The Study of The MDC Reconstruction Codes

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1 The Introduction

The BESII MDC reconstruction codes called DCJULIE is emigrated and modified from MARKIII by Dr. Liu Jing about 1996, and more improvement have made during these years by himself and calibration group people, The version number is upgraded to v102 from 100 and 101 in the period of the analysis of the R-Value scan data and the J/ψ data. The performance is well at the tracking efficiency and events reconstruction quality from the summary of the annual meeting in 1998, 1999 and 2000.

But for a large code system, There are still some bugs or some calculation method or the algorithm that need improvement, such as the track numbers for some events is different at different platform; track-parameters of some track have differences at different platform; The precision of the vertex position of the tracks with -19 fit-flag is very poor and so on. Prof. Bill Dunwoodie give us a good suggestion and very powerfully support at SLAC, let us have this good chance to do the details system study and the checking for MDC reconstruction codes.

2 The Study of the Tracking Processing on the PC-LINUX and HP-UNIX Platform(V102)

The very careful checking is done for the track find stage between the PC-LINUX and the HP platform and make the comparison in each calculation step or in some complex loops. The J/ψ data run12054 is used for this checking, the 5000 events are reconstructed by HPWS9(Beijing) and SLAC PC machine(PII350, LINUX-v6.1). There are 47 events with different track number as shown in Fig.1, The X-axis is the number of sub-detector(subtype of track list, No.3 is MDC), the Y-axis is number of events with different tracks. It is about 1% events with different track number if reconstruction the events by different platform.

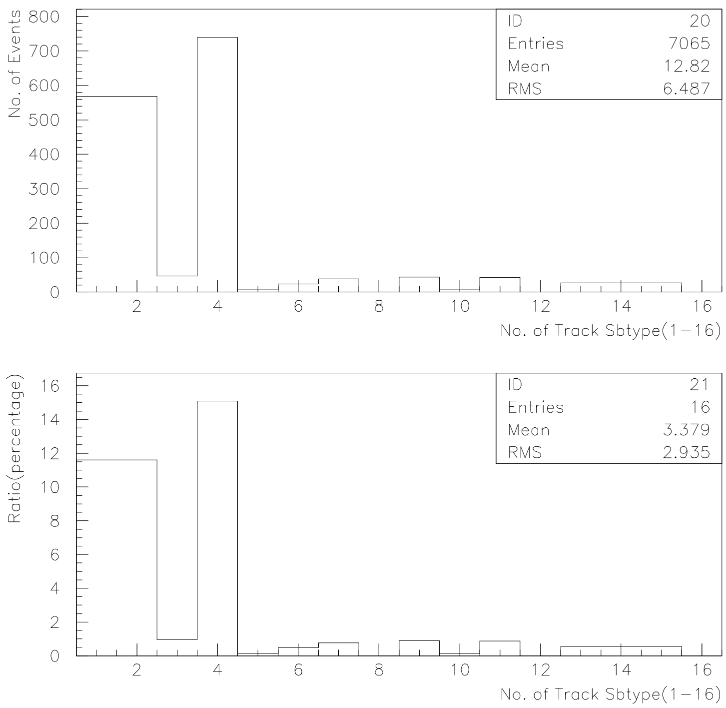


Fig.1 The comparison of track number of the events on the PC and HP platform before modifications

The tracking method of DCJULIE is the Template Matching Method. There is a dictionary, all the tracks in a event will be found in each step. we checked those events one by one, and found that: The tracks and number of OBJECTS almost same at the step of the Hit-Pattern and "OBJECT find" in two platform. The differences is created in the circle fit of the R-ϕ plane. After tracing the events we can found:

- Some of them is caused by the repeat calculation in the circle fit. The value of some variables have little differences after iteration some times, and come to larger and larger with the increasing of the iteration times.
- Some of them is caused by the different resolution of the ambiguities. The different resolution of the ambiguites also caused by some calculation.
- Another case is caused by some bugs, such as at the loop 1000 of code editrk.f: "EVLW=IAND(BYTTRK,ISHFT(EVLWRD1,-(K-1)*4))", "EVLW=IAND(BYTTRK,ISHFT(EVLWRD2,-(K-1)*4))", the EVLWRD1 is integer*4, when(k=1,10) K=10(layer number), the ISHFT(EVLWRD1,-36) will over 32, the HP machine treat this line is return zero. But LINUX system does not return zero sometimes. If the event is not very clear, many noise hit point, then may be pich up some noise points and increase one bad track. So some time the LINUX system find more tracks than HP. Actually the EVLWRD1 and EVLWRD2 are the fit-mark of layer 1,3,5,7,9, and 2,4,6,8,10 respectively set by trkevl.f or tkevls.f,

each layer need 4 bites, The first 20 bites is effectively only. After removing the bugs and modify the variables that used in the tracking subroutines into double precision, the track numbers come to consistent in two platform as shown in Fig.2.

