

Variable Beam Expander 2X-8X

User Manual



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Variable Beam Expander (VBE)

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1. Introduction

Variable Beam Expanders are ideal for the systems where different magnifications and precise control of laser beam divergence is required. Standard Variable Laser Beam Expander models with expansion rates of 2X-8X will be reviewed in this manual. The beam expander incorporates zooming and divergence compensation, which is realized by rotating external parts of the beam expander. There are two set screws to lock magnification and divergence position once desired beam size is reached.

Features:

- Diffraction limited performance
- Suitable for usage with ultrafast picosecond and femtosecond lasers
- Convenient magnification control and divergence compensation
- Custom wavelengths are available

2. Applications

- Laser beam size control
- Control of focusing parameters (Numerical Aperture)

3. Technical information

Expansion ratio: 2x-8x

Input aperture: 11 mm

Exit aperture: 19 mm

Lens material: UVFS

Wavefront distortion: $<\lambda/4$ @ 632.8 nm

Total transmission: $>97\%$ (standard)

Total transmission: $>99\%$ (under request)

LIDT: $>5 \text{ J/cm}^2$ @ 1064 nm, 10 ns, 10 Hz for VBE-2X-8X-1030-1064-B-(2M/3M)

$>0.75 \text{ J/cm}^2$ @ 532 nm, 10 ns, 10 Hz for VBE-2X-8X-0515-0532-B-(2M/3M)

$>0.6 \text{ J/cm}^2$ @ 355 nm, 10 ns, 10 Hz for VBE-2X-8X-0343-0355-B-(2M/3M)

Housing dimensions: $\varnothing 41 \times 156.5 \text{ mm}$

Mounting thread: SM1 male, SM1 female, M42x1.5 male, middle mount (optional)

Wavelength	Magnification	2x	3x	4x	5x	6x	7x	8x
1342 nm		$\varnothing 5$	$\varnothing 5$	$\varnothing 5$	$\varnothing 4$	$\varnothing 3$	$\varnothing 2.5$	$\varnothing 2.5$
1020-1070 nm		$\varnothing 5$	$\varnothing 5$	$\varnothing 5$	$\varnothing 4$	$\varnothing 3$	$\varnothing 2.5$	$\varnothing 2.5$
515-532 nm		$\varnothing 5$	$\varnothing 5$	$\varnothing 4$	$\varnothing 3$	$\varnothing 2.5$	$\varnothing 2.25$	$\varnothing 2$
343-355 nm		$\varnothing 5$	$\varnothing 5$	$\varnothing 4$	$\varnothing 3$	$\varnothing 2.5$	$\varnothing 2.25$	$\varnothing 2$

Table 1. Maximum recommended input beam diameter (mm) ensuring diffraction limited performance.

4. Alignment

4.1. 4-axis mount alignment

To obtain optimal performance it is highly recommended to align the 4-axis mount with the laser beam. Follow instructions below for 4-axis mount alignment.

Mount alignment procedure:

1. Install camera ~1200 mm from the laser output, center it and set current beam position as a reference point by placing crosshair over the center (fig. 1).

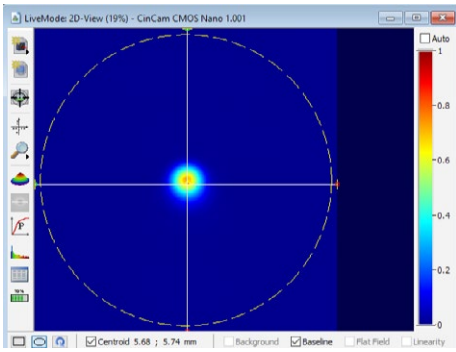


Figure 1. Setting beam position.

2. Place 4-axis mount at ~100 mm distance from the laser.
3. Align the mount with the beam:
 - a. Install the Aligner in the 4-axis mount and use the following apertures:
 - Entrance aperture of $\varnothing 2$ mm.
 - No aperture at the exit (fig. 2).

