Robustness Analysis of Imaging System for Inspection of Laser Beam Melting Systems

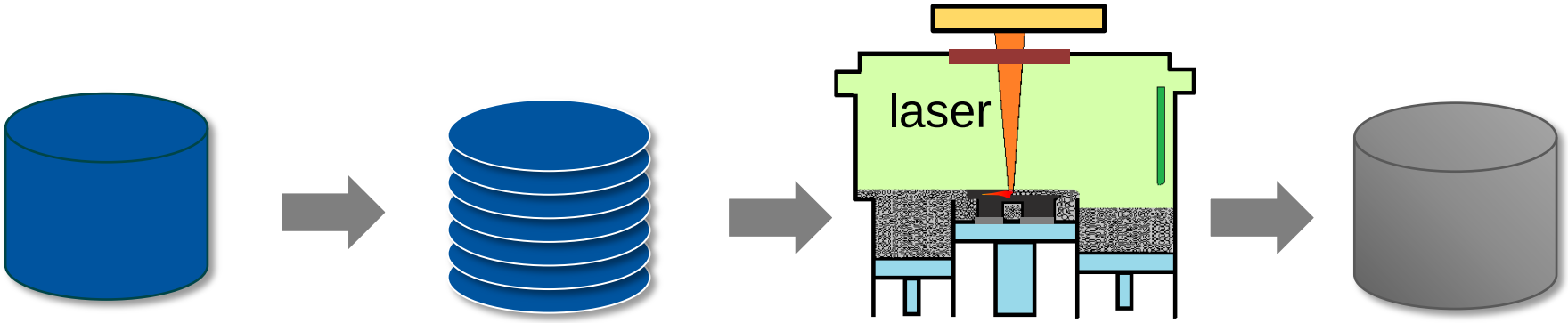
Joschka zur Jacobsmühlen[1], Stefan Kleszczynski[2], Gerd Witt[2], Dorit Merhof[1]

[1] Institute of Imaging & Computer Vision
RWTH Aachen University
Germany

[2] Institute for Product Engineering
University of Duisburg-Essen
Germany

What is Laser Beam Melting (LBM)?

