



**Ciemat**  
Centro de Investigaciones  
Energéticas, Medioambientales  
y Tecnológicas



# HL-LHC Interaction Region Magnets

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G. Ambrosio, S. Feher, T. Nakamoto, Q. Xu, F. Toral, S. Farinon, M. Statera  
A. Foussat, J.-C. Perez,  
G. Vandoni, I. del Rosario Crespo Garrido, S. Fleury



October 10<sup>th</sup> 2024, Genova

# Structure update



## HL-LHC WP3: IR magnets

E. Todesco

D. Duarte Ramos (Deputy)



September 2024

### Nb<sub>3</sub>Sn magnets

#### Triplet Q1/Q3

G. Ambrosio, S. Feher (FNAL)  
S. Izquierdo Bermudez  
(CERN WPE)

#### Triplet Q2

S. Izquierdo Bermudez  
(CERN WPE)

#### Busbars

L. Baudin (CERN)

#### Installation in the string

S. Le Naour (CERN WPE)

### Nb-Ti correctors

#### Orbit correctors

F. Toral (CIEMAT)  
J. Carlos Perez (CERN WPE)

#### High order correctors

M. Statera (INFN LASA)  
E. Gautheron (CERN WPE)

#### D2 correctors

Q. Xu (IHEP)  
A. Foussat (CERN WPE)

#### D1-DFX Connection module

R. Diaz (CERN WPE)

### Nb-Ti and resistive main magnets

#### Separation dipole D1

T. Nakamoto (KEK)  
J. Carlos Perez (CERN WPE)

#### Recombination dipole D2

S. Farinon (INFN Genova)  
A. Foussat (CERN WPE)

#### MQYY

D. Simon (CEA)  
A. Foussat (CERN WPE)

#### MBW and MQW

P. Thonet (CERN WPE)

#### Q4, Q10 in IR1 and IR5

H. Prin (CERN WPE)

Thanks to Rosario Principe !



