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# Computation of the Effective Solid Angle for Gas Scattering Experiment

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A simple numerical integration method is presented to calculate the effective solid angle for a correlation experiment using a gas target. The method is described for the case of a double slit system using a front aperture composed of two parallel edges of infinite height and a rear (detector) rectangular aperture. It is possible to calculate the angular spread for each telescope. The method is applicable even when the beam line does not interesect the center of the rotation of the telescopes. A FORTRAN program is presented in the appendix.

KEY WORDS: Gas target/ Solid angle/ Angular correlation/

## 1. INTRODUCTION

In nuclear scattering experiments with gas targets, the target thickness is defined by a pair of collimators in front of each telescope. For each telescope we have a certain section of the target which is "seen" with 100% efficiency (umbra) and an upper and lower penumbra. Since the situation for a correlation experiment using a gas target is very complicated we propose a numerical integration method.

The method described in the following section permits us to calculate the angular spread for each collimator. This is important for the theoretical analysis of the experimental data. Since this method is applicable for the case that the beam line does not intersect the center of the rotation of the telescopes we can examine the influence of the finite size of the beam.

## 2. THE METHOD OF CALCULATION

In this section the method of calculation of the effective solid angle is given for the case of a double slit system using a front aperture composed of two parallel edges of infinite height and a rear (detector) rectangular aperture. The top view of the situation is given in fig. 1. The meanings of the symbols are as follows (see fig. 1).

$2b_1$ the width of the first collimator.
$2b_2$ the width of the second collimator.

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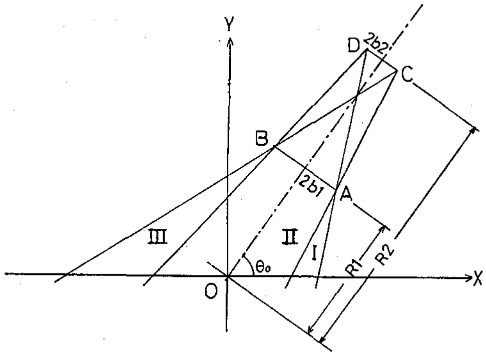


Fig. 1. Top view of the telescope for the explanation of the meanings of the symbols.

| | |
|---|---|
| $l_2$ | the height of the second collimator. |
| O | the center of the rotation of the telescope. |
| $R_1$ | the distance between the first collimator AB and O. |
| $R_2$ | the distance between the second collimator CD and O. |
| $\theta_0$ | the angle between X-axis and the center line of the slit system. |
| I and III | the upper and lower penumbra region. |
| II | the umbra region. |

Writing c for $\cos\theta_0$ and s for $\sin\theta_0$, the X and Y co-ordinates of A, B, C, D are given as

$$(X_A, Y_A) = (R_1c + b_1s,\ R_1s - b_1c),$$
$$(X_B, Y_B) = (R_1c - b_1s,\ R_1s + b_1c),$$
$$(X_C, Y_C) = (R_2c + b_2s,\ R_2s - b_2c),$$
$$(X_D, Y_D) = (R_2c - b_2s,\ R_2s + b_2c).$$

Let a point P lie on the beam line. We can calculate the solid angle from P as follows. We can get which region (I, II, III) P exists in. If P is in the region I, the solid

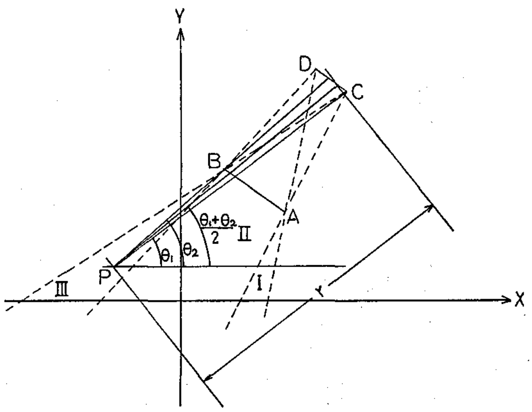


Fig. 2. Top view of the telescope showing the contribution to the solid angle from a point P on the X–Y plane.

