

# Radio Sun

A short introduction

Christophe Marqué - STCE - ROB

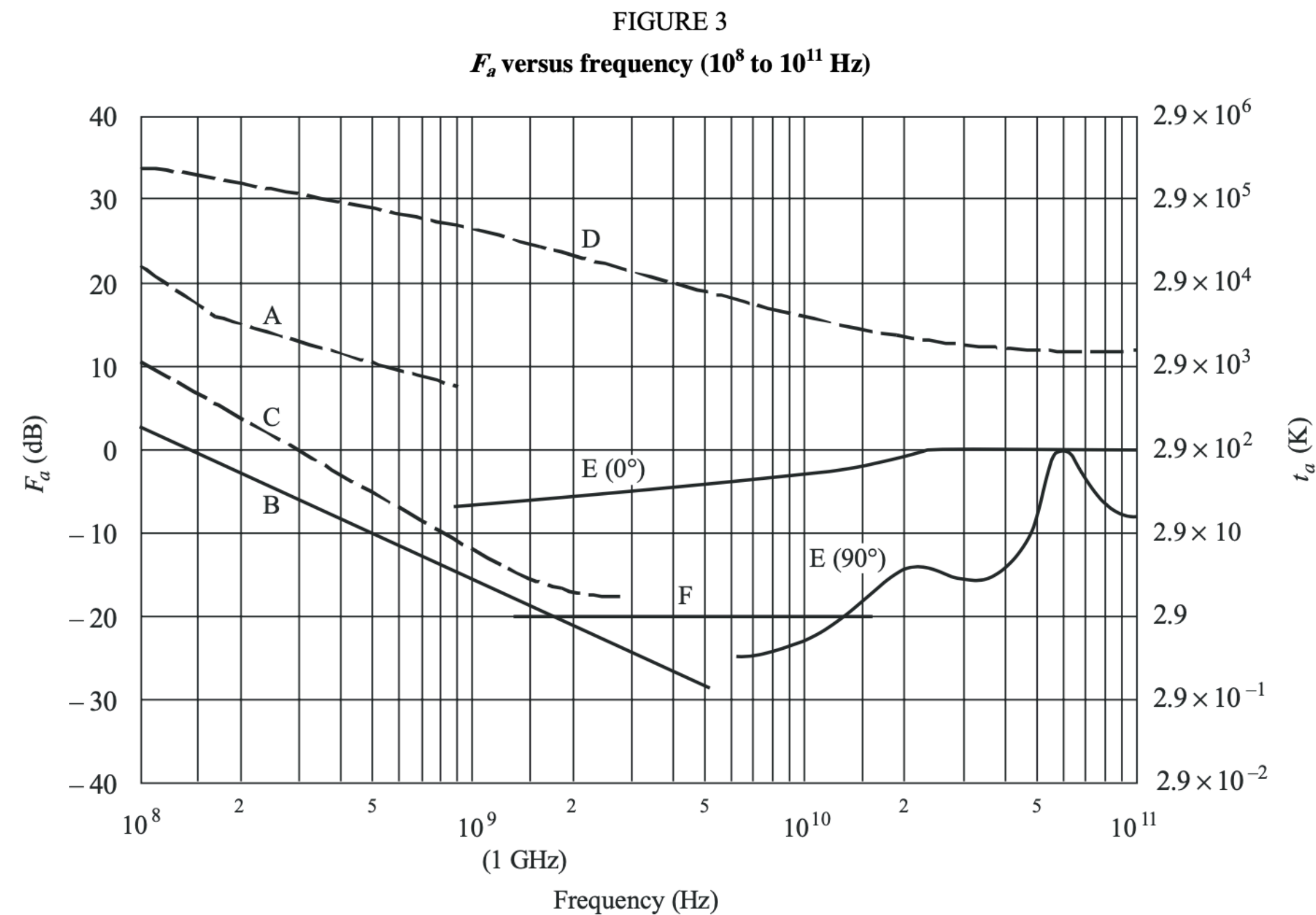
Quiet Sun

# The radio Sun

The Sun is the strongest radio source in the sky

## Quiet Sun

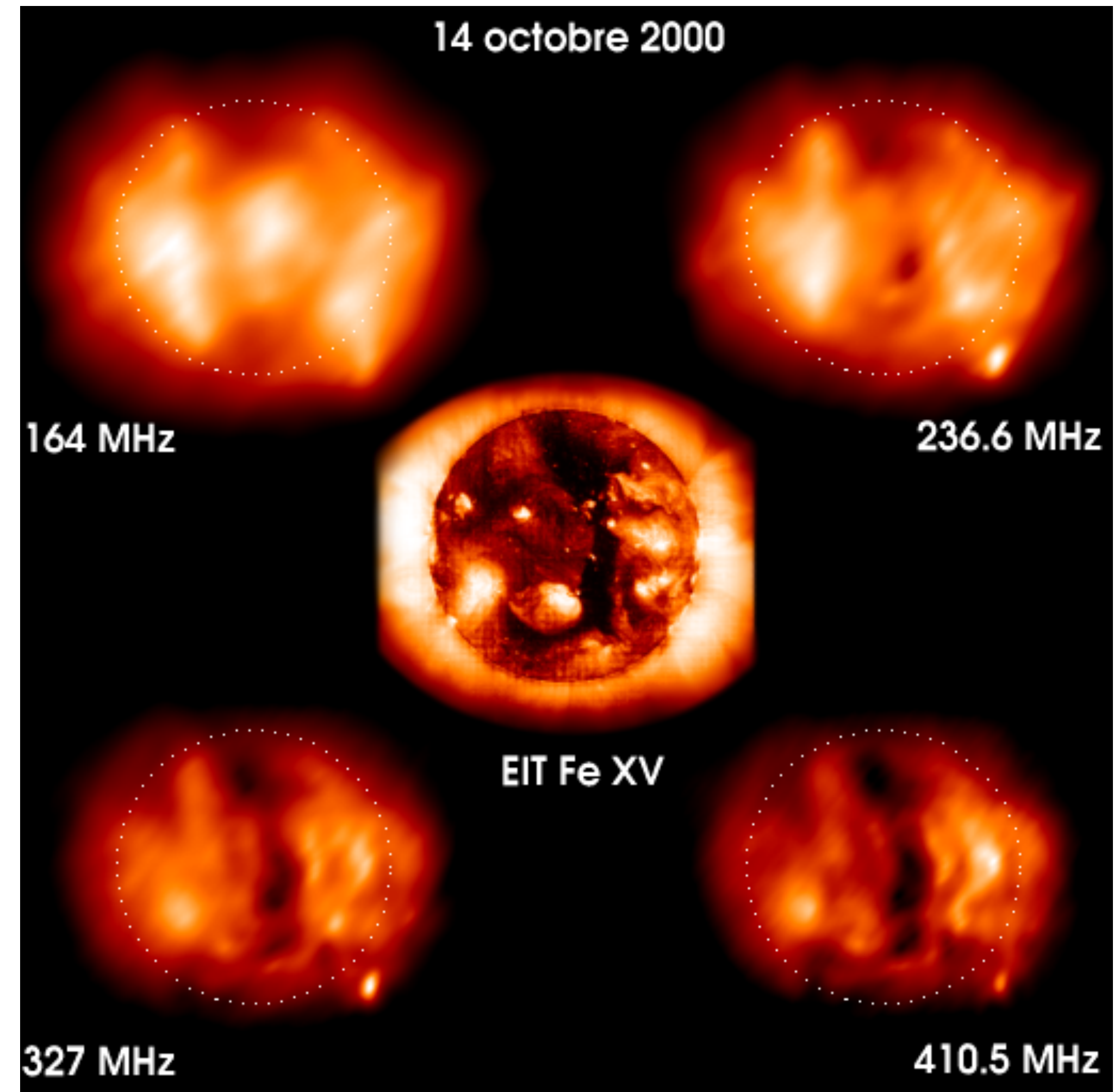
Mostly thermal emission from hot corona  
@ higher frequency gyroemission



- A: estimated median city area man-made noise
  - B: galactic noise
  - C: galactic noise (toward galactic centre with infinitely narrow beamwidth)
  - D: quiet Sun ( $1/2^\circ$  beamwidth directed at Sun)
  - E: sky noise due to oxygen and water vapour (very narrow beam antenna); upper curve,  $0^\circ$  elevation angle; lower curve,  $90^\circ$  elevation angle
  - F: black body (cosmic background), 2.7 K
- minimum noise level expected

