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WWANA
A standard package for W analysis

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Abstract

This note contains a detailed description of the structure of the WWANA program. WWANA is intended as a standard DELPHI package for use in WW physics analysis: it provides information relevant to both W mass measurements and TGC studies. The main output of the package is a Column Wise Ntuple organised in blocks of relevance to particular W decay channels and of more general event information. This document relates to WWANA version 3.00.

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1 Introduction

WWANA is intended as a standard package for W mass and TGC analyses in DELPHI. The program is written in PATCHY format and uses the SKELANA package [1] to fill the common blocks which contain the information from the DST.

The main program calls several routines which evaluate interesting physics quantities for the event: these include lepton identification, global event variables and jet analysis.

If the user is processing simulation data the event is classified according to its type, and some simulation truth information is retrieved.

WWANA contains three identification routines that provide information on the three WW decay channels:

$$QQ: \; W^+W^- \rightarrow q_1\overline{q}_2q_3\overline{q}_4 \qquad QL: \; W^+W^- \rightarrow q_1\overline{q}_2\ell\nu \qquad LL: \; W^+W^- \rightarrow \ell\nu\ell'\nu'$$

The routines return a tag flag and a number of variables which are useful in the analysis of these channels. The user can control the steering of the program and attach additional routines.

The main output of the program is a Column Wise Ntuple. By setting logical parameters, the user can choose which blocks of information to include in the ntuple. This choice will depend on which analysis and which W decay channels the user is interested in studying. All the variables and the physical quantities that have been evaluated are stored in common blocks; these have the same structure as the ntuple blocks.

2 Location of the code

The WWANA program is composed of several PAM files, which are located in the common area for DELPHI LEP200 physics on afs machines:

`/afs/cern.ch/delphi/tasks/lep200/wphysics/wwana`

The core of the program is composed of two PAM files:

- `wwcde.car` contains all the common and parameter declarations useful for the analysis: it also contains the user-defined basic selections.
- `wwana.car` is the main program with all the 'tool subroutines'

Two versions of the main program are stored in this area: a stable version `wwanaxx.car, wwcdexx.car` updated every few weeks, and a development version `wwana.car ,wwcde.car` updated as soon as changes are suggested. WWANA also uses the following files:

- `wwfit.car` contains the routines for the kinematic fit (the PUFITC package [2, 3], written by N.Kjaer)
- `sprime.car` is the SPRIME package [4] by P.Abreu et al., to calculate the effective centre of mass energy
- `durham.car` contains the routine for the DURHAM jet reconstruction algorithm [5]

A further two files are provided in this area to assist the WWANA user:

- `wwana.cra` contains an example PATCHY cradle file which shows how to use these PAM files; it should be appended to the SKELANA cradle
- `wwana.manual` documents the stable version of WWANA

3 Using WWANA

The WWANA files must be appended to the SKELANA package, which should include:

- a call to the routine WWINI in USER00
- a call to the routine WWANA in USER02
- a call to the routine WWEND in USER99

Users are expected to perform their own track selection within SKELANA, but the WWANA package handles the flags for the filling of the SKELANA common blocks. The SKELANA LVLOCK array can be used to select tracks. During the WWANA program the VECP array is re-ordered so that the locked tracks are at the end, the original order is restored at the end of the program. The SKELANA flag IFLSTR is set to 1 by default in WWINI. If SKELANA version 1.03 is used, the value of IFLVEC can be set by un-commenting the relevant line in WWINI.

4 Inputs

The user can control the flow of the program, apply some general cuts, and select the required output structure by setting some variables and logical words. These user defined WWANA inputs are in the PAM file `wwcde.car`, which is divided into the `+KEEP` blocks `WWCUTS, WWJETS, WWNTUP`.

`+KEEP,WWCUTS.` contains the basic cuts which WWANA applies for the tagging of the different WWANA decay channels. These are general cuts and are set by default to very loose values in order to maximize the tagging efficiency, thus leaving complete control to the user. Table 1 lists these cuts, their allowed range, and the default value. The numbers in brackets indicate parameter ranges.

In `+KEEP,WWJETS.` two variables, which define the natural jet clustering algorithm, can be set. The first one is called CLNJ and can assume the same values as CLU2 or CLU4 (see table) except PUYC, while the second one is DCNJ, which defines the corresponding maximum distance d_{join} (or y_{cut}), below which it is allowed to join two clusters into one.

The block `+KEEP,WWNTUP.` contains the ntuple variable's declarations, and the logical words needed to build the ntuple itself. These logical words are listed in table 2, together with their meaning and their default values.

