



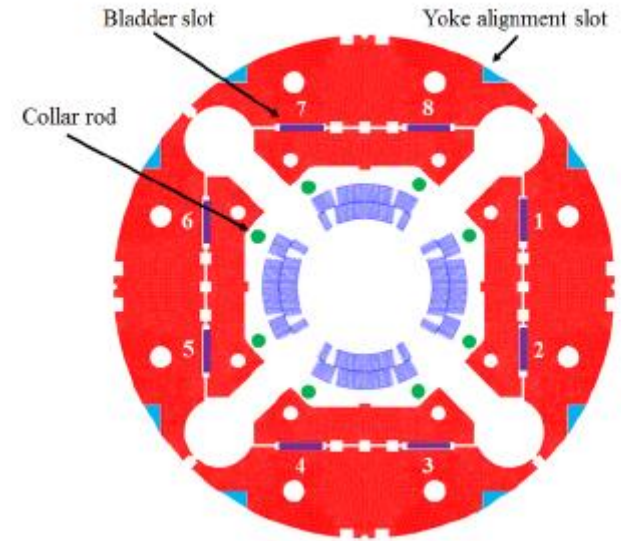
Symmetry rules in a quadrupole

Susana Izquierdo Bermudez



Magnetic shimming table

- When we look at a magnet from the connection side with a shim in bladder 1, from the non-connection side the shim would be in slot 6
- Harmonics that change sign:
 - b_5, b_9, \dots
 - a_6, a_{10}, \dots
 - b_3, b_7, \dots
 - a_4, a_8, \dots
- Harmonics that do not change sign:
 - a_5, a_9, \dots
 - b_6, b_{10}, \dots
 - a_3, a_7, \dots
 - b_4, b_8, \dots



$n = 1, 5, 9, \dots$

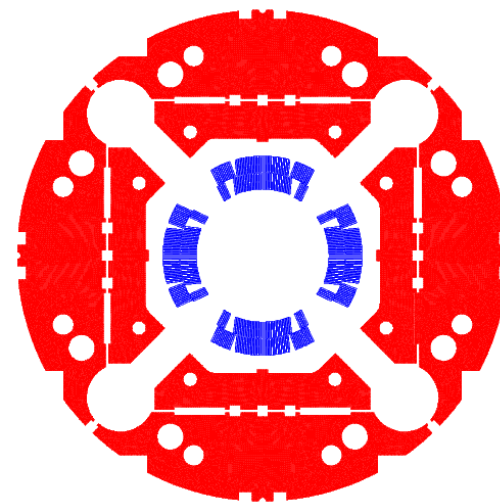
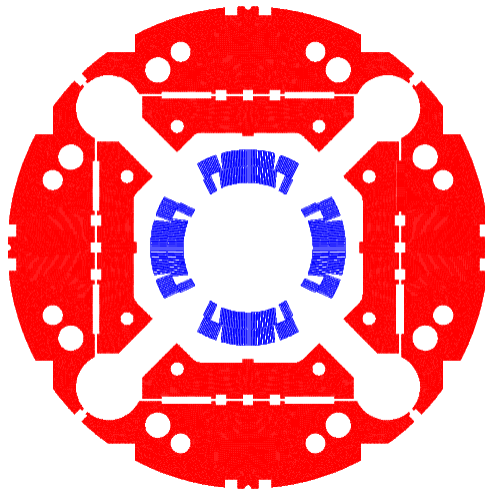
$n = 2, 6, 10, \dots$

