Beam Cruncher

Multi-camera beam alignment, tracking and profiling

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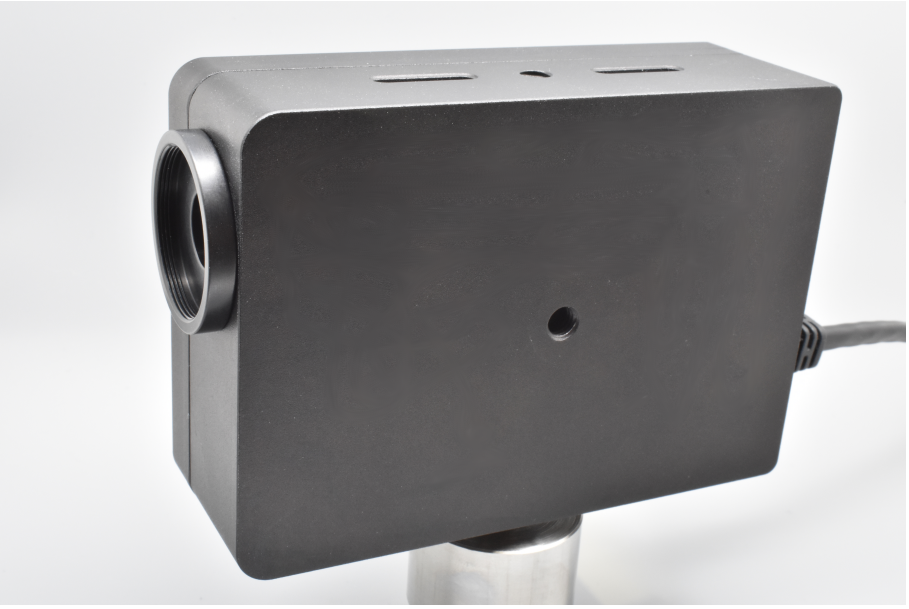


A Crunch Cam module, which acquires and processes beam image data.

Overview

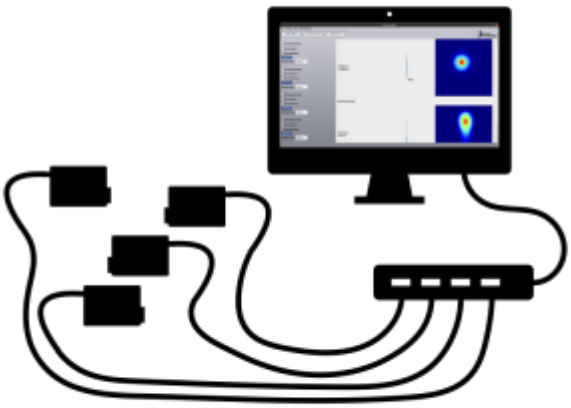
The Beam Cruncher laser diagnostic system was developed in order to assist researchers, engineers and technicians with alignment, tracking and characterization of laser beams. The software is capable of providing both qualitative and quantitative information regarding the shape, intensity, position, alignment and long-term drift of a beam.

Core Features

Beam Cruncher uses multiple, entirely self-contained Crunch Cam camera modules (shown above) which allows users to simultaneously align, track and characterize multiple beams. Through providing complete image data processing capabilities on each individual Crunch Cam, the Beam Cruncher laser diagnostic system is able to leverage the speed and efficiency of distributed computing to provide nearly instantaneous qualitative and quantitative data about all aspects of a user's laser system.

System Architecture

The Beam Cruncher laser diagnostic system consists of a client computer which runs the Beam Cruncher software and one or more Crunch Cam modules which acquire and process image data. All data collected and processed by each Crunch Cam module is then sent via a PoE (Power over Ethernet) Ethernet connection to a router connected to the Beam Cruncher client computer. This PoE Ethernet connection serves as both a data stream and power connection for the Crunch Cam.



