



MQXFBP2 – Magnetic measurements at ambient temperature

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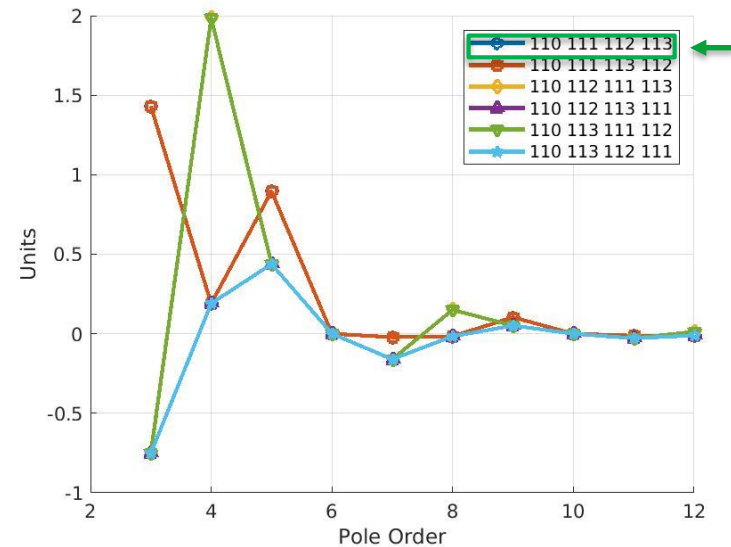
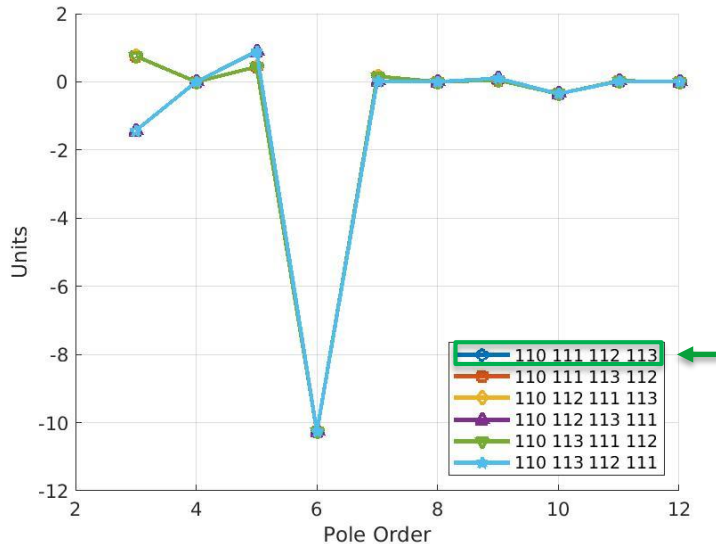


WP3 meeting – 23/09/2020

Outlook

- Coils and FQ optimization
- Measurement at ambient temperature
- Results
 - TF
 - Multipoles
- Magnetic shimming
- Comparison to other magnets
- Conclusions

MQXFBP2 Field quality optimization

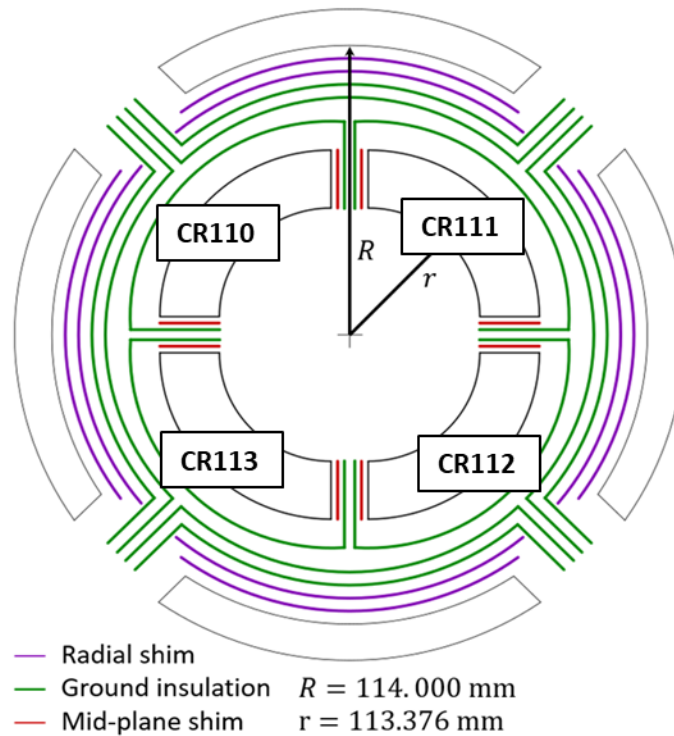


There is not big difference in between the different permutations in field quality point of view. **P1** is chosen (based on quench voltage minimization)

