# BIOENGINEERING
# Spring 2019 Seminar

**Date:** Thursday, April 4, 2019
**Time:** 12:00 pm - 1:00pm
**Location:** Krasnow, Room K229

## Samuel Patz, Ph.D.

**Biography:** Dr. Samuel Patz received his PhD in Physics from Brandeis University in 1979 where he used NMR as a tool to measure the critical behavior of an antiferromagnet. He spent two years as a postdoc at Brandeis and then worked at Xerox in Rochester, NY as an applied research scientist. He decided to return to academia in 1983 when the field of MRI was just getting started. He joined W.S. Moore and R.C. Hawkes at Harvard Medical School and the Brigham and Women's Hospital (BWH) as a postdoc. By 1986, Patz and Hawkes developed a novel method to measure slow fluid flow using a technique known as Steady State Free Precession (SSFP) and resulted in Patz receiving his first NIH R01 grant in 1987. In the early 1990's, Patz and colleagues M. Hrovat and Y.M. Pulyer developed a novel nonlinear spatial encoding methodology for MRI based on a periodic and linear field: Axsin(ky). In the mid-1990's, Patz became interested in a new technology known as hyperpolarized noble gas MRI. This technology uses a laser to magnetize either $^{3}$He or $^{129}$Xe gas to polarization levels that are ~$10^{5}$ times larger than the typical Boltzmann polarization achieved by a high field MRI scanner. Together with colleagues from the Harvard Smithsonian Center for Astrophysics, this technique was used to study gas diffusion in porous media. This naturally led to applying this technology to the lung and this is an area where Patz then devoted a substantial portion of his effort for the next twenty years. His pulmonary MRI group obtained the world's first human images of gas exchange using $^{129}$Xe MRI. They also developed an analytical model that is currently used to model the septal uptake of xenon after inhalation. Interest in the lung also led to development of a portable, low field, permanent magnet MRI device, called the Lung Density Monitor (LDM). The LDM, which is still an active project, is designed to be used in the medical ICU to assist pulmonologists in setting safe mechanical ventilation pressures in order to avoid ventilator inducted lung injury. Six years ago, Patz became interested in Magnetic Resonance Elastography (MRE). Through a strong collaboration and assistance from R. Sinkus of King's College London, who is one of the pioneers of MRE, a program in mouse brain MRE was begun. What we discovered, and which is the subject of this talk, is a completely new type of MRI contrast, i.e. a change in the shear modulus that depends on external functional stimulus. In analogy to fMRI, we call this functional MRE or fMRE.

**Title:** Imaging Localized Neuronal Activity at Fast Time Scales through Biomechanics

**Abstract:** Mapping neuronal activity noninvasively is a key requirement for neuroscience. Traditional functional Magnetic Resonance Imaging (fMRI) is based on a neuro-vascular coupling that has a temporal response of seconds and hence cannot measure high-level cognitive processes evolving in tens of milliseconds. To advance neuroscience, imaging of fast neuronal processes is required. In this talk, I will present results showing that there is a neuro-mechanical coupling that has a much faster temporal response than traditional fMRI. Results will be presented both from mice where a repetitive electric stimulation was applied to the hind limb together with more recent preliminary data from humans where a visual stimulus was used. To demonstrate a neuro-mechanical coupling, we utilized a new version of magnetic resonance elastography (MRE) that allows fast comparison of two functional states – we call this functional MRE or fMRE. In mice, we show brain stiffness changes of ~10% in response to repetitive electric stimulation of a mouse hind paw over two orders of frequency from 0.1 to 10 Hz. We demonstrate that regional patterns of stiffness modulation are synchronous with stimulus switching and evolve with frequency. For very fast stimuli (100 ms), mechanical changes are mainly located in the thalamus, which is the relay location for afferent cortical input. Preliminary data in humans is in progress and we have been able to demonstrate both a slow and fast neuro-mechanical coupling that we believe are coupled to two different physiological responses to a stimulus that occur at different time scales. In summary, our results demonstrate a new methodology for noninvasively tracking brain functional activity at high speed.

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