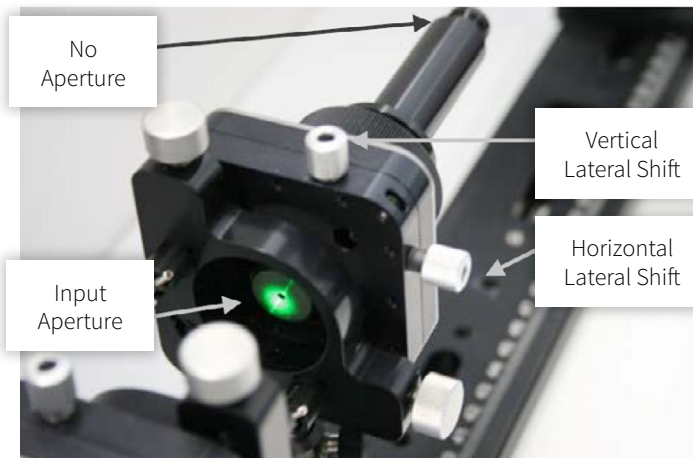


Figure 2. Mount alignment.

The following beam profile should be observed in the camera (fig. 3):

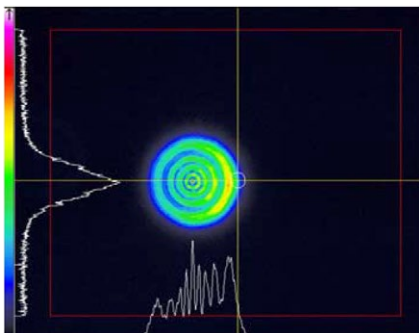
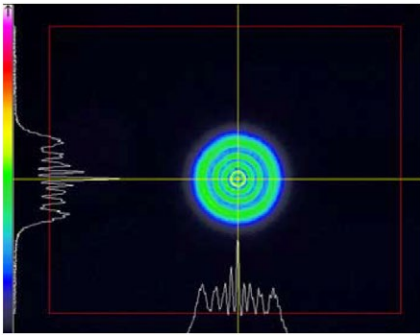


Figure 3. Observed beam profile.

Aligner apertures, mm	
In	Out
2	-

Comment: Misalignment in horizontal direction is observed.

b. By using **Lateral shifts only (X; Y)** get symmetric diffraction pattern that is centered with the crosshair (fig. 4).

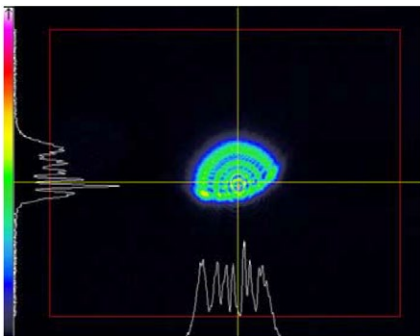


Aligner apertures, mm	
In	Out
2	-

Figure 4. Centering crosshair.

- Comments:
- Entrance aperture of the aligner is aligned.
 - Diffraction pattern is symmetric.
 - The center of rings coincides with the crosshair.

c. Install the output aperture of $\varnothing 3$ mm and check diffraction pattern on the camera (fig. 5).



Aligner apertures, mm	
In	Out
2	3

Figure 5. Diffraction pattern of $\varnothing 3$ mm.

Comment: Misalignment in vertical direction is observed.

d. Firstly, using **Tilting (θ_x ; θ_y)** get symmetric diffraction pattern that is centered with the crosshair. Afterwards, use **Lateral shifts (X; Y)** to correct the alignment, if needed (fig. 6).

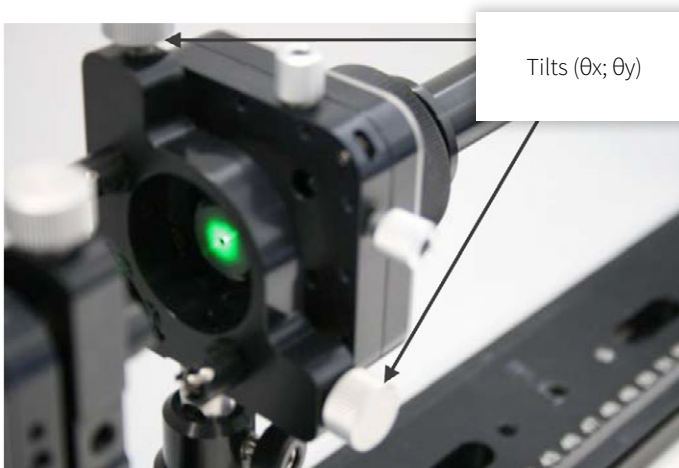
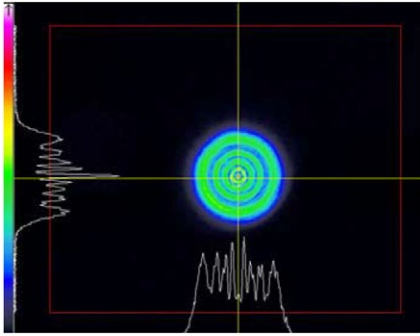


Figure 6. Alignment.

