Referee Report to the 52nd N.P. PAC at JINR:

Improvement of the JINR Phasotron and Design of Cyclotrons for Fundamental and Applied Research

The report gives a status update on the theme Phasotron and Cyclotron design by S.A. YAKOVENKO G.A. KARAMYSHEVA and gives a detailed account of steps undertaken during the period 2016 – 2019 for modernization and upgrade of the beam delivery systems and also on progress towards the realization of the goals of the project – in terms of: 1) Improvement of the JINR Phasotron and beam channels; 2) Design and modernization of the cyclotrons for medical purpose at various medical centres in Cracow, Dmitrovgrad and Hefei; 3) high-current beam acceleration in cyclotrons studies. This report will give a brief overview and recommendations therein:

Improvement of the JINR Phasotron and beam channels:

Measures were put in place for the upgrade of the power supply system and beam tracts, implementation of Automatic control system for the transport line and other modernisation in switches resulting in 900 kW energy savings. The time split of various activities undertaken during its operation was 80% medical applications, 12 % BURAN and 7% on operational needs of the accelerator. It was stated that radiobiological research has a planned allocation time of 20% for the 2020 duration.

Design and modernization of the AIC-144, C235-V3 and IPP CAS **for medical applications.**

An update is presented on the cyclotron operations for the 2011 – 2016 period in terms of proton therapy (primarily eye melanoma) and radio-isotope production. As a standard procedure for such treatment modalities, careful measures have to be put in place for quality and safety protocols related to the treatment planning, treatment fractionations, beam graders (for Bragg beam optimisation) etc. In that regard the authors have presented a summary which does capture some of the details of steps as necessary. Furthermore, a status update on the repurposing, by the JINR technical team, of the IBA C235-V3 cyclotron for the practical application of advanced radiation therapy in Dmitrovgrad. Finally a report is given on the completion of the design of the SC-200 super-conducting cyclotron. This is part of the next generation of compact (owing to being superconducting) cyclotrons. The authors also state that the design parameters were optimised to match the VARIAN superconducting cyclotron, while cheaper and more energy-efficient due to the low energy consumption of the accelerating system and superconducting winding. The Authors draw a conclusion which states that the ”low power consumption of the SC coils makes it possible to use high-temperature superconductors (HTSC)”.

Development of the cyclotron method for high-current beam acceleration

Current developments on in-house developments detailed in this report are: JINR 400 MeV/u Cyclotron Complex for Carbon Therapy, the Pronova K-230 superconducting cyclotron for proton therapy and the Ionetix ION-12SC – which is the world's smallest superconducting cyclotron for isotope production. The PAC looks forward with great interest, to further updates on these very important developments.

Recommendations:

The reports presented by the authors were of high technical standard and clearly showcase the depth of expertise of the JINR.

It would be commendable if more details on results were presented in detail: how many fractions for proton therapy were/or are planned – and this is important for the development of a larger clinical database that will be useful for future references.

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23 June 2020