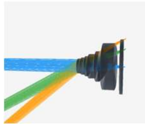


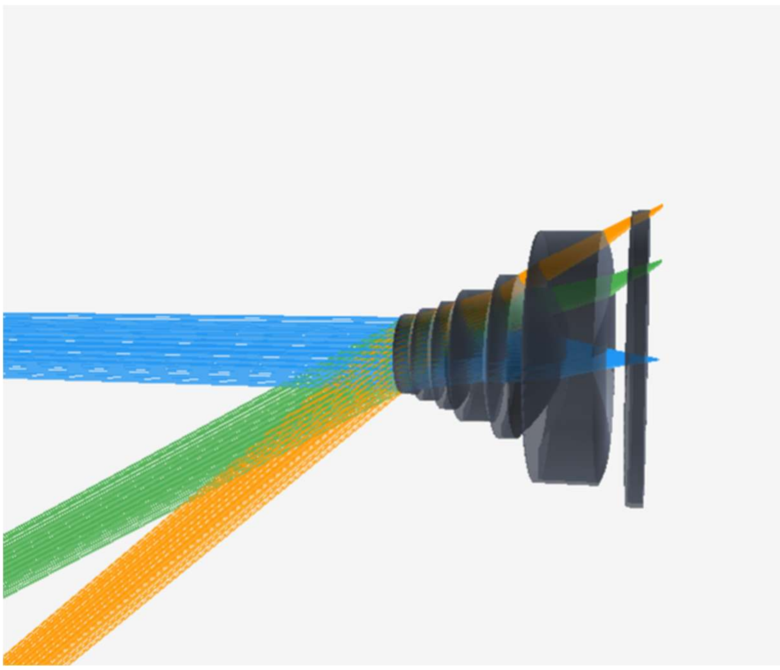
Benchmark: Smartphone lens part 1

Asphere spot diagram & MTF

This case study is inspired by the Youtube video Smartphone Camera Lens Design: A Patent Study by Stephen Remillard.

The objective of this study is to compare different metrics simulated in Etendue with those from the reference software described in the source material.

Key results: Across all evaluated metrics — Field Curvature, Distortion, MTF vs. Field, and Diffraction MTF — Etendue demonstrates strong agreement with the reference software. Spot diagram metrics show an average deviation of **4%**, while MTF profiles are **visually identical**, confirming Etendue as a reliable tool for optical system analysis.



etendue

System prescription:

The simulated setup is a patented[1] design for a smartphone camera. It's notably made of aspheric lenses as shown is the table below:

#	Surface	Comment	Type	Radius	Thickness	Semi-Ø	Material	Stop
OBJ 0	Object	Object plane	Object Plane	inf	inf	1.4303182251516553	air	
STO 1	Stop	Lens 1 front surface (aspheric	Even Asphere	1.952	0.118	0.8440594306199706	n=1.54, V=56	✓
2	S2	Aperture stop	Standard	inf	0.28	0.9211767422518342	n=1.54, V=56	
3	S3	Lens 1 rear surface (aspheric)	Even Asphere	2.978	0.069	0.6964574815376248	air	
4	S4	Lens 2 front surface (aspheri	Even Asphere	2.003	0.28	0.713041477220902	n=1.64, V=23	
5	S5	Lens 2 rear surface (aspheric	Even Asphere	2.167	0.205	0.7348748181140071	air	
6	S6	Lens 3 front surface (aspheri	Even Asphere	4.143	0.551	0.7867174091909102	n=1.54, V=56	
7	S7	Lens 3 rear surface (aspheric	Even Asphere	-3.947	0.211	0.9074851660796698	air	
8	S8	Lens 4 front surface (aspheri	Even Asphere	-0.969	0.421	0.9144155972786083	n=1.64, V=23	
9	S9	Lens 4 rear surface (aspheric	Even Asphere	-2.089	0.03	1.15627845608143	air	
10	S10	Lens 5 front surface (aspheri	Even Asphere	3.867	1.105	1.277408891940593	n=1.53, V=56	
11	S11	Lens 5 rear surface (aspheric	Even Asphere	-0.847	0.03	1.499779845379556	air	
12	S12	Lens 6 front surface (aspheri	Even Asphere	-16.711	0.44	1.6931341520177283	n=1.53, V=56	
13	S13	Lens 6 rear surface (aspheric	Even Asphere	0.785	0.7	2.292667730601692	air	
14	S14	IR-cut filter (glass)	Standard	inf	0.3	2.5666342139185283	n=1.52, V=64	
15	S15	Gap to image plane	Standard	inf	0.235	2.6706482265453118	air	
IMG 16	Image	Image plane	Image Plane	inf	0	auto	air	

