Simulation of DBS Selective field deformation in the proximity of white matter pathways

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Introduction: Deep brain Stimulation (DBS) has been recently tried as symptomatic treatment in psychiatric disorders such as depression [1]. Even though DBS' mode of operation is not completely understood, the activation of white matter structures is a key to success. Since this tissue is less electrically homogenous as hoped for, the spatial distribution of the electric field has to be considered and put into simulations[3,4].

Figure 1. 240 reconstructed Medial Forebrain Bundles from DTI MRI image of one patient (Left), same data imported in COMSOL (Right)

Computational Methods:

The second derivative of the electric potential along the axons is thought to be crucial for fiber activation[3]. The purpose of this study is to investigate which effect the presence of the elongated and highly structured medial forebrain bundle (MFB) has on the electric potential and the activation function generated by a DBS electrode implanted in human patient. As a first step, a simplified model of MFB, straight cylinders with features similar to axons, are modeled in COMSOL.

Results: Number of fibers, diameter, and physical characteristics of fibers such as electrical conductivity and relative permittivity have impacts on the field distribution.
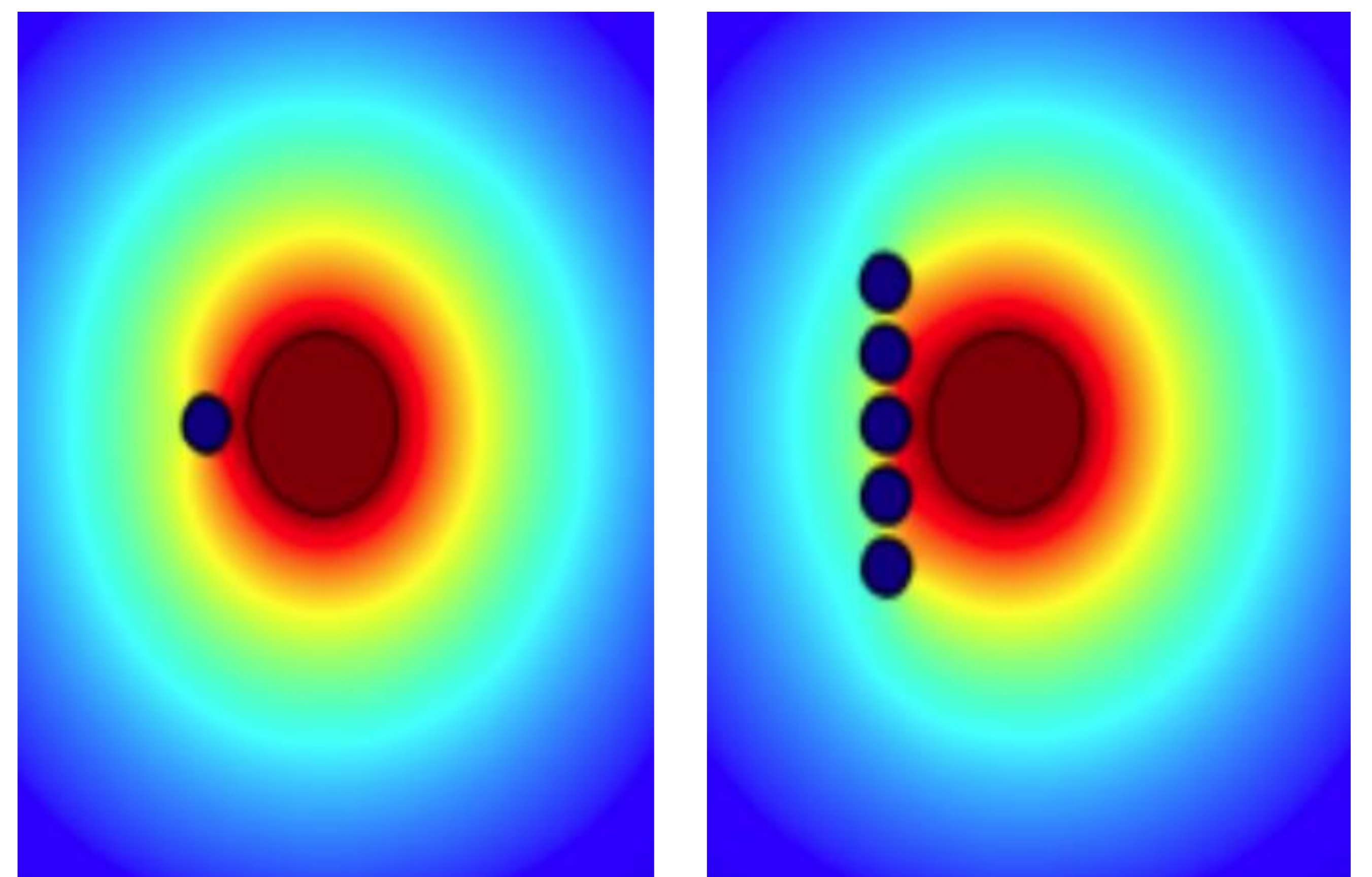

