Fermi National Accelerator Laboratory

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An ESME Update—v. 8.05

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Abstract

The program ESME for modeling the longitudinal degree of freedom of beam dynamics in proton synchrotrons is described in the “User’s Guide to ESME v. 8.0”^[1] released 8 March 1993. This note updates the User’s Guide to the state of the code at 15 June 93. To simplify moving the code to the various UNIX machines at Fermilab and sharing it with other laboratories, it has been decided to promote the HIGZ graphics version. A few new graphics parameters are described which have been introduced in consequence. This note also corrects minor errors and omissions in the User’s Guide and reports minor program enhancements. No errors producing wrong results have been found.

Introduction

Version 8 of ESME has been used for about six months by a few people. It has not been practical to test all option combinations, but most important features have been used in a variety of practical cases. Few true bugs have surfaced. Problems have arisen mostly from understanding the new data parameters and some slips in the User’s Guide.^[1] The documentation errors are reported in the next section of this note along with the additions resulting from some new features. No report of program errors is made because those found will not have resulted in false results. However, if one has copied v. 8 code, it would be well to get a fresh copy or at least check for changes in the routines related to plotting.

On the positive side, the improvement in the calculation of the beam-induced voltage has proved very powerful. The capability to effectively reduce numerically induced irregularity in the collective potential using a reasonable number of macroparticles has widened substantially the practicable domain for simulation. Even after reducing the number of particles by a factor of ten or so, the potential calculated by v. 8 fits that expected for a known distribution better than that calculated by versions 7.3 and earlier. Qualitatively, the results for filamented distributions look physical. Despite the added complexity of using two discretization intervals for the charge distribution in place of the single one in v. 7.32, the time savings amply repay some additional effort to get the input data right.

More than two years ago v. 7.x was installed at the CERN PS by Steve Stahl, who

converted the graphics for their HIGZ¹ package.^[2] That version returned to Fermilab and was used with small changes on our workstations (SUN, Solbourne, and SGI). It was not maintained after Steve's departure shortly thereafter, but continued to serve some users satisfactorily. When v. 8 was developed, the HIGZ related code was ignored so that the executable was available only on the Accelerator Division VAX and only the DI3000/GRAFMAKER² graphics could be used without a separate postprocessor. In response to requests for an exportable version, the HIGZ related parts have been brought up to date so that the latest code can be conditionally compiled for either graphics system.

Because computing within the Accelerator Division as well as in the wider accelerator physics community is now distributed among many different computers, it seems that the default option for graphics on the Accelerator Division VAX should be the HIGZ version. Then output will have similar appearance whether run on VAX, SGI, or whatever. Also, it may be more convenient to fix up results for publication using PAW³ on a HIGZ metafile rather than using the PVI Metafile Translator on a DI3000 metafile. Because Fermilab's HIGZ is interfaced to either DI3000 or X11, a Fermilab user can choose either type of metafile. The principal motivation for this documentation update is to inform local users of new parameters required by the HIGZ version; users of the existing SUN or CERN versions will already be familiar with these parameters. The defaults are set so that existing data sets should produce satisfactory output for the DI3000 QML driver (laser printer, landscape orientation). However, it will probably be necessary to modify the defaults for other devices.

Starting one week from the date of this note, those who use the DCL procedures USEV8 and RESMEVAX will get ESMEV8_HIGZ. If they have not read this note they may get a bit of a shock, because the output definitely looks different. The differences are mostly improvements. Although the simplex fonts look a little less polished, the whole is more legible when reduced and reproduced.

The admonition made in the User's Guide to switch to v. 8 is still valid. Anyone doing calculations dependent on the beam-induced potential is especially urged to do so promptly. Refinements will be made only in v. 8; only real blunders will be fixed in v. 7.32.

¹HIGZ is a high level interface to graphics and the ZEBRA memory management package from the CERN Program Library, entry Q120.

²DI3000 and GRAFMAKER are products of Precision Visuals Inc. DI3000 is the Laboratory's standard graphics system, but the GRAFMAKER high level interface is used only by the Accelerator Division.

³The Physics Analysis Workstation comes from the CERN Program Library, entry Q121.

Documentation Changes — Additions and Corrections

Items below are in their order of appearance in the User's Guide, TM-1835, and page references are to TM-1835.

