CTFusion

Steady-state spheromaks for the pursuit of economical fusion power

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Problem

We need clean, safe, and reliable energy sources to displace those harmful to people and the environment.

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Solution

Fusion is a revolutionary energy solution, provided it is ***economically attractive***.

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The CTFusion approach to economical fusion

- Simpler, compact fusion reactor design.
- More plasma current, fewer expensive superconducting coils.
- Uses breakthrough plasma current sustainment technology.

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Enabling Technology

1. Use spheromak for a simpler, more compact fusion reactor.

2. Use Imposed-dynamo current drive (IDCD) for efficient sustainment of plasma current in stable spheromaks.

Both synergistic technologies enable economical fusion power.

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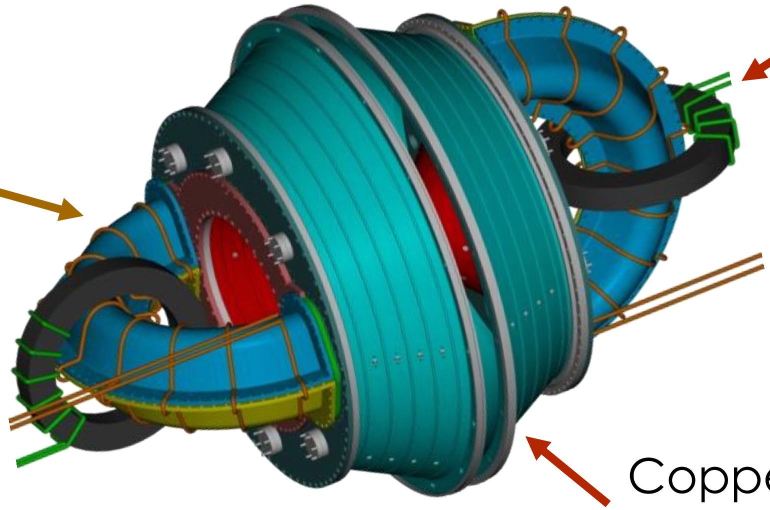
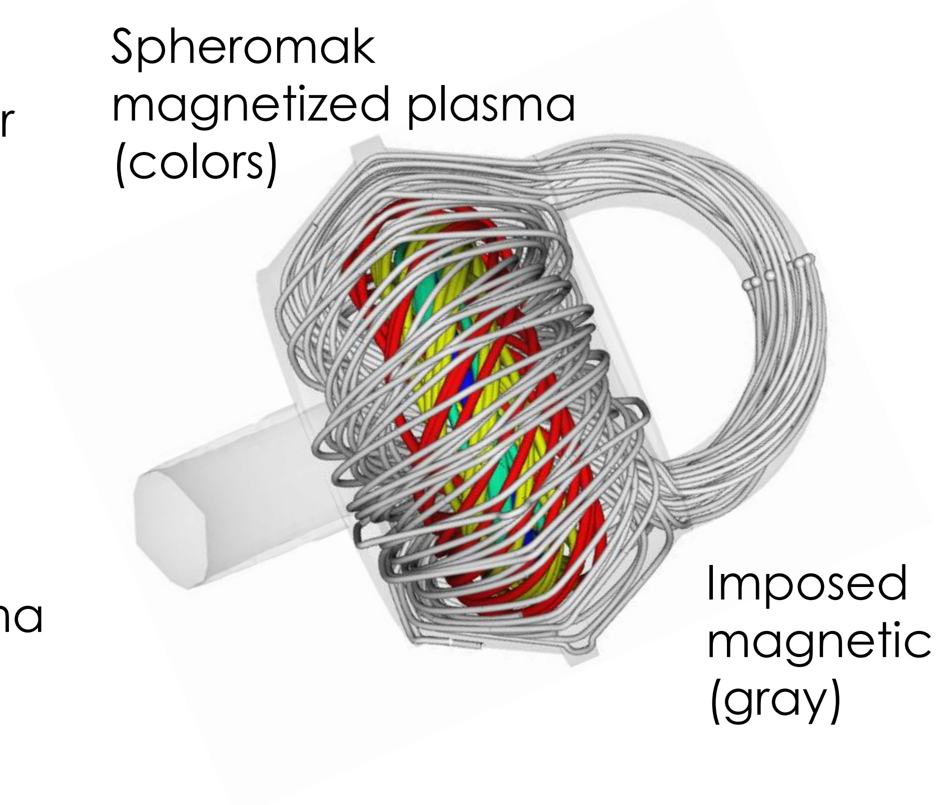
Gen I Prototype

- IDCD has been demonstrated at 1/10 commercial scale in Gen I Prototype at University of Washington (UW).





