Variable Beam Expander 1X-4X

User Manual

2020 version v.1.00

Altechna

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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/focusing is required. Standard Variable Laser Beam Expander models with expansion rates of 1X-4X will be reviewed in this manual. The beam expander incorporates zooming and focusing compensation, which is realized by rotating external parts of the beam expander. There are two set screws to lock magnification and focusing position once desired beam size is reached.

Features:

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

2. Applications

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

3. Technical information

- Expansion ratio: 1x-4x
- Input aperture: 11 mm
- Exit aperture: 19 mm
- Lens material: UVFS
- Total transmission: >97%
- Wavefront distortion: <λ/4 @ 632.8 nm
- LIDT: >6.5 J/cm^2 @ 1064 nm, 10 ns, 10 Hz for VBE-1X-4X-1030-1064-B
  >1.0 J/cm^2 @ 532 nm, 10 ns, 10 Hz for VBE-1X-4X-0515-0532-B
  >0.8 J/cm^2 @ 355 nm, 10 ns, 10 Hz for VBE-1X-4X-0343-0355-B
- Housing dimensions: Ø41.5 x 120 mm (SM1 only threaded models)
  Ø41.5 x 136.7 mm (models with M42x1.5 external threading)
- Mounting threads: SM1 male, SM1 female, M42x1.5 male, middle mount (optional)

Wavelength \ Magnification	1x	2x	3x	4x
1550	Ø8	Ø7	Ø5	Ø4
1342	Ø8	Ø7	Ø5	Ø4
1140	Ø7	Ø7	Ø5	Ø4
1020-1070	Ø7	Ø7	Ø5	Ø4
800	Ø7	Ø7	Ø5	Ø4
633	Ø6	Ø6.5	Ø5	Ø4
515-532	Ø6	Ø6.5	Ø4	Ø3
343-355	Ø4	Ø5.5	Ø3	Ø3
266	Ø4	Ø5.5	Ø3	Ø2.7

Table 1. Max 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).

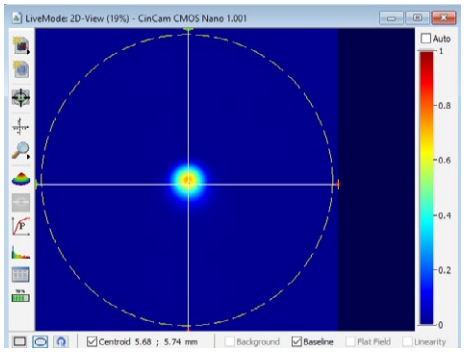


Figure 1. Setting beam position.

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 Ø2 mm.
      - No aperture at the exit (fig. 2).

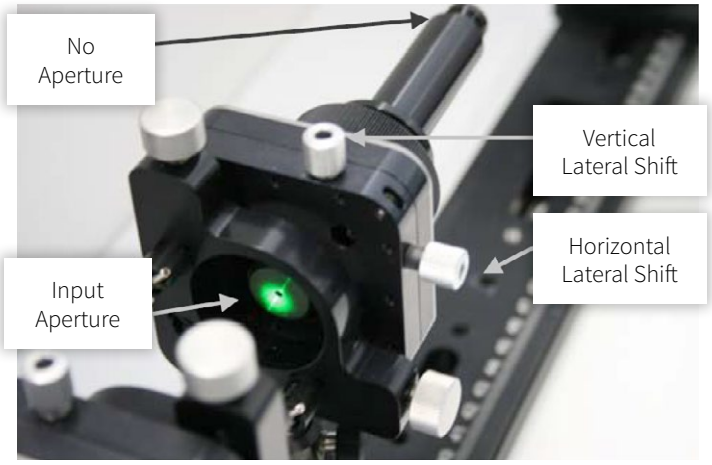
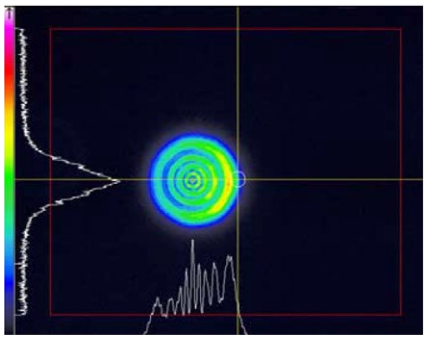


Figure 2. Mount alignment.

