



Status of the observations on flux jumps on Nb3Sn magnets

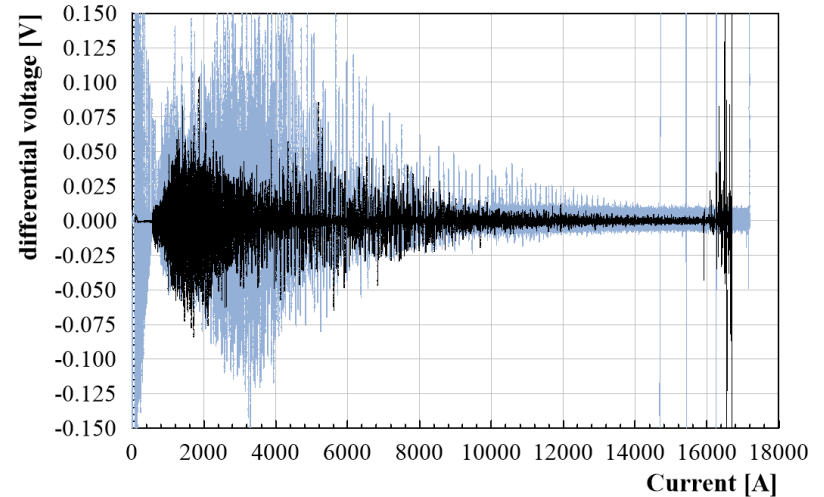
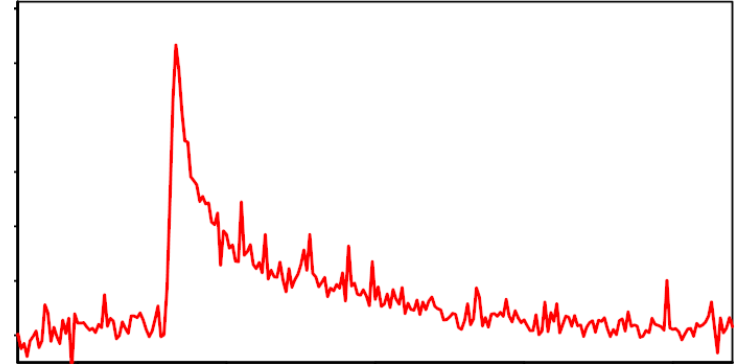
Lucio Fiscarelli

8th HL-LHC Collaboration Meeting
CERN, 17/10/2018

Flux jumps on superconducting magnets

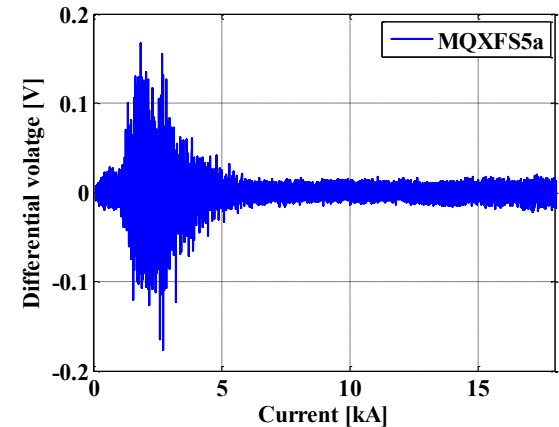
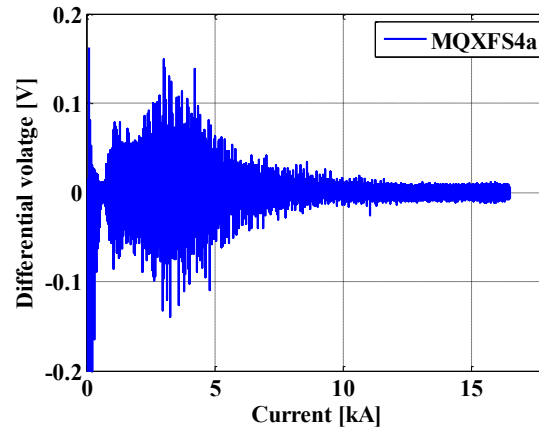
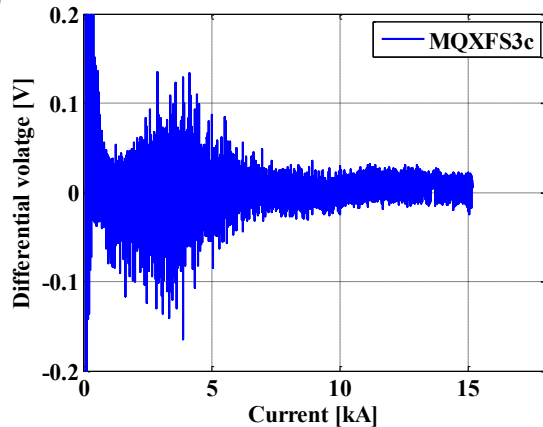
Experimental observations

