Lifetime of Channel Electron Multipliers dedicated to Plasma Instruments for Solar Orbiter and JUICE ESA missions

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Both Solar Orbiter and Jupiter Icy moon Explorer (JUICE) are long-life ESA missions, which should work in extremely difficult space environment. A very high thermal load up to 13 Solar constants will affect Solar Orbiter, and JUICE will experience a high penetration radiation influence in the Jupiter magnetosphere. The plasma packages of these missions, dedicated mostly for detection of low energy (between 1eV and 50 keV) ions and electrons shall accept a very high dynamic range of the incident charged particle flow. All these circumstances motivate us to use the Channel Electron Multiplier (CEM) as detectors in both missions. CEMs are a conventional low energy charged particle and X-ray detectors that have been used for many early space missions. Later, they were forced out by Micro-Channel Plates (MCP), which allow to provide an image of the particle distribution. But for such challenge missions as Solar Orbiter and JUICE we have to come back to CEMs because they 1) less sensible to the penetrating radiation 2) have much wide dynamical range, 3) have much longer lifetime than MCPs.

The detector lifetime is, actually, the maximum particles number accumulated by detector until its efficiency becomes too low. And this detector feature is critical for Solar Orbiter and JUICE missions.

To check the lifetime of CEMs, for different thermal conditions also, we have made a dedicated experimental setup. We irradiated several CEM samples by a strong electron flux, continuously measuring the CEM gain and keeping 80°C on the sample. The final total number of events, detected by each CEM was equivalent to two Solar Orbiter nominal mission duration.

The detailed analysis of the experimental data show that the visible degradation of CEMs gain is a function of the vacuum level in the vicinity of the CEM and its outgassing efficiency. If we normalize the CEM gain to the vacuum, expected in the flight, we will see that the pure, completely outgassed CEM can accumulate ten Coulombs of charge without any gain degradation. But in the beginning of the flight, we have to expect very fast gain degradation because of the CEM self-cleaning.