

# Ultrasonic Measurements of Temperature Profile and Heat Fluxes in Coal-Fired Power Plants

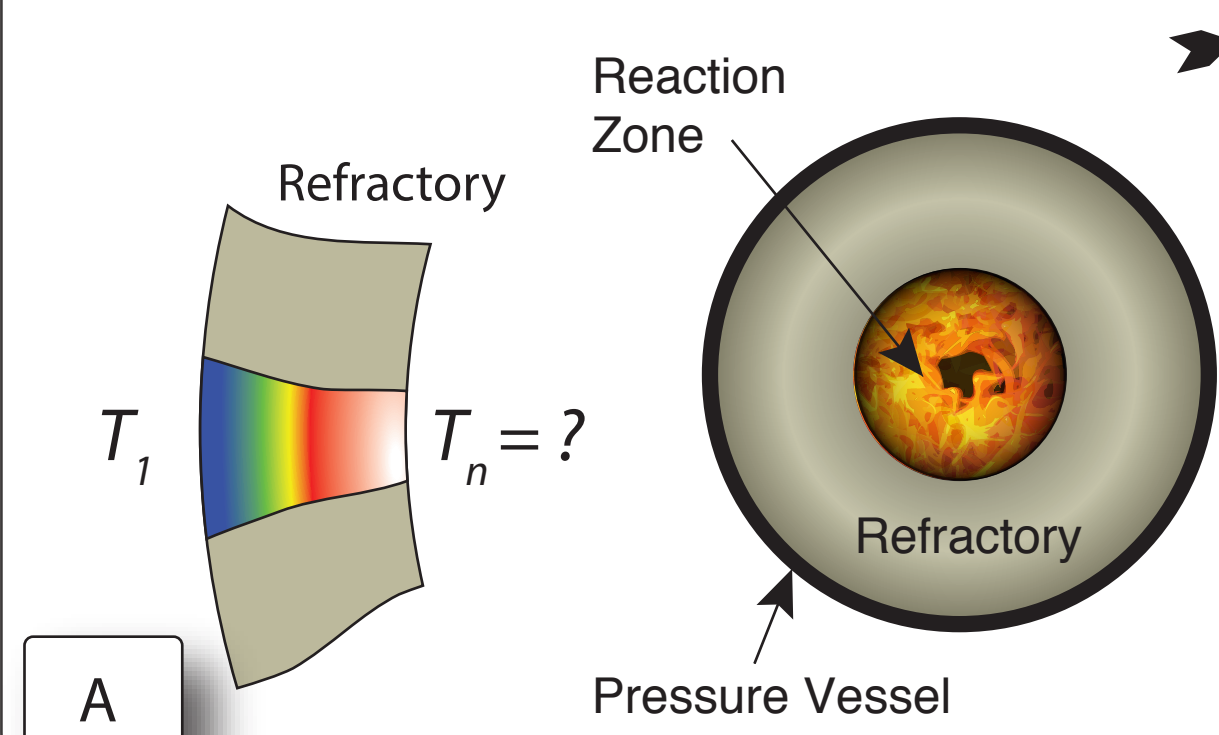
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## Project Objective

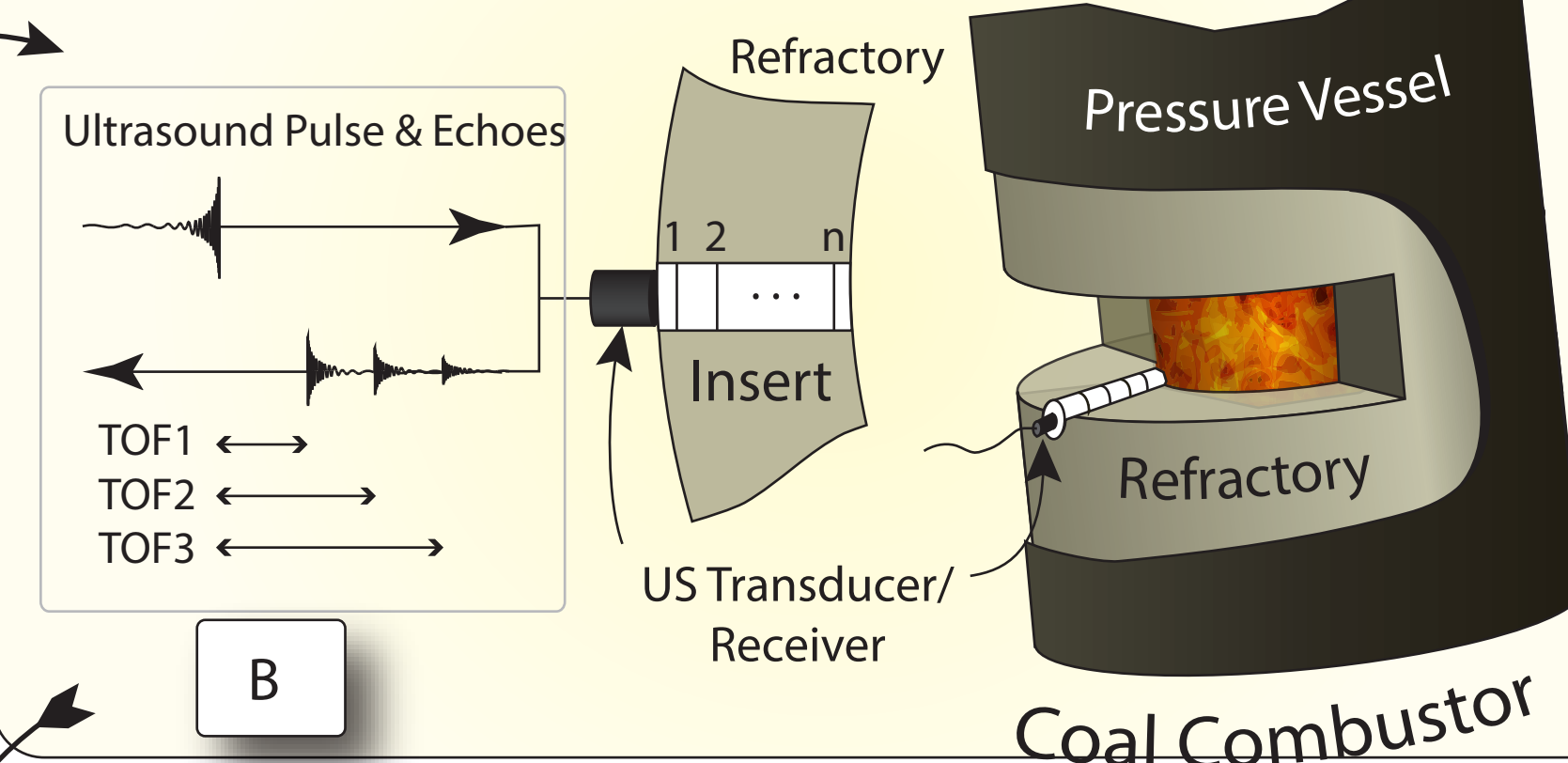
Advance technology readiness of ultrasound method for real-time measurement of temperature profiles and heat fluxes in solids. Validate a prototype multipoint measurement system in a coal-fired utility boiler.

