



Specimen Alignment Technique for Oblique-Impact Shock Physics Experiments

by Tim Cline

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Tim Cline

Weapons and Materials Research Directorate, ARL

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14. ABSTRACT The Impact Physics Branch of the U.S. Army Research Laboratory operates a high pressure gas gun for shock physics research. One of the key types of experiments that are routinely performed with this facility is an oblique-impact experiment where the impacting face of the projectile and the target material are both oriented at an angle to the gun axis. This is done to obtain simultaneous pressure and shear during the experiment. To achieve this capability, a groove has been cut along the bottom of the gun bore for the entire length of the gun tube. This groove enables a projectile with a small protrusion, or key, to travel the length of the gun without rotating, permitting an angled front face of the projectile to properly impact a pre-aligned target. Precise alignment of the target with the angled front of the projectile is critical for a successful experiment. This technical note provides a detailed procedure for performing target alignment during oblique-impact experiments.					
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1. Introduction

The Impact Physics Branch of the U.S. Army Research Laboratory (ARL) operates a high pressure gas gun for shock physics research. One of the key types of experiments routinely performed with this facility is an oblique-impact experiment where the impacting face of the projectile and the target material are both oriented at an angle to the gun axis. This is done to obtain simultaneous pressure and shear during the experiment. To achieve this capability, a groove has been cut along the bottom of the gun bore for the entire length of the gun tube. This groove enables a projectile with a small protrusion, or key, to travel the length of the gun without rotating, permitting an angled front face of the projectile to properly impact a pre-aligned target. Precise alignment of the target with the angled front of the projectile is critical for a successful experiment. This technical note provides a detailed procedure for performing target alignment during oblique-impact experiments.

2. Alignment Procedure

The general approach used to properly align the projectile front face with the target is to first align an optically flat mirror with the front of the angled projectile face that has been placed at the muzzle of the gun tube. A reflective periscope is then used to elevate a laser beam shining at the projectile location to a height above the gun and directed towards the breech end. The overall alignment scheme is depicted in figure 1. The location of the beam at the breech end of the gun is noted on a projection screen placed at this location. The reflective, oblique target is then placed in its holder for the experiment, which places it in the optical path of the laser instead of the projectile and associated mirror. The target holder is carefully rotated until the laser beam is deflected to the same location on the projection screen at the breech end of the gun. The step-by-step procedure for this task is given following the component listing.

The following components are needed for oblique-impact target alignment:

1. Class II helium neon 0.95-mW laser with adjustable tripod mounting assembly.
2. Newport Research optical periscope tower (see figure 2) consisting of the following:
 - MDL 675 beam steering device (with x-y micrometers and precision mirror),
 - MDL BP-2 adjustable mount and precision mirror,
 - 14-in MDL 75 adjustable tower, and
 - 6-in tower extension with magnetic mount.

