Lens Alignment for Pointing Feedback

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In Gen. 2 we are hoping to implement more robust measurement and control of the laser beam pointing. In order to do so I have developed a new scheme based on the light which is reflected from the field plates. The basic scheme is outlined in the diagram below. On the left, the laser light passes through an isolator and into an optical

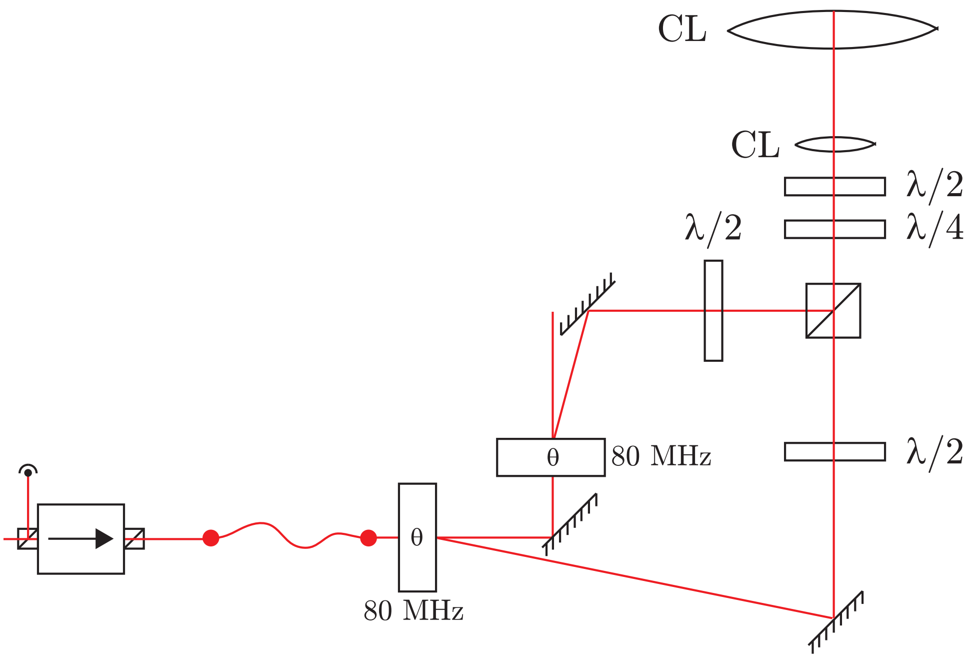

Figure 1: Schematic of the optics setup used for monitoring the perpindicularity of the laser beam to the electric field plates. See main text for description.

fiber, currently passing from the north optics table to the south optics table. There, it goes through a pair of AOMs which perform the fast polarisation switching. The light is recombined and then passes through a pair of cylindrical lenses which provide it with the desired shape, i.e. elongated in the vertical direction. Following these lenses, the light is incident on a test electric field plate piece, with the AR (ITO) coating on the near (far) side.

When the light is incident normal to the ITO surface it will be reflected along the same path, and pass back through the optical fiber, into the isolator, and be rejected out the side of a PBS, into a photodetector. It is important to carefully align the lenses used for beam shaping in order to ensure this condition. I will now give a brief outline of how I do this.

The first step is to align the reflected beam without the lenses in place. This is quite easily done — around 10% of the light is reflected meaning the reflected beam is clearly visible and easy to overlap with the incident beam. A picture of the incident beam and the test field plate piece is shown in Fig. 2. Once the beam is aligned without the lenses, the basic procedure is to put the lenses in one at a time, perturbing the beam as little as possible. This could be done more rigorously than I describe here if one is willing to perform quantitative beam profiling. This is particularly difficult to do since the beam is expanded to several inches in size.

The first step is to make a reference to show where the beam is incident without any lenses in. This is shown in Fig. 3. I have used a large post covered in tape and marked with a pen where the beam is incident.

