Interpreting Background Scattering

Even when no particles are present in water, the LISST-200X ring detectors record light energy. Typical inner rings see about 20 counts, middle rings may see about 100. This energy originates due to scattering of laser light from micro-scratches in lenses or windows. This energy is fixed in time, i.e. the variability of any ring-detector output is low, typically less than 1 digital count. A background measurement is used to record this residual scattering so it can later be removed from particle measurements. In use, low values of background are desired. Backgrounds can be degraded by a number of factors, causing increase. The most obvious one is dirty windows or dirty instrument. Other factors that can degrade the background – i.e. increase it compared to factory – are (i) increased micro-scratches; (ii) water that contains particles or bubbles, (iii) misalignment of optics, (iv) temperature fluctuations in the water; (v) poor mixing during background collection.

Software built-in to the LISST-200X for Quality Control (QC) of background captures and analyses a series of 20 scans of the ring detectors. Both the mean values of each of the 36 detector outputs and their standard deviations are computed. These are interpreted according to the following:

Increased micro-scratches: Increased micro-scratches produce a background higher than factory, but with low variability for all detectors. This increase typically occurs in the middle range of rings. This will not trigger an alarm and is generally not an issue unless excessive degradation of optics occurs.

Contaminated Water: When the water used for background collection contains bubbles or particles, it not only increases the mean energy on each ring, it also causes fluctuations in the output of rings. The QC software recognizes these fluctuations as likely caused by particles or bubbles. The software cannot distinguish particles from bubbles.

Misalignment: Slight misalignment increases background scattering on the inner rings; however, this also has low fluctuation. The QC software recognizes misalignment. Only when the misalignment is severe, a warning is given.

Temperature Fluctuations: Scintillation, similar to twinkling of stars can easily occur in the small volume of the background chamber if water temperature is just a few degrees different from instrument temperature. Scintillation produces high scattering at the inner rings, accompanied also by strong fluctuations. The fluctuations weaken at larger rings. The QC software readily recognizes scintillation and issues prompts to use water at the same temperature as the instrument.

Poor Mixing of Water: Small temperature gradients in water can develop easily if water is not stirred. The water thus becomes stratified (cold below, warm above). The laser beam passing through stratified water will bend downward, creating appearance of loss of alignment. If the water is still, fluctuations can be small enough that the QC software would indicate misalignment. A background with this effect can pass the QC software as slight misalignment. However, such a background will lead to appearance of negative net scattering on the inner rings when conducting a particle measurement! Mixing is *very important* to avoid stratification.