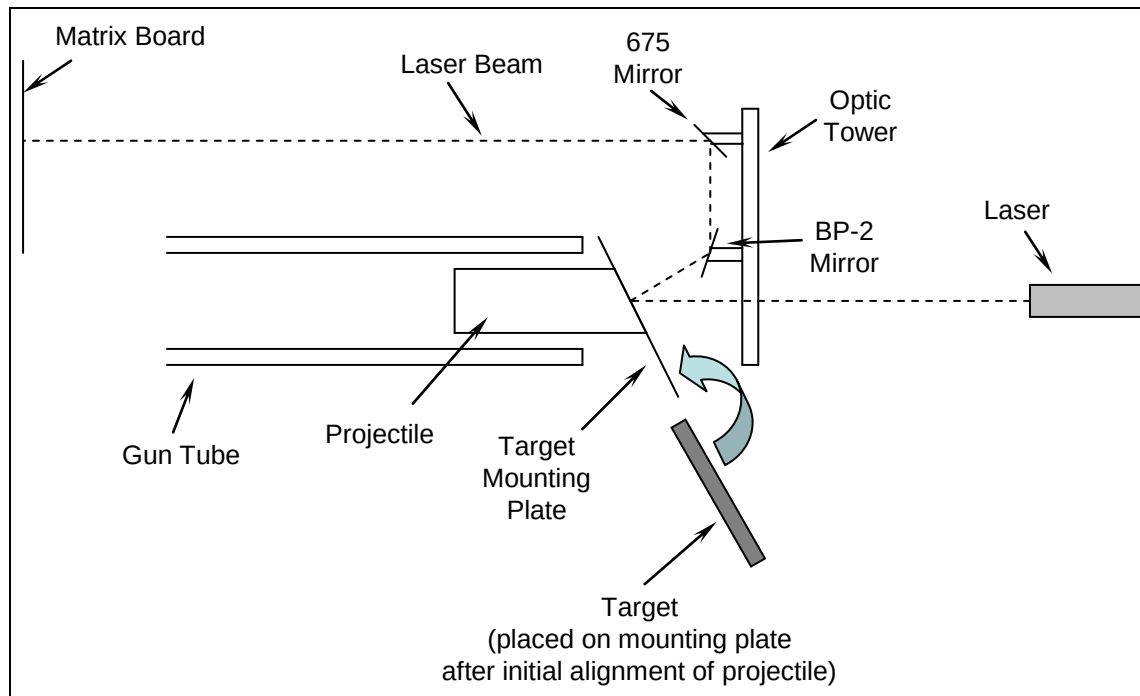


Figure 1. Overall depiction of alignment scheme.

3. 30- × 40-in nonreflective 1-in matrix target board and stand used for the laser beam projection screen.
4. Gas gun projectile assembly (see figure 3):
 - 4-in-diameter projectile,
 - angled impactor rings, of various degrees (8°, 10°, 12°, 20°, and 30°) as needed for the particular experiment being performed, and
 - flyer specimen material.
5. Gas gun target assembly:
 - 6-in lexan target ring (with four each nylon mounting screws),
 - trigger contact circuit, and
 - target specimen material.
6. Gas gun target mounting plate assemblies:
 - 1/2-in mild-steel mounting plates of various angles coinciding with the impactor ring angles and a 4 1/2-in projectile path through hole, and



Figure 2. Optic tower assembly.



Figure 3. Projectile and flyer assemblies.

- Three each (3/8 24 × 2 grade 8) adjustment bolts with compression springs. Note: The three bolt and spring assemblies apply compression tension force against the velocity block mounting plate enabling x-y tilt adjustments for the target mounting plate.
7. 6-in-diameter by 1/4-in-thick lexan disk.
 8. 4-in level or comparable.
-

3. Detailed Procedures

Step 1: Place target matrix board at the breech end of the gas gun ~5 ft uprange from the breech, as viewed in figure 4. Ensure that the top of the board rises above the gun at least 30 in to ensure sufficient space for the laser beam path to move without being obstructed by the breech.

Step 2: Place class II laser and associated mount on the muzzle end of the gas gun between the target chamber and the catch tank, as viewed in figure 5. The spacing of the laser to the target chamber should be ~8 ft axially with the gun, with the beam facing upstream of the gun. Note: Do not turn the laser on at this time.

Step 3: Install target mounting plate in the target chamber by means of the three compression tension bolts, as viewed in figure 6. The angled target mounting plate is unique for the particular angle of the projectile front face. Be sure as to not overtighten the bolts, therefore limiting your adjustment range. Place the spring between the velocity mounting plate and the target mounting plate, passing the bolt through the target plate, then the spring, and finally screwing it into the velocity mounting plate, as viewed in figure 7. This procedure will be repeated for all three mounting bolt assemblies.

Step 4: This step will align the angled front face of the projectile with the device used to hold the target. First note the location of the key in the projectile, visible in figure 8. Load the projectile into the muzzle end of the bore of the gun, ensuring the projectile key properly engages the bore slot, as viewed in figures 9 and 10. Then place the flyer ring assembly onto the end of the projectile, as viewed in figure 11. Some coarse alignment will be performed prior to permanently attaching the ring assembly. Push the projectile assembly up the gun bore until the target ring face becomes relatively flush with the target mounting plate angle, taking the 6-in lexan disk and placing it over the end of the projectile, as viewed in figure 12. Slowly rotate the impactor ring until its angle matches the face angle of the target mounting plate. Take a fine-tip permanent marker and make two reference marks on the projectile and impactor ring, ensuring no individual movement of these two components is allowed. Once this is accomplished the



Figure 4. Matrix target board.



