Stray light reduction investigations

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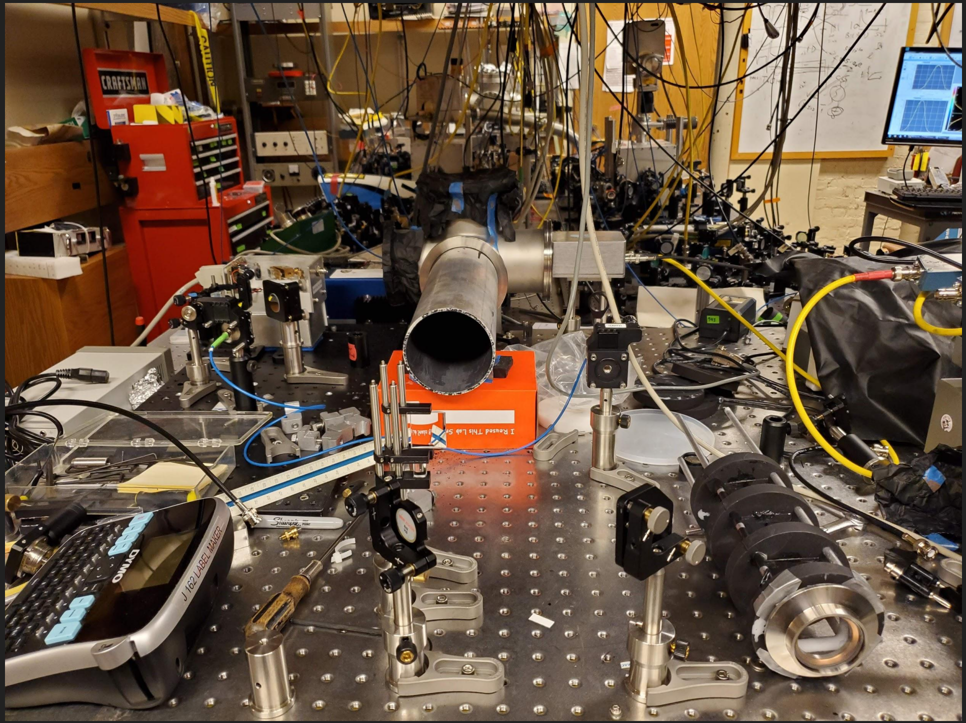
Broad Project Summary

1. Project background
2. Experimental setup
3. Results with multiple apertures
4. Results from changing distance between apertures
5. Results from changing window distance



Project Background

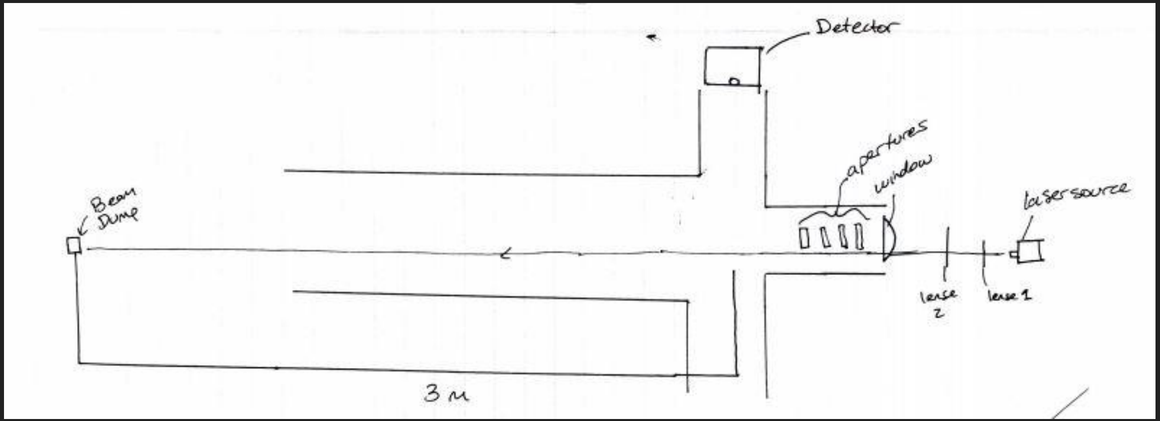
- Optical cycling can improve the detection efficiency of experiment, increasing effective signal by a factor of 4-10
- However, optical cycling involves detecting and optically pumping at the same wavelength (512 nm)
- Need to suppress light from the cycling laser from contaminating light from the molecules
- Goal: reduce scatter from laser to at least an order of magnitude below the signal level.

