



Shack-Hartmann Based Aberrometers & Basic DirectShow Concepts

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Talk Outline

- Concepts.
- Multiwavelength Shack Hartmann Aberrometer.
- PEWE (Pediatric Wavefront Evaluator).
- DirectShow.



Typical Values

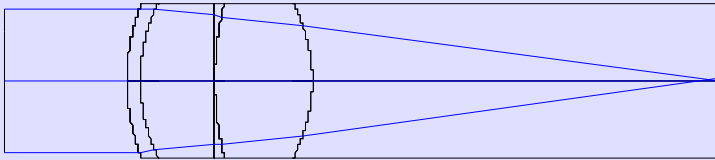
- In the study done by Thibos et. al. regarding the aberration of the Human eye on group of 100 people, they found
 - 3.1D mean spherical equivalent
 - and standard deviation of 3.0D

Although this study group was more myopic because it was chosen from the student body which more likely to be so.

- The higher order aberration were less and averaged out to 0 but spherical aberration tended to be non zero and positive.

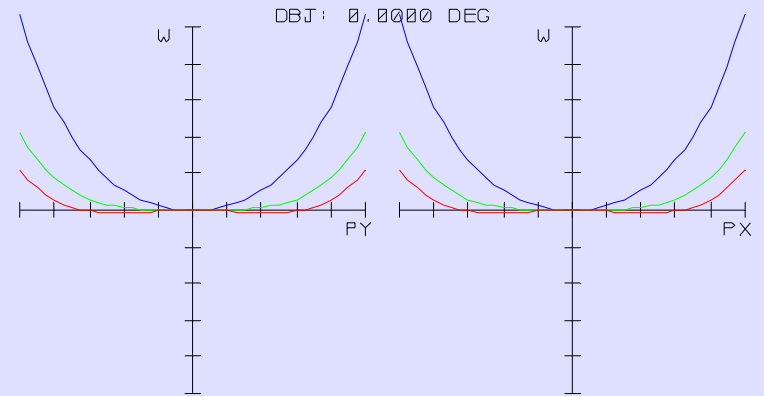


Chromatic Eye



L

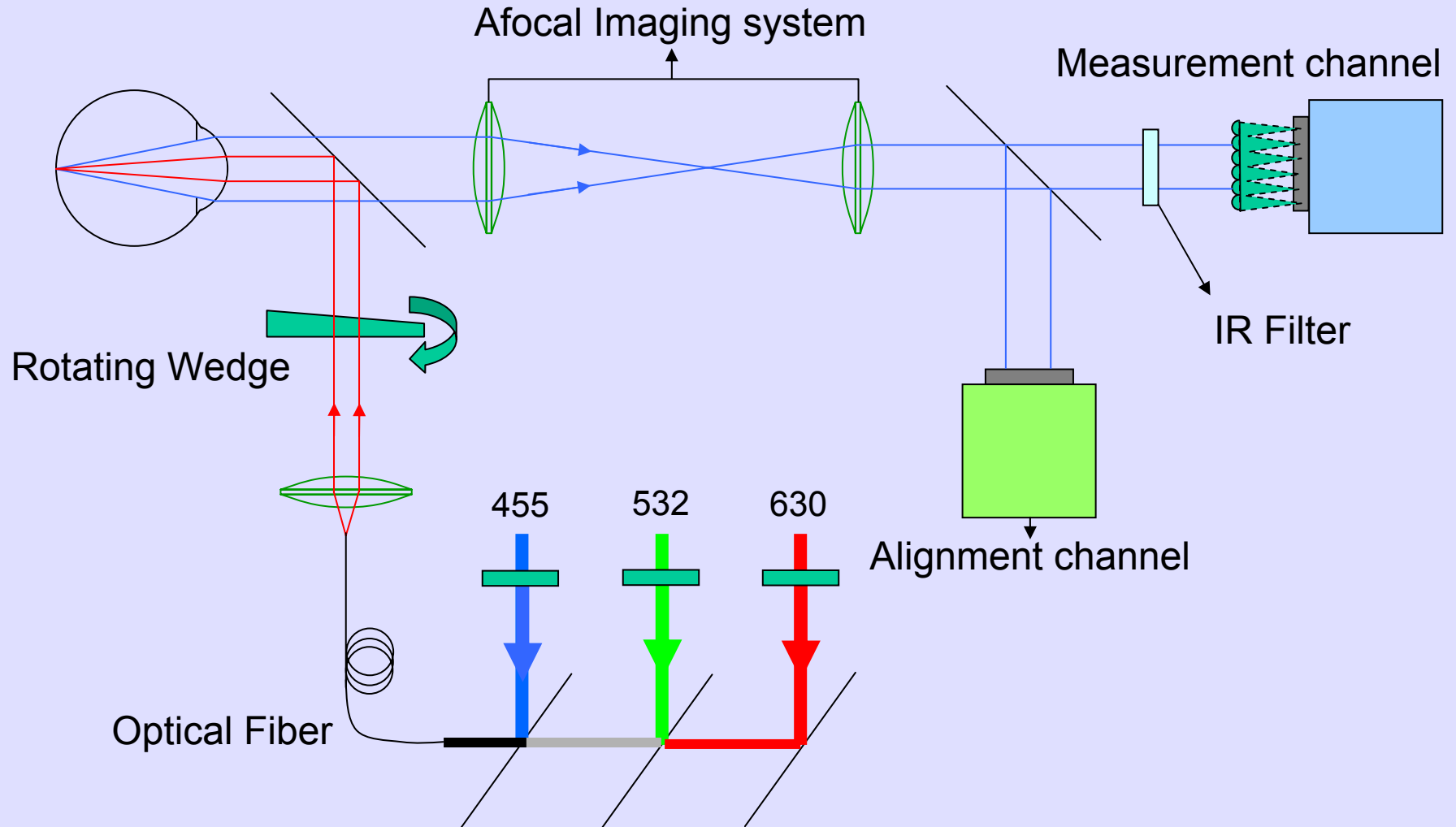
Red to Blue change of power is about 1.24D and in terms of focus position it is 0.25mm



