Electron cyclotron Emission (ECE) measurement

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1. Objective

Measurement of electron temperature profile and fluctuation

2. Apparatus

2.1. Antenna

- The sight line of ECE is on the midplane of horizontal elongated cross section.
- Antenna is installed in 8-O port. (see Fig.1)

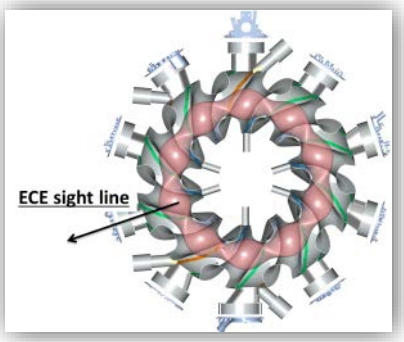

Fig. 1. ECE antenna and sight line

- Antenna system consists of four ellipsoidal mirrors (see Fig.2 and Fig.3)
- M1: 8 cm × 11 cm (in air, plane mirror)
- M2: 8 cm × 11 cm (in air, concave mirror)
- M3: 21 cm × 29 cm (in vacuum, plane mirror)
- M4: 27 cm × 37 cm (in vacuum, concave mirror, plasma faced.)
- The concaved M2 and M4 is designed by constant phase concept to improve the coupling and light harvesting of gauss beam.

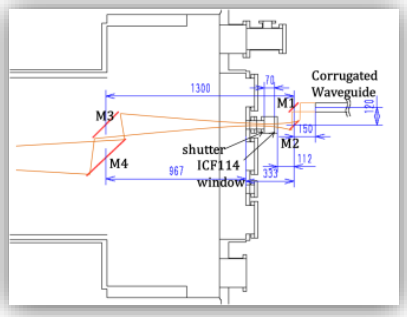

Fig. 2. Schematic layout of the ECE antenna system in the outer port of the torus in the LHD.

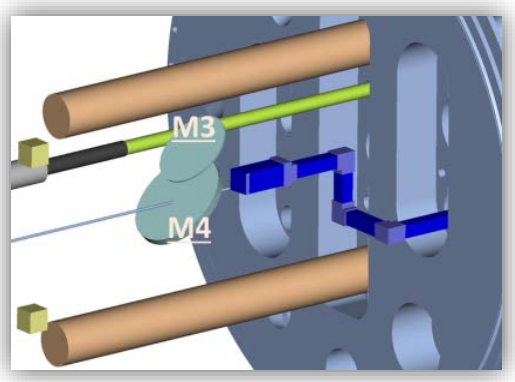

Fig. 3. 3D-CAD view of in-vessel mirrors

- The every mirror size is larger than 1.1 σ and there are no obstacles within 1.5 σ.
- The development of beam radius of ECE is optimized in the case of 60GHz (see. Fig.4)
-Beam waist is designed at plasma center and the spot size is approximately 8cm.

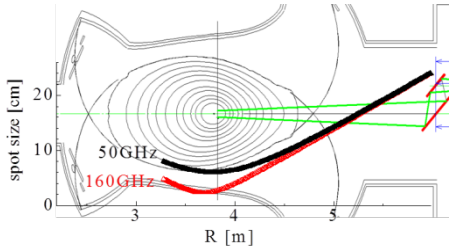

Fig. 4. Designed spot size

-Beam waist is designed at plasma center and the spot size is approximately 8cm.
- The corrugated wave guide (~100m) from LHD vacuum port to detectors system in the adjoining room are used (see Fig.5).

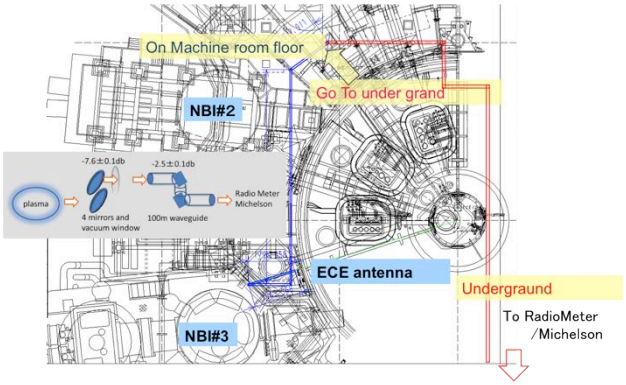

Fig. 5 Diagram of the corrugate wave guide system in LHD and the transition rate of antenna system and wave guide.

2.2. Radiometer

- Low frequency band Radiometer (named: RADL)(see.Fig.6)
    - local frequency : 70 GHz, band :53-84 GHz

- 32 ch (low frequency side:16ch, high frequency side:16ch)
- use for middle-B field experiment (eg, B_{ax}= 1.5T)
- data of each channel is acquired by PXI (1MHz, 10sec) and we7000 (100kHz, 10sec).
- some channel around 77GHz is notched because of protection from ECH.

