

Installing the Model 610024 Light Sheet Collimator

Sections

Scope	1
Unpacking and Checking the Packing List	1
Laser Safety	2
Assumptions	2
Installation Overview	2
Step 1: Install Light Sheet Optics in Light Sheet Collimator	3
Step 2: Checking the Height and Parallelism of the Laser Beam	4
Step 3: Mount the Light Sheet Collimator to the Breadboard (No Light Arm)	5
Step 4: Install the Light Arm (optional)	10
Step 5: Adjust the Collimation	11
Step 6: Adjust the Laser Beam Height (No Light Arm)	11
Step 7: Adjust the Light Arm (Light Arm Systems)	12
Appendix A. Light Sheet Height Calculations	13
Appendix B. Drawings	16
Next Step	17

Figures

1 Light Sheet Collimator Negative Cylindrical Lenses and Spherical Lens.	3
2 Rotation Adjustment Ring	4
3 Vertical Light Sheet Mounting Bracket	6
4 Collimator on Vertical Light Sheet Mounting Bracket for Coupling to Laser	6

5 Horizontal Light Sheet Mounting Bracket	7
6 Horizontal Light Sheet Mounting Bracket at Laser Height	7
7 Screws in Holes for Laser Height Mounting	8
8 Vertical Light Sheet Minimum Height	8
9 Horizontal Mounting Bracket at Minimum Height	9
10 Horizontal Mounting Bracket at Maximum Height	9
11 Screws in Slots for Adjustable Height	10
12 Light Arm Attached to Light Sheet Collimator.	11
13 Steering the Light Arm Mirrors	12
14 4 mm Beam Diameter, -25 mm lens 32 mm Light Sheet Height	13
15 4 mm Beam Diameter, -20, -25 mm lenses, 100 mm light sheet height. The collimating lens aperture would clip this light sheet to 96 mm.	14
16 2 mm Beam Diameter, -20, -25 lenses, 50 mm light sheet height	14
17 Lens separation larger than collimation (translation stage too close to input) the light sheet is converging	15
18 Lens separation smaller than collimation (translation stage too close to output) light sheet is diverging.	15
19 Light Sheet Collimator Dimensions	16
20 Light Sheet Collimator Base Plate Mounting Holes	17

Tables

1 Packing List for the Model 610024 Light Sheet Collimator	2
2 Negative Cylindrical Lenses by Laser Beam Diameter	3

Installing the Model 610024 Light Sheet Collimator

This manual gives instructions on how to install and align the Model 610024 Light Sheet Collimator in a Particle Image Velocimetry (PIV) or Planar Laser Induced Fluorescence (PLIF) system. The Light Sheet Collimator can be used with lasers at 4.25" (83 mm) beam height on a breadboard, or with a 610015 Light Arm at a variety of heights.

The Light Sheet Collimator gives a constant height laser light sheet. The thickness of the light sheet is set using a spherical lens attached to the input of the Light Sheet Collimator. The beam waist will be at the focal length of the spherical lens from the spherical lens position.

The Light Sheet Collimator has negative (concave) cylindrical lenses mounted on a translation stage to diverge the laser beam in one direction. It also has a larger positive (convex) cylindrical lens to stop the beam divergence and collimate the light sheet in the height dimension. The light sheet height can be selected by selecting the negative cylindrical lenses or the translation stage position.

The negative cylindrical lenses for a full height light sheet are dependent on the laser beam diameter.

The Light Sheet Collimator comes with two mounts for coupling in laser light at the TSI standard 4.25" optical axis height. One mount gives a vertical light sheet and the other horizontal.

If an optical axis height other than 4.25" is desired, the Light Sheet Collimator may be used with a TSI Model 610015 Light Arm.

Scope

After completing this section, you will have done the following:

- ☐ Installed the Light Sheet Collimator on the base.
- ☐ Aligned the Light Sheet Collimator with the input laser beam.

Unpacking and Checking the Packing List

Carefully unpack the other components of the Light Sheet Collimator subsystem, making sure they arrived in good condition. If there are signs of damage, contact the nearest TSI sales office or representative at TSI. See "Service Policy" on the *Warranty* page at the beginning of this manual for further details.

Compare all the components you received with those listed in Table 1. If any parts are missing, contact TSI. See "Getting Help" in *About This Manual* section for the address and phone number.

Light Sheet Collimator

Table 1
Packing List for the Model 610024 Light Sheet Collimator

Qty	Model Number	Description	Part Number
1	610024	Light Sheet Collimator	
1		Vertical Light Sheet Mount	
1		Horizontal Light Sheet Mount	
8		Screw $\frac{1}{4}$ -20 \times $\frac{3}{8}$ Socket Head Cap	5147180
4		Clamp Long	
4		Screw $\frac{1}{4}$ -20 \times $\frac{5}{8}$ Socket Head Cap	
		Light Sheet Optics:	
		–15 mm Cylindrical Lens	610090
		–20 mm Cylindrical Lens	
		–25 mm Cylindrical Lens	610091
		500 mm Spherical Lens	610062
		1000 mm Spherical Lens	610063
		Rotation Adjustment Mount	
		Optics Train Trim	
		Thumb Screws 4-40	1098846

Laser Safety

Read and follow the laser safety section of this manual.



WARNING

- ☐ Use caution when using the Light Sheet Collimator so that the output beam does not cause a hazard.
- ☐ Make all adjustments to the Collimator with the laser at minimum power to reduce the hazards.
- ☐ The light intensity is much higher at the beam-focus point. Wear laser safety goggles whenever you look at the beam (*never* look directly into the beam). The reflections may be bright enough to damage your eyes.