## US-MSTD Method

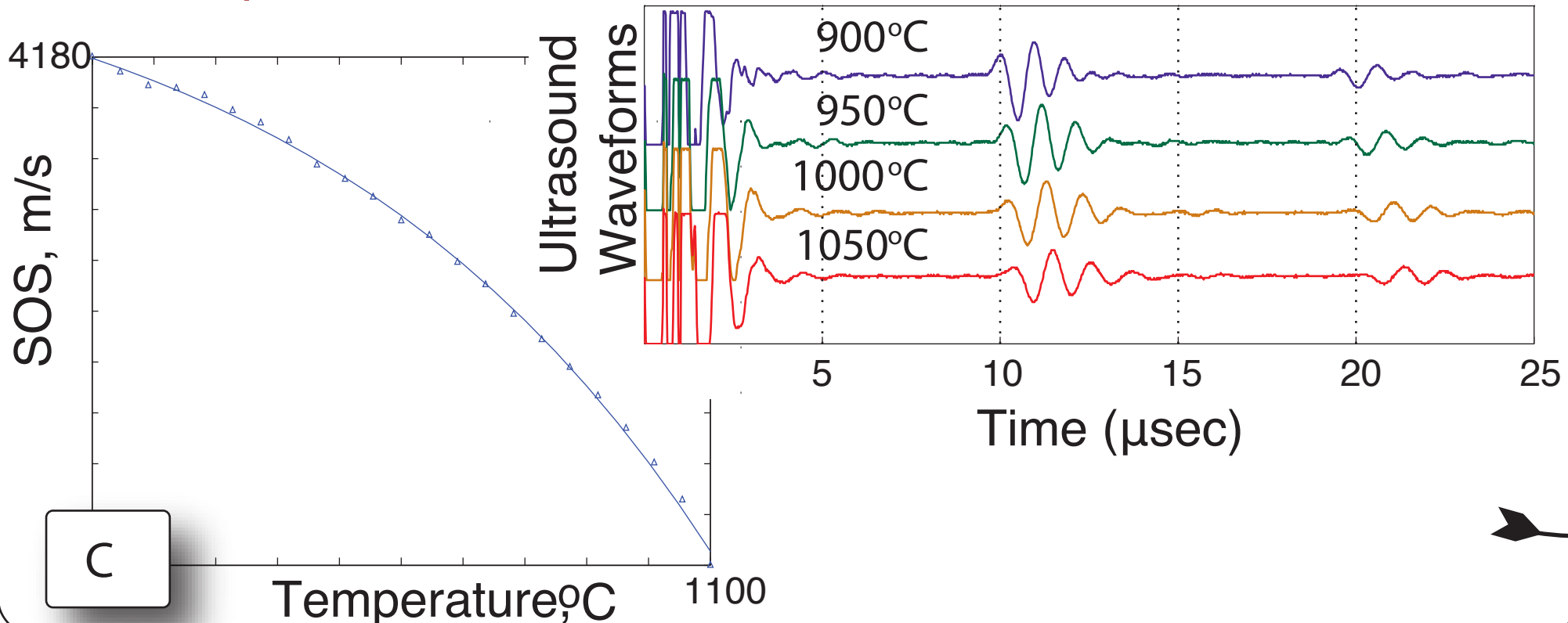
Conventional thermometry fails within harsh and inaccessible environments