Input cuts	Variable(s)	Range	Default
Polar angle of the jets ($4q$)	THMINJET,THMAXJET	(0,180)	(5,175)
Min. momentum of jets ($4q$)	MOMINJET	>0	2
Minimum and maximum multiplicity per event ($4q$, $qql\nu$, $qql\nu$, $l\nu l\nu$)	MINMUL4Q,MINMUL2Q, MAXMUL2Q,MAXMUL2L	>0	20,10, 80,20
Polar angle of the electrons ($qql\nu$)	THELMIN,THELMAX	(0,180)	(5,175)
Polar angle of the muons ($qql\nu$)	THMUMIN,THMUMAX	(0,180)	(5,175)
Polar angle of the tracks ($l\nu l\nu$)	THLLMIN,THLLMAX	(0,180)	(5,175)
Minimum momentum of leptons ($qql\nu$)	PMUCUT,PELCUT	>0	10,10
Minimum momentum of tracks ($l\nu l\nu$)	PLLCUT	>0	10
Maximum energy in a cone around a lepton... ($qql\nu$)	ENCOMU,ENCOEL	≥ 0	5
...with following opening angle (lepton id. and $qql\nu$, $l\nu l\nu$)	ANGCONE	>0	10
Min. lepton angle from nearest charged track... ($qql\nu$)	ANELMIN,ANMUMIN	≥ 0	0
...with at least this momentum	PMINANG	≥ 0	0.5
Min. angle between jet and lepton ($qql\nu$)	THLEJEMIN	≥ 0	5
Minimum acollinearity between two selected tracks ($l\nu l\nu$)	THACOLL	≥ 0	10
Exponent for momentum weighted jet charge	CAPPA	any	0.5
Number of constraints in kinematic fit ($4q$, $qql\nu$) $4 \rightarrow P_\mu$ conservation $5 \rightarrow P_\mu$ and equal masses $6 \rightarrow P_\mu$ and masses = Mw $7 \rightarrow P_\mu$ and one mass = Mw	NCON4Q,NCON2Q	[4,7]	5
Lepton selection criteria (lepton id.) (very loose, loose, standard, tight)	MUMODE, ELMODE	'V','L', 'S','T'	'L'
Clustering algorithm to force 2 or 4 jets PUJ4 $\rightarrow$ PUJET4 [2]: only for 4 jets PUYC $\rightarrow$ PUYCLU [6] LUCL $\rightarrow$ iterative PUCLUS with standard LUND d_{ij} [6] LUNR $\rightarrow$ same as LUCL, but particles are not reassigned to jets [6] MINV $\rightarrow$ PUCLUS with invariant mass cluster, no particle reassignment [6] JADE $\rightarrow$ PUCLUS with JADE d_{ij} [7] DURH $\rightarrow$ DURHAM algorithm [5]	CLU4, CLU2	'PUJ4', 'PUYC', 'LUCL', 'LUNR', 'MINV', 'JADE', 'DURH'	'PUJ4', 'PUYC'

Table 1: The user defined cuts in `+KEEP,WWCUTS`.

Logical word	Action	Default
MONTECARLO	to include/exclude MCINFO BLOCK	.TRUE.
QQANALYSIS	to include/exclude QQANA BLOCK	.TRUE.
OTHERCOMB	to include/exclude QQOTHER BLOCK	.FALSE.
QLANALYSIS	to include/exclude QLANA BLOCK	.TRUE.
FLANALYSIS	to include/exclude FLANA BLOCK	.TRUE.
ALLLEPTONS	to include/exclude LEPTON BLOCK	.FALSE.
ALLJETS	to include/exclude JETANA BLOCK	.FALSE.
BIGNEUTRALS	to include/exclude NEUT BLOCK	.FALSE.

Table 2: The user defined cuts in `+KEEP,WWNTUP`.

Using these default values of the logical switches, the MCINFO, QQANA, QLANA and FLANA blocks will be filled, while the blocks QQOTHER, LEPTON, JETANA and NEUT will be excluded from the ntuple structure.

5 Outputs

A Column Wise Ntuple is used to store all the event information: this choice allows the use of a block structure for the ntuple. As described in the previous section users can decide which of the blocks they want to include in their ntuple. The user can thus build-up an ntuple to meet the individual needs of their analysis. The ntuple output file `ww.ntp` is generated automatically when running the program.

The optional blocks of the ntuple and their contents are described below. Only the TITLE block, the HEADER block and the EVENT block are always filled, while the other blocks can be excluded (or included) by changing the corresponding logical word in `wwcde.car`.

Please note that if one of the three analysis blocks (QQANA, QLANA, FLANA) is switched off the whole corresponding analysis will be skipped in the WWANA program flow (see the flow chart below).

The ntuple blocks are decribed below:

TITLE BLOCK
This contains a user defined 'nickname' for the ntuple. It can be used to store information about the ntuple production: e.g. MC generator, clusterization algorithm, etc...

HEADER BLOCK
General information about the run.

MCINFO BLOCK
Montecarlo information about the event.

EVENT BLOCK
General event quantities.

Histogram number	Content
210	Natural jets polar angle distribution
220	Selected muons polar angle distribution
221	Selected electrons polar angle distribution
2000	Generated W mass
2001	Generated energy of leptons from W
2002	Generated ISR polar angle

Table 3: WWANA output Histograms

QQANA BLOCK
Information about the four jet analysis. The jet combination with the best χ^2 after the constrained kinematic fit has been performed is retained.

