



HAL
open science

Advanced optimization technique for robust and multiobjective metasurface designs

Mahmoud Elsayy, Mickael Binois, Enzo Isnard, Régis Duvigneau, Patrice Genevet,
Stéphane Lanteri

► **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

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

Advanced Optimization Technique for Robust and Multiobjective Metasurface designs

Mahmoud Elsayw^{1*}, Mickael Binois¹, Enzo Isnard¹, Regis Duvigneau¹, Patrice Genevet² and Stéphane Lanteri¹

Université Côte d'Azur, Inria, CNRS, LJAD, , Sophia Antipolis, France¹

Université Côte d'Azur, CNRS, CRHEA, Sophia Antipolis, France²

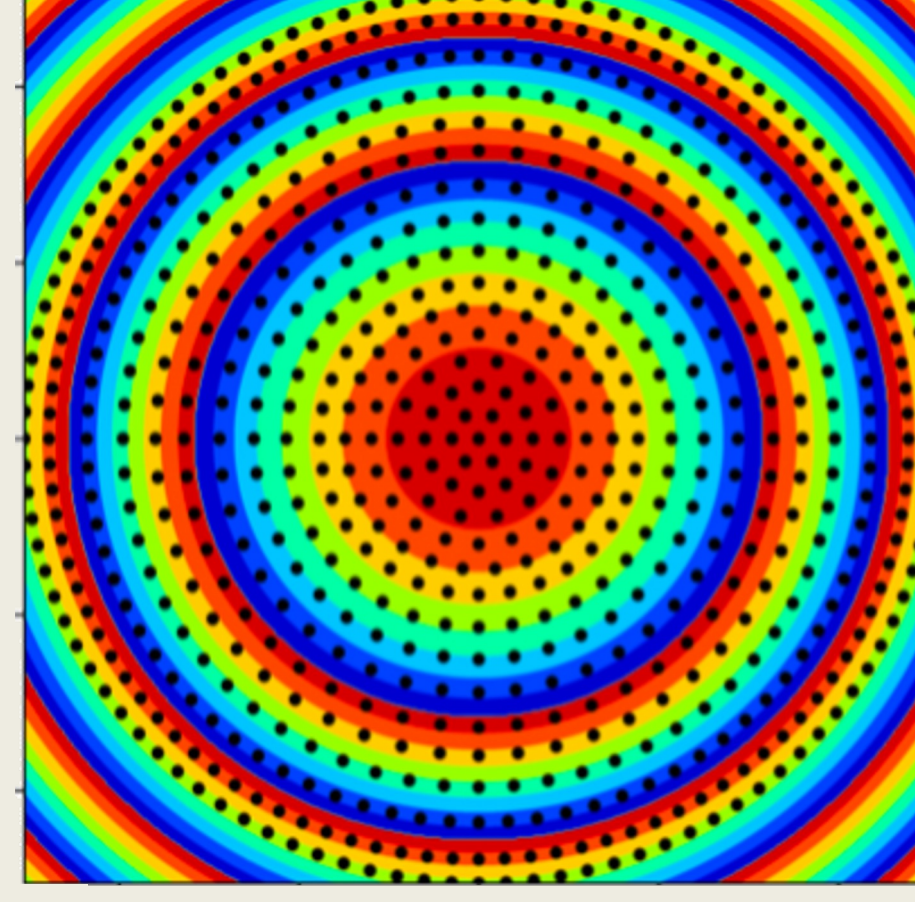


Abstract

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

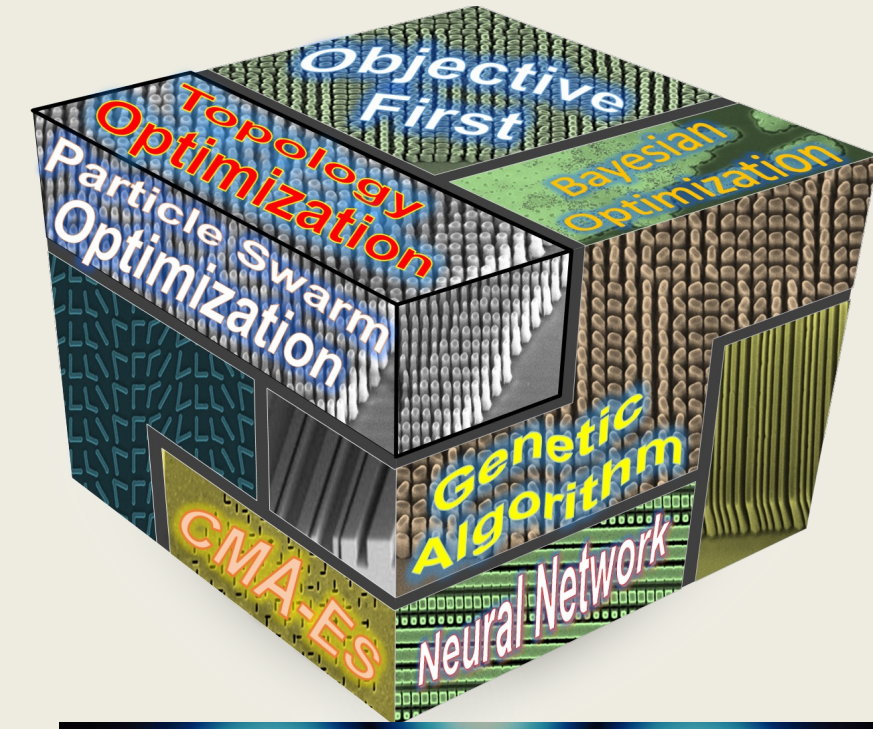
Classical approach

- 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



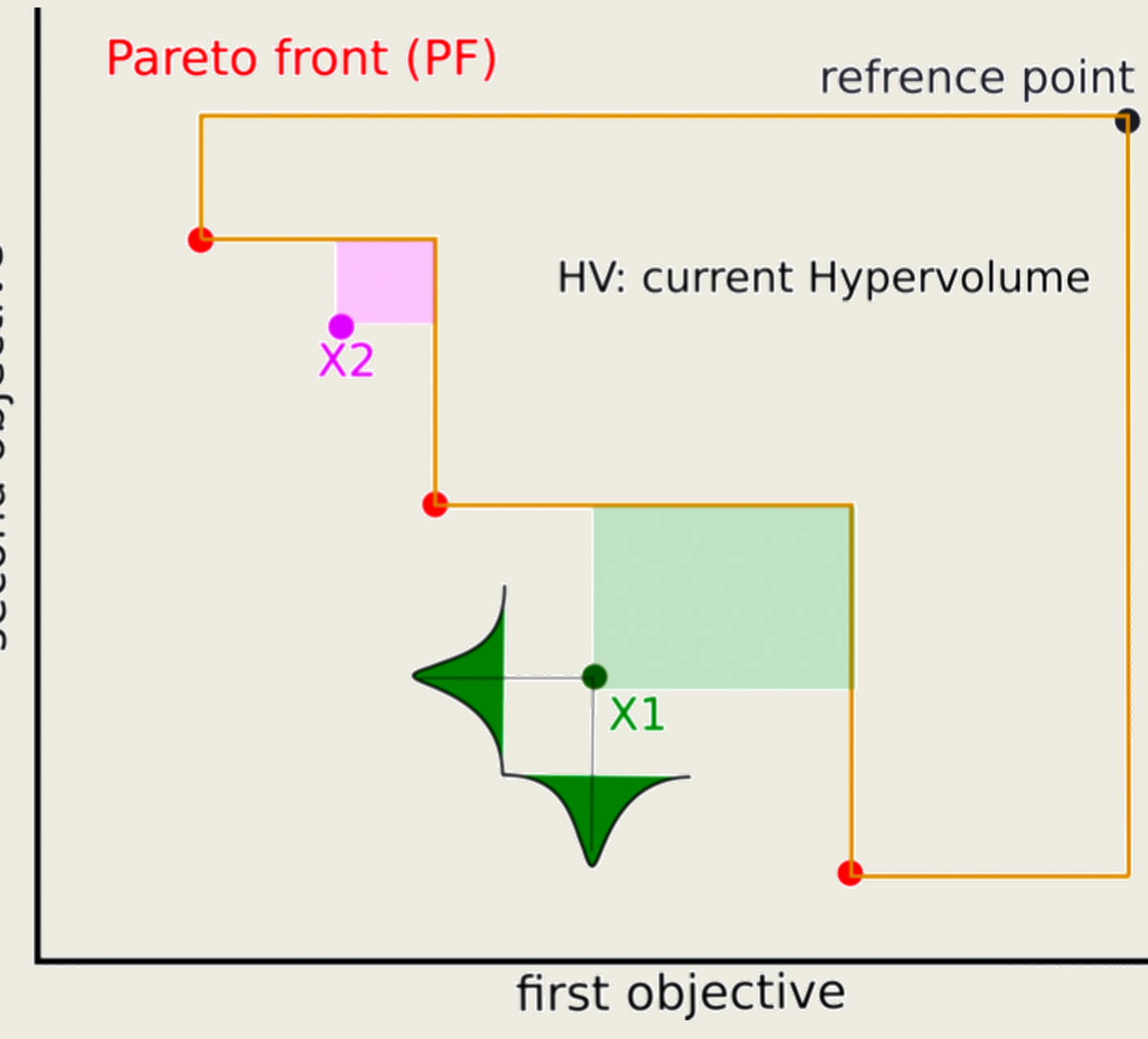