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

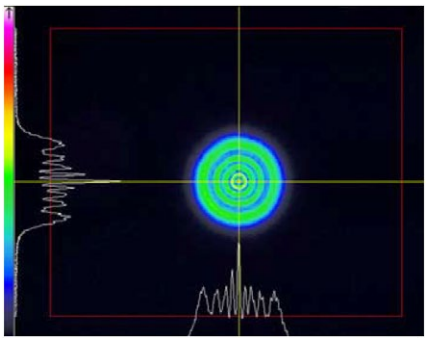


Aligner apertures, mm	
In	Out
2	-

Figure 3. Observed beam profile.

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).

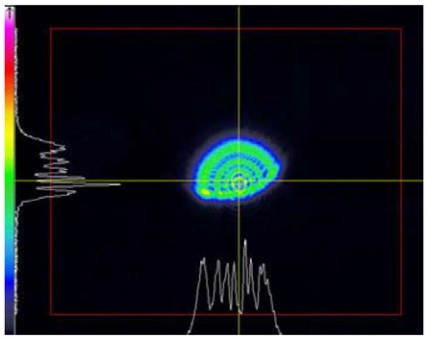


Aligner apertures, mm	
In	Out
2	-

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 Ø3 mm and check diffraction pattern on the camera (fig. 5).



Aligner apertures, mm	
In	Out
2	3

Figure 5. Diffraction pattern of Ø3 mm.

Comment: Misalignment in vertical direction is observed.

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

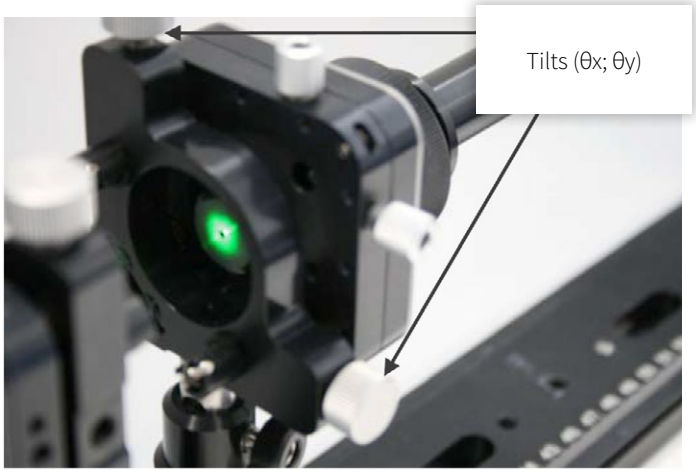
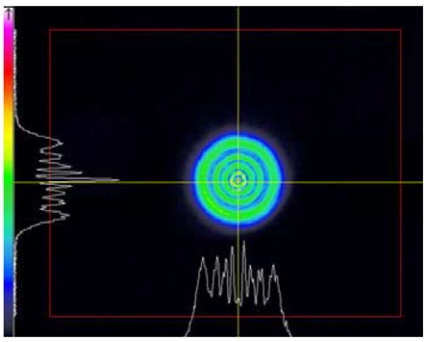


Figure 6. Alignment.

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

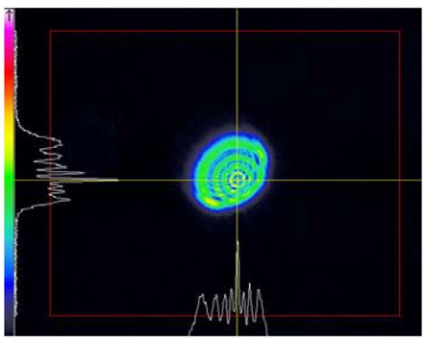


Aligner apertures, mm	
In	Out
2	3

Figure 7. Beam profile.

