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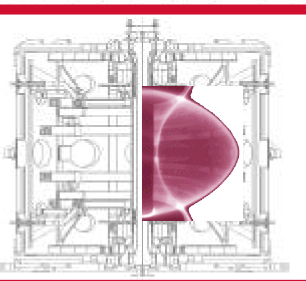
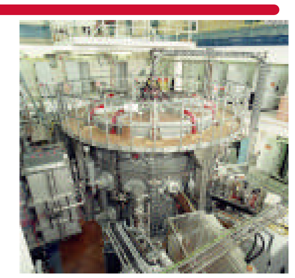


EBW Current Drive Start-up Scenario for MAST



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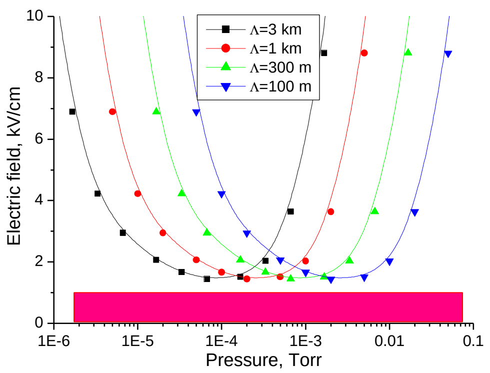
RF Pre-ionisation in MAST

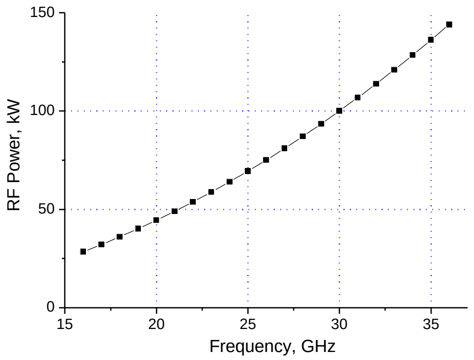
• ECRH pre-ionisation reduces the volt-second consumption during the plasma start-up phase, improves plasma purity and reproducibility and broadens the initial plasma parameter space.

• The required breakdown voltage increases with RF frequency due to the fact that the amplitude of electron oscillations becomes smaller.

$$E_{eff} = \frac{E}{\sqrt{1+(55.6/pl)^2}} \approx \frac{pl}{55.6}E$$, where p is the gas pressure and l the vacuum wavelength

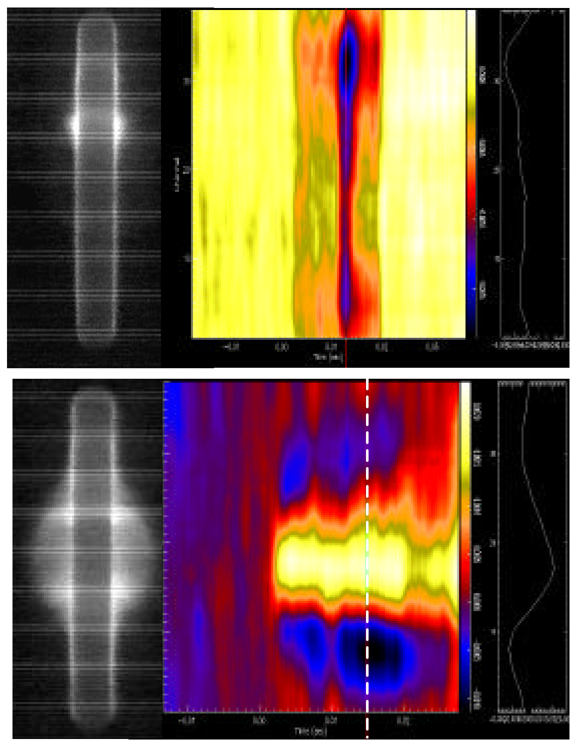


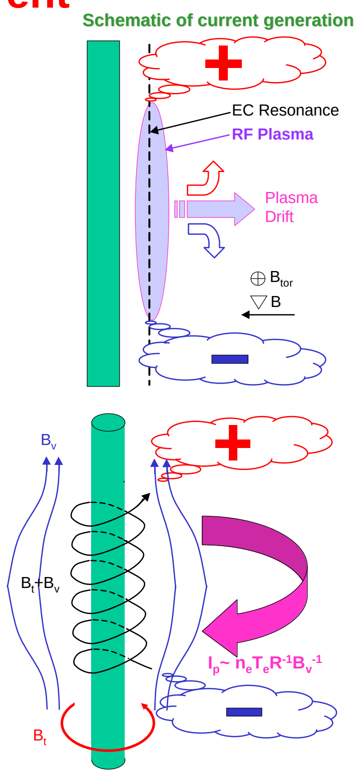
RF breakdown curves for 60 GHz in pure deuterium for different connection lengths L.



