



## **Field repeatability of MQXF**

CERN, 18/02/2020

# Content

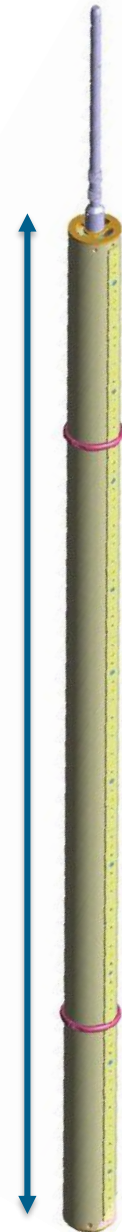
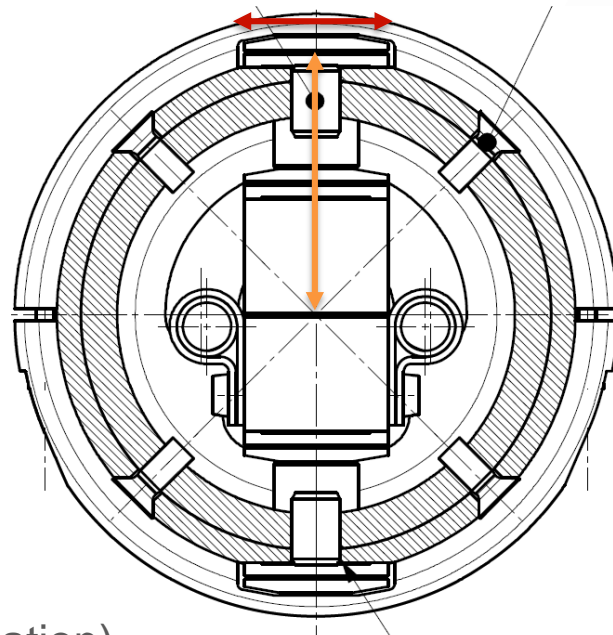
- Factors limiting the measurement precision
- Measurement results on short models:
  - MQXFS6b
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# Measurement system for short models

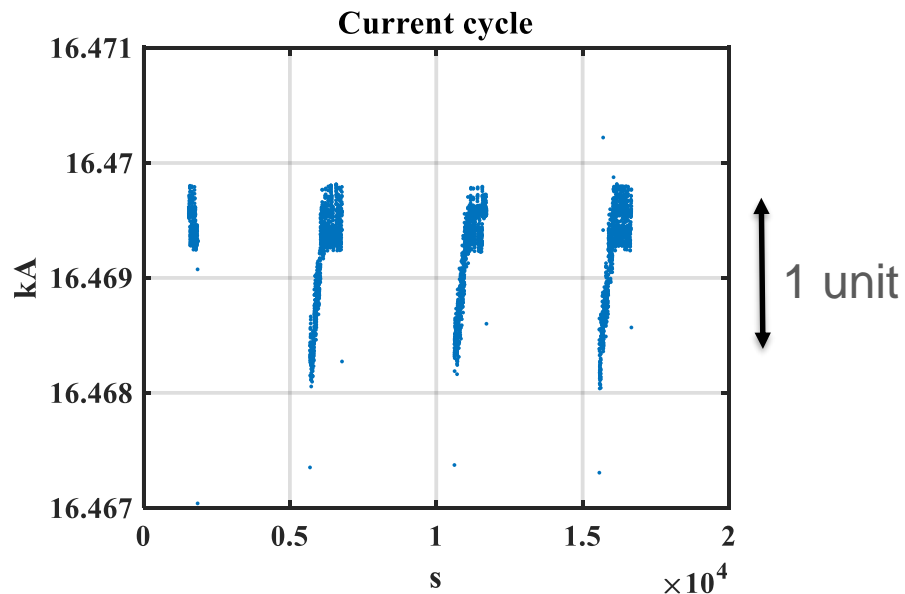
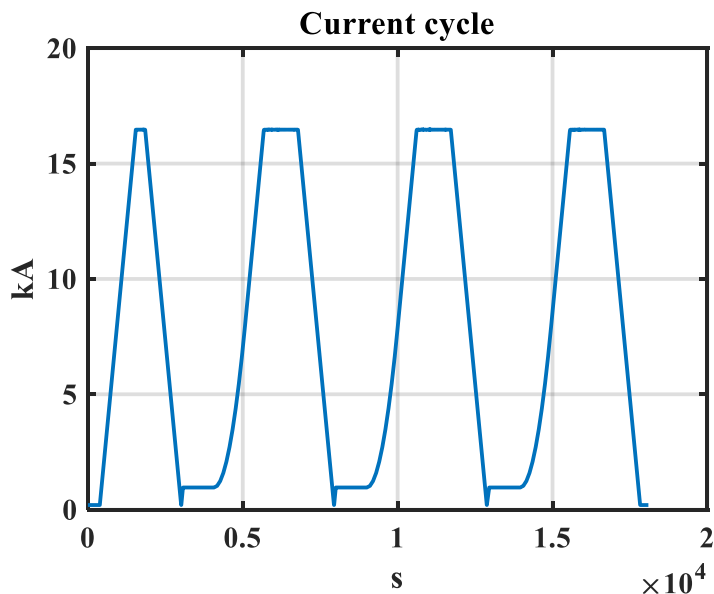
- Vertical shaft rotating in the helium bath
- Fiberglass epoxy
- Length 2.1 m
- Measurement coils at a radius of ~43 mm
- Coil width ~21 mm

