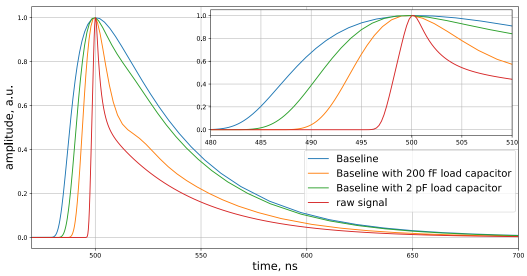

Figure 4: The SiPM signal shape before and after different amplifier configurations for the NUV-HD-MT from FBK with 25 μm micro-cell size. The amplitudes are normalized to the maximum value.

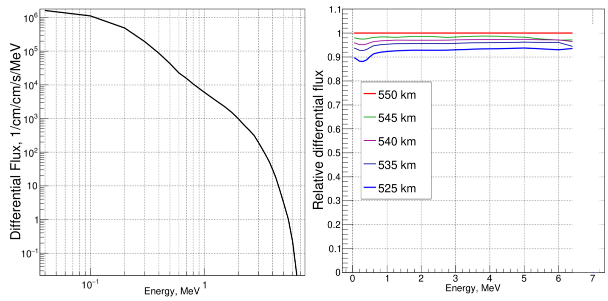

Figure 5: **Left:** Average differential electron flux at 550 km height obtained with SPENVIS [8]. **Right:** Relative variation of the differential electrons flux for different heights.

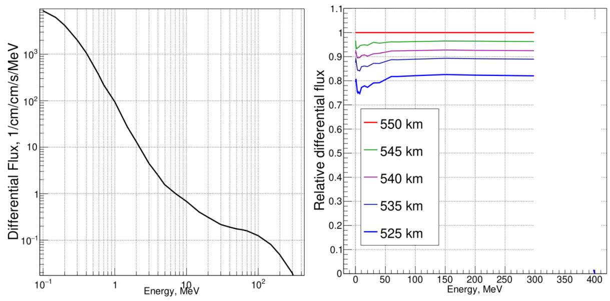

Figure 6: **Left:** Average differential proton flux at 550 km height (SPENVIS [8]). **Right:** Relative variation of the differential proton flux for different heights.

Terzina has a technological driver to explore the performance of silicon photomultipliers (SiPMs) in space. Compared to the classic photomultipliers, they are preferred for their typically higher Photon Detection Efficiency (PDE) and their robustness, although they suffer a larger background due to the higher sensitivity, and sensitivity to radiation damage. We developed a parametric waveform simulation based on the knowledge of the sensor's single photoelectron signal shaped by the amplifier and the sensor's noise rate and NGB. This simulation, together with the Geant 4 full simulation, is useful to understand the requirements of the relevant parameters of the sensor and also to define the trigger (see Sec. 5.1). Moreover, the following requirements for the SiPM operating properties are needed: the PDE at peak wavelength should be at least of 50%, the direct and delayed cross-talk CT should be lower than 10% at operation voltage, as well as afterpulse AP and the DCR preferably not higher than 100 kHz/mm^2.

The NUV-HD-LowCT SiPM technology [7], developed by FBK, has typical values (for 35 μm cell-size) of dark count rate (DCR ~ 100 kHz/mm^2), afterpulsing (AP ~ 5%;) and optical crosstalk (CT ~ 5%–20%;), and photodetection efficiency (peak PDE ~ 50%–60%.) in the blue region of the light spectrum. The highest values of the PDE are achieved with the largest cell sizes available (e.g. 35 – 40 μm), as they feature the highest fill factor (i.e. ratio between active area and total area of one micro-cell / SPAD). On the other hand, the recovery time of the micro-cell also increases with increasing cell size, as it is proportional to the micro-cell capacitance and, as a first approximation, to its area.

To further improve performance, the Collaboration is also evaluating an upgraded version of the NUV-HD technology, the NUV-HD-MT, which employs metal filling of the Deep Trench Isolation (DTI) that separates adjacent micro-cells in the SiPM, to further reduce optical crosstalk probability without sacrificing PDE.

It is to be noted that one of the expected background in space is due to relativistic charged particles which can produce Cherenkov light in the telescope optical/mechanical parts and the SiPM protective resin layer. The potential background created by cosmic ray protons and, to a reduced extent, by relativistic heavier nuclei [1] and electrons is mitigated by reducing these elements close to the sensors and by the telescope chassis with baffle.

We expect electrons and protons to be the dominant sources of background. Ionizing radiation, like protons and heavier nuclei, induces damage in the silicon of SiPMs. Moreover, neutrons can create dislocations, within the crystal structure, increasing the DCR. Electrons, on the other hand, produce secondary gammas causing non-ionising radiation damage. The level of damage depends on the cosmic ray radiation spectra that we obtain with SPENVIS for Terzina's orbit [8] (see Fig. 5 and Fig.6). We use the full simulation of the telescope to estimate the radiation dose integrated by the SiPMs knowing the electron and proton spectra (see sec. 3) .

In Fig. 7 the SiPM camera power consumption at different stages of the lifetime of the mission are shown. The black curve is measured in a laboratory test bench while the others are calculated using the linear extrapolation of the coefficient of the DCR increase with integrated radiation dose. Next, we can estimate NGB + DCR at BoL, after the first and second years of operation, and at EoL, namely for background levels of: 11 MHz, 22 MHz, 33 MHz, 44 MHz respectively. At the end of life, the power consumption of the sensors of the camera, operated at an over-voltage of about 6 V, will reach 0.2 W.

[1] These are mostly He with lower abundance of heavier nuclei up to Fe, particularly dangerous since number of Cherenkov photons is squarely scales with particle charge.