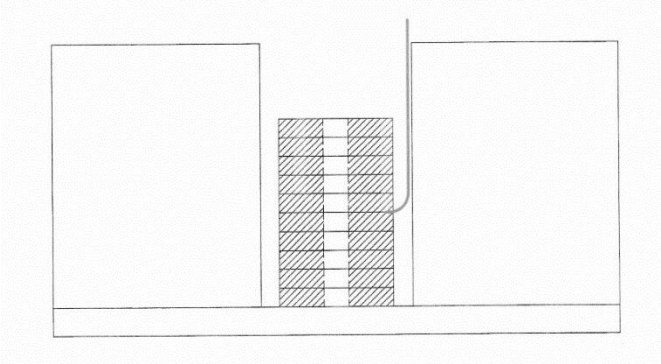
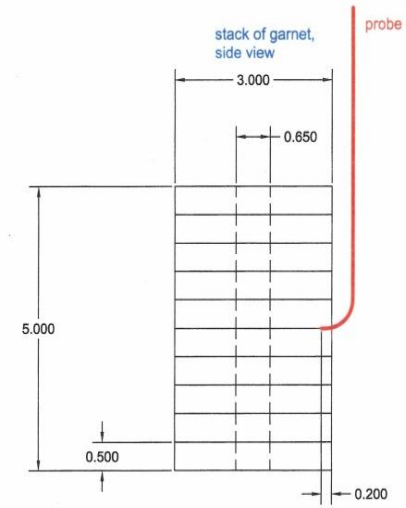
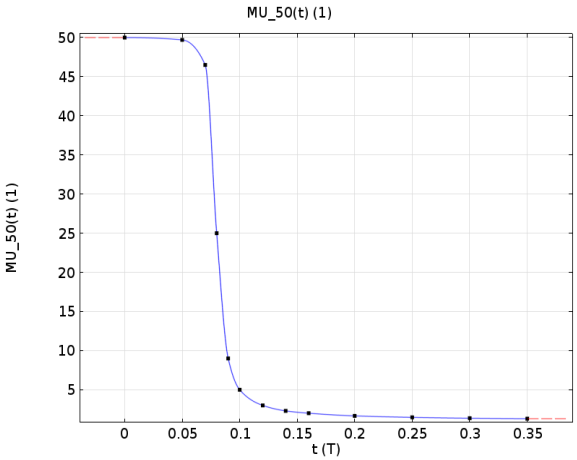
AL800 Material Permeability Measurement

Measurement Setup and Initial Assumptions

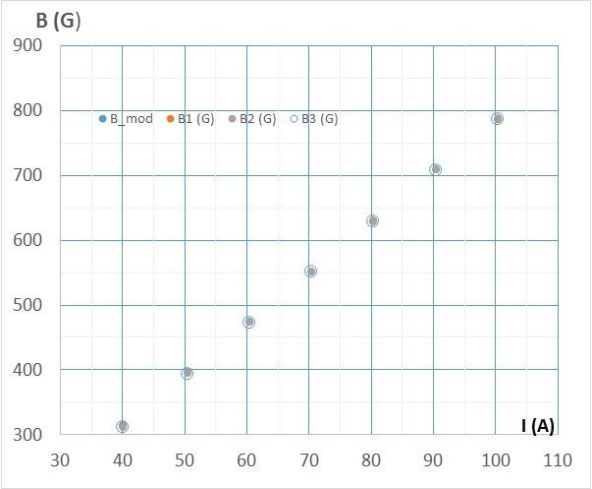






Used Magnetometers:
- Cryomagnetics (1.075);
- AlphaLab (1.016);
- DELL (0.940).

Three attempts to calibrate and cross-calibrate the devises:
1. By accepting vendor's data;
2. By using the magnetometer trusted by others;
3. Using solenoid design data



Position 1: data with the probes installed as following:
Cryomagnetics magnetometer at the bottom;
AlphaLab magnetometer in the middle;
DELL magnetometer at the top.

