Disclosures

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Introduction to Optical Coherence Tomography (OCT) Technology

Time-Domain and Spectral-Domain Including Similarities and Differences between these Technologies

FDA AGS WORKSHOP

The Validity, Reliability, and Usability of Glaucoma Imaging Devices

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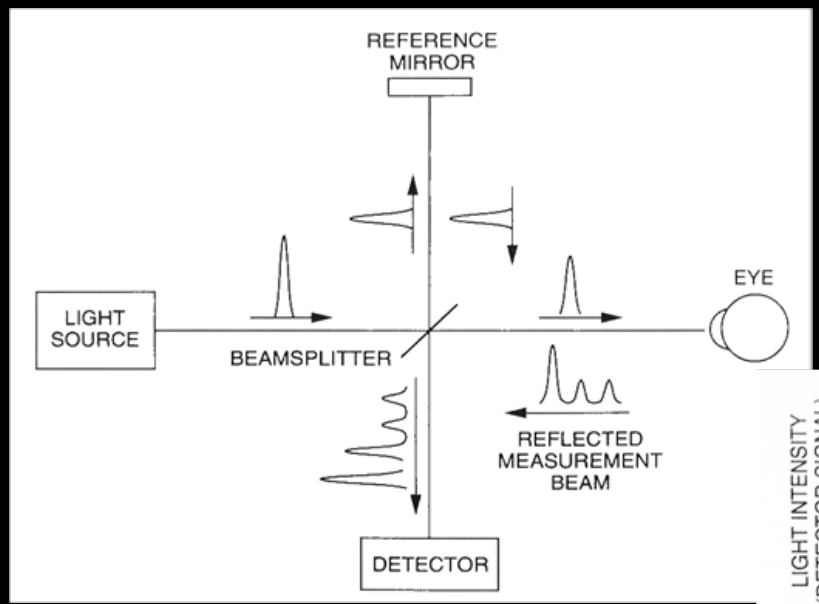
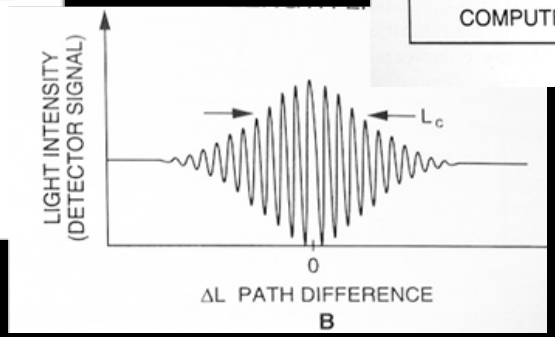
JOEL S. SCHUMAN, MD

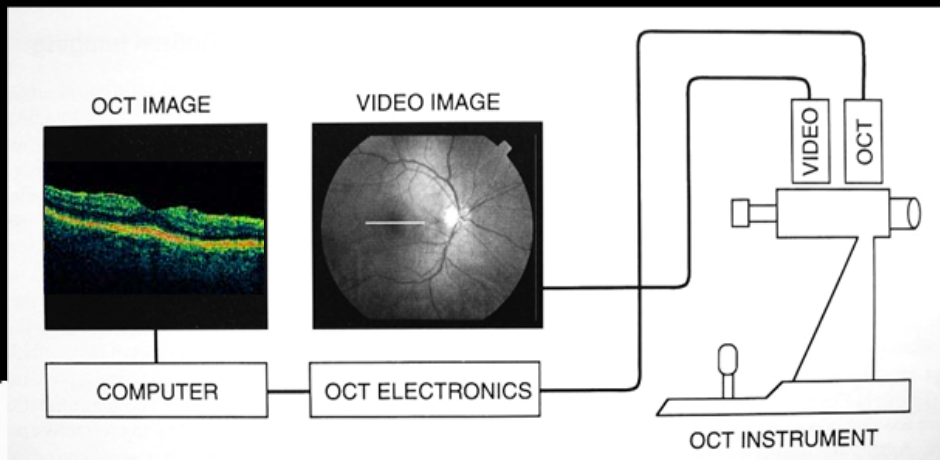
EYE AND EAR FOUNDATION PROFESSOR AND CHAIRMAN
DEPARTMENT OF OPHTHALMOLOGY, UNIVERSITY OF PITTSBURGH SCHOOL OF MEDICINE
DIRECTOR, UPMC EYE CENTER
PROFESSOR OF BIOENGINEERING, SWANSON SCHOOL OF ENGINEERING
FOX CENTER FOR VISION RESTORATION
MCGOWAN INSTITUTE FOR REGENERATIVE MEDICINE
UPMC & UNIVERSITY OF PITTSBURGH
CENTER FOR THE NEURAL BASIS OF COGNITION
UNIVERSITY OF PITTSBURGH & CARNEGIE MELLON UNIVERSITY
PITTSBURGH, PA USA

