# 3.3 What are the seed populations for energetic particles?

***Present state of knowledge:***

The low-energy particles accelerated by CME-driven shocks to SEP energies are called the seed population. The observed ionization states of SEP ions show temperatures typical of the corona, ruling out hot material on flare loops as the seeds. But SEPs also show significant abundances of ions such as 3He and singly ionized He, which are virtually absent from the solar wind. The observed energetic particle abundances indicate that the suprathermal ion pool, composed of ions from a few to a few 10 s the speed of the solar wind, is the likely source. At 1 AU the suprathermal ion pool is ~100 times more variable in intensity than the solar wind and varies in composition depending on solar and interplanetary activity. The suprathermal ions are continuously present at 1 AU, but it is not known if there is a continuous solar source, or if these ions are from other activities such as acceleration in association with fast and slow solar wind streams. Inside 1 AU, the suprathermal ion pool is expected to show significant radial dependence due to the different processes that contribute to the mixture, but it is unexplored (Desai et al. 2006; Mewaldt et al. 2007; Lee 2007; Fisk and Gloeckler 2007).

For SEPs accelerated on loops or in reconnection regions that give rise to electron and type-III radio bursts, ionization states are coronal-like at lower energies and change over to much hotter flare-like at high energies. This may be evidence for a complex source, or, more likely, of energetic particle stripping as the ions escape from a low coronal source. For SEPs accelerated at reconnection sites behind CMEs abundances and ionization states would be coronal (Klecker et al. 2006).

Critical questions in this area are: what is the suprathermal ion pool in the inner heliosphere, including its composition and temporal and spatial variations? What turbulence or stochastic mechanisms in the inner heliosphere accelerate particles to suprathermal energies? Are the source locations and arrival times of electrons from SEPs on loops or reconnection regions consistent with a low or high coronal source?

***How Solar Orbiter will address this question:***

By systematically mapping the suprathermal ion pool in the inner heliosphere with spectroscopic and in-situ data, Solar Orbiter will provide the missing seed particle data for models of SEP acceleration associated with shocks. Together with the shock and turbulence parameters also measured on Solar Orbiter, there will be the first well-constrained models. Since the suprathermal ion pool composition varies, different shock events will be expected to produce correspondingly different energetic particle populations that can be examined on a case-by-case basis. The high-latitude phase of the mission will add an important third dimension to the suprathermal pool mapping, since it will be more heavily influenced by, e.g., mid-latitude streamer belts, making it possible to probe the solar and interplanetary origins of the seed particle populations. Taken together, these observations will make it possible to construct the first complete physics-based theory and models of particle acceleration close to the Sun.

For SEPs accelerated on loops or in reconnection regions the 1/r^2 advantage of Solar Orbiter will again provide a decisive advantage since particle properties will be accurately measured and compared with much more precise information on the coronal location. This will permit distinguishing between low coronal sources that result in stripping of escaping particles vs. higher sources which could mimic stripping properties. SEPs accelerated from reconnection regions in the back of CME lift-offs will be identified by comparing energetic particle timing with the location of the CME, and energetic particle composition with that determined spectroscopically for the remote coronal source.

3.3.1 What are the properties and distribution of suprathermal seed populations?