
PRIMES
COMPETENCE IN BEAM DIAGNOSTICS

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MORE THAN BEAM PROFILING – A NEW APPROACH FOR BEAM DIAGNOSTICS IN 3D ADDITIVE MANUFACTURING SYSTEMS

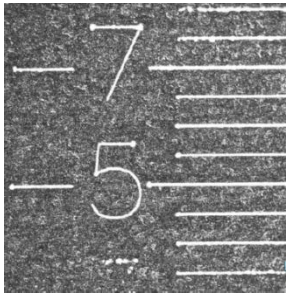
8. Primes Workshop

11.09.2018

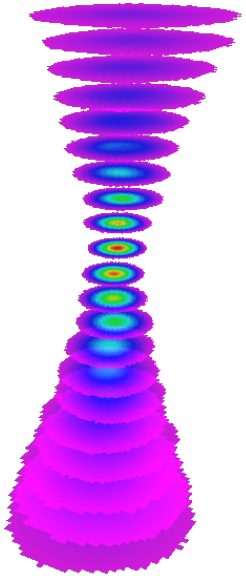
BEAM DIAGNOSTICS FOR SCANNERS

State of the art devices

- space constraints
- central position and vertical beam
- need cooling
- “only” laser beam analysis



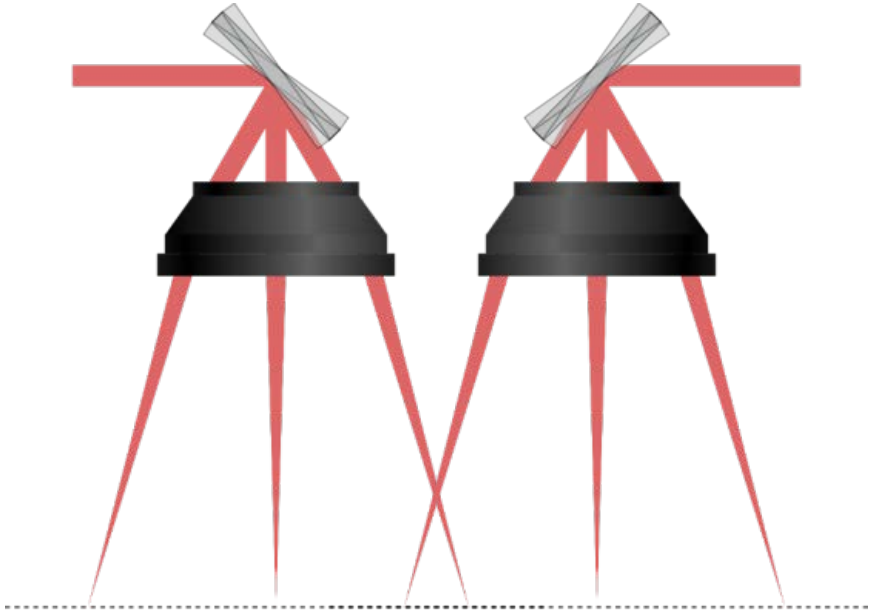
http://www.optotune.com



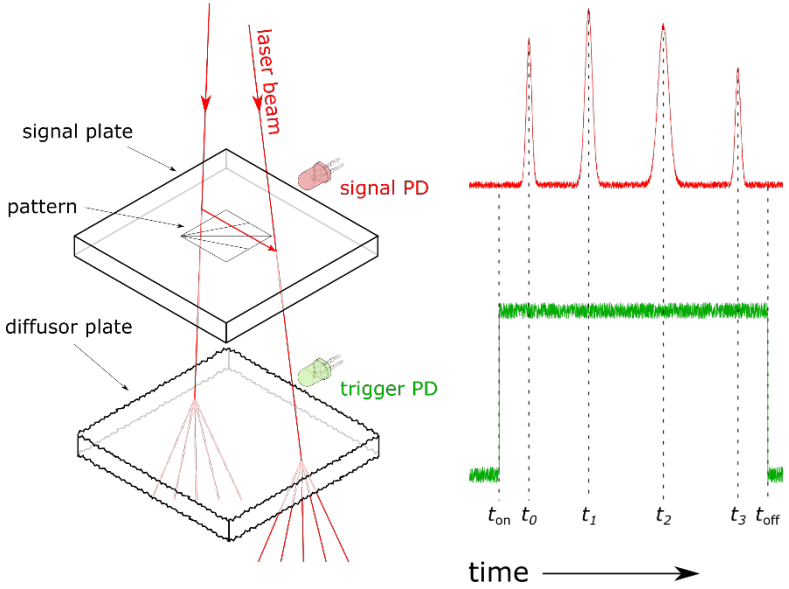
BEAM DIAGNOSTICS FOR SCANNERS

Parameters in question
(DIN 35224/ISO/ASTM CD 52903-2)

- beam diameter ✓
- position / marking speed
- propagation parameters (M^2, z_R, θ) ✓
- local power density distribution
- pincushion distortion
- localized thermal lensing
- flat field/inclination
- field overlap

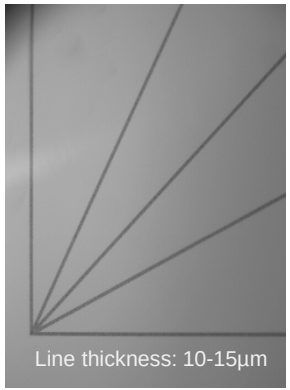


WORKING PRINCIPLE



Relative temporal spacing and peak-widths allows determination of

- marking speed
- scan vector properties
  - direction
  - length
  - absolute position
- beam width in x/y
- 1D integrated beam distribution