QQOTHER BLOCK
Information on the other possible di-jet combinations after the kinematic fit.

QLANA BLOCK
Information for two jet, one lepton analysis.

FLANA BLOCK
Information for the fully leptonic channel analysis.

JETANA BLOCK
Information on the jets - clusterized according to the selected criteria.

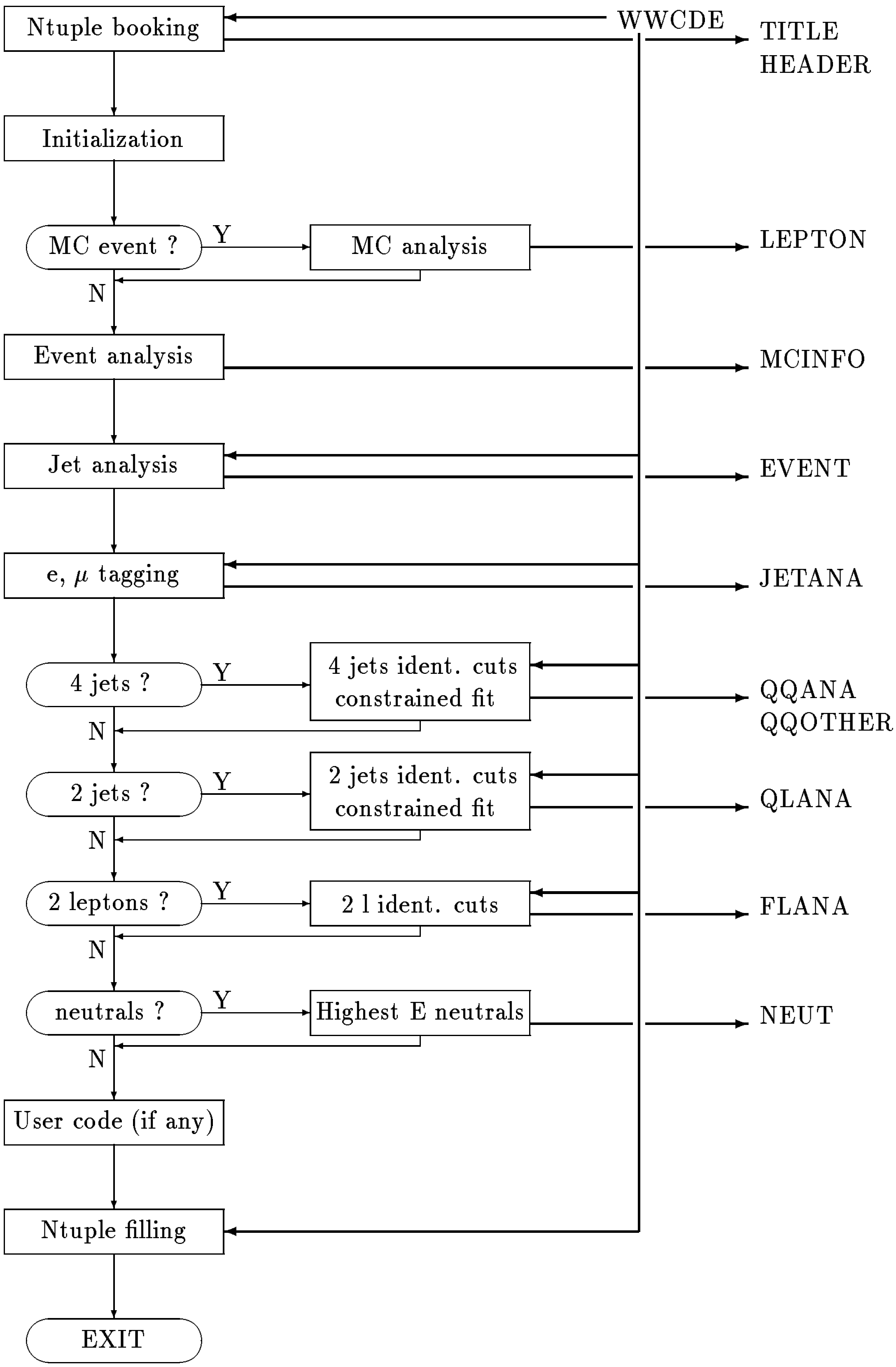
NEUT BLOCK
Information on highest energy neutral particles.

The detailed description of each block has been reported in Appendix A. Some additional, less important, information about the different analyses which has not been included in the ntuple (to save space) is kept in common blocks. The contents of the common blocks are given in Appendix B. If required these variables can easily be copied in the ntuple.

The HBOOK file created by WWANA also contains some histograms to give complementary information about track or jet quantities. There are three histogram concerning simulation and three concerning analysis: they are listed in table 3.

6 Structure of the program

A flow chart for WWANA is provided below. This section describes the function of each of the stages illustrated in the diagram.


