IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

# Fluorescence Polarization Using Smartphone-Based System

*ECpE Senior Design*
*Group: DEC1616*

*Advisor: Meng Lu*
*Members: Tianqi Luo, Xin Tong, Le Wei, Di Zhao*

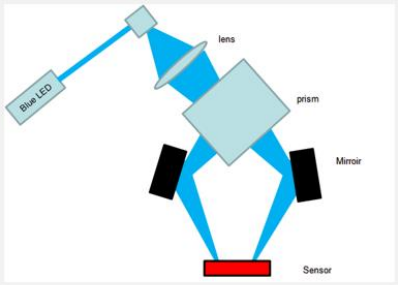
# Scope:

With innovation of technology, Portable Based Device System has been the trend in the world for a period of time.

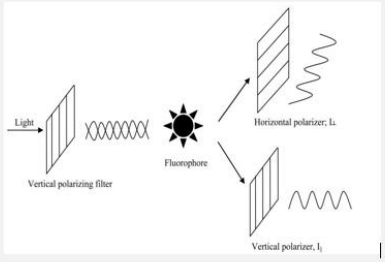
In our project, we will develop a mobile sensor technology for performing detection and identification of viral and bacterial pathogens.

This smart-phone based device system will bring update on Fluorescence Polarization, and also bring people convenience on health diagnosis.

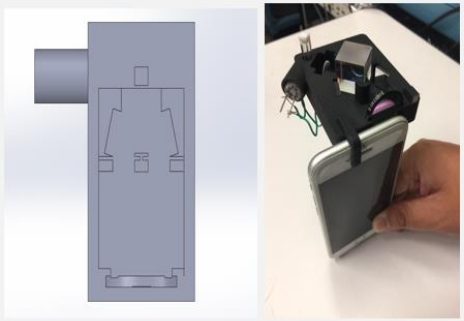
# Project Design



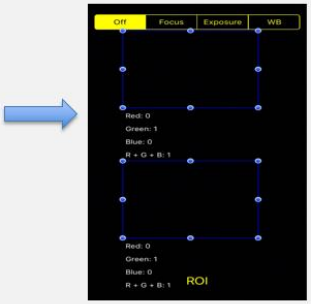

Optical Design




Fluorescence Polarization Assay



Optical Solidwork and 3D Print




App Design

- Using Lighttools to design optical model
- Designing structure by Solidworks
- Developing  App for FP assay

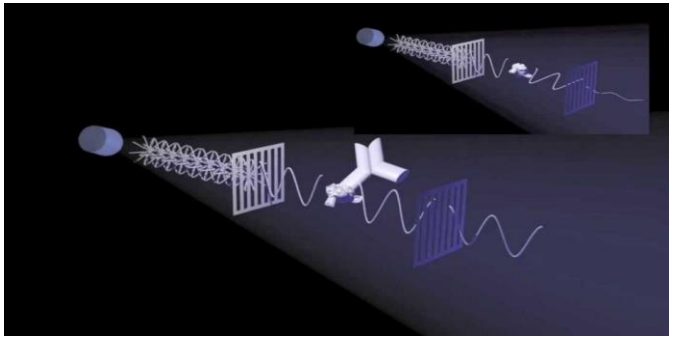
# Functional Requirement

Our system should be:

- compatible with mobile system.
- able to analyze the sample with data from indicators (will be shown in video later).
- finally calculate the polarization result based on the analyzed data.
- the whole process of measurement should take less than 10s.
- data is stored on iCloud, and can be accessed any time.

# Fluorescence Polarization (FP)

- Fluorescence polarization is 89 years old
- Perrin published the paper in 1926, which is the first research paper on FP.
- FP measurements are taken in real-time.



# Principle:

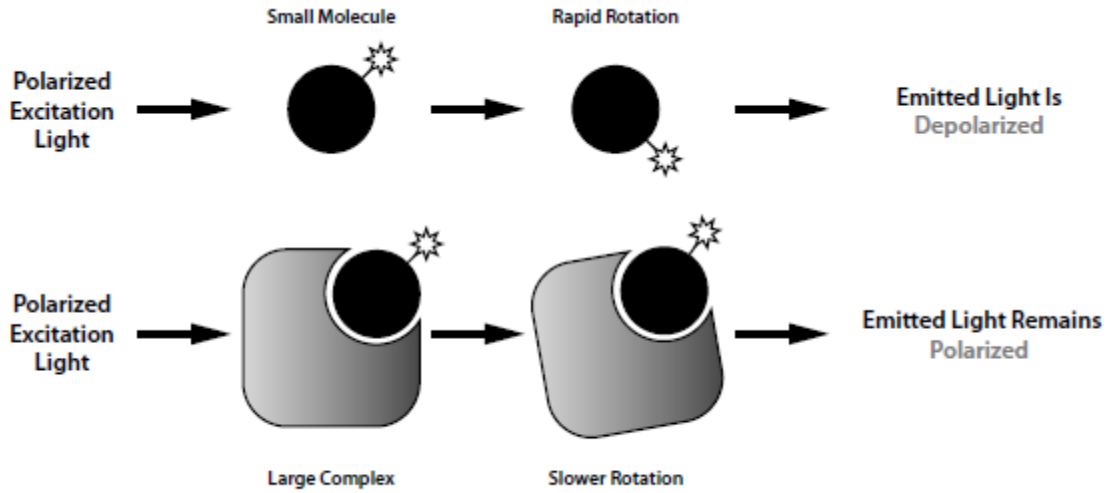
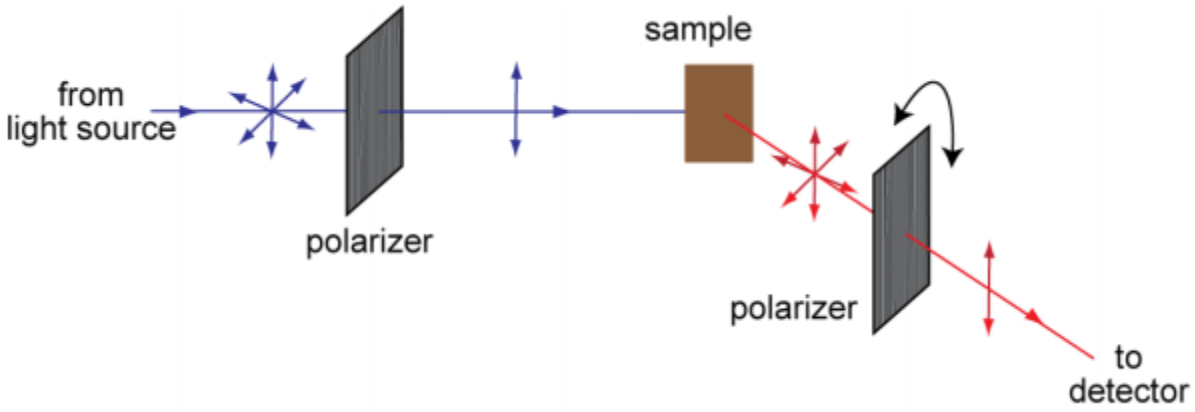



**Figure 1 .Principle of Fluorescence Polarization.**
*Small molecules rotate quickly during the excited state, and upon emission, have low polarization values. Large molecules, in this case caused by the binding of a second molecule, rotate little during the excited state, and therefore have high polarization values.*

- Protein needs to be large and Fluorescently labeled molecule should be small.

