Beyond ITER:
RF Heating and Current Drive Issues for DEMO

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The step from current devices and ITER to DEMO is clearly daunting

	Current devices	ITER	DEMO
Pulse lengths	10's of sec	~1000 sec	~ 1 year
Neutron flux	low	high	high
Power flux (MW/m)	< 15	~ 24	> 60

Need flexible RF systems for heating, CD, start-up, instability suppression, and profile control

Need to operate reliably in a high power flux, high radiation, and "steady state" nuclear environment

We need an integrated, predictive simulation model for the antenna-edge-core RF interactions

- ***Existing models unable to predict how much power can be coupled into core from a given launcher***
  - **Currently lose 10% or more power to edge / vessel**
  - **Minimal diagnostic support for RF edge interactions in program**
- ***Non-axisymmetric effects may be significant***
  - **May adversely affect both core and edge wave interactions**
  - **Limited computational or experimental effort**
- ***Controllable instability suppression with RF under development***
  - **May need Lower Hybrid for r/a > 0.6 (not currently on ITER)**
  - **Need feedback control systems and simulation models**
- ***Interactions with fast particles likely to be understood by end of ITER***
  - **No effort on possible phase-space engineering techniques (alpha channeling, etc)**
- ***It is unclear if RF (or other methods) can be used to control the pressure profile***
  - **Bootstrap current driven by pressure gradients**
  - **How much power required in a burning plasma?**

Survivability and Feasibility of RF systems in a DEMO is challenging

- *Will we have high power RF sources at the right frequencies and reliable feedback control systems for profile control?*
- *Can we inject adequate power with available ports?*
- *Will real-time variation (how fast) of the source frequencies or spectrum be required?*
  - **Can change spectrum for ICRF / LH now but not frequency**
  - **EC systems change deposition by moving mirrors…but will mirrors survive in a DEMO?**
- *Various technical questions arise in a high radiation environment:*
  - **Will voltage breakdown be worse in a radioactive environment?**
  - **Will different cooling systems be needed, since water is activated by 14 MeV neutrons?**
- *Can RF systems operate for ~ 1year?*
  - **ICRF filaments last about this long**
  - **EC systems do not yet run for extended time periods**

Facilities that provide a DEMO-relevant testing environment should be considered

- **Existing RF systems are "proof of principle" rather then "demo" level**
- **It is *not credible* that robust and reliable DEMO-relevant RF systems will be developed with the limited dedicated experimental time, hardware and computational resources, and wave-specific diagnostics currently available or planned in the fusion program**
- **Current / planned devices will not provide "test bed" for combined high power flux and year-long pulse lengths with high radiation / neutron fluxes [ITER could provide a reasonable "RF" test facility - but this use is not planned]**