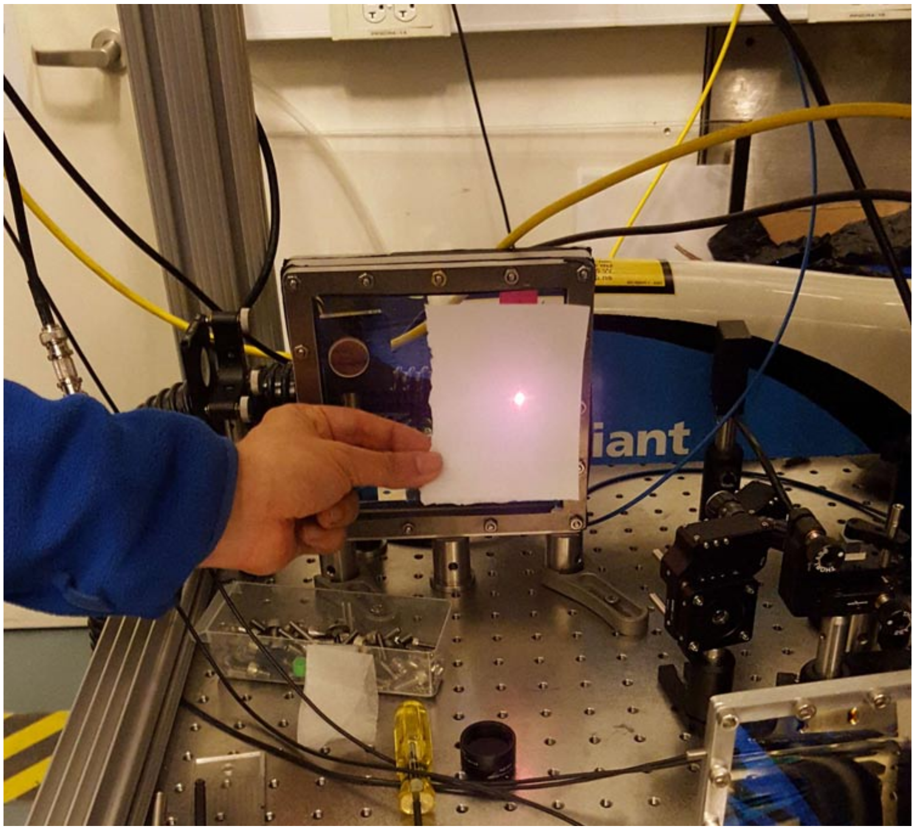

Figure 2: Incident beam in front of the electric field plate test piece.

