

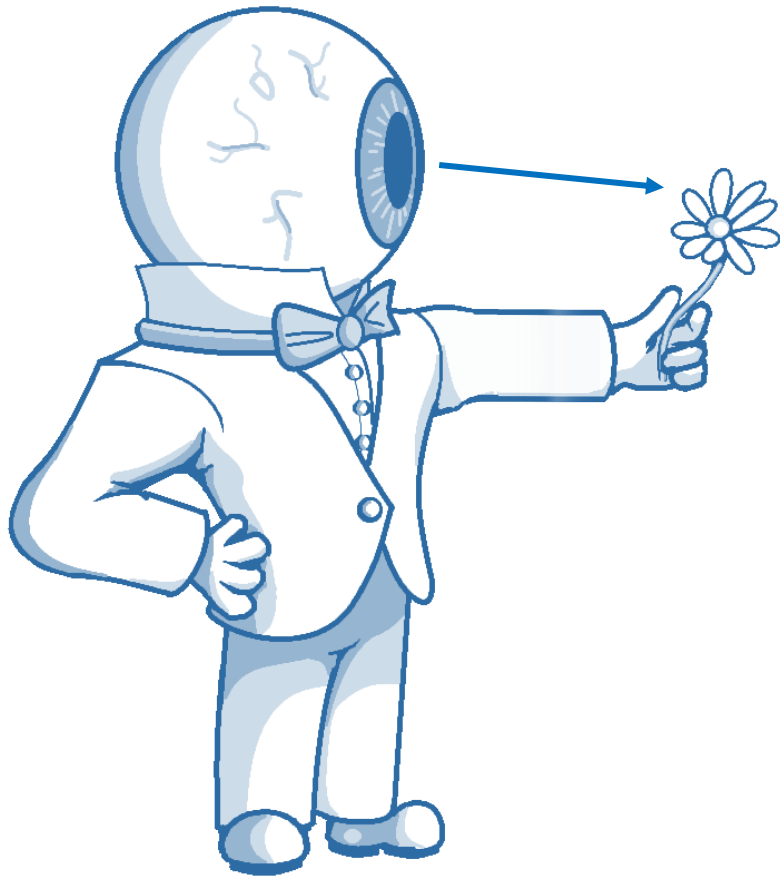
Biologic tissues properties deduction using an opto-mechanical model of the human eye

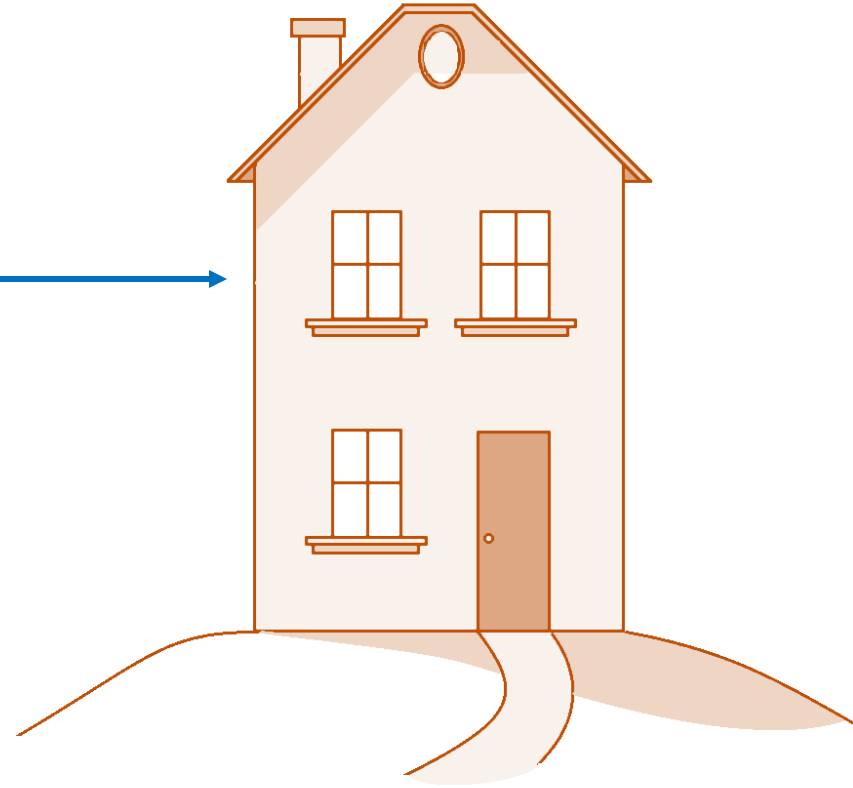
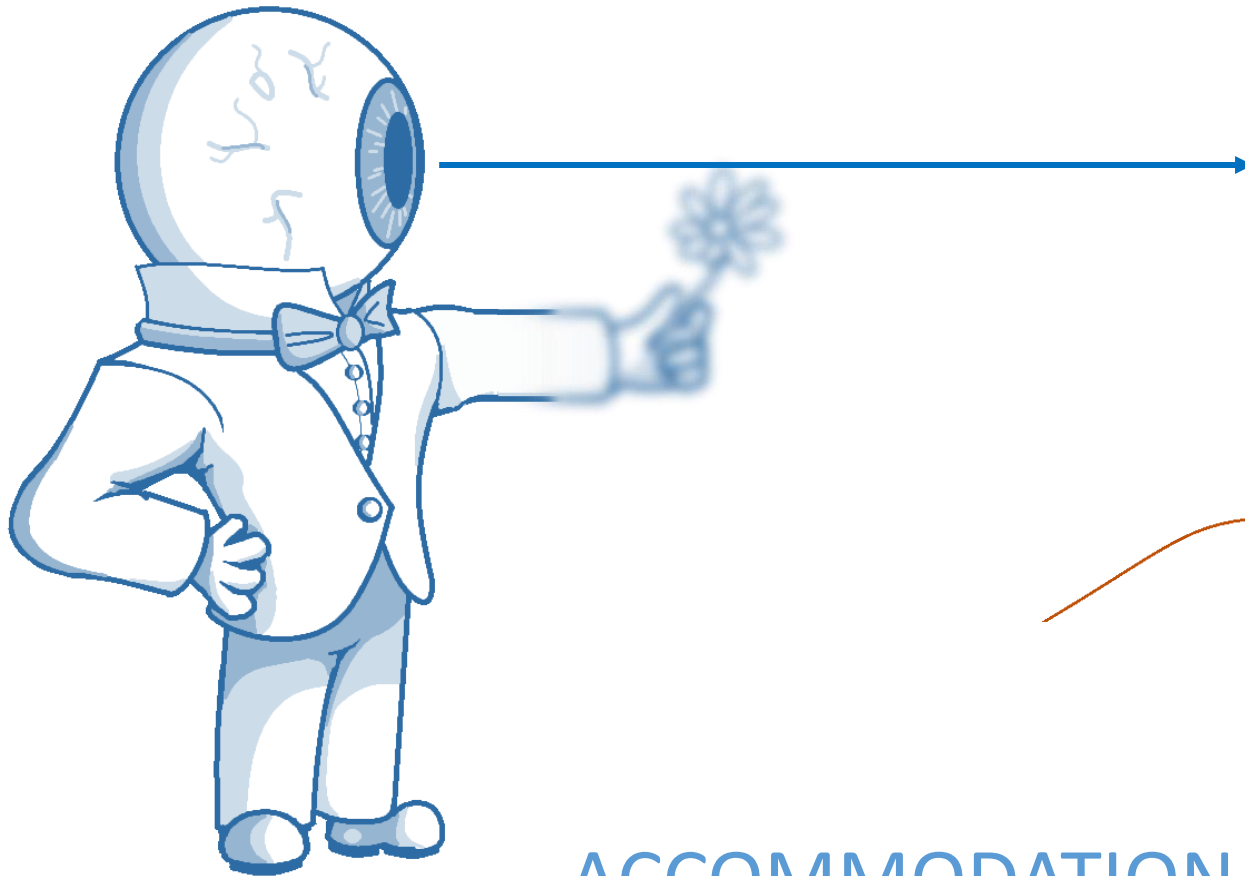
Authors: A. Maurer, D. Enfrun, C.-O. Zuber, R. Rozsnyo

