3D laser confinement in the eye assisted by adaptive optics: retinal imaging and surgery

by Antoine CHEN

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Co-supervisor: Serge Meimon	ONERA
Coordinator: Cyril Petit	ONERA
Coordinator: David Pureur	Quantel Medical

p2t physiologie physiopathologie thérapeutique
ÉCOLE DOCTORALE

ED394 : Physiologie, physiopathologie, thérapeutique

Quantel medical

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INSTITUT DE LA VISION
PARIS

Introduction

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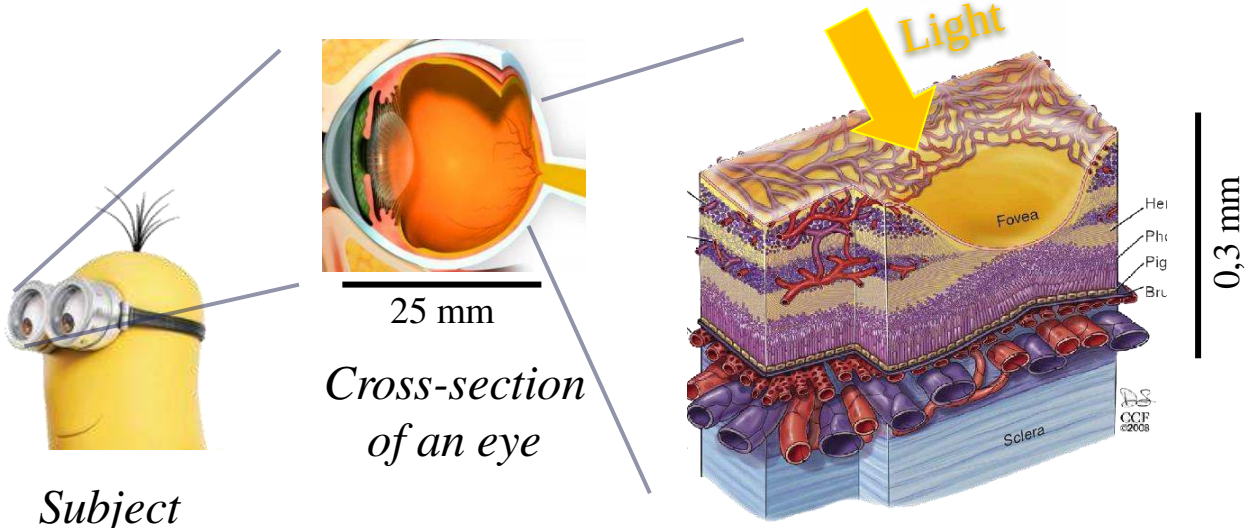

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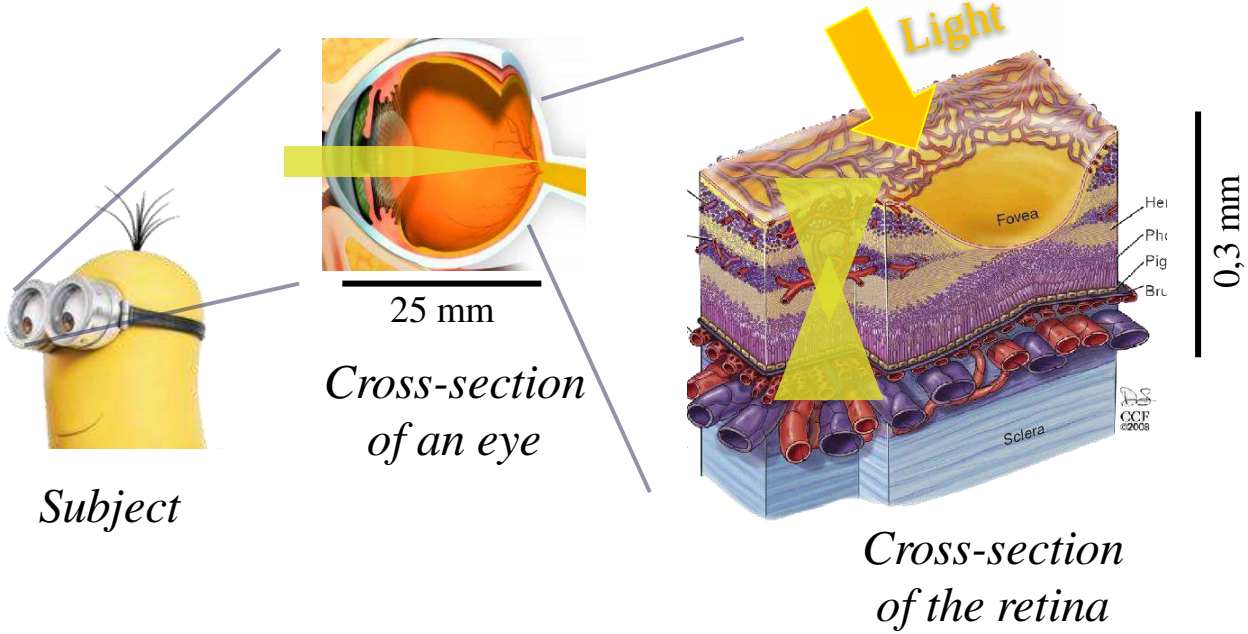

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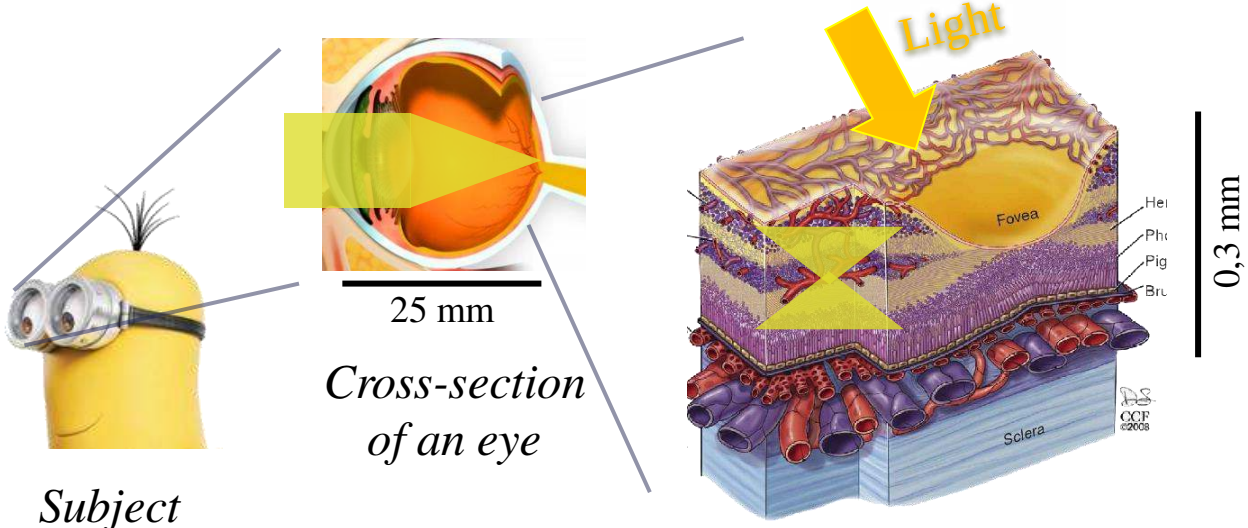

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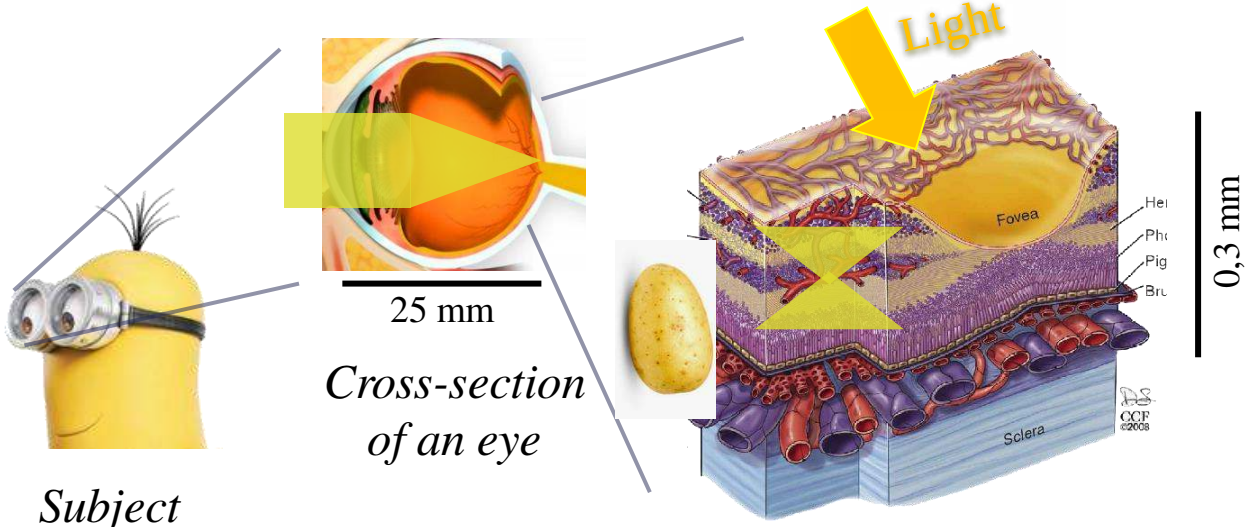

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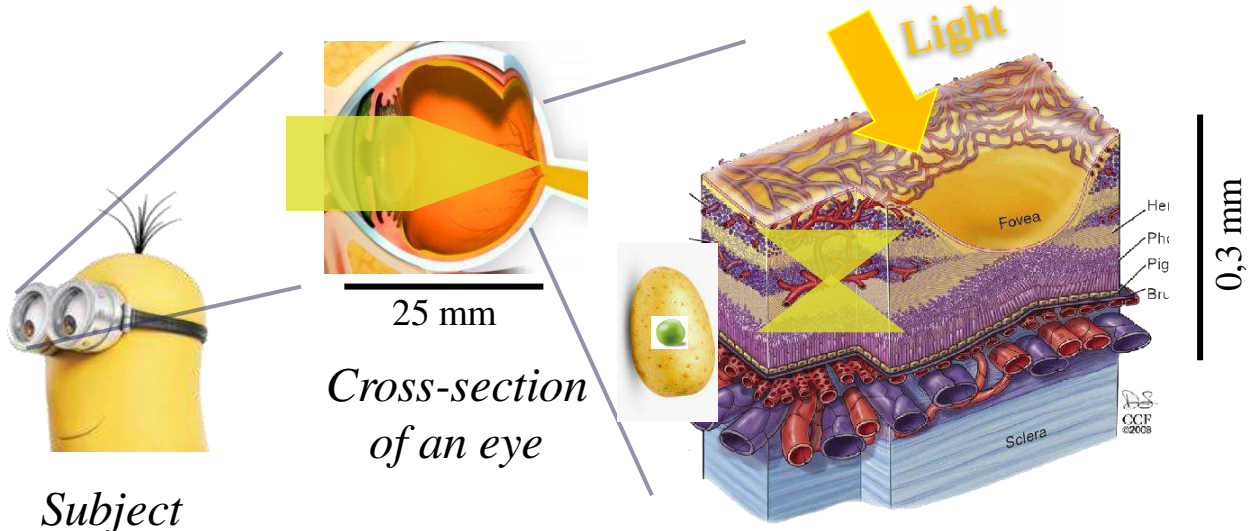

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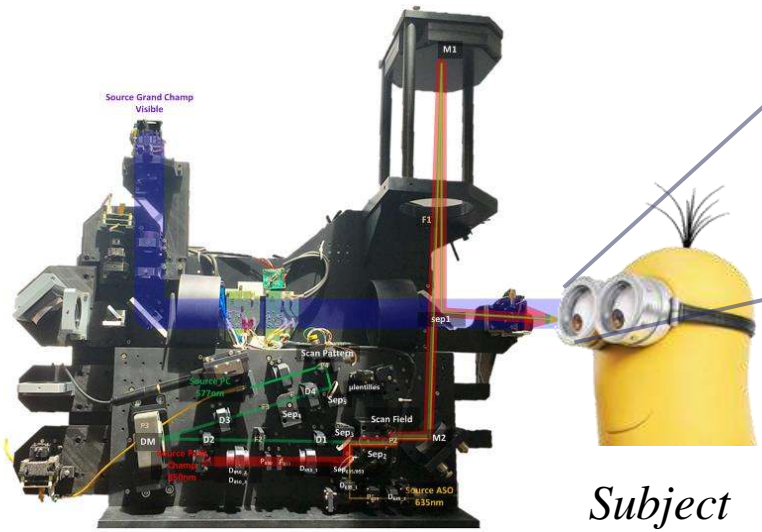
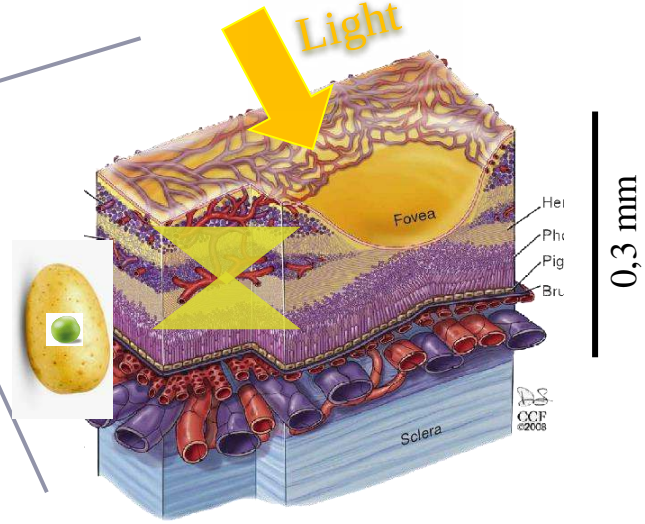


CLOVIS3D project

Subject

Cross-section of an eye



Cross-section of the retina

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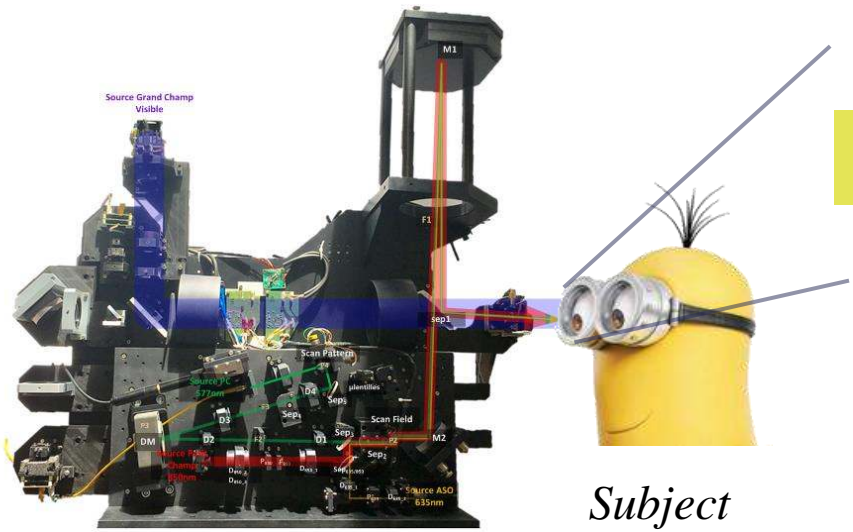

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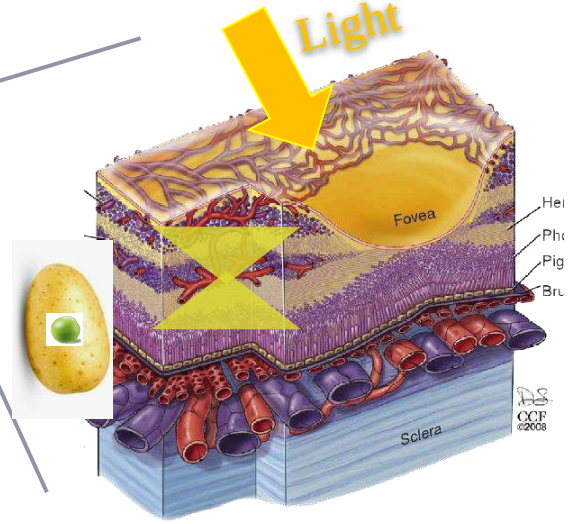

Cross-section of the retina

WHY?
Medical concerns

HOW?
Concept of AO for confinement – CLOVIS3D

WORK

Medical concerns

One of first cause of viual impairment or blindness is due to **Diabetic Macular Edema**, pathology affecting **vessels** of retina (1-2 millions en France).

