# Ephus: A Suite Of Software Tools For Electrophysiology and Circuit Mapping

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## Overview

Advanced neurophysiology experiments often integrate multiple types of measurements and demand flexibility in the specification and use of multiple channels for data I/O. There is an increasing need for software to coordinate and automate these measurements. Such software needs to meet multiple possibly conflicting demands: while it should provide intuitive graphical user interfaces for ease of use, it must also match the workflow of a large variety of experiments even within a single laboratory, requiring strategies to customize the function and the 'look and feel' of the application. We present progress in the development of a software package, **Ephus** 2.0, designed for neurophysiology laboratories. **Ephus** is designed for general-purpose data acquisition and instrument control.

**Ephus** consists of a number of object-like modules or programs (e.g. a *Stimulator*, *Acquirer*, *Ephys*, *Photodiode*, *QCam*). **Ephus** acquires data from patch clamp amplifiers and a variety of other devices through AD channels. Similarly, it controls a number of devices through DA (e.g. scan mirrors, and patch clamp amplifiers) and DIO (e.g. shutters) channels. **Ephus** enables complex multi-channel cellular electrophysiology experiments and image acquisition through control of CCDs. One specialized program, the *Mapper*, links laser scanning and electrophysiological measurements; this allows laser scanning photostimulation circuit mapping (or photochemical microscopy).

**Ephus** is an open-source software project and can be downloaded at http://research.janelia.org/wiki/display/ephus

## Patching

Patching of live cells is facilitated through the use of a CCD control and display program (*QCam*). Physiological feedback is available to the user by running the CCD software in conjunction with a real-time oscilloscope display interfaced to patch clamp amplifiers, which also reports cell parameters (ie. series resistance, etc).
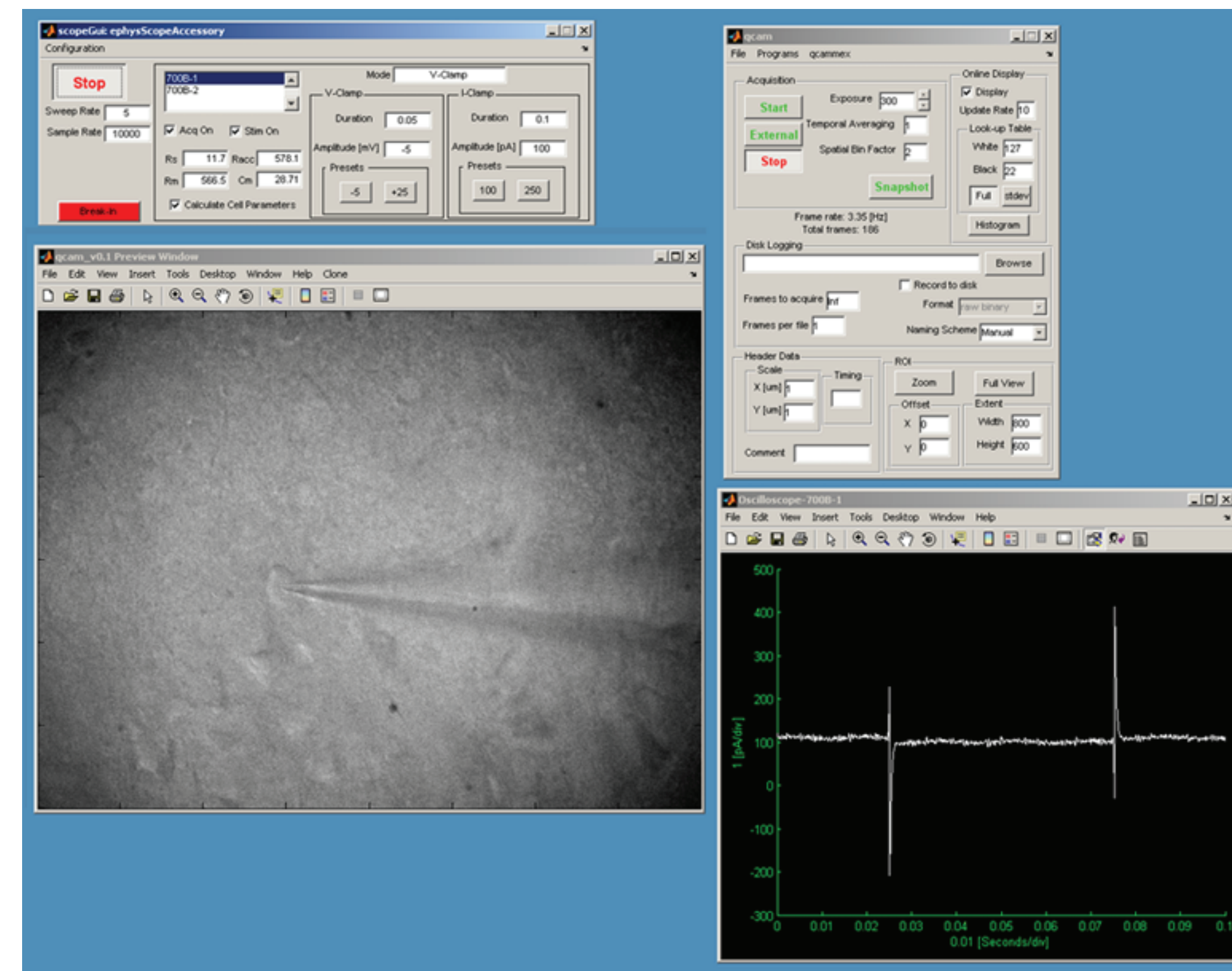
The interface has been refined to provide a simple and efficient workflow. This leaves users free to concentrate on finding and patching their desired cell, instead of worrying about the intricacies of a software interface.

