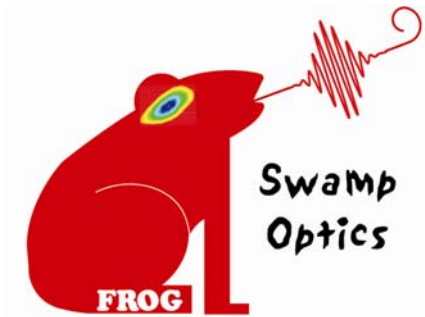


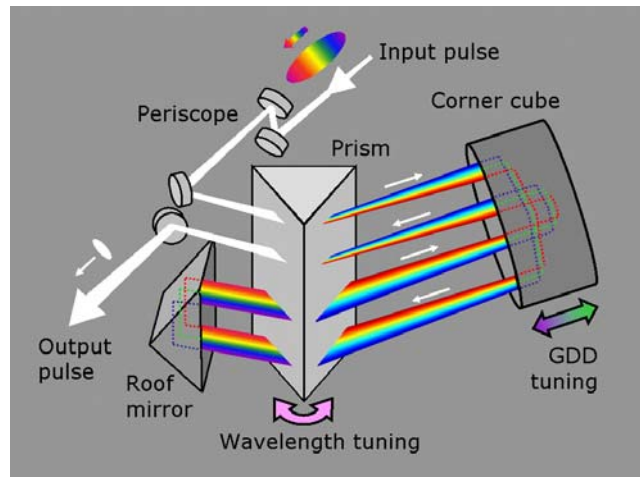
**Swamp Optics
BOA
Pulse Compressor**

User's Guide



Introduction

Thank you for purchasing the Swamp Optics BOA Pulse Compressor. It's a significant improvement over traditional two- and four-prism compressors, and we hope that it's helpful in your research.



Layout for the BOA pulse compressor.

The BOA compressor utilizes a simple, elegant, and robust design that's very easy to use—and very inexpensive.

It uses an ultra-precisely manufactured corner-cube to precisely retro-reflect the beam back to the prism. This automatically aligned arrangement avoids all the problematic distortions of two- and four-prism designs, including astigmatism, angular dispersion, spatial chirp, and pulse-front tilt.

Tuning only the prism-corner-cube distance varies the group-delay dispersion (GDD) over a wide range of values. And rotating only the prism angle accommodates any wavelength change.

Because the prism-corner-cube distance (and not the prism insertion as in other designs) is tuned, the same BOA Compressor can accommodate pulses with large, as well as small, bandwidths.

Beam alignment is also easy using a simple trick unique to the BOA Compressor. The following sections describe this procedure, which we hope you find straightforward.

Coarse Alignment

First, always remember that the BOA is a laser device. While it does not emit a beam, it is used with one, and often a powerful one. So please exhibit the same care you would use in manipulating the beam directly from your laser.

The BOA pulse compressor comes to you pre-aligned, and it should never misalign. However, like all other optical devices, it is still necessary to carefully align your beam into it. For most optical devices, this is very difficult, often requiring many hours. Fortunately, the BOA incorporates an alignment trick. It is equipped with a knob that allows you to move the internal beam steering optics out of the beam path to facilitate proper alignment. Alignment then

