Complementary measurements on the Main Dipole BHZ 31 for the Booster B-Train system

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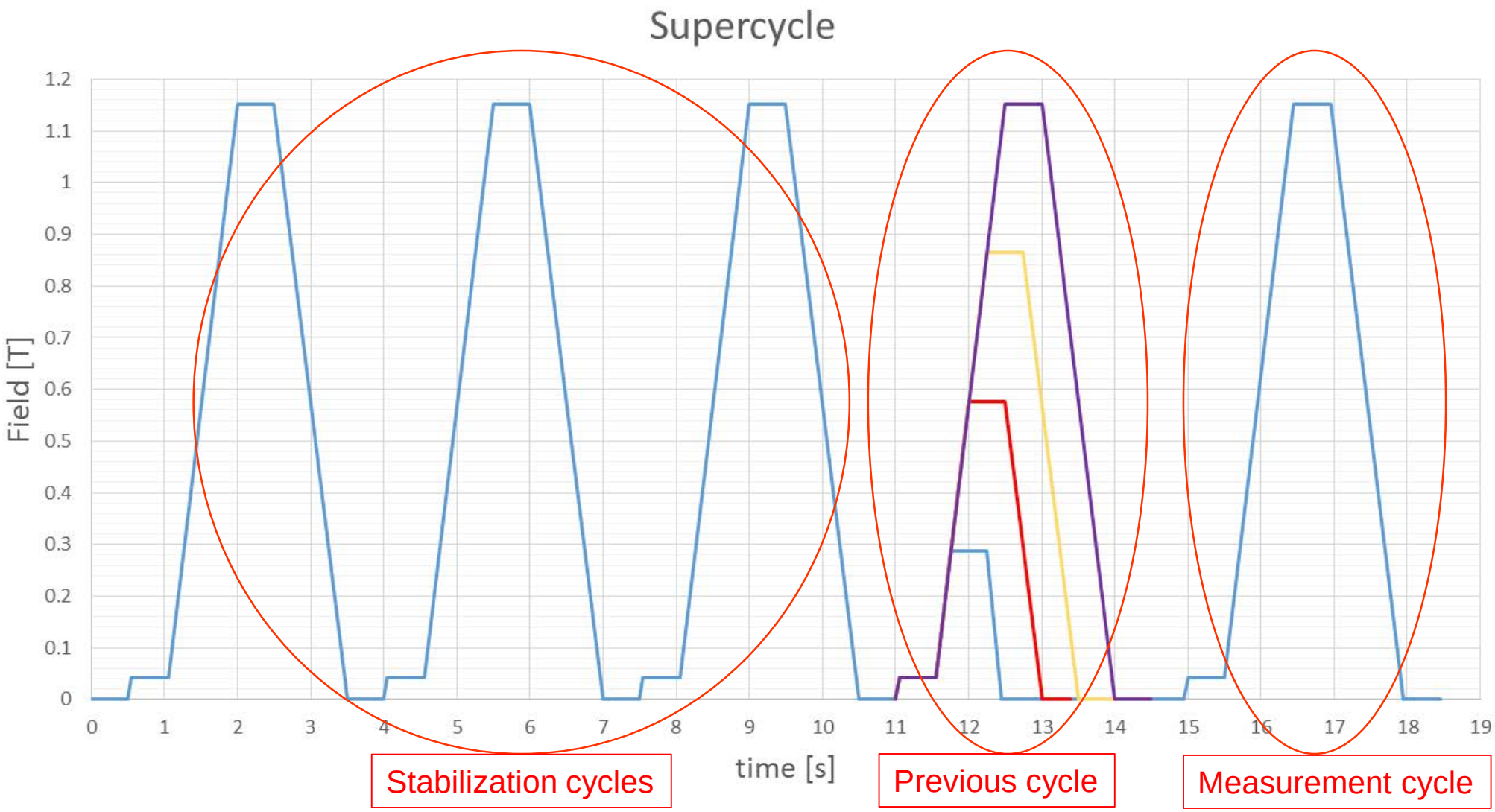
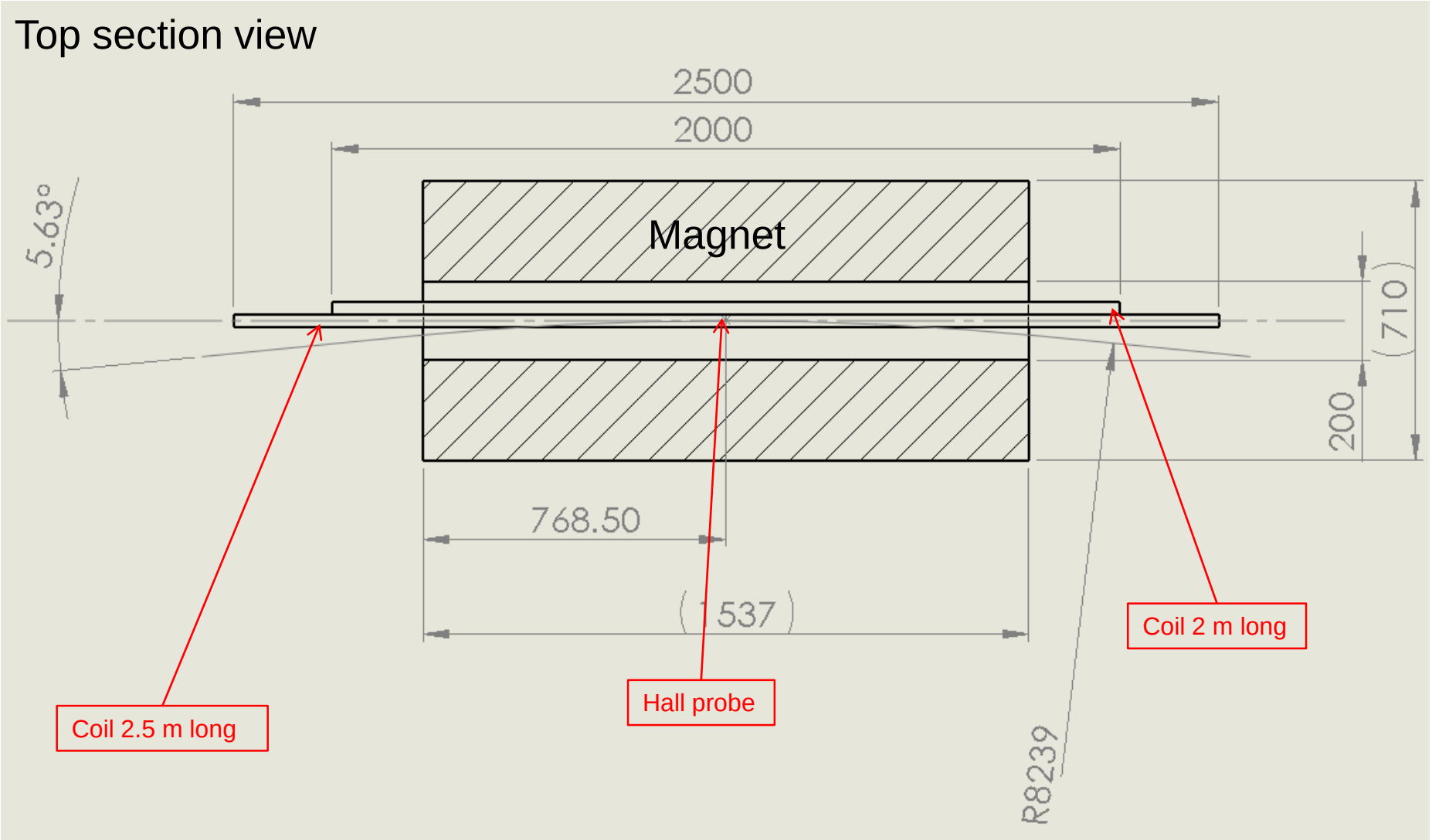
Bench overview

