



P5.8.8.6

Laser beam analysis 474 7117 EN



LEYBOLD®



Laser Sicherheitshinweise

Hiermit erklärt die Firma LD Didactic GmbH,
dass es sich bei dem angebotenen Lasersystem um einen Aufbau handelt, der sowohl in
Komponenten als auch im fertigen Aufbau einem Laser der Klasse 3A, 3B oder 4 nach DIN EN 60
825-1 entspricht. Typischerweise ist die Pumpdiode eine Nd:YAG Laser Klasse 4, ein HeNe Laser mit
Auskoppler Klasse 3A, aber ein HeNe mit zwei hochreflektierenden Spiegeln nur Klasse 1. Bitte die
Anleitung oder Aufkleber beachten.

Aus Haftungsgründen dürfen diese Geräte oder Gerätesammlungen nicht an Privatleute verkauft
werden. Der Einsatz von Lasern oberhalb Klasse 2 an allgemeinbildenden Schulen ist in
Deutschland nicht gestattet.

Gewerbliche Abnehmer, Schulen und Universitäten werden hiermit darauf hingewiesen, dass aus dem
missbräuchlichen Betrieb der Geräte ein Verletzungsrisiko, speziell für die Augen, resultiert.

Dem Benutzer obliegt insbesondere:

- Die relevanten Unfallverhütungsvorschriften zu beachten, zur Zeit beispielsweise BGV B2 und BGI 832
 - die OstrV zu beachten „Verordnung zum Schutz der Beschäftigten vor Gefährdungen durch künstliche optische Strahlung“
 - Der Betrieb der Geräte muss rechtzeitig beim Gewerbeaufsichtsamt und der Berufsgenossenschaft angezeigt werden.
 - Der Betreiber muss schriftlich einen Laserschutzbeauftragten benennen, der für die Einhaltung der Schutzmaßnahmen verantwortlich ist.
 - Die Geräte sind nur für den Betrieb in umschlossenen Räumen vorgesehen, deren Wände die Ausbreitung des Laserstrahls begrenzen.
 - Der Laserbereich ist deutlich und dauerhaft zu kennzeichnen.
 - Ab Laserklasse 4 ist eine Laser-Warnleuchte am Raumzugang notwendig.

 - Die Geräte sind zur Lehre und Ausbildung in Berufsschulen, Universitäten oder ähnlichen Einrichtungen gedacht.
 - Die Geräte nur innerhalb der in den Anleitungen vorgegebenen Betriebsbedingungen betreiben.
 - Die Geräte nur von entsprechend unterwiesenen Mitarbeitern und Studierenden benutzen lassen.
- Bei Handhabung des Gerätes durch Studenten müssen diese von entsprechend geschultem Personal überwacht werden.



Als praktische Ratschläge:

- Vor dem Einschalten auf Beschädigungen prüfen
- Nicht in den Strahl blicken
- Den Laserstrahl so führen, dass sich keine Personen, Kinder oder Tiere ungewollt im Strahlbereich befinden können
- Den Laserstrahl nicht auf reflektierende Flächen oder in den freien Raum richten
- Nicht mit reflektierenden Gegenständen im Laserstrahl arbeiten
- Armbanduhr, Schmuck und andere reflektierende Gegenstände ablegen.
- Beim Einsetzen optischer Bauteile den Laserstrahl an der Quelle abschalten oder geeignet abdecken, bis die Bauteile positioniert sind
- Teilweise wird mit unsichtbaren Laserstrahlen gearbeitet, deren Verlauf nicht sichtbar ist.
- Falls nötig, Laserschutzbrillen oder Laserjustierbrillen benutzen.

Die Firma LD Didactic GmbH haftet nicht für eine missbräuchliche Verwendung der Geräte durch den Kunden.

Der Kunde verpflichtet sich hiermit die Geräte nur entsprechend der rechtlichen Grenzen einzusetzen und insbesondere den Laserstrahl nicht im Straßenverkehr oder Luftraum zu verwenden oder in anderer Form auf Personen und Tiere zu richten.