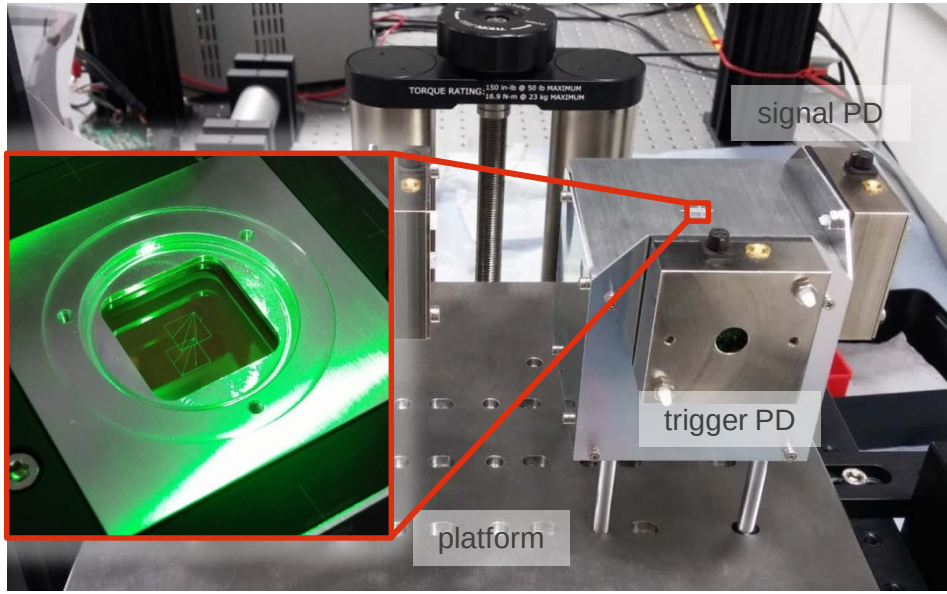
ScanFieldMonitor – LAB PROTOTYPE

Laboratory Prototype

- absolute referenced in xyz (< 50 µm)
- ~ 12 x 9 x 9 cm³
- probe: 5 mm edge length

Laboratory Setup

- 400 W single mode fiber laser
- IntelliScan20
- fθ lens system (f = 420 mm)
- 5 x 5 doweled measuring positions



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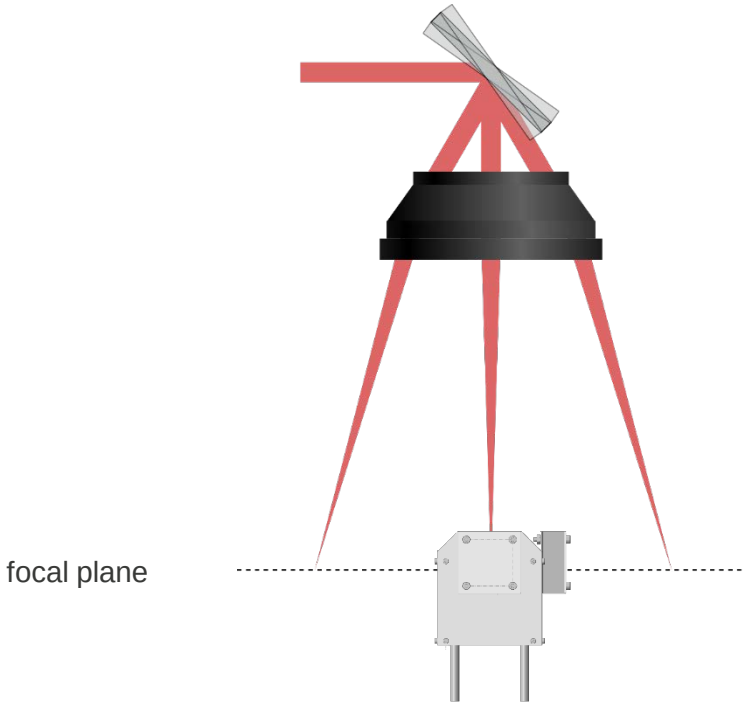
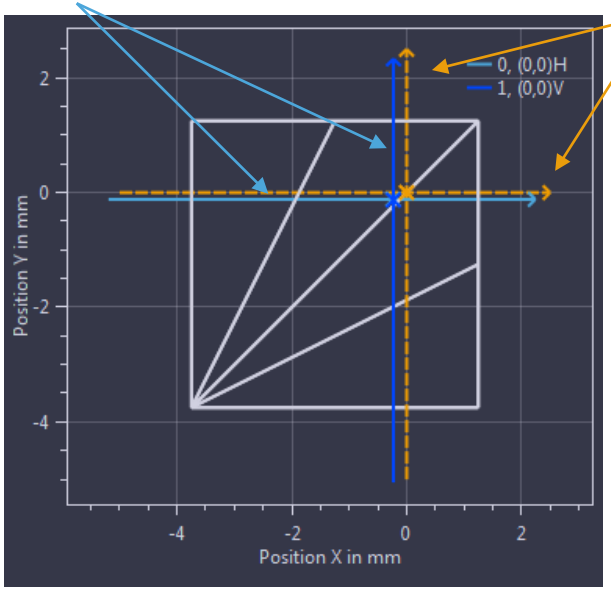