KEYWORDS: *Biomechanics, Optics, Ray Tracing, Visual Accommodation*



Visual accommodation process & Presbyopia





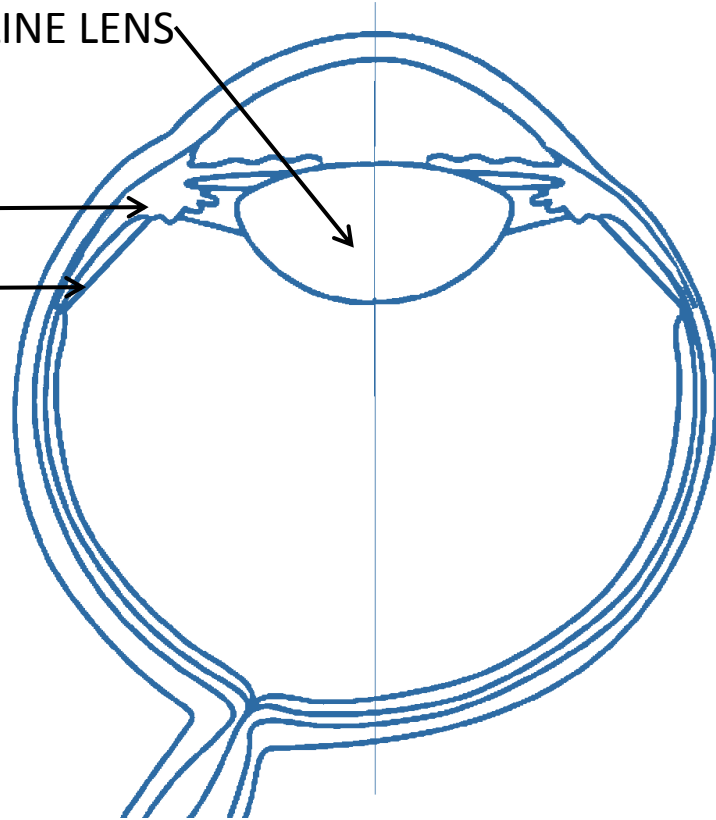
ACCOMMODATION PROCESS



CRYSTALLINE LENS

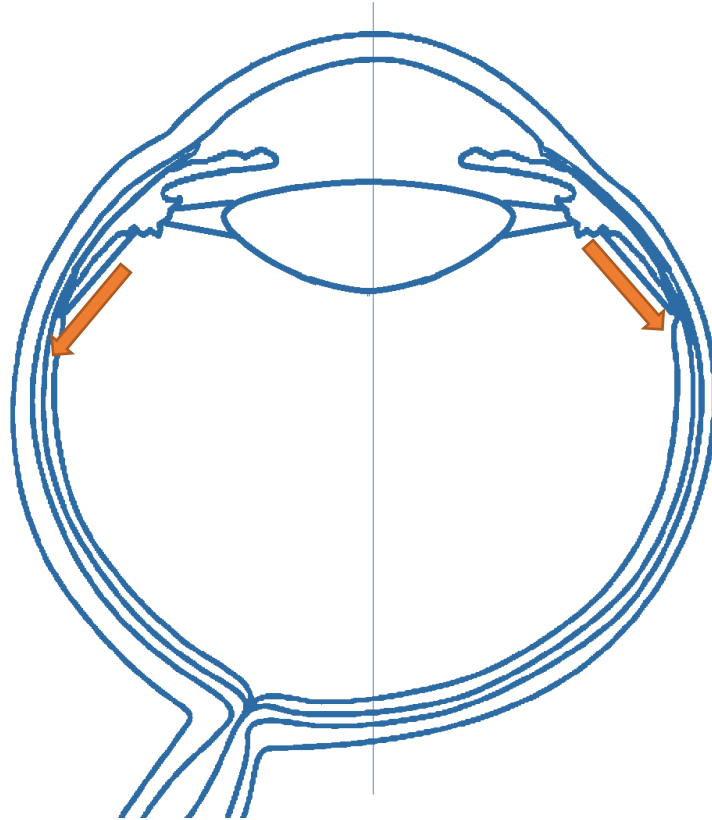
CILIARY MUSCLE

POSTERIOR ZONULA



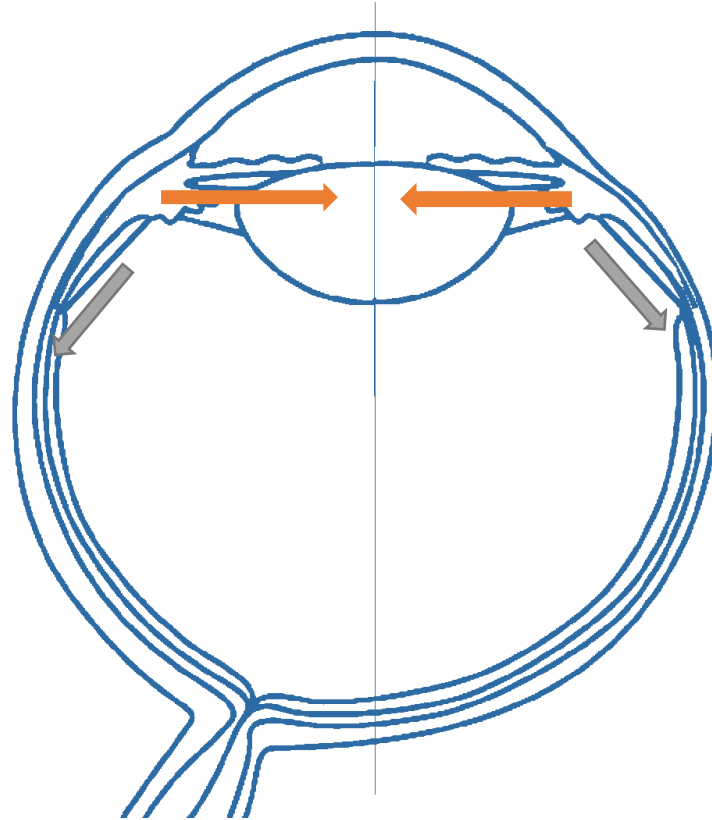


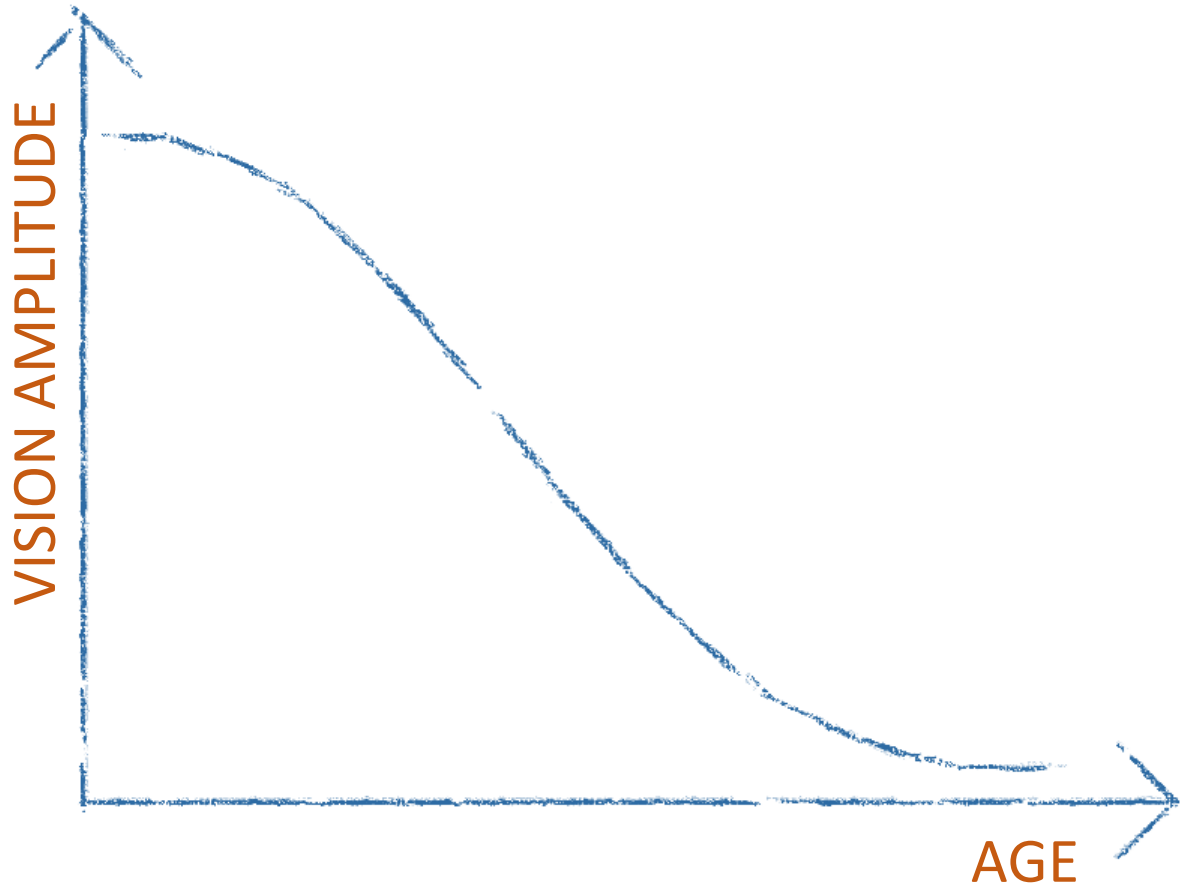
FAR VISION

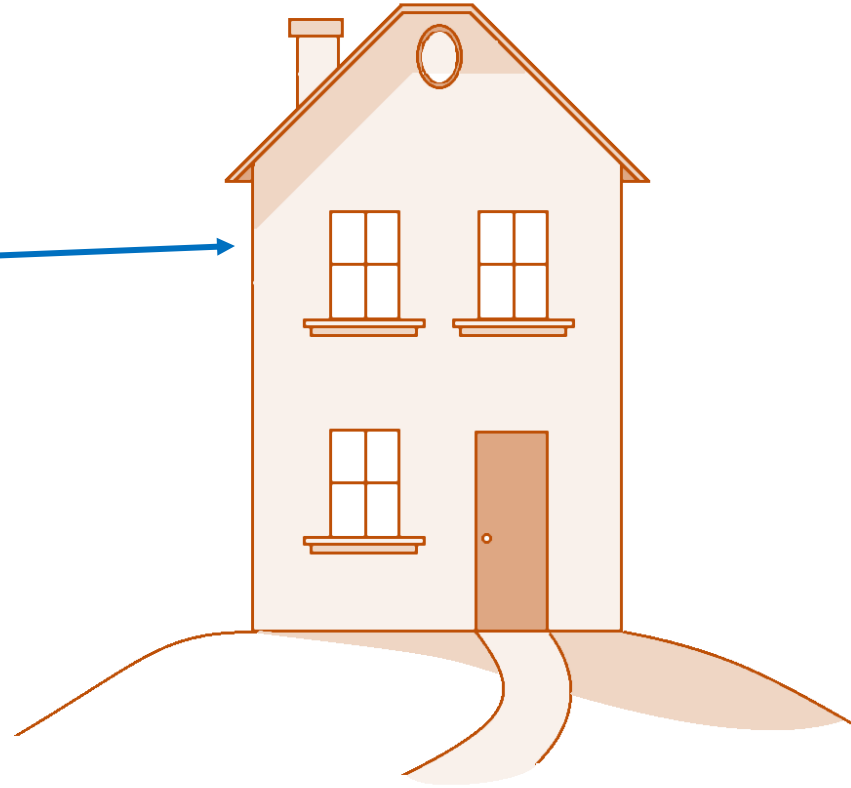
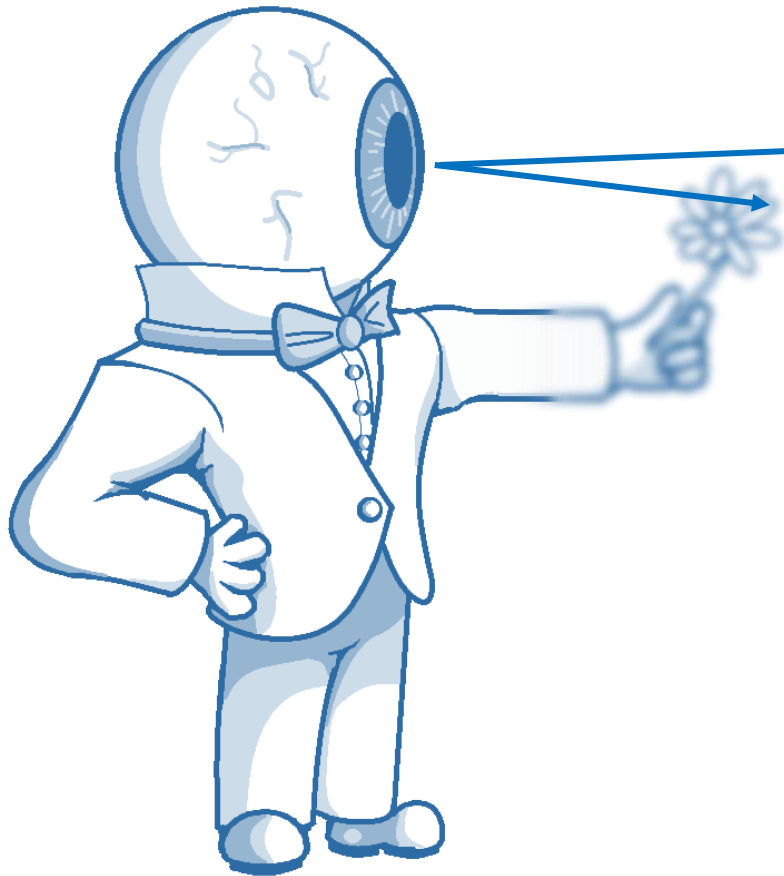


