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► **To cite this version:**

Mahmoud Elsayy, Mickael Binois, Enzo Isnard, Régis Duvigneau, Patrice Genevet, et al.. Advanced optimization technique for robust and multiobjective metasurface designs. ICMAT2023 - International Conference on Materials for Advanced Technologies, Jun 2023, Singapore (SG), Singapore. 2023. hal-04355037

**HAL Id: hal-04355037**

**<https://hal.science/hal-04355037v1>**

Submitted on 20 Dec 2023

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# Advanced Optimization Technique for Robust and Multiobjective Metasurface designs

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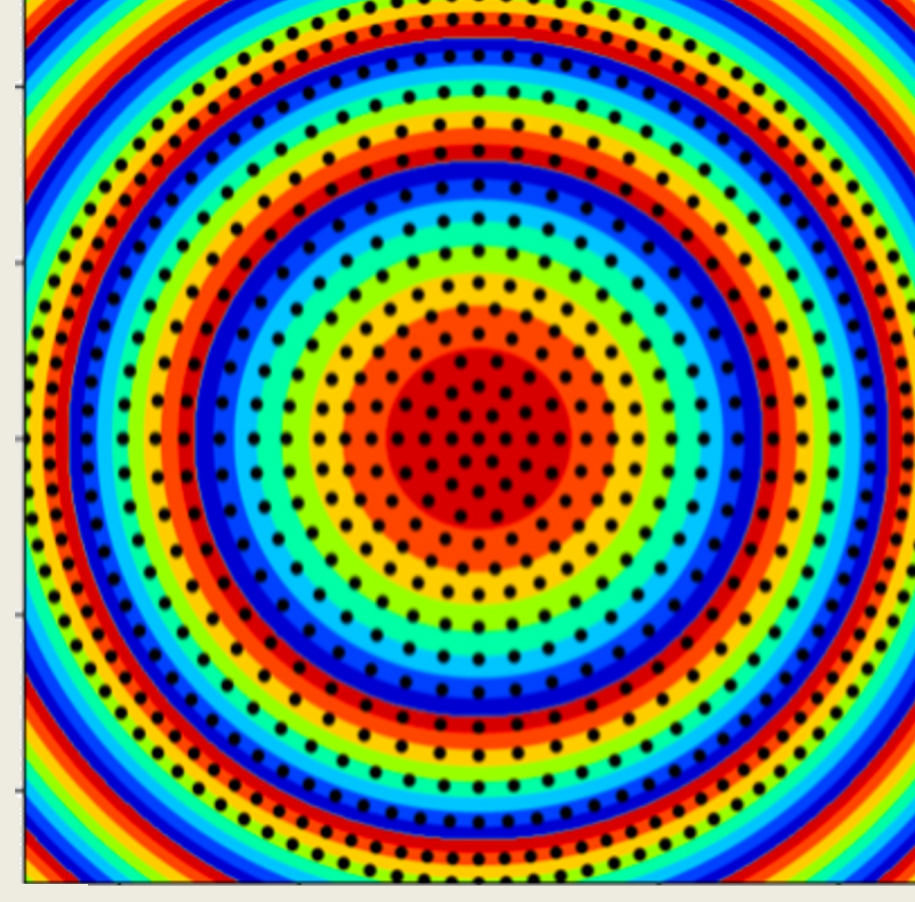


## Abstract

This poster emphasizes the paramount importance of employing optimization techniques to effectively address nonlocal resonance phenomena, accomplish multiobjective optimization, and seamlessly integrate uncertain quantification methods

