QUADOA

NEXT-GENERATION

OPTICAL DESIGN SOFTWARE

MEET QUADOA:MODERN OPTICAL DESIGN SOFTWARE

Quadoa® Optical CAD is a new optical design software for the complete prototyping process of optical systems.

With the main focus on optical simulation, analysis and optimization, Quadoa® Optical CAD features a wide range of comprehensive optical design capabilities.

The modern hierarchical object-based approach, also known from state-of-the-art mechanical CAD applications, enables a modular arrangement of lenses and assemblies.

The high-level elements significantly simplify the handling and maintenance of complex optical systems, compared to the classic surface list-based approach.

Besides freeform surfaces for the next generation of optical devices, Quadoa® provides a flexible definition of arbitrary surface shapes. This is achieved by the integrated surface stackability, which allows a definition of almost infinite surface types.

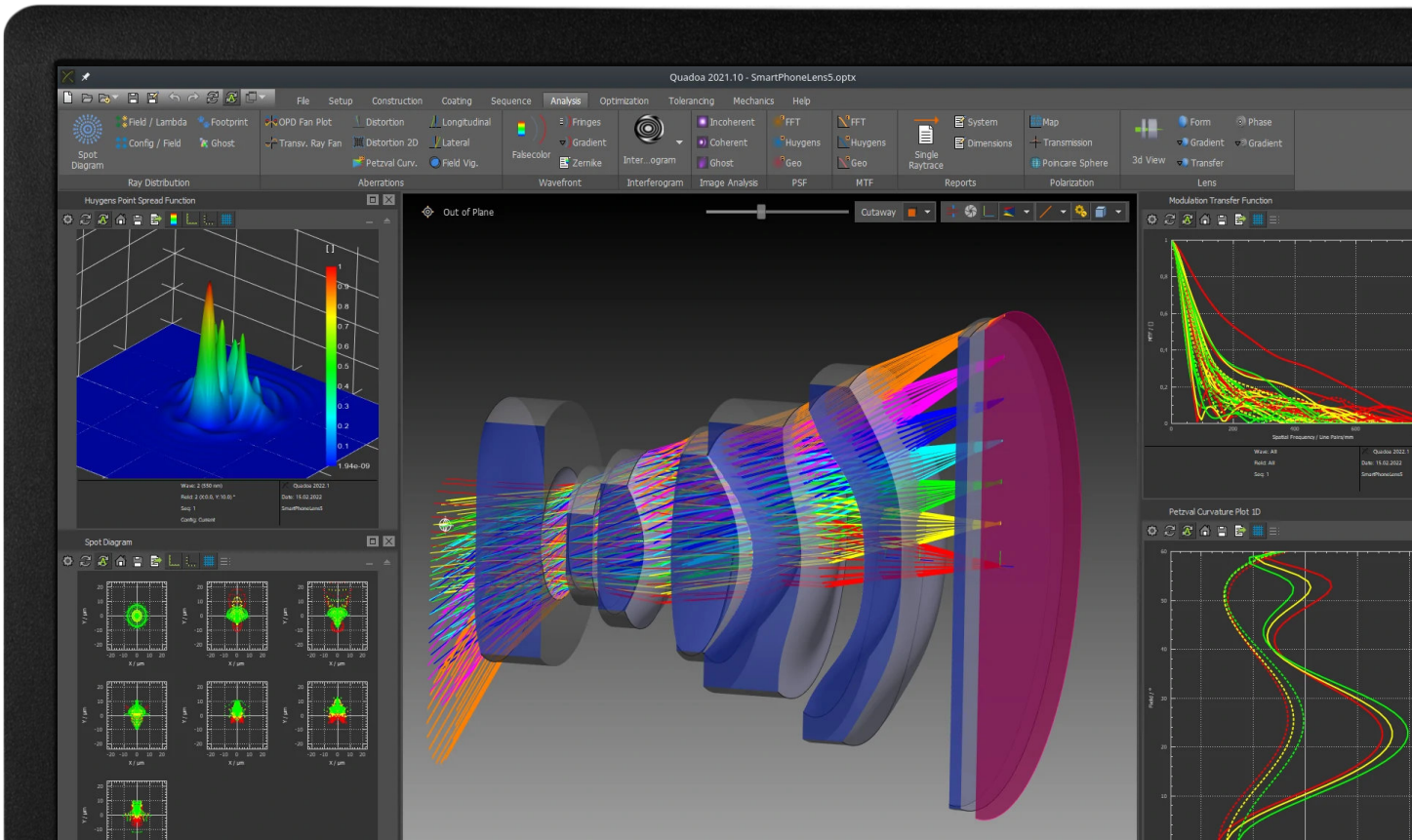
In addition to typical sequential ray tracing, Quadoa® is able to perform a new type of multi-sequential ray tracing.

This unprecedented multipath mode, enables the intuitive handling of systems, where more than one optical path is of interest and opens up a completely new range of design options and analysis features.

With the real time analysis workbench, it is possible to perform a tolerancing and ghost analysis simultaneously to the design process, directly inside the same model.

This saves unnecessary iteration steps after the final design, and therefore significantly speeds up the development cycle.

Thanks to the full bi-directional compatibility with mechanical CAD software, the development of the complete opto-mechanical system, is streamlined in a new way.