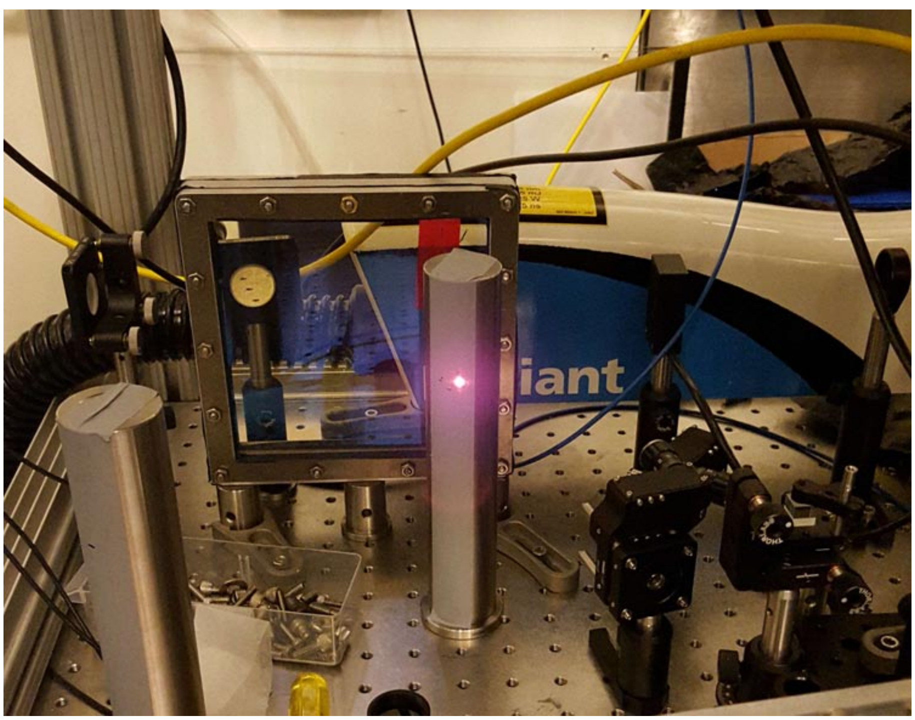

Figure 3: Large optical post covered in tape used as a reference of the beam height before any lenses are put in.

Next, place the first cylindrical lens into the beam path. It is important to note at this point we are going to place the lenses in such that the beam path is perturbed as little as possible. As such, you should not adjust the pointing of the beam with anything other than the lenses, otherwise you will end up steering the beam along a weird path. The first cylindrical lens has a short focal length and is mounted in a 6-axis Thorlabs kinematic mount, shown in Fig. 4. To begin with, this alignment should just be done by eye, trying to ensure the flat face of the lens is perpendicular to the beam and that the axes of symmetry are aligned with the appropriate lab axes.

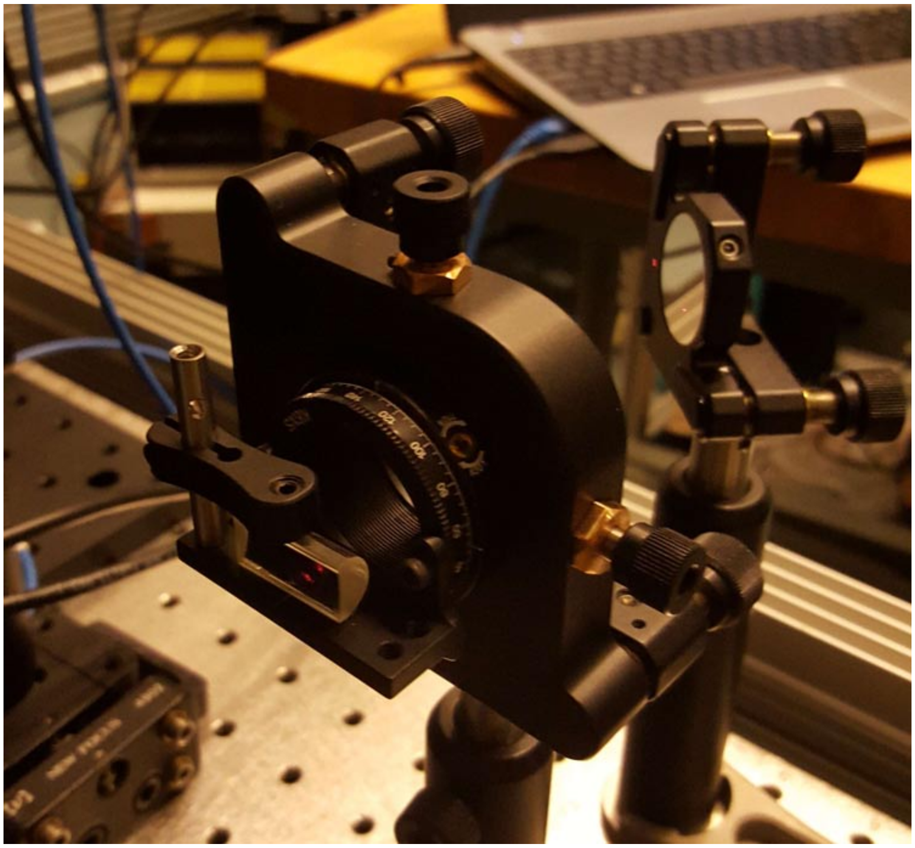

Figure 4: 6-axis mount used to align the first of the two cylindrical lenses.