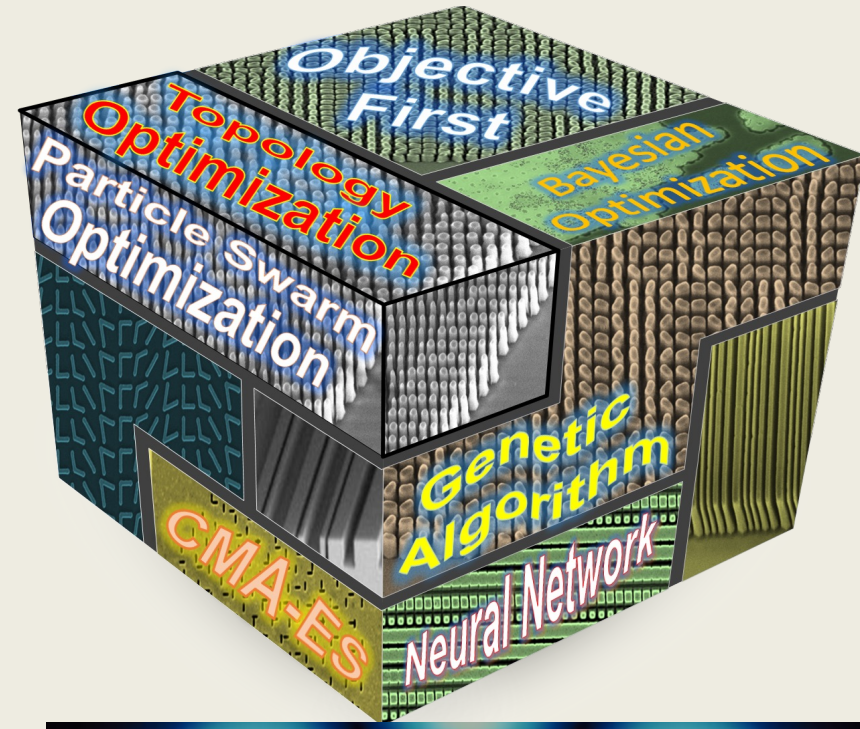
### Classical approach

- I- Lookup table: phase shift vs dimensions
- II- Synthesizing based on the required phase
- III- Low performance & neglect coupling



### Inverse design approach

- I- High performance
- II- Nonlocal interactions
- II- Difficult for multiobjective & Fabrication error



