ICTER
International Centre
for Translational Eye Research

Eye Research at ICTER

International Centre for Translational Eye Research (ICTER)
Institute of Physical Chemistry Polish Academy of Sciences

Karol Karnowski

European Union

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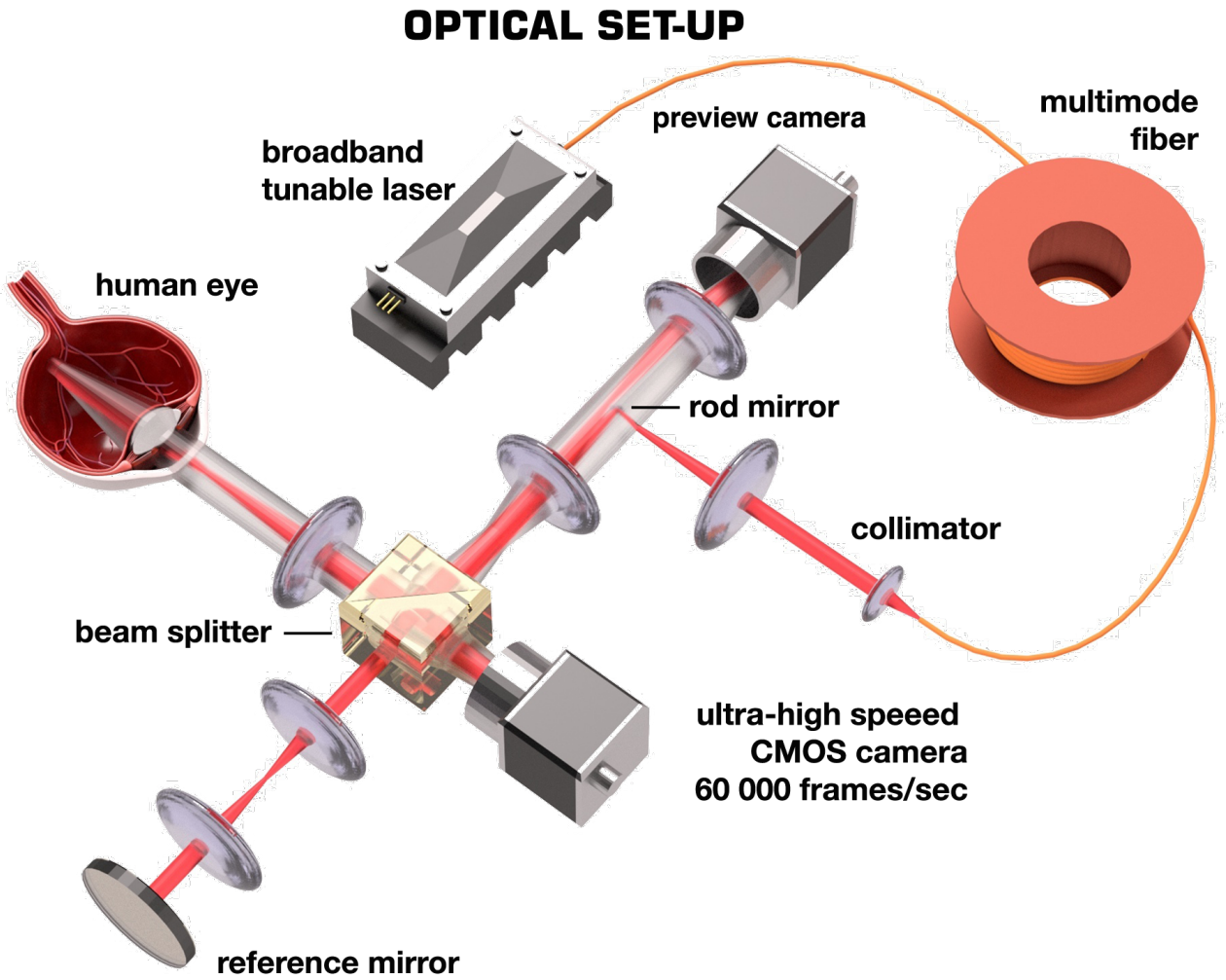
Prof. Maciej Wojtkowski
PI



Novel imaging modalities

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IMAGE-GUIDED DEVICES FOR OPHTHALMIC CARE

Dr Karol Karnowski
Acting PI

Dr Andrea Curatolo
Former PI

- Eye function and treatment monitoring,
- eye surgery planning,
- eye surgery guidance,
- low-cost solutions.

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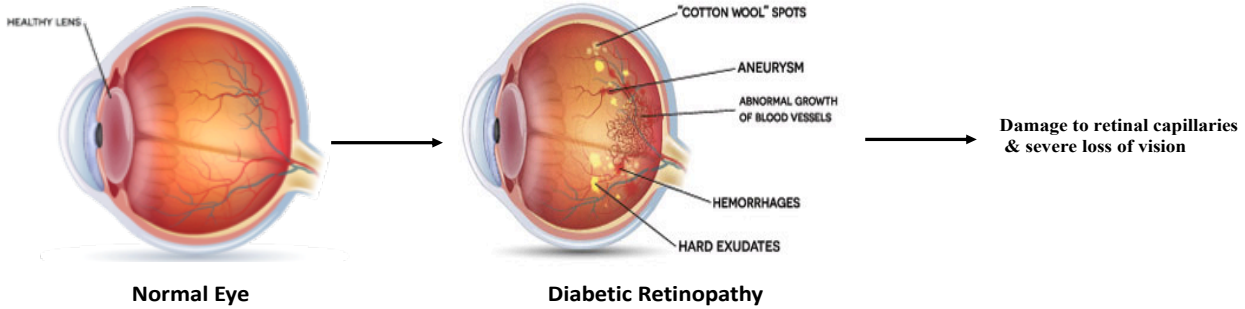
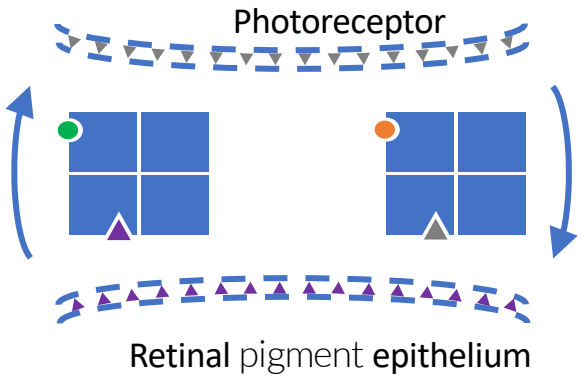
INTEGRATED STRUCTURAL BIOLOGY

Dr Humberto Fernandes
PI



Retinol binding protein 3 (RBP3)):



- 11-*cis*-retinal
- All-*trans*-retinol
- **RPE** Fatty **acids**
- Photoreceptor Fatty **acids**
- **Single RBP3** module