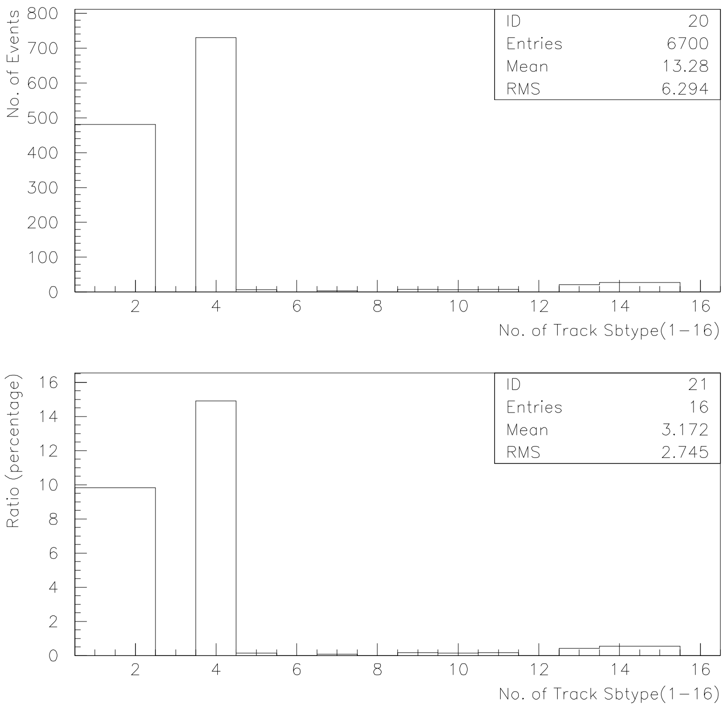


Fig.2 The comparison of the track number of events on the PC and HP platform after modifications

3 The study of the Track-parameter Differences in Two Platform

For the events with same track number, but the value of the track-parameters have some differences in two platform. The 5000 events is reconstructed at HP and PC LINUX system, the results is shown in the Fig.3. the maximum differences is about 3%, the differences of most parameters is around 2%. The deferences is defined:

Err=(Ipar_hp - Ipar_PC)/Ipar_hp. If the Err is great than 0.01, the Ipar(ith parameter) is considered as the differences.

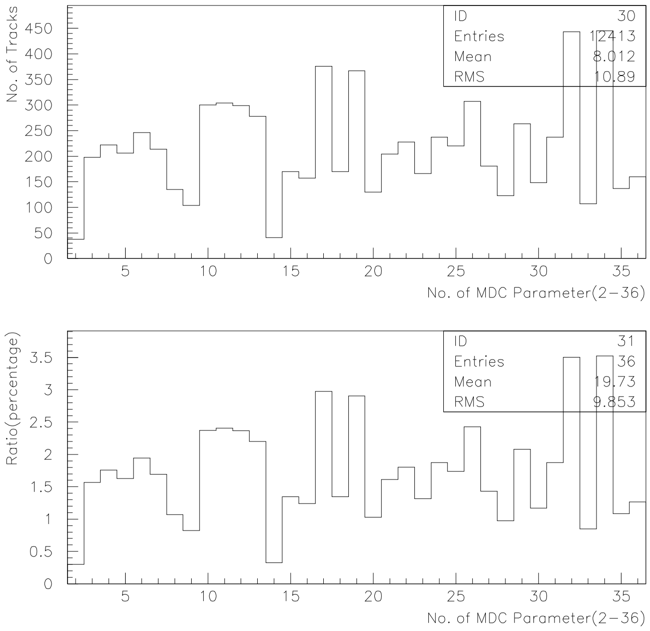


Fig.3 The comparison of the track-parameters in PC and HP platform before modifications

This is a much more complex problem than the "different tracks". After debugging those events between two platform, the main reason in summary is following:

The main parameters of a track is the azimuth angle ϕ, track curvature(1/P*cos), the slope(TAN LAMBDA) and the original position X_0, Y_0, Z_0, after the R$-\phi$ plane circule fit and the stereo layer track fitting(tracking stage). There are some differences in those parameters caused by the circle fit for some tracks. Those differences will transfer to the helix fitting. In principle the original parameters of the track should not effect the finally results if the hilex fitting times is very large, but the iteration times of the helix fitting is always limited in a given value. In most case, it will be reduced in the helix fit, but still caused a small differences in the final results for some events

The most case to caused the differences is the precision of the variables. Some calculation will be repeat many times in the hilex fitting. The new differences will be created In those processing or the old differences that transferred from the tracking stage will be developed. This faction will caused a quite different treatment in the following processing and out put quite different recults in final, such as discard the different bad points, take different χ^2 cuts, take different iteration fitting times and so on.

The another case to caused the differences is due to the bites of the processor in PC and HP is different, it will caused small differences for some variables after some operation or some fortran function. If this small differences just developed by the following processing, then it will make the different final results. This problem is the fatal problem that we can't resolve it by the program or modify some method. we have to wait the PC processor improvement in near future.

We also found some bugs in the fitting processing, such as in the "parec.f", in the processing of searching hit wires, after finding a main wire and then search the first following wire, if this wire is not hit, the processing will skip its searching in this main layer(one main layer includes 4 wires). The reasonable logical should be continue to search the second following wrie. After removing this bug the hit number of the tracks will be increased one or more.

To solve the problem of the track-parameter differences, most of the variables used in the hilex fitting codes have been changed into double precision, and most of the variables included in the seven common statement blocks that mainly used for the hilex fitting have been modified into double precision; Some fortran function used in the fitting codes also be re-writed into double precision function. Some subroutine called by many codes in the tracking step, or in the VC codes, avoid to make the confusion for VC and MDC reconstruction codes, some double precision subroutines are created to instead of the single precision subroutines and used for the MDC helix fitting only. After making those improvement for the hilex fitting codes, the track-parameter differences reduced very small as shown in the Fig.4, The charge(subtype 2) and the fit mark(subtype 14) of the track is almost same in two platform, the start position x, y and z for some tracks have differences, this is caused by the differences of the original value transferred from the tracking processing. The maxium of the differences is reduced from about 2% to about 0.03 %.

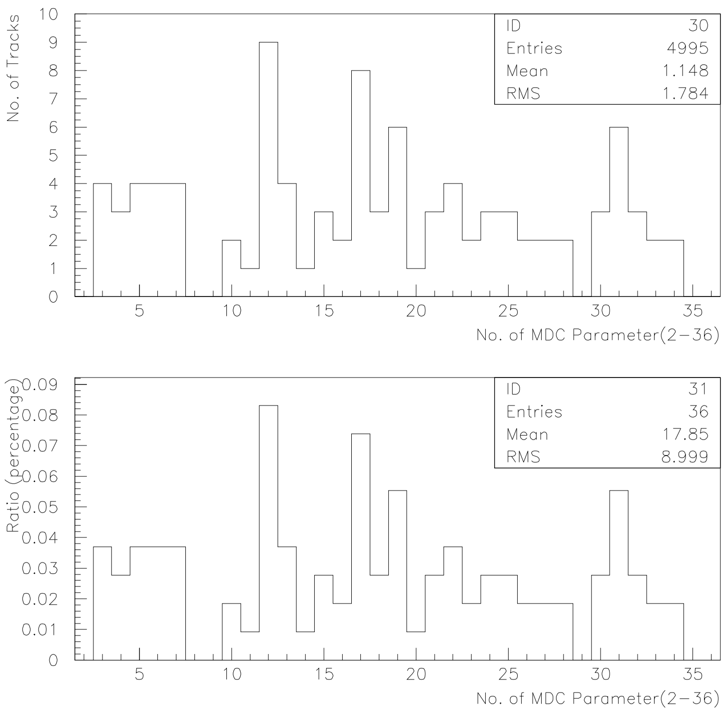


Fig.4 the comparison of the track-parameters in PC and HP platform after modifications

The global view of the reconstruction quality, the vertex position of one track should be better after this modifications. other characteristics of the tracks should be almost same as before. Because of some bugs have been removed, the hit numbers of the track and the tracking efficiency is little better than that of before as shown in the Fig.5, The total tracks with mfit=2 and -19 is 57777 and 58093 for before and after modifications respectively.

