A Platform for a MEMS-based Laser Pointing System with Position Feedback

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The Extreme Universe Space Observatory (JEM-EUSO) is a new type of observatory that will utilize the earth's atmosphere as a detector of ultra-high energy cosmic rays. An Elegant Breadboard of the Laser Pointing System for the JEM-EUSO space mission has been designed in order to demonstrate the achievement of the critical functionalities. The Laser Pointing System will be a key device to understand the atmospheric conditions in the field of view of the JEM-EUSO telescope.

The goal of the JEM-EUSO mission is to provide a solution to the problem of the origin of Ultra-High Energy Cosmic Rays (UHECR). Such cosmic rays, if entering the Earth's atmosphere, produce Extensive Air Showers (EAS) that consists of numerous electrons, positrons, and photons. EUSO captures the moving track of the resulting fluorescent UV photons and delivers information about the primary UHECR particles such as the arrival direction, the energy and also the type of the particles (Figure 1).

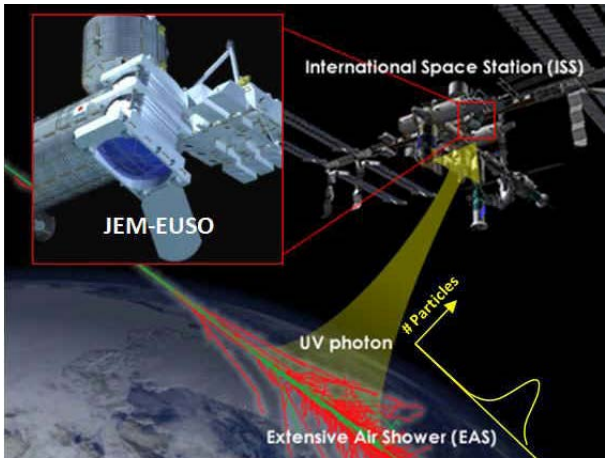

Figure 1: Principle of detection of UHECR from space with the-EUSO telescope.

The intensity of the produced UV light depends also on the properties of the atmosphere, in particular on its transmittance and scattering characteristics in the UV band. Therefore EUSO will be equipped with a dedicated Atmospheric Monitoring System (AMS) which uses a LIDAR to probe the atmospheric conditions in the Field of View. In collaboration with the University of Geneva CSEM has designed an Elegant Breadboard (EBB) of the Laser Pointing System (LPS) for this LIDAR. The key specification of the LPS is the following:

- Laser Wave Length 355 nm
- Pulse Width 15 ns
- Pulse Energy: 20 mJ / pulse
- Beam Deflection: +/- 30° from vertical
- Beam Divergence: 2 mrad

The LPS will repoint the laser beam in the direction of the last triggered EAS and shoot the laser in several directions around this location. The focal surface detector of EUSO will receive the transient flashes of the laser and provides the data for the scattering and absorption profiles. The effective time available to point the laser beam to a new location is typically a few tenths of seconds, thus requiring a lightweight MEMS mirror [1] with limited inertia and a fast control algorithm with a mirror position sensor in the feedback loop. A simplified block diagram of the LPS is given in Figure 2.

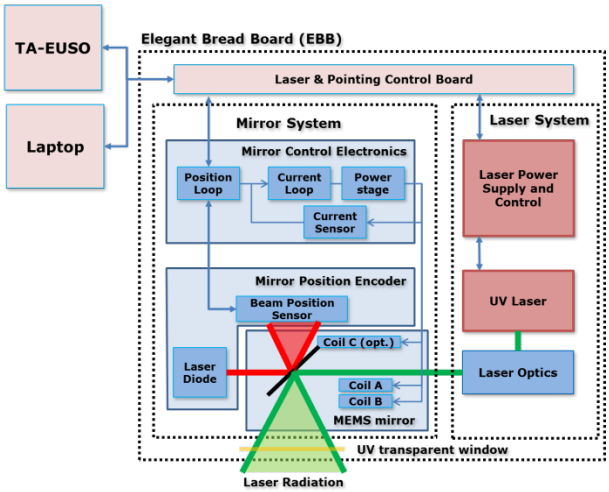

Figure 2: Block diagram of the laser pointing system (LPS).

The CAD Model of the EBB is shown in Figure 3. It is composed with the housing, the laser head, the optical system supporting the position sensor, the mems mirror and the electronics board. The red beam represents the UV laser beam, while the green one is the beam used to measure the position of the MEMS mirror through the position sensor and the supporting optical system.

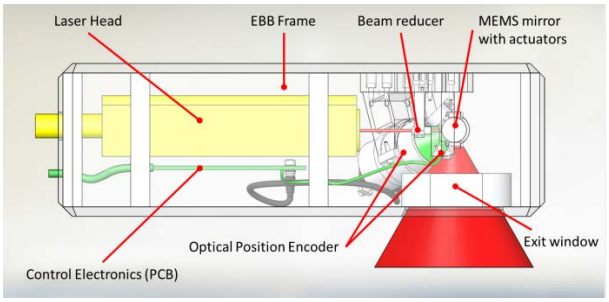

Figure 3: CAD model of the LPS elegant bread board.

The presented EBB design will be implemented during the next project phase and it is expected that a fully operational model will be available at the end of 2016. A qualification and flight model of the EUSO Laser Pointing System is planned for 2017

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[1] A. Hoogerwerf, *et al*., "MEMS Mirror for High Power, Large Angle, 2D Laser Steering", this report page 25.