“3D printing” with metal powder

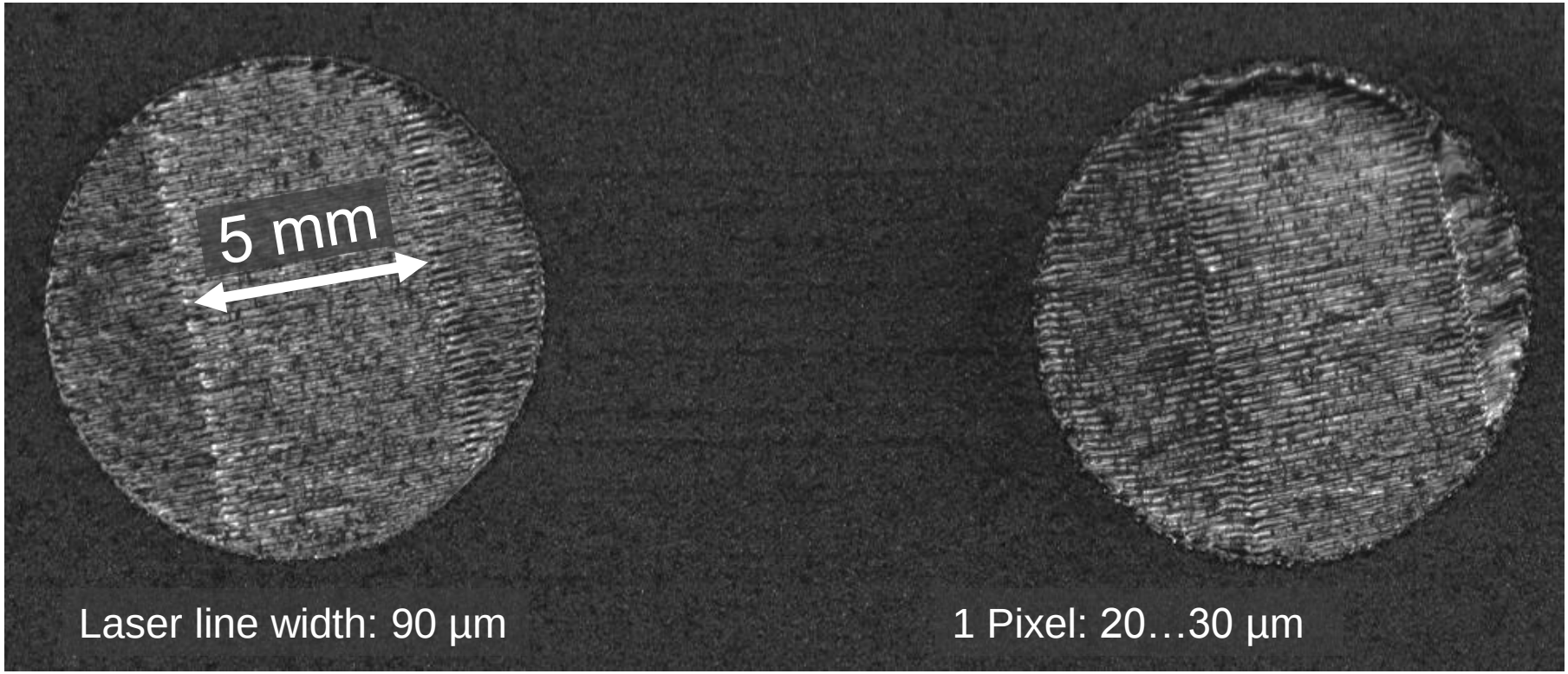


- Layer-based, iterative
- Laser melts metal powder according to layer geometry

Motivation of this Work

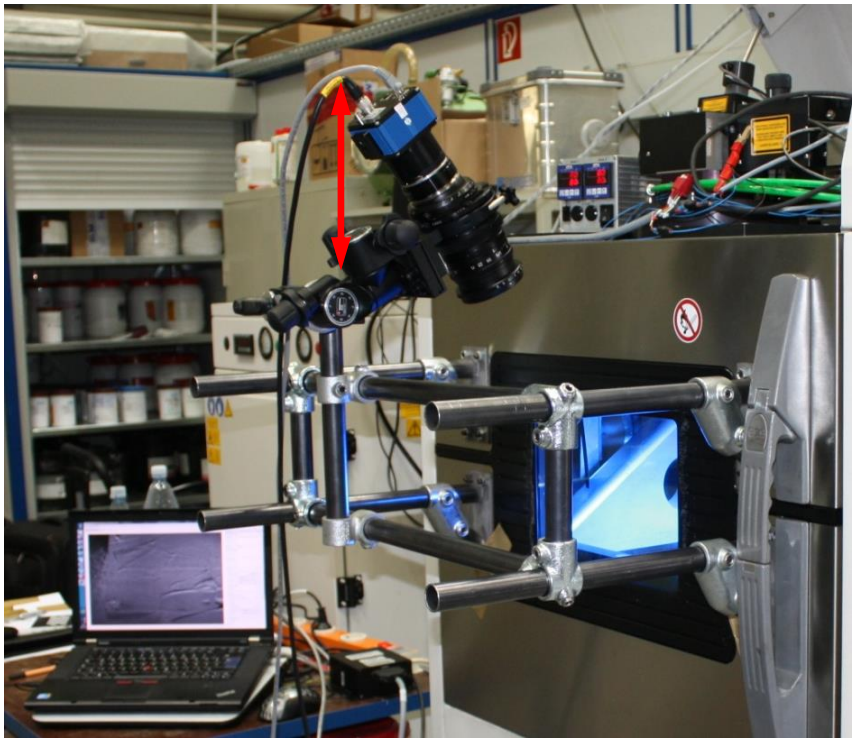
Provide Quality Control and Process Documentation for LBM Systems

