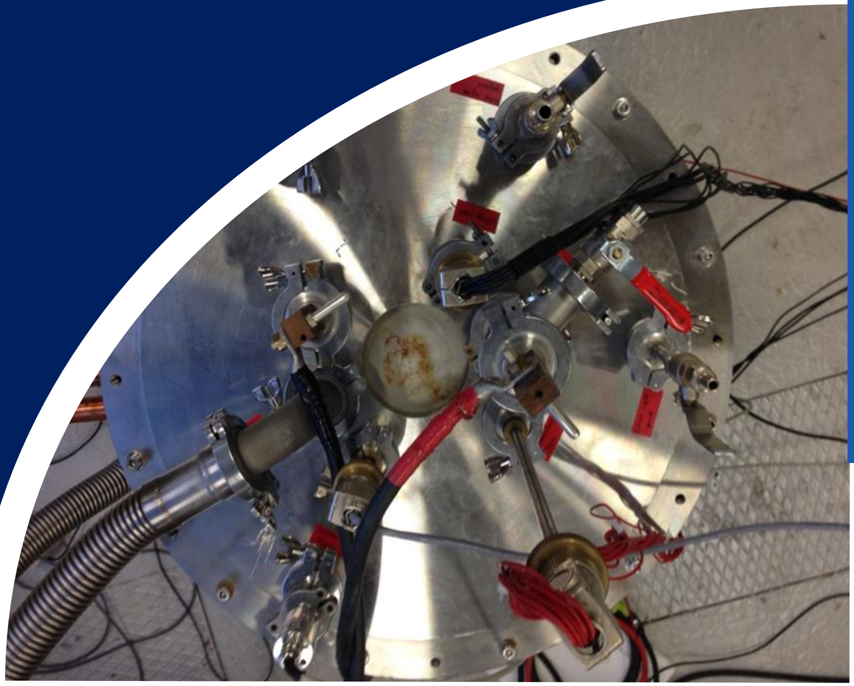

Current redistribution in the surrounding of a defect during an inhomogeneous quench on a 2G HTS tape

14th July 2022

A. Zampa, P. Tixador and A. Badel

OUTLINE

1. Context
2. Experimental observations of inhomogeneous quenches
3. Influence of local inhomogeneities in the REBCO layer
4. Current redistribution around a dissipative zone
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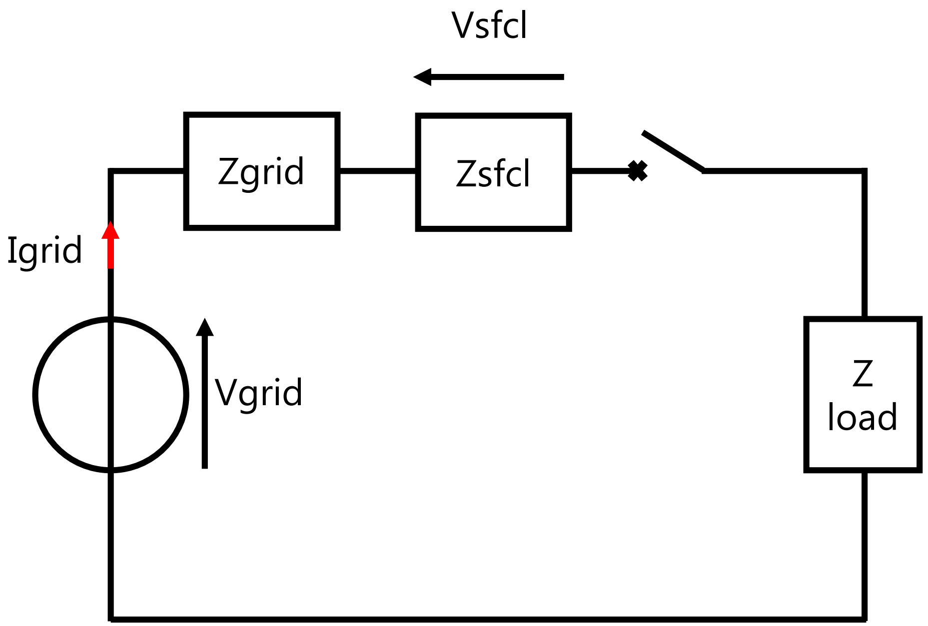
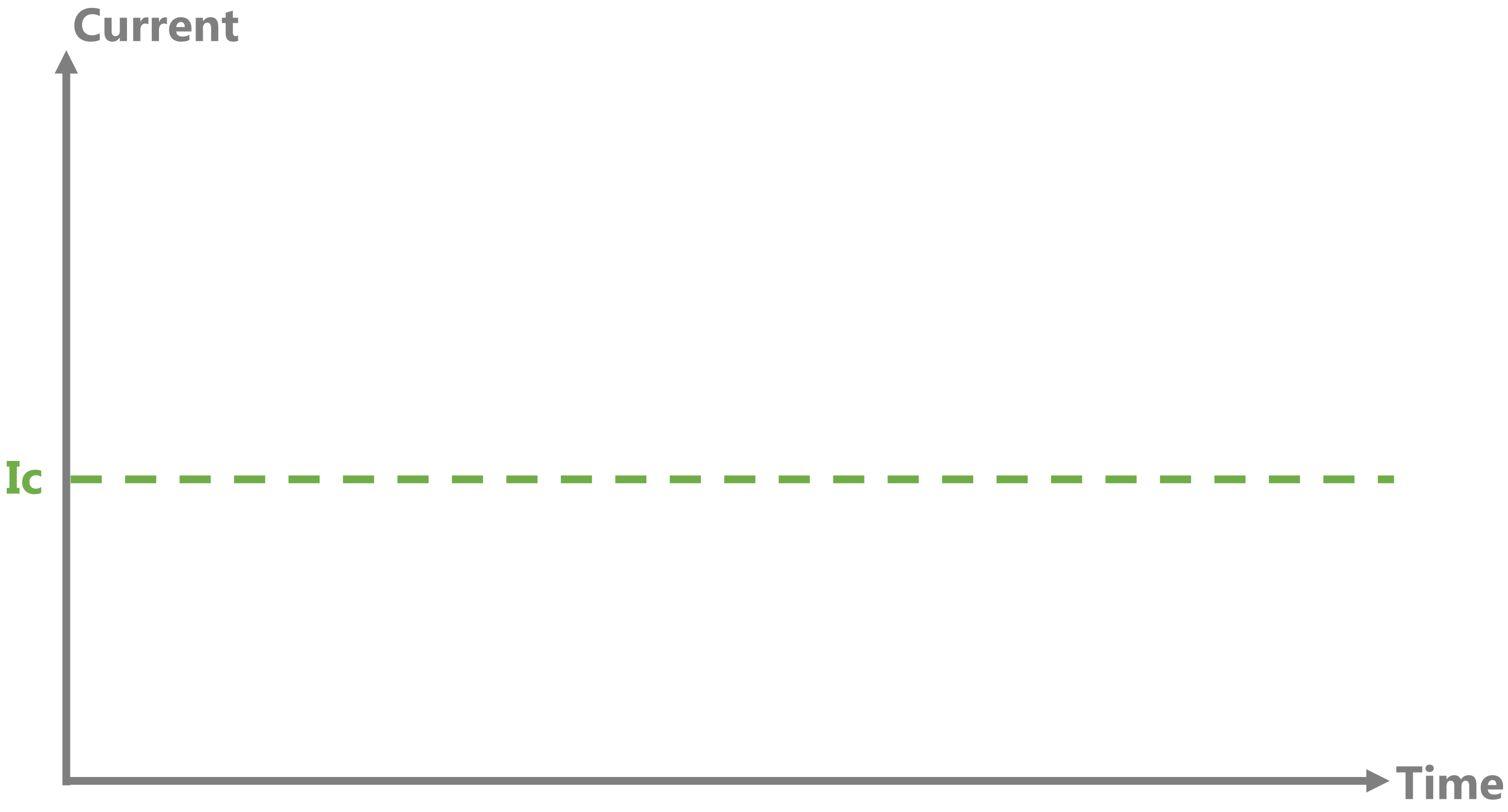
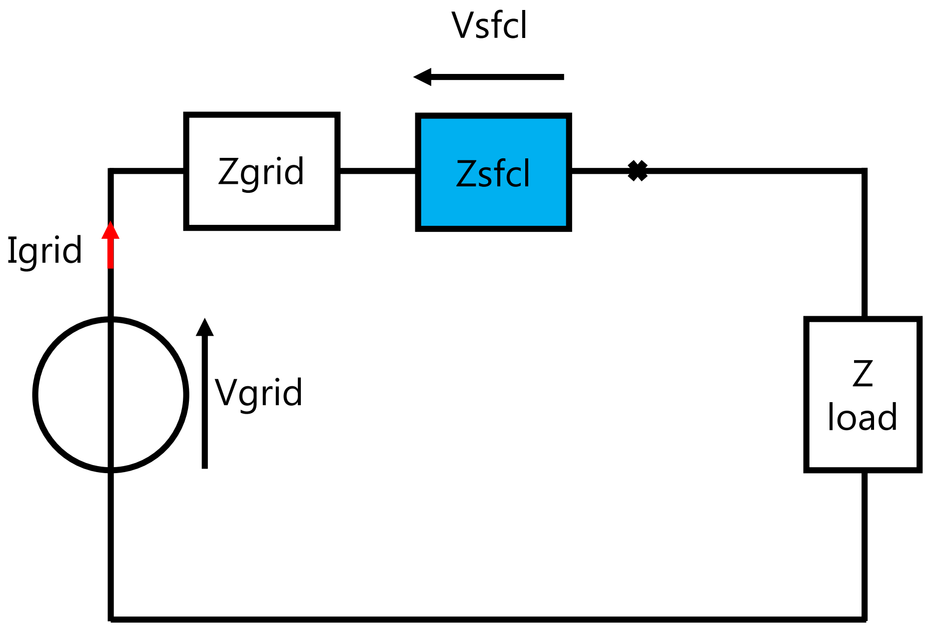
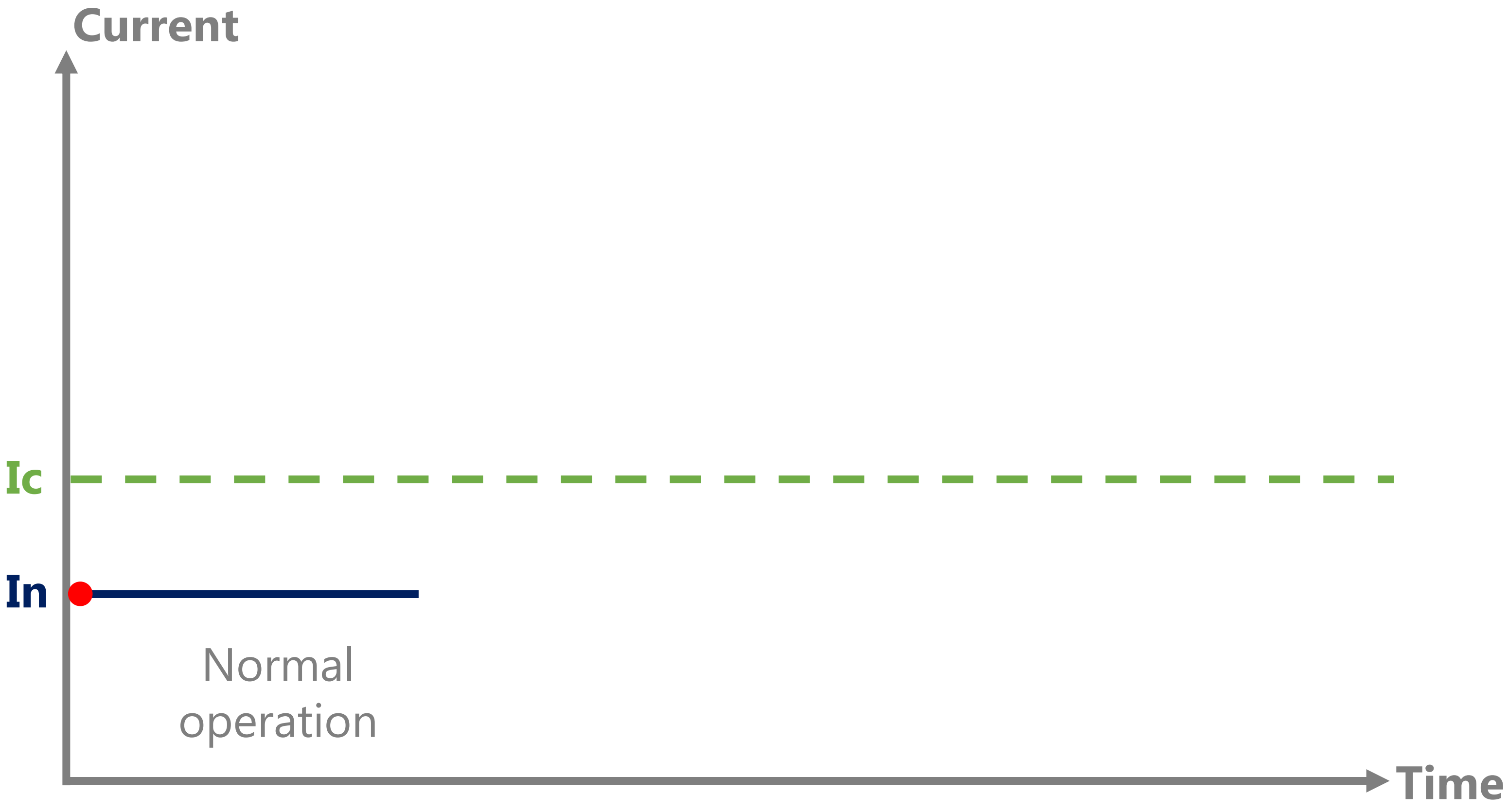
OPERATION OF A R-SFCL