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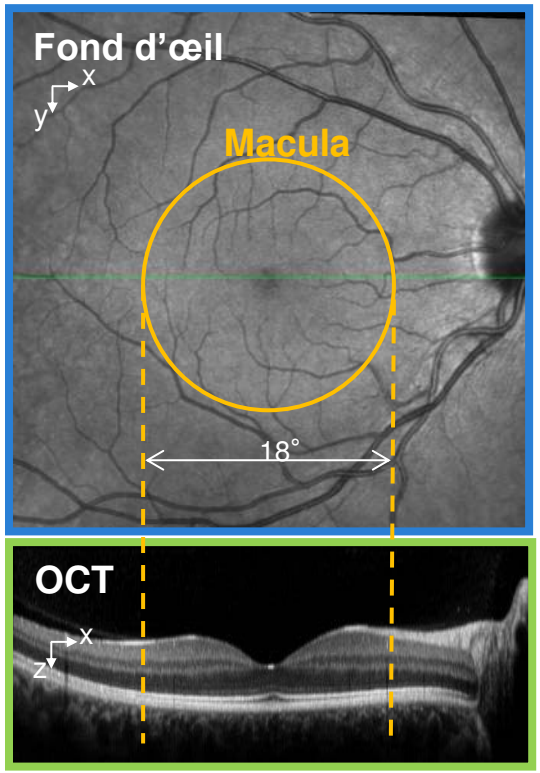
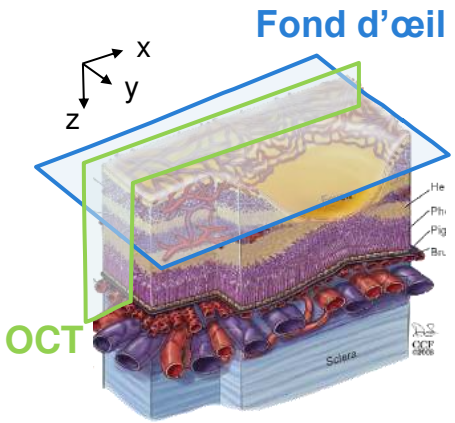


Sound retina



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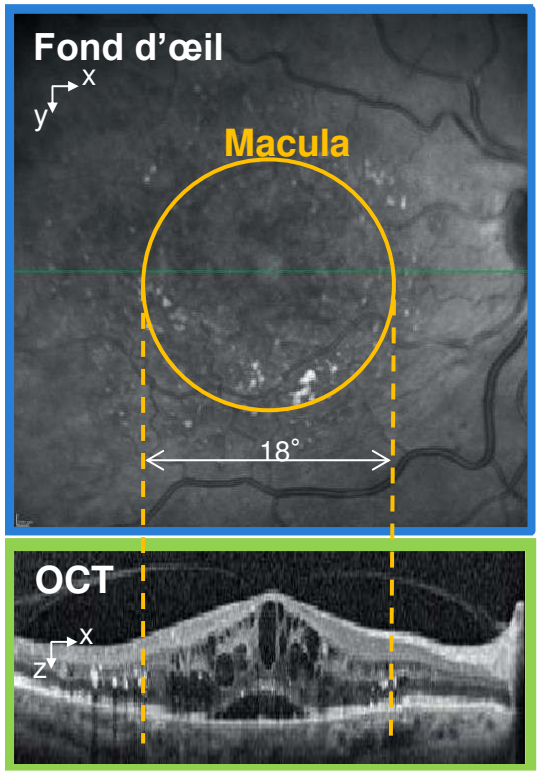

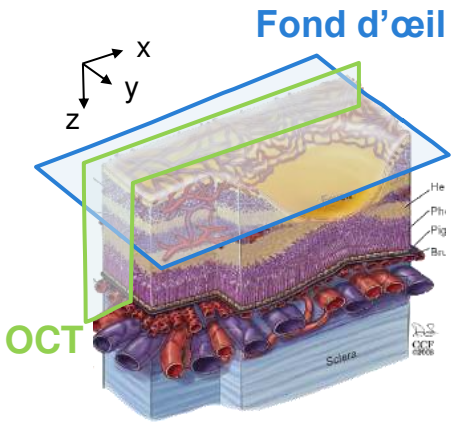

Affected retina

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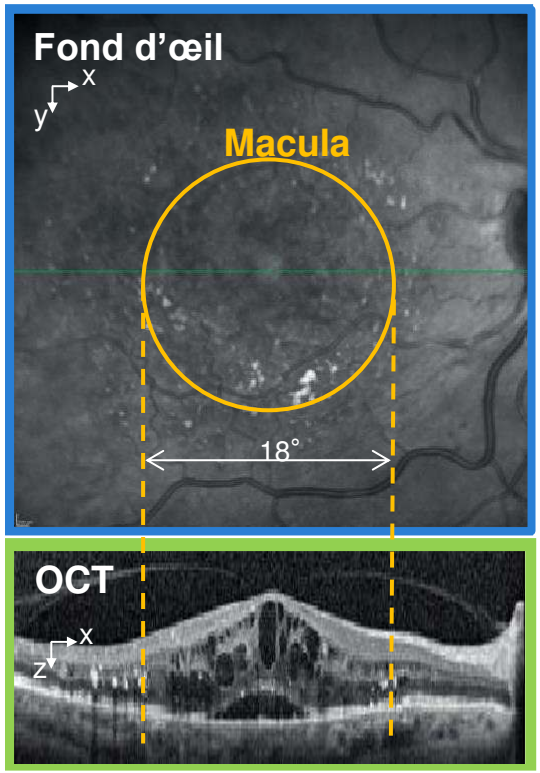

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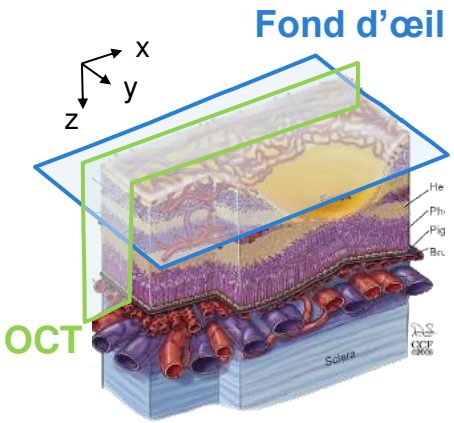

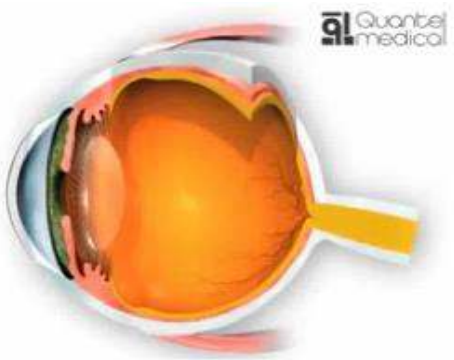

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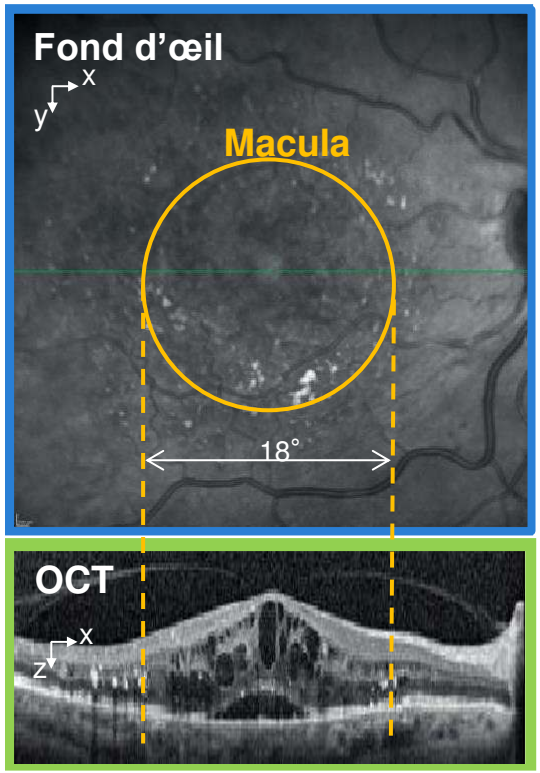

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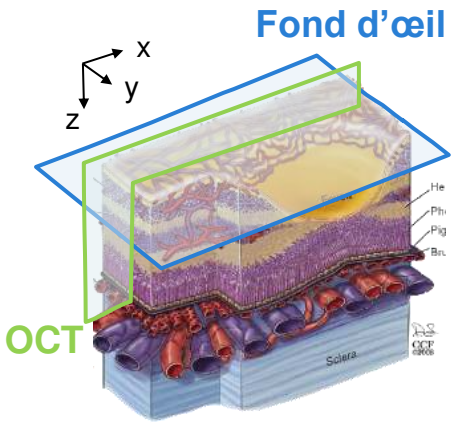

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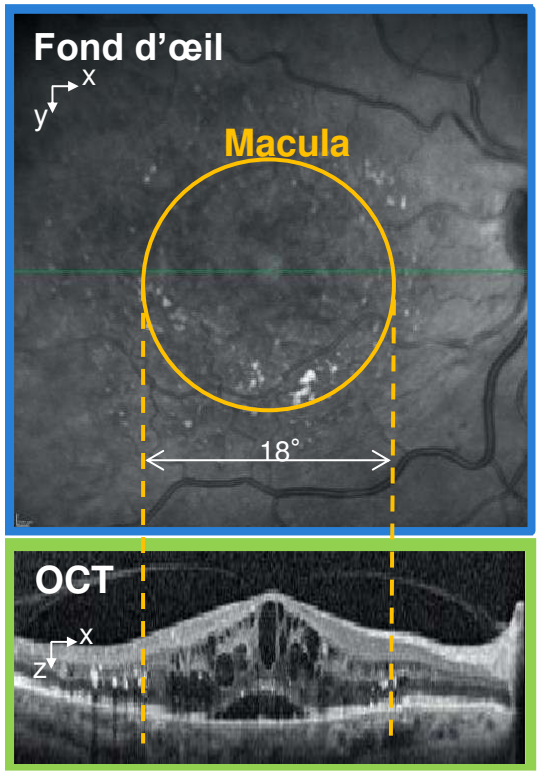

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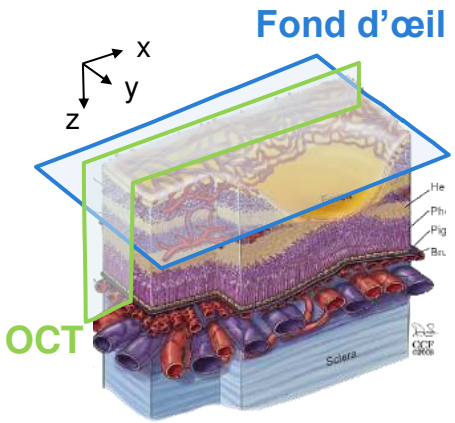

Typical evolution of a capillary macroaneurysm

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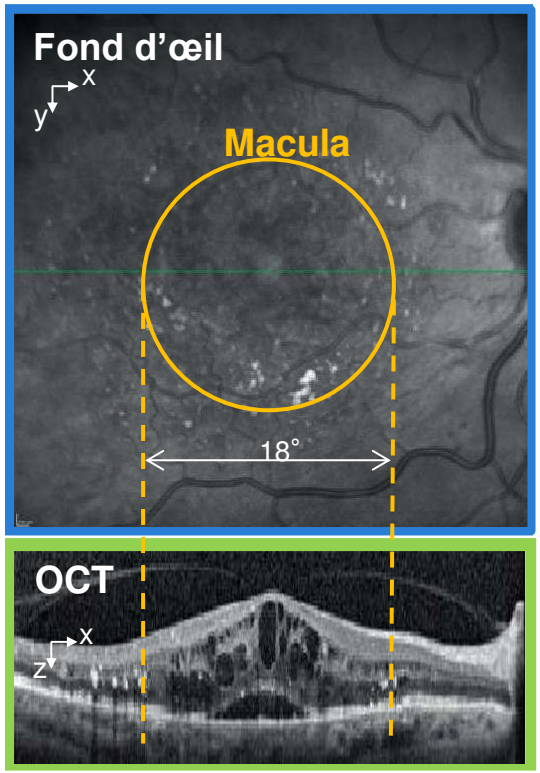

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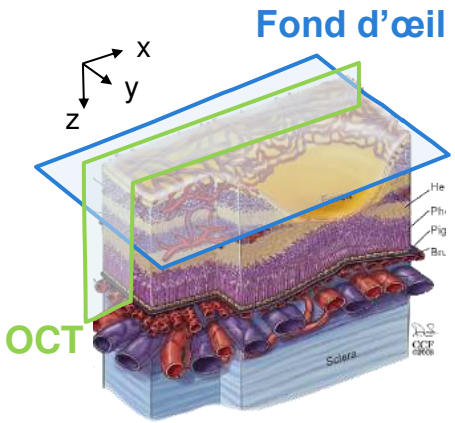

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Capillary macroaneurysm

[Images : Paques *et al.*]

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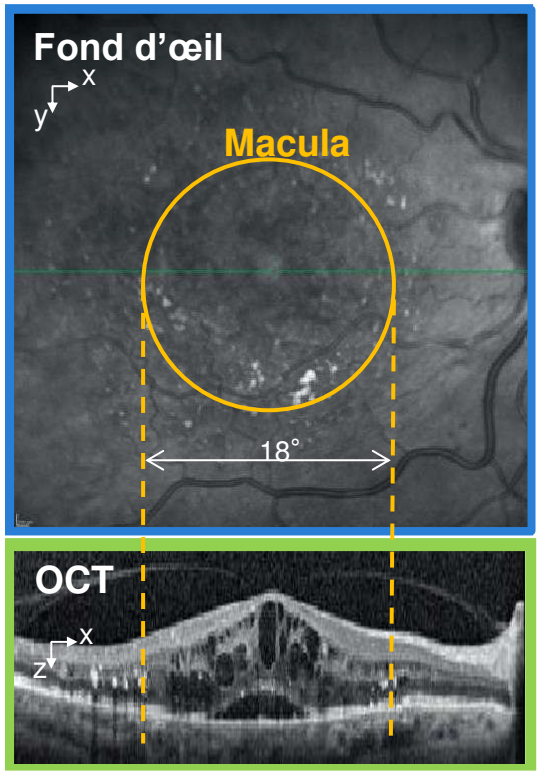

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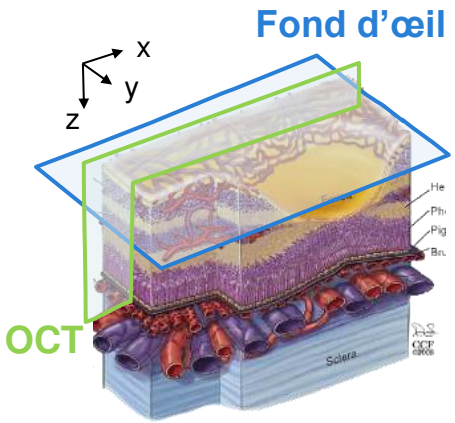

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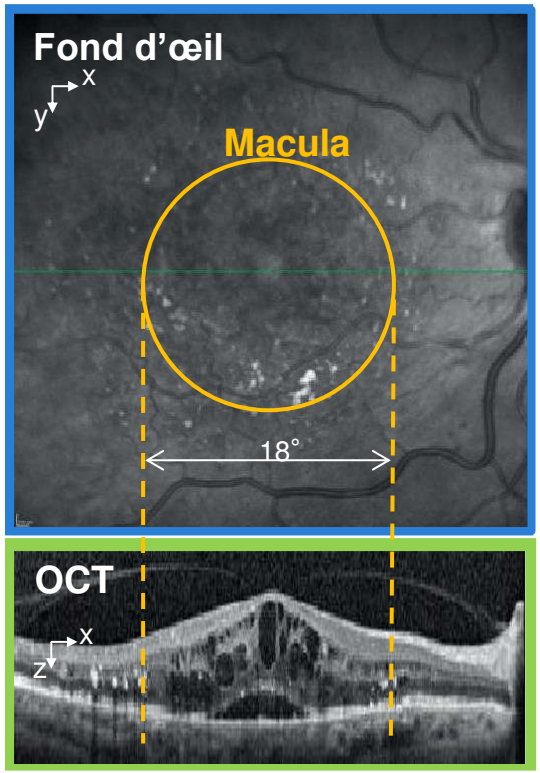

