To See or Not to See…

Tools for Early Detection, Diagnosis and Prevention of Eye Disorders

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Overview

- Simulation of eye defects (Project *Eyemovie*)
- Robotic Eye Doctor (3D Amsler Grid test)
- Wireless Intraocular Pressure Sensor (WIPS)

Camera versus Eye

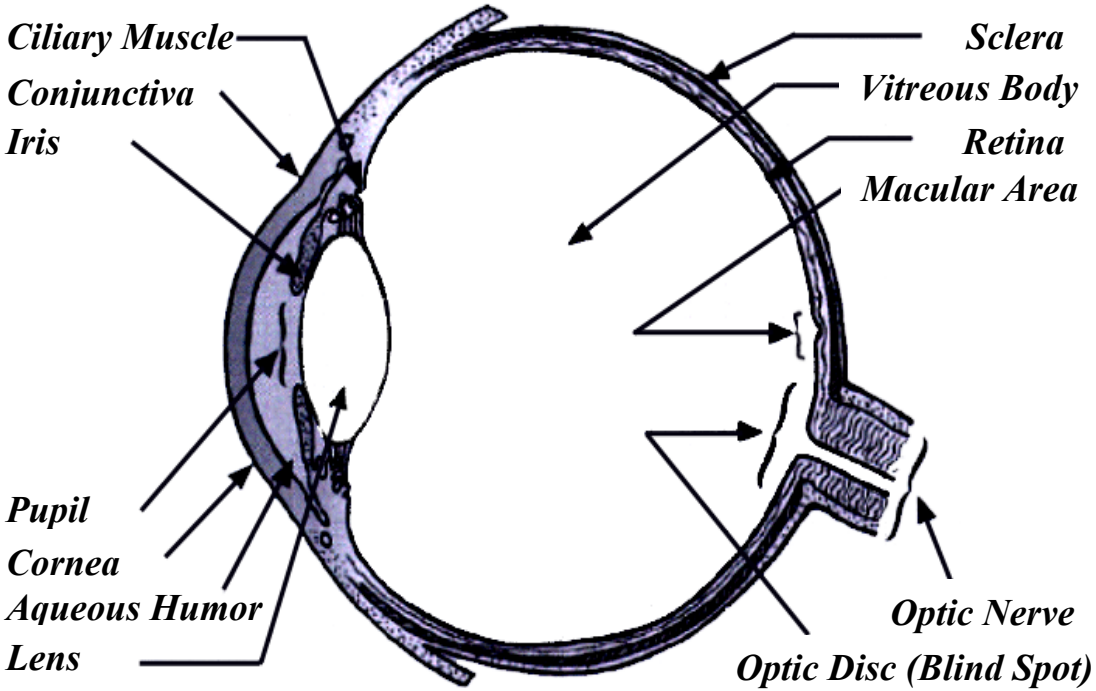
Camera	*Eye*
Optical Lens System	Cornea and Eye Lens
Film/CCD	Retina
Picture/Image	Retina and Visual Cortex

NOTE:

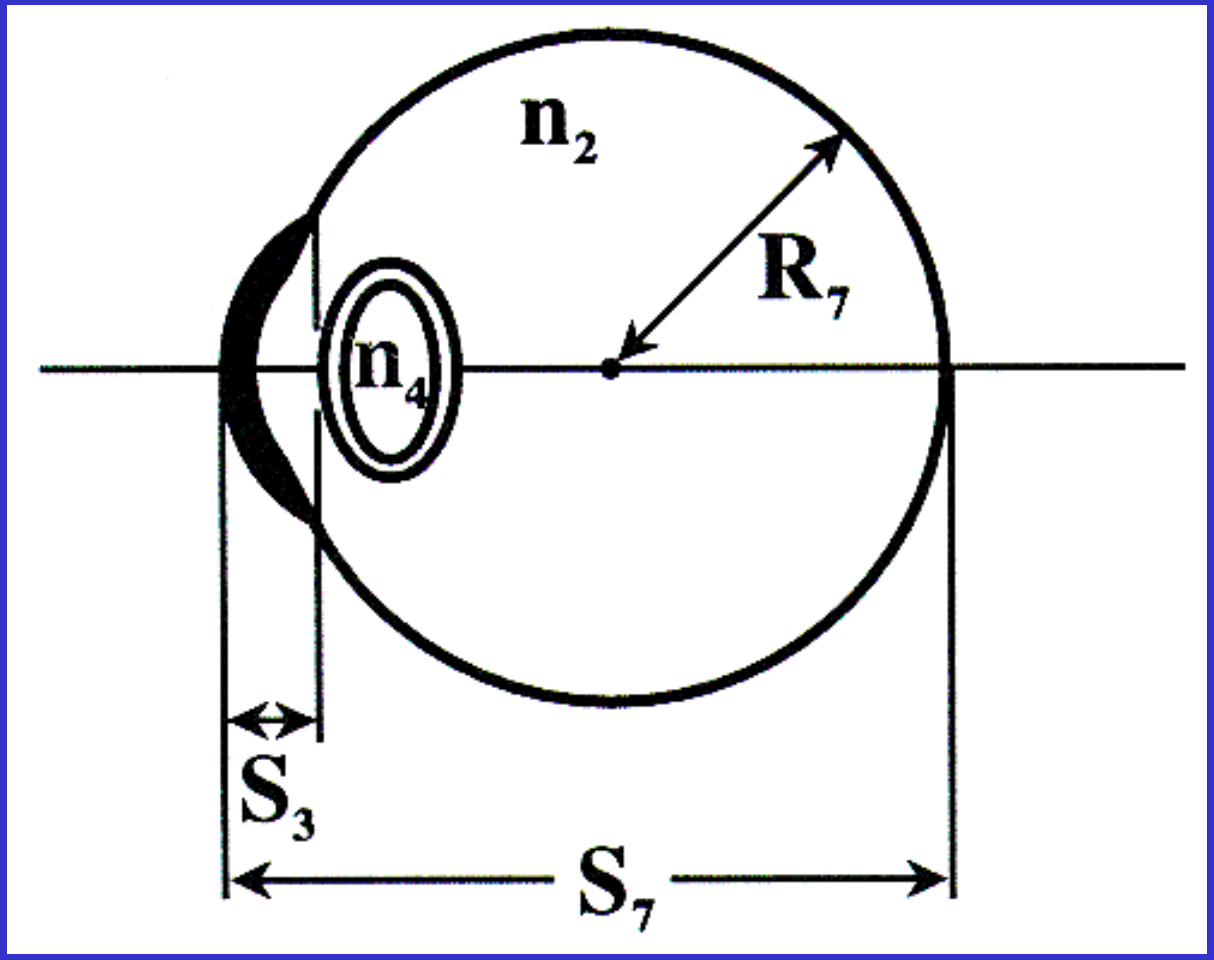
The malfunctioning of only one of these components will impair vision!

Simulation of eye defects (Project *Eyemovie*)

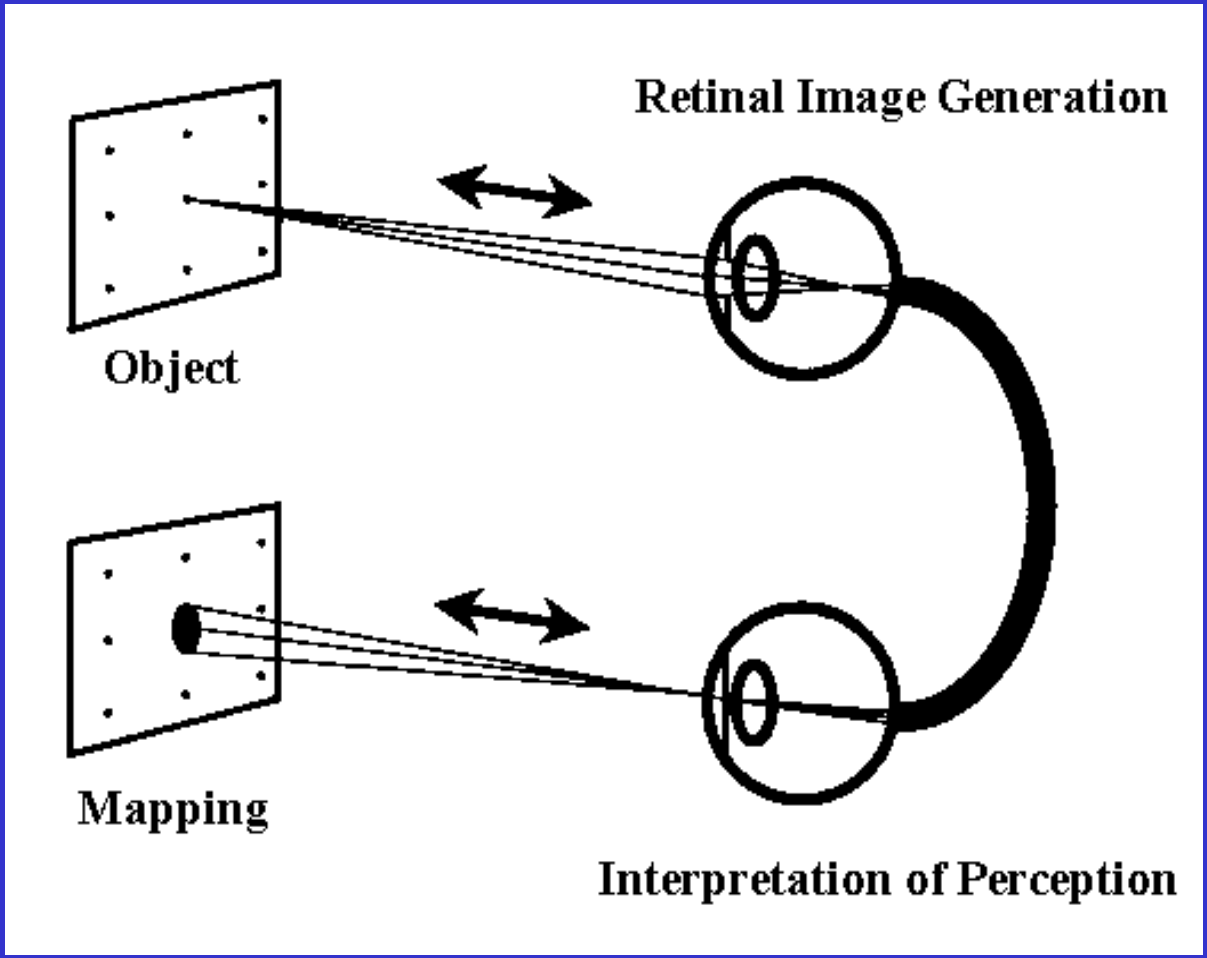
Schematic view of the normal human eye



3D Gullstrand exact schematic eye model (iris added)



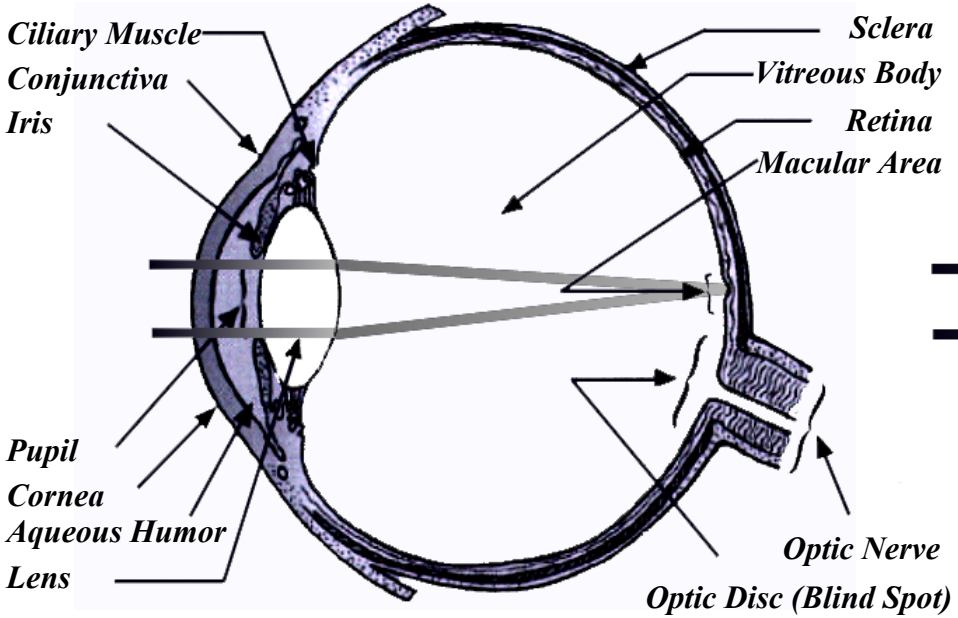
Schematic view of 3D ray tracing technique



Simulated emmetropic visual perception

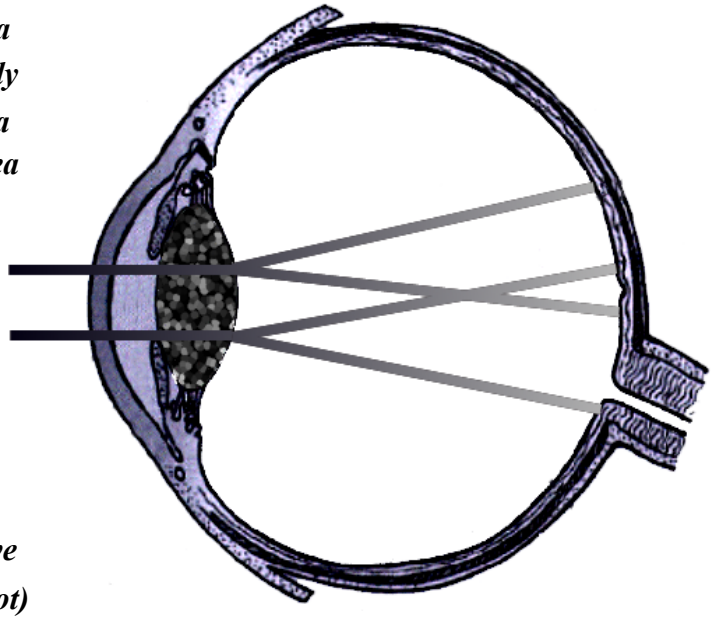
Simulated visual perception under cataract caused by microvacuoles

Schematic view of the normal human eye



In the normal eye, light enters through the lens and is focused on the retina.