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Key actions for performing IDCD

1. Driving the plasma current near the plasma chamber wall

2. While imposing oscillating magnetic perturbations

Both actions must be performed simultaneously to sustain stable spheromak plasmas

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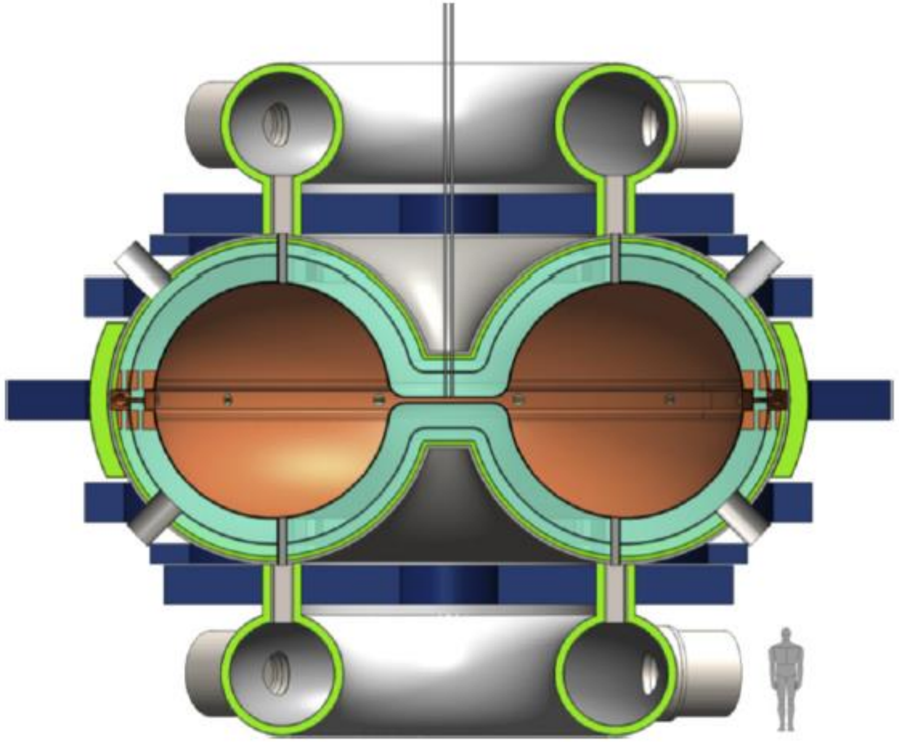
Dynomak reactor vision



Key Reactor Vision Features

Deuterium-Tritium (DT) fusion fuel
Steady-state operation
IDCD for plasma current sustainment
Molten-salt (FLiBe) liquid blanket
1000 MW-electric design point
≈$2,800/kW capital cost in 2016 USD

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Competitive Advantage

- CTFusion uses a well-developed approach to fusion: deuterium-tritium (DT) magnetic fusion energy (MFE).
- CTFusion applies the breakthrough plasma sustainment technology of IDCD to DT MFE, allowing for the use of a spheromak.
- CTFusion's approach to fusion power has low technical risk <u>and</u> maintains economic competitiveness.

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CTFusion's fusion approach is situated in a similar plasma regime as mainline MFE concepts, but has low reactor costs