# Measurement



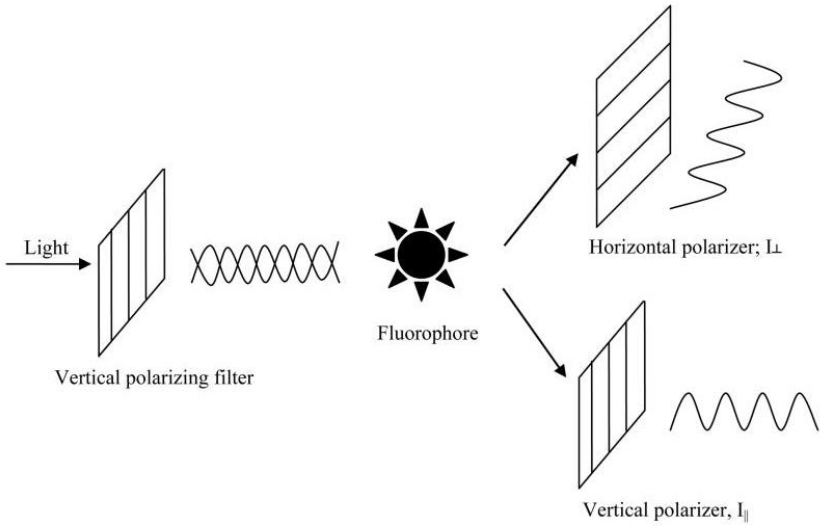

*Move vertical or horizontal*

Polarization ratio ( p ) → $$p = \frac{I_{\parallel} - I_{\perp}}{I_{\parallel} + I_{\perp}}$$

*where I|| and I⊥ are the intensity measurements of the emission signal made parallel to or orthogonal to*

# Advantage

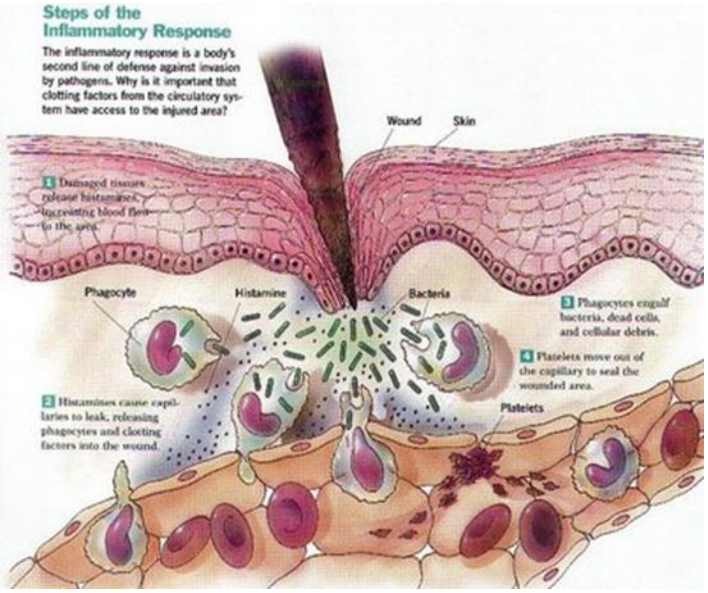
- low limit of detection
- No radioactive waste is generated
- Rapid response



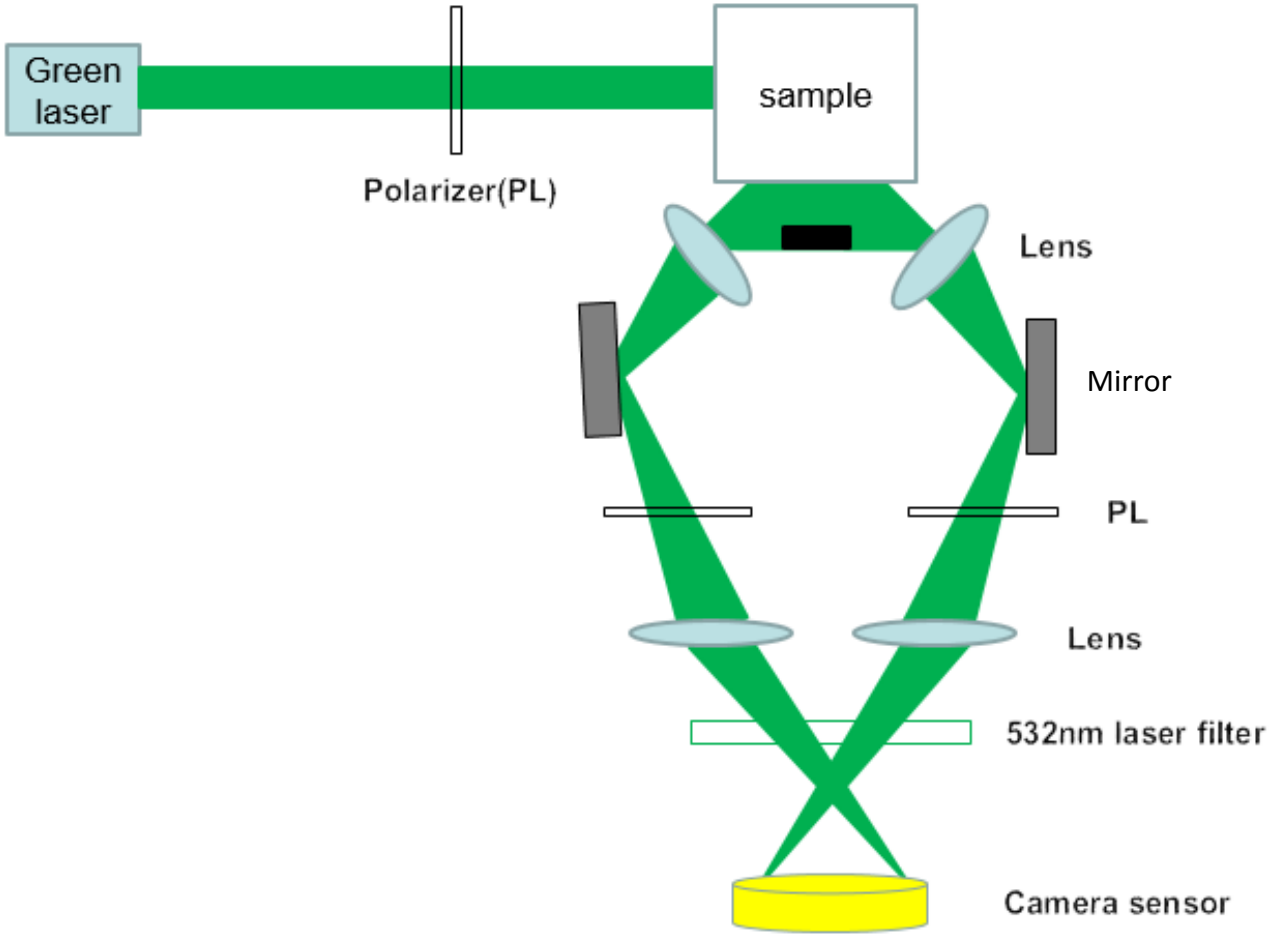
# R6G and C-Reactive Protein(CRP)

