A case for a facility to rapidly advance the CT concept (spheromaks and FRCs) as a backup DEMO

by

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to

FESAC ITER-DEMO planning panel
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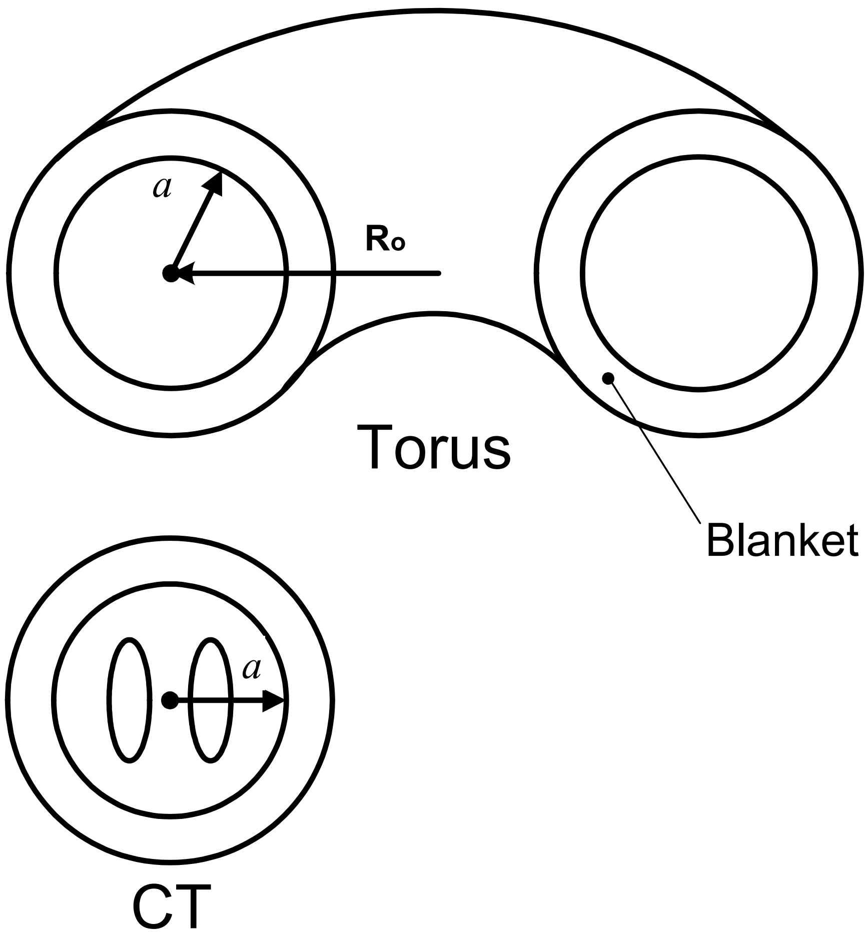
Outline

- Need for CT backup
- Advantage of simply connected
- CT and Tokamak paths to DEMO
- Recent progress
- Taking advantage of advances in computer technology
- Summary

Commercialization of a tokamak based DEMO needs a CT backup

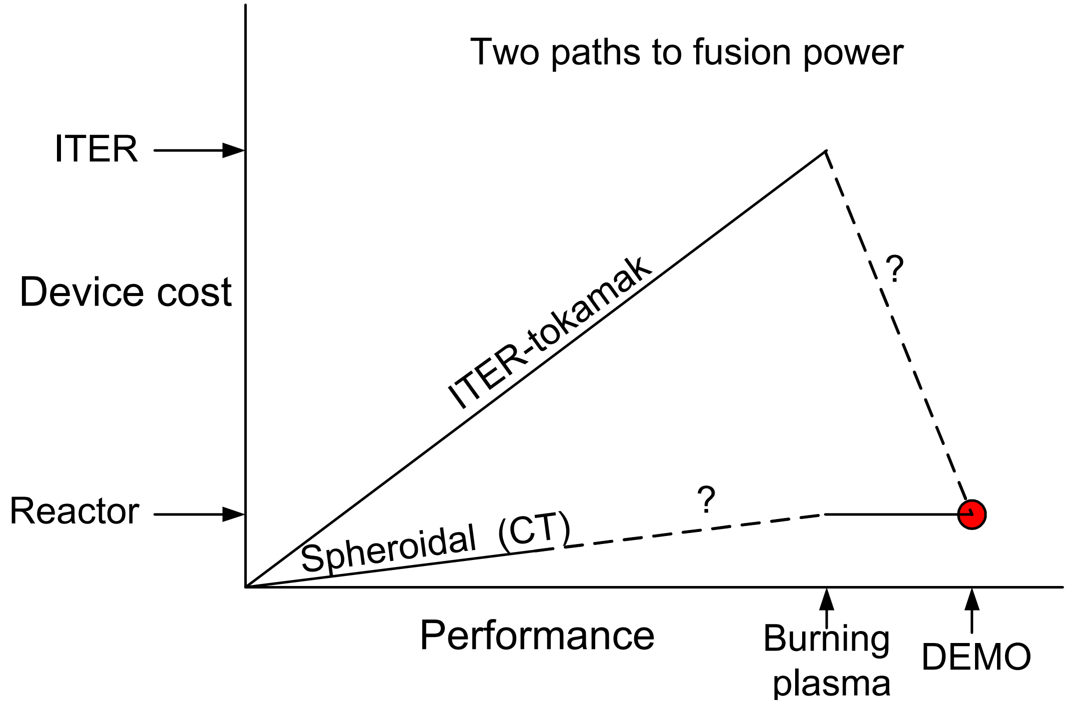
- Industry has not shown interest in the tokamak based reactor even though we have a great deal of the science in hand. DEMO will be difficult.
- The CT concept presently has considerable private investment.
- Simply connected is a **large** advantage.
- **A facility with PoP level diagnostics, heating, and neutral beams is needed to rapidly develop CT concepts**
- The USA is the world leader in CT research: we need to keep this position