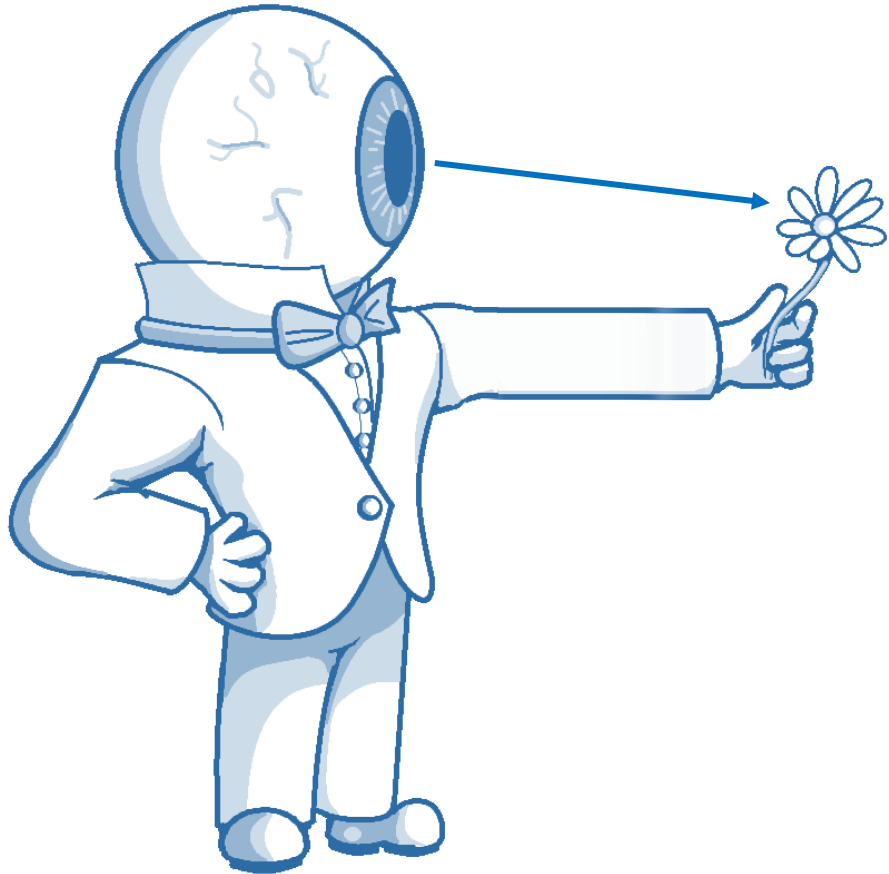


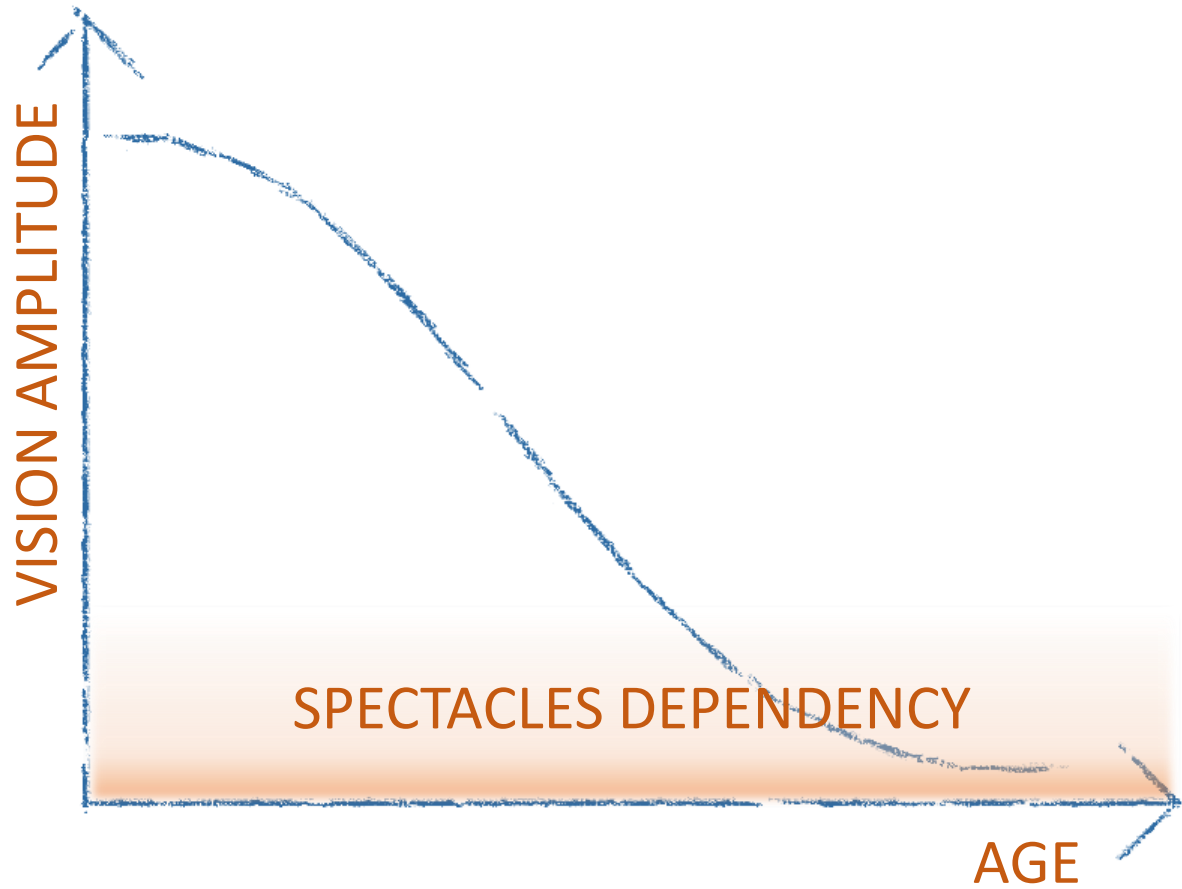
NEAR VISION













Actual Solutions for Presbyopia ?



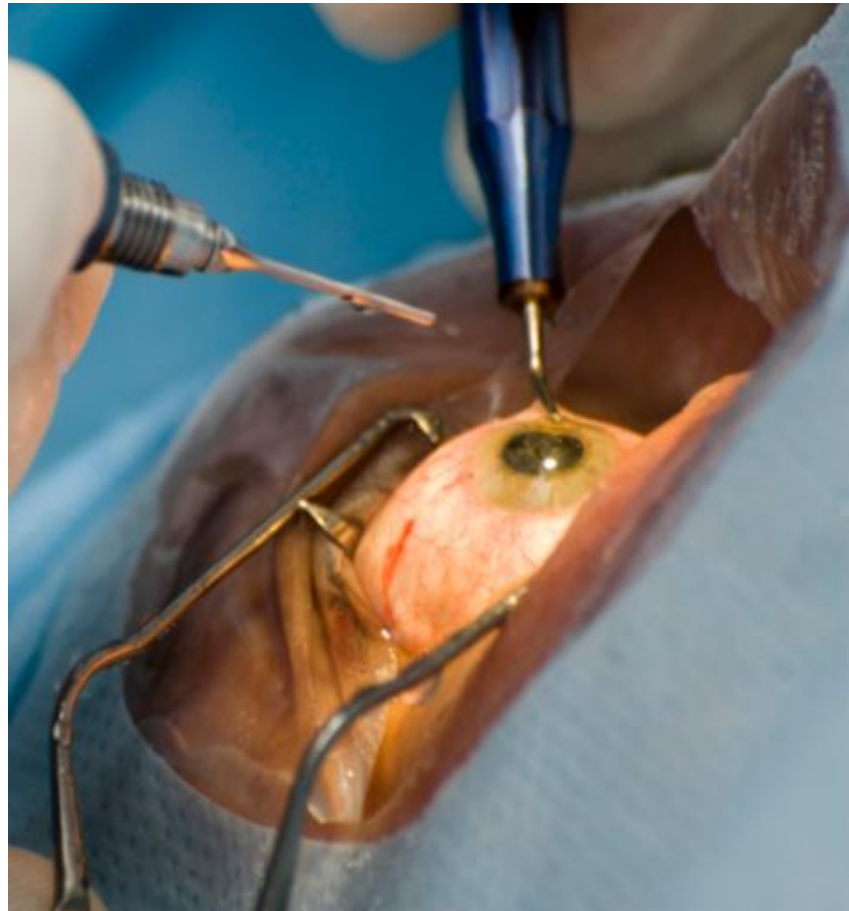
***I DON'T CARE HOW
IT WORKS BOY !***

***WHAT CAN I DO
FOR THESE UGLY
GLASSES ?***



Clear Unmet Medical Need due to Significant Compromises

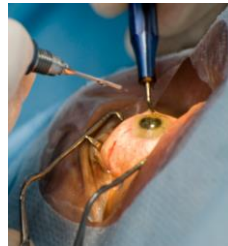
Presbyopes are looking for alternatives to reading glasses.
mostly **heavy surgeries** are available...





