EXPERIMENTAL ASSESSMENT OF SIMULTANEOUS IN-SITU HELIOSTATS CALIBRATION METHODOLOGY HELIOCONTROL AT THEMIS FACILITY

Gregor Bern

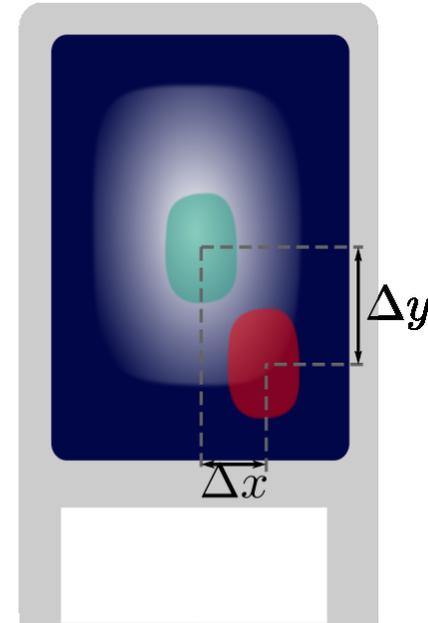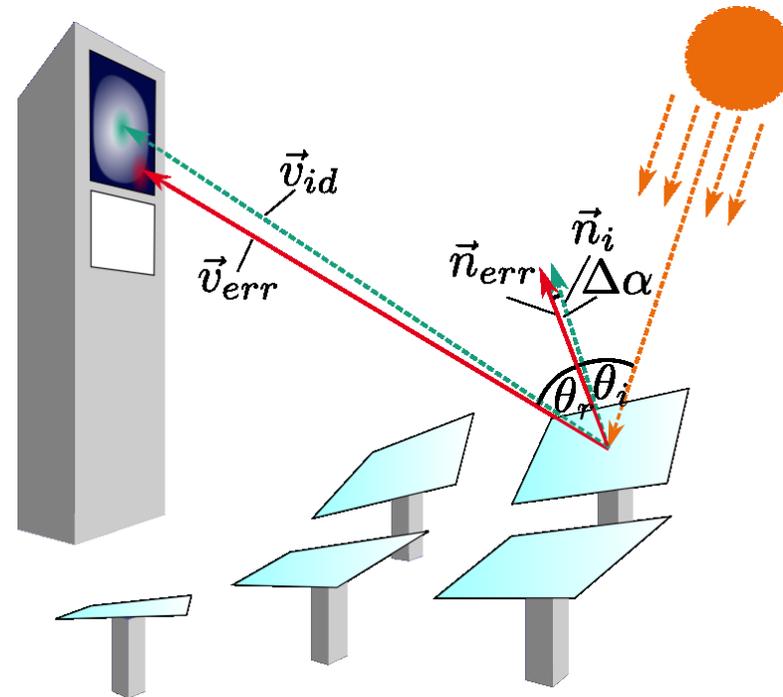Fraunhofer Institute for Solar Energy Systems ISE

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Introduction
Closed Loop Heliostat Control / In-Situ Calibration

- Pointing uncertainties:
  0.6 mrad$<$RMS$_{point}<3$ mrad

- Recalibration is necessary to feed heliostat error / drift models

- Closed loop tracking can allow for relaxed requirements and reduce heliostat costs

- Measurement at the receiver promises little error propagation

- In-situ measurement needs to work at high flux from thousands of heliostats
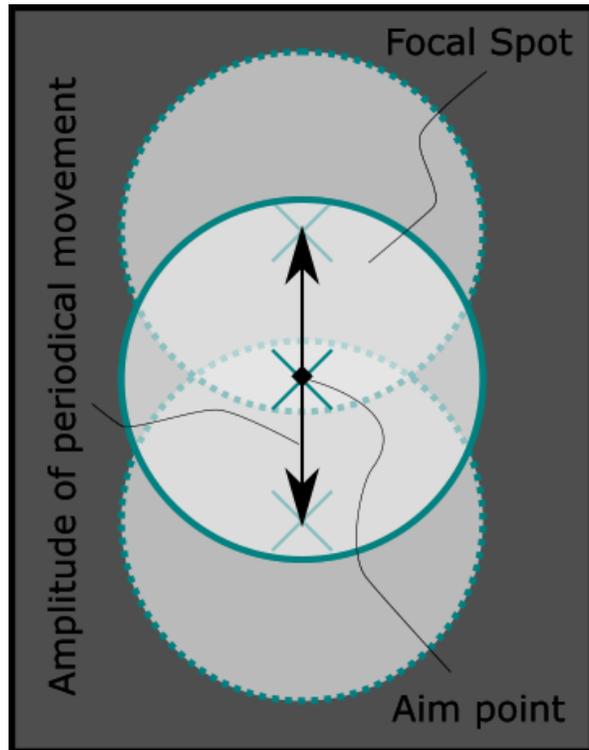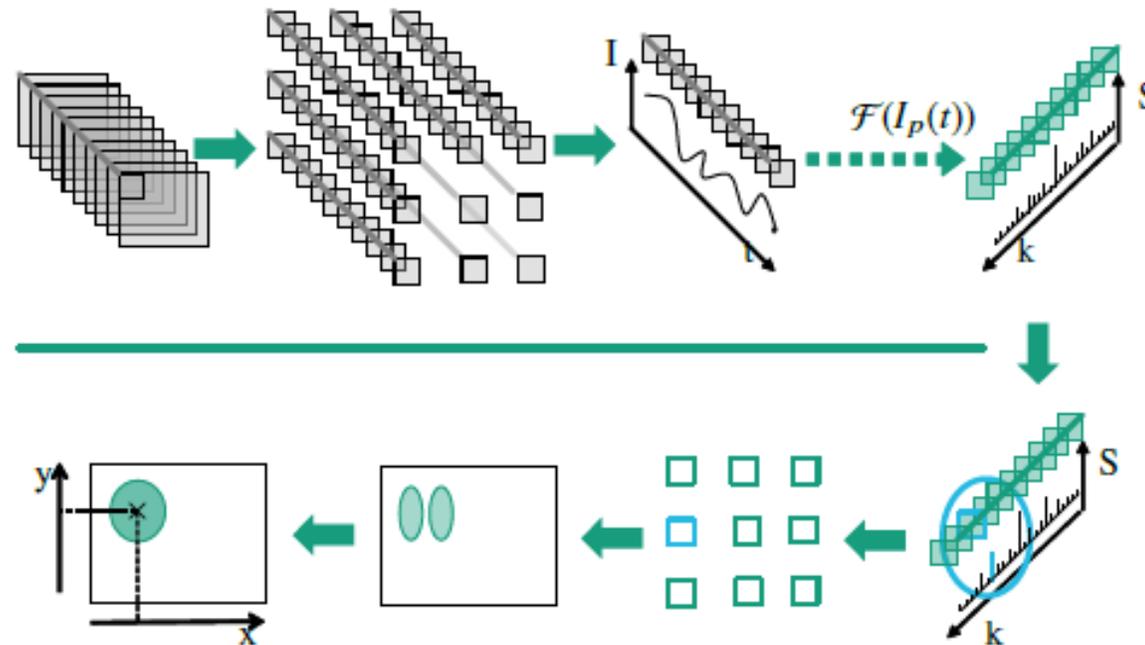
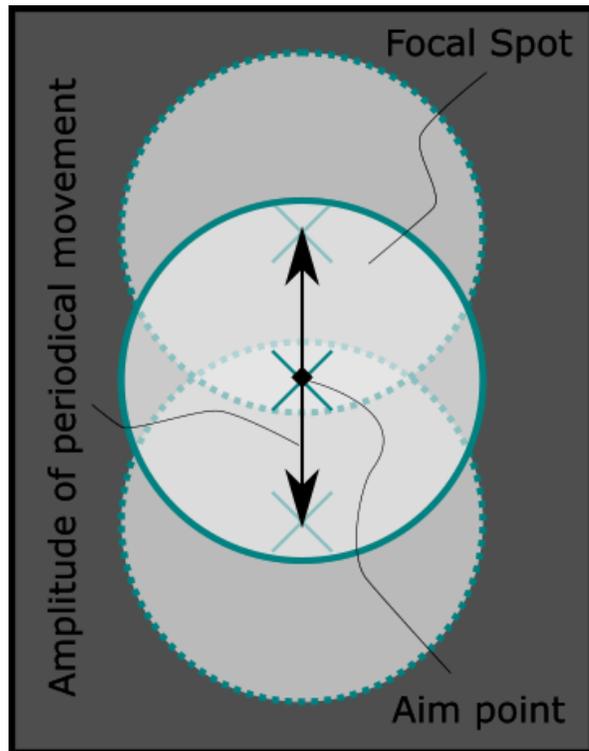- HelioControl method