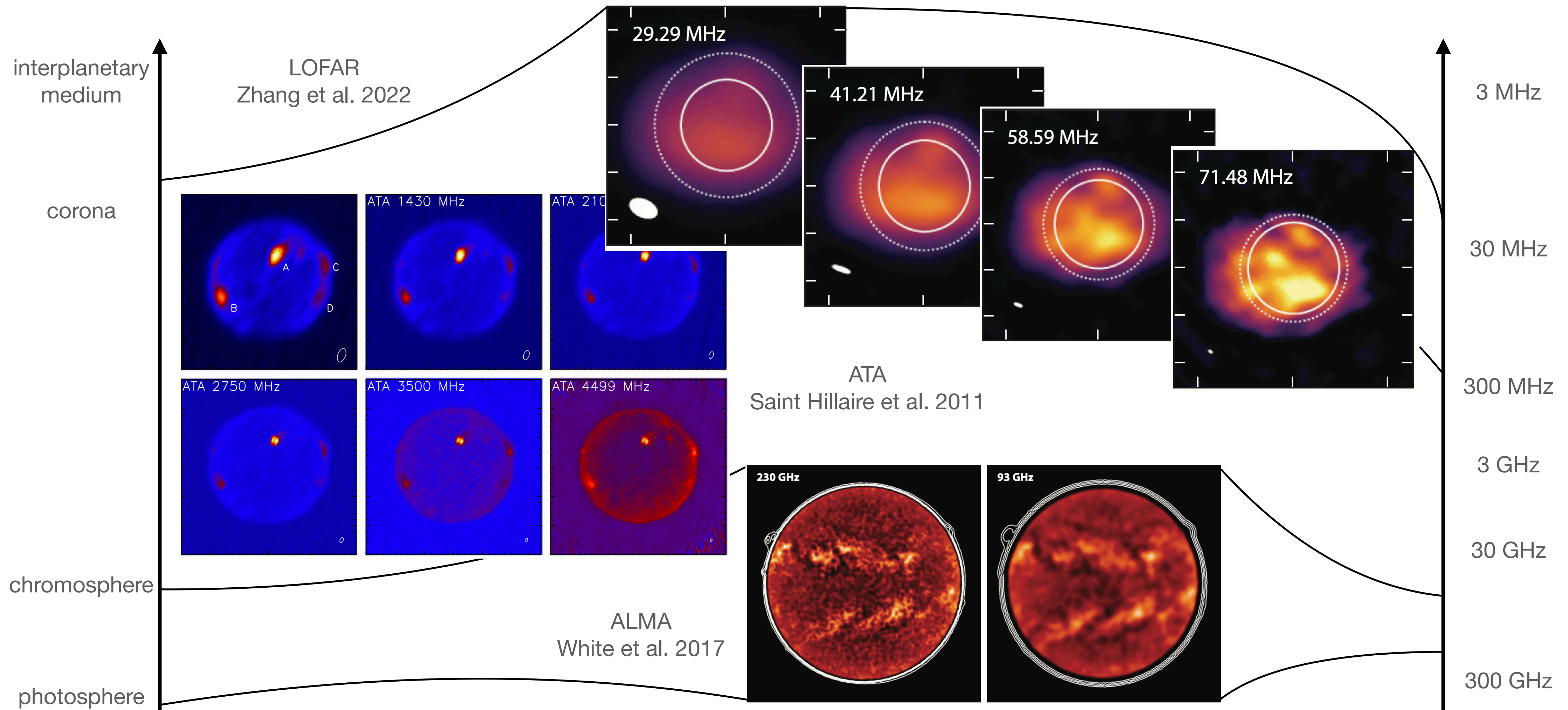
P.0372-03

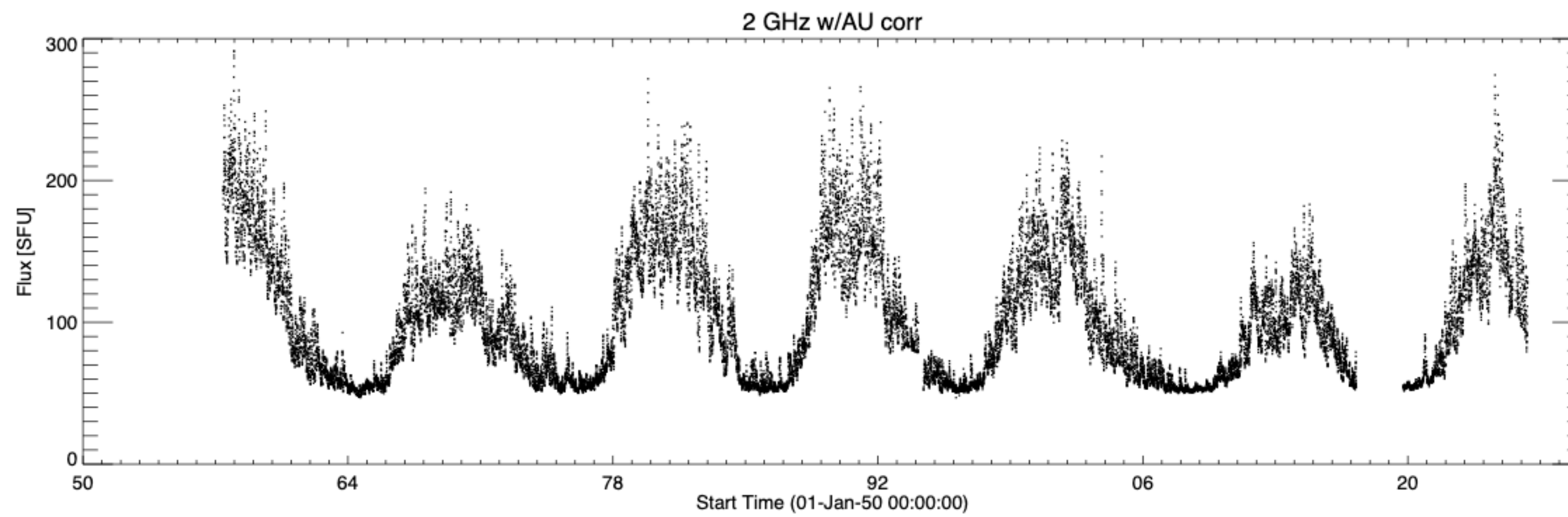
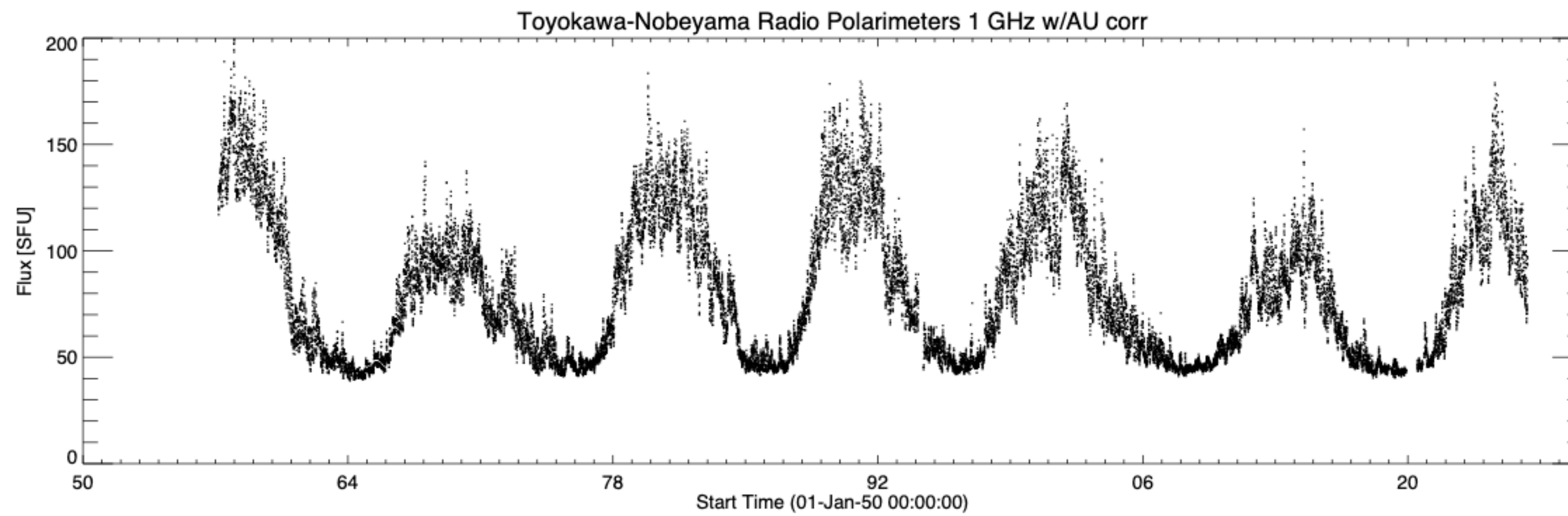
ITU REC 372