Figure 5. Alignment laser and tripod assembly.



Figure 6. Target mounting plate and tension mounting bolts.

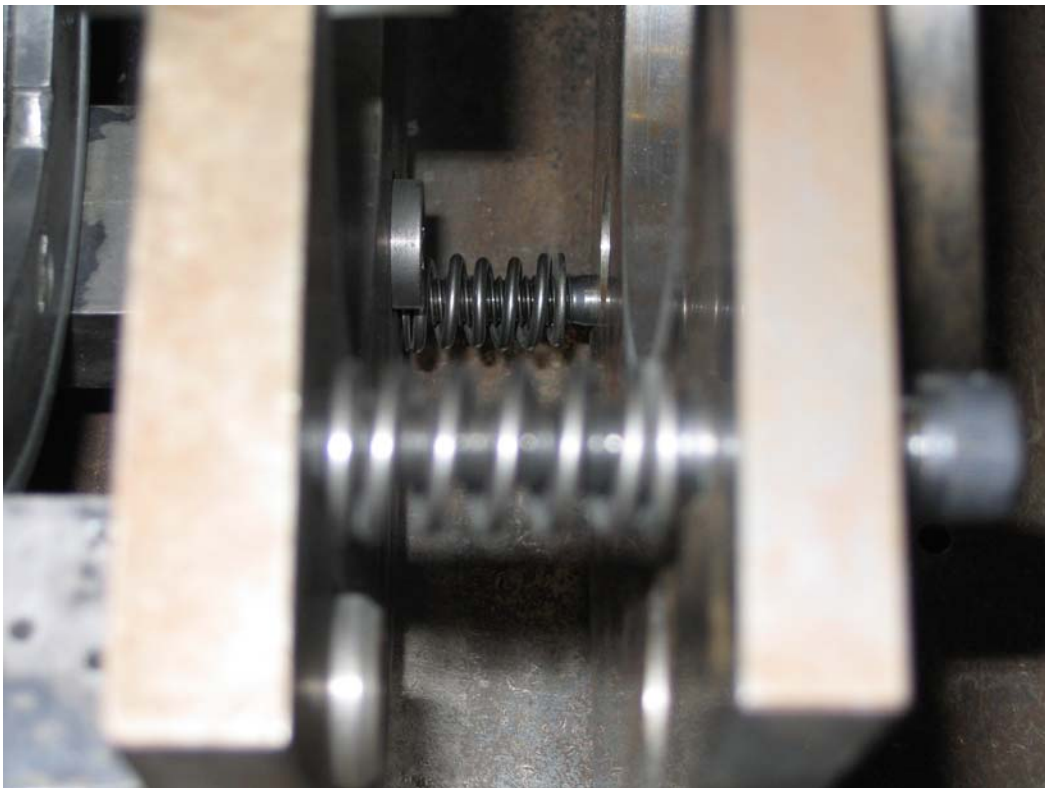


Figure 7. Tension alignment bolts.



Figure 8. Projectile with alignment key installed.



Figure 9. View of slotted keyway in gun bore.