Assumptions

Before beginning installation TSI assumes you have read the laser manufacturer's manuals and completed the following steps:

- ☐ Installed the laser.
- ☐ The laser is setup for running at low power for installation and alignment.
- ☐ Light Arm is installed (if used)

Installation Overview

To install and align the laser, you need to complete the following steps:

- Step 1.** Install Light Sheet Optics in Light Sheet Collimator
- Step 2.** Checking the Height and Parallelism of the Laser Beam
- Step 3.** Mount the Light Sheet Collimator to the Breadboard (No Light Arm)
- Step 4.** Install the Light Arm (optional)
- Step 5.** Adjust the Collimation
- Step 6.** Adjust the Laser Beam Height (No Light Arm)
- Step 7.** Adjust the Light Arm (Light Arm Systems)

Light Sheet Collimator

Step 1: Install Light Sheet Optics in Light Sheet Collimator

Table 2
Negative Cylindrical Lenses by Laser Beam Diameter

Laser Model	Beam Diameter mm	First Cylindrical Lens Focal length mm	Second Cylindrical Lens Focal length mm
Spectra Physics PIV 400	9	-20	None
Big Sky CFR 200	7	-15	None
New Wave Gemini 200, Quantel Twins B	5.5	-20	-50
Litron 50-20, 50-100, 602-100	4	-20	-25
New Wave Solo III-15	3.5	-20	-20
Big Sky Twins Ultra 30	3	-15	-20
New Wave Solo I-15, Solo II-15, Solo III-30	2.5	-15	-15

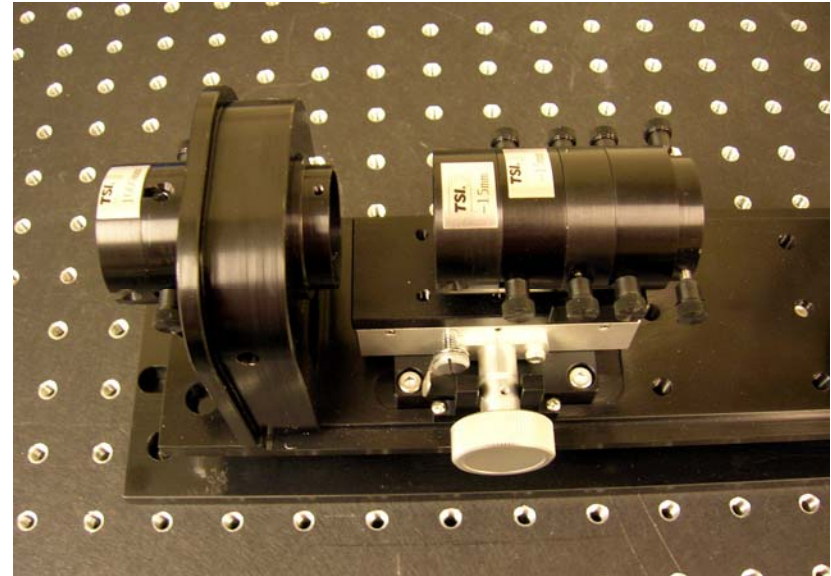


Figure 1

Light Sheet Collimator Negative Cylindrical Lenses and Spherical Lens. From right to left the optics on the slide are: Optics Train Mount; Rotation Adjustment Mount; Negative Cylindrical Lens; Negative Cylindrical Lens. The spherical lens is attached to the Light Sheet Collimator input.

Light Sheet Collimator



Figure 2
Rotation Adjustment Ring

The Optics Train Mount is attached to the screw holes on the output side of the translation stage.

The Rotation Adjustment Ring mounts on the input side of the Optics Train Mount. The Rotation Adjustment Ring has slots that allow the negative cylindrical lenses to be rotated for the best light sheet profile.

1. Remove the Light Sheet Collimator Cover by removing four #6-32 \times $\frac{3}{8}$ flat head Phillips screws and lifting the cover up.
2. Attach the Rotation Adjustment Mount to the Optics Train Mount.
3. Select the negative cylindrical lenses from Table 2.

4. Attach the first cylindrical lens to the rotation mount. The thumbscrews must be removed to insert the lens mount into the Rotation Adjustment Mount and then reattached. Rotate the cylindrical lens so that the thumbscrews are horizontal. Tighten the thumbscrews. The first cylindrical lens should be the lens with larger aperture, or if the lenses have same aperture, the longer focal length. Attaching lenses in this order reduces the likelihood of beam clipping.
5. Attach the second cylindrical lens, if used, to the first cylindrical lens. Tighten the thumbscrews.
6. Adjust the translation stage to the center of travel.
7. Attach the spherical lens to the Light Sheet Collimator input. The 12" (300 mm) length of the Light Sheet Collimator must be subtracted from the lens focal length to get the waist position from the Light Sheet Collimator output. For example with a 1,000 mm focal length spherical lens the waist will be 700 mm from the Light Sheet Collimator output.

Step 2: Checking the Height and Parallelism of the Laser Beam

Before installing the Light Sheet Collimator it is important to have the laser installed and well aligned. If the beam is not aligned properly, the output beam will not be level. Small laser alignment errors, that do not affect performance when using standard light sheet optics, can be a problem when using the Light Sheet Collimator. If the Light Arm is also used, the laser alignment is even more important. To verify that the laser beam is at 4.25 inches (83 mm) high and

Light Sheet Collimator

parallel to the base, mount the laser on a breadboard or some other rigid, flat surface that is at least 2.5 meters long. The following steps use a pair of alignment blocks that have a pinhole at 4.25 inches from the base.

1. Place the first alignment block approximately 100 mm in front of the laser head.



Caution

Make sure the laser is at low power. The laser power can be adjusted with the Q-Switch delay time for Nd:YAG lasers.

