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PROGRESS REPORT ON DATA PROCESSING IN DUMAND.

by

A. Roberts, Hawaii DUMAND Center

This report will outline the work done on various aspects of data processing in DUMAND during the last year - i.e. since the last DUMAND progress report. In that time we have investigated several different aspects of the problem:

1. Further exploration of variables used for trigger selection.

2. Modification of least-squares fitting program to include information on PMT signal intensities as well as location and timing.

3. Susceptibility of results to increases in backgrounds.

4. Reduction of spurious background tracks. Particular attention has been devoted to this problem.

The objectives of the investigations are to achieve adequate detection efficiency for minimum-ionizing muon tracks, with as economical a module spacing as possible; the achievement of adequate precision in determining track direction (one to two degrees); and demonstration of the ability to operate in the presence of background light from K^{40}, and with the inherent tube noise to be expected in large PMT's like the ones presently contemplated. We are carrying out these investigations for both smart and dumb tubes; it is too early to make a choice between these as yet.

Improving rejection of spurious background tracks retains a high priority in this work. The Monte Carlo program does this job adequately, but requires 0.3 sec or more per trial, with our VAX/780. In real time, we must handle about 10^6 trials per second. The present Monte Carlo program is too slow, by a factor of about 300,000. By using improved programming techniques, an improvement by a factor of 100 or so appears possible; but that still leaves a considerable distance to go. The problem is not yet urgent, but it cannot be avoided.

TRIGGER SELECTION VARIABLES

We recapitulate here the variables presently in use:

MINDET	Minimum no. of detectors required.
NROOS	Minimum number of Roos pairs required.
NTMIN	Minimum signal required in one member of Roos pair to be acceptable.
THRES	Minimum signal intensity to trigger a single module.
NKT	Minimum number of strings required.

We have further explored the multi-dimensional space determined by these variables, which are not all independent. Thus if NROOS = 3, there must be at least six detectors fired, making the minimum value for MINDET 6 if all pairs are to be retained.

In addition, since Roos pairs constitute the largest part of the triggered modules, the value of THRES now plays a relatively minor role. The number of strings, NKT, is important primarily for nearly vertical tracks, to make sure that they are properly treated. Thus, the first three variables are the most important ones.

We have explored varying NTMIN fairly thoroughly now; previously it had been left at 2, the minimum value needed to give significant data. Raising NTMIN has effects similar to increasing NROOS, but rather different effects on background and efficiency (see Fig. 1.)

SUSCEPTIBILITY TO BACKGROUND NOISE.

Most calculations to date have been carried out with simulated backgrounds due to K^{40} and inherent tube noise. Fig. 2 shows the effect of varying these separately, with the K^{40} rate as high as 200K/sec, and for noise rates as high as 20 kHz. We have plotted only the deterioration in track detection efficiency; there is a corresponding loss of angular resolution. Neither have we shown the spurious track rate, which increases sharply as backgrounds increase.

IMPROVING BACKGROUND REJECTION.

The rejection of background includes a least-squares minimization routine that gives the final "time" fit. The function to be minimized, which once included data on intensities as well as deviations from the expected time values, has for a long time treated only the time fit.

We have now reintroduced intensity data, in a somewhat different way, into the least-squares fit. The present algorithm minimizes the product of a time function and an intensity function. The intensity function weights each point according to the number of photoelectrons observed; however, the weighting is not linear with intensity, which weights very close encounters too strongly, but somewhat slower. The weighting function used is arrived at empirically.

The effect of the weighting function has been mixed. It produces a slightly lower efficiency of detection, especially for transverse particles. The improvement in angular accuracy, if any, is slight (see Fig. 3.) However, it has a more pronounced effect on background rejection, which is improved by a factor of about three. See Table 1.

The possibilities for background rejection offered by intensity data have by no means been exhausted. It should be possible to use not only the observed intensity data, but the absence of signals when they should have been observed.

Initial efforts along this line include the introduction of a new subroutine, TRACKTEST, that lists all modules within 50 meters of the track and their response. It does this for the original track and for the reconstructed one. It turns out that rather small changes of position or direction of a track can lead to marked changes in the intensities. For a 500-m track, a 10-mr change of direction moves the bottom end 5m., enough to make large differences in signal intensity in many cases. Thus, in principle, fitting tracks with intensity data should result in extremely good angular accuracy. As yet, we have not made serious efforts in this direction.

