A Next Generation High Resolution Adaptive Optics Fundus Imager

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***Kestrel Corporation*:**
A small business focused on spectral, imaging and related optical technologies

Introduction

- First instrument built under a NATO SfP program.
- This is the continuation under the auspices of NIH
- Redesigned instrument
- Same team from Russia and the US

High Resolution Retinal Imaging

- Increase the resolution of retinal imagers to detect pathologies and provide a diagnosis at an earlier stage
  - Vascular abnormalities
  - Drusen
- Provide a “familiar” image interpretation.
  - Not stray too much from the operation of a regular imager
- Package for ease of use and clinical installation
  - Self contained instrument

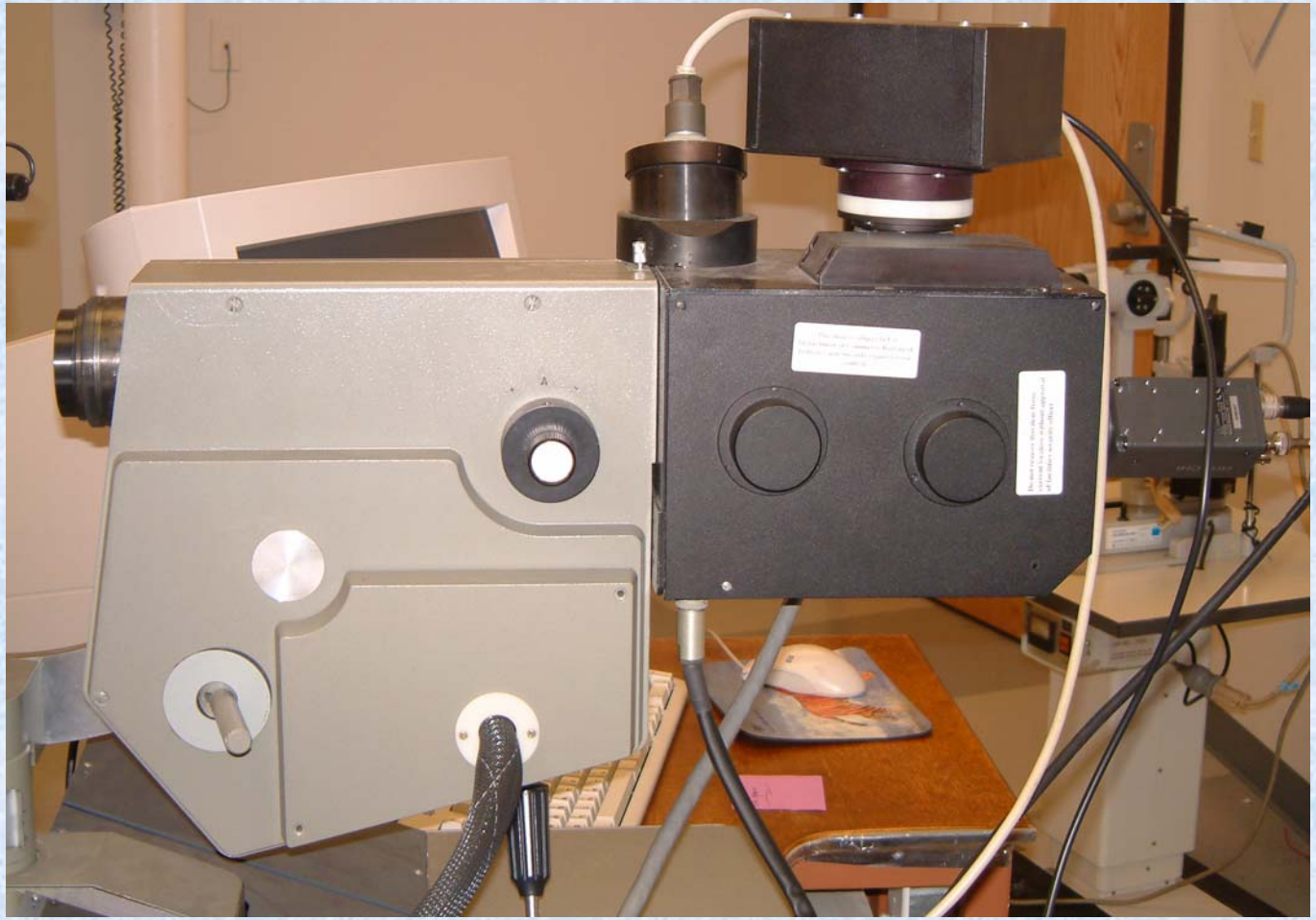
Adaptive Optics

- The resolution is limited to 20-30um due to aberrations in the eye.
- Diffraction limit is about 3um for an optical instrument with a pupil of about 6mm
- An order of magnitude improvement is available
- Eye Aberrations
  - Low order
  - Large amplitude
  - Slow temporal change