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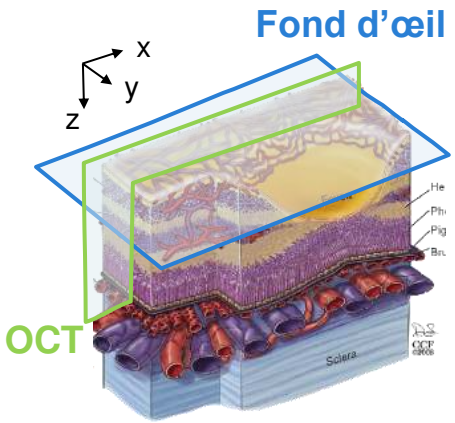

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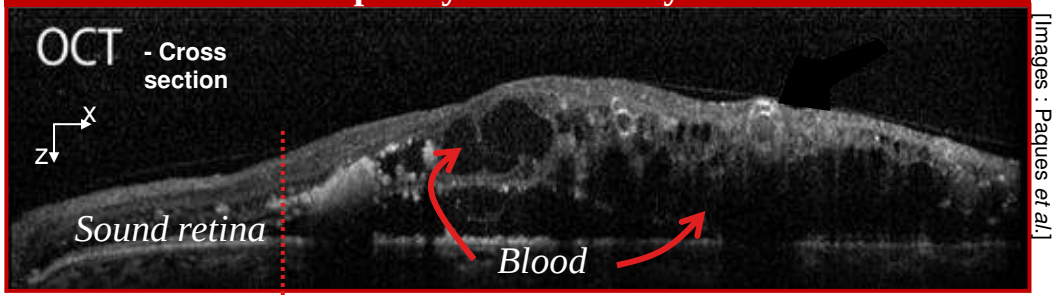

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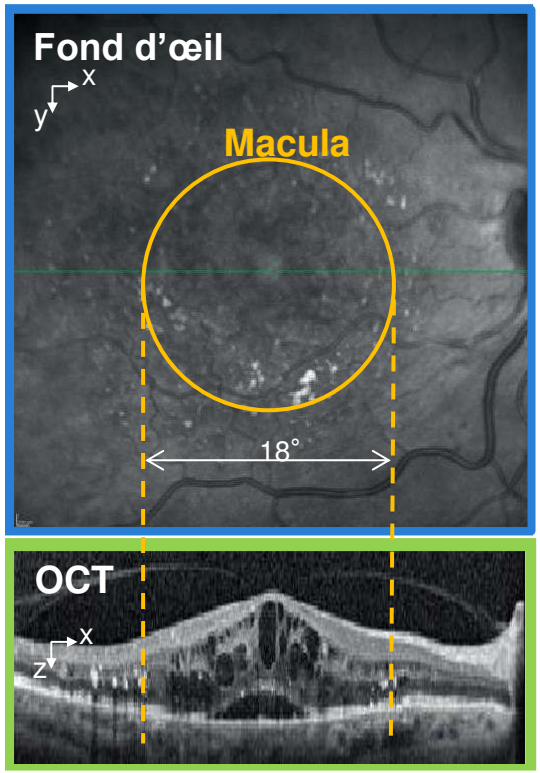

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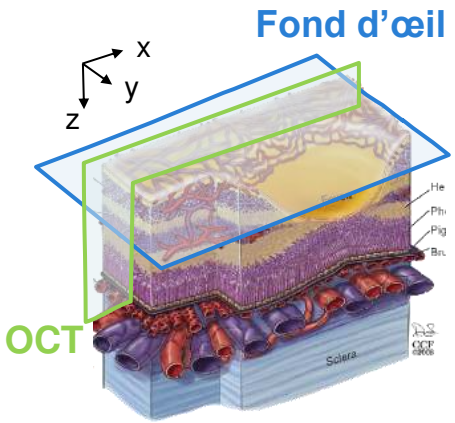

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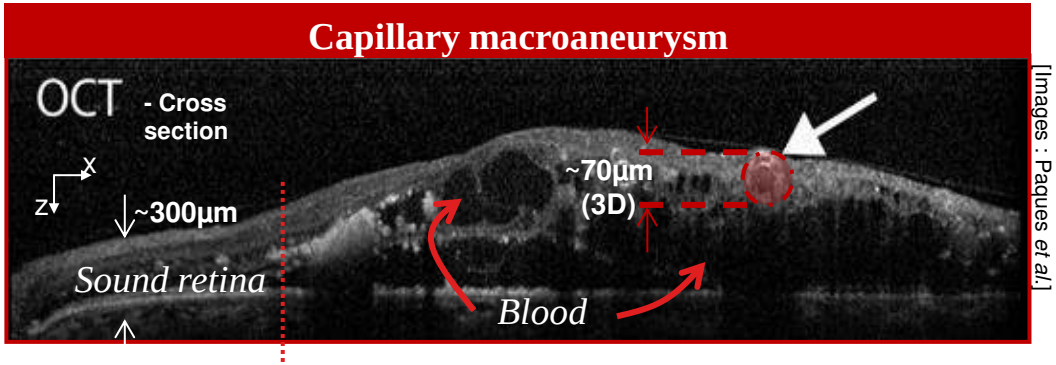

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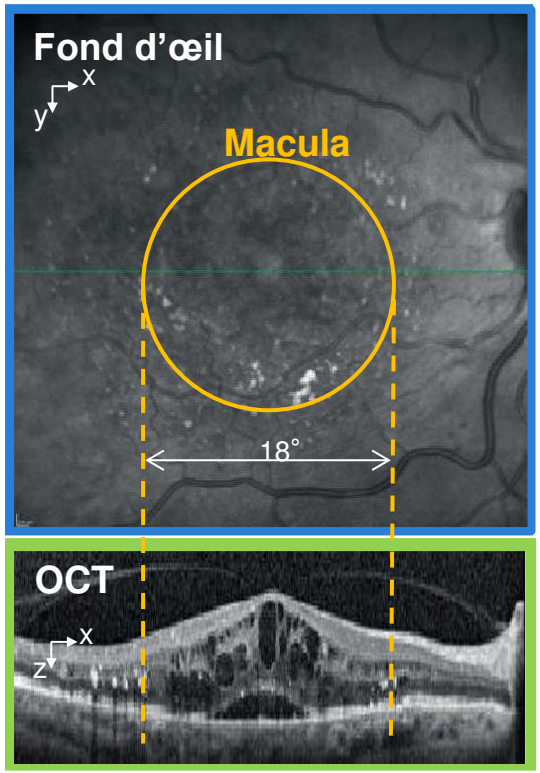

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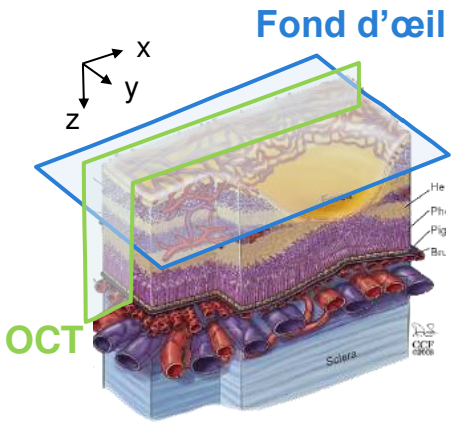
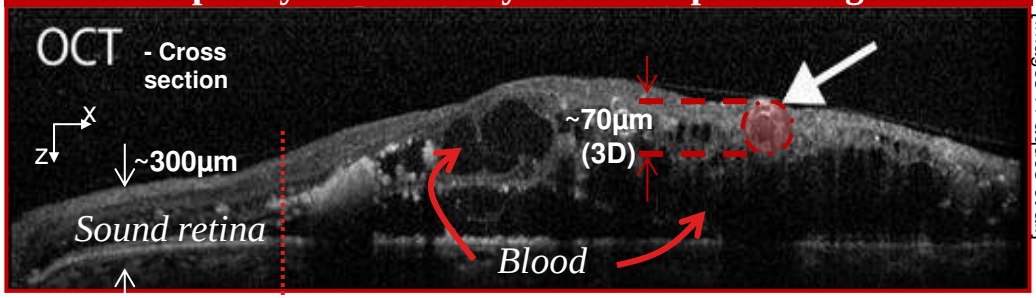


Typical evolution of a capillary macroaneurysm

Capillary macroaneurysm = therapeutic target



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Treatment

Laser photocoagulation: cauterise vessels

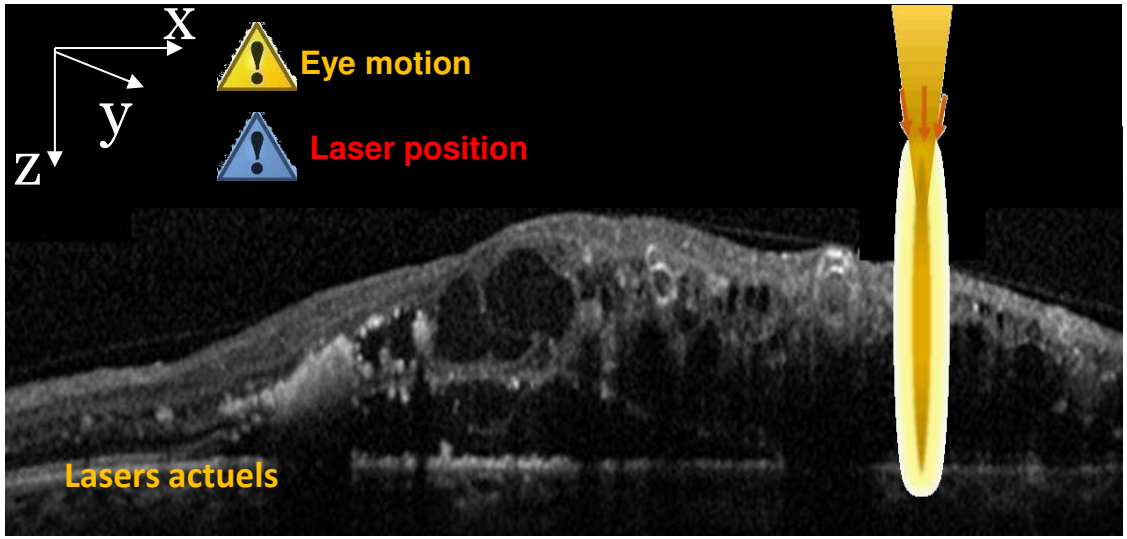
Problems and requirement

Precisely aim (in 3D) pathological areas and save sound tissues

No axial confinement

No depth control

Eye movements



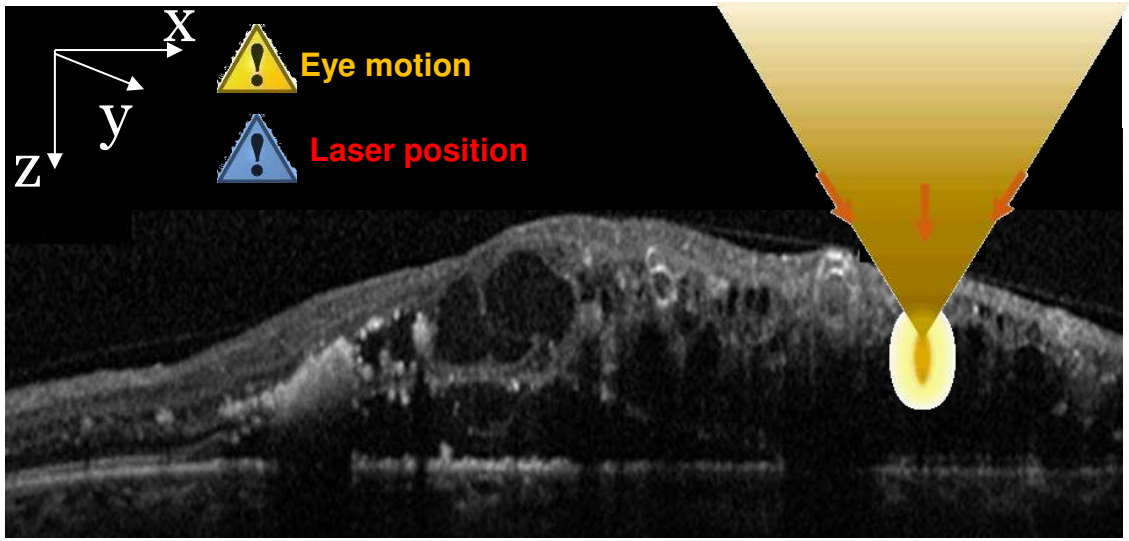
Problems and requirement

Precisely aim (in 3D) pathological areas and save sound tissues

1 3D confinement

No depth control

Eye movements



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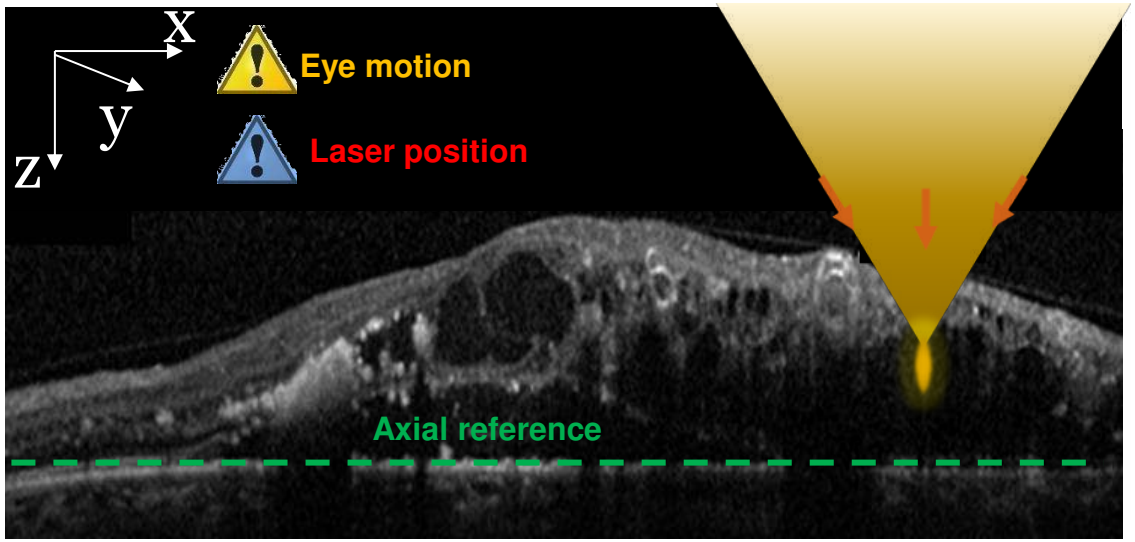
Problems and requirement

Precisely aim (in 3D) pathological areas and save sound tissues

1. 3D confinement
2. Depth stabilisation

Eye movements



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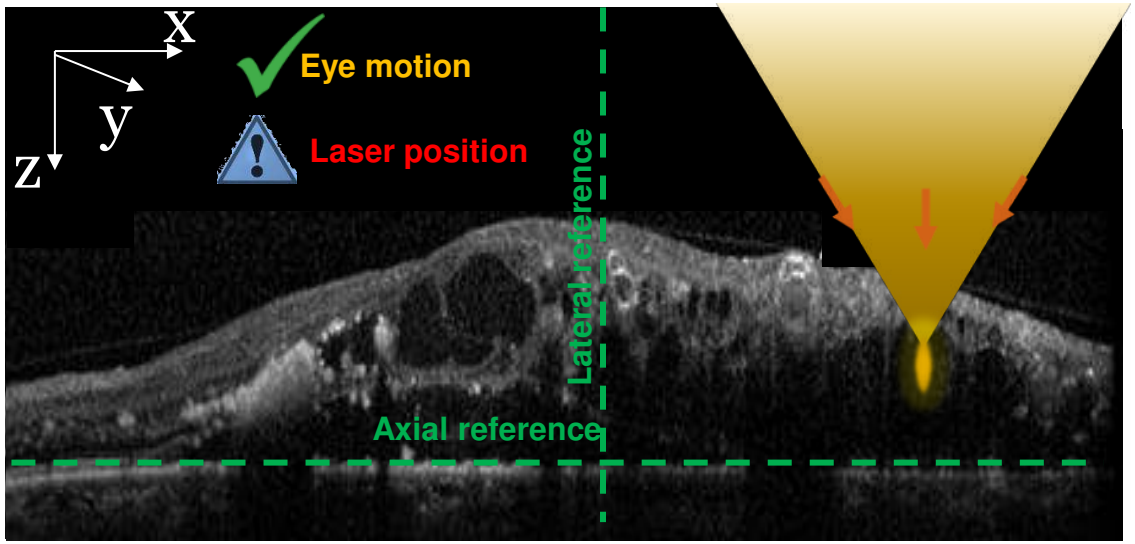
Problems and requirement