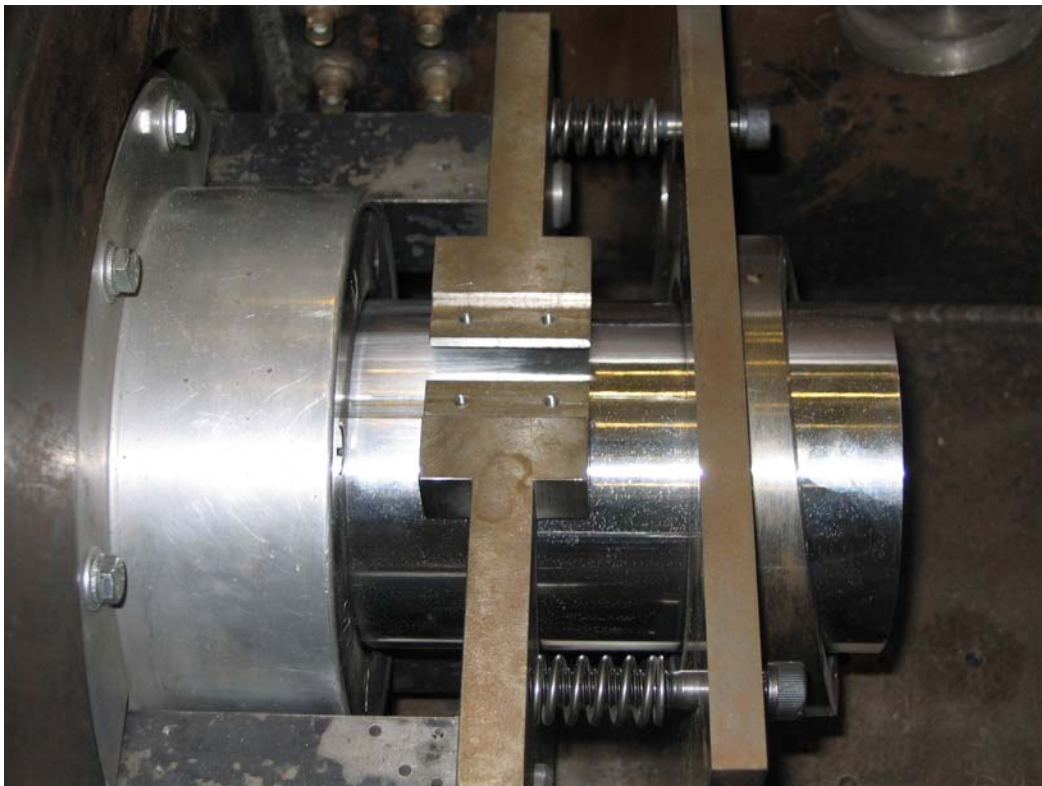


Figure 10. Loaded projectile in muzzle end of bore.



Figure 11. Projectile with flyer assembly in place.

