MEASURE FOR THE SURVEY OF THE DIMENSIONS OF A MAGNET DIPOLE

- Technical relation –

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The aim of the exercise is the measure of the dimensions of a dipole magnet (picture 5), the original technical designs of which are not more available and that it is previewed to be reused in the project "Spark".

The function of the dipole magnet, in an accelerator machine, is to bend by a determinate angle in the horizontal plan the particles beam that crosses it on the median plane between the two poles.

The work has been carried out in the room where the magnetic characteristics of various magnets are relieved (dipoles, quadrupoles, sextupoles, etc) in the within of the activity of the Alignment Group of the Mechanical Engineering Service.

For the complete development of the measure we used various instruments with relative components and accessories:

- Two theodolites Leica T3000 (picture 3)
- A notebook Toshiba on which the Leica "Axyz" program is installed (picture 1)
- The Leica power source T-link, that connects also theodolites and computer
- Taylor-Hobson spheres with D=88.9 milimeter (3.5 in.) (picture 4)
- One level with sensibility 0.02 mm/m
- One "scale bar" of L=1305.329 mm lenght, with precision of 0.002mm, produced by Wild (picture 6)

For a correct development of the measure operations it has been necessary to consult the handbooks of the "Axyz" software and of T3000 theodolite:

- Leica Axyz "Training manual for theodolites"
- Manual Leica Theomat of operation for Theodolite T3000

The structural part of the magnet has been measured with a digital caliper Borletti CEDS 60 – 0-600 millimeter useful – centesimal (picture

11), while the magnet poles have been measured with the system constituted by two theodolites managed by the Leica program (picture 3).

In order to improve the measure precision the two theodolites have been set in such way that the horizontal angle between the two instruments, when they are collimated on the points to be measured, was approximately 90°; moreover they have been set at various heights between them, in order to form, always when collimated on the same points, a vertical angle different from zero.

When the two instruments were arranged in the opportune positions, they have been accurately levelled and each one has been collimated on the other: the two angular positions of everyone have been read by the program, that it has been able therefore to gain informations on the relative position of one theodolite to the other, distance excluded. This last information has been given to the program collimating each theodolite on the two extreme points of the "scale bar", arranged on the magnet to measure. This bar is realized in Invar (alloy composed from 36% of Nichel and 64% of steel), material that has one very low thermal expansion (approximately $3x10^{-7}$). In order to complete the informations necessary to the program to define a "base" system of reference we collimated the theodolites on three points, corners of a virtual solid that contains the magnet. The program therefore has elaborated the information. The uncertainty of the calculate solution for the reference system has been of 0.006mm RMS (Root Mean Square). Then we passed to find the positions in the "base" system of reference (picture 7) of the four points, materialized by the center of a Taylor-Hobson sphere positioned on the sockets (picture 4). Therefore it has been thought opportune to replace the "base" system with a new system referred to the magnet (picture 8) and called "magnete", with the origin in the point "c_4", the axis y passing in the point "c_3", and axis x in the plan defined from the previous points and "c_1" (picture 13). Then we passed to collimate the significant points of the pole:

- "spig_polo_1" and "spig_polo_2", on one of two poles (picture 10), through which the height of the upper part of the pole has been calculated;
- "spig_polo_3" and "spig_polo_4", the first one lies on the middle point of the arc of circumference of the pole; with "spig_polo_2",

"spig_polo_3" and "spig_polo_4" the radius of the circumference, on which they lie, has been calculated;

- "spig_polo_6"; with to the point "spig_polo_2" determines the transversal length of the pole.

