

Review on the revised project report “Development of experimental techniques and applied research with slow monochromatic positron beams (PAS)”

The revised project report has clarified most of my concerns formulated in my previous report of 27 April 2021 the statements of which I am not going to reiterate here. The revised report (“Questionnaire”) clearly presents the technical status of the slow-positron source and also makes obvious which scientific achievements of the group have been achieved with and without using the facility.

First and foremost I would like to congratulate the team to their excellent publication record since January 2020. Indeed, they published 5 papers using the monochromatic slow-positron source and another 4 using conventional ^{22}Na positron source. Two of the nine papers is really brand new: they appeared since the extraordinary PAC meeting on 29 April 2021. More than half of the papers were published in highly-ranked or even top-level journals. All things considered: the publication performance of the team is exceptional and deserves all appreciation and support.

Presently the variable-energy slow-positron beam based on positrons from a ^{22}Na source and an efficient solid Ne moderator operational since 2015 can be used for Doppler broadening spectroscopy only. The efficiency of the facility was further increased in 2017 by implementing an ion etching system for thin films. Unfortunately, the positron ordering system enabling the much more efficient approach of positron annihilation lifetime spectroscopy (PALS) that would make the facility one of the best in its category worldwide is not yet operational. Therefore, at the moment, PALS experiments can be done only by the conventional laboratory PALS technique that uses high-energy unmoderated positrons penetrating deep into the bulk material.

The last 18 months bore like everywhere, also in this group the stamp of the pandemic, an understandable limitation to completing the envisaged technical development of the facility. The ordered (‘pulsed’) positron beam starts with creating extremely cold (practically stopped) positrons. The standard approach of the Surko trap was reported to have failed and is now being replaced by electron cooling in a cavity system which may or may not prove to be a suitable solution.

The table in the report on group composition along with FTE put into the project gives little clue on the FTE actually devoted to the development of the slow monochromatic positron beam. Nevertheless, I have the impression that it may not exceed 0.5 FTE, an obviously insufficient figure. To achieve the desirable goal that the beam becomes suitable for PALS experiments and that, finally, it becomes a JINR basic facility with open user programme, much more personnel effort should be brought up for this purpose. This seems to be the only way for realizing this ingenious project and to develop an almost unique, cutting-edge facility.

In accordance with its title, the present content of the project focuses on the slow monochromatic positron beam, in principle leaving no room for conventional laboratory PALS experiments. Still, about half of the research activity has been recently done using this latter technique. In the following I would like to briefly analyse if and under which conditions the conventional PALS technique may be justified at JINR.

There exist several hundred positron annihilation laboratories all over the world each hosting at least one PALS equipment. While the slow-positron beam facility ideally fits into the JINR tradition and expertise, strategically it cannot be the objective of a major research centre to set up and to run a small PALS laboratory which develops its own research programme on inalienable right. Nevertheless, the samples to be measured on the slow monochromatic positron beam facility (whether with Doppler broadening or PALS technique at the future ordered positron beam) need to be characterized/investigated with conventional laboratory PALS. Therefore I strongly recommend the group to continuously run a PALS spectrometer with a research programme strongly connected to that of the slow monochromatic positron beam.

To avoid misunderstandings and doubts, I suggest that the content of the project should be rewritten.

As concerning the financial plan, the requested budget is realistic and secures a firm base of implementing the project.

In conclusion, I suggest to prioritize this excellent and ambitious project as belonging to Category A and, accordingly, to grant it full financial support. At the same time, however, I would like to reiterate the need of securing sufficient human resources (FTE) for getting operational the ordered slow-positron beam by 2023 and, furthermore, the necessity of re-defining the detailed content of the project having in mind its possible continuation including a user programme beyond 2023. An interim report on the progress of these tasks seems to be timely at the June 2022 PAC meeting.

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