Der Kunde bestätigt, das er befugt ist, diesen Laser zu erwerben und zu verwenden.

PHYSICS

CHEMISTRY
BIOLOGY

ENGINEERING



Laser Safety Notes

LD Didactic GmbH informs the customer this is laser equipment of either class 3A, 3B or 4 according to IEC 60 825. Typically a Nd:YAG Pump Diode is class 4, a HeNe with output coupler class 3A, but a HeNe with two high reflecting mirrors only class 1. Please see manual or attached labels for the exact specification of the laser.

Special safety precautions are necessary. Please check with local regulations. Typically the use requires a safety sign and a warning lamp that is on when the laser is activated and it might also be necessary to do and document a risk assessment.

Due to product liability, the laser must not be sold to individual persons. Companies, higher schools and universities might use it, but are notified that misuse of the laser poses a health risk, especially for the eyes.

The intended use of this equipment is for lessons, education and research in higher schools, universities or similar institutions.

Do not operate the devices outside parameters specified in the manual.

People using the laser must be properly trained and students must be supervised.

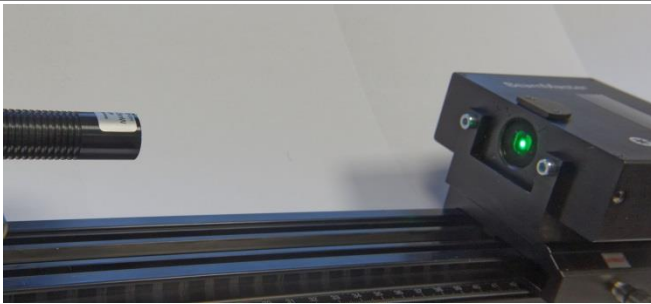
As a general guidance, the user is advised to:

- Check the laser for damages before use
- Not to look into the beam
- Take necessary measures that no people or animals can accidentally enter the beam area
- do not direct the beam on reflecting surfaces or into public areas
- do not work close to the light path with reflecting tools
- take off all jewelry and wristwatches when working with the laser to avoid reflections
- While placing or removing optical parts in the light path, switch off the laser or cover its exit
- Some of the experiments use invisible laser beams, but still might hurt the eye
- use laser protection glasses or laser adjustment glasses where necessary
- supervise students by trained personnel when they work with the laser system
- use the laser system only as described in the instruction manuals

Customer acknowledges the receipt of this information.

The customer indemnifies LD Didactic from liability for any damages that occur because of misuse of the laser.

The customer confirms that he will obey all local regulations and is allowed by law to buy and use the laser system.



Laser Beam Profiler 474 7117

Objects of the experiment

- Investigate the diameter of different laser beams
- Investigate focusing properties of laser beams

Safety notes

This experiment uses a Laser. According to EN 60825 it is rated class 3B.

474 5418:

Laser Class 3B, visible 532 nm green, CW, < 7 mW; "Danger. Visible Laser radiation. Avoid direct exposure to beam." Do not look into beam"

474 5420:

Laser Class 3B, visible 630 nm red, CW, < 7 mW; "Danger. Visible Laser radiation. Avoid direct exposure to beam." Do not look into beam"

Safety precautions are necessary. Please check with local regulations. Typically the use requires a safety sign and maybe a warning lamp that is on when the laser is activated and it might also be necessary to do and document a risk assessment. In some places it might be necessary to apply for a license or notify the relevant authorities.

Germany: According to OStrV it is necessary to inform the "Gewerbeaufsichtsamt" and the workers' insurance "Berufsgenossenschaft" 14 days prior to startup for Lasers > class 2.

Misuse of lasers poses a health risk for the eyes.

Do not operate the devices outside parameters specified in the manual.

People using the laser must be properly trained and students must be supervised.

