K-State Physics REU Project 2021

"Laser Beam Monitoring and Stabilization System"

Sara Sayer
Mentor: Cosmin Blaga
Louisiana State University

Why do we need to stabilize a laser?

Temperature, humidity, and vibrations can all cause a laser to drift off target.

An unstable laser can introduce unwanted variables to an experiment.

Instead of having to manually reset the beam, a stabilization program can save valuable time while also monitoring the health of the beam.

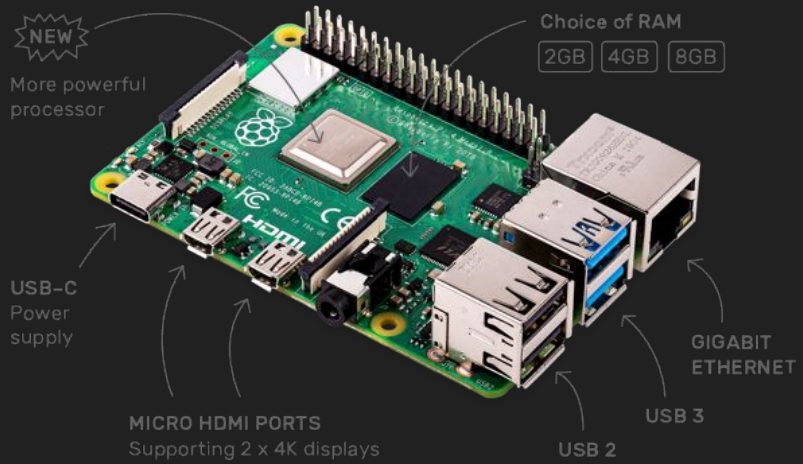
A self-stabilizing system is achieved by monitoring the position of the beam with a camera and motorizing the mirrors that direct the beam.

Goals

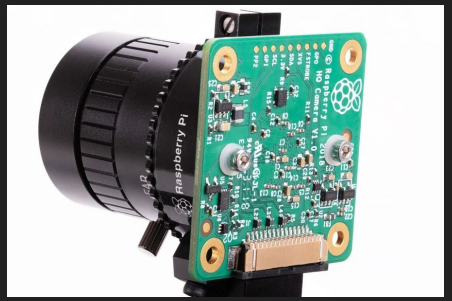
- **Active Beam Pointing Stabilization System**
- **Laser Health Monitoring System**
- This technology exists commercially for $$$
- Advantages of building it include lower cost and customization for each laser.

Price	Available
$6,317.50	Today

ThorLabs Benchtop NanoTrak® Active Auto-Alignment Controllers



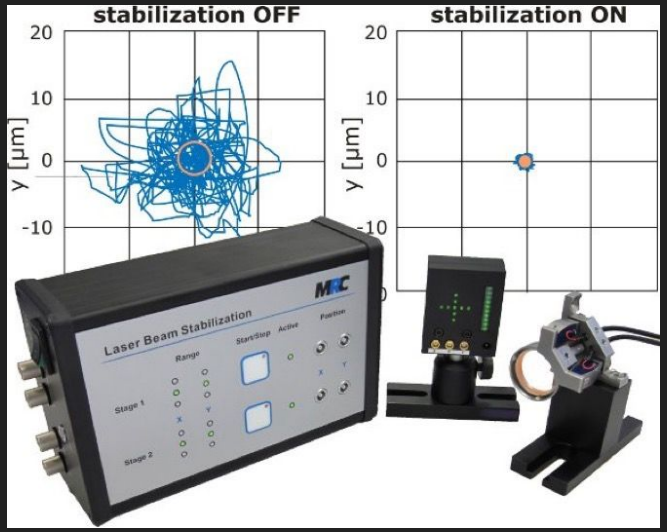
Raspberry Pi 4 Model B ($35)



Raspberry Pi High Quality Camera ($50)