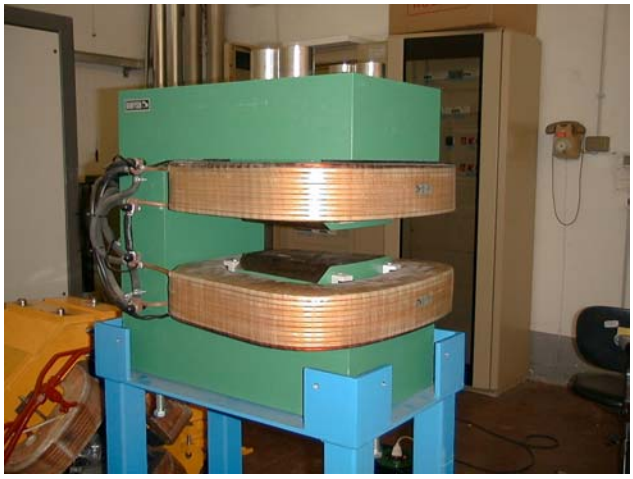
The axis y, defined from the points "c_3" and "c_4", is parallel to magnet axis of symmetry; comparing it with the line through points "spig_polo_2" and "spig_polo_6" it has been calculated the angle formed between the axis of longitudinal symmetry of the magnet and the vertical planes defined by each pole side; the angle results 10° (picture 12). For the symmetry of the pole it can be asserted that the total angle of the pole is of 20°. The position of the pole regarding the structure of the magnet has been obtained measuring a point on the inner wall.

Picture 1

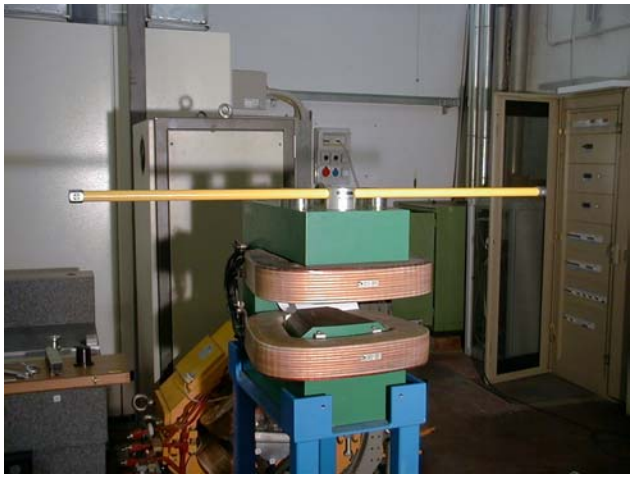
Picture 2

Picture 3

Picture 4



Picture 5



Picture 6

Point Report

Job ID: ***2002_06_25 MISURE DIPOLO LISA*** ***Axyz Coordinate Measuring System*** *V 1.4.0.0*

Job created: *2002/06/25 09:44:00.00* ***Angle unit :*** *degree*

Length unit: *millimeter* ***Coordinate type & system :*** RHR DEFAULT/BASE

Workpiece ID: DEFAULT

Point ID	*X*	*Y*	*Z*	*RMS*	*RMSx*	*RMSy*	*RMSz*	*Type*
c_1	909,8532	1353,3553	216,1779	0,0023	0,0001	0,0003	0,0023	Measured
c_2	903,3098	1413,1961	216,2325	0,0044	0,0003	0,0005	0,0044	Measured
c_3	680,3522	1388,7104	216,1817	0,0035	0,0002	0,0004	0,0035	Measured
c_4	686,9597	1328,7824	216,1899	0,0084	0,0005	0,0011	0,0083	Measured
parete_interna	879,9007	1639,6663	-172,7987	0,0033	0,0002	0,0005	0,0032	Measured
point1	835,2177	985,7520	-453,4216	0,0060	0,0004	0,0026	0,0054	Measured
point2	1138,0253	1967,0184	479,7787	0,0042	0,0003	0,0009	0,0042	Measured
point3	328,1145	1819,7121	477,9557	0,0034	0,0002	0,0008	0,0033	Measured
spig_polo_1	682,0740	1273,6648	-206,0291	0,0102	0,0006	0,0019	0,0100	Measured
spig_polo_2	711,8363	1271,2752	-180,8553	0,0144	0,0009	0,0025	0,0142	Measured
spig_polo_3	805,3867	1274,2111	-180,5696	0,0035	0,0002	0,0006	0,0034	Measured
spig_polo_4	897,3171	1291,1436	-180,5070	0,0057	0,0004	0,0010	0,0056	Measured
spig_polo_5	926,4726	1300,0047	-206,9113	0,0008	0,0000	0,0002	0,0008	Measured

