SkyWave

Intelligence Artificielle pour Analyze de Front d'Onde et Collimation

Rencontres du Ciel et de L'Espace 2022

Auteur : Dr. Vincent Suc [1]

[1] **OBS**TECH
Observatoire El Sauce
Rio Hurtado
CHILI

La Villette, 12 Novembre 2022

L'équipe Innovations Foresight

- Entreprise fondée en 2008
- Dr. Gaston Baudat CEO
- Specialisé en AI & Machine Learning
- Origine en produits ophtalmologiques.

Produits Innovations Foresight

- ONAG
- SkyGuard/SkyGuide
- SkyWave

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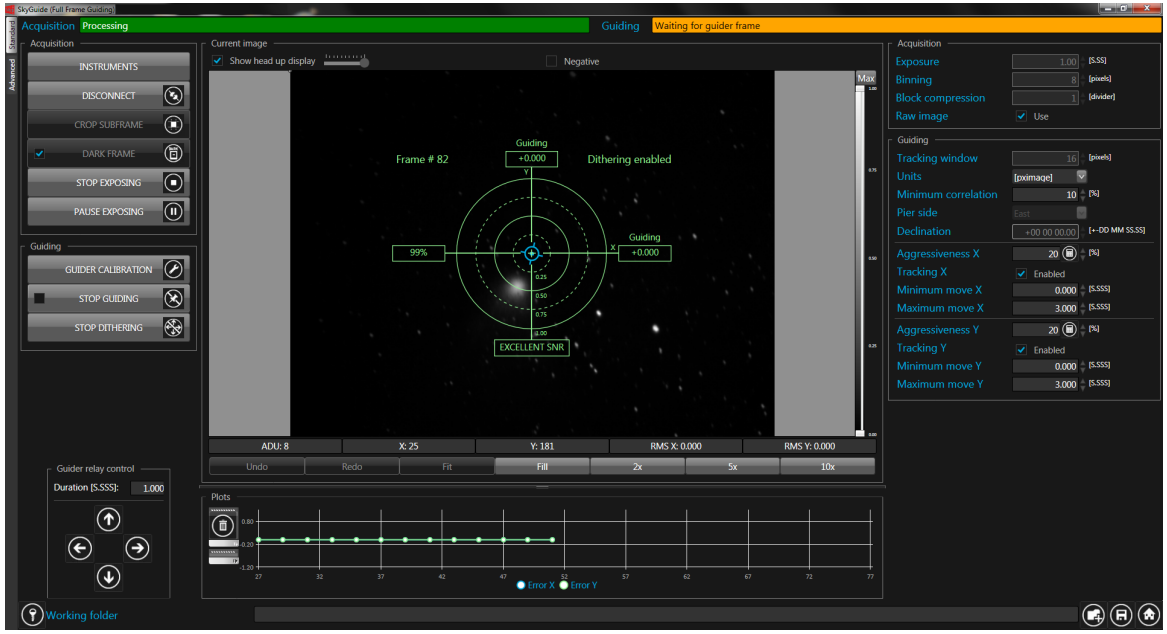

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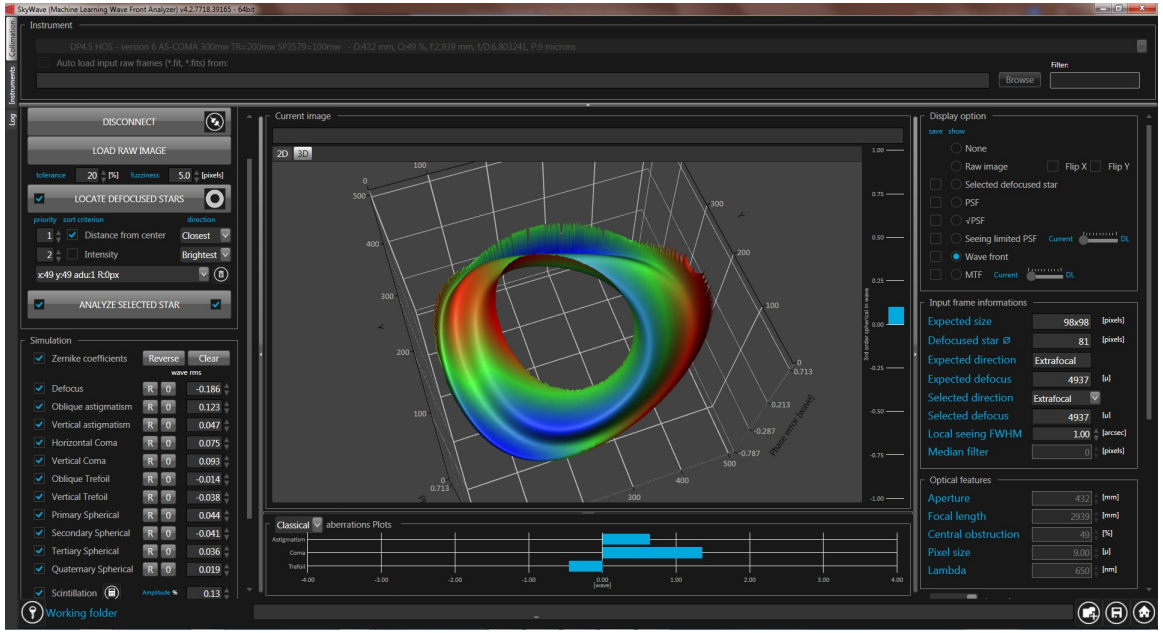

Cahier des Charges

- Pas d'élements optiques
- Calcul rapide (Eventuelle utilisation en AO)
- Fonctionne sur PC (pas besoin de FPGA/GPU)
- Analyse du front d'onde avec **une seule** image
- Analyse de tout le champ

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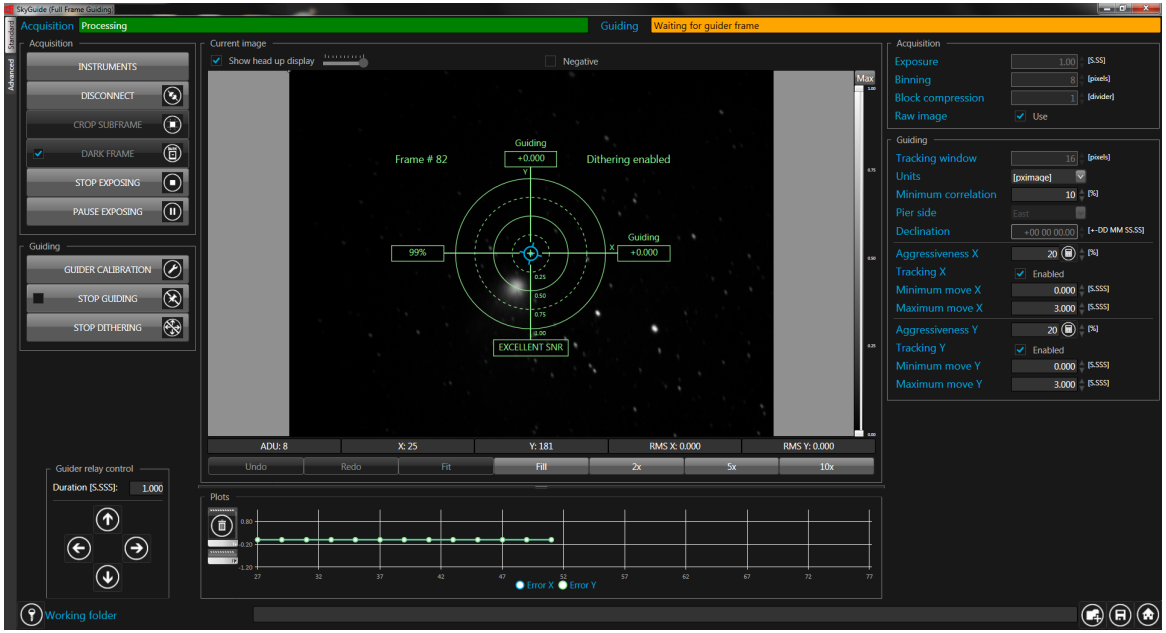

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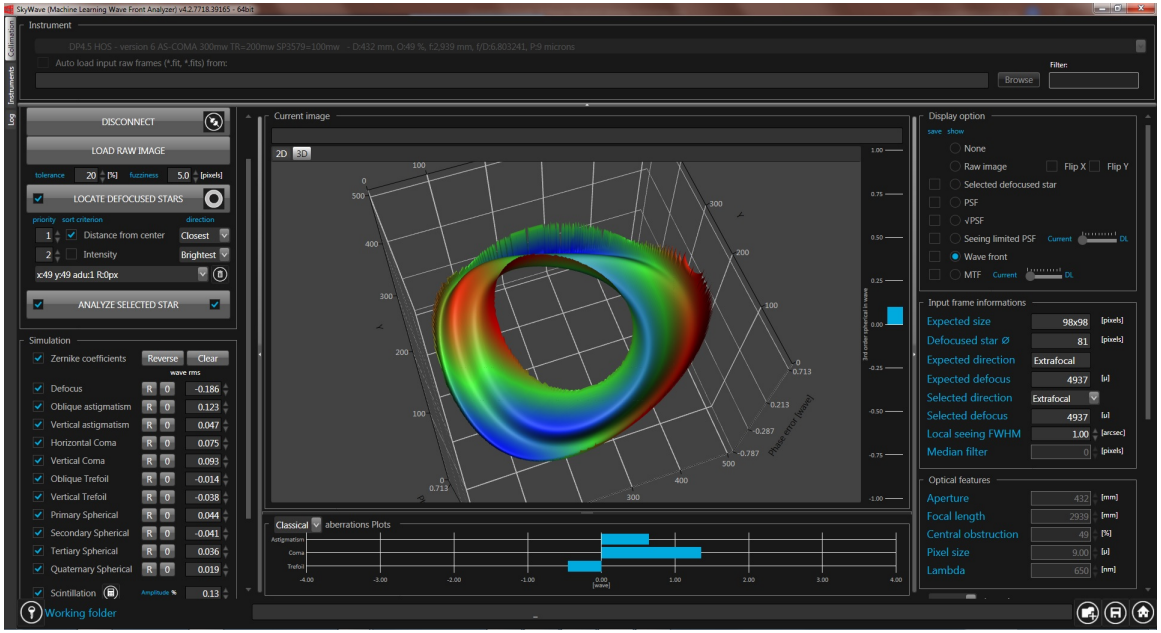
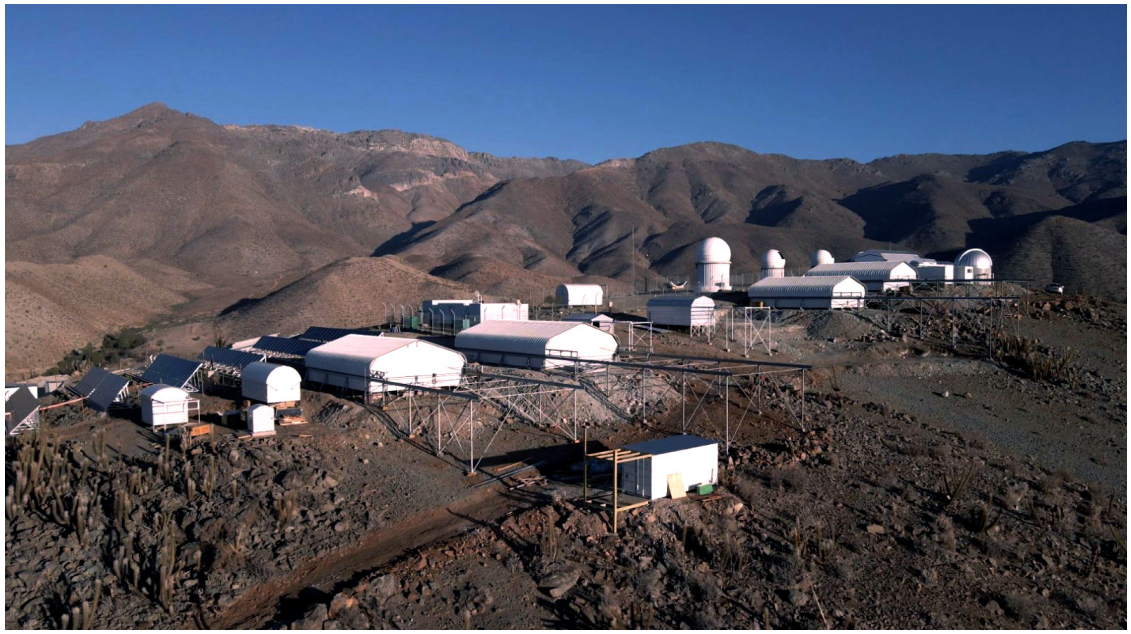


SkyWave à **OBS**TECH

- Site de Hosting
- 80 telescopes
- 25 installations en 2022
- 1 toutes les 2 semaines
- Tilt critique avec seeing <1"
- Les optiques asphériques prennent du temps !