Figure 2. Simplified models of MFB, show the effect of inhomogeneity on the electric potential caused by presence of the fibers
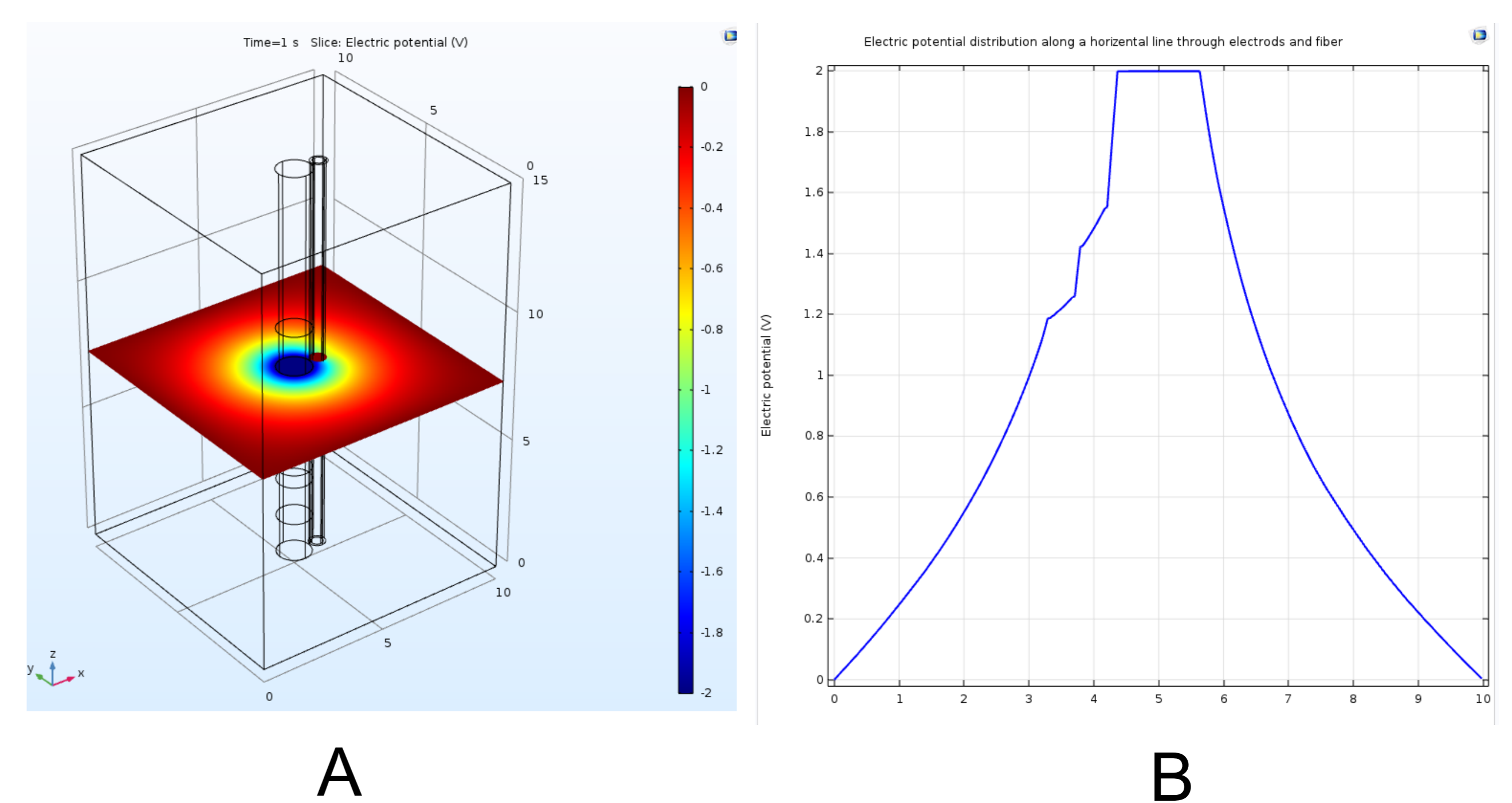

A   B

Figure 3. (A) simplified model of MFB and electrode (B)Electric field distribution along the midsection of figure 2 which depicts the difference with and without simulated fibers.

Conclusions:
We were able to show a field distorting effect on DBS relevant fields by the presence of inhomogeneous fiber bundles. This study will be extended to real human fiber bundle data imported in COMSOL

References:

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