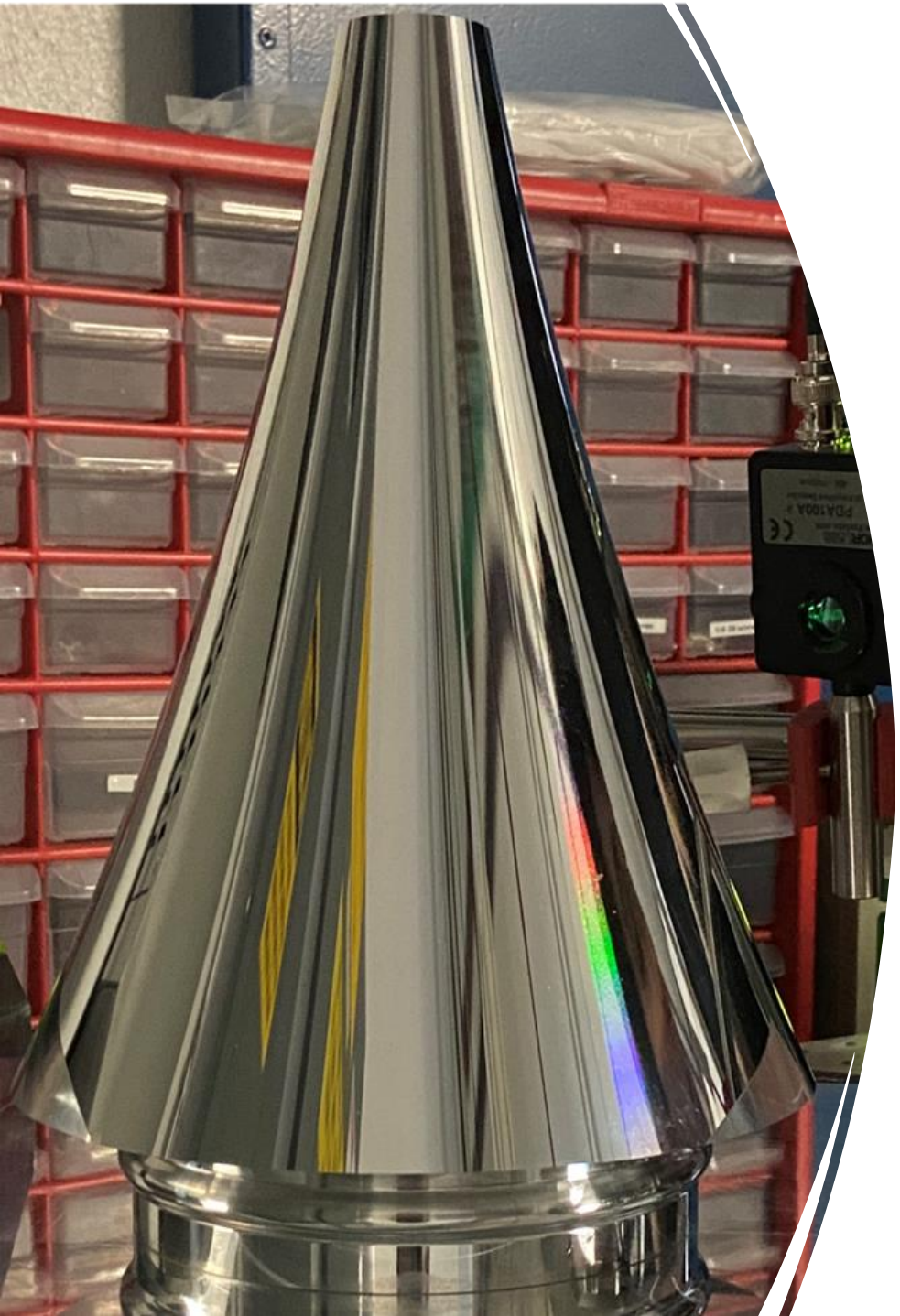
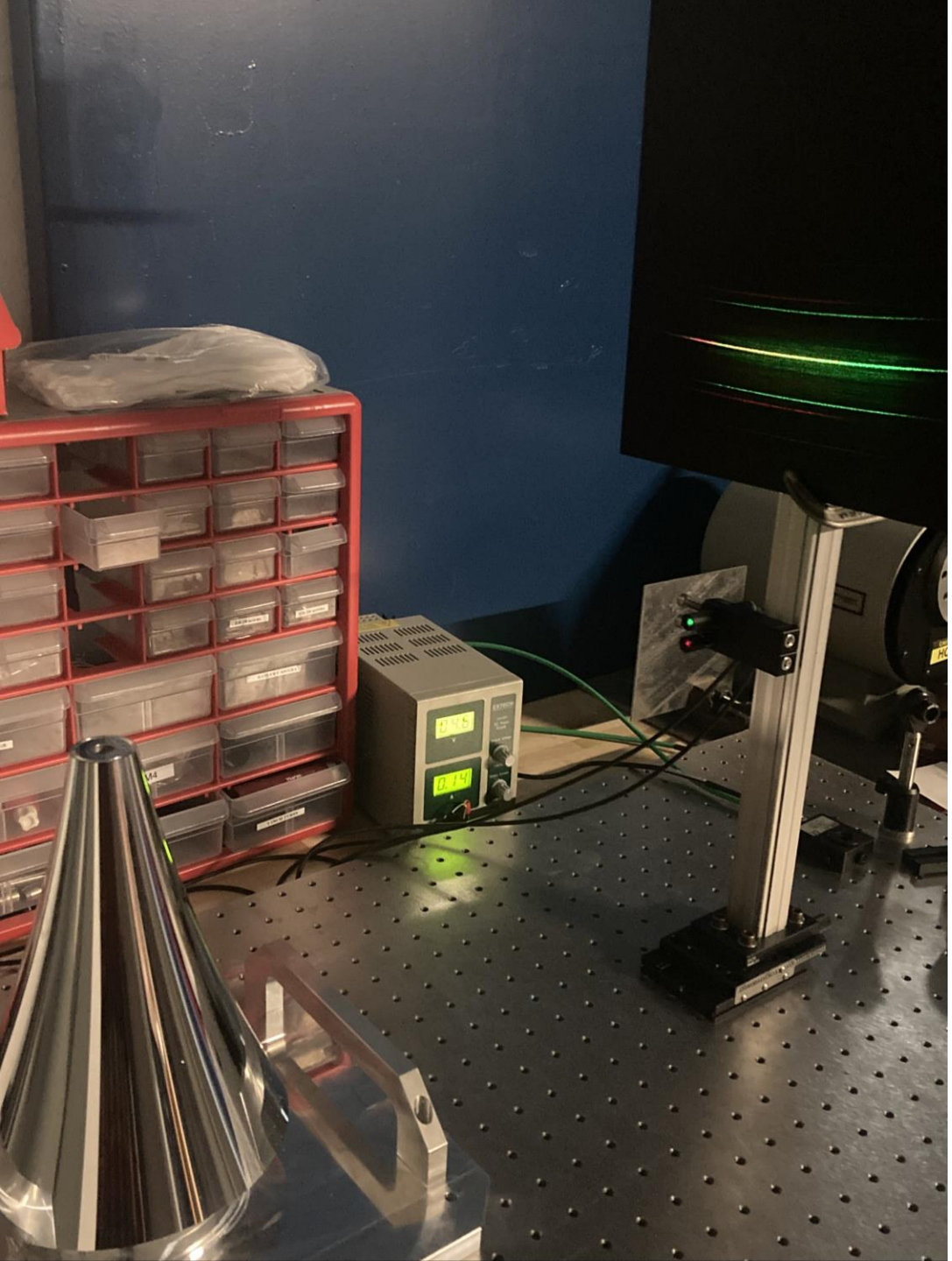


