From Design to Human Vision Experience of an AR system

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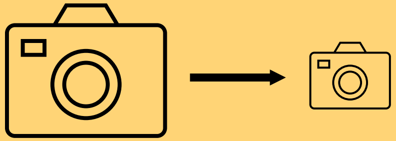
Ansys

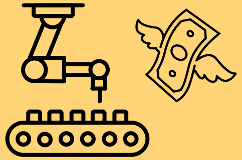
Optical System Design Challenges for AR/VR Systems

As we aim to enhance human’s ability to interact with the physical world, mixed reality systems are becoming increasingly common. These systems simultaneously relay a live scene and digital projection onto the human eye. Due to the novel nature of many mixed reality designs, engineers must tackle an array of unique challenges, including:

- Need for miniaturization and weight reduction

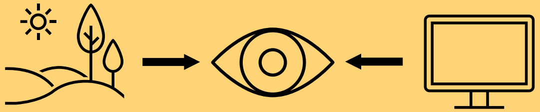


- Balancing price point & manufacturing costs



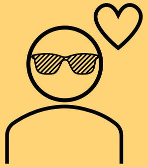
- Complex lens and diffractive profiles

- Shared optical paths for scene and display



- Real-time head, eye, and gesture tracking

- User comfort and perception

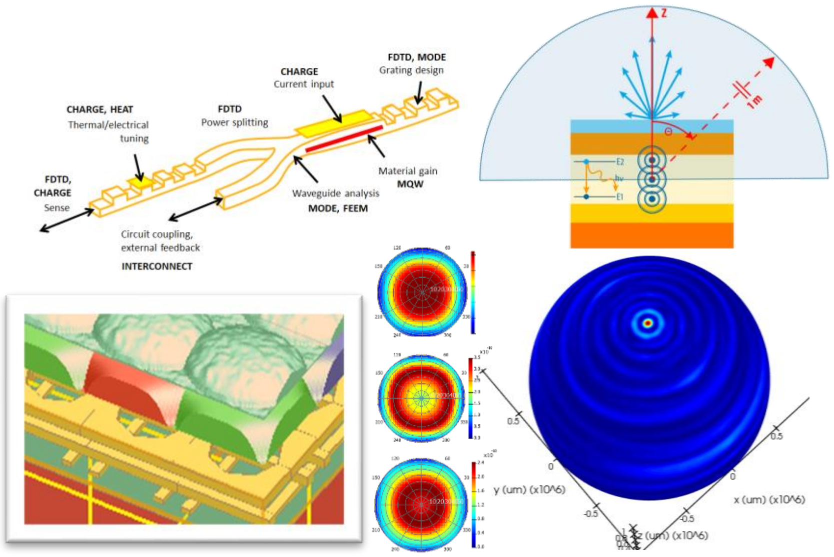


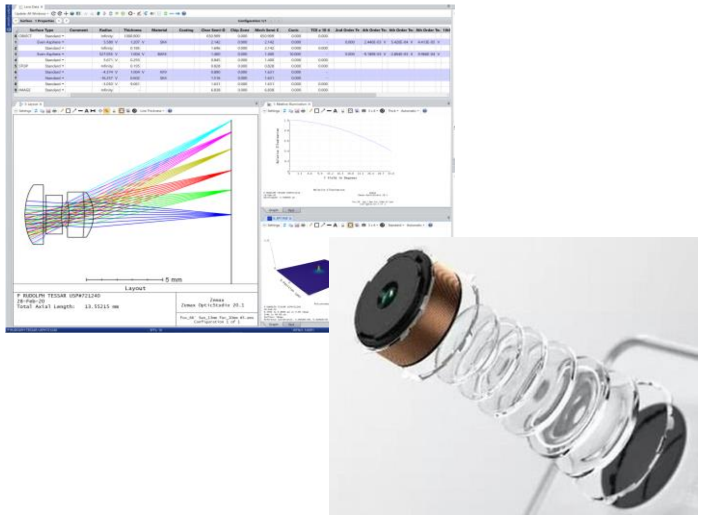
Virtual prototyping thanks to end-to-end simulation