Basic OCT Principles

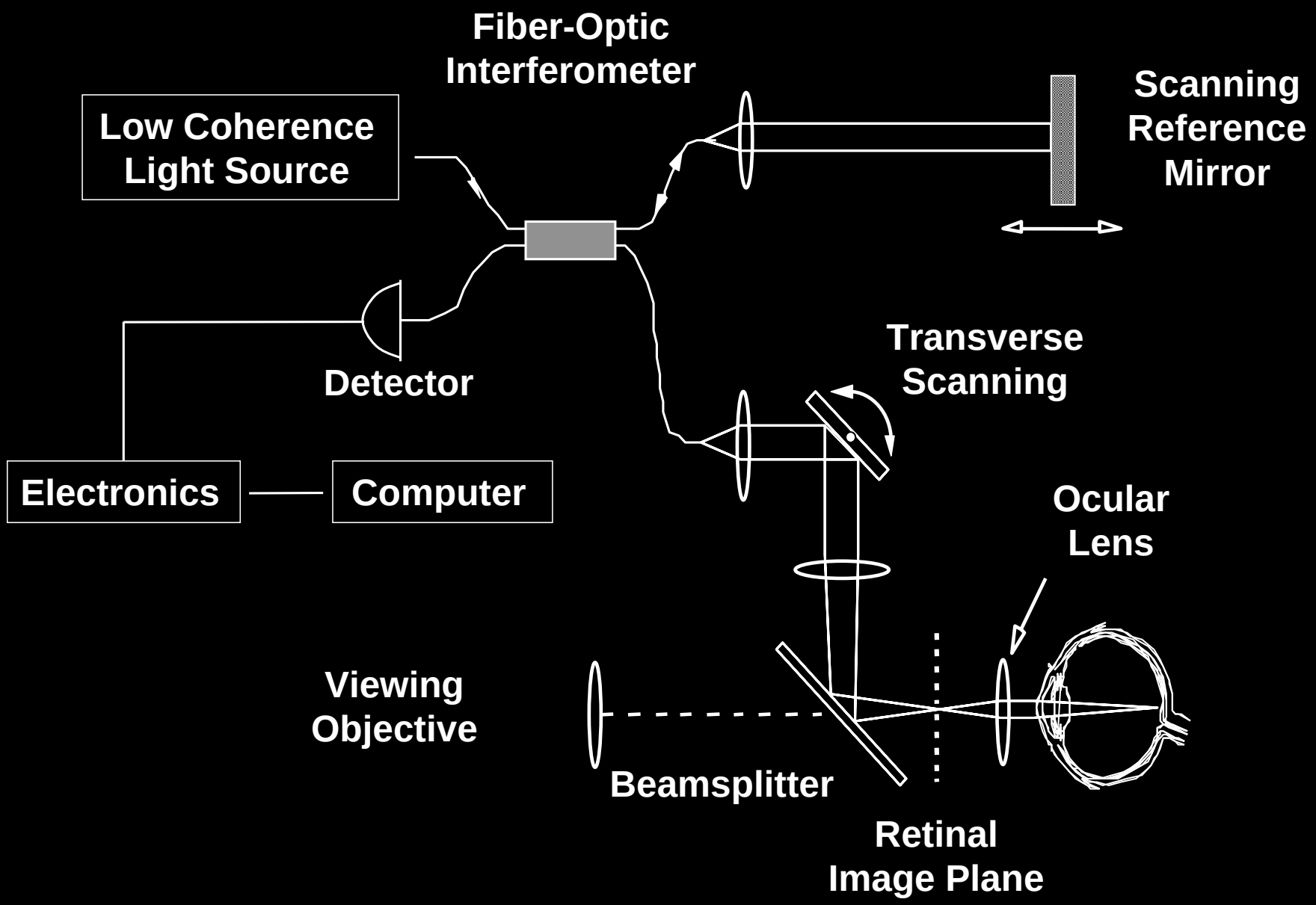
- Uses near-infrared light (~800-1310nm)
- Michelson type interferometer
  - Measures time-of-flight of light (Time-Domain)
  - Measures wavelengths of backreflected light (Spectral-Domain)
- Low coherence allows high resolution