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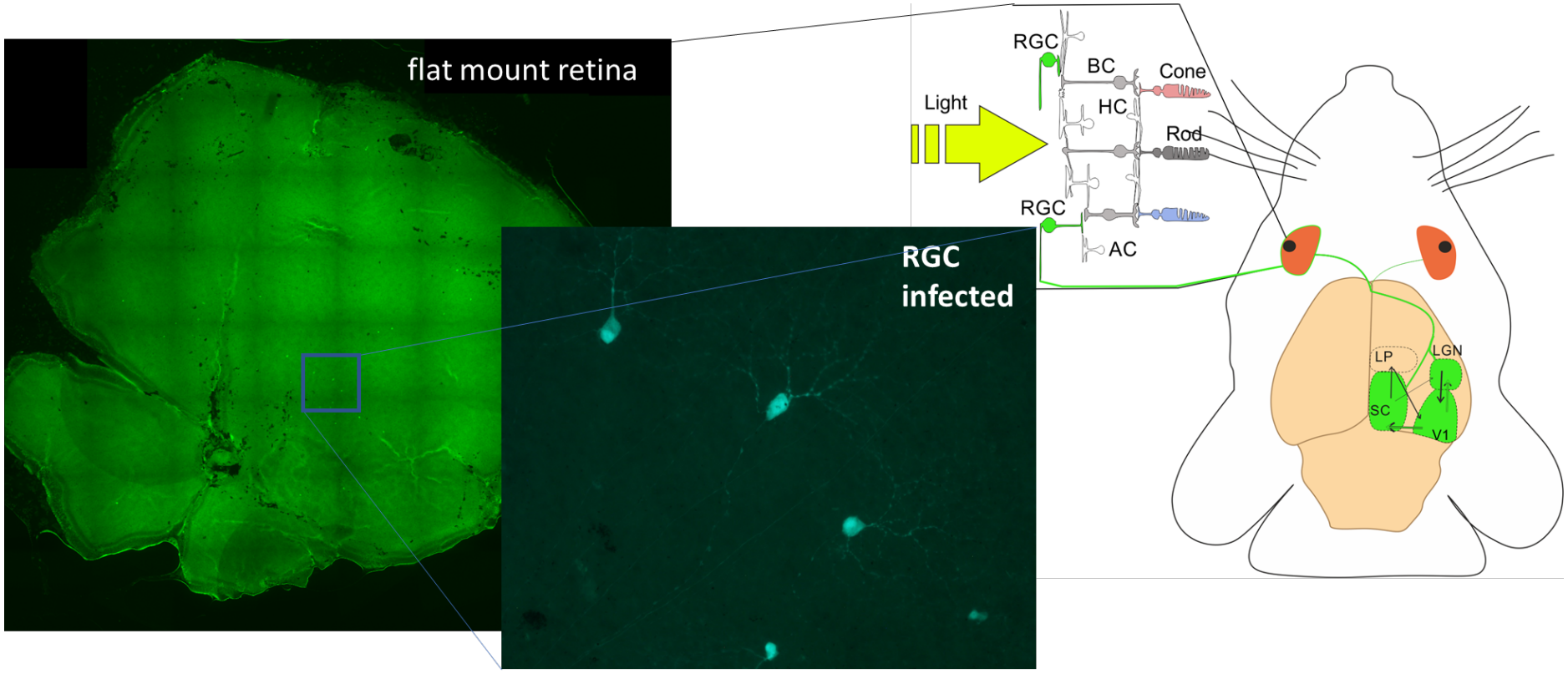
OPHTHALMIC BIOLOGY LABORATORY

Dr Andrzej Foik
PI



Effective delivery of therapeutic genes
Using a modified rabies virus (Rabies virus)
to a selected population of nerve cells - Retinal Ganglion Cells
(RGCs), which transmit visual information to the brain.

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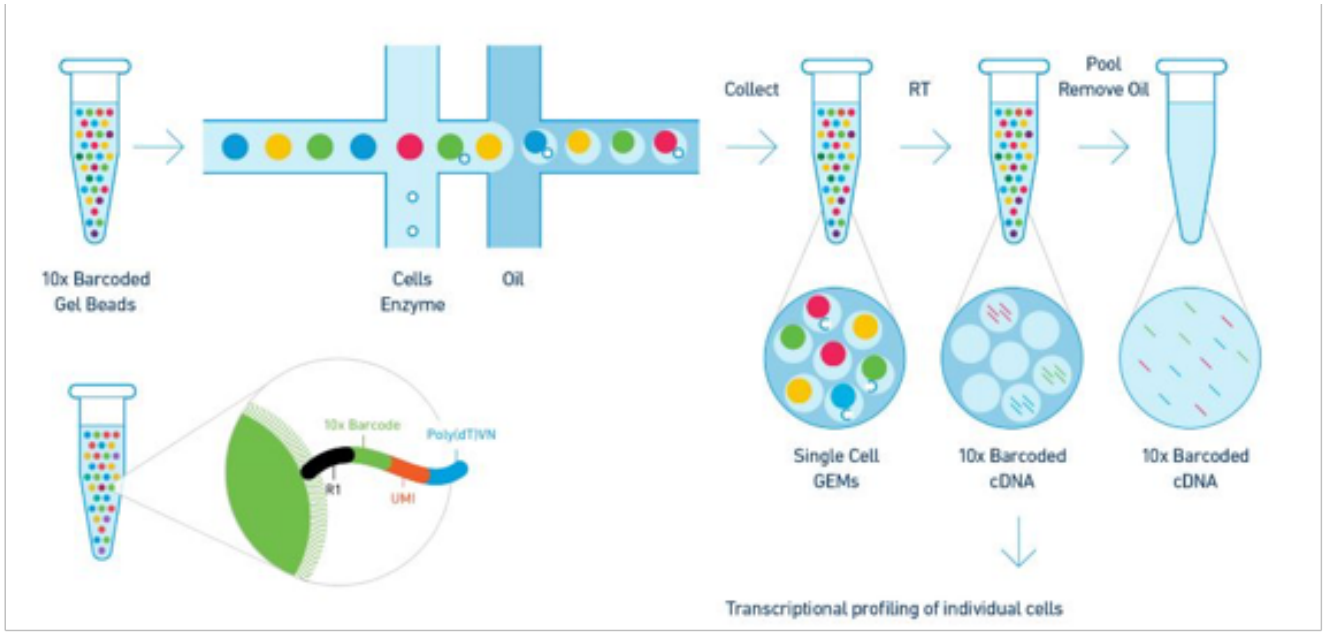
COMPUTATIONAL GENOMICS GROUP

Dr Marcin Tabaka
PI



Single-cell transcriptome & epigenome profiling

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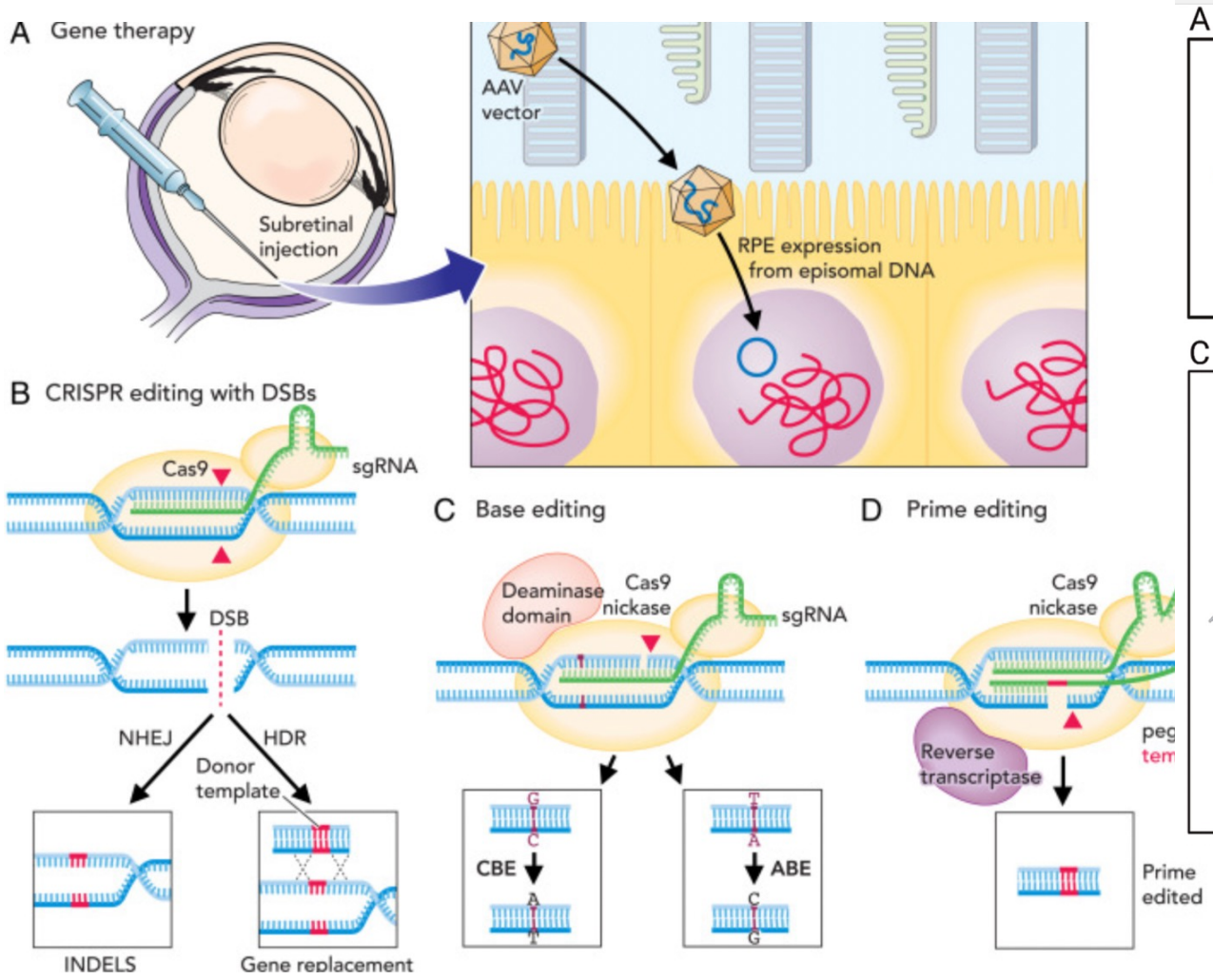
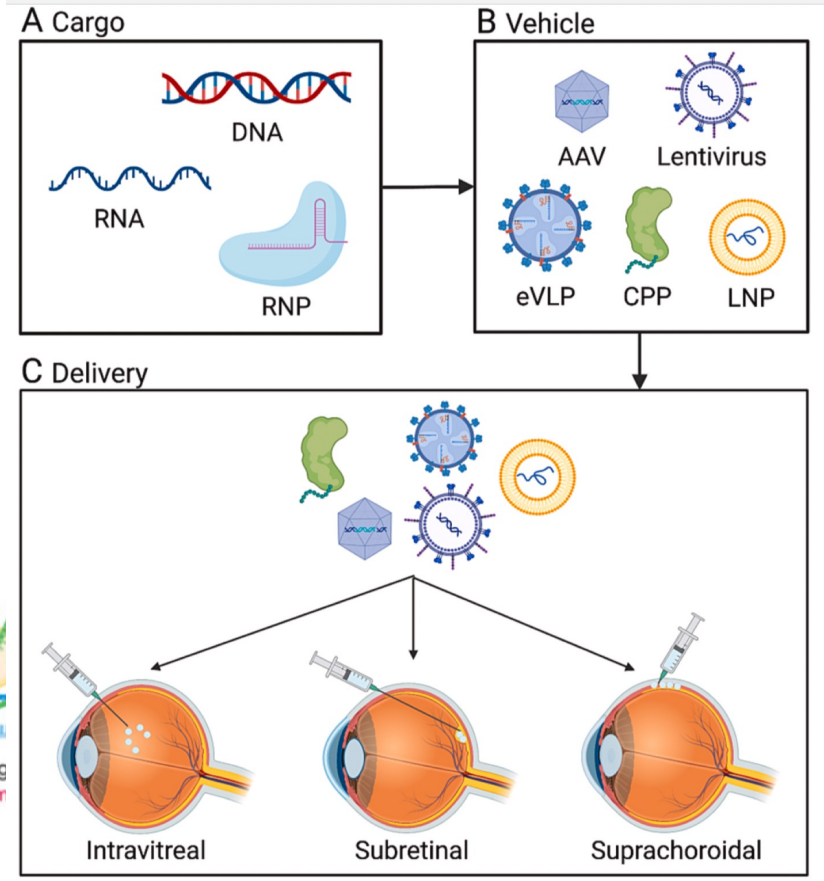
Treatment of Congenital Blindness - Gene Therapy





