The new YTOP package for Aleph

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1 Introduction

The software package described in this note was originally written for the NA32 experiment and then adapted and extended for ALEPH by G.Lutz . The new YTOP package allows to fit vertices starting not only from charged track, but also from neutral tracks or other vertices . The package allows to find aswell, given a set of tracks charged or neutral, a list of vertices and the corresponding tracks forming them. The method and formalism used in the package is described in a note "Topological Vertex Search in Collider Experiments" by G.Lutz. The package is made of building blocks. Applications of the package, as the reconstruction of the primary vertex or of V0's or gamma conversions have been implemented in the new package and can be called as options. The package is installed in ALEPHLIB. It can be called from JULIA by calling the process YTOP or from ALPHA .The various tasks performed are controlled by parameters given via the YOPT card. The first chapter describes the various subroutines of the package, the second the steering routine YTOPOL and the tasks it can perform, the third gives a list of the options and the fourth gives a template ALPHA job for user specific utilisation with an example of how to feed input parameters to the various routines

2 Topology package : the basic routines

The package has been written in a modular way, so as to allow easy adaptation to the particular task the user wants to perform. The subroutines that are the building blocks of the package are listed below with a short description of the task they perform. Input and output parameters are described in the subroutine's header. The template ALPHA job, given in the last chapter, showing an example of calls to those routines may help further the understanding of the meaning of the parameters.

- YFMVTR : The more general fitting routine that fits a new common vertex to a set of charged tracks, neutral tracks aswell as vertices. Charged tracks are standard ALEPH helices as found in the FRFT bank. Neutral tracks are reconstructed V0's, gamma's or other neutral particles. Their parameters are similar to the charged tracks except for the inverse radius of curvature that is replaced by the absolute value of the momentum and the corresponding change in the error matrix . (see in the addendum the bank YNFT for a description). Vertices could be the beam centroid or any previously reconstructed vertex formed by a subset of tracks. The routine provides the fitted vertex and its errors, refitted charged and neutral track parameters and their error matrix. It provides aswell the invariant mass and error of the mother particle together with the reconstructed momentum sum . Correlation between vertex position and momentum sum, between mass and momentum sum and between mass and vertex are also provided. The number of parameters to fit in this routine is 3 for the common vertex and 3 for each charged or neutral track. This may be rather time consuming and one is not always interested in all this refitted

parameters. An alternative fast method to find the vertex only has been developped which is the task of the routine described next.

- YFTVTR : this routine fits only a new common vertex to a set of charged tracks, neutral tracks and vertices. The routine finds the point whose weighted distance to tracks and vertices is minimum. The weighting is done in such a way that it gives identical results as the elaborate procedure of the preceeding routine but is faster.
- YTPAR : this routine is in fact a complement to the full vertex fitting routine YFMVTR. Provided the decay vertex , the reconstructed momentum sum of a mother particle together with the respective error matrices and error correlation (quantities computed by YFMVTR) it calculates the track parameters and error matrix of the mother particle , either standard charged helix parameters or neutral "helix" format. Those tracks can in turn be used as input to further vertices allowing to compute easily cascade decays.
- YVPOSS : this routine finds all possible combinations in a set of tracks which give a vertex. Many conditions on the vertices may be requested as e.g.: minimum multiplicity, inclusion of specific tracks or a number of tracks out of a subset, or exclusion of a number of specific track combinations.

3 The steering routine YTOPOL

The steering of the program is done by the YTOPOL routine. The following tasks are done in sequence for every event. The calls to the various tasks are controlled by logical flags set via the YOPT card.

1. The routine YTSTRK calculates the momentum (PRECTO) and the transverse momentum of each track (PTRECT) saved in the comdeck YTRKTO. t initializes the set of tracks considered for vertex search: it rejects tracks with a non-zero error flag, with non-positive definite error matrix, with momentum below 0.5 GeV (default value of parameter PMINS in common YPARTO), with momentum above 200 GeV, or with too large error on the curvature.
2. The routine YPIDAS assigns particle identification probabilities using the bank FRID. The result is stored in the marker KPIDF0 in the comdeck YTRKTO.
3. The routine YTCONV looks for γ conversion within charged tracks identified as electrons. The track origin is saved in the marker KPORF0 in the comdeck YTRKTO. Reconstructed γ tracks and vertices are saved in the banks YNFT and PYER (vertex type 4).
4. The routine YTRV0S looks for V0 candidates. The result is stored in the marker KPIDF0 in the comdeck YTRKTO. Reconstructed γ tracks and vertices are saved in the banks YNFT and PYER (vertex type 2).
5. The routine YTPVTX controls the primary vertex reconstruction.
   (a) It selects the set of tracks to be used for the first step of the primary vertex search , in addition to the selection done by YTSTRK:
      - Tracks with a momemtum above the minimum required (PMINQR in common YPARTO) are selected. This requirement rejects tracks with poor precision or spiralling tracks split up in several pieces . A cut at 1 GeV removes most of the problematic cases. This is the default value of the parameter PMINQR or can be read in from the bank YTPA .

