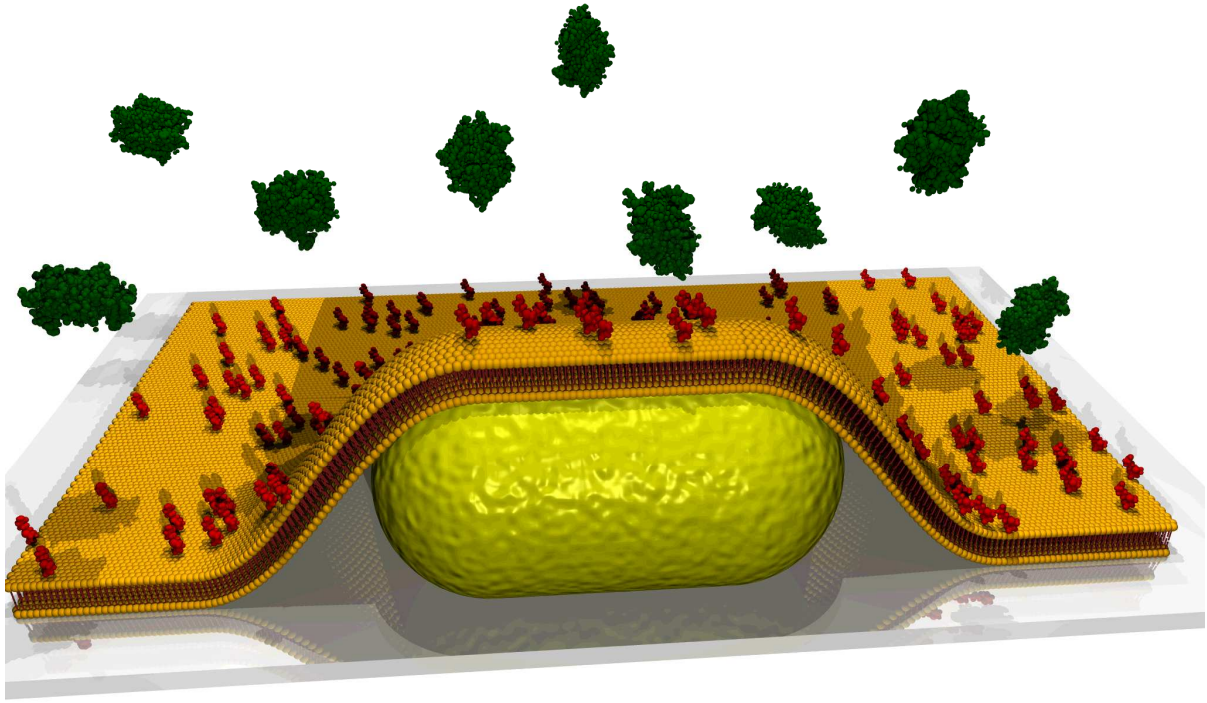
Single Plasmonic Nanoparticles as Biosensors

Plasmonic nanostructures for applications in the life sciences



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nanobiotechnology group
INSTITUTE FOR PHYSICAL CHEMISTRY

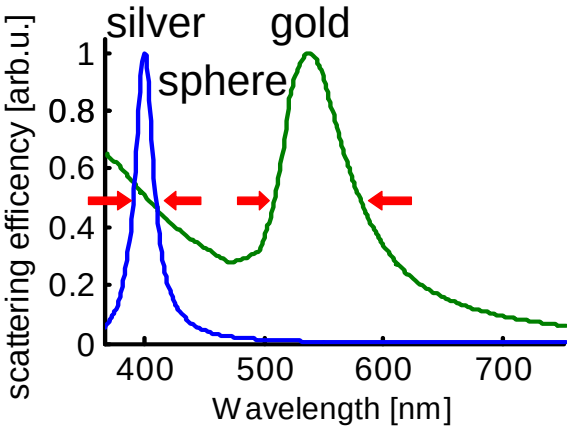
Single Plasmonic Nanoparticles as Biosensors

- Sensing properties of plasmonic particles
- Darkfield-microscopy (fastSPS)
- Protein-membrane interaction
- Improvement of Sensors

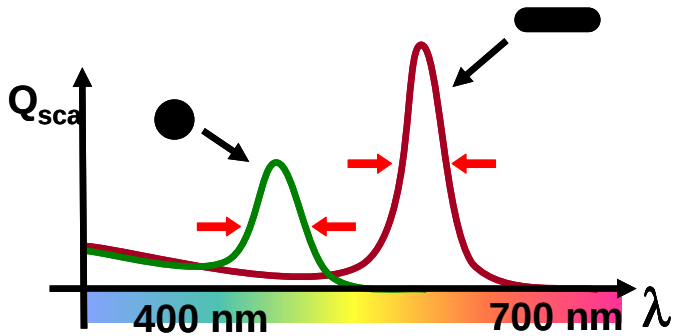
Optical Properties Depend on:

- Resonance Position
- Linewidth (FWHM)