Active Beam Pointing Stabilization System

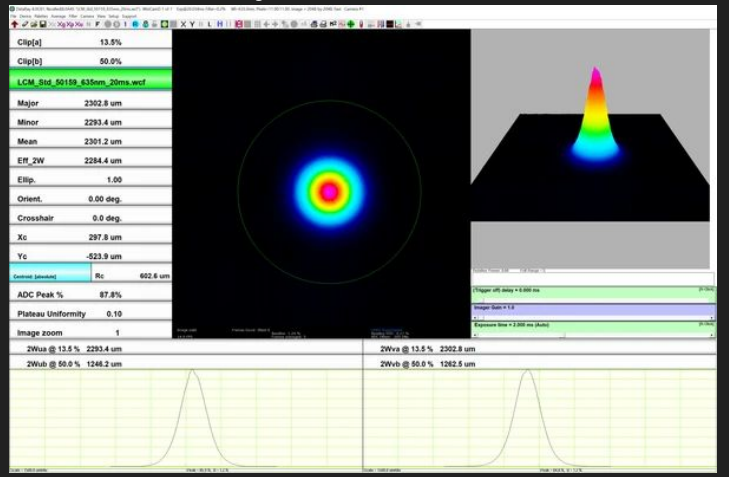
- Feedback loop with the cameras and mirrors to keep the beam on target
- “Smart” laser