- Well measured tracks, i.e. tracks with Mini-Vertex coordinates are selected for the first step of the primary vertex search in case the option 'VHIT' is selected.
- Remove tracks identified as leptons. This option is selected by the card YOPT 'RLEP'.
- Remove V0 decay tracks but add the reconstructed neutral track to the input list for the primary vertex search. This option is selected by the card YOPT 'RV0S'.
- Remove tracks from γ conversion but add the reconstructed neutral track to the input list for the primary vertex search. This option is selected by the card YOPT 'RCON'.

By default , none of those options are selected.

(b) The routine YPRIVX searches for a primary vertex within the selected set of tracks:

- Tracks very far away from the interaction point in R or Z are rejected.
- The routine YVPOSS is then called that searches for all combinations of tracks that form a vertex. The best candidate is selected : maximum multiplicity and minimum χ^2. A minimum of 3 tracks is required.
- If the option 'BCRO' is selected, the vertex is fitted including the beam crossing profile constraint.
- In case of events with only 2 charged tracks, the special procedure implemented by S.Wasserbach is used that fits the two tracks with the beam profile where the constraint in Z is removed by giving the profile a large error on that coordinate. This allows to extract primary vertex information from dilepton events

(c) Lower momentum tracks (above PMINQA) compatible with the vertex are added to it with the routine YVXBLD

(d) The bank PYER is filled and the primary vertex saved with vertex type 1. The bank PYFR is filled and contains the list of tracks used in the primary vertex.

6. The routine YTOSVT controls the search for secondary decay vertices. This option is still dummy in the new version.

7. The routine YRUSER is called where the user may put its own particular task.

Debug printout and control histograms are available. The code for the printout is controlled by the historian flag YDEBUG . Historian must be run, with the YDEBUG flag selected, on the routine where you want to get the printout . The level of printout and the number of times where the debug printout will be provided is controlled by the array IDUMPP in the common block YDUMTO.

4 The various options of the package

The various options of the package are selected via the data card YOPT either from ALPHA or JULIA. Here follows a list of the various options :

- YNEW : this option selects the new version of the YTOP package, By default the old version is selected

- FRF2 : in the new version of the package you may select the VDET refitted track bank FRFT nr 2 by using this card. By default FRFT bank nr 0 is used. The old version uses FRFT nr 0.
- PVTX : this option calls the reconstruction of the primary vertex YTPVTX The result is saved in the bank PYER and PYFR. In the old version this option used to be called by default. In the new version one has to call it explicitely.
- BCRO : if this option is selected the array BCROSS in the comdeck YBCRTO that contains the beam profile is being filled for each run by the routine YTOIRU and is used as a constraint in the primary vertex reconstruction. If the user wants to use the array BCROSS , he should not forget to call the option BCRO even if does not want to reconstruct the primary vertex. For real data, BCROSS is filled by calling the routine GETLEP . The beam centroid position is taken directly from GETLEP while the profile (variances in X,Y,Z) is taken as the precison on the centroid times the square root of the number of events (-1) that were used to define the centroid . This gives the uncertainty on the width of the beam profile. As better information will come in the future for example from the BOM's the procedure described here will have to be updated. For Monte Carlo data, the beam profile is taken from the bank KHVF. If no information is found ,some default values are set and a warning message is printed.
- RCON : this option calls the routine that reconstructs gamma conversions YTCONV . The routine was dummy in the old version but is implemented in the new version . See preceeding chapter for a short description
- RV0S : this option calls the routine that reconstructs K0's and Λ0's YTRV0S . The routine was dummy in the old version but is implemented in the new version . See preceeding chapter for a short description
- RLEP : this option removes leptons , as flagged by the routine YPIDAS, from the list of tracks to be considered for the primary vertex search.
- VHIT : with this option selected the primary vertex search is done only with tracks that have VDET hits
- SVTX : this option calls the general search for secondary vertices. This routine is under development and has not been implemented yet.
- USER : this option calls the user routine YRUSER

