

Measurement of the J_c inhomogeneity in HTS Bulks



3-MP-FP5-S16

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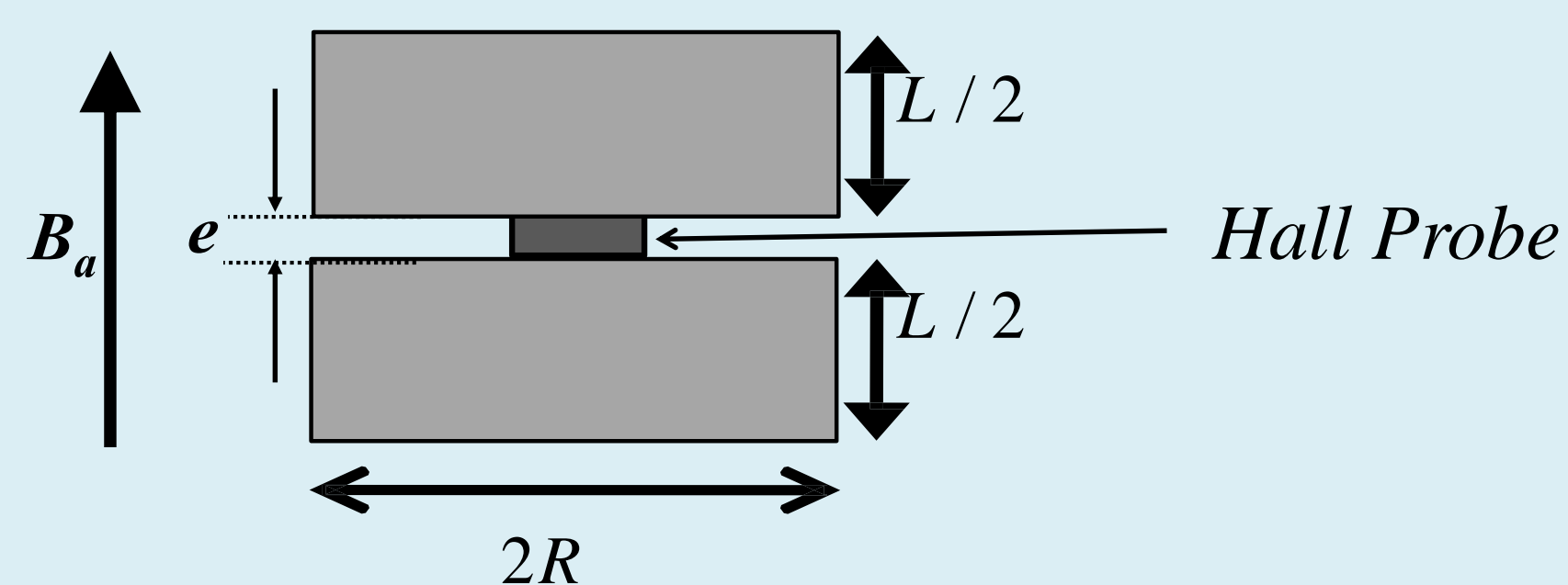
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Abstract

The characterization method of High Temperature Superconducting (HTS) bulks developed by GREEN lab described in previous papers is based on the measurement of the complete penetration magnetic field B_P . This characterization method allows determining the critical current density J_c and the n -value of the power law. The J_c inhomogeneity in axial and radial directions has to be taking account in the process of characterization. Especially the position of the hall sensors related to the seed of HTS bulk is very important and is studied and described in this paper. Many experiments were made to demonstrate this and numerical simulations were developed at the same time to validate theoretical deductions. This work should be a real improvement for the characterization of superconducting bulks.

