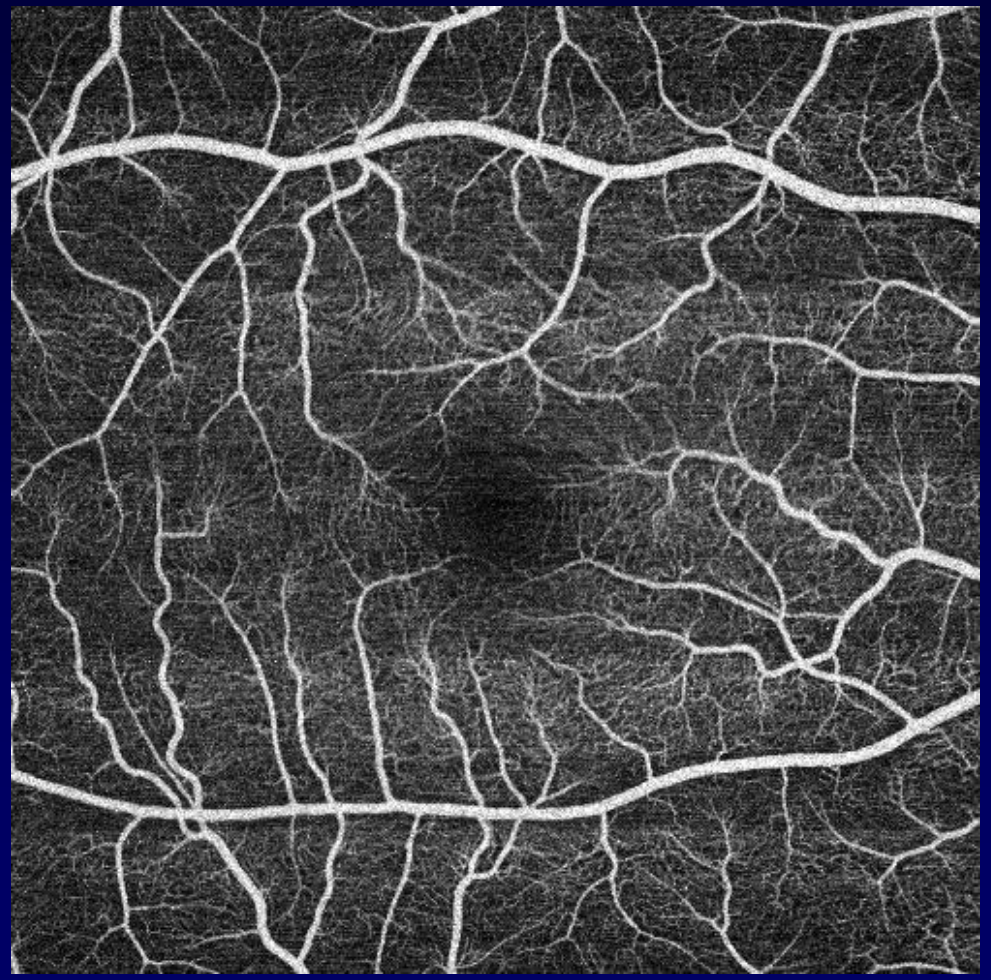
Toward quantitative OCT angiography:

Visualizing flow impairment using variable interscan time analysis (VISTA)

Stefan B. Ploner, Eric M. Moult, Nadia K. Waheed, Lennart Husvogt, Julia J. Schottenhamml, ByungKun Lee, Joachim Hornegger, Jay S. Duker, Philip J. Rosenfeld, James G. Fujimoto

OCT Angiography



- Mean en face projection over retinal vasculature
- Visualizes presence/absence of vessels
- Little information about flow speed

Part I:

Variable interscan time analysis (VISTA)

Variable interscan time analysis (VISTA)

- **Proposed by Choi & Moult *et al*. Ophthalmology. 2015.**

Ultrahigh-Speed, Swept-Source Optical Coherence Tomography Angiography in Nonexudative Age-Related Macular Degeneration with Geographic Atrophy

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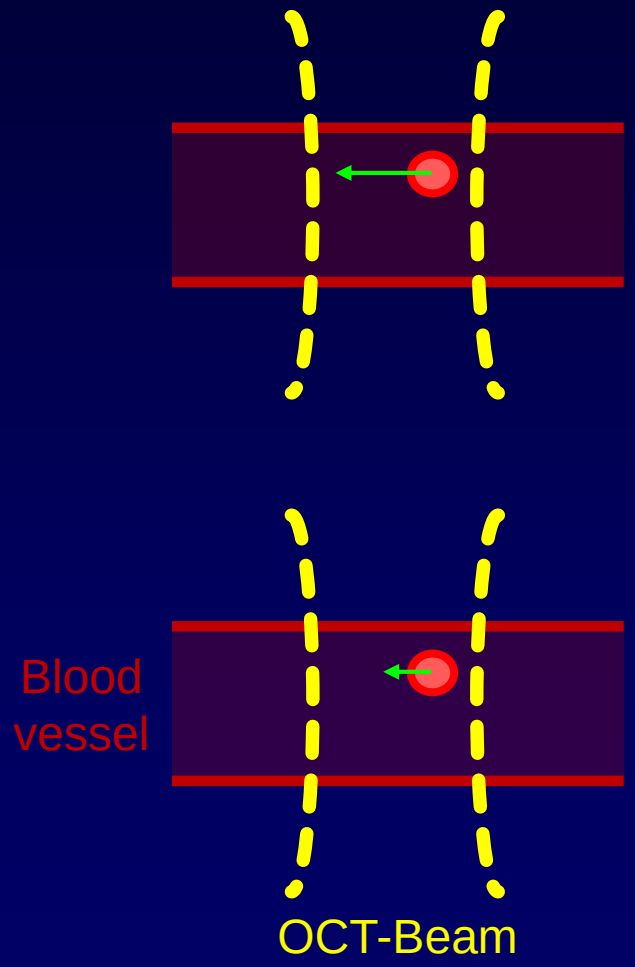
Variable interscan time analysis (VISTA)

Inter-
scan time

1·Δt

½·Δt

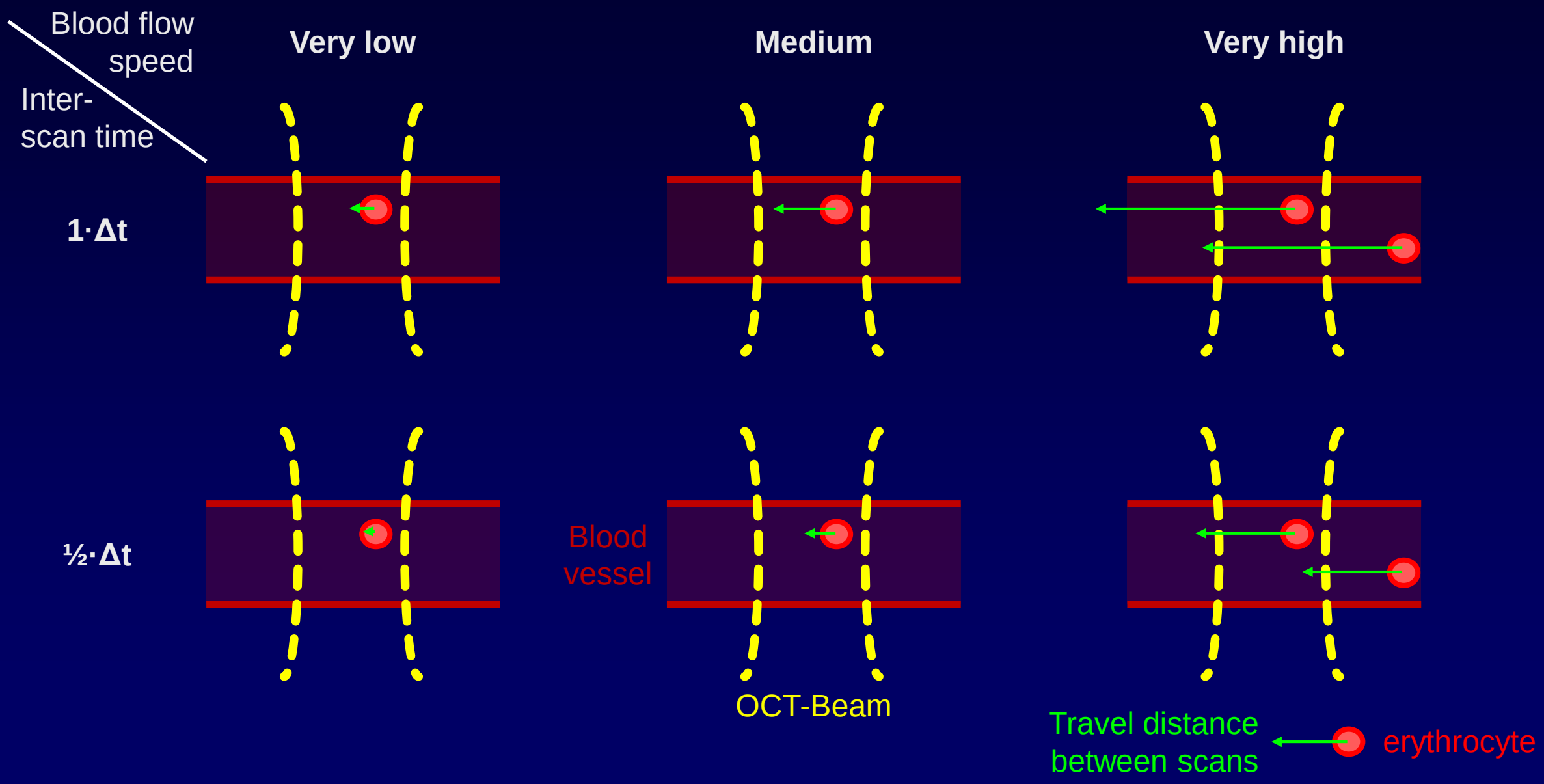


- Travel distance proportional to interscan time
- Shorter interscan time leads to reduced decorrelation

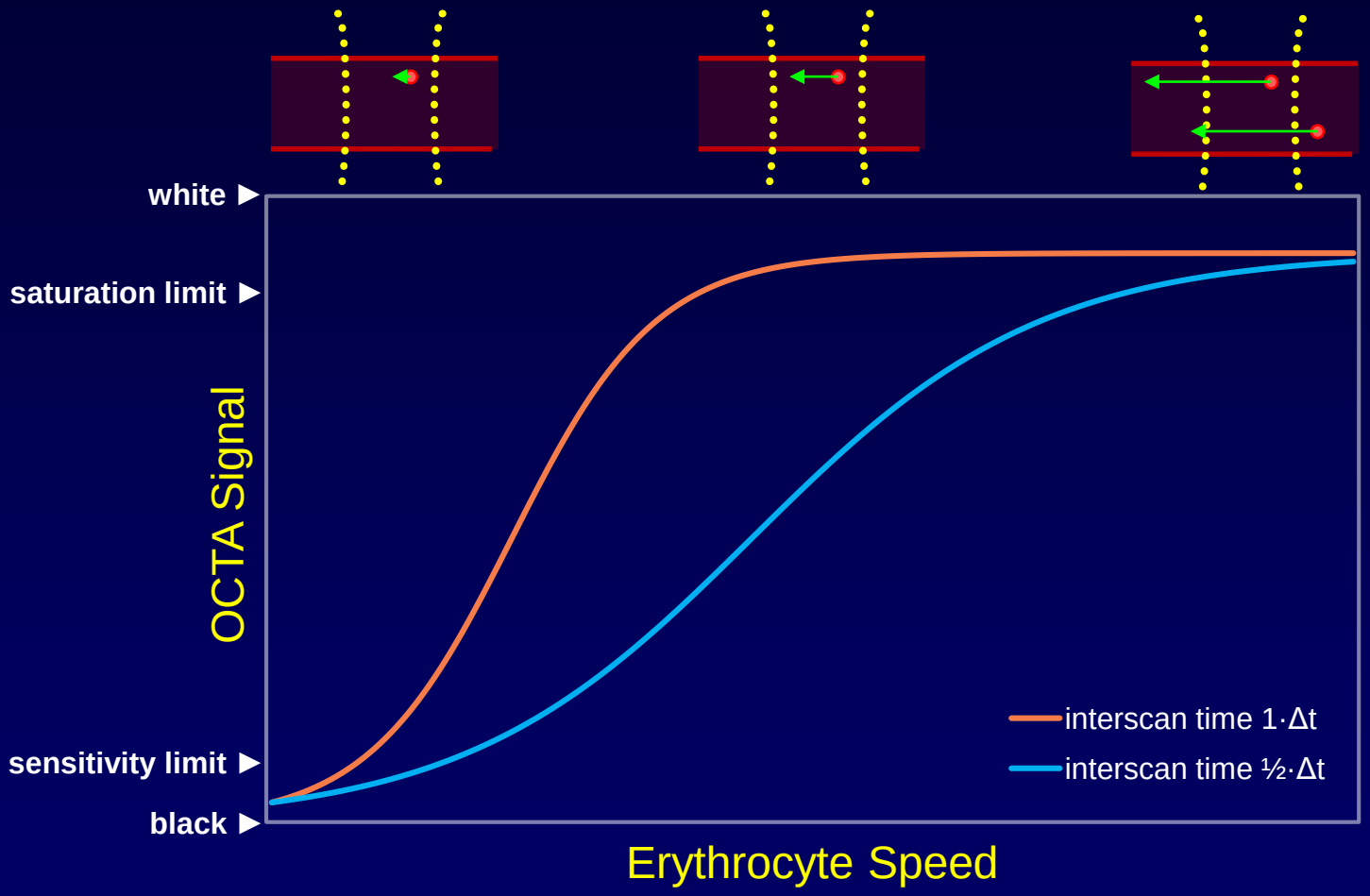
Travel distance
between scans

erythrocyte

Variable interscan time analysis (VISTA)