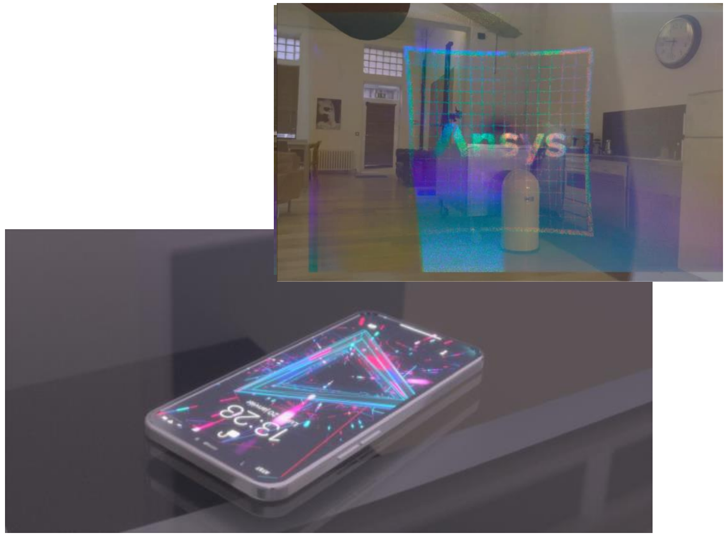
LUMERICAL — Multiphysics Photonic Modeling

ZEMAX — Optical Component Modeling

SPEOS — System Level Modeling







- Photonic components, circuits & systems
- Diffractive optical elements & waveguides
- Emissive and absorbing structures

- Lens stack optimization
- Optical/mechanical tolerancing

- 3D environment integration
- Lighting
- Human vision/perception

From Nano → **To Macro** → **To System**

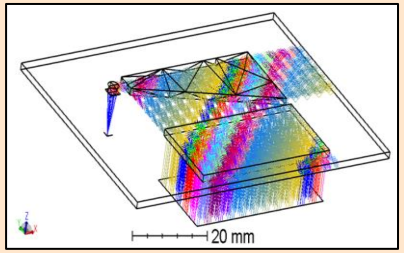
AR/VR Systems: Common Design Forms

Diffractive | **Sag Based**

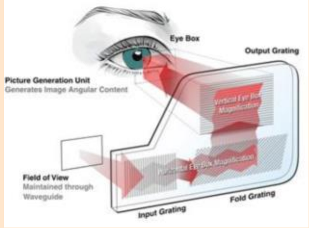
AR

Diffractive

Exit Pupil Expander (Grating)

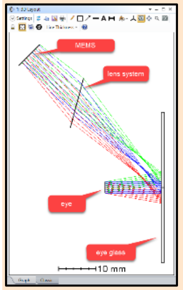


Exit Pupil Expander (Volume Hologram)



Reference: DigiLens

Combiner (Volume Hologram)

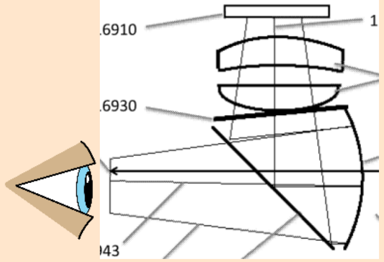


On glass

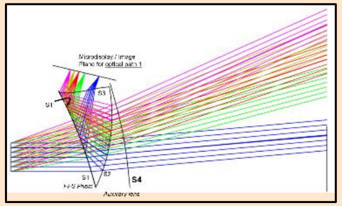
In waveguide

Sag Based

Birdbath/Freeform prism



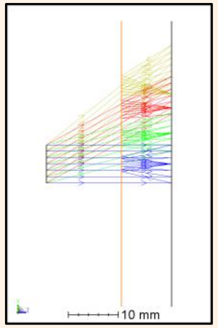
Reference: US Patent 9494800



VR

Diffractive

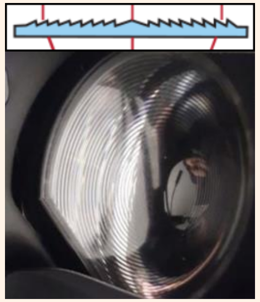
Pancake (Volume Hologram)