Alexander L. Yan, Samuel W. Du, Krzysztof Palczewski, Genome editing, a superior therapy for inherited retinal diseases, Vision Research, Volume 206, 2023

Suh S, Choi EH, Raguram A, Liu DR, Palczewski K. Precision genome editing in the eye. Proc Natl Acad Sci U S A. 2022 Sep 27;119(39):e2210104119. doi: 10.1073/pnas.2210104119. Epub 2022 Sep 19. PMID: 36122230; PMCID: PMC9522375.

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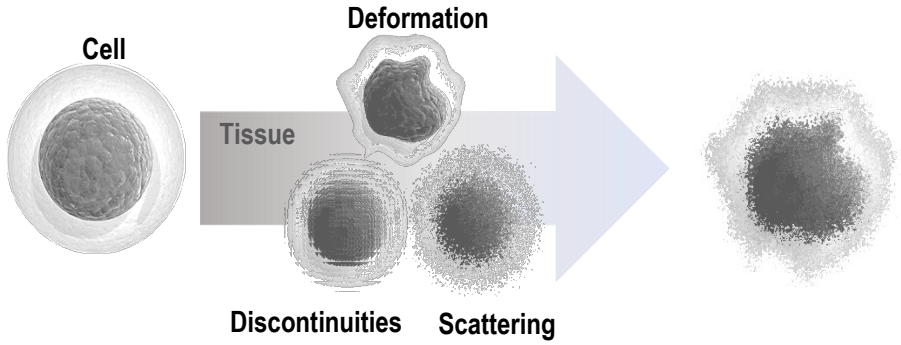
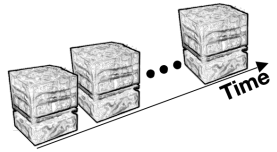
CAN WE IMAGE CELLS IN VIVO ?

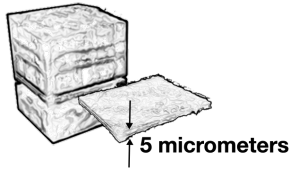


Spatio-Temporal Optical Coherence (STOC) Imaging

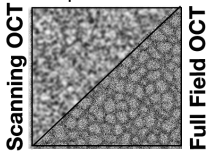
1. HIGH SPEED ACQUISITION
   30 milions A-scans per 1 sec



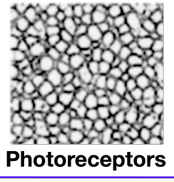
2. LOW TEMPORAL COHERENCE
   high resolution axial sectioning



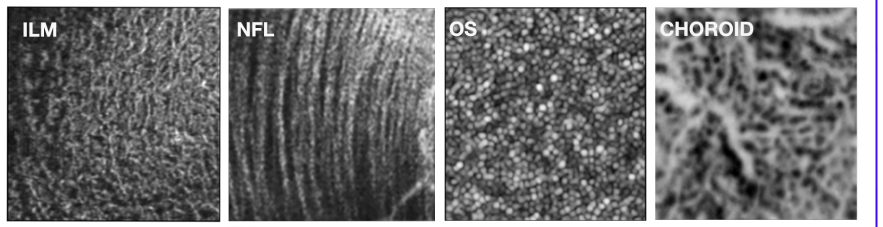
3. FULL FIELD IMAGING
   small speckle size (3microns)



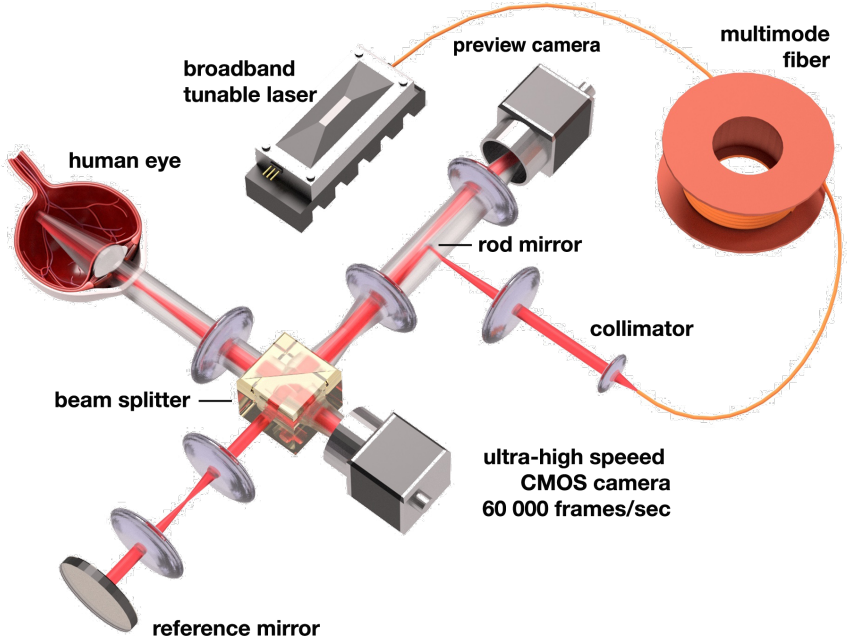
4. **LOW SPATIAL COHERENCE**
   reduced scattering effects



