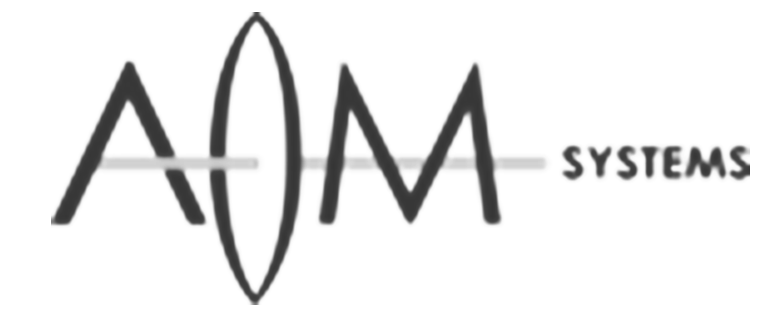
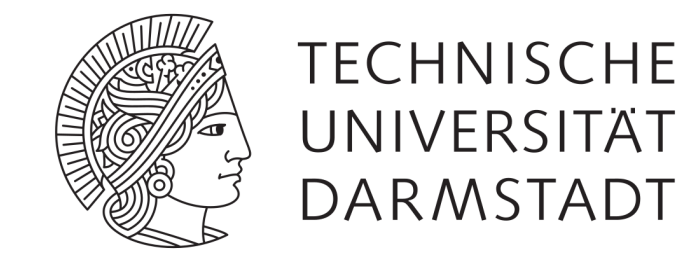


Characterization on Droplets with Embedded Particles

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[1] L. Li, S. Rosenkranz, W. Schaefer, and C. Tropea, "Light scattering from a drop with an embedded particle and its exploitation in the time-shift technique," *J. Quant. Spectrosc. Radiat. Transfer*, vol. 227, pp. 20–31, 2019, doi: 10.1016/j.jqsrt.2019.01.022. [Online]. Available: <https://doi.org/10.1016/j.jqsrt.2019.01.022>



Paper

[2] W. Schäfer, *Time-Shift Technique for Particle Characterization in Sprays*. Ph.D. dissertation, Technische Universität Darmstadt, Germany, 2012. Book edition: Berlin, Germany, 2013, ISBN 979-8161309988. [Online]. Available: <https://amzn.eu/d/08dPYjDf>

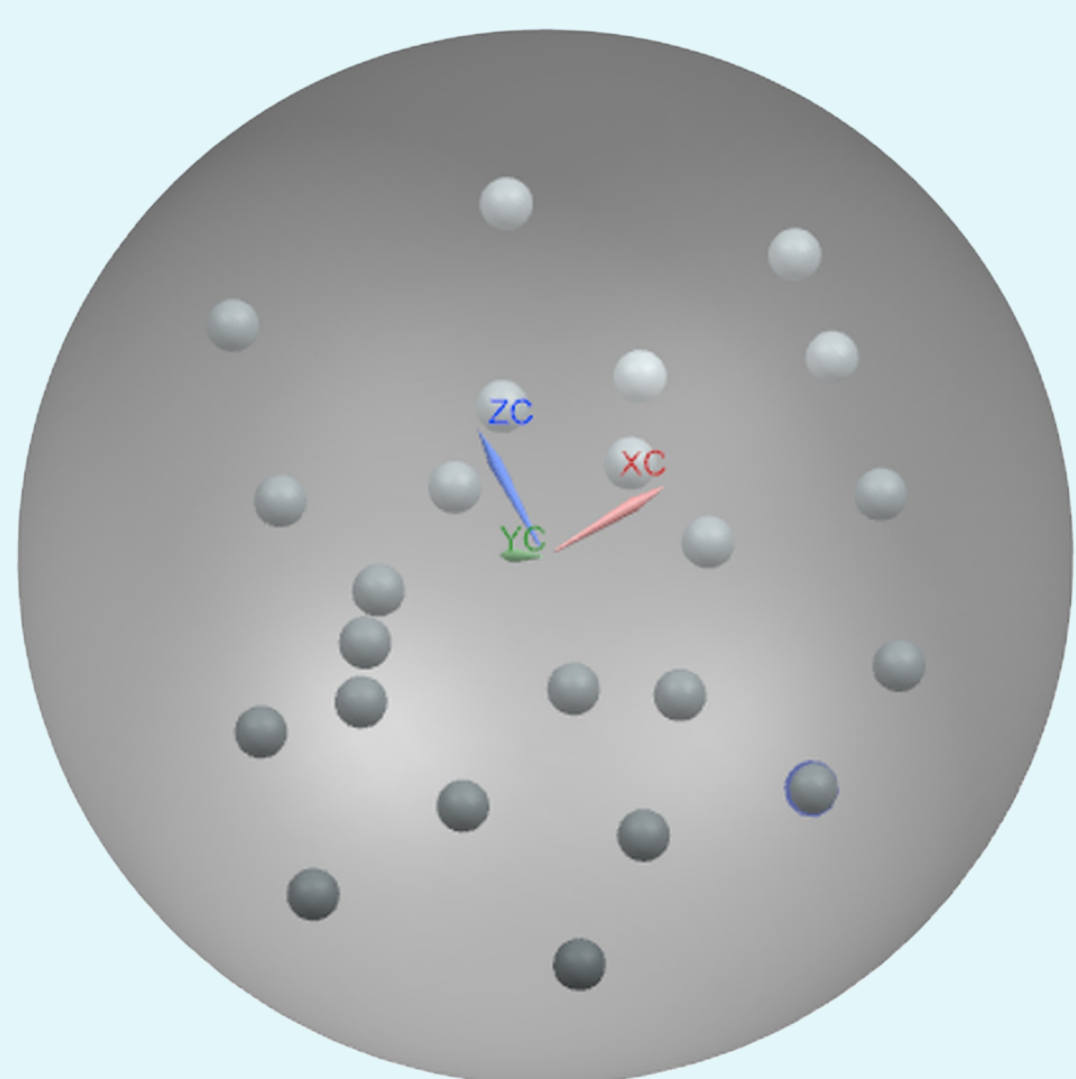


Book

There is a need for the characterization of **drops with an embedded dispersed phase** in a wide variety of industrial processes. Examples are fuels with dispersed metallic nanoparticles, metallic paints with aluminum flakes, colloidal drops (e.g., ink-jet printing) and encapsulated particles covered by a liquid layer, typical for pharmaceutical applications.

