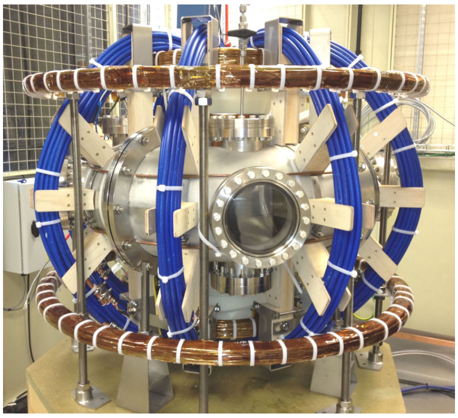
The ST25 and ST25(HTS) tokamaks

The ST25 Tokamak

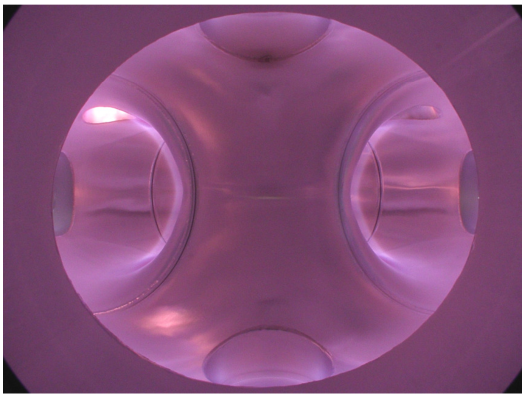
Tokamak Solutions team have built a small table-top tokamak, ST25 (denoting "Spherical Tokamak radius 25cm") with copper coils. This obtained first plasma in October 2012. A variant, using HTS (High Temperature Superconducting) coils is under construction, in collaboration with Oxford Instruments.



ST25 has major radius 25cm, minor radius 12.5cm, assembled from 4 stainless steel quadrants with insulating breaks. All coils are wound from copper cable. Power supplies are from capacitor banks: high voltage low capacity capacitors are used to provide the initial fast swing required from the solenoid and vertical field coils, linked to low voltage very high capacity supercapacitors which provide pulse control after the initial formation of the plasma current. The toroidal field magnet comprises 8 limbs each of 14 turns, powered by eight 1Farad supercapacitors.

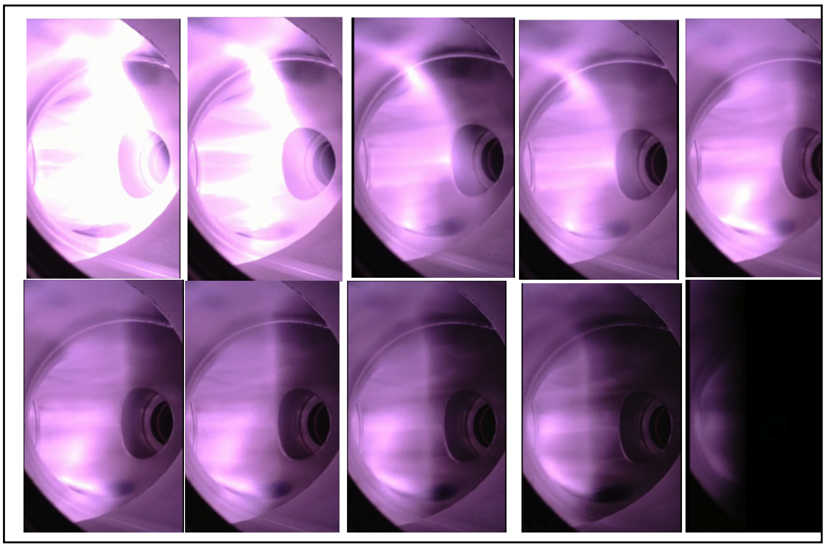
The combination of the high inductance of the 112-turn winding and the high capacity of the bank enables relatively long plasma pulses, an order of magnitude longer than the pioneering START experiment.

