The HL-LHC High Order Correctors production status

Marco Statera
on behalf of the LASA team
INFN Milano - LASA

CERN – Feb 9th 2022

TEST 1

date	Magnets	Training and quench memory	Other results
Jul 2020	**MQSXFP1c MCDXF01**	compliant	First test on a series magnet
Nov 2020	**MCDXF02 MCOXF01 MCSXF01 MCTXF01**	compliant	Wedge movement observed (MCOXF01 MCTXF01) and feedback on assembly of batch1a First test on a long dodecapole
Jan 2021	**MCDXF03 MCOXF03 MCSXF03 MCTXF2**	compliant	MCOXF03 wedge movement – accepted (*updated in Aug 2021*)
Mar 2021	**MCOXF02 MCOXF04 MCSXF02 MQSXF2**	compliant	Wedge movement observed First test on a skew quadrupole

TEST 2

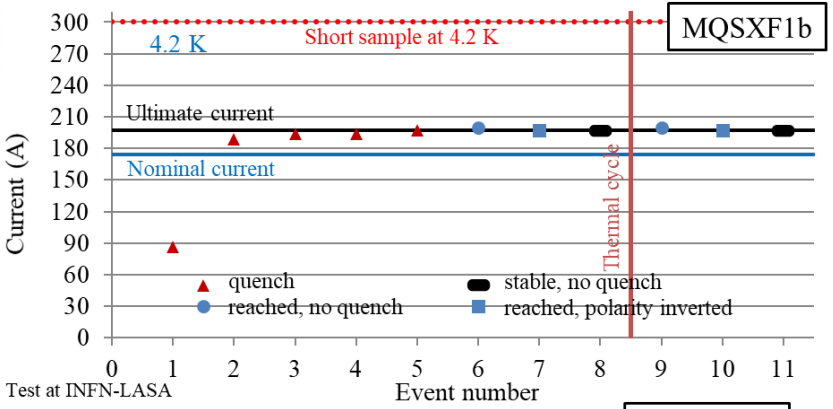
date	Magnets	Training and quench memory	Other results
Mar-Apr 2021 CERN	**MCDXF02b MCDXF04 MCSXF01b MCDXF05 MCDXF06 MCSXF04 MCDXF01b MCTXF1b**	compliant	Tested at CERN
Apr 2021	**MQSXF1 MCSXF05 MCTSXF1 MCTSXF2**	compliant	MQSXF1 performance ok but wedge supports not tightened after thermal cycles. Magnets is repaired and tested again First short dodecapole tested
Jun 2021	**MCOXF04b MCOXF07 MCSXF06 MQSXF3**	compliant	Added wedge supports for MCOXF04b and MCOXF07 Modified wedge supports for MQSXF3

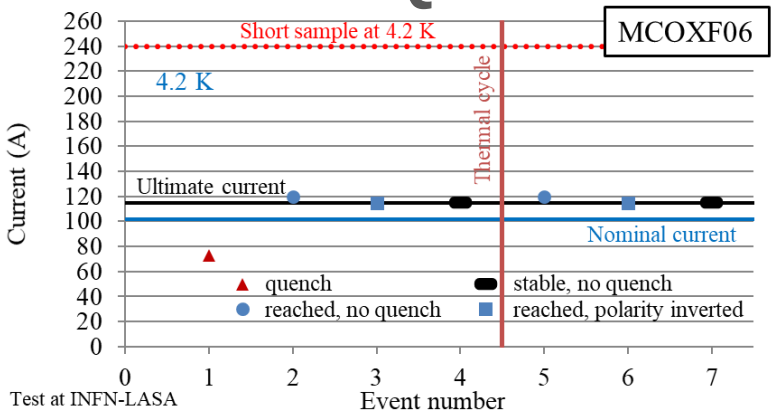
TEST 3

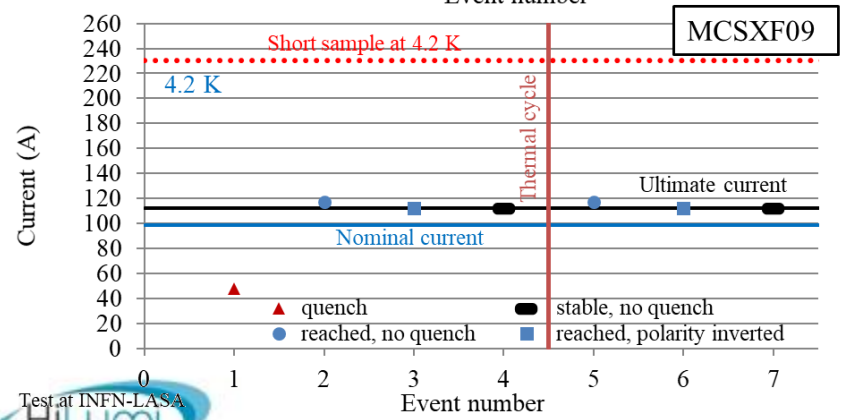
date	Magnets	Training and quench memory	Other results
Sep 2021 CD7	**MCDXF07 MCDXF08 MCSXF07 MCTXF3**	compliant	
Nov 2021 CD8	**MCOXF05 MCOXF01b MCSXF08 MCTXF4**	compliant	
Dec 2021 CD9	**MCOXF08 MCOXF06 MCSXF09 MQSXF1b**	compliant	
Feb 2022 CD10	**MCTSXF3 MCTSXF4 MCSXF10 MQSXF5**	Test ongoing	

