PROPERTIES OF THE SURFACE OF MERCURY FROM MESSENGER LASER ALTIMETER DATA AND THEIR CONSEQUENCES ON THE BEPICOLOMBO LASER ALTIMETER PERFORMANCES. J. Gouman[1*], A. Pommerol[1] and N. Thomas[1], [1]Physikalisches Institut, Universität Bern, Sidlerstrasse 5, 3012 Bern, Switzerland, *julien.gouman@space.unibe.ch

Introduction: The first European laser altimeter designed for interplanetary flight, BELA (BepiColombo Laser Altimeter) is ready to be integrated on the MPO (Mercury Planetary Orbiter) spacecraft of the BepiColombo mission to be launched to Mercury in July 2016 [1]. Nominally, it will enter a 400 km x 1500 km orbit about Mercury in 2022 and always be nadir pointing.

BELA will perform a Time-Of-Flight (TOF) topographic measurement. Of the photons that reach the surface, a small fraction is collected by the BELA receiver. The number of photons which will be scattered and detected by the BELA receiver depends on the transmitted pulse energy, the receiver parameters, the reflectance of the planet and the distance from the spacecraft to the planet. The BELA receiver will also detect some background radiation from reflected Sun light and if this background is relatively high compared to the return pulse energy, the probability to miss the return pulse will increase. The surface slope can broaden the return pulse and can also reduce the detection probability.

The parameters of the surface of the planet relevant for the instrument performance had to be estimated and when the instrument was designed. At that time, only Mariner 10 data were available. Table 1 shows the estimated ranges of these parameters and the required probability of false detection that the instrument was designed to meet. Here, we compare the observations of the MESSENGER Laser Altimeter (MLA) with previous estimates and discuss the consequences for BELA.

	Nominal conditions	Limited conditions
Normal albedo	≥ 0.18	≥ 0.10
Slope	≤ 3°	≤ 23°
Altitude	≤ 900 km	≤ 1055 km
Probability of false alarm	≤ 10%	≤ 50%

Table 1: Definitions of nominal and limited measurement conditions [1]

Methodology: The MLA instrument is one of the instrument onboard the MESSENGER spacecraft. The spacecraft has a highly elliptic polar orbit (from 200 to 15'193 km above Mercury's surface). It has been acquiring data since March 2011 and its mission will end in March 2015. The main purpose has been to provide a topographic map of the northern hemisphere of planet Mercury when the MESSENGER spacecraft is within 1'200 km of the surface of the planet. [2]. MLA also provides information to characterize topographic slopes, roughness and also information about the albedo at 1'064 nm including within craters at the north pole which are permanently shadowed, appear bright at radar wavelength and may contain water ice deposits [3]. The measurements of the reflectance performed by MLA have shown that for most of them, the reflectance inside the craters is much lower (factors of 5 to 10) than the reflectance surrounding them.

MLA detects the return pulse using a two-threshold detection technique: one for strong signals (channel 1 high and low) which records four samples of each return pulse in order to evaluate the return pulse energy; and one for weak return signals when MLA uses low detection thresholds. In order to remove false measurements, the data have been filtered for an altitude range between -5.824 and 4.024 km [4]. After filtering the data, the low thresholds are still very noisy and we have decided to use only the channel 1 high and low threshold in our analysis. From these data we compute the return pulse shape and calculate the return pulse energy.

Results: A map of the northern hemisphere of planet Mercury is shown in Figure 1. In total, MLA has recorded almost 27 millions of measurements and after filtering, 37.25% of the data are used and considered as valid measurements to produce this map. We note that most of the invalid data appear when the angle between the instrument and the normal to the surface is higher than 0.1°.

In order to produce the reflectance map, the channel 1 high and low thresholds are both needed to reconstruct the pulse shape of the return pulse. The reflectance of the surface is known with an accuracy of ± 25% when the distance between the instrument and the surface is less than 500 km and almost nadir pointing [5]. In order to get a precise measurement of the reflectance measured by MLA, the data obtained when the altitude between the instrument and the spacecraft was less than 500 km have been removed from our data set. This filter and the altitude range which has been established between -5.834 and 4.024 km [4] implies an important decrease of the amount of data: only 9.54 % of the data are considered as valid ones.

The obtained information (local slopes and reflectance of the surface) from MLA have been used to update the estimation of the performance of the BELA instrument.

Discussion: The probability of false measurement of the BELA instrument, that is to say the probability to miss the return pulse, has been calculated taking into account slopes, normal albedo and the altitude of the spacecraft above the Mercury's surface; nominal and limited measurement conditions have been defined taking into account extreme conditions for these three parameters (Table 1). In the nominal measurement conditions case, the probability to miss the return pulse is less than 10% while it is less than 50% in the limited measurement conditions case. We find that 69.0% of the slopes measured by MLA are ≤ 3° and 99.4% are ≤ 23°.