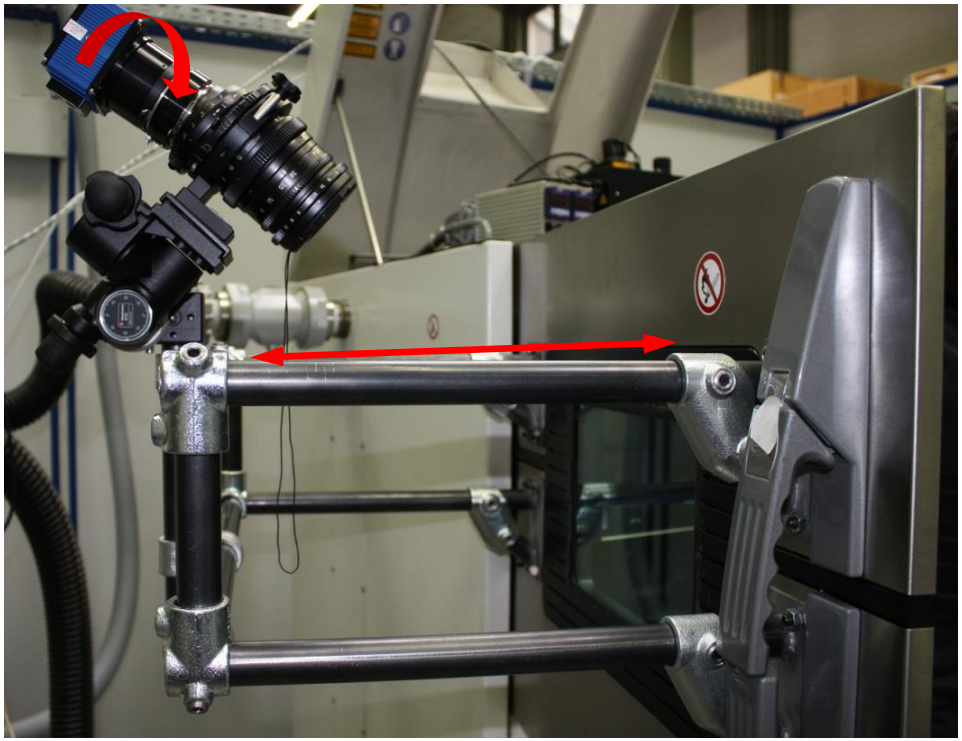
- Acquire layer images of powder layer and melt result
- Enable image analysis with high precision (measurements, surface analysis)



Our Imaging System

Custom camera mount with geared head (3 axes)

