/

10

Reconstruction of cluster energies in the barrel lead glass

JADE Computer Note 101

D. Pitzl

19.5.1988

Introduction

Some new routines for the reconstruction of photon energies in the barrel lead glass have been introduced in JCN 98 and where on the standard library JADELG.SOURCE since 22.12.1987. Here I give a summary of how to use these routines for real data and Monte Carlo, for photons and electrons and for different reactions like multi hadrons, τ-pairs, Bhabhas and 2-photon collisions.
The analysis programs for the lead glass detector have been described in JCN 14D. A flowchart is given in the appendix.
It must be remembered that everything explained in this note refers to the barrel lead glass only.

Correction of the lead glass calibration

The calibration of the JADE lead glass detector is done with Bhabha events (see JN 86). In events selected to reduce Bremsstrahlung the observed cluster energy is adjusted to the 'expected' energy by introducing a correction factor for each lead glass block. The 'expected' cluster energy is calculated from the beam energy by taking into account the following effects (see JCN 35):

- The mean energy loss of electrons in the material between the interaction point and the lead glass surface ($1.23X_0$ at $\Theta = 90^o$) is subtracted in the routine ENGLOS.
- The efficiency for the collection of Čerenkov light on the photocathode depends on the incident angle of the electron (routine ANGBAR).
- Routine BRLGN has correction factors depending on the electron impact point within one block.

In this procedure the leakage of the electromagnetic shower through the back face of the lead glass blocks is not taken into account. The block depth of 30 cm corresponds to $12X_0$ in SF5 and $18X_0$ in SF6. The average fraction of leaking shower energy is shown in fig 1. Since the

leakage is neglected the expected cluster energy is too high and all calibration constants are too high.
Consequences:

- Bhabhas: For electrons with beam energy there is perfect cancellation, since the calibration corrects their leakage. Electrons with lower energy in hard bremsstrahlung events have a smaller leakage and therefore their reconstructed energy is sytematically too high. This applies also to electrons in τ-decays and multi hadrons.

- Photons from π^0 and η decays: Photon showers below 1 GeV have small leakage (see fig 3 and 4), so their energies are overestimated by the calibration. Nevertheless the π^0 peak was approximately at its nominal value in the past due to an accidental cancellation with another effect, namely the energy loss in the lead glass readout threshold (see below). But there remained a dependence of the position of the π^0 peak on the π^0 energy and on the polar angle of the photons (see JN 136).

- Monte Carlo: Monte Carlo data are not calibrated. Therefore the cancellation of energy mismeasurements for photons from π^0 decay does not occur in the Monte Carlo, resulting in a π^0 peak around 115 MeV for multi hadrons. In the Meier Magnussen lead glass tracking this was compensated by a fudge factor which raised every photon or electron cluster energy by 11%. This fudge factor was taken out of the Meier Magnussen Monte Carlo on the library F22ELS.JMC.S in April 1987.

The lead glass calibration is now corrected for the leakage of Bhabha showers in the routine LGCLPB which is called by LGANAL and processes the clusters in the barrel part. LGCLPB calls for each block in each cluster the routine BBLEAK which returns a correction factor depending on the block position along the beam axis (the lead glass rings are numbered from 0 to 31 along the z axis) and the period (1979 - 82: only SF5 with beam energy of 17.5 GeV, 1983-86: SF6 in the rings 13 to 18 with beam energy of 17.5 Gev or 22.0 GeV). The block energy in the ALGN bank is then reduced.
Usage of BBLEAK:

- Monte Carlo: LGCLPB does not call BBLEAK for Monte Carlo events (identified by run number < 100).

- A flag in the ALGN bank indicates that the calibration correction was applied: halfword #2 (HNORML in the work common) is increased from 10000 to 22000.

- Bhabha events: The calibration constants compensate the leakage of electron showers with beam energy and therefore BBLEAK needs not to be called in LGCLPB. Then the routine LKCORR wich corrects the leakage of photon showers (see below) must not be called from LGECOR either.

- For a study of π^0 or η mesons, call BBLEAK.

- For a hard photon study, BBLEAK should be called. The leakage of photon showers is corrected by the routine LKCORR in the next step.