Rigorous fullwave solver

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

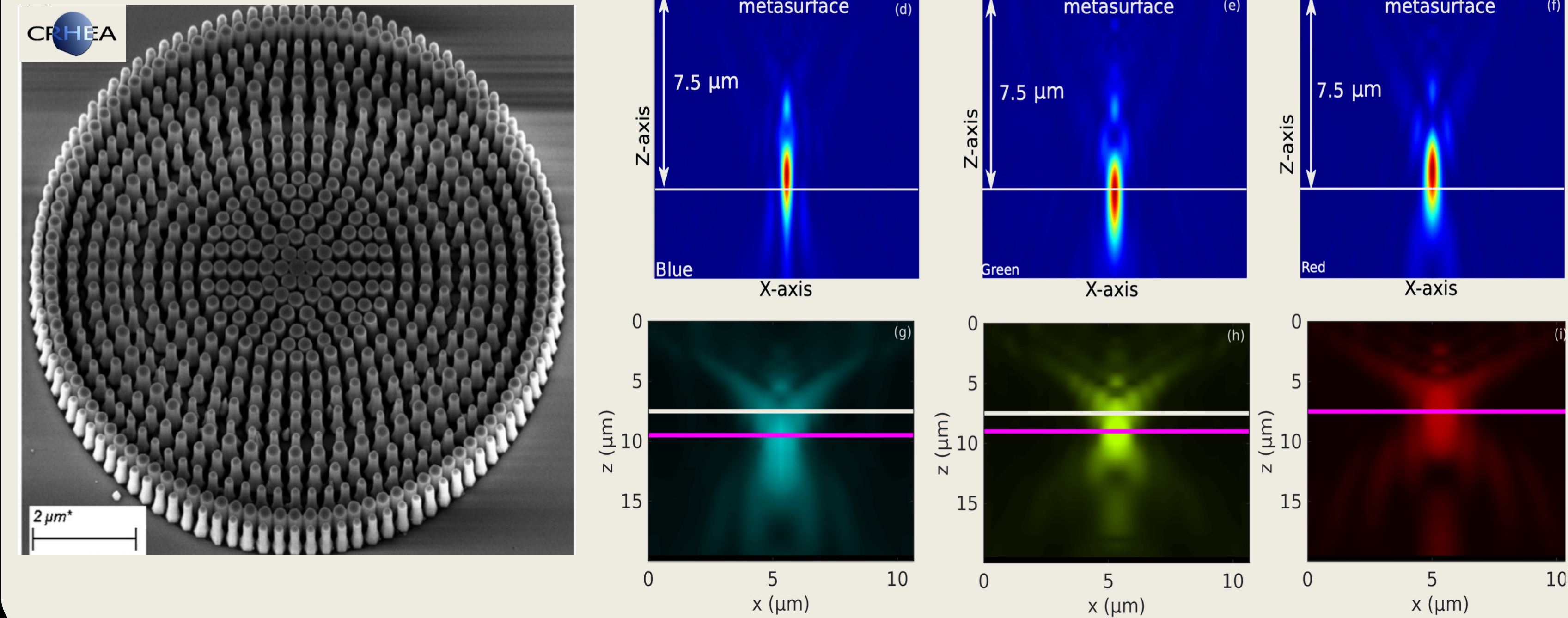


Multiobjective optimization

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

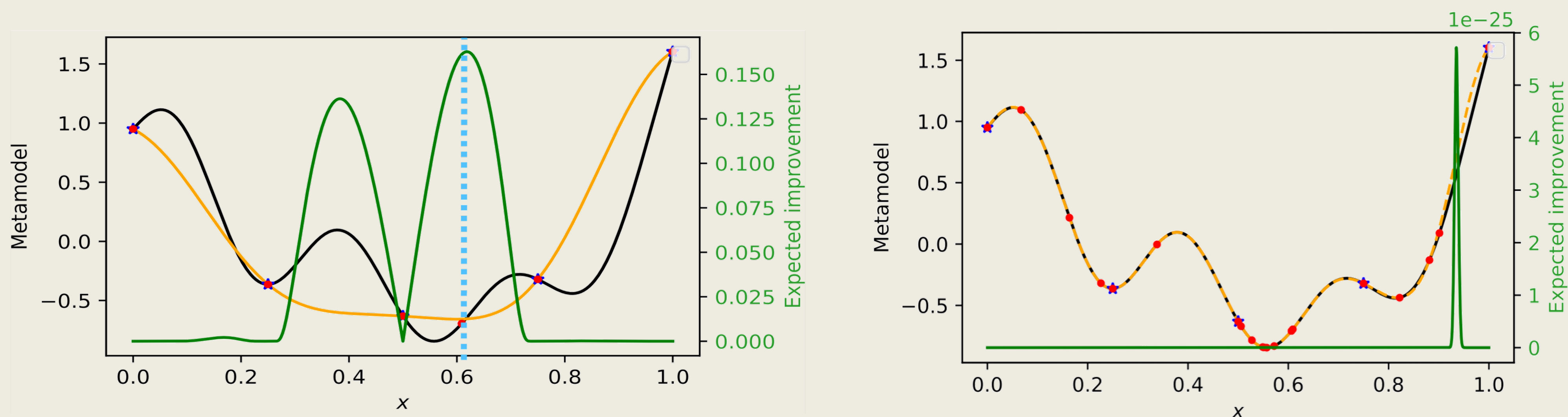


RGB Metalens Design & Fabrication