OPTICAL CHARACTERIZATION OF BREAD PARTS

Cole Browning and Aiman Imran

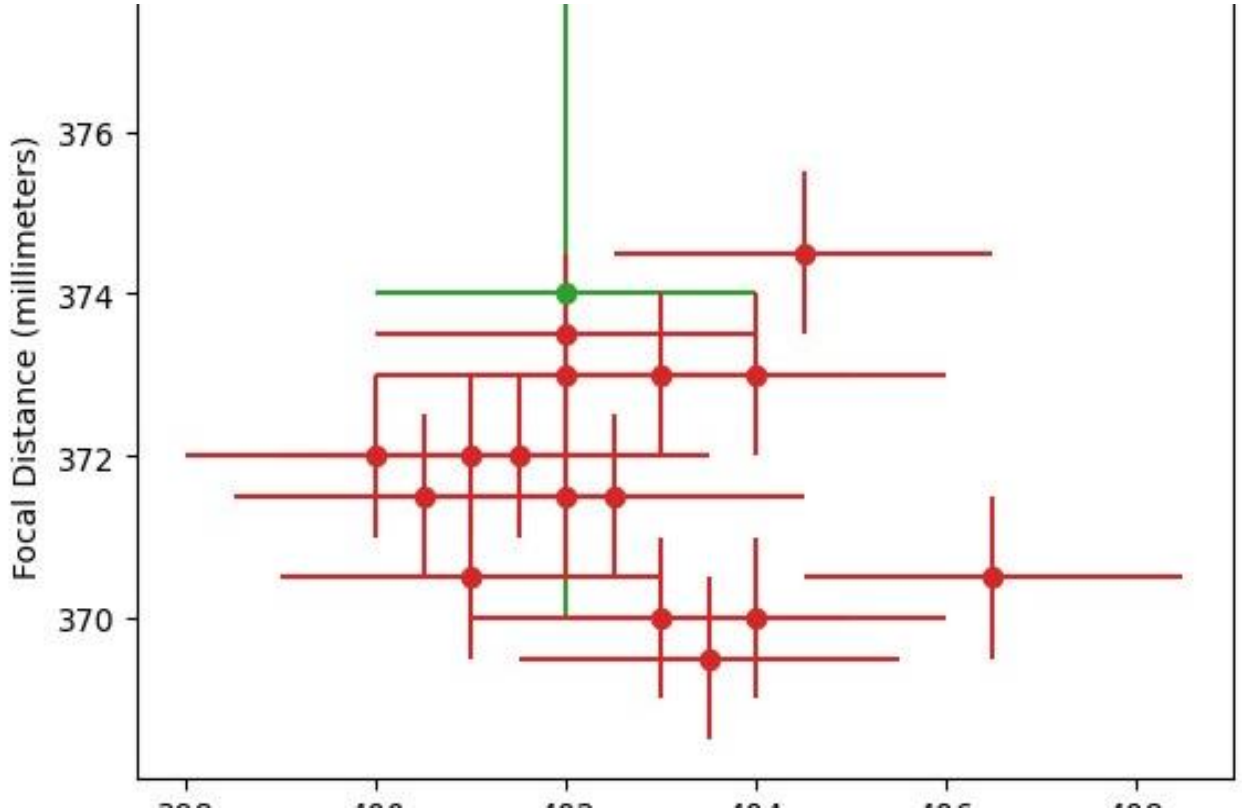
October 6, 2023



Focal Point Measurement

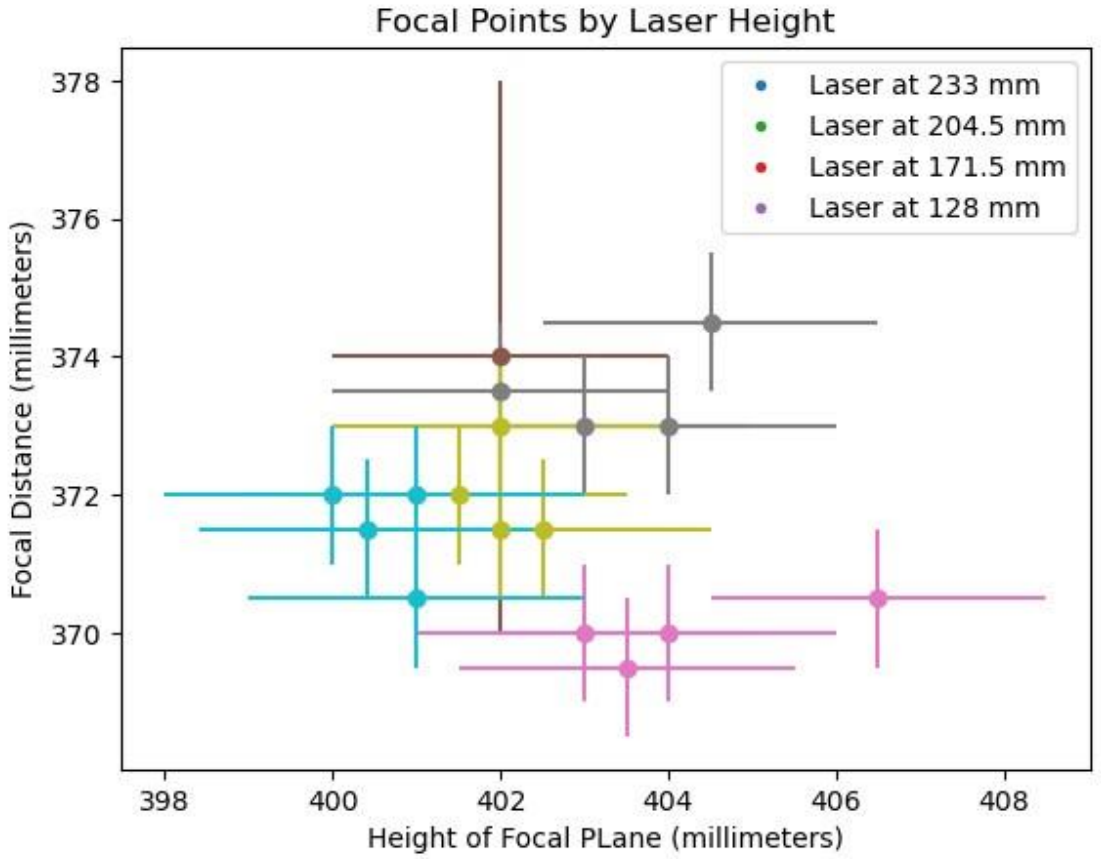
- Previous:
  - Horizontal = 402 mm +/- 2 mm
  - Vertical = 374 mm +/- 4mm
- Both lasers placed on top of each other.
- Length of diffraction lines is directly proportional to curvature.