2. With the Q-switch delay set for low laser power, turn on the laser pulsing using the INSIGHT software.
3. Slide the alignment block from side to side until the laser beam passes through the center of the pinhole. If it is impossible to align the laser beam through the center of the pinhole, the laser beam must be adjusted. Refer to the laser manual for instructions on adjusting the laser beam height.
4. With the laser beam passing through the center of the pinhole in the first alignment block, place the second alignment block at least 2 meters from the laser head.
5. Slide the second alignment block from side to side until the laser beam passes through the center of the pinhole. If it is impossible to align the laser beam through the center of the pinhole *in both alignment blocks simultaneously*, the laser beam must be adjusted. Refer to the laser manual for instructions on adjusting the laser beam.

6. When the laser beam is at 4.25 inches (83 mm) high and parallel to the base, as evidenced by the laser beam passing through the center of the pinhole in both the near (100 mm) and the far (2 m) laser alignment blocks, continue with the installation process.
7. Turn off the laser pulsing using the INSIGHT™ software.

Step 3: Mount the Light Sheet Collimator to the Breadboard (No Light Arm)

This section describes the mounting of the Light Sheet Collimator to a breadboard for systems not using a Light Arm. If you are using a light arm, skip ahead to [Step 4: Install the Light Arm](#). The Light Sheet Collimator includes mounts for vertical and horizontal light sheets.

Light Sheet Collimator

Vertical Breadboard Mount

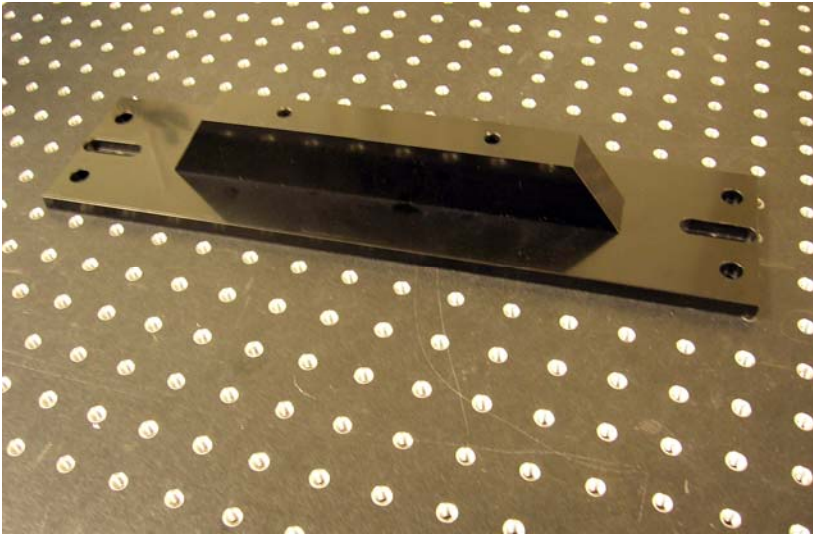


Figure 3
Vertical Light Sheet Mounting Bracket

$\frac{1}{4}$ -20 \times $\frac{3}{8}$ socket head cap screws (TSI P/N 5147180) are used to attach the vertical light sheet mount to the light sheet Collimator.



Figure 4
Collimator on Vertical Light Sheet Mounting Bracket for Coupling to Laser

With the Light Sheet Collimator mounted to the Vertical Light Sheet Mount the optical axis is at $4\frac{1}{4}$ " the laser optical axis height.

Light Sheet Collimator

Horizontal Mount

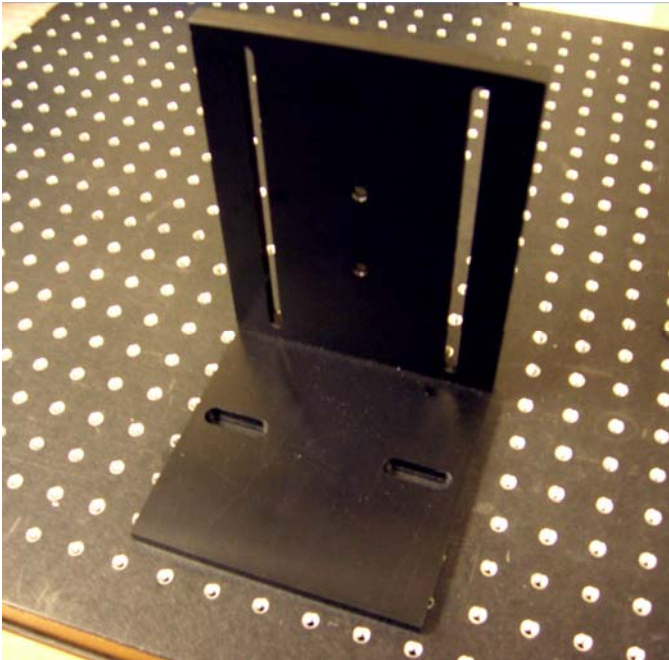


Figure 5
Horizontal Light Sheet Mounting Bracket

Attach the Light Sheet Collimator with $\frac{1}{4}$ -20 \times $\frac{3}{8}$ socket head cap screws (TSI P/N 5147180).



Figure 6
Horizontal Light Sheet Mounting Bracket at Laser Height

The horizontal mount can be used with the laser at 4¼" laser height using the two round screw holes to attach the Light Sheet Collimator to the upright.

