

## Optical properties of the PANDA barrel DIRC prototype radiator bars\*

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The PANDA experiment at the Facility for Antiproton and Ion Research in Europe (FAIR) at GSI, Darmstadt, will study fundamental questions of hadron physics and QCD. The Barrel DIRC (**D**etection of **I**nternally **R**elected **C**herenkov light) is a fast Ring Imaging Cherenkov counter, which will provide hadronic particle identification (PID) in the central region of the PANDA target spectrometer. In order to meet the PID requirements, the Barrel DIRC has to provide precise measurements of the Cherenkov angle, which is the crucial quantity for the identification of traversed particles. The Cherenkov photons propagate through the radiators by total internal reflection until they reach the detection plane, which is equipped with optical sensors. The radiators, long rectangular bars made from synthetic fused silica, have to meet very strict optical and mechanical requirements. Properties like squareness and parallelism of the sides, very smooth polished surfaces, and sharp corners are of critical importance to ensure that the Cherenkov photons reach the optical sensors without angular distortions.

A motion-controlled system using lasers with three different wavelengths (an additional UV laser will be added later), shown in Fig. 1, was set up in the new DIRC optics lab to measure important radiator quantities like transmittance and reflectivity.

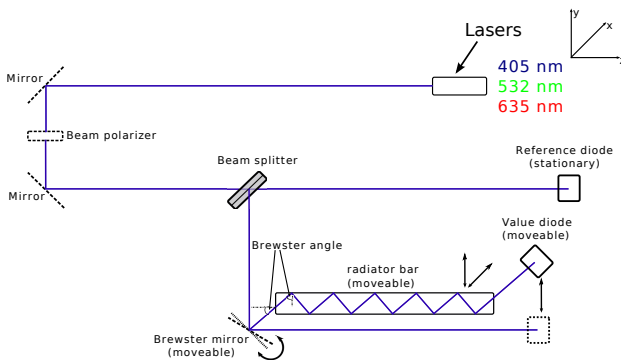


Figure 1: Schematic drawing of the current setup in the DIRC optical lab.

The laser beam enters the radiator at Brewster angle to minimize the reflected intensities of the polarized laser light at the bar ends. Depending on length and orientation of the bar the beam is internally reflected up to 31 times until it exits the bar and hits the (value) photodiode. The

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second (reference) diode is used to correct for laser intensity fluctuations. The transmission  $T$  is given as the double ratio of the intensities recorded by the value and reference diodes with and without the laser passing through the bar. The coefficient of total internal reflection  $R$  is calculated as  $T = R^N \cdot \exp\left(-\frac{L}{\Lambda}\right)$ , where  $N$  is the number of internal reflections,  $\Lambda$  the attenuation length of fused silica at this wavelength (determined in a separate measurement in the same setup), and  $L$  the optical pathlength inside the bar. The calculated transmission values are shown as a matrix plot in Fig. 2.

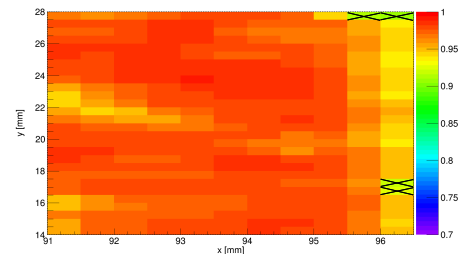


Figure 2: Transmission matrix for a radiator bar made by Schott-Lithotec. The black crosses mark measurements for laser locations that deviate more than  $3\sigma$  from the mean transmission value. The values on the X- and Y-axis represent the positions of the linear motors, which move the radiator.

The areas with smaller transmission values are the result of small imperfections of the bar and surface pollution. The beveled edges of this particular bar can lead to a diffusion of the laser beam when it exits the radiator bar near the edge, causing an intensity loss on the photodiode, leading to drop of the calculated transmission. The measured mean transmission value is  $T = 0.975 \pm 0.005$ .

The setup, based on a smaller system designed for the tests of shorter bars [1, 2], was installed and commissioned in the fall of 2014, including a detailed study of the systematic uncertainties. The system is now ready for the evaluation of a number of prototype radiator bars, made by different manufacturers, to determine if their fabrication processes meet the PANDA Barrel DIRC requirements.

## References

- [1] R. Hohler, "Prototyp-Radiatoren eines Barrel-DIRC für das PANDA-Experiment", PhD thesis, Frankfurt, Germany, 2011
- [2] G. Kalicy, "Optical Properties of Radiators for the PANDA Barrel DIRC", N14-156, IEEE, Anaheim, USA, October 2012