Welcome to Lucie Baudin and to  
Ruth Diaz Vez

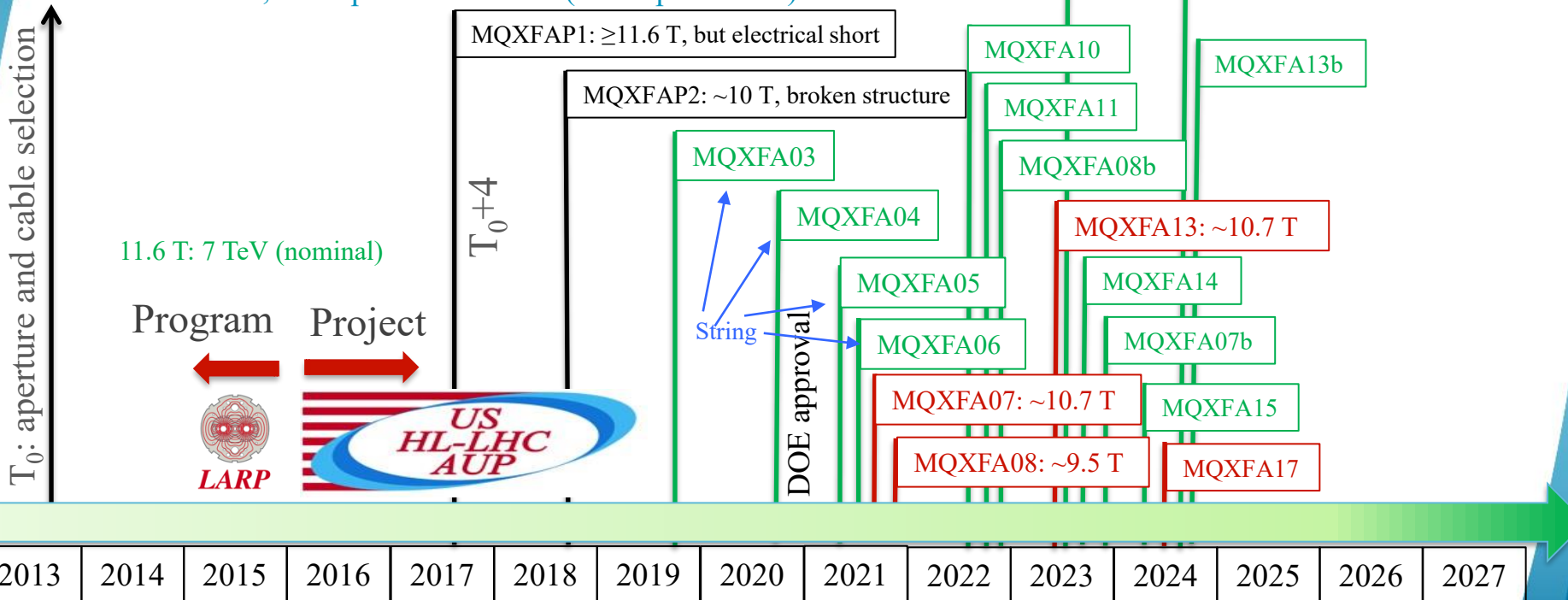


# MQXFA (see talks by G. Ambrosio, S. Feher)

10 conform magnets

First cold mass limited at 6.8 TeV after test at CERN

30% of NC test, but repair is succesful (coil replacement)



12 magnet tested, 9 more new magnets to test (9,12,16, 18-23)

E. Todesco on behalf of WP3



# MQXFB (see talk by S. Izquierdo Bermudez)



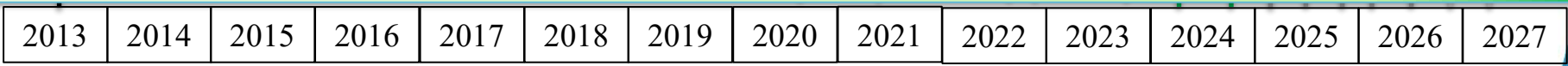
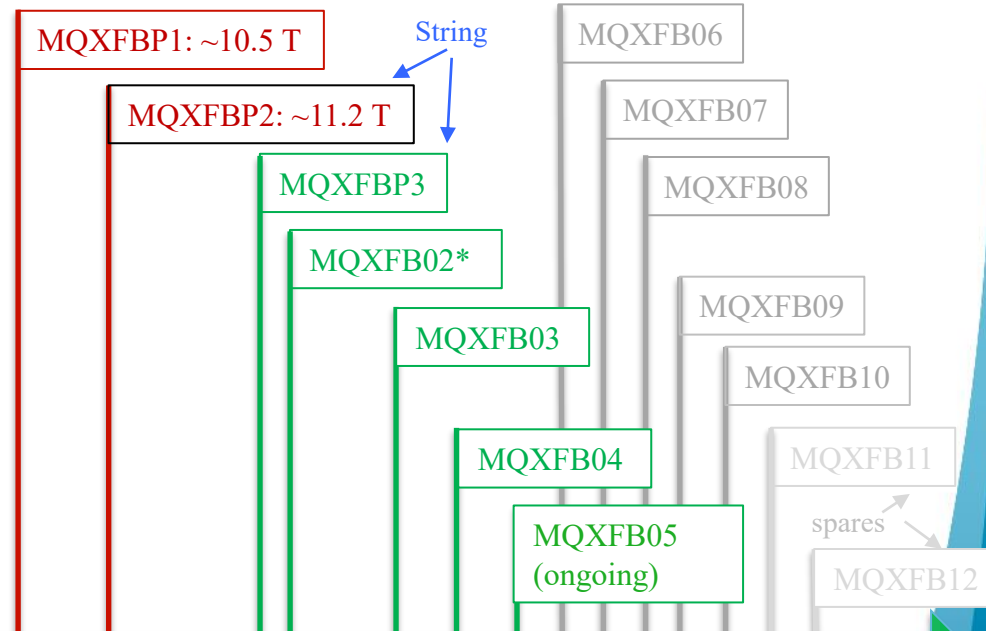
Green: conform  $\geq 11.6$  T