To align the height of this lens, I use the mark that I previously made and try and make sure that the brightest part of the elongated beam profile is at the same position, as shown in Fig. 5. This doesn't have to be perfect — we will refine this alignment later.

Next, we will want to align the orientation of the cylindrical lens in terms of its rotation about the laser beam. This can be done with the rotation mount on the front of the 6-axis mount. A useful to trick to help with this is to use a ruler. Placing it on the table allows one to align the now elongated beam with the lines on the ruler, as shown in Fig. 6.

At this point the first cylindrical lens should be fairly well aligned, and we will now add the second lens. I have mounted this one on a 5-axis translation stage from Newport, which is shown in Fig. 7. The 'first pass' for aligning this lens should just be done by hand — place the lens in such that the flat face is again perpendicular to the beam, it is the correct distance from the first lens (the sum of the focal lengths) and the beam is centred vertically on the lens. Again, one can check this using the mark on the post that was made previously. Fine adjustment of the vertical position can be done by adjusting two set screws simultaneously in the 5-axis mount.

To perform finer alignment of the perpendicularity of the larger cylindrical lens's flat face, we can now use the light which is reflected off this face. Placing a piece of paper in the beam path allows one to see whether or not this reflected beam is aligned with the incident beam or not. This is shown in Fig. 8 — sadly it does not show up well so I have put a red line to indicate the kind of profile the reflected beam will have. In this image, the reflected beam is to the left of where it should be. Using the 5-axis mount allows you to rotate the lens such that this reflected beam becomes well aligned.

Next one should align the 'longitudinal' position of the second lens, i.e. the distance between the two lenses. A trick which helps to do this is as follows. Remove the post which was previously used as a reference mark for the vertical position, allowing the beam to reflect off the ITO. Looking upstream of the lenses this reflected beam

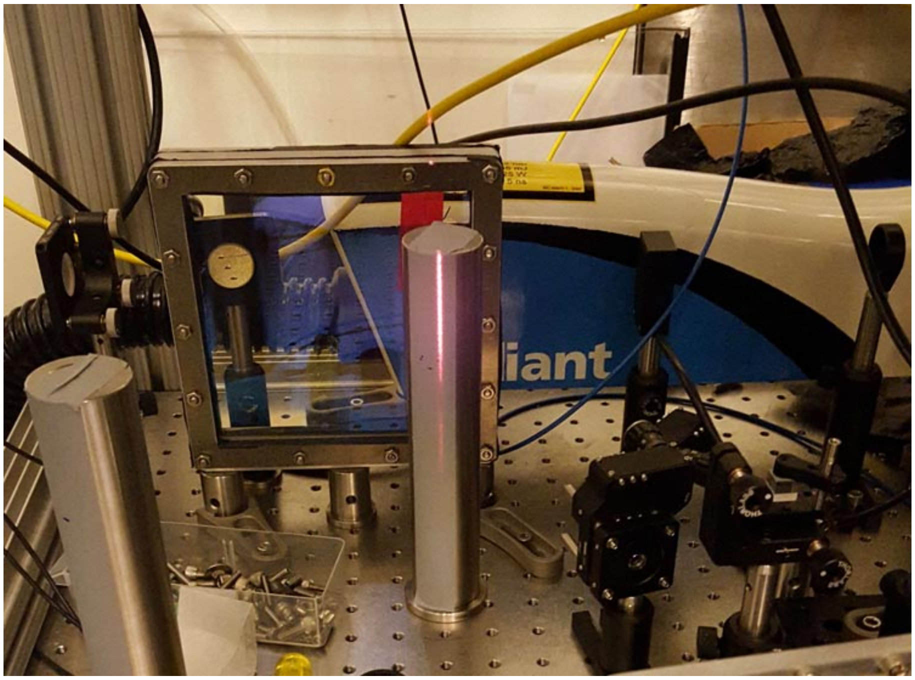

Figure 5: Now elongated beam profile, on top of the reference mark made previously.