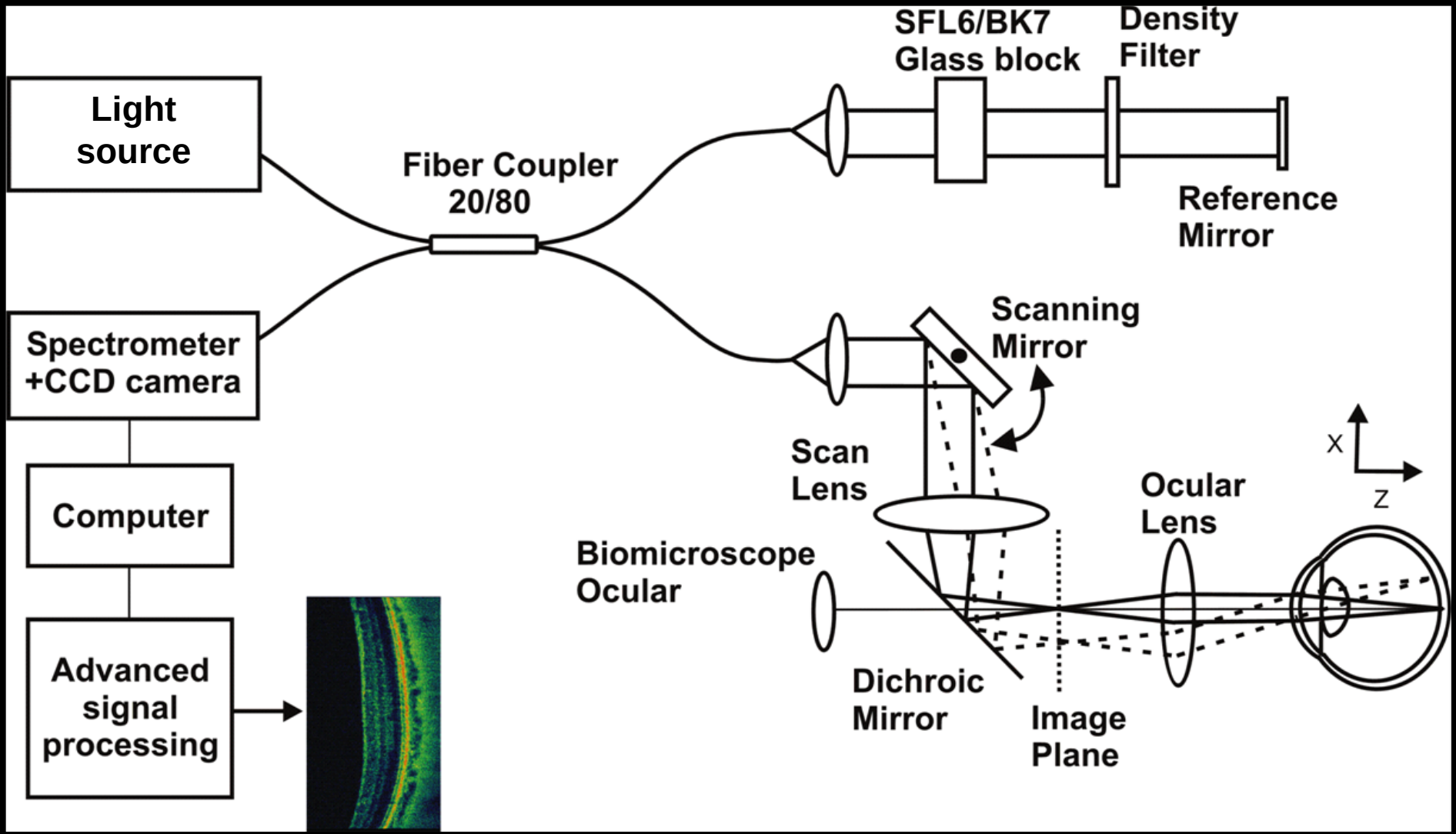




Ophthalmic OCT Imaging System



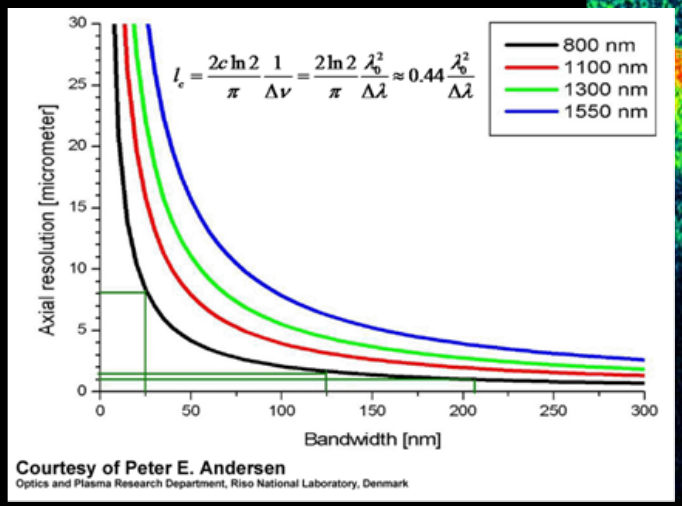