Red: non conform

Grey: to come

Light grey: spares

T<sub>0</sub>: aperture and cable selection



\* MQXFB02 had a non conform HV test, will be disassembled

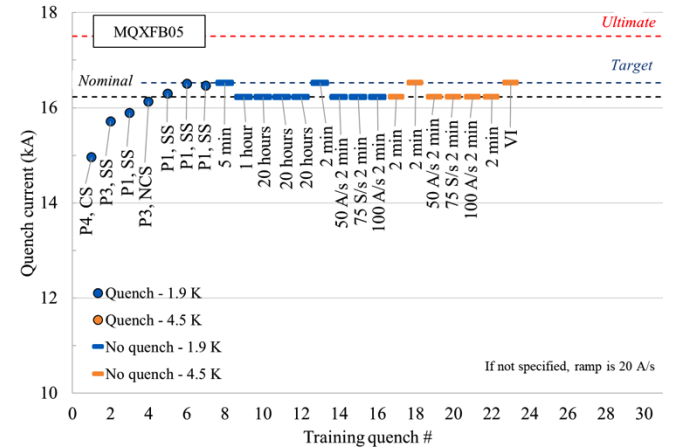
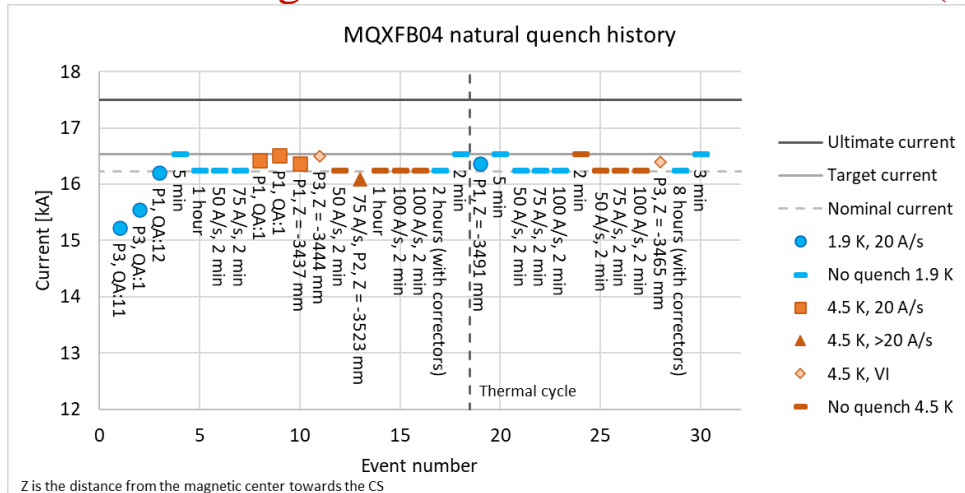
7 more magnets to test

E. Todesco on behalf of WP3

# MQXFB (see talk by S. Izquierdo Bermudez)

		38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
MQXFB	Coil	█																																											
	Magnet	█																																											
	Cold mass	█																																											
	Test	MQXFB03	MQXFB04	MQXFB05	MQXFB06	MQXFB07	MQXFB08	MQXFB09	MQXFB10	MQXFB11	MQXFB12																																		

- MQXFB05 reached requirements in 1<sup>st</sup> thermal cycle – 3<sup>rd</sup> new generation magnet
- We gain performance, and a bit more virgin training – good bargain
- All magnets reach nominal also at 4.5 K (90% of sh. sample): important for HFM



## Quench performance of MQXFB04 and 05

(Test eng. F. Mangiarotti, G Willering,, WPE: S. Izquierdo Bermudez, et al.)

