Gerard Tranquille
BE-BI-EA

ELENA electron cooler magnetic measurements

Aim of the measurements

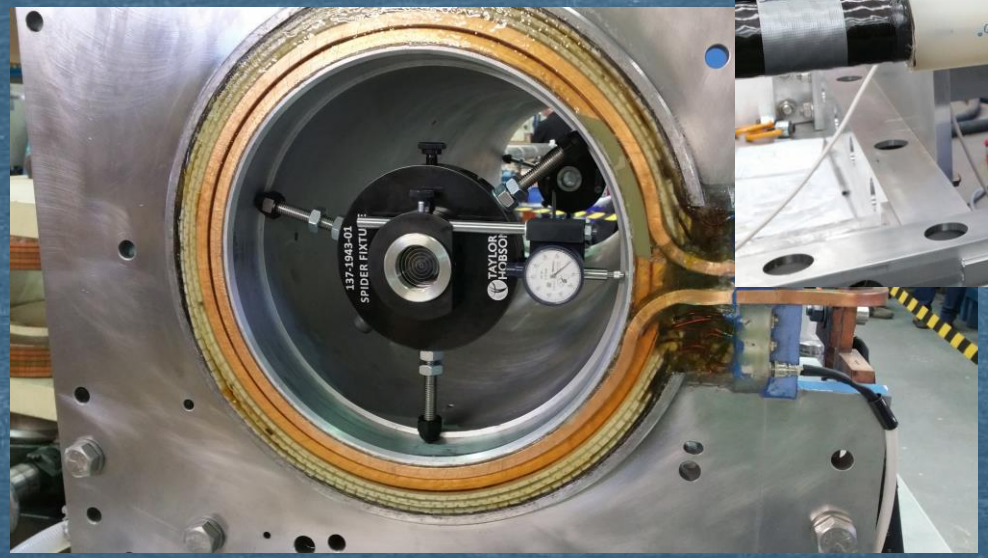
- Measure each standard solenoid to determine how to place the solenoids during assembly ($B_t/B_{||} \leq 5x10^{-3}$).
- Measure all the other magnetic circuits.
  - expansion solenoid, toroids, saddle coils, circular coils, fine-tune coils, Helmholz coils.
- Check the magnetic model proposed by TESLA Engineering.
  - effect of saddle coils, circular coils, fine-tune coils on the transverse field components.
- Field map of the electron cooler assembly.
  - $B_t/B_{||} \leq 5x10^{-4}$ in the centre of the drift solenoid.

Measurement setup

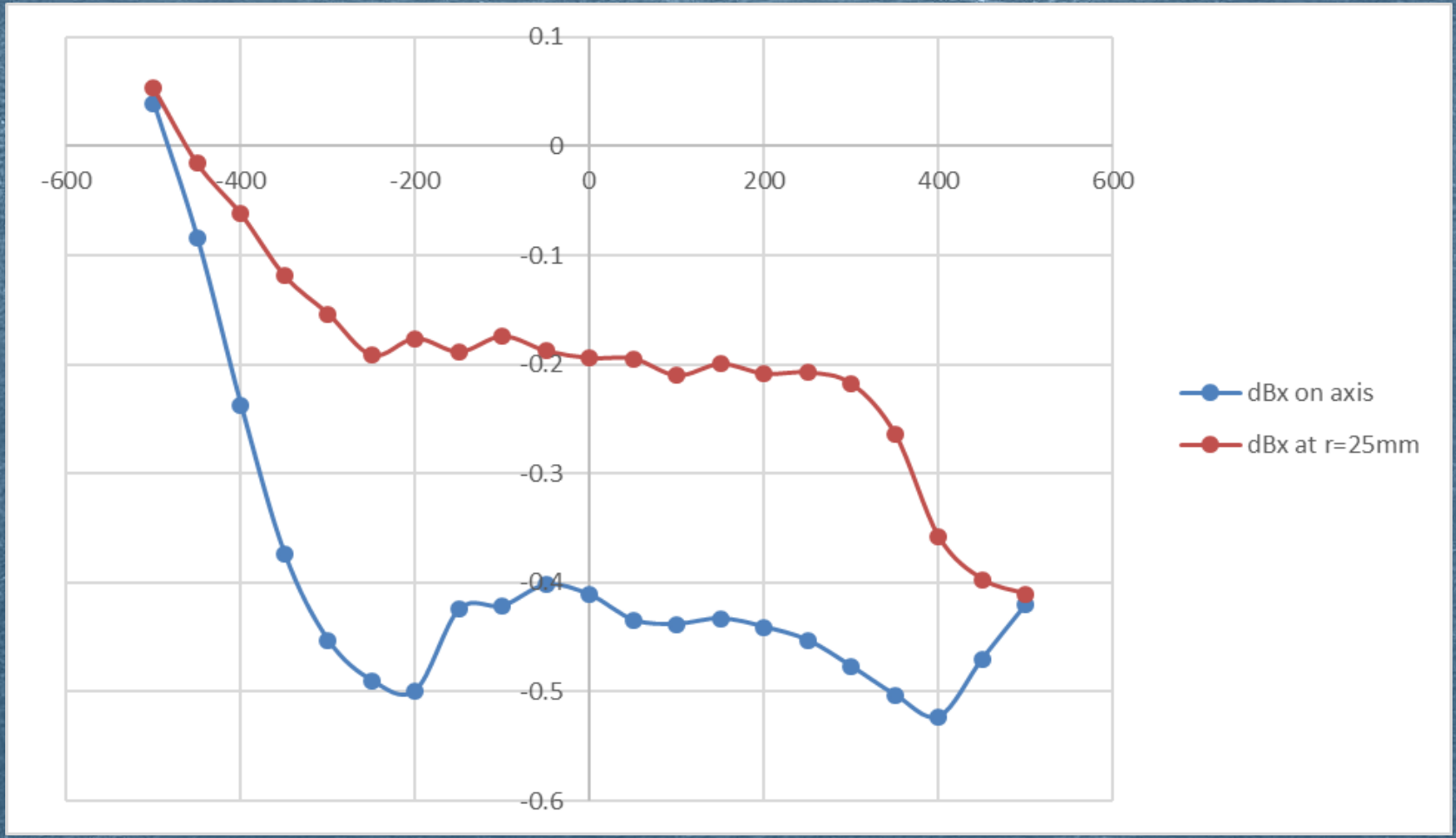
- Lakeshore Model 460 Gaussmeter with 3-axis HSE probe (1 mG resolution in range up to 300 G, accuracy of ±0.1%).
- Probe holder with mirror for precise alignment. Has 4 possible rotational positions with 3 mounting points (0, 10 and 25 mm).
- Counter balanced carbon fibre tube to hold probe holder.
- Probe carrier and tube driven and positioned with a CMM arm with ±0.5 mm accuracy.
- Precise probe alignment made with an autocollimator and spider fixtures.

- To obtain the required accuracy in the measurement particular attention needs to be paid to:
  - Alignment of Hall probe to the mirror
  - Systematic errors of the measurement system
    - Transverse Hall effect
    - Hall plate misalignment
      - Determine angles between magnetic field and Hall plates through probe characterisation in dipole and solenoid fields.
- Field components calculated using the method outlined by A. Wolf
  - CERN EP INT 84-01

tesla


SPIDER FIXTURE
TAYLOR HOBSON

- Major problem discovered after first set of measurements:
  - Measurement not reproducible – up to 0.5 G variation on transverse field



Difference (in Gauss) between two sets of measurements of the vertical field component B_x

- Sources of error investigated:
  - Equipment misalignment – alignment procedure repeated a number of times. Could only account for less than 50 mG error.
  - Probe calibration error – spurious field measurement. Probe recalibrated and no error found.
  - Background field variation – long-term measurement made varying environmental conditions (crane, draughts…) and after repeated power on/off. Less than 20 mG variation measured.
  - Probe holder/mirror instability – mirror to probe angle changes after each rotation. Nylon studding replaced with aluminium ones.

Reproducibility measurements : 3 sets of measurements made on axis and with a vertical offset of 25mm

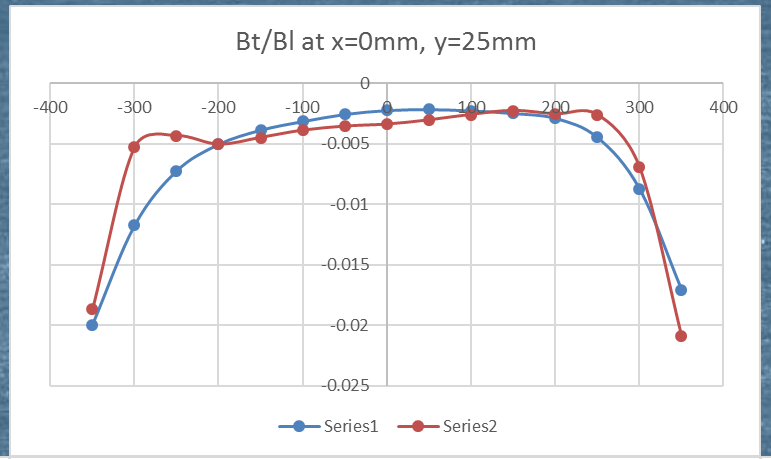
mean			std		
Bx	By	Bz	Bx	By	Bz
-0.27779	-0.27583	-46.419	0.024537	0.004314	0.019235
-0.2956	-0.15179	-66.0338	0.029354	0.004364	0.014978
-0.23845	0.060001	-81.6451	0.04059	0.001377	0.007985
-0.17998	0.217513	-91.5771	0.048201	0.000286	0.007742
-0.15592	0.299886	-97.1655	0.051614	0.006439	0.000234
-0.12859	0.328454	-100.151	0.057307	0.005255	0.003488
-0.11895	0.333786	-101.689	0.057863	0.004277	0.000754
-0.09296	0.326214	-102.473	0.051952	0.005313	0.001482
-0.05704	0.308024	-102.882	0.05438	0.006584	0.004729
-0.01331	0.289382	-103.076	0.054907	0.006822	0.002977
0.002459	0.273521	-103.097	0.052853	0.006904	0.003978
-0.00216	0.266993	-102.955	0.053388	0.007201	0.003474
-0.02437	0.273223	-102.639	0.049592	0.006977	0.004472
-0.04942	0.289278	-102.131	0.050001	0.006385	0.003977
-0.05249	0.306756	-101.336	0.050412	0.007207	0.004716
-0.04086	0.334266	-99.9355	0.051145	0.008095	0.006459
-0.00219	0.375904	-97.2306	0.049719	0.006238	0.00472
0.047262	0.438613	-91.9844	0.0408	0.002814	0.007748
0.123223	0.509497	-82.4339	0.02983	0.011689	0.00772
0.218758	0.562932	-67.1374	0.039771	0.010998	0.024976
0.196074	0.526462	-47.6834	0.024917	0.014754	0.019932

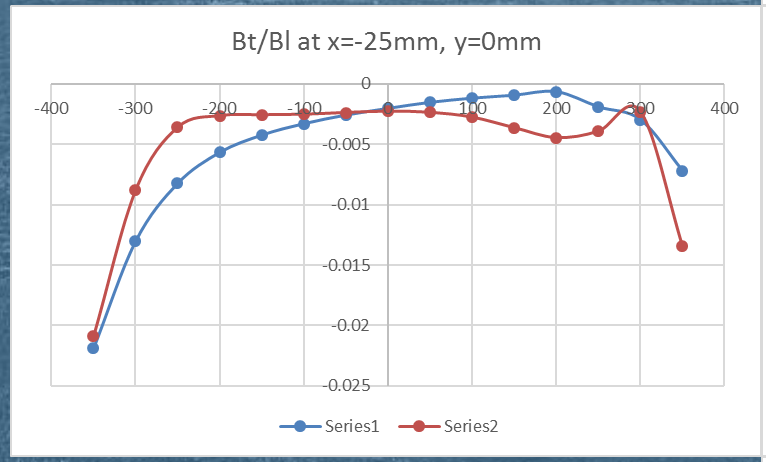
B field (G) components on axis
Z=-500mm to +500mm

