

## Detection and Control of Plasma Instabilities

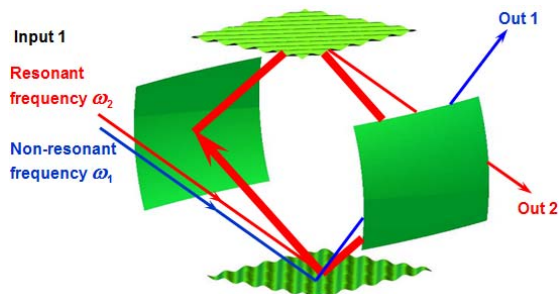
Researchers from TNO and FOM have, as part of the ITER-NL programme, carried out successful tests on the high power diplexer “FADIS” at the [Max Planck Instituut für Plasmaphysik \(IPP\)](#) at Greifswald (D). The diplexer is part of the electron cyclotron resonance heating (ECRH) system. The ECRH system keeps the fusion reaction going and suppresses the plasma instabilities. The goal of these measurements is to prove the functionality of the diplexer as component of the ECRH system

### Diplexer

The diplexer has three main functions:

- Enable in line of sight detection of instabilities.
- Combine two gyrotron bundles into one very high power bundle.
- Being able to switch the gyrotron power quickly between two launchers in order to be able to approach the plasma instabilities from two sides.

The diplexer is a quasi-optical resonator system for mm-waves. It has two entry and two exit points. The exit energy is divided over the two exit points depending on the resonating length and the actual frequency of the incoming wave. This is illustrated in figure 1.

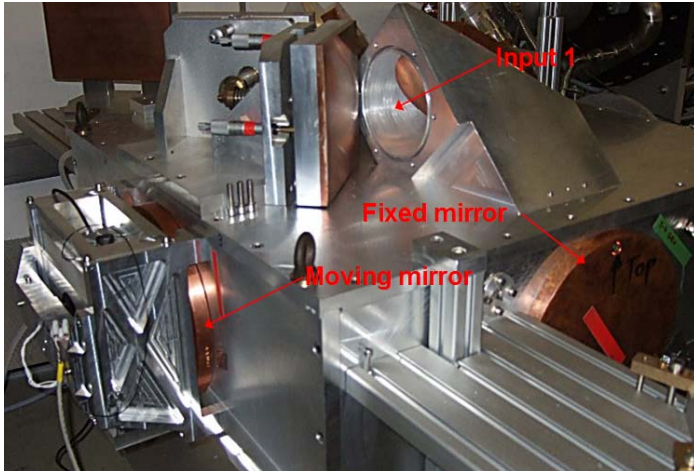


**Figure 1.** This shows how the diplexer works. The path of the incoming ray depends on the frequency and the distance between the mirrors.

For the purpose of in line of sight detection and power combination all the mm-wave energy must leave through one exit point. In the case of power switching the mm-wave energy switches rapidly between the two exit points,

### Mirrors

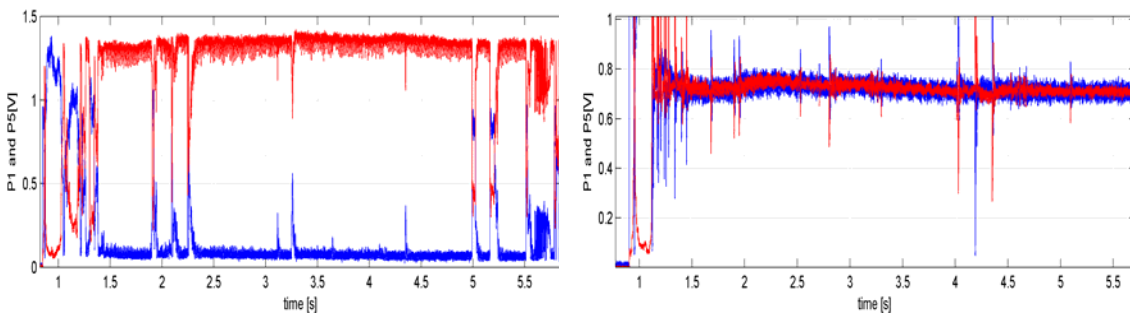
To maintain the correct resonator length and to cope with disturbances in the gyrotron frequency and with effects due to thermal expansions, TNO has developed an elastic mechanism to change the position of one of the diplexer’s mirrors. This mechanism is coupled to a control system to dynamically change the resonating length of the diplexer as required. This mechanism is shown in figure 2.



**Figure 2. The high power diplexer with a moving mirror on the left.**

The tests in Greifswald have shown that application of this mechanism involving a position controlled moving mirror is successful for the FADIS diplexer. Figure 3a shows the graph for an in line of sight detection and the mm-wave power combination: The power is controlled in exit 2 despite of the fluctuations in the frequency of the gyrotron and the thermal effects. TNO has developed an adaptive control algorithm that continuously seeks the optimal position for the mirror. The power peaks are caused by very high frequency disturbances in the gyrotron frequency. This frequency is measured using electronic equipment developed by FOM.

Figure 3b shows the test results for the launcher switching application. In this case the exit power has to be kept the same at both exits. In this case also the power is measured at both exits and this data is used to determine the best position for the mirror.



**Figure 3. Results of the switching and resonance control tests. The blue line shows the power at exit 1 end the red line shows the power at exit 2. The horizontal axis shows the time elapsed.**