



Version 9.10.296 from 06/02/2016

The 2nd order approximation equations in C-format were provided by **Robert Hipple** (Department of Physics and Astronomy, Michigan State University) based on **H.Wolnick**'s work NIM 34 (1965) 213-221

- 2nd order settings for already existed configuration
- Comparison between COSY & LISE calculations for electric dipoles
- Using 2nd order electrostatic dipoles in EMMA @ TRIUMF
- Using 2nd order electrostatic dipoles in SHELS @ FLNR/JINR
- Outlook





C1 Electrostatic Dipole Settings Optical block properties and data Section-Element construction property Senatation plane ? S-block (Section) C C E-block (Element) Horizontal 📀 🔿 Vertical Calculate the Values using Setting Charge state for the Nock (Z-Q) 84 the Setting fragment from • E (electric field) 801.16 + KV/m Ð tuning C U (voltage) ♦ <u>C</u>ut(Slite) & Acceptances 160.23 K٧ D, D22_1 C Electric rigidity 3.7695 MJ/C Optica matrix 66 Tweak 1.34 % C Magnetic rigidity 0.72379 + Tm Calculate other General setting of block ₽ (corresponds to the setting fragment) optic blocks Electrostatic Dipole Constants Advanced Elec.Dipole settings for extened configurations Distance between 0.2 m Bend type: Bt (m) 60 Matrix calculations plates (gap) = Cylindrical INF Calculate 2nd order Bend Sector matrix elements 4.705 Radius (r0) = 4.705 m C Spherical Automatically recalculate the ✓ matrix, when LISE++ has Angle = -8 deg C Toroidal changed the block rigidity Length = 0.6569 m Allow remote matrices Show ED Scheme calculation Important: Selection [X/D] in this block by Electric 🗸 ОК ? Help X Cancel rigidity, where D = d(Erho)/(Erho)

1st step: set "checked" the 2nd order box





2nd step: click "Matrix calculations" button





COSY

"Cylindrical" type; Radius = 1 m; Angle = 20 deg

LISE

"ElecDipole' Block: Matrices: "LOCAL Matrices: "LOCAL" "ElecDipole' transport format [cm-mrad] transport format [cm-mrad] * TRANSFORM 1 * * TRANSFORM 1 * 1 [X]: 2 [T]: 3 [Y]: 4 [F]: 5 [L]: 6 [D]: +8.8064e-01 +3.3510e-02 0 +1.1936e-01 +8.8073e-01 +3.3510e-02 X] T1 0 n 0 +1.1927e-01 -6.6995e+00 +8.8064e-01 0 0 0 +6.6995e+00 -6.6943e+00 +8.8073e-01 0 0 +6.6943e+00 n +1.0000e+00 0 0 +3.4910e-02 0 0 +1.0000e+00 +3.4910e-02 0 0 n n 0 Π 0 +1.0000e+00 0 0 0 0 0 +1.0000e+00 0 n -6.6995e-01 -1.1940e-02 0 +1.0000e+00 -2.8000e-02 -2.7950e-02 0 L -6.6943e-01 -1.1930e-02 0 0 +1.0000e+00 Ō ñ ñ Π 0 +1.0000e+00 bj Ω Ω Ω Ω Ω +1.0000e+00 * TRANSFORM 2 * * TRANSFORM 2 * -2.8189e-03 -2.8145e-03 1: 2 : 1 +5.7678e-04 +5.1381e-06 +5.7693e-04 2 +5.1394e-06 3 : 1 1 1 1 0 0 n 3 : 0 0 -5.9697e-06 4: 0 0 0 4 0 0 0 -5.9698e-06 5: 0 0 0 0 0 0 0 n 0 0 6 : +5.6350e-03 +9.3310e-05 0 Π Ō -1.6237e-03 +5.6290e-03 0 +9.3219e-05 0 0 -1.6231e-03 222222 1: -8.9888e-02 -3.0744e-02 2 : -5.3350e-05 -4.3966e-03 2 -1.0955e-03 -3.4837e-043: 0 0 0 3: 0 0 0 4: 0 0 0 -3.3506e-04 -3.3507e-04 4 : 0 0 0 0 0 5 : n 0 0 0 5 : 0 0 0 0 +1.5725e-01 +4.3938e-03 0 0 -1.2329e-01 6 : +1.0955e-03 Ō Ō -9.7759e-02 6: +1.9537e-01 0 3 3 1: 0 0 1: 2: 0 Ω 2 : 0 0 3 3 : n 0 Π 3 : Π Π 0 +6.7013e-04 +1.1939e-05 0 0 333 4 . +6.7015e-04 +1.1939e-05 4: 0 Π 5: 0 0 0 n 5 : 0 0 0 0 6 : 0 Ο 0 +2.8004e-05 0 0 6: 0 0 0 +2.7982e-05 0 0 1: 0 0 1: 2 : 0 0 2 0 0 3 : 0 0 0 3 0 0 0 4 : -1.1936e-03 +3.3506e-04 0 0 0 0 0 4 0 0 5 : 0 0 0 0 0 0 0 5 0 0 Ō Ō 0 0 +1.1936e-03 6 : 0 Ō Ō 6 0 Π 0 5555555 1: Π 1: -6.0224e-03 2 : 0 0 2 : -3.3386e-04 -2.0081e-05 3: 0 0 0 3: Ω Ω 0 0 0 0 4: 0 4: Π Π 0 -1.6054e-05 5: 0 ō ō 0 0 0 0 5: Π Π Π 0 ō ō ō 0 6 : 0 6: +5.3647e-03 -2.3688e-05 0 0 0 +3.8585e-04