Picture 7

Point Report

Job ID: ***2002_06_25 MISURE DIPOLO LISA*** ***Axyz Coordinate Measuring System*** *V 1.4.0.0*

Job created: *2002/06/25 09:44:00.00* ***Angle unit :*** *degree*

Length unit: *millimeter* ***Coordinate type & system :*** RHR DEFAULT/magnete

Workpiece ID: DEFAULT

Point ID	*X*	*Y*	*Z*	*RMS*	*RMSx*	*RMSy*	*RMSz*	*Type*
c_1	224,2439	0,0000	0,0000	0,0023	0,0002	0,0003	0,0023	Measured
c_2	224,2974	60,1975	0,0546	0,0044	0,0003	0,0005	0,0044	Measured
c_3	-0,0008	60,2911	-0,0083	0,0035	0,0003	0,0004	0,0035	Measured
c_4	0,0000	0,0000	0,0000	0,0084	0,0006	0,0010	0,0083	Measured
parete_interna	225,8669	287,8691	-388,9764	0,0033	0,0003	0,0004	0,0032	Measured
point1	109,8117	-357,2109	-669,6056	0,0060	0,0007	0,0025	0,0054	Measured
point2	518,2735	584,9643	263,6167	0,0042	0,0004	0,0008	0,0042	Measured
point3	-302,9018	527,2957	261,7495	0,0034	0,0003	0,0008	0,0033	Measured
spig_polo_1	-10,8734	-54,2503	-422,2196	0,0102	0,0008	0,0018	0,0100	Measured
spig_polo_2	18,4465	-59,8869	-397,0442	0,0144	0,0012	0,0024	0,0142	Measured
spig_polo_3	111,7552	-67,2200	-396,7535	0,0035	0,0003	0,0006	0,0034	Measured
spig_polo_4	204,9874	-60,4633	-396,6859	0,0057	0,0005	0,0010	0,0056	Measured
spig_polo_5	234,9398	-54,8505	-423,0886	0,0008	0,0001	0,0001	0,0008	Measured
spig_polo_6	58,0419	163,2517	-396,8042	0,0049	0,0004	0,0007	0,0048	Measured

Picture 8

Shape Report

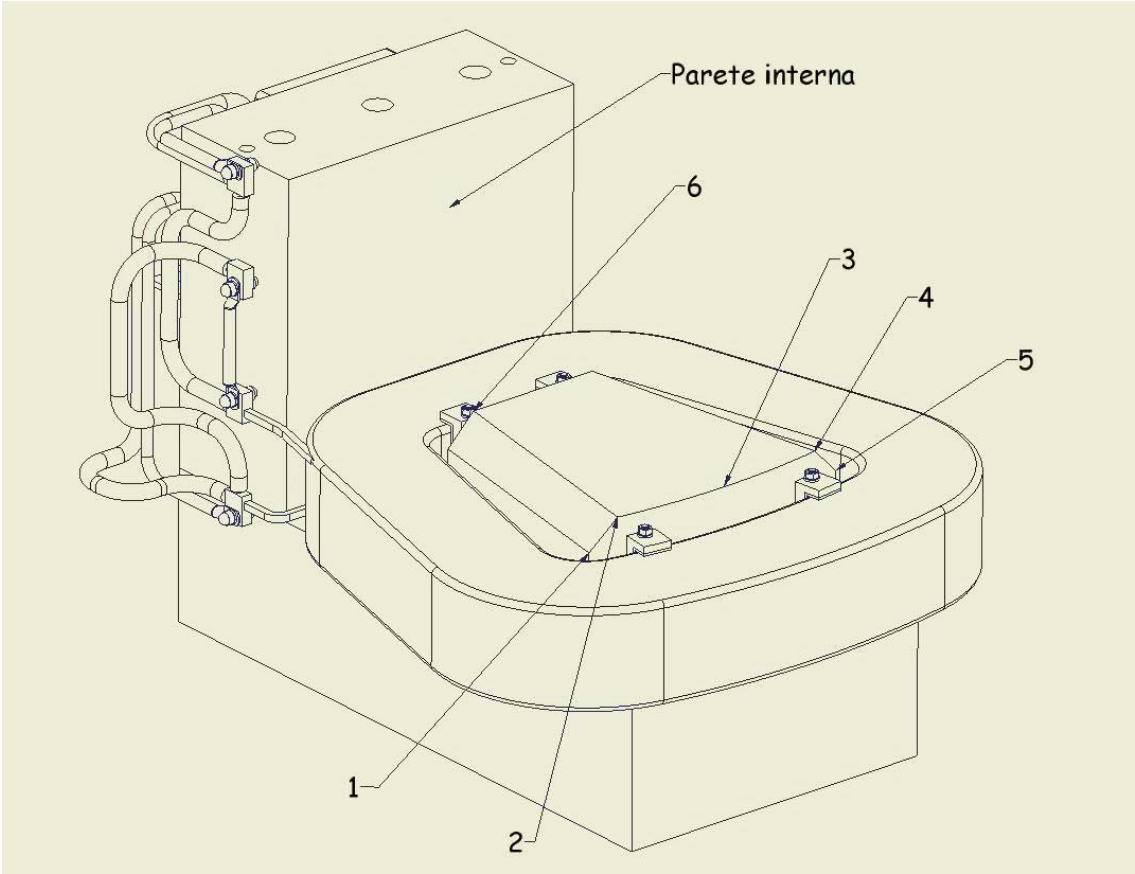
Job ID : ***2002_06_25 MISURE DIPOLO LISA*** ***Axyz Coordinate Measuring System*** *V 1.4.0.0*

