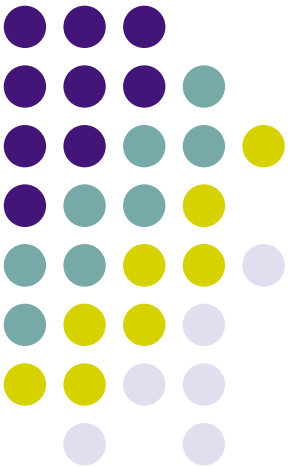
Optical Spectroscopy of Transparent Conducting Oxides – a method for determining the refractive index.



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Senior Thesis Presentation

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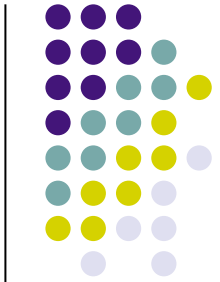
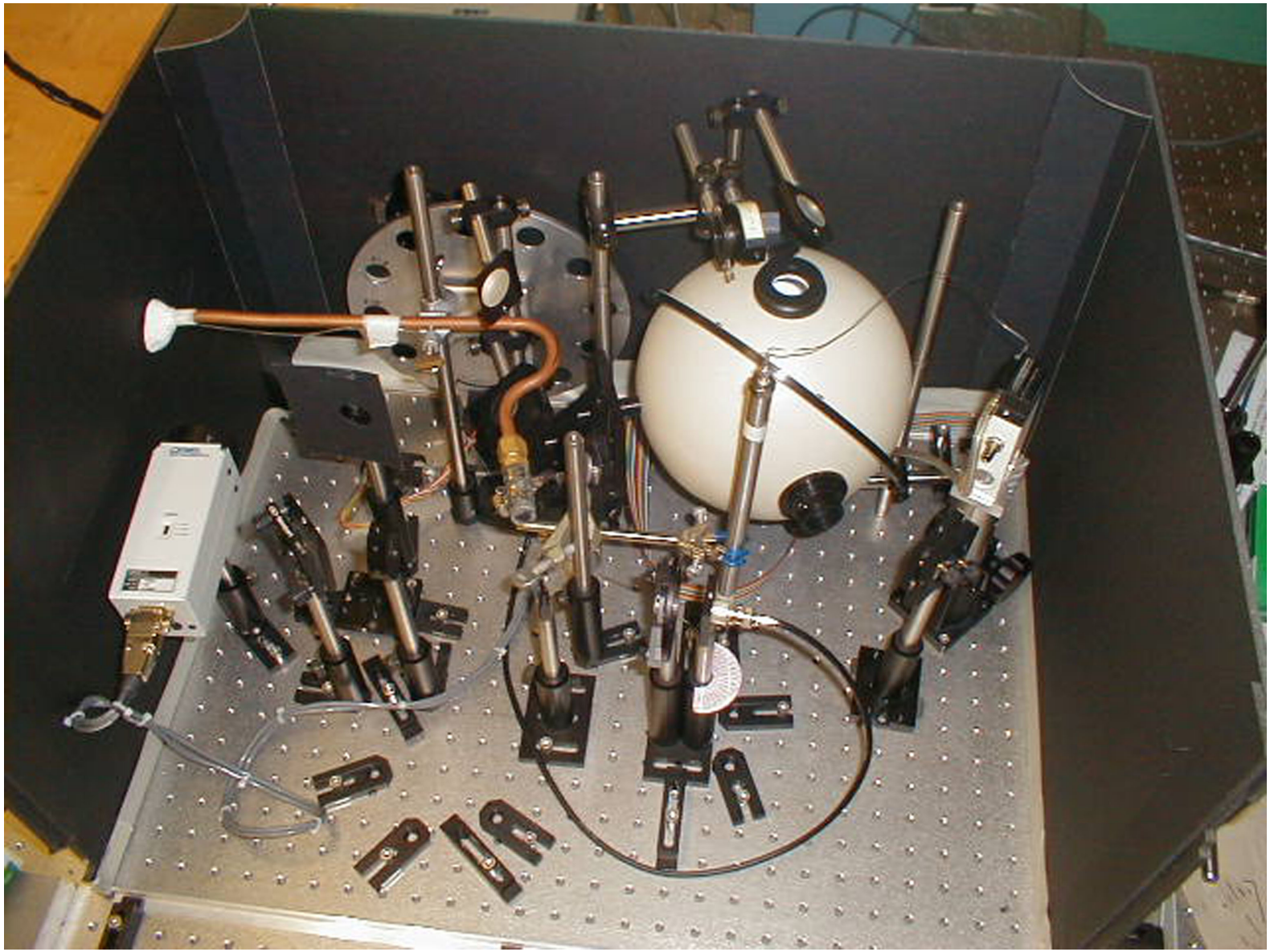
Outline