Reference: Meta

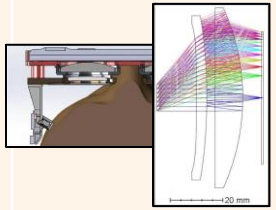
Sag Based

Fresnel Lens



Reference: HTC

Pancake



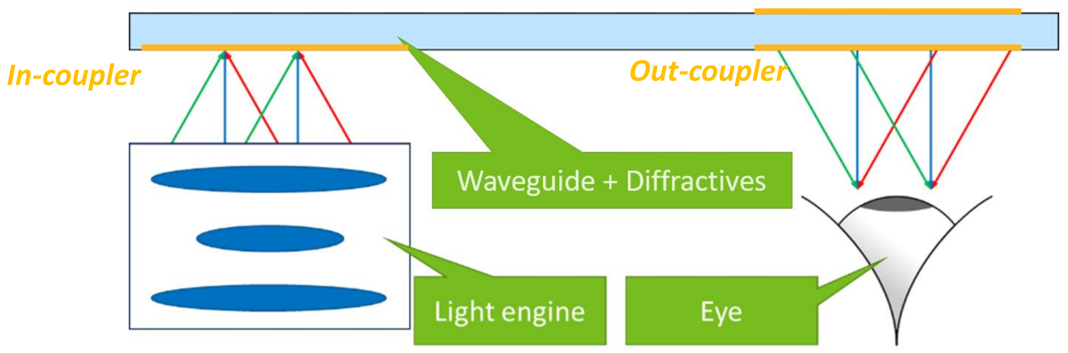
Reference: 3M & Petagron

Freeform prisms

Reference: Lynx

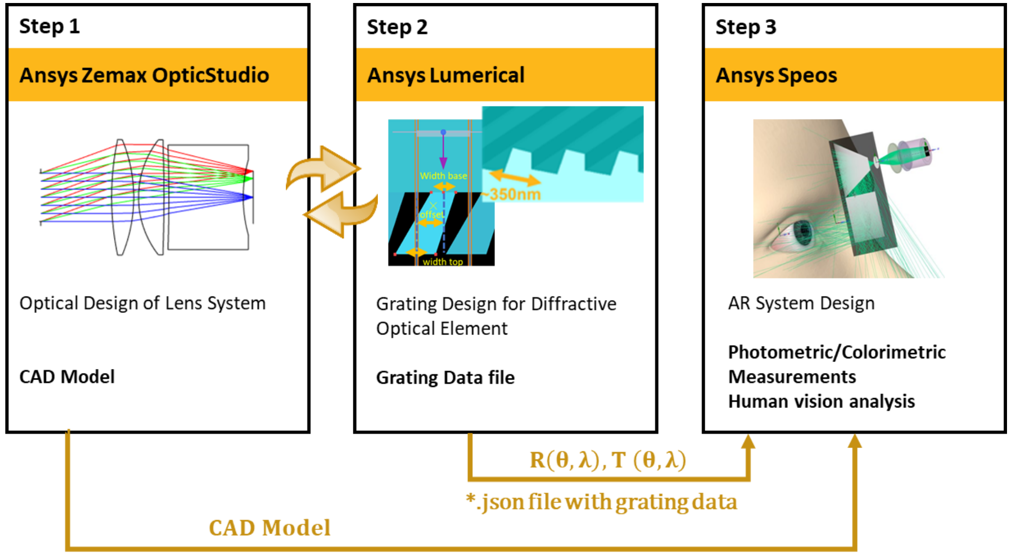
AR system with Exit Pupil Expander

AR System Schematic



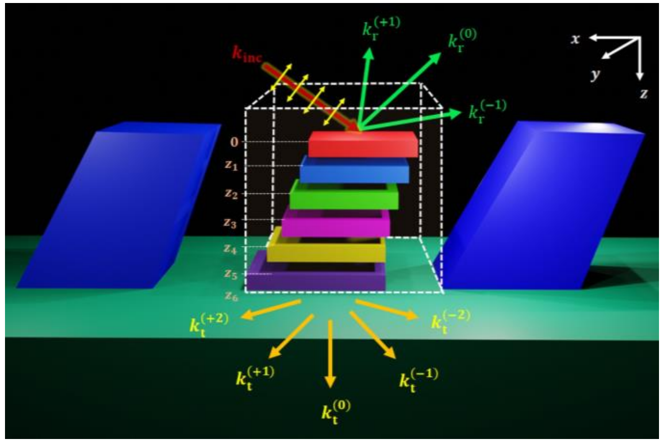
- Development of high-performance AR systems with end-to-end simulation of:
  - Display module + Projector relay lens
  - Waveguide structure with 1D/2D diffractive components for pupil expansion
  - Visual acuity simulation for output relayed image
- Solutions for designers at all stages of AR system design

