Investigations of fast proton irradiation influence using NRC KI cyclotron on superconductor materials for Large Hadron Collider magnets

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This paper studies the influence of fast protons irradiation on physical properties and structure changes of Nb_3Sn superconducting materials to be used for magnets in the Large Hadron Collider. To select the optimal proton irradiation regime for these materials, theoretical modeling and numerical calculations on the accumulation of radiation damage in two-component materials of Nb_3Sn were performed for different doses of irradiation and proton energies from 5 MeV to 2 GeV. The optimal exposure corresponds to the energy of 10 MeV protons. Irradiation of superconductor with different proton doses held at room temperatures ($T \leq 100°$ C) using the cyclotron of NRC "Kurchatov Institute". Further studies to the properties change of the irradiated superconducting materials include the analysis of magnetization change, microstructure research, including the use of transmission electron microscopy (TEM) and the high resolution x-ray diffraction on the source of synchrotron radiation of NRC KI. The results of x-ray diffraction revealed the widening and intensity decrease of diffraction peaks as concentration of radiation defects increasing. As a result of these studies, new phases in the irradiated material were founded (NbO and Nb). The density of these phases was growing with the increasing accumulation of radiation defects. Research is also carried out on changes in the lattice parameter, which increases with dose. Analysis of changes of the magnetization of the irradiated and non-irradiated samples was carried out to estimate the critical current changes. Microstructure study using high resolution transmission electron microscopy allowed to identify formation of point radiation defects on atomic level in the irradiated by protons superconducting Nb_3Sn samples.