angle is defined by the two points A and D, if in the region II, by C and D and if in the region III, by B and C. For example let P be in the region III, that is B and C are the two points which define the solid angle, and we define $\theta_1$ and $\theta_2$ as (see fig. 2)

$$\theta_1 = \arctan\{(Y-Y_C)/(X-X_C)\},$$
$$\theta_2 = \arctan\{(Y-Y_B)/(X-X_B)\}.$$

Then $(\theta_2-\theta_1)$ turns to be the angular spread for the point P to see the rear slit in the X$-$Y plane. Defining r as the distance between P and the intersection of the line through P with an angle of inclination $(\theta_1+\theta_2)/2$ which is the mean angle for the point P to see the telescope, and the segment CD, the solid angle from the point P is given as

$$\Delta\Omega = (\theta_2-\theta_1)l_2/r.$$

In the case of an angular correlation measurement we have to get the values $\Delta\Omega$ for the two detectors and multiply them to have the solid angle $\Delta\Omega_1\Delta\Omega_2$.

To calculate the solid angle for one detector or for the coincidence measurement with two detectors, we proceed as follows. We divide the segment of the beam line which is seen simultaneously by the two telescopes into small sections and compute the contribution of each section to the solid angle $\Delta\Omega$ (for a single measurement) or $\Delta\Omega_1\Delta\Omega_2$ (for a coincidence measurement). By adding the contributions of each section we get the total solid angle multiplied by the length of the target. Since the solid angle from any point can be calculated the method is applicable even when the beam line shifts from the X-axis. In the case that the finite size of the beam cannot be neglected, the solid angle can be calculated by dividing the cross section perpendicular to the beam line into small sections and adding the contributions from each section.

Fig. 3 shows an illustration of the effect of the shift of the beam line. The first telescope is set at 12.5° with $2b_1=3.75$ mm, $2b_2=2.50$ mm, $R_1=81.1$ mm, $R_2=$

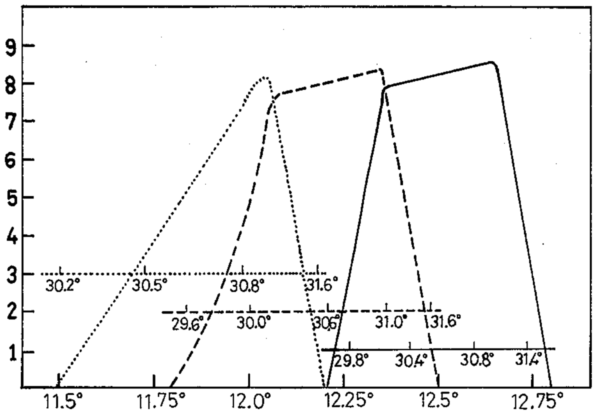


Fig. 3. Angular spread for a coplanar angular correlation experiment for the cases that the shift of the beam line is 0 mm (the solid line), 1 mm (the dashed line) and 2 mm (the dotted line). The abscissa represents the weighting factor in arbitrary units. The ordinate represents the angle of the first telescope. The angle of the second telescope is given for each spectrum.

257.5 mm, $l_2$=6.4 mm. The second telescope is set at 30.6° with $2b_1$=3.23 mm, $2b_2$=3.50 mm, $R_1$=80.2 mm, $R_2$=258.6 mm, $l_2$=6.5 mm. The solid angles for the cases that the shift of the beam line is 0 mm, 1 mm and 2 mm are $7.56\times10^{-7}$ ($sr^2\cdot mm$), $7.31\times10^{-7}$ ($sr^2\cdot mm$) and $4.02\times10^{-7}$ ($sr^2\cdot mm$) respectively. The solid angle is very much affected when the shift of the beam line amounts to 2 mm for the setting of this illustration.

## 3. PROGRAM

In appendix a program written in FORTRAN which calculates the effective solid angle for coplanar correlation experiment using a gas target and the slit system of a front aperture composed of two parallel edges of infinite height with a rear rectangular aperture for each telescope.

