The past decade has seen a dramatic increase in interest in new single-photon detector (SPD) technologies to include single-photon avalanche detectors (SPADs) due to their enormous internal gain, high sensitivity, fast response, small volume and ease of integration. Its device performance is still being continuously improved through the optimization of device structure and external/internal quenching/recovery circuits. A major cause of this trend has undoubtedly been the push towards optical quantum information applications such as quantum key distribution (QDK).

Efficient single-photon counting, with a detection efficiency greater than 50%, has, to date, been achieved only at wavelengths shorter than 2 μm. Extension of such performance to the mid-wavelength infrared (MWIR) has potential for new applications in astronomy, as well as LIDAR, dark matter searches and the fundamental study of fast molecular dynamics and chemistry. Interest in the MWIR stems primarily from the presence of numerous absorption signatures for molecules such as H_2O, CO_2, O_2, O_3, CH_4 and N_2O 3.

Having taken that into consideration the main focus of the project is to research and examine the possibility of reaching the single-photon detection efficiency (SPDE) ~20% (and assess corresponding dark count rate DCR) in the MWIR higher operating temperature (HOT, T~190 K) SPD based on the: type-II superlattice (T2SLs) InAs/InAsSb self-quenching and self-recovery avalanche photodiodes - **MUT** and two-dimensional (2D) black phosphorus (BP)/MoS_2 and BP/InSe avalanche phododiodes - **SITP**. Those materials, if possible, will be used to design SPADs operating in MWIR range (with peak wavelengths, λ ~ 3 μm) with 4-stage thermoelectric (TE, T~190 K). Mentioned research would encompass an approach to determine the MWIR SPDs' structure and technology development of the device. We plan to determine what factors have a decisive influence on the single-photon detection in analyzed devices. It must be stressed that there is a kind of competition between $A^{III}B^{V}$ and atomitically thin 2D materials.

If succeed - the device structure reliable in single-photon counting in MWIR and HOT conditions would be the worldwide breakthrough. That fully confirms that tasks to be undertaken in this project are new and original compared to the previously implemented. That have significant benefits, for example enabling reduction of the device's SWAP requirements and what is most important, reduction of the production cost (lack of the LN_2 cooling). In addition, research on extending of the IR technology into HOT conditionsis extremally important, especially for field applications where LN_2 cooling is impossible or very difficult to be deployed is extremely important.