

# Optimizing Performance of AO Ophthalmic Systems

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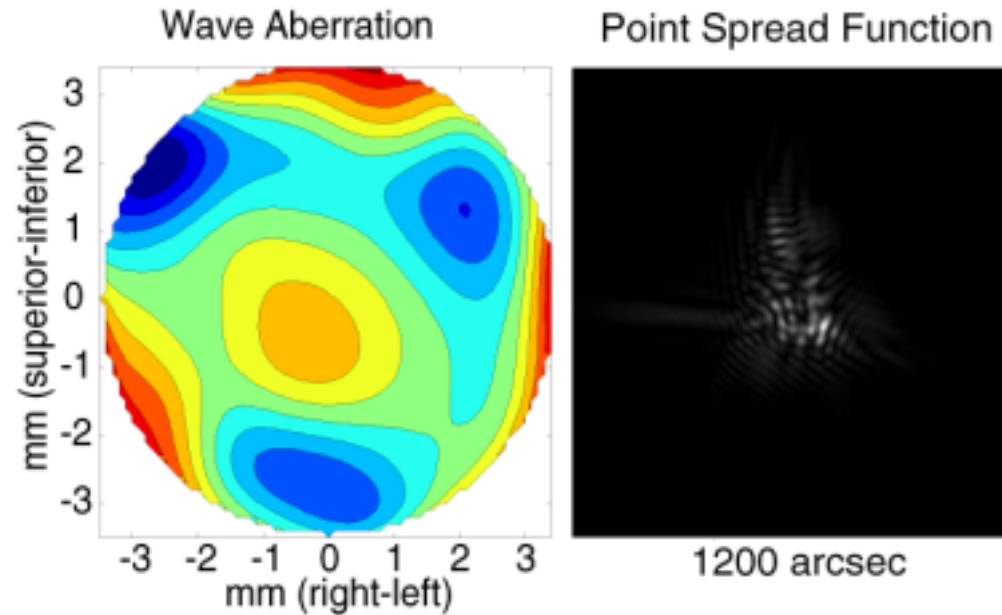
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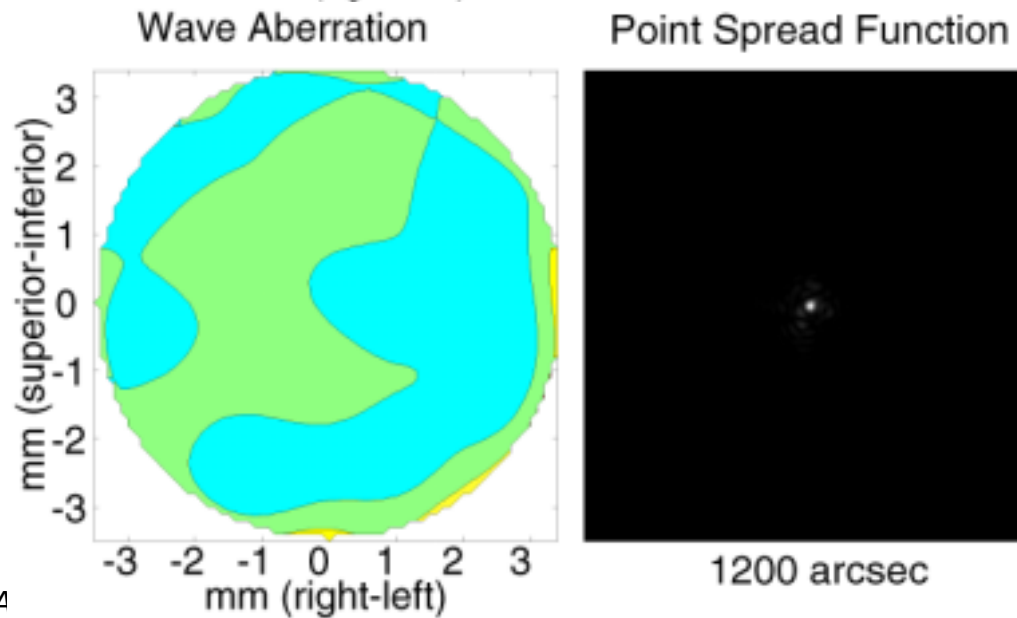


# Adaptive Optics

*AO OFF*



*AO ON*



OK, you have a working AO  
system...

*Now what??*



# Ophthalmoscopes vs Telescopes

- In a typical Vision Science lab, everyone is involved in all aspects of research
  - adaptive optics
  - optical design
  - optical alignment
  - visual optics
  - electronics
  - computer hardware and software
  - image processing
  - patient care



# Outline of Talk

- Imaging Modality?
- Human Factors
  - accommodation, pupil constriction
  - light budget
  - pupil tracking
  - proper fixation target
  - refraction
- Operational Improvements
  - contrast improvements
    - wavelength
    - polarization
    - contrast agents
  - resolution improvements