Precisely aim (in 3D) pathological areas and save sound tissues

1. 3D confinement
2. Depth stabilisation
3. 2D stabilisation



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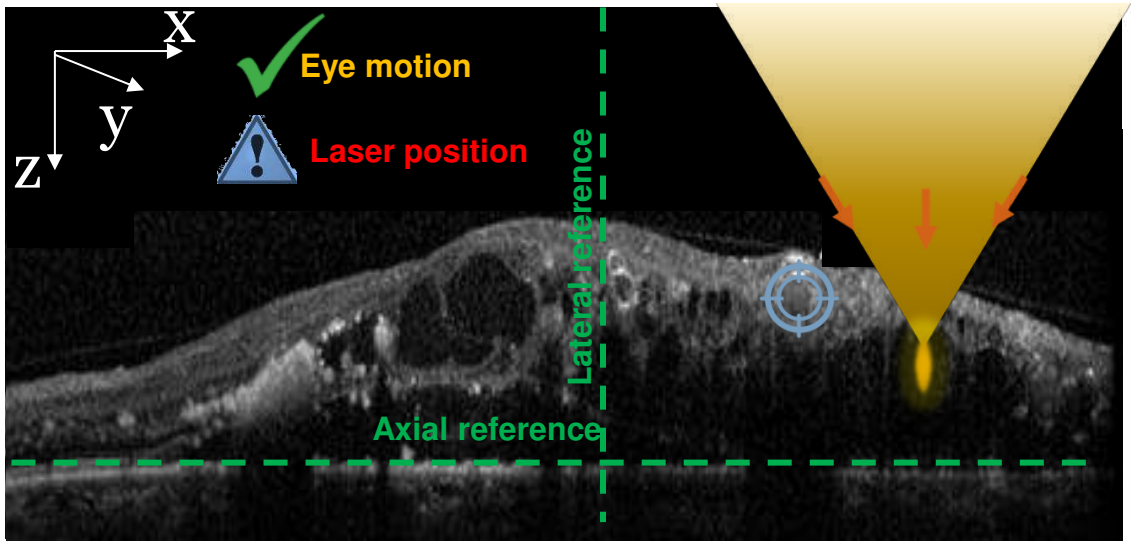
Problems and requirement

Precisely aim (in 3D) pathological areas and save sound tissues

1. 3D confinement
2. Depth stabilisation
3. 2D stabilisation
4. Target identification



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Problems and requirement

Precisely aim (in 3D) pathological areas and save sound tissues

1. 3D confinement
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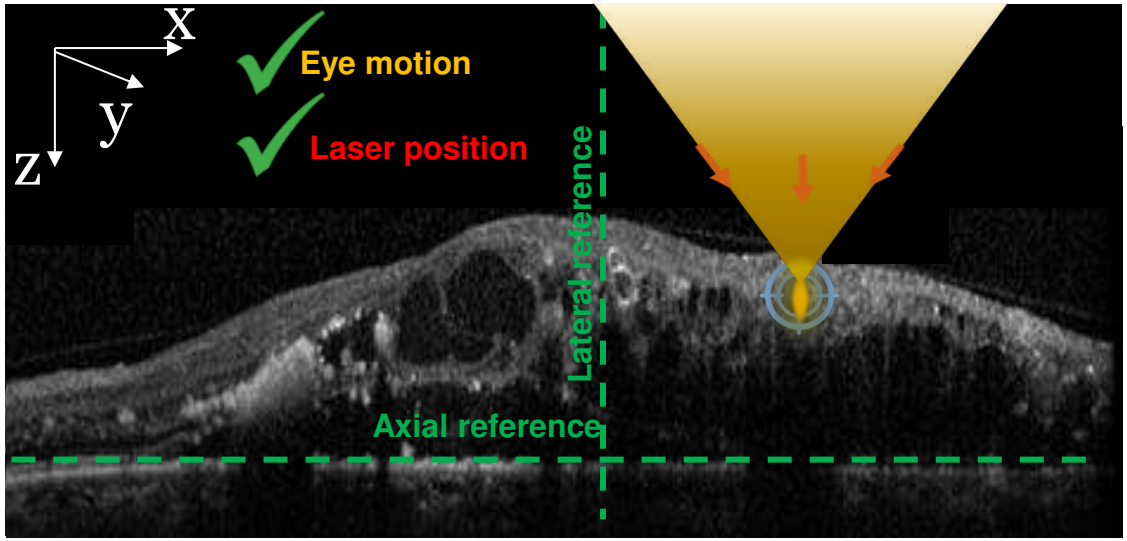
4. Target identification
5. 3D laser positioning



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Problems and requirement

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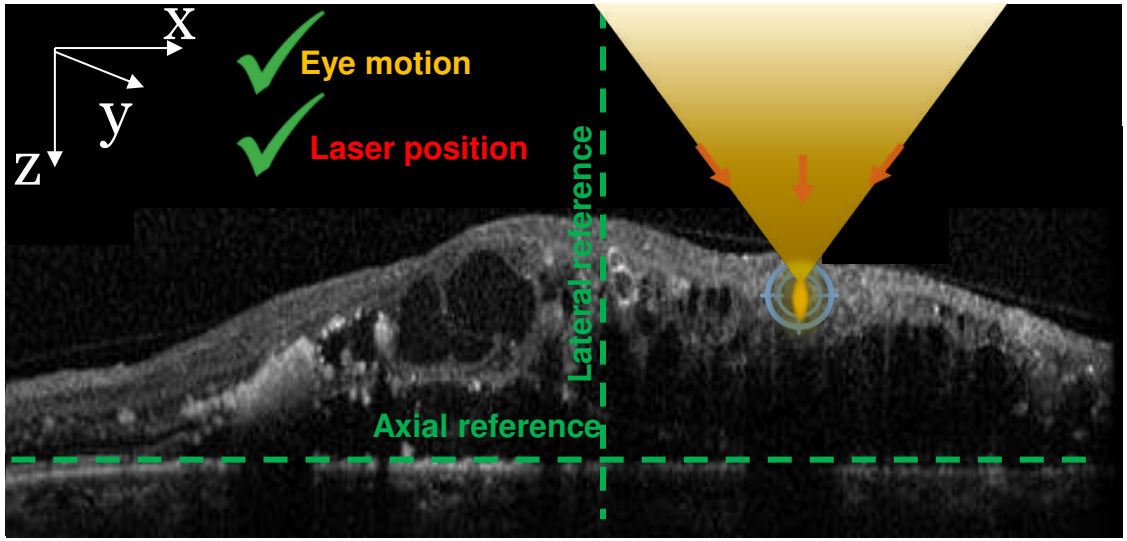
5. 3D laser positioning

Laser impact



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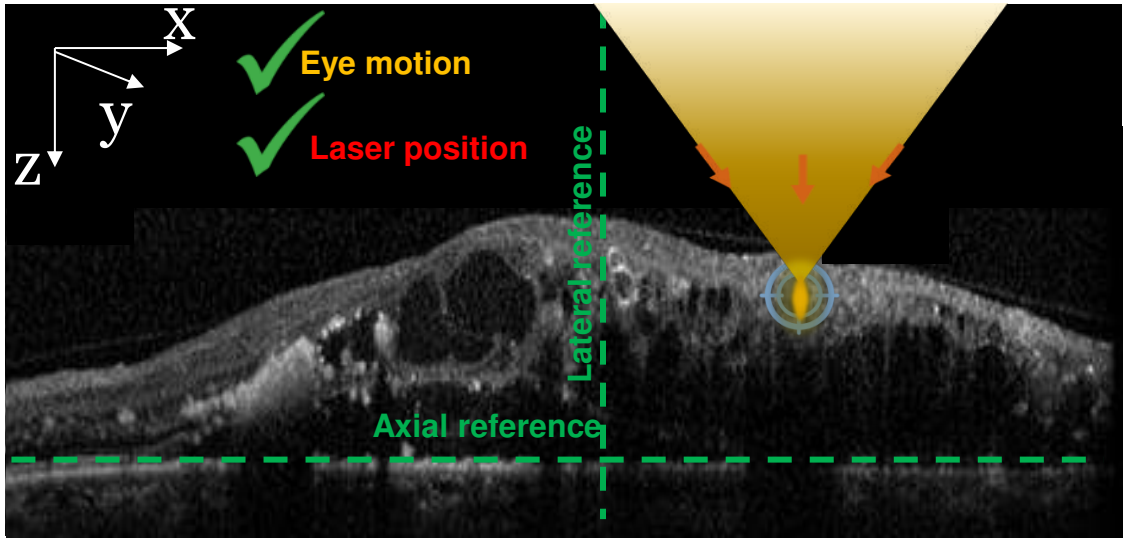

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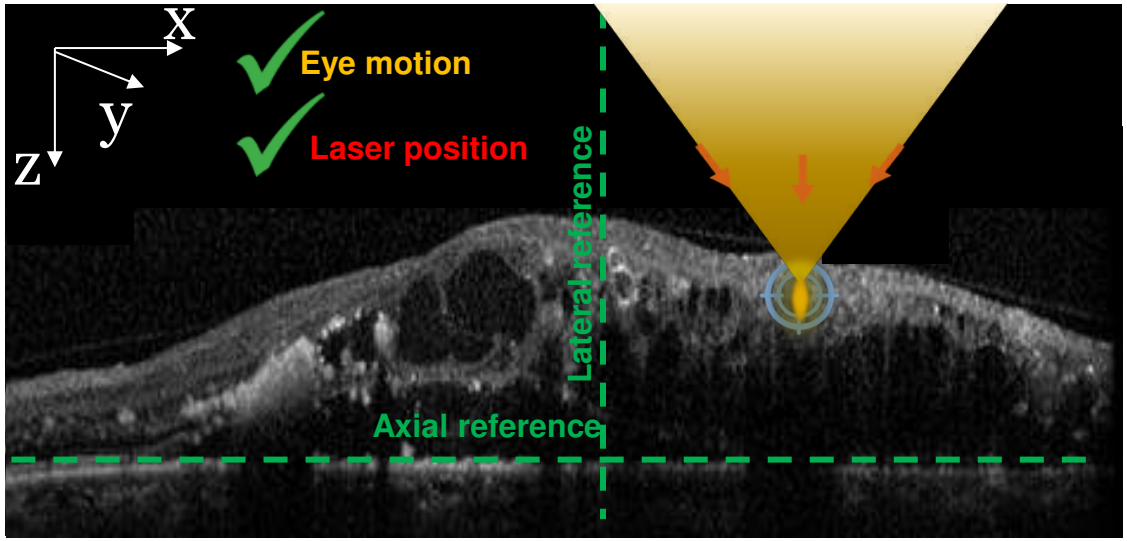

CLOVIS3D project objectives

Problems and requirement

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2. Depth stabilisation
3. 2D stabilisation
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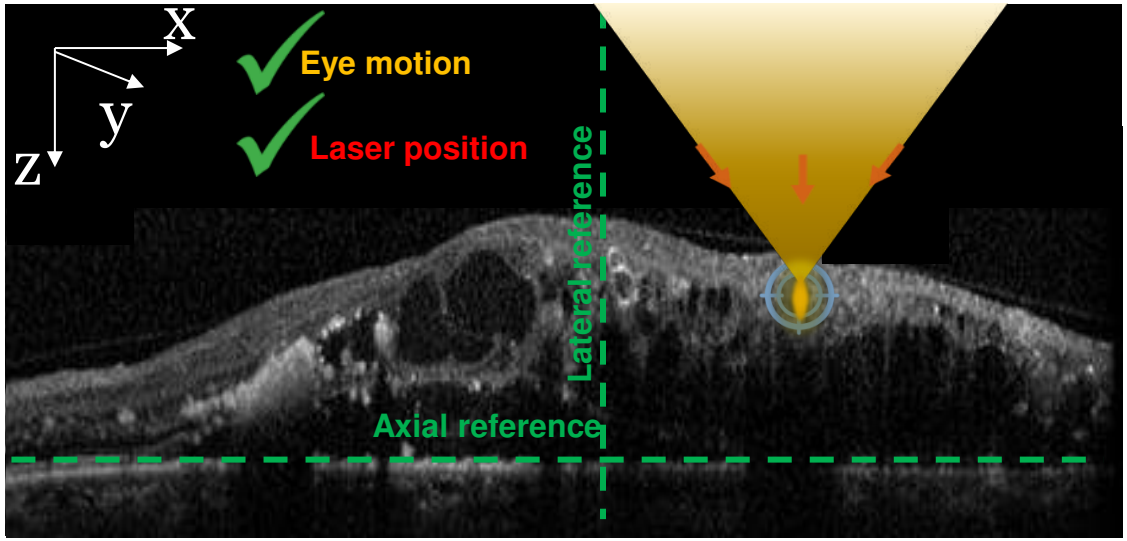
5. 3D laser positioning

Laser impact



CLOVIS3D project objectives

How?
Tools?

