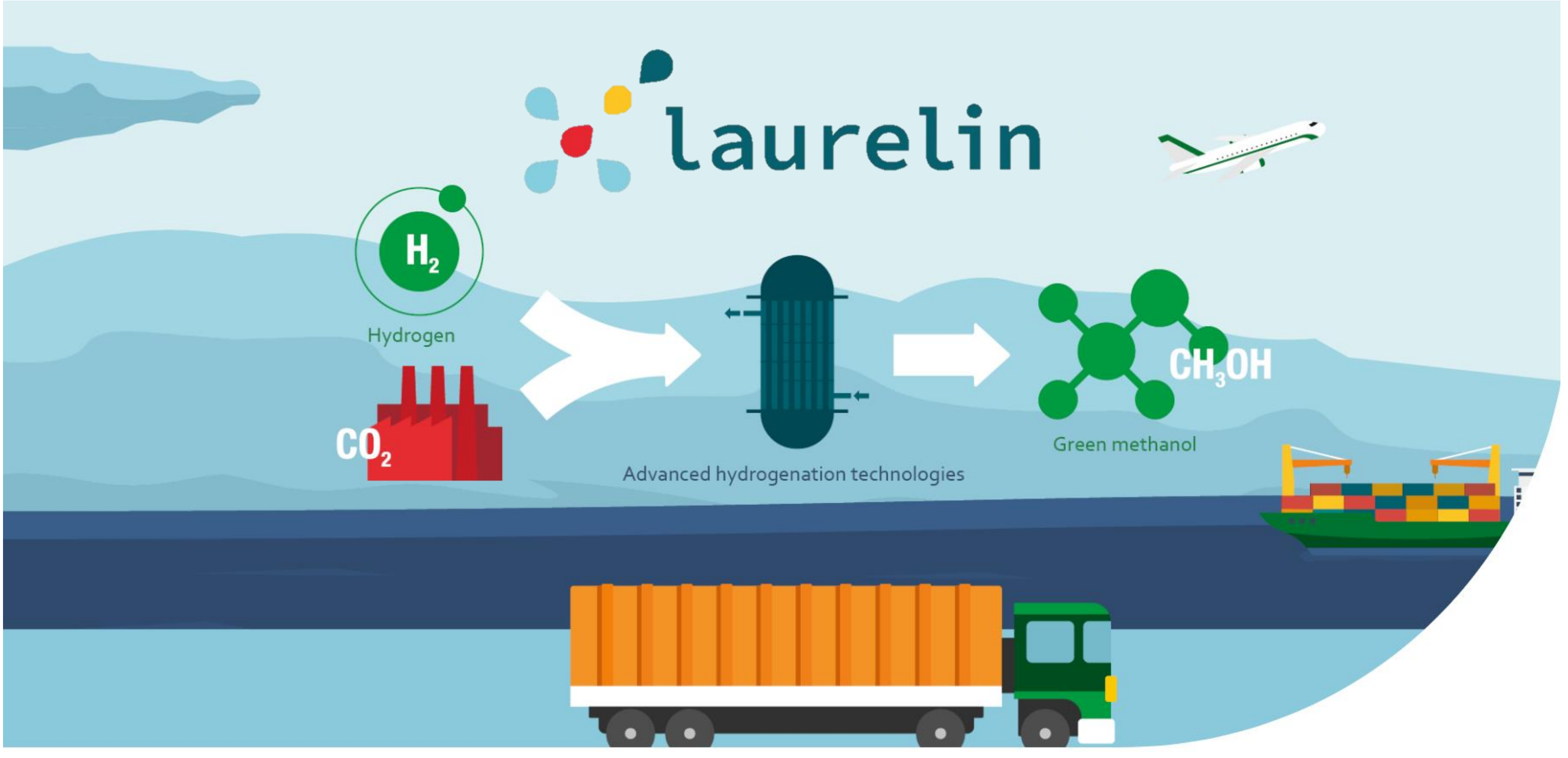

Research Complex at Harwell
Finden
CSIC
UCL

Unravelling the temperature profile of a magnetic induction reactor by *in situ* XRDCT

