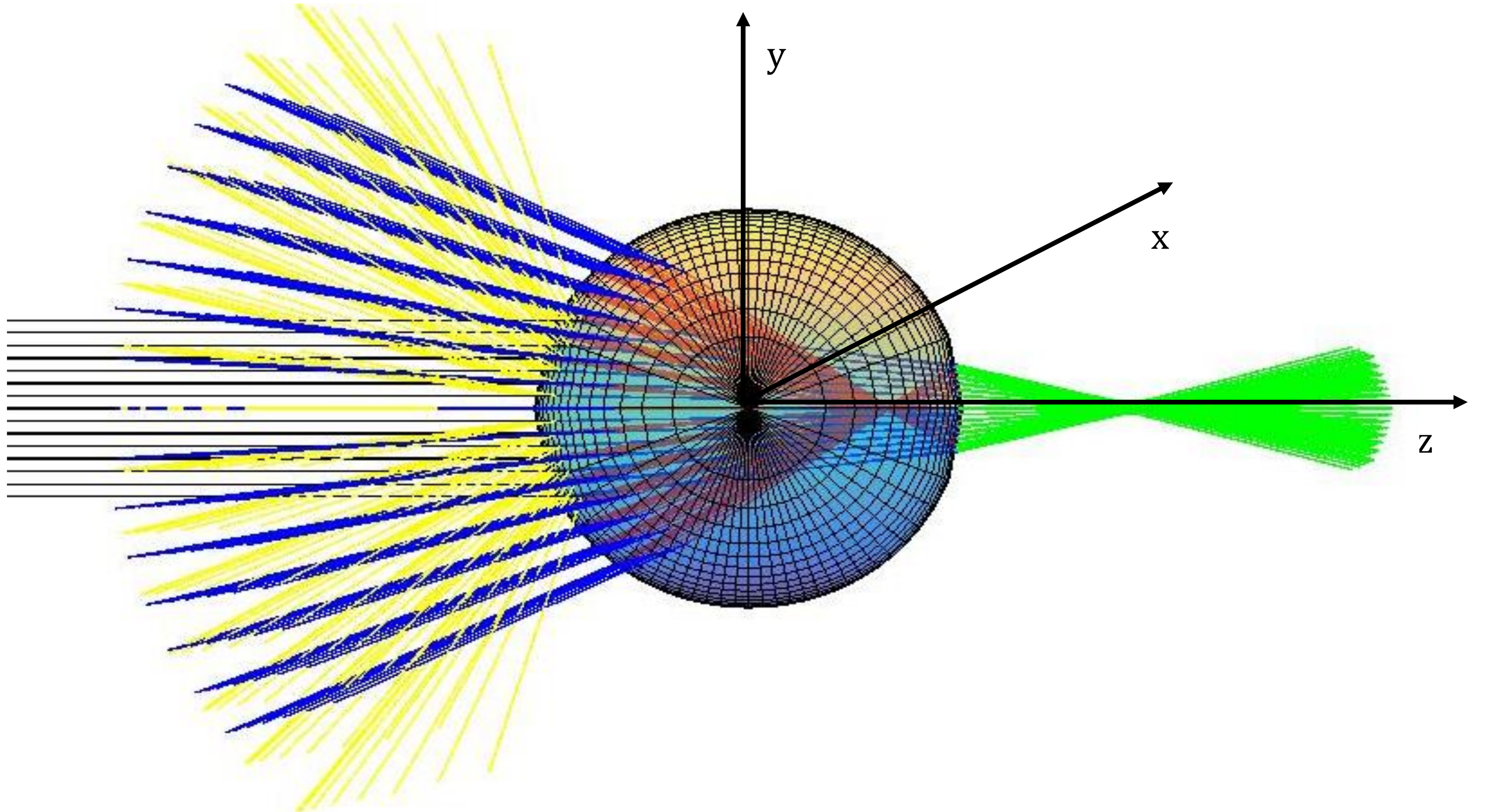
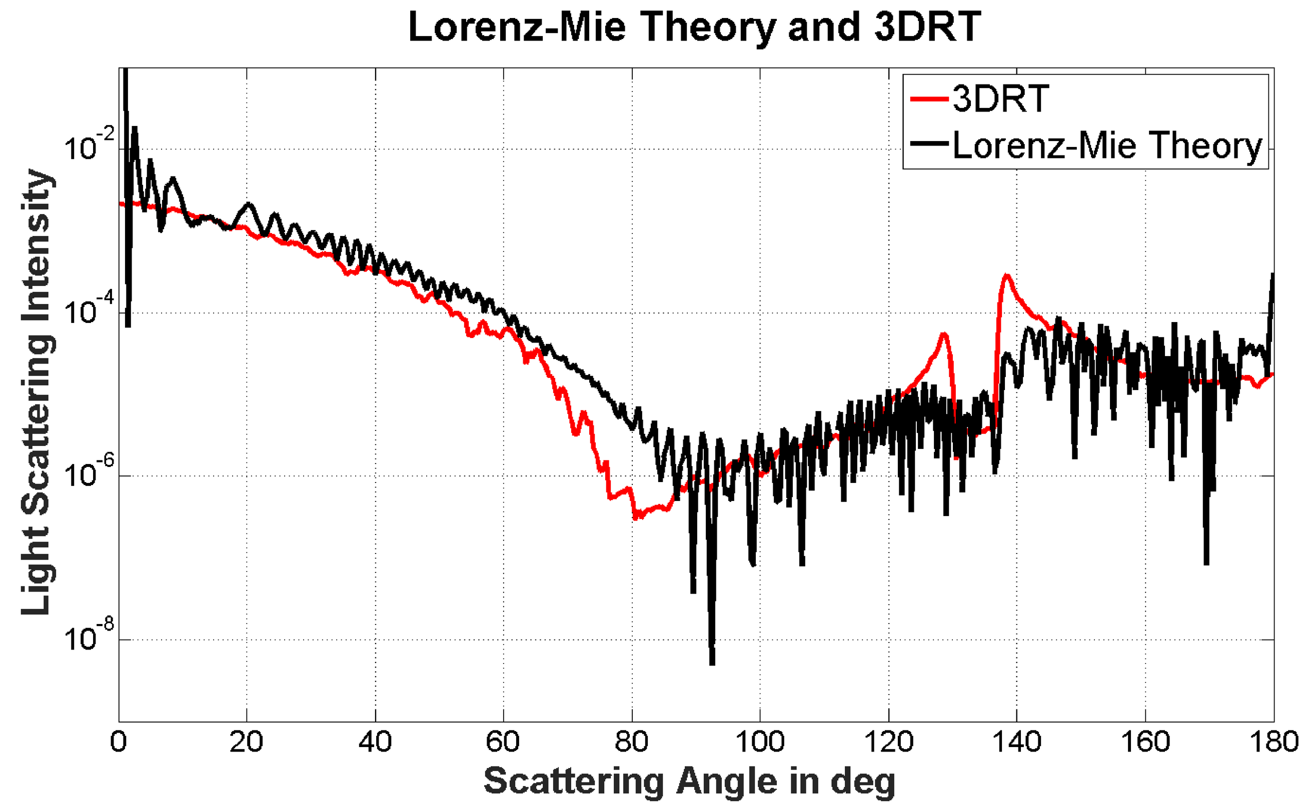
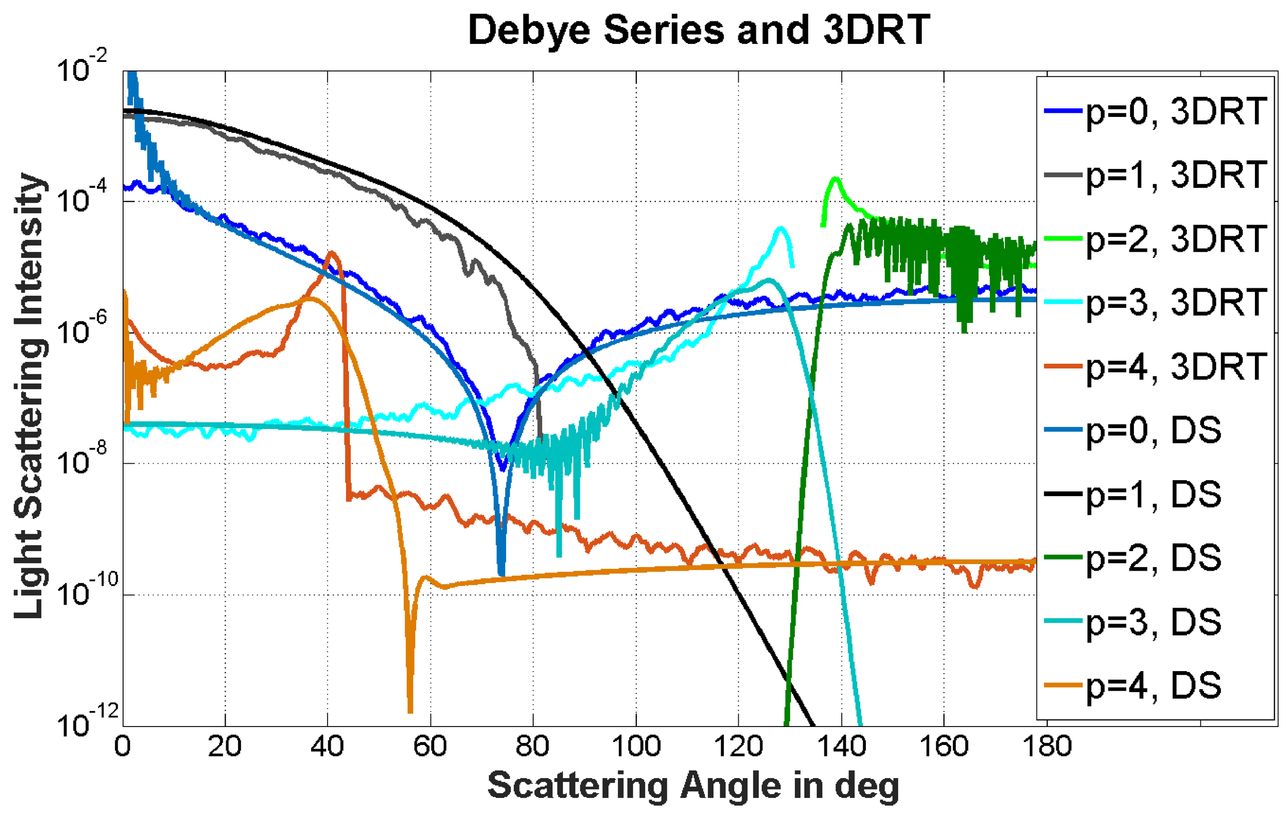
Light Scattering from a Drop with an Embedded Spherical Particle for the Time-Shift Technique