OPTICAL PATH DIFFERENCE	
ENS HAS NO TITLE.	
FILE DCT ? 2004	
MAXIMUM SCALE: ± 10.000 WAVES.	
.486 0.588 0.656	
EYE MODEL ZMX	

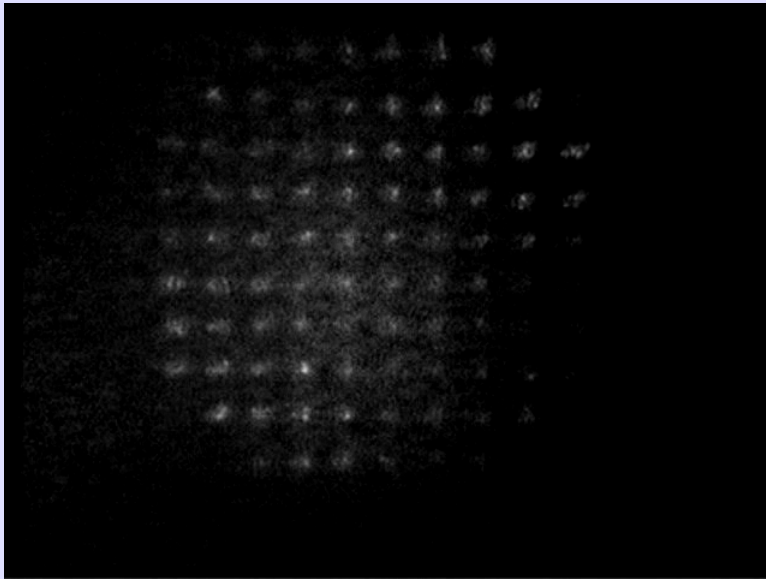


Design Layout

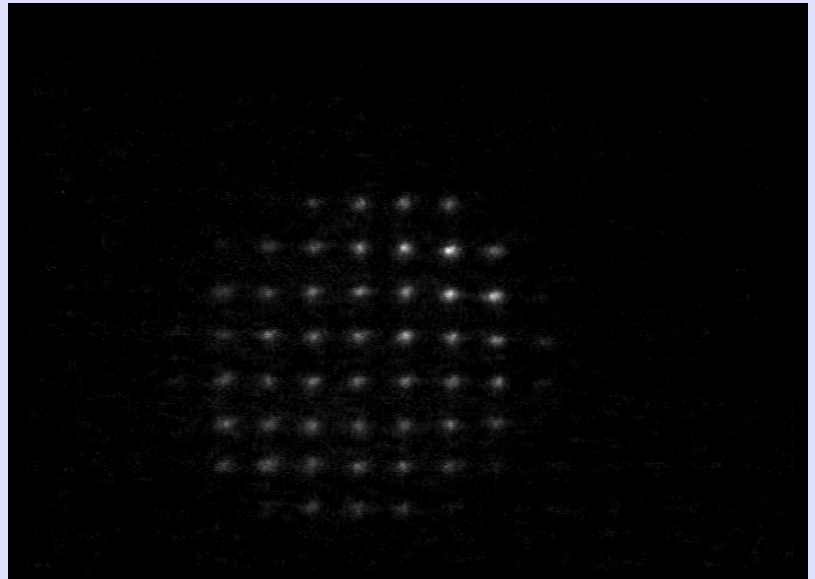




Effect of Rotating Wedge



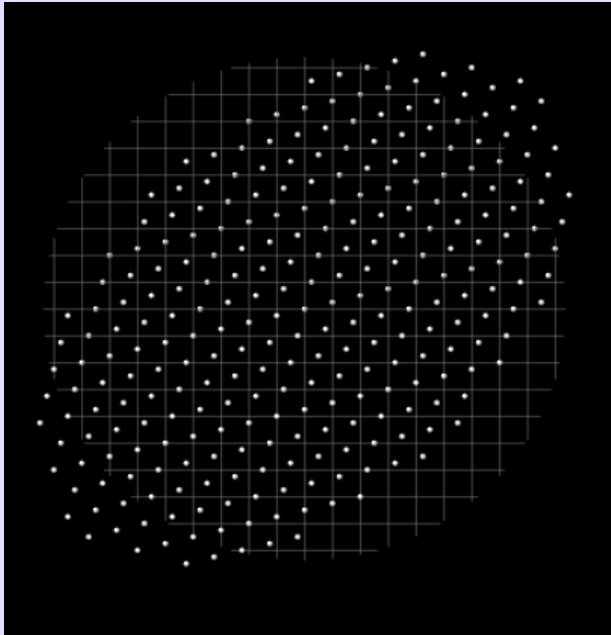
Wedge not rotating