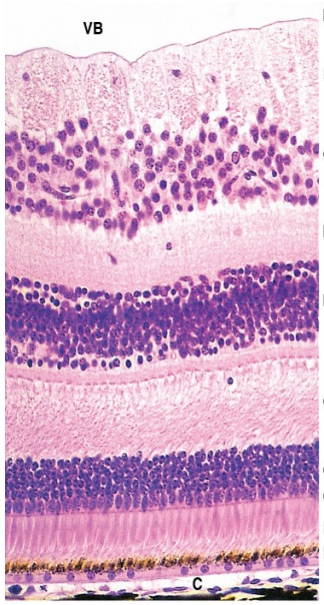
STOC-T RECONSTRUCTIONS OF ANATOMICAL LAYERS



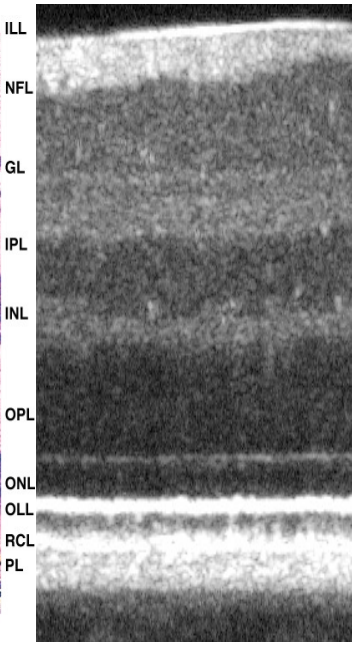
OPTICAL SET-UP



Histology of human Retina



OCT of human Retina



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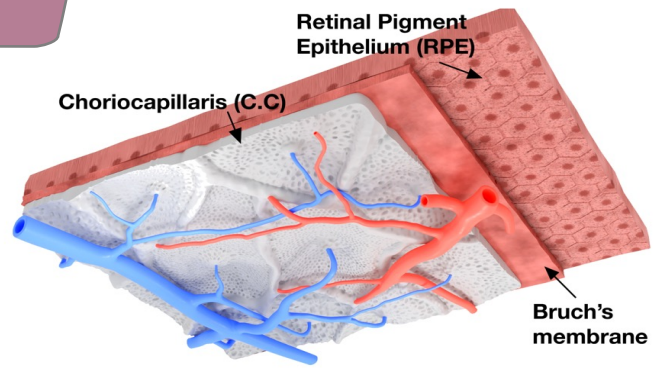
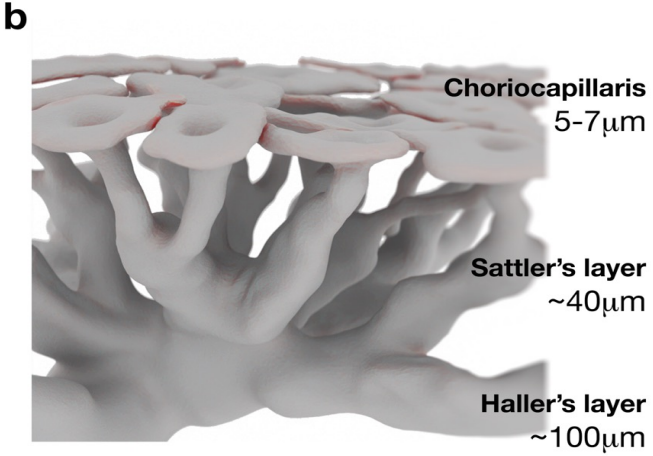
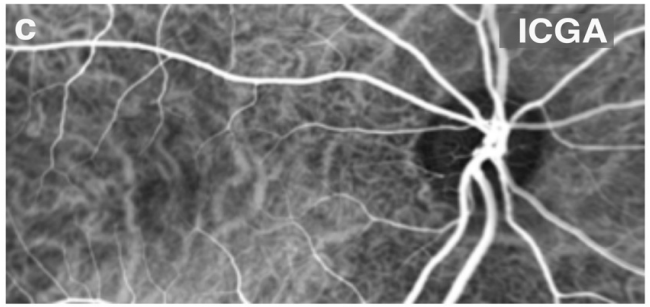
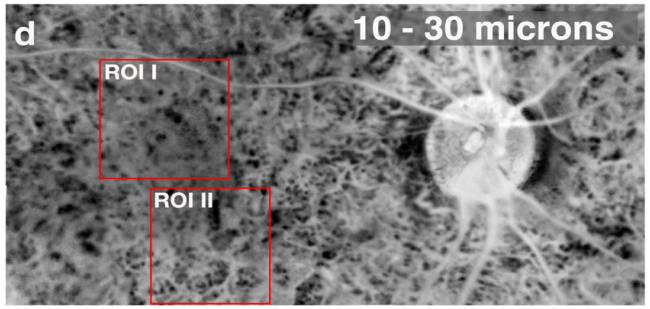
IMAGING OF CHOROID

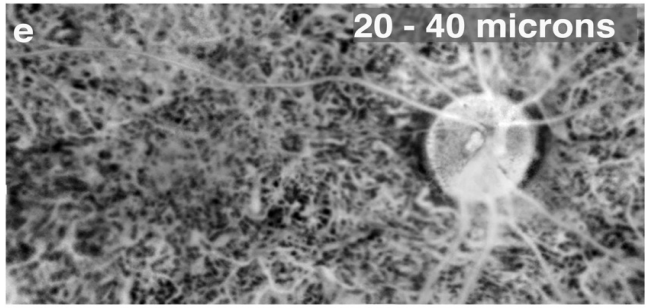
STOC-T

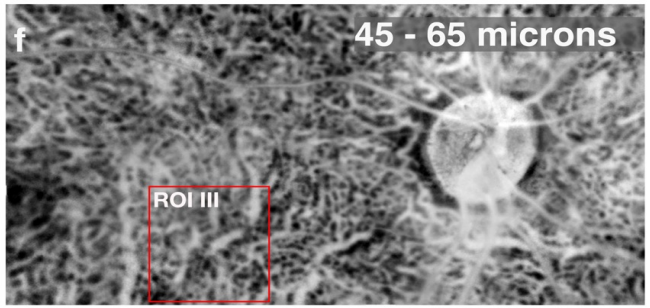


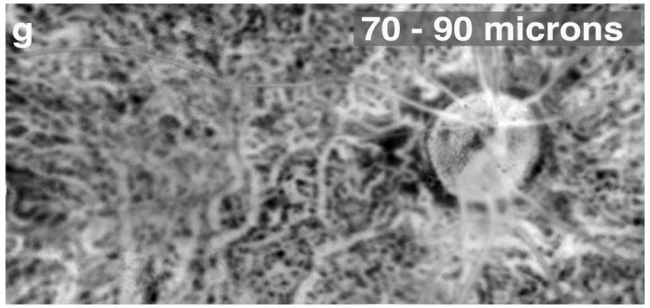


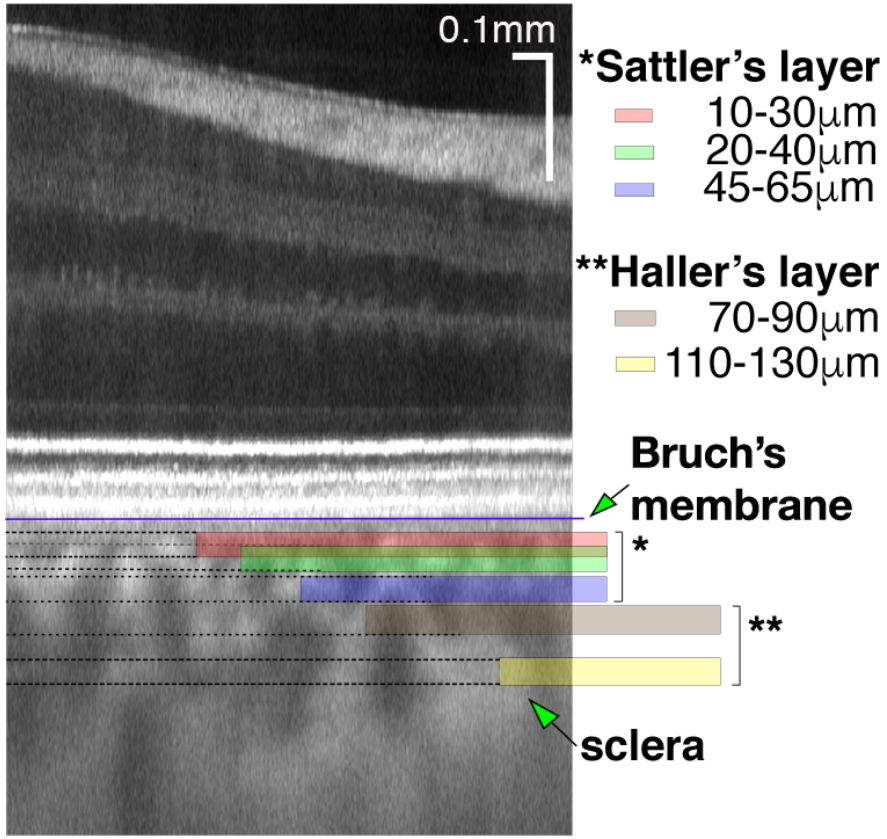












Auksorius, E., et al. Spatio-Temporal Optical Coherence Tomography provides full thickness imaging of the chorioretinal complex. **iScience**, 25, 12, 105513, (2022)

