Automatized setup for plasmonic measurements based on prism coupling technique

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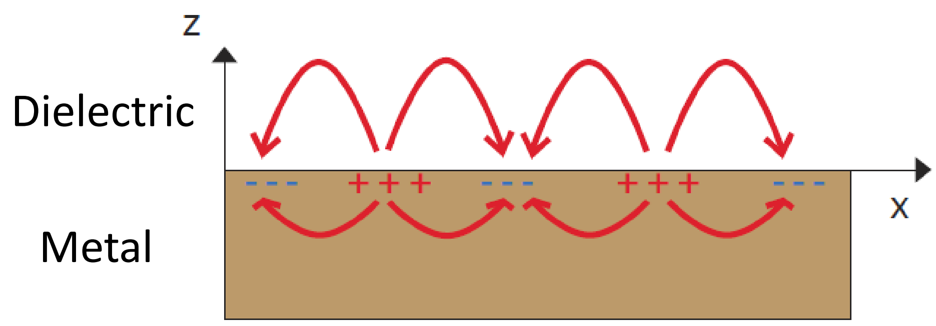
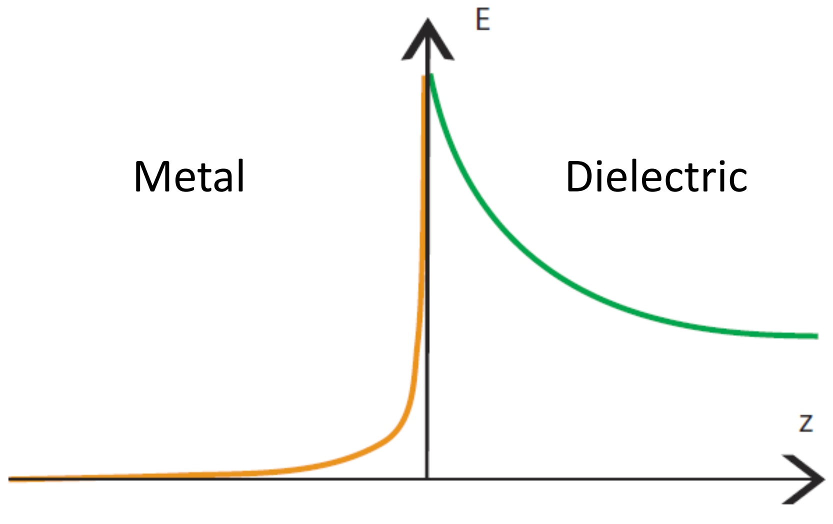
Introduction: Surface plasmons

- Electromagnetic wave confined to metal-dielectric interface
- Caused by oscillation of free charges
- Exponential decay to the both medium

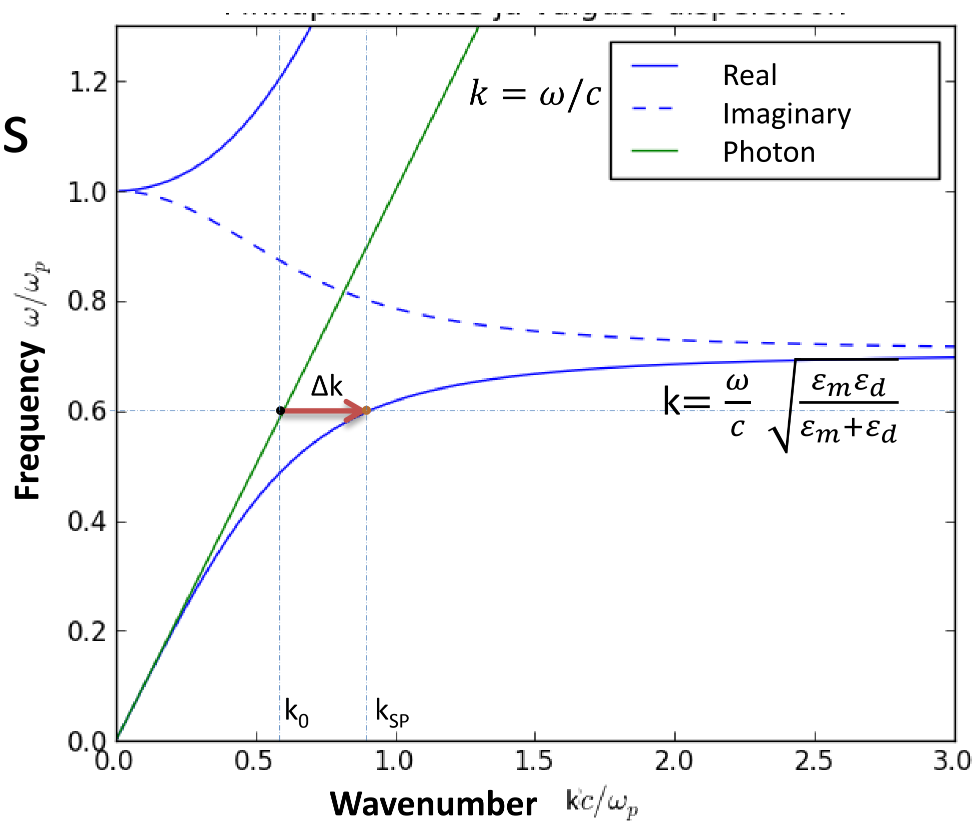




Introduction: How to excite?

