High harmonics fast wave current drive for DEMO?

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A steady-state tokamak reactor (SSTR) requires a high efficiency current drive system, from plug to driven mega-amps. RF systems working in the ion-cyclotron range of frequencies (ICRF) have high efficiency from plug to antenna but a limited current drive (CD) efficiency and centrally peaked CD profiles. The latter feature is not adequate for a SSTR where the current should be sufficiently broad to keep the central safety factor (possibly significantly) above 1. In addition, the fact that the fast wave (FW) is evanescent at the edge limits coupling, requiring high voltage operation, which makes the system dependent on plasma edge properties and prone to arcing, reducing its reliability. A possible way to overcome these weaknesses of an RF CD system is to operate at higher frequency (10 times or more the cyclotron frequency). The advantages are: (1) The coupling can be much better (waves propagate in vacuum) if the parallel refractive index $n_{//}$ is kept below one, (2) The FW group velocity tends to align to the magnetic field, so the power circumnavigates the magnetic axis and can drive off-axis current, (3) Due to the latter property, $n_{//}$ can be upshifted along the wave propagation path, allowing low $n_{//}$ launch (hence good coupling, large CD efficiency) with ultimately good electron absorption (which requires higher $n_{//}$). Note however that the $n_{//}$ upshift is a self-organized feature, that electron absorption is in competition with α-particle absorption and that uncoupling of the FW from the lower hybrid resonance at the edge requires $n_{//}$ slightly above one. These possibly counterproductive features might complicate the picture. The different aspects of this potentially attractive off-axis FWCD scheme will be discussed.