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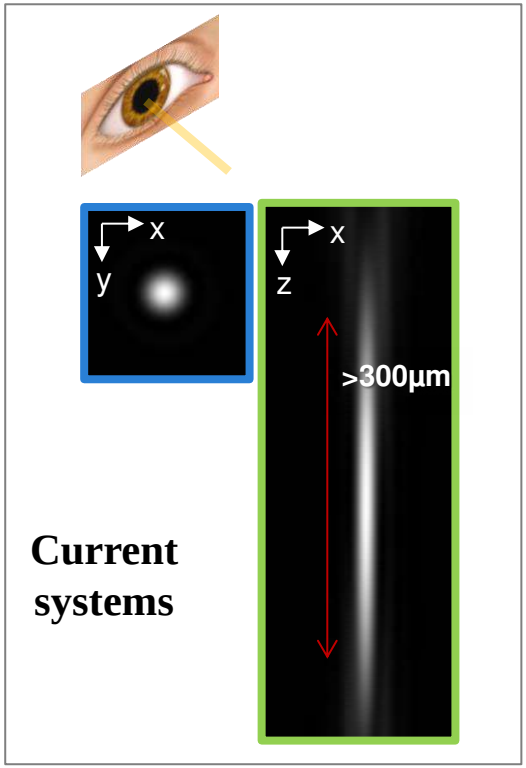
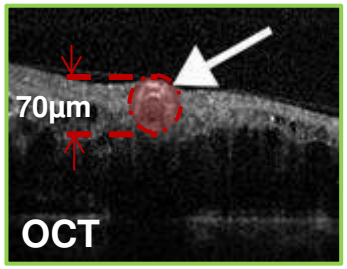
Confinement and ocular aberrations

1 3D confinement

Confinement and ocular aberrations

1 3D confinement





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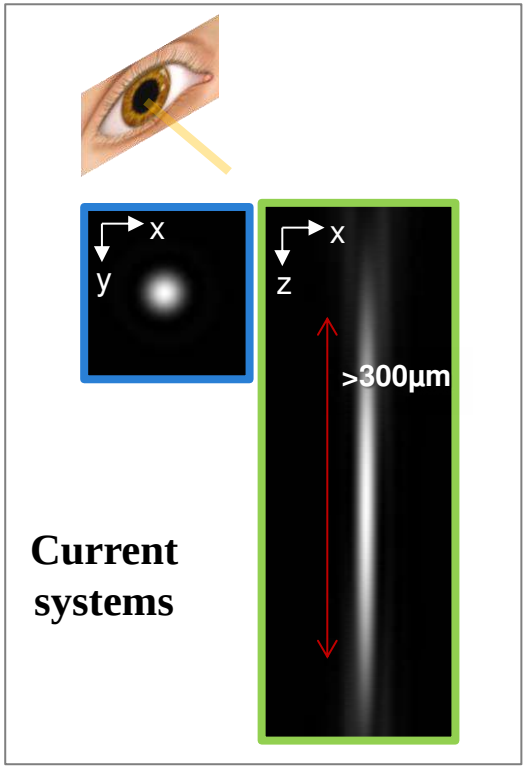
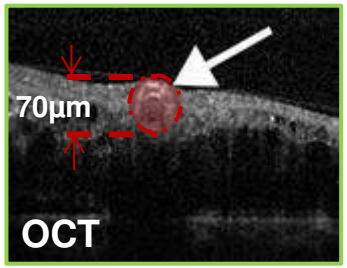
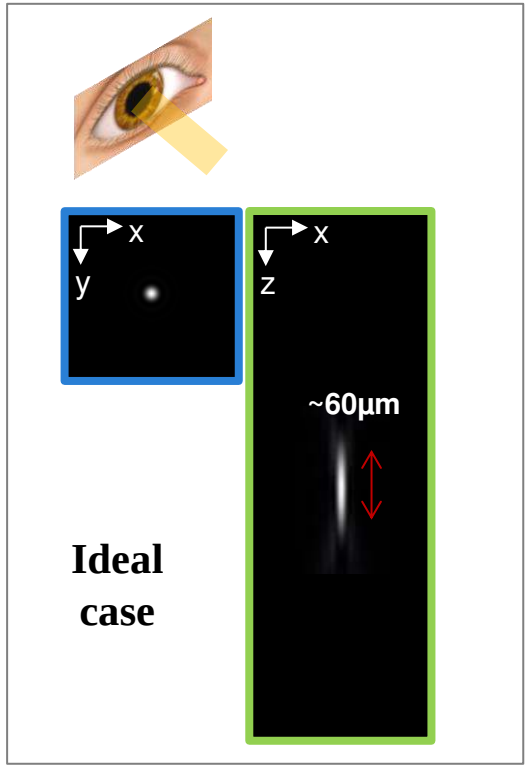
Confinement and ocular aberrations

1 3D confinement







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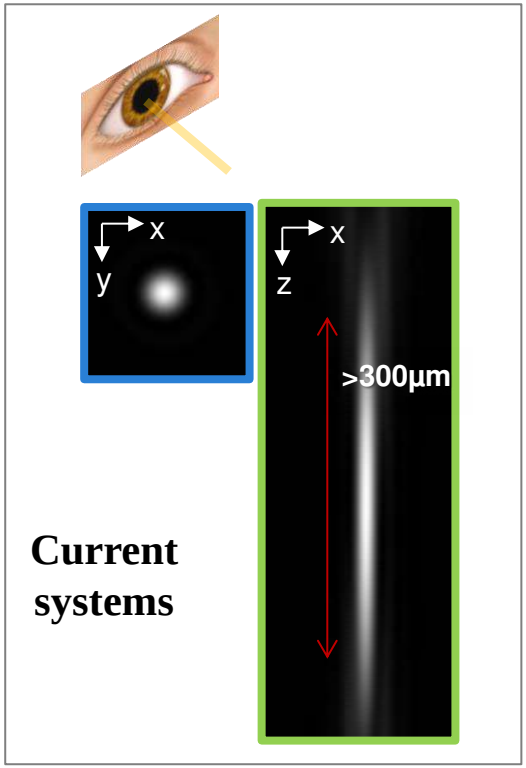
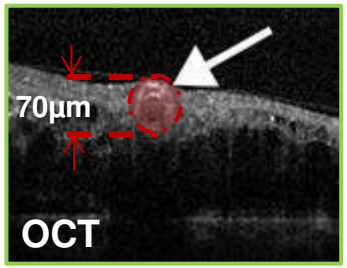
Confinement and ocular aberrations

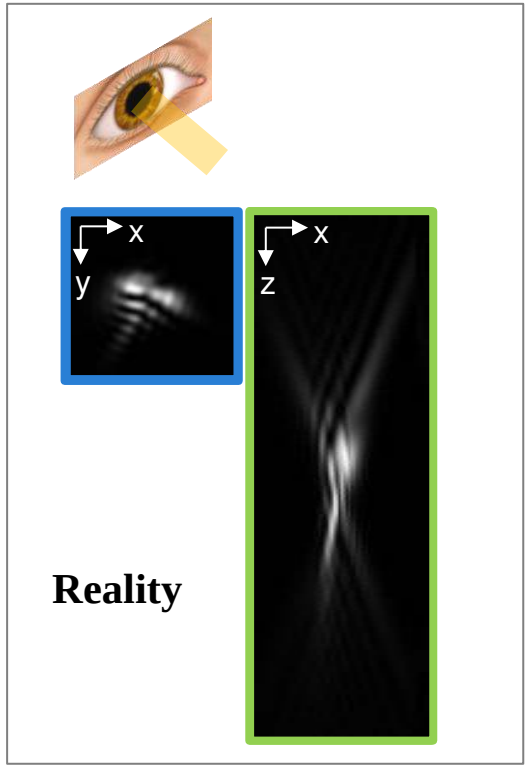
Static ocular aberrations: myopia, hypermetropia, astigmatism

1 3D confinement

Dynamic ocular aberrations (e.g. tear film)







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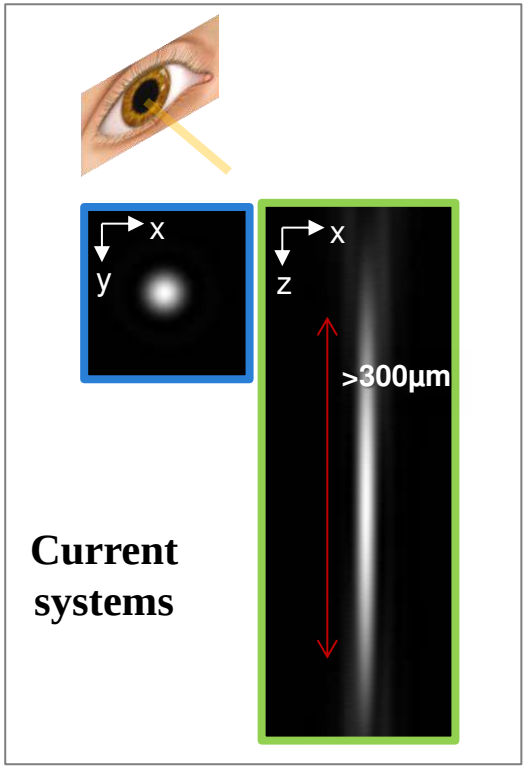

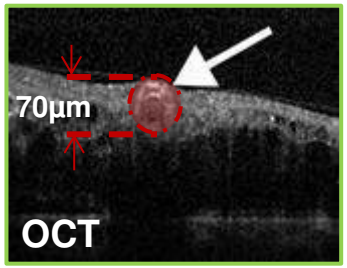

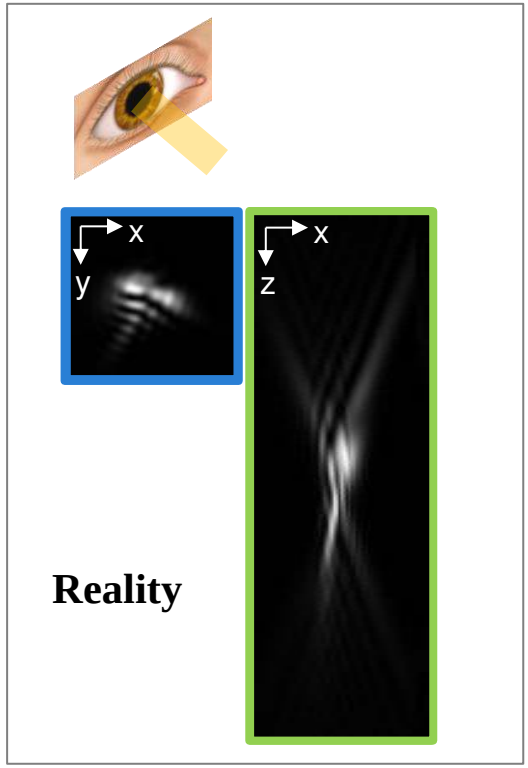

Lost of confinement / resolution!

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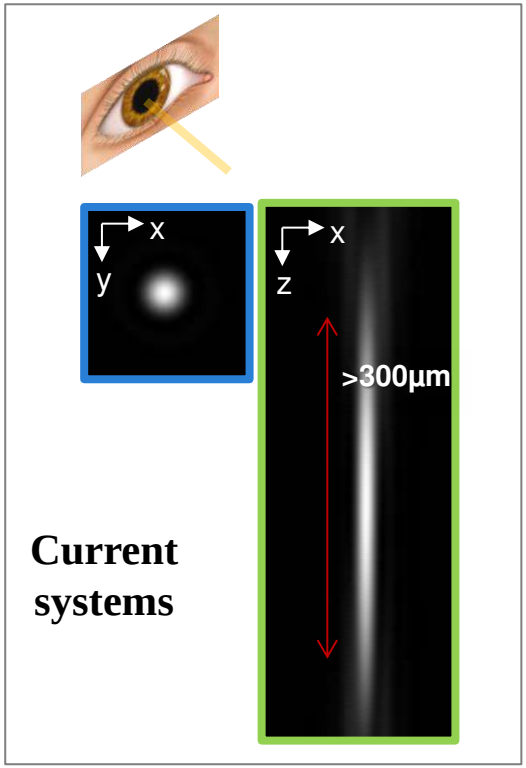
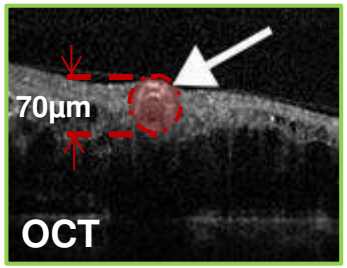
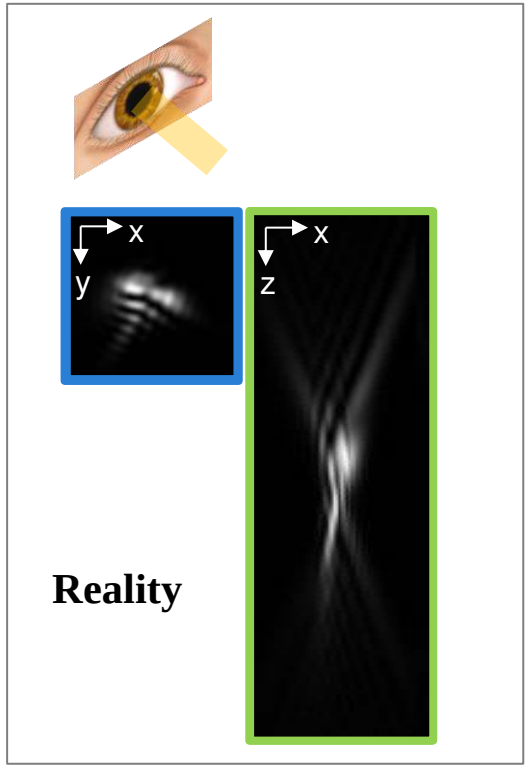


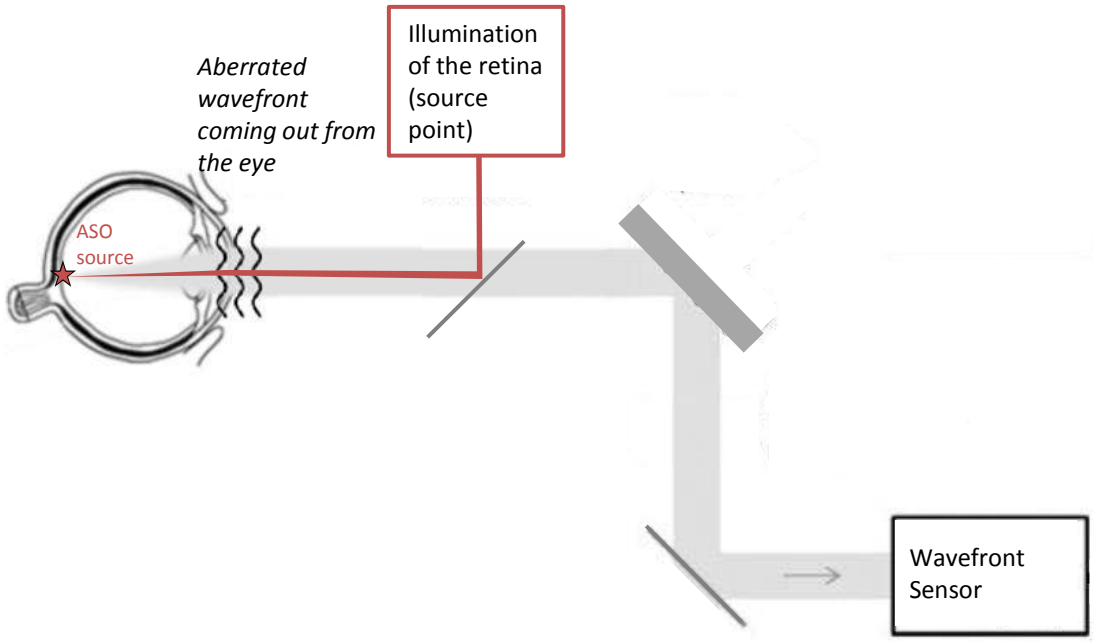




Lost of confinement / resolution!

» Real-time aberrations correction by Adaptive Optics

Laser Photocoagulation assisted by Adaptive Optics



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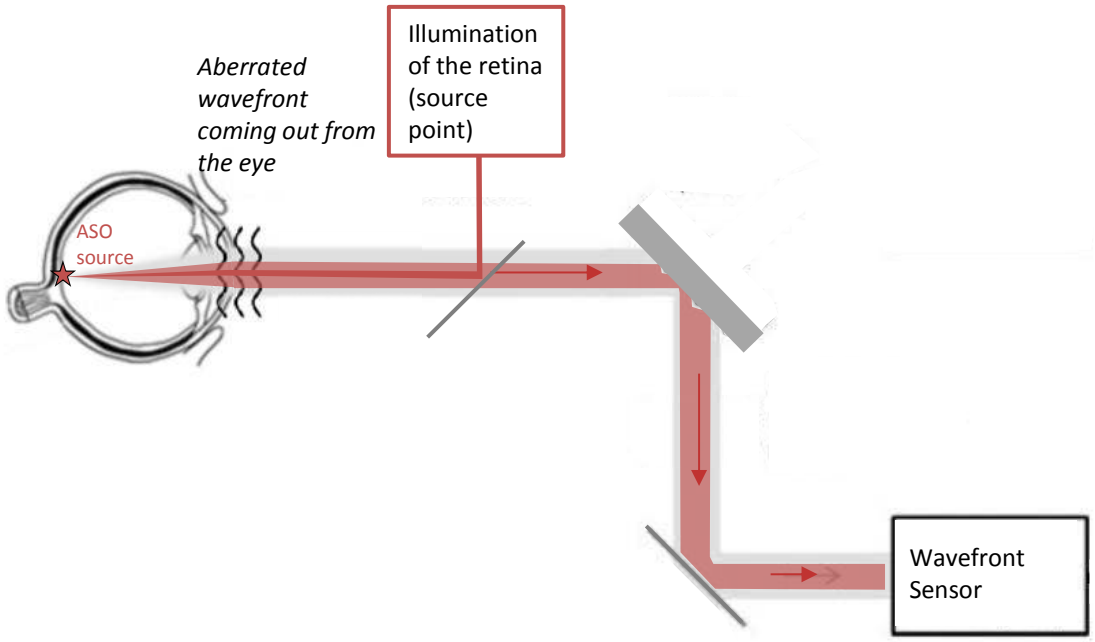