E. Todesco on behalf of WP3

# MCBXF (see talk by F. Toral)

- Internalization according to plans – MCBXFB06 completed

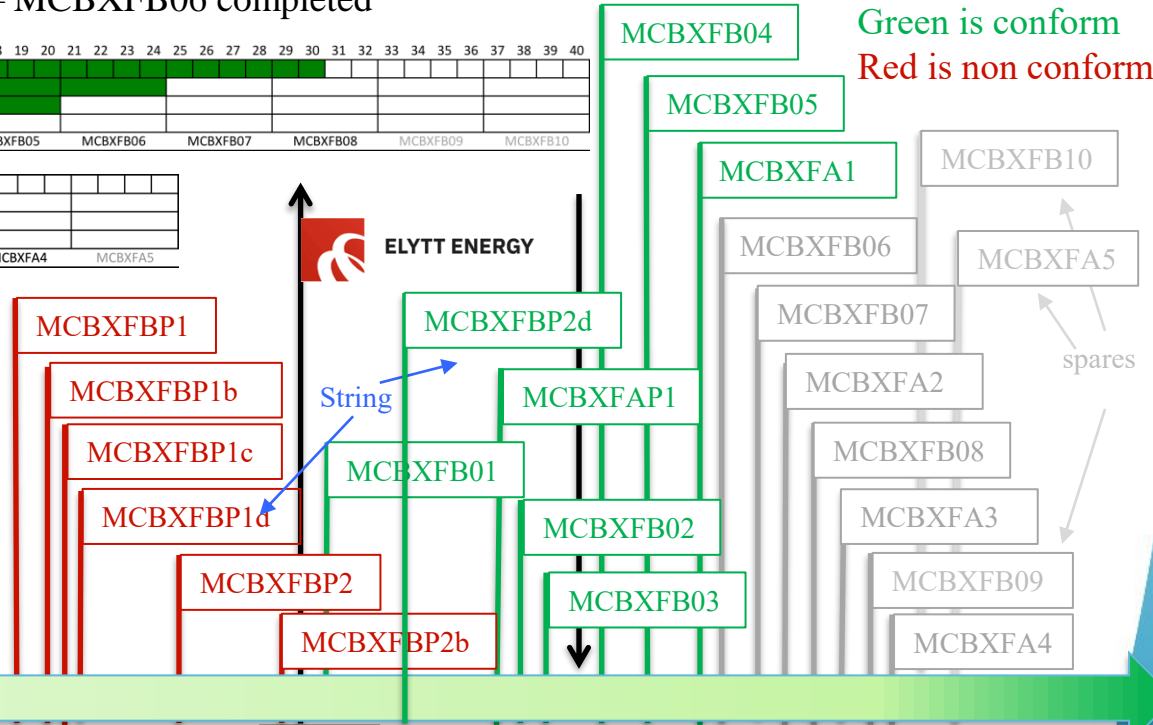
Green is conform  
Red is non conform

T<sub>0</sub>: aperture and cable selection

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Coil	[Green]																																							
Magnet	[Green]																																							
V test (CERN)	[Green]																																							
Cold mass	[Green]																																							
H test (CERN)	[Green]																																							
MCBXF	With MQXFB03				With MQXFB04				With MQXFB05				With MQXFB06																											
	MCBXF01				MCBXF02				MCBXF03				MCBXF04				MCBXF05				MCBXF06				MCBXF07				MCBXF08				MCBXF09				MCBXF10			

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Coil	[Green]																																							
Magnet	[Green]																																							
V test (CERN)	[Green]																																							
Cold mass	[Green]																																							
H test (CERN)	[Green]																																							
MCBFA	MCBFA1				MCBFA2				MCBFA3				MCBFA4				MCBFA5																							



