

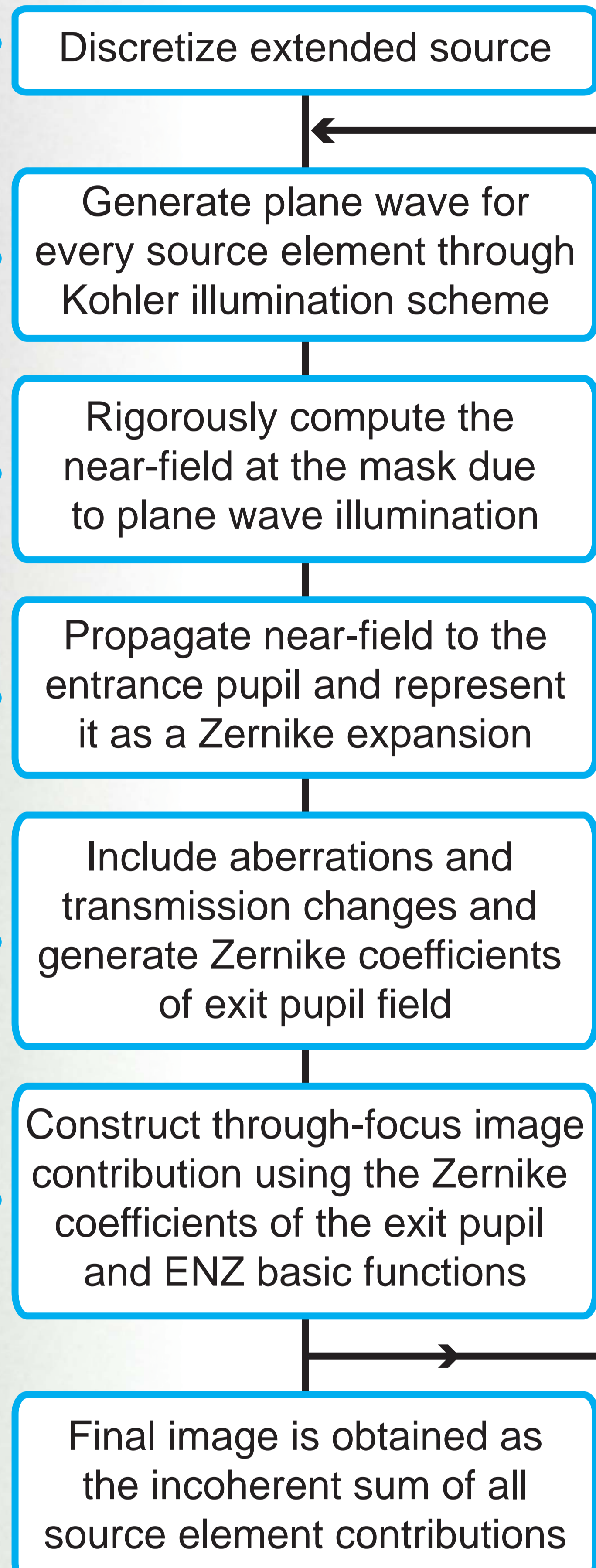
# Characterization of a novel mask imaging algorithm based on the Extended Nijboer-Zernike (ENZ) formalism

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## Introduction:

We present details of a recently developed mask imaging algorithm based on the Extended Nijboer-Zernike (ENZ) formalism [1][2]. Convergence properties of the various computational steps are discussed and a comparison with the more conventional tool Dr. Litho [3] is presented.