$n = 3, 7, 11, \dots$

$n = 4, 8, 12, \dots$

Shim	b_{4n+1}	a_{4n+1}	$b_{2(2n+1)}$	$a_{2(2n+1)}$	b_{4n+3}	a_{4n+3}	$b_{2(2n+2)}$	$a_{2(2n+2)}$
1	$+ b_{4n+1}$	$+ a_{4n+1}$	$+ b_{2(2n+1)}$	$+ a_{2(2n+1)}$	$+ b_{4n+3}$	$+ a_{4n+3}$	$+ b_{2(2n+2)}$	$+ a_{2(2n+2)}$
2	$+ b_{4n+1}$	$- a_{4n+1}$	$+ b_{2(2n+1)}$	$- a_{2(2n+1)}$	$+ b_{4n+3}$	$- a_{4n+3}$	$+ b_{2(2n+2)}$	$- a_{2(2n+2)}$
3	$+ a_{4n+1}$	$- b_{4n+1}$	$+ b_{2(2n+1)}$	$+ a_{2(2n+1)}$	$- a_{4n+3}$	$+ b_{4n+3}$	$- b_{2(2n+2)}$	$- a_{2(2n+2)}$
4	$- a_{4n+1}$	$- b_{4n+1}$	$+ b_{2(2n+1)}$	$- a_{2(2n+1)}$	$+ a_{4n+3}$	$+ b_{4n+3}$	$- b_{2(2n+2)}$	$+ a_{2(2n+2)}$
5	$- b_{4n+1}$	$- a_{4n+1}$	$+ b_{2(2n+1)}$	$+ a_{2(2n+1)}$	$- b_{4n+3}$	$- a_{4n+3}$	$+ b_{2(2n+2)}$	$+ a_{2(2n+2)}$
6	$- b_{4n+1}$	$+ a_{4n+1}$	$+ b_{2(2n+1)}$	$- a_{2(2n+1)}$	$- b_{4n+3}$	$+ a_{4n+3}$	$+ b_{2(2n+2)}$	$- a_{2(2n+2)}$
7	$- a_{4n+1}$	$+ b_{4n+1}$	$+ b_{2(2n+1)}$	$+ a_{2(2n+1)}$	$+ a_{4n+3}$	$- b_{4n+3}$	$- b_{2(2n+2)}$	$- a_{2(2n+2)}$
8	$+ a_{4n+1}$	$+ b_{4n+1}$	$+ b_{2(2n+1)}$	$- a_{2(2n+1)}$	$- a_{4n+3}$	$- b_{4n+3}$	$- b_{2(2n+2)}$	$+ a_{2(2n+2)}$

Cross check with ROXIE that the table is correct



MAIN FIELD (T) -6.621048
 MAGNET STRENGTH (T/(m⁽ⁿ⁻¹⁾)) -132.4210

NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	4.36960	b 2:	10000.00000	b 3:	1.79120
b 4:	0.59399	b 5:	0.16432	b 6:	-2.05554
b 7:	0.01454	b 8:	0.00377	b 9:	0.00079
b10:	-0.11120	b11:	0.00010	b12:	0.00003
b13:	0.00000	b14:	-0.87175	b15:	0.00000
b16:	-0.00000	b17:	-0.00000	b18:	-0.26186
b19:	-0.00000	b20:	-0.00000	b	

SKREW RELATIVE MULTIPOLES (1.D-4):

a 1:	6.25126	a 2:	2.15697	a 3:	0.10507
a 4:	-0.25994	a 5:	-0.10996	a 6:	-0.04119
a 7:	-0.01638	a 8:	-0.00706	a 9:	-0.00201
a10:	-0.00061	a11:	-0.00022	a12:	-0.00010
a13:	-0.00003	a14:	-0.00001	a15:	-0.00000
a16:	-0.00000	a17:	-0.00000	a18:	-0.00000
a19:	-0.00000	a20:	-0.00000	a	

MAIN FIELD (T) -6.621047
 MAGNET STRENGTH (T/(m⁽ⁿ⁻¹⁾)) -132.4209

NORMAL RELATIVE MULTIPOLES (1.D-4):