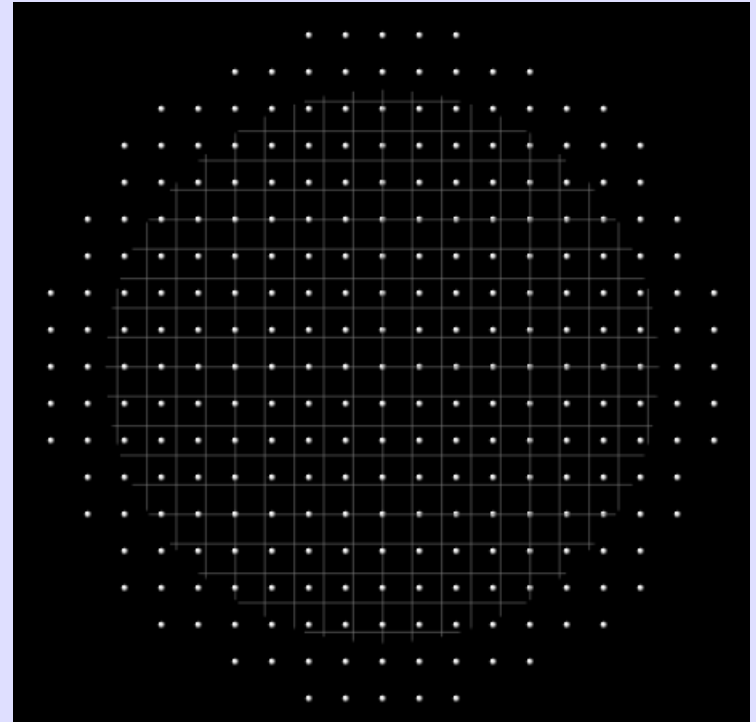
Rotating wedge



Simulations



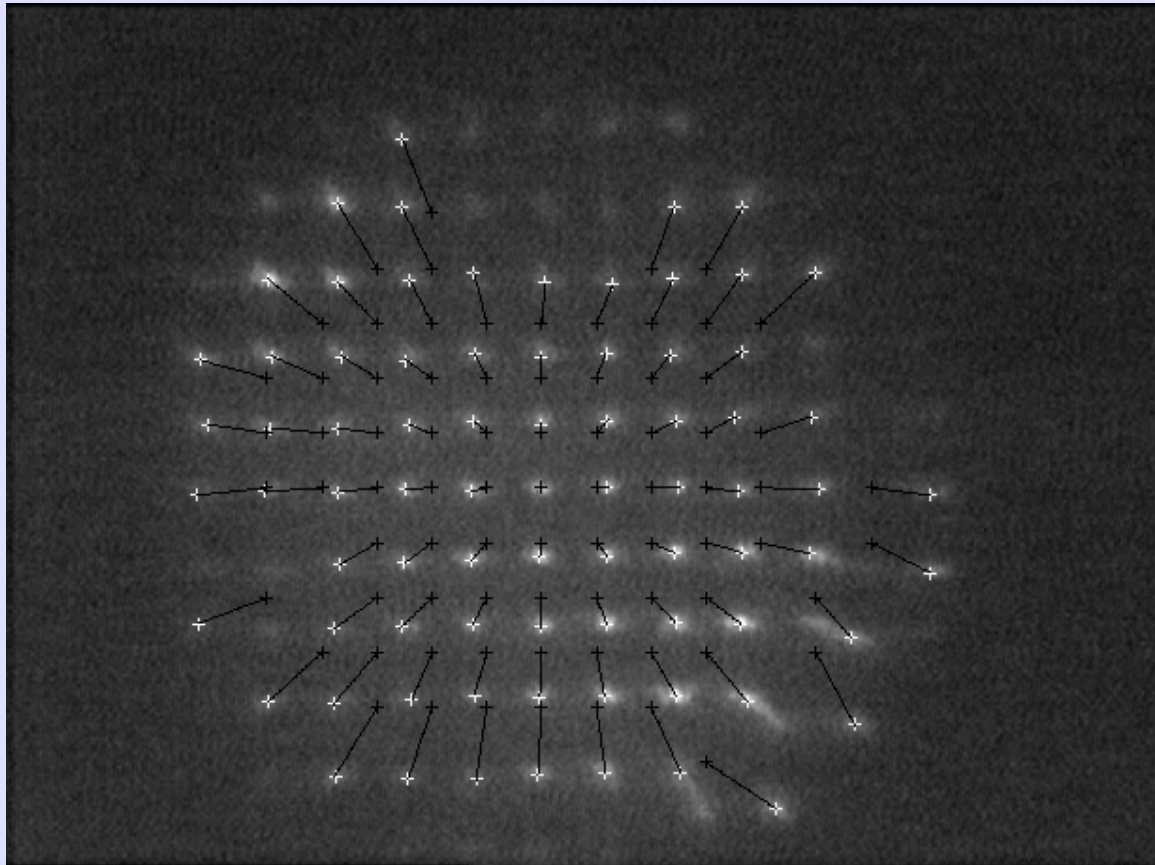
Astigmatism



Defocus



Algorithm



Spot_array = {s₁, s₂, s₃.....s_i.....s_n}



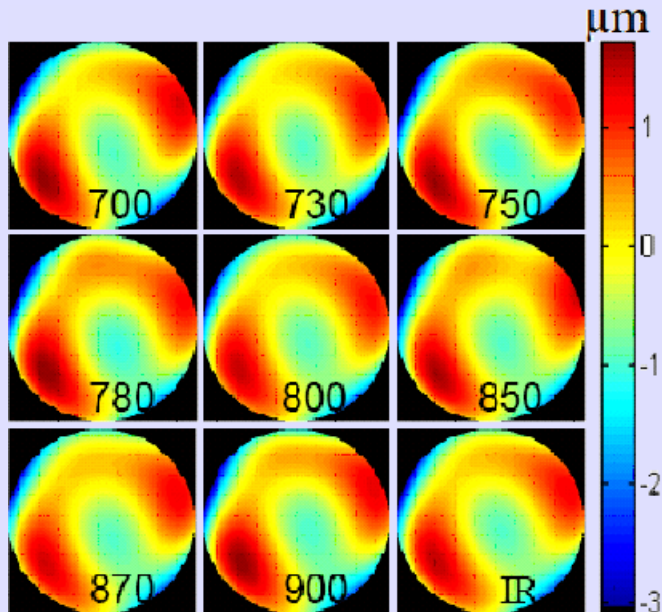
Algorithm

- Transfer slopes and reference spot locations to object space.
- Generate the slope matrix based on the reference spots.
