Interplanetary shocks as a source of sustained gamma-ray emission from the Sun

Nat Gopalswamy and Pertti Mäkelä
NASA Goddard Space Flight Center, Heliophysics, Code 671, Greenbelt, United States of America
(nat.gopalswamy@nasa.gov)

It has recently been shown that the sustained gamma-ray emission (SGRE) from the Sun that lasts for hours beyond the impulsive phase of the associated flare is closely related to radio emission from interplanetary shocks (Gopalswamy et al. 2019, JPhCS, 1332, 012004, 2019). This relationship supports the idea that >300 MeV protons accelerated by CME-driven shocks propagate toward the Sun, collide with chromospheric protons and produce neutral pions that promptly decay into >80 MeV gamma-rays. There have been two challenges to this idea. (i) Since the location of the shock can be halfway between the Sun and Earth at the SGRE end time, it has been suggested that magnetic mirroring will not allow the high energy protons to precipitate. (ii) Lack of correlation between the number protons involved in the production of >100 MeV gamma-rays (Ng) and the number of protons (Nsep) in the associated solar energetic particle (SEP) event has been reported. In this paper, we show that the mirror ratio problem is no different from that in flare loops where electrons and protons precipitate to produce impulsive phase emissions. We also suggest that the lack of Ng – Nsep correlation is due to two reasons: (1) Nsep is underestimated in the case of eruptions happening at large ecliptic latitudes because the high-energy protons accelerated near the nose do not reach the observer. (2) In the case of limb events, the Ng is underestimated because gamma-rays from some part of the extended gamma-ray source do not reach the observer.