5 Template ALPHA job

Most users will call the YTOP package from ALPHA. To initialize the package , the routine YTIJOB has to be called in the user JOB initialization routine QUINIT and the routine YTOIRU in the user RUN initialization routine QUNEWR (see an example in the following template job). If you want to use any of the tasks provide by YTOP like reconstructing the primary vertex for example, you have to call the steering routine YTOPOL . You can call it from the user event routine QUEVNT (as shown in the following example). In case you may write out many new banks like when reconstructing gammas ,V0's and the primary vertex and there could be a garbage collection it would be better to call YTOPOL before ALPHA does its unpacking and fills all its pointers since ALPHA does not tolerate garbage collection. If you want to use only some of the YTOP fitting routines, you may call them directly from QUEVNT but you need still the

initialization. The example that follows should help the user to understand how to fill the input parameters of the most important fitting routines. C

```
C-------------------------------------------------
C
C YTOPSKEL is a program to allow the use of the YTOP package
C from ALPHA.
C
C


C.....
      SUBROUTINE QUEVNT (QT,KT,QV,KV)
C
C-------------------------------------------------
C process one event
C-------------------------------------------------
C
      INCLUDE 'QCDE INC *'
C
      DIMENSION QT(KCQVEC,1), KT(KCQVEC,1), QV(KCQVRT,1), KV(KCQVEC,1)
C
C
C- Call the YTOPOL steering routine in case you want to
C- perform any of the tasks provided there
C- the options are controlled via the YOPT card
      CALL YTOPOL
C
C .......
C
C-------------------------------------------------
      SUBROUTINE YRUSER
C-------------------------------------------------
C You may put your specific applications in the routine
C YRUSER that is called automatically by YTOPOL
C with the USER option
C N.B. histogram booking may be done in the routine
C YHUSER
C
C or you may work directly in the QUEVNT routine
C
C-------------------------------------------------
C
      INCLUDE 'QCDE INC *'
C
CD YBCRTO YTOP / SYST
      COMMON/YBCRTO/BCROSS(3),VBCROS(6)
IF DOC
C BCROSS ..... current beam crossing position
C VBCROS ..... triangular covariance matrix
C stored in the order 1 2 4
C 3 5
```

```
C 6
C the correlation terms are set to 0.
C
      INTEGER IDUM
      REAL DUM
      INTEGER ITLIST(2)
C
      REAL VXOUT(3),VVXOUT(6),CHIVTX
C
      REAL AMASS,DMASS
      REAL VXOUTM(3),VVXOUM(6),HXOU(5,2),VHXOU(15,2)
      REAL PSUM(3),VPSUM(5),VPSVX(3,3)
      REAL VMVX(3),VMPS(3),CHIVTM
      REAL AMPC(2)
C
      LOGICAL LDMP
C
      DATA LDMP/.TRUE./
      INCLUDE 'QMACRO INC *'
C
C-------------------------------------------------
C
      LOUT = IW(6)
C
C- Get the track bank adresses
C- The subroutine YDEFRF provides the pointer to
C- the FRFT bank. In case the YOPT option FRF2 is selected
C- KFRFT gives then the pointer to FRFT bank nr 2
C- otherwize to bank nr 0. In the latter case KFRFT would
C- then be equal to KFRFT0 that gives always the pointer
C- to FRFT nr 0
      CALL YDEFRF(KFRFT0,KFRFT,KFRTL,IFAIL)
      IF(IFAIL.GT.0) THEN
      IF(LDMP)WRITE(LOUT,*)' No track banks found '
      RETURN
      ENDIF

C-------------------------------------------------
      User selection of the set of tracks he would like to vertex
      For example a D0 decay to Kaon and a Pion
      IAKAON ... ALPHA track selected as Kaon candidate
      IAPION ... ALPHA track selected as Pion candidate
C- those indices corresponding to ALPHA track numbers
C
C-------------------------------------------------
C- Initialize ITLIST, the list of track which will
C- be given to the fitting routine (convert to FRFT
C- numbering)
      ITLIST(1) = KTN(IAKAON)
      ITLIST(2) = KTN(IAPION)
C
```

```
C- Call the fast vertex fitting routine to see if the
C- two selected tracks form a vertex
      CALL YFTVTR(0,2,0,.TRUE.,DUM,DUM,
     + ITLIST(1),LCOLS(KFRFT),LCOLS(KFRFT),
     + RW(KFRFT+LMHLEN+JFRFIR),RW(KFRFT+LMHLEN+JFRFEM),
     + IDUM,IDUM,IDUM,DUM,DUM,
     + VXOUT,VVXOUT,CHIVTX,IFAIL)
      IF(IFAIL.NE.0) THEN
      IF(LDMP)WRITE(LOUT,*)' YFTVTR FAILED :',IFAIL
      RETURN
      ENDIF
C
C- One may cut here on the vertex chisq before going on