Supercycle


Supercycle
Field [T]
time [s]
Stabilization cycles
Previous cycle
Measurement cycle
Supercycle 1: SC#1
Supercycle 2: SC#2
Supercycle 3: SC#3
Supercycle 4: SC#4

Measurement equipment position (magnetic cycling effect + coil length)

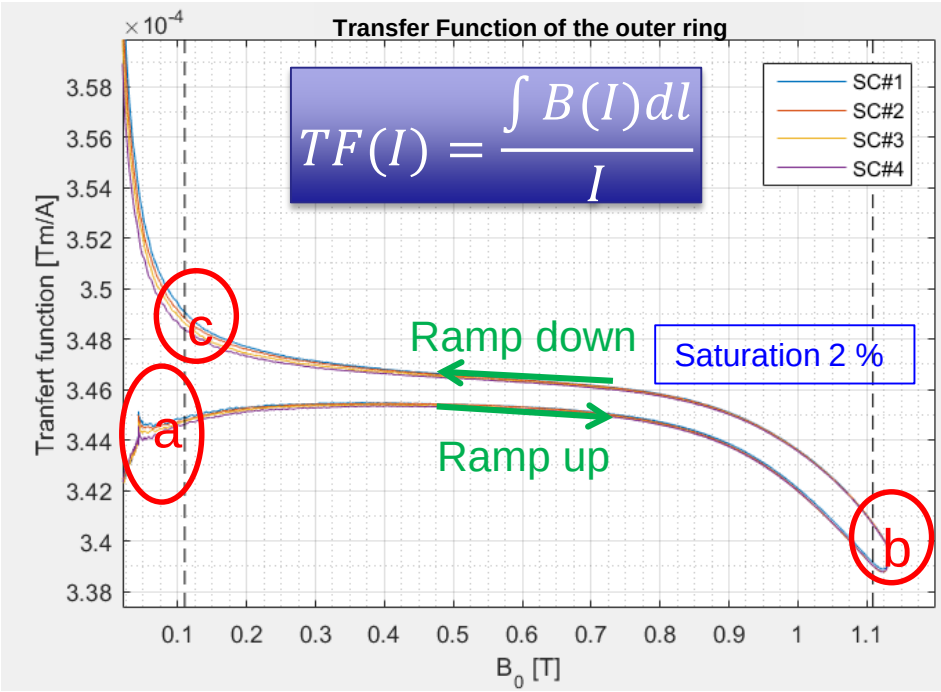
Top section view

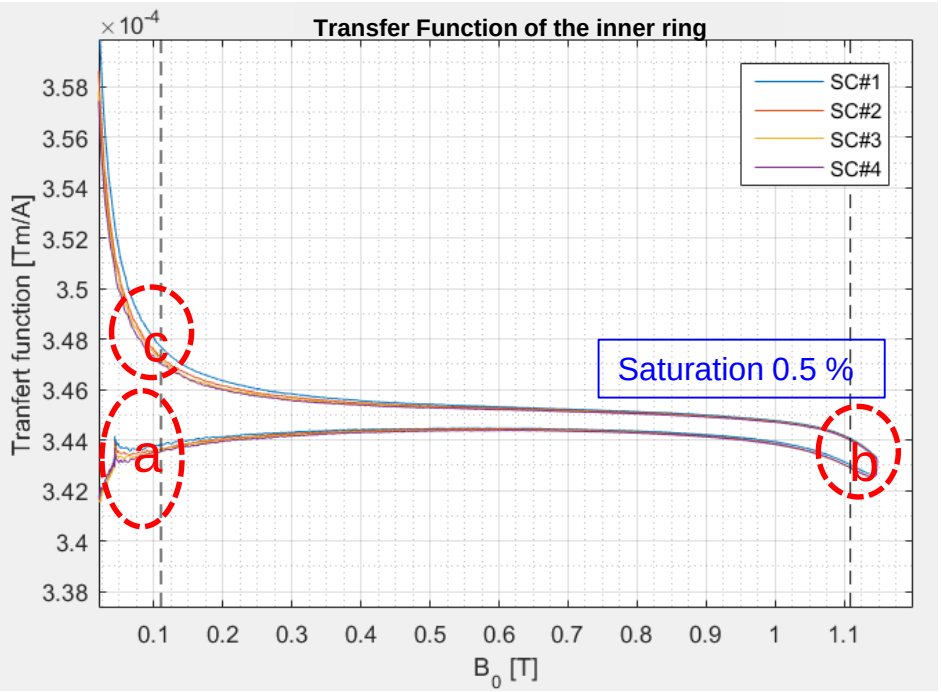


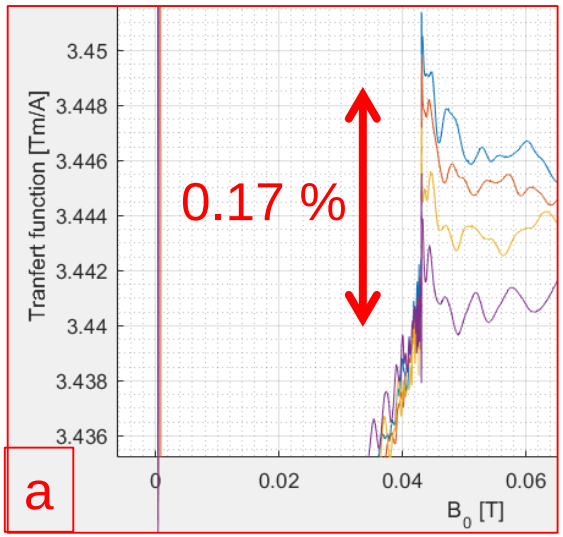
➔ Configuration #1 : 3 coils + 1 hall probe in the inner and outer ring

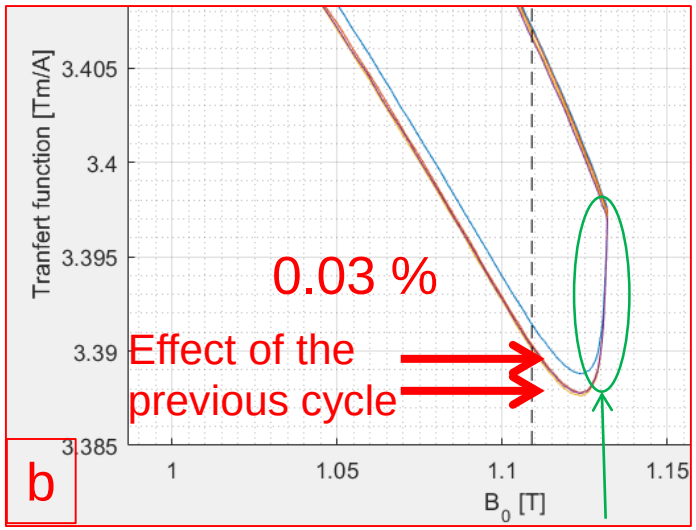
Study for the absolute field marker sensor

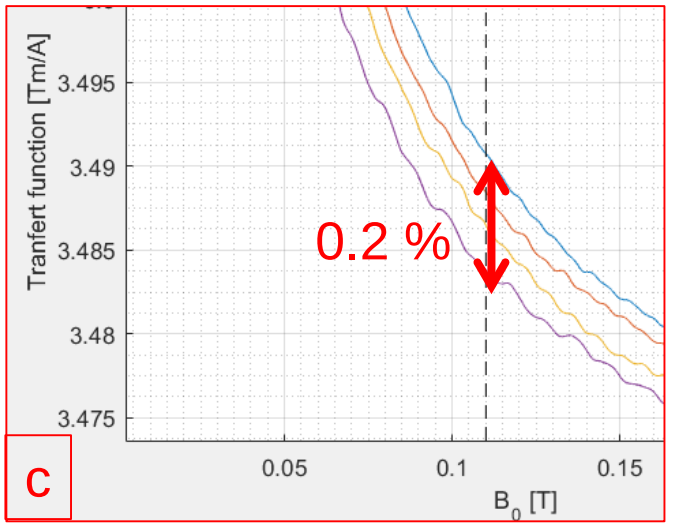
Effect of the magnetic history on the magnet Transfer Function (TF)