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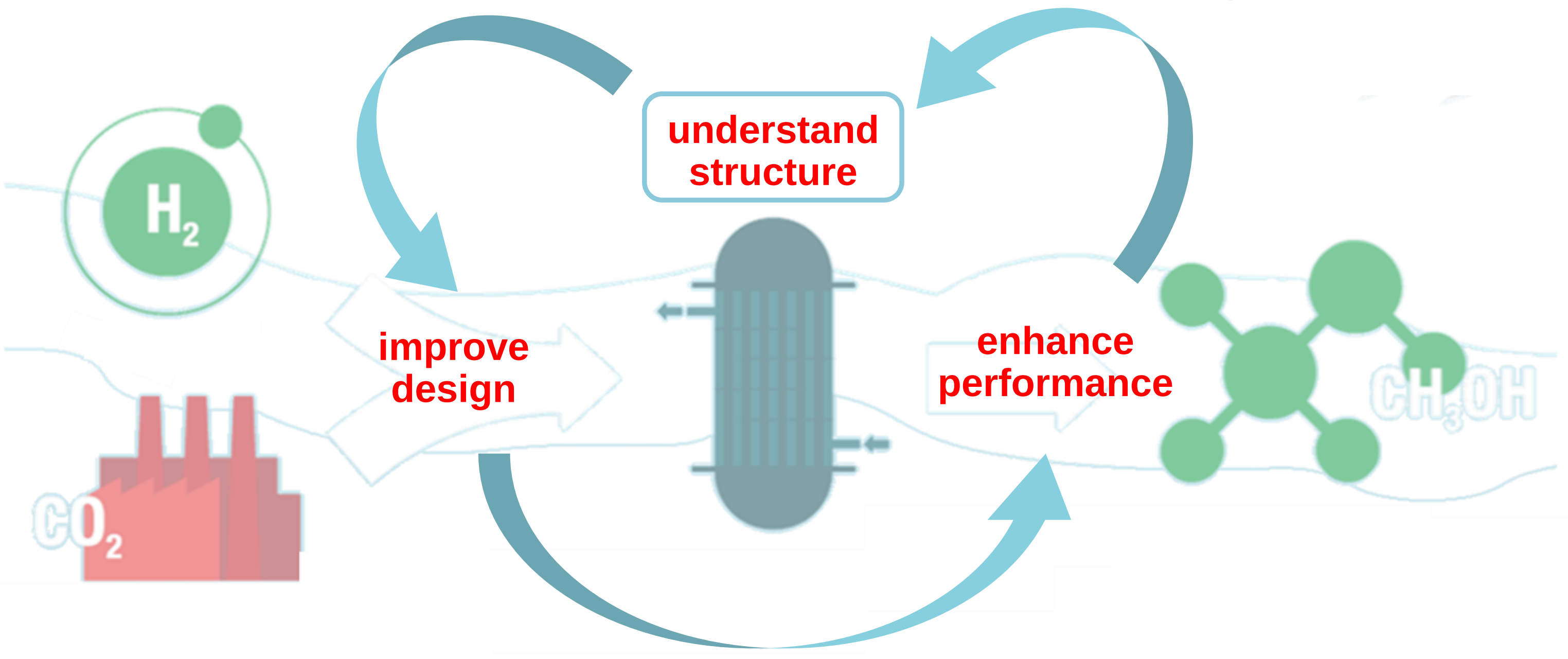
INTRODUCTION

LAURELIN: a Horizon 2020 project for **CO_2 conversion**.
Target: green methanol. The predicted global demand in 2024 is close to 200 million metric tonnes.
The consortium's role: Designing and evaluating a new generation of catalyst systems tailored for **advanced, lower energy reactor systems**.
These use: Microwave heating | Magnetic induction | Plasma induction

Pros and cons:

- ✓ The catalyst is heated directly, reaching high temperatures
- ✓ **No heat wasted** on atmosphere or other reactor parts
- ✗ The catalyst must be **magnetically active**
- ✗ Temperature probes would be magnetically heated, so are useless!

