

## VICKY: COMPUTER CODE UPDATE

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### 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  $k_{0l}$ ,  $k_1$  and  $k_{2l}$  are negative when in madx they are positive and vice versa
- For the bendings, one can give either  $k_1$  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,  $l = 0$ ,  $k_{2l} = -4.3$ ; // thin element
- SF: sextupole,  $l = 0.5$ ,  $k_2 = -8.6$ ; // 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.

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.

File	Display	Plot	Match	Selection	Orbit correction	Store for plot	Tracking										
Q1_0111	errft	errft	3102	18.4411	0.0013	0.446	1.200	1.133	0.000	-0.000	0.000	0.000	0.434	0.678	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4424	0.0013	0.445	1.133	1.133	0.000	-0.000	0.000	0.000	0.433	0.710	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4437	0.0013	0.444	1.133	1.133	0.000	-0.000	0.000	0.000	0.432	0.742	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4450	0.0013	0.443	1.133	1.133	0.000	-0.000	0.000	0.000	0.431	0.774	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4463	0.0013	0.442	1.133	1.133	0.000	-0.000	0.000	0.000	0.430	0.806	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4476	0.0013	0.441	1.054	1.133	0.000	-0.000	0.000	0.000	0.429	0.838	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4489	0.0013	0.440	1.054	1.133	0.000	-0.000	0.000	0.000	0.428	0.870	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4502	0.0013	0.439	1.054	1.133	0.000	-0.000	0.000	0.000	0.427	0.902	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4515	0.0013	0.438	1.054	1.133	0.000	-0.000	0.000	0.000	0.426	0.934	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4528	0.0013	0.437	0.975	1.133	0.000	-0.000	0.000	0.000	0.425	0.966	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4541	0.0013	0.436	0.975	1.133	0.000	-0.000	0.000	0.000	0.424	0.998	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4554	0.0013	0.435	0.975	1.133	0.000	-0.000	0.000	0.000	0.423	1.030	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4567	0.0013	0.434	0.896	1.133	0.000	-0.000	0.000	0.000	0.422	1.062	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4580	0.0013	0.433	0.896	1.133	0.000	-0.000	0.000	0.000	0.421	1.094	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4593	0.0013	0.432	0.817	1.133	0.000	-0.000	0.000	0.000	0.420	1.126	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4606	0.0013	0.431	0.817	1.133	0.000	-0.000	0.000	0.000	0.419	1.158	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4619	0.0013	0.430	0.817	1.133	0.000	-0.000	0.000	0.000	0.418	1.190	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4632	0.0013	0.429	0.738	1.133	0.000	-0.000	0.000	0.000	0.417	1.222	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4645	0.0013	0.428	0.738	1.133	0.000	-0.000	0.000	0.000	0.416	1.254	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4658	0.0013	0.427	0.738	1.133	0.000	-0.000	0.000	0.000	0.415	1.286	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4671	0.0013	0.426	0.659	1.133	0.000	-0.000	0.000	0.000	0.414	1.318	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4684	0.0013	0.425	0.659	1.133	0.000	-0.000	0.000	0.000	0.413	1.350	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4697	0.0013	0.424	0.659	1.133	0.000	-0.000	0.000	0.000	0.412	1.382	0.542	0.000	0.000
Q1_0111	errft	errft	3102	18.4710	0.0013	0.423	0.580	1.134	0.000	-0.000	0.000	0.000	0.411	1.414	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4723	0.0013	0.422	0.580	1.134	0.000	-0.000	0.000	0.000	0.410	1.446	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4736	0.0013	0.421	0.580	1.134	0.000	-0.000	0.000	0.000	0.409	1.478	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4749	0.0013	0.420	0.501	1.134	0.000	-0.000	0.000	0.000	0.408	1.510	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4762	0.0013	0.419	0.501	1.134	0.000	-0.000	0.000	0.000	0.407	1.542	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4775	0.0013	0.418	0.501	1.134	0.000	-0.000	0.000	0.000	0.406	1.574	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4788	0.0013	0.417	0.422	1.134	0.000	-0.000	0.000	0.000	0.405	1.606	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4801	0.0013	0.416	0.422	1.134	0.000	-0.000	0.000	0.000	0.404	1.638	