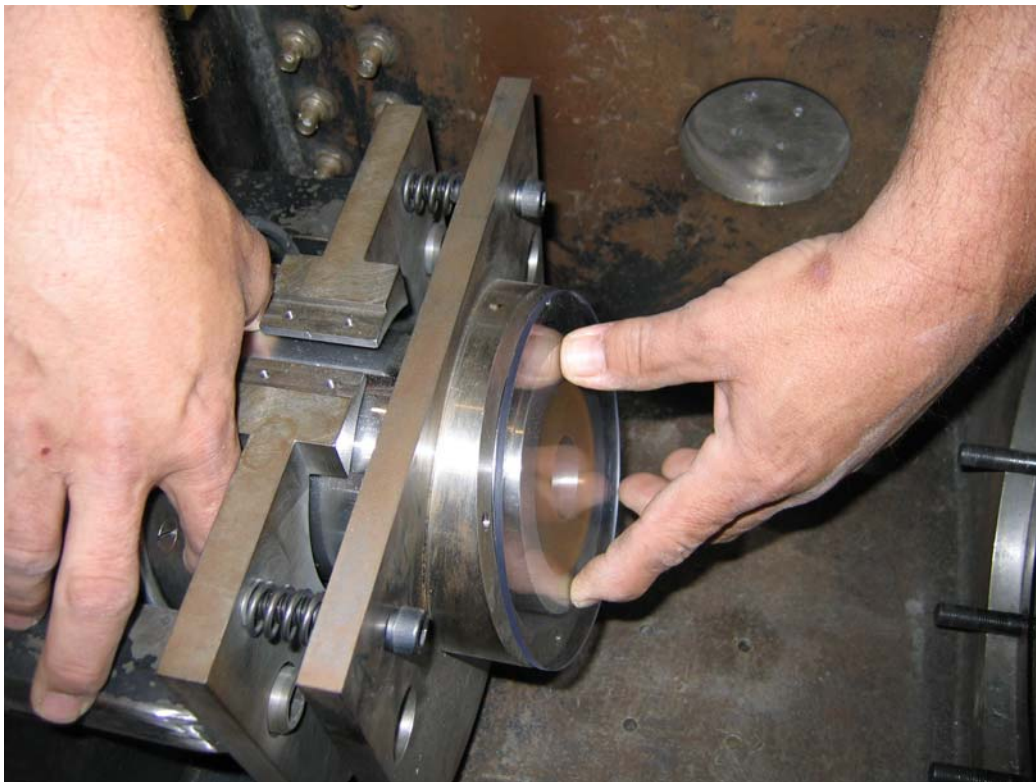


Figure 12. Aligning flyer assembly with 6-in lexan ring.

projectile and ring assembly can be removed from the bore and the two may be glued together. Ensure the two index marks meet accurately. Either PermaBond 910 or 5-min epoxy may be used to accomplish this. For experiments where high velocities will be needed (400 m/s and higher), epoxy is recommended. Once the adhesive has cured, the projectile assembly may be reloaded. Verify the assembly is flush with the target mounting plate. Reuse the lexan disk to check the face position of projectile. Coarse alignment has now been completed.

Step 5: Turn on the laser and aim it to the center of the flyer specimen. Note: Ensure all other persons are clear of the laser beam and its reflections. Although the laser is a class II (eye safe) laser, safe laser operational practices should still be adhered to. Make sure the laser is level; the bullet level may be used for this. Place the level on top of the laser body and adjust the tripod accordingly. Elevation and axial adjustments to the aim point may need to be performed after leveling the laser. Turn the laser off after the aim point is satisfactory.

Step 6: Install the optic tower in the target chamber off axis slightly to the right with the reflectors facing downstream and in vertical alignment with the laser's beam path. Note the position of the tower is to the rear of the target chamber and off axis to the right, as viewed looking up stream of the gun shown in figures 13 and 14. The first reflector adjustment will be with the lower optic element BP-2 noted in figure 15. Turn the laser on and vertically adjust BP-2 so that the laser's reflection hits at the upper most edge of the reflector. Vertical movement is achieved by loosening the 1 1/2-in adjustment knob, as viewed in figure 16, and then moving the assembly up or down the length of the tower and retightening the knob at the desired position. Now position the 675 beam steering device at the top of the tower's mast. To move the steering fixture you must loosen the 1 1/2-in adjustment knob and then rotate the opposite 1 1/2-in knob to make the positioning device translate vertically along the geared tower track, as viewed in figure 17. Next ensure both micrometer adjusters are at the midpoint of their adjustment ranges. The laser beam should be striking the upper reflector at this point. If it is not, coarse tilt adjustment will have to be performed on the lower beam reflector. To adjust the lower reflector loosen the $1/4 \times 20$ allen set screw on the BP-2 mount shown in figure 15 so that you may be able to slightly tilt the reflector vertically as to get the beam's reflection to strike the upper reflector. Once the beam meets the upper reflector on the 675 assembly, tighten the set screw. Additional adjustment may be performed by adjusting the x-y position posts on the back side of the BP-2 reflectors mounting plate, also shown in figure 18. Adjust the two posts to position the laser beam in the middle of the 675 reflector. Once this is accomplished, downstream adjustments of the beam's path have been completed.

Step 7: The laser beam location on the matrix board will now be adjusted to place it in the center of the board. Horizontal beam adjustments are accomplished by adjusting the horizontally mounted micrometer on the 675 fixture and vertical beam adjustment by the vertically mounted micrometer, visible in figure 19. Adjust the beam steering device accordingly to position the



Figure 13. View of optic tower mounted to the rear of the target chamber.