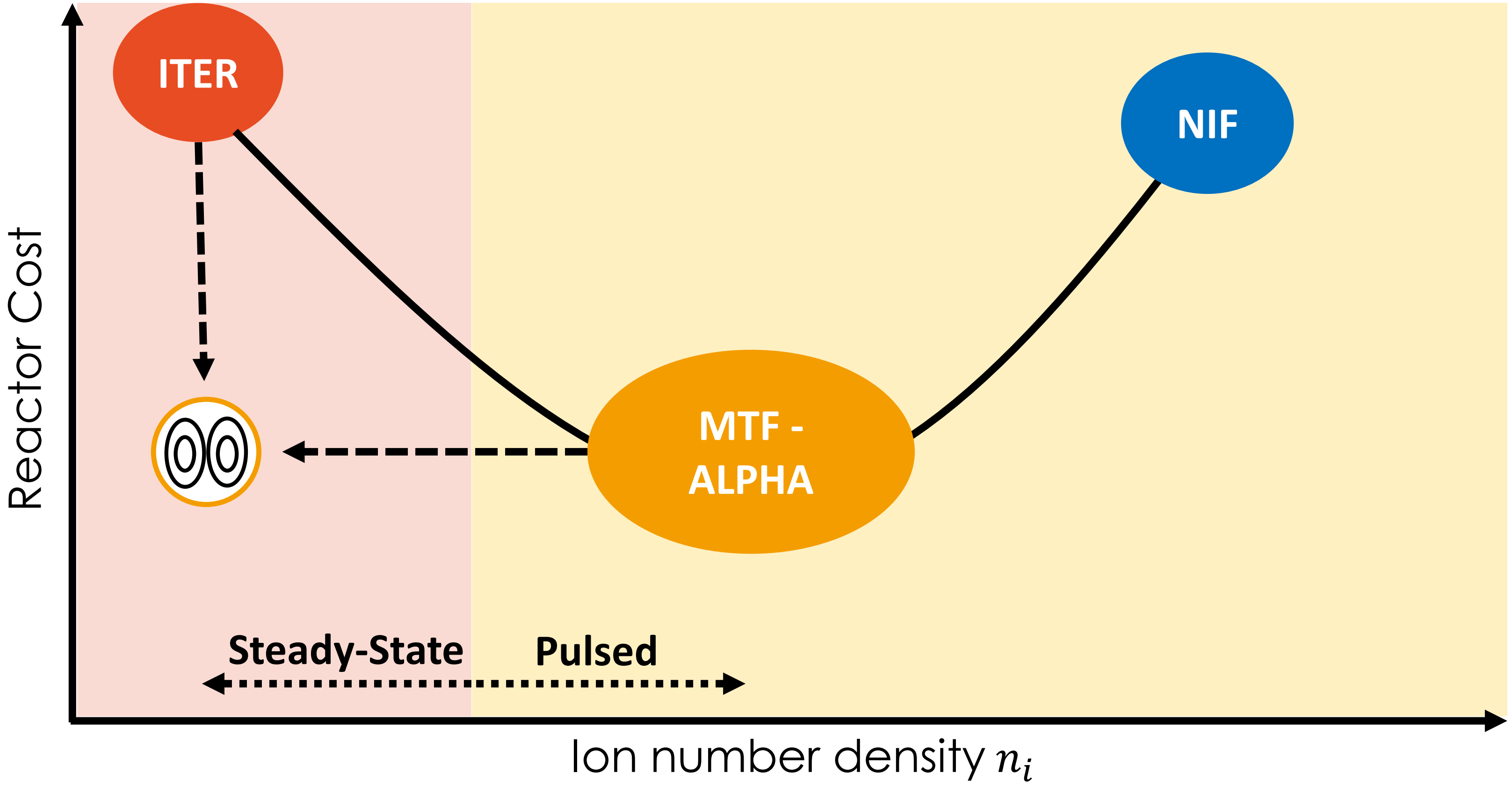

Figure paraphrased from Dr. Patrick McGrath's 2016 ARPA-E ALPHA Meeting talk

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Primary market segment: heat for electricity generation

Product: Low-cost fusion power cores

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Heat for electricity
Robust market
Strong Demand
Forecasted Growth
Multi-B$ Industry
No energy storage required

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Additional Market Segments

Secondary Segment

Neutrons for cleanup
Limited market
Potential Growth
Government Run
Regulatory challenges
Eliminates fission waste

Tertiary Segment

Deep-space propulsion
New market
Potential Growth
Earth-Mars travel
Outer solar system travel
Interstellar travel

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Research and development needs

- CTFusion must demonstrate plasma driver technology in an optimized reactor geometry.
- CTFusion must demonstrate high temperature (> 10,000,000 °C) plasma sustainment with IDCD.
- CTFusion must demonstrate net fusion power production in a fully integrated fusion reactor system.