Comments:
- Full beam after it passes through Ø2 mm input and Ø3 mm output aperture.
- Diffraction pattern is symmetric.
- The center of rings coincides with the crosshair.

e. Install the output aperture of Ø2 mm and check diffraction pattern on the camera (fig. 8).

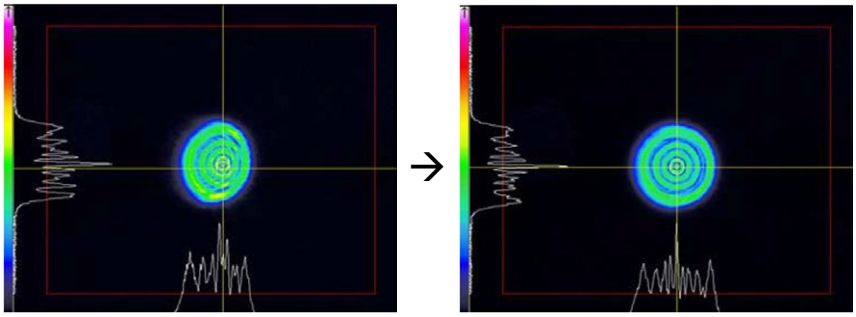


Aligner apertures, mm	
In	Out
2	2

Figure 8. Diffraction pattern of Ø2 mm.

Comment: Misalignment in horizontal and vertical direction is observed.

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

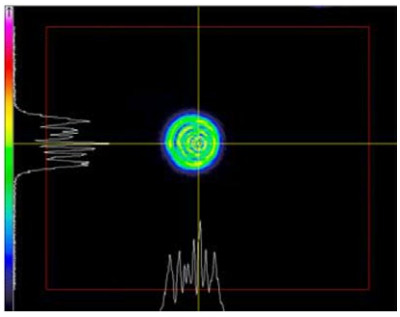


Aligner apertures, mm	
In	Out
2	2

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 Ø1 mm and check diffraction pattern on the camera (fig. 10).

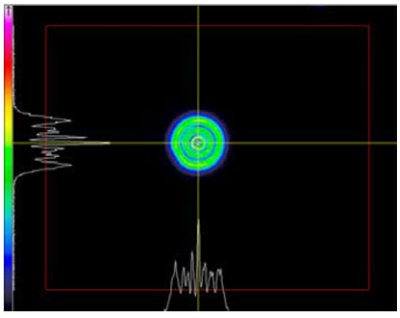


Aligner apertures, mm	
In	Out
2	1

Figure 10. Diffraction pattern of Ø1 mm.

Comment: Misalignment in horizontal direction is observed.

h. By using **Tilting only (θx; θy)** get symmetric diffraction pattern that is centered with the crosshair (fig. 11).



Aligner apertures, mm	
In	Out
2	1

Figure 11. Setting symmetric diffraction pattern.

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. 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. 12):

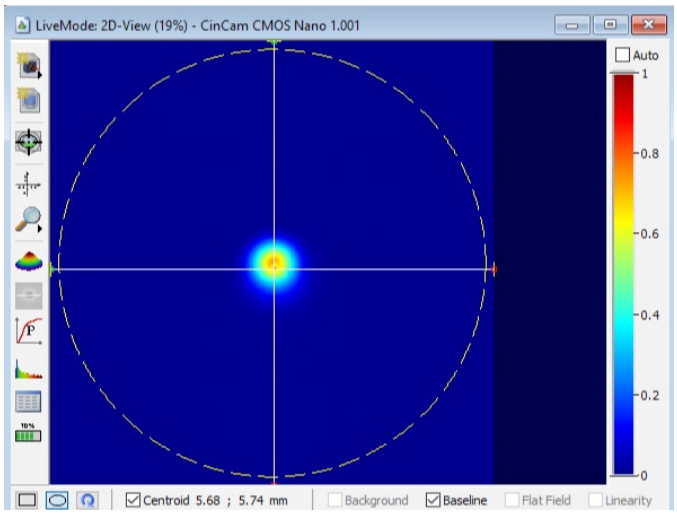


Figure 12. Setting beam position.