Ntuple booking
WWCDE
TITLE
HEADER
Initialization
MC event ?
Y
MC analysis
LEPTON
N
Event analysis
MCINFO
Jet analysis
EVENT
e, μ tagging
JETANA
4 jets ?
Y
4 jets ident. cuts
constrained fit
QQANA
QQOTHER
N
2 jets ?
Y
2 jets ident. cuts
constrained fit
QLANA
N
2 leptons ?
Y
2 l ident. cuts
FLANA
N
neutrals ?
Y
Highest E neutrals
NEUT
N
User code (if any)
Ntuple filling
EXIT

Booking and intialization: (*compulsory step*)
The ntuple and the histogram are booked and their variable initialized. The structure of the CWN is determined by the logical words read in `+KEEP,WWNTUP`.

Simulation analysis: (*optional step*)
If the event is MC like, the simulation analysis routine may be called. The aim of the routine is mainly to classify the event topology using the bitted word IGEN (see section 6.1) and to store useful variables if the event is WW like. The quantities stored are the four-momenta of W's and of the four fermions coming from them, together with their LUND codes. One special word is reserved to identify the type of decay of τ's, whenever a τ is produced from a W. Truth information on ISR is provided: total ISR four-momentum, and the energy and the polar angle of the most energetic ISR photon are stored.

Event analysis: (*compulsory step*)
The charged, total and transverse visible energies are evaluated. The missing momentum is calculated and a call to SPRIME determines the value of the effective center of mass energy.

Jet analysis: (*compulsory step*)
First the thrust and sphericity values and directions are calculated. The jet clustering is performed using the option chosen in `+KEEP,WWJETS`. Some useful variables are calculated for each jet: the momentum-weighted charge ($Q_{jet} = \sum_{i \epsilon jet} Q_i \cdot |\vec{p}_i|^{CAPPA}$), the spread (defined as the average angle between the tracks belonging to the jet and the direction of the jet itself), the isolation angle from the nearest charged track not belonging to the jet, and the associated electromagnetic energy. This information and the four-momenta and multiplicities of the jets are stored in the PJT array for further analyses.

Lepton tagging: (*compulsory step*)
Using the SKELANA modules MUID and ELID, WWANA looks for particles identified as leptons according to selection criteria defined in `+KEEP,WWCUTS`. For these particles some extra analysis is conducted: to assess the isolation of the track the total energy inside a cone around the track is evaluated, and the isolation angle from the nearest charged track is computed. The opening angle of the cone and the minimum energy required by the closest track are specified by the user in `wwcde.car`. The p_t^{in} and p_t^{out} of the track with respect to the jet they belong to is calculated: these quantites together with VECP information and SKELANA identification words are stored in the PLEPT matrix (see Appendix A for details).

Four jet event tagging: (*optional step*)
If the logical word QQANALYSIS is set to .TRUE. the four jet tagging subroutine is called. The event is required to fulfill the following cuts:

- Multiplicity $\geq$ MINMUL4Q
- At least four natural jets with
  - multiplicity $\geq$ MOMINJET

– polar angle THMINJET $< \theta_{jet} <$ THMAXJET

the event is then forced to be a four jet event, and a kinematical constrained fit is performed using NCON4Q constraints. In the four jet block the four-momenta of the four forced jets before and after the fit, their multiplicities and jet charges, the minimum angle between two jets, the fitted W mass and W polar angle, and the final χ^2 of the fit are stored. If 5 or more constraints are imposed in the fit then the variables for the fit using the di-jet combination which minimizes the χ^2 are kept in the QQANA block, while the other are stored in QQOTHER block (see Appendix A).

Two jet one lepton event tagging: (*optional step*)
If the logical word QLANALYSIS is set to .TRUE. the two hadronic jets tagging subroutine is called. The event is required to fulfill the following set of cuts:

- MINMUL2Q $\leq$ Multiplicity $\leq$ MAXMUL2Q
- At least one candidate electron with:
  - P $\geq$ PELCUT
  - $E_{cone} \leq$ ENCOEL
  - $\theta_{iso} \geq$ ANELMIN
  - THELMIN $\leq \theta_e \leq$ THELMAX
- .OR. at least one candidate muon with:
  - P $\geq$ PMUCUT
  - $E_{cone} \leq$ ENCOMU
  - $\theta_{iso} \geq$ ANMUMIN
  - THMUMIN $\leq \theta_\mu \leq$ THMUMAX

Note that if a track has been identified both as an electron and as a muon it is considered as a muon candidate. If more than one candidate lepton pass these cuts WWANA chooses the most energetic one and forces the event (excluding the selected lepton) to two jets. The kinematical constrained fit using NCON2Q constraints is then performed. The four-momenta of the two forced jets, the information about the chosen lepton, and results from the fit (including the fitted formomenta) are stored in the QLANA block.

