ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-MOPME021

VICKY: COMPUTER CODE UPDATE

F. Iazzourene, Elettra Sincrotrone Trieste, Trieste, Italy

Abstract

Vicky is a computer code for designing and simulating charged particle accelerators[1]. We recall mainly that Vicky is a very user friendly code, the particle motion is described by 10 parameters: four beta-functions, four alpha-functions and two phase advances, and a large variety of insertion devices, wigglers and undulators, linearly and elliptically polarized, are treated. The features include Twiss functions matching, orbit correction, tune and chromaticity adjustment, dynamic aperture and phase space tracking. The paper describes new aspects and the present status.

INTRODUCTION

Vicky is a computer code for designing and simulating charged particle accelerators. The code is written in C++. It uses the free packages QT for the online plots and the graphical user interface and IT++ for the mathematics. The present version offers the functionalities described in ref. [1], with some additions and extensions. We recall mainly that Vicky is a very user friendly code, the particle motion is described by 10 parameters: four beta-functions, four alpha-functions and two phase advances, and insertion devices, wigglers and undulators, linearly and elliptically polarized, are treated. The features include Twiss functions matching, orbit correction, tune and chromaticity adjustment, dynamic aperture and phase space tracking. The main additions and extensions are the magnetic field errors treatment and the makethin option.

INPUT FILE

The physical elements and markers are defined by statements in a form somewhat similar to the one used in madx.

The differences with madx are:

- The signs of k0l, k1 and k2l are negative when in madx they are positive and vice versa
- For the bendings, one can give either k1 either the index. Furthermore, the angles are introduced in deg and not in rad.

With respect to the version in ref.[1], the sextupoles and octupoles can be defined in two ways, for example:

- SF: sextupole, l = 0, k2l = -4.3; // thin element
- SF: sextupole, l = 0.5, k2 = -8.6; // thick element

The Magnetic Field Errors

They can be specified for all magnets by the statement:

efieldcomp, magnet name = name (or magnet type = type), order = integer, at_x = real, dknr = {dknr[0], dknr[1], dknr[2], …}, dksr = {dksr[0], dksr[1], dksr[2], …};

dknr[i] and **dksr[i]** refer to the normal and skew relative magnetic field errors, respectively, with 2i+2 poles

order defines the base component to which the relative errors refer to: 0 for dipoles, 1 for quadrupoles, 2 for sextupoles,...

at_x, in meter**,** is the horizontal position at which the magnetic fields have been measured

For example:
efieldcomp, name = B, order = 0, at_x = 20e-3, dknr = {-5.33e-06,-3.17e-04,3.037e-04,0};

Furthermore, these magnetic field errors can be systematic as above or/and random:

efieldcomp, type = quadrupole, order = 1, at_x = 20e-3, dknr = {-5.33e-06,-3.17e-04,3.037e-04,0} + {3e-06,2e-04} *gauss(2.5);

Makethin

The makethin tool converts selected thick elements into thin elements. The makethin statement is simply:

makethin, magnet name = name (or magnet type = type), n_thin = integer;

Example:
makethin, type = bending, n_thin = 100;
makethin, name = qf, n_thin = 110;

n_thin being the number of thin elements

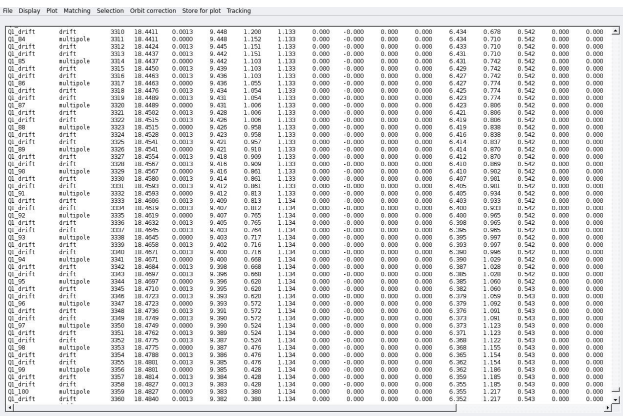
The user has nothing else to do. The bending magnets are still defined by the statement rbend or sbend with entrance and exit angles. The sliced lattice is created internally by the code, no extra file is created or needed. Each thin element is a multipole with the order and components extracted from the thick element. The edges are instead thin lens transfer matrices.

ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-MOPME021

The user is advised to compare the optics obtained without and with makethin. The suggested rule is to do makethin for one type or a specific name at a time, in order to find the optimal n_thin for each magnet or type.