UCL's role is to use **synchrotron methods** to work out the structure and environment of the **active species during reaction**

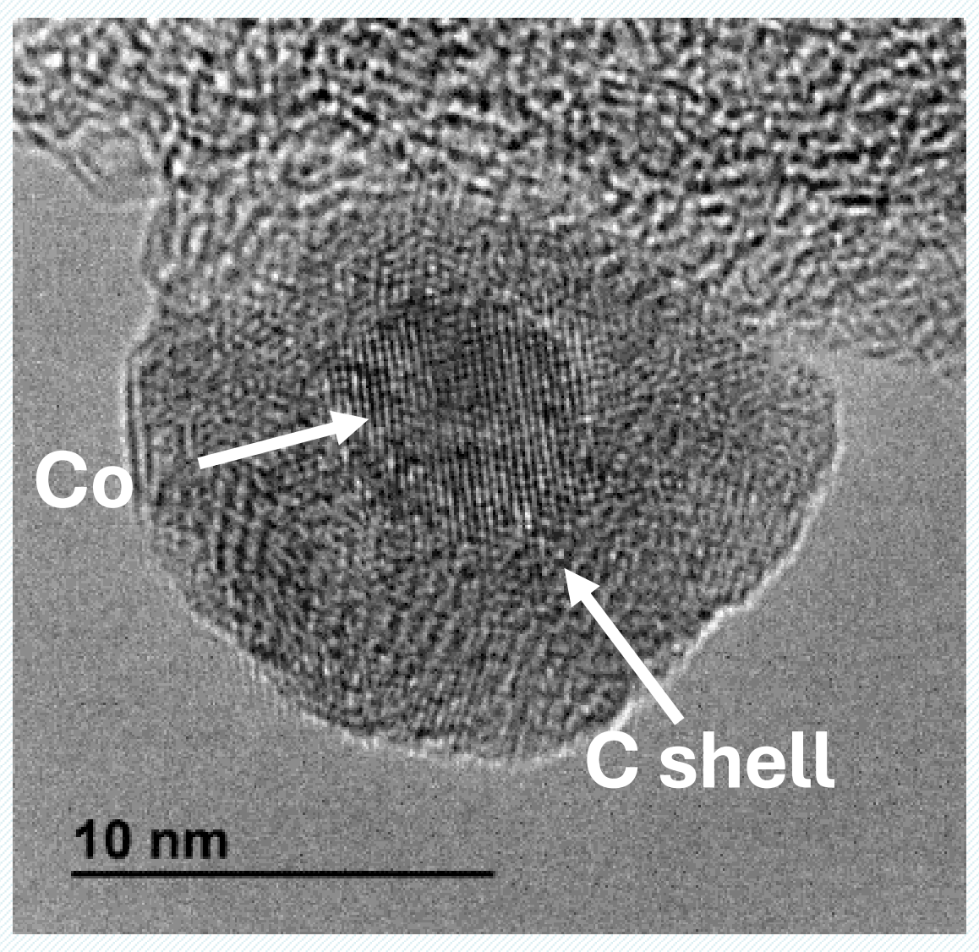


understand structure
improve design
enhance performance

***In situ* XRDCT to determine catalyst temperature**

THE EXPERIMENT

The catalyst: Co/C

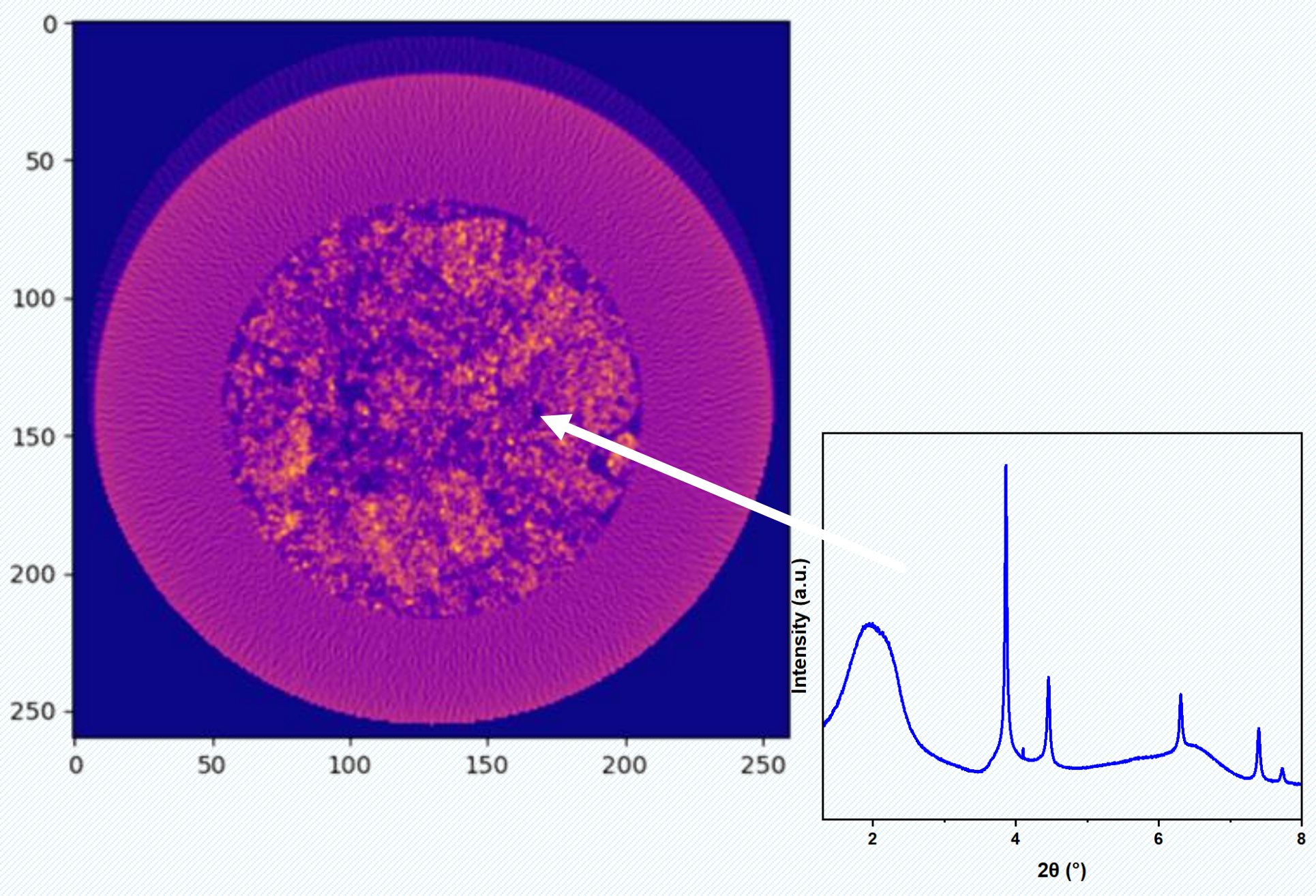


Carbon encapsulated FCC Co^0 NPs on carbon
Synthesised as a 2D MOF then decomposed.
Designed by **CSIC Valencia**

The *in situ* setup:

DESY. P21.2

Powdered catalyst in quartz reactor
(12mm OD, 2mm walls)
Electromagnetic coil,
argon gas flow,
rotation & translation stages.

