



tokamak  
energy

*a faster way to fusion*

**Fusion Power  
Associates Meeting**

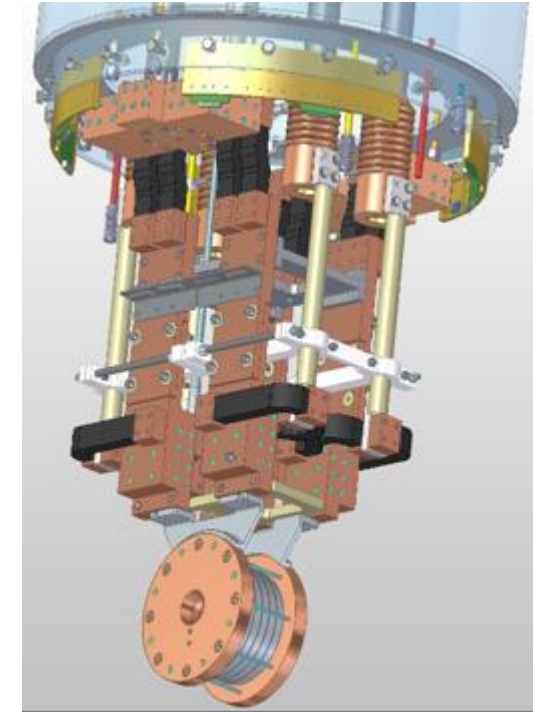
**David Kingham**

**December 2021**



# Tokamak Energy

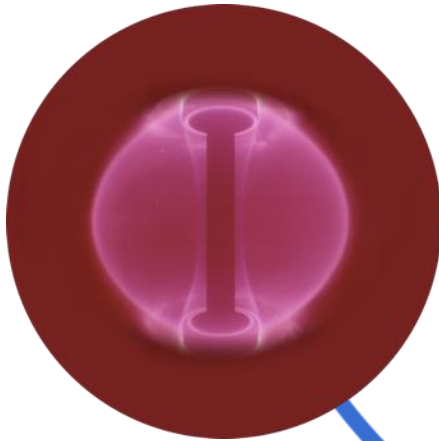
- Established in 2009 with a mission to accelerate development of fusion energy
- Private company - \$160m private investment
- Engineering centre near Oxford, UK
- Team of over 180
- Designed, built and tested 3 prototype tokamaks since 2012
- Pioneering high temperature superconducting magnet laboratory