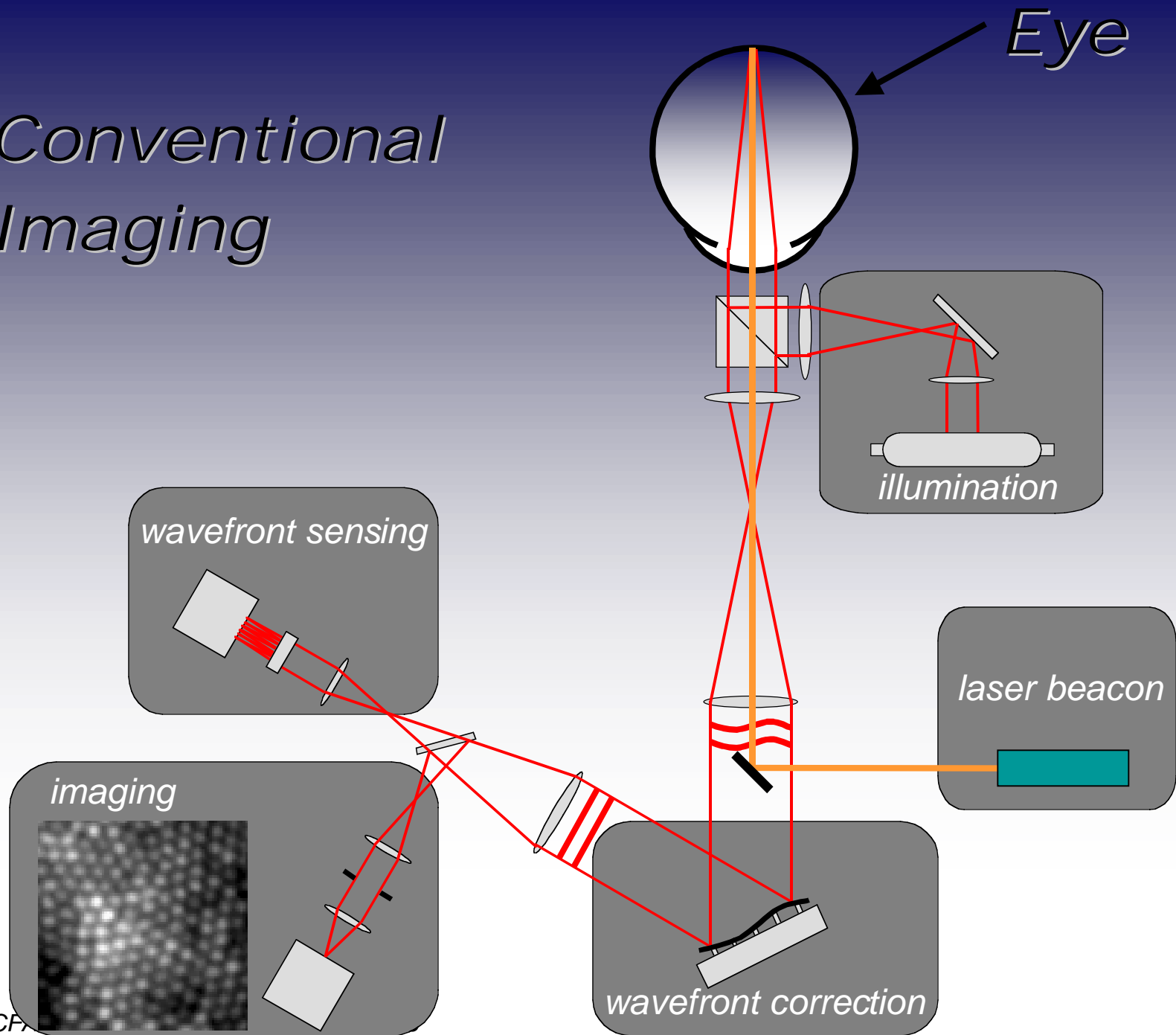


# Imaging Modality: Snapshot versus Video Imaging

- Snapshot
  - more light per frame (more photons per pixel)
  - convenient for many experiments (eg cone classing)
- Video
  - immediate feedback on focus, retinal location
  - dynamic imaging – blood flow
  - less light per frame
  - retinal exposure limits
  - huge data rates (lots of extraneous data)

