TYPE III SOLAR RADIO BURSTS AND ^{3}HE-RICH EVENTS

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ABSTRACT

We investigate the kilometric radio data for ^{3}He-rich events during the 1979-82 time period. Type III bursts are present for each event as expected from the previous electron/^{3}He-event association. A list of identified solar events is presented.

1. Introduction The association of solar ^{3}He-rich events and non-relativistic electron events by Reames, von Rosenvinge and Lin (RvL, 1985) allowed the precise timing and velocity dispersion of the electron data to be used to identify the solar events responsible for the acceleration of particles with such anomalous isotopic abundances. However, these non-relativistic electron data are only available for the first 15 months of the ISEE-3 mission while many of the larger and more interesting ^{3}He events occurred during the next several years of the mission. Fortunately, these same electrons are responsible for the rapidly drifting radio features called Type III bursts as they propagate at high velocity through the decreasing density of the interplanetary medium.

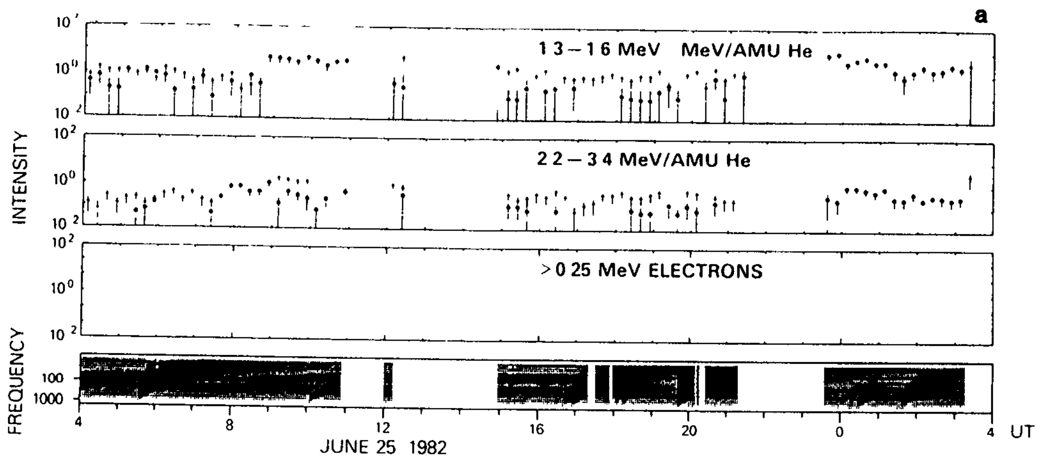
In this paper we show the relationship between the Type-III radio observations and the particle data in ^{3}He-rich events and then use this association to identify the source region for many of the events.

2. Observations and Analysis The helium observations described in this paper were obtained with the very-low-energy telescope (VLET) in the GSFC cosmic-ray experiment on ISEE-3. In a few events it was possible to observe energetic (0.25 to 2 MeV) electron increases in the high-energy telescope of the same experiment.

The kilometric radio data used to study the interplanetary portion of the Type III radio emissions were obtained from the Radio Astronomy Experiment aboard ISEE-3. These radio observations provide not only timing of the electron release at the sun but also directional information that can track the electron population in interplanetary space and locate the solar longitude of the source within 10 to 20 degrees.

A list of ^{3}He-rich time periods (Kahler et al., 1985) was re-examined for well-defined particle increases during the Dec. 1979 to Aug. 1982 study period. Dynamic radio spectra and single-frequency time histories were then examined during each of these events for the related Type III emission and the onset times and spectral characteristics of the events were determined.

In Figure 1 we show the particle and radio data for two ^3He time periods in 1982. Two events are seen in Fig. 1a, the Type III emission for the first event begins at 0533-0536 UT on June 25. There is no obvious increase in the energetic electrons from this event but the 2.2 - 3.4 MeV/AMU He nuclei begin to increase at 0745 and the 1.3 - 1.6 MeV/AMU nuclei arrive at 0830. The second event in Fig 1a begins in the radio data at 1945 and is seen minutes later (particle data are averaged in 15-min intervals) in the energetic electron data but He-nuclei from the event are not seen until after the data gap at about 2330.



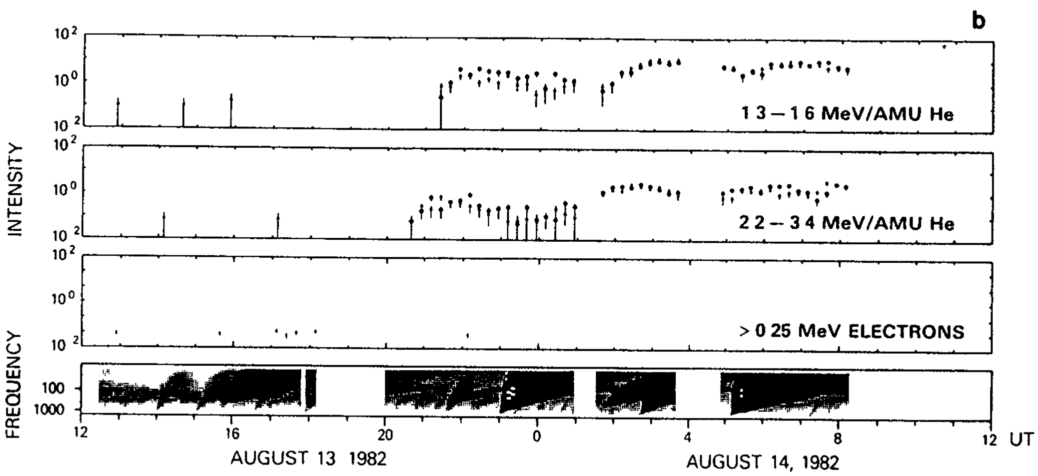


Fig. 1 Dynamic radio spectra and electron and He time histories for (a) Jun 25-26, 1982 and (b) Aug 13-14, 1982.