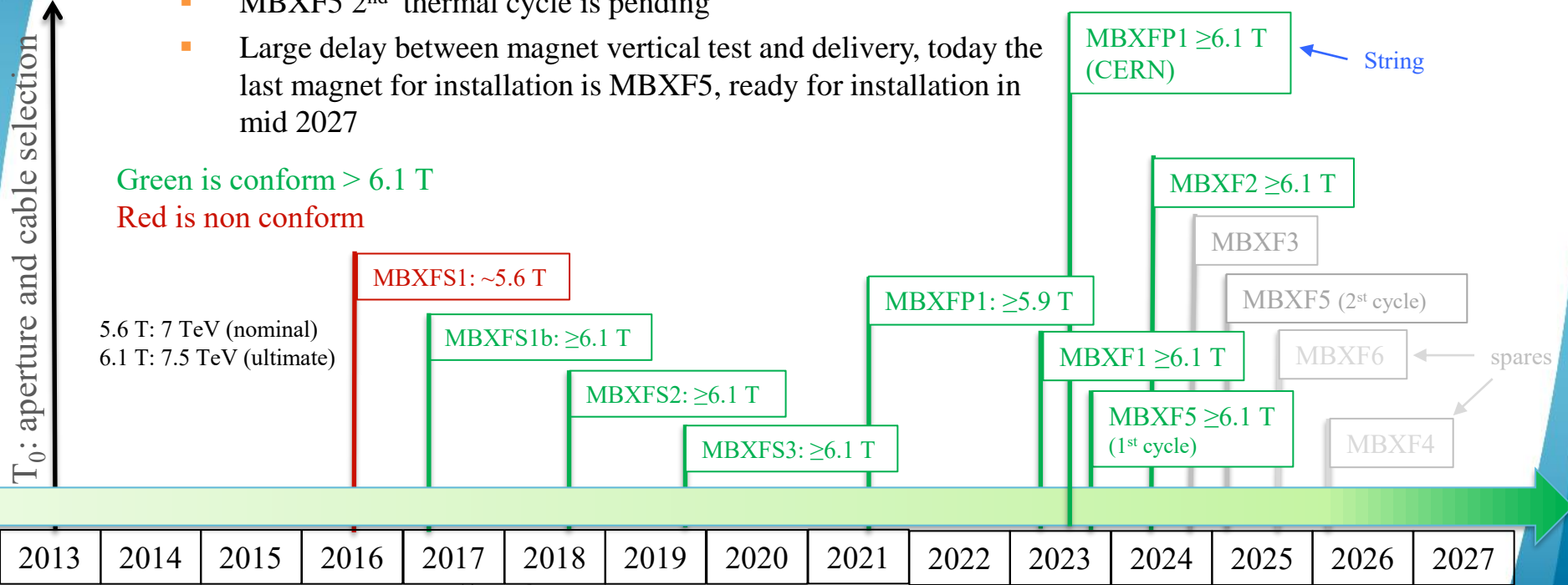
2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
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# D1 (see talk by T. Nakamoto)

- 2.5 magnets conform
- MBXF5 2<sup>nd</sup> thermal cycle is pending
- Large delay between magnet vertical test and delivery, today the last magnet for installation is MBXF5, ready for installation in mid 2027

Coil										
Magnet										
MBXF V test (KEK)										
Cold mass										
H test (CERN)	MBXF1	MBXF2	MBXF3	MBXF4	MBXF5	MBXF6				





- Coil manufacturing finished
- Issues with collaring are being solved
- MBRD1 back to CERN in October
- MBRD2 at CERN, cold mass assembly ongoing

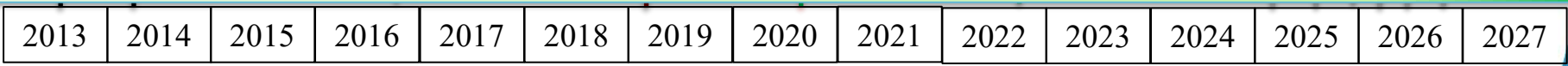
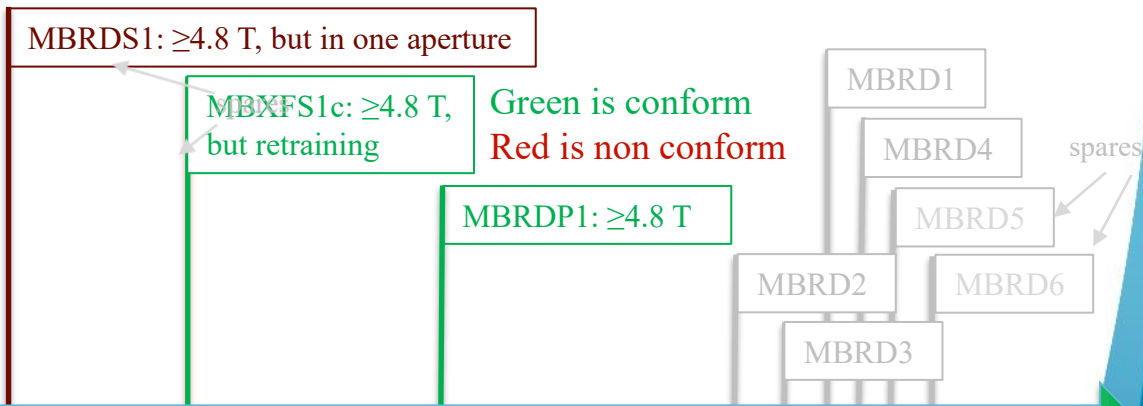
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
MBRD	Coil	[Green]																							
	Apertures	[Green]																							
	Magnet	[Green]																							
	Cold mass	[Green]																							
	Test	MBRD1				MBRD2				MBRD3				MBRD4				MBRD5				MBRD6			