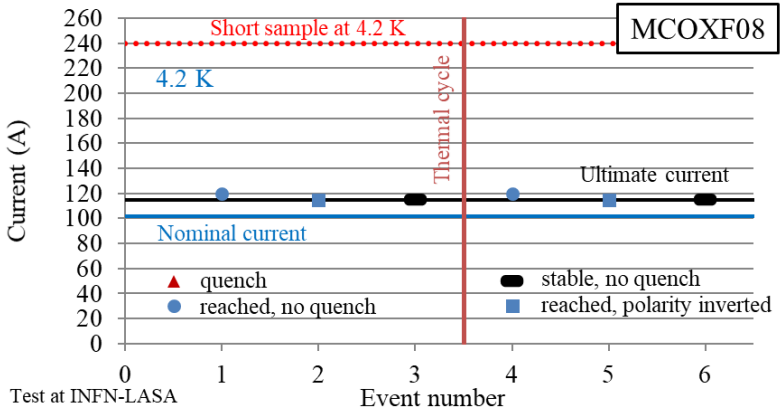
Powering test n9 HOC - training

MCOXF08 MCOXF06 MCSXF09 MQSXF1b



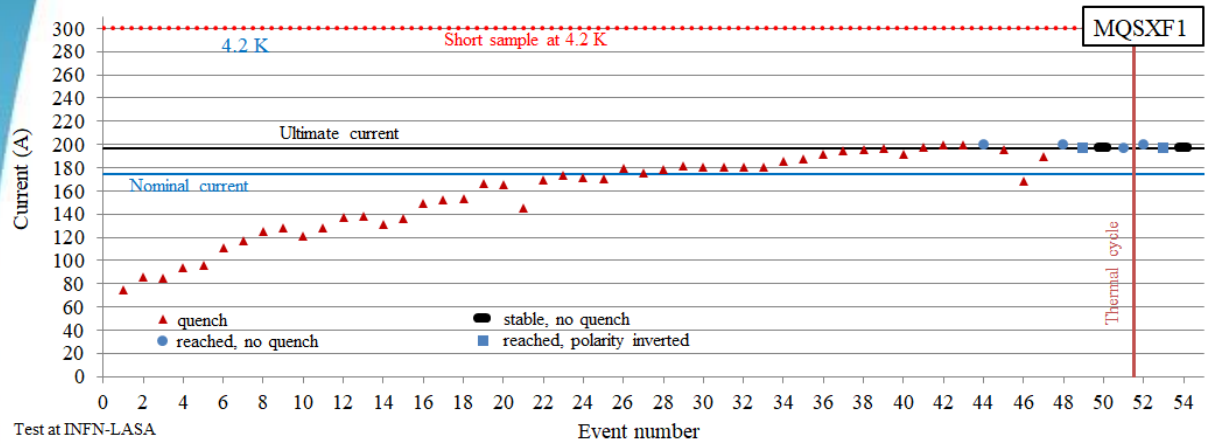






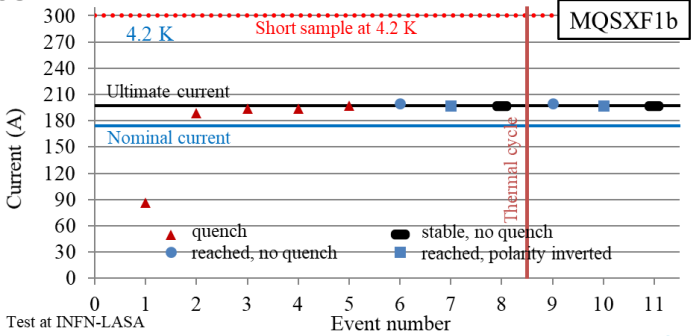
By M. Prioli
M. Statera

M04_1 assemblies comparison



Second assembly due to unfastened supports for wedges EDMS 2611005
The coils have good memory
Several quench with all coils quenched (by S. Mariotto)

Quench N	Current [A]	Measured b3 Phase gradi (°)	Std b3 Ph gradi (°)	ulated Ph gradi (°)	ch Coil Nu	A/VB QD	A/VB MN
1	86	359,52	1,1	360	2	Va	Va
2	189	45,65	1,1	45	1 and 2	Vb	Va e Vb
3	194	30,51	23,2	-	All	Vb	Va e Vb
4	193,5	240,79	26,9	-	All	Vb	Va e Vb
5	197	19,87	67,3	-	All	Va	Va e Vb