h	p1	p2	p3	p4	p5	p6
3	0.8	0.8	0.8	-1.4	0.8	-1.4
4	0.0	0.0	0.0	0.0	0.0	0.0
5	0.4	0.4	0.4	0.9	0.4	0.9
6	-10.3	-10.3	-10.3	-10.3	-10.3	-10.3
7	0.2	0.2	0.2	0.0	0.2	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.1	0.1	0.1	0.1	0.1	0.1
10	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0

h	p1	p2	p3	p4	p5	p6
3	1.4	1.4	-0.8	-0.8	-0.8	-0.8
4	0.2	0.2	2.0	0.2	2.0	0.2
5	0.9	0.9	0.4	0.4	0.4	0.4
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	-0.2	-0.2	-0.2	-0.2
8	0.0	0.0	0.2	0.0	0.2	0.0
9	0.1	0.1	0.1	0.1	0.1	0.1
10	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0

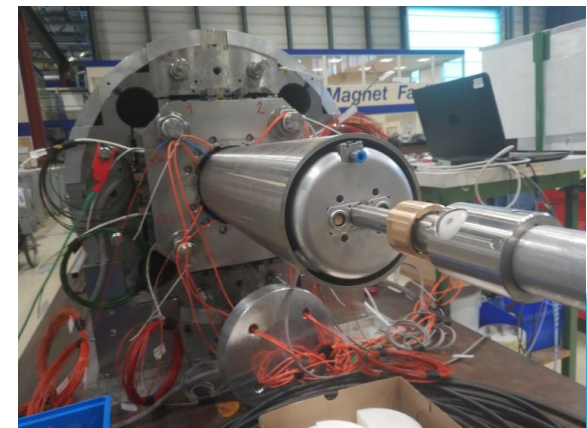
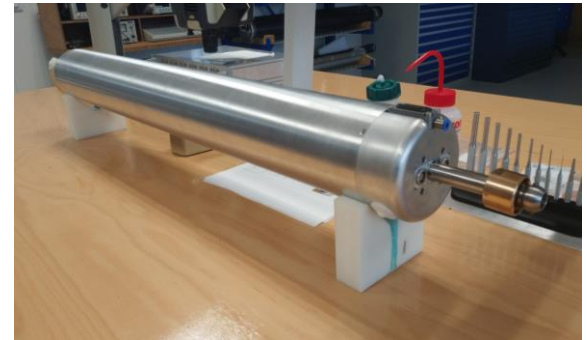
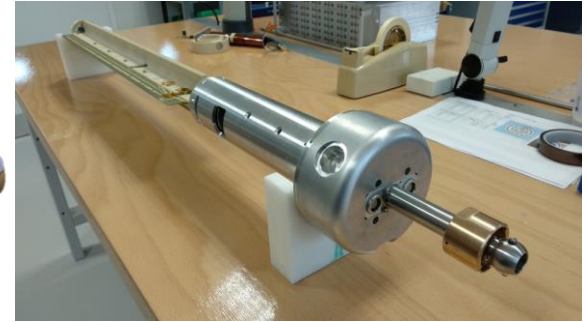
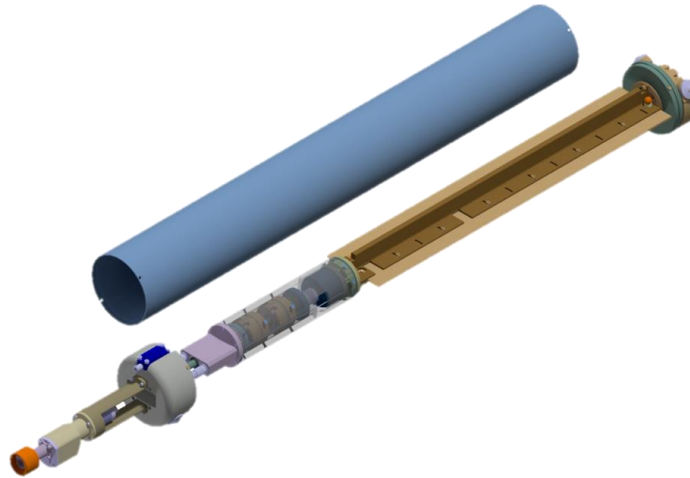
Coil ordering



Magnetic measurement reference frame is rotated by 180 degrees with respect to magnet assembly (i.e. coils as in the cold mass)

Rotating-coil scanner

- \varnothing 136 mm for the cold-bore
- Measurement radius 50 mm
- Measurement length 600 mm
- Based on PCB (printed circuit) coils
- Tilt sensor on the PCB coil
- Auto-alignment to gravity
- Retroreflectors mounted on the PCB
- On-board motor



Setup

- 4 measurements
 - Coil pack
 - After centering
 - ~50% loading
 - After loading
- 13 positions
 - 2 ends
 - 11 body
- Excitation current
 - ± 10 A



