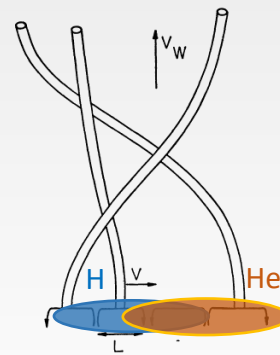
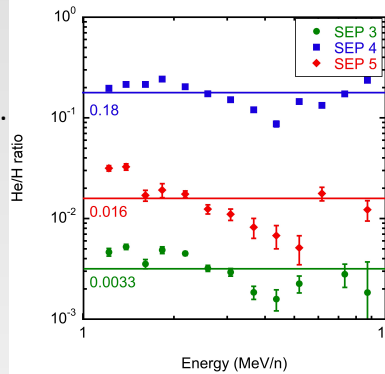
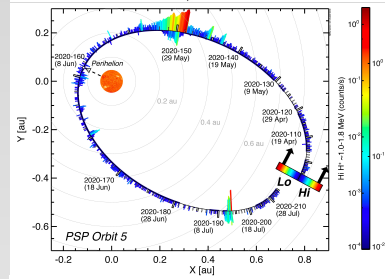
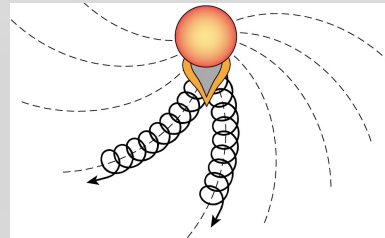


# A Field-line Braiding Model for Variable Ion Compositions of solar energetic particle (SEP) events in the inner heliosphere

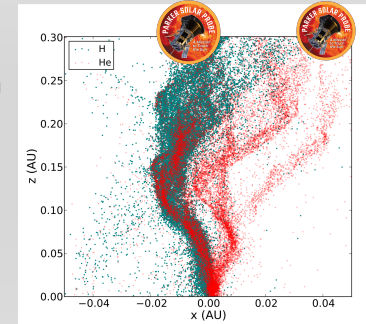


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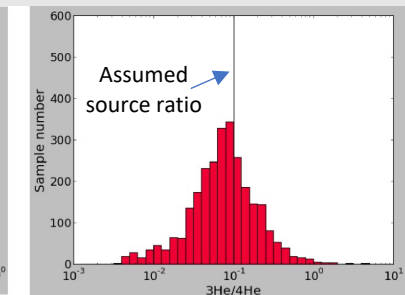
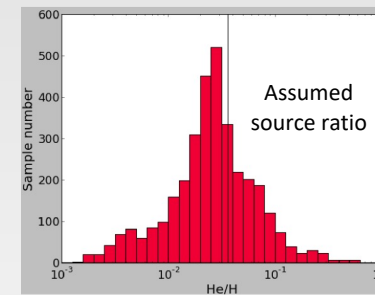
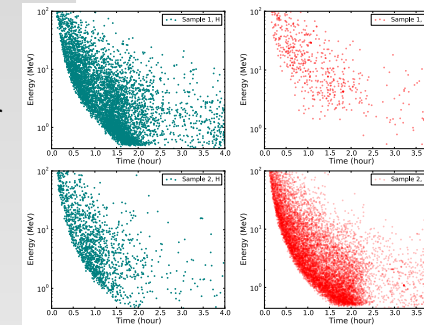
- Particle transport in the heliosphere is an important and long-standing problem.
- Small SEP events are more isolated and more suitable to study particle transport
- Parker Solar Probe (PSP) has seen multiple small SEP events, providing insights and new puzzles on particle transport in the inner heliosphere.
- Cohen et al. (2021) reported highly variable event-to-event helium to hydrogen ratio ( $\text{He}/\text{H}=0.003, 0.016, 0.18$  for 3 events from the same active region).
- Similar variations have been seen over a large amount of species, even at 1 AU. These variations have not been fully explored, in either observation or theory.
- We study the propagation of SEPs in a turbulent magnetic field model seen by PSP. We propose a scenario that the sources of H and He are offset by a distance and simulate the SEP observation.
- **Main conclusion: significant variation in observed ion composition ratios can be produced when the offset is comparable to the radius of the source regions.**



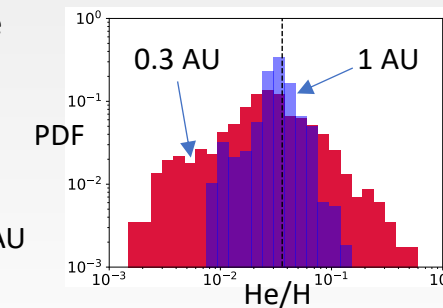
- The distribution of energetic hydrogen (cyan) and Helium (red) after 1 hour of particle release. Observers at different locations see quite different He/H ratios



- Two sample observations taken at different regions at 0.3 AU. Upper panels show a case with low  $\text{He}/\text{H} = 0.0024$  and the lower panels show a sample event with high  $\text{He}/\text{H} = 0.181$ . Note that the ratio has been normalized by the assumed nominal ratio ( $(\text{He}/\text{H})_n = 0.036$  (each Helium count corresponds to 0.036 Helium)).



- Histograms of  $\text{He}/\text{H}$  and  $^3\text{He}/^4\text{He}$  observed at 0.3 AU when the offset distance is comparable to the source radius



- $\text{He}/\text{H}$  observed at 0.3 AU and 1 AU