Chapter-3

DATA ANALYSIS, ERROR ESTIMATION AND PERFORMANCE OF THE TELESCOPE

3.1 Procedure of data analysis for the observation of discrete point sources of gamma ray :

The object of the analysis procedure is to reduce the EAS event data to quantities, that yield as much information about an individual air shower as possible. The 'dynamic' data are then converted into densities and meaningful times and finally from these quantities the gross shower parameters i,e, shower core position , shower age, shower size and shower arrival direction of interest are computed. These are needed to obtain astrophysical and nuclear physical information associated with the EAS data. Present analysis process is completed by the following three steps.

(i) Rejection of poor data,
(ii) Estimation of four basic parameters viz. core location (X_0, Y_0), shower size (N_e) and shower age parameter (s) from density detector data and
(iii) Timing data analysis for the estimation of arrival direction of incident EAS.

3.1.1. Rejection of poor data :

In the analysis procedure, we rejected those events which have lower number of density data and fast timing data. The number of detectors bearing 'good' data determines how the data are analysed. Table-1 shows the various analysis options. It is clear from the table that, option-1 & 3 showers can not be analysed because of spurious coincidence, option-2 showers can be fully analysed whereas option-4 can be partially analysed.

Table-1

Analysis option	Number of detectors giving fast timing information.	Number of detectors giving density information.	Meaning
1	< 4	< 4	Insufficient data for analysis. No analysis done because of spurious coincidence.
2	≥ 4	≥ 4	Full analysis. Timing data used to calculate (θ,φ,α and δ), density data used to calculate (X_0 ,Y_0,N_e,s)
3	<4	≥4	Insufficient timing data for analysis. It is a case of spurious coincidence.
4	≥ 4	< 4	Timing data only used to calculate (θ,φ,α and δ) only.

Table-1: Various analysis options.

3.1.2. Estimation of shower parameters from density detector data :

Estimation of basic shower parameters is a necessary preliminary in EAS analysis. The shower core location (X_0,Y_0) , shower size (N_e) and shower age parameter (s) are called shower parameters. The shower core is a location in the shower plane having maximum shower particle density. The shower size is measured by the total number of electrons present in the shower at the observation level and shower age parameter describes the longitudinal development of electromagnetic cascade. To study the shower properties , accurate measurements of these quantities are needed. There is no direct way of determination of these parameters. These are estimated by fitting the experimentally observed shower particle density data to a lateral distribution function (ldf) of shower particles. Since most of the shower particles are electrons and photons, basic shower parameters are determined by the electron-photon component.

Different authors proposed different forms of the lateral distribution of the electron component of EAS. In the present analysis 'ldf' of Hillas (Hillas A.M. et al. [1]) is used and is given by-

$$f_h(r) = C(s)\,(r/r_0)^{(a1+a2(s-1))}(1 + r/r_0)^{(b1+b2(s-1))} \quad \text{........(3.1)}$$

where C(s) is the normalisation constant and a1=-0.53,a2=1.54,b1=-3.39,b2=0 and $r_0 = 24$m.

The density of shower particles at radial distance r from the shower core is given by

$$\Delta(r) = (N_e . f_h(r))/r_0^2 \quad \text{....................................(3.2)}$$

where $\Delta(r)$ is the electron density at a distance r from the core and N_e is the shower size.

The shower parameters are determined by fitting the Hillas 'ldf' to the observed radial distribution of the densities $\Delta(r)$ by minimizing, with respect to each of the shower parameters simultaneously, the entity defined as-

$$\chi^2 (X_0,Y_0,N_e,s) = \Sigma\, W_i(\ \Delta_i^o - \Delta_i^e)^2 \quad \text{..............................(3.3)}$$

where Δ_i^o is the observed density in the ith detector which is related to the corresponding ADC reading R_i by the relation

$$\Delta_i^o = R_i/(A_i\,.C_i) \quad \text{..............................(3.4)}$$

where A_i is the area of the ith detector and C_i is the calibration factor obtained from density detector calibration which is done in chapter-2. Δ_i^e is the expected density in the ith detector which is calculated by substituting the estimated shower parameters in the Hillas function and W_i is the weight factor and is taken as

$$W_i = 1/(\Delta_i^e)^2 \qquad \text{...(3.5)}$$

Summation is taken over total number of data points.

The method of searching for the minimum value of χ^2 with respect to each of the EAS parameters simultaneously, is the gradient search method in the direction of steepest descent and the condition of minimisation of χ^2 with respect to each shower parameter is given by-

$$\delta\chi^2/\delta\xi_i = 0 \qquad \text{...(3.6)}$$

where ξ_i's are the four shower parameters X_0, Y_0, N_e and s.

Initially χ^2 is set at a large value and s is taken as 1.25. The initial estimation of the core location is made by using the symmetry of the lateral distribution function .

The centre of gravity of the density distribution is given by-

$$X_0 = \Sigma\, \Delta_i^o X_i / \Sigma\, \Delta_i^o$$
$$Y_0 = \Sigma\, \Delta_i^o Y_i / \Sigma\, \Delta_i^o \qquad \text{.............................(3.7)}$$

where X_i and Y_i are the co-ordinates of the ith detector . With these values of X_0, Y_0 and s , the initial estimation of the shower size (N_e) is made by solving the equation-

$$\delta\chi^2/\delta N_e = 0 \qquad \text{.............................(3.8)}$$

which gives a cubic equation of the type-

$$N_e^3 + c\,N_e + t = 0 \qquad \text{..........................(3.9)}$$

where c and t are the function of core location and age.

From these values of X_0 ,Y_0 ,N_e and s , the quantity χ^2 and its gradient $\nabla\chi^2$ for various components are evaluated . If the new value of χ^2 is less than its initial value , the parameters are then changed in accordance with the respective components of $\nabla\chi^2$ and a new set of parameters is obtained. The process is continued until the difference between the two successive values of χ^2 per degree of freedom is less than 0.001 and the current values of X_0, Y_0, N_e and s are taken as the best fitted values of the shower parameters. If within 500 iterations the above condition is not reached, the further minimization is abandoned because in such a case it has been found that the value of χ^2 oscillates very close to the minimum value. The current values of the parameters are accepted as the shower parameters.

3.1.3. Timing data analysis procedure:

An exact determination of arrival direction of EAS is important to identify the UHE discrete sources of gamma ray. Since 1953, air shower directions have been measured using the fast timing technique (Bassi P. et al.[2]). Pioneering work in arrival direction was done by Linsley (Linsley & Scarsi[3]).The accuracy of the arrival angle determination mainly depends on the capability of accurate measurement of the relative arrival times of the shower particles. The uncertainty in the timing measurement is due to different factors- time spread of the shower particles in shower disk, curvature of the shower front, time offset, instrumental uncertainty of the time measuring instruments, speed of photomultiplier etc.

3.1.4. Time offset of the time measuring instrument:

If a shower is incident vertically on the array, there is no time difference between particles arriving at different detectors of the array. But in practical case , there is a finite and constant difference in the actual arrival time of shower particles in the different detectors. This difference in time is known as the time offset of the timing detectors. Since the actual arrival times of shower particles are necessary to obtain true arrival direction of a shower, the measured time has to be corrected for the time offset before such times are used for the directional analysis. By the fast timing technique, the shower arrival direction is measured by relative arrival times of shower particles on each fast timing detector. Hence only relative time offsets between the different timing instruments are necessary instead of actual time offsets of the instrument.

The factors which are responsible for the relative time offsets of the time measuring instruments are given below.

(i) Difference in Photomultiplier transit time.

(ii) Difference in response time of the scintillator and photomultiplier.

(iii) Electronic propagation delay between different time measuring channel.&
(iv) Unequal length of delay cable and also manufacturing differences of cables.

The time offsets are measured in the following way.
Suppose T_i is the true arrival time of shower particles in the ith detector and T_{oi} is the total delay which includes time response delay of the detector,electronic propagation delay and cable delay etc. Therefore time measured by the ith detector will be $T_i^m = T_i + T_{oi}$. Similarly time measured by the jth detector will be $T_j^m = T_j + T_{oj}$.
Therefore,

$$T_i^m - T_j^m = T_i - T_j + T_{oi} - T_{oj}$$

$T_{oi} - T_{oj}$ is the relative time offset between the ith and jth timing instruments. If we are summing up the quantity $T_i^m - T_j^m$ for a large number of events , the quantity
$\Sigma(T_i - T_j)$ should vanish (the observed events have azimuthal isotropy as cosmic rays are highly isotropic in nature) .
Hence for each pair of detectors we get,

$$\Sigma (T_{oi} - T_{oj}) = \Sigma (T_i^m - T_j^m)$$

$$\text{or,} \quad (T_{oi} - T_{oj} - T_{ij}^m) = 0$$

$$\text{where} \quad T_{ij}^m = (\Sigma (T_i^m - T_j^m))/n.$$

n is the total number of events considered. There are eight such equations for eight detectors. Solution of these equations gives the relative time offsets between different detectors.
The relative time offsets has been measured for all the timing detectors and relative arrival time of all the timing detectors are corrected for time offsets. The corrected relative arrival time (RAT) of different detectors which are hitted by the shower particles for the two shower events are shown in fig.3.1b. and fig.3.1c.

3.1.5. **Instrumental uncertainty in timing measurements :**

Instrumental uncertainity in timing measurement is already discussed in sec.2.7.3. of chapter-2.

3.1.6. **Estimation of arrival direction :**

Arrival direction (i,e Zenith angle, Azimuth angle) is estimated by a least square fit of a plane shower front to the timing data . The plane shower front is given by -

$$lx_i + my_i + nz_i + c\,(t_i - t_0) = 0 \quad \text{.........................(3.10)}$$

where x_i , y_i , z_i are the co-ordinates of the ith detector , t_i is the arrival time of shower particles in the ith detector, t_0 is the reference time which is actually the time of arrival at a reference detector and l, m, n are the direction cosines which are given by-

$$l = \sin\theta \,.\, \cos\phi$$
$$m = \sin\theta \,.\, \sin\phi \quad \text{.............................(3.11)}$$
$$n = \cos\theta$$

where θ and ϕ are zenith and azimuth angle.
In practice the values of t are measured and the problem is to find θ and ϕ. In table-2, timing detector positions, cable delay (section-2.1.5., chapter-2) and maximum time difference that a timing detector can record in the present EAS telescope (section- 2.2. of chapter-2) to indicate the limits of relative timing measurements.

Table-2

Detector Number	**X (m)**	**Y (m)**	**Z (m)**	**Cable delay (ns)**	**Cable delay relative to detector-1 (ns)**	**Maximum value of time difference t for a shower front which traverses the indicated detector before detector-1. (ns)**
1	14	12.0	0	139	0	--------
2	7	16.0	0	174	35	27
3	14	20.0	0	159	20	26
4	21	16.0	0	155	16	27
5	0	4.0	0	166	27	58
6	0	28.0	0	146	7	71

7	29	29.5	0	193	54	77
8	28	4.0	0	180	41	54

The direction cosines are constrained by the relation -

$$l^2 + m^2 + n^2 = 1 \qquad \text{.............................(3.12)}$$

The direction cosines are obtained by the minimisation process of the quantity -

$$\chi^2 = \Sigma\, W_i\, (lx_i + my_i + nz_i + c\,(t_i - t_0))^2 \qquad \text{.......(3.13)}$$

where the summation is taken over all the timing detectors which are triggered by the incident shower front and W_i 's are weight factors of the detectors and is given by-

$$W_i = 1/(\sigma_{inst.}{}^2 + \sigma_{dsk.}{}^2) \qquad \text{..........(3.14)}$$

where $\sigma_{inst.}$ is the instrumental uncertainty and is described in section 2.7.3 of chapter-2. $\sigma_{dsk.}$ is the uncertainty in timing measurements due to finite thickness of EAS disk. The number of particles producing the signal varies due to the finite thickness of shower disk . Hence the width of the time distribution of the shower particles in the shower disk is a measure of the fluctuation in arrival time of shower particles at the detectors. This width increases with the increase of core distance. The width of the distribution is given by Linsley (Linsley J.et al[5]) as-

$$\sigma_{dsk.} = \sigma_0 \cdot (1 + r/r_t)^b / n^{0.5} \qquad \text{.........(3.15)}$$

with σ_0 = 2.6 ns, r_t = 30m., b=1.5 and n is the number of particles that hit the detector.