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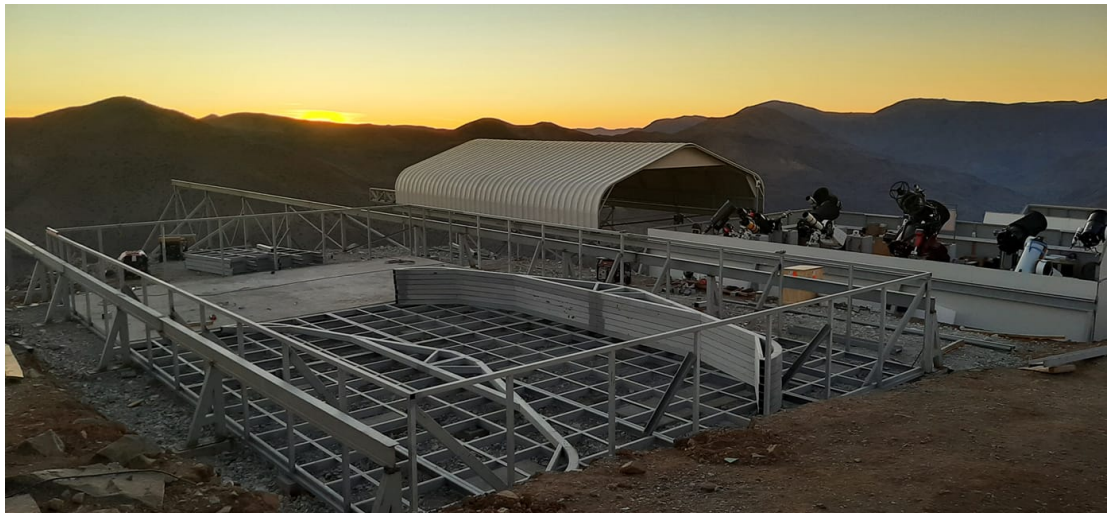

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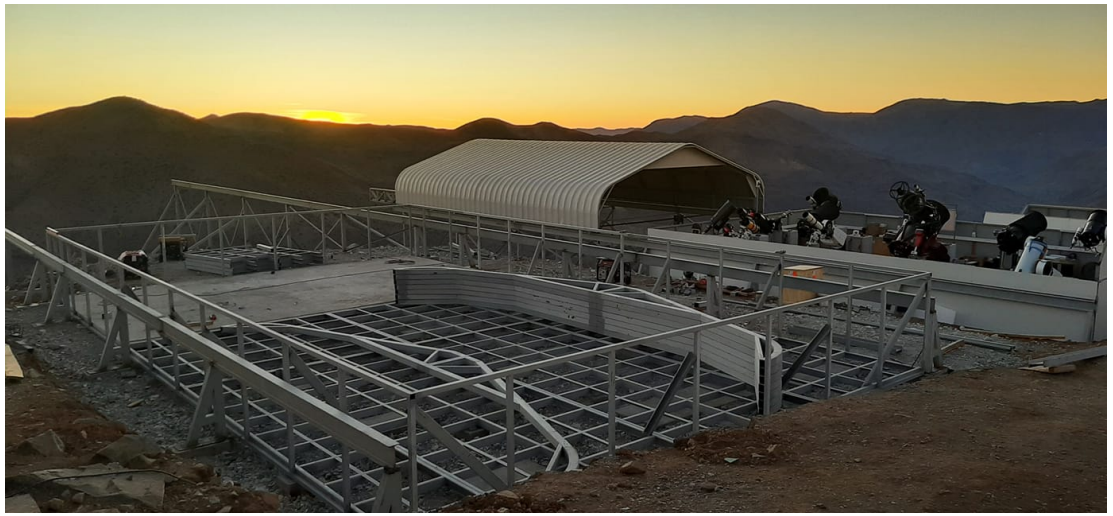

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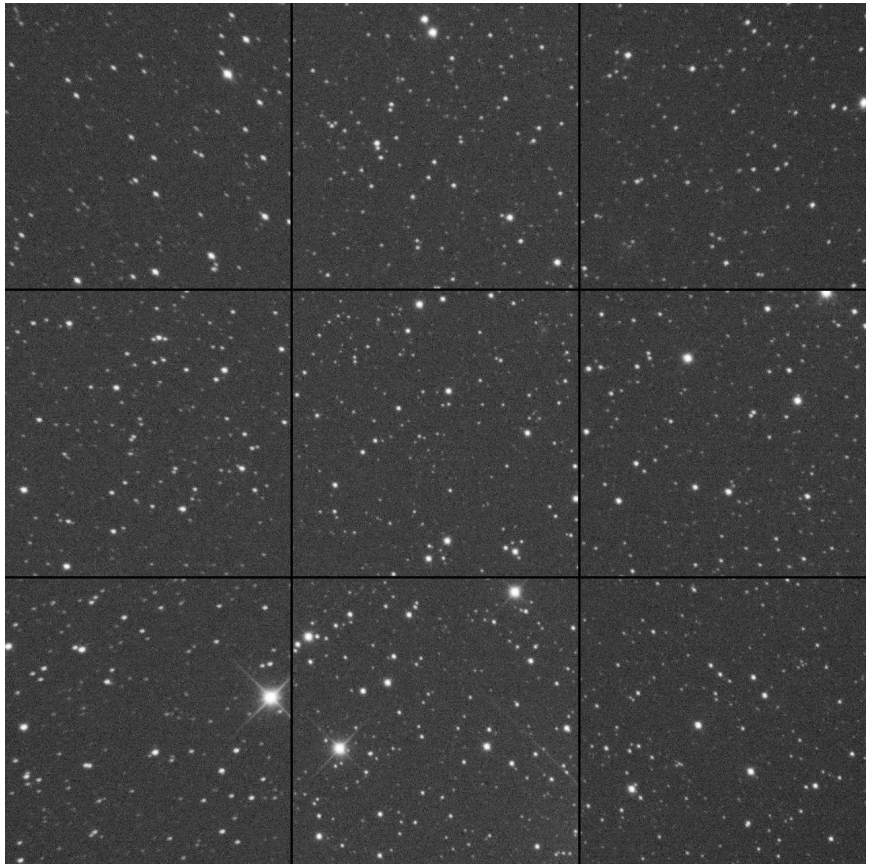

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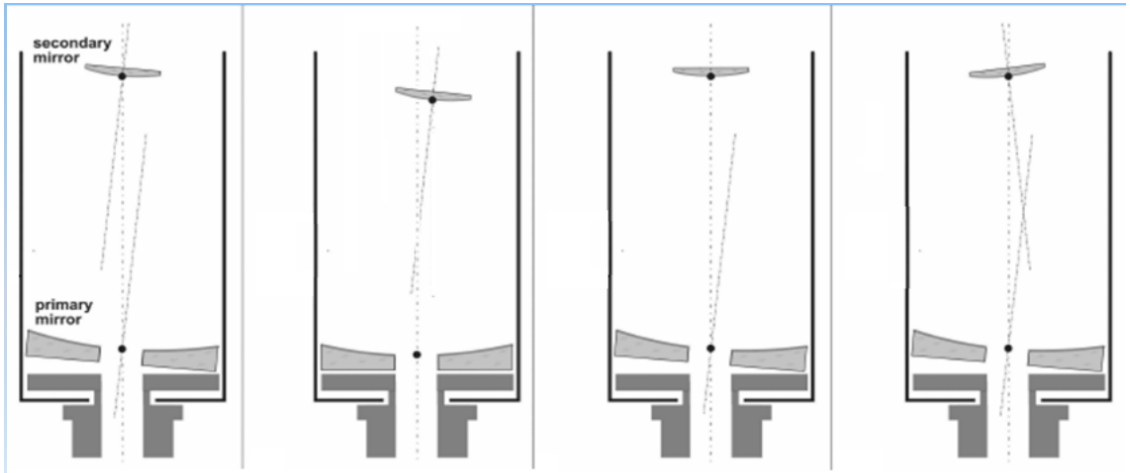
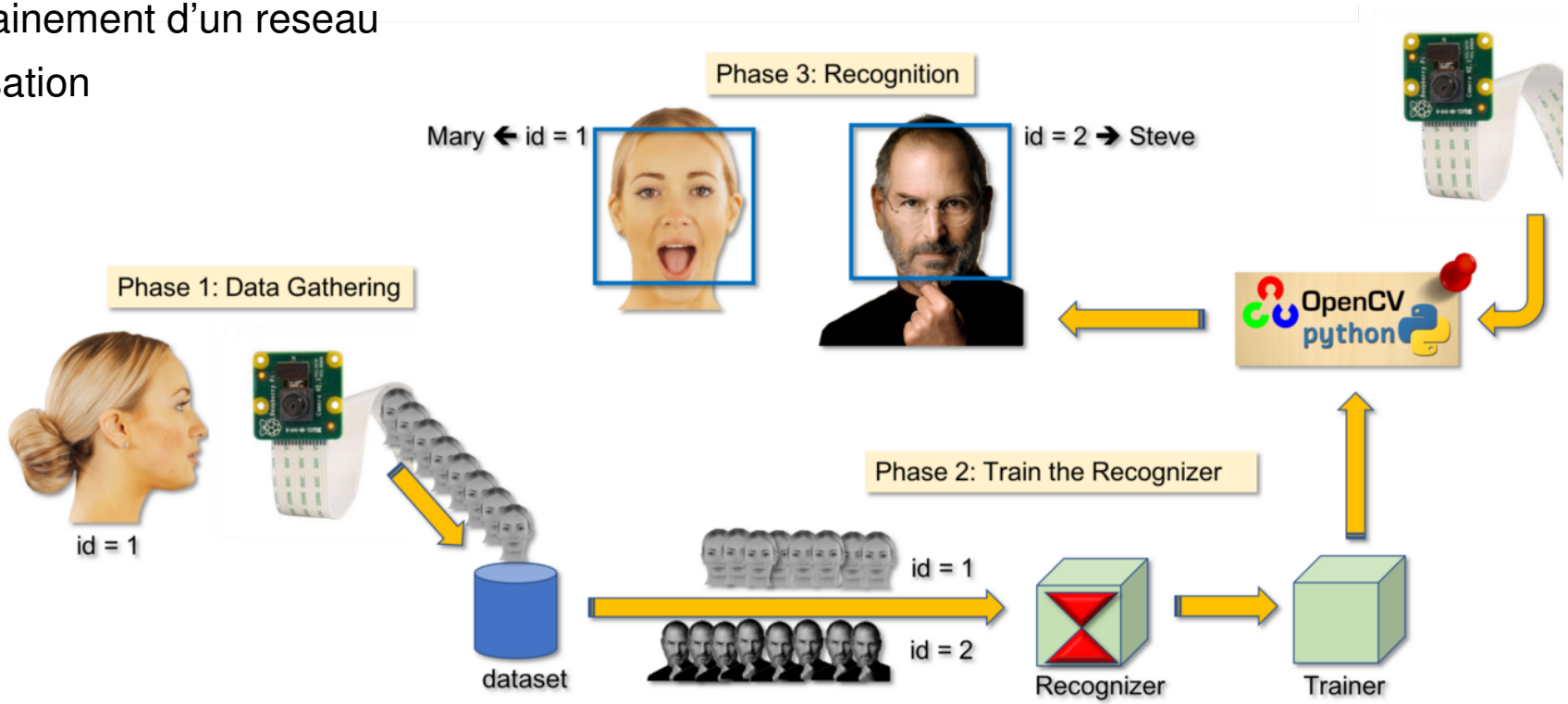


Out of alignment scope: Various misalignment scenarios (reflector)

Principes d'Intelligence Artificielle

- Information complexe -> Donnée
- Creation/recompilation de données connues
- Entrainement d'un reseau
- Utilisation



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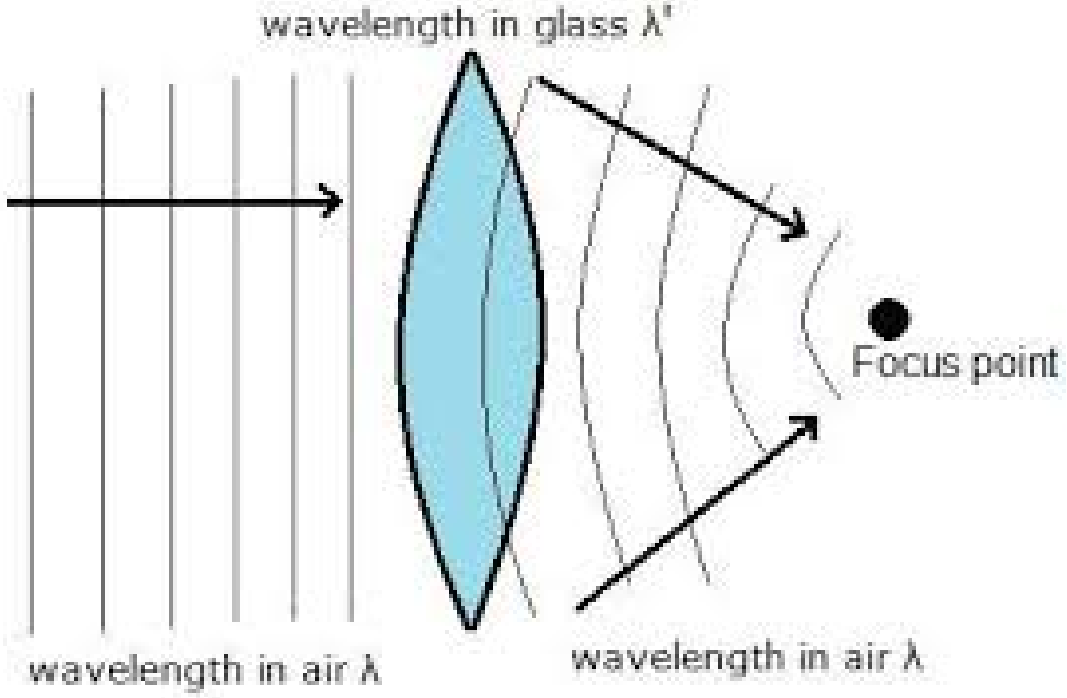
- Polynômes de Zernike



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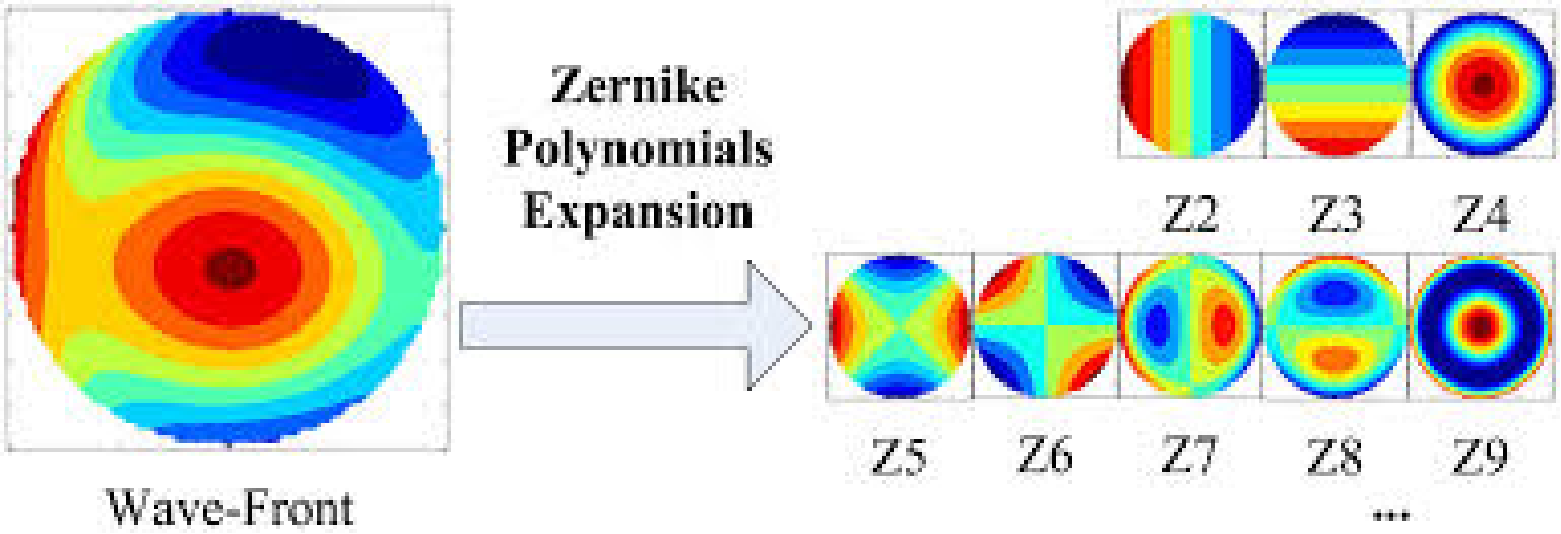