- Do the least square's fit.



RGB Motivation

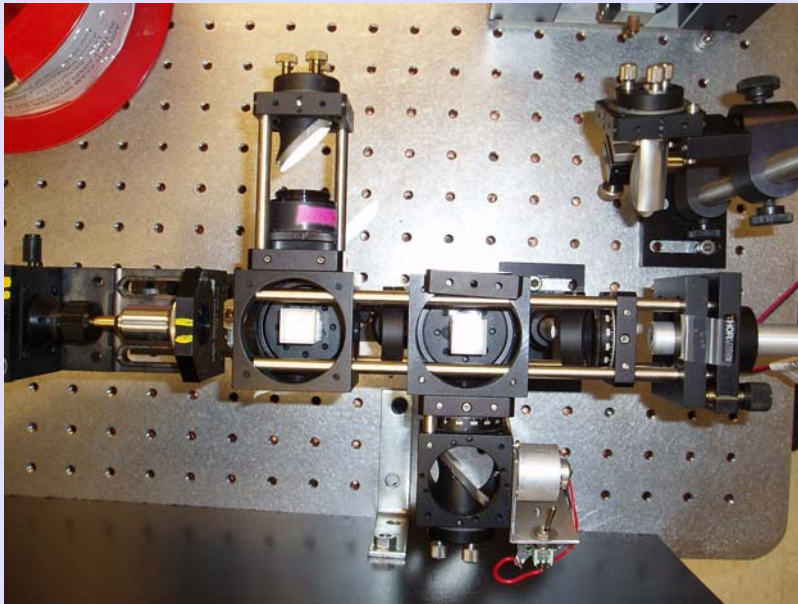
- Red to blue change in power is about 2 diopters.
- Depth of focus maximization and chromatic aberration.
- Accommodation and chromatic aberration.
- Higher order aberration variation with wavelength:



Enrique J. Fernández et al.