TABLE 1.

BACKGROUND REJECTION WITH AND WITHOUT INTENSITY DATA

1. Smart Tubes, Δz = 20m.

INTENSITY?	TRIGGER	BKGD/10^5 CTS
YES	42282	14
NO	42282	50

2. Dumb Tubes, Δz = 25m

INTENSITY?	TRIGGER	BKGD/10^5 CTS
YES	42262	37
NO	42262	75

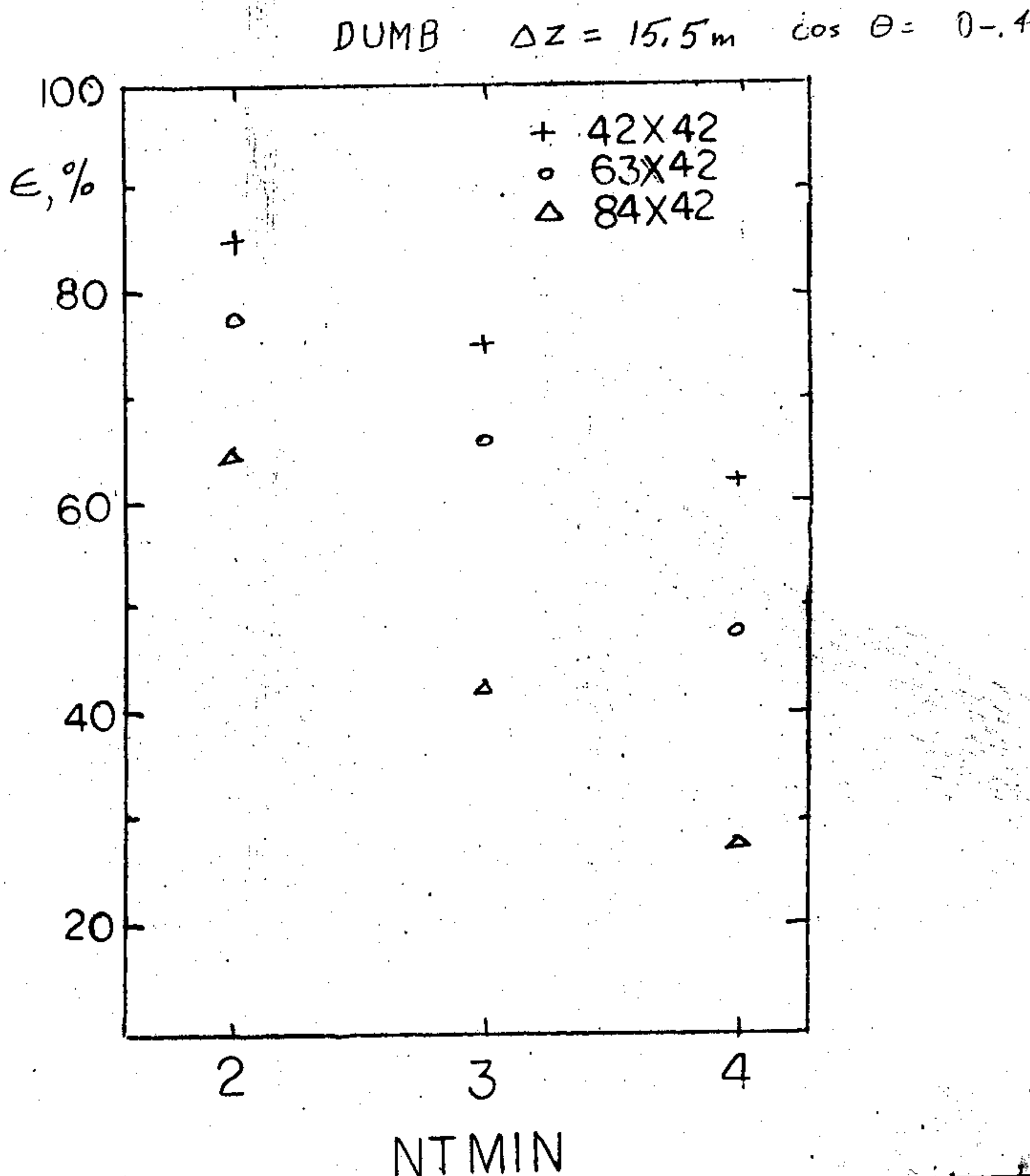

Fig. 1. Effect of varying NTMIN, keeping other parameters fixed. Increasing NTMIN gives more stringent triggering requirements; since adequate background rejection cuts detection efficiency to about 70% at cosθ = 0-.4, the value used for these data, there are three triggering values that can be considered: 44242, 43342, 42442. All give comparable efficiencies.