- We choose R6G (*Highly fluorescent dye*) and glycerol(*Big molecules*)to test our design in first semester to make sure it works well.

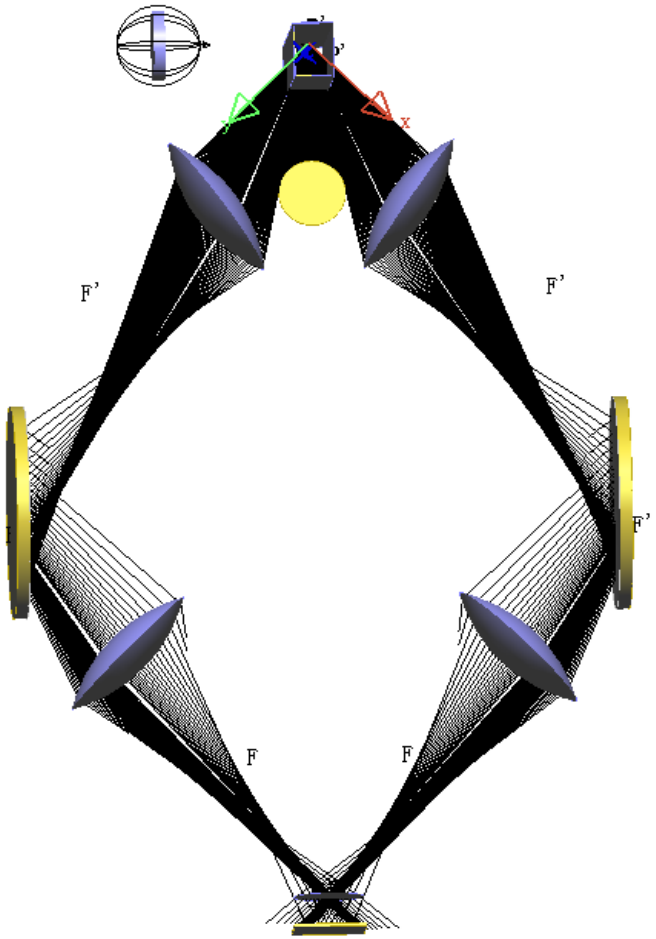
- Then we choose C-Reactive Protein(*The infection or tissue injury on body, which rises proteins*) to replace glycerol to measure data in real life.