The precision of the field measurement is given by:

- For the main field in a quad
  - stability of the radius  
 $10^{-5} * 50 \text{ mm} = 0.5 \mu\text{m}$
- For the multipoles
  - the radius
  - the bucking factor (compensation)
  - the sensitivity as function of the multipole order (kn)  
zero sensitivity:  $21 \text{ mm} / 43 \text{ mm} \rightarrow 27 \text{ degrees} \rightarrow n = 13$

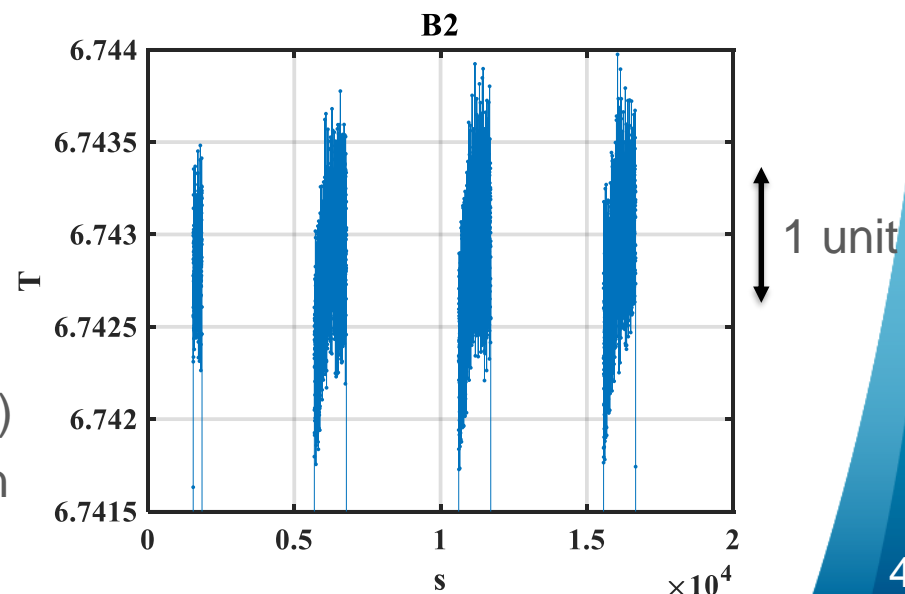


# MQXFS6b: repeatability of TF



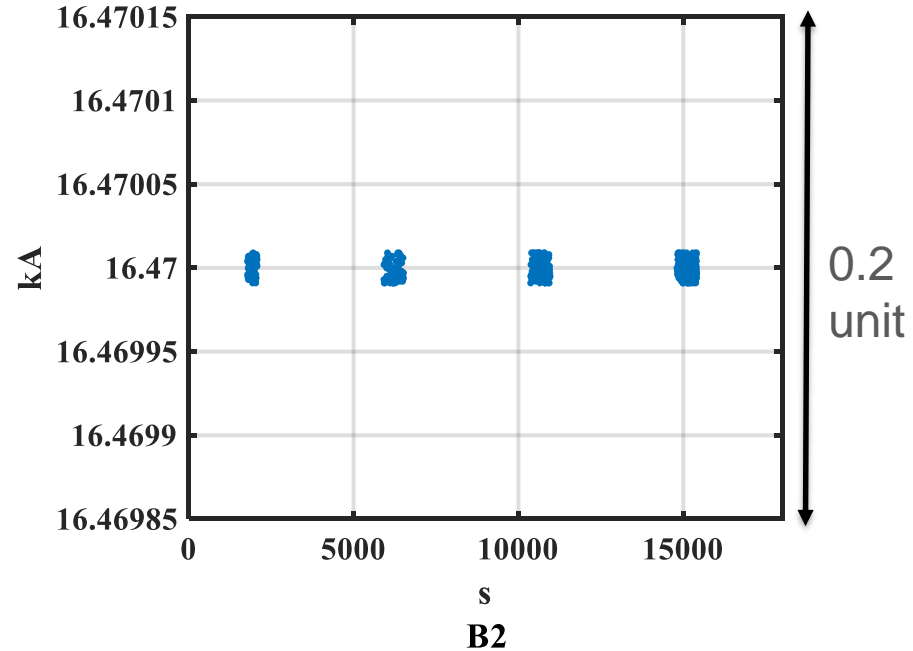
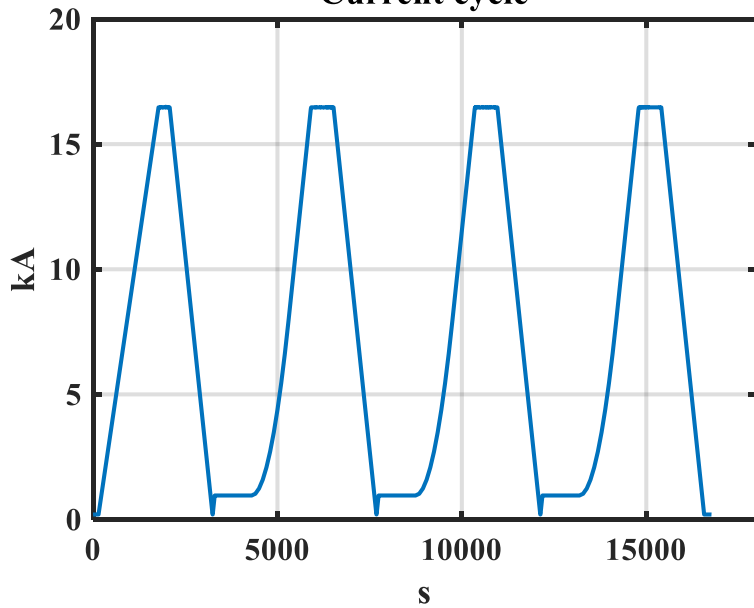
Cycle	I [A]	Relative $\Delta$	TF [T / m / kA]	Relative $\Delta$
1	16469.19	0	8.18839	0
2	16469.23	2.1E-06	8.18843	4.9E-06