Schematic view of eye with cataract

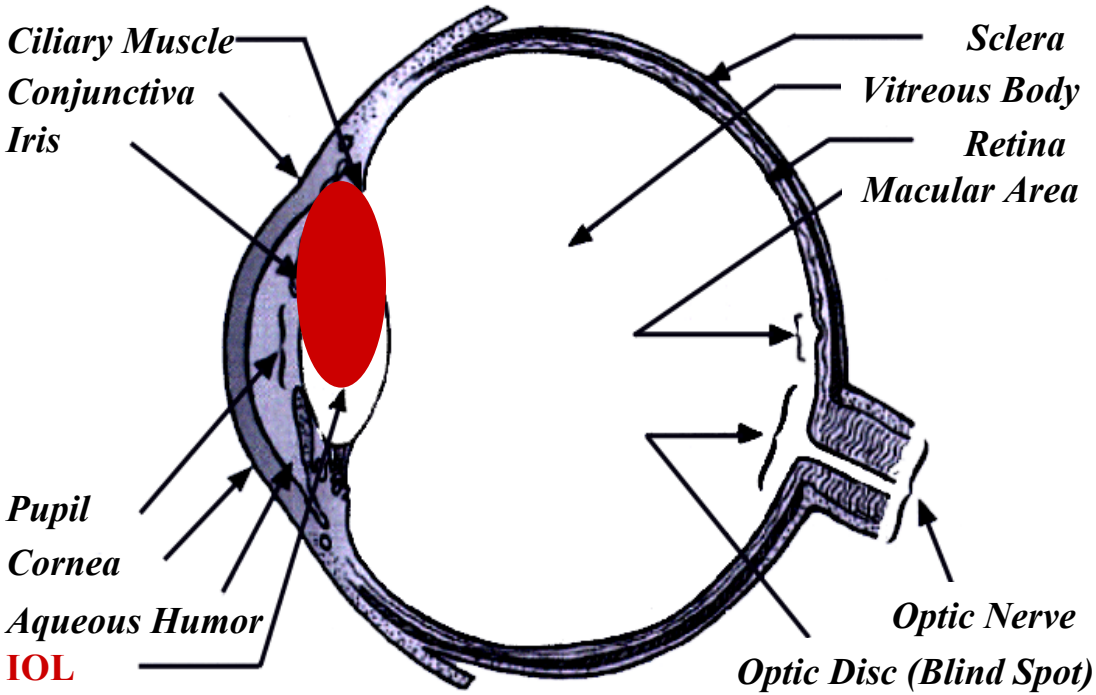


A cataract clouds the lens, preventing light from being focused properly on the retina.

Simulated visual perception under cataract caused by microvacuoles

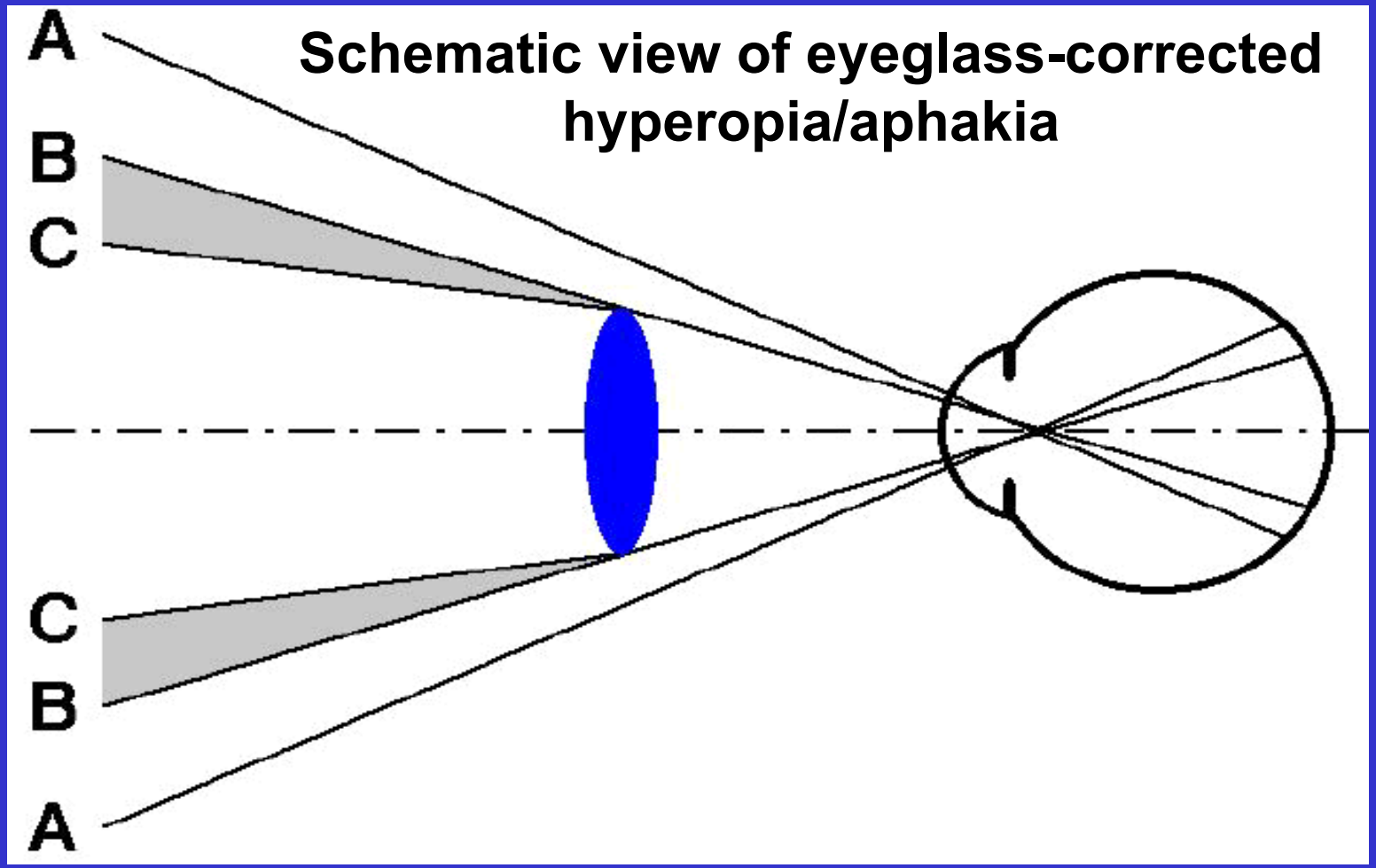
Simulated visual perception (diplopia) through a vertically dislocated IOL after cataract surgery

Schematic view of a vertically dislocated IOL

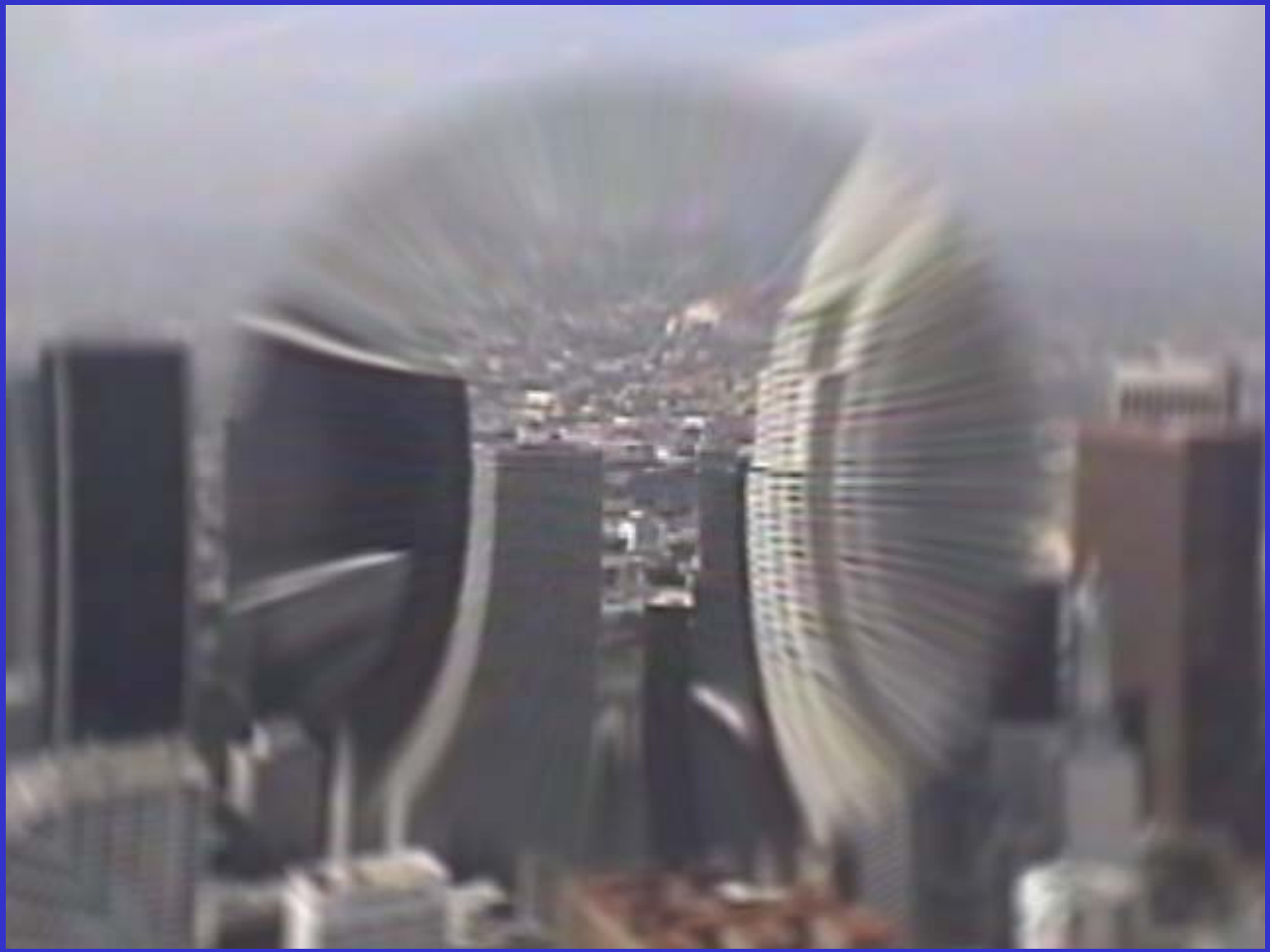


Simulated visual perception (diplopia) through a vertically dislocated IOL after cataract surgery