Two lepton event tagging: (*optional step*)
If the logical word FLANALYSIS is set to .TRUE. the two leptons tagging subroutine is called. The event is required to fulfill the following set of cuts:

- Multiplicity $\leq$ MAXMUL2L
- At least two charged tracks with:
  - P $\geq$ PLLCUT
  - THLLMIN $\leq \theta_{track} \leq$ THLLMAX
- Acoll. of two highest E tracks $\geq$ THACOLL

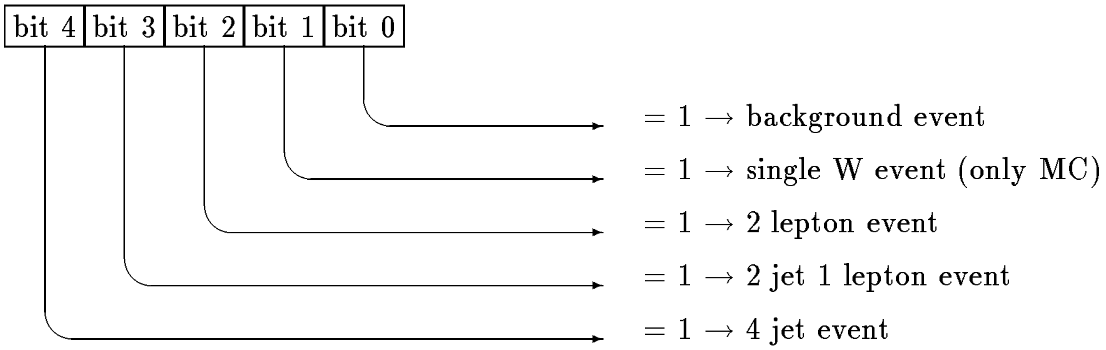


Figure 2: The structure of the bitted words IGEN and IDET.

The event is then forced to two jets. No kinematical fit can be performed in this case, because of the missing constraints due to the presence of the two neutrinos coming from the W's. The four-momenta and multiplicities of the jets are stored in the FLANA block. Information on up to four charged tracks in the event which pass the cuts are retained: This is stored in the FLPL array in the FLANA block. This array has the same structure as the PLEPT word used for lepton identification.

Leading neutrals: (*optional step*)
If the logical word BIGNEUTRALS is set to .TRUE. the subroutine to fill the NEUT block is called. The routine finds the highest energy neutral deposits in electromagnetic calorimeters HPC, EMF and STIC. The total energy, the angles and the error on the energy (from TRAC module) of the three most energetic showers in the event are stored. The identity of the calorimeter the shower comes from is also recorded.

User additions: (*optional step*)
At this point in the program a call to subroutine WWUSER is foreseen. By default only a dummy routine is present, but it can be used to perform some pre-analysis using the WWANA common. Note that even if the blocks of jets and leptons are excluded from the ntuple, the corresponding common blocks are still filled, and hence may be used in the analysis.

6.1 Tagging the events

To tag the WW event topology the three different tagging routines described above make use of bitted words; this information to be retained on multiply tagged events.

Two bitted words are avilable: IGEN is the simulation tagging word, while IDET is the one produced by the analysis routines.

The stucture of the bitted word is explained in figure 2.

For example, if IDET has the value of $2^4+2^3=24$, then the event has been tagged by WWANA both in the fully hadronic and the semileptonic channels. Naturally such ambiguities can not occur in the IGEN simulation word.

7 Conclusions

WWANA is a reliable studied package which will be a useful tool for all the analyses concerned with W production throughout the LEP 200 program. The WWANA output format is flexible and easily modifiable by the user. The user also has control of the cuts applied inside the program and may attach additional code in a transparent way.

The extensive use of the WWANA program throughout the collaboration facilitates easier comparison of the results from analyses, and exchange of information among people who are interested in similar physics topics.

WWANA has now reached a stable version, but there is always room for improvements. Comments and suggestions to the authors are encouraged, to help us meet the needs of future users.

8 Acknowledgements

We are very grateful to G.Wilkinson for testing the first (bugged !) versions of WWANA, providing us with valuable feedback, and for his assistance in making WWANA a public tool.

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9 Appendix A: Ntuple contents

HEADER BLOCK

Run number	NRUN	event, general
Event number	NEVT	event, general
Bunch number	NBUN	event, general
Fill number	NFIL	event, general
Center of mass energy	ECOM	event, general

MCINFO BLOCK

W-, W+ (resp.) mass	GWMAS(2)	MC
W-, W+ (resp.) polar angle	GWTHE(2)	MC
W-, W+ (resp.) abs. value of momentum	GWMOM(2)	MC
Four-momentum of fermion from W-	GFEP1(4)	MC
Four-momentum of antifermion from W-	GFEP2(4)	MC
Four-momentum of antifermion from W+	GFEP3(4)	MC
Four-momentum of fermion from W+	GFEP4(4)	MC
Lund codes of the four fermions from W	GFECO(4)	MC
VECP indices of the leptons from W	GLPAI(2)	MC
Type of decay of tau from W 11 $\rightarrow$ leptonic decay with electron (sign according to LUND) 13 $\rightarrow$ leptonic decay with muon (sign according to LUND) 1 $\rightarrow$ any hadronic decay	GTAUDEC(2)	MC
ISR four-momentum	GEISR	MC
Energy of the hardest ISR photon	GEMAXISR	MC
Polar angle of the hardest ISR photon	GTHEISR	MC
Bitted word for the event tagging	IGEN	MC