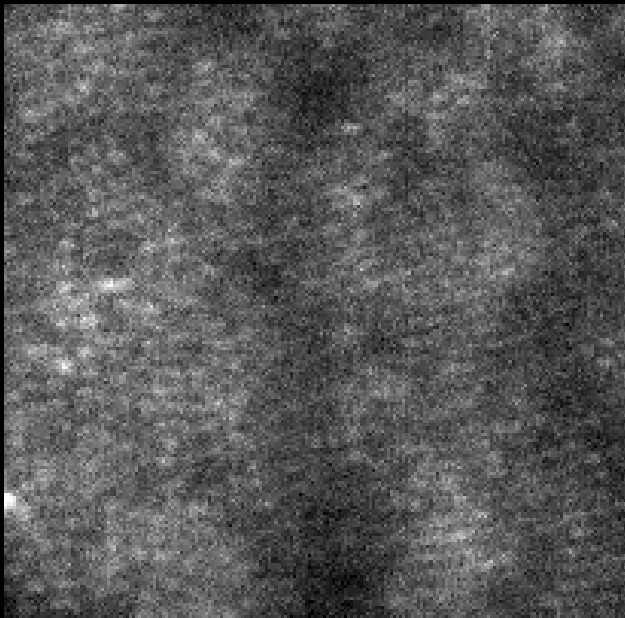


# Conventional Imaging

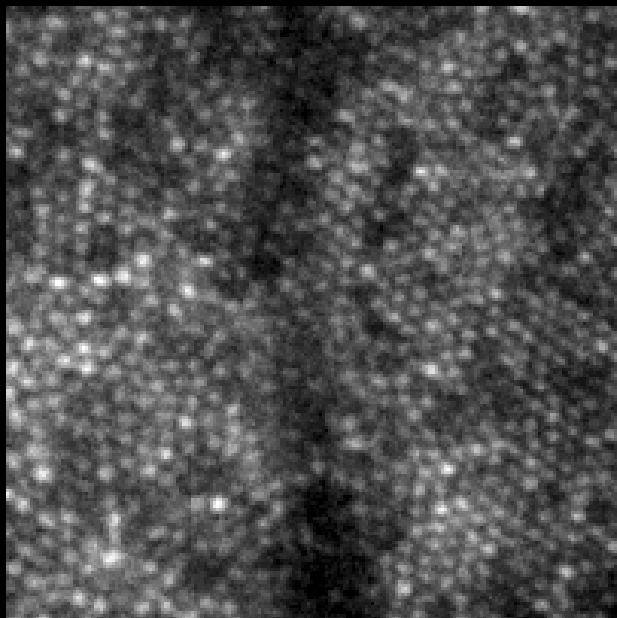


# AO Snapshot Imaging

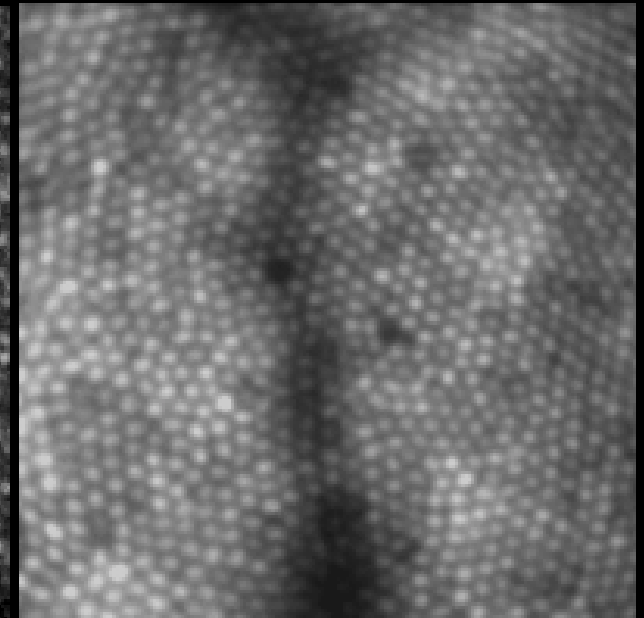
*No AO*



*With AO*



*multiple AO frames*

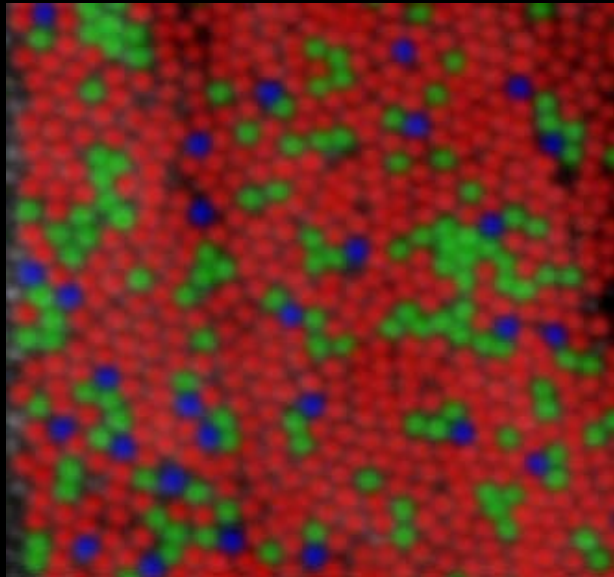


*JW right eye  
1 deg eccentricity  
image wavelength = 550 nm*

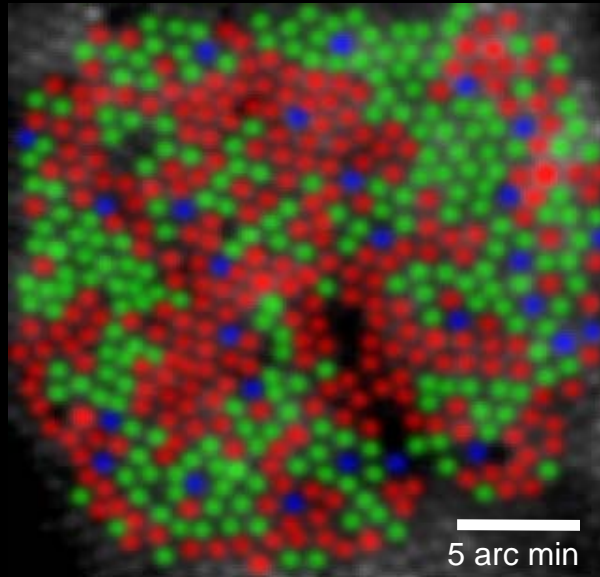


# Results from Snapshot AO Camera

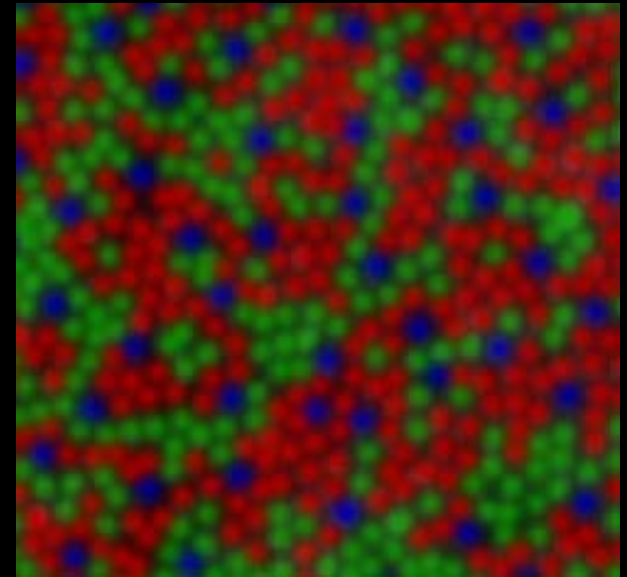
human (JW)



human (AN)

