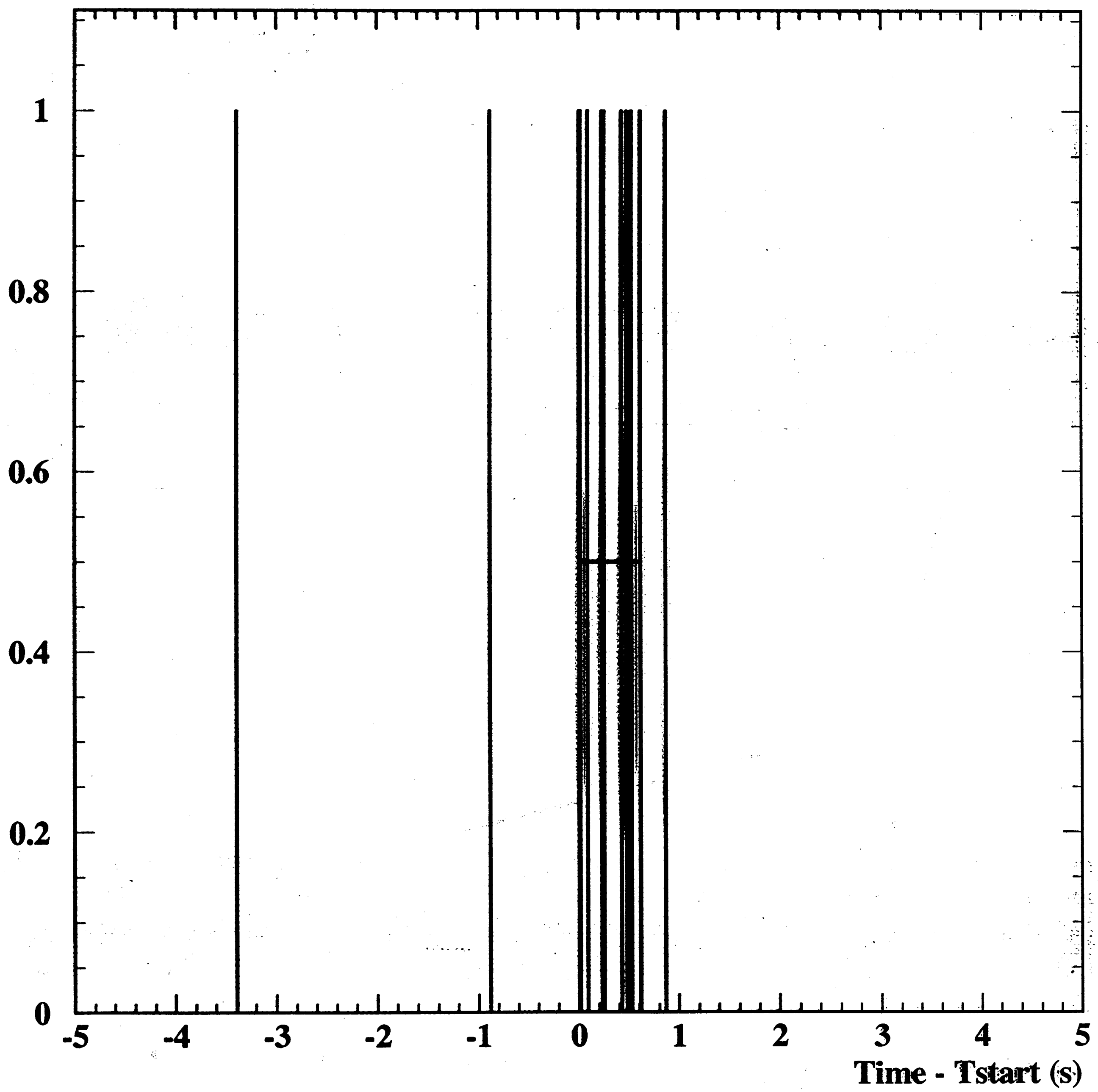
$N_{on} = 10$ back = 0.163 $P_{rob} = 3.2 \times 10^{-15}$



Dec (deg)
62
60
58
56
54
52
50
48
46
44
180
185
190
195
200
205
210
215
220
RA (deg)



