



Current challenges in optical design

EPIC Online Technology Meeting

Holger Münz

Principal Optical Design & Concepts

ZEISS Corporate Research & Technology

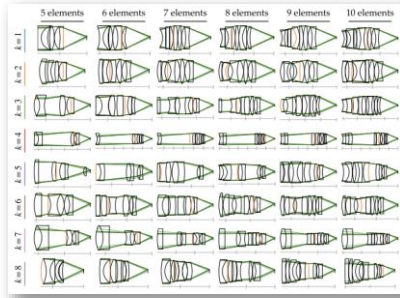
7 November 2023

Trends in optical design

Optical design is much more than just optimizing lenses

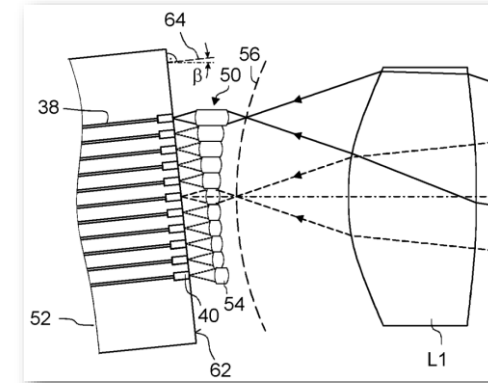
Use of artificial intelligence & novel design methodologies

- Starting systems generation
- AI-assisted design workflows
- Generative design
- Inverse design



Classical optical design

Multi-scale & hybrid systems

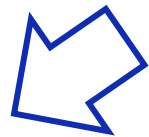


Merging macroscopic/classical optics with

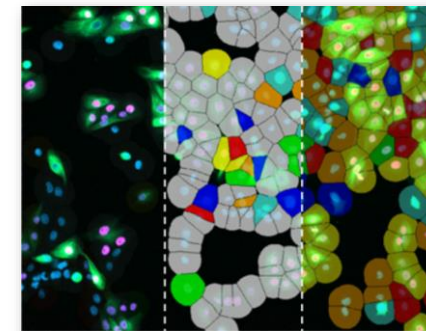
- Photonic integrated circuits (PIC)
- Microoptics
- Metasurfaces
- ...

Design to X & multi-objective optimization

- Design to cost
- Design for manufacturability
- As-built-performance optimization
- Stray light
- Thermal
- ...



Computational imaging, sensing & end-to-end optimization



- 3D reconstruction
- Denoising
- Deconvolution
- Segmentation
- Classification
- General sensing

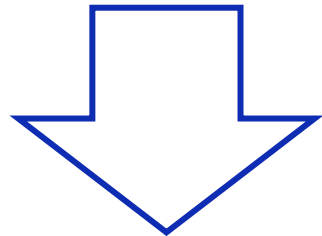
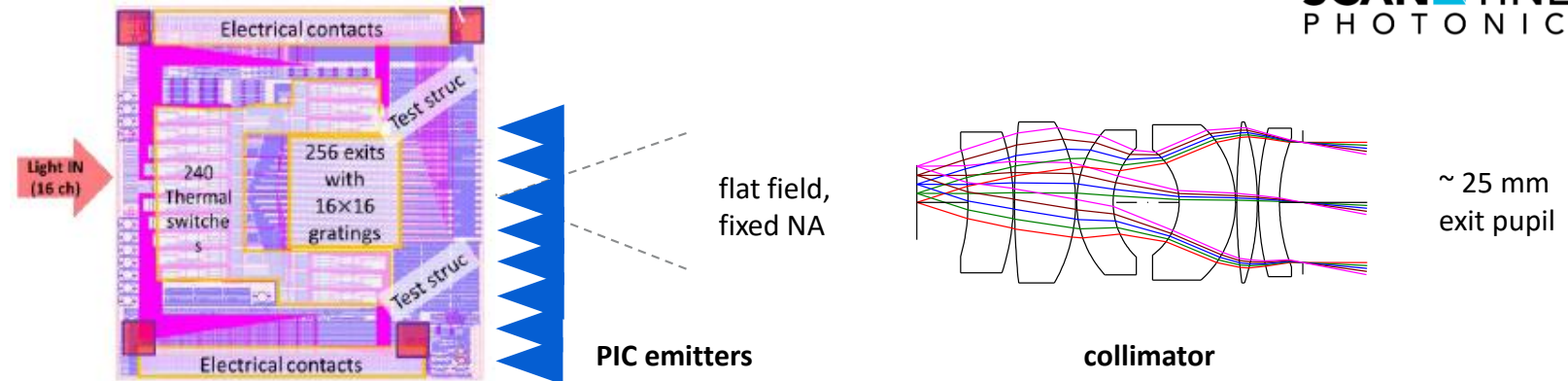
Multi-scale & hybrid systems