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In Brief - The HelioControl-Method
The Principle of Evaluation

G. Bern, P. Schöttl, D. W. van Rooyen, A. Heimsath, and P. Nitz, "Parallel in-situ measurement of heliostat aim points in central receiver systems by image processing methods," Solar Energy **180**, 648–663 (2019).
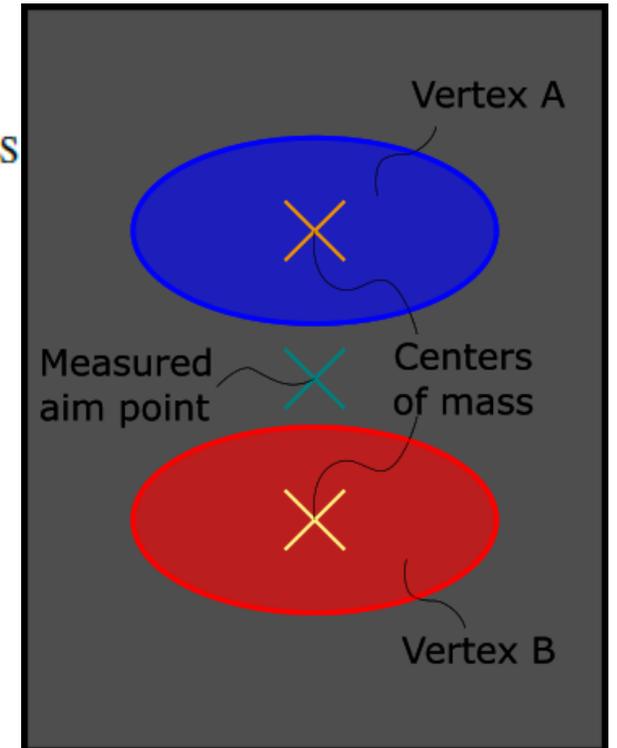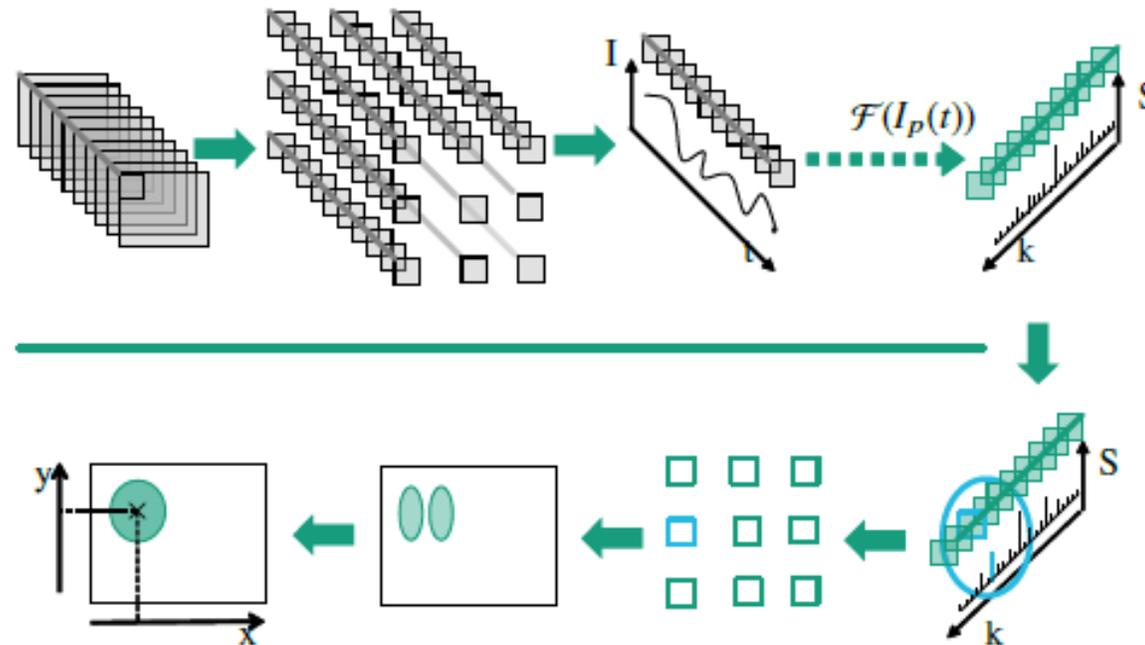
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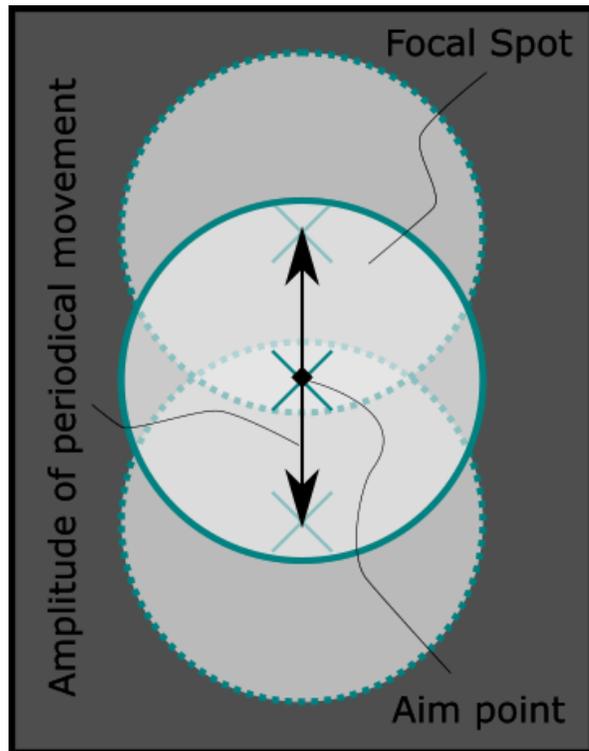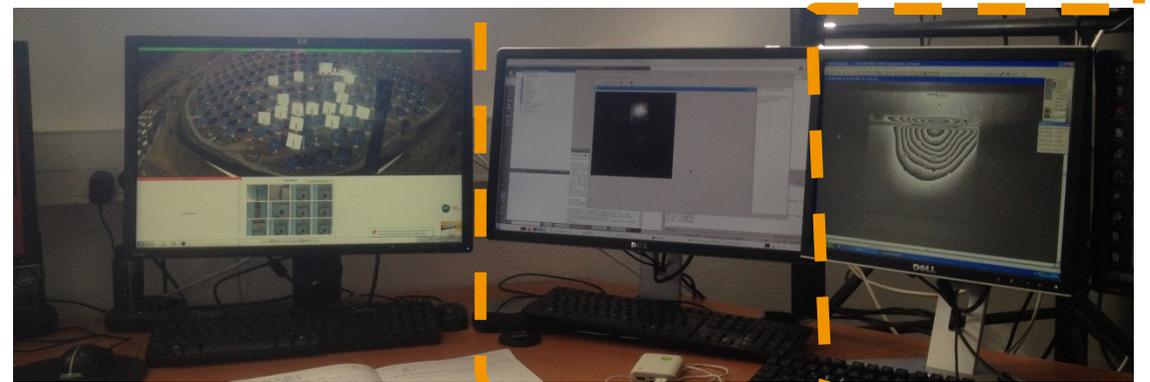# In Brief - The HelioControl-Method
The Principle of Evaluation

