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A NEW VERSION OF MINUIT PROGRAM FOR A PDP11/34A COMPUTER SYSTEM

by

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Abstract: *MINUIT is a package of subprograms originally written for a CDC computer. In this paper we present an implementation of this package on a PDP11/34A computer system and discuss the effects on numerical computations involved of a mini versus main fraim computer.*

1. INTRODUCTION

A large number of problems can be reduced to the problem of finding the minimum value taken on by a function of one or more variable parameters. The classic example is the estimation of unknown parameters in a theory by minimizing the difference (chi-square) between theory and experimental data. In this kind of problems the theory is represented by a function $F(x_i)$, where x_i are the unknown parameters of the theory.

Many programs have been suggested to solve problems like those outlined above. The most of them have no general applications. A program which can be used for a large number of different problems requiring minimization is MINUIT (JR75).

The most of the programs like MINUIT have been written for large computers. Programs which modified from large computers to work in minicomputers generally occupy double space in memory because the word of minicomputers is generally 16 bits while that of large computers is 32 or 36 bits.

In this paper we present an implementation of MINUIT on a PDP 11/34A computer system.

2. OVERVIEW OF MINUIT PROGRAM

MINUIT is a system of programs and is quite general. It incorporates three different minimization methods, each of which may be used alone or in combination with others depending on the behavior of the function and the requirements of the user. The three minimizing subroutines are:

a) SEEK—a Monte Carlo searching subroutine,
b) SIMPLX—a minimizing subroutine using the Simplex method of Nelder and Mead (NM65),
c) MIGRAD—a minimizing subroutine using the variable metric method of Fletcher (F70).

MINUIT in the original form consists of 52 subprograms. Control of MINUIT resides in two subroutines, MINNEW and COMAND. MINNEW takes care of all automatic initialization procedures, whereupon it calls COMAND, according to the flow scheme in figure 1. COMAND takes orders from the user in the form of command cards and executes them.

Table I contains a summary of the recognized by the MINUIT commands and their purpose and formats.

3. OVERVIEW OF IMPLEMENTATION

3.1. System description

The system hardware includes a PDP11/34A CPU with memory management and 96 kW memory. The system hardware also includes Extended Instruction Set, but not floating point processor. The operating system is the RSX-11M version 3.2. The FORTRAN IV was used as programming language.

The memory is logically divided into partitions where tasks are loaded and executed. These partitions are presented in table II. The partition GEN is a general use partition were any user task can be loaded and executed.

3.2. Implemetation technique.

In order to reduce the memory requirements of MINUIT the overlay technique was used. Using this technique the program is divided into a series of segments consisting of a single root segment, which is always in memory and any number of overlay segments, which either:

i) reside on disk and share virtual address space and physical memory with one another (disk-resident overlays); or

ii) reside in memory and share only virtual address space with one another (memory-resident overlays).

Segments are consisted of one or more object modules which in turn are consisted of one or more program sections. Segments that overlay each other must be logically independent; that is the component of one segment cannot reference the components of a segment with which it shares virtual address space.
Dividing a task into disk-resident overlays saves physical space, but introduces the overhead activity of loading these segments each time they are needed, but not present in memory.

In this work MINUIT was divided into disk-resident overlays because the main problem was the memory space limitation.

3.3. MINUIT overlay description.

MINUIT was divided into a root segment and 12 independent overlay segments. The overlay description chart is presented in fig. 2. As it can be seen from this chart the physical memory space that is needed for the whole task reduces to the space needed for the root segment plus the space needed for the largest of the twelve overlay segments.

In overlay structure always a COMMON is used in order to save parameter values that have been computed by the execution of an overlay segment. Then these parameter values can be used by any segment. This COMMON is included in the main program, which is in the root, and at least in one routine of each overlay segment.

The COMMON of the original form of MINUIT was used as the «overlay» COMMON. Some additions were made for the overlay structure needs. In overlay structure of MINUIT the subroutine COMAND is not yet used. This routine in the original structure of MINUIT is the driving routine and if used it was neccesary to be always in memory thus increasing the memory space requirements. Instead of COMAND nine driving routines have been produced. These are named CARDRD, MISIMI, PFRMHR, IMPRO, PARAM, SCAN, CNTOUR, LISPCF and ENEX. The flow scheme of the new vertion of MINUIT is shown in fig. 3.

On entry, subroutine MIDATA is called from the main (MINNEW) to read the parameter cards. Then every time a «command card» is to be read, the routine CARDRD is called. This routine reads the command card and sets the value of an index I. According to the value of I the appropriate command is executed through the new driving routines. The commands, that executed through each of the above driving routines are shown in table III.

As can be seen from table III some commands are executed directly by the main. Table IV represents the modules contained in each segment. Each module is referenced in table IV by its name in the program and, in parentheses, by its symbol used in figure 2.

3.4. Modifications in MINUIT routines.

Some routines of MINUIT were modified for two mainly reasons; a) for overlay requirements b) to reduce memory space.

Subroutine MIDATA was modified in order to be able the program to execute the command PARAMETER. Using the unmodified MIDATA the above was able by simply calling MIDAT 2. MIDAT2 was an ENTRY subroutine in MIDATA. Since the FORTRAN compiler of the system does not recognize the ENTRY statement, after the modification of MIDATA, the control passes to the first executable statement of MIDATA or to the «MIDAT2 block statements» according to the value of the variable WORD7(7). Whenever the value of WORD7(7) equals to 1 any call of MIDATA passes the control to the «MIDAT2 block statements».

As input, for parameter values, may be used either the terminal or the disk file «PUNCH.DAT».

Subroutine IMPROV was modified so that any call to SIMPLX from IMPROV is made through the driving routine IMPRO. That has as effect the two routines IMPROV and SIMPLX to share the same virtual space, thus reducing the total length of the segment. Figures 4a and 4b represent simplified flow charts of segment 4 using the unmodified and modified IMPROV respectively. In figure 5 is represented the effect of the IMPROV modification in the branch D of the overlay tree. Subroutine CONTOU was also modified so that it, additionally, executes the function of the routines FRAME, PAPER and NAMES which are not yet used. The matrices of the routines MSCAN, PLTCON CONT and CONTOU have been also modified because of the needs of the overlay structure of the new version of MINUIT. The subroutine FCN divided into two routines for memory space economy. The one, still named FCN, is placed in the root. The other, named FCN1, is placed in segment 7. FCN1 is called from FCN, each time FCN is called with IFLAG=1 or with IFLAG=3.

The subroutine MPUNCH was also modified so that the execution of command PUNCH has as effect the output of the current values of parameters in the disk file «PUNCH. DAT».

