tokamak energy

a faster way to fusion

Dr David Kingham

CEO, Tokamak Energy

IOP meeting on Nuclear Fusion

14 June 2017

Compact Tokamaks with High Temperature Superconducting Magnets

A new route to fusion power

Conventional tokamaks (eg JET)

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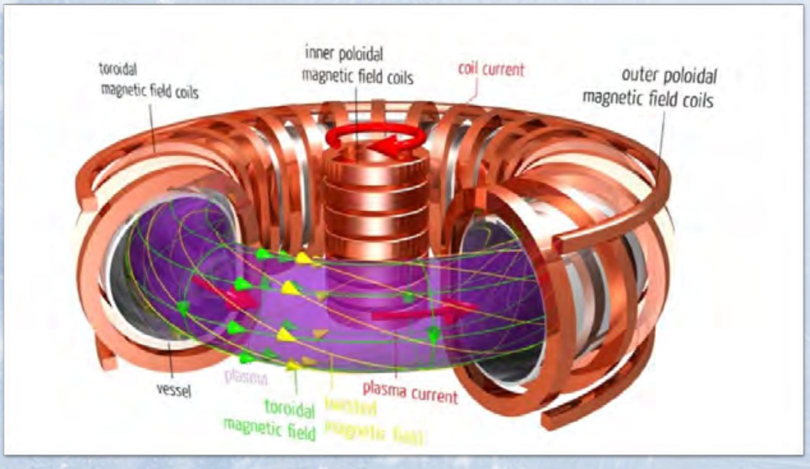
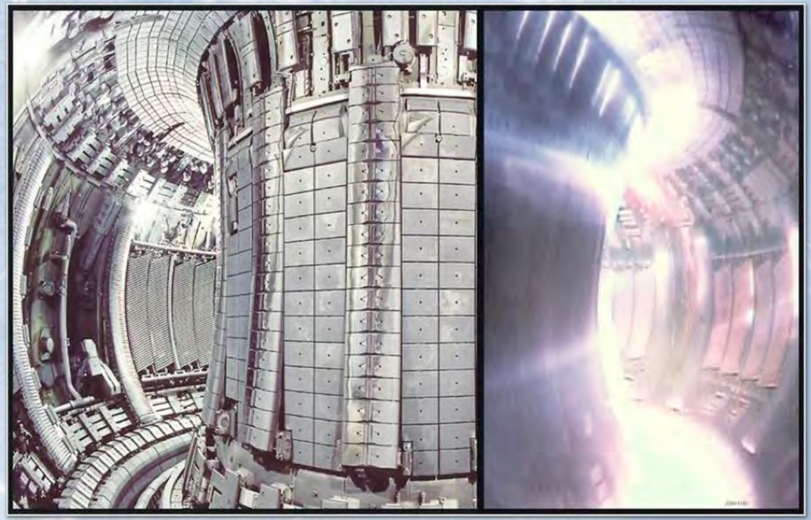
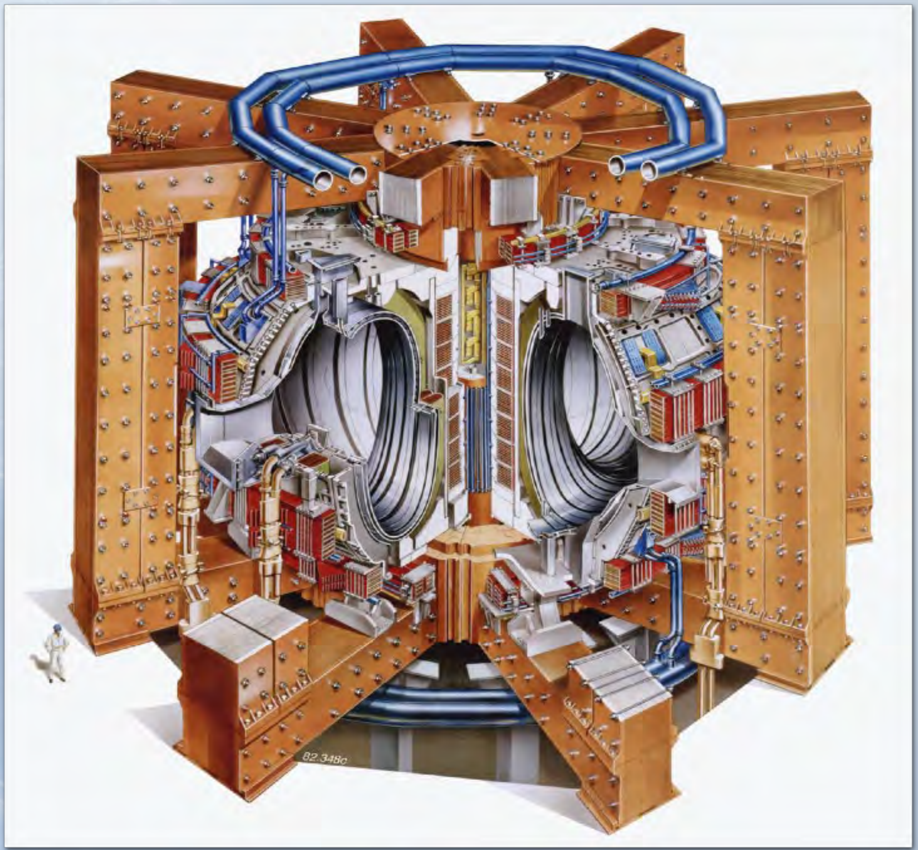




