Ultrafast Switching Multi-Plane Neural Imaging via Acousto-Optic Deflector and Remote Focusing

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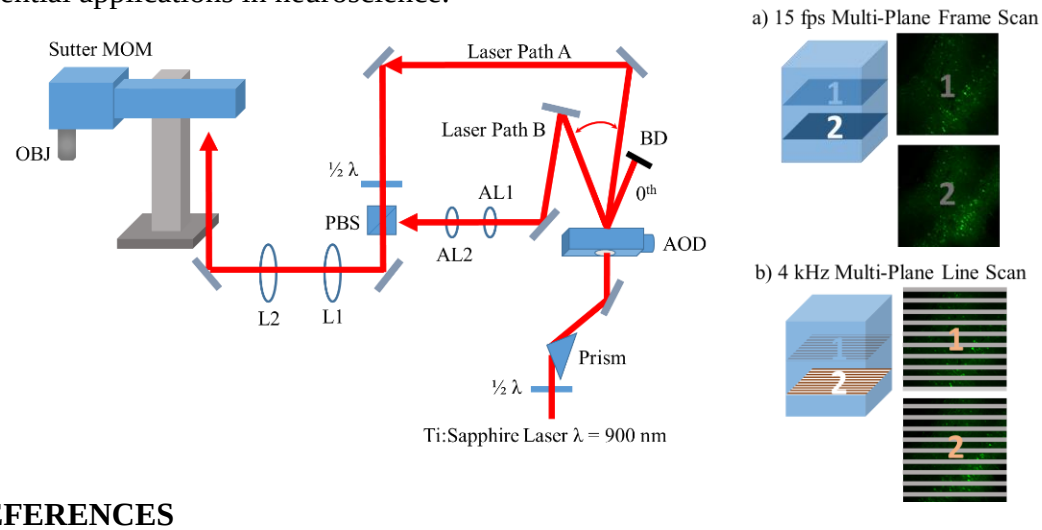
ABSTRACT

Decoding mouse brain activities can be challenging, as neural signalling is not confined to two-dimensional network structures but extends further into three-dimensional volumes. Fast volumetric imaging is therefore a preferred choice of imaging neurons tagged with calcium indicators like GCaMP, thus monitoring the dynamics of neuron action potentials, when compared with the conventional two-dimensional scanning with axial translation. Considering that, we have developed a pseudo-parallelised multi-plane two-photon excitation imaging system by combining acousto-optic switching and remote focusing techniques into a resonant scanning microscope. This enables fast plane refocusing, without moving the objective lens, on a switchable frame-by-frame or line-by-line imaging schemes. While remote focusing systems offer aberration-free axial scanning over a few hundred micrometres of depth, the acousto-optic deflector provides high speed optical switching between different laser beam paths on the sub-microsecond timescale [1, 2]. Combining these permits the recording of millisecond fluorescence transients from large population of neurons at multiple axially displaced planes without compromising the image quality. Here, we report on the development of the ultrafast multi-plane functional imaging system and demonstrate its potential applications in neuroscience.



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