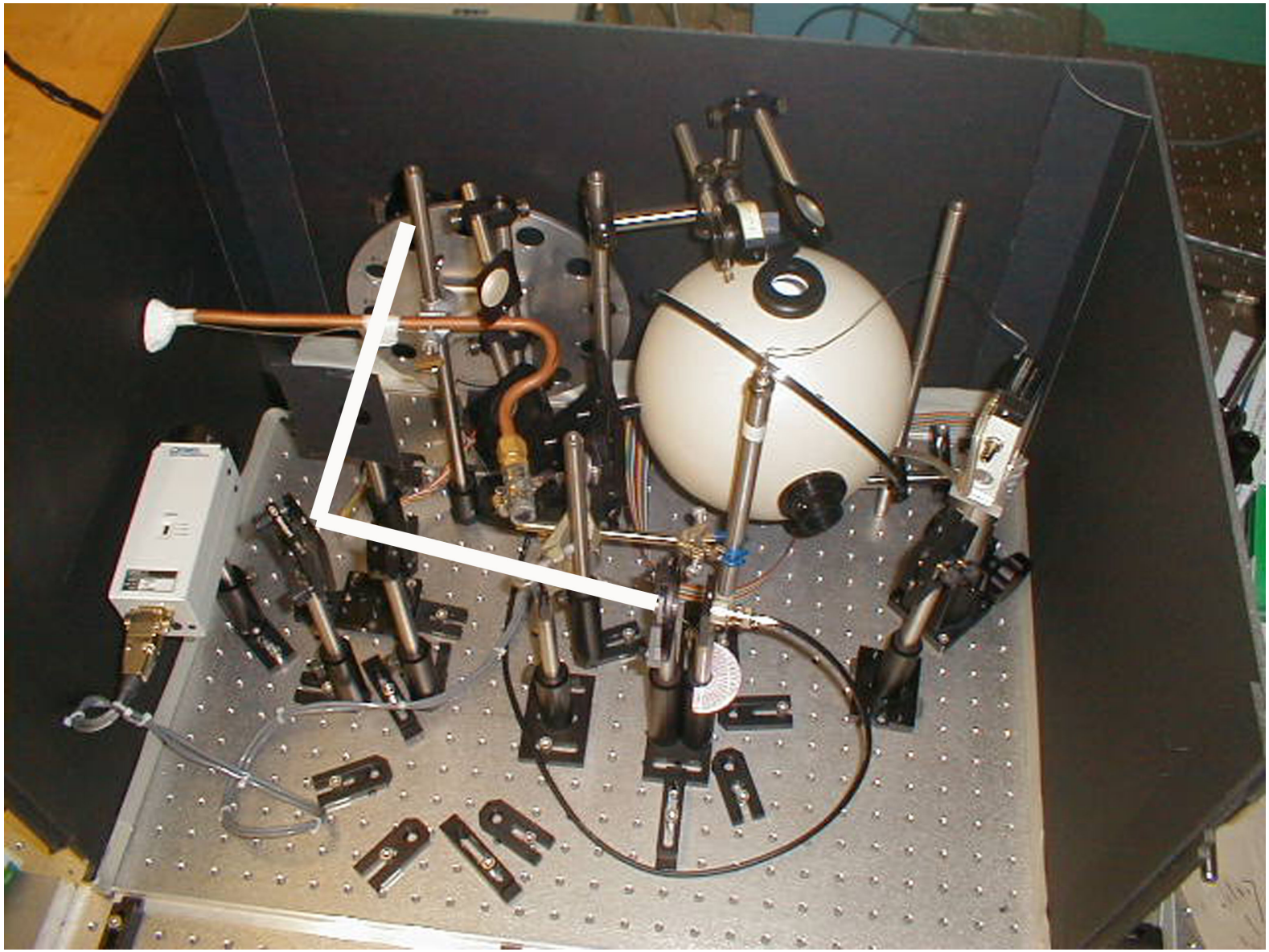


- The Spectrometer
- Spectrometry Basics
- Determining the Refractive Index
- Conclusion
- Questions