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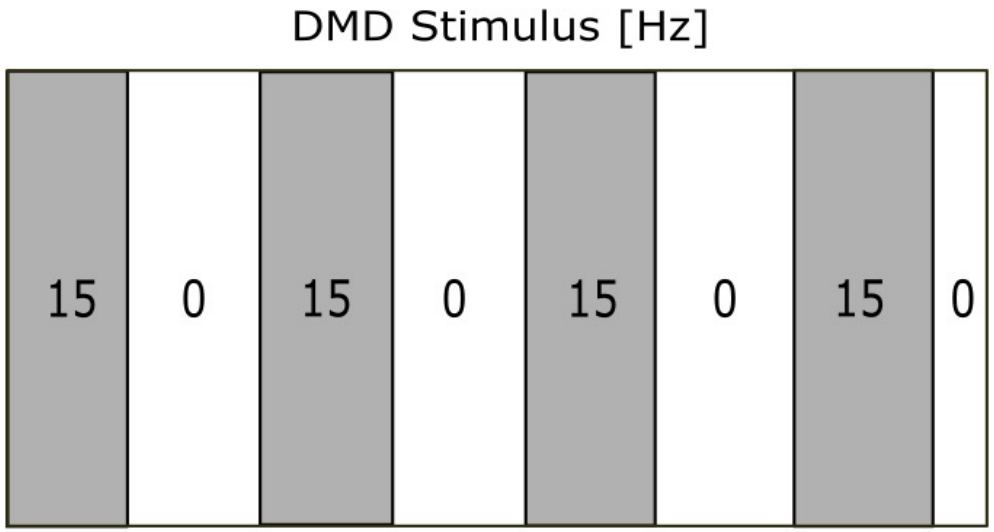
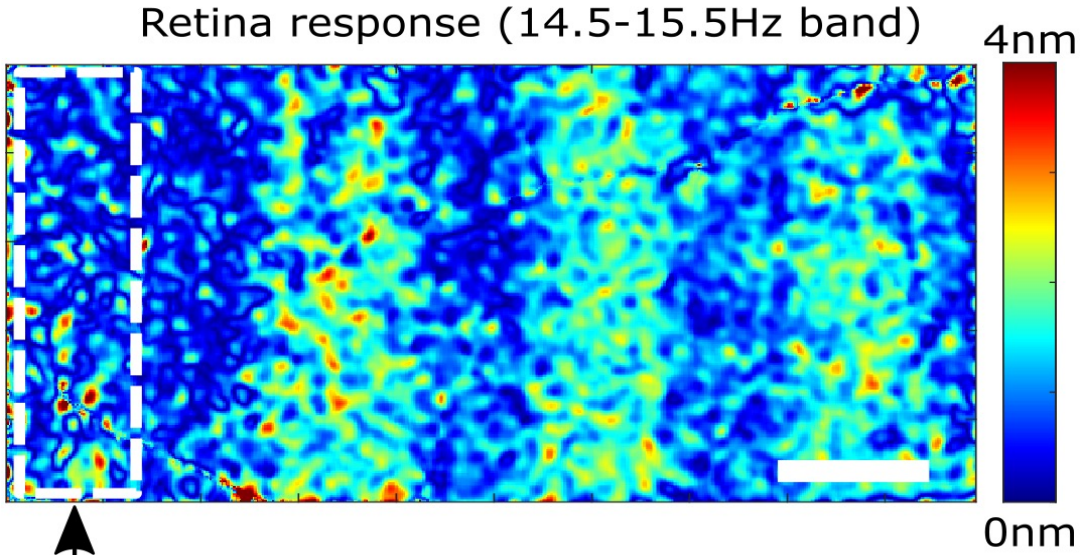
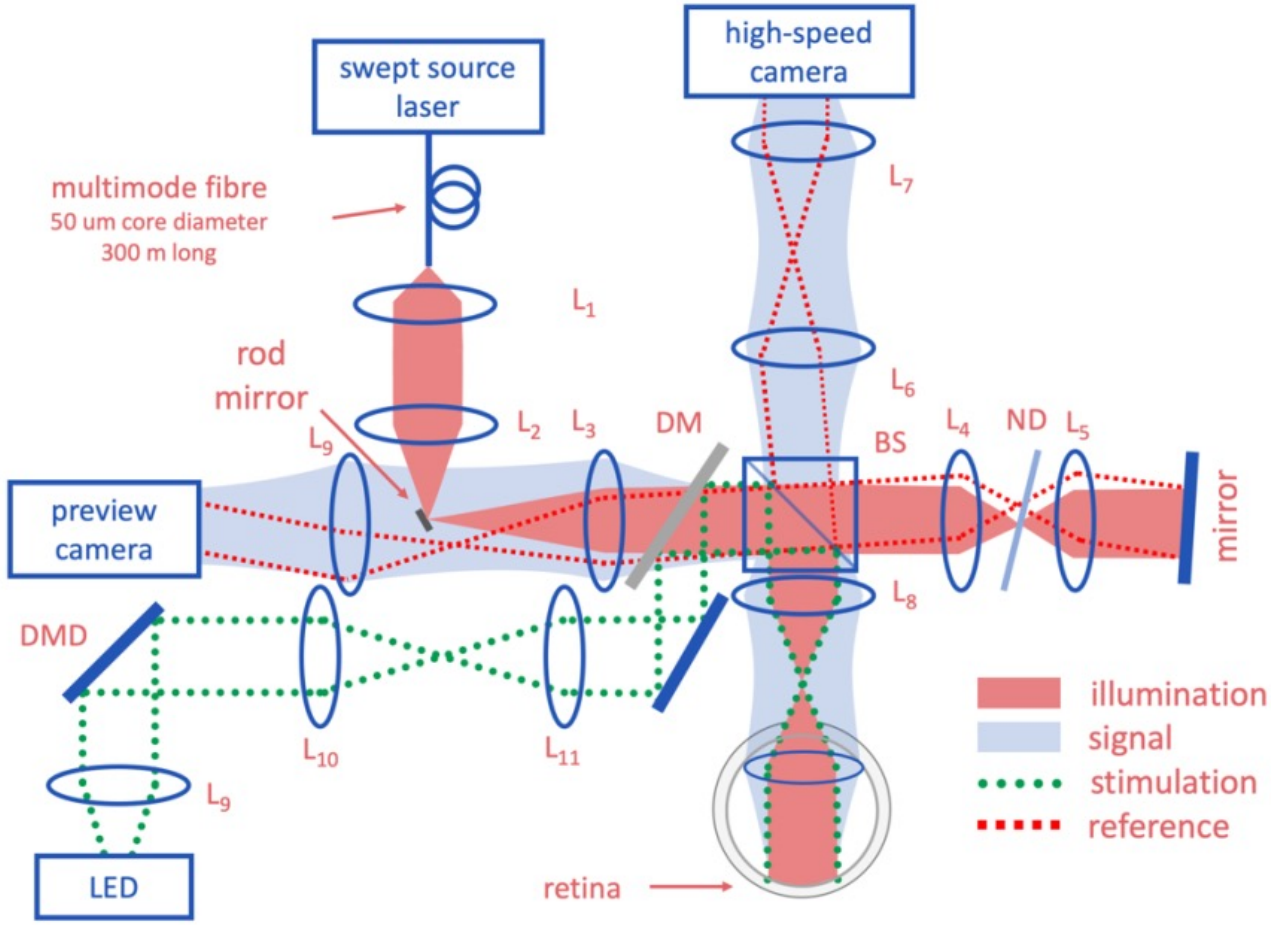
SPATIALLY-RESOLVED FLICKER ORG