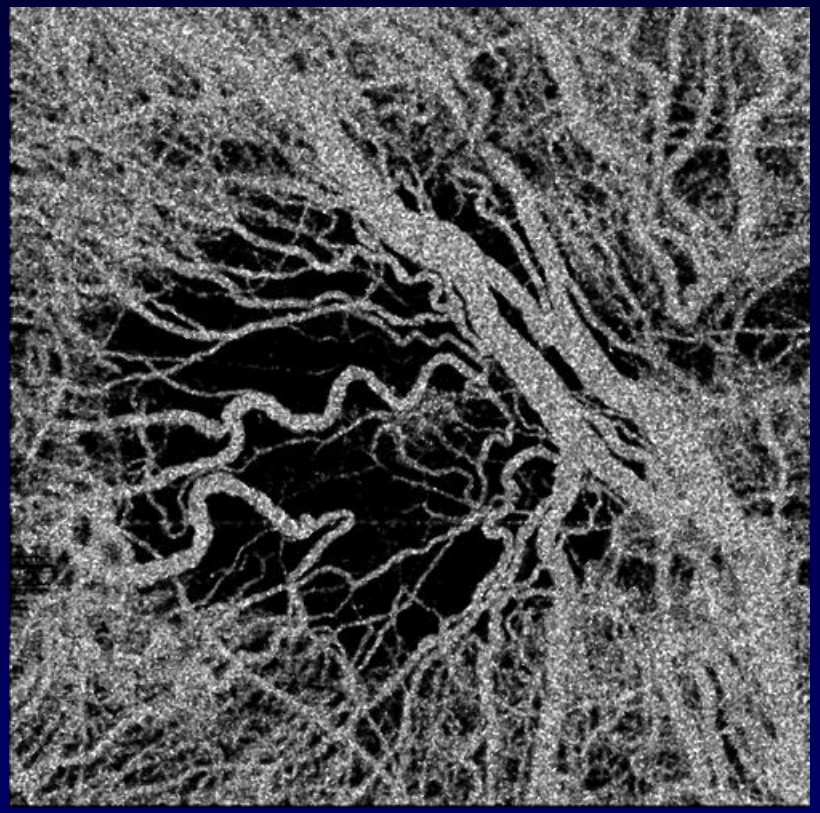
Variable interscan time analysis (VISTA)



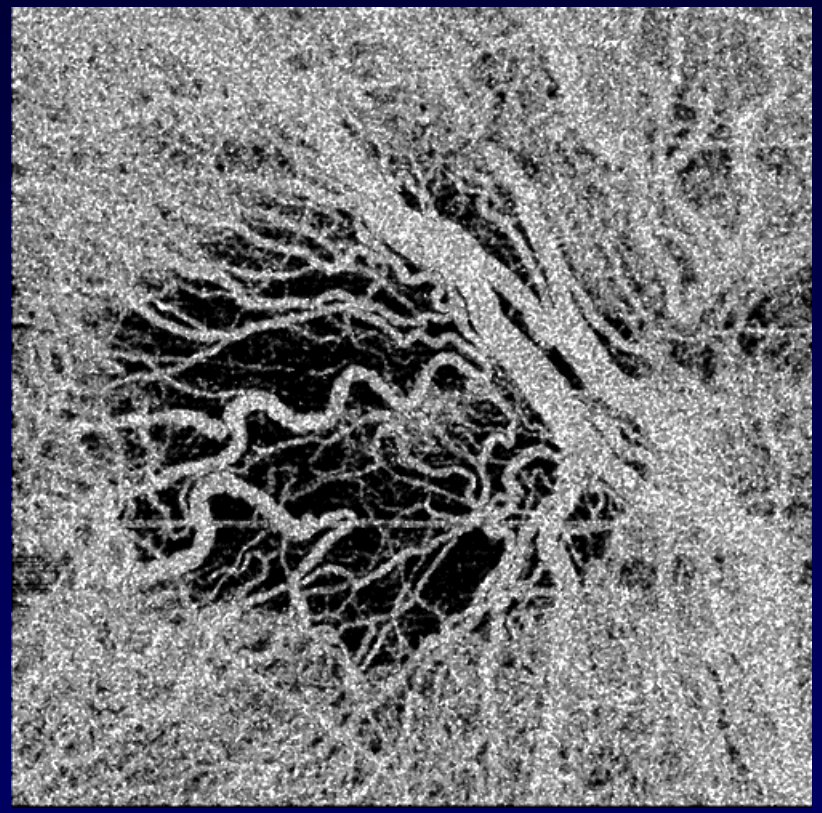
- **The interscan time determines sensitivity to flow speed**

OCTA in 75 y/o Non-Exudative AMD with GA (6x6mm)

1.5 ms interscan time

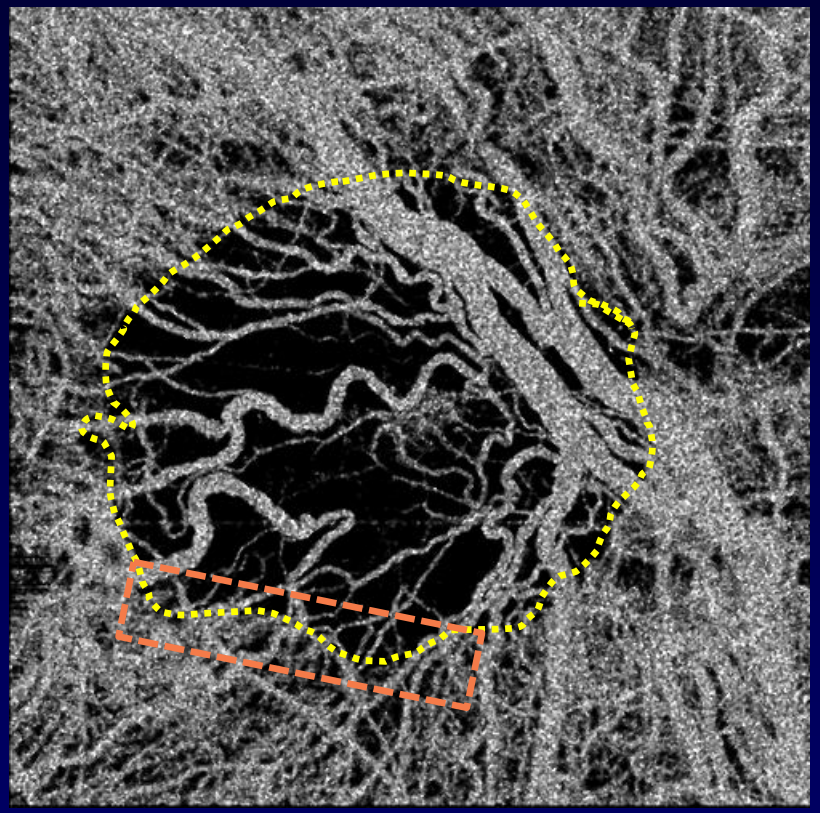


3 ms interscan time

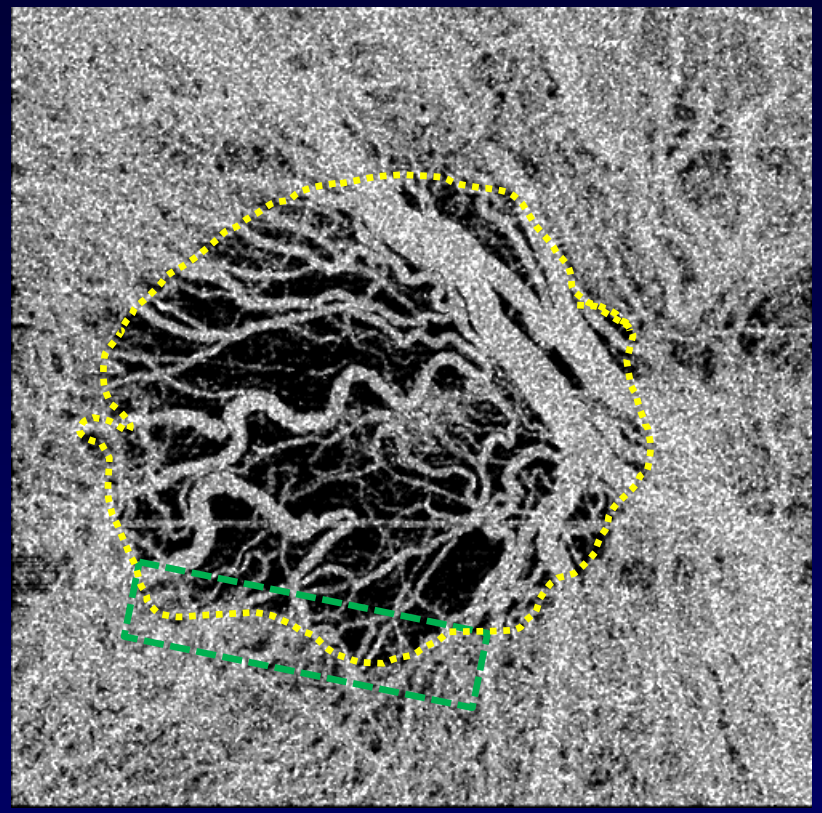


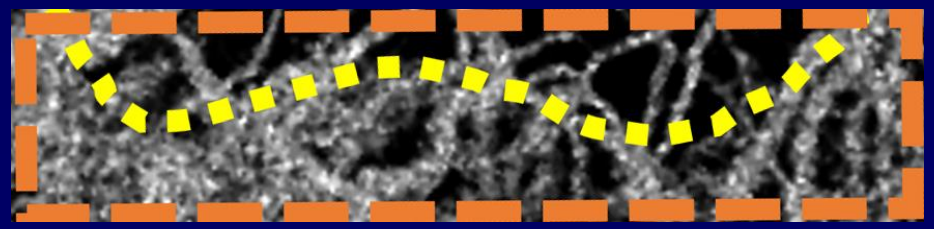
OCTA in 75 y/o Non-Exudative AMD with GA (6x6mm)

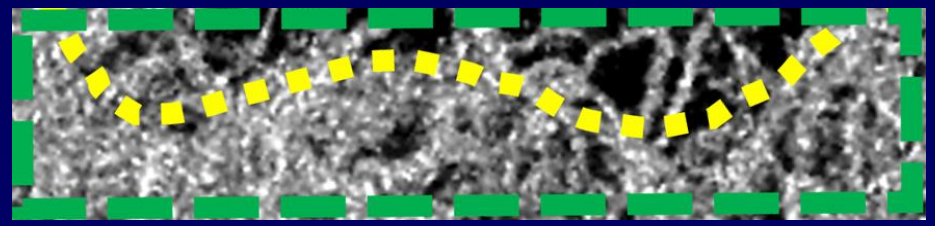
1.5 ms interscan time



3 ms interscan time







OCTA in 75 y/o Non-Exudative AMD with GA (6x6mm)

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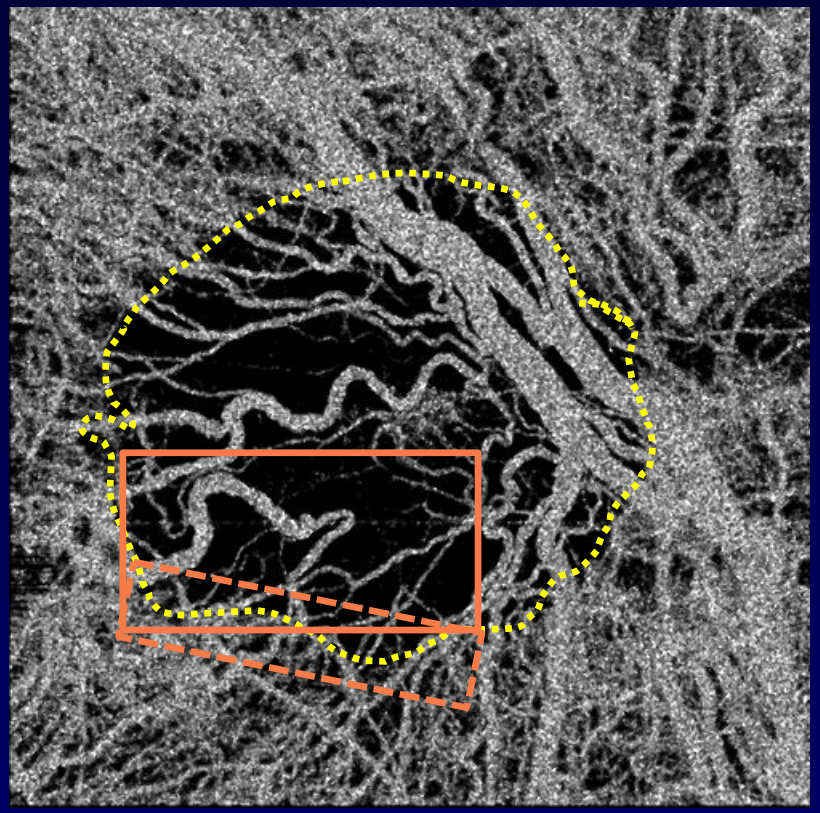
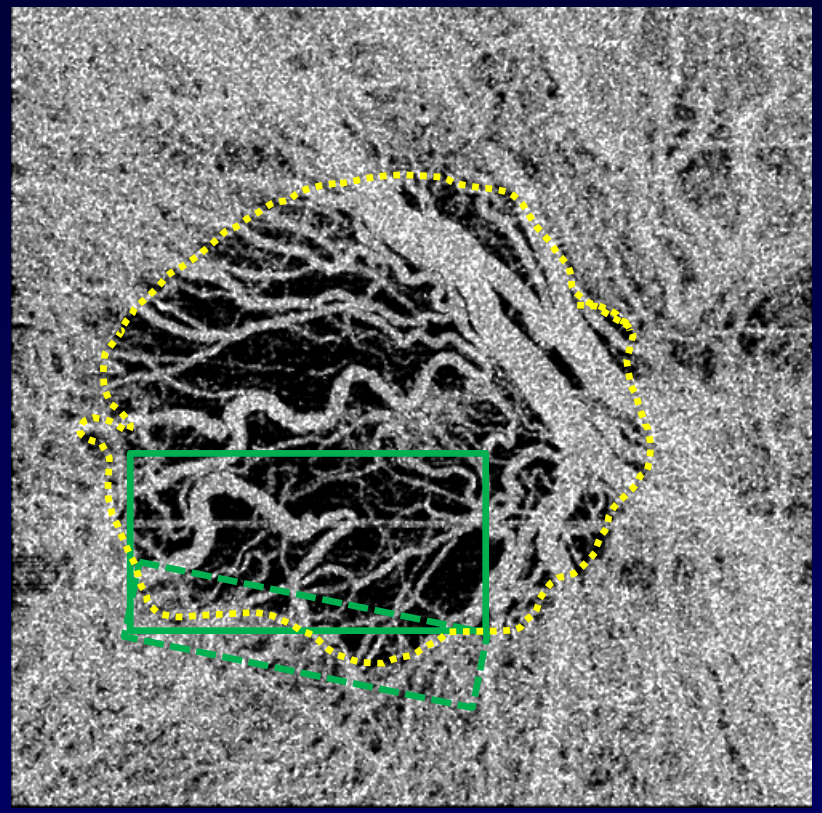
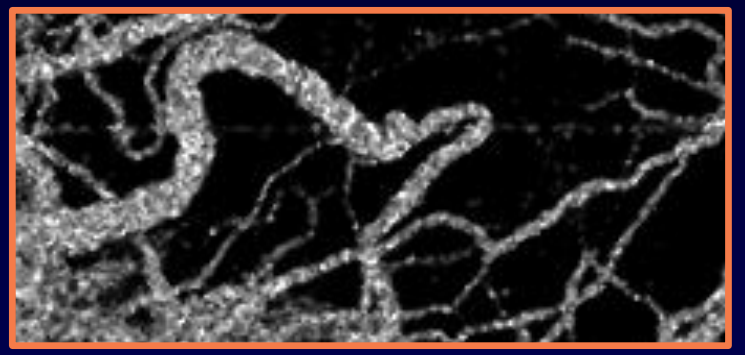
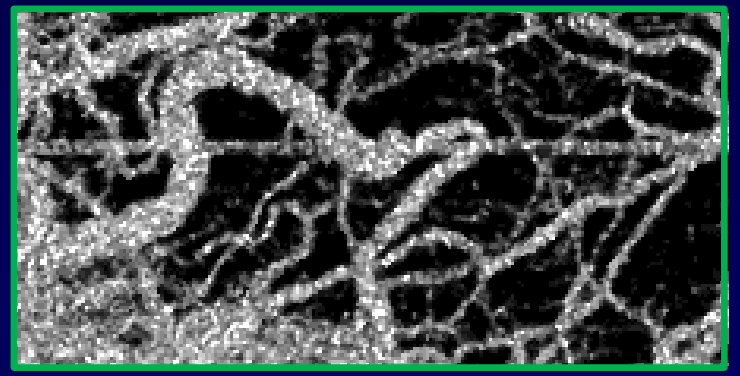
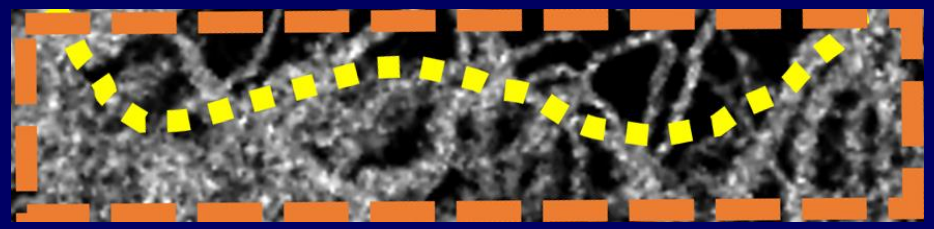
3 ms interscan time