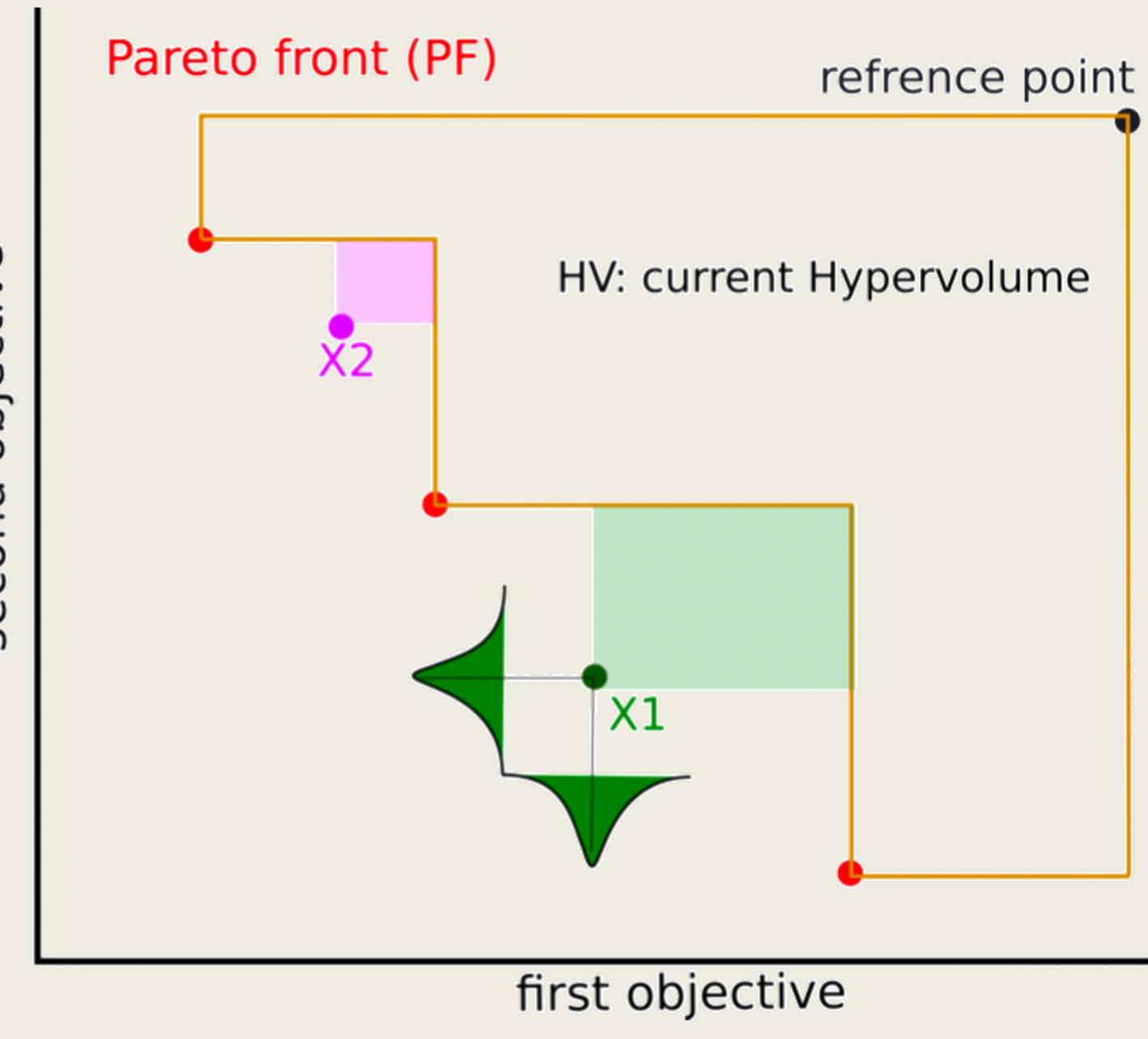
### Rigorous fullwave solver

- I- DIscOntinuous GaErkin Nano Solvers
- II- 3D Time-Domain & Frequency-Domain
- III- Complex geometry & Large-scale designs
- III- Efficient for strong near-field coupling

