

# Accelerating Physics Discovery with AI Emulators



Science and  
Technology  
Facilities Council

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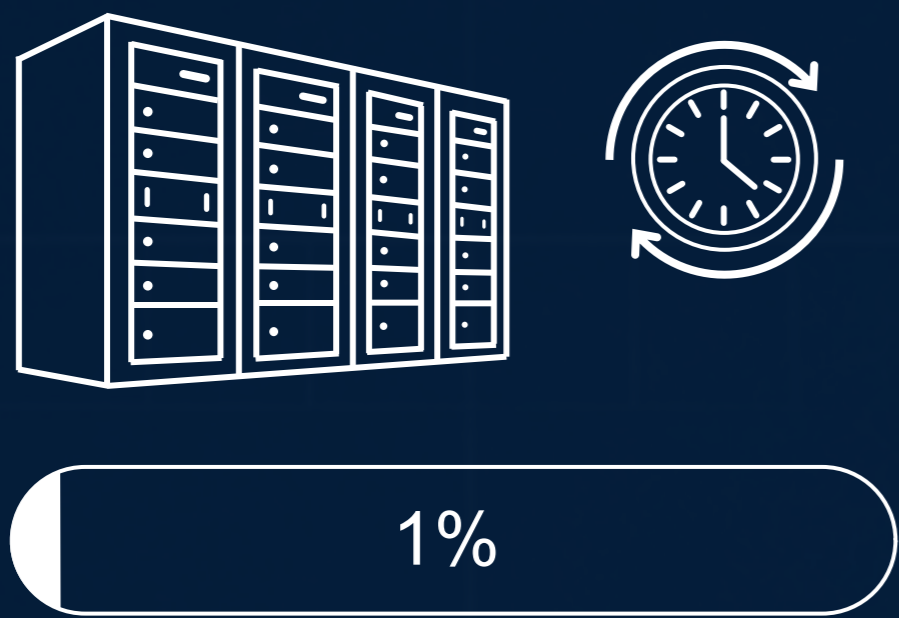


## Experimental Limits

We understand the world around us by changing variables and observing the effects. However, in physics, we cannot simply 'tweak' a black hole or the weather.

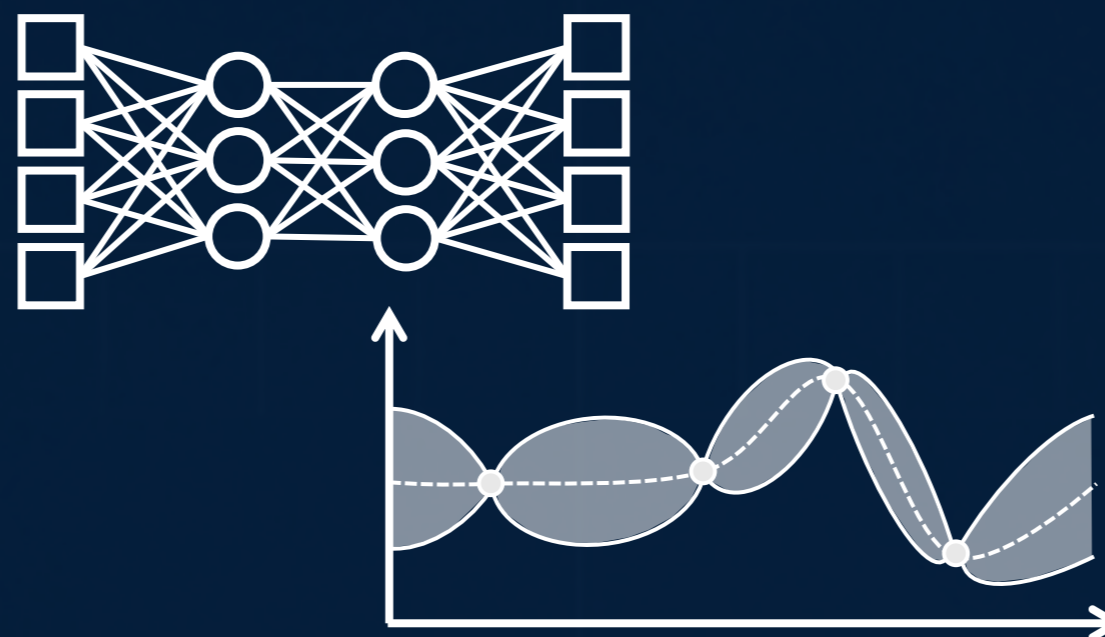
As a result, to solve physics mysteries, we frequently turn to **virtual laboratories**, massive computer simulations of these systems that allow us to experiment.

## Time Bottleneck



Running numerical simulations is often computationally slow and resource intensive.

## Faster Sampling



**AI Emulators** are lightweight replacement models that are trained to mimic a simulation's physics.

## New Discoveries



These emulators let us sample data faster than a simulation without the associated computational cost

## Black Holes

With 30 physical parameters, a single sparse search of our accretion disc wind simulations could take up to **23 billion years** — locking away discoveries.

