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Fire design of exposed mass timber in open-plan offices

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Introduction

- What is being constructed?
- What are the issues?
- What do we know and not know?
- Arup, CERIB and Imperial large-scale experiments
- Next steps

Mass timber office buildings

What are the issues?

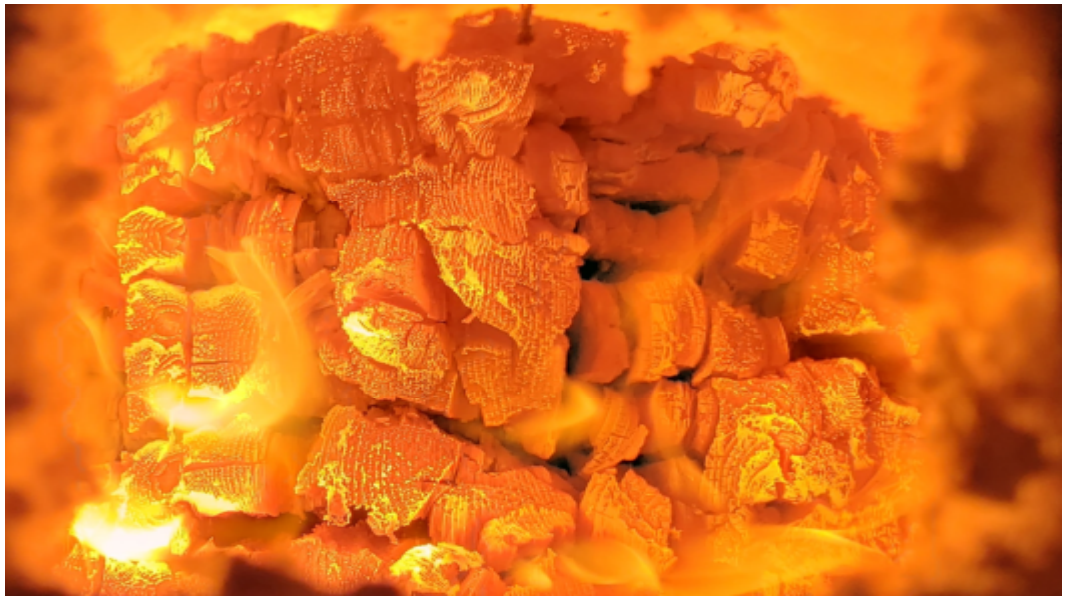
- Architects, owners, occupiers want to see the timber
- Exposed timber –
    - Significant extra fuel
    - Heat release and decay?
- Large compartments –
    - Typically do not show flashover behaviour
- Fire interacts with the timber and the charring timber influences the fire
- Important for high-rise buildings –
    - Design for structural stability
    - Life safety and fire fighting intervention