- For electrons below beam energy there exists no correction function. Their leakage is smaller than the leakage of Bhabhas and also smaller than the leakage of a photon shower of the same energy (in fig 3 and 4 Bhabhas are compared to photons). The present solution is to call BBLEAK and use the photon leakage correction LKCORR for electrons as well. This gives systematically overestimated cluster energies and the error is energy dependent.

Reconstruction of cluster energies

A photon or electron which has an energy E_0 at the interaction point produces a lead glass cluster whose observed energy is given by

$$E_{obs} = (1 + r_{calib})(E_0 - E_{loss})(1 - r_{Leak})(1 - r_{Th})f_{Clce} \qquad (1)$$

The various effects of energy loss and signal reduction are in general functions of the polar angle Θ (symmetric around 90^o), the particle energy E_0, the particle type and the time period.

r_{calib} (Θ, year) : neglection of Bhabha leakage in the calibration.

E_{loss} $(\Theta, E_0, \text{type}, \text{year})$: energy loss in the material between jet chamber and lead glass.

r_{Leak} $(\Theta, E_0, \text{type}, \text{year})$: shower leakage.

r_{TH} $(\Theta, E_0, \text{type}, \text{year})$: energy loss due to the lead glass readout threshold.

f_{Clce} $(\Theta, E_0, \text{type}, \text{year})$: Čerenkov light collection efficiency.

Since the correction factors depend on the incident energy this equation is solved for E_0 by iteration. This is done in the routine LGECOR which is called by LGCDIR. At this stage the calibration correction has already been applied to real data. Starting with the observed cluster energy as a first estimate for E_0 the particle is followed through the coil into the lead glass and all known effects of energy loss and signal reduction are taken into account. In the first iteration the resulting 'expected' cluster energy is in general smaller than the observed energy and the difference is added to the observed energy as a new estimate for E_0. The procedure is repeated until the difference between the 'expected' and the observed cluster energy is below 10 MeV. The cluster energy is stored in the LGCL bank, the block energies in the ALGN bank are not updated. Their sum (given by word #16 in the cluster data) is equal to the observed cluster energy after correction for the calibration.
Every effect has its own subroutine:

ENGLOS, ENLOSG : energy loss in the outer tank wall, z-chamber, TOF counters, coil etc. (1.04 X_0 at 90^o in 1986, see JCN 86) for electrons and photons respectively (see fig 2). The data for photons are from EGS4, the electron data are from the Tokyo group and were found to be in good agreement with EGS.

LKCORR : leakage of photon showers, values from EGS4 for 1.04 X_0 Aluminium and 30 cm lead glass SF5 or SF6 at 90^o (see fig 3 and 4).

THCORR : energy loss due to the readout threshold, data from EGS4 (see fig 5). The lead glass readout threshold was set to 5 ADC counts á 5 MeV in 1979-82 and to 6 counts á 6 MeV in 1983-86 to reduce the electronic noise. An example for the effect of the threshold is given in JCN 70.

ANGBAR : efficiency of Čerenkov light collection on the photokathode, values from the Tokyo people (see JCN 20, see fig 6).

Usage of LGECOR:

- The routines LKCORR and THCORR are valid for photon showers.
- Monte Carlo : the shower leakage is not simulated in the Meier Magnussen lead glass tracking or the 1 dimensional tracking. (selected by LFLAG(4) = .T. or .F. when calling MCJADE in the tracking step). Therefore LKCORR is not called for these Monte Carlos. The Tokyo shower program includes shower leakage (selected by LFLAG(6) = .T. , see JCN 98) and for this Monte Carlo LKCORR is used (identified by MCTYP in LGECOR).
- For electrons below 5 to 10 GeV LKCORR should be used while for electrons with higher energy a treatment as Bhabhas gives the smaller error.
- Bhabhas: do not call LKCORR, the leakage is compensated by the calibration constants if BBLEAK was not called. The same holds for Bhabha Monte Carlo with 1 dimensional or 3 dimensional Meier Magnussen tracking where leakage is not simulated. But the Tokyo shower program includes leakage which must then be corrected by a call to LKCORR.