PANEL

The main panel is the same. As an example, Fig.1 and Fig. 2 show the displayed optics in the text window and the plotted optics, respectively, for one Elettra ring achromat with quadrupole and bending magnets sliced to 100 thin elements.



Q1_drift	drift	3310	18.4411	0.0013	9.448	1.200	1.133	0.000	-0.000	0.000	0.000	6.434	0.678	0.542	0.000	0.000
Q1_84	multipole	3311	18.4411	0.0000	9.448	1.152	1.133	0.000	-0.000	0.000	0.000	6.434	0.710	0.542	0.000	0.000
Q1_drift	drift	3312	18.4424	0.0013	9.445	1.151	1.133	0.000	-0.000	0.000	0.000	6.433	0.710	0.542	0.000	0.000
Q1_drift	drift	3313	18.4437	0.0013	9.442	1.151	1.133	0.000	-0.000	0.000	0.000	6.431	0.710	0.542	0.000	0.000
Q1_85	multipole	3314	18.4437	0.0000	9.442	1.103	1.133	0.000	-0.000	0.000	0.000	6.431	0.742	0.542	0.000	0.000
Q1_drift	drift	3315	18.4450	0.0013	9.439	1.103	1.133	0.000	-0.000	0.000	0.000	6.429	0.742	0.542	0.000	0.000
Q1_drift	drift	3316	18.4463	0.0013	9.436	1.103	1.133	0.000	-0.000	0.000	0.000	6.427	0.742	0.542	0.000	0.000
Q1_86	multipole	3317	18.4463	0.0000	9.436	1.055	1.133	0.000	-0.000	0.000	0.000	6.427	0.774	0.542	0.000	0.000
Q1_drift	drift	3318	18.4476	0.0013	9.434	1.054	1.133	0.000	-0.000	0.000	0.000	6.425	0.774	0.542	0.000	0.000
Q1_drift	drift	3319	18.4489	0.0013	9.431	1.054	1.133	0.000	-0.000	0.000	0.000	6.423	0.774	0.542	0.000	0.000
Q1_87	multipole	3320	18.4489	0.0000	9.431	1.006	1.133	0.000	-0.000	0.000	0.000	6.423	0.806	0.542	0.000	0.000
Q1_drift	drift	3321	18.4502	0.0013	9.428	1.006	1.133	0.000	-0.000	0.000	0.000	6.421	0.806	0.542	0.000	0.000
Q1_drift	drift	3322	18.4515	0.0013	9.426	1.006	1.133	0.000	-0.000	0.000	0.000	6.419	0.806	0.542	0.000	0.000
Q1_88	multipole	3323	18.4515	0.0000	9.426	0.958	1.133	0.000	-0.000	0.000	0.000	6.419	0.838	0.542	0.000	0.000
Q1_drift	drift	3324	18.4528	0.0013	9.423	0.958	1.133	0.000	-0.000	0.000	0.000	6.416	0.838	0.542	0.000	0.000
Q1_drift	drift	3325	18.4541	0.0013	9.421	0.957	1.133	0.000	-0.000	0.000	0.000	6.414	0.837	0.542	0.000	0.000
Q1_89	multipole	3326	18.4541	0.0000	9.421	0.910	1.133	0.000	-0.000	0.000	0.000	6.414	0.870	0.542	0.000	0.000
Q1_drift	drift	3327	18.4554	0.0013	9.418	0.909	1.133	0.000	-0.000	0.000	0.000	6.412	0.870	0.542	0.000	0.000
Q1_drift	drift	3328	18.4567	0.0013	9.416	0.909	1.133	0.000	-0.000	0.000	0.000	6.410	0.869	0.542	0.000	0.000
Q1_90	multipole	3329	18.4567	0.0000	9.416	0.861	1.133	0.000	-0.000	0.000	0.000	6.410	0.902	0.542	0.000	0.000
Q1_drift	drift	3330	18.4580	0.0013	9.414	0.861	1.133	0.000	-0.000	0.000	0.000	6.407	0.901	0.542	0.000	0.000
Q1_drift	drift	3331	18.4593	0.0013	9.412	0.861	1.133	0.000	-0.000	0.000	0.000	6.405	0.901	0.542	0.000	0.000
Q1_91	multipole	3332	18.4593	0.0000	9.412	0.813	1.133	0.000	-0.000	0.000	0.000	6.405	0.934	0.542	0.000	0.000
Q1_drift	drift	3333	18.4606	0.0013	9.409	0.813	1.134	0.000	-0.000	0.000	0.000	6.403	0.933	0.542	0.000	0.000
Q1_drift	drift	3334	18.4619	0.0013	9.407	0.812	1.134	0.000	-0.000	0.000	0.000	6.400	0.933	0.542	0.000	0.000