Clear Unmet Medical Need due to Significant Compromises

Presbyopes are looking for alternatives to reading glasses.
mostly **heavy surgeries** are available...



But highly invasive, and coming with **visual compromises**.



Halos



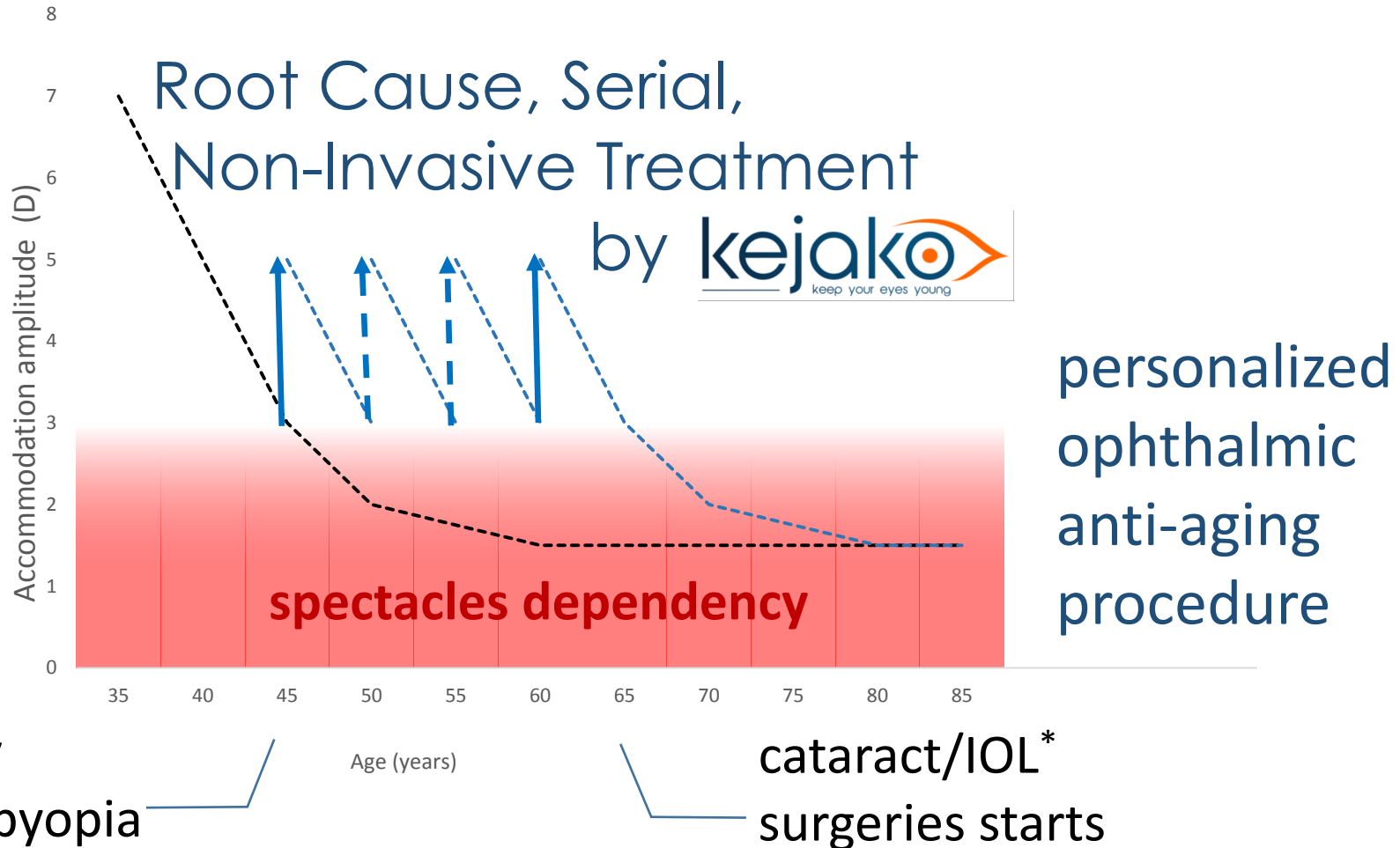
Glare



poor acuity
in dim light



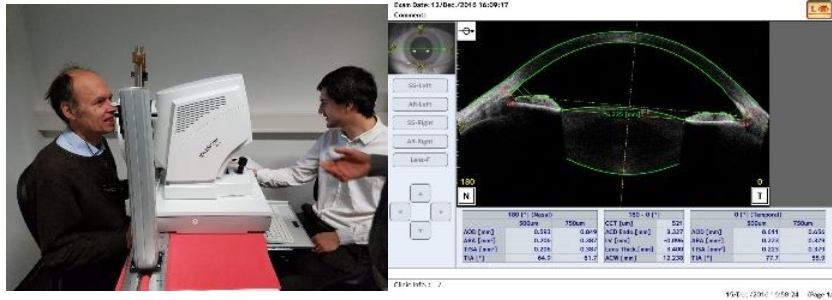
We Focus on Early Treatments to Prevent & to Maintain Healthy Visual Capacity



