Zemax OpticStudio
Optical design, optimization, analyzis and tolerancing

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Capabilities and performances

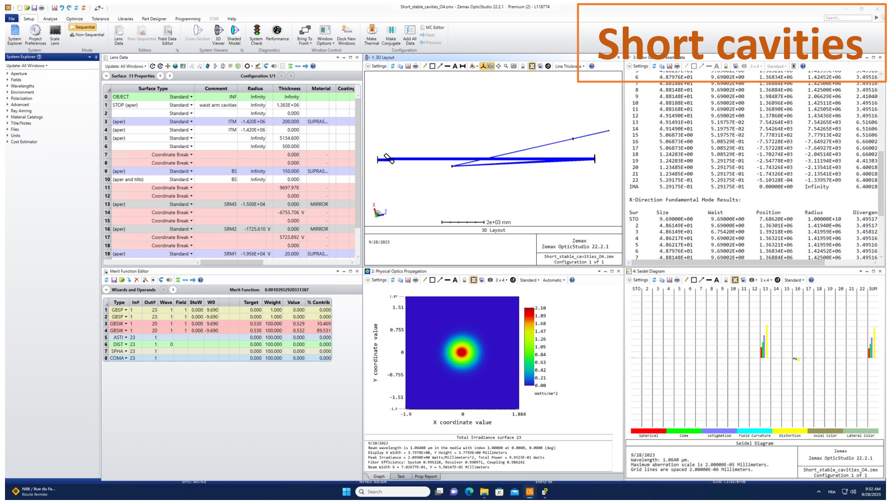
3D Optical design program used to design:

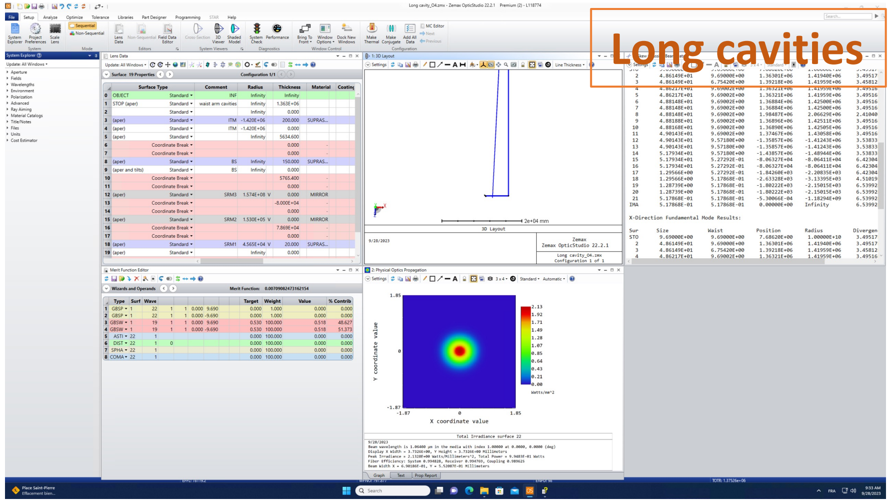
- In **sequential ray tracing**, rays are traced through a pre-defined sequence of surfaces, hitting each surface only once, while traveling from the object to the image plane.
- Sequential ray tracing is computationally fast and is extremely useful for the design, optimization, tolerancing, and analysis of such systems.
- Many conventional optical systems can be classified as imaging systems, including photographic objectives, telephoto lenses, microscopes, telescopes, relay lenses and spectrometers.

- **Non-sequential ray tracing** allows rays to propagate through optical components in any order and allows rays to be split, scattered, and reflected back to an object that they've already encountered. This property makes Non-Sequential mode ideal for analyzing stray light, scattering, and illumination for any system type.
- Rays from non-sequential sources, known as NSC rays, can be split and scattered by optical components. These rays can also be diffracted at phase surfaces/objects. The analysis options available when tracing NSC rays include evaluating radiometric data on detectors and the storing of ray data in ray database files. Detectors can be modeled as planar surfaces, curved surfaces, and even three-dimensional volumes.