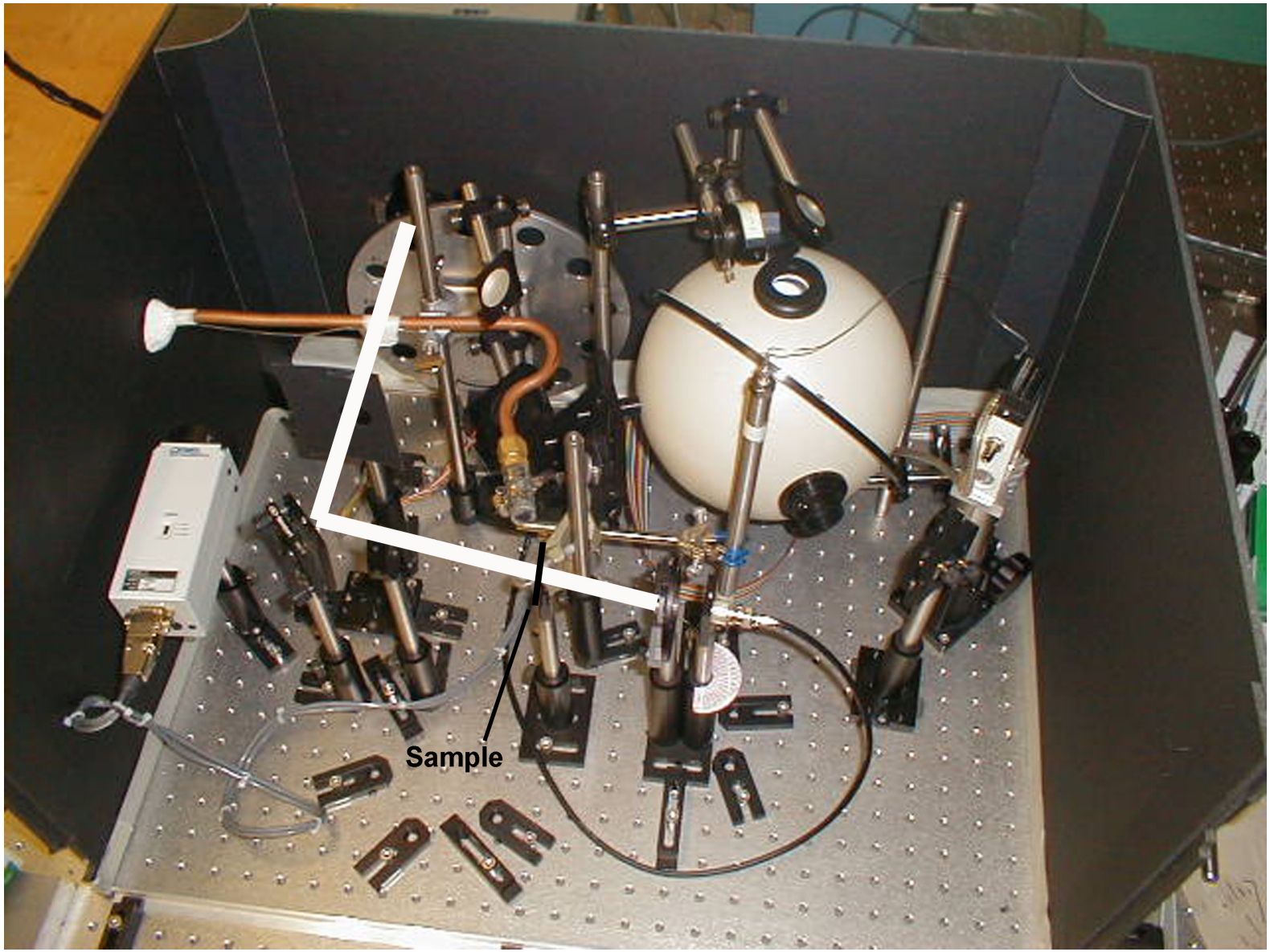
The Spectrometer



The Spectrometer

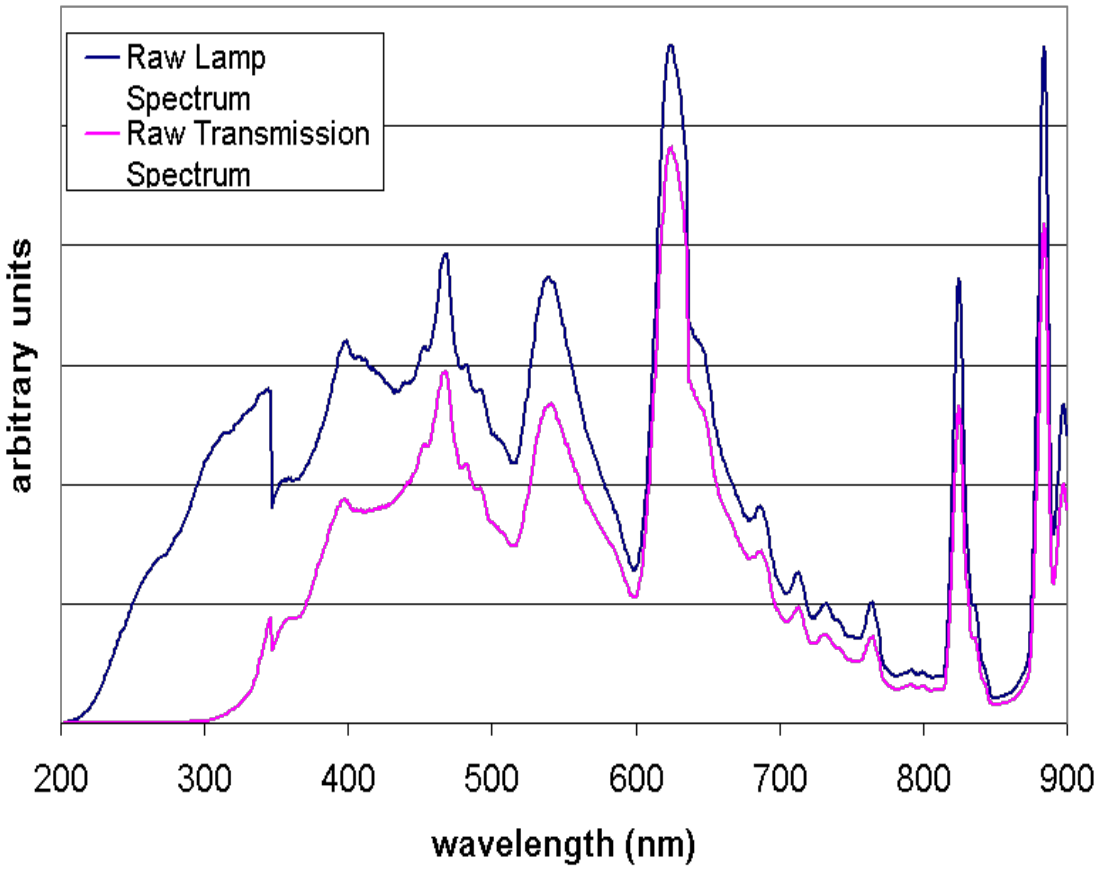


The Spectrometer



Spectrometry Basics – Raw Spectra for a $CuScO_2$ film named sm16d

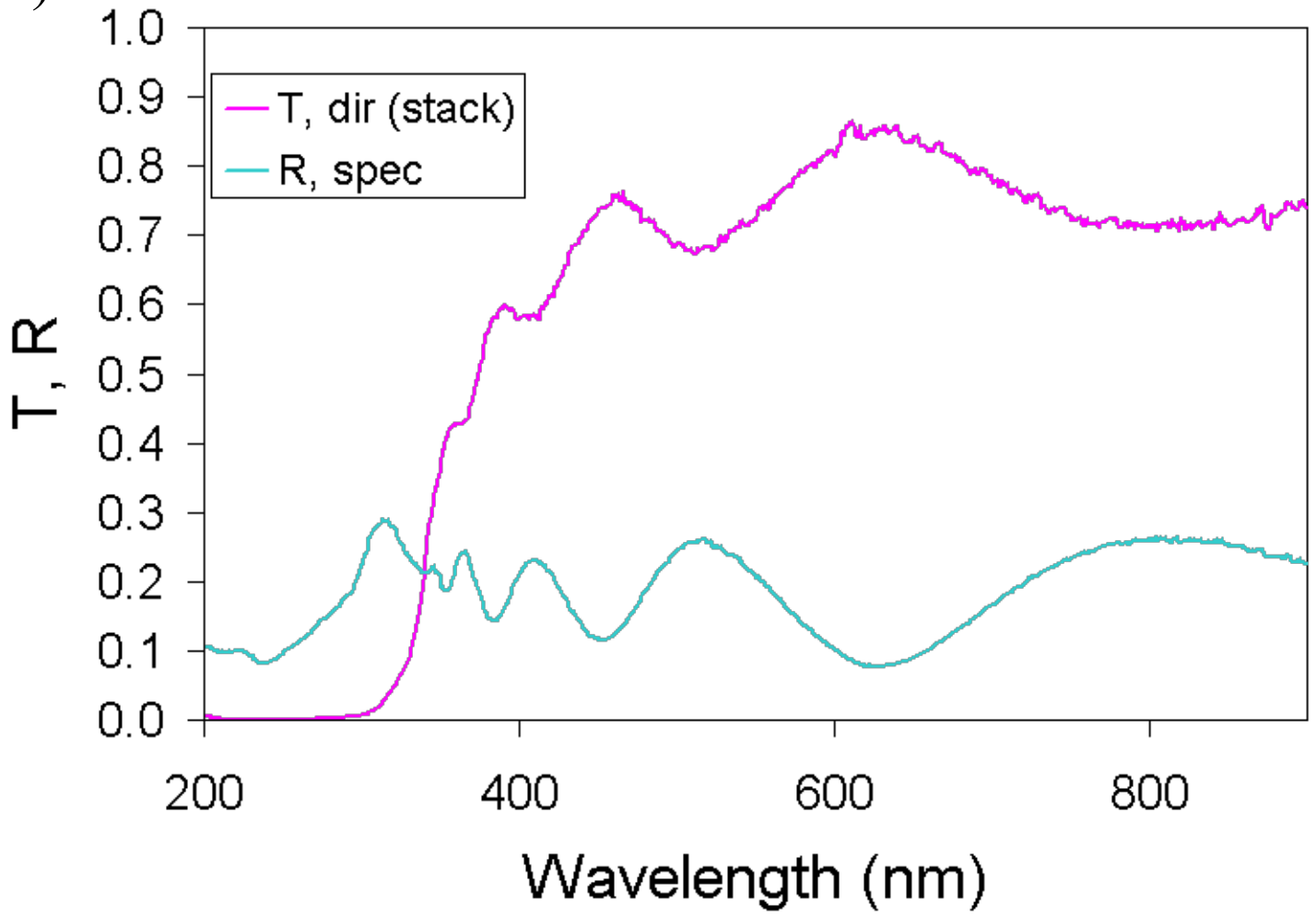
- All components of spectrometer have wavelength dependent spectrum
- A raw spectrum is a convolution of all components in the spectrometer



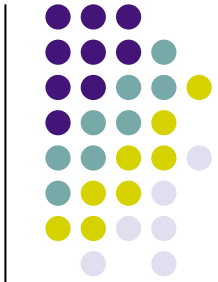
Spectrometry Basics – Normalization and Normalized spectra for $CuScO_2$ film sm16d

$$F(\lambda) = \frac{I_f(\lambda)}{I_{lamp}(\lambda)}$$

$F=R$ or T



Refractive Index – Introduction



- The Refractive index can be calculated from the fringe positions provided the film thickness (*d*) is known.

