MQXFS
Impact of Flux Jumps

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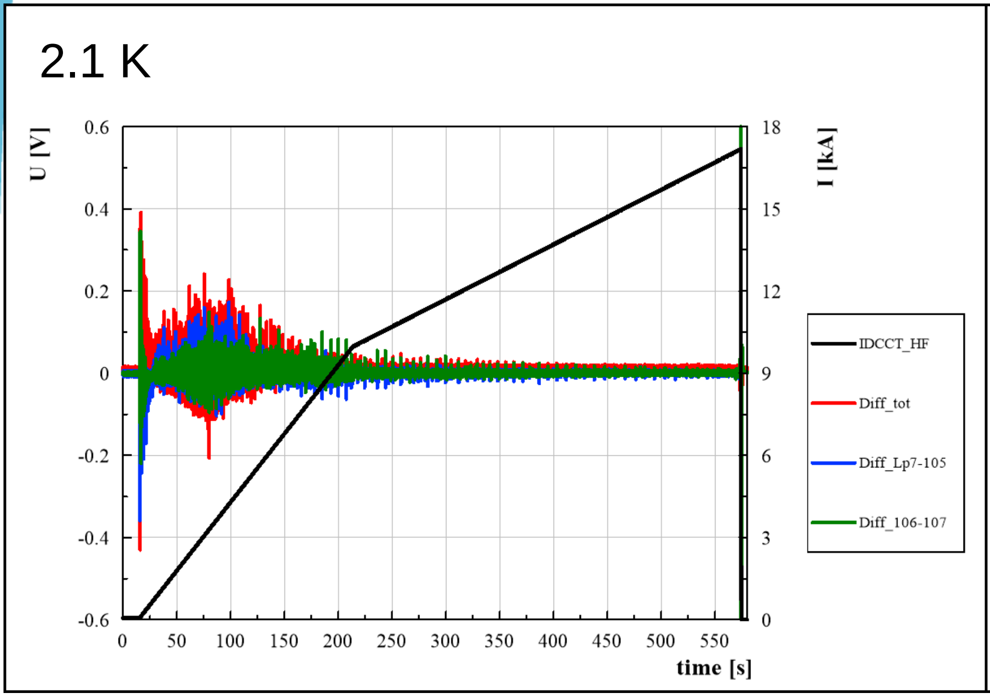
Introduction

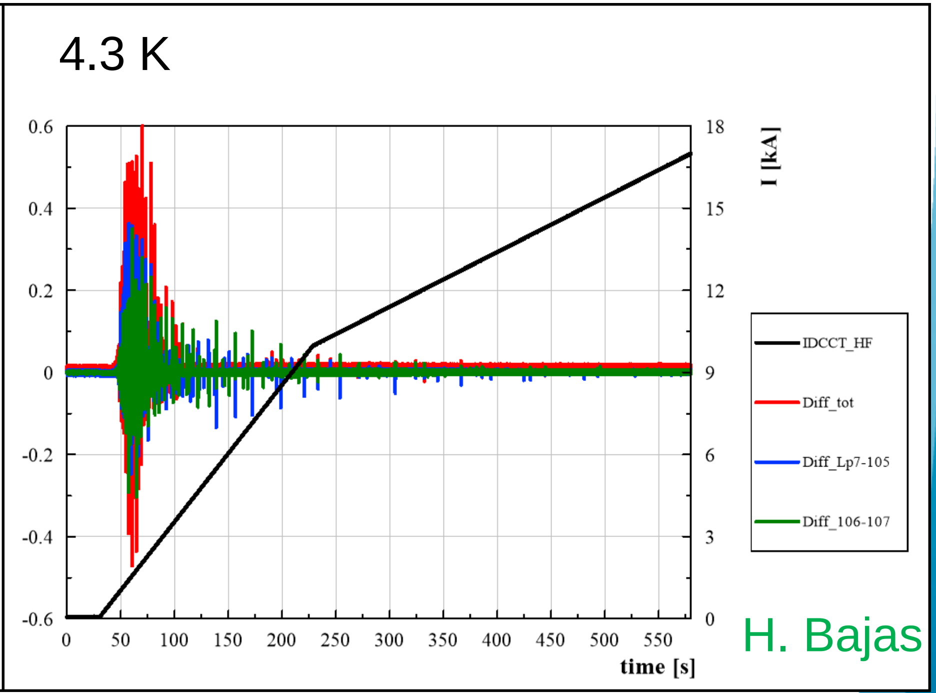
- In Nb_3Sn, **voltage spikes** at low field are typically observed due to the **flux jumps** on the superconductor.
- This is critical for the quench detection system, requiring the use of a **threshold voltage/validation delay** which is **a function of the magnet current.**