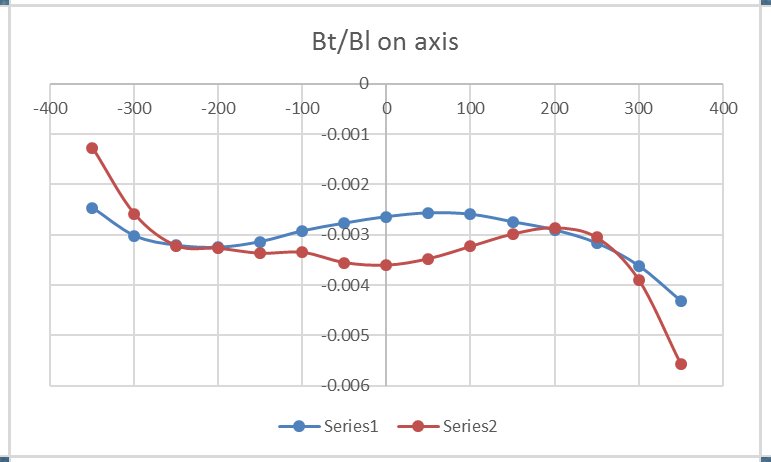
mean			std		
Bx	By	Bz	Bx	By	Bz
-5.27264	-0.13447	-46.2066	0.017255	0.034879	0.029478
-4.93498	-0.02514	-66.2036	0.027148	0.009794	0.039181
-3.46264	0.148799	-81.9268	0.032129	0.00487	0.040079
-2.10256	0.266053	-91.7799	0.042458	0.002566	0.031677
-1.23755	0.302717	-97.2866	0.048963	0.027429	0.031545
-0.7515	0.332596	-100.212	0.058527	0.003467	0.027975
-0.48877	0.324555	-101.719	0.056275	0.006067	0.025977
-0.33733	0.306311	-102.494	0.052637	0.007762	0.027965
-0.24682	0.279951	-102.9	0.051315	0.006989	0.026417
-0.1536	0.25525	-103.086	0.047883	0.006571	0.026955
-0.10044	0.236424	-103.099	0.044986	0.007895	0.025011
-0.07249	0.230913	-102.948	0.049269	0.006828	0.025543
-0.05548	0.240784	-102.626	0.049752	0.006182	0.025654
-0.03379	0.26152	-102.126	0.049163	0.006285	0.025123
0.05689	0.277938	-101.361	0.049771	0.006584	0.02445
0.283709	0.302673	-100.009	0.053073	0.009543	0.023422
0.766781	0.335278	-97.3784	0.052716	0.010543	0.024722
1.654684	0.372311	-92.2453	0.051298	0.007904	0.021506
3.05713	0.413792	-82.801	0.042838	0.006577	0.019186
4.621089	0.428037	-67.4515	0.050614	0.015442	0.018159
5.137452	0.381959	-47.6373	0.038131	0.015225	0.020997

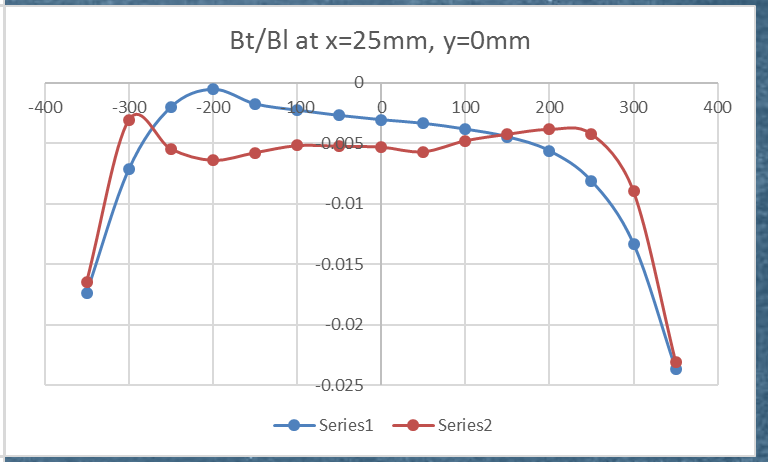
B field (G) components at y=25mm
Z=-500mm to +500mm

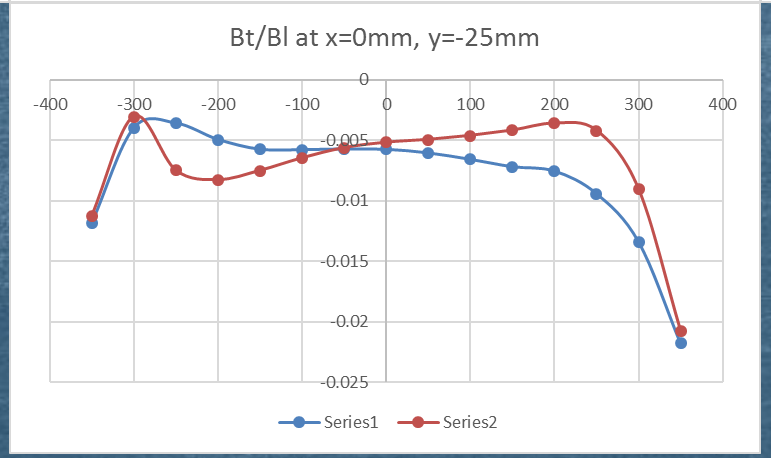
Influence of circular coils on B_t/B_l For SS#2