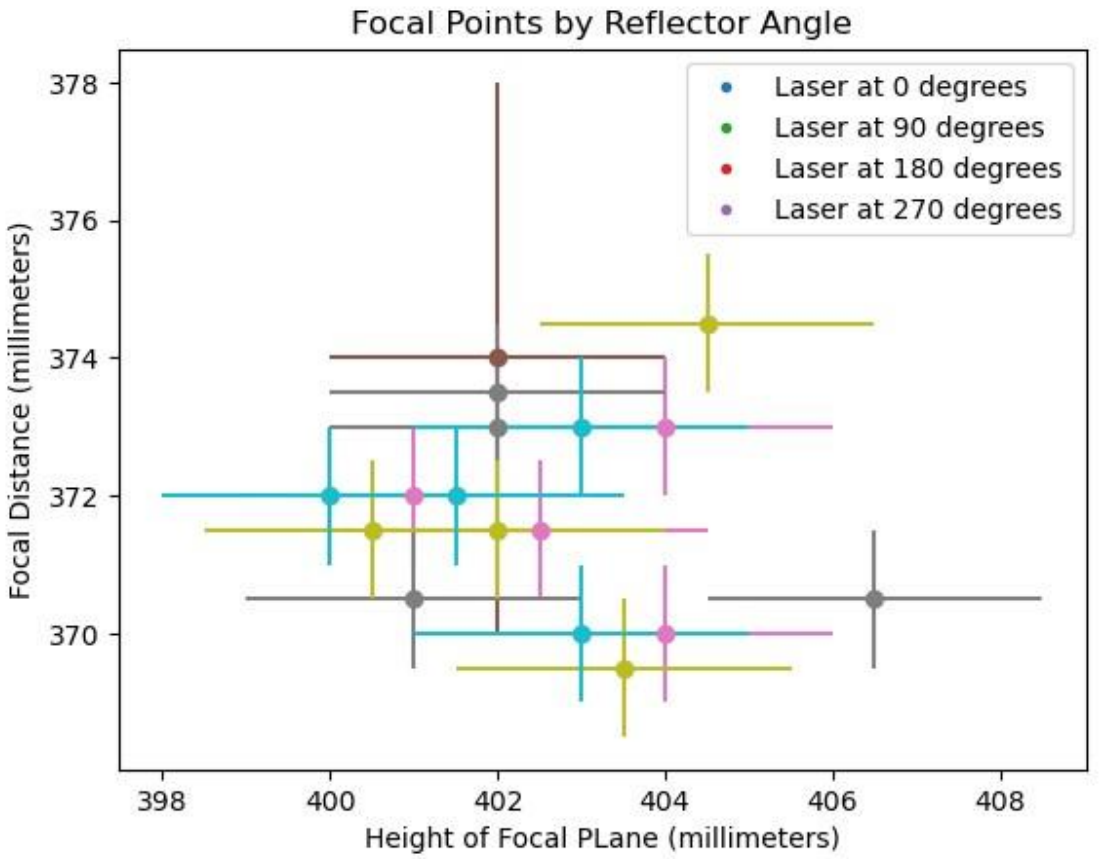
Results



- Green point is at (402, 374)
- Systematic over random

Focal Point Groupings





Surface Pattern Metrics

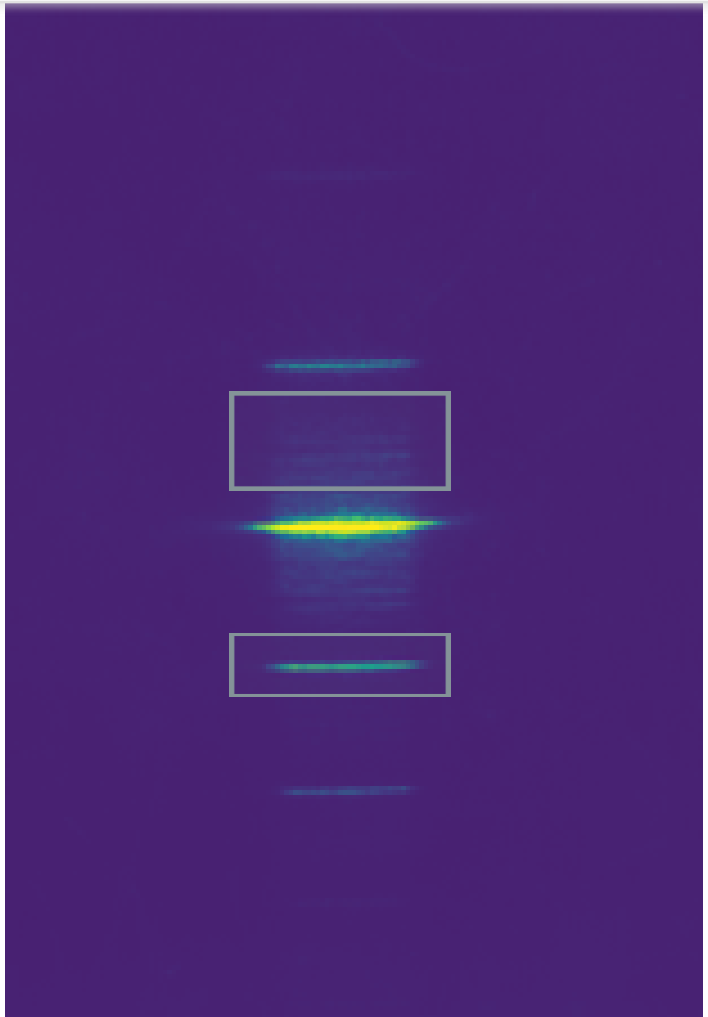
Previous:

- Diffuse/(Spectral + Diffuse) = 1%
- Period = 770 nm
- Roughness = 11 nm

$$\theta_m = \arcsin\left(\sin\theta_i - \frac{m\lambda}{d}\right)$$

High exposure

Low exposure



Diffraction

- Measurements based on m = 1 diffraction line.
- Heights measured at focal point.

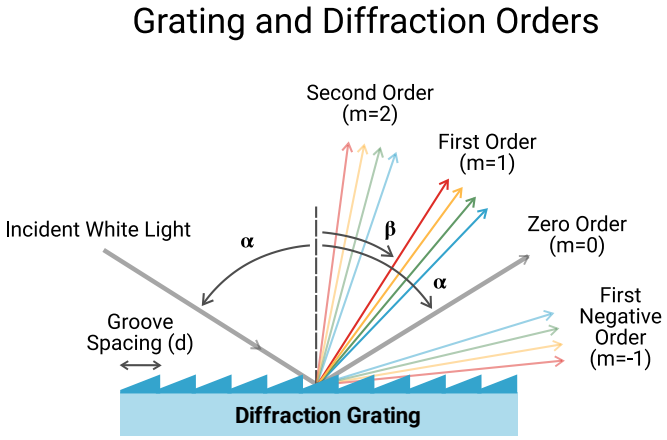
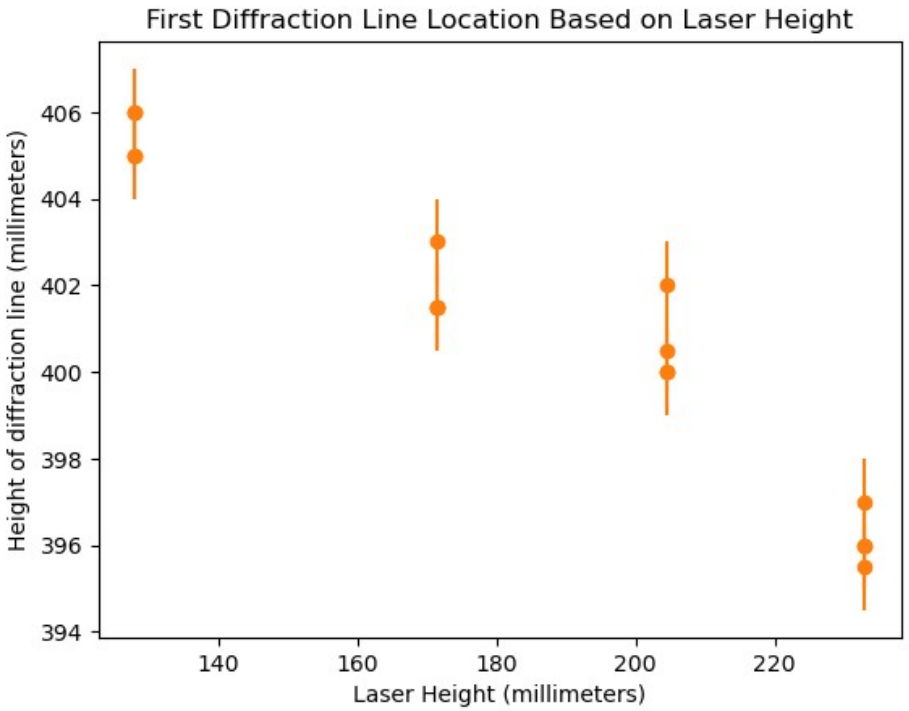
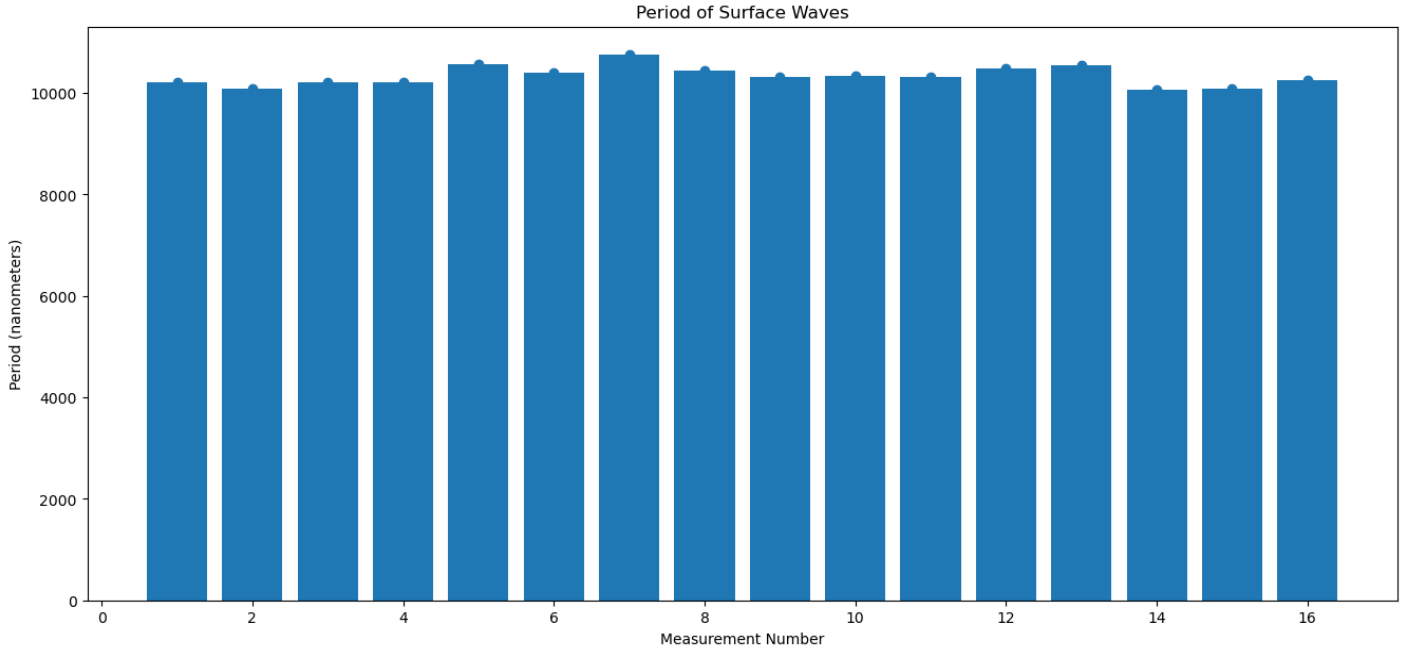


Photo Credit: MEETOPTICS

Results


First Diffraction Line Location Based on Laser Height
Height of diffraction line (millimeters)
406
404
402
400
398
396
394
140
160
180
200
220
Laser Height (millimeters)

