Acquiring and Analyzing High-Resolution Images of Velocity-Mapped Ions

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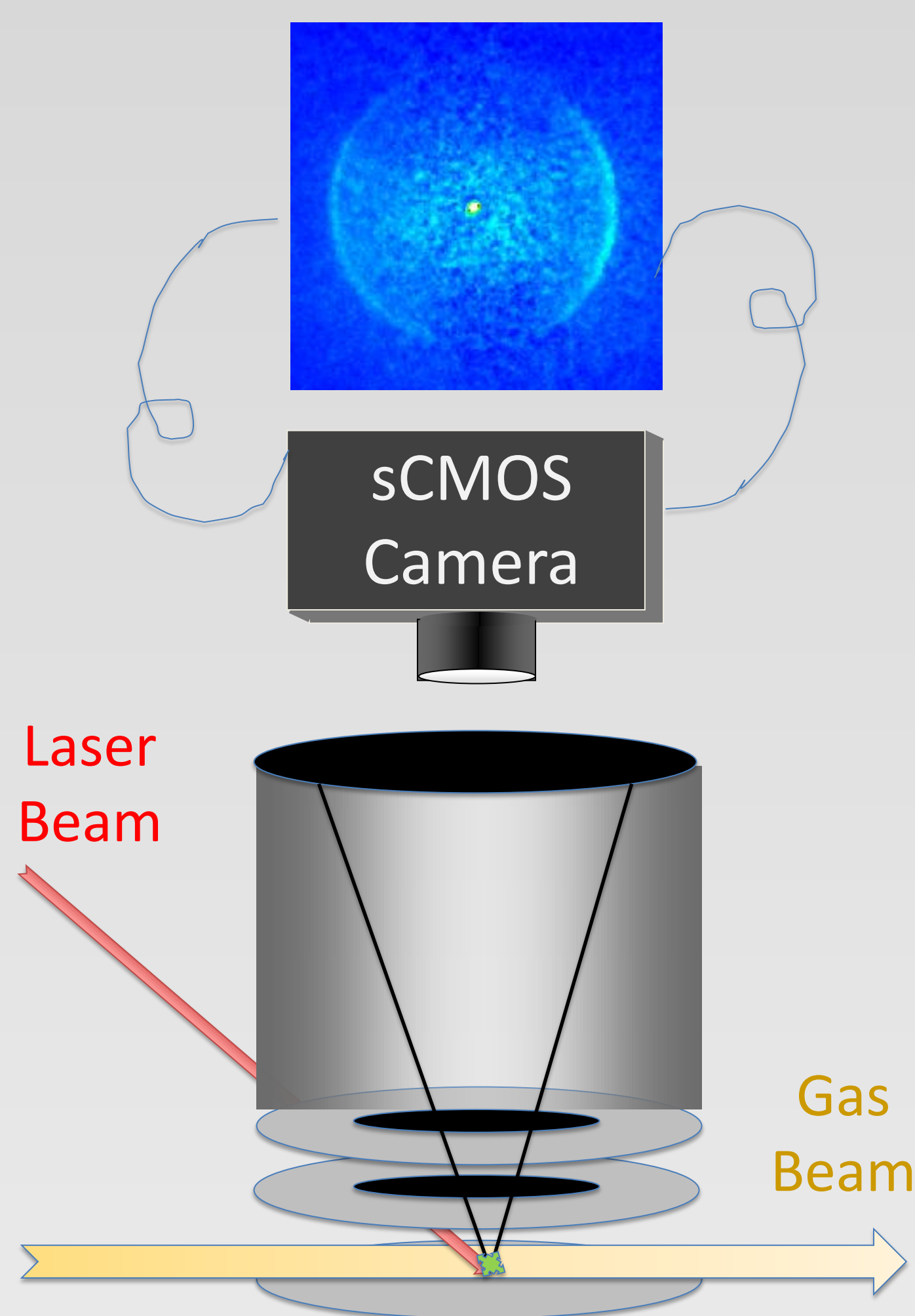**July 30, 2014**

Abstract

The purpose of this experiment is to achieve higher resolution velocity-mapped imaging data using a new state-of-the-art sCMOS camera. In order to collect data, this new camera must be interfaced with a new computer. Using a National Instruments LabVIEW program, I will write programs to acquire, background subtract, and centroid images. Employing methods like these, we will obtain a higher-resolution image that precisely maps the velocities of ions created during our experiment.