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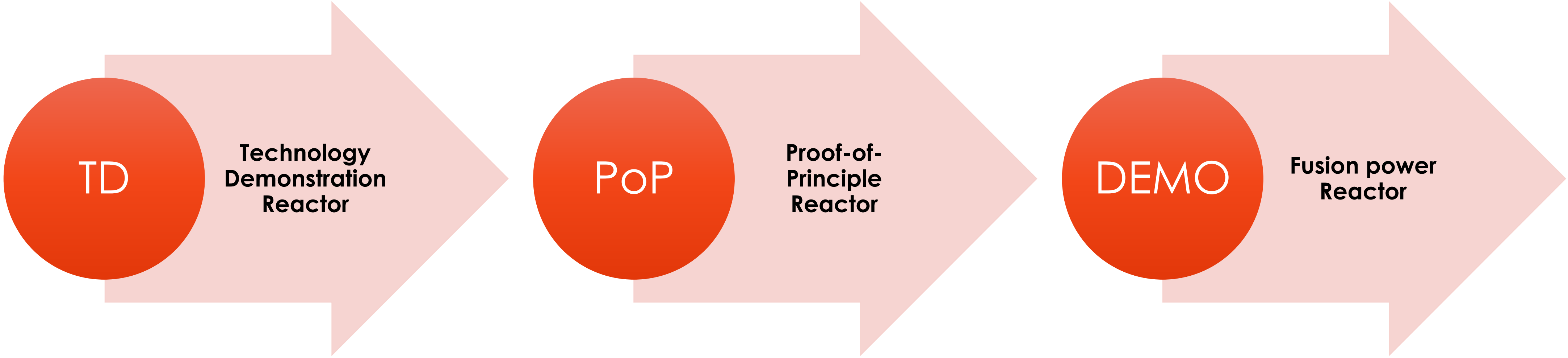
CTFusion development path



- Pulsed, no coil set.
- T_o ~ 100s of eV

Informs optimal size and geometry of PoP.

- Pulsed, with Cu coil set.
- T_o ~ 1-3 keV

Informs optimal size and material choices for DEMO.

- Steady-state, SC coils
- T_o ~ 8-15 keV

Test materials, desired end product demonstration.

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Management Team

- **Derek A. Sutherland, Co-Founder and CEO of CTFusion**
  - B.S. double major from MIT in Nuclear Engineering and Physics
  - Ph.D Candidate at University of Washington
  - Forbes 30 under 30 in Energy for 2015.
  - Experience working on various public and private fusion ventures.

- **Thomas R. Jarboe, Co-Founder and President of CTFusion**
  - Leader in the development of spheromak confinement devices since the 1980s.
  - Funded by the DOE for 27 years at ~ $1M/year.
  - Discovered and patented Imposed-Dynamo Current Drive (IDCD) in 2012.

- **Aaron C. Hossack, CTO of CTFusion**
  - Ph.D from the University of Washington.
  - Lead experimentalist in charge of operations with over 10 years experience working on all aspects of the Gen I reactor.

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Timeline of R&D and business activities

- Proto-HIT experiment from 1989-1993 at UW
- HIT experiment from 1993-1997 at UW
- HIT-II experiment from 1998-2004 at UW
- HIT-SI operated from 2004-2012 at UW

- 2011-2012: Imposed-Dynamo Current Drive (IDCD) discovered, patented, and published at UW.
- 2013-2014: Dynomak reactor vision created, patented, and published at UW.
- 2015: CTFusion formed in Seattle, WA.
- HIT-SI3 currently operating at the UW
- 2017-2018: First private fund raising round.

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Intellectual property

- Three patents have been filed that are held by the University of Washington (UW).
- CTFusion has exclusive rights to these patents through a licensing agreement with the UW.
- Any additional IP created by the company is exclusively owned by the company.

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Financial

Next step in development path is TD, which will require $10-15M total investment distributed over 3 years.

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Key press releases and publications

Press

- https://phys.org/news/2014-10-uw-fusion-reactor-concept-cheaper.html
- http://www.reuters.com/video/2014/12/10/cheap-clean-fusion-power-one-step-closer?videoId=347785484
- http://spectrum.ieee.org/energy/nuclear/inside-the-dynomak-a-fusion-technology-cheaper-than-coal

Publications

- A.C. Hossack, D.A. Sutherland, and T.R. Jarboe, *Phys. Plasmas* **24** (2017), http://dx.doi.org/10.1063/1.4975663
- T.R. Jarboe, B.A. Nelson, D.A. Sutherland, Phys. Plasmas **22** (2014), http://dx.doi.org/10.1063/1.4926522.
- D.A. Sutherland, et al., *Fus. Eng. Design* **89**, 4, 412-425 (2014), http://dx.doi.org/10.1016/j.fusengdes.2014.03.072.
- T.R. Jarboe, et al., *Nuc. Fus.* **52**, 8 (2012), http://dx.doi.org/10.1088/0029-5515/52/8/083017
- B.S. Victor, et al., *Phys. Plasmas* **21**, 8 (2014), http://dx.doi.org/10.1063/1.4892261.
- T.R. Jarboe, et al., *Phys. Plasmas* **22**, 7 (2015), http://dx.doi.org/10.1063/1.4926522.
- T.R. Jarboe, et al., *Fus. Sci. & Tech.* **66**, 3 (2014), http://dx.doi.org/10.13182/FST14-782.

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