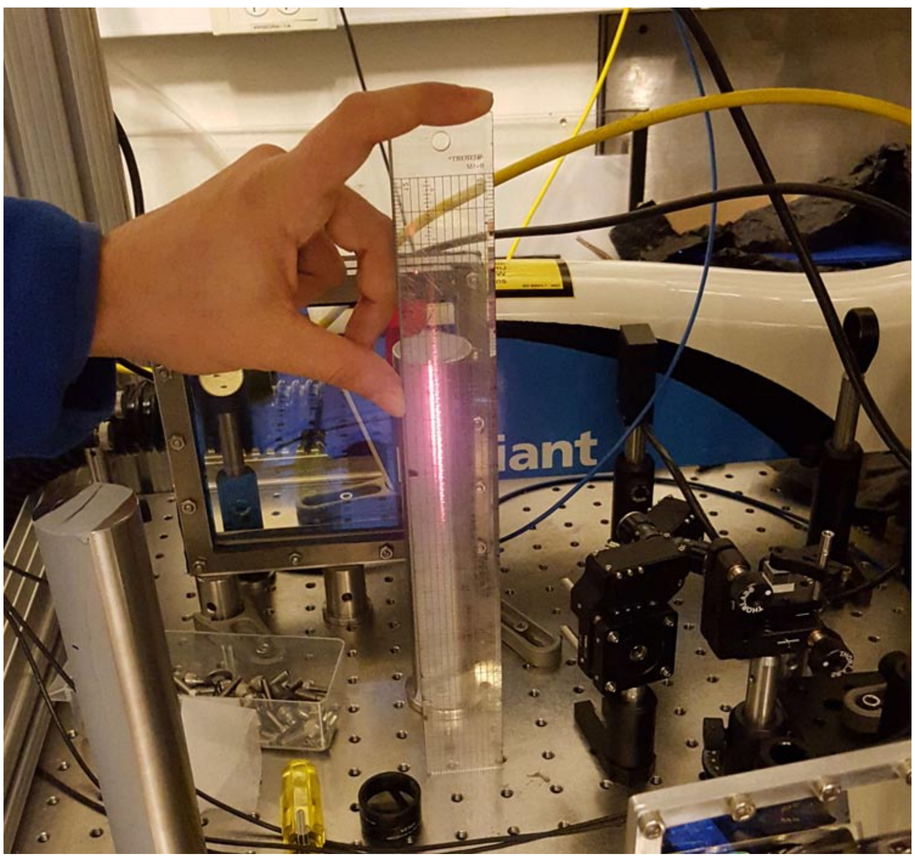

Figure 6: Ruler used to help judge whether the beam is being rotated by the cylindrical lens.

should be visible. This is shown in Fig. 9. For clarity the outline of a mirror mount has been drawn. Around the mirror mount one can see the reflected beam — it is clear that it is not well collimated due to its size.