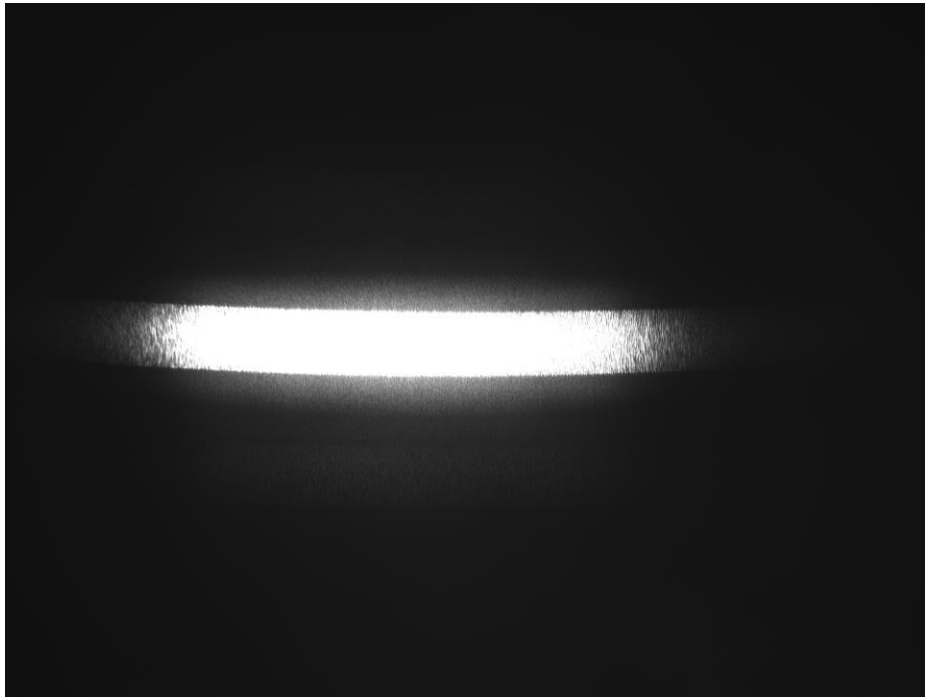

Period of Surface Waves
Period (nanometers)
10000
8000
6000
4000
2000
0
0
2
4
6
8
10
12
14
16
Measurement Number

TIS and Roughness

Roughness dependent on the TIS.

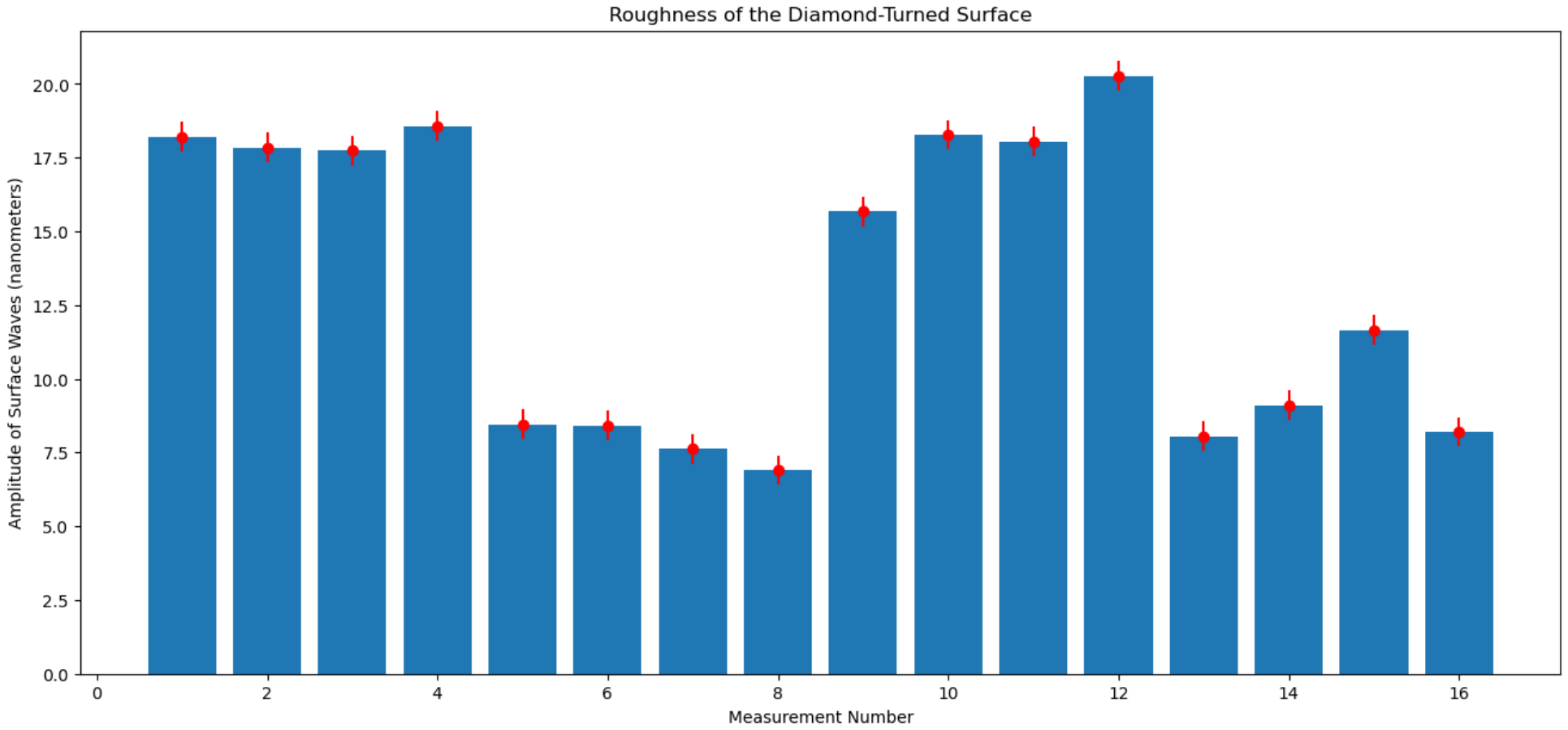
$$TIS \equiv \frac{P_s}{P_0 + P_s} = 1 - \exp\left[-\left(\frac{4\pi\sigma\cos\theta_i}{\lambda}\right)^2\right] \cong \frac{P_s}{P_0} \cong \left(\frac{4\pi\sigma\cos\theta_i}{\lambda}\right)^2$$

Low Exposure example at exposure time 120000 microseconds.

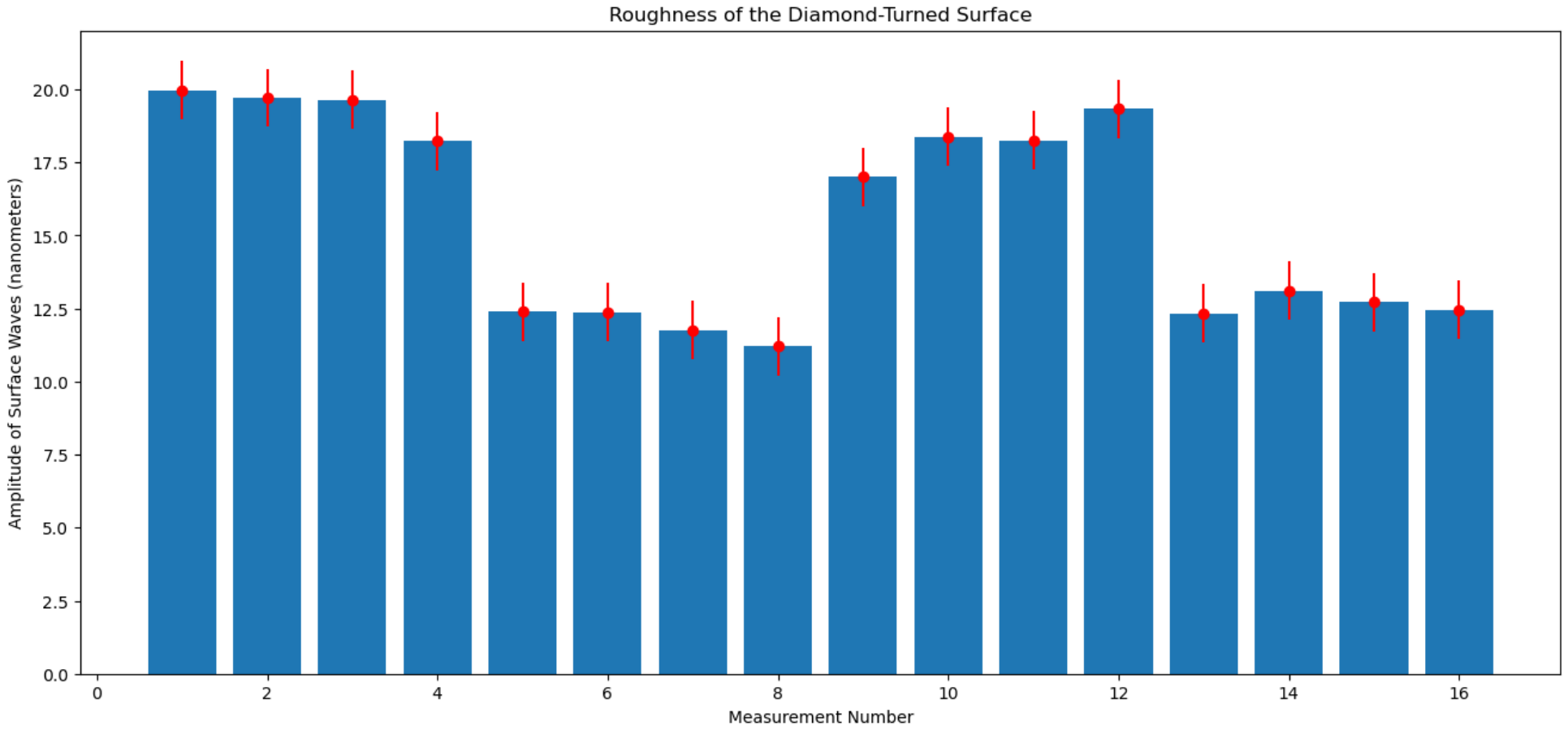


High exposure example at 2.5 million microseconds.

