CMRR
Center for Memory and Recording Research

UC San Diego
JACOBS SCHOOL OF ENGINEERING

Internet Enabled Ophthalmic Instrumentation

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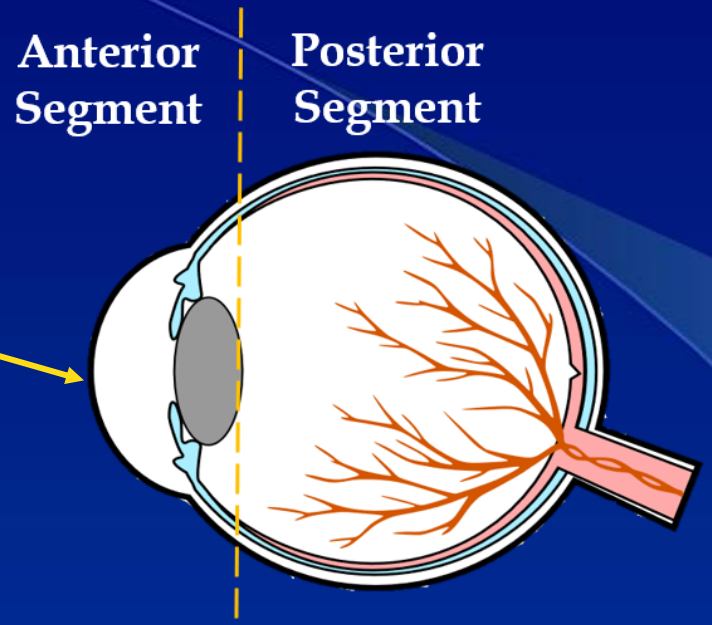
Stand of Eye Care


Slit Lamp



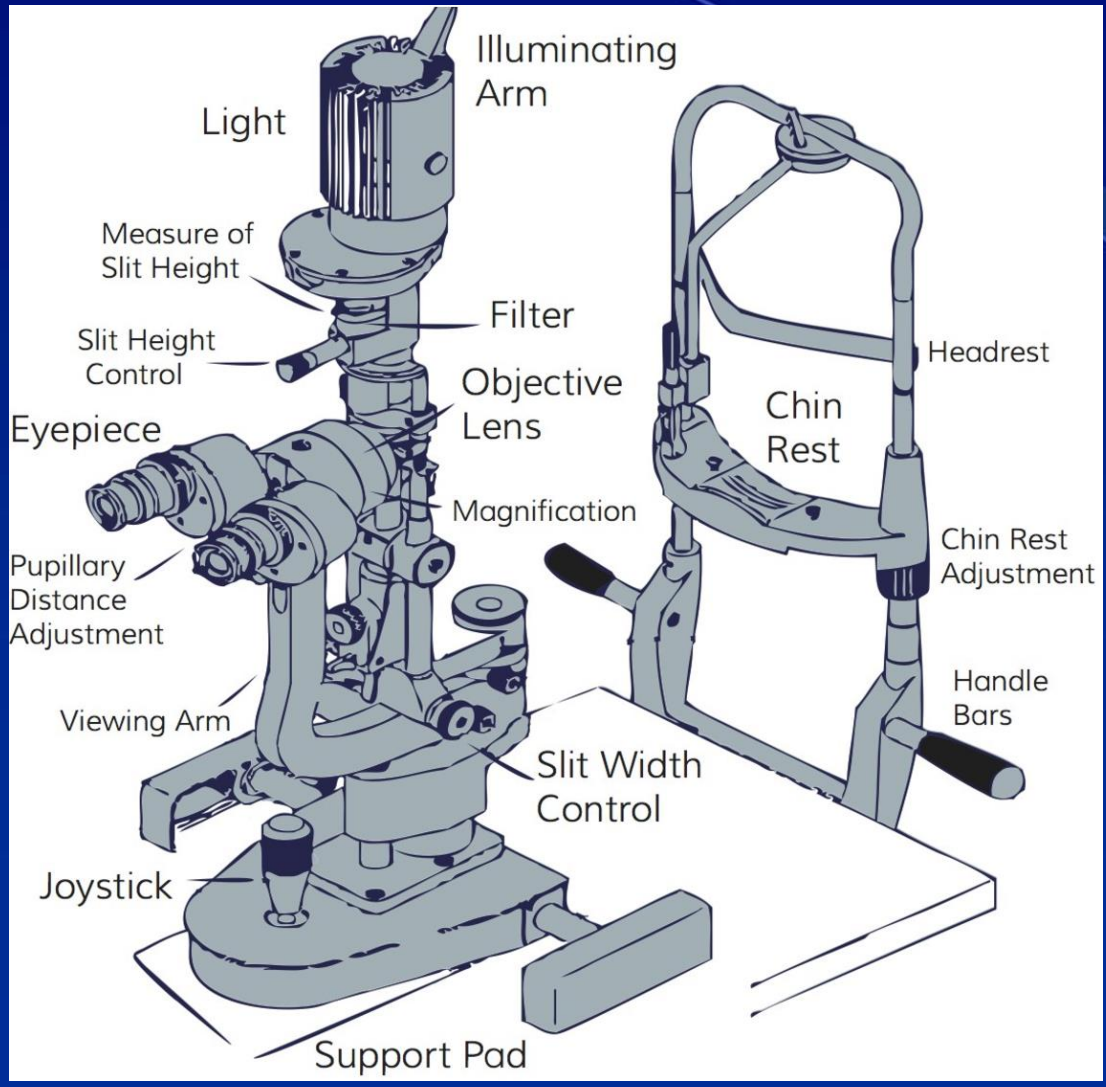
1. High equipment cost
2. Require trained technician
3. Need controlled environment

- Patients need to visit an eye clinic in-person for slit lamp exam
- Such in-person visits are time consuming and costly