## Electrophysiological Recording

Ephus provides a robust framework for electrophysiological recording, which allows numerous experiments to be designed quickly and easily. Modest efforts in customization allow virtually arbitrarily complex experiments. Ephus provides the following features:

**Multi-channel recording.** An arbitrary number of amplifier channels may be recorded. In addition, the *Acquirer* offers the option of recording data from other devices (e.g. a photodiode).

**Loops with variable time precision.** Users may specify looping acquisitions based on a Windows multimedia timer (Matlab timer) or use of the data acquisition board's clock for higher precision.

**Rich cycle definitions.** One can define virtually arbitrary sequences of cycled data acquisitions. LSPS mapping can be reduced to a cycle.

**Custom output waveforms.** Users may create and output complex waveforms. These can be created on the fly during an executing cycle, allowing for closed-loop experimental control.
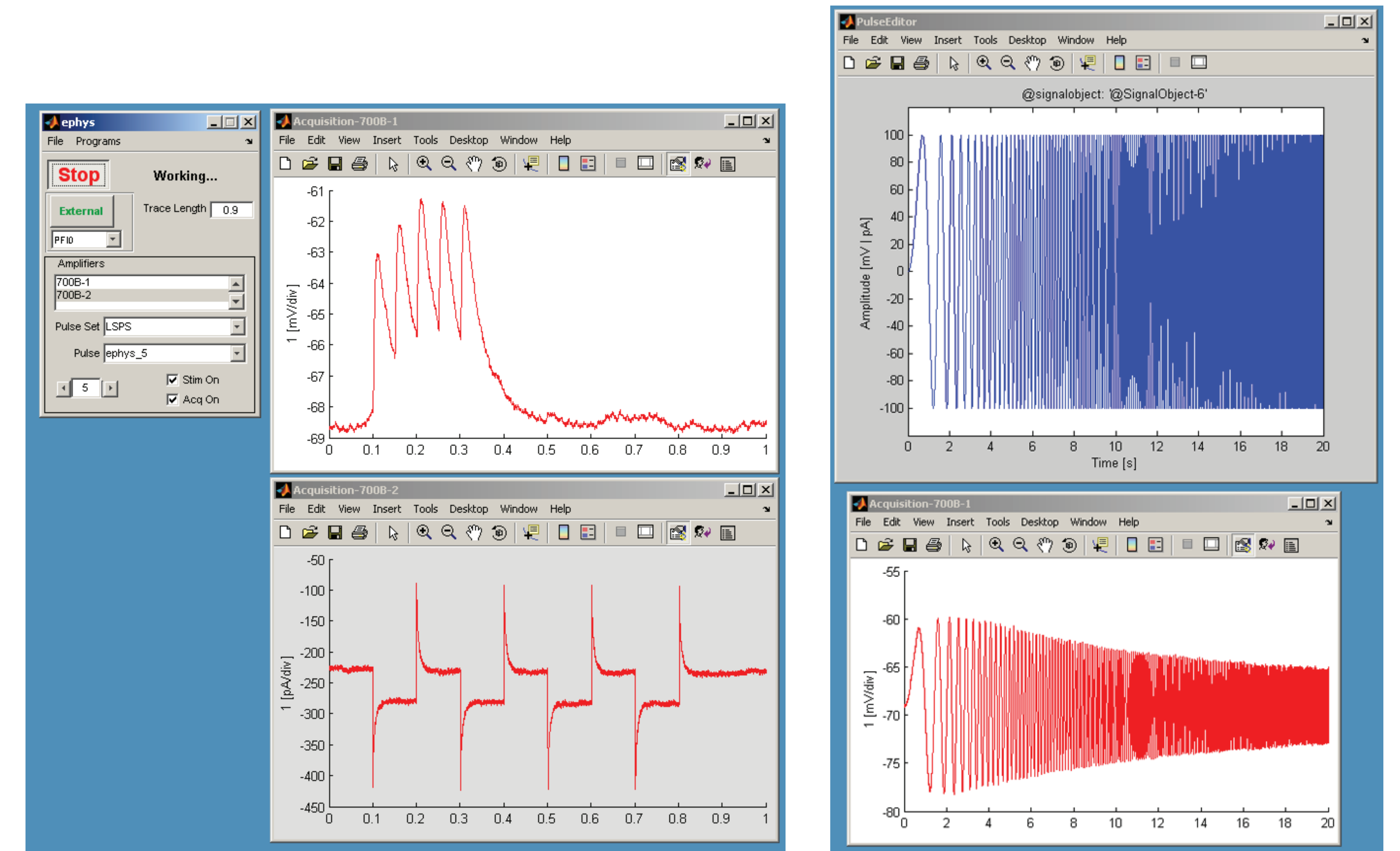
*Simultaneous recording of multiple independent channels.*