The input quantities are the $2b_1$, $2b_2$, $R_1$, $R_2$, $l_2$ for each telescope and the parameters A and B for the equation of the beam line

$$Y=AX+B$$

and the radius of the beam R, which is 0.0 if the beam can be represented by a straight line, and DX, DR which are the length of the small section along the beam line (DX) and that of perpendicular to the beam axis (DR) and TH(1), TH(2) which are the polar angles of two detectors. The program gets the input parameters from a file whose name is given from the key board.

The program permits us to calculate the influence of the finite size of the beam if we input R and DR. The weighting function is assumed to be

$$SQRT\{R^2-(XR)^2\}$$

where XR is the distance from the center line of the beam.

The contribution for the effective solid angle together with the angle and the angular spread for each small section to see each telescope are represented in a matrix form. They are useful for theoretical calculation taking account of the experimental angular setting.

## APPENDIX

SOURCE.FOR

```
C       COMPUTATION OF SOLID ANGLE FOR GAS TARGET SCATTERING EXPERIMENT
C       CODED BY T. SEKIOKA AT HIMEJI INSTITUTE OF TECHNOLOGY JAN.88
        COMMON B1(2), B2(2), R1(2), R2(2), FL2(2), FNAME, FONAME
        DIMENSION DOMEGA(500), ANG(2,500), SMEGA(500,2), ARNG(2,2)
       X,AANG(2),BB1(2), BB2(2),TH(2),SAG(2),AANGR(2),DANG(2,500)
        CHARACTER*64 FNAME, FONAME
C       WEIT IS A RADIAL FUNCTION OF BEAM INTENSITY DISTRIBUTION.
        WEIT(R,XR)=SQRT(R*R-XR*XR)
        PAI=3.141593
        RTI=PAI/180.0
        WRITE(*,950)
  950   FORMAT(' ENTER INPUT FILE NAME (OR SPACE) - '
       X¥n)
        READ(*,910) FNAME
  910   FORMAT(A)
        WRITE(*,940)
  940   FORMAT(' ENTER OUTPUT FILE NAME  - '
       X¥n)
        READ(*,910) FONAME
        OPEN(4,FILE=FONAME,STATUS='NEW')
        IF(FNAME .EQ. ' ') GO TO 200
        OPEN(3,FILE=FNAME)
  210   READ(3,*,END=900) BB1(1),BB2(1),R1(1),R2(1),FL2(1)
        WRITE(*,6999) BB1(1),BB2(1),R1(1),R2(1),FL2(1)
        WRITE(4,6999) BB1(1),BB2(1),R1(1),R2(1),FL2(1)
 6999   FORMAT(1H ,'2B1,2B2,R1,R2,FL2 FOR LEFT  ',6F7.2)
        IF (BB1(1) .EQ. 0.0) GO TO 900
        READ(3,*,END=900) BB1(2),BB2(2),R1(2),R2(2),FL2(2)
        WRITE(*,6996) BB1(2),BB2(2),R1(2),R2(2),FL2(2)
        WRITE(4,6996) BB1(2),BB2(2),R1(2),R2(2),FL2(2)