- Polarity of multipoles
 - Check by powering one coil

Transfer Function

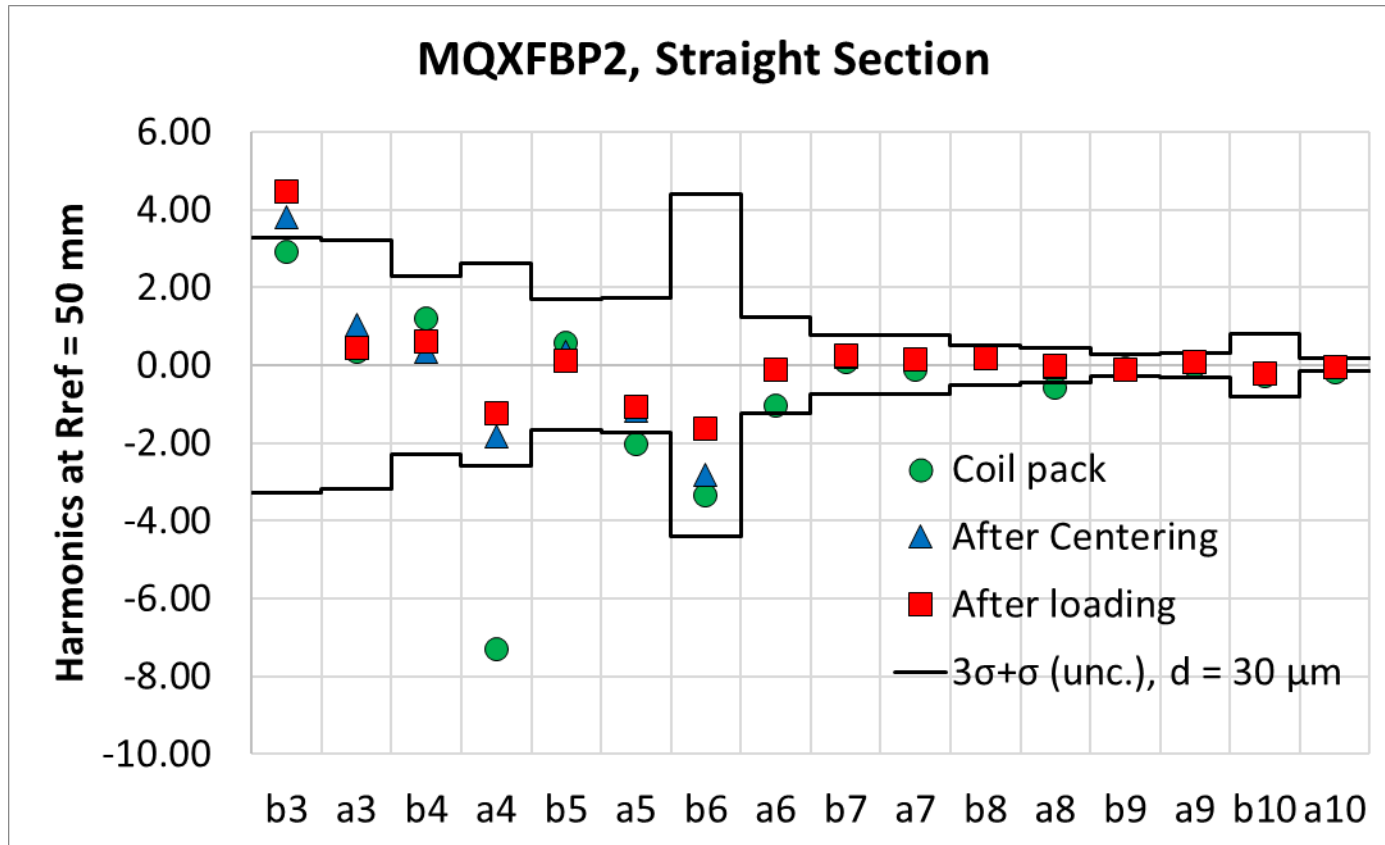
	Coil pack - transfer function			
	Measurements		Diff to average	
	Integral	Straight Section	Integral	Straight Section
	T/kA	T/m/kA	units	units
MQXFBP1	8.774	63.098	18	8
MQXFBMT2	8.721	62.718	-43	-52
MQXFBP2	8.805	63.146	25	44
average	8.766	62.988		

	After loading - transfer function			
	Measurements		Diff to average	
	Integral	Straight Section	Integral	Straight Section
	T/kA	T/m/kA	units	units
MQXFBP1	8.838	63.394	23	14
MQXFBMT2	8.783	63.167	-40	-22
MQXFBP2	8.832	63.359	16	8
average	8.818	63.307		