Powering test n9 HOC – MM field integral

High reproducibility wrt simulations

MCOXF06	Measured (Calculated)
Nominal current I_{nom}	102 A
Integrated field @ I_{nom} @ 50 mm	71.8 T mm (70.7 T mm)
Difference with calculated data @ I_{nom}	1.6 %

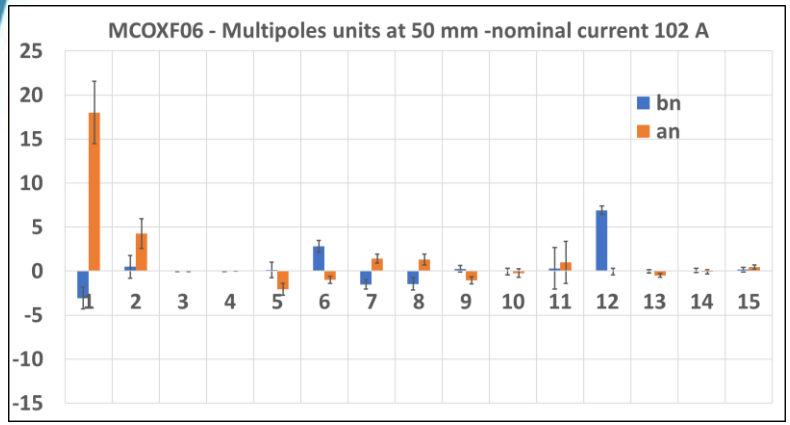
MCSXF09	Measured (Calculated)
Nominal current I_{nom}	99 A
Integrated field @ I_{nom} @ 50 mm	95.4 T mm (93.5 T mm)
Difference with calculated data @ I_{nom}	2.0 %

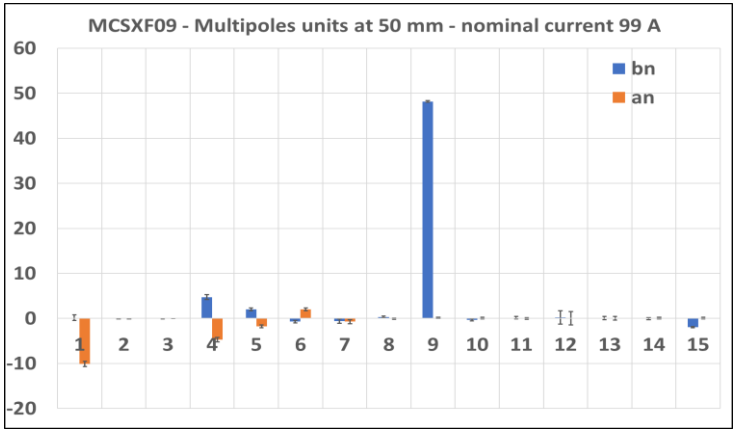
MCOXF08	Measured (Calculated)
Nominal current I_{nom}	102 A
Integrated field @ I_{nom} @ 50 mm	71.7 T mm (70.7 T mm)
Difference with calculated data @ I_{nom}	1.4 %

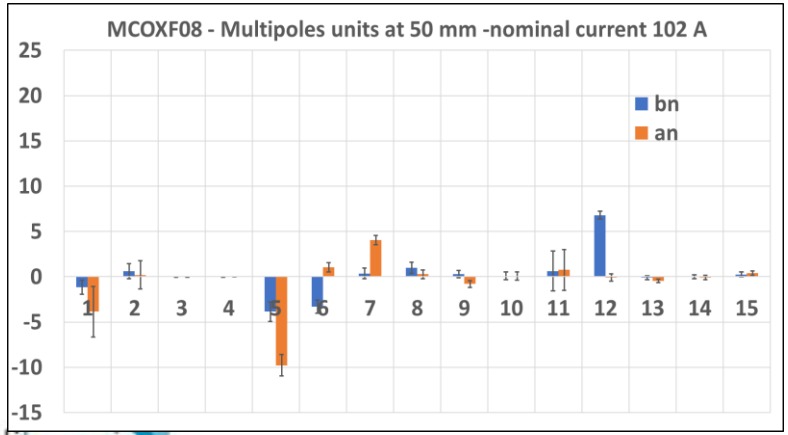
MQSXF1b	Measured (Calculated)
Nominal current I_{nom}	174 A
Integrated field @ I_{nom} @ 50 mm	719.0 T mm (700.0 T mm)
Difference with calculated data @ I_{nom}	2.7 %