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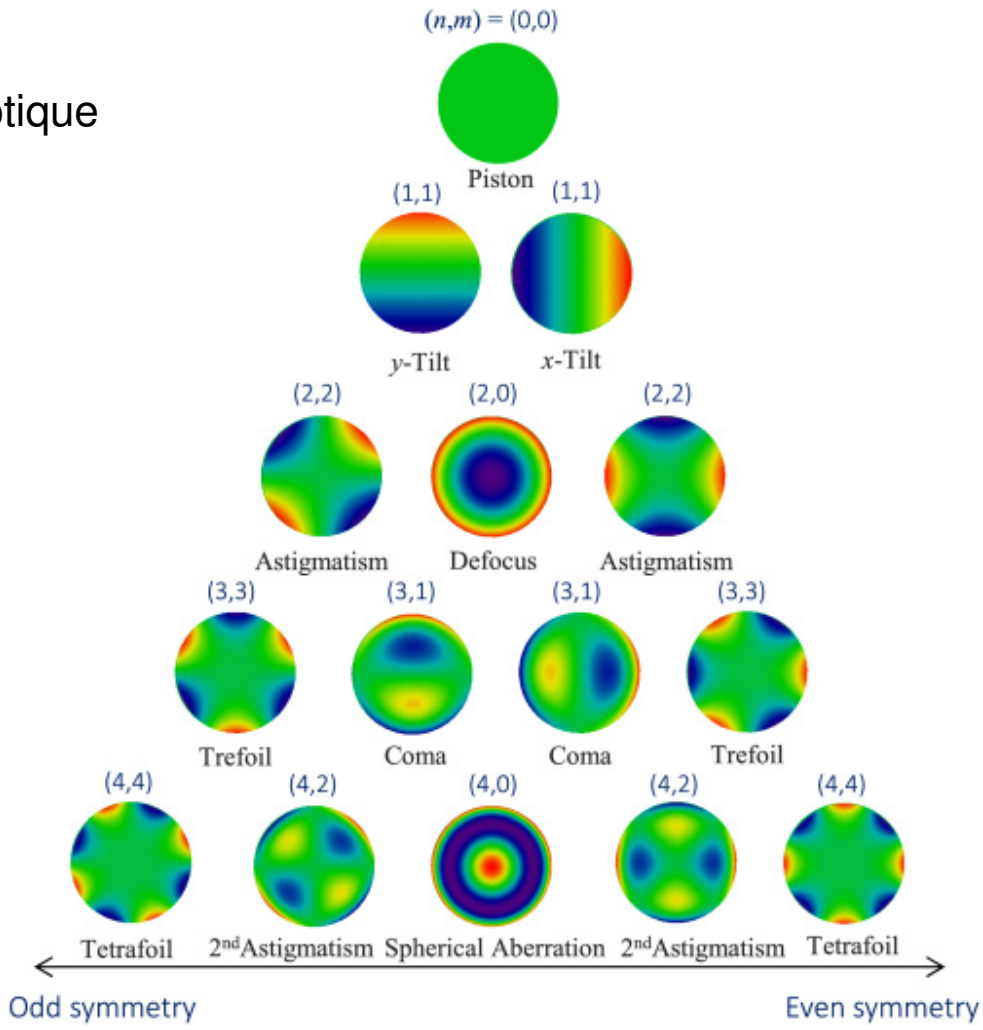
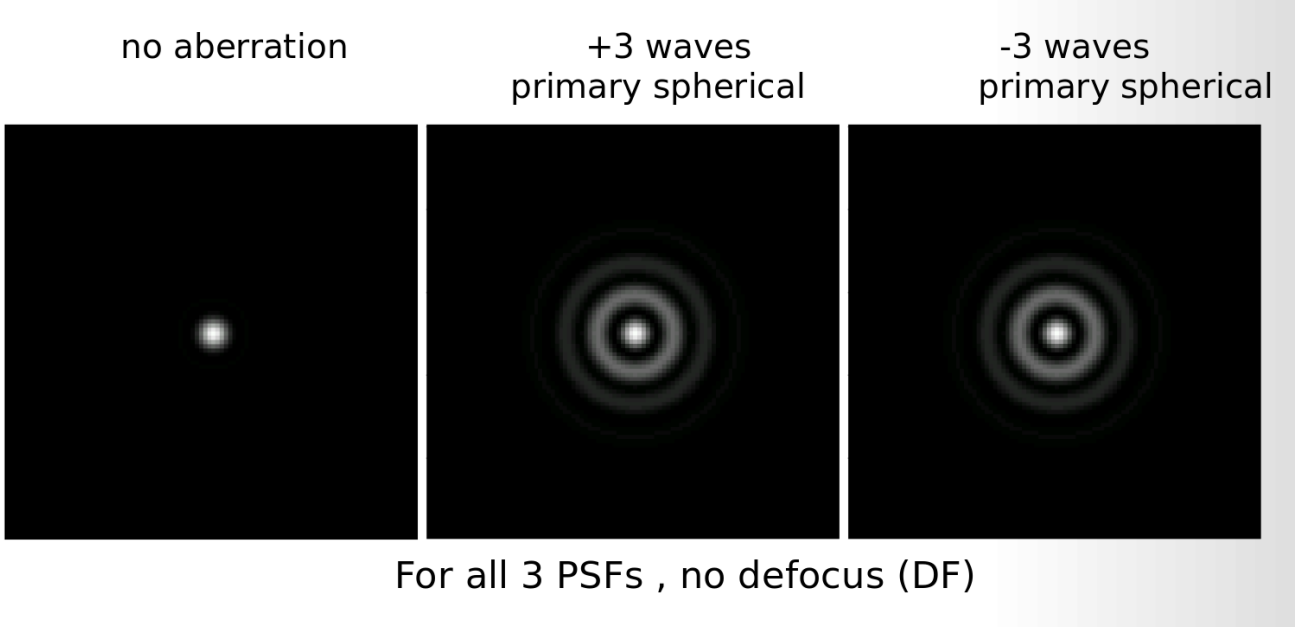


Entrainement du Réseau de Neurones



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- Défocalisation
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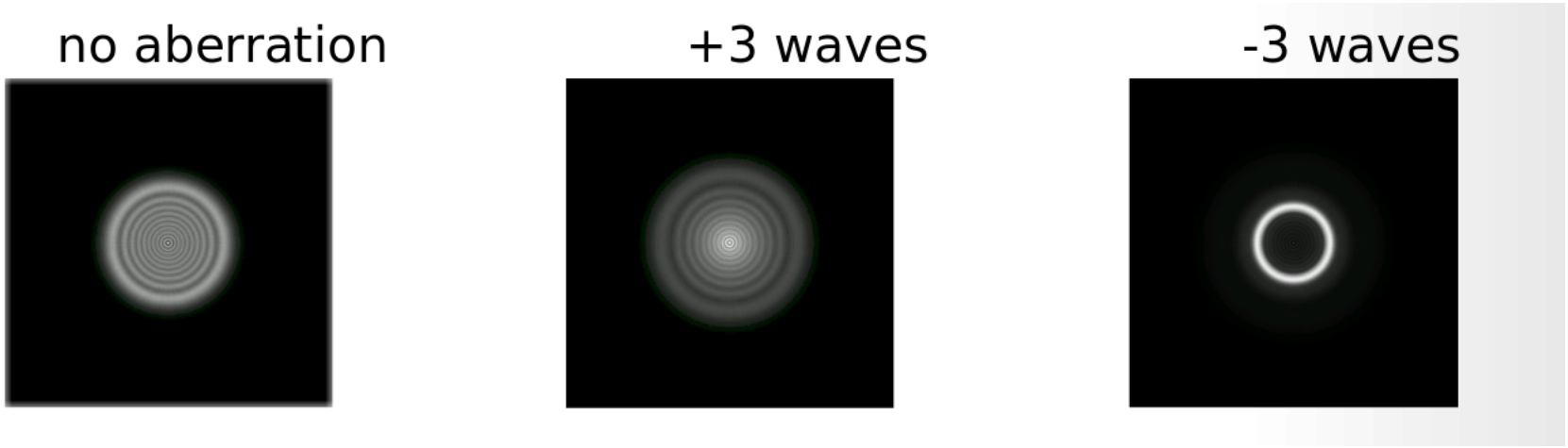

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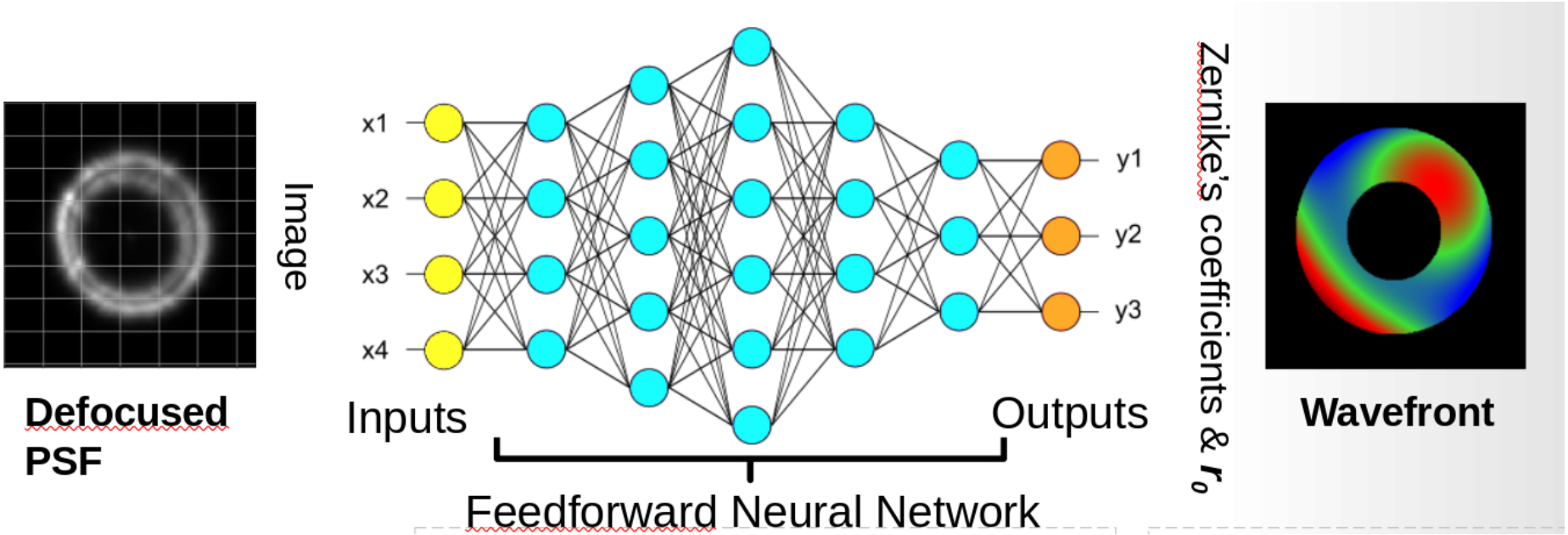

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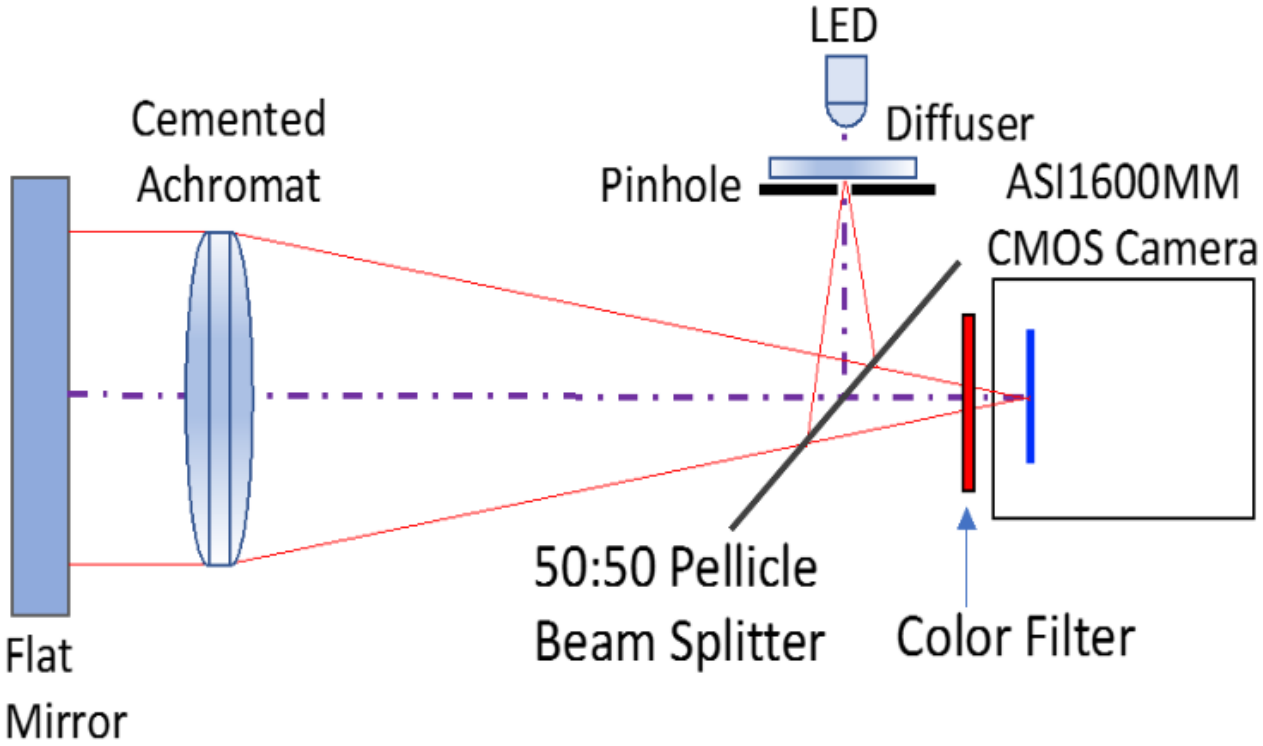
Banc Optique + Skywave