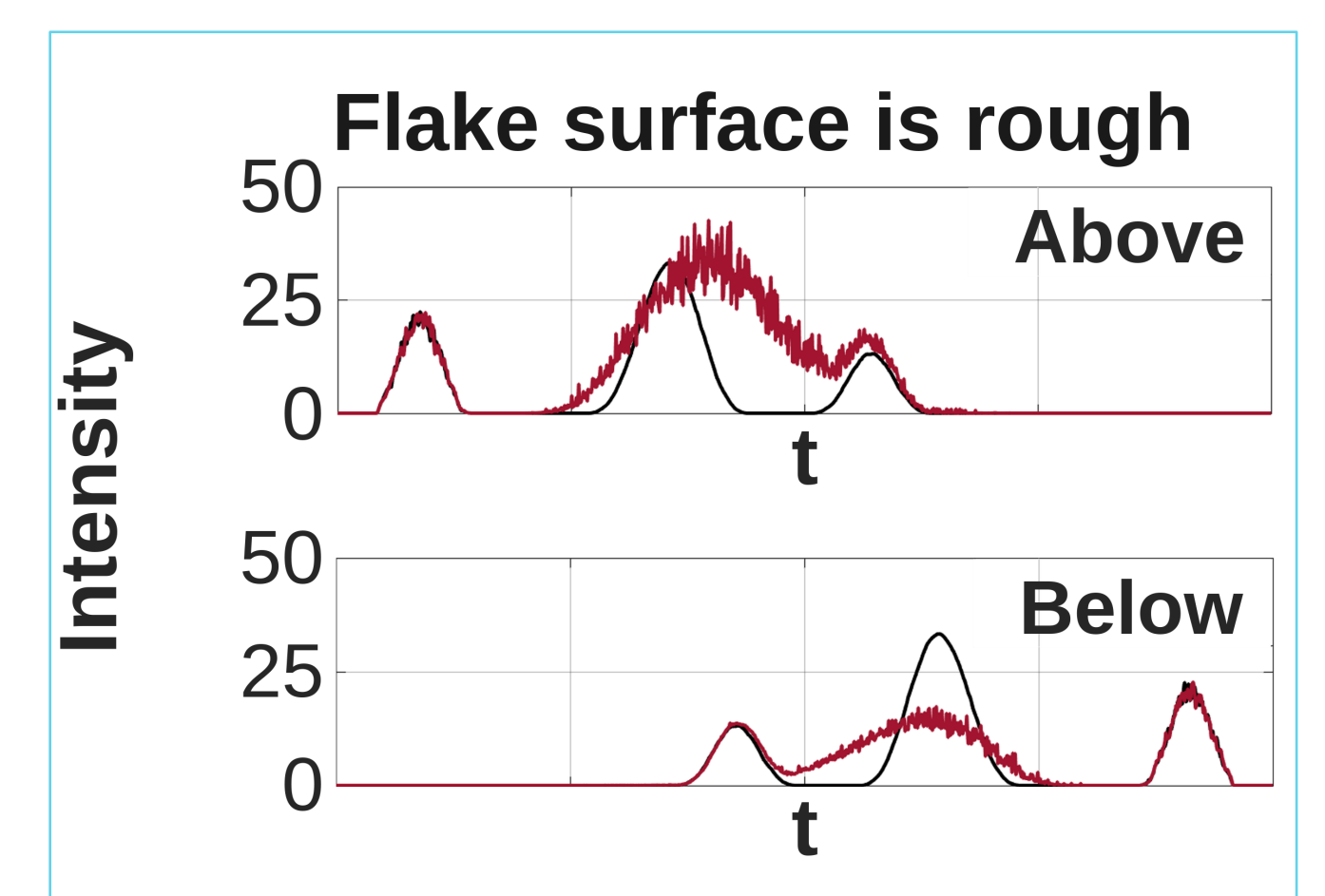
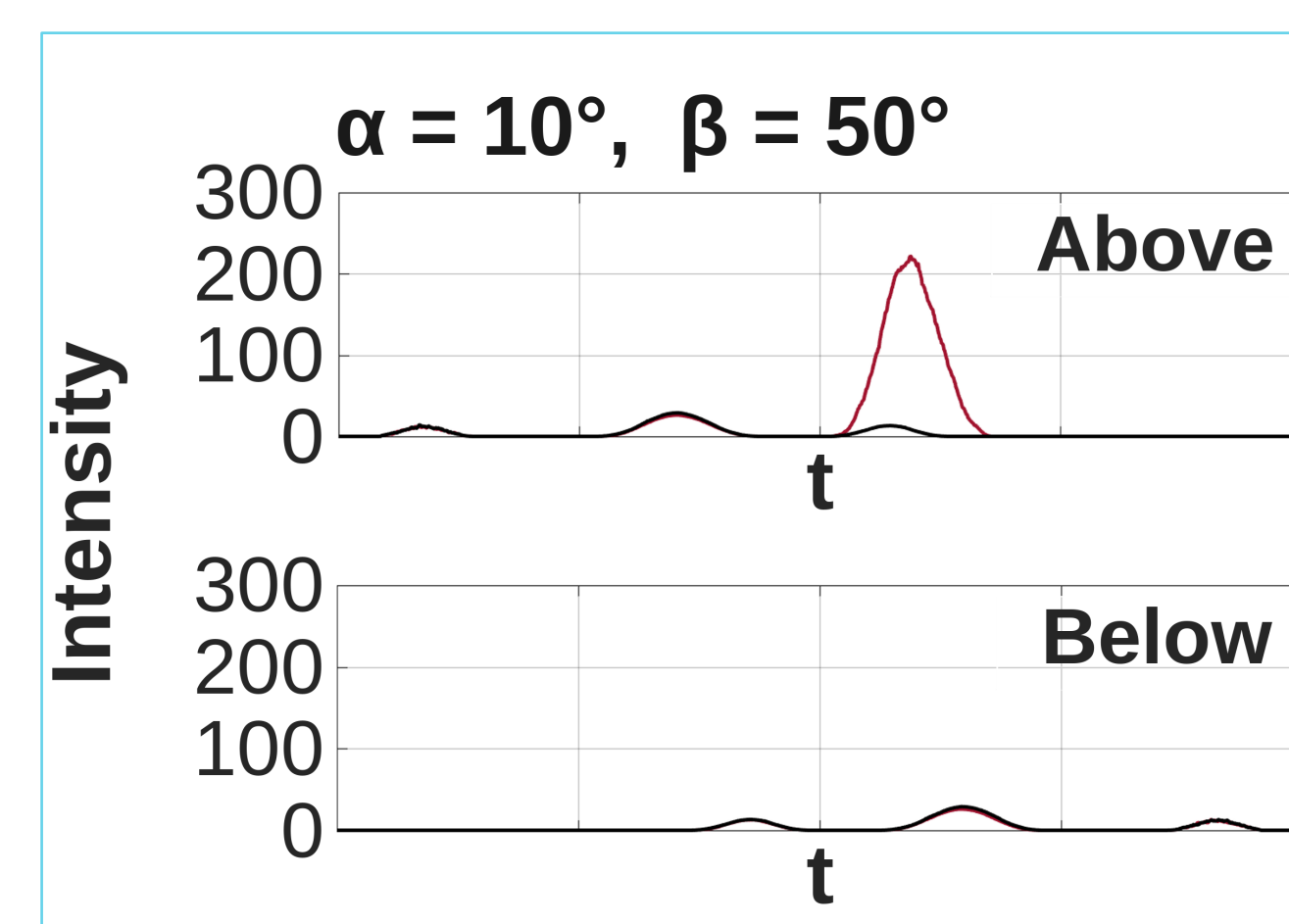
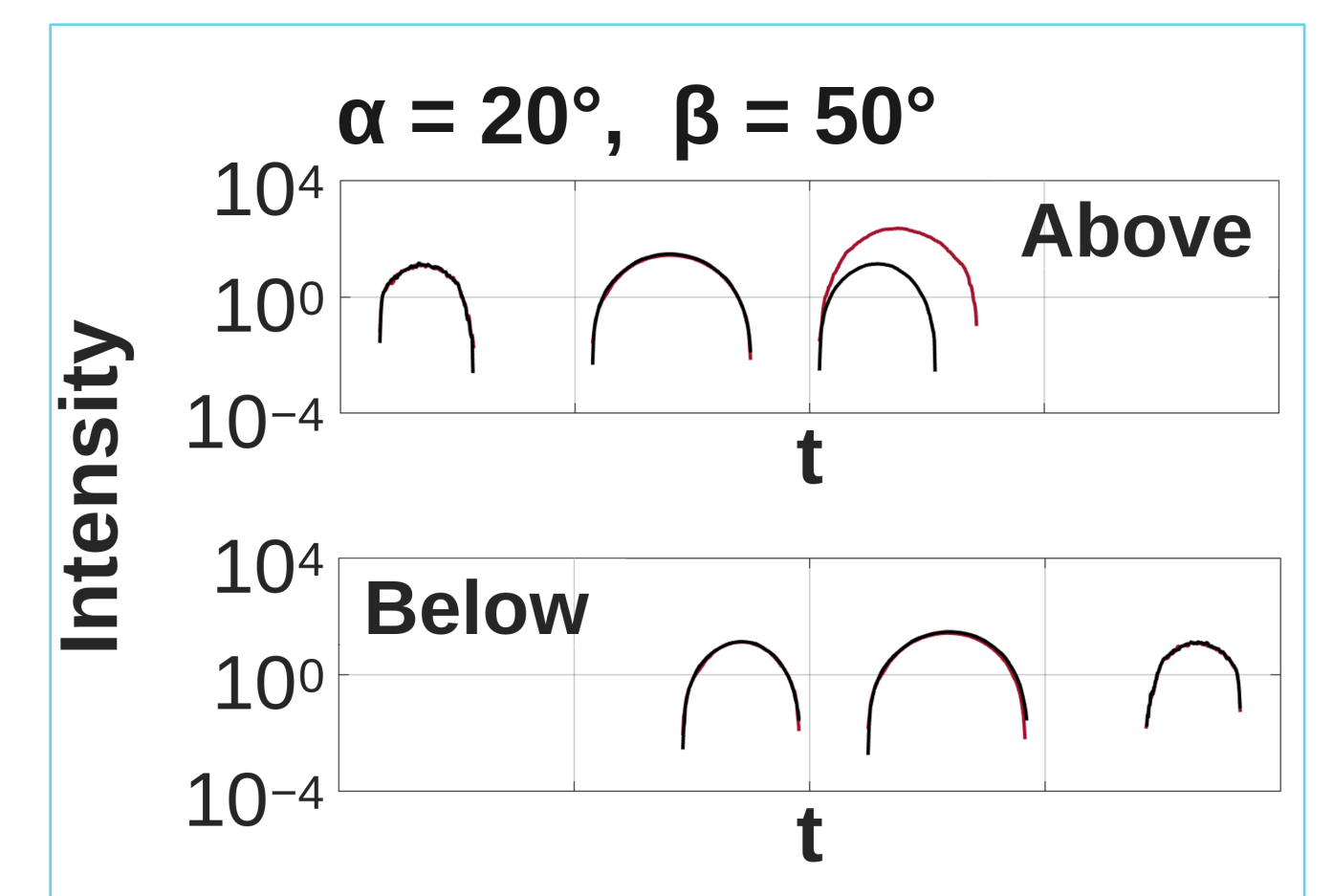
