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SOFT X-RAY SPECTROMETER WITH A HIGH COUNT RATE FOR MEASUREMENTS OF BREMSSTRAHLUNG OF PLASMA IN THE FT-2 TOKAMAK *)

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An X-ray spectrometer with a high count rate and energy resolution has been developed for measuring the dynamics of bremsstrahlung spectra in the FT-2 tokamak plasma. The spectrometer is based on the XR100-SDD module with a FASTSDD silicon drift detector (SDD) of 70 mm2 aperture and a PX-5 control unit with pulse processing from AMPTEK. The count rate of spectrometer is limited to ~105 1/sec when its resolution is <200 eV. This restriction results in hundreds of ms for measuring spectra. The photon count rate has to be increased by an order of magnitude for using the spectrometer at small tokamaks with a short discharge duration.

The problem has been solved with a new approach to photon counting and energy measurement, based on digital shaping the pulse response of a detector into a true Gaussian form [1] instead of into the traditional trapezoidal shape [2]. Gaussian shaping maintains the symmetric form of the output pulse while its width shortening to the rise time of the detector response. This significantly reduces the dead time of resolving two superimposed pulses and increases the accuracy of their inferred amplitudes, which ensures a higher counting rate at a high energy resolution of the spectrometer [3].

The new approach is implemented with the XR100-SDD module. A step-wise output signal of the module was converted by a low-noise amplifier [4] into pulse signals with a rise time of 45 ns [5], which is twice as short as in a similar amplifier of the PX-5 module. The converted signals were digitized by an ADC at 250 MHz sampling rate and a resolution of 14 bits. The spectrometer was mounted on an adjustable table for scanning the plasma in a poloidal cross-section from shot to shot. The input radiation flux was adjusted by diaphragms and filters installed on the spectrometer observation axis.

The upgraded spectrometer provided measurements of bremsstrahlung spectra from plasma with a resolution better than 150 eV at a count rate of up to 5*106 1/sec. The high resolution reveals particularities of SDD in measuring low-energy photons. The spectrometer was spectrally calibrated using fluorescence lines of light elements and photon detection efficiency was calibrated with the use of plasma Bremsstrahlung.

The bremsstrahlung spectra measured in ohmic discharges are compared with the model spectra calculated with the relativistic differential bremsstrahlung cross section [6] and the two-dimensional electron distribution in plasma. The electron distributions are found numerically from the Fokker-Planck equation in plasma with a longitudinal electric field and LH waves [7].

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