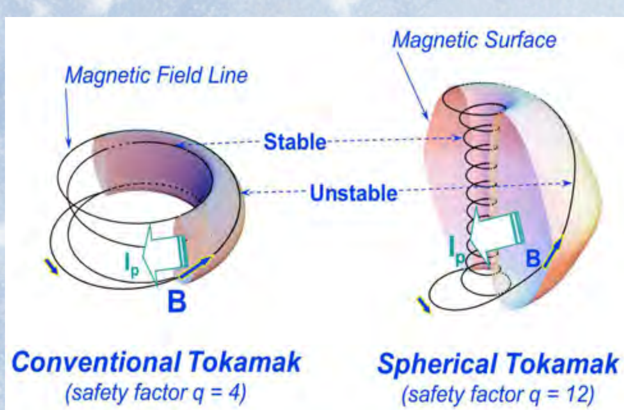


Spherical Tokamaks (ST)

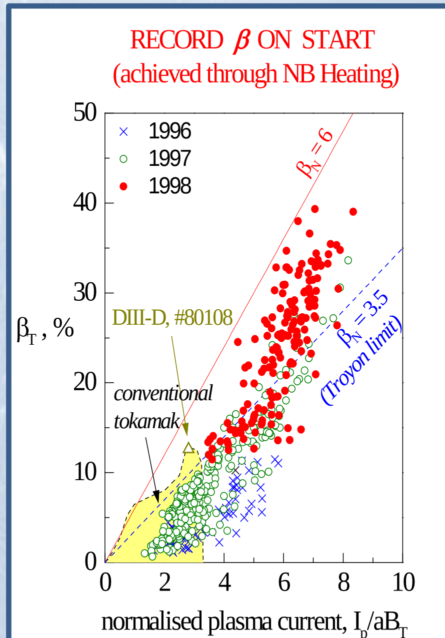
Some advantages of the ST

High bootstrap fraction

High safety factor

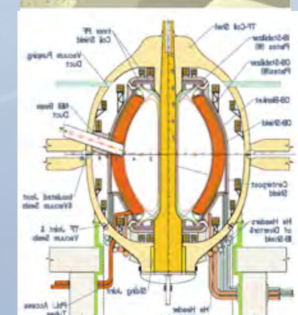


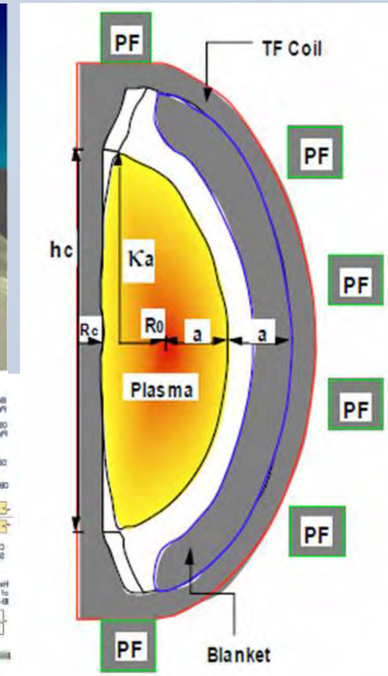
High beta (β)