T<sub>0</sub>: aperture and cable selection

T<sub>0</sub>: collaboration agreement

Contract to ASG

4.5 T: 7 TeV (nominal)  
4.8 T: 7.5 TeV (ultimate)

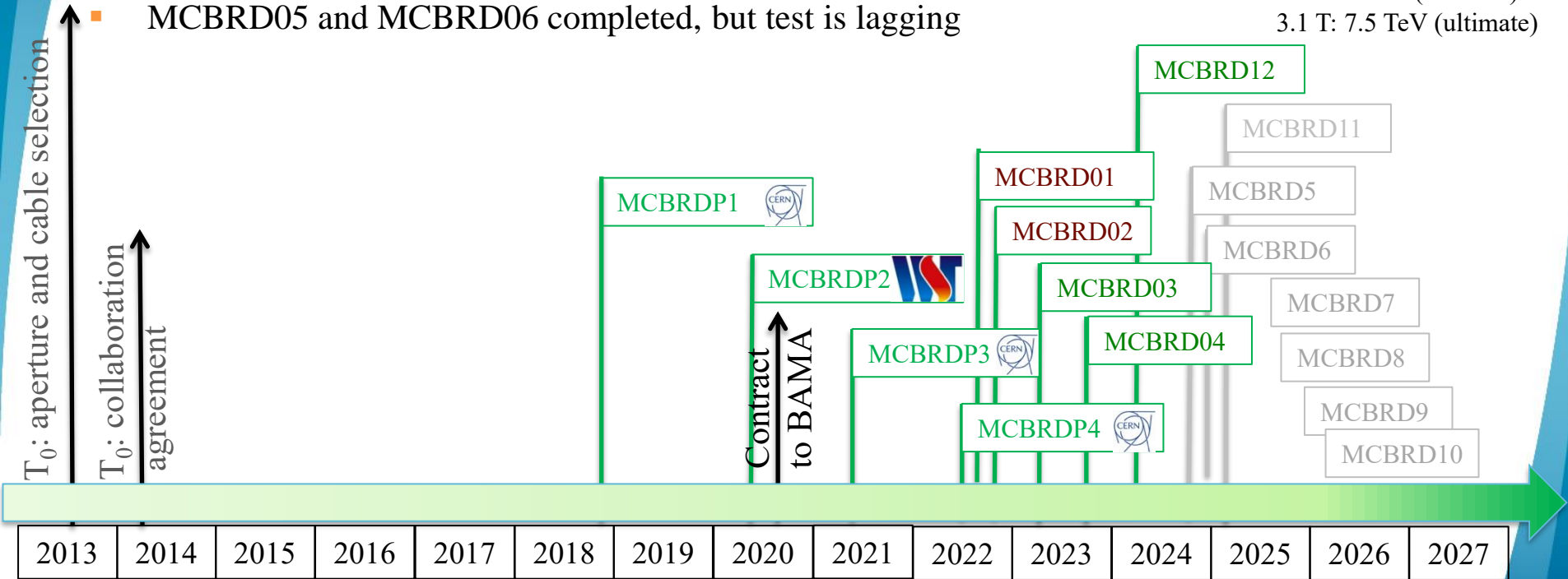


# D2 corrector (see talk by Q. Xu)

Green is conform  
Red is non conform

- At CERN, the second magnet with Chinese components MCBRD12 still to be completed – test will be in early 2025
- MCBRD05 and MCBRD06 completed, but test is lagging

2.8 T: 7 TeV (nominal)  
3.1 T: 7.5 TeV (ultimate)



7 more magnets to test

E. Todesco on behalf of WP3

# Conclusions

- Production is **advancing well, but far from being finished!**
- **Integration** of magnets from three continents is being proved
- New baseline for MQXFB coils shows **performance reproducibility**
- US MQXFA production shows ability to **recover performance limitations** via coil replacement
- First magnet **installed in the string**