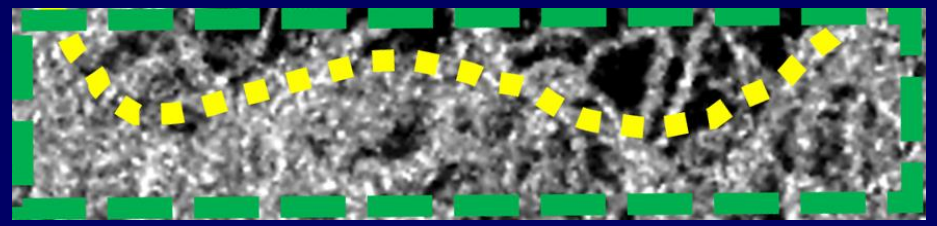












The Problem

The information provided by VISTA is not easily interpretable in its raw form.

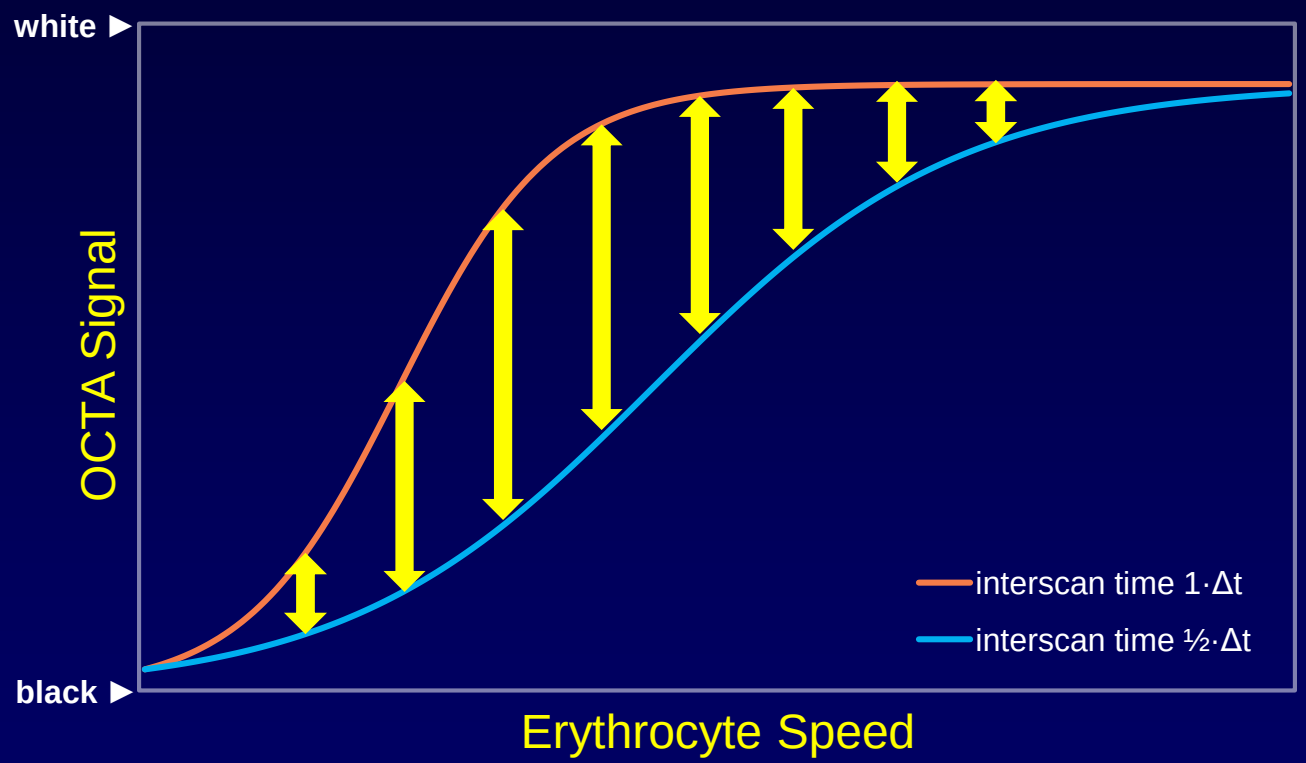
This limits the clinical applicability of VISTA.

The Solution

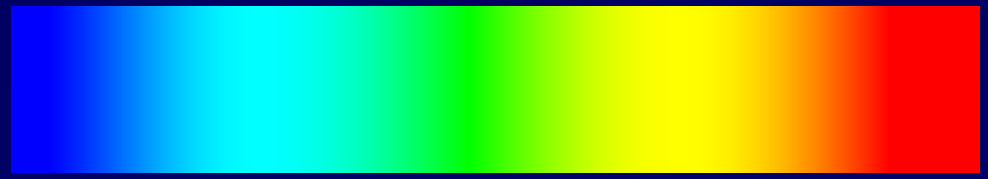
Map the raw VISTA data to an easily interpretable color map:

The VISTA visualization algorithm

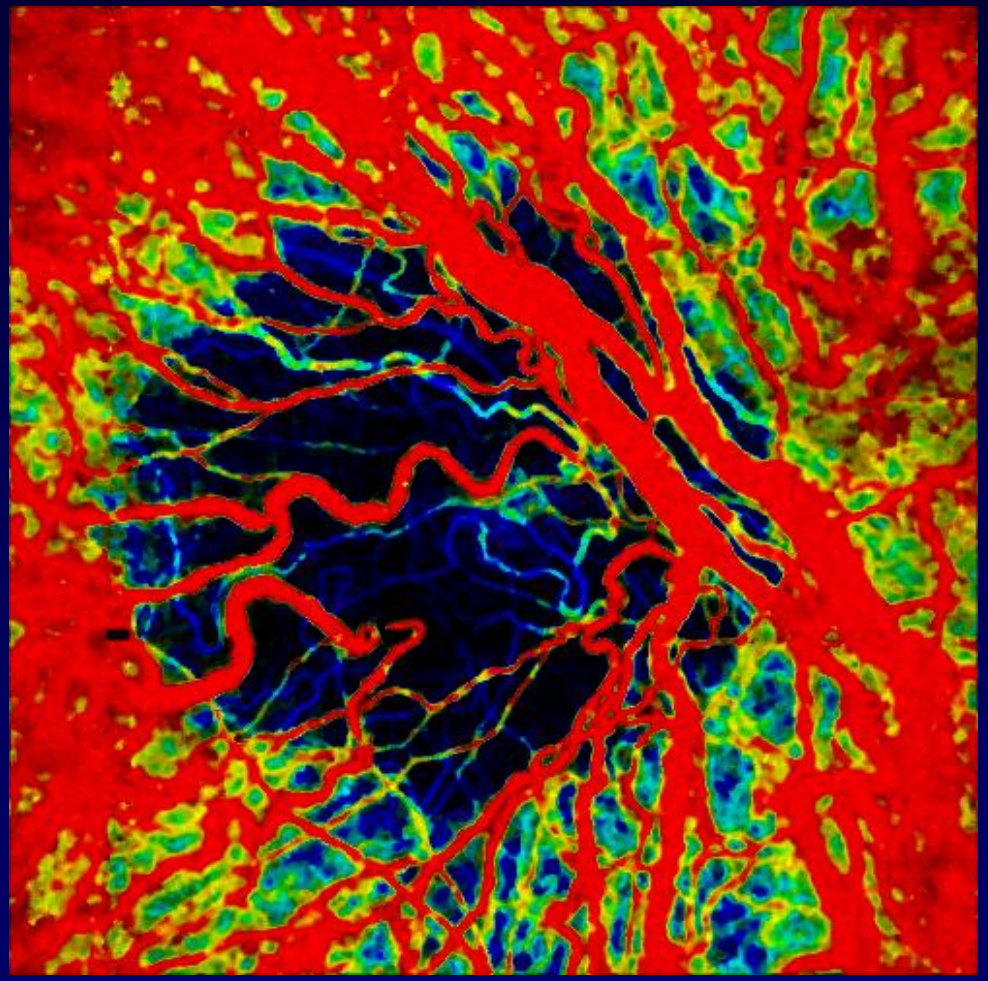
VISTA Visualization

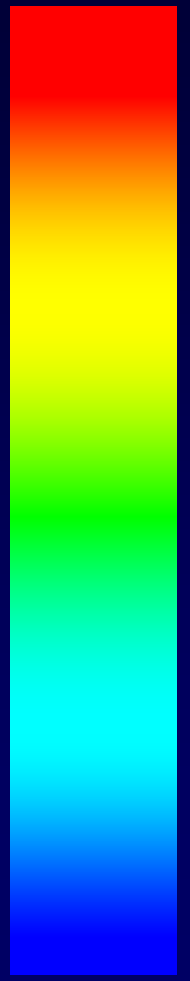


- VISTA measures two distinct interscan times
- The difference in the OCTA signal is related to erythrocyte speed
- We map the ratio to a color bar:



VISTA Visualization

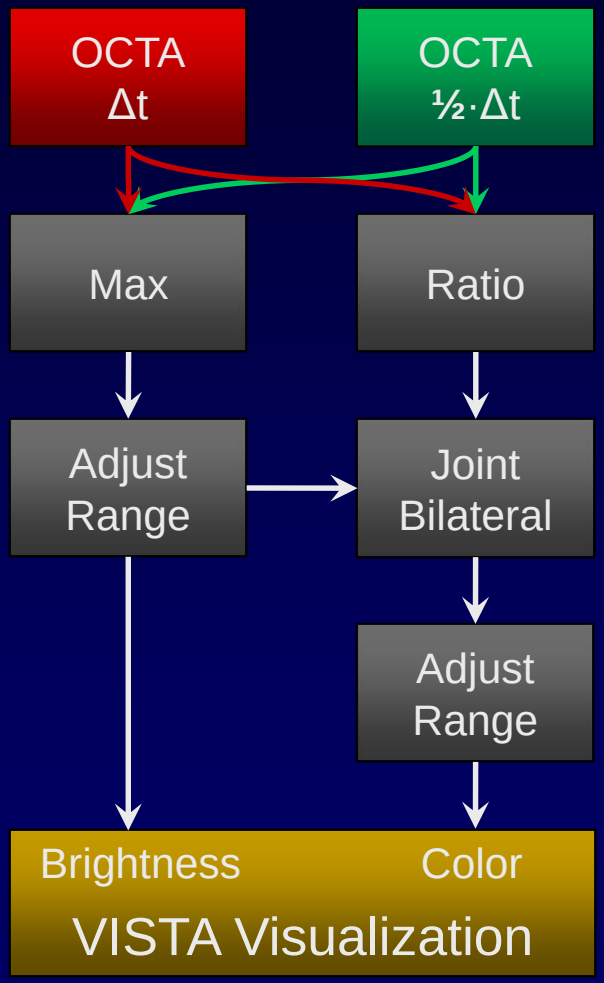


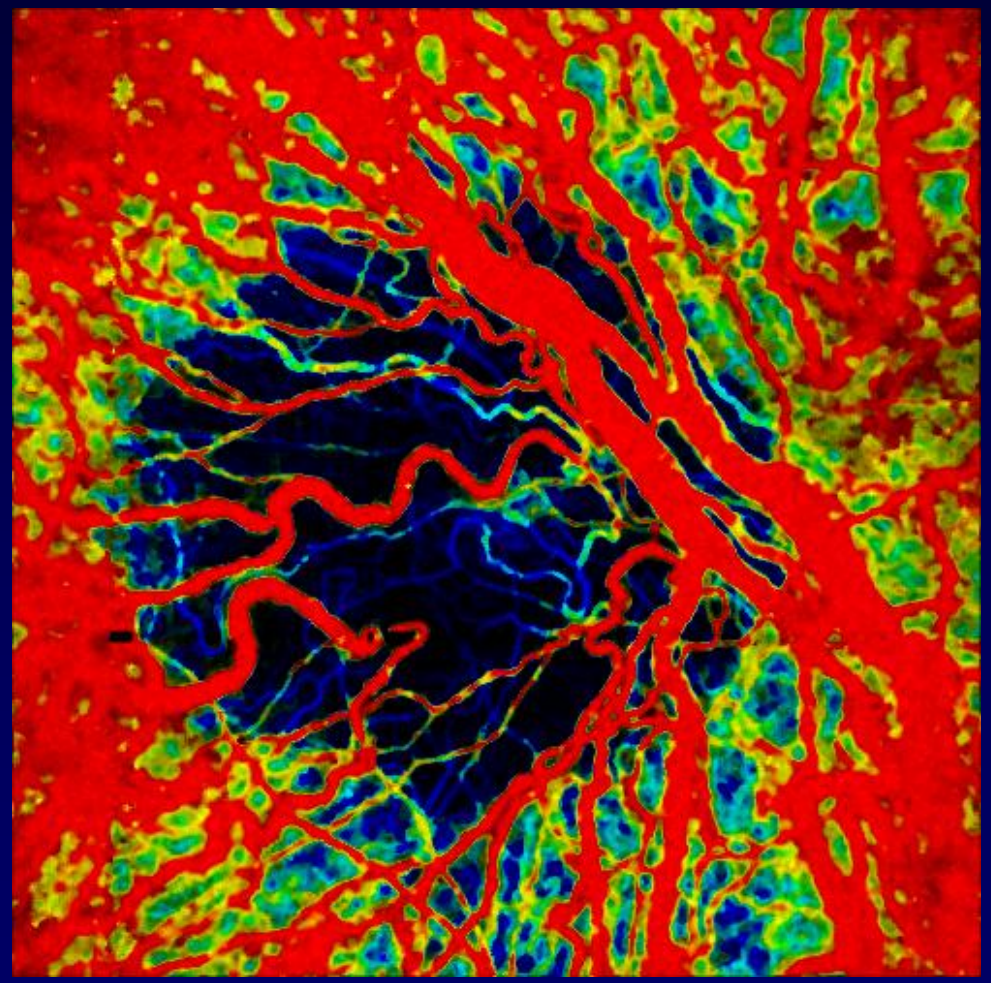


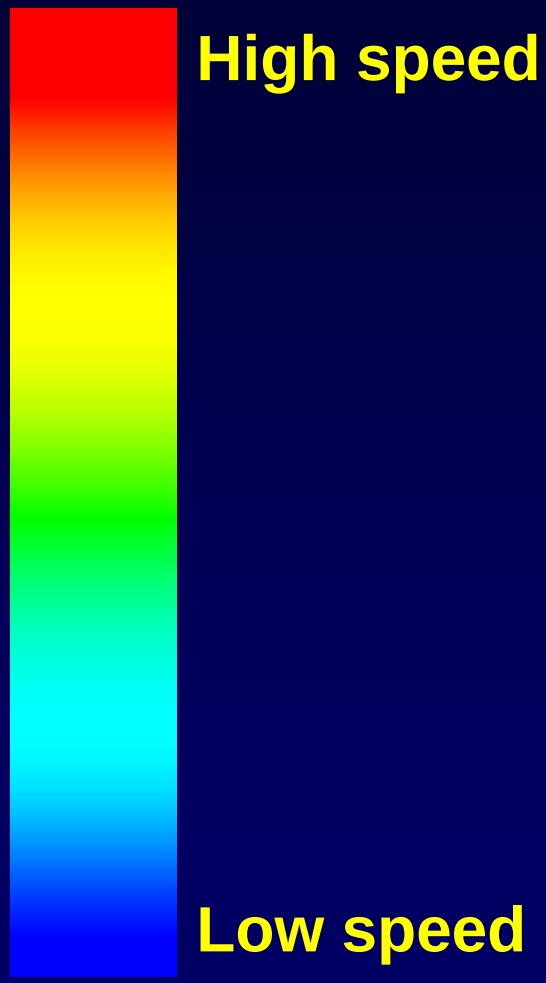
High speed

Low speed

VISTA Visualization





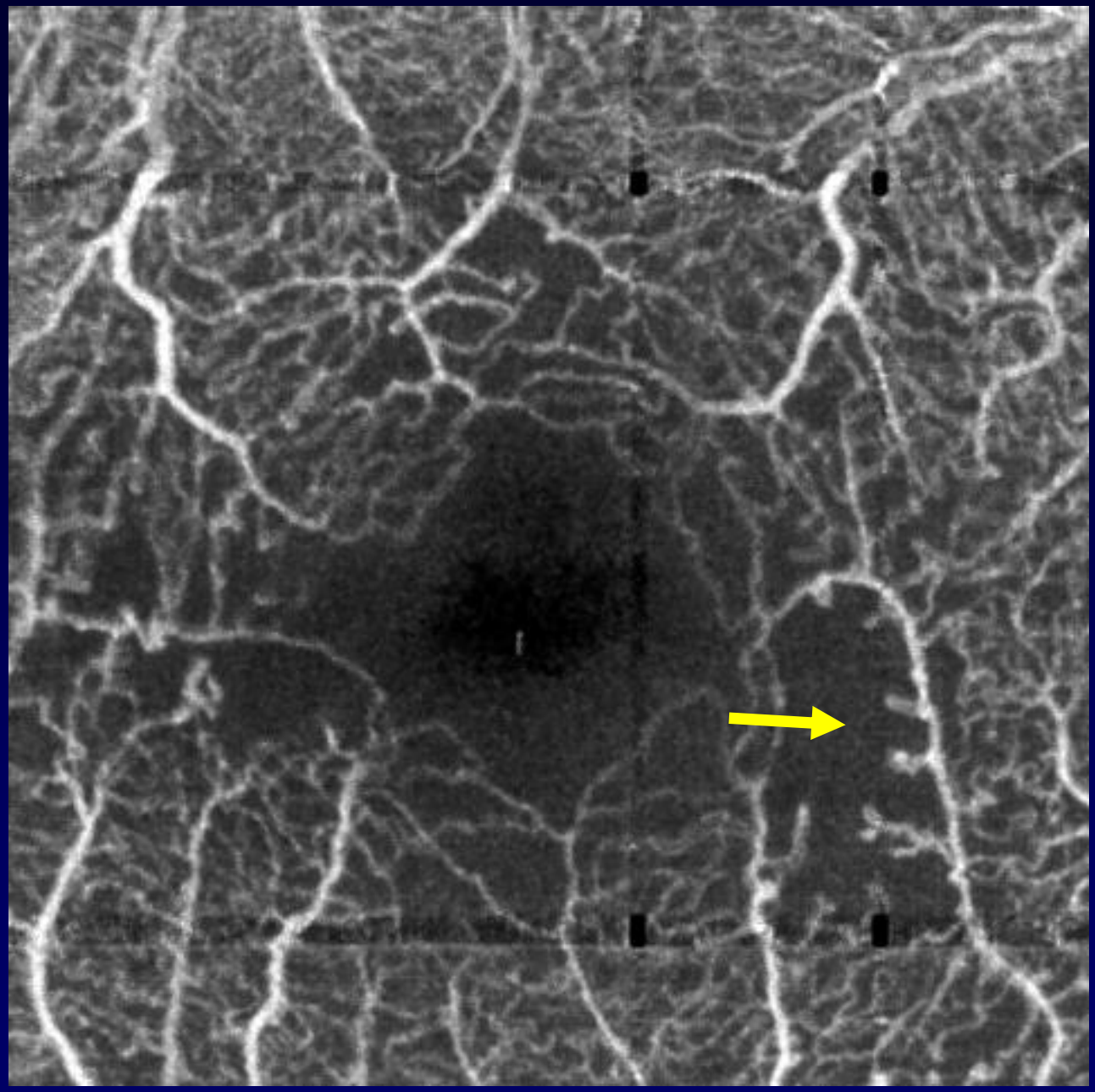


Part II:

Cases

Case 1: 51 y/o NPDR

Fundus Photo

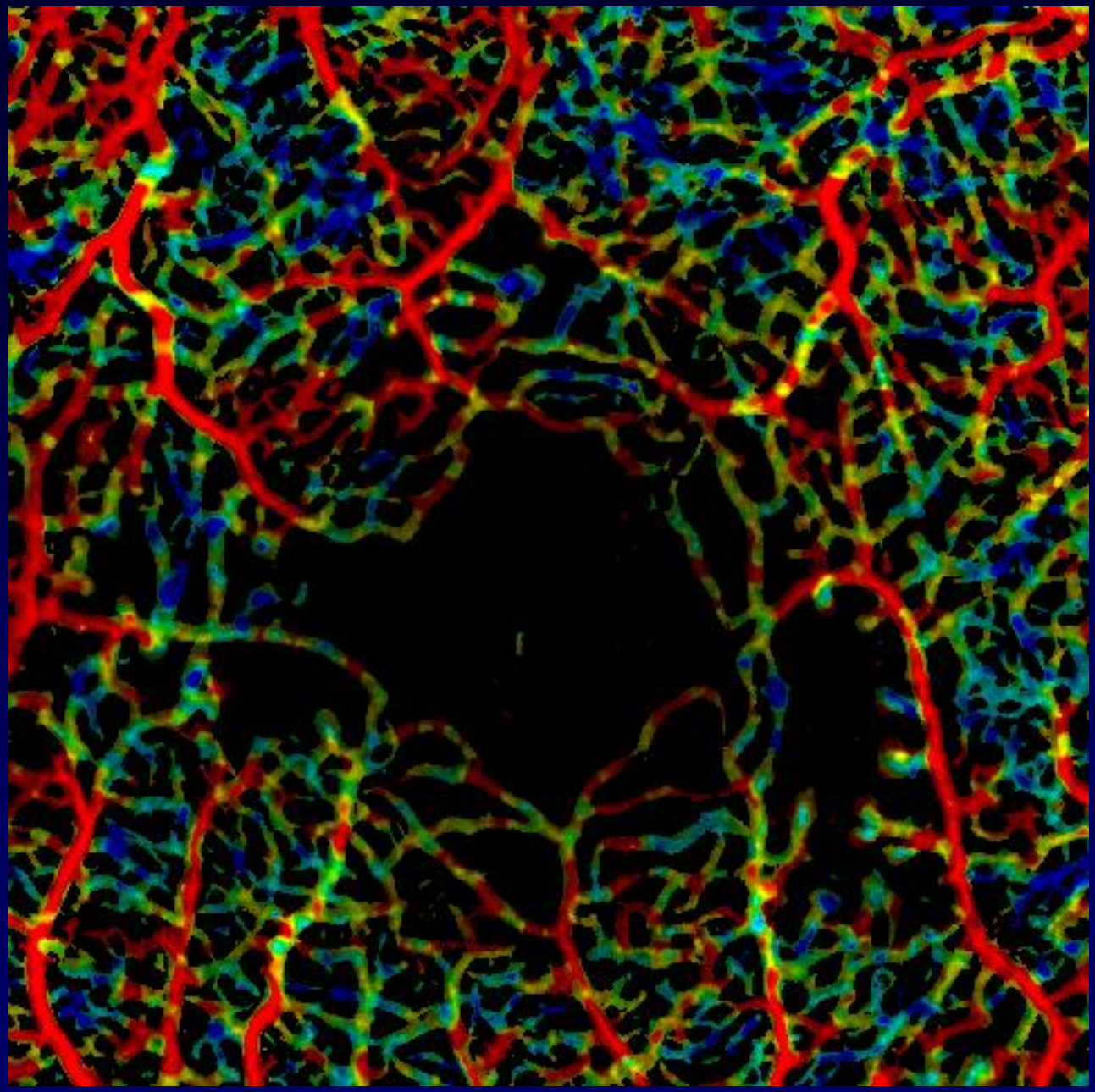


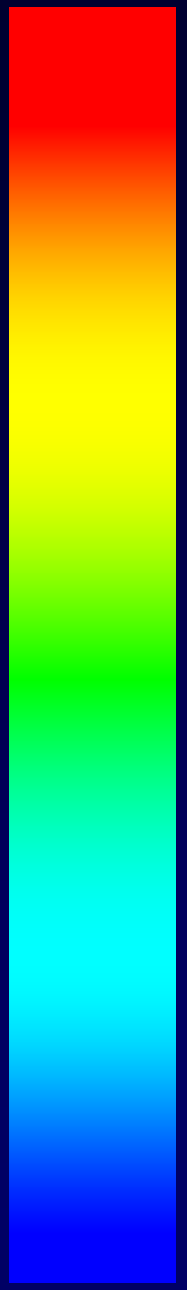
OCTA (3 ms)

