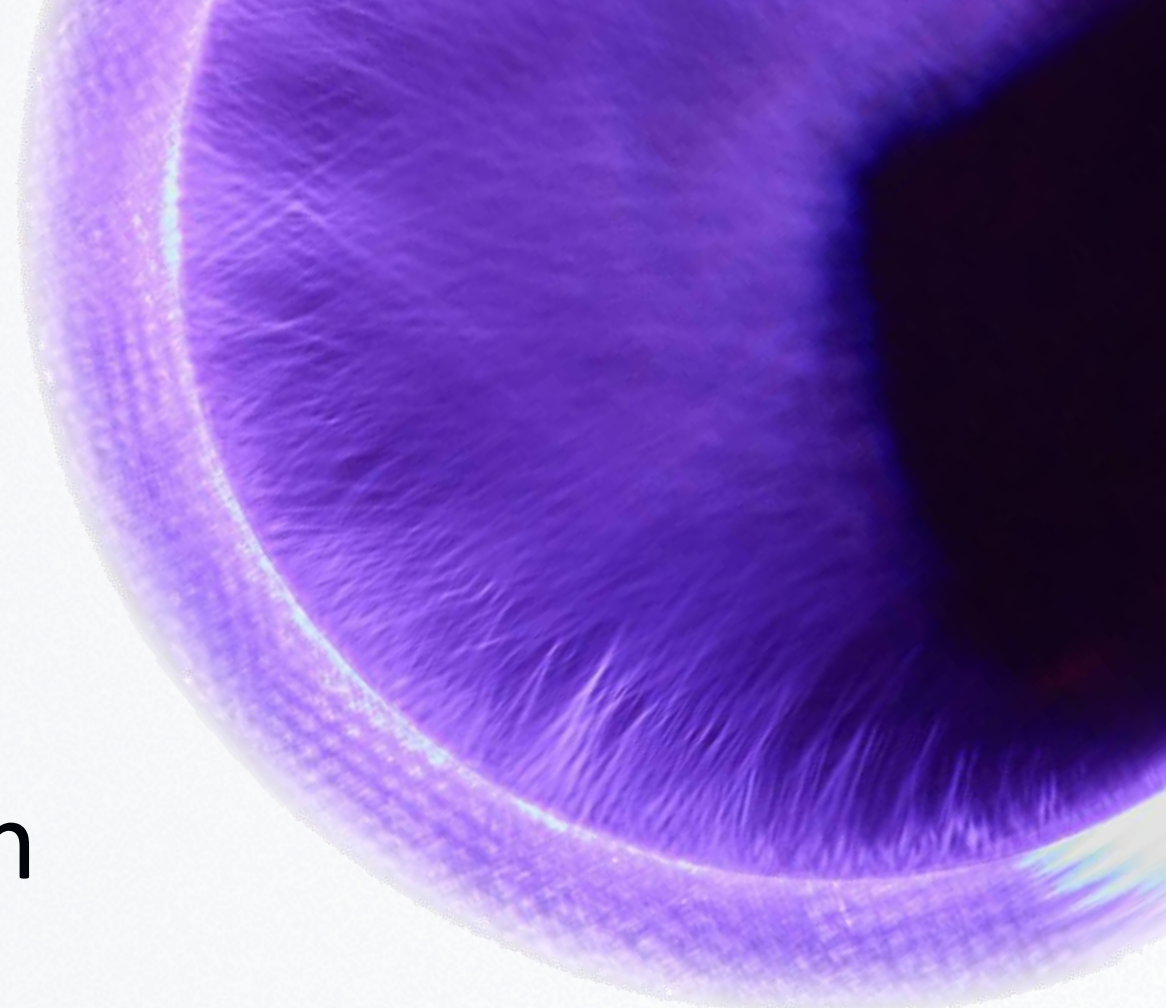




— CWFEST 2025

Next-gen commercial compact fusion reactors



— A new reactor architecture designed for scalable intense fusion neutron fluences

Astral Now – The First-Generation Multi-State Fusion (IELCF) Reactor

"Where environmental conditions permit fusion to occur within plasma and solid states simultaneously"