Determination of J_c from measurement of B_p

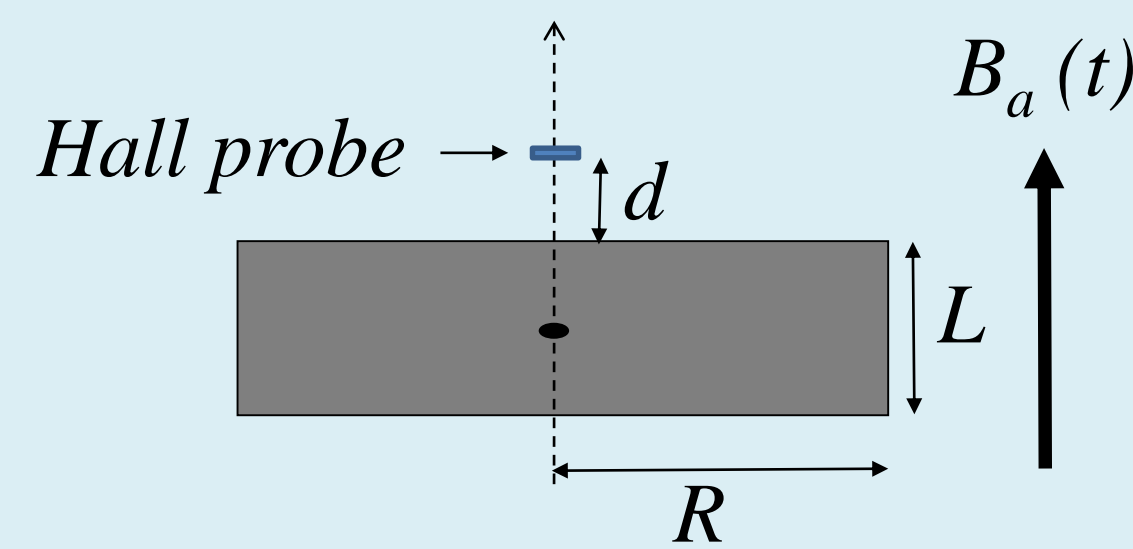
Calculation of B_P for two pellets



$$B_{PB} = \frac{\mu_0 J_c L}{4} \text{Ln} \left(\frac{\sqrt{R^2 + (L/2)^2} + R}{\sqrt{R^2 + (L/2)^2} - R} \right) \quad (1)$$

$$\begin{cases} B_P = B_{PB} \left(1 + \frac{\alpha \text{Ln} V_b + \beta}{n} \right) \\ \alpha = 1.2, \beta = 3.4, n = 50 \end{cases} \quad (2)$$

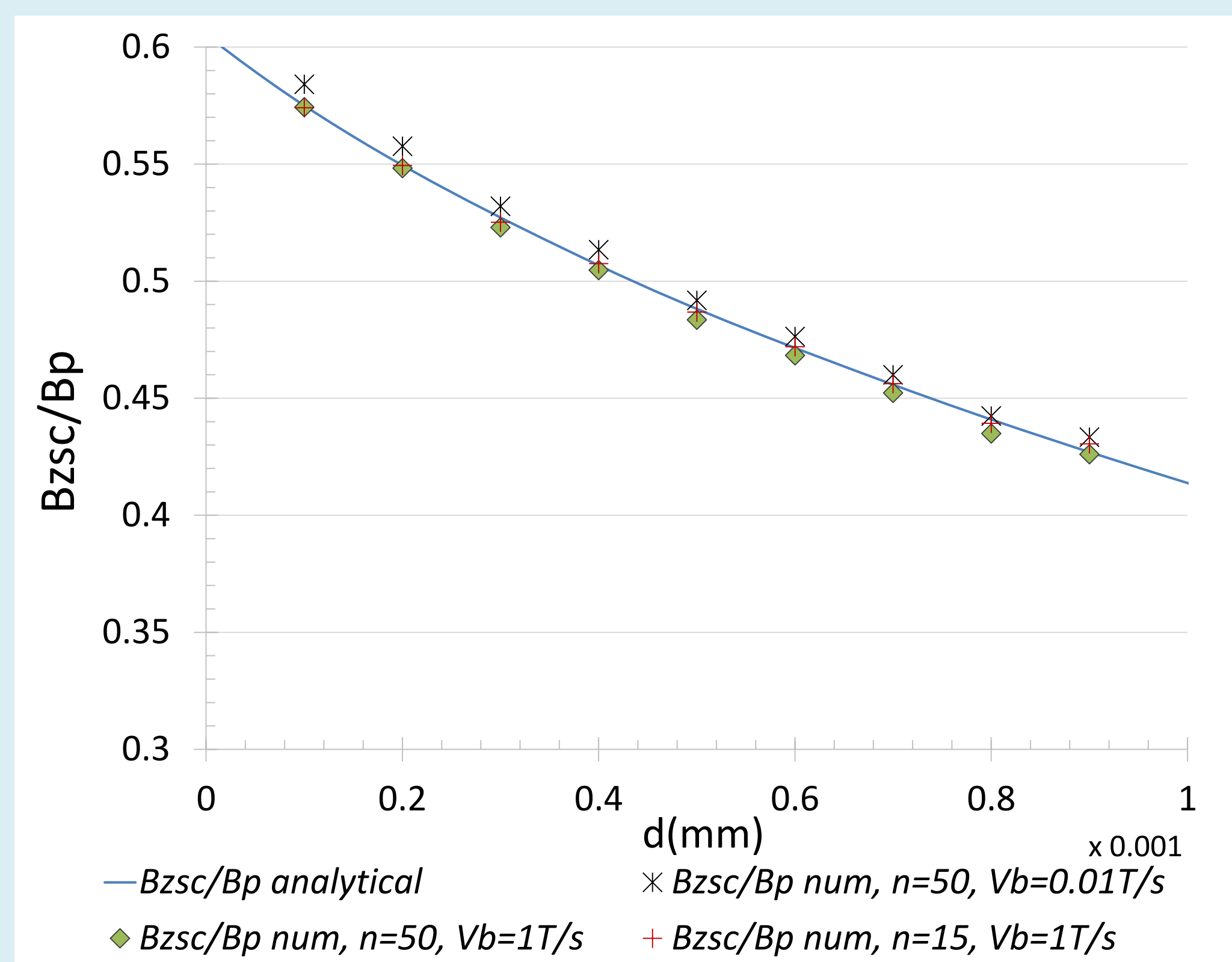
$$B_{Pm} (e = 1 \text{ mm}) = B_P (0.0350 \text{Ln}(L) + 0.7233) \quad (3)$$