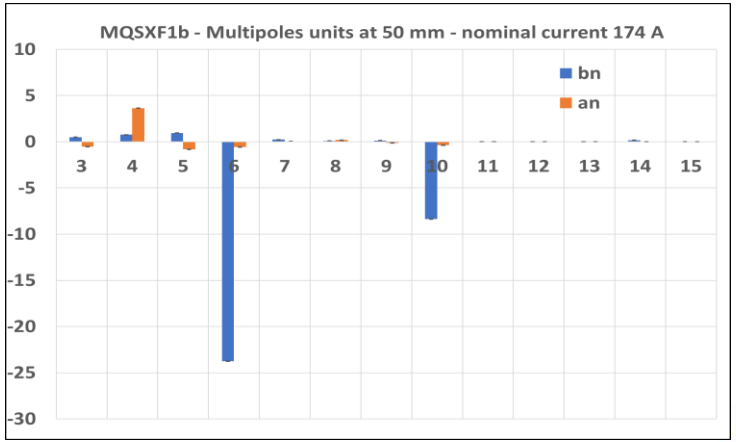
By E. De Matteis

Powering test n9 HOC – MM harmonics

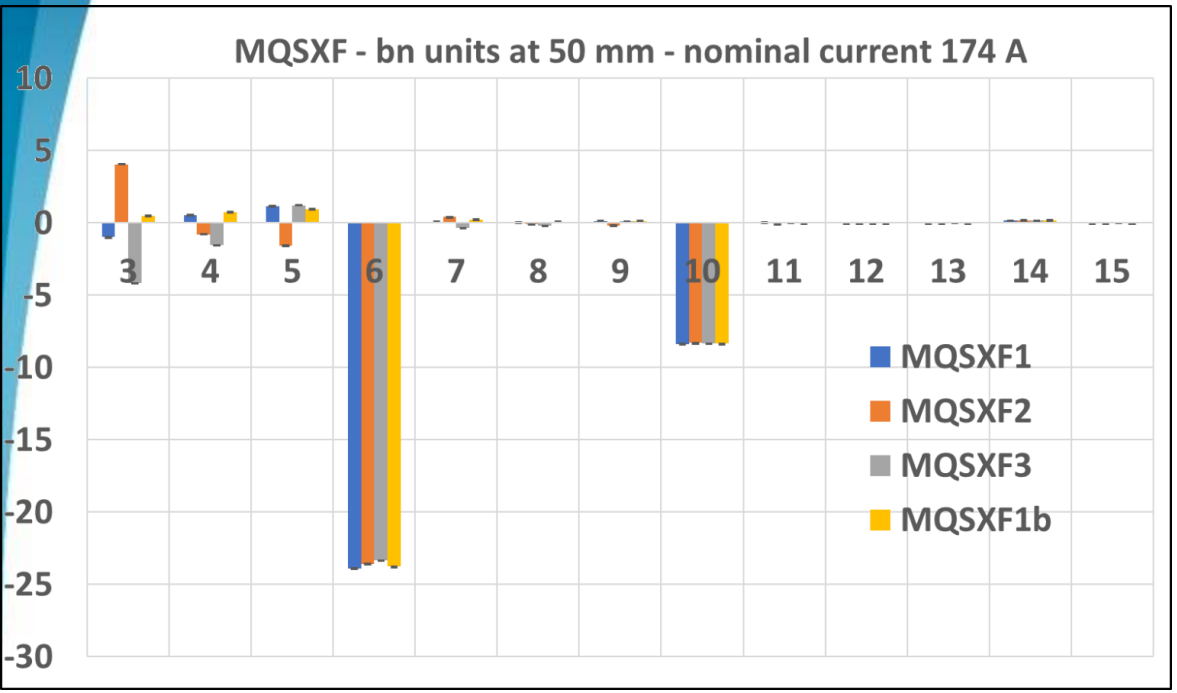






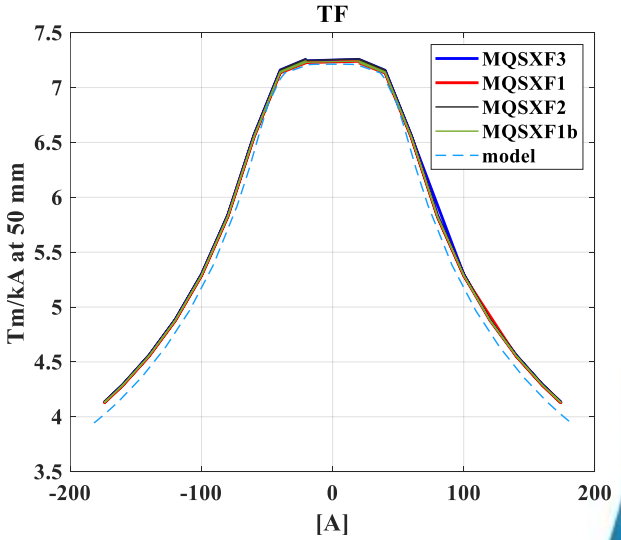


MM results – MSQXF Family

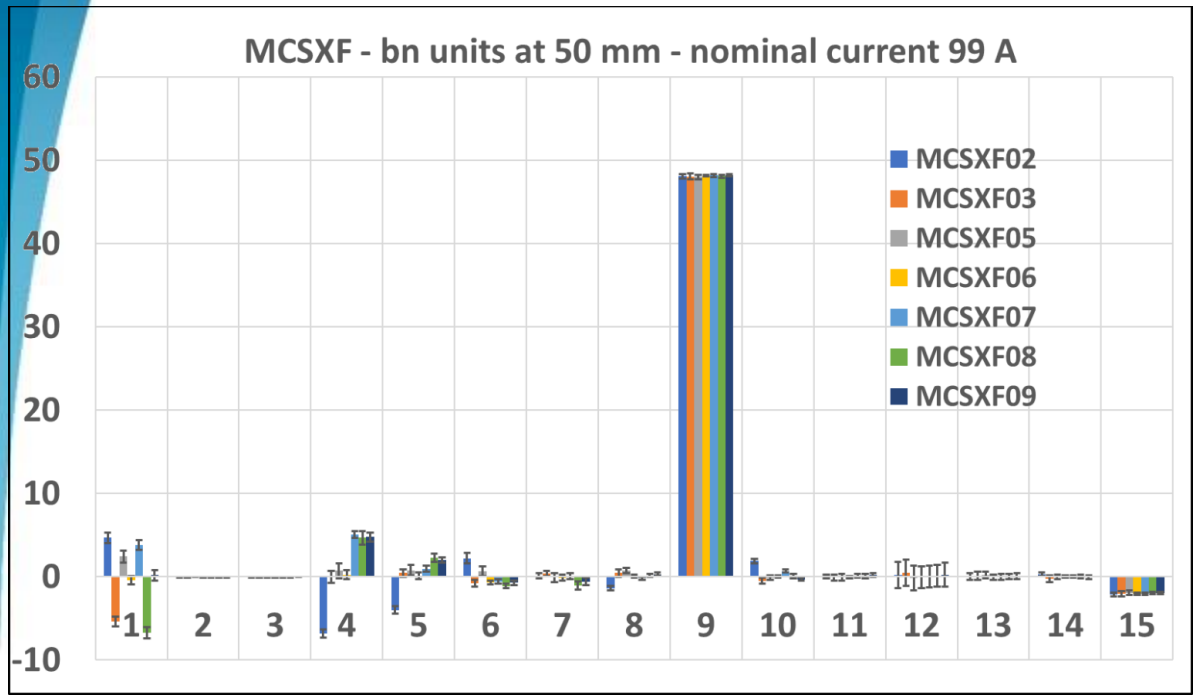


Multipoles in the specs (< 100 units)

Order	Magnet		Specification	Calculations	Measured at LASA	
		Current [A]	BdL [T mm]	BdL [T mm]	BdL [T mm]	diff [%]
2	MSQXF1	174	700	700.0	718.8	2.7
	MQSXF1b				719.0	2.7
	MSQXF2				720.36	2.8
	MSQXF3				719.6	2.8