Is there something to worry in terms of transfer function (and field quality)?

Introduction

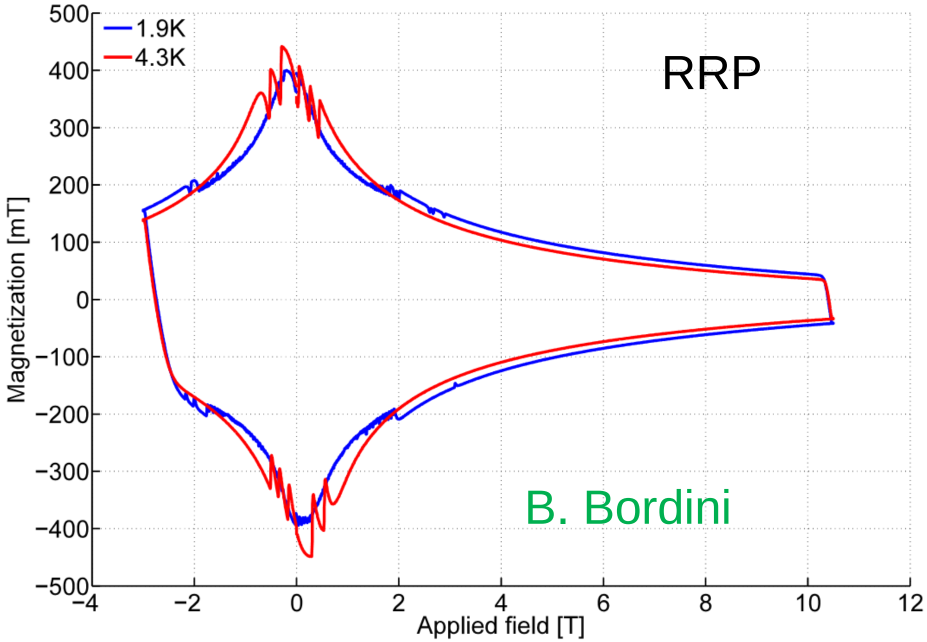
- Observations on the voltages: large voltage spikes that would trigger the detection system (nominal: 100 mV, 10 ms validation)
- At 1.9 K, more flux jumps with smaller amplitude
- At 4.3 K, fewer flux jumps but with larger amplitude