C- to a more detailed analysis
      IF(CHIVTX.GT. chisq cut ) stop ....
C
C-------------------------------------------
C- go on to perform the constraint fit to get the mass
C- and the reconstructed mother track
C- first initialize particle identification i.e. give
C- the particle masses
C- they can be taken from the comdeck YPAFMA that
C- contains the common block YPMASS
      AMPC(1) = YPMASS(JPAFKM) (Kaon mass)
      AMPC(2) = YPMASS(JPAFPP) (Pion mass)
C
C- calls the full vertex routine for two charged
C- tracks again. Give as input the vertex found
C- by YFTVTR, give as logical option not to recalculate
C- the starting value of the vertex since you are providing
C- the value, to calculate the momentum sum of the mother
C- track, the mass of the mother track and not to refit
C- the vertex INPUT value since it is already good
C
      CALL YFMVTR(0,2,0,.FALSE.,.TRUE.,.TRUE.,.TRUE.,
     + VXOUT,VVXOUT,ITLIST,
     + LCOLS(KFRFT0),LCOLS(KFRFT0),
     + RW(KFRFT0+LMHLEN+JFRFIR),RW(KFRFT0+LMHLEN+JFRFEM),
     + IDUM,DUM,
     + IDUM,IDUM,DUM,DUM,
     + 1,AMPC,
     + VXOUTM,VVXOUM,
     + HXOU,VHXOU,DUM,DUM,
     + PSUM,VPSUM,VPSVX,
     + AMASS,DMASS,VMVX,VMPS,
     + CHIVTM,IFAIL)
      IF(IFAIL.NE.0) THEN
      IF(LDMP)WRITE(LOUT,*)' YFMVTR FAILED :',IFAIL
      ENDIF
C - The refitted track parameters are given in HXOU
C- The momentum sum of the mother track in PSUM
```

```
C- The mass is AMASS
C
C-------------------------------------------------
C- One may further calculate the parameter of the mother
C- track. For that one should call the routine YTPAR
C- that uses the calculated vertex , the momentum sum
C- their respective errors and correlation matrices
C- as outputed by the routine YFMVTR to produce
C- the five parameters helices and its error matrix
C
      CALL YTPAR(1,VXOUTM,VVXOUM,
     + PSUM,VPSUM,VPSVX,
     + TRACK,VTRACK)
      IF(IFAIL.NE.0) THEN
      IF(LDMP)WRITE(LOUT,*)' YTPAR FAILED :',IFAIL
      GOTO 2000
      ENDIF
      IF(LDMP) WRITE(LOUT,999)(TRACK(II),II=1,5),
     + (VTRACK(II),II=1,5)
999   FORMAT(' Reconstructed track parameters + errors'/,
     + 5F10.3/,15E6.3)
C- In this case it is a neutral track, i.e. the first
C- parameter will give the absolute momentum of the track.
C
C- One may further check, for example, if the reconstructed
C- D0 track points to the beam centroid or the reconstructed
C- primary vertex. In this example it is the beam centroid.
C
C- Call the fast vertex fitting routine for the reconstructed track
C- and the beam centroid
      CALL YFTVTR(1,1,0,.FALSE.,BCROSS,VBCROS,
     + IXNU,5,15,TRACK,VTRACK,
     + IDUM,IDUM,IDUM,
     + DUM,DUM,
     + VXOUTP,VVXOUP,CHIVTP,IFAIL)
      IF(IFAIL.NE.0) THEN
      IF(LDMP)WRITE(LOUT,*)' POINTING YFTVTR FAILED :',IFAIL
      RETURN
      ENDIF
C- Here you may make a test on the chi square to decide
C- if the tracks comes from that vertex or not
      IF(CHIVTP.GT. cut ) then .....
      RETURN
C-------------------------------------------------
      END
C
C-------------------------------------------------
      SUBROUTINE QUNEWR(IROLD, IRNEW)
C-------------------------------------------------
C perform run initialization (read Dbase constants)
C-------------------------------------------------
```

```
C
      INCLUDE 'QCDE INC *'
C
C- call the run by run intializtion of the YTOP package
      CALL YTOIRU(IRNEW,QMFLD)
C
      RETURN
C-------------------------------------------------------------------
      END
C
C-------------------------------------------------------------------
      SUBROUTINE QUINIT
C-------------------------------------------------------------------
C PERFORM JOB INITIALIZATION
C-------------------------------------------------------------------
C
      INCLUDE 'QCDE INC *'
C
C- call the job initializtion of the YTOP package
      CALL YTIJOB
C
      RETURN
C-------------------------------------------------------------------
      END
C
C-------------------------------------------------------------------
      SUBROUTINE QUTERM
C-------------------------------------------------------------------
C! user termination
C-------------------------------------------------------------------
C
C- gives the summary of the primary vertex reconstruction if performed
      CALL YTOSUM
C
      END
```