As a general guidance, the user is advised to:

- Check the laser and LEDs for damages before use
- Never to look into the laser beam
- Take necessary measures that no people or animals can accidentally enter the beam area
- Do not direct the beam on reflecting surfaces or into public areas
- Do not work close to the light path with reflecting tools
- Take off all jewelry and wristwatches when working with the laser to avoid reflections

- While placing or removing optical parts in the light path, switch off the laser or cover its exit

- Use laser protection glasses or laser adjustment glasses where necessary

- Supervise students by trained personnel when they work with the laser system

- Use the laser system only as described in the instruction manuals

Principles

Sometimes, laser beams are simply assumed to have parallel wavefronts and keep their diameter while travelling. This assumption may be quite correct on a bench.

On the other hand, even a laser beam cannot deny the $1/r^2$ law in far field situations.

So, what is a laser beam in detail?

The simplest real laser beam is called TEM₀₀ mode, is circular and has a Gaussian intensity profile over its diameter and the beam radius is defined by some percentage of the center intensity. The wavefronts are not parallel, but have a certain radius.

Due to diffraction effects, think of a laser beam passing through an appropriate windows, the laser beam will always have the tendency to increase the diameter.

Of course, using some lens the laser beam can be focused to a spot in space and will expand afterwards.

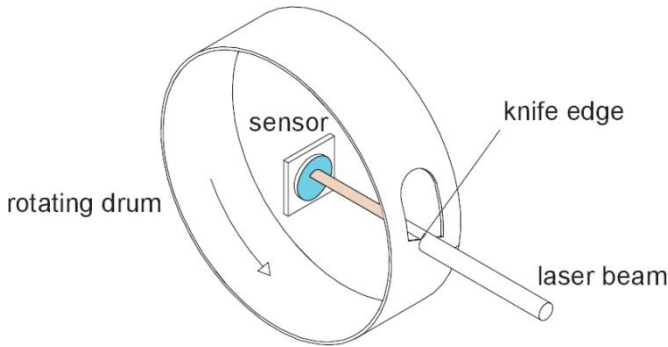
To measure a laser beam's diameter, two different ways are commercially available:

We could use a CCD chip like the one used in a digital camera, let the laser beam pass through an intensity reduction filter and record the illumination of the CCD's pixel. This is done commercially, and the resulting sensors are quite cheap and do a good job.

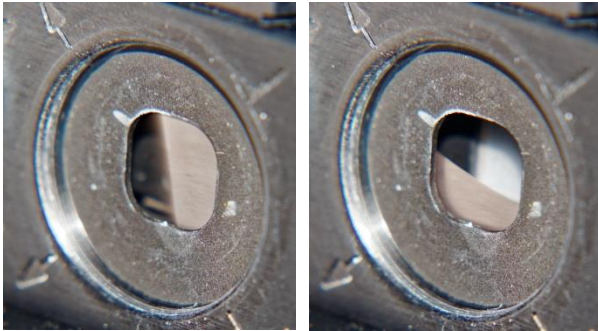
There are some limitations, though. The intensity reduction filter might deform the laser beam, maybe just by catching dust. The main problem is the pixel size. A good chip maker can do optical photodiodes in the μm range, so the beam profiling is limited to beams with several tens of μm diameter.

Smaller beams can be expanded by using optics, which will introduce their own problems.

In this experiment, a so called knife edge beam profiler is used. This is just one big photodiode and a rotating drum in front of it.



The drum has several cut-outs and while the drum rotates, many so called knife edges of the holes will “cut” through the laser beam.



An infinitely small laser beam would just be switched on and off by a knife edge passing, but a finite sized laser beam will show a more or less structured profile during the transition from on to off when the edge moves through the laser beam.

The derivative of the intensity profile on the photodiode is the beam intensity profile in one direction. Using several knife edges at different angles and a reconstruction similar to computer tomography, the beam profile can be reconstructed.

An intensity reduction filter can be placed behind the drum without disturbing the laser beam, and using a high speed analog-digital converter, the measurement steps during the knife’s transition can be made sub-micron small..

For further details of the Beammaster laser beam profiler and the software used, please take a look into the specific manual.