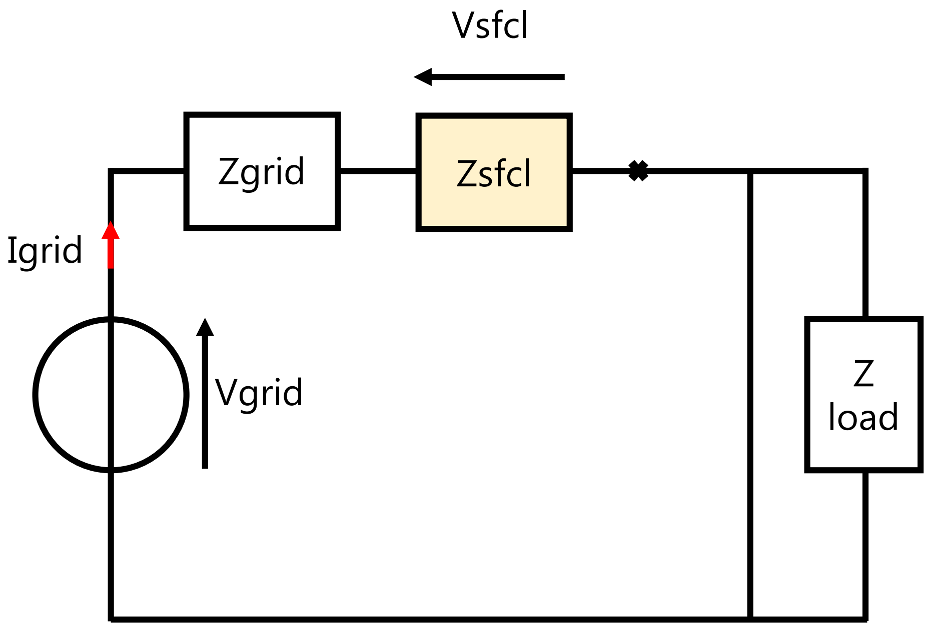


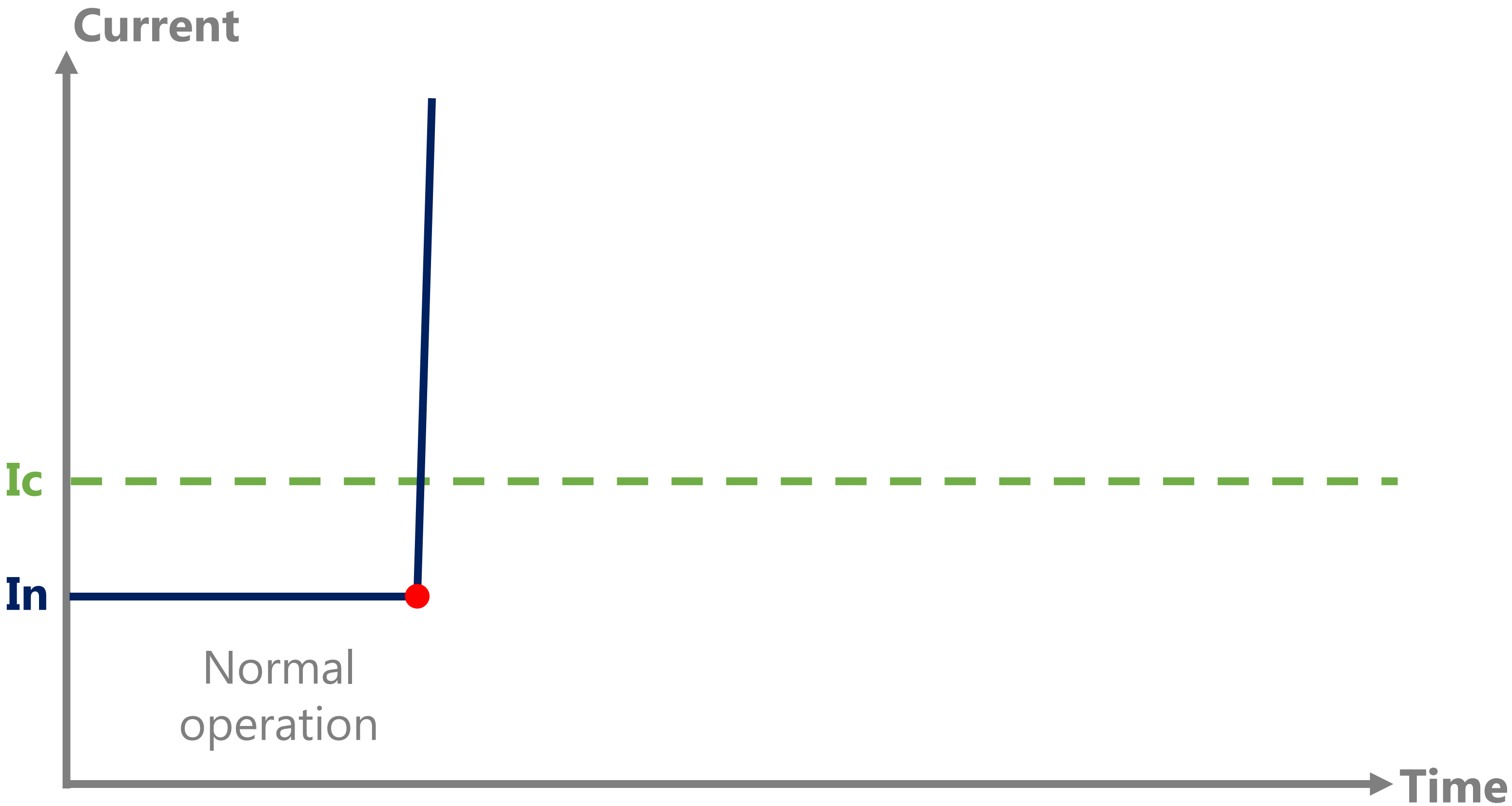
OPERATION OF A R-SFCL



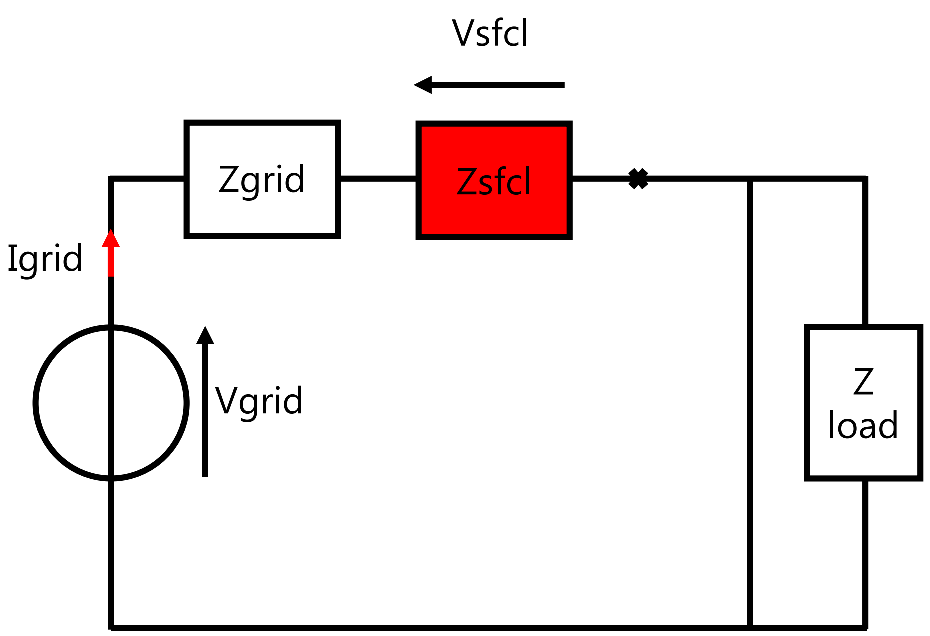


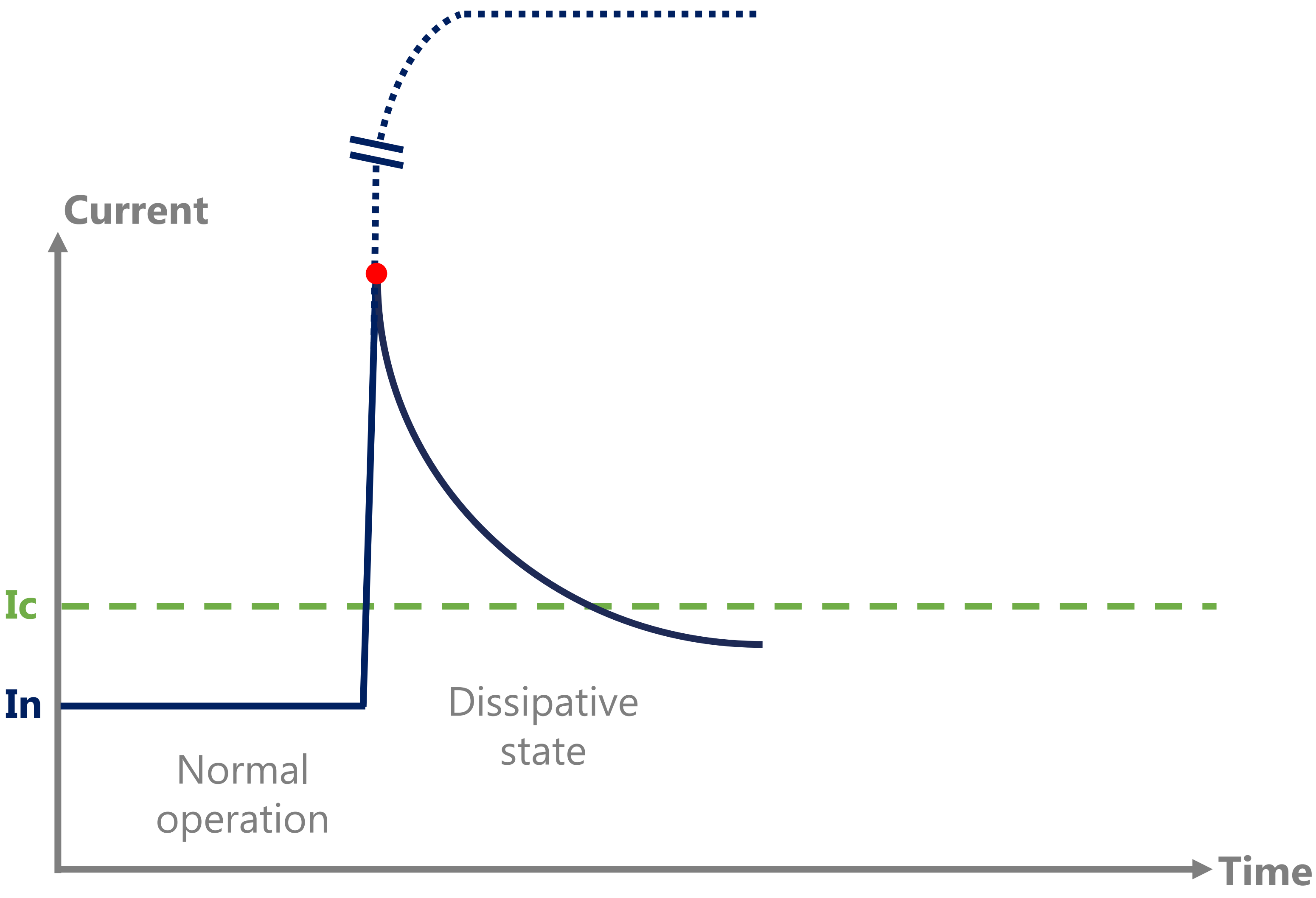
OPERATION OF A R-SFCL



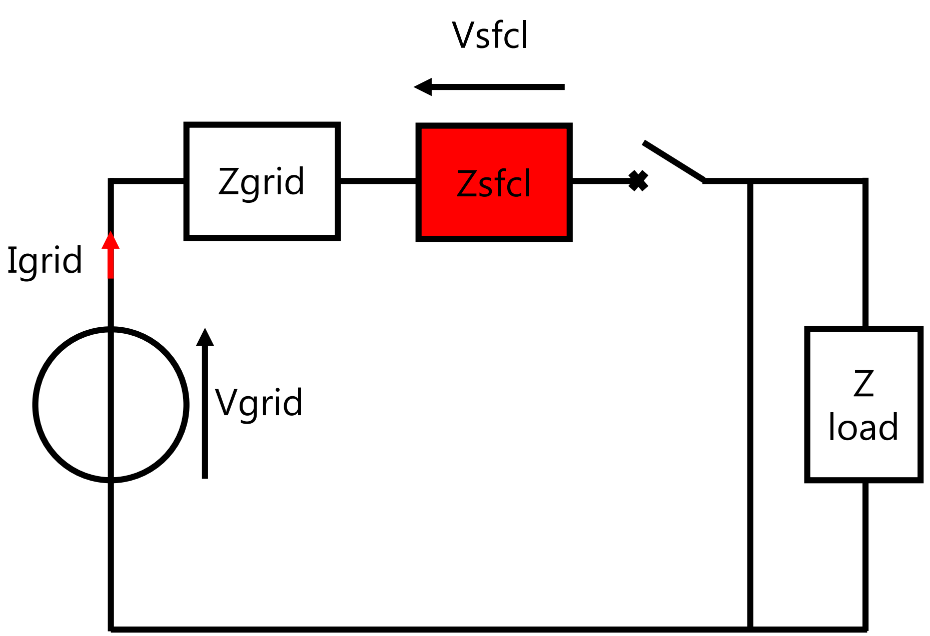


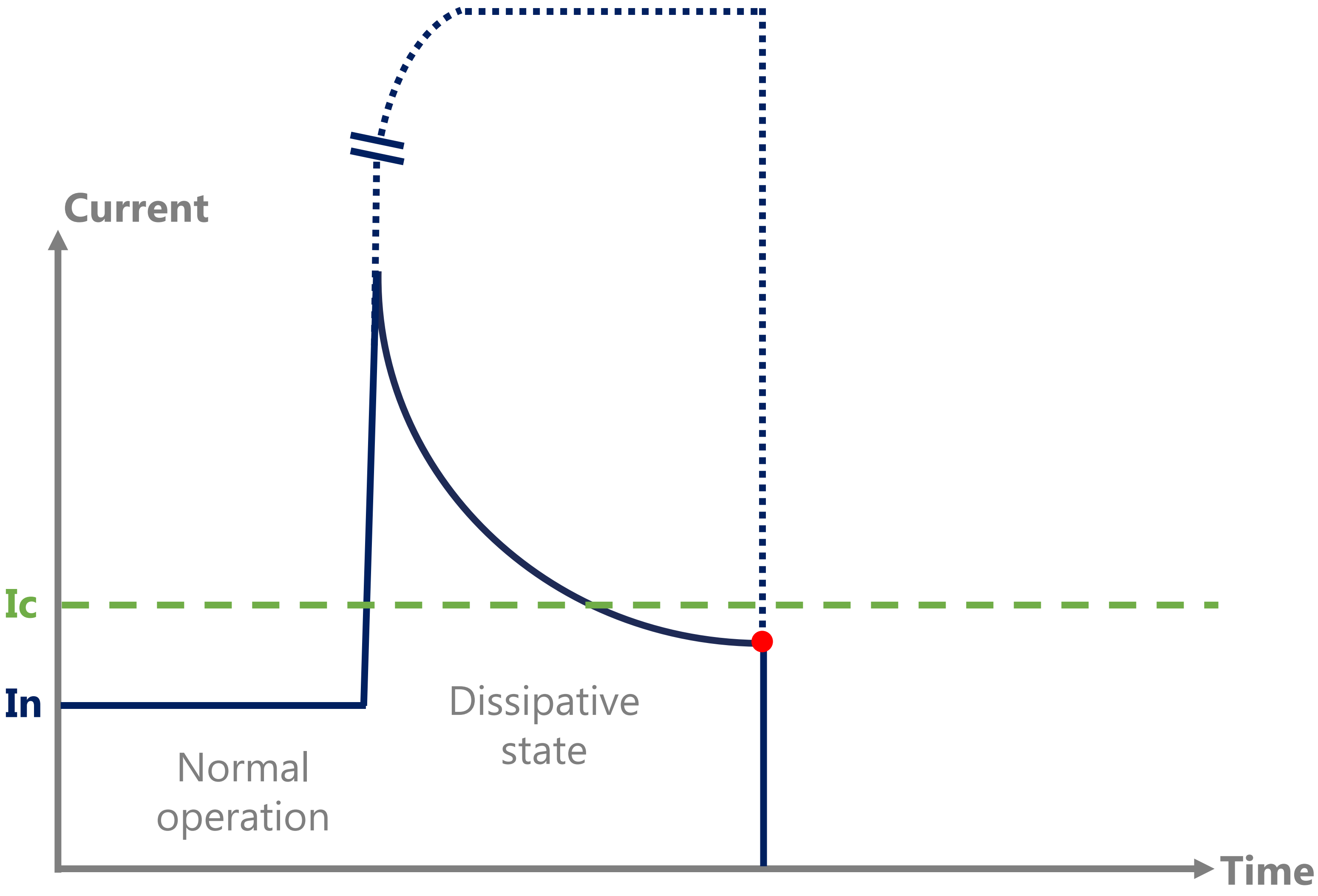
OPERATION OF A R-SFCL





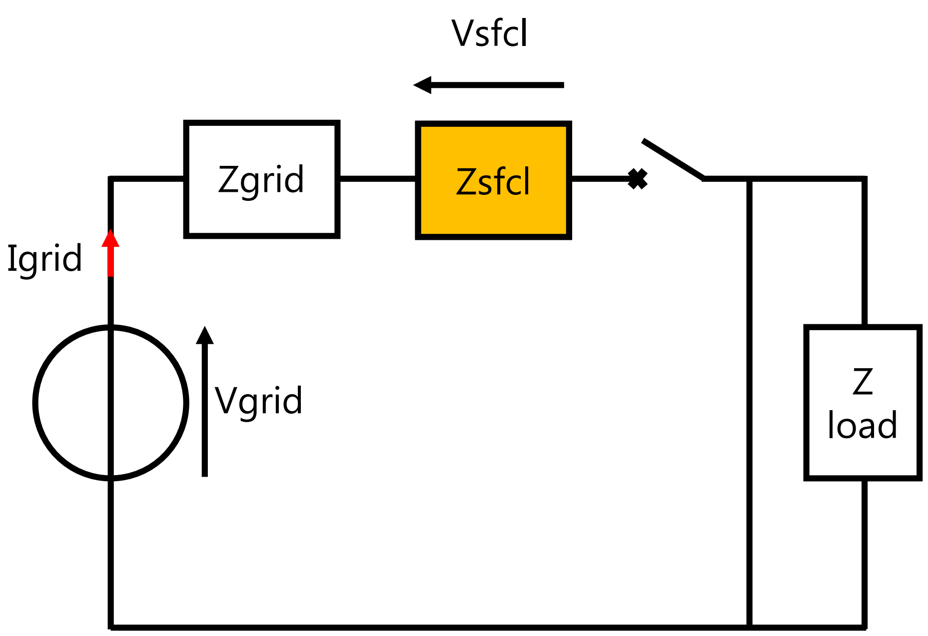
OPERATION OF A R-SFCL

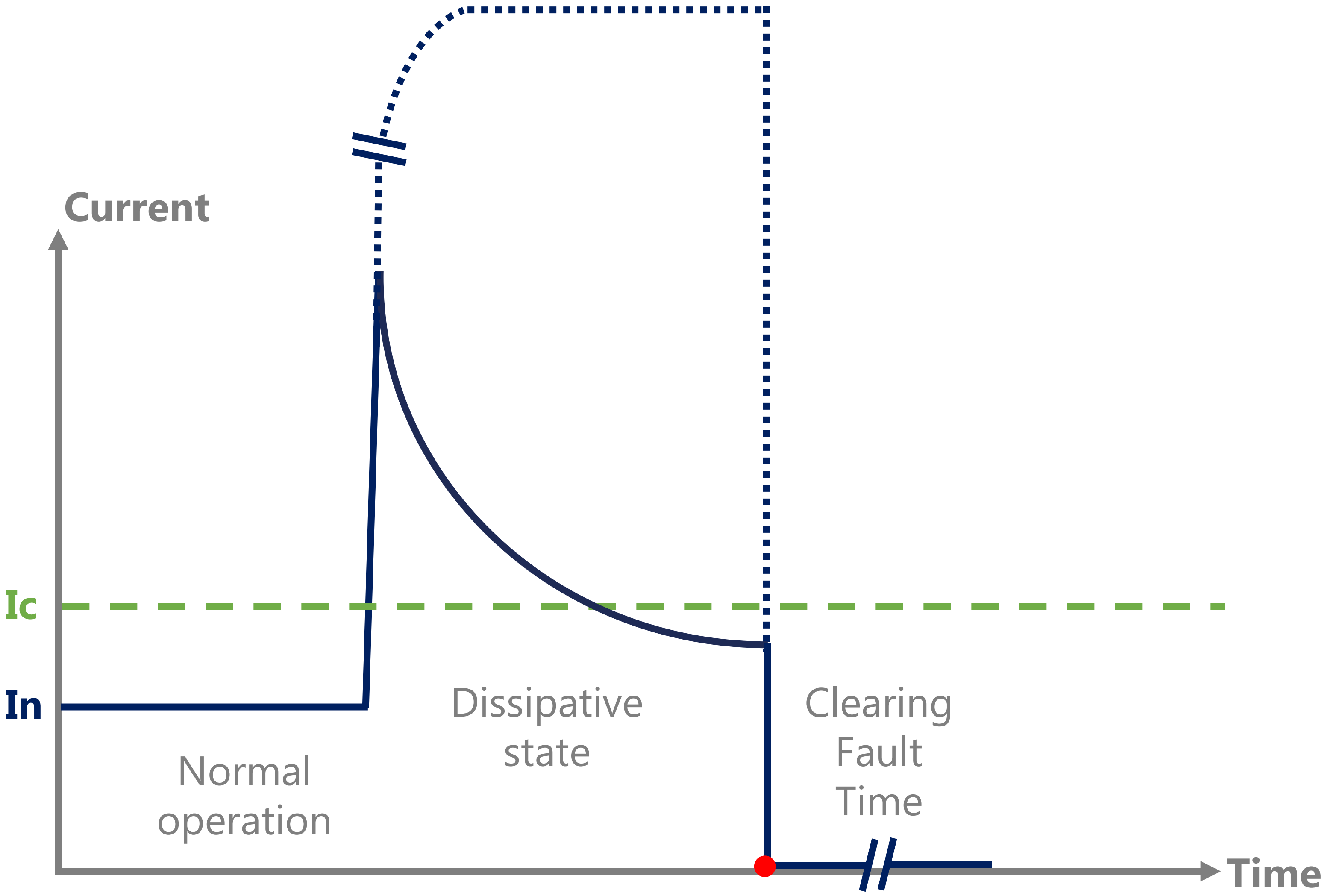




1
Context

OPERATION OF A R-SFCL

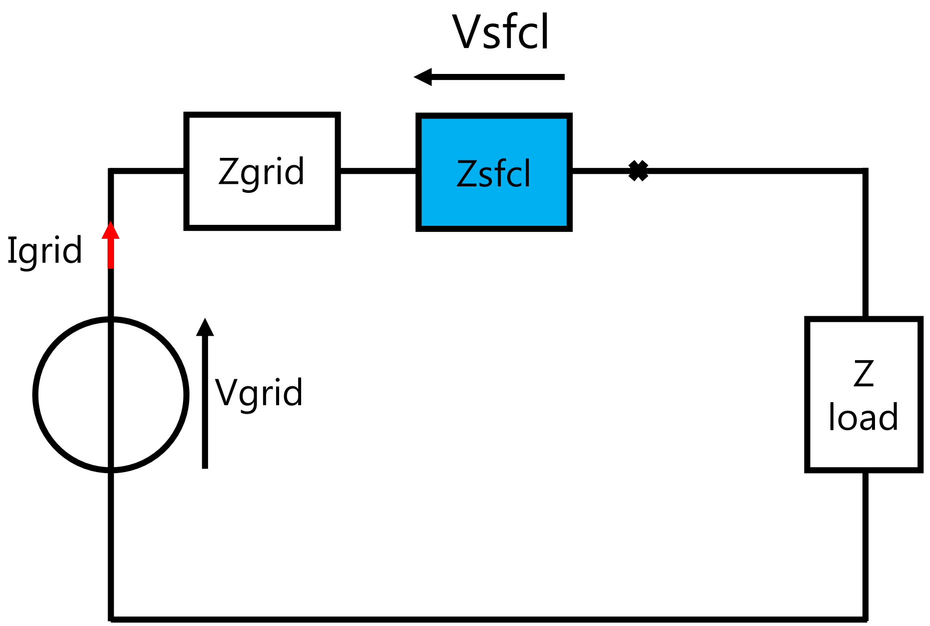


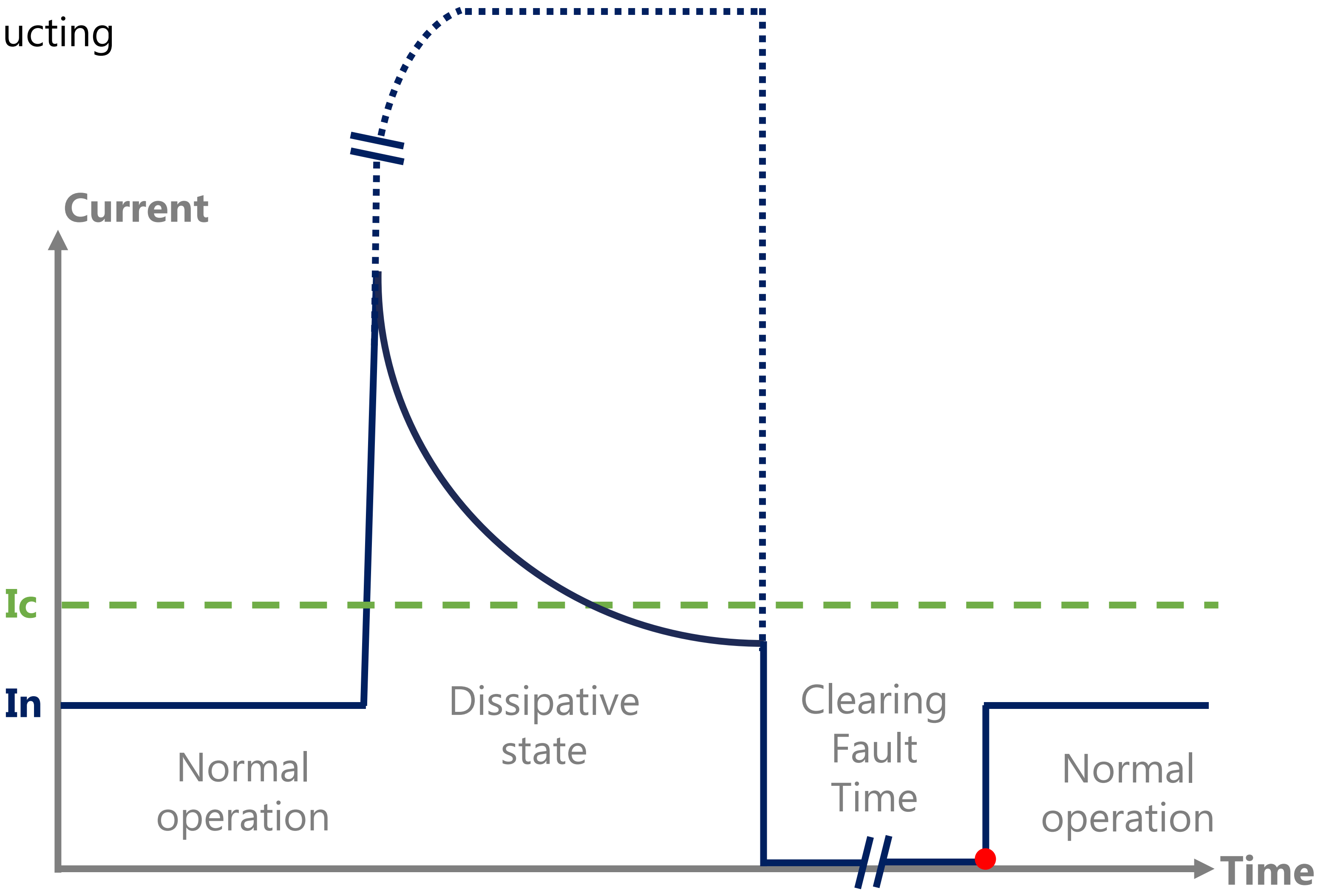


OPERATION OF A R-SFCL