Q1_92	multipole	3335	18.4619	0.0000	9.407	0.765	1.134	0.000	-0.000	0.000	0.000	6.400	0.965	0.542	0.000	0.000
Q1_drift	drift	3336	18.4632	0.0013	9.405	0.765	1.134	0.000	-0.000	0.000	0.000	6.398	0.965	0.542	0.000	0.000
Q1_drift	drift	3337	18.4645	0.0013	9.403	0.764	1.134	0.000	-0.000	0.000	0.000	6.395	0.965	0.542	0.000	0.000
Q1_93	multipole	3338	18.4645	0.0000	9.403	0.717	1.134	0.000	-0.000	0.000	0.000	6.395	0.997	0.542	0.000	0.000
Q1_drift	drift	3339	18.4658	0.0013	9.402	0.716	1.134	0.000	-0.000	0.000	0.000	6.393	0.997	0.542	0.000	0.000
Q1_drift	drift	3340	18.4671	0.0013	9.400	0.716	1.134	0.000	-0.000	0.000	0.000	6.390	0.996	0.542	0.000	0.000
Q1_94	multipole	3341	18.4671	0.0000	9.400	0.668	1.134	0.000	-0.000	0.000	0.000	6.390	1.029	0.542	0.000	0.000
Q1_drift	drift	3342	18.4684	0.0013	9.398	0.668	1.134	0.000	-0.000	0.000	0.000	6.387	1.028	0.542	0.000	0.000
Q1_drift	drift	3343	18.4697	0.0013	9.396	0.668	1.134	0.000	-0.000	0.000	0.000	6.385	1.028	0.542	0.000	0.000
Q1_95	multipole	3344	18.4697	0.0000	9.396	0.620	1.134	0.000	-0.000	0.000	0.000	6.385	1.060	0.542	0.000	0.000
Q1_drift	drift	3345	18.4710	0.0013	9.395	0.620	1.134	0.000	-0.000	0.000	0.000	6.382	1.060	0.543	0.000	0.000
Q1_drift	drift	3346	18.4723	0.0013	9.393	0.620	1.134	0.000	-0.000	0.000	0.000	6.379	1.059	0.543	0.000	0.000
Q1_96	multipole	3347	18.4723	0.0000	9.393	0.572	1.134	0.000	-0.000	0.000	0.000	6.379	1.092	0.543	0.000	0.000
Q1_drift	drift	3348	18.4736	0.0013	9.391	0.572	1.134	0.000	-0.000	0.000	0.000	6.376	1.091	0.543	0.000	0.000
Q1_drift	drift	3349	18.4749	0.0013	9.390	0.572	1.134	0.000	-0.000	0.000	0.000	6.373	1.091	0.543	0.000	0.000
Q1_97	multipole	3350	18.4749	0.0000	9.390	0.524	1.134	0.000	-0.000	0.000	0.000	6.373	1.123	0.543	0.000	0.000
Q1_drift	drift	3351	18.4762	0.0013	9.389	0.524	1.134	0.000	-0.000	0.000	0.000	6.371	1.123	0.543	0.000	0.000
Q1_drift	drift	3352	18.4775	0.0013	9.387	0.524	1.134	0.000	-0.000	0.000	0.000	6.368	1.122	0.543	0.000	0.000
Q1_98	multipole	3353	18.4775	0.0000	9.387	0.476	1.134	0.000	-0.000	0.000	0.000	6.368	1.155	0.543	0.000	0.000
Q1_drift	drift	3354	18.4788	0.0013	9.386	0.476	1.134	0.000	-0.000	0.000	0.000	6.365	1.154	0.543	0.000	0.000
Q1_drift	drift	3355	18.4801	0.0013	9.385	0.476	1.134	0.000	-0.000	0.000	0.000	6.362	1.154	0.543	0.000	0.000
Q1_99	multipole	3356	18.4801	0.0000	9.385	0.428	1.134	0.000	-0.000	0.000	0.000	6.362	1.186	0.543	0.000	0.000
Q1_drift	drift	3357	18.4814	0.0013	9.384	0.428	1.134	0.000	-0.000	0.000	0.000	6.359	1.185	0.543	0.000	0.000
Q1_drift	drift	3358	18.4827	0.0013	9.383	0.428	1.134	0.000	-0.000	0.000	0.000	6.355	1.185	0.543	0.000	0.000
Q1_100	multipole	3359	18.4827	0.0000	9.383	0.380	1.134	0.000	0.000	0.000	0.000	6.355	1.217	0.543	0.000	0.000
Q1_drift	drift	3360	18.4840	0.0013	9.382	0.380	1.134	0.000	0.000	0.000	0.000	6.352	1.217	0.543	0.000	0.000

Figure 1: Displayed optics along one Elettra ring achromat with makethin for both bending and quadrupole magnets.