Background

To obtain the data we seek in this experiment, a basic understanding of ion imaging and its components is necessary. This involves gas beams, lasers, and high voltage plates.
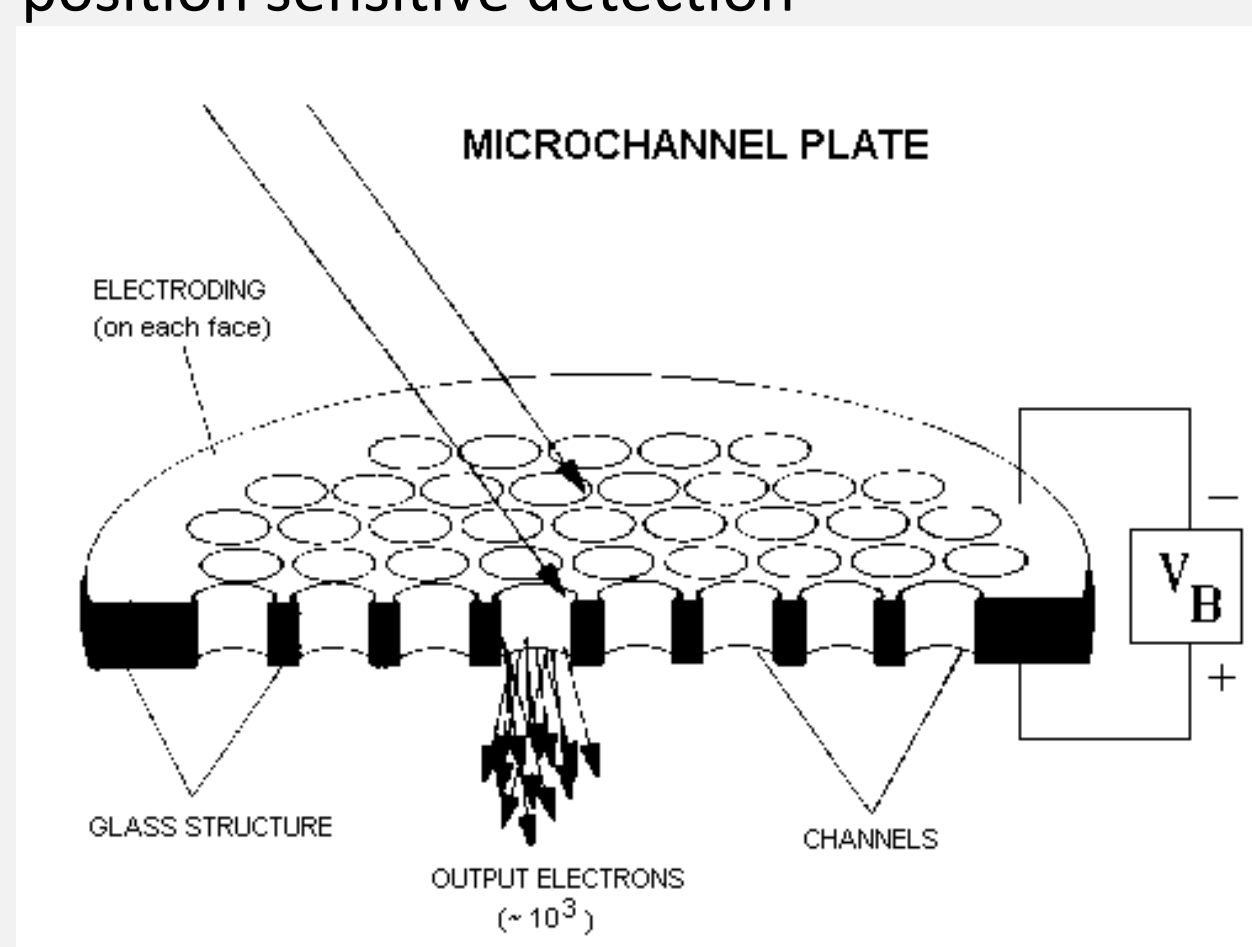
Ion Imaging

sCMOS Camera

Laser Beam

Gas Beam

► Gas is excited and ionized upon impact with laser(s)
► High-voltage plates direct ions towards micro-channel plates and phosphorescent screen
► Ions of the same velocity are projected onto the same position on the detector

