Multichannel reflectometer for measuring plasma electron density profiles in front of the ICRH antenna on ASDEX Upgrade

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Motivation

A new Ion Cyclotron Resonance Heating antenna was installed at ASDEX Upgrade, Garching, Germany:

- The new three-strap antenna design reduces the ICRF induced sputtering;
- Multiple small microwave reflectometry antennas look at the plasma from several locations.

Improving ICRF megawatt power coupling is crucial:

- Increase heating efficiency;
- Prevent damage from reflected waves;
- Can be studied by **measuring electron density profile evolution during ICRF operation using microwave reflectometry.**

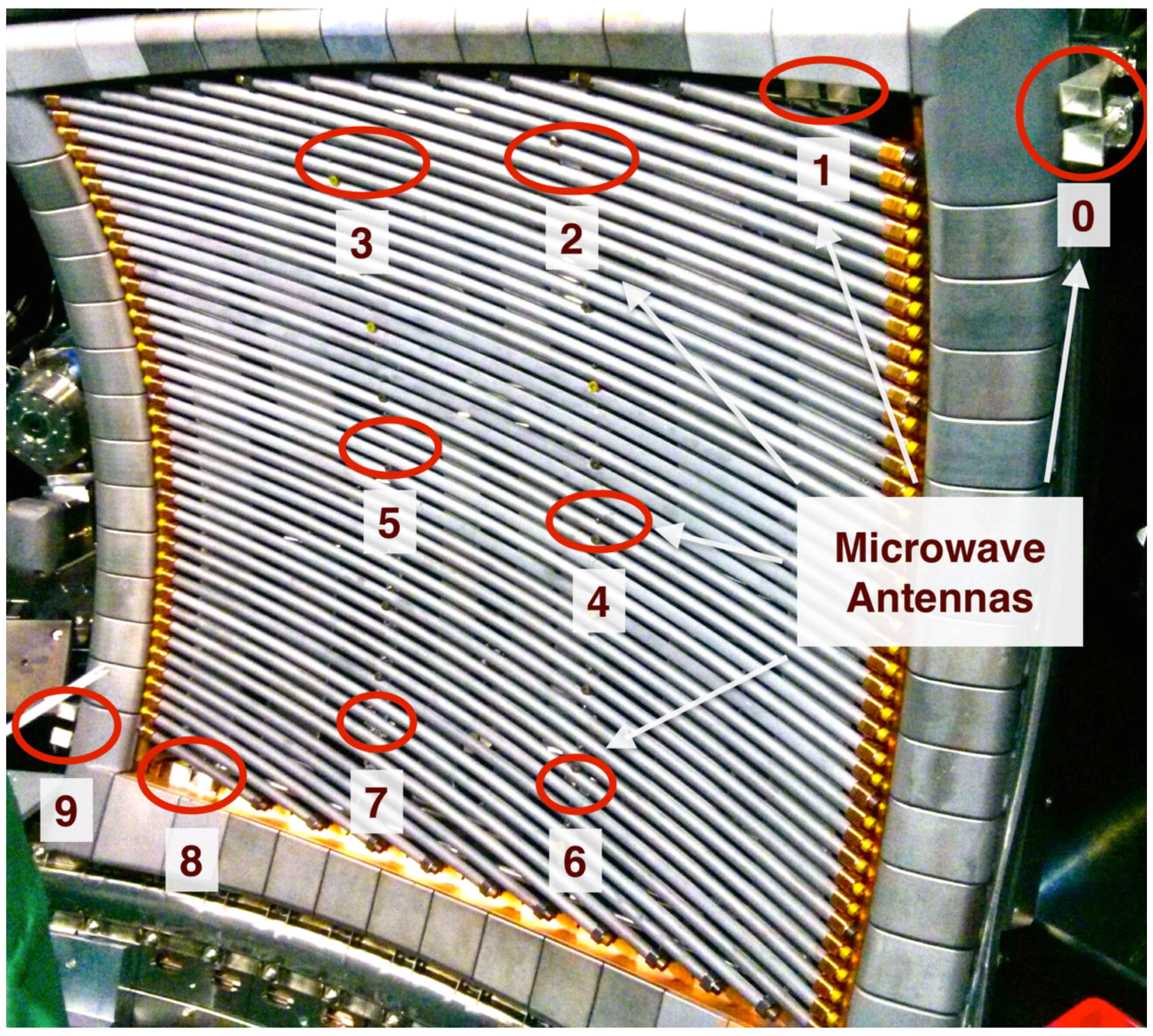

Figure 1 – ASDEX Upgrade ICRF antenna and reflectometry antenna locations.