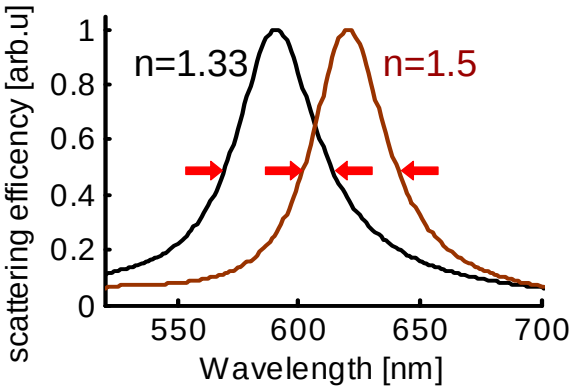
Material



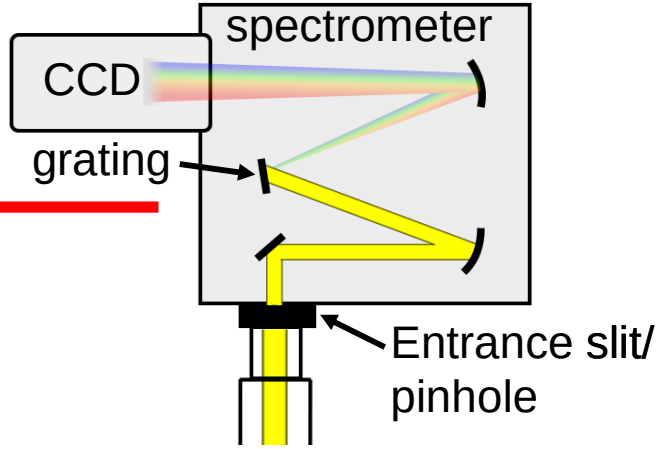
Shape

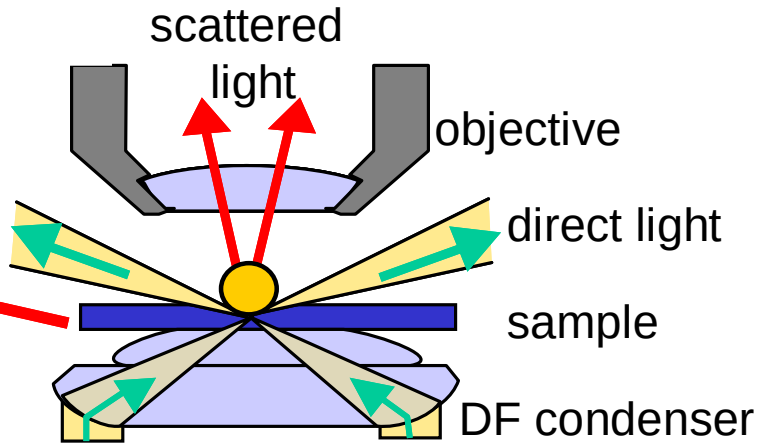


Surrounding refractive index

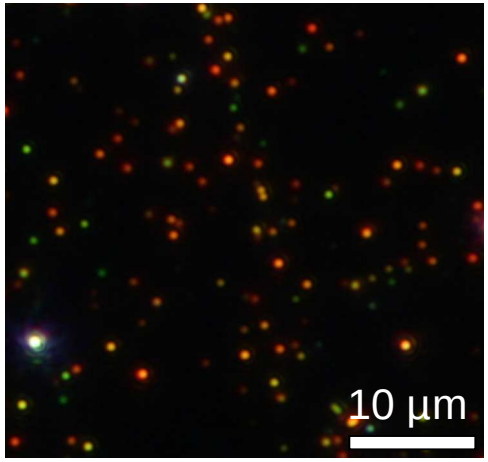


Darkfield Microscopy

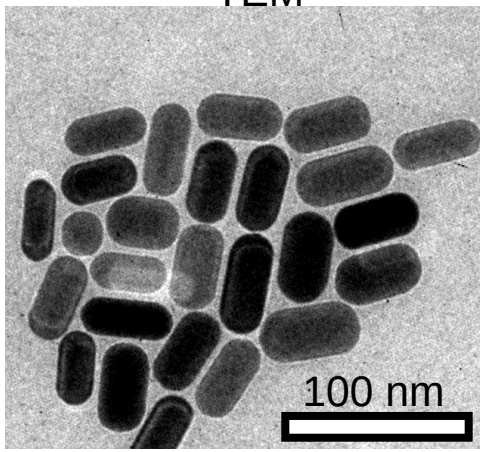




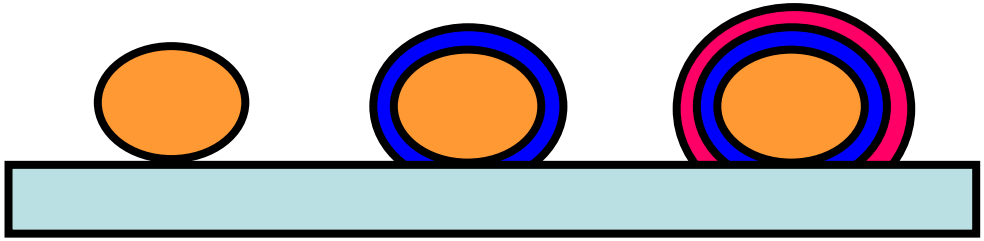
Real color image

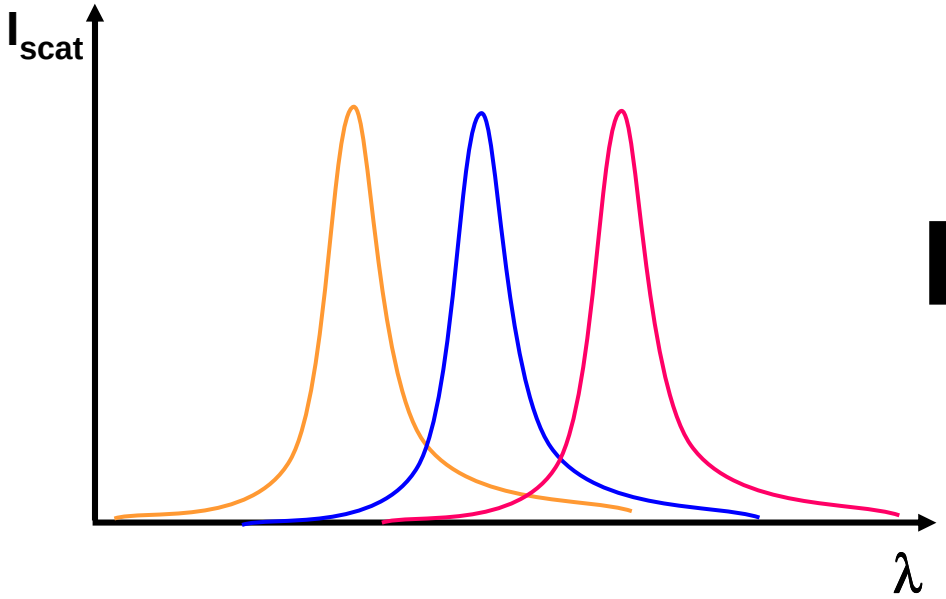


TEM



Concept of single particle plasmon sensors





Shift in resonance wavelength

For stochastic process investigation → **Statistics very important**

Single Plasmonic Nanoparticles as Biosensors

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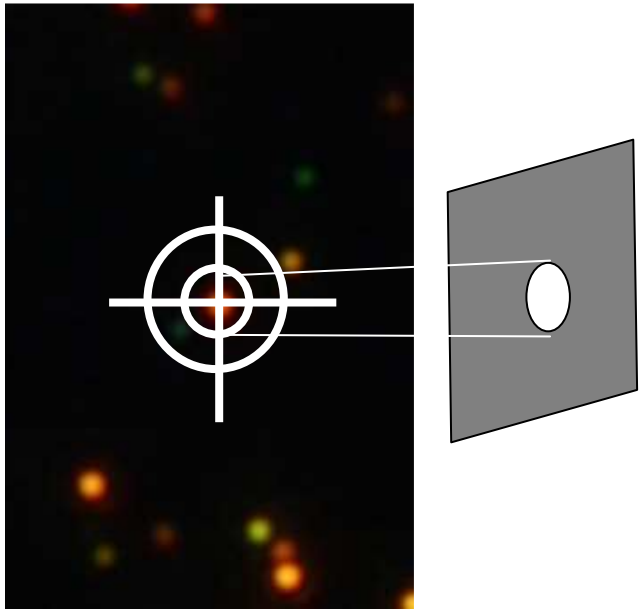
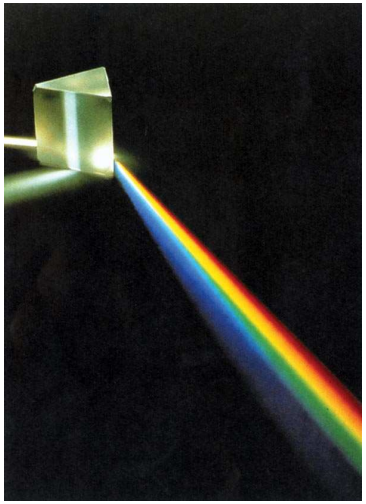
- Darkfield-microscopy (fastSPS)
- Protein-membrane interaction
- Improvement of Sensors