In Fig. 1b we show the striking series of ^{3}He-rich events on Aug 13 - 14, 1982 that include the gamma-ray event (also ^{3}He rich) at 0506 on Aug 14. The first Type-III event, is masked by the ubiquitous data gap at 1800-2000. Helium in the two energy intervals arrive at 2030 and 2115. The next three events beginning in the radio data at 2302, 0241 and 0509 each inject energetic electrons that are seen at 1 AU, and each inject fresh He nuclei that are observed after they propagate to 1 AU 2-3 hrs later as described by RvL (1985). Only the higher-energy He nuclei are seen from the large gamma-ray event before the data gap; all energies are seen again at 1200, just off the plot.

Note the difference in size and character of the Type III dynamic spectra in Fig. 1b for those events that contribute electrons and He at 1 AU and for those that do not. The other, weaker events in the same time period drift slowly to low frequencies because they lack sufficient intensities of faster, more-energetic electrons that would propagate outward more rapidly. Lacking energetic electrons, these events also lack measurable intensities of ^{3}He (see also Reames and Lin, 1985).

Note also the quiet conditions in the particle observations prior to the first Aug 13 event. During the first 6 hrs in Fig 1b (excluding data gaps seen as white areas in the radio data) only 5 ^{4}He particles enter the telescope in both energy bands. In fact, no ^{3}He particles enter the telescope in the 24-hr period prior to the first event.

The major ^{3}He-rich events in the Dec 1979 to Aug 1982 for which we can identify the likely radio onset time are shown in Table 1. Also shown are the metric-radio and H-alpha flare data for most of the events. Many of the events occur in groups from the same active region, a fact that greatly simplifies their identification. In a few cases, where other candidate events do exist, they are always smaller events from the same active region.

3. Conclusion In conclusion we have shown that the solar electron-^{3}He event association can be extended considerably by use of the kilometric radio data. Each ^{3}He-rich event we examined was found to have a candidate Type III event and in most cases an unambiguous identification could be made. Of course these data do not provide the continuous and direct extrapolation of the velocity dispersion provided by the direct observation of non- relativistic electrons. On the other hand, the directional capability of the radio experiment provides the added spatial information that was only partially exploited in this work.

The prevalence of multiple events, usually with different isotope ratios, from the same solar active region is, once again, a striking result of this study. Each event is itself composed of groups at much higher time resolution in the radio data.

Table 1. Type III and Flare Associations of ^{3}He-Rich Events

Date	1.3 He Onset	3/4	2MHz Time	Metric Time		Flare Time	Site	Imp.
1979 Dec 14	2000	1.5	1552 -1605	1550 -1559	2GG	1553 -1643	N10W51	1B
1980 Nov 9	1930	0.9	1621	1620 -1623	3G	1621 -1633	S14W44	-N
Nov 10	0000	1.4	2035	2033 -2035	2GV	2028 -2054	S12W48	-N
Nov 10	0830	1.8	0448	0448 -0449	2GV	0446 -0508	S09W51	-N
Dec 16	1830	0.5	1455					
1981 Sep 15	2315	1.2	1935	1933 -1937	3GGV			
Nov 20	1330	0.2	1045	1041 -1043	2GG	several		
1982 Mar 10	1615	>1.4	gap	1220 -1255	3GG	1213 -1308	S06W32	1B
Mar 10	2300	0.7	1845	1844 -1850	3GGV	1845 -1908	S06W34	2B
Jun 25	0830	0.3	0533 -0536	0530 -0535	3SIS	0528 -0615	N13W50	1B
Jun 25	2330	0.4	1945	1944 -1945	3GGV	1941 -2010	N17W56	2B
Jun 30	1315	>1.0	0915					
Aug 13	2130	2.0	gap	1813 -1820	2GG			
Aug 14	0200	0.8	2302	2259 -2303	3GV	2301 -2334	N13W59	-N
Aug 14	0600	1.2	0241 -0245	0238 -0244	2GV	0237 -0315	N11W60	1B
Aug 14	0800	0.2	0509	0506 -0515	3GV II	0507 -0525	N11W62 gamma-ray	1B

The event identifications begin to show a link between the impulsive electron-rich ^{3}He events and the impulsive electron-rich solar gamma-ray events with the Aug 14 event. ^{3}He has been observed in two other gamma-ray events by Van Hollebeke et al. (1985). The distinction between particle events with impulsive and long-duration X-ray events has been clearly demonstrated by Cane et al. (1985).

References

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