The following beam profile should be observed in the camera (fig. 7):

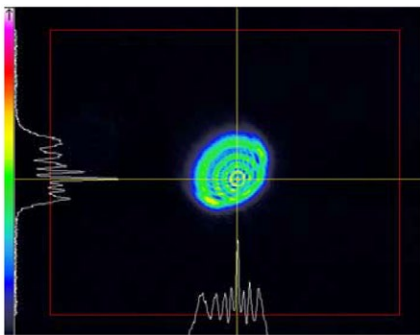


Aligner apertures, mm	
In	Out
2	3

Figure 7. Beam profile.

- Comments:
- Full beam after it passes through $\varnothing 2$ mm input and $\varnothing 3$ mm output aperture.
 - Diffraction pattern is symmetric.
 - The center of rings coincides with the crosshair.

e. Install the output aperture of $\varnothing 2$ mm and check diffraction pattern on the camera (fig. 8).

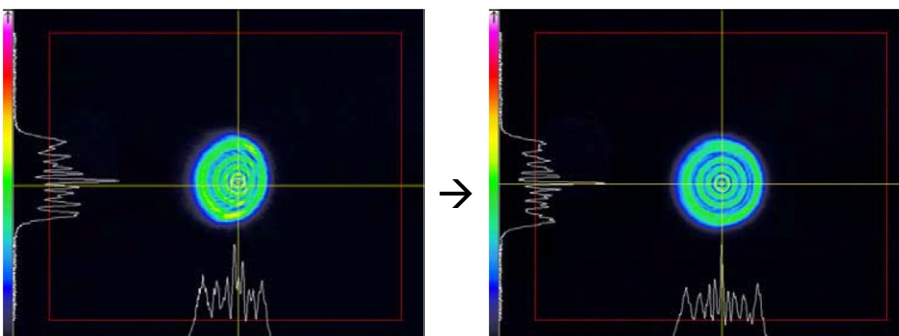


Aligner apertures, mm	
In	Out
2	2

Figure 8. Diffraction pattern of $\varnothing 2$ mm.

Comment: Misalignment in horizontal and vertical direction is observed.

f. Firstly, using **Tilting (θ_x ; θ_y)** get symmetric diffraction pattern that is centered with the crosshair. Afterwards, use **Lateral shifts (X; Y)** to correct the alignment, if needed (fig. 9).



Aligner apertures, mm	
In	Out
2	2

Figure 9. Setting symmetric diffraction pattern.

- Comments:
- First picture shows vertical misalignment eliminated.
 - Second picture shows both vertical and horizontal misalignment eliminated.
 - Diffraction pattern is symmetric.
 - The center of rings coincides with the crosshair.

g. Install the output aperture of $\varnothing 1$ mm and check diffraction pattern on the camera (fig. 10).

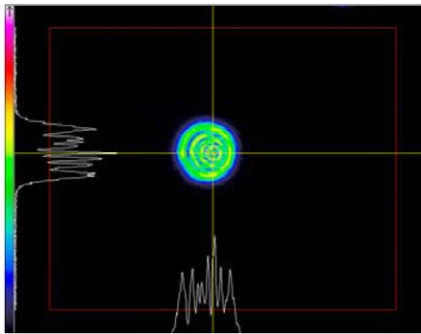


Figure 10. Diffraction pattern of $\varnothing 1$ mm.

Aligner apertures, mm	
In	Out
2	1

Comment: Misalignment in horizontal direction is observed.

h. By using **Tilting only ($\theta_x; \theta_y$)** get symmetric diffraction pattern that is centered with the crosshair (fig. 11).

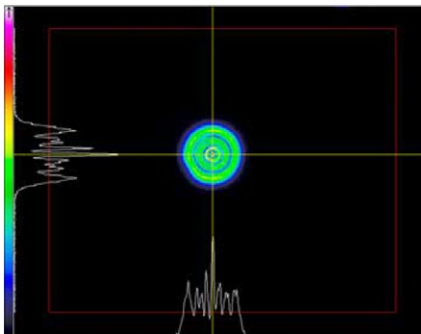


Figure 11. Setting symmetric diffraction pattern.

Aligner apertures, mm	
In	Out
2	1

- Comments:
- The Aligner is aligned.
 - Diffraction pattern is symmetric.
 - The center of rings coincides with the crosshair.

