HzTool tutorial

H. Jung, DESY

together with T.Carli (CERN), J. M. Butterworth and B. M. Waugh (UCL)

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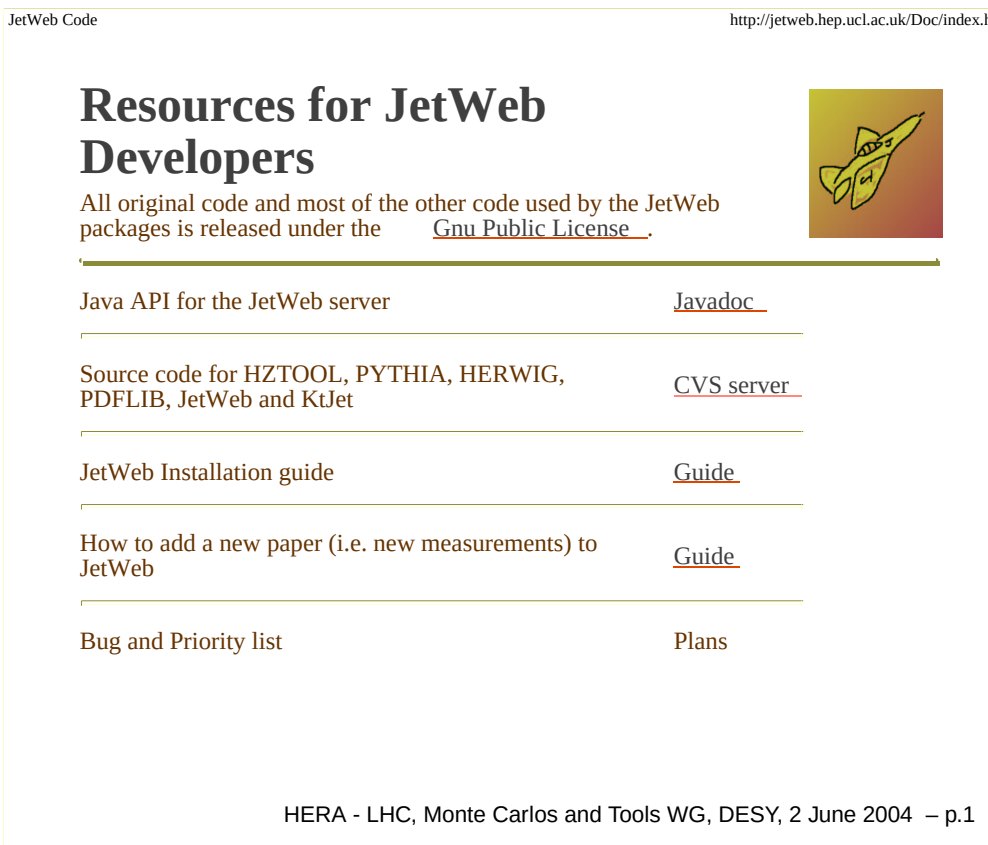
partially based on: T.Carli, HzTool - A Toolbox for MC/Data Comparisons, talk at MC@LHC, CERN, 2003

A library of generic FORTRAN routines to allow easy access to experimental published data distributions and to calculate the predictions of Monte Carlo generators for these distributions

More Information and code:
http://jetweb.hep.ucl.ac.uk/
Documentation:
http://www.desy.de/~heramc/mclist.html



HZTOOL

by N. Brook et al., with lot of work from T. Carli (Librarian)

source code: `http://jetweb.hep.ucl.ac.uk/`

docu: `http://www.desy.de/ heramc/mclist.html`

- common interface for all MC generators
- also applicable for NLO programs
- works on HEPEVT, includes tools like jet algos, boosts etc
- includes all????? H1 and ZEUS published measurements
- independent test of analysis (coded differently)
- can be used for tuning and comparison
- has data point and histos of MCs for comparison
- has kumacs for easy plotting results
- until now written in Fortran, and uses HBOOK/PAW

The basic idea of HzTool

from T.Carli, HzTool - A Toolbox for MC/Data Comparisons, talk at MC@LHC, CERN, 2003