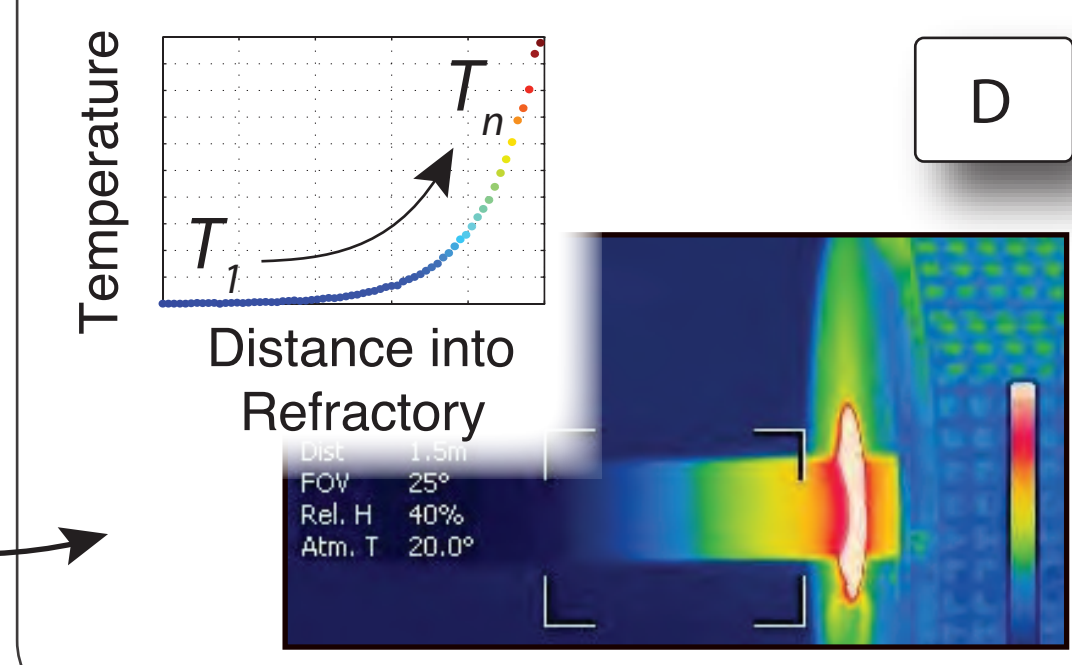
TOF of US echoes through an engineered waveguide is measured



TOF is used to obtain SOS which correlates with temperature