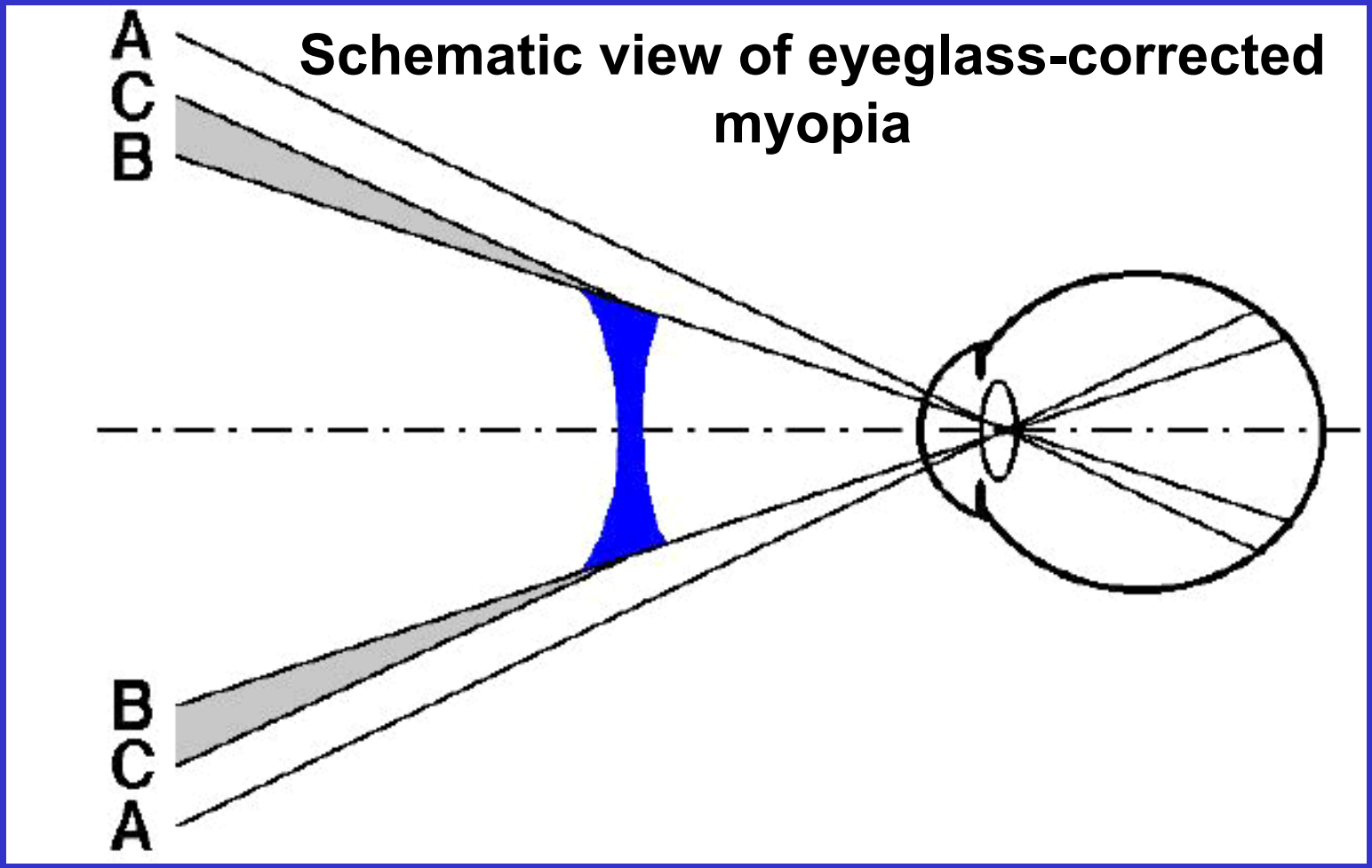
Simulated visual perception (annular scotoma) under eyeglass-corrected hyperopia/aphakia



Simulated visual perception (annular scotoma) under eyeglass-corrected hyperopia/aphakia



Simulated visual perception (diplopia) under eyeglass-corrected myopia

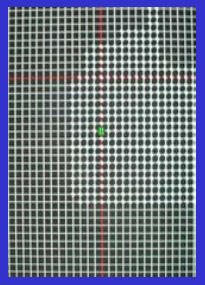


Simulated visual perception (diplopia) under eyeglass-corrected myopia

Robotic Eye Doctor (3D Amsler Grid test)

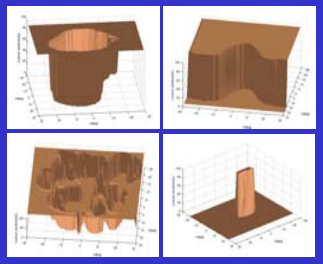
Purpose & Visions

Touchsensitive Examination Screen



Examination Software

Examination Results in 3D

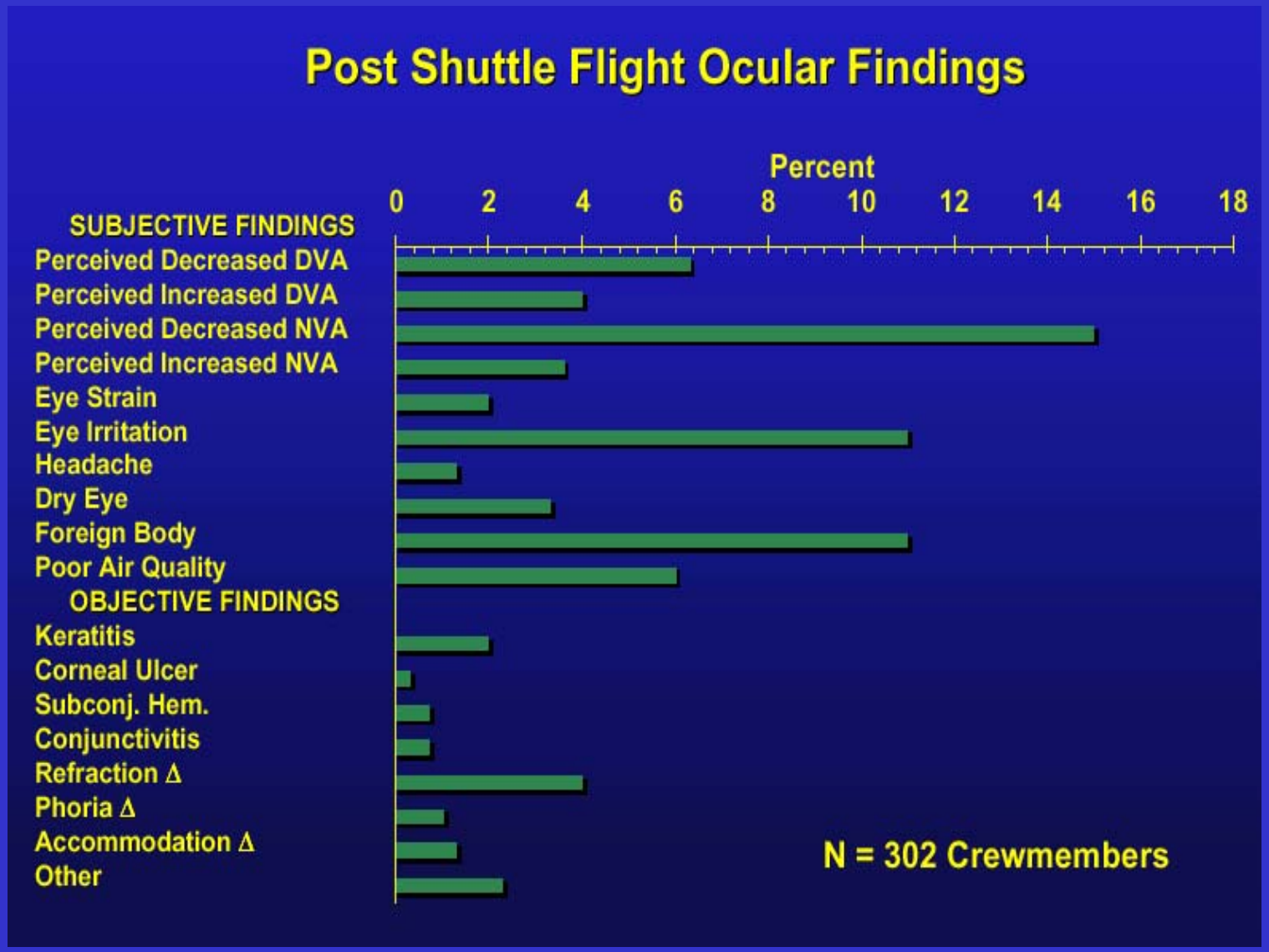


Database Analysis Diagnosis

Deployment

Vision

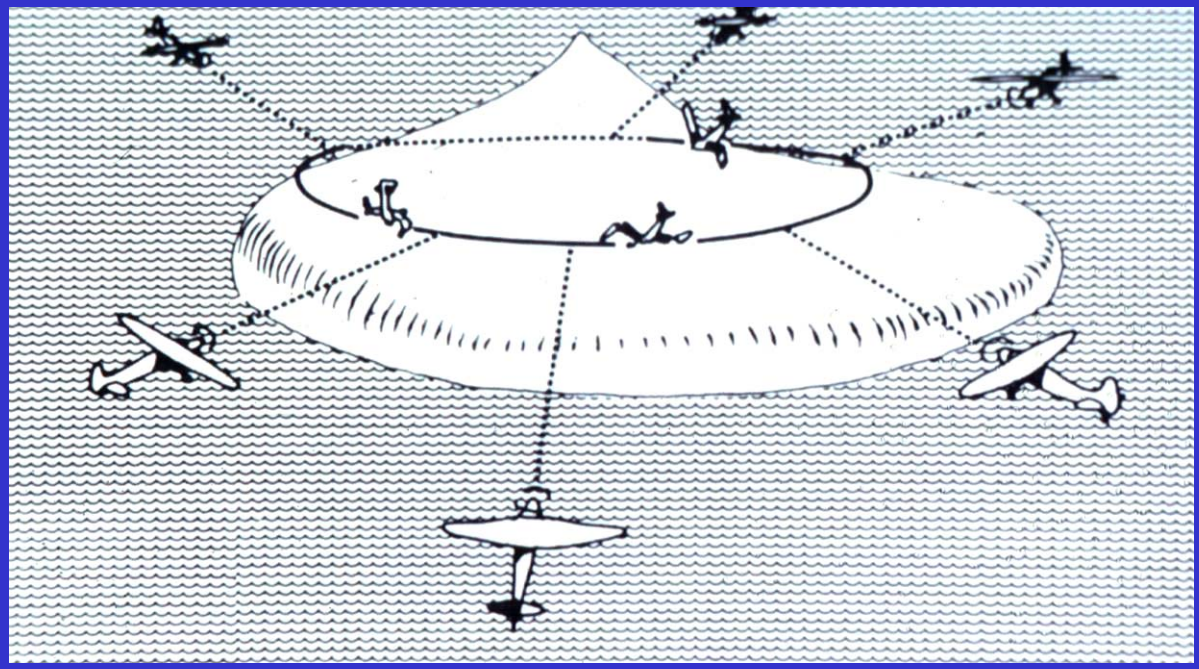
Ocular Conditions
in the Operative Environment of Space Flight



Ocular Conditions
in the Operative Environment of Space Flight

Description	ICD-9 Code	# of Diagnoses
Cataract	366.9	23
Diabetes, Background Ret.	362.01	0
Drusen, Retina	362.57	5
Glaucoma	365.9	2
Hypertension, Ocular GLAUCOMA SUSPECT	365.04	16 8
Macular Degeneration	362.50	2
Macular Hole	362.54	1
Retinal Defect without Detach.	361.3	11
Retinal Degeneration	362.60 to 362.63	3
Retinal Hemorrhage	362.81	0
Retinopathy – Hypertensive	362.11	1
Retinoschisis	361.10	0
Vitreous Floaters	379.24	2