3	16469.23	2.0E-06	8.18847	9.7E-06

The cycle-to-cycle repeatability of the main field is better than 0.1 units ( $10^{-5}$ )  
 Limited by the measurement precision



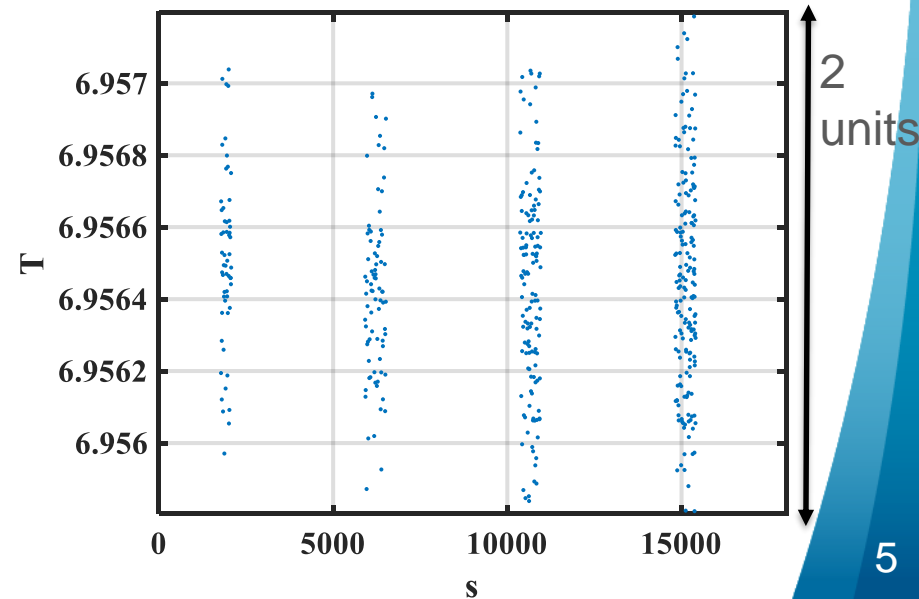
# MQXFS4a: repeatability of TF

Current cycle



Plateau	I [A]	std [A]	Rel std [-]
1	16470.000	5.3E-03	3.2E-07
2	16469.999	5.6E-03	3.4E-07
3	16469.999	5.5E-03	3.3E-07
4	16469.999	5.1E-03	3.1E-07

Plateau	TF [T m <sup>-1</sup> kA <sup>-1</sup> ]	std [T m <sup>-1</sup> kA <sup>-1</sup> ]	Rel std [-]	Cycle-to-cycle relative diff
1	8.447506	3.7E-04	4.3E-05	<b>1.5E-05</b>
2	8.447382	3.3E-04	3.9E-05	<b>0.0</b>
3	8.447379	3.8E-04	4.5E-05	<b>-3.2E-07</b>
4	8.447403	4.1E-04	4.8E-05	<b>2.4E-06</b>