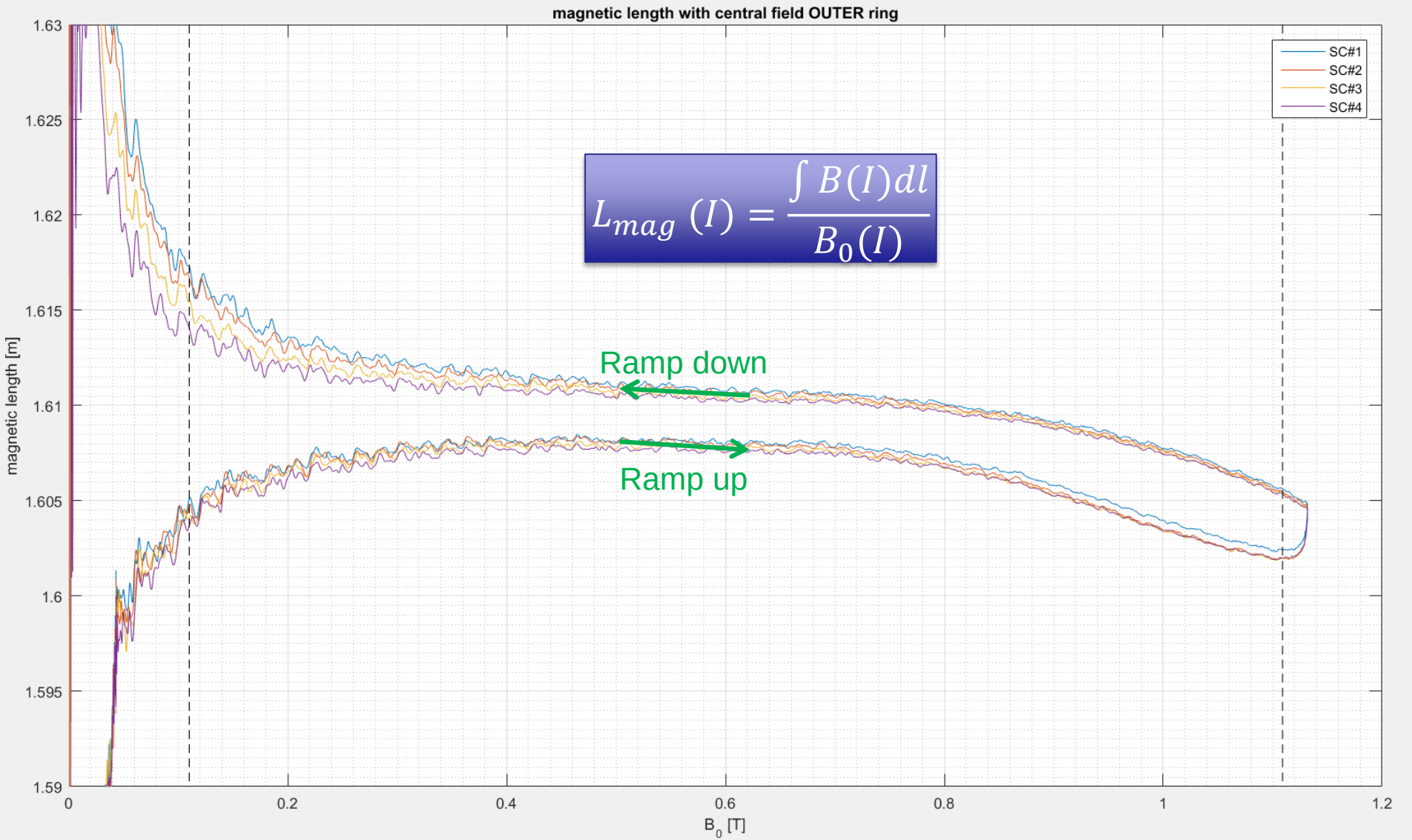




Eddy current decay

Magnetic length variation

➔ Similar effect on the magnetic length



Signal noisy due to the hall probe

Effect of the magnetic history on the magnet transfer function

➔ **Summary :**

- **Similar behaviour in the inner and outer aperture w.r.t of the magnetic history effect**

- **Effect of the magnetic history at low field**
  - **~0.2 %**

- **Effect of the magnetic history at high field**
  - **When the previous cycle goes in saturation:**

  0.03 %
  - **When the previous cycle is below saturation:**

  <0.005 %

➔ **The level of the absolute field marker has to be chosen in function of the stability and low error**

Marker proposal for the PSB- LIU

- For low field < ~0.1 T:
  - NMR (Nuclear Magnetic Resonance) probe
    - Same as the current B-train PSB marker
    - Metrological reference
    - Already available
    - Operates with dB/dt < 1.5 T/s