- Spikes on the voltage measured across the magnet leads or at the terminals of a single coil
- Bucked signals - difference of signals from two or more coils - show them more clearly
- Specific signature, different from mechanical vibrations or from power-converter noise

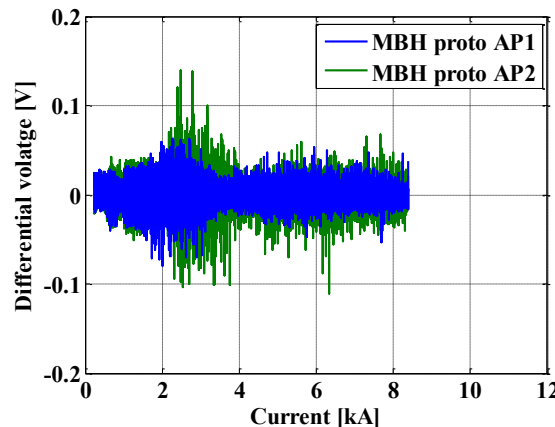
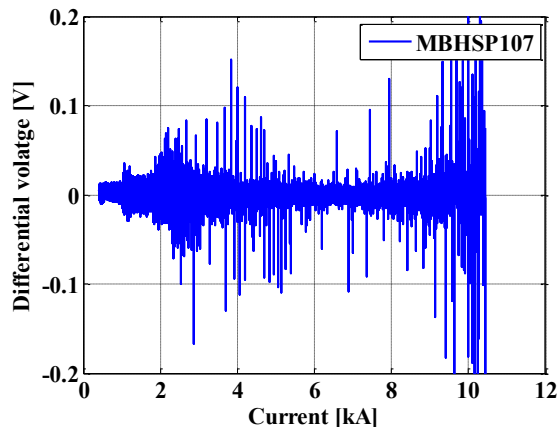


Flux jumps on the differential voltage

MQXFS (1.5 m)



MBH 11 T (1.8 m and 5 m)



Similar behavior on Nb₃Sn magnets tested at CERN to date

- Amplitude <150 mV
- Mainly at low or intermediate field
- From these data we see same amplitude on MBH full-length proto

Effects of flux jumps on the magnetic field

Flux jumps

- fast events ($\gg 1$ Hz)
- occur during ramps
- mainly at low or intermediate field levels

How can we evaluate their effect on the field?

1) Precise measurement of the current

- assumption that changes on the current will have a proportional effect on the field

