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Improvements to SKELANA for Version 2.0

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Abstract

The latest version of `SKELANA` contains a significant number of changes both in structure and content, these improvements are described here. The new features include an improved track selection, the addition of a track recovery routine, and use of the `REMCLU` electron/photon tagging package.

Contents

1 Introduction

SKELANA is an analysis program skeleton for use on the XShortDST. A reduced set of SKELANA information is available from the FullDST, this is intended for code testing purposes only. The information provided in this note is intended to be complementary to that contained in the standard SKELANA manual [1].

The latest version (2.0) of SKELANA has a significant number of changes and new features. In this note the major changes for this version are described and in the appendices descriptions of all the control flags and locking words of SKELANA are provided. We would strongly encourage all SKELANA users to read this manual and check that the default flag settings are appropriate to their analysis.

2 Structure

The main code of the program is stored in the file skelana.car and the declarations of the COMMON blocks are in the companion file stdcdes.car. The skelana.car file is divided into several PATCHY PATCHes:

PATCH	Description of Contents
PSTITLE	banner
PSMAIN	USERxx routines, for control of the program by users
PSSERV	PSxxx routines, general purpose routines
PSHORT	PSHxx - routines for filling COMMONS from XShortDST
	without re-running packages such as b-tagging.
PSFULL	PSFxx - routines for filling COMMONS for FullDST
	(where different to XShortDST)
	and re-running packages such as b-tagging
PSUTYL	general purpose routines
PSTRAC	Track Selection and Recovery routines
UNUSED	Obsolete code for FullDST

The top-level routines responsible for steering the operation of the code have been re-organised. This simplifies the operation of SKELANA and facilitates the inclusion of the new features. The routine PSHORT is the heart of the new steering scheme. PSHORTTRK is responsible for filling the most important COMMON blocks including the VECP array. These changes should be completely transparent to standard users. Flow charts illustrating the calling structure of SKELANA are provided as figures 1,2.

3 Full DST Operation

The steering of the program for the FullDST is now controlled by the same routines as for the XShortDST (see above).

The FullDST operation of SKELANA has been largely reduced to the direct filling of COMMON blocks: the running of sophisticated packages such as MAMMOTH, ELEPHANT, MUBANA, HACANA is best performed by running DSTANA to produce the XShortDST. The FullDST routines that can no longer be executed by the program are retained in the PATCH UNUSED. Furthermore, the flag IFLFIX is no longer used, but has been retained for backwards compatibility.

4 Steering Flags

Several new control flags have been introduced to SKELANA. The values are initialised in the PSINI routine. The example USER00 routine, supplied with the program, prints the currently set value of all the flags and track selection cuts used. The full list of steering flags is provided in appendix A.

Conventionally, the filling of tracks in the SKELANA commons occurs in the order charged tracks first then neutrals. Setting the flag IFLODR$=0$ fills the tracks in the PV,PA structure order of the DST. Unless you have specifically adapted all your code to this new option, it is strongly recommended to continue to use the charged then neutral filling order.

5 Rejecting or Locking Tracks

SKELANA can choose to reject tracks for several reasons: track selection cuts, multi-vertex handling , or REMCLU cluster PAs. The rejected tracks may simply be discarded or flagged as 'locked' depending on the settings of the IFLVEC and IFLSTR flags. The locking mechanism is used by default, if your code has not been adapted to this option then, to prevent double counting, IFLVEC and IFLSTR should be set to values less than 10.

'Locked' tracks are indicated in the simple LVLOCK array or more detailed LVSELE array. The latter stores information on a track's success or failure of all the programs selection criteria. This variable is in the +KEEP TRACKNTP sequence. It is intended to assist users willing to exploit the information from the new track selection, recovery and REMCLU packages. The structure of the LVSELE and LVLOCK bitted words are explained in appendix C.

Users should be aware that the jet clusterisation routine PSJETS still uses the LVLOCK word. It is the responsibility of the user to ensure the LVLOCK word is correctly filled before calling PSJETS.

6 Primary Vertex Treatment

The PSCVTX COMMON block is filled with the vertex information calculated by DELANA and DSTANA. The primary vertex in this COMMON (the first element) may be replaced by that computed in the b-tagging package. This replacement is performed if the b-tagging common is filled (IFLBTG>0) and IFLPVT$=1$.

Whichever primary vertex is selected by the user the charged track parameters are calculated with respect to this point.