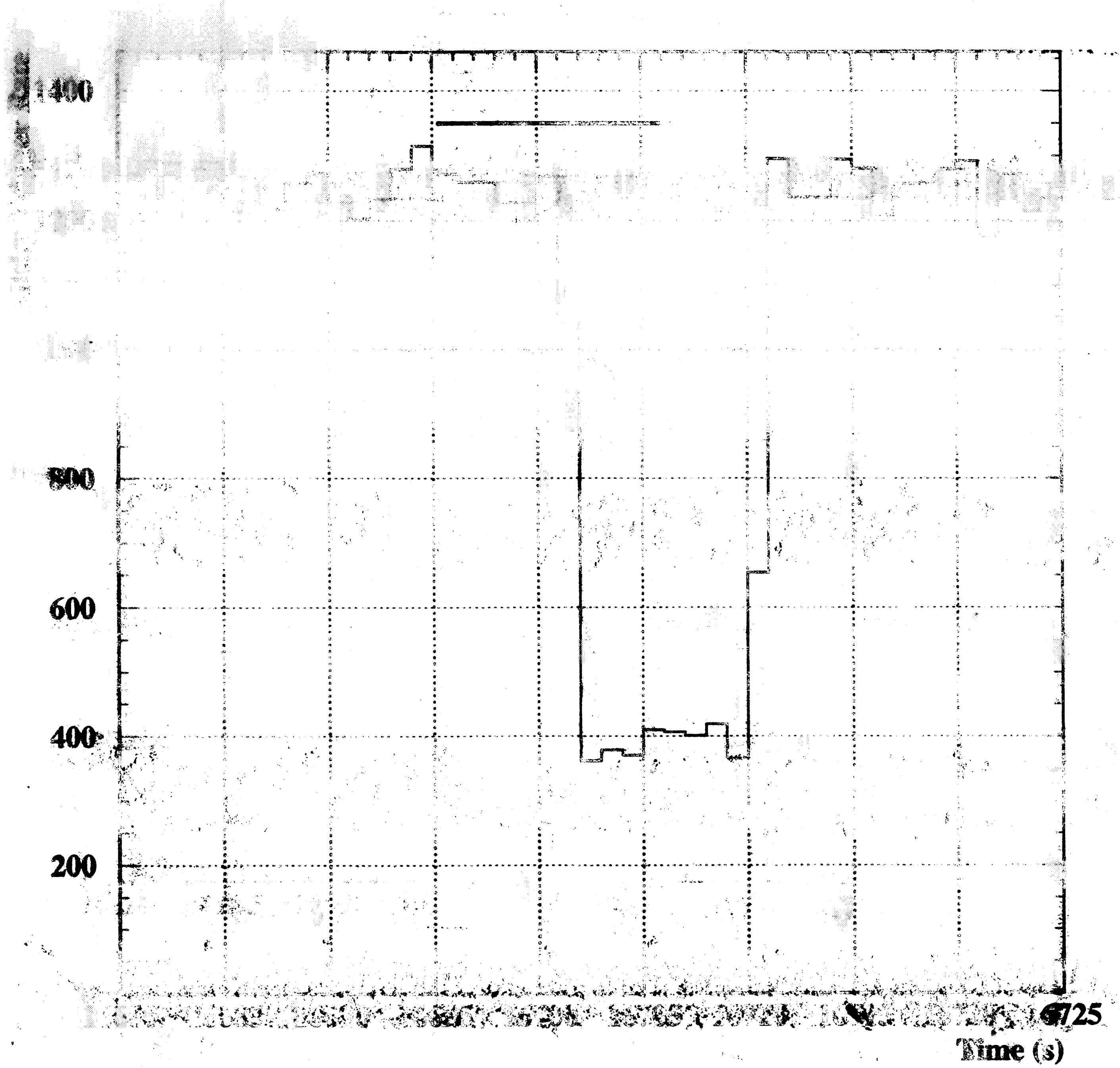
Events
10
8
6
4
2
0
-40
-30
-20
-10
0
10
20
30
40
time bins (.630957s)

