NanoMicroSpec™ series: technical details

Fully integrated dark-field/bright-field microscopy and imaging spectroscopy setups

Specifications[1]	NMS-T	NMS-R
Illumination configurations	Diascopic (transmission) bright-field and dark-field illumination Episcopic (reflection) bright-field illumination[2]	Episcopic (reflection) bright-field and dark-field illumination Diascopic (transmission) bright-field illumination
Microscopy components	Extra Long Working Distance, coverslip-corrected objectives (4x, 10x, 20x, 60x) Broad-band polarizer and analyzer Quarter-wave plates with motorized polarizer/analyzer[3] Excitation and emission filters[4]	Extra Long Working Distance bright-field/dark-field objectives (10x, 20x, 50x, 100x) Motorized broad-band polarizer and analyzer
Spectrograph	Focal length 500 mm, aperture ratio f/6.5 Motorized entrance slit for 1D hyperspectral imaging[5]	Focal length 160 mm, aperture ratio f/6.5, aberration-reduced design Motorized entrance slit for 1D hyperspectral imaging[5]
Available Gratings[6,7]	Spectral range 380-1050 nm: range 523 nm, res. 0.511 nm range 347 nm, res. 0.340 nm range 83 nm, res. 0.082 nm range 37 nm, res. 0.037 nm Spectral range 900-1700 nm[8]: range 251 nm, res. 0.393 nm range 167 nm, res. 0.261 nm range 82 nm, res. 0.129 nm range 40 nm, res. 0.063 nm	Spectral range 380-1000 nm: range 609 nm, res. 0.953 nm range 404 nm, res. 0.632 nm range 95 nm, res. 0.150 nm range 42 nm, res. 0.067 nm

[1] Specifications are subject to change without further notice
[2] Optional (Epi-illumination package)
[3] Optional (Chiral spectroscopy package)
[4] Optional (Fluorescence spectroscopy package)
[5] 2D hyperspectral imaging is possible by using motorized stage
[6] Movable reflection gratings; computer-controlled switching and positioning of up to three gratings per spectrometer
[7] Other gratings available upon request
[8] Optional (SWIR package)

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Spectrometer camera	Peltier-cooled, low-noise front-illuminated CCD, 26 µm pixel size, 256x1024 pixels, 2 MHz readout Peltier-cooled InGaAs FPA, 20 µm pixel size, 640x512 pixels, 10 MHz readout[8]	Peltier-cooled, low-noise front-illuminated CCD, 26 µm pixel size, 256x1024 pixels, 2 MHz readout
Imaging camera	2448x2050 pixels (rgb CCD; 15 fps)	2448x2050 pixels (rgb CCD; 15 fps)
Motorized scan stage	130x850 mm travel range, <1 µm repeatability, 10 nm resolution With custom-made sample holder	100x100 mm travel range, <1 µm repeatability, 10 nm resolution With custom-made sample holder
Light sources	Fiber-coupled high-intensity, ultra-stable, broadband laser-driven light source (180-2100 nm) Additional broadband halogen lamp for bright-field imaging applications Light guide-coupled high-intensity metal halide lamp for bright-field imaging and fluorescence spectroscopy[4]	Fiber-coupled high-intensity, ultra-stable, broadband laser-driven light source (180-2100 nm) Additional broadband halogen lamp for bright-field imaging applications
Available add-ons	Vacuum-sealed titanium gas flow sample cell for transmission and reflection Fully integrated gas mixing system with up to 4 channels Fluid cell optimized for in-situ monitoring of electrochemical processes	Vacuum-sealed titanium gas flow sample cell for transmission and reflection Temperature-controlled titanium gas flow cell for reflection (15 °C – 100 °C) Fully integrated gas mixing system with up to 4 channels Fluid cell optimized for in-situ monitoring of electrochemical processes