Mesure

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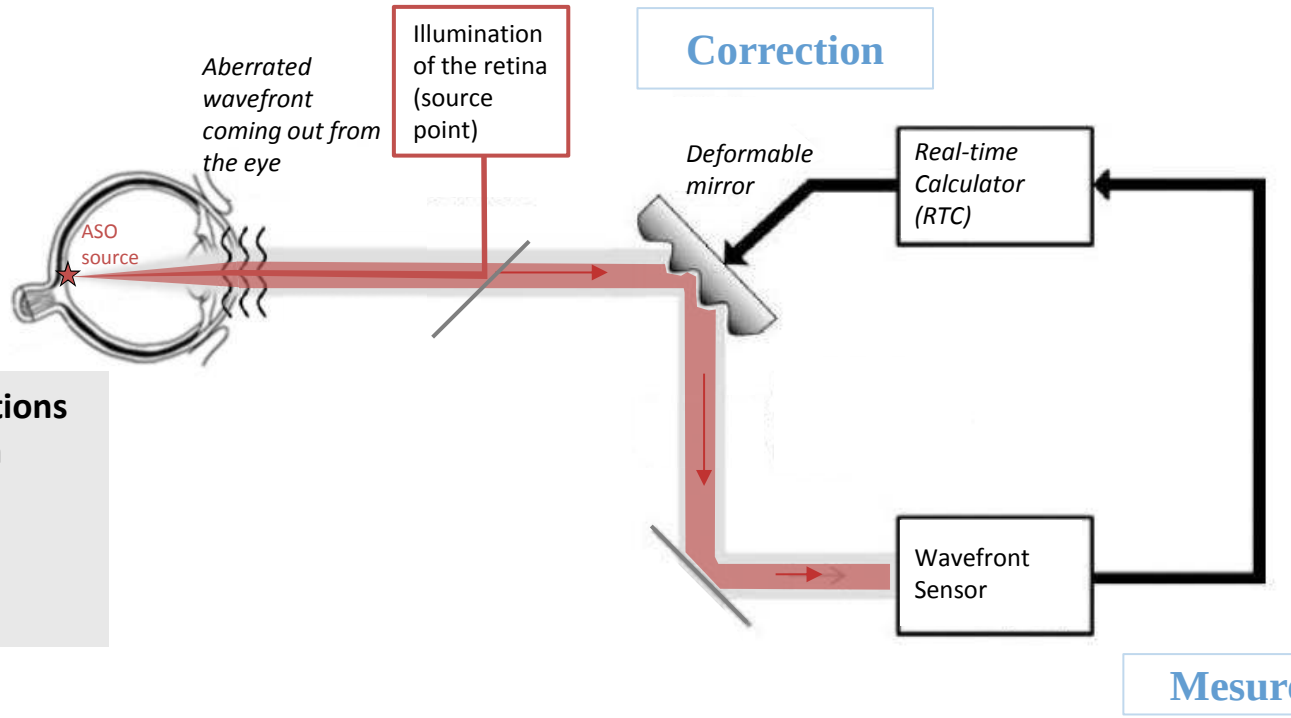
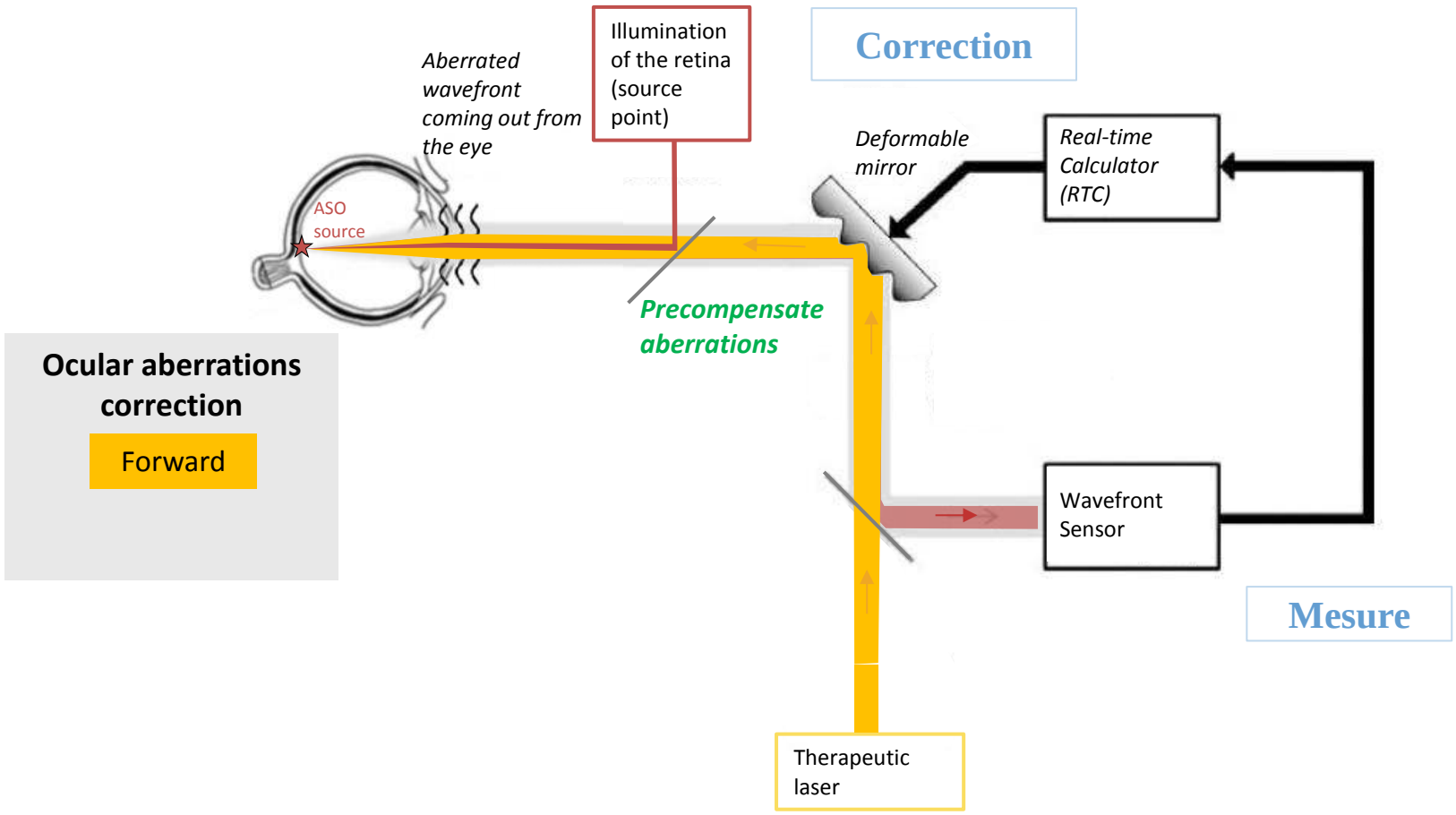
Laser Photocoagulation assisted by Adaptive Optics



Ocular aberrations correction

Laser Photocoagulation assisted by Adaptive Optics



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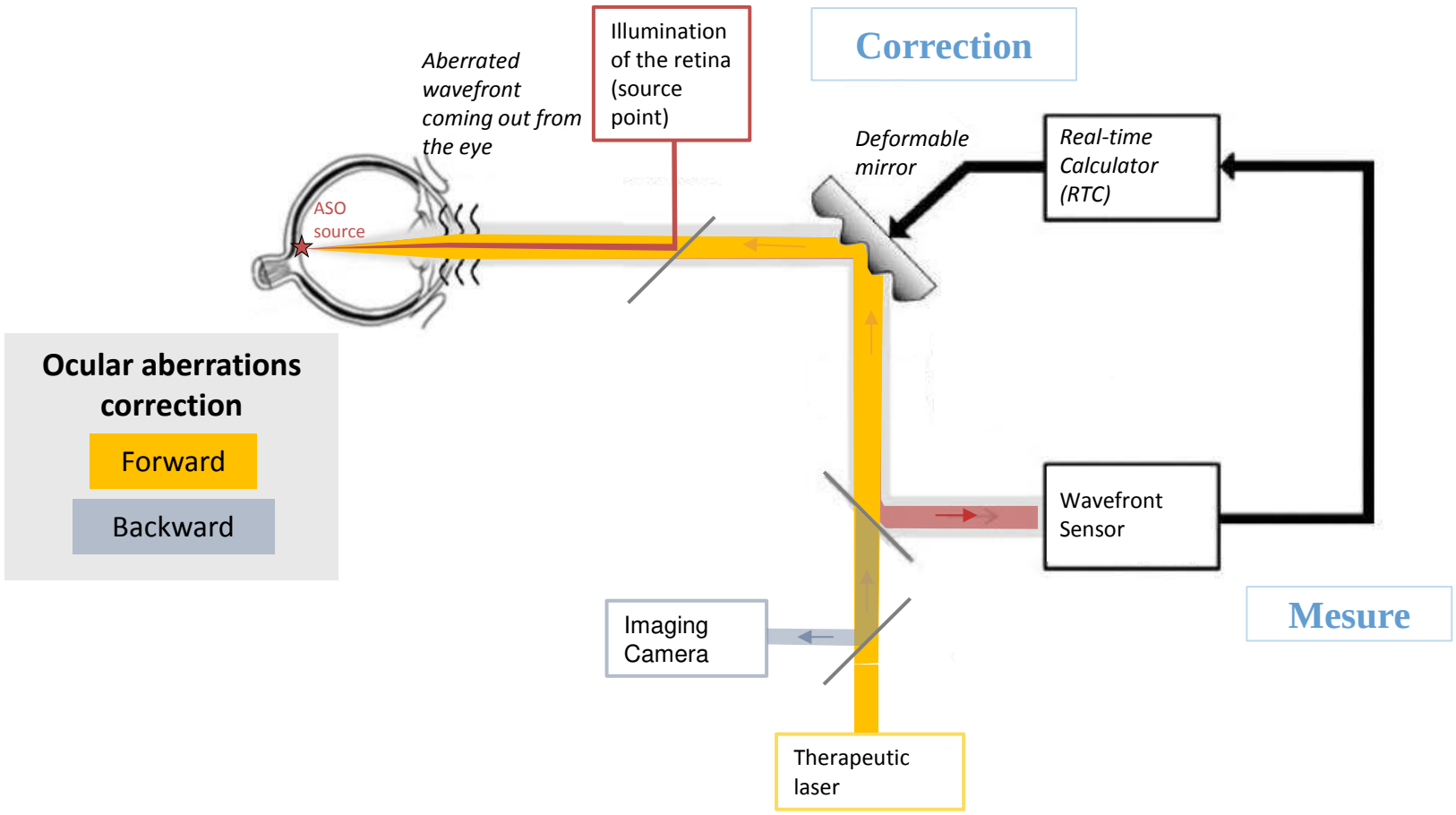
Laser Photocoagulation assisted by Adaptive Optics



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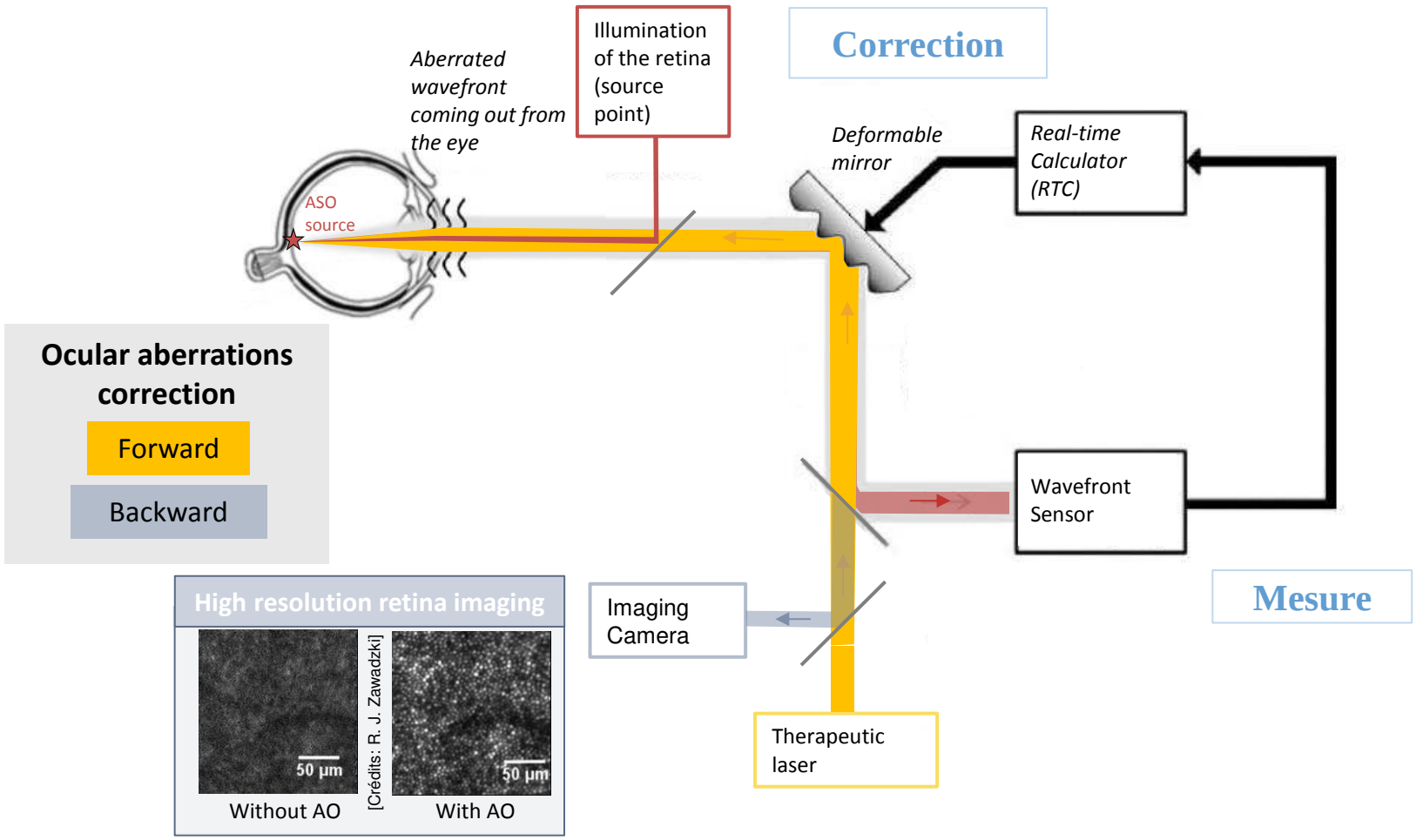
Laser Photocoagulation assisted by Adaptive Optics