Job created *: 2002/06/25 09:44:00.00* ***Angle unit :*** *degree*

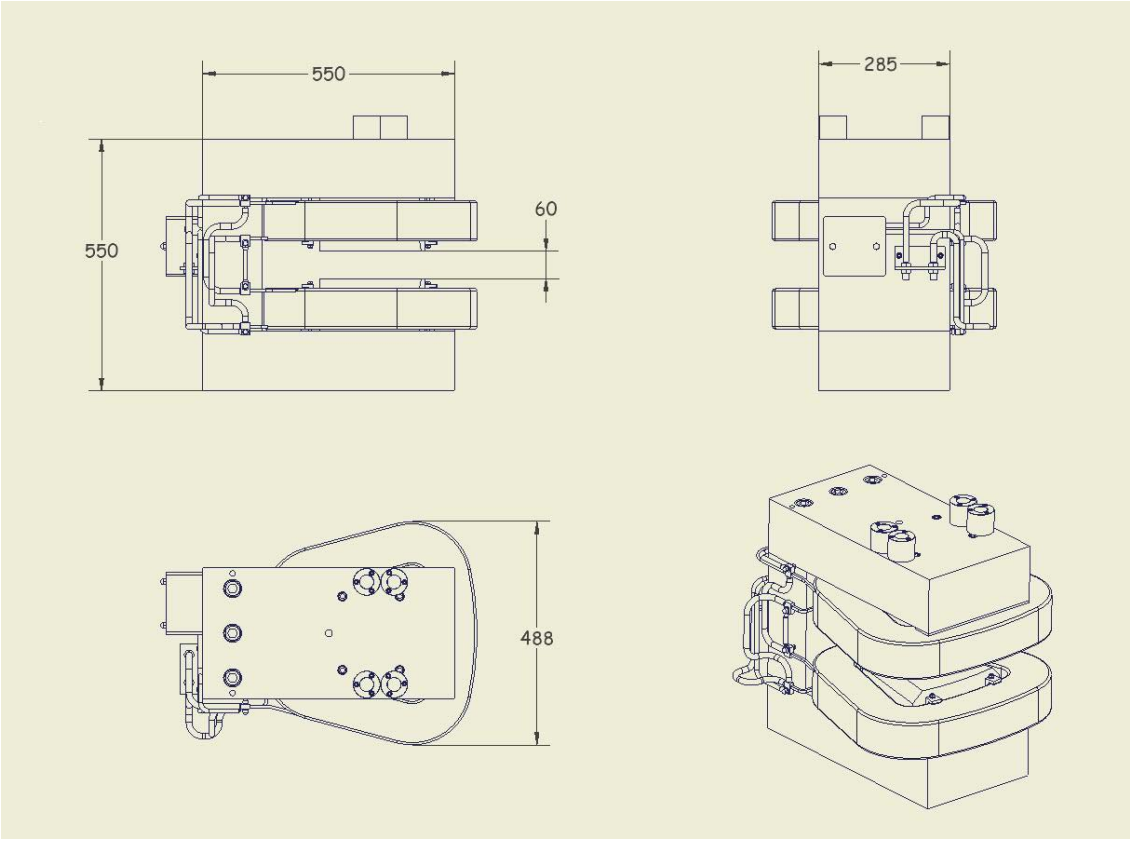
Length unit : *millimeter*

Workpiece ID	*Shape ID*	*Type*				*RMS*	*Radius*	*Output coordinate system*
DEFAULT	**curv_polo**	Circle	***X***	113,6322	359,0932	0,0000	620,8912	DEFAULT/magnete
			Y	553,5906	359,8928			
			Z	-406,5765	261,1815			
DEFAULT	**retta_magne**	Line	***X***	-0,0008	89,9921	0,0000	0,0000	DEFAULT/magnete
			Y	60,2911	0,0007			
			Z	-0,0083	0,0022			
DEFAULT	**retta_polo**	Line	***X***	18,4465	270,0616	0,0000	0,0000	DEFAULT/magnete
			Y	-59,8869	10,0623			
			Z	-397,0442	359,9902			