4.2. VBE alignment

To obtain optimal performance it is highly recommended to align the VBE with input laser beam. Follow below instructions to align the VBE.

VBE alignment procedure:

1. Move camera ~1200 mm from the laser output, center it and set current beam position as a reference point by placing crosshair over the center (fig. 12).

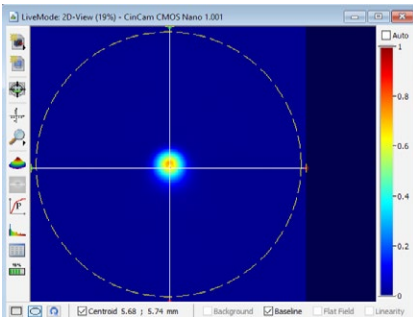


Figure 12. Centering beam position.

2. Place the VBE into the 4-axis mount and unlock expansion and focusing cylinders (release six 1.3 mm hex screws) (fig. 13).

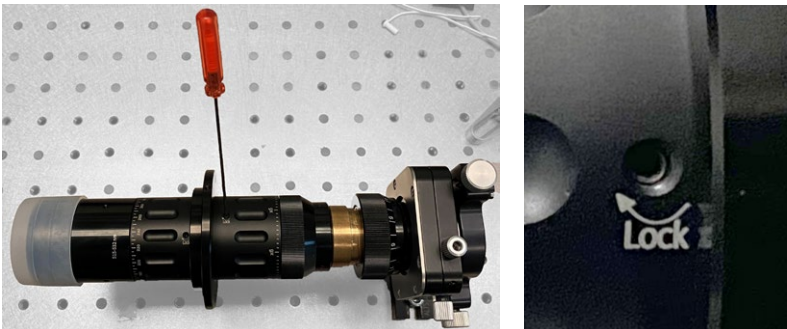


Figure 13. Unlocking expansion and focusing regulators.

3. Set VBE expansion scale to “x8” and focusing scale to position to “1152°” - turn the focusing cylinder most counter-clockwise (from 0° it will be 3 full turns and ~72°) so that sliding cylinder at the output of VBE would be most outward.



Figure 14. Setting expansion and focusing most outward.

4. After VBE placement into optical beam path laser beam will be decentered on the screen. By adjusting tilt ($\theta_x; \theta_y$) get the laser beam spot back to the center of the camera where crosshair was placed for reference (fig. 15).

