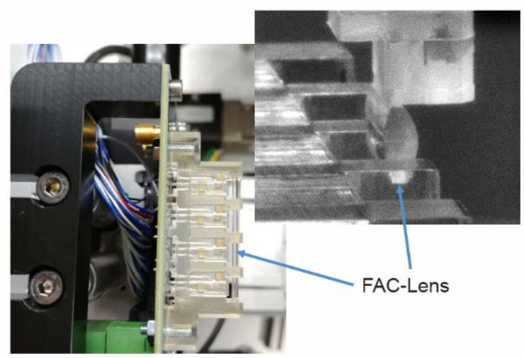
Making distance measurements with the AD-FMCLIDAR1-EBZ

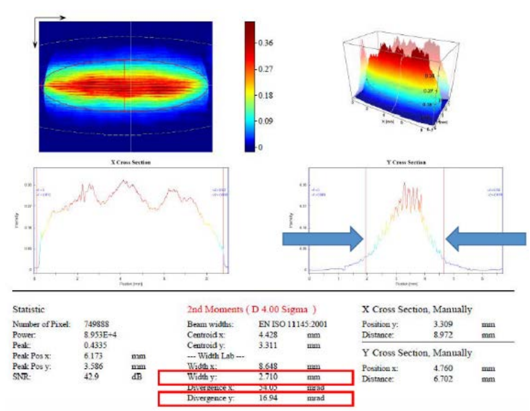
The AD-FMCLIDAR1-EBZ [1] is a prototyping platform for LiDAR applications that can be used on FPGA development boards enabled with FMC HPC connector and JESD204B support capability such as the Xilinx ZC706 and ZCU102 or the Intel Arria10SOC. It offers developers a working-out-of-box platform that can be used as a reference for designing custom LiDAR systems and for developing software and algorithms for a broad range of depth sensing industrial and automotive applications. The system is partitioned into three different boards, as follows:

- A laser emitting board to generate 905nm light pulses with programmable pulse width and frequency
- An analog front-end (AFE) board containing the avalanche photodetector (APD) sensor and the entire signal chain for conditioning the APD output signal for digitization
- A data acquisition board (DAQ) to sample and quantize the APD signal generated by the AFE board, containing a four channel 1GSps JESD204B ADC and the corresponding clocking and power

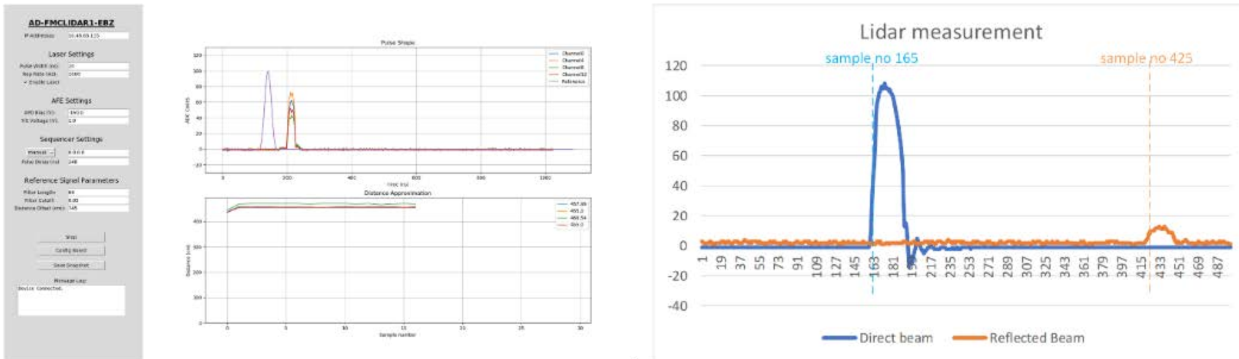
The laser and AFE boards are placed on the same geometric plane. A plano-convex lens is used to better focus the reflected pulse on the APD, which increases the signal-to-noise ratio (SNR). The lens is coated such that it filters out wavelengths outside the [650, 1050] nm range and improves the SNR by focusing the desired wavelength on the APD and filtering out the undesired wavelengths. Additionally, a 1-inch tube can be used to limit the field of view, which helps to eliminate undesired multiple path reflections. The detection range can be significantly improved by adding fast-axis-collimator (FAC) lenses in front of the four lasers to narrow the laser beam vertical divergence from 15° of 1°. This improves the measurement in terms of both accuracy, by focusing the light beam, and the SNR, by maintaining the light beam at a higher intensity than it would be if divergent. Mounting of these lenses requires a custom lens holder and also active lens alignment fitting during the manufacturing process. This was done at FISBA [2], a worldwide leading supplier of customized optical components, systems and microsystems with locations across Europe and in the US.



The vertical beam diameter, that is needed to calculate the residual divergence angle, was determined according EN ISO 11145:2001 using the method of 2nd moments that describes the behavior of the intensity profile. The beam diameter, as represented by the red vertical lines in the graph, equals the intensity level of 1/e² for Gaussian beams. The required vertical angle of 1° corresponds to ~16.9mrad as determined by the laser beam characterization software.



The AD-FMCLIDAR1-EBZ kit is accompanied by a set of applications that can be used for system evaluation and for making distance measurements using the data from all the 16 APD channels [3]. The figure below shows the user interface of a Python application which displays the logged samples and the computed distance to the target. The reflected pulse displayed by the application is used to determine the signal



propagation round-trip delay by doing a cross correlation with a reference pulse which represents the transmitted laser pulse. Without the FAC lens for the lasers the system is capable of measuring distances up to around 6m. When using the FAC lens the system was able to detect a 70% reflective target at 39m. As shown in the right portion of the figure above, the reflected signal, represented in red, has a 260 samples delay compared to the blue reference signal. Considering the ADC's sample resolution of 1ns, the measured distance is computed using this equation:

*Distance = Speed of Light * ADC sample time * Received pulse delay*

Distance = $300e^6$*m/s * 1ns/sample * 260samples = 39m*

As it can be observed in the plot, the reflected signal has a very good SNR and relatively high amplitude compared to the noise level, which means that even in this setup the longer distances could have been measured, but the experiment was limited by the available space length. The pulse amplitude is attenuated as the target is further away and also depends on the target's reflectivity, so by using higher reflectivity targets the system's measurement range can be further increased.

References

[1] AD-FMCLIDAR1-EBZ product page, https://www.analog.com/en/design-center/evaluation-hardware-and-software/evaluation-boards-kits/ad-fmclidar1-ebz.html
[2] FISBA, www.fisba.com
[3] AD-FMCLIDAR1-EBZ system evaluation, https://wiki.analog.com/resources/eval/user-guides/ad-fmclidar1-ebz/system_evaluation
[4] Open-Source LIDAR Prototyping Platform, https://www.analog.com/en/analog-dialogue/articles/open-source-lidar-prototyping-platform.html