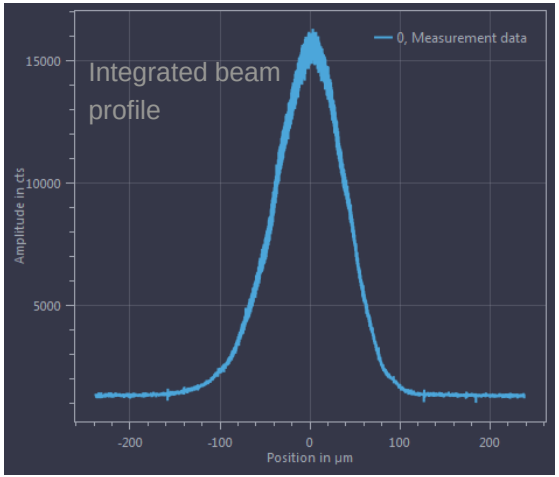
Sensorhead of
ScanFieldMonitor

IMMEDIATE MEASURANDS

measured vectors

programmed vectors

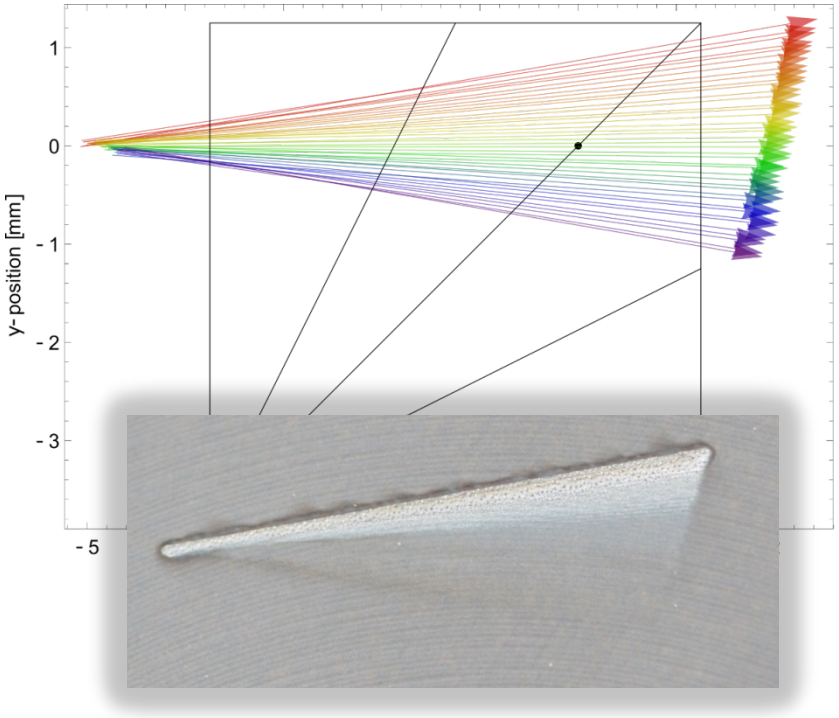


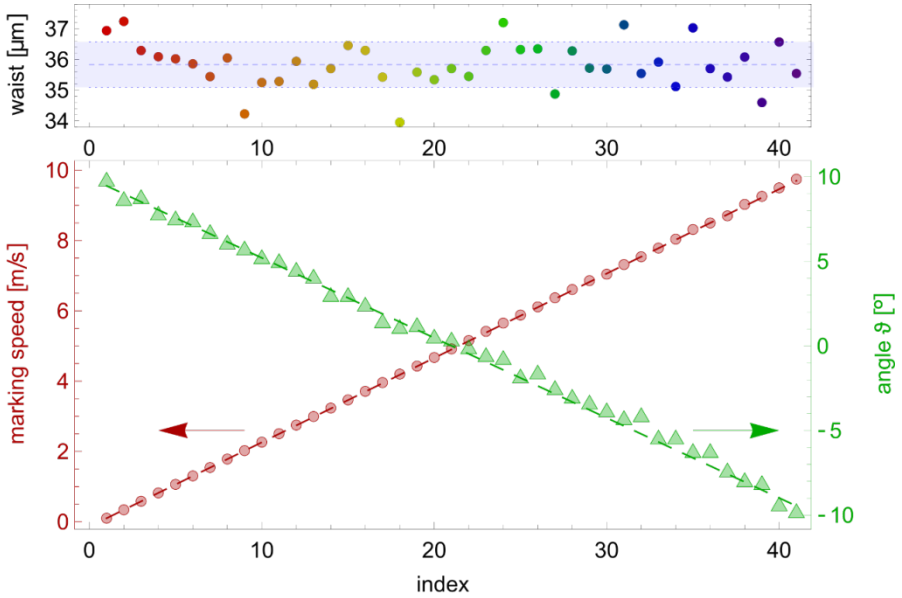


> results:

	0	1
theta in rad	0,00025	1,57031
theta in °	0,01459	89,97239
v in m/s	0,09927	0,09866
w_x in µm	79,65921	---
w_y in µm	---	77,52554
x_m in mm	-0,23603	-0,22999
y_m in mm	-0,11843	-0,13026
$x_{Mess,i}$ in mm	-5,19347	-0,23237
$y_{Mess,i}$ in mm	-0,11969	-5,05730
$x_{Mess,f}$ in mm	2,24269	-0,22881
$y_{Mess,f}$ in mm	-0,11779	2,33327
L_{Mess} in mm	7,43616	7,39057