The condition of minimisation of χ^2 with respect to l, m, n, t_0 are given by-

$$\delta\chi^2/\delta l = 0$$
$$\delta\chi^2/\delta m = 0$$
$$\delta\chi^2/\delta n = 0 \text{ and } \qquad \text{............(3.16)}$$

$$\delta\chi^2/\delta t_0 = 0$$

Solutions of these equations along with the constrained condition of direction cosines give the values of l, m, n, and t_0 in terms of spatial co-ordinates of the timing detectors and the arrival times of the shower particles at different detectors. Thus zenith angle (θ) and azimuth angle(ϕ) of each shower event are determined using equation (3.11).

3.1.7. **Arrival direction in equatorial coordinates:**

During the diurnal motion of a heavenly body, its altitude and azimuth continually changes. Also at the same instant, at places of different latitudes, the same body has different altitudes and azimuths. However right ascension and declination of a heavenly body remain the same during their diurnal motion. So equatorial coordinates (right ascension and declination) are used to define the position of a star.

If the observer's latitude is φ and θ,ϕ are the zenith and azimuth of a heavenly body, then the declination is given by

$$\delta = \sin^{-1}(\sin\varphi.\cos\theta + \cos\varphi.\sin\theta.\cos\phi) \quad ....(3.17)$$

and h be the hour angle then,

$$h = \sin^{-1}(\sin\theta.\sin\phi.\cos\delta) \quad ....(3.18)$$

If a heavenly body is observed at local siderial time LST and h is the hour angle of the body, then the right ascension of the body α is given by-

$$\alpha = LST - h \quad ....(3.19)$$

Thus from equation (3.17) and (3.19), right ascension and declination of a star are measured.

A flow-chart for χ^2- minimisation procedure for finding the shower parameters and arrival directions is shown in fig.3.1a and example of observed shower data and

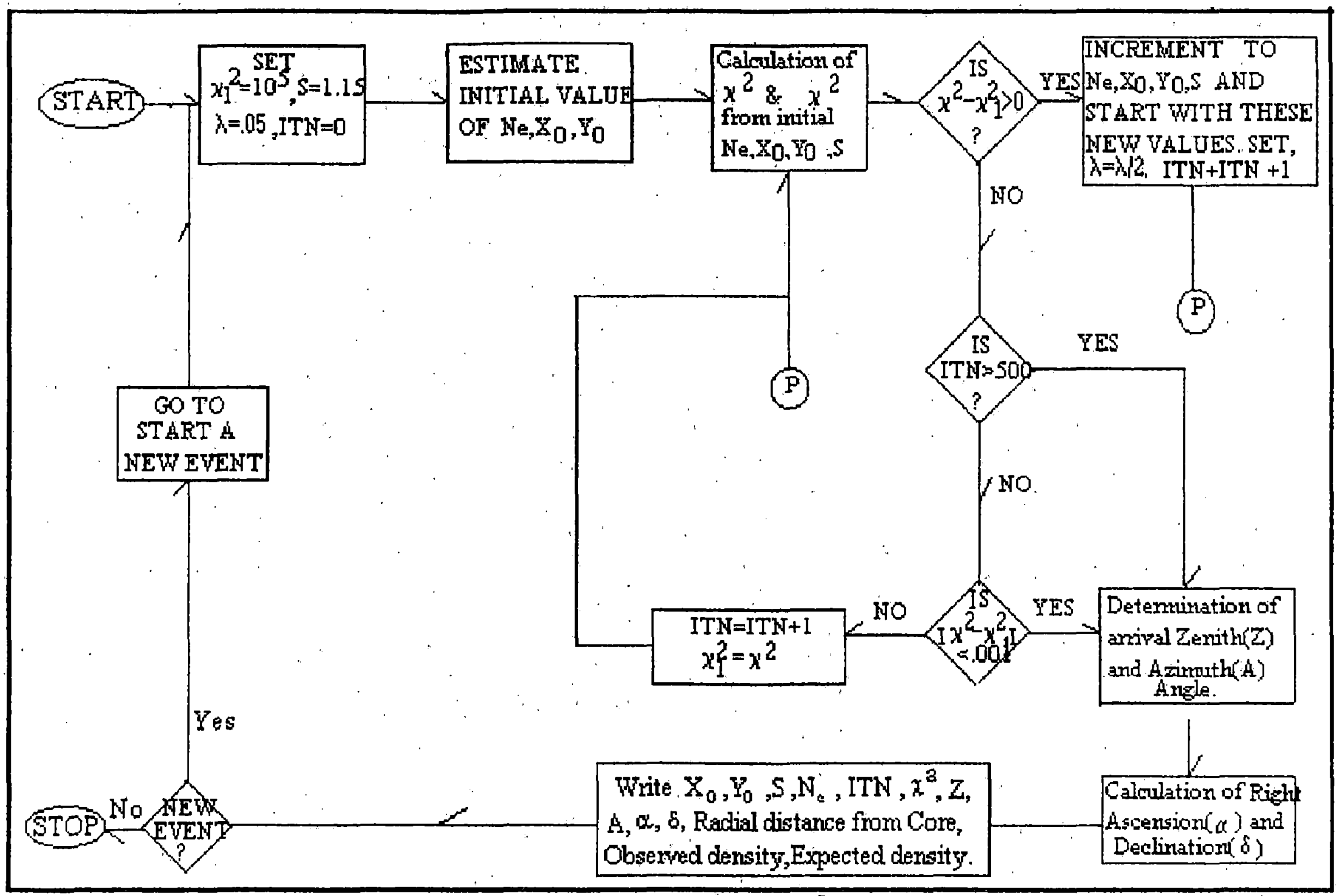

Fig.3.1a Flow Chart for χ^2 Minimisation.

reconstructed shower parameters from the observed data for two typical observed EAS events are shown in fig.3.1b and 3.1c.

3.2. **Accuracy of measurements :**

3.2.1. **Estimation of errors in shower parameters :**

It is evident that any feature of EAS will be affected by the errors in estimation of the shower parameters. So it is necessary to have an idea of errors involved in the estimation of the parameters X_0,Y_0,N_e and s of an observed shower events. An estimate of errors in shower parameters is obtained by artificial shower analysis. Here air shower events are simulated and then the simulated data are analysed with usual analysis programme.By selecting random shower sizes for an incident power law differential shower size spectrum ($N^{-2.5}$) with zenith angle distribution of form $\cos^{7.5}\theta$ in the size range 10^4-10^6, 1200 showers have been simulated and randomly projected over an circular area of radius 40m. from the array centre. Particle density in each detector for every event is calculated according to Hillas function . To obtain the experimental conditions, the statistical fluctuations in the number of particles in each detector are superposed . These simulated events are then analysed by χ^2 minimisation procedure as described by equation (3.3).

From the simulation study , it is found that there is no systematic biases in the analysis procedure employed in the experiment. The distribution of differences between the simulated parameters and fitted parameters are shown in fig. 3.2a, 3.2b, 3.2c and 3.2d.

Assuming that all the distributions are Gaussian, the standard deviation σ of all the distributions are obtained by minimizing the quantity-

$$\chi^2 = \Sigma\, (w_i^o - w_i^e)/\, w_i^{e2} \quad \text{.........................(3.20)}$$

where w_i^o is the observed probability and w_i^e is the expected probability and is given by-

$$w_i^e = e^{[-(x - m)^2/2\sigma^2]} /[\sigma.(2.\pi)^{0.5}] \quad \text{......................(3.21)}$$

Event date.7/6/96, IST.15h16m14s, X_0 = 16.75m, Y_0 =14.02m, s = 1.27, χ^2/ degrees of freedom =0.109 for density data fit, N_e= 9.2 X 10^4, Zenith Angle =11.2°, Azimuth Angle = 64.1°, R.A.=128.3°, Declination = 31.1°.

Radial distance from core (m)	Observed density	Expected density
23.02	4.0	7.21
18.36	8.0	10.53
14.65	20.0	14.21
14.25	16.0	15.30
3.41	56.0	55.21
6.58	36.0	35.50
18.47	12.0	10.42
15.07	16.0	14.15
4.69	32.0	45.74
16.87	12.0	11.99
21.82	4.0	7.92

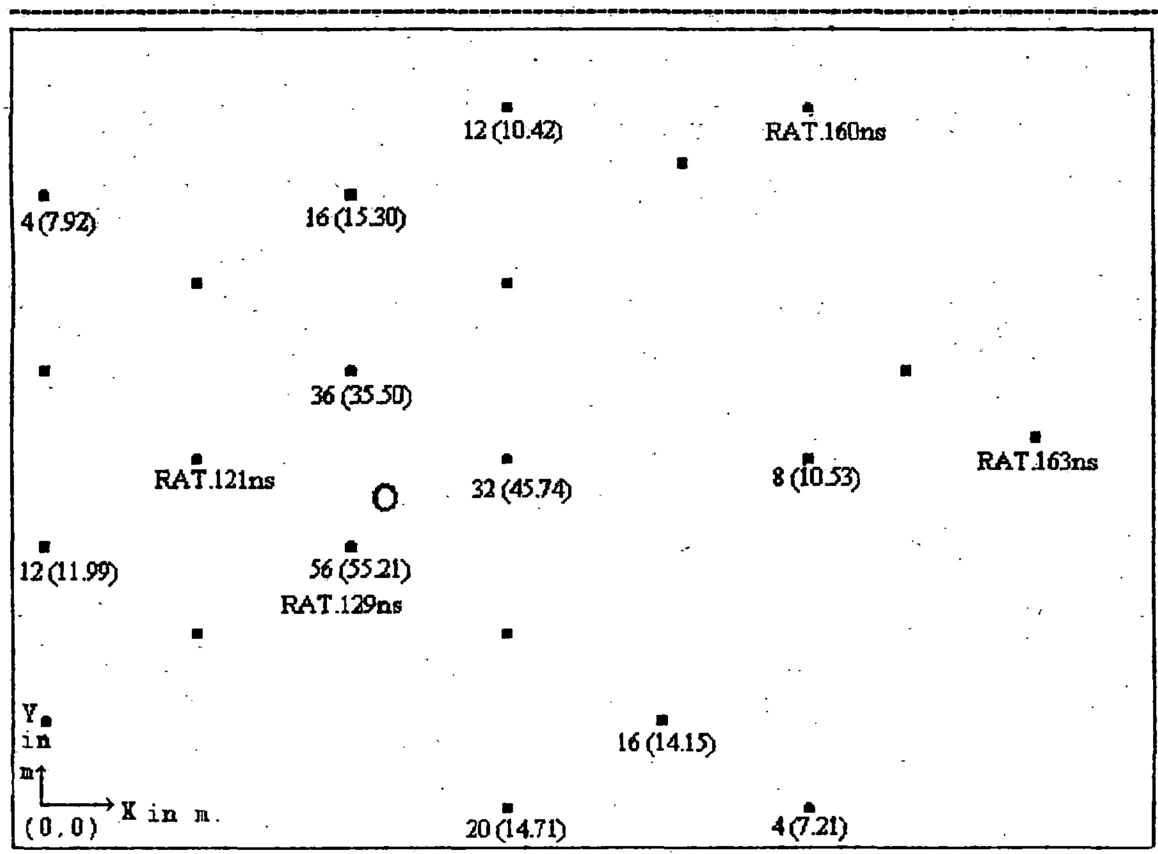

Fig.3.1b:Observed EAS event and reconstructed shower parameters from that data.