Design and Validation workflow

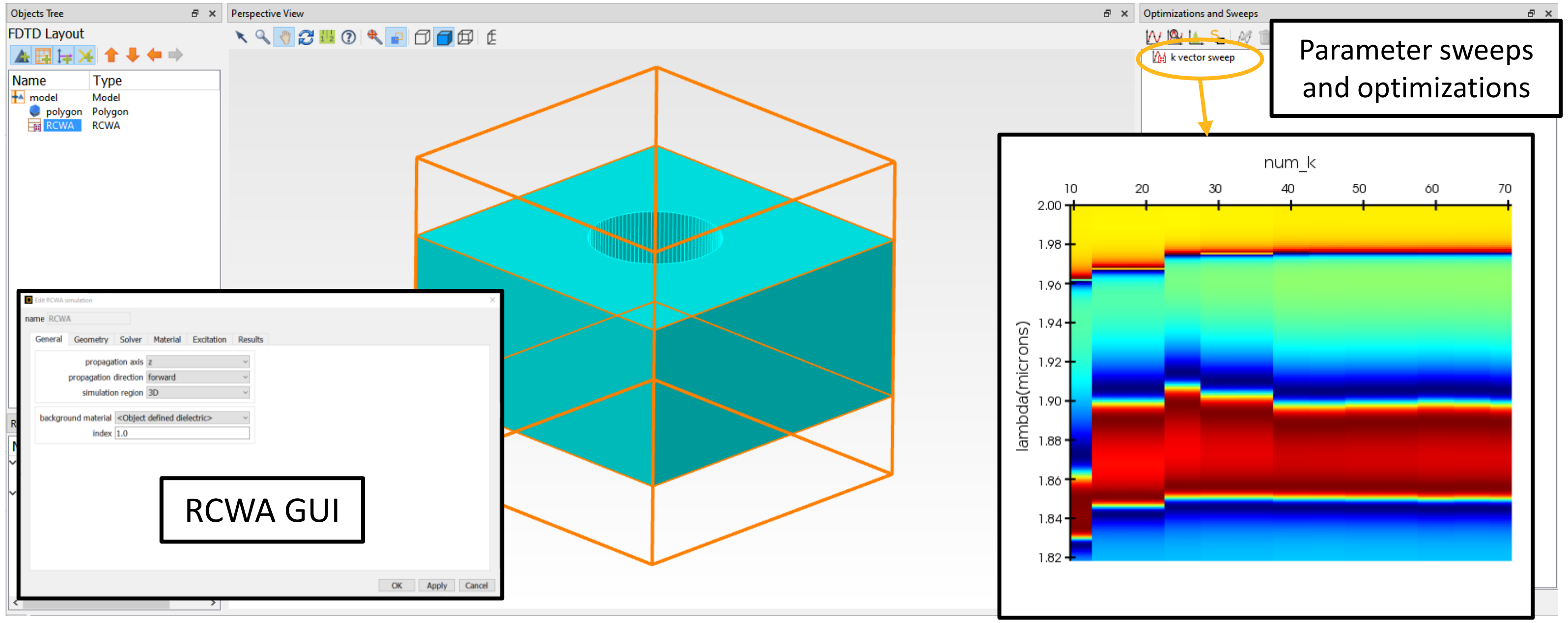


- Design projection lens for best image quality
- Design gratings for optimal light transmission
- Simulate human perception of a virtual mockup

Grating Design : Rigorous Coupled Wave Analysis (RCWA)