3.5. Usage of new version.

The new version of MINUIT can be used, as the original, in any problem that can be redused to the problem of minimizing a function F(x). The number of independed parameters x_i that can be estimated by this version of MINUIT must be less than or equal to 15 and the number of depented parameters must not exceed the 30. All the commands that were recognized by the original version can be executed from the new version of MINUIT.

The new version has been used in our laboratory in many experiments such as Positron annihilation (CDC 82), plastic detectors research (ZC81), peak analysis in γ-spectroscopy (X82), (D82), etc.

4. TESTS

The new version of MINUIT was tested with the same job as in (JR75). The output of this test run is presented at the end of the paper As it is clear the results are satisfactory closed to that comes from the original form of MINUIT by the same test run on a main frame computer (CDC 7600). The very small differences that are observed, mainly in parabolic and less in MINOS errors, may probably due, either to the better precision of the CDC 7600, or to the fact that the minimum of the function used is not very sharp. This latest is clearly shown in pages 6 and 7 of the test output where the scanning of the test function used, versus the parameters 1 (page 6) and 2 (page 7) is represented. As it can be seen from the tests the execution time on PDP11/34A is higher than that on CDC 7600. The larger delay execution time rises from three different type of sources. The first is from the difference in speed between the PDP11/34A and the CDC 7600. The second comes from the fact that the new version of MINUIT is a disk-resident overlay and, as it was mentioned above, this type of structure saves memory space but increases the execution time. The third is that the system has not floating point hardware.

Many tests of the program have shown that the use of double precision for all variables and for the FCN arguments increases very much the execution time without any significant change on the results.

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Many tests of the program have shown that the use of double precision for all variables and for the FCN arguments increases very much the execution time without any significant change on the results.

REFERENCES

JR75 James F. and Roos M. Comp. Phys. Commun. 10 (1975) 343
Long write-up of MINUIT, CERN Computer Centre 1977

NM65 Nelder J. A. and Mead R. Comput. J. 7 (1965) 308

F70 Fletcher R. Comput. J. 13 (1970) 317

CDC81 Chardalas M., Dedoussis Sp. and Charalambous Stef.
Sci. Annals Fac. Phys. and Mathem. (In this volume)

ZC81 Zamani M. and Charalambous Stef. Nucl. Tracks 4 (1981) 177

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D82 Decoussis Sp. PhD disertation, to be submitted in University of Thessaloniki

TABLE I

MINUIT commands.

COLUMNS	(1-10)	(11-20)	(21-30)	(31-40) etc
PURPOSE	COMMAND	ARG 1	ARG 2	ARG 3
Cause a call to FCN	CALL FCN	IFLAG		
Read in covariance matrix.	COVARIANCE	NPAR followed by martix elements (7F10)		
Trace contours of FCN.	CONTOUR	Param. No. (x-axis)	Param. No. (y-axis)	Size of region (dv=2.)
Signals end of data block.	END			
End of data block. Return to calling program.	END RETURN			
Set value of UP to define parameter errors.	ERROR DEF	UP value (dv=1.)		
Signals end of job.	EXIT			
Make parameter constant	FIX	Param. No.		
Inticates that derivatives will be calculated by FCN.	GRADIENT	0=check 1=no check		
List MINUIT commands.	HELP			
Calculate and print covariance matrix.	HESSE	Max. Calls (dv=1000)		
If minimum is found, look for another one.	IMPROVE	Max. Calls (dv=1000)	No. Tries (dv=NPAR+2)	
Reset parameter limits.	LIMITS	Param. No. (0=All)	Lo limit	Up limit
Print covariance matrix. (if necessary, calculate).	MATOUT			
Do MIGRAD minimization	MIGRAD	Max. Calls (dv=1000)	Tolerance (dv=0.1)	V-Stability (dv=0.1)
Minimize FCN, using both SIMPLEX and MIGRAD.	MINIMIZE	Max. Calls (dv=1000)	Tolerance (dv=0.1)	V-Stability (dv=0.1)
Do MINOS error analysis.	MINOS	Max. Calls per param. (dv=1000)	Param. Nos. (dv=all param)	(in I2 format)

Read new parameter cards.	PARAMETER	followed by parameter card(s) terminated by blank card
Set level of printout.	PRINTOUT	Level (dv=1)
Write parameter values and error matrix to PUNCH.	PUNCH	
Restore one or more previously fixed parameters to variable status.	RELEASE or RESTORE	Param. No. Param. No ....(up to 6) 0=All params 1=Last param. fixed
Show FCN value as function of one parameter.	SCAN	Param. No. (blank= all) · Lo limit of scan (dv=2 std. · Up limit of scan dev. from min.)
Do Monte Carlo minimization	SEEK	No. Calls (dv=100*NPAR)
Set parameter equal to a given value.	SET PARAM	Param. No. · Value
Do SIMPLEX minimization.	SIMPLEX	Max. Calls (dv=1000) · Tolerance (dv=0.1)
Call subroutine STAND.	STANDARD	Parameters available to STAND via COMMON/CARD/

TABLE II

The partitions of the system used. (All values are in octal)

Partition	Start address	Size	Type
LDR	000000	000000	MAIN TASK
FORRES	100000	040000	MAIN COM
FCSRES	140000	020000	MAIN COM
TTPAR	160000	017000	MAIN TASK
SYSPAR	177000	010000	MAIN TASK
FCPPAR	207000	010700	MAIN SYS
GEN	217700	360100	MAIN SYS

TABLE III

The driving routines of the new version.

Driving routine	COMMANDS
MISIMI	MINIMIZE, SIMPLEX, MIGRAD
PFRMHR	PRINTOUT, FIX, RESTORE, MATOUT, RELEASE, ERROR DEF
PARAM	PARAMETER
IMPRO	IMPROVE
SCAN	SCAN
CNTOUR	CONTOUR
LISPCF	LIMITS, SET PARAM, CALL FCN
ENEX	END, EXIT
—	MINOS
—	SEEK
—	PUNCH
—	STANDARD

TABLE IV

Names of the modules in each segment.