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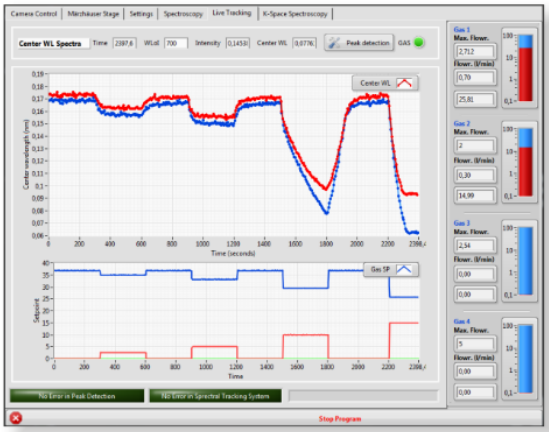
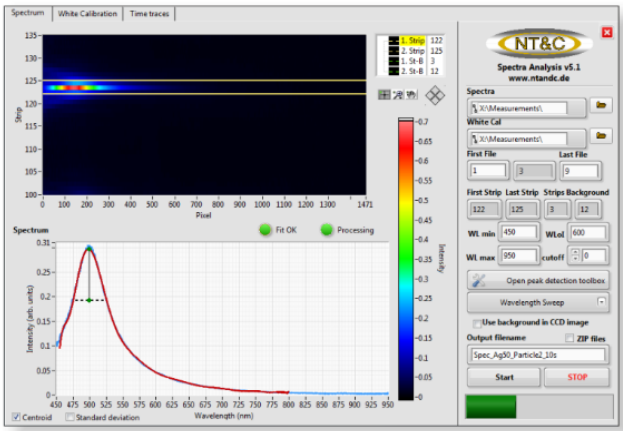
Measurement Capabilities

- **Simultaneous measurement, display, analysis** and data storage of CCD camera image, spectrograph CCD image and measured spectra (variable ROI)
- **Bright-field:** automated transmittance and reflectance measurements (using pre-defined or live reference measurements)
- **Dark-field:** automated recording of scattering spectra from individual nanoparticles; possibility of monitoring around 10 nanoparticles simultaneously
- **High versatility through modular design:** various extensions and customer-specific adaptations to microscope, spectrometer, light source and software are available
- **Programmable time-resolved measurements:** automated position sweeps, center wavelength sweeps, gas concentration control, and temperature control
- **Access to full spectral range** with any available grating via automated grating positioning and intelligent stitching
- **Live spectra analysis** for tracking centroid/peak wavelength or intensity, including numerical filtering and smoothing
- **Complete, on-the-fly measurement data storage,** allowing for extensive data analysis via batch post-processing of time series and spectral/position sweeps; access to full dataset by retrospective ROI/particle selection
- **Generalized data format:** all data (CCD images, spectra, time traces, environmental data) are stored in standardized ascii format and can be accessed by any external software independent of operating system
- **Compact, user-friendly software**, fully integrated with all hardware components/extensions