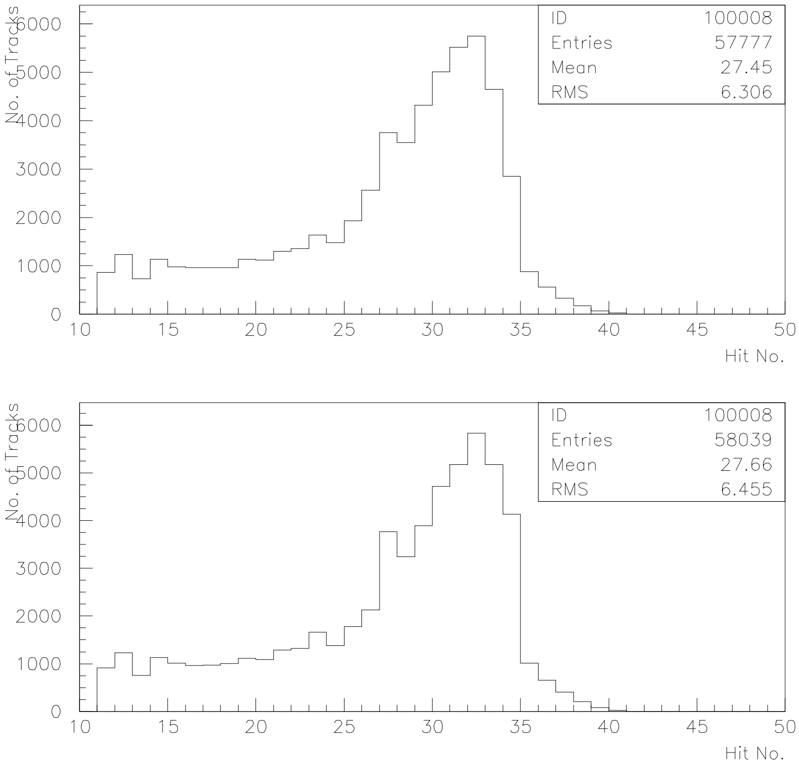
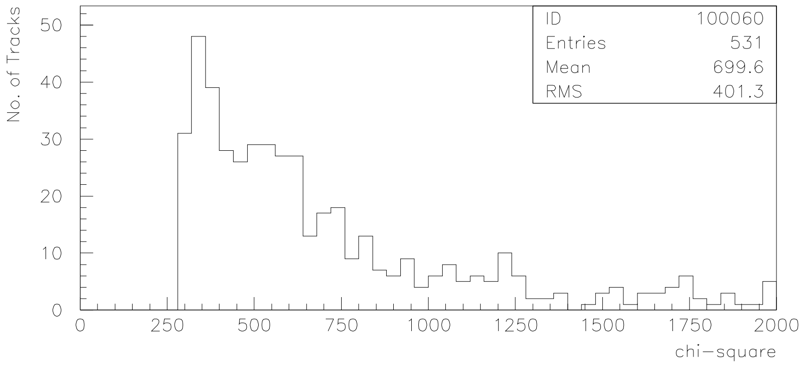


Fig.5 The distribution of hit numbers of the tracks before and after modifications

4 The Problem of the -19 Tracks

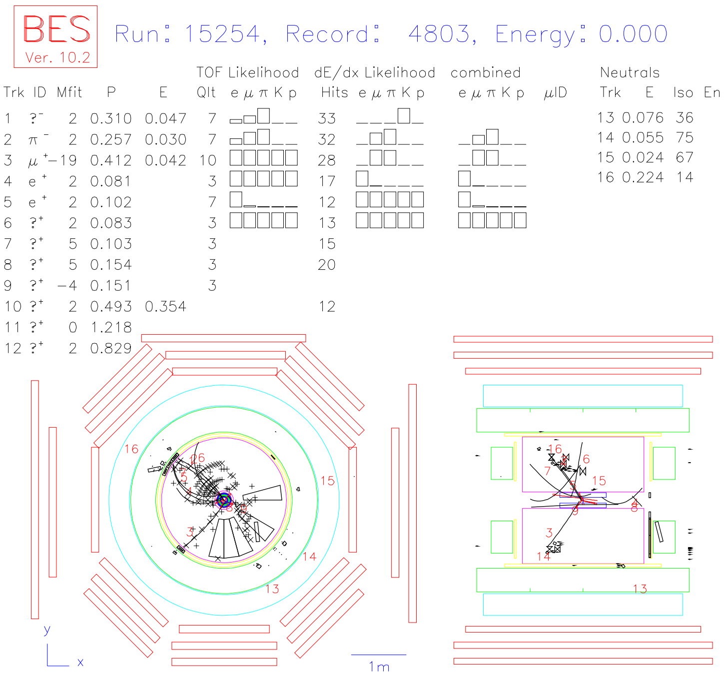
If the χ^2 of the track is more than 300, its fit mark is set to -19 in the helix fit processing. Because we did not use the normalized fit weight, we do not apply the "test of theory χ^2" to the track fit quality checking. From the distribution the χ^2, 300 is about 5 times σ of the χ^2 distribution. The ratio of the bad-good tracks(the tracks with -19 and 2 fit mark) is about 5.6 %. From the distribution of the χ^2 of the -19 tracks as shown in the Fig. 6, the up limit χ^2 cut of the good track seems can be increased to about 600, in there the shape of the distribution is dropped fast. If to do so(up limit χ^2 increased to about 10 times σ of the χ^2 distribution), the ratio of the bad-good tracks can be decreased to about 1.5 %. This is not the improvement of the tracking quality in fact, but can give the physicist more choice.