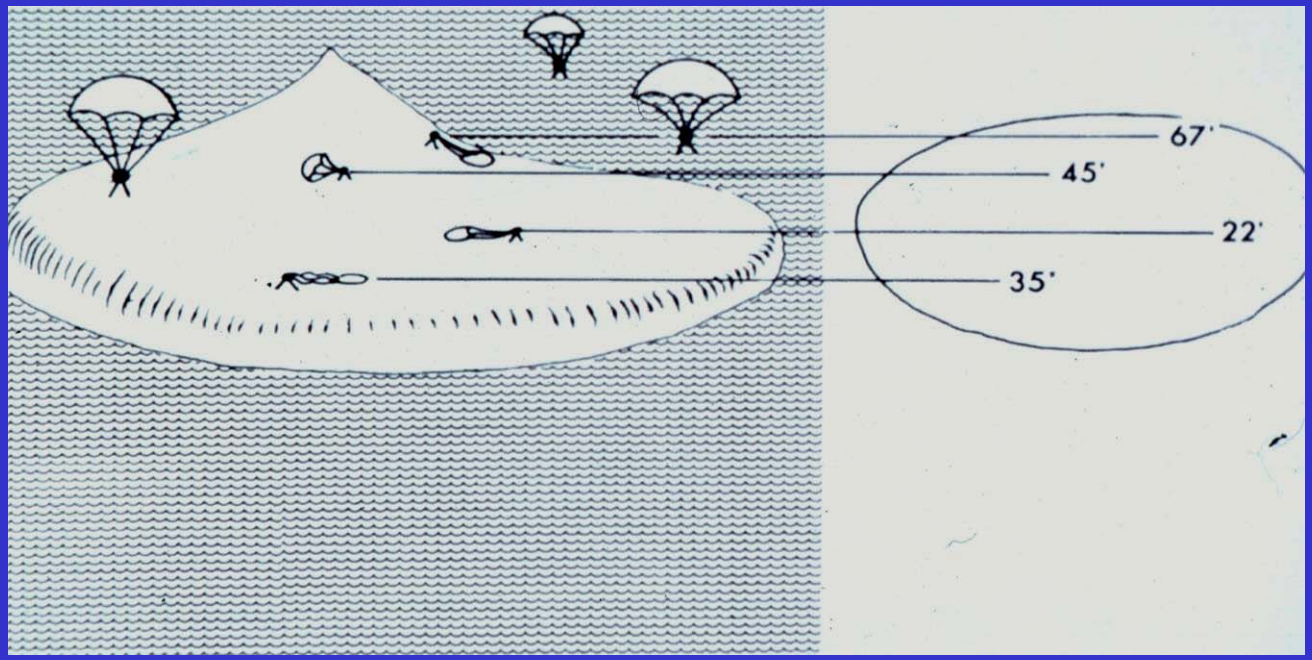
Background: Perimetry



PRO: precise info about visual field circumference

CON: no info about visual field interior

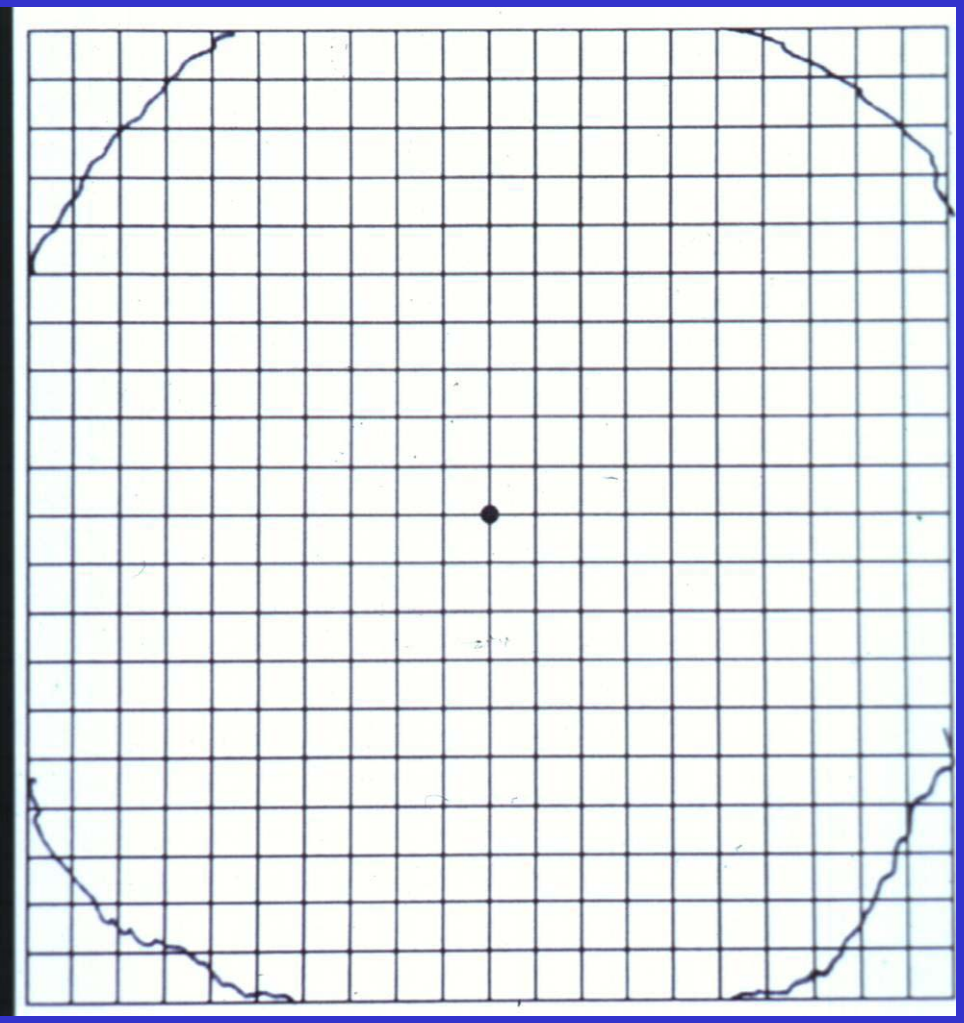
Background: Campimetry



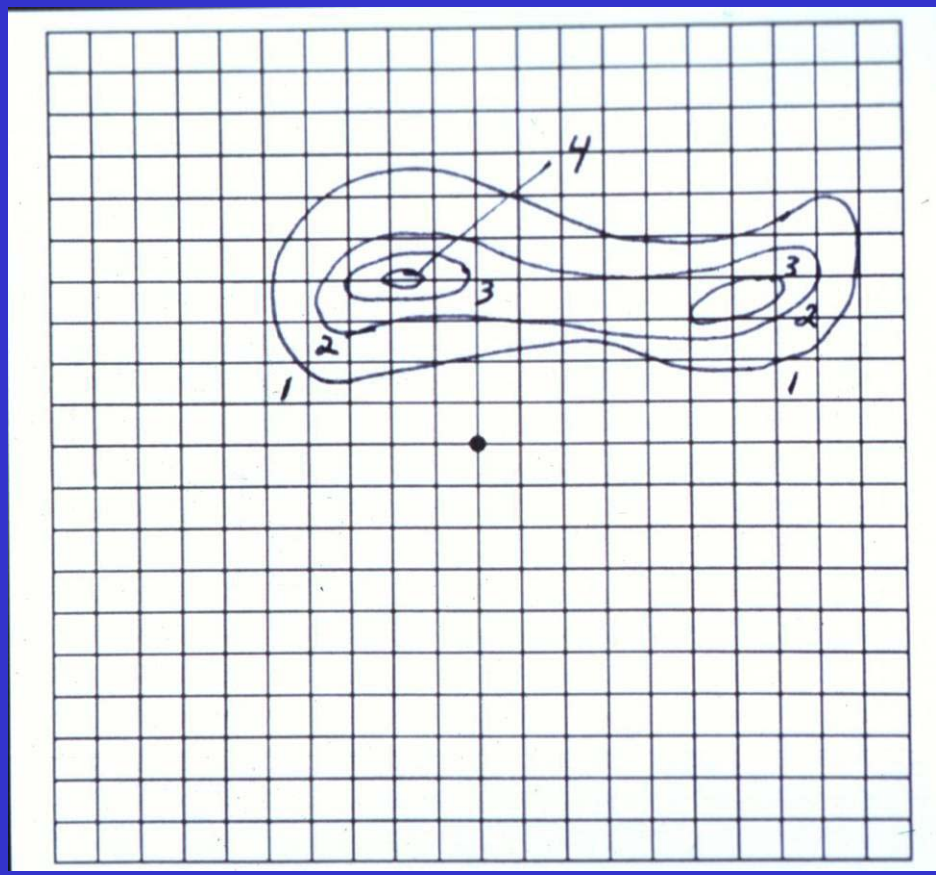
PRO: precise info about visual field interior

CON: no info about visual field perimeter; spot checks only

Background: Amsler Grid Testing



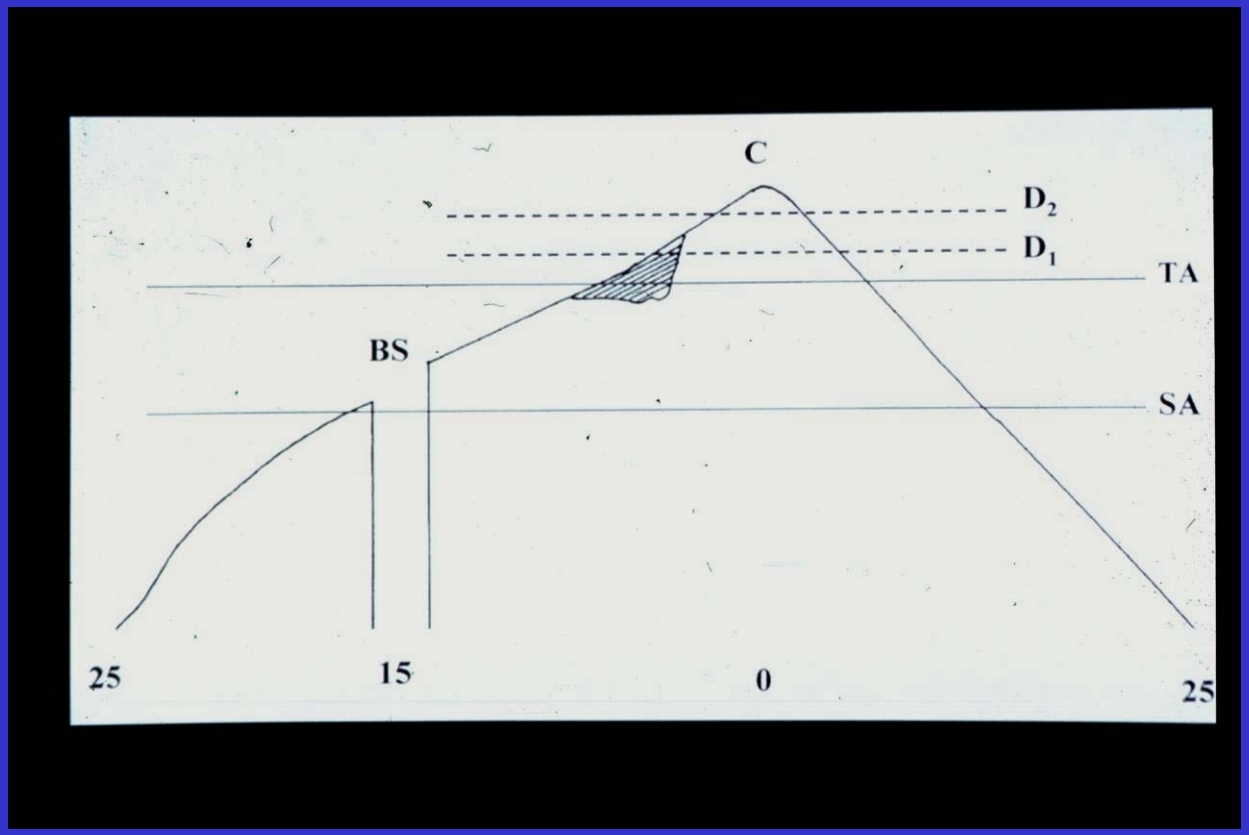
Solution: present grid at *varied* contrast