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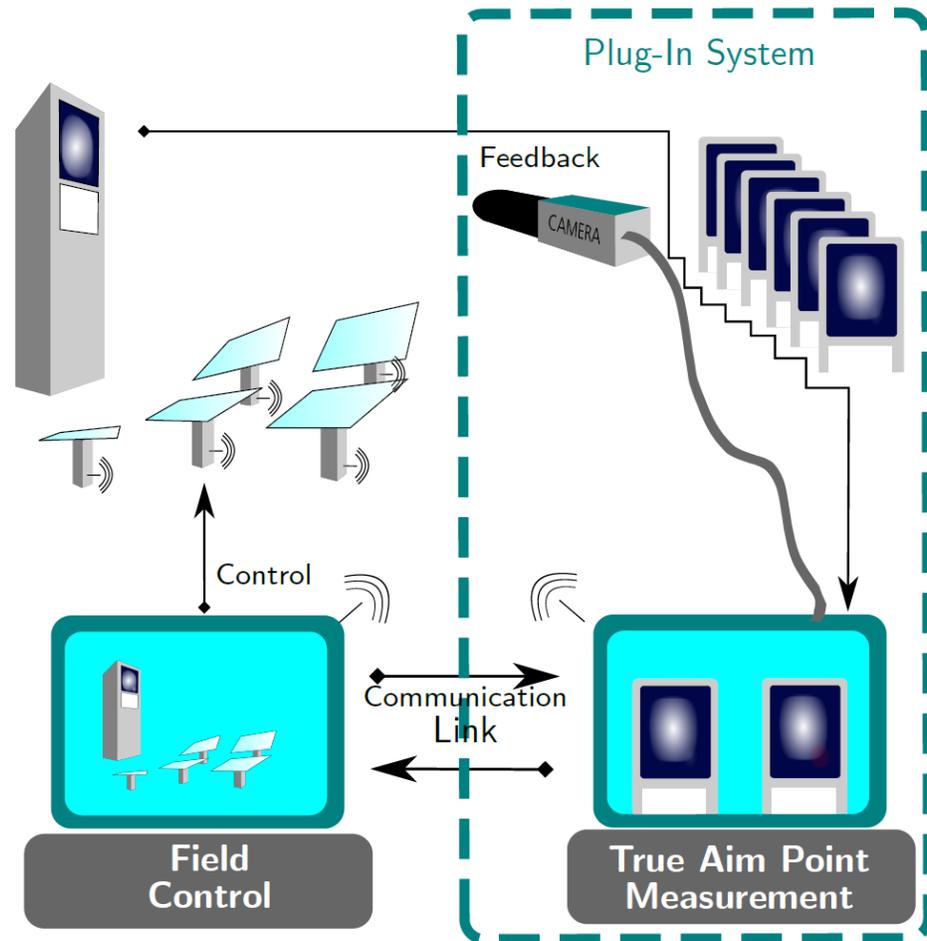# In Brief - The HelioControl-Method
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In Brief - The HelioControl-Method
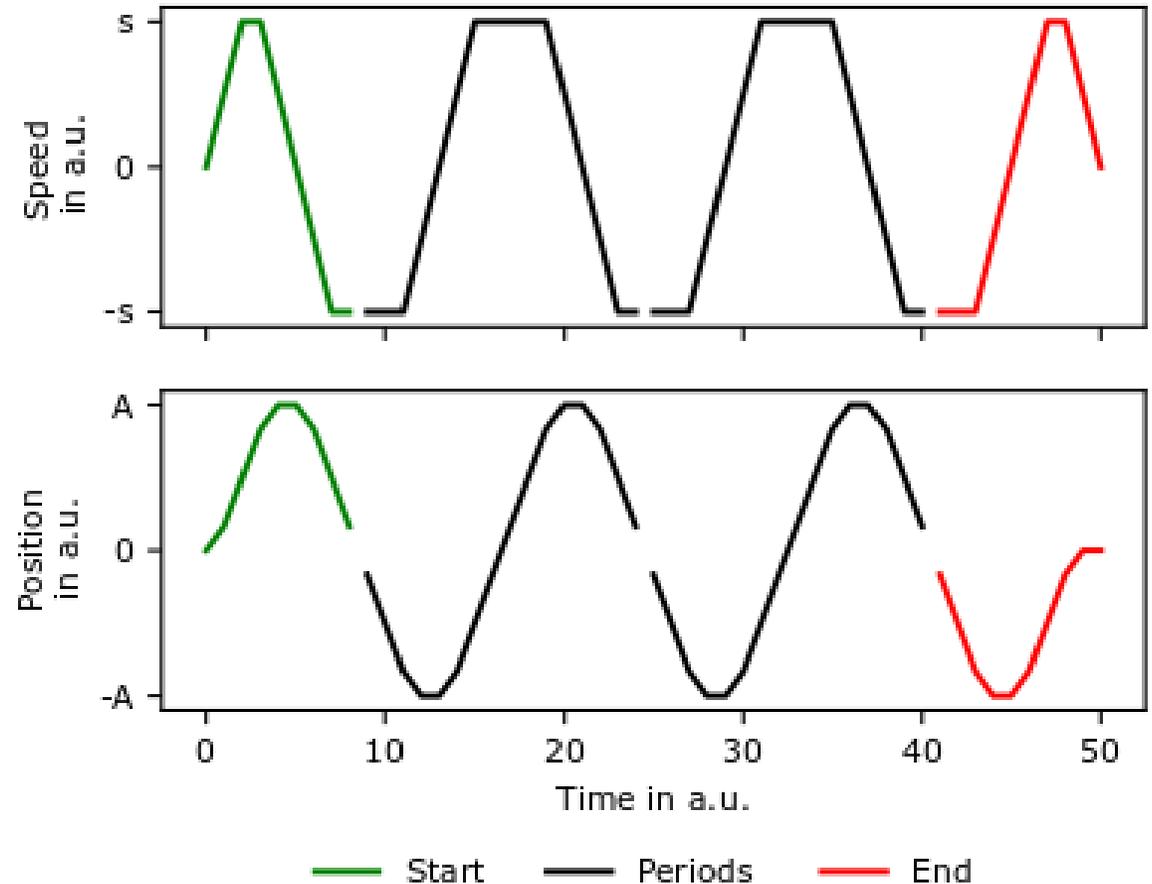## The Principle of Integration