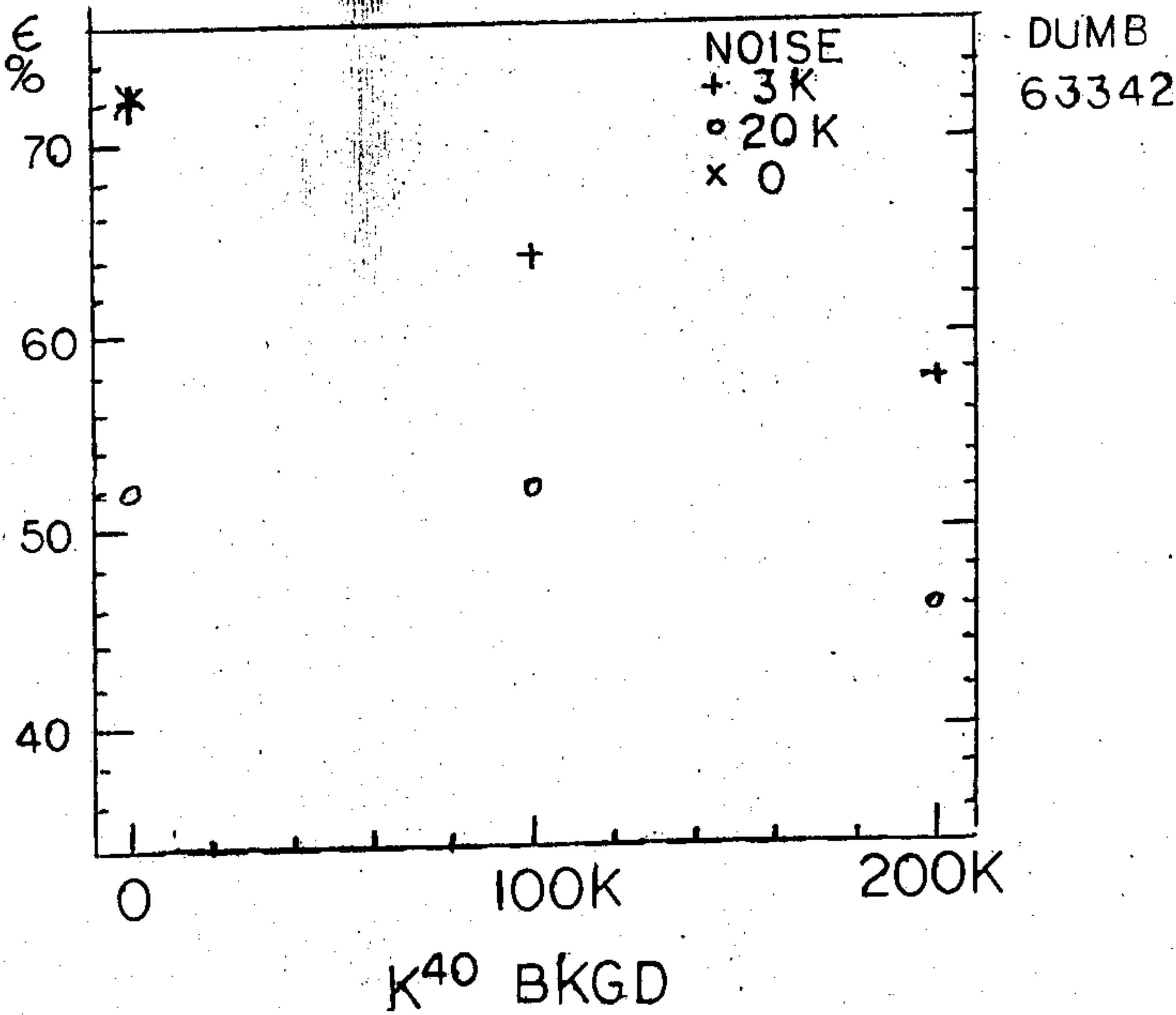

Fig. 2. Effect of varying K40 and tube noise backgrounds on track efficiency. Dumb tubes, trigger 63342, cosθ =.2-.4. K^{40} noise has Polya distribution, tube noise is Poisson with mean of 4.5 photoelectrons.

