

!SetActiveTool (NAM=NoTool)

! LCLS MAGNETIC MEASUREMENT FACILITY
! LEITZ PMM 12106 CMM
!

! QUINDOS MEASUREMENT PROGRAM
!-----

! Q VERSION : Q7
! DATE : 16-APR-2008
! PART : QUADRUPOLE FIDUCIAL BENCH
! PROGRAM : QUAD WIRE V2.0.WDB
! PROGRAM BY: E. REESE/S. Anderson

!-----
! --- CHANGE LOG ---
!-----

| ! DATE | ! VERSION | ! MODIFICATIONS |
|-------------|-----------|---|
| ! 15-apr-08 | ! 1.1 | ! completed output of values to txt file, output wire csy tra to file |
| ! 16-apr-08 | ! 2.0 | ! fixed minor problems, verified output, add polarity input to menu |
| ! 18-apr-08 | ! 2.1 | ! moved calculation of final mech csy in front of calc of final wire csy |
| ! 25-apr-08 | ! 2.2 | ! put in work around for EVATRA command which caused program crash, added polarity to element name of TB file to be imported back for average calc. |
| ! 29-apr-08 | ! 2. | ! CREATE REPORT button enabled, averages PLUS and MINUS runs and averages the points. outputs data to a file |

!-----

```
!EDIT          (NAM=INPUT_DLP, TYP=DLP)
100:ShowDialog (DLP=INPUT_DLP, OBJ=UVS:INPUT)
  GETVALS      (OBJ=UVS:INPUT, TYP=UVS, CDS=(A,D,C), CHS=(~QID,~OP,~POL))
!   LISCHS (~QID,~OP,~POL)
```

```
IFTHENS      (ST1=~OP, ST2=CAL, TYP=EQ)
  MEAS$OP=200
ELSEIFS      (ST1=~OP, ST2=TABLE, TYP=EQ)
  MEAS$OP=300
ELSEIFS      (ST1=~OP, ST2=ADJ, TYP=EQ)
  MEAS$OP=400
ELSEIFS      (ST1=~OP, ST2=MAN, TYP=EQ)
  MEAS$OP=550
ELSEIFS      (ST1=~OP, ST2=AUTO, TYP=EQ)
  MEAS$OP=500
ELSEIFS      (ST1=~OP, ST2=CREATE, TYP=EQ)
  MEAS$OP=600
ELSEIFS      (ST1=~OP, ST2=EXIT, TYP=EQ)
  MEAS$OP=700
ENDIF
```

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GOTO          (LAB=MEAS$OP)
```

```
!   1.0 --- calibrate initial probe cluster
```

```
200:CONTIN
  DELEDBPRB   (PRB=EDBPRB:PRB())
  UseArtefact (NAM=E6023)

  QualifyTool (NAM=PRB(1), DIA=3.000, NRF=Y, MGZ=1, SNT=TRX, RPT=(,,-255))
  QualifyTool (NAM=PRB(2), DIA=5.000, NRF=N, MGZ=1, SNT=TRX)
  QualifyTool (NAM=PRB(3), DIA=3.000, NRF=N, MGZ=1, SNT=TRX)
  QualifyTool (NAM=PRB(4), DIA=3.000, NRF=N, MGZ=1, SNT=TRX)
  QualifyTool (NAM=PRB(5), DIA=3.000, NRF=N, MGZ=1, SNT=TRX)
  QualifyTool (NAM=PRB(21), DIA=3.000, NRF=N, MGZ=3, SNT=TRX)
  PUTPRB
```

```
GOTO 100
```

```
!   1.0 --- find the 4 tooling ball supports
```

```
300:CONTIN
  USEPRB PRB(1)
Move      (NAM=IP_PRB(1), CSY=CSY)
  T=4
  MEPLA   (NAM=TOP(T), CSY=CSY, MOD=NOE, ITY=GSS)
  MECIR   (NAM=OD(T), CSY=CSY, MOD=NOE, PTY=TOP(T))
  BLDCSY  (NAM=POST_CSY, TYP=CAR, SPA=TOP(T), SDR=+Z, XZE=OD(T), YZE=OD(T), ZZE=TOP(T))
~RESULT$PT=TB(T)
~RESULT$CSY=CSY
  INDPRC TB_CALC
  MOVCM   (TYP=DLT, DST=(, ,450))
```

```
T=2
MEPLA          (NAM=TOP(T), CSY=CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=OD(T), CSY=CSY, MOD=NOE, PTY=TOP(T))
BLDCSY        (NAM=POST_CSY, TYP=CAR, SPA=TOP(T), SDR=+Z, XZE=OD(T), YZE=OD(T), ZZE=TOP(T))
~RESULT$PT=TB(T)
~RESULT$CSY=CSY
INDPRC TB_CALC
MOVCMM        (TYP=DLT, DST=(, ,450))
```

```
T=1
MEPLA          (NAM=TOP(T), CSY=CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=OD(T), CSY=CSY, MOD=NOE, PTY=TOP(T))
BLDCSY        (NAM=POST_CSY, TYP=CAR, SPA=TOP(T), SDR=+Z, XZE=OD(T), YZE=OD(T), ZZE=TOP(T))
~RESULT$PT=TB(T)
~RESULT$CSY=CSY
INDPRC TB_CALC
MOVCMM        (TYP=DLT, DST=(, ,450))
```