SINGLE PLANE ANALYSIS



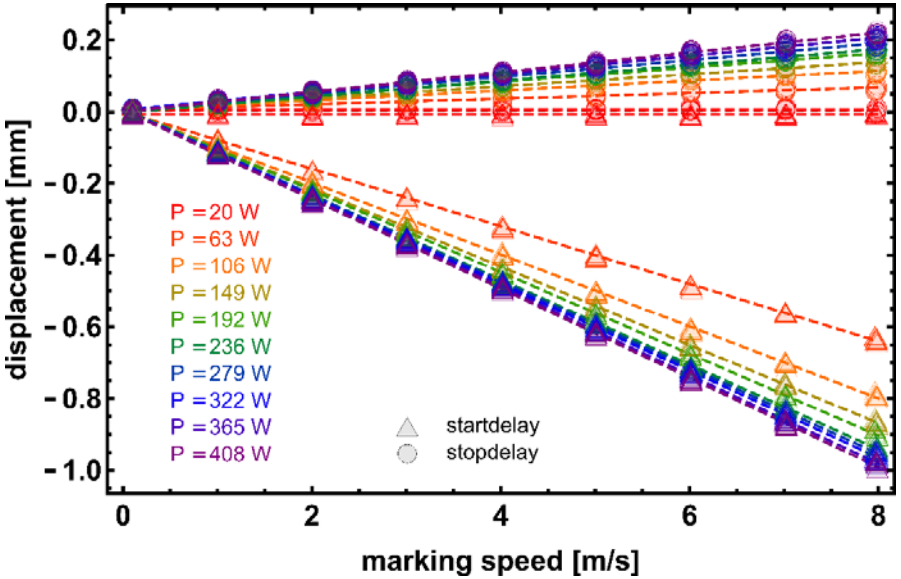


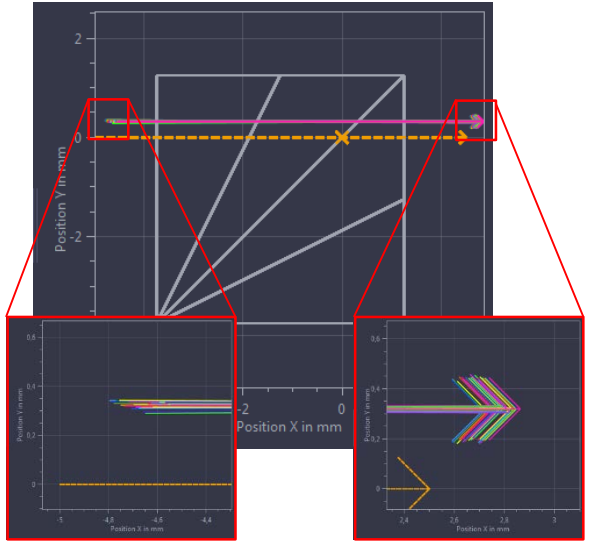
Beam waist standard deviation: ± 0,8 µm

Relative standard deviation: ± 2,2 %

DELAY-TIME ANALYSIS

- identical vector with increasing speed
- start- and endpoint variation due to timing errors





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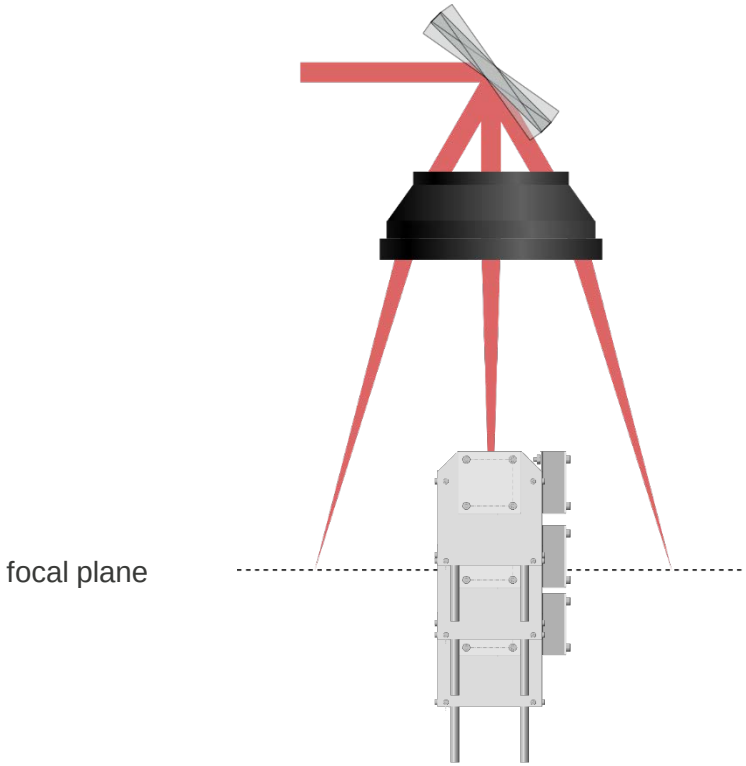
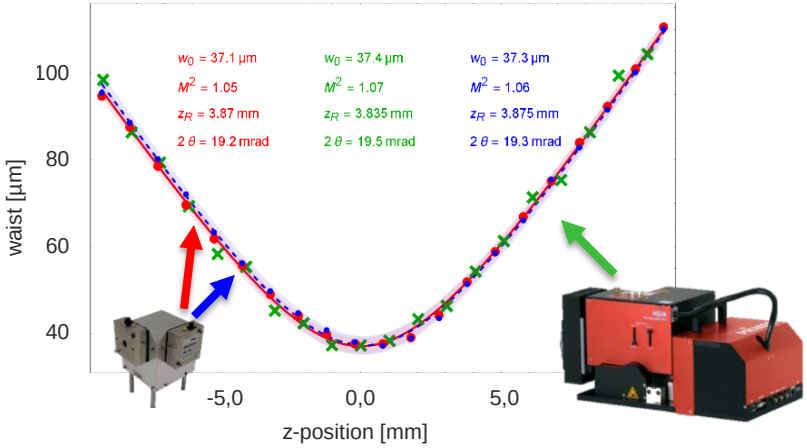
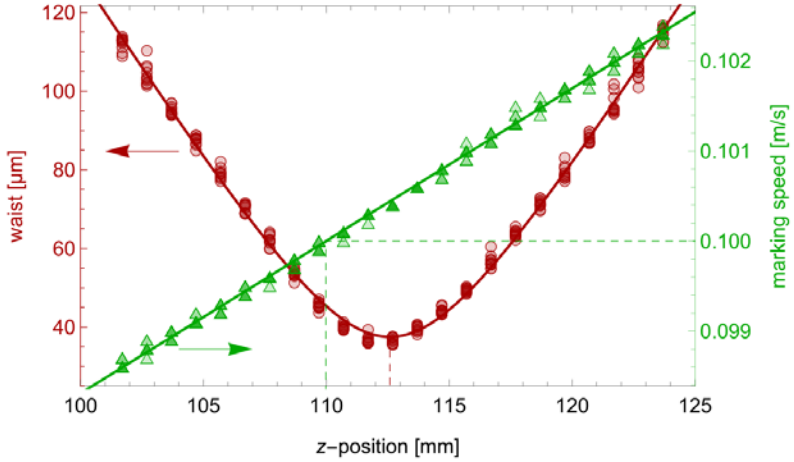


