

ELENA electron cooler magnetic measurements

(up to 1st November 2016)

Aim of the measurements

- Measure each standard solenoid to determine how to place the solenoids during assembly ($B_t/B_{\parallel} \leq 5 \times 10^{-3}$).
- Check the magnetic model proposed by TESLA Engineering (saddle coils, circular coils, fine-tune coils...).
- $B_t/B_{\parallel} \leq 5 \times 10^{-4}$ in the centre of the drift solenoid (50 mG).
- Field map of the electron cooler.

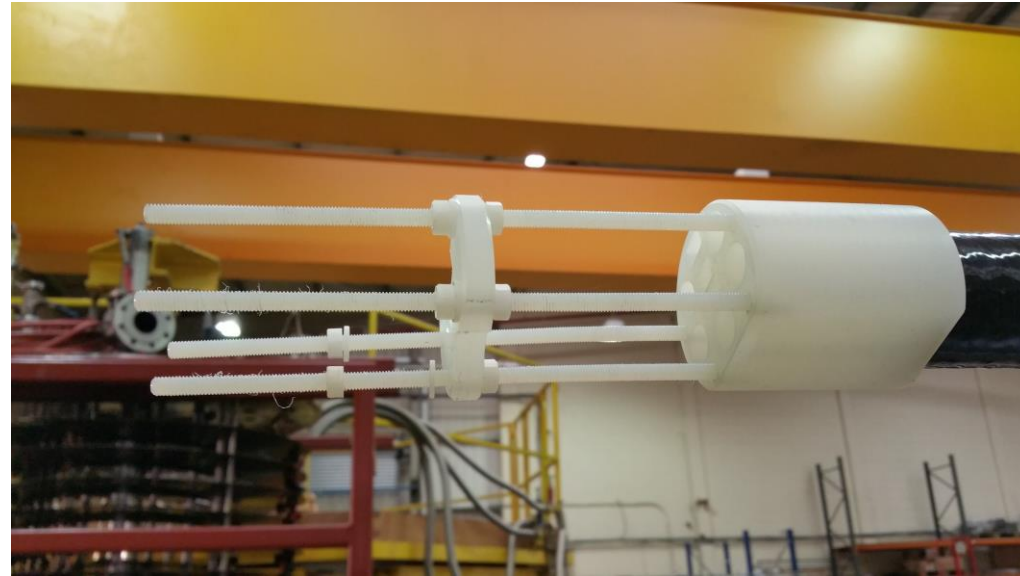
Setup

- Lakeshore Model 460 Gaussmeter with 3-axis HSE probe (1 mG resolution in range up to 300 G, accuracy of $\pm 0.1\%$).
- 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



Autocollimator

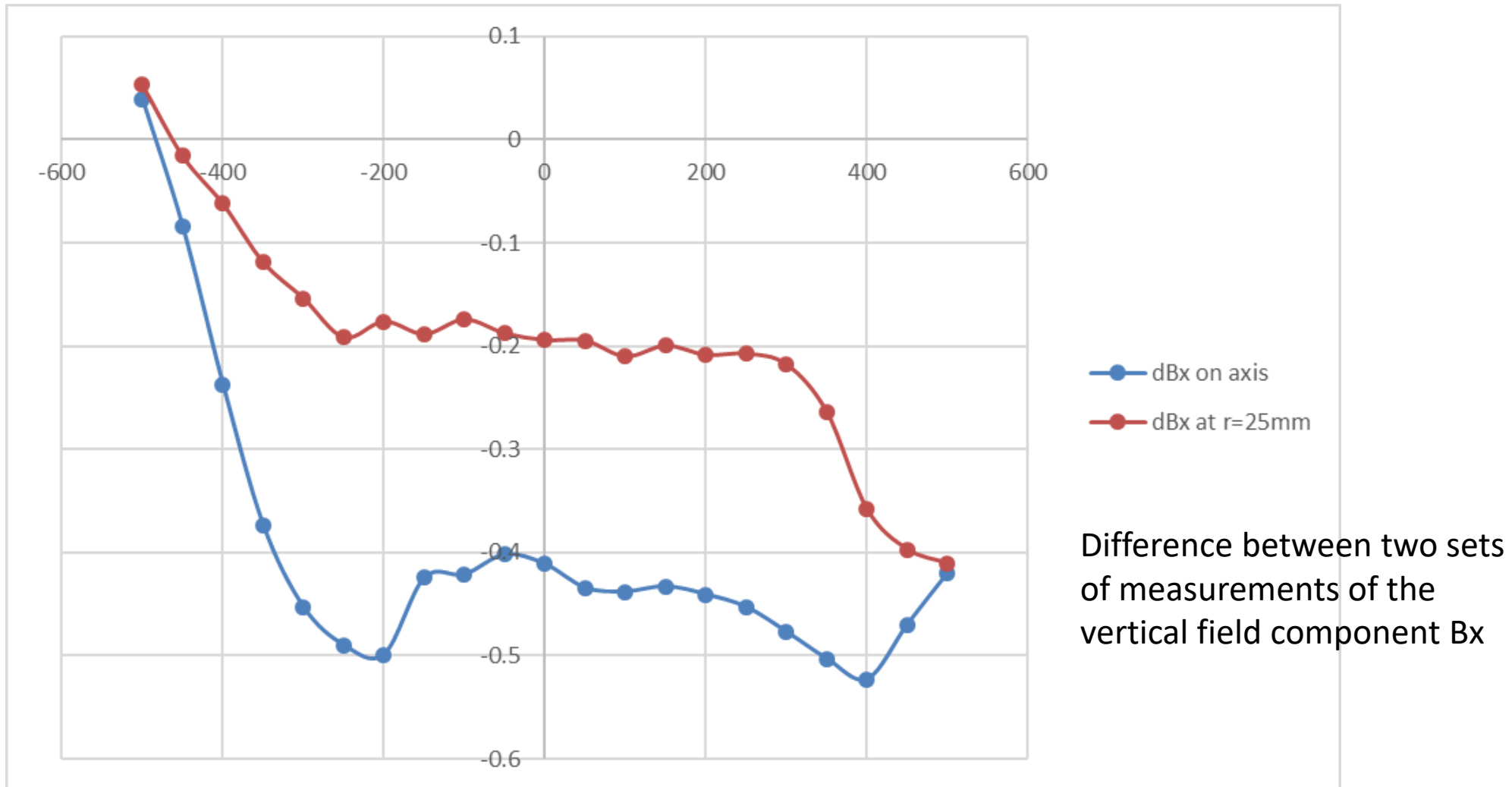


Probe holder (1st version)