Micro-Channel Plate (MCP)

► Electrons are amplified inside photomultiplier tubes to produce a better signal, allowing for position sensitive detection

MICROCHANNEL PLATE

ELECTRODING (on each face)

V_B

GLASS STRUCTURE

OUTPUT ELECTRONS (~ 10³)

CHANNELS

http://adweb.desy.de/mdi/documentation/Restgas_at/PETRA/mcp.html

Experimentation

For data acquisition, we will utilize the new camera from Andor in conjunction with National Instruments LabVIEW. Our analysis techniques will be performed in LabVIEW as well.
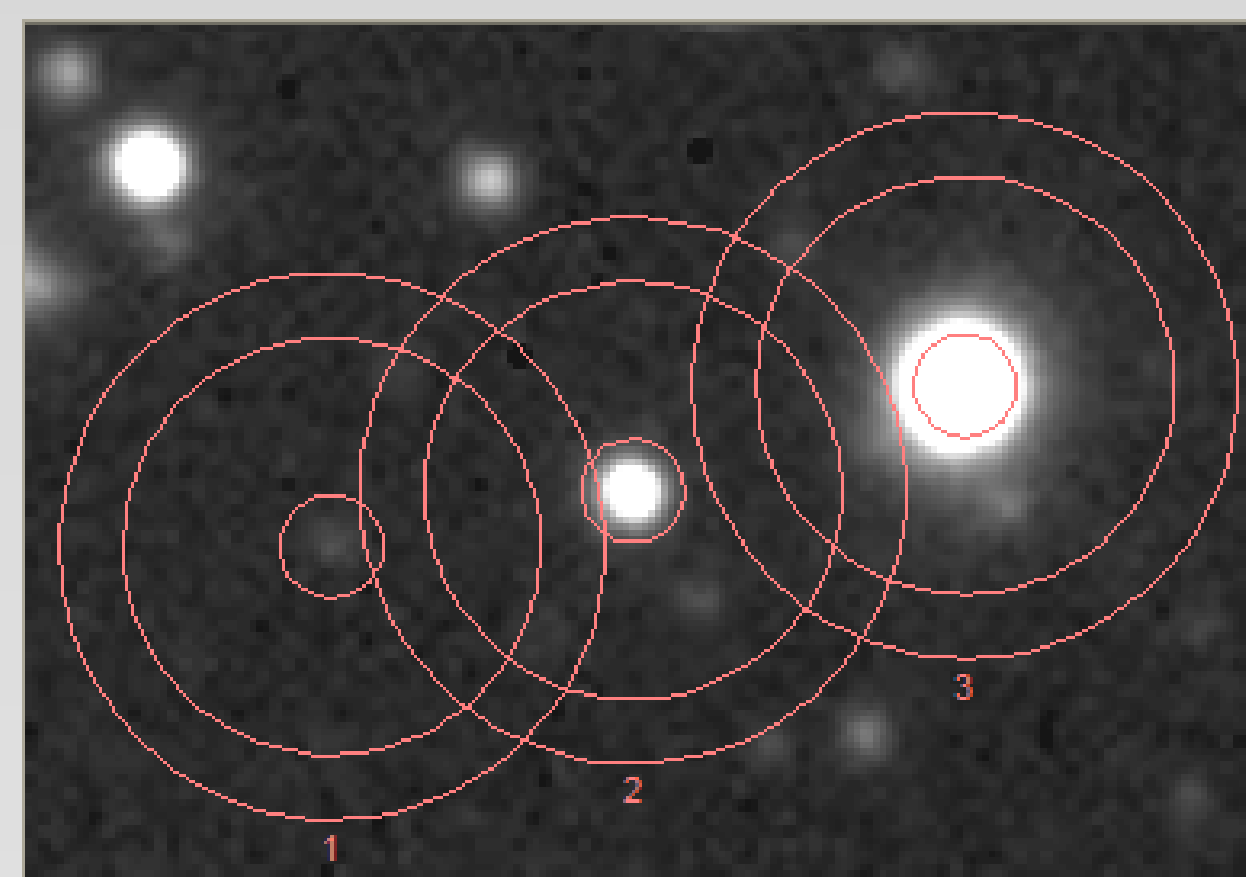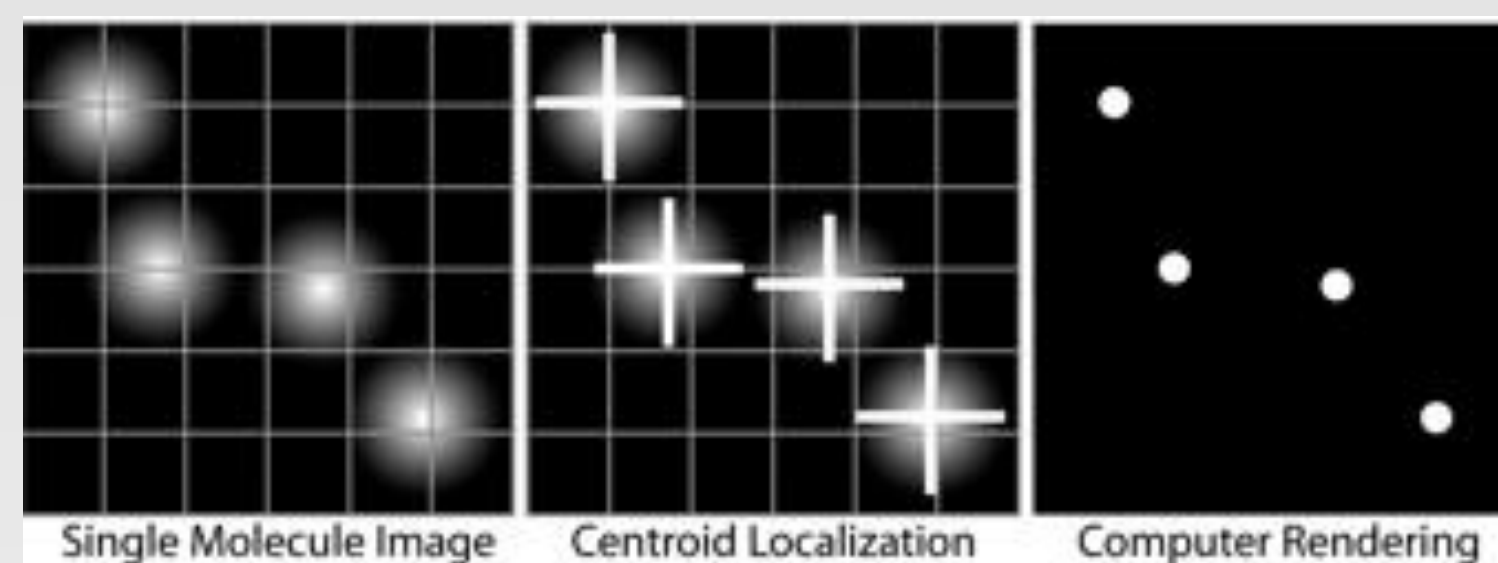
The Camera