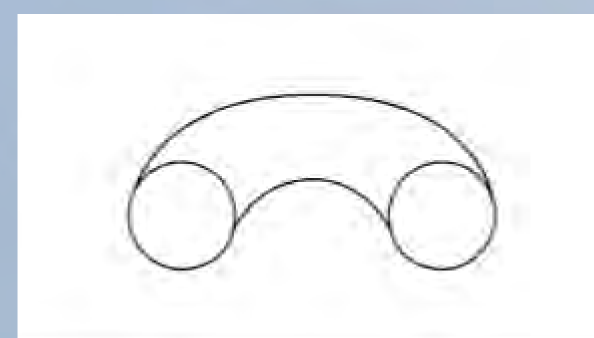


Plasma in START ST, Culham, 1996

ST Power Plant Concepts







The Technology

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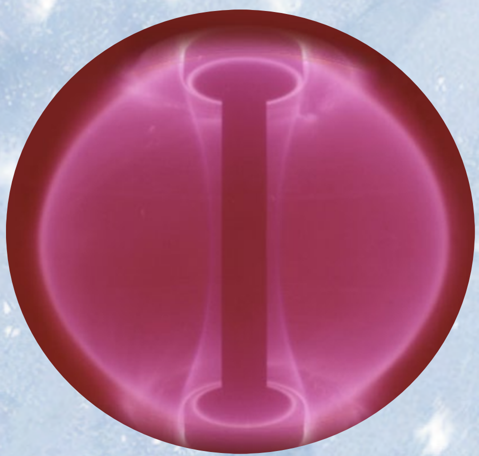
Spherical Tokamaks