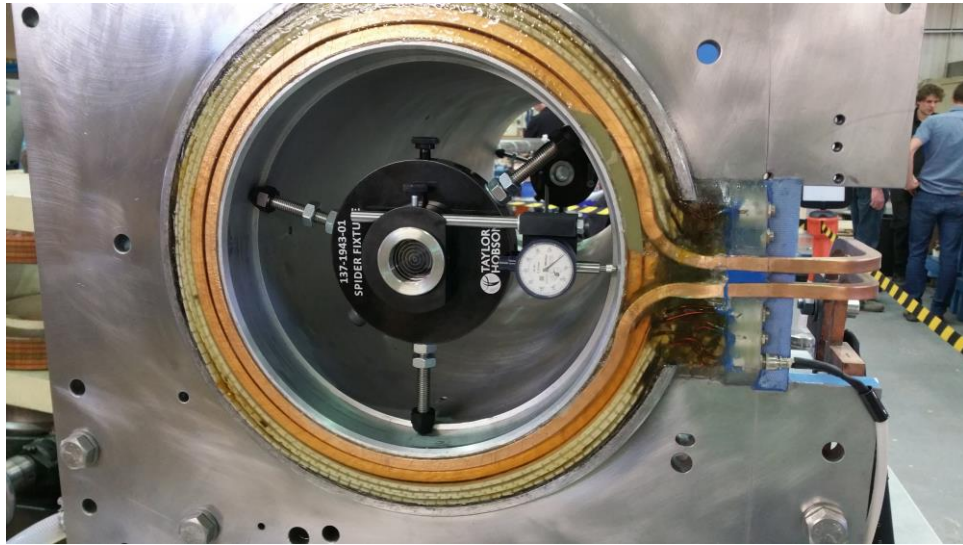
Carbon fibre arm and counter-balance

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

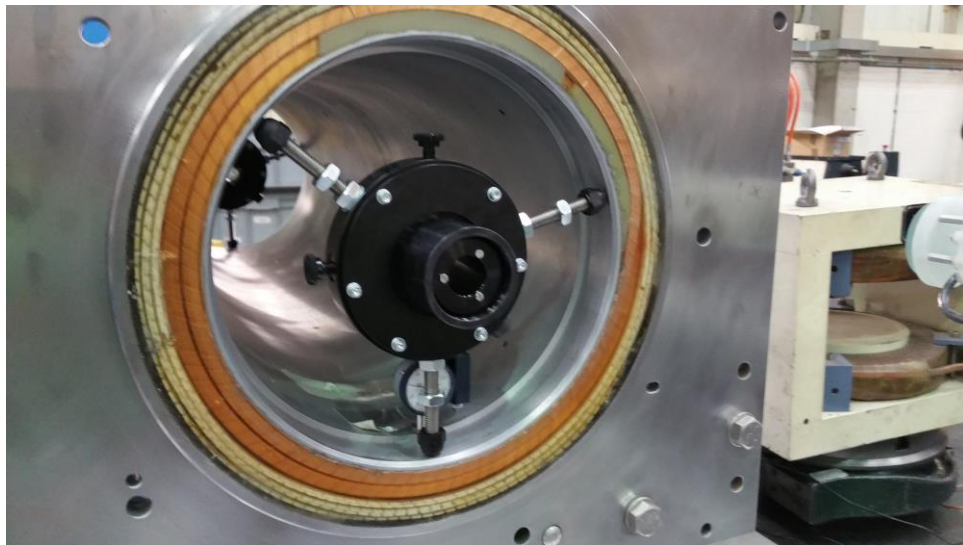


Sources of error investigated

- 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.



Spider mounts



Probe holder (final version)

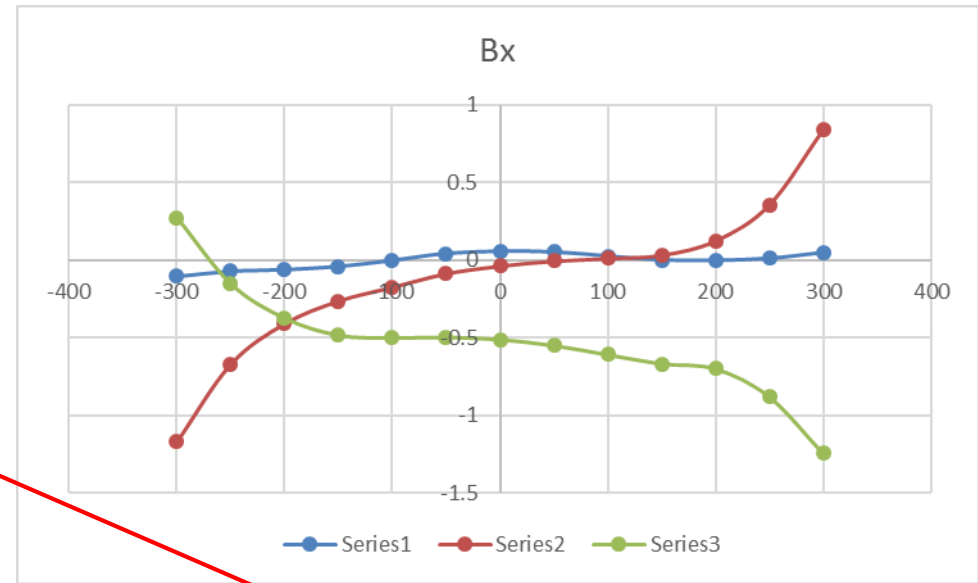
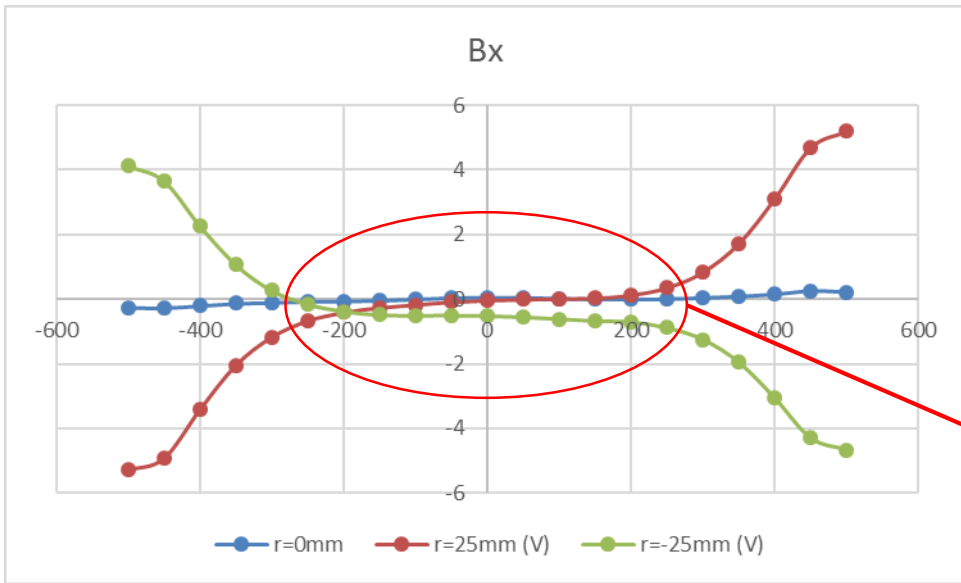
Reproducibility measurements : 3 sets of measurements made on axis and with a vertical offset of 25mm