Problem Statement

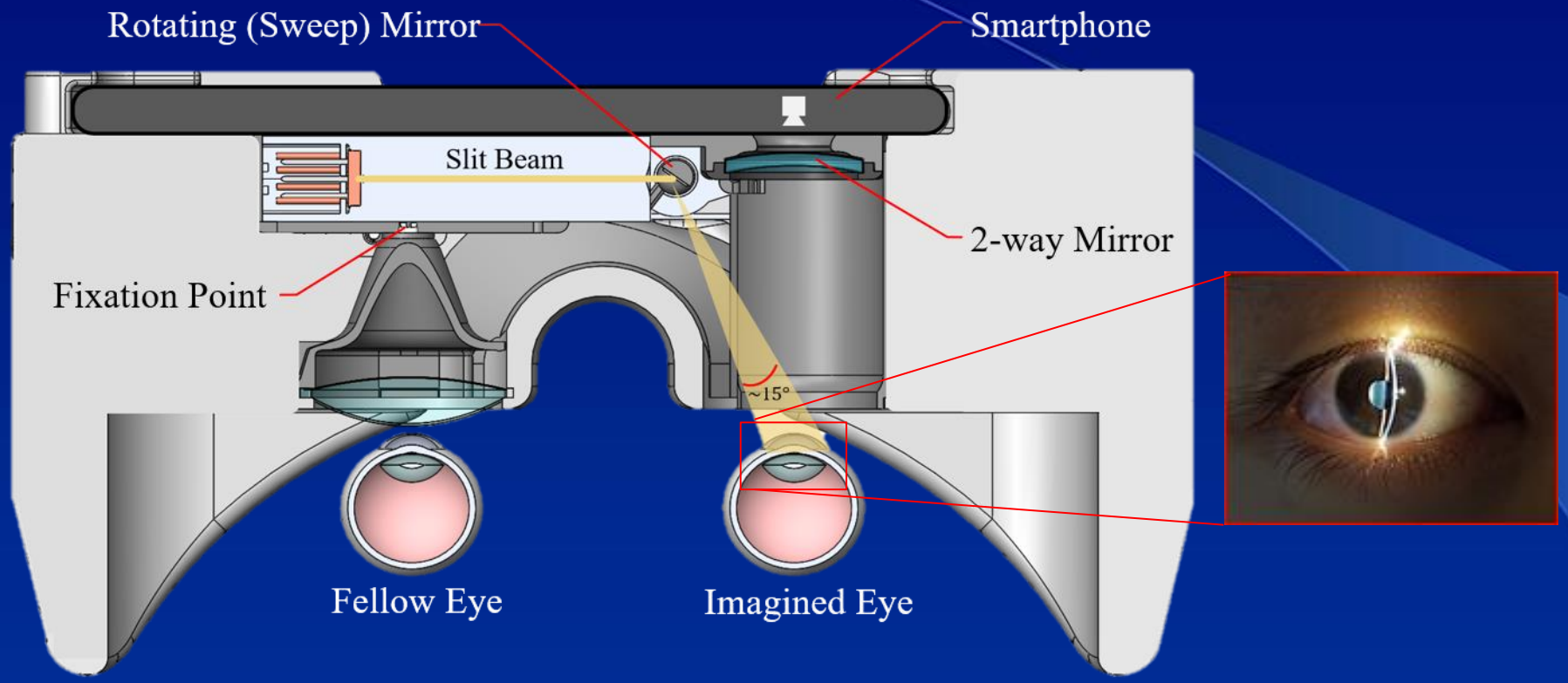
There is a need for at-home slit lamp examination to provide ophthalmologist with screening results and save patient from making the time consuming and expensive visit to an eye clinic.

Components of a Conventional Slit Lamp



Nanda, Anika, and Aachal Kotecha. "How to conduct a slit lamp examination." *Eye Spy*.

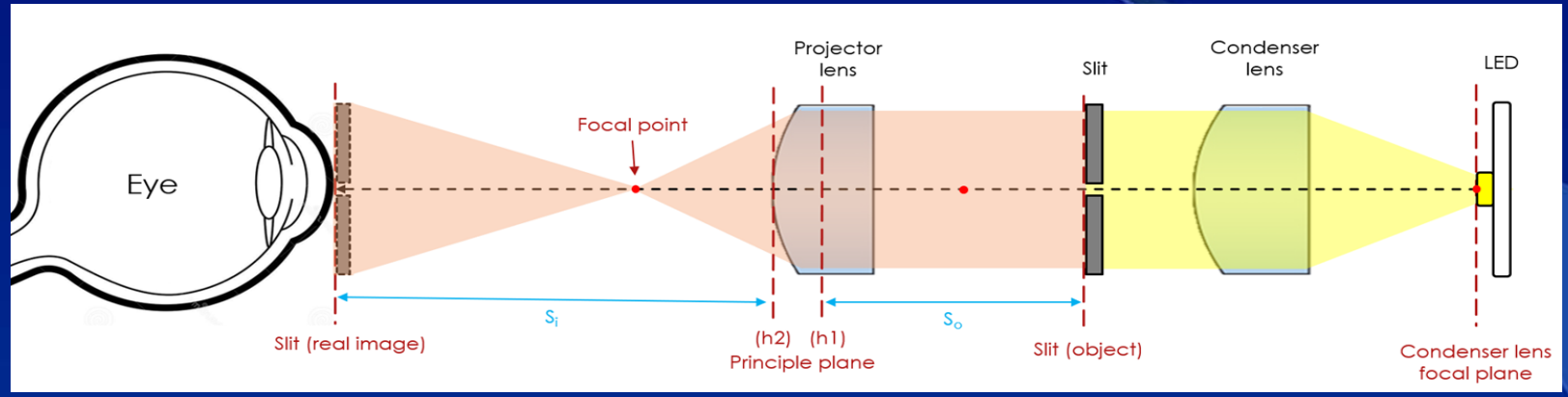
Design of Internet Enabled Slit Lamp



- **On the fellow eye**: focusing on fixation point helps center the eye
- **On the imaged eye**: a rotating mirror sweeps the slit beam from one side to the other side of the eye, while the smartphone camera images the eye

Optical Principle of Slit Lamp (Kohler Principle of Illumination)

S O A K L



- Light at the focal point of the condenser lens exits as an defocused beam
- Image of the slit gets projected onto the cornea via projector lens
- Calculate positions of principle planes:

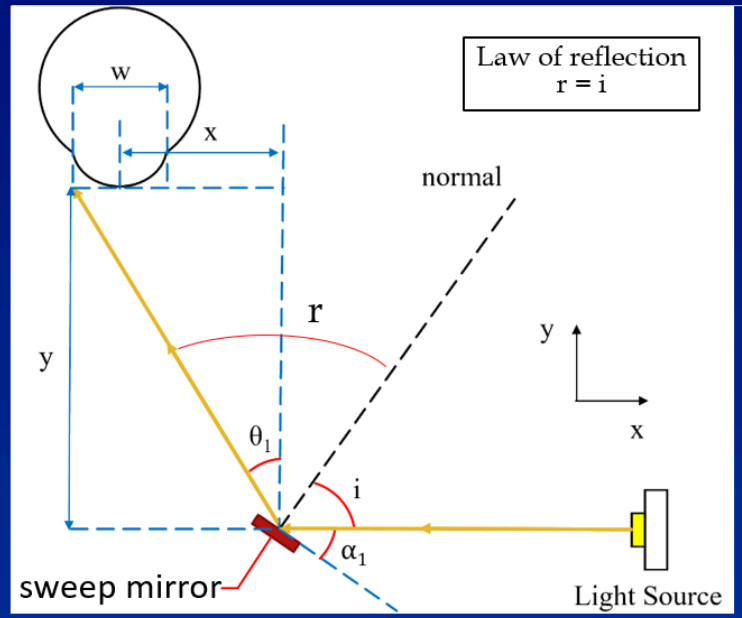
$$h_1 = -\frac{f(n-1)d}{nR_2}$$
$$h_2 = -\frac{f(n-1)d}{nR_1}$$

- Calculate image distance:

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

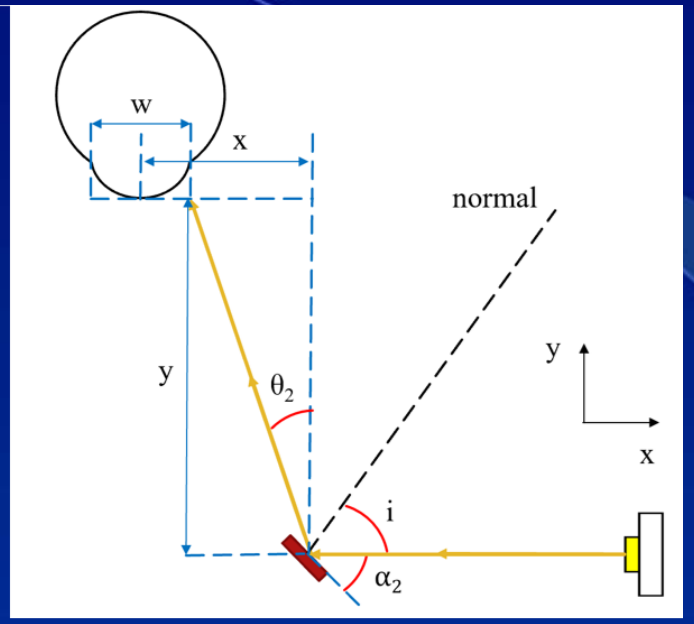
- f = effective focal length
- n = refractive index
- d = thickness of lens
- R = radius of curvature
- So = object distance
- Si = image distance

Auto Sweeping Optical Calculation



$$\theta_1 = \tan^{-1}\left(\frac{x + \frac{w}{2}}{y}\right) \quad (1)$$

$$\alpha_1 = 90° - \left(\frac{\theta_1 + 90°}{2}\right) \quad (2)$$



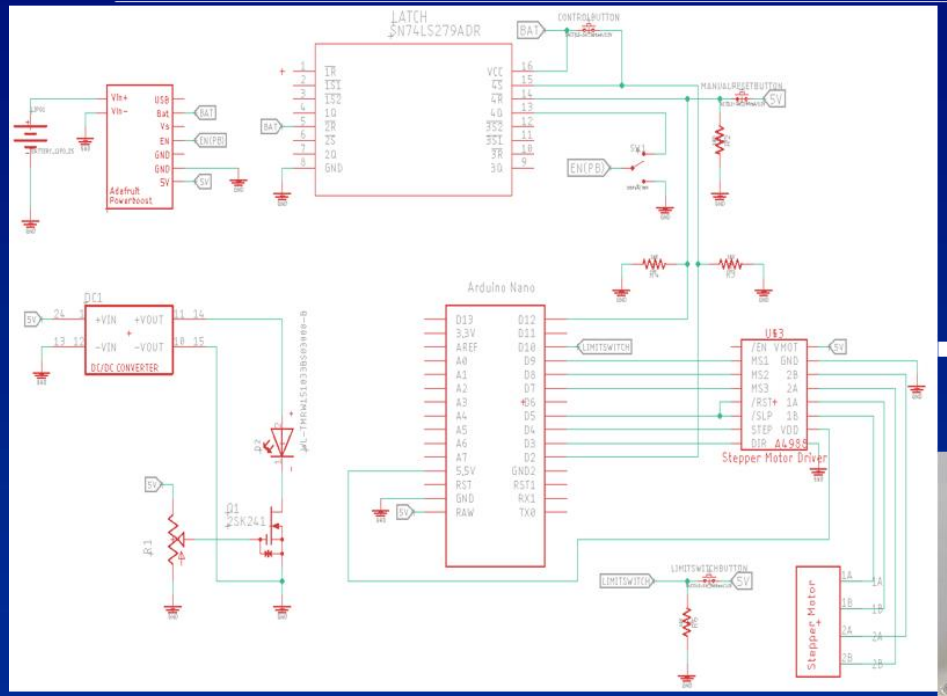
$$\theta_2 = \tan^{-1}\left(\frac{x - \frac{w}{2}}{y}\right) \quad (3)$$