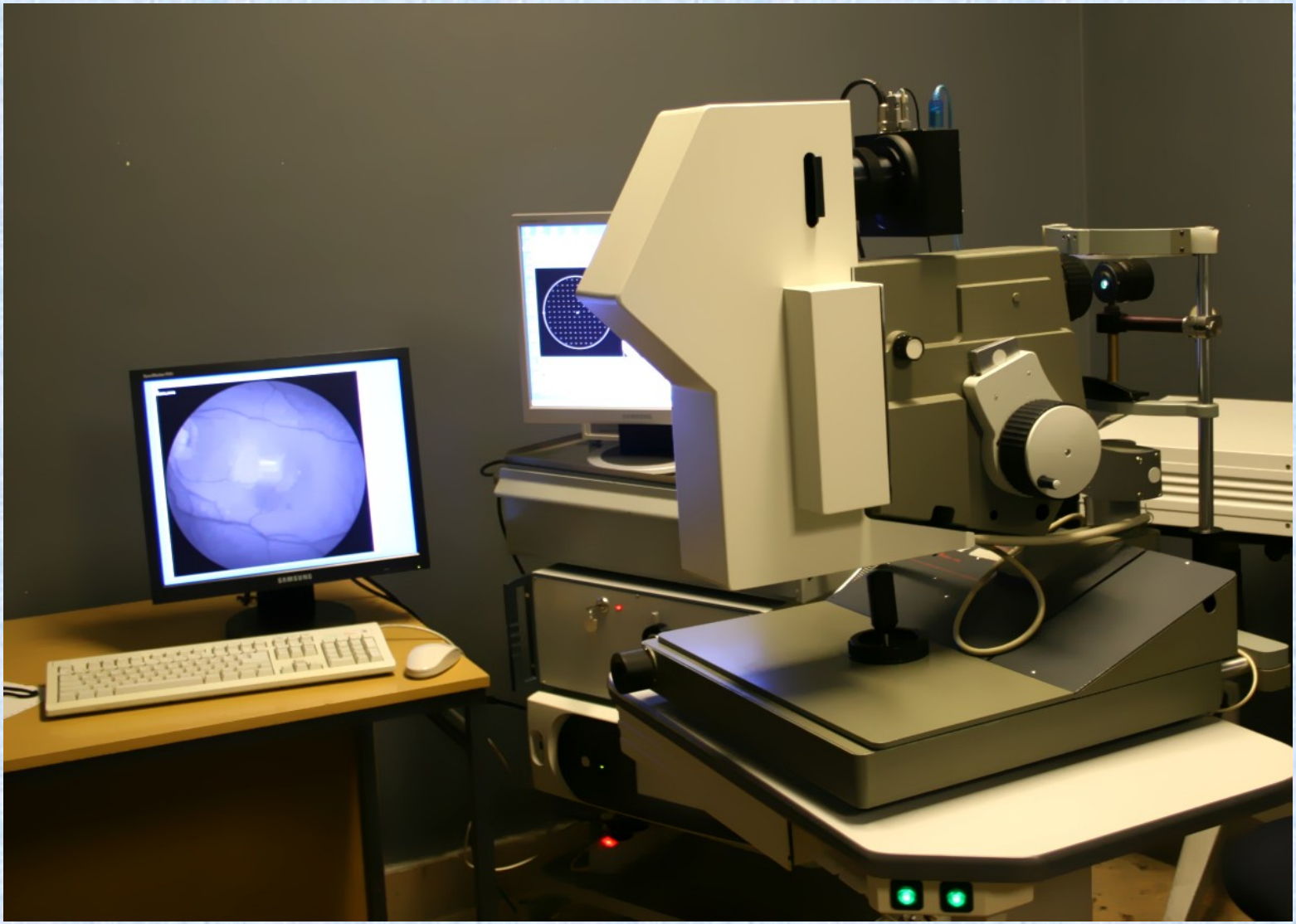
New Vs Old

- Better optical design and layout
- Mechanical integration
- Improvement of the AO close loop response
- Larger stroke mirror for increased dynamic range
- Onboard calibration source
- New user interface