7 Electron and Photon Tagging

The principle tool for electron and photon identification in SKELANA is the REMCLU package, which will be described in detail in a future DELPHI note [2]. REMCLU is the preferred identification package for most LEP2 analyses. It provides good identification for high energy (> 20GeV) electrons and photons. For lower energy showers in the barrel REMCLU provides the information from ELEPHANT [3]. In the forward region REMCLU identification of isolated clusters down to 1 GeV is provided.

The REMCLU cluster COMMON is filled if the flag IFLECL is > 0. The value 2 or 22 forces the REMCLU package to be re-run, rather than just copying the information from the XShortDST. REMCLU created clusters are copied from the bank into VECP if IFLECL < 10. These clusters are flagged in LVSELE.

The setting of IFLVEC controls the manner in which the VECP array is filled with the REMCLU clusters. In the case that IFLVEC < 10 the REMCLU clusters are added to VECP, but the PAs from which the clusters are produced are not. For the IFLVEC > 10 setting both the REMCLU clusters and the PAs from which the clusters are produced are filled into VECP. To help prevent double counting by the user these PAs are flagged in LVSELE and in LVLOCK.

The PAs used by REMCLU in producing clusters are independent of the SKELANA track selection. However, when filling VECP the track selection is run on the PAs included in the REMCLU cluster which do not have associated electromagnetic energy.

The standard ELEPHANT COMMONs (PSCELO,PSCELD) are still retained and are controlled by the IFLELE flag.

8 Track Re-fitting

VD only tracks (with a measured Z co-ordinate) and FCA-FCB tracks are by default re-fitted with the primary vertex constraint applied. This treatment significantly improves the momentum determination of these tracks. This mechanism can be disabled using the flags IFLVDR, IFLFCT.

The re-fitted track replaces the original track in VECP and in the TRAC module. This replacement only occurs if a suitable χ^2 is obtained from the track re-fit: tracks with bad impact parameters will fail this cut. If the track selection is used, the momentum and dp/p of the track must also pass the track selection cuts before the replacement will occur.

Clearly the optimum performance of these routines will only be achieved if the b-tag primary vertex is used (see section 6).

9 Track Selection

The selection applied here is based on those commonly used in many DELPHI Teams for standard hadronic analyses. These have been supplemented with a number of new ideas. While hopefully the standard selection will be of use to people working on a range of different analyses, for many analyses particular cuts will need to be studied/changed by the user. The track selection should normally be used with IFLVEC setting 2 or 22 to obtain 'new incoming' particles.

There are three possible sets of standard track selection criteria that can be selected by the user with the flag IFLCUT : the first is the old SKELANA tuning; the second is the first standard DELPHI tuning that was proposed in '98; the third is the new recommended tuning which is the default option. The user may select which tuning to apply with the variable IFLCUT, the first two are retained only from backwards compatibility.

The track selection cuts are stored in a COMMON block called with the sequence PSCUTT and are listed in appendix B. The default values of various track cuts are listed in this appendix and are defined in the PSINI routine.

The charged track selection is controlled by the routine PSHCNT, and the neutral by PSHSNT. Bits 2-11 of the LVSELE word (see appendix C) are used to indicate which track selection cut was failed by a track.

9.1 Charged Track Selection

The selection cuts applied in the standard tuning are on minimum and maximum momentum, fractional momentum error and the impact parameters of the track. The Z impact parameter cut is applied as a function of $\sin(\theta)$, where θ is the polar angle of the track. Particles with momentum greater than TRKMAX*EBeam are rejected in the track selection, the default value of TRKMAX is 1.5.

For backwards compatibility, cuts are retained on track length and $\cos(\theta)$. However, it is certainly preferable to fix or remove tracks from a particular track search or tracking detector combination rather than apply a cut on track length.

Two types of tracks that have in the past caused discrepancies[1] can be rejected using the flags, IDVDWZ and VDONLY: the first allows rejection of ID-VD tracks without Z information; and the second allows rejection of VD only tracks with or without Z information.

9.2 Neutral Cluster Selection

Minimum energy cuts may be applied for all the calorimeters. For the new tuning detector experts have been consulted to determine a suitable position of these cuts for the separation of signal and noise.

In the default tuning the minimum energy cut is not used for the HCAL, instead a noise rejection routine has been provided (see below). Noise is removed from the STIC using a minimum energy cut and a rejection of neutrals of over 2 GeV produced from only one tower. In addition a suppression cut on off-momentum electrons in the STIC is applied (see below).