Magnet body without ends

	Coil pack + Pads		After centering		50% loading		After loading	
	(warm)		(warm)		(warm)		(warm)	
	TF [T/m/kA]		TF [T/m/kA]		TF [T/m/kA]		TF [T/m/kA]	
	8.805		8.801		8.822		8.832	
n	bn	an	bn	an	bn	an	bn	an
3	2.92	0.34	3.80	1.03	4.44	0.62	4.45	0.43
4	1.18	-7.31	0.33	-1.83	0.64	-1.39	0.62	-1.25
5	0.59	-2.02	0.33	-1.17	0.14	-1.10	0.12	-1.07
6	-3.34	-1.05	-2.83	-0.11	-1.97	-0.12	-1.63	-0.13
7	0.08	-0.14	0.20	0.13	0.25	0.13	0.26	0.13
8	0.18	-0.57	0.19	-0.07	0.18	-0.04	0.18	-0.03
9	-0.08	-0.01	-0.11	0.07	-0.12	0.08	-0.12	0.09
10	-0.29	-0.17	-0.22	-0.05	-0.20	-0.05	-0.21	-0.05
11	-0.01	-0.04	0.01	0.01	0.01	0.01	0.01	0.01
12	0.04	-0.11	0.05	-0.02	0.05	-0.01	0.05	-0.01
13	-0.01	0.02	-0.01	0.03	-0.01	0.03	-0.01	0.03
14	-0.71	-0.05	-0.74	-0.03	-0.75	-0.03	-0.75	-0.03
15	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01