Segment	MODULES
ROOT	MINNEW, FCN, MINOS, UCOPY, INTOEX, MPRINT
SEG 1	MISIMI(A), SIMPLX(A1), RAZZIA(A11), MIGRAD(A2), DERIVE(A21), MATOUT(A22), VERMIN(A221).
SEG 2	PFRMHR(B), HESSE(B1), FIXPAR(B11), VERMIN(B12), RESTOR(B2), MATOUT(B3), VERMIN(B31).
SEG 3	PARAM(C), MIDATA(C1), INTRAC(C11), PINTF(C12).
SEG 4	IMPRO(D), IMPROV(D2), VERMIN(D21), CALFCN(D22), RNDM(D23), RAZZIA(D24), SIMPLX(D1), RAZZIA(D11).
SEG 5	SCAN(E), MSCAN(E1), PLTCON(E11), BINSIZ(E111), EXTOIN(E12), PINTF(E121).
SEG 6	CNTOUR(F), CONTOU(F1), BINSIZ(F11), CONT(F12), ORDRE2-D506FN(F121).
SEG 7	LISPCF(G), EXTOIN(G1), PINTF(G11).
SEG 8	ENEX(H), FCN1(H1).
SEG 9	MPUNCH(I).
SEG 10	STAND(J).
SEG 11	CARDRD(K).
SEG 12	SEEK(L), EXTOIN(L1), PINTF(L11), RNDM (L2).

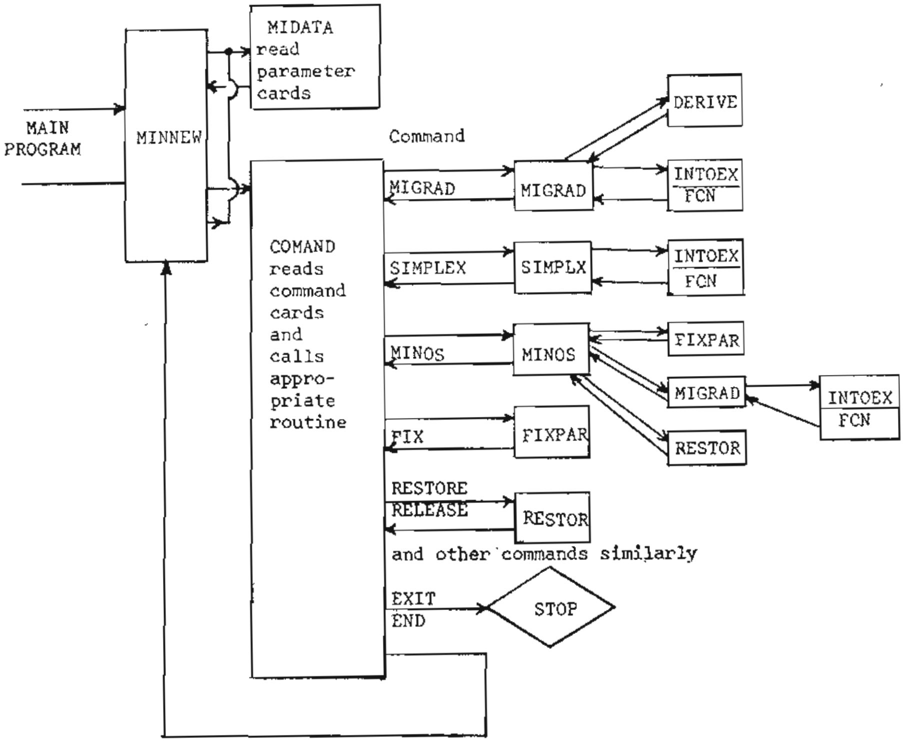


Figure 1. Flow scheme of the original MINUIT program.

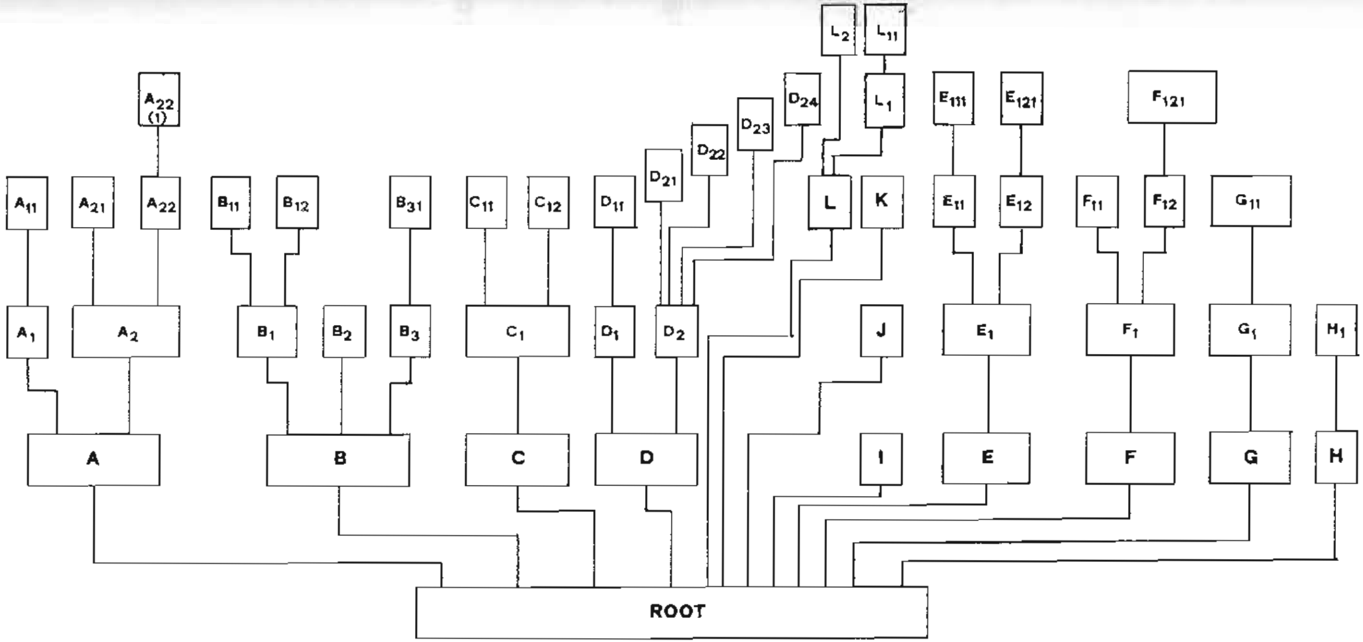


Figure 2. The overlay tree of the new version of MINUIT.

