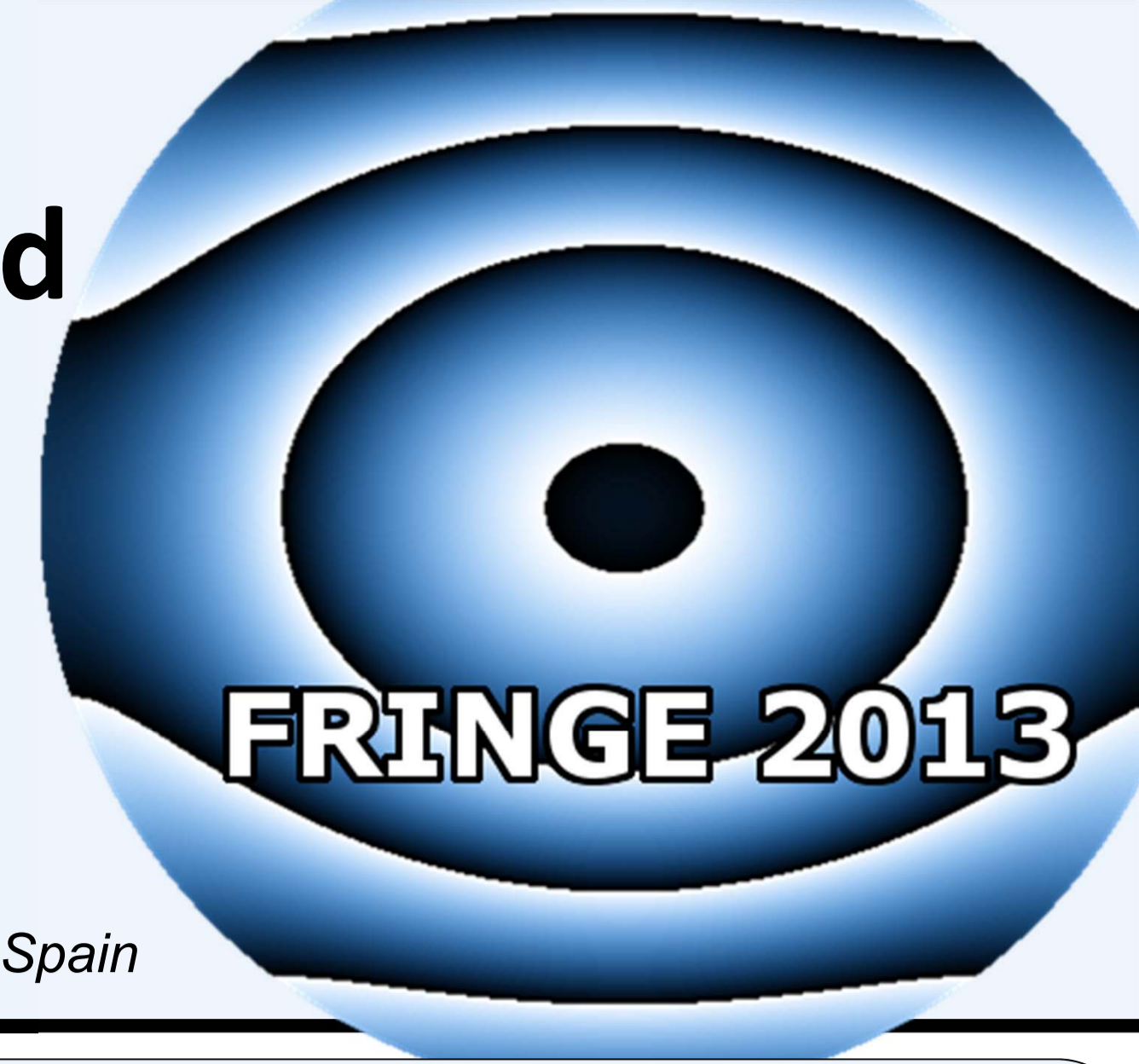


# Simultaneous temperature and deformations measurements using long-wave infrared speckle interferometry: a novel hybrid technique for industrial nondestructive testing



