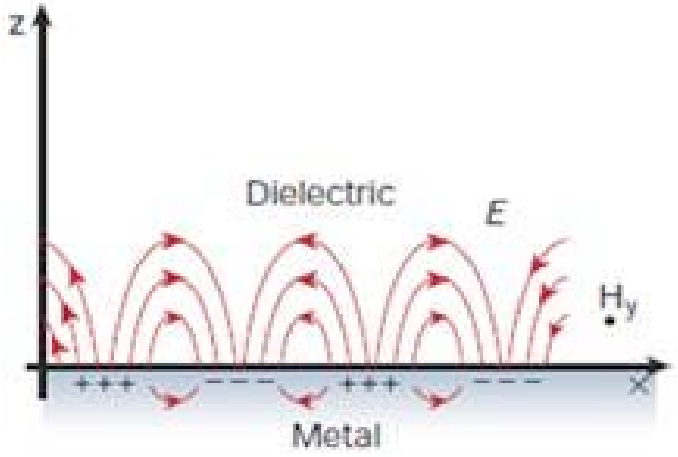
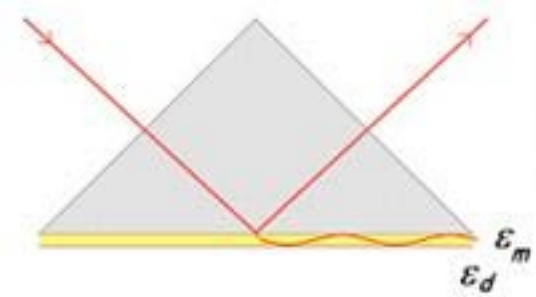
# Investigation of Surface Plasmon Resonance of Ag films capped with $Cs_2O$ Layers

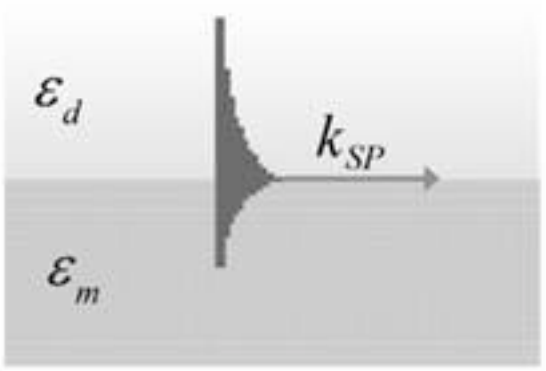
George Schwartz, 3rd Yr. CSS Scholar
Advisor: Professor R. A. Lukaszew
Collaborators: Zhaozhu Li, Matt Heimburger

# Surface Plasmon Resonance

* Oscillations of electrons in a metal resulting in evanescent electromagnetic waves which propagate along a metal/dielectric interface



# Exciting the SPR

* SPR may be excited the dielectric constants $\varepsilon_m$ (metal) and the $\varepsilon_d$ (dielectric) satisfy a dispersion relation:

$$K(\omega) = \frac{\omega}{c}\sqrt{\frac{\varepsilon_1\varepsilon_2\mu_1\mu_2}{\varepsilon_1\mu_1 + \varepsilon_2\mu_2}}$$

* SPR can occur if:

$$\mathrm{Re}[\varepsilon_m] < 0$$

$$\mathrm{Re}[\varepsilon_d] < -\mathrm{Re}[\varepsilon_m]$$

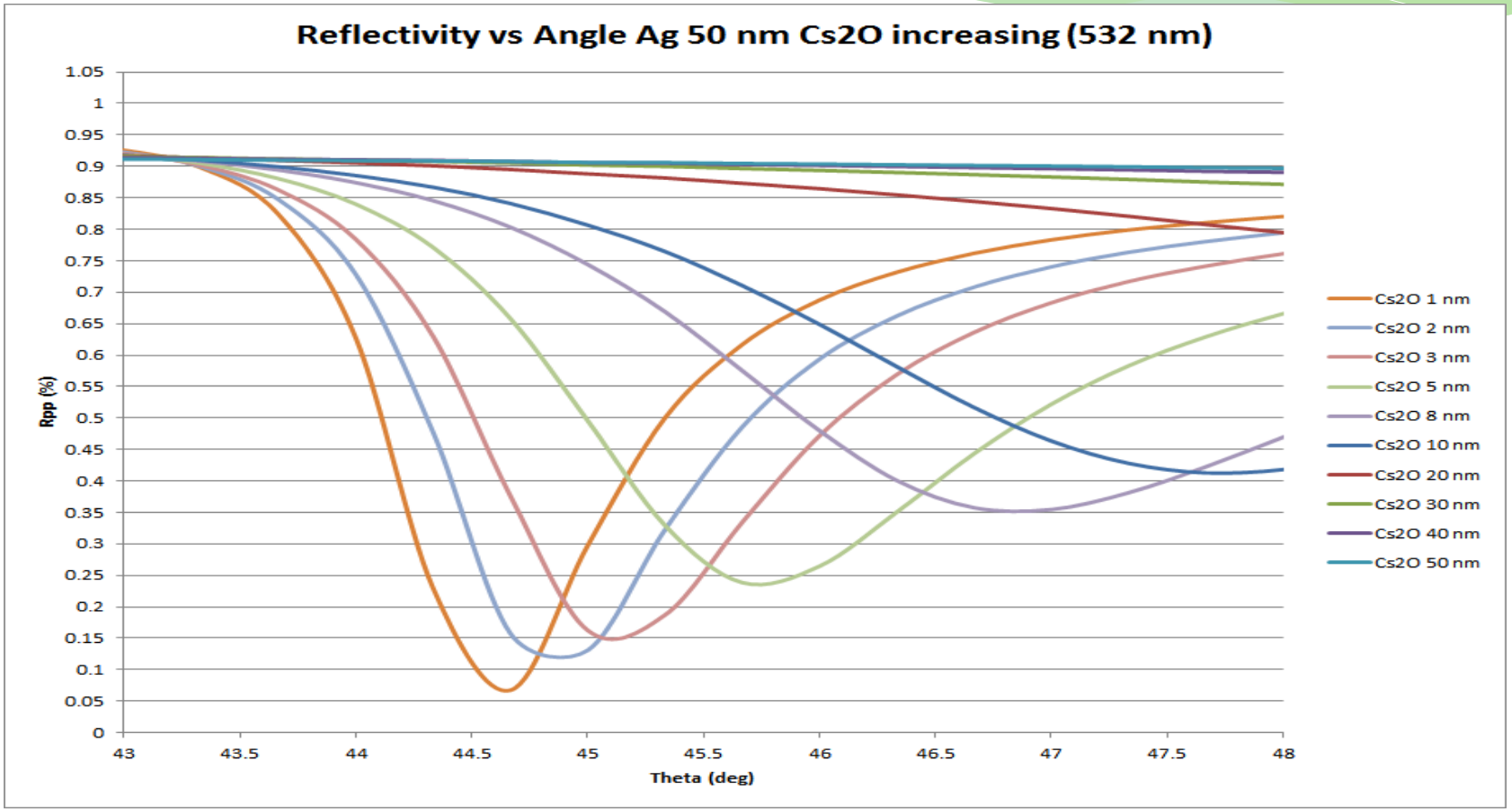
* Additionally, only can excite the SPR by matching the wave vector of the surface plasmons, $k_{sp}$, with that of incident light, $k_o$ (matching momentum)
  * Note: $k_{sp} > k_o$ always!
  * So an optical coupler (prism/grating) is needed to increase $k_o$