High Speed OCT with Spectral/Fourier Domain Detection

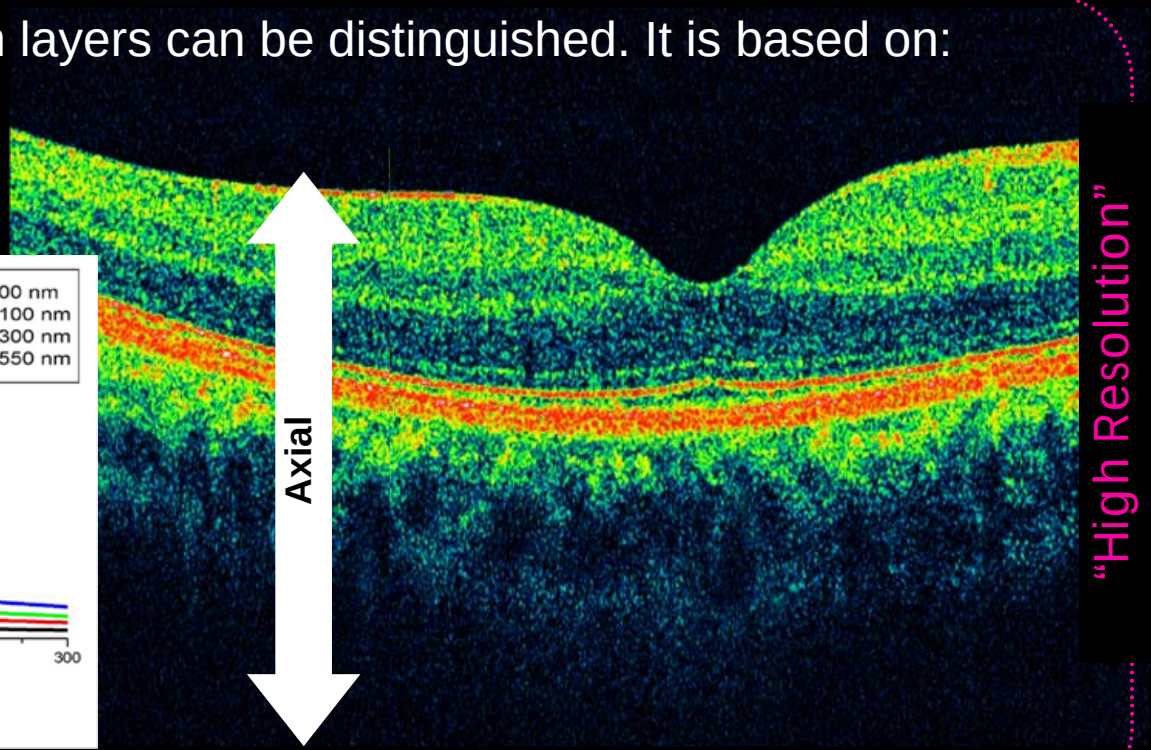


What determines OCT resolution?