Conventional Method to Measure Single-Particle Spectra

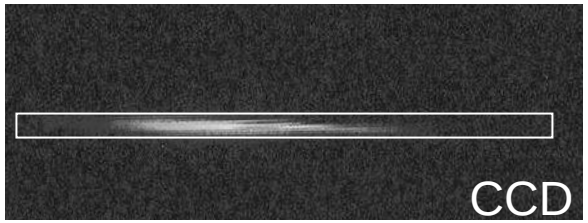


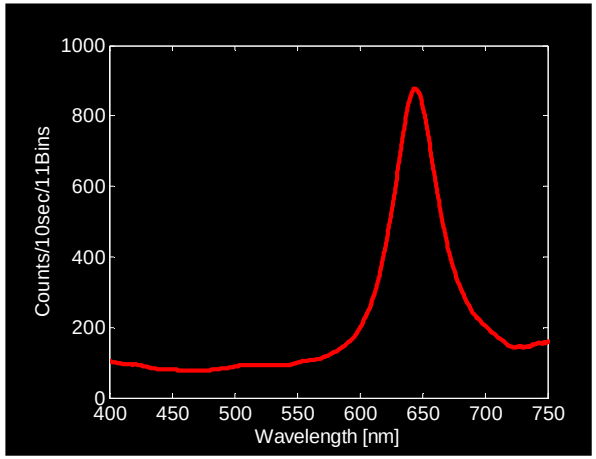
Select one particle

Disperse light



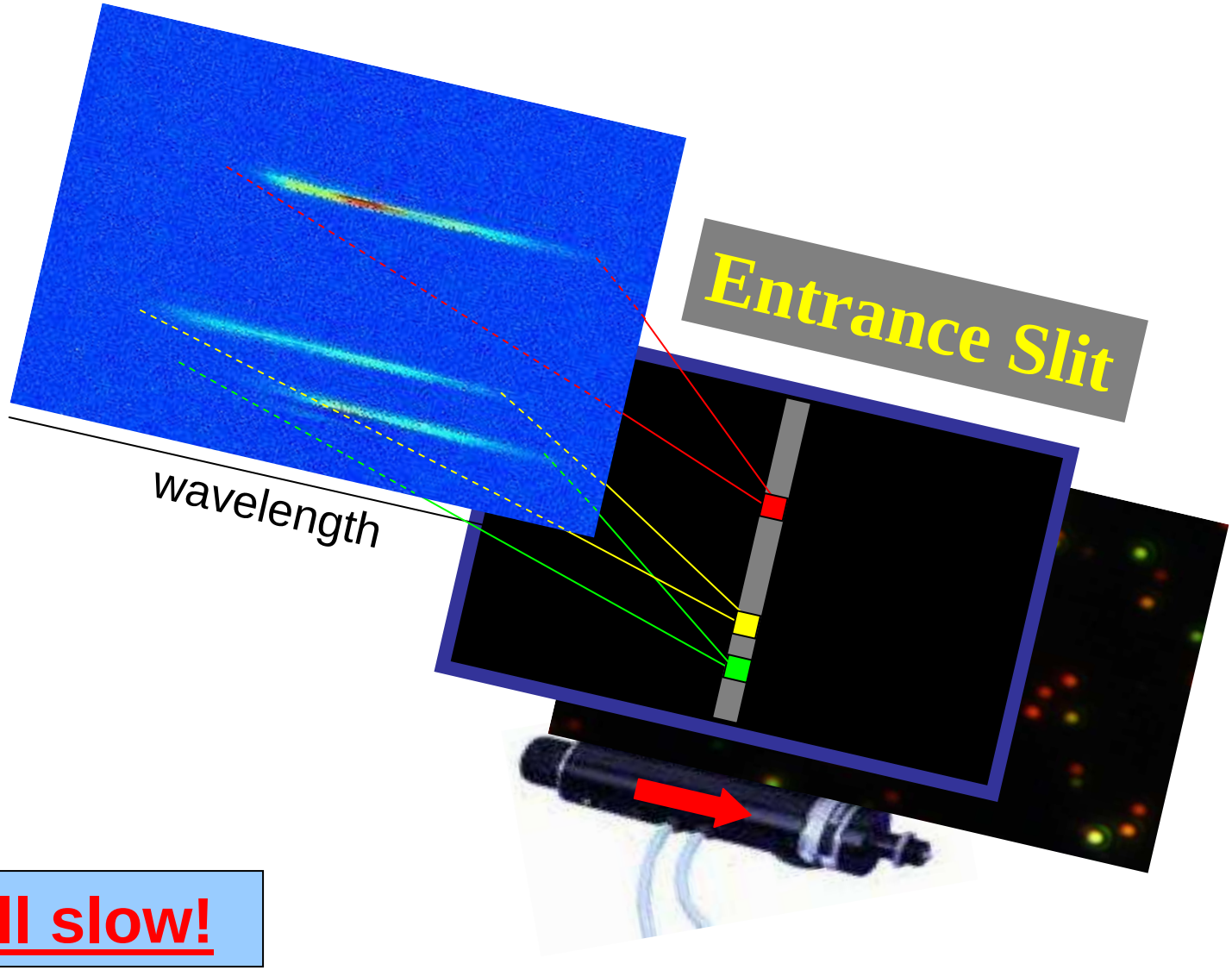
Capture the spectrum





serial process ➔ very slow!