Apparatus



Human subjects protection program office
approval required



Issues with Visible Light

- Reflectivity of retina at visible wavelength is less compared to infrared wavelengths.
- Color CCD cameras are less sensitive as well, putting more pressure on the signal strength.
- Allowed power limit for the three wavelength separately is: 50 μW for 455 nm, 400 μW for 532 and 630 nm.
- Power going in the eye was: 10 μW for 455 nm and 12 μW for 630 and 532 nm.



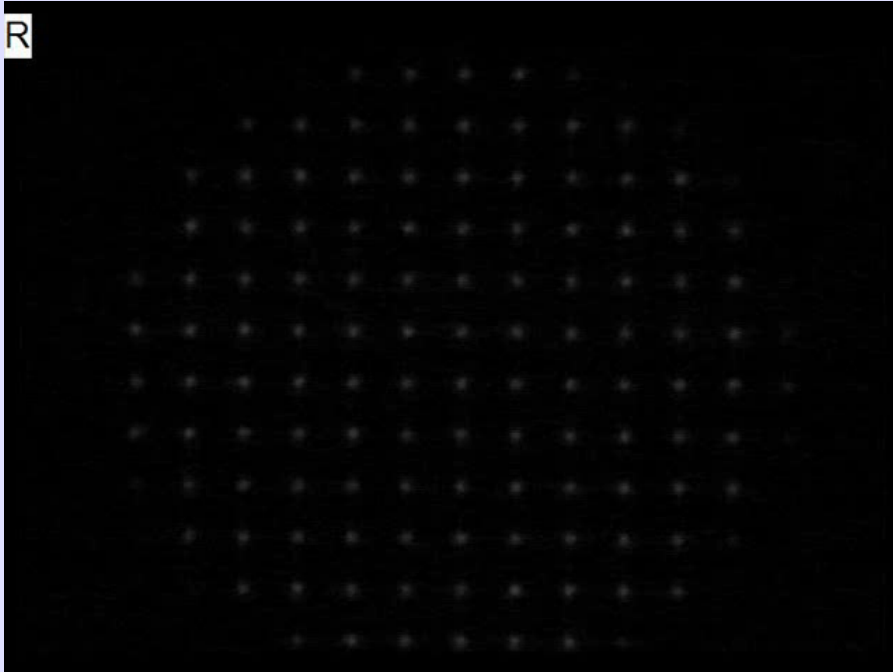
Color Calculations

$$\vec{L} = \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad \vec{C} = \begin{bmatrix} r \\ g \\ b \end{bmatrix} \quad \leftrightarrow M = \begin{pmatrix} r_1 & r_2 & r_3 \\ g_1 & g_2 & g_3 \\ b_1 & b_2 & b_3 \end{pmatrix}$$

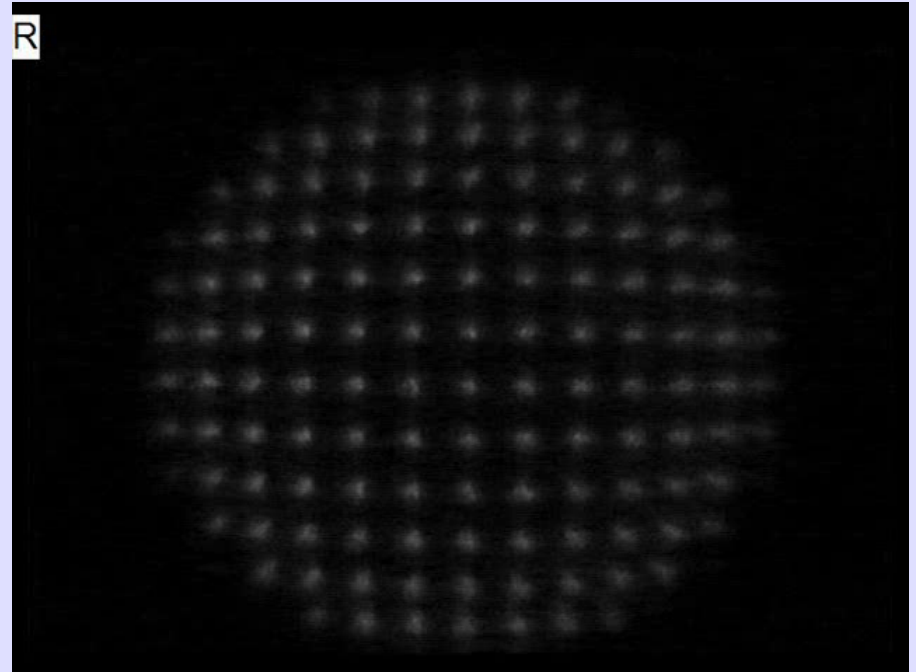
$$\leftrightarrow M \cdot \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} r_1 \\ g_1 \\ b_1 \end{bmatrix} \quad \leftrightarrow \vec{M} \cdot \vec{L} = \vec{C} \quad \Rightarrow \vec{L} = M^{-1} \cdot \vec{C}$$



