# Automatic Recognition of Coronal Type II Radio Bursts: The Method for ARBIS 2

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## Introduction

Solar flares and CMEs are the major solar weather events. They are accompanied by the solar type II and III radio bursts. These radio bursts can be used for real-time automated prediction of space weather. However, up to now, they are usually analyzed by eye.

A new method developed to detect coronal type II bursts and the 2nd version of Automated Radio Burst Identification System (ARBIS 2) are presented. The method uses the Hough transform.

Previously, we have developed a method for automatic detection of type III bursts and implemented it in ARBIS 1 [Lobzin et al., 2009]. ARBIS 1 has been working with real-time data provided by the Learmonth observatory (dynamic spectra in the frequency range 25-180 MHz with 3 s time resolution).

The aim of the present study is to present a new method for recognition of coronal type II radio bursts, ARBIS 2, where this method has been implemented, and the first type II burst found in real-time data.

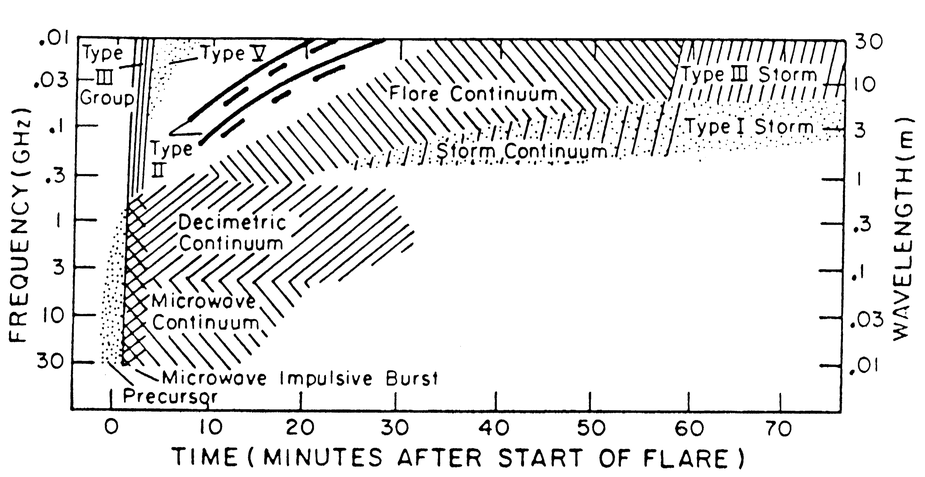


Fig. 1. Classification of solar radio bursts [Dulk 1985].

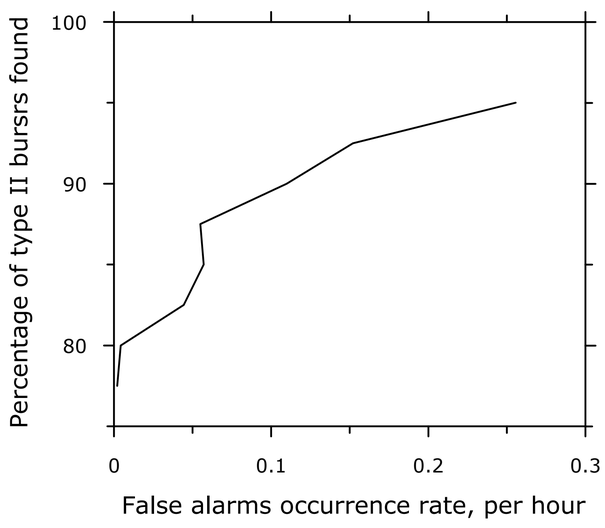


Fig. 3. Dependence of probability to detect type II burst versus the occurrence rate of false positives. Plot was obtained for a representative set of 40 daily spectra with coronal type II radio bursts observed in 2002 (high solar activity). The optimal set of parameters corresponds to ARBIS performance of ~80%. The corresponding false positives occurrence rate is equal to 1 event per 100-200 h for 2002.

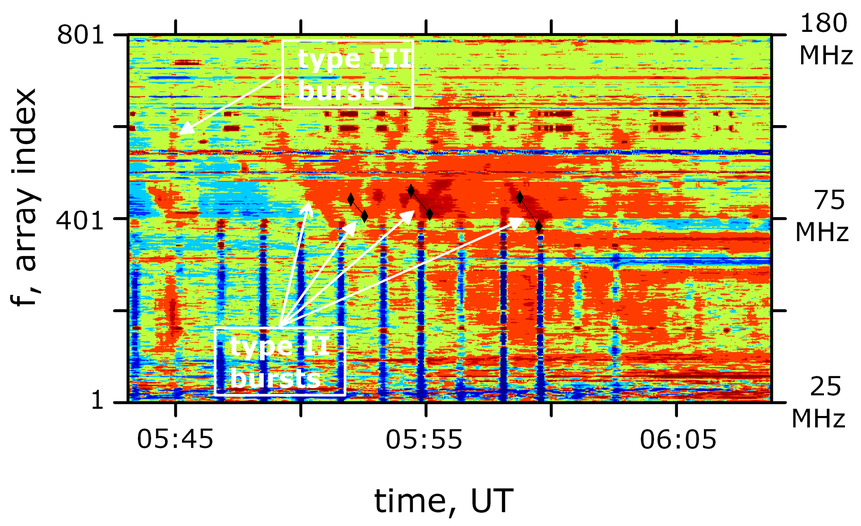


Fig. 4. The Learmonth dynamic spectrum for the first type II radio bursts found by ARBIS 2 in real-time data on 31 October 2009. The three pairs of black rhombi correspond to the ends of the straight segments found by ARBIS 2 in real-time 1/*f* vs *t* spectrum.