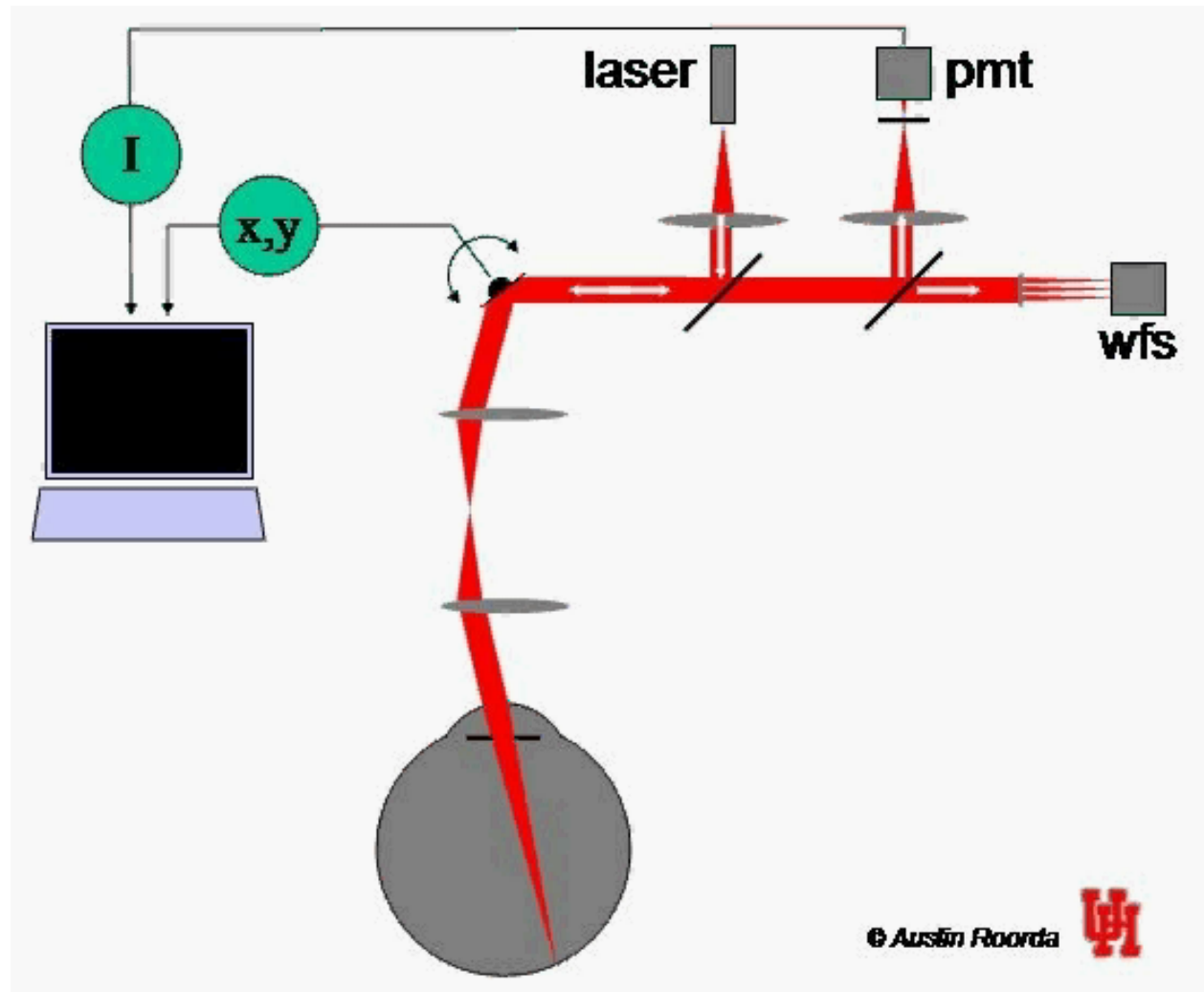


macaque



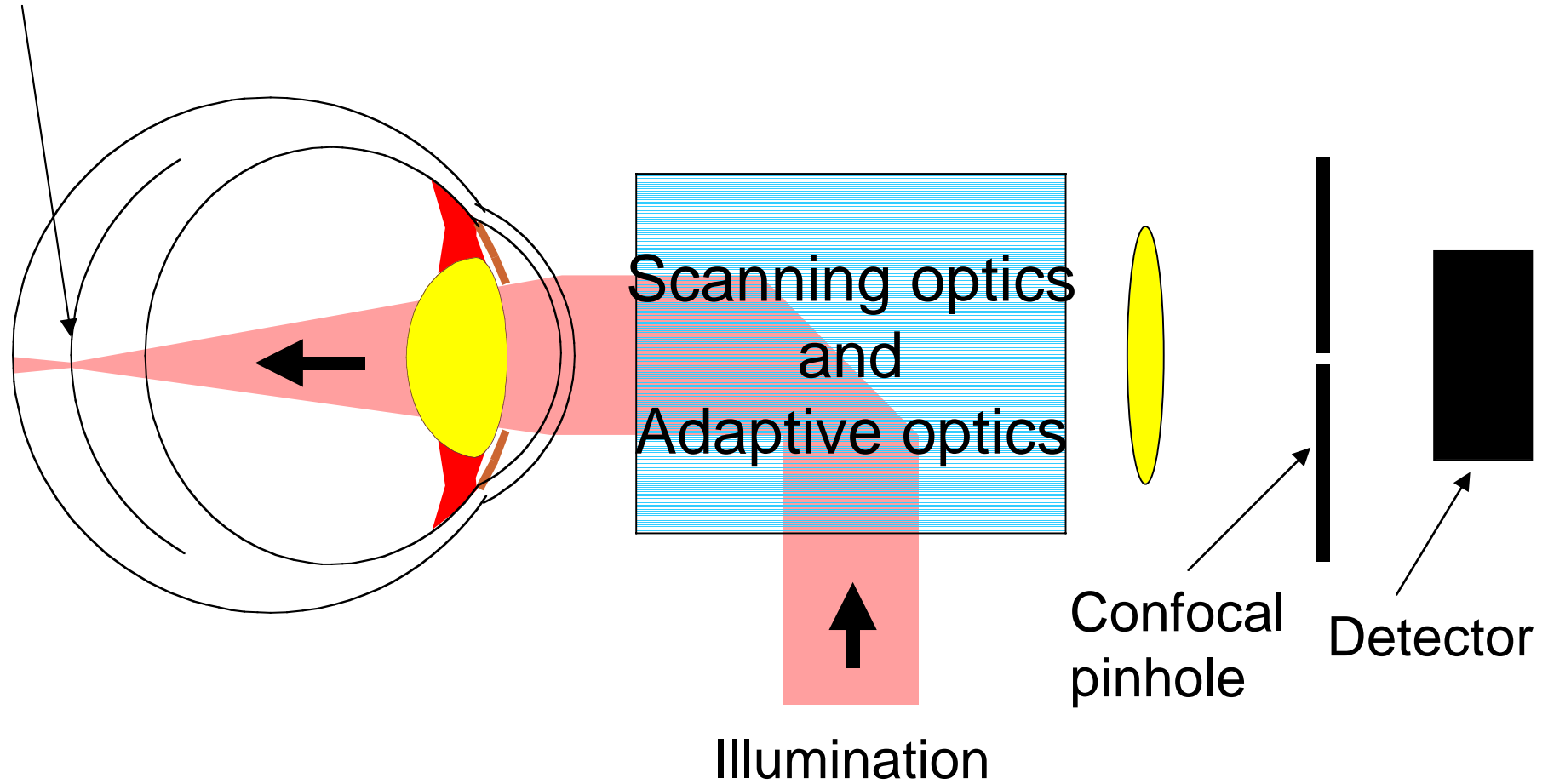
*Roorda and Williams, Nature, 1999*

# Video Imaging: Scanning Laser