Development of experimental techniques and applied research with slow monochromatic positron beams (PAS).

The project runs within the current JINR Theme 04-2-1126-2015/2023 "Novel Semiconductor Detectors for Fundamental and Applied Research". It is aimed, in final, at creating a modern experimental base for measurements by positron annihilation spectroscopy (PAS) that include beam measurements of positron lifetime and coincidence Doppler broadening of annihilation line (DBAL).

PAS is a unique and powerful experimental technique that can distinguish inhomogeneity in the crystal lattice with high precision on a nano-meter level what makes it very prominent in applied research. In accord with this the project team puts a focus on the studies of nuclear materials at high irradiation doses and surfaces modified by ion implantation.

The actual project has been designed at DLNP for the years 2016-2023 so that it is coming to its ending phase in the future three years. In the preceding years the project team has achieved a considerable progress in development of their experimental technique. They completed construction of the Slow Positron Specialized Channel, created a system for ordering of the positron flux as a part of spectrometer for measuring the lifetime of a positron in materials (Positron Annihilation Lifetime Spectroscopy – PALS), developed a reactive ion etching facility, upgraded the cryogenic source of monochromatic positrons with a closed-cycle refrigerating system. The research activity is represented by studies of materials after ion implantation, radiation damage and related phenomena in nuclear materials, mechanical damage, materials destruction due to cavitation. The project group has a remarkable publication record with 36 items in the five years period of 2016-2020 and a defended PhD thesis.

The actual project plans for the three years 2021-2023 include continuation of the studies of defect formation in different materials as a result of various physical actions and further development of the experimental technique basing on their own design such as improving DBAL spectrometer, completion of the positron flux ordering system, development of the created ion etching facility. In their "Questionnaire" the project team presents their plans for the whole period of 3 years and requests a total budget of 150 kUSD for 10 participants with 80% or 120 kUSD dedicated to materials and equipment. The requested budget remains unchanged since the presentation of the project to the PAC in 2020.

The previously collected data and design achievements together with the requested budget promise the successful and secured realisation of the project.

The PAC-CMP heard this project, more precisely a proposal of its continuation for the years 2021-2023, presented by K.Siemek in the course of the 52nd meeting of the PAC-CMP on the 2nd of July 2020. The PAC noted "…with satisfaction the progress in developing the PAS method at DLNP including construction of a reactive ion etching system and development of a system of positron ordered flux based on Cryogenic Source of Monochromatic Positrons (CSMP), which allows positron annihilation lifetime spectroscopy to be implemented in the near future. Realization of the programme presented in this project will bring the facility to a qualitatively new level opening new opportunities for experimental research in condensed matter physics and materials science." Taking into account positive reviews by D.L.Nagy, P.Yu.Apel and S.V.Stepanov the PAC recommended "extension of the PAS project for its implementation within the theme 'Novel Semiconductor Detectors for Fundamental and Applied Research' in 2021–2023."

In view of good acquired results on the foregoing stage of the project and important expected output I can propose that the extraordinary PAC meeting follows the previous PAC-52 recommendations, acknowledges the preceding work of the project team and recommends to support the project ranking it in the category A: an excellent project which should be fully funded with adequate resources and encouraged to continue and expand their impact.

Report prepared by the PAC-CMP member
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