# Two technologies unlock Commercial Fusion

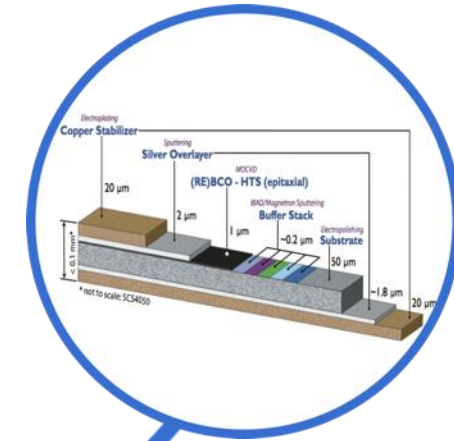
## Spherical Tokamak

Compact shape, highly efficient



## High Temperature Superconductors

High magnetic fields

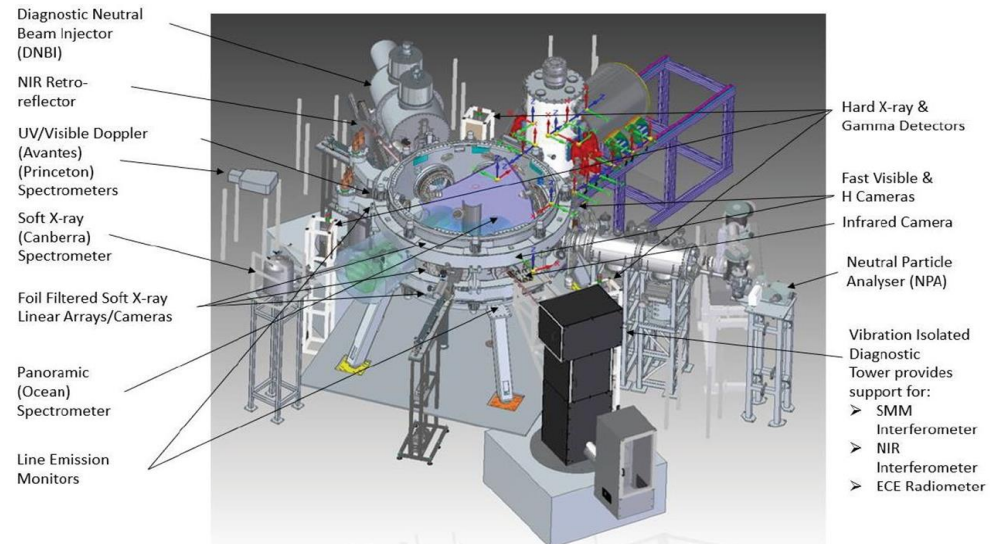
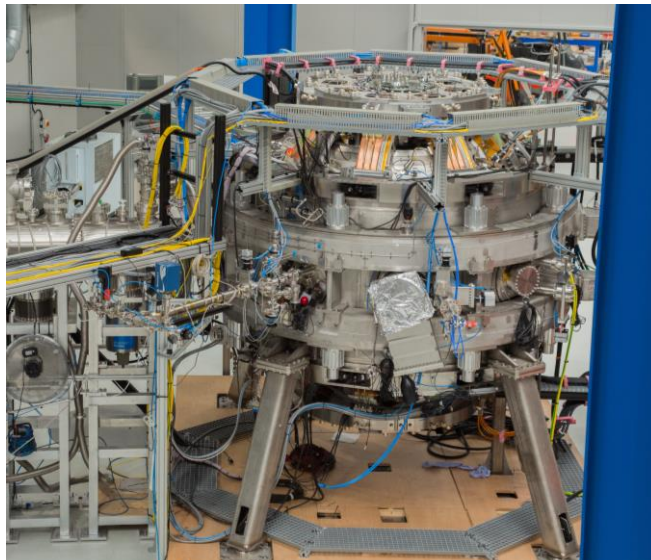
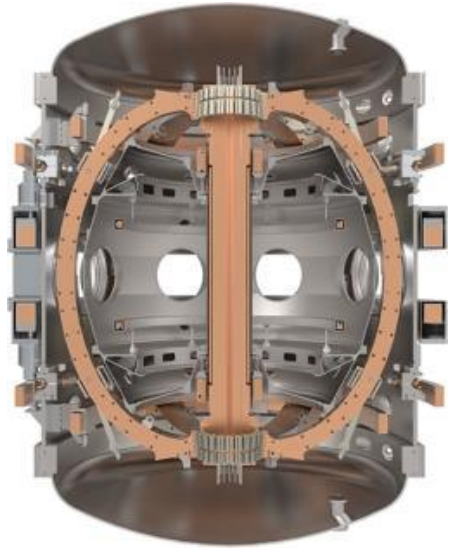