S. Tomczewski, P. Wegrzyn, D. Borycki, E. Auksorius, M. Wojtkowski, A. Curatolo, “Light-adapted flicker optoretinograms captured with a spatio-temporal optical coherence-tomography (STOC-T) system”, Biomedical Optics Express 13 (4), 2186-2201 (2022)

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INFRARED VISION

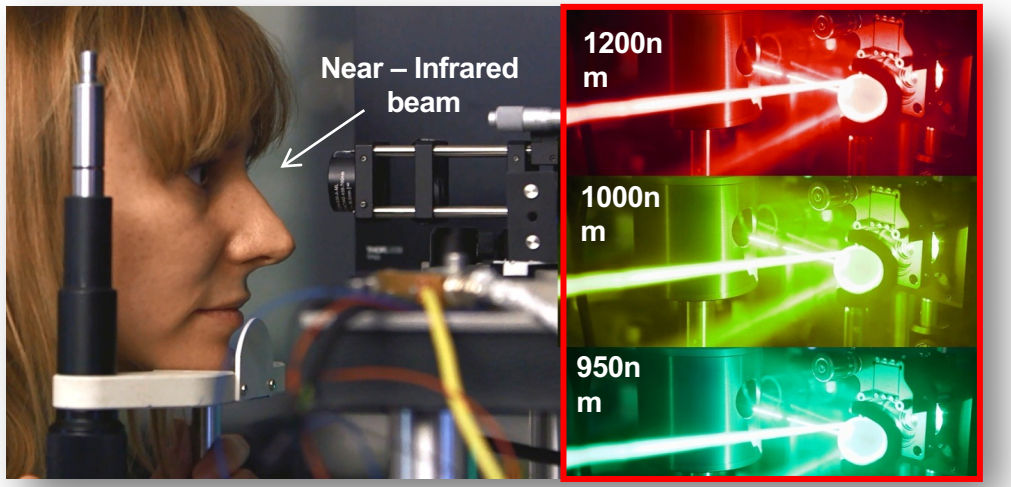
Dr Katarzyna Komar

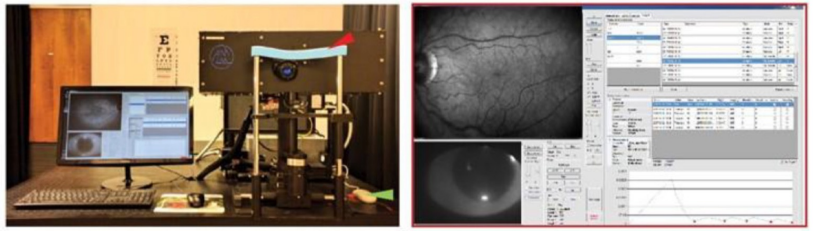
Shortening pulses intensifies the effect

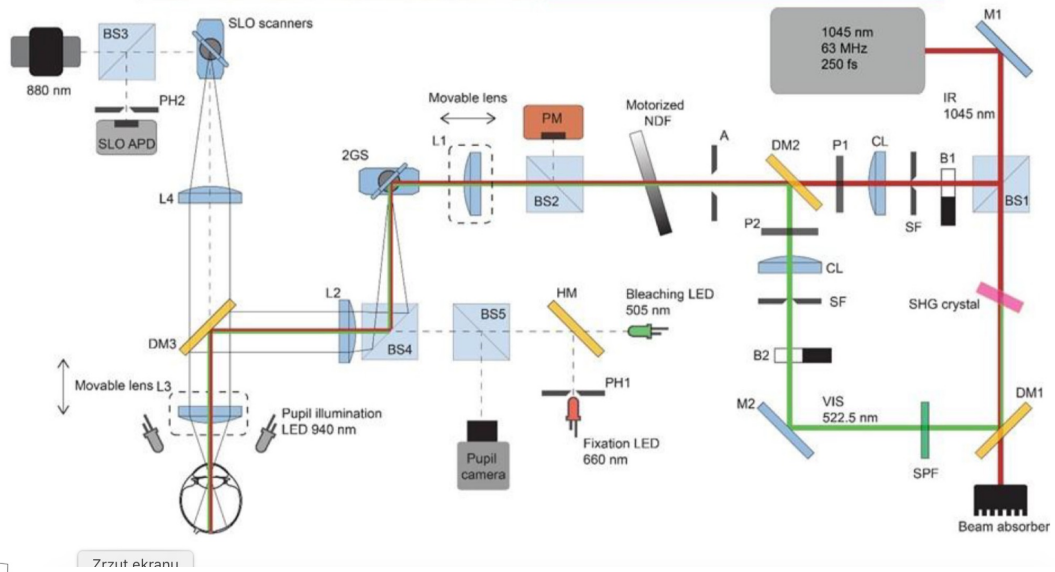
(more than100fs pulses with optical powers below MPE from ANSI and EU standards)

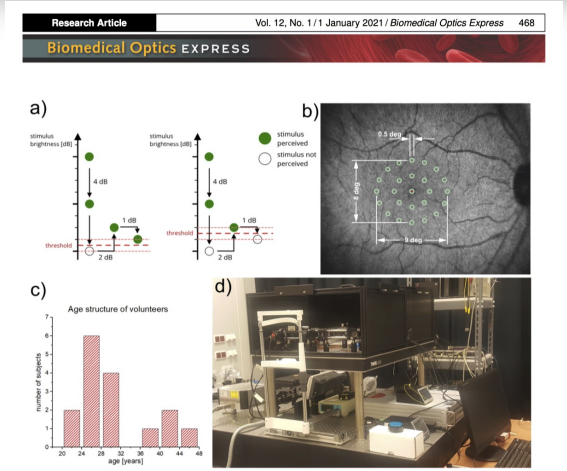
Near - Infrared vision

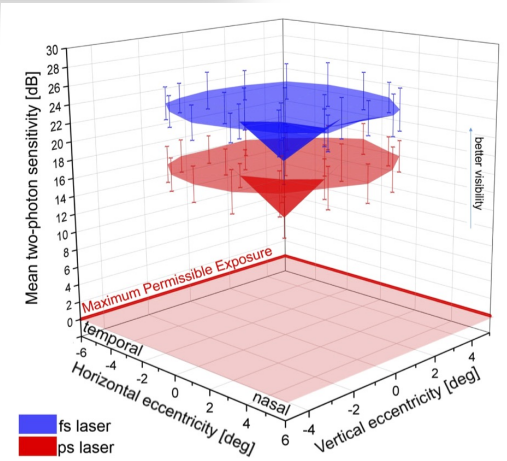
(short pulses ns-fs; 900nm-1200nm)











D. Ruminski, G. Palczewska, M. Nowakowski, A. Zielinska, V. J. Kefalov, K. Komar, K. Palczewski, and M. Wojtkowski, "Two-photon microperimetry: sensitivity of human photoreceptors to infrared light," Biomed Opt Express 10, 4551-4567 (2019).(140)

Marcin Marzejon, Łukasz Kornaszewski, Jakub Bogusławski, Piotr Ciąćka, Miłosz Martynow, Grażyna Palczewska, Sebastian Maćkowski, Krzysztof Palczewski, Maciej Wojtkowski, Katarzyna Komar, Two-photon microperimetry with picosecond puls, Biomedical Optics Express, 12, 462-479, 2021