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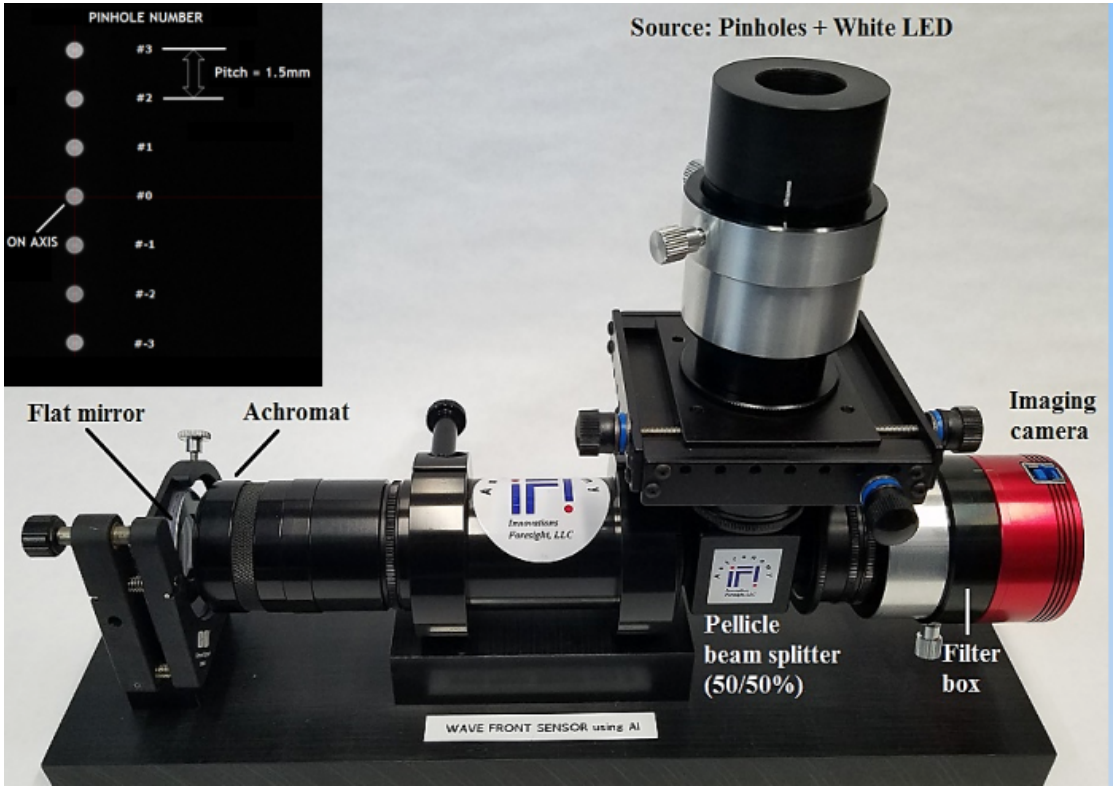
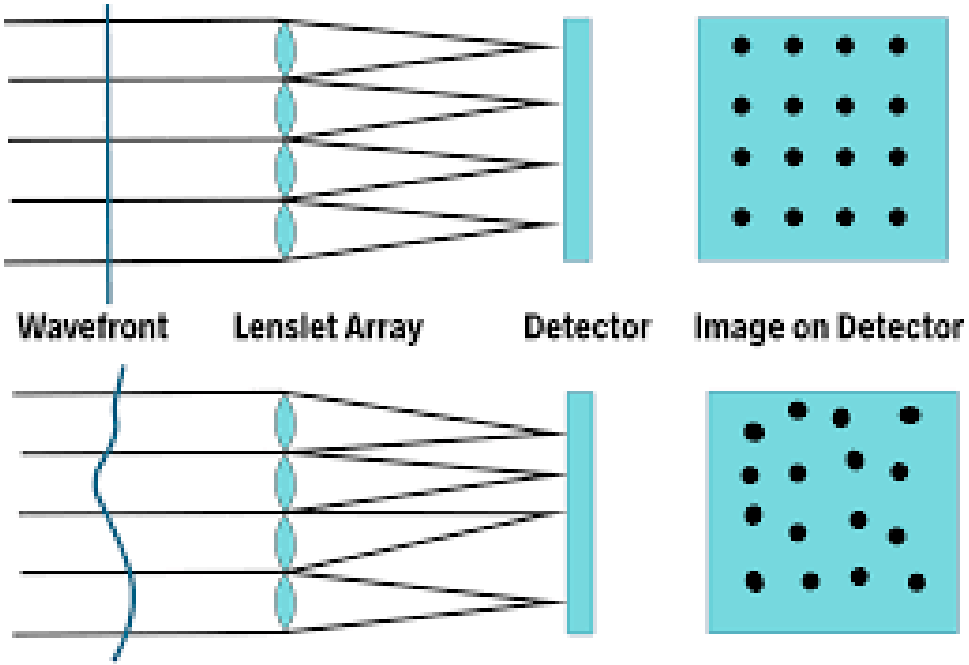


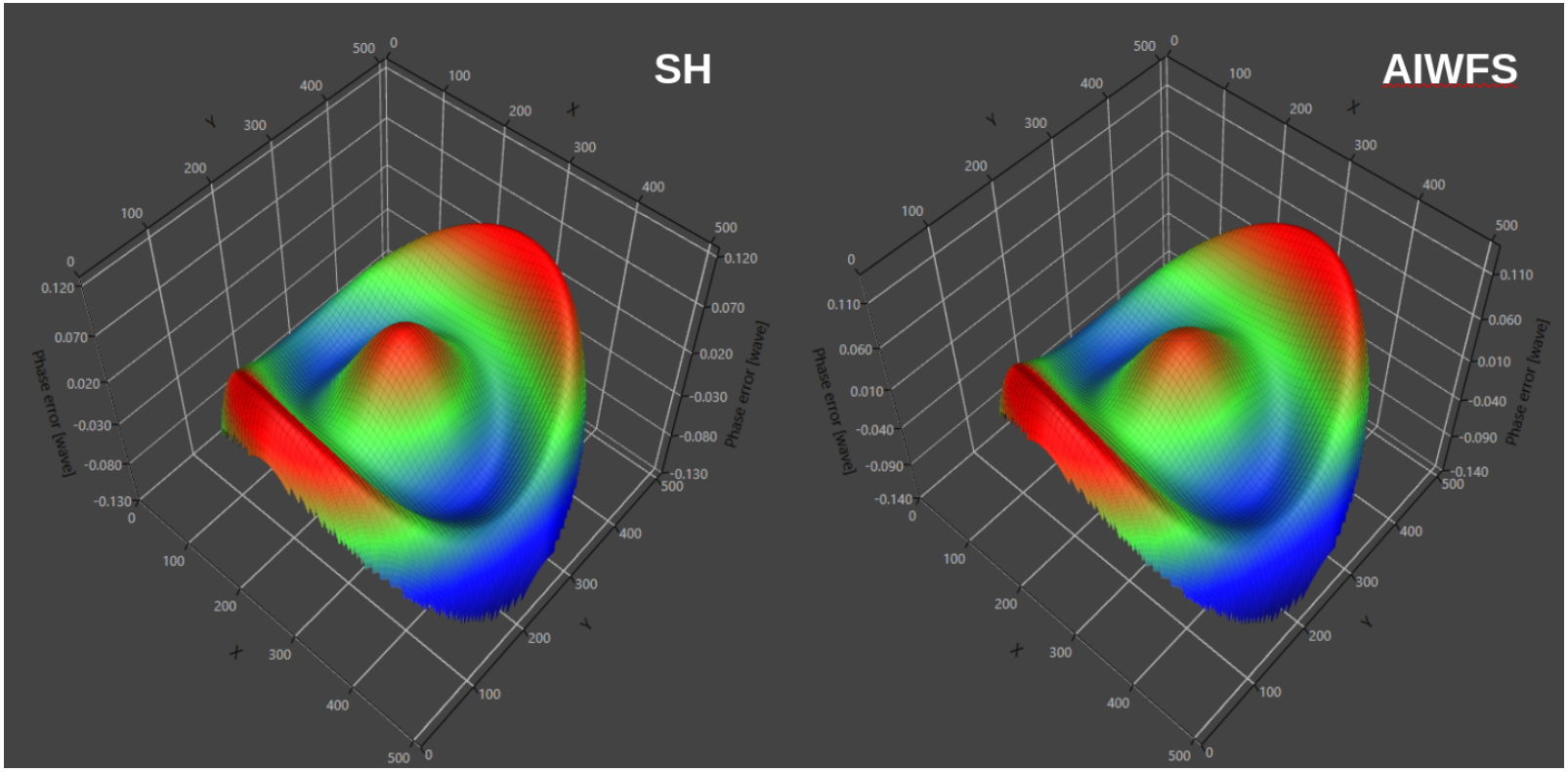
Banc Optique + Shack-Hartmann



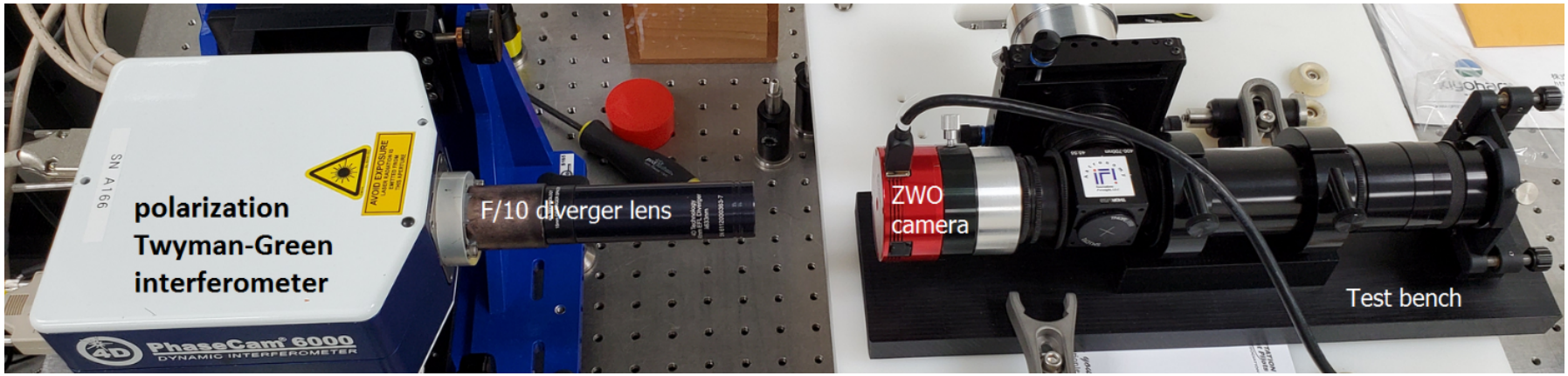
Banc Optique + Shack-Hartmann

Wvant's index	SH	AIWFS
SR	0.9864	0.9869
RMS	0.017 wave (11.2nm)	0.018 wave (11.7nm)
PV	0.127 wave (82.2nm)	0.116 wave (75.4nm)
Primary Astigmatism Z4+Z5	0.039 wave (25.0nm)	0.041 wave (26.7nm)
Primary Coma Z6+Z7	0.002 wave (1.5nm)	0.003 wave (2nm)
Primary Trefoil Z9+Z10	0.005 wave (3.5nm)	0.006 wave (3.9nm)
Primary Spherical Z8	0.002 wave (1.4nm)	0.002 wave (1.3nm)
Secondary Spherical Z15	0.021 wave (13.4nm)	0.019 wave (12.4nm)

Banc Optique + Shack-Hartmann



Banc Optique + Interferomètre



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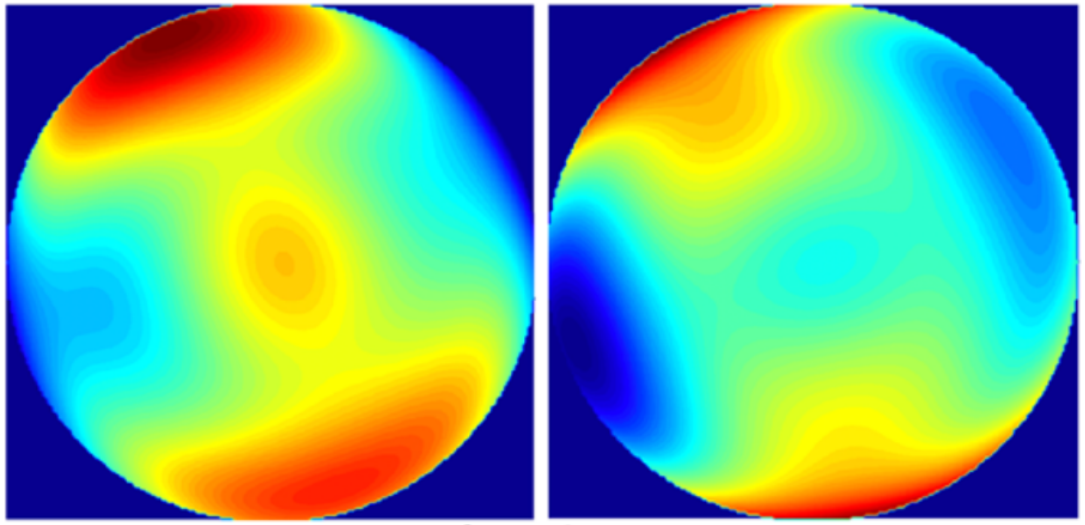
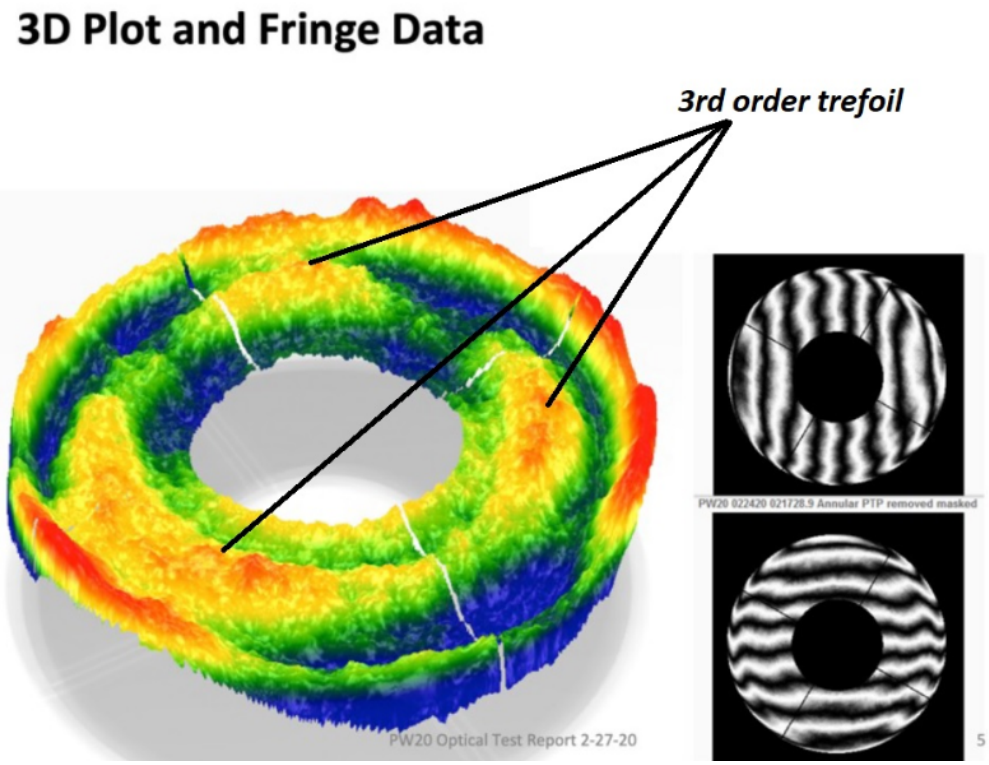