## ENZ imaging scheme:



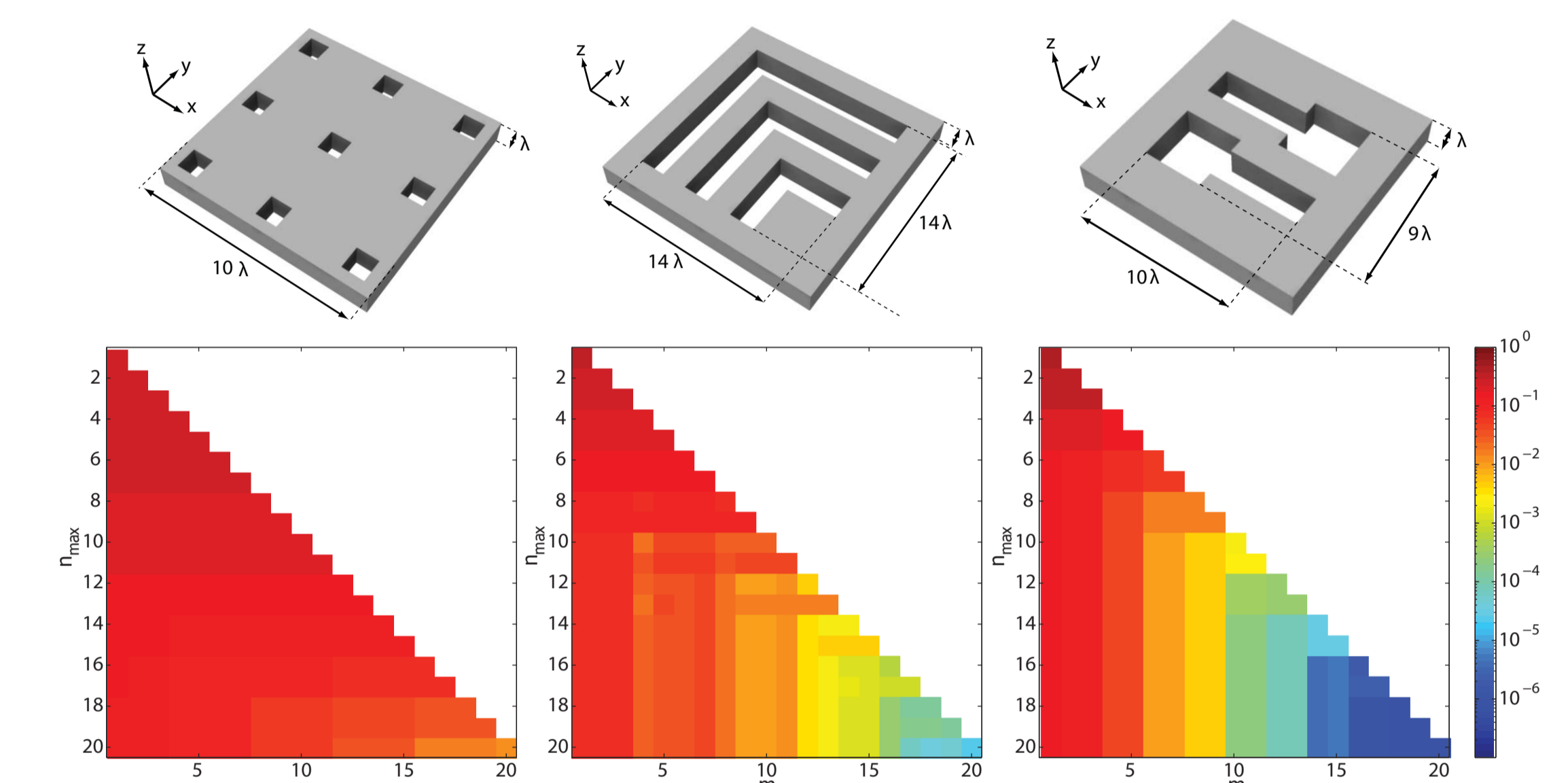
## Convergence properties:

### Rigorous solver:

Convergence considerations on the in-house developed FDTD tool and near-to-far field propagation can be found in Refs. [4] and [5].