$$\alpha_2 = 90° - \left(\frac{\theta_2 + 90°}{2}\right) \quad (4)$$

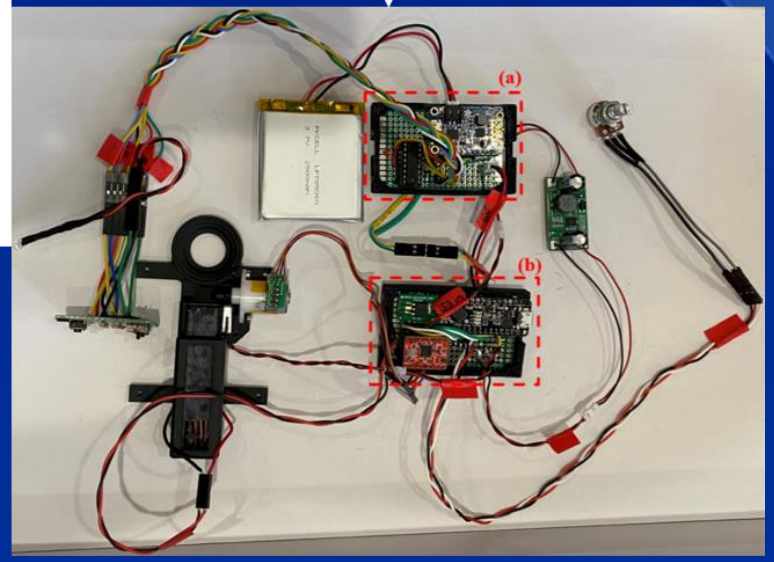
β is the sweep range of the mirror

$$\beta = \alpha_2 - \alpha_1 \quad (5)$$

Electrical Circuits

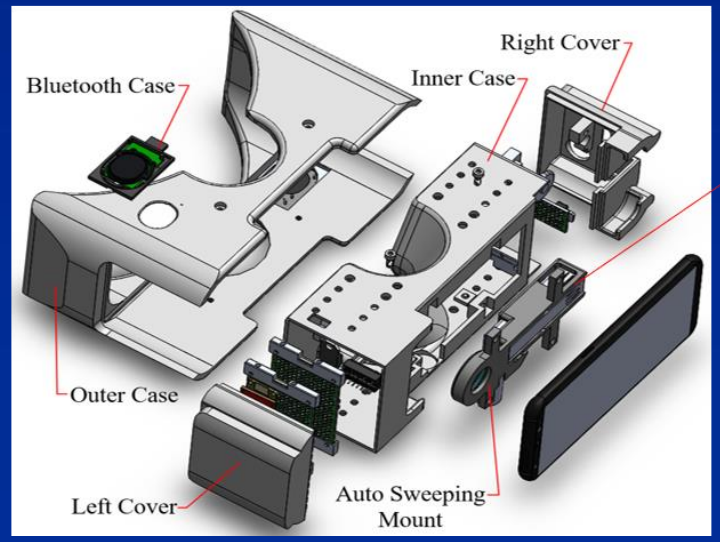


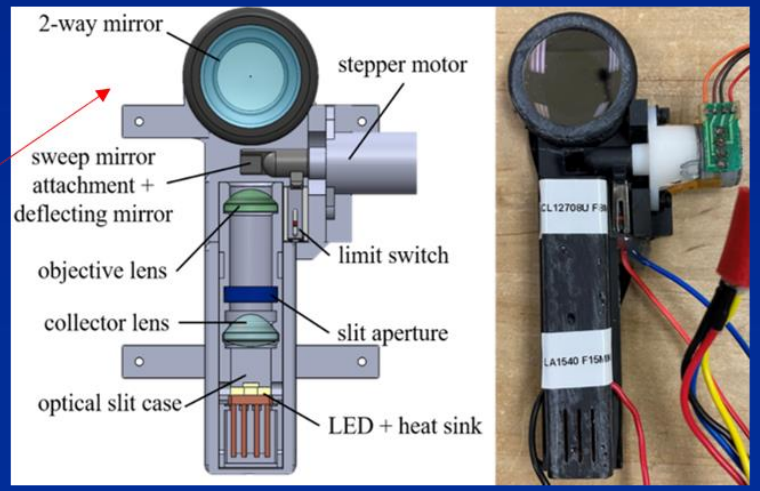
Soldered components onto 2 main prototyping boards



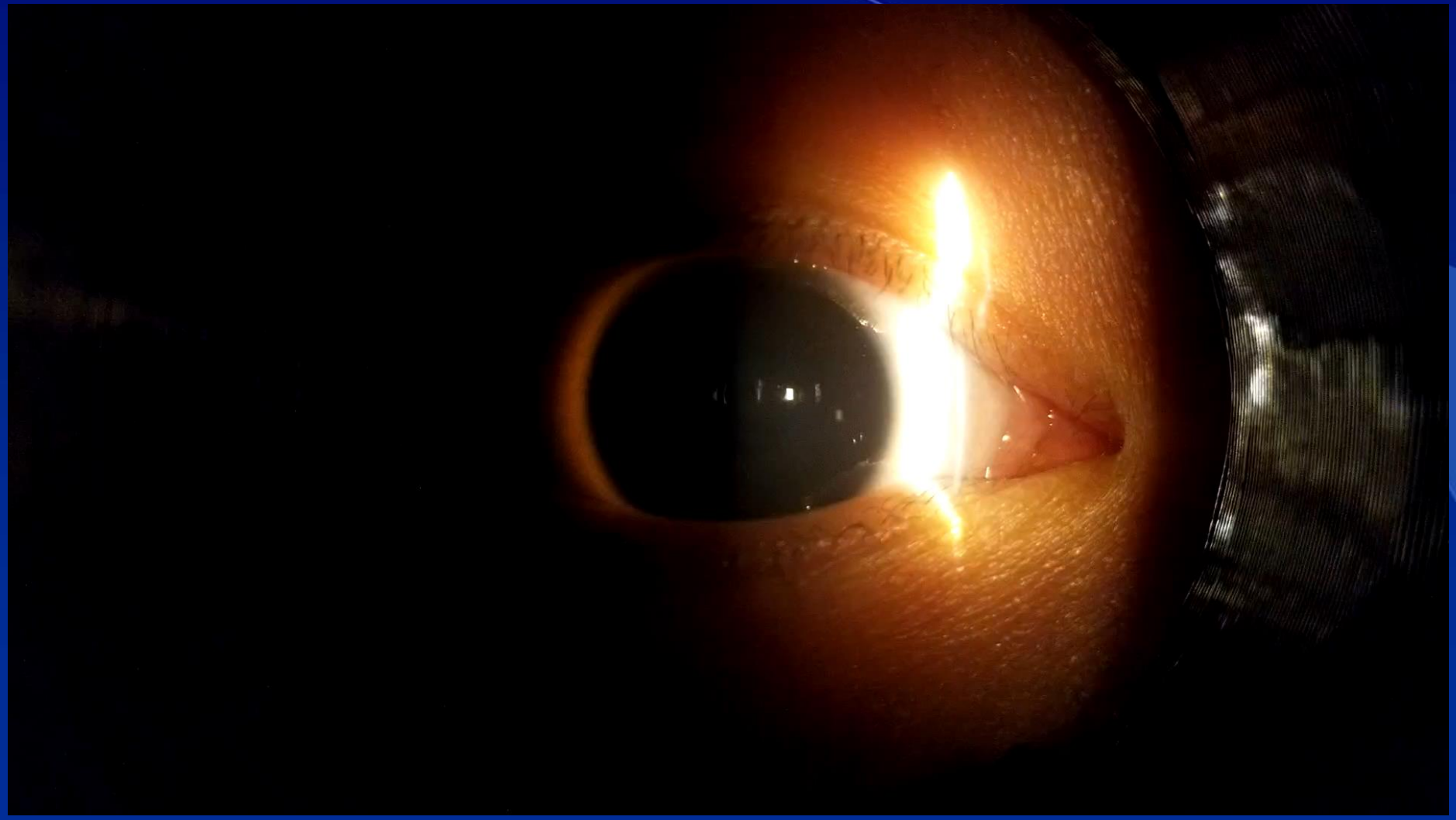
- Microcontroller controls the slit LED and the motor driver
- Dedicated current regulator maintains constant power to the slit LED