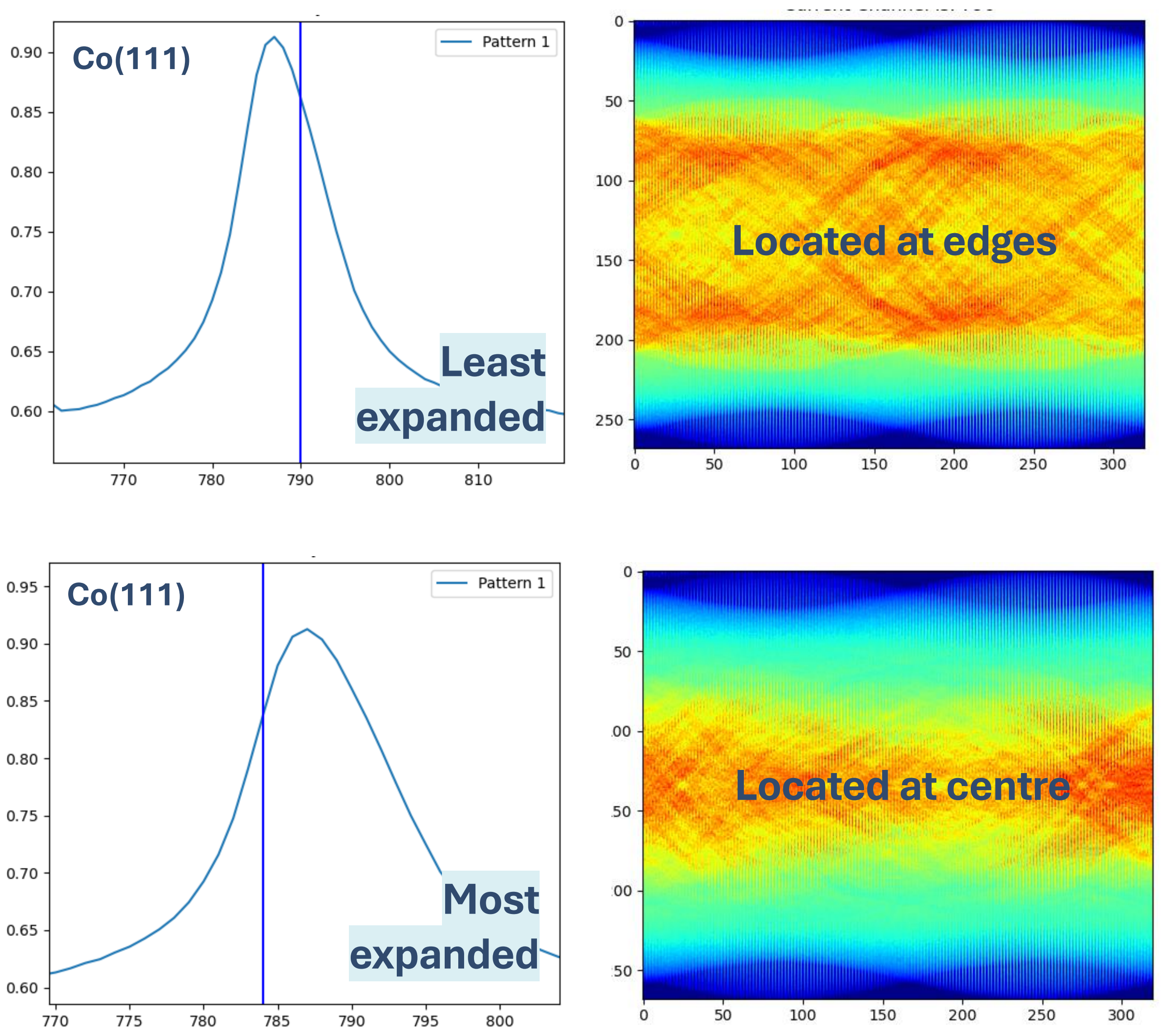


Reconstructed cross section of catalyst bed
Colour scale based on