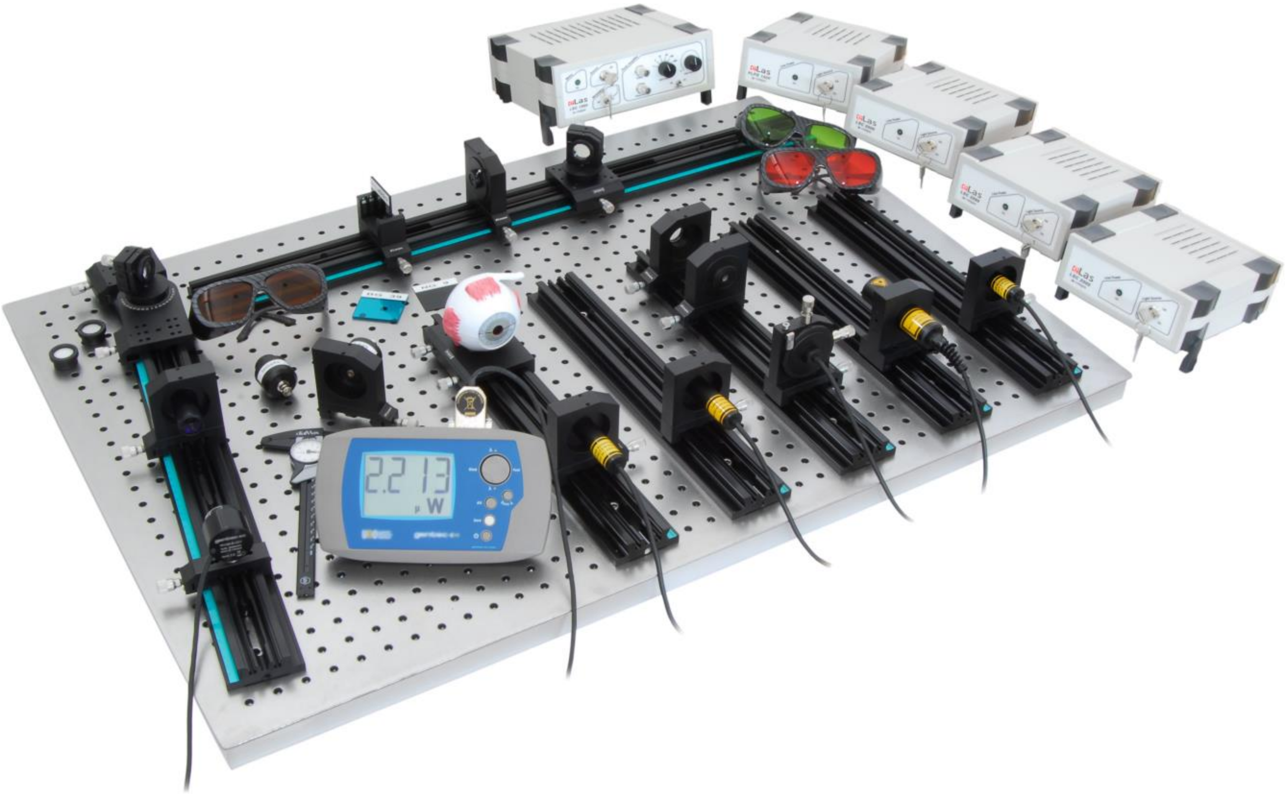
Laser Safety and Classification Full Version (CA-1110)

Advanced Version (CA-1111)

Basic Version (CA-1112)



The spectral range of lasers vary from a few nanometer up to some hundred micrometers and is mostly outside of the visible spectrum. The risk of laser radiation to eyes and skin depends strongly on the time of exposition and the laser wavelength. This is valid for direct and even scattered laser radiation.
These educational kits have been composed to lead the students to a careful and safe handling with lasers. They are excellently useful to learn the classification of different lasers into the laser safety classes. The basics and the handling of the standards EN60825, EN207 and EN208 will be introduced and trained.

Educational Objectives of Investigation

- Laser Power and Intensity
- Divergence of a Laser Beam
- Evaluation of pulsed laser systems
- Laser Safety Classification
- Maximum Permissible Emission (MPE) for eyes and skin
- Nominal Ocular Hazard Distance (NOHD)
- Demonstration of the eye damaging effect of laser radiation
- Characterization of laser safety goggles and filters

Basic – Advanced – Full Version

The **full version** is equipped with four lasers and one high-power LED source, their wavelengths range from blue to NIR with different powers and functions (cw- and pulsed lasers), according to the list of components (see below). These sources are to be classified in safety classes by power and energy measurements. Optical elements like beam expanders, filters, scattering discs, and an iris aperture are used to modify the laser beam profiles and sizes, and hence change the lasers safety classes. Direct laser light as well as its scattering cone profiles are measured with a provided laser power meter. With an eye model the effects of laser power on the human eye are simulated and MPE and MSD values are calculated and demonstrated.