2) Fixed coils

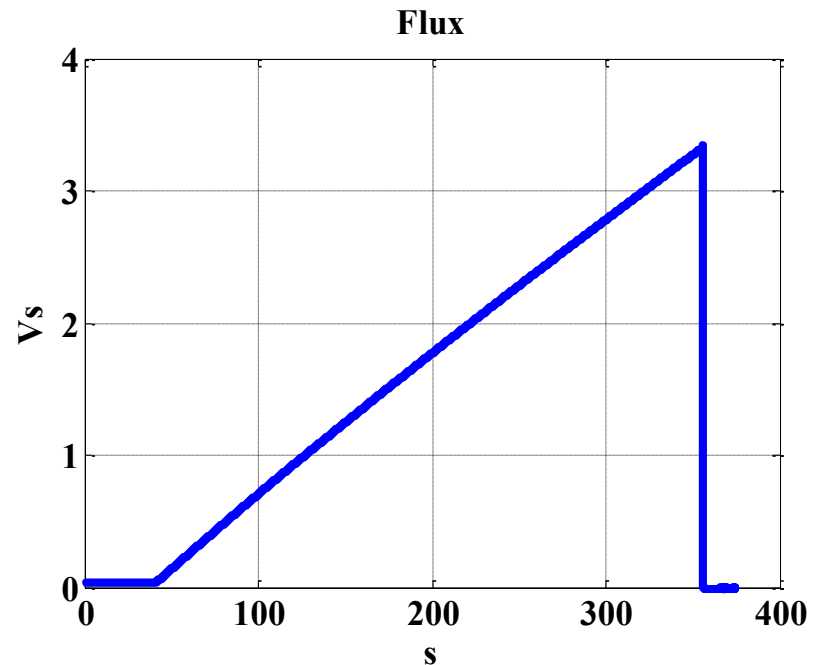
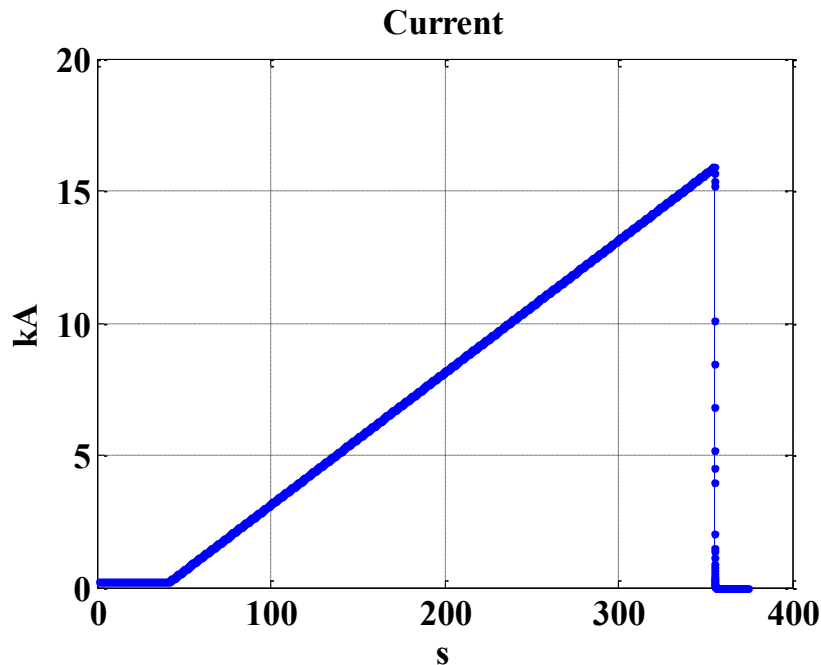
- large bandwidth (~ 1 kHz)
- relative measurement (change of field)
- precise on short time intervals (< 1 s)

3) Rotating coils are not the best option

- provide absolute field and harmonics
- best accuracy ($\sim 10^{-5}$)
- limited bandwidth (~ 1 Hz)