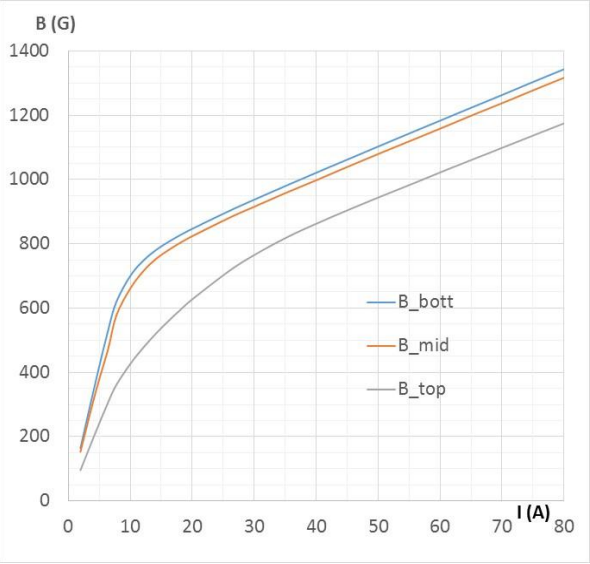
Position 2: data with the probes installed as following
Cryomagnetics magnetometer at the top;
AlphaLab magnetometer in the middle;
DELL magnetometer at the bottom.

Verification during the measurement in two positions:

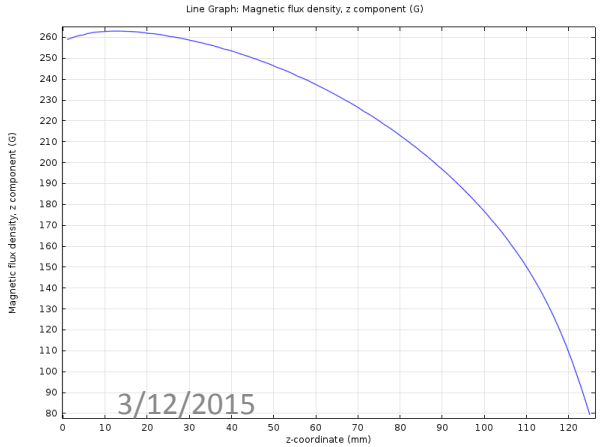
k1	k2	k3				k1	k2	k3
1.075	1.016	0.94				1.075	1.016	0.94
Corrected for Readings						Corrected for Readings & Current		
Bottom	Mid	Top				Top	Mid	Bottom
B1 (G)	B2 (G)	B3 (G)		I (A)		B1 (G)	B2 (G)	B3 (G)
170.87	151.87	91.66		1.95		99.16	153.95	158.61
386.67	343.89	206.08		4.41		221.50	333.30	355.16
552.71	493.69	294.54		6.41		318.56	450.78	508.19
635.67	574.59	346.62		7.76		376.16	581.42	604.32
715.29	661.10	412.53		10.07		444.07	665.07	688.97
760.02	715.03	462.49		12.22		497.14	719.84	739.63
789.68	751.35	503.93		14.17		539.11	755.99	772.38
813.21	777.13	542.18		16.13		576.36	783.39	798.28
832.17	798.09	575.12		17.88		606.83	804.09	818.27
851.97	819.84	611.24		19.88		639.72	825.66	839.41
908.15	878.10	706.94		26.00		725.07	883.90	896.74
945.06	914.52	760.08		30.25		775.75	920.55	933.90
988.96	958.21	816.42		35.46		827.57	964.53	977.82
1026.99	995.61	857.86		40.07		868.12	1000.90	1016.33
1068.47	1036.55	900.37		45.13		909.59	1043.54	1057.37
1113.48	1080.84	945.00		50.69		953.43	1088.67	1102.82
1156.91	1122.86	986.45		56.05		995.16	1131.29	1146.23
1195.13	1160.45	1024.70		60.81		1031.90	1169.25	1184.21
1230.75	1196.08	1058.70		65.21		1065.57	1204.47	1219.20
1270.08	1233.48	1095.88		70.12		1103.10	1243.41	1257.87
1308.30	1271.76	1132.01		74.88		1139.52	1281.24	1296.95
1352.38	1314.57	1174.51		80.39		1181.00	1325.00	1340.00

The maximum deviation from the average reaches ~4% for the top location, where the field is quite non-uniform, and for low current level. It is ~ 0.5% for the current exceeding ~25 A.