# Fusion Power

Smaller, cheaper, faster..... with distinct competitive advantage

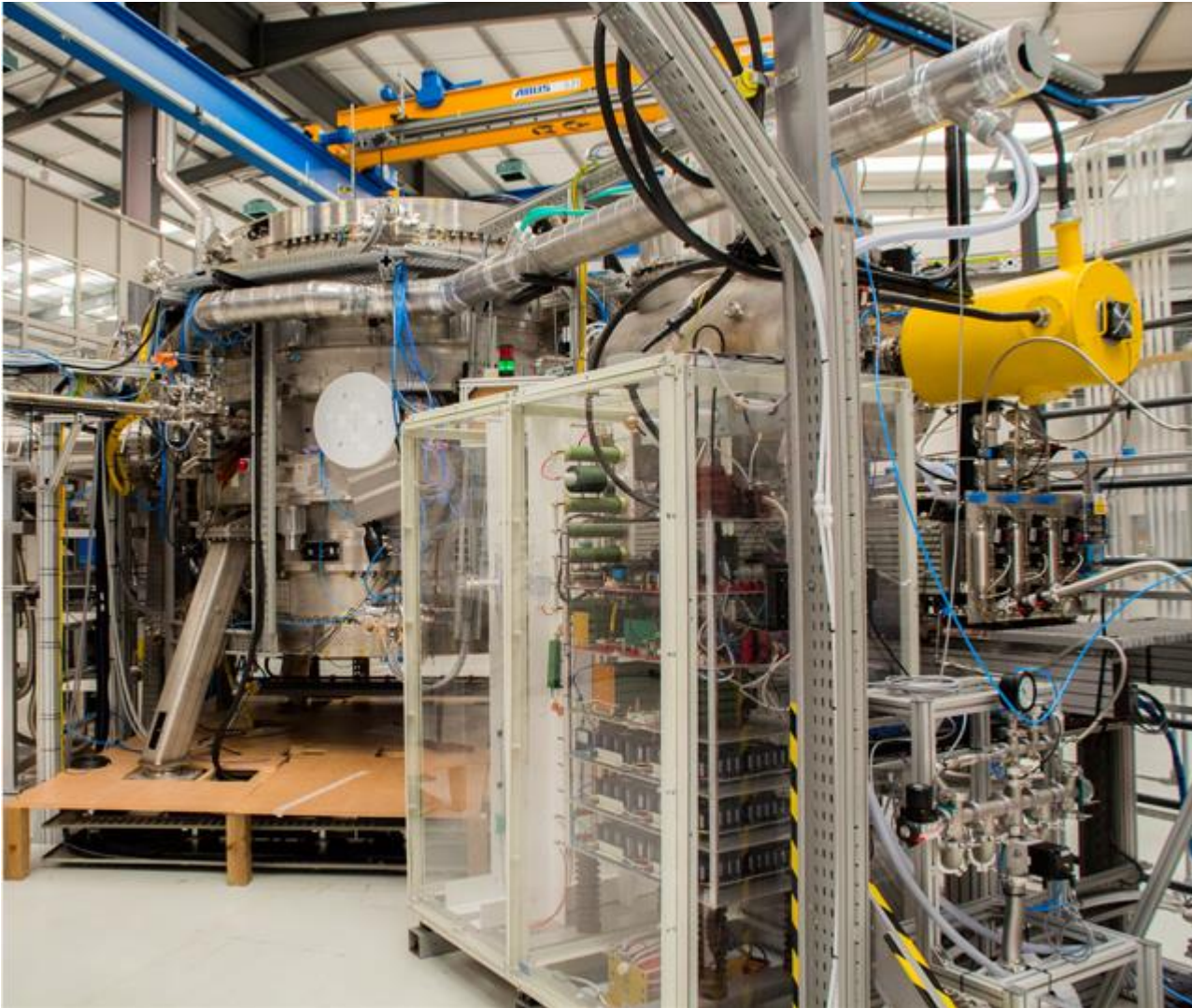


# ST40 – High Field Spherical Tokamak





# ST40 Latest Upgrade



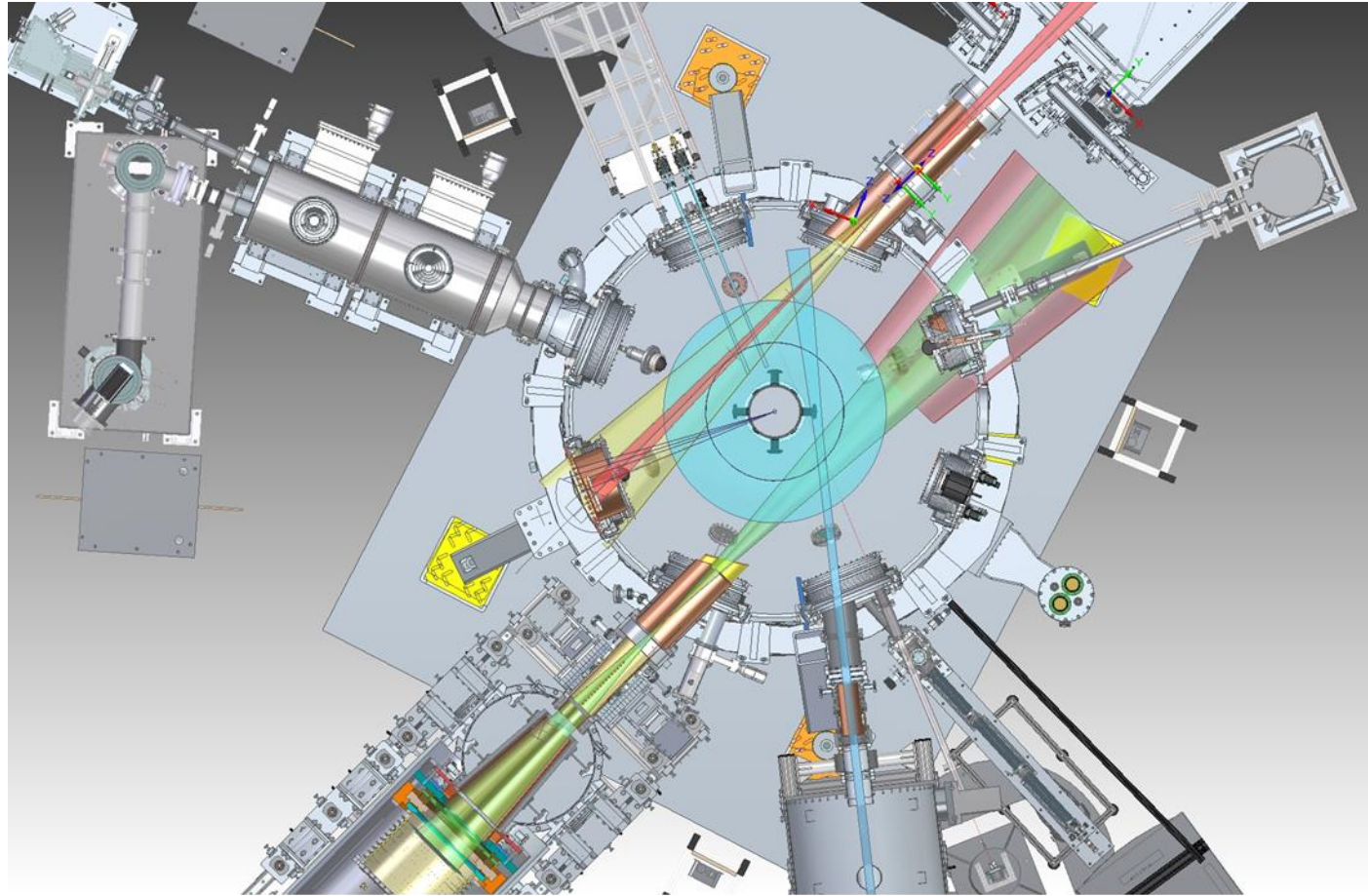


# ST40: Diagnostics

ST40 is now equipped with a comprehensive set of diagnostics to measure:

- *Equilibrium reconstruction + MHD analysis*
- *Electron density*
- *Electron and ion temperatures*
- *Rotation*
- *Impurity monitoring*
- *Radiated power*
- *Main chamber IR, visible and H-alpha cameras*
- *Fast ions*
- *Neutrons + Hard x-rays*

Planned upgrades: *TS (ne, Te) + divertor IR*



## **The ST40 high-field ST is operational**

$B_T=1.8-2.3T$ ,  $I_p=0.5-0.8MA$ ,  $P_{NB}\sim 1MW$

## **Diagnostics**

Comprehensive set of diagnostics installed with key improvements (TS + divertor IR) planned during upcoming shutdown

## **Rapid progress towards 100M°C milestone**

Preliminary results and integrated analysis suggest good progress towards this goal