mean						std		mean						std	
Bx	By	Bz	Bx	By	Bz			Bx	By	Bz	Bx	By	Bz		
-0.27779	-0.27583	-46.419	0.024537	0.004314	0.019235	46.42065	0.019062	-5.27264	-0.13447	-46.2066	0.017255	0.034879	0.029478	46.50667	0.030726
-0.2956	-0.15179	-66.0338	0.029354	0.004364	0.014978	66.03468	0.014836	-4.93498	-0.02514	-66.2036	0.027148	0.009794	0.039181	66.38732	0.039365
-0.23845	0.060001	-81.6451	0.04059	0.001377	0.007985	81.64549	0.007867	-3.46264	0.148799	-81.9268	0.032129	0.00487	0.040079	82.00005	0.038929
-0.17998	0.217513	-91.5771	0.048201	0.000286	0.007742	91.57757	0.007646	-2.10256	0.266053	-91.7799	0.042458	0.002566	0.031677	91.80433	0.030969
-0.15592	0.299886	-97.1655	0.051614	0.006439	0.000234	97.16606	0.000336	-1.23755	0.302717	-97.2866	0.048963	0.027429	0.031545	97.29492	0.031233
-0.12859	0.328454	-100.151	0.057307	0.005255	0.003488	100.1516	0.003579	-0.7515	0.332596	-100.212	0.058527	0.003467	0.027975	100.2155	0.027695
-0.11895	0.333786	-101.689	0.057863	0.004277	0.000754	101.6897	0.000835	-0.48877	0.324555	-101.719	0.056275	0.006067	0.025977	101.7206	0.025814
-0.09296	0.326214	-102.473	0.051952	0.005313	0.001482	102.4735	0.001546	-0.33733	0.306311	-102.494	0.052637	0.007762	0.027965	102.4946	0.027862
-0.05704	0.308024	-102.882	0.05438	0.006584	0.004729	102.8827	0.004779	-0.24682	0.279951	-102.9	0.051315	0.006989	0.026417	102.9012	0.026333
-0.01331	0.289382	-103.076	0.054907	0.006822	0.002977	103.0765	0.003003	-0.1536	0.25525	-103.086	0.047883	0.006571	0.026955	103.0864	0.026894
0.002459	0.273521	-103.097	0.052853	0.006904	0.003978	103.0975	0.003995	-0.10044	0.236424	-103.099	0.044986	0.007895	0.025011	103.099	0.024974
-0.00216	0.266993	-102.955	0.053388	0.007201	0.003474	102.9556	0.003493	-0.07249	0.230913	-102.948	0.049269	0.006828	0.025543	102.948	0.025506
-0.02437	0.273223	-102.639	0.049592	0.006977	0.004472	102.6396	0.004502	-0.05548	0.240784	-102.626	0.049752	0.006182	0.025654	102.6265	0.025622
-0.04942	0.289278	-102.131	0.050001	0.006385	0.003977	102.1315	0.004019	-0.03379	0.26152	-102.126	0.049163	0.006285	0.025123	102.1264	0.025099
-0.05249	0.306756	-101.336	0.050412	0.007207	0.004716	101.3363	0.004764	0.05689	0.277938	-101.361	0.049771	0.006584	0.02445	101.3611	0.024464
-0.04086	0.334266	-99.9355	0.051145	0.008095	0.006459	99.93604	0.006507	0.283709	0.302673	-100.009	0.053073	0.009543	0.023422	100.0095	0.023542
-0.00219	0.375904	-97.2306	0.049719	0.006238	0.00472	97.23134	0.004745	0.766781	0.335278	-97.3784	0.052716	0.010543	0.024722	97.38196	0.025053
0.047262	0.438613	-91.9844	0.0408	0.002814	0.007748	91.98552	0.00774	1.654684	0.372311	-92.2453	0.051298	0.007904	0.021506	92.2609	0.022232
0.123223	0.509497	-82.4339	0.02983	0.011689	0.00772	82.43558	0.007747	3.05713	0.413792	-82.801	0.042838	0.006577	0.019186	82.85846	0.020313
0.218758	0.562932	-67.1374	0.039771	0.010998	0.024976	67.14016	0.024938	4.621089	0.428037	-67.4515	0.050614	0.015442	0.018159	67.611	0.019595
0.196074	0.526462	-47.6834	0.024917	0.014754	0.019932	47.68669	0.019991	5.137452	0.381959	-47.6373	0.038131	0.015225	0.020997	47.91507	0.022241

