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Programs used to measure the misalignment of ITC/TPC in ALEPH with cosmic rays

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I. Introduction

This writeup briefly describes how to run the programs used for the measurement of the misalignment of ITC/TPC. They have been developed from existing programs [1] during the period of May to November 1988 and will be continuously updated. This writeup refers to programs which can be found on the VXCERN but most likely the improved versions are to be found at Mainz University. In any case the author should be contacted to ask for the most recent version.

For the following it might be useful to look into the particular command procedures to understand what files/logical units are needed for certain programs described below. Furthermore you should copy the whole directory DISK$USER:[ROEHN.ALIG] (except for TPCSIM.EXE, TPCSIM.COM, TPCRUN.COM) onto your area and set the pointers in these files to your own directories.

II. Generation of cosmics

A simple μ generator has been used [2] with GALEPH Version 2.02. The files needed for creating an executable image file (don't worry about the error messages during linking - the missing entries are not needed) and running it are:

a)	DISK$USER:[ROEHN.ALIG]MUGEN.COM	Command file used for creating the Fortran file
b)	DISK$USER:[ROEHN.ALIG]MUGEN.FOR	Fortran file generated by a)
c)	DISK$USER:[ROEHN.ALIG]COSMICS.COM	Command file to create an executable file and run the job
d)	DISK$USER:[ROEHN.ALIG]COSMICS.CARDS	Input cardfile used for steering

There are two cards in COSMICS.CARDS which are important for misalignment purposes:

a) KINE 'USER' 0. 0. 0. p1 p2 dZ ϕ prob+

p1 .. p2	momentum range of cosmics in GeV (e.g. 2. 20.)
dZ	z - range for half the TPC for generating cosmics at the top in cm (e.g. 200.)
ϕ	maximum angle of track to y-axis in rad (e.g. 0.785 = $\pi/4$)
prob+	probability of generating positive μ (e.g. 0.5)

b) IALI 0 / 10 1 1 0 99999999 dx dy dz α β γ 1

dx	alignment constant δX
dy	alignment constant δY
dz	alignment constant δZ
α, β, γ	three Euler - angles. They are correlated to $\delta\omega$, $\delta\varphi$ and $\delta\phi$ in the following way

$\alpha = \text{atan}(-\delta\varphi/\delta\omega)$ $\quad \beta = \delta\omega/\cos(\alpha)$ $\quad \gamma = \delta\phi - \alpha,$

$\delta\omega = \beta\cos(\alpha)$ $\quad \delta\varphi = -\beta\sin(\alpha)$ $\quad \delta\phi = \alpha + \gamma.$

TPCSIM is now available within GALEPH so that no separate procedure is needed for using it. Anyway it is highly recommended to use the standalone version which has been optimized for the needs of alignment: An error handler has been implemented and to save disk space events with no hits in the ITC are thrown away. Therefore an executable image and a command procedure is available (use @DISK$USER:[ROEHN.ALIG]TPCSIM to run this version of TPCSIM after you have copied and optionally changed DISK$USER:[ROEHN.ALIG]TPCRUN.CARDS).

III. Reconstruction of events and introduction of TPC imperfections

For the moment the reconstrucion is based on JULIA Version 2.19 which means HBOOK4 is used. So the histograms stored by the reconstruction cannot be used by older programs for displaying plots which use HBOOK3. It is sufficient to introduce the imperfections at this level. This saves a large amount of CPU - time because the same MC - samples can be used. The programs needed for reconstruction are:

a)	DISK$USER:[ROEHN.ALIG]TPREDA.FOR	JULIA - routines changed to implement TPC - coordinate distortions
b)	DISK$USER:[ROEHN.ALIG]COSREC.FOR	Fortran file for introduction of distortions and own reconstruction used for cosmics

c) DISK$USER:[ROEHN.ALIG]COS_REC.COM — Command file for compiling, linking (don't worry about the error messages during linking - the missing entries are not needed) and executing the reconstruction

d) DISK$USER:[ROEHN.ALIG]COS_REC.CARDS — Input card file for steering

There are three non-standard steering cards:

a) COSM φ ϕ ϕ^T δT_0 δv_d IDISCO IDEVCO(1..IDISCO)

φ, ϕ	angles of B-field relative to E-field in radians (e.g. 0.001 1.0)
ϕ^T	twist angle of the two TPC - halves in radians (e.g. 0.001)
δT_0	shift in T_0 of the TPC in cm
δv_d	relative shift of the drift velocity in the TPC
IDISCO	number of events to be displayed for debugging purposes. If IDISCO is greater than 0 the following array must be supplied
IDEVCO(1..IDISCO)	in which the numbers of the events to be displayed have to be given.