Why the χ^2 of those tracks is so large? In the view of the events, it is happened as following case:

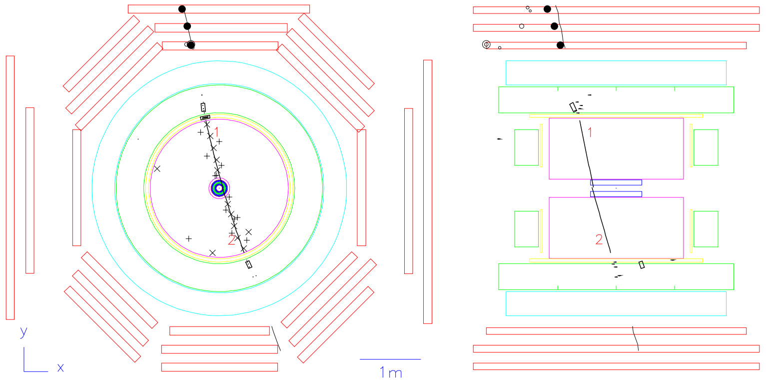
- some events are not a good event or a noise event.
- Some events are the cosmic ray events or the two tracks events around some noise points.
- The most case is the multiple track events, usually more than four tracks, and the hit points is crossed with another tracks or around the noise points.

There are three typical events shown as in following:



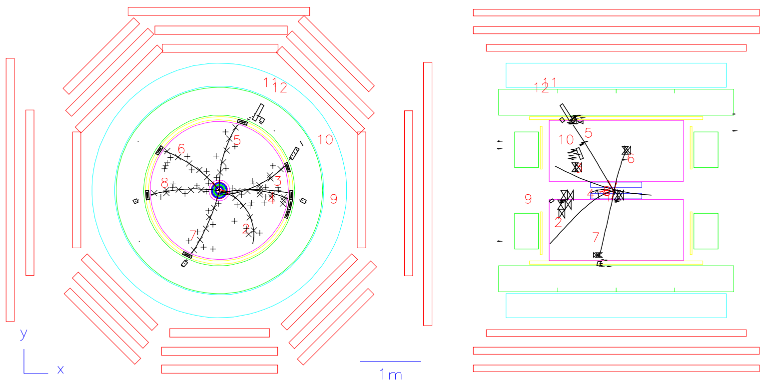
BES Ver. 10.2 Run: 15254, Record: 657, Energy: 0.000

Trk	ID	Mfit	P	E	TOF Likelihood Qlt	TOF Likelihood e μ π K p	dE/dx Likelihood Hits	dE/dx Likelihood e μ π K p	combined e μ π K p	μID	Neutrals Trk	Neutrals E	Neutrals Iso En
1	μ^+	2	1.824	0.142	8		30			1			
2	K^-	−19	3.367	0.115	3		34			0			



BES Ver. 10.2 Run: 15254, Record: 346, Energy: 0.000

Trk	ID	Mfit	P	E	TOF Likelihood Qlt	TOF Likelihood e μ π K p	dE/dx Likelihood Hits	dE/dx Likelihood e μ π K p	combined e μ π K p	μID	Neutrals Trk	Neutrals E	Neutrals Iso En
1	$?^+$	2	0.396		1		22				9	0.091	24
2	π^+	2	0.120		3		26				10	0.209	20
3	$?^-$	−19	0.318		10		24				11	0.320	7
4	π^+	−19	0.197		10		23				12	0.075	11
5	μ^+	2	0.246		1		34						
6	π^-	2	0.253		1		31						
7	π^+	2	0.451	0.092	1		31						
8	π^-	2	0.340	0.060	1		28						



If study the -19 tracks details, we can found that most of the tracks is low momentum track, about 72% tracks with momentum less than 0.5 GeV; about 17% tracks with momentum within 0.5 to 1.8GeV; about 11% tracks with momentum larger than 1.8 GeV, most of the tracks in last parts is the cosmic ray. About 67% -19 tracks have the hits in MDC only and no energy deposited in the shower counter.

