Topic: EX-W

The ITER ECH FS Upper Launcher mm-wave design

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The purpose of the ITER electron cyclotron resonance heating (ECRH) upper port antenna (or launcher) will be to drive current (ECCD) locally inside the island which forms on the q=3/2 or 2 rational magnetic flux surfaces in order to stabilize the neoclassical tearing mode (NTM). The launcher should be capable of steering the ECCD current deposition profile (j_{CD}) across the resonance surface over the range in which the q=3/2 and 2 surfaces are found, for the various plasma equilibria susceptible to the onset of NTMs[1,2]. ITER's reference design uses a front steering (FS) concept (moveable mirror close to the plasma)[3,4], which offers an enhanced physics performance (improved focusing and increased scanning range) over the alternative remote steering concept[5]. The FS launcher is capable of steering eight 2MW beams via two sets of steering mirrors as shown figure 1. The steering and focusing capabilities of the launcher are decoupled with the addition of a single focusing mirror prior to the steering mirrors, the beams are focused to a small beam waist (~20mm) approximately 1.6m into the plasma. Two design variants sharing identical underlying design principals are under consideration: an NTM (provides access over the ρ range required for NTM stabilization) and an EP Launcher (an increased access range for a Extended Physics) [6].

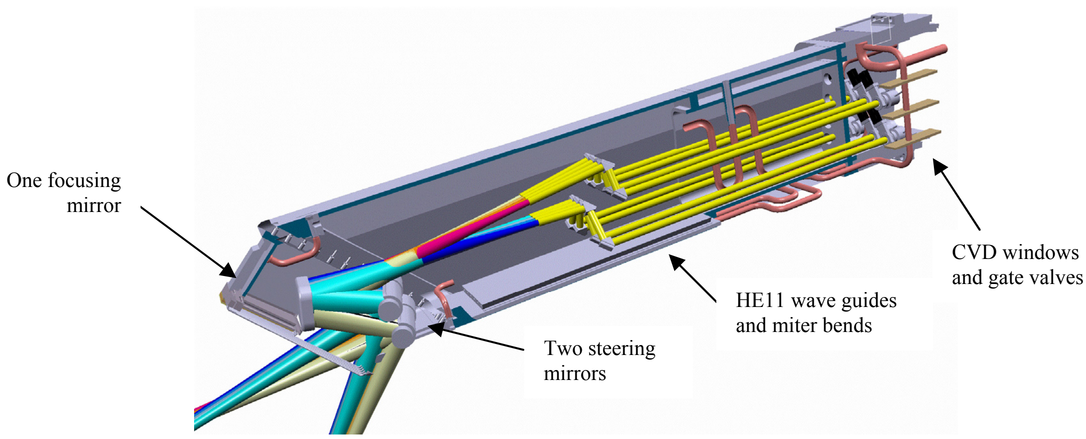
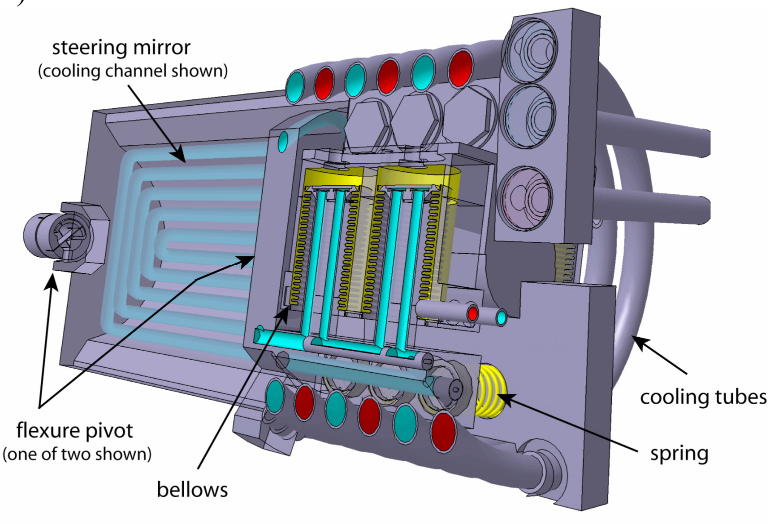


FIGURE 1. The FS launcher installed in the upper port plug.

A frictionless, backlash-free steering mechanism[7] (see figure 2a) has been developed for the FS launcher in order to increase the reliability steering mirror. The design avoids components such as bearings and push-pull rods, which tend to grip in conventional launching systems in use on present ECH systems. The proposed frictionless steering mechanism uses flexure pivots (see figure 2b) in place of traditional bearings, the flexure pivots fins bend to provide the equivalent rotation as that of the bearings. A pneumatic seal-less actuator (illustrated in figure 3) using pressurised helium integrated into the rotating mirror assembly offers a fast and precise steering response (rotation control) avoiding push-pull rods, linkages representing sliding bearings and remote actuators. The result is a highly reliable and complete self-contained frictionless kinematic assembly capable rotating the steering mirror up to ±7° (±14° for the RF beam).

a)

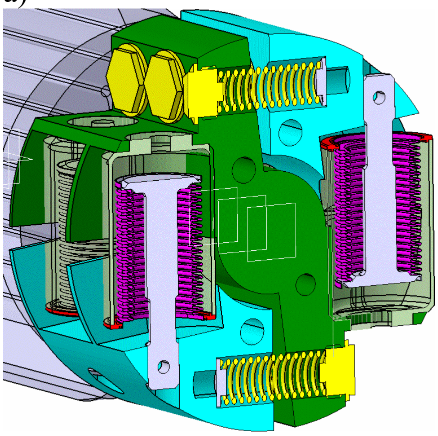


b)

Figure 2 a) The frictionless steering mechanism to be used in the launcher and b) a typical flexure pivot.

The steering mirror is cooled via a set of flexible cooling tubes (similar to the design used for the ITER equatorial launcher[8]) coiled around the body for reducing stresses to levels corresponding to ITER design requirements. The mechanism is designed to provide the required number of rotations based on the expected physics requirements for the launcher during the full 20 year lifetime of ITER. In addition, the flexure pivots are dimensioned to withstand the electro-magnetic forces induced in the mirror assembly during the vertical disruption events envisioned in ITER.

a)



b)

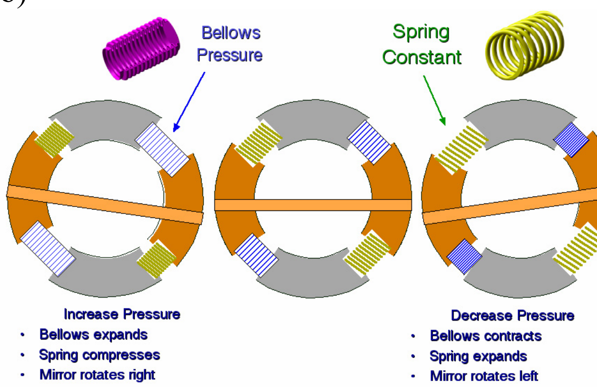


Figure 3 a) A cut away view of the bellow-spring actuator of the steering mirror and b) an illustration of the mirror rotation as the bellows pressure changes.

A description of the kinematic & structural behavior of the steering mechanism is presented, along with preliminary stress and fatigue analysis of all components. The testing programme envisioned for the launcher and steering mechanism will be outlined and recent results shown.

References

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