CAUSTIC MEASUREMENT

- Measure beam parameters in different z-Positions
- Good agreement with reference device, PRIMES MSM





Waist as a function of z-position

Velocity as a function of z-position

→ Focal plane ≠ v_{set}-plane

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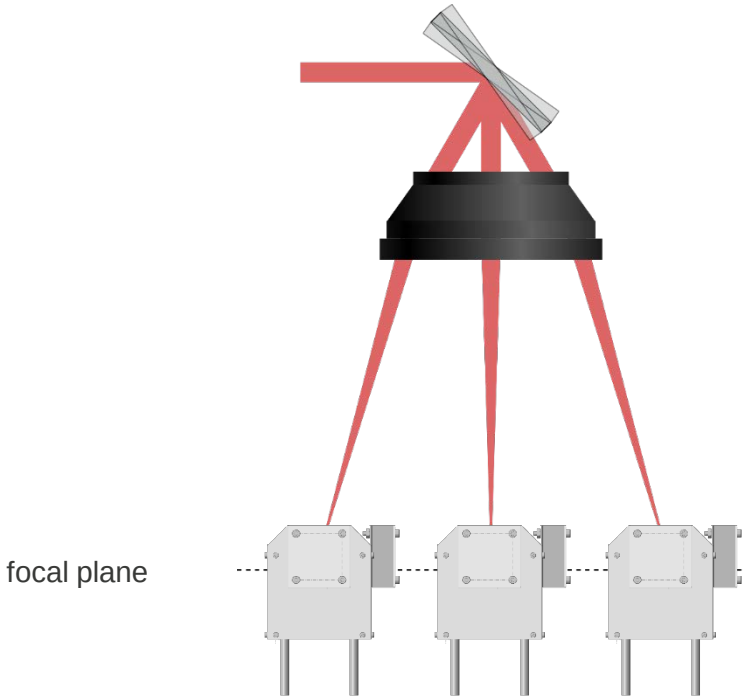
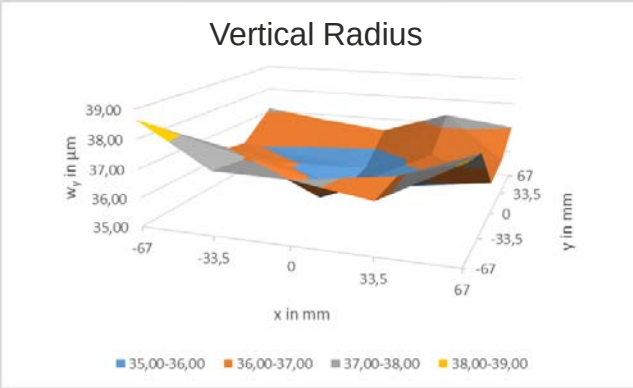
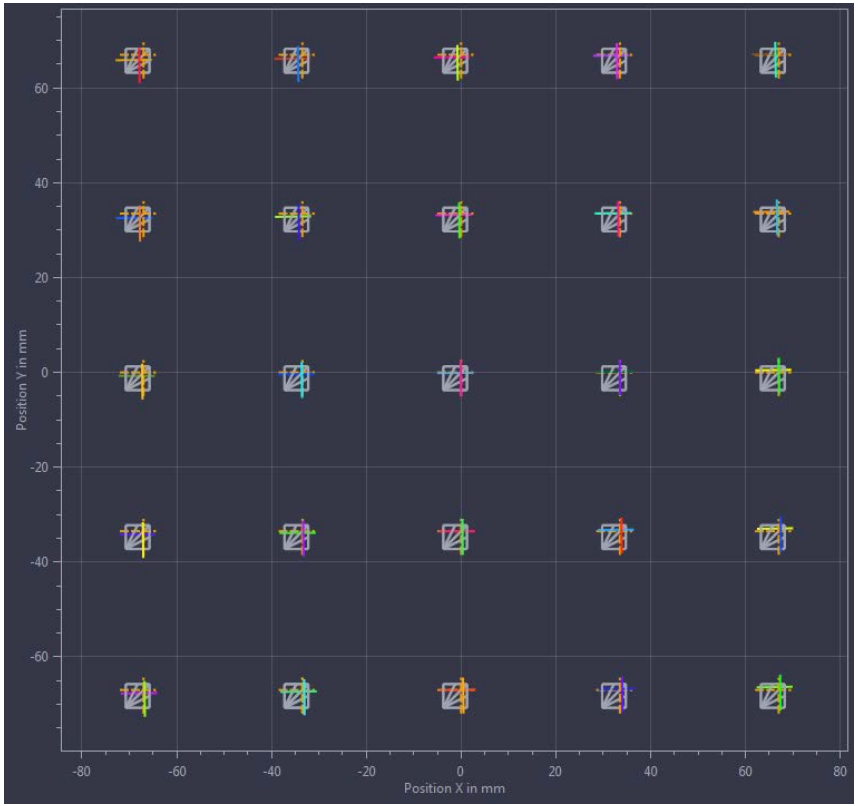