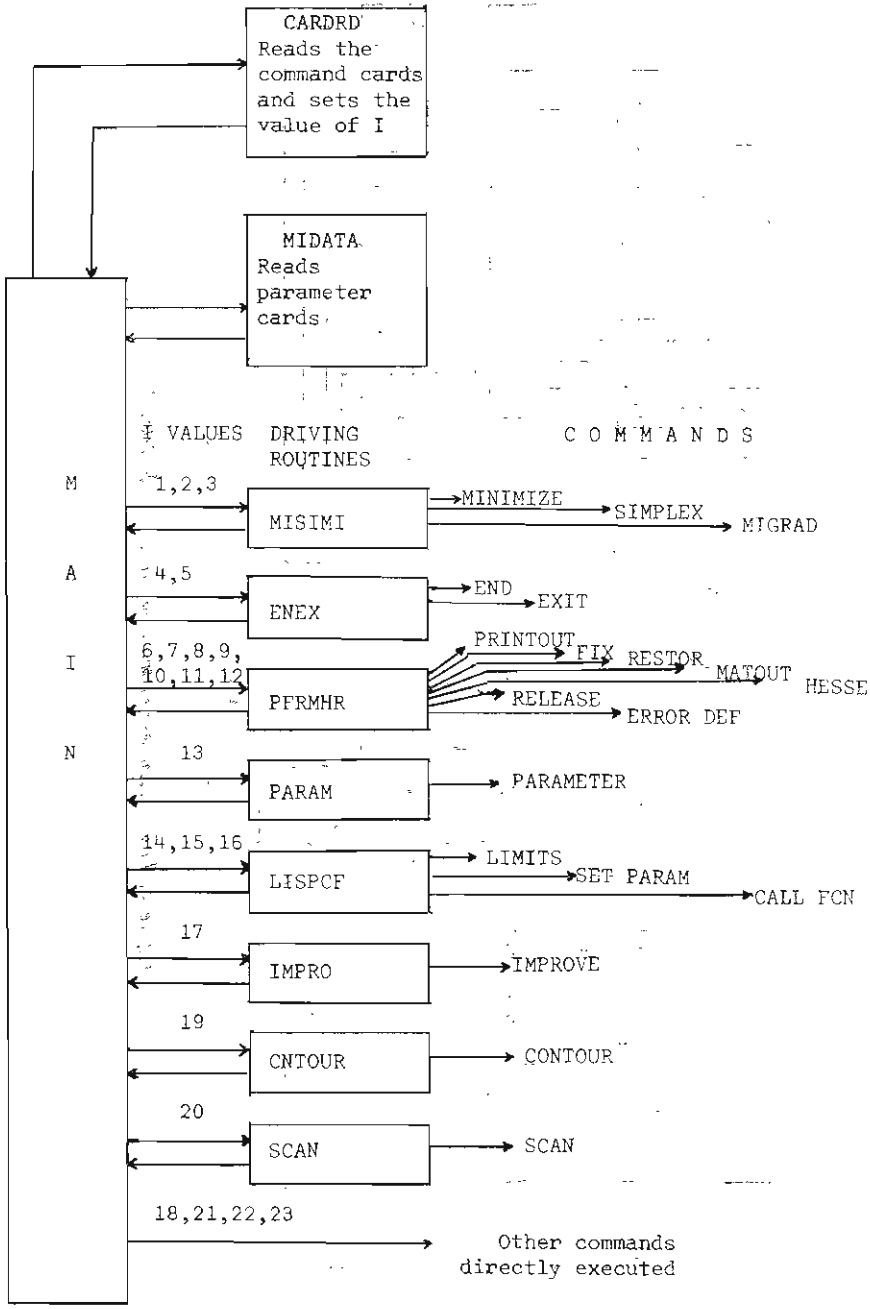


Figure 3. Flow scheme of the new version of MINUIT.

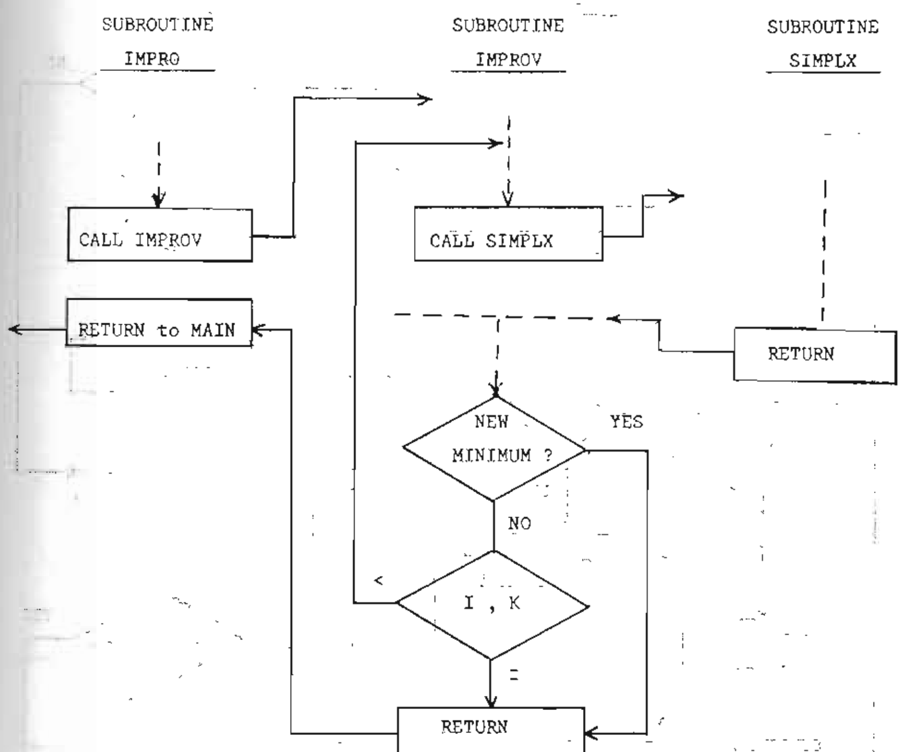


Figure 4a. Simplified chart of segment 4 using the unmodified IMPROV.