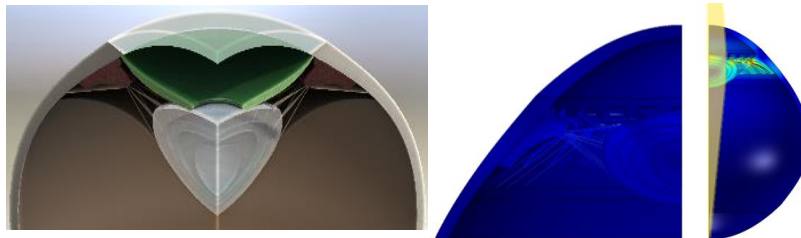
* IntraOcular Lenses



Value Proposition: “one size does NOT fit all” Computational modelling + non-invasive surgery



Eye biometry by
standard imaging
(e.g. OCT)



3D Parametric Full Eye
Model by ™
keep your eyes young



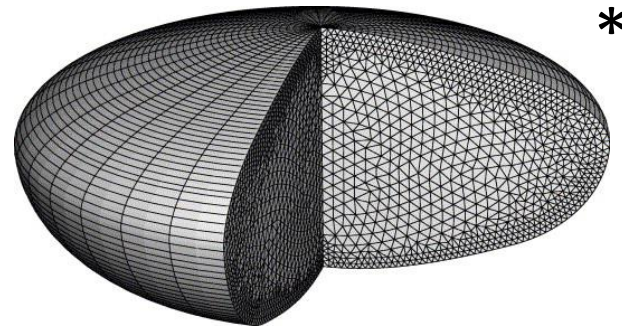
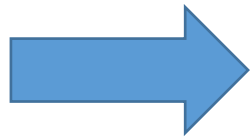
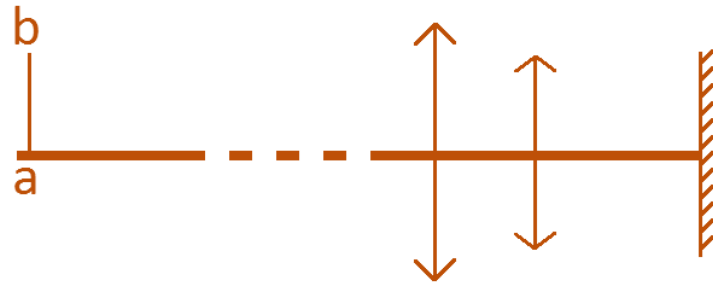
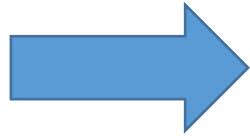
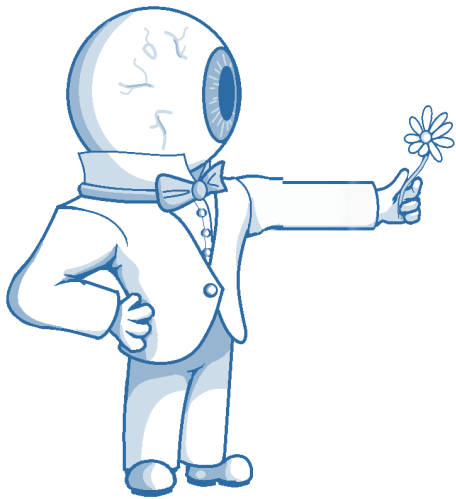
Optimization each patient treatment by ™
keep your eyes young



Customized procedure called ™



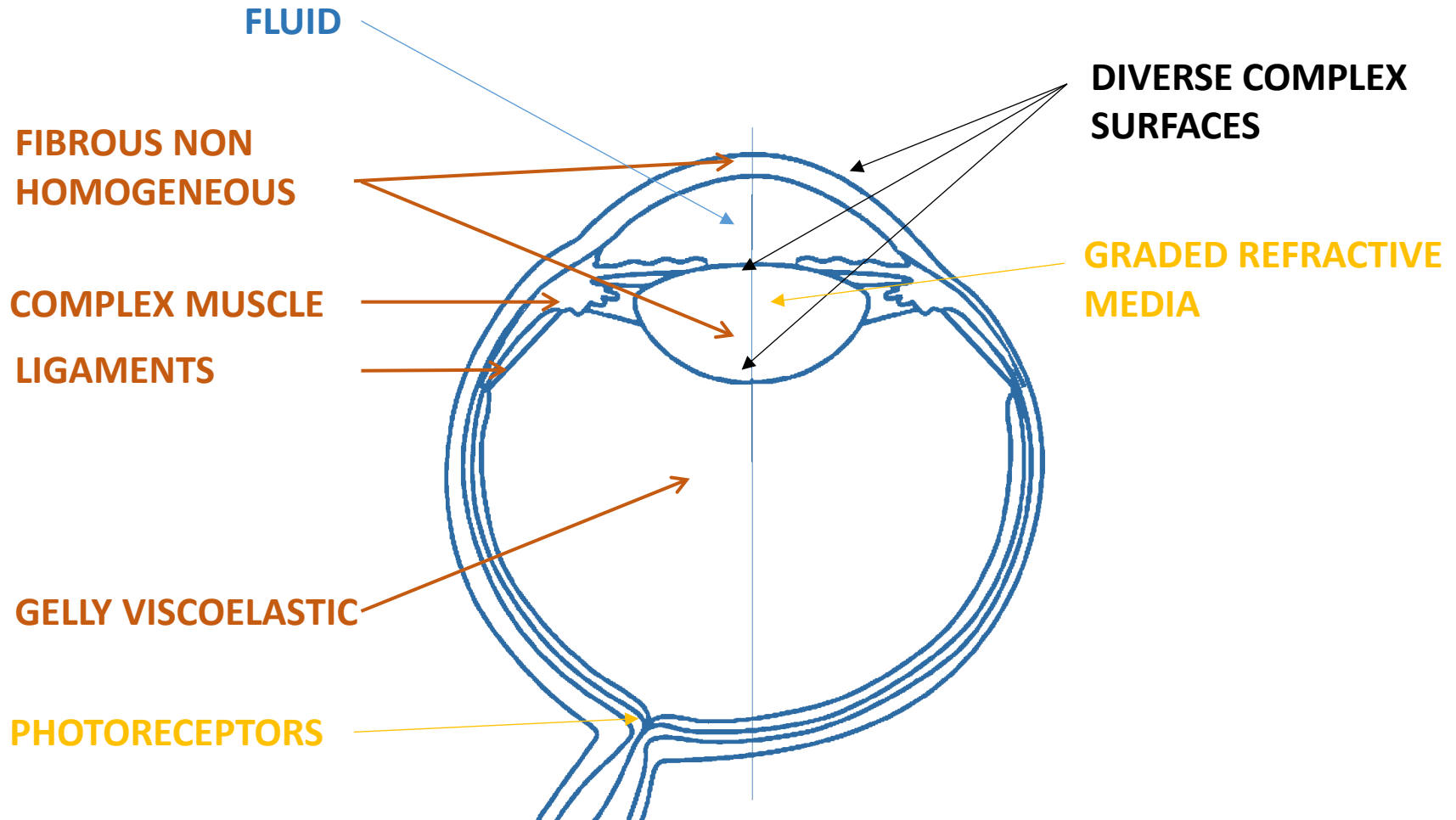
Modeling the eye ?



