Nuclear Fusion and Plasma Physics - Exercises

Prof. A. Fasoli - Swiss Plasma Center / EPFL

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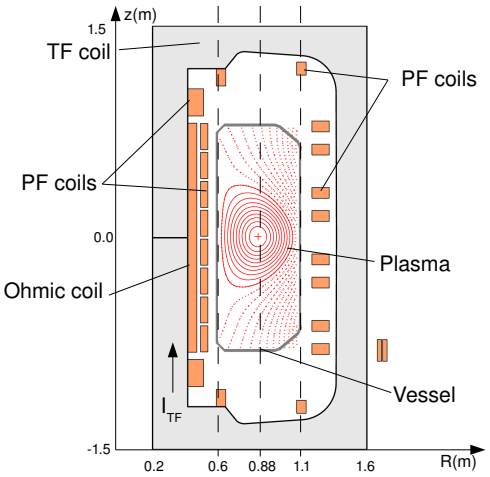
Exercise 1 - Some parameters of the TCV tokamak

The TCV tokamak (located at SPC, here in the EPFL campus) has a maximum toroidal magnetic field on axis of $B_T = 1.5\,\mathrm{T}$. This field is created by 16 water-cooled copper toroidal field coils, each one containing 6 windings. The major radius of the device is 0.88m.



a) Calculate the current through each winding of the toroidal field coils required to sustain this magnetic field.

b) Estimate the total stored energy in the TCV magnetic field. Remember that the energy density of a magnetic field is $u = \frac{B^2}{2\mu_0}$.

c) The field is created by ramping the current in the TF coils to their nominal value in 1 s. Estimate the power required for this.

d) The vertical field necessary to obtain the radial force balance is in the order of 1T. Estimate the Lorentz force at the top and bottom section of each of the 16 Toroidal field coils. How are these forces oriented?

e) The TF coils are all connected by horizontal support bars, both at the top and at the bottom, forming a unique structure. Estimate the twisting moment (with the torque vector in the vertical direction) created by these Lorenz forces on the coil structure.

To sustain these forces, the tokamak is surrounded by 8 supports arranged in a triangular structure (see picture). Estimate the minimum diameter of the supports. Assume they are made of steel with a yield stress $\sigma_{yield} = 300\,\text{MPa}$. Remember that $\sigma = \text{Force}/\text{Area}$.