# Selective Focusing of Ultrawideband Fields in Dispersive and Continuous Random Media via DORT

**M. E. Yavuz and F. L. Teixeira**
The Ohio State University, USA

In lossless and stationary media, invariance of the wave equation under time-reversal (TR) enables optimal refocusing of time-reversed signals. In practice, this can be achieved using a TR antenna array (TRA), where received signals due to a (unknown) scatterer(s)/source(s) are retransmitted back to the original media in a time-reversed fashion. As the time-reversed signals backpropagate in the medium, they interfere constructively (due to phase conjugation) at the original source position(s) resulting in focusing capabilities that can be used to aid in detection and imaging problems. Under certain conditions, focusing obtained by TR can even outperform the classical diffraction limit, characterizing *superresolution*. Ultrawideband (UWB) operation and multiple scattering in the background media are some of the factors that can enhance the focusing resolution in TR applications via frequency decorrelation and spatial decorrelation, respectively. As a result, TR techniques can be particularly attractive in scenarios where strong multiple scattering occurs. Such conditions exist, for example, in subsurface sensing applications where the intervening soil media are in general inhomogeneous. However, information about the soil constitutive parameters is often incomplete and can only be described in a statistical sense via random medium models. A further advantage of TR techniques in this case is that, under UWB operation, they are *statistically stable*, i.e., they do not depend on the particular realization of the random media, but only on its statistical properties.

Here, we apply a method based on the decomposition of the time-reversal operator (DORT) to study a selective focusing approach for UWB subsurface sensing scenarios where the inhomogeneity of soil medium is modeled by *continuous* random medium models with prescribed first and second order statistics (spatially fluctuating random permittivities and correlation functions), and including frequency dispersive effects.

In order to exploit the UWB operation, this method is implemented over the entire available bandwidth in a consistent fashion. While direct TR would produce focusing around all scatterer locations, DORT allows *selective* focusing on the desired scatterer(s). We will study the effects of first and second order medium statistics on the DORT performance and focusing properties. Since frequency-dispersion breaks the TR invariance, several compensation methods for dispersive effects will be compared. Noise sensitivity of the eigenvalues (and corresponding excitation eigenvectors) will be studied towards using it as a criterion to distinguish (distributed) background clutter eigenvalues from those that correspond to distinct (discrete) scatterers. Throughout this study, we restrict ourselves to limited aspect array configurations.