In a **basic version** two lasers and equipment for beam expansion and for scattering tests are provided. A basic range of measurements like determination of laser classes, MPE and NOHD can be performed. Changing the laser class and diverging laser beams by optical elements are possible.

An **advanced version** includes – additionally to the equipment of the basic kit – a pulsed laser. Here properties like peak power, pulse duration and energy are evaluated. In combination with an eye model, retina damaging is demonstrated. Changing laser classes by filtering with glass filters and laser goggles (not as safety goggles for the experimenter!) are trained.

In the basic and advanced systems a laser power meter is not included but is required. For laser pulse characterization a two channel 200 MHz oscilloscope is required (power meter and oscilloscope are optionally available at eLas).

The basic and advanced versions can both be upgraded to the full version with the required equipment, offered by eLas.

Ordering Information

This ordering information gives an overview of ordering numbers of the several versions of the Laser Safety kit. All modules of the kits can be ordered separately, if required.

For ordering the Laser Safety and Classification Full Version (CA-1110)
use ordering number: 490091110

For ordering the Laser Safety and Classification Advanced Version (CA-1111)
use ordering number: 490091111

For ordering the Laser Safety and Classification Basic Version (CA-1112)
use ordering number: 490091112

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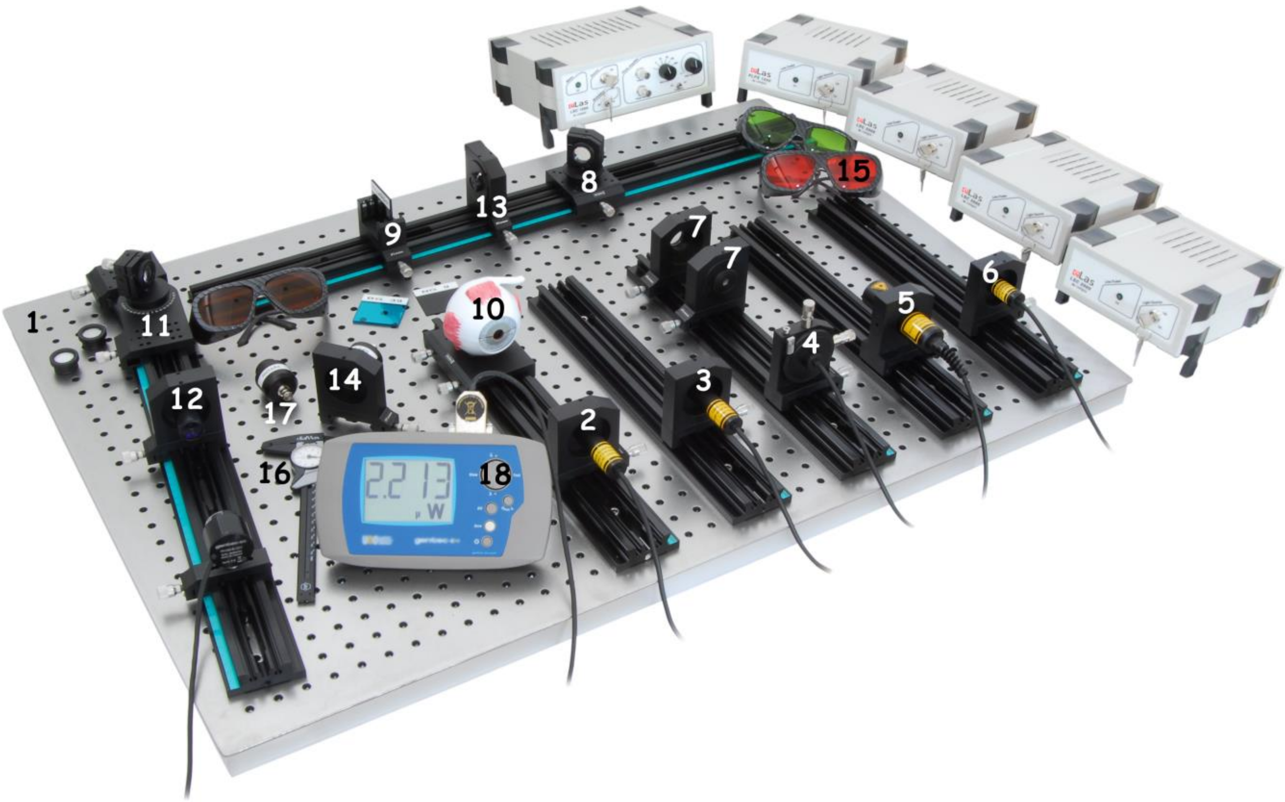
Setup and Components