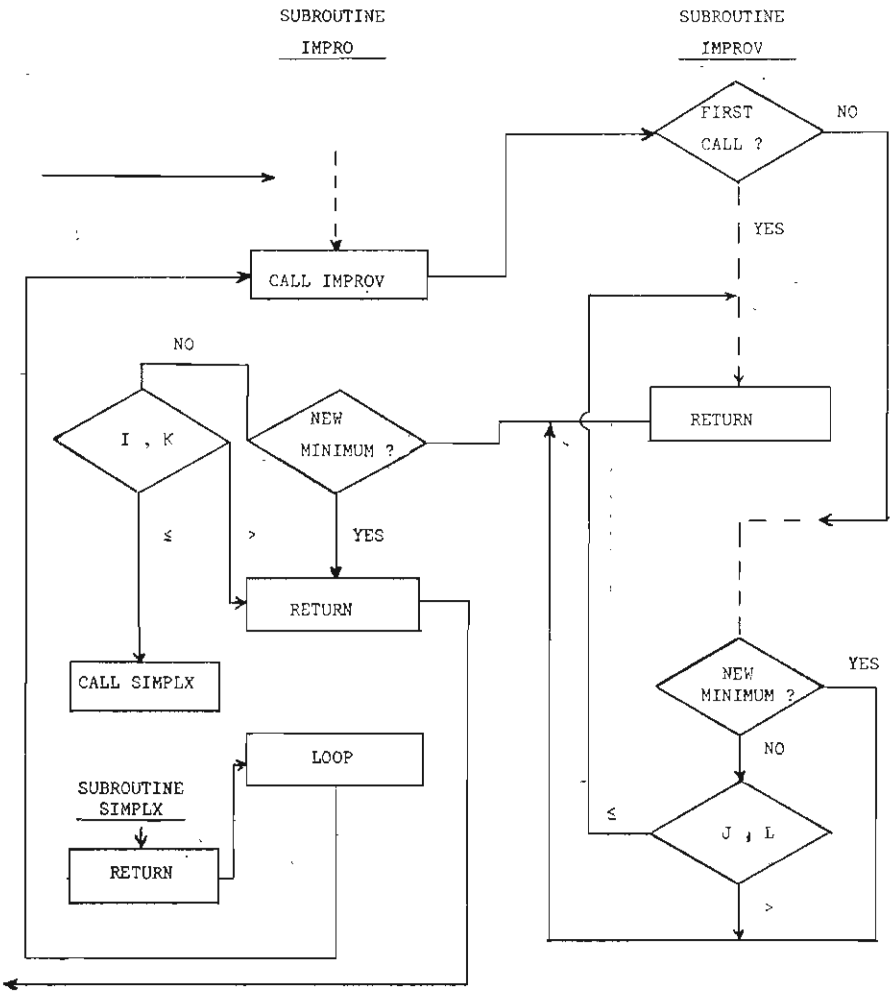


Figure 4b. Simplified chart of segment 4 using the modified IMPROV.

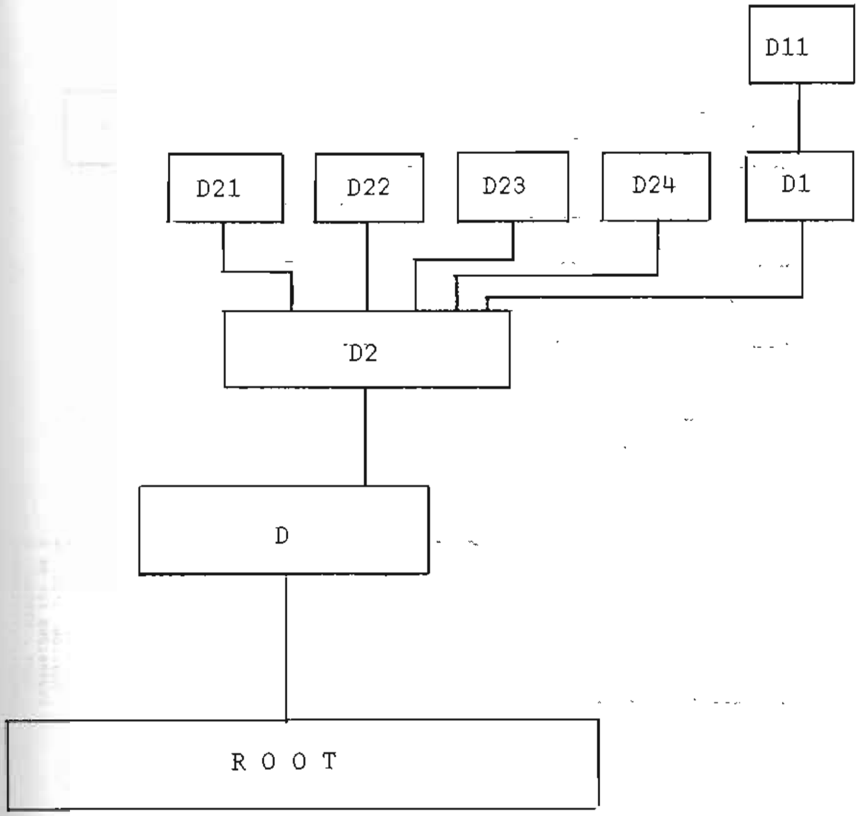


Figure 5a. The D segment with the unmodified IMPROV.

