JGR Space Physics

RESEARCH ARTICLE
10.1029/2019JA027707

Microscopic, Multipoint Characterization of Foreshock Bubbles With Magnetospheric Multiscale (MMS)

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Key Points:
- Foreshock bubbles (FBs) are large (up to 10 R_E), explosive (expansion speeds of >100 km/s) events upstream of the bow shock

- Foreshock bubbles are large (up to 10 RE), explosive (expansion speeds of >100 km/s) events upstream of the bow shock
- FBs form under a usual range of solar wind conditions between 3 and 20 RE upstream of Earth's bow shock
- FB cores often include deep, localized magnetic holes where the B-field drops to < 1 nT
- FBs should also occur at collisionless shocks elsewhere in the universe

MMS reveals in unprecedented detail the complex internal structure and nature of explosive foreshock bubbles upstream of collisionless shocks

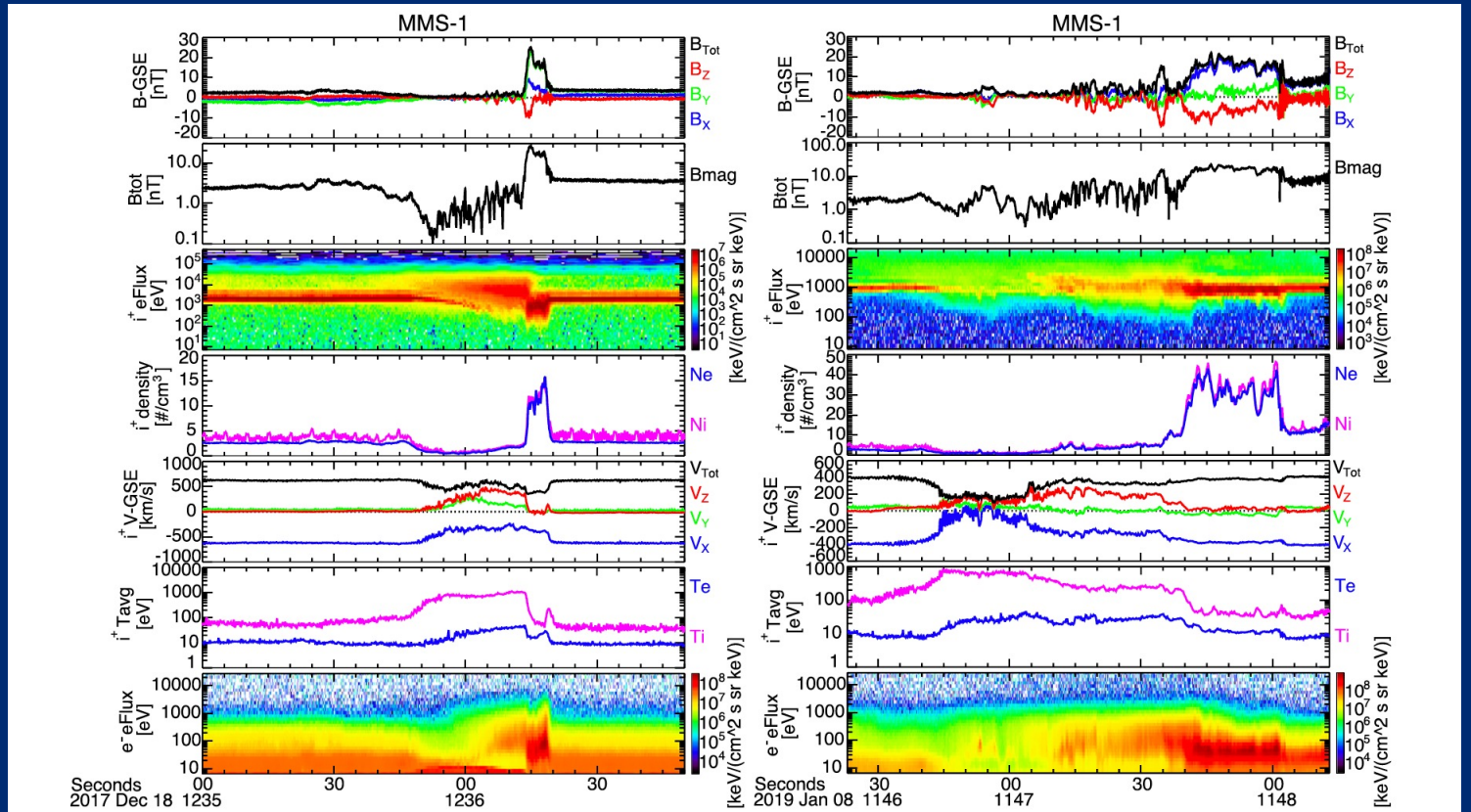

Figure 3. MMS observations of two more FBs from the list. The event on 18 December 2017 at 17:36 is shown on the left, and the event on 8 January 2019 at 11:47 is shown on the right, with both in the same format as Figure 1.