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Beam trajectory correction by steering magnets in the code ELOP

Internal Report

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Introduction.

Method for modeling steering magnet fields by two pairs of permanent magnets (using ELOP code) was submitted in the reports at 21.07.97 and 28.07.97. The method provides means for modeling the magnetic field of the yoke in accordance with corresponding magnetic measurements. Some limits that there were in previous version of ELOP program (such as possibility to model steering in the x-direction (direction of the wiggling) only, not enough range for change along z-axis (direction of the moving)) do not exist in the new version. Also it was discovered error in analytical expressions for calculating rectangular magnet magnetic field (for some values of x it got nonphysical results).

ELOP-code modernization.

There are the following improvements in the new ELOP version now:

1. The steering magnet field is described by means of the single magnetic blocks in any rectangular direction, and it is possible to correct beam trajectory in both x and y directions now.

2. In some points integration for magnetic field expressions calculated numerically. Comparison with analytical results in the "normal" points and corresponding measurements shows a good acquiescence.

3. Range for disposition of the steering magnets along z-axis is decreased such as no limits for displacement them near wiggler on the real possible distances namely ± 1500 mm from axis symmetry of the wiggler (for trajectory correction in the injection part it matter will be necessary to look through separately).

3. The rectangular field component (B_x, B_y) on the distance more than ~ 3 apertures in both side along the z-axis is assumpted equal 0, because calculated field aspires to 0 for a little means more slow then in nature and means of the field integral is corrected corresponding.

4. For convinience in the process of simulations it was incerted possibilities to change current for each steering magnet pair, which corresponds to the determined magnetic block fields (in the option "Additional coils").

Results of the testing.

There is $B_y(z)$ for the modeling of the VH4 field configuration through 4 single magnetic blocks shown on the fig. 1. For comparison on the fig. 2 it is shown the same field from opposite steering magnet current, but described by 3 blocks for half of the symmetry plate (old version, "Magnet pairs" in the option "Additional magnets").

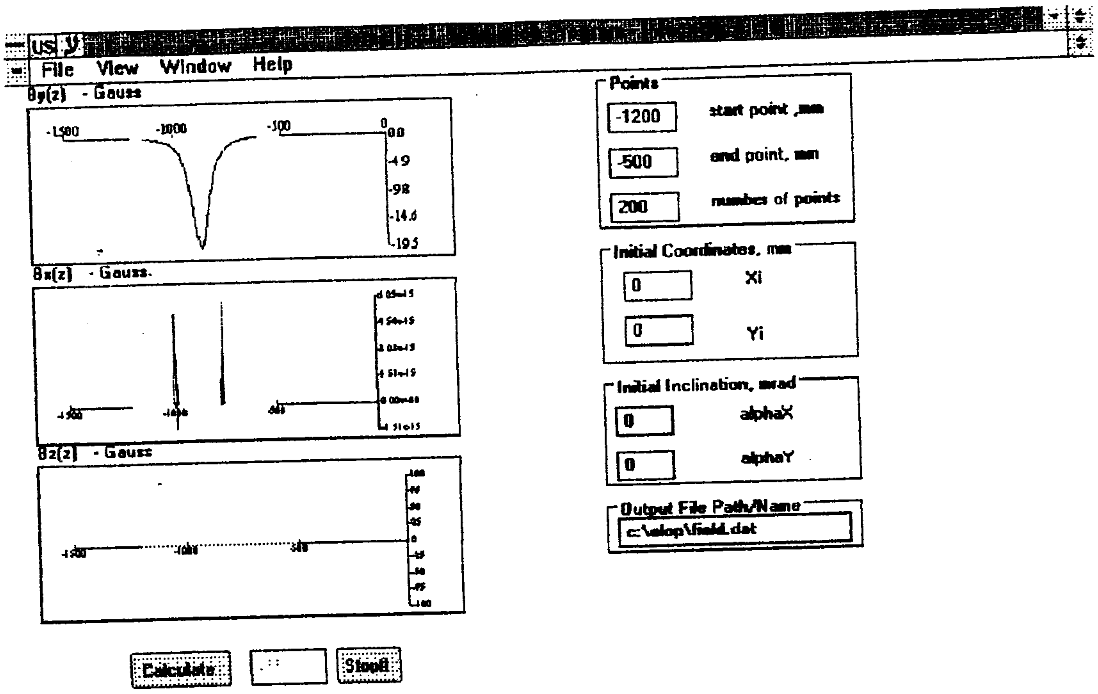


Fig.1. Magnetic field of the VH4 steering magnet modeling by "Single magnets"