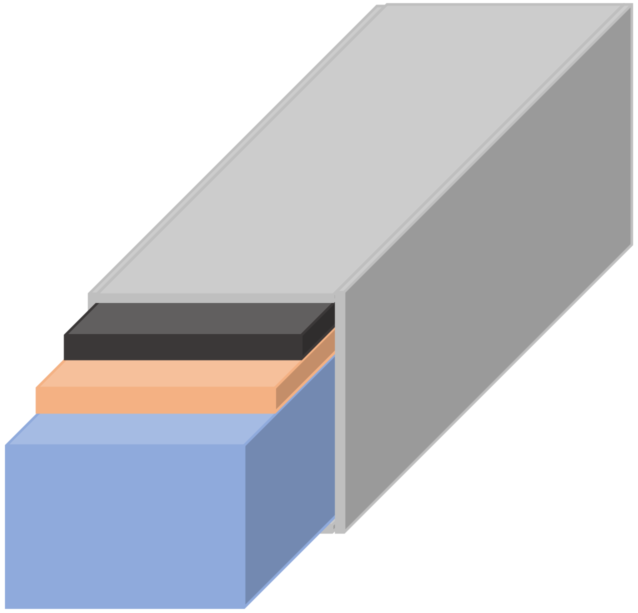
Benefits of Resistive-type Superconducting Fault Current Limiter (R-SFCL)

- A theoretical **"infinite" maximum prospective current**
- An easier fault current interruption in DC transmission (also AC)





REBCO TAPES FOR R-SFCL

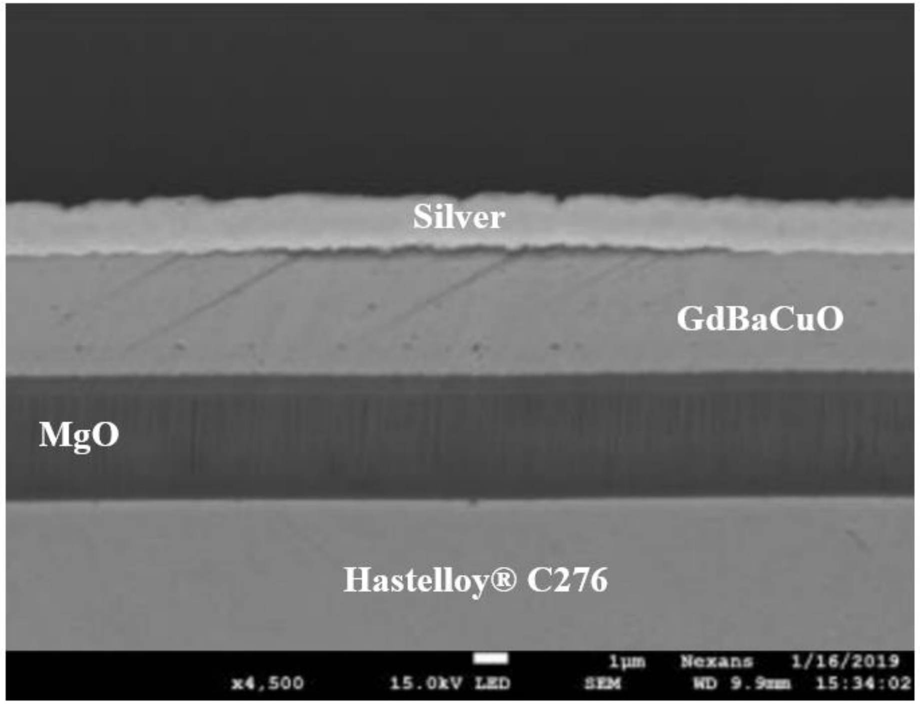


Substrate

Buffer layers

REBaCuO

Stabilizer



Courtesy of Nexans® - THEVA

High resistance per unit length

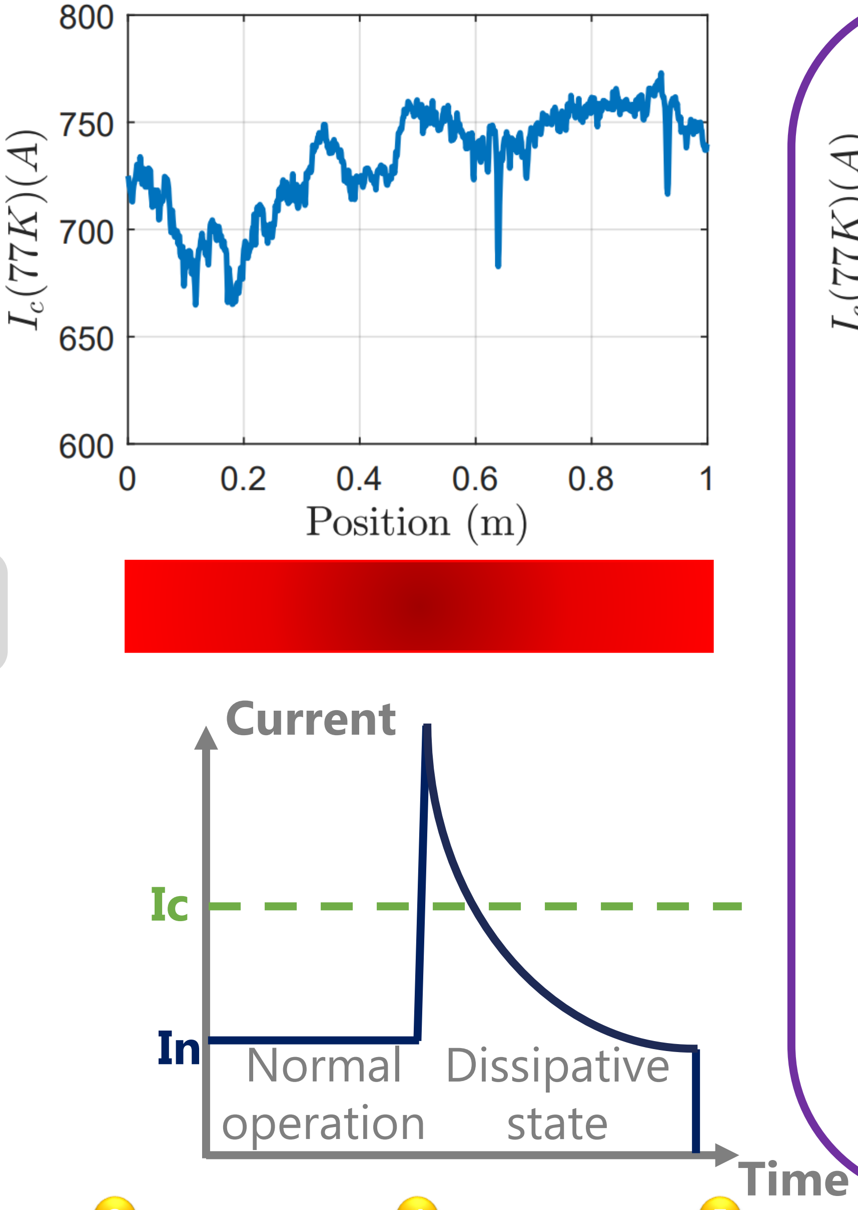
High current density (600 A/cm,w at 77 K)

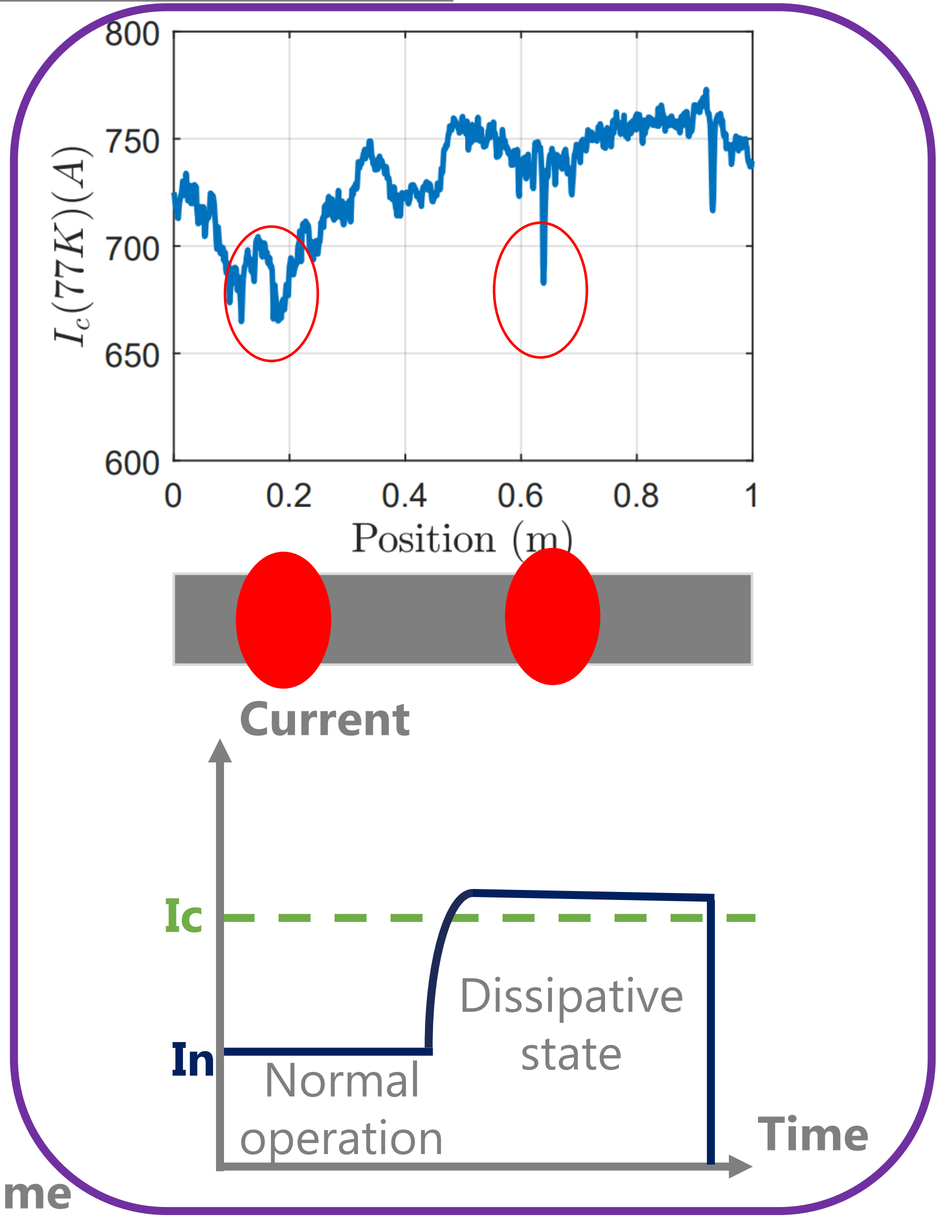
Low cryogenics costs (Tc=92 K)

No copper stabilization !