# Applications

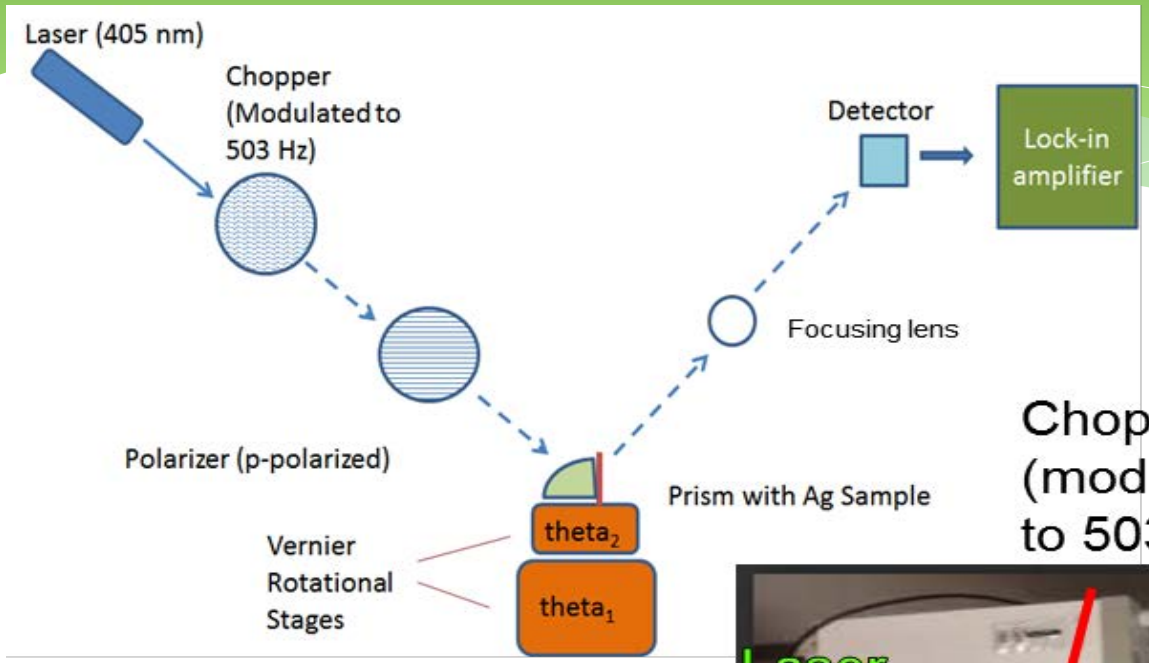
* Surface Plasmon Resonance is highly dependent on the incident light's wavelength, angle, and the material composition (metal / dielectric surfaces)
* Can exploit these properties to enhance metallic photocathodes
* Metallic Cathodes:
  * PRO: Robust (last years), <ps response time
  * CON: Low Quantum Efficiency (<<1%)
* Semi-conductor Photocathodes:
  * PRO: QE (5-50%)
  * CON: Short lifetimes (days-months), Long response times
* Applicable for High Energy Electron Colliders

# Simulation

* Prior to physically testing the SPR, we simulated how the reflectivity changed based off incidence angle and film thickness.