* "Estimating the external force acting on the human eye lens during accommodation by finite element modelling", Vision Research, E.A. Hermans, 2006

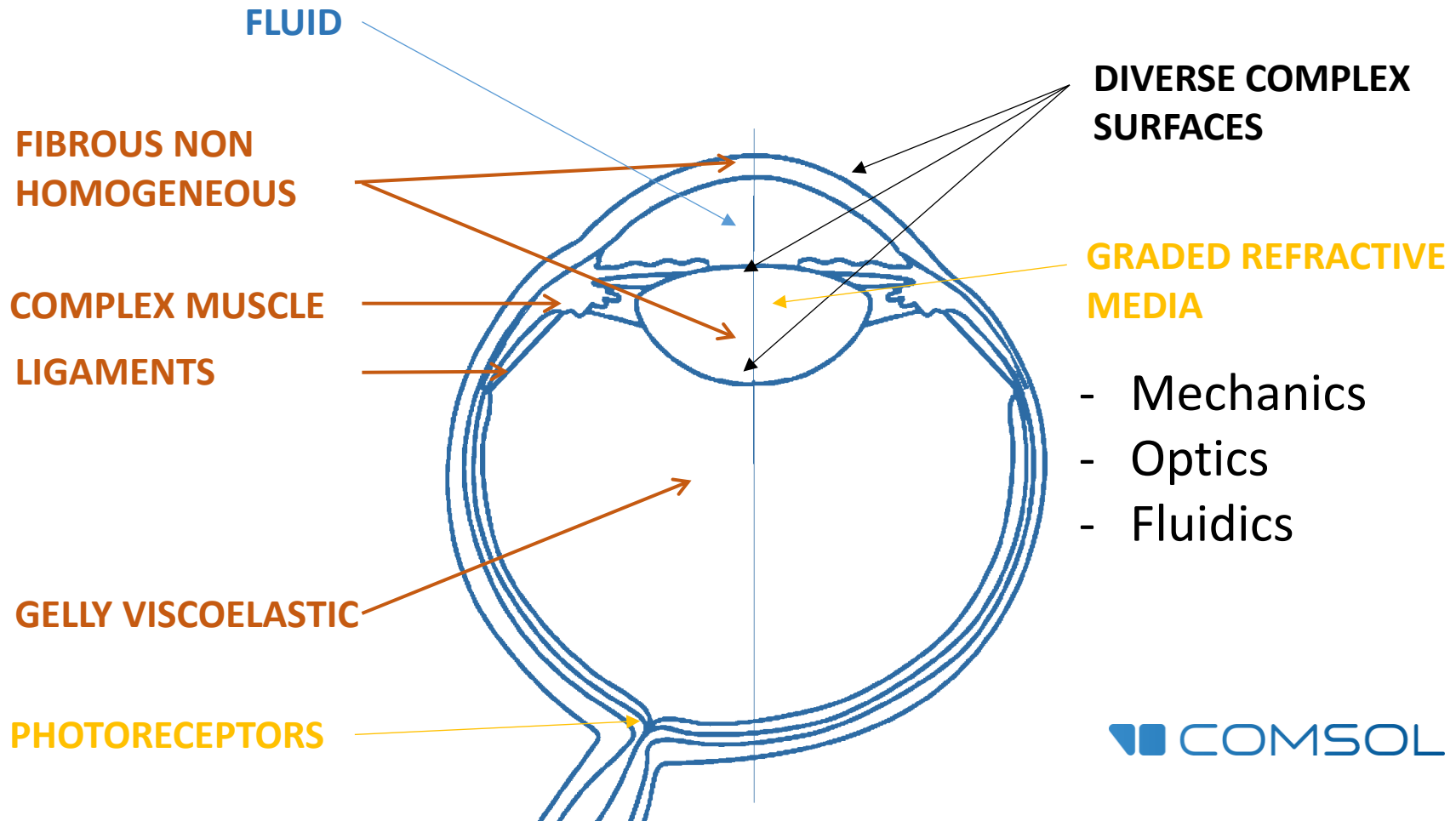


Modeling the eye ?



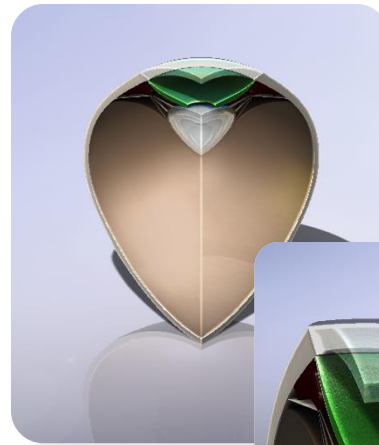
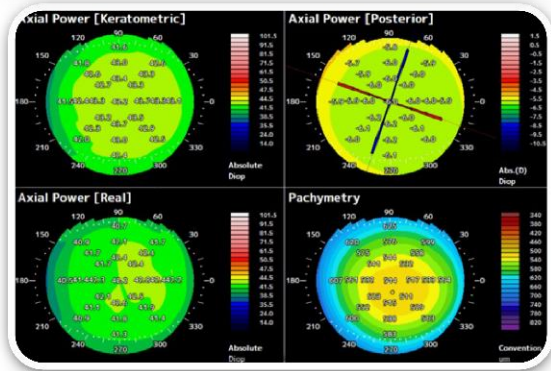
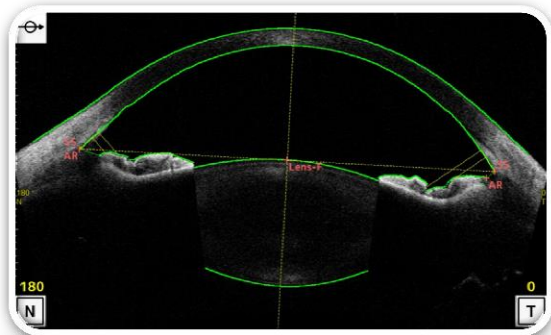


Modeling the eye ?





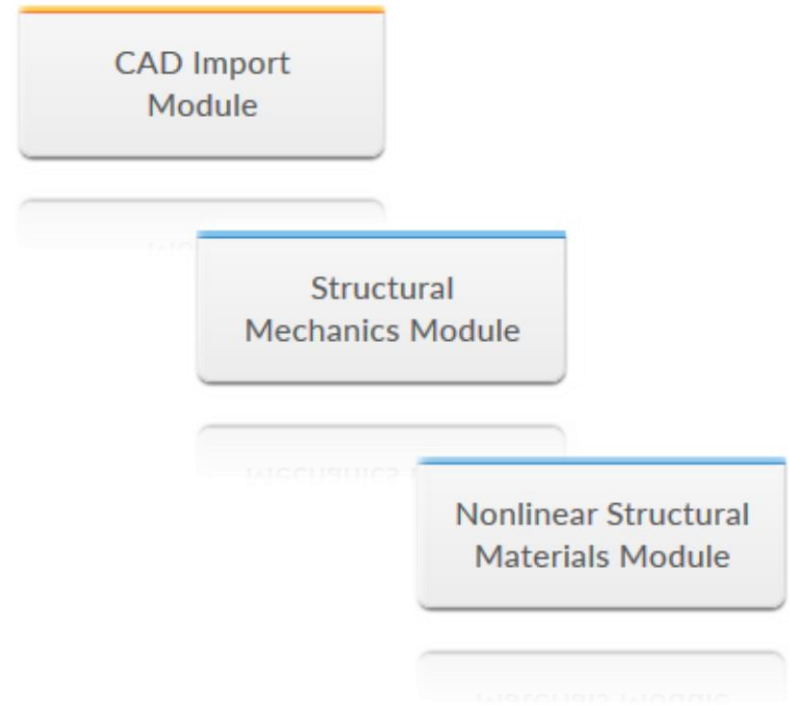
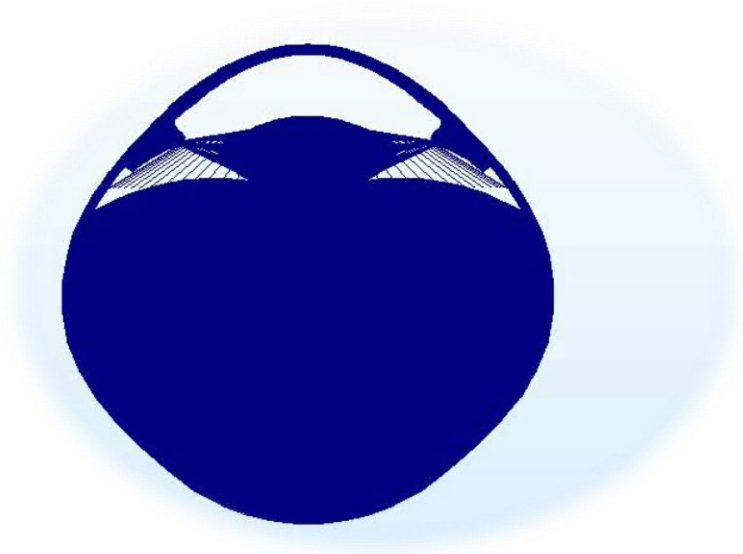
Parametric Eye Model



- > 360° Aspheric
- > Advanced surface generation
- > Modeling of visual accommodation & Presbyopia