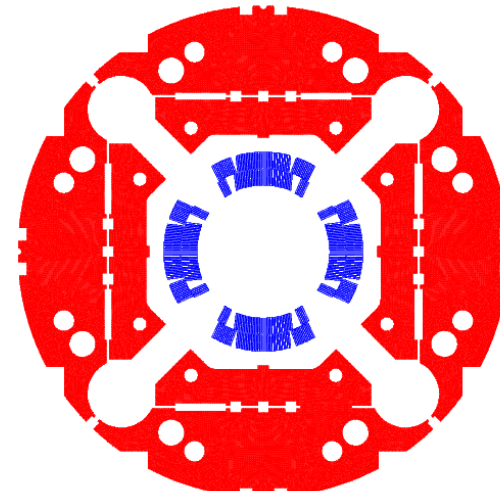
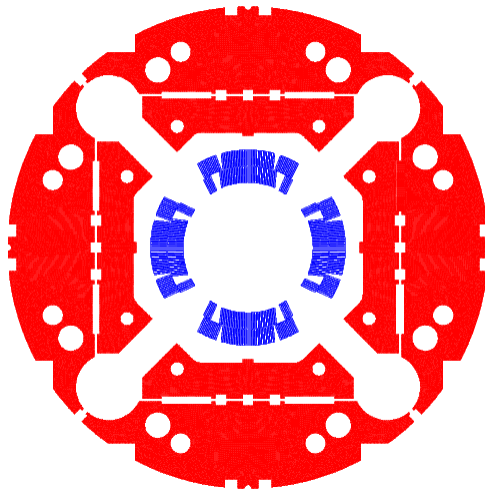
b 1:	4.35701	b 2:	10000.00000	b 3:	1.78962
b 4:	0.59747	b 5:	0.16204	b 6:	-2.05539
b 7:	0.01442	b 8:	0.00382	b 9:	0.00077
b10:	-0.11122	b11:	0.00010	b12:	0.00002
b13:	0.00000	b14:	-0.87175	b15:	0.00000
b16:	-0.00000	b17:	-0.00000	b18:	-0.26186
b19:	-0.00000	b20:	-0.00000	b	

SKREW RELATIVE MULTIPOLES (1.D-4):

a 1:	-6.27012	a 2:	-2.16049	a 3:	-0.10799
a 4:	0.25888	a 5:	0.11180	a 6:	0.04077
a 7:	0.01656	a 8:	0.00693	a 9:	0.00206
a10:	0.00059	a11:	0.00022	a12:	0.00010
a13:	0.00003	a14:	0.00001	a15:	0.00000
a16:	0.00000	a17:	0.00000	a18:	0.00000
a19:	0.00000	a20:	0.00000	a	

SURFACE OF ALL FEM-ELEMENTS (MM**2) 133326.3290

Cross check with ROXIE that the table is correct



MAIN FIELD (T) -6.621048
 MAGNET STRENGTH (T/(m^(n-1))) -132.4210

NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	4.36960	b 2:	10000.00000	b 3:	1.79120
b 4:	0.59399	b 5:	0.16432	b 6:	-2.05554
b 7:	0.01454	b 8:	0.00377	b 9:	0.00079
b10:	-0.11120	b11:	0.00010	b12:	0.00003
b13:	0.00000	b14:	-0.87175	b15:	0.00000
b16:	-0.00000	b17:	-0.00000	b18:	-0.26186
b19:	-0.00000	b20:	-0.00000	b	

SKEW RELATIVE MULTIPOLES (1.D-4):

a 1:	6.25126	a 2:	2.15697	a 3:	0.10507
a 4:	-0.25994	a 5:	-0.10996	a 6:	-0.04119
a 7:	-0.01638	a 8:	-0.00706	a 9:	-0.00201
a10:	-0.00061	a11:	-0.00022	a12:	-0.00010
a13:	-0.00003	a14:	-0.00001	a15:	-0.00000
a16:	-0.00000	a17:	-0.00000	a18:	-0.00000
a19:	-0.00000	a20:	-0.00000	a	

MAIN FIELD (T) -6.621047
 MAGNET STRENGTH (T/(m^(n-1))) -132.4209

NORMAL RELATIVE MULTIPOLES (1.D-4):