Results


Roughness of the Diamond-Turned Surface
Amplitude of Surface Waves (nanometers)
Measurement Number
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
0
2
4
6
8
10
12
14
16

Results


Roughness of the Diamond-Turned Surface
Amplitude of Surface Waves (nanometers)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
0
2
4
6
8
10
12
14
16
Measurement Number

Reflectivity

- Previous
  - 102% +/- 30%
  - Mix of photodiode and camera
- Second run: Only the camera.
  - Reflectivity = (Spectral+Diffuse)/Direct Laser Power

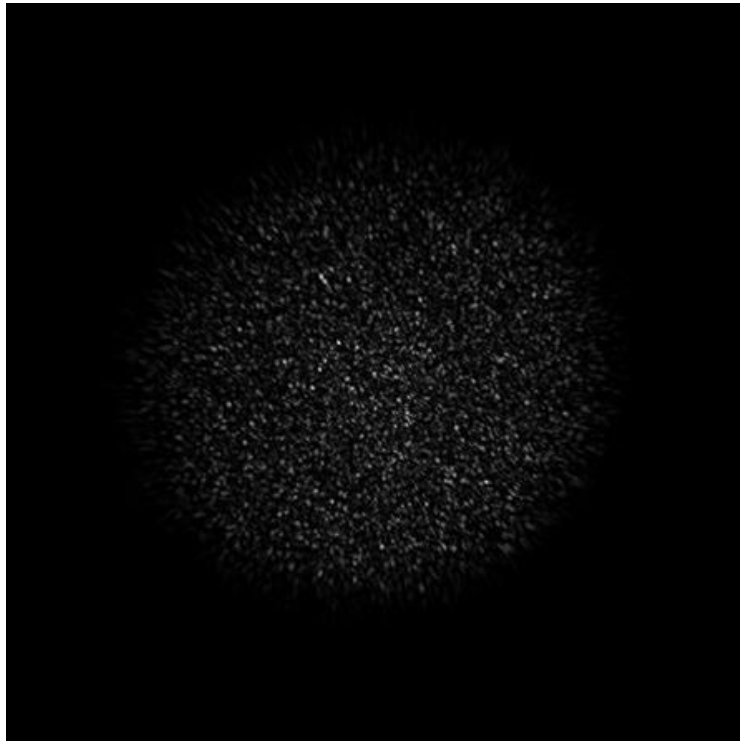
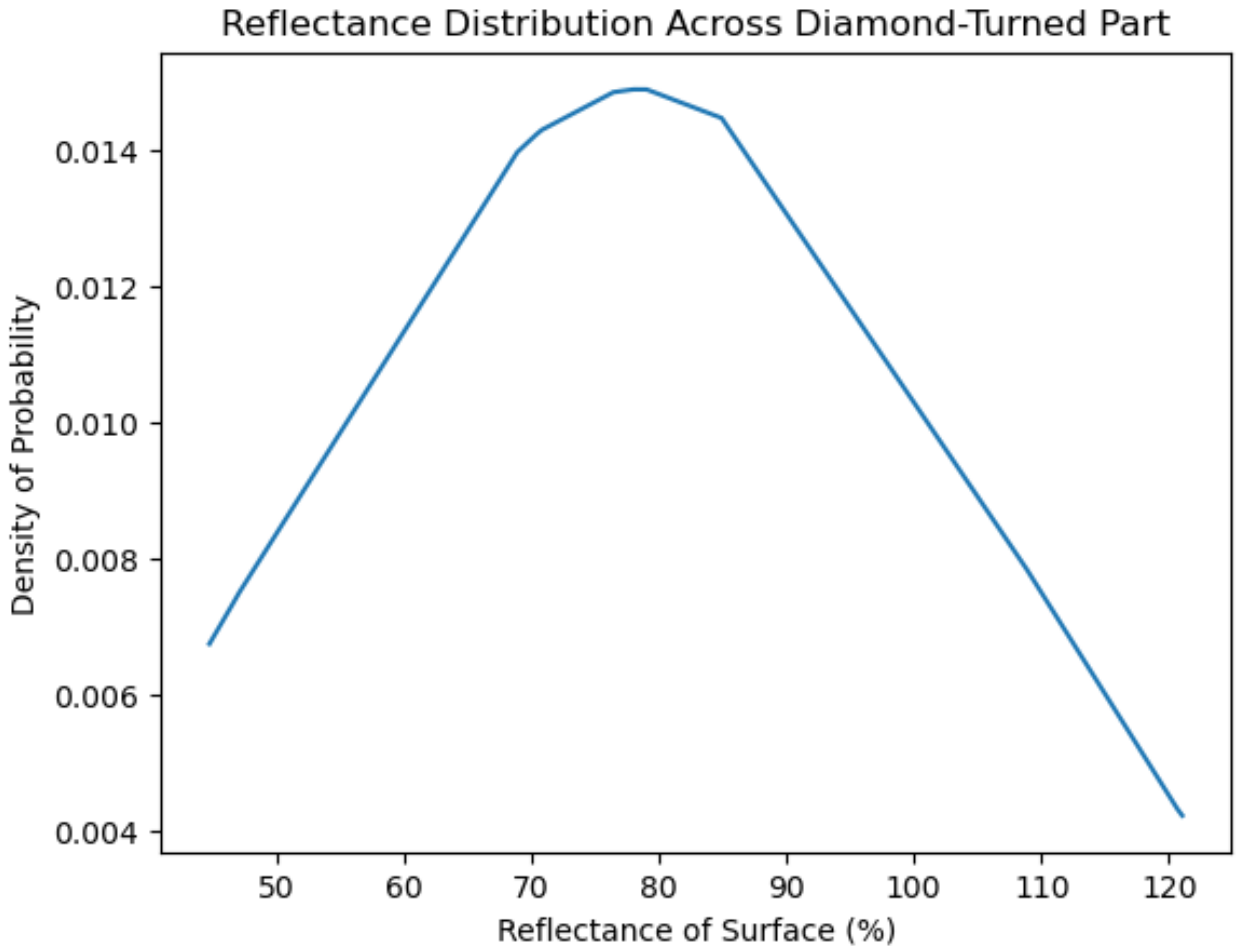


Image of the green laser directly shot onto the screen. Exposure time is 820 microseconds.

Results

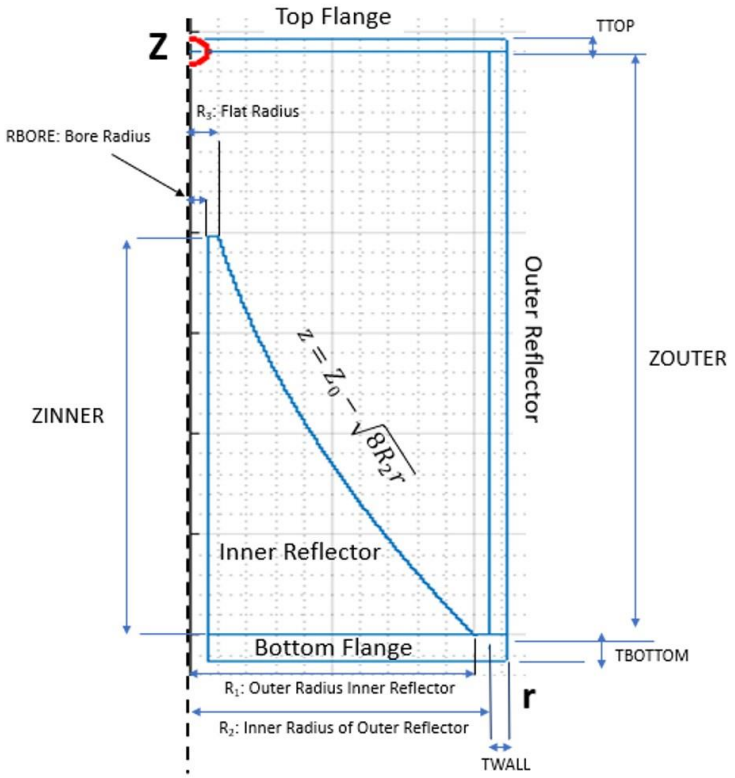

Reflectance Distribution Across Diamond-Turned Part
Density of Probability
0.014
0.012
0.010
0.008
0.006
0.004
50
60
70
80
90
100
110
120
Reflectance of Surface (%)

