Trilateral Euregio Cluster

A GENERIC METHOD FOR CONTROLLED ECRH/ECCD LOCALISATION

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Abstract

Many ECRH/ECCD applications require localisation of the power or driven current at a specific position in the plasma: suppression of (neoclassical) tearing modes, control of sawteeth, and control of internal transport barriers associated to regions with low or reversed magnetic shear.

A system for feedback control of the ECRH/ECCD localisation must:
(1) localise its position, and
(2) steer ECRH/ECCD launcher to deposit at the desired position.
(3) detect the presence of the instability or transport barrier,

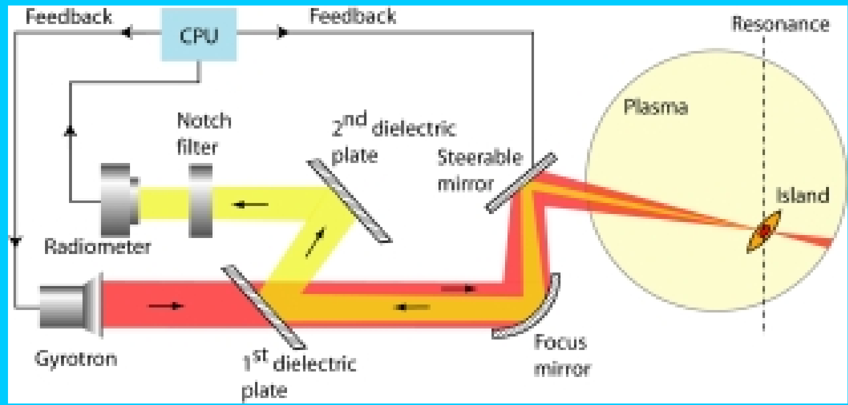
In addition, tearing mode control may require modulation of ECRH/ECCD in phase with mode rotation. Steps (2) and (3) require knowledge of the plasma equilibrium.

We present a control method that performs all three tasks in a single step without the need for equilibrium reconstruction.

The basis: along given line of sight $p_{ECRH}(r) \sim \eta_{ECE}(r)$ at same frequency f, and ECE at frequencies slightly shifted with respect to the f_{ECRH} will come from areas adjacent to r_{ECRH}.

Thus, a control loop using ECE along the sightline of the ECRH beam only needs to steer the launcher such that the desired position of power deposition or current drive is identified to lie in between two ECE frequencies on opposite sides of f_{ECRH}.

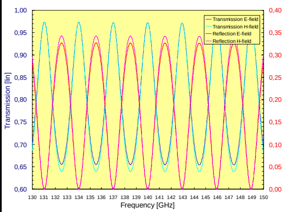
Sketch of the proposed control scheme

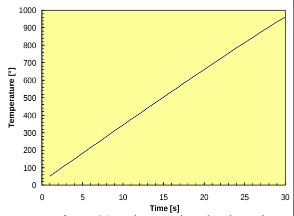


How to separate ECE from ECRH?

Answer:
By means of frequency selective transmission/reflection from a dielectric plate.

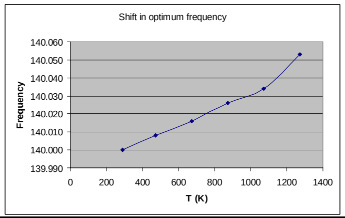
Example for an ECE system with 3 GHz separation between channels in a 140 GHz ECRH beam: a water free quartz (petrosil) plate of 23.5 mm thickness placed at an angle of 9.5°





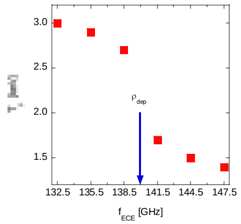
Estimated temperature for ~2% absorption in the plate

Optimum transmission frequency as function of temperature

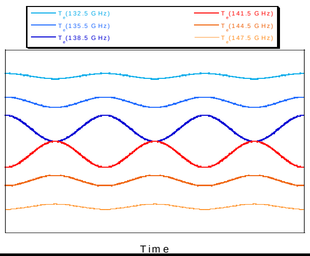


Feature recognition

Footprint of a barrier in ECE profile.



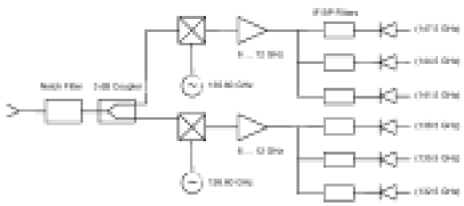
Footprint of a magnetic island in ECE signal.



ECE radiometer

Sketch of the proposed radiometer. The power that is reflected by the dielectric plate is collected and focused onto a horn antenna using two lenses (not shown). It is fed through a notch filter in order to supress the 140 GHz component and next divided over two mixers. The advantage of this scheme is that the two mixers have a moderate IF bandwidth and subsequent low conversion loss, and any remaining power at the gyrotron frequency is outside the IF amplifier band.

Bandwidth of individual channels: 200 MHz



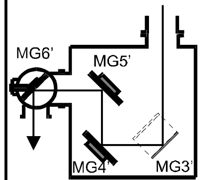
Issues for ITER application

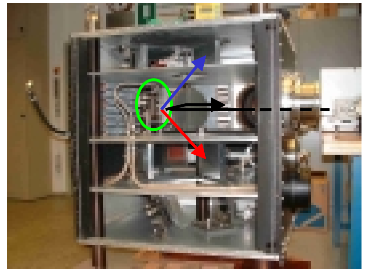
I. CW compatibility

Dielectric plate will be heated in beam and is not CW compatible. Alternative for first dielectric plate is a mirror grating (already present in MTP), which couples about 1% of radiation out of the main beam.

backward power

forward power

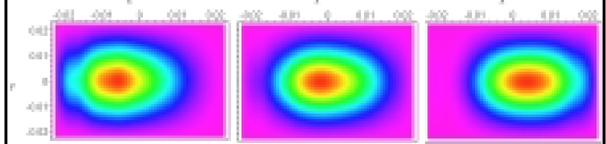




II. Remote steering

The remote steering concept is narrow bandwidth: at finite steering angles, different frequencies exit remote steering launcher from positions shifted with respect to the position for the design value.

Output at a medium steering angle of 5°:



	168 GHz	170 GHz	172 GHz
Gaussian:	99%	99%	99%
Δx:	−4.7 mm	0 mm	+4.7 mm

Shift is largely compensated by focussing last mirror. The resulting deposition profiles for the extremal steering angles (-12° right, +12° left).