Light Sheet Collimator

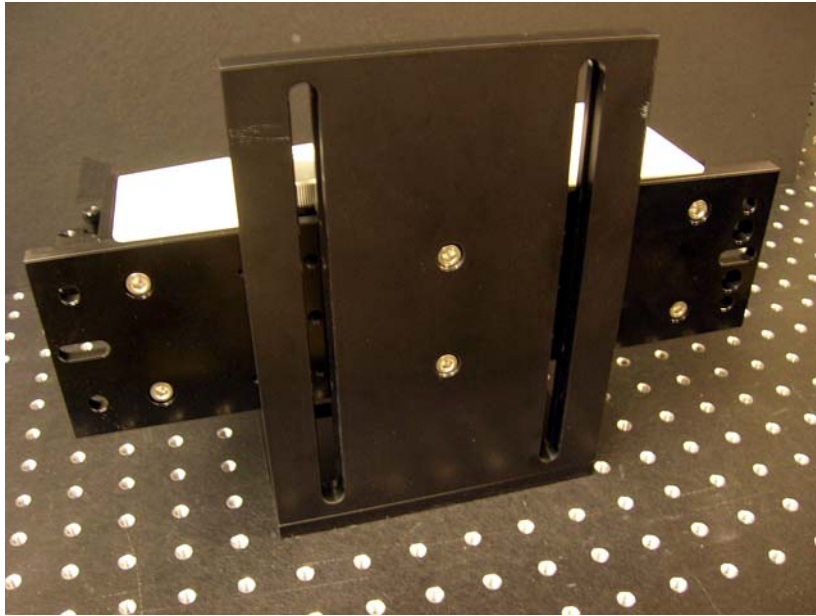


Figure 7
Screws in Holes for Laser Height Mounting

When used with a light arm the Light Sheet Collimator is attached with the slots to allow the Light Sheet Height to be set.

With Light Arm

With the light arm the Light Sheet Collimator does not have to be at the same height as the laser. The light sheet can be mounted directly to the breadboard without using the vertical mount, or horizontally using the slots in the horizontal mount.

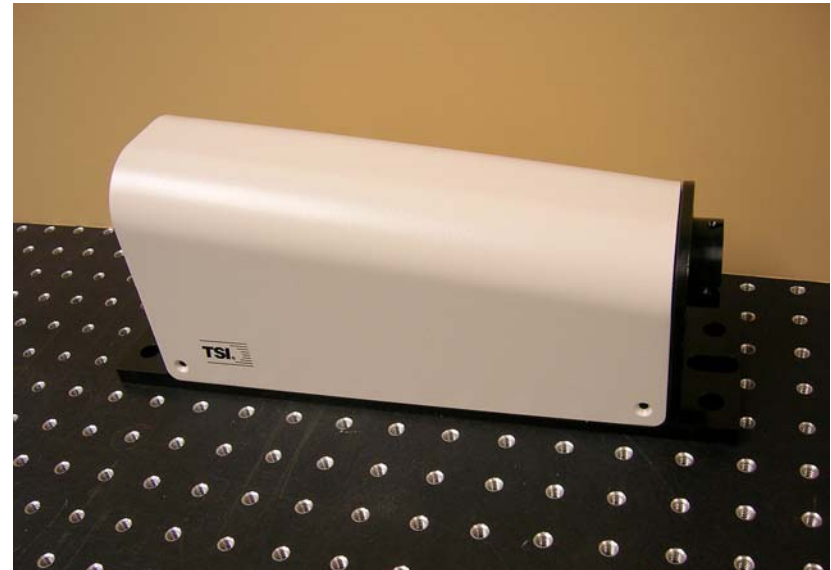


Figure 8
Vertical Light Sheet Minimum Height

Light Sheet Collimator



Figure 9
Horizontal Mounting Bracket at Minimum Height



Figure 10
Horizontal Mounting Bracket at Maximum Height

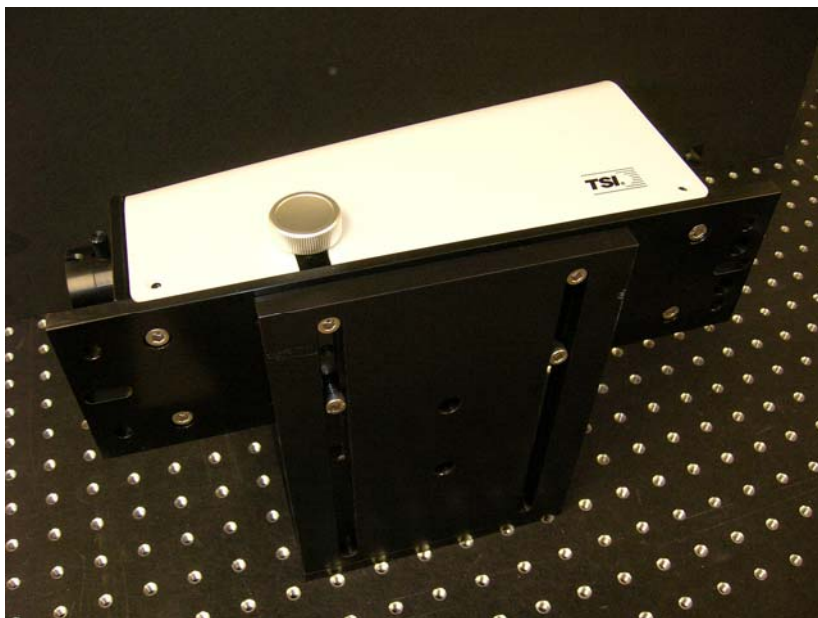


Figure 11
Screws in Slots for Adjustable Height

Step 4: Install the Light Arm (optional)

Follow the instructions in the Light Arm Installation Manual through centering the laser beam on the cross wire target. Return to these installation instructions with the shutter assembly attached to the Light Arm output.

1. Fasten the Light Sheet Collimator down to a breadboard or other solid mount.

Light Sheet Collimator



WARNING

- ❑ The Light Arm allows the laser beam to be positioned and moved very easily. Use caution when using the Arm so that the output beam does not cause a hazard. Always attach the output end of the Arm so that it cannot move unintentionally.
- ❑ Make all adjustments to the Arm with the laser at minimum power to reduce the hazards.
- ❑ The light intensity is much higher at the beam-focus point. Wear laser safety goggles whenever you look at the beam (*never* look directly into the beam). The reflections may be bright enough to damage your eyes.