- OCT has 2 independent directions of resolution
  - **Lateral** resolution determines accuracy with which size and separation of features can be identified. It is based on:
    - Width of the beam waist and is limited by optics of eye (~10-20 µm)

  - **Axial** resolution determines which layers can be distinguished. It is based on:
    - Wavelength of light source
    - Bandwidth of light source





TD-OCT

- In TD-OCT, there is a mechanical moving part, which performs the A-scan, and the information along the longitudinal direction is accumulated over the course of the longitudinal scan time
- Due to the nature of the slow mechanical moving speed, the scan time in TD-OCT is slow
  - Stratus can perform 400 A-scans/second
- Because of the eye motion, it is not feasible to use TD-OCT to precisely map retinal tissue in three dimensions

SD-OCT

- Broadband source is employed and the entire signal (at all wavelengths) is recorded in parallel by a spectrometer
- Acquire the signal in the wavelength space and Fourier-transform it to get the spatial information
- All done at same time, so speed dramatically increased (50-1000x faster than TD)

Spectral Domain Advantages

- Improved resolution
- Improved acquisition speed
  - Reduces motion artifacts
  - Digital processing not required to align adjacent axial scans = More accurate retinal scans
- 3D views
- More accurate segmentation
- Precise registration/orientation

OCT Imaging Speeds and Technologies

Time Domain OCT

400 axial scans per second (Zeiss Stratus - 2002)

8-10 um axial resolution

Spectral / Fourier Domain OCT – spectrometer

25,000 – 50,000 axial scans per second (2006)

5 - 7 um axial resolution

Next Generation Spectral / Fourier OCT

70,000 – 100,000 axial scans per second

~3 - 5 um axial resolution

100,000 – 250,000 axial scans per second

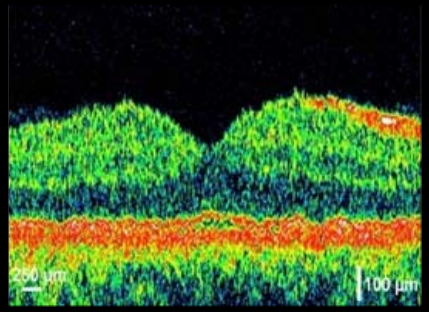
~5 - 10 um axial resolution

Swept Source / Fourier OCT – swept laser

200,000 + axial scans per second

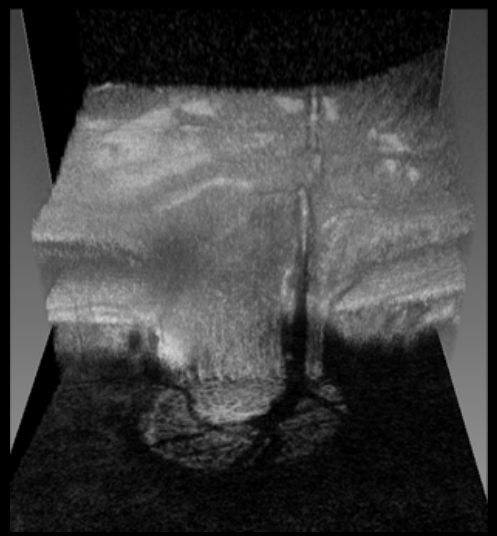
~5 - 7 um axial resolution at 1050 nm wavelengths

Zeiss StratusOCT



512 A-scan Image, ~1.3 seconds

Ultrahigh Speed



500 x 500 A-scans, ~2 seconds

OCT – The Next 5 Years?

- Competition between manufacturers will drive rapid innovation of technology
- Ophthalmologists will have the possibility to assess retinal pathology like pathologists
- Software advances will enable advanced quantitative assessment and display of 3D OCT data
- Subtle changes in pathology will be measurable, enabling more accurate monitoring of disease progression and response to therapy
- New, lower cost OCT instruments will enable wider spread access, especially in the international community

Summary

- OCT performs “optical biopsy” imaging tissue pathology in situ and in real time
- Retinal pathology can be examined at the level of individual retinal layers
- 3D OCT provides comprehensive information about structure
- Reproducible registration, longitudinal follow up, quantitative assessment
- Many new clinical studies are possible to develop biomarkers for earlier diagnosis, track disease progression and response to therapy


UNIVERSITY OF
VERITAS
1787
VIRTUS
PITTSBURGH