The laser beam profiler is attached to the USB port of the computer. Install the software first and then attach the USB cable.

There is one big disadvantage in this knife edge system. Using a pulsed laser or any other non-CW light source will interfere with the scanning process.

There are two lasers provided, a green Nd:YAG laser and a red laser diode. The red laser diode is truly CW, but the green YAG laser only seems to the eye being continuous. Manufacturers prefer to inherently pulse such green lasers to increase efficiency. The nonlinear conversion from infrared laser emission to green light works best at highest intensities and it is done best with short, intense pulses. The output of the green laser is pulsing at 100 kHz frequency.

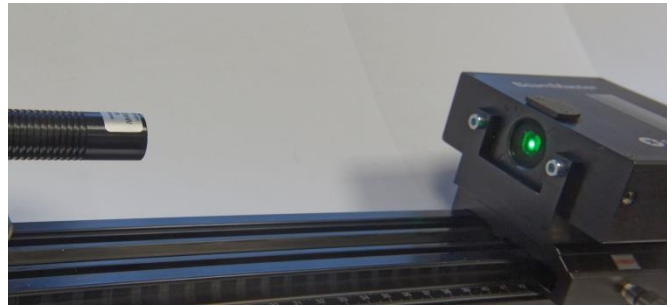
Experiments

With the lasers and optics provided several experiments can be done.

Experiment 1:

- 1 Diode Laser Module, 532 nm 474 5418
- 1 Beammaster BM-7S 474 5470

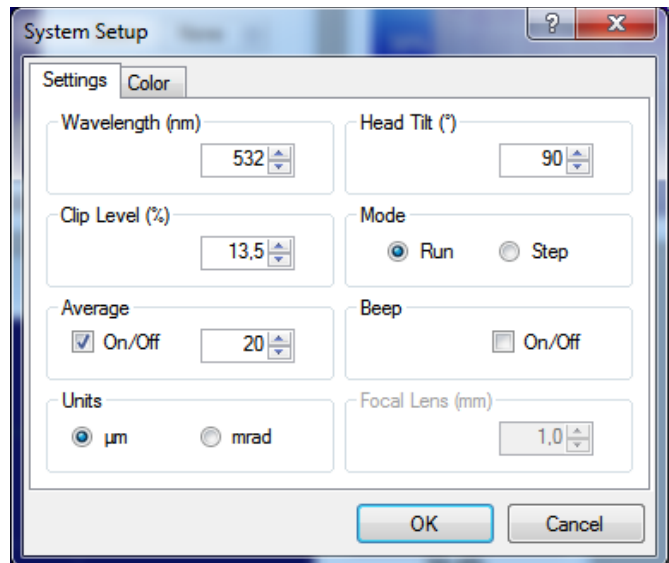
- 1 Adjustment holder, 4 axes, carrier 20 mm 474 211
- 1 Profile rail, 500 mm 474 5442



Put the green laser in the adjustment holder and point it to the window of the beammaster.

