New achievements in the simulator of photon counting planetary altimeter

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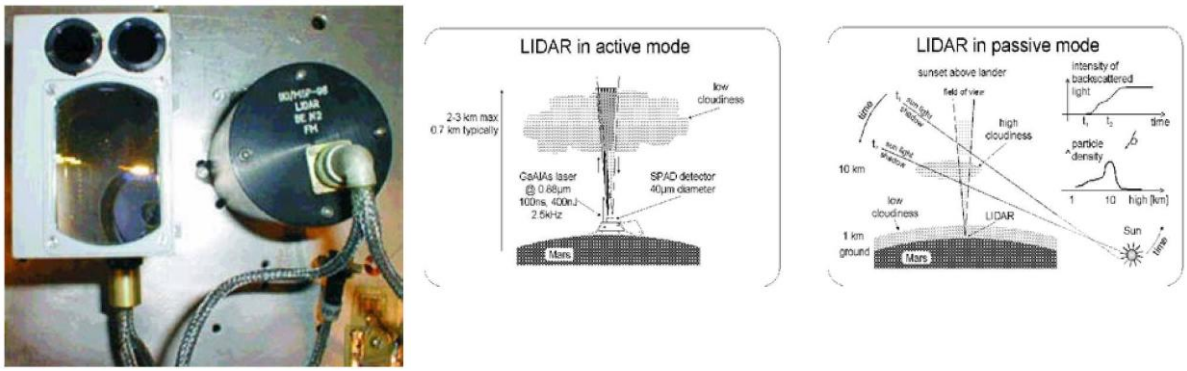
Abstract

We are presenting new achievements in single photon counting altimeter simulator. The existing planetary altimeter simulator has been extended. The new design is prepared for cooperating with map and surface relief system and results of the photon counting laser altimeter simulator are presented. The simulator is designed to be a theoretical and numerical complement for a Laser Altimeter Technology Demonstrator of the space borne laser altimeter for planetary studies built on our University.

Realizations of photon counting altimeter and lidar

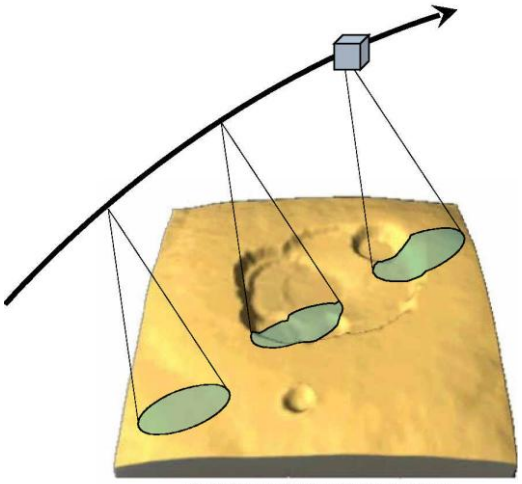


Photon counting altimeter on board of Soviet/Russian missions Mars 92 and 96 and Iidar on board NASA mission Mars Polar Lander 98. Photo of the flying modul (left) with big detector aperture and two smaller apertures of semiconductor lasers and operatinal scheme in active and passive mode.

The steady state photon counting simulator has been already developed by our group [4]. The presented results report the next step of development when a sequence of static simulations allow simulate a move of altimeter using existing terrain map. This work was initiated by the fact that the European Space Agency (ESA) has nominated [3] the photon counting altimeter as one of the attractive devices for planetary research. The requirements on the device are rather strict: total mass in the range of 5-8 kilograms, power consumption below 10 Watts. Additionally, the harsh radiation environment near some planets requires, among others, small optical aperture of the device. The photon counting concept of the altimeter together with its energy budget link and signal to noise ratio has been studied for ESA by U. Schreiber et al. [5]. This concept seems to be only one acceptable for these requirements. Together with Technology Demonstrator [2] of laser altimeter presented simulator is developing.

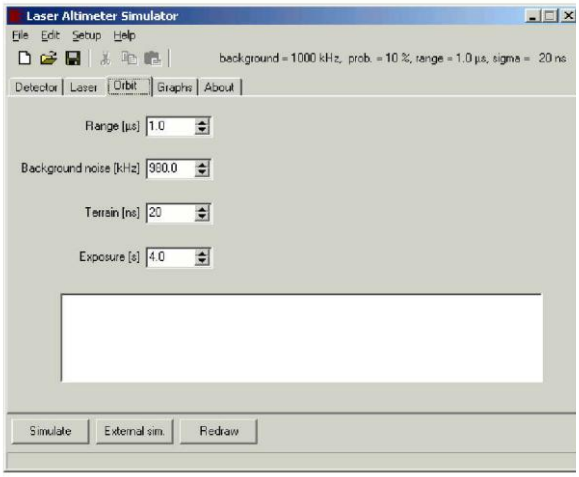
Modular structure of the simulator

Data describing surface height, slope, roughness, and albedo are extracted from map systems and together with calculated trajectory and background photon flux they are used for altimeter results simulation.



terrain: Alwyn Botha of www.the-planet-mars.com

The expected next step of our research is the integration of our simulator with some terrain map database. The physical model of simulator is based on classical time correlated photon counting scheme. The results of simulation are stored in text files and using internally called Gnuplot program are plotted in graphical report shown in the right poster frame.