3-Dimensional Ray Tracing Technique (3DRT)







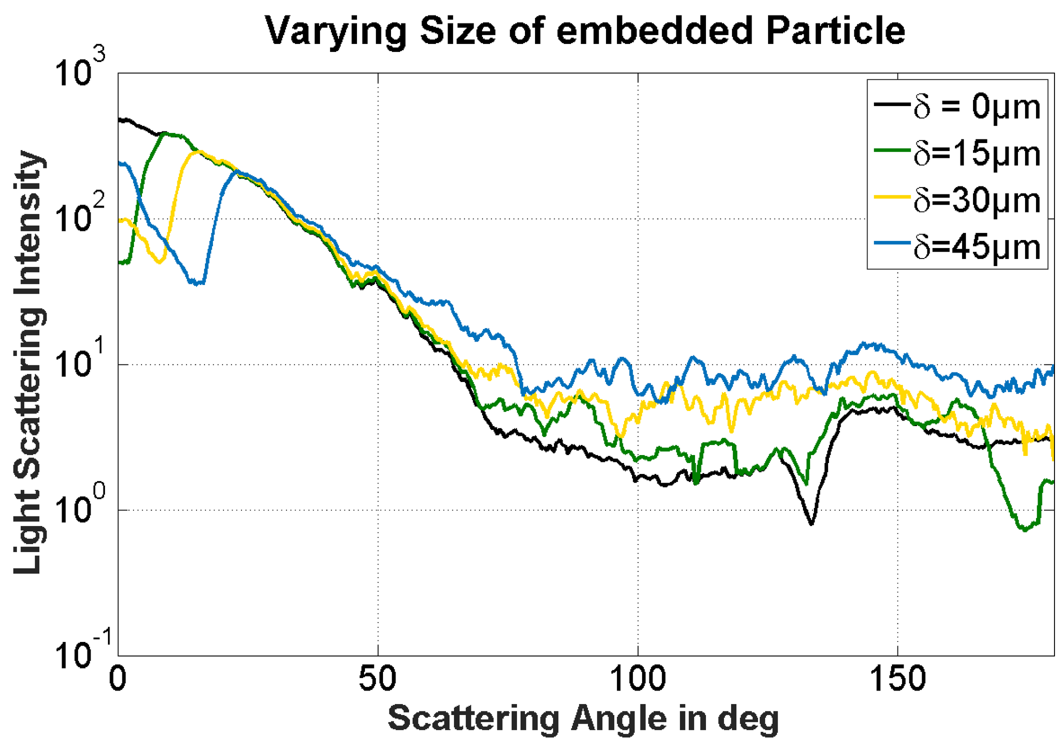
This study is devoted to light scattering from drops with an embedded, reflecting particle, as would be expected in an encapsulation / coating process or with spraying of metallic paints. The present study falls within a broader effort to explore the possibility of utilizing the time-shift technique for such characterization tasks. Ray tracing is used, computing the trajectories of a large number of incident rays defined by an incident plane wave and superimposing all rays scattered in a given direction to result in a scattering diagram. Rays up to p=10 are used to compute the scattered light intensity field. The scattering intensity for higher order refraction is computed according to