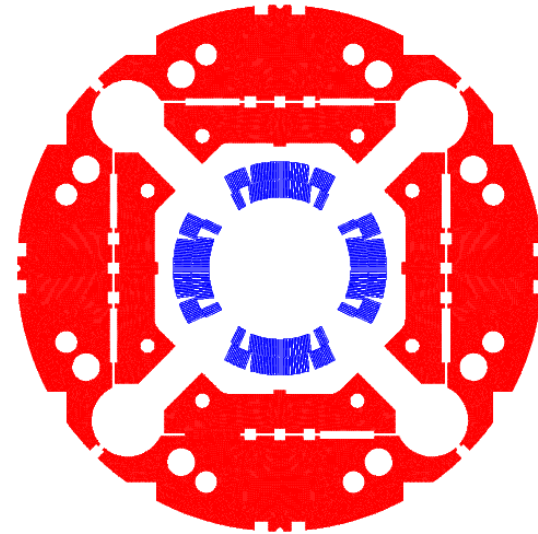
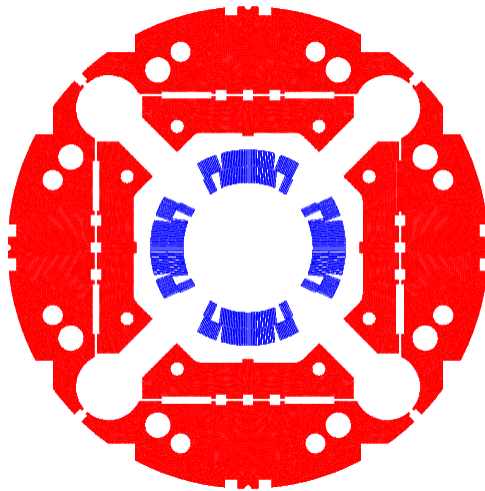
b 1:	6.26560	b 2:	10000.00000	b 3:	-0.10828
b 4:	-0.59322	b 5:	-0.11160	b 6:	-2.05554
b 7:	0.01653	b 8:	-0.00371	b 9:	-0.00205
b10:	-0.11122	b11:	0.00022	b12:	-0.00002
b13:	-0.00003	b14:	-0.87175	b15:	0.00000
b16:	0.00000	b17:	-0.00000	b18:	-0.26186
b19:	0.00000	b20:	0.00000	b	

SKEW RELATIVE MULTIPOLES (1.D-4):

a 1:	-4.35212	a 2:	2.17002	a 3:	1.78933
a 4:	0.25841	a 5:	-0.16310	a 6:	-0.04103
a 7:	0.01449	a 8:	0.00693	a 9:	-0.00079
a10:	-0.00059	a11:	0.00010	a12:	0.00010
a13:	-0.00000	a14:	-0.00001	a15:	0.00000
a16:	0.00000	a17:	0.00000	a18:	-0.00000
a19:	-0.00000	a20:	0.00000	a	

SURFACE OF ALL FEM-ELEMENTS (MM**2) 133326.3290

Cross check with ROXIE that the table is correct



MAIN FIELD (T) -6.621048
 MAGNET STRENGTH (T/(m^(n-1))) -132.4210

NORMAL RELATIVE MULTIPOLES (1.D-4):
 b 1: 4.36960 b 2: 10000.00000 b 3: 1.79120
 b 4: 0.59399 b 5: 0.16432 b 6: -2.05554
 b 7: 0.01454 b 8: 0.00377 b 9: 0.00079
 b10: -0.11120 b11: 0.00010 b12: 0.00003
 b13: 0.00000 b14: -0.87175 b15: 0.00000
 b16: -0.00000 b17: -0.00000 b18: -0.26186
 b19: -0.00000 b20: -0.00000 b

SKREW RELATIVE MULTIPOLES (1.D-4):
 a 1: 6.25126 a 2: 2.15697 a 3: 0.10507
 a 4: -0.25994 a 5: -0.10996 a 6: -0.04119
 a 7: -0.01638 a 8: -0.00706 a 9: -0.00201
 a10: -0.00061 a11: -0.00022 a12: -0.00010
 a13: -0.00003 a14: -0.00001 a15: -0.00000
 a16: -0.00000 a17: -0.00000 a18: -0.00000
 a19: -0.00000 a20: -0.00000 a

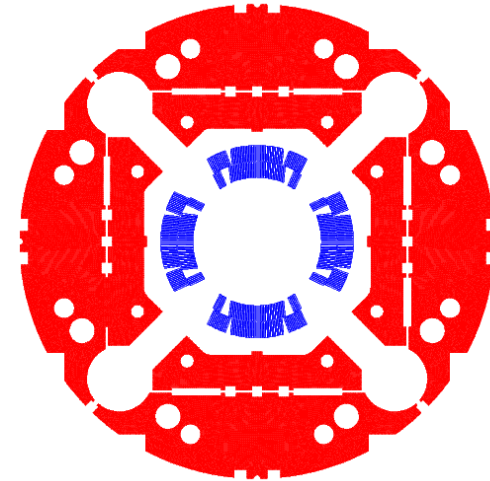
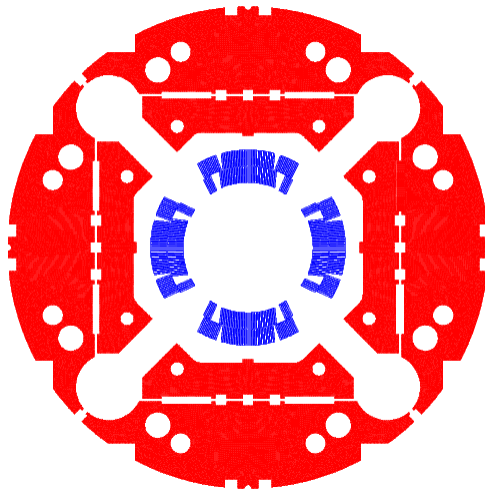
MAIN FIELD (T) -6.62104
 MAGNET STRENGTH (T/(m^(n-1))) -132.420