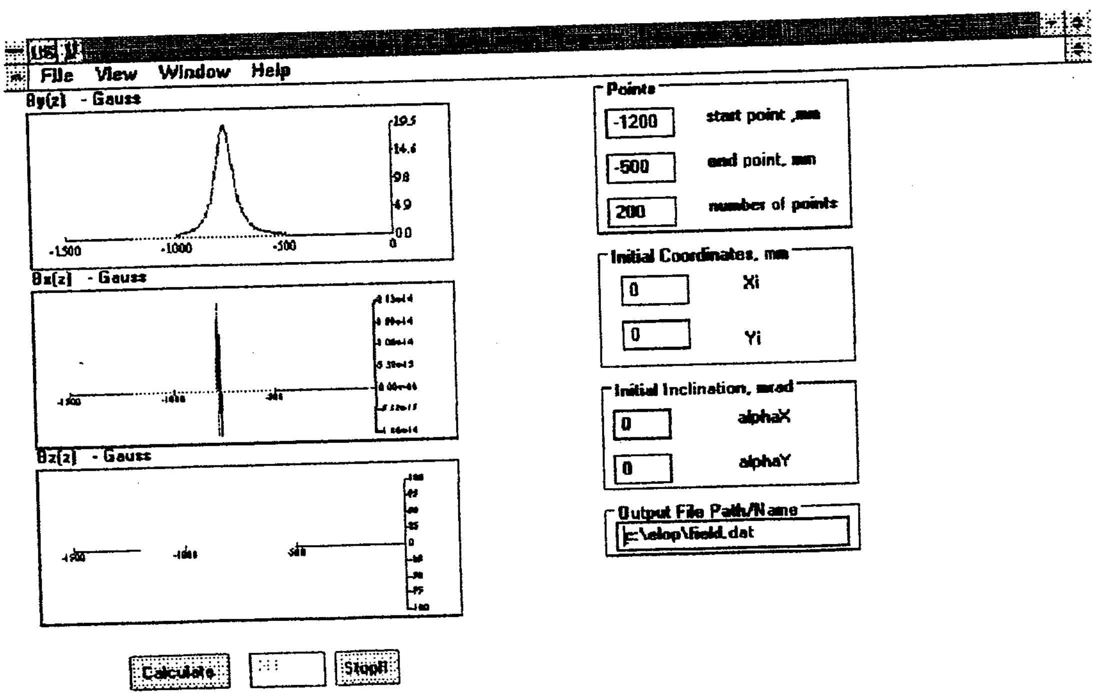


Fig.2. VH4 field modeling by "Pair of the magnets".

Table from ELOP with model geometry of the steering magnets for both cases of VH4 steering magnet modeling is on the Fig. 3. Mean of the field is shown for "Single magnets" case (type H1).

File View Window Help

Entrance magnet pairs: 3 — To edit values double-click on the cell:

	a	b	c	d	t	alpha	Bx
1	123.5	50.75	11	25.375	280	180	0
2	101.5	50.75	11	25.375	280	0	0
3	123.5	11	11	56.25	280	0	0

Exit magnet pairs: 3 — To edit values double-click on the cell:

	a	b	c	d	l	alpha	Bx
1	50.8	11.11	11.11	16.05	11.11	0	0
2	50.8	11.11	5.55	31.05	22.22	90	0
3	50.8	11.11	5.55	14.05	31.05	180	0

Single magnets: 32 — To edit values double-click on the cell:

	a	b	c	Xm	Ym	Zm	alpha	betha	Bx	Type
1	11	101.5	11	56.25	0	-880	0	0	3181.269	H1
2	11	101.5	11	-56.25	0	-880	0	0	3181.269	H1
3	123.5	11	11	0	56.25	-880	180	0	396.604	H1
4	123.5	11	11	0	-56.25	-880	180	0	396.604	H1
5	11	185	11	98	0	-625	180	0	0	H2

Fig. 3. Geometry of the VH4 steering magnets for describing both as pair of magnets both as single magnet.