total diffracted intensity

THE RESULTS

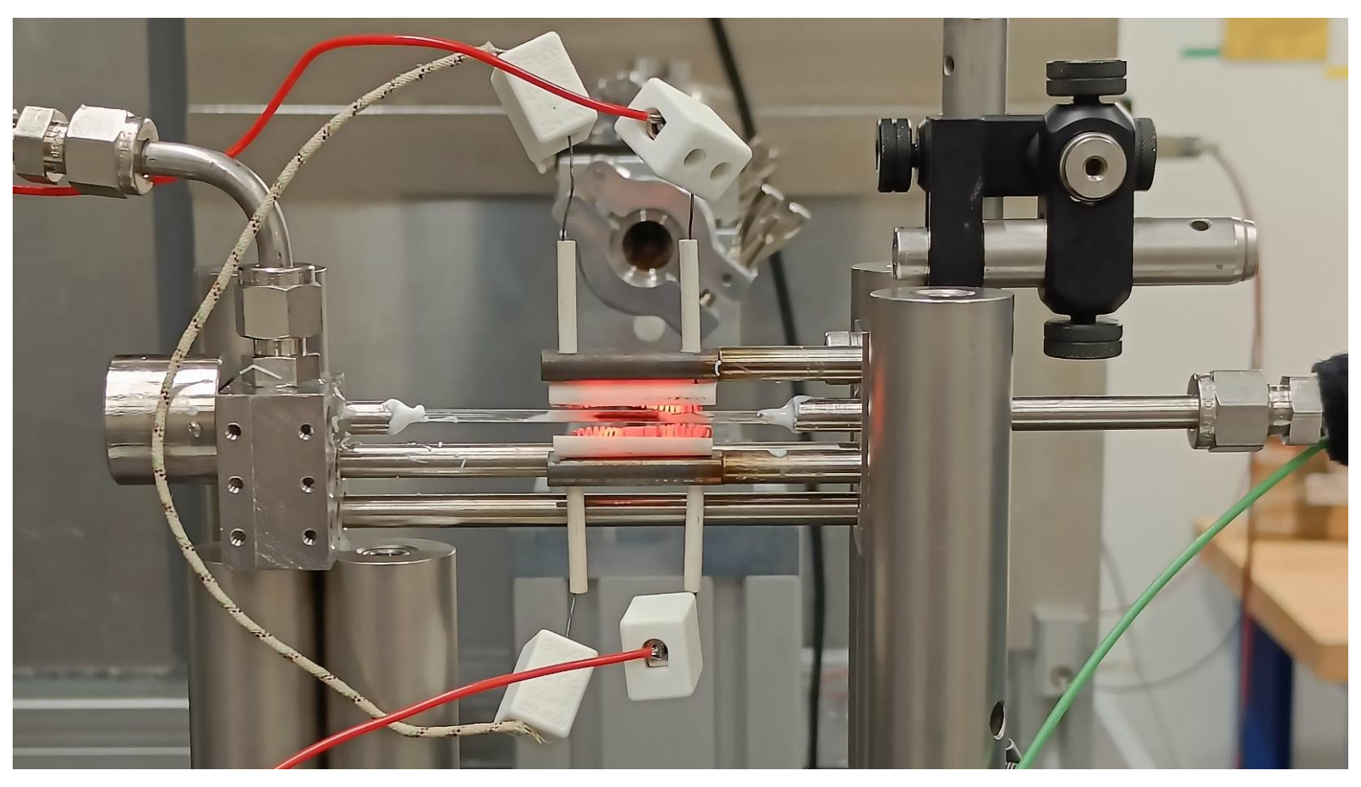
Spatially resolved information:

Uncovered **huge thermal gradients** across the catalyst bed



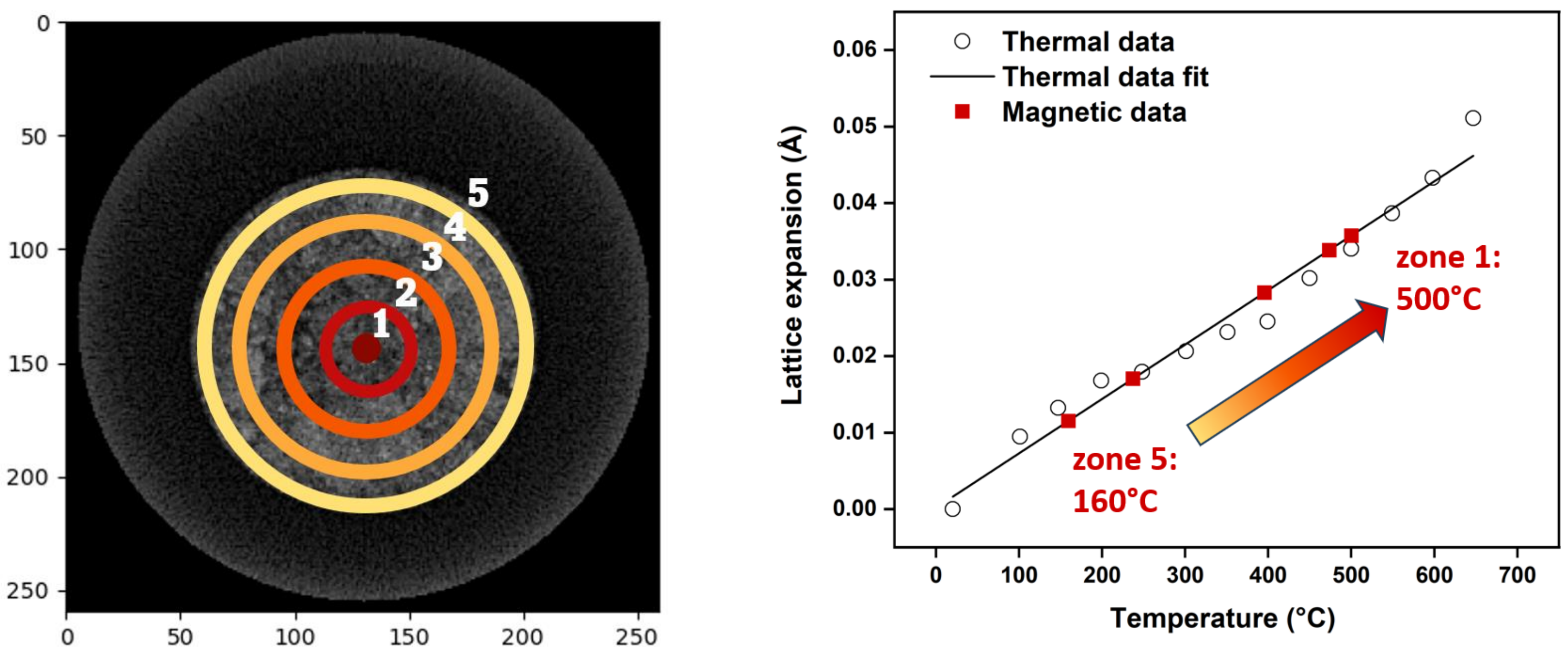
Sinograms at 100% magnetic power, colour scale based on Co(111) intensity.
The hottest **Co was in the centre** of the reactor, **cooling towards the edges**.
These **gradients didn't equilibrate** during the 3 hour measurement