400m

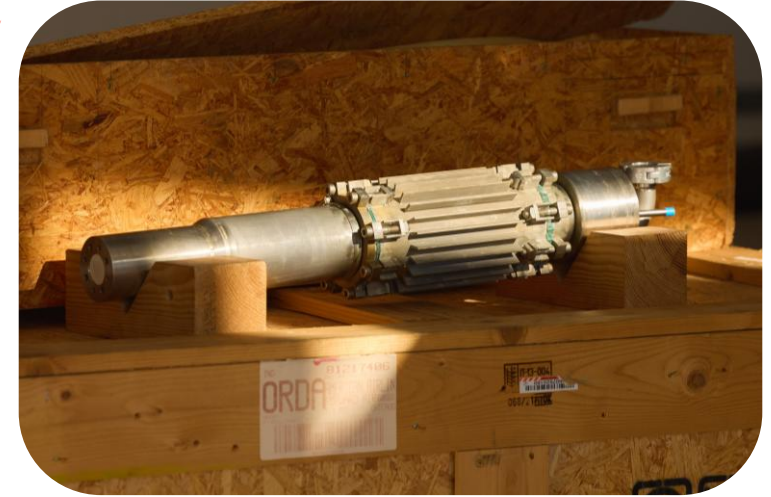
times higher fuel density

than those achievable in the plasma

>1e11 n/s 14.1 MeV DT

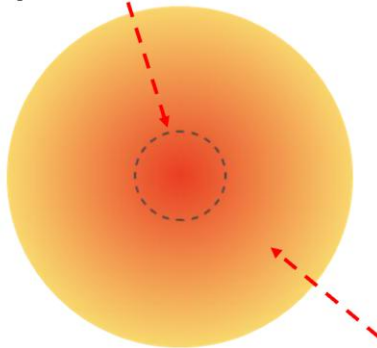
>3e8 n/cm2/s peak flux

This represents Mark-1, with a clear path to higher performance



Our Sun

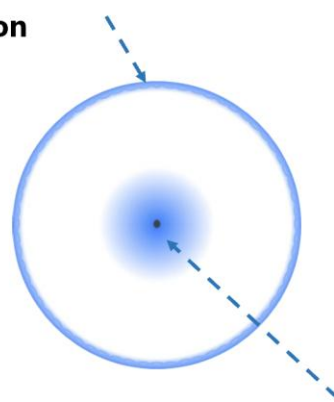
The densest innermost 0.8% of the solar volume accounts for 99% of its fusion power