3 x 3 mm

VISTA
Visualization

3 x 3 mm



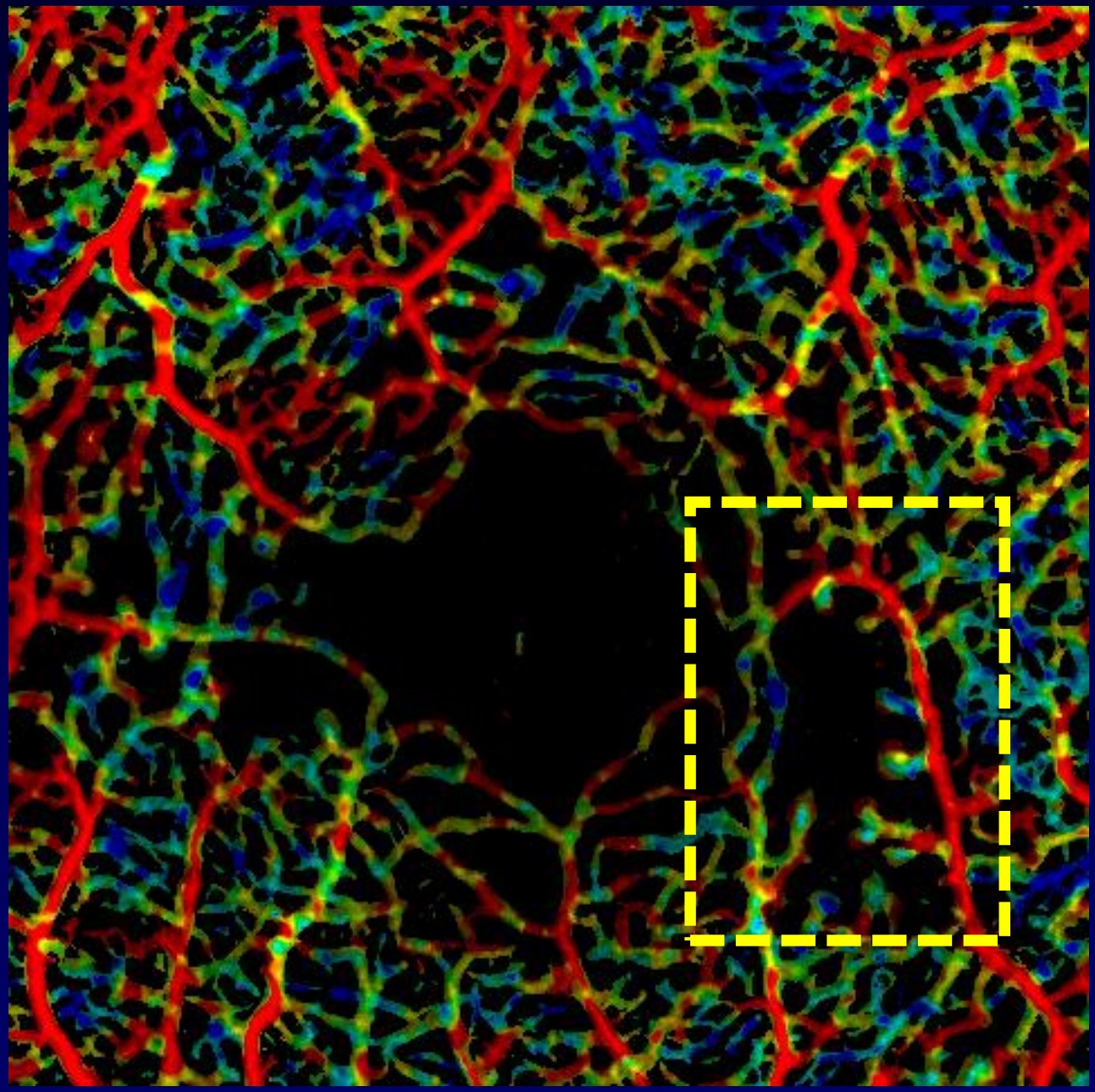


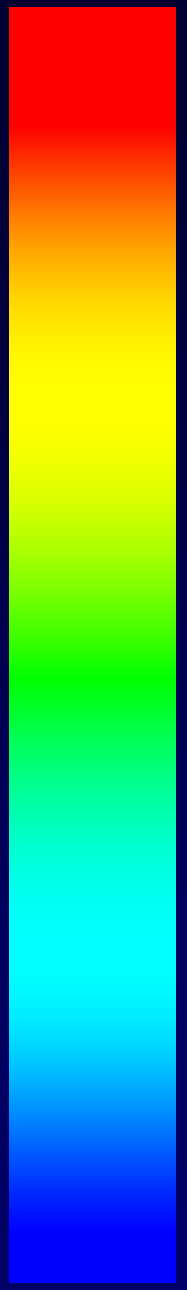
High speed

Low speed

VISTA
Visualization

3 x 3 mm

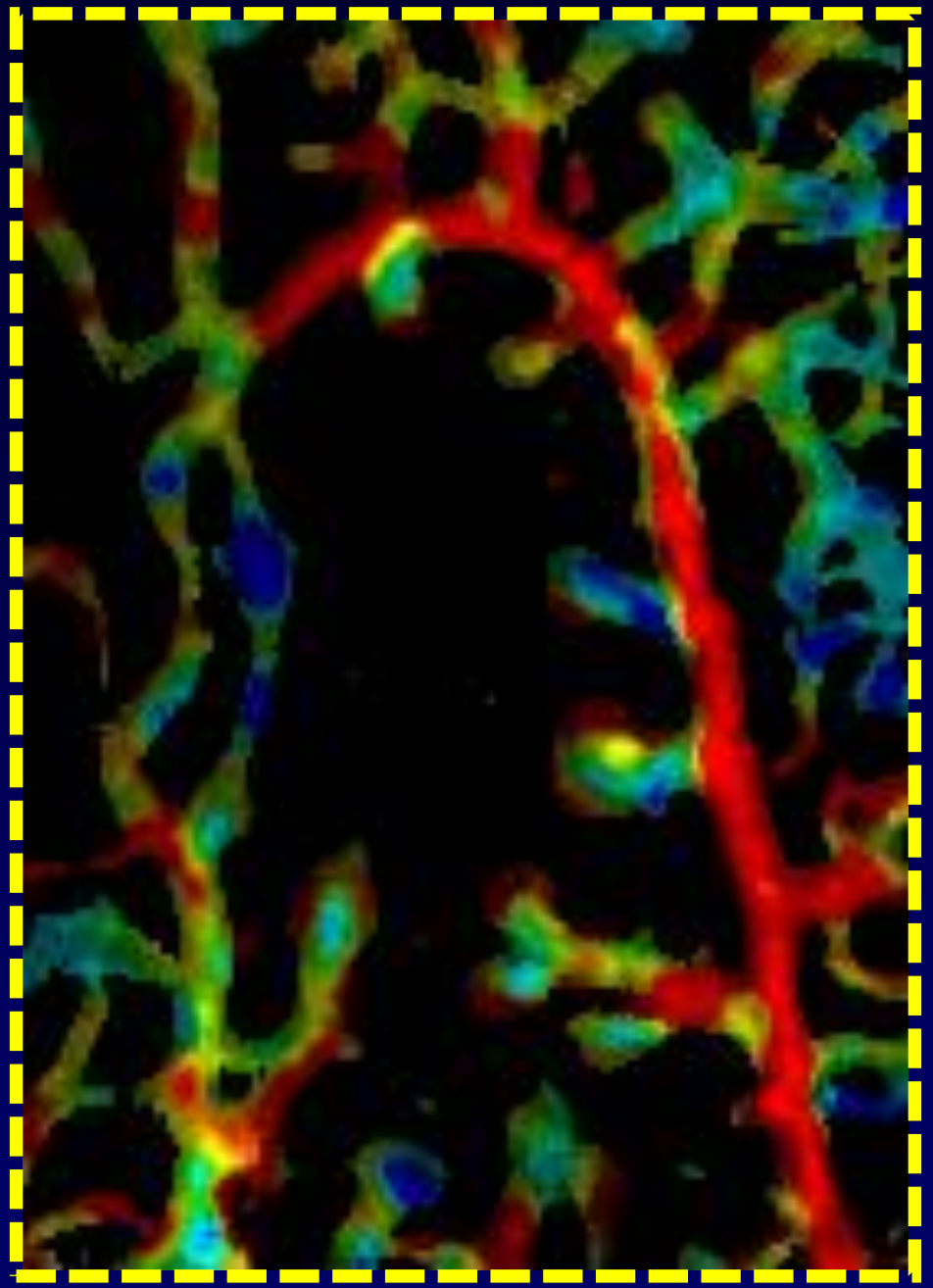




High speed

Low speed

VISTA
Visualization
enlarged



High speed

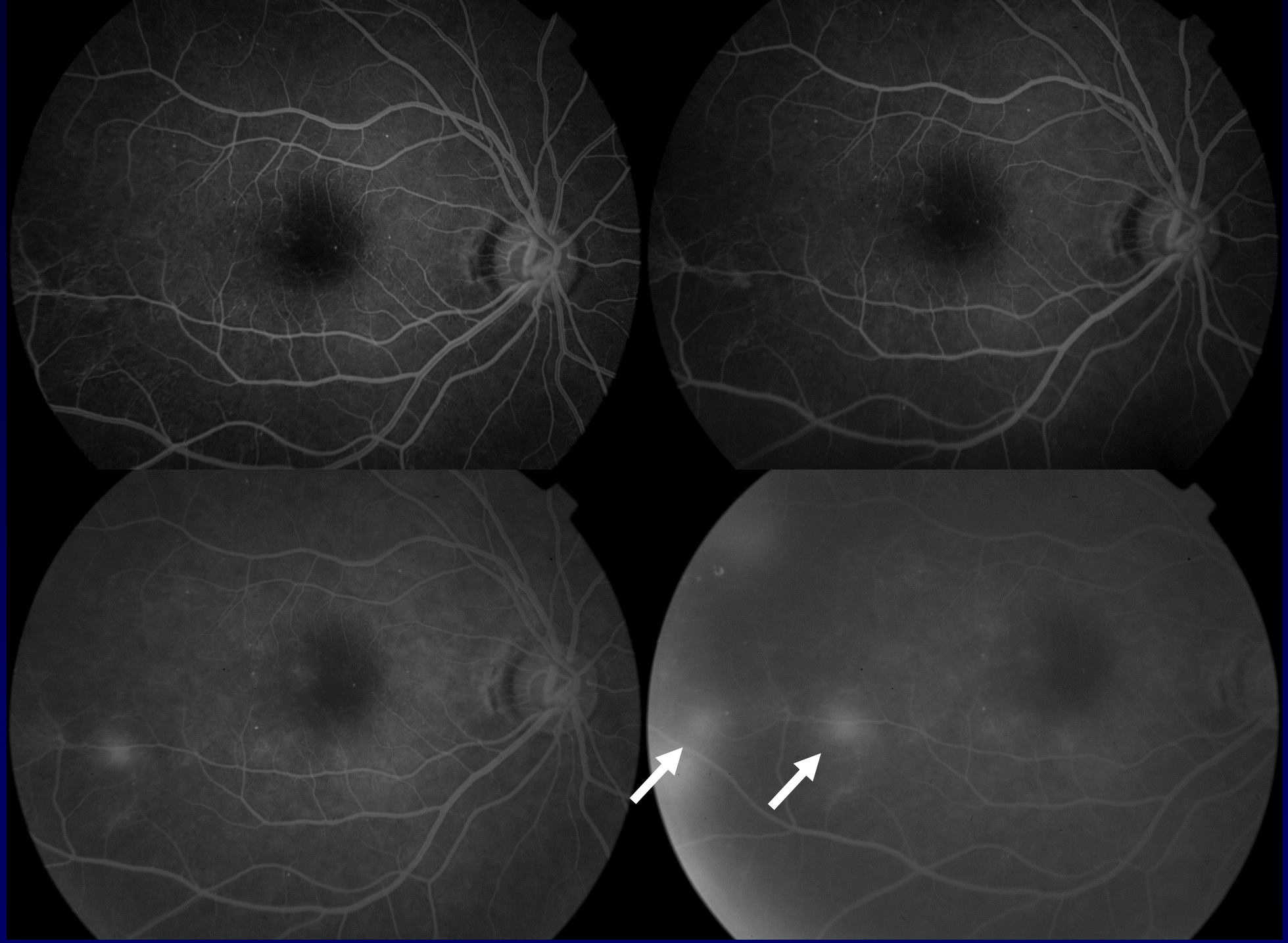
Low speed

Case 2: 30 y/o PDR

Fundus Photo

23 s

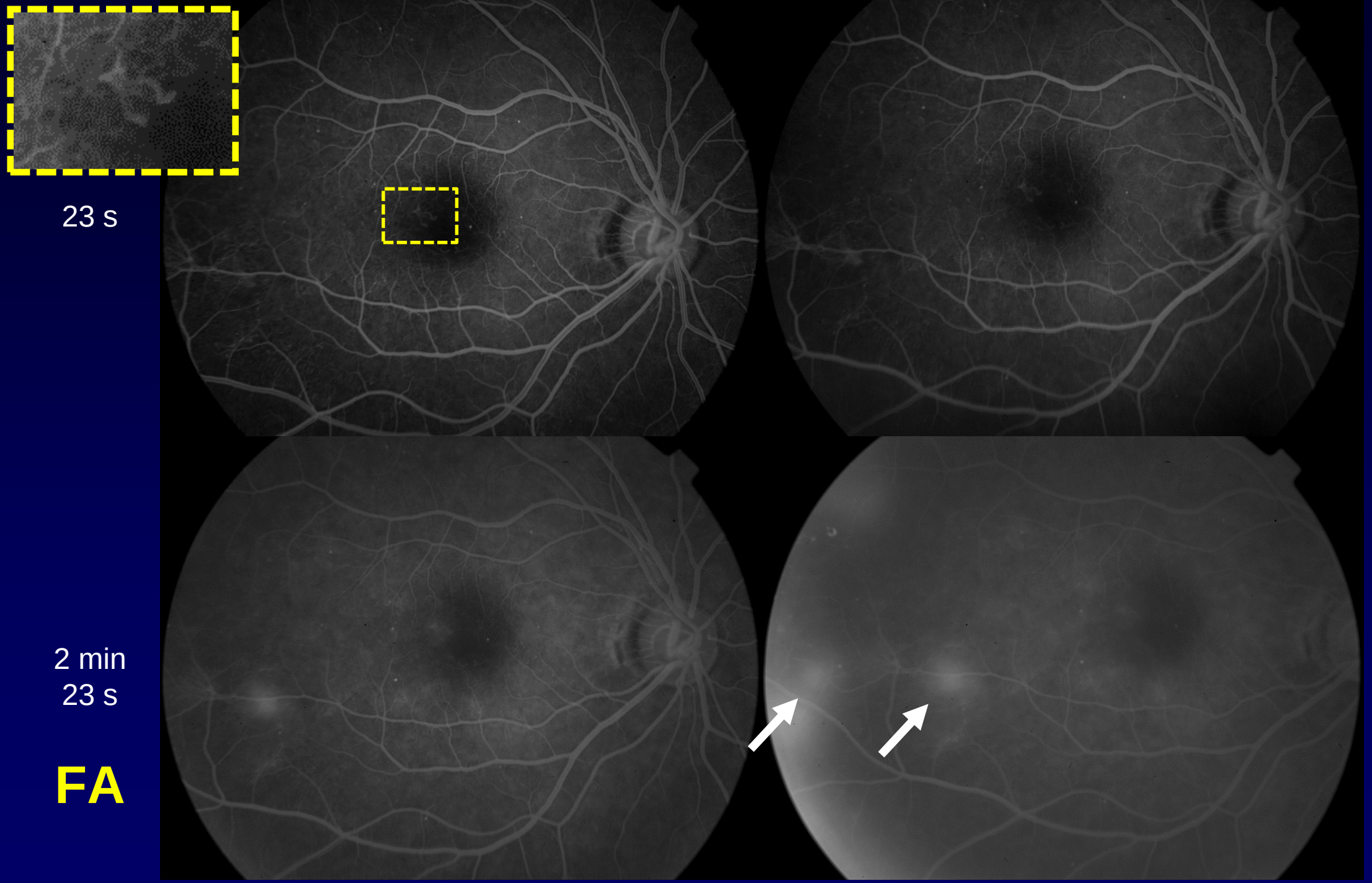
37 s

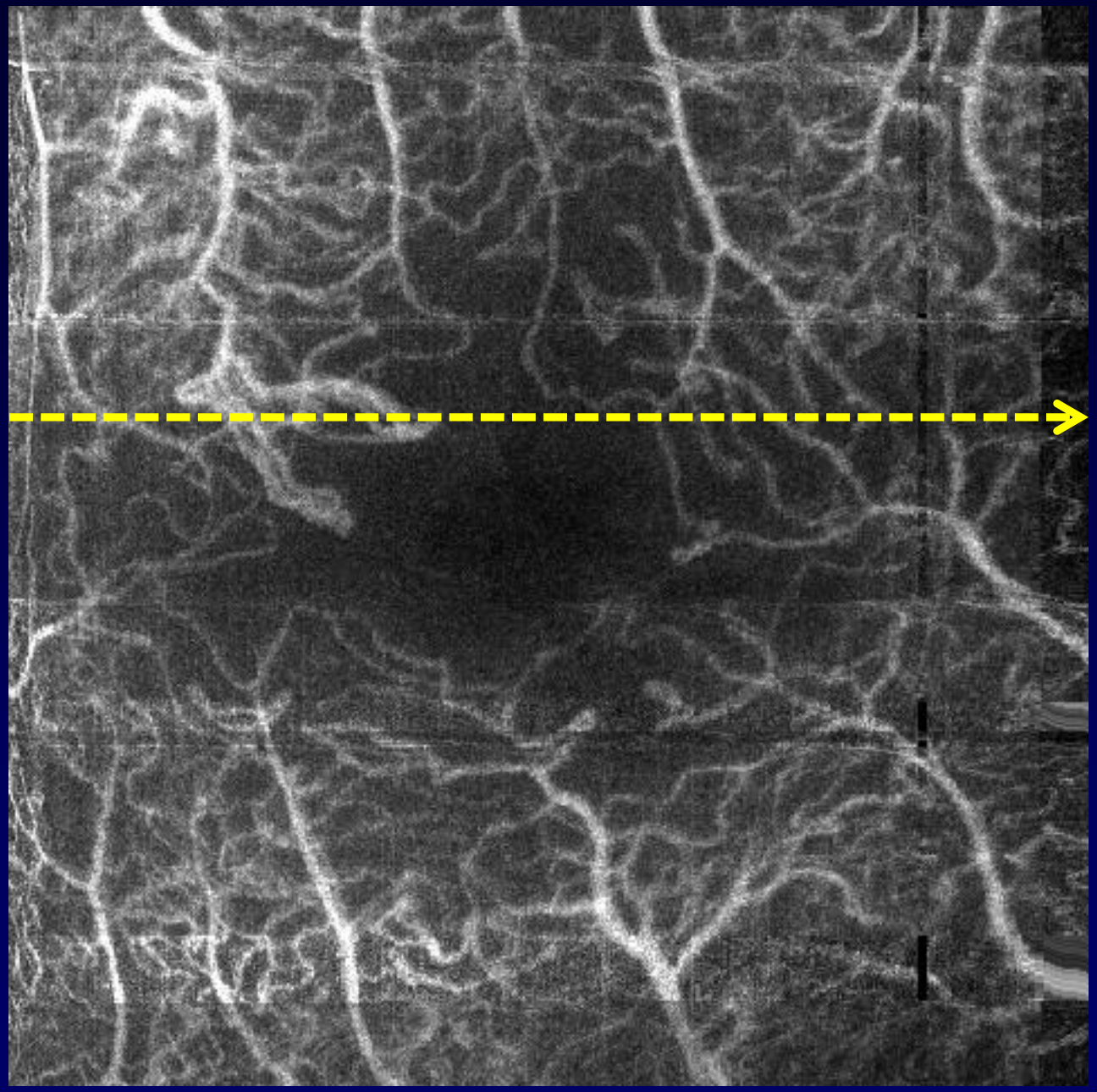


2 min
23 s

6 min

FA

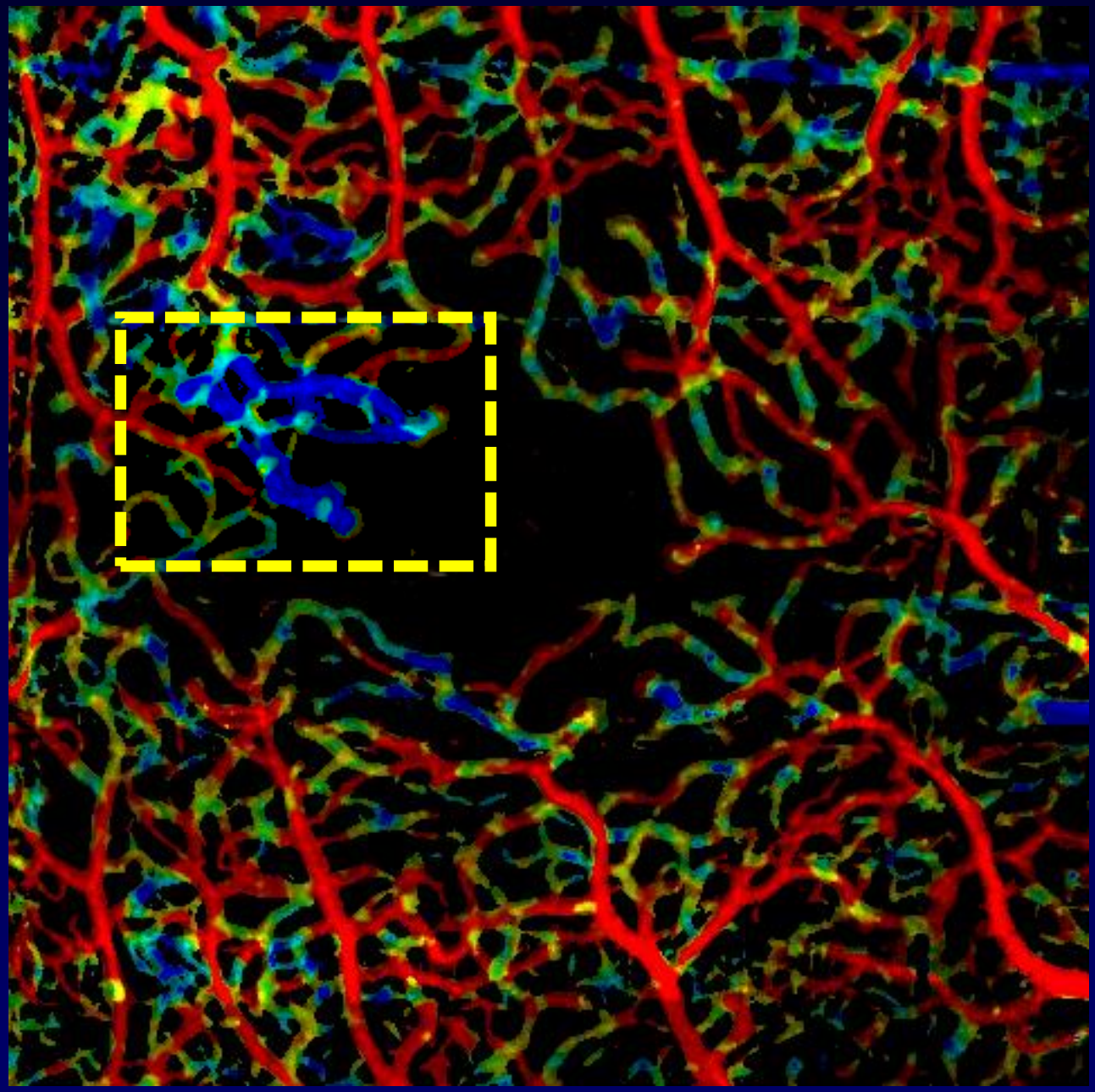

23 s
37 s
2 min
23 s
6 min
FA



OCTA (3 ms)