NORMAL RELATIVE MULTIPOLES (1.D-4):
 b 1: -6.27533 b 2: 10000.00000 b 3: 0.11217
 b 4: -0.59242 b 5: 0.11179 b 6: -2.05526
 b 7: -0.01651 b 8: -0.00369 b 9: 0.00206
 b10: -0.11122 b11: -0.00022 b12: -0.00002
 b13: 0.00003 b14: -0.87175 b15: -0.00000
 b16: 0.00000 b17: 0.00000 b18: -0.26186
 b19: -0.00000 b20: 0.00000 b

SKREW RELATIVE MULTIPOLES (1.D-4):
 a 1: -4.29452 a 2: -2.18879 a 3: 1.80064
 a 4: -0.25790 a 5: -0.16223 a 6: 0.04105
 a 7: 0.01458 a 8: -0.00687 a 9: -0.00079
 a10: 0.00060 a11: 0.00010 a12: -0.00010
 a13: -0.00000 a14: 0.00001 a15: 0.00000
 a16: -0.00000 a17: 0.00000 a18: 0.00000
 a19: -0.00000 a20: -0.00000 a

SURFACE OF ALL FEM-ELEMENTS (MM**2) 133326.329

Cross check with ROXIE that the table is correct



MAIN FIELD (T) -6.621048
 MAGNET STRENGTH (T/(m^(n-1))) -132.4210

NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	4.36960	b 2:	10000.00000	b 3:	1.79120
b 4:	0.59399	b 5:	0.16432	b 6:	-2.05554
b 7:	0.01454	b 8:	0.00377	b 9:	0.00079
b10:	-0.11120	b11:	0.00010	b12:	0.00003
b13:	0.00000	b14:	-0.87175	b15:	0.00000
b16:	-0.00000	b17:	-0.00000	b18:	-0.26186
b19:	-0.00000	b20:	-0.00000	b	

SKEW RELATIVE MULTIPOLES (1.D-4):

a 1:	6.25126	a 2:	2.15697	a 3:	0.10507
a 4:	-0.25994	a 5:	-0.10996	a 6:	-0.04119
a 7:	-0.01638	a 8:	-0.00706	a 9:	-0.00201
a10:	-0.00061	a11:	-0.00022	a12:	-0.00010
a13:	-0.00003	a14:	-0.00001	a15:	-0.00000
a16:	-0.00000	a17:	-0.00000	a18:	-0.00000
a19:	-0.00000	a20:	-0.00000	a	