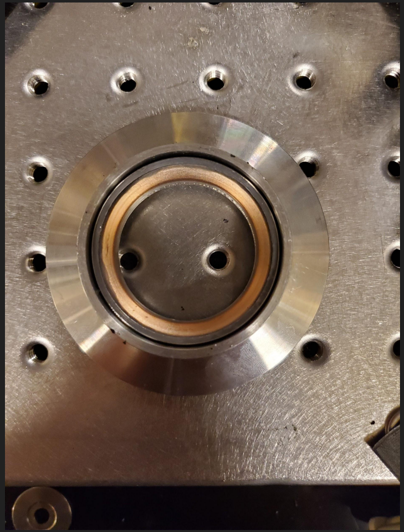
Goals

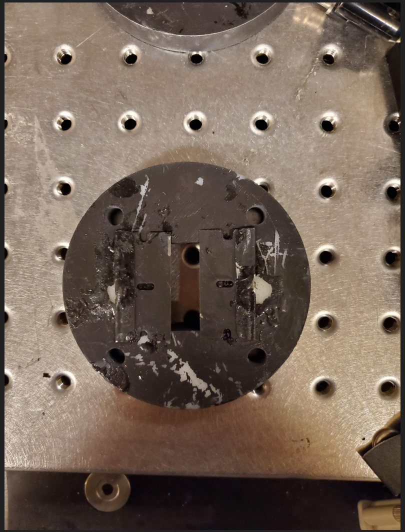
- The laser that we use emits 3*10^15 photons in 10 ms.
- In the meantime, we are now detecting 3*10^5 photons in 10 ms in ACME II.
    a. In the 4 ms pulse length this translates to roughly 8*10^4 photons/ms
- If we assume that no improvements are made in ACME III in signal, this means scatter must be reduced to less than 3* 10^-11 in terms of absolute suppression (assuming we want it at least an order of magnitude below the signal).
- Based on my my initial data collection, I found my absolute suppression to be 3.32E-10 meaning a reduction of a single order of magnitude is necessary to achieve the goal

Apparatus Setup

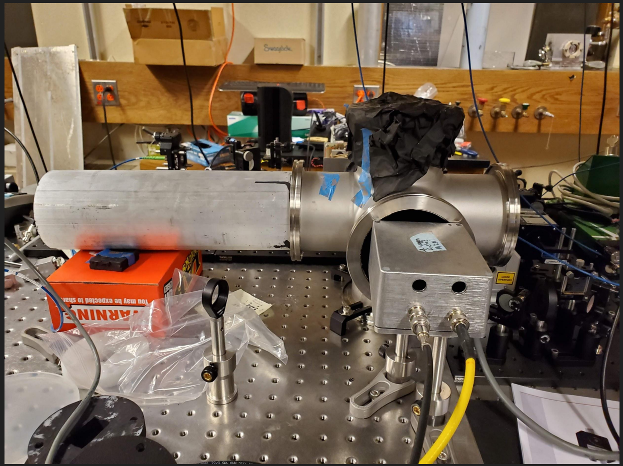
1. Detectors that we used
   a. Thorlabs PDF10a
   b. Hamamatsu R8900
2. We used a 512 ECDL
3. We expanded the laser beam 6x to 1.2 cm
4. We did this by using two lenses to widen and collimate the beam
5. We painted the inside of our tube black using MH2200 paint that absorbs ~96% of light found here.