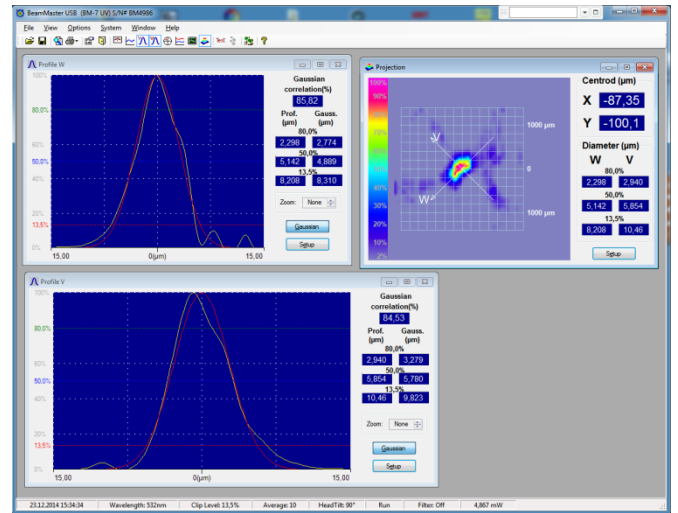
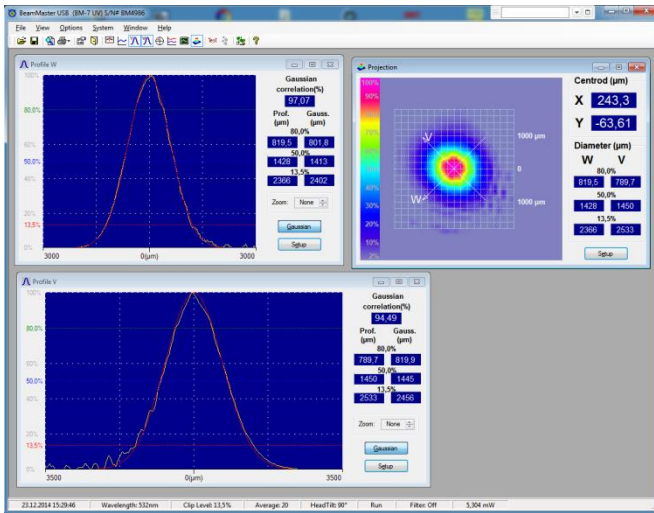
There is no need to use an intensity reduction filter.

Setup the software like this:

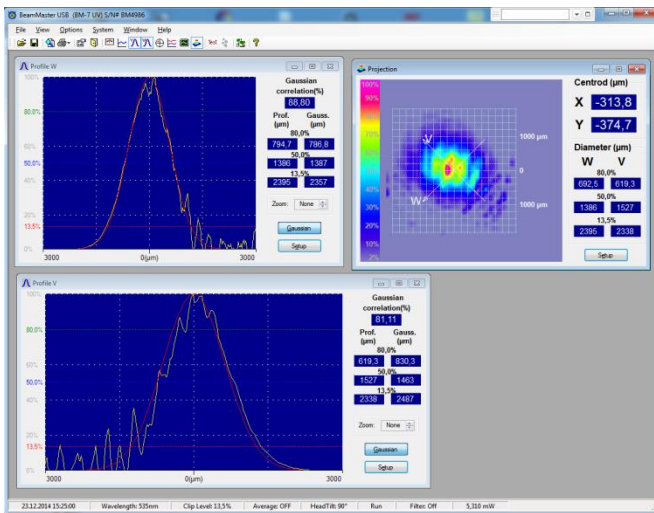


Note the “average” setting which is required here because of the pulsed green laser.

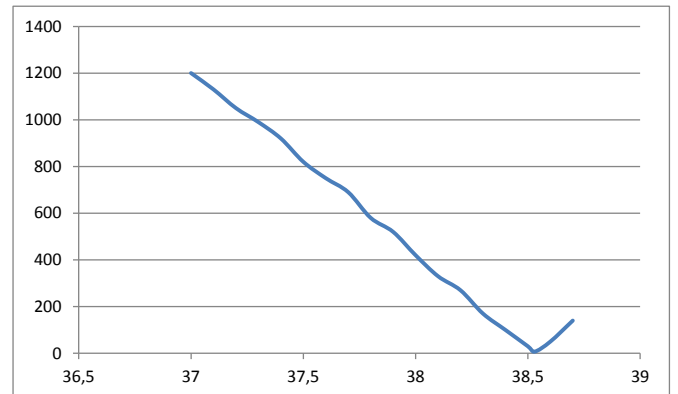
The “head tilt” is set to 90° to match the position of the head on the bench.