MRC Systems Active Laser Beam Stabilization

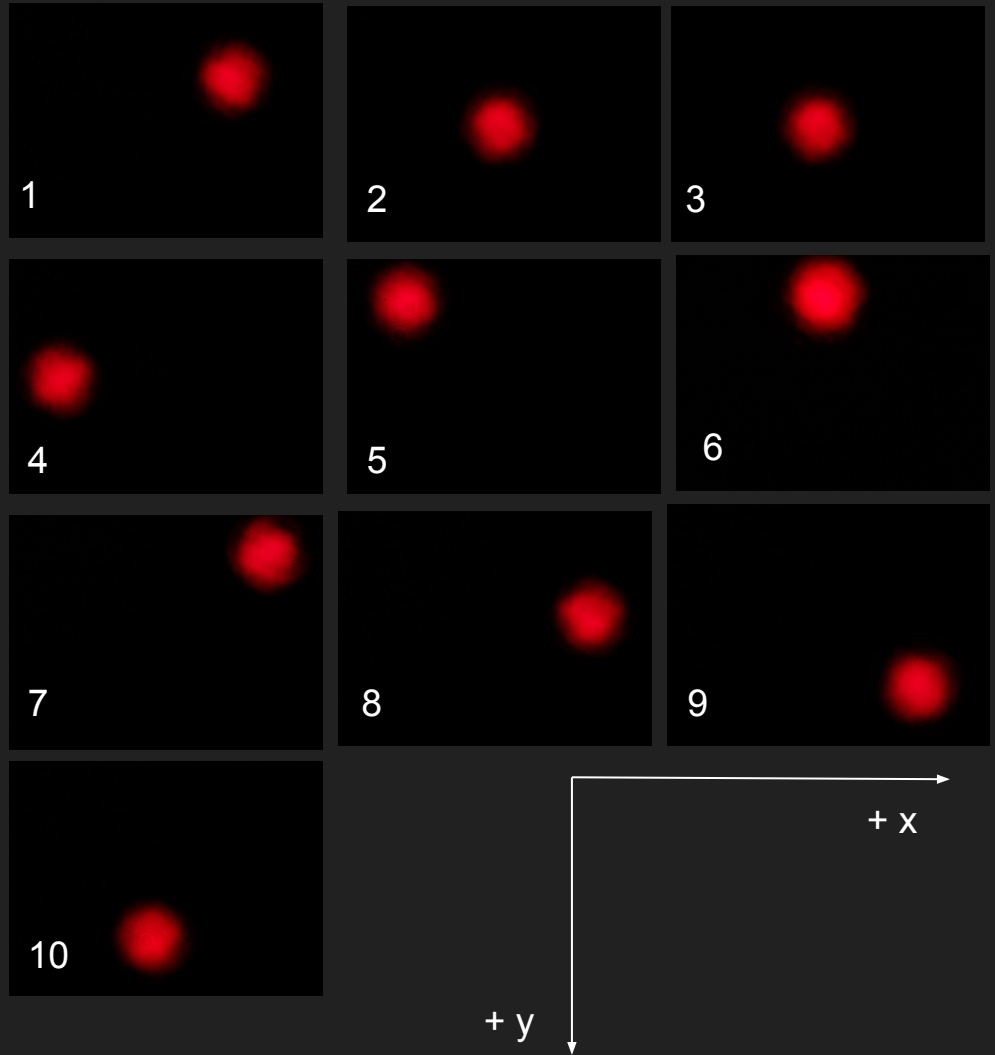
Laser Health Monitoring System

- Monitors the beam profile for things like temperature, shape, size, records data
- Shut off the beam if it were to drift entirely off camera

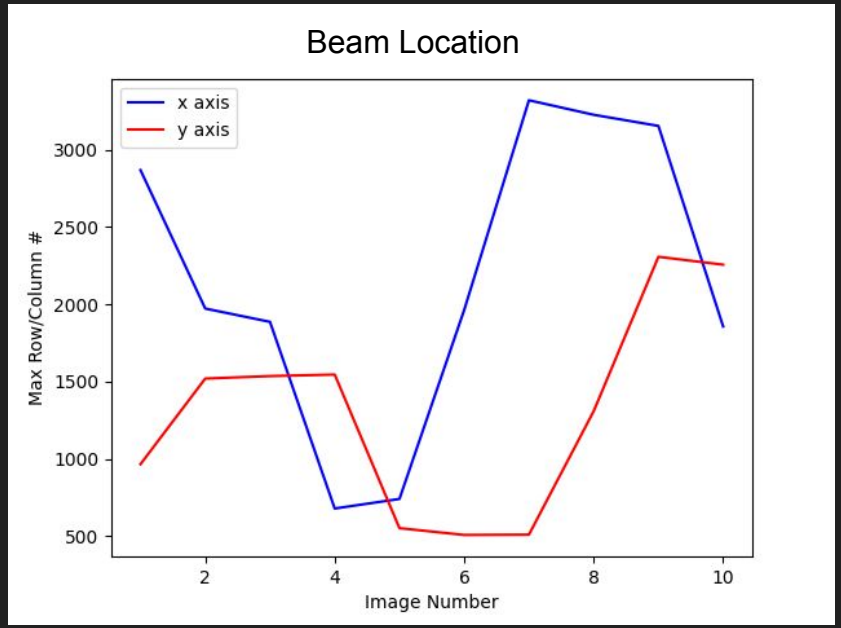


DataRay Visible Laser Beam Profiling

Exaggerated Beam Walk



Images taken with the HD camera using a HeNe laser.