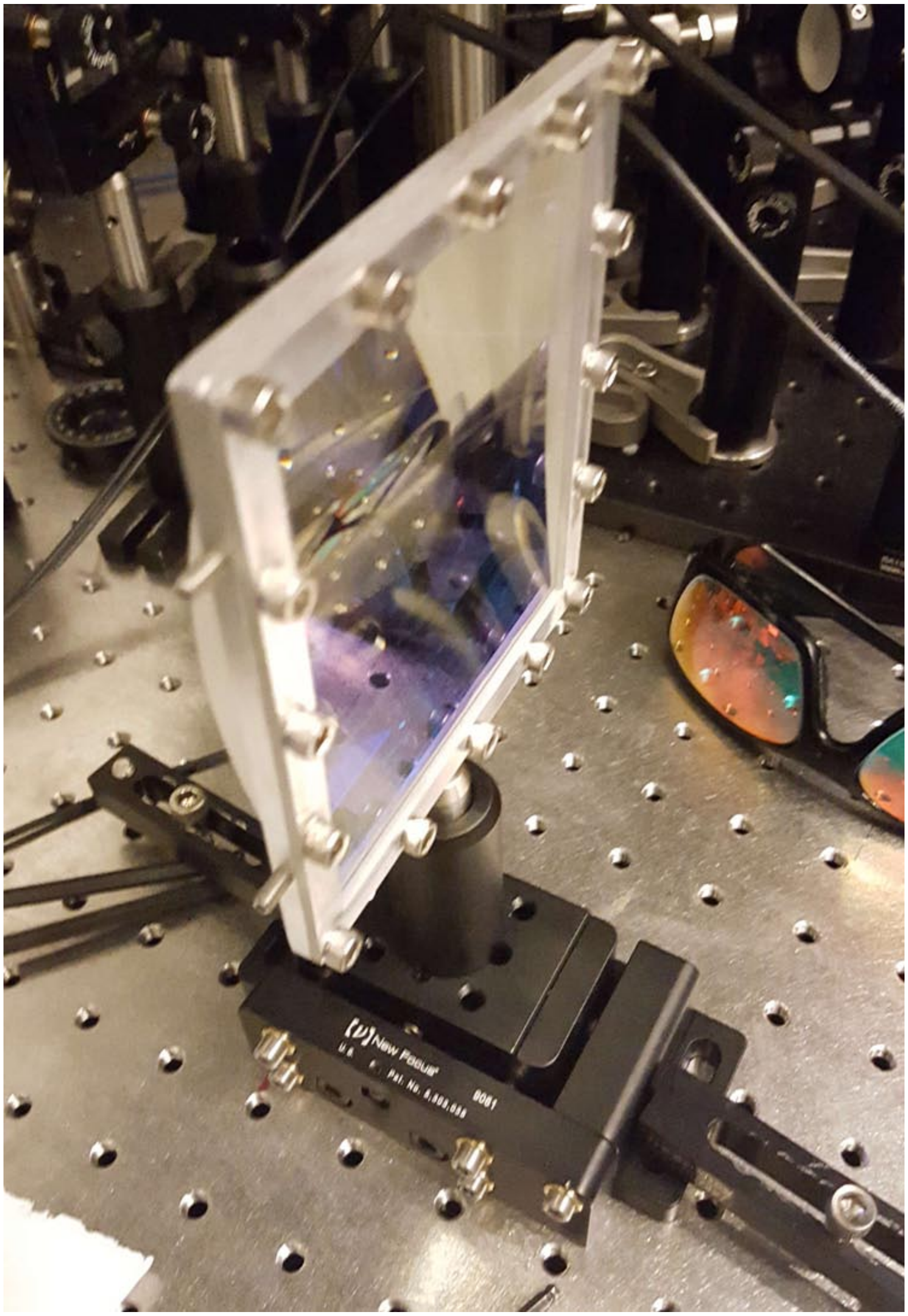

Figure 7: 5-axis mount used to hold the second cylindrical lens.

First, you should align the rotation of the first cylindrical lens about the beam axis (we did this previously using the ruler trick) — looking at the reflected beam you should try and make it aligned vertically. Next, by moving the second lens along the beam path you should be able to make the reflected beam well collimated. It is unlikely that the vertical alignment of the second lens will be spot on, in which case it should be easy to tell when it is well collimated, as the beam becomes small and bright, as shown in Fig. 10. In this example you can see that the reflected beam is much too high! After doing this you should repeat the vertical alignment of the second lens. At this point, you should probably be able to see the reflected signal.