```
T=3
MEPLA          (NAM=TOP(T), CSY=CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=OD(T), CSY=CSY, MOD=NOE, PTY=TOP(T))
BLDCSY        (NAM=POST_CSY, TYP=CAR, SPA=TOP(T), SDR=+Z, XZE=OD(T), YZE=OD(T), ZZE=TOP(T))
~RESULT$PT=TB(T)
~RESULT$CSY=CSY
INDPRC TB_CALC
MOVCMM        (TYP=DLT, DST=(, ,450))
```

```
COLPTS        (NAM=TB_PLA, CSY=CSY, DEL=Y, ELE=(TB(1), TB(2), TB(3)), TYP=PLA)
COLPTS        (NAM=TB_AXI, CSY=CSY, DEL=Y, ELE=(TB(1), TB(2)), TYP=AXI)
BLDCSY        (NAM=TABLE_CSY, TYP=CAR, SPA=TB_PLA, SDR=+Y, PLA=TB_AXI, PDR=+Z, XZE=TB(1))
TRAELE        (NEW=TB_NEW(4), TRA=TABLE_CSY, OLD=TB(4), RPL=N, EVA=Y)
```

```
Move          (NAM=STR_PNT, CSY=CSY)
GOTO 100
```

```
! ---- measurement of quad tooling balls for initial location
```

```
! -- qtb-1
400:CONTIN
USEPRB PRB(1)
DFNCMM        (NAM=OFF$2, POF=3, ENB=N, CPY=EDBCMM:SAVE$CMM)

USECMM OFF$2
QTB=1
T=1
MEPLA          (NAM=QUAD_P(QTB), CSY=TABLE_CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=QUAD_C(QTB), CSY=TABLE_CSY, MOD=NOE, PTY=QUAD_P(QTB))
BLDCSY        (NAM=POST_CSY, TYP=CAR, SPA=QUAD_P(QTB), SDR=+Z, XZE=QUAD_C(QTB), YZE=QUAD_C(QTB))
USECMM SAVE$CMM
~RESULT$PT=QUAD_TB(T)
~RESULT$CSY=TABLE_CSY
INDPRC TB_CALC

USECMM OFF$2
```

```

QTB=2
T=2
MEPLA          (NAM=QUAD_P(QTB), CSY=TABLE_CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=QUAD_C(QTB), CSY=TABLE_CSY, MOD=NOE, PTY=QUAD_P(QTB))
BLDCSY        (NAM=POST_CSY, TYP=CAR, SPA=QUAD_P(QTB), SDR=+Z, XZE=QUAD_C(QTB), YZE=QUAD_P(QTB))
USECMM SAVE$CMM
~RESULT$PT=QUAD_TB(T)
~RESULT$CSY=TABLE_CSY
INDPRC TB_CALC

USECMM OFF$2
QTB=3
T=3
MEPLA          (NAM=QUAD_P(QTB), CSY=TABLE_CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=QUAD_C(QTB), CSY=TABLE_CSY, MOD=NOE, PTY=QUAD_P(QTB))
BLDCSY        (NAM=POST_CSY, TYP=CAR, SPA=QUAD_P(QTB), SDR=+Z, XZE=QUAD_C(QTB), YZE=QUAD_P(QTB))
USECMM SAVE$CMM
~RESULT$PT=QUAD_TB(T)
~RESULT$CSY=TABLE_CSY
INDPRC TB_CALC

USECMM OFF$2
QTB=4
T=4
MEPLA          (NAM=QUAD_P(QTB), CSY=TABLE_CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=QUAD_C(QTB), CSY=TABLE_CSY, MOD=NOE, PTY=QUAD_P(QTB))
BLDCSY        (NAM=POST_CSY, TYP=CAR, SPA=QUAD_P(QTB), SDR=+Z, XZE=QUAD_C(QTB), YZE=QUAD_P(QTB))
USECMM SAVE$CMM
~RESULT$PT=QUAD_TB(T)
~RESULT$CSY=TABLE_CSY
INDPRC TB_CALC

COLPTS        (NAM=QUAD_TB$PLA, CSY=TABLE_CSY, DEL=Y, ELE=(QUAD_TB(4), QUAD_TB(3), QUAD_TB(2)))
COLPTS        (NAM=QUAD_TB$AXI, CSY=TABLE_CSY, DEL=Y, ELE=(QUAD_TB(3), QUAD_TB(2), QUAD_TB(1)))
BLDCSY        (NAM=QUAD_TB$CSY, TYP=CAR, SPA=QUAD_TB$PLA, SDR=+Y, PLA=QUAD_TB$AXI, PDR=X)

Move          (NAM=STR_PNT, CSY=CSY)
!----- delete objects from ldb before new objects from file
DELETE        (NAM=TRA:CSY$TRA_P, CNF=N)
DELETE        (NAM=TRA:CSY$TRA_F, CNF=N)
DELETE        (NAM=ELE:NOM$TB, CNF=N)
!--- stripout extra characters from QUAD NAME
~QID6=~QID
~NULL=' '
SUBSTR        (NAM=~QID6, LM1=7, RSD=~NULL)

CONCAT        (NAM=~QUAD$DIR, STR=('C:\Undulator Quad Transformation\',QUAD,'_',~QID6,'\
CONCAT        (NAM=~QUAD$TRA, STR=('Quad', '_',~QID6,'.TRA'), LMG=1, INI=Y)
CONCAT        (NAM=~FIL$CNV, STR=(~QUAD$DIR,~QUAD$TRA), LMG=1, INI=Y)
CNVFIL ~FIL$CNV