EVENT BLOCK

Total multiplicity	NTMUL	event, general
Charged multiplicity	NCMUL	event, general
Number of natural jets	NJETS	PUCLUS
Number of tagged electrons	NELE	WWANA
Number of tagged muons	NMUO	WWANA
Total visible energy	EVIS	WWANA
Transverse energy	ETRANS	WWANA
Total charged energy	ECHARG	WWANA
Vector missing momentum	PMISS(1:3)	WWANA
Absolute value of PMIS	PMISS(4)	WWANA
Thrust value	THRUST	VECSUB
Thrust axis polar angle	THETHR	VECSUB
Sphericity	SPHER	VECSUB
Acoplanarity	APLA	VECSUB
S'	SPRM	SPRIME
Highest energy cluster in STIC	ESTC	SPRIME
SPRIME quality flag	IFQSPR	SPRIME
Bitted word for the event tagging	IDET	WWANA

QQANA BLOCK

Four-momentum of forced jet 1	QQP1(1:4)	WWANA
Four-momentum of forced jet 2	QQP2(1:4)	WWANA
Four-momentum of forced jet 3	QQP3(1:4)	WWANA
Four-momentum of forced jet 4	QQP4(1:4)	WWANA
Total multiplicities of jets	QQTM(1:4)	WWANA
Charged multiplicities of jets	QQCM(1:4)	WWANA
Momentum weighted charges of 4 jets	QQCH(1:4)	WWANA
Energy of the lowest energy jet	QQEMIN	WWANA
Minimum angle between two jets	QQANJJ	WWANA
Fitted four-momentum of jet 1	QQOB1(1:4)	PUFITC
Fitted four-momentum of jet 2	QQOB2(1:4)	PUFITC
Fitted four-momentum of jet 3	QQOB3(1:4)	PUFITC
Fitted four-momentum of jet 4	QQOB4(1:4)	PUFITC
Fitted W masses	QQWM(1:2)	PUFITC
Fitted W- polar angle	QQWTH	WWANA
Chi square of the 4 jets fit	QQCHI	PUFITC
Number of degrees of freedom in the fit	QQDOF	PUFITC
Chosen dijet combination	ICOMB	PUFITC

(NOTE: The information from the fit on the W- , selected using the jet charge, is stored first)

QQOTHER BLOCK

Number of di-jet combinations with the chosen n of constraints	NCOMB	WWANA
Fitted four-momentum of 'object' 1	QQOB1(1:4,1:NCOMB)	PUFITC
Fitted four-momentum of 'object' 2	QQOB2(1:4,1:NCOMB)	PUFITC
Fitted four-momentum of 'object' 3	QQOB3(1:4,1:NCOMB)	PUFITC
Fitted four-momentum of 'object' 4	QQOB4(1:4,1:NCOMB)	PUFITC
Fitted W masses	QOWM(1:2,1:NCOMB)	PUFITC
Fitted W polar angle	QOWTH(1:NCOMB)	WWANA
Chi square from constrained fit	QOCHI(1:NCOMB)	PUFITC

QLANA BLOCK

Information on chosen lepton (as PLEPT,see below)	QLPL(1:18)	WWANA
Four-momentum of forced jet 1	QLP1(1:4)	WWANA
Four-momentum of forced jet 2	QLP2(1:4)	WWANA
Total multiplicities of jets	QLTM(1:2)	WWANA
Charged multiplicities of jets	QLCM(1:2)	WWANA
Momentum weighted charges of 2 jets	QLCH(1:2)	WWANA
Codes of the four fitted 'objects'	QLCOD(4)	WWANA
1 $\rightarrow$ jet		
3 $\rightarrow$ neutrino		
11 $\rightarrow$ electron (sign according to LUND)		
13 $\rightarrow$ muon (sign according to LUND)		
Fitted four-momentum of 'object' 1	QLOB1(1:4)	PUFITC
Fitted four-momentum of 'object' 2	QLOB2(1:4)	PUFITC
Fitted four-momentum of 'object' 3	QLOB3(1:4)	PUFITC
Fitted four-momentum of 'object' 4	QLOB4(1:4)	PUFITC
Fitted hadronic W mass	QLWMH	PUFITC
Fitted leptonic W mass	QLWML	PUFITC
Fitted W polar angle	QLWTH	WWANA
Chi square of the 2 jet fit	QLCHI	PUFITC
Number of degrees of freedom in the fit	QLDOF	PUFITC
Angle lepton-jet	QLANLJ	WWANA
Angle between the two jets	QLANJJ	WWANA

(NOTE: The information from the fit on the W- , selected using the lepton charge, is stored first)