$$I_j(\theta_S, p>0) = \frac{I_0}{4R^2} d^2 \frac{\sin(\theta_i)\cos(\theta_i)}{\sin(\theta_S)} \frac{\sqrt{m^2-\sin^2(\theta_i)}}{2[p\cos(\theta_i)-\sqrt{m^2-\sin^2(\theta_i)}]} \left[\left(1-r_j^2(m,\theta_S)\right)\left(-r_j(m,\theta_S)\right)^{p-1}\right]^2.$$

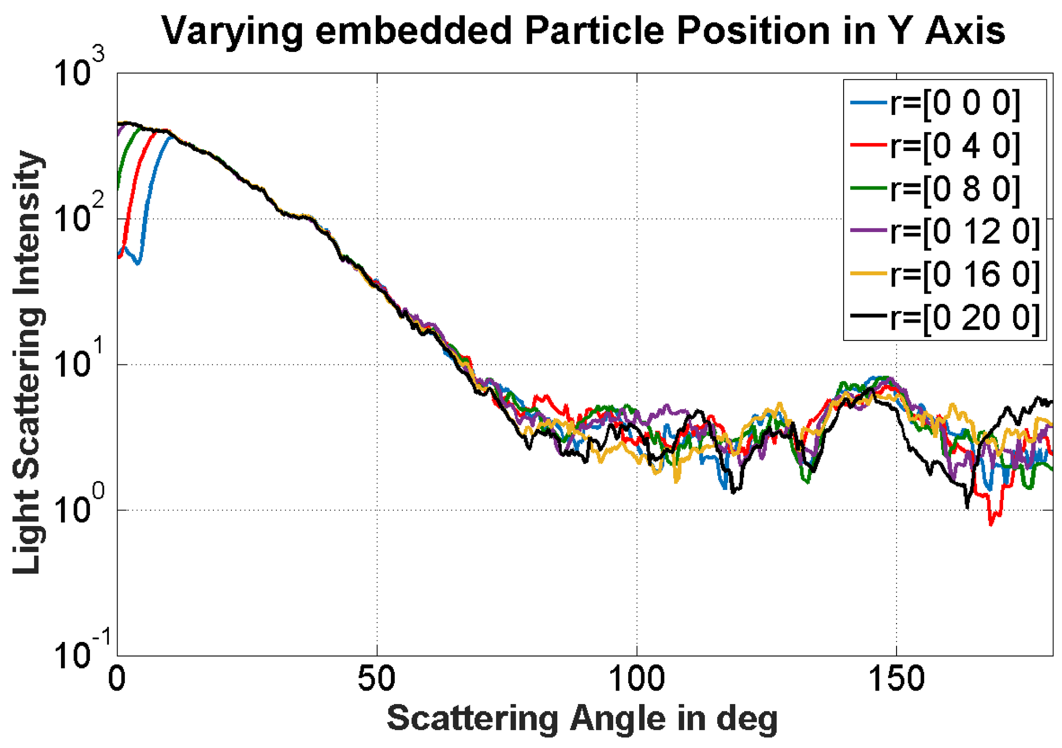
Verification of the simulations is performed through comparison with selected, known solutions.

