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Self-consistent Modelling of Nuclear Processes in Solar Flares using FLUKA

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We use the Monte Carlo particle physics code FLUKA to calculate gamma-ray spectra expected from solar flare energetic ion distributions. The FLUKA code includes robust physics-based models for electromagnetic, hadronic and nuclear interactions, sufficiently detailed for it to be a useful tool for calculating nuclear de-excitation, positron annihilation and neutron capture line fluxes and shapes, as well as ~GeV continuum radiation from pion decay products. We show nuclear de-excitation gamma-ray line model spectra from a range of assumed primary accelerated ion distributions and find them to be in good agreement with those found using the code built by Ramaty and collaborators, currently one of the main tools for the analysis of solar flare gamma-ray data. We also show full gamma-ray model spectra which exhibit all the typical structures of gamma-ray spectra observed in solar flares. From these model spectra we build templates which are incorporated into the software package Objective Spectral Executive (OSPEX) and used to fit the combined Fermi Gamma-ray Burst Monitor (GBM)/Large Area Telescope (LAT) spectrum of the 2010 June 12 solar flare, providing a statistically acceptable result. To the best of our knowledge, the fit carried out with the FLUKA templates for the full gamma-ray spectrum can be regarded as the first attempt to use a single code to implement a self-consistent treatment of the several spectral components in the energy range from ~ 100s keV to ~100s MeV.

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