Appendix

Flowchart for the lead glass analysis routines mentioned in this note :

FORTRAN IV code on JADELG.SOURCE, compiled versions on JADELG.LOAD

Main program or SUPERVISOR

- LGINIT : block data for geometrical constants and cuts
- event loop
- LGCALB : lead glass calibration, creates ALGN bank from ALGL bank
- LGANAL : cluster search, creates LGCL bank
  - LGCLPB : process clusters in the barrel part
    - BBLEAK : calibration correction
- LGCDIR : links tracks to clusters, calculates direction cosines, writes onto LGCL bank
  - LGECOR : corrects photon and electron energies
    - ENGLOS, ENLOSG : energy loss of electrons and photons in coil
    - LKCORR : leakage of photon showers
    - THCORR : energy loss due to readout threshold
    - ANGBAR :angle dependence of Čerenkov light collection efficiency

next event

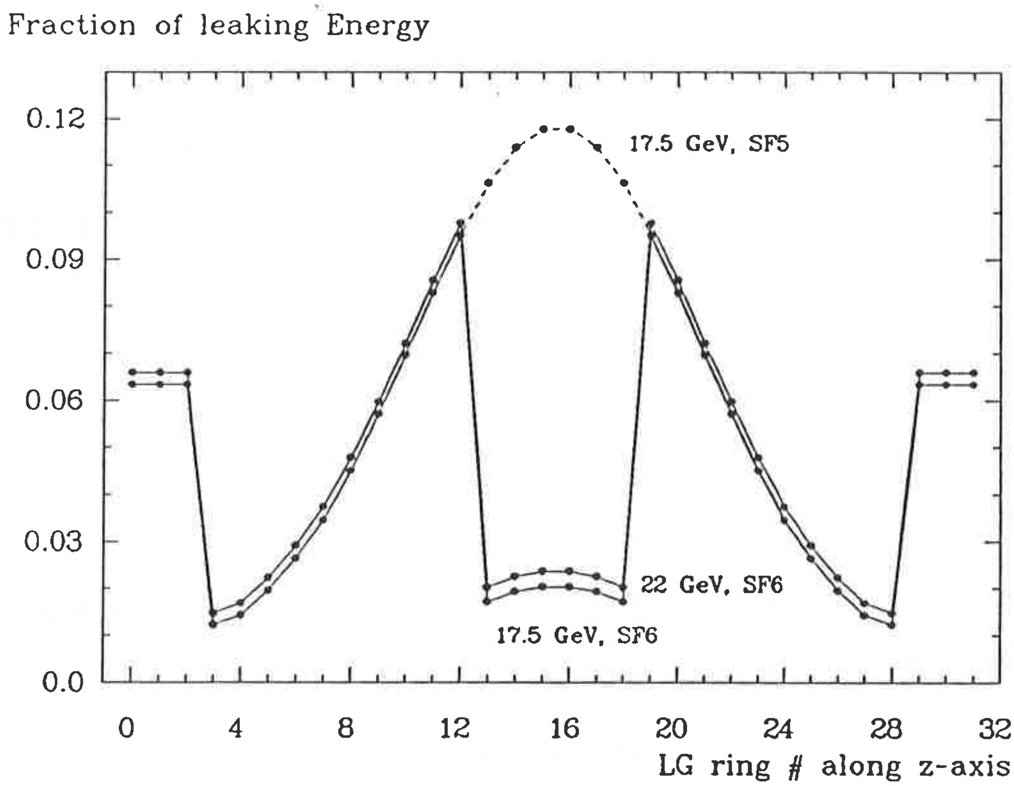

Figure 1: *Leakage of bhabha showers*

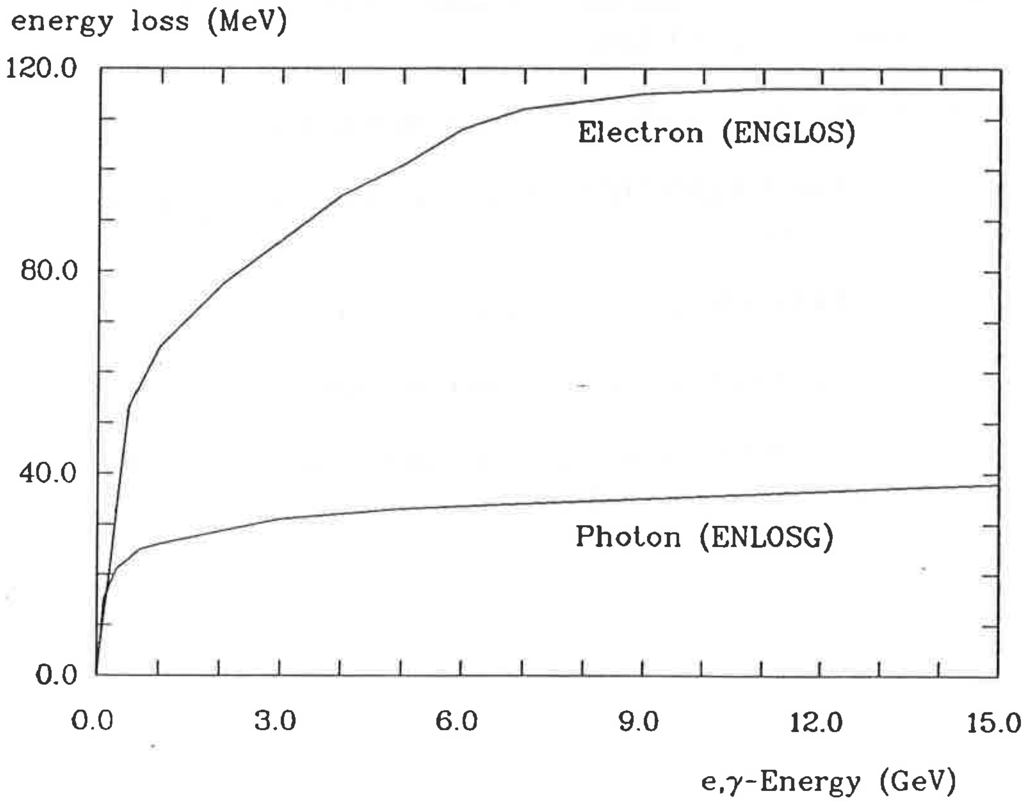

Figure 2: *Energy loss of electrons and photons in 1 X_0 Aluminium*

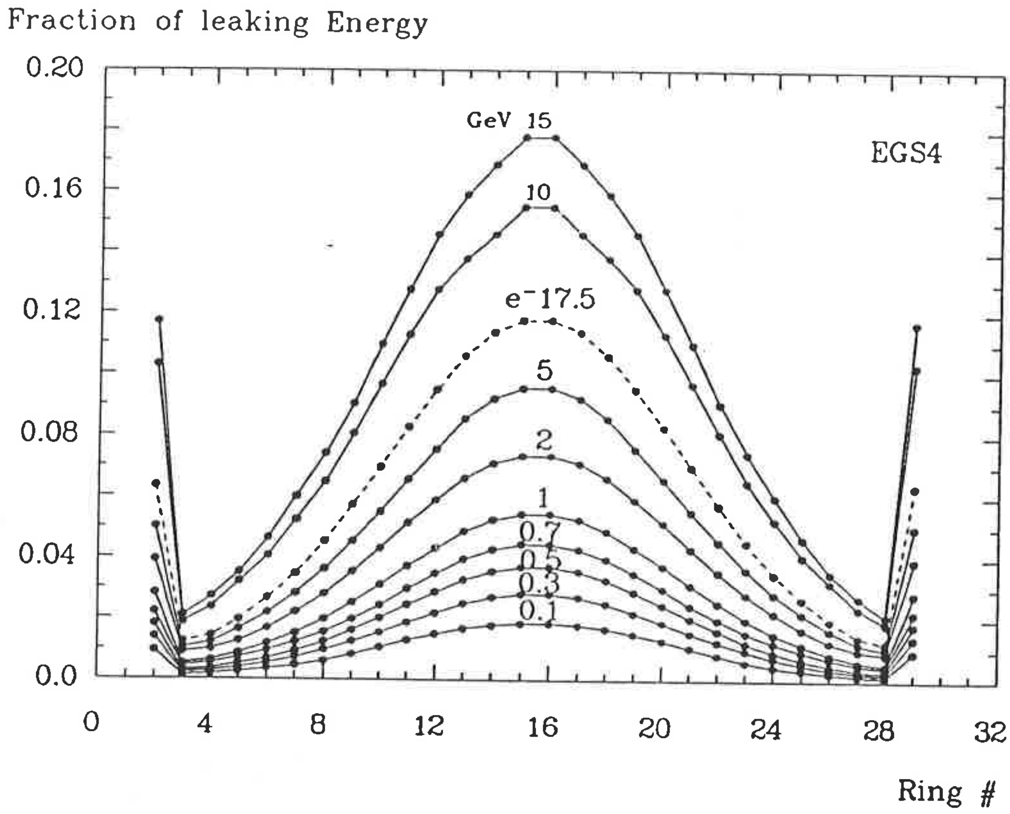