The Scanning Method

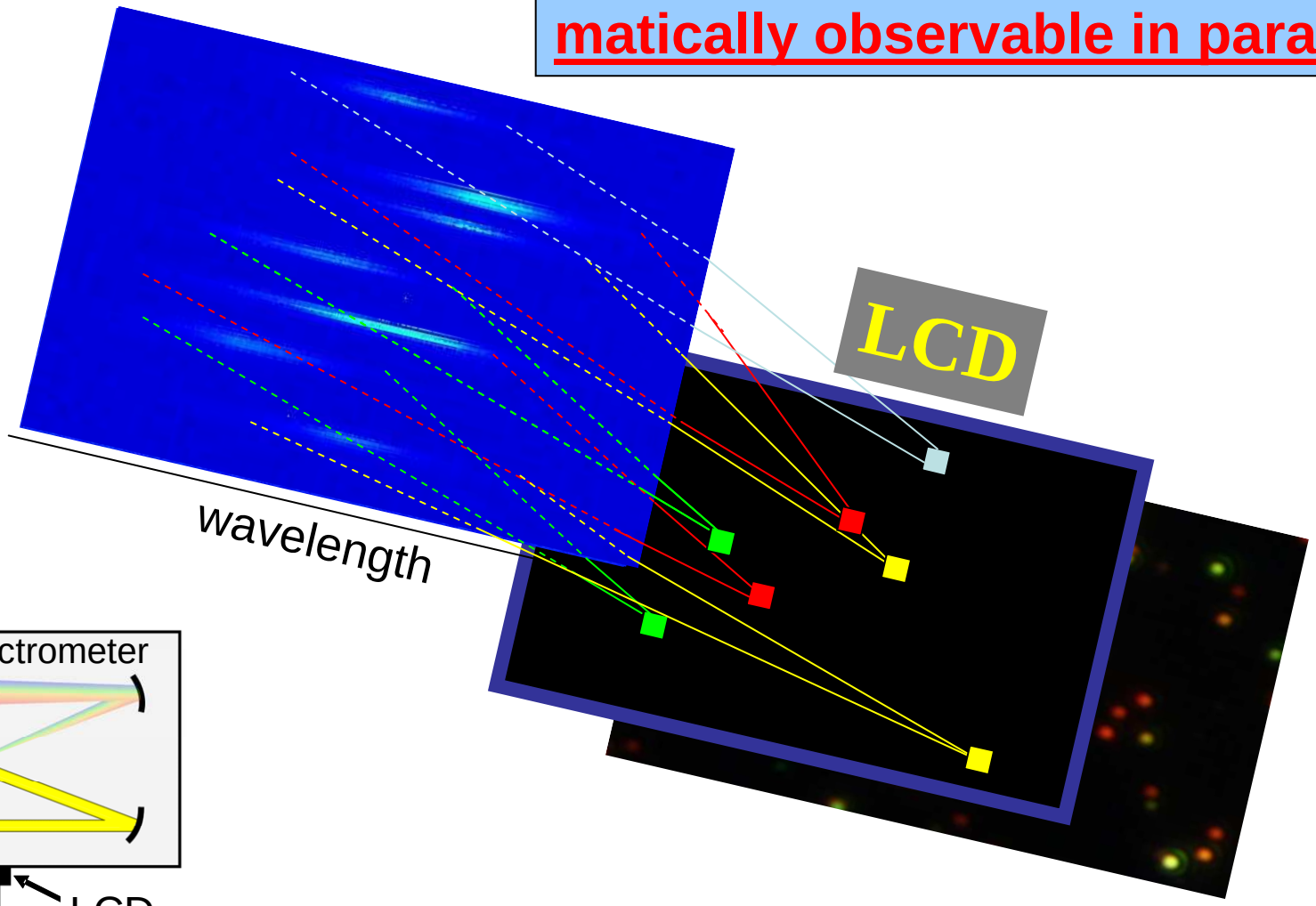


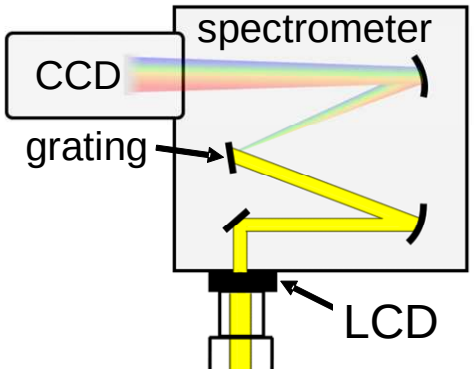
➔ still slow!

The fastSPS Method

fastSPS: fast Single Particle Spectroscopy

➔ many particles auto-matically observable in parallel



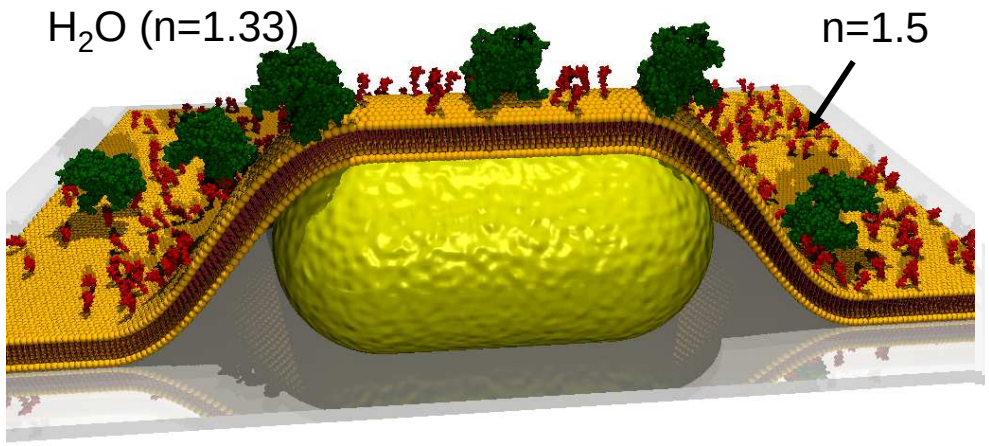


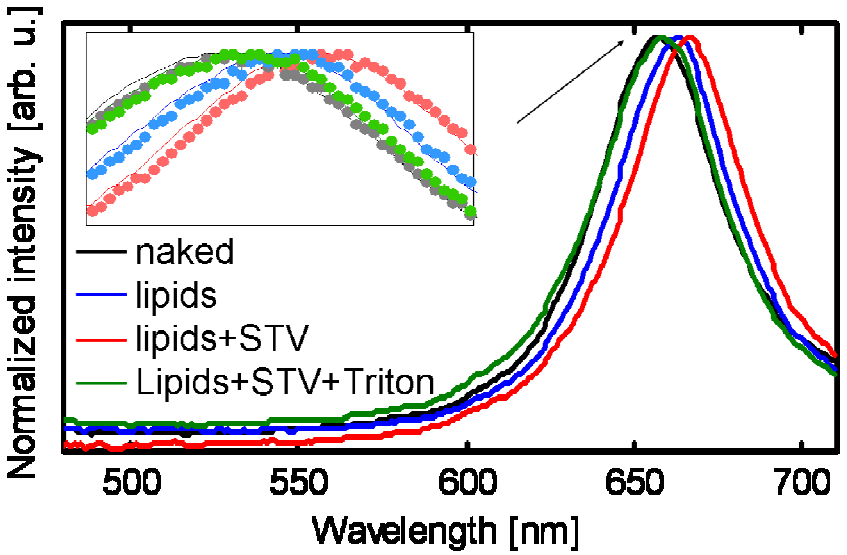
Nano Lett. (**2007**), 7, 1664

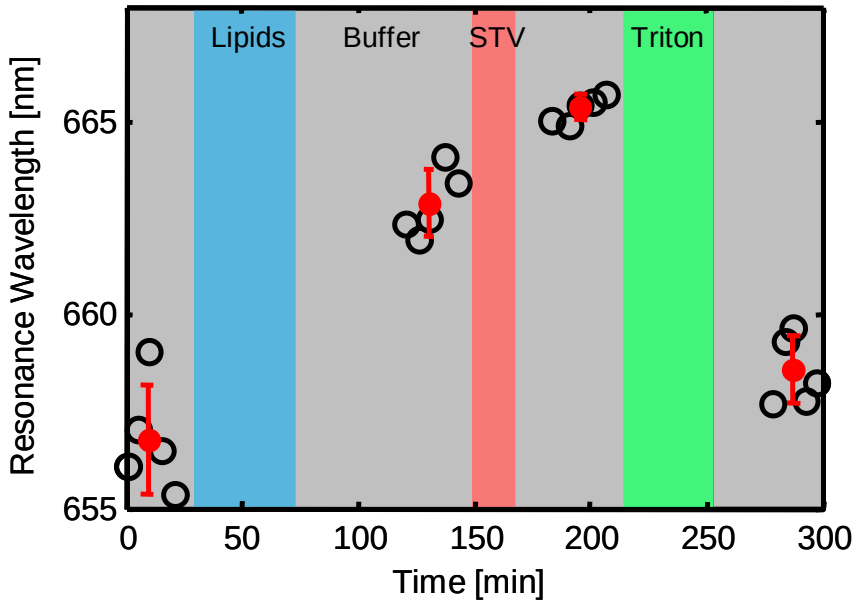
Single Plasmonic Nanoparticles as Biosensors