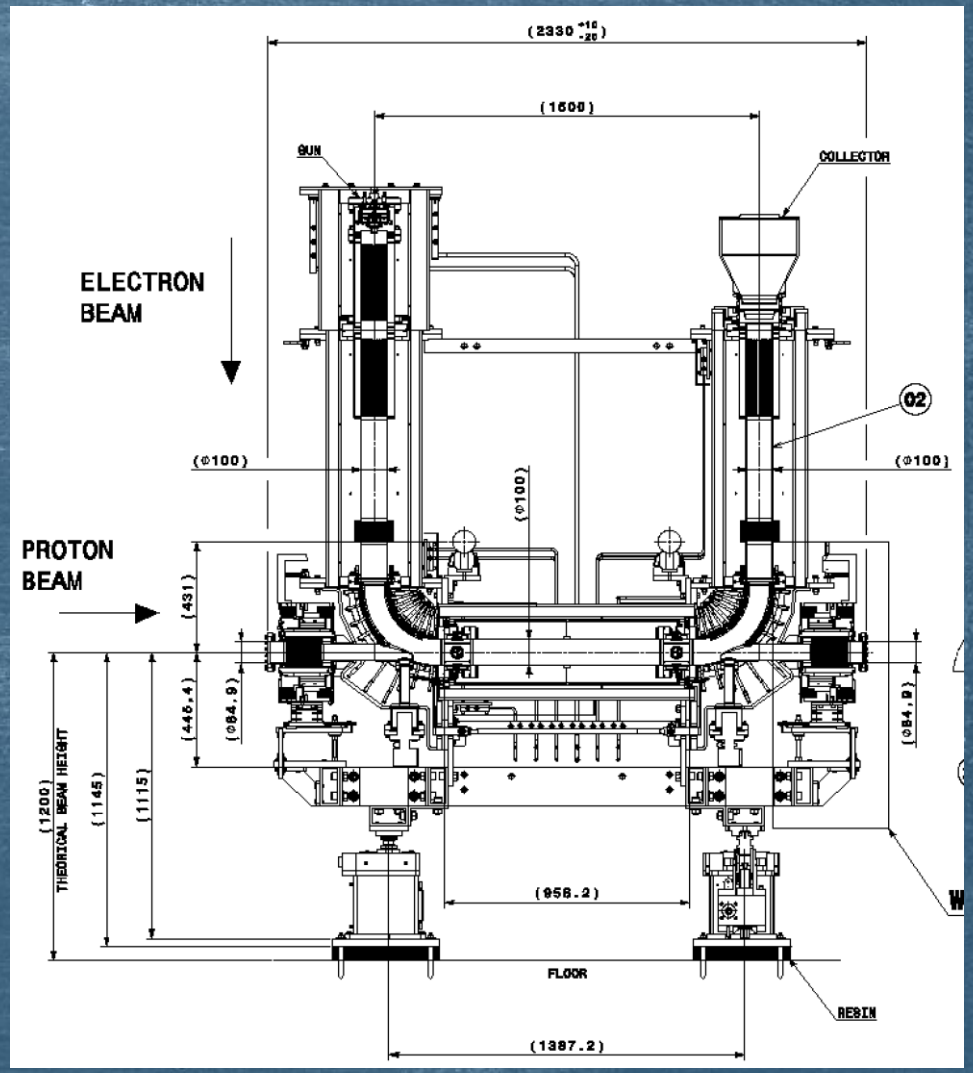


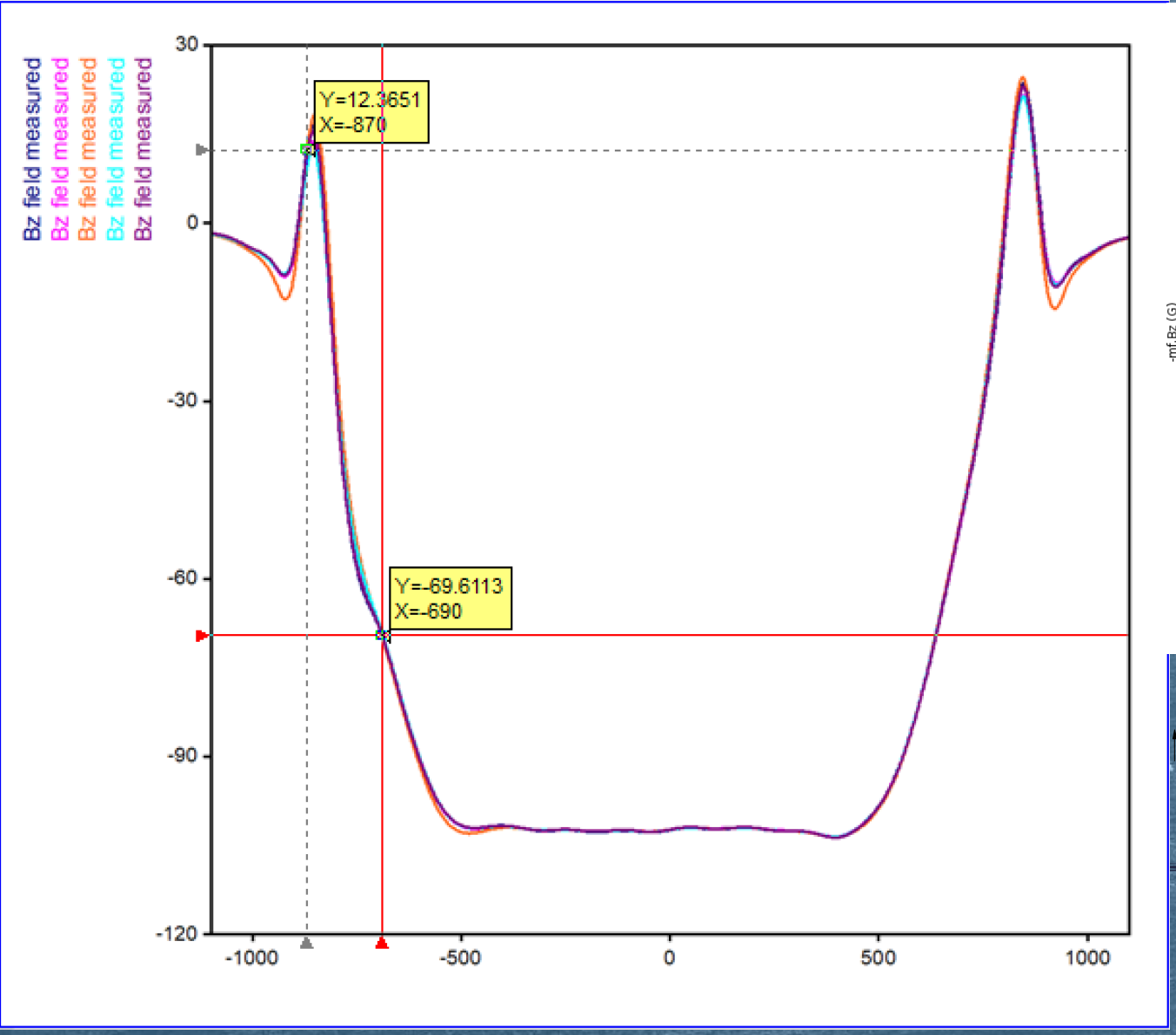


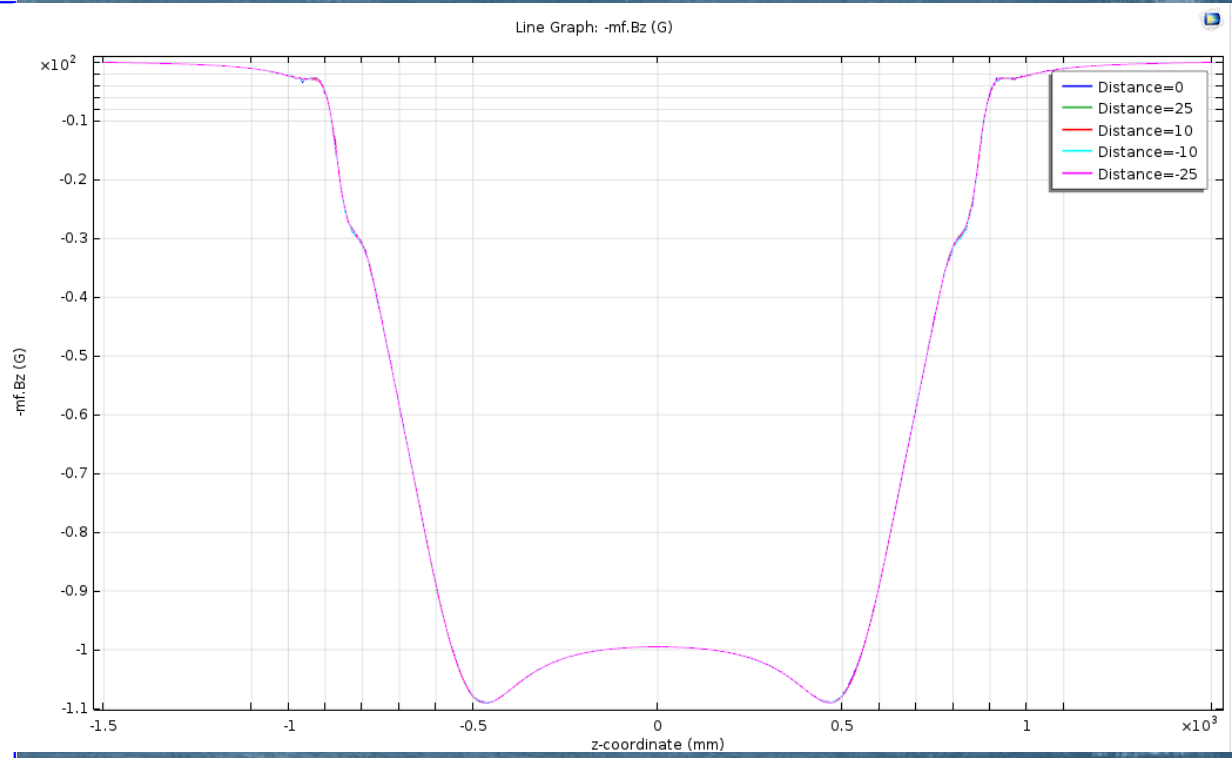


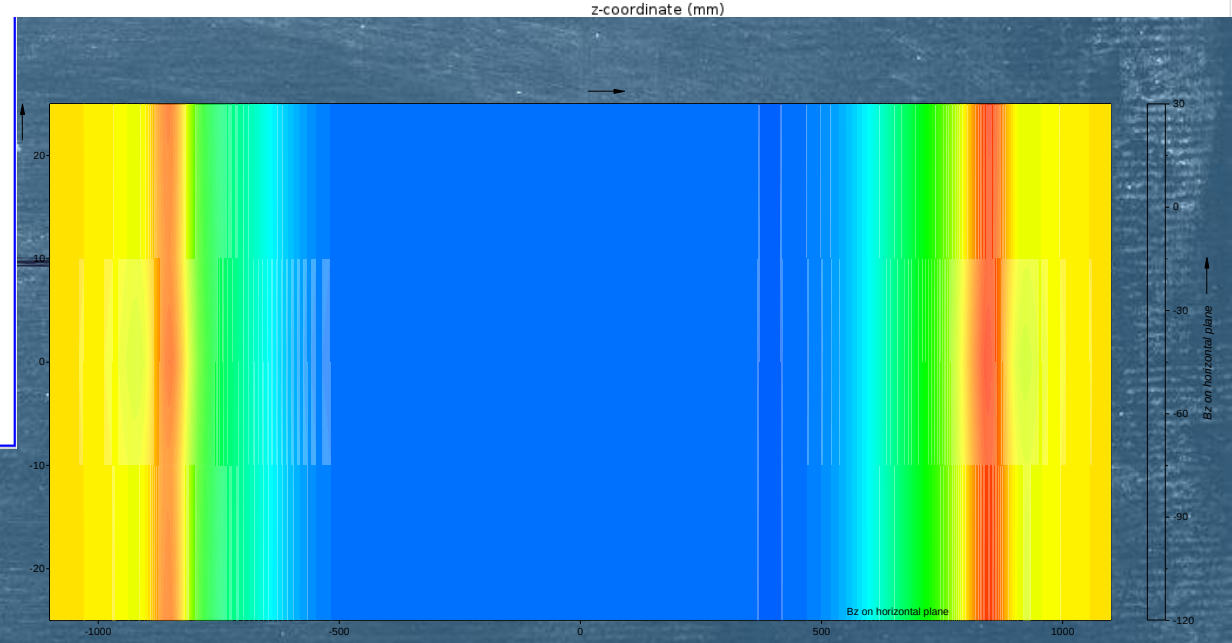


Full assembly measurement

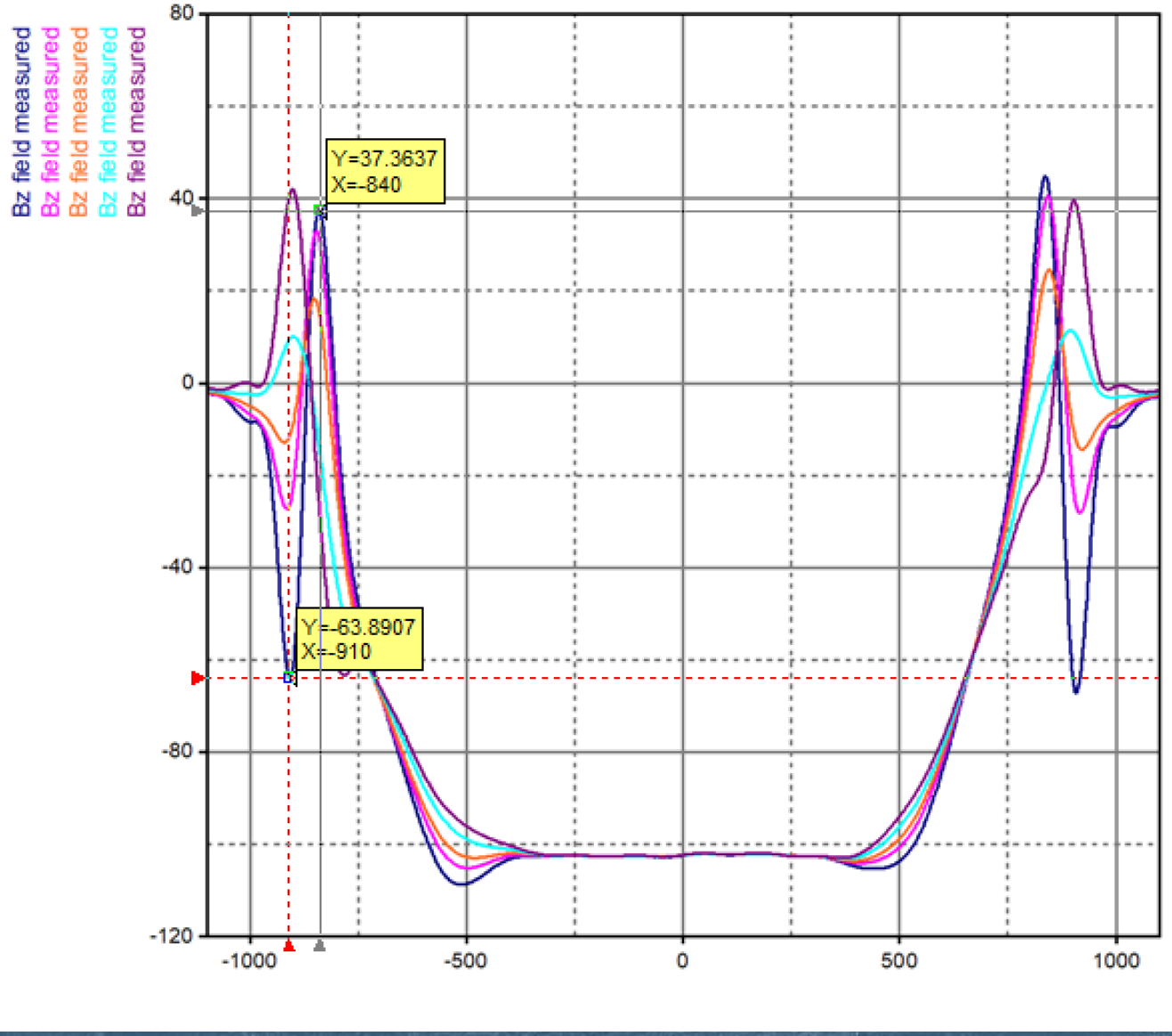


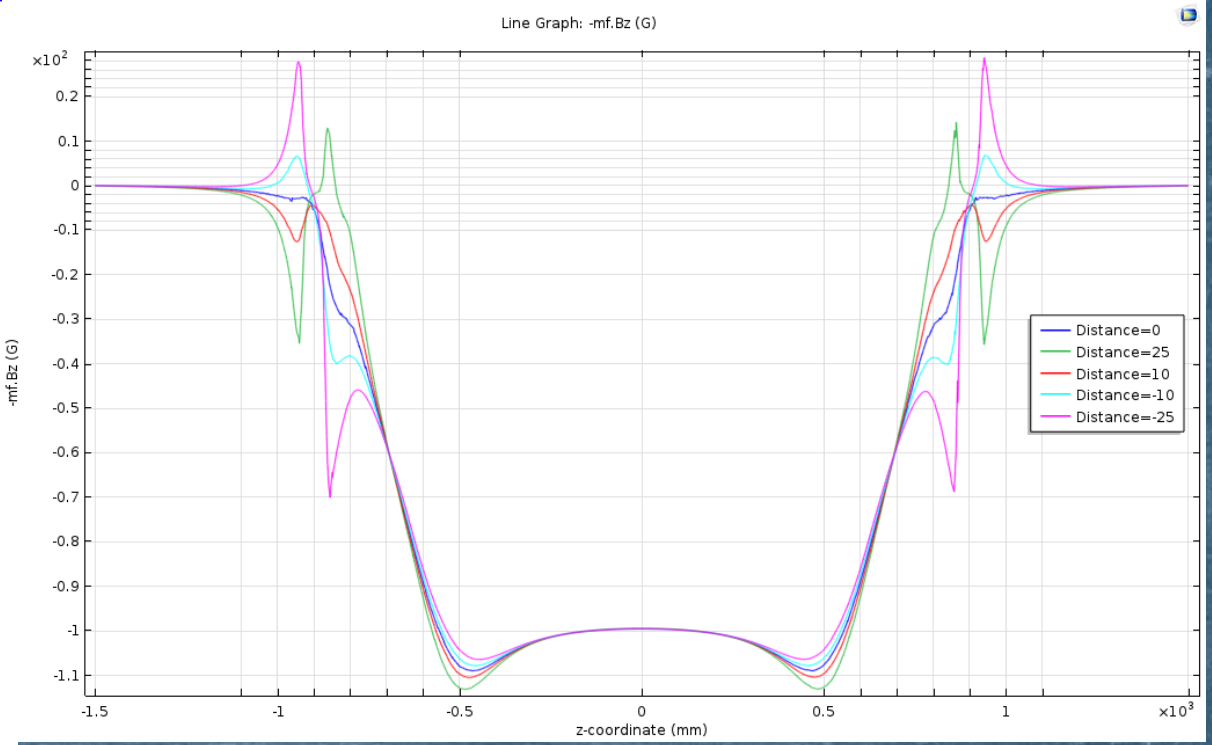


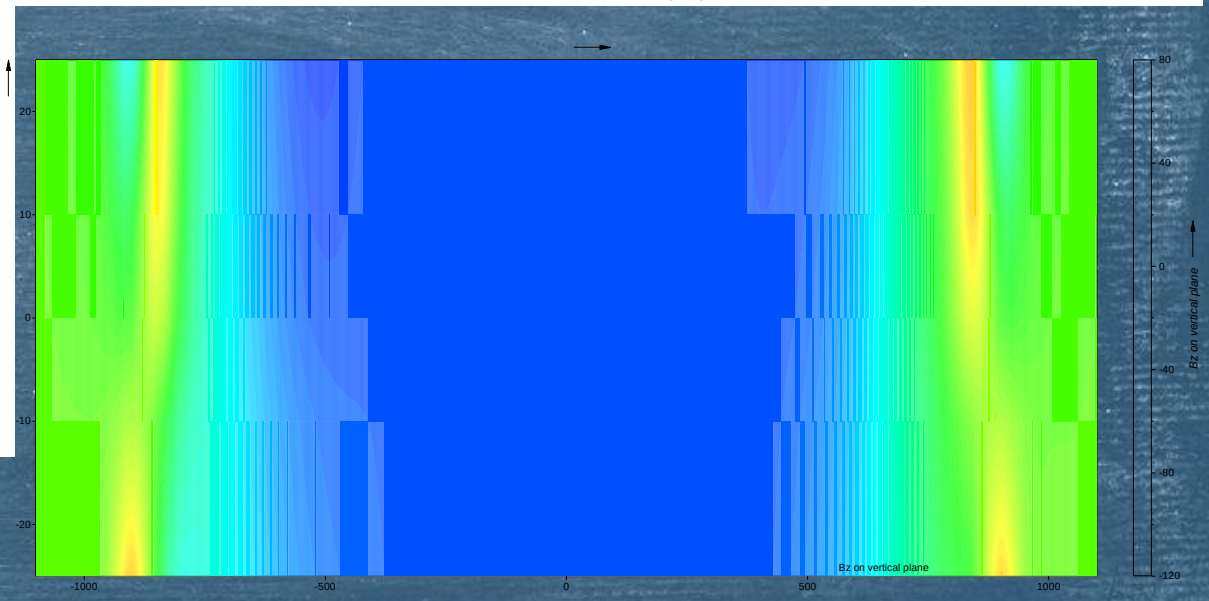




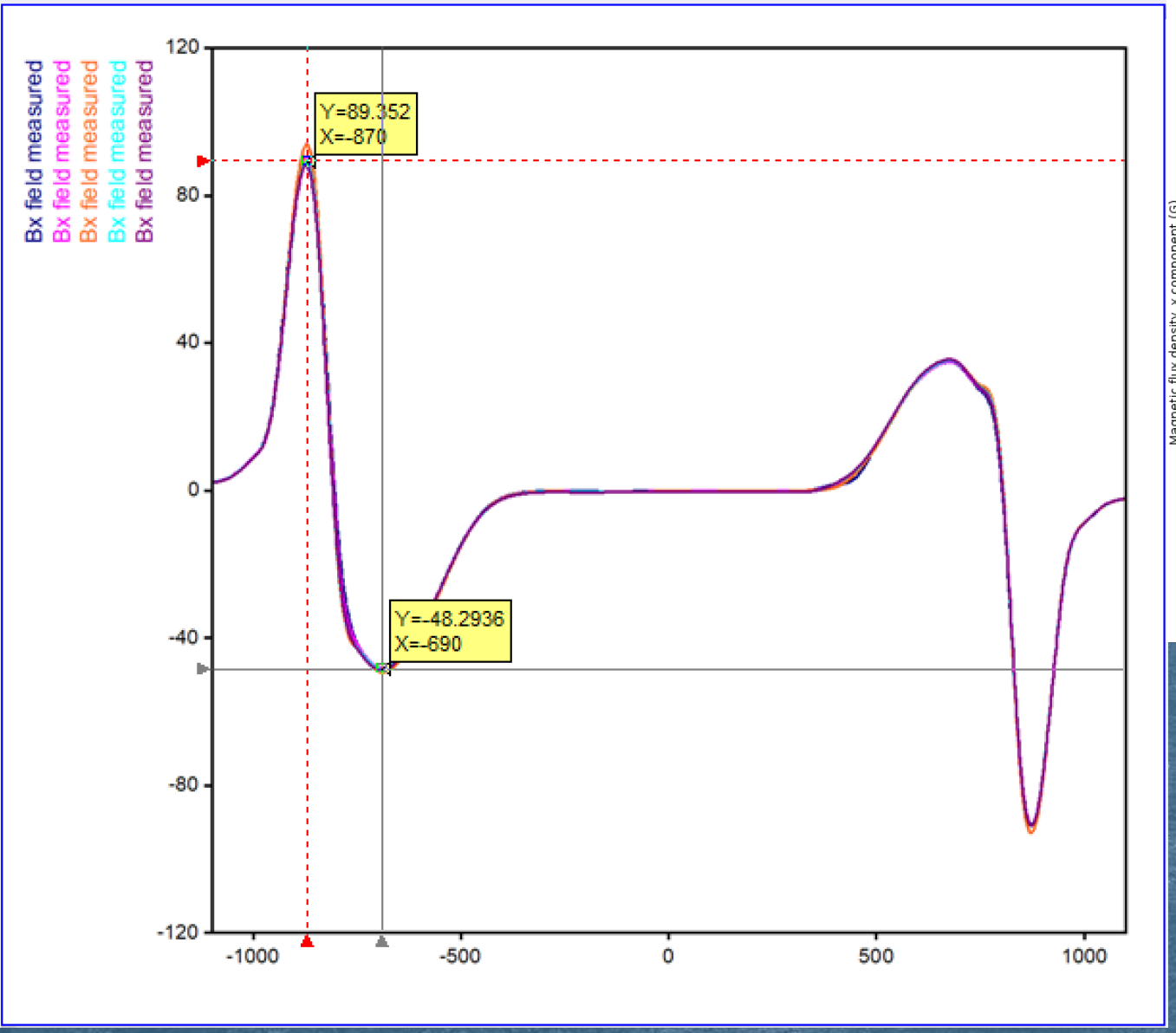
B_z vs. horizontal position

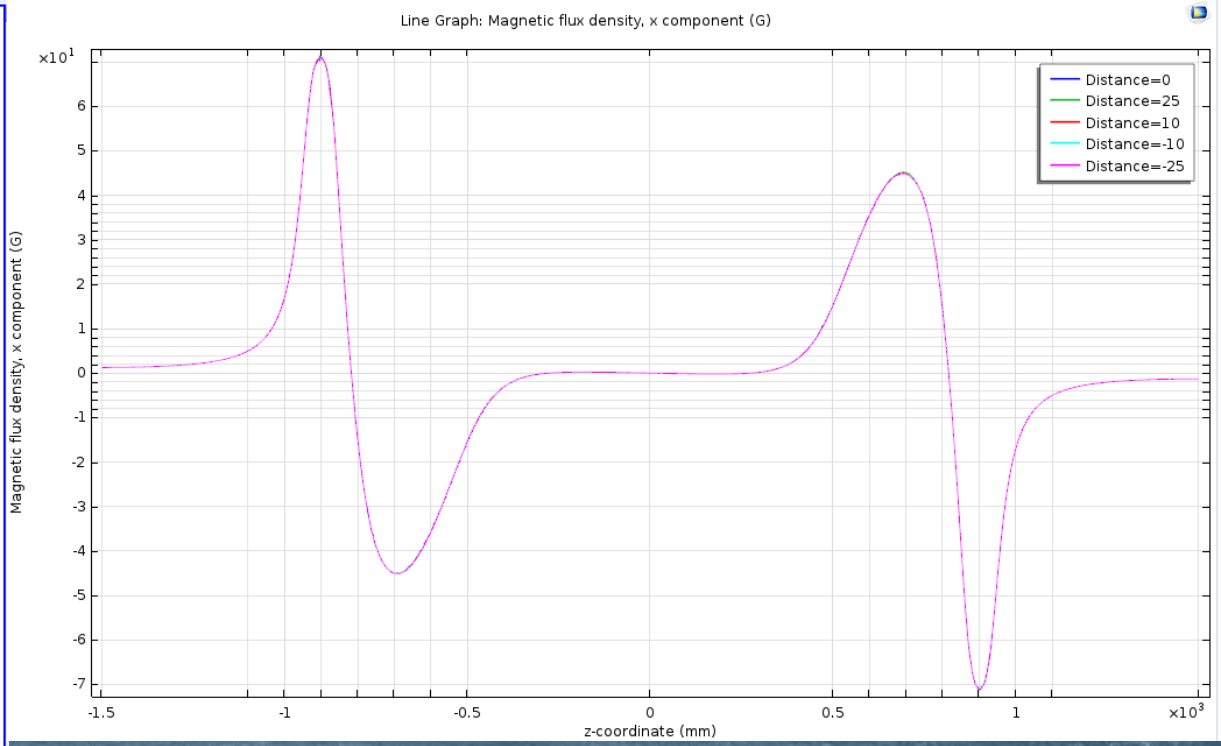


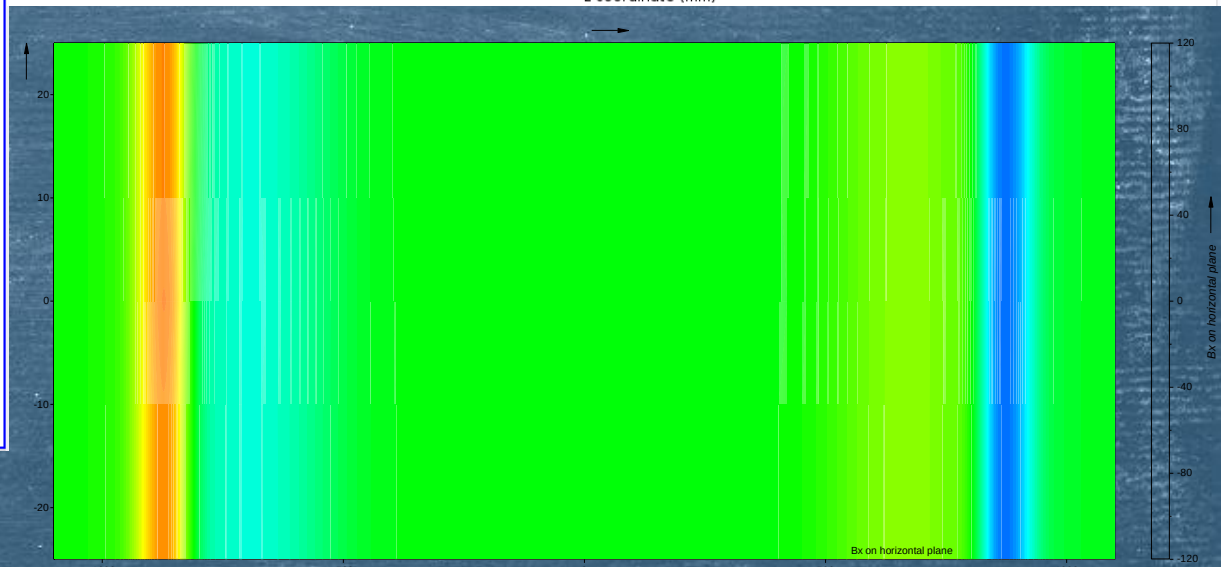