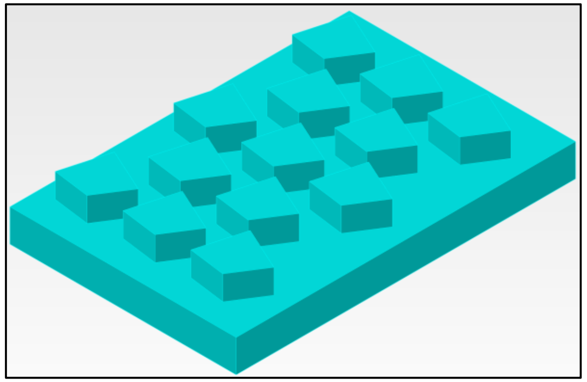
- Computational electromagnetic technique for analysis of layered, periodic structures
- Rigorous, semi-analytical frequency-domain solver
- Calculates the reflected and transmitted fields from a plane wave incident on the structure
- Optimization of the in-coupler grating to obtain optimal light transmission based on FoV

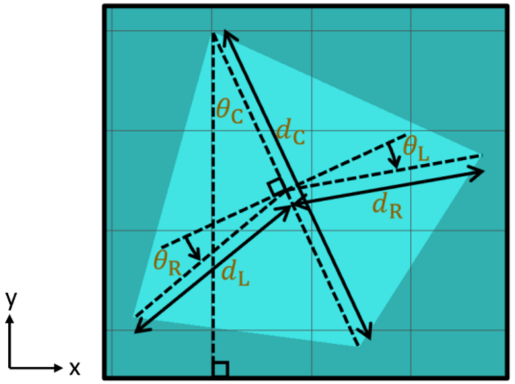


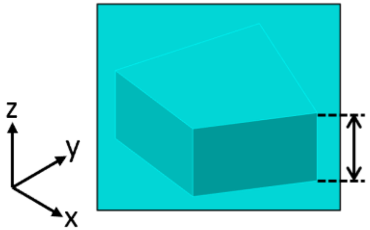
Optimization of all the Gratings on Waveguide

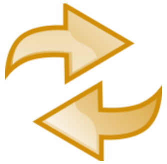
- Dynamic link between RCWA solver (Lumerical) and ray tracing solver (Zemax OpticStudio)