- Developed at HERA, i.e. enviroment where MC have difficulties to describe the data, but where MC are needed for precision physics
- common project between ZEUS and H1
- extended to gamma-gamma collisions of LEP (OPAL)
- easily extendable to TEVATRON and LHC data

Contains published data in the form of HBOOK-histograms
Allows to easily calculate the MC prediction for the data distributions
It is not always easy to find out:

- the exact cuts which need to be applied
- the exact definition of an observable

Interface: Experiment and Theory

Using HzTool

from T.Carli, HzTool - A Toolbox for MC/Data Comparisons, talk at MC@LHC, CERN, 2003

- needs HBOOK initialisation
- Hztool-routine called by user-analysis-routine of MC generator

subroutine user.f

if (BEGIN) CALL HZXXXX(1) ! Histogram initialisation
if (PROCESS) CALL HZXXXX(2) ! Histogram filling
if (END) CALL HZXXXX(3) ! Histogram normalisation
END

Results in:

- set of histogram in HBOOK subdirectory (call HCDIR('XXXX'))
  ID: Monte Carlo prediction
  -ID: data distribution

KUMACS to manipulate or overlay
histograms in complicated cases are provided

Structure of HzTool

from T.Carli, HzTool - A Toolbox for MC/Data Comparisons, talk at MC@LHC, CERN, 2003

HEPEVT-Common

- Contains 4-vectors of all produced particles and event history

Results

- Data and MC histogram in HBOOK subdirectory unique for each paper

Tools:

- find jets
- find charged particles
- calculate pseudo-rapidity
- calculate thrust, sphericity
- calculate jet shape variables
- find partons
- boost and rotate particles
- find kinematics x,Q^2 etc
- find largest rapidity gap
- normalise histos with non-equidistant bins

Only software in HzTool or CERN libraries is allowed code can run independent of other generators or collaboration code

Generators

from T.Carli, HzTool - A Toolbox for MC/Data Comparisons, talk at MC@LHC, CERN, 2003

HzTool is interfaced to all standard generators

- PYTHIA, HERWIG, LEPTO-MEPS, LEPTO-ARIADNE
- RAPGAP, CASCADE + some for exotic processes
- NLO programs (NLOLIB)

Routines

from T.Carli, HzTool - A Toolbox for MC/Data Comparisons, talk at MC@LHC, CERN, 2003

In total $>$ 45 histograming routines are available written by about $>$ 30 authors from $>$ 45 scientific publication !

Available are:

- transverse energy flows and particle spectra in DIS and photoproduction
- charged particles multiplicities
- strange particle spectra
- fragmentation functions
- leading baryon spectra
- diffractive structure functions
- jet cross-sections and event shapes (DIS, γp, diffraction) (...1, 2, 3 jets and event shape in current and target region)
- Jet cross-section in $\gamma\gamma$-collisions at LEP
- particle spectra

In one run complete overview of hadronic final state The correct MC can describe all data !
It is easy to tune one data distribution, all is a challenge !

How to get started - hzana.F ?

```
        Subroutine hzcaana
        Implicit None

      Integer NMXHEP
      PARAMETER (NMXHEP=4000)
      Integer NEVHEP,NHEP,ISTHEP,IDHEP
      Integer JMOHEP,JDAHEP
      Double Precision PHEP,VHEP
      COMMON/HEPEVTP/NEVHEP,NHEP,ISTHEP(NMXHEP),IDHEP(NMXHEP),
     & JMOHEP(2,NMXHEP),JDAHEP(2,NMXHEP),PHEP(5,NMXHEP),VHEP(4,NMXH

      Character*8 Gen
      Double Precision Xsec
      Integer ichrg
        Real Ntot,wtx
      Common /HERACMN/ Xsec, Gen, ichrg(nmxhep), Ntot,wtx

      Integer Iflag,nev,i
        Logical First
        Data First/.true./
        If(First) Then
C--- open hbook file
          call qhbkin
          gen='CASCADE'
          write(6,*) ' Generator= ',GEN
* write out version of Hztool
*
          call hzvers
*
*      ini step for histograms
*
          call HZFILHEP
          iflag=1
          INCLUDE 'hzxxxx.inc'
*
          write(6,*) ' hzcaana start show directory '
          call HLDIR(' ','T')
            First=.false.
*
      endif
      nev=nev+1
      if (nev.lt.10)    i=1
      if (nev.gt.10)    i=100
      if (nev.gt.10000) i=10000
      if (mod(nev,i).eq.0) write(6,*) 'hzcaana processing event',nev
*
      call HZFILHEP
*
      iflag=2

      INCLUDE 'hzxxxx.inc'
      RETURN
      END
```