Ways to Improve

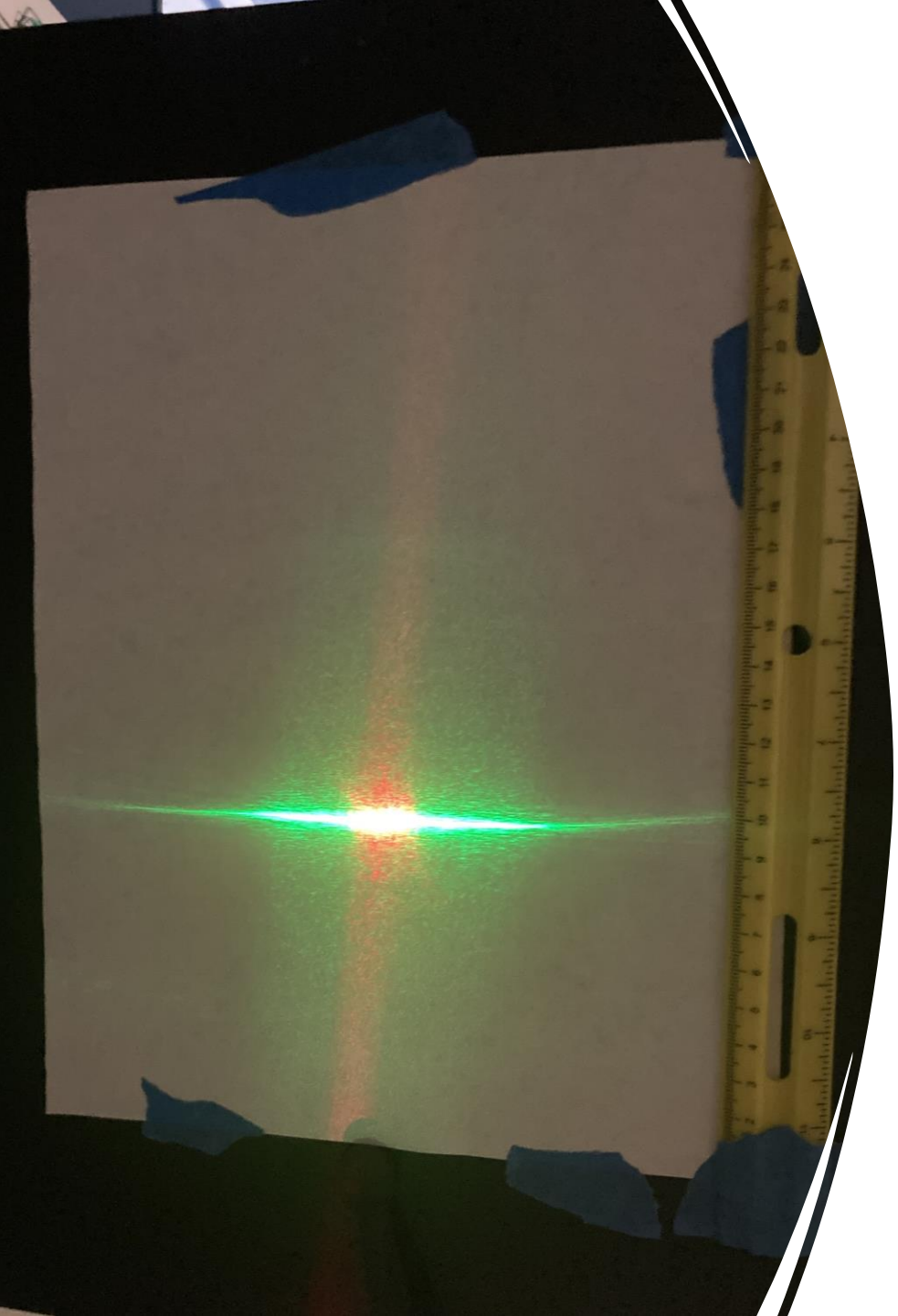
- Accurate data removal when finding diffraction bands.
- Less background light
- Hitting the surface parallel to the focal plane.
- One size fits all exposure times DO NOT WORK.

The RF Reflector

- The last picture of Stefan this week.
- Full size reflector
  - From CMM, height is 411.5 mm.
  - Theoretical focal point at 567.1 mm.



Parameter	Expression	Value [mm]	Tolerance +/- [mm]
R_1		200.0	0.2
R_2		201.00	0.05?
R_3		15.0	0.2
RBORE		25.4/2	0.2
Z_0	$\sqrt{8R_1R_2}$	567.1	-
ZINNER	$Z_0 - \sqrt{8R_2R_3}$	411.8	0.2
ZOUTER		567.10	0.05?
TWALL		25.4/4	0.2
TTOP		25.4/8	0.2
TBOTTOM		25.4/2	0.2

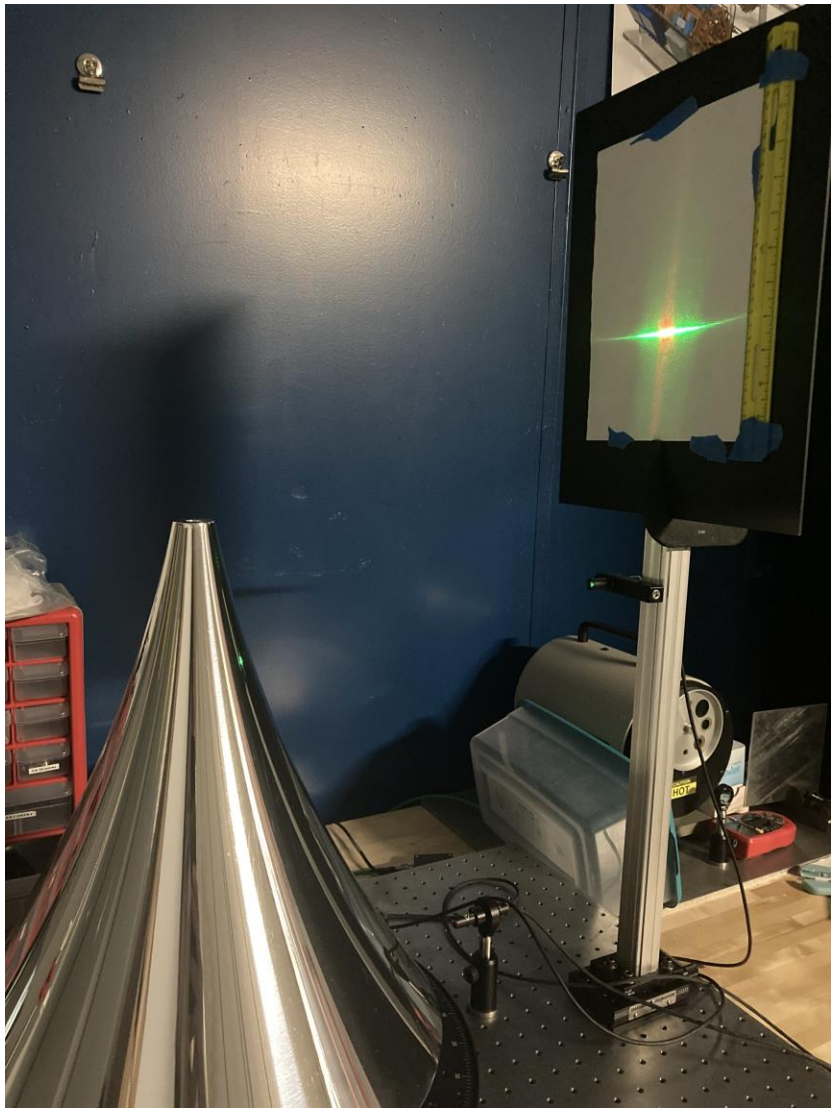


Diffraction Bands

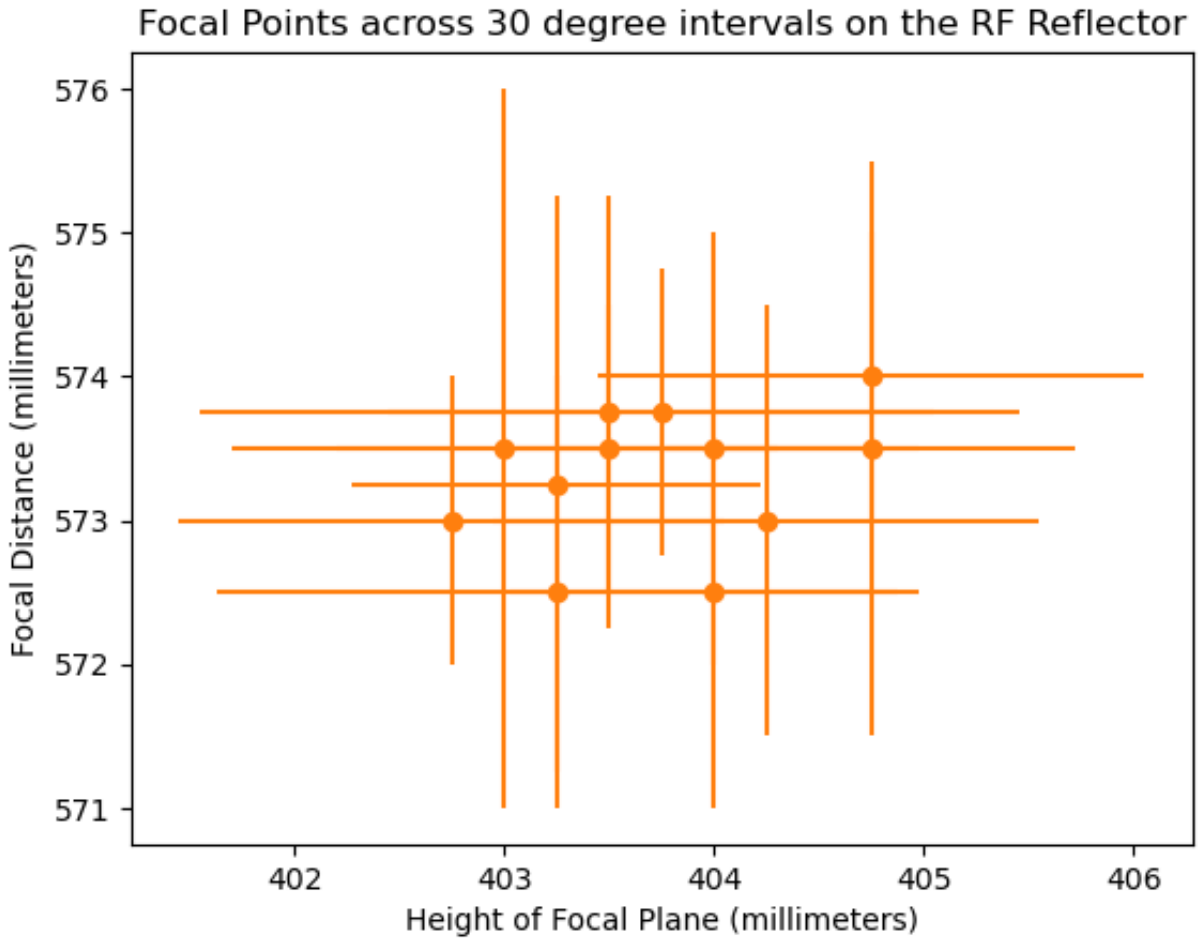
- Higher order bands are not visible.
  - Hand lathing vs. Single Diamond-Turn