Squashed shape

Highly efficient

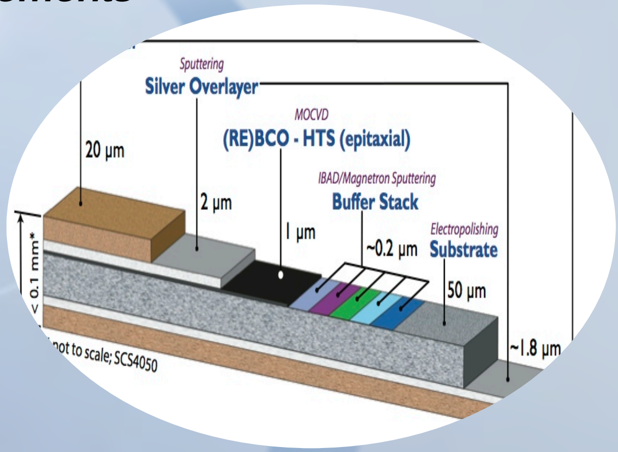
From 12% to 40% efficiency, β



High Temperature Superconductors

High current at high field

Lower cryogenic cooling requirements



smaller, cheaper, faster

High temperature superconductors

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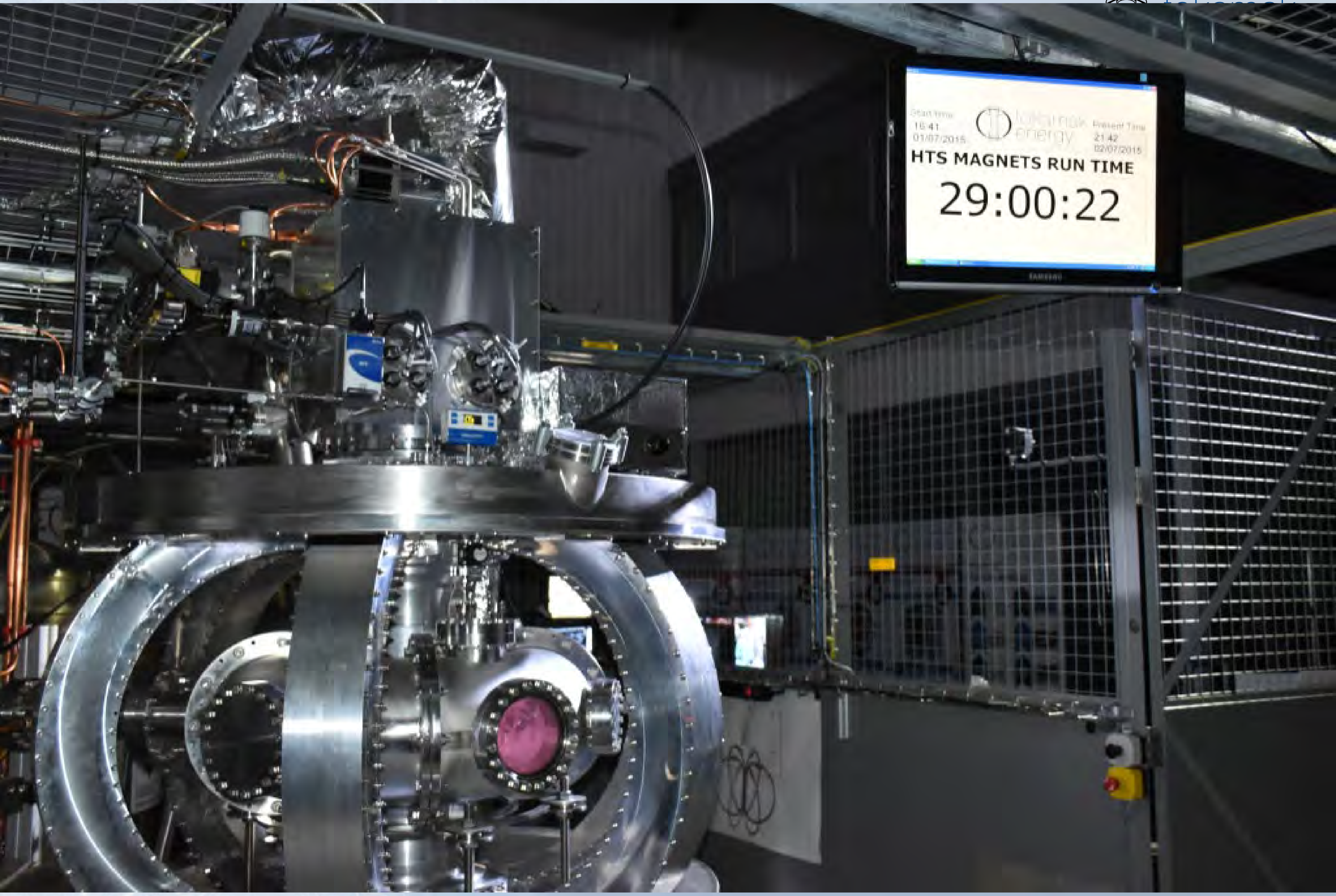
HTS MAGNETS RUN TIME
29:00:22

Top of the *Nuclear Fusion* charts!

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Fusion nuclear science facilities and pilot plants based on the spherical tokamak

J.E. Menard *et al* 2016 *Nucl. Fusion* **56** 106023

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Supporting Evidence

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PPPL PRINCETON PLASMA PHYSICS LABORATORY
A Collaborative National Center for Fusion & Plasma Research

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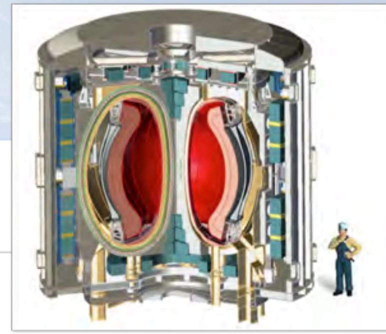


IAEA **nuclear fusion**

PAPER

Fusion nuclear science facilities and pilot plants based on the spherical tokamak

J.E. Menard[1], T. Brown[1], L. El-Guebaly[2], M. Boyer[1], J. Canik[3], B. Colling[4], R. Raman[5], Z. Wang[1], Y. Zhai[1], P. Buxton[6] Show full author list

Published 16 August 2016 • © 2016 IAEA, Vienna
Nuclear Fusion, Volume 56, Number 10

The ST concept investigated by NSTX-U can operate at high plasma pressure (which provides more fusion power) and at relatively weak magnetic field (which reduces cost) compared to conventional tokamaks. The practical impact is that this offers the possibility, for example, of designing a fusion pilot plant or fusion nuclear science facility of a size significantly reduced from that based on conventional tokamaks. A fusion pilot plant would generate net electricity and perform an integrated test of a full fusion energy system, including testing materials

Achievements

- Patent applications (HTS magnets)
- Private investment of £20M
- Designed ST40 spherical tokamak
- Established HTS magnet development team and laboratory
- Demonstrated a small tokamak ST25 1.0
- Demonstrated a second small tokamak will all HTS magnets
- World Economic Forum Technology Pioneer 2015