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

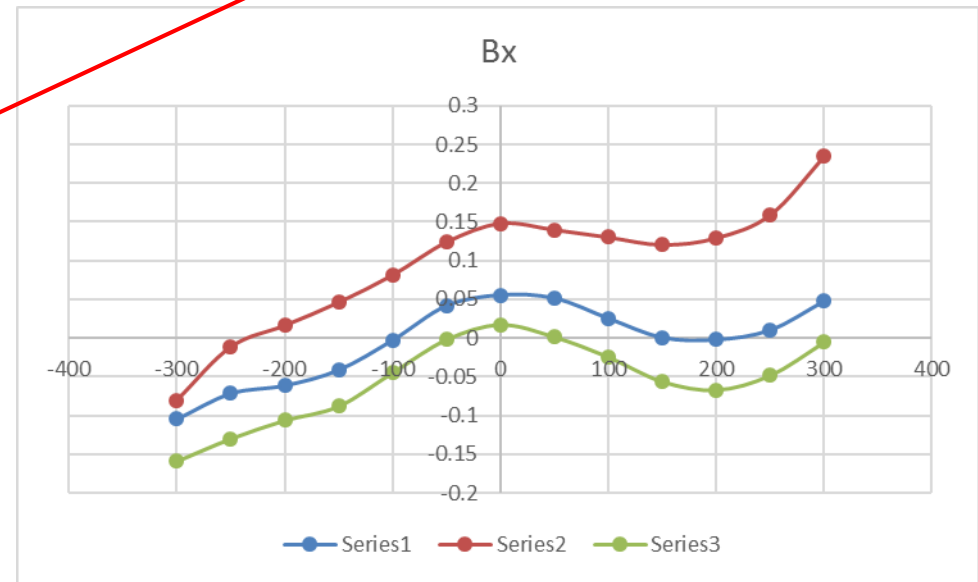
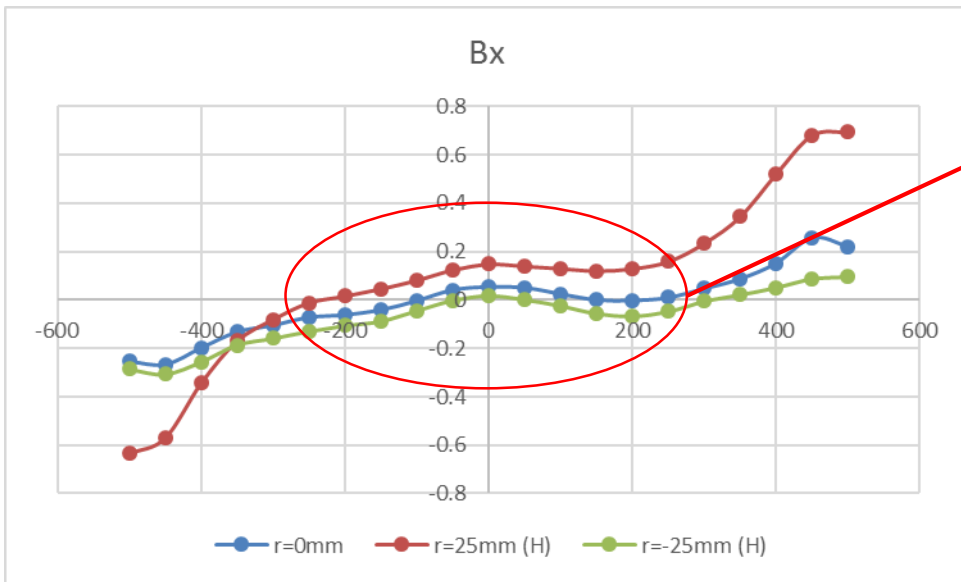
B field (G) components at y=25mm
Z=-500mm to +500mm

Average and spread of field components

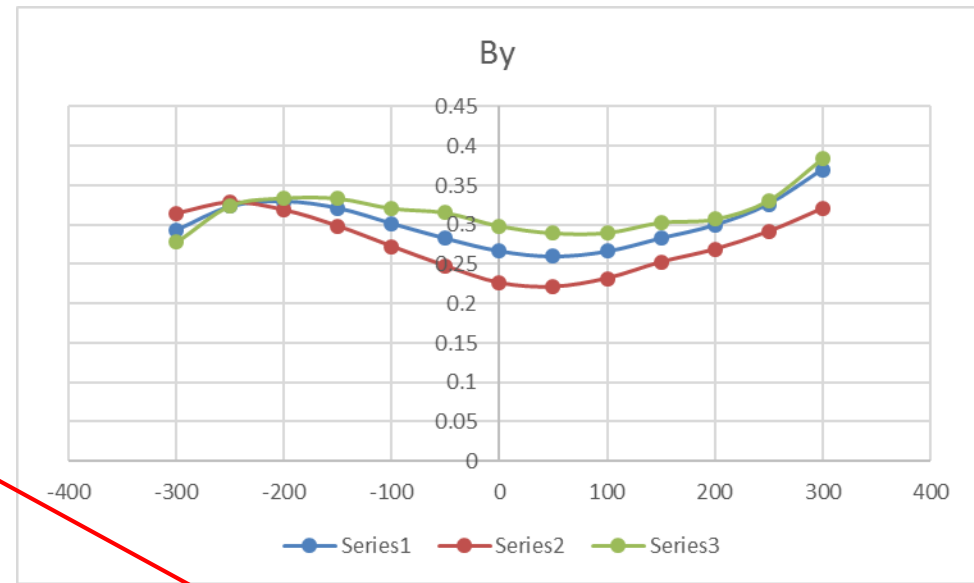
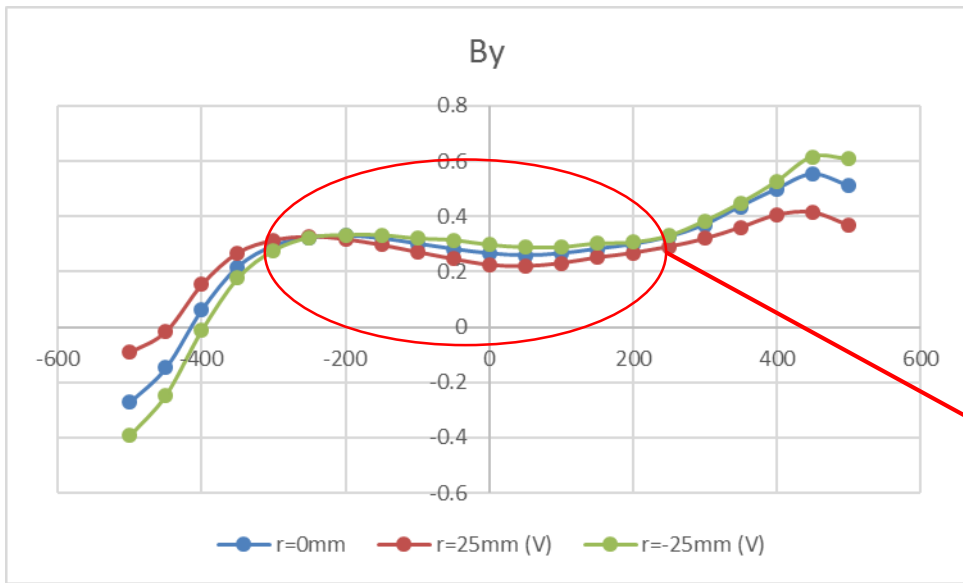