2. Attach the Shutter output to the spherical lens input. The spherical lens is attached to the Light Sheet Collimator input.



IMPORTANT

All necessary alignment procedures may be performed by adjusting the alignment of the laser or the Light Arm Mount. **Do not** make any adjustment to the mirrors at the light arm knuckles. The alignment of the mirrors in the arm is a complex procedure and is **not** to be performed in the field.

Light Sheet Collimator

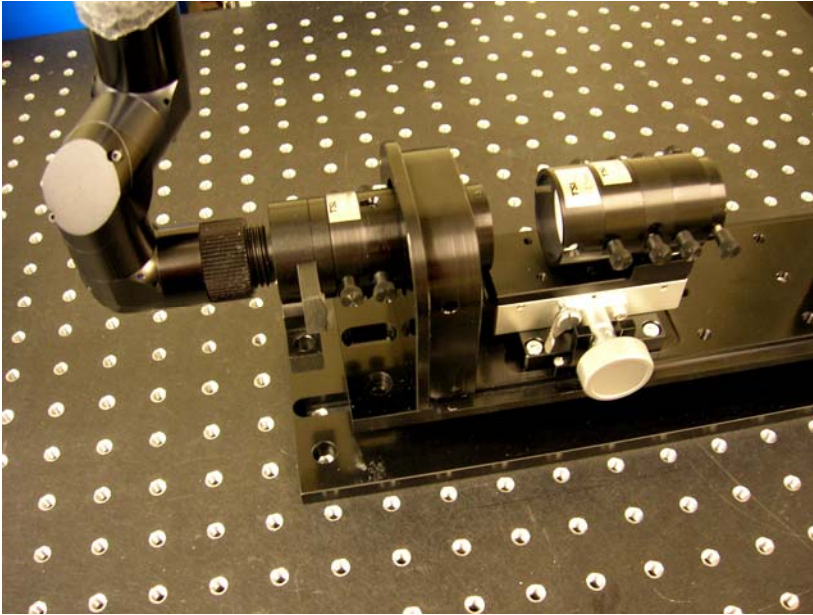


Figure 12
Light Arm Attached to Light Sheet Collimator.

Step 5: Adjust the Collimation

The collimation is adjusted by adjusting the negative cylindrical lens position by rotating the knob on the side of the Light Sheet Collimator. When the negative cylindrical lenses are too close to the large collimating lens, the light sheet will be diverging. When the negative cylindrical lenses are too far from the collimating lens, the light sheet will be converging. When the lenses are at the correct position, the focal back focal point of the large collimating lens, the light sheet will be collimated.

Adjust the collimation by turning the knob on the outside of the collimator until the light sheet height is the same far from the Light Sheet Collimator and up close.

Step 6: Adjust the Laser Beam Height (No Light Arm)

If the output collimated light sheet is not level (parallel to the breadboard) with the Light Sheet Collimator, two methods may be used to adjust it.

1. First try rotating the negative cylindrical lenses 180° by loosening the thumb screws, remove and replacing the lens. If the lens is slightly off center, the beam may be better aligned with the lens flipped. Try this with each negative lens to see if the light sheet can be made level.
2. If the light sheet is still not level, adjust the laser height to align the laser optical axis with the Light Sheet Collimator Optical axis.
3. Loosen the four lockdown screws at the four corners of the laser feet. Turn the four height adjustment set screws $\frac{1}{2}$ each in the clockwise or counter clockwise direction. Observe if the light sheet is better or worse. If worse, turn the set screws 1 turn in the other direction. Turn all four height adjustment set screws an equal amount until the light sheet is level with the breadboard.
4. Verify that the laser does not rock, and turn one height adjustment set screw if necessary.
5. Tighten the four lockdown screws.

Light Sheet Collimator

Step 7: Adjust the Light Arm (Light Arm Systems)

The output light sheet is made level by adjusting the light arm steering mirrors on the Light Arm Base. Make small mirror changes to make the light sheet level. See the Light Arm manual for information on adjusting the light arm steering mirrors.

Make only small adjustments to the steering mirrors. If too large an adjustment is made, the laser beam will hit the light arm tube. The reflected beam may look almost normal but not well collimated. Once the beam reflects off a tube wall it is usually necessary to remove the shutter from the Light Sheet Collimator and repeat the beam centering with cross hairs.



IMPORTANT

All necessary alignment procedures may be performed by adjusting the alignment of the laser or the Light Arm Mount. **Do not** make any adjustment to the mirrors at the light arm knuckles. The alignment of the mirrors in the arm is a complex procedure and is **not** to be performed in the field.



Figure 13
Steering the Light Arm Mirrors

When the Light Sheet Collimator is moved, it may be necessary to re-adjust the light arm steering mirrors to re-level the light sheet.

Light Sheet Collimator

Appendix A. Light Sheet Height Calculations

If you want the light sheet to be less than the full 100 mm height, use a longer combination effective focal length. This can be done by removing a lens or using a long focal length lens.

