Approximately 40 % of all Polish cancer patients receive radiation therapy (RT) as part of their treatment. The goal of RT is to deliver the necessary dose to a treated volume (tumor), with minimal damage to the surrounding healthy tissue, all to optimize curative effects and lowering side effects. In order to meet the expectations of effective and safe RT, nowadays modern RT techniques are being used. At the Institute of Nuclear Physics of the Polish Academy of Sciences (IFJ PAN), one of the most advanced and precise RT techniques - *proton radiotherapy*, has been put into operation in 2011, as the first such method in Poland. The unique nature of the protons interactions with matter, which transfer their energy / dose mainly at the end of their path in the patient's body, forming the so-called Bragg peak, allow to deliver high doses of radiation to cancerous cells, while sparing healthy tissues and critical areas that are near the tumour. In order to reflect as much as possible the shaped of a treated volume/tumour, complex *three-dimensional (3D)* treatment plans are using during therapeutic procedures. Thus, spatial 3D dosimetry methods are also required to properly validate such a therapeutic plans during the proton radiotherapy. However, the clinically available dose-verification tools do not measure high-resolution 3D dose distributions. The current state-of-the-art tool for quality assurance (QA) systems in RT are ionization chambers. On the other hand, passive methods such as based on luminescence detectors in form of small chips, are widely applied, however, always giving only point, one-dimensional (1D) dosimetry information.

One of the new and very promising 3D dosimetry approach developed at the IFJ PAN, based on technology consisting of a flat and flexible sheets made of a polymer, with the embedded *optically-stimulated luminescence (OSL)* material. With the appropriately designed optical read-out system, consisting of illuminating light source and CCD camera, a real 3D dosimetric verification can be obtained, also directly into the clinical applications.

The newly developed system has been tested during the verification of the proton depth dose distribution of the eyeball treatment at the Proton Eye Radiotherapy Facility at the IFJ PAN. The obtained results showed the great potential of the system that can be further optimized to verify a real 3D proton depth dose distribution. However, to exploit the true 3D potential of the technology, a number of aspects of the dosimetric and optical nature must be solve.

Therefore, the scientific goal of the project is to initiate a new elaborate research program concerning first, the dosimetric properties of the OSL-silicone based formulation and second, the improvements and optical developments within the readout system.

In the first one, the following issues will be optimized; OSL material developments (dopants concentrations), signal stability, fading, sensitivity, detector efficiency and many others. In the second, we will re-construct a readout system with optimized properties in terms of appropriate foils size (min. 10 x 10 mm^2), spatial resolution, field of view and data acquisition. The system design will be based on the detailed optical characterization of the OSL from the different materials investigated.

The current project aims at developing a new formulation for a very promising and innovative spatial dosimeter system, which in the future may overcomes the problems in existing attempts to perform 3D dosimetry. Therefore, the most important achievements of the project are related to obtain the following parameters of the dosimeter system:

* The dosimeter can register a delivered radiation dose in 3D based on OSL, with high spatial resolution and dose precision including other relevant and basics dosimetric properties.

*The optical imaging system based on an appropriately designed combination of illuminating light source (e.g. laser/LEDs diodes) and optical detection setup (emission and excitation filters in combination with EMCCD camera) for the illuminating light, all to demonstrate in reality the anticipated signal levels for relevant foils size.

* The dosimeter is reusable (enables multiple read-out and scan procedures) and the signal can be erased by an intensive light field.

* The dosimeter allows quick and easy read-out procedure (no computational algorithms). Additionally, at the same time the dose can be stored for extended periods of time.

* The dosimeter can be made in different forms e.g. circular/square foils/sheets. By using a stack of foils, a real 3D dose distribution can be reconstructed, which allows to simulate treated shapes and its deformations (e.g. lifelike phantom/organ/tumor).

* The dosimeter is resistant to environmental conditions (e.g. water, magnetic field) and offer easy ship and handling.

* The dosimeter system is evaluated for use with proton therapy and optimized for measuring simultaneously the dose and the clinically important linear-energy-transfer (LET) value.