P polarization, d=100μm, n=1,33, λ=633nm

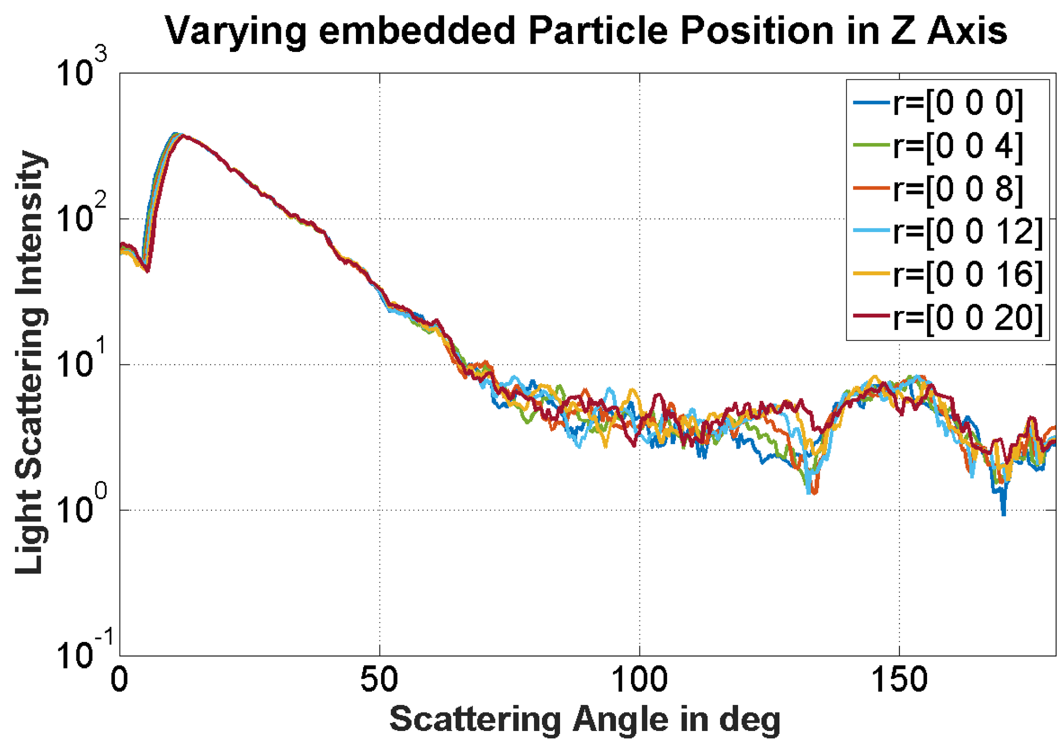
Light Scattering Diagram for a Drop with an embedded Particle



