New advanced radiotherapy techniques have been delivering increasingly higher doses to volumes with smaller margins. This involves the use of higher fractional doses delivered by dynamic techniques such as VMAT or IMRT which are realised by a sequence of small fields. However, these techniques pose challenges in patient-specific quality assurance, PSQA. Radiochromic films are commonly used for planar dosimetry and high-resolution active detector matrices, but both have some drawbacks.

The main objective of the doctoral thesis was to explore the use of plastic scintillators for PSQA in radiotherapy for small dynamic high-dose fields. The objectives included characterising plastic scintillators, investigating the optimum parameters of an affordable CMOS camera as a readout system, and developing post-processing methods. The designed measurement system consisted of the following elements: a custom phantom, a plastic scintillation detector, a CMOS camera, and developed MATLAB scripts.

The research was conducted in several stages. In the first step, thorough studies allowed the characterisation of the main component of the system as a radiation detector. The plastic scintillation detector, PSD, demonstrated potential as a reliable tool for radiotherapy dosimetry with its performance consistent with publications. As a result, a custom phantom was designed and manufactured for PSQA with the previously investigated components.

In the second step, a novel system for small dynamic fields planar dosimetry based on plastic scintillator material and a high-resolution CMOS camera was developed. The study presented the comprehensive analysis of designed and manufactured PSD system for radiotherapy dosimetry, comparing it with Gafchromic EBT-3 films and the SunNuclear SRS MapCHECK active detector matrix.

Statistical analysis of Gamma Index, GI, results showed that the developed PSD system yields values that are comparable to the reference methods for a GI tolerance limit of 90%. For a tolerance limit of 95%, results were aligned with results from SRS MapCHECK. GI histogram analysis showed that, in general, the GI distribution for examined fields was lower than that from other methods. Despite this, the outcome of the PSD system was free from potentially false-positive results.

The discussion of obtained results includes potential system enhancements, such as improving spatial resolution and decreasing noise by using a high-end CMOS sensor or enhancing the readout system for immediate image analysis.

The objectives of the study were achieved. The developed plastic scintillator-based PSQA system demonstrated comparable results with commonly used methods. The promising results suggested considering the use of the developed system in everyday practice at the Katowice Oncology Centre and indicated the possible further development of the system.