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Open magnetic flux tubes in the corona and the transport of solar energetic particles

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We investigate how magnetic fields guide energetic particles through the corona into interplanetary space and eventually to a spacecraft near the Earth. A set of seven simple particle events is identified, where energetic electrons (30-500 keV) or protons (5-55 MeV) were detected at the *Wind* or SoHO spacecraft near 1 AU. The particles were released together with low-energy electron beams producing metric-to-kilometric type III emission. Imaging of the coronal (metre-wave) part of this emission with the Nançay Radioheliograph is used to identify the open flux tubes which guide these electrons - and by inference all particles detected at 1 AU. Open coronal field lines are furthermore computed using potential magnetic field extrapolations, constrained by a source surface and by SoHO/MDI measurements in the photosphere (code by Schrijver and DeRosa). We find that in all events the type III radio sources lie in open flux tubes in the potential magnetic field extrapolations. The open flux tubes are rooted in small parts of the parent active region, with a heliocentric angle of a few degrees in the photosphere. But they expand rapidly above the neighbouring closed magnetic structures and cover several tens of degrees in longitude on the source surface. Some of these open field lines are found to connect the parent active region to the footpoint of the nominal Parker spiral on the source surface, within the uncertainty of about $\pm 10^\circ$ inherent to the evaluation of its connection longitude. This is so even when the parent active region is as far as 50° away. We conclude that energetic particles accelerated in active regions are guided through the corona along non-radial open field lines over several tens of degrees in longitude even in simple impulsive particle

events. These field lines are adequately described by potential magnetic field models.