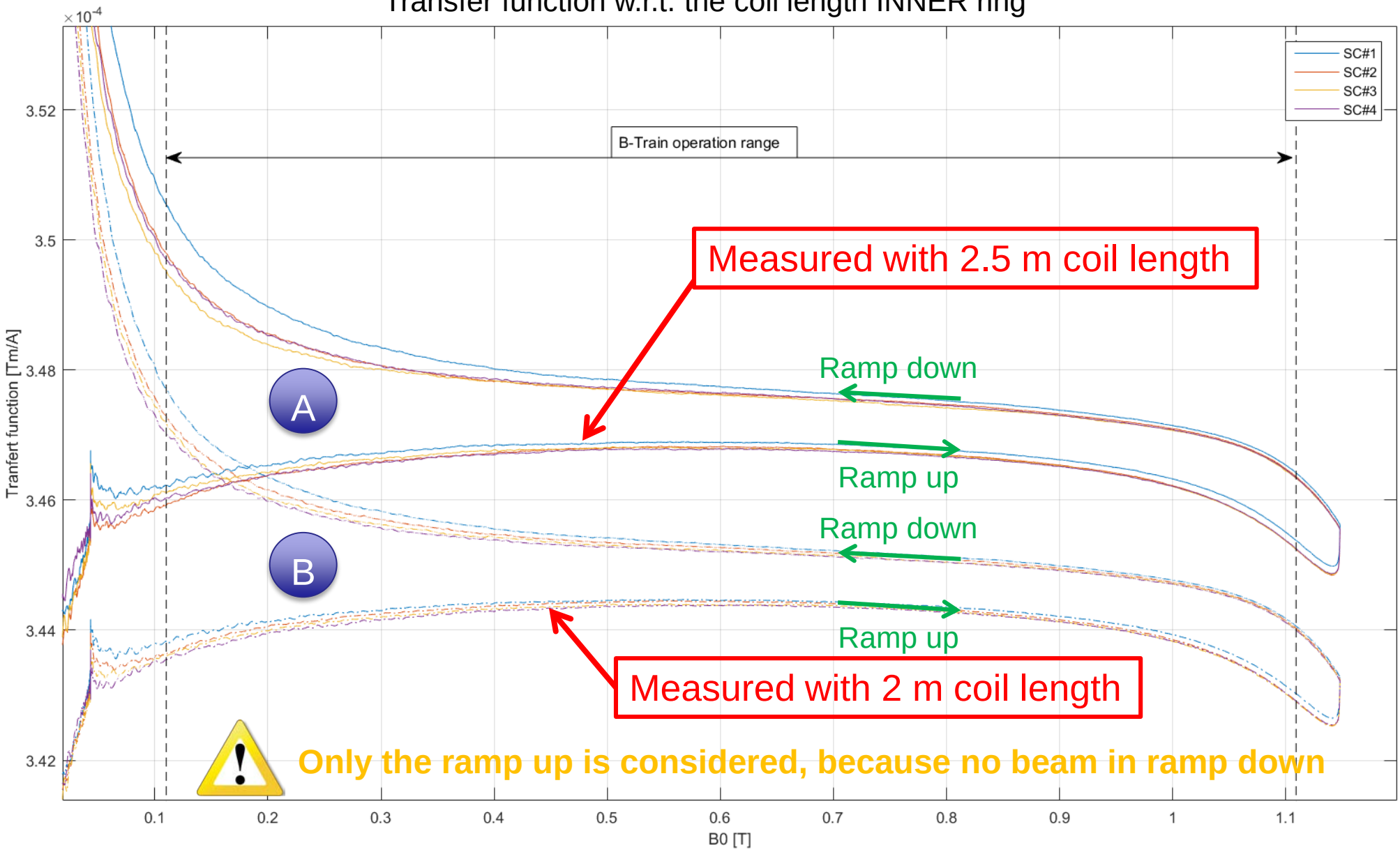
- For medium to high field > ~0.1 T :
  - FMR (Ferri Magnetic Resonance) probe
    - Under test for the PS B-Train
    - Operates with dB/dt > 1.5 T/s
    - To be produced for the PSB requirements