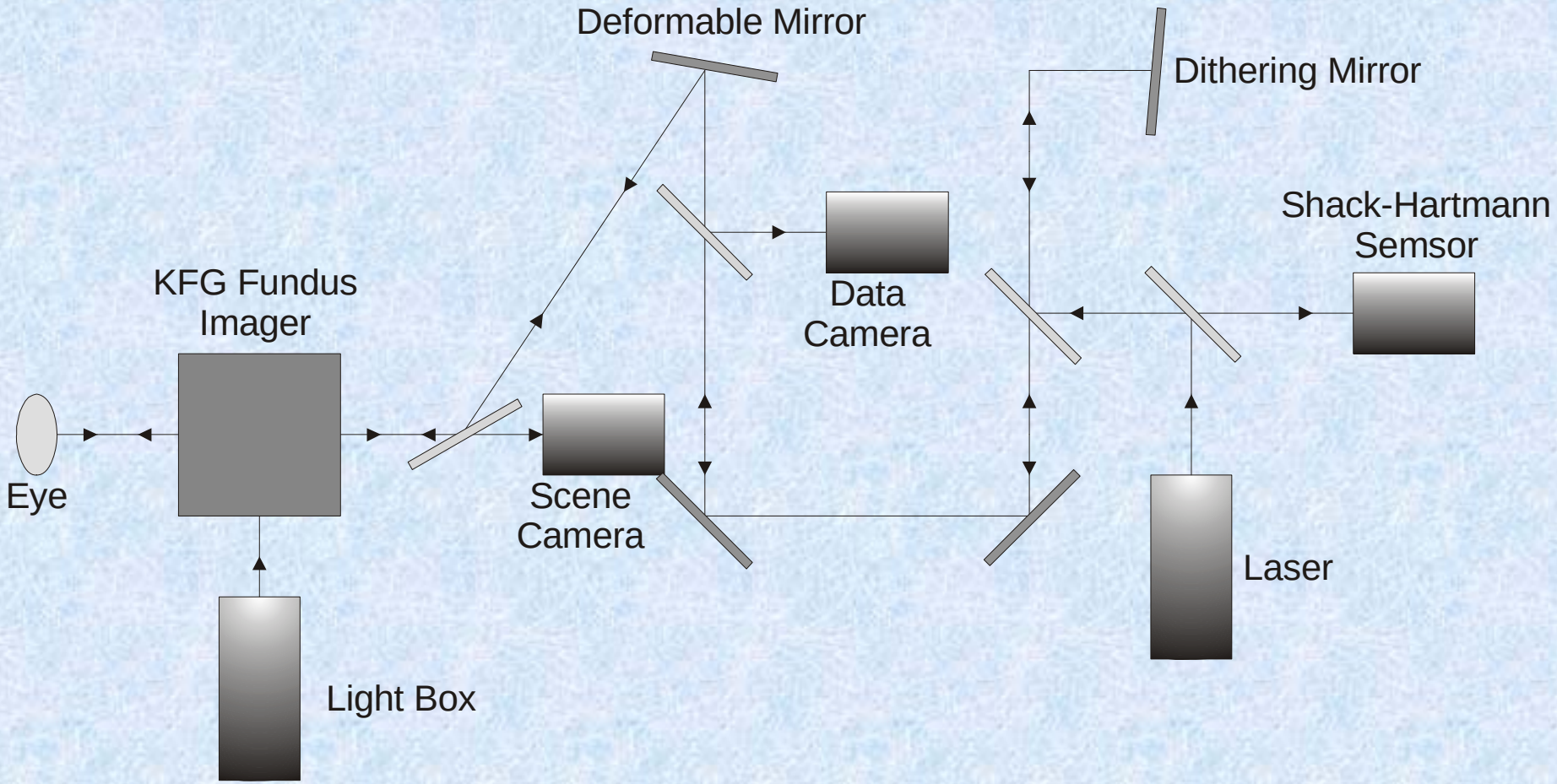
System Integration



New System Integration



Old Optical Layout



New Optical Layout

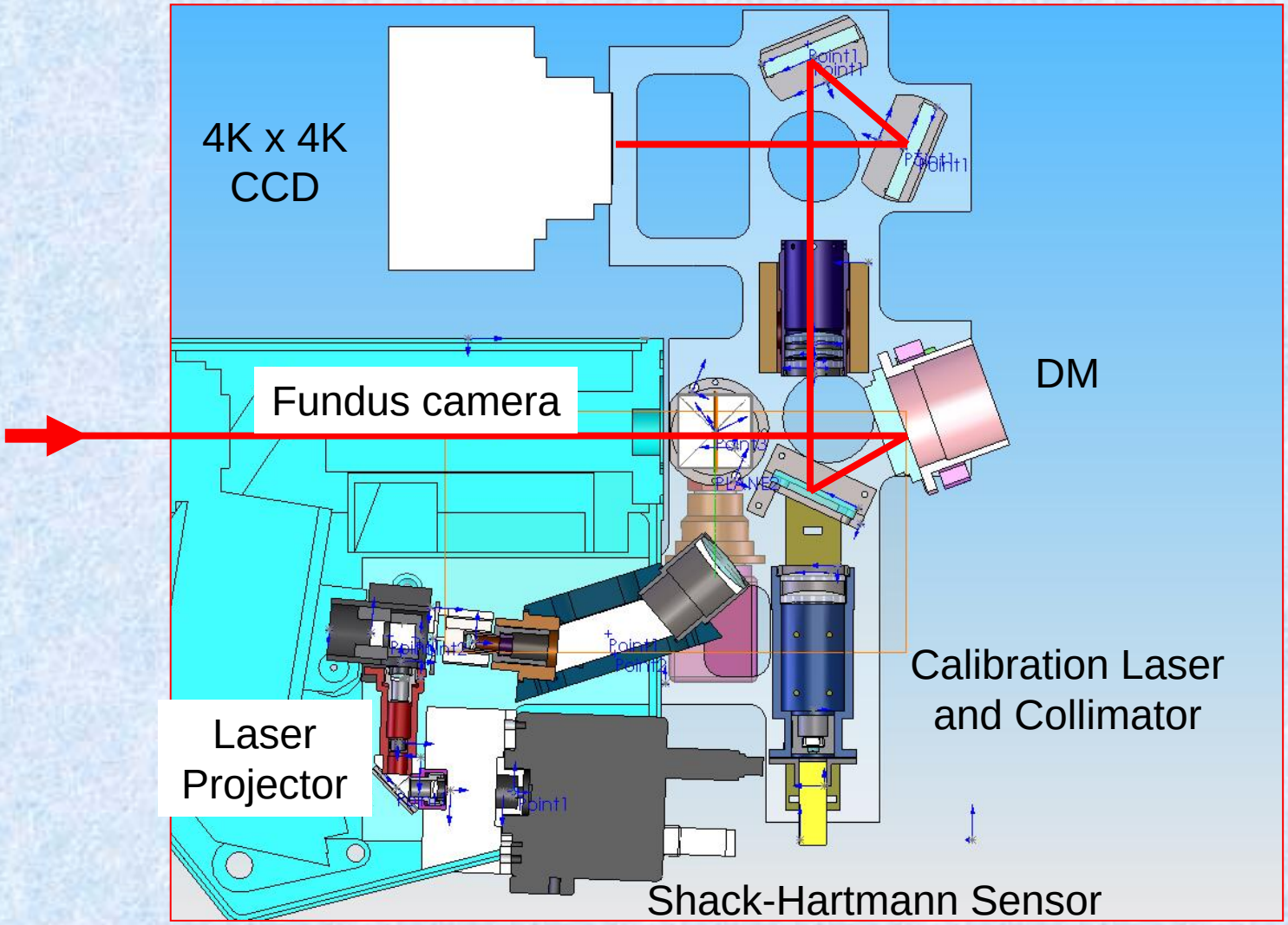
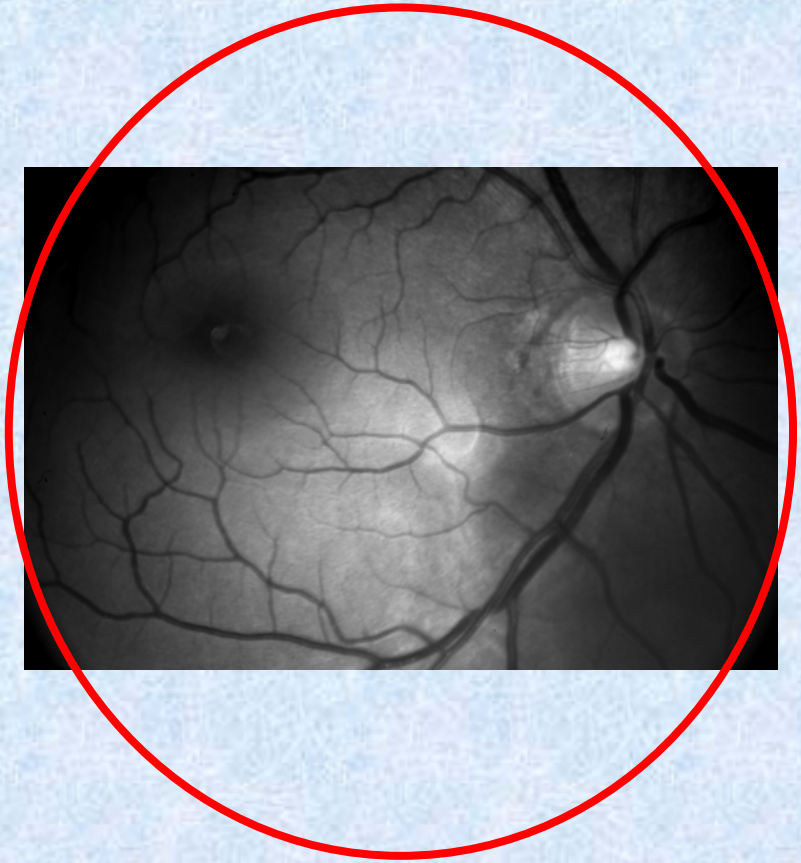
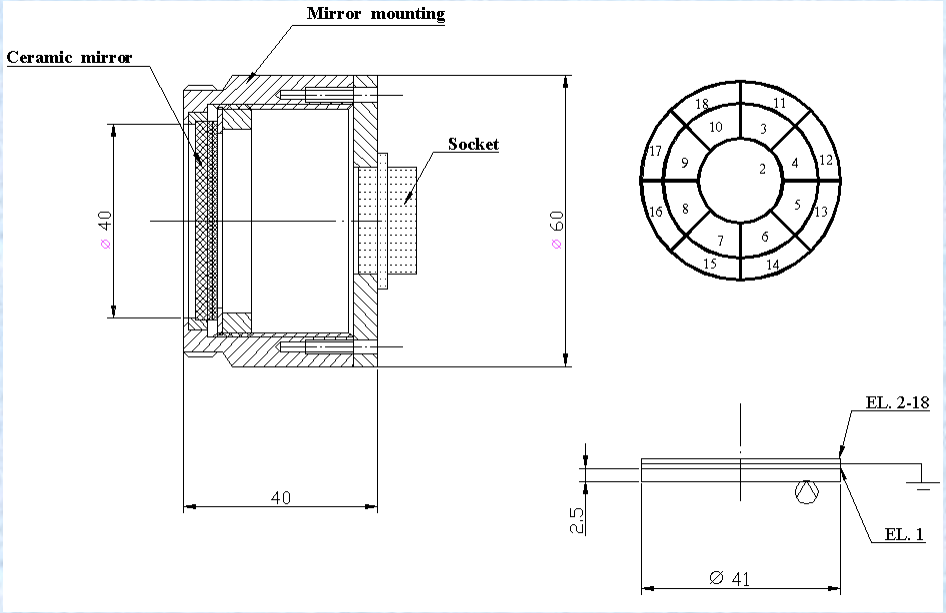
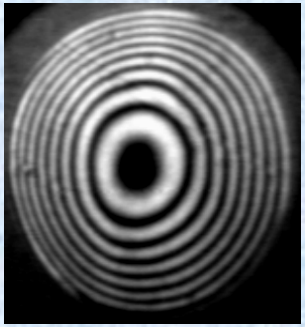