TRACSY        (NEW=QUAD_MECH$CSY, TRA=CSY$TRA_P, OLD=QUAD_TB$CSY, CAD=N)
FINDTRA       (NAM=QUAD_Z$LOC, CS1=TABLE_CSY, CS2=QUAD_MECH$CSY)
! ---- location of Quad Mech c\l to table csy
GETVALS       (OBJ=QUAD_Z$LOC, TYP=TRA, RDS=(Z,X,Y), REA=(QUAD$Z,QUAD$X,QUAD$Y))
Z_CORR=253.1-QUAD$Z

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CVREACHS (NAM=~QUAD\$Z, VAL=QUAD\$Z, INT=N, ANG=N, SPZ=N, RLS=Y, RTZ=Y)
CVREACHS (NAM=~QUAD\$CORR, VAL=Z_CORR, INT=N, ANG=N, SPZ=N, RLS=Y, RTZ=Y)

!EDTMSG QUAD\$Z
CPYMSG (FRM=QUAD\$Z, TO =QUAD\$Z(1), DEL=Y)
RPLSTR (NAM=MSG:QUAD\$Z(1), FRM=zzzzzz, TO =~QUAD\$Z)
RPLSTR (NAM=MSG:QUAD\$Z(1), FRM=aaaaaa, TO =~QUAD\$CORR)
INQYESNO (CHS=~ITR(1), MSG=QUAD\$Z(1), RED=Y)

!EDTACT (NAM=QUAD_CSY\$YAX)
TRAELE (NEW=YAX_TO_TABLE, TRA=TABLE_CSY, OLD=QUAD_CSY\$YAX, RPL=N, EVA=Y)
GETVALS YAX_TO_TABLE.EVA(1), , D, ROLL\$DEG
ROLL\$MRAD=ROLL\$DEG*((F_PI(1)/180)*1000)
CVREACHS (NAM=~RMAD, VAL=ROLL\$MRAD, INT=N, ANG=N, SPZ=N, RLS=Y, RTZ=Y)

ADJ\$VAL=((-198)*FTAN(ROLL\$DEG))/2
CVREACHS (NAM=~ADJ_R, VAL=ADJ\$VAL, INT=N, ANG=N, SPZ=N, RLS=Y, RTZ=Y)
CVREACHS (NAM=~ADJ_L, VAL=-1*ADJ\$VAL, INT=N, ANG=N, SPZ=N, RLS=Y, RTZ=Y)

!EDTMSG (NAM=ROLL\$MSG)tund
CPYMSG (FRM=ROLL\$MSG, TO =ROLL\$MSG(1), DEL=Y)
RPLSTR (NAM=MSG:ROLL\$MSG(1), FRM=xxxxxxx, TO =~RMAD)
RPLSTR (NAM=MSG:ROLL\$MSG(1), FRM=yyyyyy, TO =~ADJ_R)
RPLSTR (NAM=MSG:ROLL\$MSG(1), FRM=zzzzzz, TO =~ADJ_L)

INQYESNO (CHS=~ITR, MSG=ROLL\$MSG(1), RED=Y)

REMEAS=0
IFTHENS (ST1=~ITR(1), ST2=N, TYP=EQ, LEN=1)
REMEAS=1
ELSEIFS (ST1=~ITR, ST2=N, TYP=EQ, LEN=1)
REMEAS=1
ENDIF

IFGOTO (VAL=REMEAS, EQ0=100, GT0=400)

550:CONTIN

!EDTWKP (NAM=DET_CALIBRATION)
! --- measure the tooling balls on the detectors --
! --- build local csy and of set along line between balls form ball 1 of each set
START (WKP=DET_CALIBRATION, SER=~QID, TOP=N)
DFNCMM (NAM=SLOW_OFF2, PSP=0.5, POF=1.5, ENB=Y, CPY=EDBCMM:SAVE\$CMM)
USECMM (NAM=SLOW_OFF2)
! -- first detector (X)
D=1
DX(1)=-47.5955
USEPRB PRB(3)
SETITR (NAM=PD_TB1A(D), VAL=12.7, INO=0, FIX=N, FIY=N, FIZ=N, FID=N, FIA=N, LCK=Y)
MESPH (NAM=PD_TB1A(D), CSY=TABLE_CSY, ITY=GSS)
USEPRB PRB(5)
SETITR (NAM=PD_TB2A(D), VAL=12.7, INO=0, FIX=N, FIY=N, FIZ=N, FID=N, FIA=N, LCK=Y)
MESPH (NAM=PD_TB2A(D), CSY=TABLE_CSY, ITY=GSS)
COLPTS (NAM=PD_LINE(D), CSY=TABLE_CSY, DEL=Y, ELE=(PD_TB2A(D), PD_TB1A(D)), TYP=AXI)