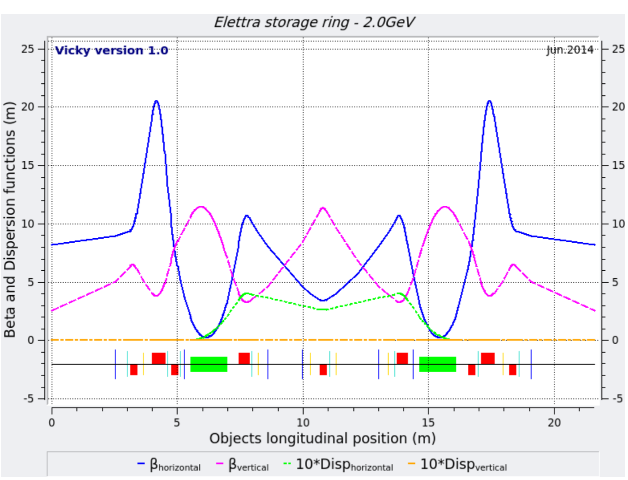


Figure 2: Plotted optics along one Elettra ring achromat with makethin for both bending and quadrupole magnets.

COMPARISON WITH OTHER CODES

During the whole development process of Vicky, a comparison has been made with the codes Racetrack[2], madx[3], ptc[4], Tracy[5] and Beta[6], according to the developed tools.

For the undulators treated as kick maps, Tracy and Beta codes have been used for comparison. The main difficulty was the fixed format of the input file and some bugs. With Tracy, the results differ, but the results were different also without undulators. The reason was that Tracy splits the quadrupoles into thin lenses.

Racetrack has been used for the undulators treated as in racetrack and for phase space and dynamic aperture tracking. The comparison with Racetrack was straightforward.

Madx and ptc have been used for the rest. The checks with madx/ptc started when madx was still under development. As the bugs got fixed, the agreement with Vicky improved. Another difficulty was with the assignment of the misalignments and magnetic field errors. Once this was clear, the comparisons got easier.

For the misalignments, the results agree well with both madx and ptc as far as one deals with the displacements along the three coordinate axes. The rotations around the horizontal and vertical axes give the same results if the rotations have the opposite sign with respect to madx. Actually, ptc does set them to opposite sign inside the code. For the rotation along the longitudinal axis, Vicky agrees with madx but not with ptc. It seems that ptc has a different definition for that rotation.

There is agreement with magnetic field errors.

Vicky agrees with ptc for tilted magnets: dipoles, quadrupoles, sextupoles and octupoles. With madx, the optics agree only for tilted bending magnets. However, the tests with tilted magnets was done when madx was under development. So, more tests are foreseen to check with the final madx version.

Optics with makethin agree very well. The chromaticities are the same if the user splits the rbend or sbend with entrance angle e1 and exit angle e2 into a multipole at entrance, an sbend without entrance and exit angles and a multipole at exit:

SE1: multipole, KnL= 0, value1=real,value2=real ;
BS: sbend,L = real, ANGLE = real,K1=real;
SE2: multipole, KnL= 0, value1=real,value2=real ;

with value1 = tan(e1)/rho for entrance angle e1,

value1 = tan(e2)/rho for exit angle e2

CONCLUSION

The code provides several treatments and tools. It's really easy to use. A lot has been done. More is foreseen. Several checks and comparisons with other codes have been done. Up to now, the results are quite satisfactory.

ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-MOPME021

However, a systematic check of Vicky final version with the final version of madx and of ptc if any, including all the treatments and tools developed so far is necessary. After that, the code will be available for the accelerator physicists community, together with a user guide.

REFERENCES

[1] F. Iazzourene, “Vicky: A Computer Code for Use in the Design and Simulation of Particle Accelerators”, IPAC’11, San Sebastian, June 2011, p. 2256 (2011); http://www.JACoW.org

[2] F. Iazzourene et all., “Racetrack user's guide, version 4.01”, Internal report, Trieste, Italy

[3] MAD team et all., “MADX user's guide”, CERN, Switzerland; http://cern.ch/mad. version madx-5.01.00

[4] E. Forest and F. Schmidt, “PTC User's Reference Manual”, Geneva, Switzerland, October 15, 2010. version madx-5.01.00

[5] Tracy code, Soleil version

[6] Beta code, Soleil and ESRF versions