INHOMOGENEITY OF THE IC IN REBCO TAPES

Data from THEVA (77 K, self-field)





Ic dependencies - Ic(**x**,T,|B|,θ)

Ic is **inhomogeneous** along the tape length

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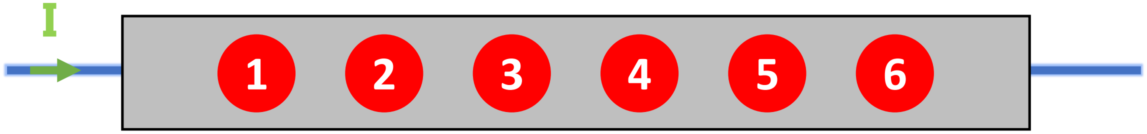
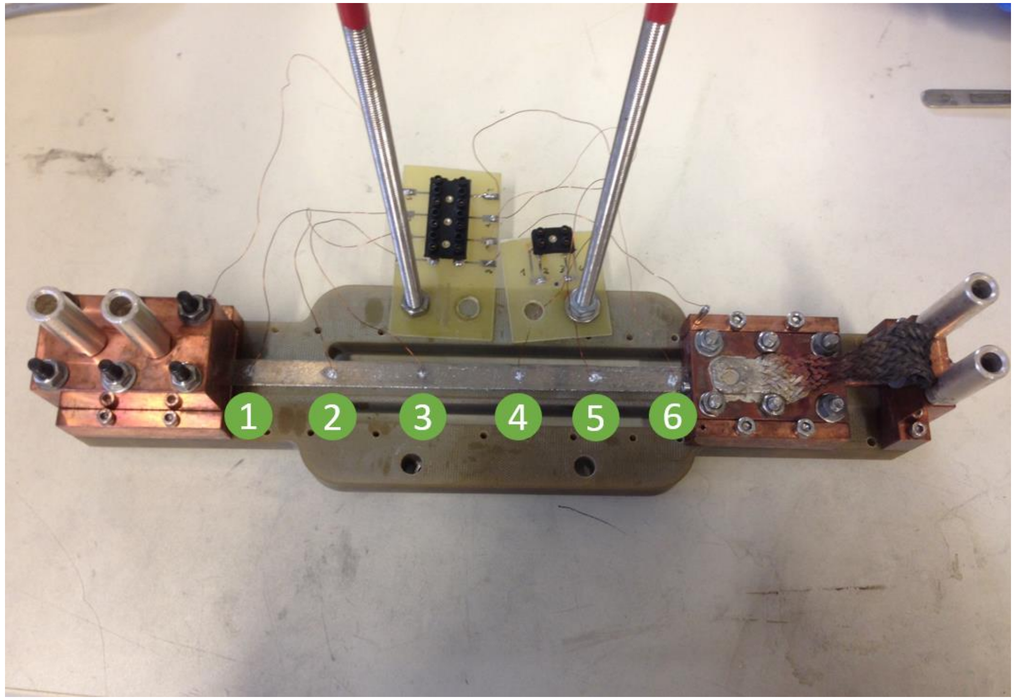
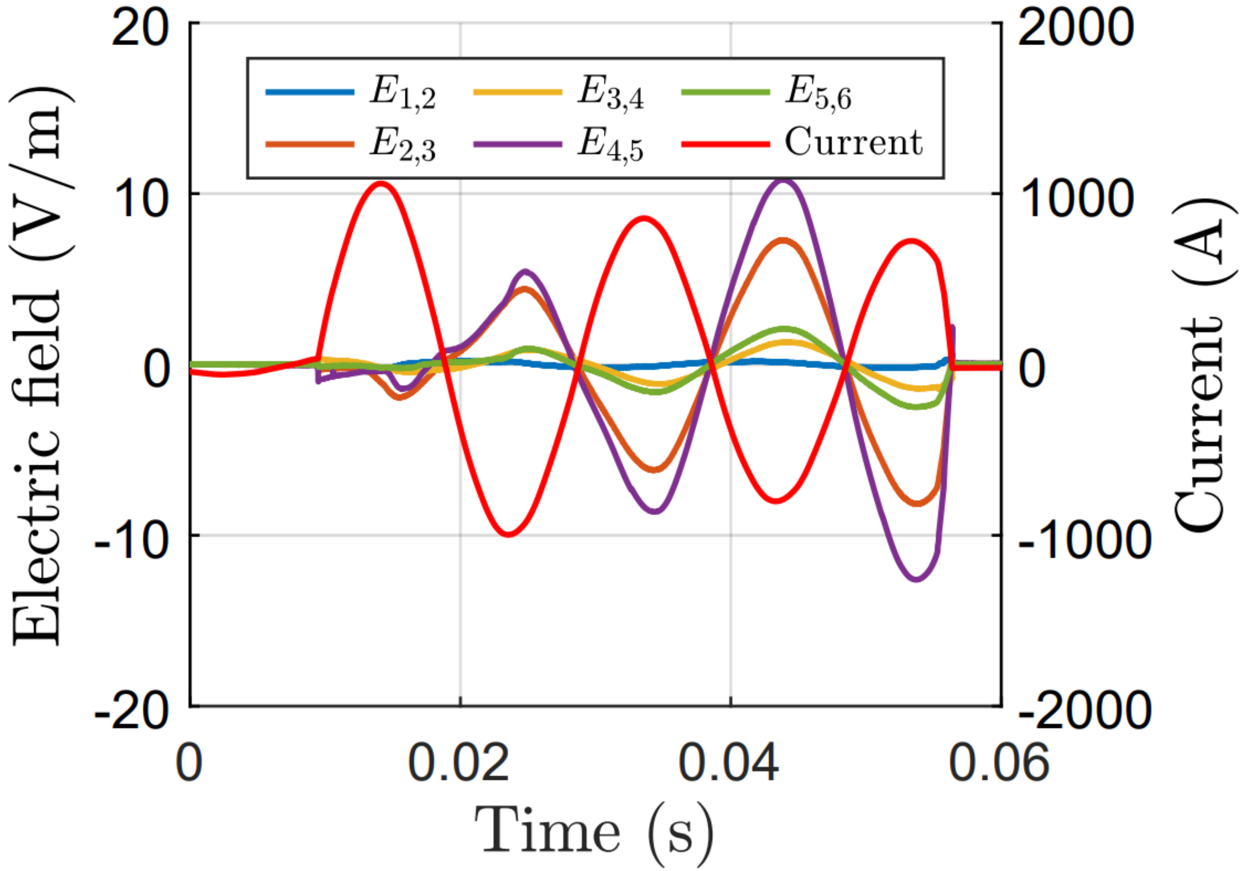
OBSERVATION THROUGH VOLTAGE MEASUREMENTS

A HTS tape from THEVA with multiple voltage taps connected to a power supply **shows inhomogeneous voltages** along its length



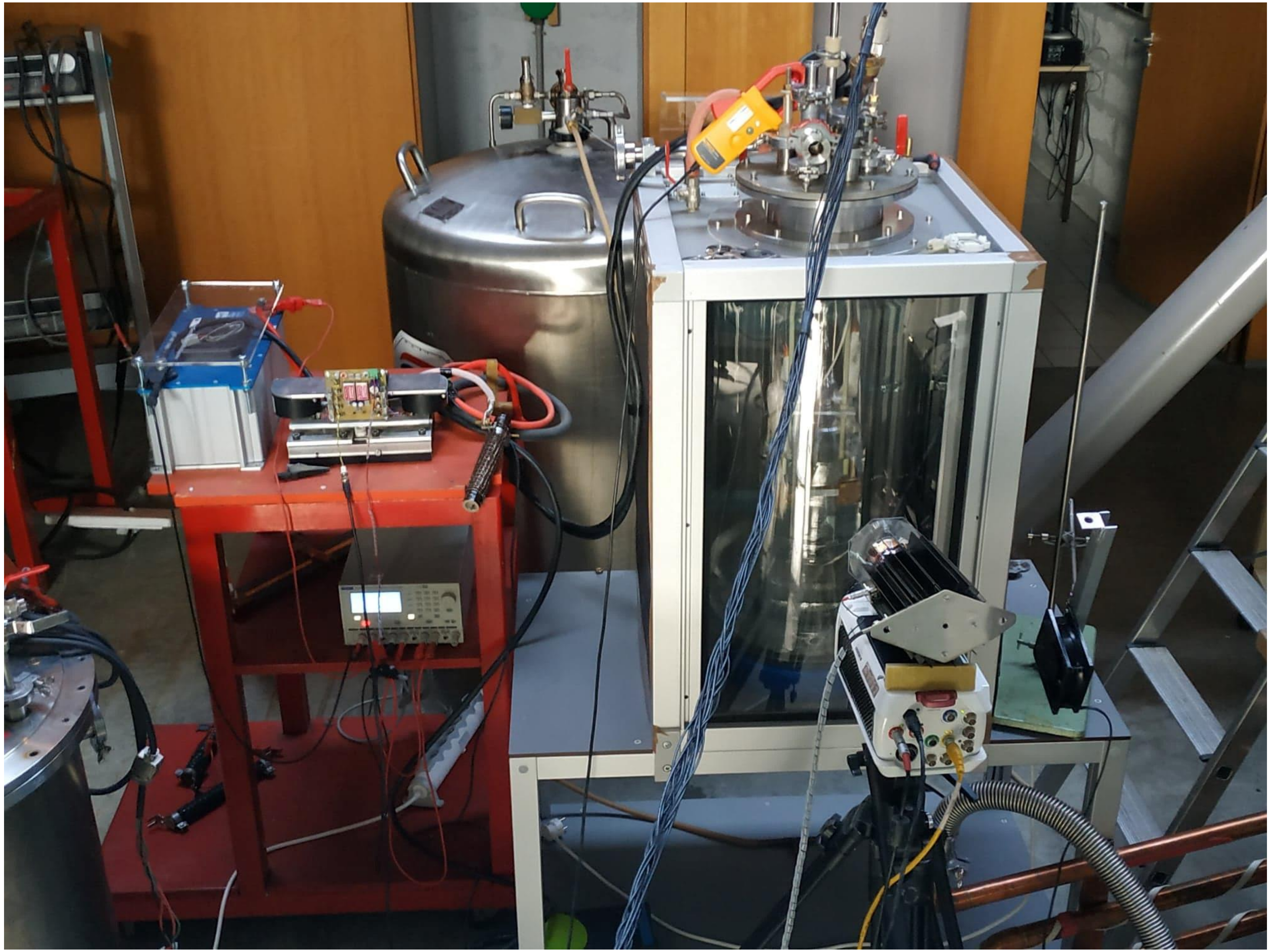




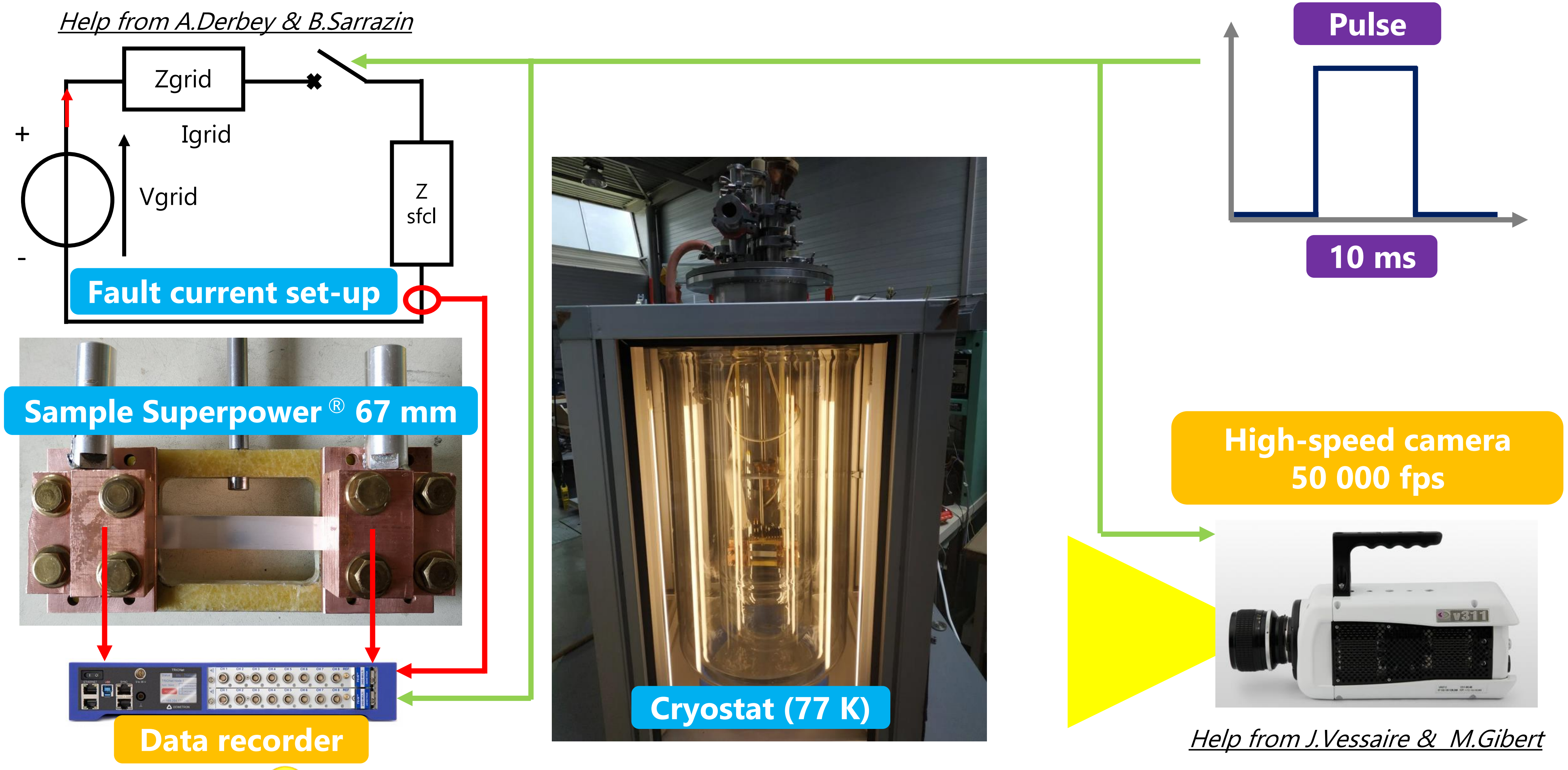
Sample from Theva (77 K)

VISUALIZATION OF A TAPE DURING A QUENCH

Experimental set-up to observe the **very beginning of a quench**

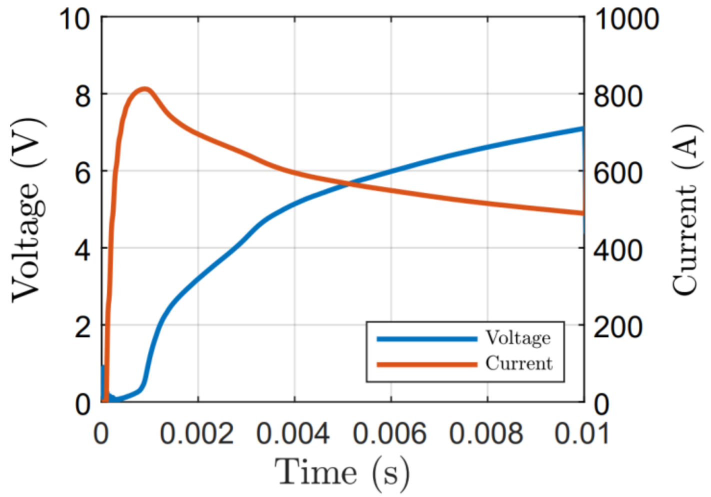


VISUALIZATION OF A TAPE DURING A QUENCH

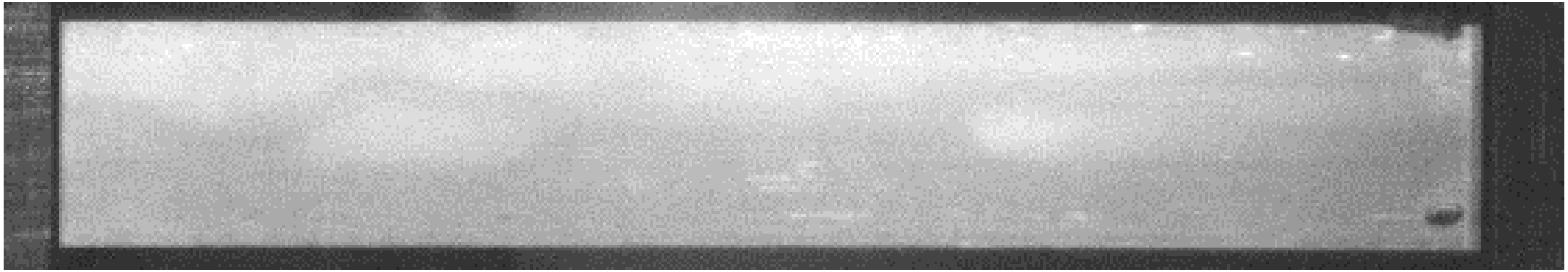


VISUALIZATION OF A TAPE DURING A QUENCH

Images recorded
for 10 ms



12 mm



67 mm

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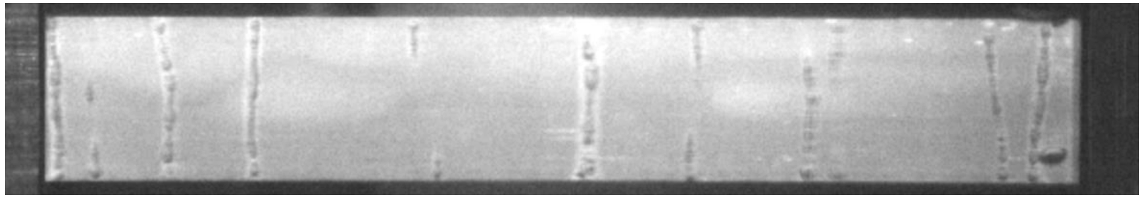
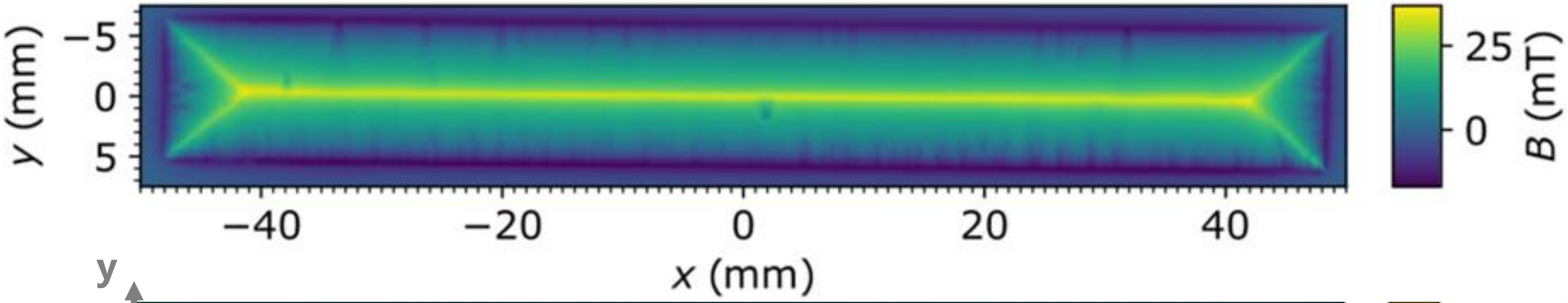
RECOGNITION OF LOCAL INHOMOGENEITIES