After doing this, you shoud start to make small tweaks to the alignment. The ones that I have found good success with in improving the signal are: fine tuning the position of the second lens along the beam path, and the two axes of rotation of the second lens (about x and y if the electric field plates are in position). At this point you can also try tweaking the horizontal alignment of the mirror immediately before these lenses — note that the lenses

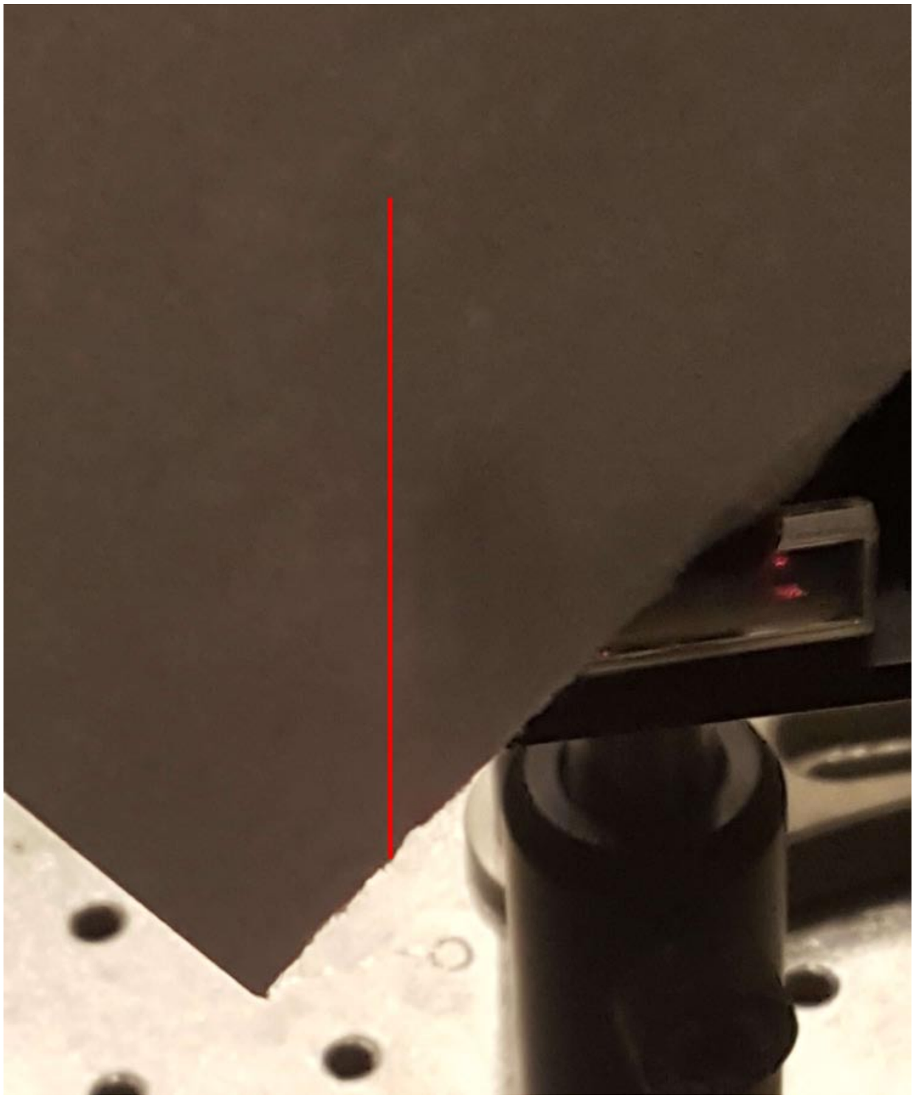

Figure 8: Reflected beam from the flat face of the second cylindrical lens, viewed next to the first cylindrical lens.

should not affect this pointing direction much. Once you think that everything is tweaked as best as possible, you can try aligning the vertical axis of the mirror immediately before the lenses. If you have aligned everything well it should not need to move far at all. The final nob that you can try turning to improve the signal is to change the collimation of the beam coming out of the fiber — sometimes a small improvement can be gained.

I have been able to get signal sizes which are around 90% of the signal obtained without the cylindrical lenses in, although not perfectly reliably — anything about 0.1 V is pretty good and should give good scans when using the piezo-actuated mirrors.

Figure 9: Light reflected off the ITO coating. The elongated shape shows that it is not well collimated. Outline of a mirror mount is drawn in for clarity.