  - EPR (Electron Paramagnetic Resonance) probe
    - Under R&D

Study for the field tracking sensor

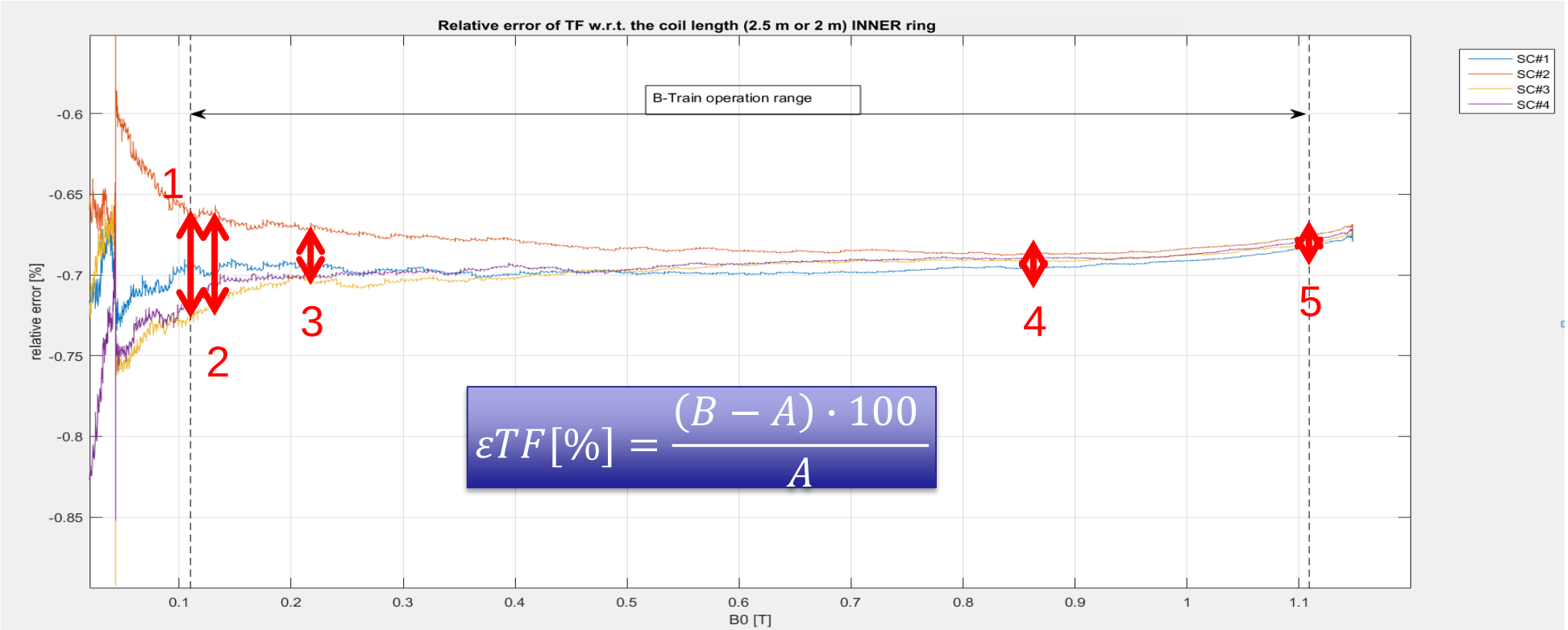
Measurement coil length effect

➔ **Error from the coil length on the TF : tested on the inner ring with coil with a 2.5 m or 2 m long**