Abstract diagram of the Beam Cruncher system architecture. Each of the Crunch Cam modules is connected to the Beam Cruncher client computer with a single Ethernet cable, which provides both a data stream and power for the Crunch Cam.

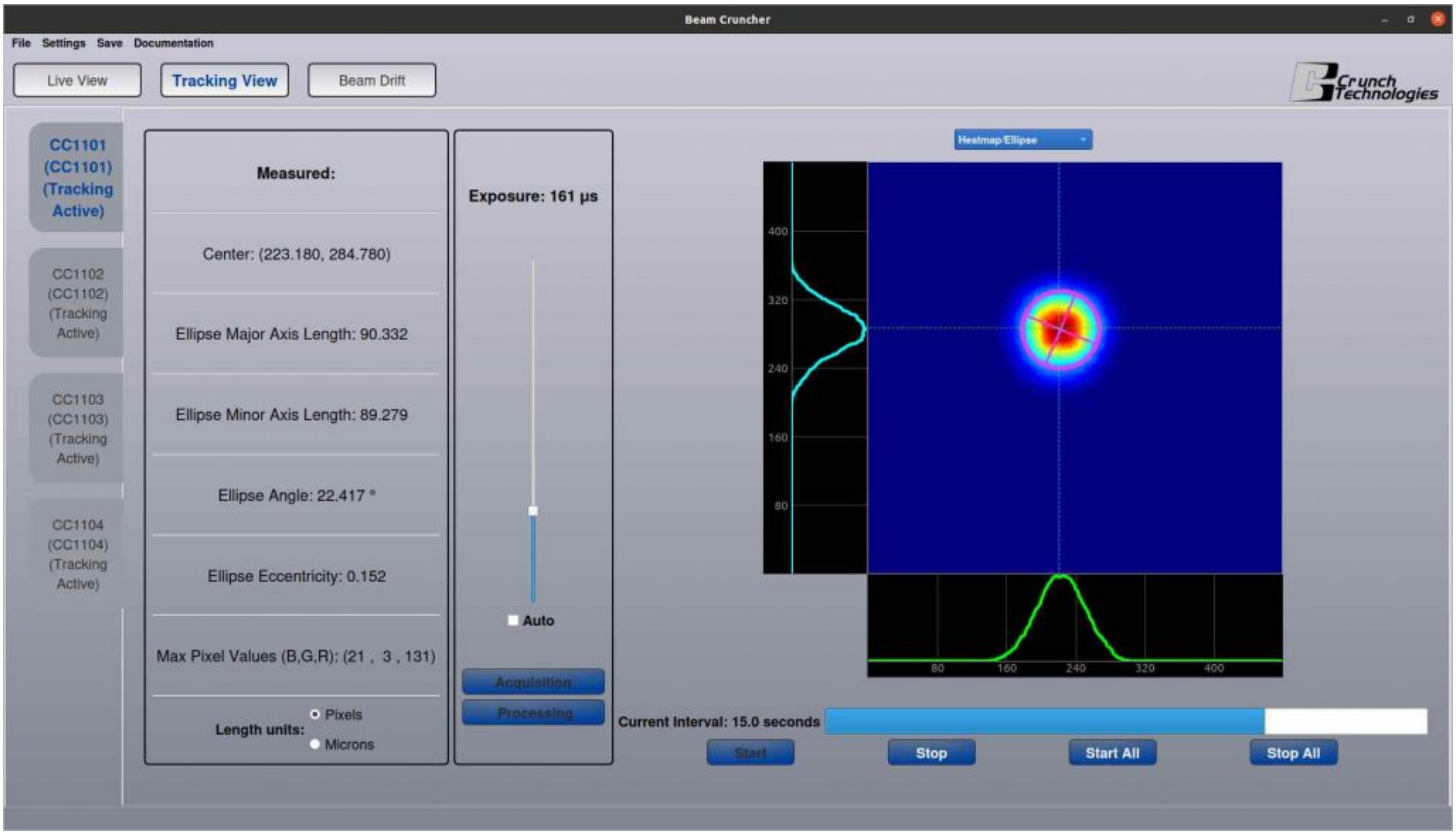
All data sent to the Beam Cruncher client computer is displayed within the Beam Cruncher software. Additionally, configuration of the image acquisition and processing parameters is available within the Beam Cruncher software. The various interface elements that allow users to monitor and diagnose their laser beams are described in detail in the following sections of this document.

