Control of density profiles during AT operation by CT fueling

- Equally applies to high beta, high bootstrap current fraction, non-inductive ST operation.

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Snowmass Summer Fusion Study

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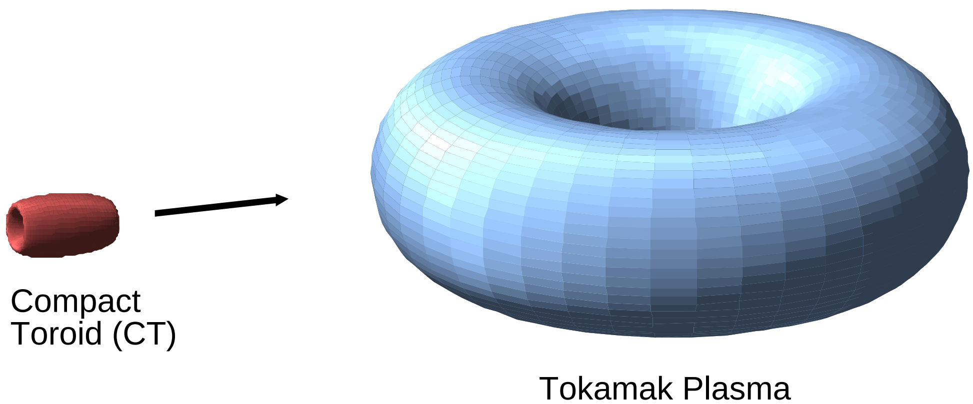
AT Operation

Under AT mode of operation, the fueling system must deposit small quantities of fuel at the desired location, but more frequently *without significantly altering the optimized density profile*.

CT Fueling



The CT injection concept has the potential to arbitrarily alter the CT mass and the fuel deposition location on each pulse as required by the control system (exactly what is needed for fueling AT discharges), but this technology is largely undeveloped.

Summary

- Excellent density profile control will enable AT discharges to reach their highest potential.

- A reactor relevant fueling system to control the density profile during AT operation does not exist.

- The CT injection concept has the potential to meet this need, but the technology is largely undeveloped.

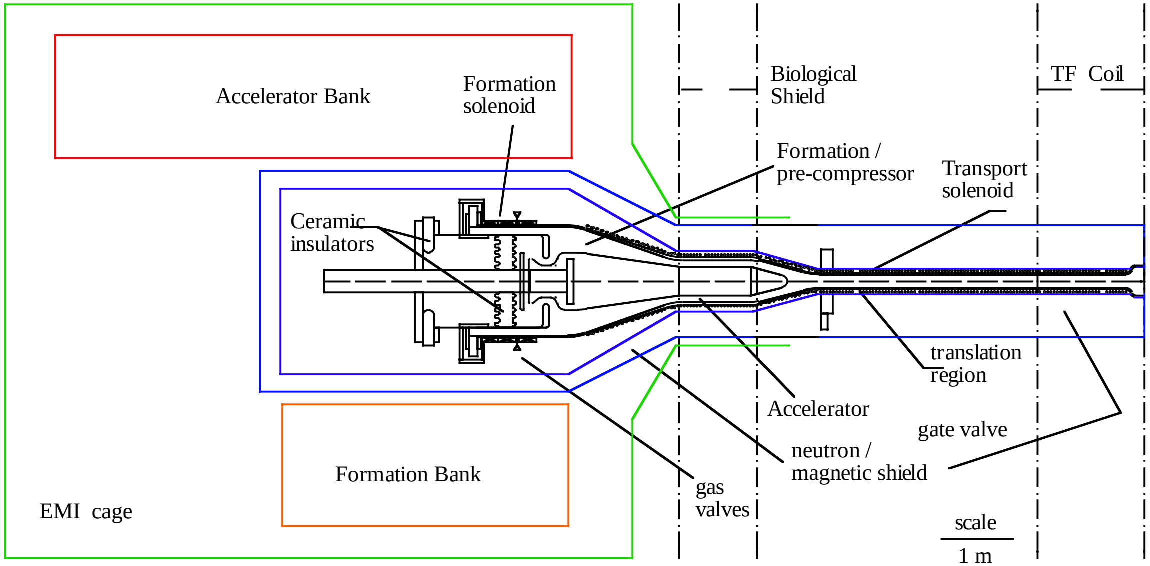
- The CT is also a source of momentum input, and so has the potential to sustain transport barriers (the α power is isotropic, so reactors will lose the benefit of directed NBI power).

- Other benefits include isotope tailoring of the injected fuel.

- Eventually in high Q, high bootstrap current fraction reactors, precision fueling will become the method of choice to control the fusion burn.

Conceptual CT Fueler design for ITER

CTF



R. Raman and P. Gierszewski, " ITER TASK D315 (1997): Conceptual design definition of a compact toroid injection system," CFFTP G-9729, September (1997), *Fusion Engineering and Design*, **39-40** (1998) 977-985.

ITER CT injector parameters

Number of injectors	1
CT radius	0.1 m
CT length	0.2 m
CT density (D+T)	9×10^{22} m^{-3}
CT mass	2.2 mg DT (2.6 T_2)
N_{CT}/N_{ITER}	0.3%
Fuelling rate (D+T)	5.3×10^{20}/pulse
Fuelling frequency	Up to 20 Hz
CT injection speed	300 km s^{-1}
CT kinetic energy	100 kJ (120 T_2)
Fraction of gas trapped in CT	75%
Fraction of gas leaked to Tokamak	25%
Formation section r/L (m)	0.75/2
Accelerator section r/L (m)	0.30/2
Transport section r/L (m)	0.1/5
Total CT injector length (m)	12
Total power consumption	8 MWe (10 T_2)

Present tokamak experiments too small to study localized deep fueling

CTF