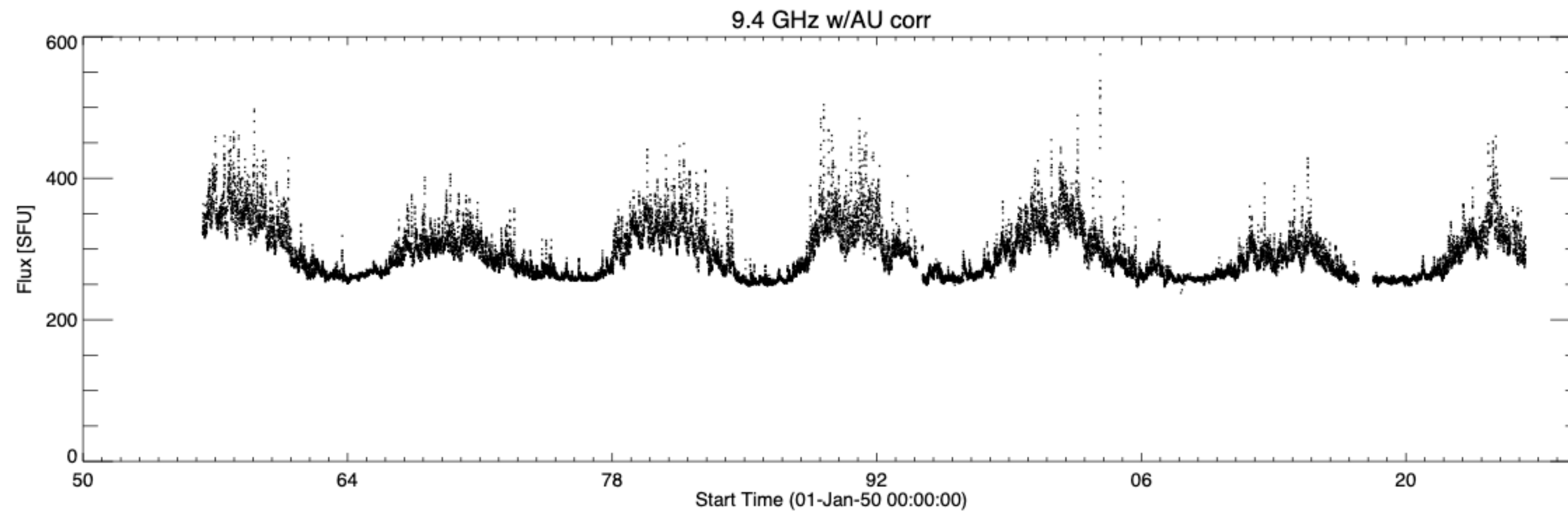
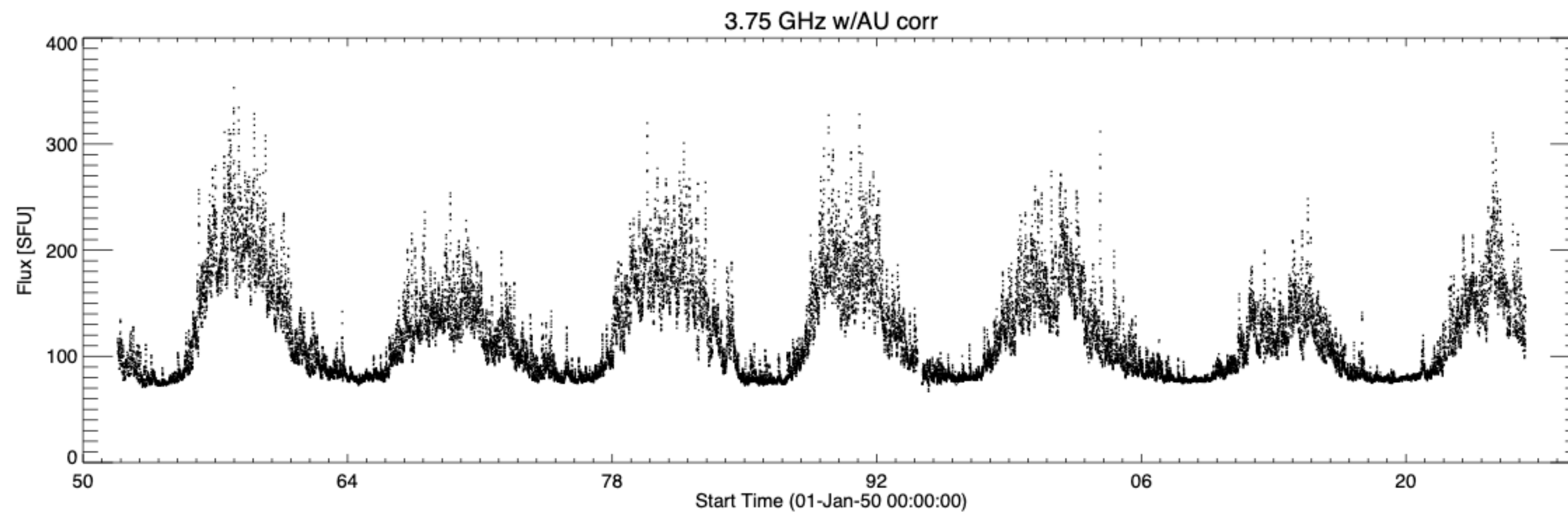