PRO: precise info about visual field perimeter & interior

CON: only one grid contrast

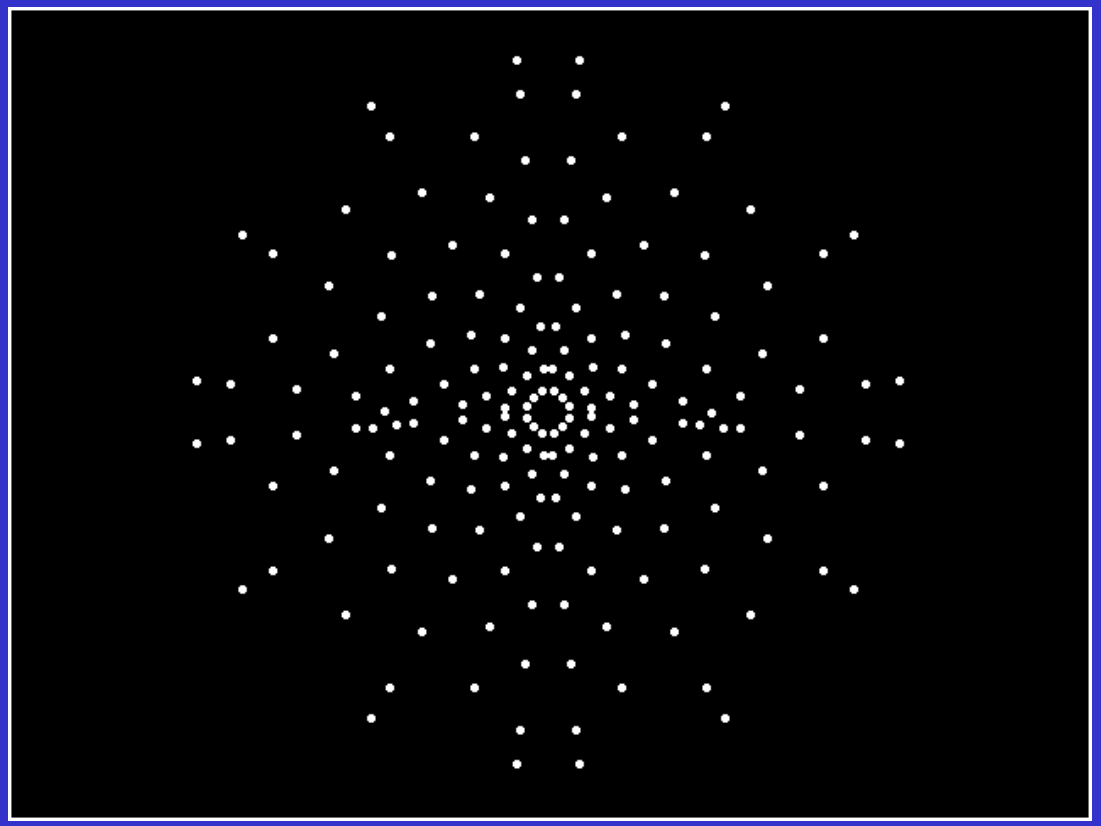
Background: Island-of-Vision/ Hill-of-Vision



State-of-the-art
Standard Automated Perimetry

Perimeter

Arrangement of Point Stimuli

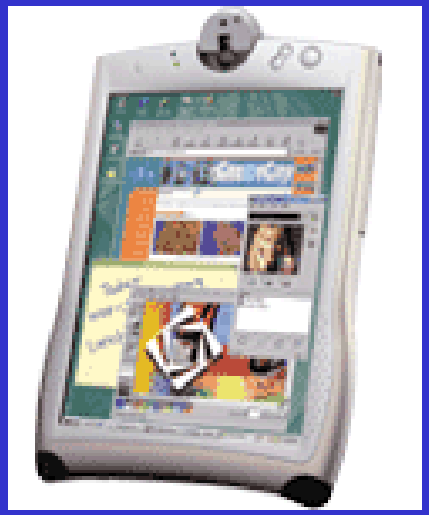


CON: Examination time up to tens (40) of minutes, strenuous!

Examination via Touchscreen Technology

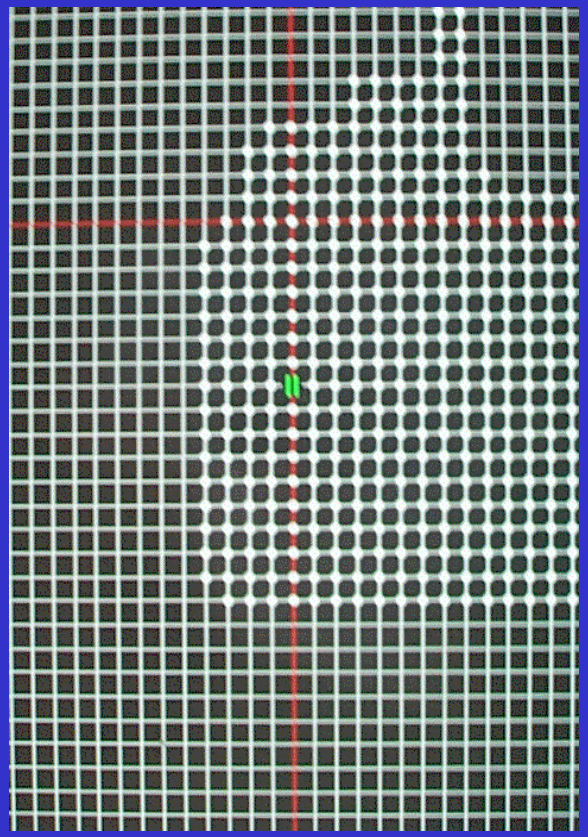
3D Computer-Automated Threshold Amsler Grid Test

Touchsensitive TFT-panels

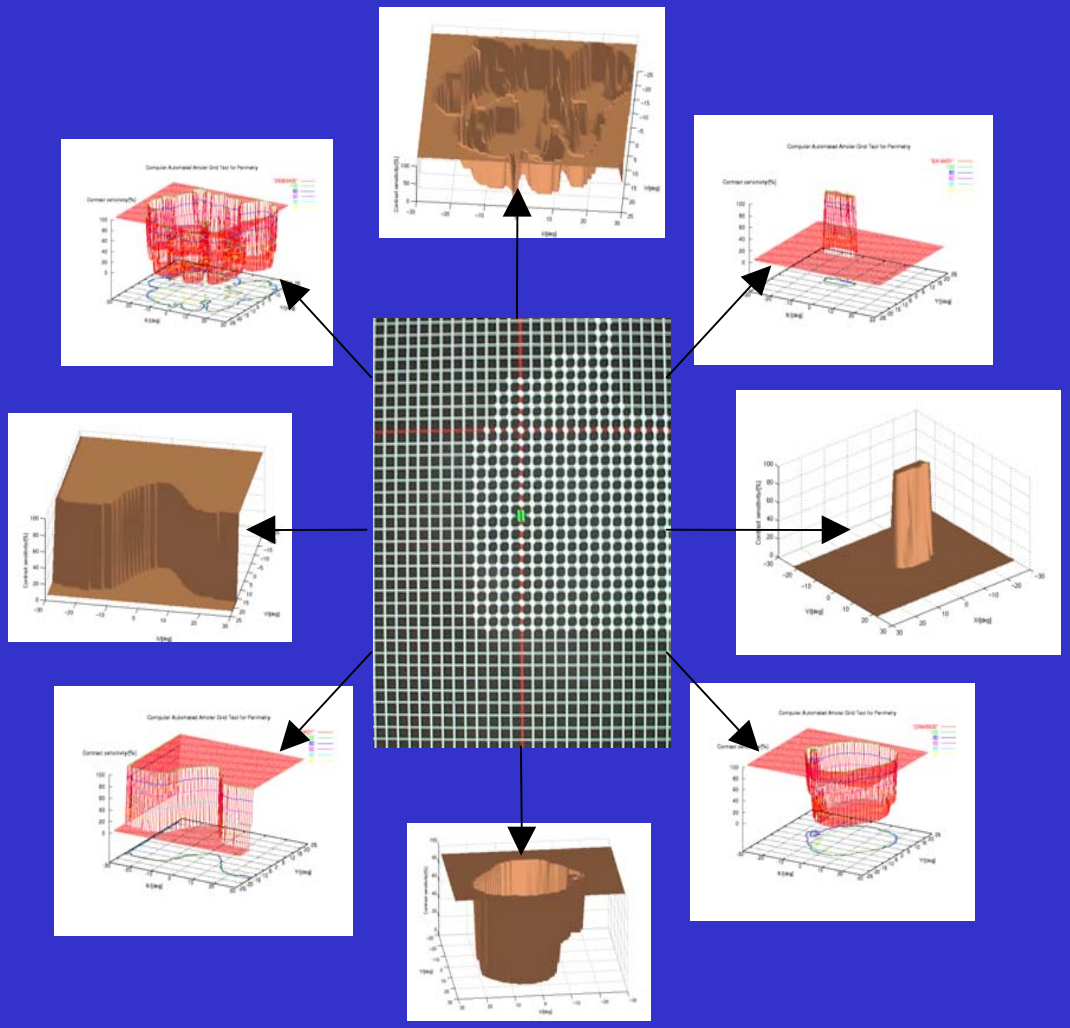


or

Touchsensitive Monitors



Advantages of
3D Computer-Based Threshold Amsler Grid Test



Major Advantages:

Non-invasive

Easy & Quick (4-5 min per eye)

High Spatial Resolution & Accuracy
(typically 1 °, down to 15 ‘)

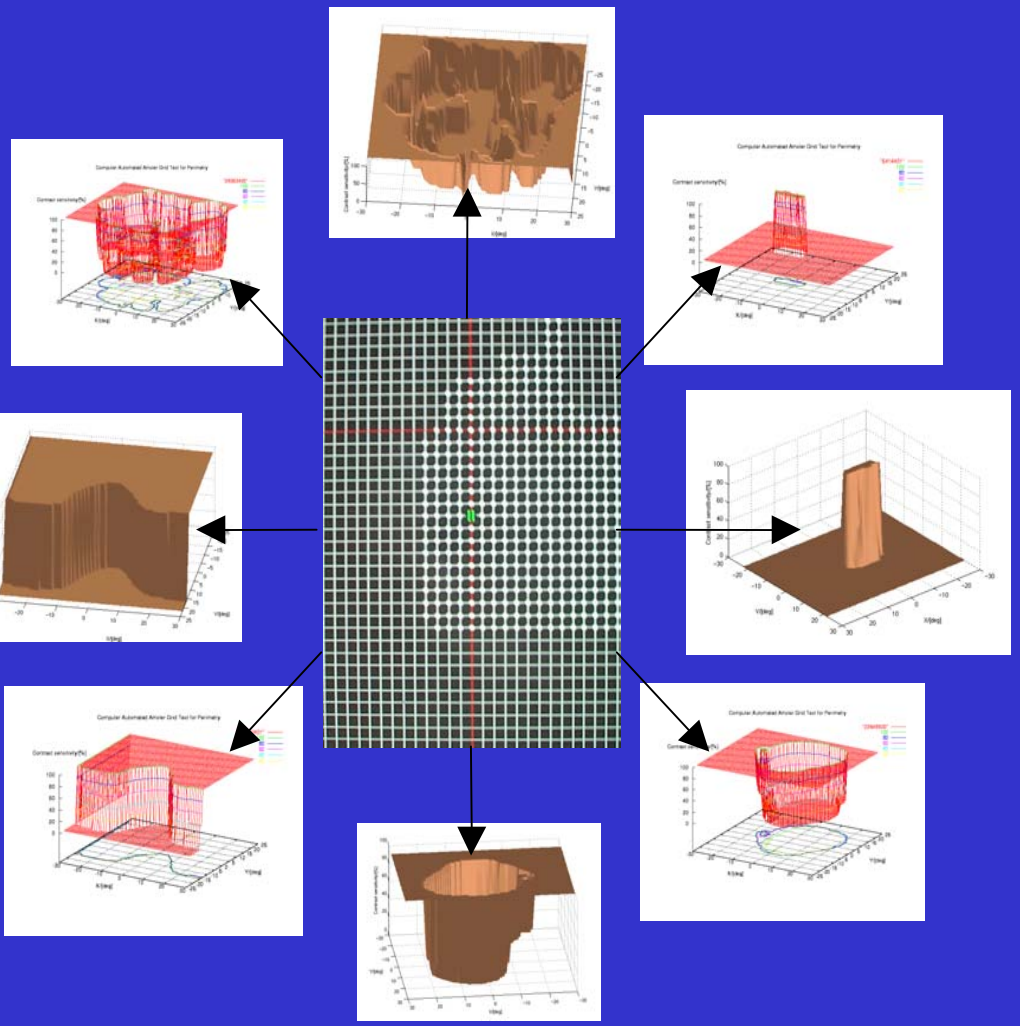
3D Structure of Visual Field Defects
e.g.: location, depth, shape, extent,
and slope information

No additional Payload (NASA)

Now available on the Internet

Further Information on the 3D Visual Field Test:
http://www.wfbabcom5.com/wf335.htm

3D Computer-Automated Threshold Amsler Grid Test



Devised by *Fink & Sadun* in 2000

Recent Publicity in Press & Audio-Visual Media:

CNN Headline News
NASA TV
KCAL
KCET "Life & Times Tonight"
TechTV
National Geographic
Reuters
NSF Press Release
NSF News Highlights
Caltech Press Release
JPL Media Release
JPL website
USC News "USC Today"
USC "HSC Weekly"
USC "Trojan Family Magazine"
USC "USC Health Magazine"
Spiegel Online
Informationweek
SpaceDaily
SPACE.com
Spinoff Technologies
Aerotech News and Review
Federal Telemedicine News
GeoCities
MacNow Magazine
Science News Network
PITSCO The Cause

Caltech patents pending!