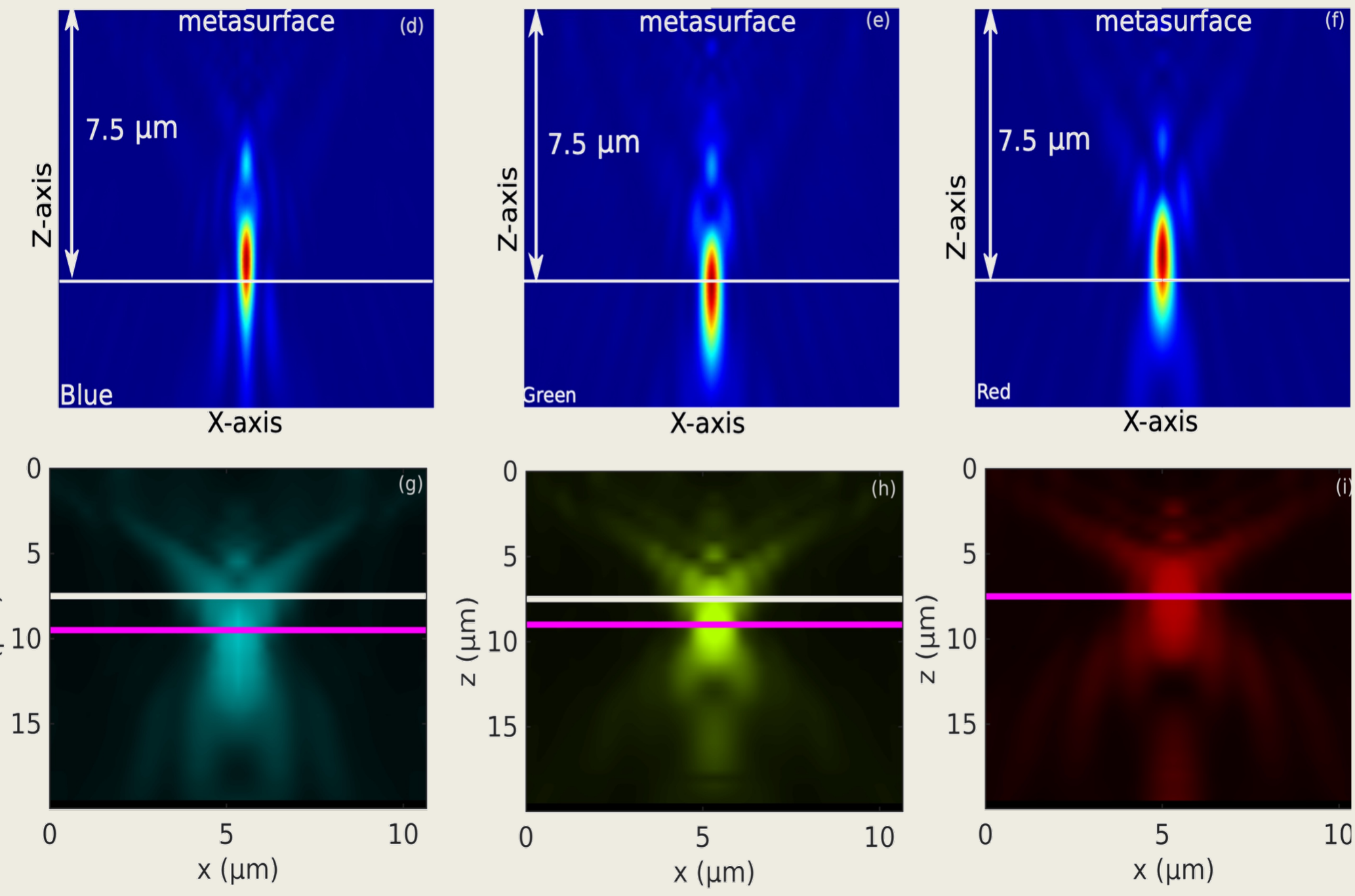