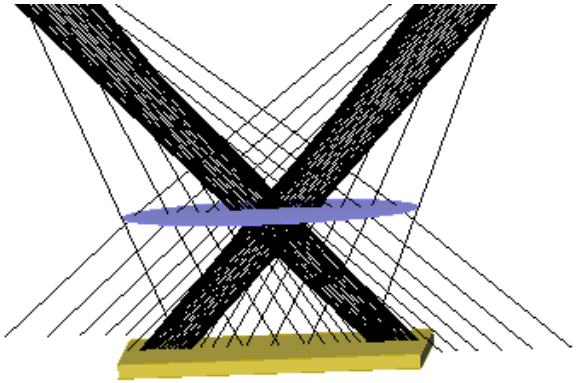
# 1st Generation



# Optical Simulation by Using Synopsys Software



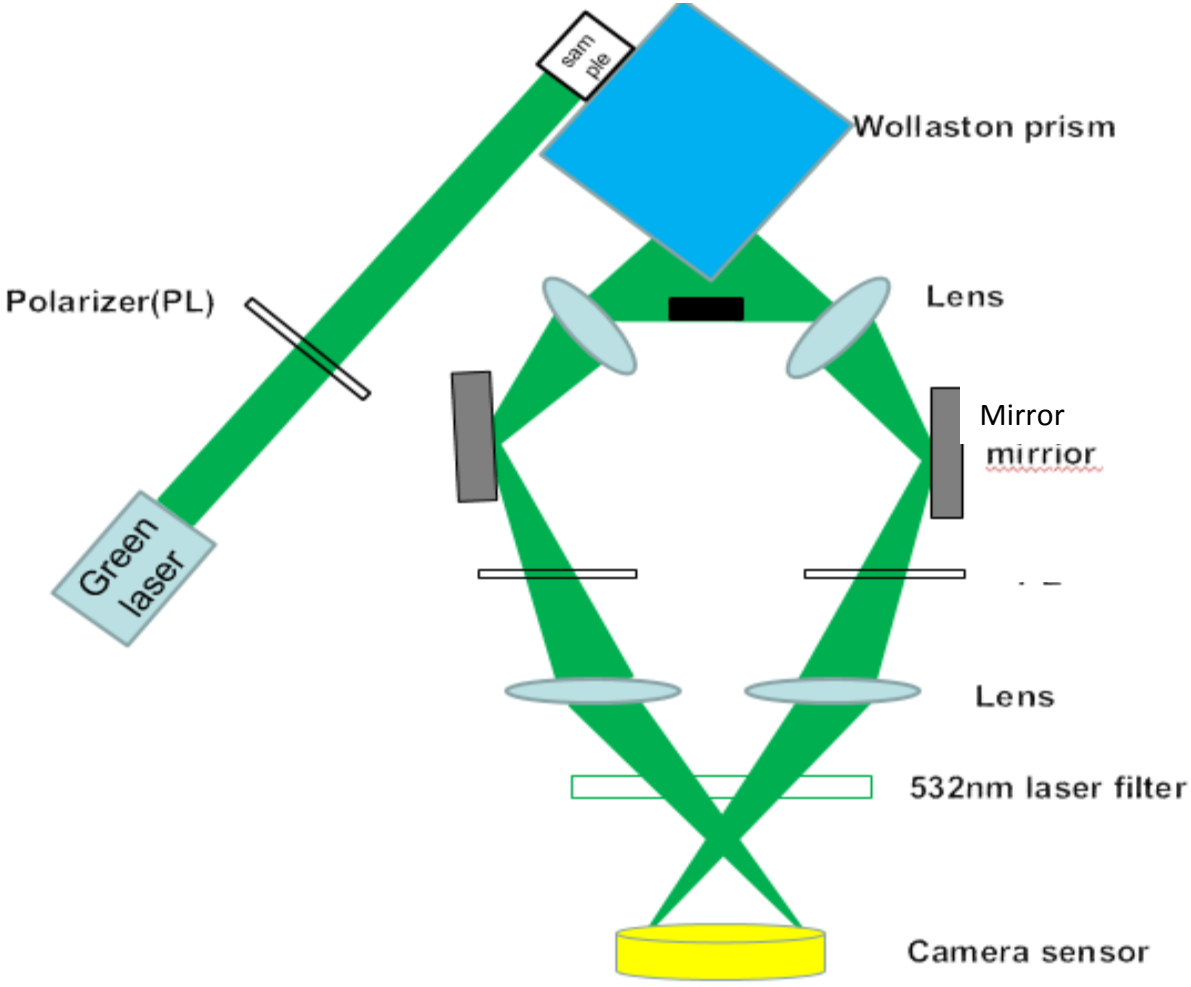

## ZOOM In



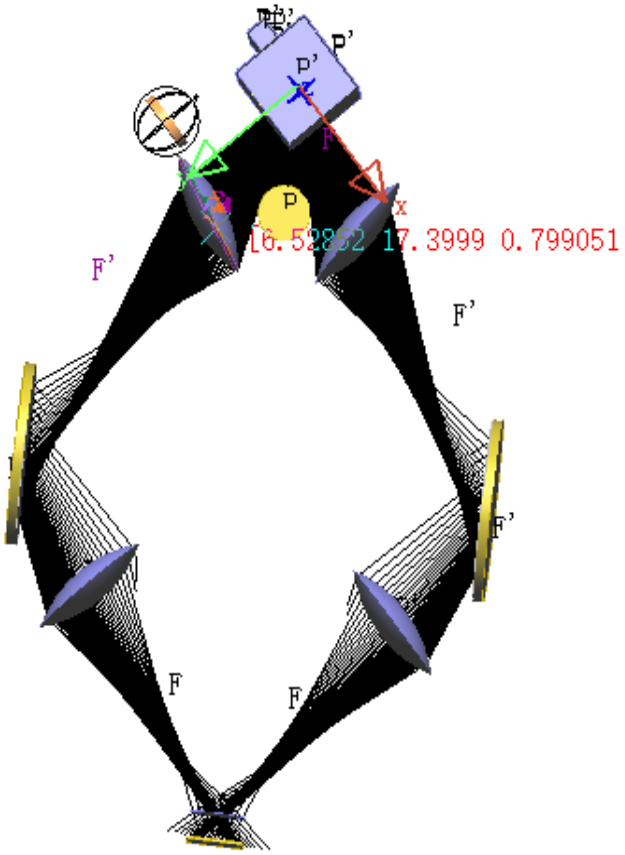
## Parameters

First two lens: diameter is 18mm. focal length is 15mm.
Second two lens: diameter is 10mm. focal length is 15mm.
Mirrors: diameter is 20
sample: 5mm width and 20mm height.
Whole device: 53.74mm width and 60mm length.