Geometry of the steering magnets for correction beam trajectory near wiggler is on the Fig. 4 and Table 1.

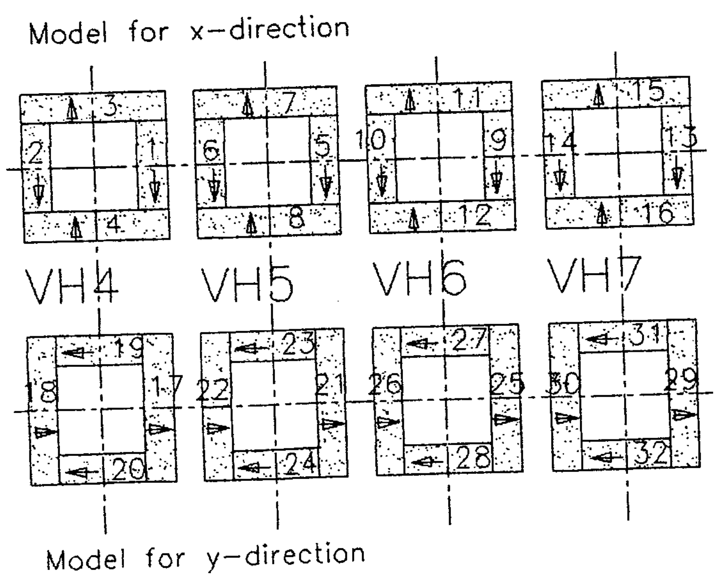


Fig. 4. Structure of the modeling magnet blocks.

Table 1.

N	a, mm	b, mm	c, mm	x_m, mm	y_m, mm	z_m, mm	alpha	betha	B_s/1A Gs/A	Type
1.	11	101.5	11	56.25	0	-880	0	0	2175.23	H4
2.	11	101.5	11	-56.25	0	-880	0	0	2175.23	H4
3.	123.5	11	11	0	56.25	-880	180	0	271.18	H4
4.	123.5	11	11	0	-56.25	-880	180	0	271.18	H4
5.	11	185	11	98	0	-625	0	0	6654.53	H5
6.	11	185	11	-98	0	-625	0	0	6654.53	H5
7.	207	11	11	0	98	-625	180	0	1189.17	H5
8.	207	11	11	0	-98	-625	180	0	1189.17	H5
9.	12	193	12	102.5	0	600	0	0	1795.59	H6
10.	12	193	12	-102.5	0	600	0	0	1795.59	H6
11.	217	12	12	0	102.5	600	180	0	236.83	H6
12.	217	12	12	0	-102.5	600	180	0	236.83	H6
13.	11	101.5	11	56.25	0	995	0	0	2175.23	H7
14.	11	101.5	11	-56.25	0	995	0	0	2175.23	H7
15.	123.5	11	11	0	56.25	995	180	0	271.18	H7
16.	123.5	11	11	0	-56.25	995	180	0	271.18	H7
17.	123.5	11	11	56.25	0	-880	0	-90	271.18	V4
18.	123.5	11	11	-56.25	0	-880	0	-90	271.18	V4
19.	11	101.5	11	0	56.25	-880	0	90	2175.23	V4
20.	11	101.5	11	0	-56.25	-880	0	90	2175.23	V4
21	207	11	11	98	0	-625	0	-90	1189.17	V5
22	207	11	11	-98	0	-625	0	-90	1189.17	V5
23	11	185	11	0	98	-625	0	90	6654.53	V5
24	11	185	11	0	-98	-625	0	90	6654.53	V5
25	217	12	12	102.5	0	600	0	-90	236.83	V6
26	217	12	12	-102.5	0	600	0	-90	236.83	V6
27	12	193	12	0	102.5	600	0	90	1795.59	V6
28	12	193	12	0	-102.5	600	0	90	1795.59	V6
29.	101.5	11	11	56.25	0	995	0	-90	271.18	V7
30.	101.5	11	11	-56.25	0	995	0	-90	271.18	V7
31.	11	123.5	11	0	56.25	995	0	90	2175.23	V7
32.	11	123.5	11	0	-56.25	995	0	90	2175.23	V7

Comments for Table 1.