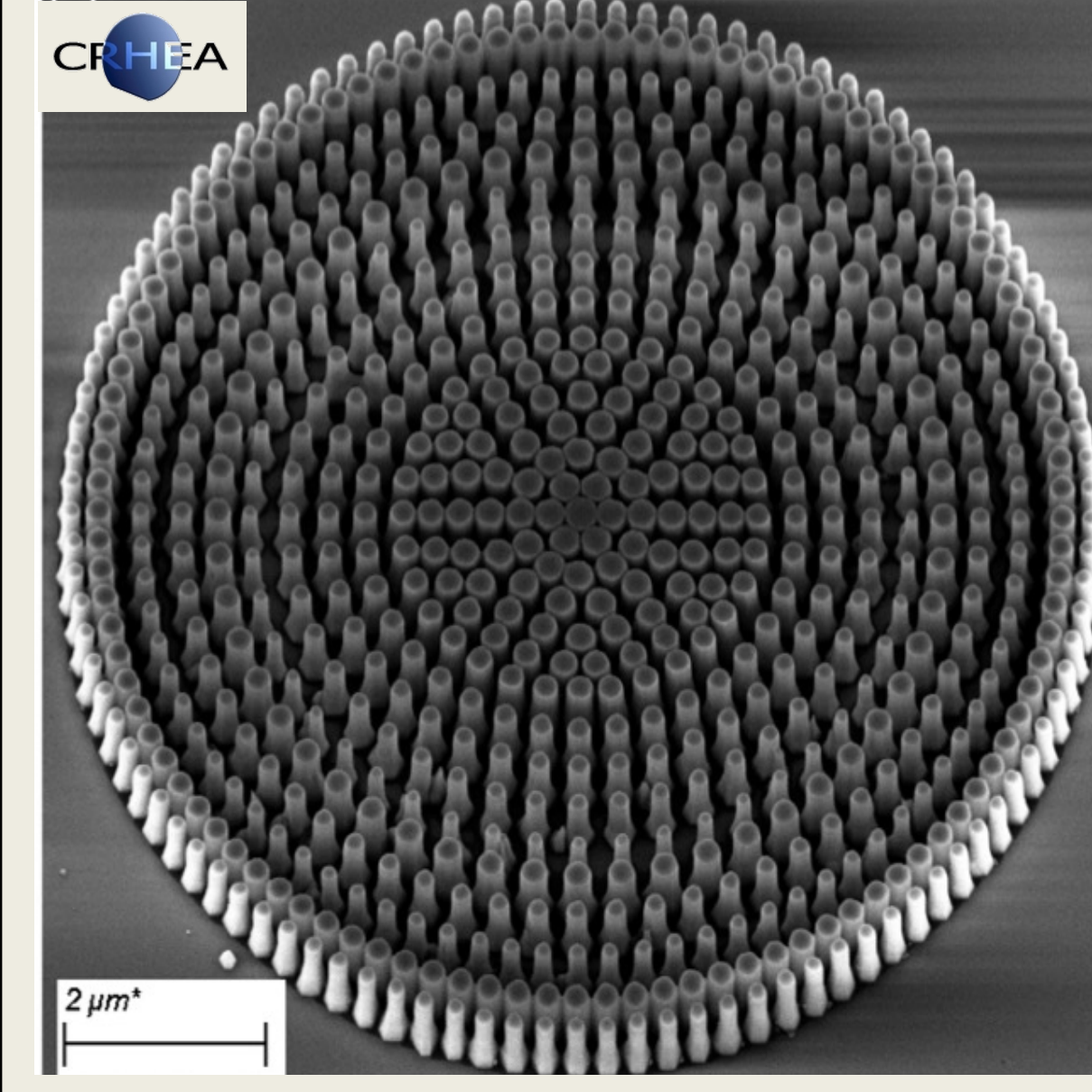