Multichannel microwave reflectometer

- An electromagnetic wave propagates through the increasing density regions of the plasma and is reflected at a plasma layer with a specific density.
- The density of the reflection layer depends on the wave frequency and local magnetic field.
- By sweeping the frequency and measuring each wave's time of flight:
  A density profile can be obtained

Specifications for the multichannel ICRF reflectometer:

- X-mode
- Three transmitter and receiver channels
- Measure densities below $1 \times 10^{19}\ m^{-3}$
- Magnetic fields between 1.5 T and 2.7 T
- Extended U-band: ranging from 40 to 68 GHz

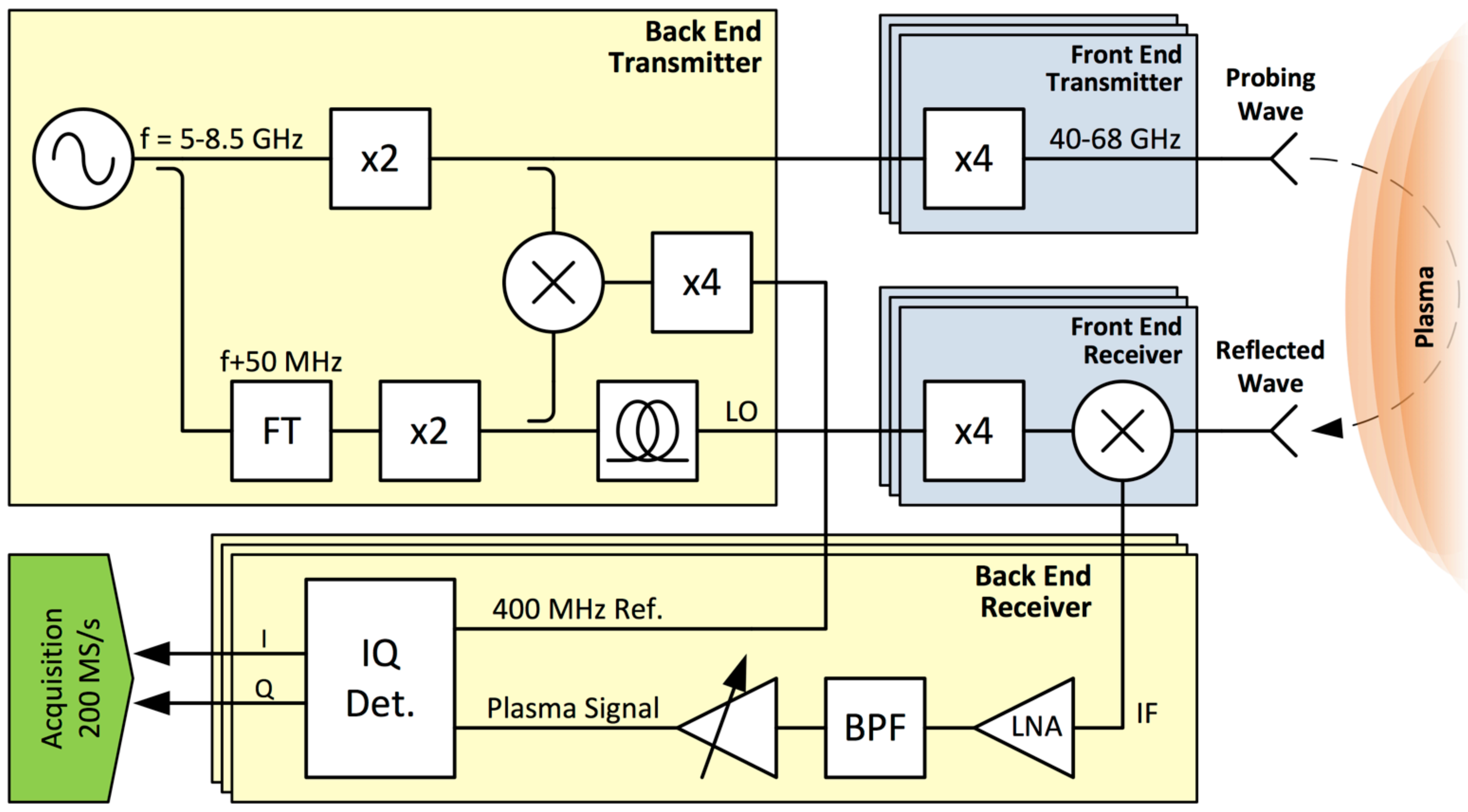

Figure 2 – Simplified diagram of the two step heterodyne microwave reflectometer.