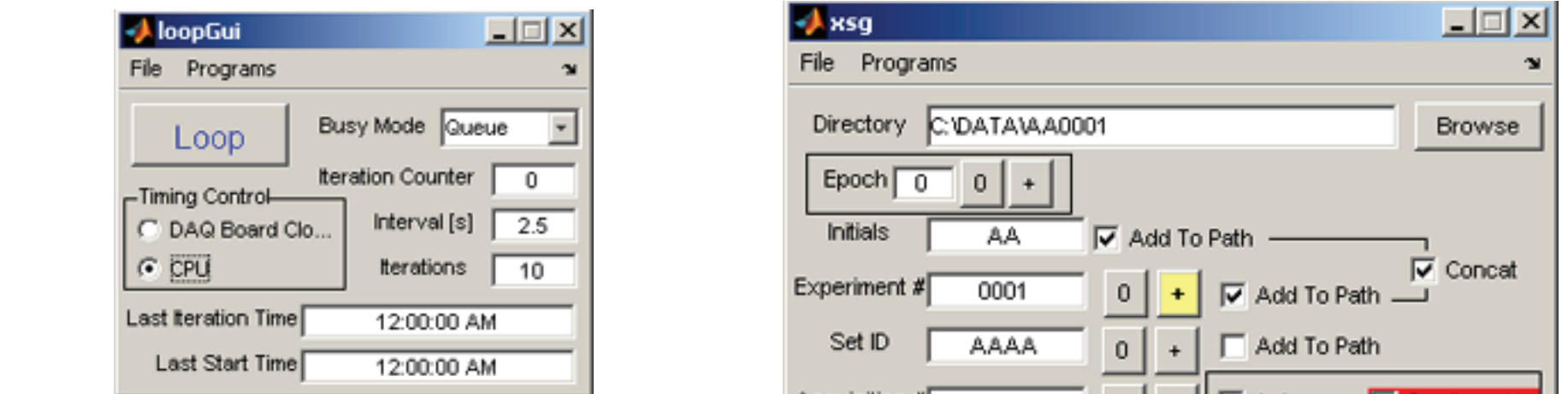*A complex stimulus waveform and the associated response.*

## Key Components

### Program Configurations

All Ephus programs are associated with configurations comprising the program properties (including location & visibility) which can be saved and loaded individually or en masse (configuration set). The Hotswitch program allows one to rapidly switch between experimental modalities in one click.

**HotSwitch** - Rapidly switch between user defined program configurations.

### Synchronization & Data Binding

Ephus programs defer core functionalities to centralized programs.