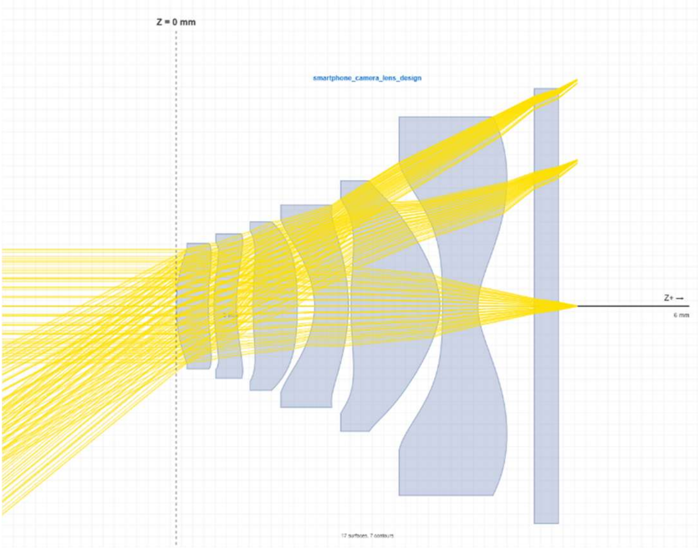
And the coefficients are listed in this table:

#	SURFACE	TYPE	COEFFICIENTS k	A2	A4	A6	A8	A10	A12	A14	A16
1	Lens 1 fr...	Even Asphere	-2.1201	0	0.0035988	0.37387	-1.3929	1.4094	2.0282	-3.6199	0
3	Lens 1 r...	Even Asphere	-20	0	-0.17492	0.098443	0.66244	-1.7257	0.66955	-0.34243	0
4	Lens 2 f...	Even Asphere	-12.382	0	-0.26551	0.57642	-1.1253	1.1555	0.014439	-1.9141	0
5	Lens 2 r...	Even Asphere	-3.006	0	-0.25306	0.31573	-0.21258	0.094103	-0.27001	0.1111	0
6	Lens 3 f...	Even Asphere	1	0	-0.1468	-0.019199	0.11489	-0.1691	-0.11287	0.12615	0
7	Lens 3 r...	Even Asphere	0	0	-0.044328	-0.16599	0.048223	0.0094653	0.012137	-0.008155	0
8	Lens 4 f...	Even Asphere	-1.4213	0	0.33847	-0.87891	1.1445	-0.91578	0.59482	-0.20143	0
9	Lens 4 r...	Even Asphere	-3.0569	0	0.14102	-0.27755	0.32138	-0.24968	0.12901	-0.027976	0
10	Lens 5 f...	Even Asphere	-6.3368	0	-0.16984	0.14944	-0.099124	0.013353	0.0016198	0.0012524	0
11	Lens 5 r...	Even Asphere	-4.2091	0	-0.067672	-0.030645	0.10444	-0.083869	0.026536	-0.002786	0
12	Lens 6 f...	Even Asphere	-20	0	-0.13442	0.038933	-0.006238	0.0007535	0.0002200	-0.000052	0
13	Lens 6 r...	Even Asphere	-5.1631	0	-0.075325	0.024095	-0.005892	0.0010269	-0.000115	0.0000059	0