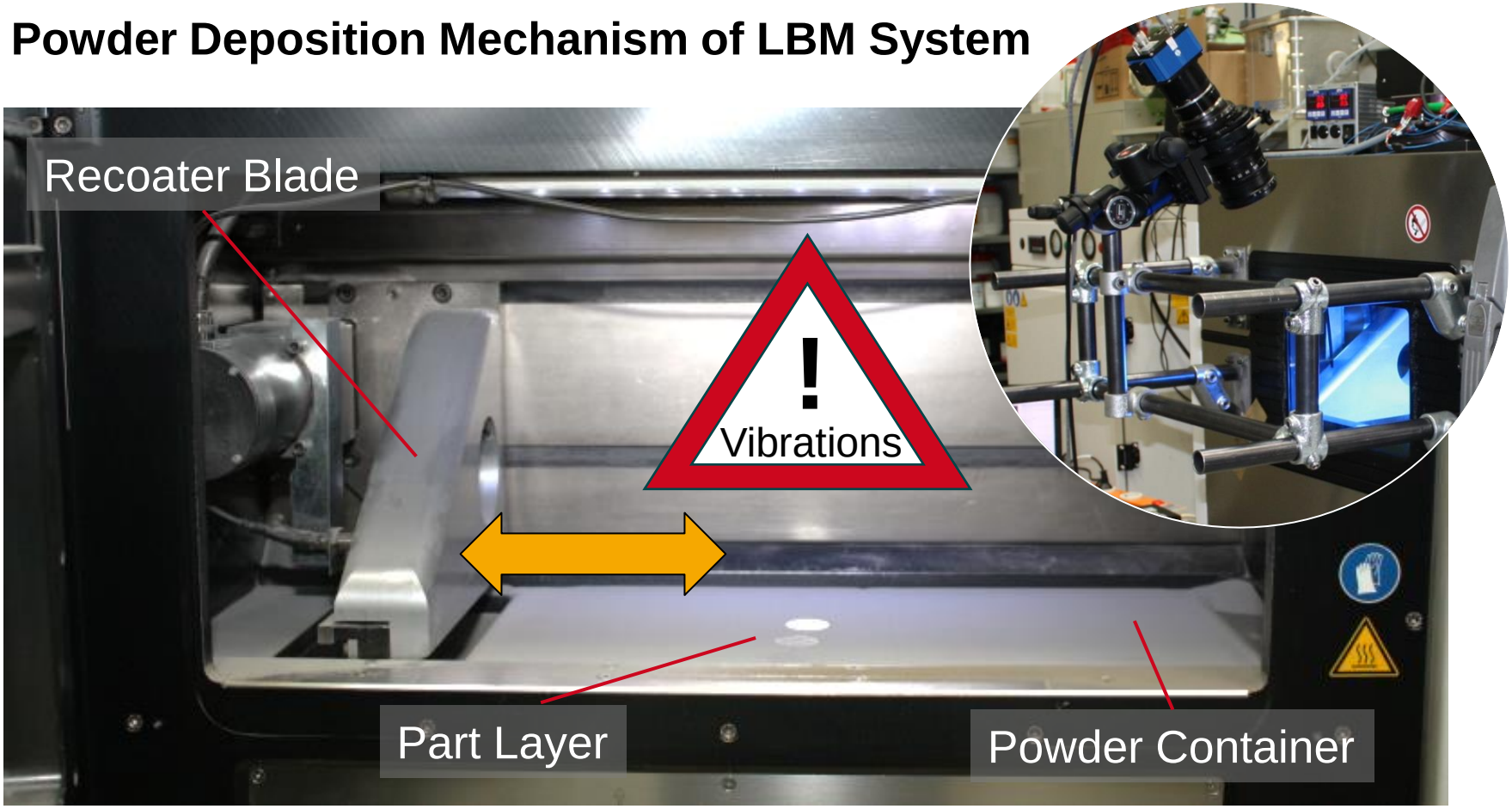




29 Megapixel camera (monochrome)

The Problem

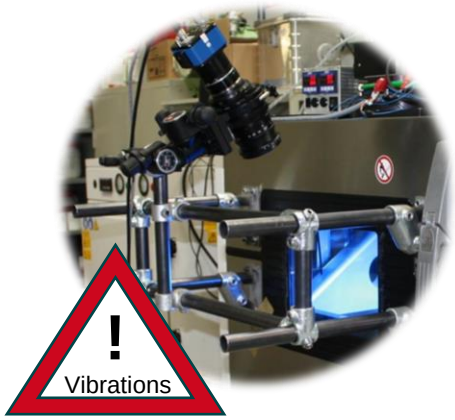
Powder Deposition Mechanism of LBM System