Focal Point Measurements

- New adjustments.
  - Neither laser moves.
    - Separated as far as possible.
  - Reflector on a rotating table.
  - "White screen"



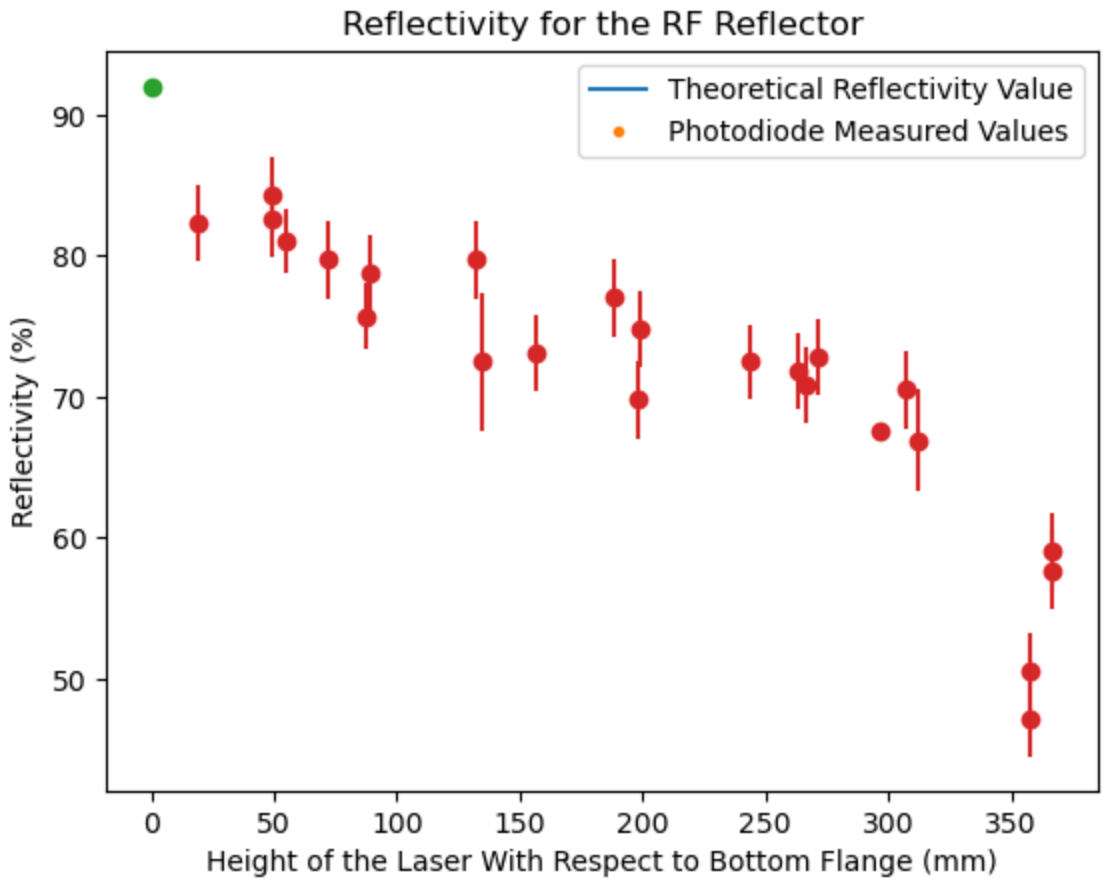
Focal Point Results



Reflectivity

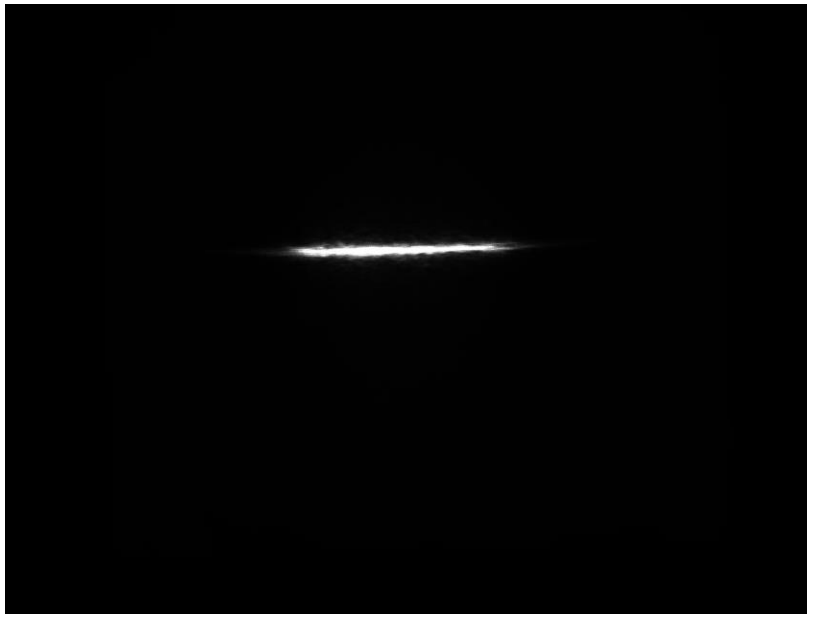
- Back to the basics.
  - Photodiode
- Rate
  of laser dispersion directly prop
  ortional to curvature.