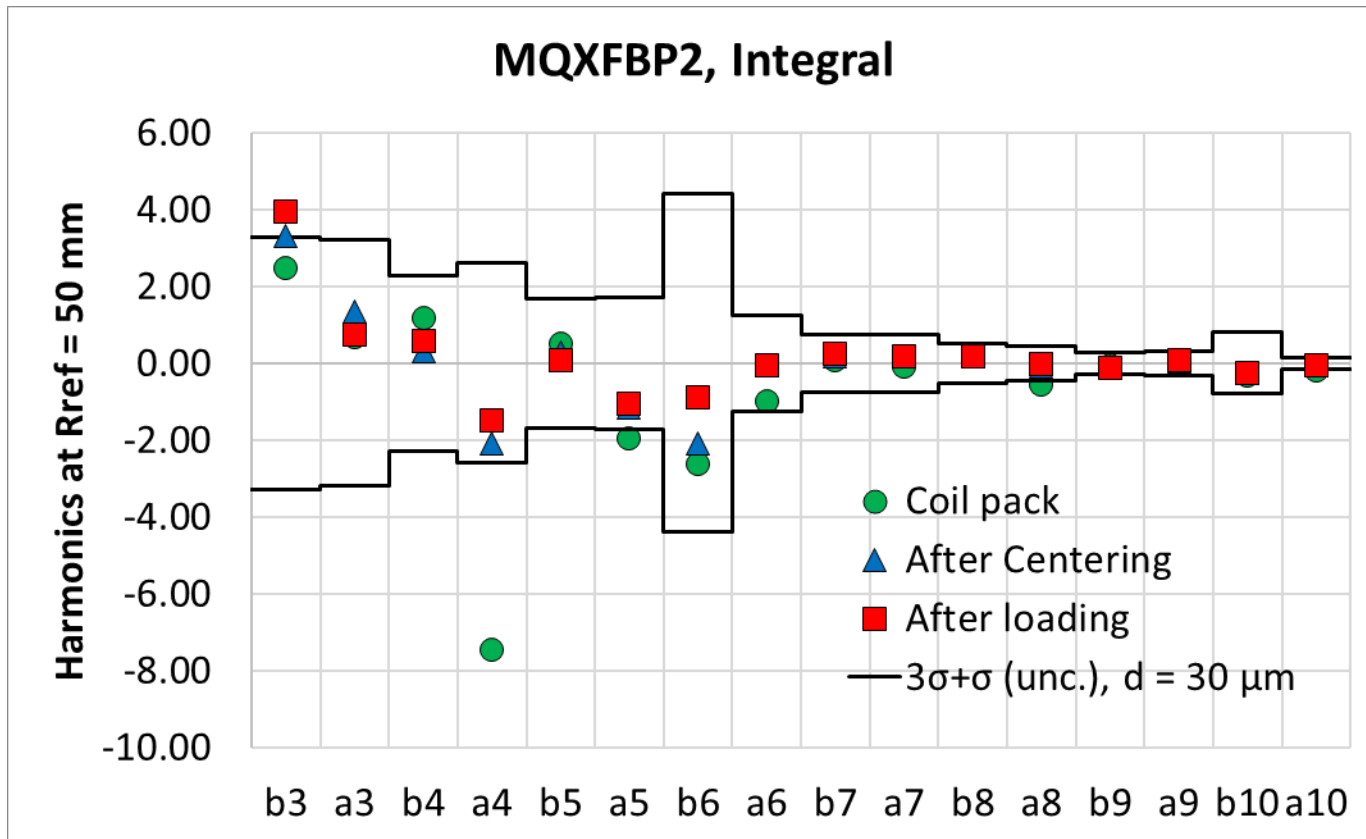
Multipoles – magnet body without ends



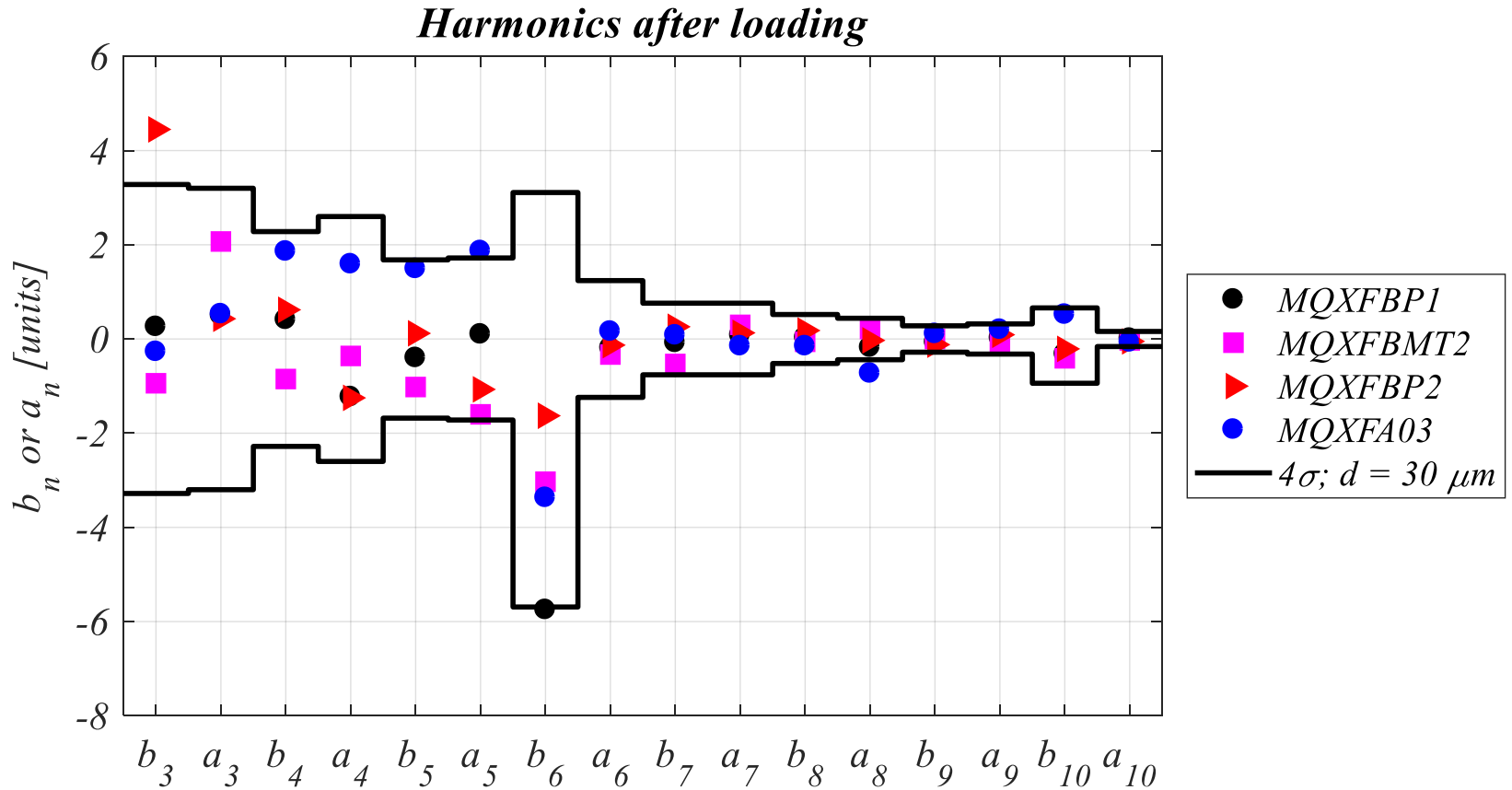
Integral including ends

	Coil pack + Pads		After centering		50% loading		After loading	
	(warm)		(warm)		(warm)		(warm)	
	TF [T/kA]		TF [T/kA]		TF [T/kA]		TF [T/kA]	
	63.146		63.122		63.283		63.359	
Lm [m]	7172		7172		7174		7174	
n	bn	an	bn	an	bn	an	bn	an
3	2.47	0.69	3.33	1.35	3.95	0.95	3.94	0.75
4	1.19	-7.44	0.32	-2.10	0.62	-1.63	0.59	-1.50
5	0.52	-1.97	0.29	-1.16	0.11	-1.09	0.08	-1.04
6	-2.63	-0.99	-2.09	-0.06	-1.24	-0.05	-0.89	-0.07
7	0.07	-0.08	0.18	0.18	0.23	0.18	0.24	0.17
8	0.16	-0.57	0.17	-0.07	0.17	-0.04	0.17	-0.04
9	-0.07	-0.02	-0.10	0.06	-0.11	0.07	-0.11	0.08
10	-0.32	-0.18	-0.26	-0.06	-0.24	-0.06	-0.25	-0.06
11	-0.01	-0.03	0.01	0.01	0.01	0.01	0.01	0.01
12	0.04	-0.11	0.04	-0.02	0.04	-0.01	0.04	-0.01
13	-0.01	0.02	-0.01	0.02	-0.01	0.03	-0.01	0.03
14	-0.71	-0.06	-0.74	-0.05	-0.75	-0.04	-0.75	-0.05
15	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01