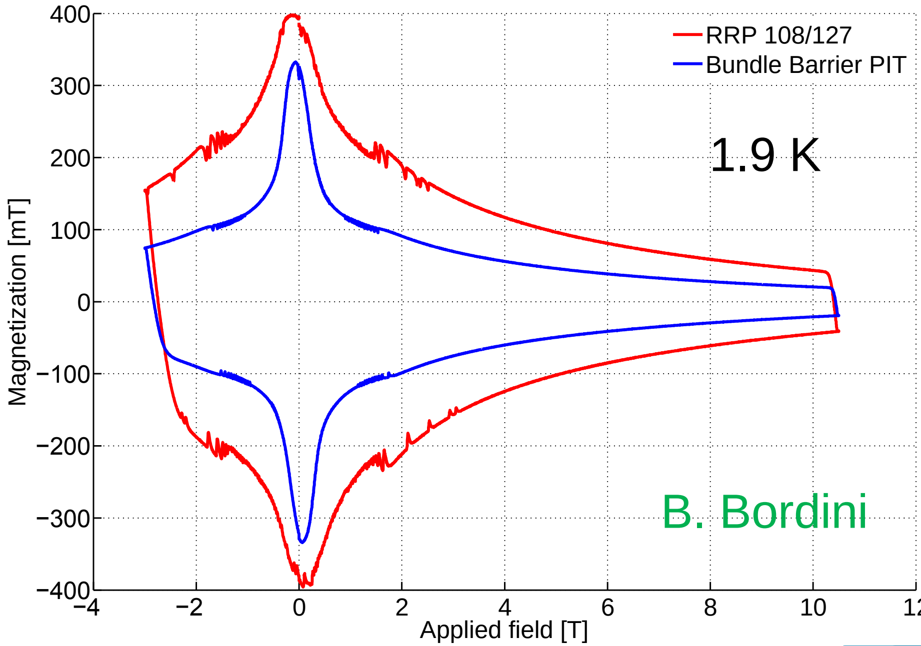




Introduction

- Effects of flux jumps are also visible on strand magnetization measurement, consistent with the observations on the magnets (larger amplitude @ 4.3 K but less frequent)
- Effects of flux jumps are also different depending on the type of conductor (PIT or RRP): Less flux jumps are expected for PIT conductor
  - MQXFS5 measurements will be done to characterize flux jumps effects on a magnet produced using PIT technology.