Event date.28/5/96, IST.11h02m30s, X_0 = 18.42m, Y_0 = 14.00m, s = 1.21, χ^2/ degrees of freedom = 0.072 for density data fit, N_e = 9.1 X 10^4, Zenith Angle = 23.3°, Azimuth Angle = 44.7°, R.A. = 54.5°, Declination = 41.6°

Radial distance from core (m)	Observed density	Expected density
21.70	8.0	7.95
16.70	8.0	12.44
14.24	20.0	15.91
14.68	12.0	15.19
4.85	56.0	51.85
7.45	32.0	35.33
18.19	12.0	10.82
18.36	12.0	10.65
13.85	12.0	16.55

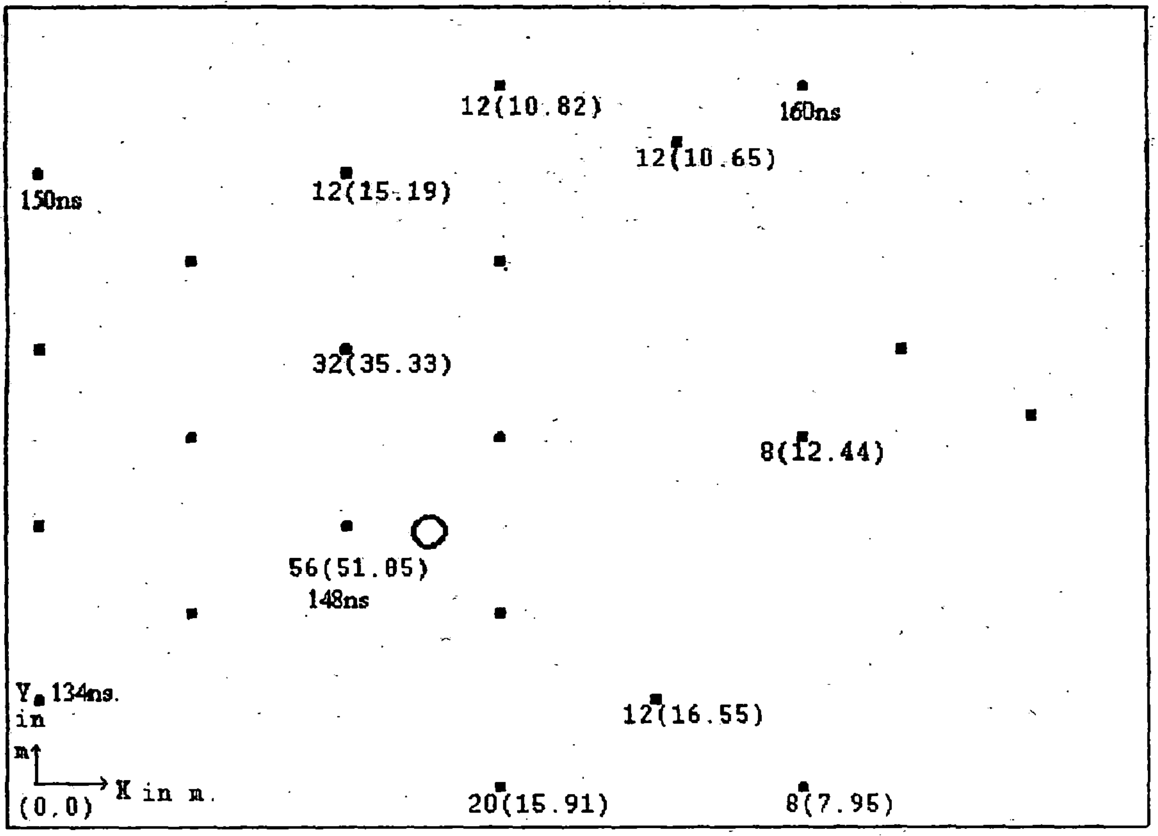

Fig.3.1c : Observed EAS event and reconstructed shower parameters from that event.

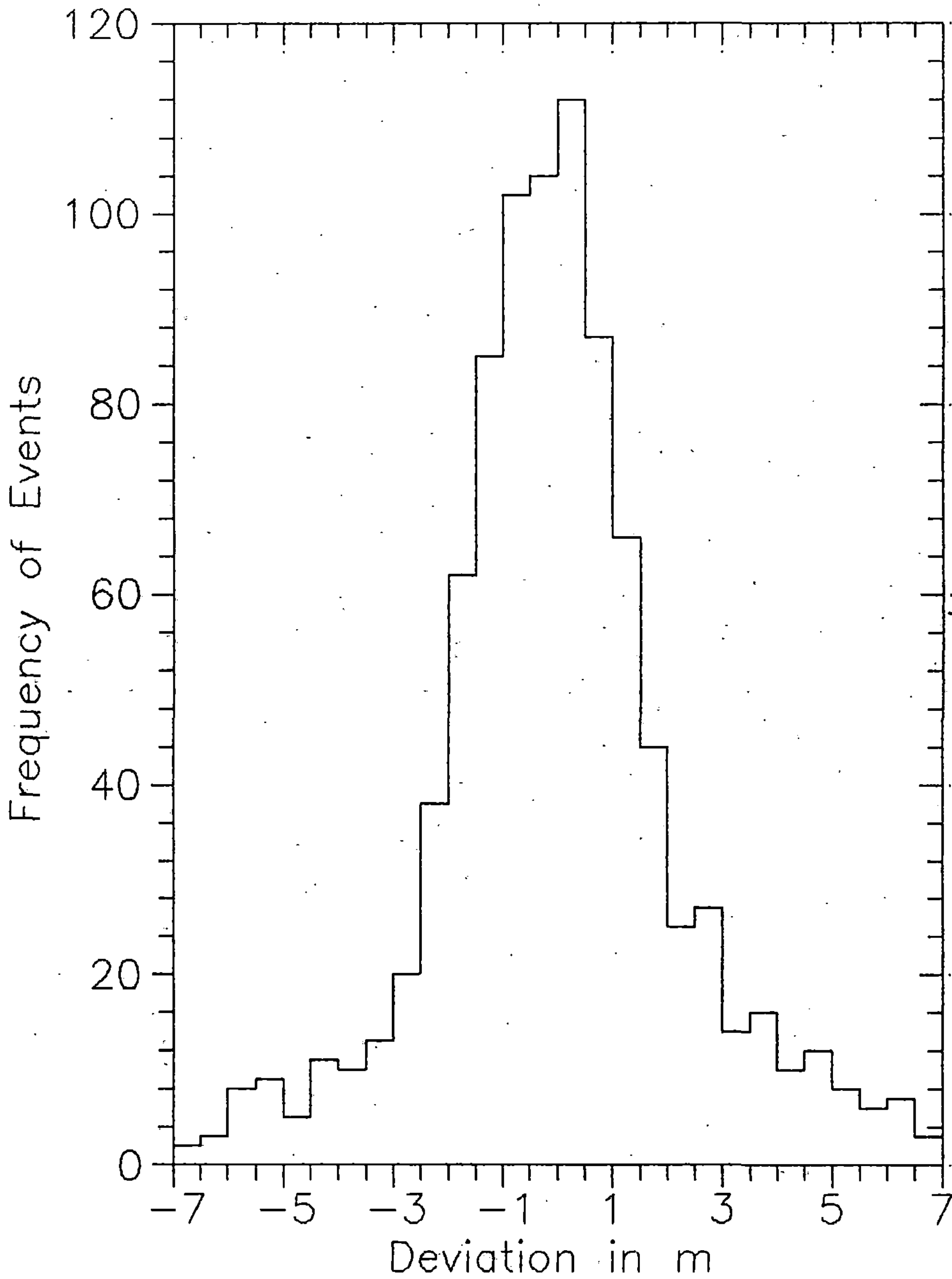

Fig.3.2a.
Distribution of deviations of the estimated core location from true core position along X−axis.(Simulated results)

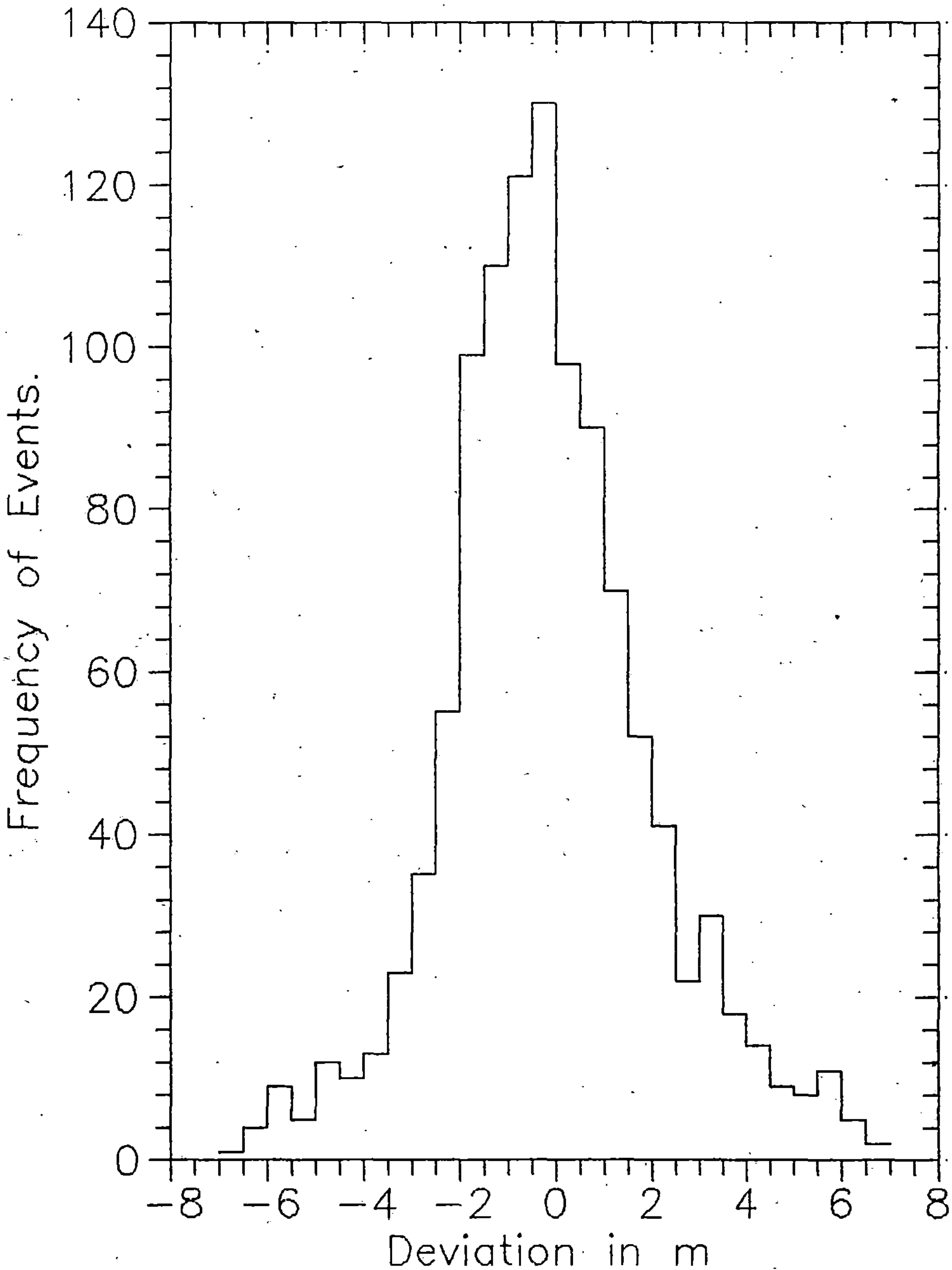

Fig.3.2b.
Distribution of deviations of the estimated core position from true core position along Y−axis.(Simulated results)