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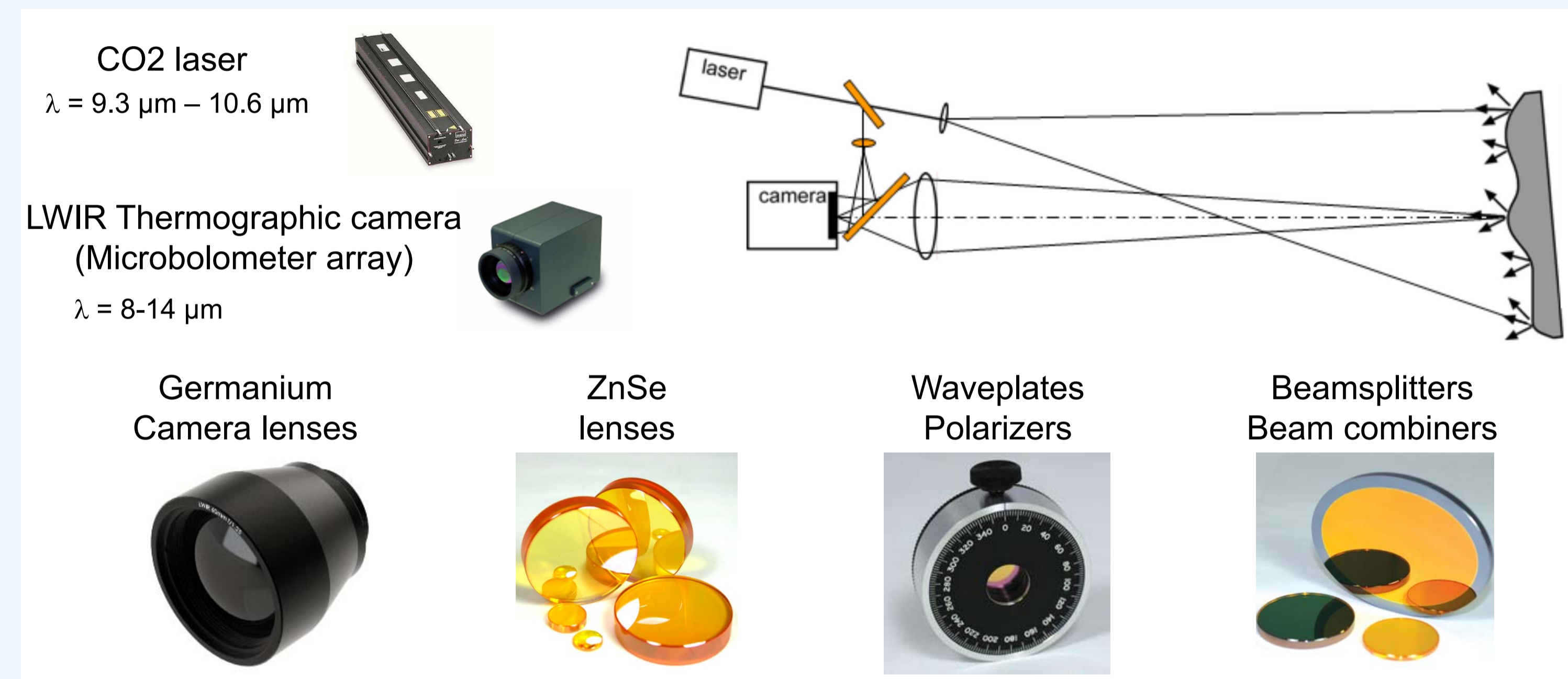
Poster #108

## Abstract

Speckle interferometry applied in the Long-Wave InfraRed (LWIR) range requires the use of thermal infrared cameras and CO<sub>2</sub> lasers. This allows to simultaneously record the thermal background of the object and the speckle pattern when the laser is emitting. Based on this principle, the European FP7 project FANTOM\* aimed at developing a mobile instrument which has been demonstrated with success in industrial field nondestructive testing applications. One advantage is that mechanical deformation measurement can be correlated to thermal change directly. This finds many applications in characterization of materials and thermo-mechanical assessment of structures. Another application is in nondestructive testing where the method allows combining the advantages of thermography and holography for increasing the probability of detecting defects. In particular it was used at Airbus plant for defect detection in a large composite structure.