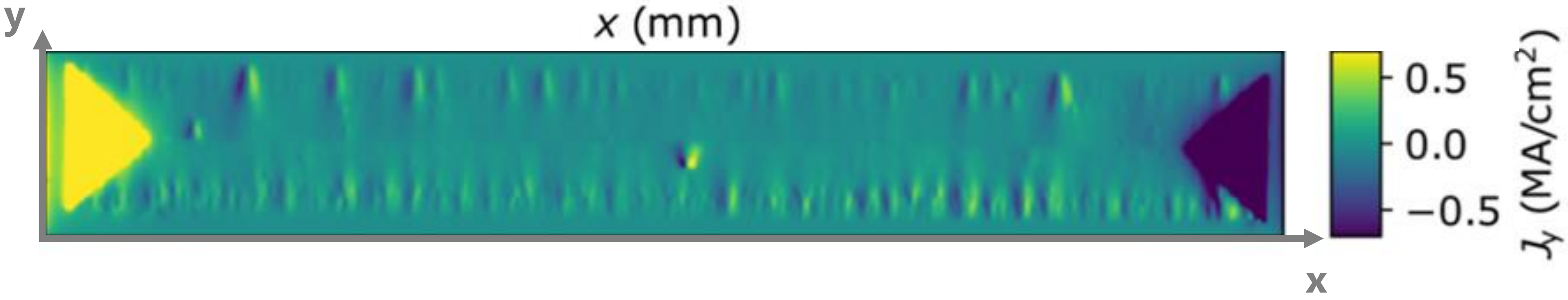


Work carried out by S.Holleis and M.Eisterer from TU Vienna

Measurement of the **remnant field** after magnetization



Inversion of the magnetic problem gives $J(J_x,J_y)$

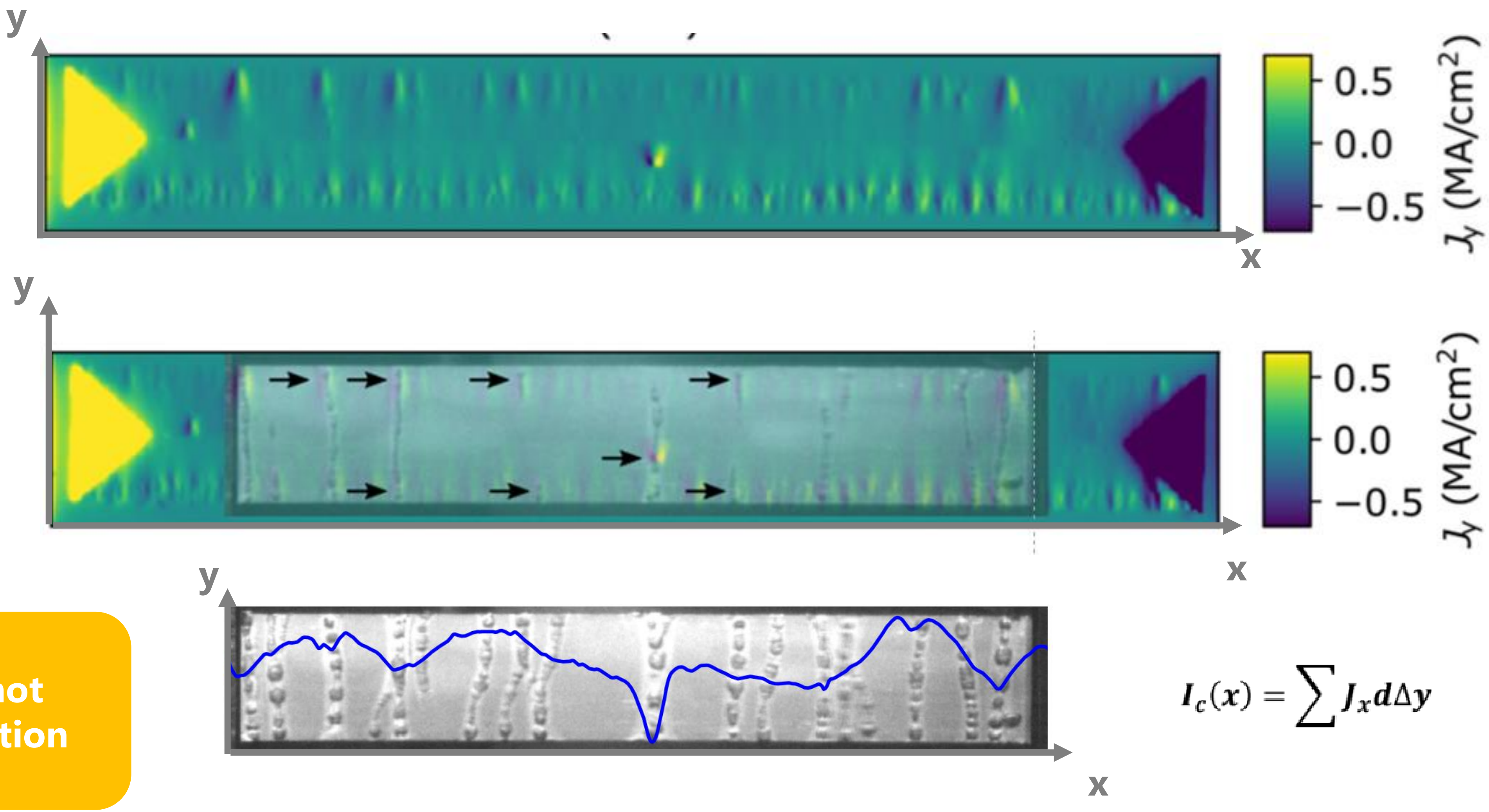


RECOGNITION OF LOCAL INHOMOGENEITIES

Work carried out by S.Holleis and M.Eisterer from TU Vienna

Positions of bubble columns and inhomogeneities match well

Local Ic based on magnetization does not describe all the dissipation phenomena

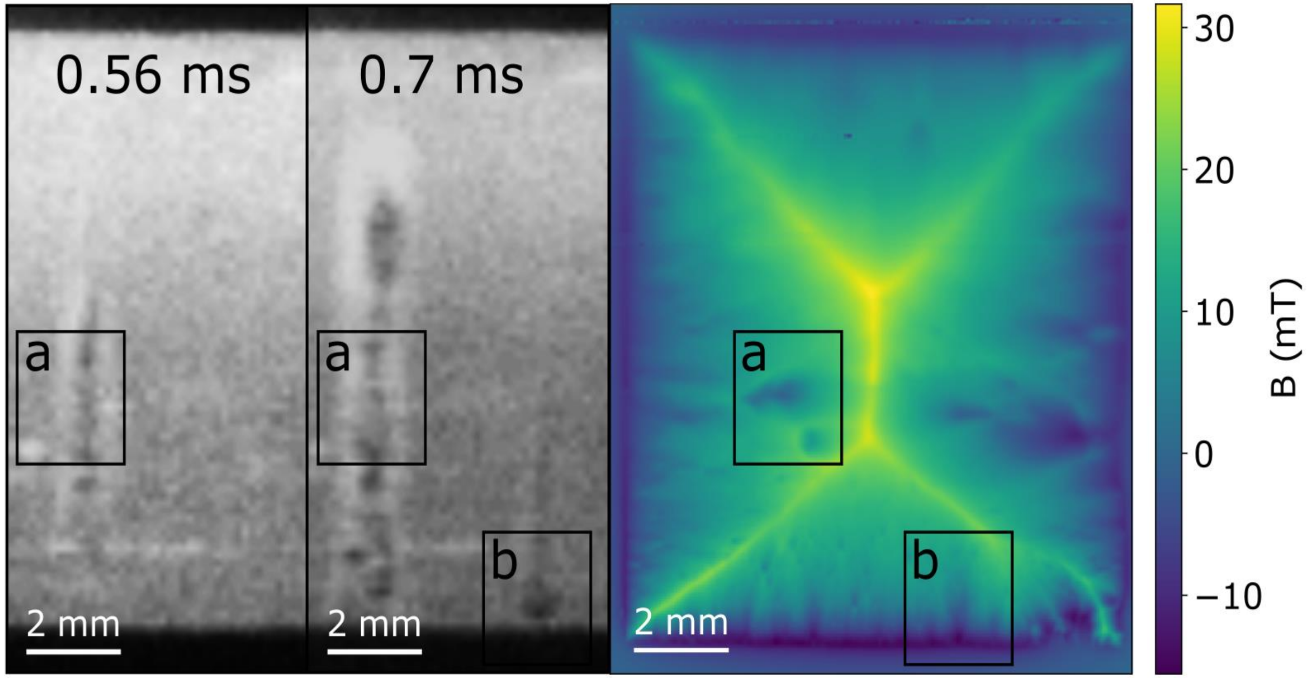


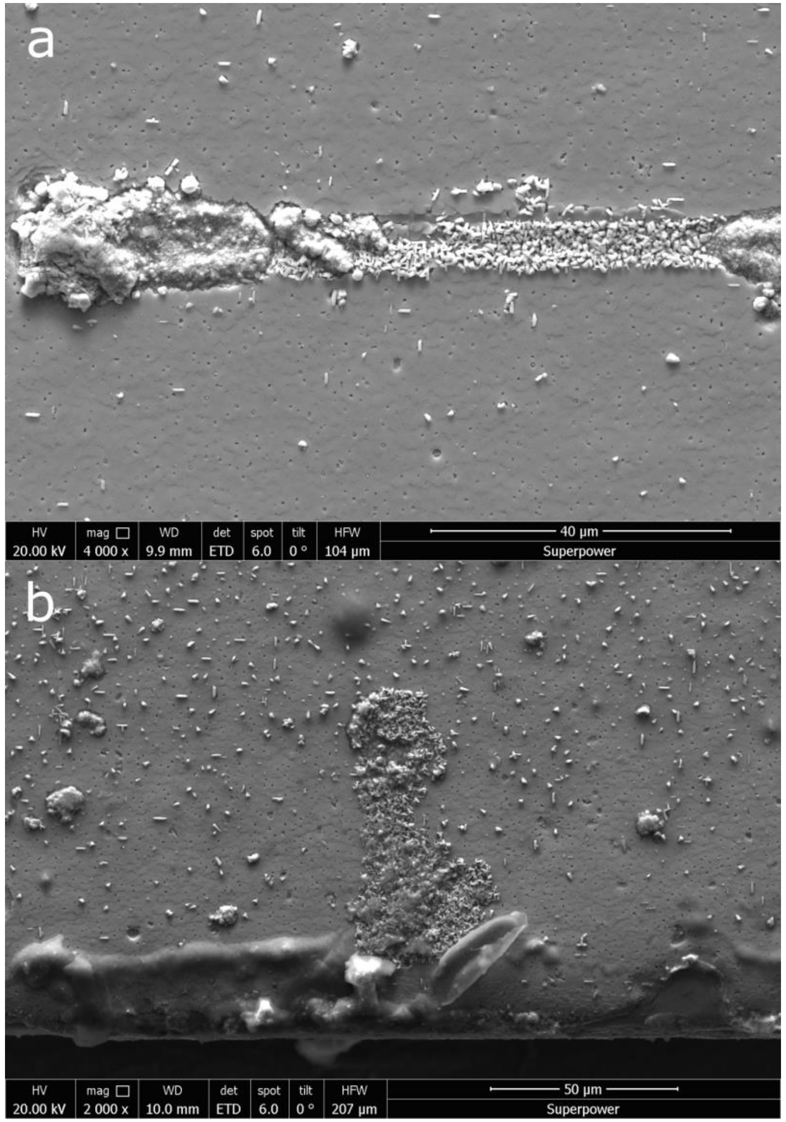
$$I_c(x) = \sum J_x d\Delta y$$

Influence of Local Inhomogeneities in the REBCO Layer on the Mechanism of Quench Onset in 2G HTS Tapes IEEE TAS

NON-EPITAXIAL GROWTH OF THE REBCO LAYER

Work carried out by S.Holleis and M.Eisterer from TU Vienna





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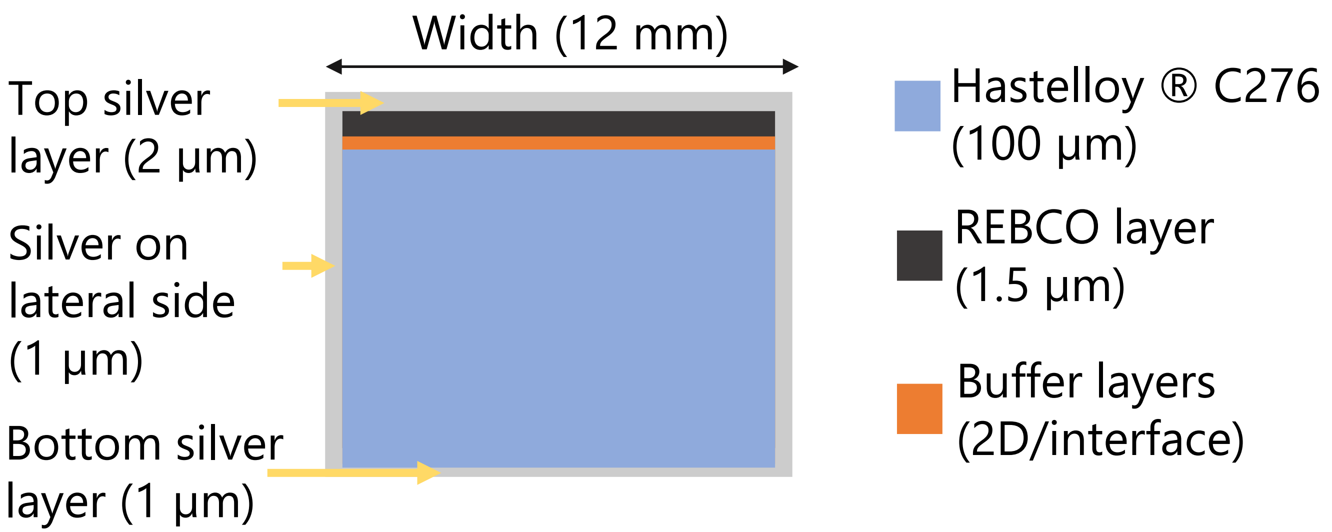
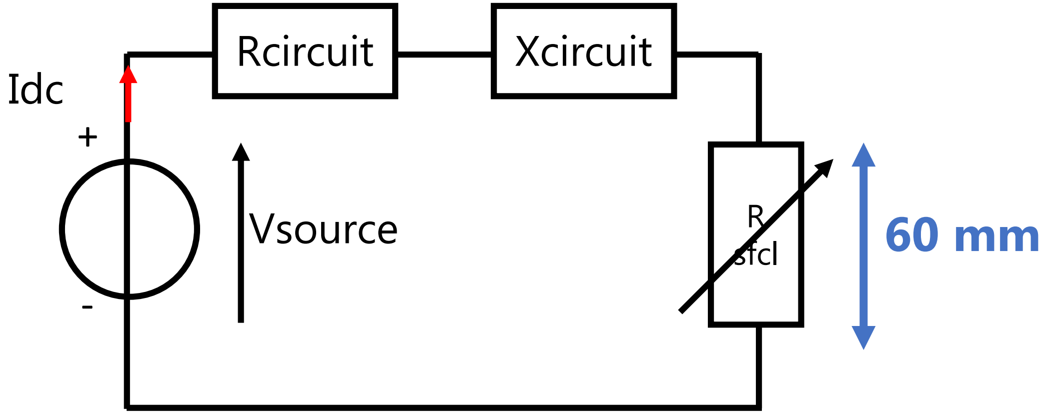
3D FEM ELECTRO-THERMAL MODEL