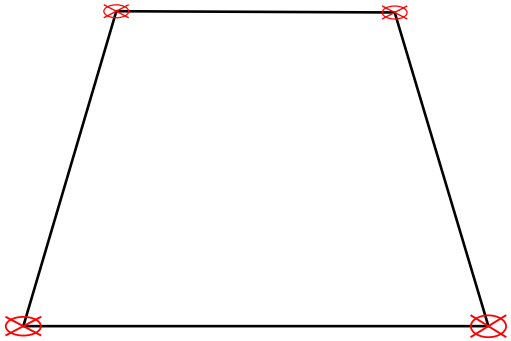
Objective of this Work

Enable precise layer image analysis

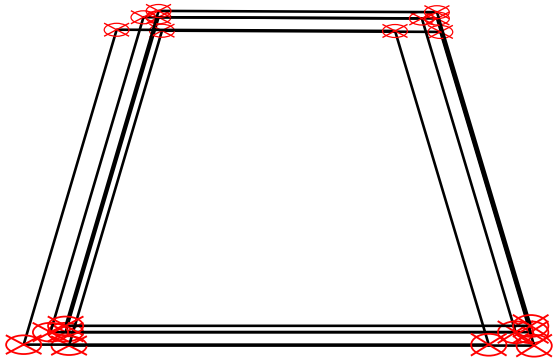
Vibrations may move camera: misalignment of layer images