## Multiobjective optimization

- i) Different surrogate models
- ii) Expected Hypervolume improvement
- iii) x1 will be simulated in next iteration

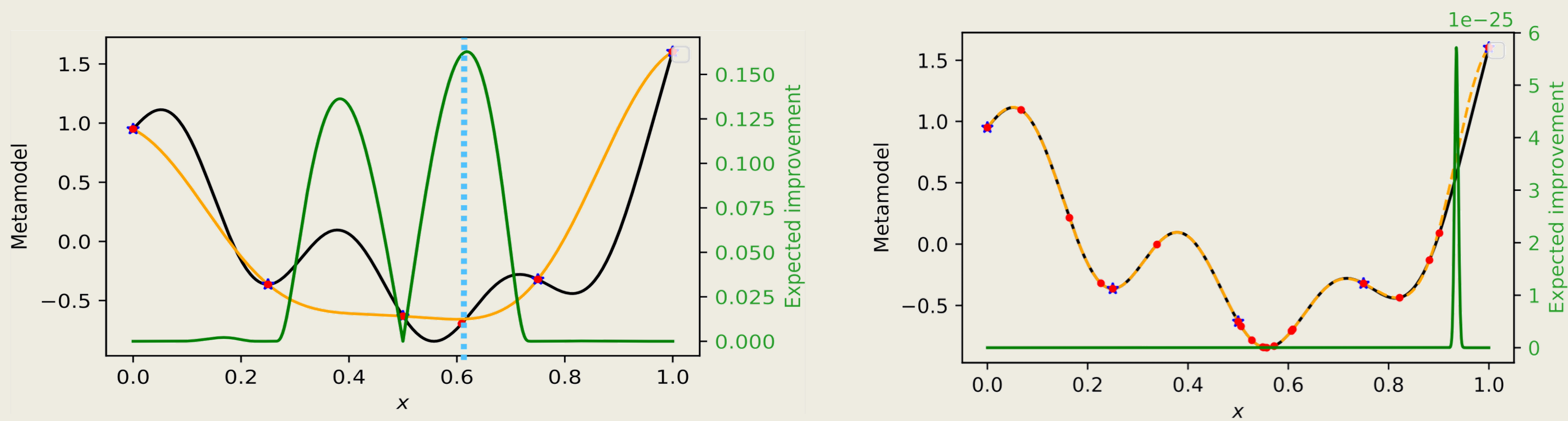


## RGB Metalens Design & Fabrication

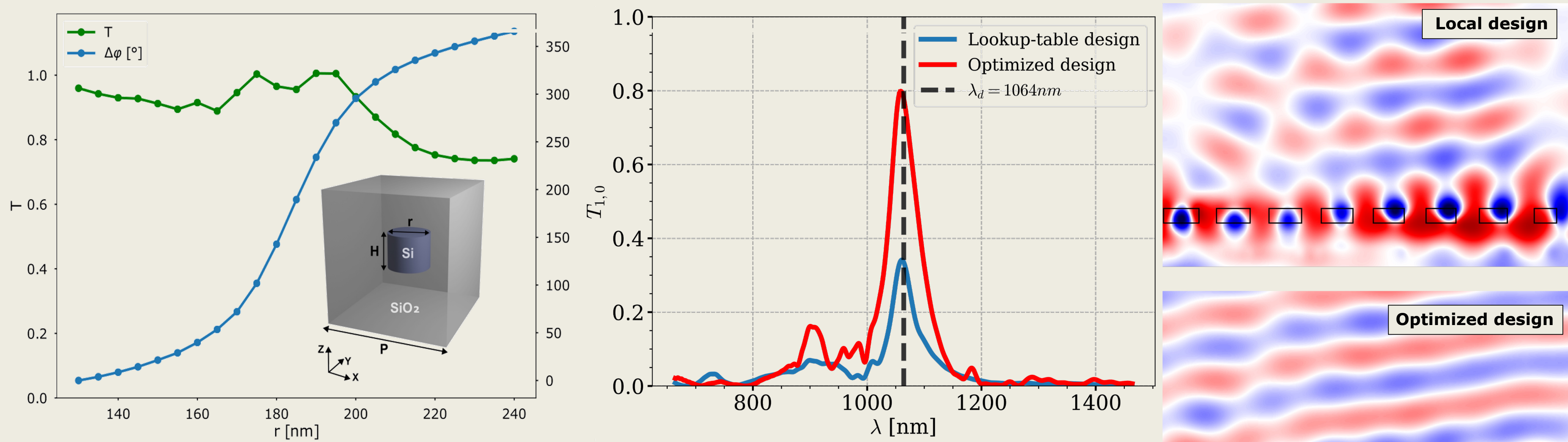


## Statistical learning optimization

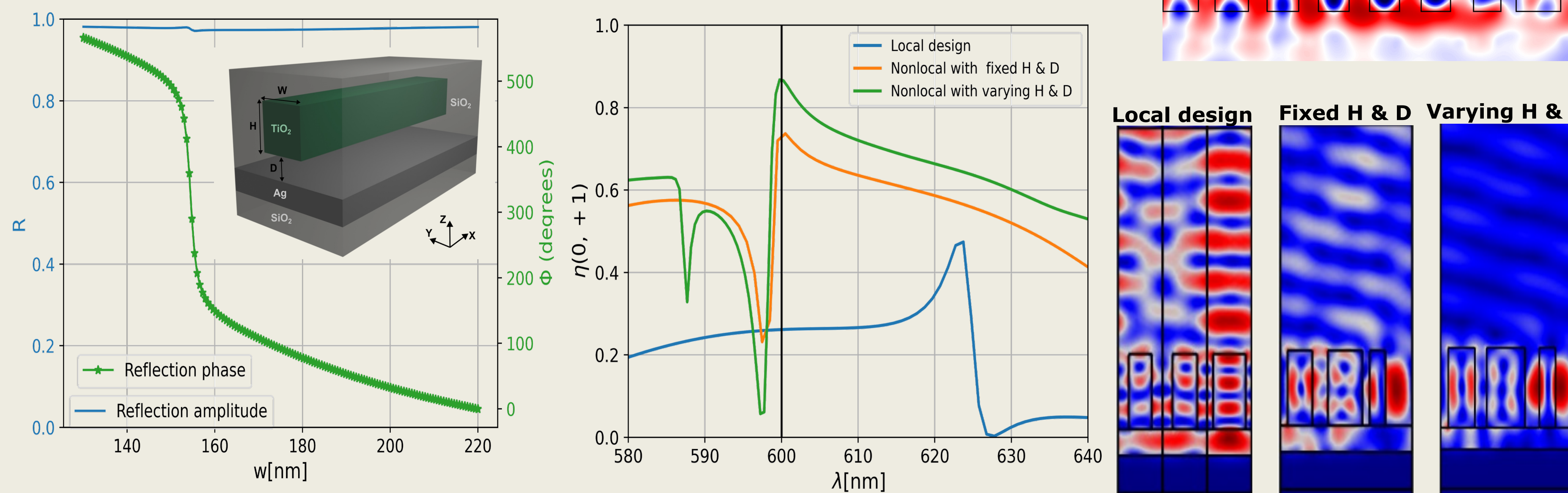
- Design of experiments (DOEs)
- Construct a surrogate mode
- $y(x)$  with standard deviation  $\sigma$  (orange curve)
- $Y(x) = N(y(x), \sigma^2)$
- Expected improvement:  $E(\max(y_{best} - Y(x), 0))$