- call qhbkin:
  booking of hbook file
- call hzfilhep:
  filling of HEPEVT and generator dependent variables in HZTOOL common
- hzxxxx.inc: file containg call to analyis routines

```
c for f2 H1
        call hz96039(iflag)
        call hz00181(iflag)
c ZEUS F2
        call hz96076(iflag)
        call hz01064(iflag)
c fwd jets (H1)
        call hz98143(iflag)
```

How to finish - hzend.F ?

```
       Subroutine hzcaend
       Implicit None
      INTEGER          NHBOOK
      PARAMETER       (NHBOOK = 1000000)
      REAL             H
      COMMON /PAWC/ H(NHBOOK)
      CHARACTER*6      HRFTOP
      PARAMETER       (HRFTOP ='HISTO')
      INTEGER          MPRHIS
      PARAMETER       (MPRHIS = 10000)
      LOGICAL          HBKOUT
      COMMON /QHBKLO/ HBKOUT
       Integer    NRECL
      PARAMETER   (NRECL=1024)
      SAVE

      Integer NMXHEP
      PARAMETER (NMXHEP=4000)
      Integer NEVHEP,NHEP,ISTHEP,IDHEP
      Integer JMOHEP,JDAHEP
      Double Precision PHEP,VHEP
      COMMON/HEPEVTP/NEVHEP,NHEP,ISTHEP(NMXHEP),IDHEP(NMXHEP),
     & JMOHEP(2,NMXHEP),JDAHEP(2,NMXHEP),PHEP(5,NMXHEP),VHEP(4,NMXHEP)

      Character*8 Gen
      Double Precision Xsec
      Integer ichrg
        Real Ntot,wtx
      Common /HERACMN/ Xsec, Gen, ichrg(nmxhep), Ntot,wtx

      Integer Iflag
*  term step for functions
*

      iflag=3
      INCLUDE 'hzxxxx.inc'
*
*  write out histograms
*
       call HCDIR('//PAWC',' ')
*
       call HCDIR('//'//HRFTOP,' ')
*
       call qhbkou
*
*  scan through all directories and print chi2
*
       call Hzterm

*
C-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o

      RETURN
      END
```

- hzxxxx.inc: file containg call to analyis routines, as before
- call qhbkou: fill and terminate hbook file
- call hzterm: scan through all subdirectories, print χ^2/ndf, etc