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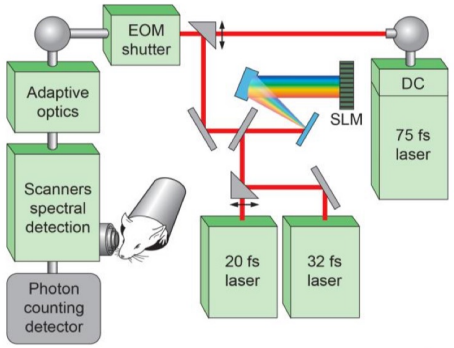
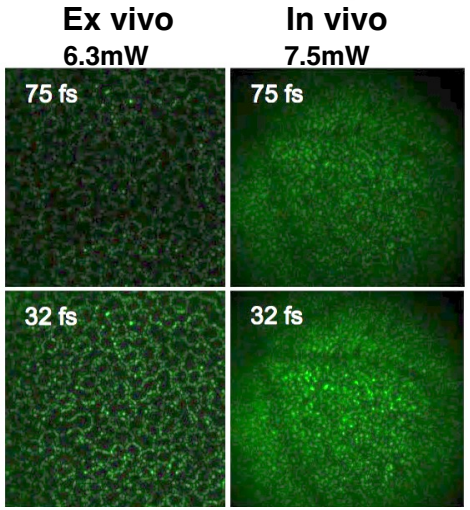
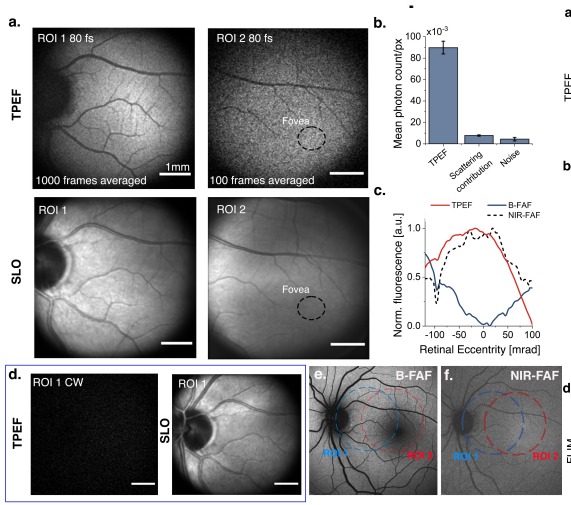
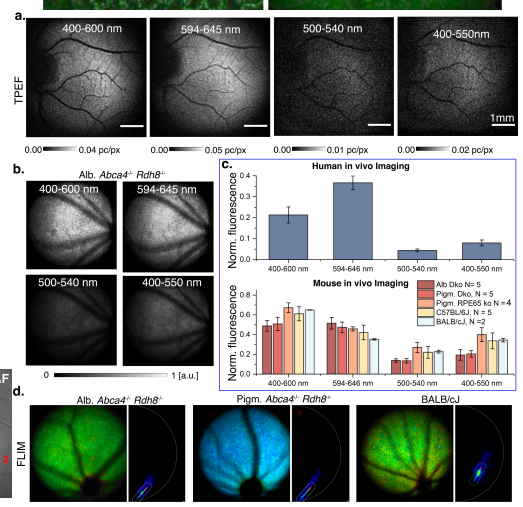
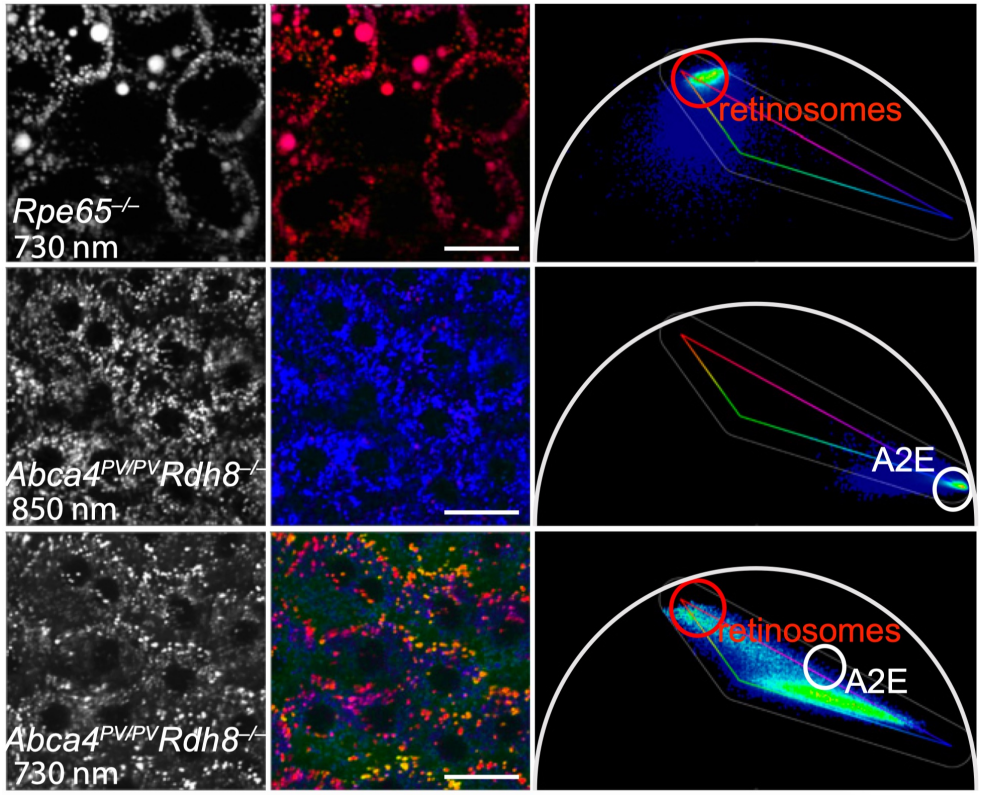
TOWARDS TWO-PHOTON RETINAL IMAGING IN HUMANS











G. Palczewska, **P. Stremplewski**, S. Suh, N. Alexander, D. Salom, Z. Dong, **D. Ruminski**, E. H. Choi, A. E. Sears, T. S. Kern, **M. Wojtkowski**, and K. Palczewski, "Two-photon imaging of the mammalian retina with ultrafast pulsing laser", **JCI Insight**, 3(17):e121555, 2018

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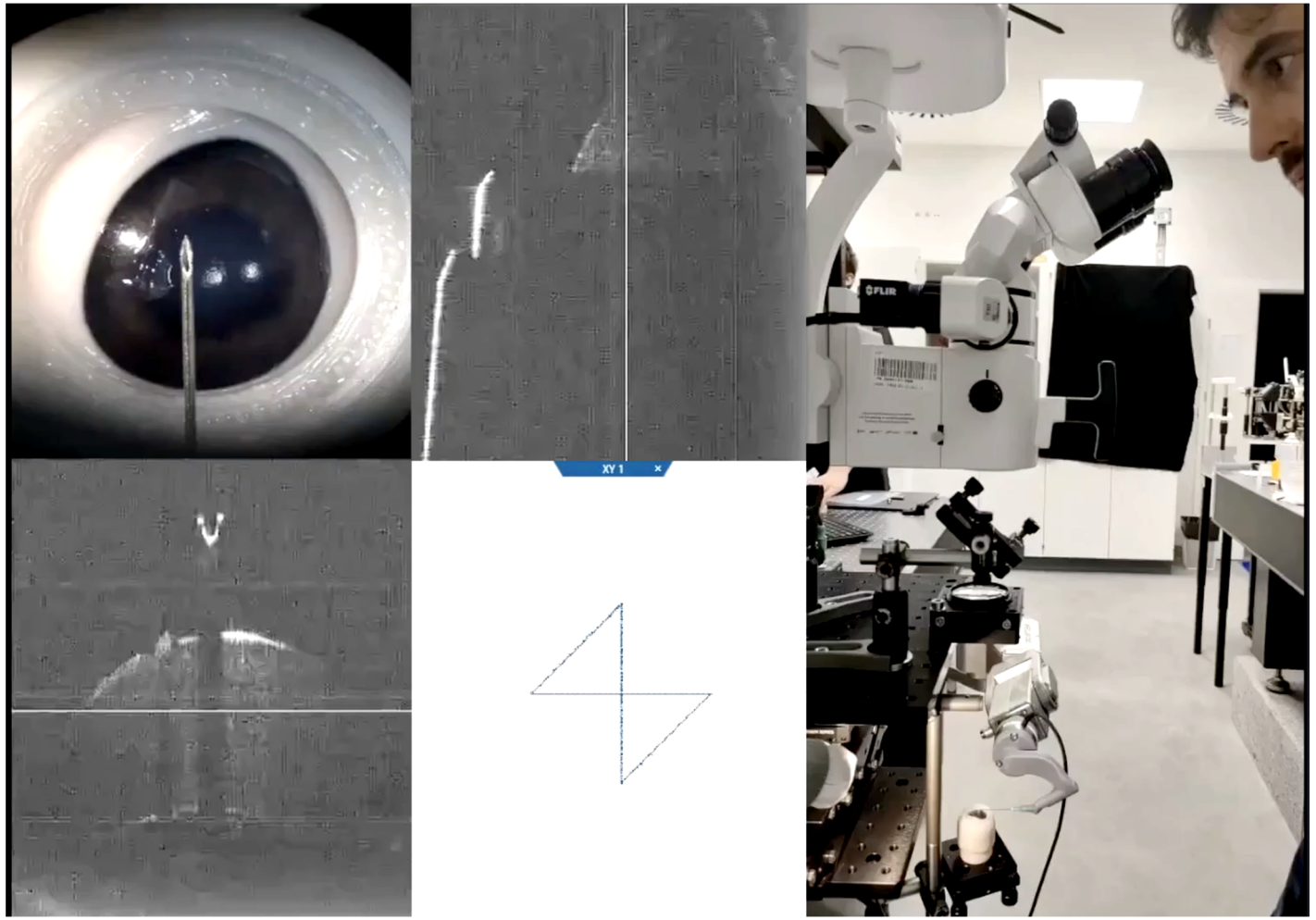
INTRAOPERATIVE OCT WITH ROBOTIC TRACKING OF SURGICAL TOOLS