Figure 3: *Leakage of photon showers, 9 cm Al and 30 cm lead glass SF5*

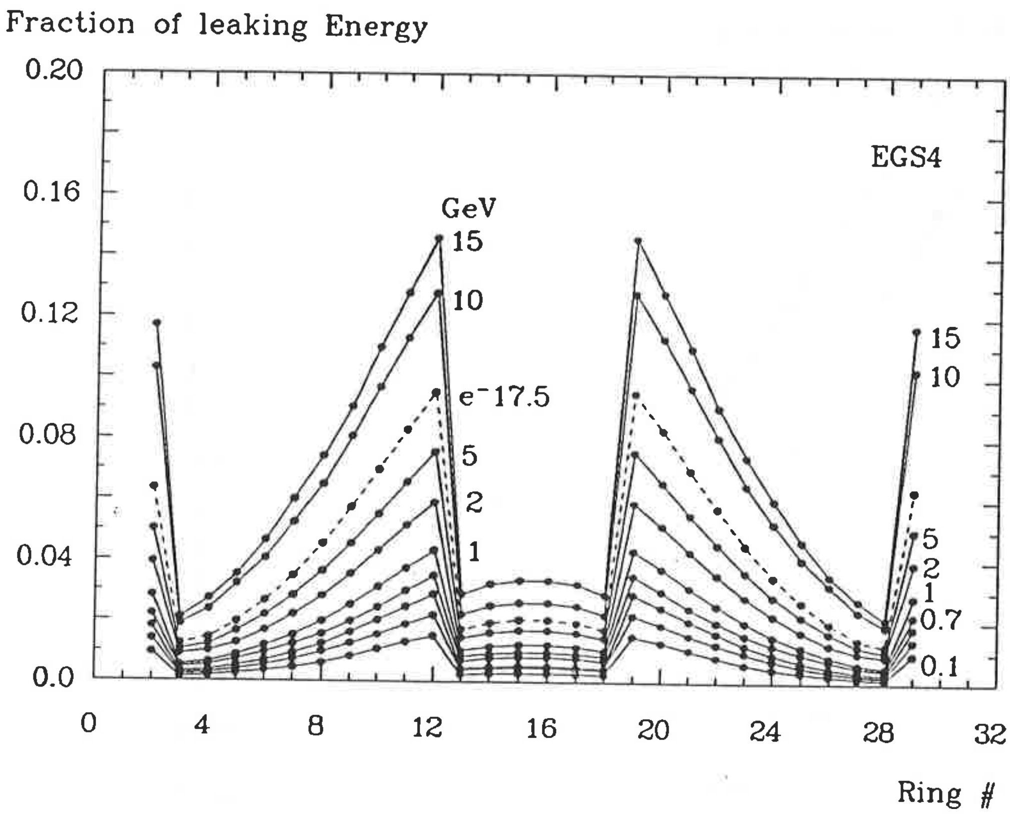

Figure 4: *Leakage of photon showers, SF6 in the 6 central rings*

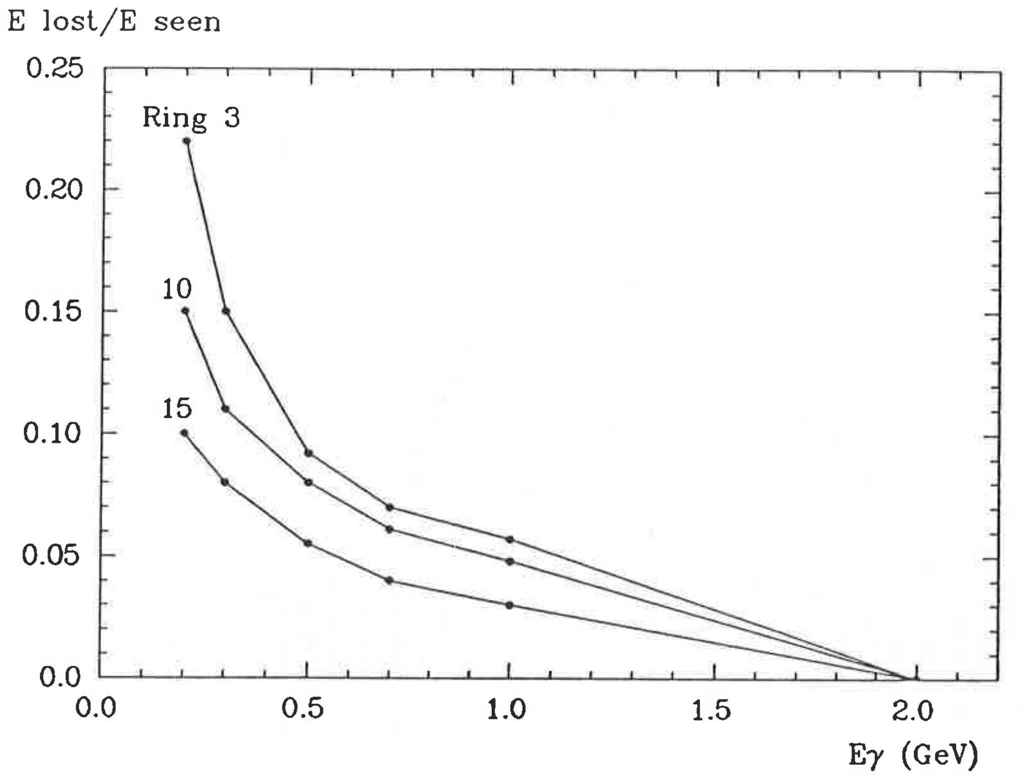

Figure 5: *Energy loss due to a readout threshold of 36 MeV*

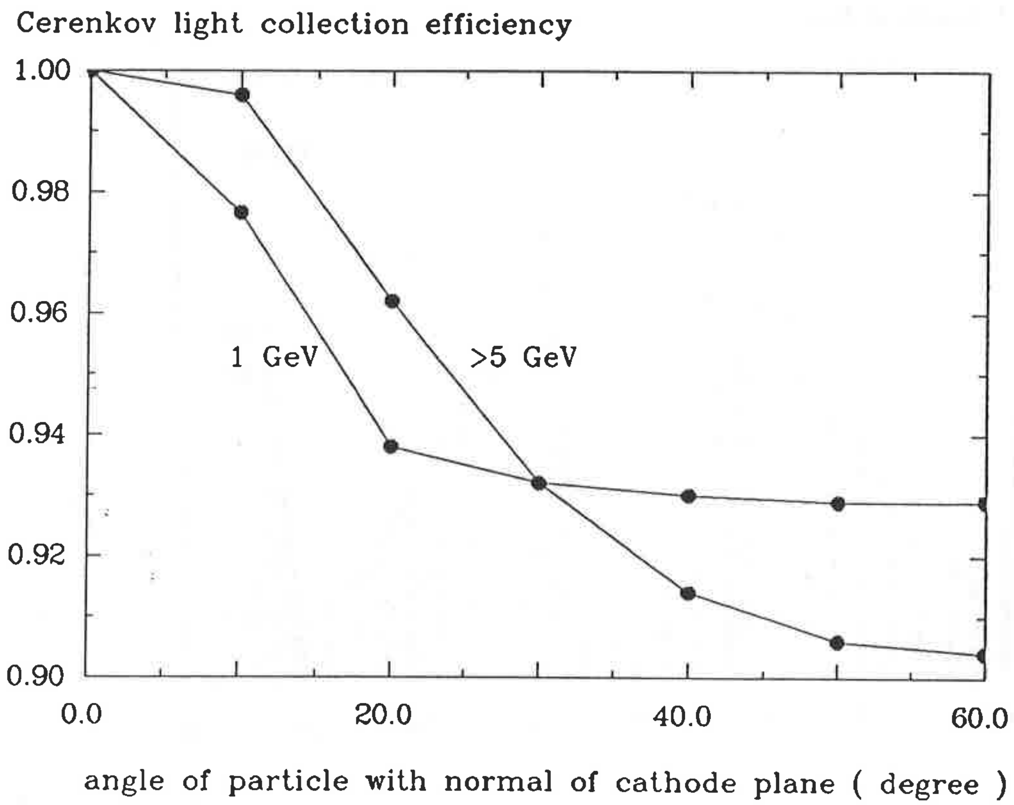

Figure 6: *Efficiency of Čerenkov light collection*