

# Siemens Competition

## Math : Science : Technology

### National Finalist

**Name:** Andrew Chen

**High School:** Mission San Jose High School

**Mentor:** Dr. Xiaodong Tao, University of California, Santa Cruz

**Project Title:** *Enhancing Imaging Resolution and Depth With Adaptive Optics Focal Modulation Two-Photon Microscopy*

Optical microscopy is a fundamental tool for imaging biological samples and making new scientific discoveries. However, imaging resolution and imaging depth are restricted by aberrations and background noise, which result in image distortion and blur. The introduction of spatial time-variant aberrations at the focal plane (focal modulation) of a two-photon microscope with adaptive optics enabled the desired signal to be separated from the background fluorescence and scattering noise. A fast algorithm was developed to perform spectral analysis. Adaptive optics also removed system aberrations so that only photons from the very small focal region can be detected, which substantially increases image resolution and contrast.

For regular microscopy, visualization stops at about 10 microns of tissue depth. However, fluorescent microbeads up to a depth of 600 microns could be imaged in an artificial tissue sample with adaptive optics focal modulation two-photon microscopy. The measurements showed that the lateral resolution was more than doubled and the signal-to-noise ratio was improved by 7 dB at a depth of 500 microns. This novel method allows optical sectioning and near diffraction-limited spatial resolution to be achieved when imaging deep inside a highly scattering medium.