→ Use this existing tool to design, optimize, analyze optical systems

Simulations of the stable cavities



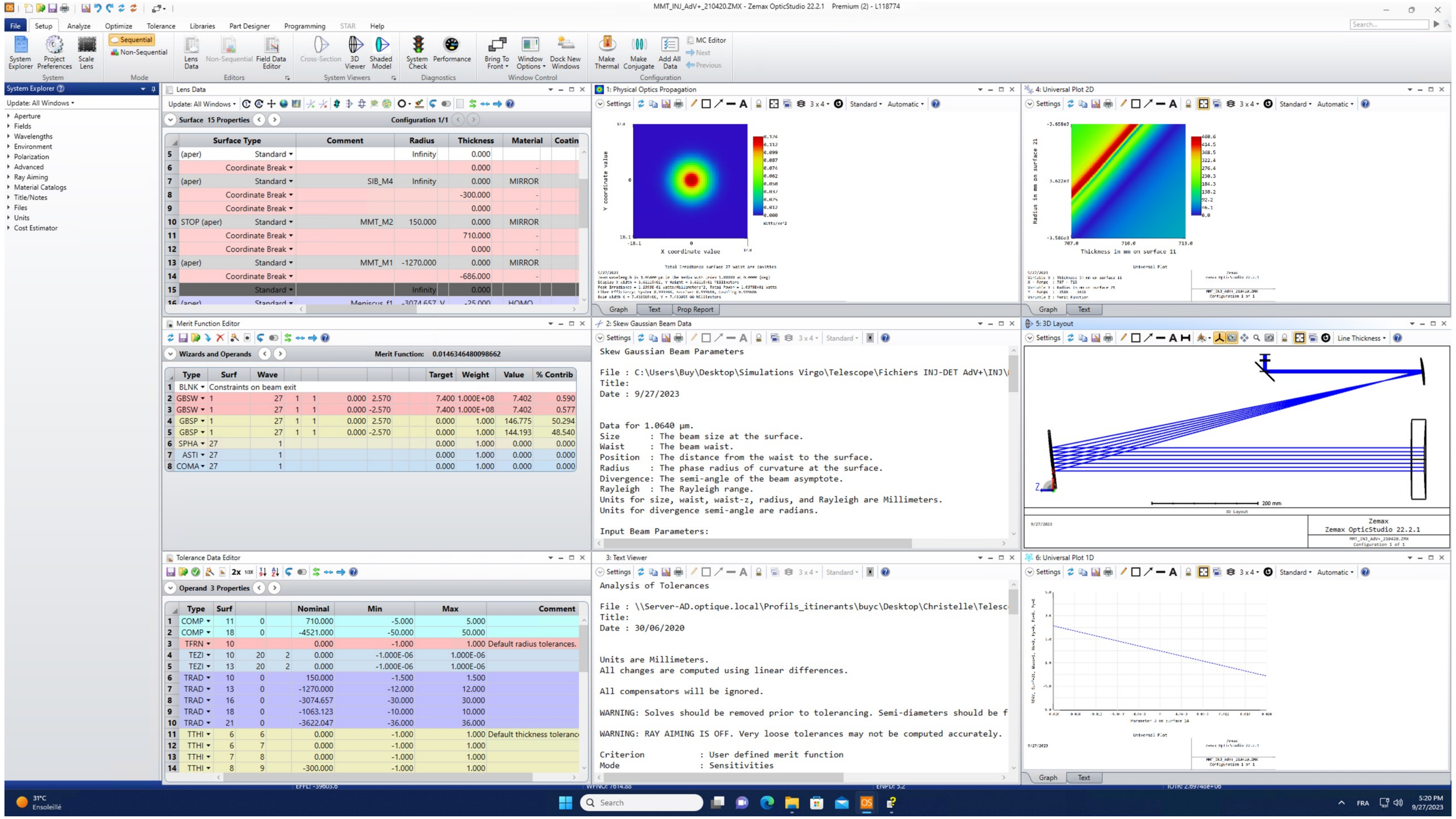


- Optical design and comparison with other tools (ABCD matrices code): waist size, position, aberrations
- Optimization – compensation of the astigmatism
- Analyzis: aberrations, gaussian parameters, wavefront, Gouy phase