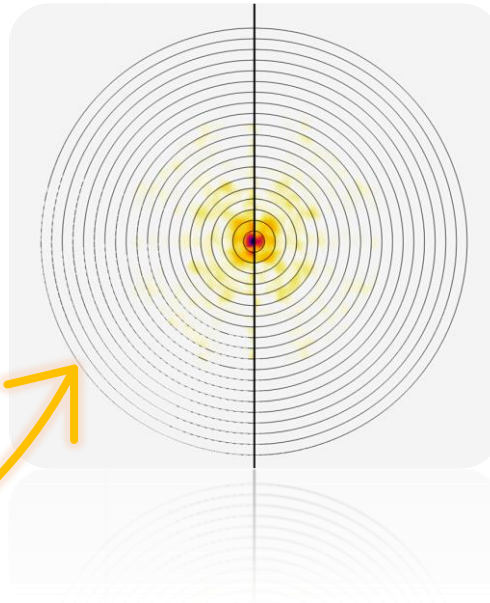
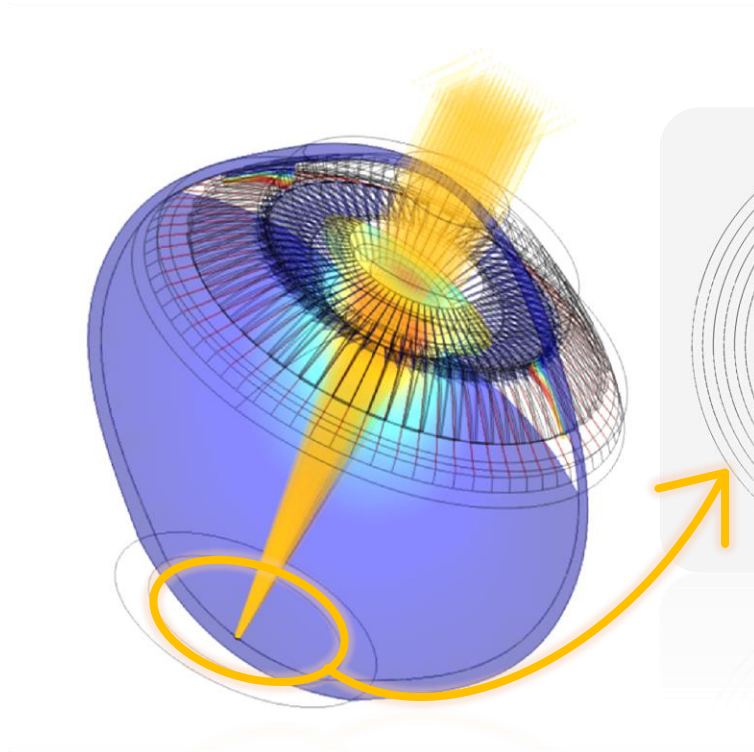


Mechanics of Visual Accommodation





Optical Evaluation



Ray Optics
Module

- Ray Tracing
- Refractive properties & GRIN
- Retina Modeling
- Sharpness of Vision
- Objective Amplitude of accommodation

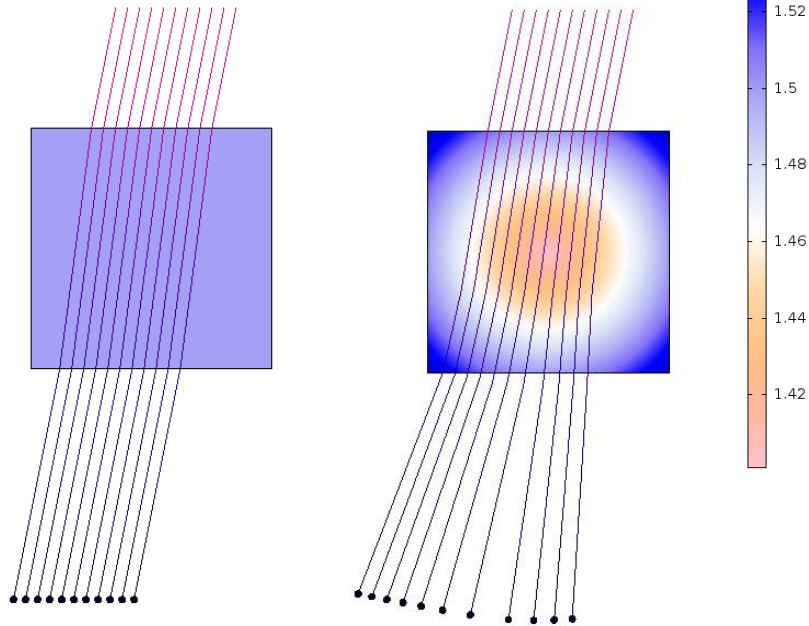


Use Case : *Retrieving the GRIN value from simulation*

GRIN => GRradient of **Refractive IN**dex

Snell-Descartes Law :

$$n_1 \cdot \sin(i_1) = n_2 \cdot \sin(i_2)$$



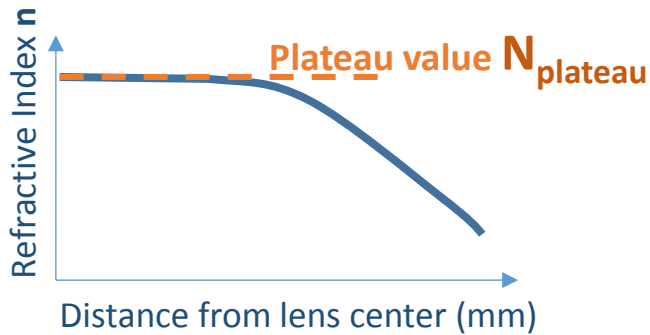
Homogeneous

Gradient



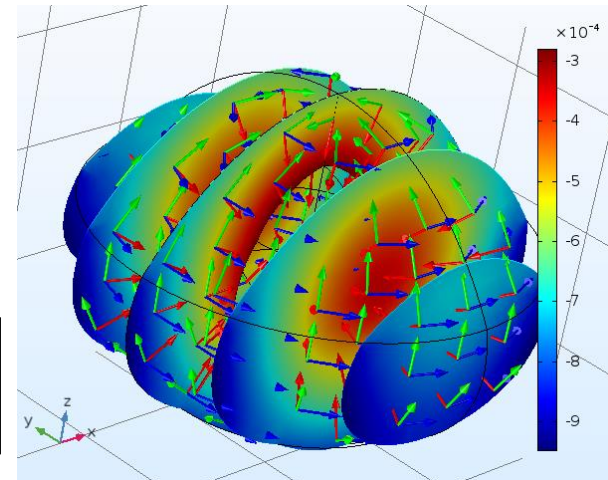
Use Case : *Retrieving the GRIN value from simulation*

GRIN => **GR**radient of **Refractive IN**dex



$$n = f(x + \vec{u}, \vec{N}_{\text{plateau}}, G_{\text{int}})$$

Curvilinear Coordinates & Wall Distance Interfaces

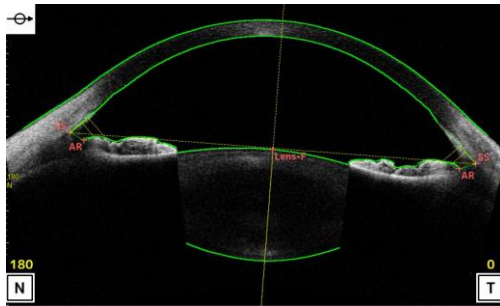


=> DIFFICULT TO MEASURE !



