A MEMS UV Laser Pointing Mirror for Atmosphere Monitoring

A. Hoogerwerf, D. Z. Bayat, B. Timotijevic, V. Revol, T. Burch

A MEMS mechanism is being developed that allows a tip-tilt, large angle (+/- 15° optical), actuation of a ultra-violet laser mirror. The aim of the development is a scientific space mission, but the design can be used for other applications that need a steerable mirror for the pointing of a high energy laser beam.

The goal of the Extreme Universe Space Observatory (EUSO), to be installed on the International Space Station (ISS), is to detect about 10^3 Ultra-High Energy Cosmic Ray (UHECR) "events" and produce, for the first time, a large signal statistical all-sky map of the distribution of the arrival directions of the highest energy cosmic rays with angular resolution close to 1 degree. EUSO[1] will use the Earth's atmosphere as a calorimeter particle physics detector, measuring the ultraviolet fluorescence produced by the air molecules excited by the UHECR induced extensive air shower (EAS). The EUSO ultraviolet telescope has an aperture of 2.5 m, a field of view of 60°, and will be operating in the 300-400 nm wavelength range.

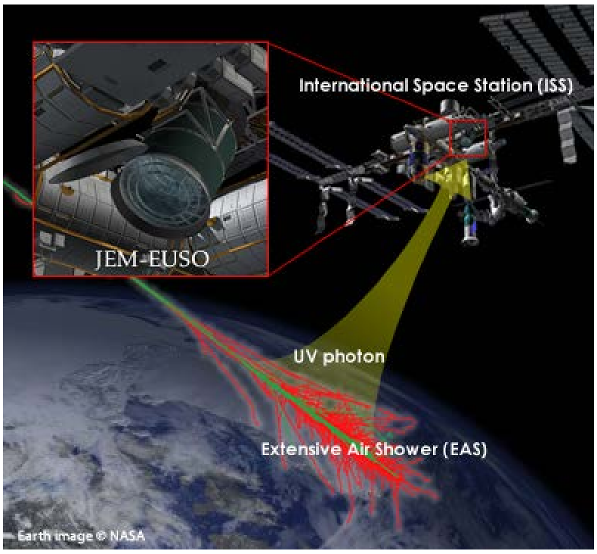

Figure 1: The EUSO concept.

EUSO will be equipped with a dedicated Atmospheric Monitoring (AM) system consisting of an infrared camera and a LIght Detection And Ranging (LIDAR) device, since the intensity of the UV light is strongly affected by the transmittance and scattering characteristics of the atmosphere around the shower. The LIDAR is composed of a transmitting and a receiving system. The transmission system comprises a Nd:YAG laser, whose the third harmonic wavelength at 355 nm is used and a pointing system to steer the laser beam in the direction of the triggered EAS events. The receiver of the laser backscattered signal will be the EUSO telescope.

The pointing system of the LIDAR consists of a 3.5 mm diameter quartz UV mirror with an optical aperture of 3 mm, sandwiched between two silicon MEMS structures. The minimum size of the mirror is determined by its ability to withstand the high energy pulses of the UV laser. The silicon structures, consisting of planar springs, form together with the mirror a steering mechanism. Actuating the mechanism in the X- and Y directions by two voice coils generates a tip-tilt movement of the mirror. The mirror can be oriented in two directions with a +/- 15 degree angle. The angle will be measured for a precise closed loop control feedback.

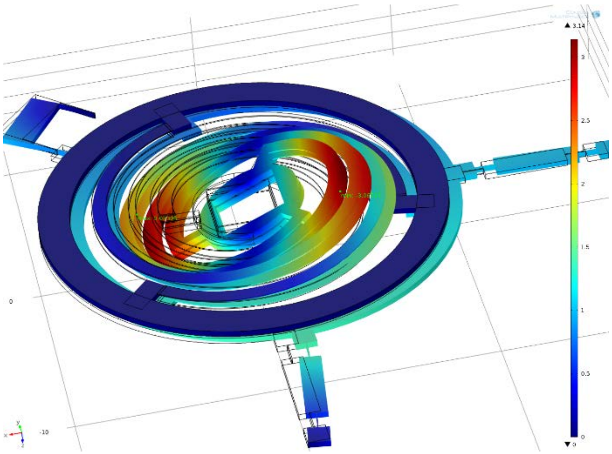

Figure 2: The deformation of the silicon mechanism that converts a linear actuation in a tilting movement of the mirror.

A full-scale functional model of the mechanism has been fabricated and assembled, with the primary goal to verify the functional parameters of the device to compare them with the simulation results. The manufacturability of the device could be demonstrated and a first model could be assembled with glue. The current focus of the fabrication is on the assembly of the device with pressure fittings for space requirements compatibility.

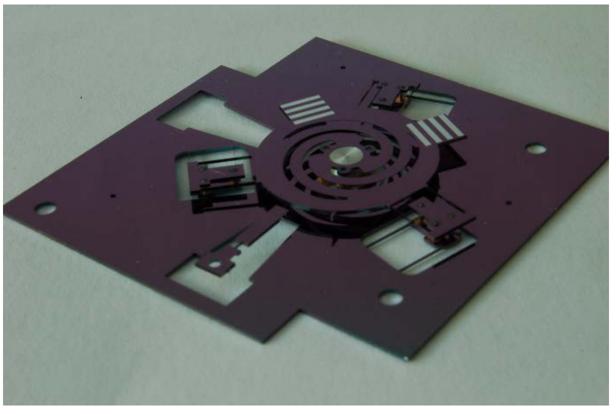

Figure 3: Functional model assembled from precision silicon mechanical parts.

The work has been funded by the Swiss Space Office under the PRODEX programme.

[1] J. H. Adams,.*et al.*, "The JEM-EUSO mission: An introduction", http://adsabs.harvard.edu/abs/2015ExA....40....3A.