Grating structure

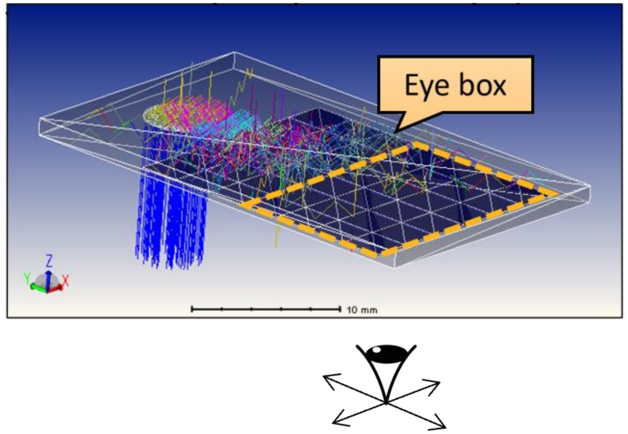




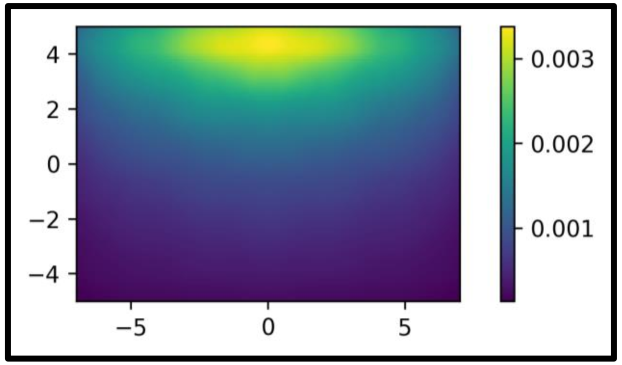




Waveguide system



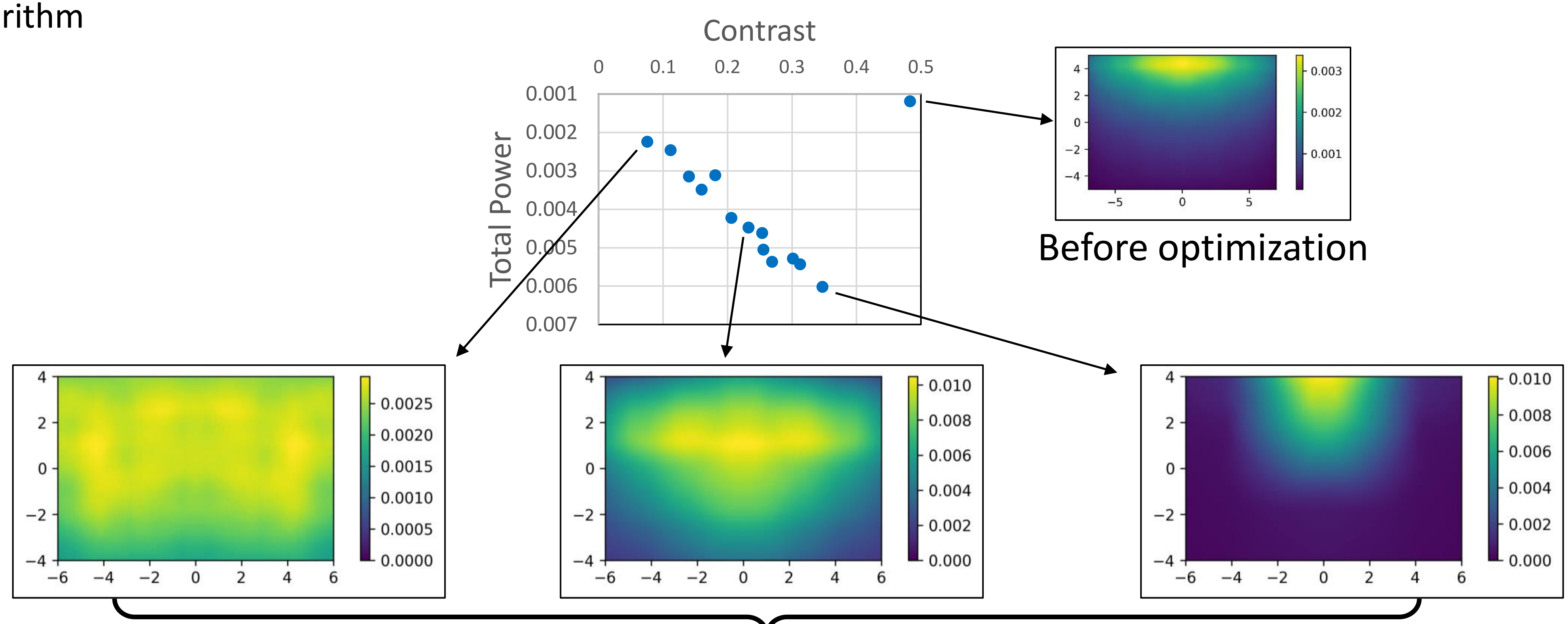
Initial results before optimization



Optimization of all the Gratings on Waveguide

- 32 variables linked to the designs of all the gratings
- 2 Target: contrast and total power
- Optimization with optiSLang using evolutionary algorithm

- Several best results are selected for different balance between total power and contrast



Before optimization

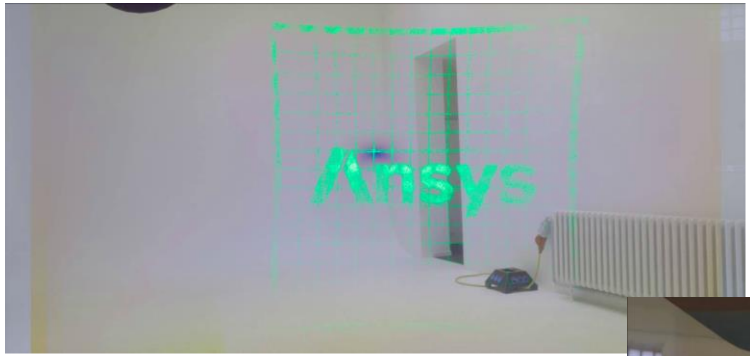
After optimization

System Validation

- Test and validate design in a virtual controlled scenario from human perspective.
- Multiple environments: Interior, Exterior, Natural light, Artificial light, Daytime, Nighttime, etc.
- Human Vision
  - Analyze what the human eye sees
  - Human vision model includes: Eye sensitivity (scotopic, mesopic, photopic), Glare, Shadow to bright light eye adaptation, Color vision deficiency, Observer age , Vision acuity, Depth of field
  - Tools for legibility and visibility
  - Tools to distinguish if different colors can be perceived by human eye
- Perceived Quality – how other perceives the headset user?