Measurement of current and flux

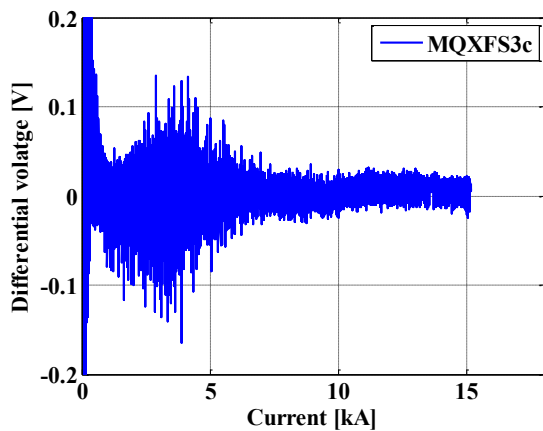
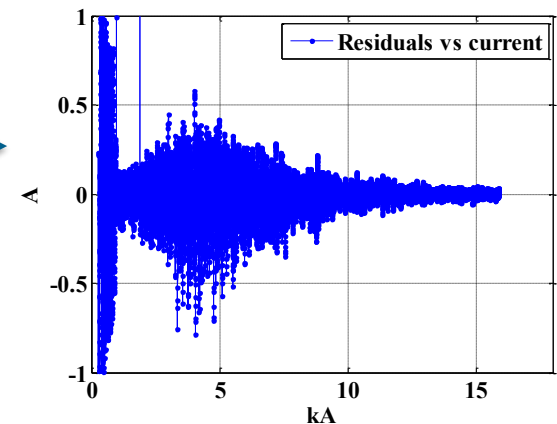
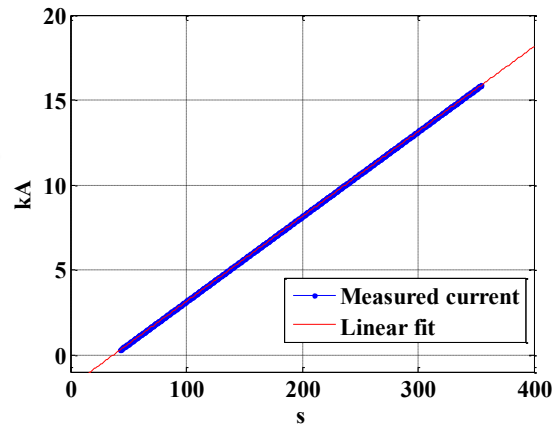
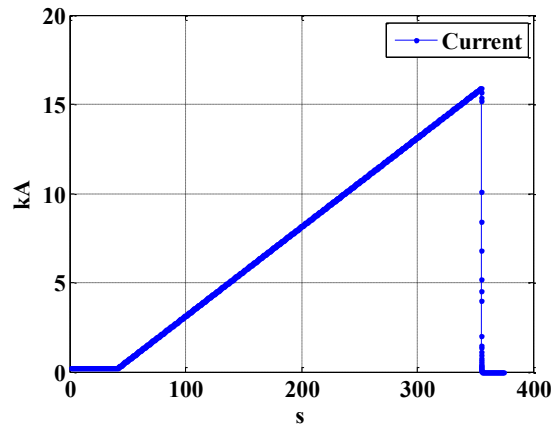
MQXFS3c



- Ramp at 50 A/s followed by a CLIQ discharge
- Current measured at 50 Hz (given by the FGC)
- Flux measured via a fixed coil at 7.5 kHz
- Absolute timestamp for synchronization

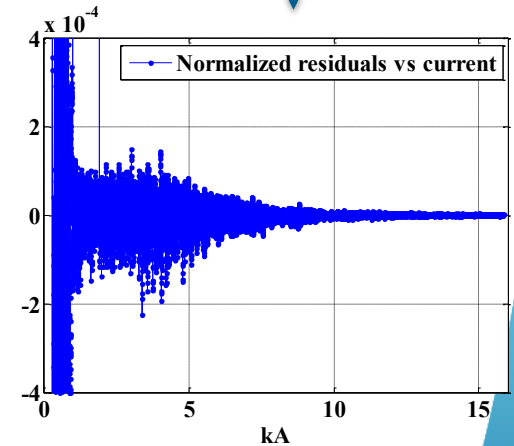
Measurement of the current

MQXFS3c



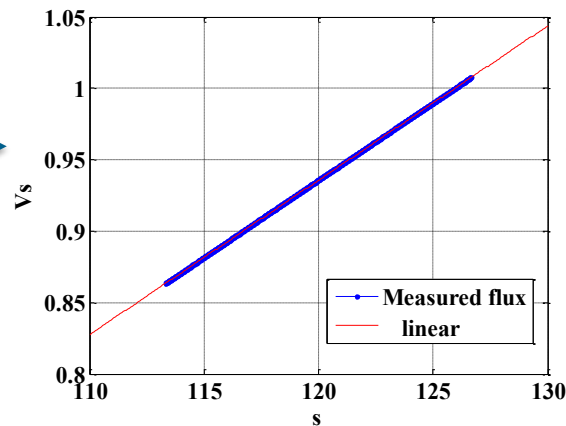
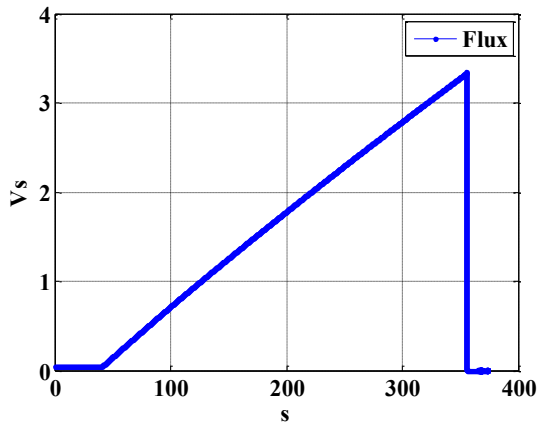
There is “noise” on the measured current