## **Upcoming operations**

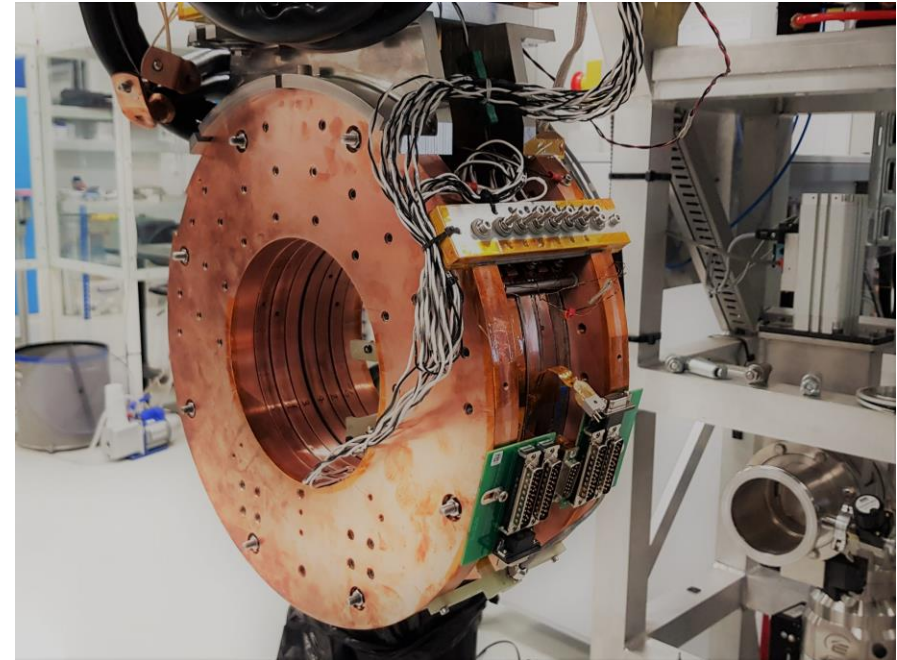
Further increases in toroidal field and deuterium operations planned

## Non-Insulated (NI) Coils



**>20 T HTS magnet @ 20 K.**  
Exceptional stability and robustness.  
Quench simulation tools verified.

## Partially Insulated (PI) Coils



Tunable turn-to-turn resistance  
Stable - Quench-free operation.  
Robust – forced quenches from full field cause no damage.