Reflectivity Results

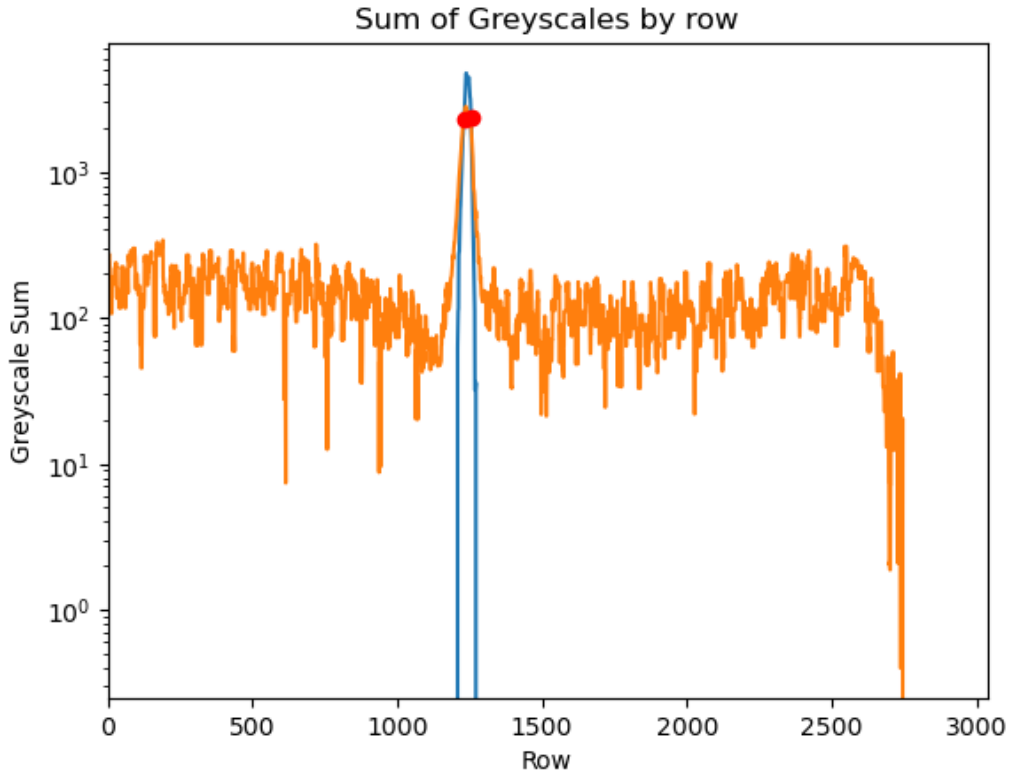


TIS/Roughness

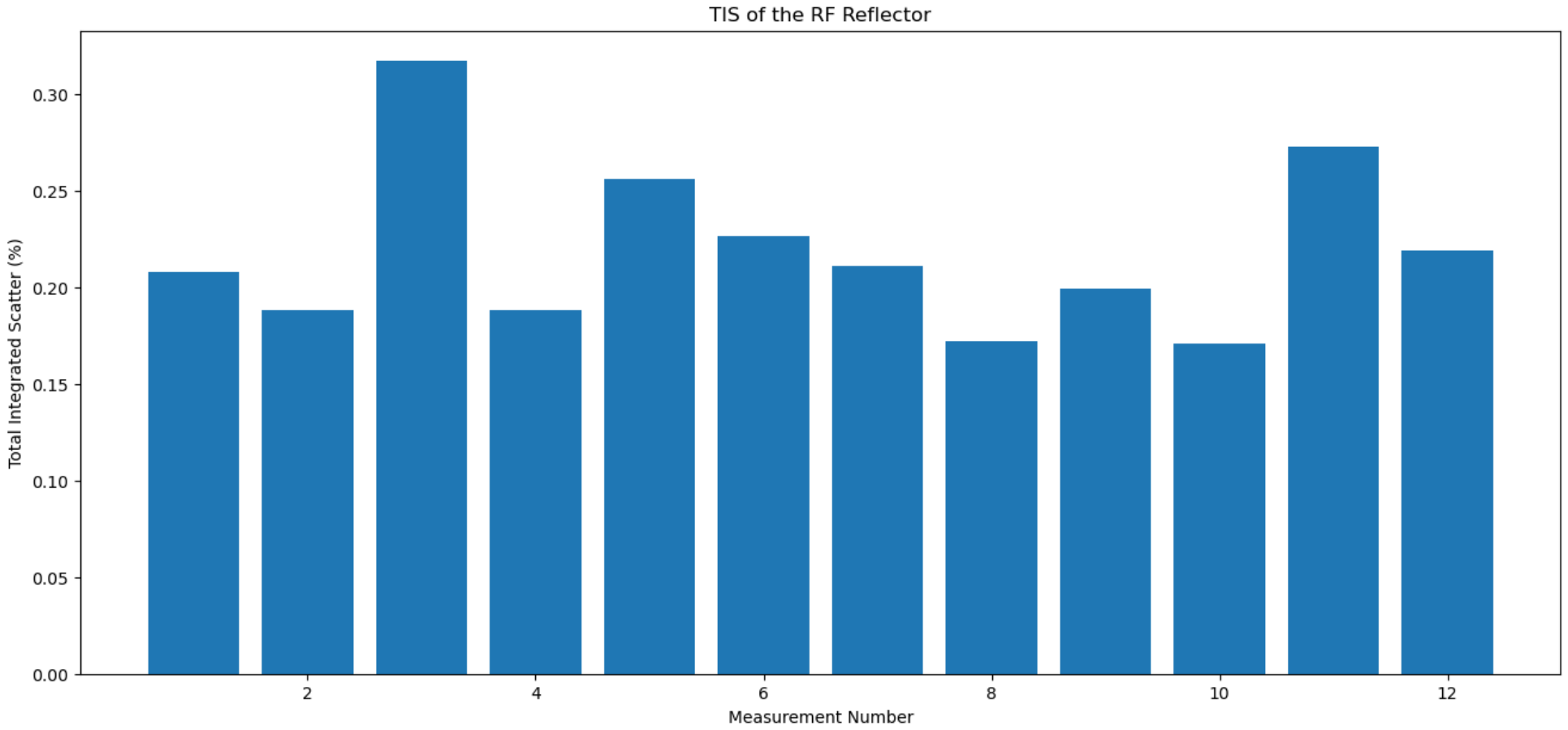
- Each optimal exposure time individually calculated.
- Mono12, not Mono8.
- Camera refocused.



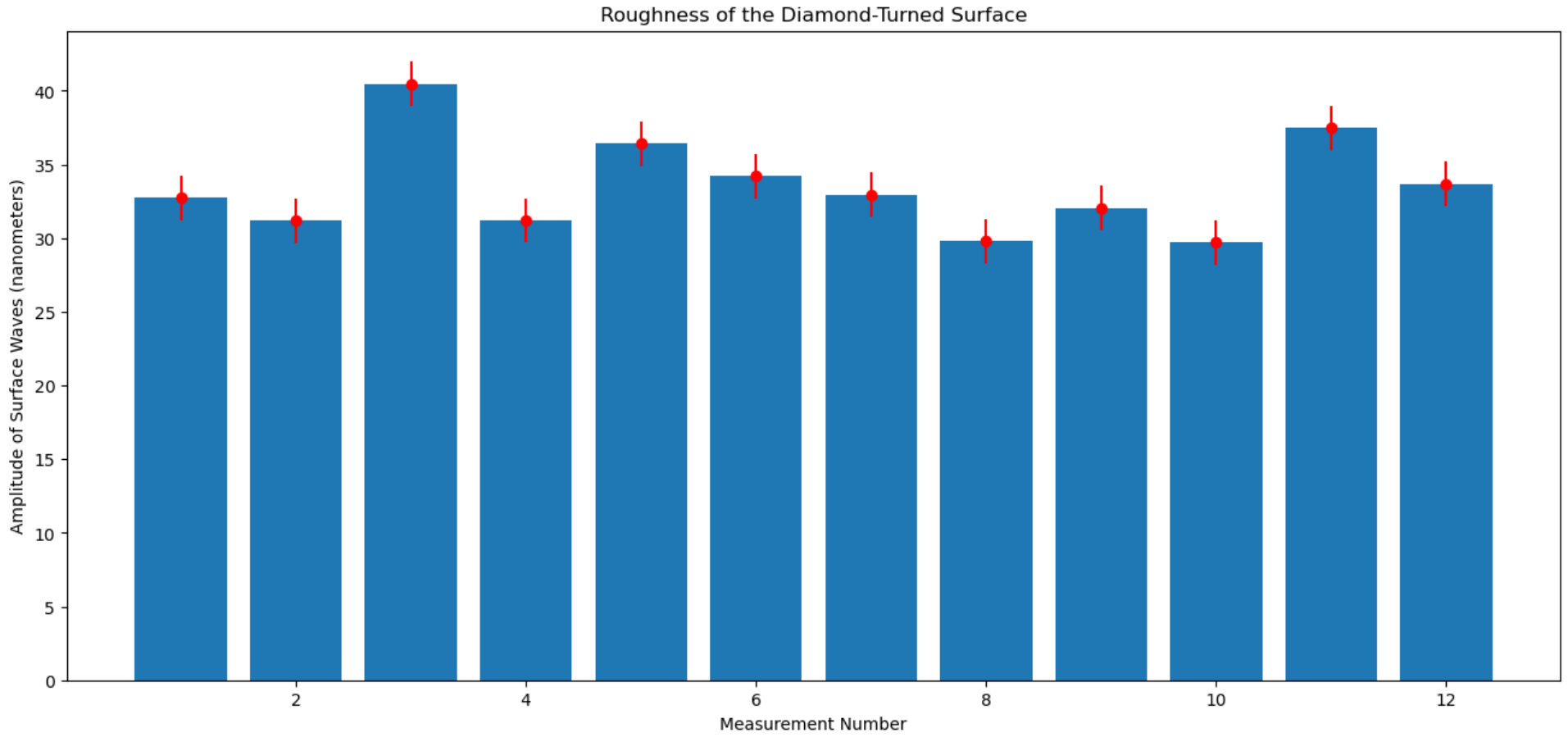
High exposure at 10000 microseconds.



TIS Results

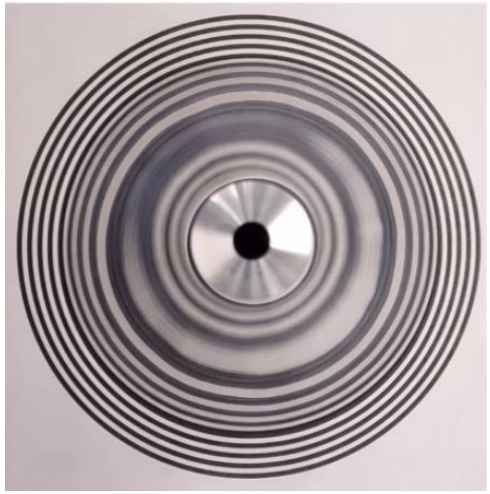

TIS of the RF Reflector
Total Integrated Scatter (%)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
2
4
6
8
10
12
Measurement Number

Roughness Results



What's Next

- Receive the bottom half of the diamond-turned reflector and redo the measurements.
- Calibrating tilt of each laser, making sure they are parallel to each other and the optical table.
- Statistical significance.
- A pole-arm for the photodiode?
- Simulations with Fred Optical Engineering Software



OOPS

I found one more.