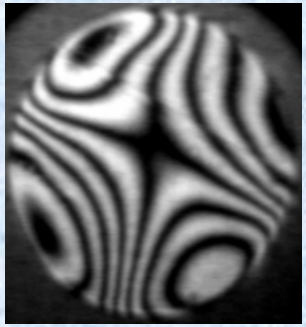
Image Uniformity and Filling

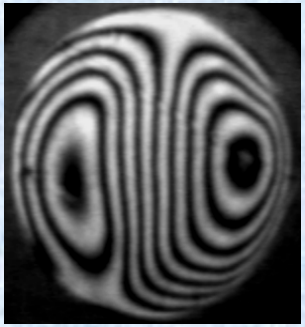


Bimorph Deformable Mirror



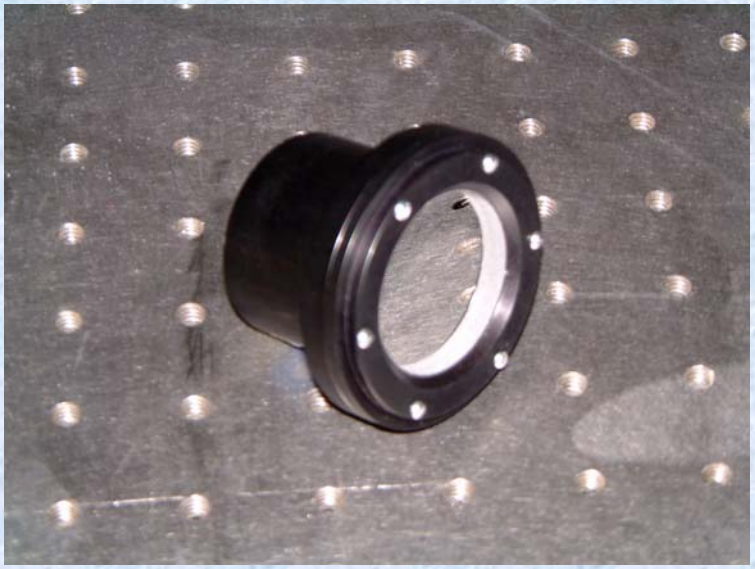

Defocus


Astigmatism

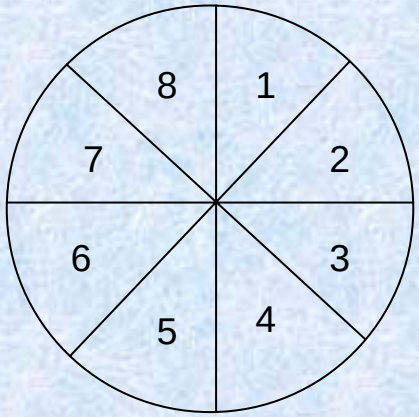

Coma

- Mirror Parameters
  - 40mm aperture
  - 18 actuators
  - 9µm defocus

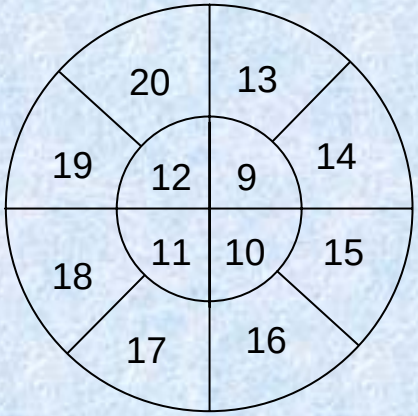
New DM



First Piezo Disk



Second Piezo Disk

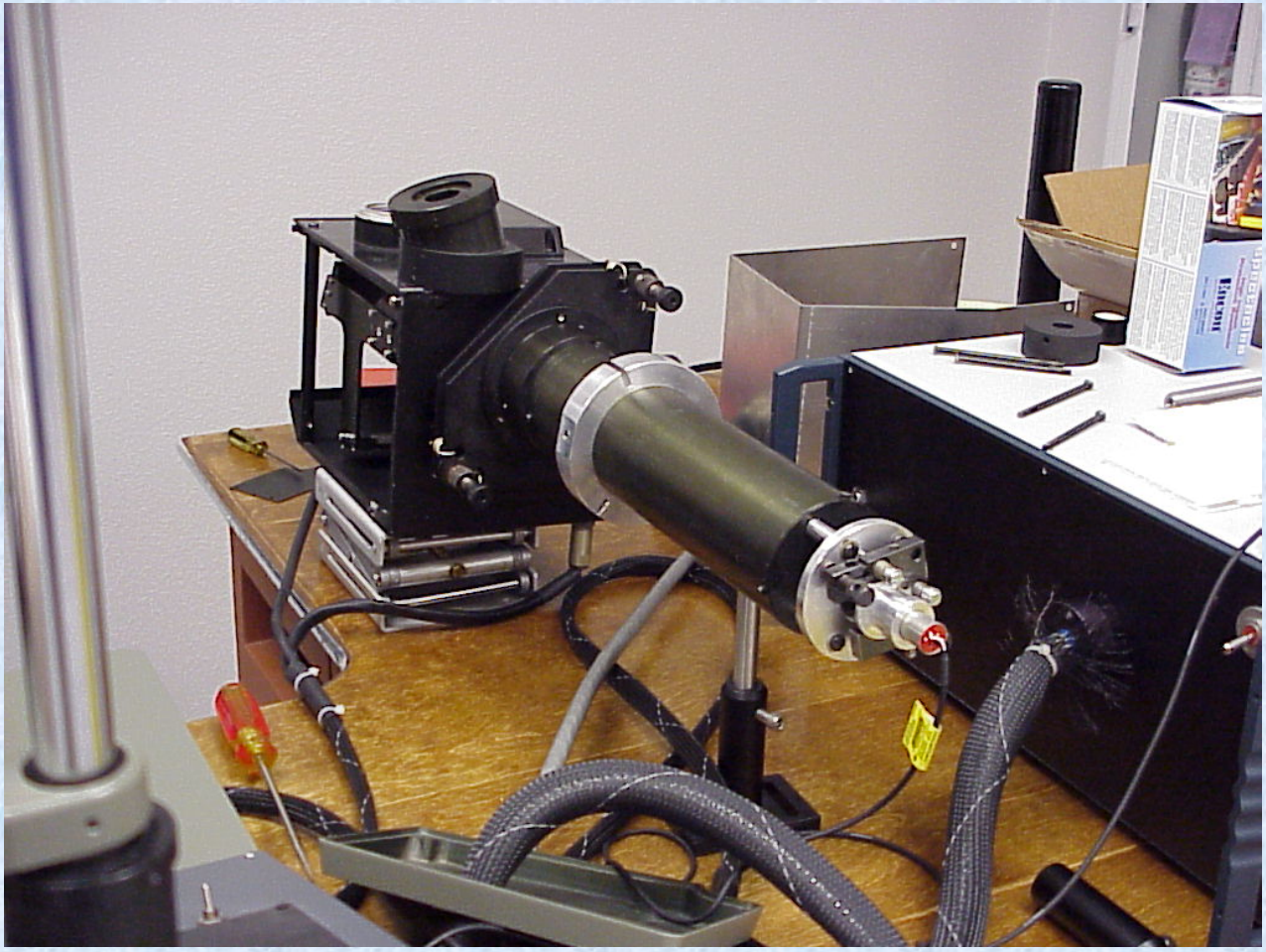


- Mirror Parameters
  - 38mm aperture
  - Double stack
  - 20 actuators
  - 35µm defocus stroke
  - 25um astigmatism stroke

