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Neutral Particle Analyzer for Studies of Fast Ion Population in Plasma

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Analysis of the energy distribution of charge-exchange neutrals is an informative diagnostic for fusion plasmas. Both passive and active (beam-assisted) diagnostics of charge-exchange particles are widely used and different types of neutral particle analyzers based on electric or magnetic field for particle separation have been designed. With the recent achievements in electronics and particle detection technique, a new advanced neutral particle analyzer (ANPA) has been developed in the Budker Institute of Nuclear Physics for better performance and additional plasma diagnostic possibilities. In the analyzer, charge-exchange neutrals are stripped on a thin (10 nm) solid carbon film, accelerated and focused by an electric field, split in energies by a permanent magnet-separator, and separated vertically based on their masses by a transverse electric field. As a result, the energy distributions of both hydrogen and deuterium ions can be measured simultaneously. This feature makes it possible to perform a new class of experiments to distinguish between different sources of ions, such as originated by preliminary plasma, gas puffing, heating and diagnostic injection. The examples of such experiments may be measurements of mass dependence of lifetime, mean energy, spatial distribution of fast ions, or efficiency of gas puffing. Twenty channels of registration (ten for each mass) are used for detection of charge exchange particles. The channels cover energy range 0 –40 keV with energy resolution of 2-3 keV. Calculations of registration efficiency show that analyzer can simultaneously measure ion temperature of bulk plasma from 500 eV and the energy distribution of fast ions in the range of 3-40 keV.
The analyzer was used in two plasma facilities with injection of fast neutrals –on the MST reversed field pinch (University of Wisconsin) and the field reversed configuration C-2 (Tri Alpha Energy). In this paper, the design of the analyzer, calculation of efficiency of registration, results of analyzer calibration and experimental results from MST and C-2 experiments are presented.

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