2. Place 4-axis mount at ~100 mm distance from the laser.

3. Align the mount with the beam.

4. Place the VBE into the 4-axis mount and unlock expansion and focusing cylinders with 1.3 mm hex (fig. 13):

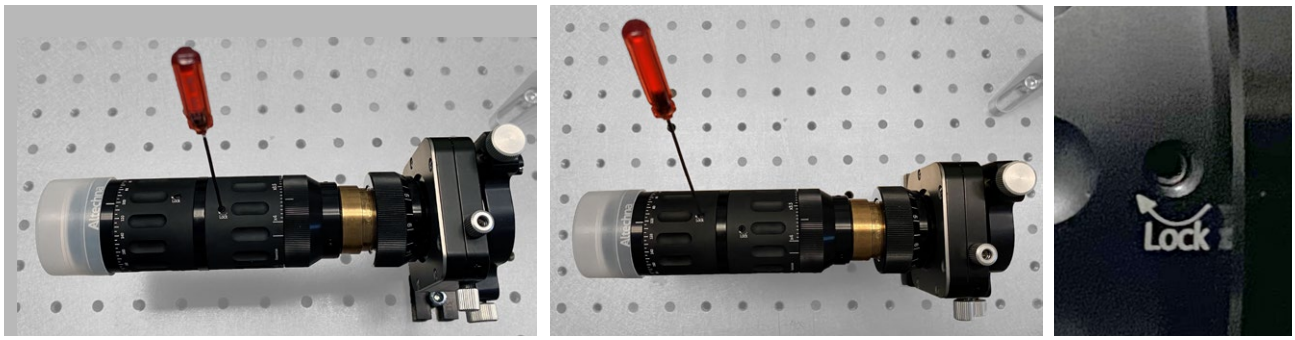


Figure 13. Unlocking expansion and focusing regulators.

5. Set VBE expansion scale to "**x4**" and focusing scale cylinder most counter-clockwise so that sliding cylinder at the output of VBE would be most outwards, it should correspond to ~260° mark on the scale (fig. 14):

Figure 14. Setting the focusing most outwards.