Ophthalmoscope



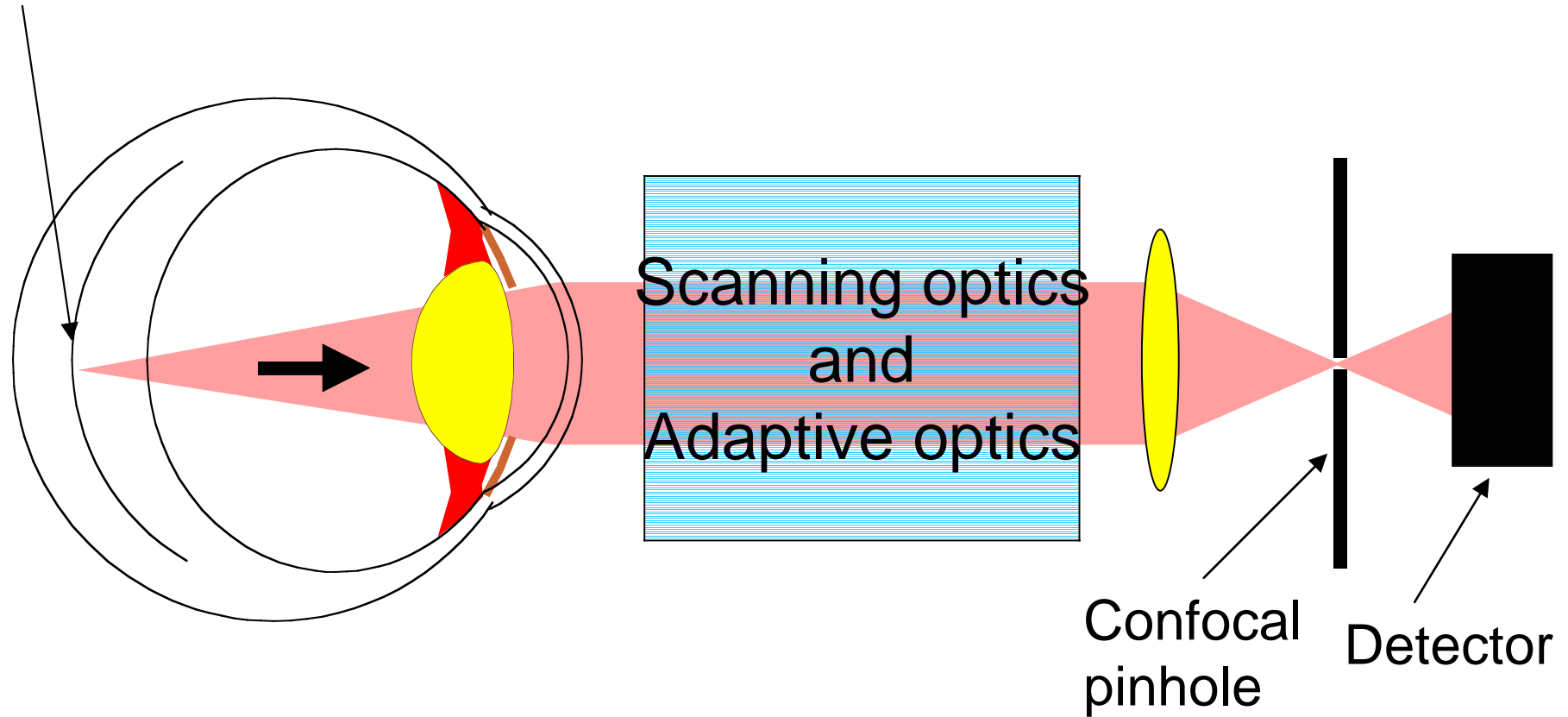
# Illumination

Plane of focus



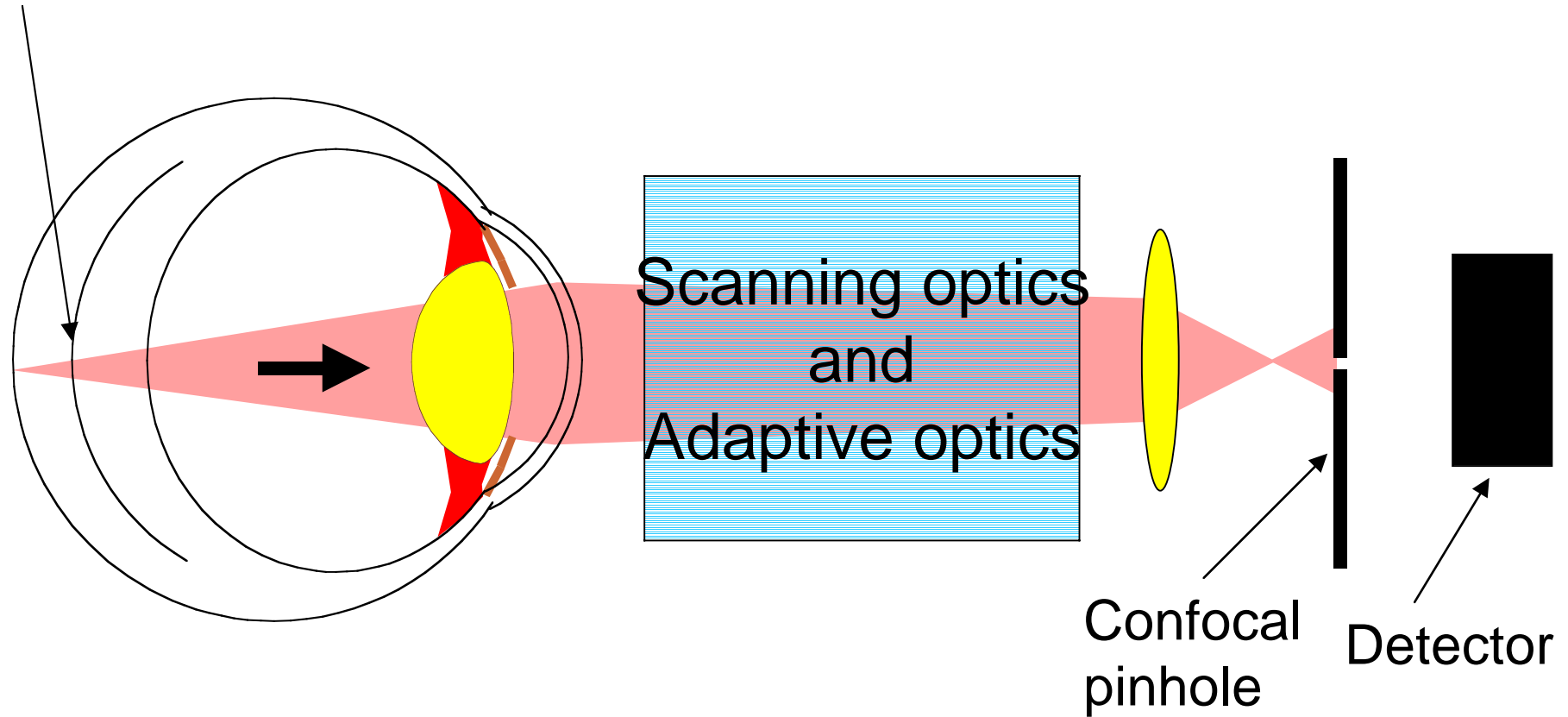
# Scattered Light from the Plane of Focus