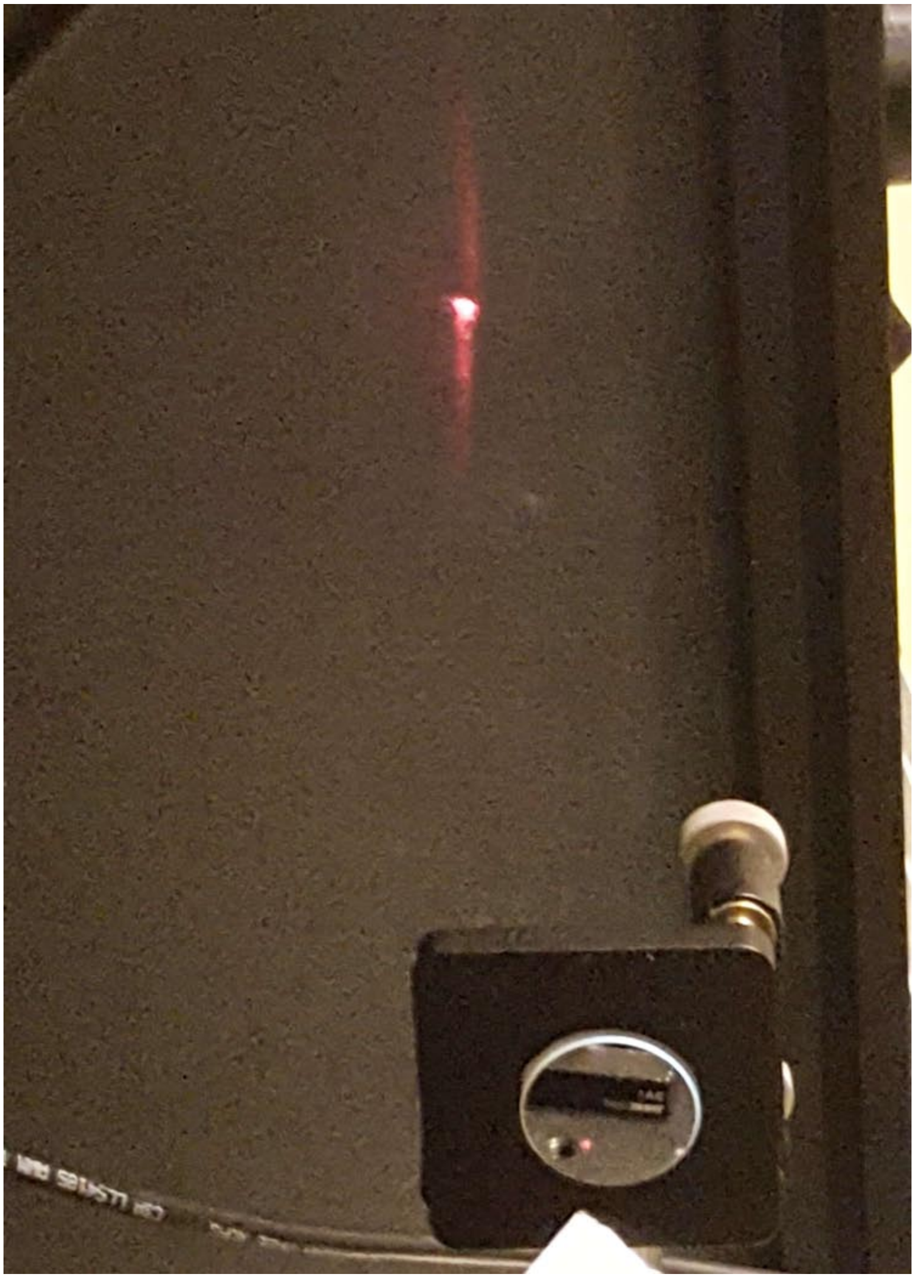

Figure 10: Light reflected off the ITO coating, now better collimated, but poorly aligned vertically.