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

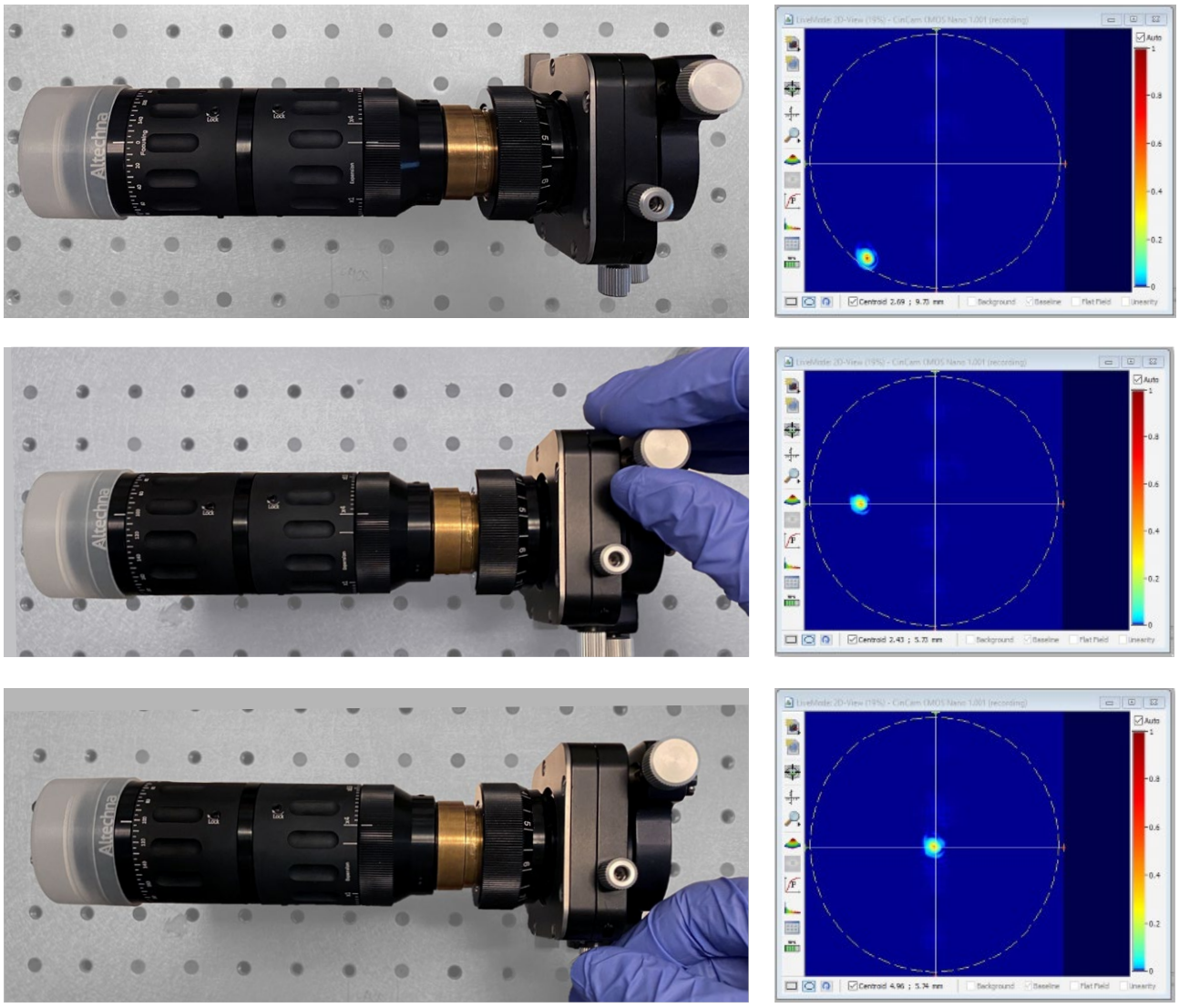


Figure 15. Centering laser beam spot.

7. Set VBE expansion scale to “**x1**”and focusing scale to number “**0°**” (fig. 16):

Figure 16. Setting VBE expansion and focusing.

8. After magnification and focusing are changed, the laser beam spot will be decentered on the screen again.

9. Set current beam position as a reference point by placing crosshair over the center (fig. 17):

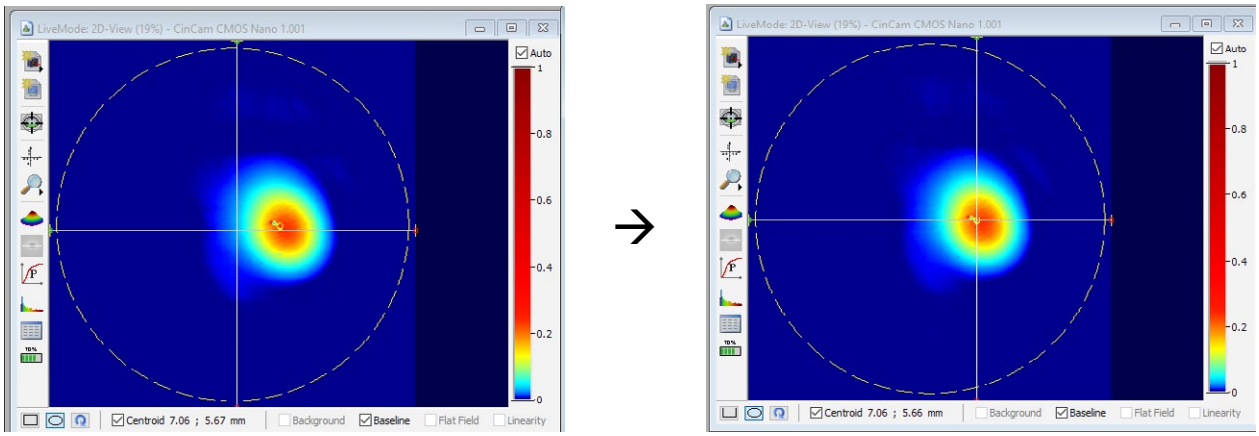


Figure 17. Setting laser beam position.