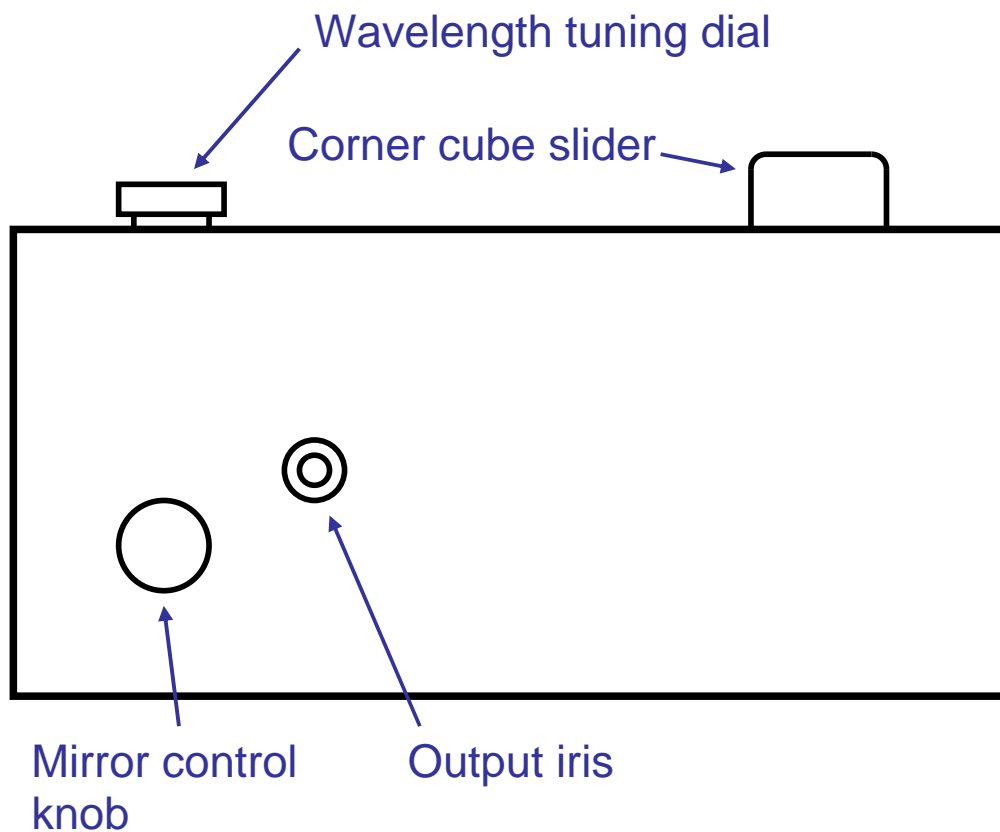


Fig. 1. Right side view of the BOA.

consists of simply aligning your beam to pass straight through the BOA. After alignment, you should move these mirrors back into position.

Also, you should place two broadband ultrafast (usually metal-coated) mirrors mounted in stable adjustable mounts in the beam path in front of the BOA so that the beam can be "walked" into proper alignment through the BOA. (see Fig. 2)