 6996   FORMAT(1H ,'2B1,2B2,R1,R2,FL2 FOR RIGHT ',6F7.2)
  310   READ(3,*,END=900) ARCT, B, R, DX, DR
        WRITE(*,6998) ARCT, B, R, DX, DR
        WRITE(4,6998) ARCT, B, R, DX, DR
        IF (DX .EQ. 0.0) GO TO 210
  410   READ(3,*,END=900) TH(1), TH(2)
        WRITE(*,6997) TH(1),TH(2)
        WRITE(4,6997) TH(1),TH(2)
        IF (TH(1) .EQ. 0.0) GO TO 310
        IF (TH(2) .EQ. 0.0) GO TO 310
 6998   FORMAT(1H ,'ARCT,  B,  R, DX, DR          ',5F7.3)
 6997   FORMAT(1H ,'THETA(1)=',F8.3,' THETA(2)=',F8.3)
        GOTO 750
  200   WRITE(*,6001)
        READ(*,*) BB1(1),BB2(1),R1(1),R2(1),FL2(1)
        WRITE(*,6999) BB1(1),BB2(1),R1(1),R2(1),FL2(1)
        WRITE(4,6999) BB1(1),BB2(1),R1(1),R2(1),FL2(1)
        IF (BB1(1) .EQ. 0.0) GO TO 900
        WRITE(*,6002)
        READ(*,*) BB1(2),BB2(2),R1(2),R2(2),FL2(2)
 6001   FORMAT(1H ,' 2B1   2B2   R1    R2    L2   FOR LEFT COUNTER')
 6002   FORMAT(1H ,' 2B1   2B2   R1    R2    L2   FOR RIGHT COUNTER')
        WRITE(*,6996) BB1(2),BB2(2),R1(2),R2(2),FL2(2)
        WRITE(4,6996) BB1(2),BB2(2),R1(2),R2(2),FL2(2)
  300   WRITE(*,6003)
        READ(*,*) ARCT, B, R, DX, DR
 6003   FORMAT(1H ,'(EQ. OF BEAM LINE Y=TAN(ARCT)*X+B, R=RADIUS, IF=0 LINE)'
       X,' DX OR DR =LENGTH OF SEGMENT'/
       X,'  ARCT   B    R    DX    DR')
        WRITE(*,6998) ARCT, B, R, DX, DR
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      WRITE(4,6998) ARCT, B, R, DX, DR
      IF (DX .EQ. 0.0) GO TO 200
 400  WRITE(*,6004)
6004  FORMAT(1H ,'TH1  TH2   IF INPUT=0 GO TO SET OF BEAM LINE')
      READ(*,*) TH(1), TH(2)
      WRITE(*,6997) TH(1),TH(2)
      WRITE(4,6997) TH(1),TH(2)
      IF (TH(1) .EQ. 0.0) GO TO 300
      IF (TH(2) .EQ. 0.0) GO TO 300
 750  CONTINUE
      A=TAN(ARCT*RTI)
      B1(1)=0.5*BB1(1)
      B1(2)=0.5*BB1(2)
      B2(1)=0.5*BB2(1)
      B2(2)=0.5*BB2(2)
      IF (R .EQ. 0.0) GO TO 500
      IF (DR.EQ. 0.0) GO TO 500
      FR=R/DR
      NR=FR
      IF(NR .GT. 500) NR=500
      FNR=NR
      DDR=R/FNR
      SRWEIT=0
      SMG=0.0
      SAG(1)=0.0
      SAG(2)=0.0
      WRITE(*,6110) R,DDR
      WRITE(4,6110) R,DDR
6110  FORMAT(1H ,'CALCULATION OF FINITE SIZE OF BEAM. R=',F6.3
     X,' DDR=',F5.3)
      DO 1000 KR=1, NR
      FKR=KR
      XR=(FKR-0.5)*DDR
      RWEIT=WEIT(R,XR)
      SRWEIT=SRWEIT+RWEIT
      BR=B+XR*SQRT(1+A*A)
      CALL SLDANG(A,BR,DX,DDDX,TH,ANG,DANG,