MAIN FIELD (T) -6.621045
 MAGNET STRENGTH (T/(m^(n-1))) -132.4209

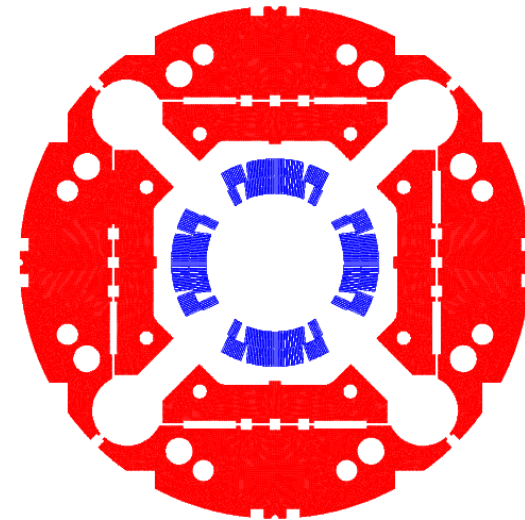
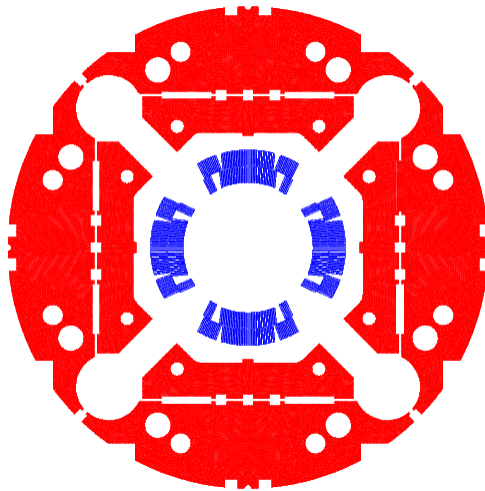
NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	-4.36076	b 2:	10000.00000	b 3:	-1.79390
b 4:	0.59293	b 5:	-0.16370	b 6:	-2.05582
b 7:	-0.01459	b 8:	0.00374	b 9:	-0.00078
b10:	-0.11121	b11:	-0.00010	b12:	0.00003
b13:	-0.00000	b14:	-0.87175	b15:	-0.00000
b16:	-0.00000	b17:	0.00000	b18:	-0.26186
b19:	0.00000	b20:	-0.00000	b	

SKEW RELATIVE MULTIPOLES (1.D-4):

a 1:	-6.24750	a 2:	2.16583	a 3:	-0.10512
a 4:	-0.26006	a 5:	0.11010	a 6:	-0.04124
a 7:	0.01637	a 8:	-0.00705	a 9:	0.00200
a10:	-0.00061	a11:	0.00022	a12:	-0.00010
a13:	0.00003	a14:	-0.00001	a15:	0.00000
a16:	-0.00000	a17:	0.00000	a18:	-0.00000
a19:	0.00000	a20:	-0.00000	a	

Cross check with ROXIE that the table is correct



MAIN FIELD (T) -6.621048
 MAGNET STRENGTH (T/(m⁽ⁿ⁻¹⁾)) -132.4210

NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	4.36960	b 2:	10000.00000	b 3:	1.79120
b 4:	0.59399	b 5:	0.16432	b 6:	-2.05554
b 7:	0.01454	b 8:	0.00377	b 9:	0.00079
b10:	-0.11120	b11:	0.00010	b12:	0.00003
b13:	0.00000	b14:	-0.87175	b15:	0.00000
b16:	-0.00000	b17:	-0.00000	b18:	-0.26186
b19:	-0.00000	b20:	-0.00000	b	

SKEW RELATIVE MULTIPOLES (1.D-4):

a 1:	6.25126	a 2:	2.15697	a 3:	0.10507
a 4:	-0.25994	a 5:	-0.10996	a 6:	-0.04119
a 7:	-0.01638	a 8:	-0.00706	a 9:	-0.00201
a10:	-0.00061	a11:	-0.00022	a12:	-0.00010
a13:	-0.00003	a14:	-0.00001	a15:	-0.00000
a16:	-0.00000	a17:	-0.00000	a18:	-0.00000
a19:	-0.00000	a20:	-0.00000	a	