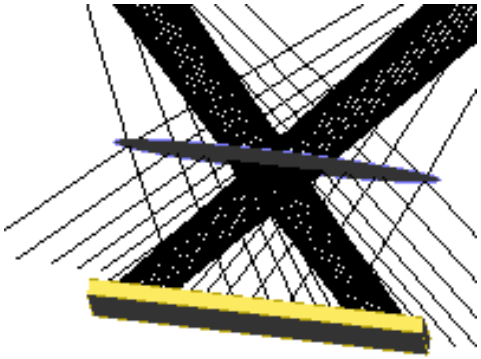
# 2nd Generation



# Optical Simulation by Using Synopsys Software



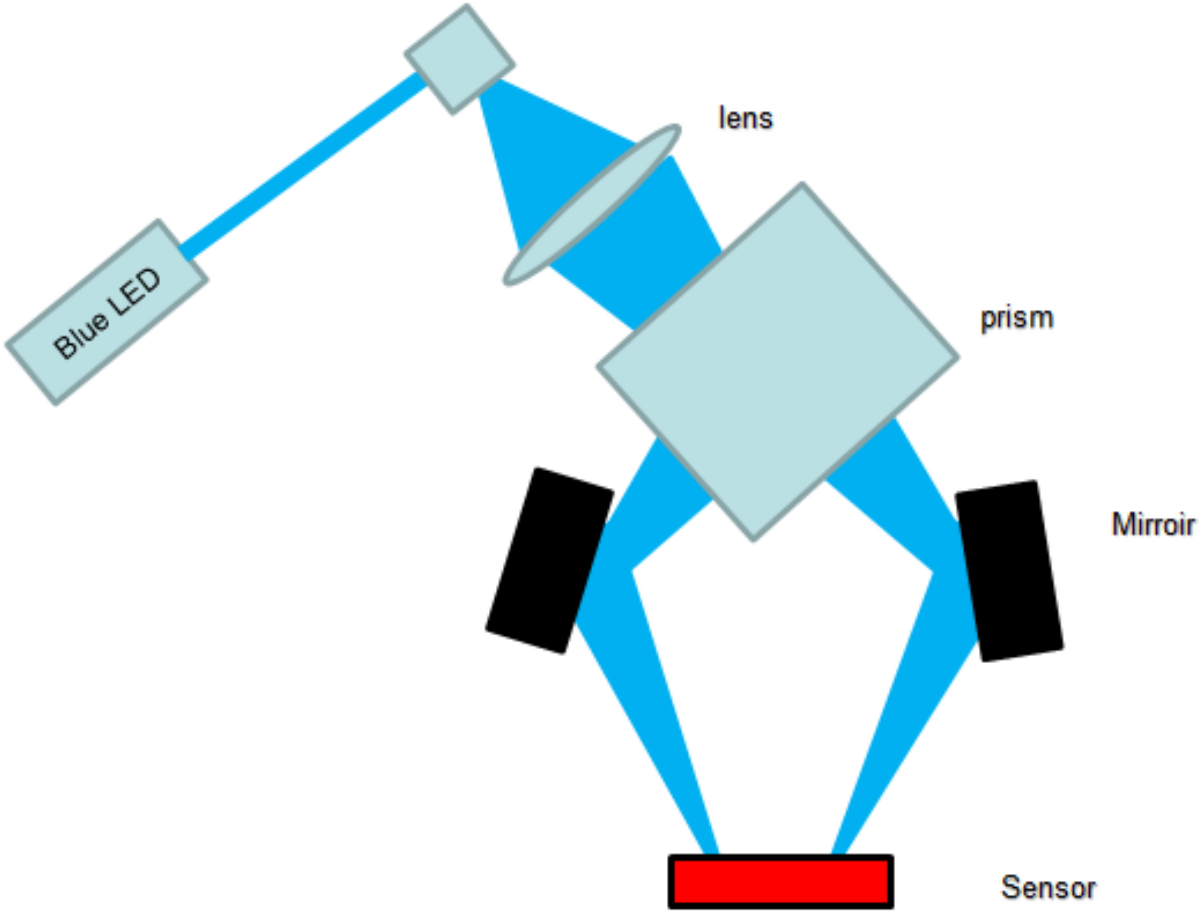

ZOOM In



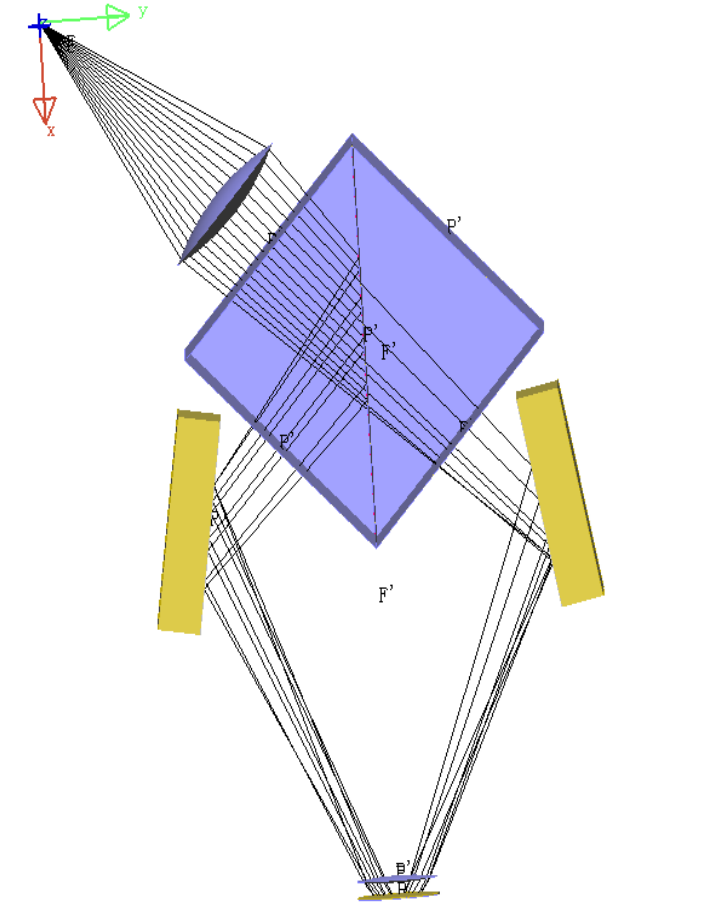
Parameters

First two lens: diameter is 18mm. focal length is 15mm.
Second two lens: diameter is 10mm. focal length is 15mm.
Mirrors: diameter is 20
sample: 5mm width and 20mm height.
Whole device: 53.74mm width and 72mm length.