Neutrals clusters which have been created from the detection of clean photon conversions, π^0s, or V^0s are retained.

9.3 HCAL Noise Rejection

Noise rejection in the HCAL is controlled by setting the track selection parameter IHADRJ. The noise rejection algorithm selects the showers with energy deposited in one layer only and makes a decision based on the shower's energy, number of hits, and the longitudinal position of the shower. The first level cut (IHADRJ= 1) is intended to reject noise showers only; there should be minimal signal loss. The standard recommended cut level (IHADRJ=

[1] Please note that ID-VD without Z and VD without Z tracks are not present in the '99 data sets

2) gives better data/simulation agreement, at the expense of removing some genuine low energy showers.

9.4 Off-momentum Electrons

This routine is controlled by the track selection parameter `ISTOEL`. Because of the very large rate of off-energy electrons hitting the STIC, there is a non-negligible probability to have an off-energy electron in the STIC in coincidence with a genuine physics event.

In analyses which veto on energy in the STIC a couple of percent of the signal is lost due to this problem. However, the situation is more problematic for analyses in which the events are selected based on requirements on the STIC energy. The off-energy electrons can then cause strange effects and should be rejected. The most effective way of doing this is by an angular cut since the angular distribution is very steep; whilst the energy distribution is broad with many showers having an energy up to 50-60 GeV. It has been demonstrated that if STIC showers below 3 degrees in polar angle are rejected the probability to have an off-energy electron in coincidence with a physics event is reduced by more than one order of magnitude. Further information on this topic is available in [4].

10 Recovery Routine

A recovery mechanism for tracks that failed the track selection cuts can be enabled with the three digit flag `IFLRVR`. The flag is described in appendix A, the default setting of 111 activates all three recovery algorithms. These algorithms are described in the following sub-sections.

At present, only a charged tracks recovery has been implemented, this is steered by the routine `PSHSCTRECOVER`. If the user wishes to insert a neutral cluster recovery then this would be performed from `PSHSNTRECOVER`.

If a track has been recovered this is indicated by the setting of the appropriate bits of the `LVSELE` word (see appendix C).

10.1 MAMMOTH Recovery

A recovery routine is applied to `MAMMOTH` [5] reconstructed incoming tracks that have been rejected by the track selection. The interactions reconstructed by `MAMMOTH` are hadronic interactions with at least two outgoing particles and kinks with only one outgoing track. The incoming track will be of the types VD only, ID-VD, ID-VFT or VFT only. These tracks typically have a good resolution on the direction but bad momentum resolution due to their short measured length: this is particularly true of the VD only and VFT only tracks.

In the `XShortDST` version 1.07, and later, a corrected momentum for the products of the interaction is computed and stored in the word Q(LPV+15), where LPV is the pointer to the PV bank for the interaction vertex. For the recovered track, this corrected momentum is used while the direction of the original incoming track is retained. This procedure allows us to improve the energy and momentum resolution on tracks causing interactions.

This recovery procedure is not applied if the incoming track fails the impact parameter cuts, since the measured direction of these tracks will be unreliable.

10.2 Unphysical high momentum particles

The class of tracks which fail the maximum momentum cut are treated with this recovery procedure. In the simulation the origin of these tracks is most typically found to be true tracks of fairly high momentum.

The success of various recovery procedures were assessed on simulation tracks by observing the correlation between the recovered momentum and the true momentum, and in data from the acolinearity of hadronic Z events. Recovery procedures considered include re-fitting the track without OD or FCB hits, using the TPC TE when available, and imposing a fixed momentum.

The approach adopted is to re-fit the track imposing as a constraint the primary vertex of the event. This is performed by the routine `PSHCTRECPBS`. The track is recovered if acceptable values are obtained of the re-fit probability, the re-fitted momentum and its estimated uncertainty. The `SKELANA VECP` array and components of the `PSCTRA` COMMON block are overwritten with the re-fit parameters extrapolated to the primary vertex.

If this procedure does not recover the track it may still be recovered by the neutral energy recovery option, otherwise the track is rejected.