     X DOMEGA,AANG,SMEGA(KR,1),KMAX,ILL)
      ARNG(1,1)=AANG(1)
      ARNG(1,2)=AANG(2)
      IF(ILL .EQ. 0) GO TO 610
      WRITE(*,6901) ILL
 610  CONTINUE
      WRITE(*,6100) XR,KR,SMEGA(KR,1), AANG(1), AANG(2)
      WRITE(4,6100) XR,KR,SMEGA(KR,1), AANG(1), AANG(2)
      BR=B-XR*SQRT(1+A*A)
      CALL SLDANG(A,BR,DX,DDDX,TH,ANG,DANG,
     X DOMEGA,AANG,SMEGA(KR,2),KMAX,ILL)
      ARNG(2,1)=AANG(1)
      ARNG(2,2)=AANG(2)
      IF(ILL .EQ. 0) GO TO 620
      WRITE(*,6901) ILL
 620  CONTINUE
      WRITE(*,6100) -XR,KR,SMEGA(KR,2), AANG(1), AANG(2)
      WRITE(4,6100) -XR,KR,SMEGA(KR,2), AANG(1), AANG(2)
6100  FORMAT(1H ,'XR=',F8.4,' SMEGA(',I3,')=',E13.6
     X,' AANG1=',F10.5,' AANG2=',F10.5)
      SMG=SMG + RWEIT*(SMEGA(KR,1)+SMEGA(KR,2))*0.5
      SAG(1)=SAG(1) + RWEIT*(ARNG(1,1)+ARNG(2,1))*0.5
      SAG(2)=SAG(2) + RWEIT*(ARNG(1,2)+ARNG(2,2))*0.5
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1000 CONTINUE
     TOMEGA=SMG/SRWEIT
     AANGR(1)=SAG(1)/SRWEIT
     AANGR(2)=SAG(2)/SRWEIT
     WRITE(*,6200) TOMEGA, AANGR(1),AANGR(2)
     WRITE(4,6200) TOMEGA, AANGR(1),AANGR(2)
6200 FORMAT(' TOMEGA=',E13.6, ' ATH1=',F10.5,' ATH2=',F10.5)
     IF (FNAME .EQ. ' ') GO TO 400
     GO TO 410
 500 CONTINUE
     CALL SLDANG(A,B,DX,DDDX,TH,ANG,DANG,
    X DOMEGA,AANG,SOMEGA,KMAX,ILL)
     WRITE(*,6120) KMAX,DDDX
     WRITE(4,6120) KMAX,DDDX
6120 FORMAT(1H ,'KMAX=',I3,' LENGTH OF SEGMENT=',F7.5)
     IF(ILL .EQ. 0) GO TO 600
     WRITE(*,6901) ILL
     GO TO 900
 600 CONTINUE
     NKMAX=KMAX/5
     DO 550 NK=1, NKMAX
     NK5=(NK-1)*5
     WRITE(*,6310) NK5,(DOMEGA(J),J=(NK-1)*5+1,NK*5)
     WRITE(*,6320) (ANG(1,J),DANG(1,J),J=(NK-1)*5+1,NK*5)
     WRITE(*,6320) (ANG(2,J),DANG(2,J),J=(NK-1)*5+1,NK*5)
     WRITE(4,6310) NK5,(DOMEGA(J),J=(NK-1)*5+1,NK*5)
     WRITE(4,6320) (ANG(1,J),DANG(1,J),J=(NK-1)*5+1,NK*5)
     WRITE(4,6320) (ANG(2,J),DANG(2,J),J=(NK-1)*5+1,NK*5)
 550 CONTINUE
     NK5=NKMAX*5
     IF(NK5 .GE. KMAX) GO TO 560
     WRITE(*,6310) NK5,(DOMEGA(J),J=NK5+1,KMAX)
     WRITE(*,6320) (ANG(1,J),DANG(1,J),J=NK5+1,KMAX)
     WRITE(*,6320) (ANG(2,J),DANG(2,J),J=NK5+1,KMAX)
     WRITE(4,6310) NK5,(DOMEGA(J),J=NK5+1,KMAX)
     WRITE(4,6320) (ANG(1,J),DANG(1,J),J=NK5+1,KMAX)
     WRITE(4,6320) (ANG(2,J),DANG(2,J),J=NK5+1,KMAX)
6310 FORMAT(1H ,I3,5E15.6)
6320 FORMAT(1H ,3X,5(F8.3,'(',F5.3,')'))