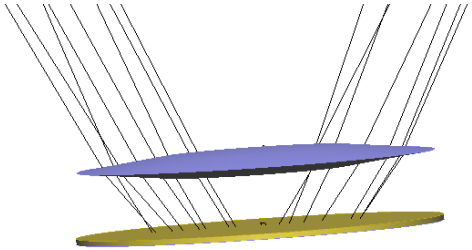
# 3rd Generation



# Optical Simulation by Using Synopsys Software



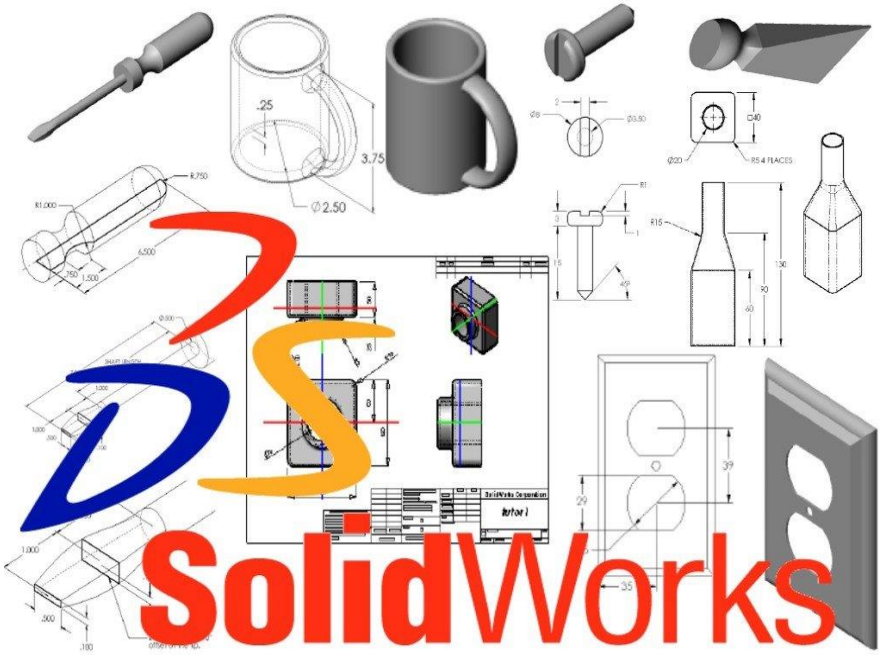

ZOOM In

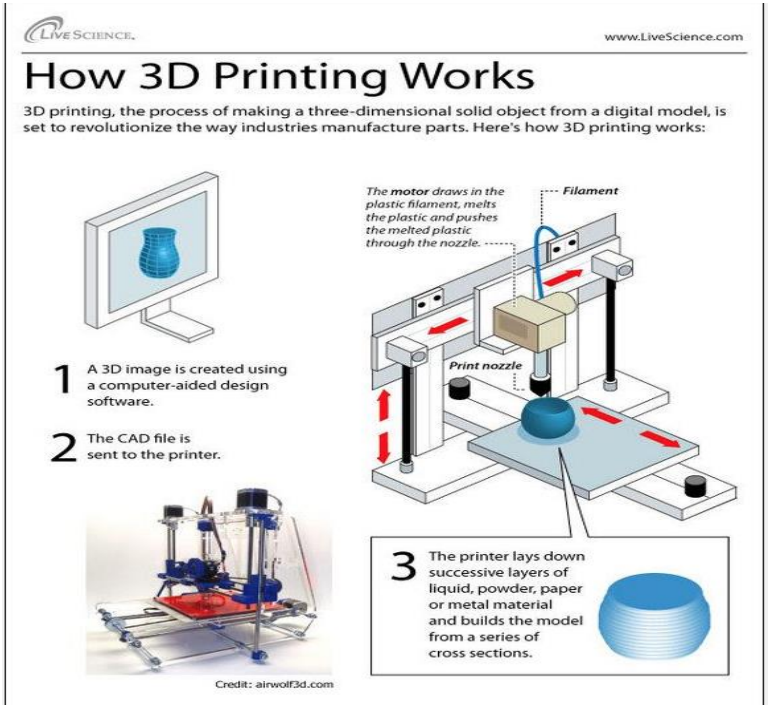


## Parameters

lens: diameter is 12.5mm. focal length is 16mm.
sample: 5mm width and 20mm height.
Whole device: 60mm width and 80mm length.