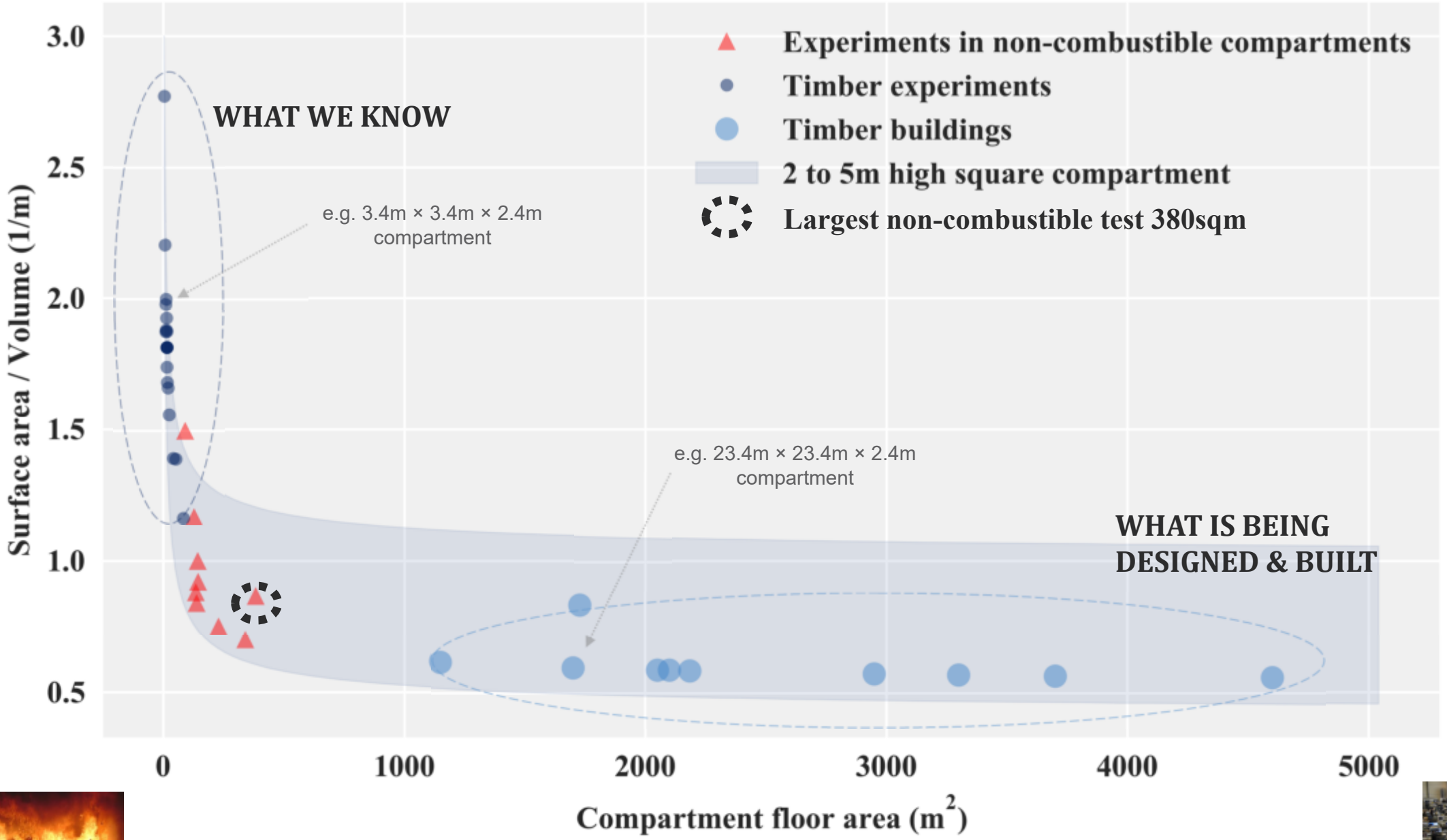
What do we know?

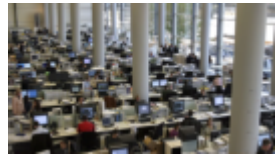
- Small scale, room scale and large scale experiments (up to ~90m^2)
- Over 40+ room and large scale compartment burns, residential set-up
- Flashover behaviour
- Area of exposed timber matters
- Timber type (glue line integrity)
- HRR decay is an important factor
- Reliable timber encapsulation matters
- A lot of very good research and outcomes

What do we not know?

- Open plan office fire spread mechanism
  - Travelling fires?
  - Impact of ventilation
- How do we get predictable decay?
- Smouldering behaviour
- Thermal penetration depth
- External flame projections
- Fire fighting tactics
- Predictive engineering tools and models







Flashover Fires

Travelling Fires

Large scale open plan office experiments

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- Arup-CERIB-Imperial College
- Interested in the fire behaviour (primarily)
- How do large areas of exposed CLT influence the fire
  - We know a reasonable amount about how fires influence the timber
- Direct comparison with non-combustible ceiling travelling fire experiments (x-One and x-Two)
- Need to engineer based on data and facts
  - Concern that engineering is occurring without the data
- Don’t try and do too much
- Results presented here are preliminary only

Set up details – First experiment

- 385m^2 in floor area
- Openings on all four sides
- Central support beam (steel and protected)
- 5 ply CLT of 140mm (40-20-20-20-40) from Hasslacher
- CLT exposed to underside, with proven glue-line integrity
- Two 400mm x 400mm glulam columns from Hasslacher
- Single fire protected steel column (board protection)
- Fuel of continuous wood crib (same as x-One and x-Two)
- Fuel load of 374MJ/m^2
- Opening factor of 0.071m$^{1/2}$ (1 / opening factor = 14.1)
- Instrumentation throughout (17 TC trees, plate thermometers)
- Thermocouples within CLT and glulam
- Screens above two openings to measure flame extension and temperatures
- Large number of cameras located externally
- No loading on the building


