§50. Angular Resolved Multi-Sightline Neutral Particle Analyzer (ARMS-NPA)

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Helical-shape magnetic field reactor is one of the candidates for the future fusion reactor. However the fast particle behavior in such kind of devices is more complicated and hasn't been investigated as well as in tokamaks. The presence of loss-cone regions has been theoretically predicted for the helical type reactors. However they could not be measured so far by existing diagnostics. For loss-cone measurements and understanding of the fast particle confinement in helical plasma the Position Sensitive Detector (PSD) based diagnostic has been developed on LHD. Later it was renamed as Angular Resolved Multi-Sightline Neutral Particle Analyzer (ARMS-NPA)[1,2]. The diagnostic is based on a linear position sensitive AXUV-20EL detector [3] consisting of 20 independent sections. This detector together with aperture positioned in front of it forms a system of 20 sightlines for plasma scanning.

The novel diagnostic can be installed at one of two 9-O LHD ports: the port for scanning tangentially emitted from plasma particles (Tangential Port) and the port for scanning of the perpendicular plasma region in vertical (radial) and horizontal (tangential) directions (Perpendicular Port). The range of pitch angles covered by diagnostic at the Tangential Port (TP) is 95÷160 degrees and at Perpendicular Position (PP) is 60÷100 degrees. The very initial experimental results were obtained by two sightlines at the PP during 9th experimental campaign. Full diagnostic operation by all 20 sightlines was arranged by 10th experimental campaign at the TP. Measurements were made for a wide range of varied plasma parameters such as electron density, magnetic axis position, positive and negative magnetic field directions, magnetic field strength. Obtained data demonstrated angular dependence of fast particle distribution on the type of heating and plasma parameters. Measured fast particle spectra in most cases demonstrate that in the pitch angle region of 80÷85 degrees loss cone region may exist (Fig.1).

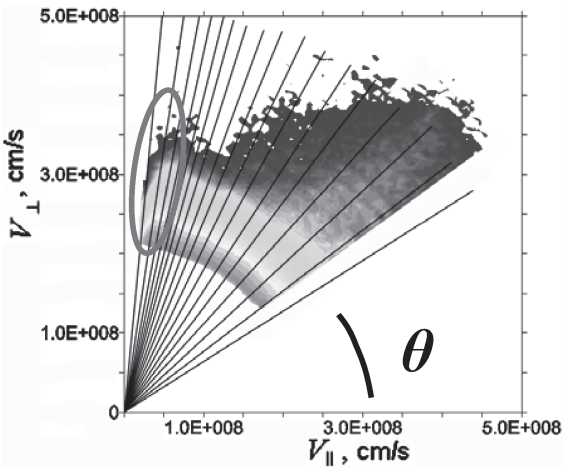

Fig.1 Energy spectrum measured along 20 sightlines. (θ is the angle between the sightline and magnetic axis). The ARMS-NPA diagnostic chamber is at the TP.

In order to confirm the presence of the loss-cone in the perpendicular region the diagnostic chamber of the ARMS-NPA was installed at the PP last (11th) experimental campaign to make the detailed scan of perpendicular region in horizontal direction. The experimental results of fast particle angular distribution are shown on Fig.2 from which the evidence of the loss-cone existence near perpendicular region can bee seen. These results confirm experimental results obtained in the 10th experimental campaign and theoretical predictions about the loss-cone presence near perpendicular region [4,5].

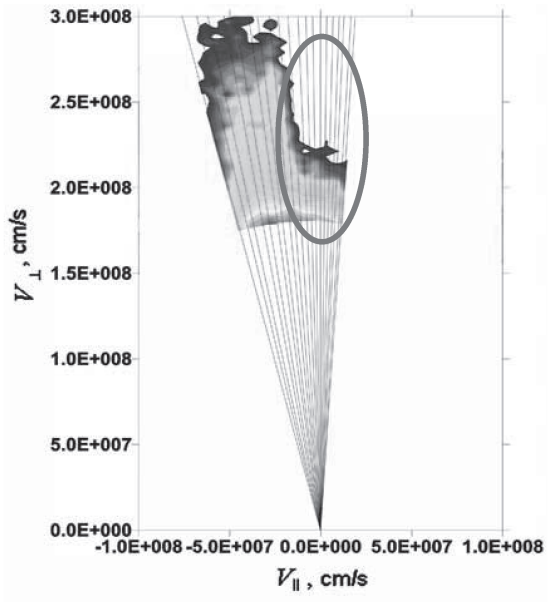

Fig.2 Energy spectrum measured along 20 sightlines. The ARMS-NPA diagnostic chamber is at the PP.

One of the advantages of the novel ARMS-NPA is the possibility to make radial scan of the plasma column. The initial data of fast particle radial distribution were obtained last experimental campaign and shown on Fig.3.

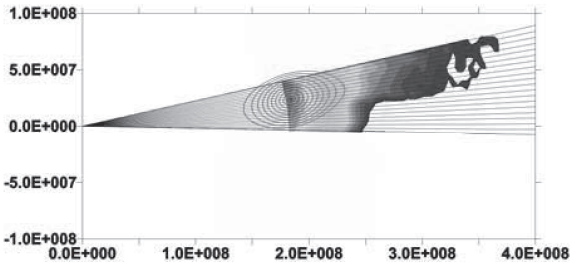

Fig.3 Radial distribution of fast particles in LHD

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[2] E.A.Veshchev *et.al.*, Plasma and Fusion Research, **2**, (2007) S1073.
[3] http://www.ird-inc.com/axuvarr.html
[4] H.Sanuki, J.Todoroki and T.Kamimura. Phys. Fluids B **2** (9), (1990) 2155.
[5] T.Kamimura et. al, "Numerical Studies of Particle Drift Orbits in Helical System" private communication (1987).