- Optimization with the last parameters in the next weeks
- Analyzis in transmission of the mirrors (gaussian parameters, aberrations, paths)
- Preparation for the telescope design on the suspended benches

3D design of the ITF – work on more complete simulations to analyze accurately aberrations and physical propagation

Simulations of the telescopes



- Optical design
- Optimization: aberration mitigation, compacity, alignement facility
- Physical propagation: gaussian parameters, diffraction
- Coupling efficiency
- Tolerancing: specifications and mechanical design – anticipate misalignements (ex. B4 aberrations)

- SNEB/SWEB telescopes for the large test masses/05
- SIB1/SDB1/SPRB telescopes design/optimization/analyzis for the stable cavities

Summary

Use a 3D optical software to:

- Prepare the optical designs, optimization, tolerancing, analyzis for the upgrade of Virgo / Virgo_nEXT
- Develop several telescope configurations, optimize the designs according to the space constraints and the alignement facility, study the tolerances to develop an adapted mechanics
- Prepare the work for Einstein Telescope: methods, optimizations – importation or exportation of associated tools (CAD, Matlab, Python)
- Limitation of Zemax: physical analyzis for complex system in sequential mode (BS, cavities) -> discussion to develop a code mixing Zemax and Optocad / 3D physical propagation for complex systems

Summary

R&Ds some examples/ Optical simulations

VIRGO FRANCE October 2023

3 PhD on this topic

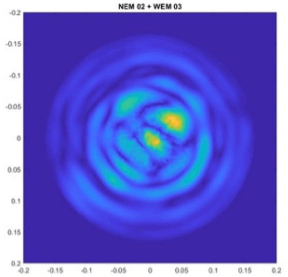
VIRGO

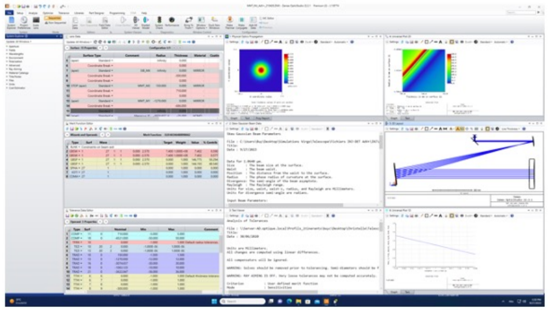
… current crisis is, in part, a result of choices made in the past (marginally stable cavities) and the sum of different causes at different levels

➢ The internal discussion has already begun. Some "scattered" considerations:
- Competition with other projects
- Insufficient hiring/replacement of retiring staff in some labs with crucial hardware responsibilities → too many single points of failure
- Good results in O2 and O3 could have contributed to put the limitations associated with marginally stable recycling cavities in the background and no clear showstopper for going on with MSRC
- Insufficient effort in simulations to predict the behavior of complex systems and providing guidance for commissioning
- Insufficient effort in QA/QC and system engineering
- Issues in the current organization/management

➢ EGO Council will set up a committee to review the current Virgo/EGO organization

G. Gemme – LVK sept. 2023





- Development of optical simulation software (OSCAR, DarkF, Finesse...)
- Design studies using optical simulation tools (Zemax, Optocad, OSCAR,...)
- Simulation studies for the understanding/anticipation of the interferometer behaviour:
  - Impact of defects and optical losses
  - Impact of high power
  - Coupling of technical noises

Simulation studies are (more and more) essential for:
- the understanding of Advanced Virgo+
- the design of Virgo_nEXT and ET (guided by AdV+ experience)

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