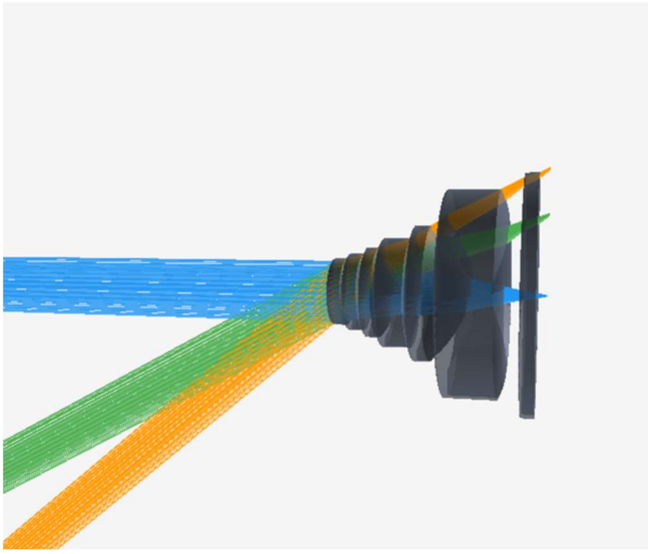
[1] Chen, Chun-Shan, Tsung-Han Tsai, and Ming-Ta Chou. "Optical image lens system." U.S. Patent No. 11,561,375. Jan. 24, 2023

Simulation results:

Before analyzing the simulated values, an initial visual check confirms that the system has been correctly reconstructed by the AI using screenshots from the reference material:



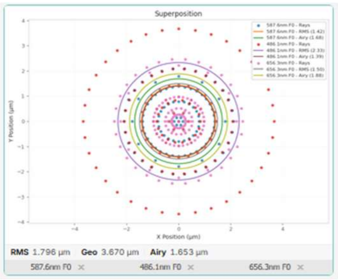
2D cut

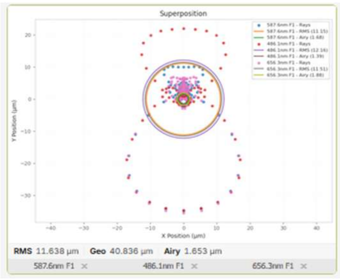


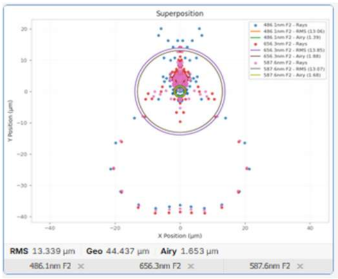
3D view

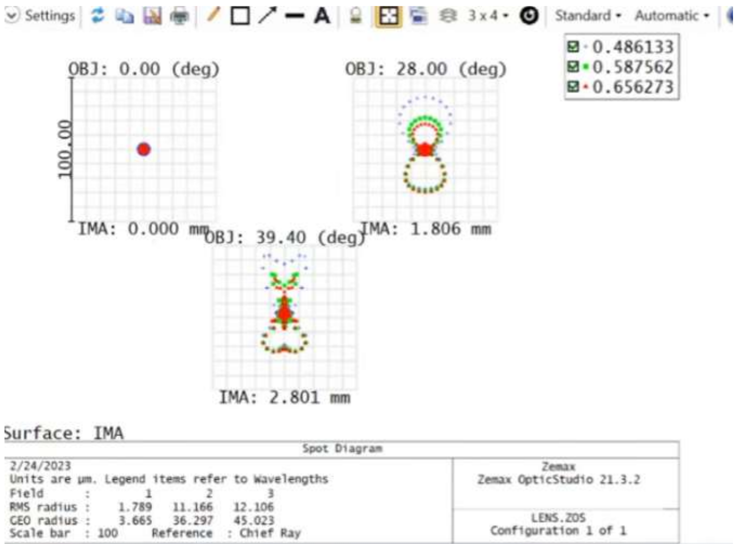
Spot diagrams:

Looking at the spot diagrams in etendue and the reference software, we can also confirm that spot diagrams have similar profiles:







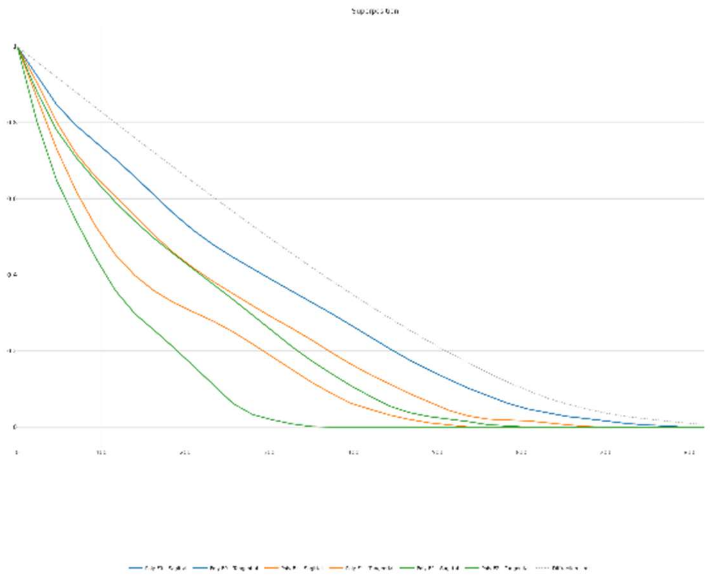


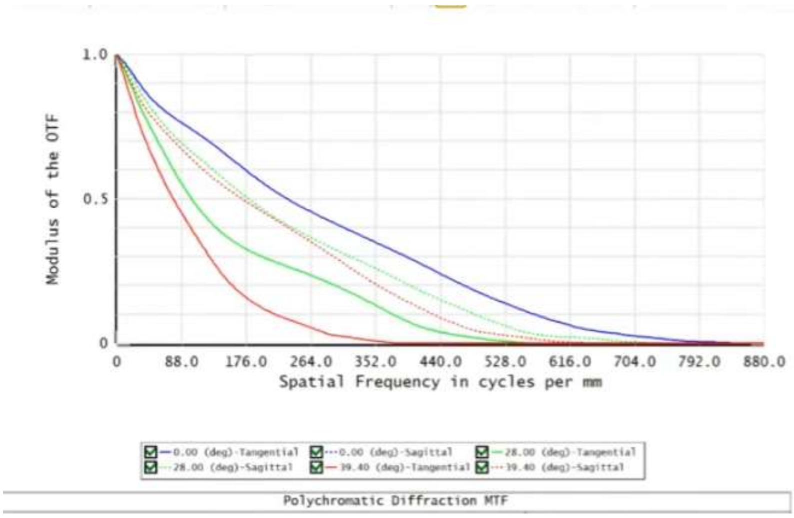
And a closer look at the numbers gives a 4% average error:

Spot diagram	F0		F1		F2	
	RMS	GEO	RMS	GEO	RMS	GEO
Etendue	1.796	3.67	11.638	40.836	13.339	44.437
Competitive	1.789	3.665	11.166	36.297	12.106	45.023
Difference	0,4%	0,1%	4,1%	11,1%	9,2%	-1,3%

MTF analysis

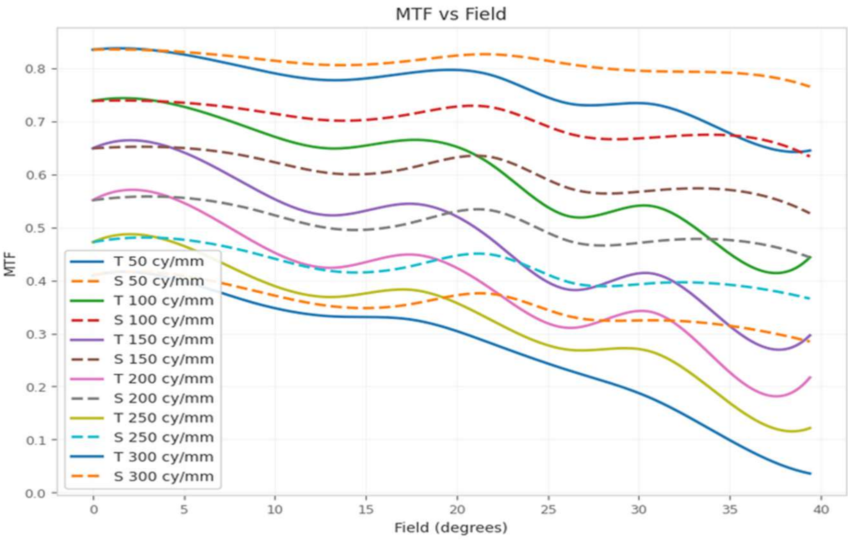
In his video, S. Remillard also discusses in length the MTF of the system, let’s compare reference plots against etendue’s ones:

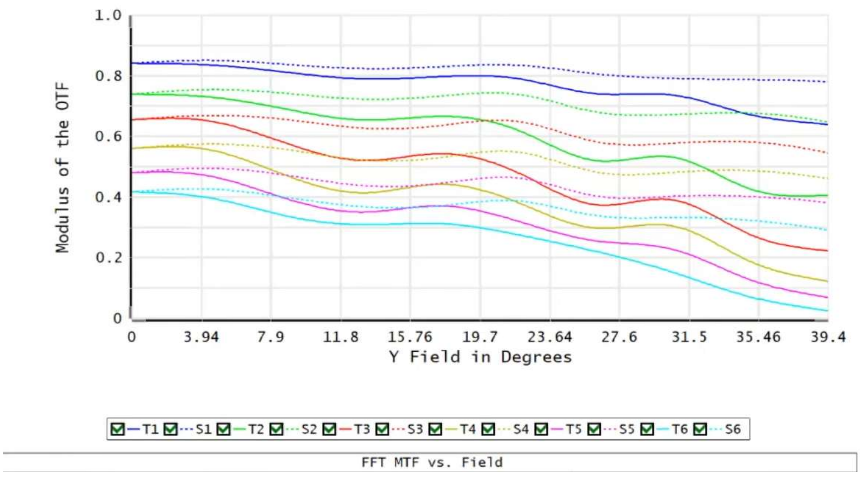




Both plots show the same fundamental behavior: MTF starting at 1.0 on-axis and decreasing monotonically with spatial frequency, with a clear degradation at larger field angles. The relative ranking of field positions (on-axis best, full field worst) is fully consistent between the two tools.

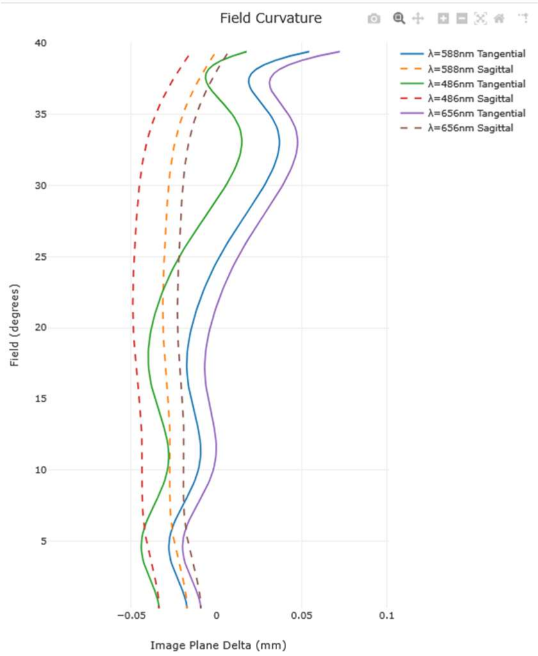
MTF vs field

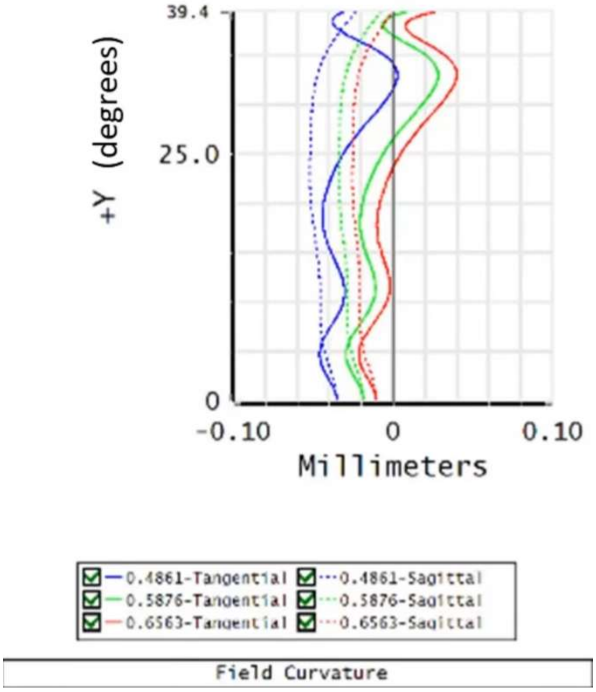




Both plots show the same general behavior: MTF decreasing with field angle, with characteristic oscillations around 15–20° and 27–30°, and a consistent T/S separation across all spatial frequencies. The ranking of frequency curves (higher MTF at lower lp/mm) is well preserved.