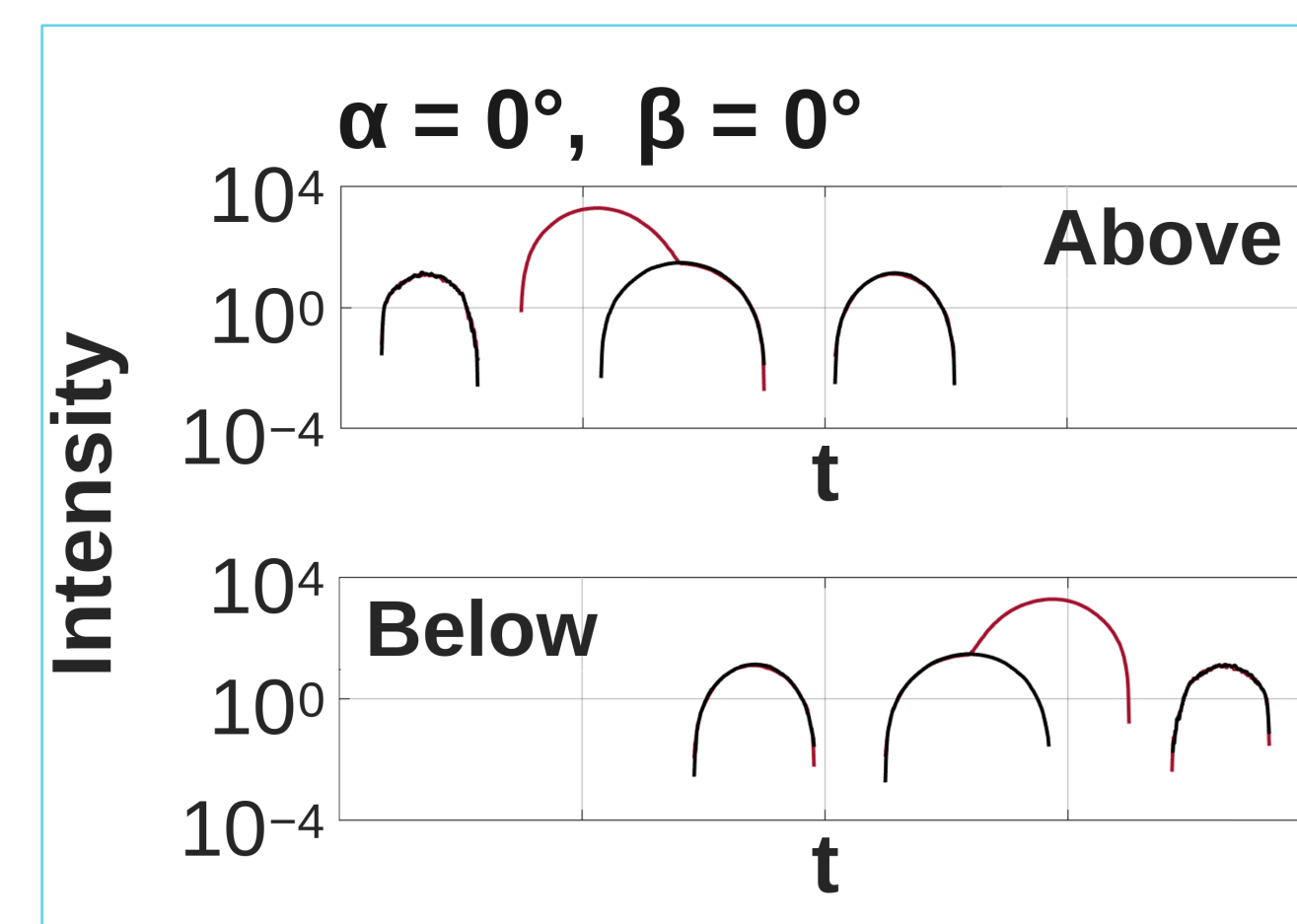
1 Simulation of TSTOF signal from a droplet with an embedded flake

