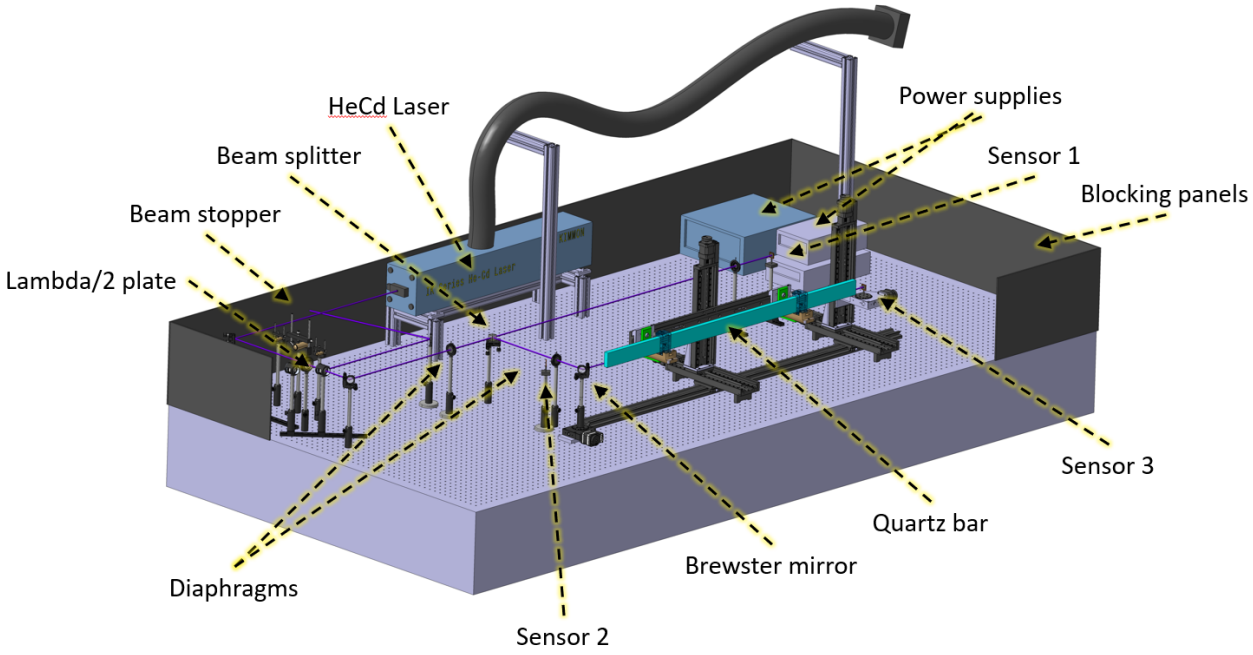

Objective: The modular dark room in EEL108 will host a laser setup for the optical quality assurance of the disassembled BaBar DIRC bars. The bar surfaces will be evaluated by determining the efficiency of the light transport inside the DIRC bar, calculated from measurements of the bulk attenuation and the coefficient of total internal reflection, performed at two HeCd laser wavelengths.

Components: The schematic of the setup is shown on the figure above. All components are mounted on an optical table.
The HeCd laser operates at two wavelengths, 325nm ("UV") and 442nm ("blue"), which are selected with a manual switch at the front of the laser. The laser housing is mounted on a stage to adjust the height and assure the beam is parallel to the table surface. A pipe takes the hot air from the laser cooling fan away from the setup. At the laser exit the UV line has an output power of up to 14mW, a beam diameter below 1mm, and a beam divergence of 0.5mrad. The blue line has an output power of up to 44mW, a beam diameter below 1mm, and a beam divergence of 0.5mrad.
UV-enhanced aluminium mirrors, coated with MgF_2, guide the laser beam in the optical plane, which is parallel to the table surface. The Lambda/2 plate changes the orientation of the polarisation plane of the beam. A set of diaphragms is used at several points of the setup to help with alignment and reduce the halo of the laser.

