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Density Holes, Hot Flow Anomalies and SLAMS Upstream of Earth's Bow Shock

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Density holes (DH), Hot Flow Anomalies (HFA) and Short Large Amplitude Magnetic Structures (SLAMS) are transient structures observed in the upstream region of Earth's bow shock. The densities in these structures are depleted and in some cases as much as 99% of the ambient solar wind (SW) density. Moreover, the velocity moments of the SW show slow down and diversion in front of these structures. These structures, which can be as short as 4s (spin period of the spacecraft), are seen only when back-streaming particles are present. But not all backstreaming particles produce upstream structures and the conditions for forming these structures still remain unknown. In 2010 and 2011, the Cluster plasma ion experiment was configured to sample 3D distributions of the SW and the backstreaming particles with spin period time resolution (4s). These results show the SW beam in the hole is persistent and that evolving structures can be produced within existing DHs, HFAs and SLAMS. We present new observations of upstream structures including examples of how the structures can evolve into shocks.