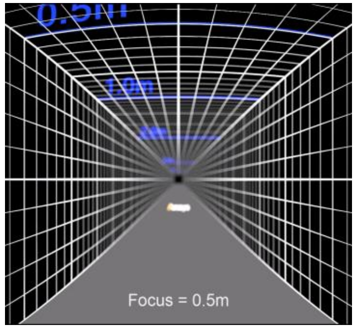
Optical Polished | *With AR coating* | *With AR coating & light filter* | *Optical Polished & headset display reflection*

Green display

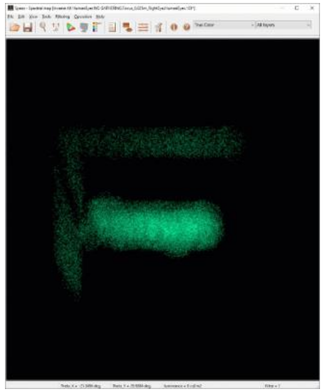


RGB display

The eye can change accommodation by focusing at specific distances



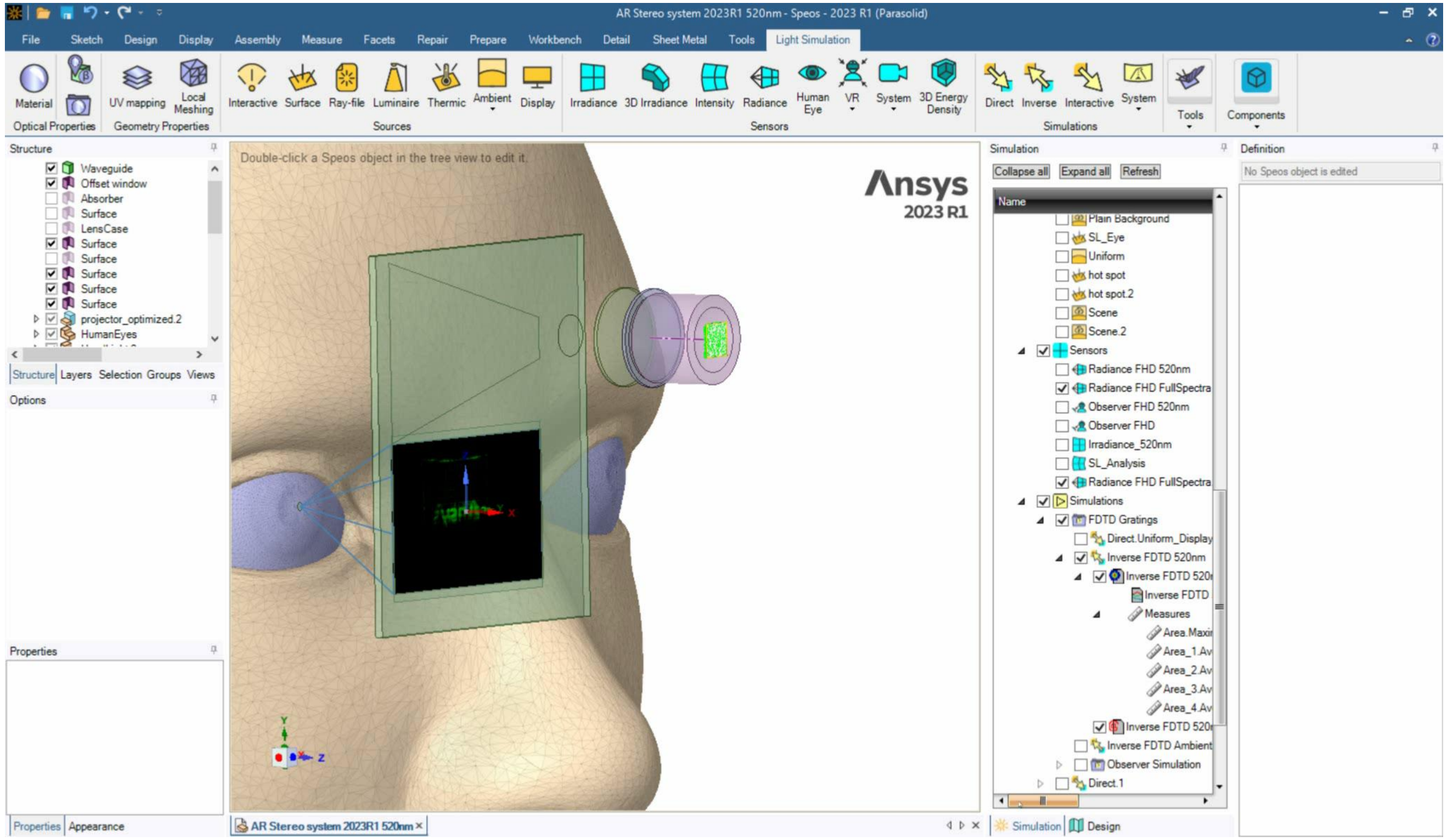
AR system perceived from human eye



Stray Light Analysis from display

Stray Light is the unwanted light in an optical system:

- Sequence identification
- Visualize specific ray paths with the light expert tool
- Analyze energy contribution of different sequences
- Identify noise paths
- Separate sequences with layers on sensors.
- Quantify the image deterioration contributor

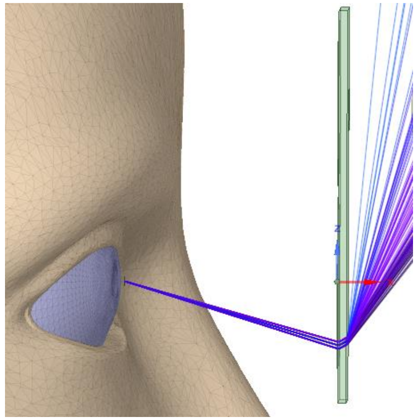


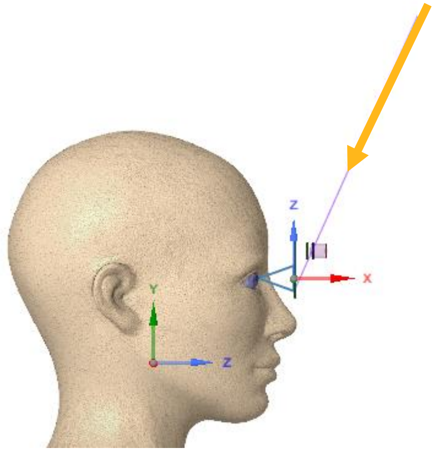
Stray Light Analysis from environment

Stray Light is the unwanted light in an optical system:

- Sequence identification