**loopGUI** - Syncronizes and schedules program actions.

**xsg** - Aggregates headers (program properties) and acquired data from all programs into a shared file.

### Extensibility

Ephus programs fire *events* to which custom *user functions* can respond

**userFcns** - Binds events and user functions.

### Hardware Support

Ephus supports A/D, D/A, and DIO channels (Nat Inst), amplifiers (Axon Inst) and QImaging CCD cameras. A single NI USB board can run an entire LSPS experiment.
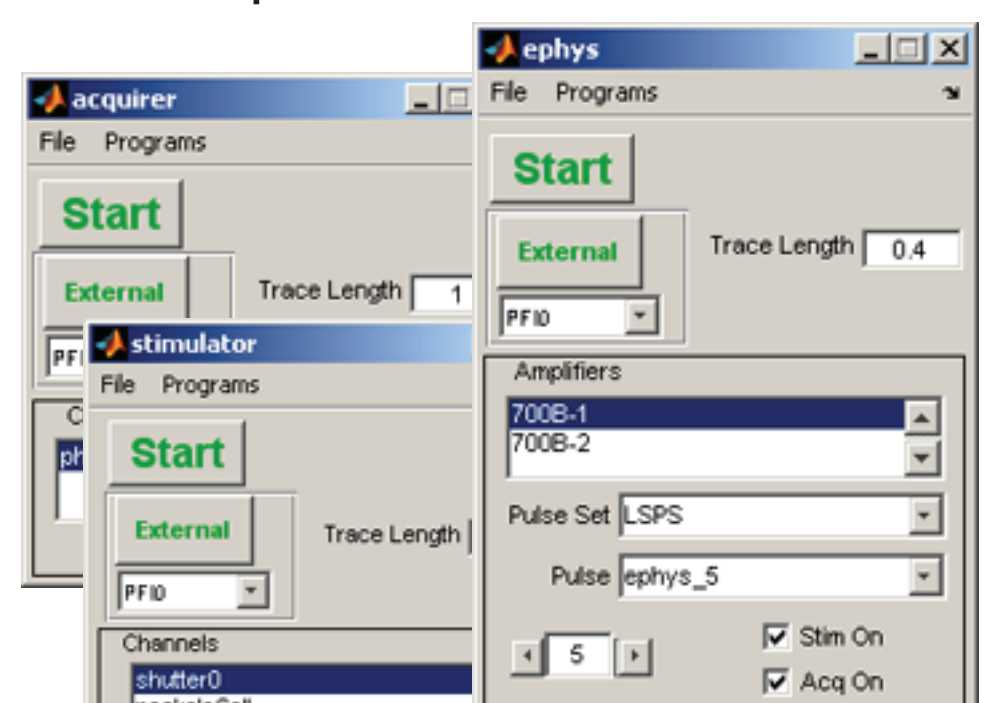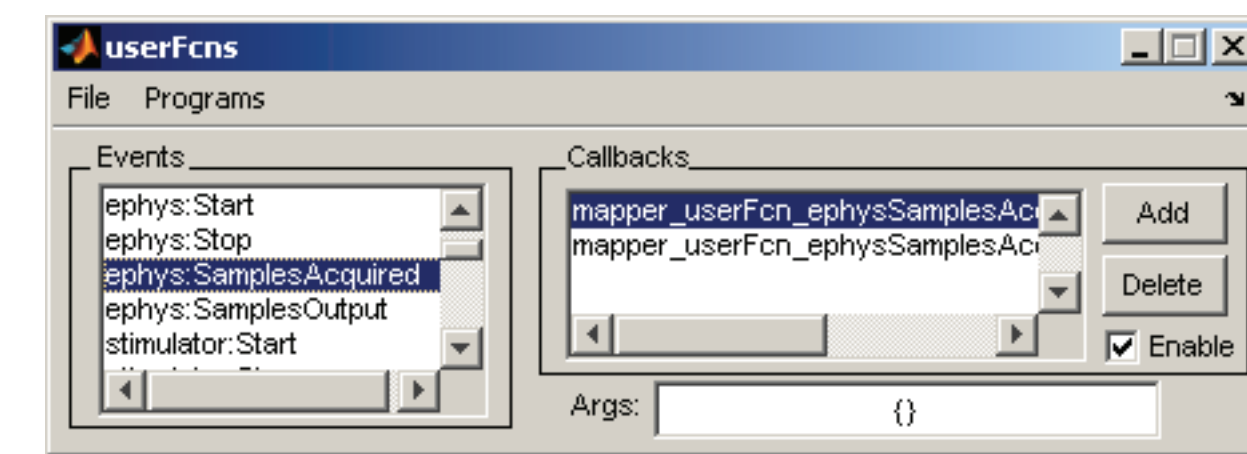
**acquirer, stimulator, ephys** - Core programs for I/O channels.
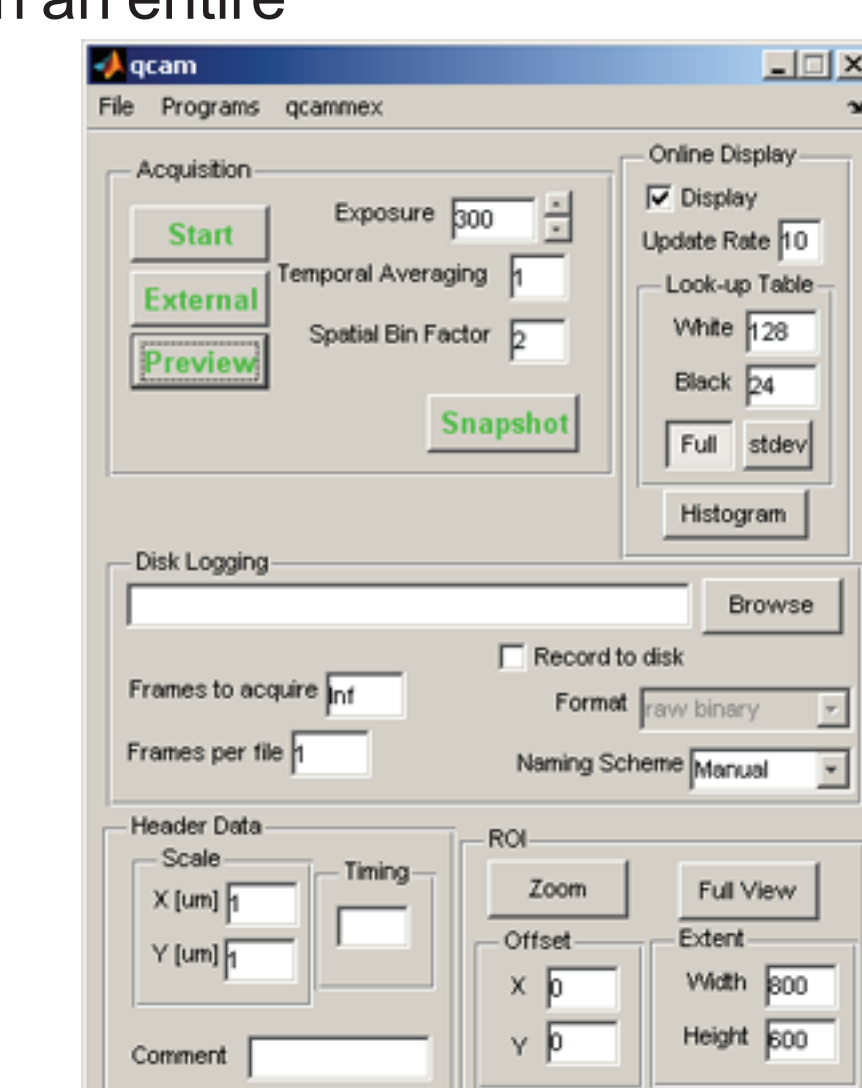
**qcam** - Provides full functionality for QImaging cameras within Ephus.