- Middle frequency band Radiometer (named: RADM)
  - local frequency : 95 GHz
  - 12 ch (only high frequency side:12ch)
  - use for high-B field experiment (eg, B_{ax}= 2.75T)
  - observation area is edge region
  - data of each channel is acquired by we7000 (100kHz, 10sec).
- High frequency band Radiometer (named: RADH)
  - local frequency : 70 GHz, band: 106- 156 GHz
  - 32 ch (low frequency side:16ch, high frequency side:16ch)
  - use for high-B field experiment (eg, B_{ax}= 2.75T)
  - data of each channel is acquired by PXI (1MHz, 10sec) and we7000 (100kHz, 10sec).

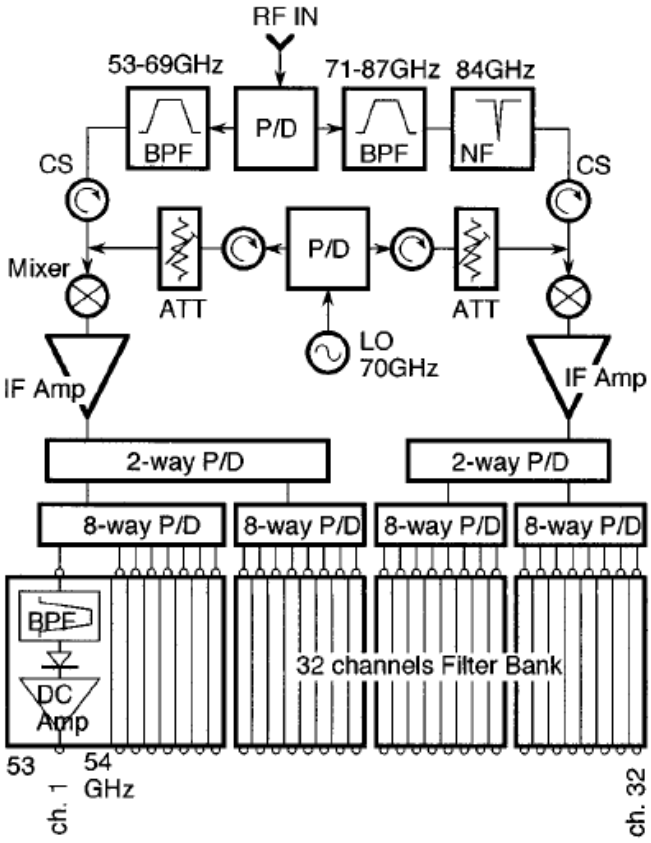

Fig. 6 The radial profile of of right hand cut off frequency, 2nd harmonics ECE, rotation transform (iota), magnetic field intensity and the viewpoints of radiometers. The magnetic configuration is Rax = 3.6m, Bax = 2.75T.

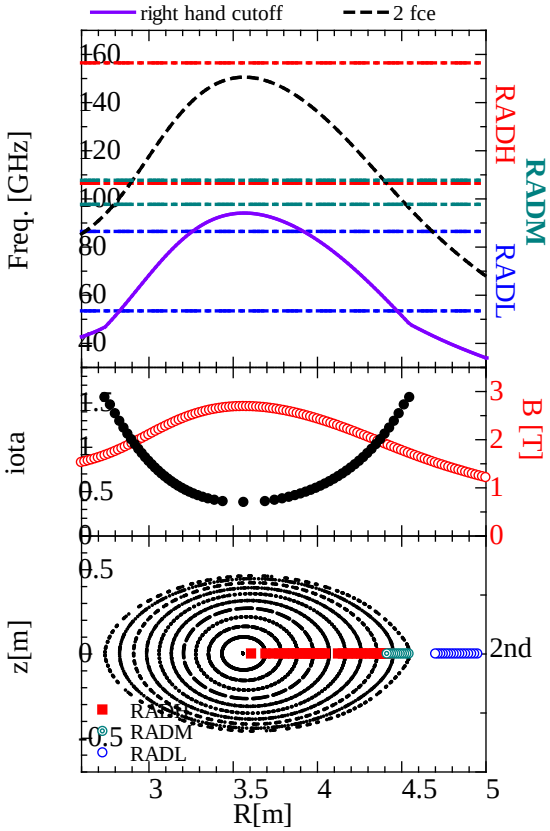

Fig. 7 The radial profile of of right hand cut off frequency, 2nd harmonics ECE, rotation transform (iota), magnetic field intensity and the viewpoints of radiometers. The magnetic configuration is Rax = 3.6m, Bax = 2.75T.

