

Zemax OpticStudio

Optical design, optimization, analysis and tolerancing

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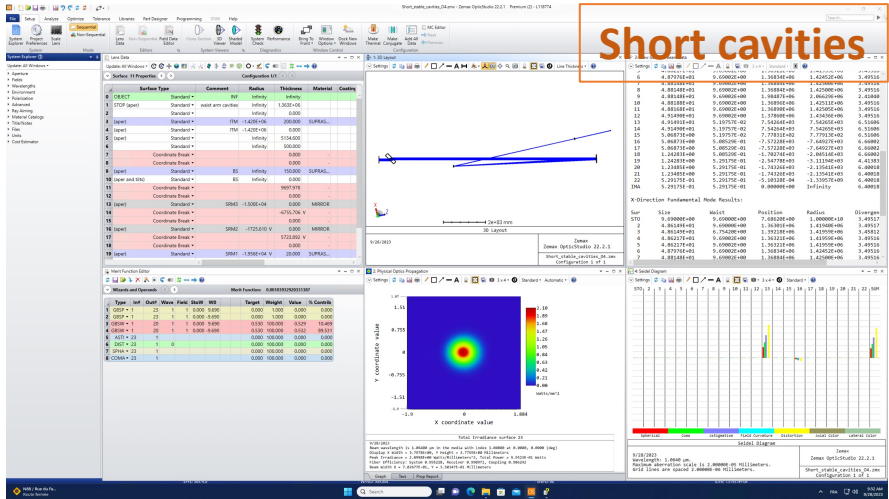
3D Optical design program used to design:



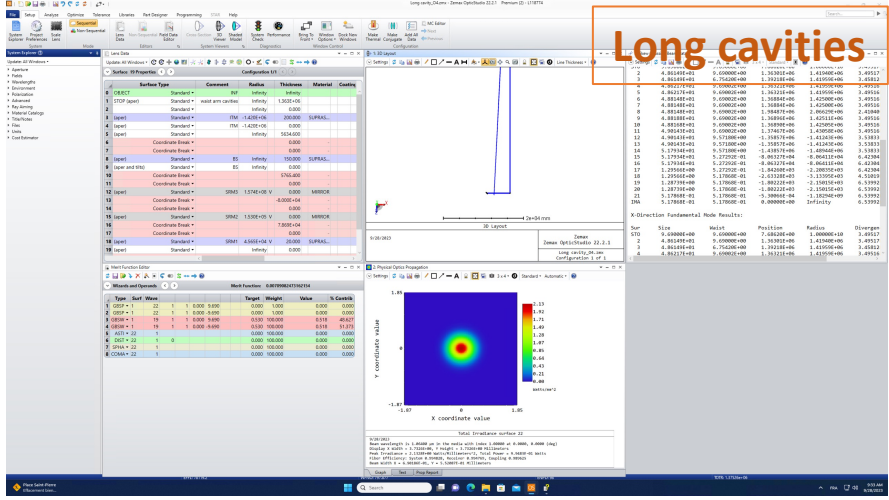
- In sequential ray tracing, rays are traced through a pre-defined sequence of surfaces, hitting each surface only once, while traveling from the object to the image plane.
- Sequential ray tracing is computationally fast and is extremely useful for the design, optimization, tolerancing, and analysis 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



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



- Optimization with the last parameters in the next weeks
- Analysis 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

The screenshot displays the Zemax OpticStudio interface with several key windows open:

- Surface Properties Table:**

Surf	Type	Comment	Radius	Thickness	Material	Coat
5	(aper)	Standard	Infinity	0.000		
6	Coordinate Break					
7	(aper)	Standard	SIB_M4	Infinity	0.000	MIRROR
8	Coordinate Break					
9	Coordinate Break					
10	STOP (aper)	Standard	MMT_M2	150.000	0.000	MIRROR
11	Coordinate Break					
12	Coordinate Break					
13	(aper)	Standard	MMT_M1	-1270.000	0.000	MIRROR
14	Coordinate Break					
15	Standard					
- Merit Function Editor:**