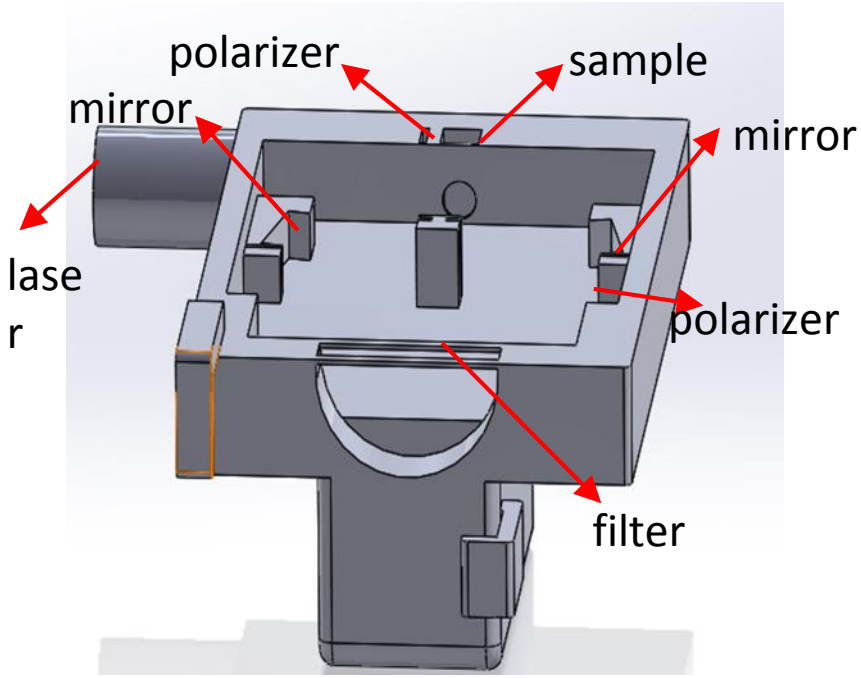
# SolidWorks and 3D Printer



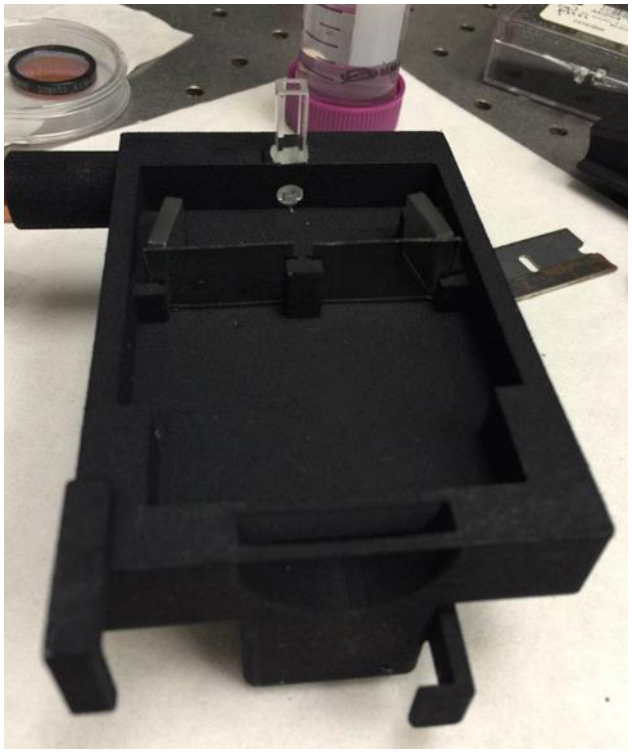



# 1st Generation Design

Designed in SolidWorks



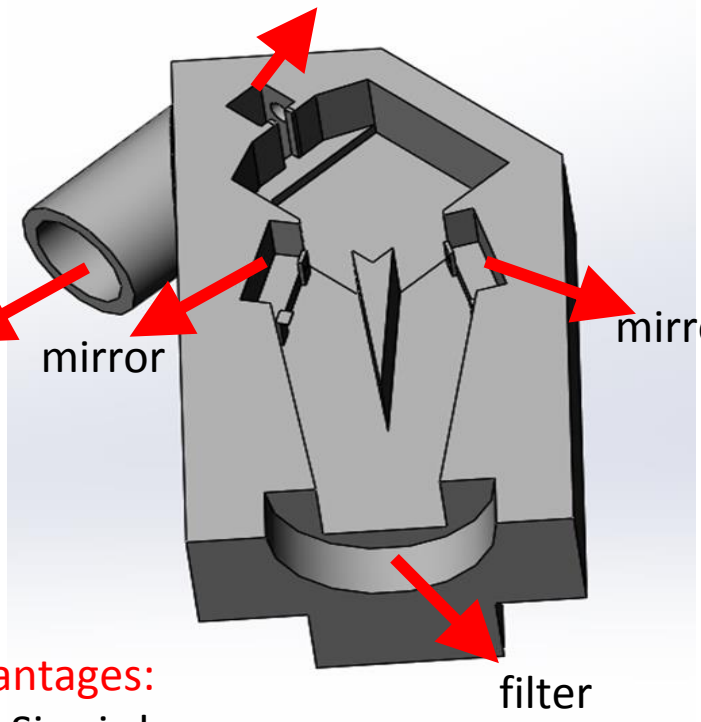

The Real Model



SIZE

# 2nd Generation Design

Designed in SolidWorks



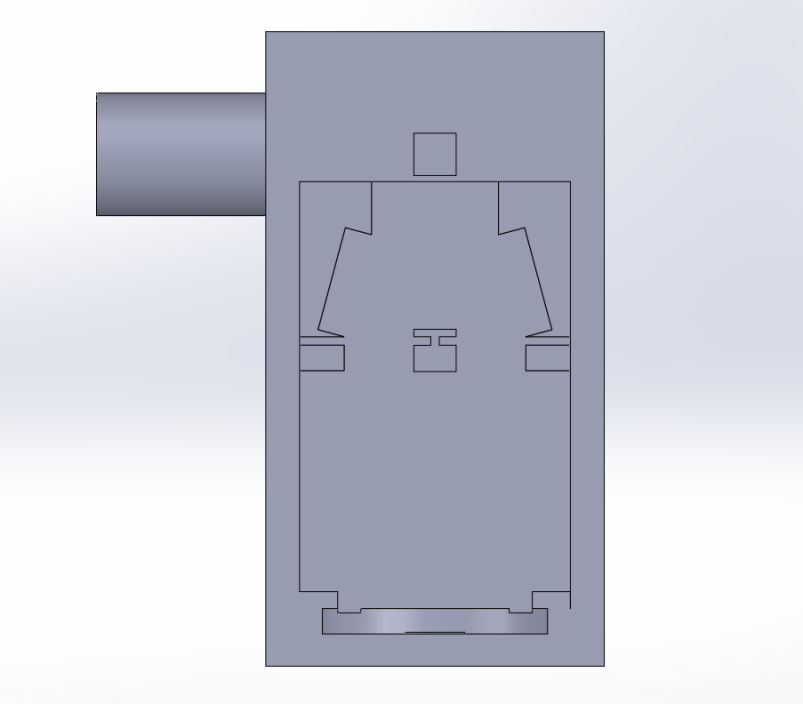

The Real Model

Advantages:

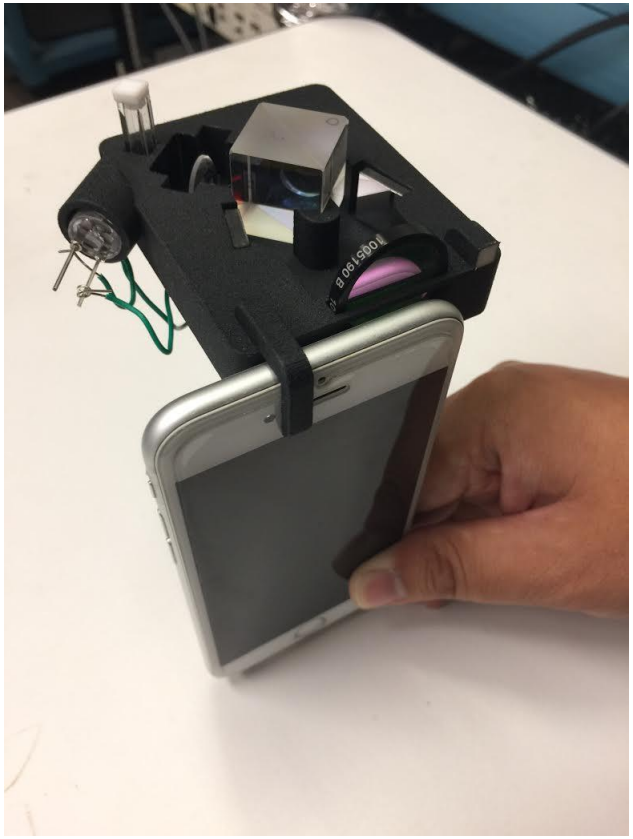
- Size is larger
- Structure is more compact
- We use the beam splitter to get the image clearly
- Increasing the ratio of the light beam

# 3rd Generation Design

Designed in SolidWorks



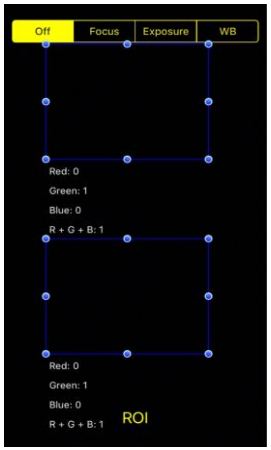
The Real Model



# Flowchart

- CCD is working on ADC (Analog Digital Conversion).
- Digital image will be displayed on mobile screen.
- App is analyzing the color and calculate the polarization based on coding.

CCD



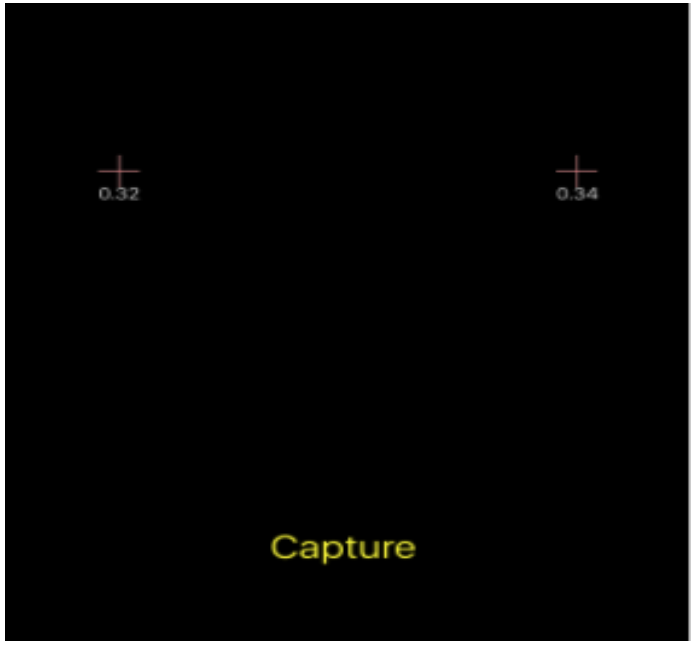

App
Platform

Code

# New FP APP

For demonstration to clients purpose, we design this new app.

One UI only, user is able to operate for testing.



# Updates from old App

Instead of using resizable rectangle feature, the indicators are changed to two crosses.

Cross indicators are movable by touch hold.