Our emulator diagnoses "wind imprints" within spectral light from the distant universe **in minutes**, allowing astronomers to:

**Save Millions of Working Hours**

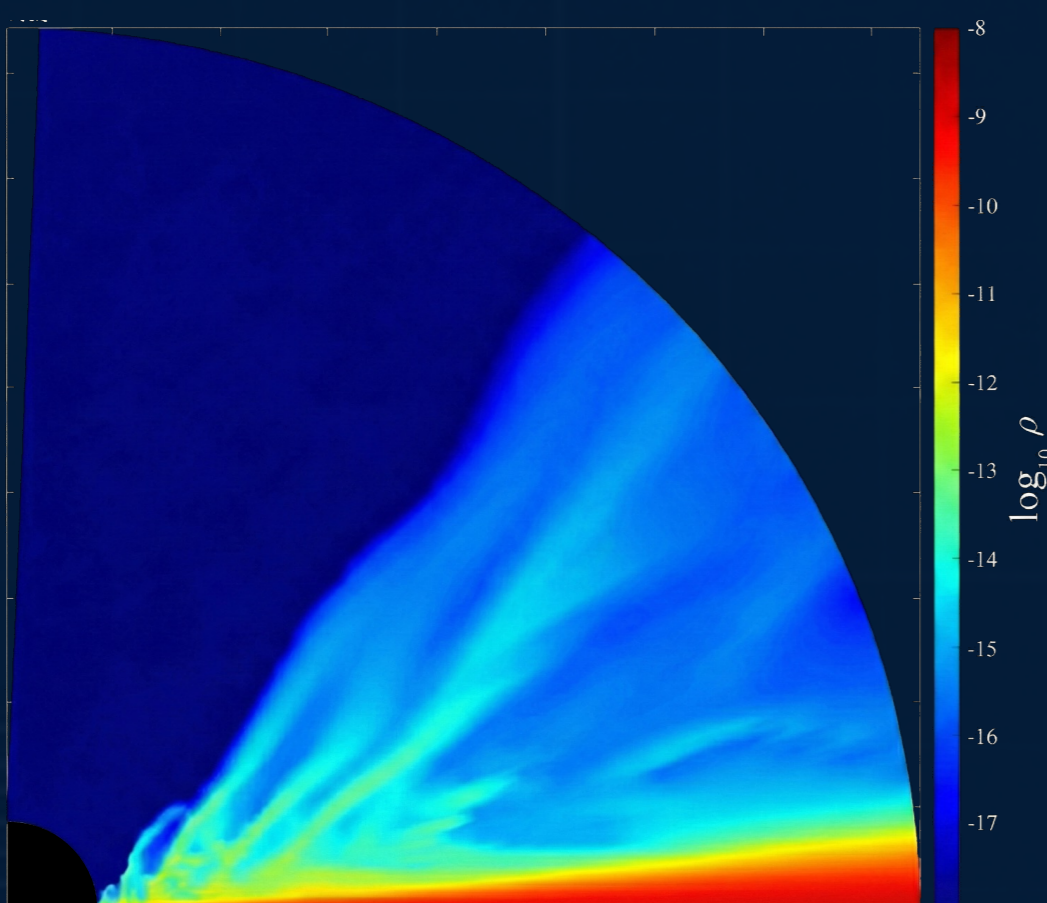


Image Credit: Amin Mosallanezhad

## Fusion Energy

Our fast-particle pressure emulator is **2 million times faster** than traditional models. It can provide real-time data to help engineers stabilise plasma burns — a critical step toward clean, limitless energy for the UK.

This emulator is also a core component driving a **digital twin tokamak**, enabling us to:

**Save the UK Billions in Engineering Costs**

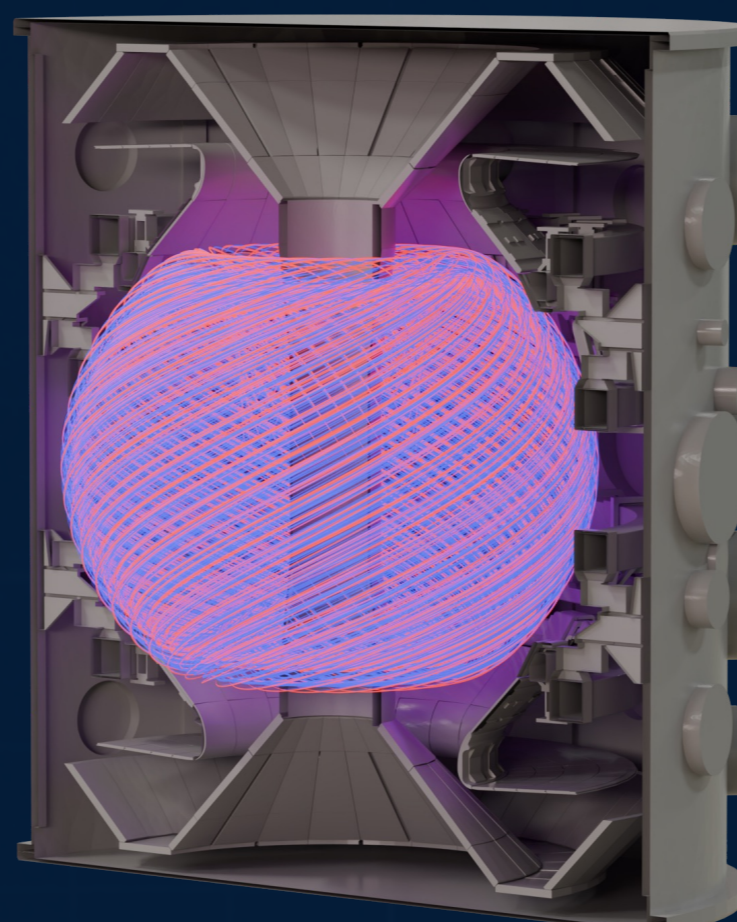


Image Credit: Rui Costa

## Extreme Weather

Weather forecasts rely heavily on historical data, but climate change is triggering **never-seen-before** conditions. This makes record-breaking events a greater challenge to predict.

We created synthetic 'black swan' events from simulations to further train more powerful, **AI foundational models**, letting us:

**Save Lives with More Reliable Forecasts**

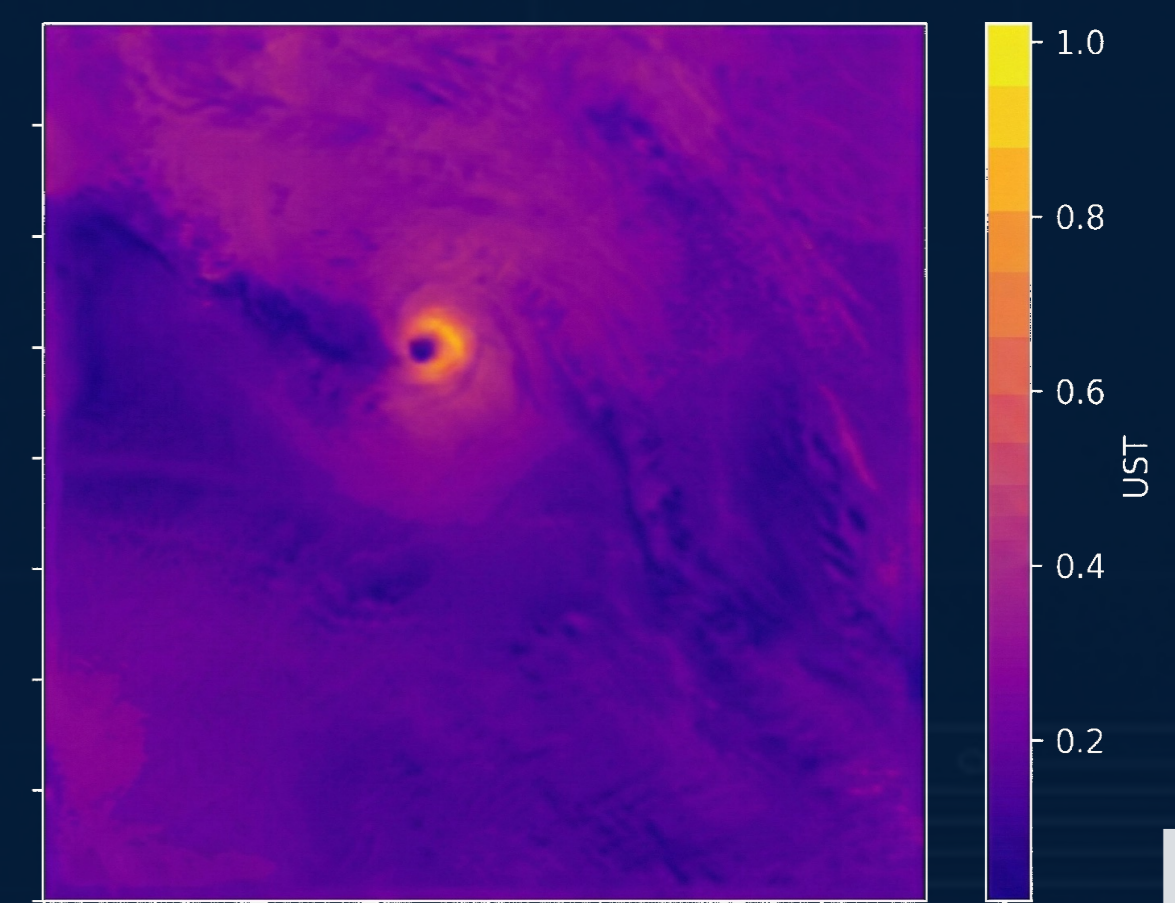


Image Credit: Austen Wallis