FLANA BLOCK

Information on the four most energetic tracks in the event	FLPL(1:16,1:4)	WWANA
P cartesian components	FLPL(1:3,i)	
energy	FLPL(4,i)	
simulated mass code	FLPL(5,i)	
index in VECP array	FLPL(6,i)	
mass code of the simulated PA	FLPL(7,i)	
charge	FLPL(8,i)	
electron 'bitted word'	FLPL(9,i)	
muon 'bitted word'	FLPL(10,i)	
gamma conversion	FLPL(11,i)	
energy in cone	FLPL(12,i)	
angle from nearest charged track	FLPL(13,i)	
impact parameter wrt primary vtx	FLPL(14,i)	
jet number	FLPL(15,i)	
electron best est. energy	FLPL(16,i)	
Accoll. of two highest p tracks	FLANLL	WWANA
Four momentum of forced jet 1	FL2P1(1:4)	WWANA
Four momentum of forced jet 2	FL2P2(1:4)	WWANA
Charged multiplicity of jet 1,2	FLLCM(1:2)	WWANA
Total multiplicity of jet 1,2	FLLTM(1:2)	WWANA

LEPTON BLOCK

Number of leptons selected	NLEPT	WWANA
Track info of the selected leptons:	PLEPT(1:17,1:MAXLEP)	WWANA
abs.value of momentum	PLEPT(1,i)	
theta of momentum	PLEPT(2,i)	
phi of momentum	PLEPT(3,i)	
tag flag (ELTAG+10*MUTAG, each tag being 0 or 1)	PLEPT(4,i)	
simulated LUND mass code (if link exists)	PLEPT(5,i)	
VECP index	PLEPT(6,i)	
mass code of simulated PA	PLEPT(7,i)	
charge	PLEPT(8,i)	
electron 'bitted word' (KELID(1,i))	PLEPT(9,i)	
muon 'bitted word' (KMUID(1,i))	PLEPT(10,i)	
gamma conversion (KELID(2,i))	PLEPT(11,i)	
energy in a cone	PLEPT(12,i)	
angle from nearest charged track with a given min. energy	PLEPT(13,i)	
impact parameter wrt primary vtx	PLEPT(14,i)	
number of the jet the lepton belongs to	PLEPT(15,i)	
ptin wrt 'natural' jets	PLEPT(16,i)	
ptout wrt 'natural' jets	PLEPT(17,i)	
best estimate for electron energy at vertex	PLEPT(18,i)	

JETANA BLOCK

Number of 'natural' jets	NJT	WWANA
Four-momenta of the jets	PJT(1:4,1:NJT)	WWANA
Total Multiplicities of jets	PJT(5,1:NJT)	WWANA
Charged multiplicities of jets	PJT(6,I:NJT)	WWANA
Jet charge of the jet	PJT(7,1:NJT)	WWANA
Spread of the jet	PJT(8,1:NJT)	WWANA
Angle from the nearest charged track not belonging to the jet	PJT(9,1:NJT)	WWANA

NEUT BLOCK

Total energy of shower	ENEUT(1,1:3)	WWANA
Theta of most energetic shower	ENEUT(2,1:3)	WWANA
Phi of most energetic shower	ENEUT(3,1:3)	WWANA
Error on energy (from TRAC module)	ENEUT(4,1:3)	WWANA
Particle identification code (not for STIC)	NNEUT(1,1:3)	WWANA
Bitted word for detector	NNEUT(2,1:3)	WWANA

10 Appendix B: Other variables only in common

As mentioned in the text, more variables are computed by the program but not included in the ntuple. They are however available in common blocks. Here we report them and the `+KEEP` block where they can be found:

Quantity(ies)	Variable(s)	`+KEEP` block	source
Thrust direction	THRVER(1:3)	WWJETS	PUCLUS
Sphericity direction	SPHVER(1:3)	WWJETS	PUCLUS
No. of natural jet to which each track belongs (order of VECP)	IASJET(1:300)	WWJETS	
Center of mass energy from the triangle rule	E3ANG	WWEVIN	SPRIME
Boost vector from the lab frame to the effective c.o.m.	SBOOST(1:4)	WWEVIN	SPRIME
STIC quality flag	IQSTIC	WWEVIN	SPRIME
SPRIME flag for candidate Z	IZ0RAD	WWEVIN	SPRIME
All the four-momenta of the ISR photons	VECISR(1:4,1:20)	WWMCIN	MC
No. of tracks selected by LVLOCK	NLOCK	WWEVIN	
No. of charged tracks selected	NCLOCK	WWEVIN	
Indexes (original VECP format) of tracks selected by LVLOCK	ILOCK	WWEVIN	
Error matrix BVB from PUFITC for 4 jet fit	QQERMAT	WWFITC	PUFITC
Error matrix for 2 jet one lepton	QLERMAT	WWFITC	PUFITC

11 Appendix C: Plots

The following plots are intended to show some performances of different parts of the WWANA package. They are obtained on simulated LEP2 data samples, which have been processed through the full DELPHI simulation and analysis chain.