Flat mirror

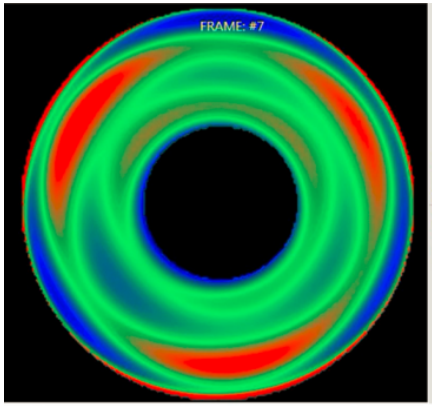
mw	AI	PhaseCam
PV	166	135
rms	27	22
Strehl	97	98
SA3	18	11
CMA3	36	16
ASTG3	-127	-102
Z8	3	2
Z15	16	12
Zernike Trefoil magnitude	14	18

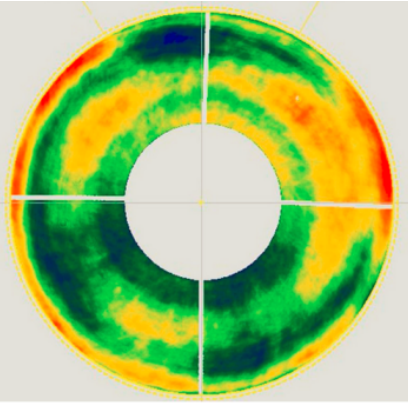
Zernike Wyant's index

Planewave CDK500 + Interferomètre

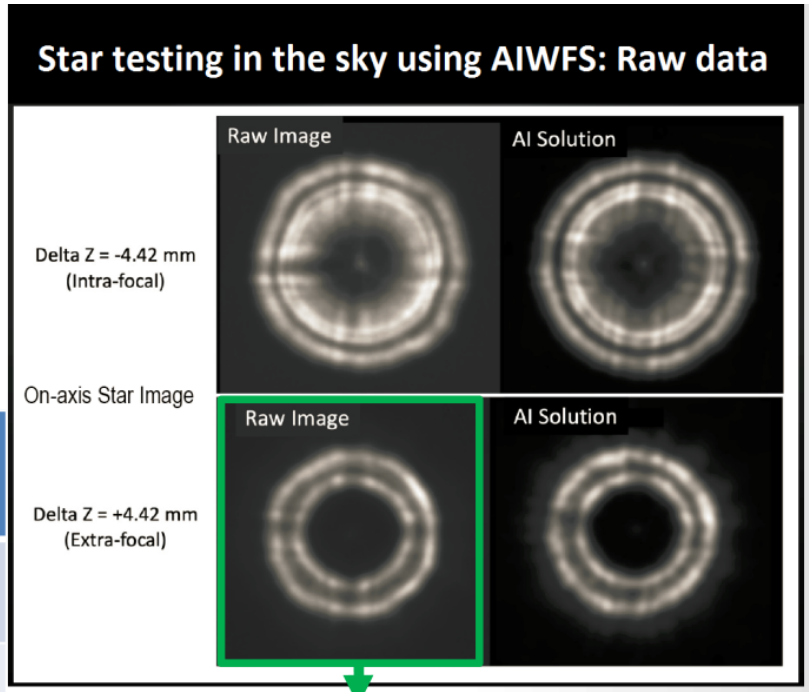


Planewave CDK500 + Skywave



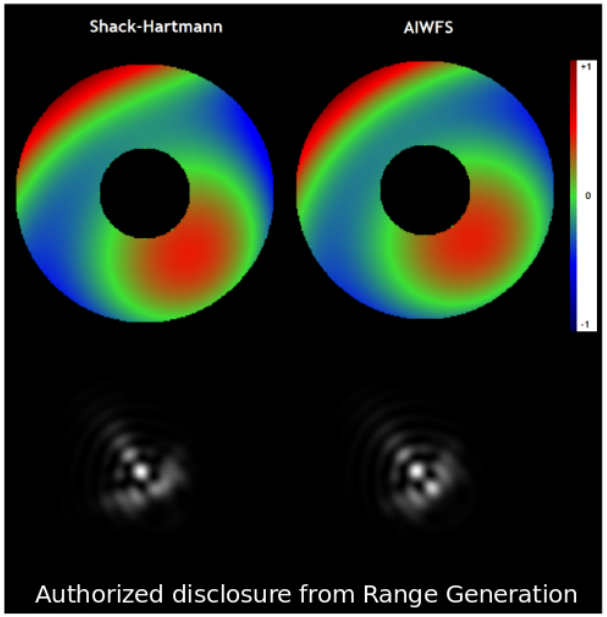


AIWFS (sky)	PhaseCam (lab)
One single frame	**Average 512 frames**
RMS = 0.070 wave	RMS = 0.0647 wave
Measured SR = 0.82	Measured SR = 0.85



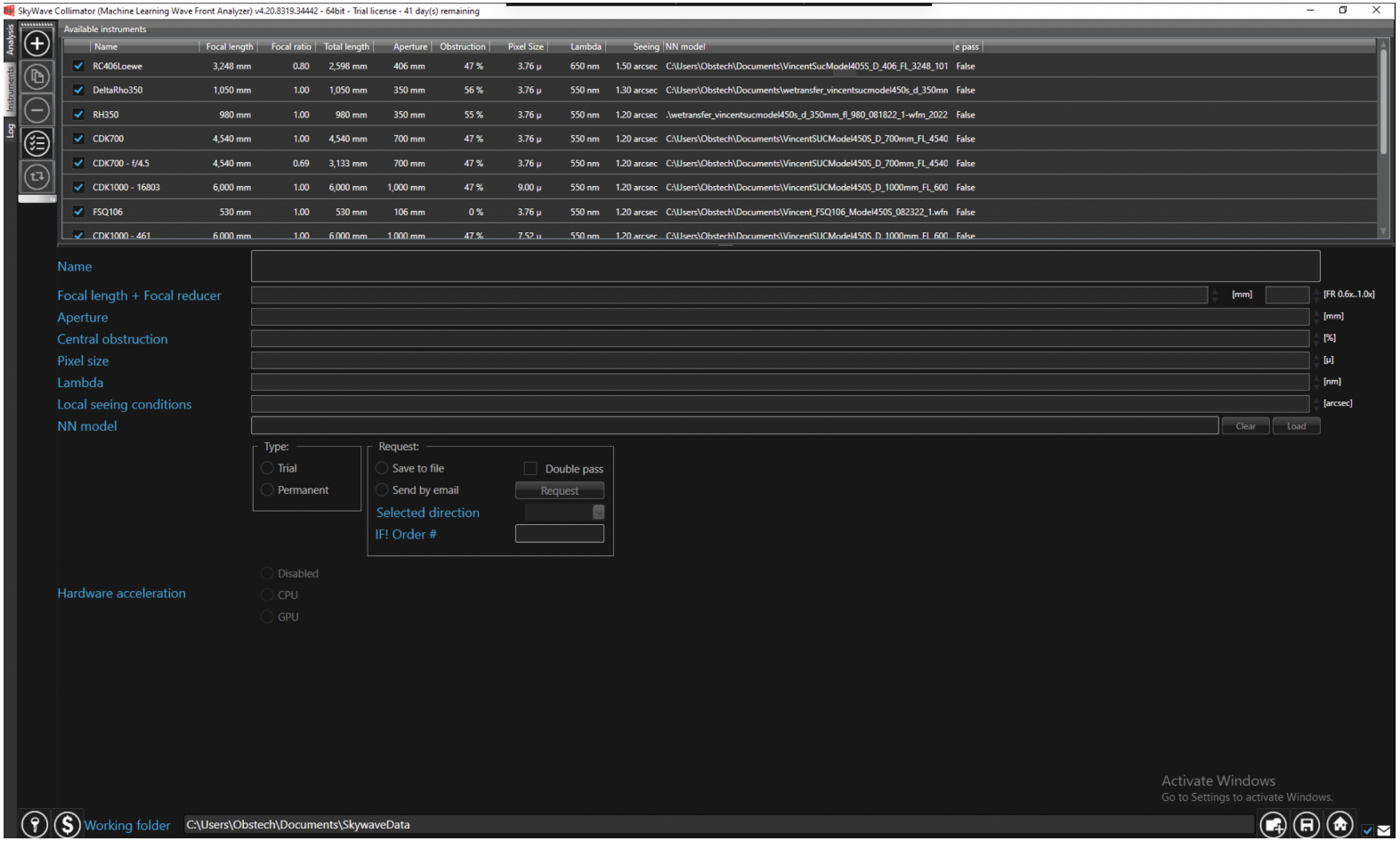
Input image to NN

Planewave CDK500 + Shack-Hartmann



Zernike Wyant's index		SH	AIWFS
SR		0.14	0.19
RMS		0.277 wave	0.271 wave
Astigmatism	Z4+Z5	0.96 wave	0.91 wave
Coma	Z6+Z7	0.98 wave	0.98 wave
Trefoil	Z9+Z10	0.05 wave	0.11 wave
Spherical	Z8	0.05 wave	0.11 wave

Obtention du Modele



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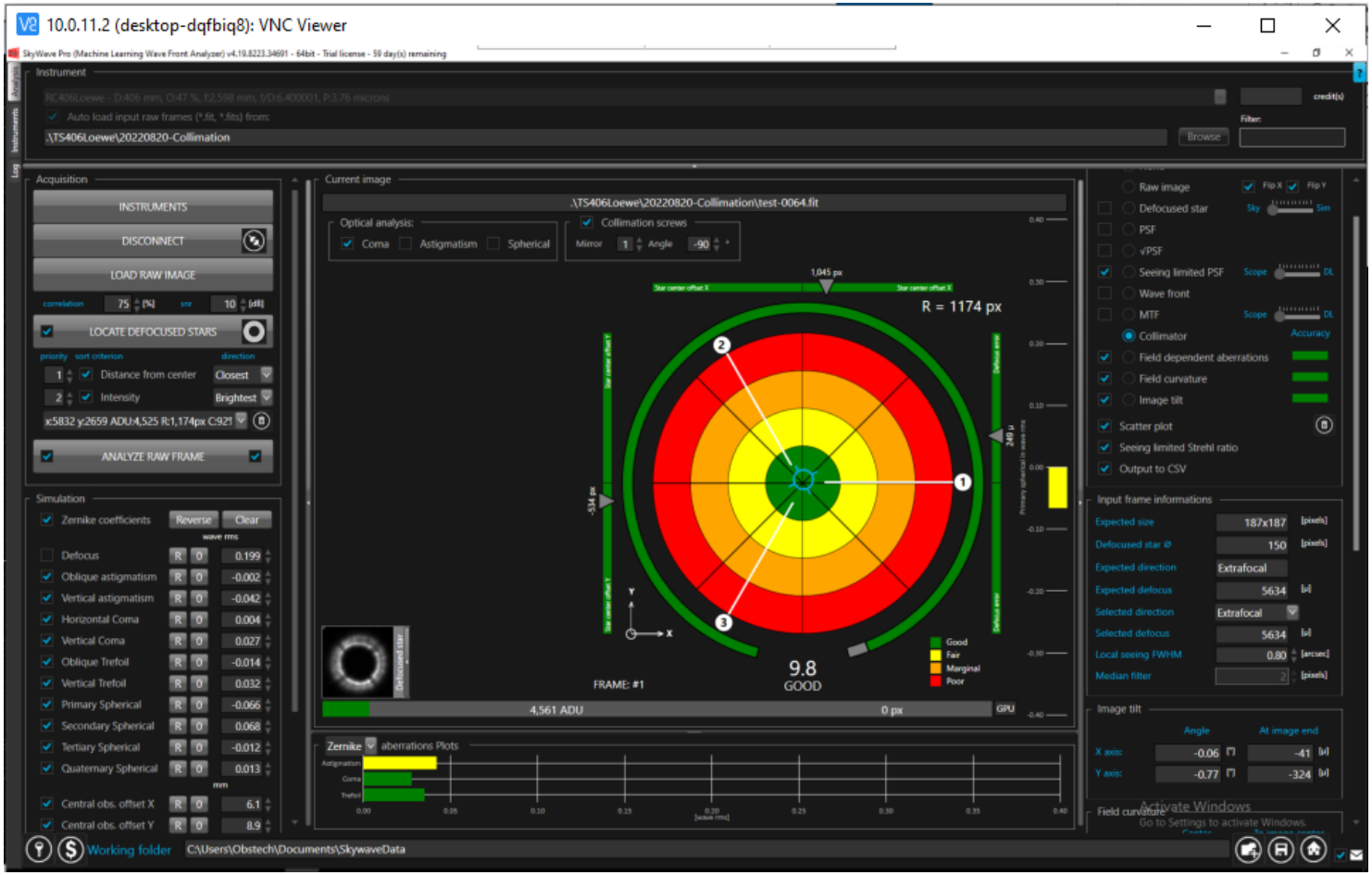