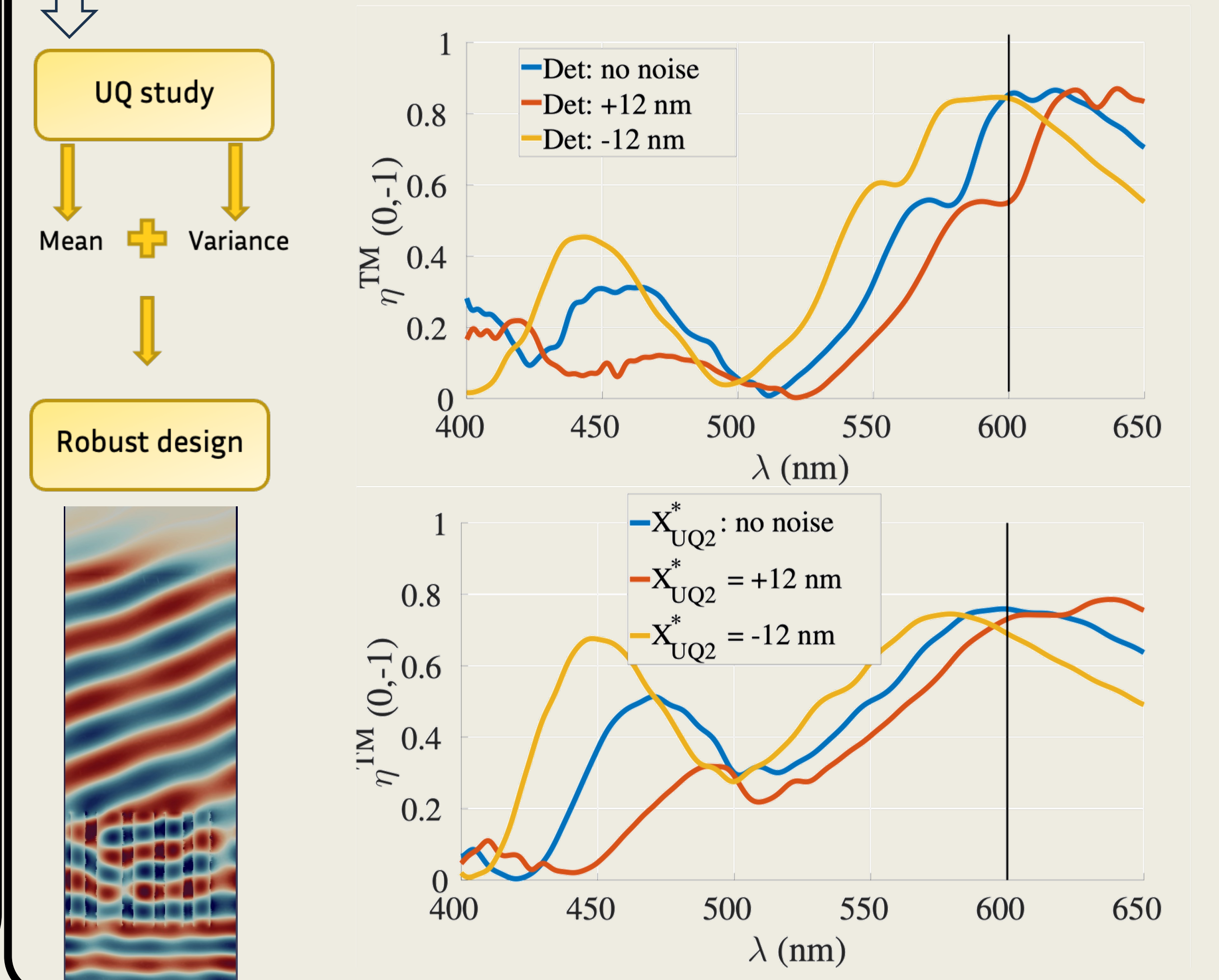
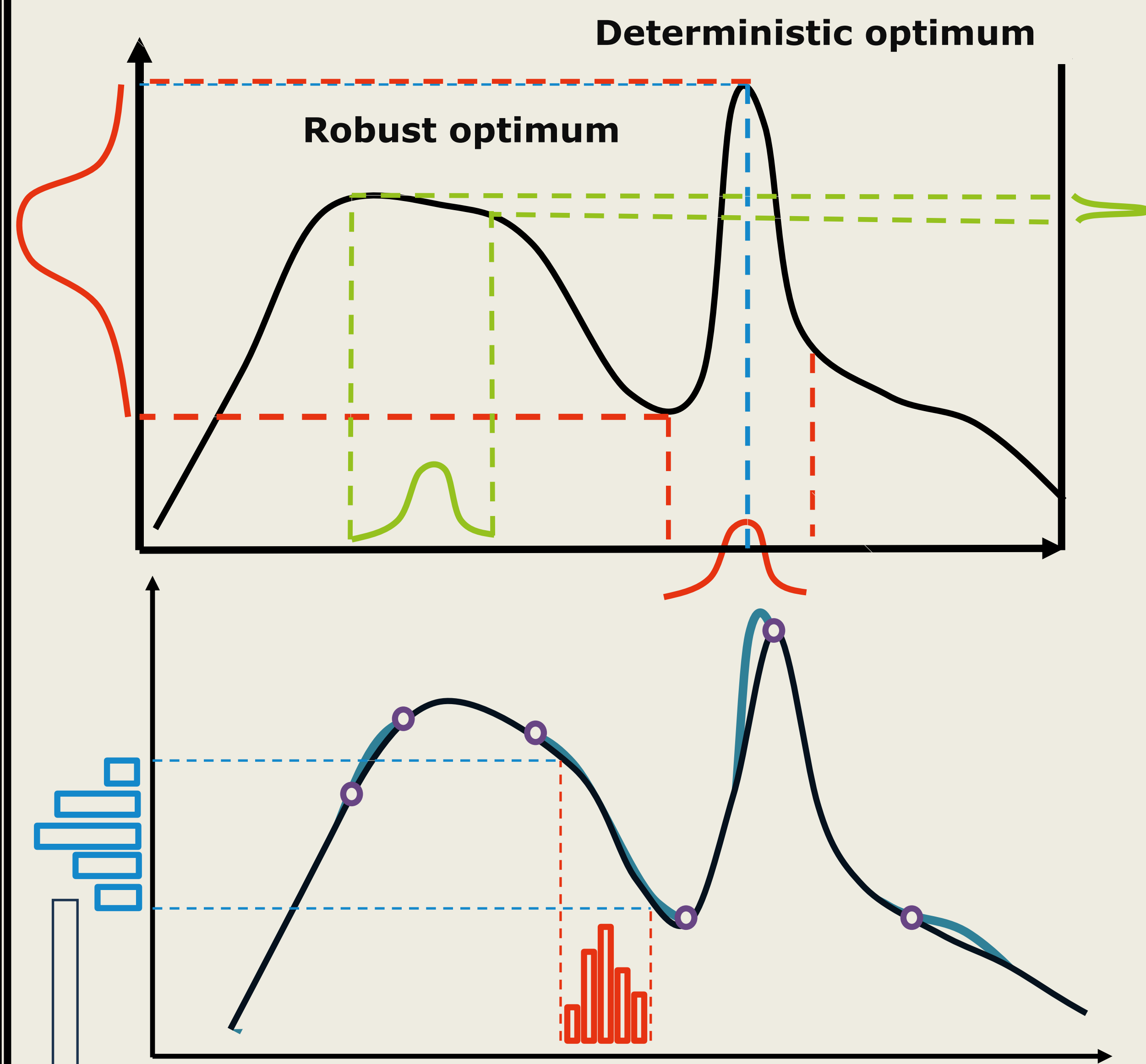
### i) Nonlocal Huygens resonant metasurface



### ii) Nonlocal Gires-Tournois resonant metasurface



## Fabrication imperfection



1. Elsayw, et al. Numerical optimization methods for metasurfaces. *Laser & Photonics Rev*, 14, 190045, (2020).
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3. Isnard, et al. Advancing wavefront shaping with Resonant nonlocal metasurfaces: Beyond the limitations of lookup tables. *submitted* (2023)
4. Elsayw, et al. Multiobjective statistical learning optimization of RGB metalens. *ACS photonics* 8, 2498–2508 (2021).
5. Elsayw, et al. Optimization of metasurfaces under geometrical uncertainty using statistical learning. *Opt. Express* 29, 29887–29898 (2021).