Problems:

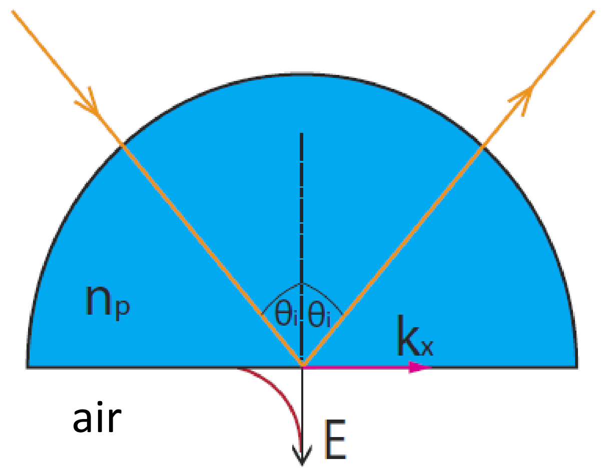
- Photon momentum is smaller than surface plasmons at the same energy

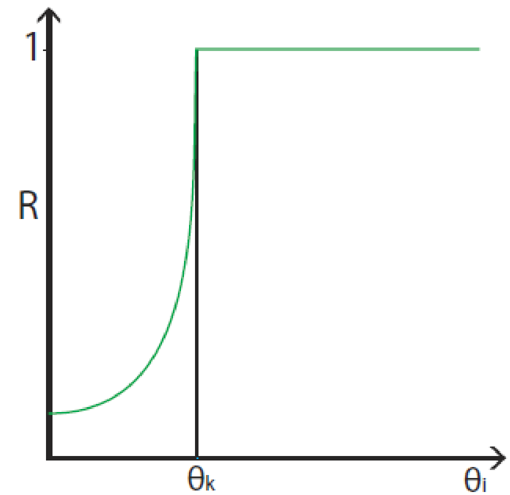


Introduction: Kretschmann scheme

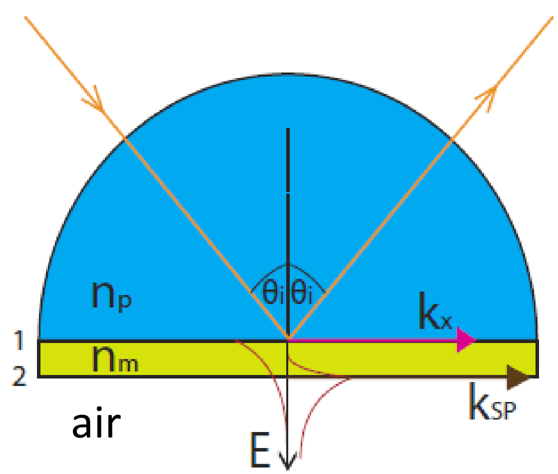
Total internal reflection:

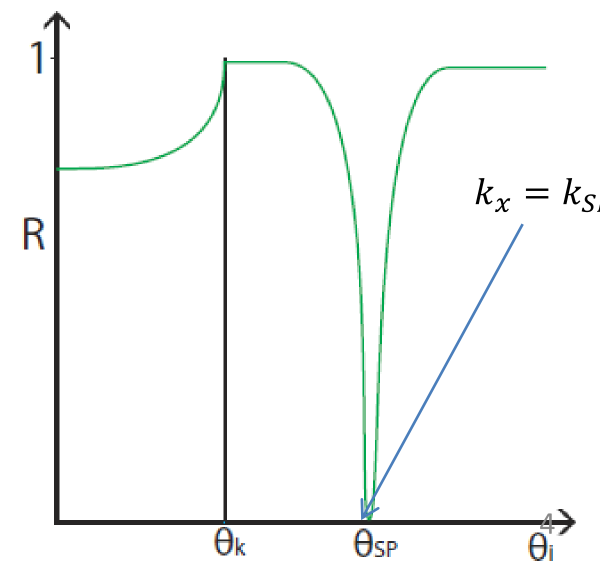
$$k_x = n_p k_0 \sin(\theta_i)$$



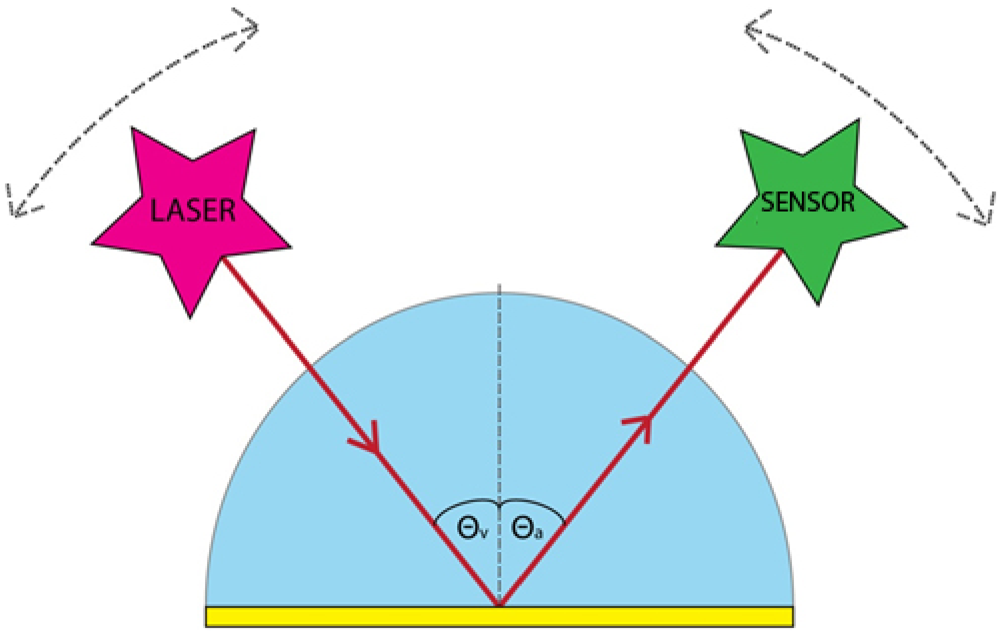


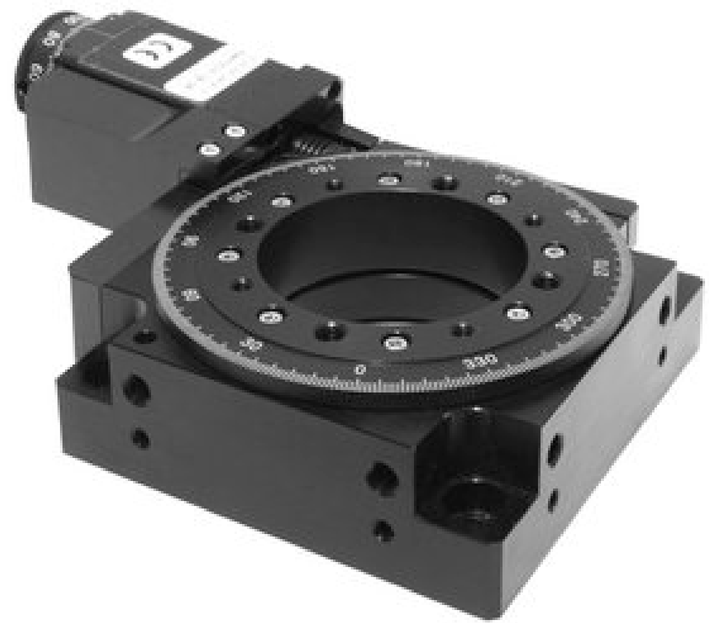
Exciting surface plasmons with Kretschmann scheme:





