Graz kHz SLR LIDAR: First Results

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Abstract

Following an idea presented by NERC in Canberra 2006, we developed a kHz SLR LIDAR for the Graz station: Photons of each transmitted laser pulse are backscattered from clouds, atmospheric layers, aircraft vapour trails etc. A Single-Photon Counting Module (SPCM), installed in the main receiver telescope, detects these photons. Using our FPGA card, these detection times are stored with 100 ns resolution (15 m slots in distance). Event times of any number of laser shots can be accumulated in up to 4096 counters (according to> 60 km distance).
The LIDAR distances are stored together with epoch time and telescope pointing information; any reflection point is therefore determined with 3D coordinates, with 15 m resolution in distance, and with the angular precision of the laser telescope pointing.
First test results to clouds in full daylight conditions - accumulating up to some 100 laser shots per measurement - yielded high LIDAR data rates (> 100 points per second) and excellent detection of clouds (up to 10 km distance at the moment). Our ultimate goal is to operate the LIDAR automatically and in parallel with the standard SLR measurements, during day and night.

Hardware

To detect the backscattered photons, we use a Single Photon Counting Module (SPCM) from Micro Photon Devices (www.micro-photon-devices); the Peltier cooled 100 urn diode has a rather low dark noise of about 500 Hz, and is operated in ungated mode. A standard 0.3 nm interference filter transmits about 35 % of the laser wavelength, rejecting most of the daylight background noise.
For the first tests, the device was installed in the main telescope; a mirror switched between SLR or LIDAR measurements. In the next step however, the SPCM will get its own small telescope (15 em diameter), and will be operated in parallel to all SLR activity.

A separate Graz FPGA card has been programmed to do the hardware job (fig.l): The output pulses are counted in up to 4096 counters, according to their "range slot"; each counter integrates only the photons of its dedicated 15 m range bin. For each cycle, the number of shots to be integrated can be set between 1 and up to 65535 (i.e. up to 30 seconds @ 2 kHz).

The resulting counter contents after each cycle are shown on the Real-Time screen of our kHz SLR system (fig. 2); the rather strong reflections from clouds are clearly visible, even in the daylight conditions.

After each cycle, the counter data is stored, together with all relevant telescope pointing information, for later evaluation.