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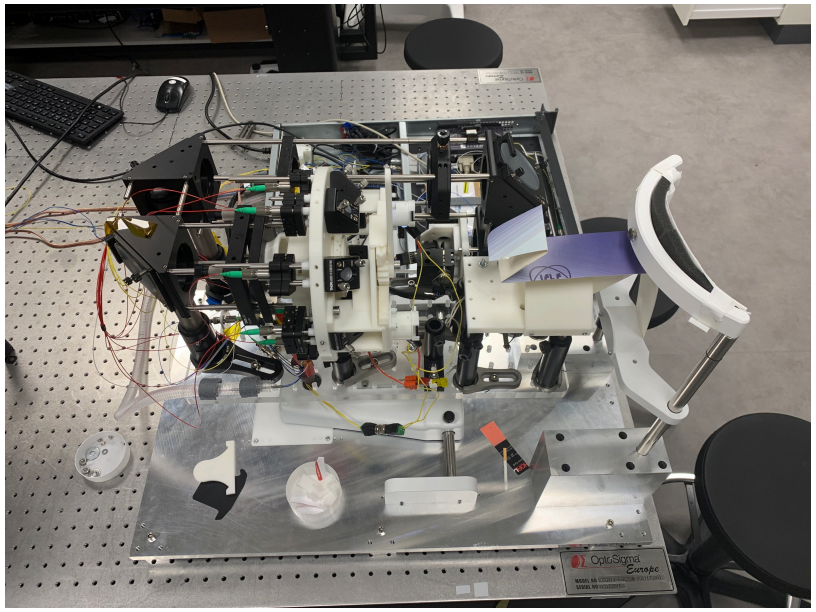
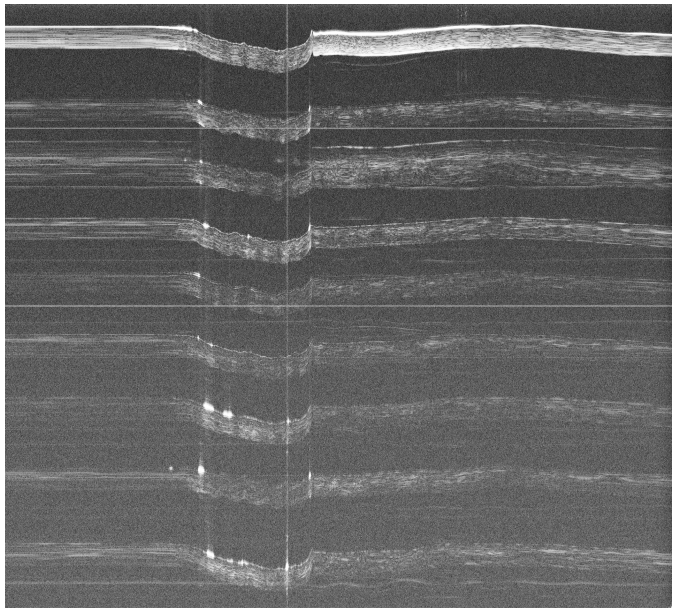
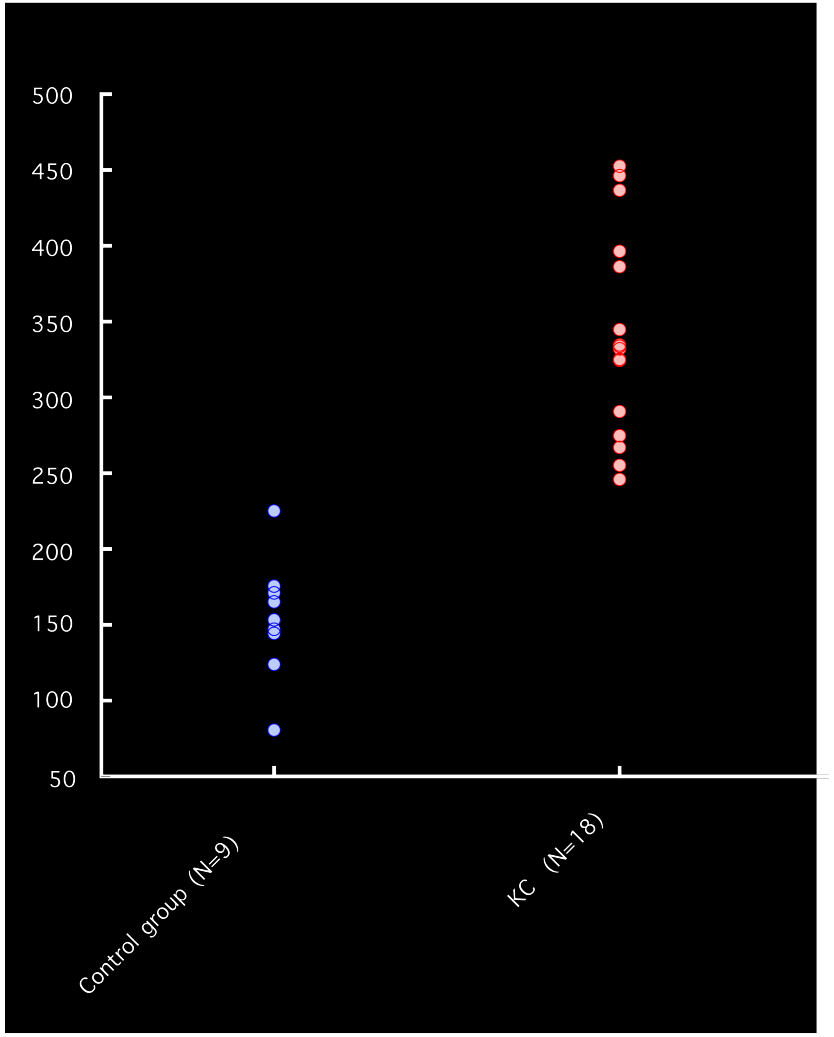
MEASUREMENTS OF AIR-INDUCED EYE DEFORMATIONS







Clinical prototype >100 eyes measured in an ophthalmic clinic

The low-cost device in the future?

TAKE HOME MESSAGE FOR PHOTONIC INDUSTRY

Optical research around the Eye

Novel systems and basic science
(at this point price tag is not so important)

Light sources
Pulsed lasers (ns-fs)
Swept lasers:
- >100 kHz, 100 nm bandwidth, >20-30 mW
- <1kHz, 75-100 nm bandwidth, >30-50 mW (k-linear), λ_C - 800/1060 nm

Detectors:
Digitizers: GHz range, k-clock (nonlinear)
Alazar Tech

Ultrafast cameras (e.g. Photron)
-expensive, not designed for science, lack of non-VIS solutions

Product, market analysis, accessibility
(people seek low-cost, small footprint solutions)

Light sources
Pulsed lasers (ns-fs) – compact, low-cost
Swept lasers:
- >100 kHz, 100 nm bandwidth, >20-30 mW
- <1kHz, 5-50 nm bandwidth, >few mW (low-cost)
- Current tuning for VCSEL diodes

Detectors
With a low-spec laser one can go for a low-cost digitizer

$$\delta z = \frac{2ln2}{\pi}\frac{\lambda_c^2}{\Delta\lambda_{3dB}}$$

$$z_{max} \cong B\frac{f_{sampling}}{f_{laser}}\frac{\lambda_c^2}{\Delta\lambda}$$