NT&C LabControl™ and SpectraAnalysis™ software





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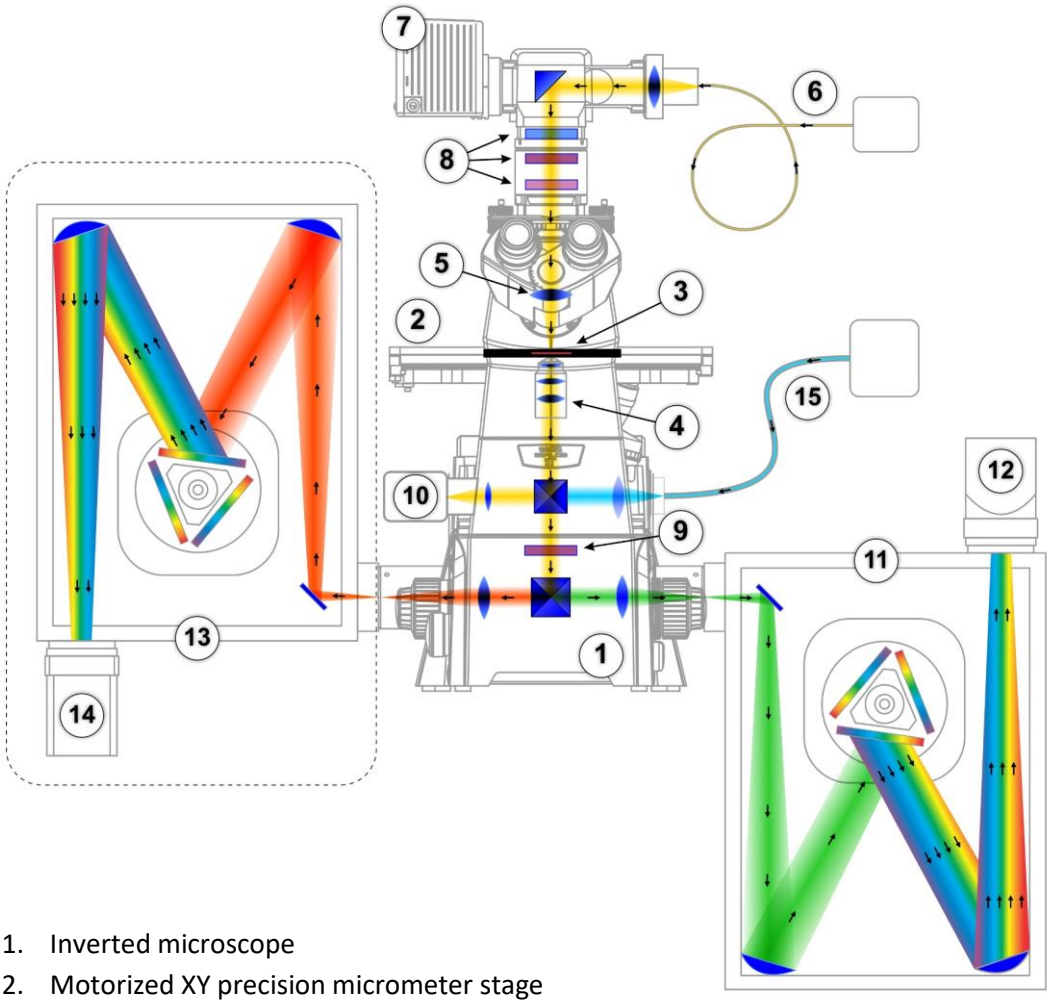
System layout: NanoMicroSpec-Transmission



1. Inverted microscope
2. Motorized XY precision micrometer stage
3. Sample plane
4. Microscope objectives (4x, 10x, 20x, 60x)
5. Bright-field/dark-field condenser
6. Fiber-coupled high-intensity, ultra-stable broadband light source[9]
7. Additional halogen lamp for wide-field imaging[9]
8. Excitation beam conditioning: polarizers, filters, iris stop, quarter-wave plate
9. Emission beam conditioning: analyzers, filters
10. Imaging CCD camera
11. 2D spectrograph VIS/NIR
12. Peltier-cooled CCD camera, spectral range 380-1050 nm
13. 2D spectrograph SWIR (optional)
14. Peltier-cooled InGaAs Focal Plane Array camera, spectral range 900-1700 nm (optional)
15. Fluorescence spectroscopy/epi-illumination package (metal halide lamp, light coupling and filters)[9]

[9] Positions 6/7 and positions 6/15 are interchangeable for reflection/transmission mode.

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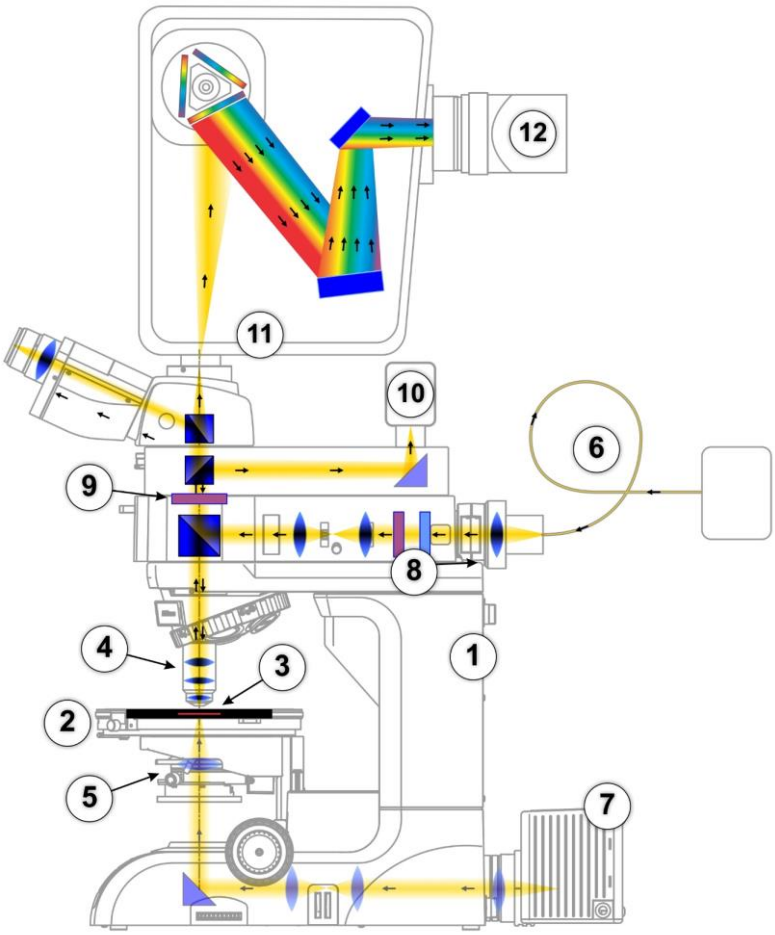
System layout: NanoMicroSpec-Reflection