1. a - the size of the magnet block along x-axis in the own coordinate system;
   b - the size along y-axis;
   c - The size along z - axis;
   x_m, y_m, z_m - coordinates of each block center relatively to center of the wiggler;
   alpha - angle of turn own y - axis around x of the main coordinate system;
   betha - angle of turn own y - axis around z of the main coordinate system.
2. z_m - coordinates for steering magnets was changing and these data are lead for tests only. Now their values are: z_m(VH4)=5653mm, z_m(VH5)=5904mm, z_m(VH6)=7263mm, z_m(VH7)=7521mm.

The example of the using ELOP for simulated particle trajectory correction by two pairs of the steering magnets VH4-VH5 (distance between them 255mm) and VH6-VH7 (distance 395mm) for case when initial and final deflections of the particle in x- and y- directions from z-axis are 10mm is led on the Fig. 5.

Means of steering magnet currents for parallel carrying (Fig.5) are follow: I=1.463A (for H4,V4), I=0.839A (for H5, V5), I=1.861A (for H6, V6), I=0.960A (for H7, V7).

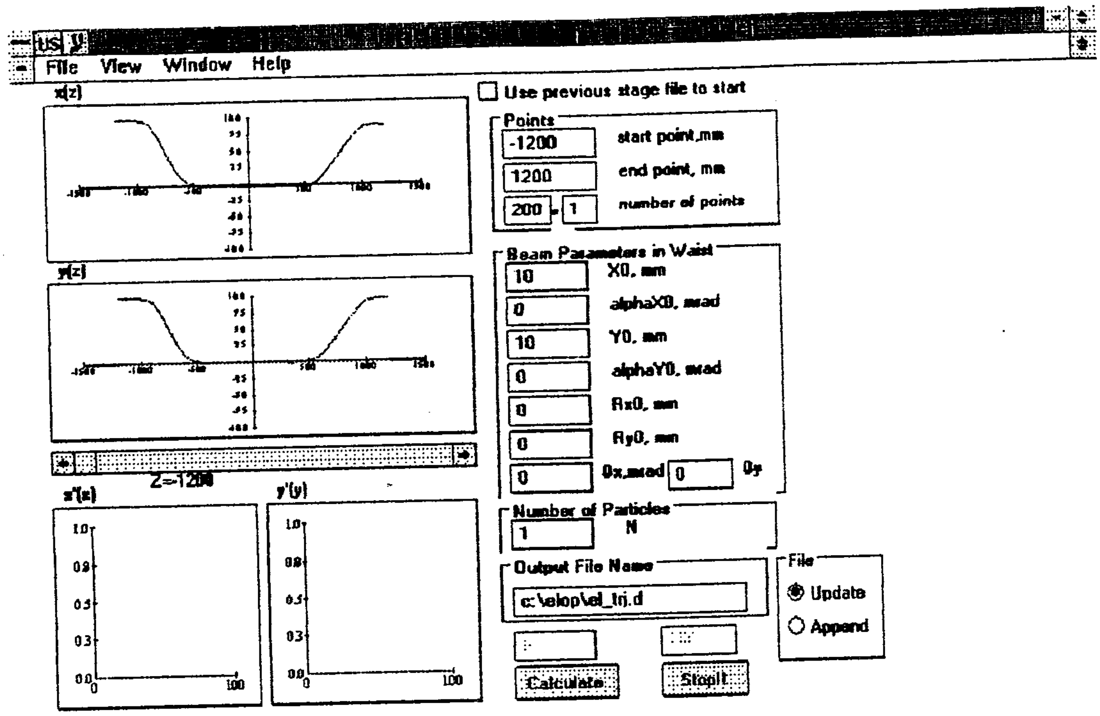
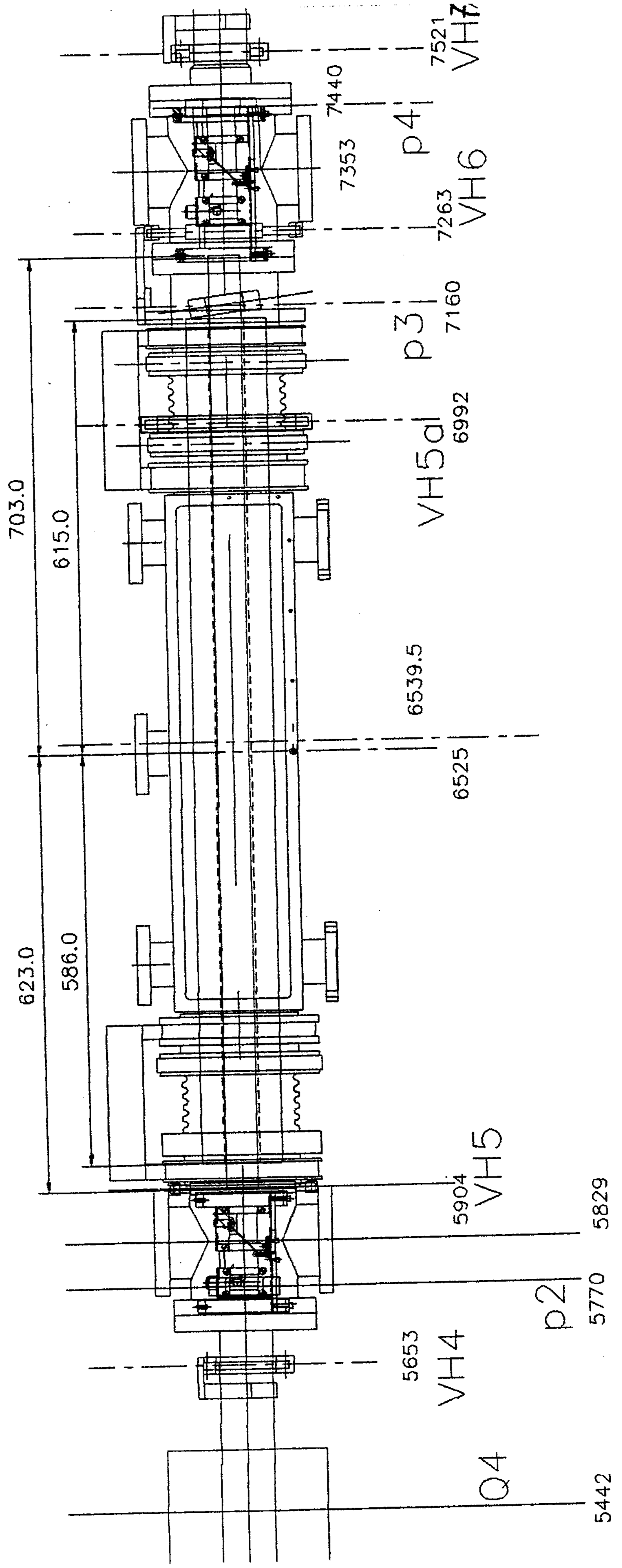


Fig.5. Double parallel carrying of beam trajectory by two pair steering magnets for the x- and y- direction with data from Table 1.

Conclusion.

The new options are input in the code ELOP such as “Single magnet” (in the section “Additional magnets”) with corresponding it “Steering UCLA-type coils” (in the section “Additional coils”), that take possibilities to simulate beam dynamic in the FEL with steering magnets of any configurations.



7521
VH7
7440
p4
7353
VH6
7263
7160
p3
6992
VH5a
703.0
615.0
6539.5
6525
623.0
586.0
VH5
5904
5829
5770
p2
5653
VH4
Q4
5442