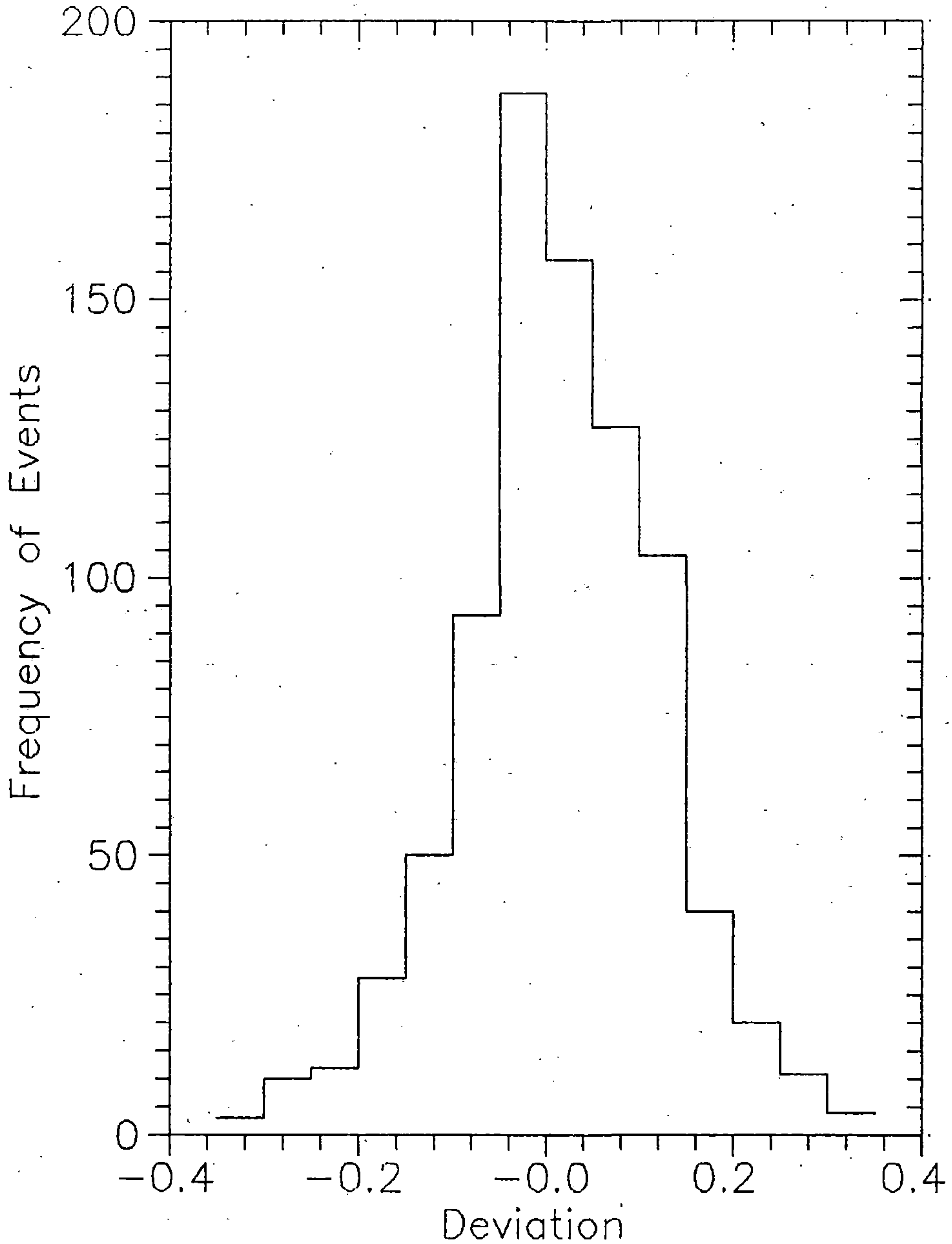

Fig.3.2c.
Distribution of deviations of the estimated age (s) from the true age (Simulated results).

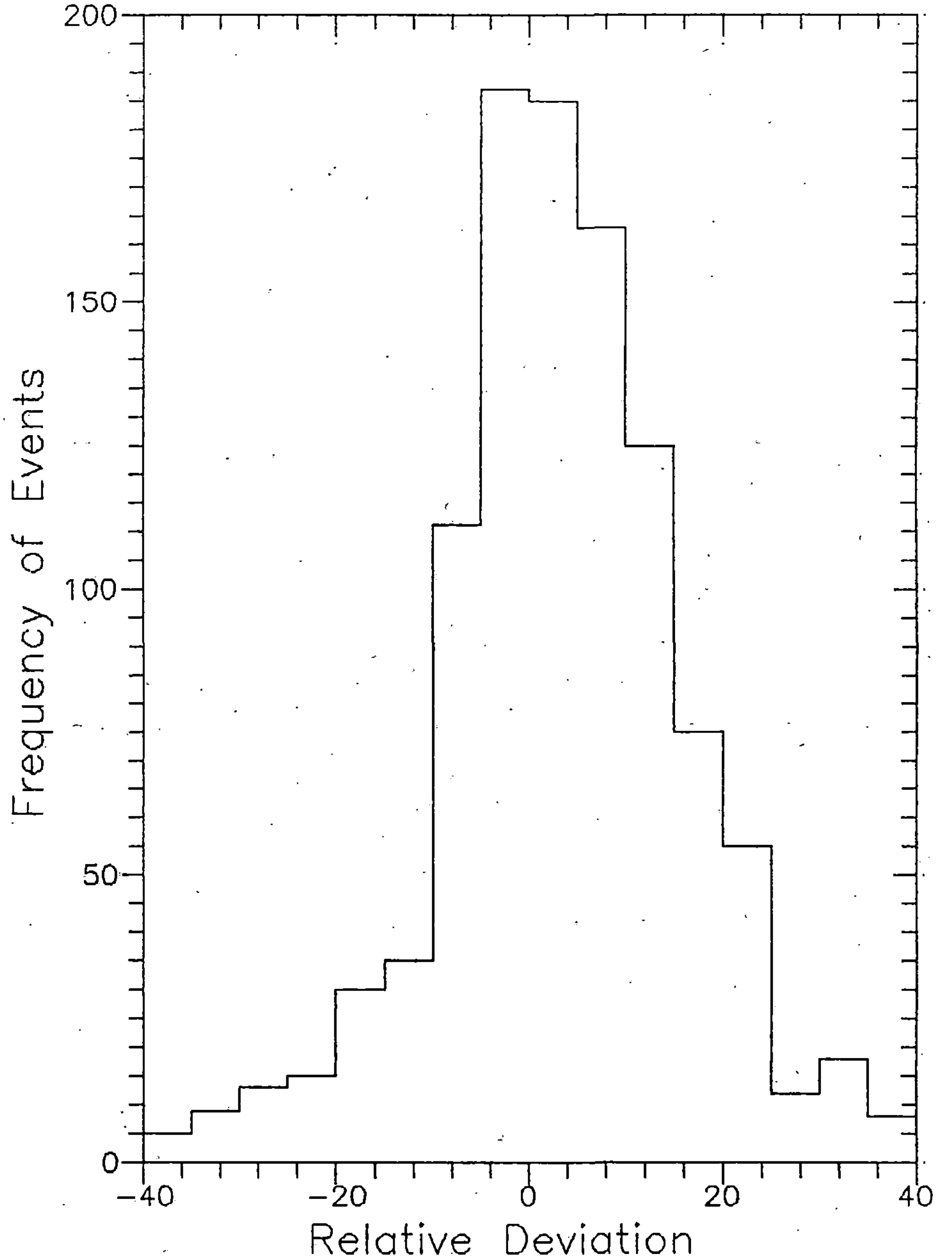

Fig.3.2d.
Distribution of relative deviations of the estimated size(N_e) from true size (Simulated results).

where σ is the standard deviation , x is the measured value and m is the mean values of any of the shower parameters.

From these minimisation , uncertainity in different parameters are as follows-

(i) Uncertainty in core location (a) $\delta X_0 = (2.18 \pm 0.05)$ m.

(b) $\delta Y_0 = (2.17 \pm 0.05)$ m.

(ii) Uncertainty in shower size $\delta N_e / N_e = (12.97 \pm 0.27)$ % and

(iii) Uncertainty in shower age $\delta s = (0.11 \pm .003)$.

The χ^2– distribution of the experimentally observed showers and artificial showers is shown in fig.3.2e.

3.2.2. **Angular resolution of the new NBU EAS telescope:**

To detect reliably UHE particle emission from specific directions and to search for clustering, an exact determination of angular direction is necessary. Again, a zenith angle error of 3^o leads to an uncertainity in atmospheric depth traversed by a shower of 74 gm/cm^2 for $\theta = 32^o$ and 115gm/cm^2 for $\theta = 47^o$ for an array at sea level (1018 gm/cm^2) (Watson A.A[4]), which also demands an accurate measurements of angular direction. This might be a significant effect in the interpretation of some experiments .

Thus angular resolution of an air shower array is a very important parameter to estimate. The angular resolution of the NBU EAS telescope has been estimated by the conventional 'split array' method. For this method , only those events are taken where timing information of all the eight fast timing detectors are present. Here all the detectors are devided into two sets,(1st four and remaining four) and from the two sets , two individual estimation of the arrival direction of the same event has been calculated. The frequency distribution of difference in zenith angle and azimuth angle is shown in fig. 3.2f and 3.2g. If we fit this distribution to Gaussian distribution function, the width of the Gaussian distribution gives the uncertainity in measurements of corresponding parameter. Since error in determining angular coordinates from the two independent sub array added quadritically in the resulting distribution and there are twice as many detectors in the whole array , so the angular resolution of the whole array will be $1/2^{1.5}$ times of the width of the distribution. The resolution of the array in different angular co-ordinates is shown in Table-3.

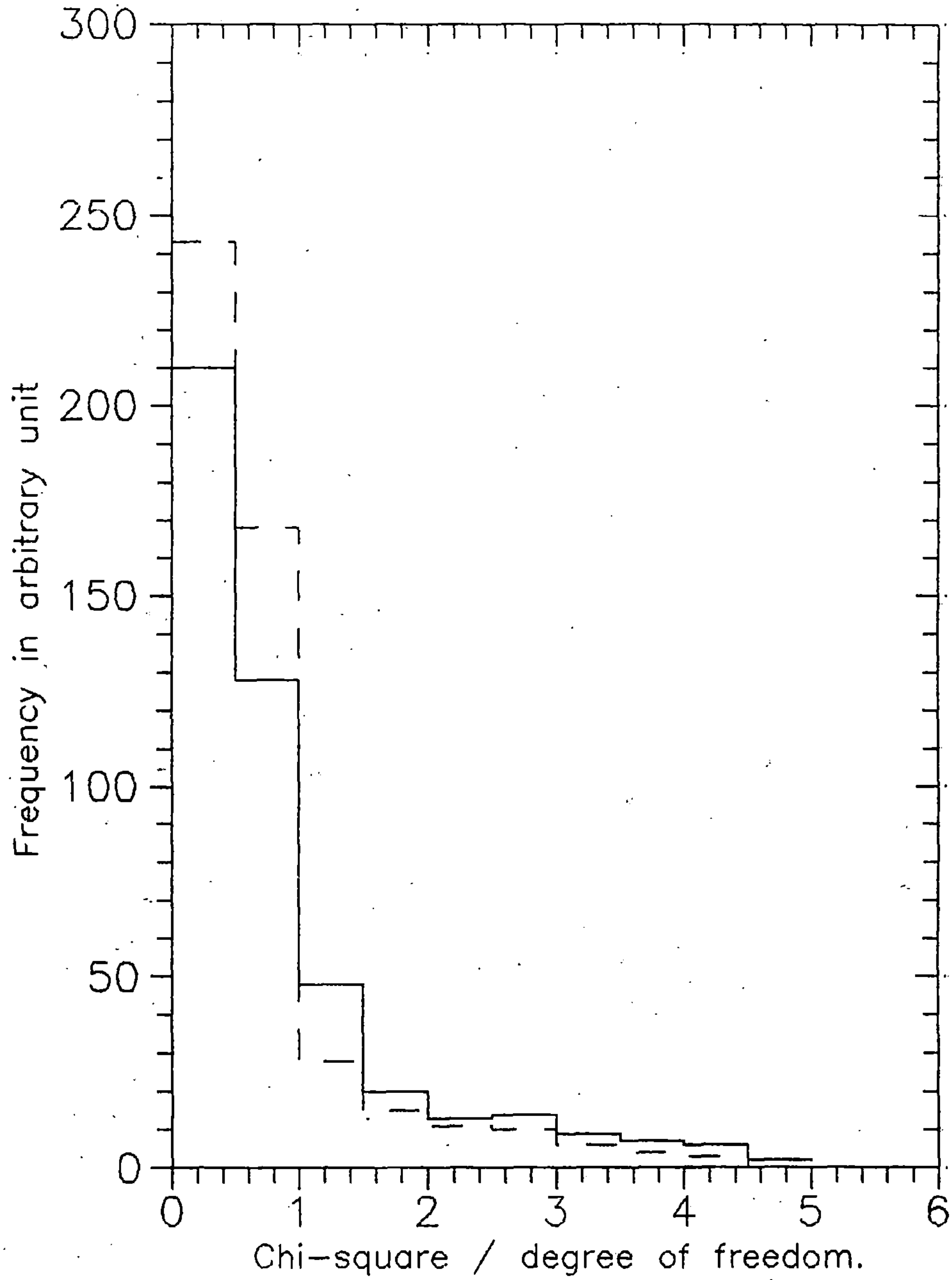

Fig.3.2e
Chi-square distribution of the experimentally observed showers (solid line) and artificial showers (dashed line).