Vertical field component on, above, and below axis

Zoom +/-300mm

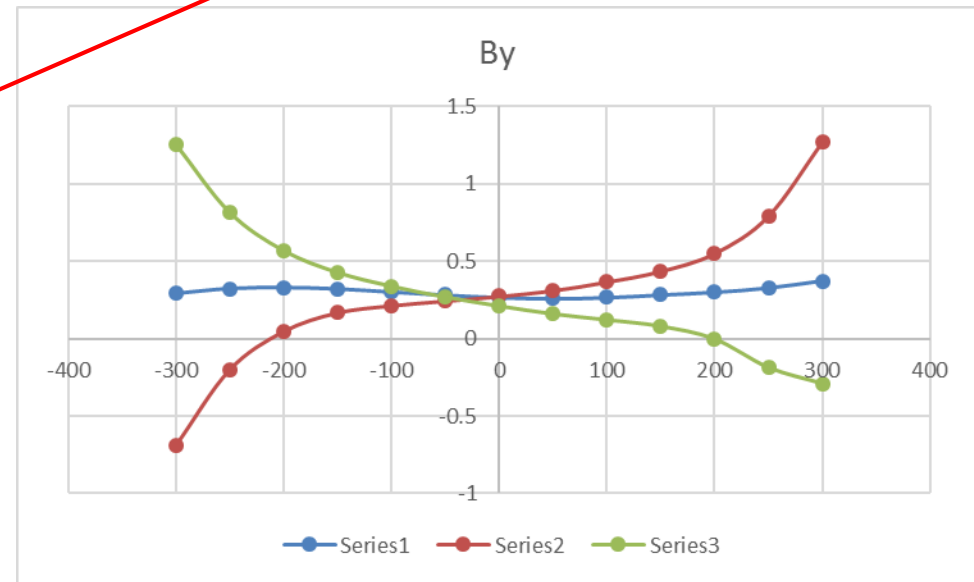
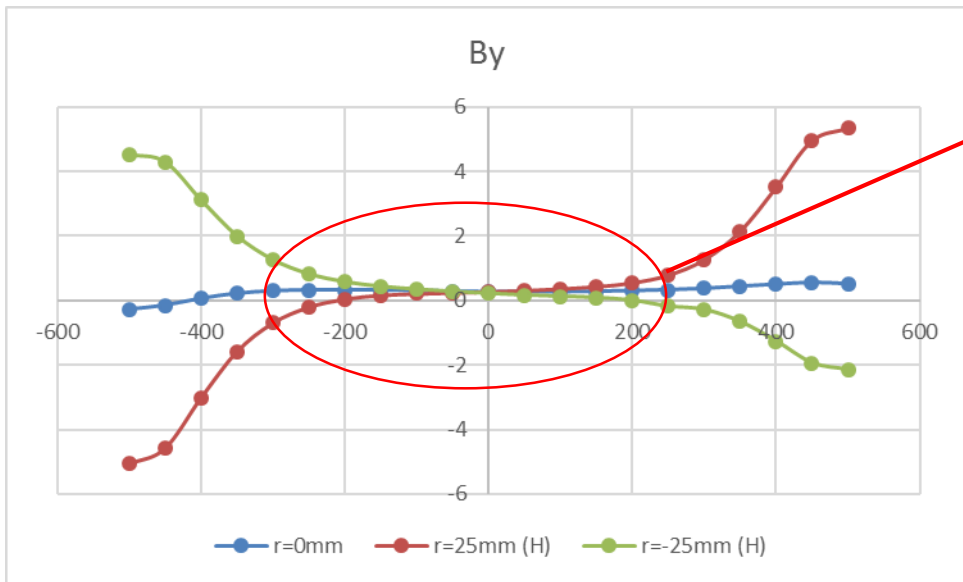


Vertical field component on, to the right, and left of axis



Horizontal field component on, above, and below axis

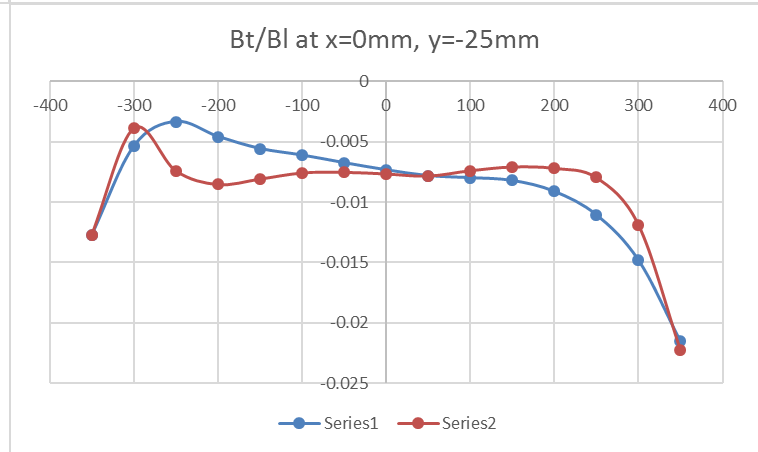
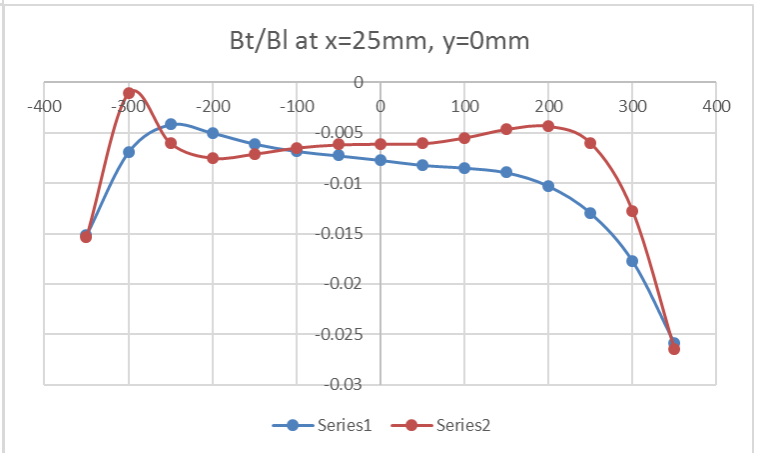
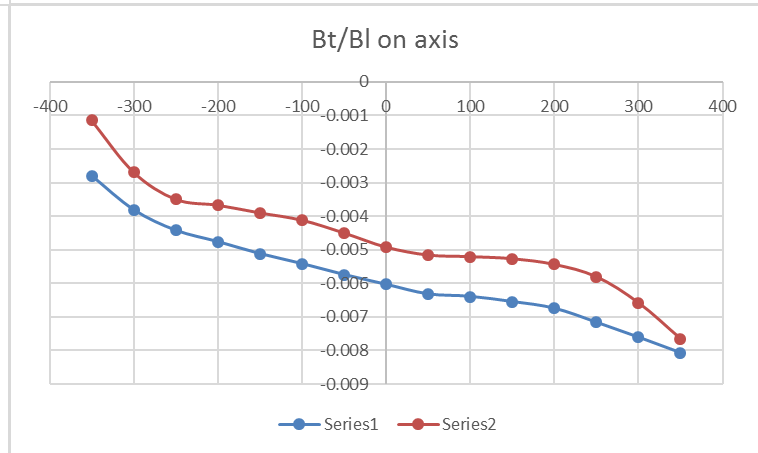
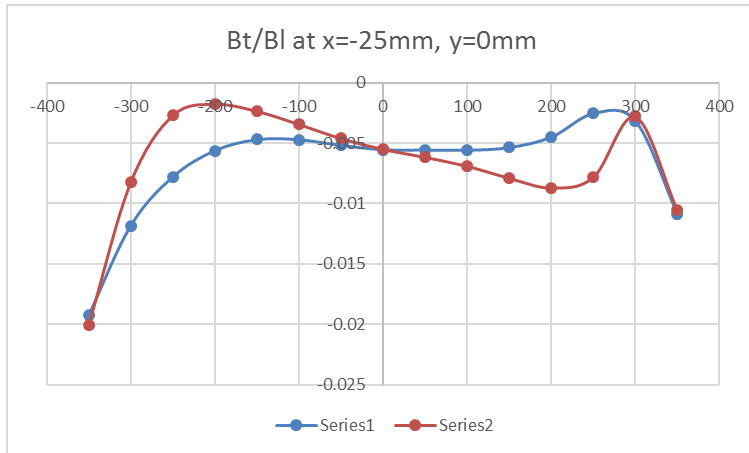
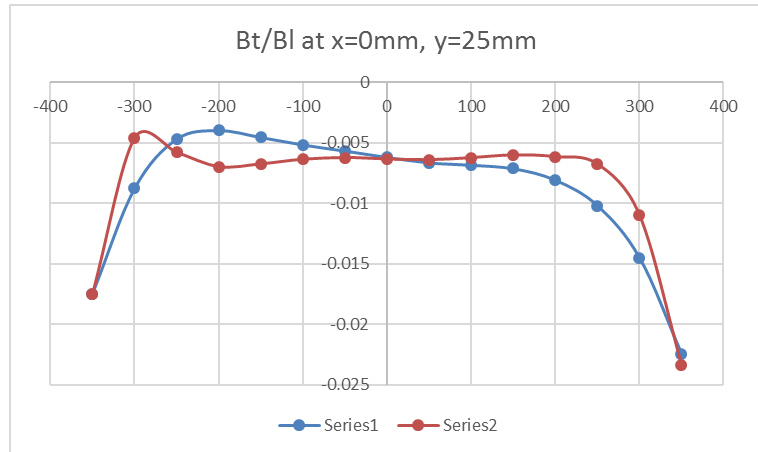
Zoom +/-300mm