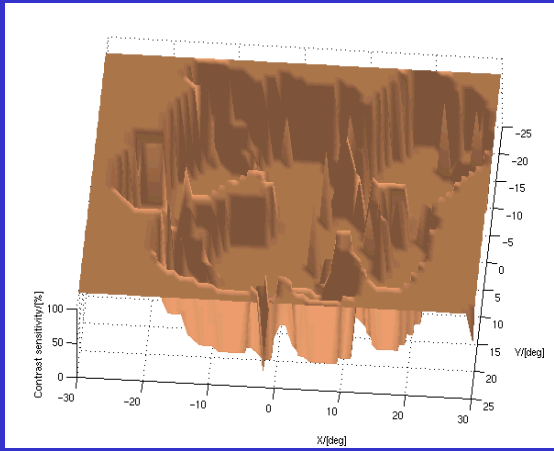
Further Information on the 3D Visual Field Test:

http://www.wfbabcom5.com/wf335.htm

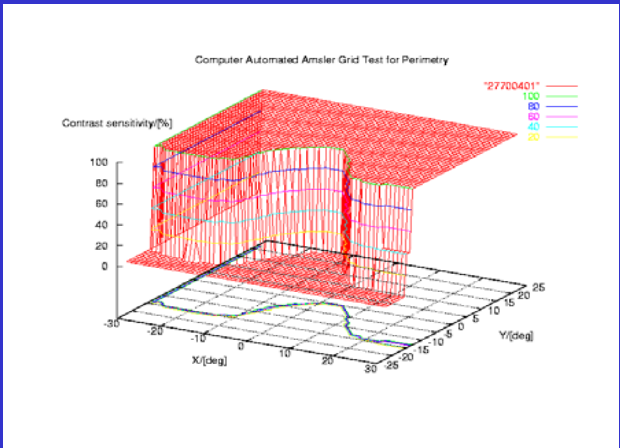
Dr. Wolfgang Fink

Clinical Pilot Studies Conducted

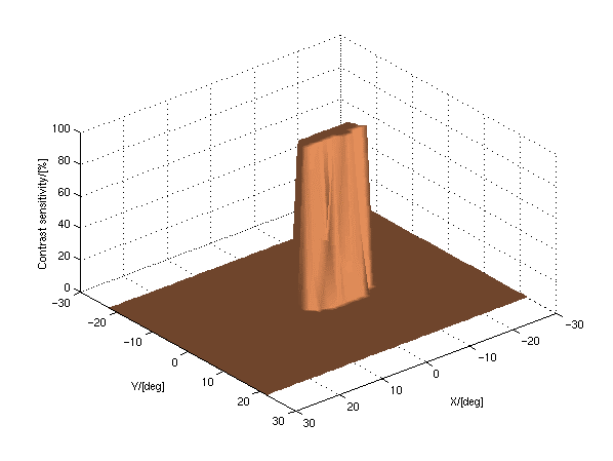
Optic Neuritis



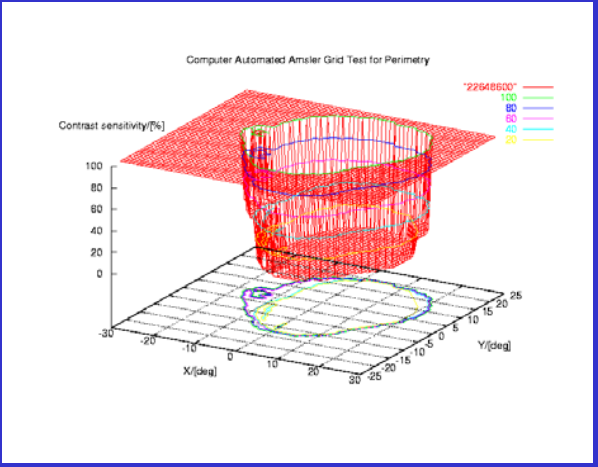
Anterior Ischemic Optic Neuropathy (AION)



Glaucoma

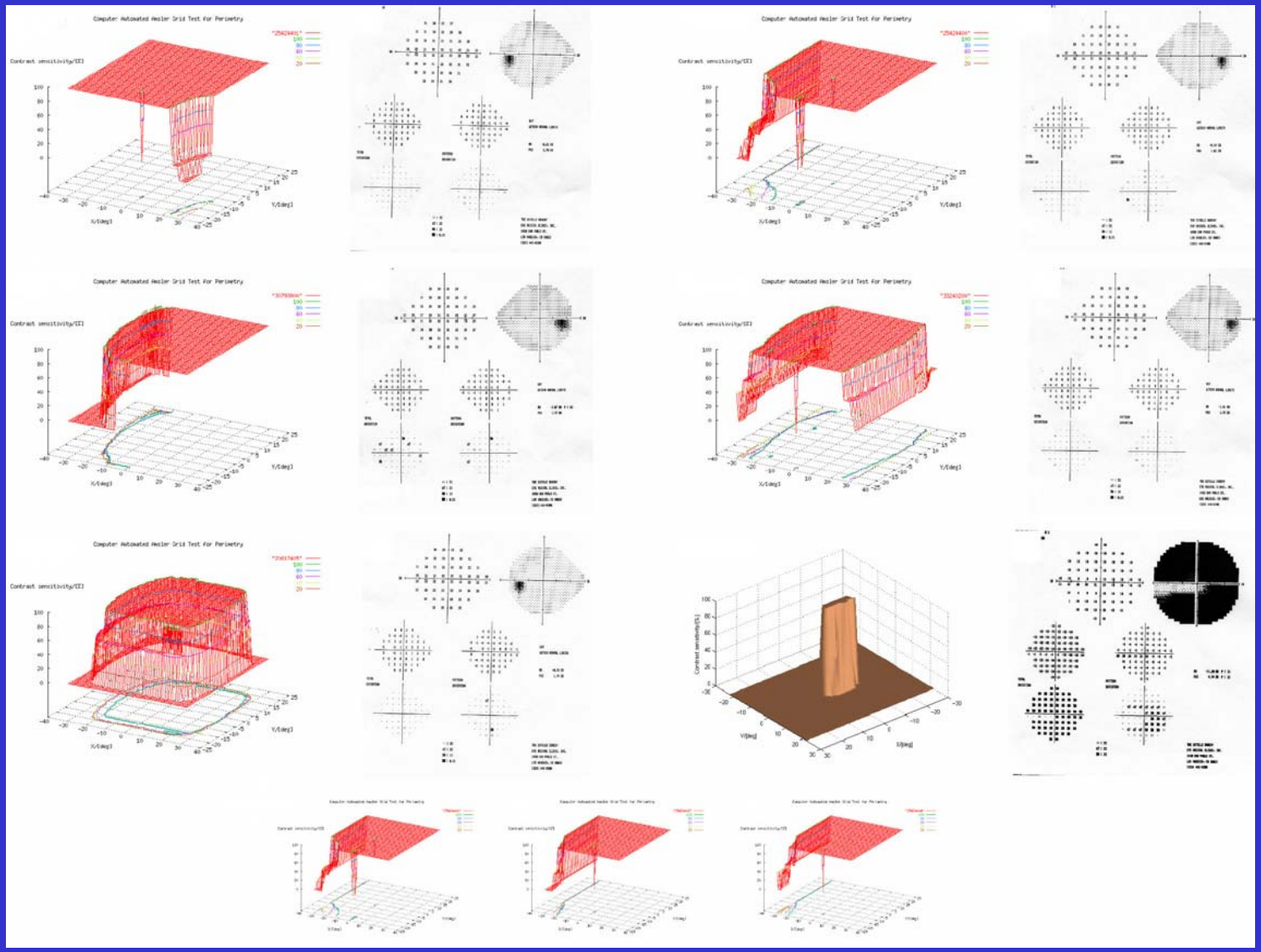


ARMD: “dry” vs. “wet”