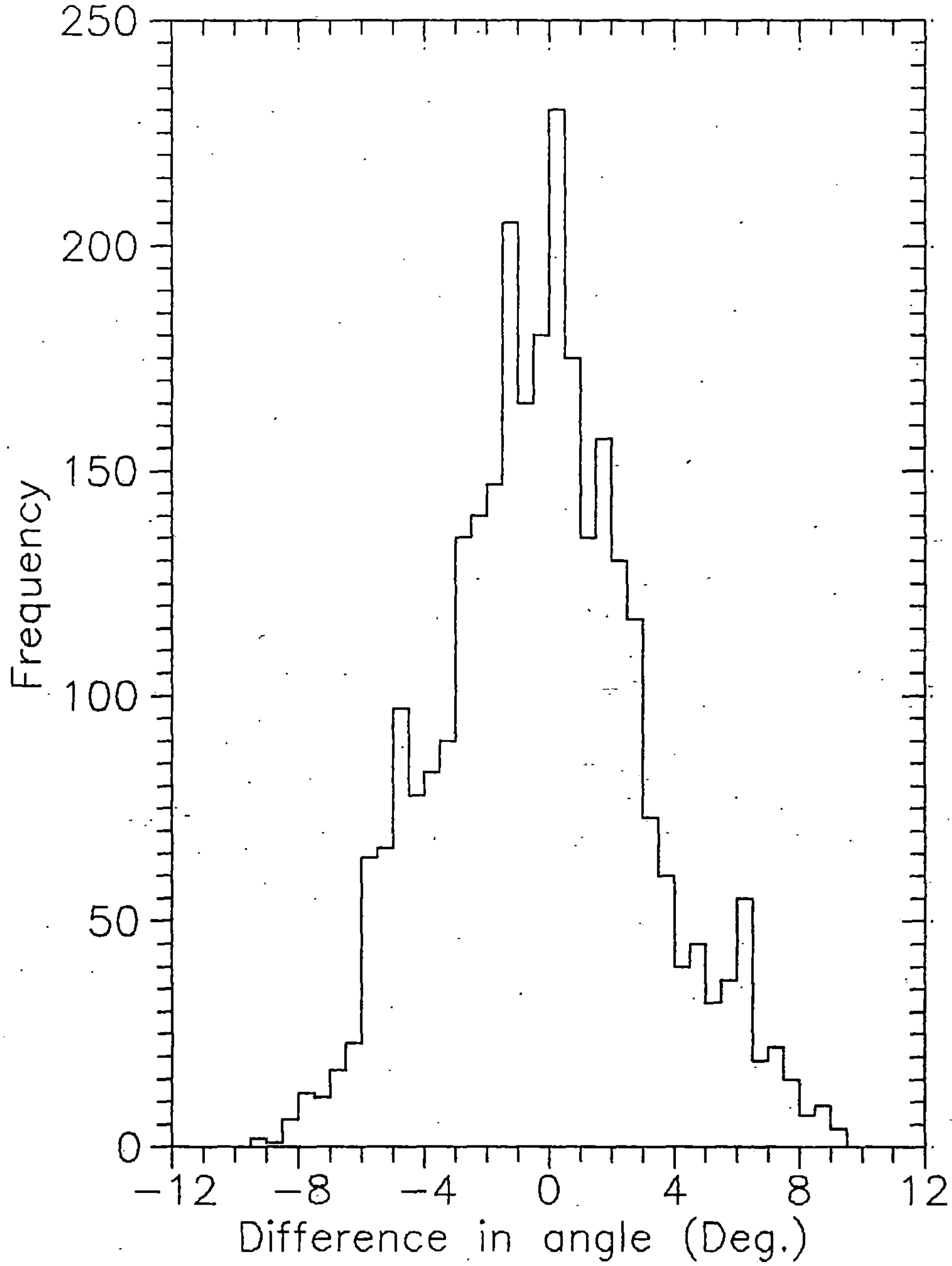

Fig.3.2f.
Distribution of relative deviations in Zenith angle (Sigma=3.26 ± 0.043)

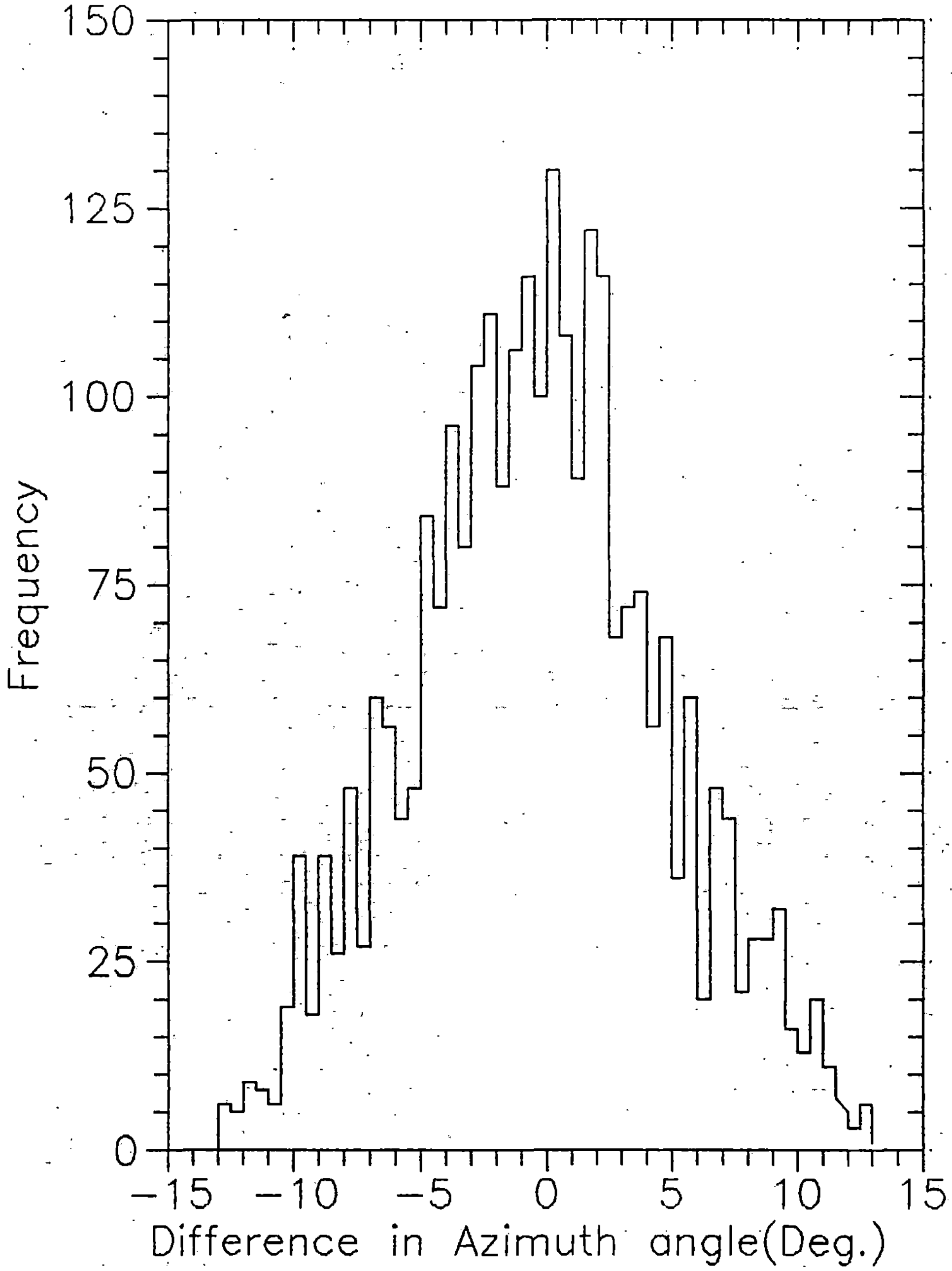

Fig.3.2g.
Distribution of relative deviations in Azimuth angle.
(Sigma= 5.02 ± 0.067)

Table-3

Angular Co-ordinates	**Resolution from Expt.**	**Resolution from Simulation**
Zenith Angle	$(1.15 \pm 0.015)^o$	$(0.65 \pm 0.024)^o$
Azimuth Angle	$(1.80 \pm 0.024)^o$	$(1.65 \pm 0.07)^o$

Table-3: Angular resolution of the NBU EAS telescope.

From Table-3 it is seen that azimuthal resolution is not very good. This may be due to the small number of fast timing detectors.

Resolution of arrival direction is also estimated by Monte Carlo Simulation method. Here particle arrival time at the different detectors are calculated for a particular direction. Assuming a curvature of the shower front, the rms spread of time of shower particles in the shower disk is imposed on each simulated arrival time at the different detectors by Linsley formula (Linsley J.[5]). The instrumental uncertainity is also included. The arrival times are then fitted to the conical shower front with proper weightage. Thus arrival directions are estimated. The distribution of the differences between estimated direction and the particular direction is shown in fig.3.2h and 3.2i. The angular resolution obtained by the simulation method is also shown in table-3.

3.3. Sensitivity of the NBU EAS telescope :

The sensitivity of the array telescope have been determined using the normal EAS events due to the charged primary cosmic ray nuclei which form the background for the UHE directional showers. To observe the sensitivity of the EAS telescope, the detection efficiency and triggering probability at different N_e and s have to be determined.

3.3.1 Detection efficiency of the EAS telescope :

The detection efficieny is defined by the fraction of showers that were detected. The detection efficiency at any point of the array is measured by the following way.