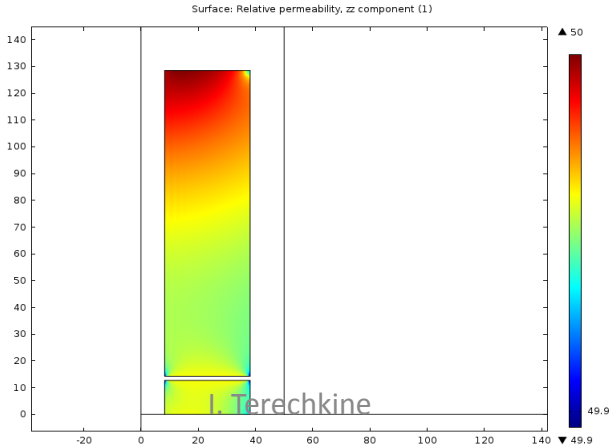
I (A)	B_bott	B_mid	B_top
1.95	164.74	152.91	95.41
4.41	370.92	338.60	213.79
6.41	530.45	472.24	306.55
7.76	620.00	578.01	361.39
10.07	702.13	663.09	428.30
12.22	749.83	717.44	479.81
14.17	781.03	753.67	521.52
16.13	805.74	780.26	559.27
17.88	825.22	801.09	590.97
19.88	845.69	822.75	625.48
26.00	902.44	881.00	716.00
30.25	939.48	917.53	767.91
35.46	983.39	961.37	822.00
40.07	1021.66	998.25	862.99
45.13	1062.92	1040.04	904.98
50.69	1108.15	1084.75	949.21
56.05	1151.57	1127.07	990.80
60.81	1189.67	1164.85	1028.30
65.21	1224.97	1200.27	1062.13
70.12	1263.98	1238.44	1099.49
74.88	1302.63	1276.50	1135.77
80.39	1346.19	1319.79	1177.76



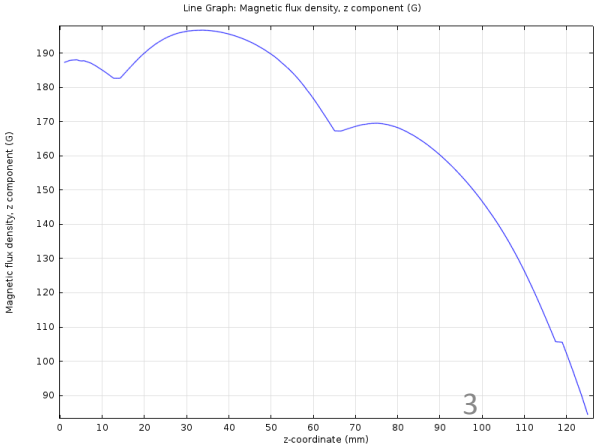
No gaps



Small Current (I < 5 A)



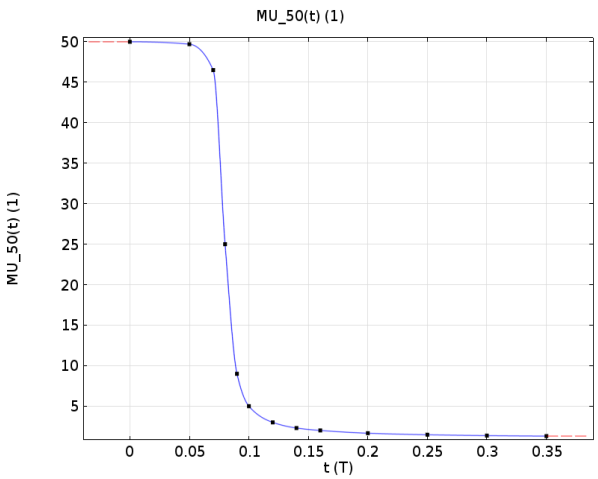
Gaps introduced

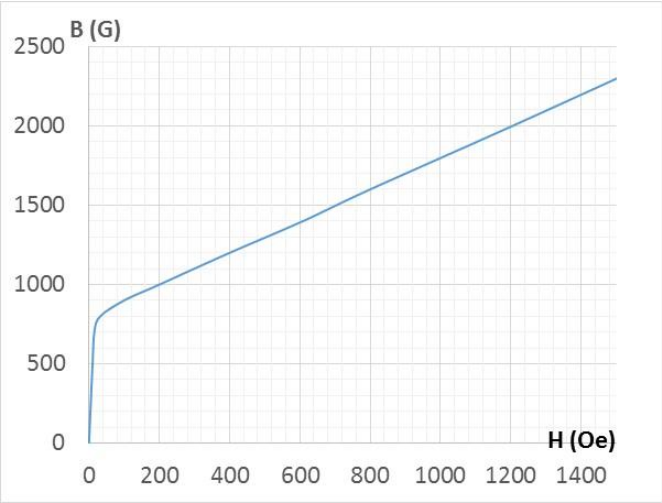


Evolution of Magnetization Curve

Initial assumption:

