The unexpected creation of new electron and proton radiation belts during the March 24, 1991 geomagnetic storm have challenged scientists to rethink the formation and stability of the Earth’s radiation belts. Satellite measurements showed that the new belts appeared within minutes near the “slot region” at 2.5 \( R_E \) when an interplanetary shock rapidly compressed the Earth’s magnetosphere (the largest compression on record). The newly formed belts persisted until 1994. Empirical diffusion models give energization rates that are orders of magnitude too slow for such events; and they only describe the intensification of existing zones of MeV particles rather than the formation of new stable belts.

A promising new technique for modeling radiation belt dynamics during strong magnetospheric compressions embeds a particle-pushing code for radiation belt particles in a global MHD simulation of the solar wind–magnetosphere interaction. Results\(^1\) for the 1991 storm (see figure) show that an initial outer zone electron source population, represented by the average NASA AE8MIN model in the upper right insert, was transported radially inward by the shock-induced electric field to the sparsely populated slot region. This transport occurs on the MeV electron drift time of 1-2 minutes and produces the observed flux peak at 13 MeV for the 1991 event. A new proton belt was also formed at the same location by the same mechanism, but with greater energy (>20 MeV), trapping and transporting inward the extreme solar energetic protons produced by the interplanetary shock.