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BLDCSY          (NAM=PD_CSY(D), TYP=CAR, SPA=PD_LINE(D), SDR=+X, PLA=TB_PLA, PDR=+Y, XZE=PD_TB
TRAOBJ          (NEW=PD_SHIFT$CSY(D), OLD=PD_CSY(D), SHX=DX(1), AXI=+Z, DTY=CSY)
! -- second detector (Y)
D=2
DY(2)=-47.3295
USEPRB PRB(5)
SETITR          (NAM=PD_TB1(D), VAL=12.7, INO=O, FIX=N, FIY=N, FIZ=N, FID=N, FIA=N, LCK=Y)
MESPH           (NAM=PD_TB1(D), CSY=TABLE_CSY, ITY=GSS)
SETITR          (NAM=PD_TB2(D), VAL=12.7, INO=O, FIX=N, FIY=N, FIZ=N, FID=N, FIA=N, LCK=Y)
MESPH           (NAM=PD_TB2(D), CSY=TABLE_CSY, ITY=GSS)
COLPTS          (NAM=PD_LINE(D), CSY=TABLE_CSY, DEL=Y, ELE=(PD_TB2(D), PD_TB1(D)), TYP=AXI)
BLDCSY          (NAM=PD_CSY(D), TYP=CAR, SPA=PD_LINE(D), SDR=+Y, PLA=TB_AXI, PDR=+Z, XZE=PD_TB
TRAOBJ          (NEW=PD_SHIFT$CSY(D), OLD=PD_CSY(D), SHY=DY(2), AXI=+Z, DTY=CSY)

! -- third detector (Y)
D=3
DY(3)=-47.4922
USEPRB PRB(3)
SETITR          (NAM=PD_TB2(D), VAL=12.7, INO=O, FIX=N, FIY=N, FIZ=N, FID=N, FIA=N, LCK=Y)
MESPH           (NAM=PD_TB2(D), CSY=TABLE_CSY, ITY=GSS)
SETITR          (NAM=PD_TB1(D), VAL=12.7, INO=O, FIX=N, FIY=N, FIZ=N, FID=N, FIA=N, LCK=Y)
MESPH           (NAM=PD_TB1(D), CSY=TABLE_CSY, ITY=GSS)
COLPTS          (NAM=PD_LINE(D), CSY=TABLE_CSY, DEL=Y, ELE=(PD_TB2(D), PD_TB1(D)), TYP=AXI)
BLDCSY          (NAM=PD_CSY(D), TYP=CAR, SPA=PD_LINE(D), SDR=+Y, PLA=TB_AXI, PDR=+Z, XZE=PD_TB
TRAOBJ          (NEW=PD_SHIFT$CSY(D), OLD=PD_CSY(D), SHY=DY(3), AXI=+Z, DTY=CSY)

! -- fourth detector (X)
D=4
DX(4)=-47.3683
USEPRB PRB(3)
SETITR          (NAM=PD_TB1A(D), VAL=12.7, INO=O, FIX=N, FIY=N, FIZ=N, FID=N, FIA=N, LCK=Y)
MESPH           (NAM=PD_TB1A(D), CSY=TABLE_CSY, ITY=GSS)
USEPRB PRB(5)
SETITR          (NAM=PD_TB2A(D), VAL=12.7, INO=O, FIX=N, FIY=N, FIZ=N, FID=N, FIA=N, LCK=Y)
MESPH           (NAM=PD_TB2A(D), CSY=TABLE_CSY, ITY=GSS)
COLPTS          (NAM=PD_LINE(D), CSY=TABLE_CSY, DEL=Y, ELE=(PD_TB2A(D), PD_TB1A(D)), TYP=AXI)
BLDCSY          (NAM=PD_CSY(D), TYP=CAR, SPA=PD_LINE(D), SDR=+X, PLA=TB_PLA, PDR=+Y, XZE=PD_TB
TRAOBJ          (NEW=PD_SHIFT$CSY(D), OLD=PD_CSY(D), SHX=DX(4), AXI=+Z, DTY=CSY)

USECSY          (NAM=CSY)
MOVCMM          (TYP=DLT, DST=(, ,100))
! ---- build detector csy

! --- define element at center of each detector csy
DFNELE          (NAM=XD$PT(1), TYP=POI, CSY=PD_SHIFT$CSY(1), DEL=N)
DFNELE          (NAM=YD$PT(2), TYP=POI, CSY=PD_SHIFT$CSY(2), DEL=N)
DFNELE          (NAM=YD$PT(3), TYP=POI, CSY=PD_SHIFT$CSY(3), DEL=N)
DFNELE          (NAM=XD$PT(4), TYP=POI, CSY=PD_SHIFT$CSY(4), DEL=N)

! --- move x detector center points into table csy and
! --- create temp wire axis between center of x detectors
TRAELE          (NEW=US_X$PT, TRA=TABLE_CSY, OLD=XD$PT(1), EVA=Y)
TRAELE          (NEW=DS_X$PT, TRA=TABLE_CSY, OLD=XD$PT(4), EVA=Y)
COLPTS          (NAM=TEMP$WIRE, CSY=TABLE_CSY, DEL=Y, ELE=(DS_X$PT,US_X$PT), TYP=AXI)

! --- project and intersect y detector axis onto temp wire axis
INTPNT          (NAM=US_X$PT, CSY=TABLE_CSY, EL1=PD_LINE(2), EL2=TEMP$WIRE, PPI=IM)

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INTPNT          (NAM=DS_X$PT, CSY=TABLE_CSY, EL1=PD_LINE(3), EL2=TEMP$WIRE, PPI=IM)

! --- move y detector center points into table csy and
TRAELE          (NEW=US_Y$PT, TRA=TABLE_CSY, OLD=YD$PT(2))
TRAELE          (NEW=DS_Y$PT, TRA=TABLE_CSY, OLD=YD$PT(3))