Simply connected is a large advantage



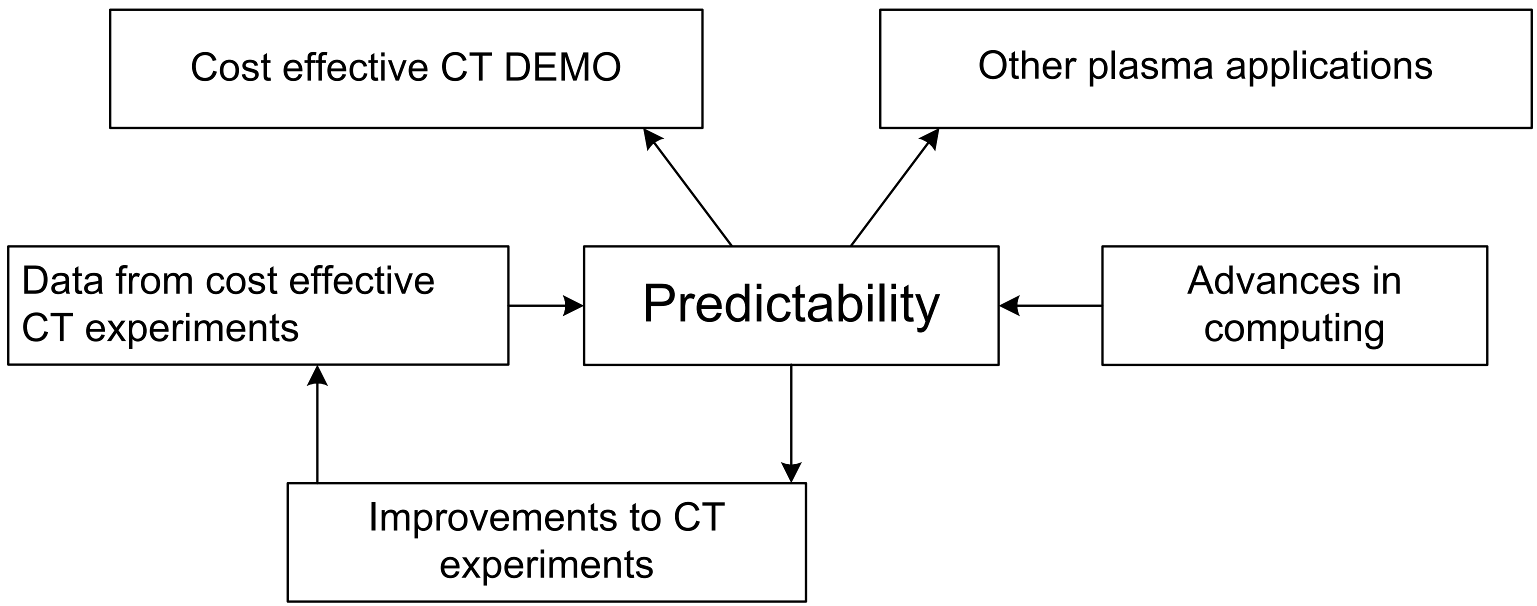
- The optimum size of a reactor has: $a \gtrsim$ thickness of the blanket, shield and coil. Assume $a = 3$ m for both.
- For $R_o = 2a$ and $P_{thermo} \cong 2.0$ GW
    - Torus wall loading $\cong 2.5 MWm^{-2}$
    - CT wall loading $\cong 15 MWm^{-2}$
    - Area ratio $\cong 6$
    - Vol. ratio $\cong 10$
- Reduces capital cost by a factor of 10 compared to tokamak [Hagenson R. L. and Krakowski R. A., Fusion Technol. **8**,1606 (1985).]

Gaps in the low cost path to Demo need to be closed *in addition* to closing the gaps in the tokamak path to Demo



- The research gaps are shown by the dashed part of each path.

Closing the gaps in the low cost CT path will be knowledge-led through comprehensive predictive modeling of whole experiments



- Advances in computers is the enabling technology
- Success gives the USA a competitive edge in fusion energy and plasma science technology

Progress with CTs justifies the facility

- Recently, steady-state inductive methods have formed and sustained both spheromaks (30kA) and FRCs (100kA) (invited talks at up coming APS/DPP)
- High power pulsed formation methods have produced spheromaks with T_e = 0.5 keV, and FRCs with T_i = 1.5 keV.
- Recent experiments, theory, and numerical calculations have shown many avenues (minimum-energy states, rotation, kinetic particles, RMF pondermotive forces) for achieving full stability, even in FRCs.
- Use of ultra high vacuum (UHV) techniques, have resulted in low input power steady-state CTs with $T_e > 100$ eV and overall confinement improving rapidly with temperature.

Summary

- The “commercially attractive” feature for the tokamak DEMO is not certain and a backup is needed.
- The CT advantage of being simply connected makes possible a major improvement that might be enough for an attractive DEMO if the tokamak fails to be attractive enough.
- Improvements in vacuum and wall conditioning have led to major advances in steady-state-CT research. A facility is needed where additional known technologies such as neutral beams can be applies for further advancement.
- Increased support of the CT will provide a possible breakthrough bridge to a commercially attractive DEMO and keep the USA the world leader in CT research.