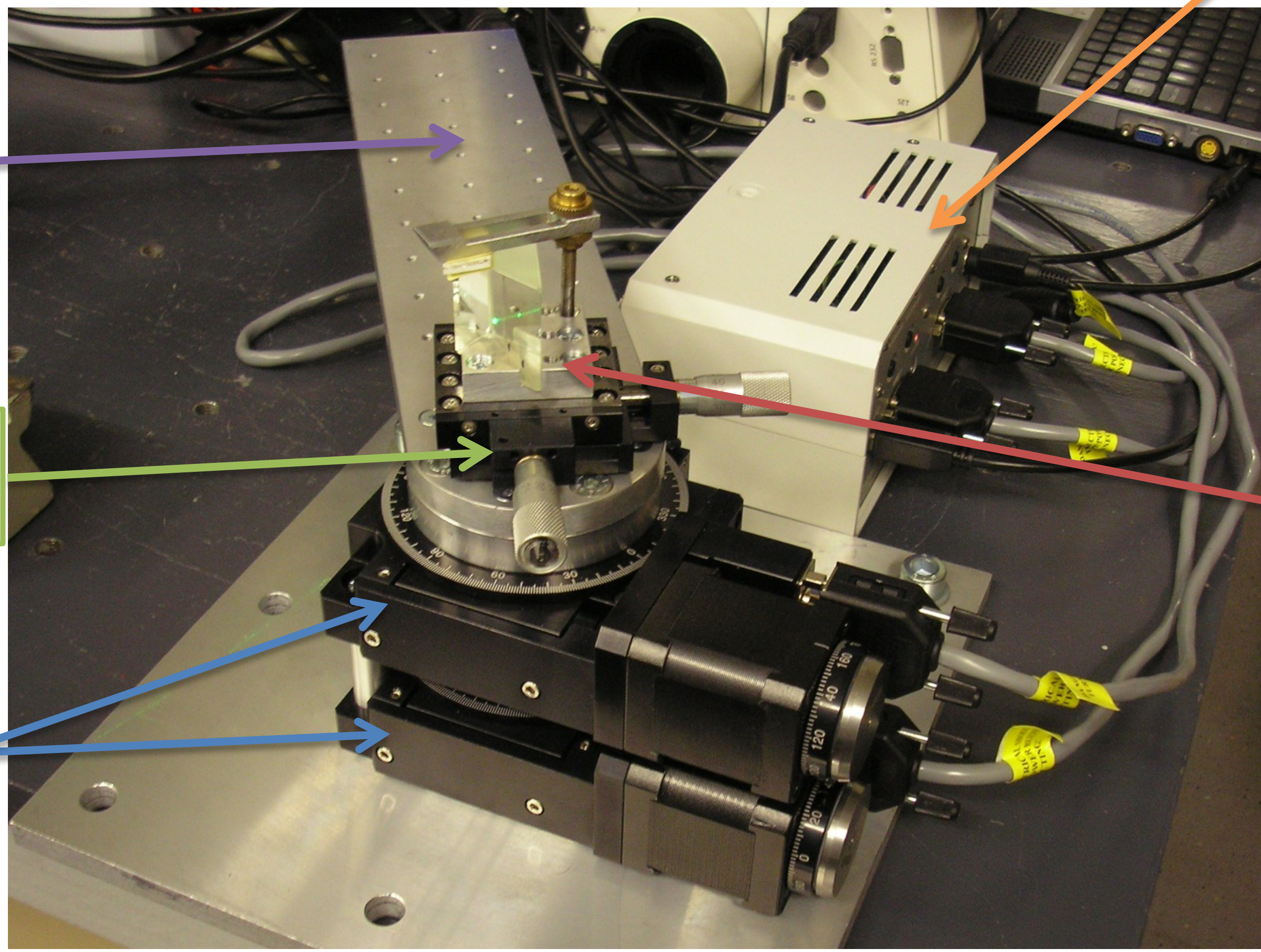
Built machine: 2-axis motorized goniometer





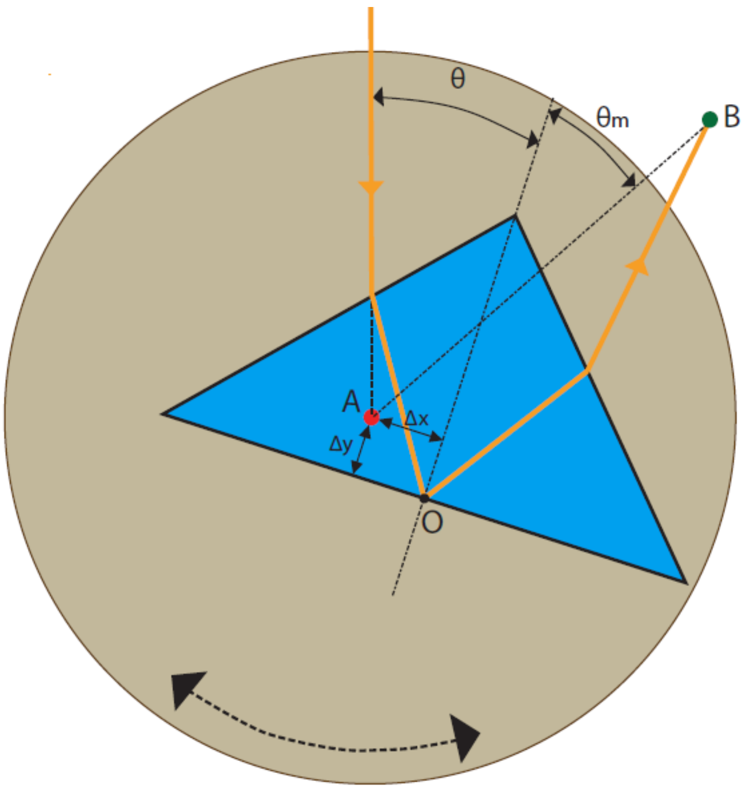
- Based on two motorized rotational stages (STANDA)
- Angle resolution: 0.00125°