Plane of focus



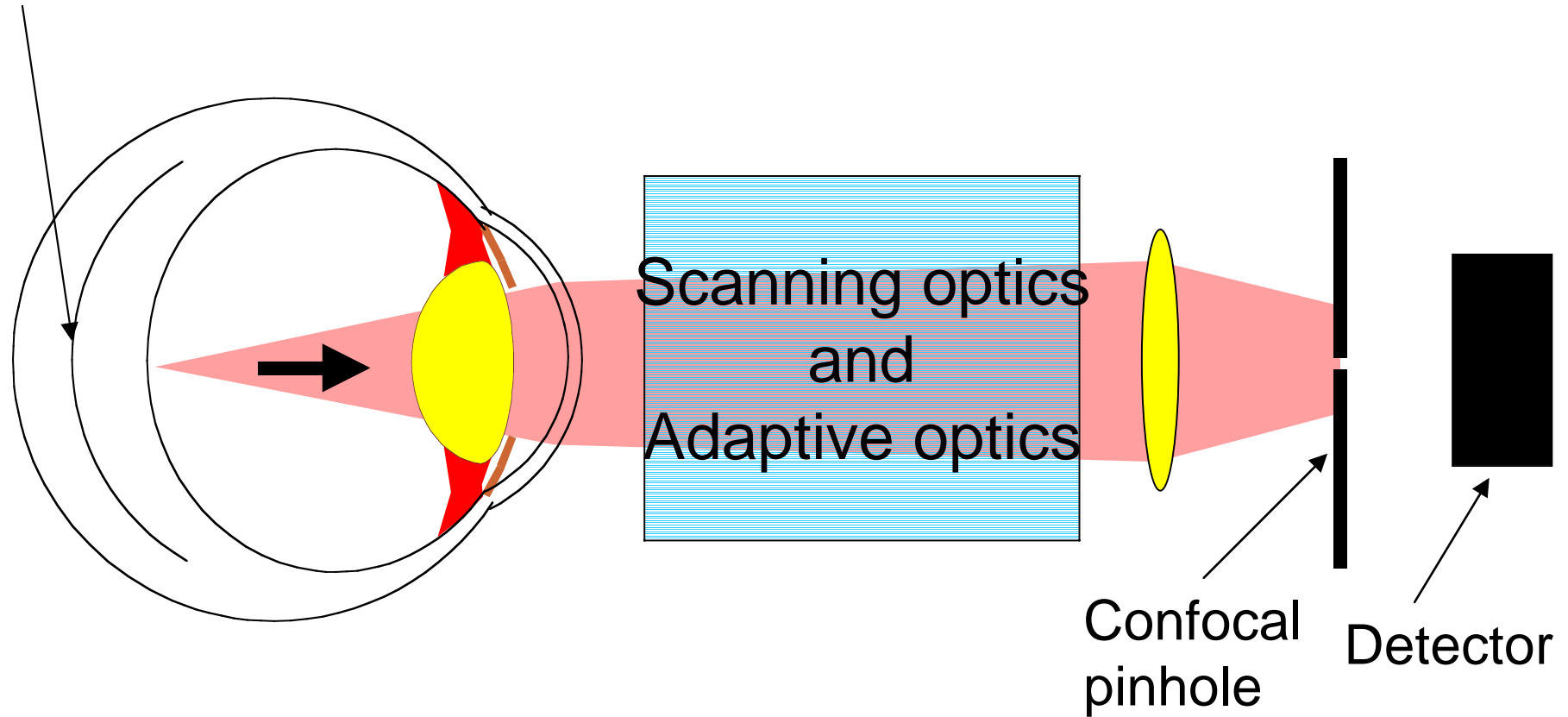
# Scattered Light from *Behind* the Plane of Focus