"Cylindrical" type; Radius = 4 m; Angle = 20 deg

LISE

COSY

Block: "ElecDipole" Matrices: "LOCAL"						: "E	lecDipole" M	Matrices: "LOC	Ses: "LOCAL" transport format [on mod]				
transport format [cm-mrad]								- TRANCEORN 1		tran	sport format	[Cm-mrad]	
1 [X]: 2 [T]: 3 [Y]: 4 [F]: 5 [L]: 6 [D]:	+8.8064e-01 -6.6995e+00 0 -6.6995e-01 0	* 1KANSFORM 1 +3.3510e-02 +8.8064e-01 0 -1.1940e-02 0	* 0 +1.0000e+00 0 0	0 0 +3.4910e-02 +1.0000e+00 0 0	0 0 0 +1.0000e+00 0	+1.1936e-01 +6.6995e+00 0 -2.8000e-02 +1.0000e+00	K]: T]: V]: F]: L]: D]:	+8.8073e-01 -6.6943e+00 0 -6.6943e-01 0	* 1RANSFORM 1 +3.3510e-02 +8.8073e-01 0 -1.1930e-02 0	0 0 +1.0000e+00 0 0	0 0 +3.4910e-02 +1.0000e+00 0 0	0 0 0 +1.0000e+00 0	+1.1927e-01 +6.6943e+00 0 -2.7950e-02 +1.0000e+00
* TRANSFORM 2 *									* TRANSFORM 2				
1 1: 1 2: 1 3: 1 4: 1 5: 1 6:	-2.8189e-03 +5.7678e-04 0 0 +5.6350e-03	+5.1381e-06 0 0 0 +9.3310e-05	0 0 0 0	-5.9697e-06 0 0	0 0	-1.6237e-03	1: 2: 3: 4: 5: 6:	-2.8145e-03 +5.7693e-04 0 0 +5.6290e-03	+5.1394e-06 0 0 +9.3219e-05	0 0 0 0	-5.9698e-06 0 0	0 0	-1.6231e-03
2 1: 2 2: 2 3: 2 4: 2 5: 2 6:	-8.9888e-02 -4.3966e-03 0 0 +1.5725e-01	-5.3350e-05 0 0 0 +4.3938e-03	0 0 0 0	-3.3506e-04 0 0	0	-1.2329e-01	1: 2: 3: 4: 5: 6:	-3.0744e-02 -1.0955e-03 0 0 +1.9537e-01	-3.4837e-04 0 0 0 +1.0955e-03	0 0 0 0	-3.3507e-04 0 0	0 0	-9.7759e-02
3 1: 3 2: 3 3: 3 4: 3 5: 3 6:	0 0 +6.7013e-04 0 0	0 0 +1.1939e-05 0 0	0 0 0 0	0 0 +2.8004e-05	0 0	0	1: 2: 3: 4: 5: 6:	0 0 +6.7015e-04 0 0	0 0 +1.1939e-05 0 0	0 0 0 0	0 0 +2.7982e-05	0	0
4 1: 4 2: 4 3: 4 4: 4 5: 4 6:	0 0 -1.1936e-03 0 0	0 0 +3.3506e-04 0	0 0 0 0	0 0 +1.1936e-03	0 0	0	1: 2: 3: 4: 5: 6:	 0 0 0 0 0 0	0 0 0 0 0	0 0 0 0	0 0 0	0 0	0
5 1: 5 2: 5 3: 5 4: 5 5: 5 6:	0 0 0 0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0	0	1: 2: 3: 4: 5: 6:	-6.0224e-03 -3.3386e-04 0 0 0 +5.3647e-03	-2.0081e-05 0 0 0 -2.3688e-05	0 0 0 0	-1.6054e-05 0 0	0 0	+3.8585e-04