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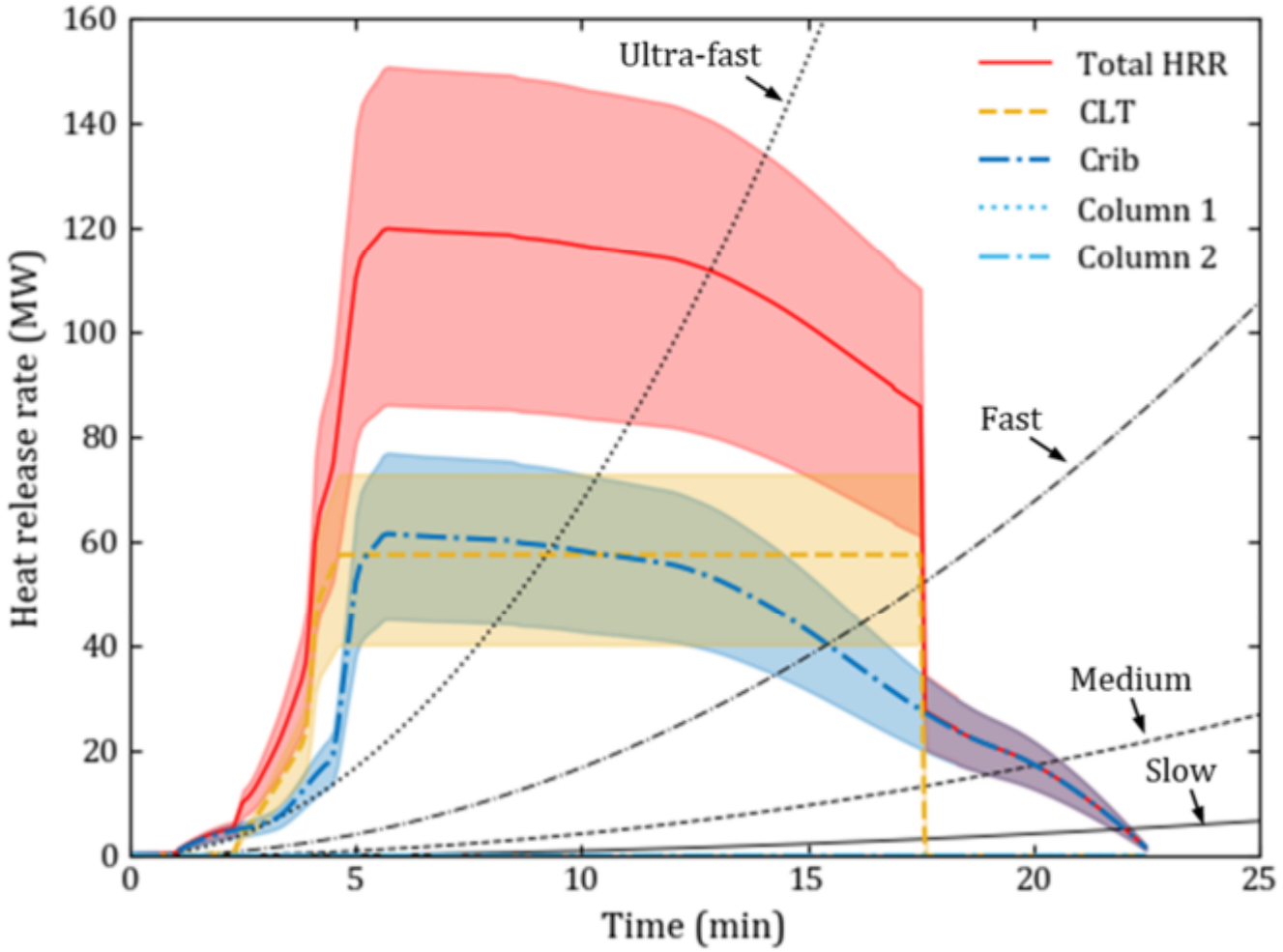

Approximated heat release rates of the crib, CLT, and timber columns estimated from photographs and video footage to establish extent of burning region and duration, summed to give the total heat release rate. The cloud error bars capture uncertainty in combustion efficiency (0.60-0.75), variations in CLT char depths and fuel density. Standard t^2 fire growth rates are provided for comparison