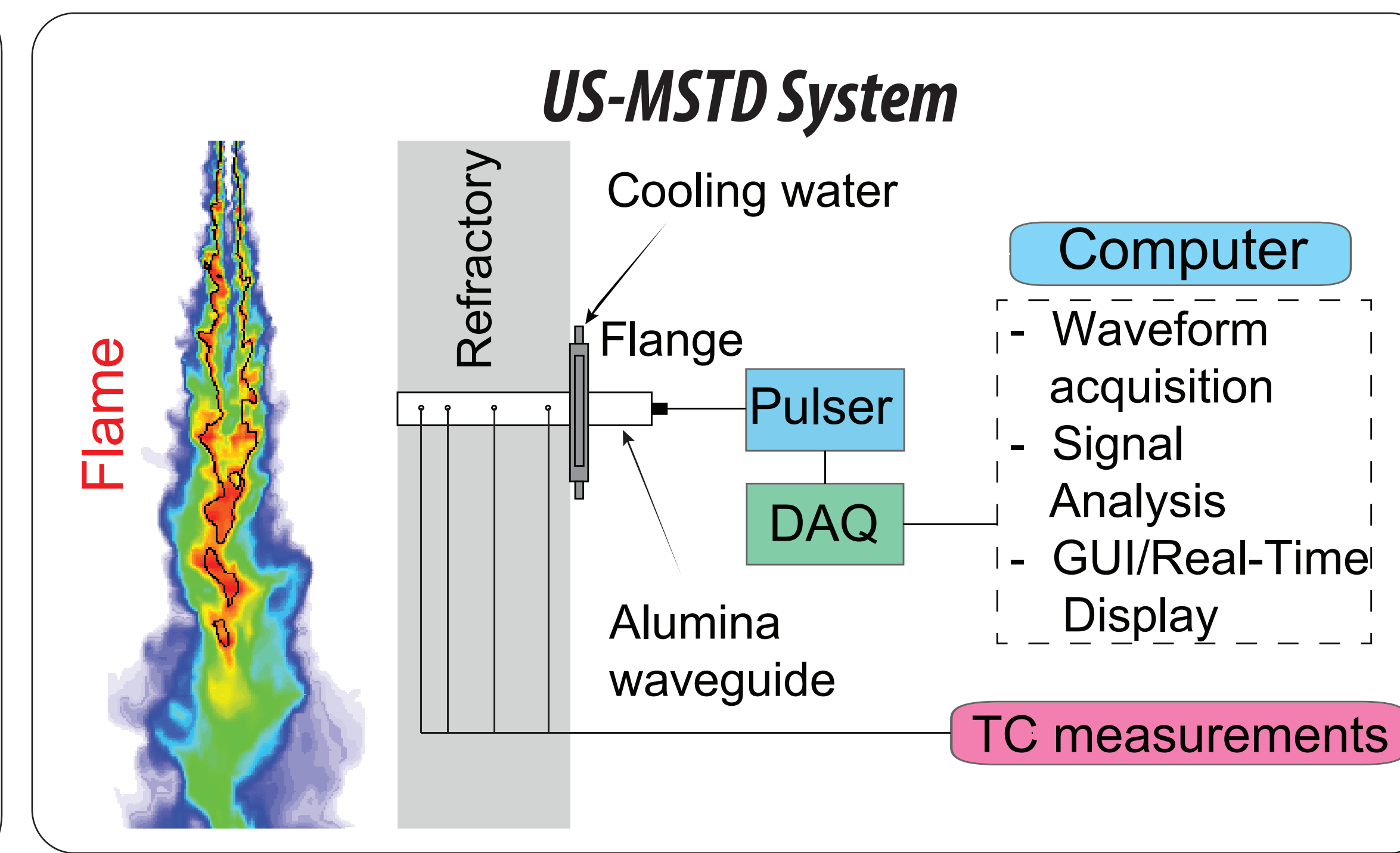
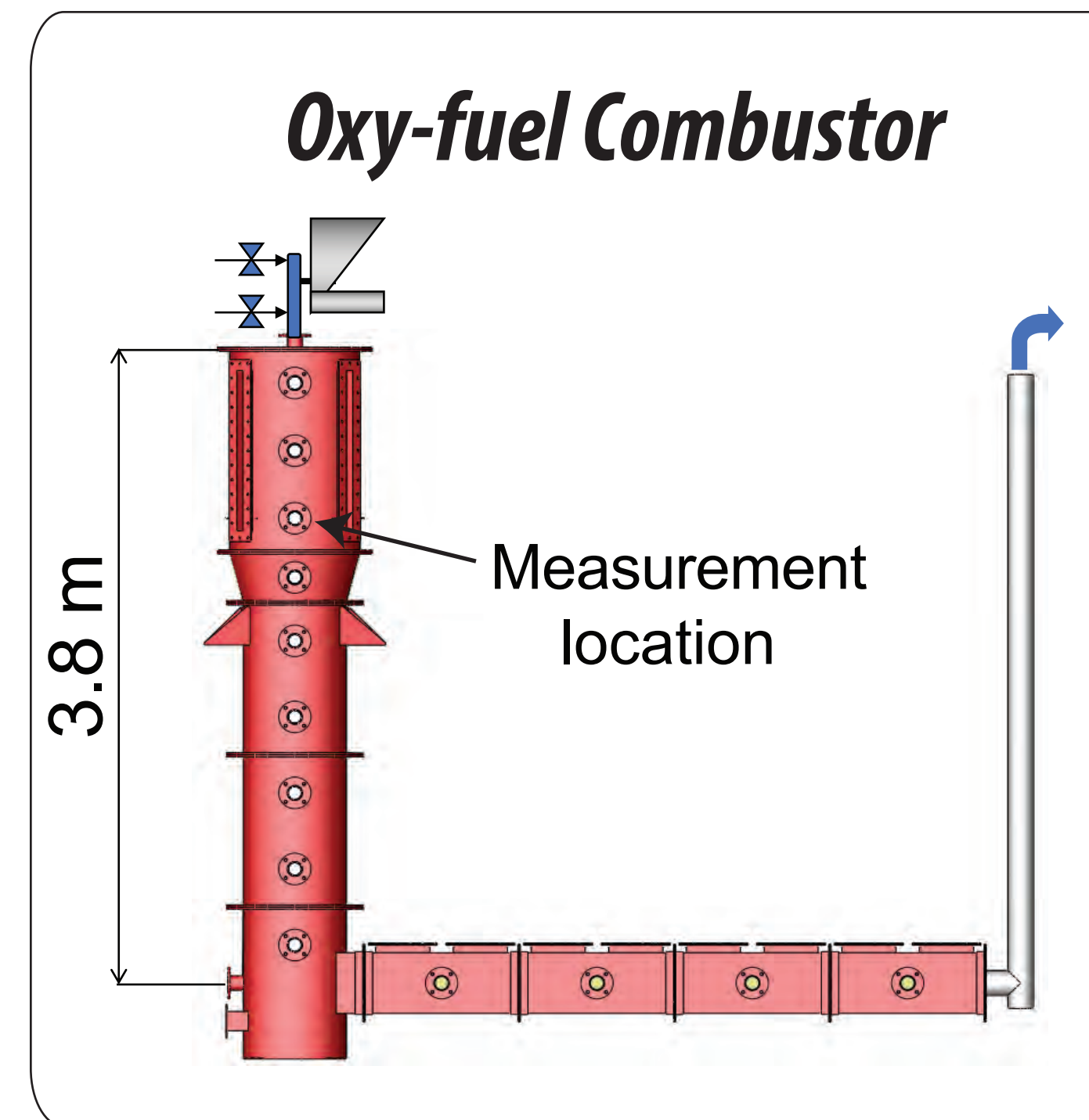
Changes in TOF enable temperature measurements and monitoring of combustor and gasifier operations