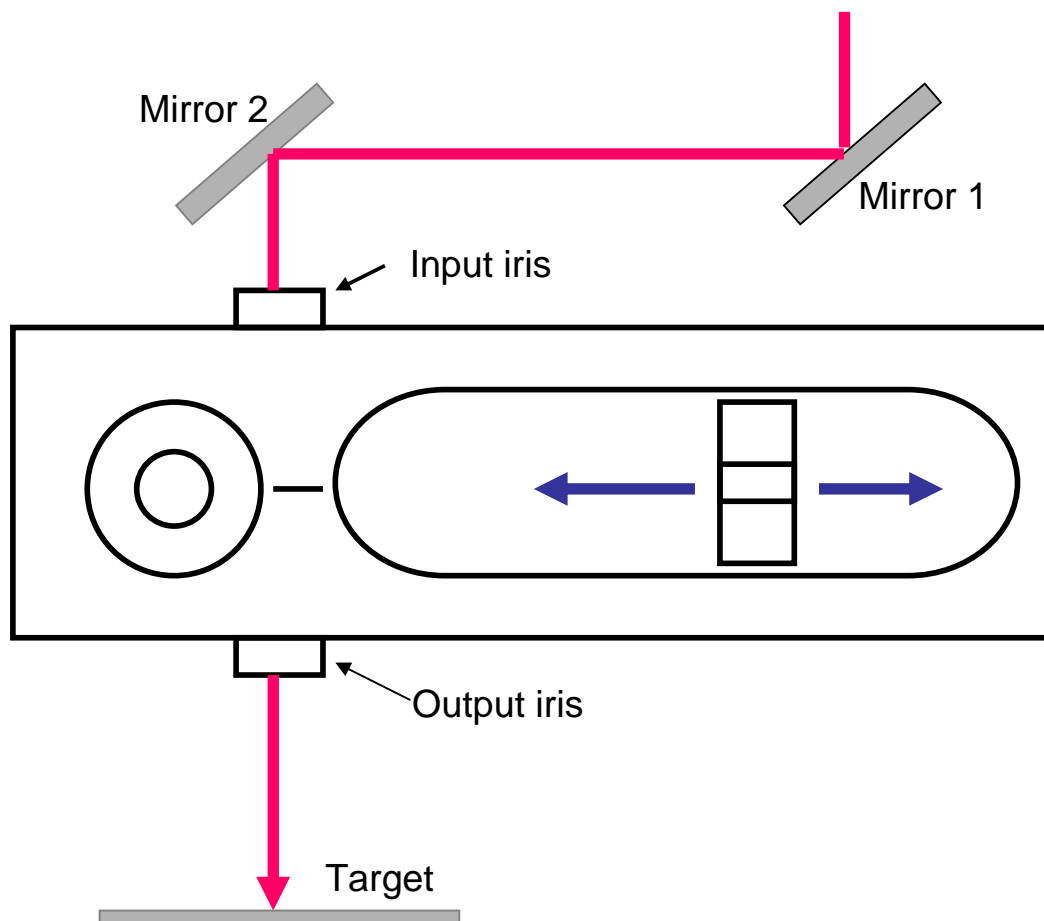


Fig. 2. Example of BOA alignment showing 2 turning mirrors before the BOA and a beam target after the BOA.

The BOA is meant to operate with horizontal polarization. Using vertical polarization will result in considerable loss inside the BOA (due to Fresnel reflections off the prism faces) and hence poor transmission. If your beam is vertically polarized, rotate its polarization or the BOA by 90° . A 90° polarization rotation can be introduced with the two alignment mirrors by introducing a 90° turn in a periscope configuration. Or you can use a half-wave plate (available from any optical component company).

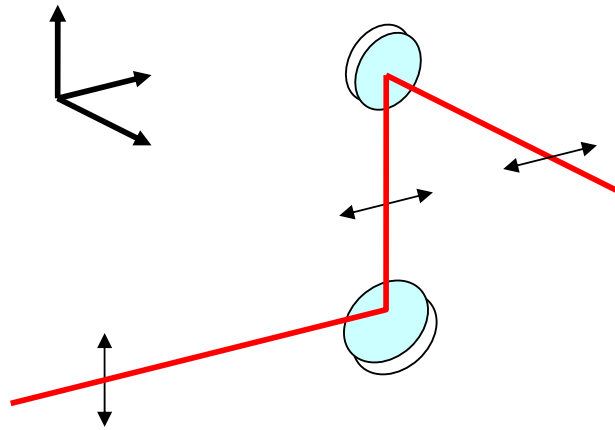


Figure 3: Using a pair of mirrors to rotate the polarization of the beam

1. Mount the BOA firmly to your optical table. A variety of mounting holes have been provided on the base-plate for this purpose.
2. Rotate the mirror-control knob located on the right side of the BOA to the OUT position. (see Fig.1) This moves the BOA's first and last steering mirrors out of the beam, so you can align your beam into the BOA. The goal will be to send your beam straight through the BOA, which should correspond to the approximate correct alignment.

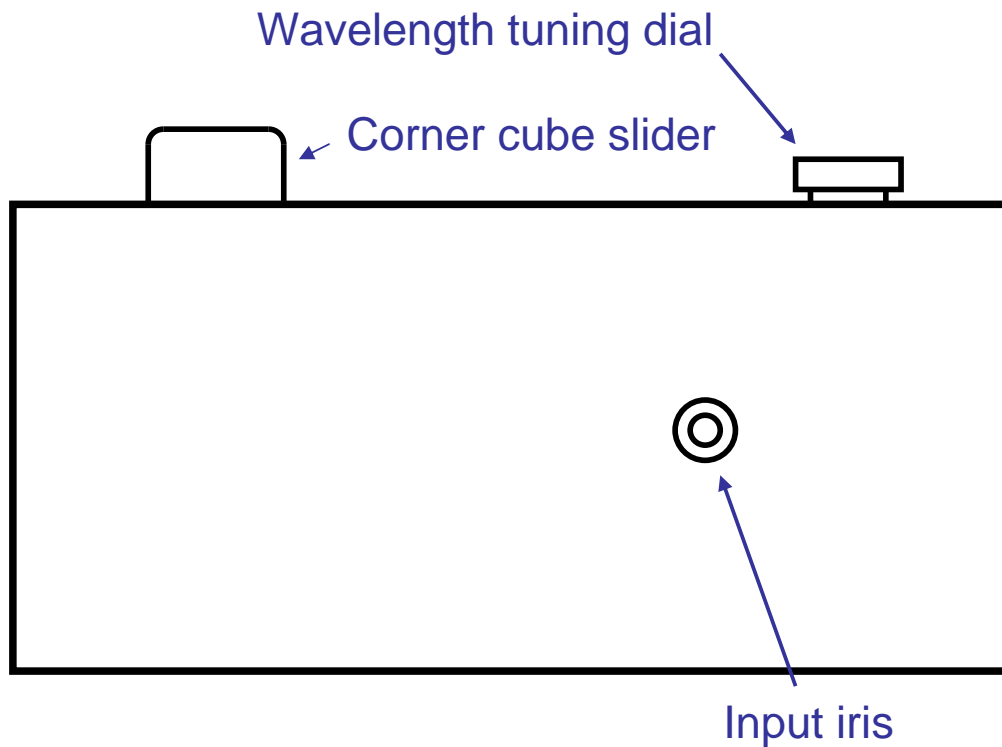


Fig. 4. Left side view of the BOA.