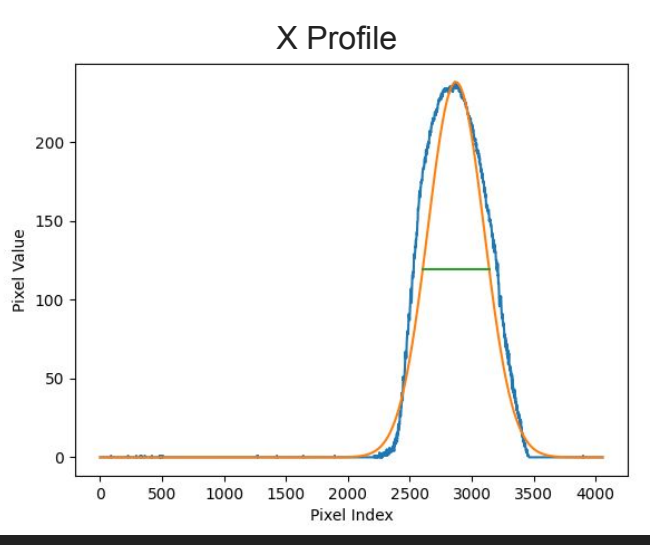


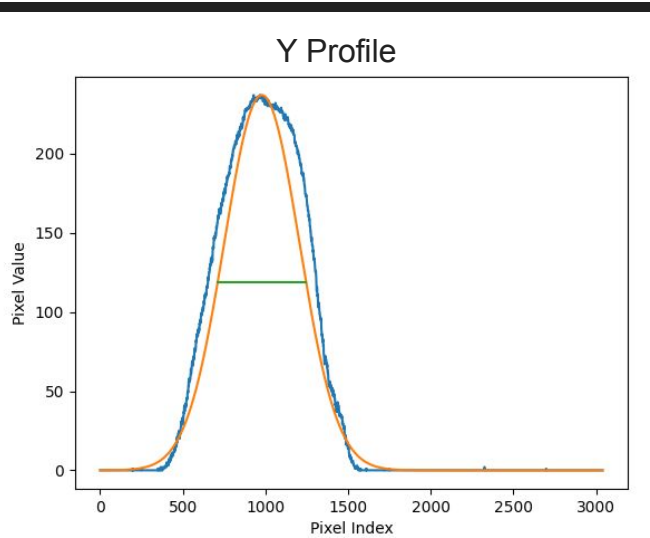
Resolution: 4056 x 3040

Beam Profile

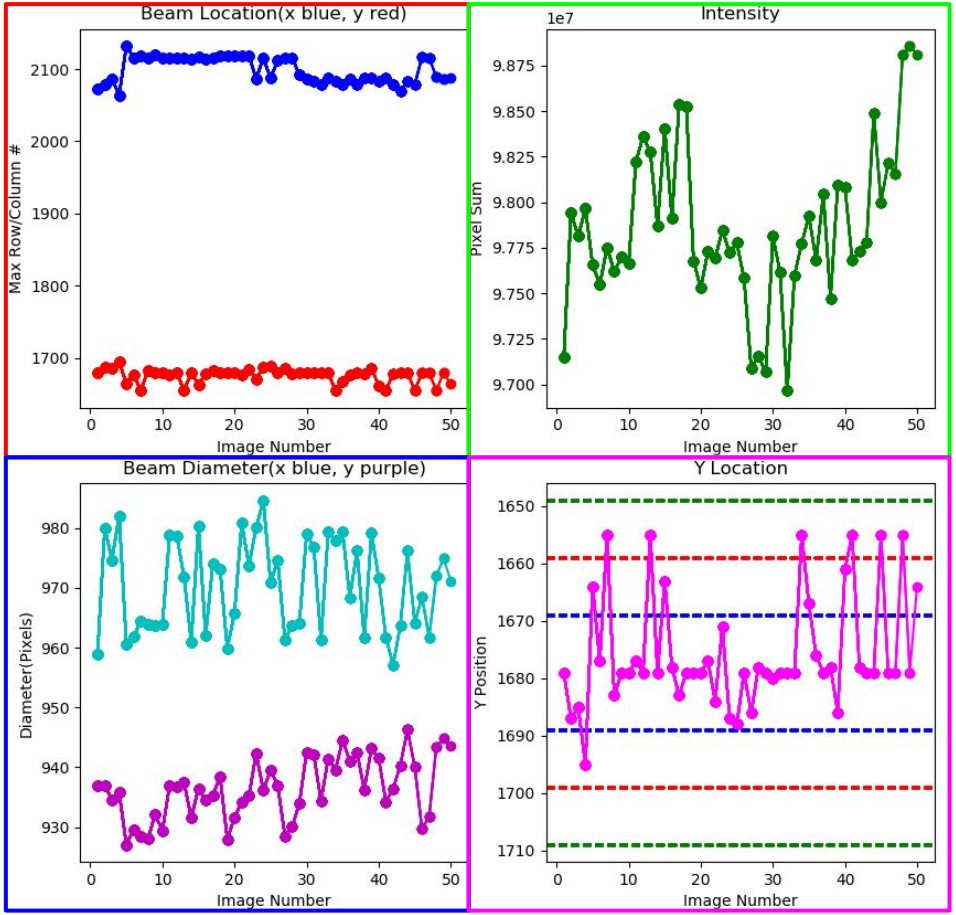
$$w = \frac{\mathrm{FWHM}}{\sqrt{2\ln 2}}$$