MULTIPLE VECTORS AT DIFFERENT POSITIONS

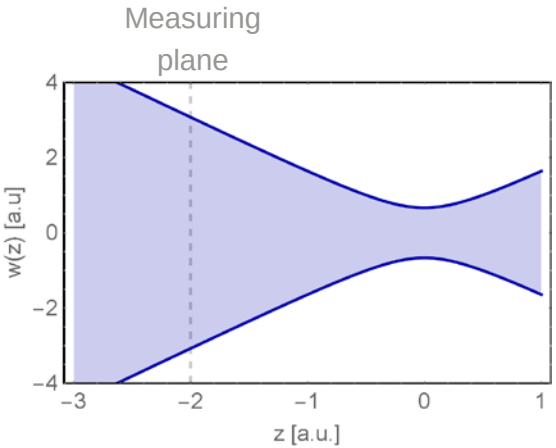
- Measuring vectors at different positions
- 1D integrated beam distribution for each position
- Reconstruction of pincushion distortion possible

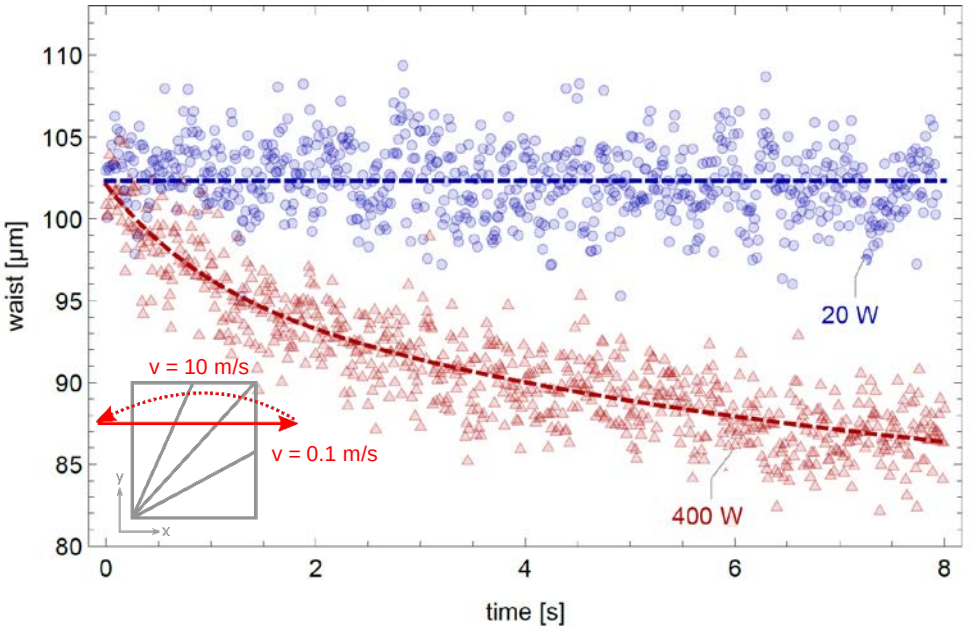




TIME RESOLVED FOCAL SHIFT ANALYSIS

- repeated scan over pattern with 20 W and 400 W
- measuring frequency: ~ 100 Hz





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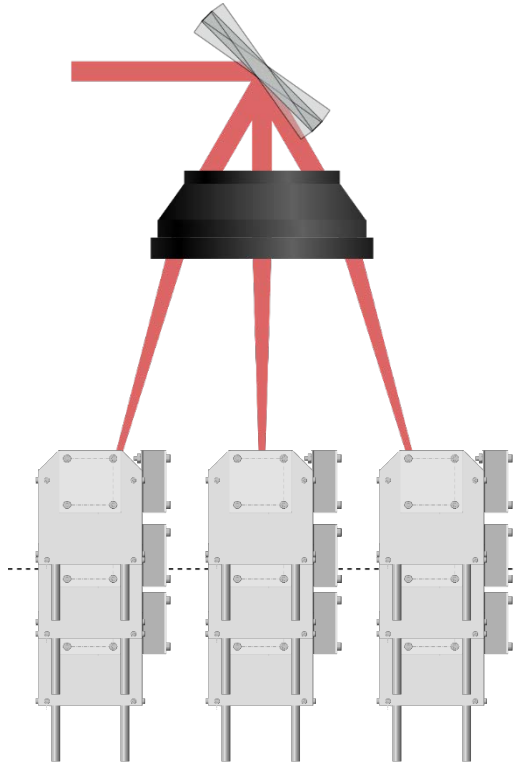