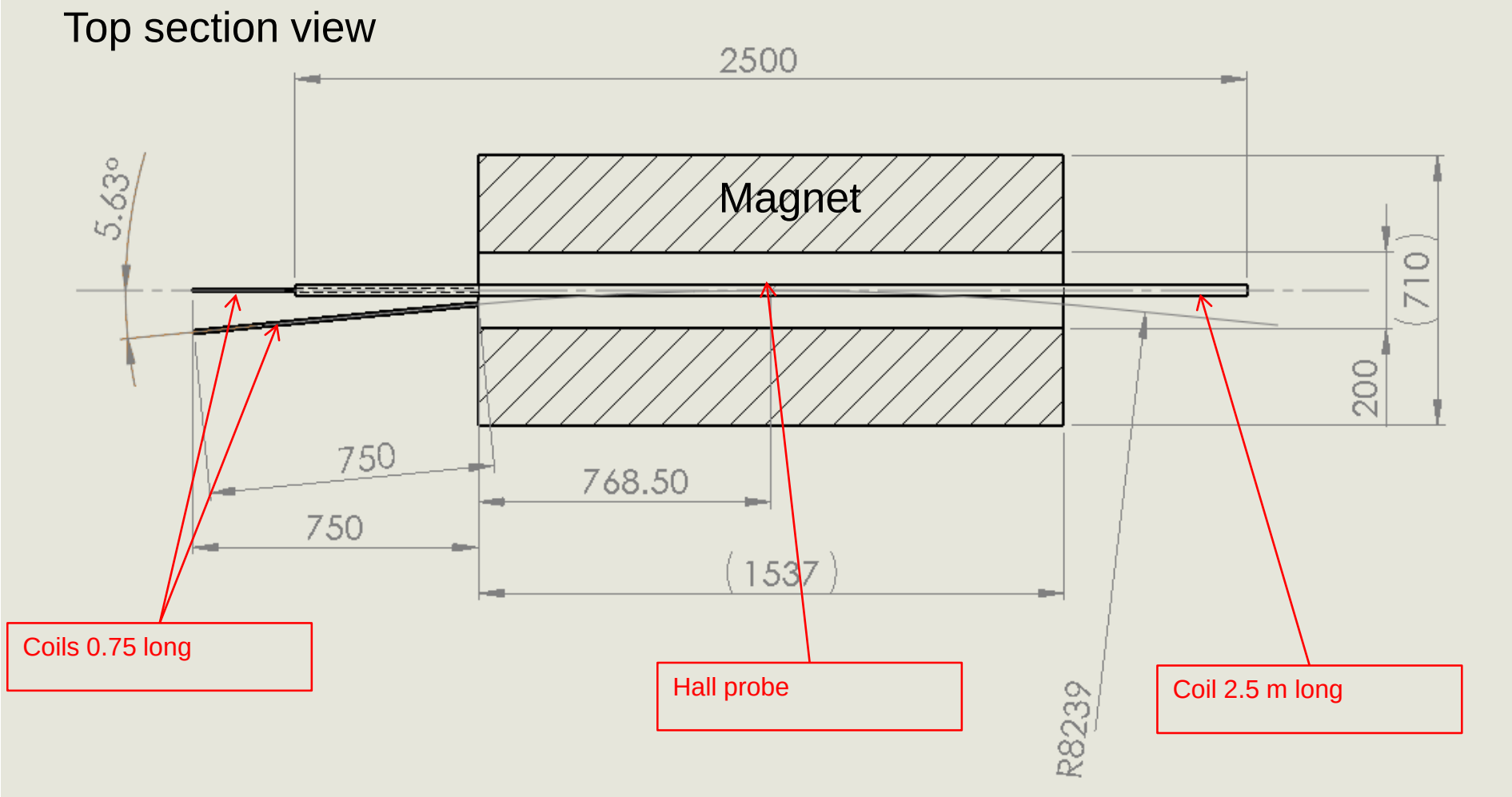
Measurement coil length effect

➔ **Relative error from the coil length on the TF : tested on the inner ring with coil with a 2.5 m or 2 m long**



		Scaling factor due to coil length 2.5 m versus 2 long	
		Magnetic field [T]	scaling factor error [%]
1	At current marker level	0.1108	**0.06**
2	At injection (50 MeV) Linac 2	0.1256	**0.06**
3	At injection (160 MeV)Linac 4	0.2311	**0.03**
4	At Extraction (1.4 GeV)	0.8671	**0.01**
5	At Extraction (2 GeV)	1.273	**<0.01**

Measurement equipment position (coil shape)



➔ Configuration #2 : 3 coils + 1 hall probe

Measurement coil shape

➔ **Error from the coil shape: straight vs curved trajectory on the integral**