 560 CONTINUE
     WRITE(*,6250) SOMEGA, AANG(1), AANG(2)
     WRITE(4,6250) SOMEGA, AANG(1), AANG(2)
6250 FORMAT(' SOMEGA=',E13.6,'   AANG1=',F8.3,'   AANG2=',F8.3)
6901 FORMAT(' ERROR ILL=',I2)
     IF (FNAME .EQ. ' ') GO TO 400
     GO TO 410
     CLOSE(3,STATUS='KEEP')
     CLOSE(4,STATUS='KEEP')
 900 CONTINUE
     STOP
     END

     SUBROUTINE SLDANG(A,B,DX,DDX,TH,ANG,DANG,
    X DOMEGA,AANG,SOMEGA,KMAX,ILL)
     COMMON B1(2), B2(2), R1(2), R2(2), FL2(2)
     DIMENSION DOMEGA(500), ANG(2,500), AANG(2),TH(2)
    1,XA(2),YA(2),XB(2),YB(2),XC(2),YC(2),XD(2),YD(2)
    2,NCH(2),AL(2),BL(2),CL(2,4),DL(2,4),NREG(2)
    3,DMG(2),SANG(2),XISC(2,4),THR(2),ANGCA(2),DANG(2,500)
     DO 10 J=1,500
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```
      DOMEGA(J)=0.0
      ANG(1,J)=0.0
      ANG(2,J)=0.0
      DANG(1,J)=0.0
      DANG(2,J)=0.0
   10 CONTINUE
      PAI=3.141593
      RTI=PAI/180.0
      THR(1)=TH(1)*RTI
      THR(2)=TH(2)*RTI
      ILL=0
      DO 100 I=1,2
      C=COS(THR(I))
      S=SIN(THR(I))
      XA(I)=R1(I)*C + B1(I)*S
      YA(I)=R1(I)*S - B1(I)*C
      XB(I)=R1(I)*C - B1(I)*S
      YB(I)=R1(I)*S + B1(I)*C
      XC(I)=R2(I)*C + B2(I)*S
      YC(I)=R2(I)*S - B2(I)*C
      XD(I)=R2(I)*C - B2(I)*S
      YD(I)=R2(I)*S + B2(I)*C
      AL(I)=(YD(I)-YC(I))/(XD(I)-XC(I))
      BL(I)=(YC(I)*XD(I)-XC(I)*YD(I))/(XD(I)-XC(I))
      CL(I,1)=(XD(I)-XA(I))/(YD(I)-YA(I))
      DL(I,1)=(YD(I)*XA(I)-XD(I)*YA(I))/(YD(I)-YA(I))
      CL(I,2)=(XC(I)-XA(I))/(YC(I)-YA(I))
      DL(I,2)=(YC(I)*XA(I)-XC(I)*YA(I))/(YC(I)-YA(I))
      CL(I,3)=(XD(I)-XB(I))/(YD(I)-YB(I))
      DL(I,3)=(YD(I)*XB(I)-XD(I)*YB(I))/(YD(I)-YB(I))
      CL(I,4)=(XC(I)-XB(I))/(YC(I)-YB(I))
      DL(I,4)=(YC(I)*XB(I)-XC(I)*YB(I))/(YC(I)-YB(I))
      DO 200 J=1,4
      IF(I.EQ.1) XISC(I,J)=(B*CL(I,J) + DL(I,J))/(1-A*CL(I,J))
      IF(I.EQ.2) XISC(I,J)=(-B*CL(I,J) + DL(I,J))/(1+A*CL(I,J))
  200 CONTINUE
      NCH(I)=1
      IF (XISC(I,2) .LT. XISC(I,3)) NCH(I)=2
      IF (NCH(I) .EQ. 1) GO TO 100
      XISC(I,3)=BBB
      XISC(I,3)=XISC(I,2)
      XISC(I,2)=BBB
  100 CONTINUE
      DO 119 I=1,2
C     WRITE(*,6997) I,(XISC(I,J),J=1,4)
 6997 FORMAT(1H ,'XISC I='I2,2X,4F10.5)
C     WRITE(*,6995) I,(CL(I,J),J=1,4)
 6995 FORMAT(1H ,'CL   I='I2,2X,4F10.5)
C     WRITE(*,6994) I,(DL(I,J),J=1,4)
 6994 FORMAT(1H ,'DL   I='I2,2X,4F10.5)
C     WRITE(*,6993) A, B