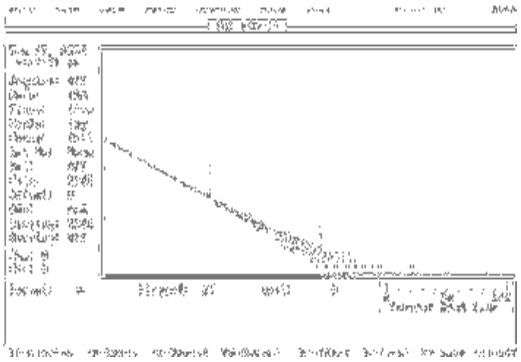


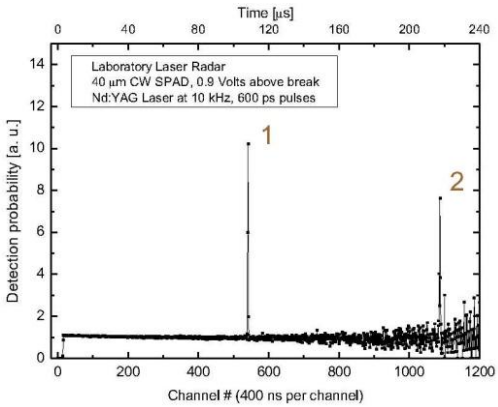
GUI (gray snapshot) allows set up of parameters of the laser (pulse width, repetition rate, wavelength), output optics (output divergence), detector (field of view, detection efficiency, dark noise, temporal resolution), orbit parameters (range, background noise, local terrain profile (on snapshot empty white rectangle), speed of altimeter), sequence of prepared orbit parameters and some parameters for control of graphical output.

Indoor photon counting signal processing tests

To realize altimeter or lidar ranging experiments in indoor conditions the Technology demonstrator - device with down-scale optical part - has been developed and constructed. The screenshot on right side is the measurement of time correlated photon counting acquired by multichannel analyzing card. Two signals (numbered 1 and 2) can be recognized.

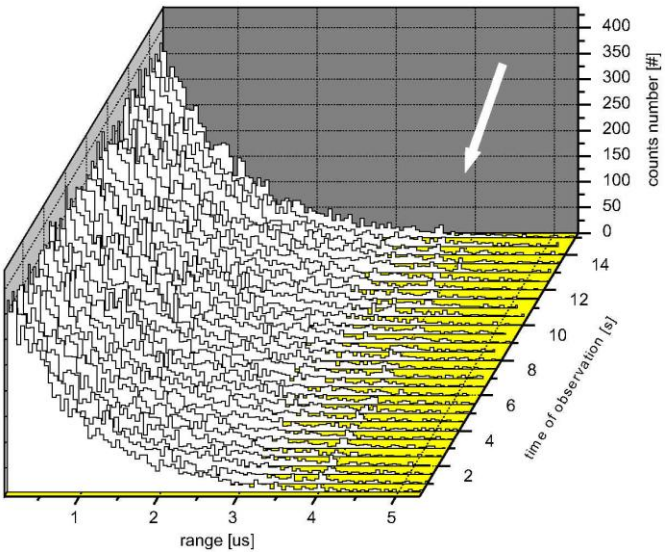
The bottom figure represents the same data recalculated into detection probability in selected time window. Peeks of useful signals - echoes - can be recognized more easily.



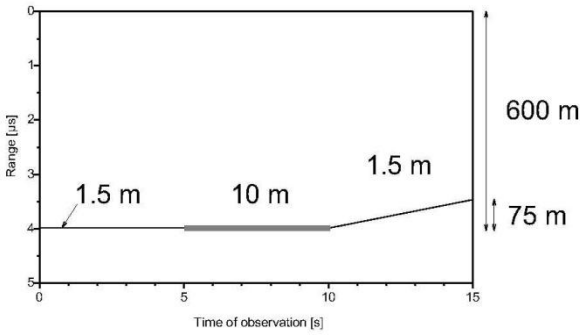


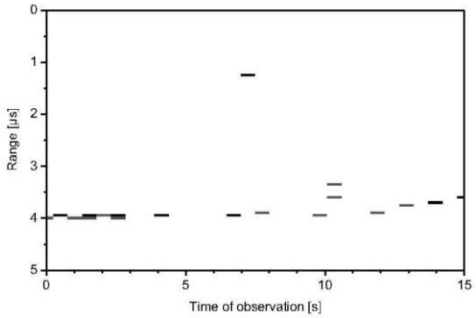
Compare both graphs of real experiment data with graphical output simulator report in right frame of this poster.