field @ 0.11 T (field marker level) worth case	INNER ring			OUTER ring	
	Integral [Tm]	fringe field [Tm]	ratio fringe field vs integral	fringe field [Tm]	ratio fringe field vs integral
Z axis (straight coil)	0.17765	4.58E-03	2.58E-02	4.41E-03	2.48E-02
S axis (curved coil)		4.59E-03	2.58E-02	4.48E-03	2.52E-02
Error between straight and curved fluxmeter			**0.01 %**		**0.04 %**

➔ Summary :

- Coil length error between 2.5 m vs 2 m
  - 0.06 %

  ➔ Coils length under discussion due to Printed Circuit Board (PCB) standard manufacturing up to 2.2 m

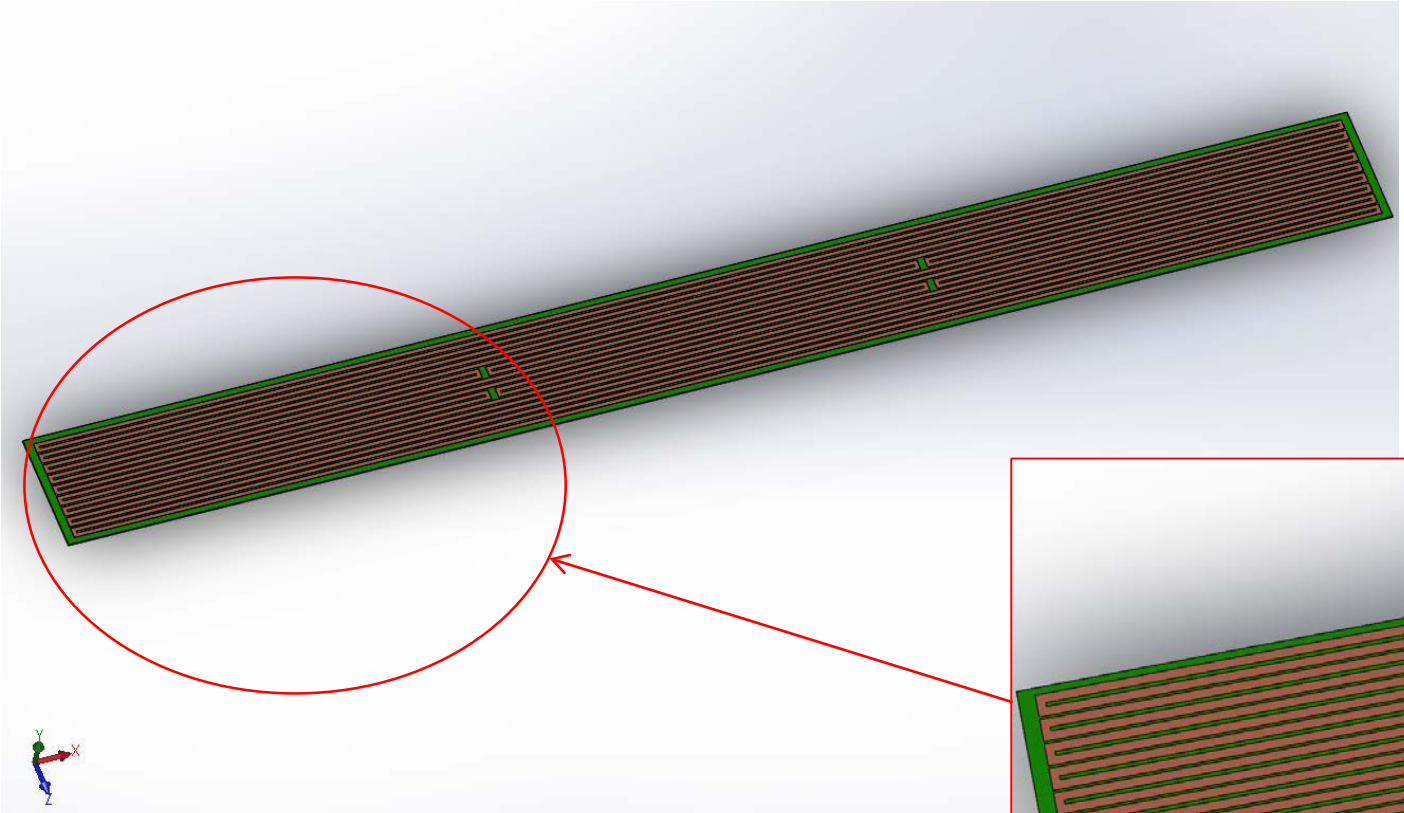
  ➔ For an extension to 2.5 m wired coils has to be used