RF power required for breakdown in MAST.

Pressure Driven Current



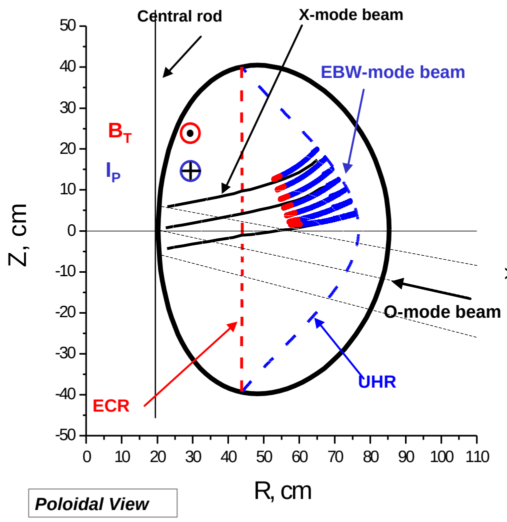


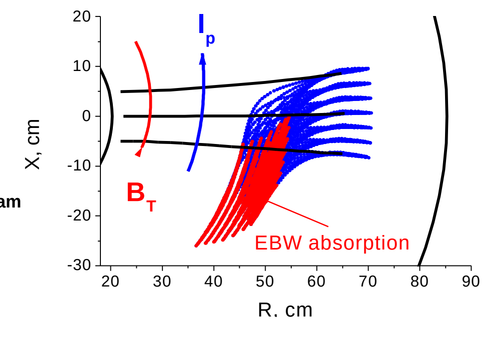
CCD image of RF (60 GHz) breakdown in pure toroidal field (above) and with 5 mT vertical magnetic field (below). Vertical magnetic field induced by plasma (right) during RF breakdown. ECRH pulse of 60 GHz, 0-20 ms (0.3 MW), O-mode polarisation. Pressure (ECRH) driven current is estimated to be 5 kA.

Proposed EBW CD Scenario in MAST

• As soon as the temperature exceeds 5-10 eV the EBW CD mechanism can be activated if a sufficient fraction of incident RF power is converted into EBW.

• EBW power absorbed above the midplane will generate current in the co- direction with Ip





Schematic of the EBWCD plasma initiation. EBW ray-tracing simulations were performed with experimental data. Equilibrium was taken from the hybrid start-up scenario at 30 ms, shot #9867, MAST

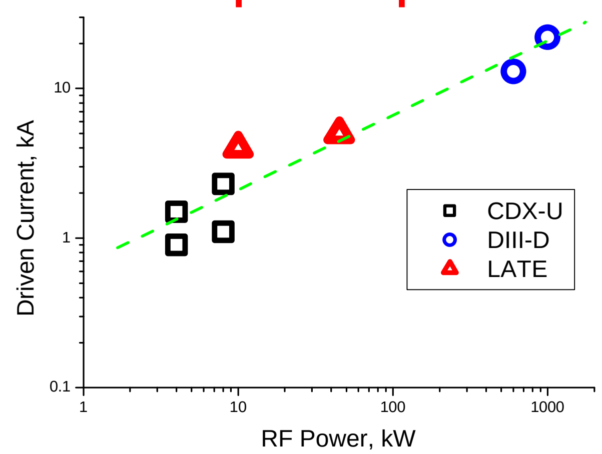
• The O-mode beam launched from the LFS converts into the X-mode beam by a grooved mirror-polariser incorporated in the central rod.

• The X-mode beam reflected from the polariser propagates back to the plasma and experiences X-EBW conversion near the upper hybrid resonance.

• The EBW beam propagates towards the fundamental electron cyclotron harmonic, where it is effectively absorbed by electrons via Landau damping.

• The mirror polariser must be incorporated into the central rod to provide the O-X polarisation transformation. To be fitted on MAST in Nov 2004.