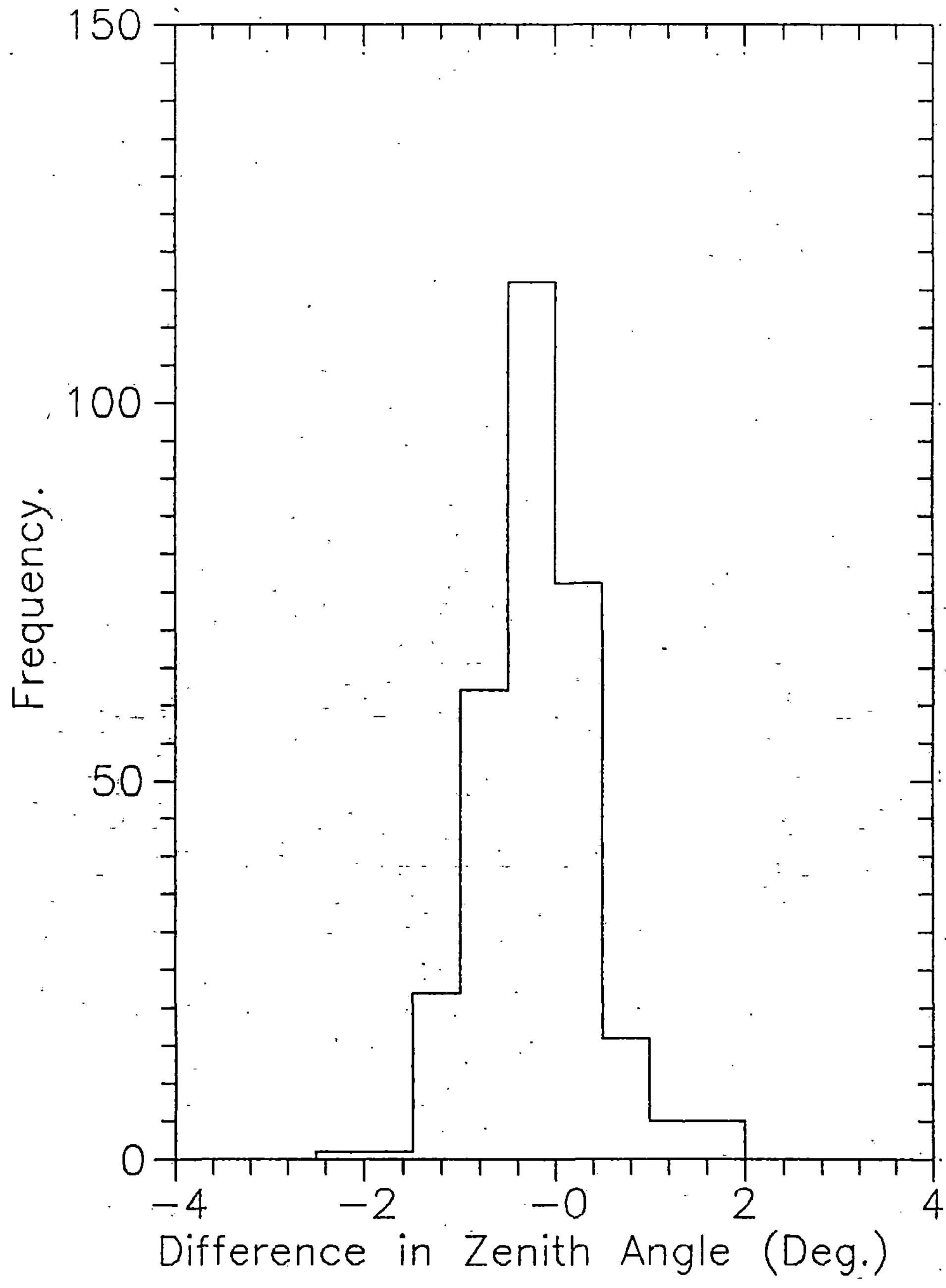

Fig.3.2h.
Distribution of relative deviations in Zenith angle (Simulated results).

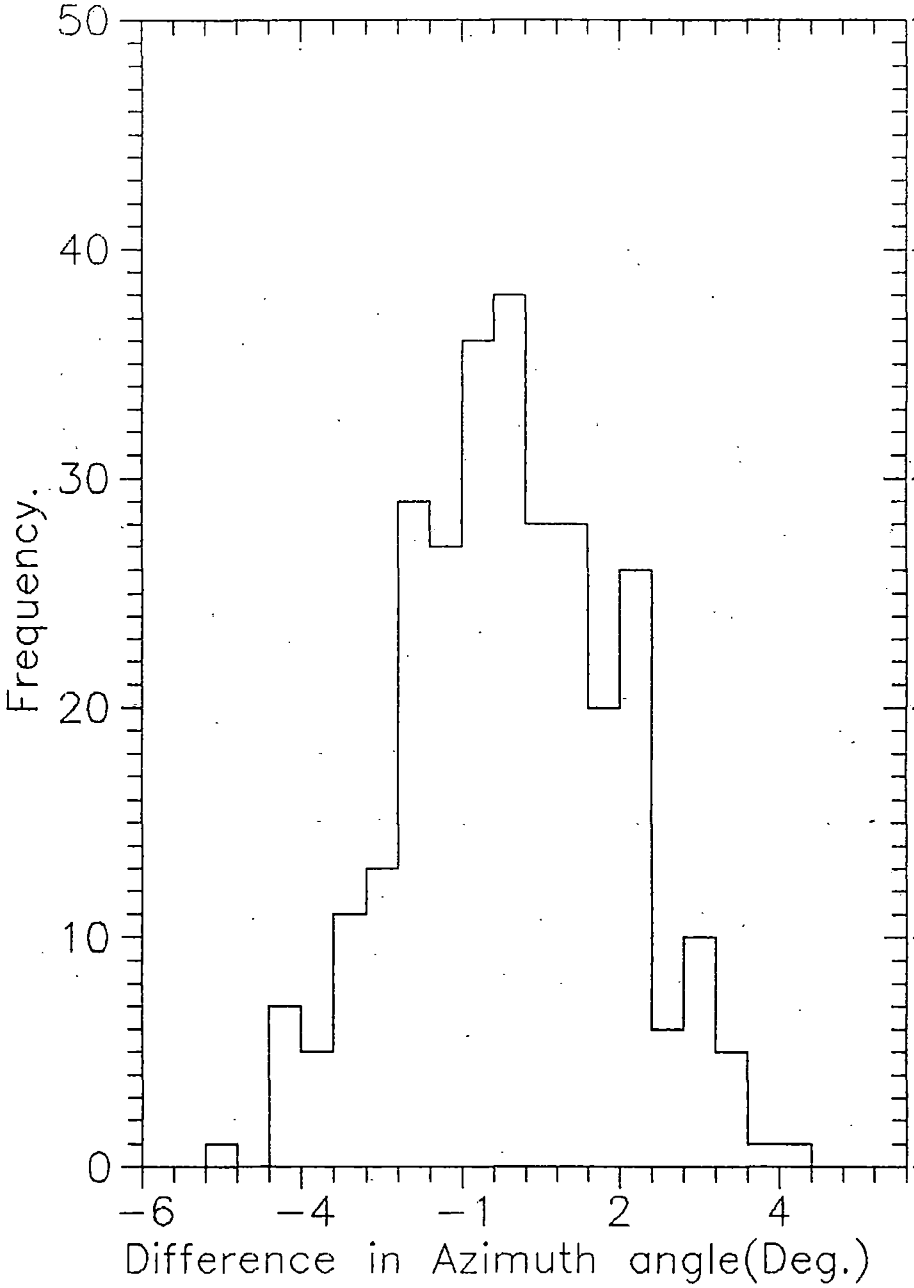

Fig.3.2i.
Distribution of relative deviations in Azimuth angle (Simulated data).

The array is devided into annular rings around the array centre. For a particular shower size and age , the shower core is randomly selected in a particular ring and the density expected at each detector is calculated using Hillas structure function (equation 3.1). To these densities , the Poissonian and systematic errors are imposed. Using these fluctuations the selection criterion was applied and checked whether the particular shower is selected or not. 500 showers were generated in each annualar ring for a given initial size and age. The fraction of showers out of the total showers gives the efficiency for a particular annular ring. The variation of detection efficiency with radial distance for different N_e and s are shown in fig. 3.3a, 3.3b, 3.3c and 3.3d.

3.3.2. Triggering probability and effective area of the EAS telescope :

Calculation of average triggering probability is based upon the assumption that the number of cosmic ray particles that are detected in an instrument follow Poission statistics and ,if this is so , then the detection probability P_i may be written as-

$$P_i = \exp(-\Delta_i.S_i)\,\Sigma\,(\Delta_i.S_i)^{\mu}/\mu! \quad \text{.........................(3.23)}$$

where Δ_i is the particle density on the ith detector calculated by Hillas function and S_i is the area of that detector whose particle threshold is μ.

Since in the analysis process only those showers are analysed whose cores fall within the array, the minimum number, 4 particles / m^2 must be present at the farthest triggering detector (by imposed trigger condition) from the shower core. Therefore

the probability of detection of particles less than $4/m^2$ by the farthest triggering detector is-

$$P_i = \Sigma \exp(-x)\, x^{\mu}/\mu! \quad \text{......................(3.24)}$$

where μ is the number of particles in the farthest triggering detector for a particular shower.

Hence. triggering probabilty ,for a particular shower size , of the array is given by

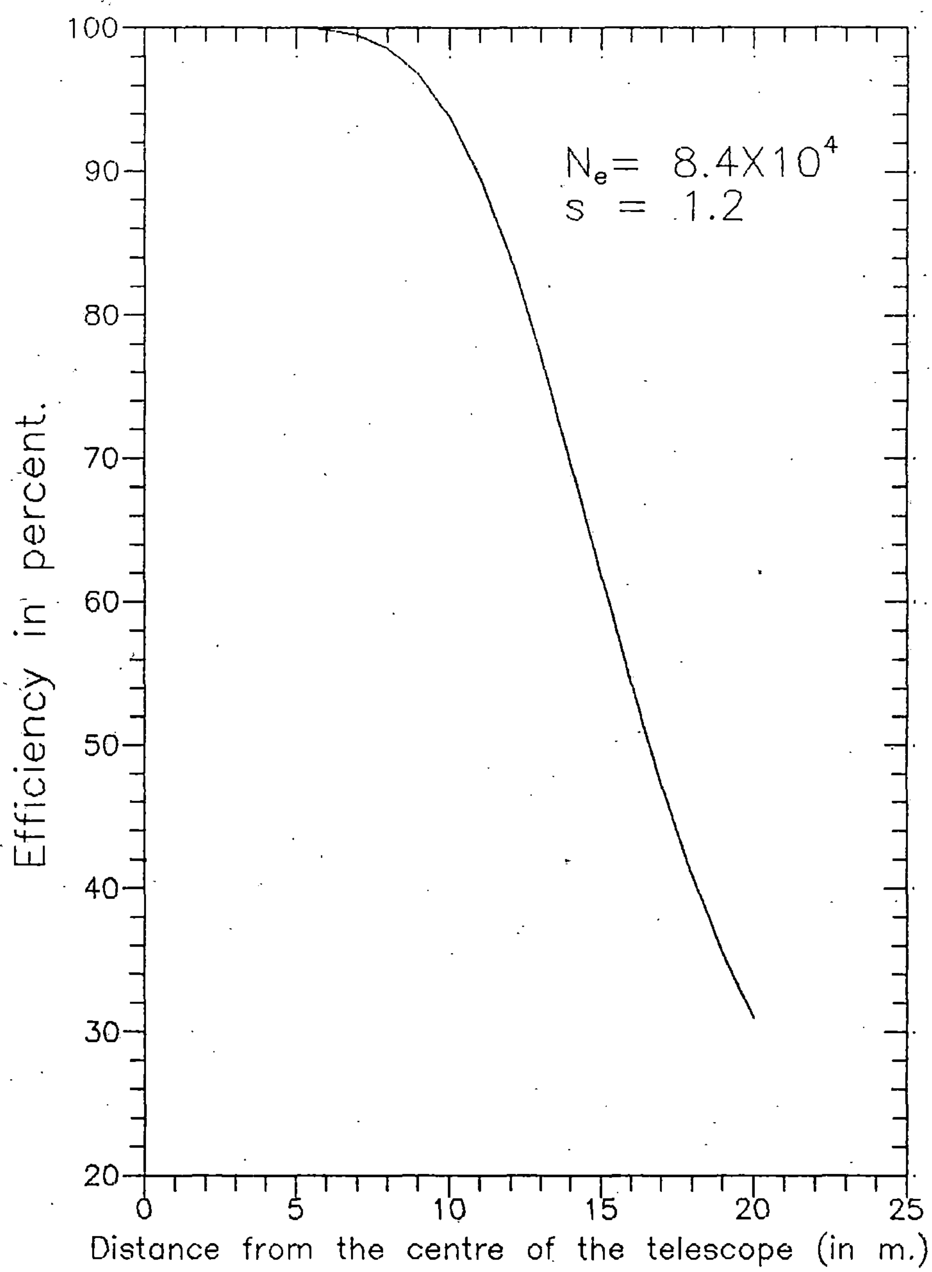

Fig.3.3a.
The detection efficiency of the telescope as a function of distance from the centre of the telescope.