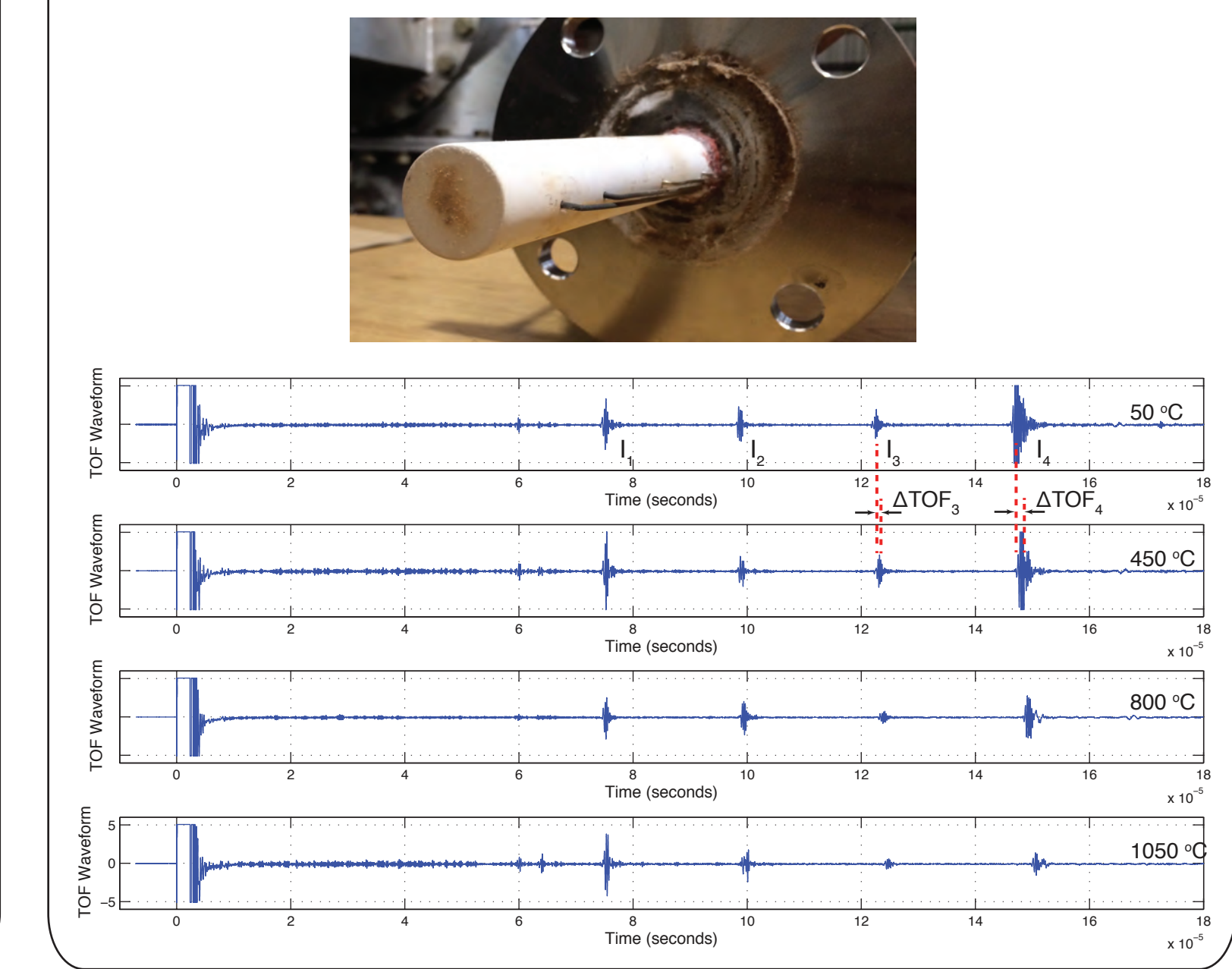
## Technology Status

- Method provide accurate continuous non-invasive real-time measurements of temperature distributions in solids.
- Performance demonstrated in laboratory and pilot-scale oxy-fuel combustor.
- Heat fluxes inside structures can be measured.
- Measurements in multiple locations are possible.
- Can be used with existing and integrated into new energy conversion units.