**mapper** - Specialized program for LSPS mapping; makes use of core programs and user functions

## Laser Scanning Photostimulation Mapping

The *Mapper* implements laser scanning photostimulation experiments. A major design principle was to have throughput limited only by the biology. The *Mapper* coordinates the core programs (*Acquirer*, *Stimulator*, *Ephys*) for data acquisition; this illustrates the flexibility of the system as a whole.
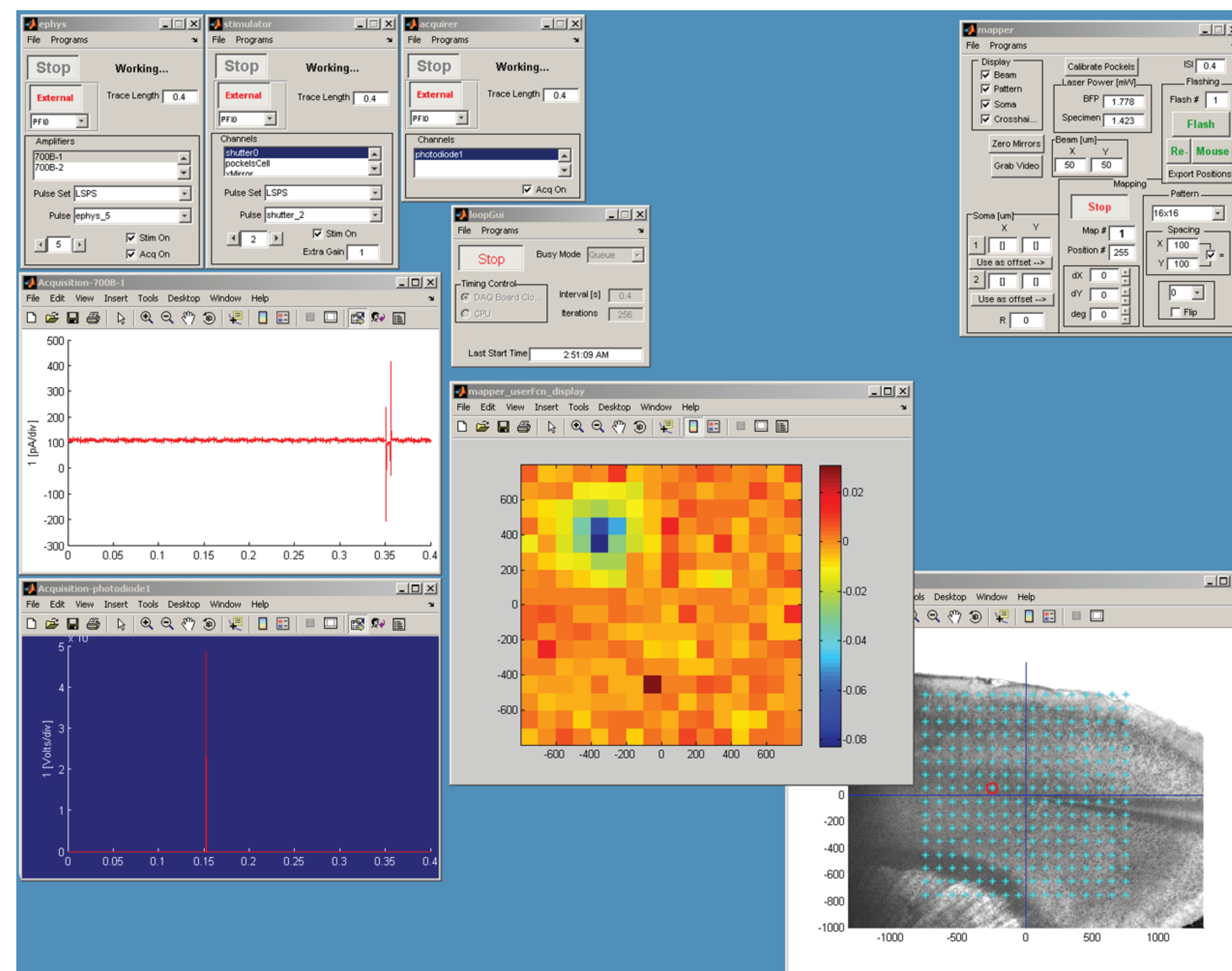
The *Mapper* features include:

**Customizable online analysis.** The *Mapper's* analysis routines are implented as user functions, allowing for customized analysis code to be implemented. It even allows for custom actions to be taken in response to a the analysis results.

**Simplified CCD alignment.** The tricky business of aligning scan mirrors to coincide with a CCD image, and the overlay of a map pattern on top of this image, is made simple.

**Customized optical stimulation.** The photostimulation is defined as a set of pulses, allowing for great flexibility.

**Works transparently with multiple lasers.** Switching between UV and blue lasers is simple.

**User definable map patterns.**

*Automated looping through a preconfigured cycle, using a series of varying current steps.*

## Download Info

*Ephus* is available for download on our wiki site:

**http://openwiki.janelia.org/wiki/display/ephus**

Registration is required. Since Summer 2008, over 100 labs worldwide (15 countries) have registered for *Ephus* or *ScanImage* -- a companion software package for laser scanning microscopy [SFN 485.2].