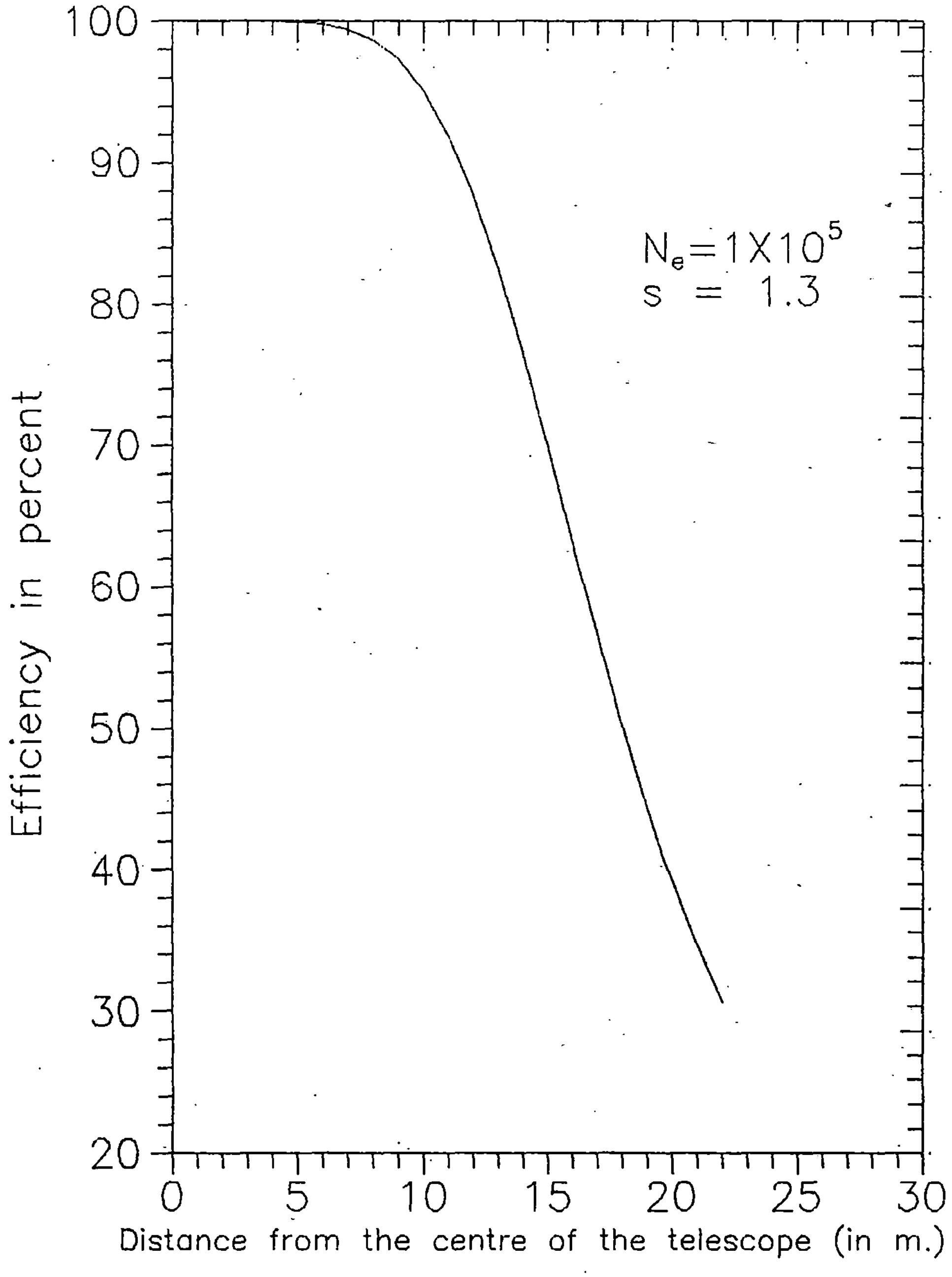

Fig.3.3b.
The detection efficiency of the telescope as a function of distance from the centre of the telescope.

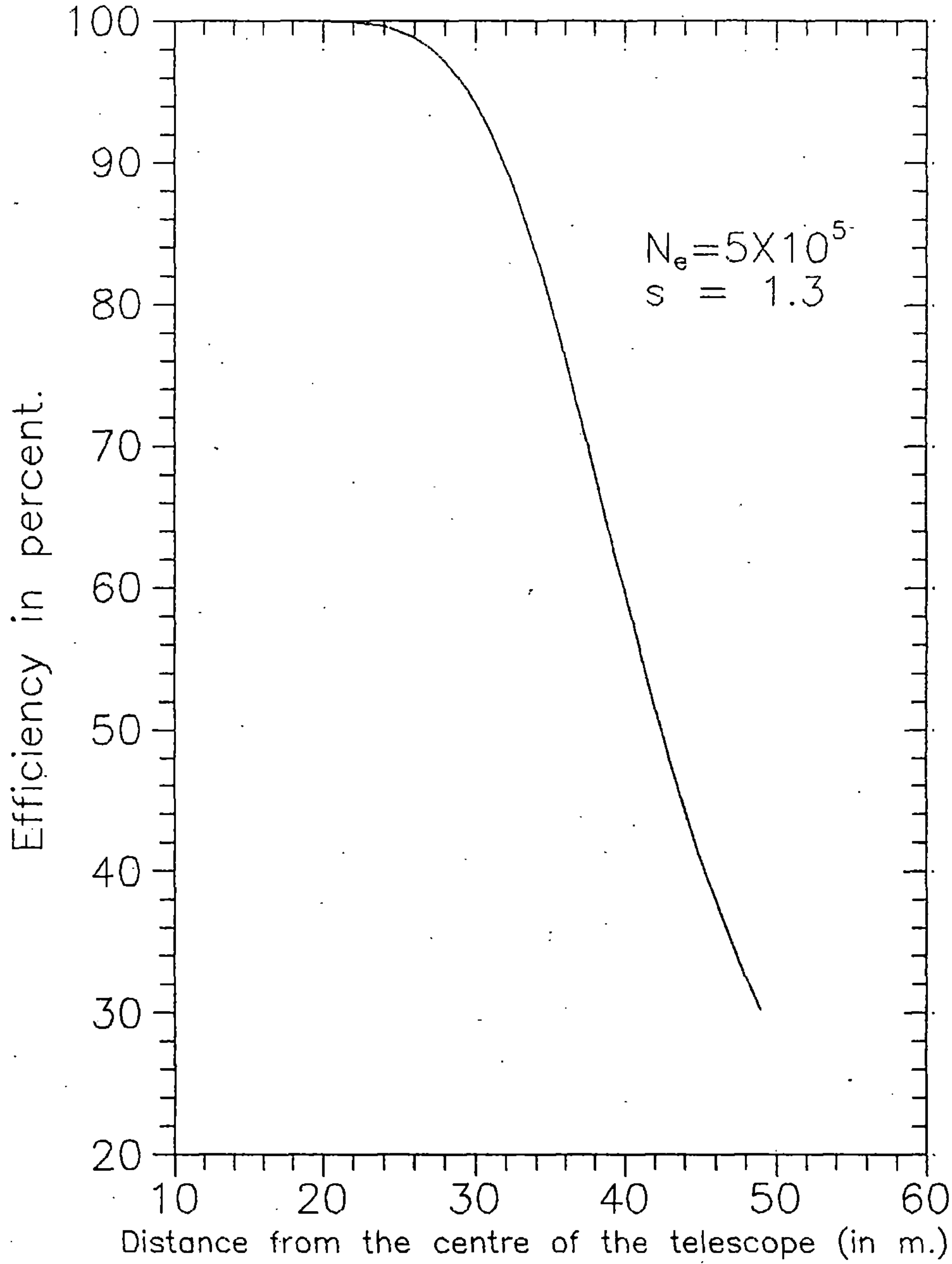

Fig.3.3c.
The detection efficiency of the telescope as a function of distance from the centre of the telescope.

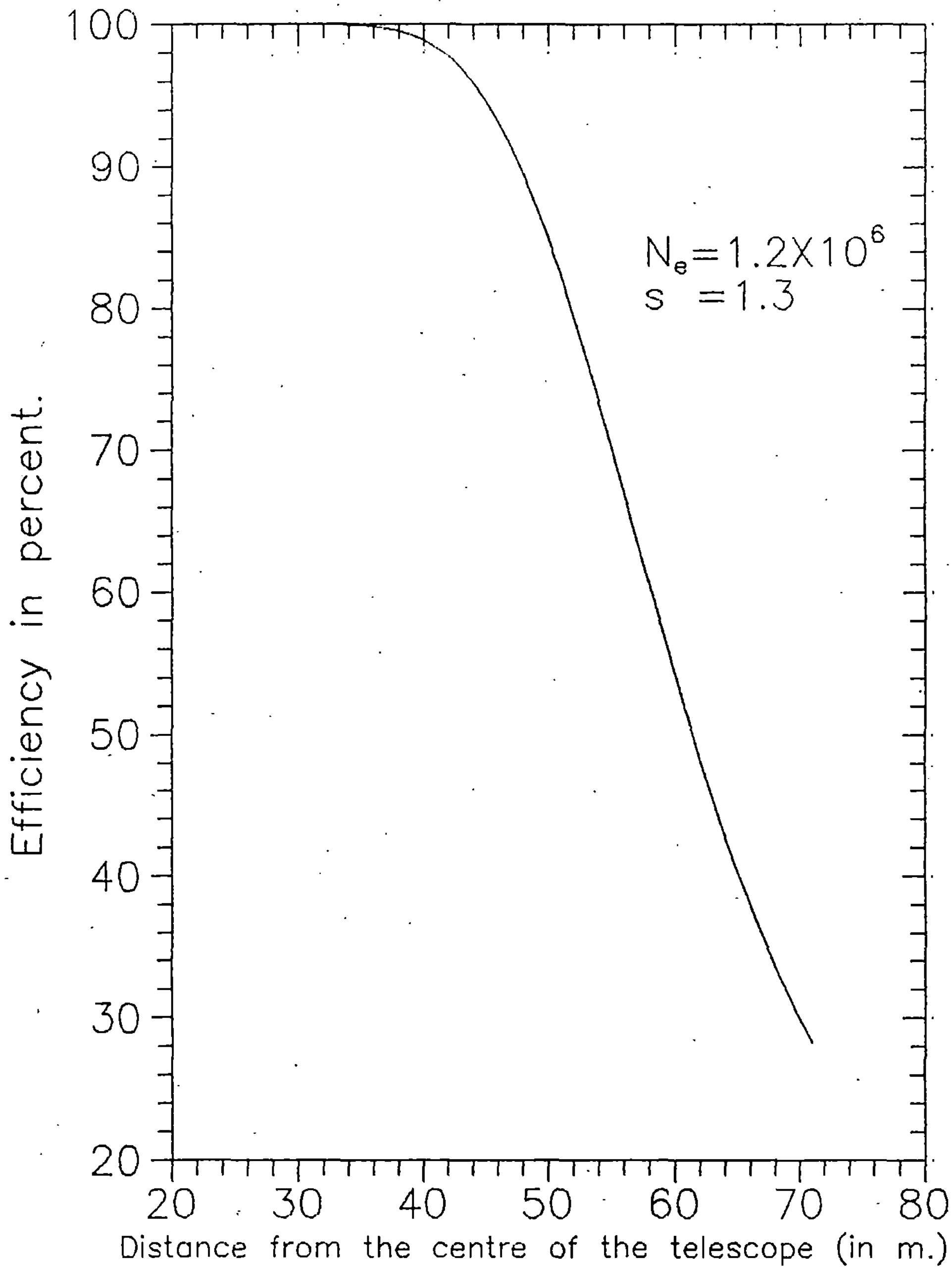

Fig.3.3d.
The detection efficiency of the telescope as a function of distance from the centre of the telescope.

$$W_i = 1 - P_i \quad \text{.........................(3.25)}$$

The variation of triggering probability with shower sizes for core distance 20m , 30m and 40m with different shower age is shown in fig. 3.3e, 3.3f and 3.3g. Since triggering probabilty is 1 for the shower size greater than $2X10^5$ particles, effective area of the array is the total area of the array.