In Brief - The HelioControl-Method
The Periodic Movement

- Parameters
  - Drive Acceleration
  - Maximum speed
  - Amplitude of high speed
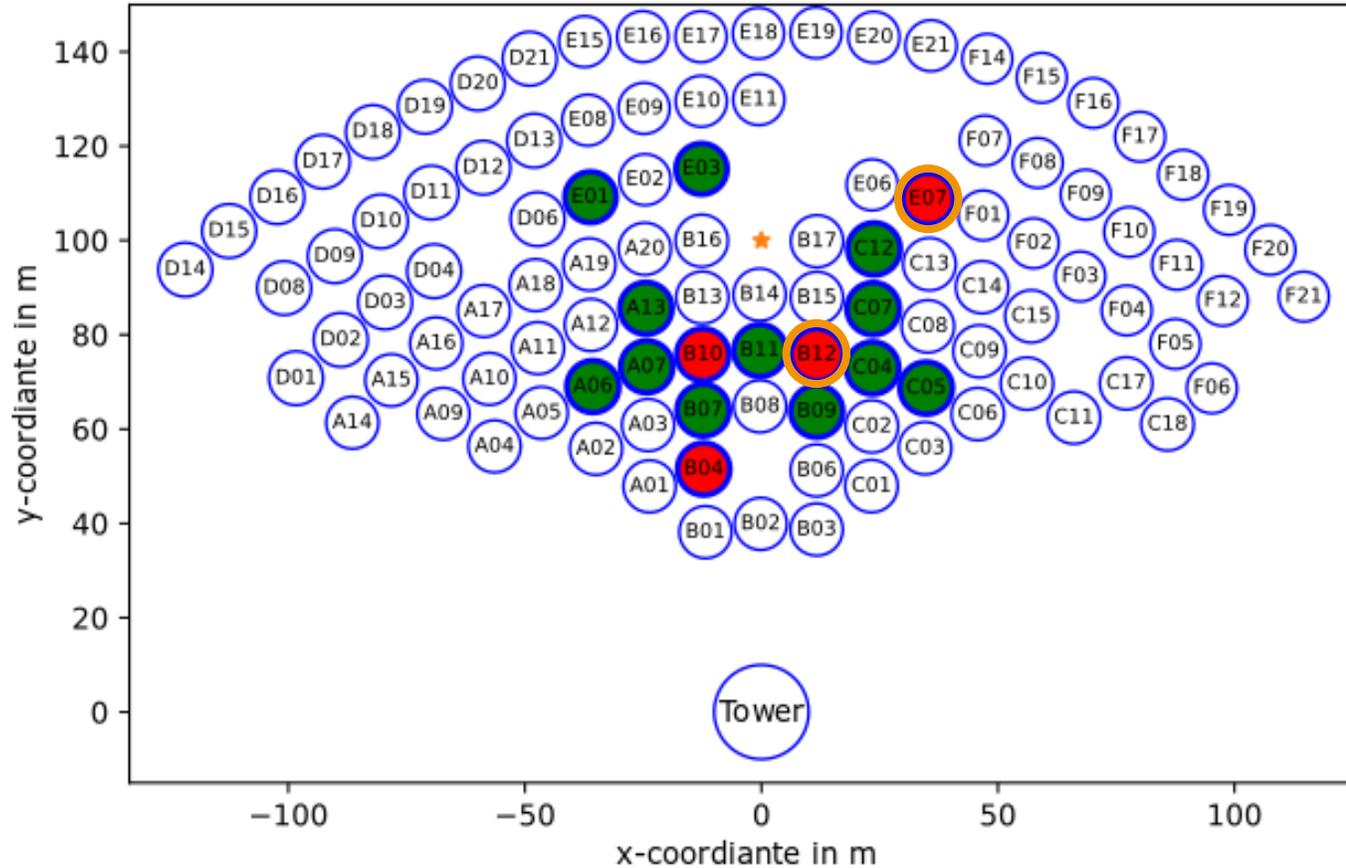
- At Themis:
  - Periodic movement of focal spot implemented
  - Frequencies between 0.04 – 0.23 Hz
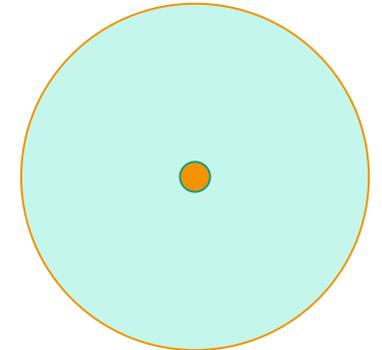 - 4 Heliostats equipped
    0.04 Hz; 0.1 Hz, 0.16 Hz, 0.23 Hz
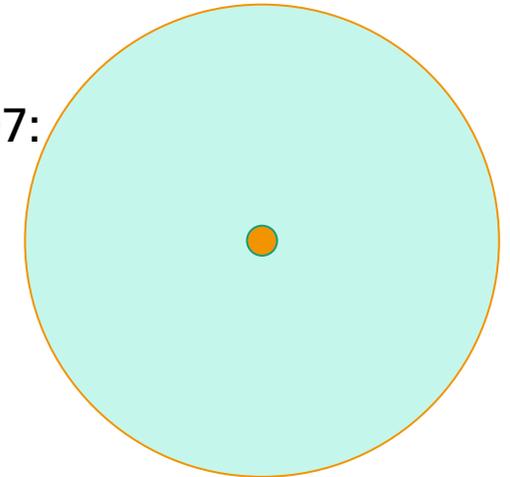
Measurement at Themis
Aiming at Large Flux Target

Uncertainty B12:
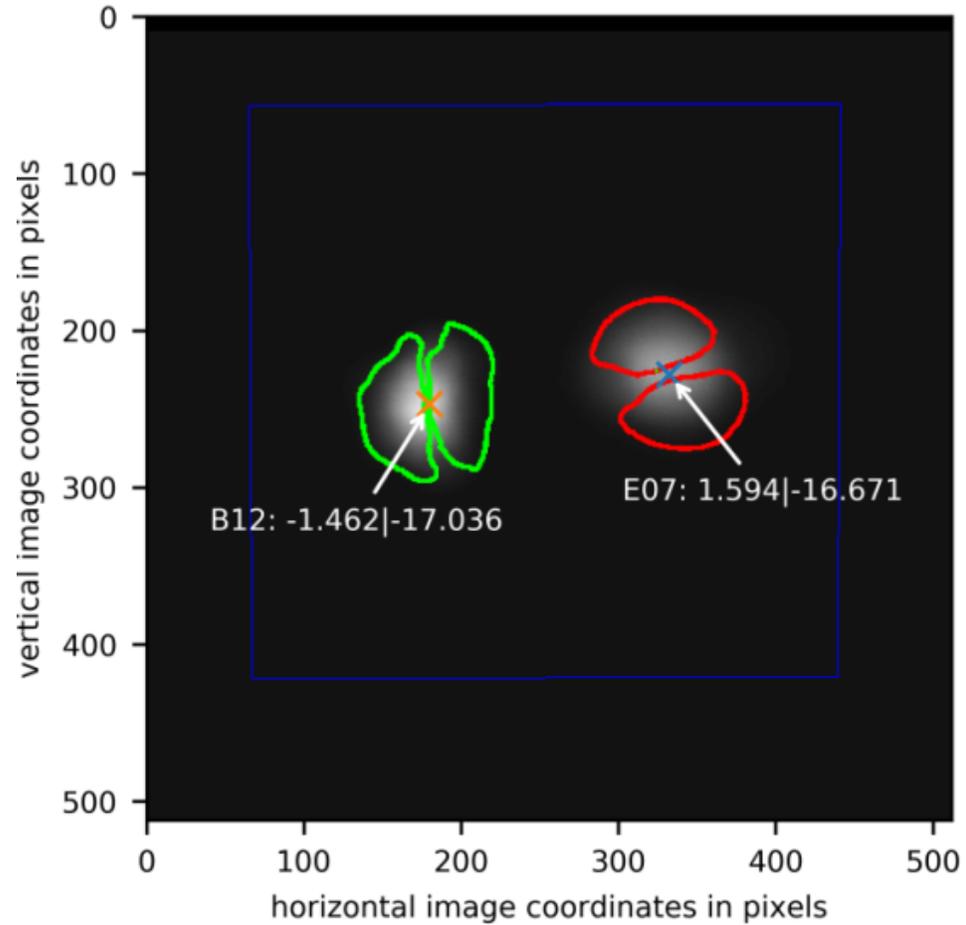
ca ±33 mm

Uncertainty E07:

ca ±45 mm
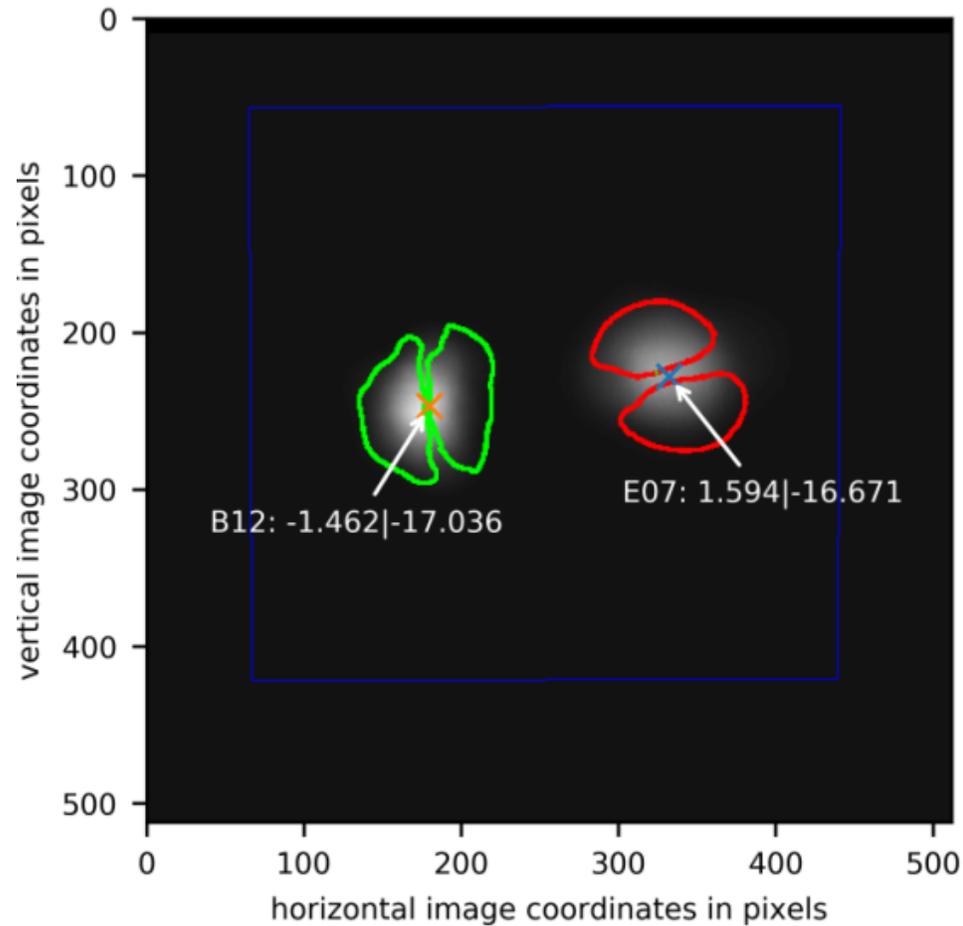
Measurement at Themis
Large Flux Target Results

Measurement at Themis
Large Flux Target Results

Measurement at Themis
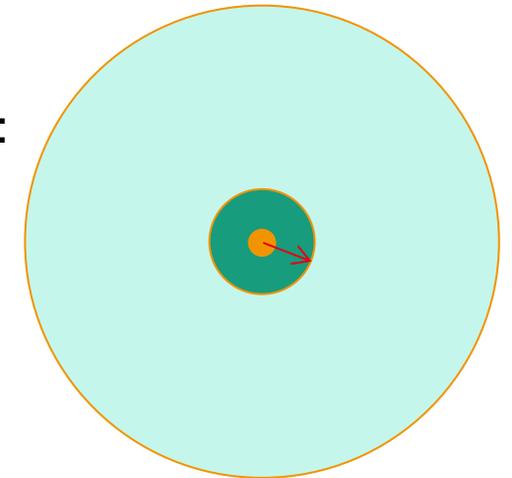## Large Flux Target Results

Uncertainty:

ca ±33 mm

Deviation
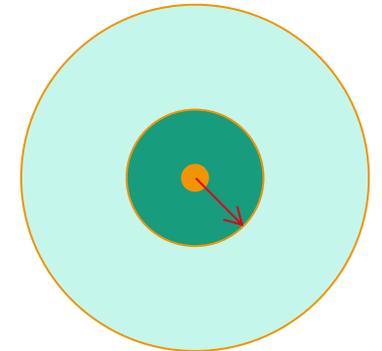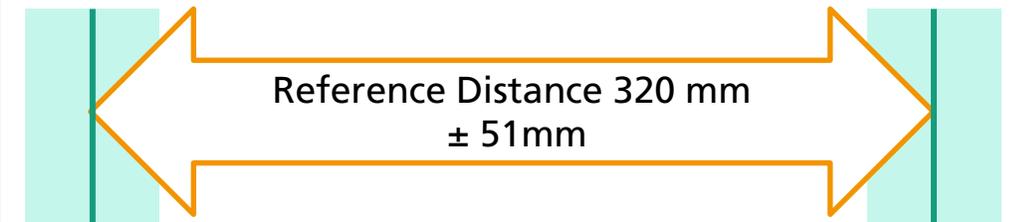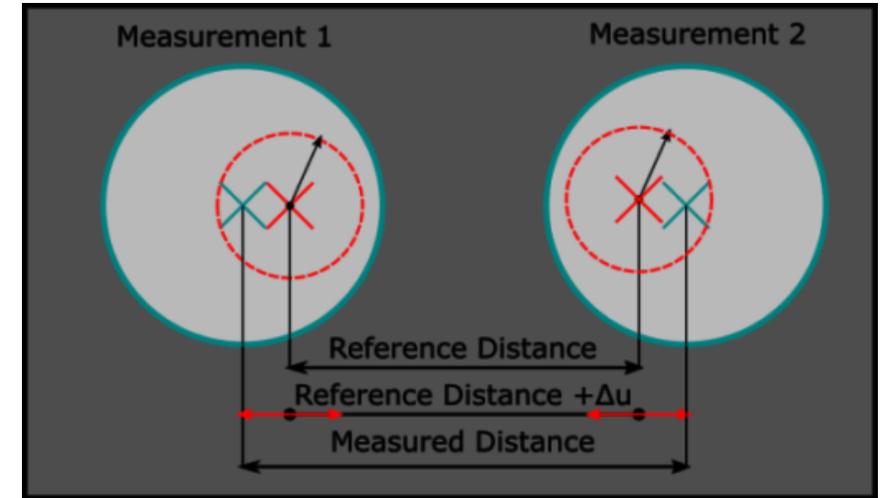B12: 13 mm