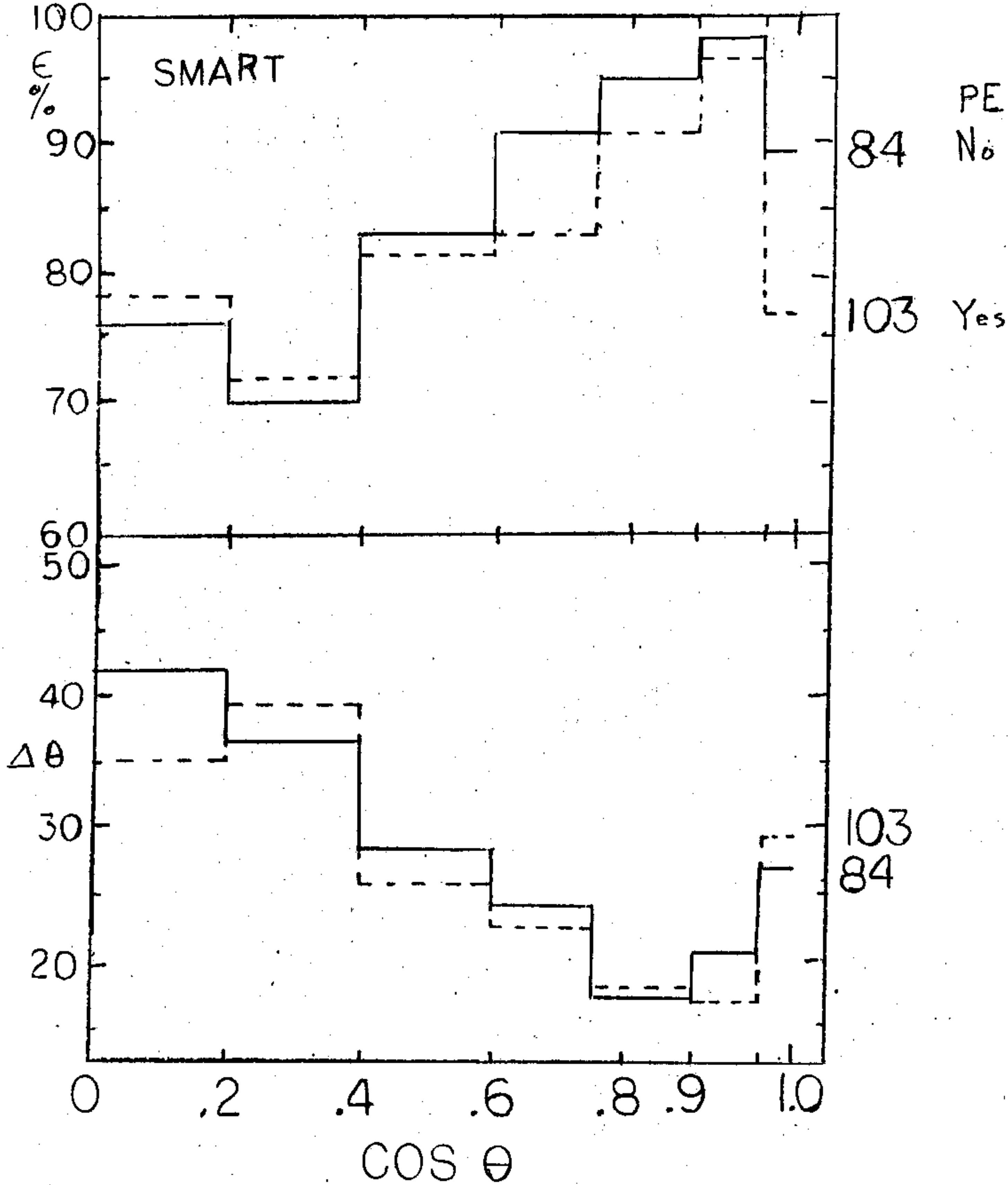

Fig. 3. Detection efficiency and angular resolution vs cosθ, smart tubes, for two runs, one with intensity data used for least squares fitting, other without it. The difference, if any, is small.