AL1$USER3:[BOSMAN.DDL]YTOP.ADD;9 of 6-AUG-1991 16:18

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Subschema: YtopJULPOTBanks

| YNFT | Reconstructed neutral mother tracks NR=0.

1		I	Number of words/track (=28)	
2		I	Number of tracks	
1	MO	F	MOmentum	[*,*]
			particle momentum	
2	TL	F	TanLambda	[*,*]
			tangent of dip angle	
3	P0	F	Phi0	[0.0,6.30]
			Phi at closest point of approach to line x=y=0	
4	D0	F	D0	[-180.,180.]
			Closest distance of approach to line x=y=0 in the x-y plane (impact parameter) (signed +ve if particle has a positive angular momemtum around the origin, -ve otherwise)	
5	Z0	F	Z0	[-220.,220.]
			Z-coordinate at D0	
6-20	EM	F	EcovarM	[*,*]
			Triangular covariance matrix stored in the order: 1 2 4 7 11 3 5 8 12 6 9 13 10 14 15	
21	C2	F	Chis2	[0.0,*]
			Chisquare of fit	
22	DF	I	numDegFree	[0,23]
			Number of degr. of freedom/ 3 for vertex + 2*3 per track	
23	CH	I	Charge	[-2,2]
			Particle charge	
24	ND	I	NumDaughter	[0,10]
			Number of daughter tracks	
25	PT	I	PointTrack	[0,*]
			Pointer to 1rst daughter track	
26	NM	I	NumMass	[0,*]
			Number of mass assignments	
27	PM	I	PointMass	[0,*]
			Pointer to 1rst mass	
28	PV	I	PointVertex	[0,*]
			Pointer to the vertex bank	

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Subschema: YtopJULPOTBanks

+------+
| YNMA | Mass assignment of
+------+ rec.neutral tracks NR=0.

1		I	Number of words/mass (=4) assignment	
2		I	Number of mass assignments	
1	MT	I	MotherTrack	[0,*]
			Mother track number	
2	PA	I	PartAss	[0,*]
			Particle Assignment	
3	MA	F	MAss	[0.0,*]
			Mass (GeV)	
4	EM	F	ErrorMass	[0.0,*]
			Error on the mass	

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Subschema: YtopJULPOTBanks

+------+
| YNMO | 3-momentum of rec. neutral
+------+ tracks NR=0.

1		I	Number of words/tracks (=3)	
2		I	Number of tracks	
1	PX	F	Px	[*,*]
			X-proj. of rec. momentum	
2	PY	F	Py	[*,*]
			Y-proj. of rec. momentum	
3	PZ	F	Pz	[*,*]
			Z-proj. of rec. momentum	

AL1$USER3:[BOSMAN.DDL]YTOP.ADD;9 of 6-AUG-1991 16:18

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Subschema: YtopJULPOTBanks

| YNTR | Daughter tracks of rec. neutral tracks NR=0.

1		I	Number of words/tracks (=4)	
2		I	Number of tracks	
1	MT	I	MotherTrack	[0,*]
			Mother track number	
2	DT	I	DaughterTr	[0,*]
			Daughter track number	
3	TT	I	dTrkType	[0,*]
			Daughter track type 1 - normal track 2 - rec. neutral track 3 - rec. charged track	
4	MA	I	Mass	[0,*]
			Mass assigned to daughter	