Built machine

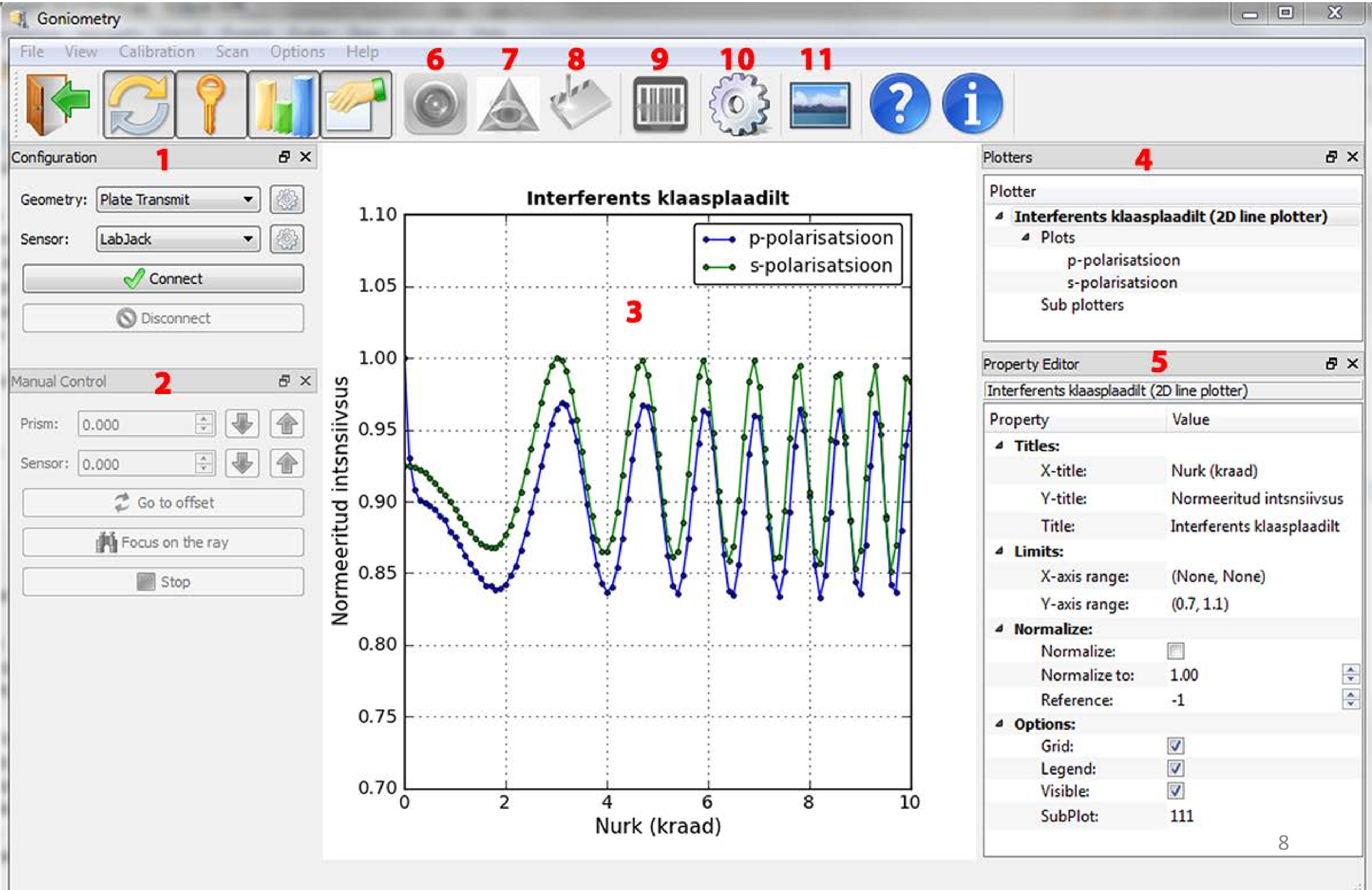


Built machine: Control logic

- Python (numpy, scipy, matplotlib etc) and C++ (boost)
- More than 8000 lines of code (object oriented)
- Graphic user interface (Qt)
- Calibration algorithms
  - Prism position
  - Sensor position
  - Ray center finder
- Measurement setups
- Sensors:
  - Labjack
  - Light power meters
  - Spectrometers