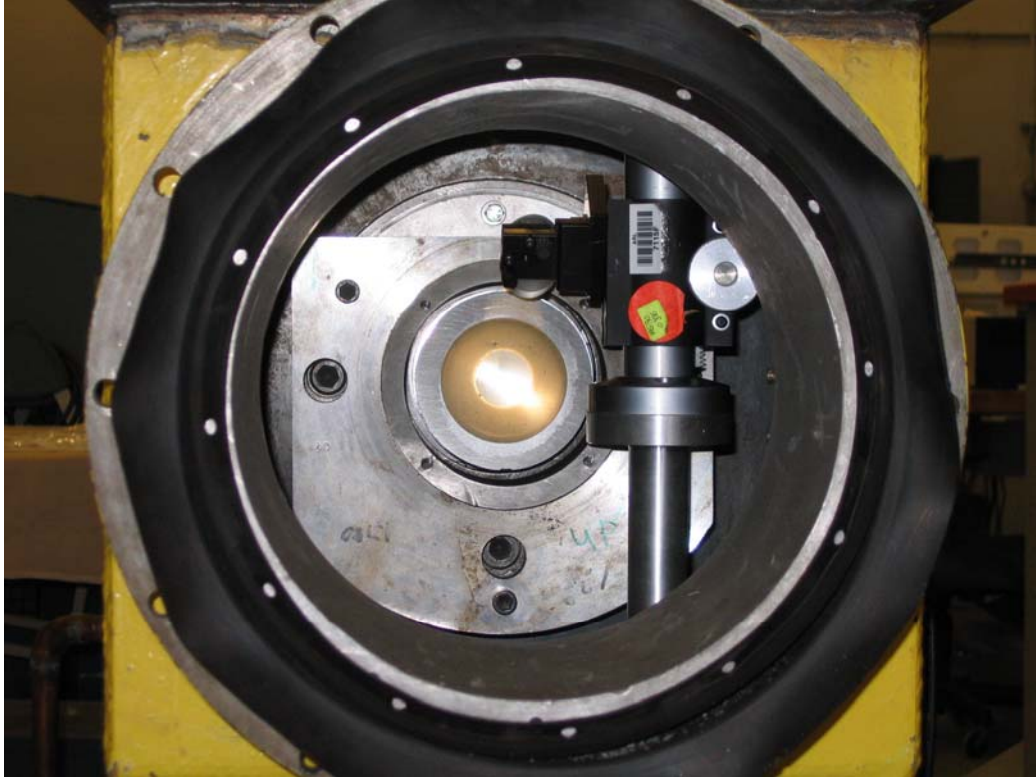


Figure 14. View of optic towers off axis alignment.