b) CUCO NT1 NT2 NI1 NI2 RESID χ^2_{TPC} χ^2_{ITC} $D_{0,max}$ P_{min} ICUTCO

NT1	minimum number of hits in TPC required (recommended NT1 > 30, NT1 = 22, NT1 = 10 for ICUTCO = 0, 1, 2)	
NT2	maximum number of hits in TPC allowed (recommended NT1 = 42, NT1 = 42, NT1 = 18 for ICUTCO = 0, 1, 2)	
NI1	minimum number of hits in ITC required (recommended 16)	
NI2	maximum number of hits in ITC allowed (recommended 16)	
RESID	maximum allowed residuals for the ITC in cm (recommended 0.05)	
χ^2_{TPC}	maximum χ^2 allowed for TPC helix fit (recommended 2.0)	
χ^2_{ITC}	maximum χ^2 allowed for ITC helix fit (recommended 2.0)	
$D_{0,max}$	maximum allowed D_0	
P_{min}	minimum demanded momentum	
ICUTCO	ICUTCO = 0 ...	no slicing of tracks at all
	ICUTCO = 1 ...	slicing tracks, so that only hits on one side of the TPC are taken into account for one track
	ICUTCO = 2 ...	as 1, but only inner sectors of the TPC are used
	ICUTCO = 3 ...	single tracks from the vertex can be reconstructed

c) REIT $T_{0,width}$ $T_{0,init}$ $T_{tolerance}$

$T_{0,width}$	width of simulated jitter in ITC in ns
$T_{0,init}$	offset of simulated jitter in ITC in ns
$T_{tolerance}$	tolerance in ns for iteration for measuring the jitter (recommended 0.1)

TPCSIM processed data can be reconstructed as well as GALEPH output.

The command file COS_REC.COM produces a data file on unit 95 where all track parameters, cuts and cut statistics are stored. This file is read by the program described below.

IV. Determination of the alignment constants

For measuring the alignment constants COSALI_MIN.FOR gives the result of the analysis using a MINUIT fit [3] differing from the old procedure [1]. It splits the TPC into two halves analysing them separately. It measures 5 alignment constants (δZ is not measured) per TPC-half. Furthermore they are interpreted as the x-and y components of the drift velocity in the TPC (induced e.g. by the ExB effect) and the twist angle as well. The true values have to be given within the MINUT steering cards. In case imperfections are used these values can be computed with the formulas given in [3]. COSALI_MIN.FOR treats the TPC as one detector in case ICUTCO = 0 for the reconstruction. So one needs:

a)	DISK$USER:[ROEHN.ALIG]COSALI_MIN.FOR	Fortran file for measuring the alignment offsets and TPC parameters
b)	DISK$USER:[ROEHN.ALIG]COSALI_MIN.COM	Command file for compiling, linking and running the program.
c)	DISK$USER:[ROEHN.ALIG]MINUIT.CARDS	Card file for steering of Minuit.

Some explanations for the MINUIT.CARDS: After the parameters have been given, you should give the true values after a blank line. They must obey the scheme:

X1	X2	X3	X4	X5	X6	X7	X8
Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8

Xi are the values for the TPC - parameters

$$(\Psi_x, \Psi_y, \delta X^{ITC}, \delta Y^{ITC}, \delta\Psi^{ITC}, \delta\omega^{ITC}, \delta\phi^{ITC}, \phi^T),$$

Yi are the pure alignment constant values for the TPC - B ($z_0<0$)

$$(\delta X^{TPCB}, \delta Y^{TPCB}, \delta\Psi^{TPCB}, \delta\omega^{TPCB}, \delta\phi^{TPCB}, 0, 0, 0)$$

Zi are the pure alignment constant values for the TPC - A ($z_0>0$)

$$(\delta X^{TPCA}, \delta Y^{TPCA}, \delta\Psi^{TPCA}, \delta\omega^{TPCA}, \delta\phi^{TPCA}, 0, 0, 0).$$

It is best to take the file MINUIT.CARDS given above and modify it as you wish to do.

V. Changes in ALEPH - software

It should be mentioned that due to the changes in the most recent versions of GALEPH (2.02), TPCSIM (2.06) and JULIA (2.19) at CERN compared to the versions used at MAINZ (GALEPH 2.01, TPCSIM 2.04, JULIA 2.17) for the studies presented in [3] the results are not identical. Furthermore different versions of GEANT give reason for additional differences. The resulting increase of the χ^2 when using TPCSIM 2.06 will be subject of further investigation.

VI. References

[1] R. W. Forty: Alignment of the ITC, ALEPH - Note 87-015
[2] Subroutine written by R. Beuselinck
[3] St. Roehn: Alignment of TPC/ITC, ALEPH - Note 88-20