- Sensing properties of plasmonic particles
- Darkfield-microscopy (fastSPS)
- Protein-membrane interaction
- Improvement of Sensors

Au rods as Biosensor for Protein Binding



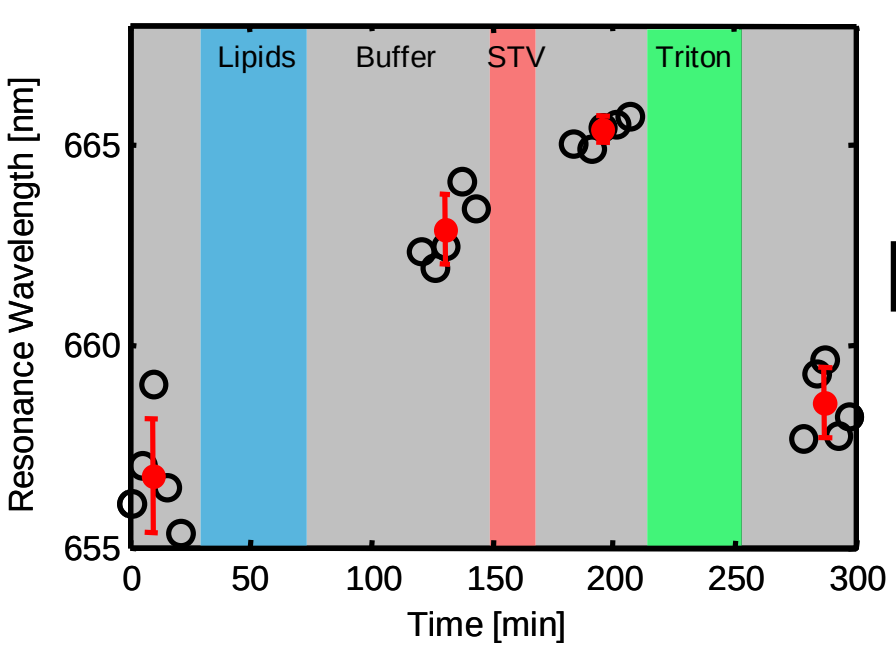




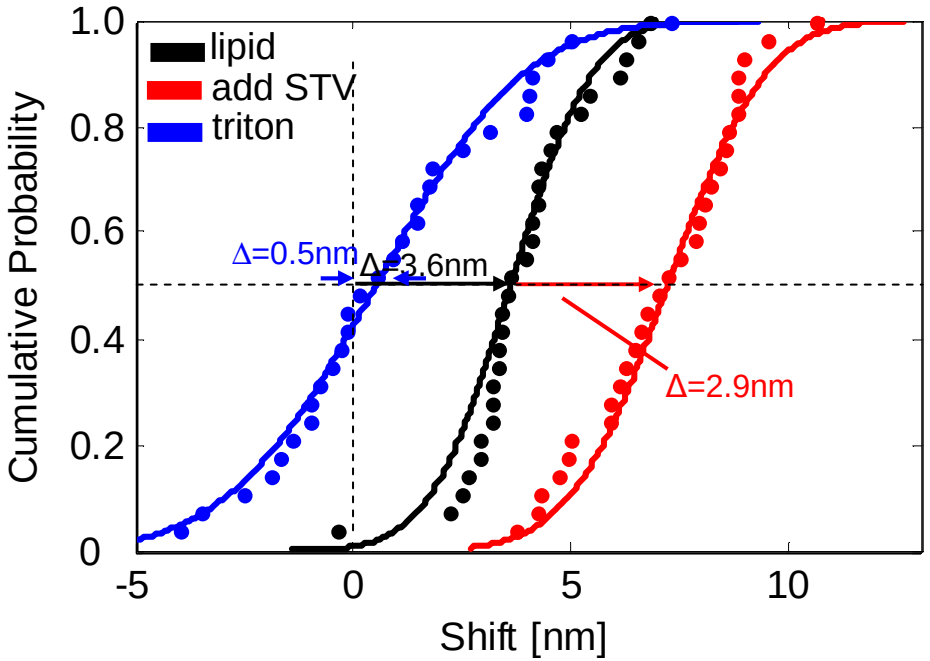
Nano Lett. (**2008**), 8, 1724

FastSPS gives statistics with only one experiment

Single particle spectra:



Statistics on 29 particles

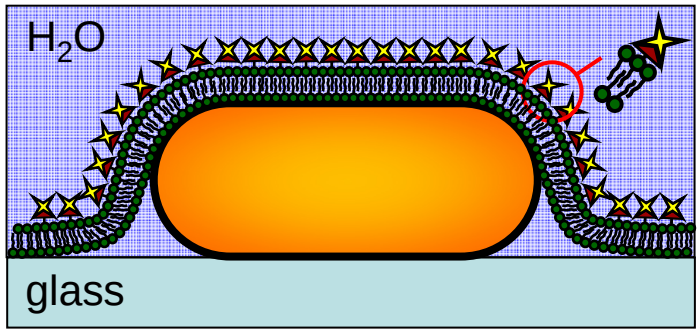


Nano Lett. (**2008**), 8, 1724

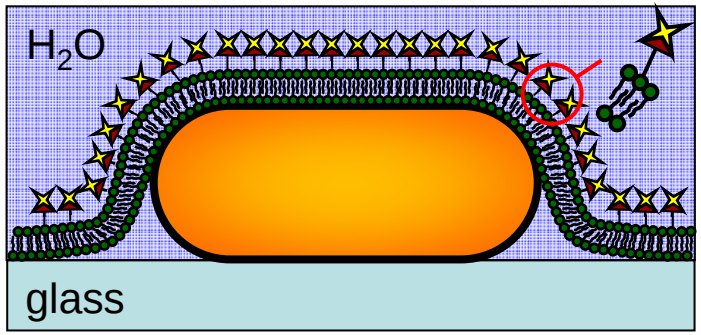
Sensitive detection of small spacer length

Shift due to streptavidin binding:

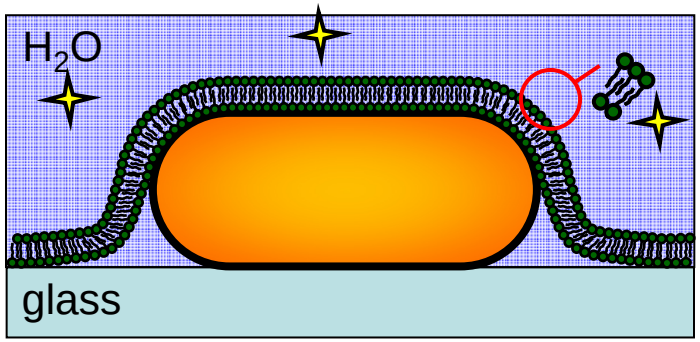
Incl. biotin:
Δ=5.3 ± 0.7nm

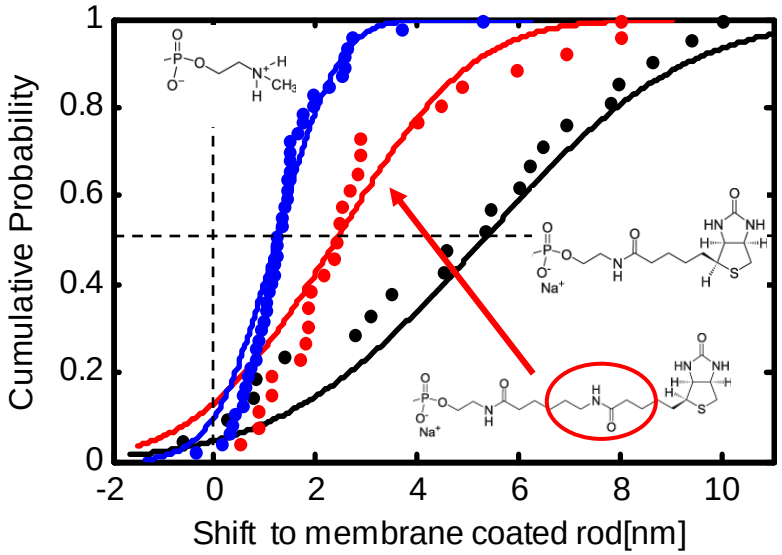


Incl. spacer
Δ=2.4 ± 0.4nm



No biotin
Δ=1.2 ± 0.1nm





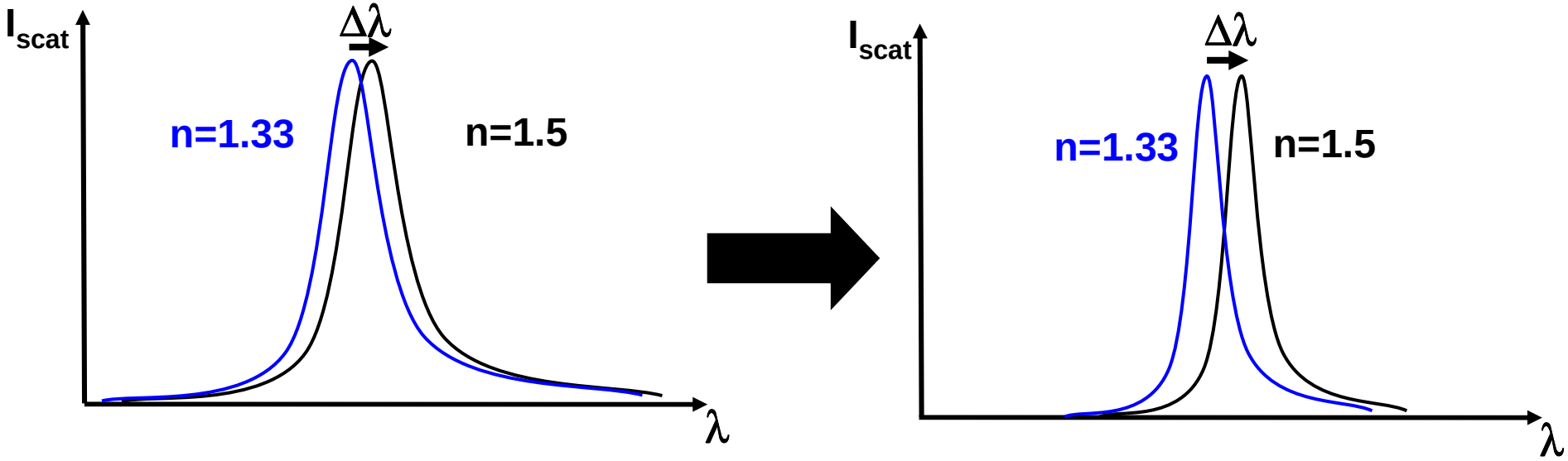
- smaller shift with longer spacer
- Membrane suppresses nonspecific interactions

Nano Lett. (**2008**), 8, 1724

Single Plasmonic Nanoparticles as Biosensors

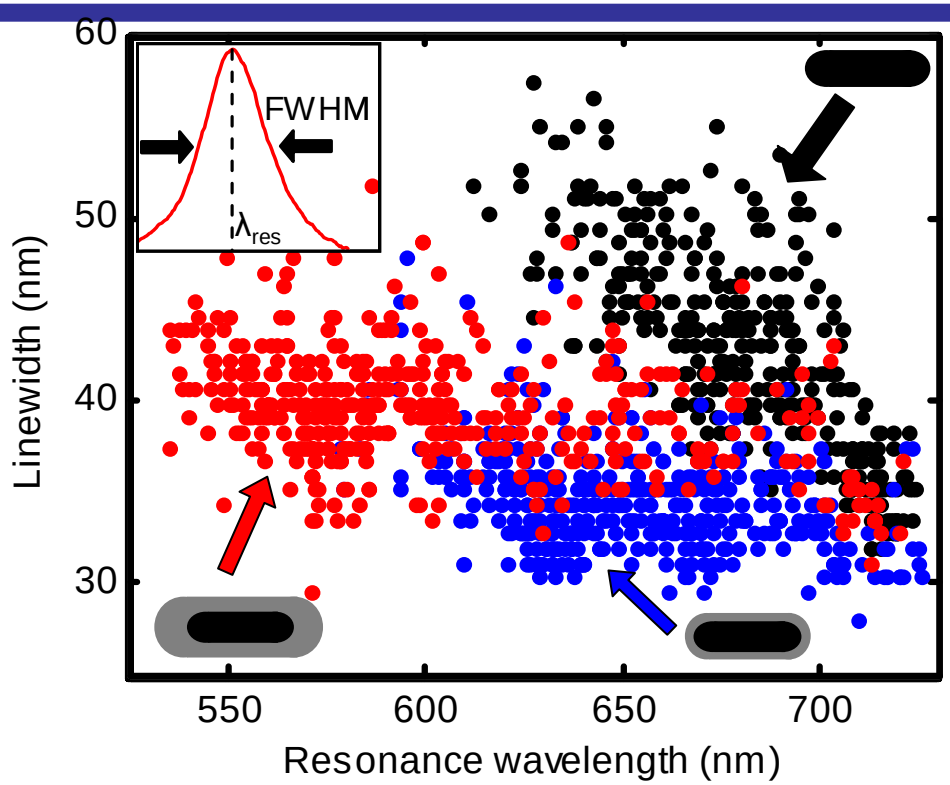
- Sensing properties of plasmonic particles
- Darkfield-microscopy (fastSPS)
- Protein-membrane interaction
- Improvement of Sensors
  - Reduction of Single Particle Linewidth
  - Increasing Plasmon Sensitivity

