§32. Position Sensitive Detector (PSD) Based Neutral Particle Analyzer

Veshchev, E.A., Ozaki, T., Goncharov, P.R., Sudo, S.

Understanding of the fast particle confinement in plasma is one of the key necessities for the successful development of a fusion reactor. For this purpose a variety of neutral particle analyzing diagnostics have been developed on LHD e.g. one-chord Compact Neutral Particle Analyzer (CNPA) [1] and six-chord Silicon-Detector NPA (SD-NPA) [2]. CNPA is intended primarily for active localized measurements and works in combination with Tracer Encapsulated Solid Pellet (TESPEL) injector. The aim of the SDNPA is to make angle-resolved passive measurements of fast particles. According to some theoretical estimations [3,4], in heliotron devices the transition particles may be lost from the confinement region through a loss cone. The loss cones of fast particles from LHD plasma could not be measured so far by the existing diagnostics mainly due to the poor angular resolution. To clarify the situation with loss-cones and to improve the angular resolution versus the existing SDNPA analyzer, a novel 20-sightline diagnostic based on a Position Sensitive Detector (PSD) has been developed.

The diagnostic is based on a linear position sensitive AXUV-20EL detector [5] consisting of 20 independent sections Fig.20. This is the first time of applying AXUV detectors for fast particle measurements. It can work in a high magnetic field, does not use high voltage and does not require such components as a stripping gas cell and a bending magnet. The simultaneous work of all sections enables measurements of energetic particles (>15keV) with 3keV energy resolution can be made along 20 sightlines. The new PSD diagnostic is equipped with a special rotary mechanism which allows one freely to change a diagnostic plane during experiments without depressurization of the linear detector chamber.

The main advantage of this system is the possibility to make time, energy, and angle-resolved measurements of charge exchange neutral particles in a single plasma discharge.

First measurements by PSD diagnostic with real plasma have been made on LHD for a variety of plasma heating conditions. The typical energy-resolved spectrum measured along a single sightline is presented at Fig.1. The set of such spectra along all sightlines forms the angular distribution of fast particles as it is shown in the 2nd picture. For visual illustration of the flux dependence on the direction of the sightline the slope θ of every spectra was assumed as the angle between the sightline and magnetic axis.

Among the NPA diagnostics used on tokamaks only few can make angular resolved measurements of fast particles along several sightlines simultaneously. For example one of NPA system used on TFTR operates six sightlines in equatorial plane which are capable of being scanned in both toroidal and vertical direction [6]. Solid state neutral particle analyzer array on NSTX consists only of four viewing chords [7]. Multi-channel SDNPA on LHD can scan plasma by six sightlines [2]. Thus in the light of multi-sightline NPA systems available to make angular-resolved measurements of fast particles a new PSD Diagnostic with its 20 channels of scanning is going to become a powerful tool for fast particles study.

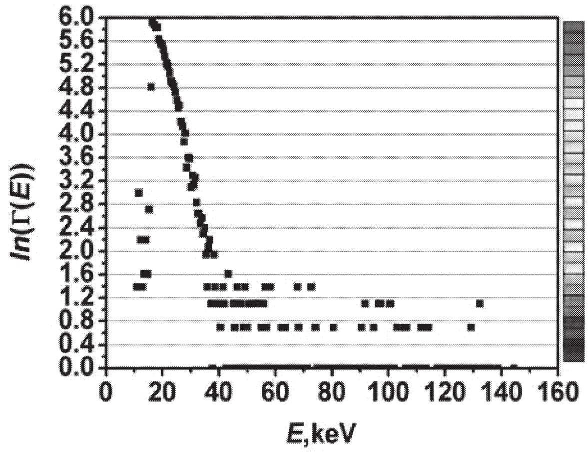

Fig.1 Energy spectrum measured along one of the 20 sightlines

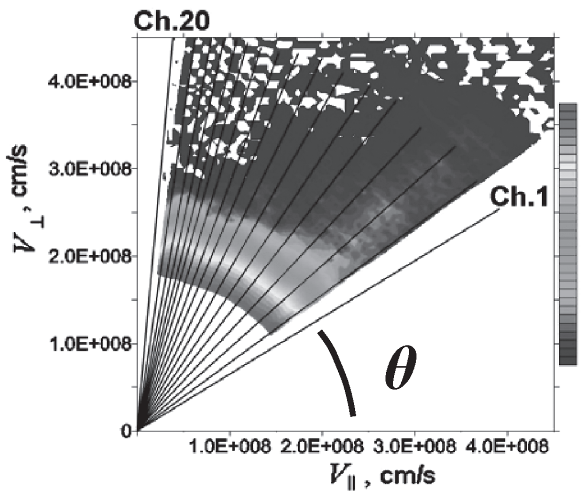

Fig.2 Energy spectrum measured along 20 sightlines. (θ is the angle between the sightline and magnetic axis)

[1] P.R. Goncharov *et al.*, Rev. Sci. Instrum., **77**, 10F119-1 (2006)
[2] T. Ozaki *et al.*, Rev. Sci. Instrum., **71**, (2000) 2698
[3] M. Wakatani, *Stellarator and Heliotron Devices*, 1998
[4] H.Sanuki, J.Todoroki and T.Kamimura, Phys.Fluids B **2**(9), (1990) 2155
[5] http://www.ird-inc.com/axuvarr.html
[6] S.S. Medley and A.L. Roquemore, Rev. Sci. Instrum., **69**, (1998) 2651.
[7] K. Shinohara *et al.*, Rev. Sci. Instrum., **75**, (2004) 3640.