

The Ganymede Laser Altimeter (GALA) for the Jupiter Icy Moons Explorer (JUICE): Performance Model Simulation

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GALA (GAnymede Laser Altimeter) is one of the payload instruments of the JUICE (JUpter ICy moons Explorer) to be launched in 2023 to the Jovian icy moons, Ganymede, Europa, and Callisto. GALA is developed by the international collaboration of Germany, Japan, Switzerland, and Spain.

With the GALA performance model, we searched the interface conditions that satisfy the science requirements on the probability of false detection (PFD) and the range accuracy.

The science requirements on GALA performance can be summarized as following four criteria: [A] for Europa fly-by, PFD is less than 0.2 from an altitude of 1300 km or lower, [B] under the worst observation condition for albedo and surface slope of GCO500 (Ganymede Circular Orbit whose height is 500km), the accuracy of ranging is less than 10 m and PFD is less than 0.2, [C] under the nominal observation condition of GCO500, the accuracy of ranging is less than 2 m and PFD is less than 0.1, and [D] under the best observation condition of GCO500, the accuracy of ranging is less than 1 m and PFD is less than 0.1. The minimum SNR (R_SNR) which satisfies each requirement from [A] to [D] is summarized in Table 1 through the simulation of output signal of the GALA matched filter, where the range accuracy for [A] is assumed to be ' $< 10m$ '. R_SNR should be less than C_SNR which is evaluated by our GALA performance model for each criterion.

For the assessment, however, we must use data for the characteristics of the laser detector of GALA, avalanche photodiode (APD) degraded due to the severe radiation environment around Jupiter. Now, we carried out realistic model simulation using GALA performance model with these degradation effects of APD. Characteristics of APD, such as gain, quantum efficiency, excess noise index, surface dark current, and bulk dark current, were re-evaluated through radiation tests using the data of dark and photo current of the APD irradiated with 2-MeV-electron and 50-MeV-proton beams, which are considered to be equivalently severe on the APD as in the radiation condition of JUICE-GALA around Jupiter.

These degraded characteristics of APD by radiation were introduced to our performance model of GALA. As a result, our performance simulation of GALA showed that the science requirements ($R_SNR < C_SNR$) are satisfied even after considering the degraded characteristics of APD (Table 1).

Keywords: JUICE, GALA, laser altimeter, APD, matched filter, radiation

Table 1. Comparison of C_SNR and R_SNR

Criterion	[A] Europa fly-by	[B] worst GCO500	[C] nominal GCO500	[D] best GCO500
C_SNR	23.2	28.8	202	357
R_SNR	22	22	43	122