A beam splitter reflects about half the beam intensity on a photodiode (Sensor 1) to monitor the laser intensity. The remaining beam is steered into the bar, either parallel to the long axis of the bar, or at an angle of typically 56deg, by the remote-controlled so-called “Brewster” mirror. Two diodes record the intensity of the beam reflected from the front face of the bar (Sensor 2) and detected after transmission through the bar (Sensor 3). Each photodiode has an active are of $10x10mm^2$. The data is collected by ADC cards connected to a PC computer.
The DIRC bar is placed in its 3D-printed holders (“horseshoes”) on a horizontal support beam, which is connected to X/Y stages controlled by stepper motors to move the bar through the laser beam. Additional stepper motors control the rotation of the Brewster mirror and movement of the “Sensor 3” photodiode. All actuator motors can be controlled manually at the setup or remotely from the computer, to automatize the measurement process.
A set of non-transparent and non-reflective side panels is attached to all sides of the table, extending well beyond the laser beam plane to prevent the laser from being reflected outside the setup. Power supplies for the laser and motion control stages are placed at one corner of the table.

Measurement procedure: The bulk attenuation is determined with the beam going parallel to the long axis of the bar. The intensity on Sensor 3 is measured when the bar is in the laser beam and compared to the intensity when the bar is outside the laser beam. Sensor 1 is used to correct the data for laser intensity fluctuations.
For the reflection coefficient measurement, the beam enters the bar at the Brewster angle to minimize the front surface loss (the reflected intensity can be monitored by Sensor 2). The beam is internally reflected up to 55 times in the bar, depending on the bar orientation. Using the linear actuator motors, the bar is moved through the laser beam to create an array of laser entry points on the front surface of the bar, corresponding to an array of reflection points on the bar surface. The intensity recorded by Sensor 3 is used, in combination with the measured bulk attenuation, to calculate the coefficient of total internal reflection. The measurement procedure is the same for both HeCd wavelengths.

Setup and preparation: The quartz bars are brought into the dark room in the short-term storage cart. Each bar is mounted in two horseshoes that allows for easy handling and mounting of the bar in the setup using a holder on the support beam that fixes the bar into the correct position.

Dark room laser setup operation modes:

1. Initial alignment - done only once with power-lowering filter in place
2. Expert mode - initial operation with experts inside the dark room
3. Automatized mode - Full scale operation with control outside of the dark room

1. The initial setup and alignment of components will be performed by the expert in full PPE and with power-attenuating filter in place. A beam stopper will be available to place into the beam between the HeCd laser and any following element of the setup. Optical elements will be mounted and positioned to avoid any reflections that could steer the beam above the beam-blocking panels on the side of the table. Afterwards, the fine tuning of optical elements is performed at low power, using a fluorescent card, to guide the beam to the photodiode sensors. Any changes after this step require only fine tuning of the beam inside the established optical plane, parallel to the table surface, with no changes leading to a reflected beam outside of the enclosed part of the optical table.

2. In the expert manual mode, with with power-attenuating filter and a beam blocker in place, a quartz bar mounted in two horseshoes, is placed on alignment pins on the support beam, controlled by the linear X/Y motor stage.
The laser is then turned on to full power and the beam blocker removed. Fine tuning of the laser beam going through the bar is performed to assure the required position of the beam on the entry face of the bar and on Sensor 3.
The manual measurement of the bulk attenuation and/or reflection coefficient is performed for several bar positions by moving the bar through the beam in horizontal and vertical direction with direct control of the step motor. The position of Sensor 3 photodiode is adjusted manually to find the position corresponding to the maximum laser intensity for each bar position. The changes to the position of the bar and photodiode are at less than one inch, with no angle changes that could cause unwanted reflections.
This mode is foreseen for the initial setup and occasional measurements of the reference bars and cross-checks with a few selected bars, in case of inconsistent results.

3. The fully automatized mode of operation does not require the presence of a person inside the dark room during the measurements since the stepper motors and DAQ system are controlled by software on the PC. Experts will enter the room to replace the bar in the setup with the laser beam turned off. Afterwards the

movement of the bar and sensor photodiode will be controlled by the computer located outside of the setup.
This mode is foreseen for the vast majority of the disassembled BaBar DIRC bars.