10.3 Neutral Energy Recovery

If the quality of a charged track is insufficient for standard use in the analysis then the track can be converted into a neutral. If the track has calorimetric energy associated with it greater than `RECCAL` GeV then a neutral particle entry in `VECP` is created. The standard neutral track selection code is run for this particle. Only the `VECP` array is overwritten with the new information, the `TRAC` module is unaffected. Note that the `DST` information of the original charged track is still recoverable since the PA address is obtainable from `LVECP`. Please note that the `LVSELE` word is filled with bits 2-11 set from the original charged track.

In the introduction the comment was made that the default settings of the program will not be suitable for all analyses: this routine provides a suitable illustration of this point. If the user is interested in high momentum muons, then the recovery of failed muons as calorimeter energy deposits will probably not be appropriate.

10.4 Acknowledgements

We would like to thank all the people who provided feedback on our proposals and on the code, and in particularly Wolfgang Adam for his work on testing the program.

References

[1] SKELANA - Skeleton Analysis Program, T.Spassoff, N.Smirnov

[2] REMCLU, Forthcoming DELPHI note, F. Cossutti, F. Mazzucato, A.Tonazzo

[3] ELEPHANT Reference Manual, DELPHI 96-82 PROG 217, M.Feindt, C.Kreuter, O. Podobrin

[4] LEP Machine Background and Noise in the DELPHI Calorimeters, DELPHI 99-157 LEDI-12, V.Hedberg et al.

[5] How to use the MAMMOTH Program, DELPHI 96-52 PROG 216, M.Feindt, W.Oberschulte gen. Beckmann, C.Weiser

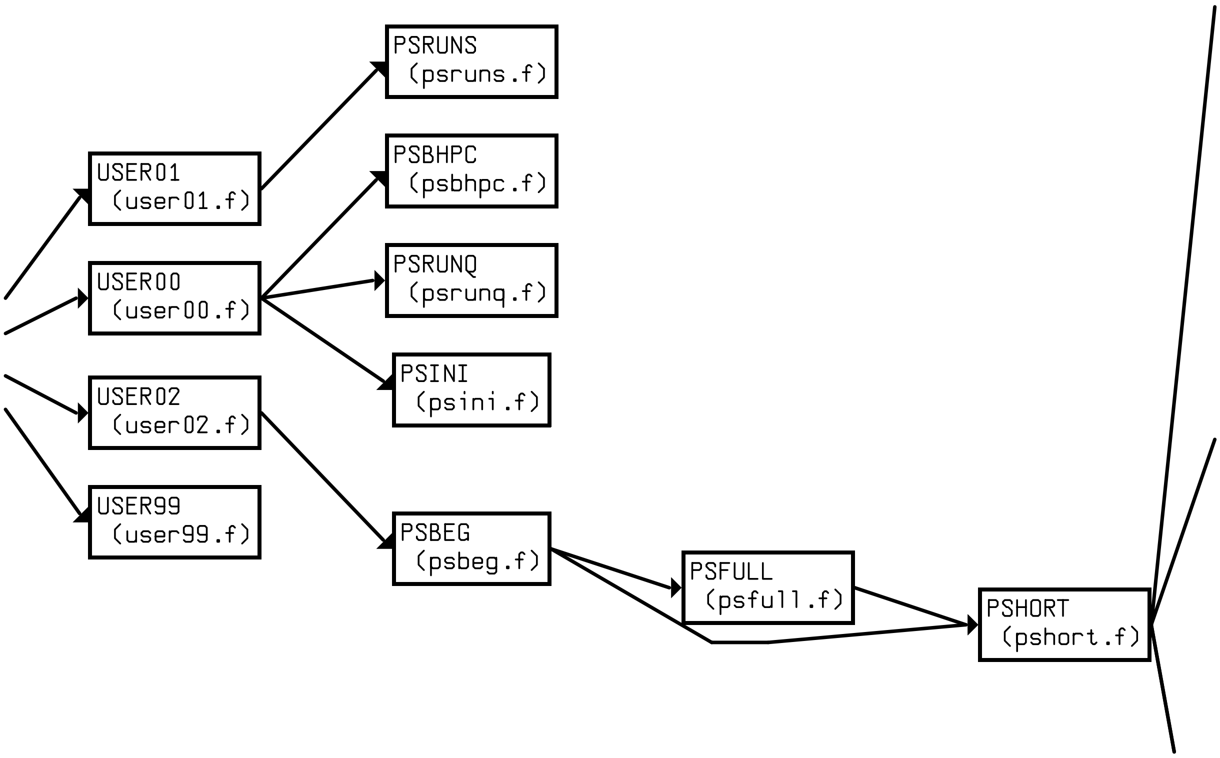

Figure 1: A flow chart showing the highest level routines of `SKELANA`. The `USER`xx routines are those which are under user control. The main filling of COMMON blocks is steered by the `PSHORT` routine as shown in the next figure.