C. Marqué

# All layers of the solar atmosphere are accessible to radio observations





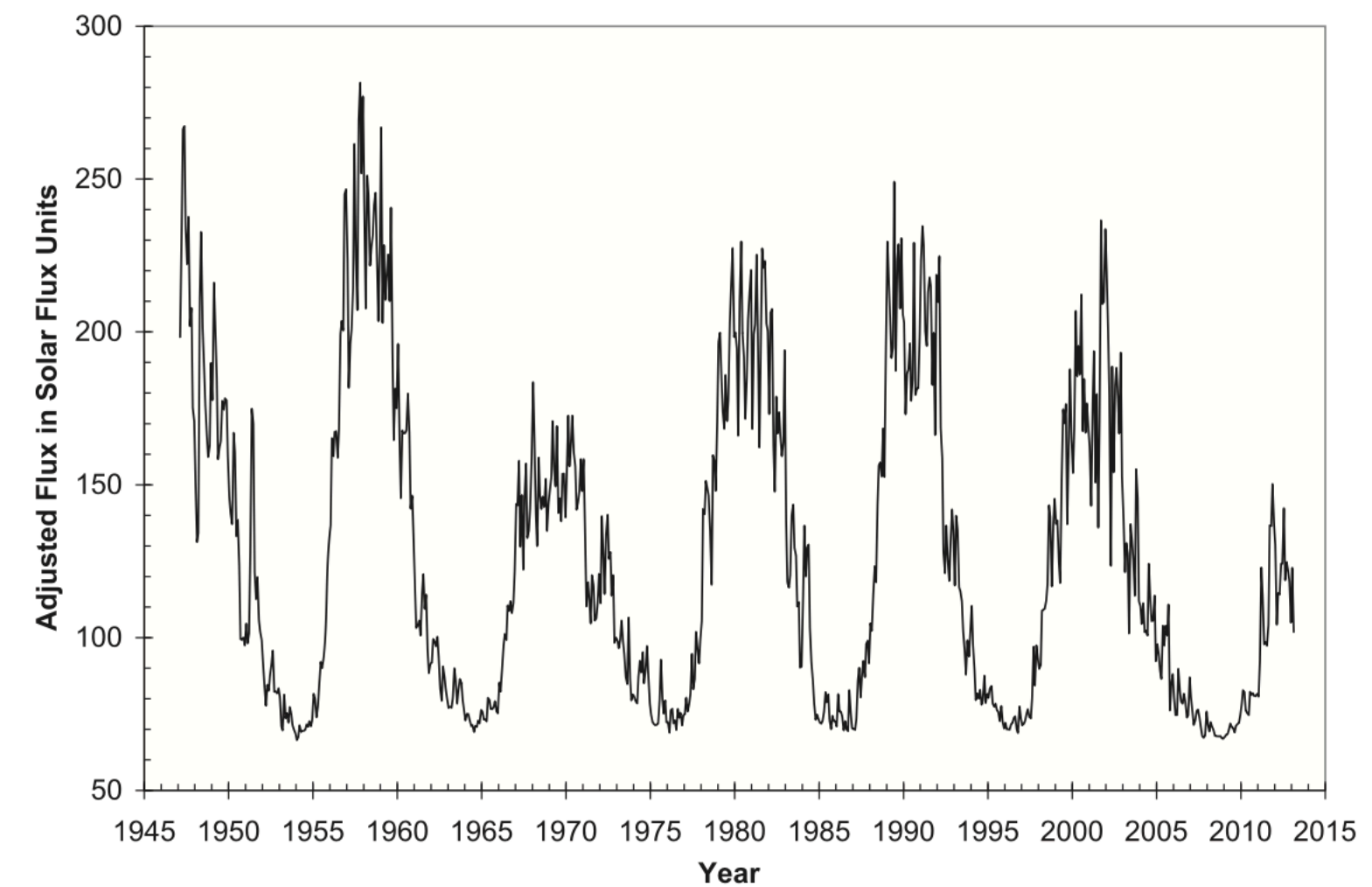


# F10.7 index

$$\lambda = 10.7 \text{ cm} \equiv 2.8 \text{ GHz}$$



**Figure 3.** The flux monitors. Flux Monitor 1, the secondary instrument is in the foreground; Flux Monitor 2, the primary instrument is in the background, on the tower.



**Figure 1.** Monthly averages of the adjusted (scaled for an Earth-Sun distance of 1 AU)  $F_{10.7}$  values since 1947.

Tapping 2013

# F10.7

$$\lambda = 10.7 \text{ cm} \equiv 2.8$$



Figure 3. The flux secondary instrument 2, the primary instrument on the tower.

**JSWSC** All issues Accepted Manuscripts Topical Issues Agora About Search Menu

All issues ▶ Volume 11 (2021) ▶ J. Space Weather Space Clim., 11 (2021) 47 ▶ Full HTML

**Open Access**

Issue	J. Space Weather Space Clim. Volume 11, 2021
Article Number	47
Number of page(s)	15
DOI	<a href="https://doi.org/10.1051/swsc/2021032">https://doi.org/10.1051/swsc/2021032</a>
Published online	07 September 2021

J. Space Weather Space Clim. 2021, 11, 47  
*Research Article*

## The operational and research DTM-2020 thermosphere models

Sean Bruinsma\* and Claude Boniface  
OMP/GET-CNES, Space Geodesy Office, 14 avenue E. Belin, 31401 Toulouse cedex 4, France

\* Corresponding author: [sean.bruinsma@cnes.fr](mailto:sean.bruinsma@cnes.fr)

Received: 11 June 2021 | Accepted: 23 August 2021

**Abstract**  
*Aims:* The semi-empirical Drag Temperature Models (DTM) predict the Earth's thermosphere's temperature, density, and composition, especially for orbit computation purposes. Two new models were developed in the framework of the H2020 Space Weather Atmosphere Models and Indices (SWAMI) project. The operational model is driven by the trusted and established F10.7 and *Kp* indices for solar and geomagnetic activity. The so-called research model is more accurate, but it uses the indices F30 and the hourly H<sub>po</sub>, which are not yet

**Table of Contents**

Article contents

- Abstract
- Full HTML
- PDF (1.879 MB)
- ePUB (6.413 MB)
- References

**Database links**

- NASA ADS Abstract Service

**Metrics**

Show article metrics

**Services**

Articles citing this article

- CrossRef (62)

Same authors

- Google Scholar
- EDP Sciences database

Recommend this article

Download citation

**Related Articles**

- Semi-empirical thermosphere model evaluation at

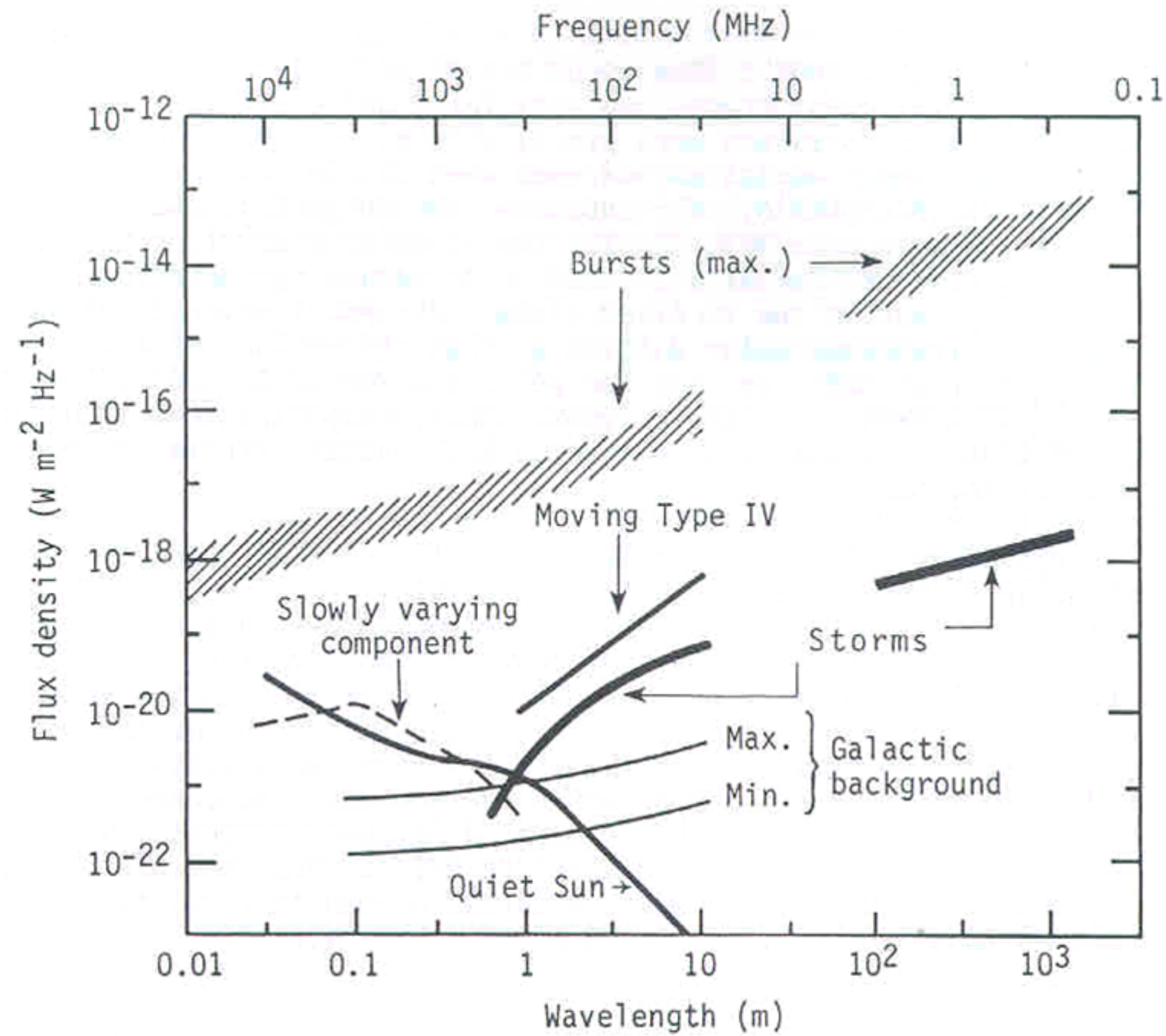
2015

d for  
47.