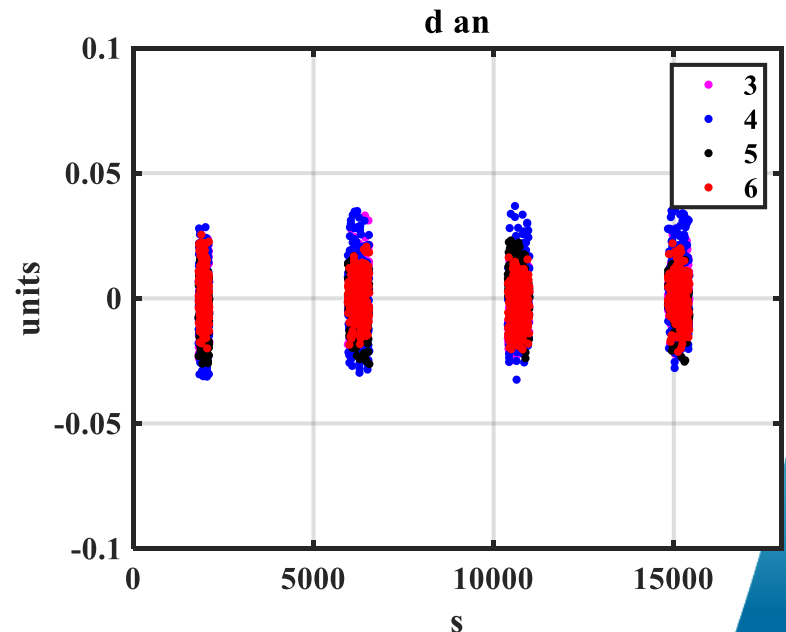
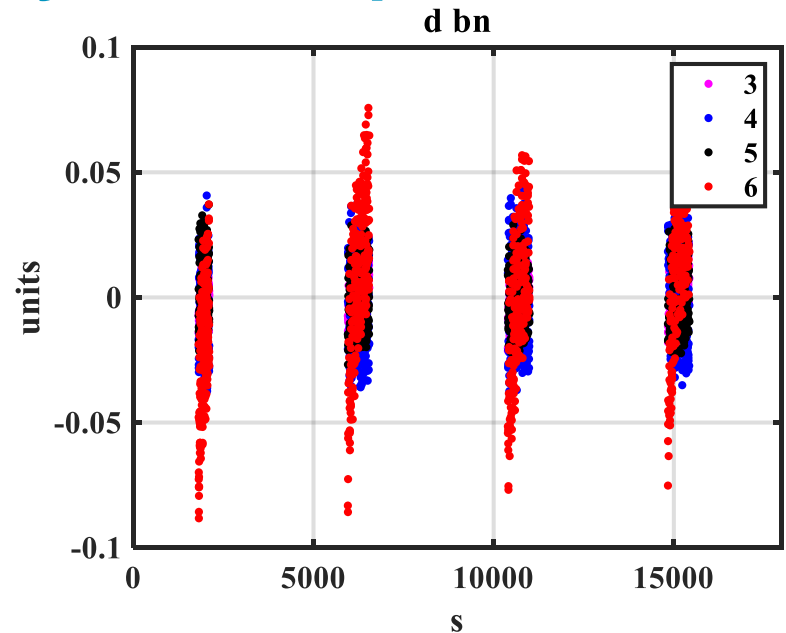
# MQXFS4a: repeatability of multipoles

n	bn [units]				std
3	2.636	2.643	2.638	2.641	0.003
4	0.560	0.559	0.563	0.568	0.004
5	-3.155	-3.157	-3.159	-3.157	0.002
6	-3.741	-3.713	-3.721	-3.706	0.015
7	0.314	0.315	0.318	0.310	0.003
8	-0.002	0.001	0.013	0.001	0.007

n	an [units]				std
3	-1.172	-1.179	-1.171	-1.180	0.005
4	-4.749	-4.751	-4.754	-4.755	0.003
5	-0.215	-0.216	-0.221	-0.216	0.003
6	-0.370	-0.367	-0.363	-0.367	0.003
7	-0.194	-0.194	-0.189	-0.194	0.003
8	-0.783	-0.787	-0.785	-0.787	0.002

The cycle-to-cycle repeatability of multipoles is better than 0.01 units ( $10^{-6}$ )

Limited by the measurement precision



# Conclusions

The cycle-to-cycle repeatability of the field in MQXF magnets is

- better than  $10^{-5}$  for the main field ( $n=2$ )
- better than  $10^{-6}$  for the multipoles ( $n>2$ )

The measurement precision is the limiting factor