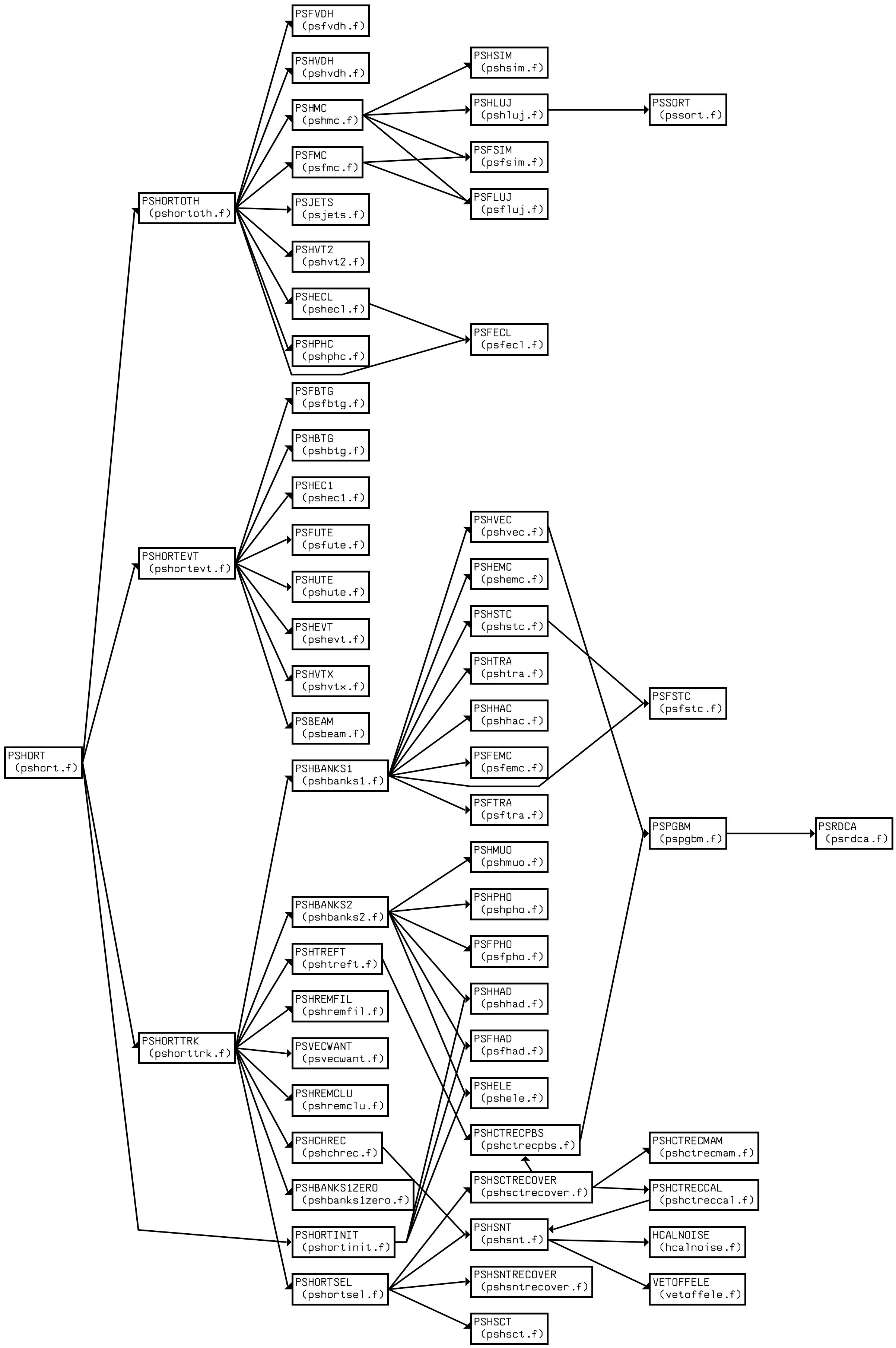

Figure 2: A flow chart showing the control structure of the main COMMON block filling of `SKELANA`. The filling of the `VECP` array and other track level information is steered by the routine `PSHORTTRK`.