Chromatic Aberration of Lens



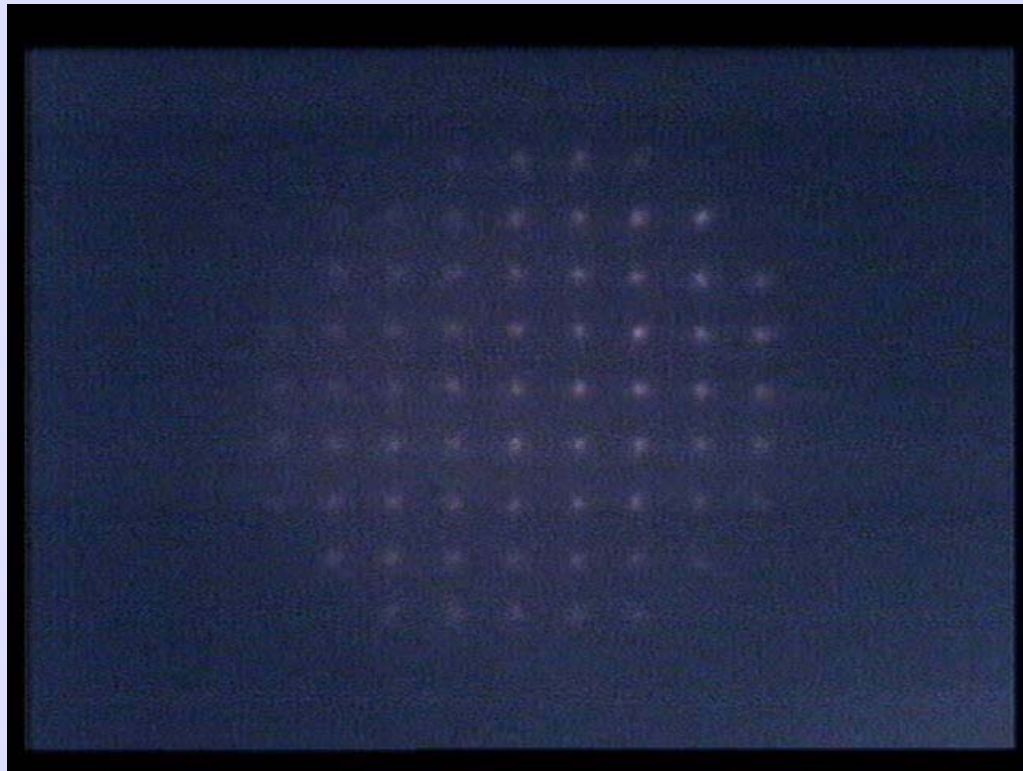
Achromatic doublet



Singlet lens

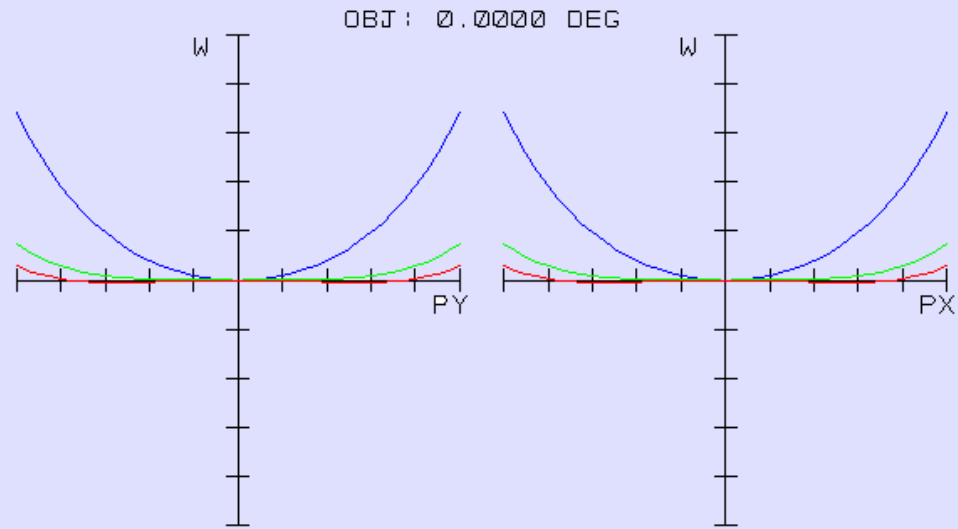
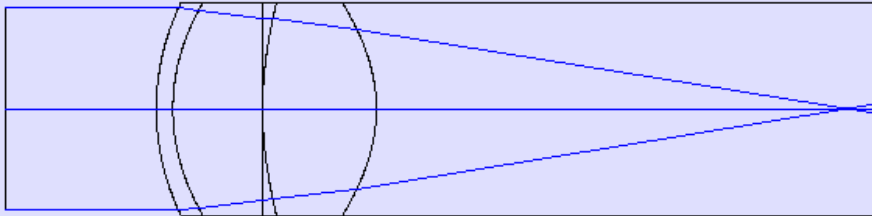