013

# Solar radio bursts

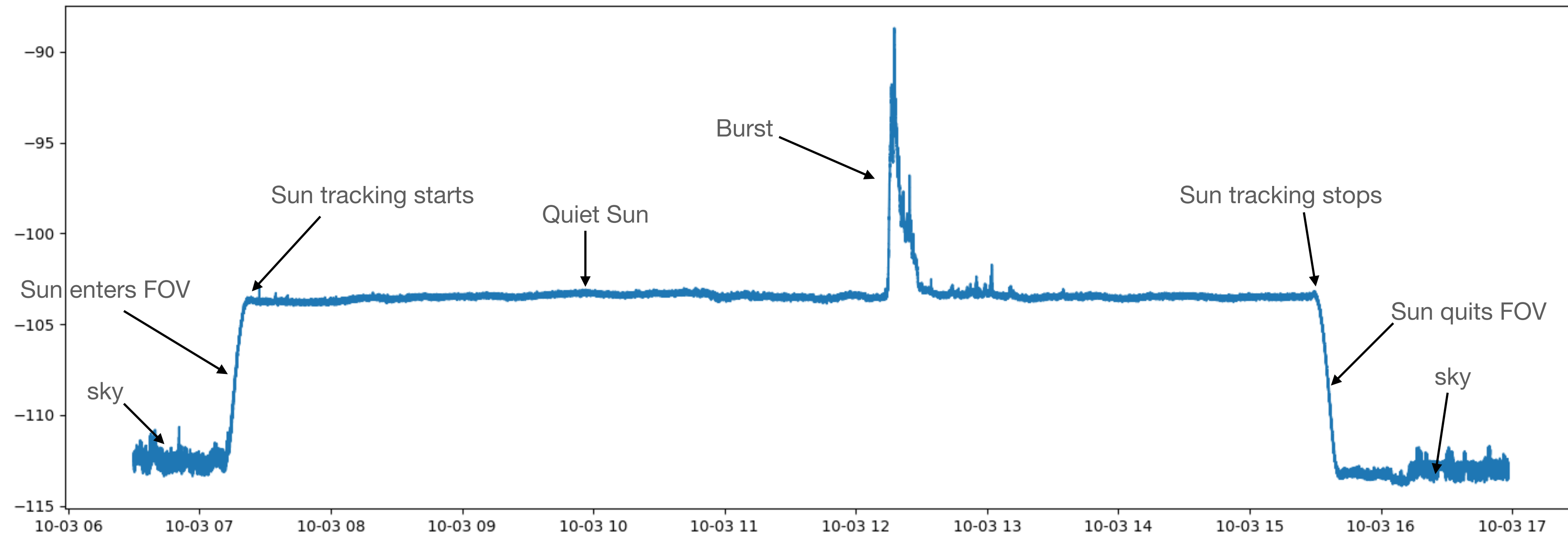
# Solar radio bursts



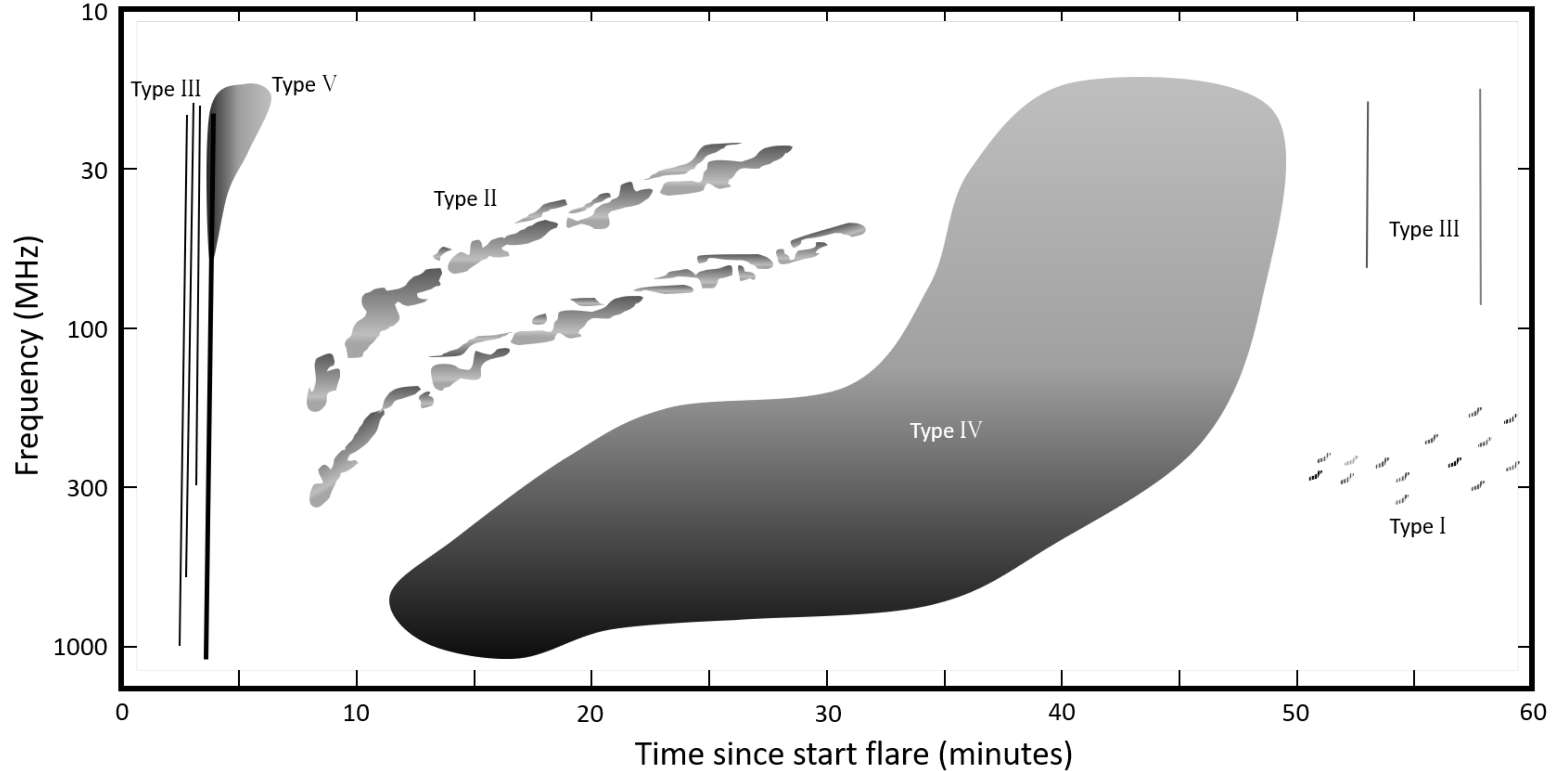
Bursts are mostly intense from HF to S band