COMSOL

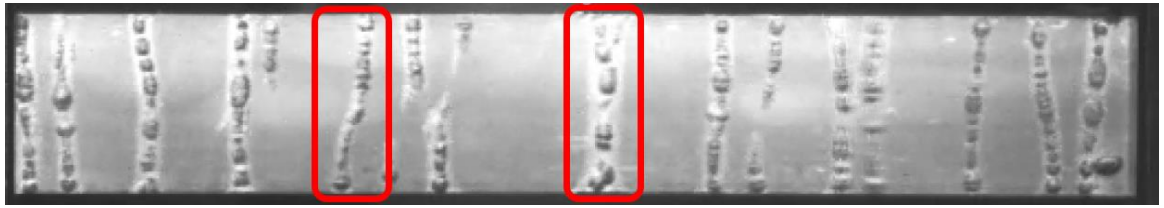
Thermo-electrical model developed by C.Lacroix & F.Sirois from EPM

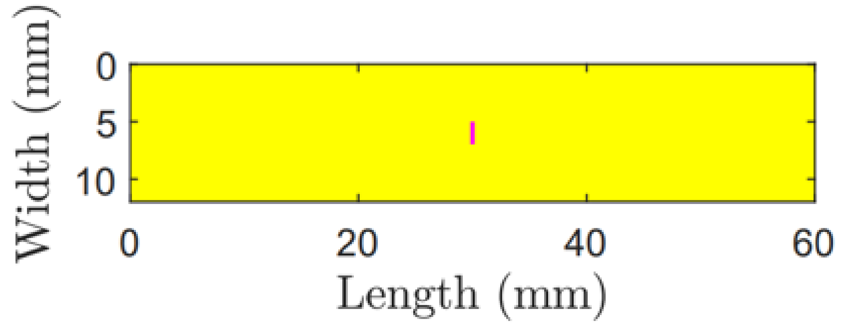
- Temperature and current dependence of REBCO layer under Tc

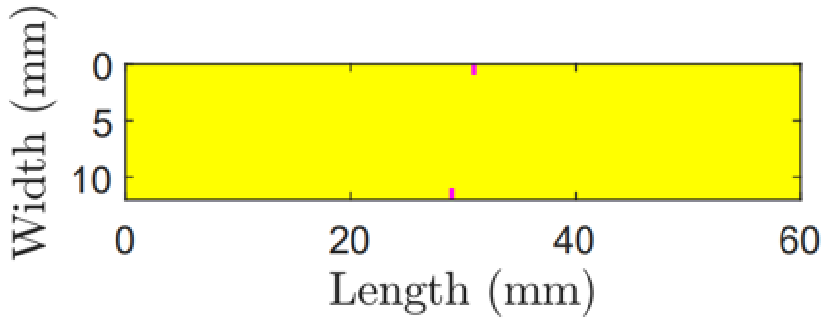


POLYTECHNIQUE MONTRÉAL
UNIVERSITÉ D'INGÉNIERIE

3D FEM ELECTRO-THERMAL MODEL







$J_c = 3.3\ 10^{10} A/m^2$

$J_c = 0.33\ 10^{10} A/m^2$

COMSOL

Thermo-electrical model developed by C.Lacroix & F.Sirois from EPM

- Temperature and current dependence of REBCO layer under Tc
- Inhomogeneous critical current density (x,y)

POLYTECHNIQUE MONTRÉAL
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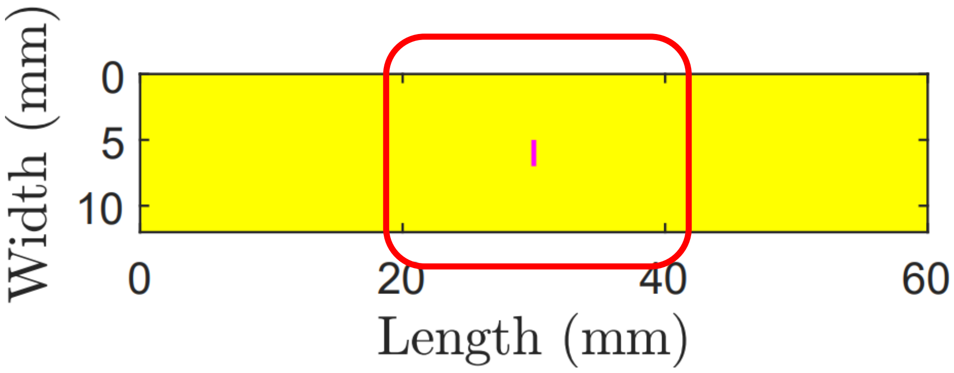
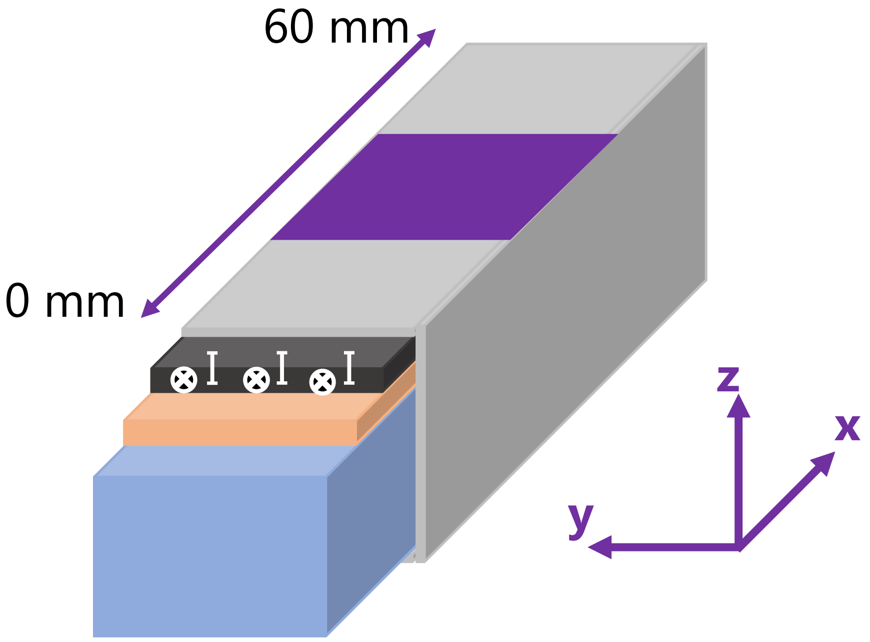
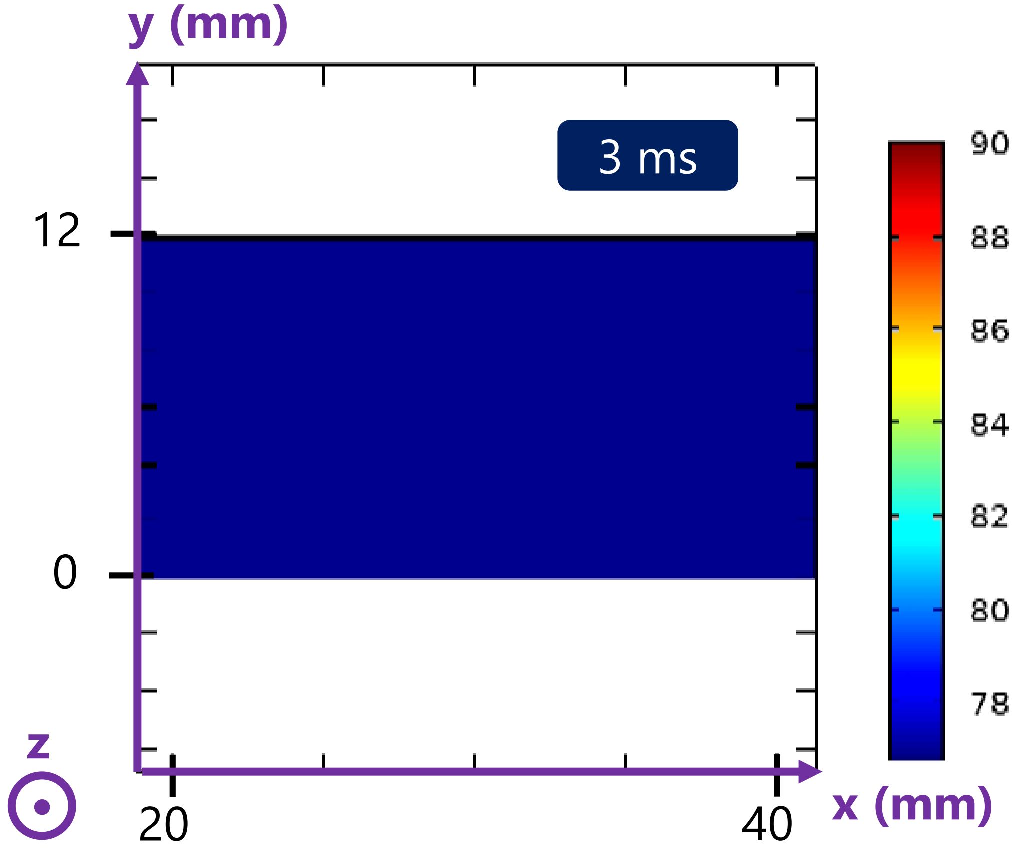
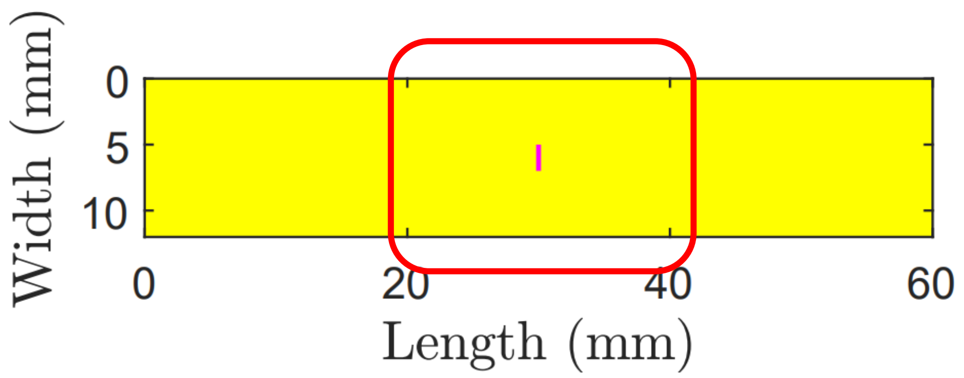
TEMPERATURE EVOLUTION ALONG THE WIDTH

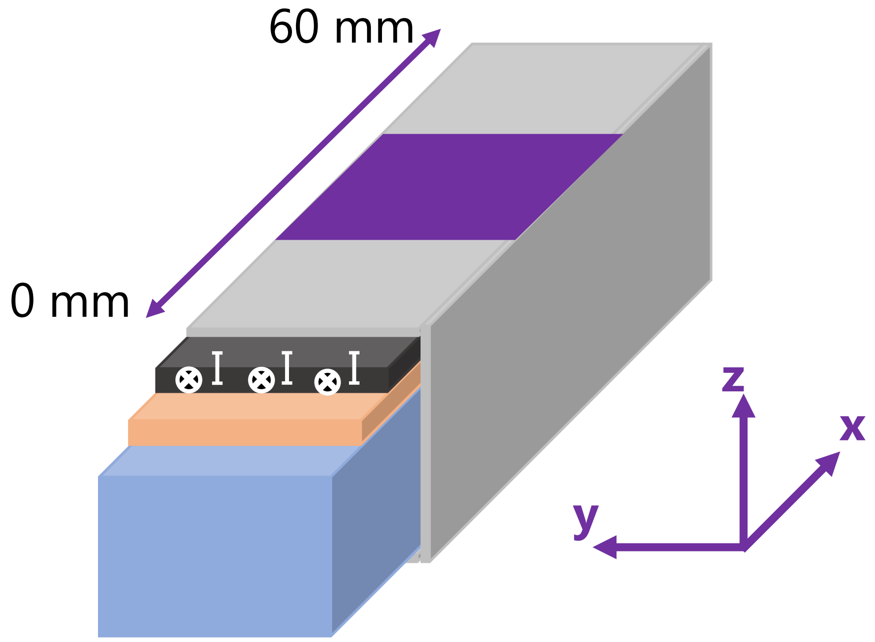


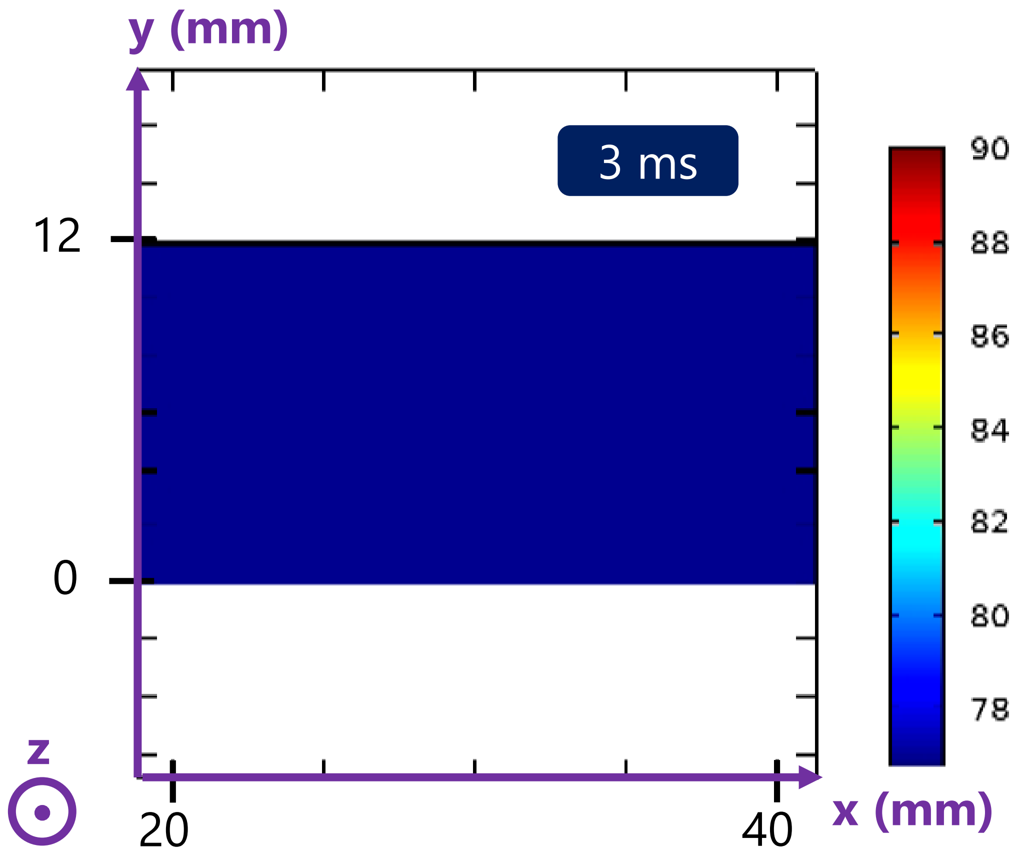




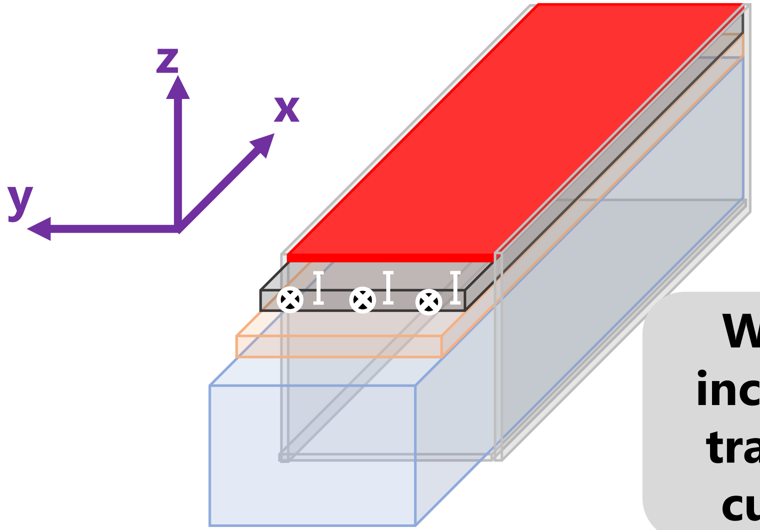
TEMPERATURE EVOLUTION ALONG THE WIDTH



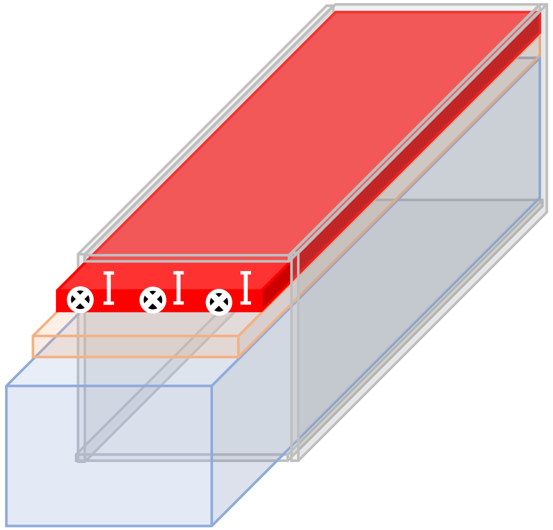


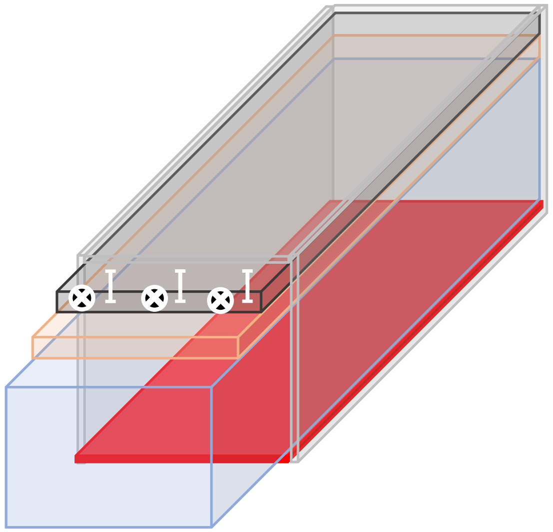


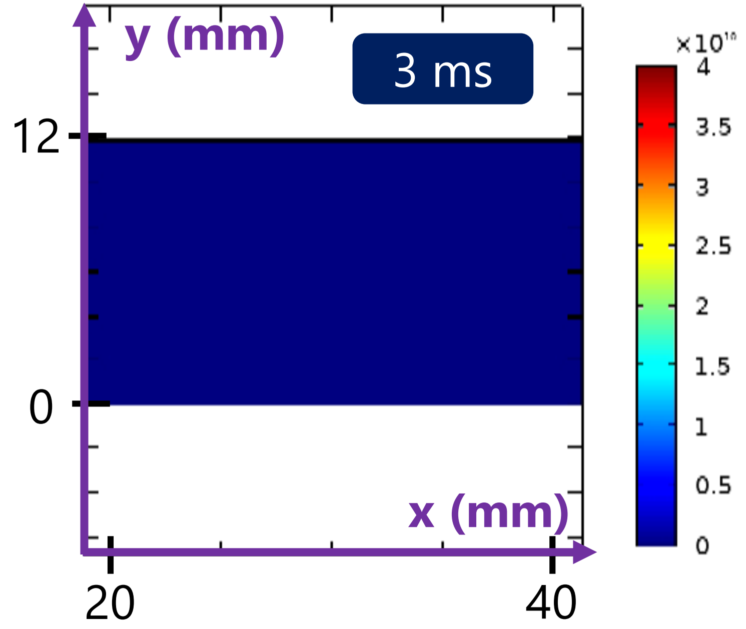
CURRENT DENSITY EVOLUTION ALONG THE WIDTH