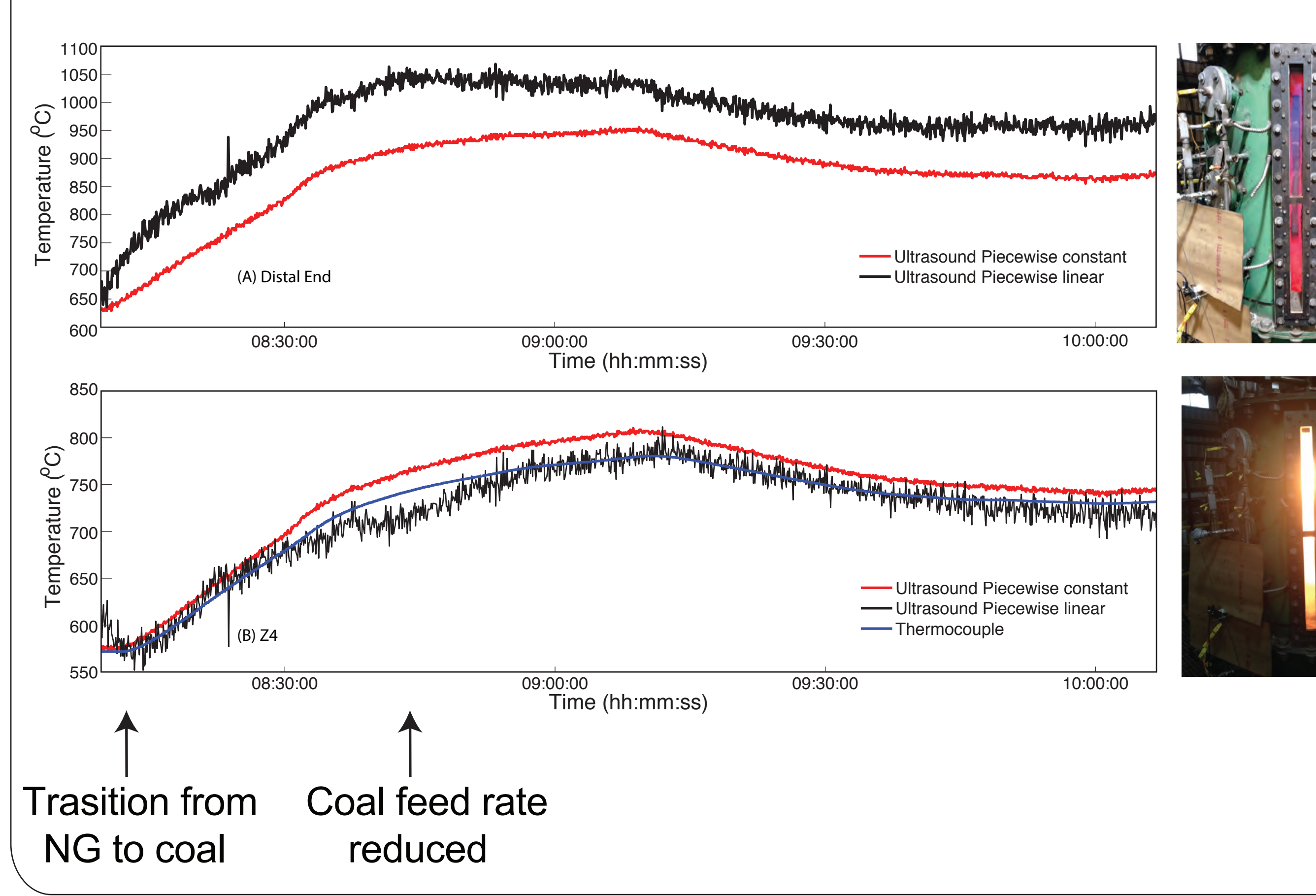
## Pilot-Scale Demonstration



## US Waveguide



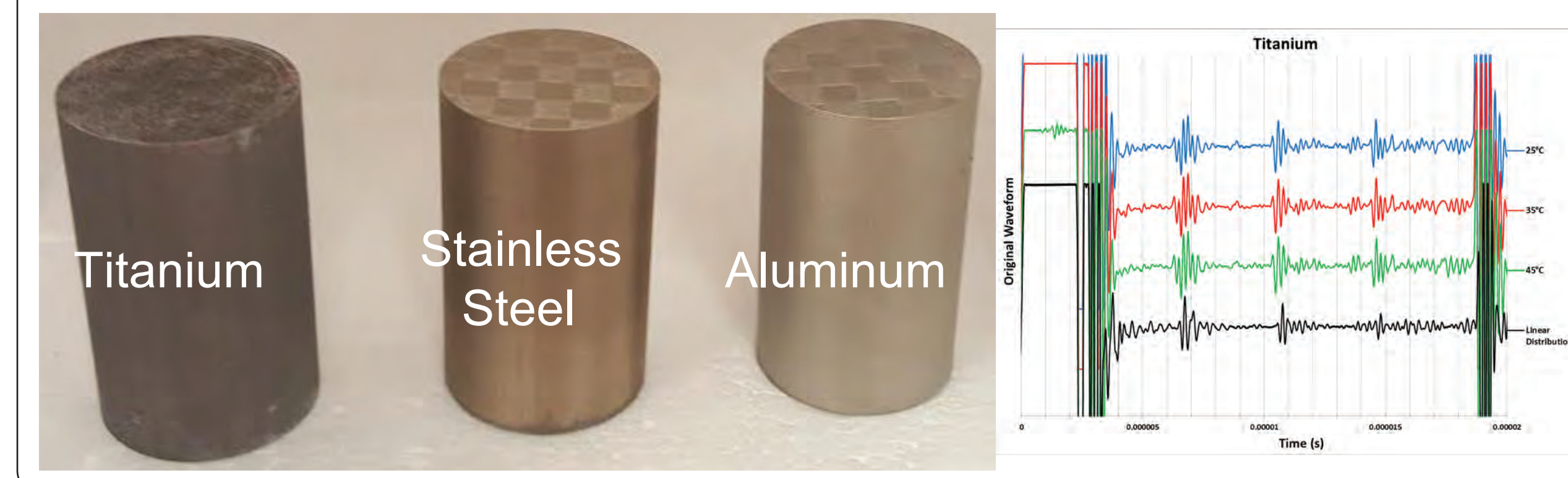
## Transition of NG to Coal at Varying Feed Rate



## Broad applicability

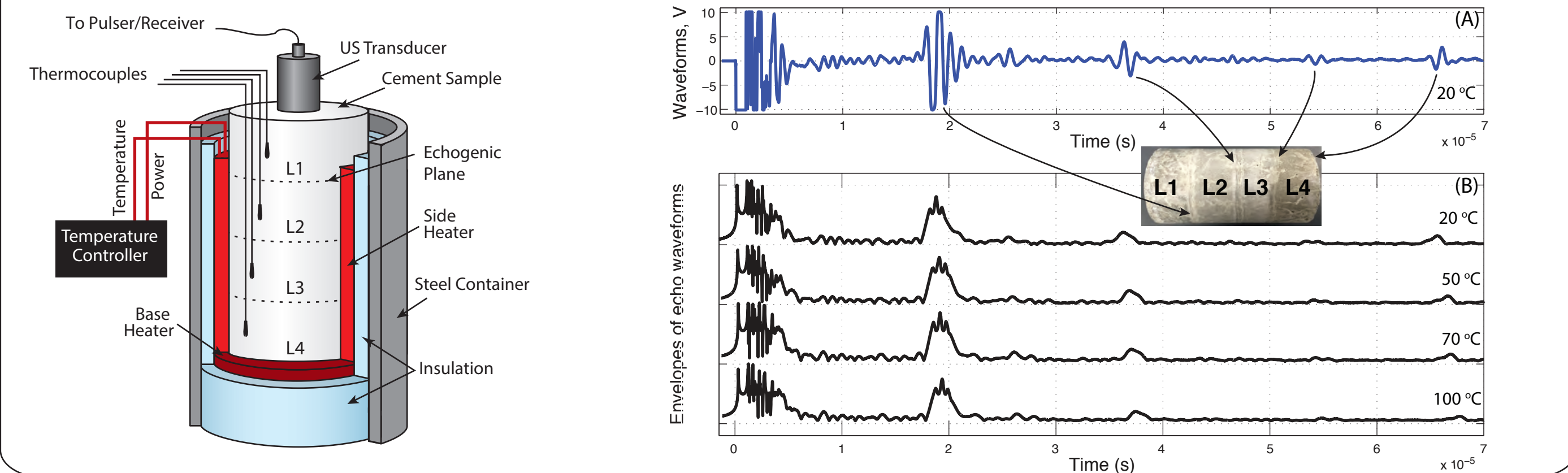
1. Temperature distributions on a line, surface, or in a volume can be measured.
2. Energy, chemical, military, space, and other applications with extreme conditions where conventional probes fail.
3. Alternative to insertion sensors.
4. The only method to measure internal heat fluxes.
5. State of health and state of change monitoring in batteries.
6. Temperature measurements in micro- and nano-devices.
7. Functionalization through additive manufacturing.

