P6-30

Soft and Ultra-Soft X-ray Detector Array Systems for Measurement of Edge MHD Modes in the Large Helical Device

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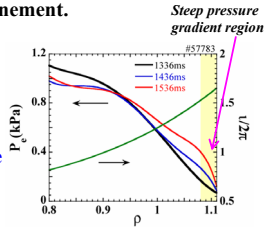
1. Background

- The rational surface of these edge MHD modes are located near the LCFS or the ergodic region outside the LCFS. Suppression of these edge MHD modes driven by edge pressure gradient is crucial for generating high performance plasma in the LHD.

⇒ It is important to clarify the characteristics of the edge MHD modes and the effects of the plasma confinement.

- Several 20-channel Soft X-ray (SX) detector arrays are used to observe the radial structures of SX fluctuations related to MHD instabilities.
- Recently, 20-channel absolute extreme ultraviolet (AXUV) detector arrays have also been installed in the LHD.

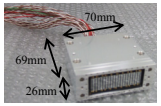


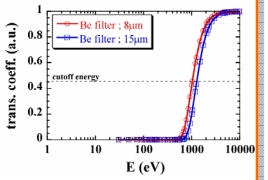
2. SX detector and AXUV detector array

SX photodiode detector array

- Thickness of silicon layer; 200μm
- Detected region; 200eV – 30keV
- Pre-amplifier; 10^5V/A
- Use with beryllium foil

⇒ 8μm (< 1.09keV)
15μm (< 1.34keV)

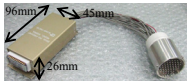


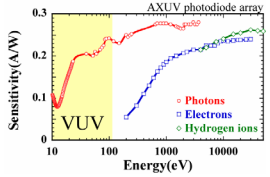


Channel Number	20ch
Sensitive Area [mm²]	1.5 x 12 = 18

AXUV photodiode detector array

- Thickness of silicon layer; 30-40μm
- Visible light, VUV light, Soft X-ray
- Pre-amplifier; 10^4V/A
- Use without beryllium foil
- H_α light cannot be detected





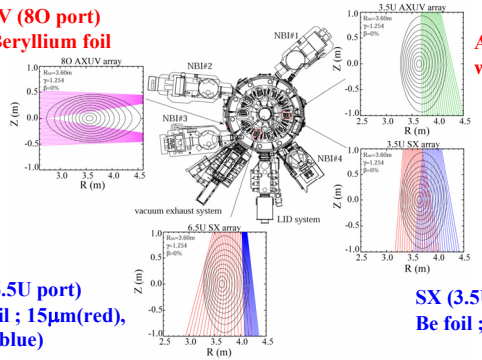
Channel Number	20ch
Sensitive Area [mm²]	0.75 x 4 = 3

3. SX and AXUV array systems on LHD

SX array (20ch x4sets) AXUV array (20ch x3sets)

AXUV (8O port) w/o Beryllium foil

AXUV (3.5U port) w/o Beryllium foil



SX (6.5U port) Be foil ; 15μm(red), 8μm(blue)

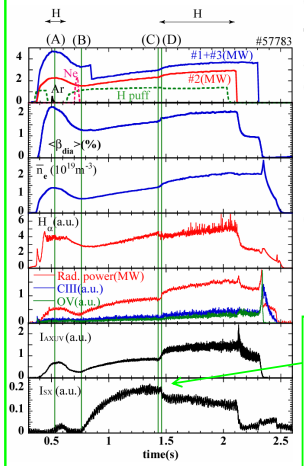
SX (3.5U port) Be foil ; 8μm(red, blue)

4. Typical L-H transition plasma

Condition; B_t = 0.75 T, R_{ax} = 3.6m, γ= 1.22, B_q=100%

Heating; Co-injection (#2) and Ctr-injection (#1, #3) at the B_t.

Gas puff; Hydrogen (H), Argon (Ar) (for ion temperature measurement), Neon (Ne) (for SX emission enhancement)



(A, B)

The Ar and Ne gas puff increases edge AXUV and SX emission.

(C)

Edge AXUV emission light increases with the increase in radiation loss by the L-H transition.

⇒ Edge SX emission light isn't increased.

(D)

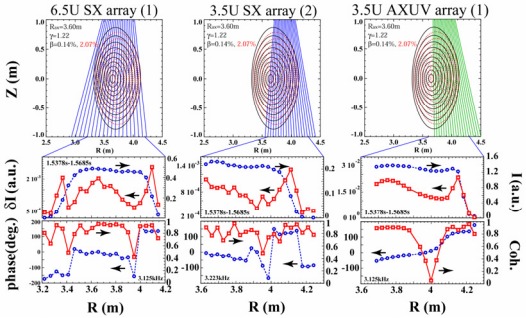
Edge SX emission light decreases from saturation time of the $<\beta_{dia}>$ after the L-H transition.

⇒ This possible cause is the slight decrease in electron temperature due to strong density rise in the edge region by the L-H transition.

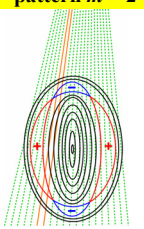
$$I_{sx} \propto n_e^2 \zeta \sqrt{T_e} \exp(\frac{-E_c}{T_e})$$

T_e ↓, n_e ↑ ➡ I_{sx} ↓

5. Information of edge MHD mode



Fluctuation pattern m = 2



- Radial information of an edge MHD mode (m/n = 2/3) observed by the SX and AXUV array on the vertically elongated sections of 6.5U and 3.5U ports is shown in this figures as a function of the major radius where the line sights of the SX and AXUV arrays intersect with the mid-plane of the LHD.
- Cancellation effect of edge MHD mode fluctuation amplitude is often given the important information of the edge MHD mode pattern.
  ⇒ Several channels have a low coherence because of cancellation by the path integral effect of the line of sight.
- The phase difference among these channels gives an information of the mode structure, that is, the 'even' or 'odd' character of the poloidal mode number m.

6. Summary

- In LHD, the AXUV array systems were installed for a further measurement of the edge MHD modes in addition to the SX array systems.
- The AXUV fluctuation amplitudes are often clearer than the SX fluctuation ones, i.e. AXUV array is suitable for the measurement of the low electron temperature and low density edge plasmas.
- The emission signal from the SX with beryllium foil is sensitively dependent on electron temperature because of low edge T_e, while the signal from the AXUV array without the foil is mostly dependent on the products of electron density and impurities.
- The measurement of edge MHD modes enables more powerful diagnostics by use of the combination of SX array and AXUV one.
- This different sensitivity should be reminded for both SX and AXUV detector array on the LHD. Nevertheless, the combination of the these arrays is concluded to be very powerful for investigation of edge MHD instabilities.