Significant benefit from co-design of micro- and macroscopic optics



“Classical” approach for an automotive Lidar system

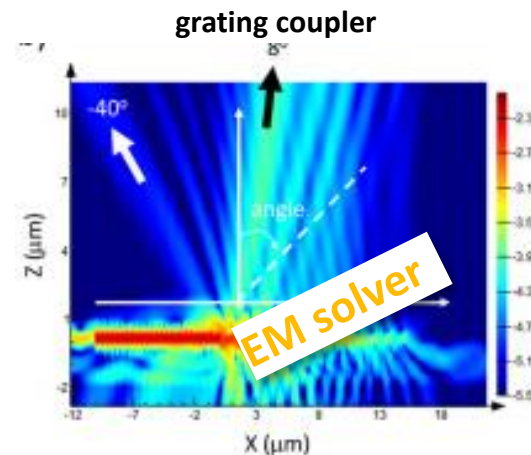
- Fully solid state 2D scanner demonstrator for Scantinel
- Separate design of multi-beam PIC emitter and collimator lens



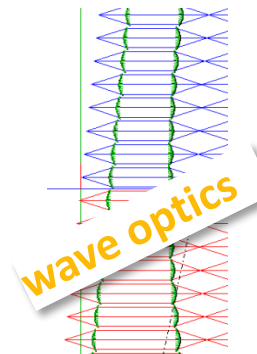
Estimated signal gain: +10 dB

Co-design concept to be optimized for optical performance:

- PIC coupler emission angle & NA
- Intermediate focal plane field tilt and field curvature