## 3D-printed samples with echogenic features

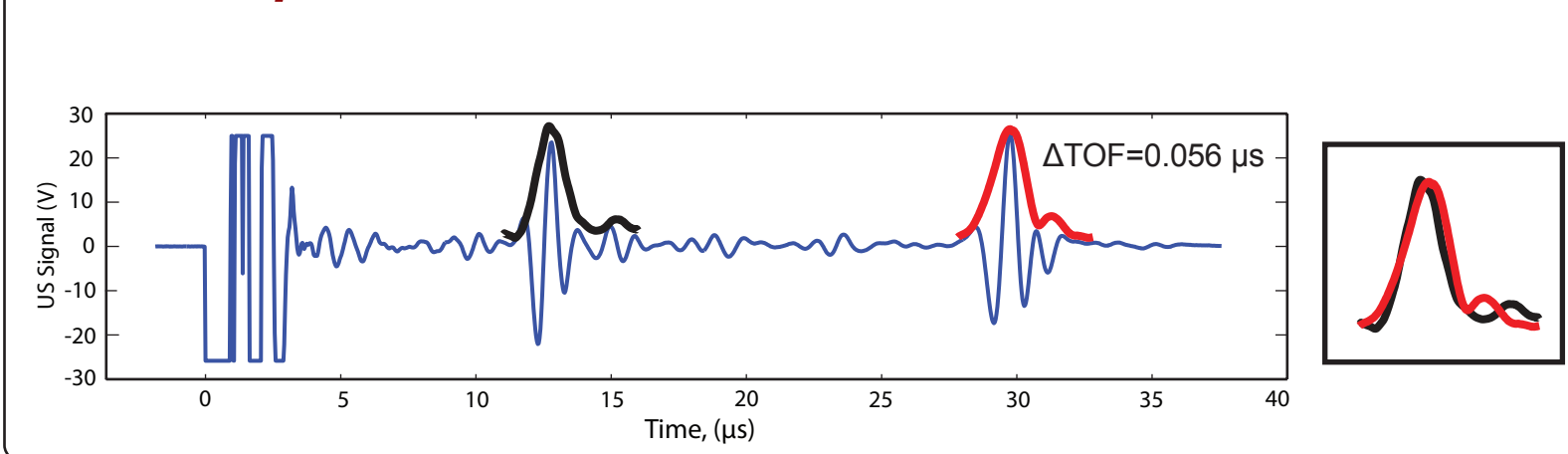


## 3D Temperature Measurements

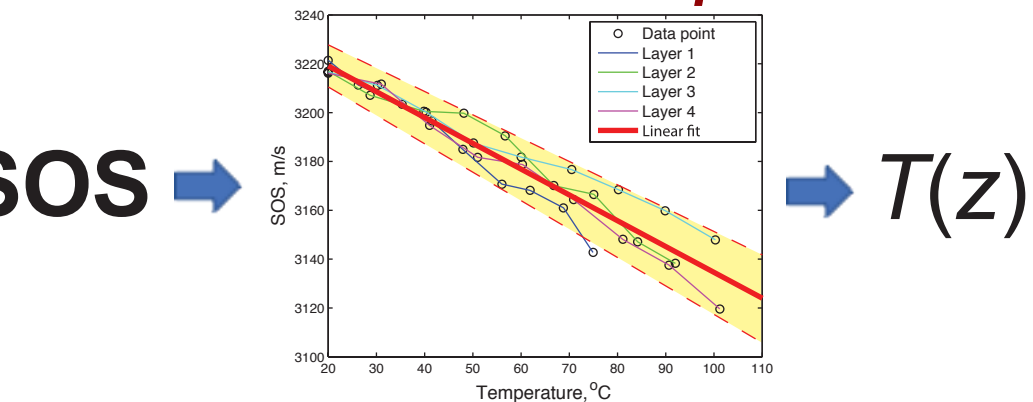
US propagates through waveguide. Echogenic features produce echoes



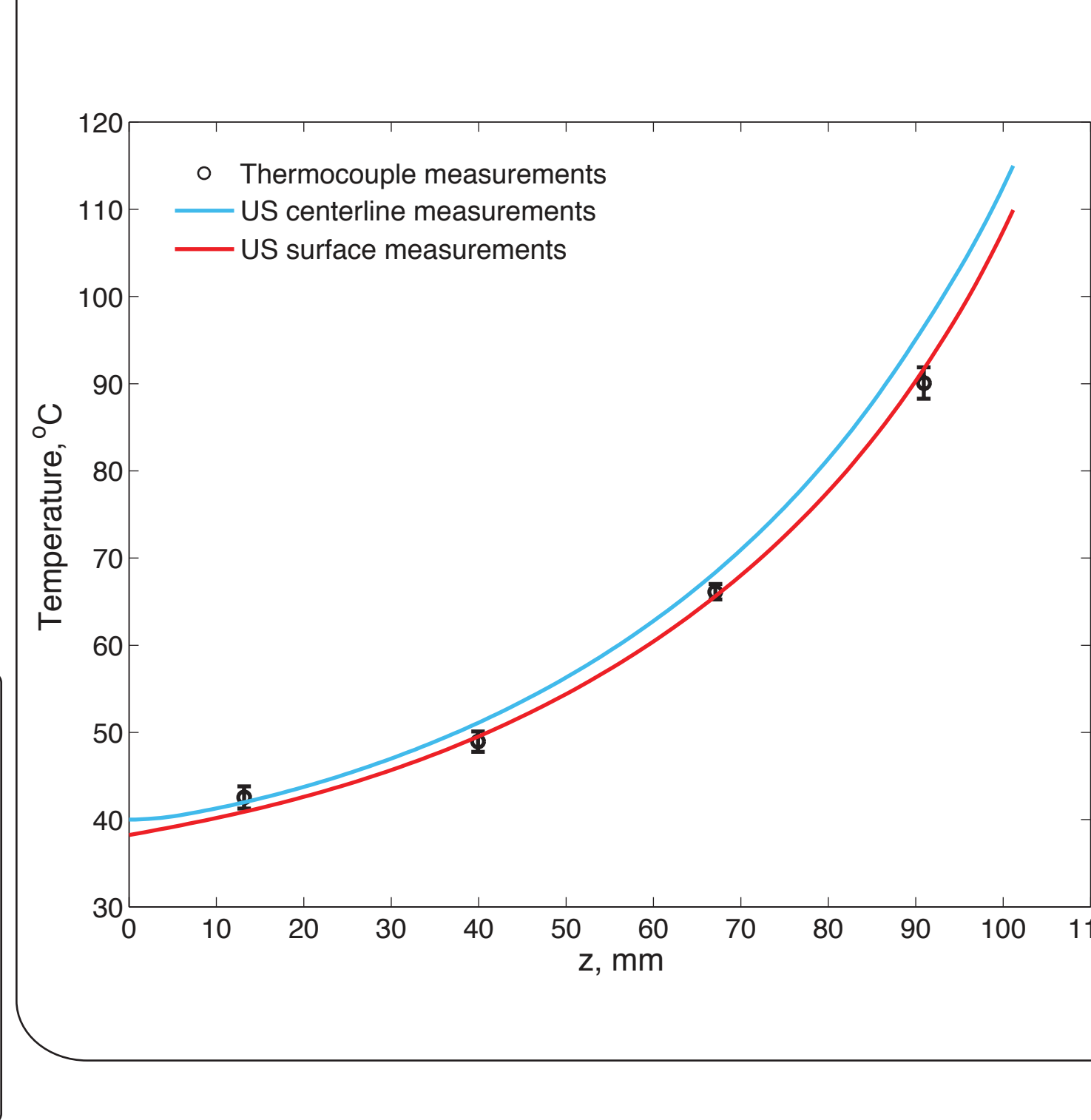
Envelopes are used to find TOF of echoes



