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How to Gluing Analog and Photon Counting signals (by using Raymetrics Software)

Intro:
Depending on your lidar configuration many detected signals are recorded simultaneously by two methods. Analog and Photon Counting method.
The combination of both signals allows using the high linearity of the analog signals for strong signals (near fields) and the high sensitivity of the photon counting for weak signals (far fields). The mean idea to combine the signals, is that there should be a region where both signals (analog and photon) are valid and have a good signal to noise ratio. For a typical case this region extends from 0.5 to 20 Hz in photon counting mode.
Before we glue signals the photon counting data should be dead time corrected (raymetrics software do that). There are two typical deat-time scenarios, while the Licel photon counter can be best described as nonparalyzable.
In that case the dead time corrected photon counting signal is given by the following equation:

$$S = \frac{N}{1 - N * \tau_d}$$

Where S is the corrected counties, N is the observed count rate and τ_d is the system dead time. Raymetrics software uses a value of 260 MHz for τ_d

For detailed discussion of the theory of photon counting dead time correction please see the following paper: D. P. Donovan, et.al. “Appl. Opt. 32, 6742-6753 (1993).

The gluing
In the region where both signals are valid (between the lower toggle frequency – typical 0.5 MHz and the upper toggle frequency – typical 20 MHz) one seeks the linear regression coefficient to transfer the analog data into photon counting data.
After transferring analog to photon the scaled analog signal is used above the upper toggle frequency and the photon counting signal

When gluing is possible:

The peak value of the deaditme corrected photon counting signal is above the maximum toggle frequency (save values for maximum toggle frequency is between 10 MHz and 70 MHz for the dead time corrected signal) and the background of the dead time corrected photon signal is below the minimum toggle frequency.
If the signal is too weak (maximum peak of photon counting signal less than 20 Hz) use only photon (gluing is not useful)
If the signal is too strong (background of the dead time corrected signal more than 20 MHz)

Raymetrics software

The first step is to figure out until what range the analog signal has good signal to noise ratio. A suggested way is to remove the background noise and then to figure out until what point the signal is 2 to 5 times more than LSB. The value of LSB (The minimum change in voltage required to guarantee a change in the output code level is called the least significant bit (LSB) voltage. The resolution *Q* of the ADC is equal to the LSB voltage.) depends on the full range of the pre-amplifier that you have select during the measurements. There are three possible values for the full range, 500, 100 and 20 mV and the LSB is $500/2^{12}$=122 mV, $100/2^{12}$=24.4 mV, $20/2^{12}$=4.8 mV.
Let assume that the maximum memory bin that the signal is 5 times the LSB is Xa.
In addition let assume that the Photon Counting signal has a value of 50 MHz at memory bin Xp. If Xp < Xa then glouing is possible. If not then glouing is not suggested.