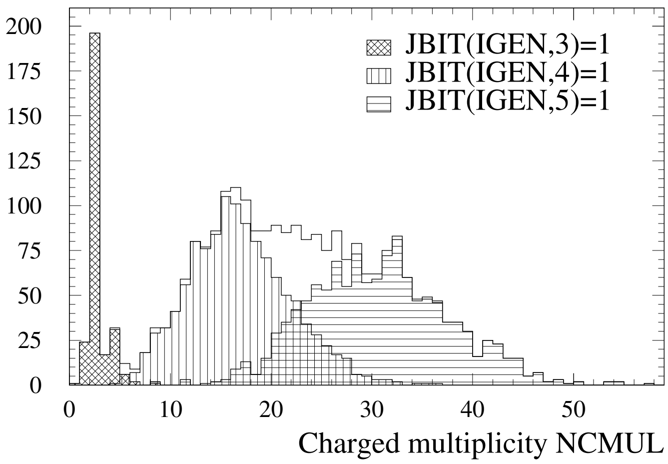

Figure 3: Charged multiplicity of the WW events at the center of mass energy of 161 GeV in the different decay channels. The meaning of the bitted word IGEN is explained in section 6.1

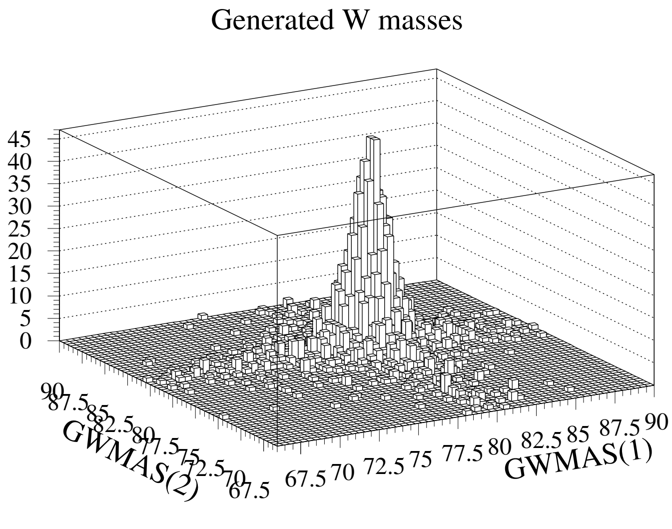

Figure 4: Masses of the two W boson in the simulation truth at the center of mass energy of 175 GeV.

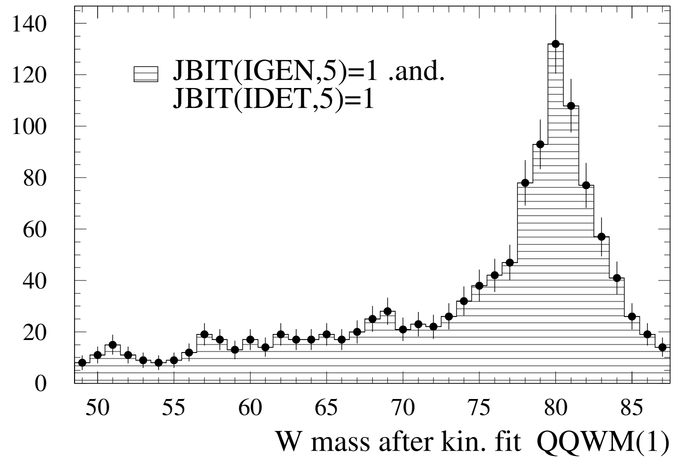

Figure 5: Invariant mass of the two reconstructed jet pairs applying the standard WWANA cuts and using the PUFITC 5-constraint fit.

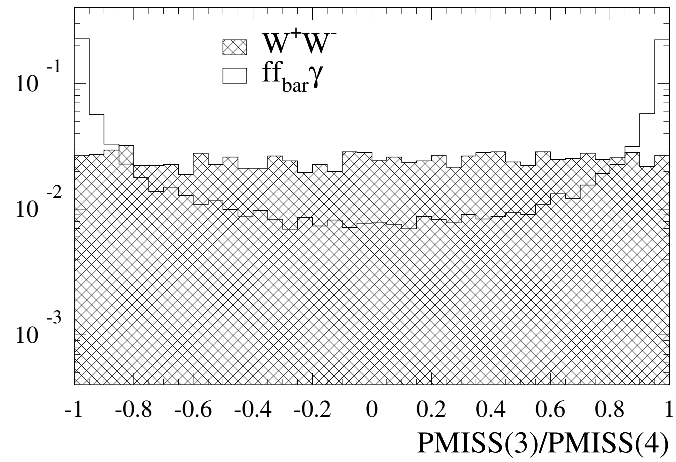

Figure 6: Cosine of the polar angle of the missing momentum for WW events and for radiative fermion pair production. In the latter type of events, which represent the main background for W physics, the missing momentum is generally due to an energetic ISR photon lost in the beam pipe. Both distributions are normalized to 1.