1. Upright microscope
2. Motorized XY precision micrometer stage
3. Sample plane
4. Bright-field/dark-field microscope objectives (10x, 20x, 50x, 100x)
5. Transmission bright-field condenser
6. Fiber-coupled high-intensity, ultra-stable broadband light source[10]
7. Additional halogen lamp for wide-field imaging[10]
8. Excitation beam conditioning: polarizers, filters, field/aperture stop
9. Emission beam conditioning: analyzers, filters
10. Imaging CCD camera
11. Aberration-reduced 2D spectrograph VIS/NIR
12. Peltier-cooled CCD camera, spectral range 380-1000 nm

[10] Positions 6 and 7 are interchangeable.

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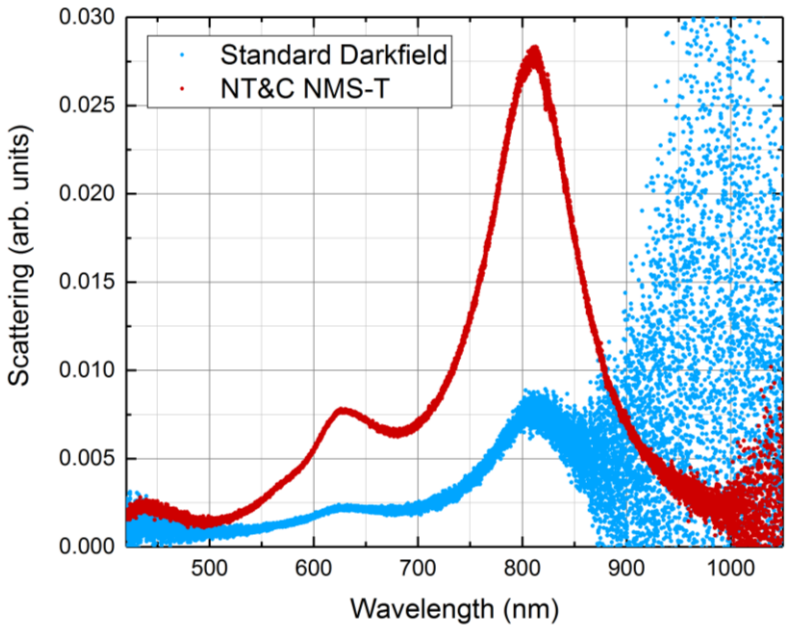
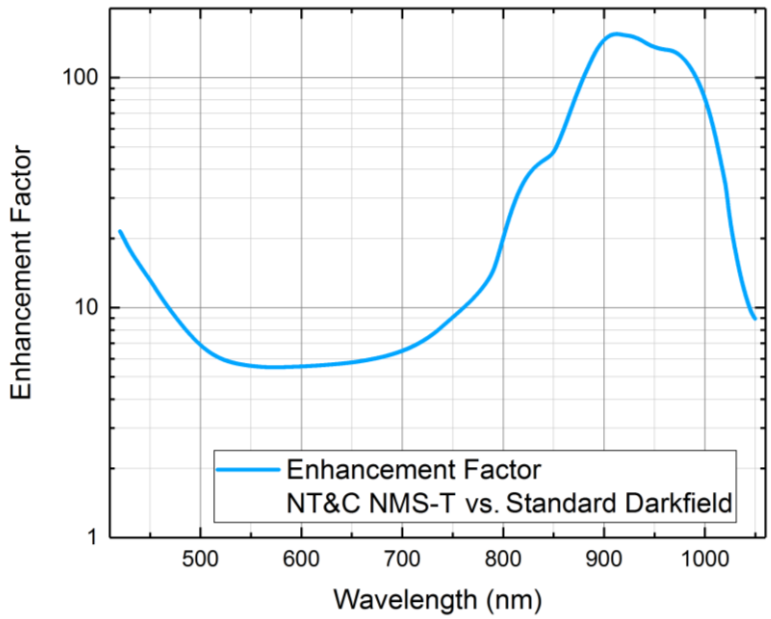
Comparison NMS-T to standard dark-field optics