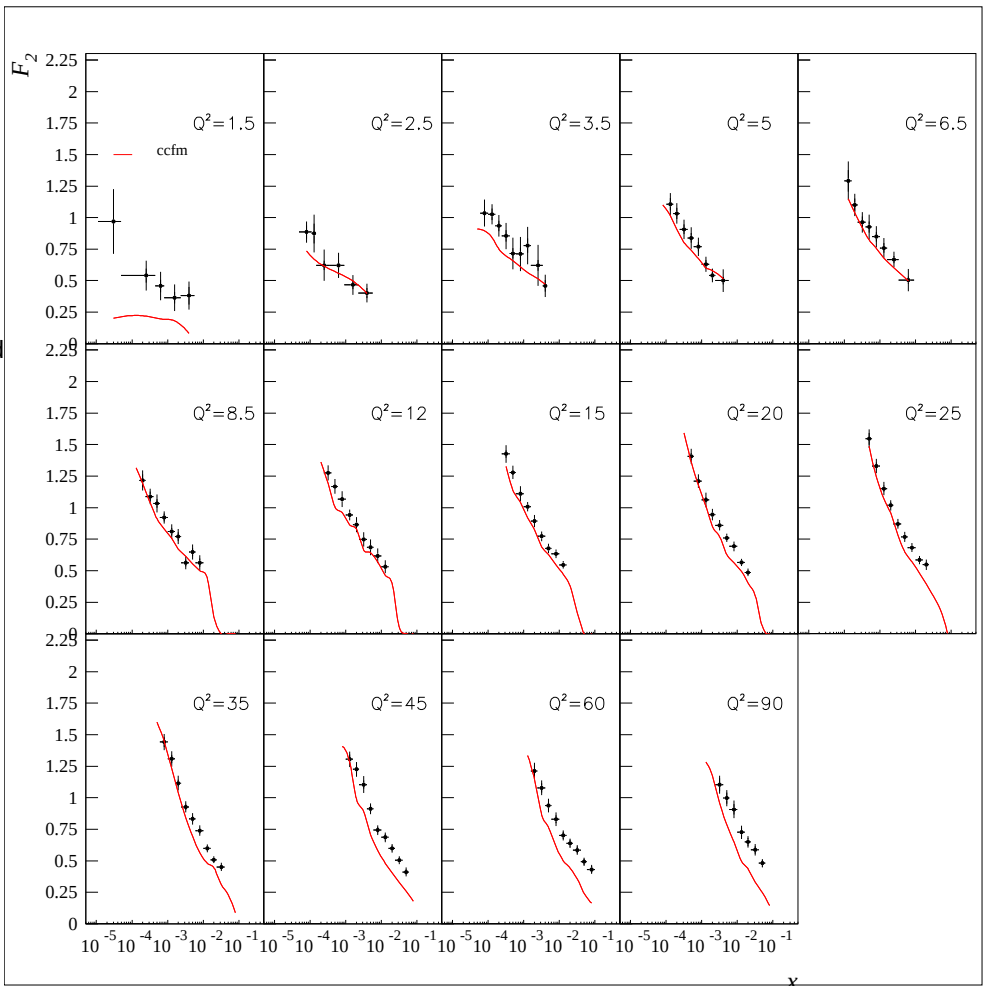
How to plot results ?

```
macro k_hzcascade
close 0
set *
igset *
exe k_hzunit
set *
igset *
exe k_hz96039
set *
igset *
exe k_hz00181
set *
igset *
exe k_hz96076
set *
igset *
exe k_hz01064
set *
igset *
set *
igset *
exe k_hz98143
clos 0

*
macro k_hzunit
************************************************************

* Purpose:
* Reading of HzTool generator files
*
* You have to perform the following steps:
* 1:
*   Here you have to specify the *.hbook files you would li
*   to use (up to 4 files can be used on unit 31 to 34)
* 2:
*   Define vector iunit to activate the corresponding unit
************************************************************
*
h/file 31 ccfm.hbook
alias/create cfile1 'ccfm '
************************************************************
*
*
*
nunit = 1                    | # of units opened (must be <
*
* set here how many units should be activ (= 3 ), off =0
*
*     switch for unit 31 32 33 34
*
ve/cr iunit([nunit]) R 3  3  3  3  3   | '3' for generator
*
* define color for iunit
ve/cre col(5) r 4 6 2 4 5
return
```

- `k_hzunit`:
  define hbook file
  colors, scale factors, legend, etc
- `exe k_hz96039`
  plot results from `hz96039`
  predefined kumac, including data points and MC prediction

How to plot results - PAW sample session

```
fig/examples> paw
 ********************************************************
 *                                                      *
 *            W E L C O M E    to   P A W               *
 *                                                      *
 *       Version 2.10/09       1 March 1999             *
 *                                                      *
 ********************************************************
 Workstation type (?=HELP) <CR>=1 :
 Version 1.25/05 of HIGZ started
 *** No default PAWLOGON file "/home/jung/.pawlogon.kumac" found

PAW >
PAW > exe k_hzexample
 *** VECTOR/CREATE IUNIT(1): too many initializers
  global chi/ndf  2.28439 123.357 54
PAW >
PAW > pi/lis
     1: PICT1 <-- Current Picture (Active)
PAW > pi/pl 1
PAW > pi/pri hzexample.eps
```