The surrounding low-density plasma produces 1% of its fusion power

Multi-State Fusion

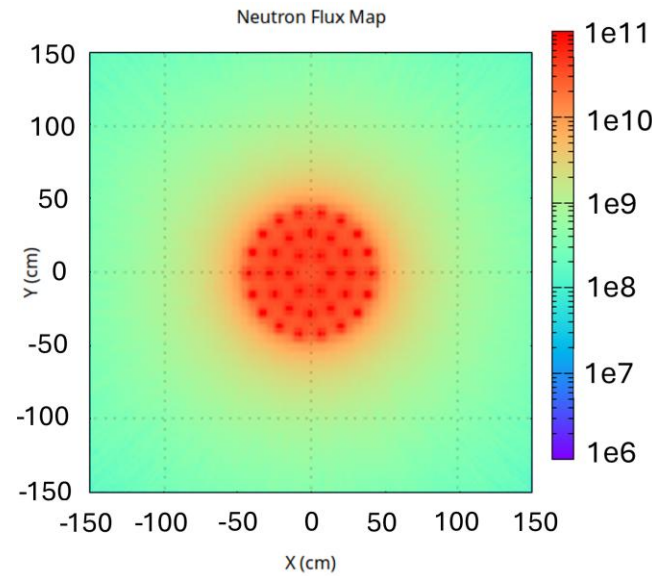
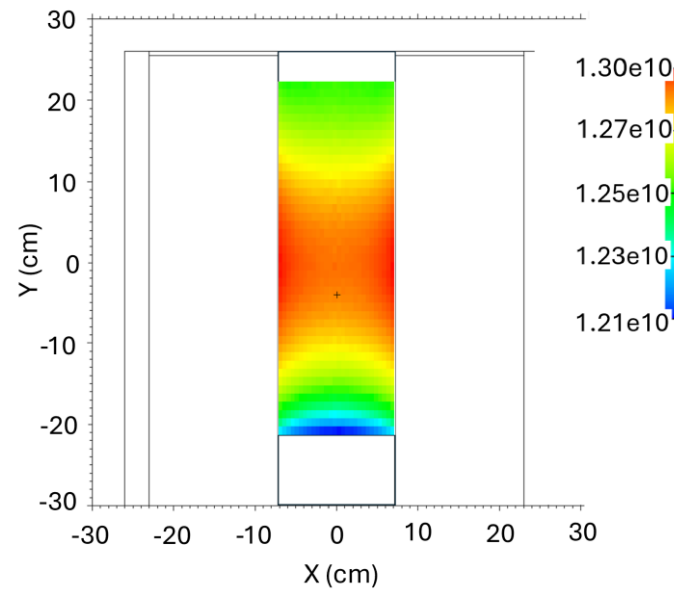
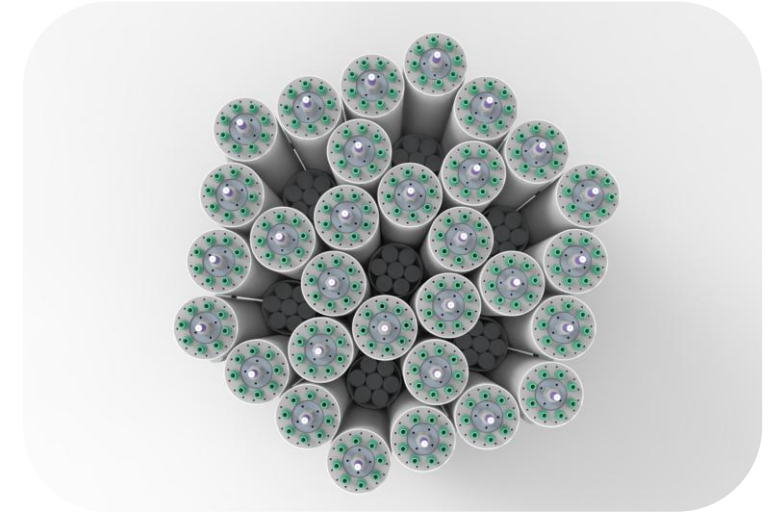
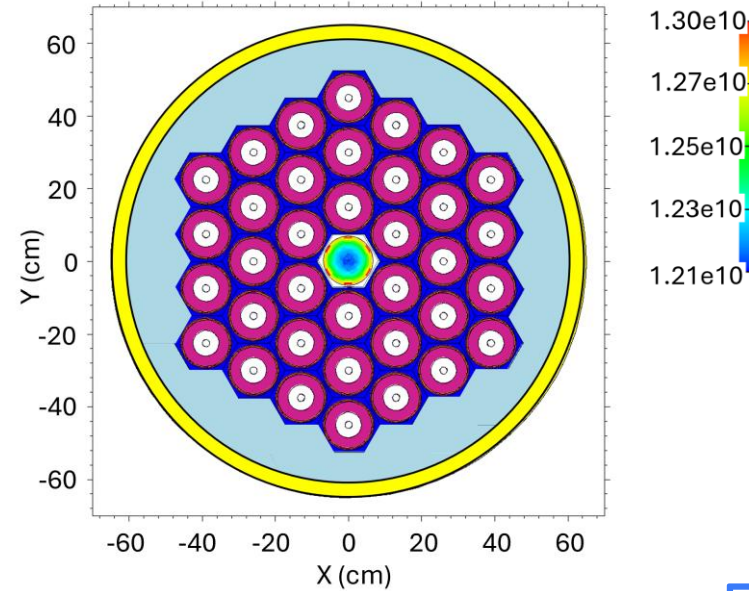
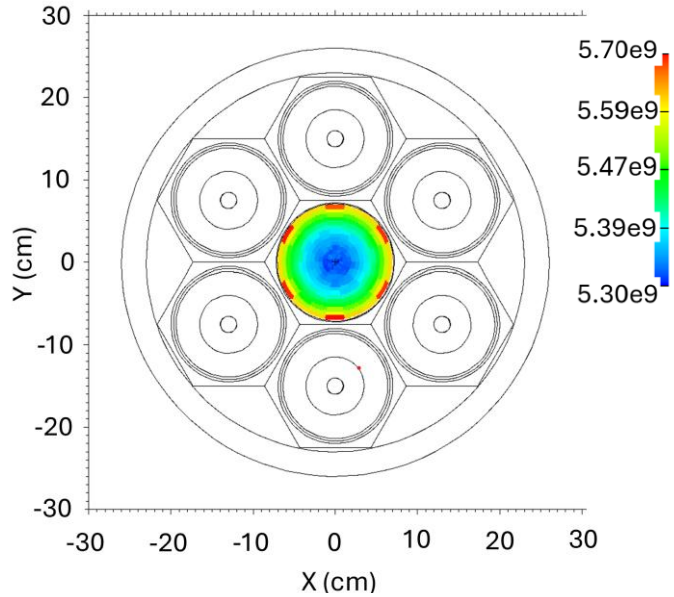
The densest <0.8% of the active reactor volume produces 99% of the fusion