# Example in L band

## Solar observations from Belgium



# Radio bursts



source: STCE

# Radio bursts

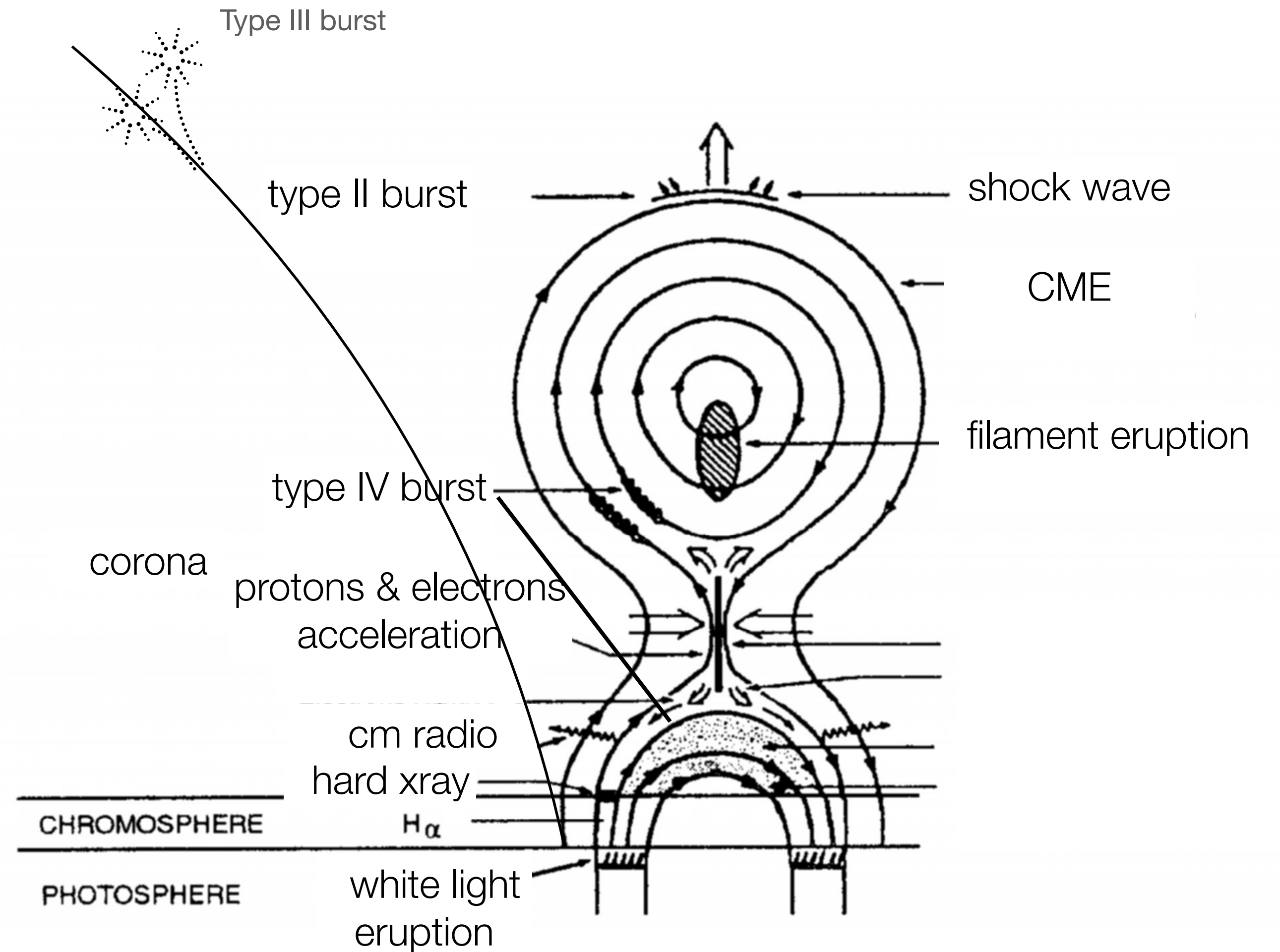
Solar radio bursts are produced by **non thermal electrons** accelerated during eruptive events of all magnitudes

For frequencies (f) below ~ 1- 2 GHz, the dominant emission is called **plasma emission**, where energetic electrons trigger local plasma oscillations which are then converted into E. M. radiations

$$f \propto \sqrt{n_e}$$

Spectral signatures (type I, type II, type III ...)

Above, gyroemissions, gyrosynchrotrons or bremstrahlung emissions dominate

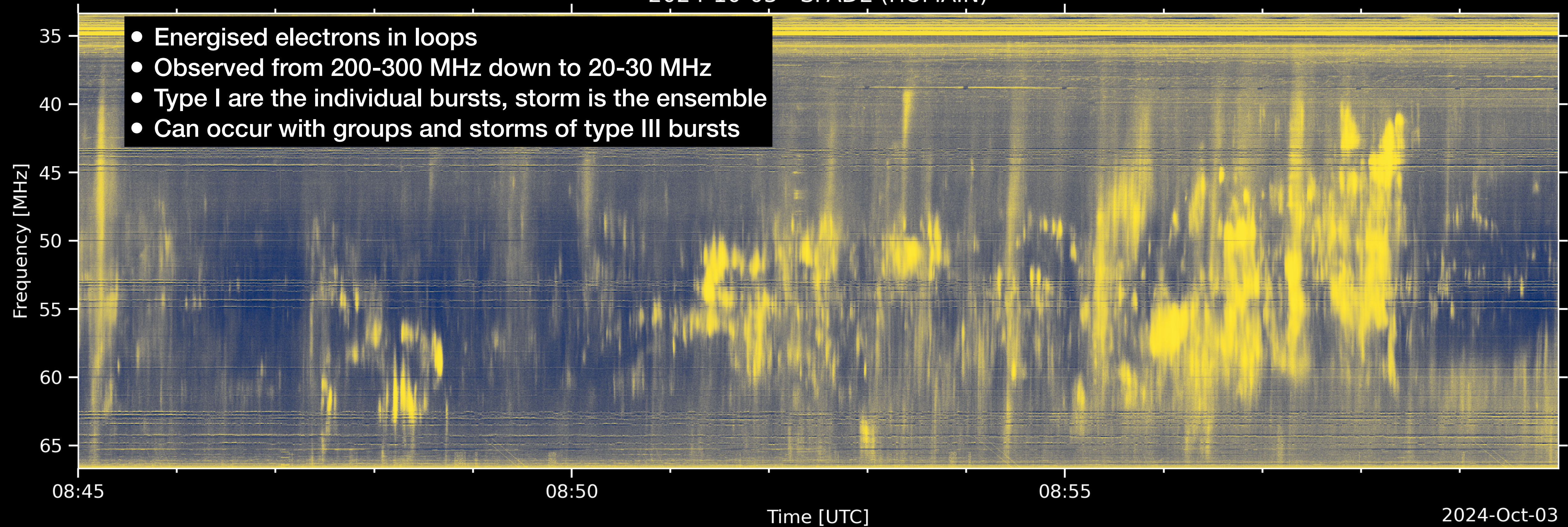


# Type I & noise storms

## Non flaring radio bursts linked to sunspots

2024-10-03 - SPADE (HUMAIN)

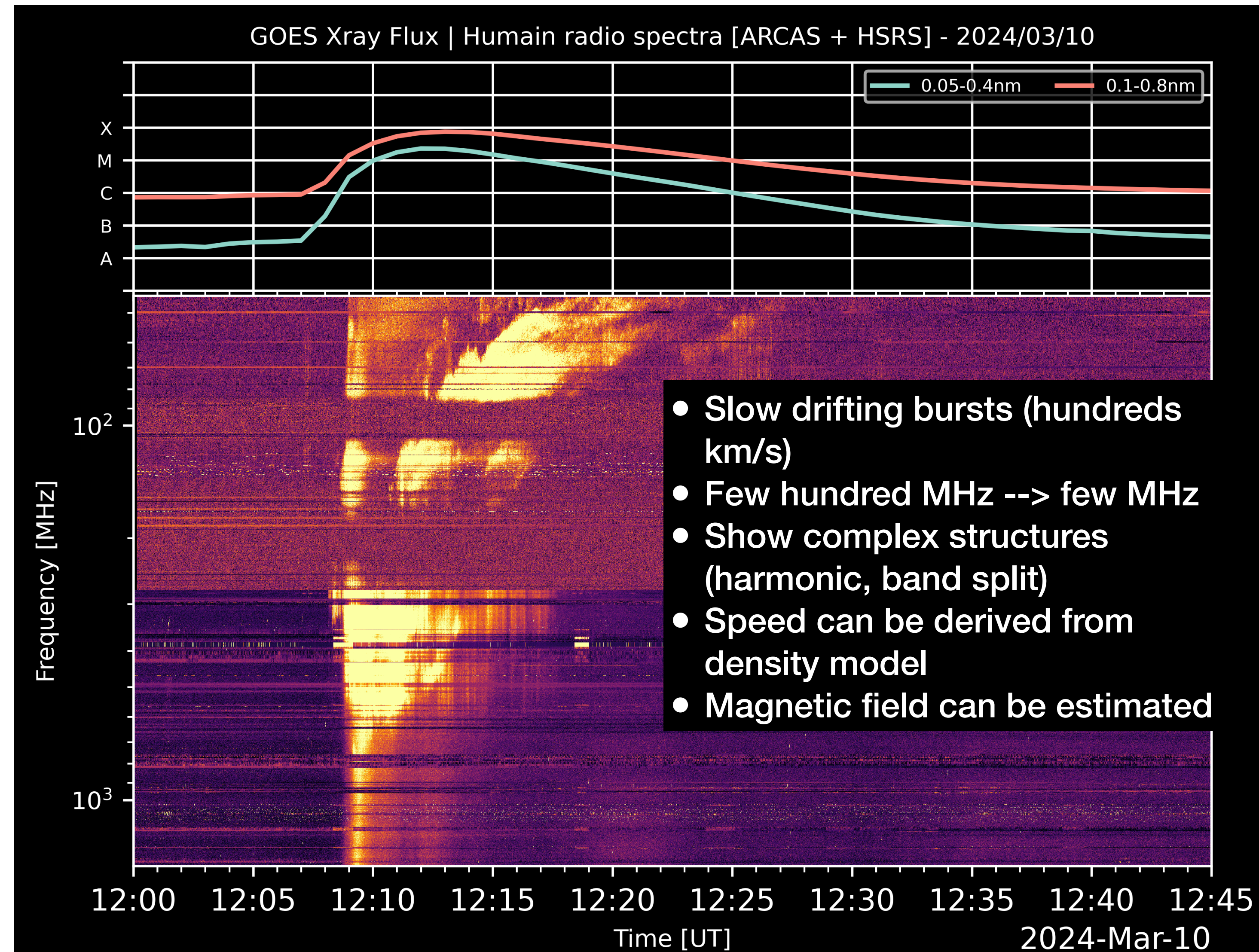
- Energised electrons in loops
- Observed from 200-300 MHz down to 20-30 MHz
- Type I are the individual bursts, storm is the ensemble
- Can occur with groups and storms of type III bursts



