
I. Mueller¹, R.D. Horansky², J.H. Lehman², S.W. Nam², I. Vayshenker², L. Werner¹, and M. White²

1. Physikalisch-Technische Bundesanstalt, Abbestr. 2-12, Berlin 10587, Germany

The Physikalisch-Technische Bundesanstalt (PTB) and National Institute of Standards and Technology (NIST) are working in a joint effort to improve the traceability of the detection efficiency of optical fiber-coupled single photon detectors. Traceability in this field is a prerequisite for applications such as remote sensing and quantum communications. However, achieving this aim is difficult due to the very different optical power levels suitable for classical radiation detectors on the one hand and single photon detectors on the other hand. In order to further improve the traceability an experimental validation of the existing calibration methods is mandatory.

The experimental validation of the calibration methods is based on a two-step approach. In the first step, which is described here, the two calibration methods used at NIST have been validated using a high-speed superconducting nano-wire single photon detector (SNSPD) operated by PTB. In the second step the NIST results will be compared with calibration results obtained at the Metrology Light Source, the dedicated electron storage ring of PTB [1].

The two NIST calibration methods for optical fiber-coupled single photon detectors at telecom wavelengths are based on calibrated metrology grade optical power meters. The first method uses a set of calibrated attenuators to set the appropriate photon flux to measure the detection efficiency of the device under test (DUT) [2]. The second method, called direct-substitution method, is based on a power meter that has been well characterized in terms of its linearity [3] and allows measuring the reference detector and the DUT at identical power levels, which are, however, limited to the range above 0.5 pW. Thus, a high-speed single photon detector is necessary to compare the results of both methods in the power range at or above 0.5 pW. The measurements described here are the foundation of the first comparison of the radiometric scales of NIST and PTB at the pW level.

During the calibration we observed that the detection efficiency strongly depends on the optical fiber and connector. For example, the detection efficiency obtained with the direct-substitution method was 13.3 % (u ≈ 2%) but changed to 14.5 % (u ≈ 2%) with a different set of optical fibers and mating connectors. With the calibrated attenuator method, a detection efficiency of 13.6 % (u ≈ 2%) was obtained. These results force us to question the importance of fiber-core dimensions and fiber-connector repeatability. Currently the detailed uncertainty budget is being compiled and the influence of the fiber-coupling efficiency on the calibration result is being evaluated.

References