Omitting the “average” setting will give a distorted beam profile like this:



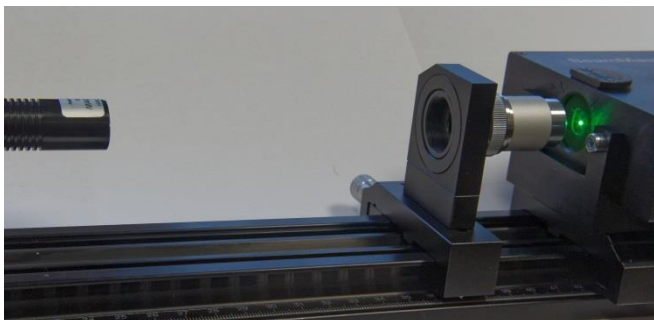
Plotting the beam diameter vs. position of the lens gives the following curve, the beam diameter changes by 0.8 mm when the lens is traveling 1 mm.



Do not move the lens to close to the rotating drum to avoid mechanical damage.

Using the beam expander we can first increase the beam diameter and then focus the beam onto the beam profiler.

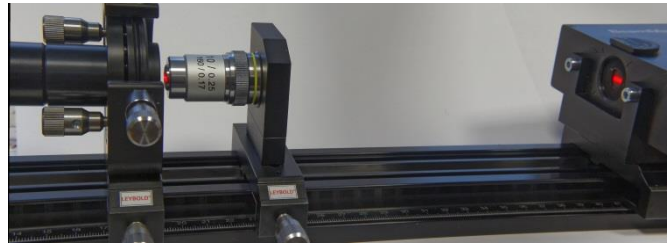
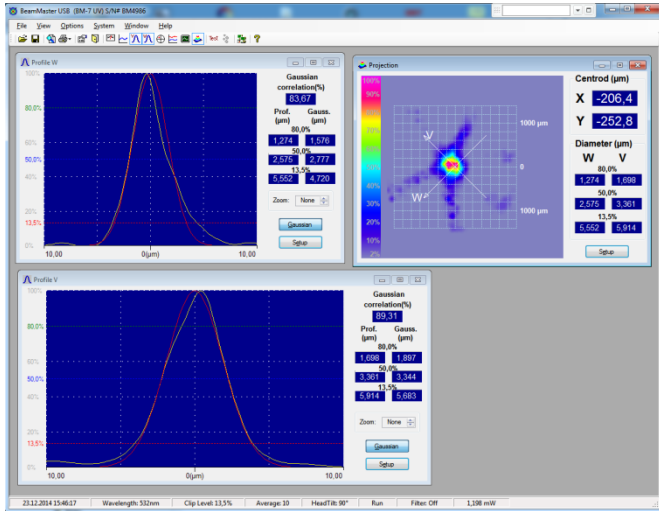
Using the microscope lens provided, the laser can be focused onto the rotating drum.



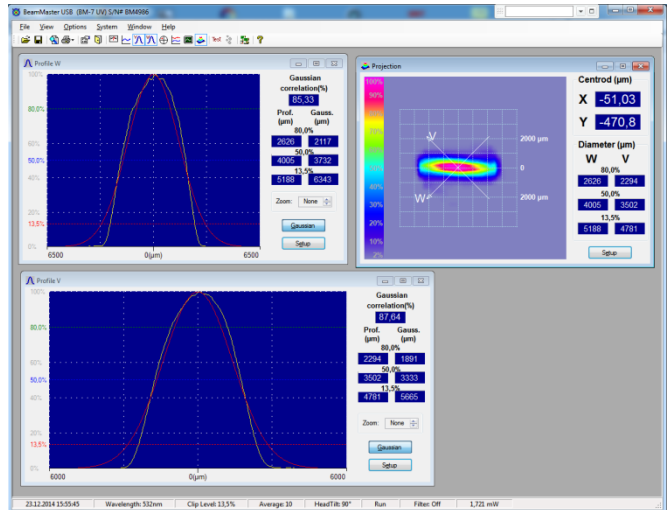
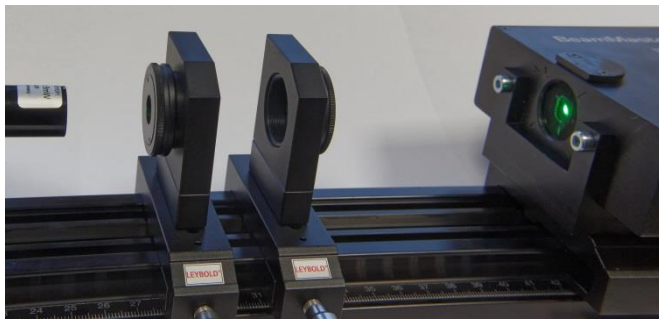
As a result, the minimum beam diameter changes and the slope of the cone too.