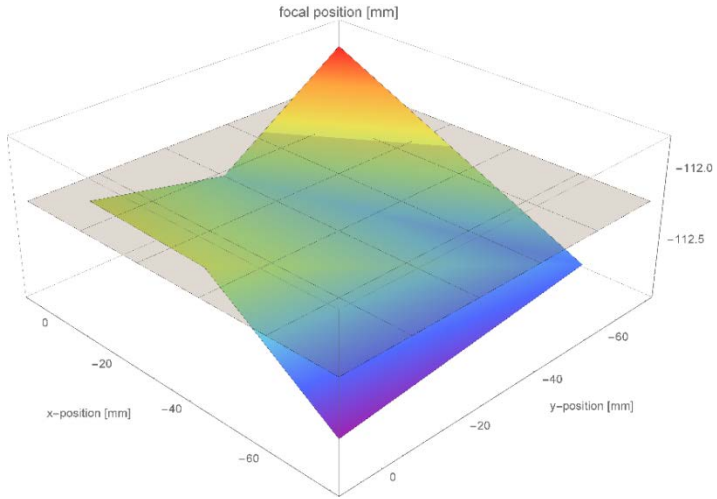
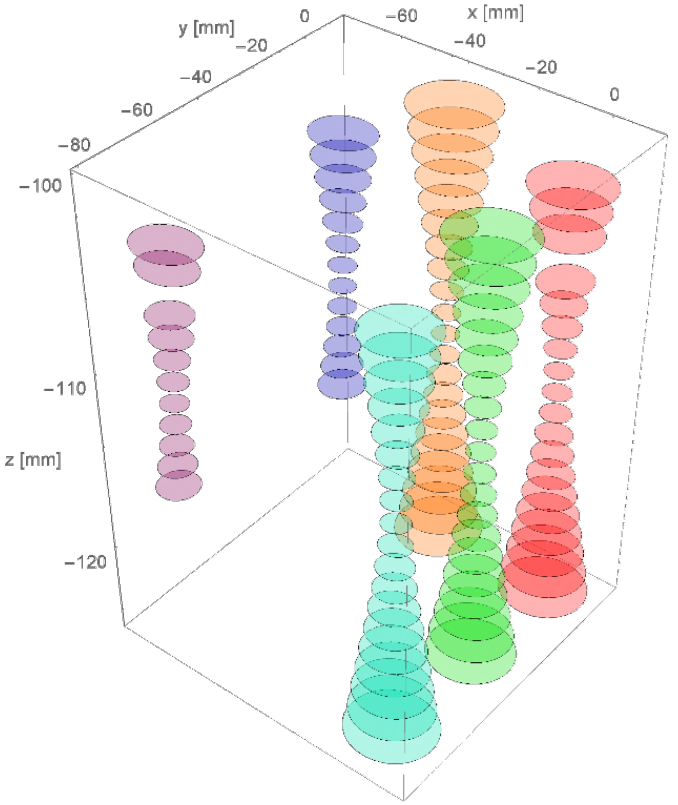


MULTIPLE VECTORS AT DIFFERENT POSITIONS

- Measuring caustics at different positions
- Beam parameters for each position
- Reconstruction of flat field/inclination possible





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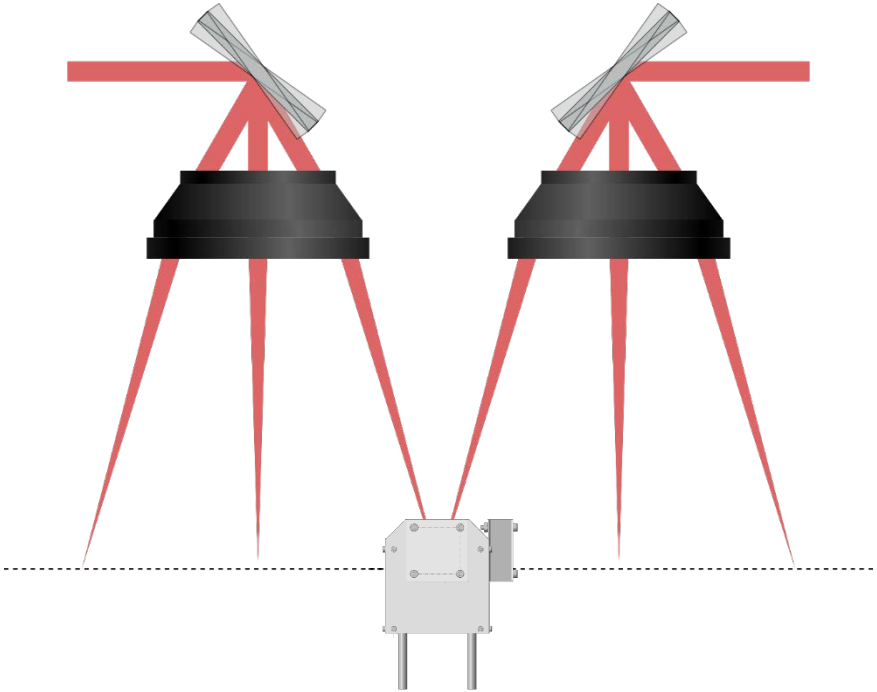
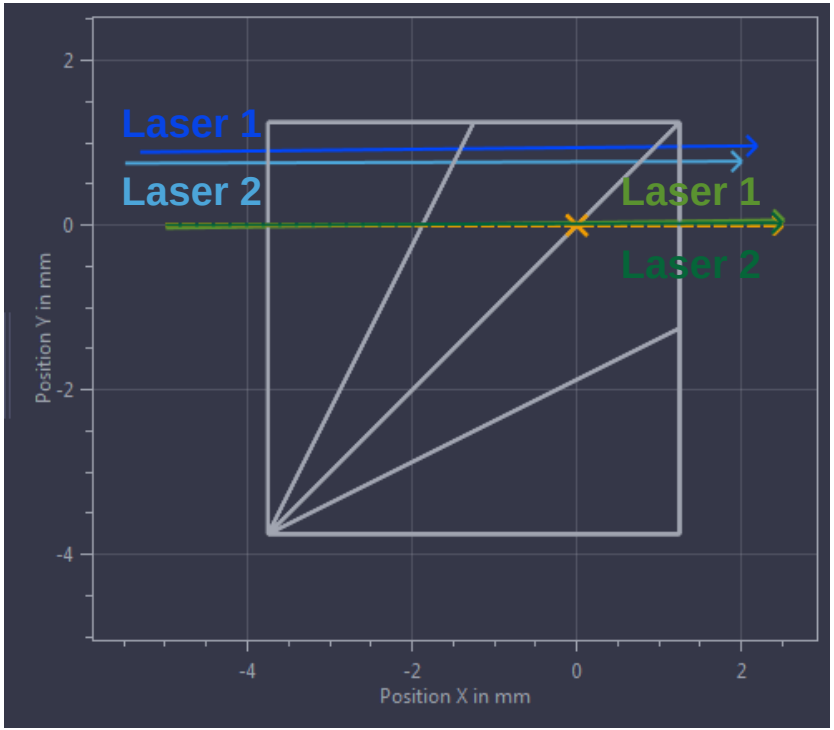