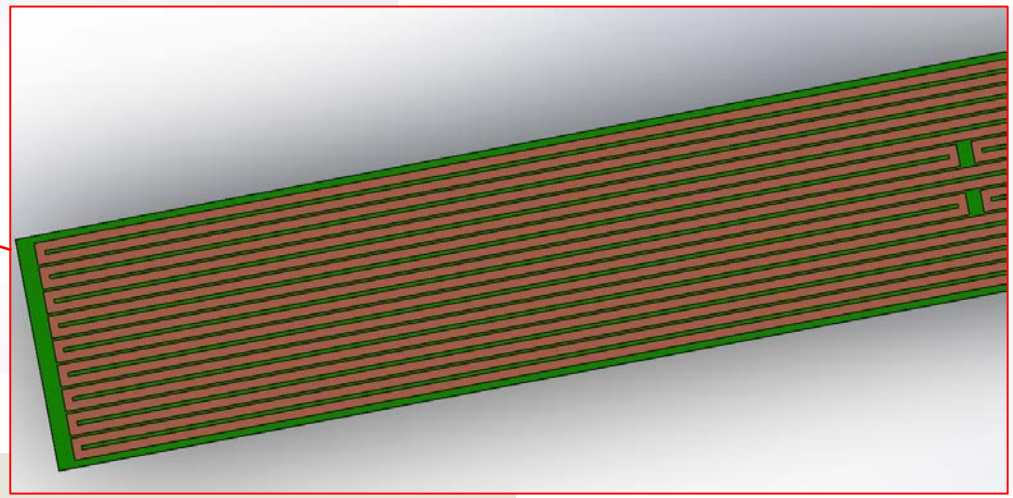
- Coil shape error between straight vs curved
  - 0.04 %

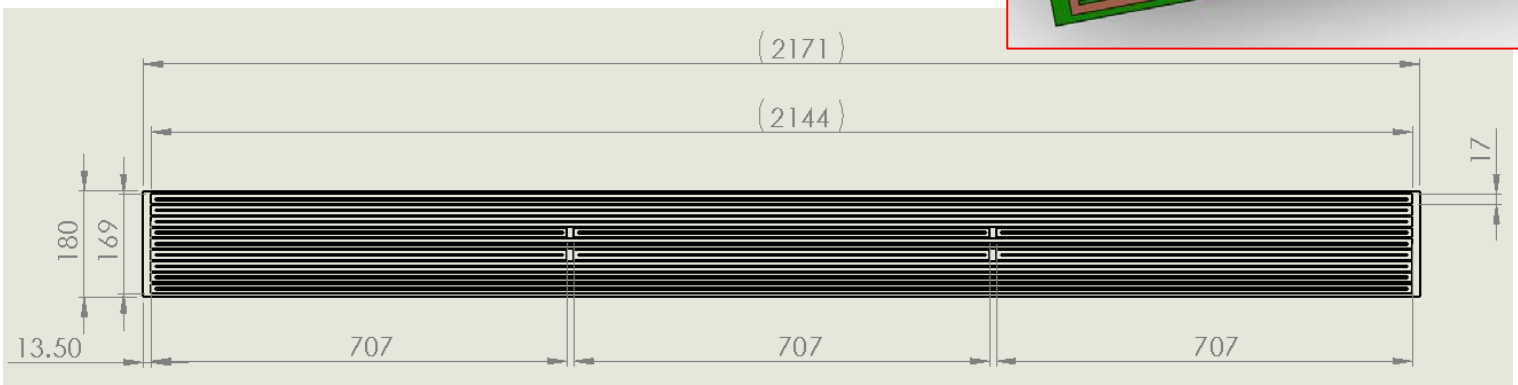
  ➔ Straight coils can be used to reduce the complexity of the manufacturing

Coil proposal :PCB fluxmeter

- Array of straight coils
- 7 long coils (2.14 m t.b.c.)
- 6 short coils (0.7 m)
- 17 mm wide
- 36 turns







Conclusion

- The effect of the magnetic history is 0.2 % on the integrated field
- The coil length of 2 m impact the integrated field measurement by minimum 0.06 %
- The measurement error of the integrated field on a curved trajectory or on a straight line is 0.04 %
- For the B-train system the inner and outer rings will be equipped with measurement sensors (markers and pickup coils)
- The field markers will be done by NMR and/or FMR probes
- The field tracking measurement will be done by straight coils array
  - in PCB for ~2.2 m long
  - in standard coil winding technique for 2.5 m long

Thank you for your attention