### Least-square pupil fit convergence:

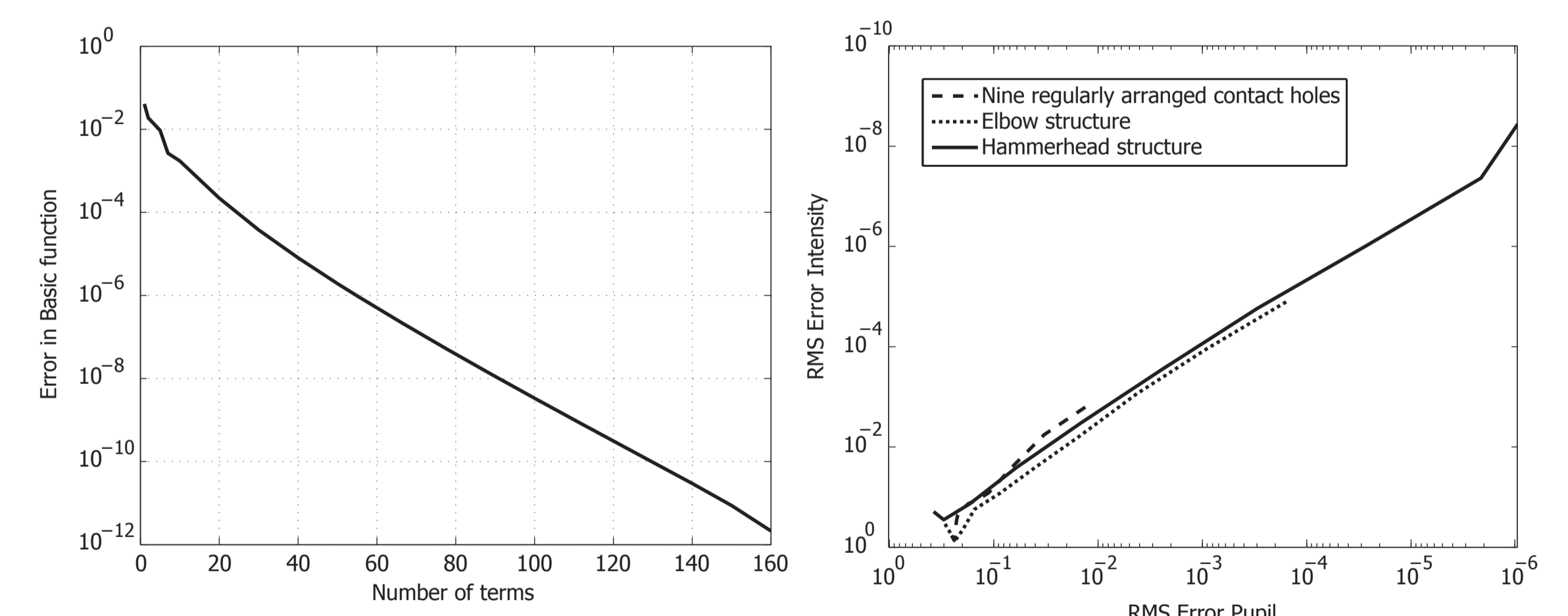
Maximum radial and azimuthal order of Zernike functions required for an accurate fit strongly depends on the object.



Fitting accuracy in entrance pupil versus (N<sub>max</sub>, M<sub>max</sub>)

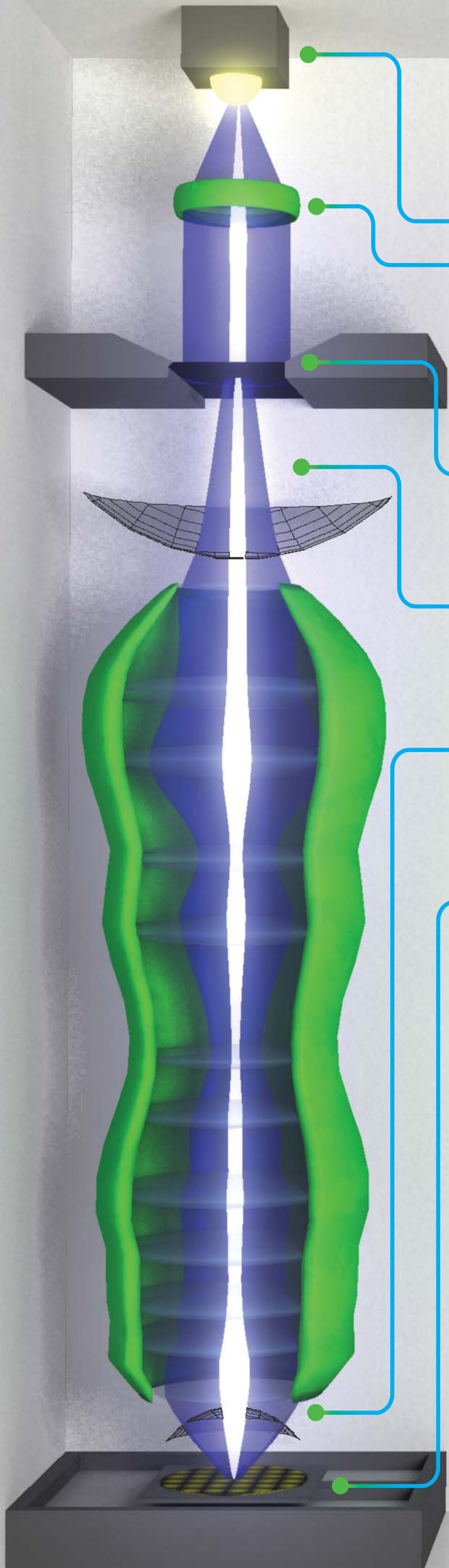
### ENZ basic functions and final image:

The ENZ basic functions are computed using a well converging series expansion (see lefthand graph). They are independent of the object and can therefore be computed and stored in advance. As a result, the image accuracy is in practice only limited by the quality of the Zernike expansion in the entrance pupil. The righthand graph shows the RMS error in the image versus the RMS error in the expansion for the objects introduced above.