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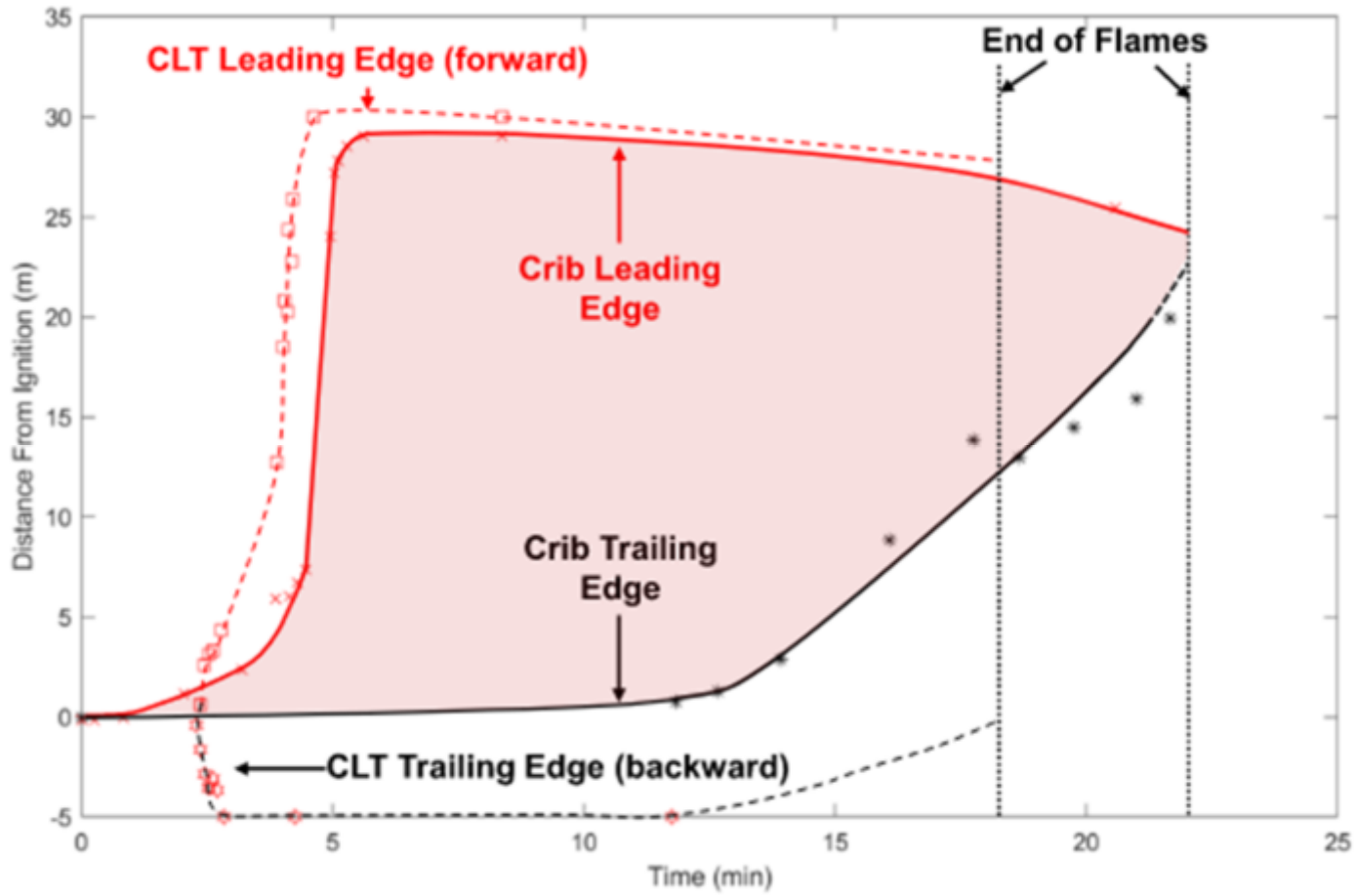
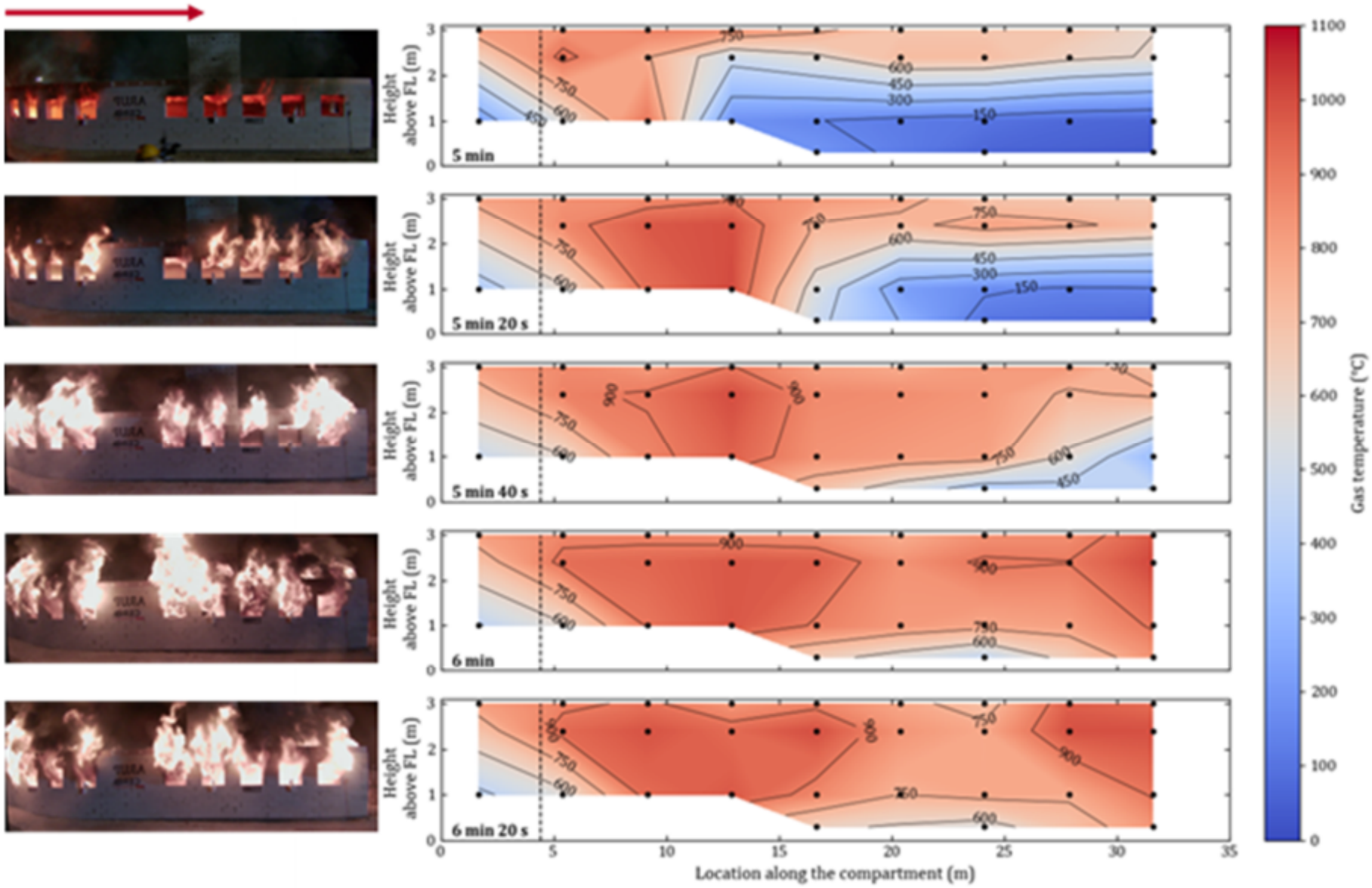