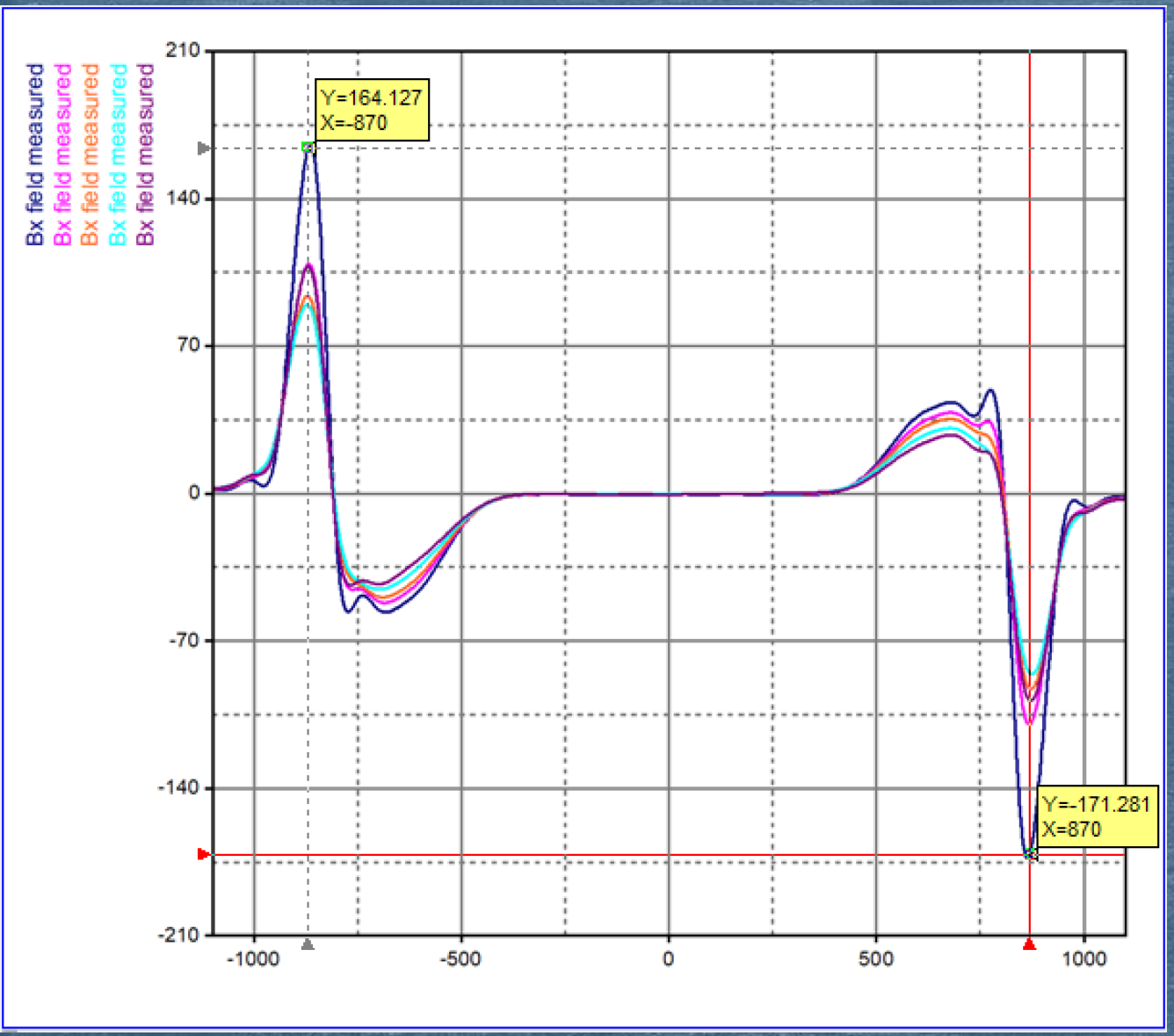
B_z vs. vertical position

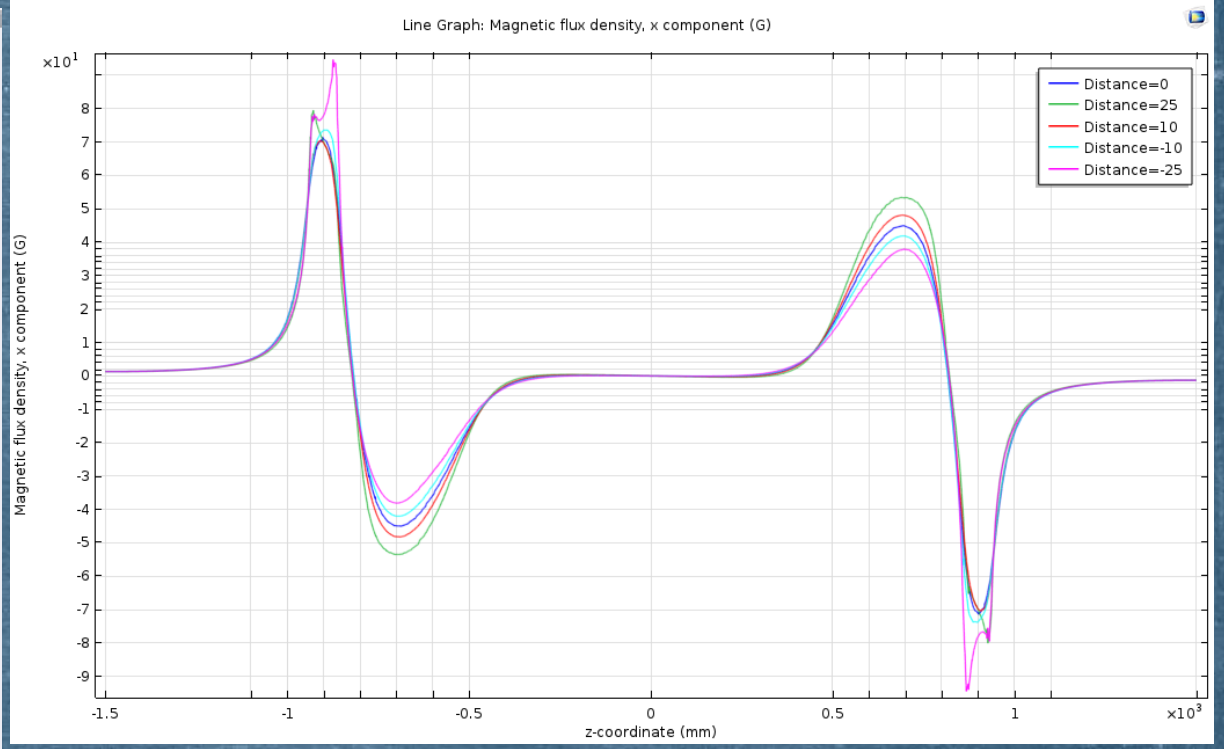


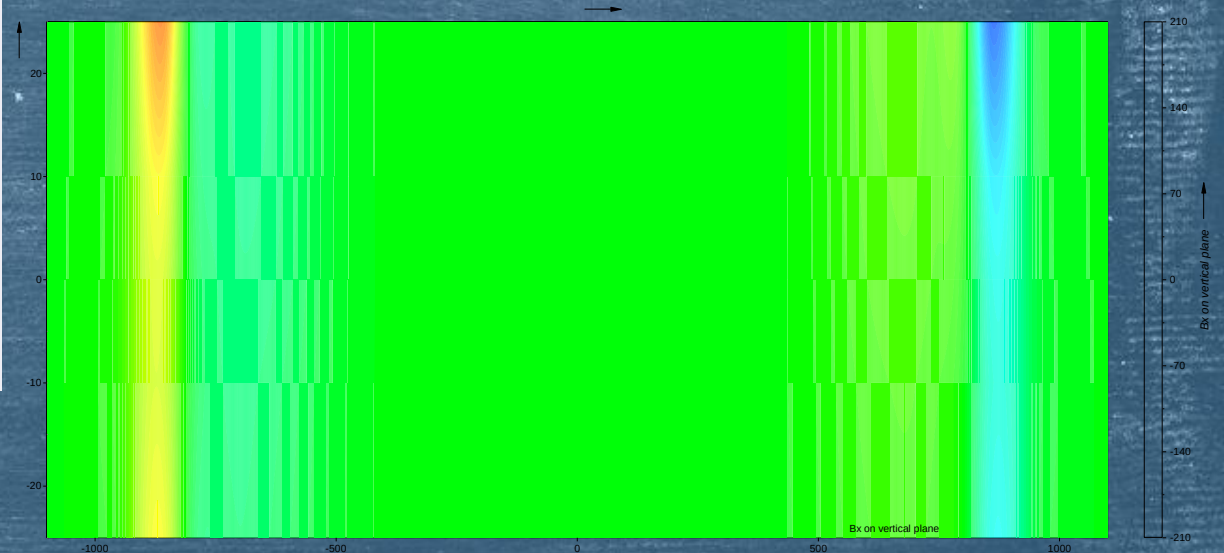




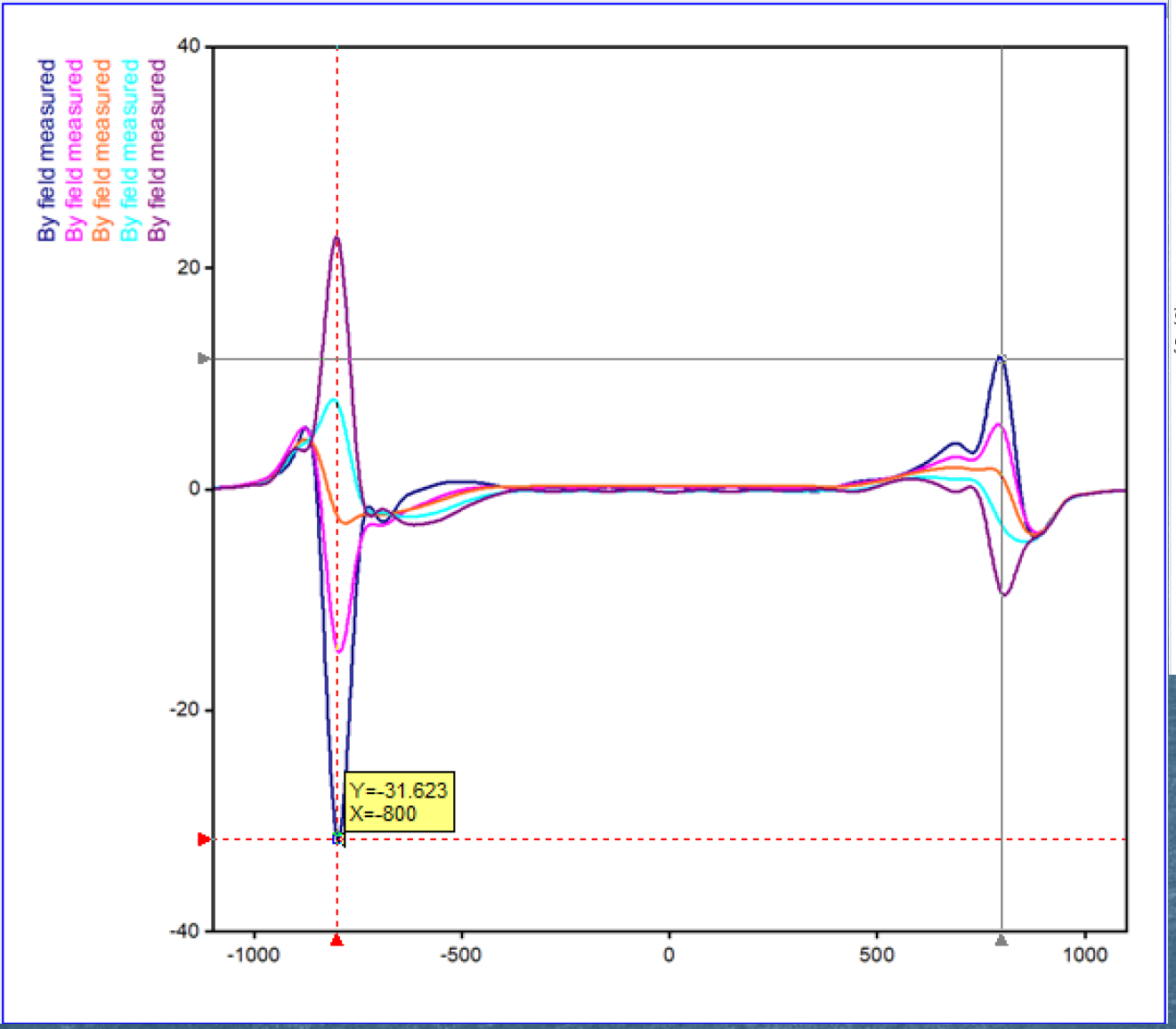
B_x vs. horizontal position

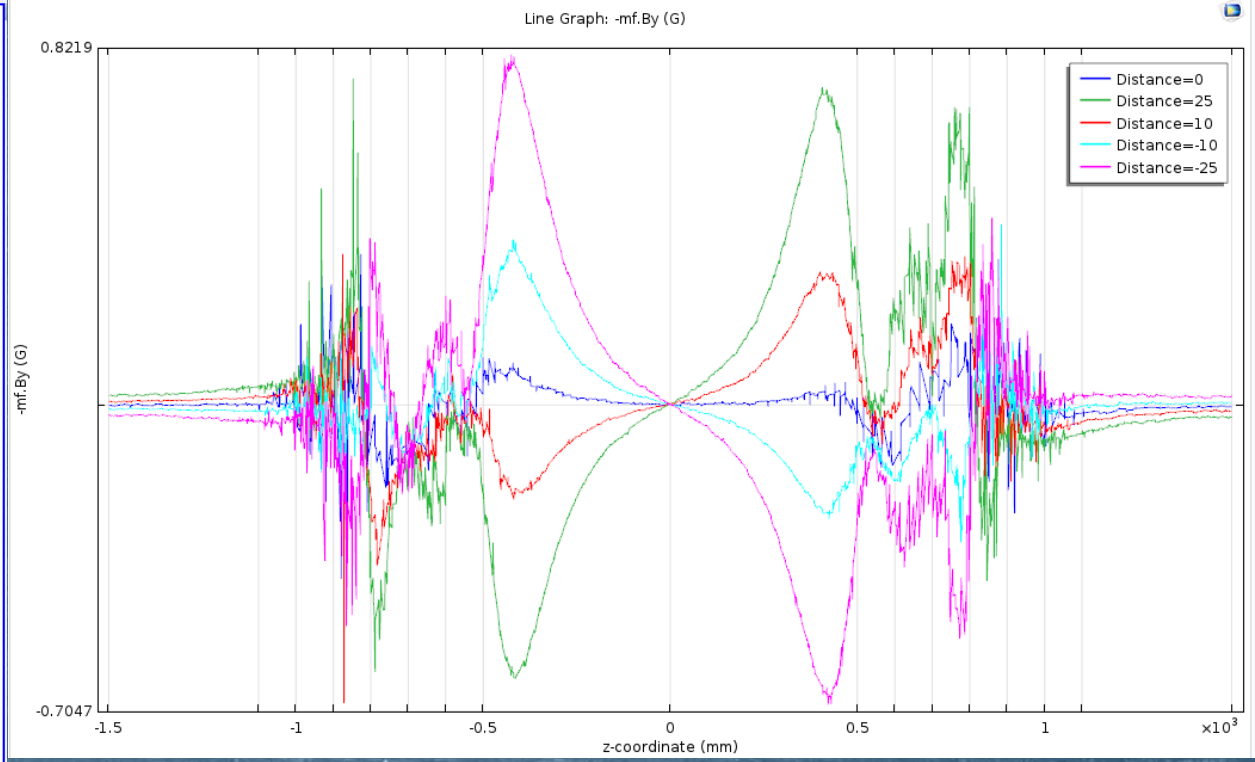


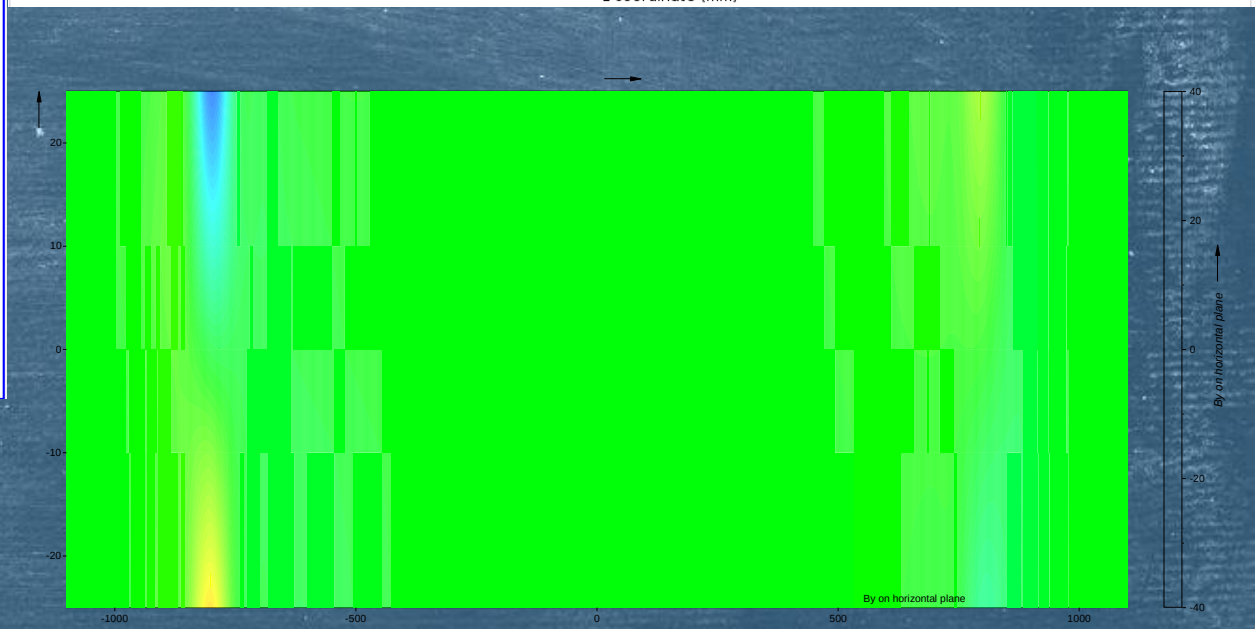




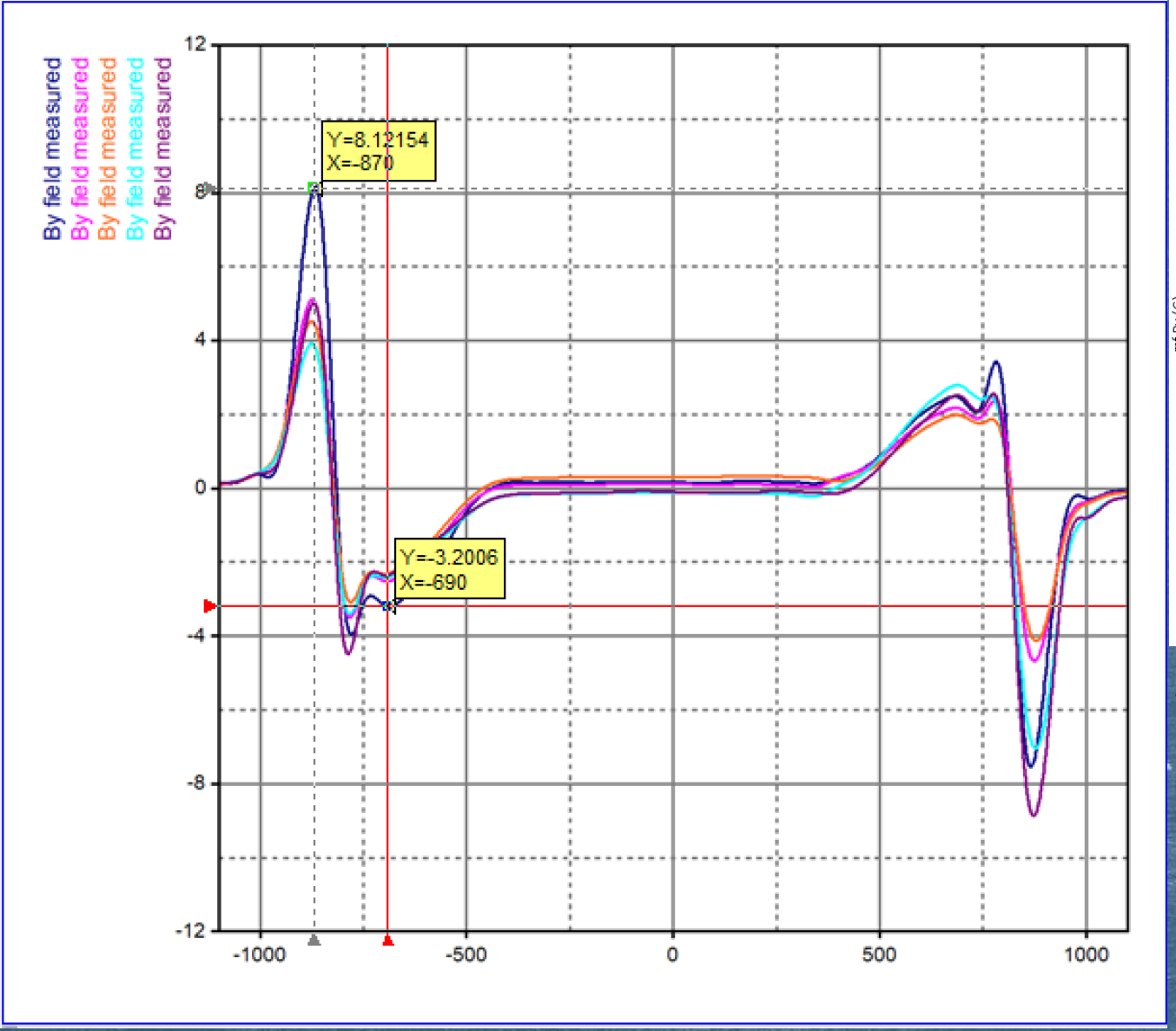
B_x vs. vertical position

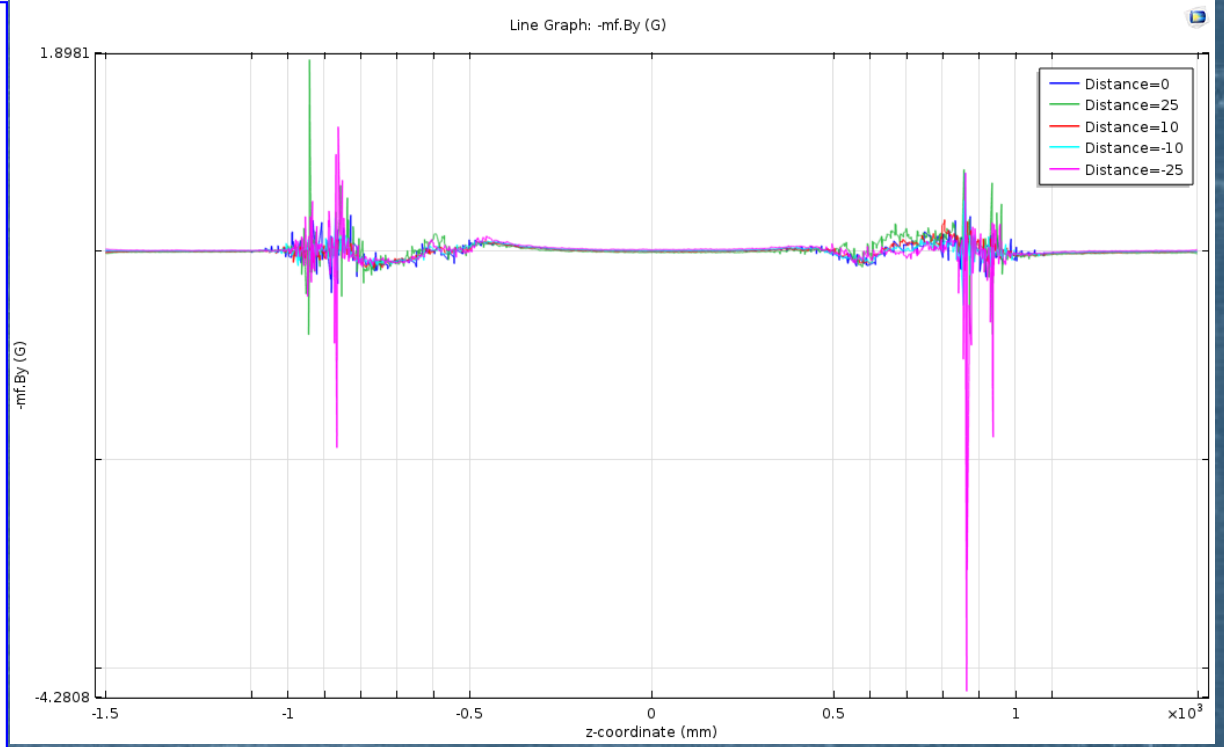


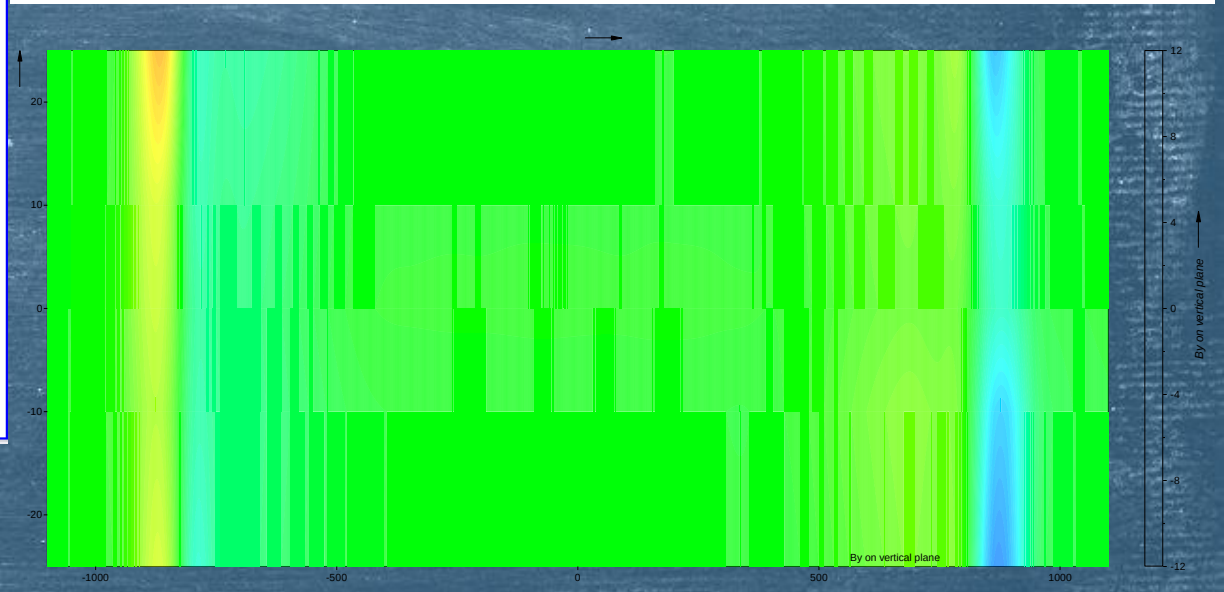