R Command, p 10

The parameter KURVEB is used to select the form of the magnet ramp. The value KURVEB = 5 selects a parabolic segment with specified beginning, end, and final slope. In v. 7.32 and earlier the initial slope was taken from the data and the final time adjusted if necessary for consistency. This choice was awkward; a little discontinuity in the slope at the beginning of a ramp segment is less likely to cause difficulty than a change in the segment duration. Another awkward feature has been that the start and end points of the segment are specified by their kinetic energy. This choice was compatible with a Main Ring console program but is otherwise usually a nuisance. Therefore, for the majority of users who don't worry about Main Ring ramps, a cognate curve specified by initial and final momentum and final $\dot{p}$ can now be selected with KURVEB = 6. The parameters in the table below have been introduced for this curve. It should be noted that the functional dependencies (linear, parabolic, *etc.*) provided by the other KURVEB values apply to the momentum variation even though the initial and final momenta are represented in the input data by the corresponding kinetic energies.

Variable	Default		Description
	Value	Unit	
TI	0.0	s	Time of start of magnetic field ramp
TF	0.0	s	Time of end of magnetic field ramp
KURVEB	1		Magnetic field ramp from EK0I (PI) to EK0F (PF) 1 - Linear in momentum 2 - Increasing parabola in momentum, initial $\dot{p} = 0$. 3 - Biased sinusoidal 4 - Decreasing parabola in momentum, final $\dot{p} = 0$. 5 - Parabolic, specified by EK0I, EK0F, and EKFDOT 6 - Parabolic, specified by PI, PF, and PFDOT
PI	0.0	MeV/c	Initial momentum for a KURVEB = 6 ramp
PF	0.0	MeV/c	Final momentum for a KURVEB = 6 ramp
PIDOT	0.0	MeV/c/s	Initial slope for KURVEB = 6 ramp (target) ^a
PFDOT	0.0	MeV/c/s	Final slope for KURVEB = 6 ramp

^aactual value is determined by consistency with other parameters

O Command, p 17

New parameters apply only to the HIGZ version and may be completely ignored if the DI3000/GRAFMAKER version or postprocessed graphics are used.

Variable	Default		Description
	Value	Unit	
IMETA	-1		Directs graphic output: < 0 - Output is written to a HIGZ metafile 0 - Output goes to device IDEV ^a > 0 - Output to both HIGZ metafile and IDEV
XCRNR	135.	0.001	Fraction of full width of plot frame between left-hand edge and bottom left corner of plot
YCRNR	69.0	0.001	Fraction of full height of plot frame between bottom edge and bottom of plot
XAXISL	750.	0.001	Plot width as fraction of frame width
YAXISL	475.	0.001	Plot height as fraction of frame height

^acan be a DI3000 metafile if HIGZ.DI3000 is used

M and N Commands, p 26

Near the end of p. 26 of TM-1835 there are two references to SMOOTH = .TRUE.. These are vestiges of text from the v. 7.1 User's Guide. In v. 8, SMOOTH is an integer switch as indicated in the parameter table. The meaningful values are less than, equal to, and greater than zero.

Figure 4.1, p 45

The counter for the second-outermost loop is given as NCAV; the counter in the program has always been IKAV. NCAV is the input parameter which is the limit for the loop in question.

Plans

No major developments are under way. The addition of a cubic magnet ramp with an initial slope of zero is anticipated for the near future. This corresponds to the VPARAB which is used for power supply turn-on in the Main Ring. It will be indicated by KURVEB = 7 and defined by the start and end points and the final slope with the initial derivatives zero. This is the kind of minor and specialized change which would generally be handled with a private SHAZAM routine, but the facility to directly employ parameter files from the Main Ring console program may be sufficiently useful in general to warrant documented changes. It is intended to keep v. 8 stable for some time to make certain that the many

changes from v. 7.32 have not introduced subtle problems. Also, there are still new features that have only received cursory checkout so far.

The description of ESME given in the User's Guide for v. 8.0 (TM-1835) remains generally correct at v. 8.05 (15 June 93). New parameters are available for the **R** command to implement a general parabolic magnet ramp segment defined by momentum values and for the **O** command to control the appearance of graphical output from the HIGZ version of the program. Several months of use have revealed little in the way of real problems and have given very encouraging results in calculations where the beam induced voltage is important. Those looking for more background on the methods and capabilities of ESME may be interested in a recent overview^[3] in addition to the references given in the User's Guide. The biggest gap in the documentation is a discussion of the new techniques for calculation of the collective potential and the phase space flow contouring facilities. These omissions may be corrected as byproduct of a note in gestation on dynamics at transition.

References

- [1] J. MacLachlan, "User's Guide to ESME v. 8.0", Fermilab internal note TM-1835 (8 March 93)
- [2] S. Hancock, J. MacLachlan, and S. Stahl, "User's Guide to ESME version 7.3 at CERN", CERN/PS 92-31 (RF) (April 1992)
- [3] J. A. MacLachlan, "Particle Tracking in $E - \phi$ space for Synchrotron Design and Diagnosis" FERMILAB-Conf-92/333 (November 1992)