- with amplitude $\sim 1 \cdot 10^{-4}$
- can be related to the flux jumps measured on the voltage

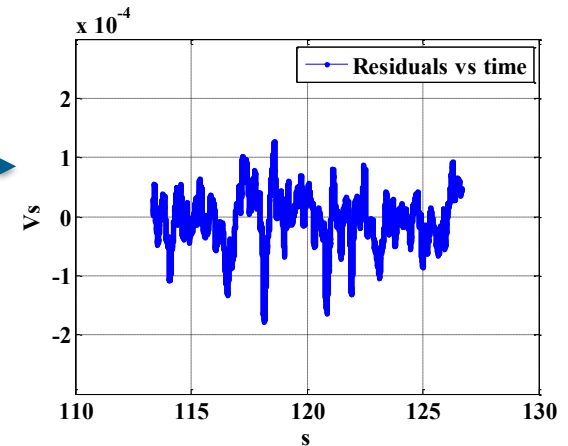


Measurement of the flux

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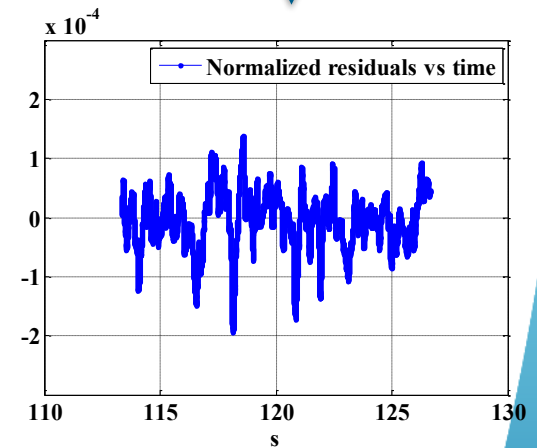