Interface – Tracking View

The Tracking View within the Beam Cruncher software displays the latest quantitative and qualitative data collected and processed for each Crunch Cam, each of which can be selected from the tabs on the left side of the view. Additionally, the image acquisition and processing settings for each Crunch Cam are controlled by the user from this screen.

Each time that the Beam Cruncher receives new image data for the Crunch Cam that is currently selected, this the data in this view will be updated. The user is also able to select which type of qualitative image data is

shown (i.e. raw image, greyscale, or heatmap/ellipse). Additionally, if a Gaussian fit is found for the last beam image processed, both the Gaussian fit parameters found and plots of the one-dimensional fit in both the horizontal and vertical directions can be selected for display.



The Tracking View tab within the Beam Cruncher software.

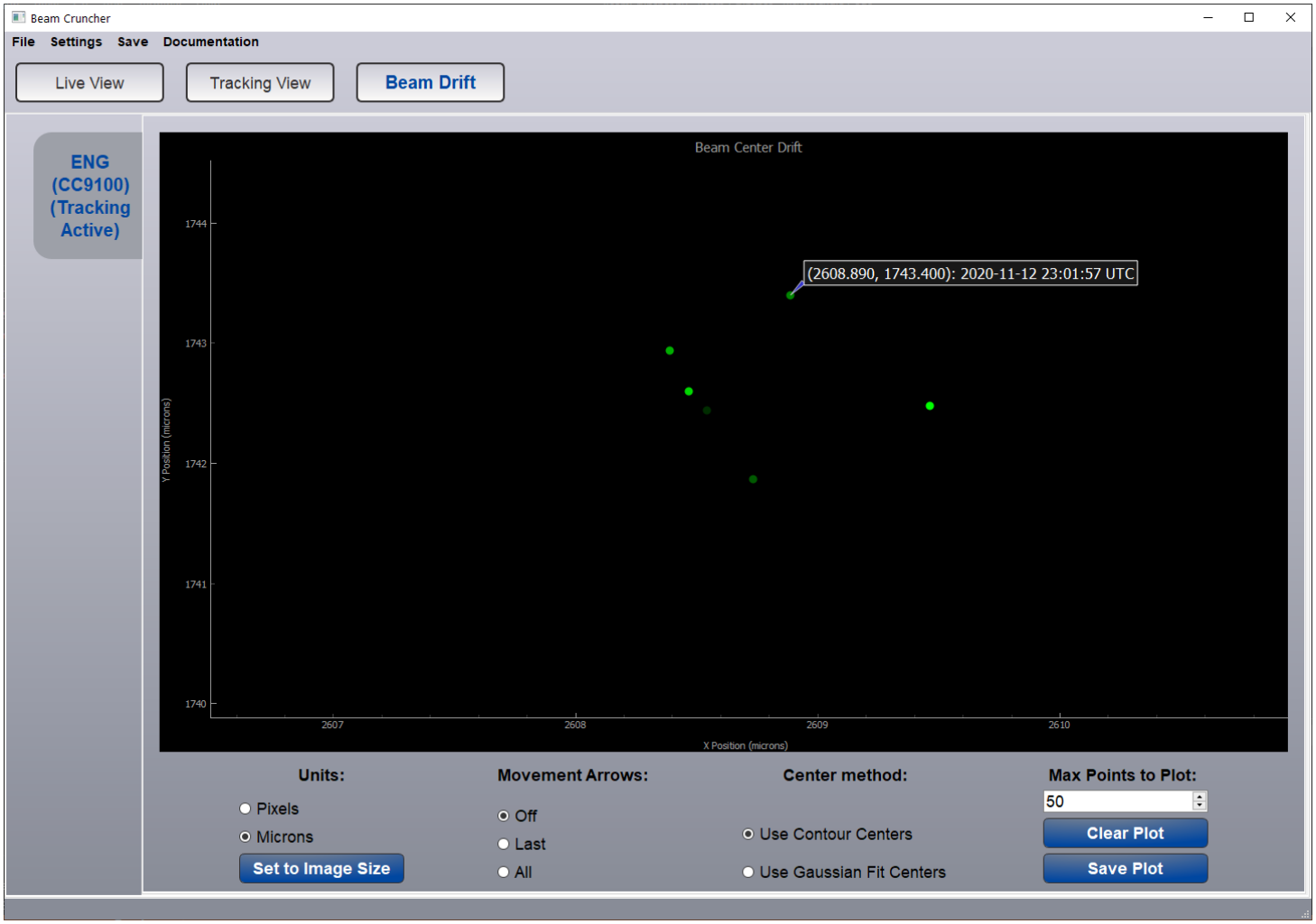
Interface – Live View

The Live View within the Beam Cruncher software allows the user to simultaneously see live streams from each Crunch Cam. This view also allows the user to set targets on each Crunch Cam live stream to assist in alignment and can be configured to visually track the movement of a beam's center.

Interface – Beam Drift

The Beam Drift view within the Beam Cruncher software displays a scatter plot for each Crunch Cam which represents the movement of a beam's center over time. This view is intended to assist users in determining the degree and direction of beam drift over a particular time interval.

These scatter plots are fully interactive and a user can easily choose an area of interest to focus their beam drift investigations on. Additionally, the Beam Drift scatter plot for each Crunch Cam can be saved to disk as an image to allow the user to refer back to beam drift phenomena or present these beam drift findings to colleagues.



The Beam Drift tab within the Beam Cruncher software.

Available Data