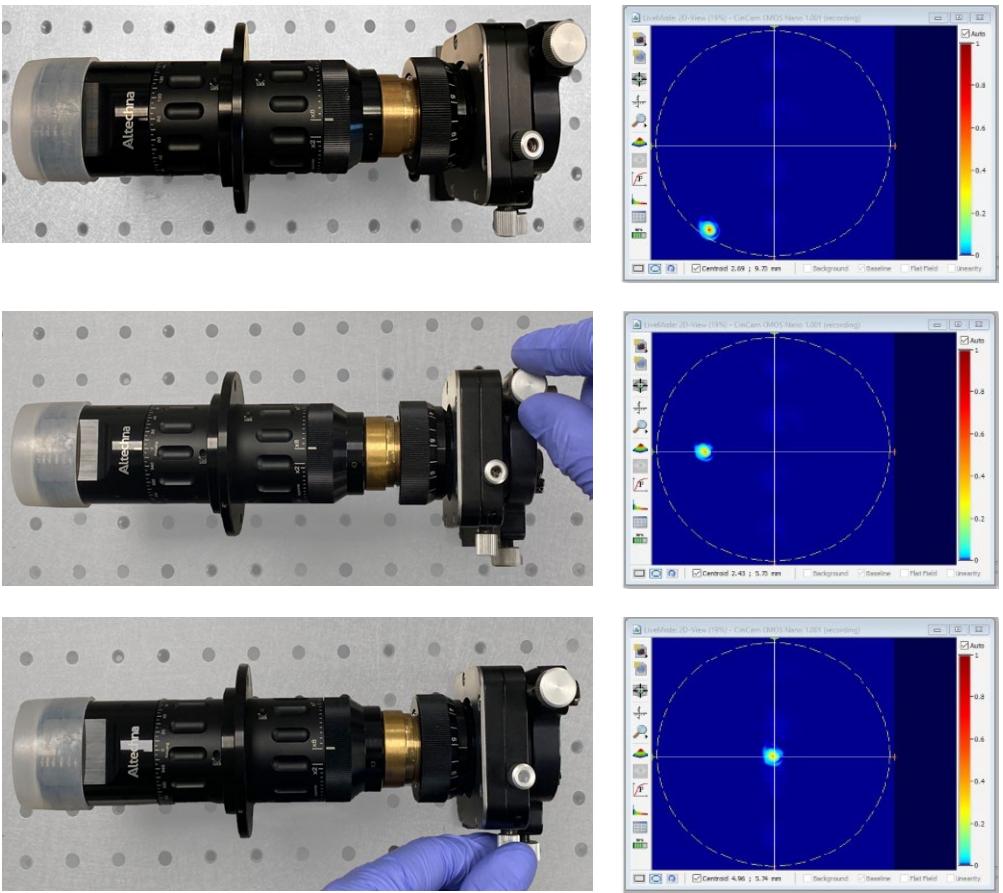


Figure 15. Centering laser beam.

5. Set VBE expansion scale to “x2” and focusing scale to position “0°” (turn the focusing cylinder most clockwise so that sliding cylinder at the output of VBE would be most inward) (fig. 16).



Figure 16. Setting expansion and focusing most inward.

6. After magnification and focusing are changed, the laser beam spot will be decentered on the screen again.
7. Set current beam position as a reference point by placing crosshair over the center (fig.17).

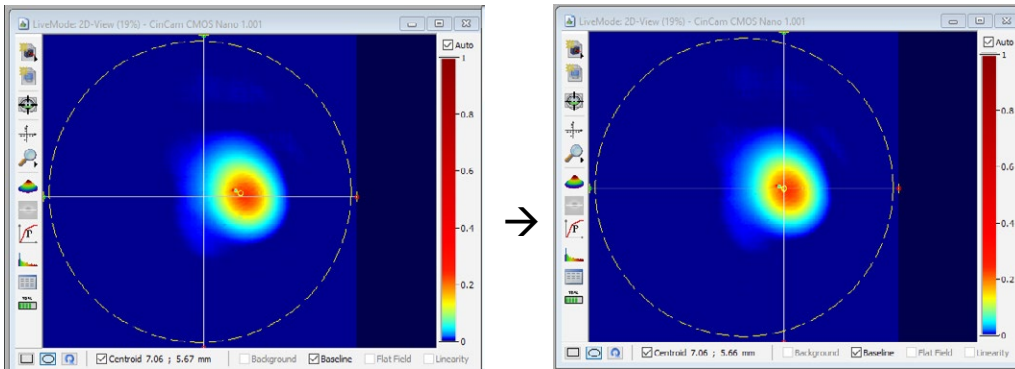


Figure 17. Placing crosshair over the center.

8. Set VBE expansion scale back to “x8” and focusing scale to position “1152°” (fig. 18).



Figure 18. Setting expansion and focusing most outward.

9. The laser beam spot will be moved from the crosshair again. By adjusting tilt (θ_x ; θ_y) get the laser beam spot back to the crosshair (fig. 19).

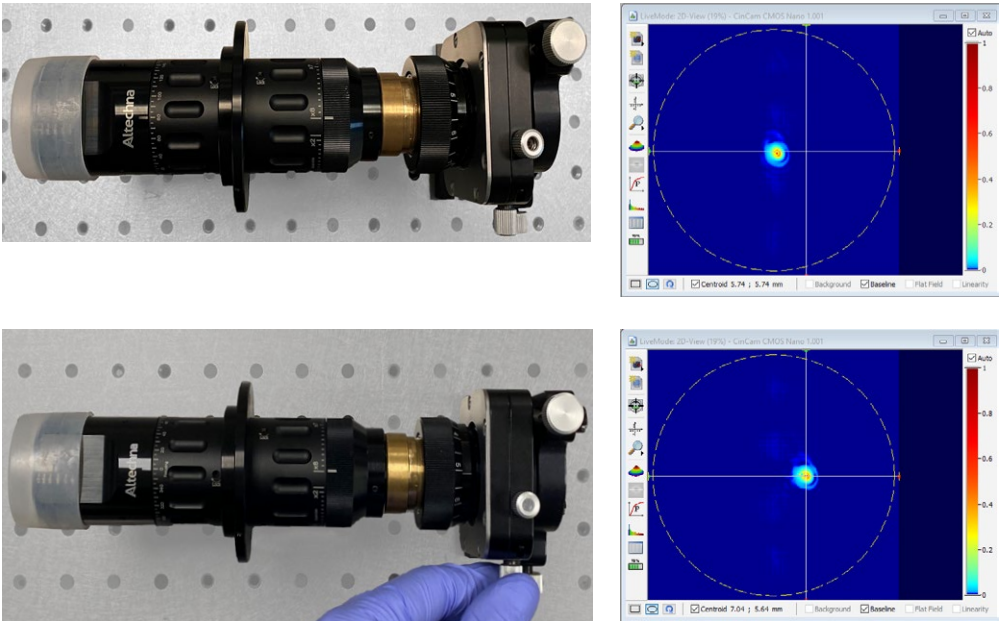


Figure 19. Setting laser beam back to crosshair.

