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High-Speed Photon Counting System for Airborne HSRL Applications

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Estimating the microphysical properties of the aerosols by measuring them from satellites is a fundamental requirement for the precise evaluation of the aerosols' radiative forcing. This requires at least 3 backscatter coefficients and 2 extinction coefficients (Müller et al., 2001), which can be retrieved using the Raman- as well as the HSRL (High Spectral Resolution Lidar) techniques. While the Raman technique is not suitable for space missions due to its weak backscatter signal, HSRL systems will be installed onboard on the ADM-Aeolus and EarthCARE satellites launched by ESA.
MULTIPLY is an airborne HSRL system (I. Serikov et al., 2017) currently being developed by a European consortium in the frame of the ESA/ESTEC contract No. 4000112373/14/NL/CT. The system will support the ESA space lidar systems calibration and validation from the ground, as well as during airborne campaigns doing underpass flights coordinated with the satellites trajectories.
Being an airborne system, there are several specific constraints that MULTIPLY is subjected to. The first one comes from the necessity of using a relatively small pulse energy (2mJ @ 1064Nm, 1.5mJ @ 532Nm, 1.5mJ @ 355Nm), to comply with safety regulations, considering a flight altitude of 8km. In order to achieve the desired measurement precision and spatial resolution, a high pulse repetition rate (4kHz) has to be used which requires a fast photon counting system. The second constraint is volume- and weight-related, considering the HSRL system will be installed onboard of a small research aircraft (Beechcraft C90). The entire system must be tightly packaged without compromising its performance.
The data acquisition system used with MULTIPLY needs to measure the atmospheric signals on all 3 wavelengths using 'near range' and 'far range' telescopes. Additionally, various monitoring signals have to be measured to determine the system health and to evaluate correction parameters for the atmospheric signals. To improve the estimation of microphysical properties, MULTIPLY has been designed to provide depolarization measurements on all 3 wavelengths. So, a total of 24 counting channels have been identified.
In 2007/8 the Max Planck Institute for Meteorology in Hamburg (MPI-M) has developed a novel photon counting system supporting a virtually unlimited number of counting channels. Since 2010 these counters are used in all lidars operated by the MPI-M. Additionally, all new Polly lidars produced by the Institute for Tropospheric Research in Leipzig (TROPOS) are equipped with these counters since 2013.
Based on these well-proven counters a new data acquisition system has been designed for MULTIPLY. This new system contains 3 counter modules. Each module contains 8 counting channels. These channels are measuring profiles with a height resolution of 7.5m. These profiles are averaged over 10 seconds comparing to 40,000 shots. Each profile contains a short timeseries of pre-trigger values and extends to up to 4096 samples comparing to a range of approximately 30km.
The whole system is controlled by a PC system using a WEB interface. This interface allows operation as well as monitoring of the data acquisition.