$$B_{ZSC}(d, R, L) = \frac{\mu_0 J_c}{4} \left[(d+L) \text{Ln} \left(\frac{1 + \frac{R}{\sqrt{(d+L)^2 + (L/2)^2}}}{1 - \frac{R}{\sqrt{(d+L)^2 + (L/2)^2}} \right) - d \text{Ln} \left(\frac{1 + \frac{R}{\sqrt{d^2 + (L/2)^2}}}{1 - \frac{R}{\sqrt{d^2 + (L/2)^2}} \right) \right] \quad (4)$$

Analytical calculation of B_{ZSC} at $B_a = B_P$

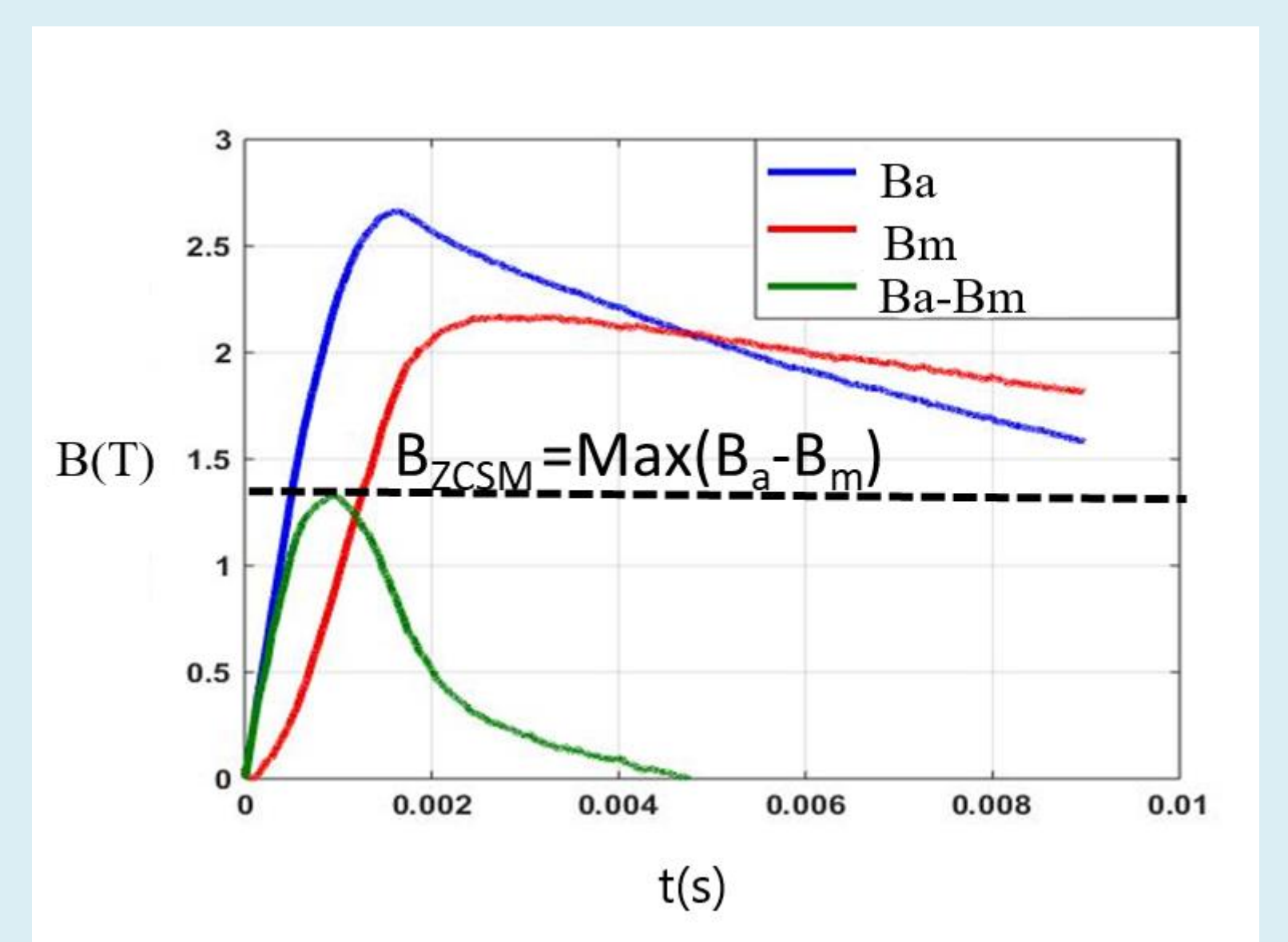
