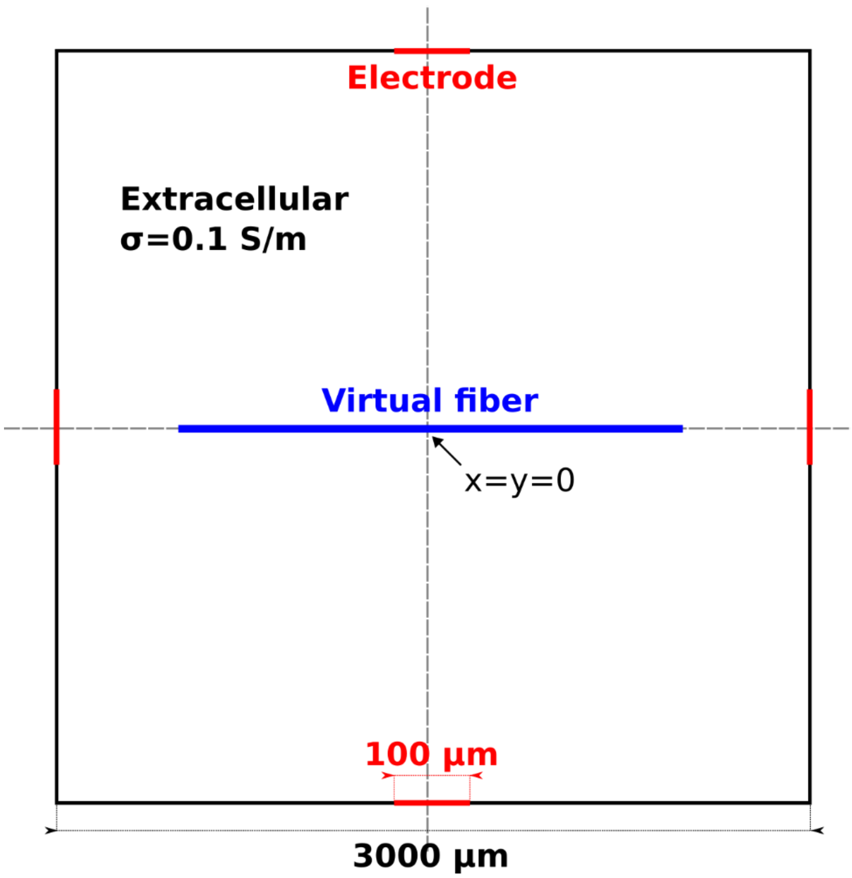
Exercise 4 (18 pts in total)

Get familiar with Agros2D (http://www.agros2d.org/). Every FEM computation consists of multiple steps: i) drawing of a geometry, ii) setting boundary conditions, iii) specification of the problem, iv) meshing (spatial discretization), v) solving the problem vi) post-processing of the results. Hint: You have to convert all units to SI units (meters etc.).

1. Open a new file in Agros2D and Add a *Current field* with standard properties. In *Preprocessing*, create a quadratic extracellular space (black) 3x3 mm in size. Add 4 stimulating electrodes (red, 100 µm length/diameter) to each edge. Add a label and create a new material Extracellular (Parameter σ=0.1 S/m) and apply it to the label. Create two boundary conditions: 1) Ground with a *Fixed voltage* of 0 V and 2) Electrode with a *Current density* of 1e-6 / (50**2*3.14*1e-12) A/m^2, i.e., 1 µA on a disk electrode with radius 50 µm. Apply the Ground boundary condition to the outer walls of the extracellular space (black) and the Electrode boundary condition to each electrode (red). Run *Mesh area* followed by *Solve*. Now you should see the distribution of the electric potential within the extracellular space. Describe the result and describe whether the solution is accurate or not. (**4 pts**) Go to *Chart* and plot the electric potential along a line from -1000 to 1000 µm on the X axis (Y=0 µm) as well as a line close to the upper stimulating electrode (Y=1450 µm). Pick the *X* option as the *Horizontal axis* and select 500 *Points*. Describe the potential distribution along the two lines regarding its accuracy. (**2 pts**)



2. In a next step refine the mesh sequentially from 1 to 3 iterations (*Properties*/*Current field*/*Mesh parameters*). Compare the resulting mesh in *Mesh* and potential distribution both in *Post 2D* as well as *Chart* along the two lines from task 1. Describe the changes with increasing number of refinements. (**2 pts**)

3. In *Chart*, export the potentials along the line [-1000/0,1000/0]. In HH_multi.py/m the file can be imported by specifying the *FEM* option for *elecType* as well as the *FEMfile* as exported. Calculate the anodic and cathodic threshold (accuracy 10 µA) (**1 pt**) for the exported potentials in two ways: 1) Scale the imported potentials in HH_multi.py/m by the stimulus amplitude *I*. 2) Set *I* to 1 µA and change the applied *Current density* directly in Agros2D by modifying the Electrode boundary condition. (**2 pts**) How do the results from the two approaches compare to each other? (**1 pt**)

4. Change the applied *Current density* in Agros2D back to 1e-6 / (50**2*3.14*1e-12) A/m. Set the upper and lower electrode's boundary condition to Ground and export the computed potentials. Do the same for the left and right electrode (upper and lower electrode are now active again). Compute the anodic and cathodic threshold (accuracy 10 µA) for the two configurations (i.e., left/right or upper/lower active) and compare them to the previous solution (all four electrodes active). (**3 pts**) Examine the location along the fiber where action potentials are initiated and compare it across the three electrode configurations. (**3 pts**)

Short meaningful answers underlined with screenshots of the results are appreciated. For programming tasks, also provide the source code.

After completion of all four exercises, send your reports including your name and student ID to paul.werginz@tuwien.ac.at.