3D Printed Housing

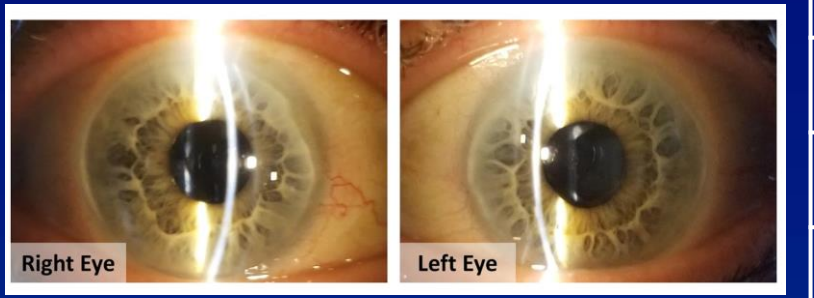




Video of Slit Lamp Sweep

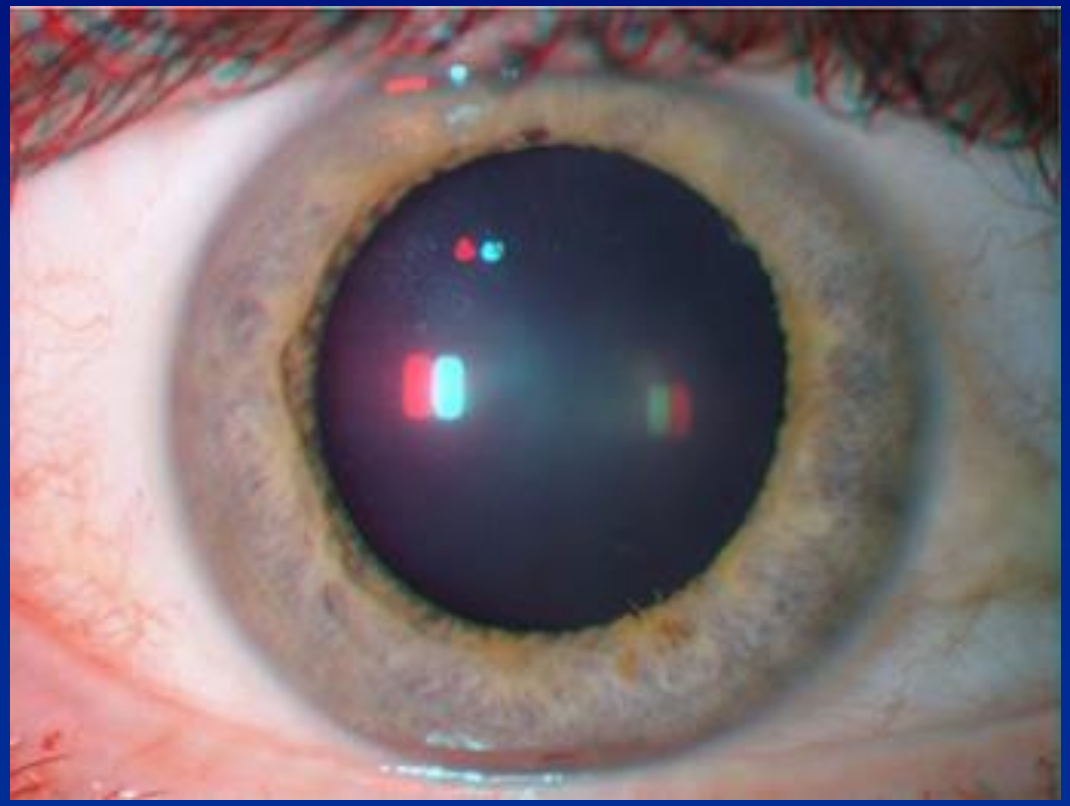


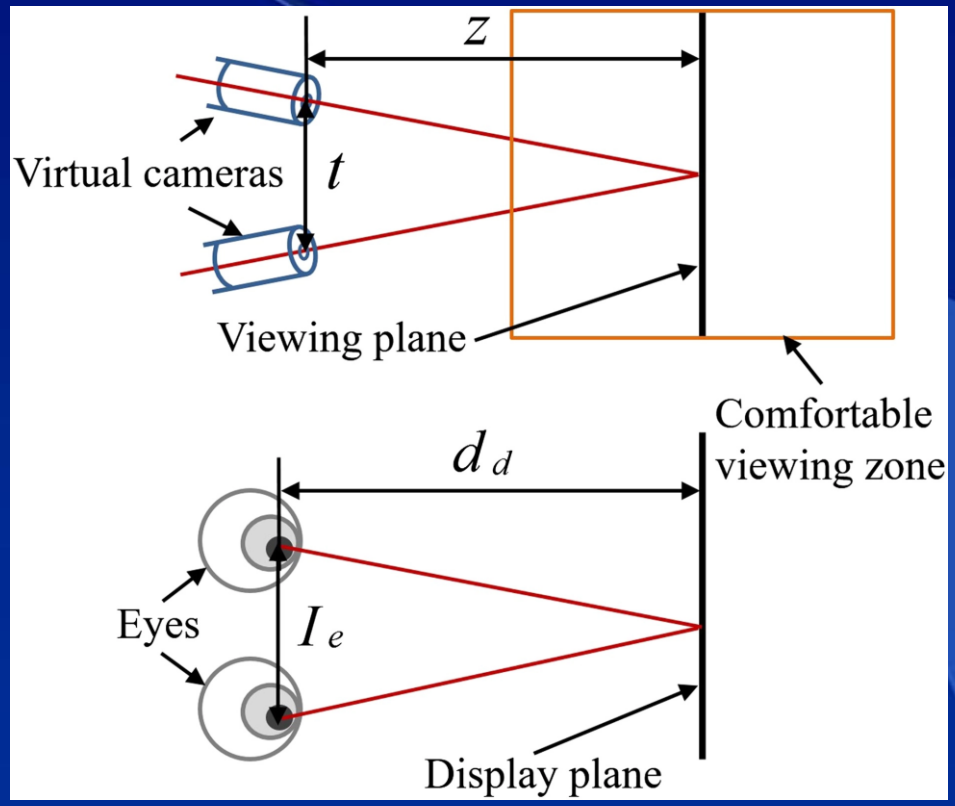
Clinical Results



Number of eyes/patients	10/10
Gender (female/male)	5/5
Eye (right/left)	5/5
Mean age in years (+/- standard deviation)	82 (+/-9)
Age range in years	61 - 90
Result	
Quality score out of 5 (1=poor; 5=excellent) • Video score (+/- standard