2024-Oct-03

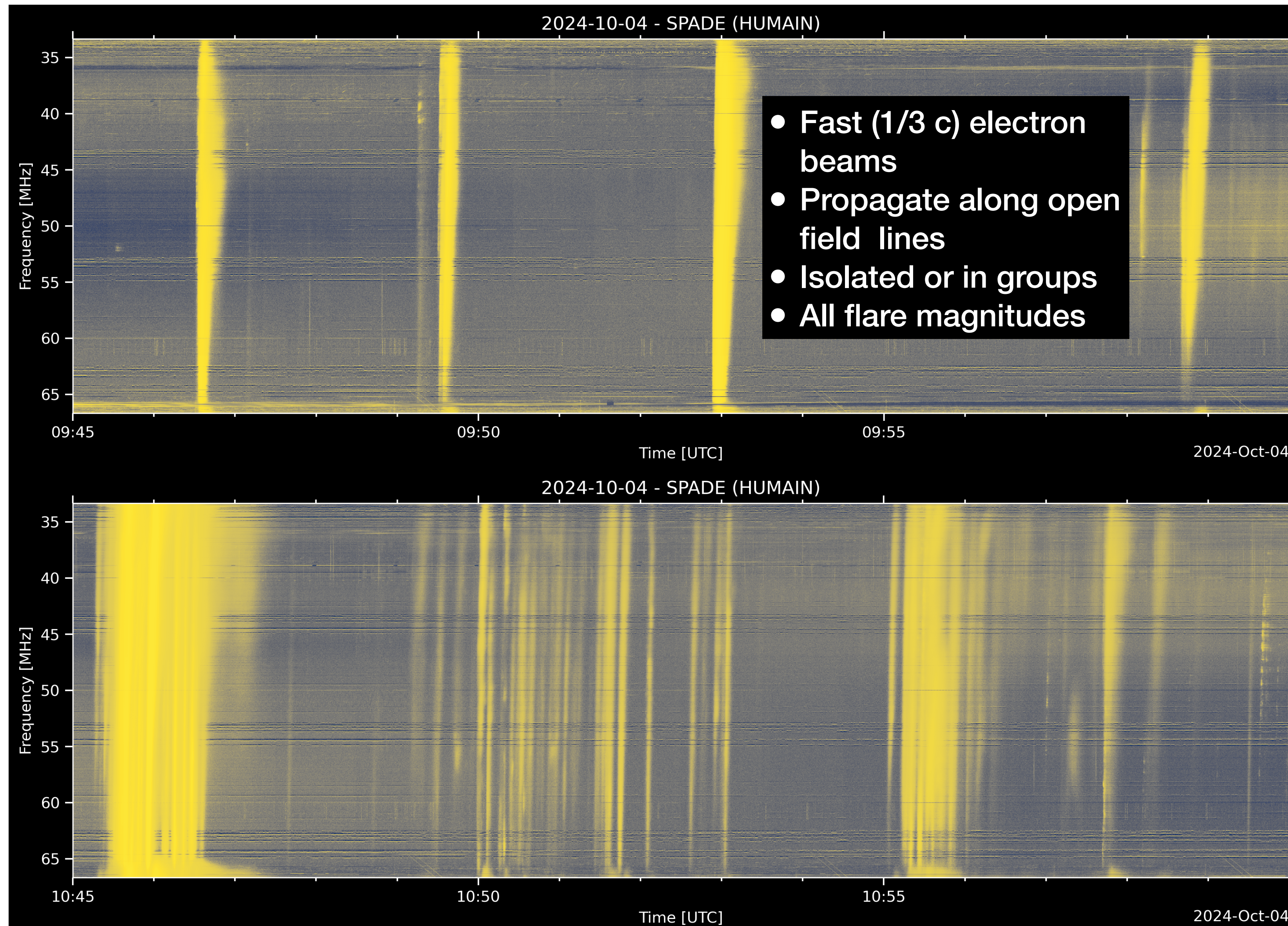
# Type II bursts

linked to shock waves propagating out in the corona



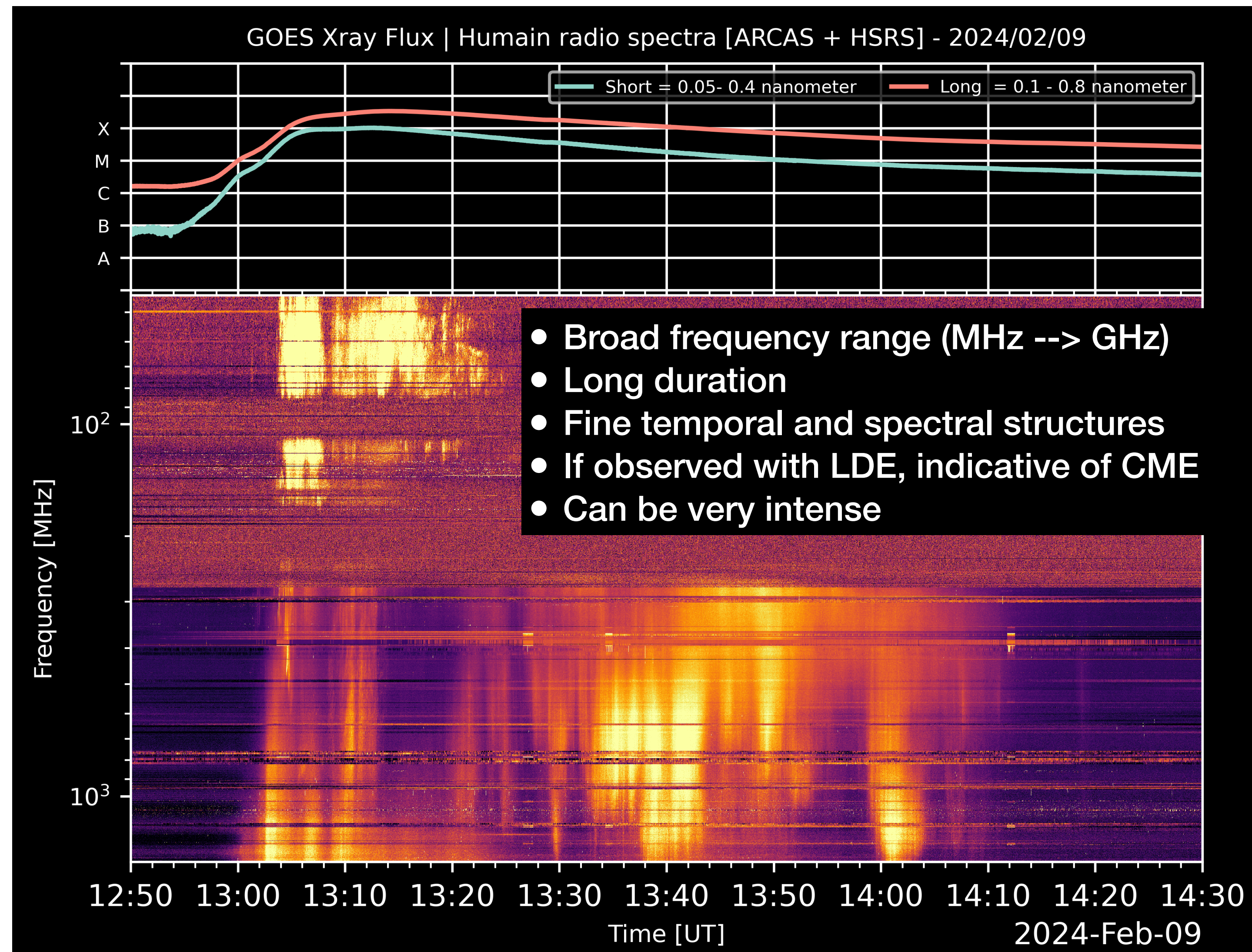