MAIN FIELD (T) -6.621049
 MAGNET STRENGTH (T/(m⁽ⁿ⁻¹⁾)) -132.4210

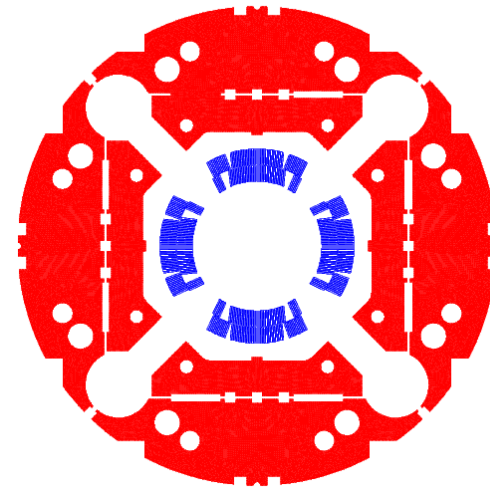
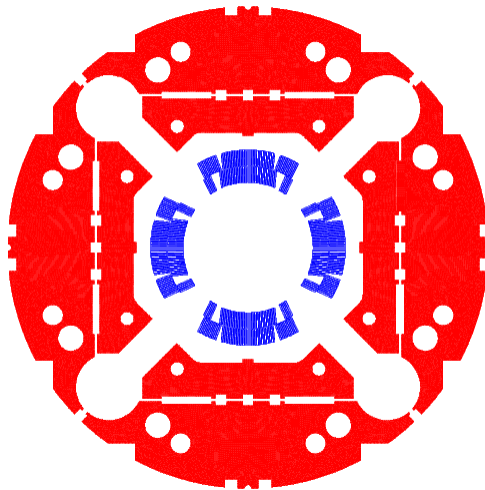
NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	-4.33256	b 2:	10000.00000	b 3:	-1.79040
b 4:	0.59855	b 5:	-0.16274	b 6:	-2.05522
b 7:	-0.01443	b 8:	0.00381	b 9:	-0.00078
b10:	-0.11122	b11:	-0.00010	b12:	0.00003
b13:	-0.00000	b14:	-0.87175	b15:	-0.00000
b16:	-0.00000	b17:	0.00000	b18:	-0.26186
b19:	0.00000	b20:	-0.00000	b	

SKEW RELATIVE MULTIPOLES (1.D-4):

a 1:	6.27858	a 2:	-2.17210	a 3:	0.10759
a 4:	0.25892	a 5:	-0.11231	a 6:	0.04072
a 7:	-0.01654	a 8:	0.00694	a 9:	-0.00207
a10:	0.00059	a11:	-0.00022	a12:	0.00010
a13:	-0.00003	a14:	0.00001	a15:	-0.00000
a16:	0.00000	a17:	-0.00000	a18:	0.00000
a19:	-0.00000	a20:	0.00000	a	

Cross check with ROXIE that the table is correct



MAIN FIELD (T) -6.621048
 MAGNET STRENGTH (T/(m^(n-1))) -132.4210

NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	4.36960	b 2:	10000.00000	b 3:	1.79120
b 4:	0.59399	b 5:	0.16432	b 6:	-2.05554
b 7:	0.01454	b 8:	0.00377	b 9:	0.00079
b10:	-0.11120	b11:	0.00010	b12:	0.00003
b13:	0.00000	b14:	-0.87175	b15:	0.00000
b16:	-0.00000	b17:	-0.00000	b18:	-0.26186
b19:	-0.00000	b20:	-0.00000	b	

SKEW RELATIVE MULTIPOLES (1.D-4):

a 1:	6.25126	a 2:	2.15697	a 3:	0.10507
a 4:	-0.25994	a 5:	-0.10996	a 6:	-0.04119
a 7:	-0.01638	a 8:	-0.00706	a 9:	-0.00201
a10:	-0.00061	a11:	-0.00022	a12:	-0.00010
a13:	-0.00003	a14:	-0.00001	a15:	-0.00000
a16:	-0.00000	a17:	-0.00000	a18:	-0.00000
a19:	-0.00000	a20:	-0.00000	a	