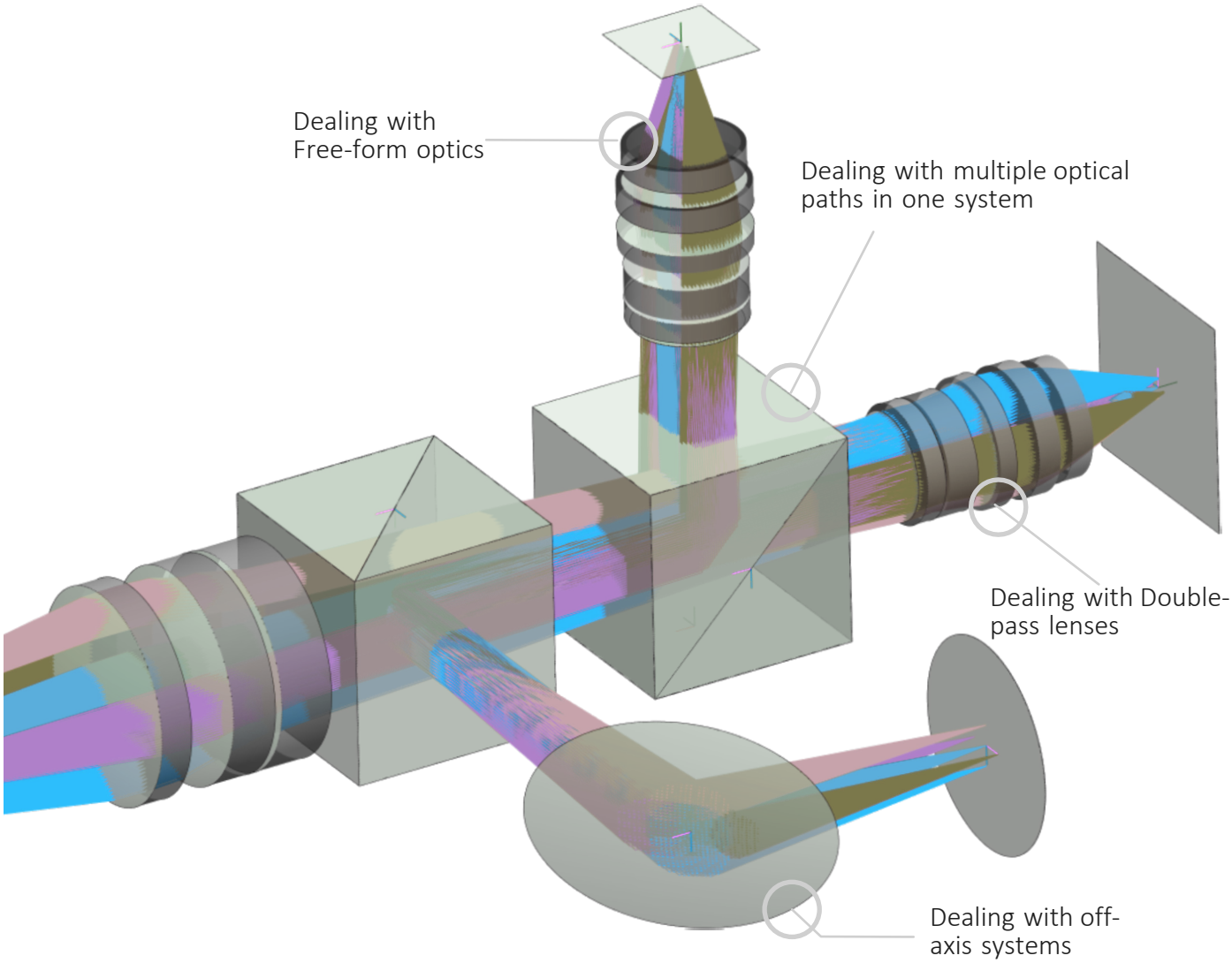


HOW IS OPTICAL DESIGN EVOLVING?

The digital prototyping of optical systems remains a high-growth area for optical engineers.

However, rising requirements for more powerful, compact devices (e.g. for optical sensors) increases complexity for optical designers and raises new questions:

- How can we deal efficiently with complex designs like off-axis systems, free-form optics, or double-pass lenses?
- How can we improve overall productivity and save engineering time?
- How can we improve the handling of existing designs and streamline collaboration with non-optical engineers?



WHAT IS THE PROBLEM WITH LIST-BASED DATA STRUCTURE?

Most sequential optical design software packages available on the market still work with surface-based lists to represent the digital protoype of an optical system.

This concept was first developed decades ago to suit the requirements as well as the limited computing capacity of that time.

The increased complexity of modern optical systems reveals the drawbacks of this approach, often resulting in non-intuitive and error-prone workarounds.

- Multi-pass and multi-sequence systems require redefinition of physically identical elements. This increases the setup time and complicates further analysis and design steps
- Tolerancing requires an intricate manual setup to represent basic mechanical dependencies
- The low level of abstraction prevents an easy access to users without optical design experience

	Surface Type	Radius		Thickness	Material		Coating
0	OBJECT	Infinity		Infinity			
1	STOP	61.815		15.000	N-BK7		
2		-404.828		1.000			
3		29.408		18.000	N-F2		
4		43.977		1.000			
5		11.572		8.000	N-BK7		
6		11.182		10.084			
7		Infinity		0.000	MIRROR		
8		Infinity	P	-10.084		P	
9		11.182	P	-8.000	N-BK7	P	
10		11.572	P	-1.000		P	
11		43.977	P	-18.000	N-F2	P	
12		29.408	P	-1.000		P	
13		-404.828	P	-15.000	N-BK7	P	
14	IMAGE	61.815	P	-		P	

1

OBJECT-BASED PROTOTYPING

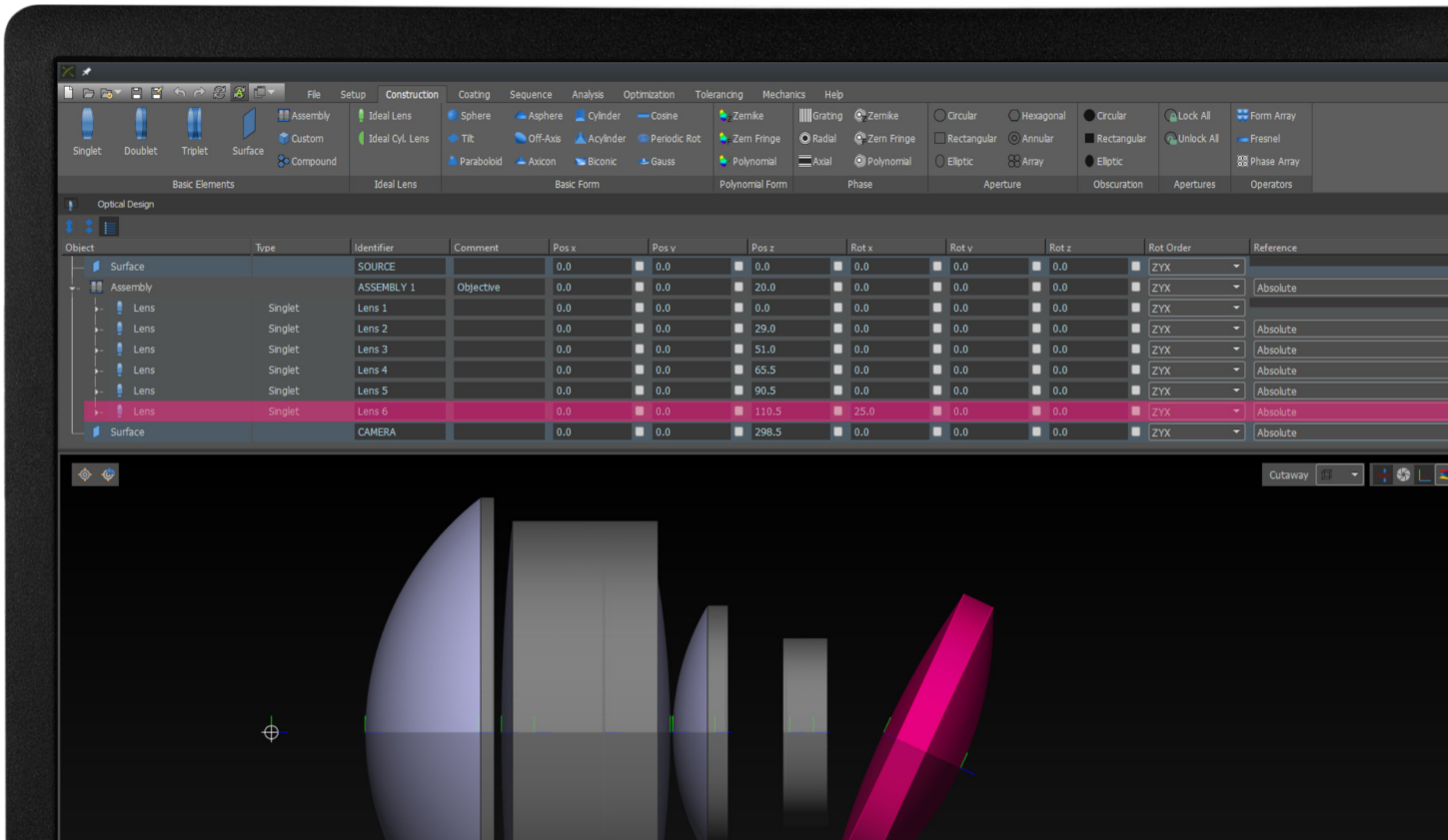
The model architecture of Quadoa® is based on a high level hierarchical structure. Working with high level objects like lenses, mirrors and assemblies provides a much more intuitive way to design an optical system, compared to lists of surfaces as used by most common optical design software packages.