Simulated TSTOF signals for a droplet with an embedded flake at varying flake orientations within the drop. The signals are compared with the reference signal for the flake detection (α : zenith angle, β : azimuthal angle) [1, 2].



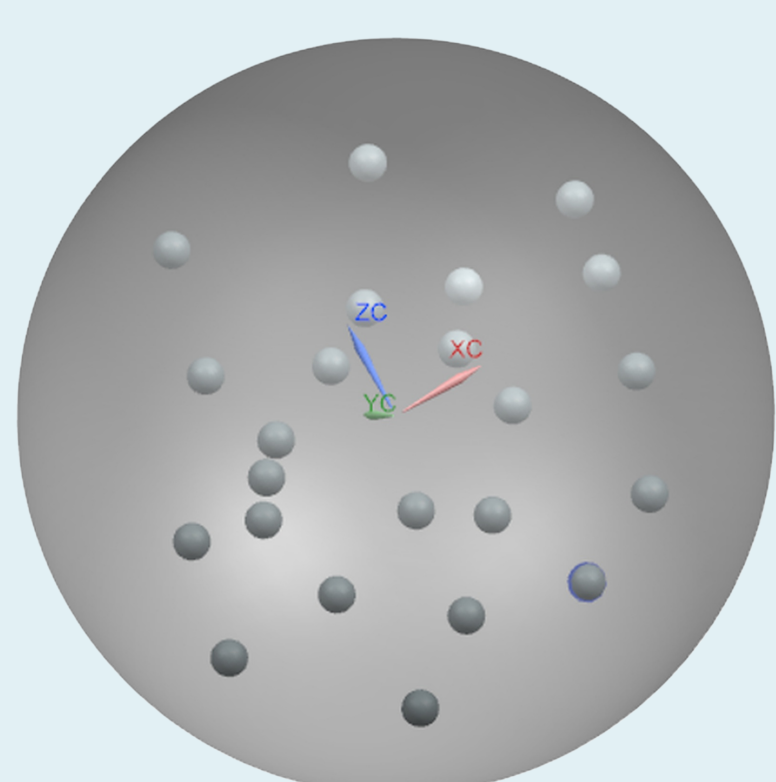
— Detector signal
— Reference signal
Above / Below: detector above or below the laser beam

- Signal peak from the reflection scattering has a significantly higher intensity.
- Signal width of the reflection peak becomes significantly wider.
- Signals from detectors above and below the laser beam lose their symmetry.