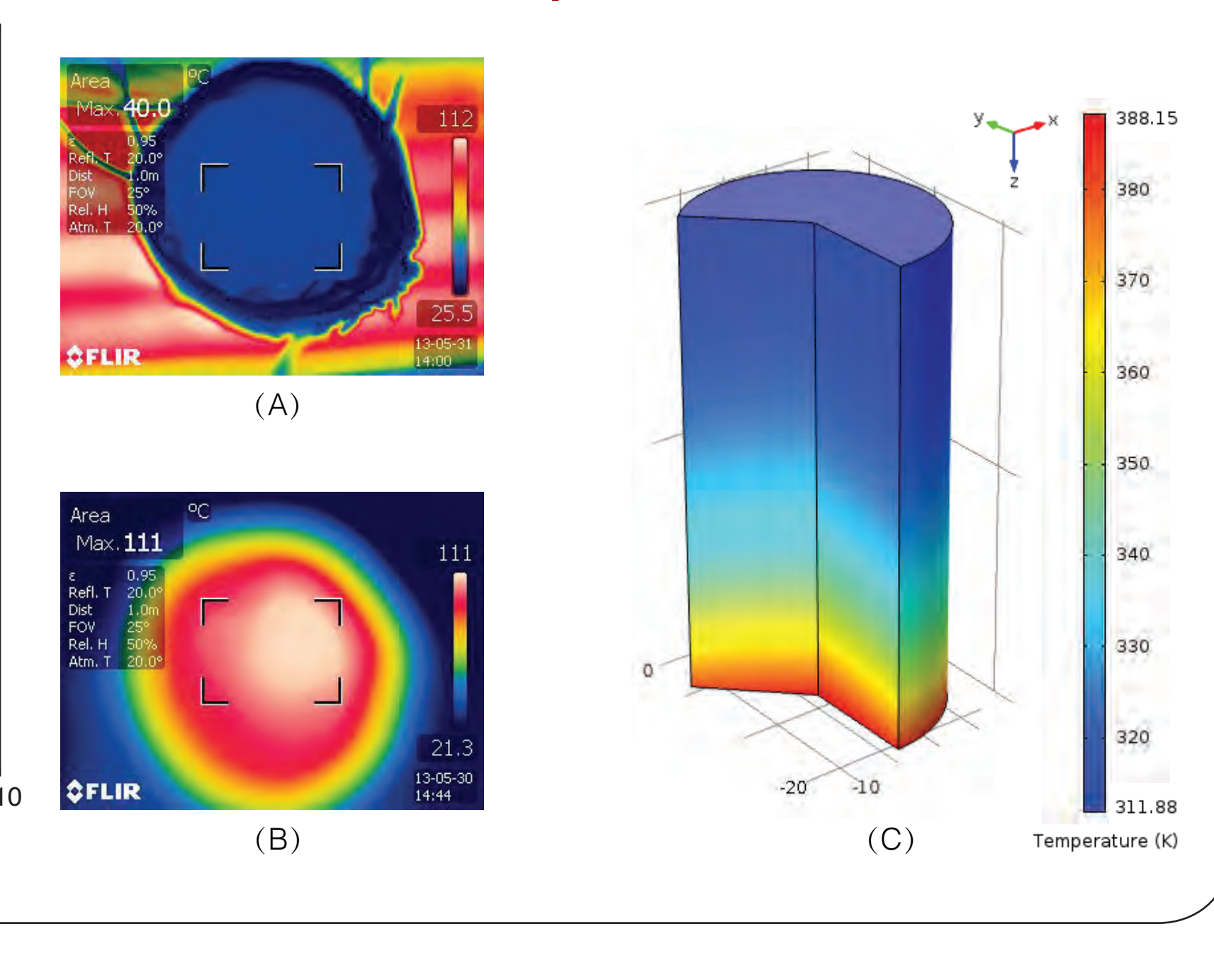
TOF measurements are converted to temperature



## Axial and surface measurements



## 3D reconstruction of temperature distribution



## References

1. M. Skliar, K. Whitty, and A. Butterfield, "Ultrasonic temperature measurement device," US Patents 8,801,277 and 9,212,956.
2. Y. Jia and M. Skliar, "Noninvasive Ultrasound Measurements of Temperature Distribution and Heat Fluxes in Solids," Energy & Fuels, 30:4363–4371, 2016.
3. Y. Jia, V. Chernyshev, and M. Skliar, "Ultrasound measurements of segmental temperature distribution in solids: Method and its high-temperature validation," Ultrasonics, 66:91-102, 2016.

## Acknowledgment

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