§56. The 14-channel Grating Polychromator for ECE Measurements in LHD

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A 14-channel Grating Polychromator (GPC) for the purpose of measuring the Electron Cyclotron Emission (ECE) spectrum has been developed and installed on LHD. The GPC has a Czerny-Turner set-up. The main advantage of the GPC is that it has a broad spectral range. Hence, it can be utilized at different magnetic field strengths. Changing the angle or replacing the grating can do this. Gratings with a grid constant of d=2.3, 3 and 5 mm and a blaze angle of 20° can be applied and the scattered spectrum is directed to 14-liquid He cooled InSb detectors. Standard operation is performed with d=3 mm, f= 148-105 GHz. This is second harmonic ECE for B=2.75 T. Each channel has a spectral resolution of Δf(FWHM)=2.6 GHz or $f/\Delta f$=60 at f=150 GHz.

The radiation from the plasma is transmitted through a corrugated waveguide to the GPC. The grating has high diffraction efficiencies at higher orders of the grating. In order to suppress the contributions from the higher harmonics to the output signals, low pass grating filters (f < 168 GHz) are installed in front of the GPC. The radiation diffracted by the grating is focused by the condensing mirror onto 14 exit slits and transferred to the detector cryostat through 14 waveguide transitions. The detector elements are the indium-antimonide hot-electron bolometers (optical responsivity ~3 kV/W, rise time < 10-6 s, optical NEP < 10^{-12}W $Hz^{-1/2}$). They are mounted in an Oxford Instruments MD Series cryostat, having 10 litres capacity of liquid helium, which provides 35-40 days continuous operation. This excellent cryogenic performance was achieved by the use of efficient short wavelength blocking filters (carbon-loaded polythene and black paper). The 14 detectors are arranged in a single raw of input channels with throughput of some 12mm ϕ, and mounted behind a f/3 quasi-parabolic horn. They are connected to low noise (2.4 nV/Hz1/2) pre-amplifiers having a gain of 60 dB and bandwidth of 0.01 Hz to 1 MHz. The performance of the polychromator has been measured in advance by using a microwave source (139 GHz Gunn oscillator). Figure 1 shows the line width of the 14 channels. The channel responsivity is observed to be different for each channel, as is the line width. The line width is approximately Δf (FWHM)=3.1 GHz for the lower frequency channels and decreases to 2.2 GHz at channel 14. The spatial resolution estimated by using the frequency resolution is ~25 mm around the half plasma radius. Example of ECE data from LHD 12 times traces of local temperatures measured by the GPC are shown in Fig.2, ranging from the plasma center to the edge (r=0.8). However, during the first 500 ms of the discharge, the high power ECH and the low density affect the ECE data.

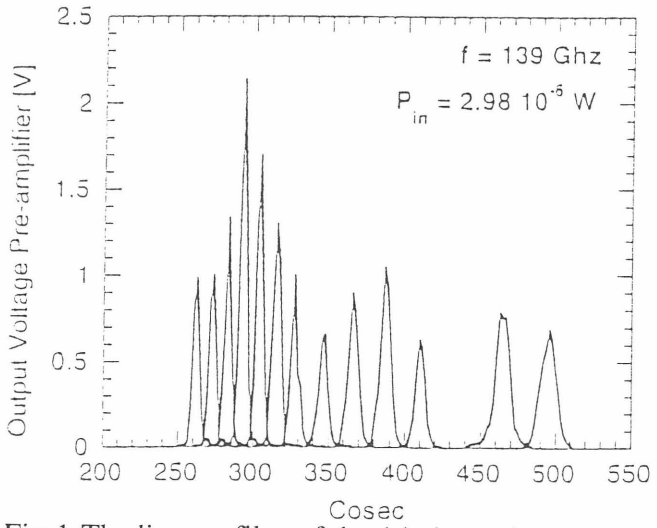

Fig.1 The line profiles of the 14 channels measured using a f=139 GHz source.

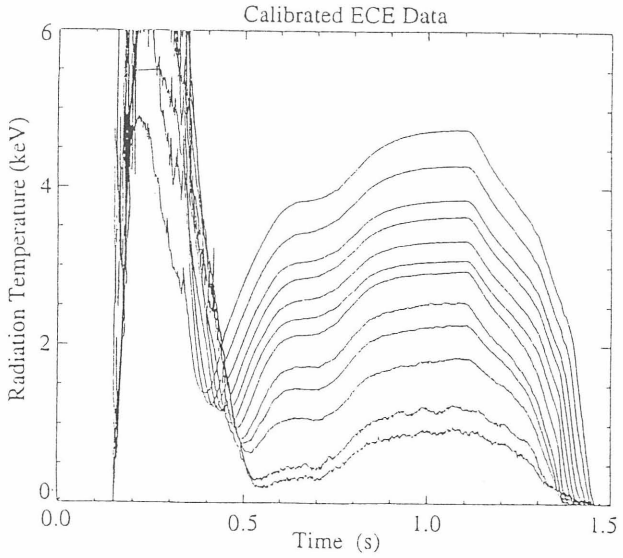

Fig.2 Example of ECE data from LHD 12 times traces of local temperatures