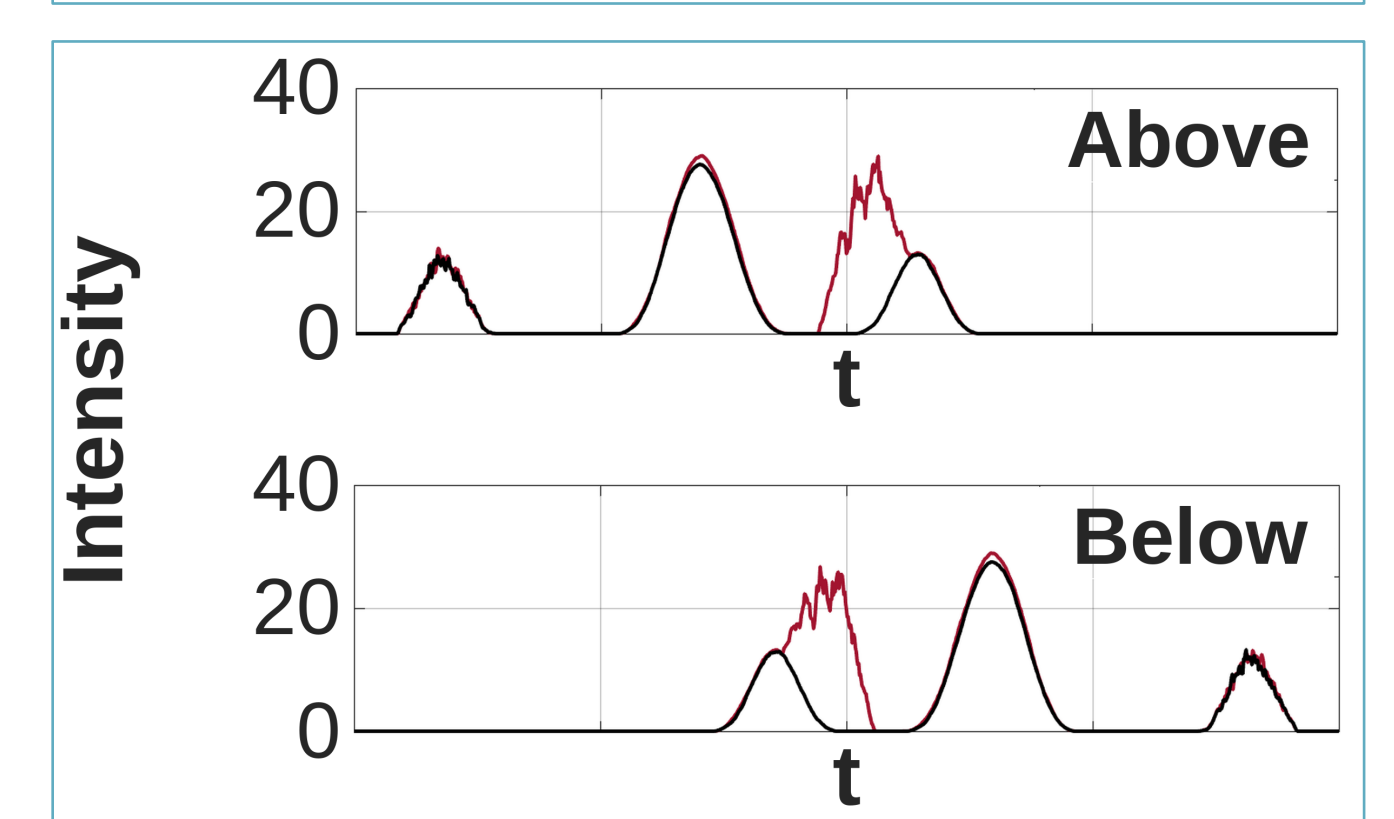
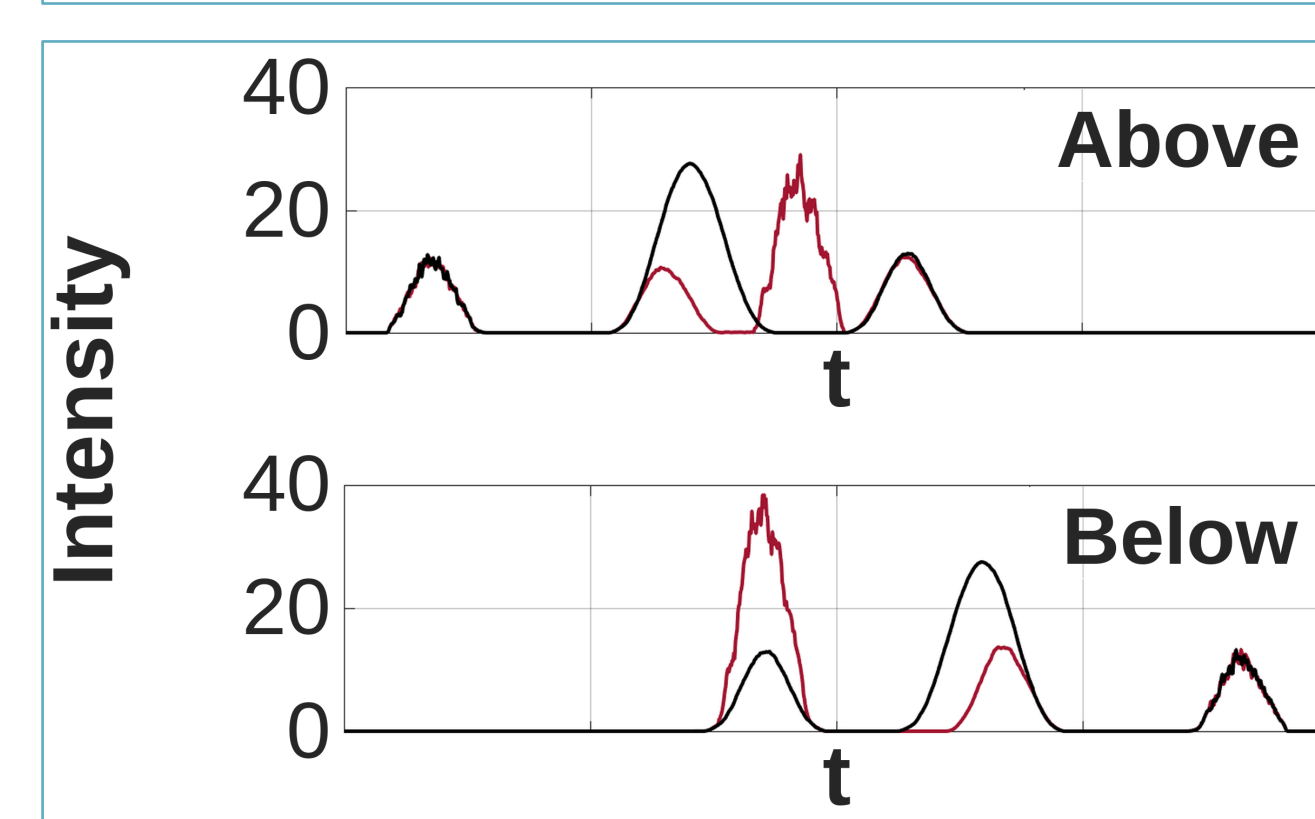
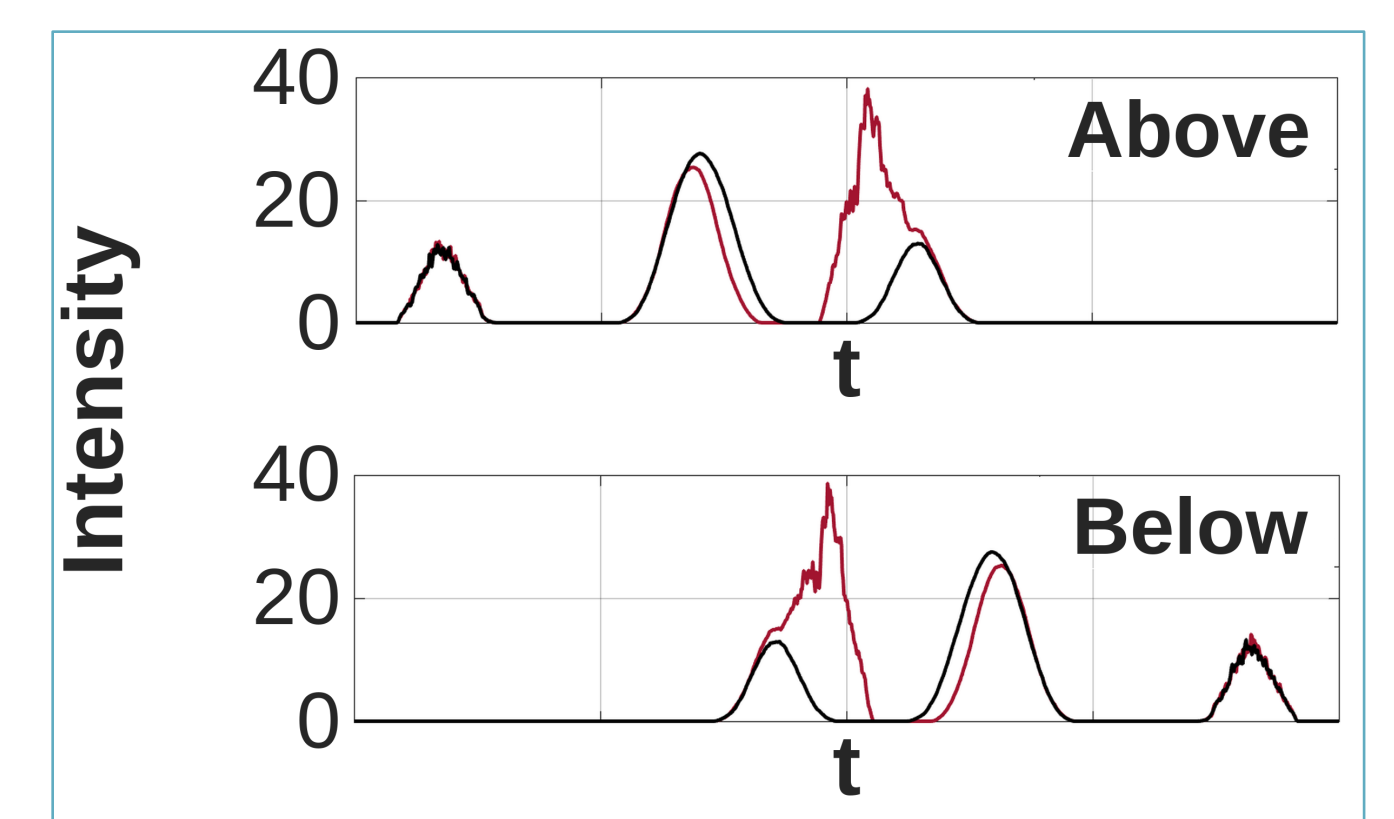