\*FANTOM=Full Field Advanced Nondestructive Technique for Online Thermo-Mechanical Measurement on Aeronautical Structures

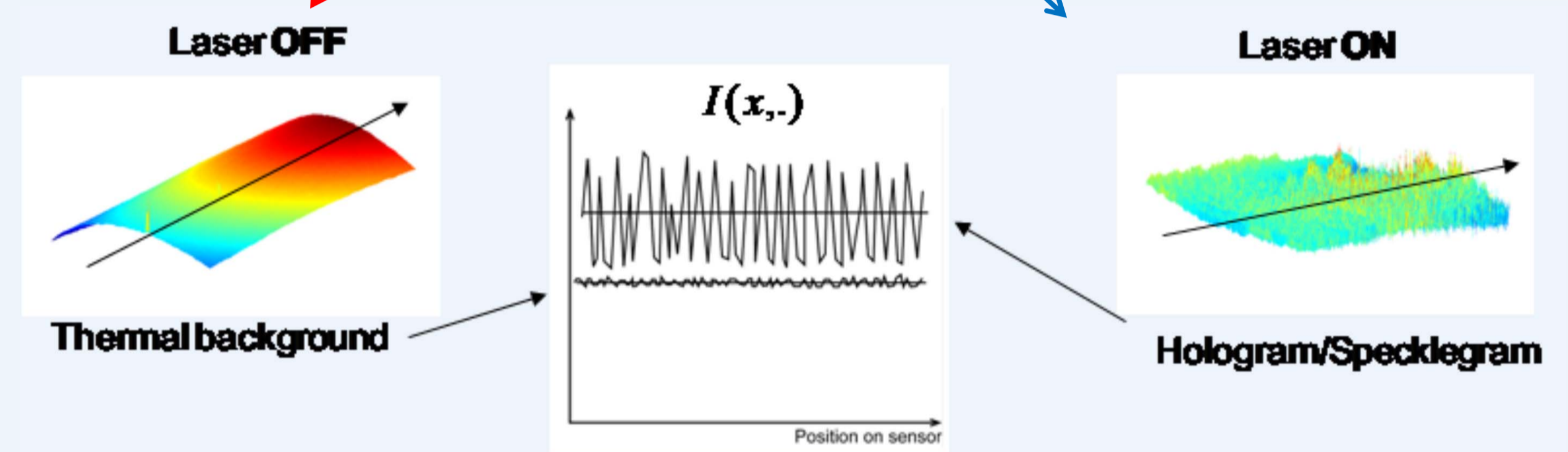
### Classical ESPI set-up with LWIR components