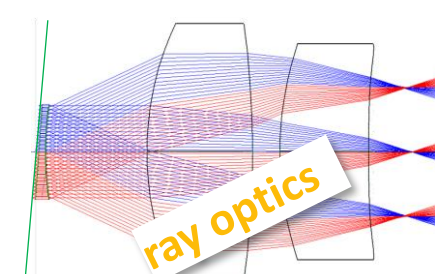


lenslet array



wave optics

aspheric collimator



ray optics

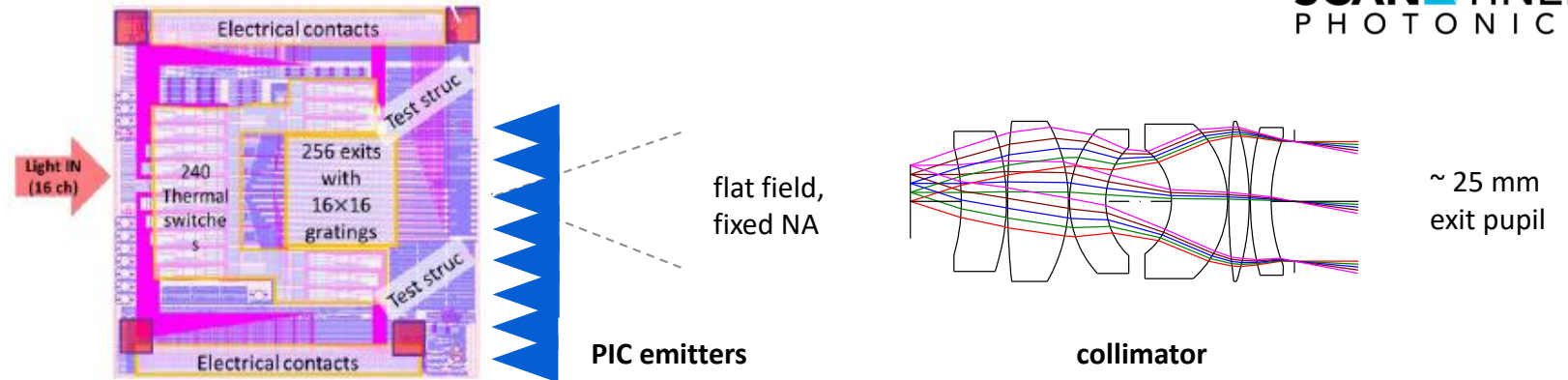
End-to-end optimization

Significant benefit from co-design of micro- and macroscopic optics

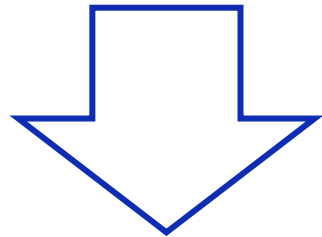


“Classical” approach for an automotive Lidar system

- Fully solid state 2D scanner demonstrator for Scantinel
- Separate design of multi-beam PIC emitter and collimator lens



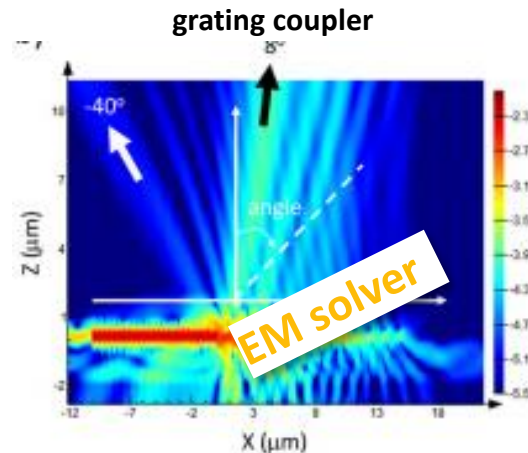
SCANTINEL[®]
PHOTONICS



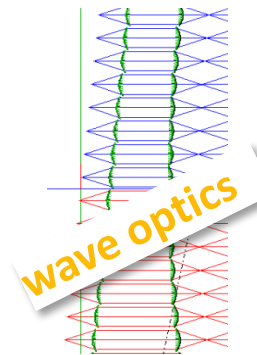
Estimated signal gain: +10 dB

Co-design concept to be optimized for system performance:

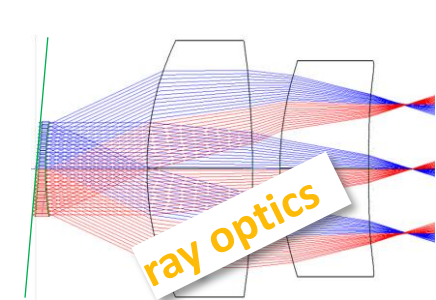
- PIC coupler emission angle & NA
- Intermediate focal plane field tilt and field curvature
- **Beam shape and wavefront**



lenslet array



aspheric collimator



Signal generation

V. Blahnik, “Merging optics and photonics”, UKODM 2022

Artificial intelligence & novel design methodologies

Solution landscapes instead of single designs

- We see first successful applications of AI in optical design
- We can expect automated processes and much larger number of system variants in the future
 ⇒ **our tools should be oriented towards working with many systems**

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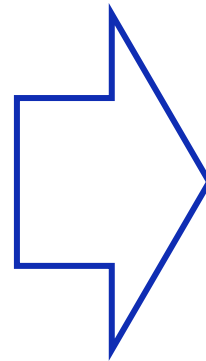
Inferring the solution space of microscope objective lenses using deep learning