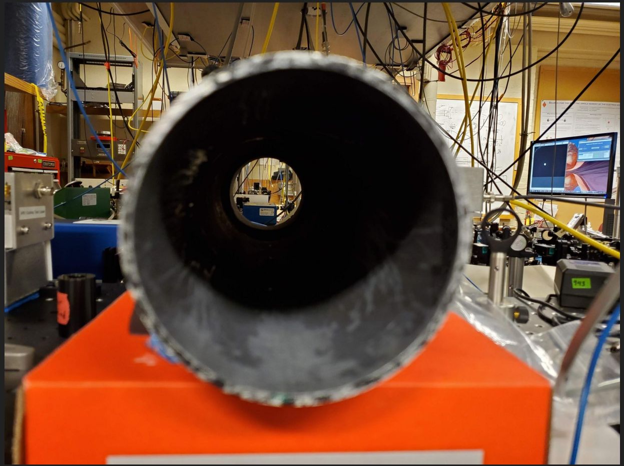


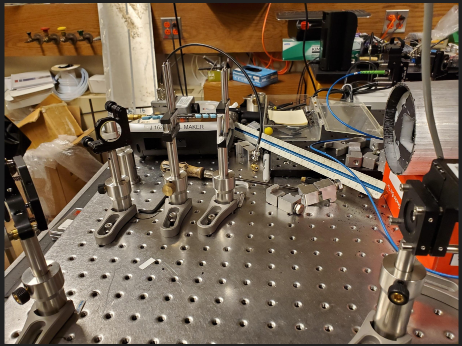




Relevant Pictures

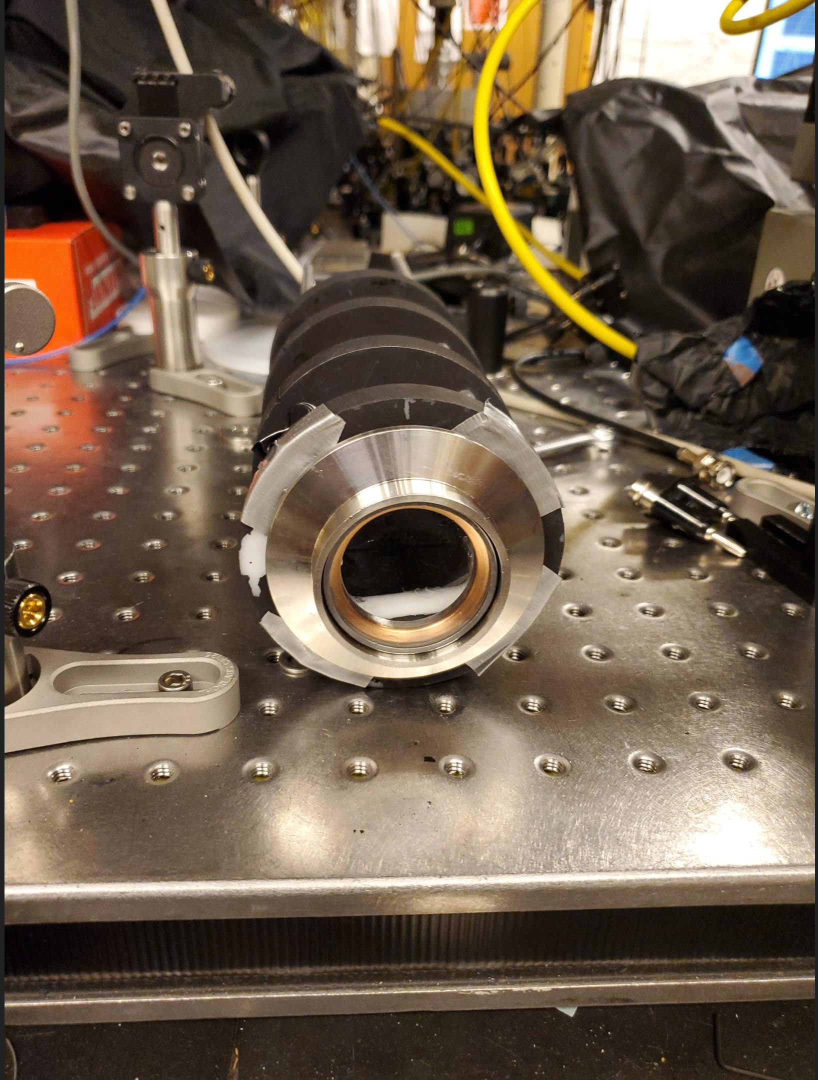




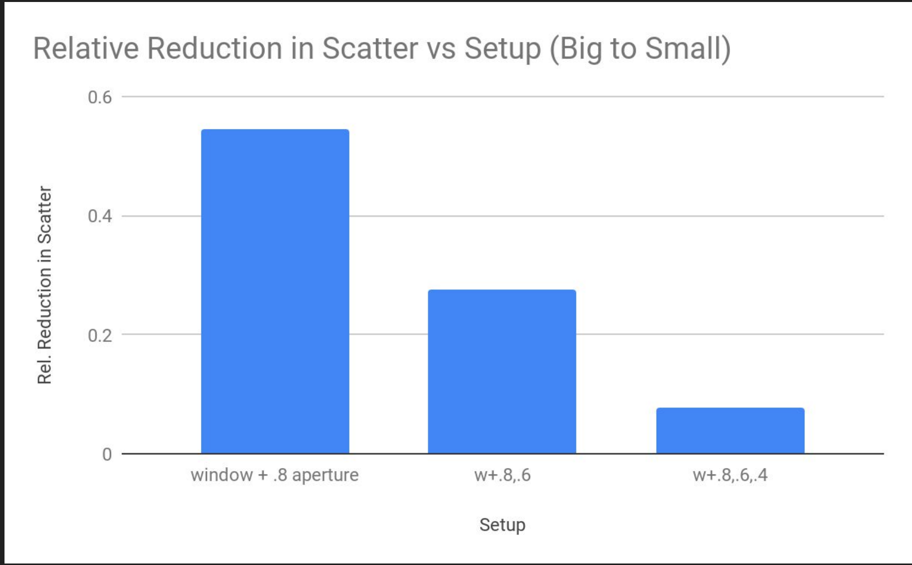


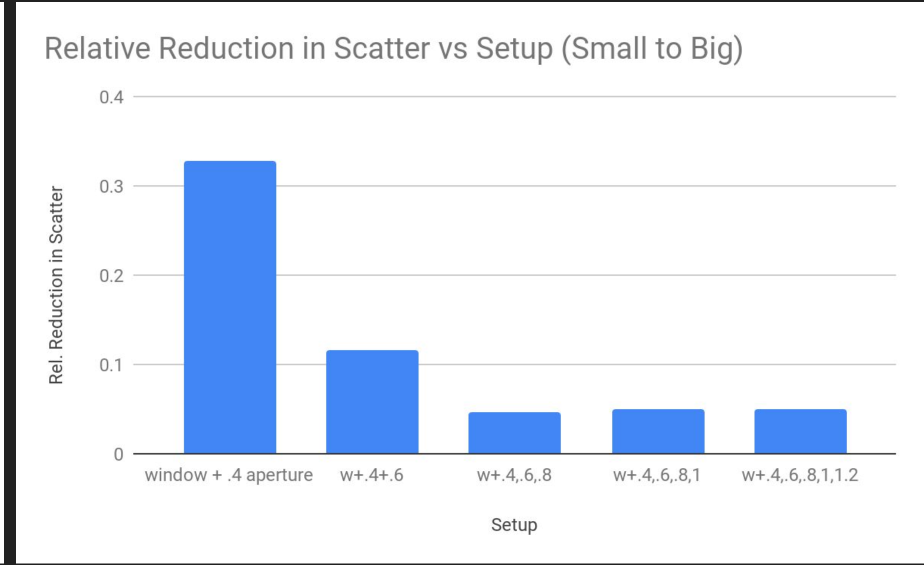
Scatter Tests

1. Apertures
2. Distances between them
3. Window Distance



Data Taken With Multiple Apertures

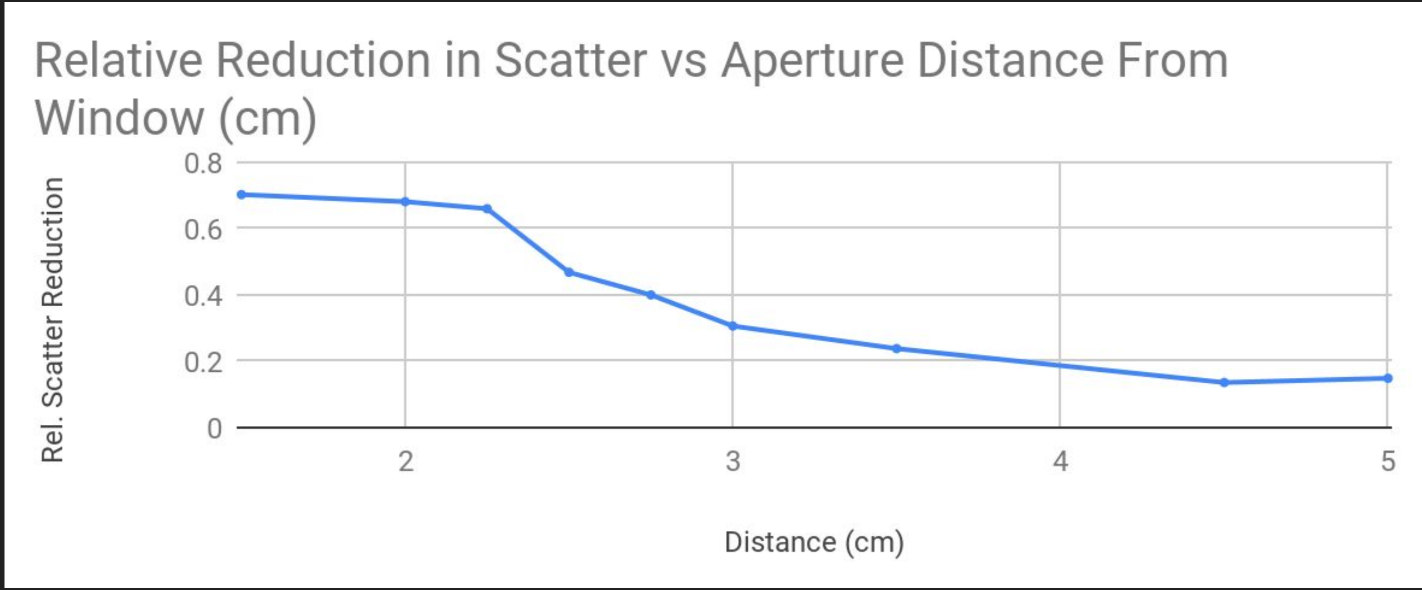




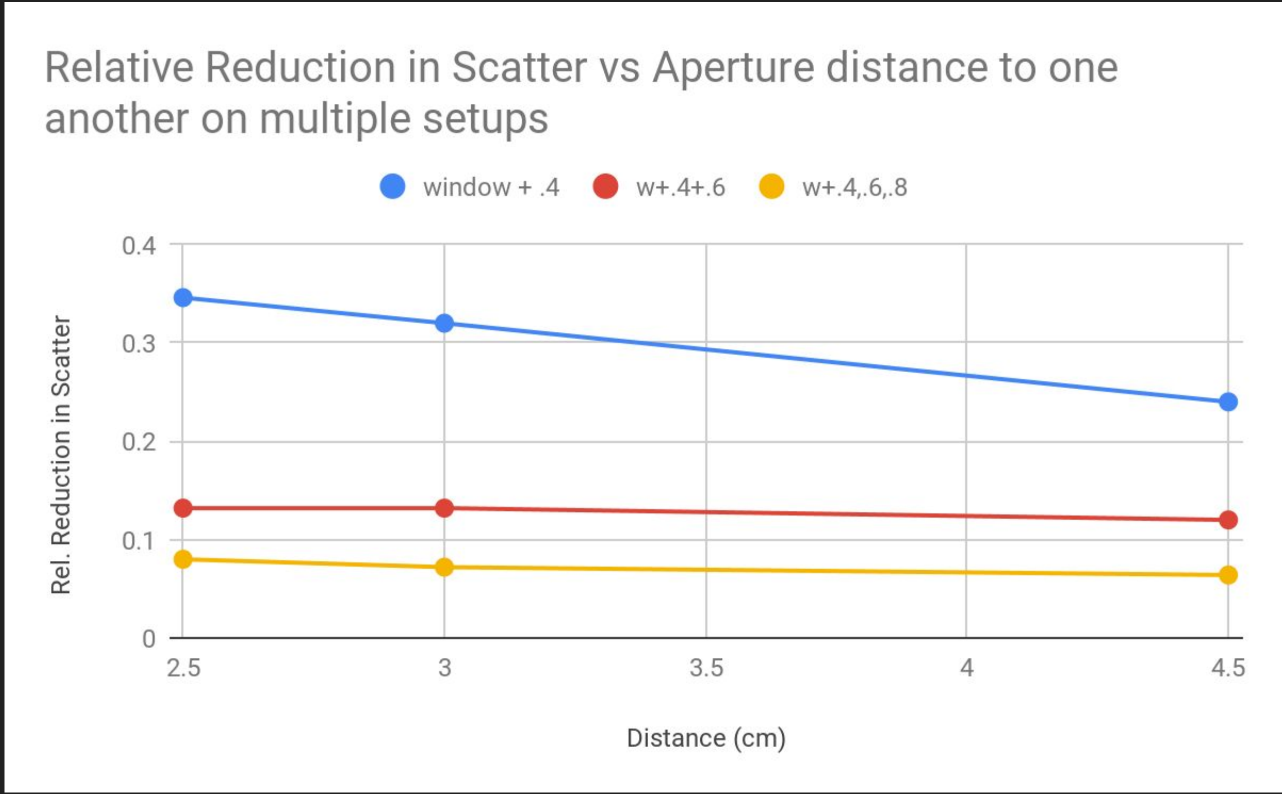
- In both cases, the data is shown in terms of relative reduction in scatter with respect to the case of the laser shining through a window without a single aperture
- For the Big to Small case, final reduction was .076 of original
- For the Small to Big case, final reduction was **.049** of original

The Optimal Aperture Distance from Window

- Based on this graph, it shows the optimal distance to place an aperture with respect to the window is 4.5 cm
  - This was confirmed when I used multiple apertures



Finding the Optimal Distance between Apertures Using Multiple Apertures



- This test shows that at 4.5 cm from another the scatter is minimized
- Final relative reduction was .048
- In second and third iterations, the apertures not being tested were fixed at optimal distance

Window Distance from Front of Shaft

- Optimal window distance shows to be 19 cm
    - Stopped at 20 cm because I could not push window in further

Key Takeaways

- Initial goal was to achieve a scatter reduction by a factor of 10
- I achieved this twice using the multiple aperture test and the multiple aperture test using optimal distances between the apertures
    - Reduced scatter by a factor of 20 leading to an absolute suppression of 1.66e-11
- Due to time I was not able to do a test with the optimal window distance along with multiple apertures at optimal distance
    - Can't say anything about if their individual reductions would multiply or not
    - But, by just using apertures, I was able to reduce the absolute suppression to the established goal
- Caveats
    - The beam dump was not in the apparatus itself
    - Have not put in field plates
    - Detection is not in final configuration