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Picosecond Pulse Delivery to Biological Tissue by a Dielectric Rod Antenna

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Picosecond pulsed electric fields in the range of 20 kV/cm can affect electrically excitable cells such as neurons. A noninvasive applicator in the form of a wideband dielectric rod antenna was designed to achieve these ends in the brain. The antenna consists of three sections (a conical wave launcher, cylindrical waveguide, and conical emitting section). In a simulation utilizing a human voxel model, the dielectric rod antenna was able to deliver pulses to brain tissue. The electric field in the brain tissue at a depth of 2 cm was 11.5 V/m. To create the critical electric field for biological effects at this location, the input voltage needs to be 175 kV. The spot size at this depth is approximately 1 cm2. In order to confirm the accuracy of the simulation an experimental study of the conical launching section was conducted in free space. The results set the foundation for high voltage in situ experiments on the complete antenna system and the delivery of pulses to biological tissue. Finally, to improve the design we show simulation results of a dielectric rod antenna which integrates a collimating lens. By collimating the rays emitted from the conical launching section it is possible to reduce the losses along the dielectric rod, decrease the scattering off of the end of the emitting section, and increase focusing. In terms of the antenna's performance, this reduces the beam width and increases the antenna gain. This allows for more efficient delivery of pulsed electric fields to the brain tissue. One can also use this device for superficial targets, such as skin.

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