Selection of a smaller range to limit the TF non-linearity of the magnet



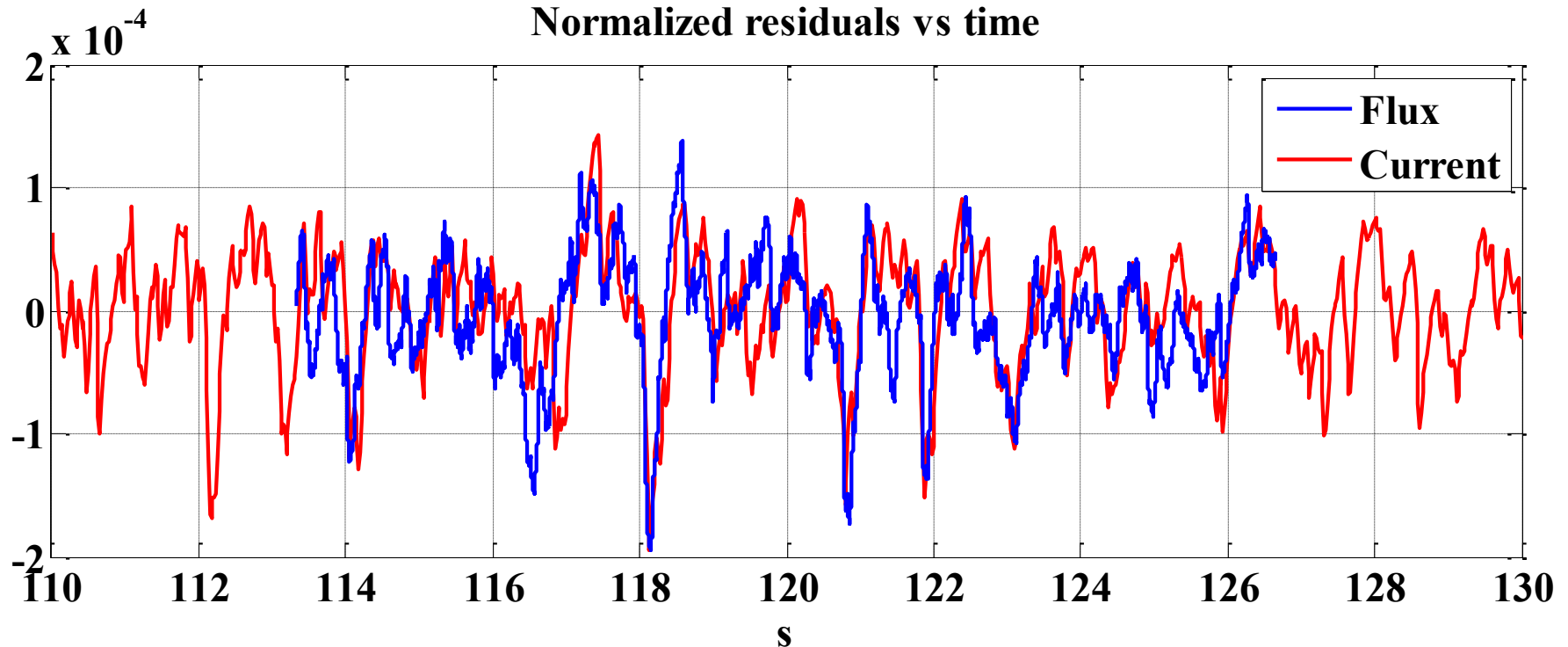
There is “noise” on the measured flux

- with amplitude $\sim 1 \times 10^{-4}$
- can be related to the flux jumps measured on the voltage



Comparison current and flux

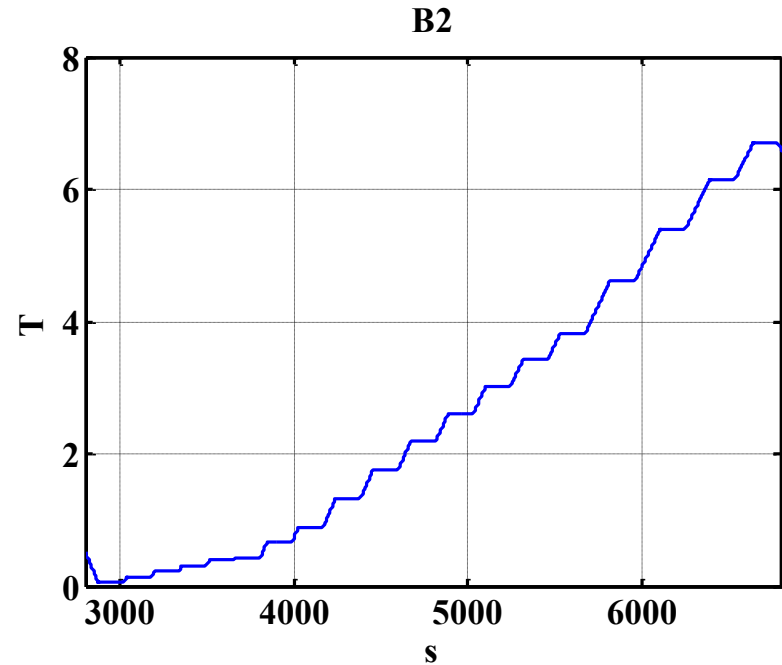
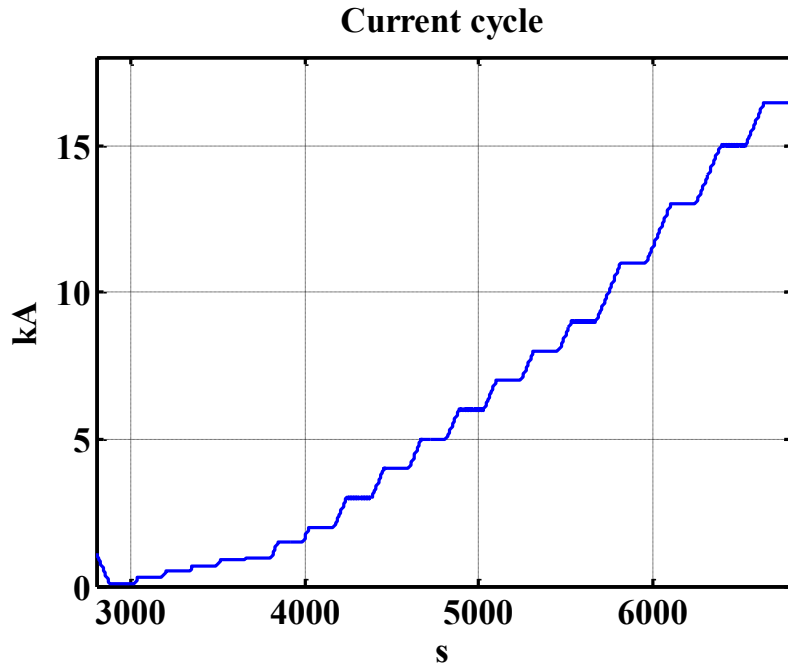
MQXFS3c