Designing new analysis routine (a)

```
      subroutine HZana(IFLAG)
      IMPLICIT NONE
*
* Function declarations for Hztool functions
*
          DOUBLE PRECISION HzPhmang
          DOUBLE PRECISION HzDiskin
          DOUBLE PRECISION HzPhokin
          DOUBLE PRECISION HZETA
          DOUBLE PRECISION HZPHI
          DOUBLE PRECISION HZET
          DOUBLE PRECISION HZPT
          DOUBLE PRECISION HZTHETA
          DOUBLE PRECISION hzeekin
          Integer hzeebeam
          Integer hzeegamn
          Integer HzIpgamn
          Integer HzIdelec
          Integer HzIpgam
          Integer HzIbeam
          Integer HzLchge
          Integer HzLcomp
*
* HEP event prime common
* (for explanation see manual)
      Integer NMXHEP
      PARAMETER (NMXHEP=4000)
      Integer NEVHEP,NHEP,ISTHEP,IDHEP
      Integer JMOHEP,JDAHEP
      Double Precision PHEP,VHEP
      COMMON/HEPEVTP/NEVHEP,NHEP,ISTHEP(NMXHEP),IDHEP(NMXHEP),
     & JMOHEP(2,NMXHEP),JDAHEP(2,NMXHEP),PHEP(5,NMXHEP),VHEP(4,NMXHEP)
*
*
* HERA common
*
*     GEN: Name of generator
*     XSEC: total cross section (in pb)
*     IHCHRG: charge of particle/parton times 3
*     NTOT : Number of total events
*     WTX  : event weight
*
      Character*8 Gen
      Double Precision Xsec
      Integer ihchrg
      Real    wtx, Ntot
      Common /HERACMN/ Xsec, Gen, ihchrg(nmxhep), Ntot,wtx
*
*
*     MAXHZJETS: maxmial number of jet allowed
*     NUMJETS: number of jets from jet algo
*     NSEL  : number of selected jets
*     IPJET : pointer to selected jets
*     JETS  : Jet variables (eta,phi,et,e,px,py,pz,m) in choosen frame
*     IJETNO: pointer which objects in PHEP common belong to jets
*
      INTEGER MAXHZJETS
      PARAMETER (MAXHZJETS=50)
      INTEGER NSEL,NUMJETS,IPJET(MAXHZJETS),IJETNO(NMXHEP)
      DOUBLE PRECISION JETS(MAXHZJETS,8)
*
      COMMON /HZJETCMN/JETS,NUMJETS,NSEL,IPJET,IJETNO
*
*
*
*     MAXHZJETS: maxmial number of jet allowed
*     NUMJETS: number of jets from jet algo
*     NSEL  : number of selected jets
*     IPJET : pointer to selected jets
*     JETS  : Jet variables (eta,phi,et,e,px,py,pz,m) in choosen fr
*     IJETNO: pointer which objects in PHEP common belong to jets
*
      Integer Nentry
      Integer Iflag,ierr
      Real nall,Nevt
      Character*5 xxxx
*
      Real pi,rd,eb,ee,Qpi,qqradp,lumnb,lumpb
      Integer iel,idum,ibeam,igam,ifj,afj,bfj
      Parameter (pi=3.1415927,rd=180./pi)
      Real x,y,q2,enel,thel

      save xxxx,nall
      Data xxxx/'ana'/,NENTRY/0/


      real sigm,wt

*********************************************************************
*
*                     Initialization
*
*********************************************************************
      wt=wtx
      NENTRY=NENTRY+1
*
      IF (iflag.eq.1) then
*
         write(6,*)' hz98121 my private Version'
         Qpi = 4.*atan(1.)
         qqradp = 180./qpi
*
*
*      Initialisation: The following MUST always be done
*      (i) make subdirectory in PAWC
*       - use the name as the xxxxxx in HZxxxxxx subroutine
*      (i) make subdirectory in o/p file
*
         Call hcdir('//PAWC',' ')
         call hmdir(xxxx,'S')
         Call hcdir('//HISTO',' ')
         call hmdir(xxxx,'S')
         call hbook1(221,' y   ',100,0.,1.,0.)
         call hbook1(222,' Q2  ',100,0.,100.,0.)
```