Since this high level of abstraction is already the industry standard in the world of mechanical CAD, as a common language it further helps to streamline the workflow between optical designers and mechanical engineers.

All objects like lenses or assemblies contain knowledge of relationships and behaviour of properties. This is mandatory for realistic tolerancing, optimization or analysis.

As a result, the new approach leads to a simpler, less error prone and faster design process.

- Positioning of elements with relative or global coordinates
- No dummy surfaces for the manipulation of coordinate systems required
- Proven, tree-nested data structure, describing the digital prototype with real world elements like assemblies or lenses significantly speeds up development cycles
- Easily build, manage and maintain complex optical designs. Share designs between parties and immediately understand its logic
- Objects contain physical & mechanical dependencies
- Less error prone due to automatically defined dependencies



2

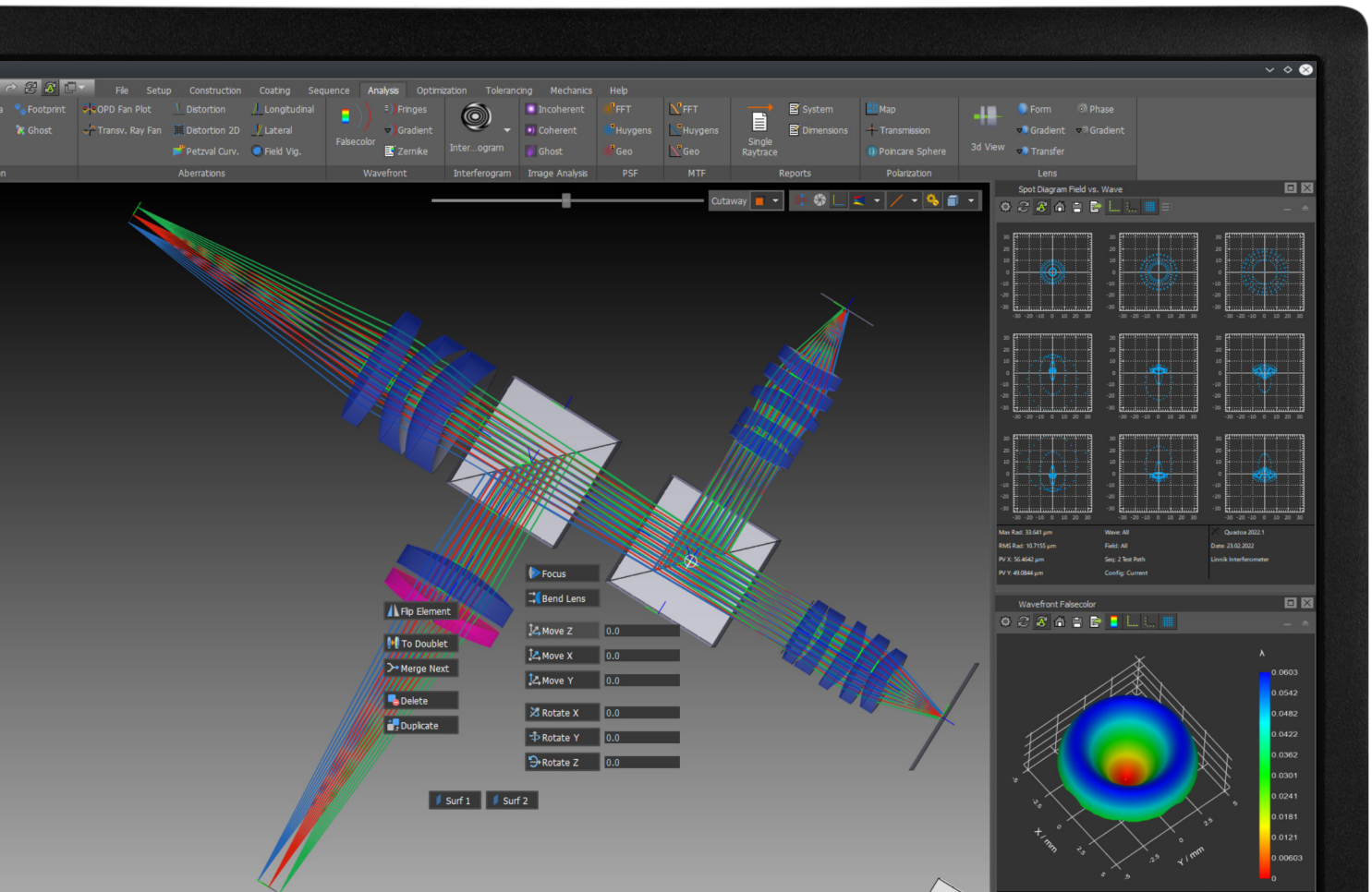
MULTI-SEQUENTIAL RAY TRACING IN A SINGLE MODEL

Quadoa®'s unique multi-sequential ray tracing allows to define an arbitrary number of sequential paths inside a single model. This approach enables the intuitive handling of systems like interferometers, where more than one optical path is of interest.

Optimization of sub-assemblies of complex optical systems can be solved by a separate sequence as well, while being able to analyze the effect on the performance of the complete system.

Multi-sequential ray tracing also brings sequential performance and analysis benefits to applications previously exclusive to non-sequential simulation.

- Direct definition of multiple sequences in a single model
- Easy handling of multi path systems like interferometers
- Extremely fast compared to non-sequential ray tracing



3

INTUITIVE GRAPHICAL USER INTERFACE

Quadoa®'s design is inspired by modern engineering software as widely known from mechanical CAD. Lenses and assemblies can be managed by simple drag and drop actions.

A live 3D-View of the system directly shows the effect of any change on the optical system and allows direct editing of the elements. Any relevant data like wavefront aberrations or ray distributions can be visualized.