Field curvature :



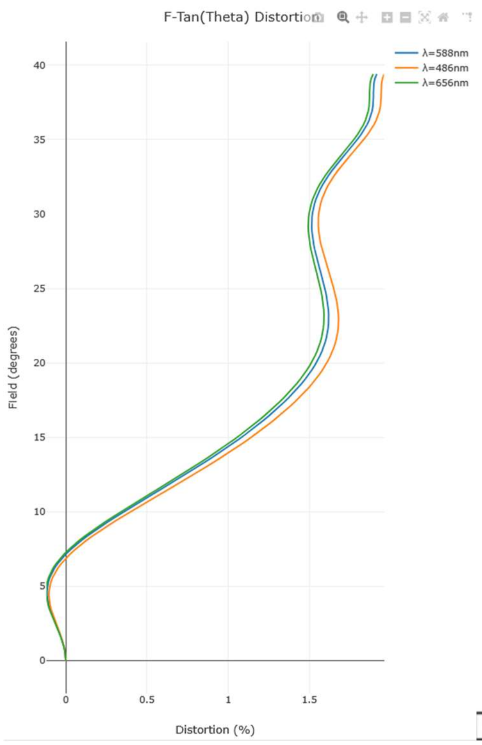


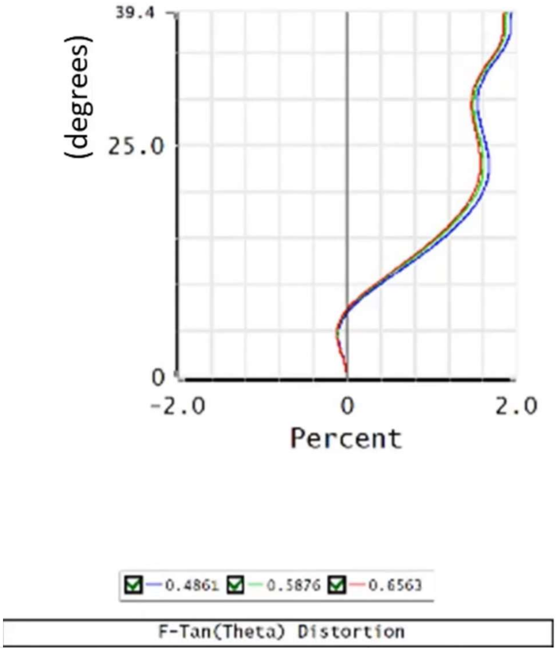
A visual examination of both plots reveals similar profiles; small deviations point to either a diverging ray tracing model at wide fields or heavier smoothing of the output data.

Angle	Source	T_587	S_587	T_486	S_486	T_656	S_656
0°	Etendue	-17*	-17	-33	-33	-9	-9
	Competitive	-18	-18	-35	-35	-11	-11
25.0°	Etendue	+2	-30	-21	-48	+13	-21
	Competitive	*-7*	*-33*	*-33*	*-58*	*+5*	*-21*
39.4°	Etendue	+5	-2	+17	-14	+6	1
	Competitive	*+10*	-10	*-30*	*-22*	*+22*	*0*

**Units in µm.*

Distortion F(than(theta)





Both plots are in excellent agreement. The S-curve shape, amplitude (~1.9% at full field), zero-crossing location, and overall field behavior are fully consistent between the two tools. Chromatic separation between the three wavelengths is equally tight in both cases.

Conclusion:

Analyzed metrics are similar, demonstrating Etendue's core engine reliability and precision.

The workflow in Etendue is fast and easy to set up, largely thanks to the AI assistant, which successfully reconstructed the system from scratch by analyzing screenshots from the source material.

The next case study on this system will focus on tolerancing and optimization.