During ramps, in the field range where the flux jumps have maximum amplitude, we measure a “noise” with amplitude $\sim 1 \times 10^{-4}$ on both current and field.

Measurement with rotating coils

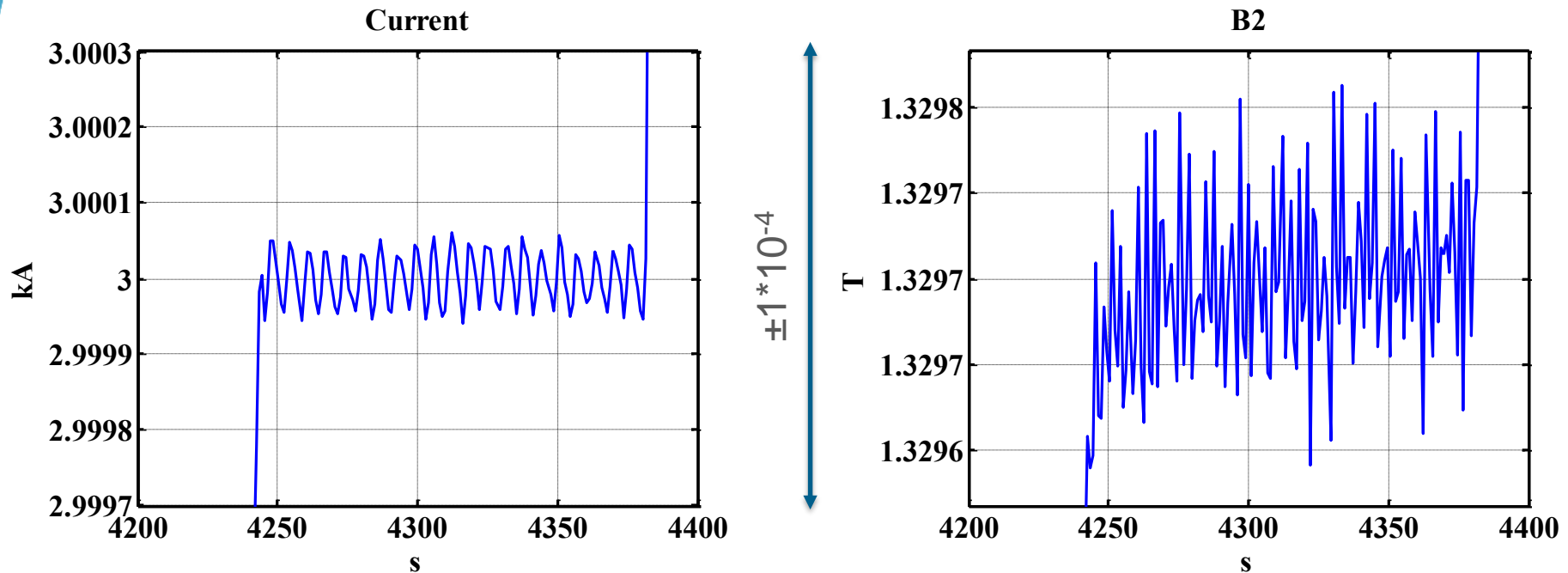
MQXFS5



- Sequence of ramps (at 15 A/s) and plateaus (120 s)
- Current measured at 1 Hz (down sampling of the reading at 50 Hz)
- Field measured at 1 Hz (rotation speed of the rotating coil)