## References:

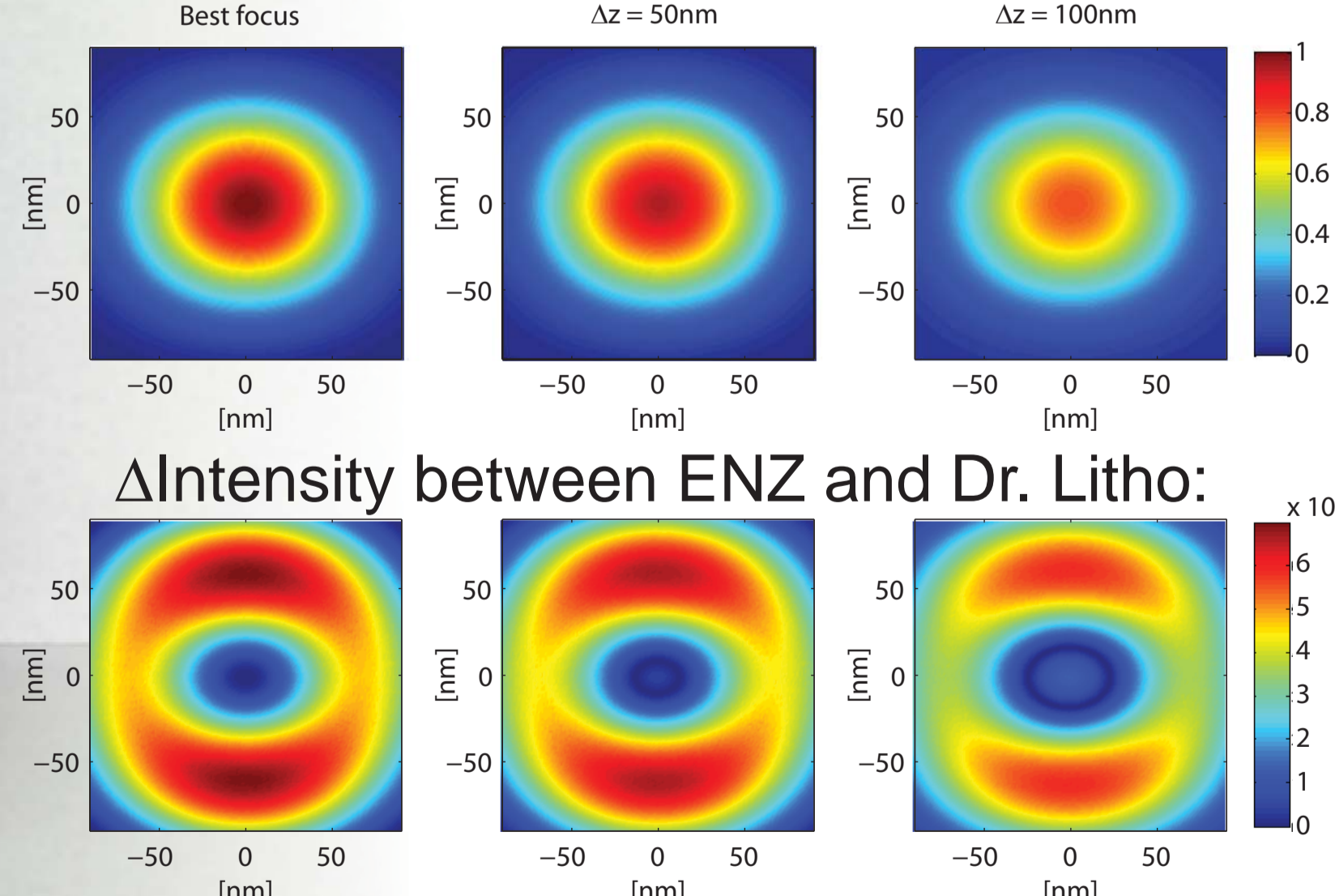
- [1] S. van Haver, et al., Proc. SPIE **6924**, 69240U (2008)
- [2] ENZ website: <http://www.nijboerzernike.nl>
- [3] Dr. Litho software tool, <http://www.dritho.com>
- [4] P. Lalanne, et al., J. Eur. Opt. Soc. Rap. Publ. **2**, 07022 (2007)
- [5] O.T.A. Janssen, et al., Proc. SPIE **6924**, 692410 (2008)



## Comparison with Dr. Litho:

90nm square contact hole is imaged by an immersion lithographic system (NA = 1.1, λ=193nm, im. fl. water).

### Through-focus image:



\*Artists impression by Olaf Janssen