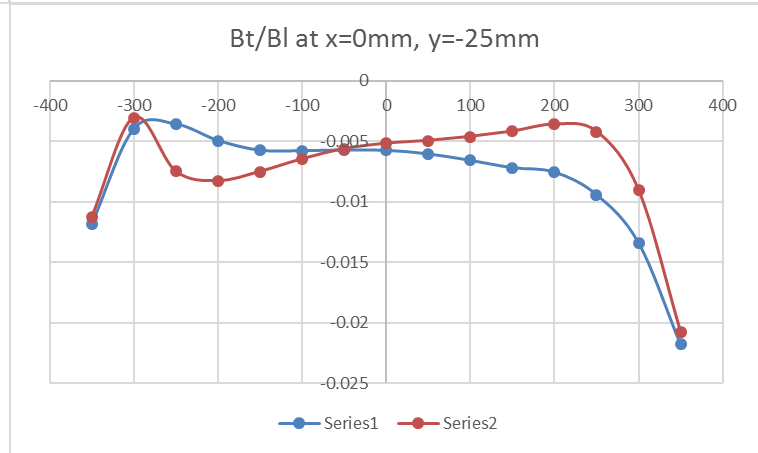
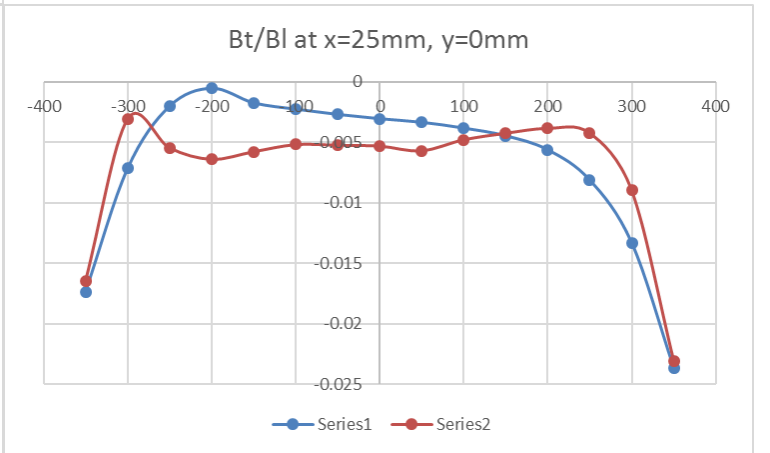
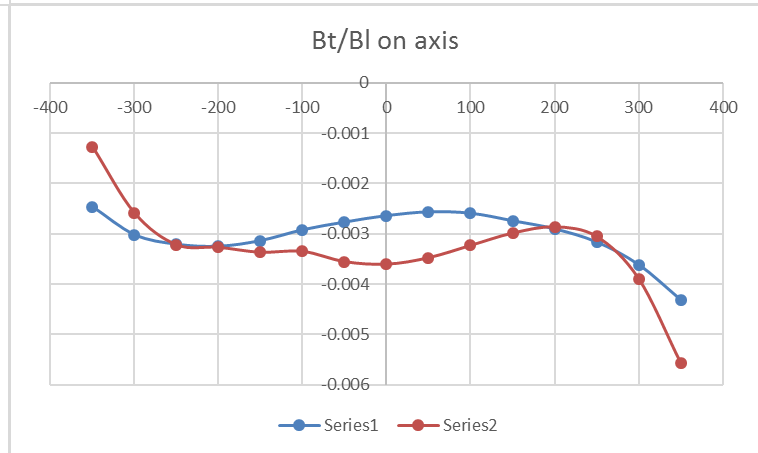
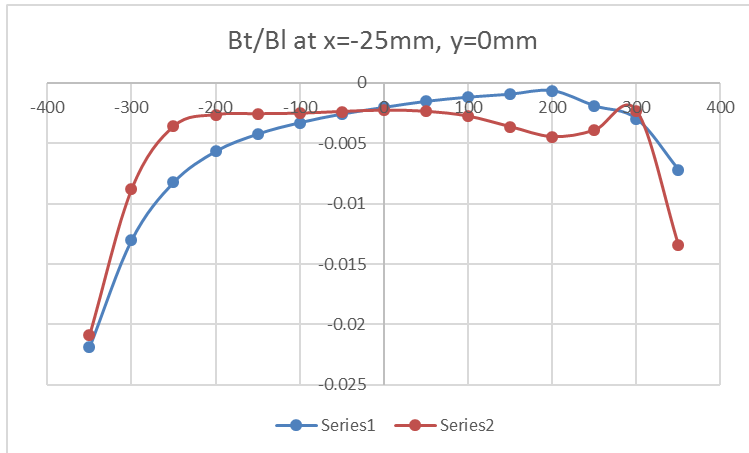
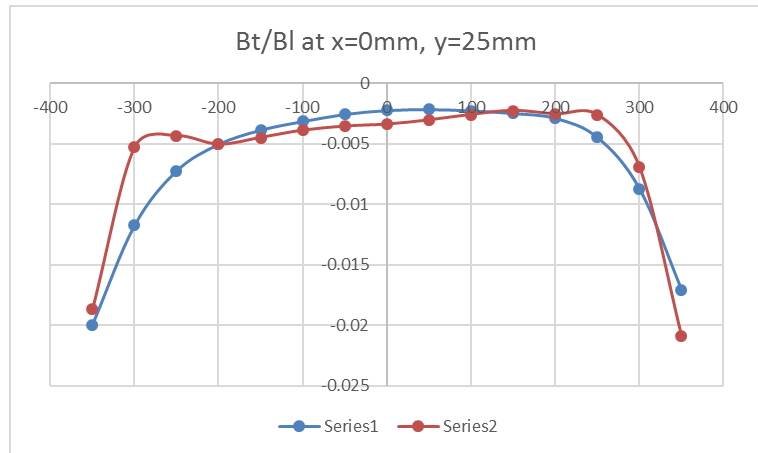
Horizontal field component on, to the right, and left of axis