10. The VBE is aligned.

5. Usage

To set desired magnification on Variable Laser Beam Expander two adjustment steps must be performed:

1. Unlock expansion and focusing cylinders with 1.3 mm hex.
2. Expansion cylinder should be rotated so that desired magnification value on the scale is aligned with reference mark. e.g. “x6” (fig. 20).



Figure 20. Setting expansion to “x6”.

3. Then focusing cylinder should be rotated so that focusing cylinder reference mark is aligned with the same magnification value. This time it must be “x6”. Then it should be fine-tuned to have desired collimation level (fig. 21).



Figure 21. Setting focusing to the same value as expansion (“x6”).

4. Alternative (more precise) method to find the right position of collimation lens is: Focusing cylinder is at 360° marking (fig. 22).



Figure 22. Setting focus.

Total available rotation is $\sim 1152^\circ$ (3 full rotations and $\sim 72^\circ$). Collimation curve below shows divergence cylinder rotation positions, which correspond to collimated output beam according to theoretical simulation.

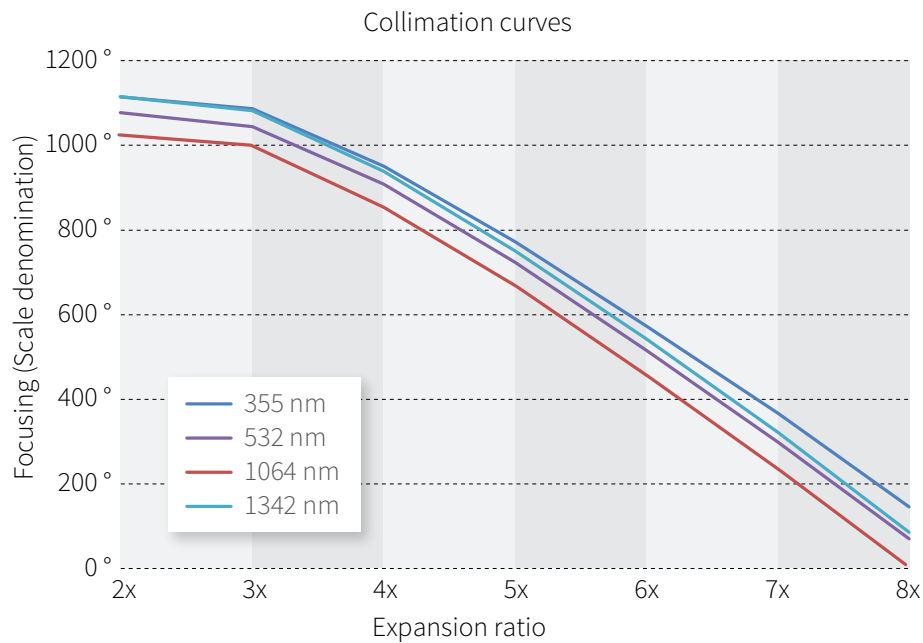


Figure 23. Collimation curves.

Values of the collimation curves							
	2.0x	3.0x	4.0x	5.0x	6.0x	7.0x	8.0x
343 – 355 nm	1108°	1082°	948°	770°	571°	360°	142°
515 - 532 nm	1073°	1041°	902°	717°	511°	293°	67°
1030 – 1064 nm	1020°	992°	850°	663°	453°	230°	1°
1342 nm	1106°	1079°	935°	747°	535°	311°	80°

Table 2. Values of the collimation curves taken from the simulation.

Note: In real applications divergence scale should be fine-tuned to obtain best collimation of the beam. The reason lays in laser beam parameters (diameter, divergence and M^2) which are unique to individual laser source. As a result, VBE, adjusted to collimate one laser beam might not show the same performance with another laser of the same type. Altechna beam expander’s focusing scale is designed for maximum beam diameter recommended for maximum expansion (e.g. if maximum recommended beam diameter @ 532 nm with x8 magnification is Ø2 mm, then the scales are designed for VBE operation with Ø2 mm beams) (fig. 23).

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