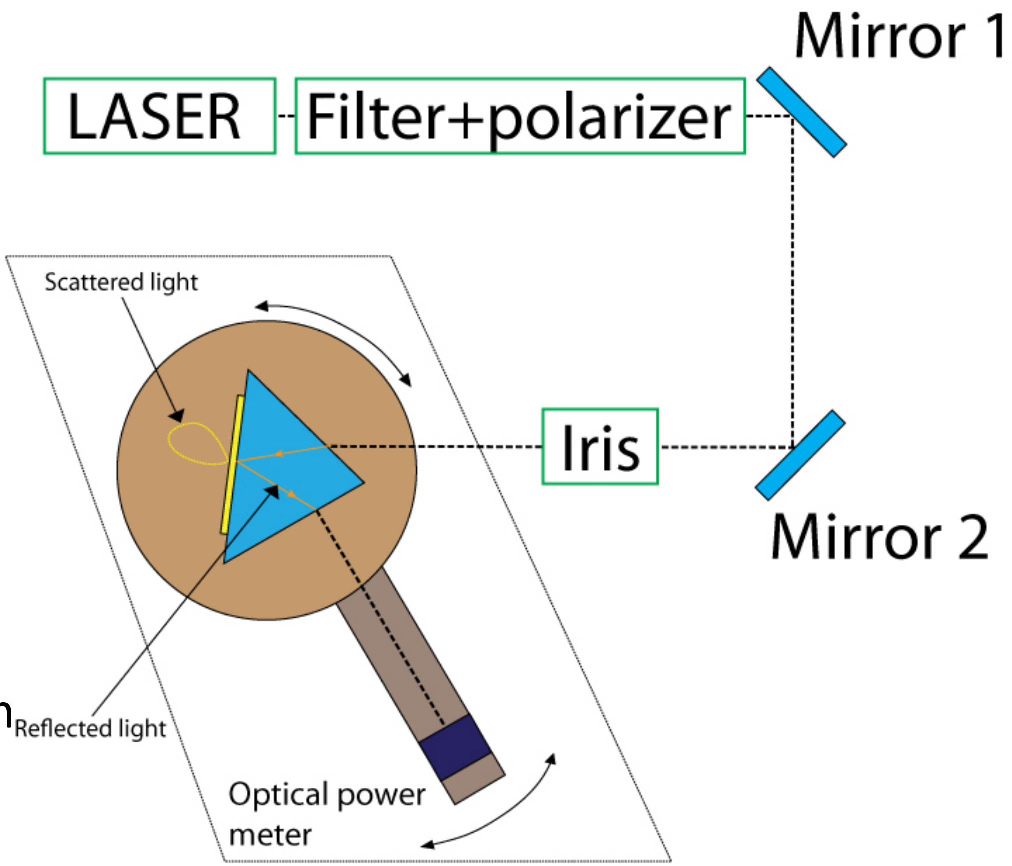


Built machine: graphical user interface

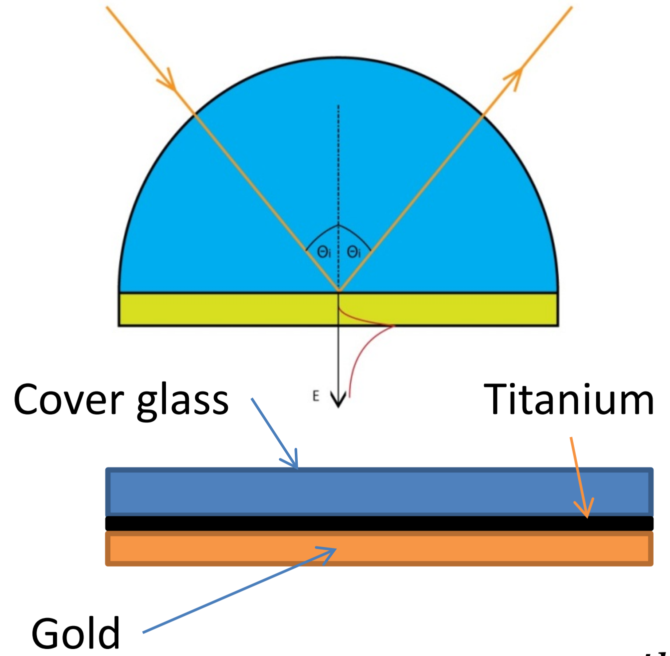


Experiment: Setup

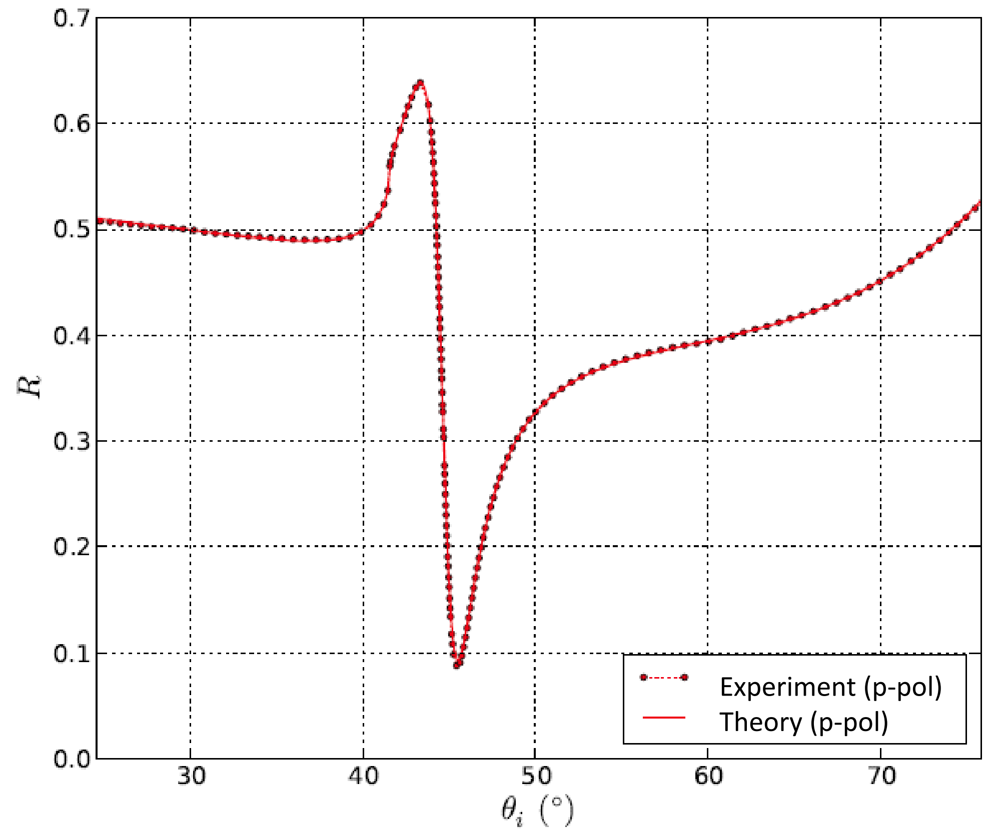
- Laser: 532, 593 nm
- Triangular prism
- Optical power meter:
  - Thorlabs PM100
  - Silicon Senor PM130
- Aim
  - Test setup by
    - Characterize thin gold film using surface plasmons
    - Study surface roughness influence