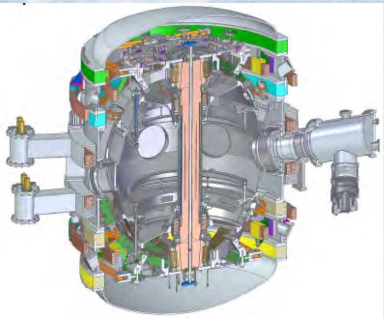

Milestones 2017-2019

ST40 tokamak demonstrations

First plasma	April 2017
15 million degrees	Q4 2017
100 million degrees	Q3 2018
Energy Gain conditions	Q2 2019

HTS magnet demonstrations

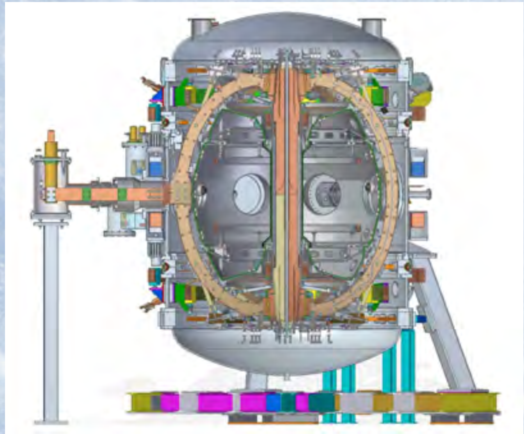
3 tesla prototype	Q4 2017
5 tesla prototype	Q3 2018
ST40 Toroidal Field magnet	Q2 2019

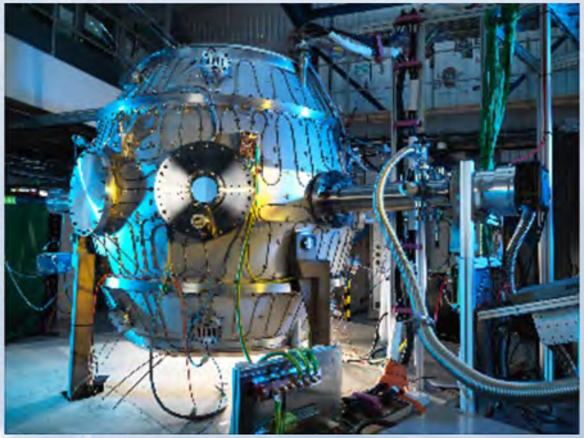


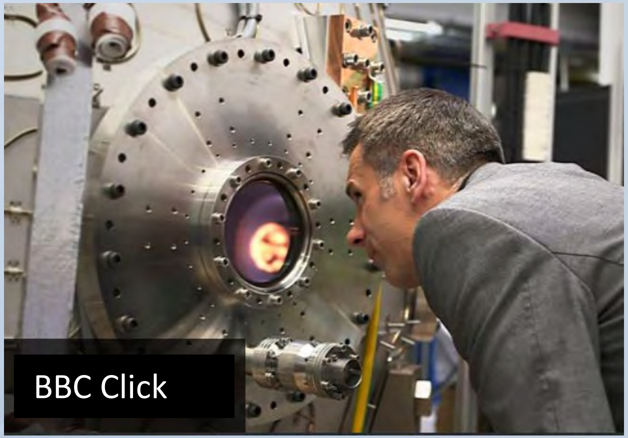
Complete validation of concept for the high field HTS spherical tokamak

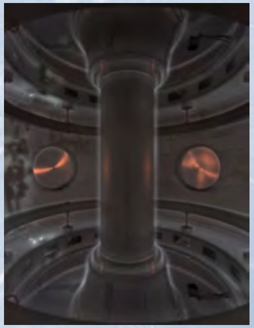
Ready to receive major investment (e.g. IPO)