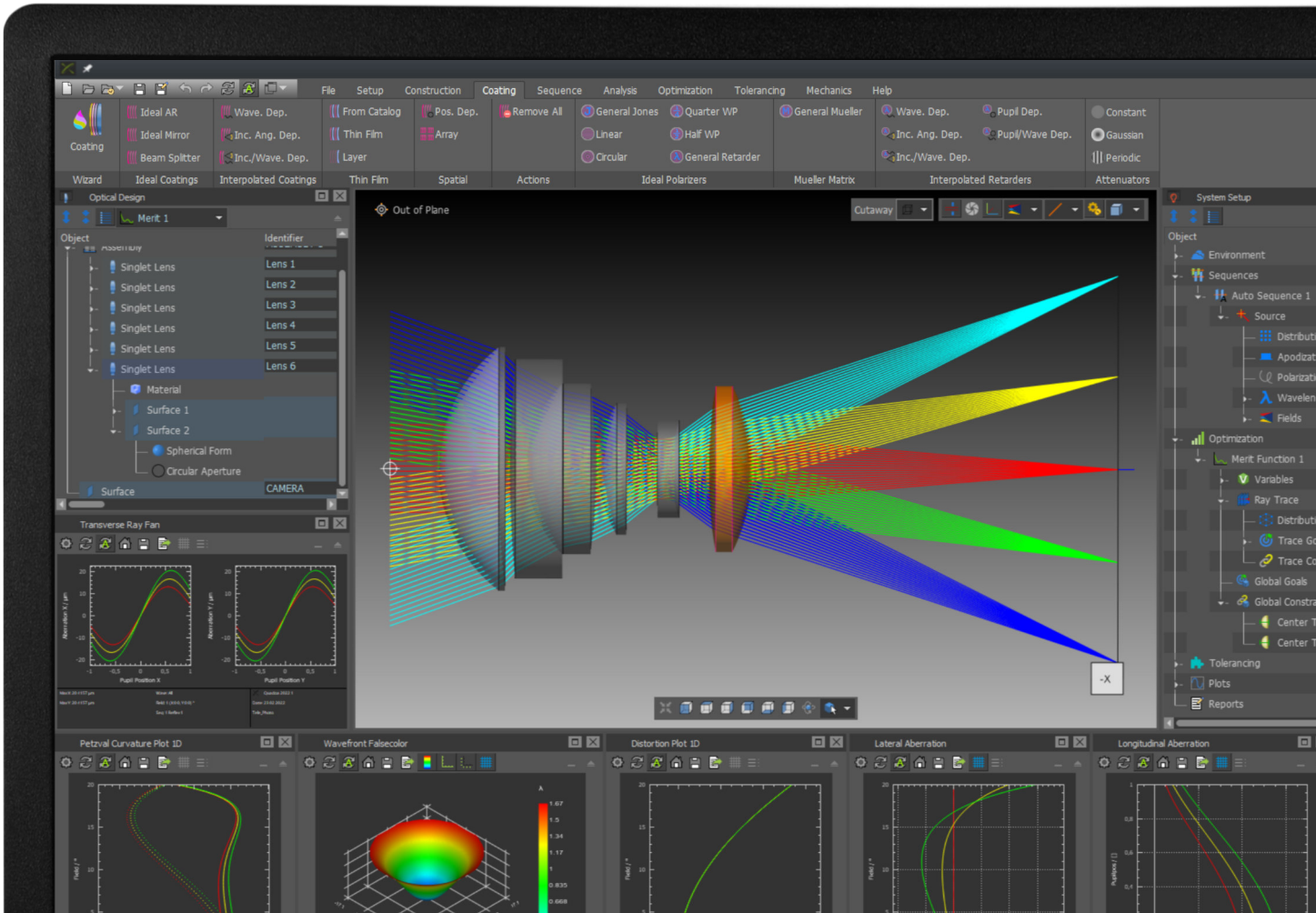
During the whole development process, the intuitive handling of the GUI has always been of high priority.

The result is a software package, that allows the user to quickly get started on working on the technical task without having to invest a large amount of time on learning how to control the software.

Furthermore, a fluent design workflow can be achieved by granting quick access to any feature.

For power users, customizable shortcuts to the most commonly used features provide increased eficiency.

Also for beginner optical designers, Quadoa®'s intuitive architecture allows to keep the entry threshold low.



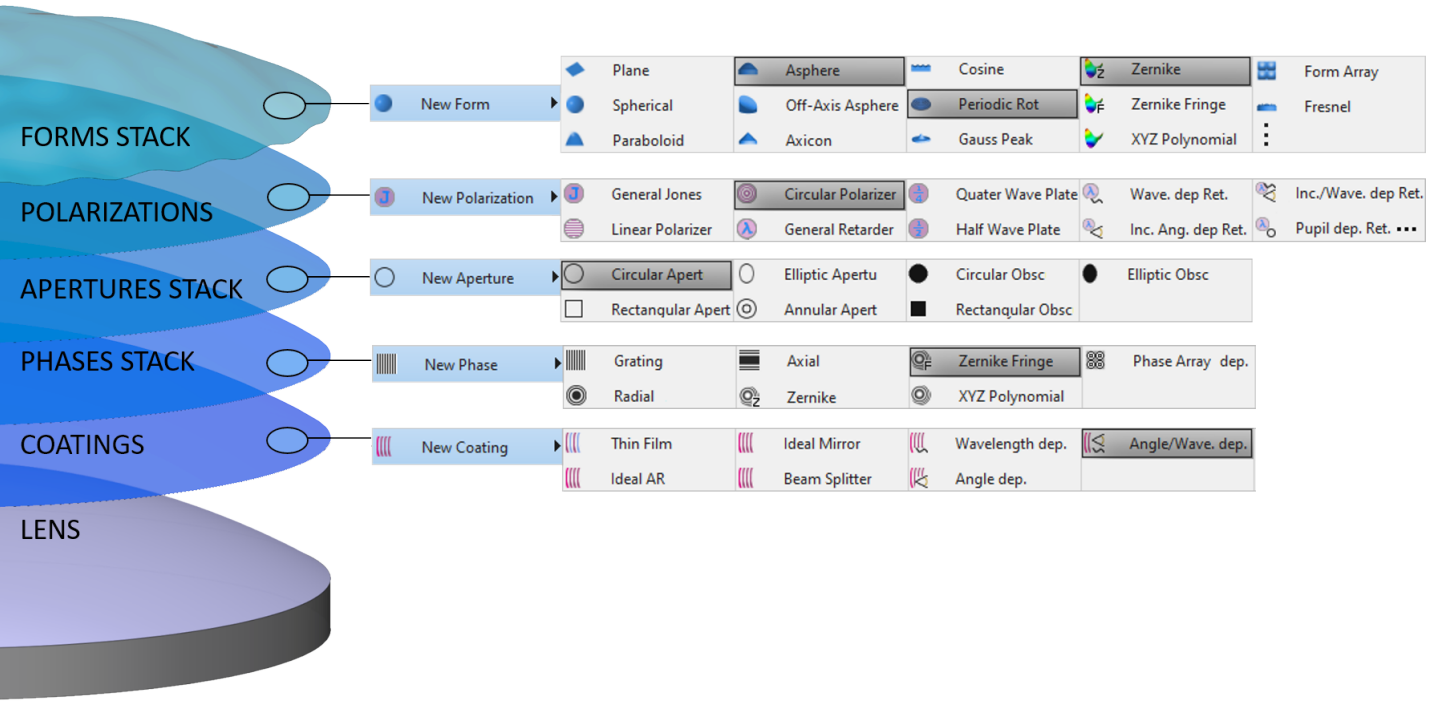
4

FLEXIBLE SURFACE TYPE DEFINITION

Besides freeform surfaces for the next generation of optical devices, Quadoa® provides a flexible definition of arbitrary surface shapes.

This is achieved by the integrated surface stackability, which allows a definition of almost infinite surface types by combining any surface shapes together with any other properties like surface deviation from measurement data, polarizers, apertures, coatings and phase-functions.