Concerning the albedo from the northern hemisphere of Mercury which has been recorded by the MLA instrument, we find that only 46.8% of the albedos measured are ≥ 0.18 and 70.7% are ≥ 0.10.

Table 2 shows the average of the reflectance of 12 craters which are bright at radar wavelength but appears dark at 1'064 nm. Concerning these 12 craters, the average of the reflectance of their interior is in agreemant with the albedo of cometary nuclei which is in the range of 0.02 – 0.06 [6]. The estimation of the albedo to calculate the probability to miss the return pulse has been underestimated when considering the albedo parameter. The reflectance inside the dark craters which have been measured at the north pole was roughly equal to 0.06. 24% of the the measurements recorded by the MLA instrument are ≤ 0.06.

Crater item	Reflectance inside the crater	Reflectance surrounding the crater
1	0.08 ± 0.02	0.16 ± 0.04
2	0.08 ± 0.02	0.16 ± 0.04
3	0.04 ± 0.01	0.15 ± 0.04
4	0.05 ± 0.01	0.14 ± 0.04
5	0.06 ± 0.02	0.15 ± 0.04
6	0.06 ± 0.02	0.15 ± 0.04
7	0.05 ± 0.01	0.15 ± 0.04
8	0.05 ± 0.01	0.20 ± 0.05
9	0.06 ± 0.02	0.17 ± 0.04
10	0.07 ± 0.02	0.17 ± 0.04
11	0.08 ± 0.02	0.17 ± 0.04
12	0.08 ± 0.02	0.17 ± 0.04
13	0.42 ± 0.11	/

Table 2: Average of the reflectance measured inside and surrounding the craters which are bright at radar wavelength

The field of view of the BELA flight model receiver has been enlarged to 530 µrad from 460 µrad due to significant concern about the quality of the flight model telescope which lead to an increase of the background radiation of 32.7%.

Figure 2 shows the expected signal and background using the MLA data when Mercury is at perihelion (worst case) for a surface reflectivity equal to 0.05 and 0.17.

Conclusions and further work: The data we obtained from the MLA instrument have shown that some parameters concerning the planetary surface have been overestimated. The updated values concerning the planetary surface will allow us to update the probability of false detection of the BELA instrument. Results from the end-to-end test of the instrument with these parameters will be presented at the meeting.

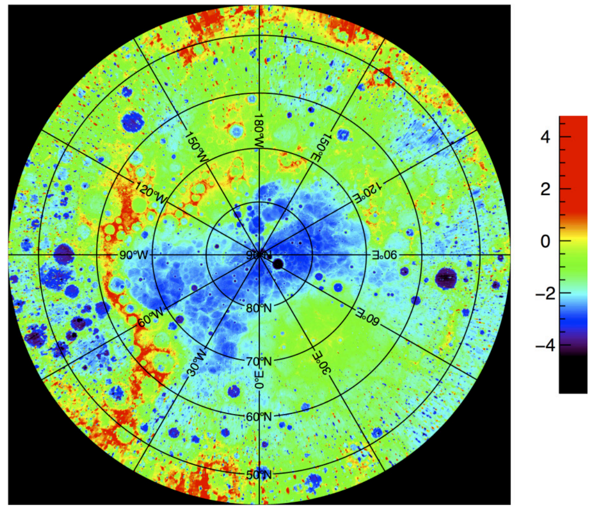

Figure 1: Altitude map of the northern hemisphere of Mercury [km]

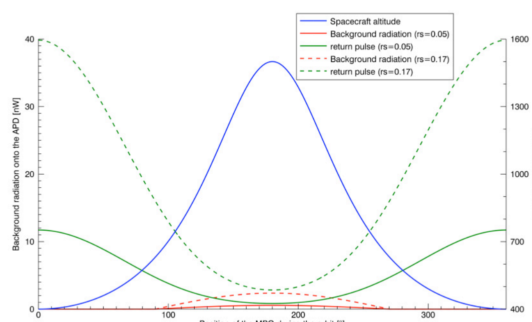

Figure 2: Energy expected onto the BELA FM APD from the received pulse and the background radiation, for a surface reflectivity equal to 0.05 and 0.17, when Mercury is at perihelion

References: [1] Thomas et al. (2007) *Planet. Space Sci*., 55:1398–1413., [2] Cavanaugh et al. (2007) Space Sci. Rev, 131:451–479. [3] [Harmon et al. (2001), Icarus, 149:1–15. [4] [Zuber et al. (2012), Science, 336:217–. [5] Neumann et al. (2012) lpsc, page 2651. [6] Lamy et al. (2004) The sizes, shapes, albedos, and colors of cometary nuclei, pages 223-264.