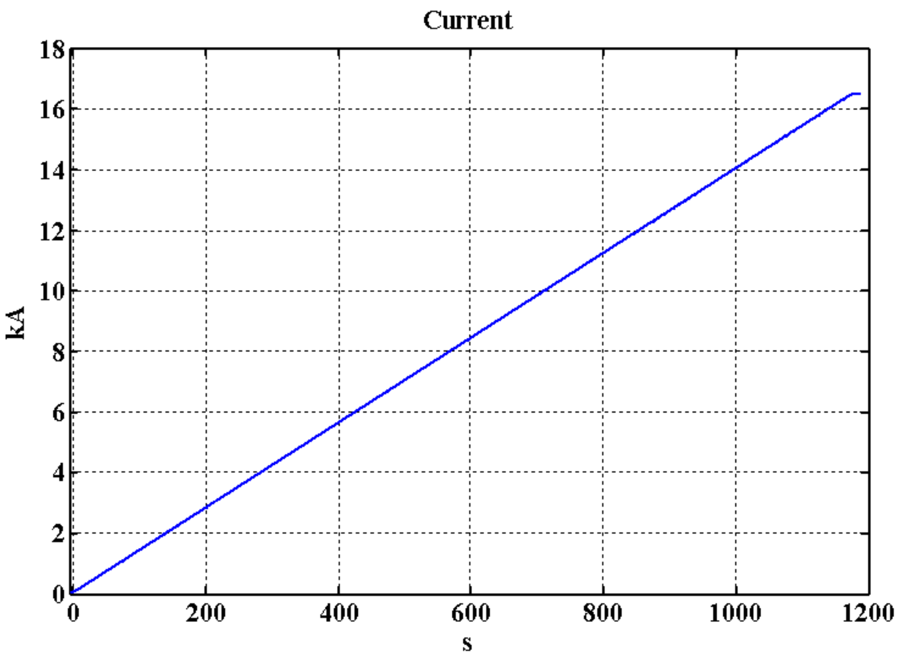


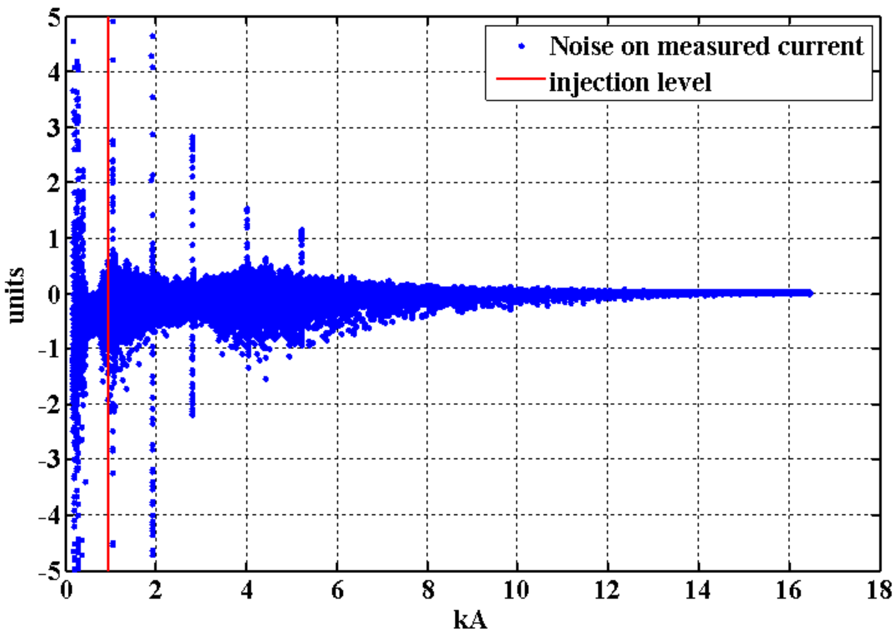
MQXF review: https://indico.cern.ch/event/524804/

MQXFS3 – Flux jumps effects on the current

- Linear ramp from 100 A to 16470 A with a ramp rate of 14 A/s (ramp up of a pre-cycle), for a cycle at 2.1 K
- Sampling rate: 50 Hz
- Difference of the measured current and a perfect linear ramp ±1 unit
- The effect is smaller than 1 unit below 6 kA, and smaller than 0.1 unit at 7 TeV
  - The larger spikes visible at 1 , 1.9 , 2.8, 4.0, and 5.2 kA should be related to an interference produced by thyristors present in the SM18 circuit.

L. Fiscarelli





MQXFS3 – Impact on transfer function

- The impact of flux jumps on the transfer function is within the measurements noise, both at 1.9 K and 4.3 K