- Flexible surface definition
- Easy definition of aspheres, freeforms or CGHs



5

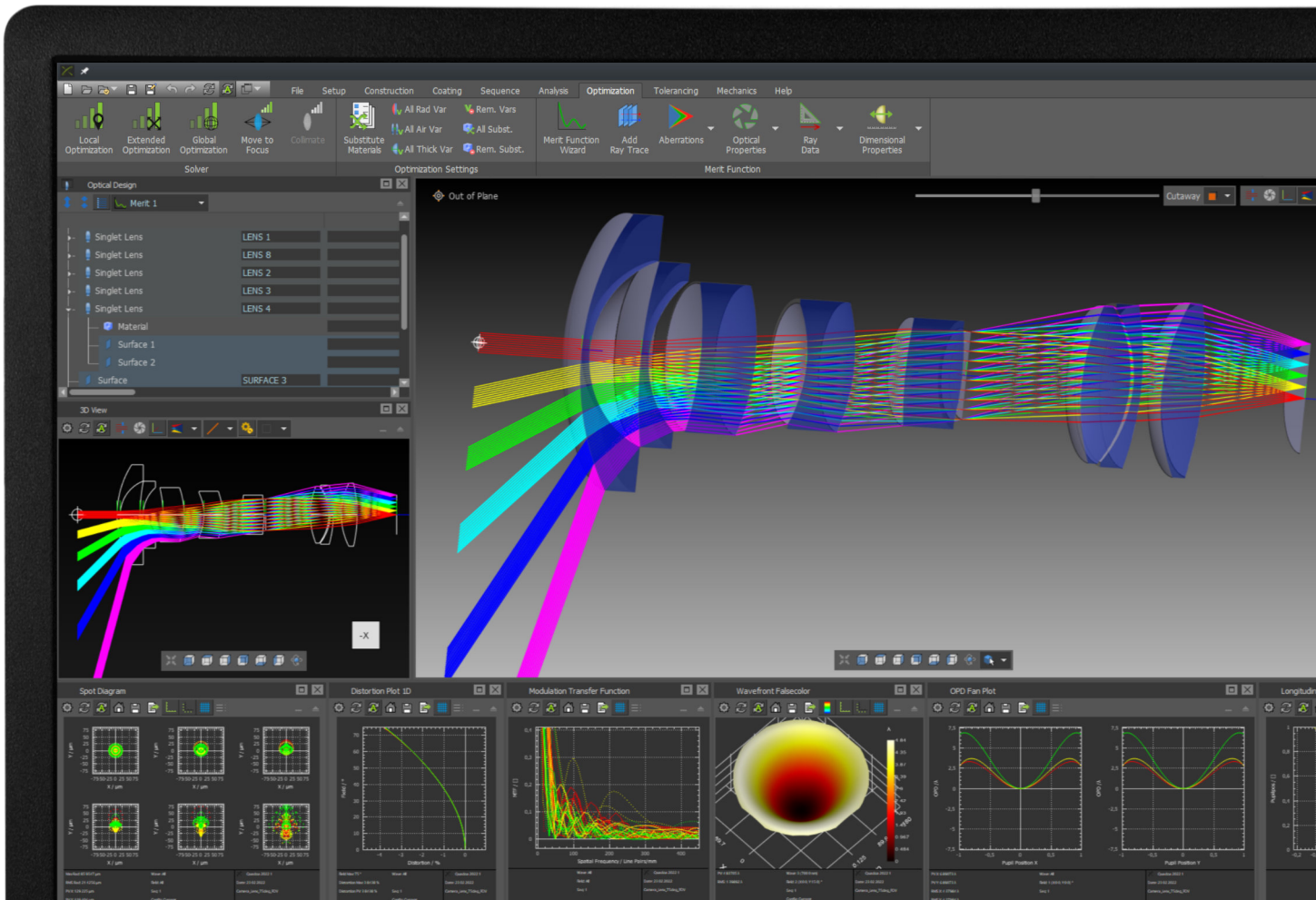
POWERFUL OPTIMIZATION

Quadoa® provides a set of powerful local and global optimization algorithms that cover all the steps of the optical design process, from the search for a starting system to the final fine tuning of the lens performance.

The optimization is not limited to parameters of the lens and surface properties but is also able to search the glass catalogs that are included in Quadoa® to identify the best fitting materials for a design.

The wide range of available design goals and constraint options allow defining even complex lens specifications. In combination with the power of modern multi-core CPUs, all these features make it possible to quickly find a solution even in the case of complex design problems.

- Powerful local and global optimization algorithms for all steps of the optical design process
- Wide range of available design goals and constraint options



