# An initial study of demountable high-temperature superconducting toroidal field magnets for the Vulcan tokamak conceptual design

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Recent developments have made it possible to consider high-temperature superconductor (HTS) for the design of tokamak toroidal field (TF) magnet systems, potentially influencing the overall design and maintenance scheme of magnetic fusion energy devices. Initial assessments of the engineering challenges and cryogenic-dependent cost and parameters of a demountable, HTS TF magnet system have been carried out using the Vulcan tokamak conceptual design ($R = 1.2$ m, $a = 0.3$ m, $B_0 = 7$ T) as a baseline. Jointed at the midplane to allow vertical removal of the primary vacuum vessel and routine maintenance of core components, structural D-shaped steel support cases provide cryogenic cooling for internally routed YBCO superconducting cables. The cables are constructed by layering ~50 μm thick commercially available YBCO tape, and the interlocking steel support cases self align during assembly to form internal resistive joints between YBCO cables. It is found that designing the TF magnet system for operation between 10 K and 20 K minimizes the total capital and operating cost. Since YBCO is radiation-sensitive, Monte Carlo simulation is used to study advanced shielding materials compatible with the small size of Vulcan. An adequate shield is determined to be 10 cm of zirconium borohydride, which reduces the nuclear heating of the TF coils by a factor of 11.5 and increases the YBCO tape lifetime from two calendar years in the unshielded case to 42 calendar years in the shielded case. Although this initial study presents a plausible conceptual design, future engineering work will be required to develop realistic design solutions for the TF joints, support structure, and cryogenic system.

**Motivating background**

Start with something that everyone in your audience cares about. The background should provide context for your problem or knowledge gap.

**Problem statement or knowledge gap**

What central question are you trying to answer? Focus in on the specific need that your research addresses; this is the primary motivation for your work.

**“Here we show…”**

State what you specifically did to solve the problem. Example statements might include: “We simulated/measured XYZ…”

**Results**

Briefly summarize your main results or conclusions that address the problem statement or knowledge gap. You can include key data but save the fine details for the main document.

**Implications**

Explicitly state the implications of your findings by linking back to the motivating background. What impact do your findings have on this area of research? Try to answer “so what?” and “now what” questions.