Andor Zyla-X (sCMOS) Camera:

► Faster bit rate and higher resolution than previous camera
► More compact design

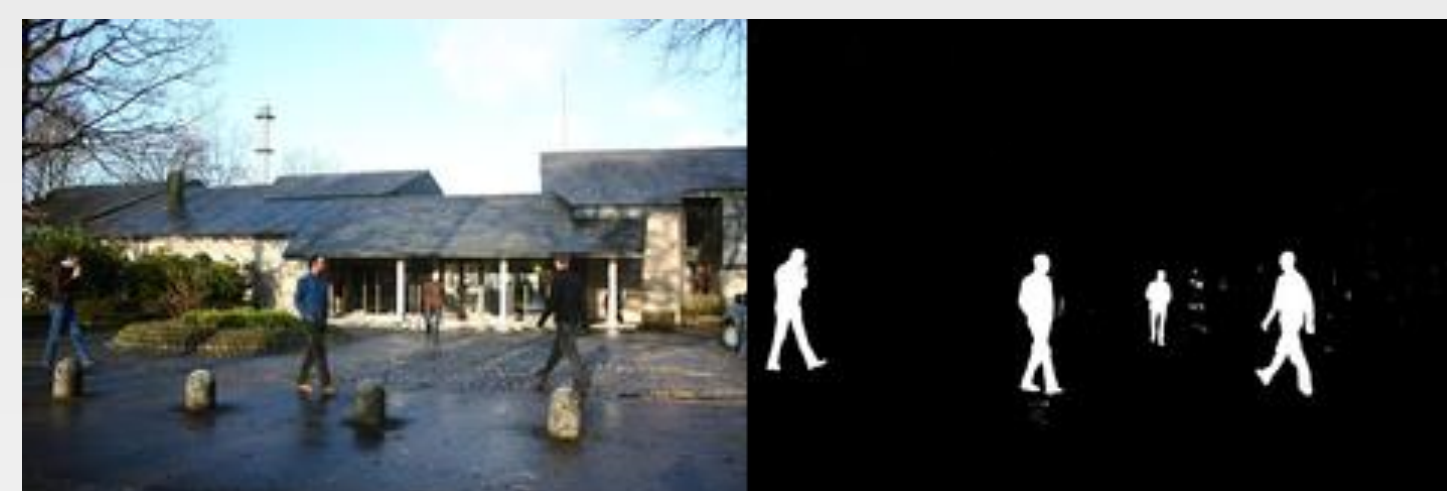http://microscopeespa.blogspot.com/2012/04/andor-zyla-550-cmos.html

Centroiding

http://www.nature.com/nmeth/journal/v11/n3/full/nmeth.2844.html?message-global=remove

► Electrons from MCP might not hit the center of the pixels, making it difficult to tell the location of the ions
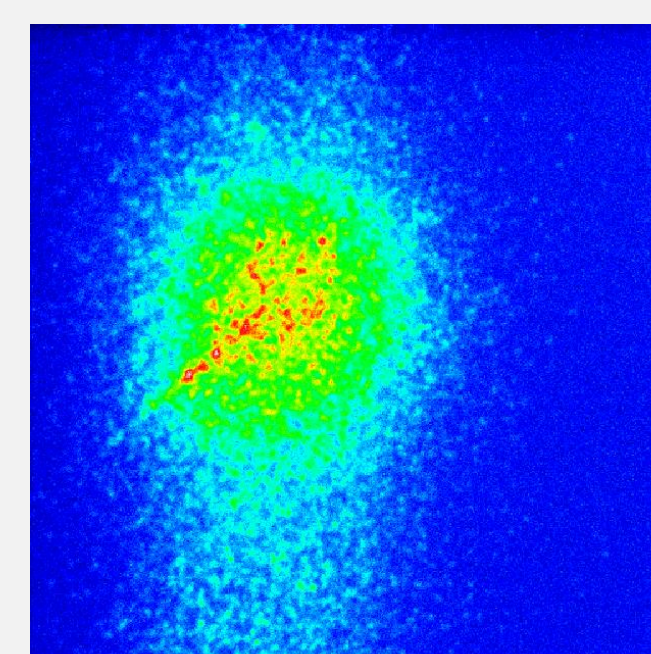► Centroiding allows us to approximate the "center" of that impact and distinguish it from the other pixels