3. Open the input iris, located on the left side of the BOA, and align the laser beam into the input iris.
4. Open the output iris, located on the right side of the BOA, and, with the aid of an alignment card, IR viewer, or alignment camera, search for the laser beam exiting the output iris.
5. Close down each iris to the approximate diameter of the laser beam, and adjust the alignment of the beam through the input and output irises so that the beam is perfectly centered on each iris.
6. Adjust the wavelength dial located on the top of the BOA for the center wavelength of the laser beam. (see Fig.5)

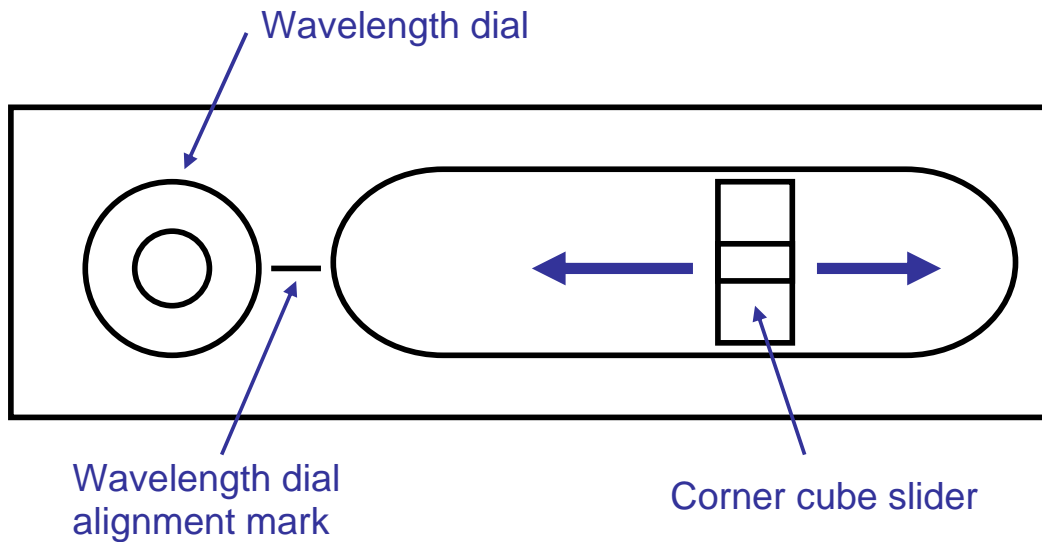


Fig. 5. Top view of the BOA.

7. Slide the corner cube (see Fig. 4) to the forward position, toward the wavelength dial.
8. Rotate the mirror control knob (see Fig. 1) to the IN position, moving the BOA mirrors back into position.
9. Verify that the laser beam is exiting the output iris.
10. If you cannot see the laser beam, then double check the initial alignment by repeating steps 2 through 9.

Fine Alignment

1. Check for movement in the beam exiting the BOA when the corner cube slider is translated forward and backward. (see Fig. 5) It may be helpful to make a target and align it so that the laser beam is centered on it. (see Fig. 6)