! --- extract coordinate values of points and assign to variables
GETVALS         (OBJ=DS_X$PT, RDS=(X,Z), REA=(DS$X,DS$Z))
GETVALS         (OBJ=DS_Y$PT, RDS=Y, REA=DS$Y)
GETVALS         (OBJ=US_X$PT, RDS=(X,Z), REA=(US$X,US$Z))
GETVALS         (OBJ=US_Y$PT, RDS=Y, REA=US$Y)

! --- create wire endpoints by creating points with extracted coordinates
DFNELE          (NAM=DS_WIRE$PT, CSY=TABLE_CSY, DEL=N)
PUTVALS         (OBJ=DS_WIRE$PT, TYP=ELE, RDS=(X,Y,Z), VAL=(DS$X,DS$Y,DS$Z))
DFNELE          (NAM=US_WIRE$PT, CSY=TABLE_CSY, DEL=N)
PUTVALS         (OBJ=US_WIRE$PT, TYP=ELE, RDS=(X,Y,Z), VAL=(US$X,US$Y,US$Z))

! --- create final wire axis
COLPTS          (NAM=WIRE$AXI, CSY=TABLE_CSY, DEL=Y, ELE=(US_WIRE$PT,DS_WIRE$PT), TYP=AXI)
!EDTAPT WIRE$AXI
! --- perpendicular distance from pin wire axis to detector points
!EDTACT         (NAM=WIRE_PIN$DS)
!EDTACT         (NAM=WIRE_PIN$US)
!COLPTS         (NAM=PIN_WIRE, CSY=TABLE_CSY, DEL=Y, ELE=(WIRE_PIN$DS,WIRE_PIN$US), TYP=AXI)
PEPNTAXI       (NAM=US_DT_OFF, CSY=TABLE_CSY, EL1=US_WIRE$PT, EL2=PIN_WIRE.$AXI)
PEPNTAXI       (NAM=DS_DT_OFF, CSY=TABLE_CSY, EL1=DS_WIRE$PT, EL2=PIN_WIRE.$AXI)

GETVALS         (OBJ=US_DT_OFF.EVA(1), RDS=D, REA=OFF_X)
GETVALS         (OBJ=US_DT_OFF.EVA(2), RDS=D, REA=OFF_Y)
GETVALS         (OBJ=US_DT_OFF.EVA(3), RDS=D, REA=OFF_Z)
DFNELE         (NAM=US$OFFSET, DEL=N)
PUTVALS         (OBJ=US$OFFSET, RDS=(X,Y,Z), VAL=(OFF_X,OFF_Y,OFF_Z))

GETVALS         (OBJ=DS_DT_OFF.EVA(1), RDS=D, REA=OFF_X)
GETVALS         (OBJ=DS_DT_OFF.EVA(2), RDS=D, REA=OFF_Y)
GETVALS         (OBJ=DS_DT_OFF.EVA(3), RDS=D, REA=OFF_Z)
DFNELE         (NAM=DS$OFFSET, DEL=N)
PUTVALS         (OBJ=DS$OFFSET, RDS=(X,Y,Z), VAL=(OFF_X,OFF_Y,OFF_Z))

! ---- measure quad tooling balls in final location
! -- qtb-1

USEPRB PRB(1)
DFNCMM          (NAM=OFF$2, POF=3, ENB=N, CPY=EDBCMM:SAVE$CMM)

USECMM OFF$2
QTB=1
T=1
MEPLA          (NAM=QUAD_P(QTB), CSY=TABLE_CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=QUAD_C(QTB), CSY=TABLE_CSY, MOD=NOE, PTY=QUAD_P(QTB))
BLDCSY         (NAM=POST_CSY, TYP=CAR, SPA=QUAD_P(QTB), SDR=+Z, XZE=QUAD_C(QTB), YZE=QUAD
USECMM SAVE$CMM
~RESULT$PT=QUAD_TB(T)
~RESULT$CSY=TABLE_CSY
INDPRC TB_CALC

```

```

USECMM OFF$2
QTB=2
T=2
MEPLA          (NAM=QUAD_P(QTB), CSY=TABLE_CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=QUAD_C(QTB), CSY=TABLE_CSY, MOD=NOE, PTY=QUAD_P(QTB))
BLDCSY        (NAM=POST_CSY, TYP=CAR, SPA=QUAD_P(QTB), SDR=+Z, XZE=QUAD_C(QTB), YZE=QUAD
USECMM SAVE$CMM
~RESULT$PT=QUAD_TB(T)
~RESULT$CSY=TABLE_CSY
INDPRC TB_CALC

```

```

USECMM OFF$2
QTB=3
T=3
MEPLA          (NAM=QUAD_P(QTB), CSY=TABLE_CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=QUAD_C(QTB), CSY=TABLE_CSY, MOD=NOE, PTY=QUAD_P(QTB))
BLDCSY        (NAM=POST_CSY, TYP=CAR, SPA=QUAD_P(QTB), SDR=+Z, XZE=QUAD_C(QTB), YZE=QUAD
USECMM SAVE$CMM
~RESULT$PT=QUAD_TB(T)
~RESULT$CSY=TABLE_CSY
INDPRC TB_CALC

```