### Principle

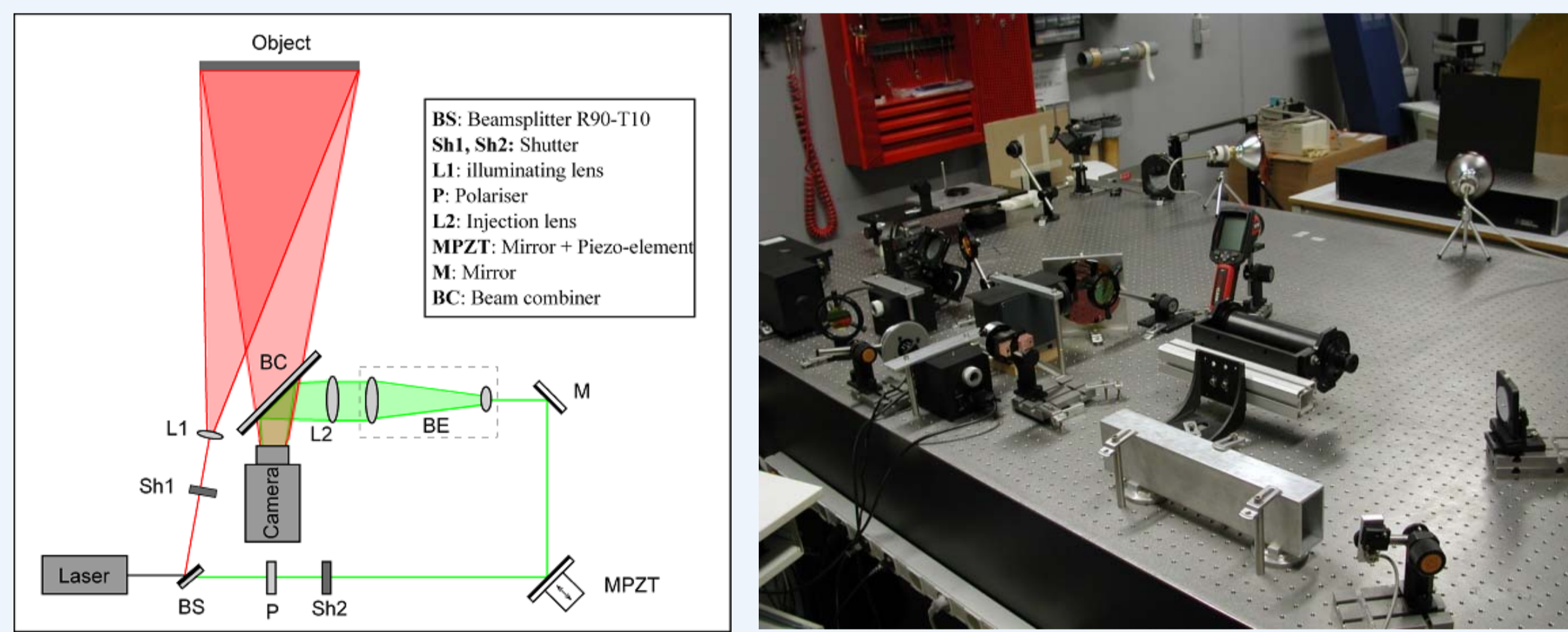
Recorded pattern is the superimposition of thermal background and specklegram

$$I(x, y) = I_{\text{thermal}}(x, y) + I_{\text{average}}(x, y) + C(x, y) \cos[\psi(x, y)]$$