## Mission

*To build and test a full spherical tokamak magnet system*

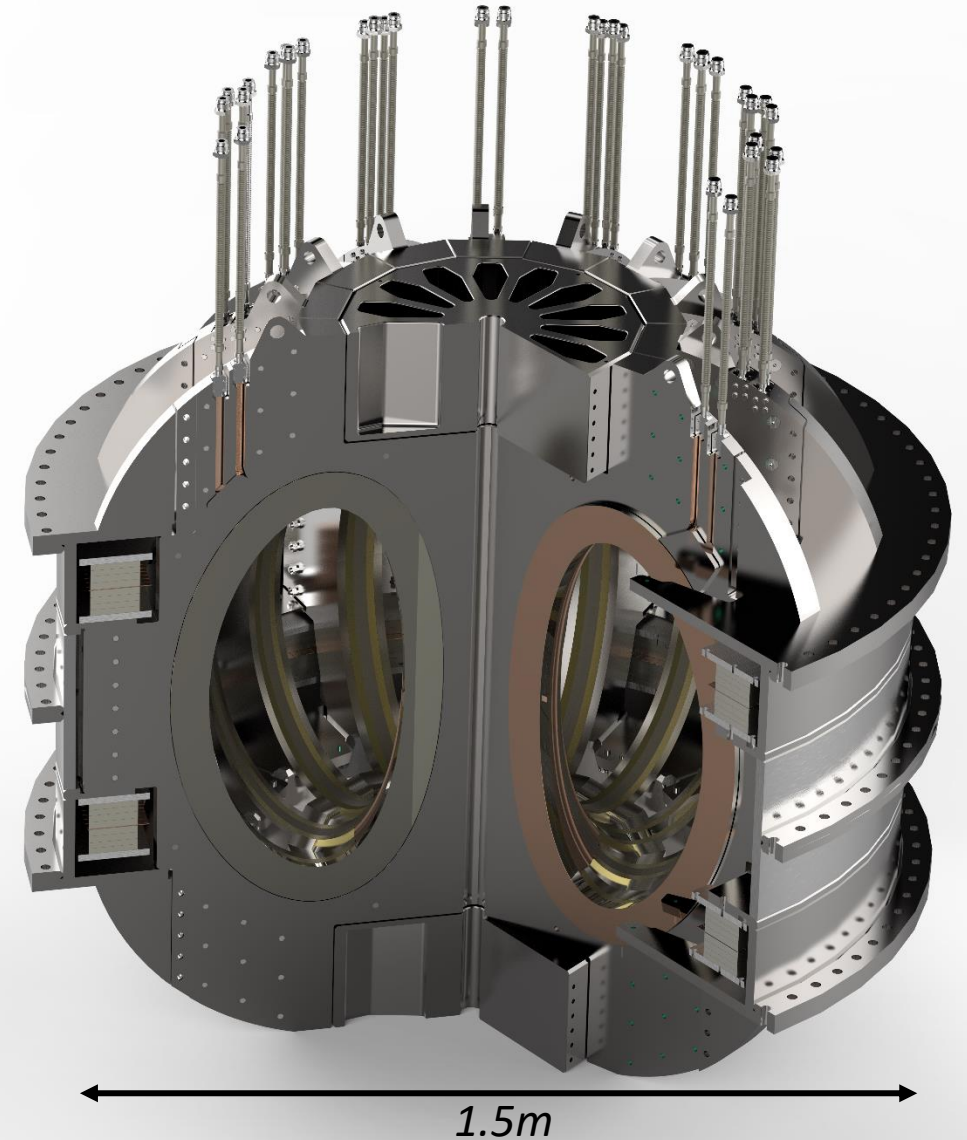
**Full-System Interactions**

**Manufacturing**

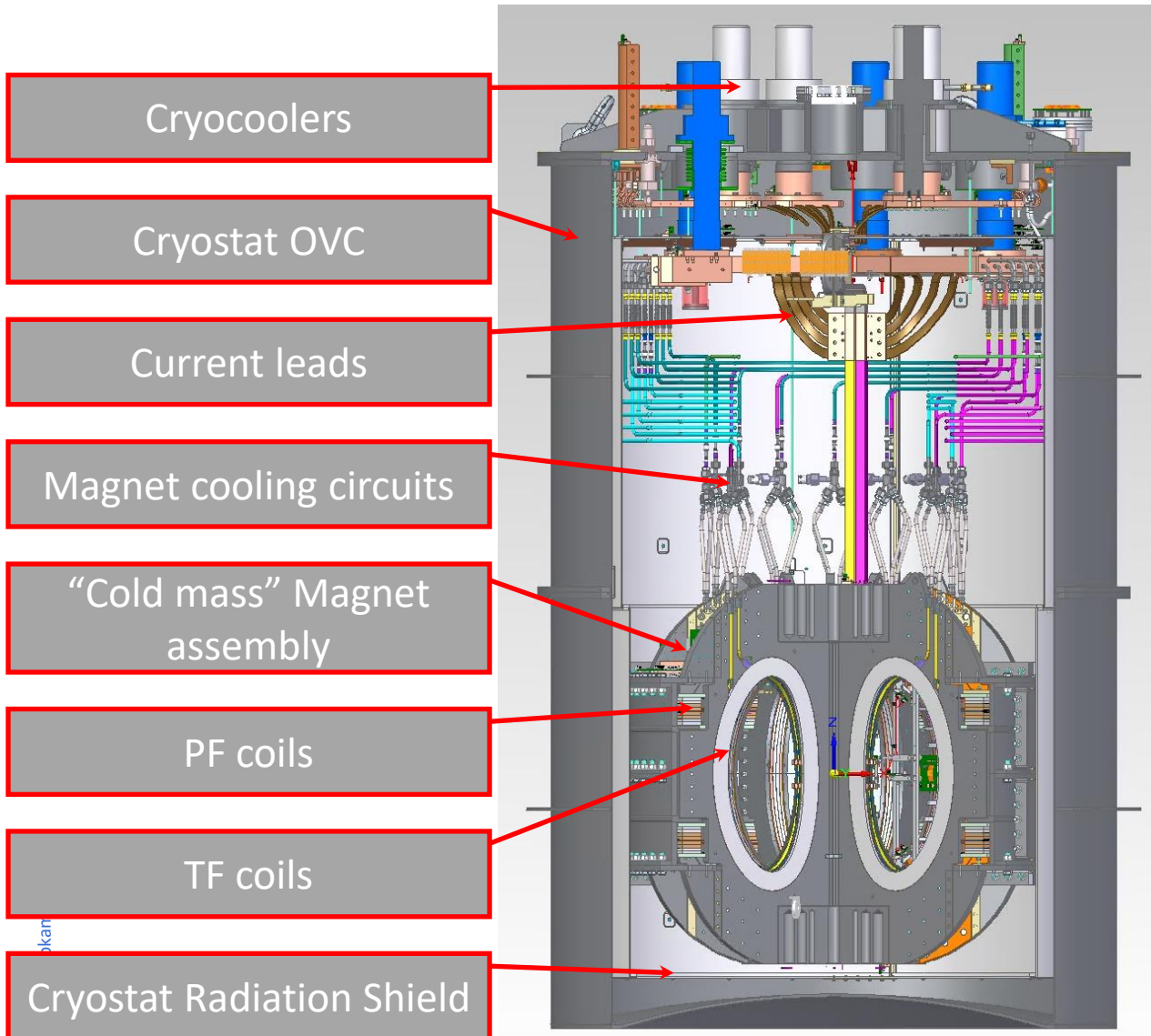
**Stress** – *Manage high stresses in HTS coil structures*