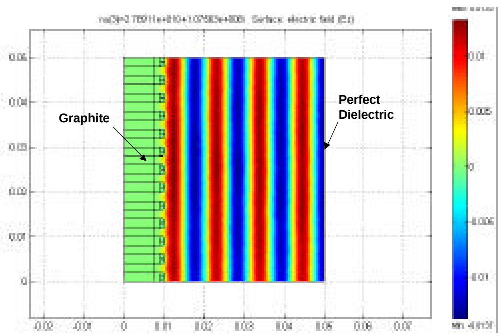
RF Start-up CD Experiments



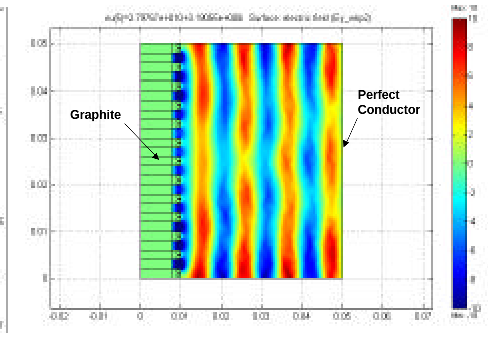
CDX-U, DIII-D: Forest C., Phys. Plasmas, 1994, 1(5), 1568.
LATE: Maekawa T., Proc. 15th Top. Conf. on RF Power in Plasmas, 2003, 340.

Graphite Polariser Design with FEMLAB

The method can be applied for arbitrary groove shape, arbitrary incidence, arbitrary reflector material and for free-space or waveguide propagation.



Eigenfrequency solution (28 GHz) for TE mode.

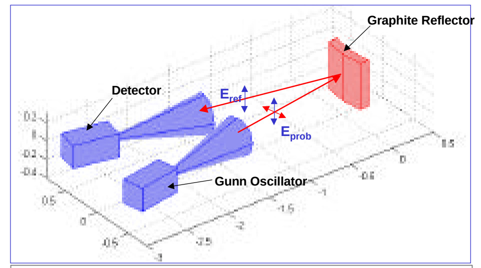


Eigenfrequency solution (28 GHz) for TM mode.

The optimal grooves are 3 mm width, 6 mm period and 2.35 ± 0.1 mm depth. Grooves are rounded with a radius of 1 mm. Grooved area is 20 cm in diameter. Such a mirror can provide high performance: ~98% reflection and >92% mode conversion efficiency.

Mirror-polariser manufactured on a polycrystalline graphite EK986 tile used on MAST centre column.

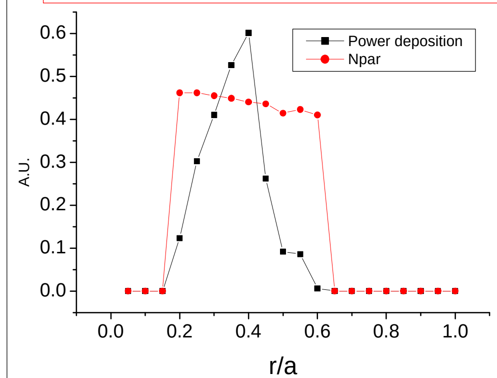
Smooth Graphite	Grooved Graphite
P_{vert}: U_{det}=100mV	P_{vert}: U_{det}=2.4 mV
P_{hor}: U_{det}=2.5 mV	P_{hor}: U_{det}=92 mV



Polariser test set-up. Polarisation of the incident beam can be selected either vertical or horizontal by rotating the source by 90º.

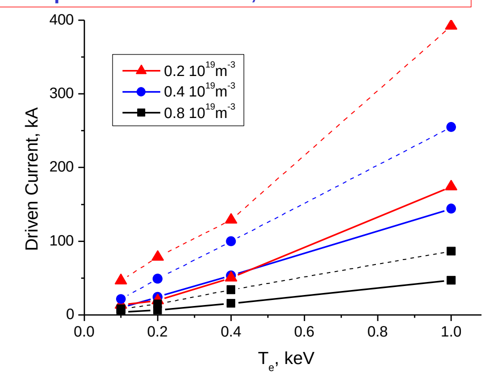
EBW CD Start-up Modelling

The equilibrium was taken from a "hybrid" start-up scenario at 30 ms, shot #9867 in MAST



EBW power deposition and $N_{||}$ profile in the absorption region for the case shown in the ray-tracing figure with n_{e0} = 0.4 10^{19} m^{-3} and T_{e0} = 0.4 keV.

Input power 150 kW, 28 GHz.



EBW driven current with (solid curves) and without trapping effects (dashed curves) for a range of plasma temperatures and densities.

Input power 150 kW, 28 GHz.

Modelling predicts that non-inductive current up to 150 kA can be generated with EBW CD start-up. We plan to test this in 2005.

Acknowledgements

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