$$n = \frac{m \cdot \lambda_{\max,\min}}{2 \cdot d}$$

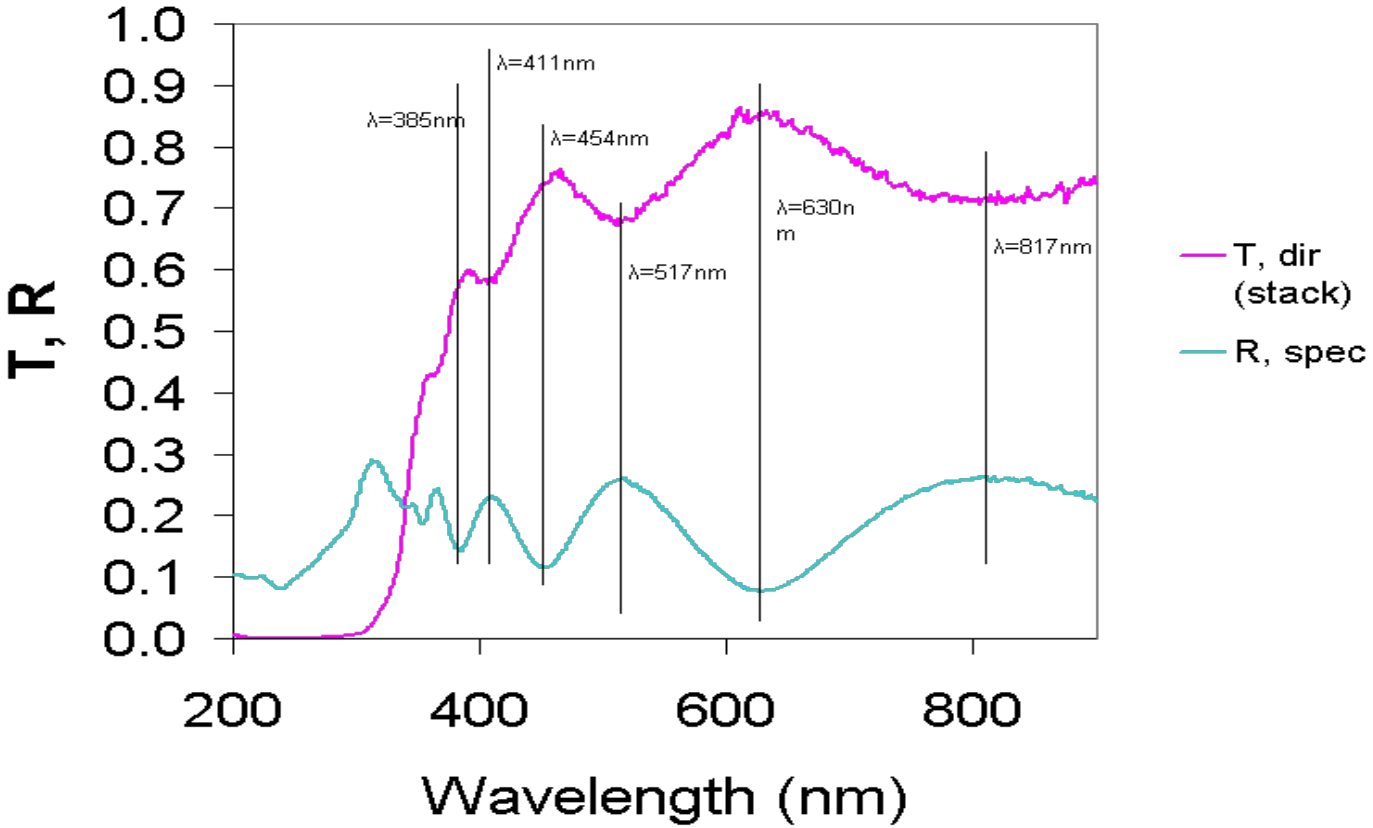
$$m_{R-\max} = \frac{3}{2}, \frac{5}{2}, \frac{7}{2} \ldots$$

$$m_{R-\min} = 1,2,3,4 \ldots$$

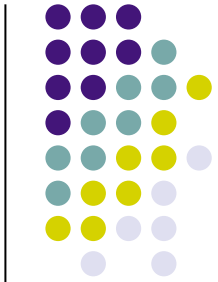
- These *m*'s work provided the index of the film is higher than the index of the substrate. Otherwise they are reversed.

Refractive Index – T and R spectra of sm16d with reflection maxima and minima labeled.

Pick out locations of maxima and minima in Reflection Spectrum to determine refractive index.



Refractive Index – Producing data



- Now create a table of the locations of the fringes and their corresponding *m* values.
- Recall *d*=300nm
- Calculate *n* according to the equation:

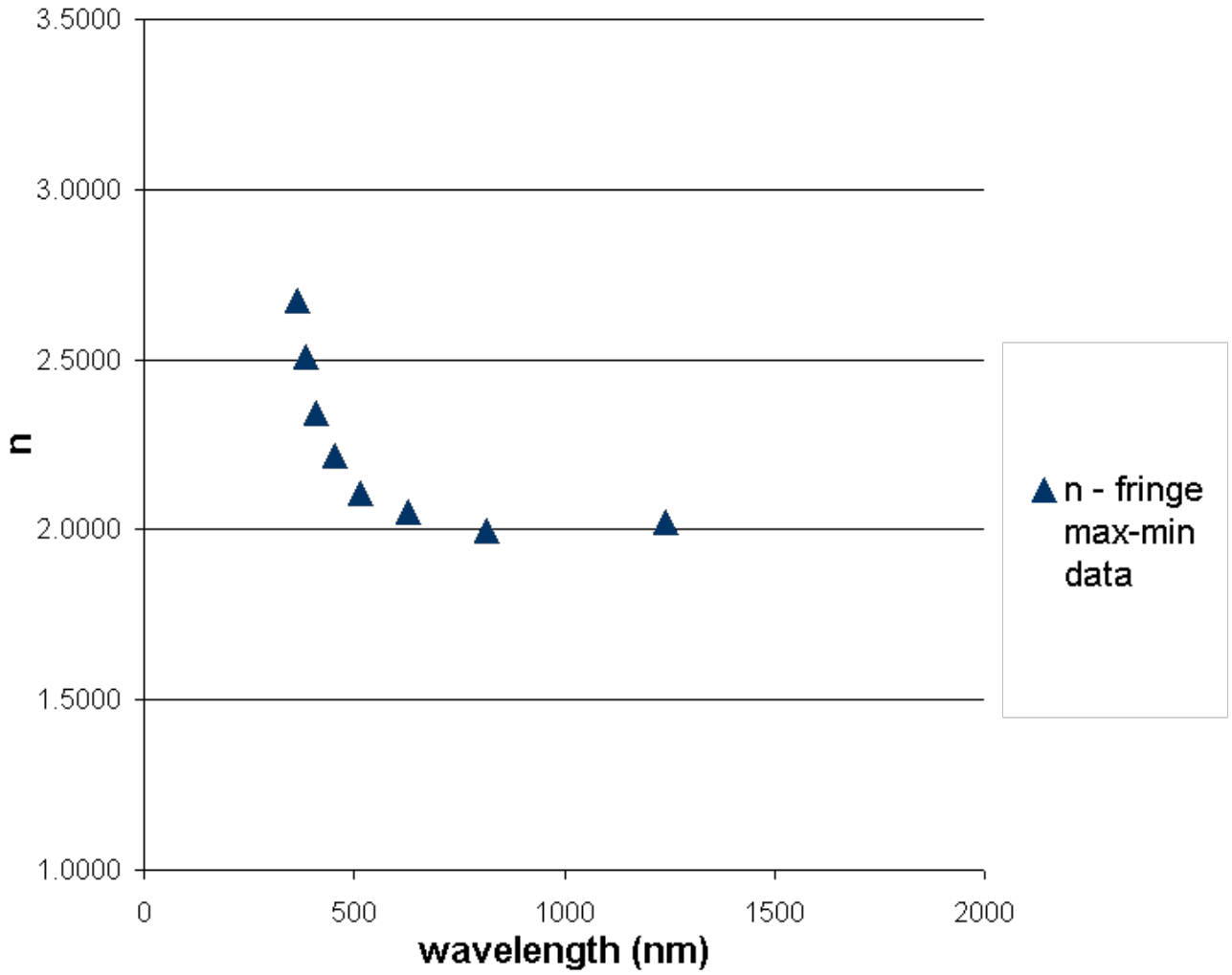
$$n = \frac{m \cdot \lambda_{\max,\min}}{2 \cdot d}$$

- These values of *n* are good numerical values around their corresponding wavelength.

m	λ	*n*
1.5	817	1.9959
2	630	2.0521
2.5	517	2.1050
3	454	2.2182
3.5	411	2.3428
4	385	2.5081
4.5	365	2.6751

Refractive Index – Plotting and Fitting the data.

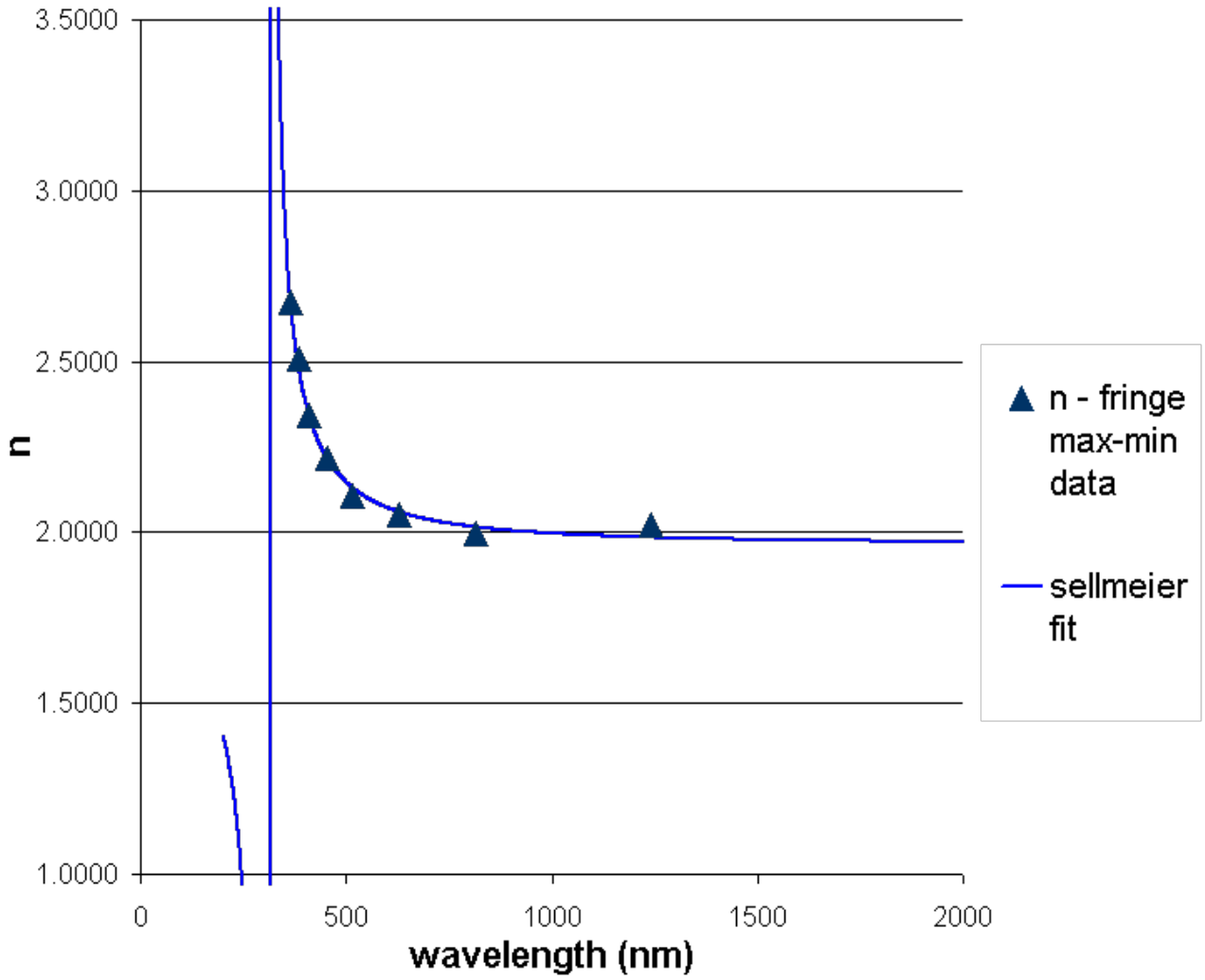
- Now plot these data points:



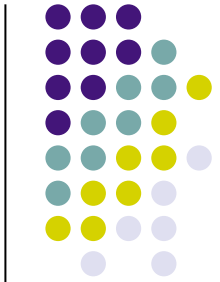
Refractive Index – Plotting and Fitting the data.

- Now plot these data points:
- And fit to an approximation to the Sellmeier equation:

$$n = \sqrt{A + \frac{\lambda^2 \cdot G_g}{\lambda^2 - \lambda_g^2}}$$

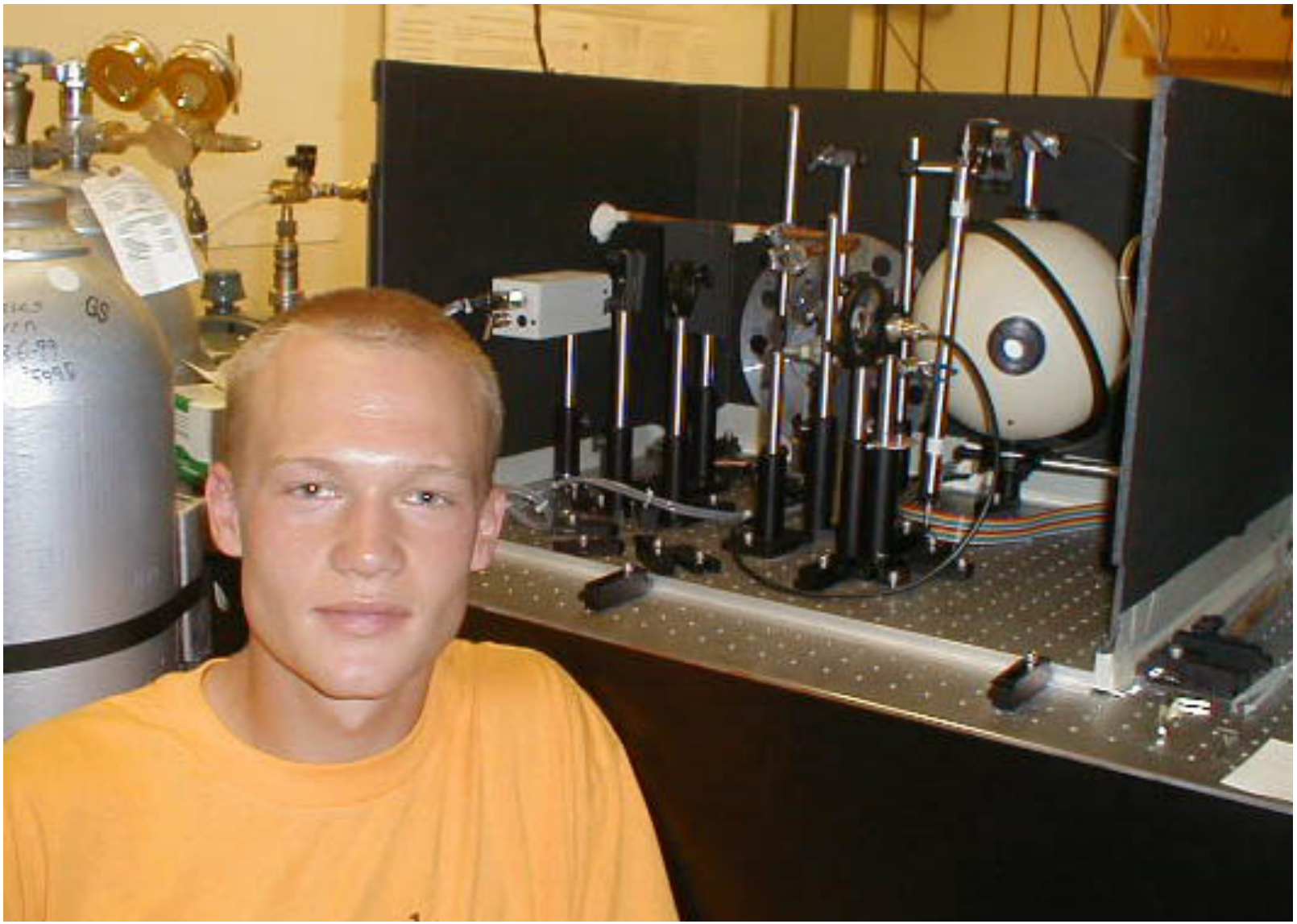


Conclusion

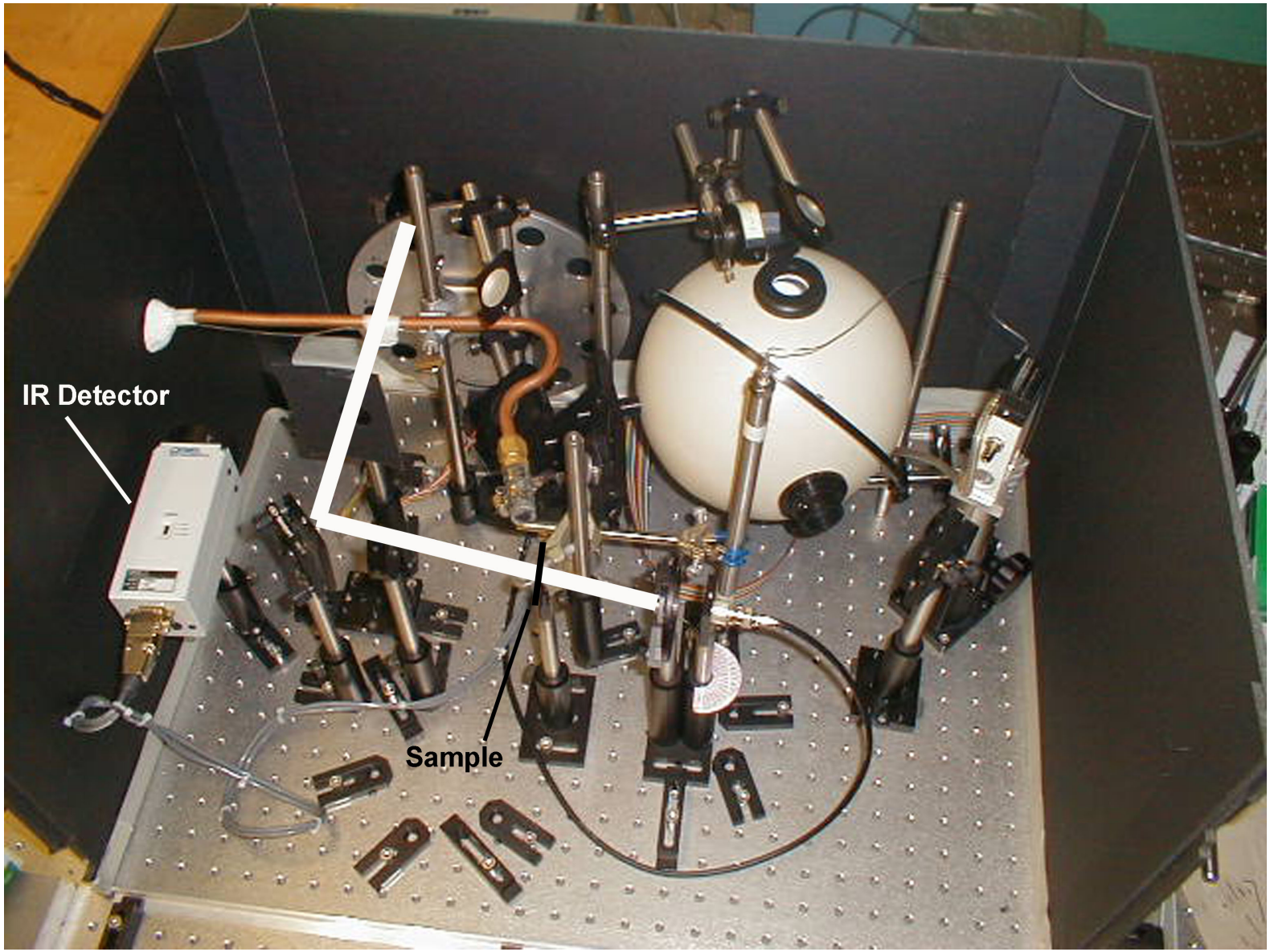


- A method for determining the refractive index of thin films has been used and applied to new materials.
- A refractive index of ~2.1 was found in the visible for the $CuScO_2$ film sm16d.
- Other $CuScO_2$ Samples not presented here had similar values.
- index_calc.xls Workbook.
- Questions?

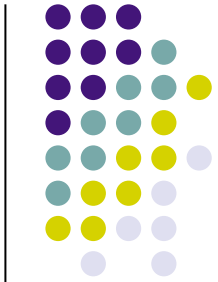
That's All Folks



IR Spectrometry



IR Spectrometry – Compare and Contrast: silicon vs. lead-sulfide detectors



- Silicon (Si) Band gap ~1.14eV
- Corresponds to:

$$\lambda_c \cong 1.1\mu m$$

- Range: 200-900nm
  Lower limit due to Ozone production in air.

- Lead-sulfide (PbS) Band Gap ~0.41eV
- Corresponds to:

$$\lambda_c \cong 3.0\mu m$$

- Range 800-2700nm
  Limit due to OH absorption in lenses

IR spectrometry – Transmission and Reflection of $CuScO_2$ film sm16d