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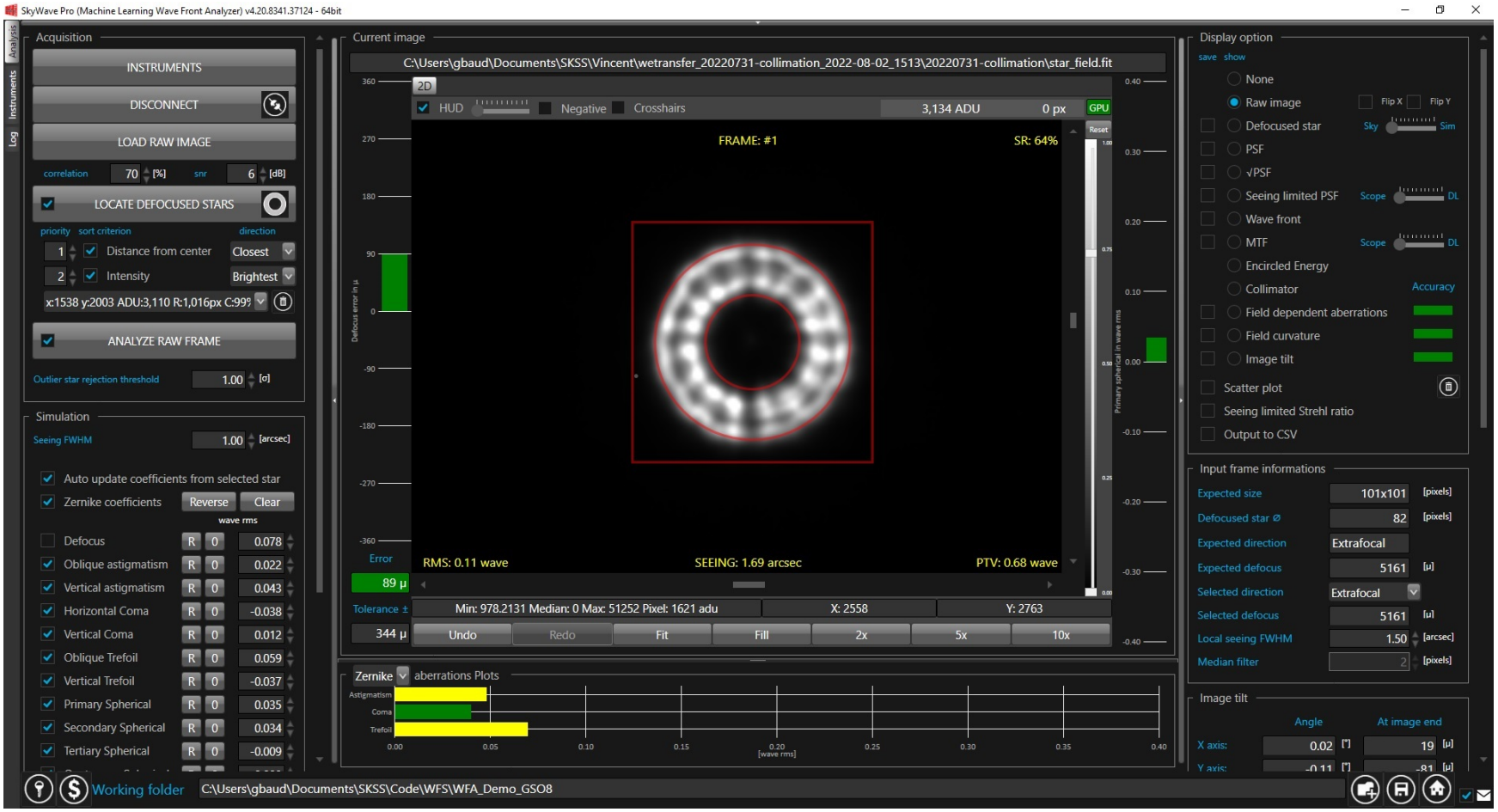

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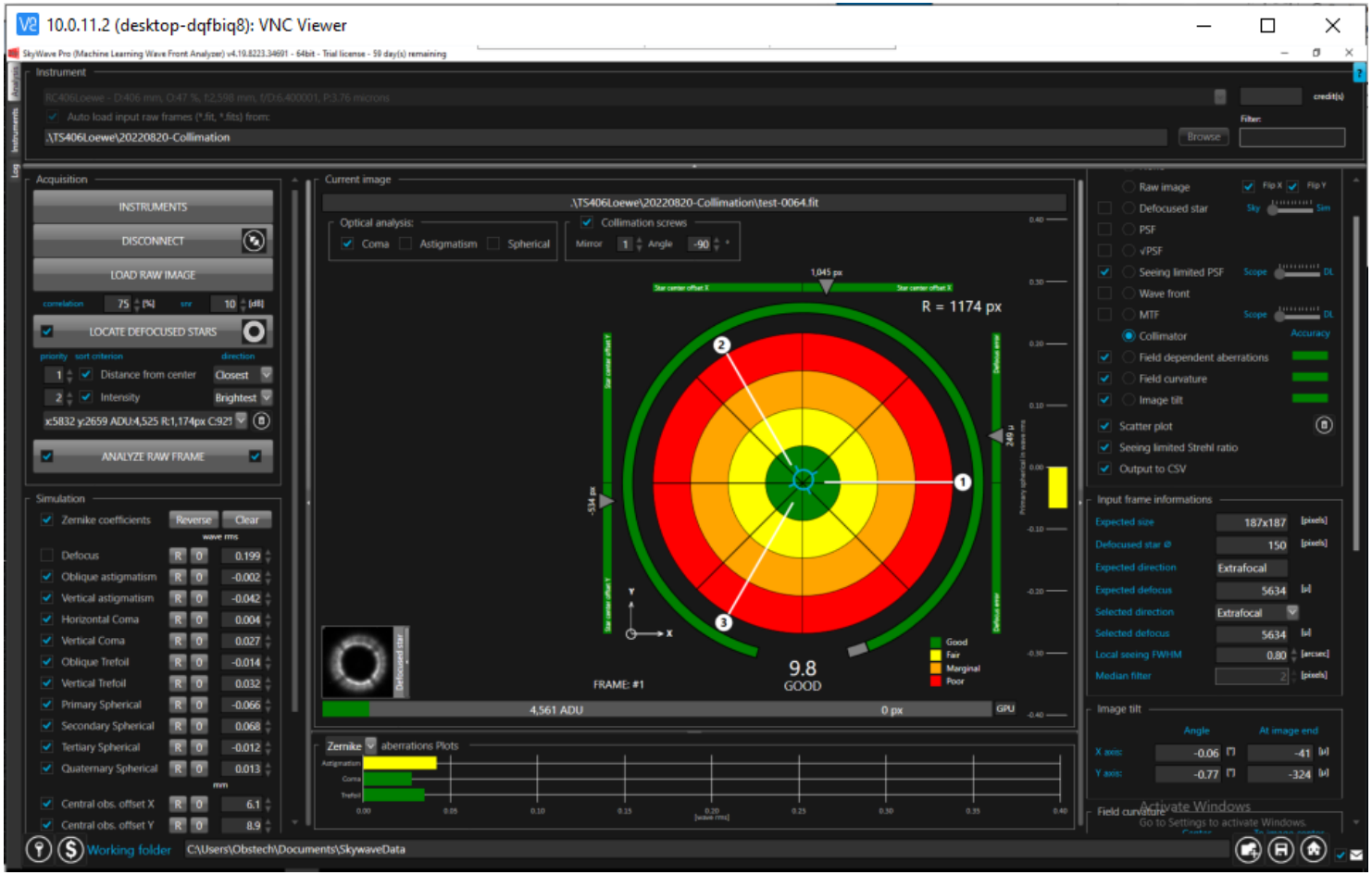

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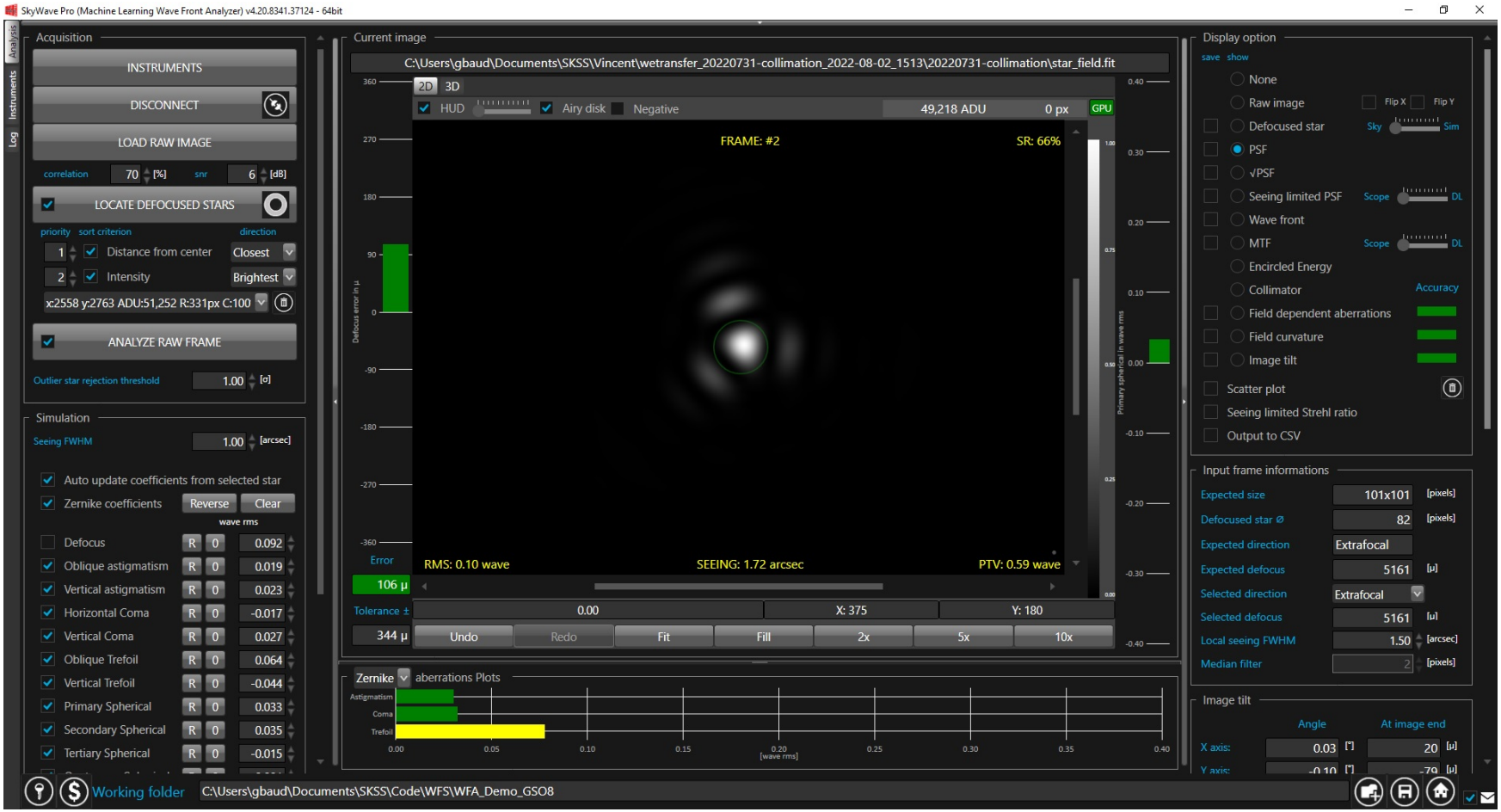

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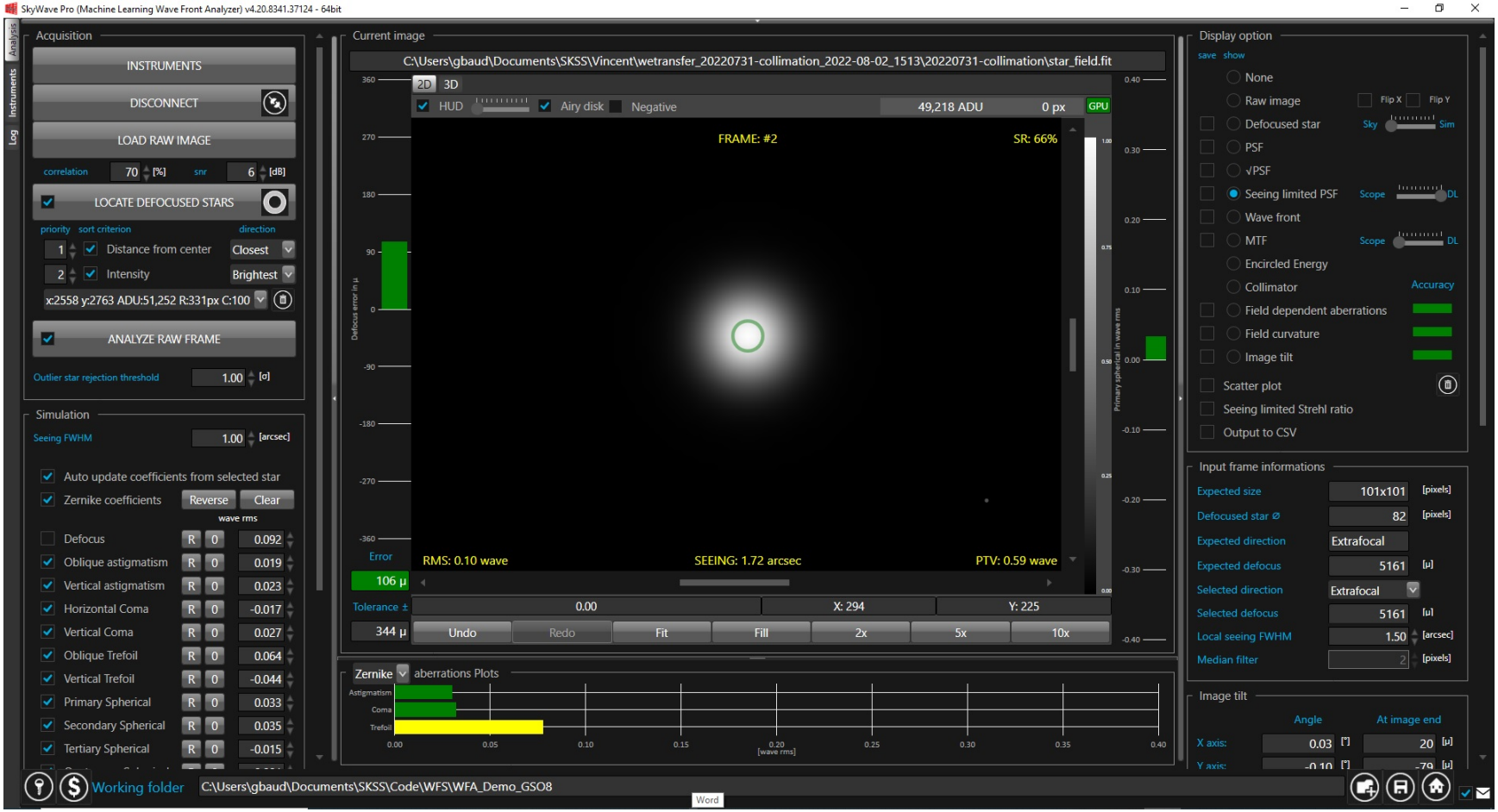