Experiment: Exciting surface plasmons



$$n_k = n + ik$$



Theory calculated with Transfer Matrix Method (Python module)

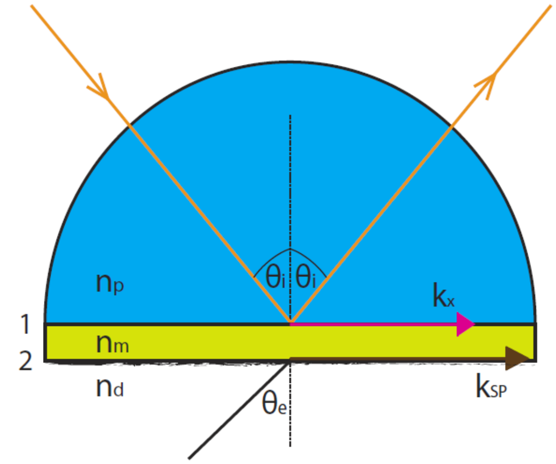
$\delta_m = 31\ nm$

$\delta_d = 242\ nm$

$L = 4{,}3\ \mu m$

Medium	**Intial guess (Palik)**			**Fitted parameters**		
	h (nm)	n	k	h (nm)	n	k
Cover glass	∞	1,51		∞	1,51	
Titanium	5,0	2,02	2,78	5,78	2,11	3,72
Gold	50,0	0,26	2,97	48,75	0,28	2,86
Air	∞	1,0		∞	1,0	