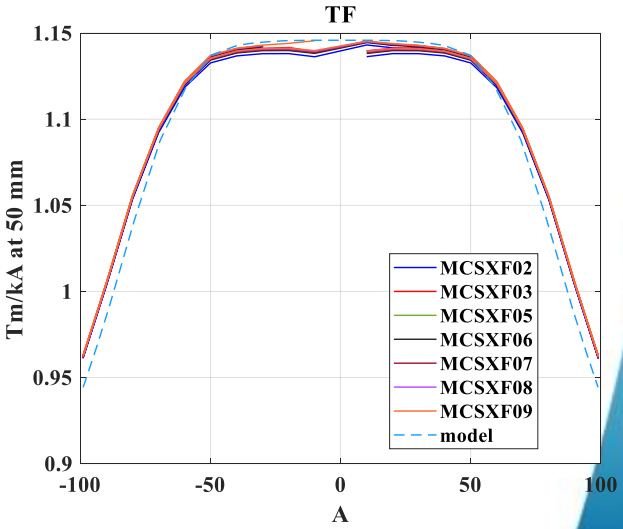


MM results – MCSXF Family

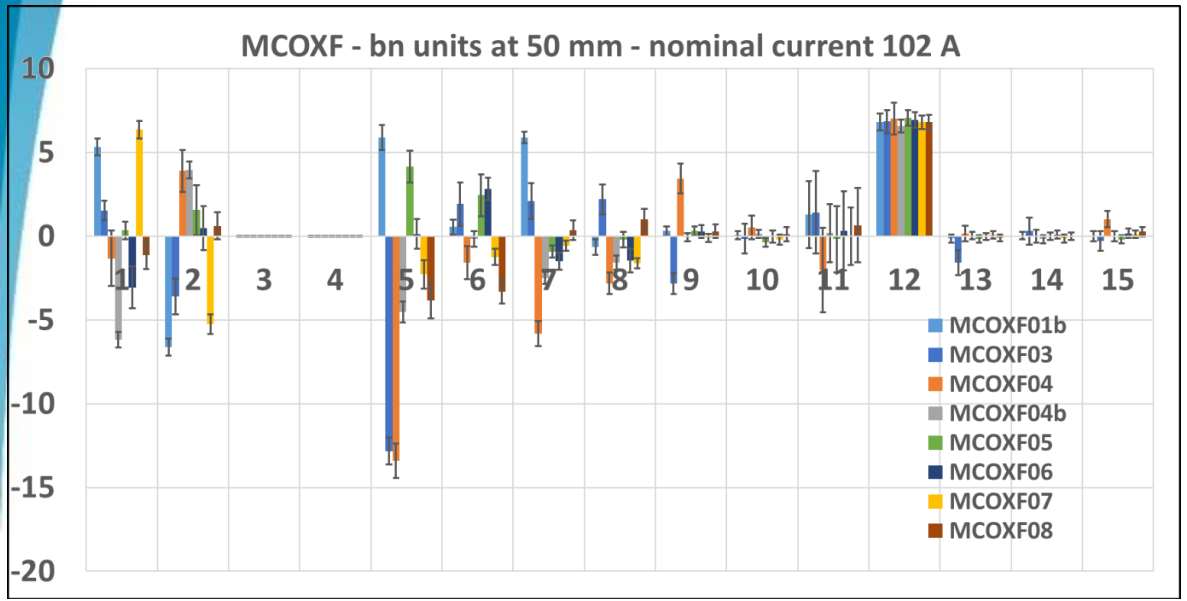


Multipoles in the specs (< 100 units)

Order	Magnet		Specification	Calculations	Measured at LASA	
		Current [A]	BdL [T mm]	BdL [T mm]	BdL [T mm]	diff [%]
3	MCSXF02	99	93.5	93.5	95.22	1.8
	MCSXF03				95.22	1.8
	MCSXF05				95.31	1.9
	MCSXF06				95.27	1.9
	MCSXF07				95.34	2.0
	MCSXF08				95.29	1.9
	MCSXF09				95.37	2.0

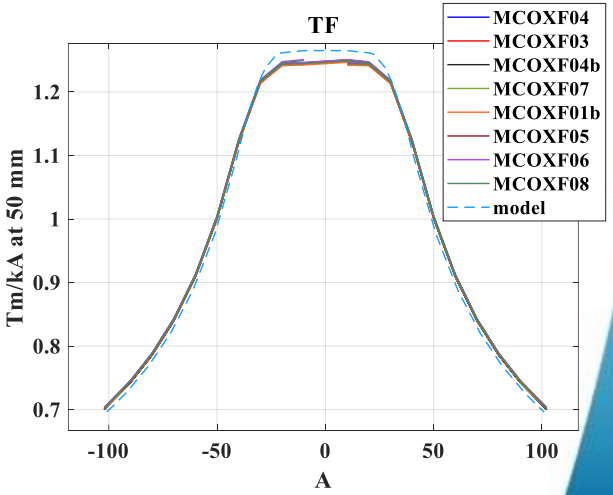


MM results – MCOXF Family



Multipoles in the specs (< 100 units)

Order	Magnet		Specification	Calculations	Measured at LASA	
		Current [A]	BdL [T mm]	BdL [T mm]	BdL [T mm]	diff [%]
4	MCOXF01b	102	69	70.7	**71.57**	**1.2**
	MCOXF03				71.59	**1.3**
	MCOXF04				71.54	**1.2**
	MCOXF04b				71.48	**1.1**
	MCOXF05				71.67	**1.4**
	MCOXF06				71.81	**1.6**
	MCOXF07				71.59	**1.3**
	MCOXF08				71.70	**1.4**



MM results – MCTXF Family

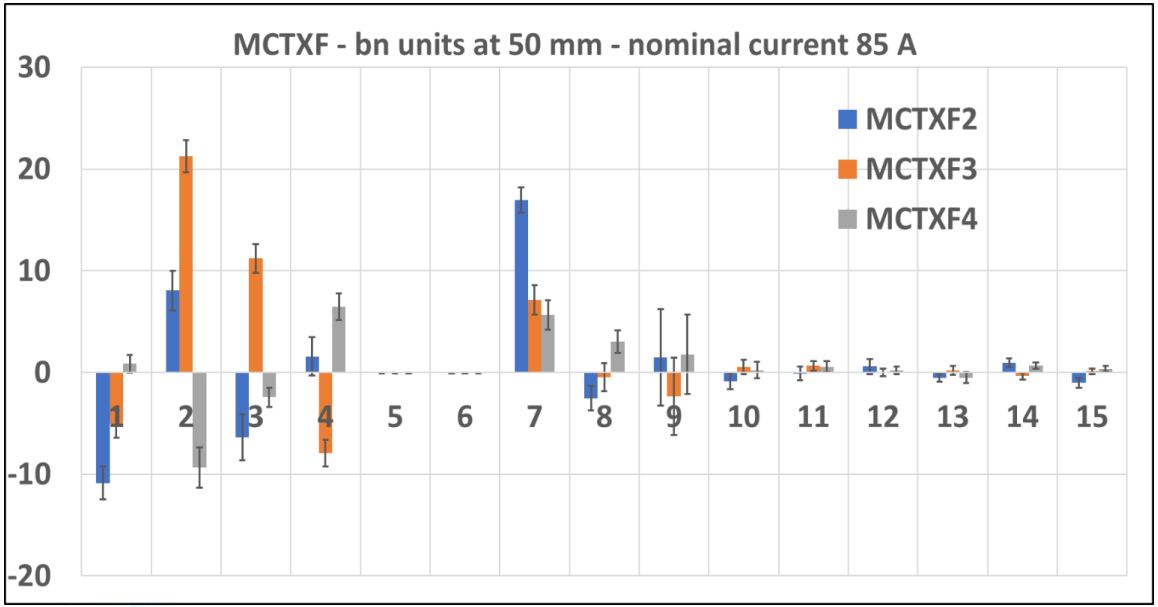
Magnet-to-magnet Magnet-to-magnet repeatability is 0.3%