B_y vs. horizontal position

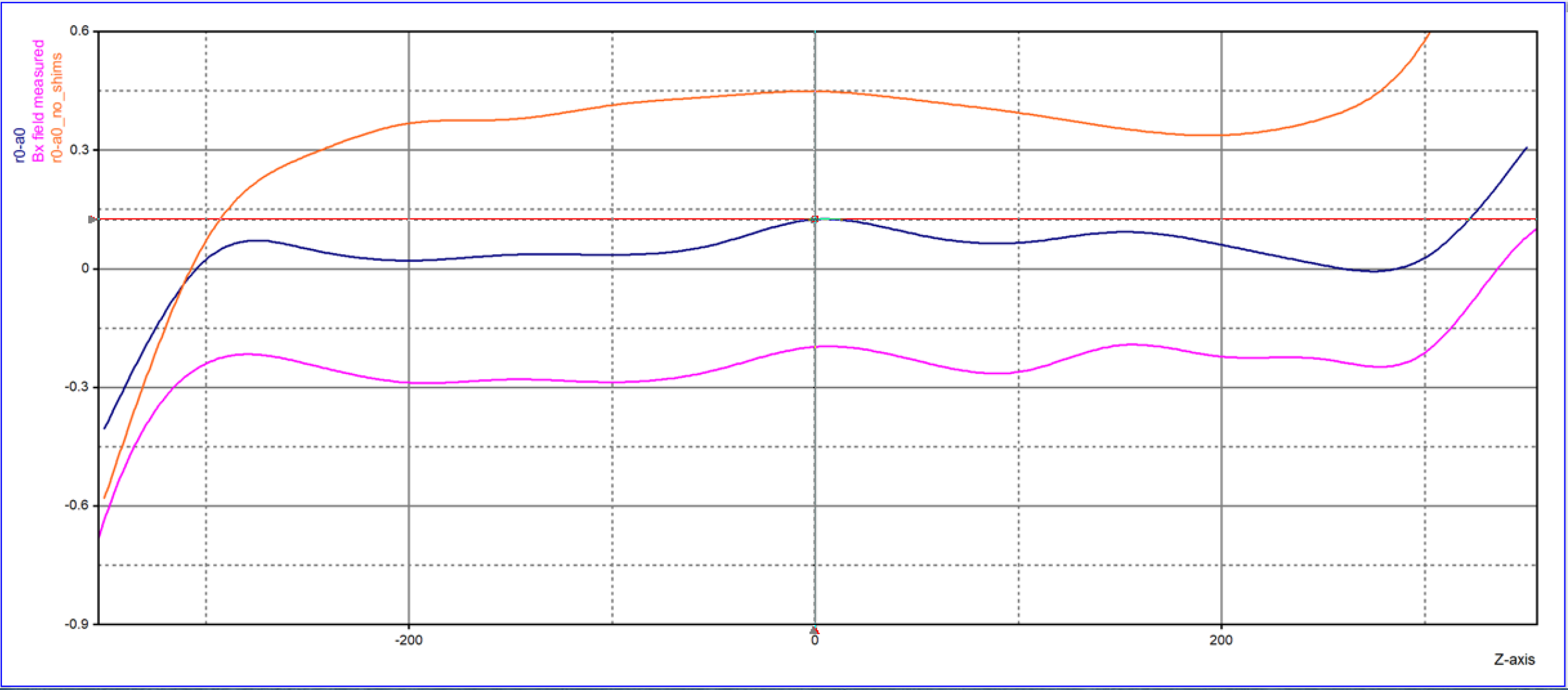




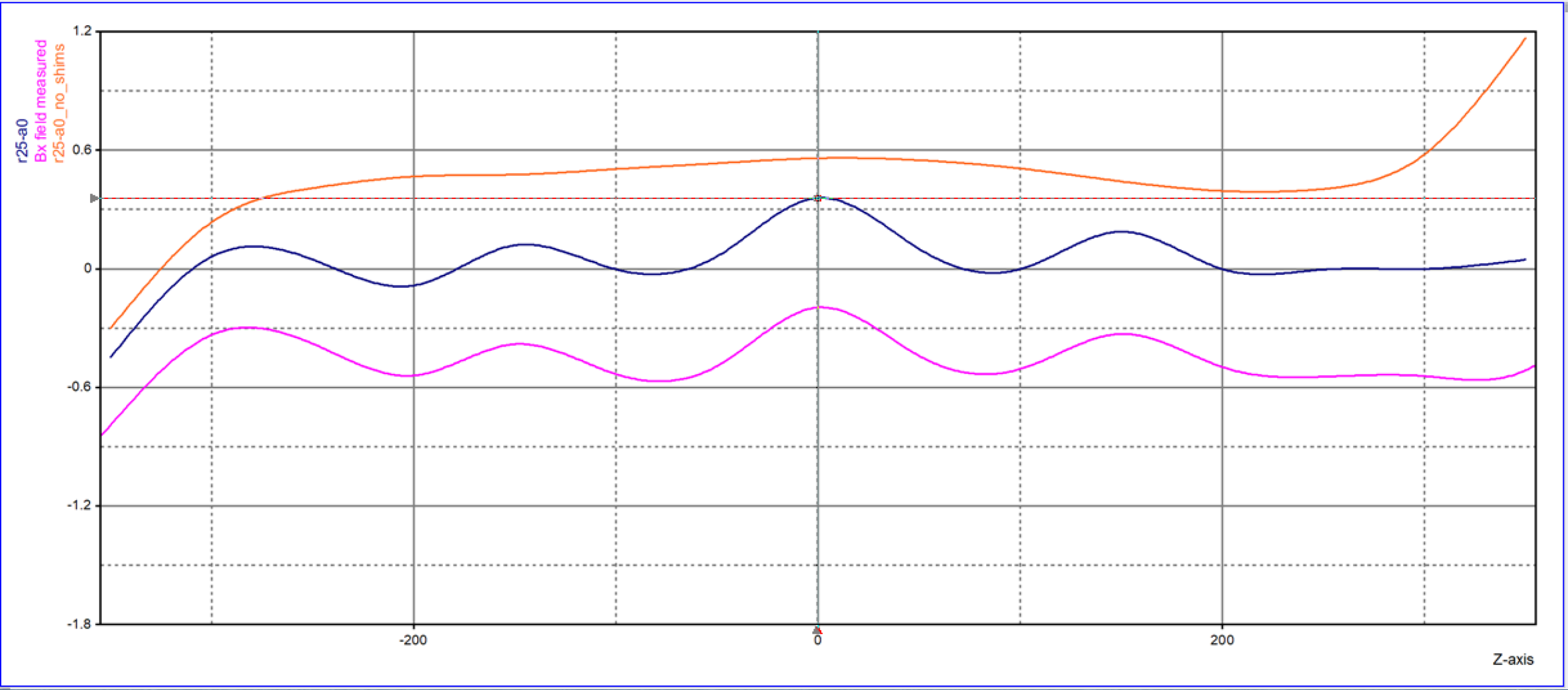


B_y vs. vertical position

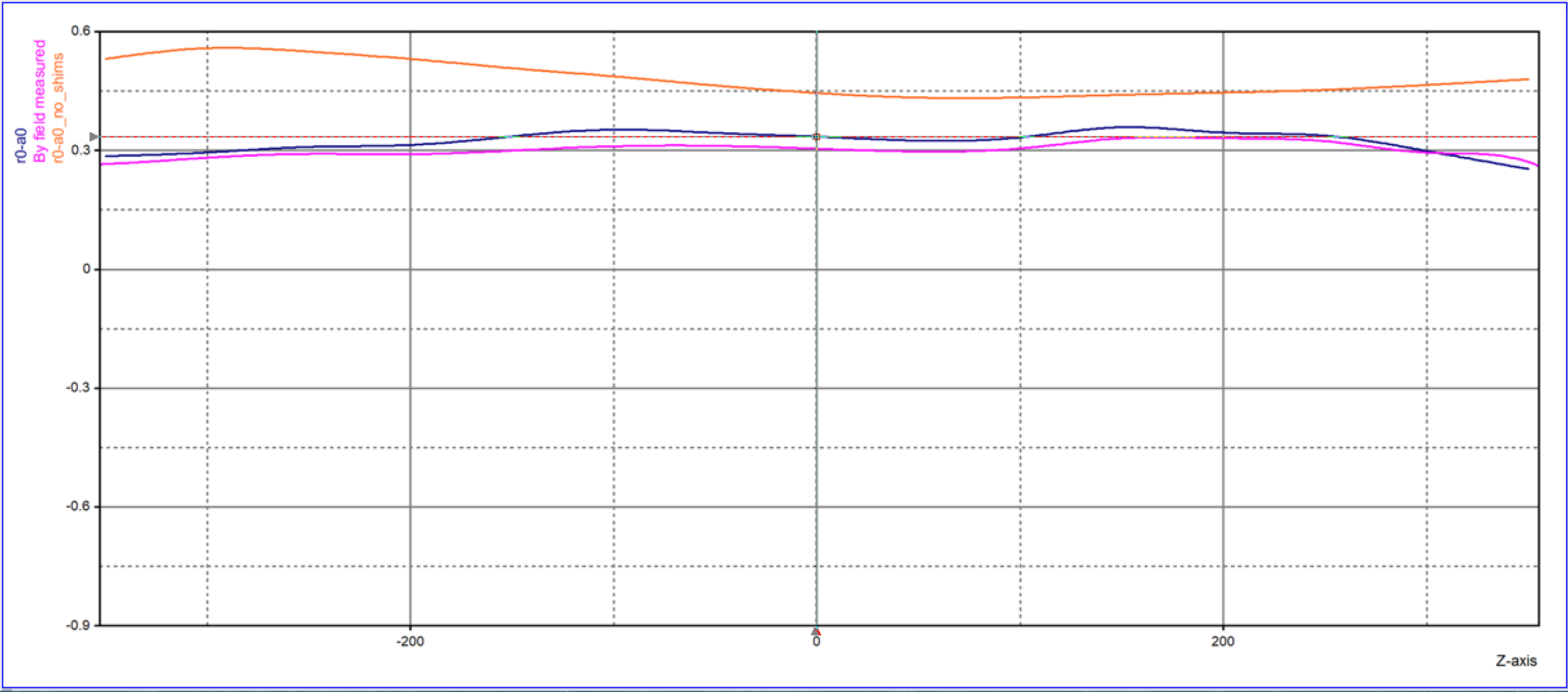
B_x on axis, calculated & measured with/without fine tune coils



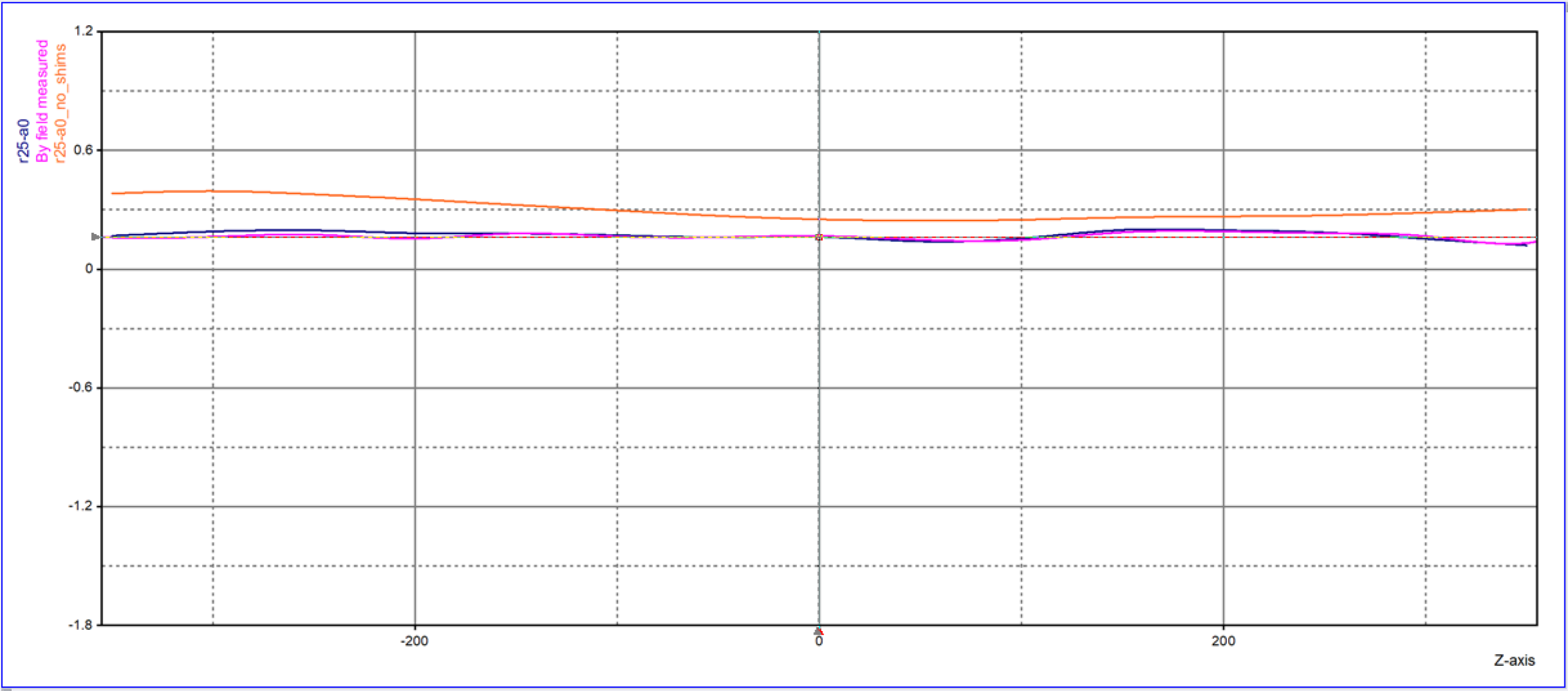
B_x at r=25mm, calculated & measured with/without fine tune coils



B_y on axis, calculated & measured with/without fine tune coils



B_y at r=25mm, calculated & measured with/without fine tune coils