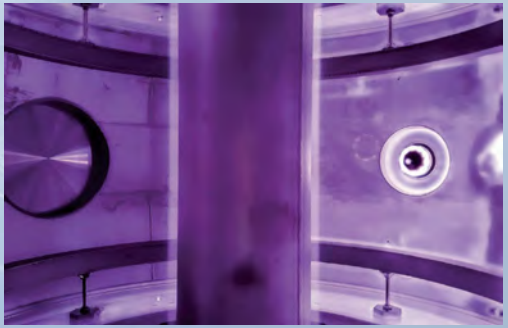
Recent Progress

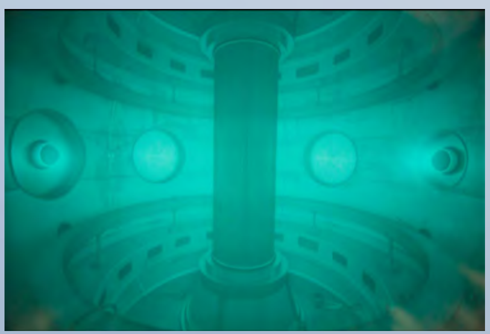












Breakthrough Energy Ventures

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Climate Impact
- technologies that have the potential to reduce greenhouse gas emissions by at least half a gigaton.

other investments
- companies with real potential to attract capital from sources outside of BEV and the broader Breakthrough Energy Coalition.

scientific possibility
- technologies with an existing scientific proof of concept

filling the gaps
- companies that need the unique attributes of BEV capital.

Why now?

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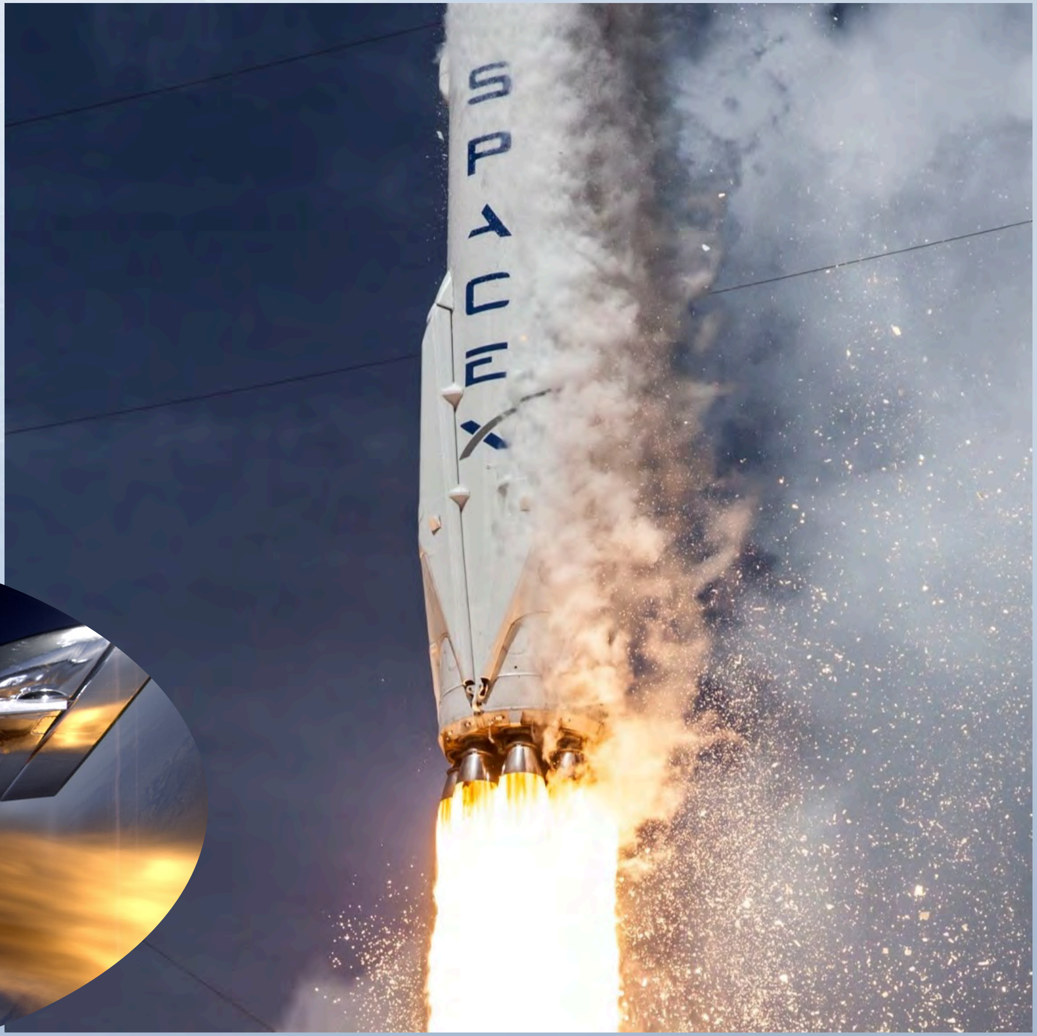