A Appendix : Description of all Control Flags

Flag	Description	Values	Default
`IFLTRA`	Track Information 0 - COMMON not filled 1 - COMMON filled	0 - 1	1
`IFLODR`	Re-order tracks 0 - Order of `DST` PAs 1 - Charged then neutral	0 - 1	1
`IFLVEC`	`VECP` vector filling 0 - No `VECP` filling 1 - Fill all tracks except the 'new incoming' ones and PAs in `REMCLU` clusters 11 - Fill all tracks, lock the 'new incoming' ones 2 - Fill all tracks except the 'charged outgoing' ones and PAs in `REMCLU` clusters 22 - Fill all tracks, lock the 'charged outgoing' ones	0 - 22	22
`IFLSTR`	Track selection 0 - No selection applied 1 - Selection applied (see `IFLCUT`), rejected tracks removed 11 - selection applied (see `IFLCUT`), rejected tracks locked in `LVLOCK` and `LVSELE`	0 - 11	11
`IFLCUT`	Track selection tuning 1 - Old `SKELANA` selection 2 - May 98 tuning for 97 data 3 - Recommended tuning, developed for `XShortDST` 1.07	0 - 3	3
`IFLRVR`	Recovery routine 0 - Recovery routine not applied >0 - Routine applied, overwrites `VECP`, `TRAC` COMMON ..1 - High momentum track re-fit with PV constraint .1. - `MAMMOTH` recovery 1.. - Recover charged tracks as neutrals (e.g. 111- run all three, 011 - don't use neutral recovery)	0 - 111	111
`IFLSIM`	Simulation Information 0 - COMMON not filled 1 - COMMON filled	0 - 1	1

Flag	Description	Values	Default
IFLBSP	Beam Spot Information 0 - COMMON not filled 1 - Filled from DST/XShortDST 2 - Read from beamspot file	0 - 2	2
IFLBTG	B tagging Information 0 - COMMON not filled 1 - Fill from XShortDST, or for full DST recalculate 2 - Recalculate with AABTAG	0 - 2	2
IFLPVT	Primary vertex treatment 0 - DELANA primary vertex 1 - B-tagging primary vertex (if b-tagging used)	0 - 1	1
IFLVDR	VD only (with Z) track re-fit with PV constraint 0 - Inactive 1 - Active	0-1	1
IFLFCT	FCA/FCB track re-fit with PV constraint 0 - Inactive 1 - Active	0-1	1
IFLRNQ	Run quality selection 0 - Don't apply 1 - Read runquality file and apply selection	0 - 1	0
IFLBHP	Skip the bad 1997 HPC events 0 - No 1 - Yes	0 - 1	1
IFLUTE	Unassociated TE banks 0 - COMMON not filled 1 - COMMON filled	0 - 1	1
IFLVDH	Vertex Detector hits 0 - COMMON not filled 1 - COMMON filled	0 - 1	1
IFLMUO	Muon Identification 0 - COMMON not filled 1 - COMMON filled for XShortDST	0 - 2	1

Flag	Description	Values	Default
IFLECL	Electromagnetic cluster Information 0 - no REMCLU 1 - from the DST, fill VECP with clusters 2 - re-run, fill VECP with clusters 11 - from the DST, fill PSCECL COMMON only 22 - re-run, fill PSCECL COMMON only	0 - 22	2
IFLELE	ELEPHANT Electron Identification 0 - COMMON not filled 1 - COMMON filled for XShortDST	0 - 1	1
IFLEMC	Electromagnetic Calorimetry 0 - COMMON not filled 1 - COMMON filled	0 - 1	1
IFLPHO	Photon Identification 0 - COMMON not filled 1 - COMMON filled	0 - 1	1
IFLPHC	Photon Conversion 0 - COMMON not filled 1 - COMMON filled for XShortDST	0 - 1	1
IFLSTC	STIC Information 0 - COMMON not filled 1 - COMMON filled	0 - 1	1
IFLHAC	Hadron Calorimetry 0 - COMMON not filled 1 - COMMON filled	0 - 1	1
IFLHAD	Hadron Identification 0 - COMMON not filled 1 - COMMON filled	0 - 1	1
IFLRV0	V0 Reconstruction 0 - COMMON not filled 1 - COMMON filled for XShortDST	0 - 1	1
IFLJET	Jet reconstruction algorithm 0 - no reconstruction 1 - LUCLUS (standard) 2 - JADE scaled inv. mass 3 - JADE fixed inv. mass	0 - 3	0
IFLFIX	Dummy variable, unused	0	0

B Appendix : Track Selection Control

The Track Selection is activated by the flag `IFLSTR`. Three track selection tunings are available and are selected by the flag `IFLCUT`. The recommended tuning is `IFLCUT`= 3, the default values of the track cuts for this tuning are provided in the following tables.