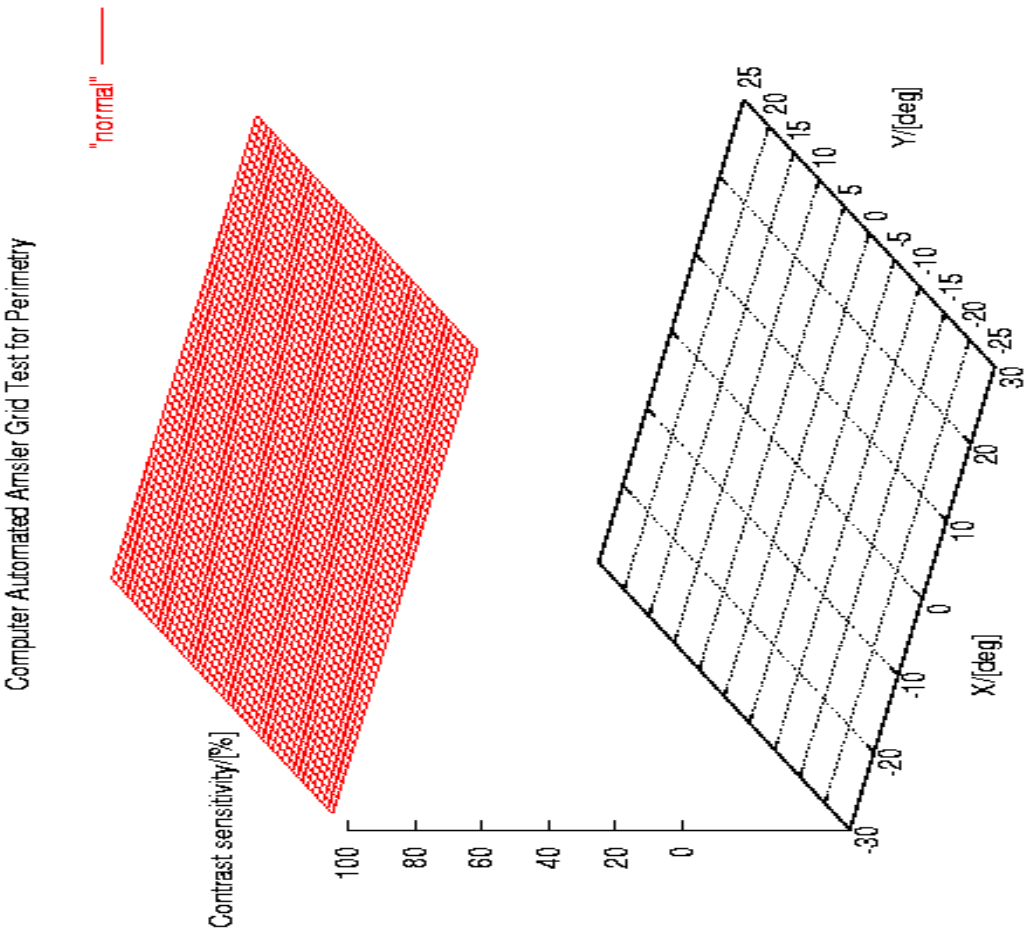


Clinical Pilot Studies Conducted

Glaucoma Suspects

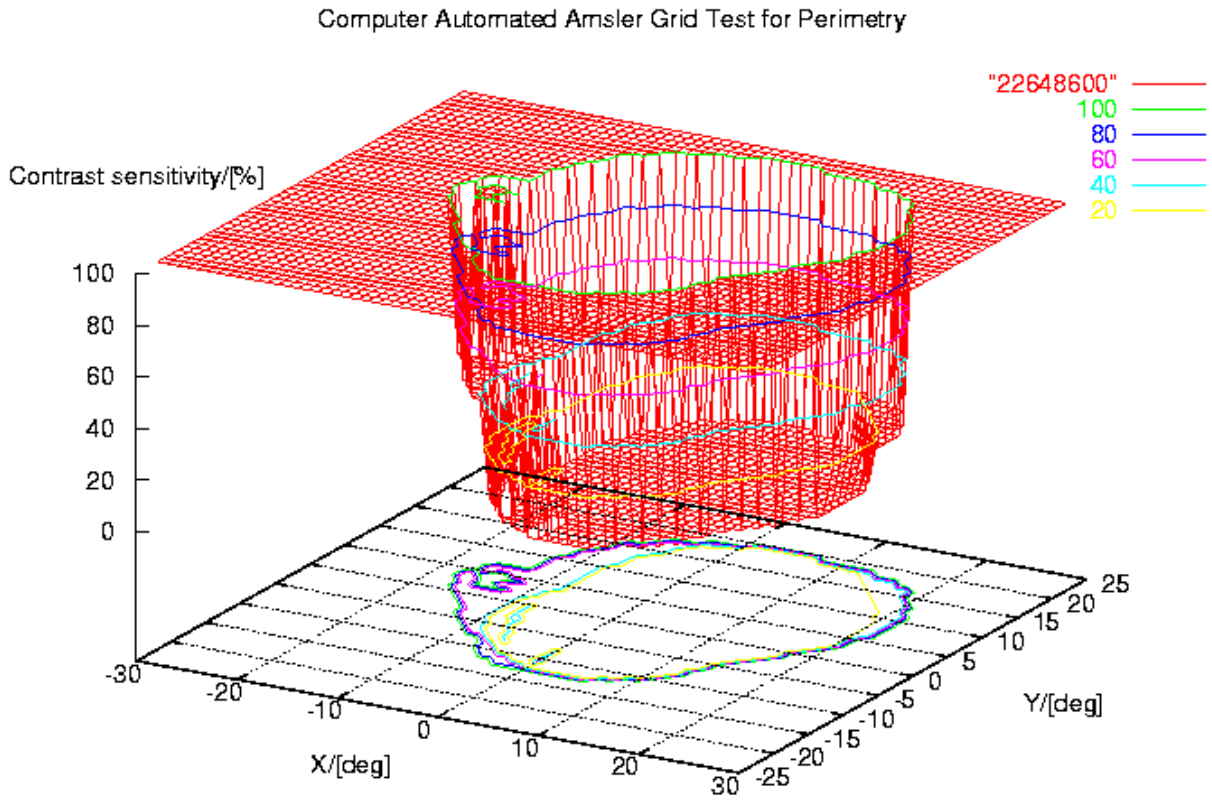


Example Examination Result



NORMAL

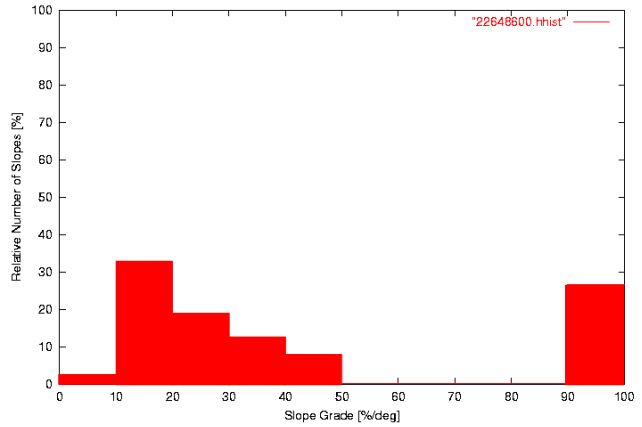
Example Examination Result



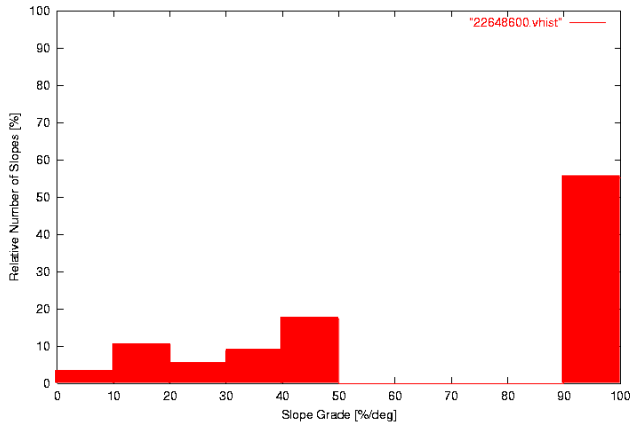
ARMD

Example Analytical Analyses

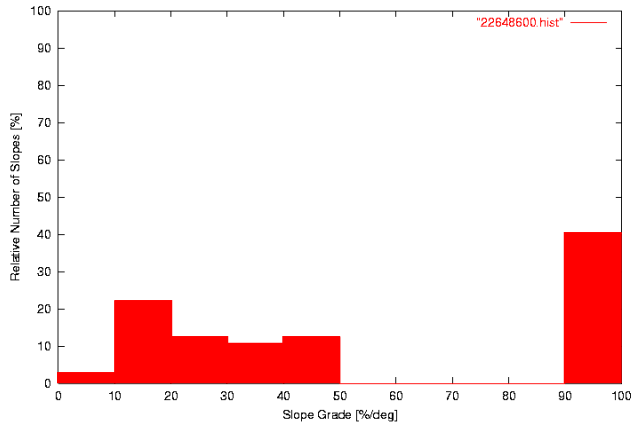
Histogram of Horizontal Slopes



Histogram of Vertical Slopes



Histogram of Horizontal & Vertical Slopes



VF Area at Contrast Sensitivity 0%	685 deg^2
VF Area at Contrast Sensitivity 20%	44 deg^2
VF Area at Contrast Sensitivity 40%	131 deg^2
VF Area at Contrast Sensitivity 60%	11 deg^2
VF Area at Contrast Sensitivity 100%	1874 deg^2
Total Visual Field (VF) Area tested	2745 deg^2
Hill-of-Vision Volume lost	29.26 %
Average Value of *horizontal* Slopes	45±35%/deg
Average Value of *vertical* Slopes	70±35%/deg
Average Value of *all* Slopes	57±37%/deg

Database + Analysis

Patient examination data retrieval

Database of *shapes* and *slopes* of 3D structure of visual field defects

Identification of *signature patterns* for various ophthalmological and neurological conditions

Development of Autodiagnosis-System

Knowledge extraction from large database of *3D shapes* and *slopes* that are likely to be *signature patterns* for various ophthalmological and neurological conditions

Sophisticated Pattern Recognition Classification Algorithms

using

Analytical Analyses

Neural Networks

Classifier Systems

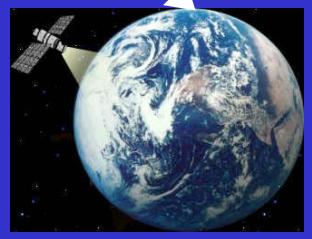
Examination in Space and on Earth

Autonomous (Onboard) Physician

Screening & Monitoring on a frequent and regular basis

Early Detection of various Eye/Brain Diseases

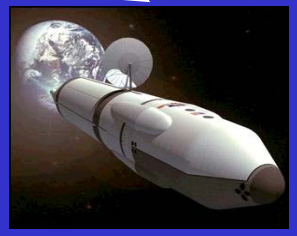
Reduced Astronaut Medical Data Transmission



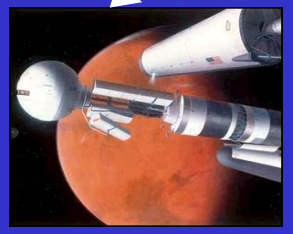
Centralized Worldwide Remote Diagnosis (Telemedicine)

Autonomous Onboard Physician on Shuttle Missions

Autonomous Onboard Physician on ISS



Autonomous Onboard Physician on Trip to Mars

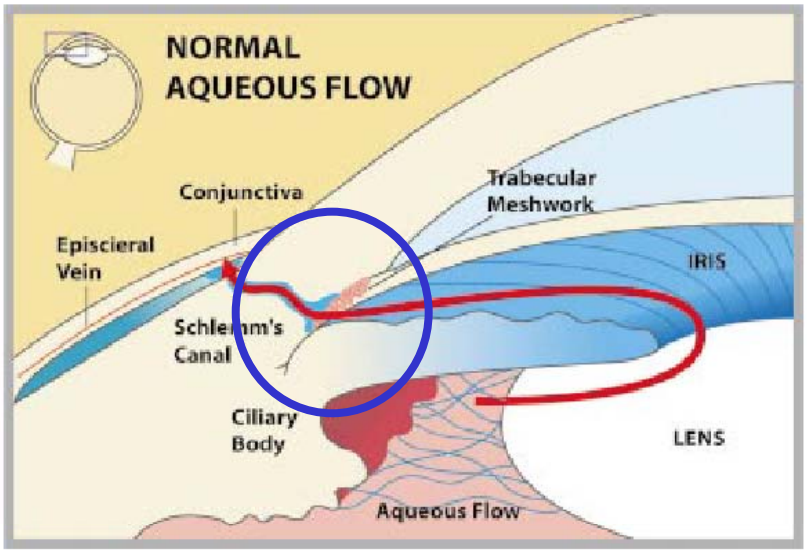


Autonomous Onboard Physician on Trip to Jovian Moons

Wireless Intraocular Pressure Sensor (WIPS)

”Definition” of Glaucoma

Exhibit 4 ◆ Flow in a Normal Eye

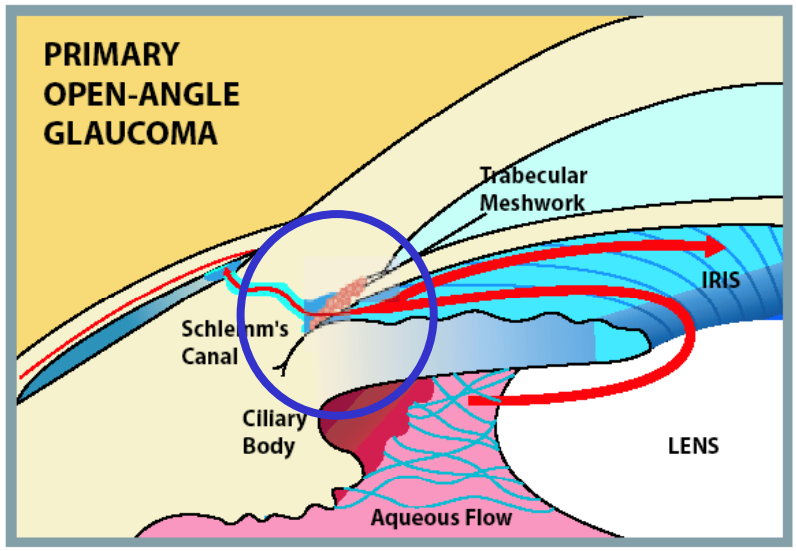


Source: American Academy of Ophthalmology and DRW

Normal

Glaucoma

Exhibit 5 ◆ Flow in an Eye with POAG

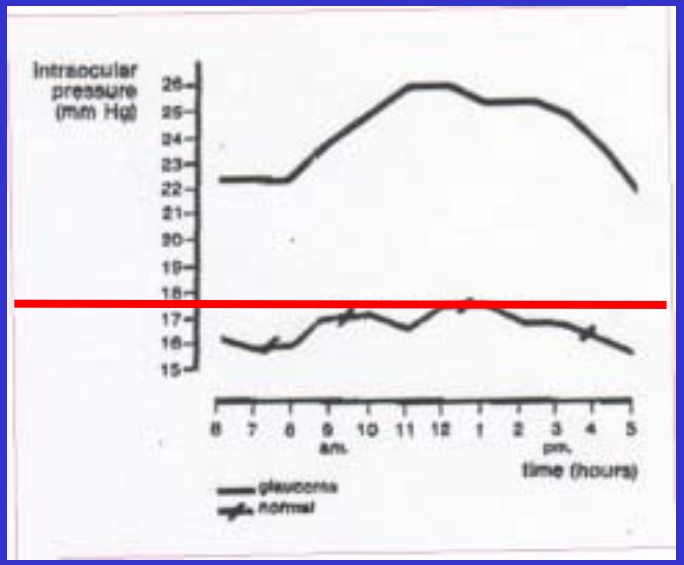


Source: American Academy of Ophthalmology and DRW

Problem in Glaucoma/Glaucoma Therapy

Diurnal Oscillations of Intraocular Pressure (IOP)