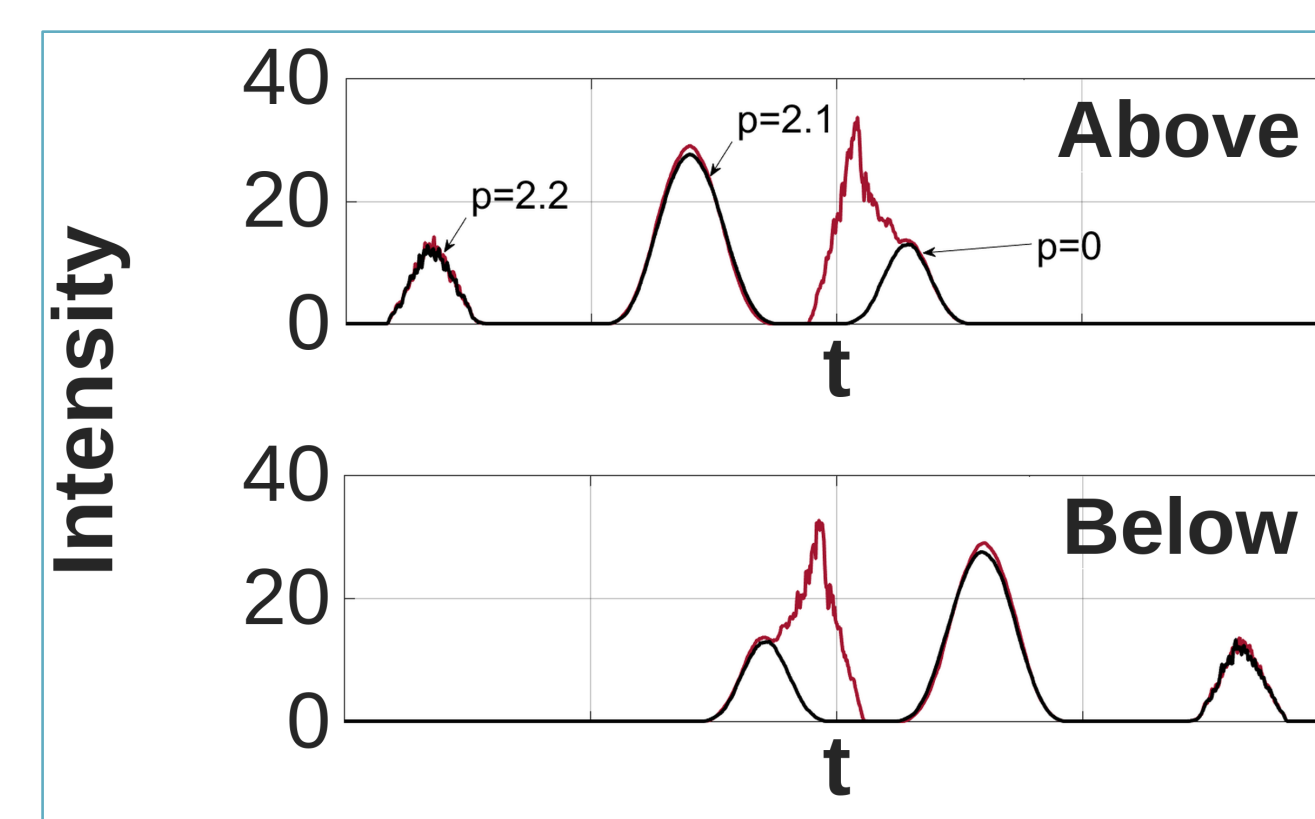
2 Simulation of TSTOF signal from a droplet with an embedded sphere