Multipoles – integral including ends

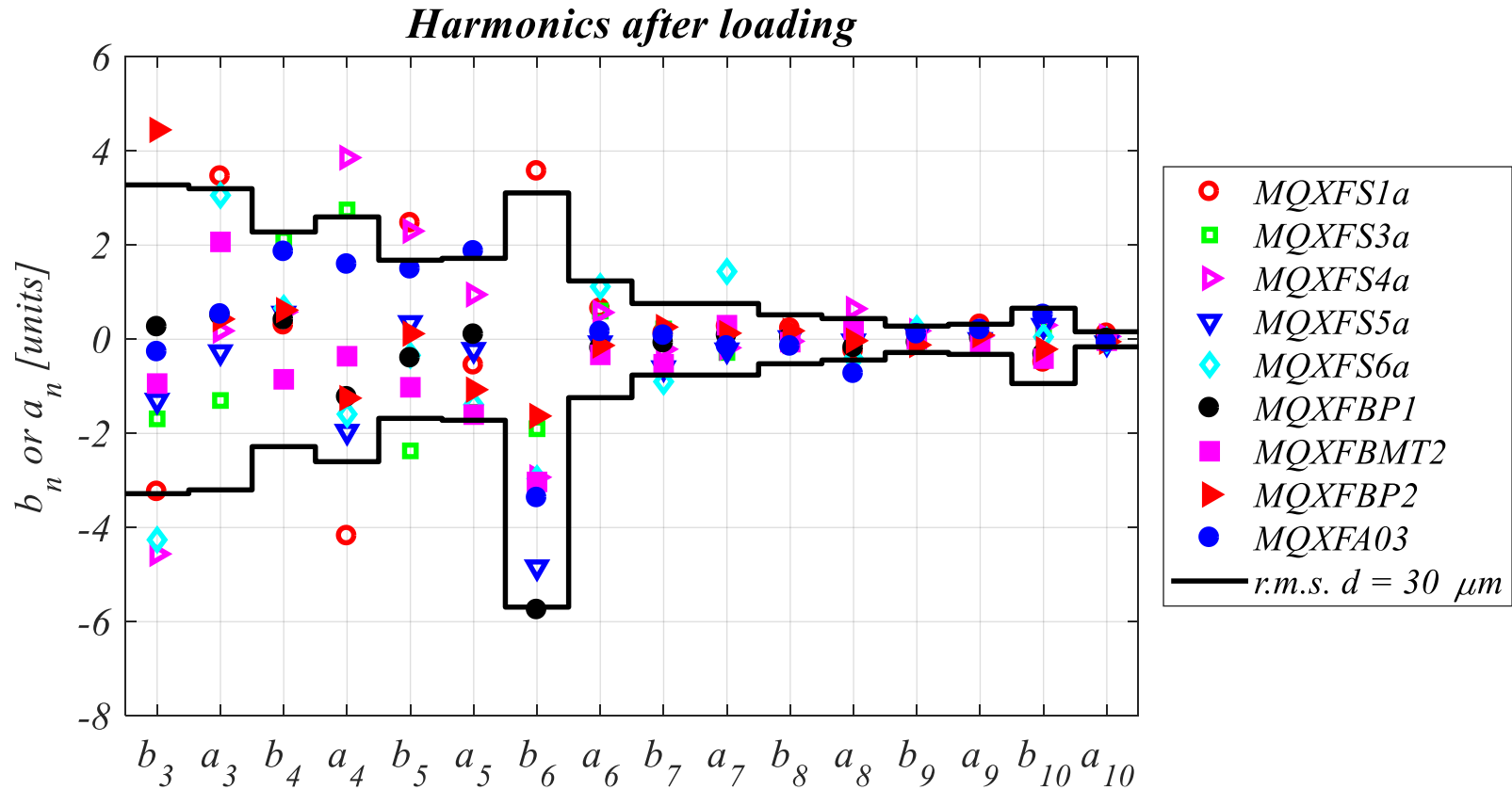


Comparison to other magnets After loading – long magnets



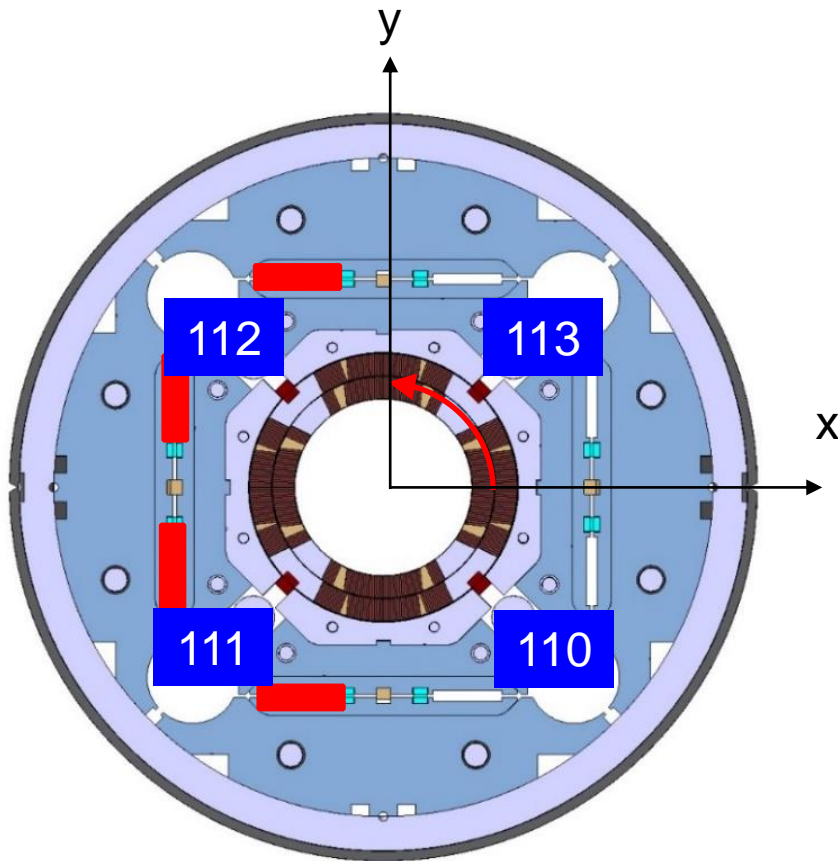
Comparison to other magnets

After loading – all magnets



Magnetic Shimming MQXFBP2

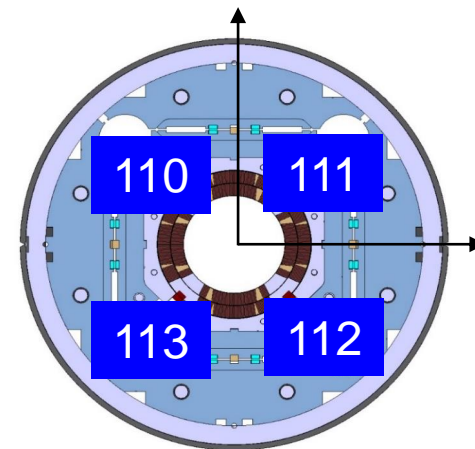
Magnet and coil positioning
(*magnetic reference axis*)



Correction capability using 9x58 mm shim in the bladder slots

Order	b_n	a_n
3	-3.37	0.00
4	0.00	0.00
5	-0.11	0.00

Careful, mechanical references, for the magnet seen from the lead end are different than the magnetic references!
Mechanical references (view from LE end):