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JEAN-FRANÇOIS LALONDE,¹ AND SIMON THIBAUT¹

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a) JP 2013-222078 b) JP 2013-222078 c) USP 7158310 d) USP 5920432 e) USP 6128139
 f) USP 5889618 g) JP 2010-134405 h) JP 2007-206404 i) JP S60-070412 j) JP H09-265044

Training set: 34 lenses



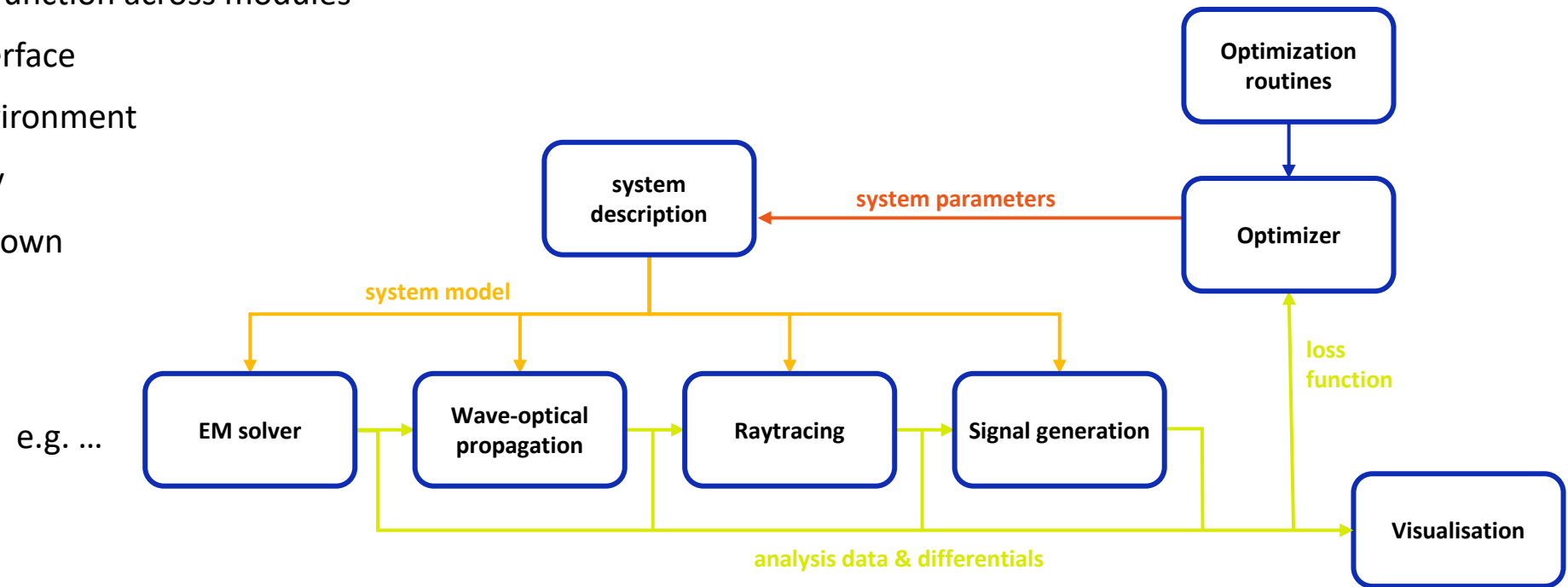
	5 elements	6 elements	7 elements	8 elements	9 elements	10 elements
k=1						
k=2						
k=3						
k=4						
k=5						
k=6						
k=7						
k=8						

Generated set: 7432 lenses

Requirements for a future tool landscape

System performance optimization in an open environment

- Unified parametric system description
- Standardized model and data interfaces
- Differentiable quantities throughout
- Compound merit/loss function across modules
- Open optimization interface
- Single visualization environment
- Multi-system capability
- Open environment for own & 3rd party modules





Seeing beyond