The figures show the simulated TSTOF signal for a droplet with an embedded sphere at varying positions of the sphere [1, 2].



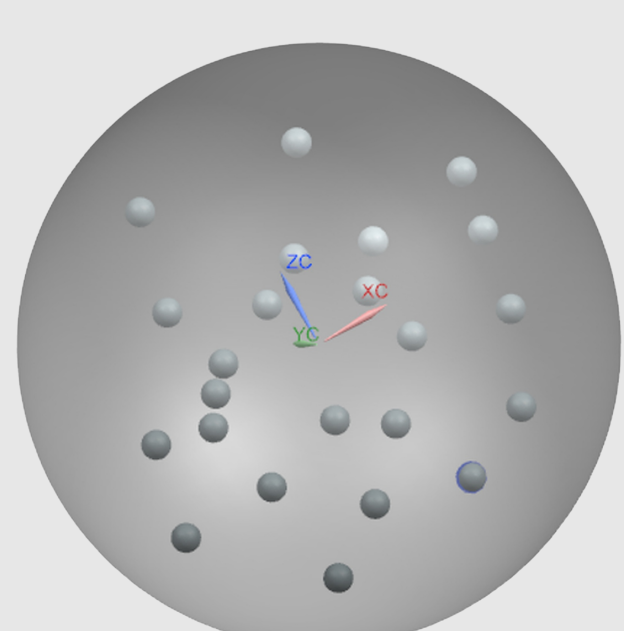
— Detector signal
— Reference signal
Above / Below: detector above or below the laser beam

- Signal peak from the reflection scattering has a significantly higher intensity.
- Signal amplitude of the second-order refraction peak is reduced significantly.
- Signals from detectors above and below the laser beam lose their symmetry.