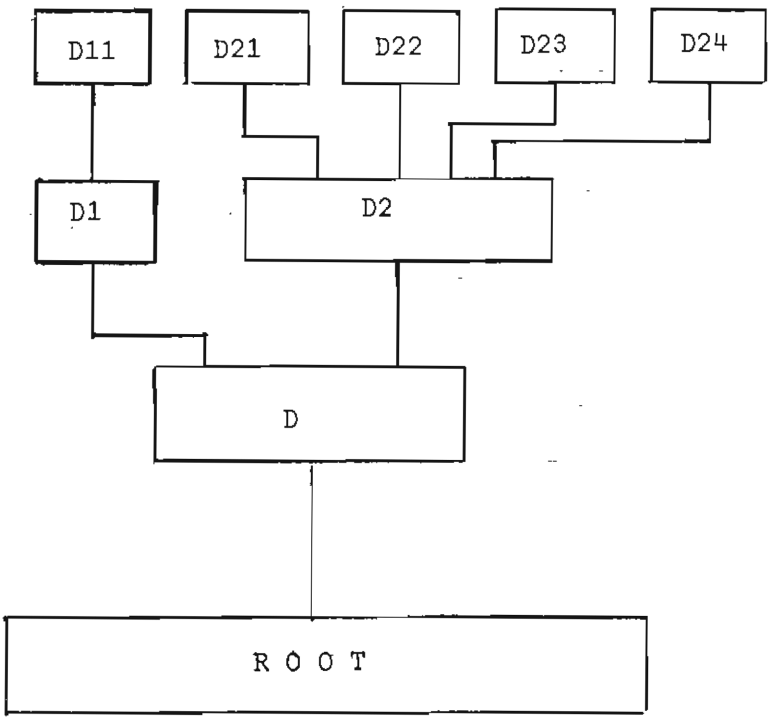


Figure 5b. The D segment with the modified IMPROV.

```
                                    *********************
                                    *   D506   MINUIT   *
                                    * DIMENSIONS 15/ 30 *
                                    *   VERSION  2.77   *
                                    * DATA BLOCK NO.  1 *
  *************************************************************************************************
   FIT TO TIME-DISTR OF KZERO LEPTONIC DECAYS                          TIME21:43:32
  *************************************************************************************************
  *************************************************************************************************
        1          AL  0.000000    0.100000      0.000000    0.000000
        2          AG  0.000000    0.100000      0.000000    0.000000
        3          RM   1.00000    0.100000      0.000000    0.000000
        4          LT  0.460000
  *************************************************************************************************

FIRST ENTRY TO FCN

  FCN VALUE      CALLS    TIME      EDM        INT.EXT. PARAMETER      VALUE          ERROR        INTERN.VALUE     INT.STEP SIZ
 0.7648158E+01      1 21:43:40   0.00E+00       1   1          AL   0.00000E+00    0.10000E+00    0.00000E+00    0.10000E+00
                                                2   2          AG   0.00000E+00    0.10000E+00    0.00000E+00    0.10000E+00
                                                3   3          RM   0.10000E+01    0.10000E+00    0.10000E+01    0.11000E+01
                                                    4          LT   0.46000E+00
**********
***  1****MINIMIZE
**********
START SIMPLEX MINIMIZATION                     CONVERGENCE CRITERION -- ESTIMATED DISTANCE TO MINIMUM (EDM) .LT.  0.10E+00

  FCN VALUE      CALLS    TIME      EDM        INT.EXT. PARAMETER      VALUE          ERROR        INTERN.VALUE     INT.STEP SIZ
 0.7453609E+01     11 21:43:51   0.14E+02       1   1          AL  -0.40000E-01    0.71116E-01   -0.40000E-01    0.40000E-01
                                                2   2          AG   0.10000E+00    0.73206E-01    0.10000E+00    0.10000E+00
                                                3   3          RM   0.10000E+01    0.77853E+00    0.10000E+01    0.17600E+00
SIMPLEX MINIMIZATION HAS CONVERGED

  FCN VALUE      CALLS    TIME      EDM        INT.EXT. PARAMETER      VALUE          ERROR        INTERN.VALUE     INT.STEP SIZ
 0.7209389E+01     24 21:44:00   0.41E-01       1   1          AL  -0.24506E-01    0.11778E+00   -0.24506E-01    0.22037E-01
                                                2   2          AG  -0.20679E-01    0.35579E+00   -0.20679E-01    0.64815E-01
                                                3   3          RM   0.95193E+00    0.14631E+00    0.95193E+00    0.73331E-02
                                                    4          LT   0.46000E+00

                                               ERRORS CORRESPOND TO FUNCTION CHANGE OF      1.0000
START MIGRAD MINIMIZATION.                     CONVERGENCE CRITERIA  --  ESTIMATED DISTANCE TO MINIMUM (EDM) .LT. 0.10E-05
                                               OR EDM .LT. 0.10E+00 AND FRACTIONAL CHANGE IN VARIANCE MATRIX .LT. 0.40E-01

  FCN VALUE      CALLS    TIME      EDM        INT.EXT. PARAMETER      VALUE          ERROR        INTERN.VALUE     INT.STEP SIZ
 0.7209389E+01     30 21:44:11   0.15E+00       1   1          AL  -0.24506E-01    0.16244E+00   -0.24506E-01    0.23555E-02
                                                2   2          AG  -0.20679E-01    0.16115E+00   -0.20679E-01    0.71159E-02
                                                3   3          RM   0.95193E+00    0.48446E-01    0.95193E+00    0.29262E-02
MIGRAD MINIMIZATION HAS CONVERED

  FCN VALUE      CALLS    TIME      EDM        INT.EXT. PARAMETER      VALUE          ERROR        INTERN.VALUE     INT.STEP SIZ
 0.7137547E+01     67 21:44:28   0.58E-07       1   1          AL  -0.35417E-01    0.24412E+00   -0.35417E-01   -0.18215E-04
                                                2   2          AG  -0.12016E-01    0.31986E+00   -0.12016E-01   -0.25571E-04
                                                3   3          RM   0.96670E+00    0.74054E-01    0.96670E+00   -0.36955E-05
                                                    4          LT   0.46000E+00

                                               ERRORS CORRESPOND TO FUNCTION CHANGE OF      1.0000

      INTERNAL COVARIANCE MATRIX               LAST FRACTIONAL CHANGE WAS    0.012396
      CORRELATION COEFFICIENTS
    INT.   1      2
     2 0.729
```

```
3 0.418 0.735

                                              GLOBAL CORRELATION
                                    PARAMETER     COEFFICIENT
                                 1     AL           0.56123
                                 2     AG           0.75535
                                 3     RM           0.56935
*********
***  2****CONTOUR          1.00000          2.00000
*********
```

```
AG
 0.800-*--------------------------------------------------*
       I 666       555         4444                      4I
       I66       555         444                          I
       I        555        444          33333333333       I
       I      555        444       33333           333    I
       I    555        444       333                 33   I
       I  555        4444      3333                  33   I
       I555        444       333                      3   I
       I5        444       333       22222222222      33  I
       I       444       333      2222           22     3 I
 0.300 .     444       3333     2222              2    33 .
       I   444       333      222                 2    3  I
       I444        333      222      11111        2    3  I
       I         333      222     1111   11       2   33  I
       I       333      222    1111       1     22   33  4I
       I     333      222    111          1    22   33  44I
       I   333      222     11     00     11   22   33  44 I
       I33        222     111      00   111   22   33   44 I
       I        22      11            111   222   33   44  I
       I      222      11           111    22   333   44  5I
-0.200 .    22        11      11111    222   33   444  555.
       I   22        '1111111      2222   333    44   55  I
       I   2                      222    333   444  555  6I
       I   2                   22222   3333   444  555  666I
       I   222             222222    333    444  555   66  I
       I     222222222222        33333   4444  555   666  7I
       I                   33333    4444   555   666  777I
       I              333333     4444    5555   666  777  I
       I     3333333333       4444,   555   6666  777  88I
       I333333            444444    5555   666   777  888 I
-0.700 .              444444     55555   6666  7777  888  9.
       I   4444444444       55555    6666  7777  8888  999I
       I4444          555555    66666  7777   888  9999   I
       I          55555555    66666   7777   8888  999    I
-0.850-*--------------------------------------------------*
       /          /          /          /          /          /
    -0.650     -0.400     -0.150      0.100      0.350      0.600
                  AL                        ONE COLUMN = 0.250E-01
```