Target and the beam

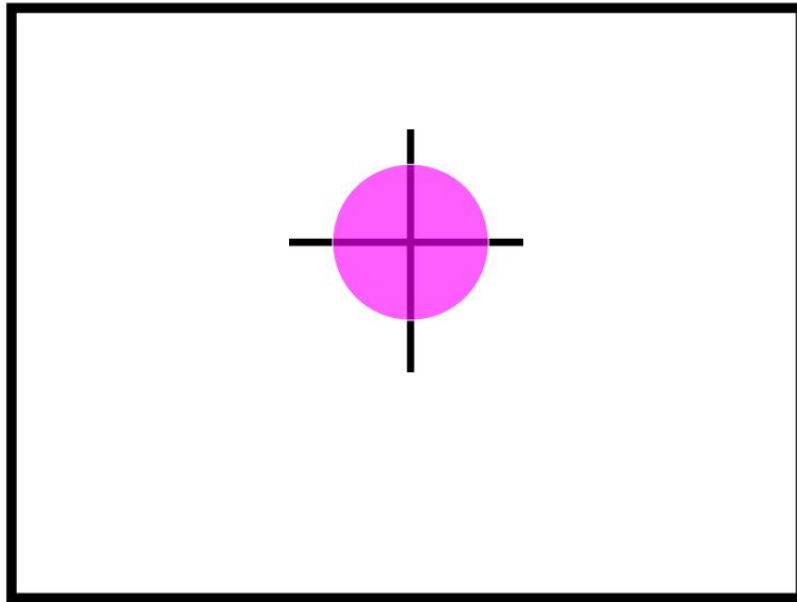


Fig. 6. Example of a target.

2. If the beam exiting the BOA moves vertically when the corner-cube slider is translated, a fine tweak on the vertical axis of steering mirror 2 (Fig. 2) can correct this movement.
3. If the beam exiting the BOA moves horizontally when the corner cube slider is translated, a fine tweak on the horizontal axis of steering mirror 2 (Fig. 2) can correct this movement.
4. Repeat the fine alignment, steps 2 and 3, a few times, if necessary, until the laser beam exiting the BOA does not move when the corner-cube slider is translated.
5. Note that the transmission of the BOA (like most other pulse compressors) is not 100%, so, if you are performing multi-photon microscopy, where the average power incident on the sample is usually limited by sample damage considerations, you can now turn up the laser power to compensate for this

loss. In this manner, when the pulse length is optimized by the BOA, you should see more multi-photon signal with it than without it.

6. If your beam center wavelength changes, you will need to tune the wavelength knob to re-orient the prism to accommodate the new wavelength. Keep in mind that the numbers on the wavelength dial are only approximate, so simply tuning the wavelength knob to the new wavelength may not suffice, in which case, the beam exiting the BOA will move horizontally when the corner-cube slider is translated. In this case, a fine tweak on the wavelength dial can correct for this movement.
7. Finally, while the BOA will not introduce any distortions into your pulse, ultrafast lasers and other optics are well-known to introduce such distortions themselves, so you should always align your laser carefully, and measure its output pulse accurately, checking for spatio-temporal distortions. We recommend the pulse-measurement devices, FROG and GRENOUILLE (www.swampoptics.com), which measure, not only the pulse intensity and phase (color) in time, but also the pulse spatial profile and the above spatio-temporal distortions. Like the BOA, they are also very easy to use.

Using the BOA Pulse Compressor

Using the BOA is very easy.

Tune the GDD slider to vary the group-delay dispersion (GDD) and hence the pulse chirp and length. If you place additional optics in your beam, move the slider to a more negative value of GDD for the shortest output pulse. And if you remove optics from your beam, move the slider to a less negative value of GDD to obtain the shortest output pulse. Keep in mind that pulses from ultrafast lasers drift from day to day, requiring different amounts of GDD compensation from day to day. It's best to monitor the output pulse length and shape with a pulse-measurement device, such as a FROG or GRENOUILLE.

Also, some pulses have complex shapes and/or higher-order phase distortions. Such pulses cannot be compressed effectively with a pulse compressor. Also, pulses with large amounts of positive GDD (positive chirp) can be compressed using a pulse compressor, such as the BOA, but the compressed pulse will have higher-order phase distortions.

The BOA is meant to operate with horizontal polarization. Using vertical polarization will result in considerable loss inside the BOA (due to Fresnel reflections off the prism faces) and hence poor transmission. If your beam is vertically polarized, rotate its polarization or the BOA by 90° .

While the irises are labeled input and output, you may use the BOA in the opposite direction, sending your beam into the output iris. It should work equally well in this orientation.

Additional Information

For more information on pulse compressors, see any textbook on ultrafast optics, or access the Power Point lectures of Prof. Rick Trebino (Georgia Institute of Technology), which provide an excellent free introduction to ultrafast optics, as well as pulse compressors (www.physics.gatech.edu/gcuo/lectures). The Ultrafast Optics lectures on *Dispersion* and *Spatio-temporal Optics* are particularly relevant.