Observations

- Probe alignment is very delicate.
  - Probe orientation measured at each point making the measurement sequence very long.
  - Vertical oscillation of the long carbon fibre tube takes a long time to damp.
- Correction of the vertical field component in the full assembly is problematic due to a random offset in the measurement (not present during the measurement of the individual solenoids).
  - The correction algorithm gives too large currents in the fine-tune coils.
- Anomalous behaviour of B_y and B_z in the vicinity of the toroid shielding and compact corrector magnet.
  - Incorrect model?
  - Shielding touching the yoke?

Conclusion

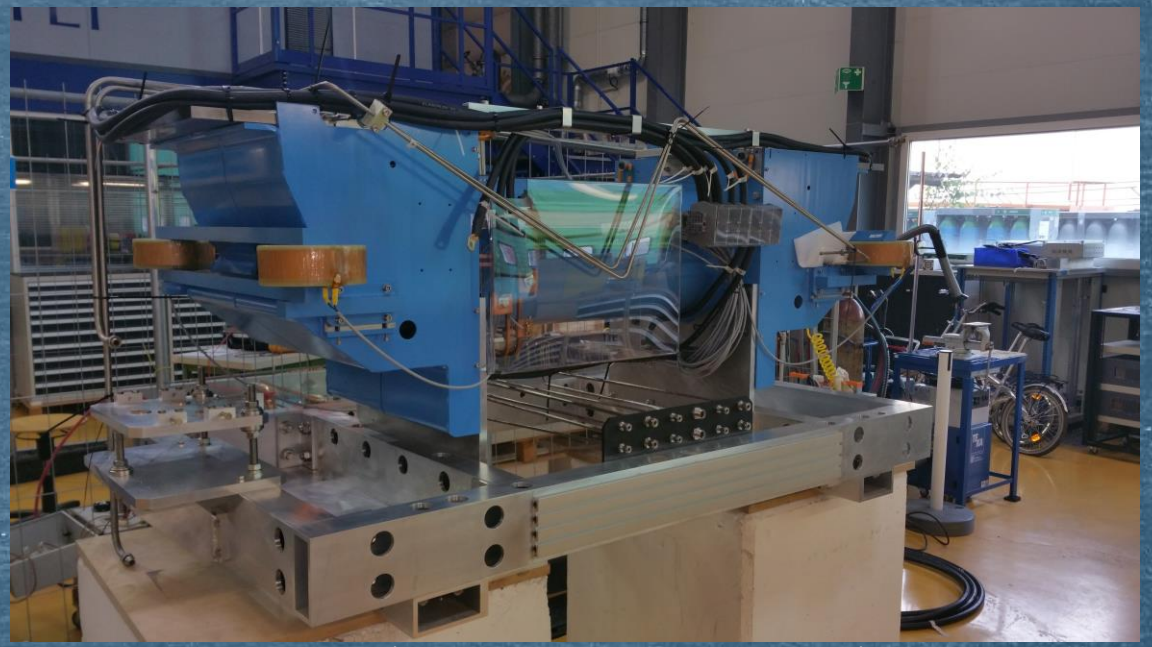
- All magnetic elements have been individually measured on and off axis. Data available in EXCEL file.
- The effect of the correction coils on the B field is measured.
- Standard solenoid 2 chosen as the “drift” solenoid.
- Anomalous field behaviour needs to be investigated.
- New correction algorithm will be used.
  - Helmholtz coils correct the offset.
  - Fine-tune coils reduce the spread of the transverse field components.

What next?

- Magnetic system arrived two weeks ago.

What next?

- With TE/MSC for certification.



- The electron cooler will be mounted outside the ELENA ring before installation in the ring at a later date.
  - Still waiting for the toroid vacuum chambers.

Questions & Discussion