Surface relief reconstruction example



To demonstrate single photon counting altimeter operation the surface described in figure below left has been selected. It consists from 3 segments with different roughness and slope. The all other parameters (albedo, background photon flux, height, ...) are constant, the selected orbit segment is small in compare with its variations. Generally, the system of line segments is input format for any more complex modeled surface relief. The model is calculating with clean atmosphere without clouds.

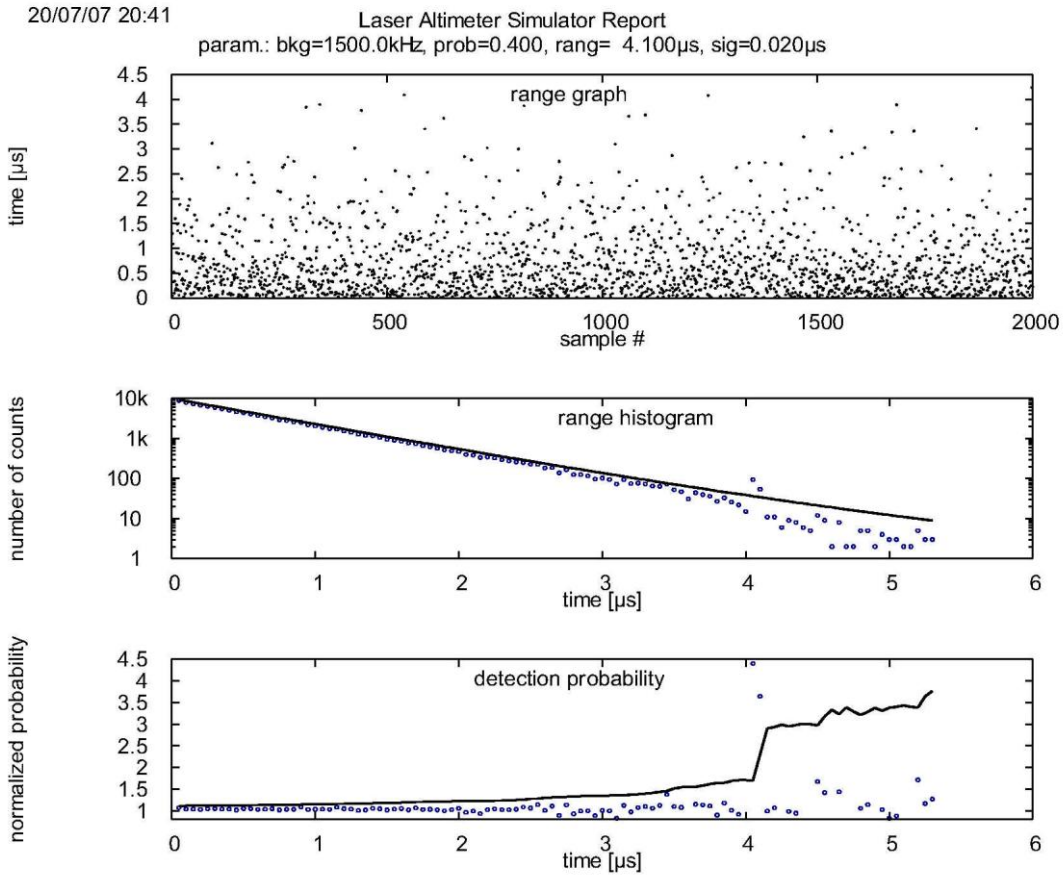




Altimeter operation parameters: 16 kHz rep. rate, 1 MHz overall background noise, 10 % efficiency incl. optics and albedo, sub-ns laser pulse and detector temporal resolution. Data have been separated into groups by 0.5 s (8000 echoes) Series of histograms are shown in the big top figure, the histogram cellwidth is 50 ns. The white arrow indicates the area, where the useful signal is observable. The reconstructed relies using application of 30 filtering criterion is in smaller right figure. The gray level corresponds to SNR.

The simulator user interface (GUI) is developed in Delphi environment. It allows set up of parameters of laser (pulse width, repetition rate, wavelength), output optics (output divergence), detector (FOV, DE, dark noise, temporal resolution), orbit parameters (range, background noise, local terrain profile, speed of altimeter), and some parameters for control of graphical output. From these the five parameters were calculated using radar equation - number of shots, range, noise, probability of detection, and the overall temporal resolution. These parameter inputs into simulator core based on a standard pseudo random number generator and the array of echoes is produced. Two histograms are calculated from this array and simulator produce the list of commands for plotting software to plot report as displayed in figure at next page. Optionally, the orbit parameters set is substituted by a external text file describing orbit and surface as a list of pre-calculated values.

Example of simulator graphical output report



Automatically generated simulator output report. The black lines are distinguish levels of 30 criterion for counts number and detection probability respectively.

Acknowledgements

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References

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