Positional data of leading and trailing edge of flame spread across the CLT (dashed lines) and the crib (solid lines). Time of end of observed flaming of the CLT and crib are marked with vertical dotted lines (established from photographic information)



Vertical temperature distribution at centreline of the compartment at various times from 5 min (top) to 6 min 20 seconds (bottom) after ignition. Black dots indicate location of thermocouples, black dashed line gives the ignition location. The photographs provide a visual of the compartment fire at the time of the adjacent contour plot.

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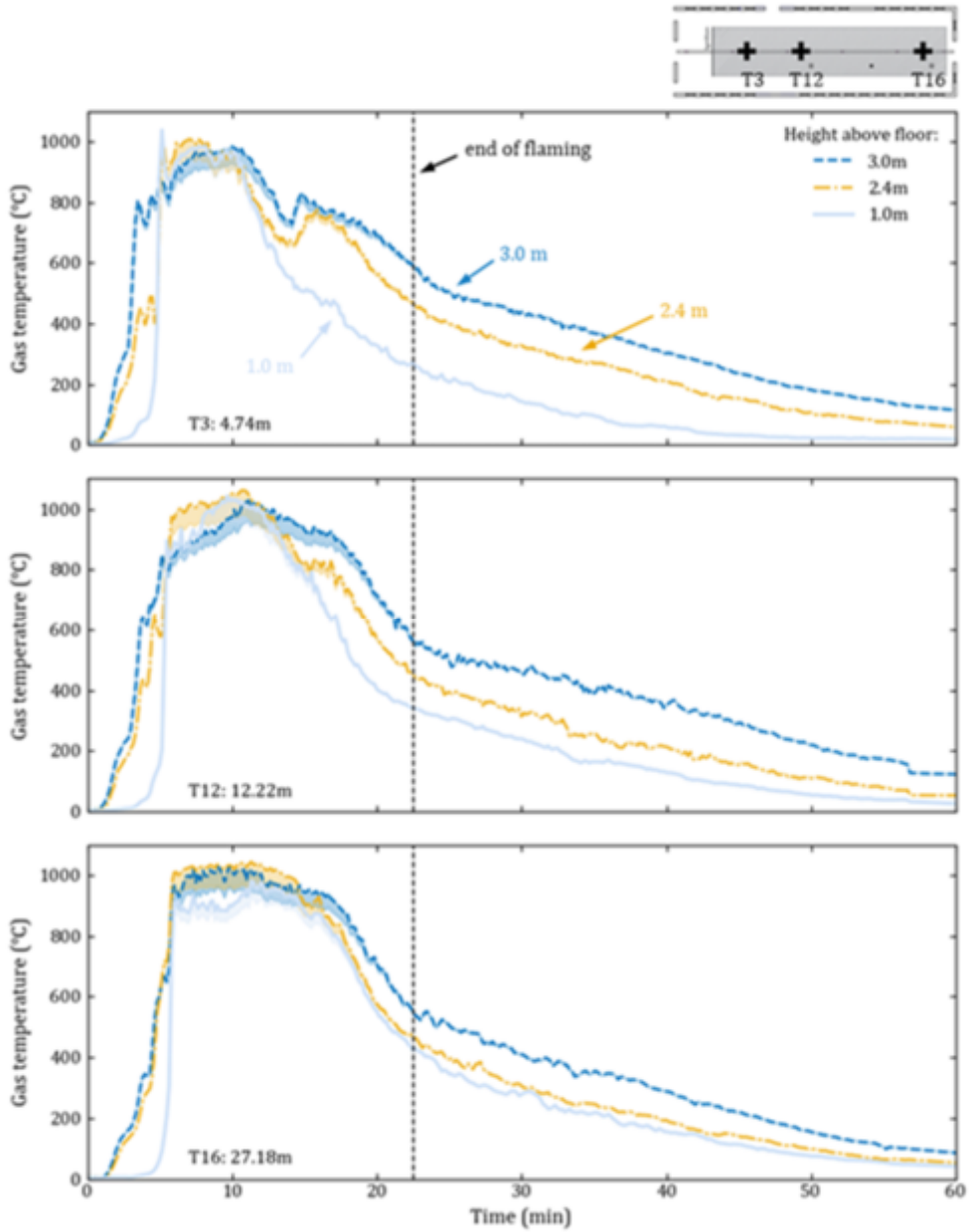

Vertical temperature variation within the compartment at 3 locations along the centreline: 4.74m (top), 12.22m (middle), and 27.18m (bottom)

What's next?

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- Publish paper on initial findings
  - Separate papers on fire dynamics, external flaming, timber behaviour to follow
- Second experiment in June – half the ventilation
- Confirm the findings from the first experiment, or possible raise new issues and findings
- Supporting two Phd's at Imperial
- Third test being considered
- Developing engineering methods for open plan offices
- A lot to digest and work on

Thanks to:

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The steering group

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