deviation) • Photo score (+/- standard deviation)	 3.7(+/-0.5) 3.8(+/-0.4)
Ease-of-use score on a 5 points scale	3.7(+/-1.1)

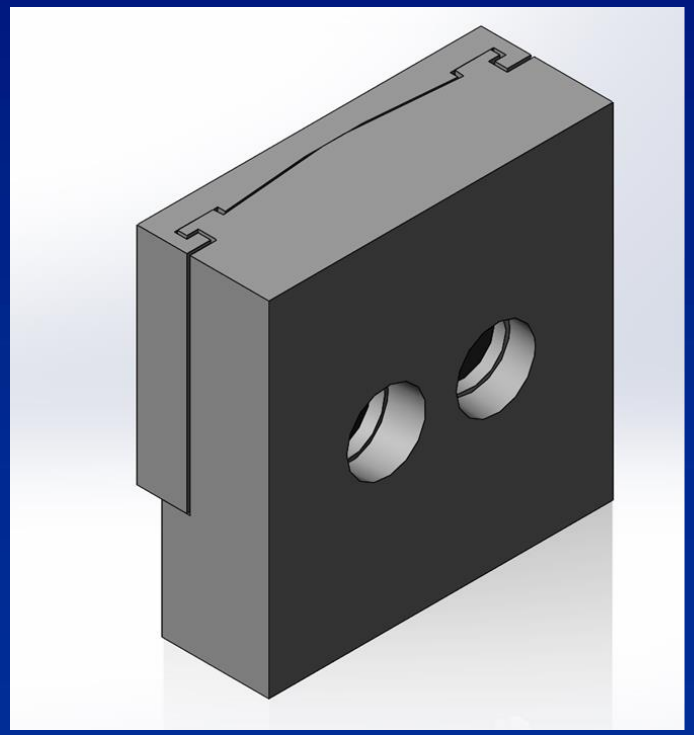
Stereo Anaglyph Image

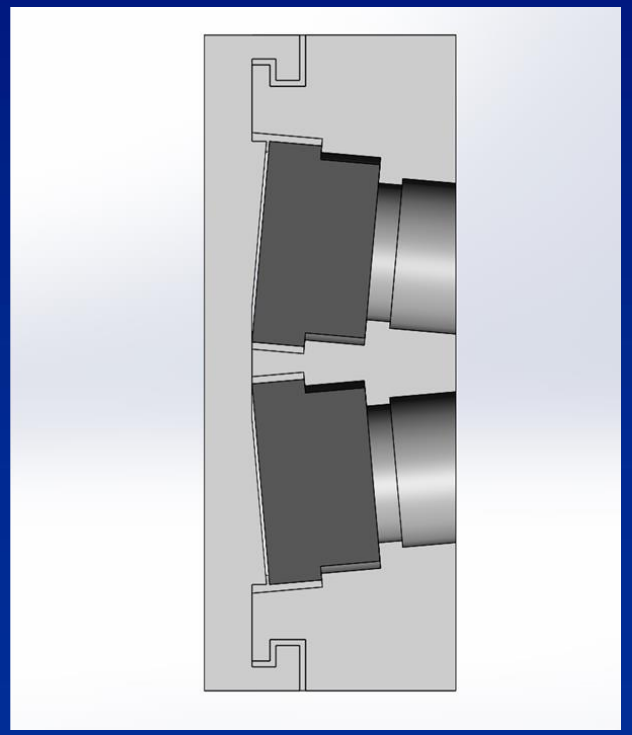




Gao, Yuanqian, et al. "Modeling the convergence accommodation of stereo vision for binocular endoscopy." The International Journal of Medical Robotics and Computer Assisted Surgery 14.1 (2018): e1866.