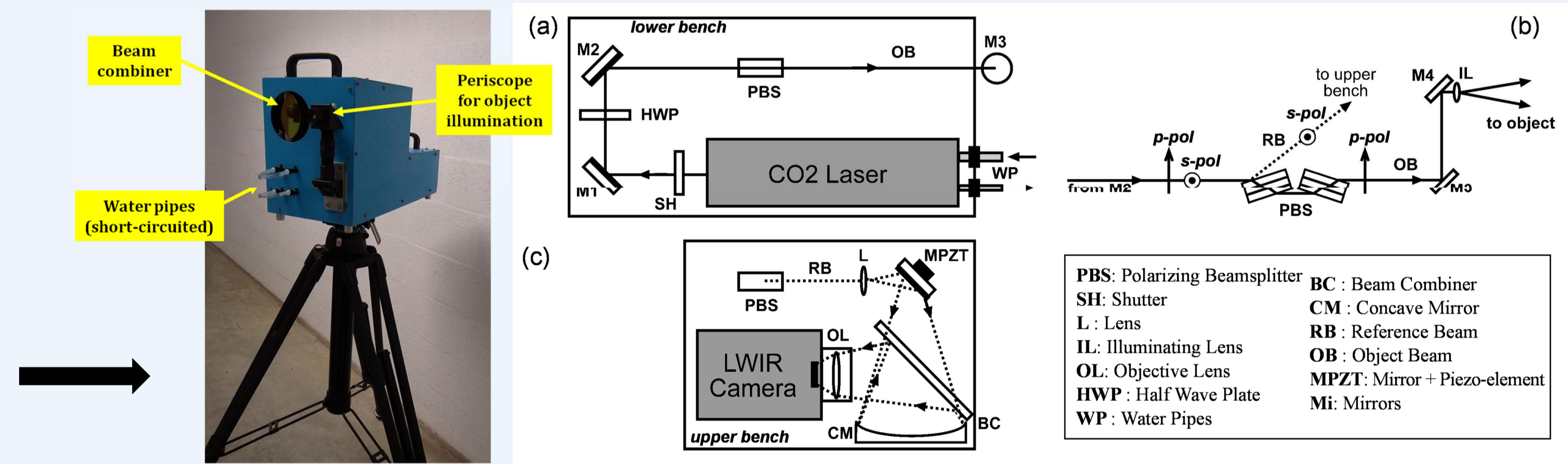
## FANTOM project developments

### Laboratory studies and various set-up



[1] Alexeenko, I., Vandenrijt, J-F, Georges, M., Pedrini, G., Cédric, T., Osten, W., Vollheim, B. (2010) Digital holographic interferometry by using long wave infrared radiation (CO<sub>2</sub> laser), Appl. Mech. Mater. 24-25, 147-152  
[2] Alexeenko, I., Vandenrijt, J-F, Pedrini, G., Thizy, C., Vollheim, B., Osten, W., Georges, M. (2013) Nondestructive testing by using long wave infrared interferometric techniques with CO<sub>2</sub> lasers and microbolometer arrays, Appl. Opt. 52(1), A56-A67

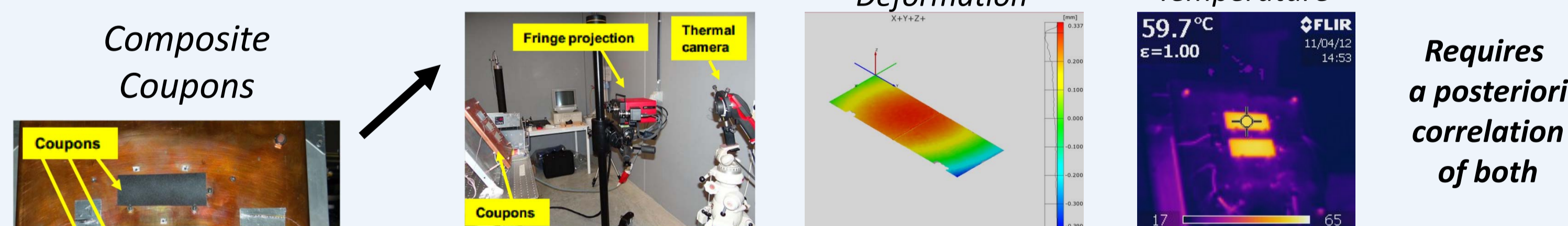
### Choice of more suitable configuration for mobile instrument



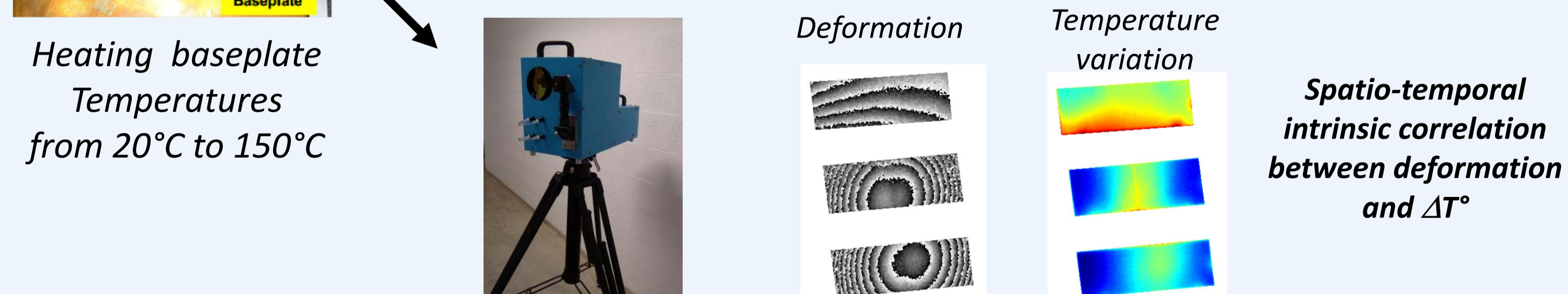
[3] Vandenrijt, J-F, Thizy, C., Alexeenko, I., Pedrini, G., Rochet, J., Vollheim, B., Jorge, I., Venegas, P., Lopez, I., Osten, W., Georges, M.P. (2013) Mobile speckle interferometer in the long-wave infrared for aeronautical nondestructive testing in field conditions, Opt. Eng. 52(10), 101903