Measurement with rotating coils

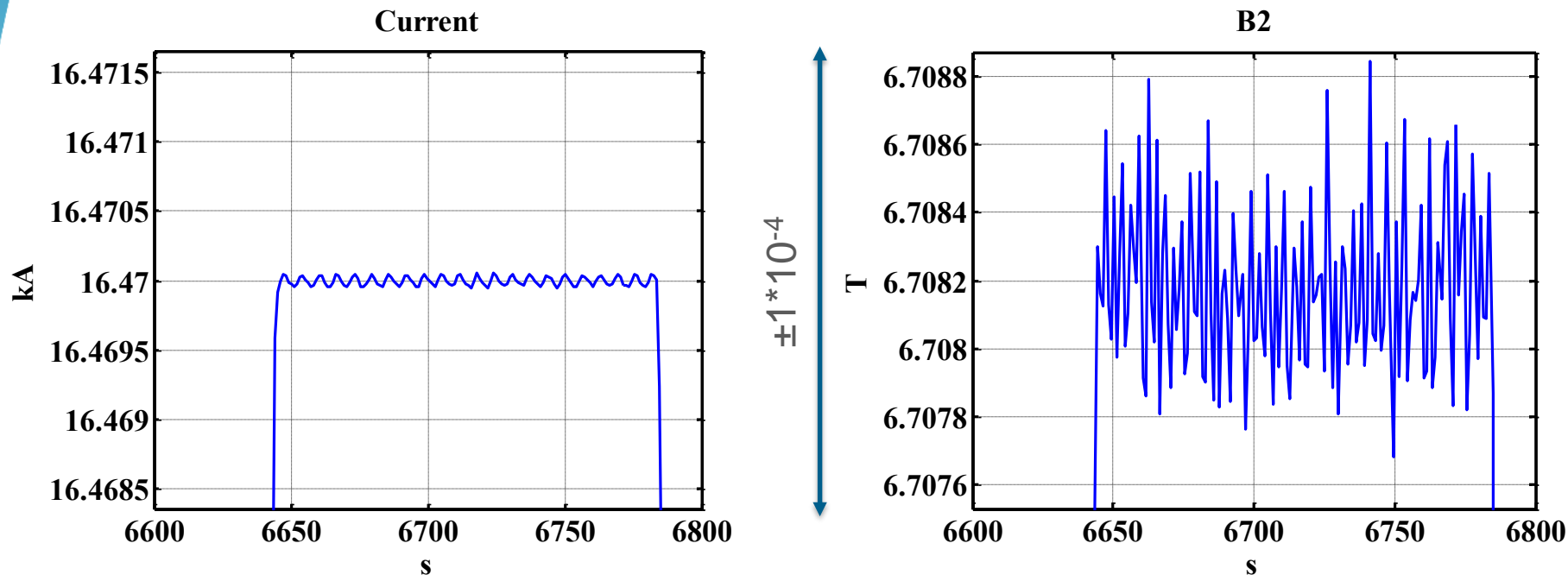
MQXFS5



During plateaus, at field levels in the range where the flux jumps have maximum amplitude, we see noise on the measured field with amplitude $< 1 \cdot 10^{-4}$ (limited by measurement precision).

Measurement with rotating coils

MQXFS5



During plateaus at nominal field, the noise on the field has amplitude $< 1 \times 10^{-4}$ (limited by measurement precision).

Conclusions

- Flux jumps are visible on the (differential) voltage of all Nb₃Sn magnets tested to date at CERN
 - Still little experience on “long” magnets
- It seems that the current could be affected
 - This must be checked in respect of
 - control loop of the converter
 - inductance of the circuit
 - To date we have observed effects $\sim 1 \cdot 10^{-4}$ during ramps
- When current is affected a proportional effect is visible on the field
- No effects during plateaus