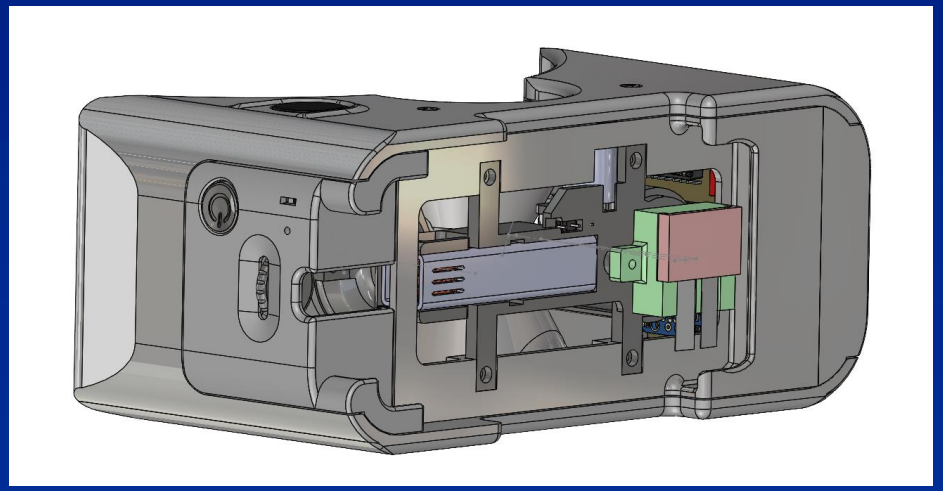
Size & Convergence Angle Optimization

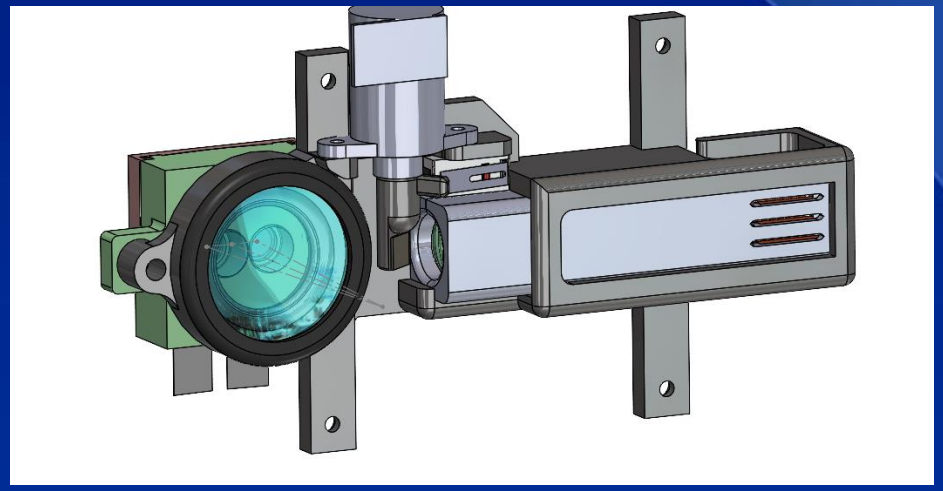




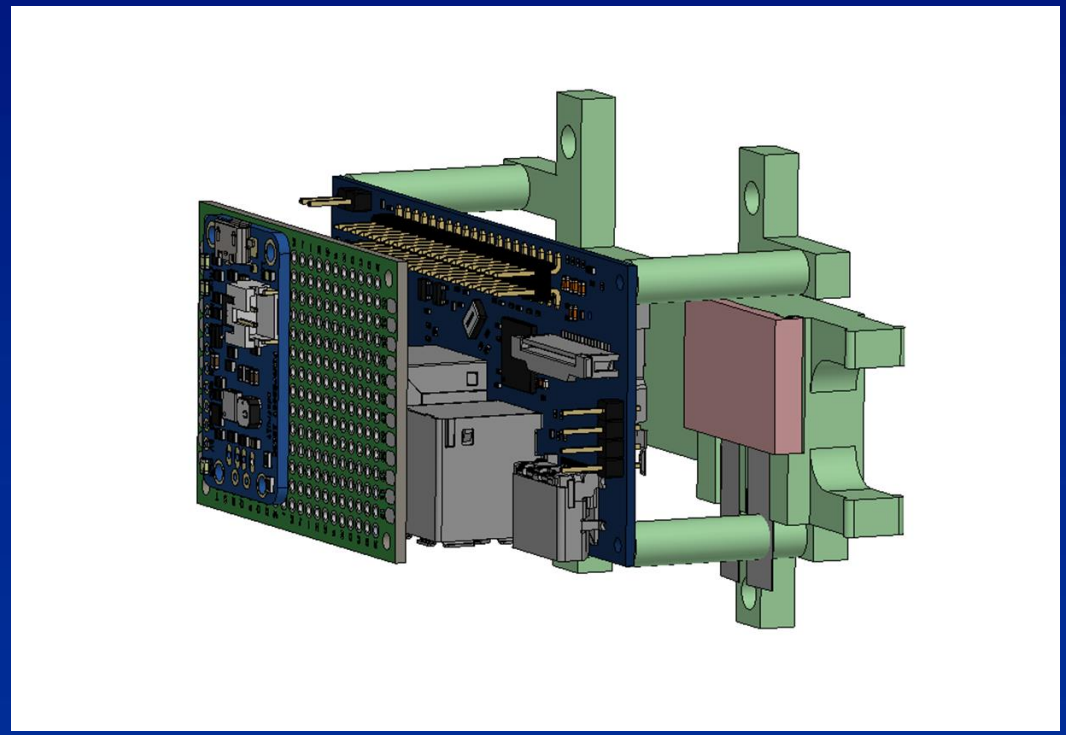
Initial Testing