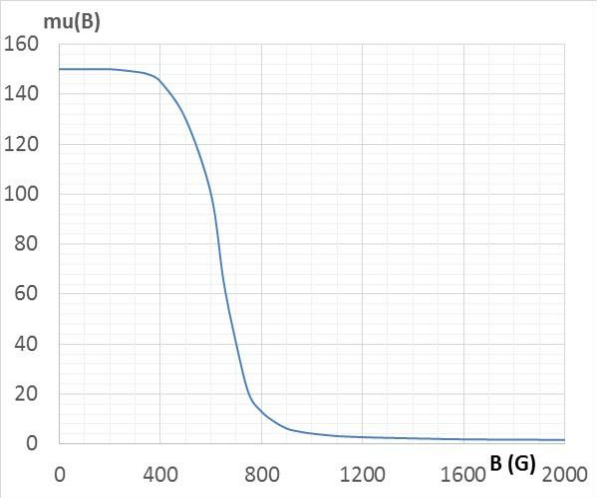
B(T)	mu_static
0	50
0.05	49.7
0.07	46.5
0.08	25
0.09	9
0.1	5
0.12	3
0.14	2.3
0.16	2
0.2	1.66
0.25	1.47
0.3	1.36
0.35	1.3

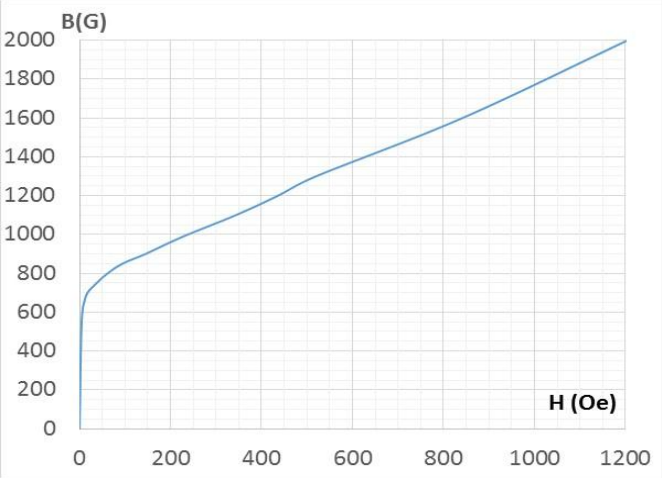




Febr. 02 data:

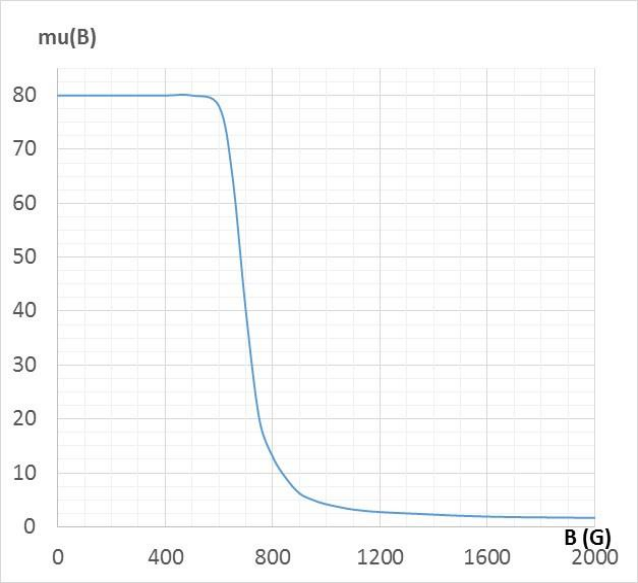
H (Oe)	B(G)	mu(B)
0.00	0	150
0.67	100	150
1.33	200	150
2.01	300	149
2.36	350	148
2.76	400	145
3.85	500	130
6.00	600	100
10.00	650	65
17.50	700	40
37.50	750	20
61.54	800	13
94.44	850	9
145.16	900	6.2
190.00	950	5
238.10	1000	4.2
343.75	1100	3.2
436.36	1200	2.75
520.00	1300	2.5
842.11	1600	1.9
1204.82	2000	1.66