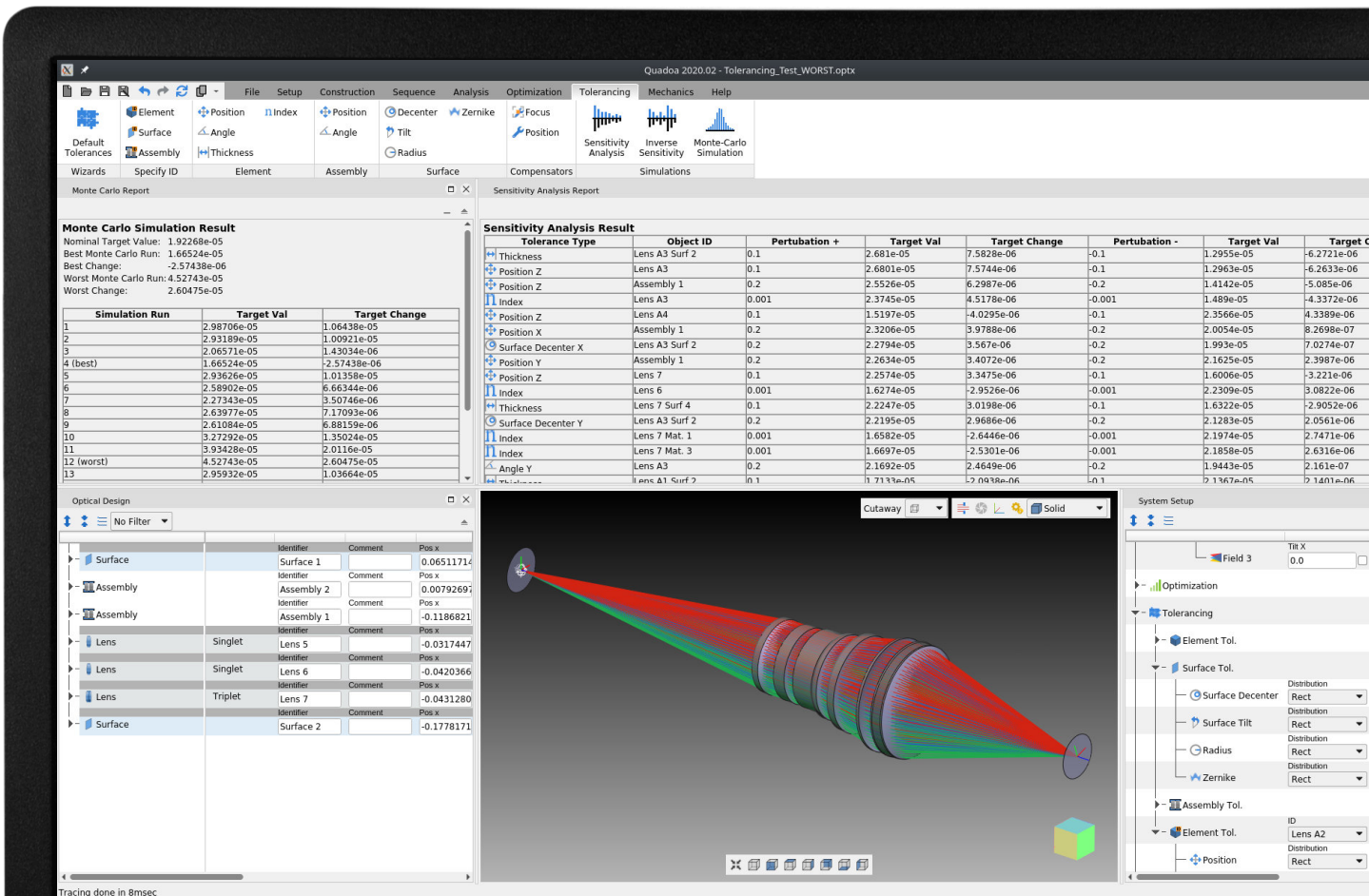
6

REAL-TIME TOLERANCING

With the approach of Quadoa®, tolerancing can be done directly inside the same data structure simultaneously to the design process.

The tolerancing workbench allows the simulation of the effects on the optical performance that arise from fabrication imperfection or mounting errors. Furthermore, it allows the designer to optimize the system or single elements in regard to looser tolerances, resulting in a more robust and cost efficient optical design.

- Tolerancing of system simultaneously during design process
- Tolerancing workbench for analysis of real world performance
- Analysis of the effect of fabrication error or mounting tolerances on the system performance
- Analysis on the sensitivity of the system to certain tolerances



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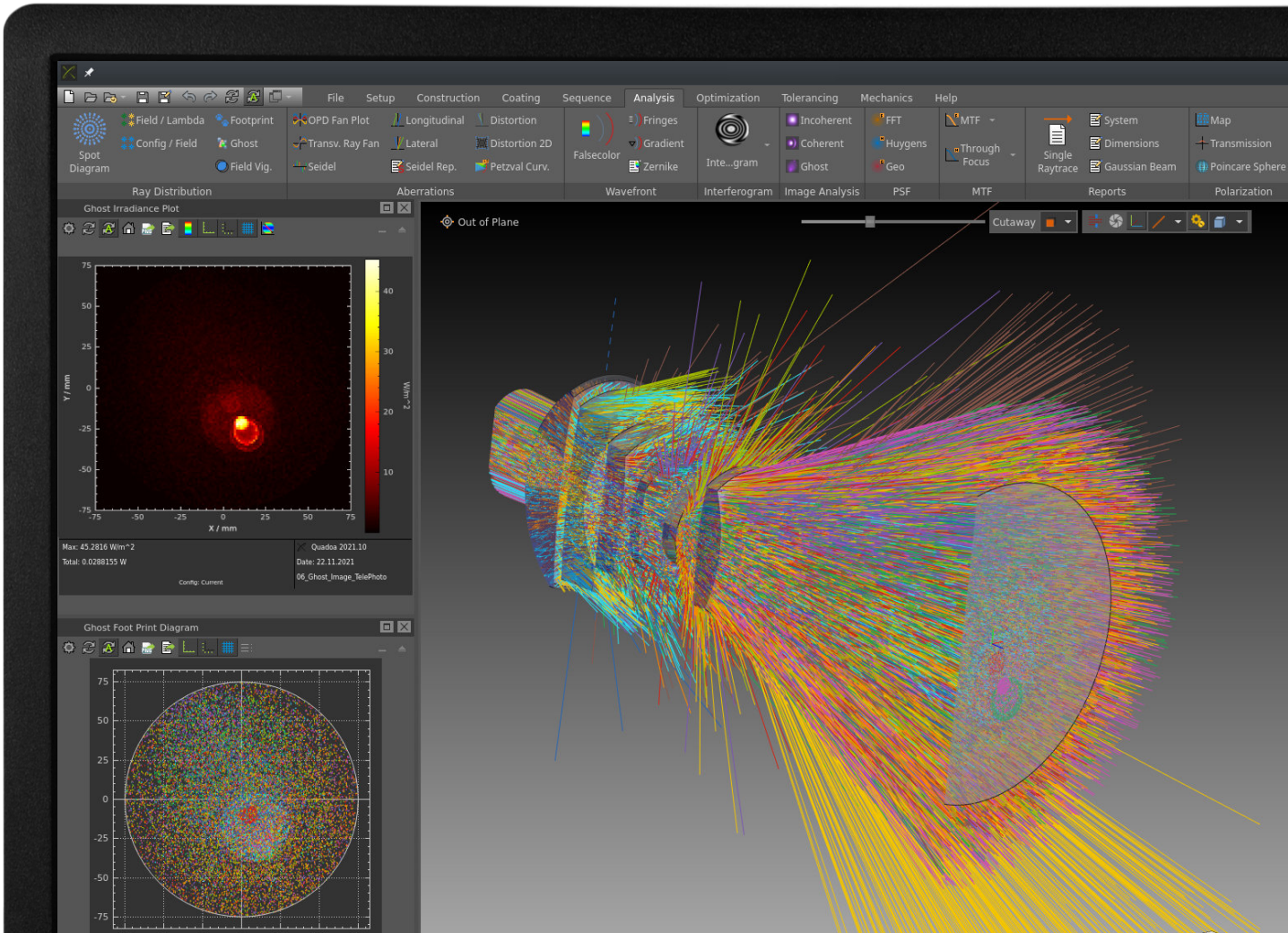
REAL-TIME GHOST ANALYSIS DURING DESIGN PROCESS

During the optical design process, ghost wizards implemented in Quadoa® allow the automated generation of ghost sequences for any of the defined sequences in the system.

Besides ghost images emerging from surface reflections, ghosts that result from undesired diffraction orders at diffractive elements can be automatically generated by the wizard as well.

Due to the sequential definition, the time needed for a ghost analysis can be reduced by several orders of magnitude compared to non-sequential ghost analysis.

- Automated generation by wizards
- Fast real-time analysis during design process
- No need for extra files with ghost sequence
- A lot faster than non-sequential analysis