Plane of focus



# Scattered Light from *Before* the Plane of Focus

Plane of focus



# Photoreceptors and Blood Flow

## Photoreceptors and Blood Flow

**AR OS 02/05/02**

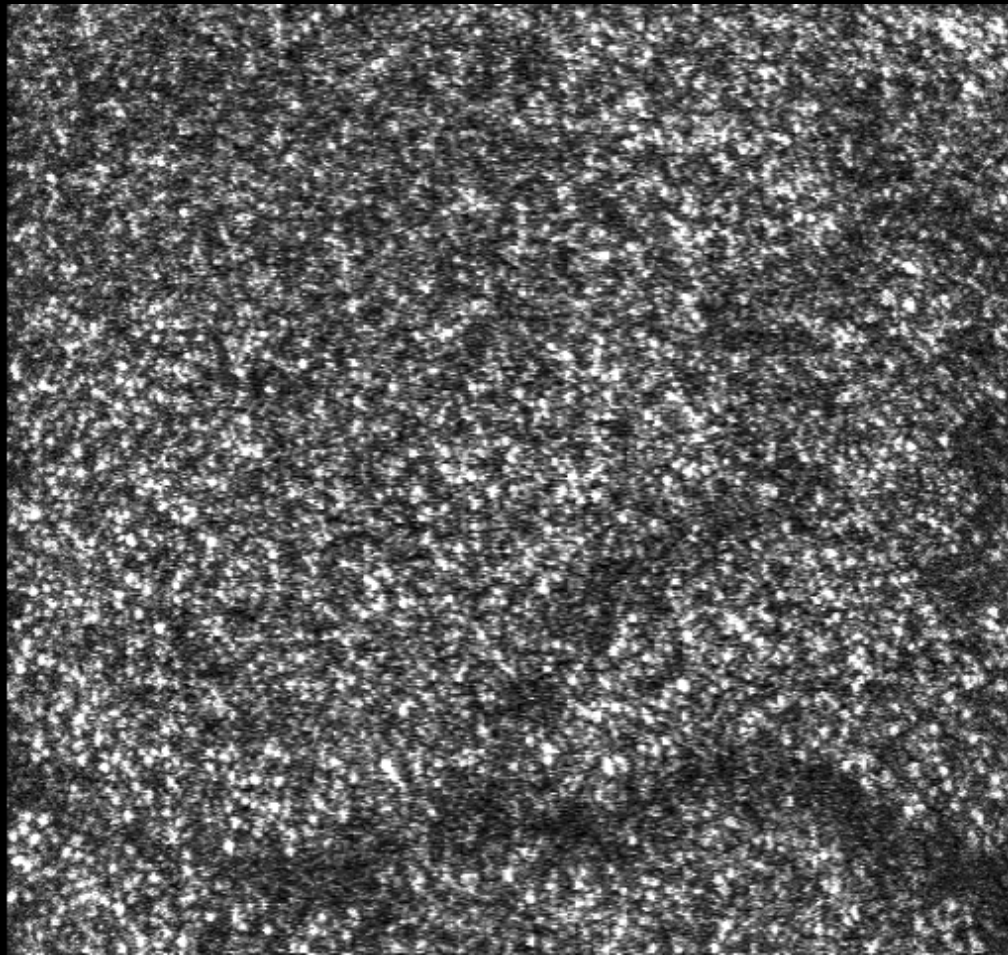
←—————→  
*1.5 deg*



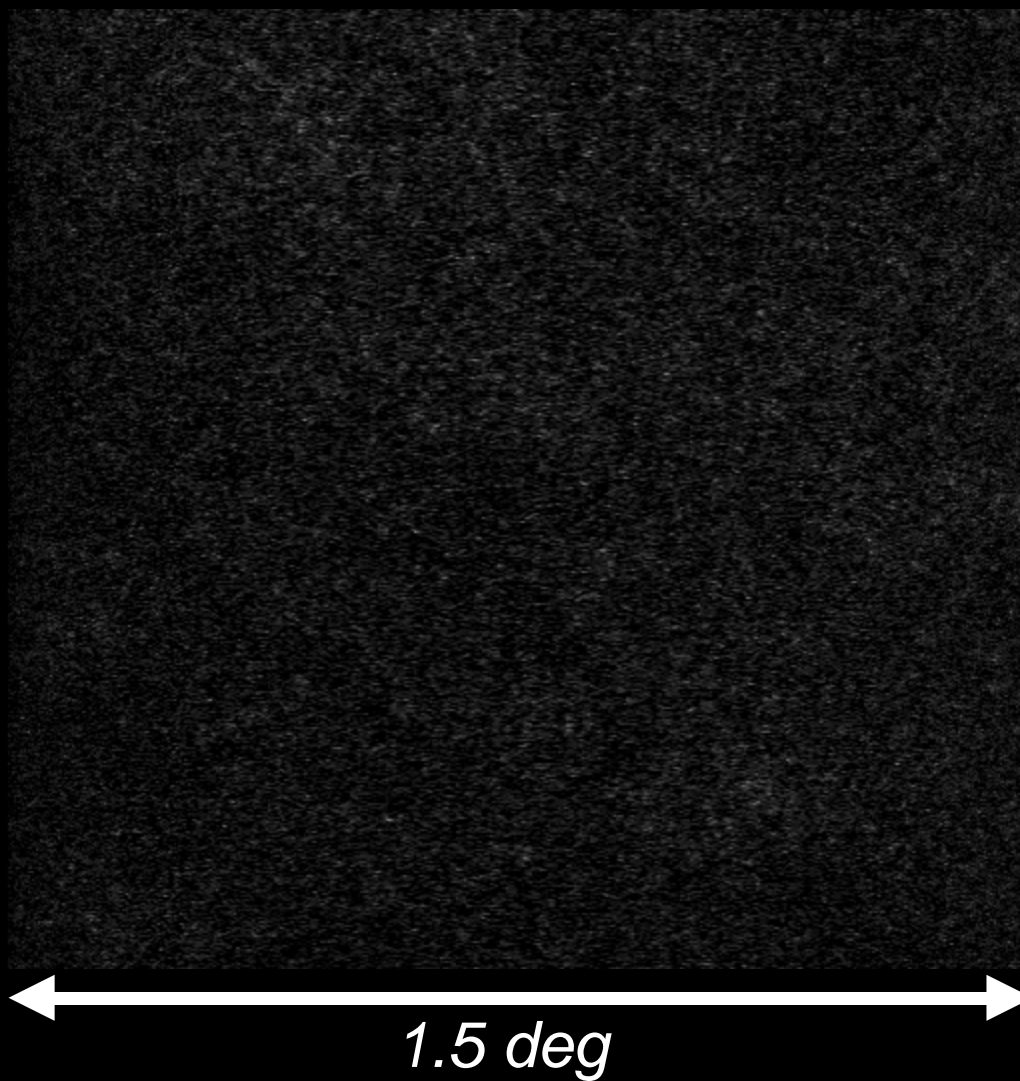
*AR left eye, fovea*



Fixational eye movements do not blur the image, but they warp the image



# Optical Sectioning



*AR left eye,*



# Huge data rates

- uncompressed 512X525, 8 bit images obtained at 30 fps.
- data rate is **~450 MB per minute** of video
- one imaging session fills at least one DVD disk



# Other Imaging Modalities

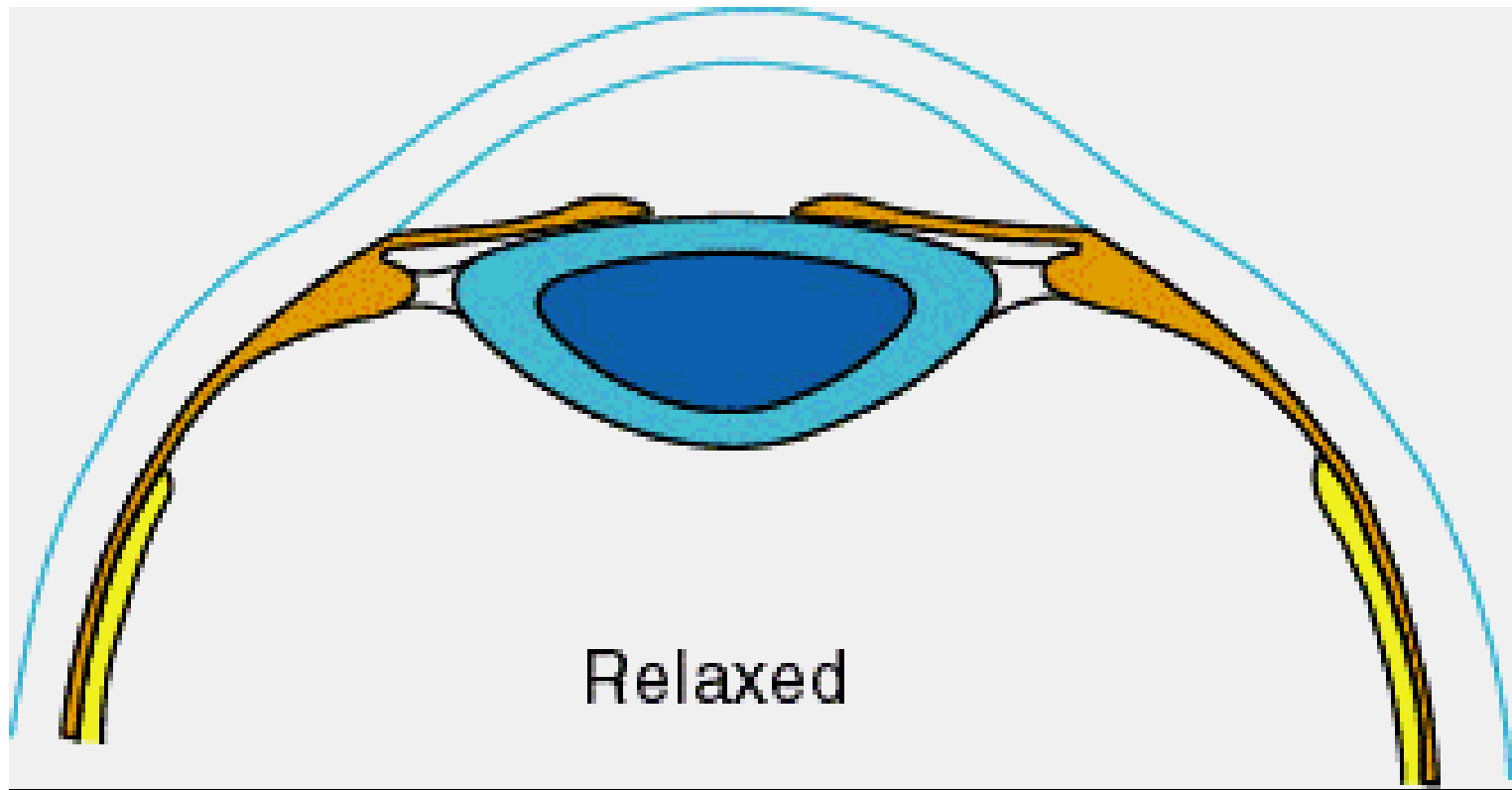
- Optical Coherence Tomography Imaging (coherence gated imaging)
- Two (or multi) photon imaging?