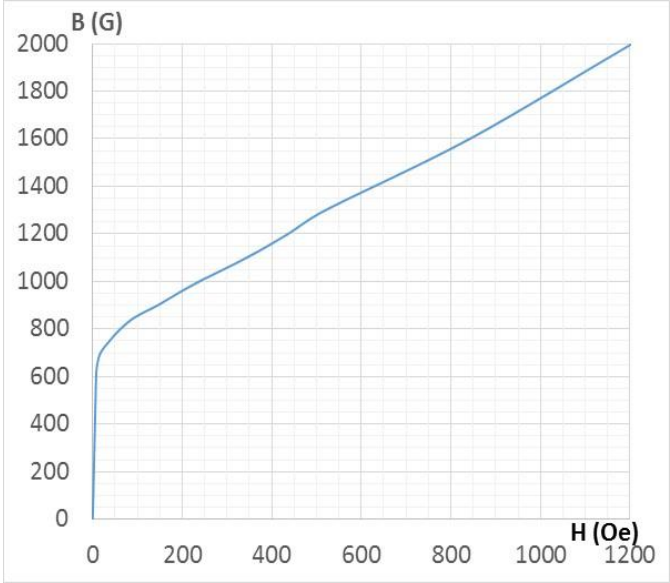




Febr. 17 data: → No satisfactory consistency at low current

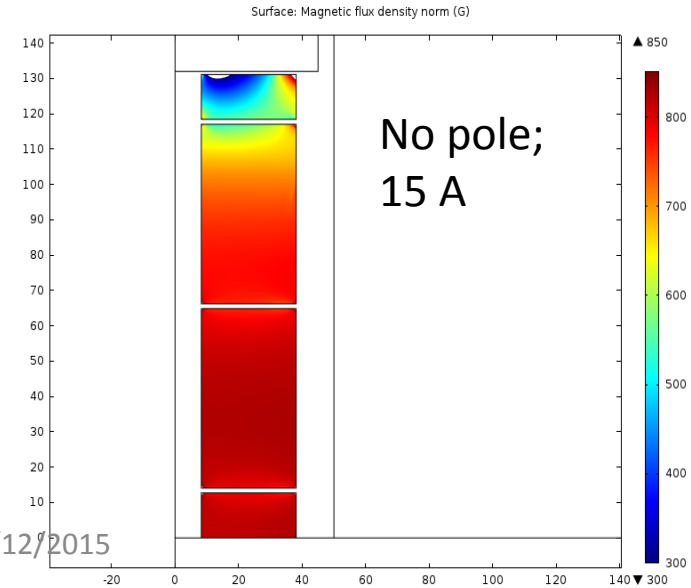
B (G)	mu
0	80
100	80
200	80
300	80
400	80
500	80
600	78
650	65
700	40
750	20
800	13
850	9
900	6.2
950	5
1000	4.2
1100	3.2
1200	2.75
1300	2.5
1600	1.9
2000	1.66

