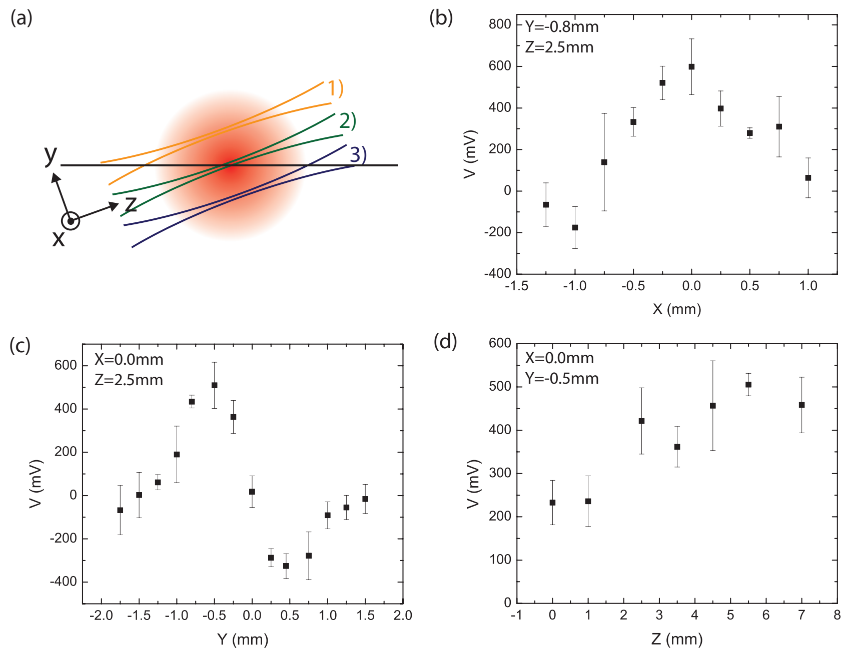

Fig. 3. (a) Geometry of the split image and laser alignment. The horizontal line symbolizes where the D-shaped mirror M2 splits the image into two halves. The two halves of the image are then detected with the two APDs. The coordinate system indicates how the coordinates at the CO_2 laser focusing lens translate at the MOT image plane. z is the propagation axis of the laser beam and passes through the center of the MOT. x (y) is the horizontal (vertical) axis at the lens position. The three focused laser beams (1-3) show the location of the CO_2 focus within the cloud for three differnet positions along the y-axis. The green beam (2) corresponds to the focus being aligned to the center of the MOT along the y-dimension, where the overall signal vanishes (see Fig.(c)) (b)-(d)Signal due to the imbalance caused by the pulsed CO_2 laser as a function of position. The focus of the laser beam is moved along one dimension, while the other two are held constant. (b) The focus of the laser beam is moved along the x-axis. (c) The focus of the laser beam is moved along the y-axis. (d) The focus of the laser beam is moved along the z-axis (along the beam propagation axis). Error bars indicate statistical uncertainties. The inset in the upper left corner indicates the alignment in the other two dimensions.

APD signals, not the absolute value. Figure 3(d) shows that the method we describe in this paper is not very sensitive to the alignment of the focus along the beam propagation axis, as expected from the long Rayleigh length along this dimension. The Rayleigh lengths of our CO_2 are 522 μm and 1102 μm respectively.

With the CO_2 laser pre-aligned to the general location of the MOT, a first signal can easily be found. Once a first signal is detected, a systematic scan of the focus of the CO_2 laser beam in combination with an understanding of the geometry of the setup finds the center of the MOT. First the center along the x-axis is determined by finding the maximum signal when scanning along the x-dimension, as long as $y \neq 0$ mm. Having found the center along the x-axis, the center along the y-axis is determined by scanning the y-dimension. Because the method described is insensitive to the precise location along the z-dimension, the optimization along this axis is best done by directly maximizing the number of atoms transfered into the CO_2 laser dipole trap. Using this alignment procedure we are able to align the CO_2 laser beam to the center of the MOT.

4. Conclusion

In this paper we have presented a novel technique to align a laser beam to a cloud of trapped atoms. We demonstrated that we can align the focus created by a CO_2 laser beam to the center of an atomic cloud in the plane perpendicular to the laser beam propagation. This leaves one degree of freedom (along the beam propagation axis) left to be aligned. Fortunately this dimension is the least critical due to the larger Rayleigh length of a laser beam as compared to its waist.

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