Temperature calibration:



An ***in situ* thermal experiment** determined the lattice expansion at different temperatures for the same catalyst (○).

The **bed was divided into zones**, and data in each zone integrated independently.
The resulting expansion data (■) was **fit to the thermal calibration line.**

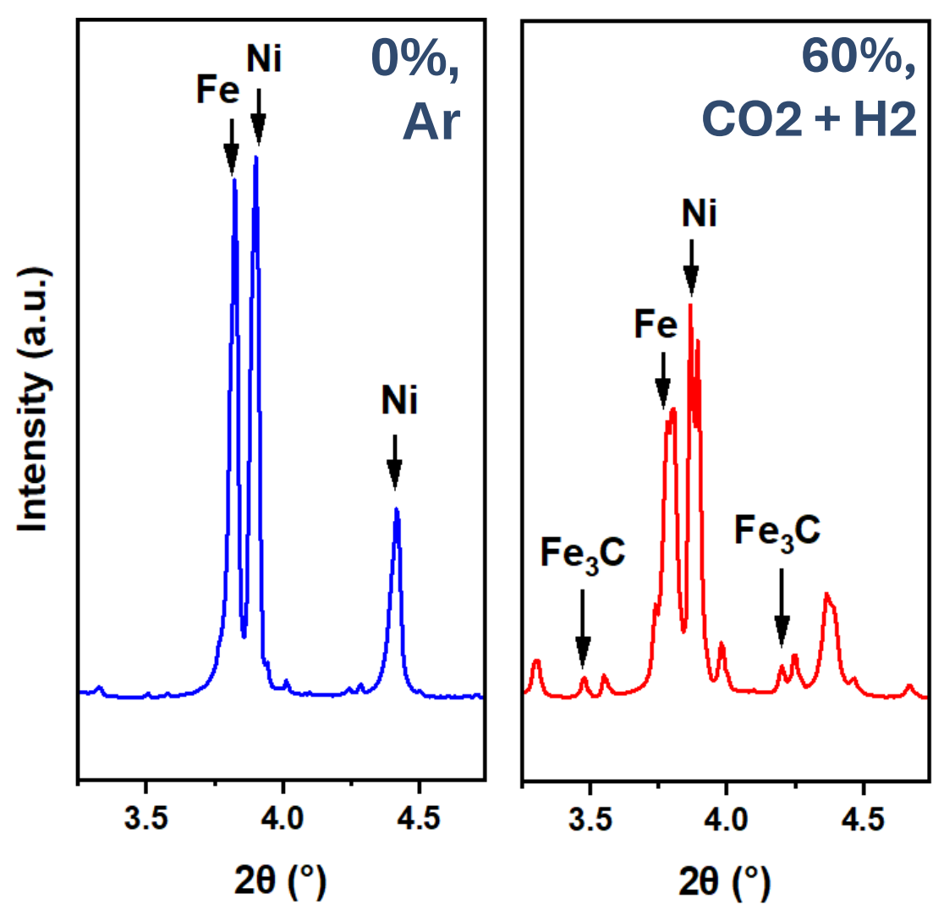


Temperature variation of up to 350 °C across bed!

NEXT STEPS

1. Extreme heat loss a result **of high temp. differentials** inside and outside quartz.
   - Design and construct reactor **insulation** to **homogenize bed**
2. Investigate **bimetallic systems** (e.g. FeNi)
   - Operando Fe carbide formation, effect of alloying on heating

FeNi/C



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