MAIN FIELD (T) -6.621048
 MAGNET STRENGTH (T/(m^(n-1))) -132.4210

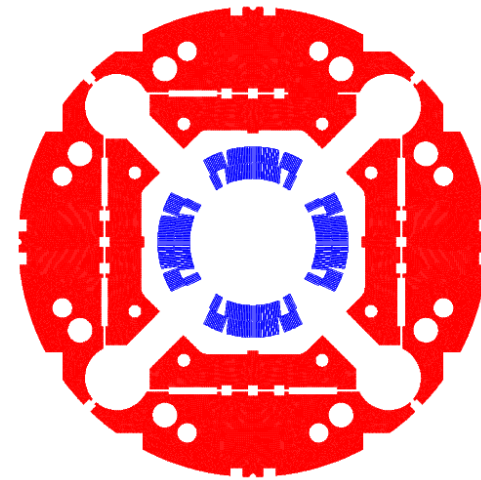
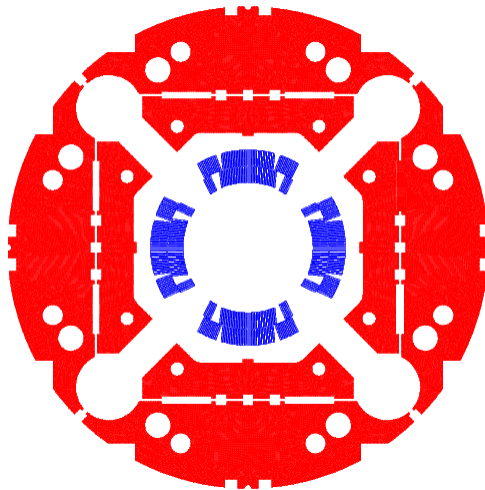
NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	-6.28107	b 2:	10000.00000	b 3:	0.11174
b 4:	-0.59200	b 5:	0.11127	b 6:	-2.05531
b 7:	-0.01650	b 8:	-0.00367	b 9:	0.00204
b10:	-0.11122	b11:	-0.00022	b12:	-0.00002
b13:	0.00003	b14:	-0.87175	b15:	-0.00000
b16:	0.00000	b17:	0.00000	b18:	-0.26186
b19:	-0.00000	b20:	0.00000	b	

SKEW RELATIVE MULTIPOLES (1.D-4):

a 1:	4.31035	a 2:	2.17114	a 3:	-1.79770
a 4:	0.25824	a 5:	0.16198	a 6:	-0.04108
a 7:	-0.01453	a 8:	0.00688	a 9:	0.00078
a10:	-0.00060	a11:	-0.00010	a12:	0.00010
a13:	0.00000	a14:	-0.00001	a15:	-0.00000
a16:	0.00000	a17:	-0.00000	a18:	-0.00000
a19:	0.00000	a20:	0.00000	a	

Cross check with ROXIE that the table is correct



MAIN FIELD (T) -6.621048
 MAGNET STRENGTH (T/(m^(n-1))) -132.4210

NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	4.36960	b 2:	10000.00000	b 3:	1.79120
b 4:	0.59399	b 5:	0.16432	b 6:	-2.05554
b 7:	0.01454	b 8:	0.00377	b 9:	0.00079
b10:	-0.11120	b11:	0.00010	b12:	0.00003
b13:	0.00000	b14:	-0.87175	b15:	0.00000
b16:	-0.00000	b17:	-0.00000	b18:	-0.26186
b19:	-0.00000	b20:	-0.00000	b	

SKEW RELATIVE MULTIPOLES (1.D-4):

a 1:	6.25126	a 2:	2.15697	a 3:	0.10507
a 4:	-0.25994	a 5:	-0.10996	a 6:	-0.04119
a 7:	-0.01638	a 8:	-0.00706	a 9:	-0.00201
a10:	-0.00061	a11:	-0.00022	a12:	-0.00010
a13:	-0.00003	a14:	-0.00001	a15:	-0.00000
a16:	-0.00000	a17:	-0.00000	a18:	-0.00000
a19:	-0.00000	a20:	-0.00000	a	

MAIN FIELD (T) -6.621049
 MAGNET STRENGTH (T/(m^(n-1))) -132.4210

NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	6.32999	b 2:	10000.00000	b 3:	-0.11563
b 4:	-0.59130	b 5:	-0.11072	b 6:	-2.05546
b 7:	0.01623	b 8:	-0.00370	b 9:	-0.00203
b10:	-0.11121	b11:	0.00022	b12:	-0.00002
b13:	-0.00003	b14:	-0.87175	b15:	0.00000
b16:	0.00000	b17:	-0.00000	b18:	-0.26186
b19:	0.00000	b20:	0.00000	b	

SKEW RELATIVE MULTIPOLES (1.D-4):

a 1:	4.32214	a 2:	-2.17106	a 3:	-1.79799
a 4:	-0.25913	a 5:	0.16357	a 6:	0.04159
a 7:	-0.01458	a 8:	-0.00639	a 9:	0.00078
a10:	0.00061	a11:	-0.00010	a12:	-0.00010
a13:	0.00000	a14:	0.00001	a15:	-0.00000
a16:	-0.00000	a17:	-0.00000	a18:	0.00000
a19:	0.00000	a20:	-0.00000	a	