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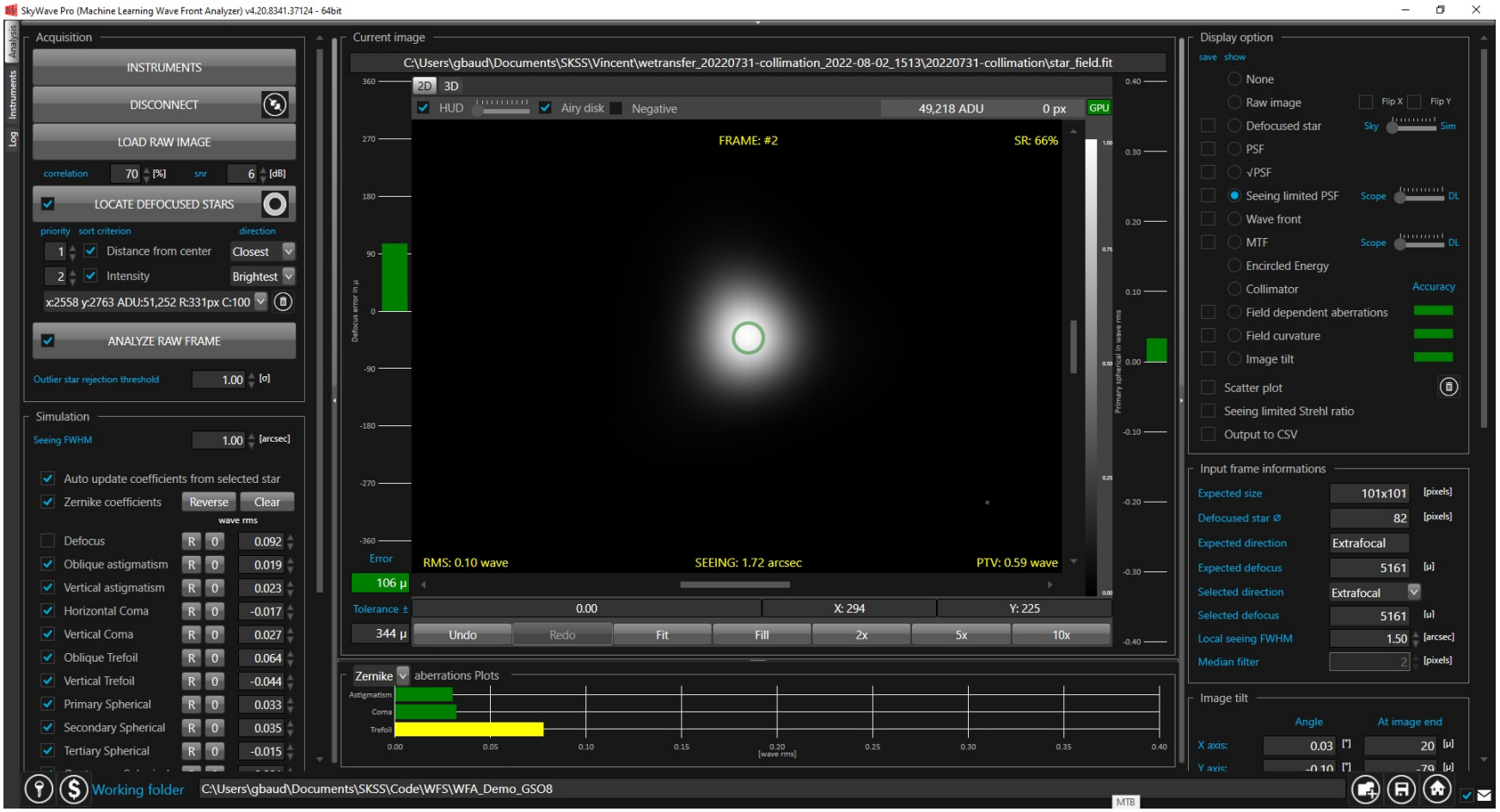

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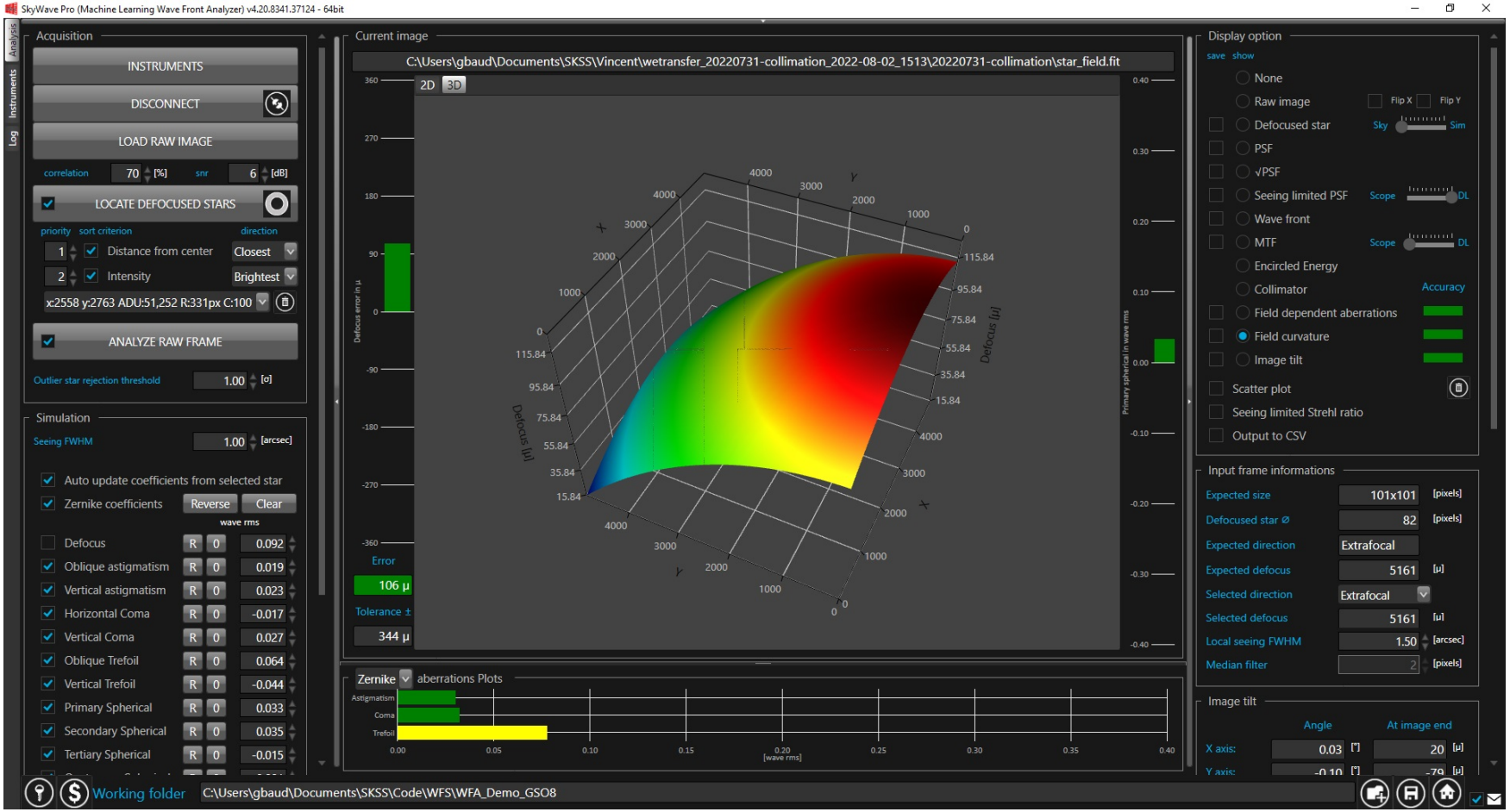

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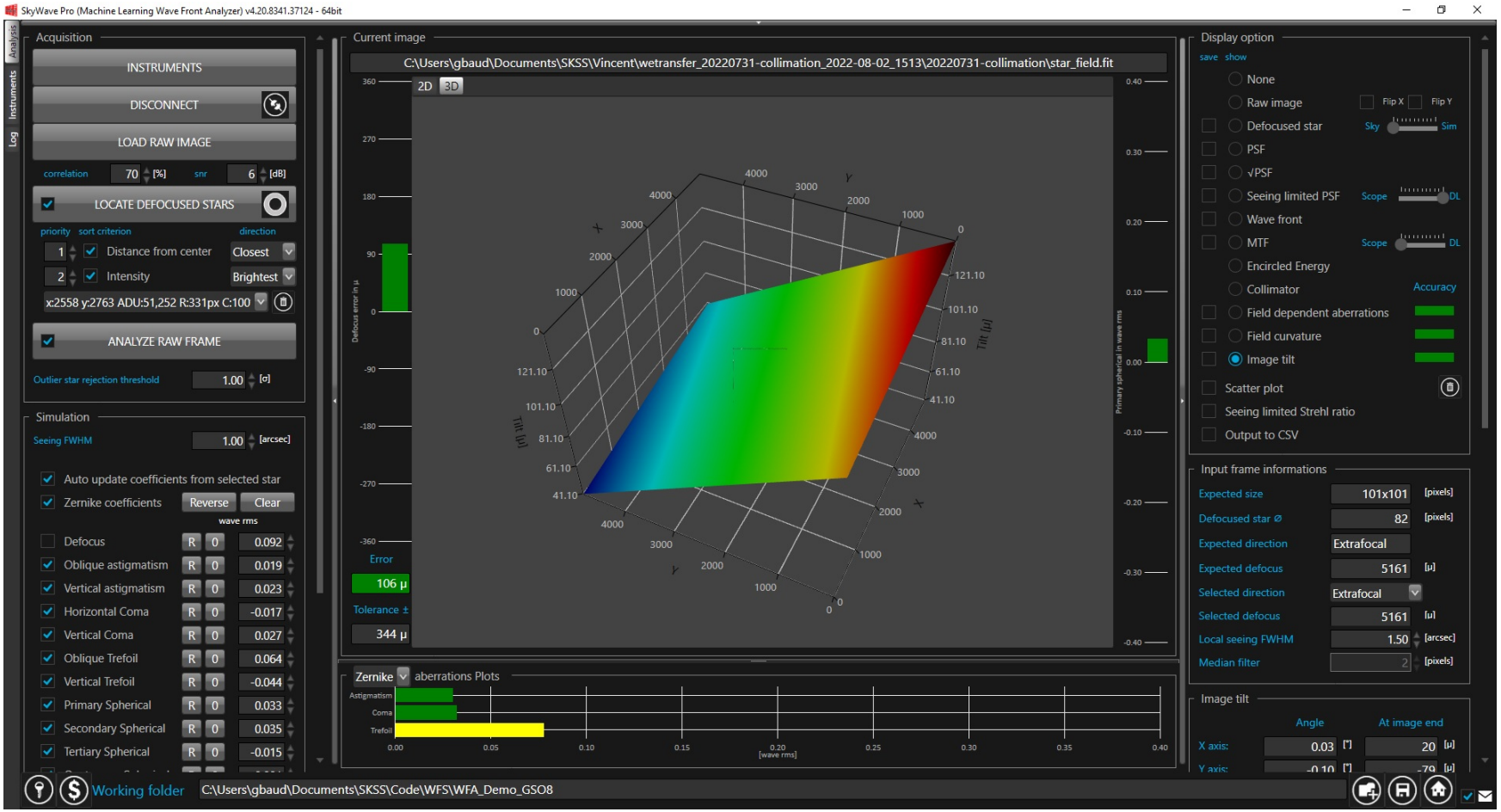

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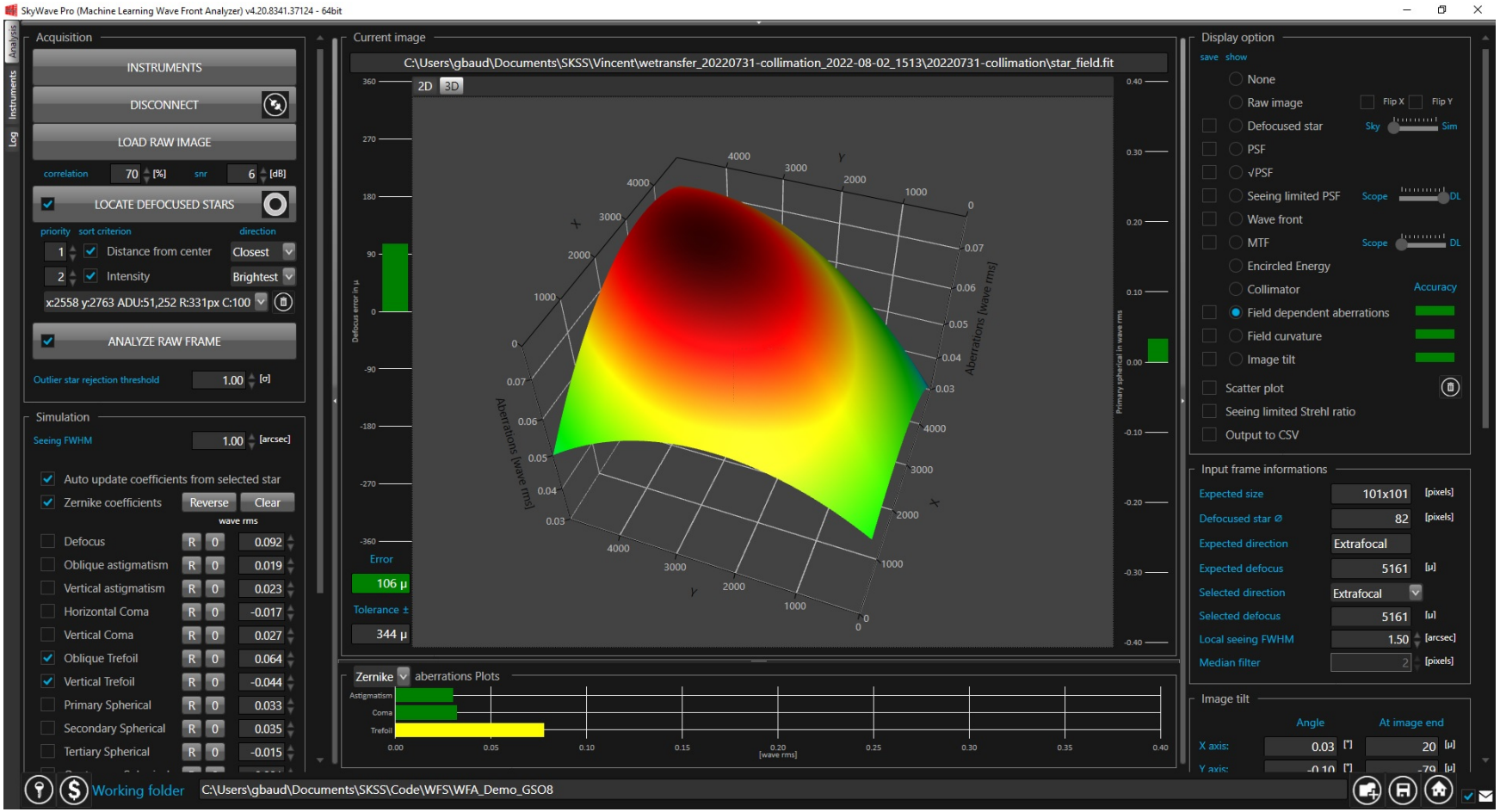