The low-density plasma produces only 1% of the total fusion output



Array Characteristics – Mark-2 Performance



50k cc

available irradiation volume

Internal and m³ external

100% Uptime

No single point of failure

Enabling high fluence campaigns



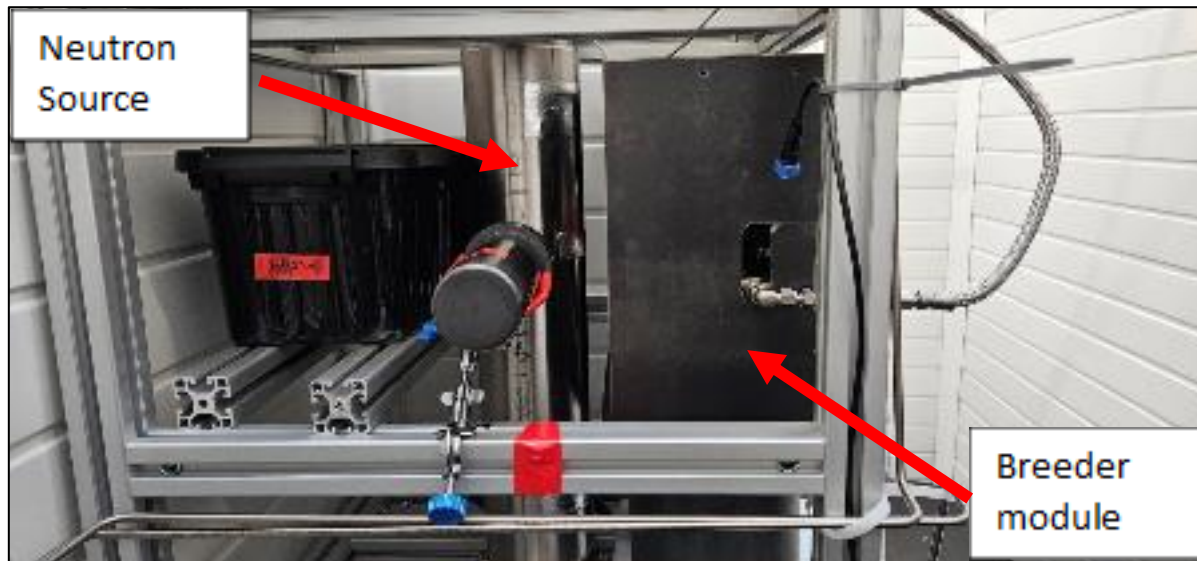
DD 2.45 MeV R&D Facility

- R&D focused MSF reactors
- $1e8$ n/s & $\sim 3e5$ n/cm²/s
- Output limited by bunker shielding
- ~ 50 - 60 hours of irradiation time per week



SCORPIO: Project results – Tritium bred!