Use Case : *Retrieving the GRIN value from simulation*

0-6D STIMULATED YOUNG EMMETROPIC PATIENT

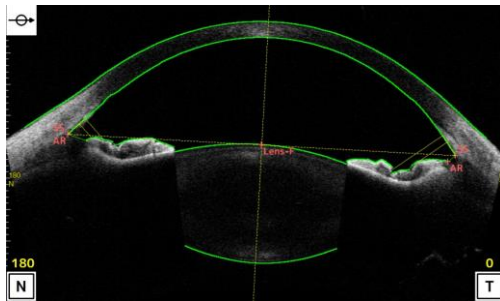


0 D FAR VISION



Hypothese :
Equivalent homogeneous
refractive index

$$N_{\text{far vision}} = 1,436$$



6 D NEAR VISION

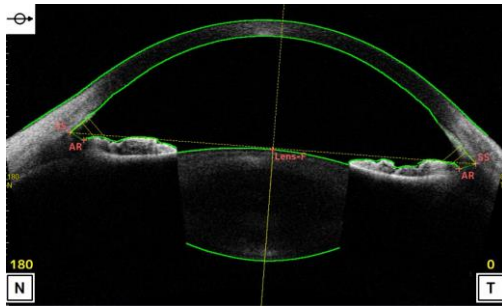


$$N_{\text{near vision}} = 1,441$$

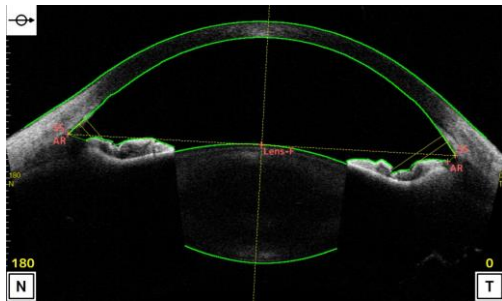


Use Case : *Retrieving the GRIN value from simulation*

0-6D STIMULATED YOUNG EMMETROPIC PATIENT

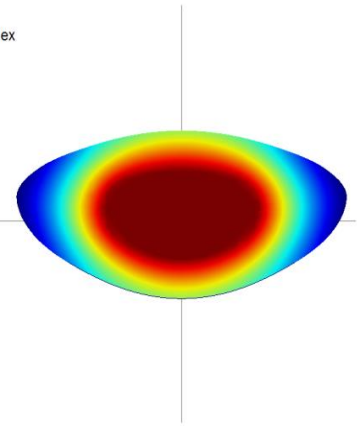
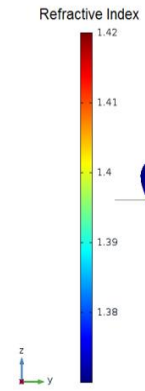
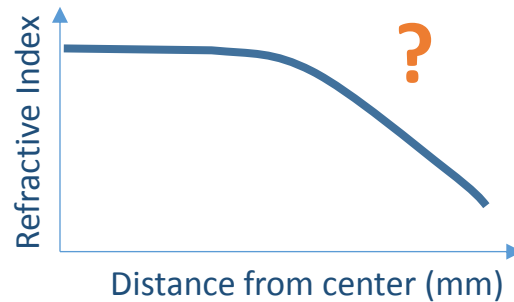


0 D FAR VISION



6 D NEAR VISION

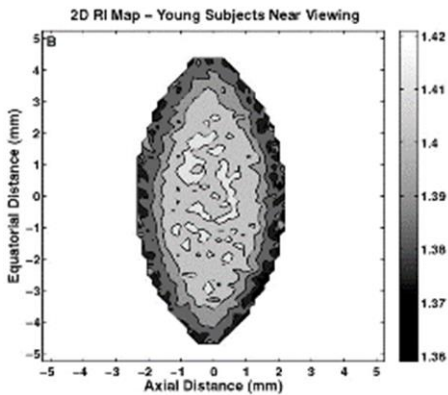
~~Hypothese :
Equivalent homogeneous
refractive index~~



*GRIN value
and distribution*

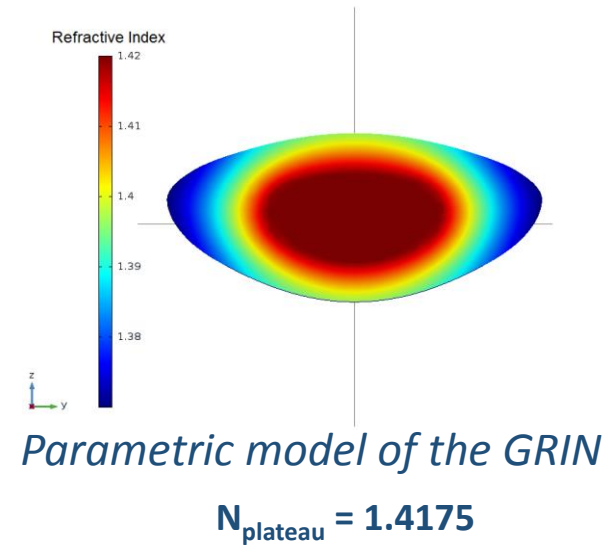
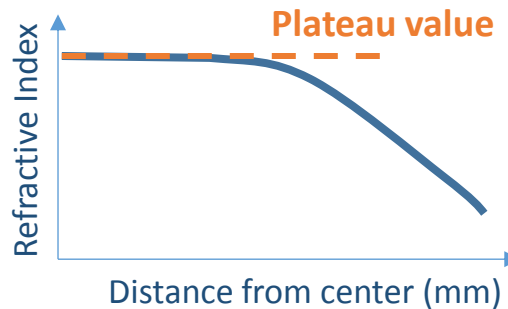


Use Case : *Retrieving the GRIN value from simulation*



*MRI Measure of the GRIN**

$$N_{\text{plateau MRI}} = 1,42$$

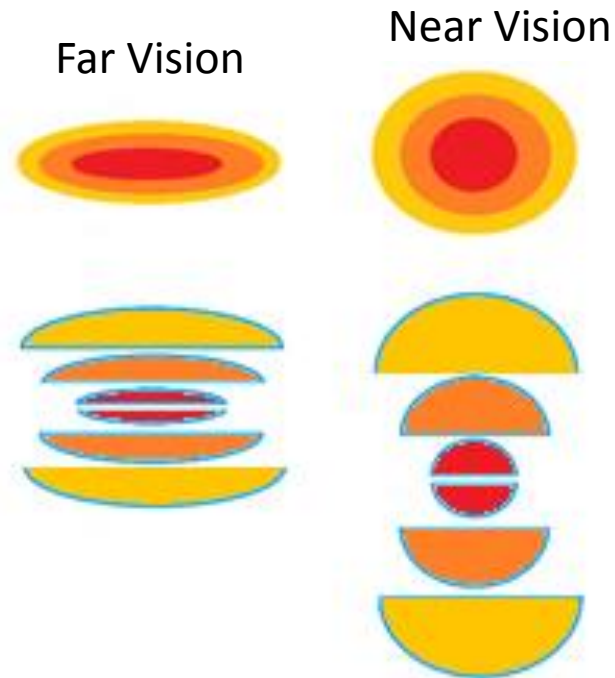


* Sanjeev Kasthurirangan; Emma L. Markwell; David A. Atchison; James M. Pope, "In Vivo Study of Changes in Refractive Index Distribution in the Human Crystalline Lens with Age and Accommodation"



Use Case : *Retrieving the GRIN value from simulation*

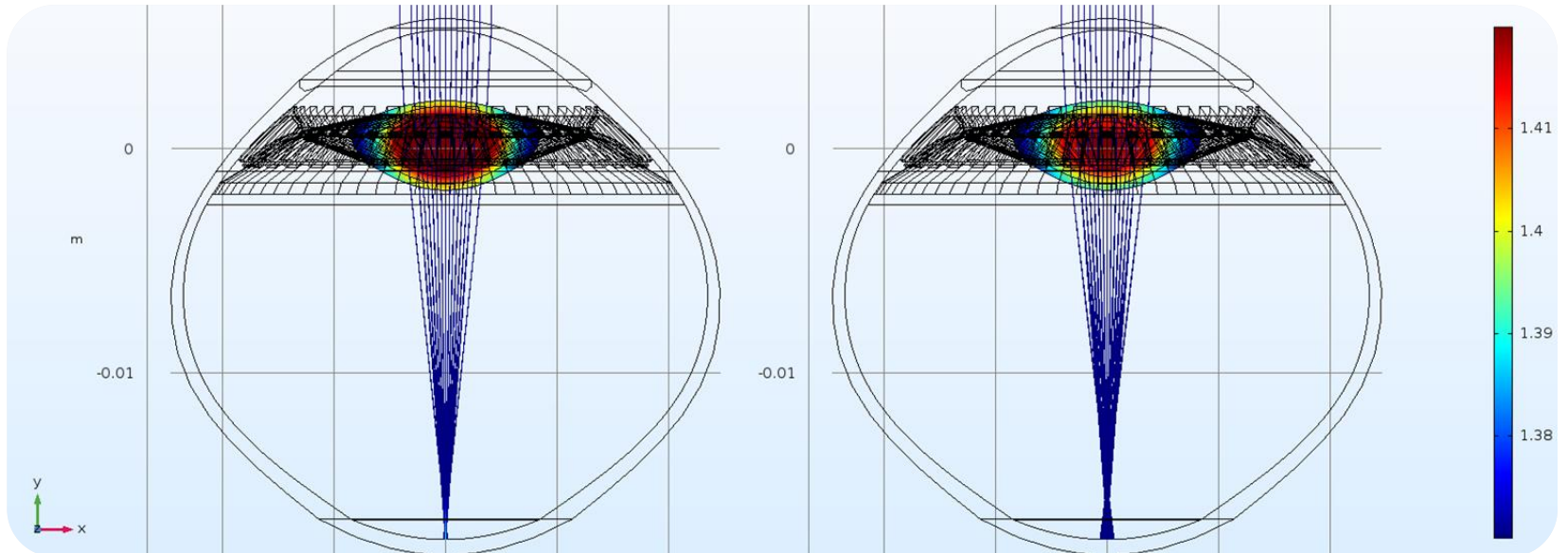
Non-Linear Response of the GRIN





Use Case : *Retrieving the GRIN value from simulation*

Example : Influence of the refractive distribution





Conclusion

- 3D full eye parametric & Multiphysics model of the eye
- *In-Silico* based on *in-vivo* imaging
- R&D purposes for *in-silico* POC
- Validated for visual accommodation analysis, presbyopia simulation & treatment optimization (>50 eyes)
- GRIN results are consistent with literature
- Versatile tool for research applications and path to individualized ophthalmology



Thank you for your attention !

Meet us at poster #19

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