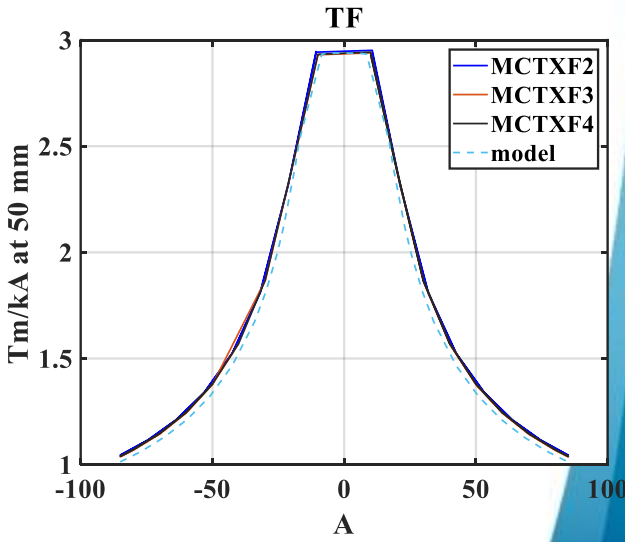
Difference wrt the model of about 2.5%

repeatability is 0.3%

Difference wrt the model of about 2.5%

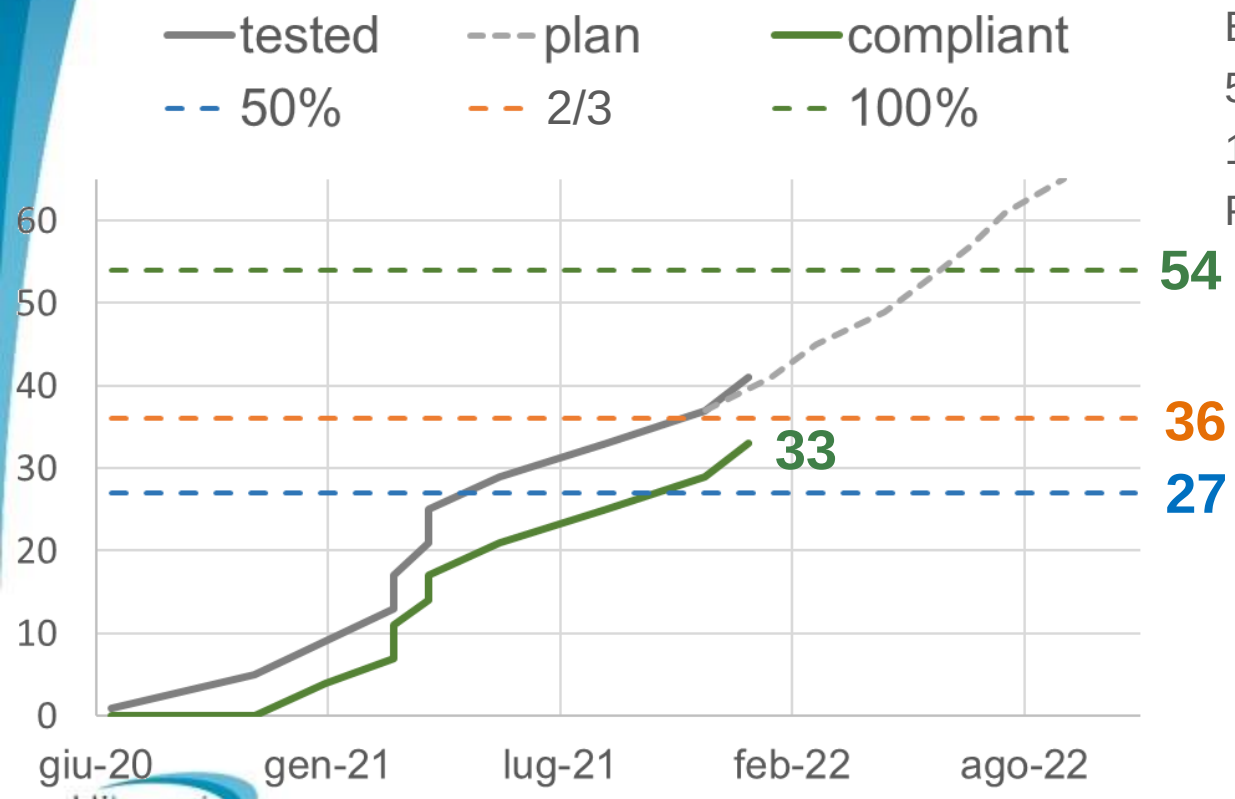
Order	Magnet		Model	Measured at LASA	
		Current [A]	BdL [T mm]	BdL [T mm]	diff [%]
6L	MCTXF2	85	86.1	88.82	3.1
	MCTXF3			88.20	2.4
	MCTXF4			88.41	2.7