10. Set VBE expansion scale back to “**x4**” and focusing most counter-clockwise, it should correspond to ~260° mark on the scale (fig. 18):

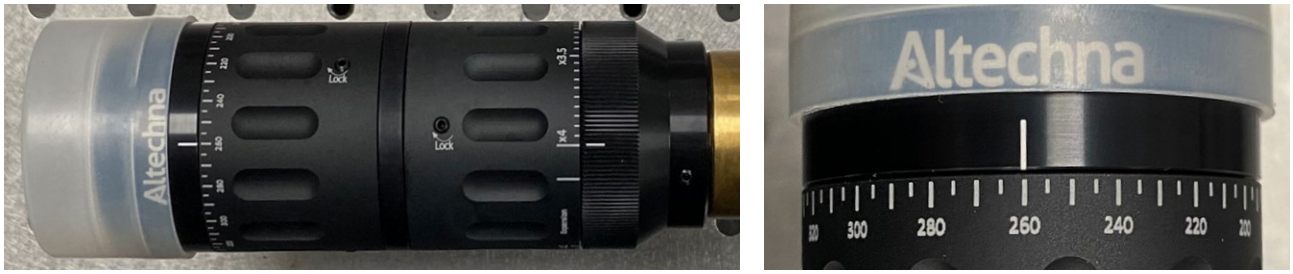


Figure 18. Setting expansion and focusing.

11. The laser beam spot will be moved from the crosshair again. By adjusting tilt (θx; θy) get the laser beam spot back to the crosshair (fig. 19):

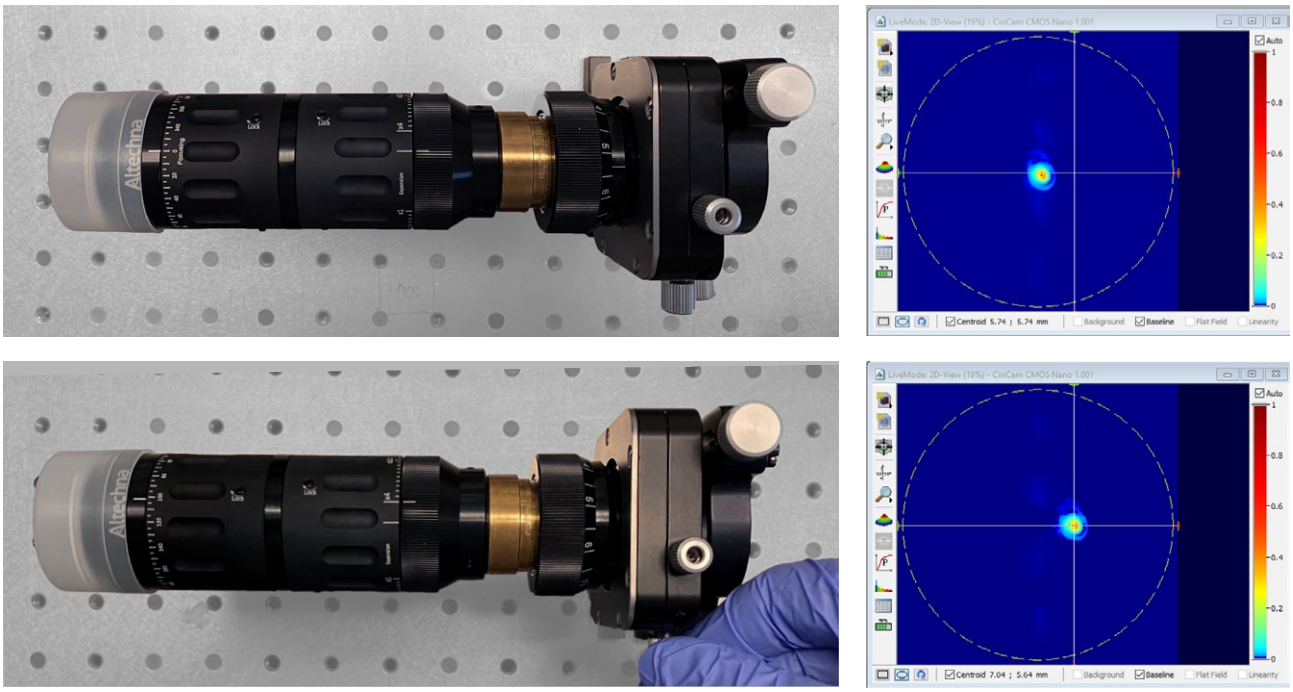


Figure 19. Centering laser beam sport with crosshair.