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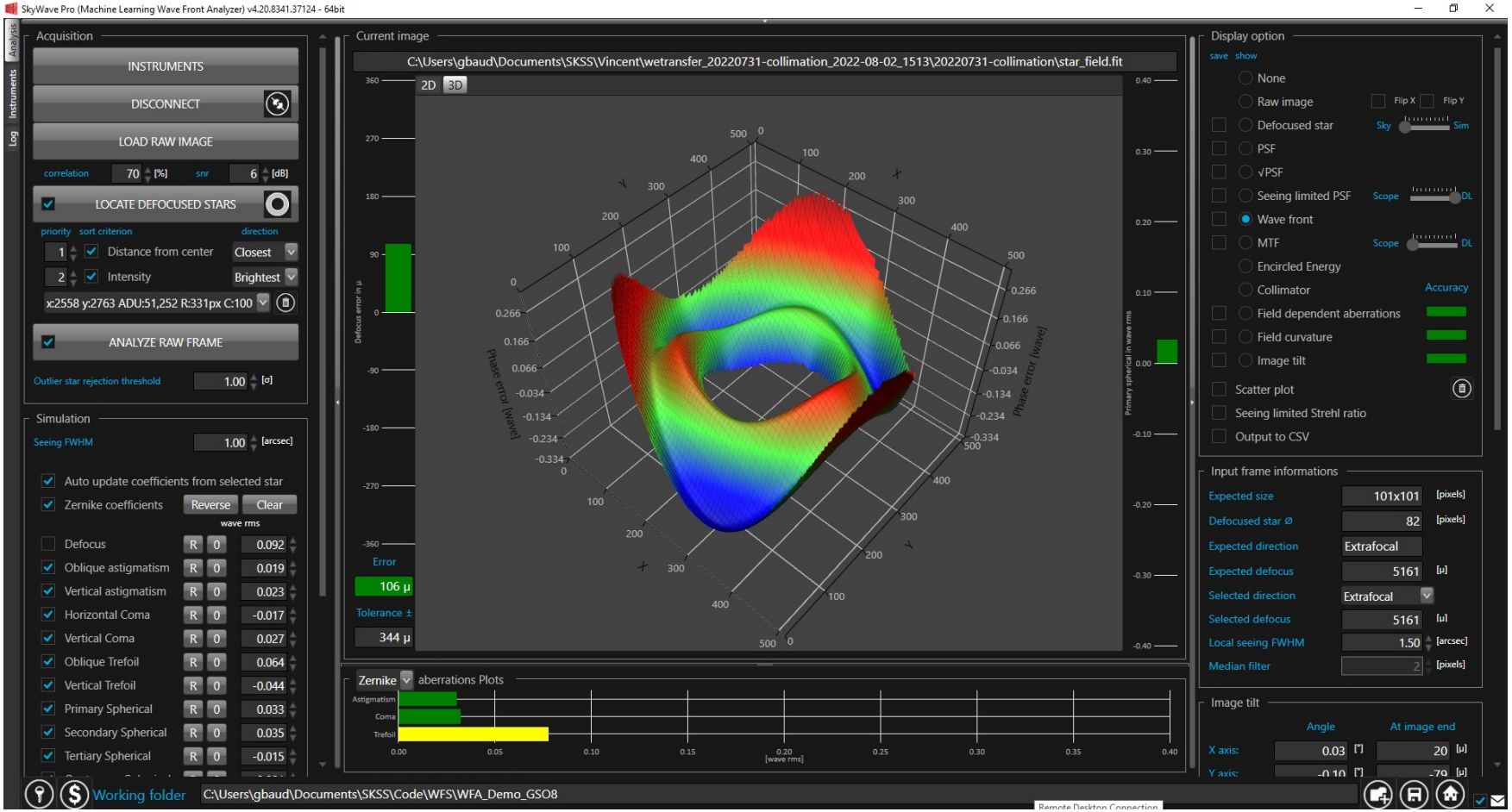

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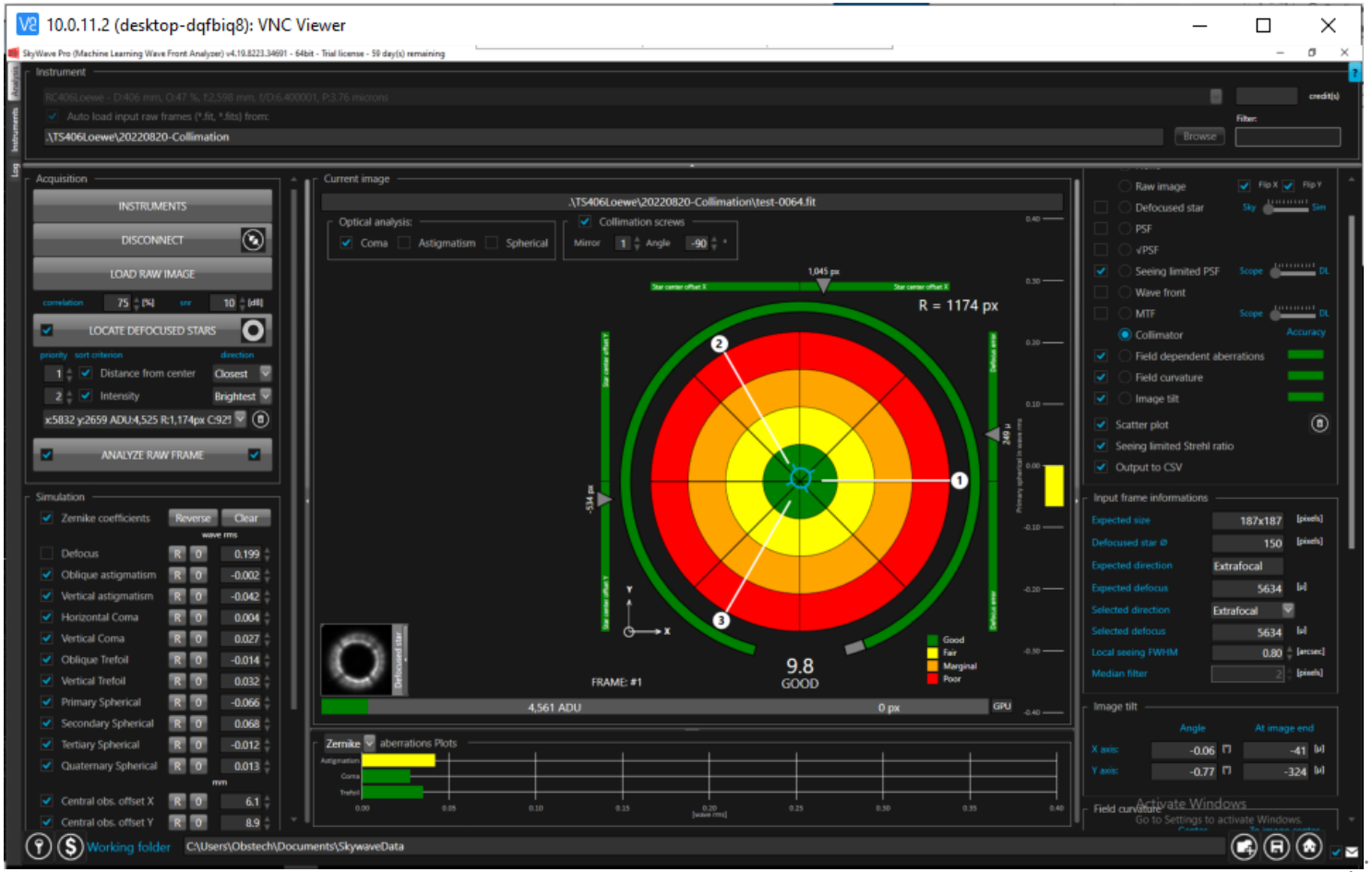

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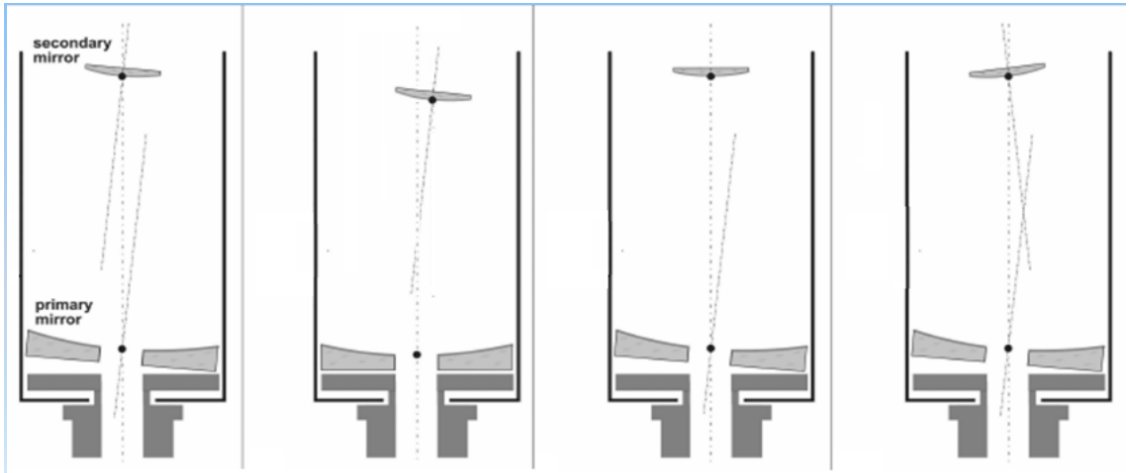

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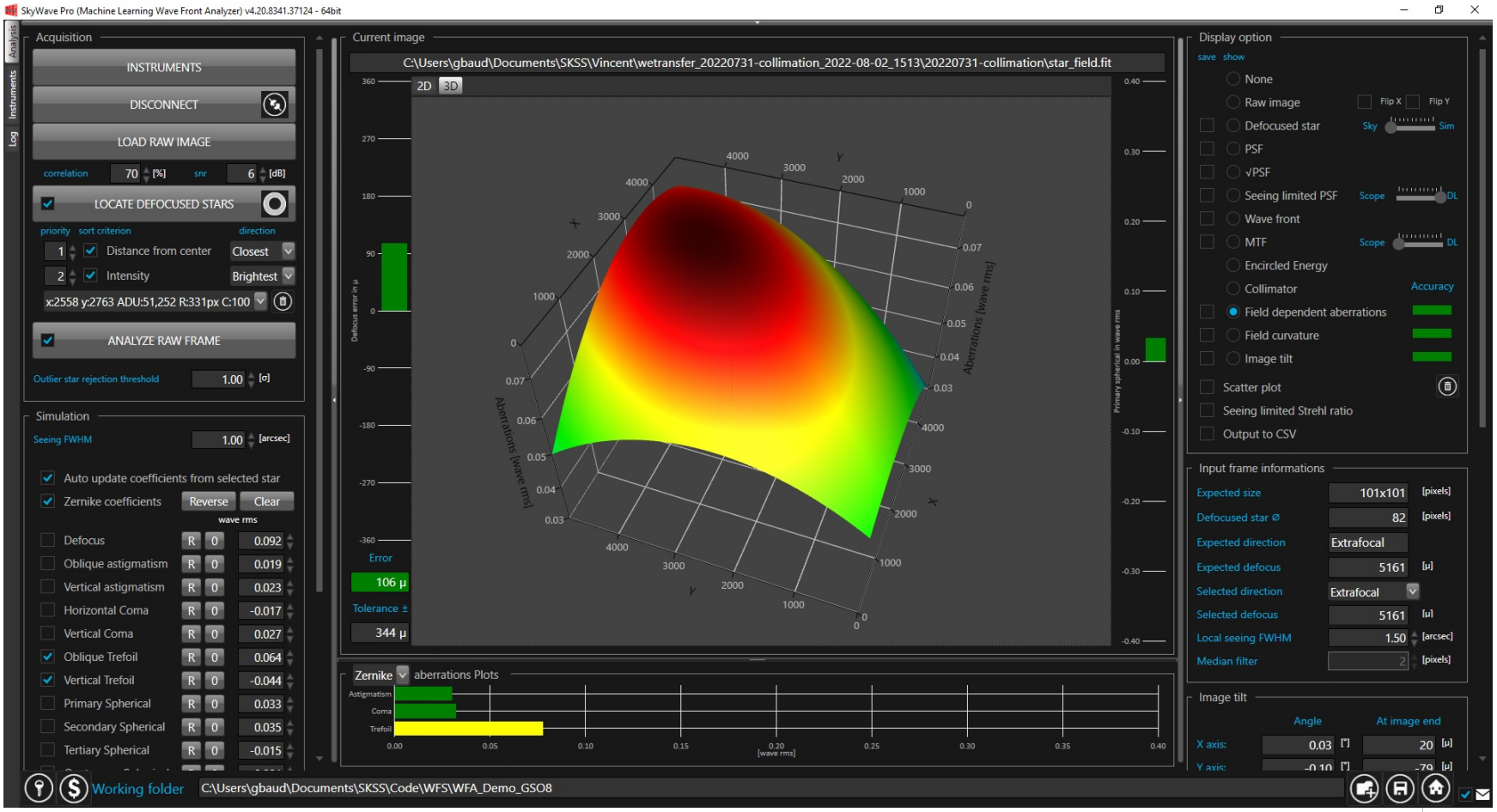
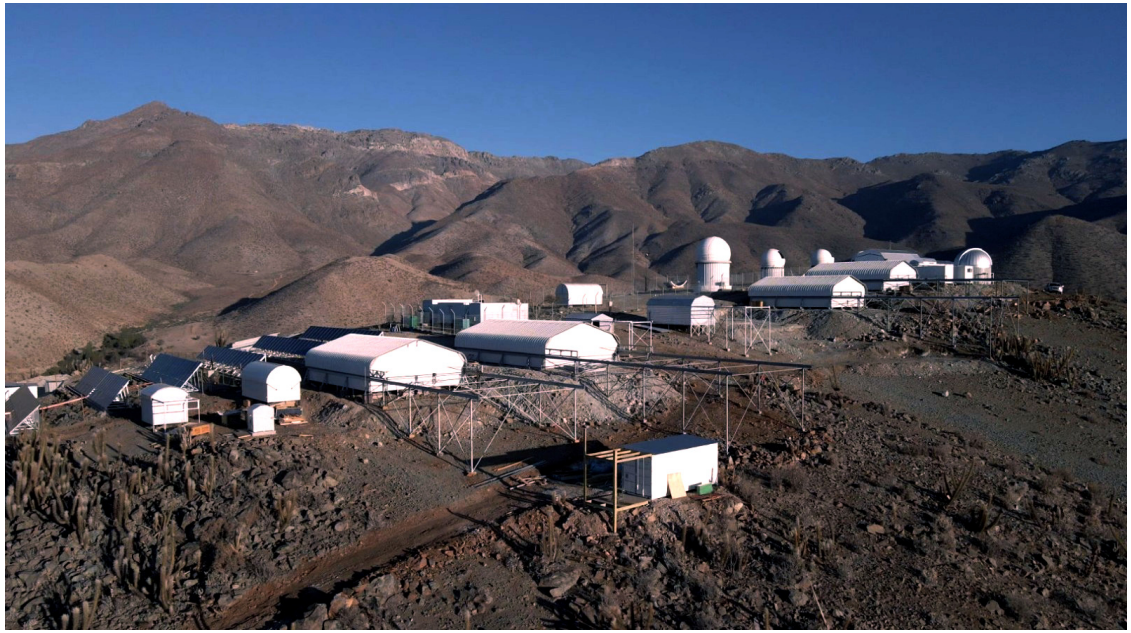


Conclusion

- Mesure quantitative
- Sensorless
- Equivalent a un Shack Hartmann
- Analyze de champ
- Possibilites d'Evolution