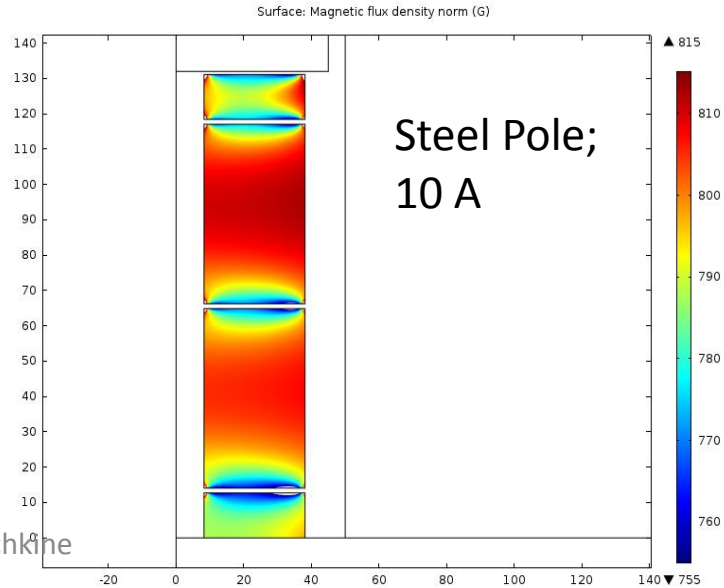




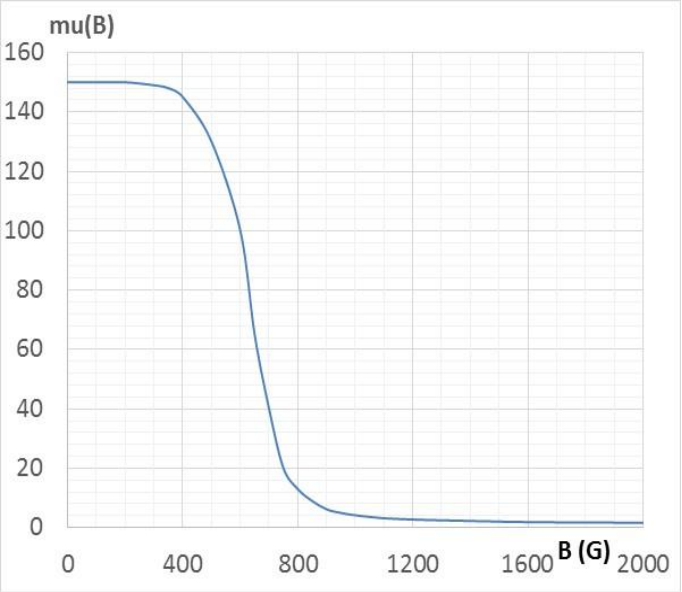
Modified Measurement Setup.

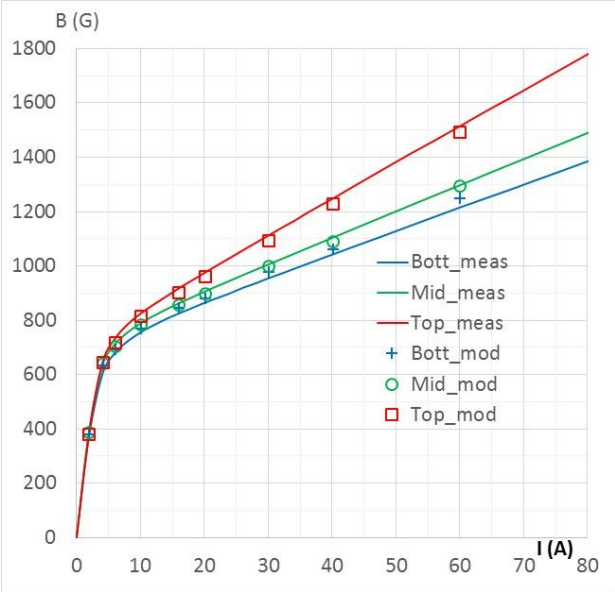
The goal – to improve uniformity of the field by adding a steel pole.