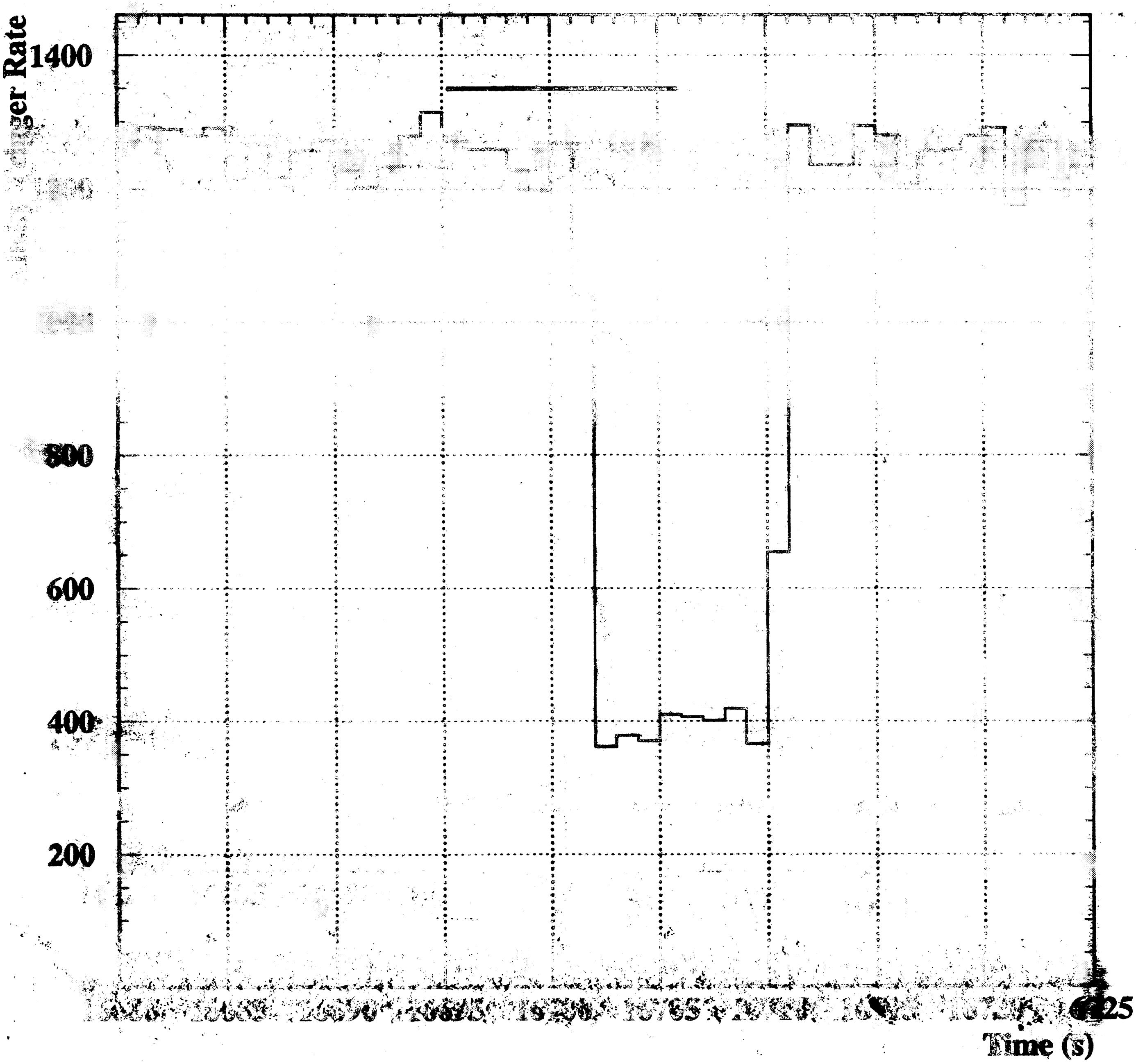

1
0.8
0.6
0.4
0.2
0
-5
-4
-3
-2
-1
0
1
2
3
4
5
Time - Tstart (s)

Candidate GRB Background

0.16 $\longrightarrow$ 0.25 events

	Back	
prob:	.163	3×10^{-15}
	.250	2×10^{-13}


1400
800
600
400
200
6725
Time (s)


1400
800
600
400
200
Time (s)

Candidate GRB Background

0.16 $\rightarrow$ 0.25 events

	Back	
Prob:	.163	3×10^{-15}
	.250	2×10^{-13}

Comment on Trials

if $5\sigma \sim$ Discovery (Prob $< 10^{-7}$)

BATSE/GCN/IPN 50/year

~ 1000 spatial trials.

$\Rightarrow 10^{-7}/50{,}000 \sim \underline{7\sigma}$

For 5σ with 10^{15} trials

$\Rightarrow 10^{-7}/10^{15} \approx 10^{-22}$

$\Rightarrow \lesssim 10\sigma$

Lose only $\sim 40\%$ Flux Sens.

<u>Satt. provides Confirmation!</u>