12. The VBE is aligned.

5. Usage

To set desired magnification on Variable laser beam expander three adjustment steps must be performed:

Adjustment procedure:

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.

3. Focusing cylinder should be rotated to match the angle on focusing scale as per graph below. Please note, that collimation curves are different for different wavelengths (fig. 20).

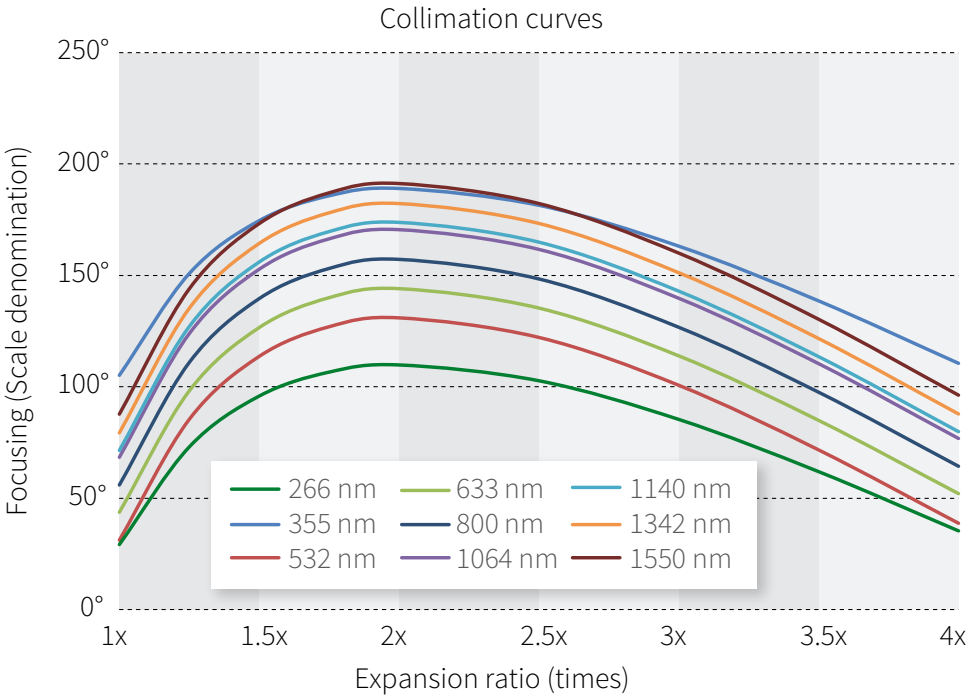


Figure 20. Collimation curves.

Note: Above graph is based on simulation with the following input beam diameters: Ø3 mm @ 355 nm, Ø3.8 mm @ 532 nm, Ø4 mm @ 633 nm, Ø4 mm @ 800 nm, Ø4 mm @ 1064 nm, Ø4 mm @ 1342 nm, Ø4 mm @ 1550 nm.

In real applications focusing scale might require different fine-tuning to obtain best collimation of the beam. The reason lays in laser beam characterization parameters (diameter, divergence and M^2) which are unique to every 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.

4. Depending on input beam diameter, collimation might require slightly shifted setting than indicated on the curves above. Please refer to the graph below for comparison of collimation curves for Ø2 mm; Ø4 mm and Ø6 mm beams @ 532 nm (fig. 21).