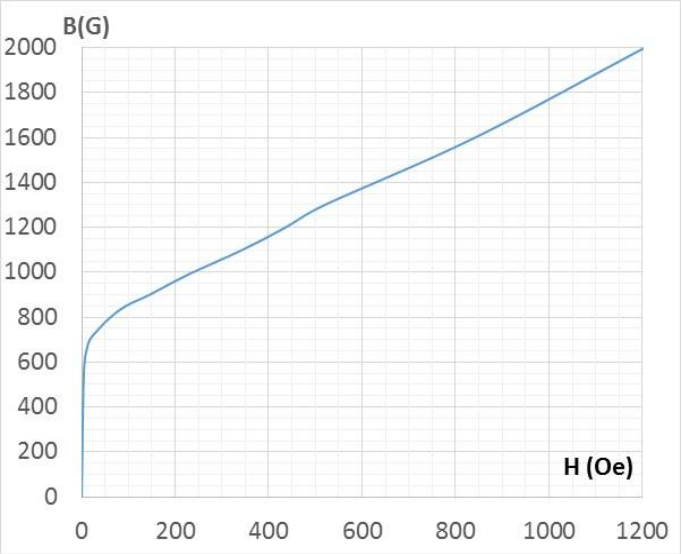


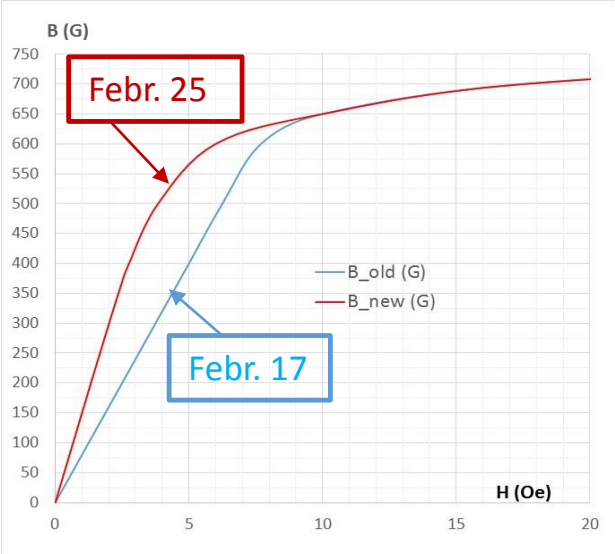


H (Oe)	B(G)	mu(B)
0.00	0	150
0.67	100	150
1.33	200	150
2.01	300	149
2.36	350	148
2.76	400	145
3.85	500	130
6.00	600	100
10.00	650	65
17.50	700	40
37.50	750	20
61.54	800	13
94.44	850	9
145.16	900	6.2
190.00	950	5
238.10	1000	4.2
343.75	1100	3.2
436.36	1200	2.75
520.00	1300	2.5
842.11	1600	1.9
1204.82	2000	1.66







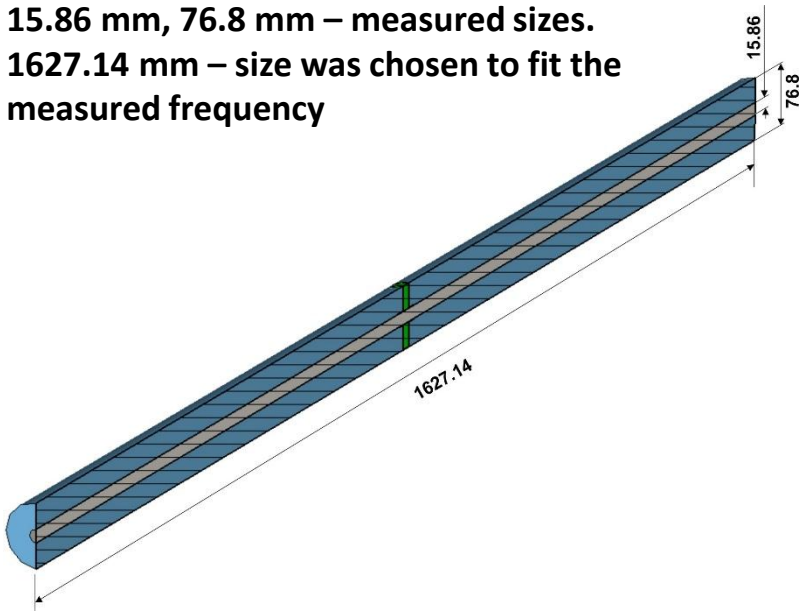


Permittivity measurements were made by Sergey Kazakov using half-wave coaxial RF cavity.
One or two AL-800 rings were placed at the location of maximum electric field.
Measured frequency deviations in the presence of the rings was compared with predictions made by modeling.

The measurement setup and results are summarized by slides provided by Sergey:

Empty cavity:
Measured frequencies:
92.074 MHz, Q = 1964
276.421MHz, Q = 3004
Simulated frequencies:
92.075 MHz, Q = 3000
276.225 MHz, Q = 5188

15.86 mm, 76.8 mm – measured sizes.
1627.14 mm – size was chosen to fit the measured frequency



Sample #1

Din = 16.45 mm
Dout = 76.21 mm
H = 12.70 mm

Measured frequencies:
85.997 MHz, Q = 621.6, Shift = 6.077 MHz
258.627 MHz, Q = 183.4, Shift = 17.794 MHz

Simulated frequencies:
Eps = 13.088
85.992 MHz, Shift = 6.083 MHz.
Q = 710 (loss tng = 0.01), Q = 220 (loss tng = 0.04).
258.546 MHZ, Shift = 17.679 Mz.
Q = 882 (loss tng = 0.01), Q = 257 (loss tng = 0.04).

Sample #2

Din = 16.48 mm
Dout = 76.18 mm
H = 12.71 mm

Measured frequencies:
85.926 MHz, Q = 628.8, Shift = 6.148 MHz
258.354 MHz, Q = 164.1, Shift = 18.067 MHz

Simulated frequencies:
Eps = 13.48
85.923 MHz, Shift = 6.152 MHz
Q = 717 (loss tng = 0.01)
258.369 MHZ, Shift = 17.856 MHz
Q = 882 (loss tng = 0.01)