Human Subject Data



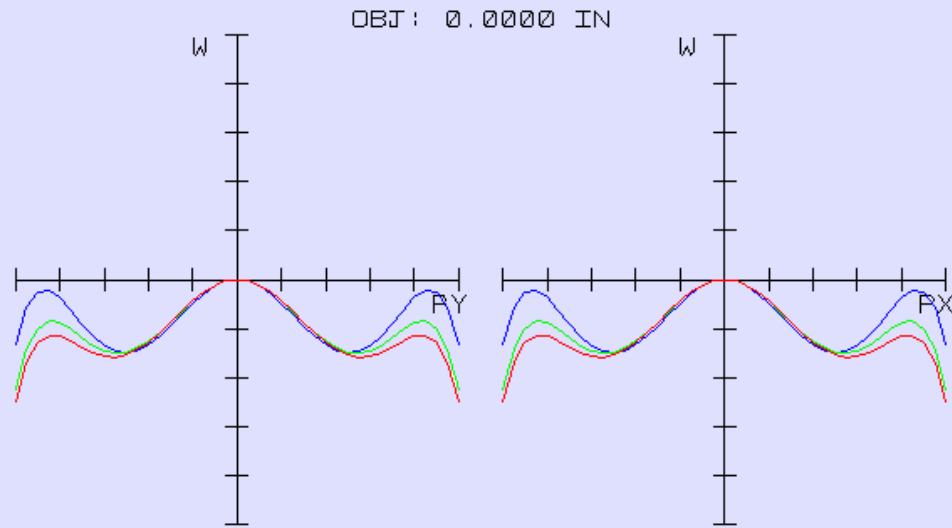


Achromatization of the Eye



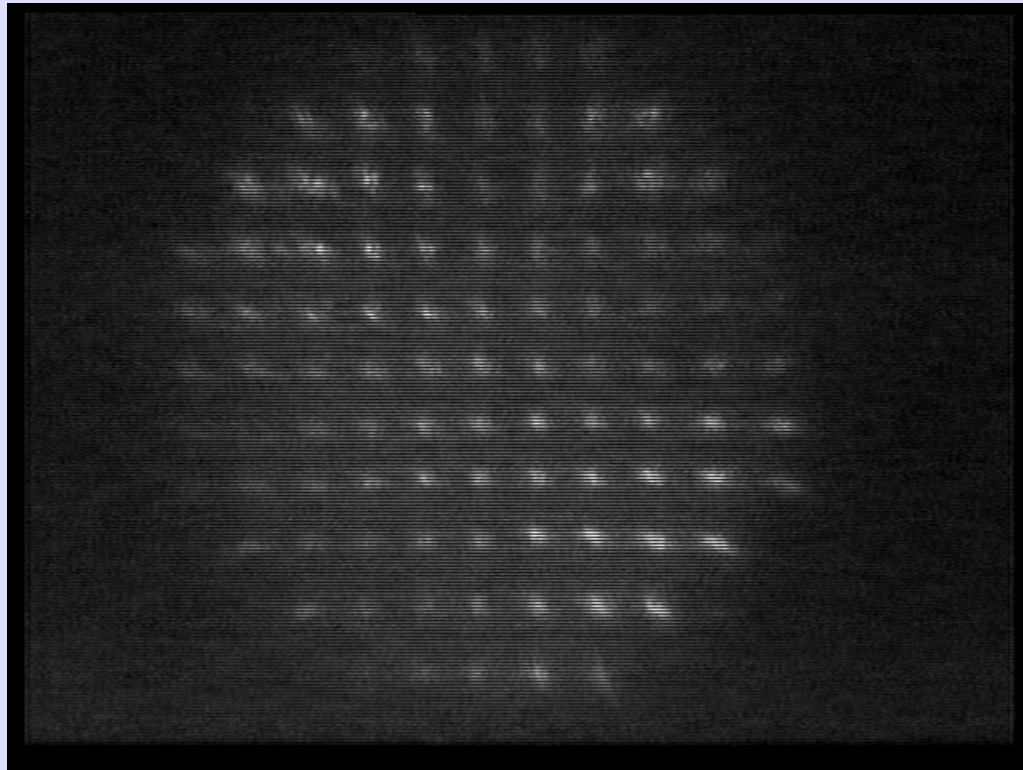


Achromatization of the Eye





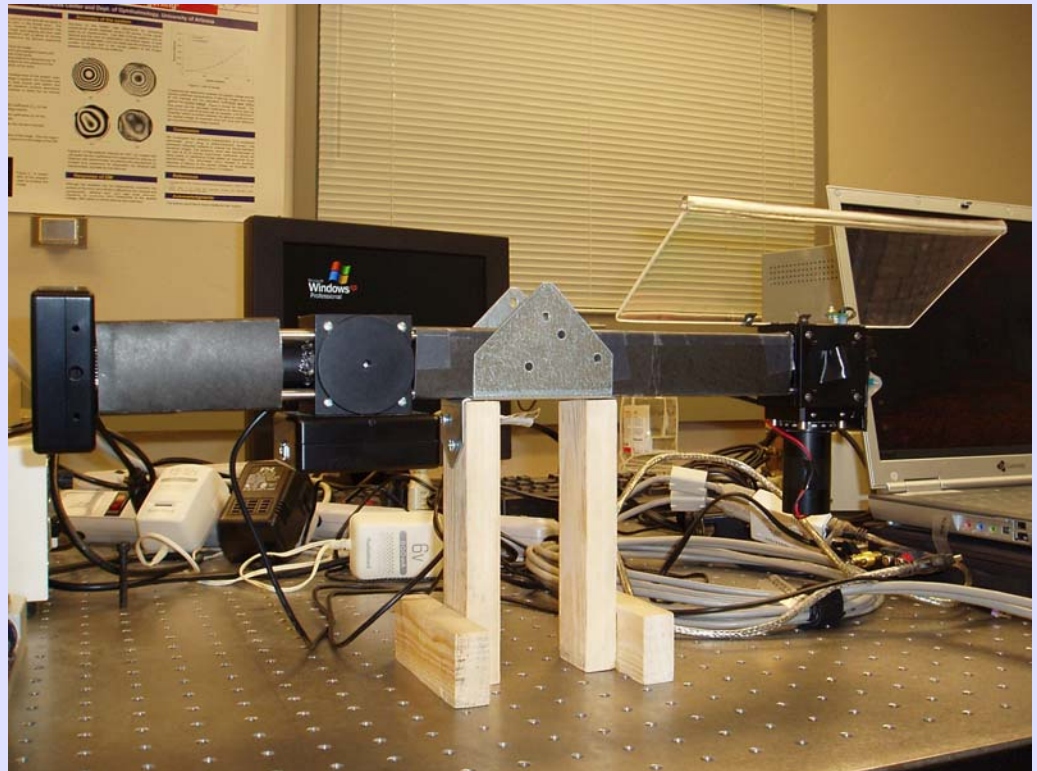
Human Subject Data





PEWE Motivation

- Kids
- Unobtrusive






PEWE Screen Shot





DirectShow

- A component of Direct X 9.0 
- Microsoft DirectShow is an architecture for streaming media on the Microsoft Windows platform.
- Complete SDK freely downloadable from Microsoft.com
- Does not work with QuickTime formats (Apple).



Why DirectShow

- Different camera, different SDK.
- Same application controls many cameras.
- Optimized to exploit any hardware acceleration.
- Don't have to worry about different media type formats.



Hardware and DirectShow

- Camera or frame grabber driver based on WDM or the driver is specifically written for DirectShow.
- Go digital instead of analog.
- Some hardware do not support DirectShow.



Underlying Concept

- Component based programming.





Sample Program

- Cut and past is the name of the game.

```
hr = CoCreateInstance(CLSID_FilterGraph, NULL, CLSCTX_INPROC_SERVER,  
                    IID_IGraphBuilder, (void **)&pGraph);
```

```
hr = pGraph->QueryInterface(IID_IMediaControl, (void **)&pControl);
```

```
hr = AddFilterByCLSID(pGraph, CLSID_AsyncReader, L"File Reader", &pFileReader);
```

```
hr = pFileReader->QueryInterface(IID_IFileSourceFilter, (void **)&pSource);
```

```
hr = pSource->Load(compfilename, NULL);
```

```
hr = ConnectFilters(pGraph, pFileReader, pAVISplit);
```

```
hr = pControl->Run();
```



References

1. “The Eye’s Mechanisms for Autocalibration”, Heidi Hoffer and David R. Williams, *Optics & Photonics News*, January 2002.
2. “Imperfect optics may be the eye’s defence against chromatic blur”, James S. McLellan et al., *Nature* Vol. 417, 9 May 2002.
3. “Effects of longitudinal chromatic aberration on accommodation and emmetropization”, Anne Seidemann, Frank Schaeffel, *Vision Research* 42 (2002) 2409–2417.
4. “Ocular aberrations as a function of wavelength in the near infrared measured with a femtosecond laser”, Enrique J. Fernández et al., 24 January 2005 / Vol. 13, No. 2 / *Optics Express*.