Single Molecule Image | Centroid Localization | Computer Rendering

http://www.photometrics.com/resources/technotes/fpalm.php

Background Subtraction

http://www2.ulg.ac.be/telecom/research/vibe/

► Background images (noise) are subtracted from foreground images (data) to get a higher signal to noise ratio
► Differentiates between the data resulting from the experiment and the constant background signal inherent to the instrumentation
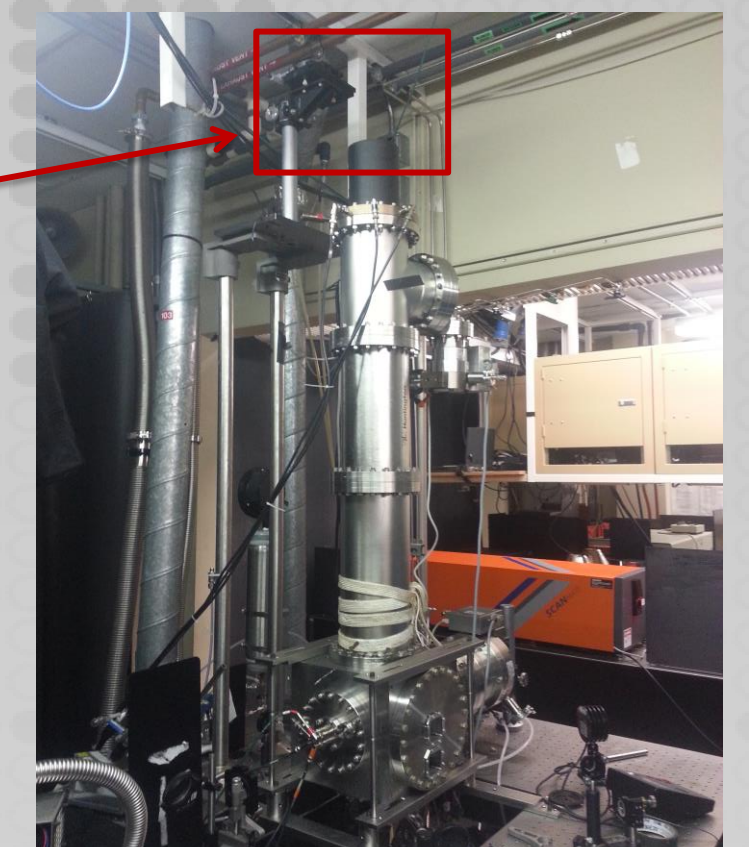
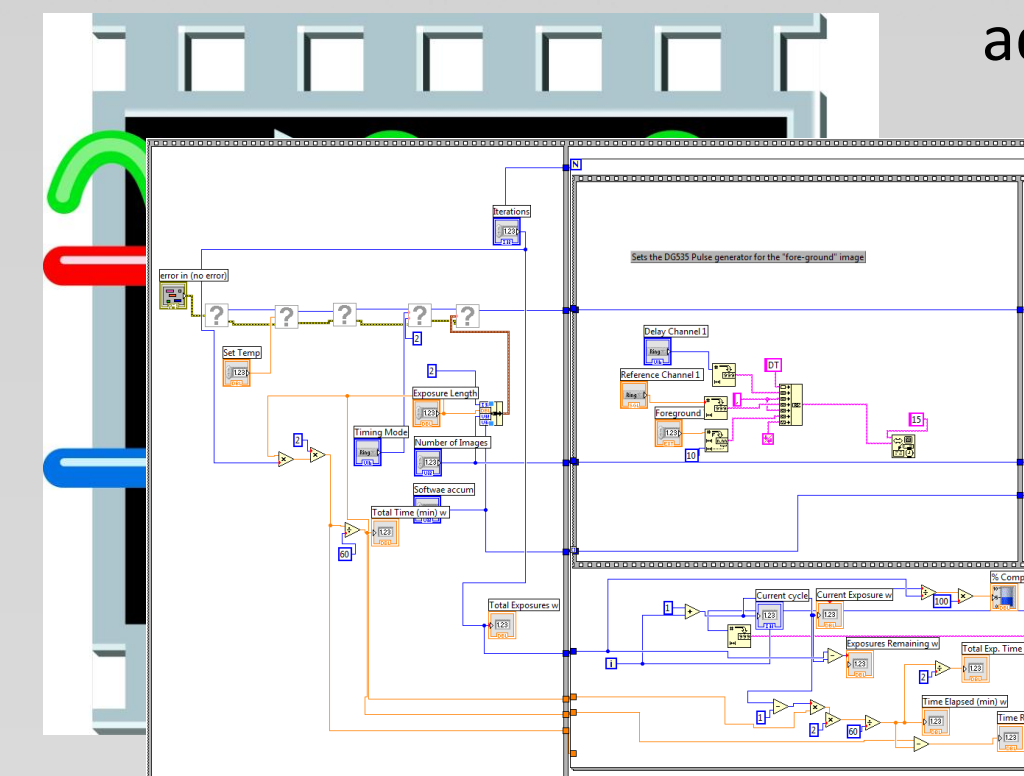► An image of thermal background. This is what we wish to subtract out, as it interferes with our data