CONTUR	FCN VALUE	CONTUR	FCN VALUE
0	7,14755	1	8.13755
2	11,13755	3	16.13755
4	23,13755	5	32.13755
6	43,13755	7	56.13755
8	71,13755	9	88.13755

FCN VALUE	CALLS	TIME	EDM	INT.	EXT.	PARAMETER	VALUE	ERROR	INTERN.VALUE	INT.STEP SIZ
0.7137547E+01	1767	21:54:23	0.58E-07	1	1	AL	-0.35417E-01	0.24412E+00	-0.35417E-01	-0.18215E-04
				2	2	AG	-0.12016E-01	0.31986E+00	-0.12016E-01	-0.25571E-04
				3	3	RM	0.96670E+00	0.74054E-01	0.96670E+00	-0.36955E-05
					4	LT	0.46000E+00			

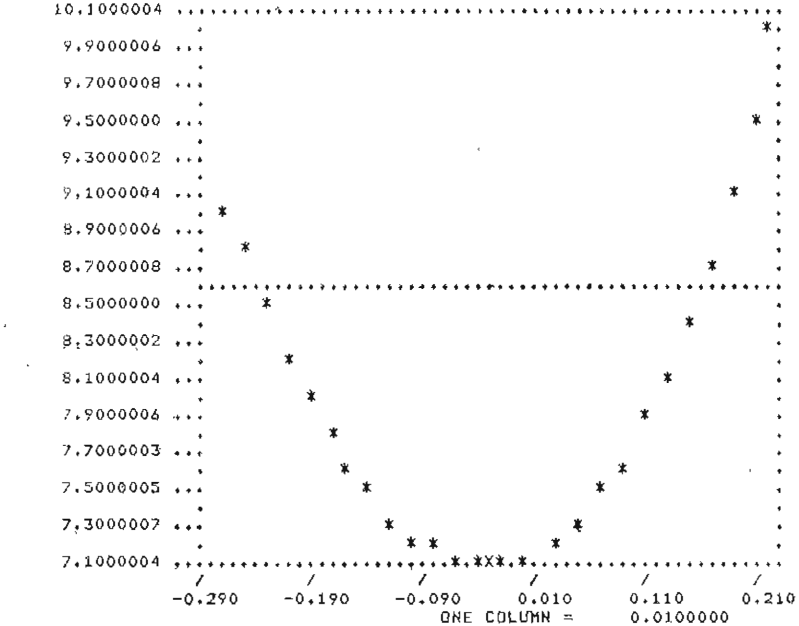
ERRORS CORRESPOND TO FUNCTION CHANGE OF 1.0000

```
**********
***  3****PRINTOUT
**********
**********
***  4****MINOS
**********
MINOS ERRORS REQUESTED FOR PARAMETERS  1  2  3

DETERMINATION OF POSITIVE MINOS ERROR FOR PARAMETER  1          AL
```

```
PARAMETER   1 SET TO -0.354E-01 +  0.244E+00 =    0.209E+00
MIGRAD FAILS TO FIND IMPROVEMENT
MIGRAD MINIMIZATION HAS CONVERED

PARAMETER   1 SET TO -0.354E-01 +  0.208E+00 =    0.173E+00
MIGRAD FAILS TO FIND IMPROVEMENT
MIGRAD MINIMIZATION HAS CONVERED

                                        THE POSITIVE MINOS ERROR OF PARAMETER  1,        AL, IS  0.2128E+00
                                        ***************************************************************************

DETERMINATION OF NEGATIVE MINOS ERROR FOR PARAMETER  1          AL

PARAMETER   1 SET TO -0.354E-01 + -0.244E+00 =   -0.280E+00
MIGRAD MINIMIZATION HAS CONVERED

PARAMETER   1 SET TO -0.354E-01 + -0.290E+00 =   -0.325E+00
MIGRAD MINIMIZATION HAS CONVERED

                                        THE NEGATIVE MINOS ERROR OF PARAMETER  1,        AL, IS -0.2991E+00
                                        ***************************************************************************

DETERMINATION OF POSITIVE MINOS ERROR FOR PARAMETER  2          AG

PARAMETER   2 SET TO -0.120E-01 +  0.320E+00 =    0.300E+00
MIGRAD MINIMIZATION HAS CONVERED

                                        THE POSITIVE MINOS ERROR OF PARAMETER  2,        AG, IS  0.3070E+00
                                        ***************************************************************************

DETERMINATION OF NEGATIVE MINOS ERROR FOR PARAMETER  2          AG

PARAMETER   2 SET TO -0.120E-01 + -0.320E+00 =   -0.332E+00
MIGRAD MINIMIZATION HAS CONVERED

PARAMETER   2 SET TO -0.120E-01 + -0.340E+00 =   -0.352E+00
MIGRAD MINIMIZATION HAS CONVERED

                                        THE NEGATIVE MINOS ERROR OF PARAMETER  2,        AG, IS -0.3413E+00
                                        ***************************************************************************

DETERMINATION OF POSITIVE MINOS ERROR FOR PARAMETER  3          RM

PARAMETER   3 SET TO  0.967E+00 +  0.741E-01 =    0.104E+01
MIGRAD MINIMIZATION HAS CONVERED

                                        THE POSITIVE MINOS ERROR OF PARAMETER  3,        RM, IS  0.7283E-01
                                        ***************************************************************************

DETERMINATION OF NEGATIVE MINOS ERROR FOR PARAMETER  3          RM

PARAMETER   3 SET TO  0.967E+00 + -0.741E-01 =    0.893E+00
MIGRAD MINIMIZATION HAS CONVERED

                                        THE NEGATIVE MINOS ERROR OF PARAMETER  3,        RM, IS -0.7590E-01
                                        ***************************************************************************
```

```
                         RESULTS OF FULL MINOS ERROR ANALYSIS
                         ************************************

             FIT TO TIME-DISTR OF KZERO LEPTONIC DECAYS

                                                                                PARABOLIC    ...... MINOS ERRORS ......
 FCN VALUE      CALLS     TIME       EDM      INT.EXT. PARAMETER      VALUE       ERROR        POSITIVE      NEGATIVE
0.7137547E+01   1946 21:55:58   0.58E-07     1   1          AL   -0.35417E-01  0.24412E+00  0.21281E+00  -0.29908E+00
                                             2   2          AG   -0.12016E-01  0.31986E+00  0.30703E+00  -0.34129E+00
                                             3   3          RM    0.96670E+00  0.74054E-01  0.72835E-01  -0.75897E-01
                                                 4          LT    0.46000E+00

                                             ERRORS CORRESPOND TO FUNCTION CHANGE OF     1.0000

     INTERNAL COVARIANCE MATRIX
     CORRELATION COEFFICIENTS
   INT.    1     2
    2 0.729
    3 0.418 0.735

                                                                GLOBAL CORRELATION
                                                  PARAMETER        COEFFICIENT
                                              1      AL              0.56123
                                              2      AG              0.75535
                                              3      RM              0.56935

**********
***  5****SCAN              1.00000
**********
```