## Data processing – finding type II bursts.

1) find and remove bad data
2) find missing data and fill the corresponding gaps
3) remove low-frequency part of spectra (up to 44 MHz)
4) remove jump of intensity at 75 MHz
5) histogram equalization and normalization
6) 1/*f* transform
7) filtering
8) find maxima in the filtered spectrum and transform the spectrum into the binary one, $B(t, f) = 0$ or 1
9) morphological filtering of the binary spectrum $B(t, f)$
10) Hough transform and thresholding.

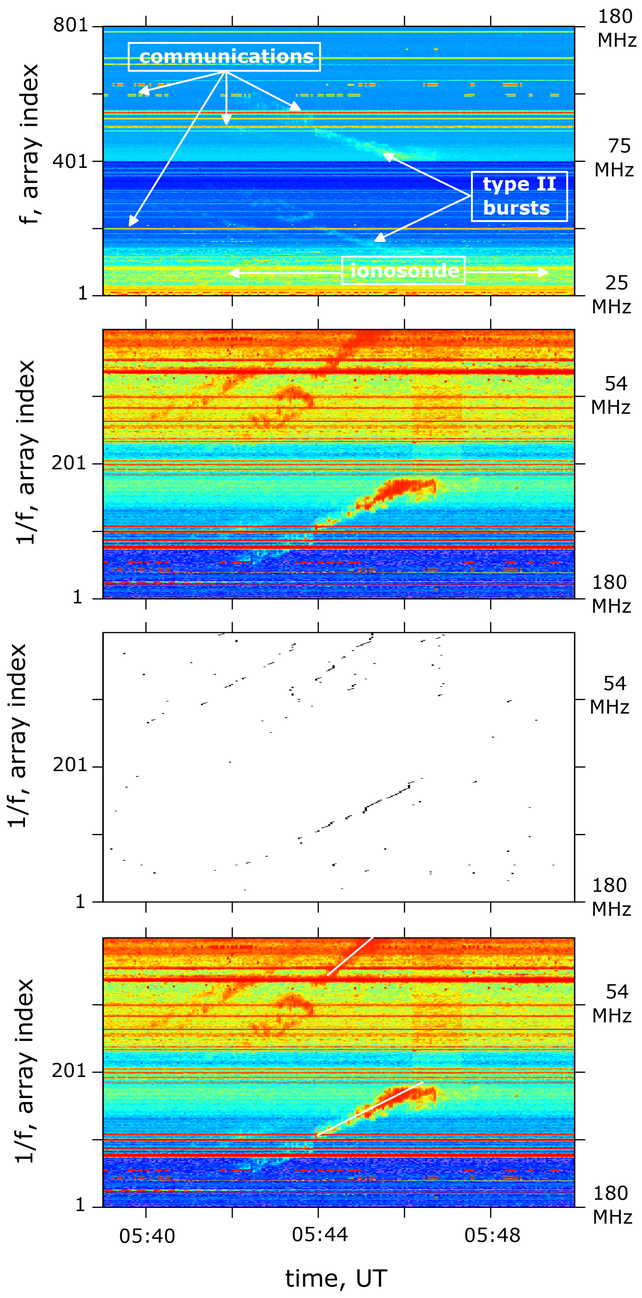


Fig. 2. The (top) dynamic spectrum of a single type II burst observed on 1 March 2002 from 0542 to 0547 UT, (top middle) corresponding 1/*f* vs *t* spectrum, (bottom middle) binary image *B* upon filtering, (bottom) 1/*f* vs *t* spectrum with the found straight segments shown by white lines. In the binary image the pixels are black where $B = 1$ and white for $B = 0$.

## Conclusions

A new method developed to detect coronal type II bursts and the 2nd version of Automated Radio Burst Identification System (ARBIS 2) are presented. The method uses the Hough transform.

The main advantages of the method are:

1) it allows one to find the bursts more objectively;
2) the method is quite quick and efficient to be used in automated systems
3) performance of ARBIS 2 method is quite high, ~80%, while the occurrence probability for false positives is reasonably low, 1 false positive per 100-200 hours for high solar activity and more than 10,000 hours for low solar activity periods.

The first automatically detected coronal type II radio burst is also presented. This burst is probably the first one that was observed by a ground-based instrument in solar cycle 24.

## References

Dulk, G.A. (1985), Radio emission from the Sun and stars, *Ann. Rev. Astron. Astrophys.*, 23, 169.

Hough, P. V. C. (1962), Method and means for recognizing complex patterns, U.S. Patent 3069654.

Lobzin, V. V., I. H. Cairns, and P. A. Robinson (2008), Evidence for wind-like regions, acceleration of shocks in the deep corona, and relevance of 1/*f* dynamic spectra to coronal type II bursts, *Astrophys. J.*, *677*, L129.

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The ARBIS web page is temporarily located at http://www.physics.usyd.edu.au/~lobzin/arbis