- Single Au nanoparticles on glass substrate, measured with NMS-T using 60x objective. Measured with standard dark-field illumination optics and halogen light source, and with NT&C dark-field illumination optics and high-intensity broadband light source, at similar integration times.



- Dark-field illumination enhancement factor: Intensity at sample using NT&C light source/optics vs. standard dark-field illumination. Recorded on isotropically scattering white calibration sample.



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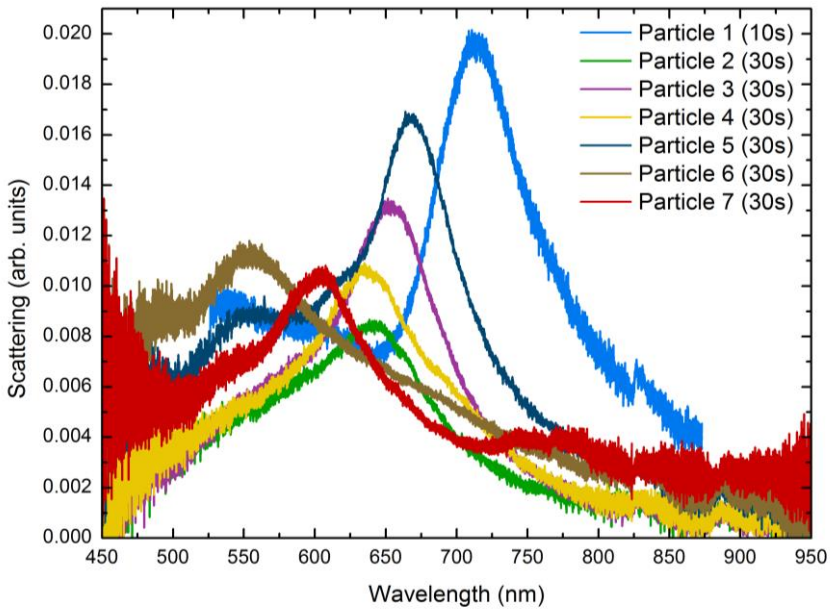
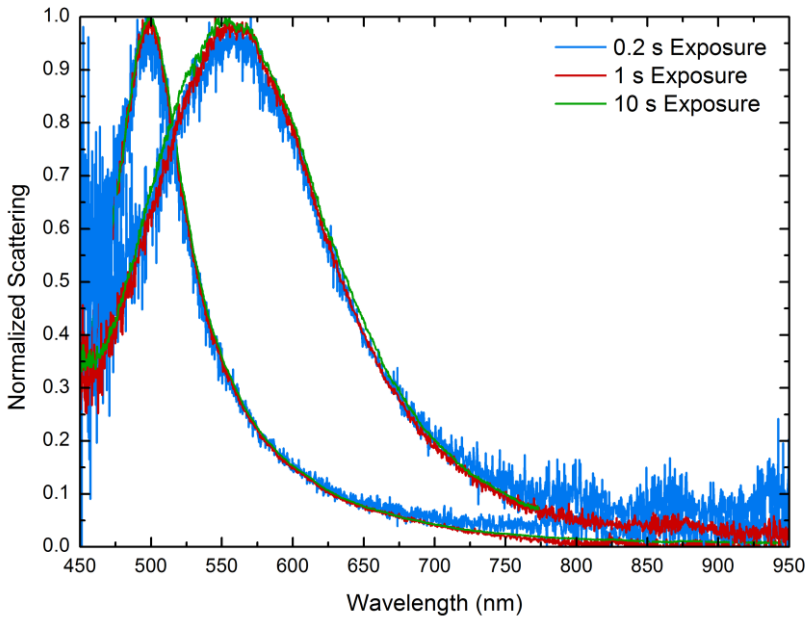
Exemplary single-nanoparticle measurements NMS-T

- Single Au nanoparticles on glass substrate, precipitated from solution containing Au nanoparticles of varying diameters (20, 30, 50, and 100 nm). Measured with NMS-T at different integration times using 60x objective and dark-field condenser.