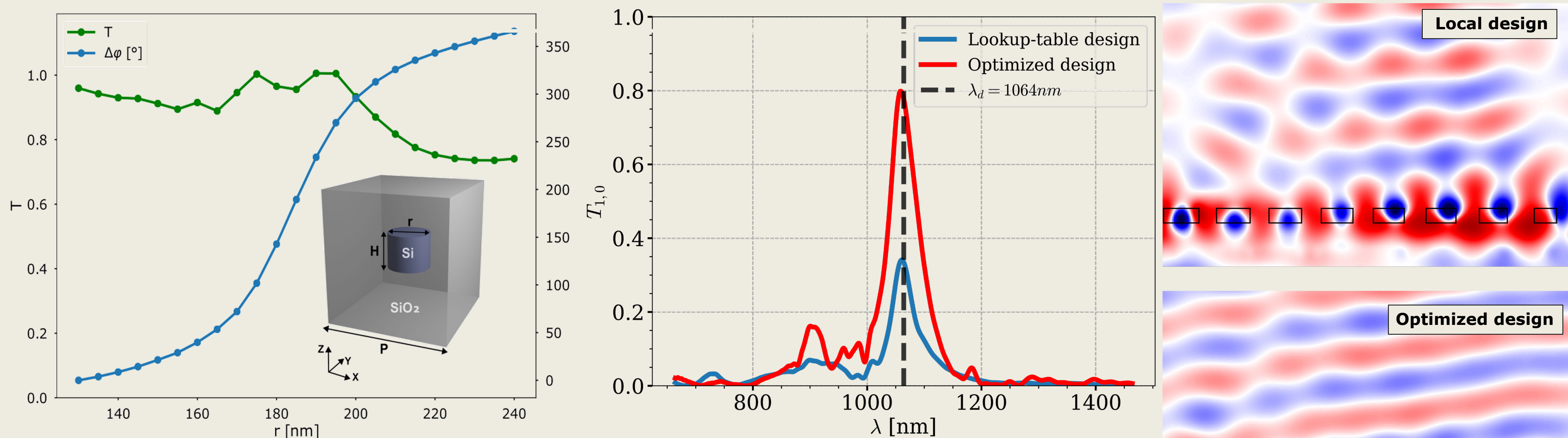


Statistical learning optimization

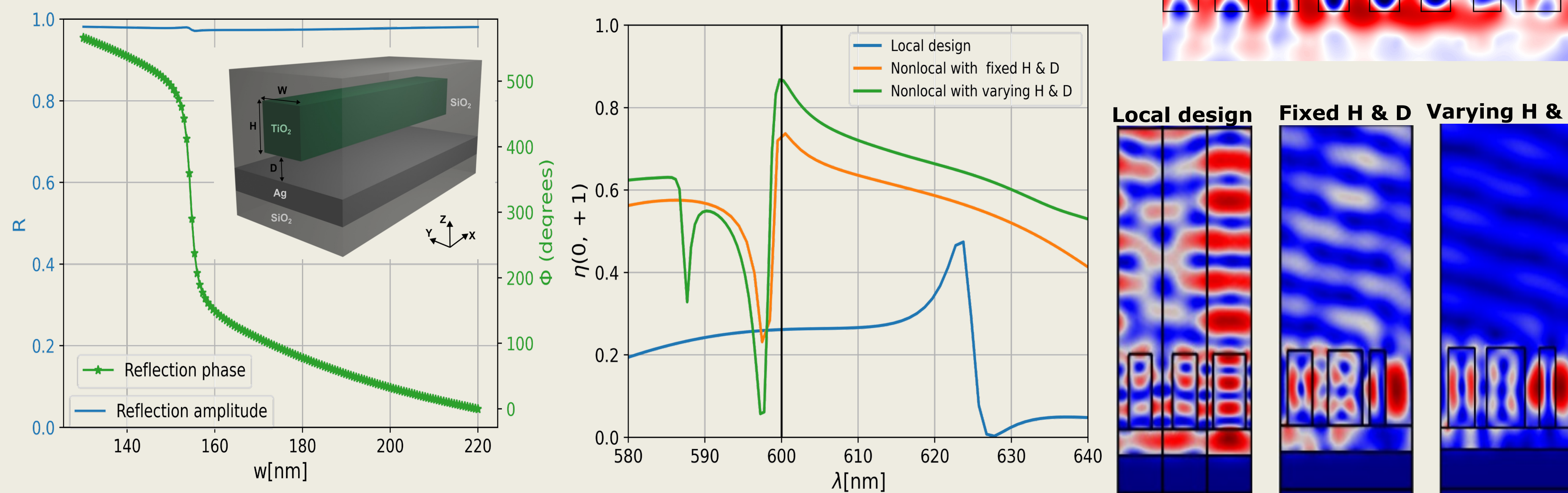
- Design of experiments (DOEs)
- Construct a surrogate mode
- $y(x)$ with standard deviation σ (orange curve)
- $Y(x) = N(y(x), \sigma^2)$
- Expected improvement: $E(\max(y_{best} - Y(x), 0))$