Progress

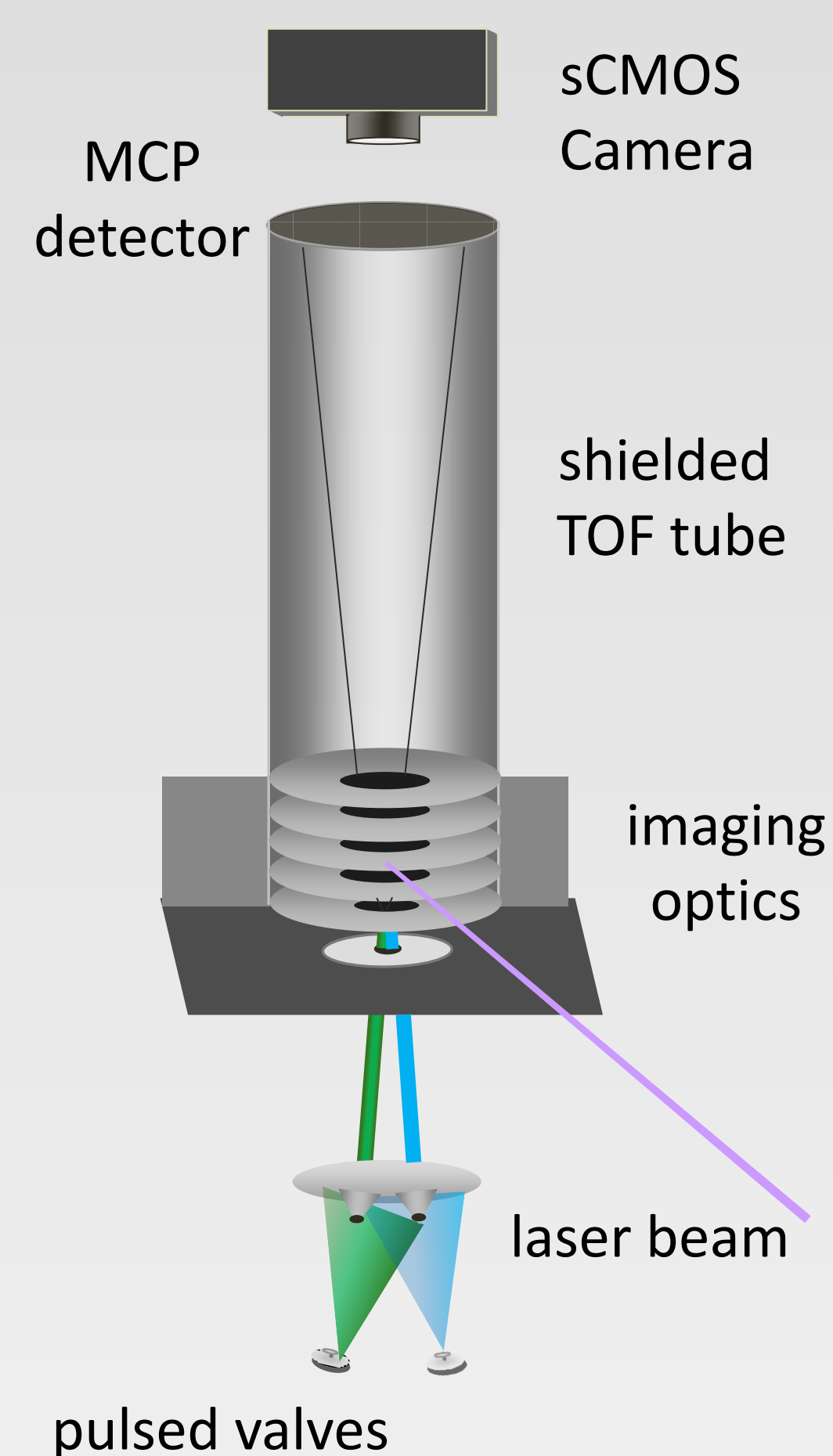► Camera, computer and other equipment are coming together. Will be mounted atop the experimental apparatus

► Experimental apparatus is constructed, awaiting addition of the camera

► LabVIEW program in the process of being modified to run the new camera

Endeavors

The equipment and analysis techniques chosen will be incorporated into our new "merged beam" instrument.

sCMOS Camera

MCP detector

shielded TOF tube

imaging optics

laser beam

pulsed valves

► Allows us to study low-energy molecular collisions, where resonances have been found to occur
► Resonances have very narrow energy widths, which calls for a high resolution detection scheme to observe them.

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