- Visualize specific ray paths with the light expert tool
- Analyze energy contribution of different sequences
- Identify noise paths
- Separate sequences with layers on sensors.
- Quantify the image deterioration contributor

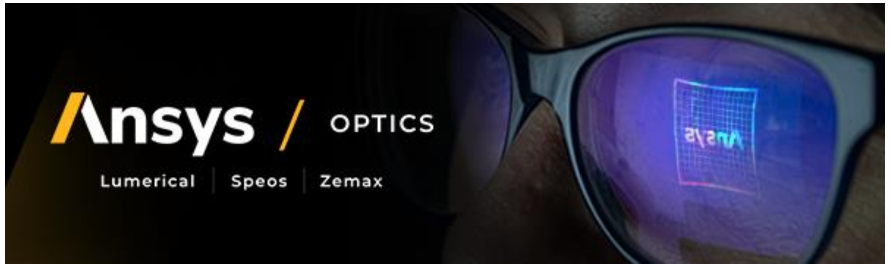
Second sequence





Summary

- End-to-end simulation with Ansys Optical Solution can help with:
  - Photonic Component Modeling and optimization
  - Optical Component Modeling and Characterization
  - Optical performance and light leakage for illumination in AR system
  - Perceived Quality from human vision
- What's coming next:
  - Example of optimized grating to avoid stray light from environment
  - Human Vision simulation of AR headset system compatible with GPU
- Those optical simulation tools can be combined with other physics solvers to provide a complete Multiphysics solution (Structural, Thermal, Optical Performance analysis)



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