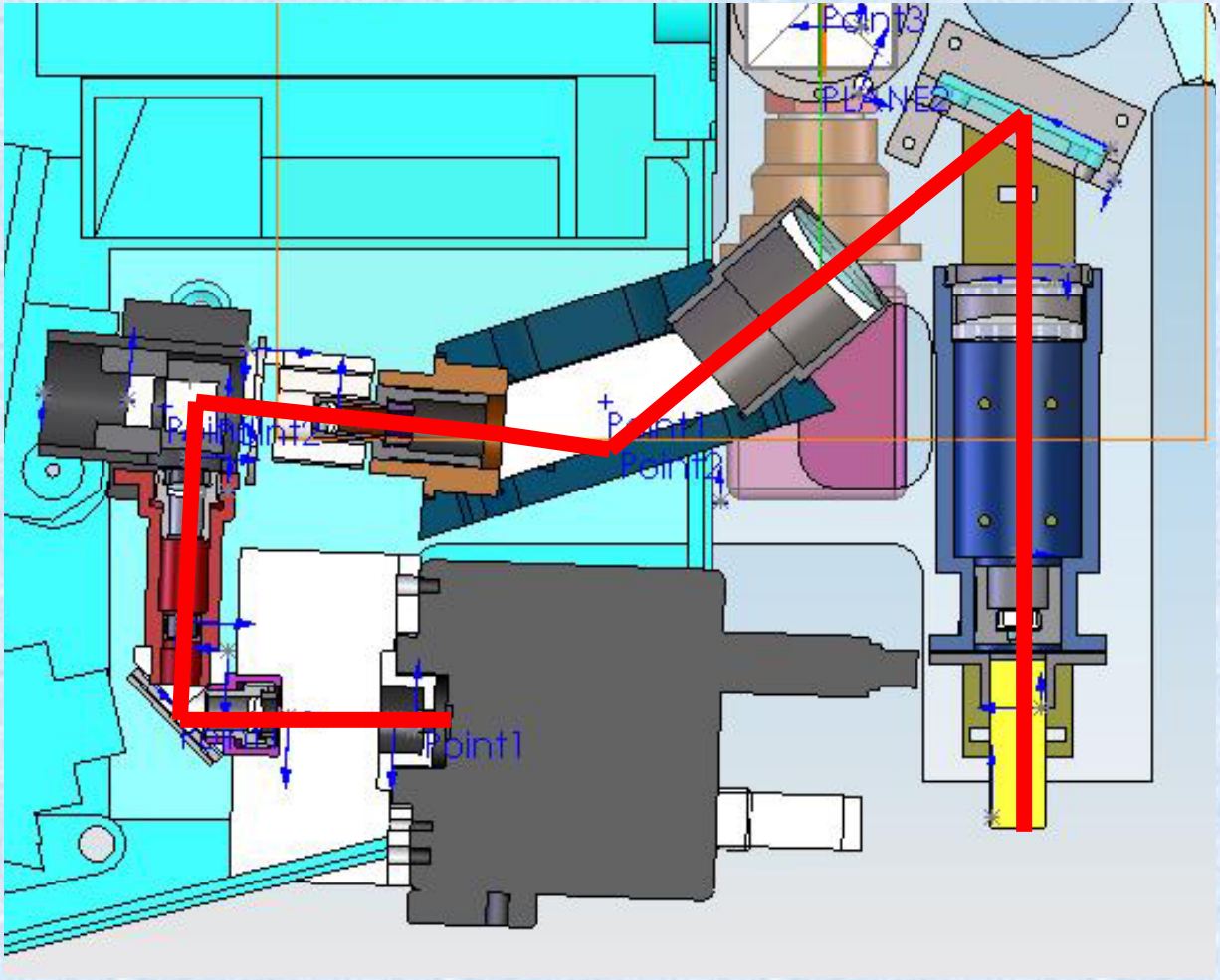
Clinical Environment

- Fundus photographer
  - Trained professional to interact with patient but with little experience of advanced optical system. They must concentrate on imaging the patient, not on operating the instrument
- Limited time
  - Patients are people and must be tended with care and timeliness. The instrument must be easy to set-up.
- Examination rooms
  - Small rooms with little space to move around
  - No space for extra equipment
- To meet the requirements, the alignment / set-up and the operation of the instrument must be simplified.