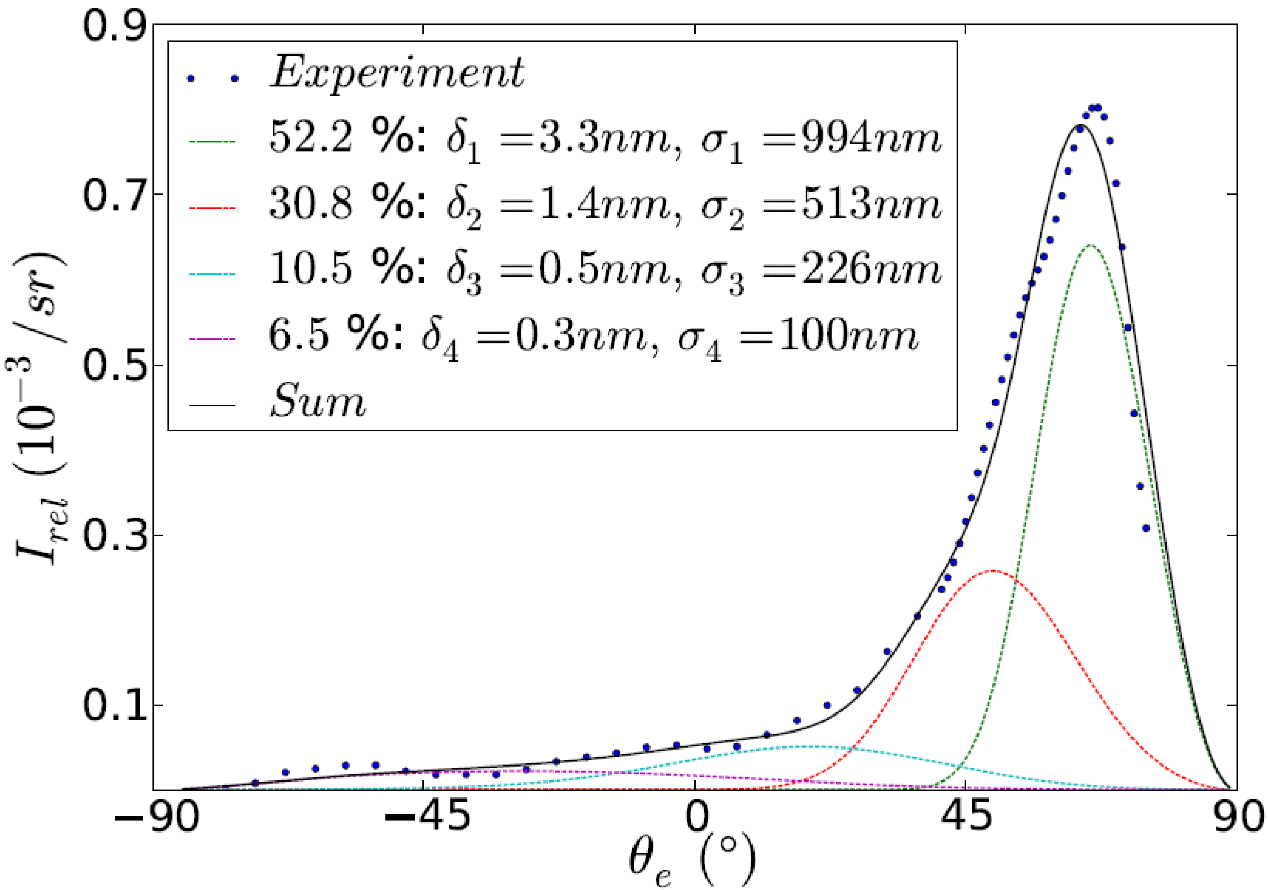
Experiment: Surface roughness



Theory:

A. Hoffmann, Z. Lenkefi, Z. Szentirmay (1998)

E. Kröger, E. Kretschmann (1970)



δ − *root mean square*

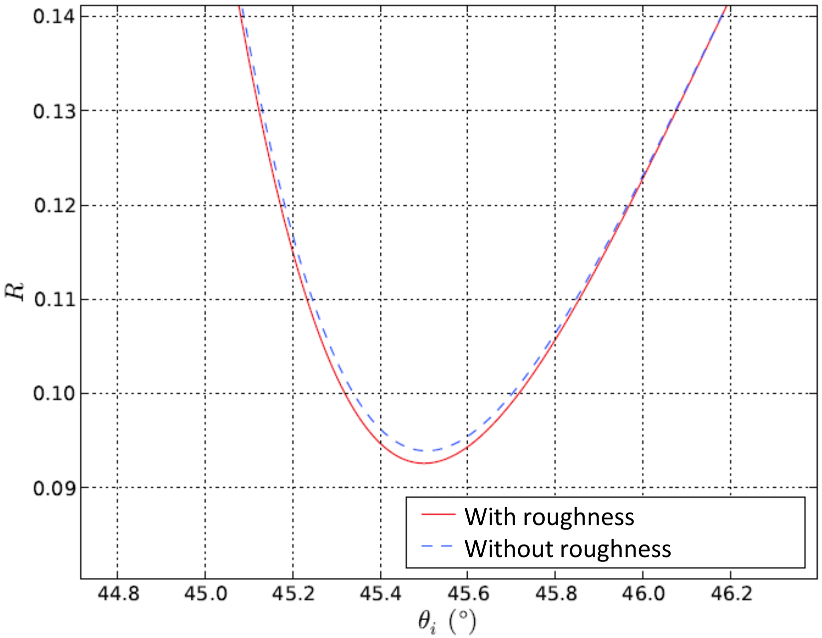
σ − *correlation length*

AFM measurements:

$\delta = 3.5\ nm$

Experiments: Surface roughness effect on gold parameters

Transfer Matrix method doesn't include surface parameters.
Surface roughness influences dispersion relation **->** reflectivity curve changes **->** previously obtained gold parameters might be inaccurate



Surface Plasmons propagation constant:

$$\beta_{measured} = \beta_{smooth\ surface} + \Delta k_r$$

Surface roughness influence on dispersion relation (calculated by E. Fontana & R. H. Pantell (1988) formulas)

Propagation constant	Real part (m^{-1})	Imaginary part (m^{-1})
Measured wavenumber ($\beta_{measured}$)	11365564	115543
Roughness influence (Δk_r)	29	1574
Without roughness ($\beta_{smooth\ surface}$)	11365535	113969

Conclusions

- Built setup is essential to study any angular dependency
- Device can be used to characterise thin metal films

Thank you for listening!
Questions?