At summary, to reduce the -19 tracks is how to reject the noise points, especially for low momentum tracks in the multiple track events, and the hits number is not too many in most tracks, so it is difficult that try to reject the noise points by dispoint the bad points like that did in the helix fit processing. The essential way should be done in the tracking processing, that will take many changes or modify the algorithm for current reconstruction codes.

5 The Summary

The status of the modification of the reconstruction codes and the common statements:

- There are 7 common blocks have been modified: arccone.inc, arcdrve.inc, chnom.inc, arcctle.inc, arcinte.inc, drresk.inc, zblock.inc
- There are 84 reconstruction codes are concerned with the modifications of the common blocks above, the names are listed in the appendix A.
- There are 46 reconstruction codes have beed modified in total, The names are listed in the appendix B.

The improvements of the events reconstruction quality:

- The tracking efficiency is increased about 0.5% after modifications.
- The track number of the event reconstructed in PC and HP platform become into consistent.
- The charge and the fit-mark of the tracks become into consistent in two platform.
- The track-parameter differences is reduced from 2% to 0.03 %.

What should be done in next step:

- If want to apply the data reconstruction on the PC-LINUX, the codes of the MDC extrapolation part and the Reconstruction codes of other detectors should be check.
- If want to improve the data reconstruction quality further, such as reduce the bad tracks, increasing the precision of track-parameters, increasing the power of the rejection noise points, more efforts should be pay to the algorithm of the pattern recognition.

6 Acknowledge

This job is suggested by Prof. Bill Dunwoodie in the 1999 and get lots of the helps during this period at SLAC, the achievements above were done under his guiding. He also give us some other ideal to improve the BES events reconstruction codes in future. We are very grateful indeed to professor Bill Dunwoodie for his friends and powerful helps on the BES works.

7 Appendix

A. The names of the codes concerned with the modifications of the common blocks above:

```
arcdmp,  arcsv,   arcsv2,   blkjul,    bmfit0,   bokfil,   calc_resk,
clrmem2, cndzee,  cndzee2,  cslate,    dbunch,   dbundl,   dccons,
dcdist , dcdist2, dcdistmc, dcdistmc2, dcjulf1,  dcjulie,  dcjulie2,
dclose,  dclose2, dcunpack, dexfil,    dsimpl,   editrk,   evalu8  ,
fielbes, fillxy,  getgeo ,  getgeo2,   getvcobj, getwir,   helixv,
init,    leapit,  lftrgt,   lraspnt,   objsng,   parce ,   parce2,
parcit,  parcit2, radwir,   radwird,   resder,   resder2,  set_resk,
skipcc,  skipcc2, smxind,   strzee,    strzeed,  strzeevc, swimit,
tkevls,  trkcir,  trkcph,   trkcphd,   trkevl,   trksht,   trkzee,
trkzee2, trkzsh,  trkzsh2,  turnit,    unpk64,   untang,   untang2,
vcpfil,  vcdcah,  vcdchc,   vcdcsh,    vcjini,   vclose,   vcparc,
vc_dccons, vctcir, xtra2vc,  xtrap,    zfit,     zshard
```

B. The names of the codes in which some fortran function, variables or something else have need modified:

```
arcsv,     arcsv2,    bokfil,  calc_resk, clrmem2, dcdist,  dcdist2,
dcdistmc,  dcdistmc2, dclose,  dclose2,   editrk,  evalu8,  fielbes,
helixv,    init,      leapit,  lftrgt,    lraspnt, objsng,  parce,
parce2,    parcit,    parcit2, radwird,   resder,  resder2, skipcc,
skipcc2,   smxind,    strzeed, strzeevc,  swimit,  trkcir,  trkcphd,
trkevl,    trksht,    trkzee,  trkzee2,   turnit,  vcdcah,  vcdchc,
vcjini,    vcparc,    vctcir,  zfit
```