Also, see: S. Akturk, X. Gu, M. Kimmel, and R. Trebino (2006). "Extremely simple single-prism ultrashort-pulse compressor." *Opt. Expr.* **14**(21): 10101-8, which is available free online at www.opticsexpress.org.

Finally, the Swamp Optics tutorial on pulse compressors is also very helpful. It is also available free online at http://www.swampoptics.com/tutorials_pulsecompressor.htm.

If you have any questions or problems, please email Support@SwampOptics.com with the details. We will return your email or call you as quickly as possible.

BOA COMPRESSOR SPECIFICATIONS

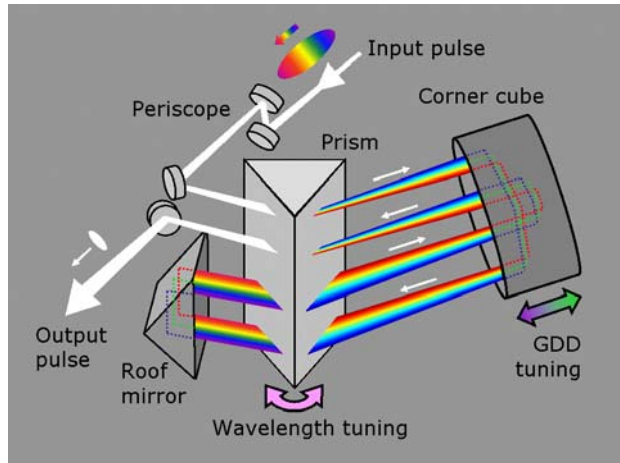
Pulse compressor model:	BOA-8	BOA-10
Prism material:	PBH-71	
Wavelength range:	750 – 1050 nm	1000 – 1100 nm
GDD range @ 800 nm:	-14,000 – +150 fs ²	na
GDD range @ 1000 nm:	-7,000 – +800 fs ²	-7,000 – +800 fs ²
Transmission ¹ :	>70% @ 800 nm	>75%
Maximum bandwidth at minimum GDD ² :	300 nm	100 nm
Maximum bandwidth near maximum GDD ² :	40 nm	60 nm
Maximum peak power:	500MW	
Total additional beam path:	< 0.9 m	
Pulse repetition rate:	Any	
Angular dispersion (dθ/dλ) added:	0	
Pulse-front tilt (dt/dx) added:	0	
Spatial chirp (dx/dλ) added:	0	
1D beam magnification:	1	
Output/input beam collinearity:	< 10 mrad	
Required input polarization:	Horizontal	
Polarization rotation:	<0.1°	
Required input-beam diameter:	1 – 4 mm (collimated)	
Input-beam lateral-displacement tolerance:	1 mm	
Number of alignment knobs:	Zero	
Time to set up:	~ 10 minutes	
Dimensions (L x W x H):	33 cm x 7.5 cm x 16.5 cm	
Weight:	3 kg	

1. The transmission varies with wavelength in the BOA-8 model, from ~70% at 750 nm to ~60% at 1050 nm.

2. As with all dispersive pulse compressors, the maximum bandwidth is limited by beam clipping on the second pass through the prism and so depends on the prism-corner-cube separation (and hence the device's maximum negative GDD). A unique advantage of the BOA single-prism/corner-cube design, which tunes GDD by varying this separation, however, is that, if less than the full negative GDD is needed, the beam path will be shorter, and, as a result, the compressor can accommodate a pulse with a larger bandwidth. In addition, the maximum bandwidth also depends on the wavelength and is slightly larger at longer wavelengths. Finally, users of any pulse compressor should keep in mind that, for large bandwidths, higher-order distortions will become apparent.

ADDITIONAL NOTES

- The added spatio-temporal distortions—angular dispersion, pulse-front tilt, and spatial chirp—can be proven to always be identically zero and were all immeasurable in our experiments.
- If your beam is larger than 4 mm, please let us know, and we can easily design a pulse compressor with a larger aperture, most likely at no extra cost.
- Alignment of the pulse compressor into a beam is achieved using a simple trick: turning a knob moves the pulse compressor input and output mirrors out of the beam. When the beam passes through its input and output apertures, the pulse compressor is then properly aligned.
- The pulse compressor itself is auto-aligning, so no alignment knobs are required, and no computer or external electronics is required.
- If the pulse compressor is bumped, as long as no beam cropping occurs, the BOA will remain aligned and the output beam will remain collinear with the input beam.



Layout for the BOA single-prism pulse compressor