Coherent heterodyne reflectometer operation:

1. A single oscillator generates a 5 to 8.5 GHz wave, which is split and multiplied by 8 to launch the three 40 to 68 GHz probing waves.
2. A frequency translator introduces a 50 MHz frequency shift in the LO;
3. The reflected wave is mixed with the LO producing an IF signal;
4. 10 meters of waveguides are compensated by delay lines;
5. A quadrature demodulator is used to obtain the amplitude and phase information of the plasma signal;
6. The I/Q signals are sampled using dedicated 8 channel 200 MS/s acquisition system;
7. Density profile is calculated from the group delay.

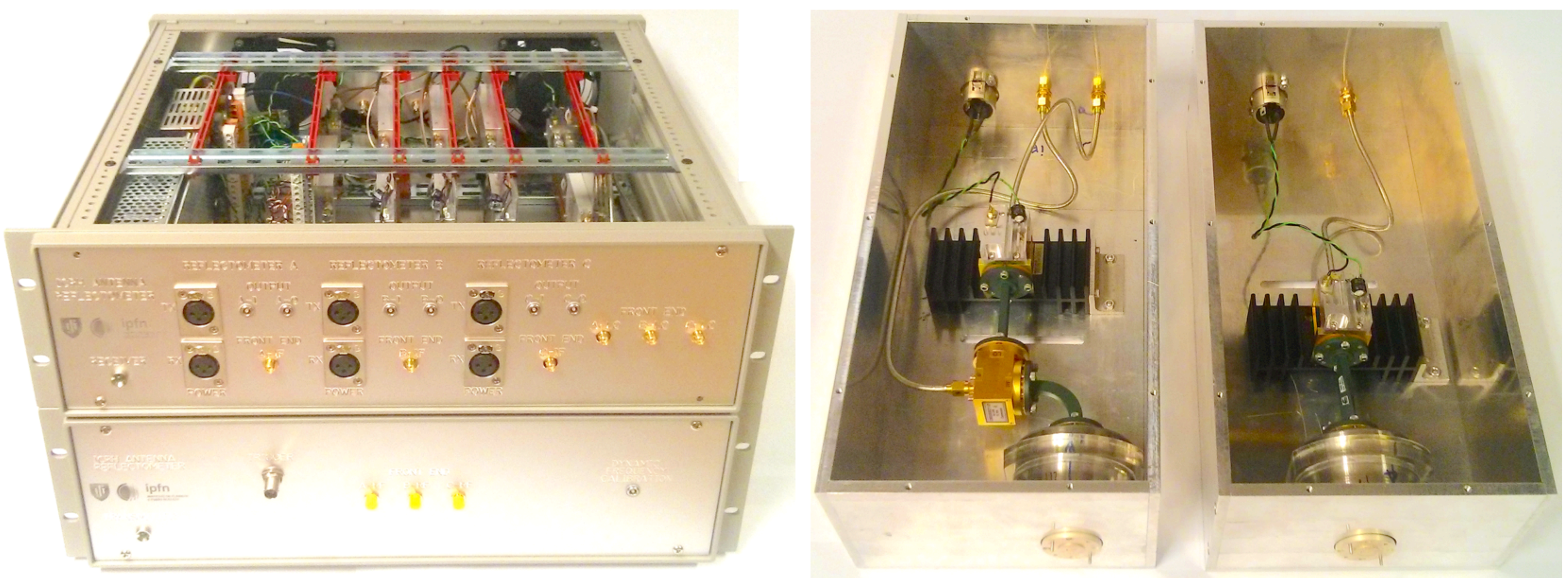

Figure 3 – Left: Receiver (top) and transmitter (bottom) back-ends; Right: Single front-end pair of receiver (left) and transmitter (right).

Conclusion

A multichannel X-mode reflectometer to measure the edge electron density profiles of the plasma at three different observation points in front of the ICRH antennas at ASDEX Upgrade, is being developed. This reflectometer will enable the first consistent study and direct measurement of the plasma layers in front of the antennas and allow the understanding of the coupling between ICRF power and the plasma in front of it.

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