The Ganymede Laser Altimeter – Instrument design overview with radiation hard transmitter.

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Introduction: The JUICE (Jupiter Icy Moons Explorer) mission is part of ESA‘s Cosmic Vision Programme and its objective is to study Jupiter‘s plasma environment and the three icy moons Ganymede, Europa and Callisto. The JUICE spacecraft will be launched in 2022 on an Ariane 5 rocket. After its 8 year cruise it will enter an orbit around Jupiter. During the following three years the orbit will be gradually adjusted and after several fly-bys at Callisto, Europa and Ganymede the space-craft will reach its final circular orbit around Gany-mede. One of the ten scientific instruments is the Ganymede Laser Altimeter – GALA (Fig. 1). It will determine the topography and time dependent shape of the moon by direct laser altimetry approach.

Instrument Design: The instrument is composed of three units: Transceiver Unit (TRU), Laser Electronics Unit (LEU) and Electronics Unit (ELU). The TRU contains the transmitter laser

Therefore the instrument is equipped with a Nd:YAG laser system with a nominal pulse repetition frequency of 30 Hz and a pulse energy of 17 mJ. The laser is a side-pumped by laser diodes unstable resonator which is encapsulated in a pressurized compartment. Heritage of this configuration is from BELA which is designed and verified for ESA‘s BepiColombo mission. For GALA the laser must fulfil strong requirements especially on radiation hardness, power efficiency and lifetime. Furthermore a reflective 25 cm RC telescope is included to receive the transmitted light pulses [1].

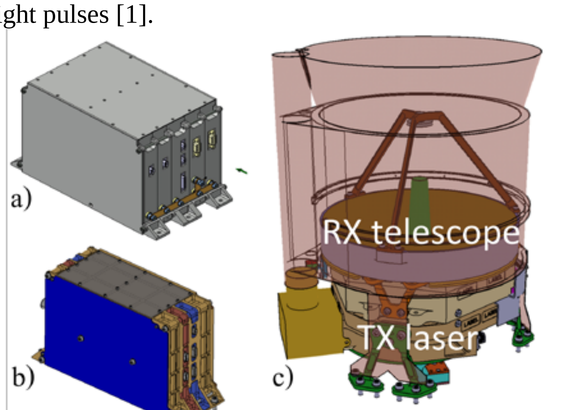

Fig. 1: GALA is composed of an Electrical Unit (a), a Laser Electronics Unit (b) and a Transceiver Unit (c). The latter one is in contrast to the other two accommodated on an space exposed optical bench on the S/C.

Mission constraints: The environment of Jupiter is challenging for a S/C and a laser instrument because besides the common space related factors, e.g. vacuum, thermal loads, limited mass and power, micrometeoroids, plasmas etc., it is strongly dominated by high energetic particles and in particular electrons. These are caught by the strong Jovian magnetic field which with 428 µT at the equator is about one order of magnitude stronger than Earth‘s [2].

Degradation Mechanisms: The physics of degradation mechanisms by radiation are complex and numerous. A major effect is that protons and electrons cause ionization and displacement damage (DD). These result in darkening of optical glasses, damage of optical coatings as well as loss of adhesion of coatings, increase of laser threshold and loss of optical output power of laser diodes. Furthermore electrons lead, especially in strong dielectrics, to charging which can result in damage or failure of components by discharge arcs.

Methods: In order to realize the goal of achieving the optimal overall configuration of the laser for a Jupiter mission, trade-offs must be made carefully. This is because advantages on one parameter can have contrary impact on others, e.g. increasing the efficiency of the resonator by making the cross-section of the pumped volume smaller leads to increased risk of laser incuced damage (LID) at optical surfaces, e.g. the polarizing beamsplitter (PBS).

Therefore it is investigated which effect or parameter influences the system in which manner, i.e.

for radiation hardness:

- ionizing radiation and non-ionizing radiation
- dielectric charging

for power efficiency:

- laser diodes threshold, slope, pump duration
- laser rod geometry, absorption loss
- Pockels cell rise time

for lifetime:

- redundancy
- laser diodes degradation
- pressurization of resonator

The tools used for assessment of the radiation doses (TID and DD) and fluxes are GRAS, Fastrad and SPENVIS [3]. From those results conditions for representative radiation tests are derived. Particular attention amongst others is paid on charging effects caused by energetic electrons, but also displacement damage.

A tool to quantitatively assess the impact of different factors on the system shall help to design the transmitter of this and other missions. Description of approach and some results are part of this work.

References: [1] K. Lingenauber, H. Hussmann et al. The Ganymede Laser Altimeter (GALA) on ESA's JUICE mission: Overview of the instrument design. (2014) Conference Paper.; [2] Jovian Factsheet: http://nssdc.gsfc.nasa.gov/planetary/factsheet/joviansat fact.html; [3] Space Environment Information System https://www.spenvis.oma.be/