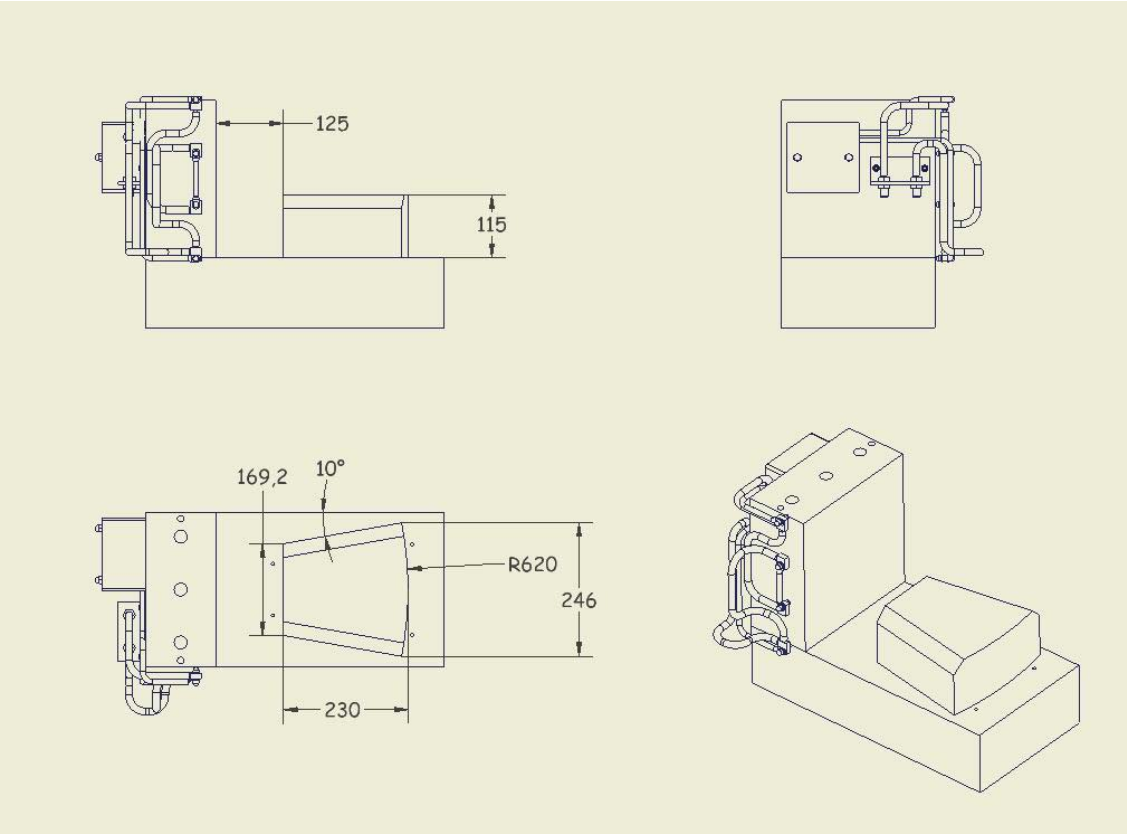
Picture 9



