# 3.1.2.8 Explore the type III radio bursts delays

Impulsive SEP events are generally accompanied by solar type III radio bursts, indicative of electrons escaping from the Sun, that drift down to near the local plasma frequency (tens of kHz). At 1 AU, for most impulsive events the injection of the >25 keV electrons at the Sun, inferred from the observed velocity dispersion, is delayed by ~10-30 min after the type III radio bursts (Krucker et al., 1999; Haggerty & Roelof, 2002). These delays have been suggested to be due to propagation effects in the interplanetary medium (Cane & Erickson 2003; Cane 2003), or to delayed acceleration by large-scale coronal transient (EIT or Moreton) waves or by shock waves associated with narrow CMEs (Simnett et al. 2002; Rouillard et al., 2012), or by coronal magnetic restructuring in the aftermath of CMEs (Maia & Pick 2004; Klein et al. 2005; van Driel-Gesztelyi et al., 2014). Recent analyses of highly scatter-free impulsive electron events show evidence for two injections (Wang et al. 2006): a low-energy (~0.4 to ~12 keV) injection that begins ~10 min earlier than the type III radio burst, and a high-energy (>~13 to 300 keV) injection that starts ~10 min after. This confirms that type III bursts are produced by ~1-12 keV electrons, consistent with the type III-producing Langmuir waves being detected in situ at the time of their arrival at 1 AU. Recent theoretical studies suggest that some of the delays for higher energy electrons may be due to propagation effects.

In a few events, the injection of energetic ions can be inferred, and they lag behind the electrons by ~30-60 minutes more. SOHO EIT and LASCO images suggest an association of impulsive events with jets or narrow fast CMEs (Wang et al 2006); perhaps they accelerate electrons lower down and ions higher up in the corona. However, the pattern of high charge states observed in impulsive events suggests the ions are accelerated in relatively high-density regions.