An approximate formula for the light sheet height is:

$$H = \frac{D(L - f)}{f}$$

Where

H = light sheet height

D = laser beam diameter

f = lens focal length (negative)

L = distance between negative and positive lenses approx
160 mm

For 4 mm input beam, -25 mm lens and 160 mm lens separation the approximate light sheet height is:

$$\frac{4[160 - (-25)]}{-25} = -29.6 \text{ mm}$$

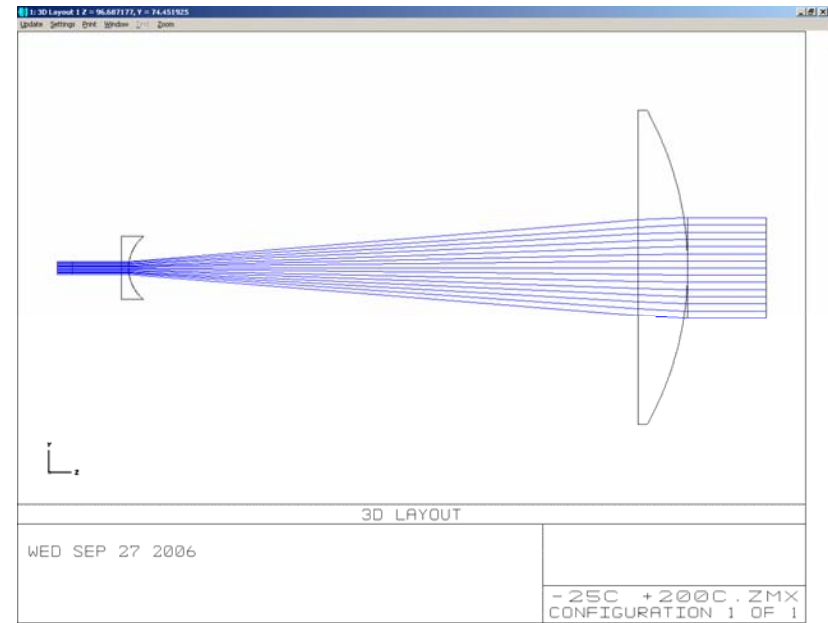


Figure 14
4 mm Beam Diameter, -25 mm lens 32 mm Light Sheet Height

Two negative cylindrical lenses can be used together to achieve a smaller combination effective focal length with a relatively large clear aperture. When stacking lenses, use lenses with the smallest aperture first to minimize clipping on lens apertures. When lenses have the same aperture size, use the longest focal length first.

A simplified version of the combination lens equation is:

$$\frac{1}{f} = \frac{1}{f1} + \frac{1}{f2}$$

Light Sheet Collimator

For example if you are combining a -20 mm and -25 mm lenses the approximate combination focal length is of

$$\frac{1}{-20} + \frac{1}{-25} = -.90$$

$$\frac{1}{-.90} = -1.1 \text{ mm combination focal length}$$

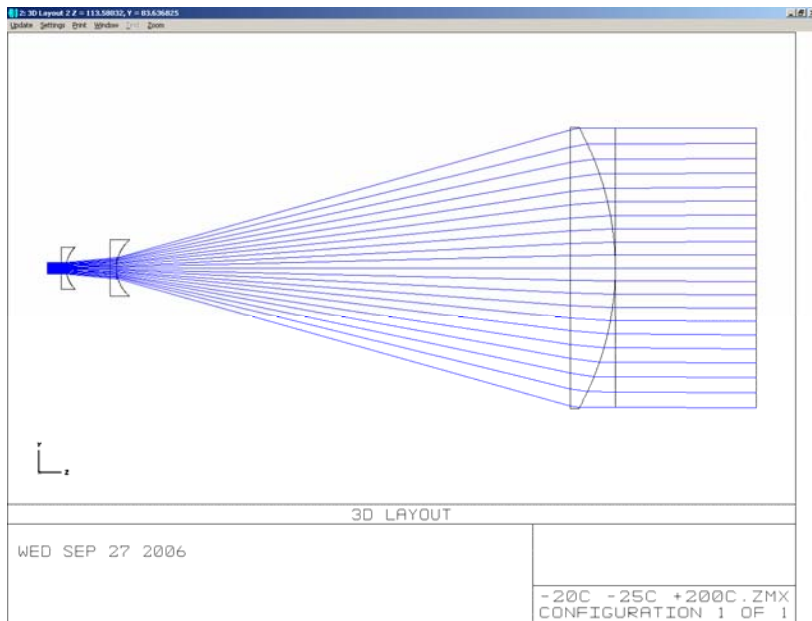


Figure 15
4 mm Beam Diameter, -20, -25 mm lenses, 100 mm light sheet height. The collimating lens aperture would clip this light sheet to 96 mm.

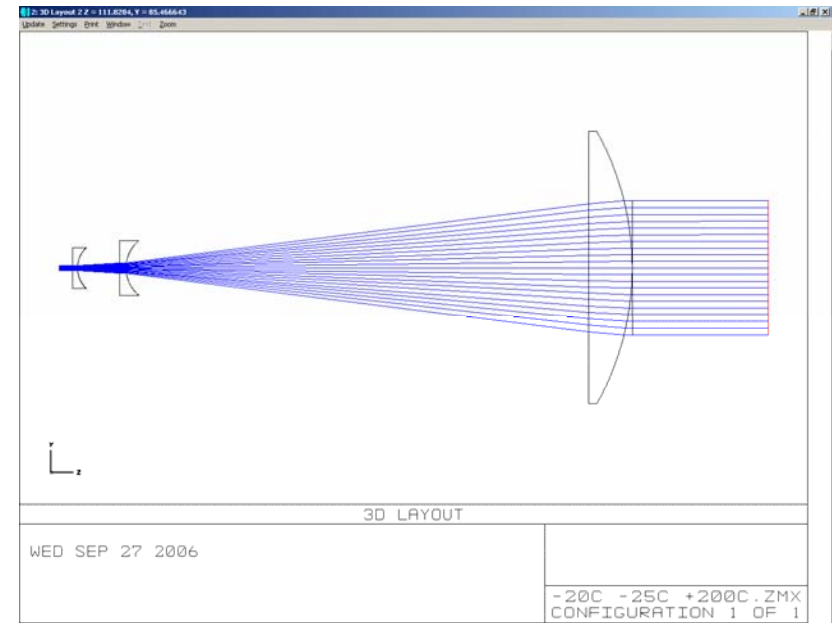


Figure 16
2 mm Beam Diameter, -20, -25 lenses, 50 mm light sheet height

This figure shows how the light sheet height has decreased with input beam diameter.