# Human Factors: Accommodation & Pupil Constriction



# The Original Adaptive Optics System



# Human Factors: Fixation



# Fixation

- how do you work with a small field of view?
- every eye is different
- every clinical condition is different



# Fundus Photograph 30 deg

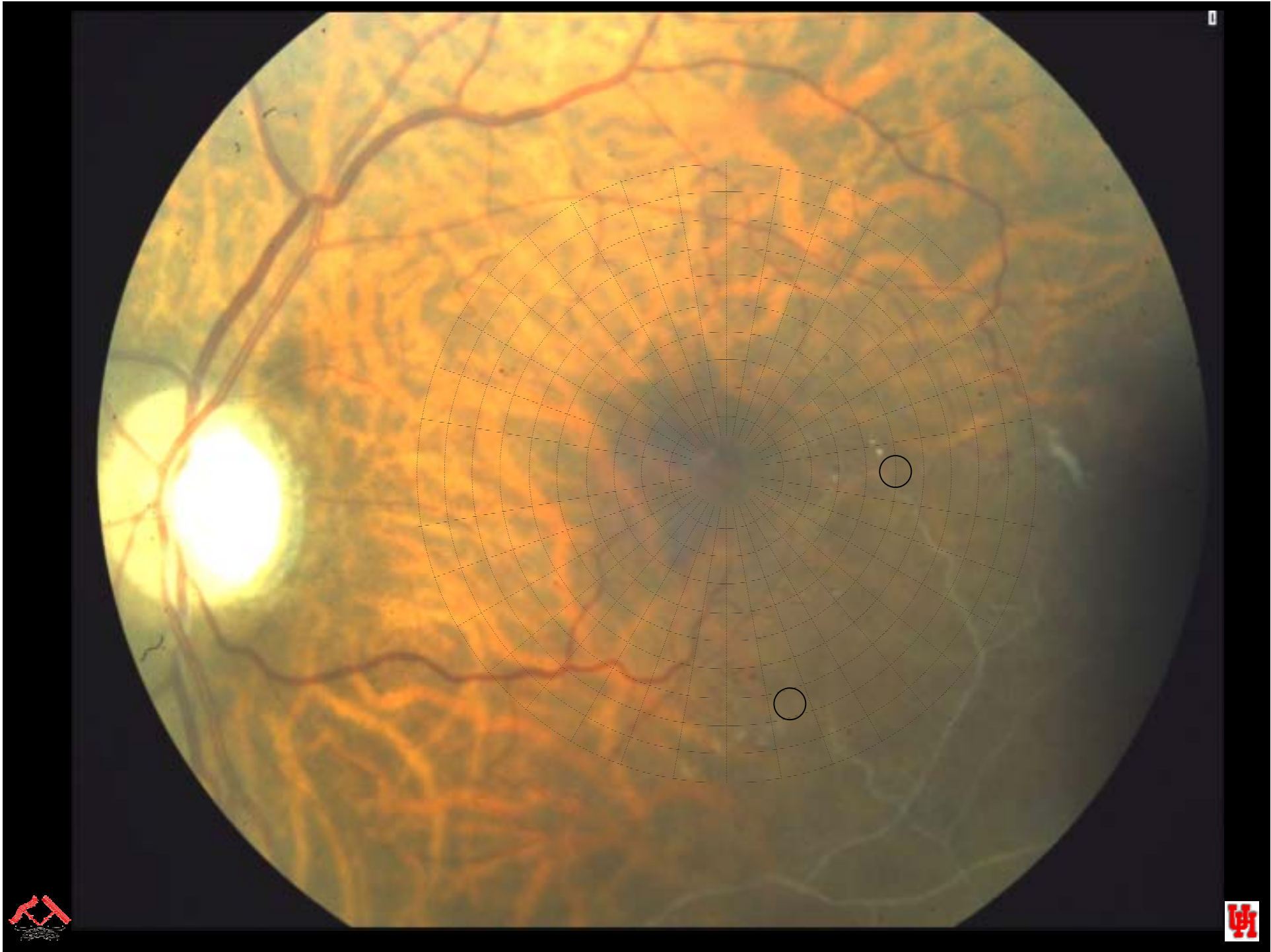


AOSLO Image  
1.5 X 1.4 deg

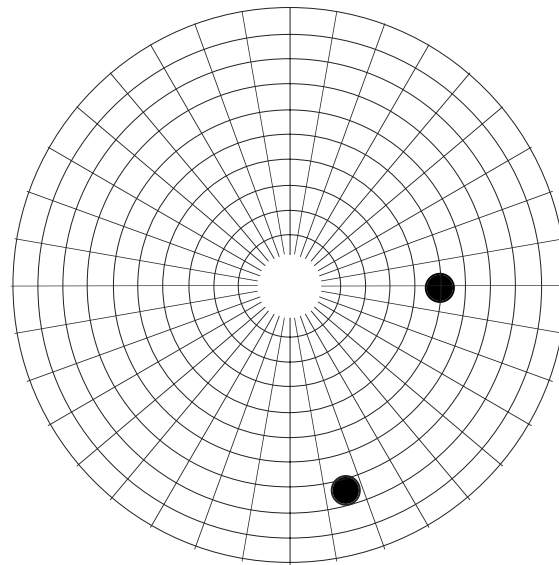
# Fixation

- preplanning is important
- provide a fixation target with a field of about 30 degrees
- provide a single fixation spot or fixation light





# Patient Fixation Target



# When the Patient gets Tired, the Fixation Starts to Degrade



# Human Factors: Pupil Tracking