- Tritium breeder material was irradiated with **DD neutrons** (Astral Systems source) and purged with a gas mixture
- Tritium successfully detected in purge gas mixture



- Our extensive experimental campaign continues
- Results will be sent for publication

Breeding arrangement with breeder module and neutron source (Astral Systems)

Credit: Dr Hugo Dominguez

Commercial Irradiation Facility @ Bristol

- Both DD & DT (2.45 & 14 MeV)
- DD $1e10$ n/s & $\sim 3e7$ n/cm²/s
- DT $1e11$ n/s & $\sim 3e8$ n/cm²/s
- DT Output limited by bunker shielding
- Continuous operation possible



Commercial Irradiation Facility @ Berkeley (UK)

- DT 14 MeV
- DT 1e12 n/s & $\sim 3e9$ n/cm²/s (Q2 2026)
- DT 1e13 n/s & $\sim 3e10$ n/cm²/s (Q4 2026/Q1 2027)
- DT 1e14 n/s & $\sim 3e11$ n/cm²/s (Late 2027)
- Continuous operation possible



Commercial Irradiation Facility @ McMaster (CA)

- DT 14 MeV
- DT $1e11$ n/s & $\sim 3e8$ n/cm²/s (Q3/Q4 2026)
- Continuous operation possible
- Primarily used for nuclear medicine/medical isotope production research



- putting reactors into the hands of strategic partners first

Current Manufacturing and Development Timeline

Q1 2026

- Deploy six commercial 14.1 MeV Deuterium-Tritium MSF reactors in an array, characterise absolute neutron flux and angular distribution with UKAEA and UK-NPL

Q1 2027

- Complete manufacture of thirty commercial MSF reactors for a mixture of internal use and deployment with strategic partners

2028 and beyond

- Progress internal R&D efforts to exceed $>1e13$ n/cm²/s performance in an array

Neutron Source Iteration	Individual NPR n/s	36-Unit Array Total n/s	36-Unit Flux n/cm ² /s	18-Unit Flux n/cm ² /s	6-Unit Flux n/cm ² /s
Mark 2	1e12	3.6e13	1.3e10	1e10	5.7e9
Mark 3	3e13	1.1e15	7.7e11	4.6e11	3.9e11
Mark 4	3.2e14	1.2e16	1.1e13	7e12	3.9e12





Business Stages

1) R&D Contracts / Reactor Sales

2) Neutron Irradiation Services / Fusion Component Qualification

3) Medical Isotope Production

4) Nuclear Waste Transmutation

5) Fusion/Fission Hybrid Power (Terrestrial & Space Applications)

ASTRAL SYSTEMS

The Astral Systems Multi-state fusion Reactor: Architecture and Applications

Why?

Density & Scalability

Fusion reactor designs based on plasma or gas states are innately constrained in terms of the neutron flux, where the ratio of total neutron output to flux is usually around 10,000:1 or more.

By producing fusion in the solid state, a ratio of ~100:1 or better can be achieved. Meaning equivalent neutron fluxes relevant for fusion science can be achieved in a far more compact form factor, smaller shielding footprint, and at lower cost.

By the end of 2025 Astral will have three operational fusion reactors sites in the UK, ranging from 10 to ~100 tonnes of shielding for up to m³ volume 2.45 and 14.1 MeV irradiations.

Availability

By analogy, TRIUMF fission research reactors were deployed around the globe in the 1960's to promote fission science and for their speech in 1953.

Since the peak of 197 operational reactors, we now have only 36 reactors currently operating. Where the rate of fusion science and technology development is directly tied to this number.

The more fusion devices there are for people to use to progress the field, the faster mankind will be able to deploy fusion power at scale.

Figure 1: Fusion Power

Multi-State Fusion:

Where environmental conditions permit fusion to occur within plasma and solid states simultaneously.

Our Sun

The densest innermost 0.8% of the solar volume accounts for 99% of its fusion power.