Designing new analysis routine (b)

```
*
*                       Event Processing
*
*****************************************************************
      Else if(iflag.eq.2) then
*
* Filling: The following MUST always be done
* (i) move to the correct sub-directory in PAWC
*
         call hcdir('//PAWC/''//xxxx,'' ')
*
         Nevt = Nevt + wtx
*
         ierr=HZIBEAM(ibeam,idum)
*
* get kinematics
*
         q2=real(HZDISKIN(1))
         x =real(HZDISKIN(2))
         y =real(HZDISKIN(3))
           sigm = real(Xsec)
*
* get electron
*
         iel=HZIDELEC(idum)
         if (iel.eq.-1) then
            write(*,*) 'Hz''//xxxx,' electron not found '
            return
         endif
        Ee=real(PHEP(4,iel))
*
          call hfill(221,real(y),0.,1.)
          call hfill(222,real(q2),0.,1.)
*****************************************************************
*
*                       Termination
*
*****************************************************************

      Else if(iflag.eq.3) then
* Termination: The following MUST always be done
* (i) Move to the correct PAW subdirectory
*
         call hcdir('//PAWC/''//xxxx,'' ')
*
         lumnb=999999.
         lumpb=999999.
         if (xsec.ne.0.) then
            lumnb=1000.*real(Nevt)/real(xsec)
            lumpb=real(Nevt)/real(xsec)
            print *,'Number of events procesed:',Nevt
            print *,'Total cross section:',xsec
            print *,'Equivalent luminosity [nb] :',lumnb
         else
            write(6,*) 'hz',xxxx,' xsec=0 !'
         endif
      endif
*
      RETURN
      END
```

Designing new routine for jet analysis (a)

```
* version for jets with kt algo.

C hztool nlo common
      INTEGER NLO, TOT, DIJET, TRIPJET, QUADJET
      COMMON /HZNLO/NLO, TOT, DIJET, TRIPJET, QUADJET

      Integer modjet

c for ktalgo use modjet = 3
      Parameter (modjet=3)
        Integer ktmode
        Parameter (ktmode=3212)

.............

*********************************************************************
*
*                       Event Processing
*
*********************************************************************
      Else if(iflag.eq.2) then
*
* Filling: The following MUST always be done
* (i) move to the correct sub-directory in PAWC
*
         call hcdir('//PAWC/'//xxxx,' ')
*
         IF(NLO.eq.1.and.TOT.ne.1) GoTo 11112
            Nevt = Nevt + wtx
11112      Continue
         if(Nevt.le.0) then
              write(6,*) ' NLO ',NLO,' TOT ',TOT,wtx,nevt
           endif

           NLOJET = DIJET + TRIPJET + QUADJET

*
         ierr=HZIBEAM(ibeam,idum)

*
* get kinematics
*
         q2=real(HZDISKIN(1))
         x =real(HZDISKIN(2))
         y =real(HZDISKIN(3))

*
* get electron
*
         iel=HZIDELEC(idum)
         if (iel.eq.-1) then
            write(*,*) 'Hz'//xxxx,' electron not found'
            return
         endif
         Ee=real(PHEP(4,iel))
         The=real(HZPHMANG(PHEP(3,iel), sqrt(PHEP(1,iel)**2+PHEP(2,iel)
     +   **2)))*rd
         Phe = HZPHMANG(PHEP(1,iel),PHEP(2,iel))*rd

           etae=real(HZETA(iel))
*
* select DIS events for fwd jets
*
         fjet=.true.
         if (ylow.gt.y) fjet=.false.
         if (q2low.gt.q2) fjet=.false.
         if (Eelow.gt.Ee) fjet = .false.
*
* fill Dis histos
*
         call hfill(101,x,0.,wtx)
         call hfill(103,y,0.,wtx)
         call hfill(104,q2,0.,wtx)
         if(fjet) then
              IF((NLO.eq.1).AND.(NLOJET.eq.0)) goto 11114
                Ndis = Ndis + 1
*
* find jets
*
            ierr=HZIBEAM(ibeam,idum)
            if (.not.(ierr.eq.1)) then
               write(6,*) 'HZ'//xxxx,' beams not found !'
               goto 20
            else
               Do i=1,4
                  pbeam(i)=PHEP(i,IBEAM)
               enddo
            endif
            ierr=HZIPGAM(ph)
            if (ierr.eq.-1) then
               write(6,*) 'HZ'//xxxx,' boson vector not found !'
               call VZERO(ph,5)
            else
               Do i=1,4
                  pgam(i)=ph(i)
               enddo
            endif
            call HZHCMINI(pbeam,pgam,ierr)
            if (ierr.eq.1) then
               write(6,*) 'HZ'//xxxx,' problem with boost to cms !'
               goto 20
            endif

            Do ihep=5,nhep
               Do i=1,4
                  Ph(i)=PHEP(i,ihep)
                  Plab(i,ihep)=PHEP(i,ihep)
                  phep(i,ihep)=0.0
               enddo
* pcm in had cms
               call HZHCM(phc,pcm,ierr)
               if (ierr.eq.1) then
                  write(6,*) 'HZ'//xxxx,' problem with boost to cms !'
                  goto 20
               endif
               Do i=1,4
                  PHEP(i,ihep)=Plab(i,ihep)
               enddo

            enddo


            call hzjtfind(modjet,rcone,nj1,pj)
```