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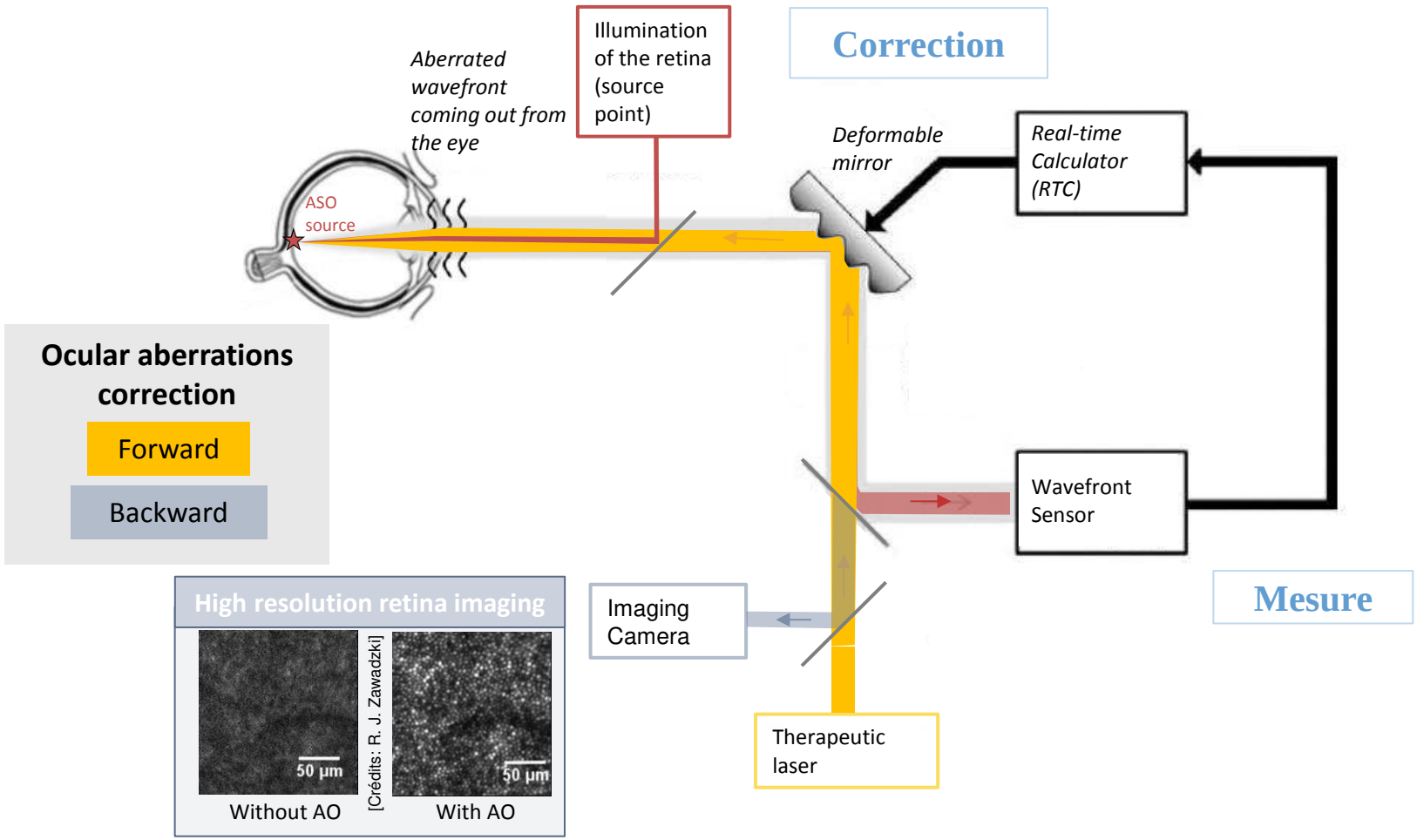

Retinal surgery and imaging assisted by Adaptive Optics

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Laser impact stabilisation, localisation and positioning

3. 2D stabilisation
4. Target identification
5. 3D laser positioning

Laser impact stabilisation, localisation and positioning

Stabilisation: eye movements (shifts) estimation by high resolution images correlation	

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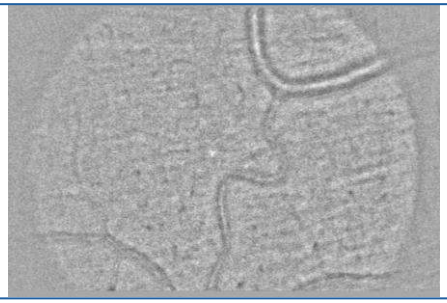

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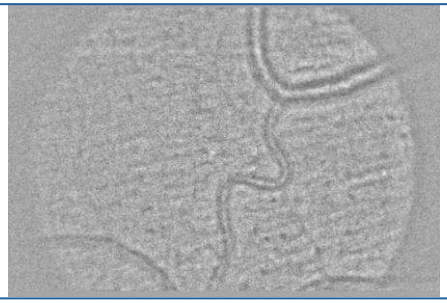

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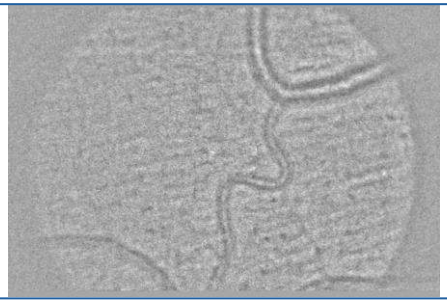

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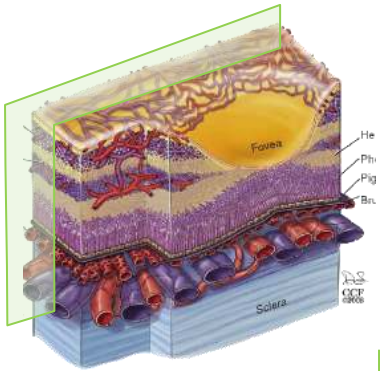
Imaging camera on translation stage: localisation & positioning



[Images : Paques *et al.*]

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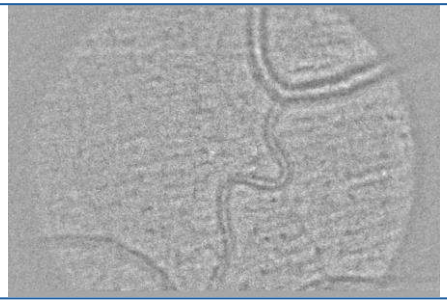

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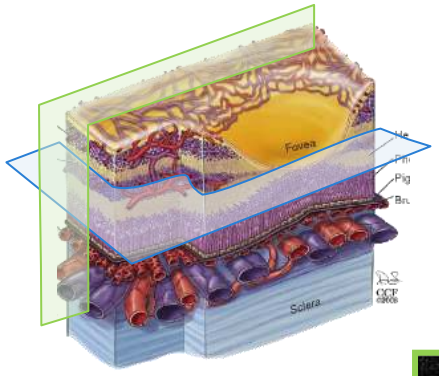

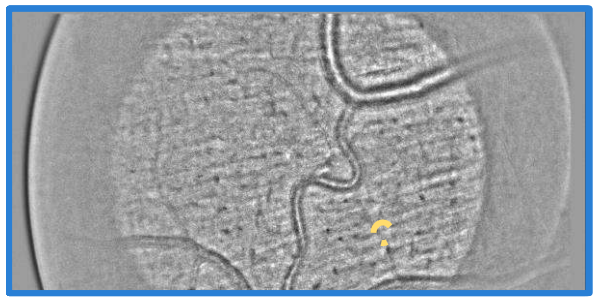

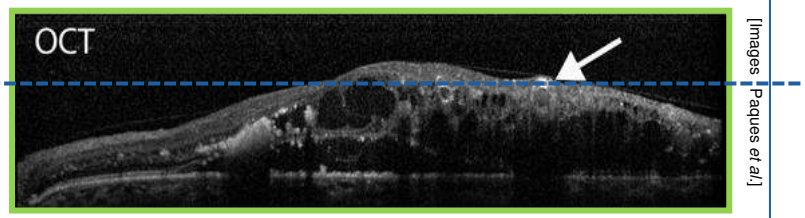

[Images Paques *et al.*]

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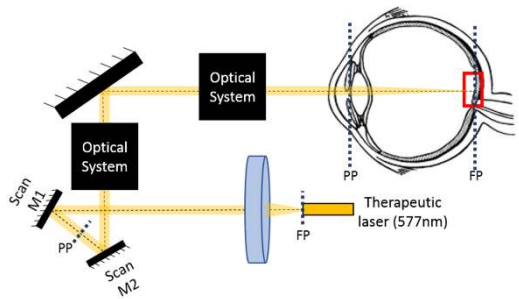
CLOVIS3D project

Current laser



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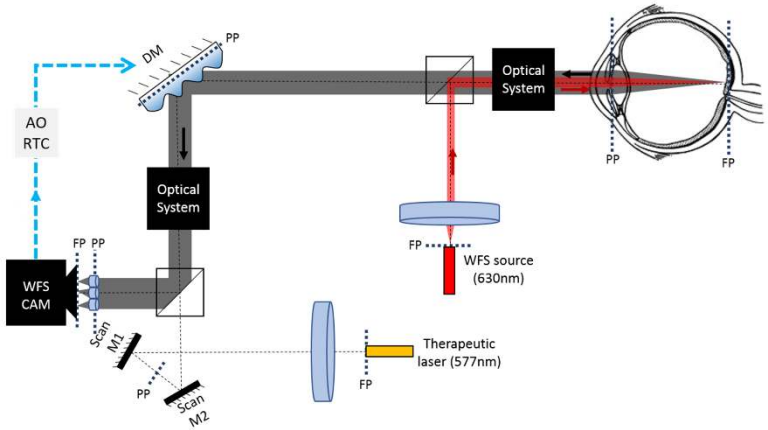
CLOVIS3D project

Current laser

+

1 3D confinement



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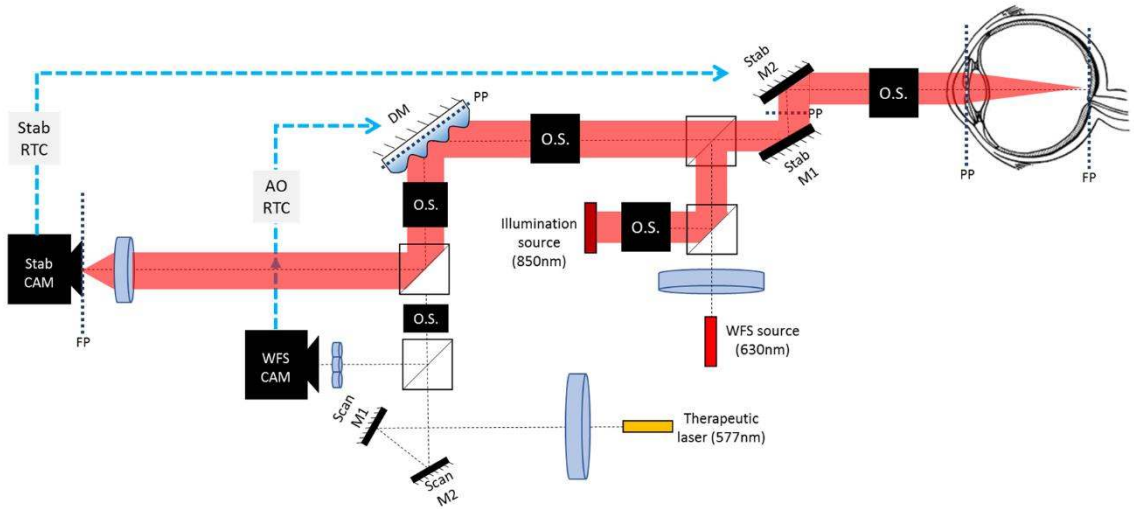
2&3 Stabilisation



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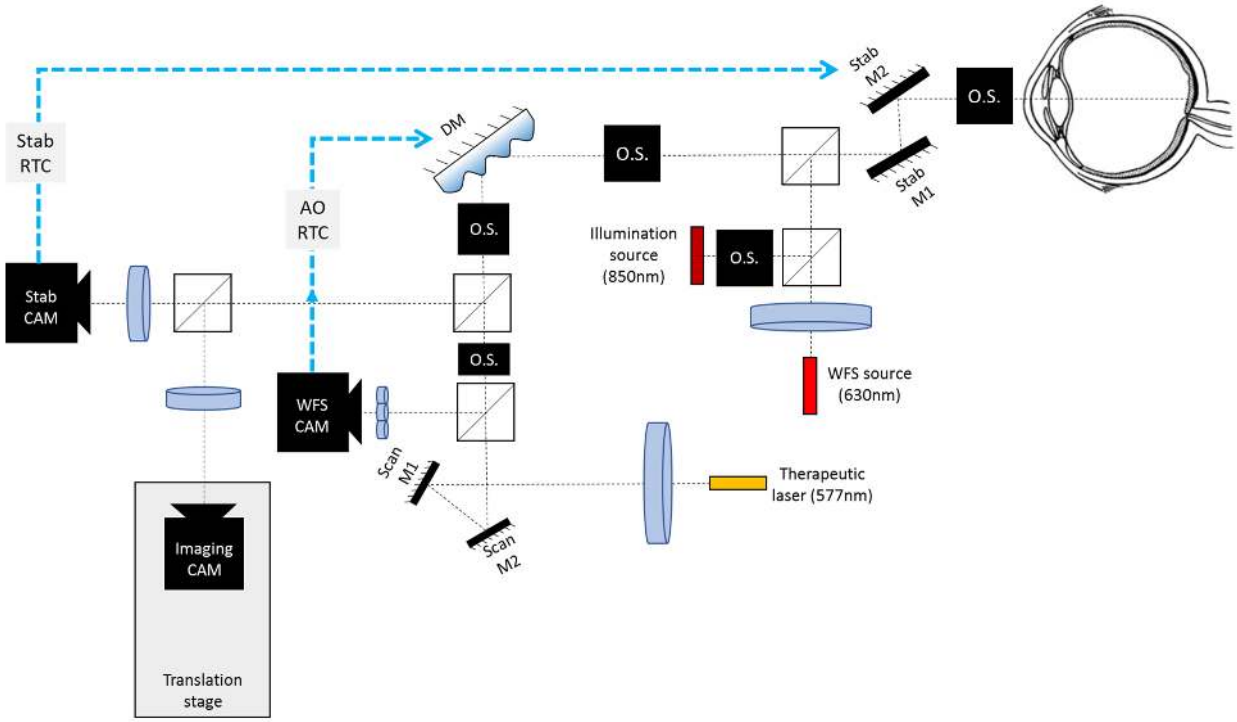
4 Target 3D imaging and localisation



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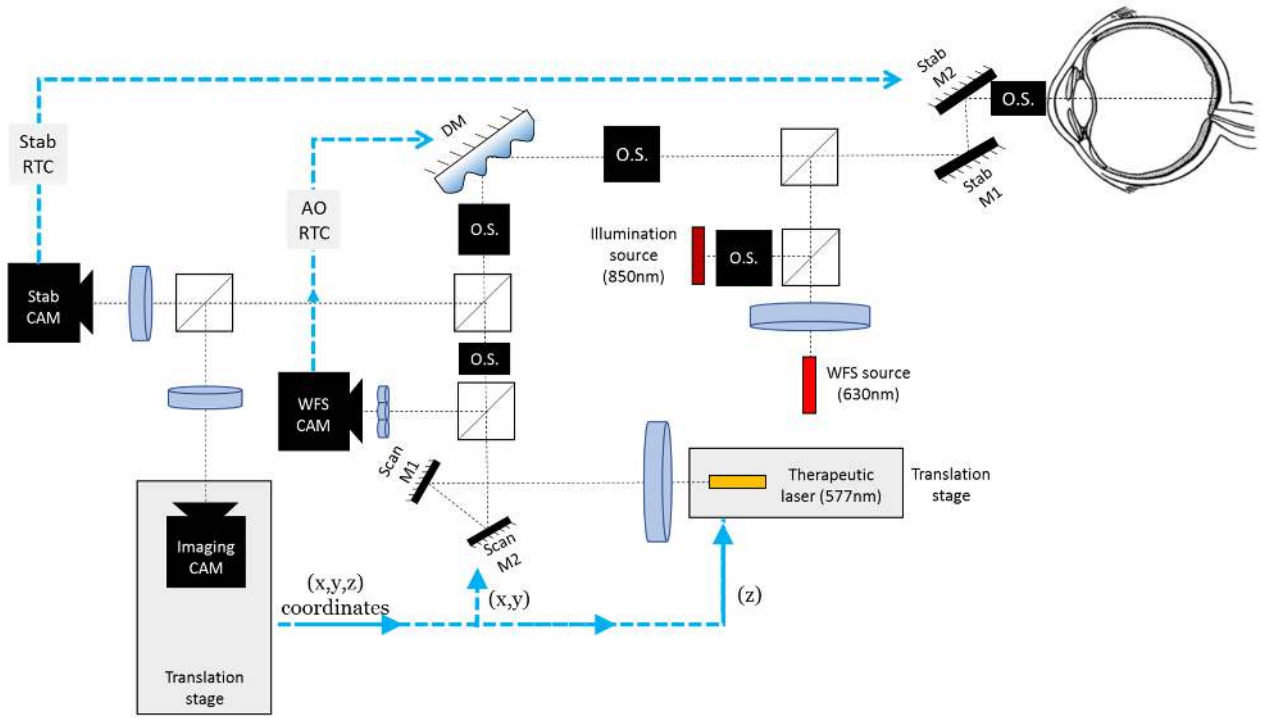
5 3D positioning of the therapeutic laser