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4814	0.0013	0.415	0.422	1.134	0.000	-0.000	0.000	0.000	0.403	1.670	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4827	0.0013	0.414	0.343	1.134	0.000	-0.000	0.000	0.000	0.402	1.702	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4840	0.0013	0.413	0.343	1.134	0.000	-0.000	0.000	0.000	0.401	1.734	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4853	0.0013	0.412	0.343	1.134	0.000	-0.000	0.000	0.000	0.400	1.766	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4866	0.0013	0.411	0.264	1.134	0.000	-0.000	0.000	0.000	0.399	1.798	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4879	0.0013	0.410	0.264	1.134	0.000	-0.000	0.000	0.000	0.398	1.830	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4892	0.0013	0.409	0.264	1.134	0.000	-0.000	0.000	0.000	0.397	1.862	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4905	0.0013	0.408	0.185	1.134	0.000	-0.000	0.000	0.000	0.396	1.894	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4918	0.0013	0.407	0.185	1.134	0.000	-0.000	0.000	0.000	0.395	1.926	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4931	0.0013	0.406	0.185	1.134	0.000	-0.000	0.000	0.000	0.394	1.958	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4944	0.0013	0.405	0.106	1.134	0.000	-0.000	0.000	0.000	0.393	1.990	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4957	0.0013	0.404	0.106	1.134	0.000	-0.000	0.000	0.000	0.392	2.022	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4970	0.0013	0.403	0.106	1.134	0.000	-0.000	0.000	0.000	0.391	2.054	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4983	0.0013	0.402	0.027	1.134	0.000	-0.000	0.000	0.000	0.390	2.086	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.4996	0.0013	0.401	0.027	1.134	0.000	-0.000	0.000	0.000	0.389	2.118	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5009	0.0013	0.400	0.027	1.134	0.000	-0.000	0.000	0.000	0.388	2.150	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5022	0.0013	0.399	0.027	1.134	0.000	-0.000	0.000	0.000	0.387	2.182	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5035	0.0013	0.398	0.027	1.134	0.000	-0.000	0.000	0.000	0.386	2.214	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5048	0.0013	0.397	0.027	1.134	0.000	-0.000	0.000	0.000	0.385	2.246	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5061	0.0013	0.396	0.027	1.134	0.000	-0.000	0.000	0.000	0.384	2.278	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5074	0.0013	0.395	0.027	1.134	0.000	-0.000	0.000	0.000	0.383	2.310	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5087	0.0013	0.394	0.027	1.134	0.000	-0.000	0.000	0.000	0.382	2.342	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5100	0.0013	0.393	0.027	1.134	0.000	-0.000	0.000	0.000	0.381	2.374	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5113	0.0013	0.392	0.027	1.134	0.000	-0.000	0.000	0.000	0.380	2.406	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5126	0.0013	0.391	0.027	1.134	0.000	-0.000	0.000	0.000	0.379	2.438	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5139	0.0013	0.390	0.027	1.134	0.000	-0.000	0.000	0.000	0.378	2.470	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5152	0.0013	0.389	0.027	1.134	0.000	-0.000	0.000	0.000	0.377	2.502	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5165	0.0013	0.388	0.027	1.134	0.000	-0.000	0.000	0.000	0.376	2.534	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5178	0.0013	0.387	0.027	1.134	0.000	-0.000	0.000	0.000	0.375	2.566	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5191	0.0013	0.386	0.027	1.134	0.000	-0.000	0.000	0.000	0.374	2.598	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5204	0.0013	0.385	0.027	1.134	0.000	-0.000	0.000	0.000	0.373	2.630	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5217	0.0013	0.384	0.027	1.134	0.000	-0.000	0.000	0.000	0.372	2.662	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5230	0.0013	0.383	0.027	1.134	0.000	-0.000	0.000	0.000	0.371	2.694	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5243	0.0013	0.382	0.027	1.134	0.000	-0.000	0.000	0.000	0.370	2.726	0.543	0.000	0.000
Q1_0111	errft	errft	3102	18.5256	0.0013	0.3											

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 al., “Racetrack user's guide, version 4.01”, Internal report, Trieste, Italy
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