A few thoughts…

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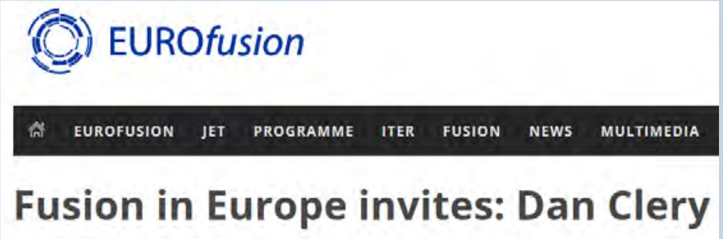
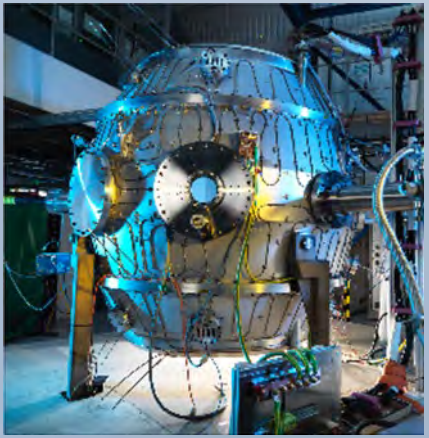
Does fusion research lack diversity?
Dan Clery, Dec 2014,
in Eurofusion News



The energy and initiative of the private companies could give fusion a much needed shot in the arm, and for them to take the next step towards viability they will need much more money, and could use support rather than disdain.

Perhaps in fusion, as in biology, diversity will promote health and vitality. And you never know, one of them might actually work.



A few more thoughts…

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Private fusion machines aim to beat massive global effort

Startups avoid ITER's path with new prototype reactors

Great balls of fire

Three startup fusion companies are challenging ITER, an over-budget and overdue public project.

NAME	LOCATION	TECHNOLOGY	STAFF	FUNDING	STATUS	TARGET TEMPERATURE
Tokamak Energy	Milton, U.K.	Spherical tokamak	35	$25 million	New ST40 device in 2017	100 million degrees Celsius
Tri Alpha Energy	Foothill Ranch, California	Beam-driven plasma rings	160	>$500 million	New C-2W device in 2017	30 million degrees Celsius
General Fusion	Burnaby, Canada	Target implosion	65	>$75 million	Prototype in 3–5 years	100 million degrees Celsius
ITER	Cadarache, France	Tokamak	2300	$20 billion	Under construction. First plasma in 2025	150 million degrees Celsius

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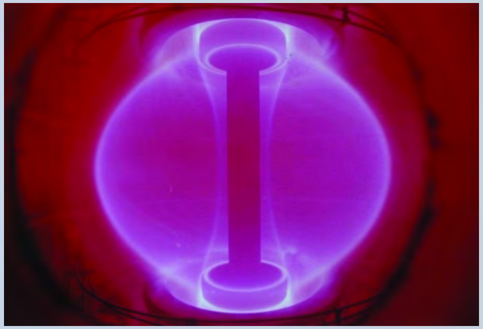
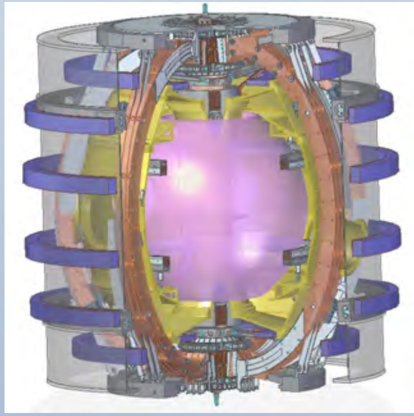
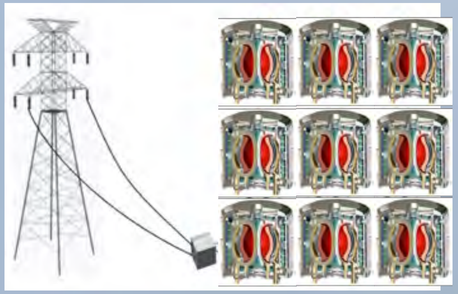
Summary