Multi-State Fusion

The densest <0.8% of the active reactor volume produces 99% of the fusion

The surrounding low-density plasma produces 1% of its fusion power

The low-density plasma produces only 1% of the total fusion output

Applications:

- Radioisotope Production
- Tritium Breeding Materials Testing
- Neutron Radiation Hardness Testing
- Fusion Reactor Component Testing and Qualification
- Special Nuclear material detection
- Nuclear Imaging and activation
- Nuclear Waste Transmutation
- Hybrid Fusion Driven Fission Power
- 14 MeV Nuclear Data Generation

We endeavour to empower researchers and communities with increased access and availability of high energy fusion neutrons.

How?

Modularity

Much like a fission fuel rod, the Astral MSF reactor can be thought of as a 'fusion fuel rod' which can be clustered together into arrays to increase neutron flux.

The capability of these systems has already enabled the first demonstration production of tritium in a lithium reactor.

Six commercial deuterium-tritium MSF reactors are currently in production with several reserved for sale to fission research capabilities.

Such systems are also ideal for training the next generation of fusion engineers with hands-on experience.

Open for Collaboration

Calls are open for our Q1 2026 irradiation campaign.

MSF Reactor Mark-1

DD 2.45	DD Flux	DT 14.1	DT Flux	Est.
MeV n/s	n/cm ² /s	MeV n/s	n/cm ² /s	
280	287	163		
261	289			

MSF Reactor Mark-2

DD 2.45	DD Flux	DT 14.1	DT Flux	Est.
MeV n/s	n/cm ² /s	MeV n/s	n/cm ² /s	
280	287	163		
261	289			

ASTRAL SYSTEMS

Multi-State Fusion Reactor for Diverse Applications

Han-Ying Liu, Erin Holland, Orl Lennan-Morgan, Owen Thomas, Robert Annamandrew, Shuvay Singh, Alex O'Farrell, Muddia Woodward, Tom Haywood, Tom Wallace-Smith, Taimon Firestone, and Mahmoud Bakr

Unit 10, Boscobel Business Park, Severn Road, Bridle, BS10 7SR, United Kingdom

Multi-State Fusion (MSF) Reactor

- Sealed vessel with low electrodes under low pressure (P)
- A negative biased (10s of kV) cathode held in the centre of system, surrounded by grounded anode
- Induce high voltage and current to create a potential well and ionization of gas to discharge a plasma
- Ionized fuel gas accelerated and increasing particle collisions and fusion chance

$D + D \rightarrow ^3He + n$ (2.45 MeV)

$D + T \rightarrow ^4He + n$ (14.1 MeV)

$D + ^3He \rightarrow ^4He + p$ (14.7 MeV)

Neutron Yield enhancement from MSF

Effect of electrode materials of the reaction yield

- Changing from stainless steel to Titanium increased fusion performance by 4.7 times
- Astral Systems in partnership with the University of Bristol since 2017, leading in development of enhanced MSF technology for UK nuclear research production

System and Material Developments:

- Performance comparison since 2021: Over 3000 data points, 3 reactors, different vessel geometries, electrode materials, and more
- New designs are being prepared, and further data will be generated in due course

Neutron Yield Dictated Applications

Approx. 1000 - 10000 n/s

Lattice Confinement Fusion

- Building a fusion reactor with a lattice confinement fusion (LCF) design
- LCF design is a fusion reactor design that uses a lattice of solid materials to confine the plasma
- LCF design is a fusion reactor design that uses a lattice of solid materials to confine the plasma
- LCF design is a fusion reactor design that uses a lattice of solid materials to confine the plasma

Collaborations

ASTRAL SYSTEMS



Astral's Business Today (Stages 1 to 3)

- 6 commercial MSF reactors in final assembly phase right now!
- First two MSF reactor sales to Bangor University and Technical University Munich
- Currently conducting Tritium breeder blanket research
- Building a network of isotope production partners – “Airdropping”
- Operations expanding to the Berkeley Science Park to build and operate a high flux 14 MeV irradiation facility (Multi-Reactor Array)



— CWFEST 2025

Let's solve global health and energy challenges today – not tomorrow.

Talmon Firestone

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Tom Wallace-Smith

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