3 x 3 mm

OCT B-Scan

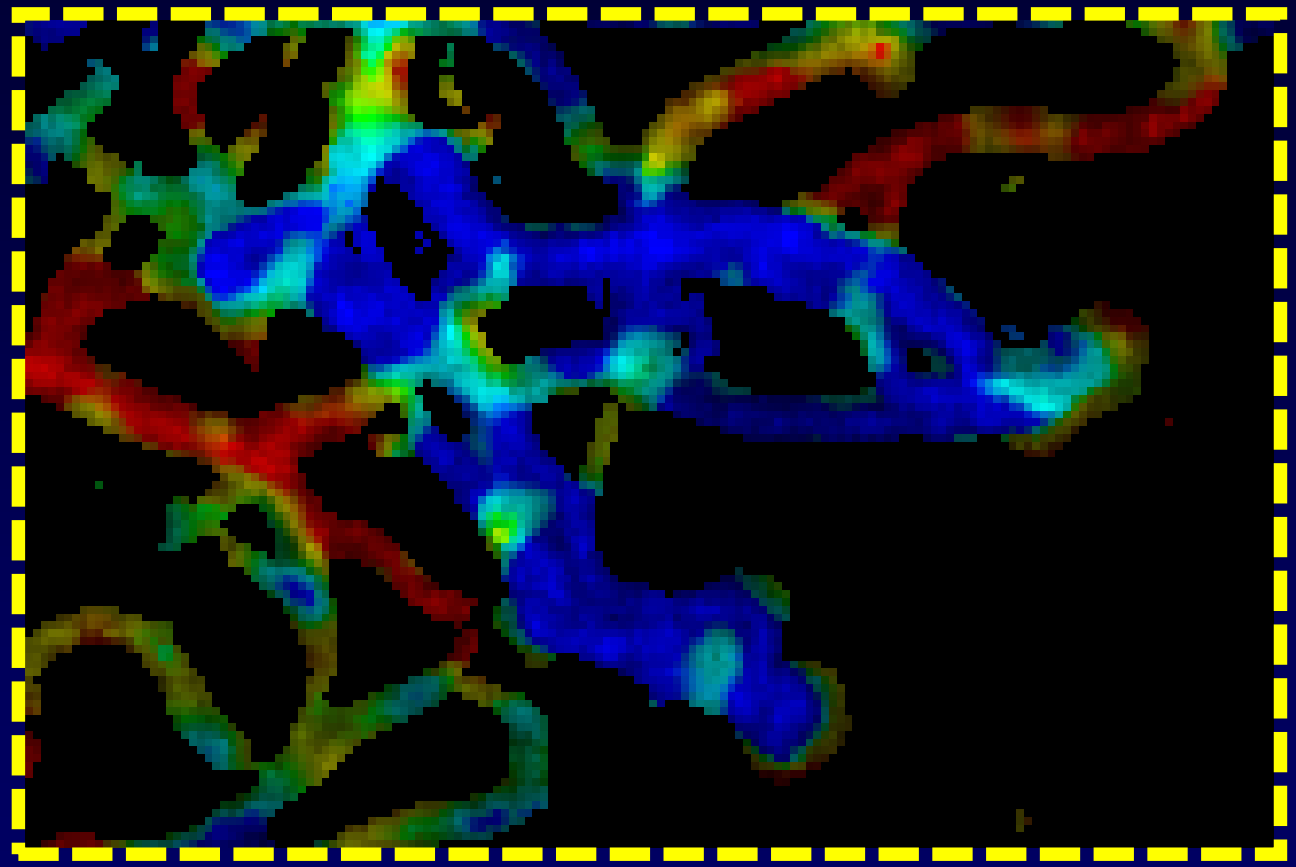


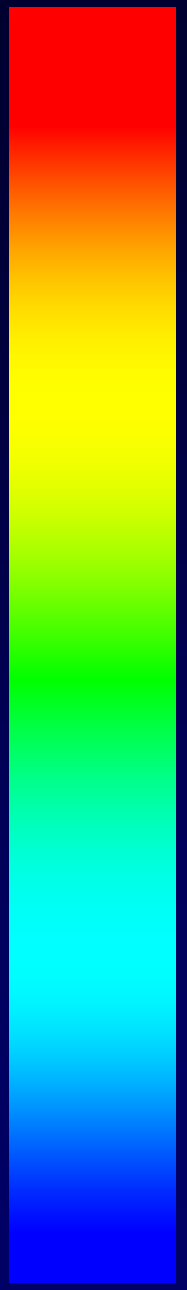
High speed

Low speed

VISTA
Visualization

3 x 3 mm





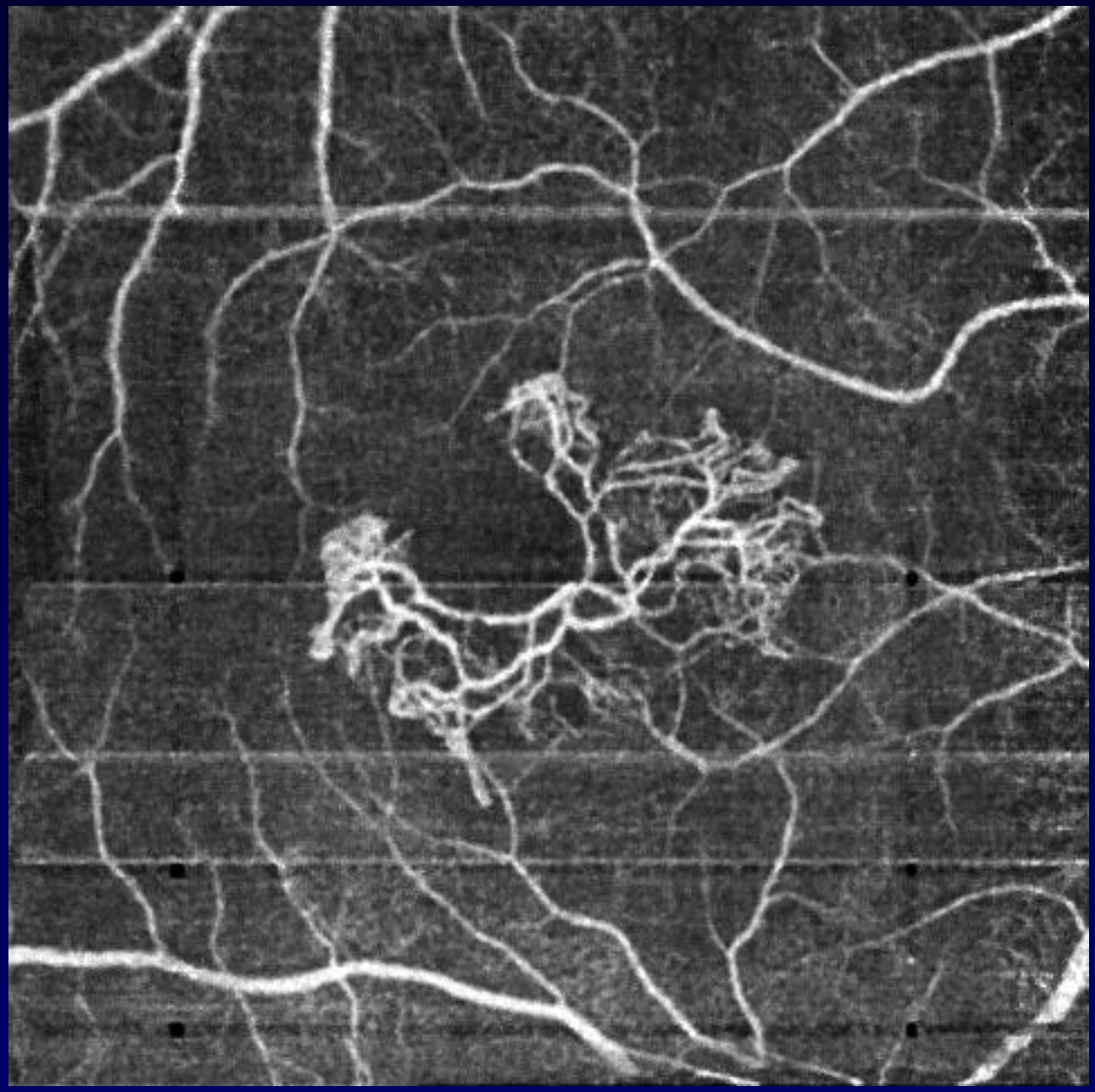
High speed

Low speed

VISTA Visualization enlarged

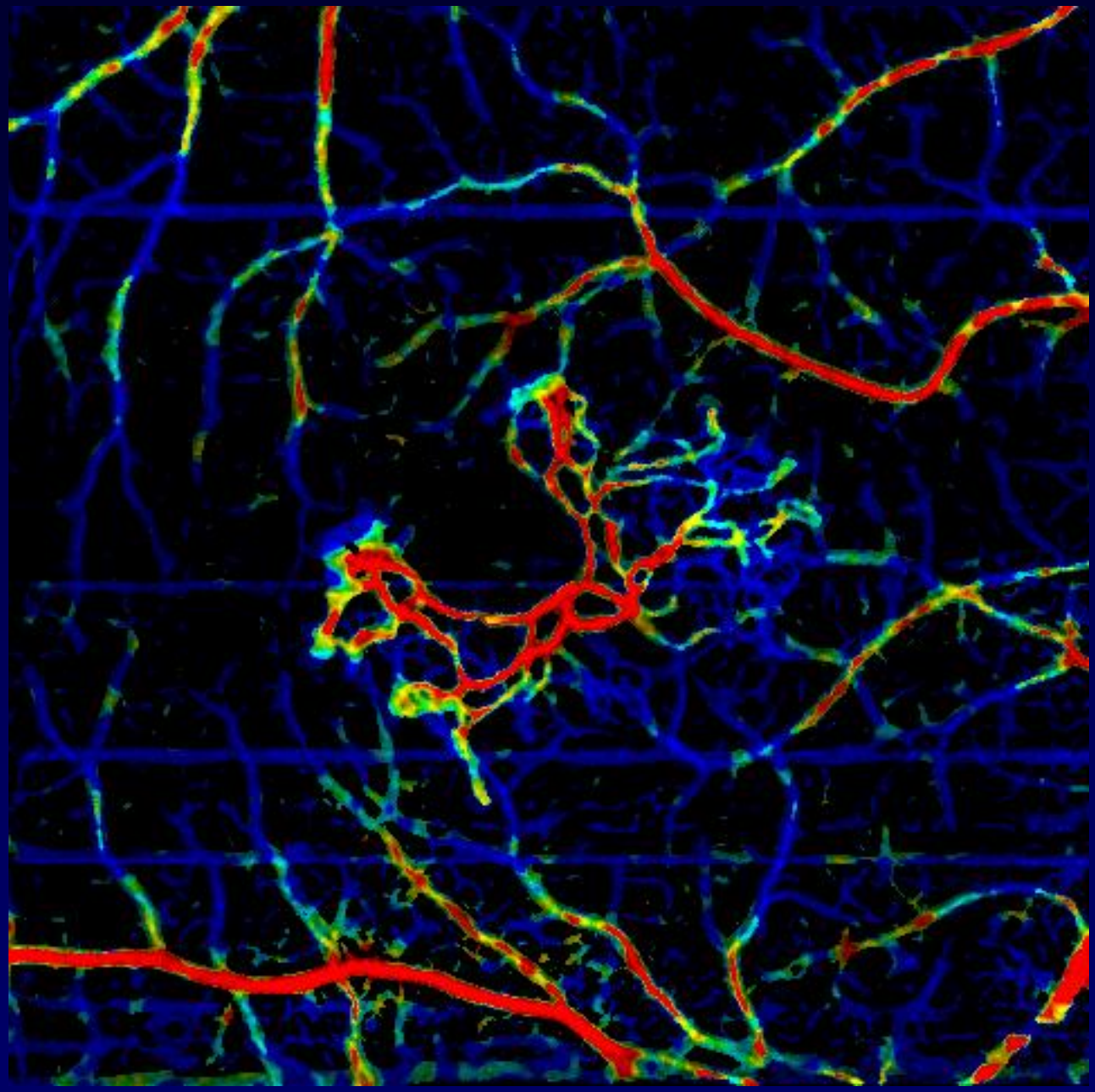
Case 3: 90 y/o CNV

Fundus Photo



OCTA (3 ms)

6 x 6 mm



High speed

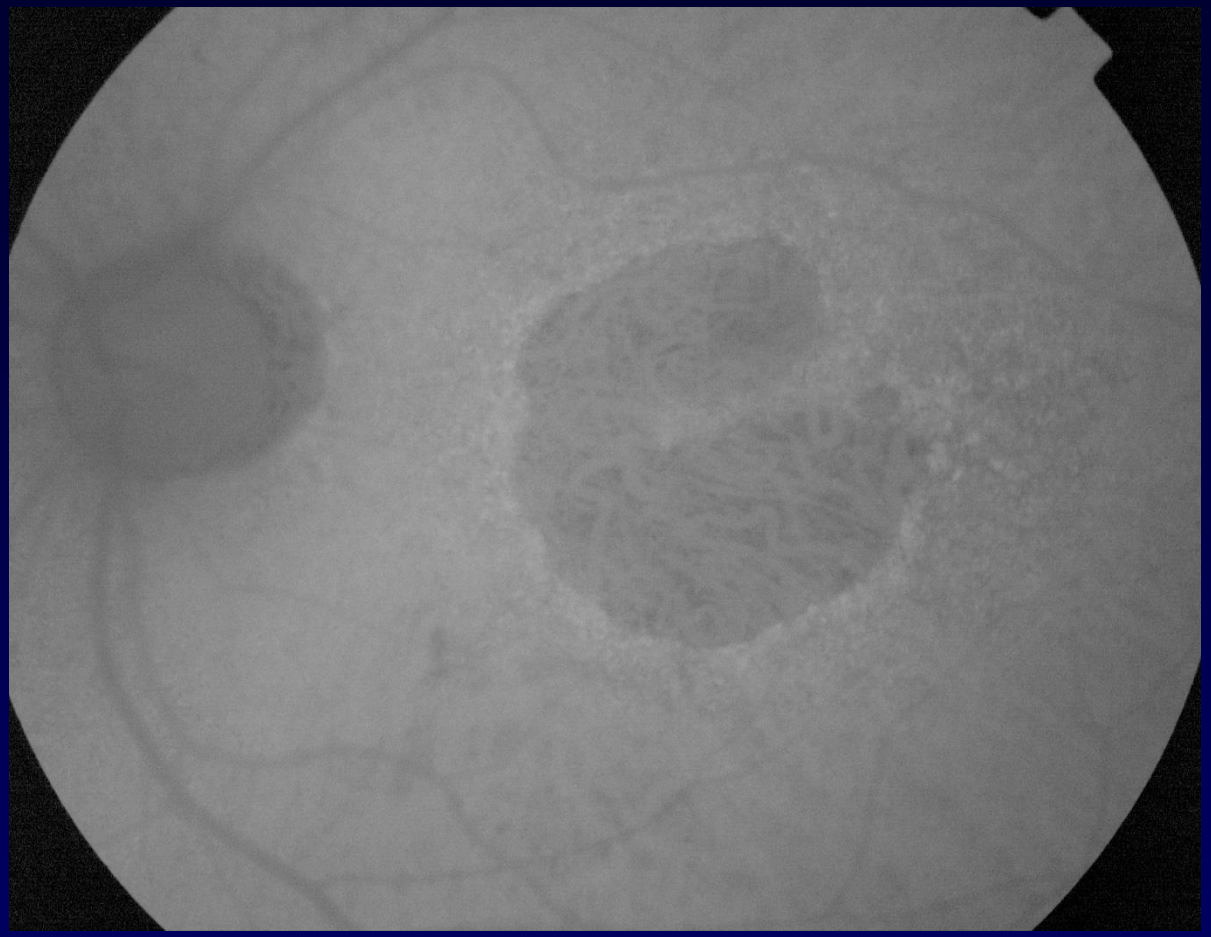
Low speed

VISTA
Visualization