FIELD OVERLAP

- Multi scanner system
- Measurement in overlapping region
- Beam incidence ±20°
- Coarse correction already yields improved overlap



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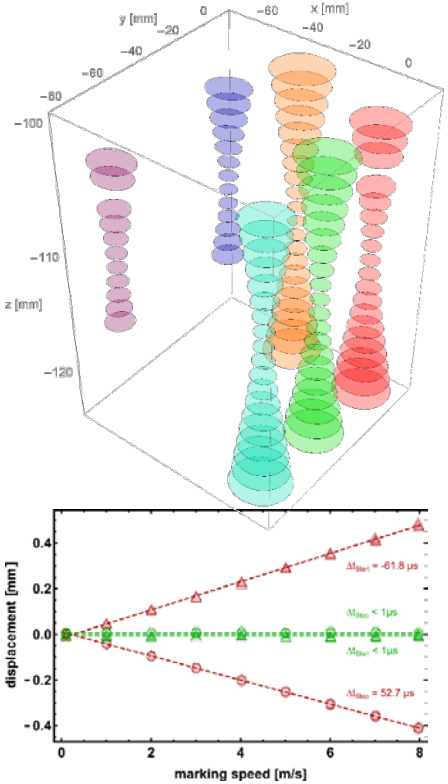
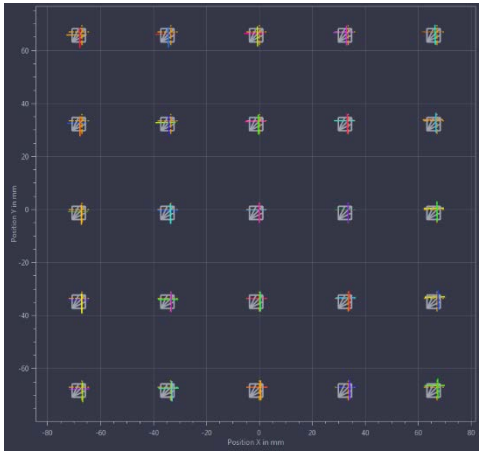


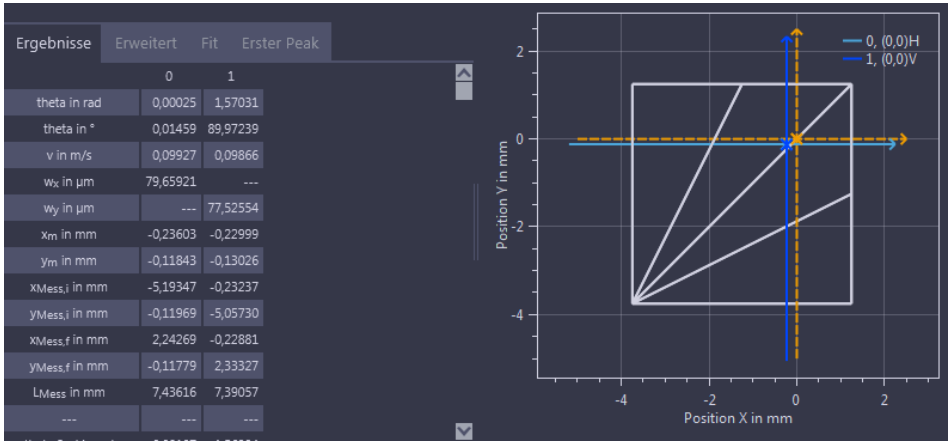


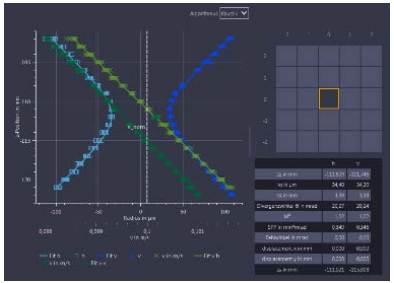
ScanFieldMonitor

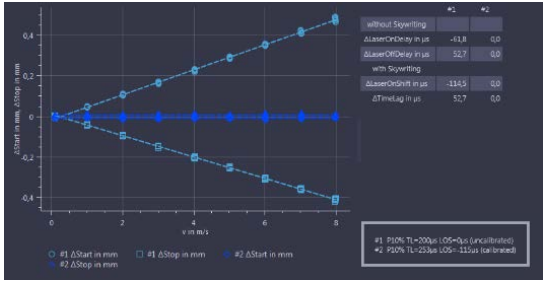
Preliminary technical specifications

- power density: < 100 MW/cm²
- scanning speed: < 10 m/s
- angle of incidence: < ± 20°
- position accuracy: < 50 µm
- dimensions: ~ 12 x 9 x 9 cm³

Suitable for more than 3D printing e.g. remote welding







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QUESTIONS?

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