```

USECMM OFF$2
QTB=4
T=4
MEPLA          (NAM=QUAD_P(QTB), CSY=TABLE_CSY, MOD=NOE, ITY=GSS)
MECIR          (NAM=QUAD_C(QTB), CSY=TABLE_CSY, MOD=NOE, PTY=QUAD_P(QTB))
BLDCSY        (NAM=POST_CSY, TYP=CAR, SPA=QUAD_P(QTB), SDR=+Z, XZE=QUAD_C(QTB), YZE=QUAD
USECMM SAVE$CMM
~RESULT$PT=QUAD_TB(T)
~RESULT$CSY=TABLE_CSY
INDPRC TB_CALC

```

```

COLPTS        (NAM=QUAD_TB$PLA, CSY=TABLE_CSY, DEL=Y, ELE=( QUAD_TB(3), QUAD_TB(2), QUAD
COLPTS        (NAM=QUAD_TB$AXI, CSY=TABLE_CSY, DEL=Y, ELE=(QUAD_TB(3), QUAD_TB(2)), TYP=
BLDCSY        (NAM=QUAD_TB$CSY, TYP=CAR, SPA=QUAD_TB$PLA, SDR=+Y, PLA=QUAD_TB$AXI, PDR=X
TRACSY        (NEW=QUAD_MECH$CSY, TRA=CSY$TRA, OLD=QUAD_TB$CSY, CAD=N)

```

```

TRAELE        (NEW=YAX_TO_TABLE, TRA=TABLE_CSY, OLD=QUAD_CSY$YAX, RPL=N, EVA=Y)
GETVALS YAX_TO_TABLE.EVA(1), , D, ROLL$DEG
ROLL$MRAD=ROLL$DEG*((F_PI(1)/180)*1000)
DFNELE        (NAM=QUAD$ROLL, DEL=N)
PUTVALS        (OBJ=QUAD$ROLL, RDS=(X,Y,Z), VAL=(ROLL$MRAD,0,0))
CVREACHS      (NAM=~RMAD, VAL=ROLL$MRAD, INT=N, ANG=N, SPZ=N, RLS=Y, RTZ=Y)
FINDTRA        (NAM=QUAD_Z$LOC, CS1=TABLE_CSY, CS2=QUAD_MECH$CSY)
EVATRA        (PNT=QUAD_Z$LOC, TRA=QUAD_Z$LOC, MOD=EVA)

```

!LISCHS ~RMAD

! measure quad tb 5 in quad tb csy

```

USEPRB PRB(2)
T=5
~RESULT$PT=QUAD_TB(T)
~RESULT$CSY=TABLE_CSY
USECMM        (NAM=SAVE$CMM)
MEPLA        (NAM=TBA_PLA(T), CSY=QUAD_TB$CSY, ITY=GSS)
MECYL        (NAM=TBA_CYL(T), CSY=QUAD_TB$CSY, ITY=GSS)

```



```
BLDCSY (NAM=TBA_CSY(T), TYP=CAR, SPA=TBA_PLA(T), SDR=+Z, XZE=TBA_CYL(T), YZE=TBA_CYL(T),
DFNELE (NAM=PLA_25P4(T), TYP=PLA, CSY=TBA_CSY(T), DEL=N)
PUTVALS (OBJ=PLA_25P4(T), RDS=(X,Y,Z,U,V,W), VAL=(0,0,25.4,0,0,1))
INTPNT (NAM=~RESULT$PT, CSY=~RESULT$CSY, EL1=PLA_25P4(T), EL2=TBA_CYL(T).$AXI, PPI=NO, C
```

```
! --- get the sigma of TB_PLA() and TB_CYL() and put into fields D&E of pnt for tb loc.
DO (NAM=I, BGN=1, END=5, DLT=1)
  GETVALS (OBJ=TBA_PLA(I), RDS=F, REA=P$SIG)
  GETVALS (OBJ=TBA_CYL(I), RDS=F, REA=C$SIG)
  PUTVALS (OBJ=QUAD_TB(I), RDS=(D,E), VAL=(P$SIG,C$SIG))
ENDDO
```

```
MECOL (NAM=STR_PNT, CSY=CSY)
```

```
!--- update quad mech csy in ref to balls 1,2,3,5 to table csy
```

```
COLPTS (NAM=QUAD_TB$PLA, CSY=TABLE_CSY, DEL=Y, ELE=(QUAD_TB(3), QUAD_TB(2), QUAD_TB(1)))
COLPTS (NAM=QUAD_TB$AXI, CSY=TABLE_CSY, DEL=Y, ELE=(QUAD_TB(3), QUAD_TB(2)), TYP=CAR)
BLDCSY (NAM=QUAD_TB$CSY, TYP=CAR, SPA=QUAD_TB$PLA, SDR=+Y, PLA=QUAD_TB$AXI, PDR=X)
```

```
TRACSY (NEW=QUAD_MECH$CSY, TRA=CSY$TRA_F, OLD=QUAD_TB$CSY, CAD=N)
```

```
FINDTRA (NAM=QUAD_Z$LOC, CS1=TABLE_CSY, CS2=QUAD_MECH$CSY)
```

```
!***** EVATRA causes program crash *****
```

```
EVATRA (PNT=QUAD_MECH$LOC, TRA=QUAD_Z$LOC, MOD=EVA)
```

```
!---- work around for EVATRA which causes program crash -----
```

```
!DFNELE (NAM=QUAD_MECH$LOC, TYP=POI, CSY=TABLE_CSY, DEL=*)
!GETVALS (OBJ=QUAD_Z$LOC, TYP=TRA, RDS=(X,Y,Z), REA=(TX,TY,TZ))
!PUTVALS (OBJ=QUAD_MECH$LOC, RDS=(X,Y,Z), VAL=(TX,TY,TZ))
```