Light Sheet Collimator

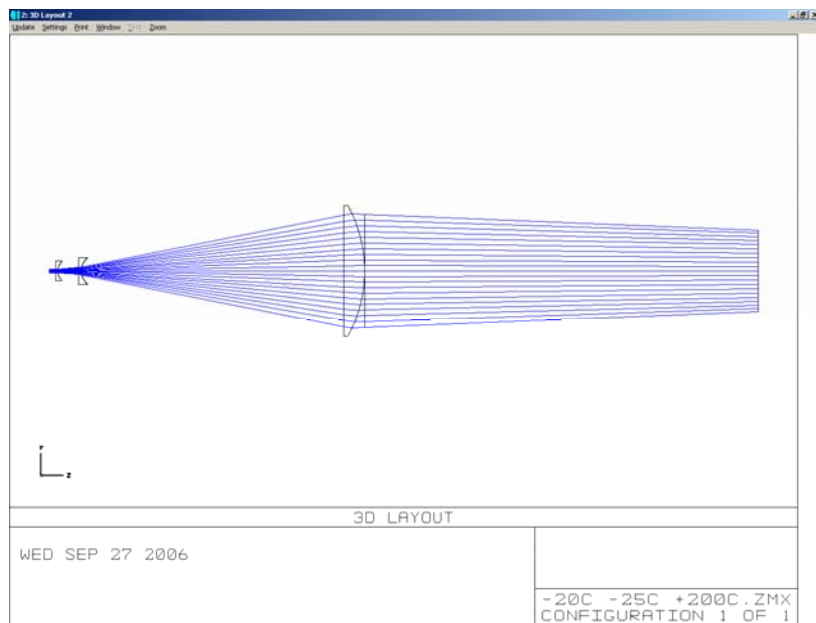


Figure 17

Lens separation larger than collimation (translation stage too close to input) the light sheet is converging

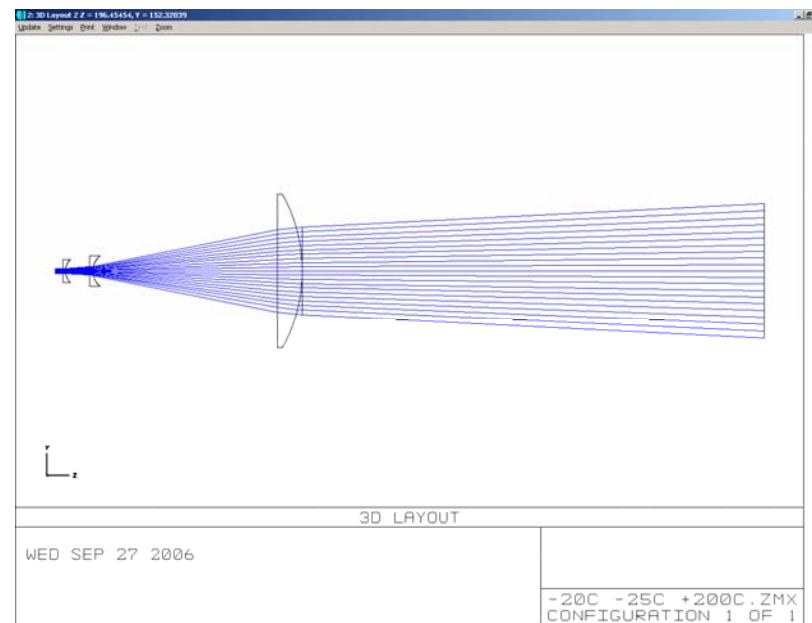


Figure 18

Lens separation smaller than collimation (translation stage too close to output) light sheet is diverging.