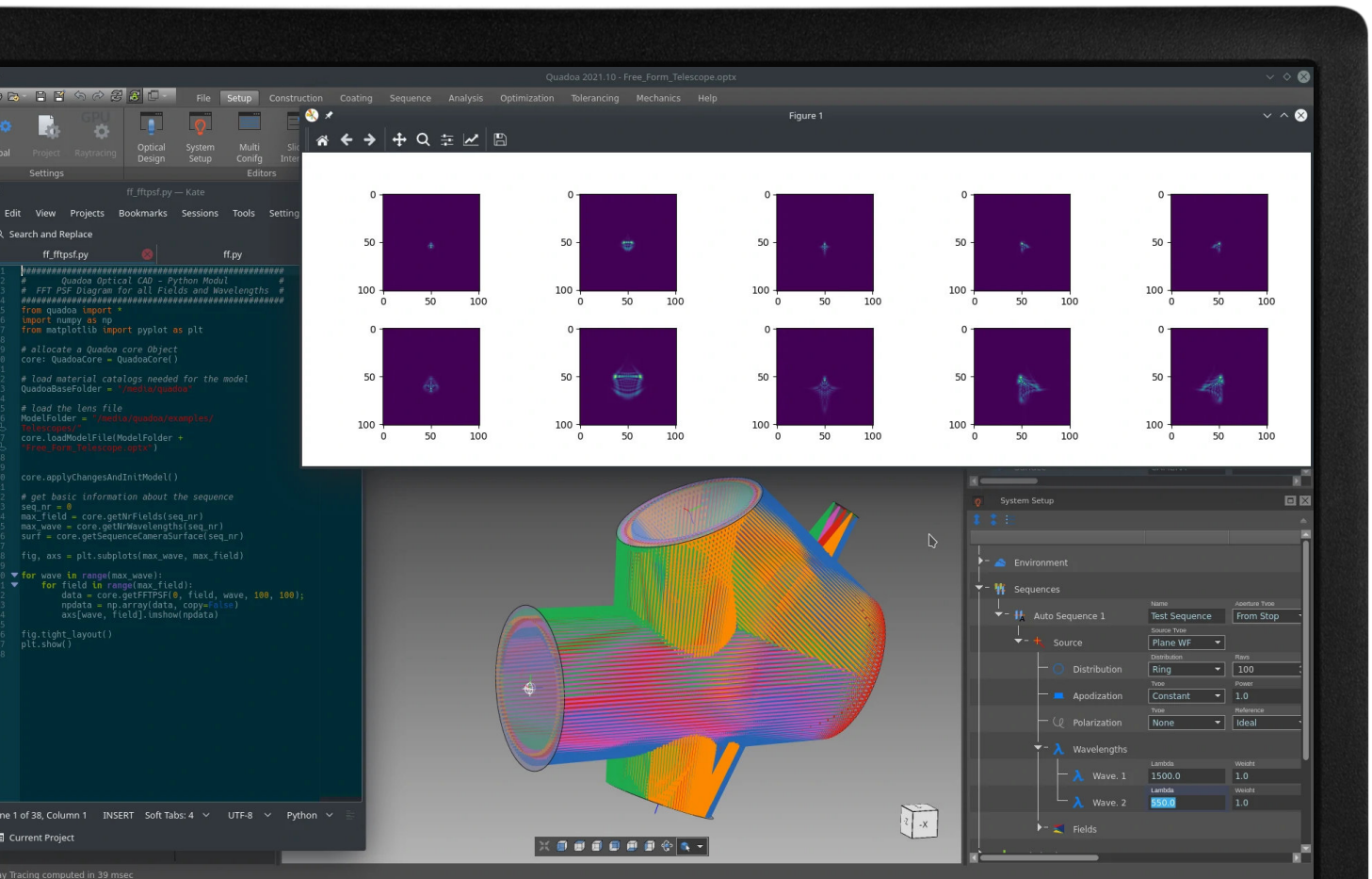
8

INTERFACE TO PYTHON, MATLAB® AND C++ SDK ACCESS

All core functions of Quadoa® Optical CAD can be directly called out by the powerful scripting languages Python and MATLAB® or by C++ SDK. This allows to use the core as a powerful raytracing and optimization engine, which is totally independent from the graphical user interface.

Due to the scripting, many tasks of the optical design process can be automated. Besides, it is possible to integrate the core into other applications, e.g. for system calibration or simulations.

- Python, MATLAB® & C++ SDK interface
- Core independent from GUI
- Flexible integration in other projects



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EXCHANGE DATA WITH MECHANICAL CAD

The linking to common mechanical CAD software allows the import and export of CAD data. This makes the interaction between mechanical- and optical engineers straightforward and easy. In the past, sharing optical designs with mechanical engineers was often associated with considerable errors and clarification needs because of the different data structure of list-based optical design and object-based mechanical CAD data.

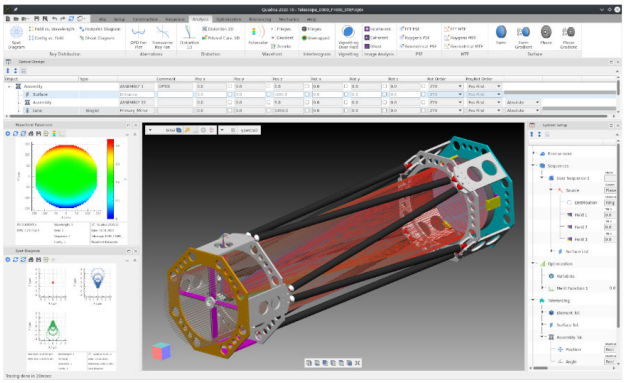
With Quadoa®, optical designers work with the same hierarchical, object-oriented data structure as known from most modern mechanical CAD software.

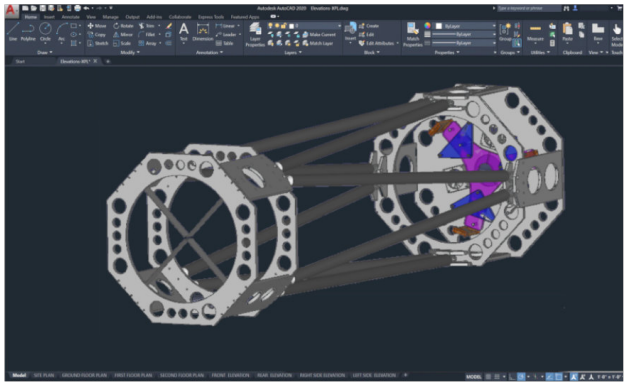
As a result, the communication between optical designer and mechnical engineer is much easier, as both sides are working with an object-based data structure.

Time intensive "translation" of the traditional lists into object-based information for the manufacturing process is omitted, saving a lot of time and effort due to less troubleshooting.

- Import & export of STEP, IGES, STL CAD files
- Work directly inside Quadoa® with mechanics
- No need of error prone translation due to same data format

Import to Quadoa® Optical CAD





Export to Mechanical CAD

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WAVE OPTICS

Quadoa®'s Wave Optics Toolbox enables coherent beam propagation to simulate optical effects such as interference and diffraction. The algorithm is based on well proven Gaussian beamlet propagation methods.