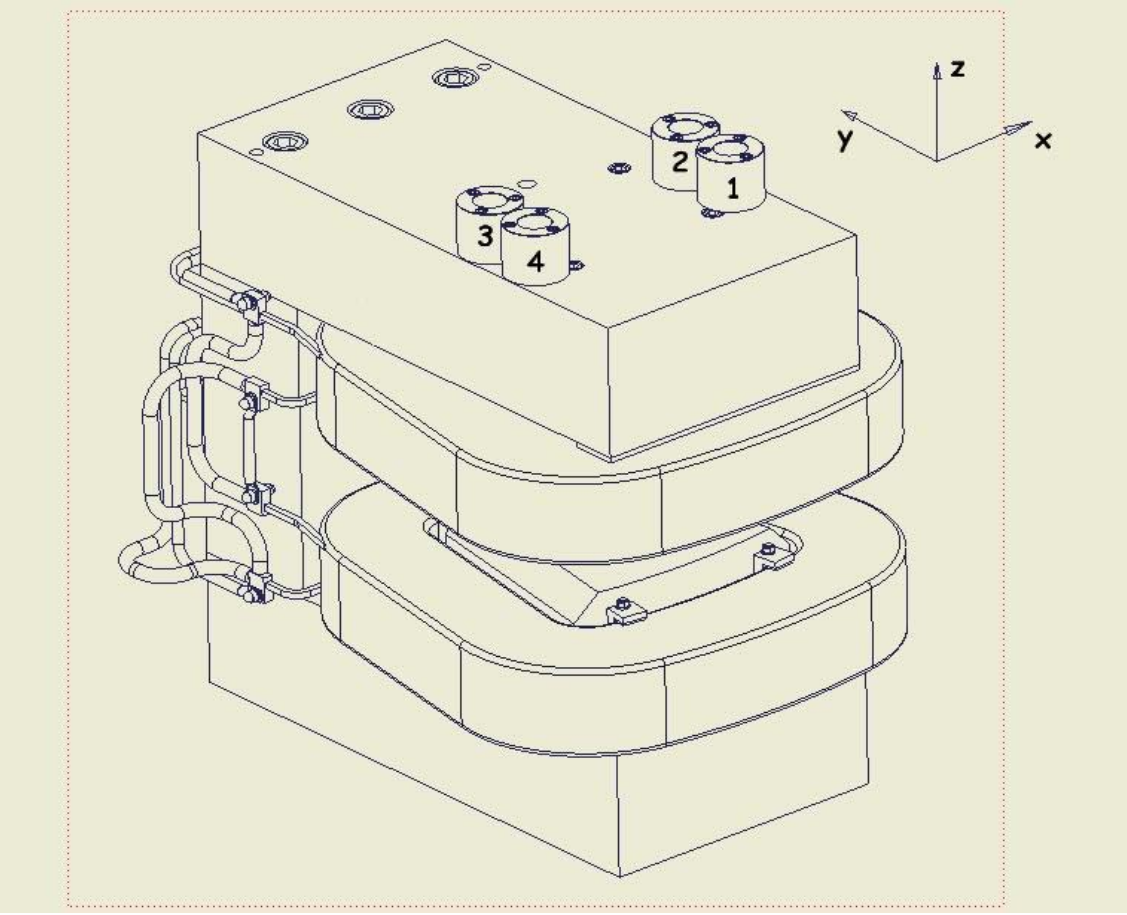
Picture10



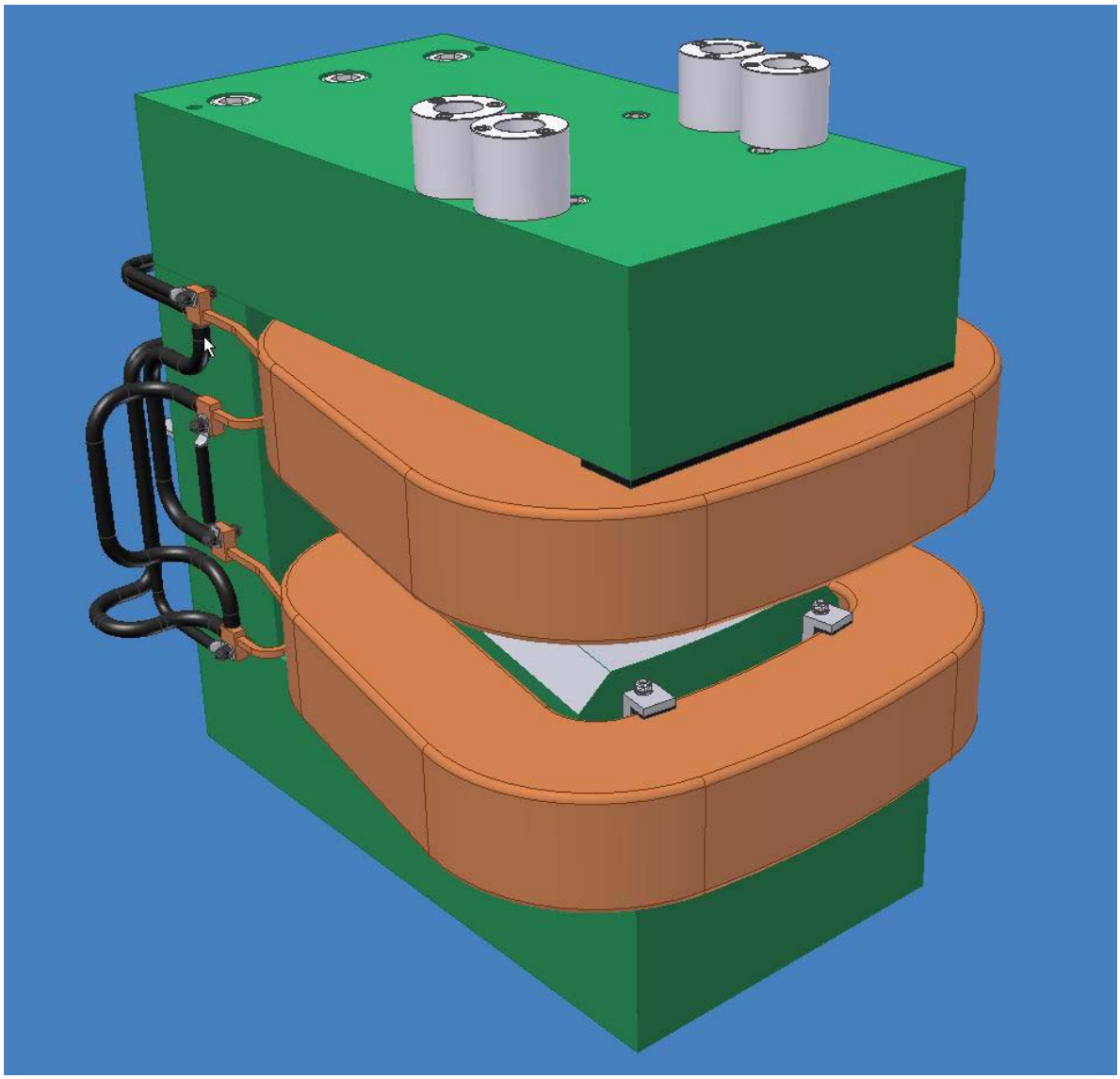
Picture 11



Picture 12



Picture 13



Picture 14