optimum: perfect alignment



worst: large deviations

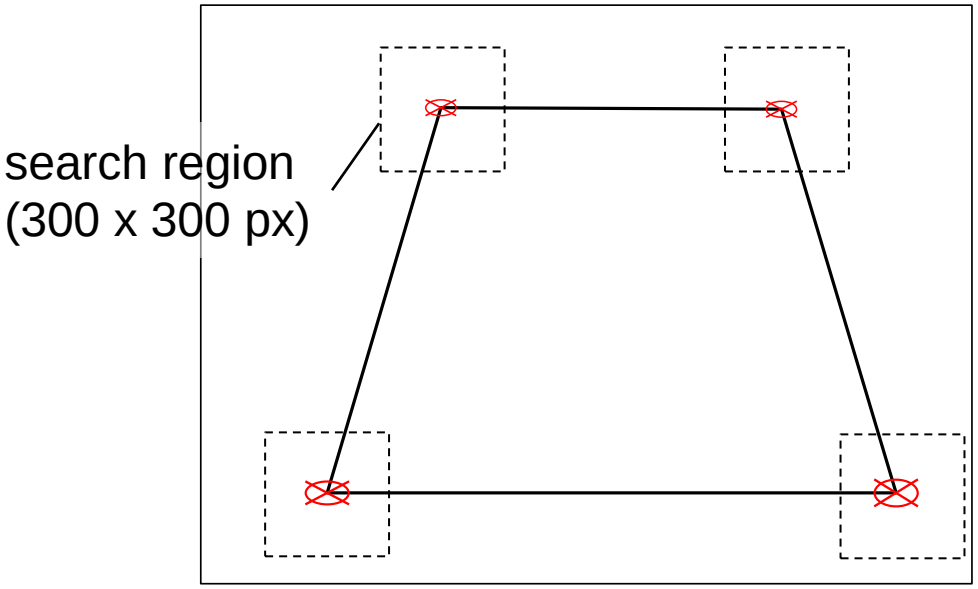


- **Analyse robustness of imaging setup against vibrations and shocks**

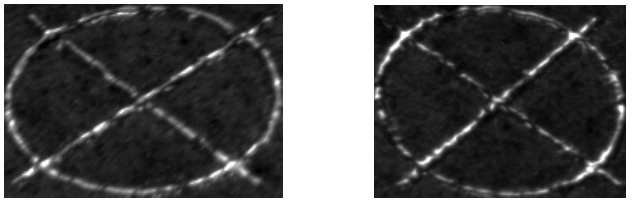
Method

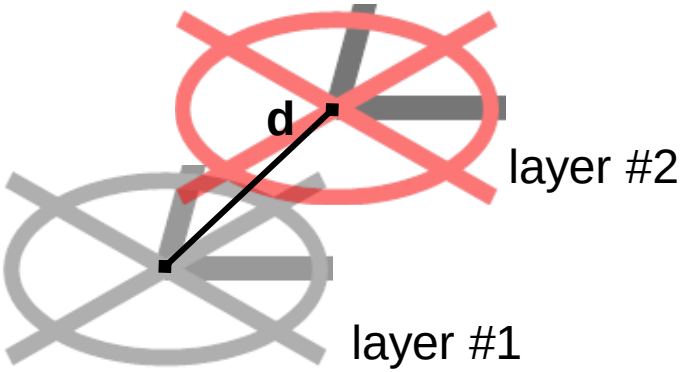
Build calibration markers in multiple layers and compare positions

1. Define templates and search regions in reference layer image
2. Find markers in other layers using template matching [1]
3. Compute distance d to reference position



sample templates





[1] Briechle and Hanebeck. Template Matching using Fast Normalized Cross Correlation. Proc. SPIE, vol. 4387, 2001

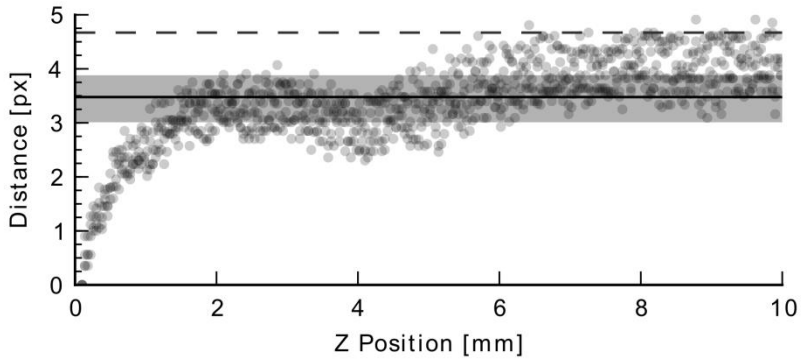
Results

Process	# layers	Distance [pixels]		
		Median	75%-Quantile	Max.
A	250	1.12	**1.46**	3.16
B	249	3.48	**3.88**	**4.91**
C	601	1.00	**1.46**	3.82

Laser scan width: 90 µm
Max. distance: 156 µm on part
Most deviations < 46 µm on part

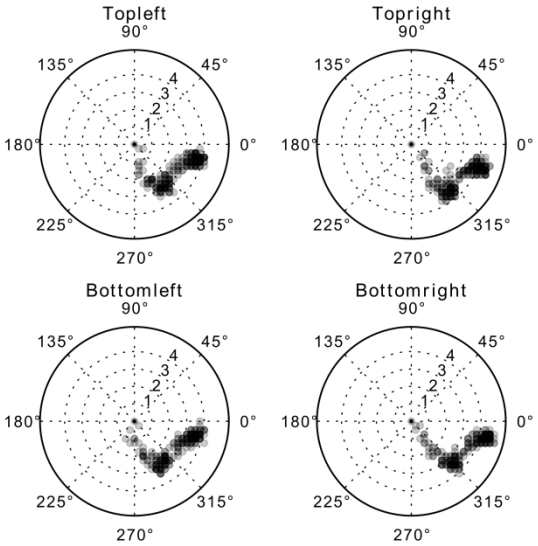
Example: Analysis Plots (Process B)

Distances



– median 25%...75% - - 99% quantile

Positions



Conclusions

Objective: Analyse robustness of imaging setup against vibrations/shocks

- Deviations are significant for measurement task (compared to laser width)
  - ➢ impact on image analysis
- A single calibration of perspective correction is not sufficient (drift)

➢ **Build markers every N layers and repeat calibration**

- detect markers using presented template matching method

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Joschka zur Jacobsmühlen
joschka.jacobsmuehlen@lfb.rwth-aachen.de

Institute of Imaging & Computer Vision
RWTH Aachen University
Germany
http://www.lfb.rwth-aachen.de/research/industrial/bigs/