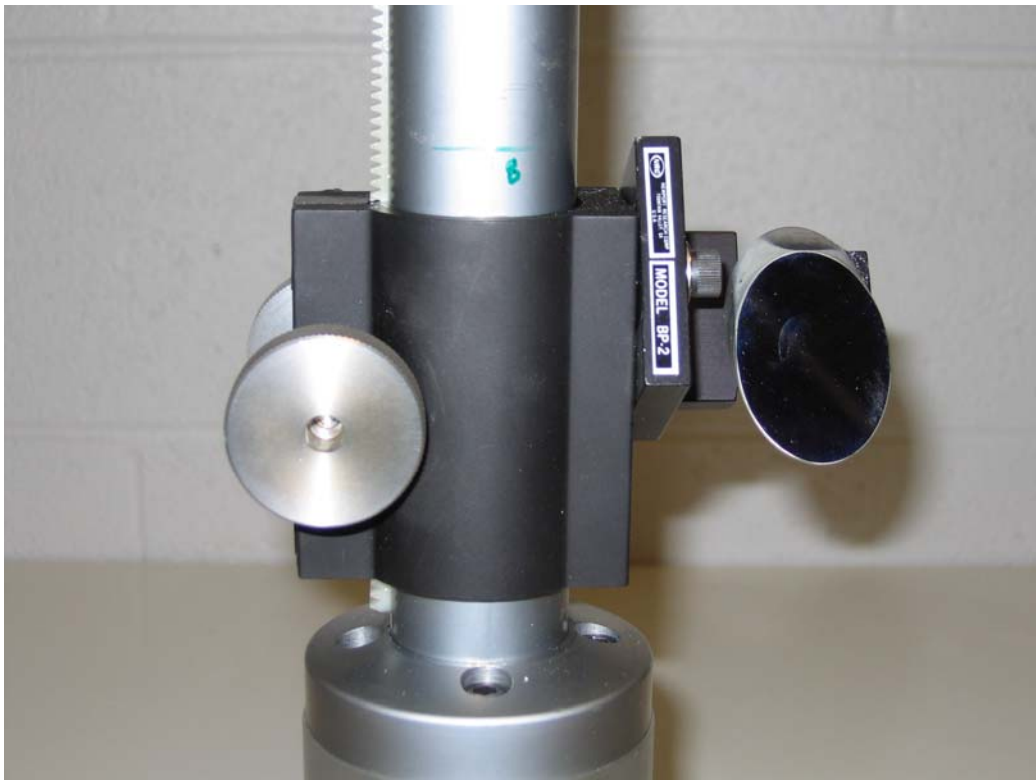


Figure 15. A view of the lower optic assembly.



Figure 16. The 1 1/2-in tension adjustment knobs (lower optic).



Figure 17. Geared track assembly with associated tension knobs (upper optic).

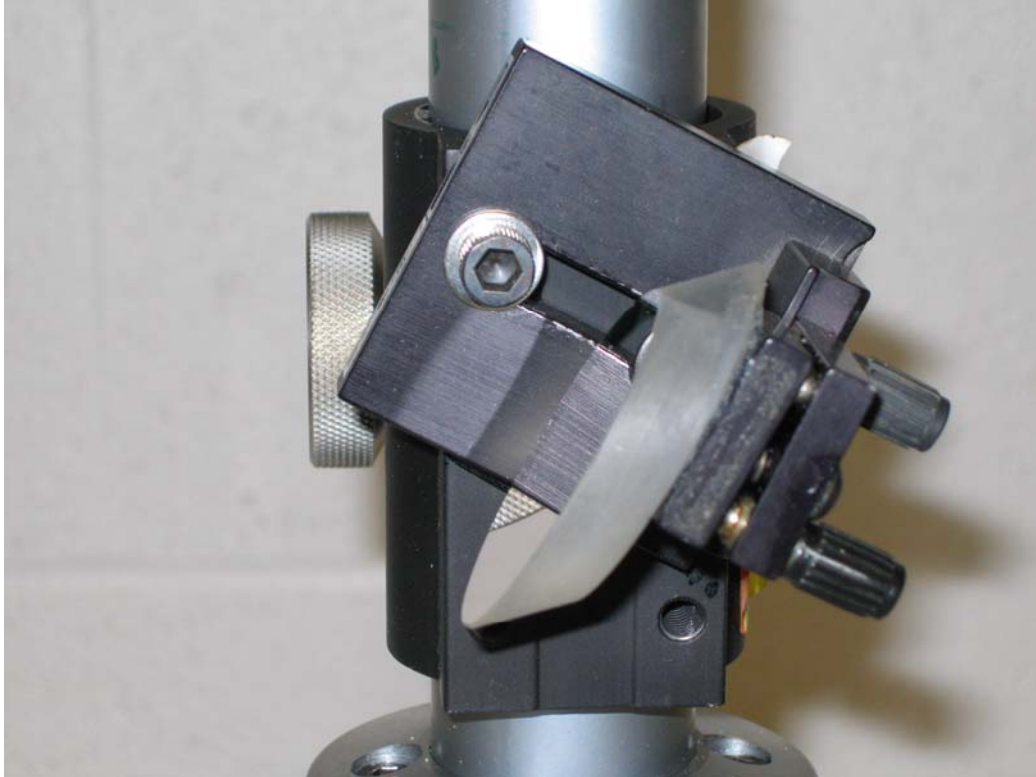


Figure 18. A view of the 1/4 20 set screw and x-y position posts.



Figure 19. Vertical and horizontal adjustment micrometers on the upper optic assembly.

beam in the approximate center of the matrix board. Mark the location with an erasable marker so as not to make a permanent beam location on the board. Turn the laser off at this point, making sure there is absolutely no movement in the laser while doing so.