Attached at bottom of two indicators are calculated data “Intensity”

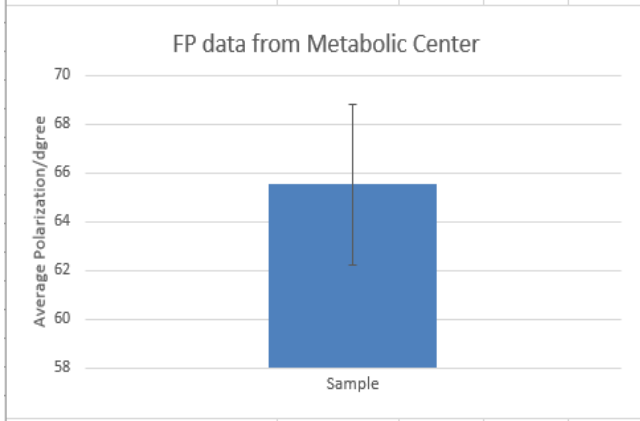
Intensity is dynamically roaming based on the location of indicators

# Video for testing

# Data Graph

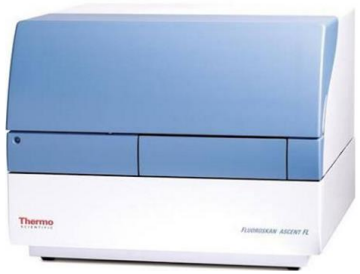
| FP Test | | 1st TEST | 2nd Test | 3rd Test | 4th Test | Average |
|---|---|---|---|---|---|---|
| Sample 1 Whole R6G | Sample 1 | -1.63282 | -0.71586 | 0.76097 | 2.00697 | 0.104815 |
| Sample 2 R6G : Glycerol 4:1 | Sample 2 | 4.72059 | 7.54502 | 9.95417 | 6.24277 | 7.115638 |
| Sample 3 R6G : Glycerol 1:1 | Sample 3 | 13.54107 | 23.80695 | 22.88187 | 28.12515 | 22.08876 |
| Sample 4 R6G : Glycerol 1:2 | Sample 4 | 62.79327 | 64.8936 | 65.74705 | 68.64647 | 65.5201 |
| | Sample | 65.5201 | | | | |
| | Sample | 45.63 | | | | |

| | | | | |
|---|---|---|---|---|
| Parallel Intensity | 1978 | 2052 | 2045 | 2037 |
| Parallel Intensity | 1890 | 1959 | 1980 | 1931 |
| Parallel Intensity | 497 | 521 | 500 | 520 |
| Parallel Intensity | 1838 | 1821 | 1709 | 1710 |
| Perpendicular Intensity | 1984.47 | 2054.94 | 2041.89 | 2028.84 |
| Perpendicular Intensity | 1872.24 | 1929.66 | 1940.97 | 1907.04 |
| Perpendicular Intensity | 483.72 | 496.77 | 477.63 | 491.55 |
| Perpendicular Intensity | 1620.81 | 1599.06 | 1498.14 | 1490.31 |




# Approximate Cost

| Item | Qty. | Cost(each). | Part Description |
|---|---|---|---|
| 1 | 2 | $70.00 | Send the design to the 3D printer company to print the model |
| 2 | 1 | $140.00 | Glass Cuvette |
| 3 | 2 | $15.00 | Buy 4 Convex lens |
| Total | 5 | $225.00 | |



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# Technical Consideration

- Holder is not very stable for the smartphones. **We make a little design to make it perfect.**
- Intensive light: Some laser is intensive enough to hurt human's eyes. **We use led instead of the laser.**
- Light from environment can affect the result. **We make the cover to make sure the data is accurate.**
- App UI is misplaced due to updates on Xcode.

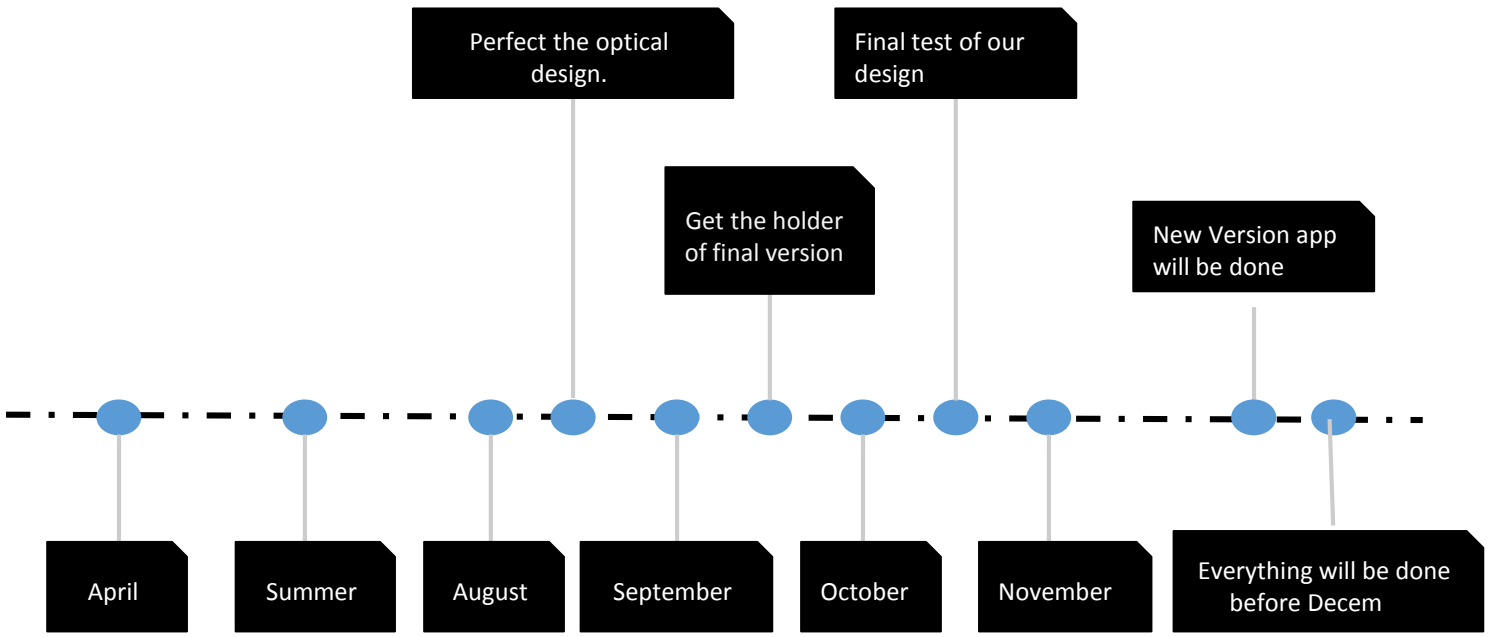
# Test Plan

- Application design: test if the application in the smartphone can catch and analyze the lights.
- Sample analyze: test if the data from the apps match the theoretical value.

# Current Project Status

- Optical design: we finish the 3rd version of our optical design, and it works.
- 3D printer design: we sent the blueprint to the company, and we have both 1st,2nd and 3rd version of holder.
- Application design: new version of APP has been made, and is under utilizing.
- Sample analyze: we get the data from the center and compare with our experience.

# Time Line


Perfect the optical design.
Final test of our design
Get the holder of final version
New Version app will be done
April
Summer
August
September
October
November
Everything will be done before Decem

# Questions