Influence of circular coils on Bt/BI For SS#1

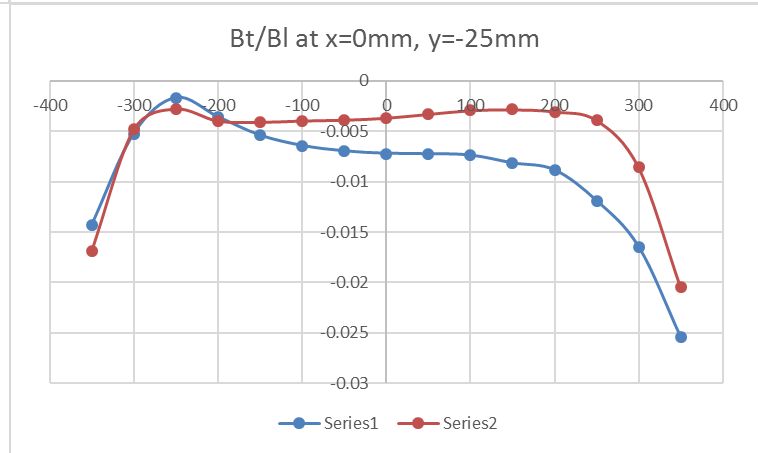
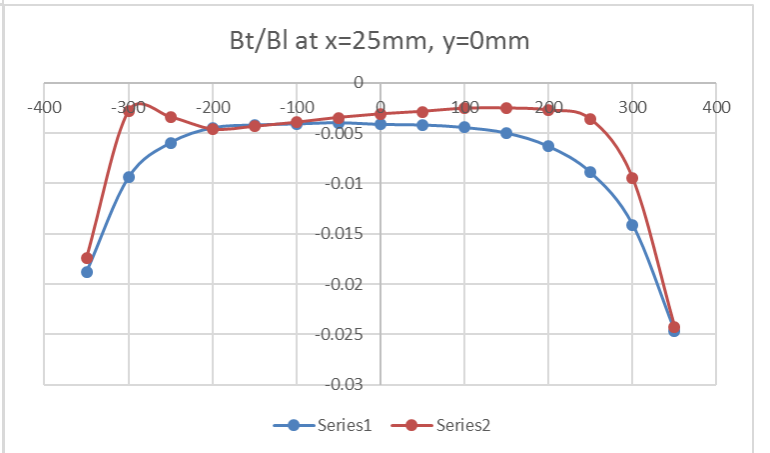
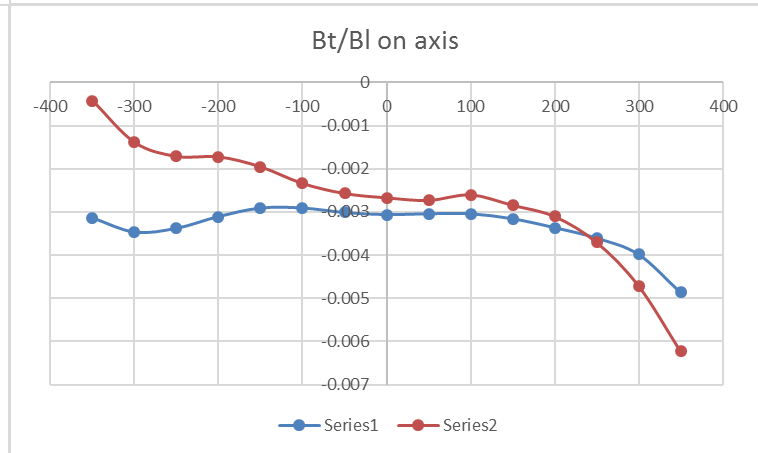
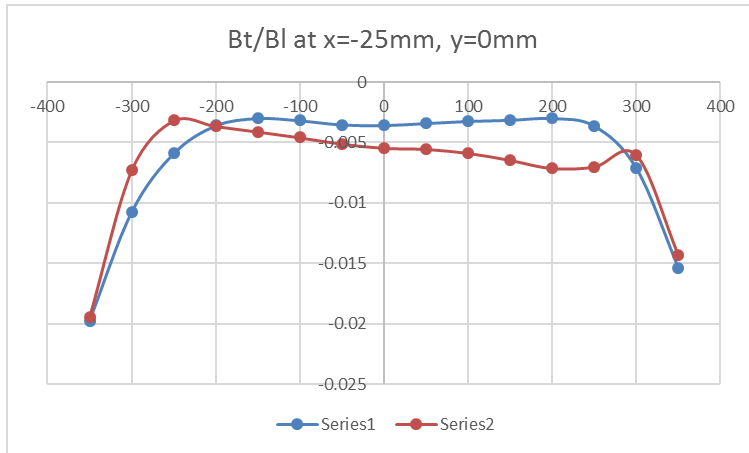
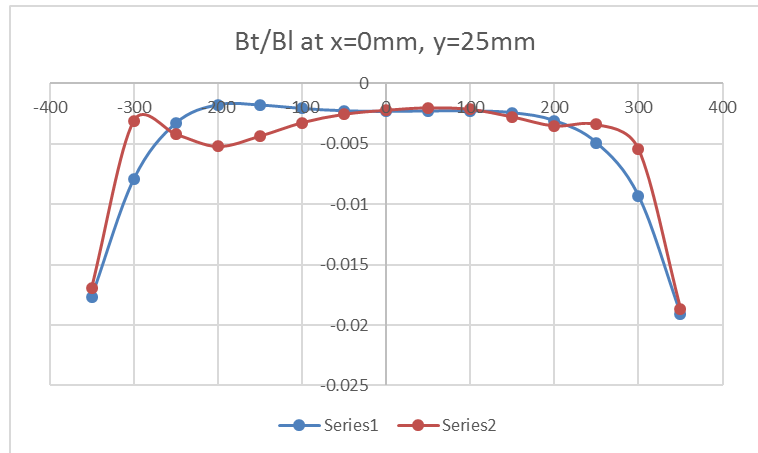
$$B_t = \sqrt{B_x^2 + B_y^2}$$