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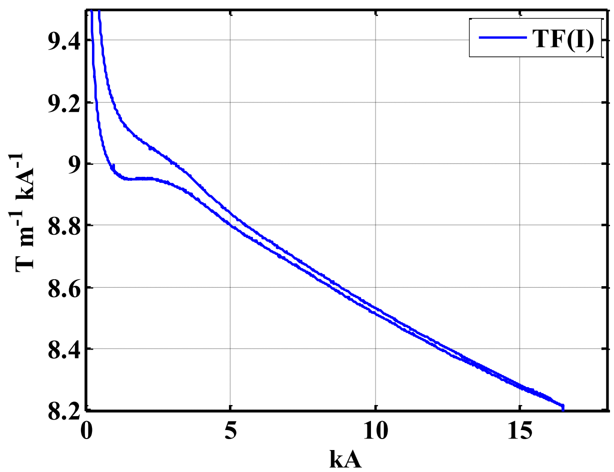
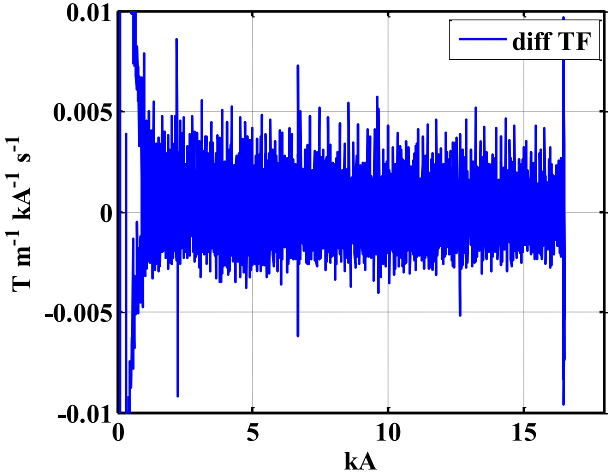
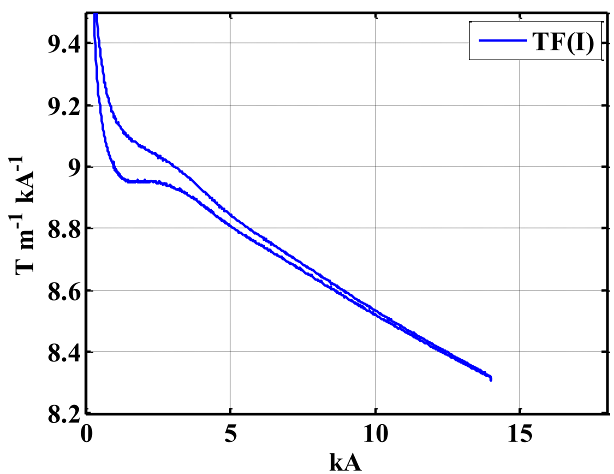
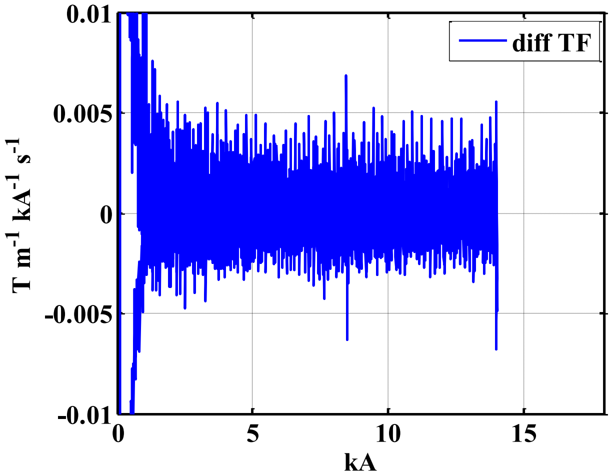
1.9 K





4.3 K





MQXFS3 – Impact on b_6

- Visible effect, but small, in b_6
- The measurements are consistent with the evidences we see in the voltage signals and strand magnetization measurements:
  - At 1.9 K, more flux jump with smaller amplitude
  - At 4.3 K, fewer flux jumps but with larger amplitude