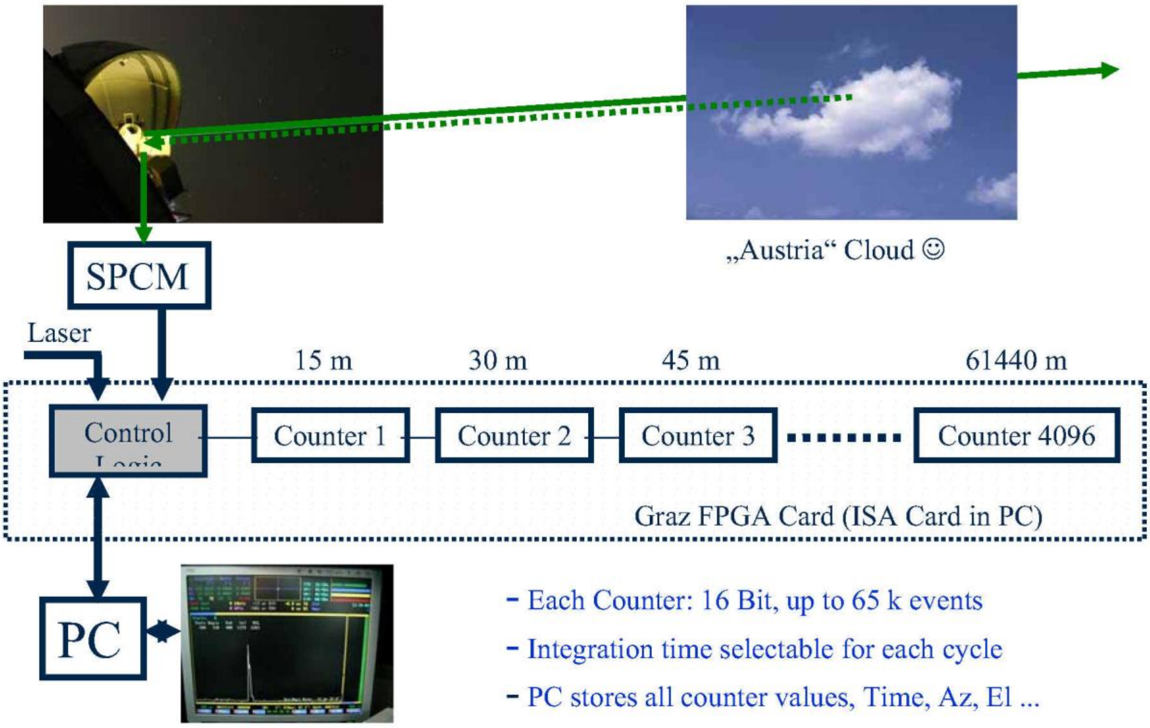

Figure 1. Schematics of Graz kHz LIDAR Hardware

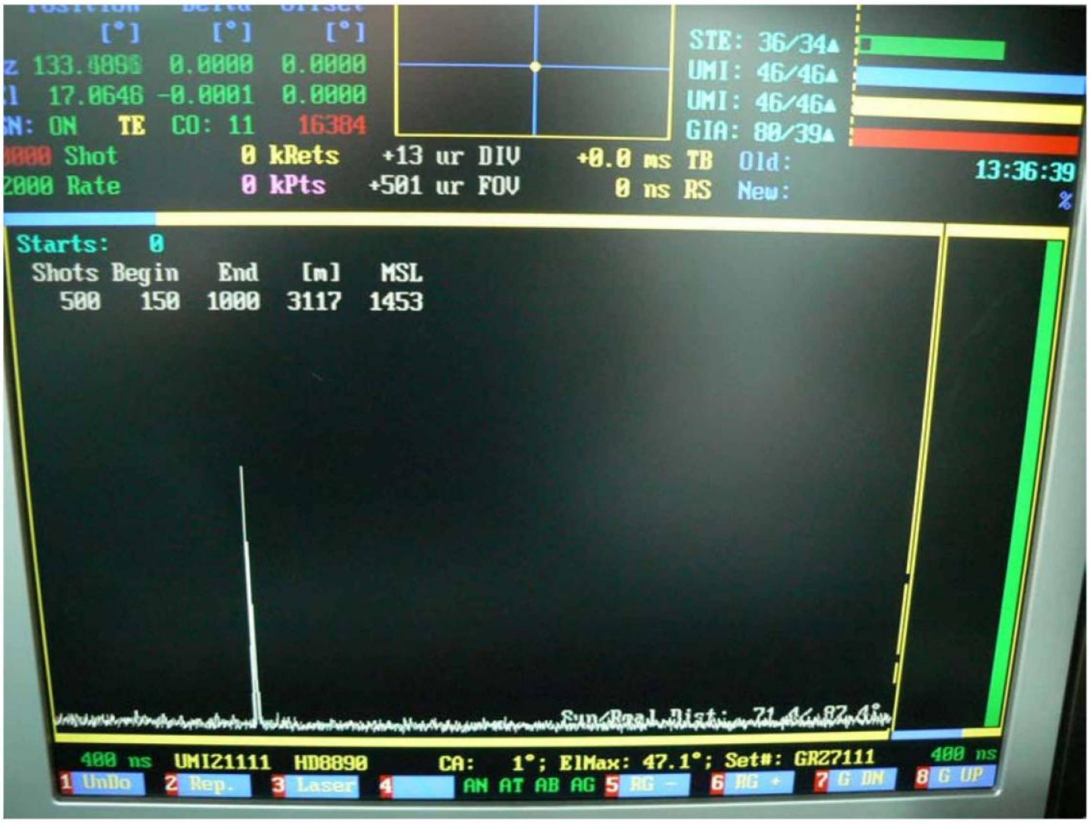

Figure 2. Real Time Dsiplay of Graz kHz LIDAR: A strong backscatter signal at 3117 m distance, from a cloud in 1453 m altitude (MSL); full daylight, single photon detection