Type	Surf	Wave	Target	Weight	Value	% Contrib					
1	BLNK										
2	GBSW	1	27	1	0.000	2.570	7.400	1.000E+08	7.402	0.590	
3	GBSW	1	27	1	1	0.000	-2.570	7.400	1.000E+08	7.402	0.577
4	GBSP	1	27	1	1	0.000	2.570	0.000	1.000	146.775	50.294
5	GBSP	1	27	1	1	0.000	-2.570	0.000	1.000	144.193	48.540
6	SPHA	27						0.000	1.000	0.000	0.000
7	ASTI	27						0.000	1.000	0.000	0.000
8	COMA	27						0.000	1.000	0.000	0.000
- Physical Optics Propagation (POP):** Shows a 2D intensity plot of the beam profile.
- Skew Gaussian Beam Parameters:**

File: C:\Users\Buy\Desktop\Simulations Virgo\Telescope\Fichiers IND-DET AdvV\INDV
Date: 9/27/2023

Data for 1.0640 μm .

 - Size: The beam size at the surface.
 - Waist: The beam waist.
 - Position: The distance from the waist to the surface.
 - Radius: The phase radius of curvature at the surface.
 - Divergence: The semi-angle of the beam asymptote.
 - Rayleigh: The Rayleigh range.

Units for size, waist, waist-z, radius, and Rayleigh are Millimeters. Units for divergence semi-angle are radians.
- Analysis of Tolerances:**

File: \\Server-AD.optique.local\Profils_itinerants\buy\Desktop\Christelle\Telesc
Date: 30/06/2020

Units are Millimeters. All changes are computed using linear differences. All compensators will be ignored. WARNING: Solves should be removed prior to tolerancing. Semi-diameters should be f... WARNING: RAY AIMING IS OFF. Very loose tolerances may not be computed accurately.

Type	Surf	Nominal	Min	Max	Comment		
1	COMP	11	0	710.000	-5.000	5.000	
2	COMP	18	0	-4521.000	-50.000	50.000	
3	TRFN	10	0	0.000	-1.000	1.000 Default radius tolerances.	
4	TEZI	10	20	2	0.000	-1.000E-06	1.000E-06
5	TEZI	13	20	2	0.000	-1.000E-06	1.000E-06
6	TRAD	10	0	150.000	-1.500	1.500	
7	TRAD	13	0	-1270.000	-12.000	12.000	
8	TRAD	16	0	-3074.657	-30.000	30.000	
9	TRAD	18	0	-1063.123	-10.000	10.000	
10	TRAD	21	0	-3622.047	-36.000	36.000	
11	TTHI	6	6	0.000	-1.000	1.000 Default thickness toleranc	
12	TTHI	6	7	0.000	-1.000	1.000	
13	TTHI	7	8	0.000	-1.000	1.000	
14	TTHI	8	9	-300.000	-1.000	1.000	

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



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

Use a 3D optical software to:

- Prepare the optical designs, optimization, tolerancing, analysis for the upgrade of Virgo / Virgo_nEXT
- Develop several telescope configurations, optimize the designs according to the space constraints and the alignment 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 analysis for complex system in sequential mode (BS, cavities) -> discussion to develop a code mixing Zemax and Optocad / 3D physical propagation for complex systems

VIRGO FRANCE October 2023

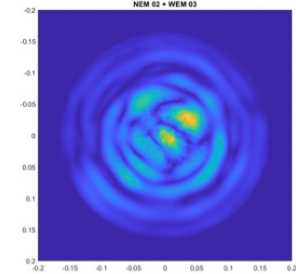


R&Ds some examples/ Optical simulations



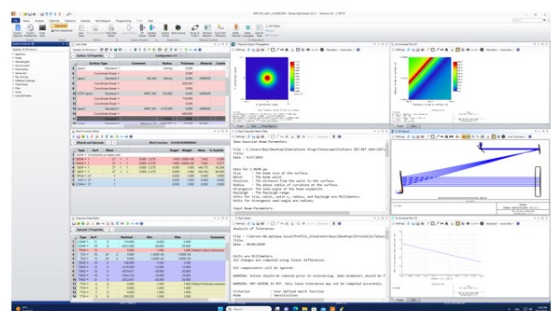
3 PhD on this topic

- 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)