Designing new routine for jet analysis (b)

```
                nj = nj1
              do ihep=5,nhep
                 Do i=1,4
                    PHEP(i,ihep)= Plab(i,ihep)
                 enddo
              enddo
*
              if (nj.le.0) return
              if (nj.gt.numjet) then
                 write(6,*) 'hz',xxxx,' too many jets found !'
                 return
              endif
              Njet=0
              Nmue = 0
              Nfwd = 0
              Nfwd2 = 0
*
* look for fwd jets, it is assumed that in pj they are ordered in pt
              nfj = 0
              do 10   ij=1,nj
*
                 ej=real(pj(ij,4))
                 ptj=real(pj(ij,3))
                   etajf = real(pj(ij,1))
*
                 if (ptj.lt.Etlow) goto 10
                 if ((ptj**2/q2).lt.0.5) goto 10
                 if ((ptj**2/q2).gt.2.0) goto 10

                 Njet=Njet+1

                 if ( (etajf.gt.etalow.and.etajf.lt.etahigh)) then
*     you got a fwd jet!
                    Nfwd = Nfwd + 1
                    call hfill(203,ptj,0.,wtx)
                    call hfill(204,etajf,0.,wtx)
                 endif
   10         continue


              do ihep=1,nhep
                 Do i=1,4
                    PHEP(i,ihep)= Plab(i,ihep)
                 enddo
              enddo
11114           continue

           endif
   20      continue

*
*********************************************************************
*
*                       Termination
*
*********************************************************************

      Else if(iflag.eq.3) then

* Termination: The following MUST always be done
* (i) Move to the correct PAW subdirectory
*
```

```
           call hcdir('//PAWC/'//xxxx,' ')
*
           lumnb=999999.
           lumpb=999999.
             write(6,*) ' end xsec = ',xsec
           if (xsec.ne.0.) then
              lumnb=1000.*real(Nevt)/real(xsec)
              lumpb=real(Nevt)/real(xsec)
             write(6,*) 'hz',xxxx
             print *,'Number of events procesed:',Nevt
             print *,'Total cross section:',xsec
             print *,'Equivalent luminosity [nb] :',lumnb
             print *,'Number of DIS events :',Ndis
           else
              write(6,*) 'hz',xxxx,' xsec=0 !'
           endif
*
*      normalize the histos
*
* jets
           call hopera(203,'+E',203,203,1./lumpb,0.
           call hopera(204,'+E',204,204,1./lumpb,0.


              call hzhinrm(203, 0, 1. , 1 )
              call hzhinrm(204, 0, 1. , 1 )
        endif
*
        RETURN
        END
```

Summary

- HzTool is a common interface for all MC generators
- also applicable for NLO programs
- works on HEPEVT, includes tools like jet algos, boosts etc
- includes all????? H1 and ZEUS published measurements
- can be used for tuning and comparison
- has data point and histos of MCs for comparison
- has kumacs for easy plotting results
- until now written in Fortran, and uses HBOOK/PAW
- include also C++ ??
- include possibility for ROOT ??
- further help from all experiments needed...
  HERA and Tevatron/LHC