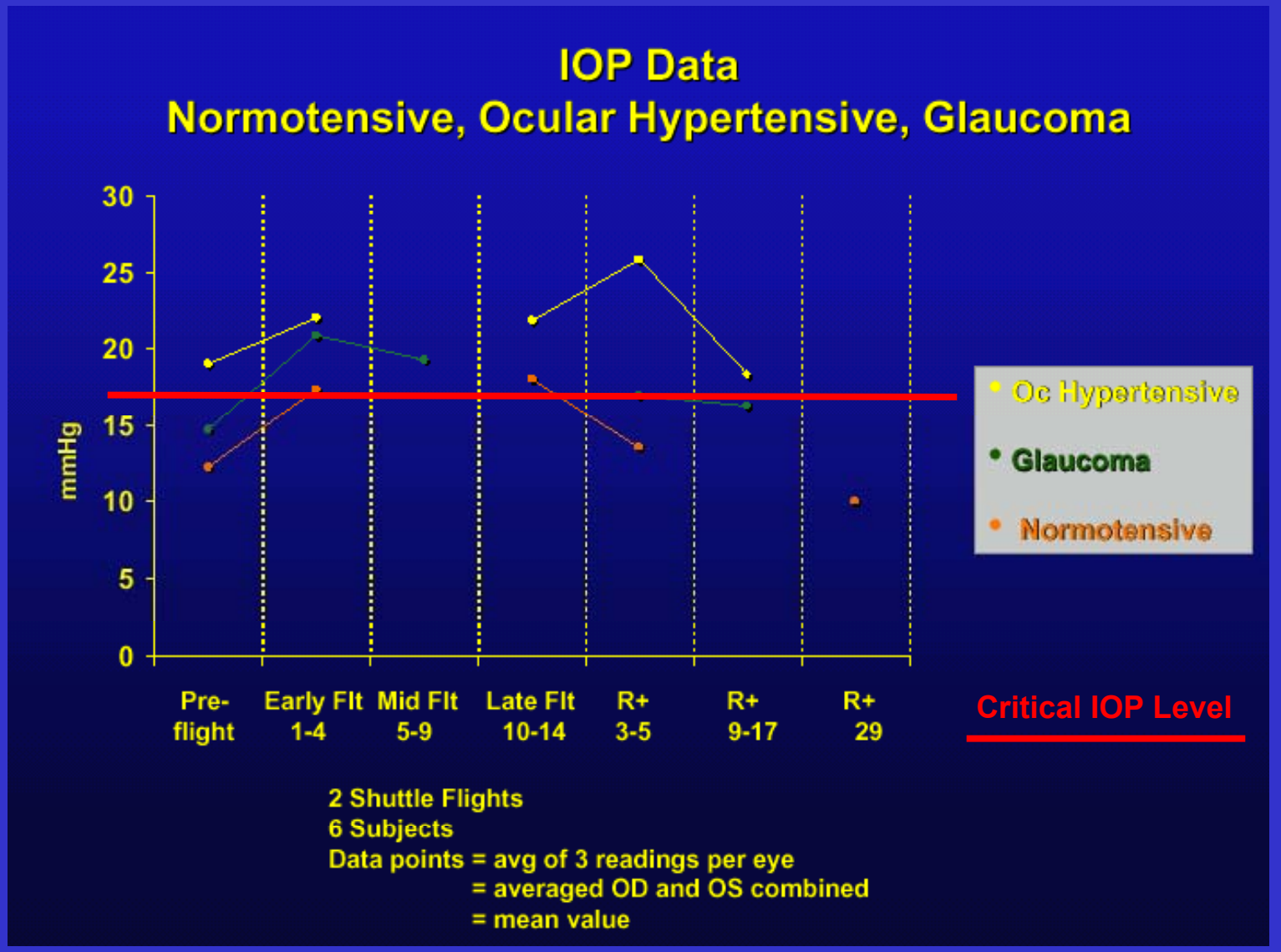
Normal



Glaucoma

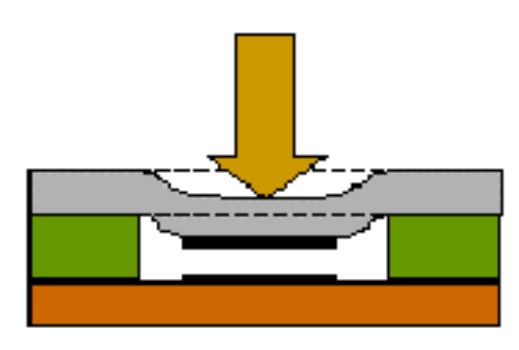
Critical IOP Level

IOP Data from Shuttle Flights

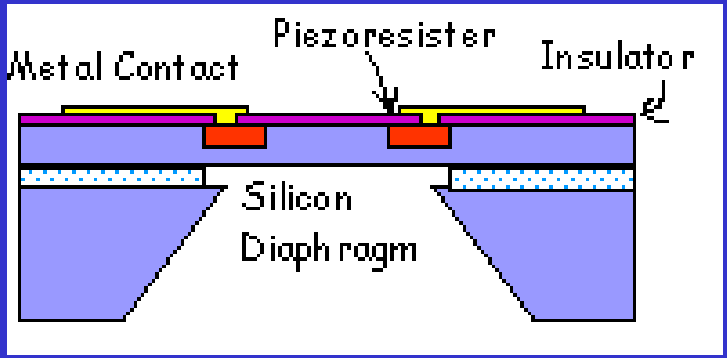


Types of Pressure Sensors

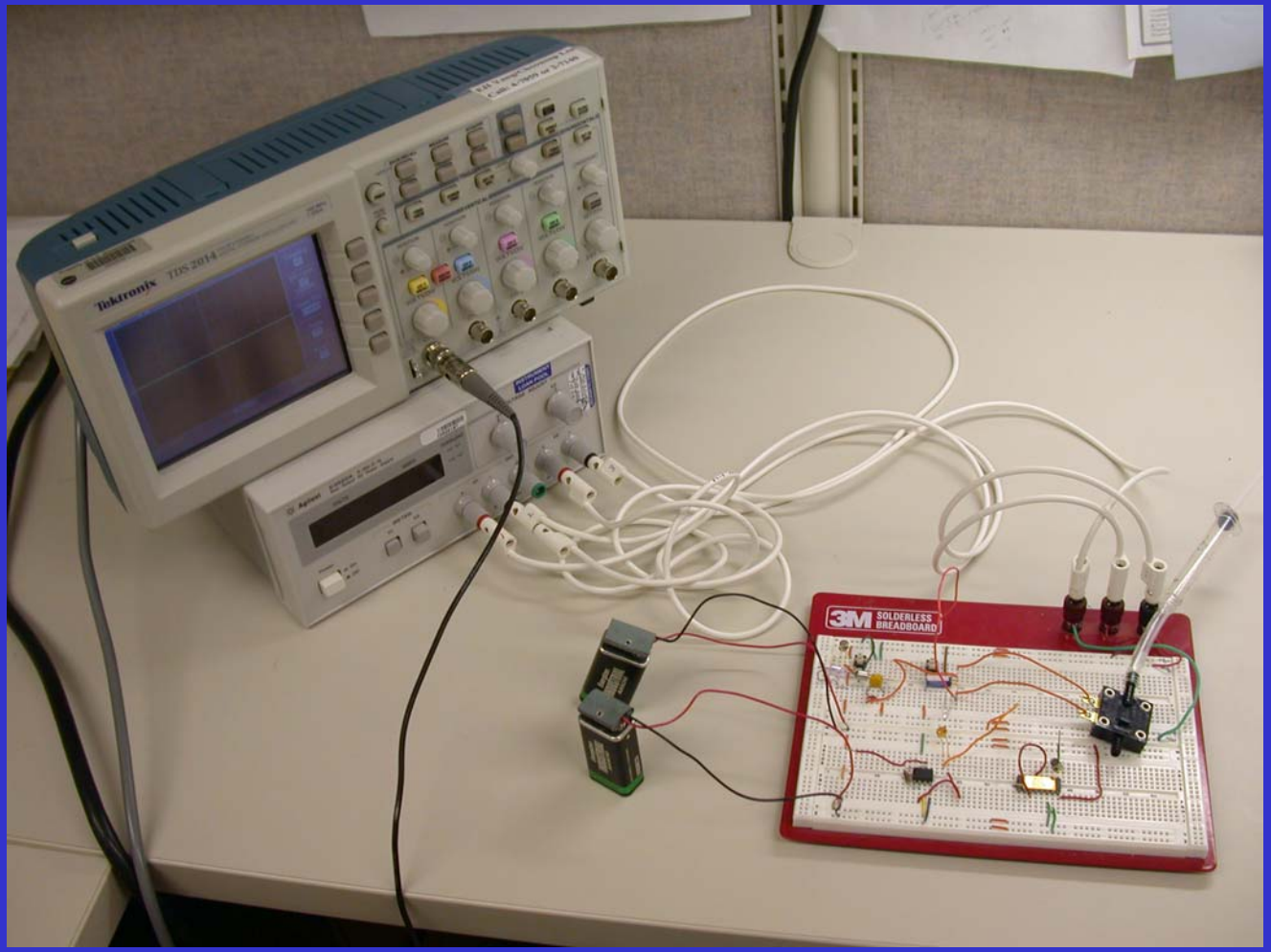
Capacitive Pressure Sensor



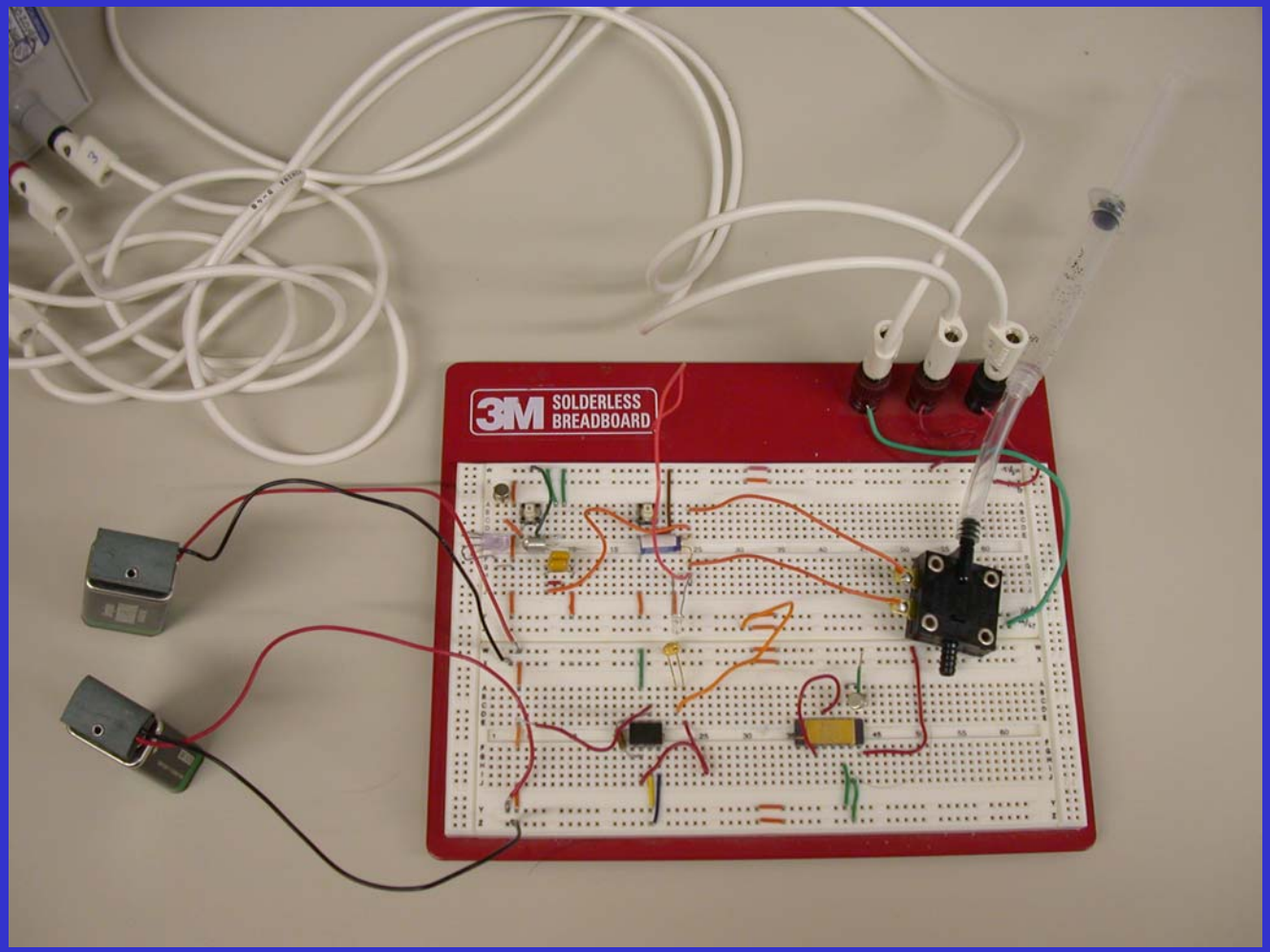
Piezoresistive Pressure Sensor



Wireless Intraocular Pressure Sensor (WIPS)
Testbed



Wireless Intraocular Pressure Sensor (WIPS)
Current Development Status



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Dr. Tim Krabach and Dr. Darrell Jan, 6500

Dr. Thomas George and Dr. EH Yang, Div. 38

Dr. Yoshi Hishinuma and Dr. Choonsup Lee, Div. 38

Dr. Mark Humayun and Dr. Alfredo Sadun, Doheny/USC

Dr. Jonathan Clark, NASA Johnson Space Center

Dominic Mazzoni and Lucas Scharenbroich, Div. 36

Wayne Waller, Leslie Maxfield, Carolyn Patterson, Digital Media Center, Caltech

Dr. Bradley Filippone and John Huber, Kellogg Lab, Caltech

Khorshed Dastoor, Patricia Liggett, and Dr. James Weiss, JPL

Carolina Martinez, JPL

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