## Application 1: Thermo-mechanical measurements

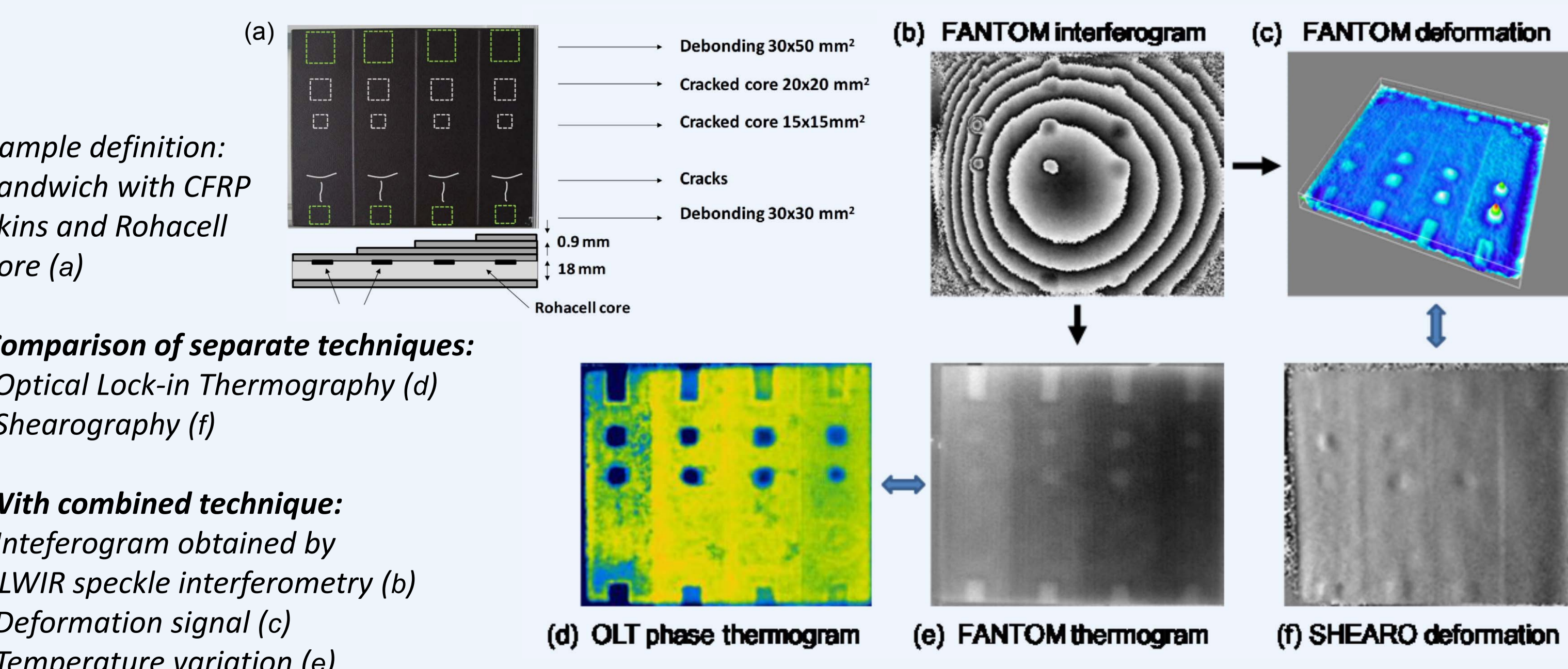
### Measurements with separate techniques : fringe projection and thermography



