§11. Installation of the VUV Spectrometer "SPRED" for TESPEL Diagnostic

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The vacuum ultraviolet (VUV) spectrometer "SPRED" (Survey Poor REsolution Diagnostic: Fig. 1) is installed in LHD for the experiment of the Tracer-Encapsulated Solid PELlet (TESPEL). This spectrometer is a grazing incidence flat field survey spectrometer predominantly used for plasma impurity diagnostic in fusion confinement devices [1]. In the TESPEL experiment, several expected intense lines in VUV range for titanium, magnesium and fluorine (Table I) as a tracer material of the TESPEL can be covered with the SPRED. This permits the rapid broadband VUV survey, which is not included in the feature of the high-resolution soft x-ray spectrometer "SOXMOS" now in used and the novel multilayer mirror x-ray monochromator [2].

The SPRED was designed specifically for rapid acquisition of broadband VUV spectra. The toroidal diffraction grating with aberration-corrected curved grooves disperses the incident radiation and places a desired spectral region of a flat focal field, 40mm wide (see Fig. 1). On the surface of the toroidal diffraction grating, the 290 groove/mm are ion etched into glass and overcoated with gold. The wavelength range is 16.2 to 165.5 nm with resolution (FWHM) of 0.16 nm. The focal field is made to coincide with the front input surface of a micro channel-plate (MCP) detector. A broad spectrum on a flat focal plane can be obtained without repositioning the MCP.

The gain of electron multiplication is 9.8×10^5 for the applied potential of 1.2 kV to the MCP with the aspect ratio of 60:1. The photon-induced electrons that exit from the output side of the MCP impinge on a phosphor coating, and the resulting visible pattern on phosphor is carried out through the vacuum shielded fiberoptic image conduit. The visible pattern on the surface of the fiberoptic is captured by high-speed CCD camera that can scan 1024 element in a few tens of millisecond (or scan selected elements in shorter periods), and is finally recorded into a computer.

The field of view of the SPRED is rectangular zone with 5 cm × 33 cm on the magnetic axis of R = 3.6 m, which is currently fixed as shown in Fig. 2. It should be noted that the neutral beam (NBI-3) deposition area is at R ~ 4.0 m for 5-O. The performance evaluation test for SPRED has been done by means of the hollow cathode VUV light source with helium gas. As seen in Fig.3, the covered wavelength range of the SPRED can be confirmed by the spectral pattern of emission lines from the light source.

Table I. Expected intense lines in the wavelength range of the SPRED for the TESPEL experiment.

Li like ($2s$-$2p$)	Be like ($2s^2$-$2s2p$)
Ti XX: 25.9 nm / 30.9 nm	Ti XIX: 17.0 nm
Mg X : 61.0 nm / 62.5 nm	Mg IX : 70.6 nm
F VII : 88.3 nm / 89.1 nm	F VI : 53.5 nm

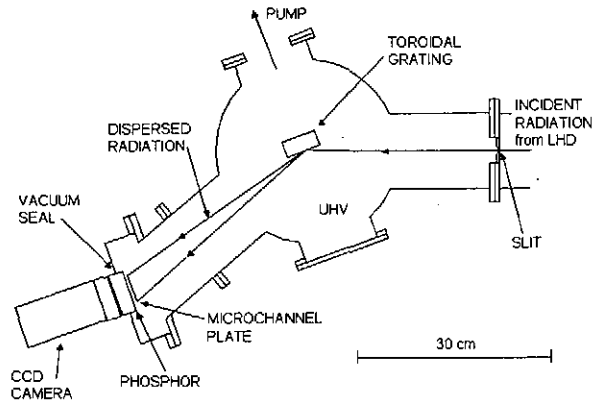

Fig.1. Schematic of the VUV spectrometer SPRED.

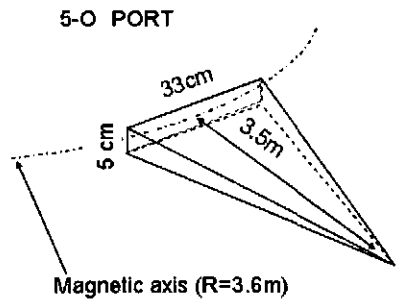

Fig.2. Field of view for the SPRED.

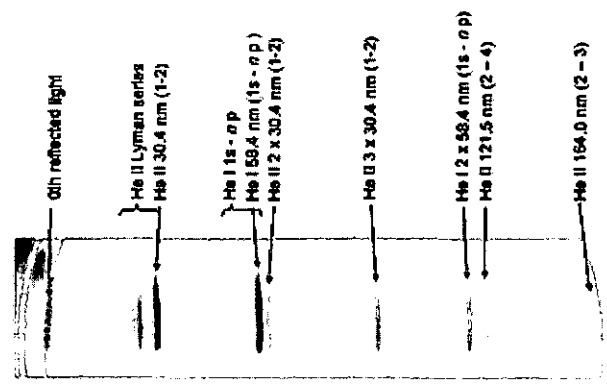

Fig.3. Photograph of the spectral pattern on the fiberoptic image conduit for the helium hollow cathode discharge.

References
[1] Fonck, R.J., et al., Applied Optics **21** (1982) 2115.
[2] Kalinina D., et al., J. Plasma Fusion Res., **80** (2004) in press.