d=100μm, δ∈{0, 15, 30, 45}μm
(r_x, r_y, r_z) = (0, 0, 0)μm

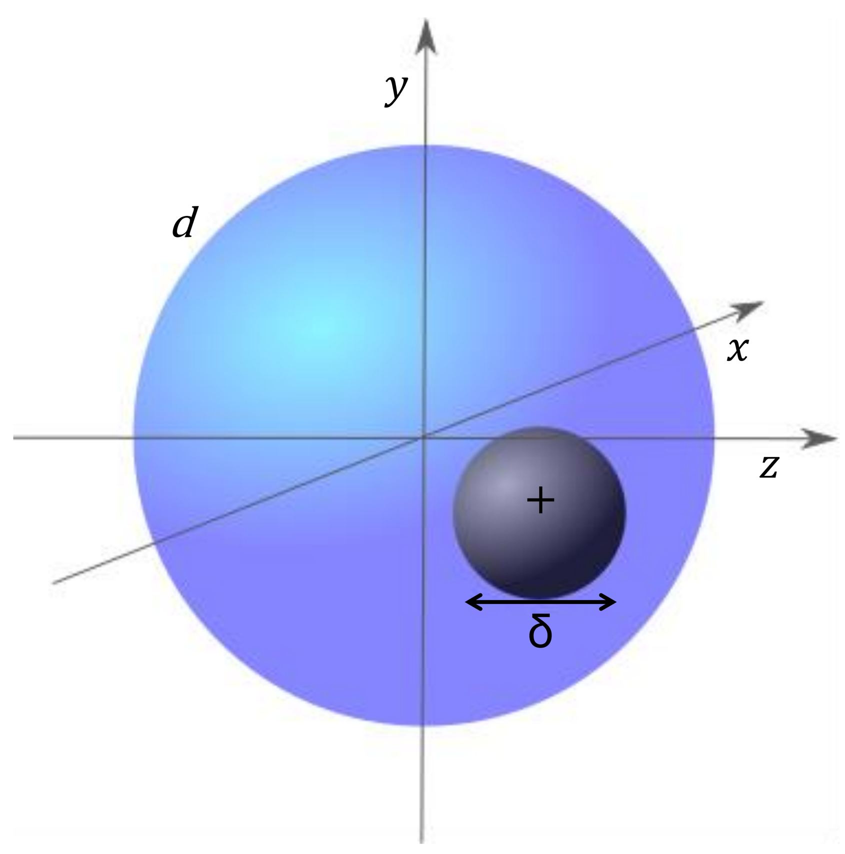


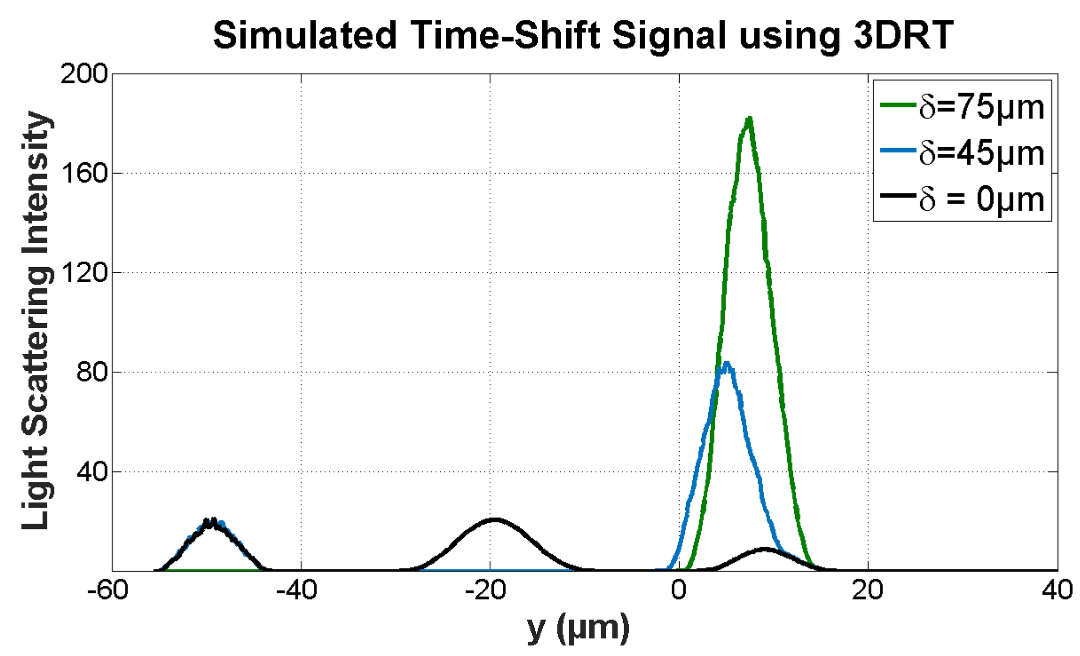
d=100μm, δ=20μm
r_y∈{0, 4, 8, 12, 16, 20}μm



d=100μm, δ=20μm
r_z∈{0, 4, 8, 12, 16, 20}μm

Light Scattering Simulation for the Time-Shift Technique





The scattering light from a drop including an embedded particle at the detector location is given by

$$I_P(x) \rightarrow S_P(t) = \sum_i A_i f_i\left(t_0^{(i)}\right) + \xi_i(\delta, d, r)$$

where the distortion $\xi_i(\delta, d, r)$ depends on drop size (d), particle size (δ) and its location (r).

The ray tracing program can simulate a time-shift signal for a drop containing an embedded particle. In this case the incident wave is a highly focused Gauss beam.

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