Resolution: 4056 x 3040





Working Interface



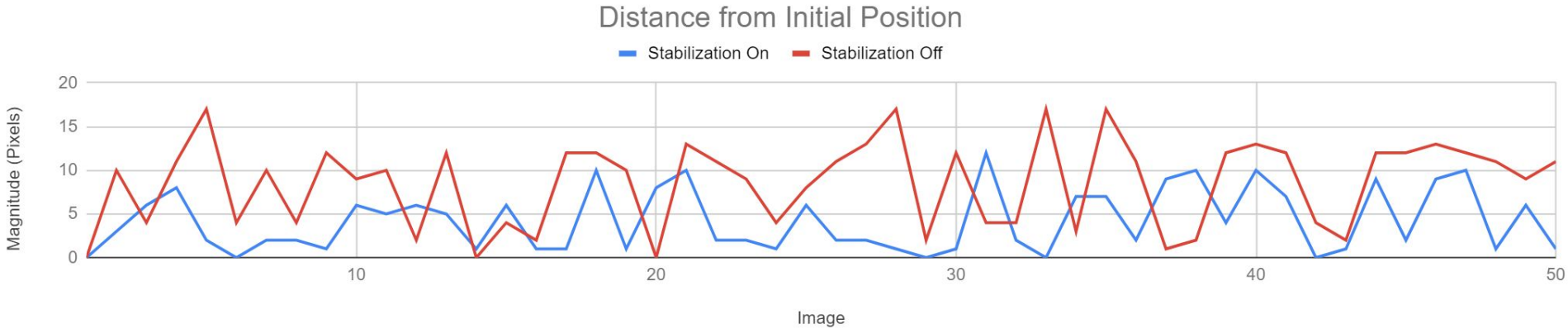
1. Shows broad view of vertical and horizontal position, same type of plot as the exaggerated beam walk plot.
2. Shows intensity of the beam by summing the pixel values in an area of ($3FWHM_X$ x $3FWHM_Y$).
3. Shows diameter of the beam using FWHM calculated in the beam profile.
4. Shows vertical location of the beam with stabilization limits.

Proof of Concept

- Took 50 images 10s* apart with stabilization on vs off
- Found the distance between the current position of the beam and its initial position for all images
- Calculated the average of these values

Averages

Run	S. On	S. Off
1	4.2	8.5
2	4.7	17.7
3	6.1	9



Conclusions and Future Work

- Laser beam monitoring systems exist commercially but can be recreated for a much smaller cost with the added benefit of being customizable.
- The stabilization program’s effectiveness can be practically demonstrated.
- We plan on having a fully interactive graphical user interface (GUI), automatically turning off the laser if it drifts off camera, as well as implementing an already existing temperature monitoring program.
- Will be presented at the Symposium on Undergraduate Research at the DLS (Division of Laser Science, APS) meeting in November.

Acknowledgements

- Cosmin Blaga
- Del Kanku
- Pavan Muddukrishna, Eric Mullins, Sajed Hosseini-Zavareh
- Kim Coy, Bret Flanders, Loren Greenman
- Kansas State University and National Science Foundation