Light Sheet Collimator

Appendix B. Drawings

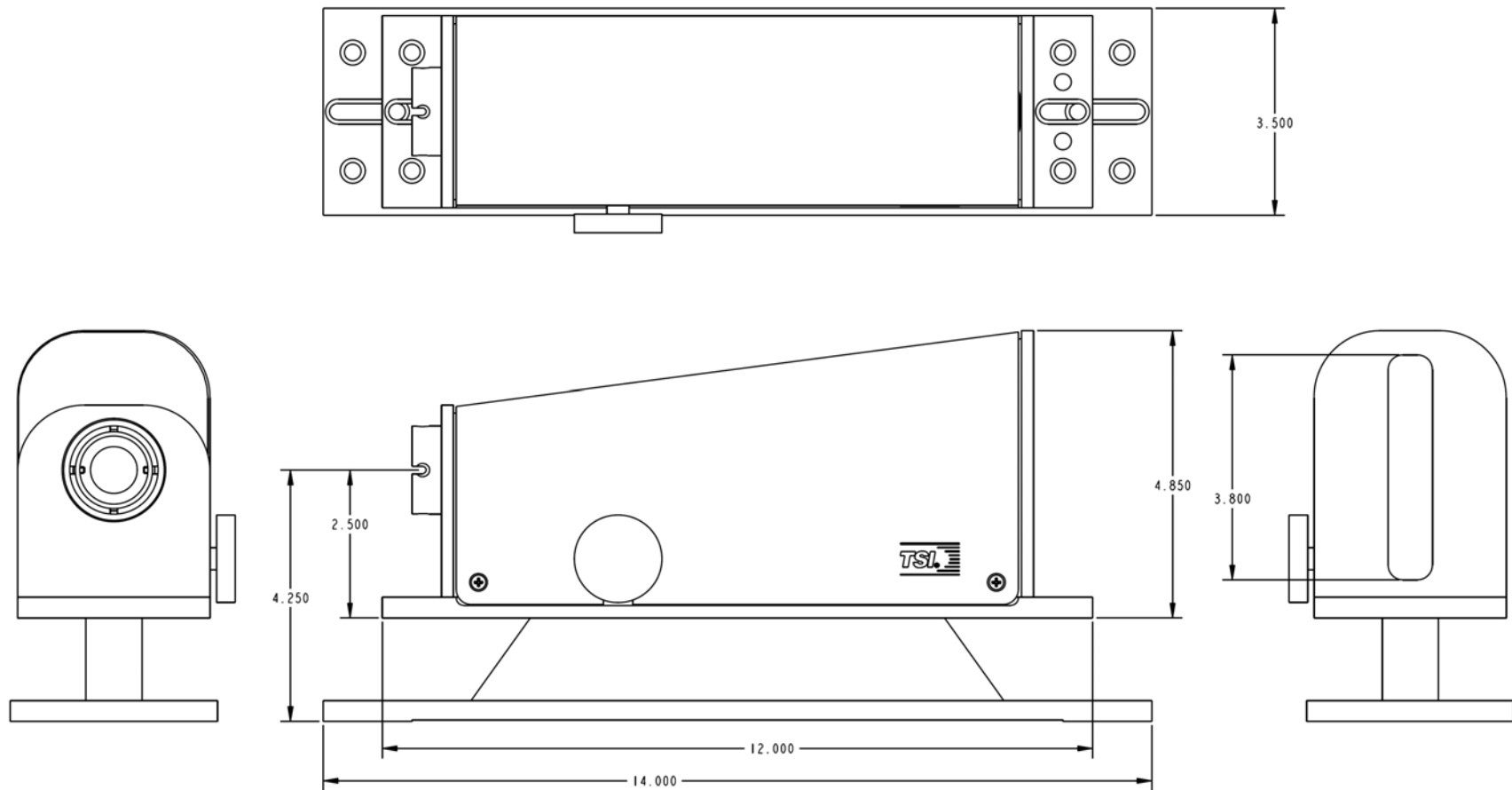


Figure 19
Light Sheet Collimator Dimensions

Light Sheet Collimator

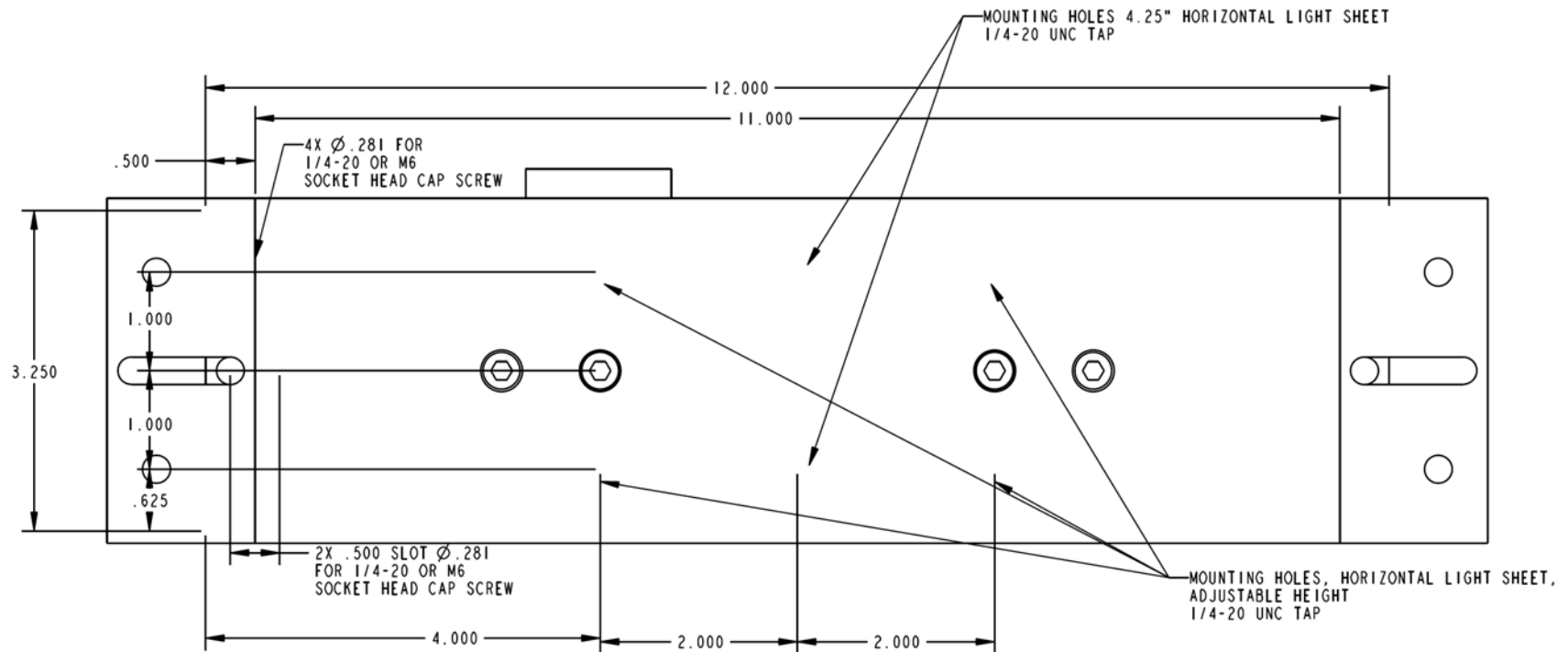


Figure 20
Light Sheet Collimator Base Plate Mounting Holes

Next Step

You need to install the Image Capturing components of the PIV system. See *Image Capture* next, for details.