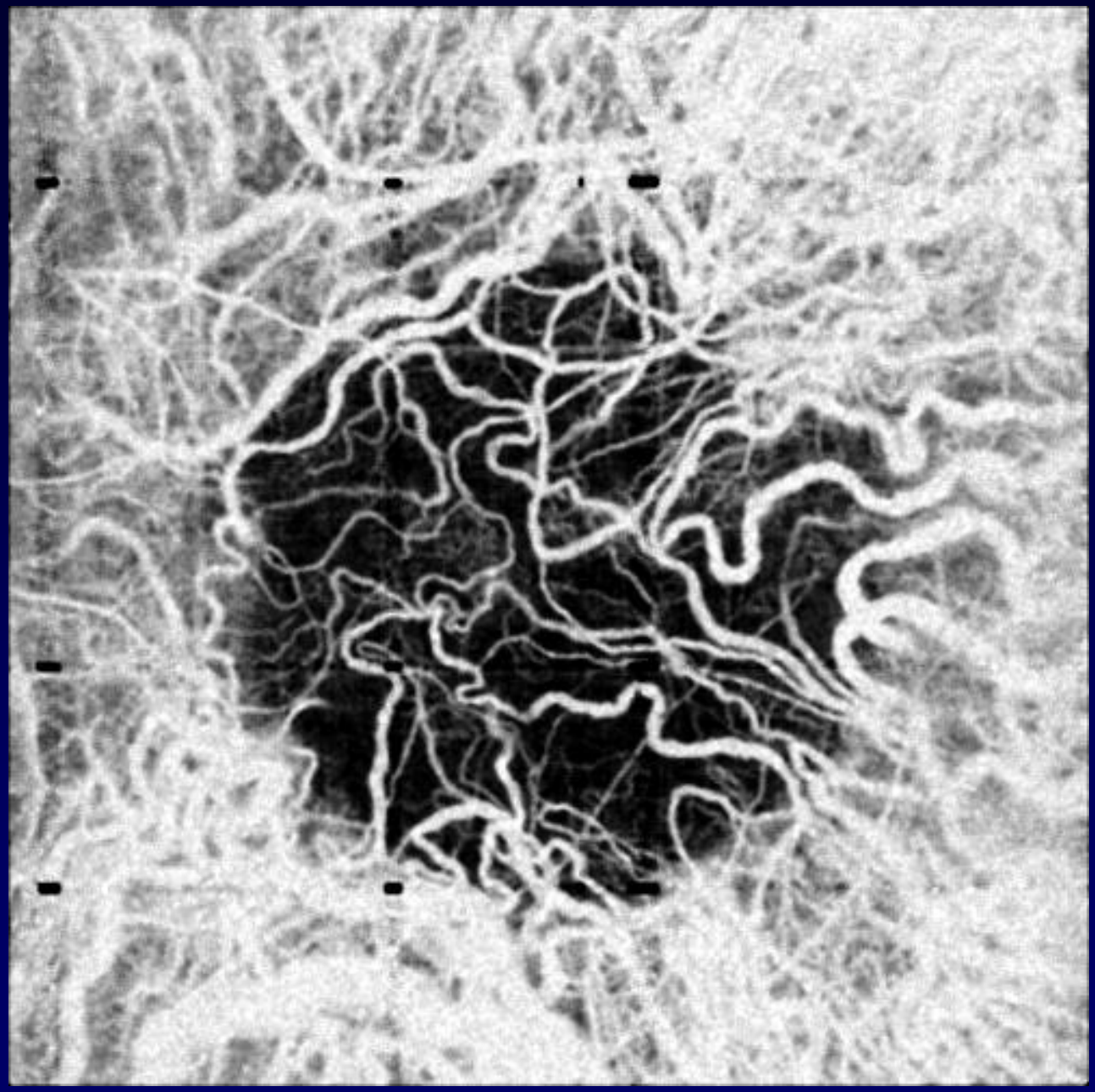
6 x 6 mm

Case 4: 75 y/o GA

Fundus Photo



FAF

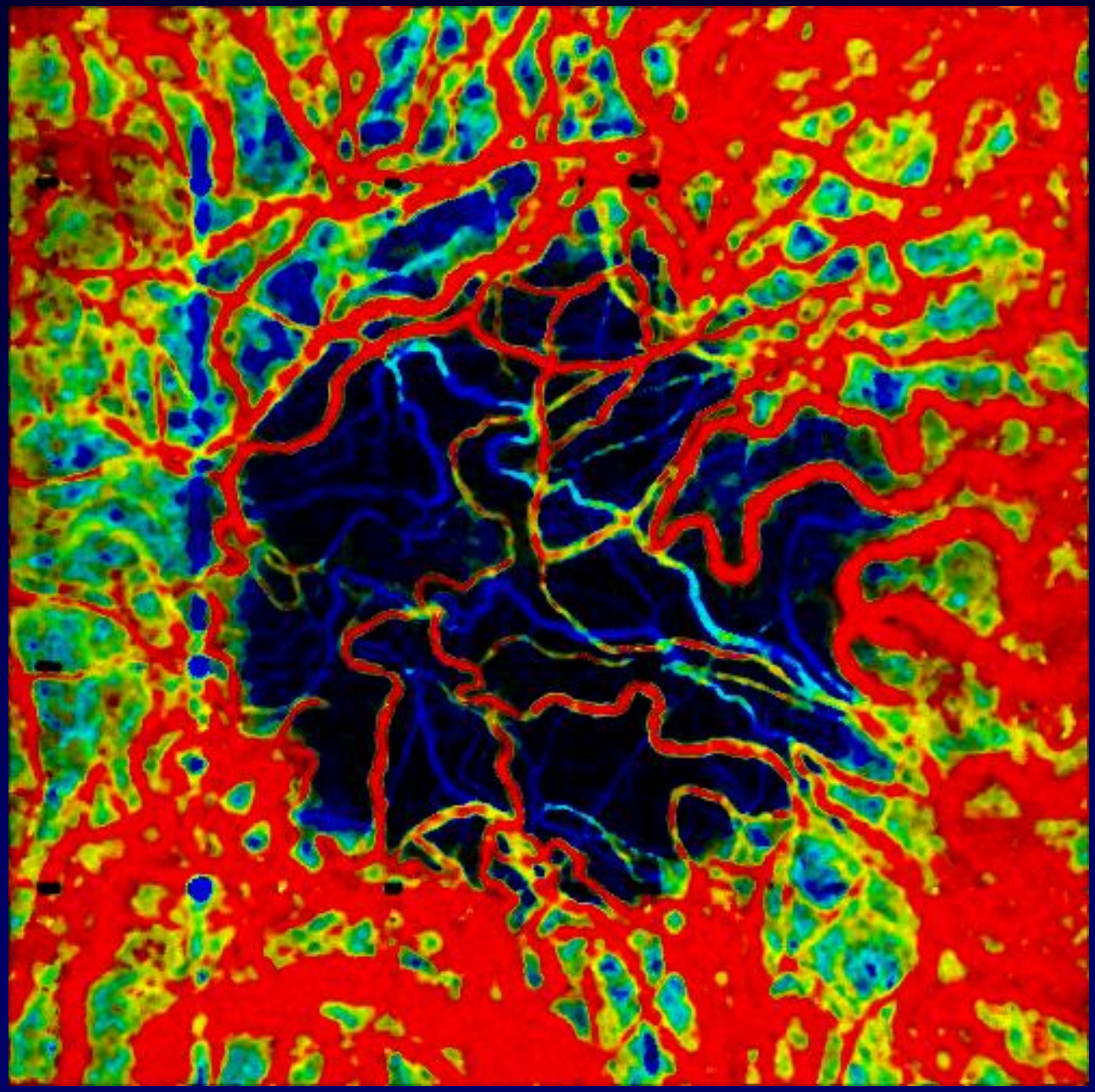


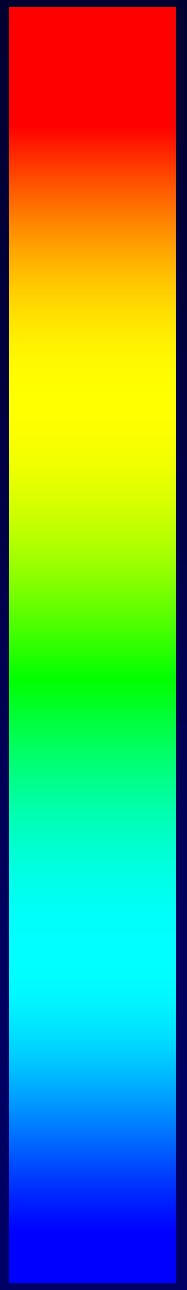
OCTA (3 ms)

6 x 6 mm

VISTA
Visualization

6 x 6 mm





High speed

Low speed

Future Directions

- Incorporate multiple (>2) and/or different interscan times
- Use VISTA to investigate markers for disease progression
- Make OCT Angiography fully quantitative!