Sensor Improvement

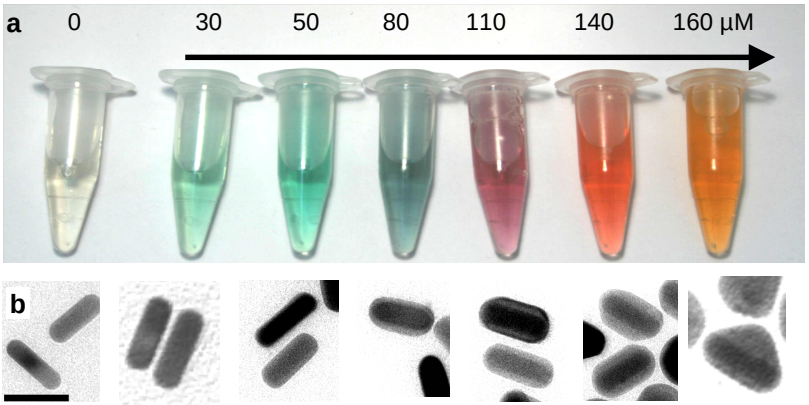


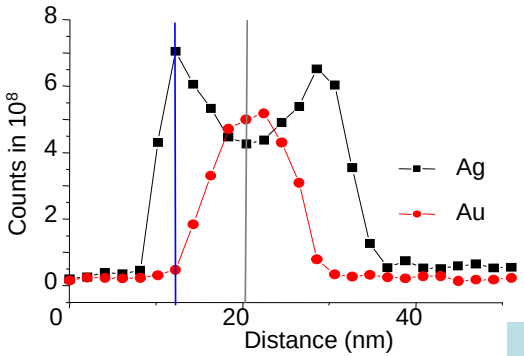
- Reduction of single particle linewidth increases resolution

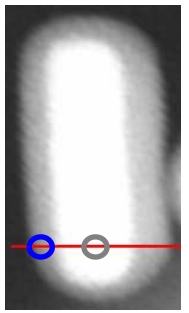
Ag Coating Reduces Single Particle Linewidth