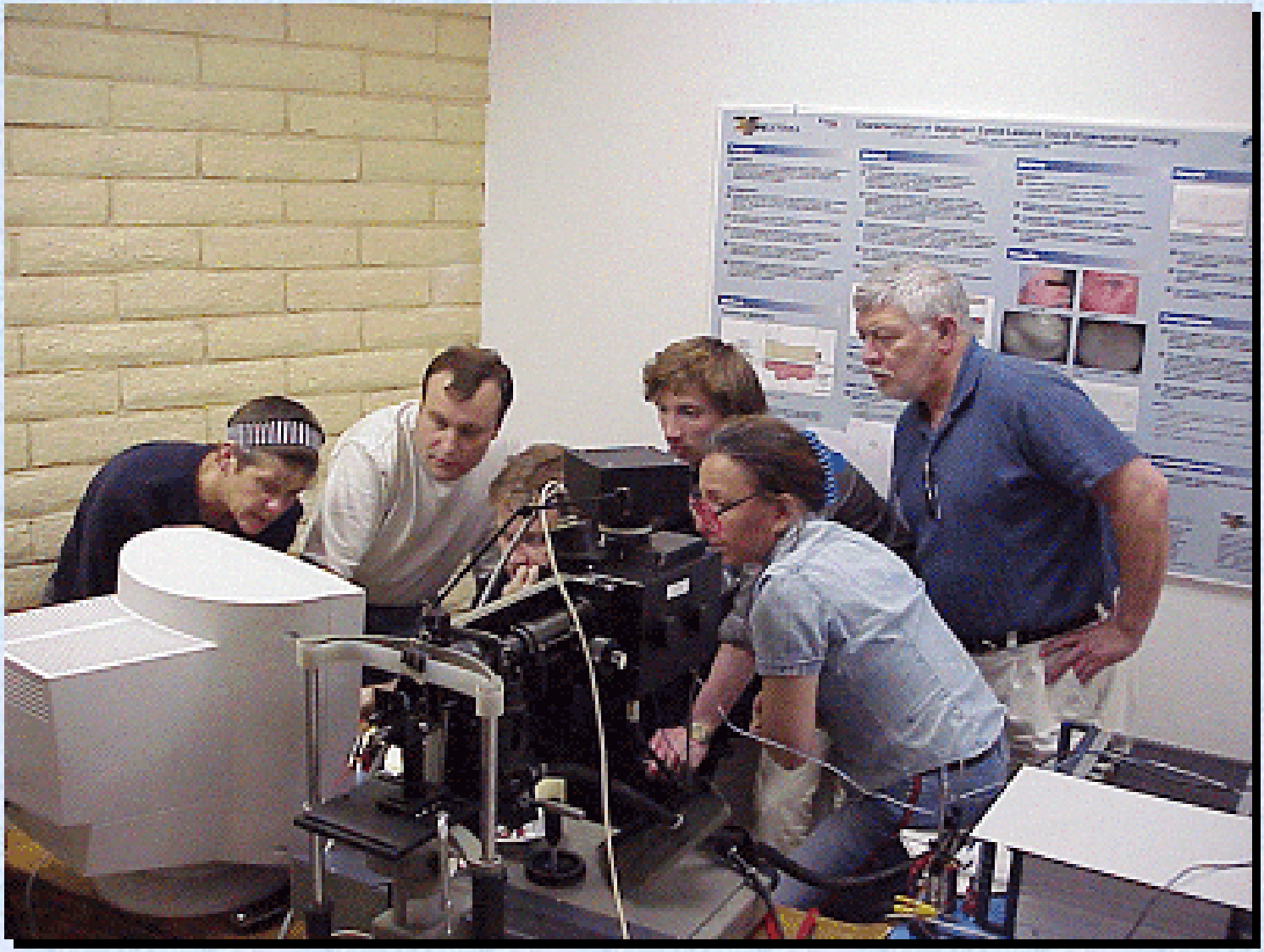
Previous Calibration Procedure



Onboard Calibration Laser

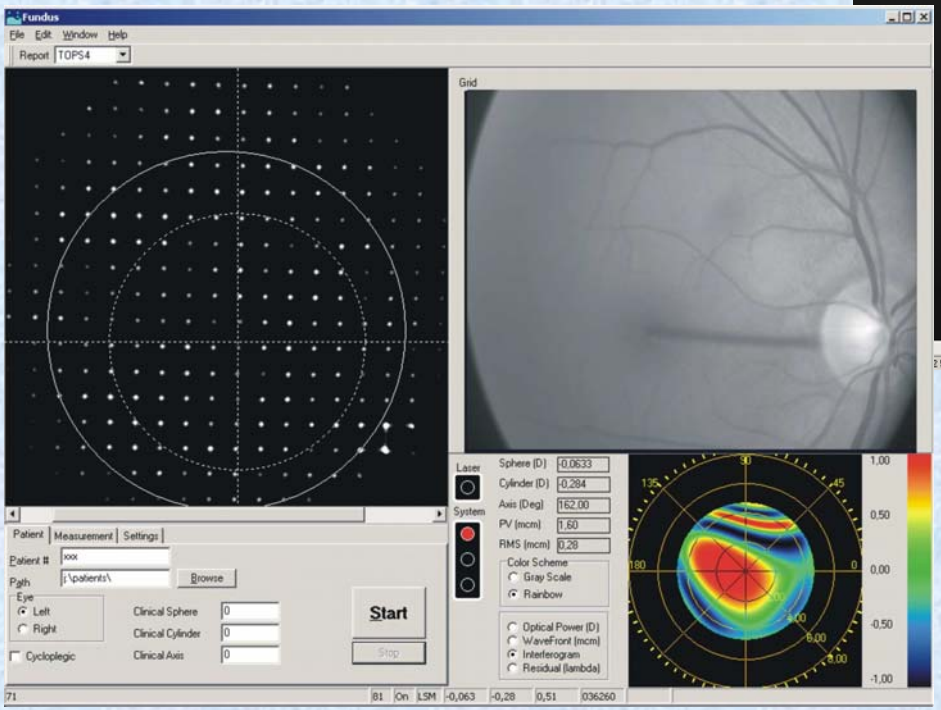


Ease of use



New User interface

- Control panel
  - Go-No-Go condition
  - Filter selection
  - Exposure control

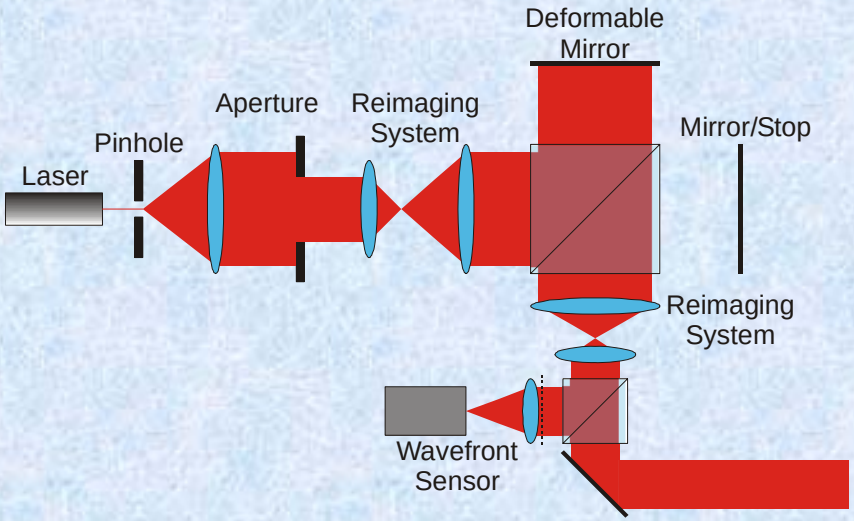


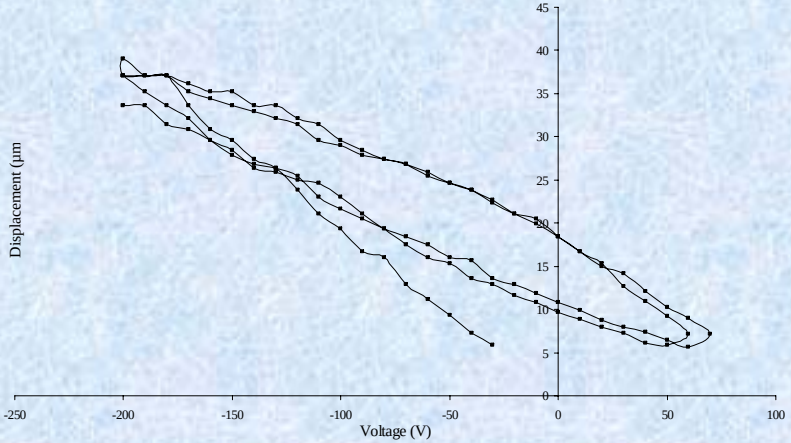
- Viewing panel
  - Direct View of Data
  - Simple image manipulation