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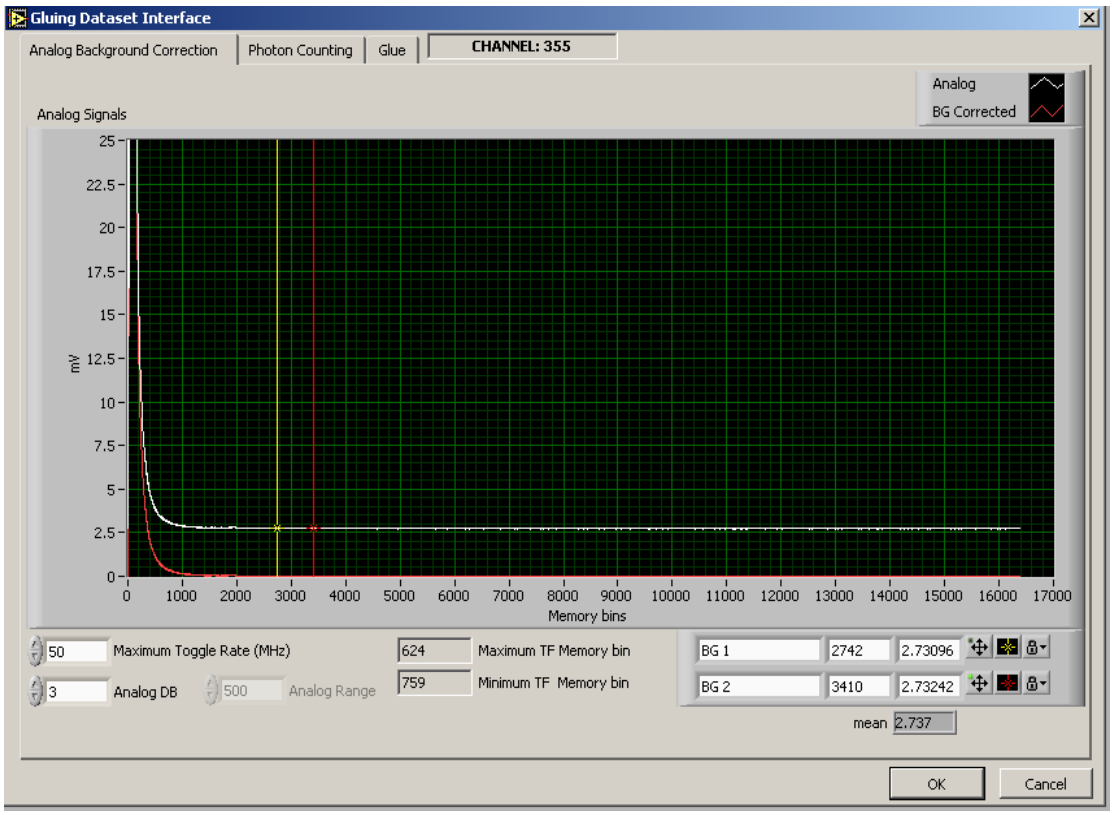
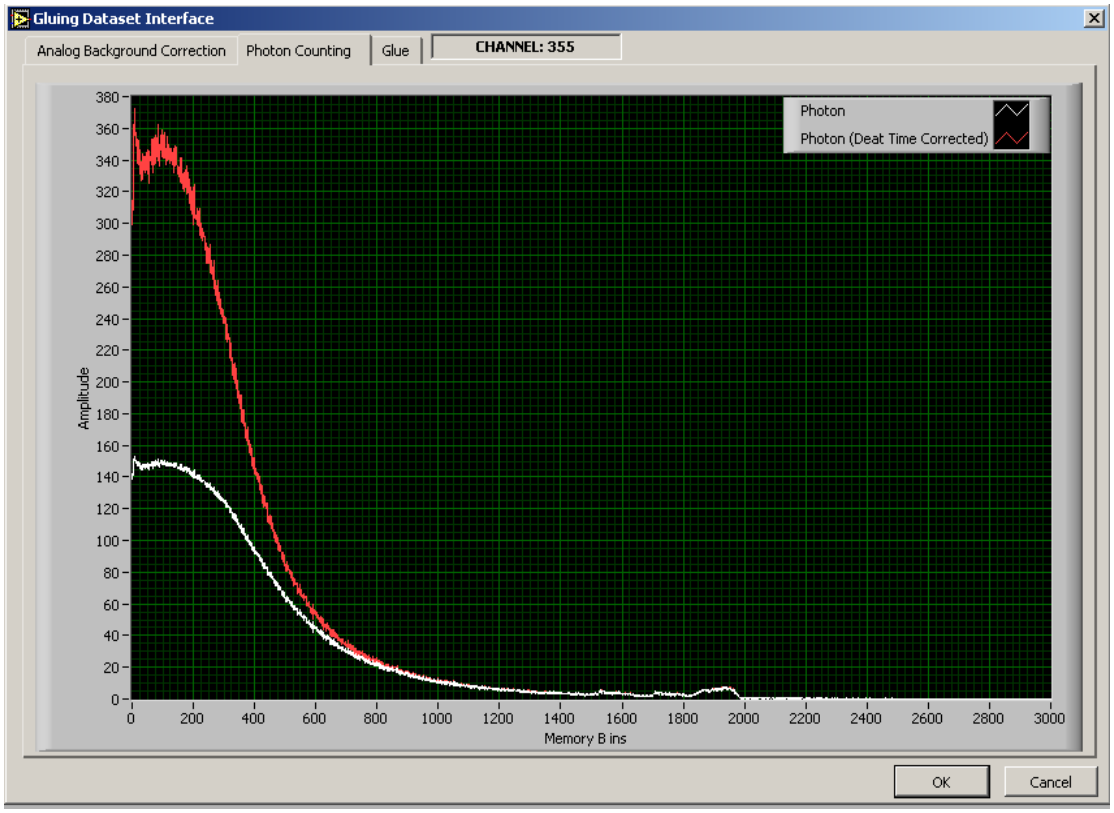