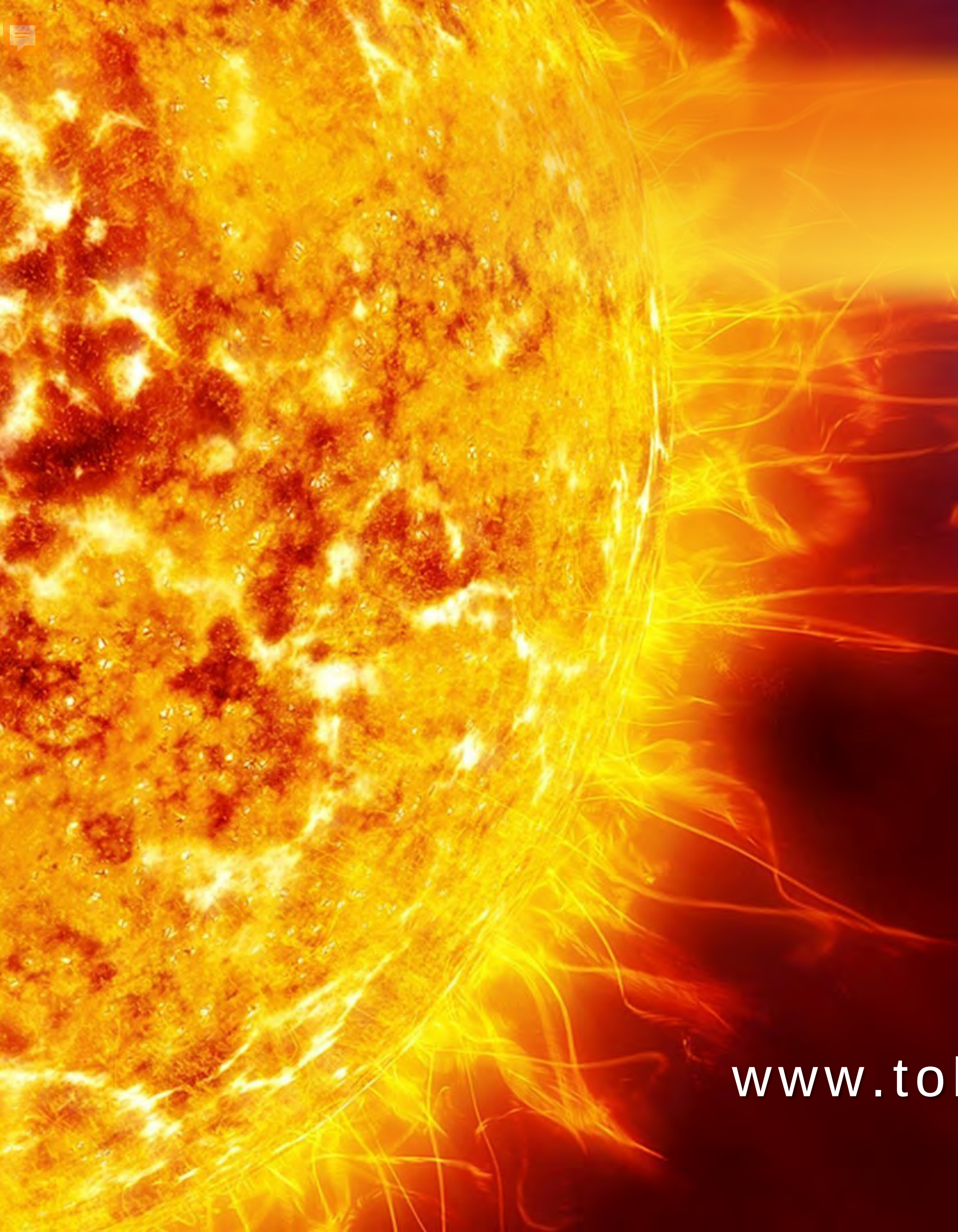
- Fusion energy is a goal worth pursuing!
  - Private investors are getting interested
  - We are the only venture developing tokamaks.
  - The evidence for our route to fusion is growing.

- Our clear goals will enable us to raise more investment.
- Early success will inject excitement into fusion
- And we will work with investors and partners to succeed









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Thank you

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