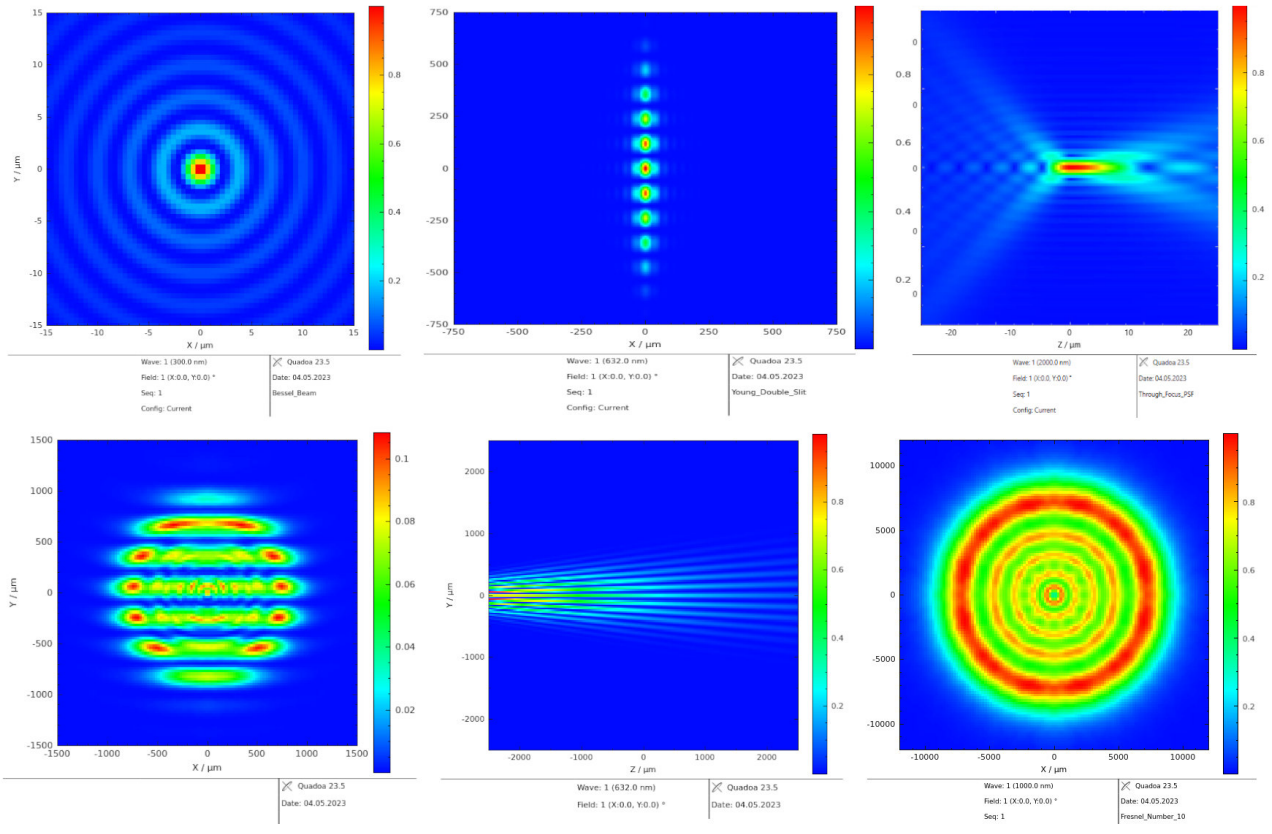
Each beamlet is defined by a series of rays, therefore the method can be applied to any system that can be simulated via ray tracing.

The propagation method is not limited to single sequences and is perfectly integrated within QUADOA®'s Multi-Sequential Ray Tracing.

It is also suitable for sequences where the rays pass through a faceted mirror or other type of compound surface, enabling simulation of beam interference and diffraction effects.

This method also makes it easier to use compared to other algorithms, where it is often difficult to find suitable beam sampling settings to obtain an accurate result.

- **Point Spread Function (PSF)**
  A plot of the irradiance, phase, or complex amplitude distribution of a single ray sequence at any surface in the system.
- **Through Focus PSF**
  A through focus (YZ) plot of irradiance, phase, or complex
  amplitude distribution of a single ray sequence at any surface in the system.
- **Interferogram**
  Coherent summation of the fields from two separate ray sequences
- **Fiber Coupling Efficiency**
  Calculated using the mode-matching overlap-integral of the beam propagation PSF with a single mode fiber
- **API Access via the Scripting Toolbox** All beamlet propagation analyses are available directly via Python, MATLAB®, or C++



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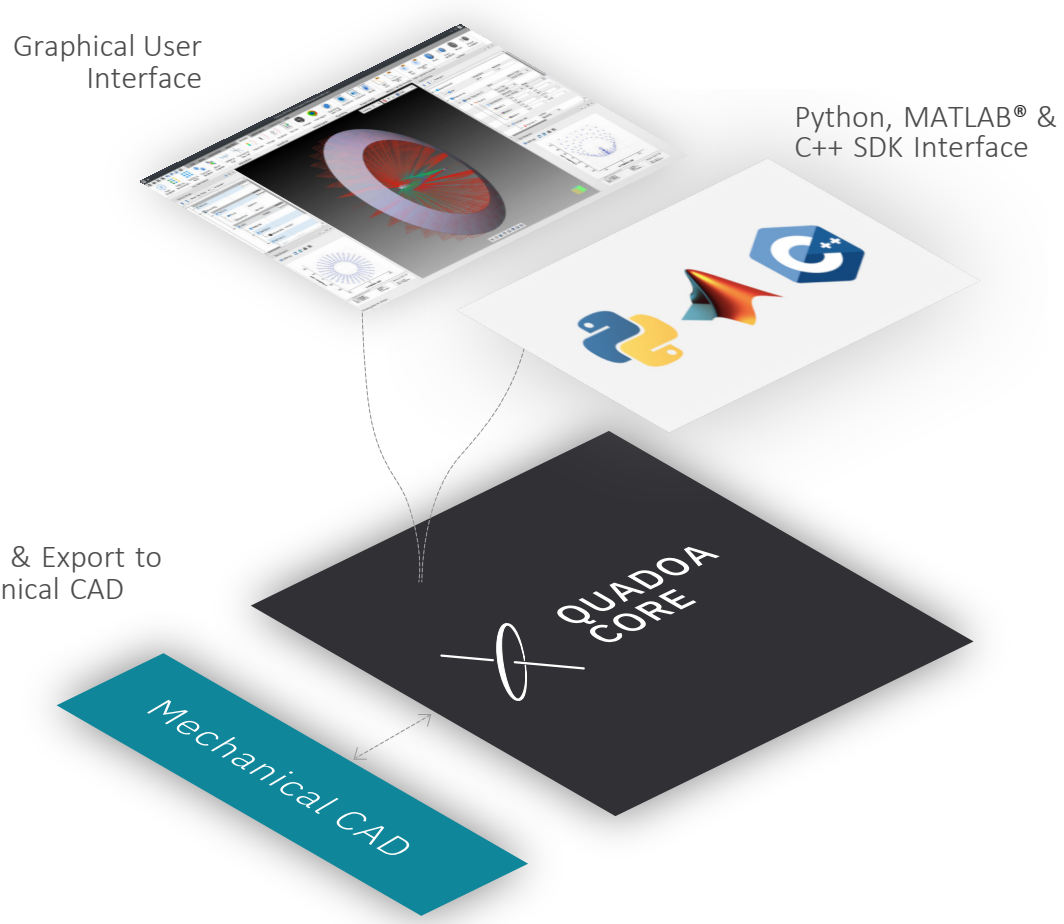
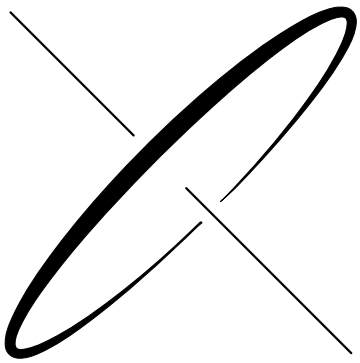
FLEXIBLE, HIGH-END ARCHITECTURE

Quadoa® was developed to accelerate optical design tasks in leading corporations and research institutions:

- Future proof core with state of the art algorithms in the fields of construction, raytracing, optimization and analysis
- For experts, optional toolboxes offers the possibility to adapt Quadoa® exactly to the design needs
- Only buy the tools needed
- Windows and Linux suitable





GET STARTED

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