**Quench Management**

**Performance goal** – *20 T peak toroidal field.*



# Demo4: Cryomagnetic System



**Demo4 is a conduction cooled, cryogen free, ~20 K HTS magnet test bed.**

## **TF Magnet**

- 14 limbs, 2 stacked HTS pancakes per limb.
- Partially insulated.

## **PF Magnet**

- 2 PF stacks, 8 pancakes per stack.
- Fully insulated (copper stabilised).

**Total of ~50 km of full-width HTS tape in coils**





Recent Topical Review by authors at PPPL and UKAEA

IOP Publishing

Plasma Physics and Controlled Fusion

Plasma Phys. Control. Fusion 63 (2021) 123001 (37pp)

<https://doi.org/10.1088/1361-6587/ac2b38>

## Topical Review

# Thermal confinement and transport in spherical tokamaks: a review

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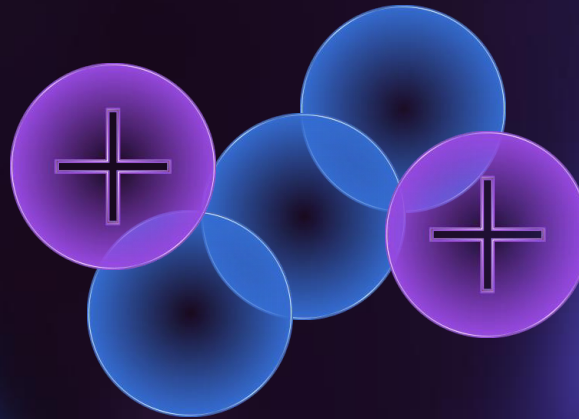
*“STs have revealed a very strong improvement in normalized confinement with decreasing collisionality, much stronger than at higher aspect ratio, which bodes well for an ST-based fusion pilot plant should this trend continue at an even lower collisionality than has already been accessed.”*

## Fusion Energy : A game-changer

- Tokamak Energy has a **unique and efficient approach.**

- Established science baseline, **new technologies**, private funding, agility.

- **World-class team** : fusion, engineering and operational credentials.







- We are **serious about delivery** of economic fusion energy

- We are **generating significant IP** - well protected.

- We will **deliver fusion faster with public-private collaboration**





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