```
! --- build final wire csy
```

```
BLDCSY (NAM=FINAL$WIRE_QR, TYP=CAR, SPA=WIRE$AXI, SDR=+Z, PLA=QUAD_MECH$CSY.$YDI,
BLDCSY (NAM=FINAL$WIRE_TR, TYP=CAR, SPA=WIRE$AXI, SDR=+Z, PLA=TABLE_CSY.$YDI, PDR=X)
DFNELE (NAM=QUAD$ZERO, TYP=POI, CSY=FINAL$WIRE_TR, DEL=N)
TRAELE (NEW=QUAD$ZERO_T, TRA=TABLE_CSY, OLD=QUAD$ZERO, EVA=Y)
```

```
! --- translate quad tooling ball coordinates into final csys
```

```
DO (NAM=I, BGN=1, END=5, DLT=1)
  TRAELE (NEW=QUAD_TB$QR(I), TRA=FINAL$WIRE_QR, OLD=QUAD_TB(I), RPL=N)
  TRAELE (NEW=QUAD_TB$TR(I), TRA=FINAL$WIRE_TR, OLD=QUAD_TB(I), RPL=N)
ENDDO
```

```
! ---- get ave of coordinates for balls 1-4
```

```

DO                (NAM=I, BGN=1, END=4, DLT=1)
  GETVALS         (OBJ=QUAD_TB$QR(I), RDS=(X,Y,Z), REA=(QR$X(I),QR$Y(I),QR$Z(I)))
  GETVALS         (OBJ=QUAD_TB$TR(I), RDS=(X,Y,Z), REA=(TR$X(I),TR$Y(I),TR$Z(I)))
ENDDO

TB$QR_X=(QR$X(1)+QR$X(2)+QR$X(3)+QR$X(4))/4
TB$QR_Y=(QR$Y(1)+QR$Y(2)+QR$Y(3)+QR$Y(4))/4
TB$QR_Z=(QR$Z(1)+QR$Z(2)+QR$Z(3)+QR$Z(4))/4
DFNELE           (NAM=QR$Y(1234), CSY=FINAL$WIRE_QR, DEL=*)
PUTVALS          (OBJ=QR$Y(1234), RDS=(X,Y,Z), VAL=(TB$QR_X,TB$QR_Y,TB$QR_Z))

TB$TR_X=(TR$X(1)+TR$X(2)+TR$X(3)+TR$X(4))/4
TB$TR_Y=(TR$Y(1)+TR$Y(2)+TR$Y(3)+TR$Y(4))/4
TB$TR_Z=(TR$Z(1)+TR$Z(2)+TR$Z(3)+TR$Z(4))/4
DFNELE           (NAM=TR$Y(1234), CSY=FINAL$WIRE_TR, DEL=*)
PUTVALS          (OBJ=TR$Y(1234), RDS=(X,Y,Z), VAL=(TB$TR_X,TB$TR_Y,TB$TR_Z))

!--- collect tb coordinates and ave of 1,2,3,4 into final csy
  COLPTS          (NAM=QUAD$T_BALLS, CSY=FINAL$WIRE_QR, DEL=Y, ELE=(QUAD_TB$QR(1), QUAD_TB$
! --- load tooling ball coordinates from mech. fid.
! --- ELE:NOM$TB loaded with tranformations
  USECSY          (NAM=FINAL$WIRE_QR)
  DELELE NOM$TB,N$
  CONCAT          (NAM=~QUAD$DIR, STR=('C:\Undulator Quad Transformation\',QUAD,' ',~QID6,'\
  CONCAT          (NAM=~QUAD$TB_FILE, STR=('Quad', ' ',~QID6, ' ','Tooling Balls','.txt'), L
  CONCAT          (NAM=~FIL$CNV, STR=(~QUAD$DIR,~QUAD$TB_FILE), LMG=1, INI=Y)
  CNVFIL ~FIL$CNV

! --- put imported tooling balls in correct csy
PUTSTR           (OBJ=NOM$TB, DSC=H, STR=FINAL$WIRE_QR)
DO              (NAM=I, BGN=1, END=5, DLT=1)
  COLAPT         (NAM=QUAD$MECH(I), CSY=FINAL$WIRE_QR, DEL=Y, PTS=NOM$TB.ACT.PT(I), FRS=
ENDDO

DO              (NAM=I, BGN=1, END=5, DLT=1)
  GETVALS       (OBJ=NOM$TB.ACT.PTS(I), RDS=(X,Y,Z), REA=(MECH$X,MECH$Y,MECH$Z))
  GETVALS       (OBJ=QUAD_TB$QR(I), TYP=ELE, RDS=(X,Y,Z), REA=(ACT_X,ACT_Y,ACT_Z))
  DFNELE        (NAM=M_W$DIFF(I), CSY=FINAL$WIRE_QR, DEL=N)
  PUTVALS       (OBJ=M_W$DIFF(I), RDS=(X,Y,Z), VAL=(ACT_X-MECH$X,ACT_Y-MECH$Y,ACT_Z-MEC
ENDDO