With careful alignment we will find that there is a minimum diameter the laser beam can be focused to.

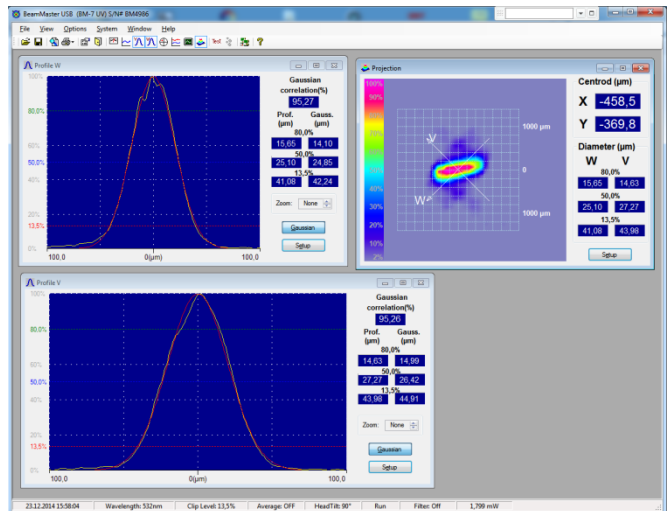
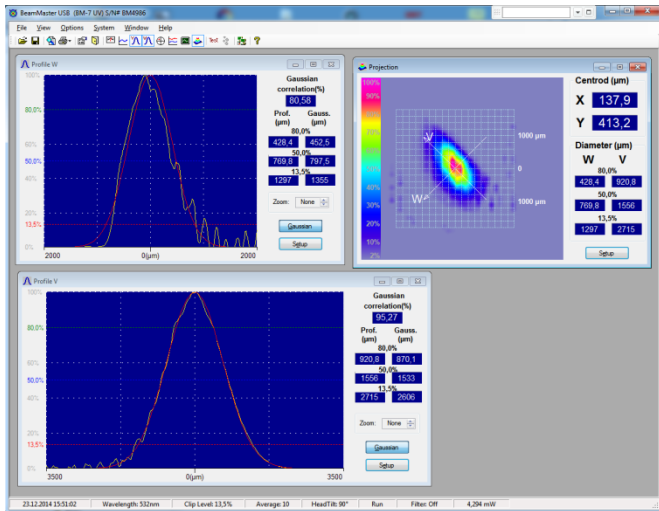
Recording the position of the lens on the bench and the resulting diameter of the beam at the beam profiler will show the cone before and after the beam waist. The cone angle of course depends on the initial laser beam diameter and the focal length of the lens.



Using the two cylinder lenses with parallel focusing direction, we can build an afocal telescope and change the beam diameter in one axis, resulting in an elliptical beam.



Of course the lens could be used to create a focal spot on the beam profiler, also with elliptical profile.