3 Simulation of TSTOF signal from a droplet with colloidal particles

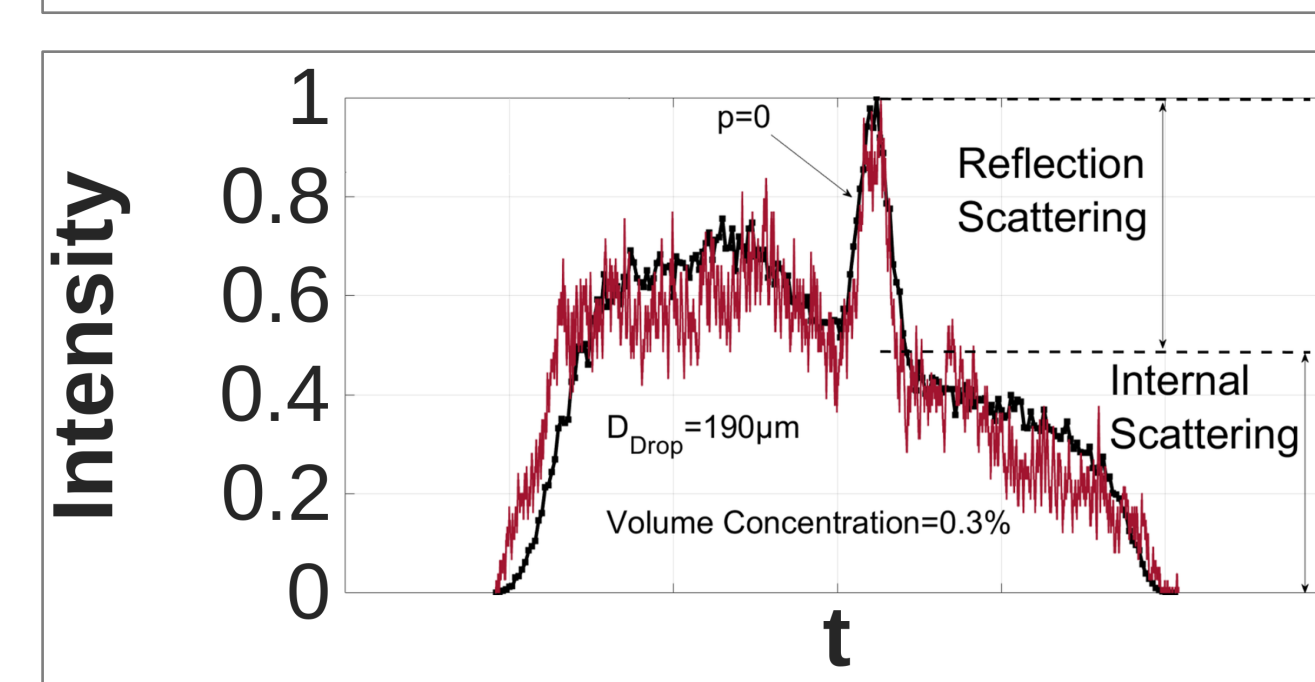
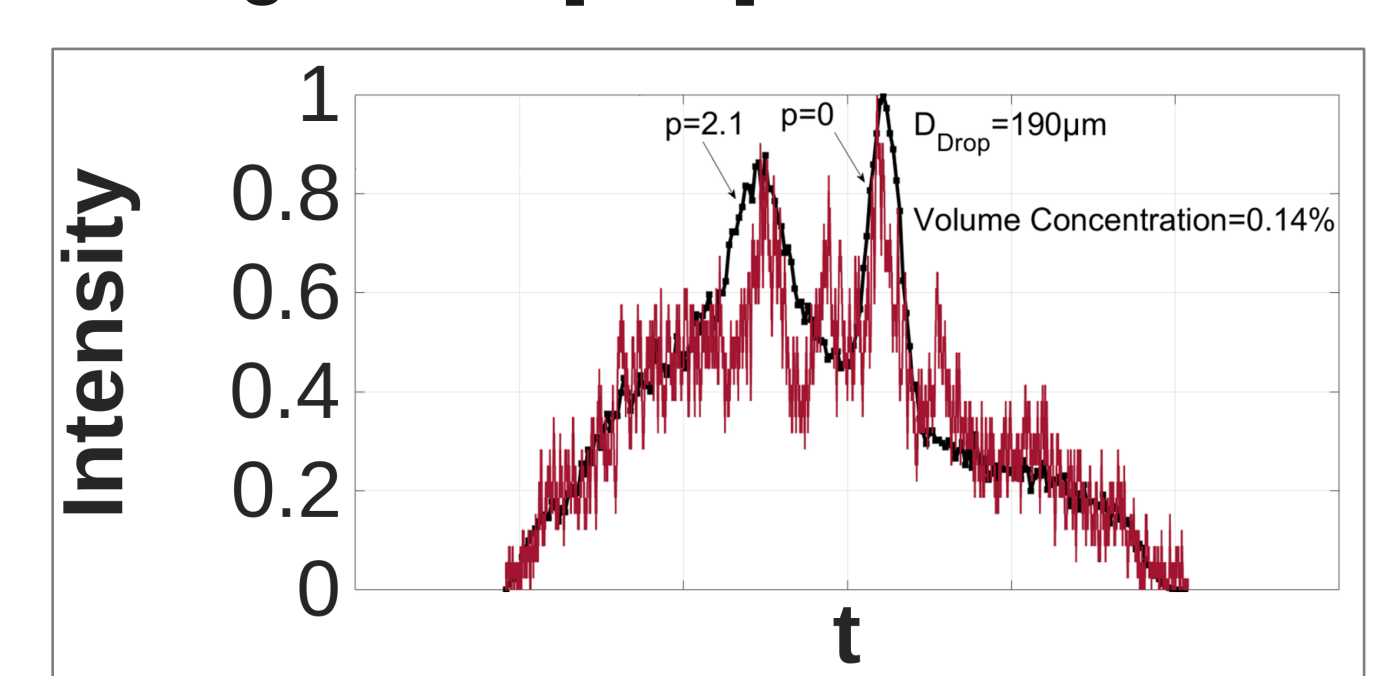
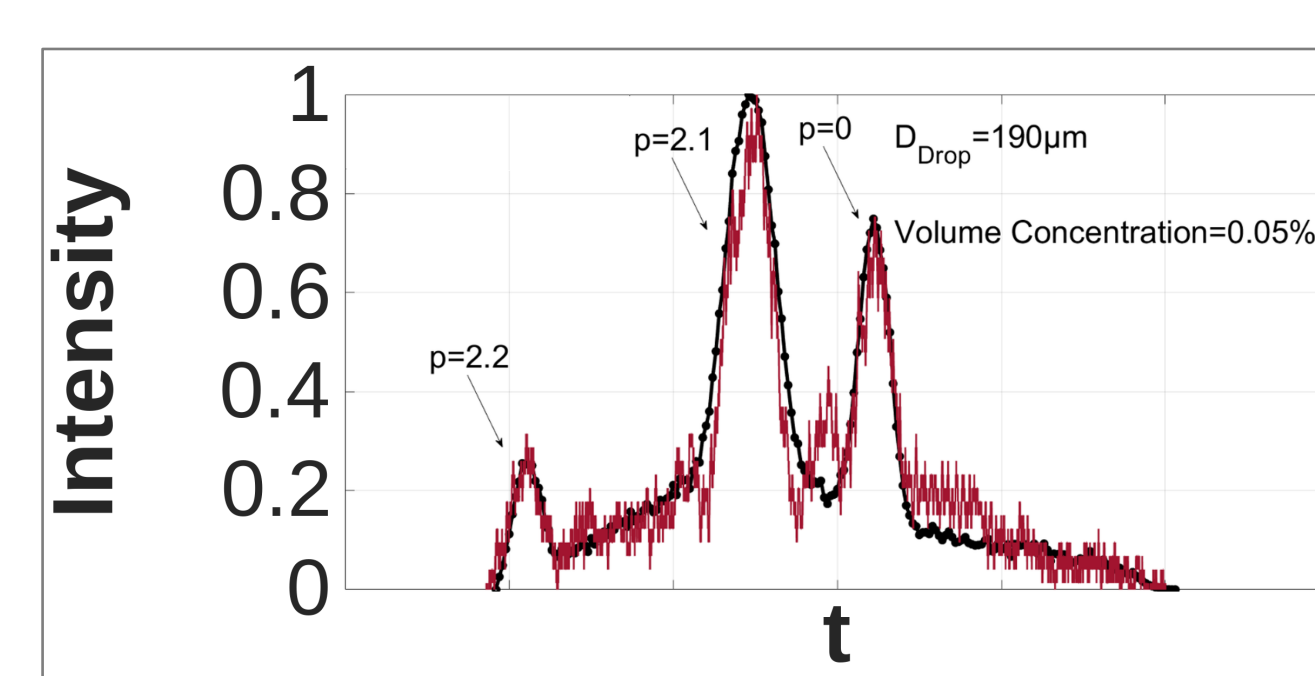
A 3D Monte-Carlo ray-tracing model simulates the light scattering. The incident laser sheet is treated as a large number of polarized light rays: the Stokes vector of each ray is tracked by multiplying the rotation matrix and the Mueller matrix after each scattering event [1, 2].



— Simulated TSTOF signal
— Measured TSTOF signal

- η depends on the volume concentration of the colloidal particles: for droplets of the same size, η increases with increasing volume concentration of the colloidal particles.

$$\begin{pmatrix} I_{sca} \\ Q_{sca} \\ U_{sca} \\ V_{sca} \end{pmatrix} = \begin{pmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos 2\varphi & -\sin 2\varphi & 0 \\ 0 & \sin 2\varphi & \cos 2\varphi & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} I_i \\ Q_i \\ U_i \\ V_i \end{pmatrix}$$



$$\eta = \frac{IS(\text{Internal Scattering})}{RS(\text{Reflection Scattering})}$$