! --- get run number from WKP and append to file name

  CONCAT        (NAM=~CMM$DIR, STR=('C:\CMM DATA\',QUAD,' ', ~QID,'\'), LMG=1, INI=Y)
  CONCAT        (NAM=~CMM$FILE, STR=(~CMM$DIR,'CMM RUN', ' ',~QID,' ',~POL,'.TXT'), LMG=1,
  CONCAT        (NAM=~T_BALL$FILE, STR=(~CMM$DIR,'TOOLING BALLS', ' ',~QID,' ',~POL,'.TXT'
  CONCAT        (NAM=~QUAD$FILE, STR=('C:\CMM DATA\QUAD', ' ',~QID,, ' ',~POL,'.WDB'), LMG
  MAKEDIR       (DIR=~CMM$DIR, OPT=C)
! --- output tooling ball data to file
  OPEN          (FIL=~CMM$FILE, DEV=D1, STA=NEW, ACC=A)
  OUTPUT        (NAM=$SCOTT, DEV=D1, TYP=ELE, STY=ACT, MSK=ACT$OUT)
  CLOSE        (DEV=D1)
! --- add polarity to element name so mane is unique
  CONCAT        (NAM=~T$BALL_ELE, STR=(QUAD$T_BALLS_,~POL), LMG=1, INI=Y)

```

```

CPYAPT          (FRM=QUAD$T_BALLS, TO =~T$BALL_ELE, DEL=Y)
FMTOBJ          (FIL=~T_BALL$FILE, NAM=~T$BALL_ELE, STA=NEW, TYP=ELE, STY=APT, DSC=(X,Y,Z))

!--- output tra from tooling ball csy to wire csy
CONCAT          (NAM=~QUAD$DIR, STR=('C:\Undulator Quad Transformation\',QUAD,'_',~QID6,'\
CONCAT          (NAM=~QUAD$TRA, STR=('Quad', '_',~QID6,' ',WIRE,'.TRA'), LMG=1, INI=Y)
CONCAT          (NAM=~FIL$TRA, STR=(~QUAD$DIR,~QUAD$TRA), LMG=1, INI=Y)

FINDTRA         (NAM=QUAD_WIRE$LOC, CS1=QUAD_TB$CSY, CS2=FINAL$WIRE_QR)
FMTOBJ          (FIL=~FIL$TRA, NAM=QUAD_WIRE$LOC, TYP=TRA)

!--- save complete wdb
CONCAT          (NAM=~QUAD$FILE, STR=('C:\CMM DATA\QUAD', ' ',~QID,, ' ',~POL,'.WDB'), LMG
SAVE            (FIL=~QUAD$FILE)

GOTO 100

! --- calculate and ouput average of plus and minus tooling ball values
600:CONTIN
USECSY CSY
DELELE         (NAM=(QUAD$T_BALLS_MINUS, QUAD$T_BALLS_PLUS), CNF=N)
DELELE         (NAM=ELE:AVE$TB(), CNF=N)
CONCAT          (NAM=~T_BALL$FILE_P, STR=(~CMM$DIR,'TOOLING BALLS', ' ',~QID,' ',PLUS,'.TX
CONCAT          (NAM=~T_BALL$FILE_M, STR=(~CMM$DIR,'TOOLING BALLS', ' ',~QID,' ',MINUS,'.T
CNVFIL ~T_BALL$FILE_P
CNVFIL ~T_BALL$FILE_M

DO              (NAM=I, BGN=1, END=5, DLT=1)
  COLAPT        (NAM=AVE$TB(I), CSY=CSY, DEL=Y, PTS=QUAD$T_BALLS_MINUS, FRS=I, LST=I)
  COLAPT        (NAM=AVE$TB(I), CSY=CSY, DEL=N, PTS=QUAD$T_BALLS_PLUS, FRS=I, LST=I, TY
  PUTVALS      (OBJ=AVE$TB(I), RDS=(D,E,F), VAL=(0,0,0))
ENDDO

! ---- get ave of coordinates for balls 1-4 and bld point
DO              (NAM=I, BGN=1, END=5, DLT=1)
  GETVALS      (OBJ=AVE$TB(I), RDS=(X,Y,Z), REA=(AV$X(I),AV$Y(I),AV$Z(I)))
ENDDO

TB$AV_X=(AV$X(1)+AV$X(2)+AV$X(3)+AV$X(4))/4
TB$AV_Y=(AV$Y(1)+AV$Y(2)+AV$Y(3)+AV$Y(4))/4
TB$AV_Z=(AV$Z(1)+AV$Z(2)+AV$Z(3)+AV$Z(4))/4
DFNELE        (NAM=AVE$Y(1234), CSY=CSY, DEL=*)
PUTVALS      (OBJ=AVE$Y(1234), RDS=(X,Y,Z), VAL=(TB$AV_X,TB$AV_Y,TB$AV_Z))

CONCAT          (NAM=~T_BALL$AVE, STR=(~CMM$DIR,'TOOLING BALLS', ' ',~QID,' ',AVERAGE,'.TX

! --- output tooling ball data to file
OPEN           (FIL=~T_BALL$AVE, DEV=D1, STA=NEW, ACC=A)
OUTPUT        (NAM=(AVE$TB(1),AVE$TB(2),AVE$TB(3),AVE$TB(4),AVE$TB(5),AVE$Y(1234)), DEV=
CLOSE         (DEV=D1)

GOTO          (LAB=100)

700:STOP

```

!EDTTXT ACT\$OUT_TXT
!CNVTXT ACT\$OUT_TXT
!EDTQUE \$SCOTT

!EDTTXT EVA\$OUT_HDR
!EDTTXT EVA\$OUT_TXT
!CNVTXT EVA\$OUT_TXT