Uncertainty:

ca ±45 mm

Deviation
E07: 10 mm

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Measurement at Themis
Aiming at Small Cavity Receiver

Reference Distance 320 mm ± 51mm
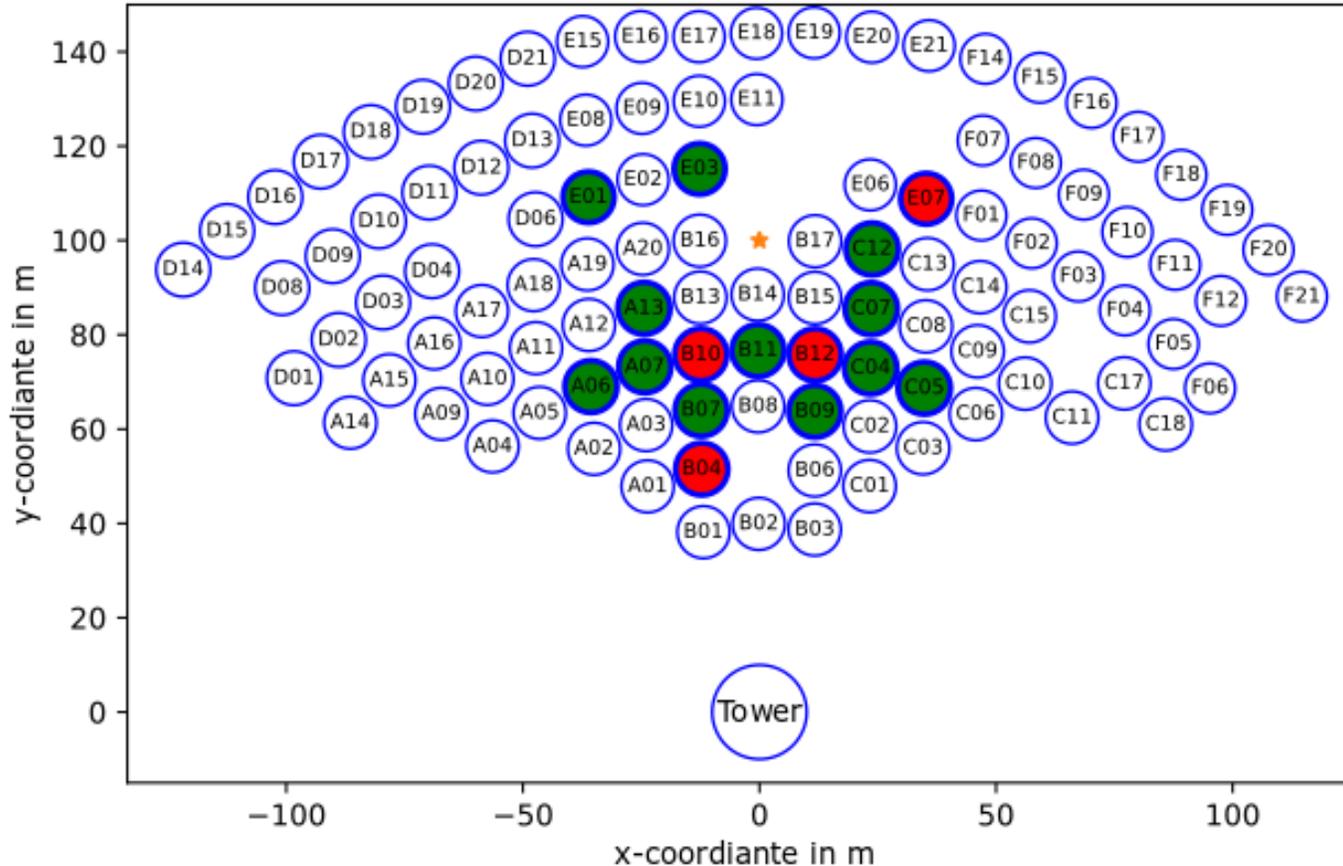
- Exp. I: 5 static, 4 moving
- Exp. II: 12 static, 4 moving
- Distance between two reference positions
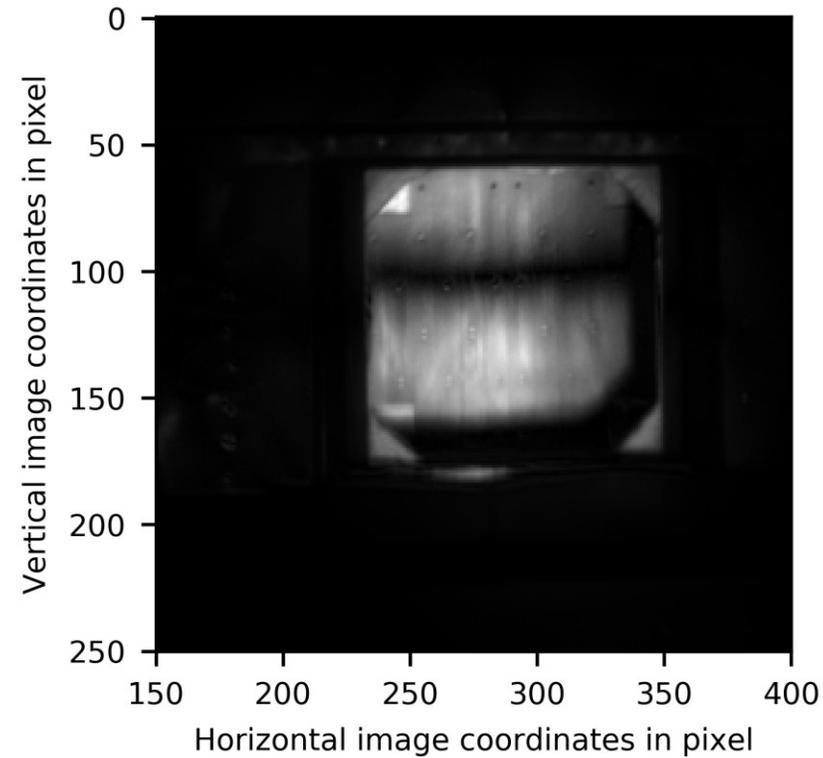
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Measurement at Themis
Aiming at Small Cavity Receiver