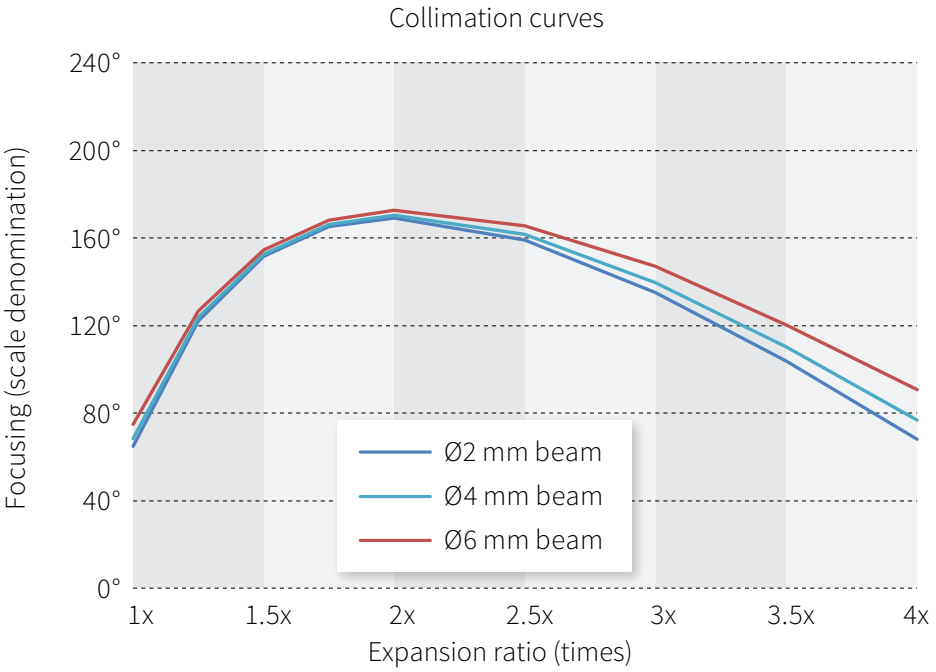


Figure 21. Collimation curves.

5. Depending on input beam divergence, collimation might require extra tuning, especially on the lower expansion end. Please refer to the graph below for comparison of collimation curves for Ø2 mm beam with Ø4 mm and Ø6 mm beams (fig. 22).

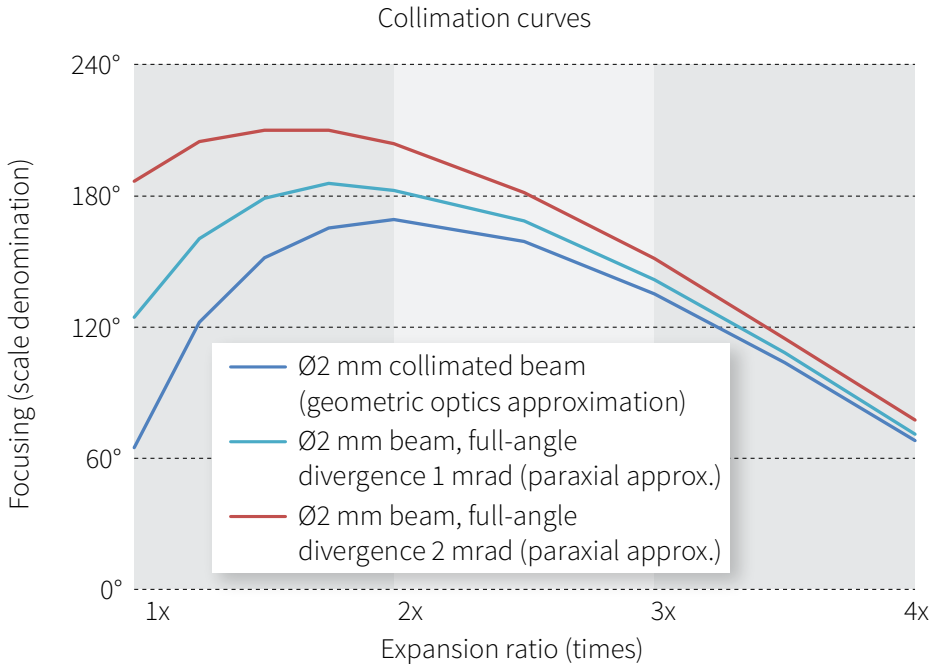


Figure 22. Collimation curves.

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