SCAN OF PARAMETER NO. 1, AL

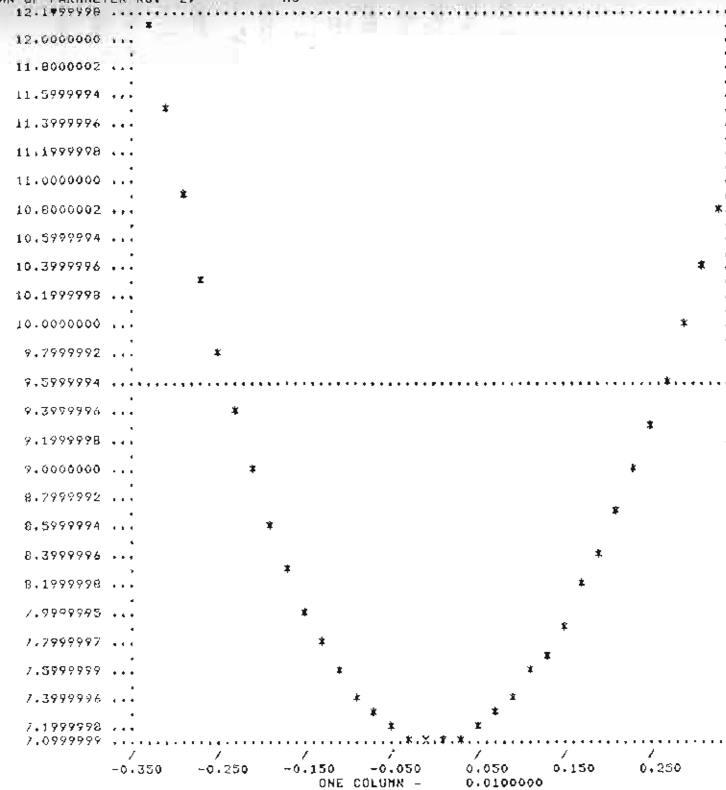


FCN VALUE	CALLS	TIME	EDM	INT.	EXT.	PARAMETER	VALUE	ERROR	INTERN.VALUE	INT.STEP SIZ
0.7137547E+01	1972	21:56:48	0.58E-07	1	1	AL	-0.35417E-01	0.24412E+00	-0.35417E-01	-0.51112E-04
				2	2	AG	-0.12016E-01	0.31986E+00	-0.12016E-01	-0.36745E-03
				3	3	RM	0.96670E+00	0.74054E-01	0.96670E+00	0.74203E-02
					4	LT	0.46000E+00			

ERRORS CORRESPOND TO FUNCTION CHANGE OF 1.0000

```
**********
***  6****SCAN          2.00000
**********
```

SCAN OF PARAMETER NO. 2, AG



FCN VALUE	CALLS	TIME	EDM	INT,EXT.	PARAMETER	VALUE	ERROR	INTERN.VALUE	INT.STEP SIZ
0.7137547E+01	2006	21:57:56	0.58E-07	1 1	AL	-0.35417E-01	0.24412E+00	-0.35417E-01	-0.51112E-04
				2 2	AG	-0.12016E-01	0.31986E+00	-0.12016E-01	-0.36745E-03
				3 3	RM	0.96670E+00	0.74054E-01	0.96670E+00	0.74203E-02
				4	LT	0.46000E+00			

```
                                                  ERRORS CORRESPOND TO FUNCTION CHANGE OF      1.0000
**********
***  7****END
**********

CALL TO FCN WITH IFLAG = 3

IT2  --  STOP
```

ΠΕΡΙΛΗΨΗ

ΠΡΟΣΑΡΜΟΓΗ ΤΟΥ ΠΡΟΓΡΑΜΜΑΤΟΣ MINUIT ΓΙΑ ΤΟΥΣ ΥΠΟΛΟΓΙΣΤΕΣ ΤΥΠΟΥ PDP11/34A

ὑπὸ

ΔΕΔΟΥΣΗ ΣΠ., ΧΑΡΔΑΛΑ Μ. ΚΑΙ ΧΑΡΑΛΑΜΠΟΥΣ ΣΤΕΦ.

Ἐργαστήριο Ἀτομικῆς καὶ Πυρηνικῆς Φυσικῆς
Πανεπιστήμιο Θεσσαλονίκης

Παρουσιάζεται μιὰ τροποποιημένη μορφὴ τοῦ προγράμματος MINUIT ἔτσι ὥστε νὰ μπορεῖ νὰ χρησιμοποιηθεῖ σὲ μικροὺς ὑπολογιστὲς τῶν 16 bits ὅπως ὁ PDP11/34A. Γιὰ τὴν μετατροπὴ τοῦ MINUIT χρησιμοποιήθηκε ἡ τεχνικὴ overlay. Τὸ πρόγραμμα χωρίστηκε σὲ 13 segments ἐκ τῶν ὁποίων τὸ ἕνα, root segment, βρίσκεται πάντα στὴ μνήμη ἐνῶ τὰ ἄλλα 12, overlay segments, βρίσκονται σὲ ἕνα δίσκο καὶ ἐναλλάσσονται μεταξύ τους στὴν μνήμη ἀνάλογα μὲ τὴν ροὴ τοῦ προγράμματος.

Γιὰ τὸν ἔλεγχο τοῦ προγράμματος δημιουργήθηκαν 9 νέες ρουτίνες σὲ ἀντικατάσταση τῆς ρουτίνας COMAND.

Ὅλες οἱ commands τῆς πρωτότυπης μορφῆς ἐκτελοῦνται ἀπὸ τὴν νέα μορφὴ χωρὶς καμία διαφορετικὴ ἐνέργεια τοῦ χρήστη.

Παρουσιάζονται οἱ δυνατότητες χρήσης τοῦ νέου προγράμματος καὶ γίνεται σύγκριση τῶν ἀποτελεσμάτων ἀπὸ τὴν ἐκτέλεση τῆς πρωτότυπης μορφῆς σὲ ἕνα μεγάλο ὑπολογιστὴ μὲ αὐτὰ ἀπὸ τὴν ἐκτέλεση τῆς νέας μορφῆς στὸν ὑπολογιστὴ PDP11/34A.