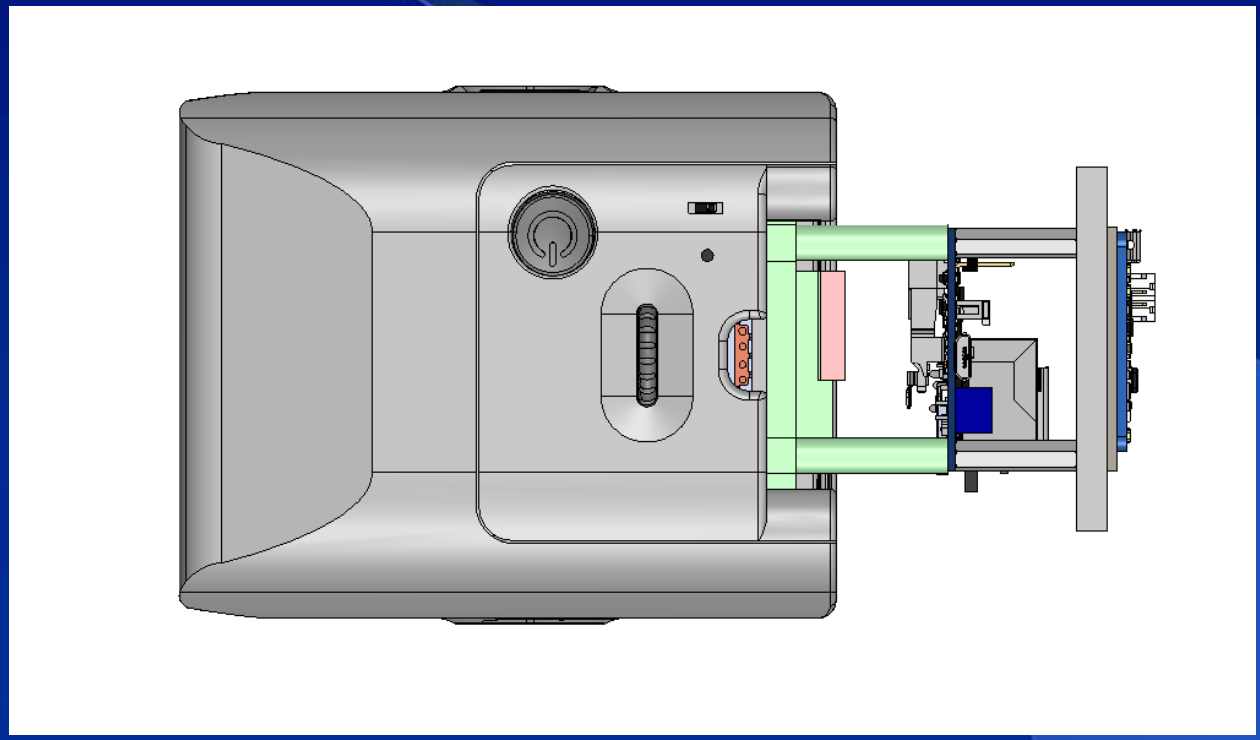
Optics Assembly



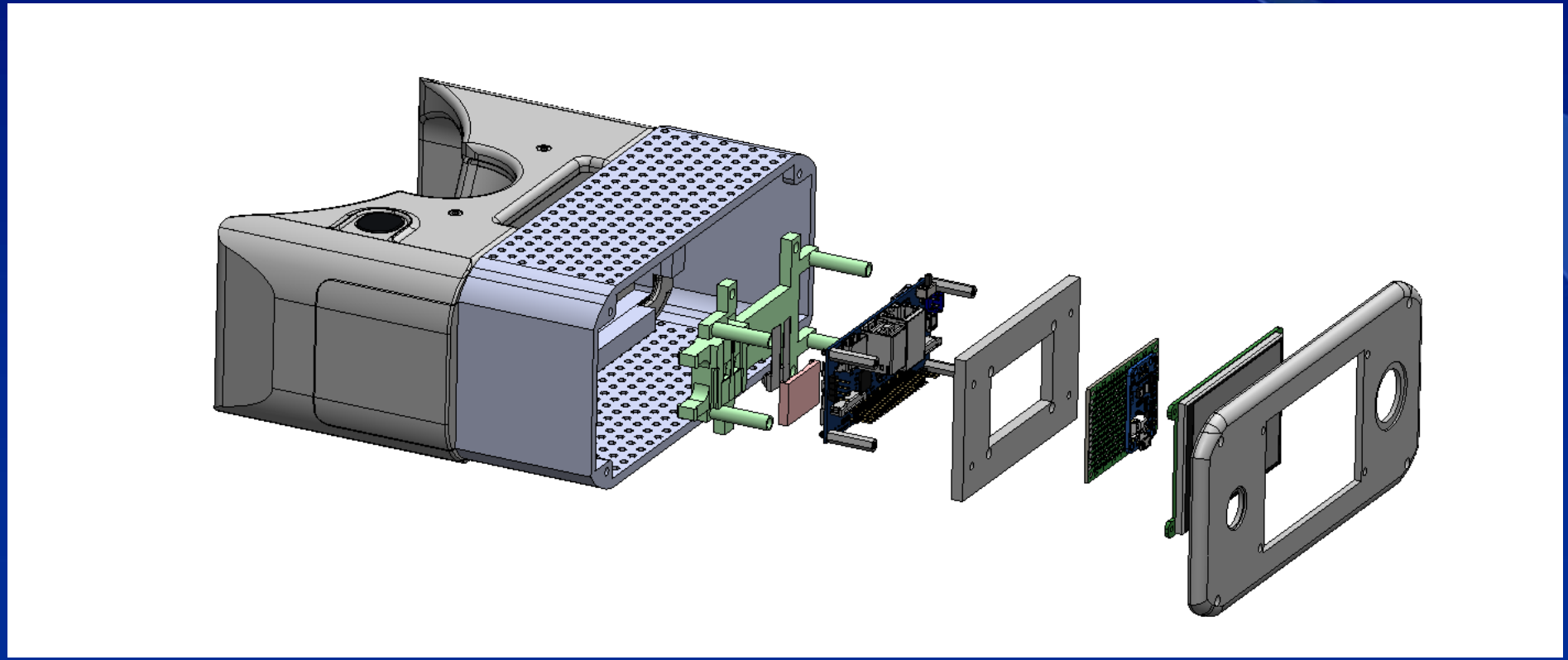


Internal Electronics Subassembly





Exploded View of Enclosure



3D Printed Prototype