The numbers in the following components lists refer to this picture

Components of full version:

1	Base plate with 7 flat rails for components
2	Pulsed laser light source 1535 nm with pulsed laser controller PLPS 1000
3	Laser light source 532 nm with light source controller LSC 2000
4	High power LED light source 590 nm with light source controller LSC 2000
5	Laser light source 635 nm with light source controller LSC 1000 and integrated signal amplifier
6	Laser light source 405 nm with light source controller LSC 2000
7	Beam shaping optics in holders on carrier
8	Beam deviation on carrier
9	Beam attenuators in filter holder on carrier
10	Retina simulator on carrier
11	Beam deviation with mirror and scattering discs on articulated connector
12	Beam expander in holder on carrier
13	Iris diaphragm in holder on carrier
14	PIN photo detector in mount in holder on carrier with BNC cables
15	Set of laser safety goggles (not for experimenter protection!)
16	Non-reflecting caliper
17	InGaAs photo detector in mount
18	Laser power meter with monitor and power meter head on carrier

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Components of basic version:

1 Two flat rails for components: 800 mm and 500 mm (without baseplate)
3 Laser light source 532 nm with light source controller LSC 2000
5 Laser light source 635 nm with light source controller LSC 1000 and integrated signal amplifier
7 Beam shaping optics in holders on carrier
11 Beam deviation with mirror and scattering discs on articulated connector
14 PIN photo detector in mount in holder on carrier with BNC cables
16 Non-reflecting caliper

Components of advanced version:

1 Three flat rails for components: 800 mm, 500 mm and 400 mm (without baseplate)
2 Pulsed laser light source 1535 nm with pulsed laser controller PLPS 1000
3 Laser light source 532 nm with light source controller LSC 2000
5 Laser light source 635 nm with light source controller LSC 1000 and integrated signal amplifier
7 Beam shaping optics in holders on carrier
9 Beam attenuators in filter holder on carrier
10 Retina simulator on carrier
11 Beam deviation with mirror and scattering discs on articulated connector
13 Iris diaphragm in holder on carrier
14 PIN photo detector in mount in holder on carrier with BNC cables
15 Set of laser safety goggles (not for experimenter protection!)
16 Non-reflecting caliper
17 InGaAs photo detector in mount

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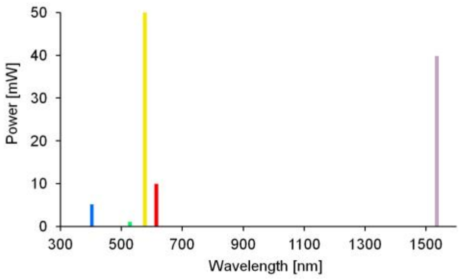
Measurements and Handling

Some of the possible measurements are presented in the following list:

- **Characterization of pulsed and cw lasers and LED of different wavelengths (possible with provided sources of the different versions)**



Power measurements: values like average power, peak power or power density are determined by measuring with the power meter and oscilloscope. A provided low reflection caliper is used for beam diameter measurement.

Divergence determination: the laser sources show different divergences which are measured by use of the caliper or the photo detector on the hinge connected optical rail.

- **Determination of maximum permissible radiation (MPR-value; possible with provided sources of the different versions)**

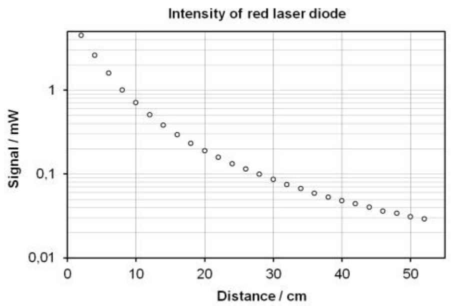
Maximum Permissible Exposure (MPE) tables

Wavelength (nm) \ Exposure time t(s)	10^{-13} to 10^{-9} (< 1ns)	10^{-9} to 10 (1 ns to 10s)	10 to 10^3 (10 to 1000s)	10^3 to 3×10^4 (1000 to 30,000s)
180 to 302.5	3×10^{10} Wm^{-2}	30 Jm^{-2} (30/t Wm^{-2})		
302.5 to 315		$t \le T_1$: C_1 Jm^{-2} where $C_1 = 5.6 \times 10^3 t^{0.25}$; $t > T_1$: C_2 Jm^{-2} where $C_2 = 10^{0.2(\lambda-295)}$; $T_1 = 10^{0.8(\lambda-295)} \times 10^{-15}$s	C_2 Jm^{-2} where $C_2 = 10^{0.2(\lambda-295)}$	
315 to 400		C_1 Jm^{-2} where $C_1 = 5.6 \times 10^3 t^{0.25}$	10^4 Jm^{-2} (10^4/t Wm^{-2})	10Wm^{-2} (10t Jm^{-2})

Maximum Permissible Exposure (MPE) at the cornea for direct ocular exposure to laser radiation - UV section.