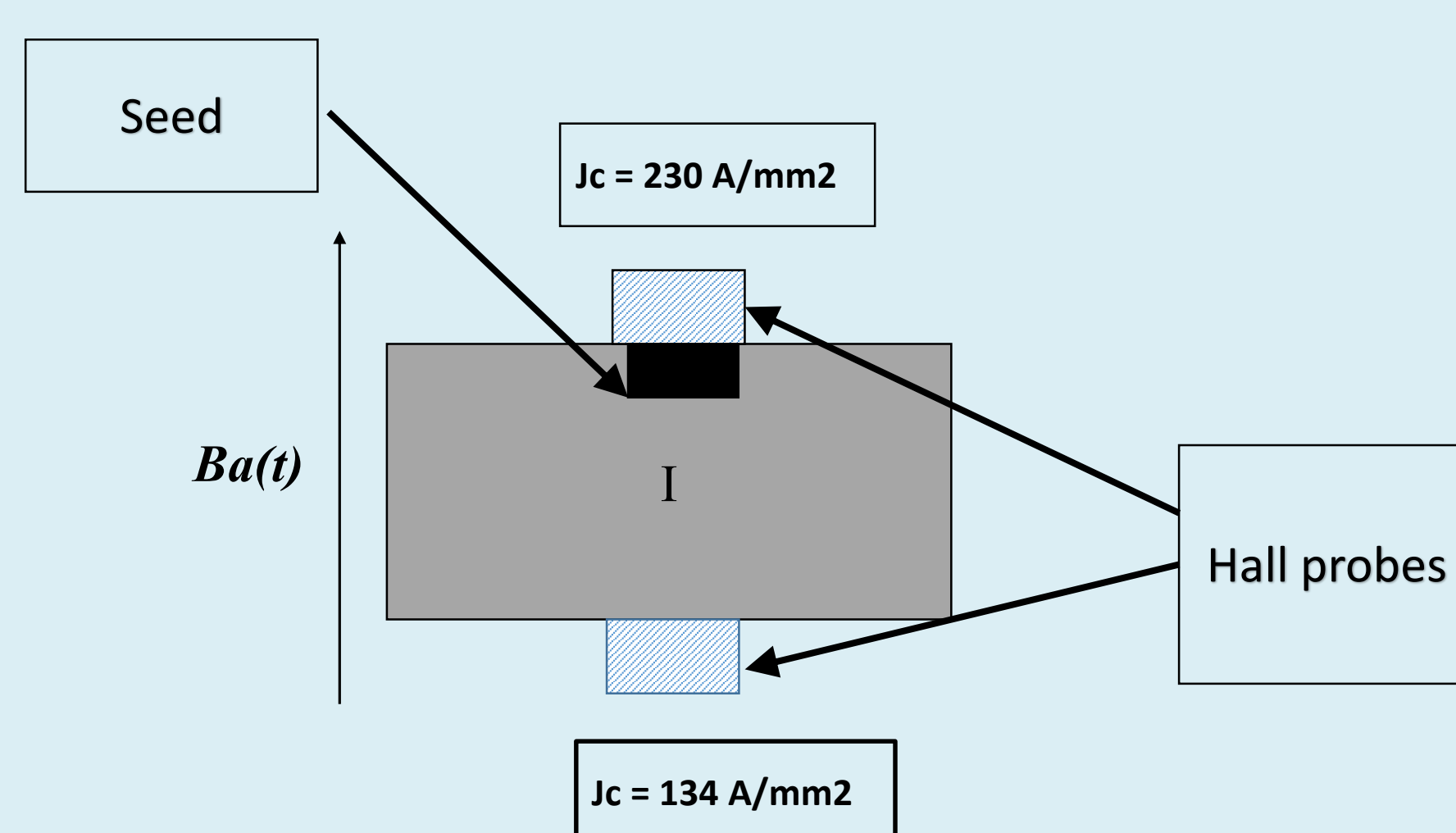
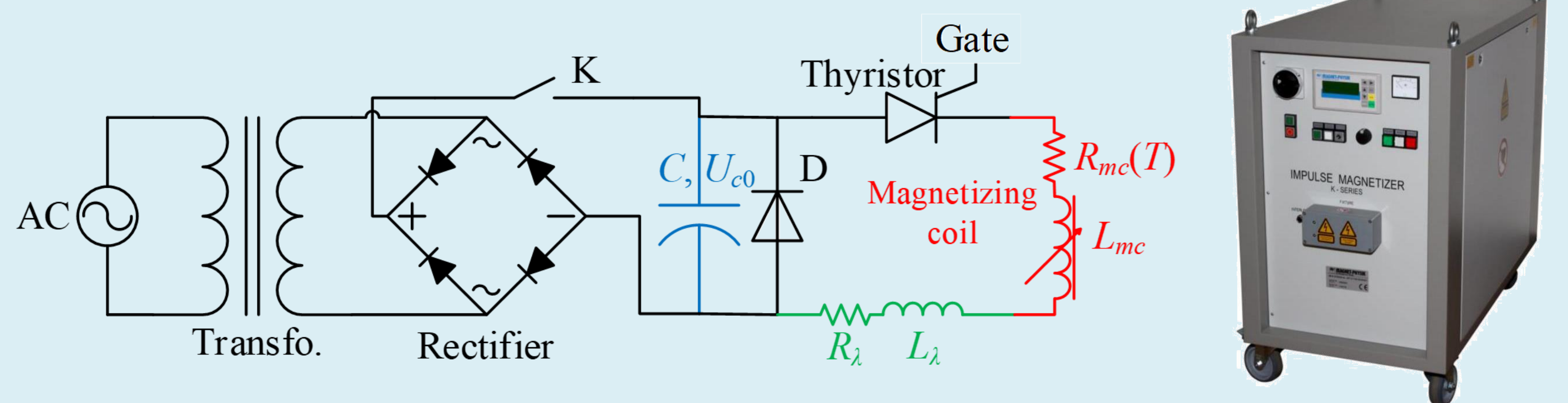
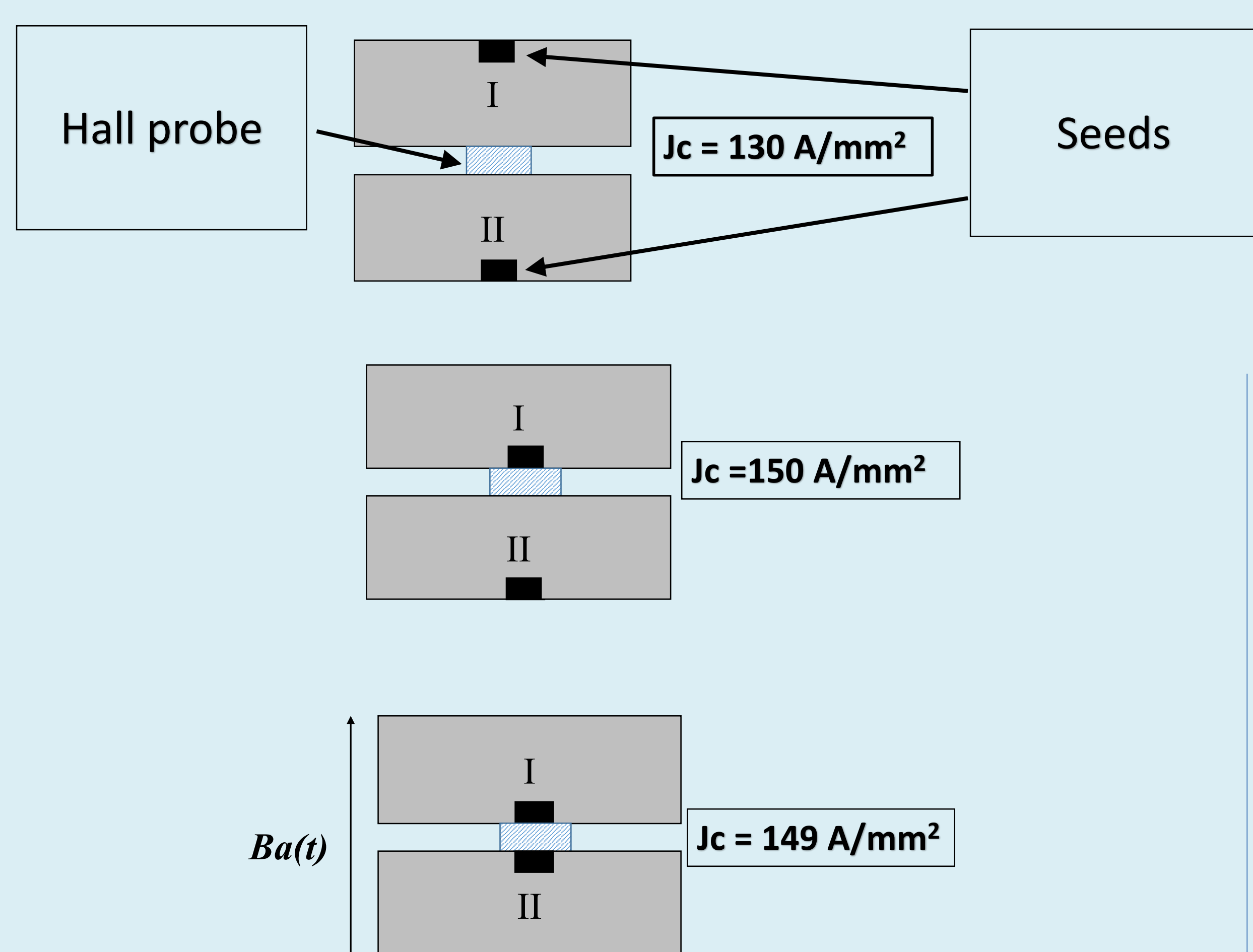
Calculation of B_P for one pellet



Analytical and numerical calculation of B_{ZSC}/B_P

$$B_P = (B_{ZSC}/B_P)_{analytical} \cdot (B_a - B_z)_{max} \quad (5)$$

Highlighting the inhomogeneity of J_c



Conclusions and prospective

- The position of the hall sensors related to the seed of HTS bulk has to be take into account in the process of the characterization of HTS bulks
- Many experiments were necessary to confirm it
- Association of experimental results and numerical simulations will be necessary to validate our characterization methods
- A new model with different J_c in different parts of the HTS bulks is necessary

References

- [1] B. Douine, C.H. Bonnard, F. Sirois, K. Berger, A. Kameni, J. Leveque "Determination of J_c and n -value of HTS Pellets by Measurement and Simulation of Magnetic Field Penetration" IEEE Trans. on Appl. Supercond., vol. 25 (4), 2015.
- [2] B. Douine, K. Berger, C.H. Bonnard, F. Sirois, A. Kameni, J. Lévêque, Improved Method for determining the n -value of HTS bulks, "IEEE Trans. on Appl. Supercond., vol. 26 (3), 2016.