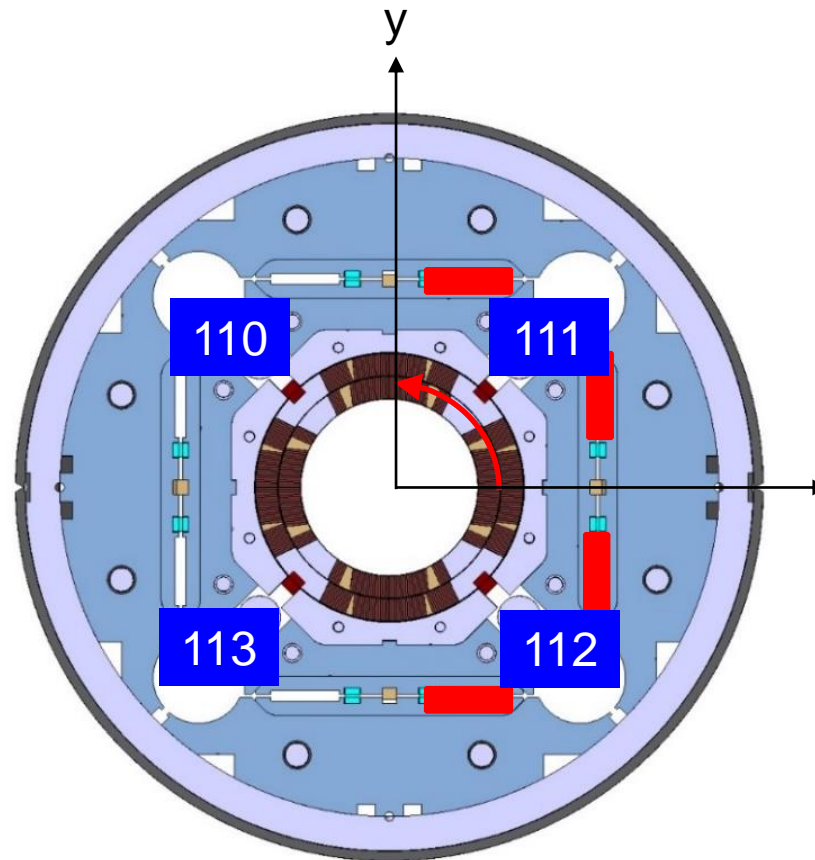


Magnetic shimming for MQXFBP2

Magnet, coil positioning and position of the magnetic shims.

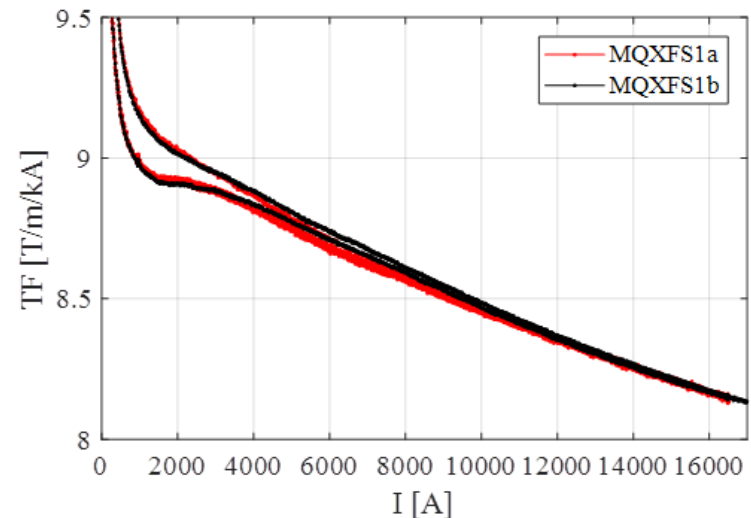
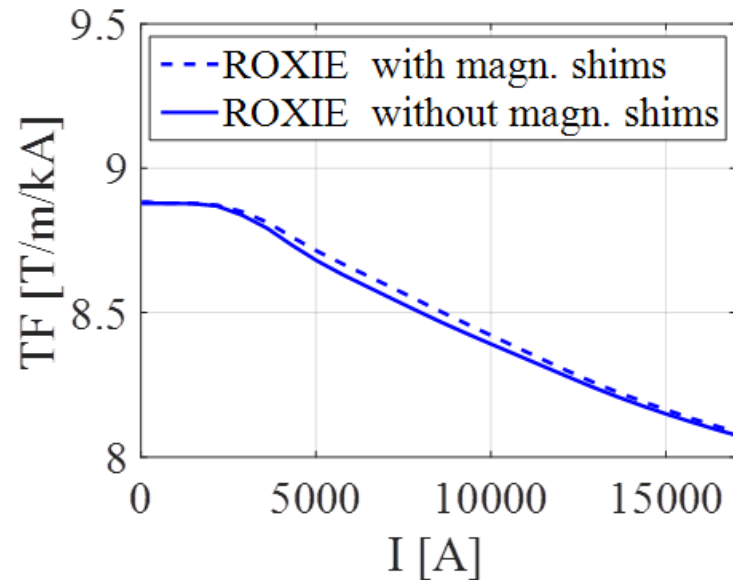
View from the connection end

(mechanical reference frame for coil pack and magnet assembly)



Effect of shims on TF

- Influence of the magnetic shims on the TF
 - From calculations
 - +15 units at nominal
 - larger at intermediate levels
 - From measurements
 - Only one magnet (MQXFS1) has been measured with and without shims
 - ~10 units at nominal



Conclusions

- TF within 10 units wrt MQXFBP1
- b6 with respect to BP1 + 4.6 units (SS), + 5 units (integral)
 - +5.3 units expected from simulations
- a4 changes from coil-pack to centering
 - is this happening in MQXFA magnets?
 - which is the cause?
- b3 (+4 units) will be corrected by using the magnetic shims

Additional slides