The existing installation has max toroidal field of 0.2Tesla, and plasma current of 10-20kA (both field and current can be increased by adding extra capacitors). Switching is by means of modern IGBT devices, giving options of detailed waveform control. Plasma control and data handling are provided by a LabView system.



Glow discharge in Argon in ST25

The ST25 tokamak is equipped with a 3kW magnetron (steady-state operation) of 2.45GHz with high-field side injection, capable of driving plasma current via the EBW (Electron Bernstein Wave) mechanism. First results (December 2012) appear promising: long discharges (approx 2s, which can be increased to ~5s) show evidence of current drive.



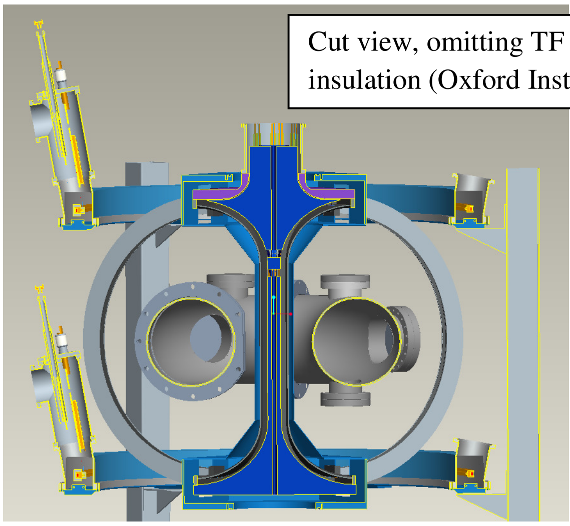
Images of a hydrogen discharge with plasma initiated by RF injection, terminating when the resonance disappears into the centre column as the toroidal field falls

A feature of the facility is that the tokamak and all its ancillaries and power supplies are contained in a Faraday cage of approx. 6m x 4m, and require only 16A of 415V power supplies.

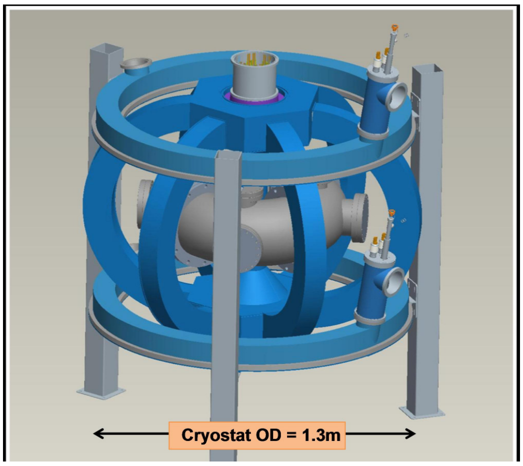
The purpose of the ST25 tokamak is twofold: first to provide a saleable table-top complete tokamak facility; and second, as the basis of the upgrade version, denoted ST25(HTS) in which the toroidal and vertical field coils will be replaced by HTS windings using YBCO and operated at ~20K. This will provide the possibility of steady-state operation.

Superconducting version: ST25(HTS)

The version of ST25(HTS) now under construction (in collaboration with Oxford Instruments) will have toroidal field of at least 0.4T and possibly higher, dependent on tests: the HTS (High Temperature Superconductor) toroidal field magnet, inside a 6-limb cryostat, will be the most complex HTS magnet yet constructed. Although the HTS tape becomes superconducting at liquid nitrogen temperatures (~77K), the ST25(HTS) tokamak is designed to operate at ~20K as this provides the advantages of much increased current capability, resilience from quenching, whilst heat removal is more efficient than at liquid helium temperatures (4K).



Cut view, omitting TF cryostat insulation (Oxford Instruments)



View of complete ST25(HTS)

The option of lithium injection is being developed for both copper and superconducting versions; lithium injection has been shown in other tokamaks to provide up to a six-fold increase in plasma energy confinement time. A dust injector is also under design, to provide studies of dust behavior in tokamak plasmas.

For further information on these tokamaks please contact technical director Alan Sykes
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