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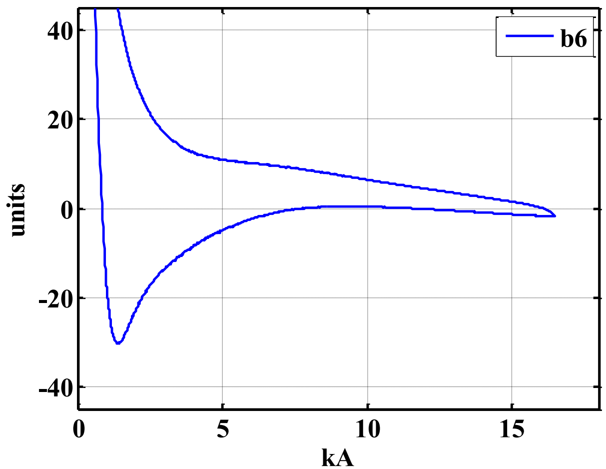
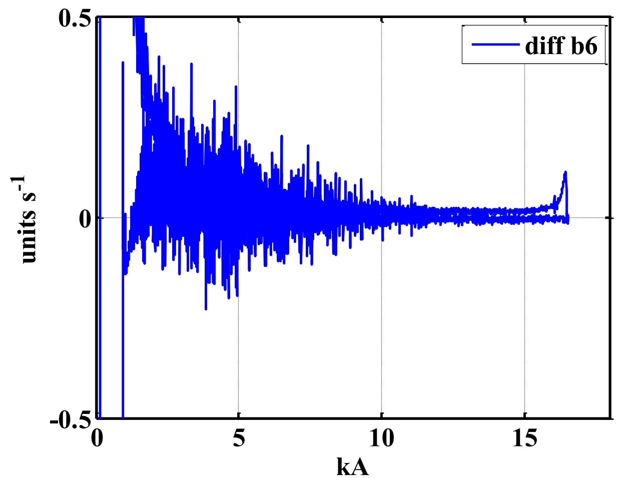
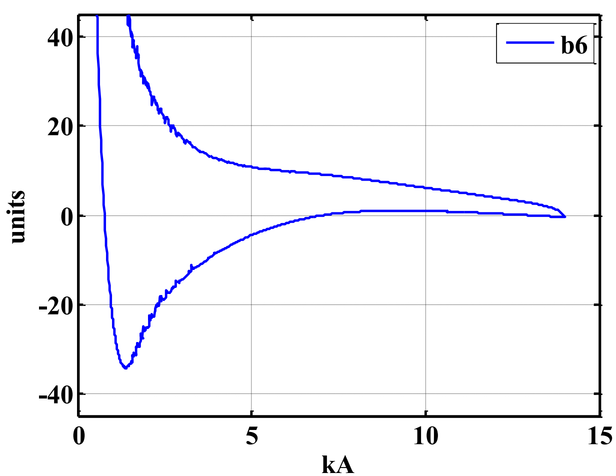
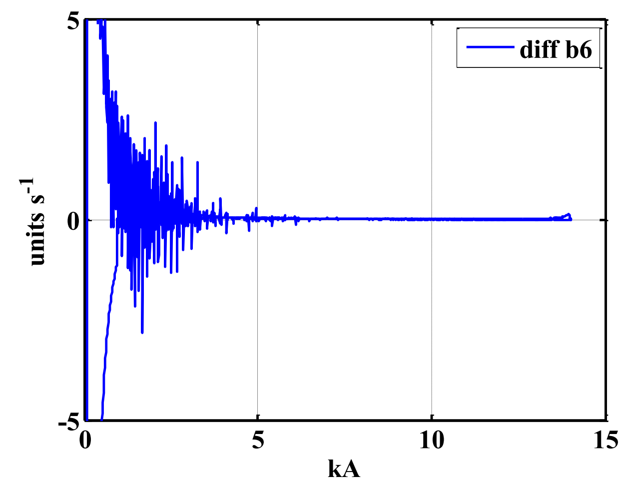
1.9 K





4.3 K





Measurement on upcoming magnets

- Short models (measurements on He bath)
  - Rotating coils: High accuracy for the harmonics, low bandwidth (1 Hz)
  - Fixed coils (same shaft as the one using for rotating coil measurements): Lower accuracy for the harmonics, high bandwidth (1-5 kHz)
  - Hall probe: not clear what we will get. At 50 Hz should work, at higher frequency to be checked
- Prototype (anti-cryostat for magnetic measurements)
  - Hall probes
    - Try to use the sextupole head that was used in the LHC to measure decay and snapback with high bandwidth (to be verified)
  - NMR cannot be use for MQXF, but will be use for the 11 T
    - High precision on the main field (better than rotating coils) , low bandwidth (1 Hz)

Conclusions

- Flux jumps as observed in the tested MQXF short model (MQXFS3) do not affect significantly the quadrupole gradient and are no critical in terms of field quality.
  - For gradient: less than 1 unit around injection, less than 0.1 units at 7 TeV
- Systematic characterization of the flux jumps effects will be done on the different magnets to be tested.
- Measurements on the prototype will tell us how this effect scales with the magnet lengh.