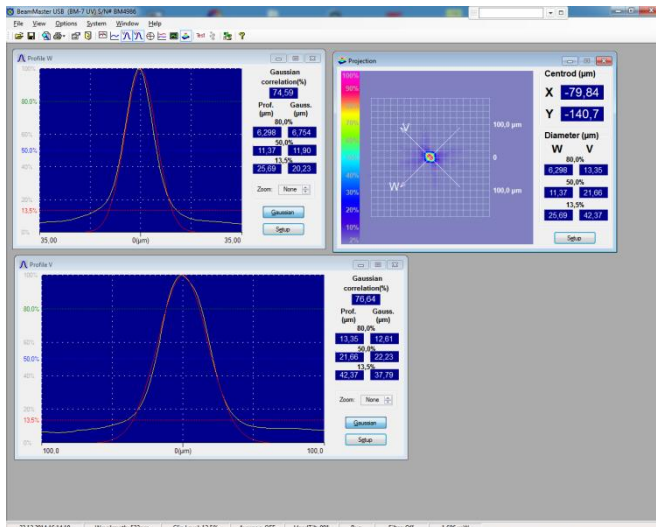


The red laser diode has no built-in collimating optic, due to the small exit window of the active laser medium inside the chip there is significant single slit diffraction of the beam. The emitted light can be focused by a lens into a beam. Since the exit window is rectangular with two different dimensions, the resulting beam has an elliptical shape.

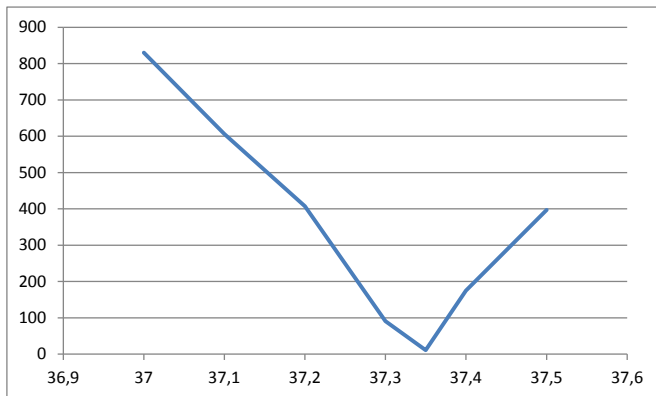
To compensate the elliptical beam profile, we can use two cylindrical lenses in orthogonal orientation. The shorter focus lens is placed in the orientation of the larger emitting angle of the laser diode.



The resulting beam can then be focused onto the beam profiler again.



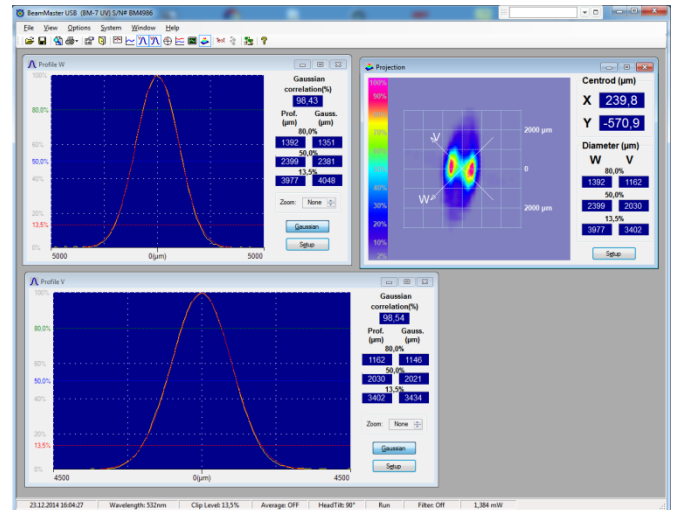
Varying the distance between lens and beam profiler, we can record the cone angle.



Here we have much larger angle than in the green laser example, since the initial laser beam has a larger diameter.

Using the two cylinder lenses out of focus, a lot of different beam profiles can be created.

The following looks quite Gaussian in the U and V directions indicated on the beam profiler. But the full 2D pattern shows the bifurcated maximum outside those axes.



- 1 Diode Laser Module, 532 nm 474 5418
- 1 Dimo diode laser module, 630 nm 474 5420
- 1 Beammaster BM-7S 474 5470

- 1 Adjustment holder, 4 axes, carrier 20 mm474 211
- 1 Collimating Optics on Carrier 474 1036
- 1 Collimating cylindrical lens f = 20 mm 474 5266
- 1 Collimating cylindrical lens f = 80 mm 474 5267
- 1 Beam expander 6x 474 5263

- 1 Profile rail, 500 mm 474 5442
- 3 Mounting Plate C25 with Carrier 20 mm474 209



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