(3) Diagnostic Systems

The Large Helical Device is equipped with 57 diagnostics for the precise measurements of radial profiles and fluctuations of various plasma parameters.

Tracer-Encapsulated Solid pellet (TESPEL)
Impurity pellet injector
Laser blow-off
Movable electron gun and material probe
Magnetics
Flux loop array
High-frequency magnetic probe
Discone & loop antennas
Sniffer probe
YAG Thomson scattering system
Heterodyne radio meter
Michelson interferometer
Pulse Height Analyzer (PHA)
Hard X-ray scintillation detector
Charge Exchange Spectroscopy (CXS)
X-ray crystal spectrometer
Fast Ion Charge eXchange Spectroscopy (FICXS)
E//B-Neutral Particle Analyzer (NPA)
Si Fast Neutral Analyzer (FNA)
Tangential Angular Resolved neutral particle measurement System (ARMS-T)
Perpendicular Angular Resolved neutral particle measurement System (ARMS-P)
Lost-fast ion probe (8-O)
Scintillator Lost Ion Probe (SLIP)
Compact Neutral Particle Analyzer (CNPA) & Pellet Charge eXchange (PCX)
Far InfraRed (FIR) laser interferometer
Two color millimeter-wave interferometer
CO2 laser imaging heterodyne interferometer
Microwave reflectometer
Divertor interferometer
Fast response Ha Array (FHA)
SX and AXUV arrays
Beam Emission Spectroscopy (BES)
Two dimensional Phase Contrast Imaging (PCI)
Heavy Ion Beam Probe (HIBP)
Helium Beam Probe (HeBP)
Hybrid Direction Langmuir Probe (HDLP)
Langmuir probe array on the divertor plates
Fast scanning Langmuir probe
Visible spectroscopy
Visible spectroscopy for divertor
Impurity monitor
Toroidal array
Vacuum UltraViolet (VUV) spectroscopy: SOXMOS, SXPM
Space-resolved VUV and EUV spectrometers
Fast framing tangentially viewing VUV Camera
Absolute eXtreme UltraViolet photoDiode (AXUVD) diagnostic
Soft X-ray(SX) CCD camera
Zeff
Motional Stark Effect (MSE) spectroscopy
Neutral beam emission spectrometer
Plasma monitor camera
Resistive metal film bolometer
Infrared imaging video bolometer
Penning spectroscopy and gauges for the vacuum vessel
Fast ionization gauge (ASDEX pressure gauge)
LABCOM data acquisition and management system
Control data processing system

FIG. 1: List of diagnostics in Large Helical Device[1].

Figure 1 shows the list of the diagnostics in LHD[1]. The integration of the diagnostic data has been developed as well as the improvement of each diagnostic. Some examples of the integration in 15th experiment campaign are described below. The measurements of radial profiles of ion and electron temperature and density are important for the transport study. The radial profiles of electron temperature and density are measured with "YAG Thomson scattering system", where the electron density is calibrated by "Far InfraRed (FIR) laser interferometer". The radial profiles of ion temperature and poloidal and toroidal rotation velocity are measured with "Charge Exchange Spectroscopy (CXS)". The radial profiles of radial electric field is measured with the CXS near the periphery and with "Heavy Ion Beam Probe (HIBP)" in the core. Since the profiles of plasma parameters are measured at different toroidal angle, the mapping from real coordinate (R, z, ϕ) to the effective minor radius $(r_{\rm eff})$ as a flux coordinate is important in the profile measurements. Recently the mapping system using in-out symmetry of electron temperature profiles measured with YAG Thomson are developed. Mapping to the flux coordinate at each time slices of T_e measurement is done between shot intervals. The precise transport analysis is established with accurate mapping of ion and electron temperature and density profiles to the flux coordinate of effective minor radius $(r_{\rm eff})$.

Studies for plasma response to the perturbation is recognized to be important in understanding the transport and MHD stability in the plasma. Therefore the instruments that give the perturbation to the plasma are categorized to a part of diagnostic tool by combining the other diagnostics. "Tracer-Encapsulated Solid pellet (TESPEL)" is originally used for impurity transport study, but it becomes to be used in the cold pulse propagation experiment for non-local transport study by combining temperature measurements with 'Heterodyne radio meter of electron cyclotron emission (ECE)". The study on magnetic topology (stachastization) is done by combining the magnetic shear measured with "Motional Stark Effect (MSE) spectroscopy" and heat pulse propagation speed measured with ECE in the modulation electron cyclotron heating (MECH) experiment. The relation between the temperature gradient and turbulence intensity measured with "Microwave reflectometer" is also studied and interesting results are obtained in 15th experiment campaign. Further integration of the diagnostic data is desirable for deeper understanding of transport and MHD stability in LHD plasmas.

[1] LHD Experiment Technical Guide 2012

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