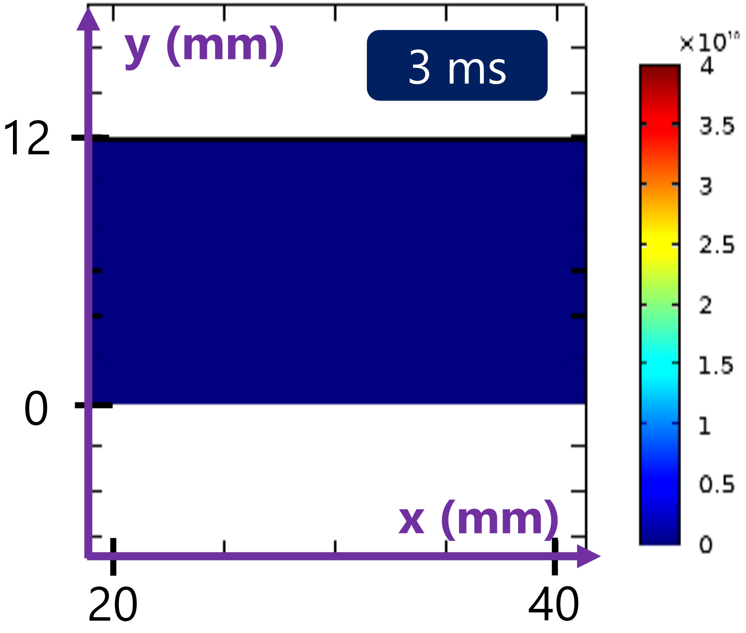


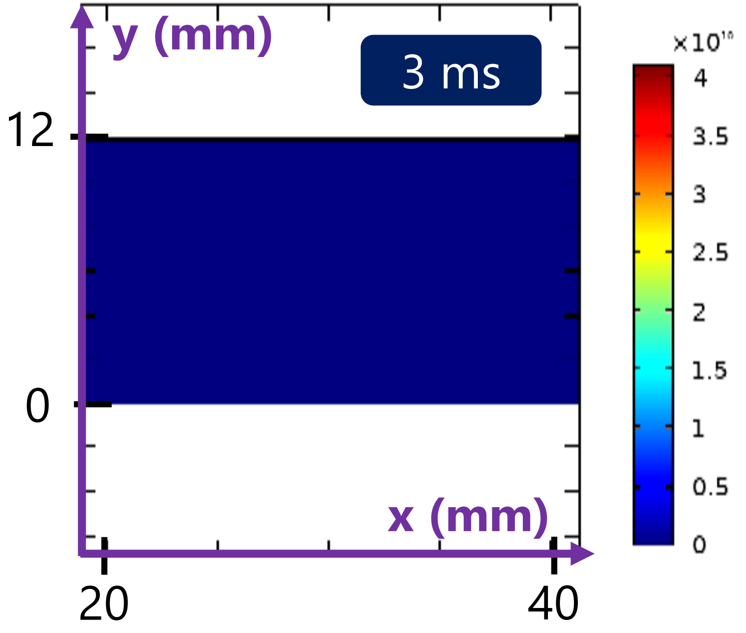
With an increasing transport current!







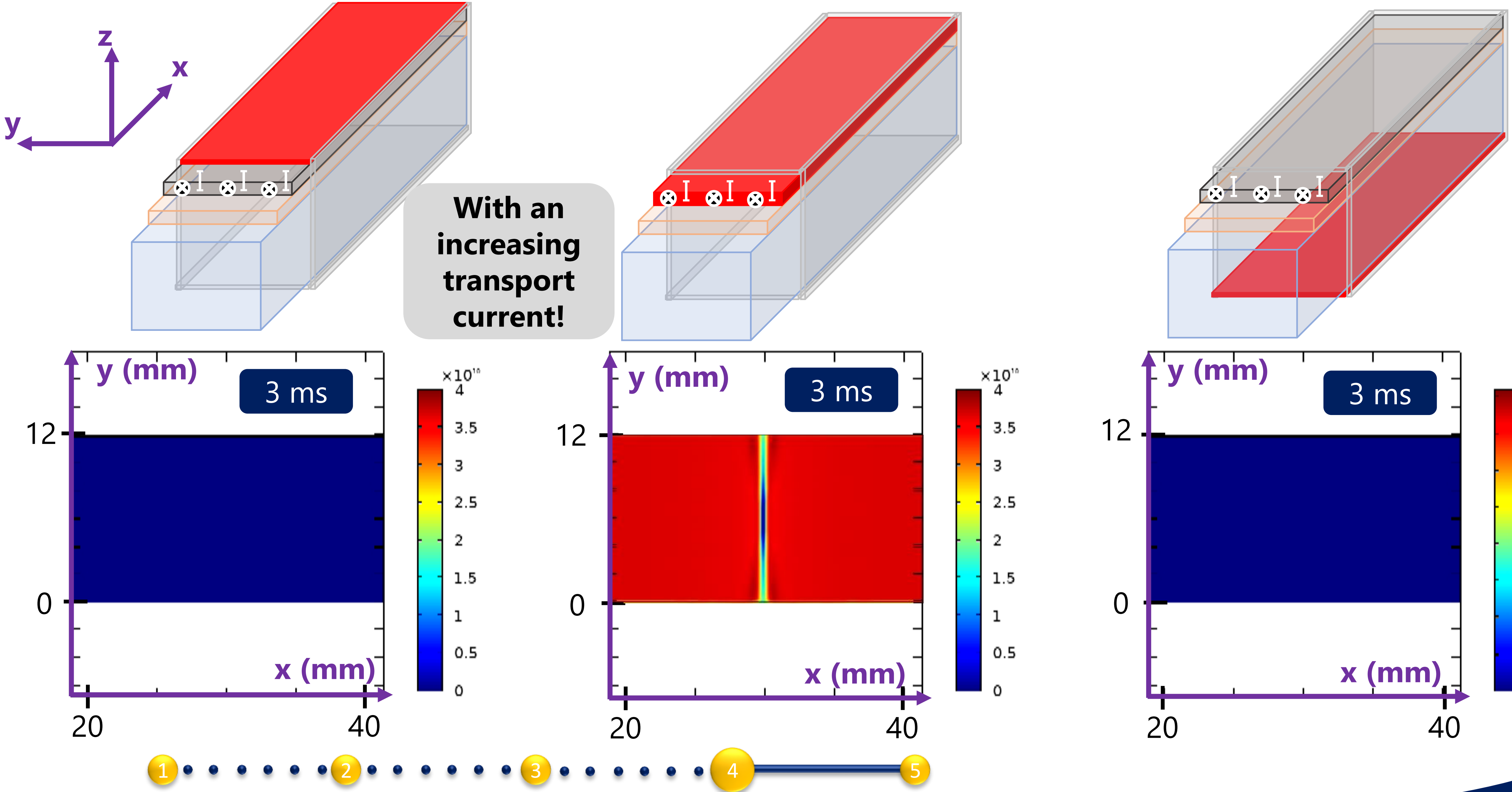




1 2 3 4 5

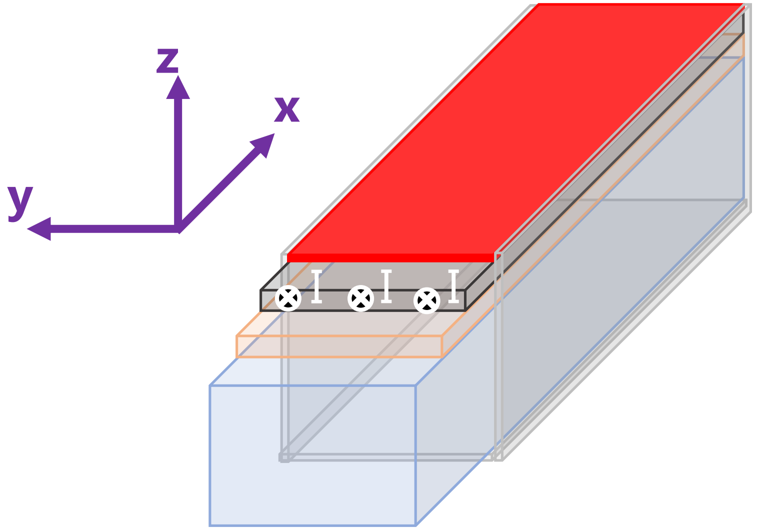
Current redistribution around a dissipative zone

CURRENT DENSITY EVOLUTION ALONG THE WIDTH



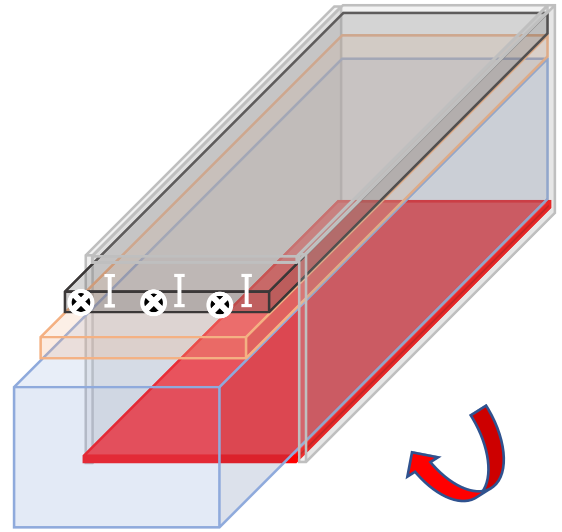
Current redistribution around a dissipative zone

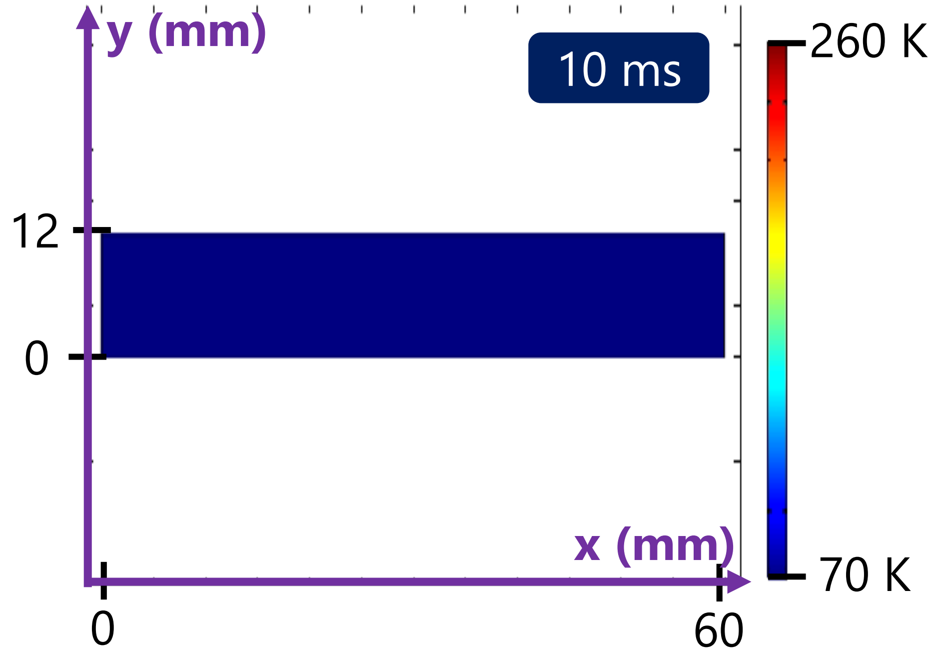
TEMPERATURE EVOLUTION ALONG THE LENGTH

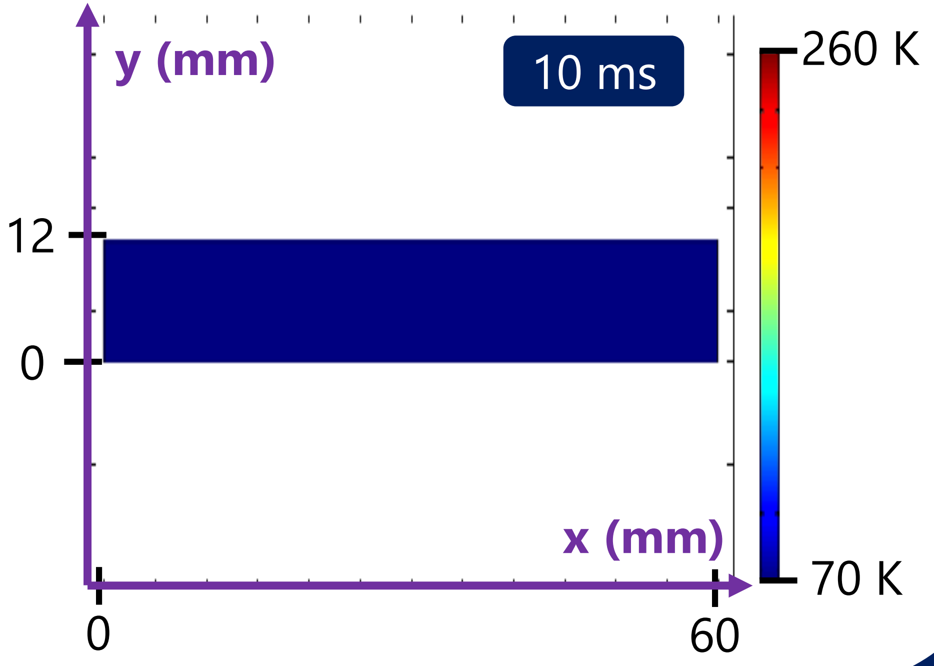


With an increasing transport current!