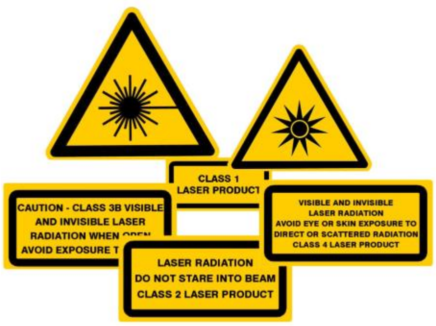
For the laser sources the MPR values are determined according to calculations and value tables as shown below. The difference in calculations for cw and pulsed lasers is evaluated. An influence of optical instruments on the MPR value is demonstrated by means of lenses and telescopes.

- **Minimum Safety distance (MSD) to a radiation light source (possible with provided sources of the different versions)**



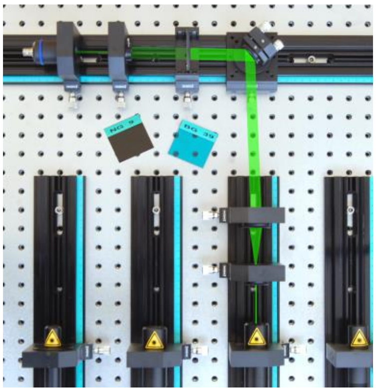
The necessary calculations for determination of the required safety distance for direct or scattered light of different laser sources is demonstrated and performed. Safety distances for the human eye and skin are calculated.

- **Determination of laser classes (possible with provided sources of the different versions)**



With respect to their wavelengths and output powers the five light sources are classified according to international laser safety standards.

- **Change of the laser safety class**

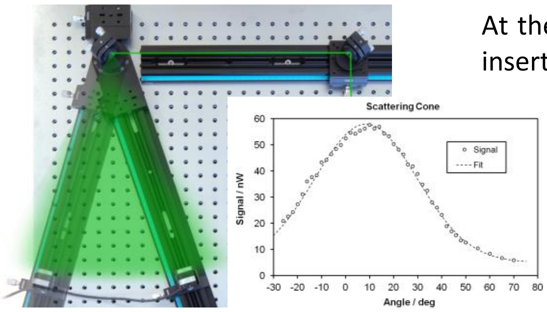


The safety class of the lasers can be changed by

a. changing the beam diameter by expanding the beam
b. inserting a color or neutral density filter
c. truncating the beam by an iris aperture

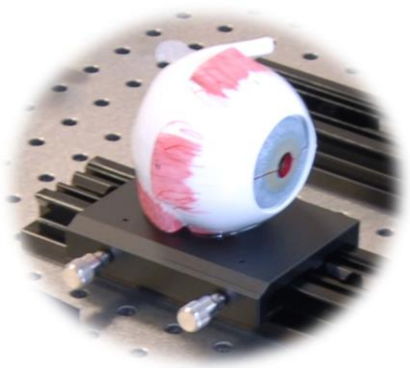
With the basic version beam expansion is possible. The advanced set includes beam expansion and filters. With the full version all three techniques are possible.

- **Beam reflection and scattering (possible with provided sources of the different versions)**



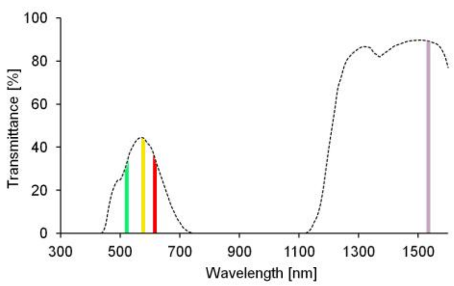
At the hinge angle connection a mirror or scattering discs can be inserted. The beam cone of reflected and scattered light is measured and the danger of scattered light is evaluated. Depending on the scattering or reflecting surface, scattering profiles of ideally and partially reflected or completely scattered light are recorded.

- **Retina simulation (advanced and full version only)**



A model of an eye is inserted in a laser beam. Focusing of a laser beam by the lens onto the retina is performed. Thermal damaging of the retina is impressively demonstrated using an IR laser.

- **Characterization of three laser safety goggles (advanced and full version only)**



The safety goggles are tested with the different laser sources with respect to

Blocking of light of different wavelengths

Absorption value / Optical density

Protective classes of laser goggles are introduced and discussed.

Version 1/16

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