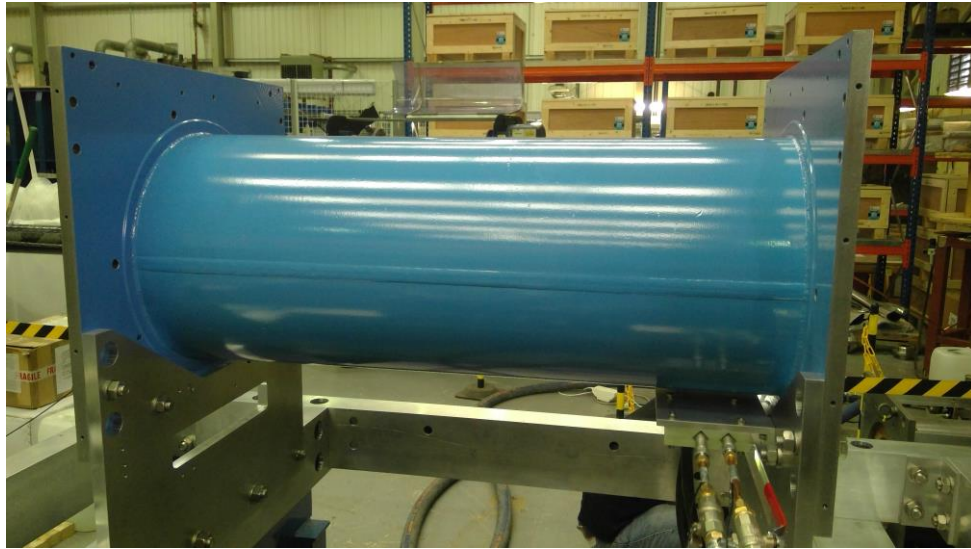


Influence of circular coils on Bt/BI For SS#2

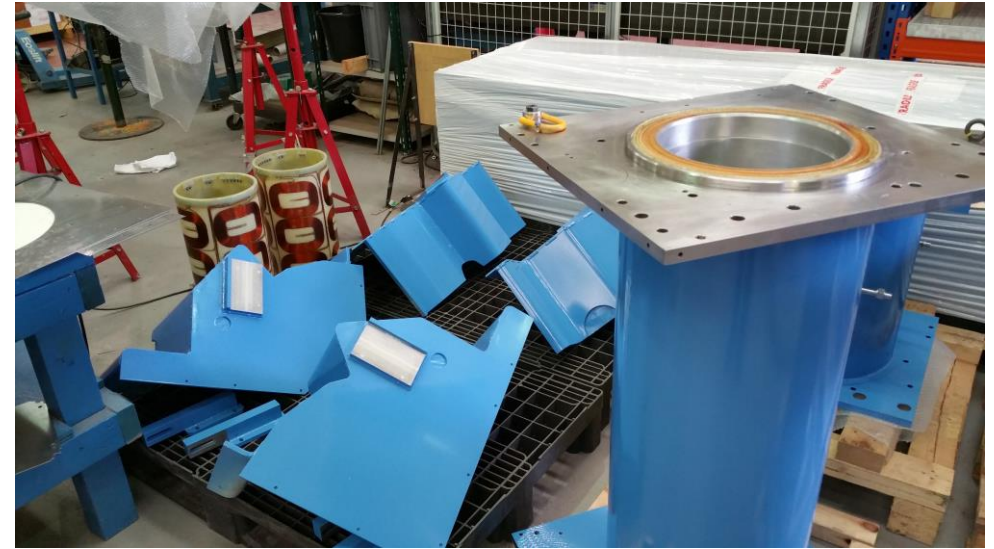


Influence of circular coils on Bt/BI For SS#4

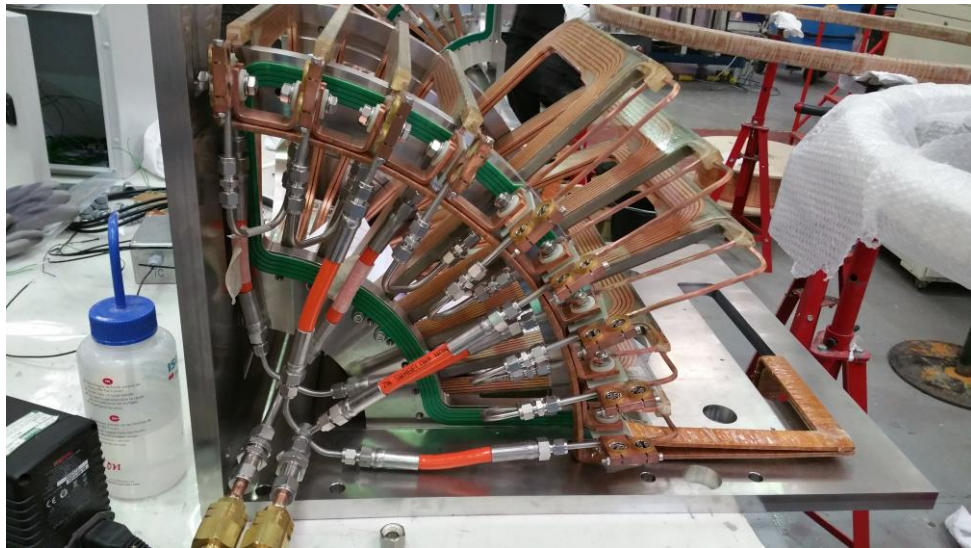




Standard solenoid on measurement bench



Shielding, standard solenoids and expansion solenoid



Toroid assembly



- Solenoid SS#3 is being measured.
- Expansion solenoid to be measured next week.
- Toroids will follow.
- Mount the full assembly (with mock chambers and orbit correctors) to check the mounting procedure.
- Perform magnetic measurements on the full assembly, validate fine-tune coils.
- Dismount and ship to CERN. (end 2016?)
- Certification. (Jan/Feb 2017?)
- Install in ELENA. (from March 2017?)