Analog Background Correction



Photon Counting and Dead time photon counting

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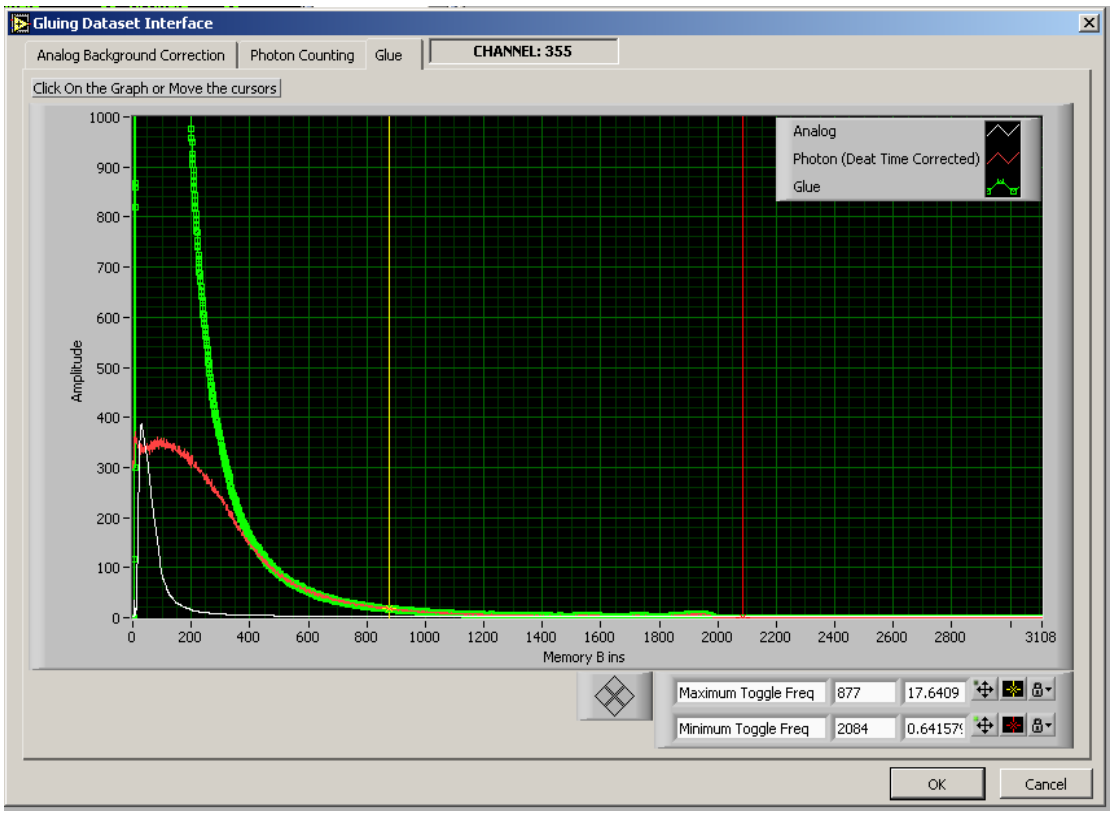

Use the two cursor to change Maximum or/and Minimum Toggle Frequency (if you want), or just click on the graph and then OK button.