### Measurements with single LWIR speckle interferometry instrument

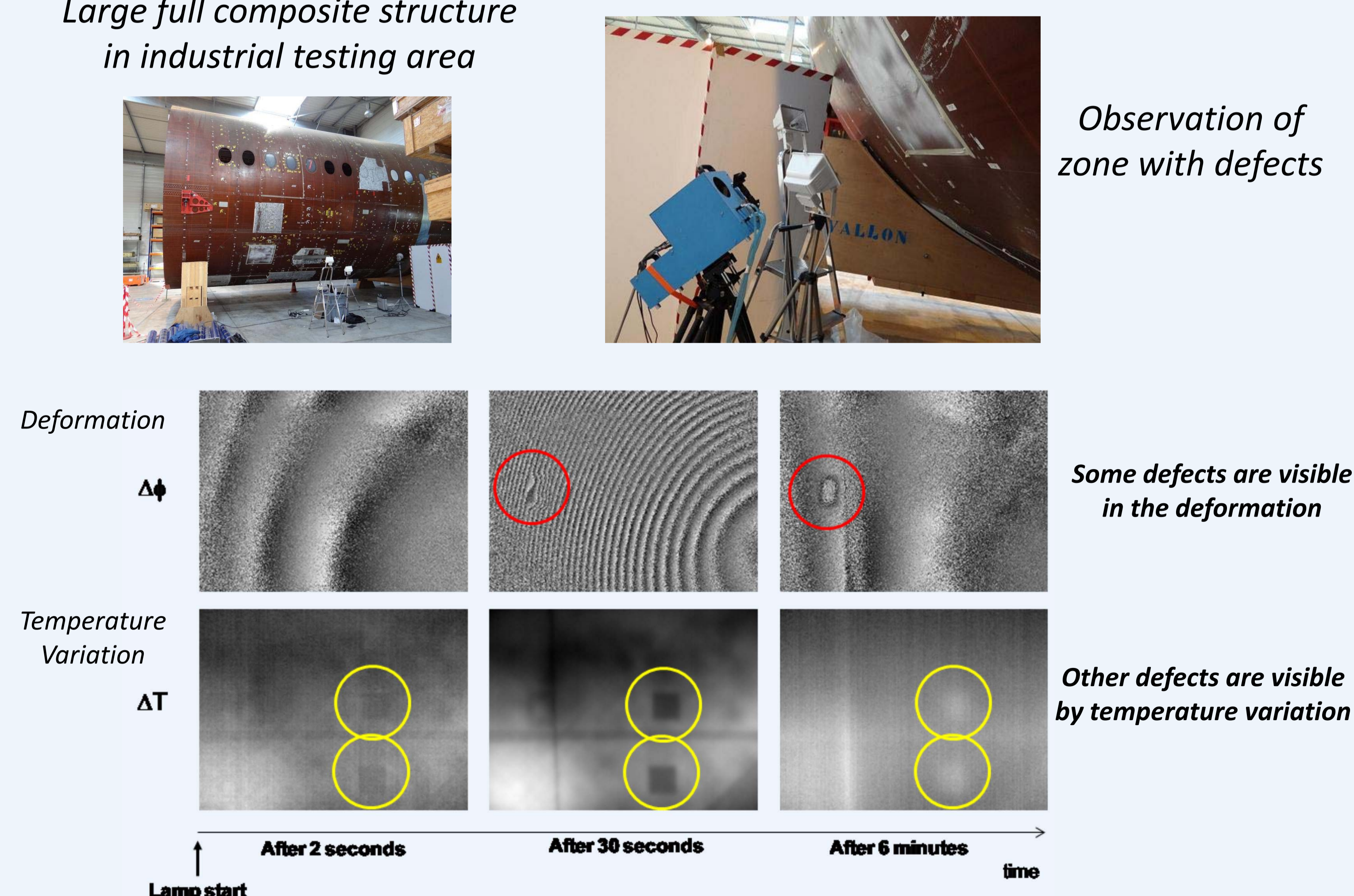


## Application 2: Detection of defects in composites



## Application 3: On-site defect detection

### Large full composite structure in industrial testing area



## Conclusion

Long Wave InfraRed speckle interferometry allows :

- Large deformation measurements (due to large wavelength)
- Highly stable measurements in industrial environments
- Simultaneous measurements of deformation and temperature variations
- Various nondestructive testing and metrology applications

**Acknowledgment :** FP7 FANTOM project, Contract N 213457 ([www.fantom-ndt.eu](http://www.fantom-ndt.eu))