- Single Ag nanocubes, side lengths 50 nm and 110 nm. Measured with NMS-T at different integration times (0.2s, 1s, 10s) using 60x objective and dark-field condenser



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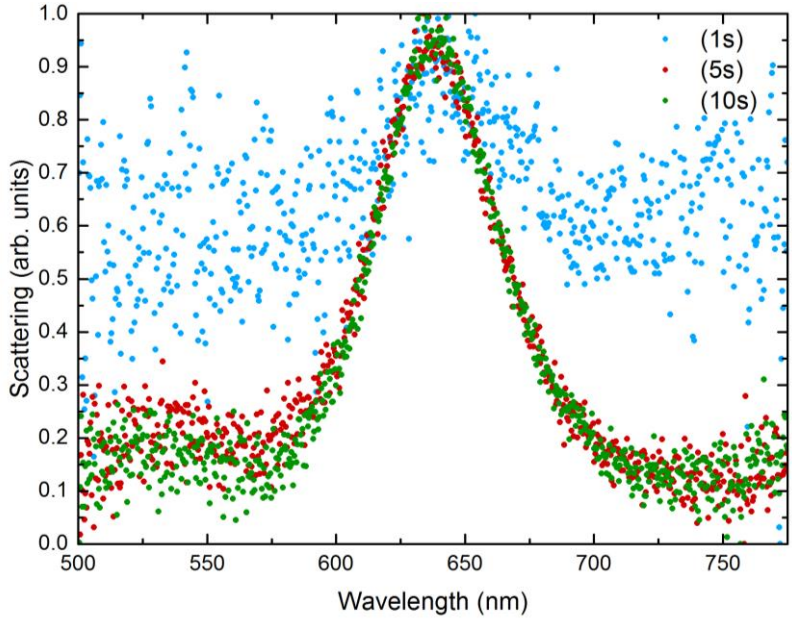
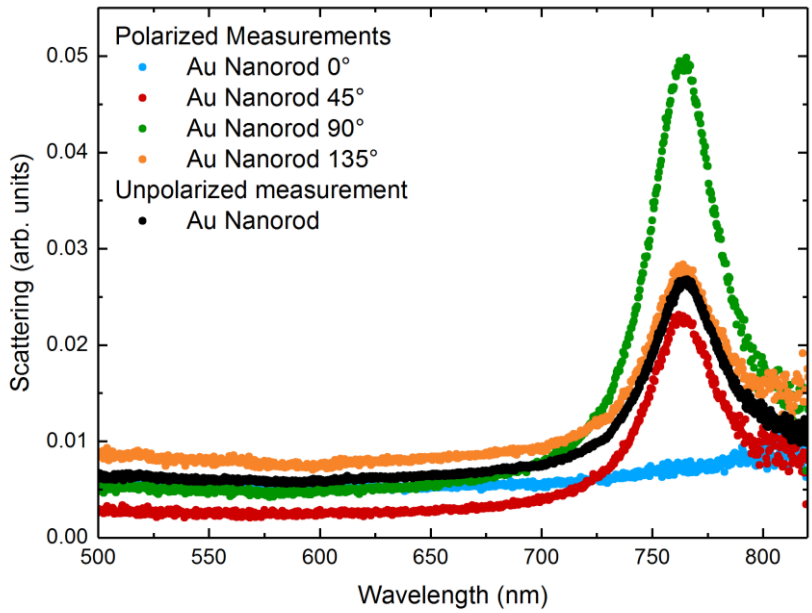
Exemplary single-nanoparticle measurements NMS-R

- Single Au nanoparticle on glass substrate, diameter 20 nm. Measured with NMS-R at different integration times (1s, 5s, 10s) using 50x dark-field objective



- Single Au nanorod on glass substrate, dimensions 50x10 nm. Measured with NMS-R, using spectra stitching at 30 seconds integration time using 50x dark-field objective



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