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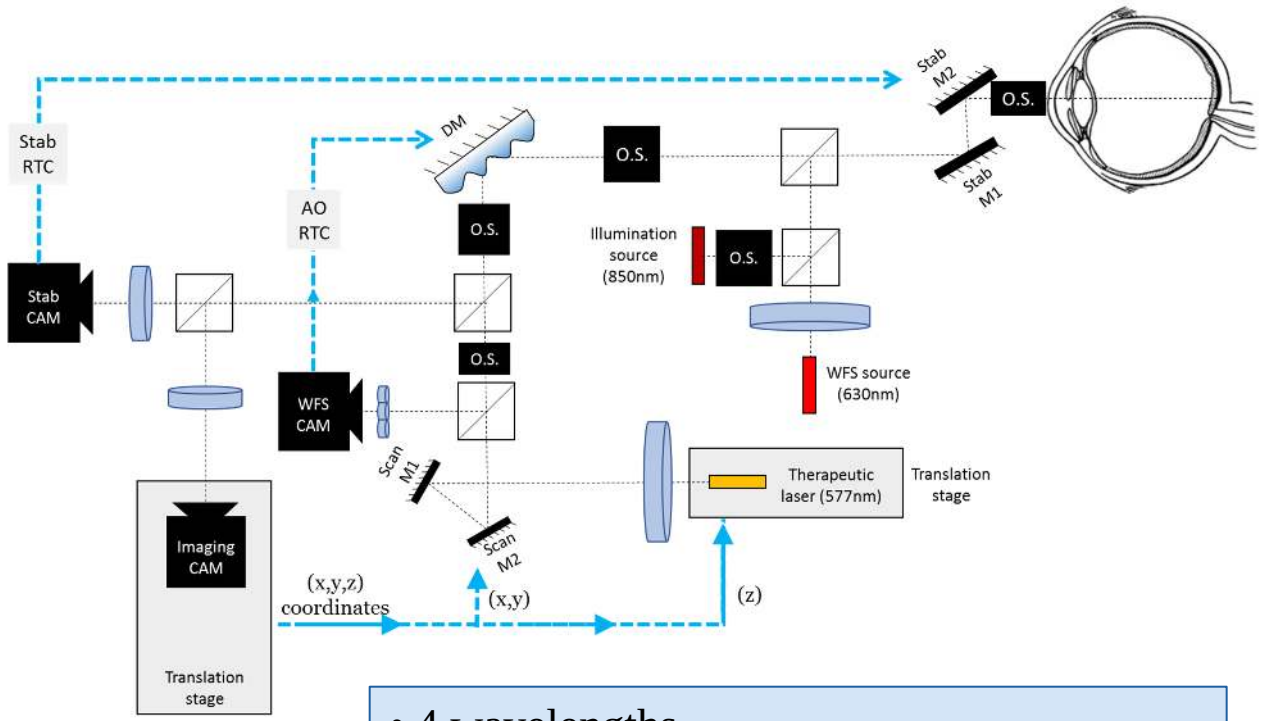

- 4 wavelengths
- 1 A.O. system
- 5 imaging systems

Increasing complexity!

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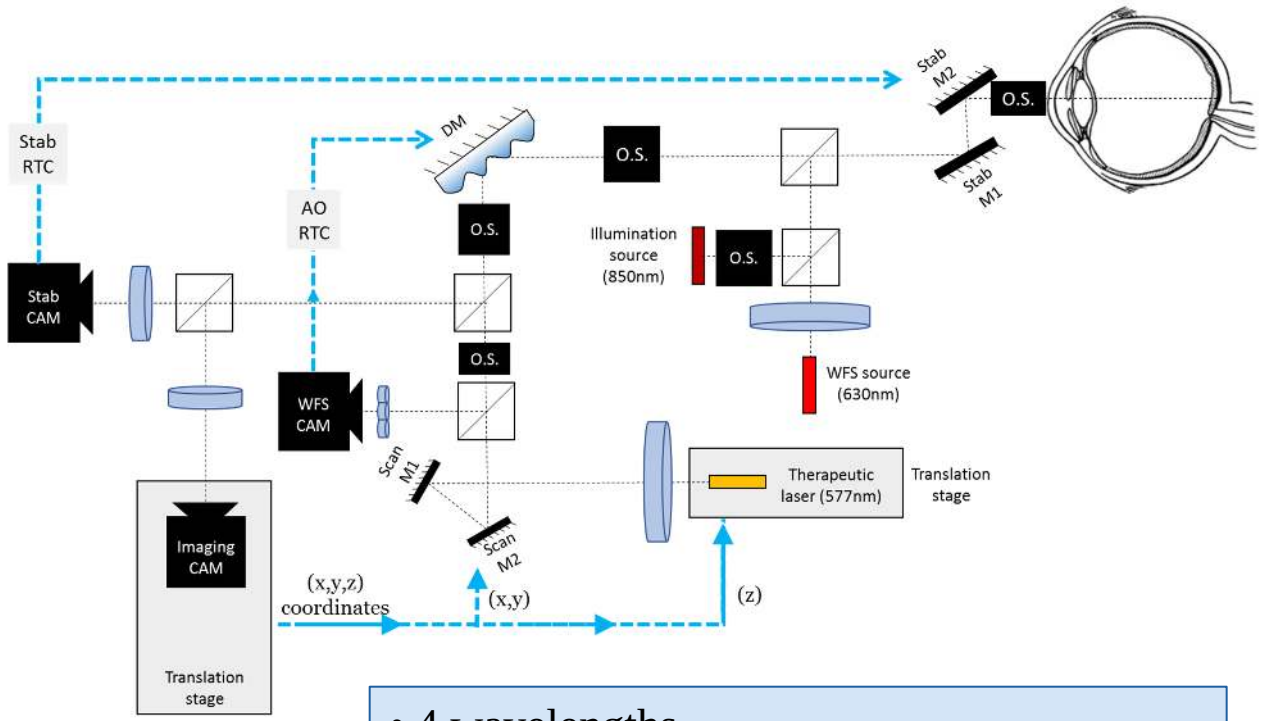

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» 1st photocoagulation laser system assisted by A.O. for retinal surgery

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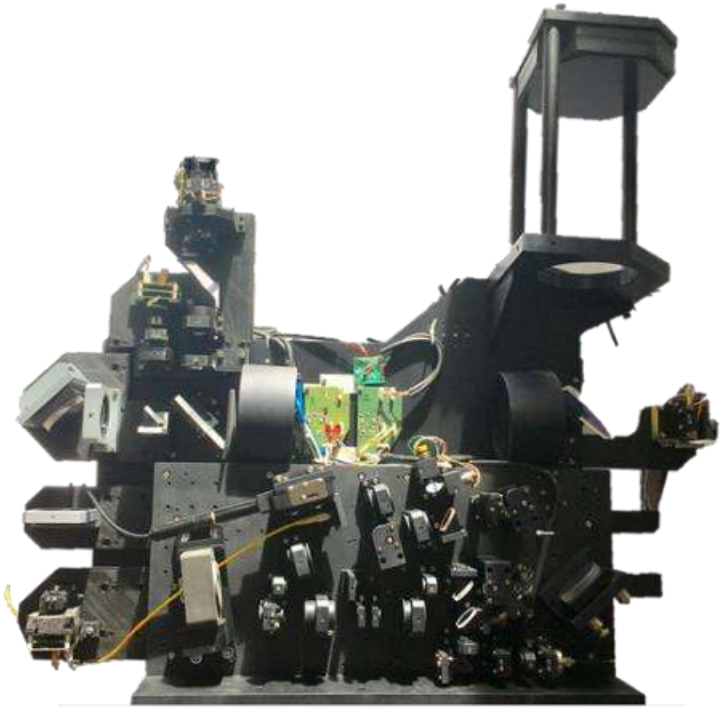
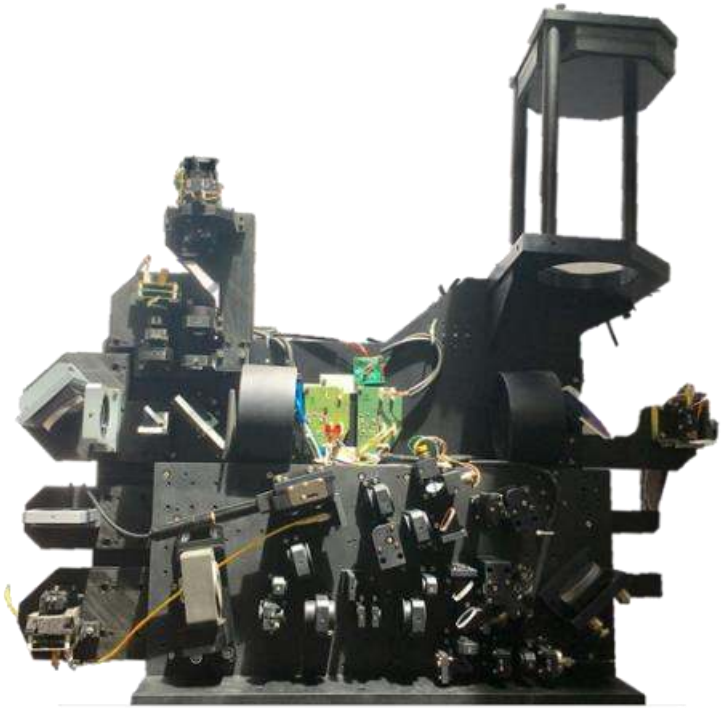
CLOVIS3D bench



Systems dimensions are 80×30×80cm (D×L×H).

CLOVIS3D bench



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NORDEN table à rabat

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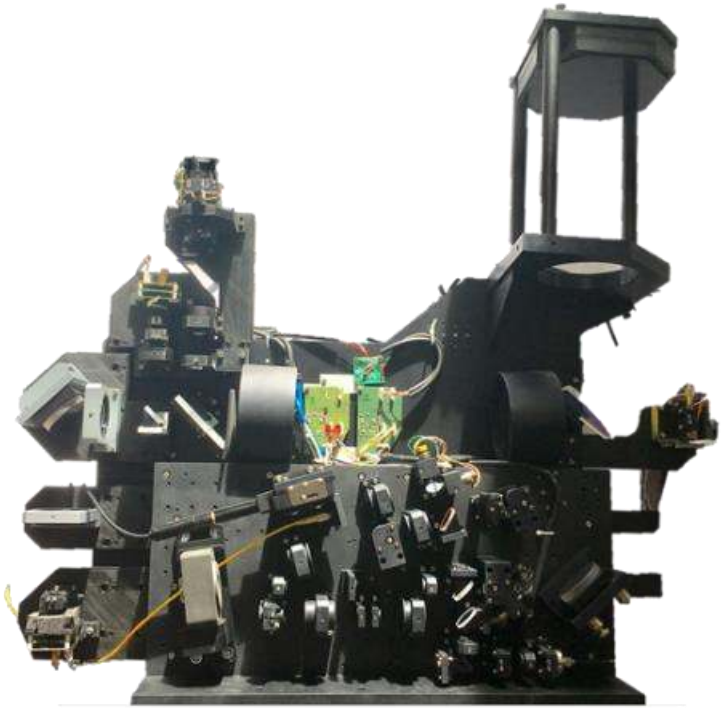

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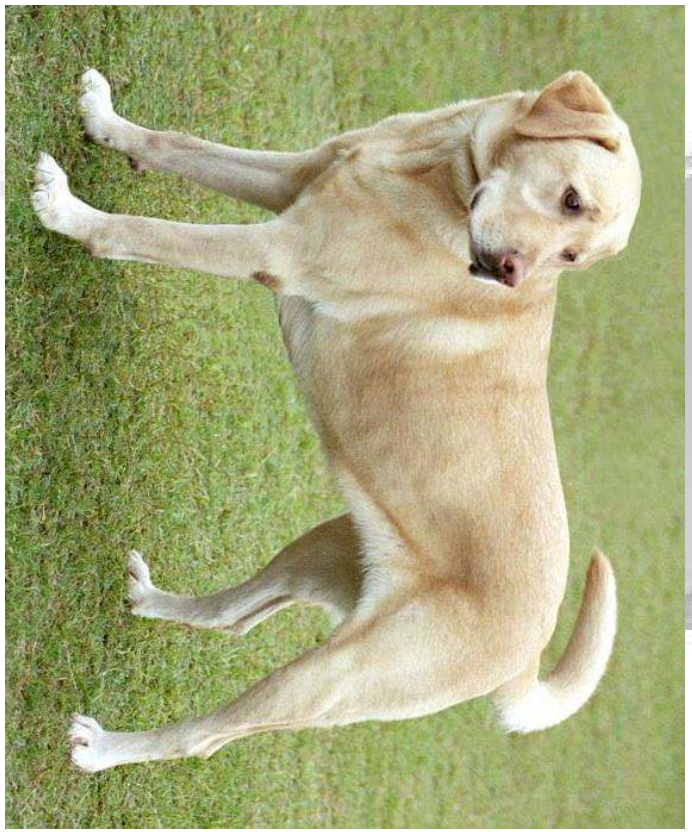

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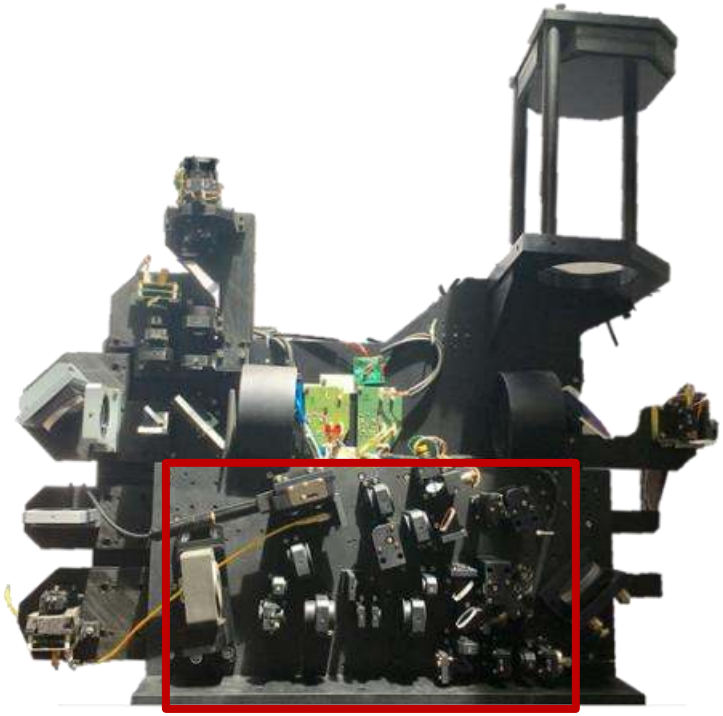

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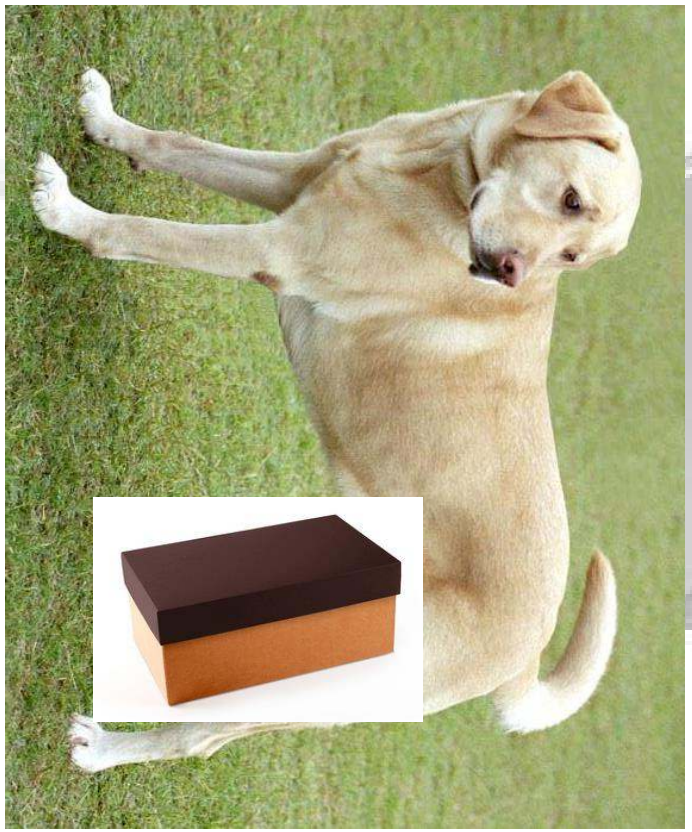

NORDEN table à rabat

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» Optical integration of the bench and coupling of all functions

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» Laser-tissue interaction: energy – confinement – beam-shaping

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Thank you!

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Thank you!

Questions?