Measurement at Themis
Aiming at Small Cavity Receiver

Vertical image coordinates in pixel

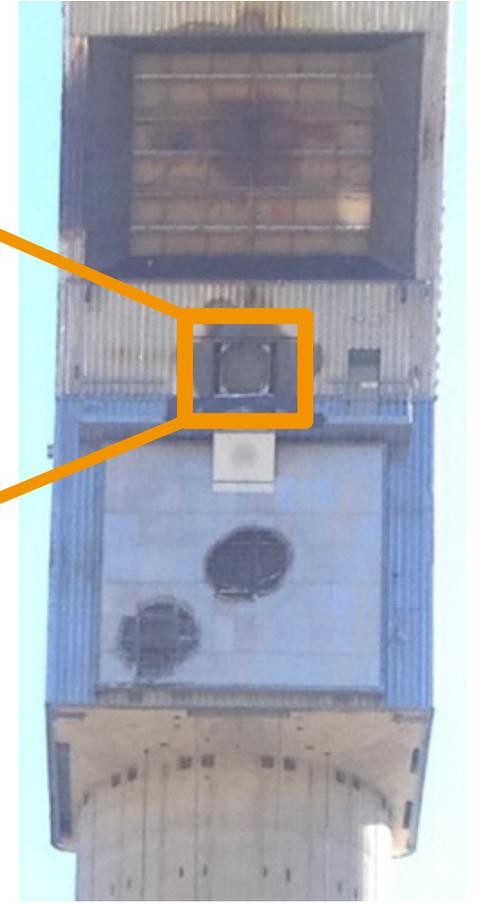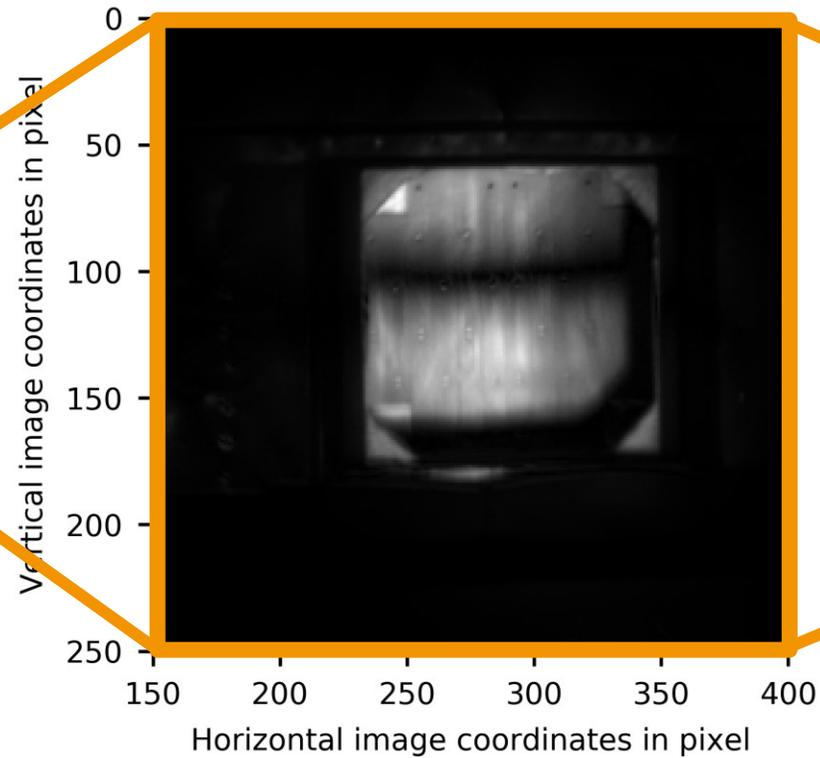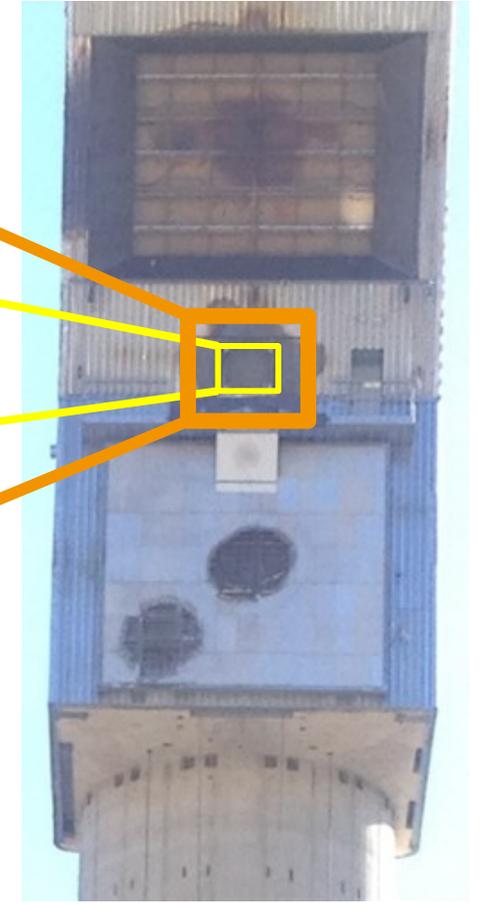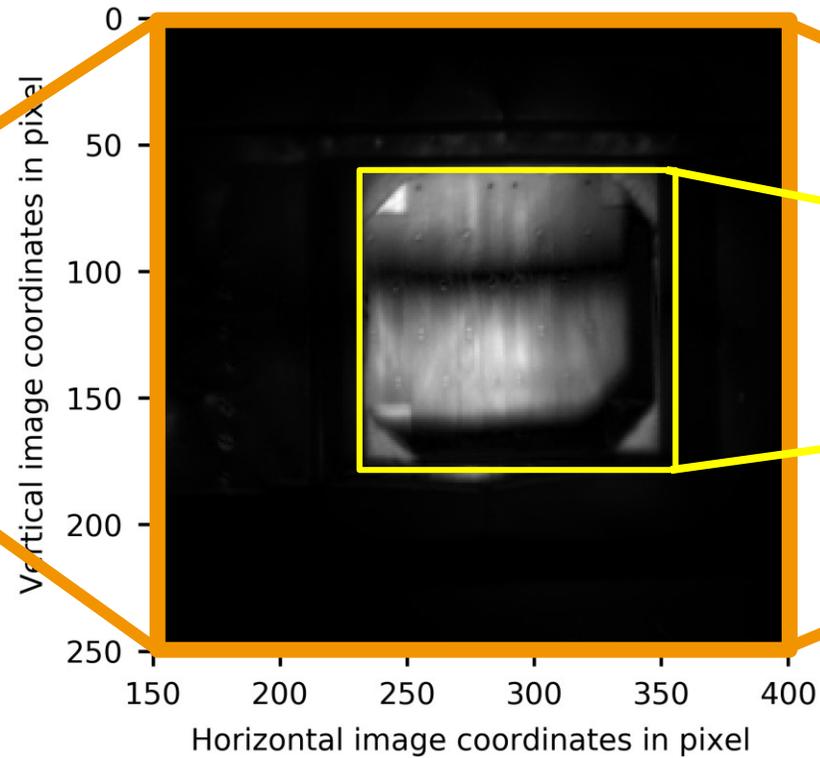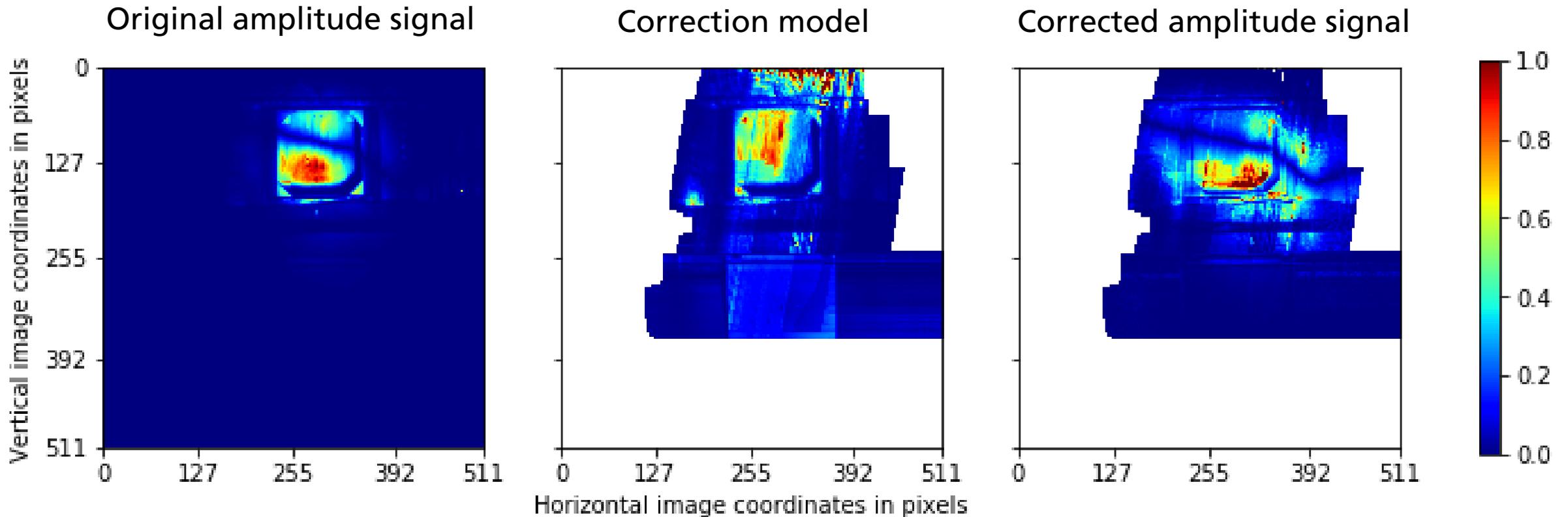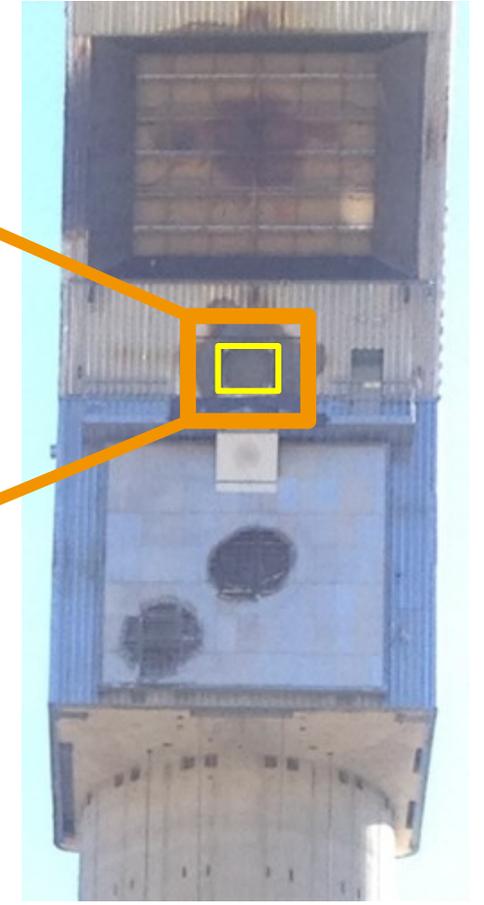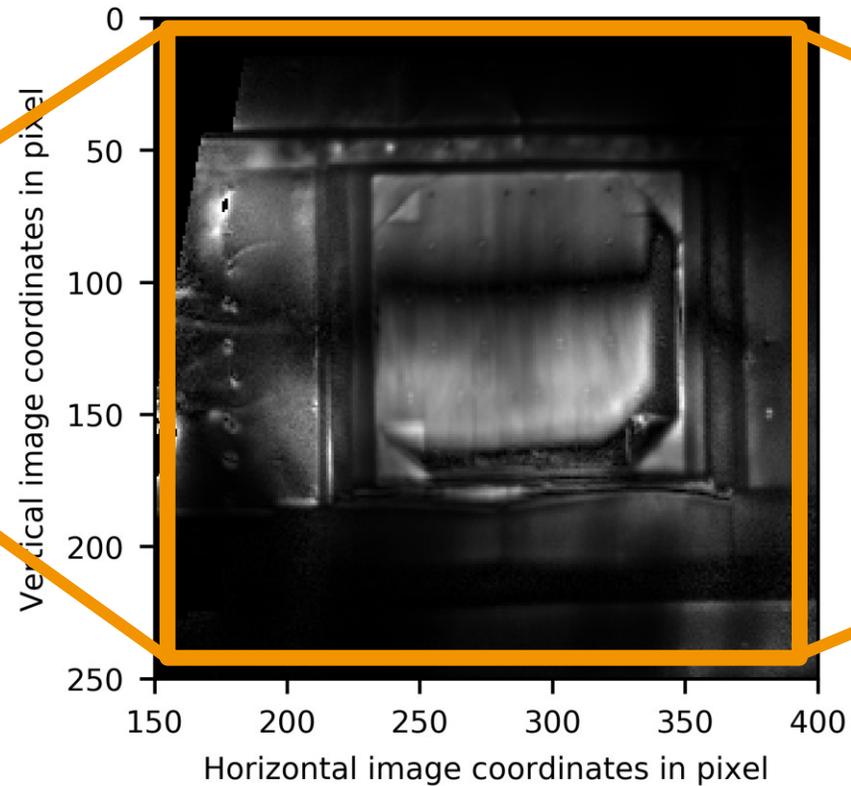Horizontal image coordinates in pixel