The charged track tuning is controlled by the following variables.

Variable	Description	Default
`TRKMOM`	Min track momentum in GeV	0.1
`TRKMAX`	Max momentum in GeV	$1.5 \times$ EBeam
`TRKERR`	Max dp/p	1.
`TRKRPH`	Max R-Phi impact parameter in c.m.	4.
`TRKZET`	Max Z impact parameter in c.m./ $\sin(\theta)$	4.
`TRKLEN`	Min Track length in c.m.	0.
`TRCCOS`	Max $\cos(\theta)$ for charged tracks	1.
`VDONLY`	Reject VD only tracks 0-2	1
	0 - Inactive	
	1 - Reject VD only without measured Z tracks	
	2 - Reject all VD only tracks	
`IDVDWZ`	Reject ID-VD without Z tracks 0-1	1
	0 - Inactive	
	1 - Reject ID-VD without measured Z tracks	
`IHADRJ`	Hadron calorimeter noise rejection level 0-2	2
	0 - Inactive	
	1 - reject most noisy clusters (tight tag)	
	2 - reject noisy clusters (loose or tight)	
`ISTOEL`	Off momentum electrons rejection in STIC 0-1	1
	0 - Inactive	
	1 - Active	

The neutral track tuning is controlled by the following variables.

Variable	Description	Default
`EHPC`	HPC energy for neutral tracks in GeV	0.3
`EFEMC`	FEMC energy for neutral tracks in GeV	0.4
`EHAC`	EHAC energy for neutral tracks in GeV	0.
`ESTIC`	ESTIC energy for neutral tracks in GeV	0.3
`TRNCOS`	$\cos(\theta)$ for neutral tracks	1.

The recovery routines are activated by the flag `IFLRVR`. The tuning is controlled by the following variable.

Variable	Description	Default
`RECCAL`	recover as neutrals rejected charged tracks with minimum calorimeter deposits (GeV)	5.

C Appendix : LVSELE and LVLOCK words

The success or failure of the various SKELANA selection criteria is indicated by the detailed LVSELE and simpler LVLOCK arrays. LVLOCK is stored in the +KEEP sequence PSCVEC and LVSELE in the TRACKNTP sequence.

The structure of the LVSELE word is as follows.

bit 1	Standard track selection flag
bit 2-11	Cut that caused the rejection
bit 12-19	Reserved for future SKELANA changes
bit 20-22	Recovery step result
bit 23-29	Reserved for future SKELANA changes
bit 30	REMCLU cluster added to VECP
bit 31	PA part of a REMCLU cluster
bit 32	Multi-vertex structure handling

The multi-vertex structure is the same as in LVLOCK. This bit flags tracks from unwanted vertices according to the settings of the flag IFLVEC.

For charged tracks the meaning of bits 2-11 of the LVSELE bitted word is as follows.

bit 2	Main module
bit 3	Low momentum
bit 4	Track length
bit 5	Theta of track
bit 6	Impact parameters R-Phi
bit 7	Impact parameters Z
bit 8	High momentum
bit 9	dp/p
bit 10	VD only
bit 11	ID-VD w/o Z

For neutral tracks the meaning of bits 2-11 of the LVSELE bitted word is as follows.

bit 2	Main module
bit 3	Theta track
bit 4	HPC
bit 5	FEMC
bit 6	HAC
bit 7	STIC
bit 8-11	Not used

For the track recovery routine the meaning of bits 20-22 f the LVSELE bitted word is as follows.

20	Recovery as a neutral
21	Re-fit with primary vertex constraint successful
22	Recovery of MAMMOTH kinks/interactions successful

The old LVLOCK word is retained and the same bits are filled as in previous SKELANA versions.

bit 1	Track selection
bit 32	Multi-vertex structure handling + REMCLU PA locking
bits 2-31	Available for the users