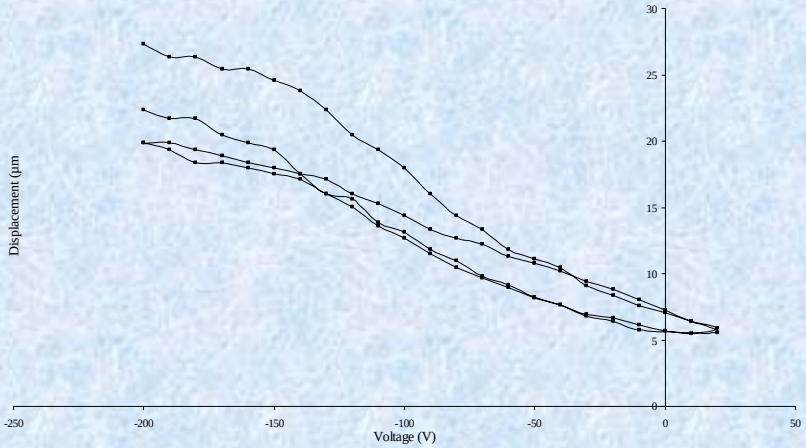
Testing Results

- Deformable mirror performance
- Spatial resolution
- Clinical Human Testing

DM Testing results



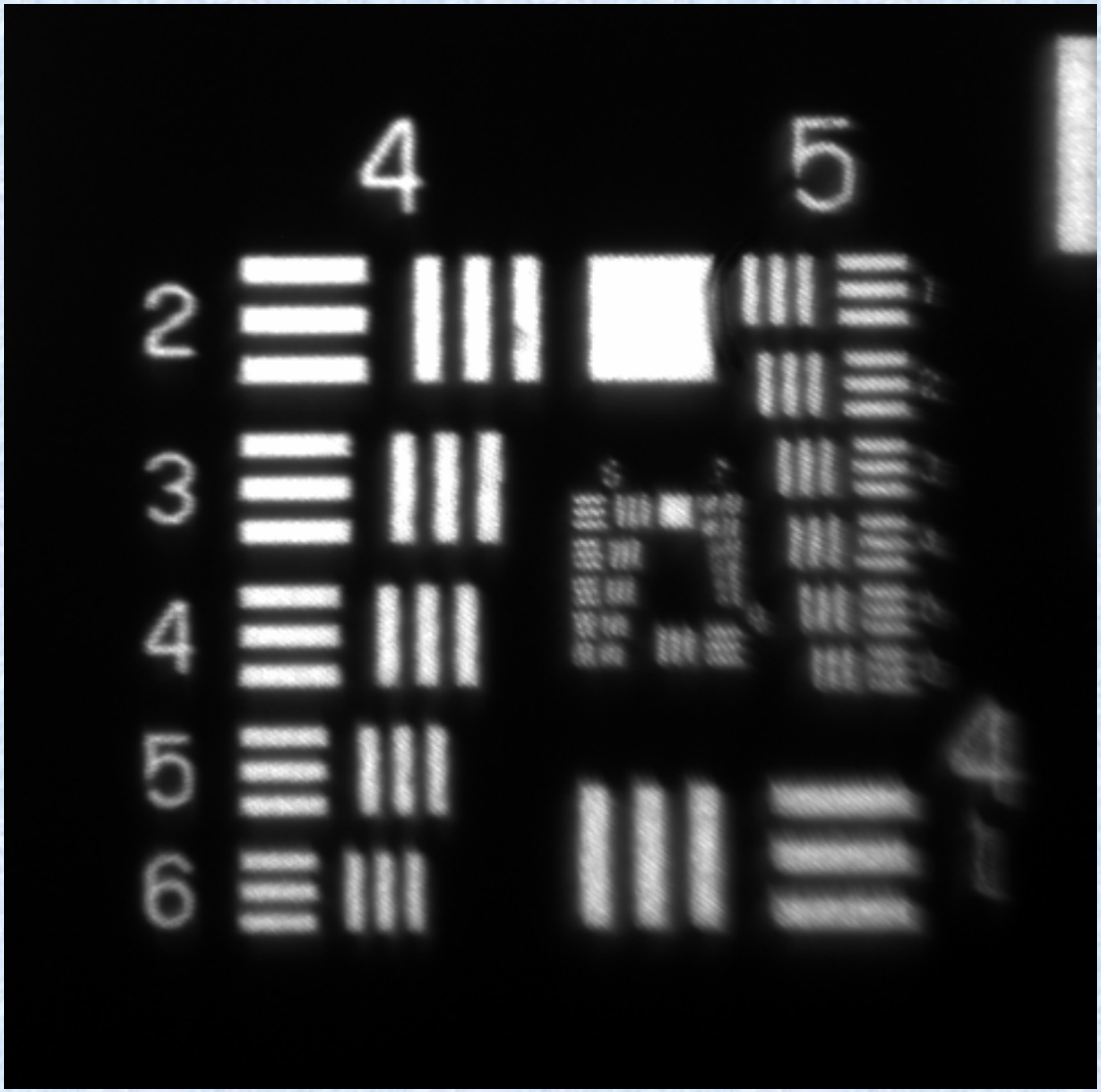




- Stroke measurement
  - Focus distance measurement
  - 35um focus
  - 25um astigmatism
  - 15% hysteresis

Spatial Resolution

- Resolution
  - Group 6-4, 6-5
  - 90 to100 cycles/mm
  - 5um line-width

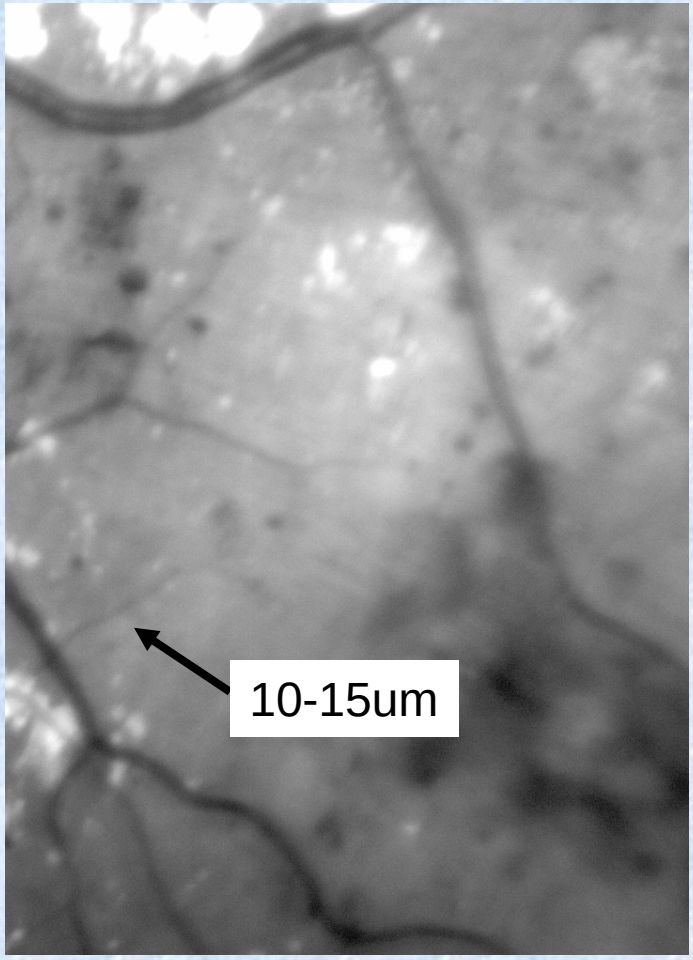


Human testing

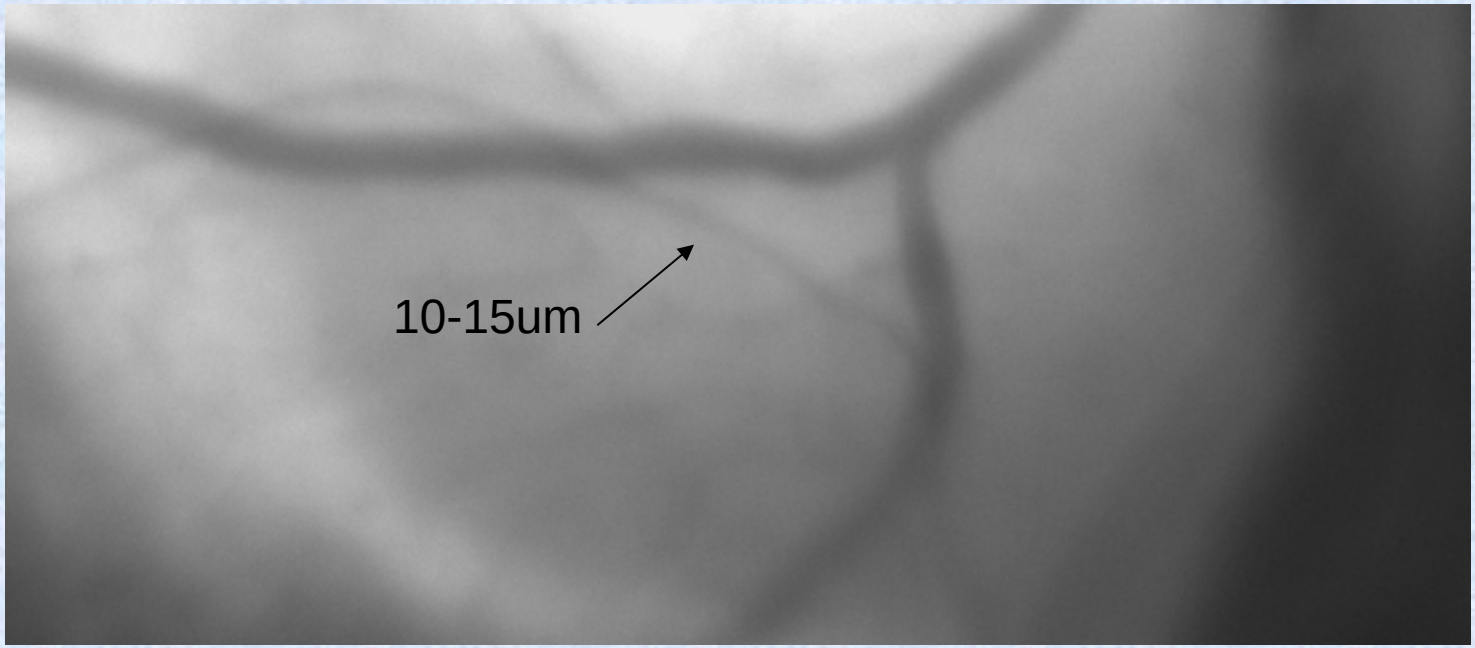
- In collaboration with the Moscow Eye Institute
- 14 patients
- Clinical environment
- Performed by a resident doctor