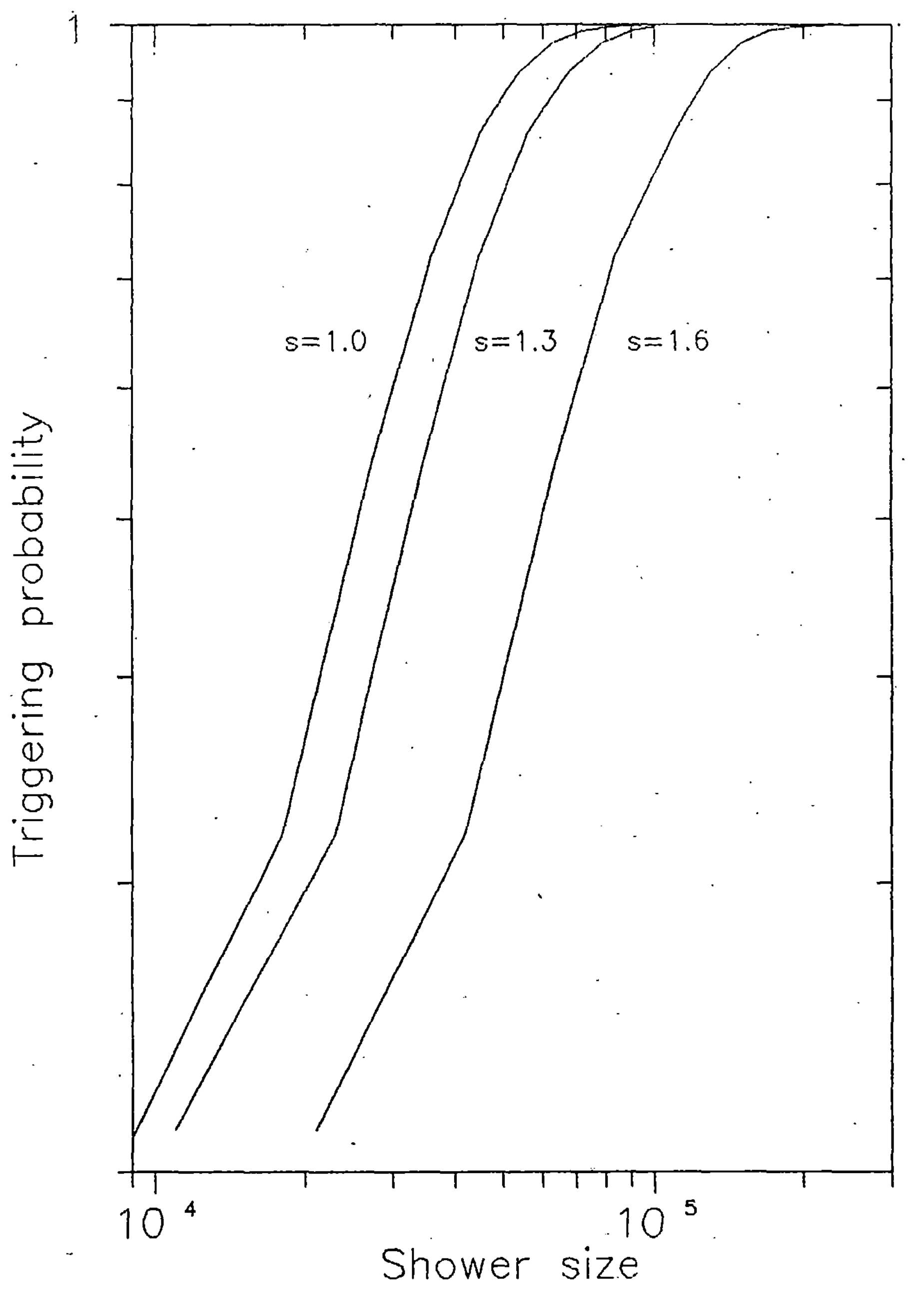

Fig.3.3e.
The average triggering probability for the NBU EAS Telescope as a function of shower size and age for core distance 20m.

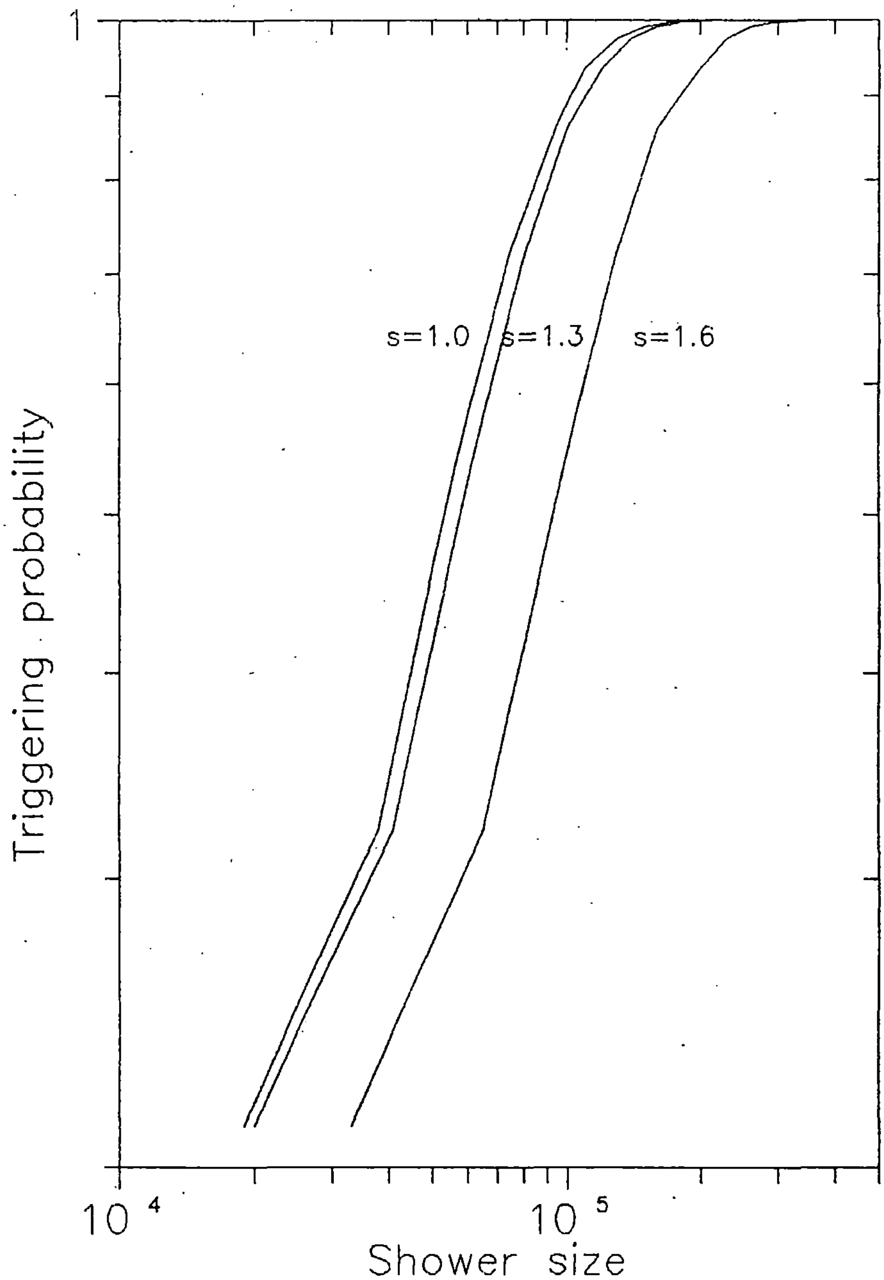

Fig.3.3f.
The average triggering probability for the NBU EAS Telescope as a function of shower size and age for core distance 30m.

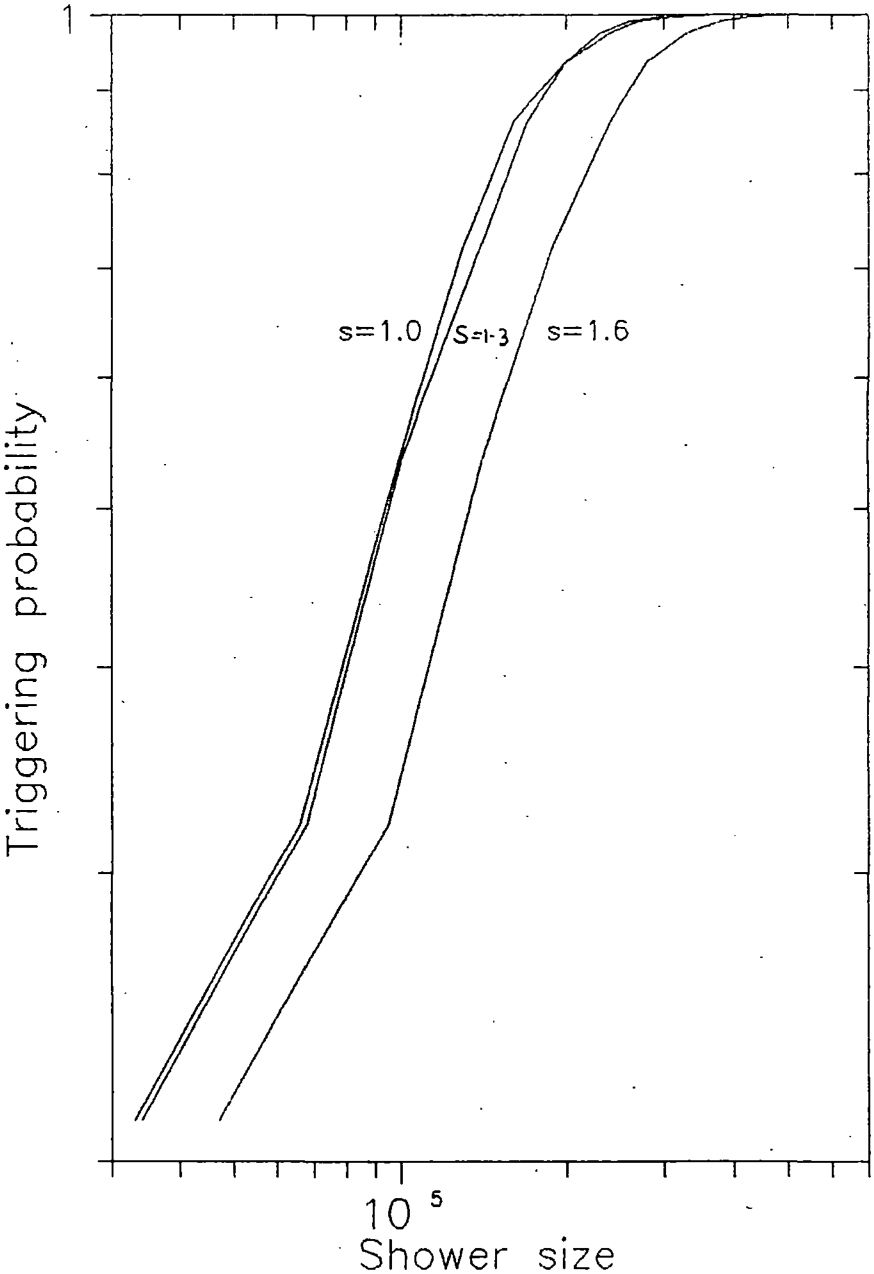

Fig.3.3g.
The average triggering probability for the NBU EAS Telescope as a function of Shower size and age for core distance 40m.