2.3. Michelson spectrometer

- The detector is a hot-electron InSb bolometer cooled to liquid helium temperature
- The frequency resolution is 4 GHz.
- Each scan produces an interferogram which is to be Fourier transformed to produce a spectrum of the ECE signal from approximately 60 to 600 GHz.
- The scanning frequency is 20 Hz.

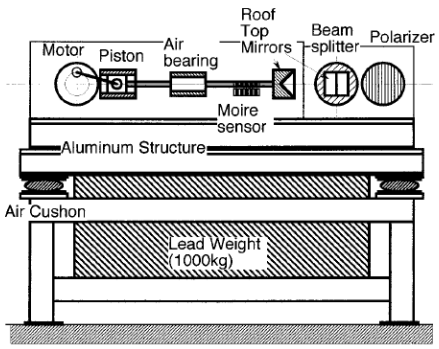

Fig. 8 Schematic view of the structure of the Michelson spectrometer

3. Operation

3.1. High magnetic field experiment mode (B>2.0T)

- X mode is distributed to RADH and Michelson spectrometer.
- O mode is distributed to RADL.
- RADM is optional,

3.2. Middle magnetic field experiment mode (B<2.0T)

- X mode is distributed to RADL and Michelson spectrometer.
- O mode is distributed to RADH.
- RADM is optional

3.2. Long pulse experiment mode

- Sampling rate of PXI is set to 200kHz, and streaming acquisition.

4. Available data by “Retrieve”

4.1. LABCOM

- Raw data can be retrieved by “Retrieve” command.
- The data is not calibrated.
- The call Diag. name is as follows.
    - “RADH” : we7000 data of RADH
    - “RADHPXI”: PXI data of RADH
    - “RADMWE”: we7000 data of RADM
    - “RADLPXI”: PXI data of RADL
    - “RADLWE”: we7000 data of RADL

4.2 Kaiseki-data server

- The information file of ECE is available. The file includes channel assignment, location information, and calibration factor.
    -“radhinfo”: Information of RADH
    -“radminfo”: Information of RADM
    -“radlinfo”: Information of RADL

5. Remarks

Discussion with operator is recommended at unique magnetic configuration experiment.

References

[1] H.Tsuchiya, *et.al.*, Plasma Fusion Res. 6 (2011) 2402114.

[2] Y.Nagayama, *et.al.*, Rev. Sci. Instrum. 70 (1999) 1149292.

Numerical Code

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1. Purpose / Application

2. Developer / Improver

3. General Description (function, usage, etc.)

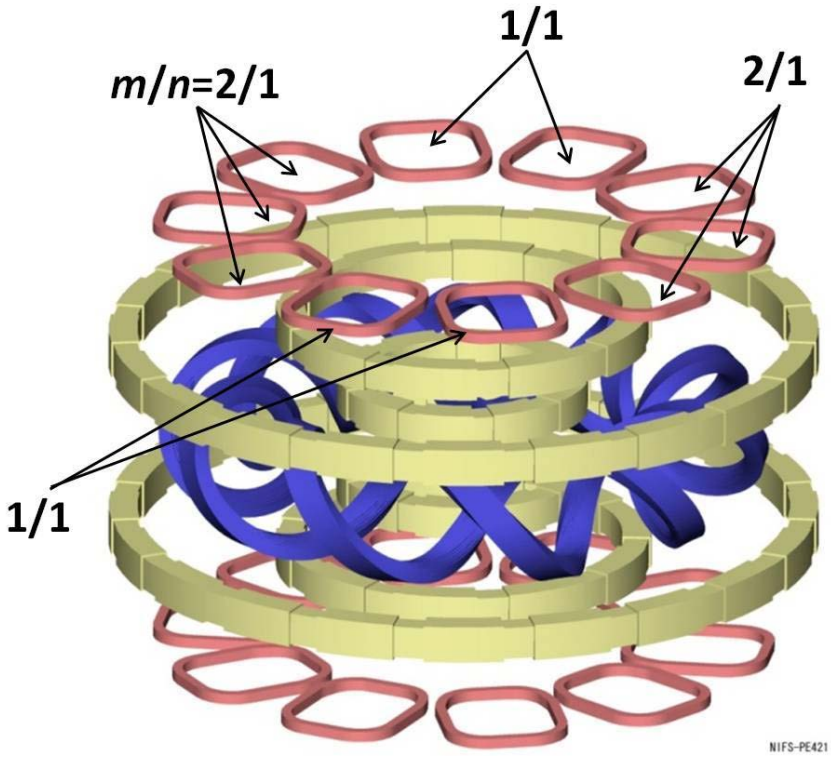

Figure 1 Coil geometry of LHD.

4. Requirement in Use

4.1. Platform(s)

4.2. Required resources

4.3 Usability

5. Type in Use

References

[1] T. Nifs et al., Fusion Science and Technology 58 (2010) 232.