"Spherical" type; Radius = 4 m; Angle = 45 deg

LISE

COSY

			217.0				-1	-Di-1-9 3	M-1	- 1 T #				
Slock: "ElecDipole" Matrices: "LOCAL" transport format [cm						[cm-mrad]	CK: "Ele	schibole. 1	Matrices: "LOC	transport format [cm-mrad]				
* TRANSFORM 1 *								* TRANSFORM 1 *						
1 [X]: 2 [T]: 3 [Y]: 4 [F]: 5 [L]: 6 [D]:	+7.0717e-01 -1.7674e+00 0 -1.4141e+00 0	+2.8285e-01 +7.0717e-01 0 -2.3429e-01 0	0 0 +7.0711e-01 -1.7678e+00 0 0	0 0 +2.8284e-01 +7.0711e-01 0 0	0 0 0 +1.0000e+00 0	+2.3429e+00 +1.4141e+01 0 -1.2524e+00 +1.0000e+00	[X]: [T]: [Y]: [F]: [L]: [D]:	+7.0717e-01 -1.7674e+00 0 -1.4141e+00 0	+2.8285e-01 +7.0717e-01 0 -2.3429e-01 0	0 0 +7.0711e-01 -1.7678e+00 0 0	0 0 +2.8284e-01 +7.0711e-01 0 0	0 0 0 +1.0000=+00 0	+2.3429e+00 +1.4141e+01 0 -1.2524e+00 +1.0000e+00	
* TRANSFORM 2 *								* TRANSFORM 2 *						
1 1: 1 2: 1 3: 1 4: 1 5: 1 6:	-1.2502e-03 +1.0000e-03 0 0 +1.9997e-02	+8.2843e-05 0 0 +3.3133e-03	+2.5889e-04 +2.0711e-04 0 0	-1.0000e-04 0 0	0 0	-2.1418e-02	1: 2: 3: 4: 5: 6:	-1.2498e-03 +1.0001e-03 0 0 +1.9998e-02	+8.2851e-05 0 0 +3.3133e-03	+2.5896e-04 +2.0712e-04 0	-1.0000e-04 0 0	0 0	-2.1421e-02	
2 1: 2 2: 2 3: 2 4: 2 5: 2 6:	-5.0031e-02 -7.0730e-03 0 0 +1.9990e-01	-8.2863e-04 0 0 +5.6557e-02	+9.1533e-04 +1.7678e-03 0 0	-5.0001e-04 0 0	0 0	-1.9997e-01	1: 2: 3: 4: 5: 6:	0 0 0 0 +7.0698e-02	-7.0712e-04 0 0 0 -1.1922e-06	+9.1571e-04 +1.7679e-03 0 0	-5.0000e-04 0 0	0	-2.1212e-01	
3 1: 3 2: 3 3: 3 4: 3 5: 3 6:	0 0 -5.1780e-04 +1.2071e-03 0 0	0 -2.0711e-04 +2.0000e-04 0 0	0 0 0 +4.1417e-03	0 0 +1.6567e-03	0	0	1: 2: 3: 4: 5: 6:	0 0 -5.1766e-04 +1.2071e-03 0 0	0 -2.0709e-04 +2.0001e-04 0 0	0 0 0 +4.1417e-03	0 0 +1.6567e-03	0 0	0	
4 1: 4 2: 4 3: 4 4: 4 5: 4 6:	0 0 +2.0708e-02 -4.9995e-03 0 0	0 -8.2846e-03 +2.0001e-03 0 0	0 0 0 +2.4997e-02	0 0 +9.9990e-03	0	0	1: 2: 3: 4: 5: 6:	0 0 +4.4203e-03 -7.3210e-04 0 0	0 +7.3237e-04 +3.0634e-08 0 0	0 0 +3.5352e-02	0 0 +5.8574e-03	0 0	0	
5 1: 5 2: 5 3: 5 4: 5 5: 5 6:	0 0 0 0 0 0 0	0 0 0 0 0	0 0 0 0				1: 2: 3: 4: 5: 6:	-1.8747e-03 -1.4999e-03 0 0 +1.7175e-03	-2.6567e-04 0 0 0 -2.0584e-03	-1.1426e-03 -8.5730e-05 0	-1.0000e-04 0 0	0 0	+1.2124e-02	





http://lise.nscl.msu.edu/9_10/EMMA.pdf



The new version with 2nd order electrostatic dipoles :

http://lise.nscl.msu.edu/9 10/ED/EMMA 2016.lpp

Or in the LISE** package "files\examples\TRIUMF\EMMA_2016.lpp"



Using 2nd order electrostatic dipoles in EMMA @ TRIUMF



NIM A544 (2005) 565



LISE++ v.9.10.207

LISE++ v.9.10.296



2nd order

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2nd order





NIM A544 (2005) 565

LISE⁺⁺ v.9.10.296

2nd order



Fig. 4. Calculated spatial focus of EMMA, showing rays corresponding to a single mass emitted from the target with angles of $0, \pm 1.5^{\circ}$, and $\pm 3^{\circ}$ in the vertical and horizontal directions. The dominant geometric aberration in the dispersive direction, proportional to the square of the horizontal angle, is evident in the horizontal extent of the final focus.

2nd order





NIM A544 (2005) 565

LISE++ v.9.10.296



Fig. 2. Calculated mass focus of EMMA, showing rays corresponding to 9 adjacent masses emitted from the target with vertical angles of -2° , 0° , and 2° . At the focal plane, the 9 masses are seen to be dispersed horizontally and focussed vertically. Angular focussing in the horizontal direction is shown in Fig. 4.



2nd order

2nd order





v.9.8.166 from 11/23/14

http://lise.nscl.msu.edu/9_8/SHELS/ SHELSinLISE.pdf





To find out why the difference between H.Wolnik (used in LISE⁺⁺) and COSY calculations for $\theta/^{**} \& \phi/^{**}$ elements