Multipoles in the specs (< 100 units)

Tested Magnets



More than 50% tested magnets

End of testing Sep 2021

5 Cool Down + spares

12P_1 tested @CERN

Protection w/o dump R crosscheck

Tested Magnets 2

	Batch	Serial	TEST
M06	1a	1	
		2	
	1b	3	
		4	
	2	5	
		6	
		7	
		8	
	3	9	
		10	
		11	
		12	
M08	1a	1	
		2	
	1b	3	
		4	
	2	5	
		6	
		7	
		8	
	3	9	
		10	
		11	
		12	

	Batch	Serial	TEST
M10	1a	1	
		2	
	1b	3	
		4	
	2	5	
		6	
		7	
		8	
	3	9	
		10	
		11	
		12	
M12	1a	1	
	1b	2	
	2	3	
		4	
	3	5	
		6	
M13	1a	1	
	1b	2	
	2	3	
		4	
	3	5	
		6	

	Batch	Serial	TEST
M04	1a	1	
	1b	2	
	2	3	
		4	
	3	5	
		6	

TESTED

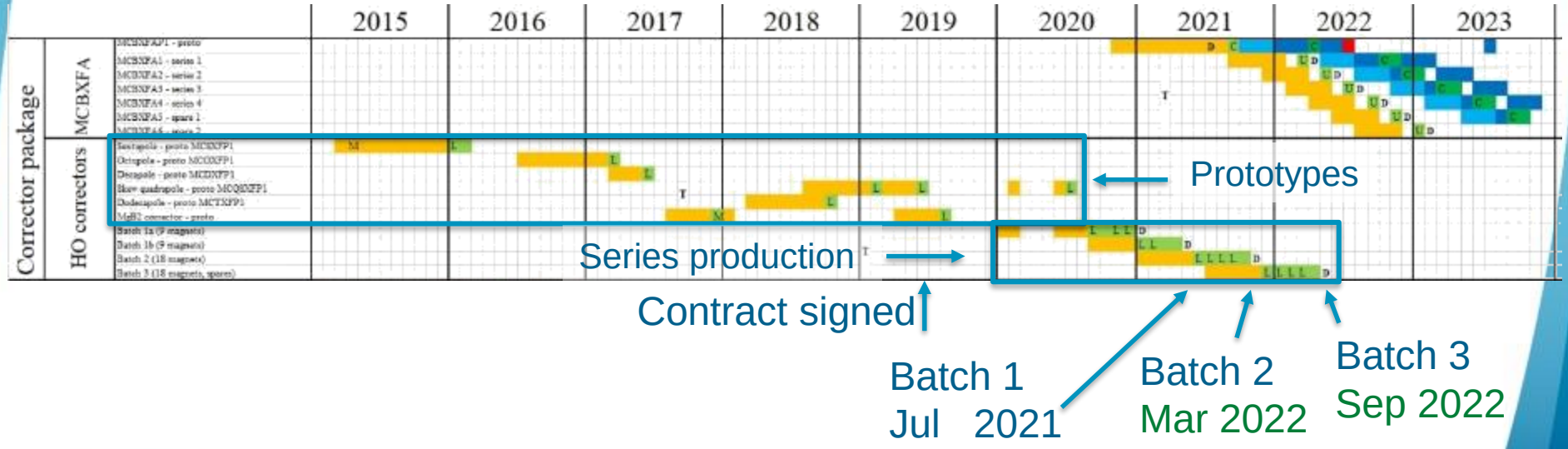
REPAIRED TO BE RE-TESTED

NEXT TEST / ONGOING

Today shipping to CERN
M08_05 M08_06 M08_08 M06_08
M12_1c (from SRV) and M12_4

Schedule

- Completion of assembly expected in Oct 2021. Done
- Expected end of testing at LASA Aug 2022 / Sep 2022



Conclusion

- HO Correctors series production test ongoing
  - 54 HO Correctors produced by SAES Rial Vacuum
  - 33 magnets compliant
  - Quench protection crosscheck ongoing
- 24 magnets at CERN
- 6 magnets travelling this week to CERN

INFN
LASA

THANK YOU

LASA team
F. Broggi, E. De Matteis, S. Mariotto,
A. Paccalini, A. Palmisano, A. Pasini,
D. Pedrini, A. Leone, M. Quadrio, M. Prioli,
M. Sorbi, M. Statera, M. Todero, C. Uva

HiLumi HL-LHC PROJECT
INFN