Acknowledgment

University of Erlangen (FAU)

- Joachim Hornegger
- Andreas Maier
- Julia Schottenhamml
- Lennart Husvogt
- Martin Kraus

Bascom Palmer

- Philip Rosenfeld

National Institute of Health

- R01-EY011289-29A
- R44-EY022864
- R01-CA075289-16

Air Force Office of Scientific Research

- FA9550-15-1-0473
- FA9550-12-1-0499

MIT

- James Fujimoto
- Zhao Wang
- Michael Giacomelli
- Ben Potsaid
- WooJhon Choi
- Hsiang-Chieh Lee
- Kaicheng Liang
- Ben Lee
- Chen Lu
- Osman Ahsen
- Eric Moult
- Dorothy Fleischer
- Tadayuki Yoshitake
- Hamid Hosseiny
- Lucas Cahill
- Patrick Yiu
- Avilash Cramer

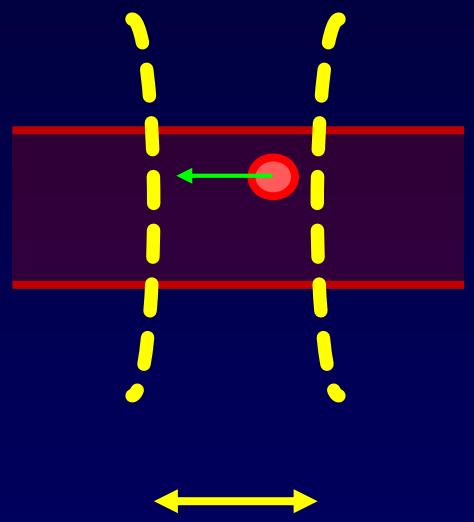
NEEC

- Jay Duker
- Nadia Waheed
- Caroline Baumal
- Eduardo Novais
- Emily Cole
- Ricardo Louzada
- Sabin Dang
- Andre Witkin
- Mark Lane
- Mehreen Adhi
- Talisa De Carlo
- Marco Filho
- Adam Chin
- Daniela Ferrara
- Lauren Branchini
- Seddon, Johanna

Thorlabs and Praevium

- Alex Cable
- Peter Heim
- Scott Jobling
- Pak Cho
- Changyi Li
- Si Cho
- John Hryniewicz
- Alan Donaldson
- James Y. Jiang
- Anjul Davis
- Jens Peupelmann
- Vijaysekhar Jayaraman

What is the minimal required interscan time for VISTA?



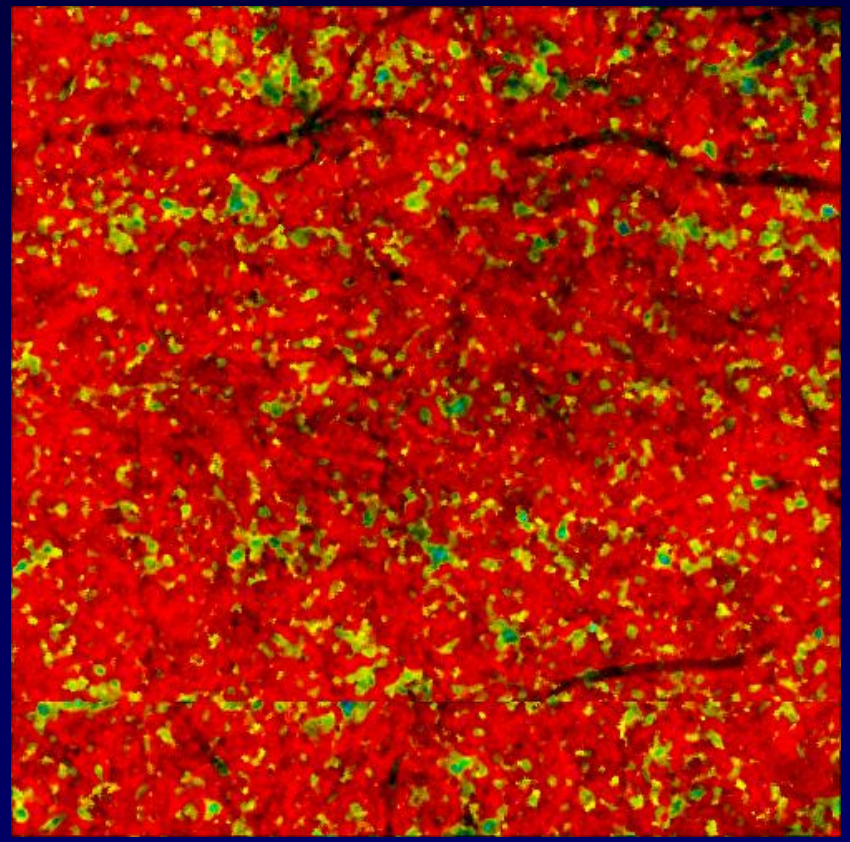
Blood flow speed: 1cm/s

Spot size: 30μm (at $1/e^2$)

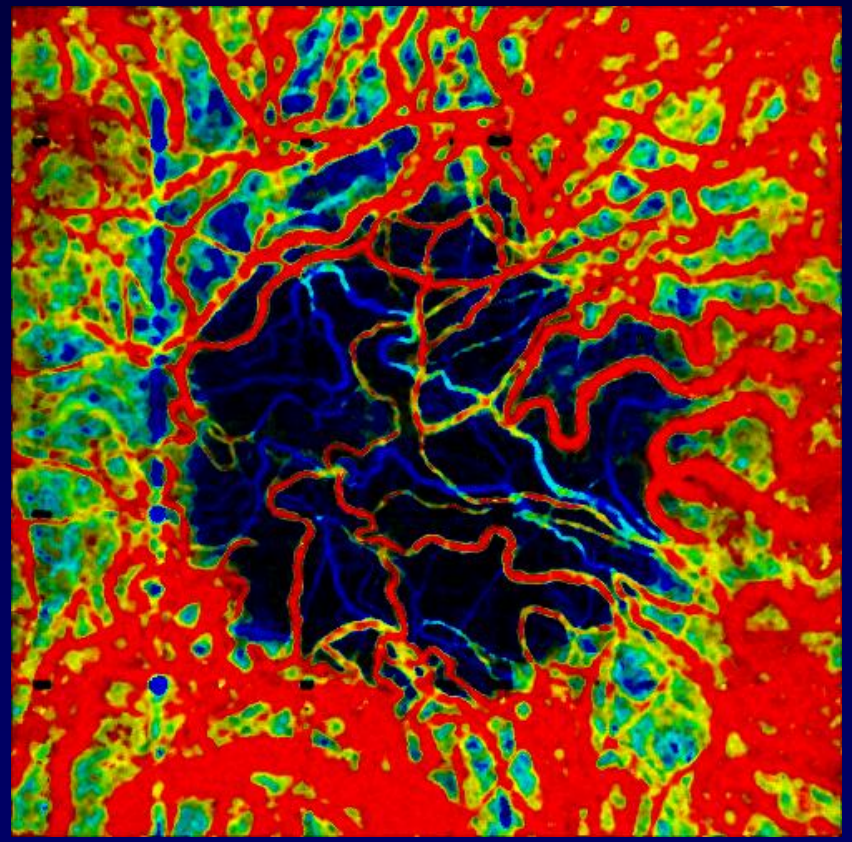
- Time to cross the spot: 30μm / (1cm/s) = 3ms
- Saturation at 3ms interscan time or less
- Observation: 1.5 ms and 3 ms were used in this presentation; 3 ms and 4.5 ms seemed to be too long.

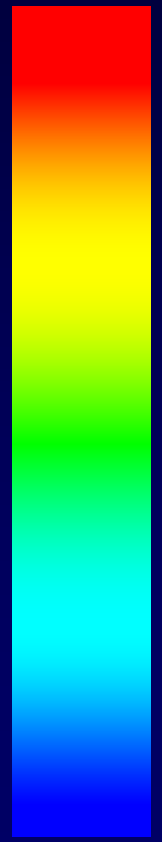
VISTA Visualization, choroid, comparison with normal

43 y/o normal



75 y/o GA

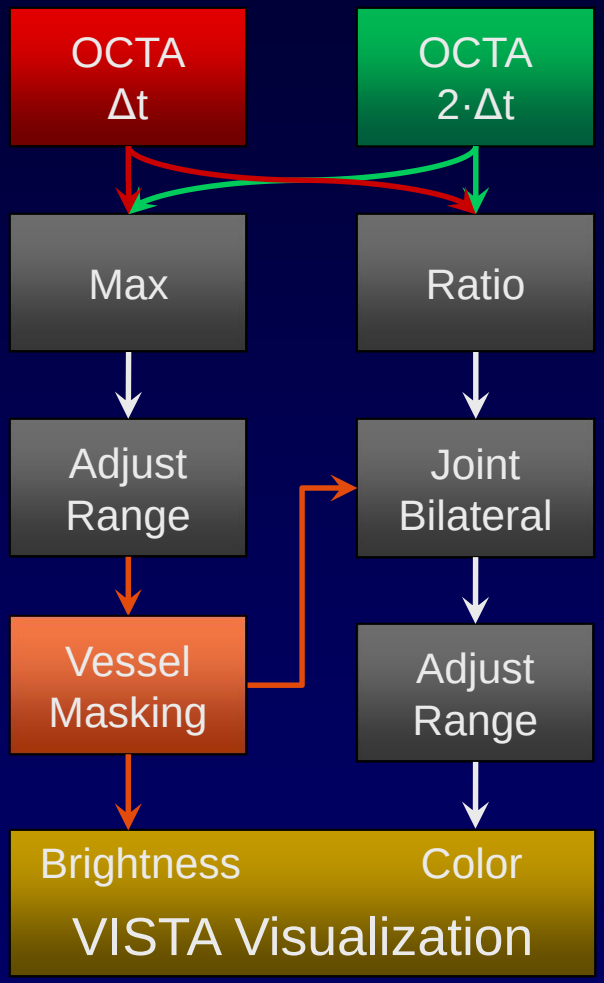




High speed

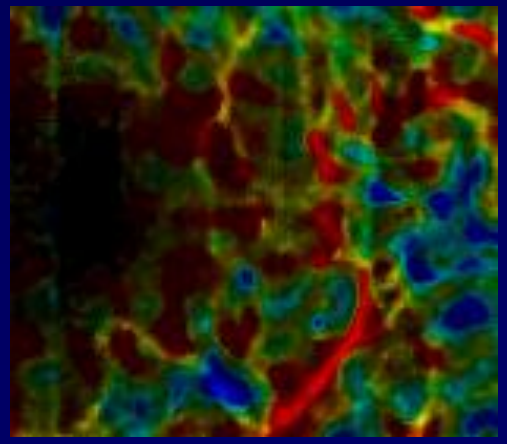
Low speed

VISTA Visualization in Retina Projections

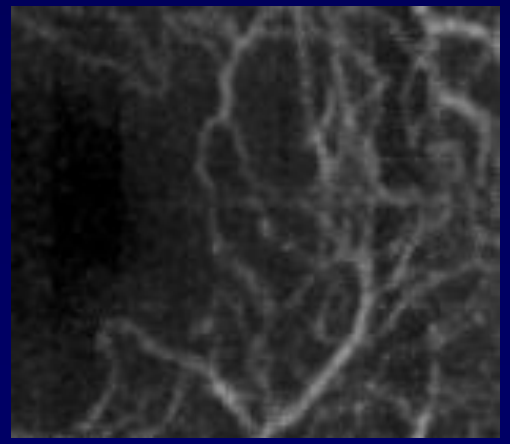


- **Reduced brightness perception in color images**
- **No erythrocytes moving outside of vessels**
- **Make outside vessel pixels fully black**

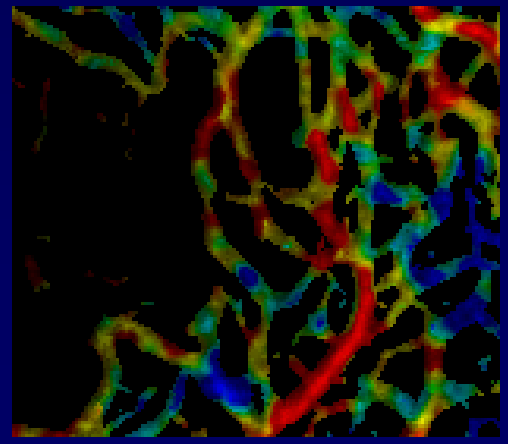
VISTA w/o masking



OCTA (3 ms)



VISTA w/ masking



Variable interscan time analysis (VISTA)