Temperatures similar on each side of the tape…







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Current redistribution around a dissipative zone

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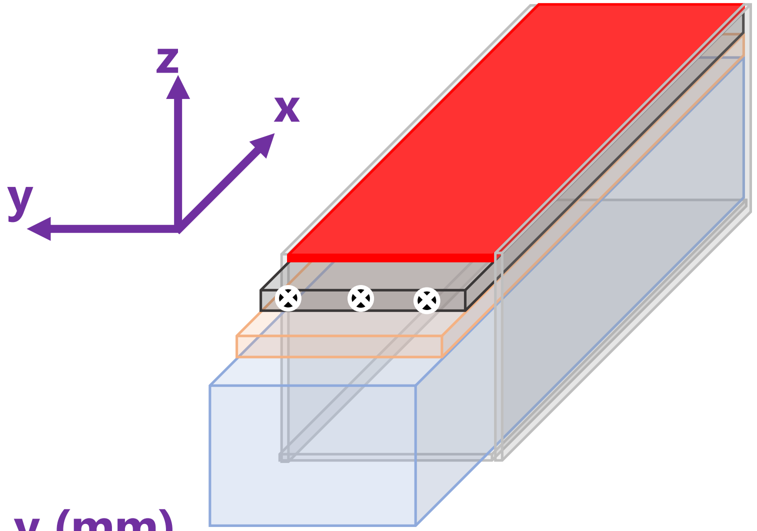

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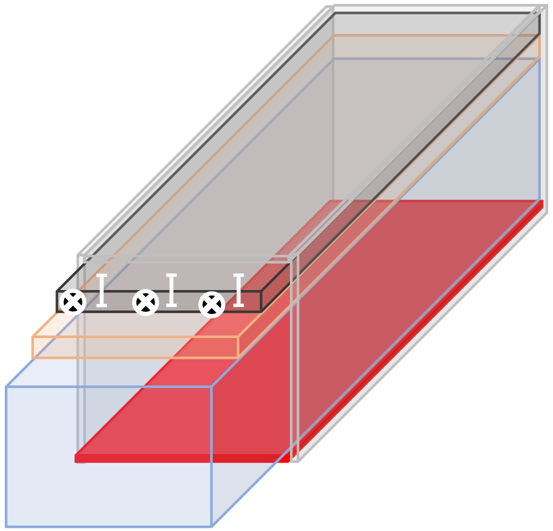
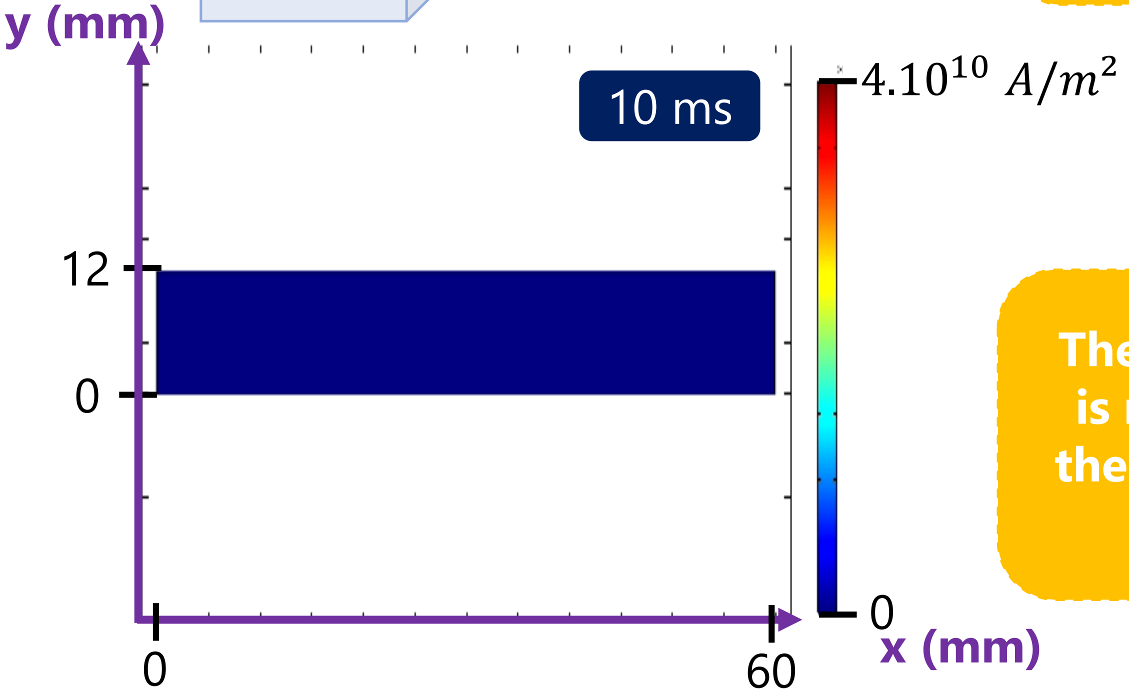
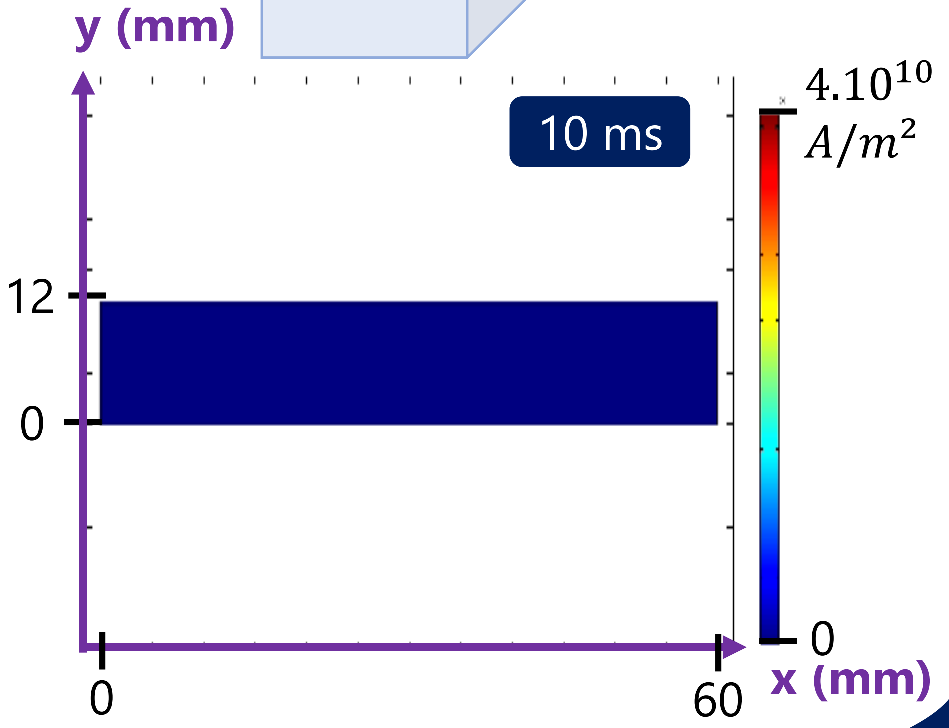
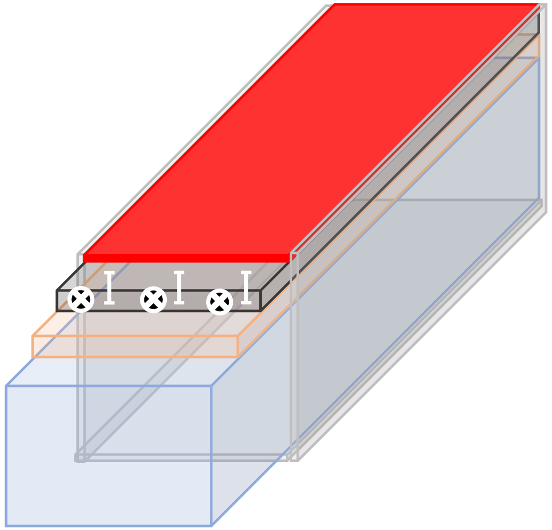


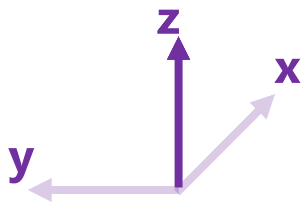


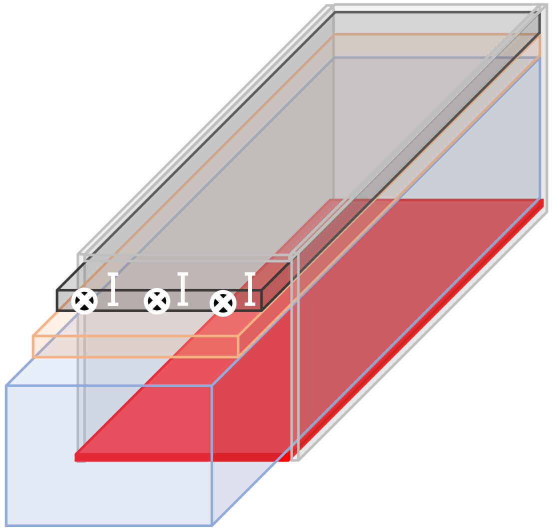
The current density is not identical on the top and bottom silver layers

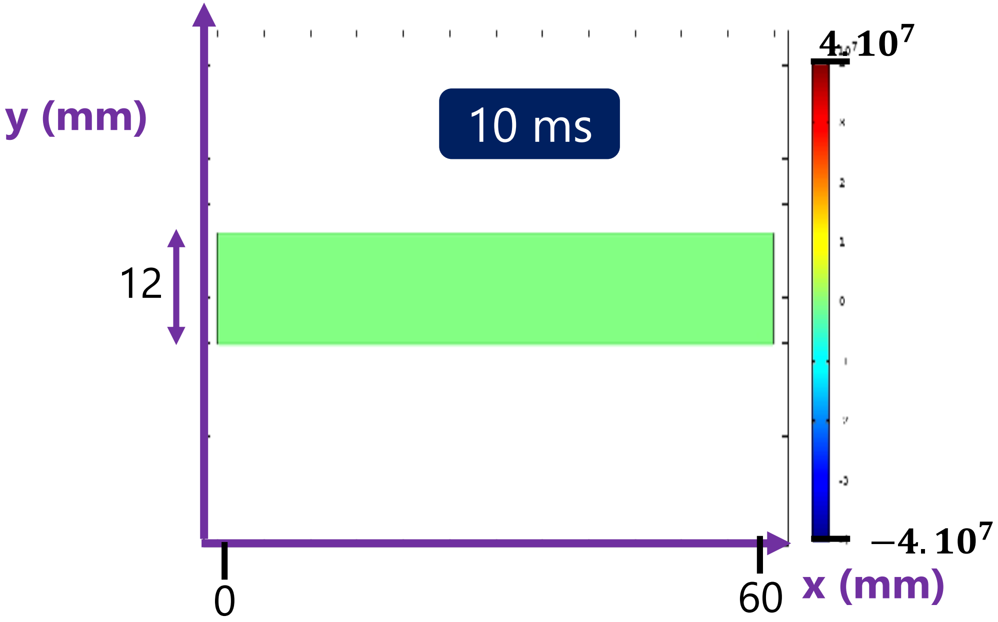


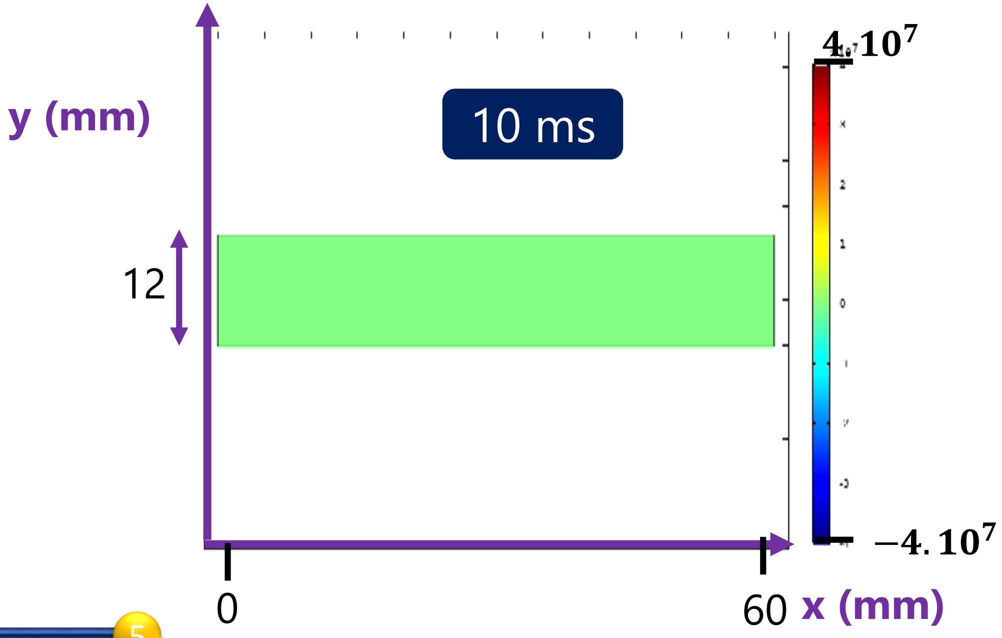
CURRENT DENSITY EVOLUTION ALONG THE LENGTH





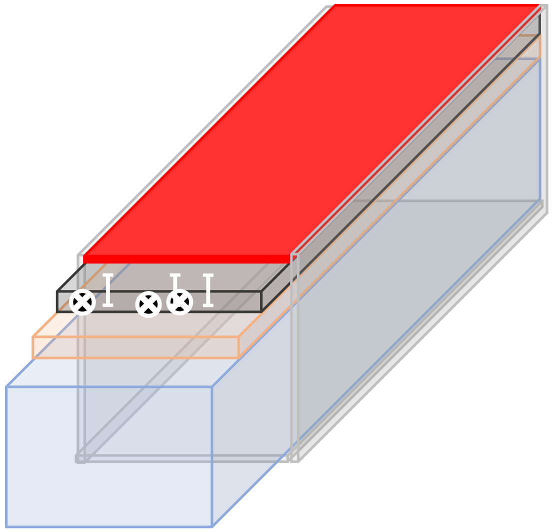


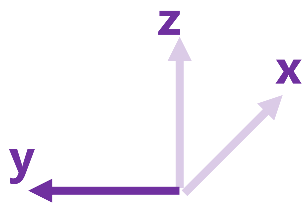


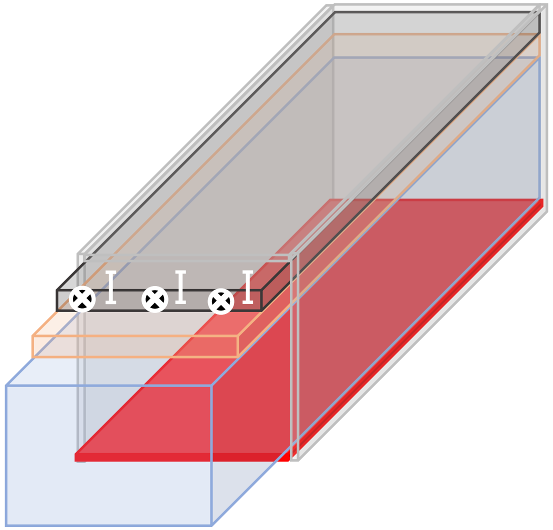


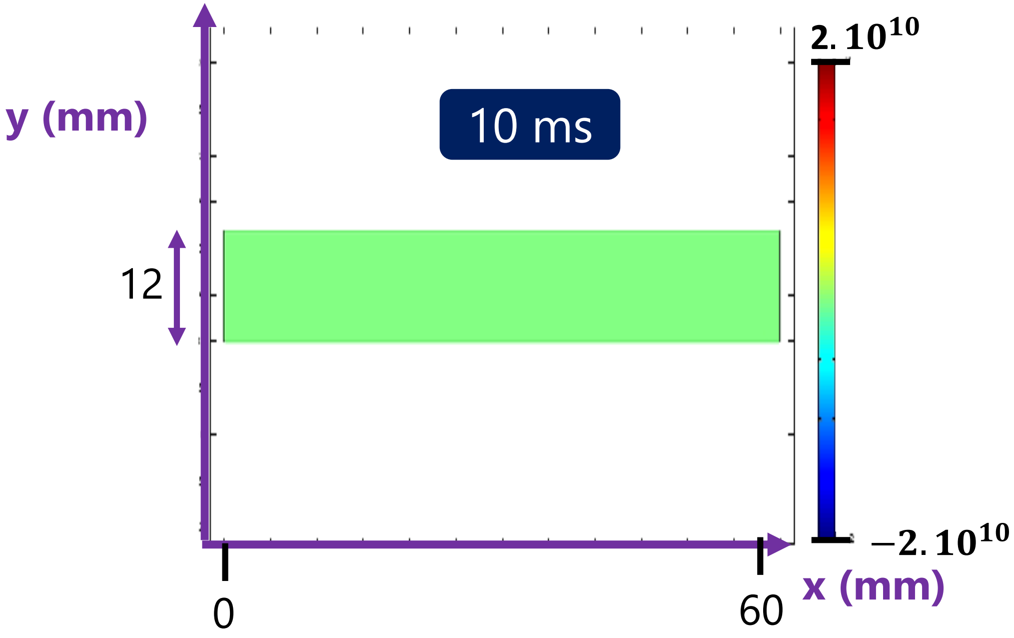
Current redistribution around a dissipative zone

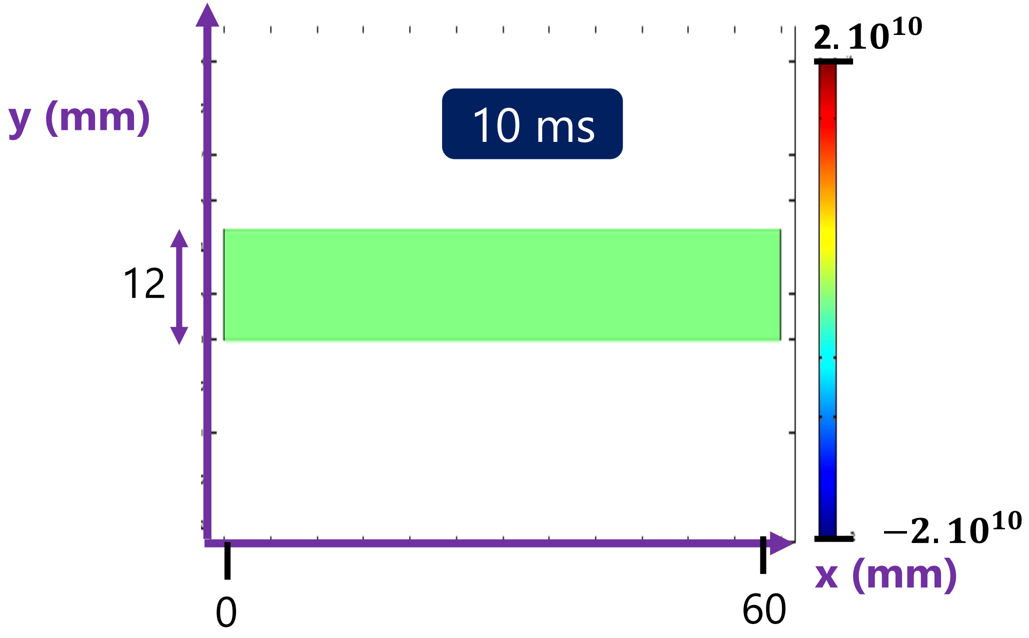
CURRENT DENSITY EVOLUTION ALONG THE LENGTH











Current redistribution around a dissipative zone

CONCLUSIONS

Inhomogeneous and homogeneous dissipation regimes **are successive behaviors**

Positions of dissipation spots and zones of non-epitaxial growth of the REBCO **are in good agreement**

Ic as a function of the position should be improved to describe dissipation phenomena

Thermo-electrical mechanism of quench onset

Three practical outputs of the study :
- **Assessment of the impact of a lack of stabilizer on one side**
- **Voltage taps positions for Ic measurement (superconductor side VS substrate side)**
- **Evaluation of the NZPV through data processing**