Particle Characterization

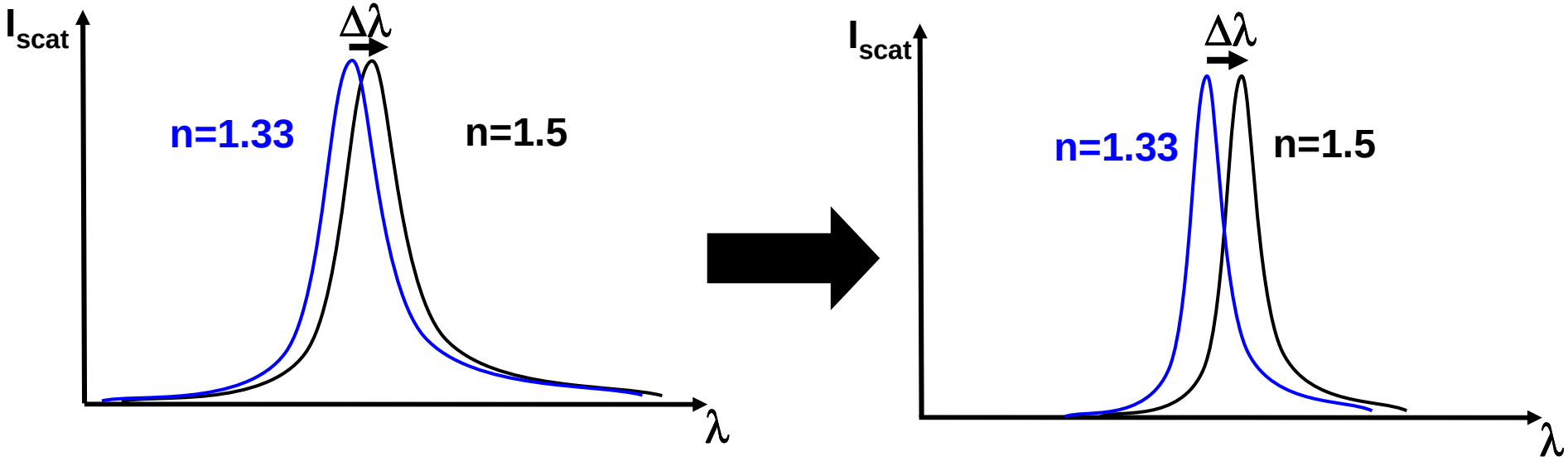




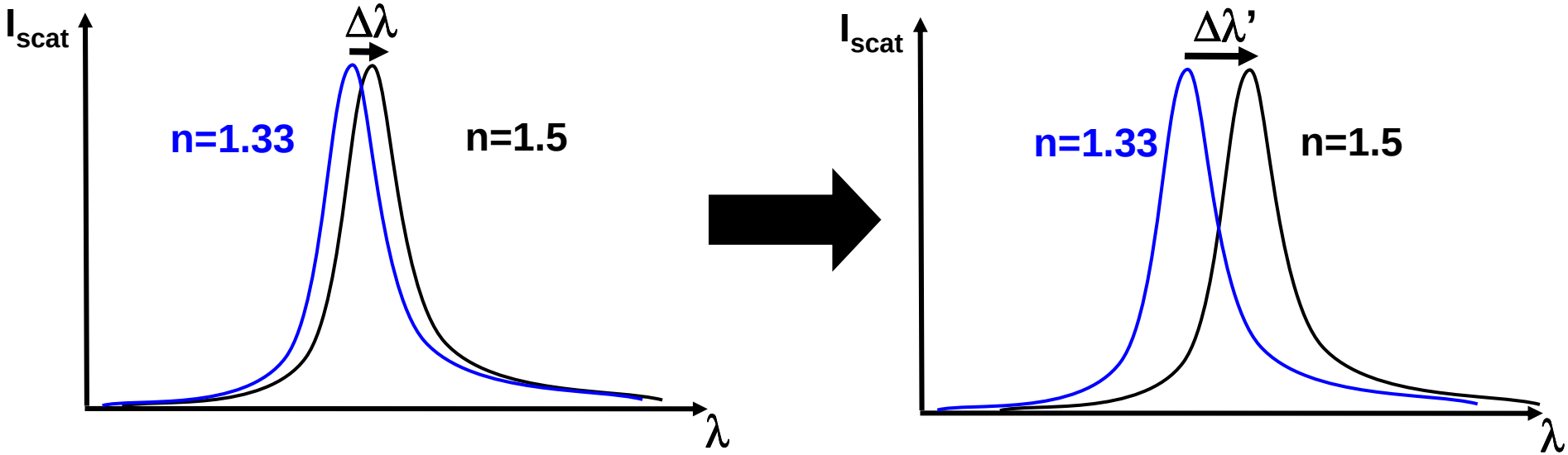


Nano Lett. (**2008**), 8, 1719

Sensor Improvement

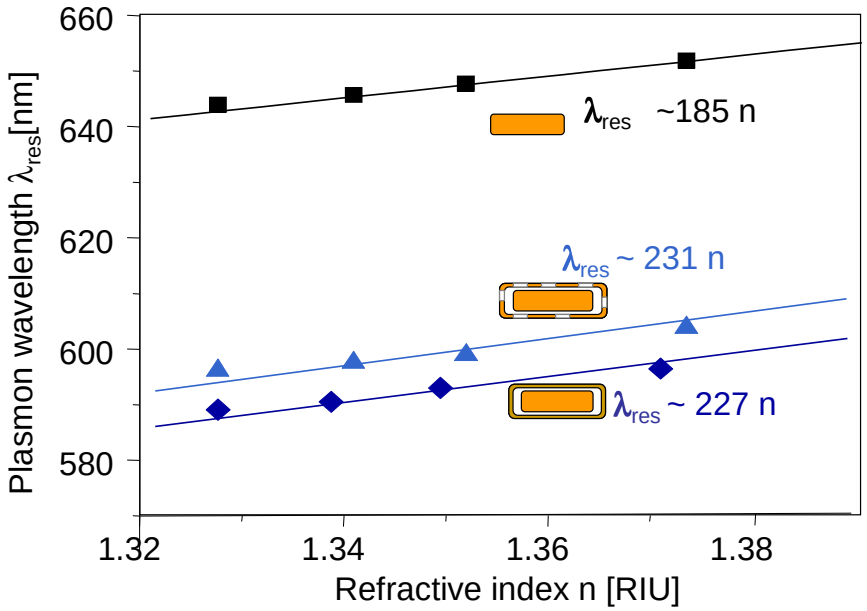


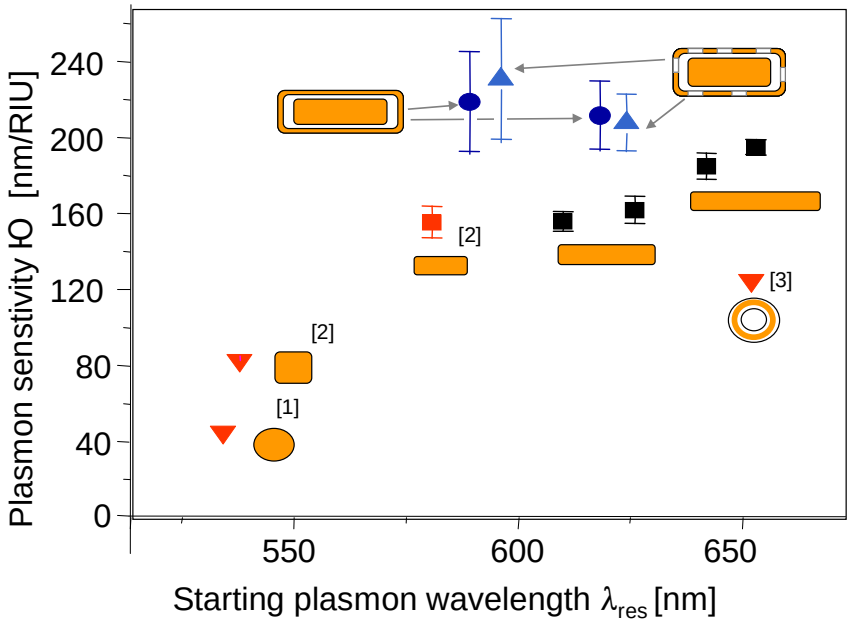
- Reduction of single particle linewidth increases resolution

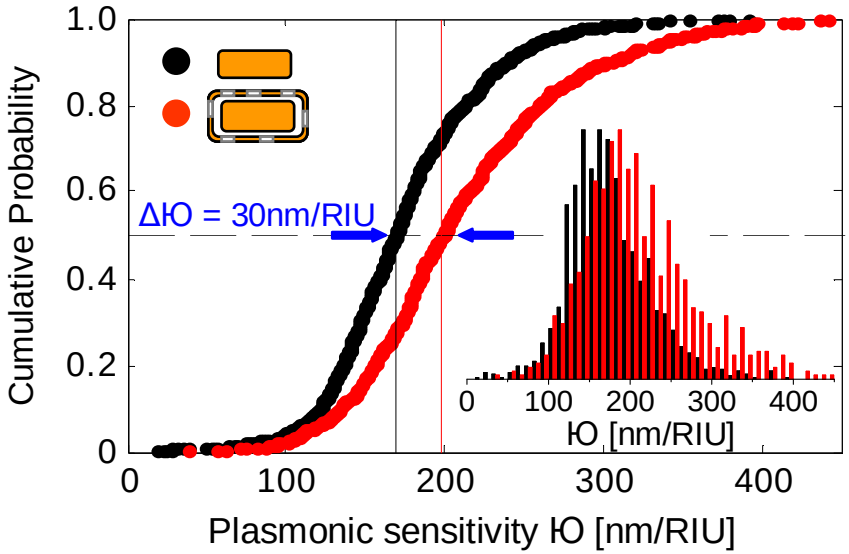


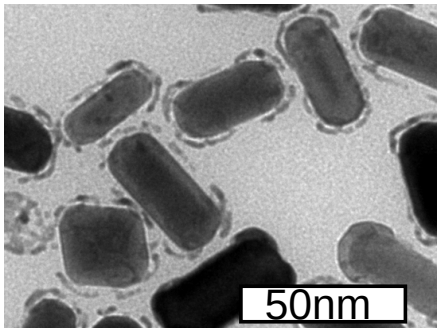
- Increased plasmon sensitivity results in larger wavelength shifts

Gold Nanorattles Show Improved Sensitivity







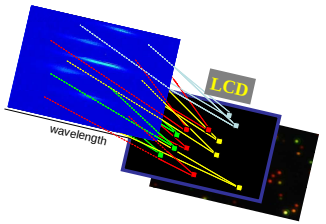


JACS, submitted

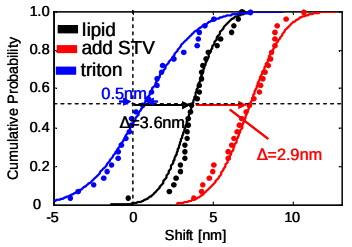
[1] Raschke *et al.* Nano Lett. (**2003**), 3, 935
[2] Chen *et al.* Langmuir (**2008**), 24, 5233
[3] Raschke *et al.* Nano Lett. (**2004**), 4, 1853

Conclusions

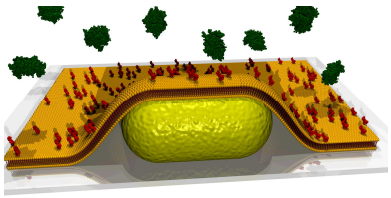
- fastSPS allows continuous observation of many (up to 30) nano-particles in parallel



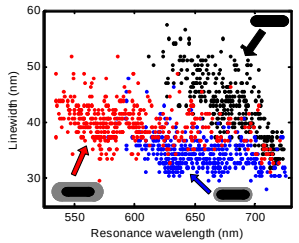
- Membrane and protein binding can be detected by shift in resonance wavelength of single nanorods



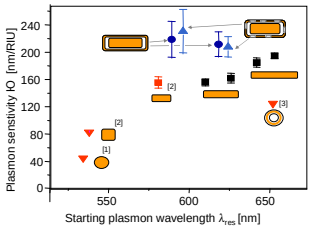
- Simple functionalizability of membranes (many different headgroups available)
  ➔ ideal characterization tool for biomolecules



- Ag coating of Au rods reduces the single particle linewidth (at same resonance wavelength)



- Gold Nanorattles show improved sensitivity on changes in refractive index



Acknowledgement

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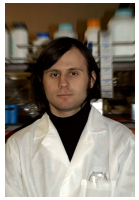
Y. Khalavka 

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