Step 8: This step will complete the alignment process by aligning the target with the projectile face using the optical periscope. Pull the projectile to the breech of the gun, moving it away from the location in which you will be mounting the target assembly on the target mounting plate. Mount the target assembly flush against the target mounting plate using the four nylon mounting screws in their associated holes in the mounting plate as shown in figure 20. Turn the laser back on, being sure not to move it in any way and observe the beams location on the matrix board. The three allen-head mounting bolts located through the target mounting plate will now be the means by which the beam will be adjusted to its previously marked location. The bottom most bolt will be the primary vertical adjustment and the left and right bolts will be used to make left and right adjustments. Adjust the three bolts so as to translate the laser beam to the previously marked location on the matrix board. When this has been accomplished, you have completed alignment of the impactor assemblies face with the target's impact surface face exactly. At this time, turn off the laser and remove it from the catch tank assembly area. Remove the matrix board and optical periscope, and complete the remainder of the experiment.

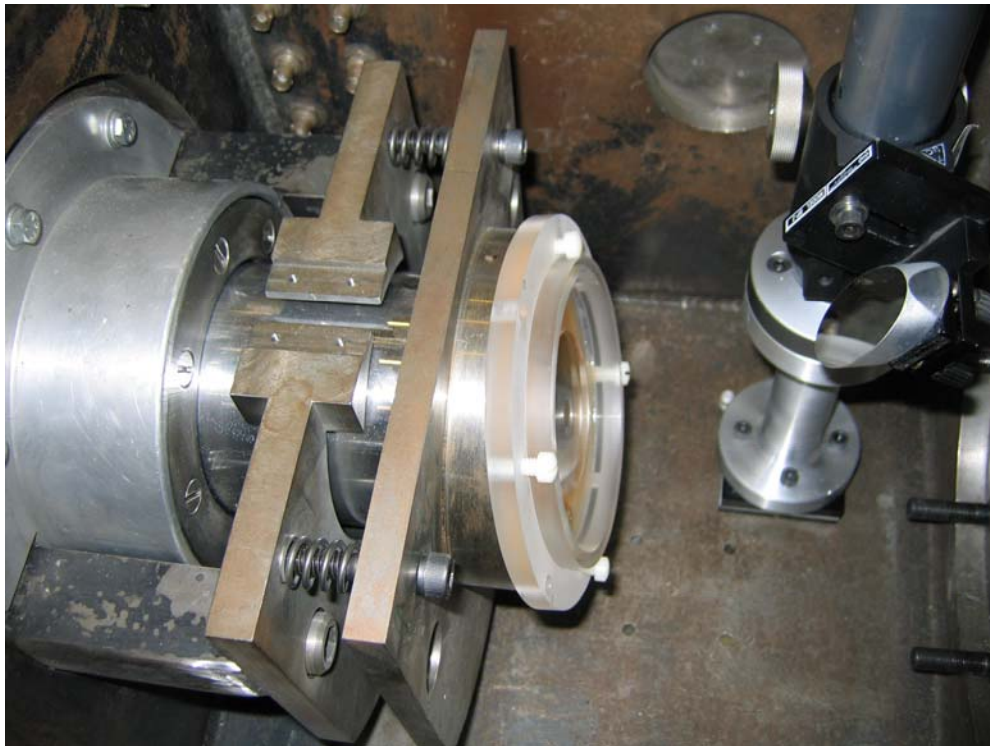


Figure 20. Nylon target mounting screws with plate assemblies.

4. Conclusions

The method for aligning the projectile and target used for oblique-impact (pressure-shear) shock physics experiments is described in sufficient detail to enable others to perform this task in the future. The technique is specific for the 4-in Light Gas Gun Facility with a keyed bore alignment groove located in the Impact Physics Branch of ARL. This technique has evolved through years of experimental practices and facility upgrades motivated by the need for improved alignment accuracy. Implementation of the optical steering tower has been crucial to achieving the desired accuracy, as evident by the quality of data obtained from the pressure-shear shock physics experiments.

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