All quantitative data collected by the Beam Cruncher laser diagnostic system is stored locally on the Beam Cruncher client computer. This data is stored in a comma-separated values format and can be easily imported into any third-party or custom software which can process this standard data file format. Additionally, a Beam Cruncher user can opt to save all image data (i.e. the beam images taken and processed) through the data options in the Beam Cruncher client GUI.

The Beam Cruncher client software is packaged with an additional standalone utility which enables the user to visualize beam drift data. This provides a way for the user to easily plot a subset of the beam drift data collected over a particular time period of interest.

Additionally, the Beam Cruncher client software can be configured to publish all quantitative and image data collected to an MQTT broker running on either the client computer or a remote server. A user can then instruct a custom script or application to subscribe to relevant data topics that are published by this MQTT broker.

Camera Upgrade

The standard Beam Cruncher laser diagnostic system utilizes the Sony IMX219 8-megapixel color sensor to collect image data. If a higher performance image sensor is required for a customer's application, this sensor can be upgraded to ON Semiconductor's MT9P031 5-megapixel monochrome sensor, which features larger sensor and a hardware trigger. This hardware trigger can be utilized by the Beam Cruncher software to control image acquisition. A more in-depth comparison of these two sensors is presented in the table below.

Sensor	Sony IMX219 (standard sensor)	ON Semiconductor MT9P031
Mono / Color	Color (RGB)	Monochrome
Sensor Size	1 / 4"	1 / 2.5"
Pixel Size	1.12 µm	2.2 µm
Full Resolution Framerate	30 fps	14 fps
A/D Max Bit Depth	10 bits	12 bits
Shutter	Rolling	Rolling
Hardware Trigger	No	Yes

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About Crunch Technologies

Crunch Technologies was launched in August 2014 by Benjamin Langdon to specialize in contract opto-mechnanical and ultra-fast optical design. The company leverages Dr. Langdon's previous experience designing, building and supporting first-of-their kind Ti:sapphire amplifiers to serve the academic, national lab and basic research markets.