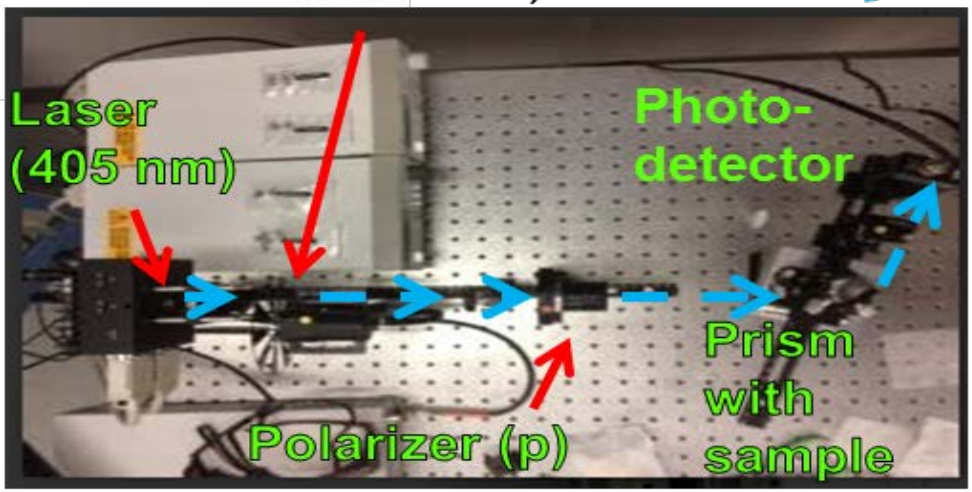


# Optical Set-up



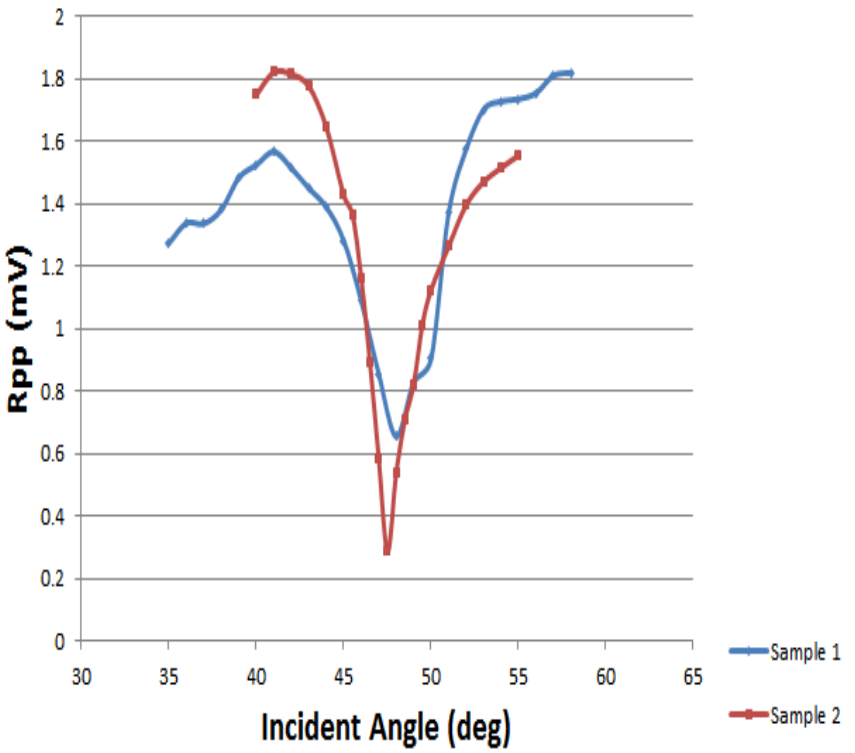

Lock-in Amplifier

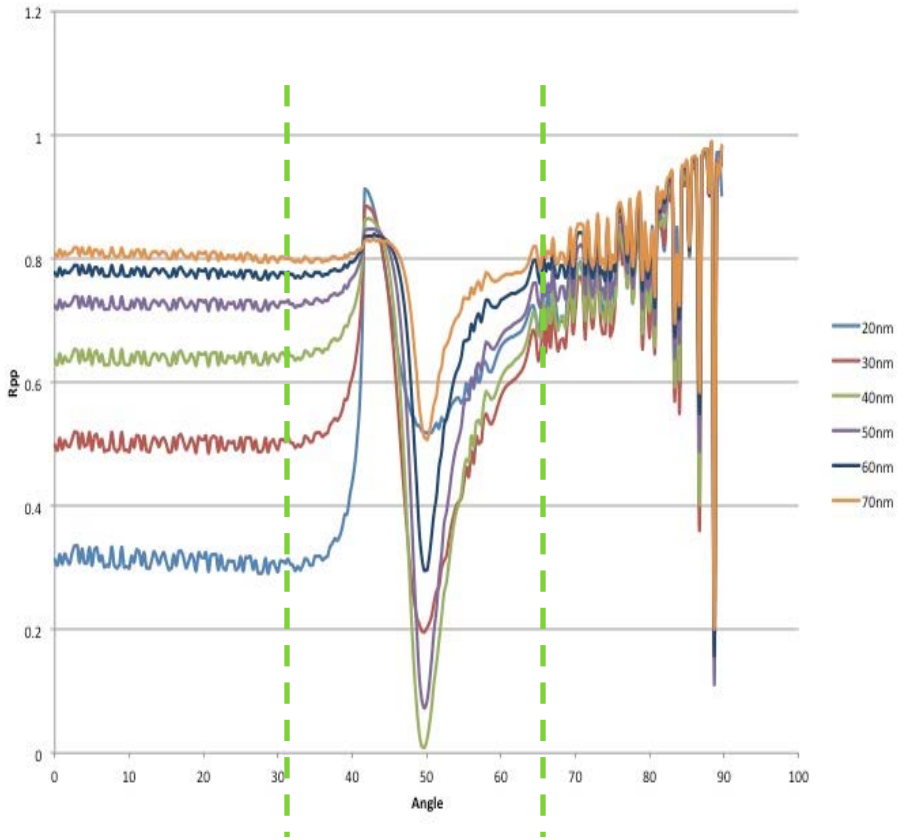
Chopper
(modulated
to 503 Hz)



# SPR Results

* After the set-up was fully aligned, we tested it for Ag (40 nm) films for 405 nm blue light and compared it to the simulation.



# Future Steps

* Investigation of $Cs_2O$ properties (dielectric constant) and lowering the work function of Ag films
* Adjusting the simulation of $Ag/Cs_2O$ for 405 nm light as a standard of comparison for future experimental data
* Deposition at oblique incidence to improve the precision of the SPR dip

# Acknowledgements


* I would like to thank Professor Lukaszew for being an amazing mentor, both with the research and teaching me valuable life lessons
* My co-workers Zhaozhu Li and Matt Heimburger for integrating me into the project and assisting me throughout the summer
* VMEC foundation for providing funding for this summer's research
* The College Science Scholars Program