VUV Optics for the HADES Project

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An optical laboratory has been established for developing optical components for the HADES- RICH (Ring Imaging CHerenkov) detector. Relativistic leptons are selectively detected in this setup by the cherenkov light which is emitted in a radiator gas (C_6F_{10}) at atmospheric pressure. A spherical mirror (1.5m diameter, R=87cm), consisting of 18 identical segments, is used to direct the cherenkov light onto a large position sensitive multiwire proportional counter (MWPC) photo-detector. The detector gas of the MWPC is separated from the radiator gas by an optical window of 1.4m diameter.

An important aspect in the design of the optical components of the RICH detector is the wavelength dependence of the various parameters such as detector sensitivity, reflectivity of the mirror and transmission through the optical window. Since the quantum efficiency of the photodetector increases with decreasing wavelengths, starting at 200nm, the parameters have to be optimized and measured in the vacuum ultraviolet (VUV) spectral region, typically between 120 and 200nm.

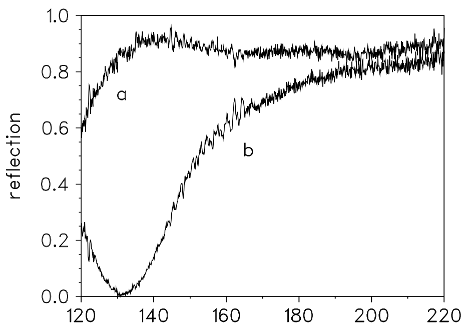

Fig. 1: Optical reflection of two different mirror samples (floatglass substrate (a) and a carbon-fiber substrate made by SESO (b), coated at CERN). Although the reflection in the near UV and visible spectral range ($\lambda \geq 200nm$) is almost identical, large differences occur in the VUV, showing the necessity of reflection measurements.

An optical system has been built for testing the reflectivity of large samples in the VUV spectral region. It consists of a deuterium lamp used as a light source, a large (1m diameter) vacuum vessel in which the mirrors can be mounted and illuminated via adjustable mirrors, and a VUV monochromator - detector system for light detection. Due to the curvature of the mirror to be tested the reflected light will not use the same optical path as the reference light, a necessity for absolute reflection measurements. The measurement of the reflection will therefore be perfomed in two steps. In a first step a relative reflection will be determined from the ratio of two spectra in which the light path does and does not include the sample mirror, respectively. In a second measurement the absolute reflectivity at the position of the sample mirror being tested is determined using a well collimated, momochromatic beam of light e.g. from an ArF laser. Reflectivity curves of two different mirror samples measured using a smaller test setup and applying the procedure described above are shown in fig. 1.

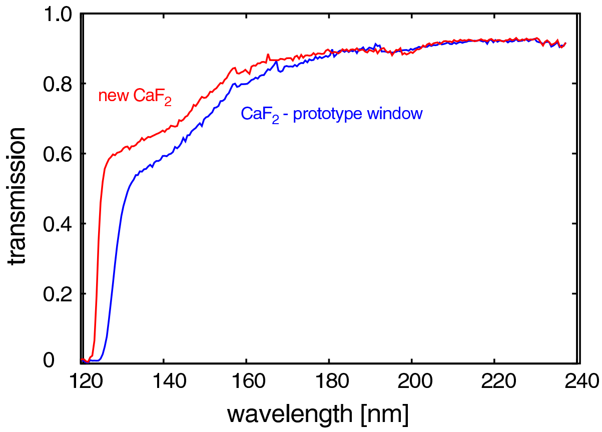

Fig. 2: Optical transmission of two different CaF_2 samples. Differences in transparency increase towards shorter wavelengthes

The optical window of the HADES - RICH detector will be built from about 60 CaF_2 crystals and will have an outer diameter of 1.4m. The crystals are 5mm thick and have a hexagonal shape with 200mm diameter of the circumference. The crystals will be glued together with the outer ones cut in a way to form a circular window.

Two setups for testing the VUV transmission of the crystals will be used. In one case the optical transmission is precisely measured versus wavelength at a $\simeq$1cm spot of the crystal. The other one is being designed for viewing the whole crystal in transmission using a $\simeq$30nm broad wavelength band around 160nm. It will be used for testing the homogeneity of the VUV transmission of the CaF2 crystals.

The first setup is already fully operational and has been used for testing the specifications of 7 CaF_2 crystals forming an optical window of 40cm diameter used in a test experiment. A beam of collimated light which is produced by a deuterium lamp and a VUV monochromator is sent through the CaF_2 samples which are mounted on a movable stage and detected by a VUV-phototube operated in the counting mode. Transmission data of different CaF_2 samples are shown in fig 2. The new high qualitiy material will be used for the large optical window of the HADES - RICH detector.

In the second setup the crystals will be illuminated by a deuterium lamp with a VUV filter with peak transmission at 145nm. A sodium salicylate fluorescence screen will be positioned behind the sample and viewed by a CCD camera. Comparing images with the crystals in place and removed will reveal potential inhomogeneities in the VUV transmission.