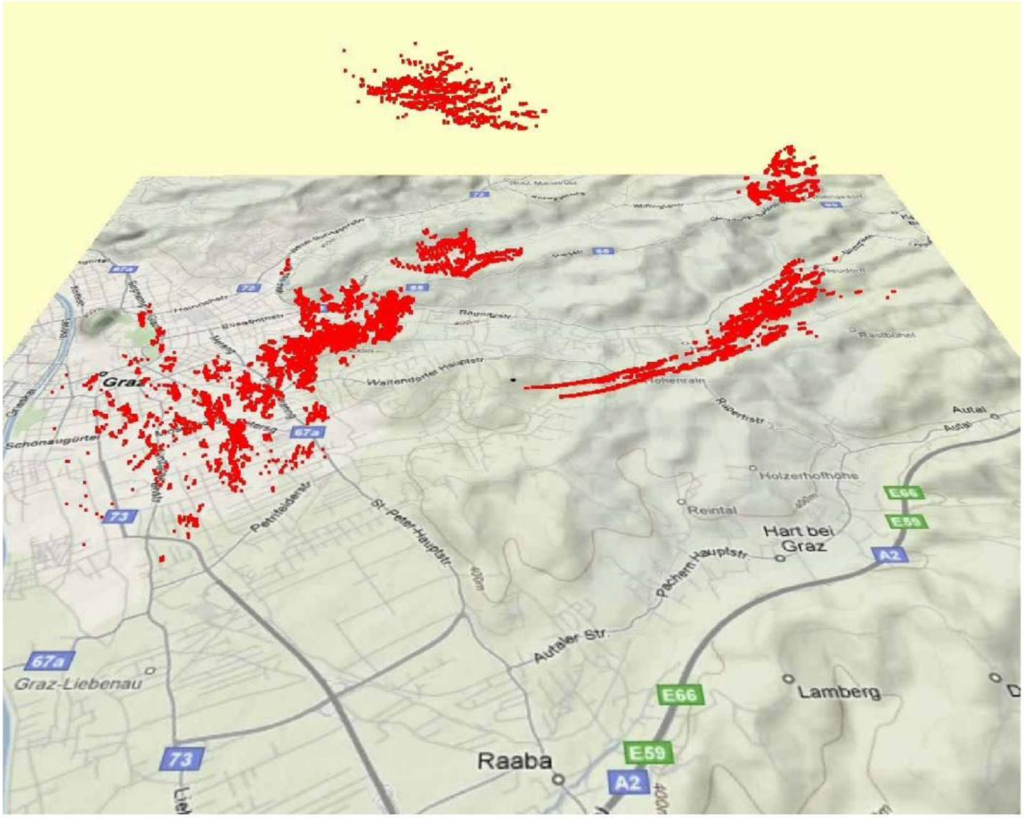

Figure 3. LIDAR scans of several clouds around the SLR Station Graz (black dot in centre)

Future Goals

We intend to operate the kHz SLR LIDAR fully automatically day and night, mainly in parallel to all SLR activities; it will collect - as a by-product to SLR - some information about atmosphere, layers, clouds, inversions, aircraft vapor trails etc. We also hope to get some correlation between SLR return rates, and atmospheric backscatter.

Outside SLR activity, dedicated scans could map dimensions and increase of cumulonimbus clouds, measure cloud top altitudes, determine wind speeds in altitudes of aircraft vapor trails, and similar items.