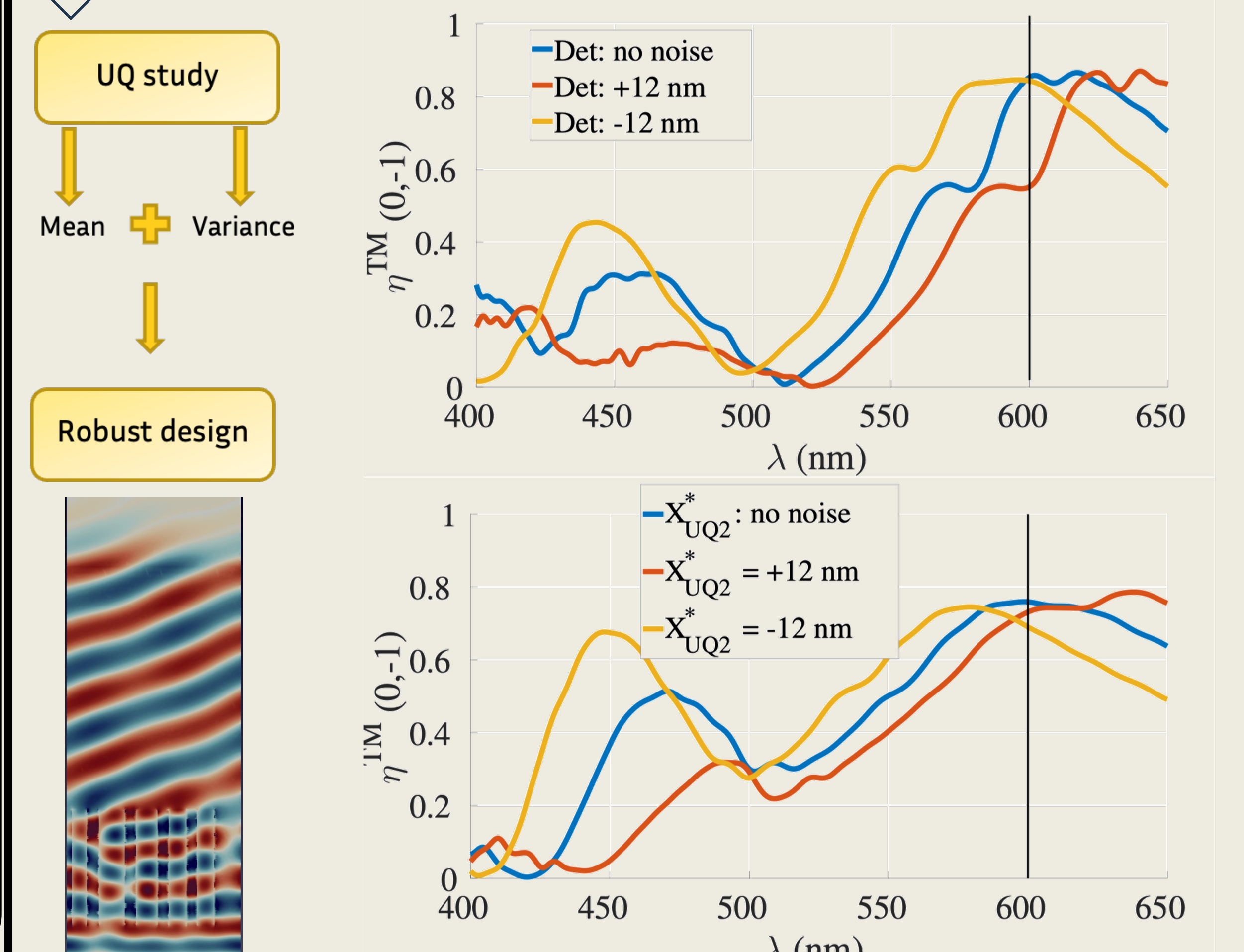
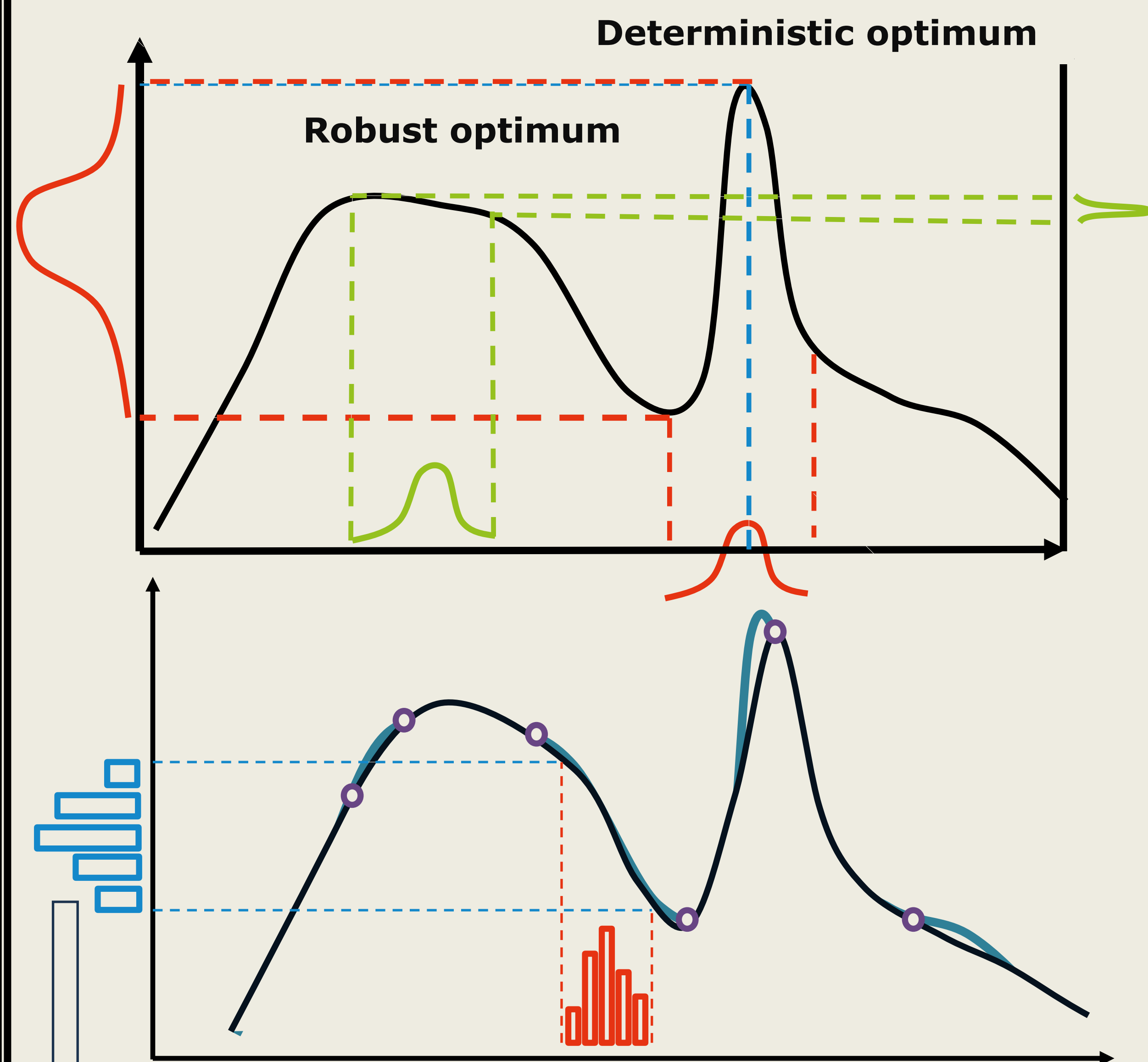
i) Nonlocal Huygens resonant metasurface



ii) Nonlocal Gires-Tournois resonant metasurface



Fabrication imperfection



1. Elsayw, et al. Numerical optimization methods for metasurfaces. *Laser & Photonics Rev*, 14, 190045, (2020).
2. Elsayw, et al. Global optimization of metasurface designs using statistical learning methods. *Sci. reports* 23, 9, 1–15 (2019).
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).

