It is well known that every human suffers lifetime axonal injuries caused by different factors: physical traumas, genetic diseases, inflammation, toxins etc., sometimes the damage takes the form of axonal swellings. The present study aims to investigate and assess the influence of axonal swellings on nerve impulse transmission between Ranvier nodes. We studied damaged axons in prepared samples of human brain white matter obtained postmortem from schizophrenia patients. In previous studies of electron micrographs of brain white matter slices it was shown that these characteristic changes in myelin structure (axonal swellings) are typical for schizophrenia disease. Although very important, those studies did not yield enough information on 3D properties of swellings crucial for modeling the electromagnetic signal propagation between Ranvier nodes. To collect this data we also performed volumetric study of brain white matter with nanometer resolution utilizing FEI® FIB/SEM Auto slice&view© technique as well as transmission electron microscopy methods (electron tomography) in the present study. Based on the data obtained, we were able to incorporate true 3D shapes of axonal swelling deforming myelin sublayers into our model. The model simulations of electromagnetic impulse propagation along axon body between Ranvier nodes has shown that such axonal swellings will cause weakening, loss, or deformation of neural pulse shape - in the same way the waveguide with distorted geometry causes signal loss or distortions. The simulation was performed on a 3D model describing the myelin layer (this area did not contain Ranvier nodes or para-nodes) as a dielectric waveguide with intracellular and extracellular liquids serving as its boundaries. The axonal swellings were supposed to have the same electromagnetic parameters as the intracellular media. In accordance with this model we performed computer simulation of electric field distribution within myelin layer and demonstrated the influence of myelin damage on signal loss during nerve impulse transmission between Ranvier nodes.

Acknowledgement: Authors want to acknowledge Natalia Uranova (Mental Health Research Center, Moscow, Russia) for helpful and critical discussions.