 6993 FORMAT(1H ,'A=',F10.5,' B=',F10.5)
  119 CONTINUE
      XBIGIN=XISC(1,4)
      IF (XISC(1,4) .LT. XISC(2,4)) XBIGIN=XISC(2,4)
      XEND=XISC(1,1)
      IF (XISC(2,1) .LT. XISC(1,1)) XEND=XISC(2,1)
      XREG=XEND-XBIGIN
C     WRITE(*,6996) XBIGIN,XEND
 6996 FORMAT(1H ,'XBIGN=',F10.5,' XEND=',F10.5)
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      IF(XREG .GT. 0.0) GO TO 300
      WRITE(*,6901)
 6901 FORMAT(' XREG<0.0. ERROR')
      ILL=1
      RETURN
  300 CONTINUE
      FX=XREG/DX
      NX=FX+1
      IF(NX .GT. 500) NX=500
      FNX=NX
      DDX=XREG/FNX
      NREG(1)=3
      NREG(2)=3
      DO 400 I=1,2
      IF(XBIGIN .GT. XISC(I,3)) NREG(I)=2
      IF(XBIGIN .GT. XISC(I,2)) NREG(I)=1
  400 CONTINUE
      SANG(1)=0.0
      SANG(2)=0.0
      SS=0.0
      SSA=0.0
      DO 1000 KX=1, NX
      FKX=KX
      X=XBIGIN+(FKX-0.5)*DDX
      Y=A*X + B
      ANGCA(1)= ATAN(A)/RTI
      ANGCA(2)=-ATAN(A)/RTI
      DO 2000 I=1,2
      IF (I .EQ. 2) Y=-Y
      IF (X .GE. XISC(I,NREG(I))) NREG(I)=NREG(I)-1
      GOTO (2100,2200,2300) NREG(I)
 2100 CONTINUE
      TH1=ATAN((YA(I)-Y)/(XA(I)-X))
      TH2=ATAN((YD(I)-Y)/(XD(I)-X))
      GOTO 2500
 2200 CONTINUE
      GOTO (2210,2220) NCH(I)
 2210 TH1=ATAN((YC(I)-Y)/(XC(I)-X))
      TH2=ATAN((YD(I)-Y)/(XD(I)-X))
      GOTO 2500
 2220 TH1=ATAN((YA(I)-Y)/(XA(I)-X))
      TH2=ATAN((YB(I)-Y)/(XB(I)-X))
      GOTO 2500
 2300 CONTINUE
      TH1=ATAN((YC(I)-Y)/(XC(I)-X))
      TH2=ATAN((YB(I)-Y)/(XB(I)-X))
      GOTO 2500
 2500 CONTINUE
      THE=0.5*(TH1+TH2)
      DTHE=0.5*(TH2-TH1)
      CTAN=COS(THE)/SIN(THE)
      YIS=(AL(I)*X+BL(I)-AL(I)*CTAN*Y)/(1-CTAN*AL(I))
      R=ABS((YIS-Y)/SIN(THE))
      DMG(I)=FL2(I)*(TH2-TH1)/R
      ANG(I,KX)=THE/RTI - ANGCA(I)
      DANG(I,KX)=DTHE/RTI
C     WRITE(*,6998) I,DMG(I),TH2/RTI,TH1/RTI,NREG(I)
 6998 FORMAT(1H ,'I=',I2,' DMG=',E13.6,' TH2=',F10.5
     X,' TH1=',F10.5,' NREG=',I2)
 2000 CONTINUE
```

```
      DOMEGA(KX)=DMG(1)*DMG(2)
      SANG(1)=SANG(1) + ANG(1,KX)*DOMEGA(KX)
      SANG(2)=SANG(2) + ANG(2,KX)*DOMEGA(KX)
      SS=SS + DOMEGA(KX)*DDX*SQRT(1.0+A*A)
      SSA=SSA + DOMEGA(KX)
C     WRITE(*,6999) KX, DOMEGA(KX)
 6999 FORMAT(' DOMEGA(',I3,')=',E13.6)
 1000 CONTINUE
      AANG(1)=SANG(1)/SSA
      AANG(2)=SANG(2)/SSA
      SOMEGA=SS
      KMAX=NX
      DDDX=DDX*SQRT(1.0+A*A)
      RETURN
      END
```