Diagnosis	# of subjects	Diagnosis	# of subjects
Normals (non-age matched)	3	Glaucoma (visual loss)	3
Diabetes, preproliferative	2	Diabetes, non-proliferative	2
ARMD (wet, CNV)	2	ARMD (dry, drusen)	2

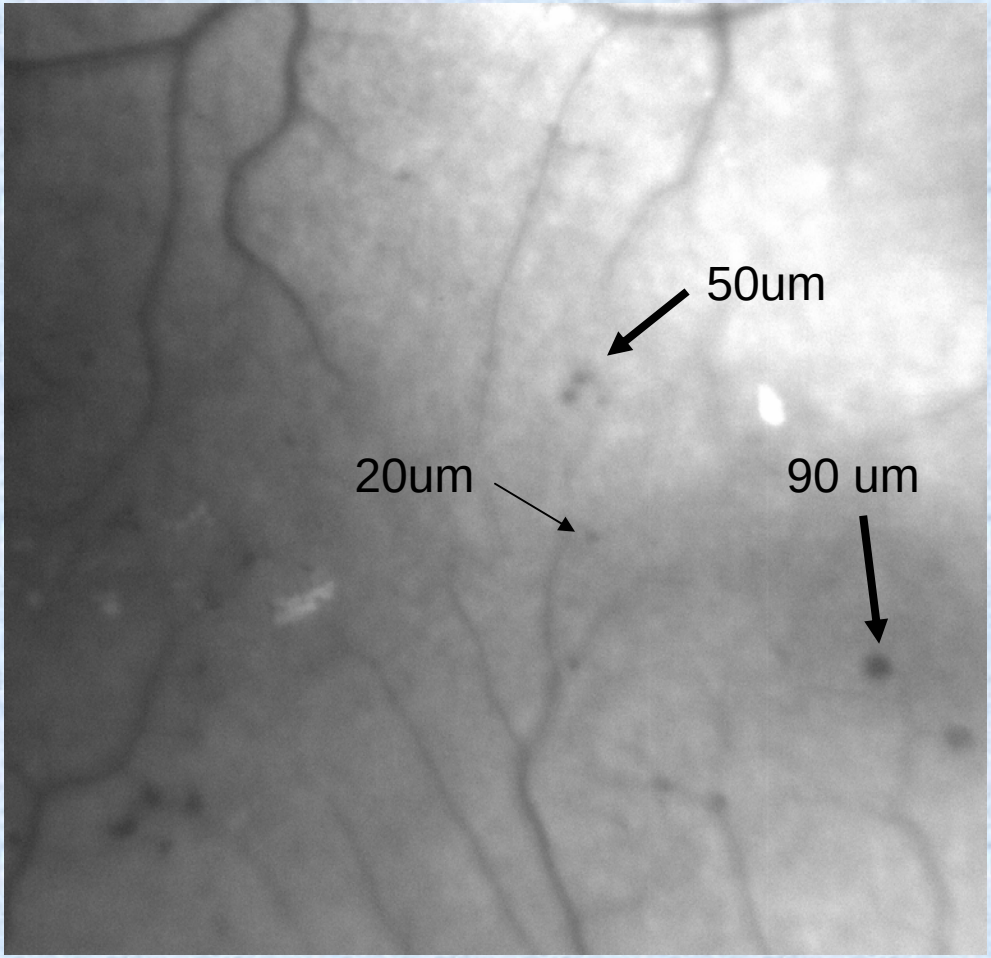
Proliferative small vessel



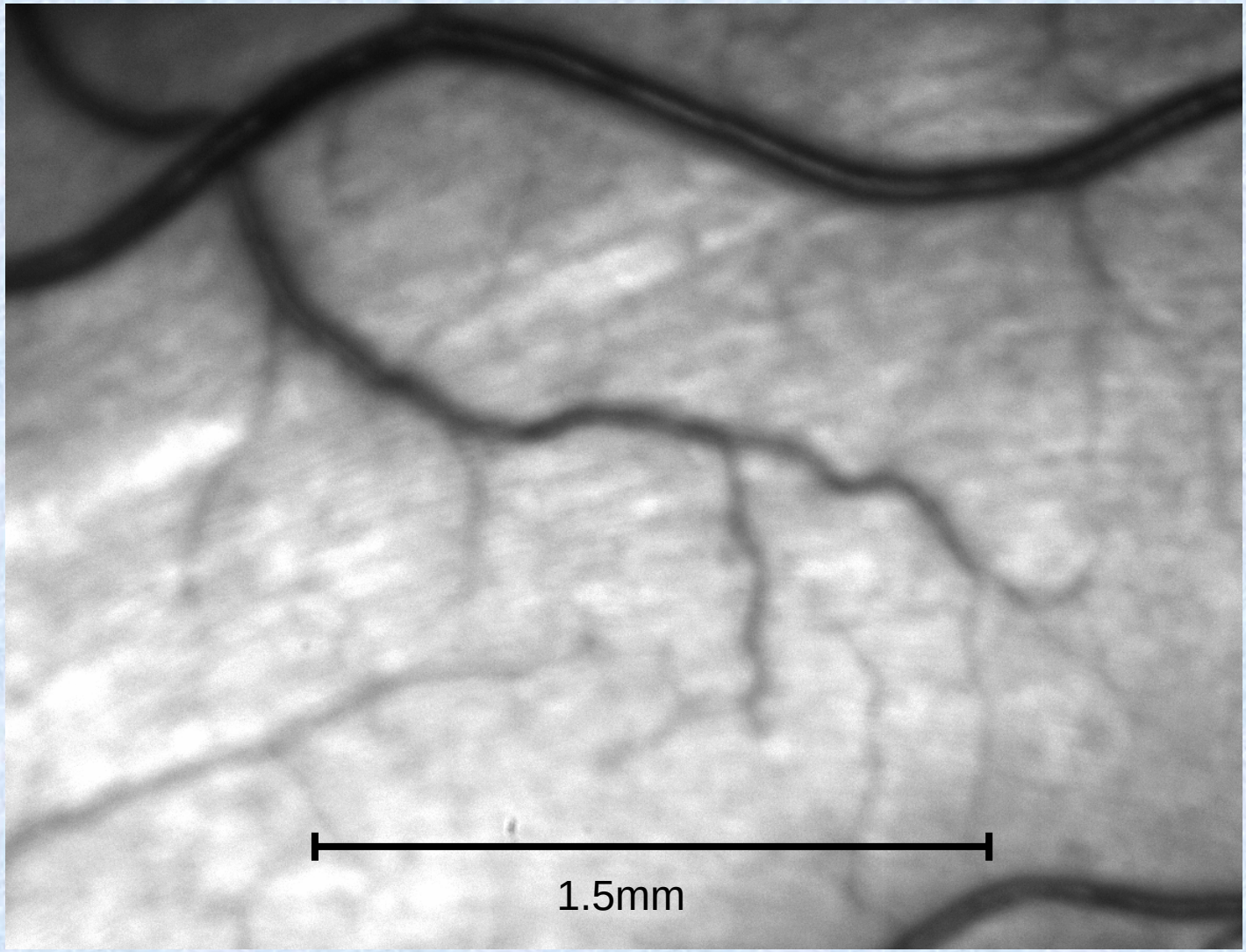
Disc Vascular Features



Microaneurisms



Nerve Fiber Layer



Conclusion

- Instrument performs as designed
- Clinical deployment was a success
- Continue the evaluation at Kestrel
- Moving to Iowa University for larger studies

Acknowledgment

- NIH
- Russian Team
  - Andrey Larichev, Nikita Iroshnikov
  - Sergey Mitrakov
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