Measurement at Themis
Aiming at Small Cavity Receiver

Measurement at Themis
Reflectance Correction Model

Original amplitude signal

Correction model

Corrected amplitude signal

Measurement at Themis
Aiming at Small Cavity Receiver

The image shows a measurement setup with a labeled plot. The plot has:
- Vertical axis: "Vertical image coordinates in pixel" with values 0, 50, 100, 150, 200, 250
- Horizontal axis: "Horizontal image coordinates in pixel" with values 150, 200, 250, 300, 350, 400

Measurement at Themis
Cavity Receiver Results

Measured Distance (I) 340 mm

Measured Distance (II) 357 mm

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Measurement at Themis
Cavity Receiver Results

Measured Distance (I) 340 mm

Reference Distance 320 mm ± 51mm

Measured Distance (II) 357 mm

→ Deviation towards *reference distance* of 20 mm and 37 mm respectively

→ Corresponding to 0.2 and 0.38 mrad for the present heliostat position

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Conclusion

- HelioControl successfully integrated with heliostat field control

- Scheme of periodic movement with different frequencies implemented

- Method can precisely extract and find aim points

- At special receivers with high variances in reflectance a correction model can be generated and applied

- Deviations of aim point measurement well below reference uncertainty

Outlook:

- Measurement campaign with thorough statistical evaluation necessary for representative uncertainty assessment

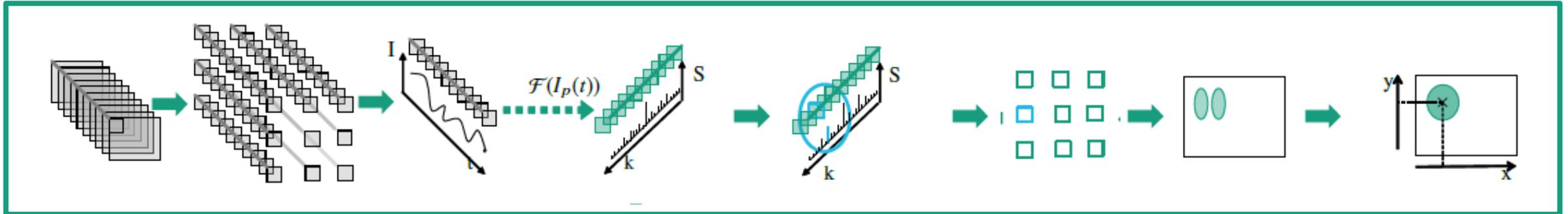- Test in commercial scale power plant during operation

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Thank you for the attention

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Alain Ferriere, Yann Volut,

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