# Type III bursts

Most frequent type of bursts

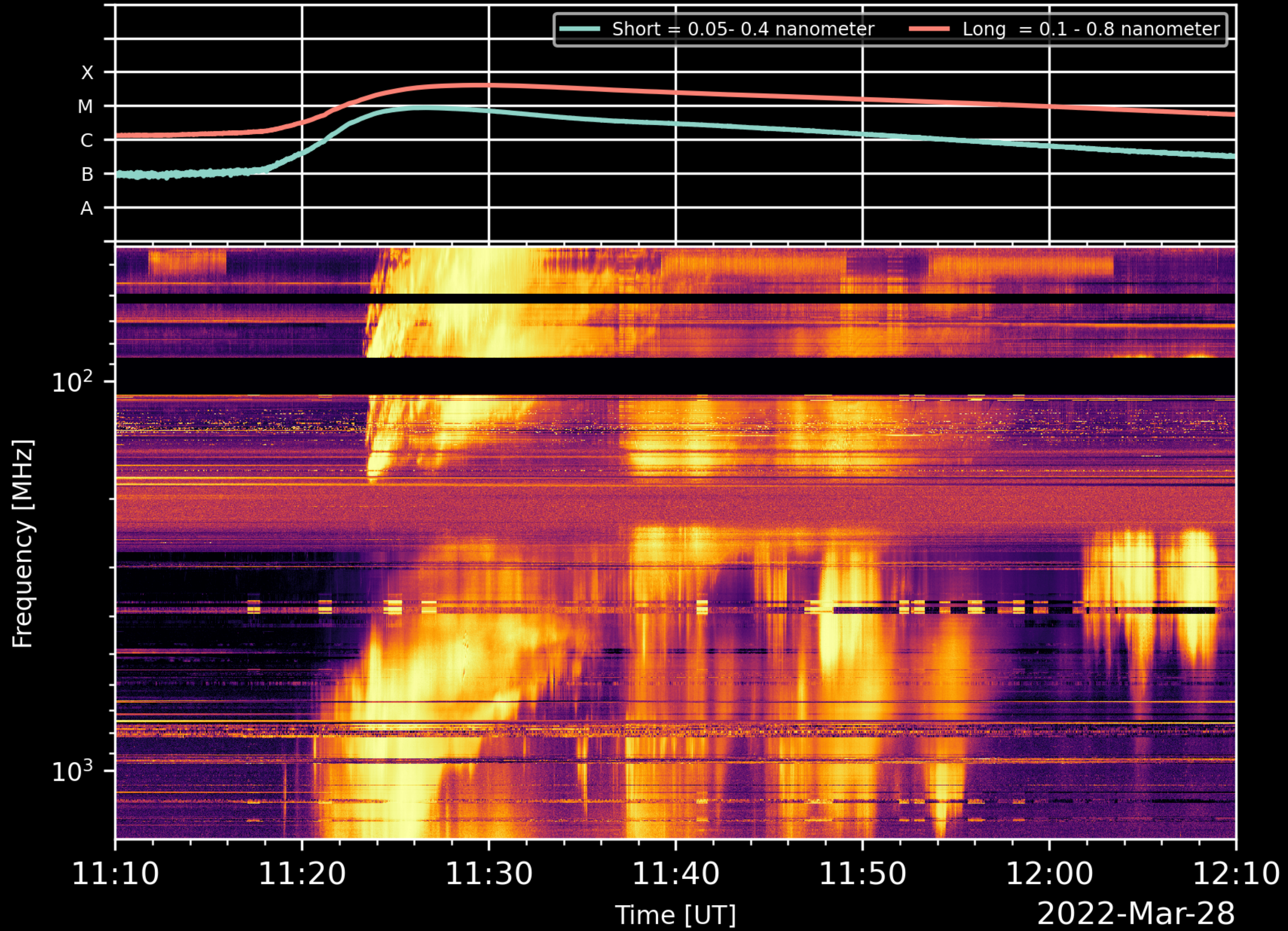


# Type IV bursts

Energetic electrons trapped in post-flare loops



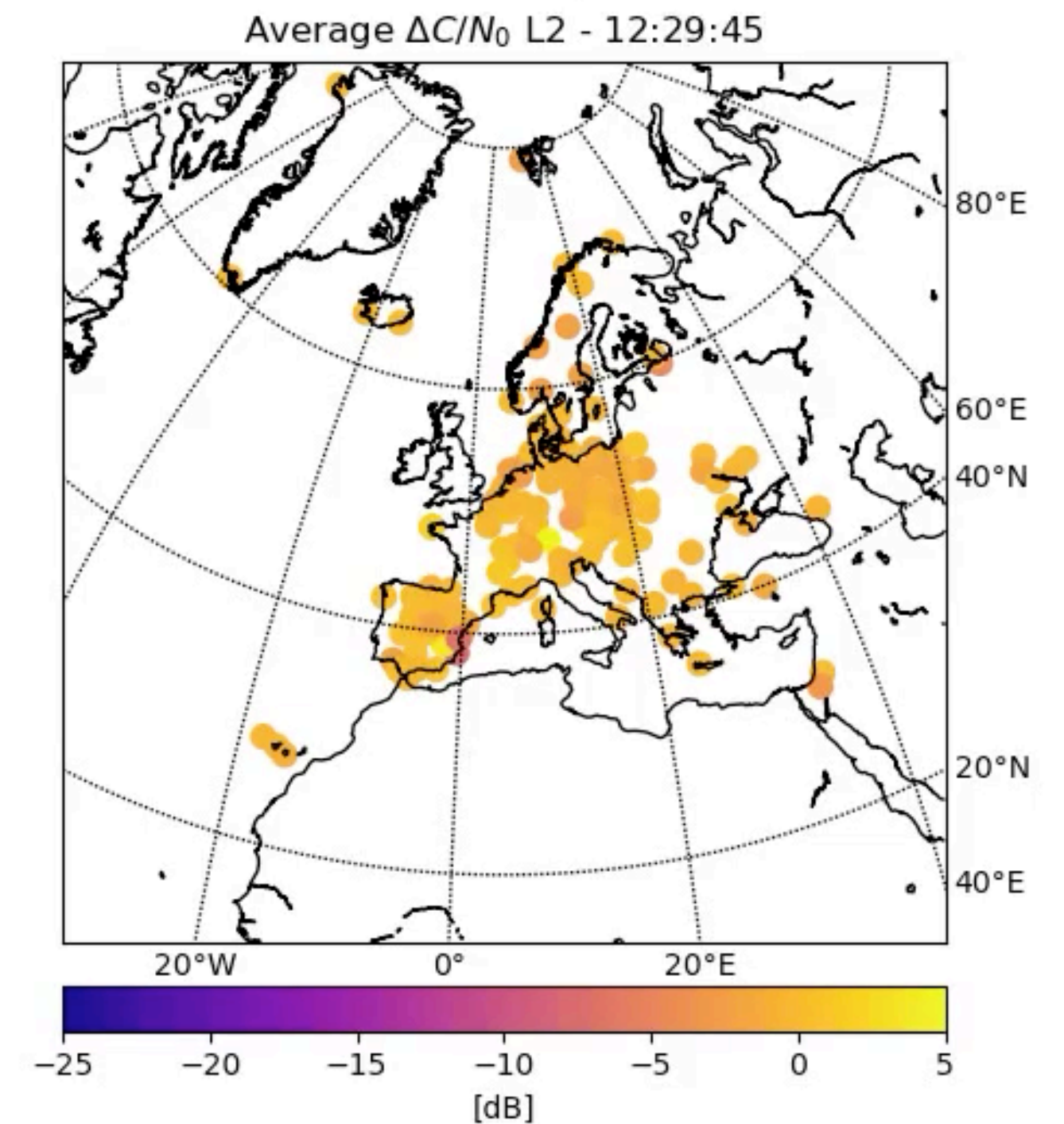
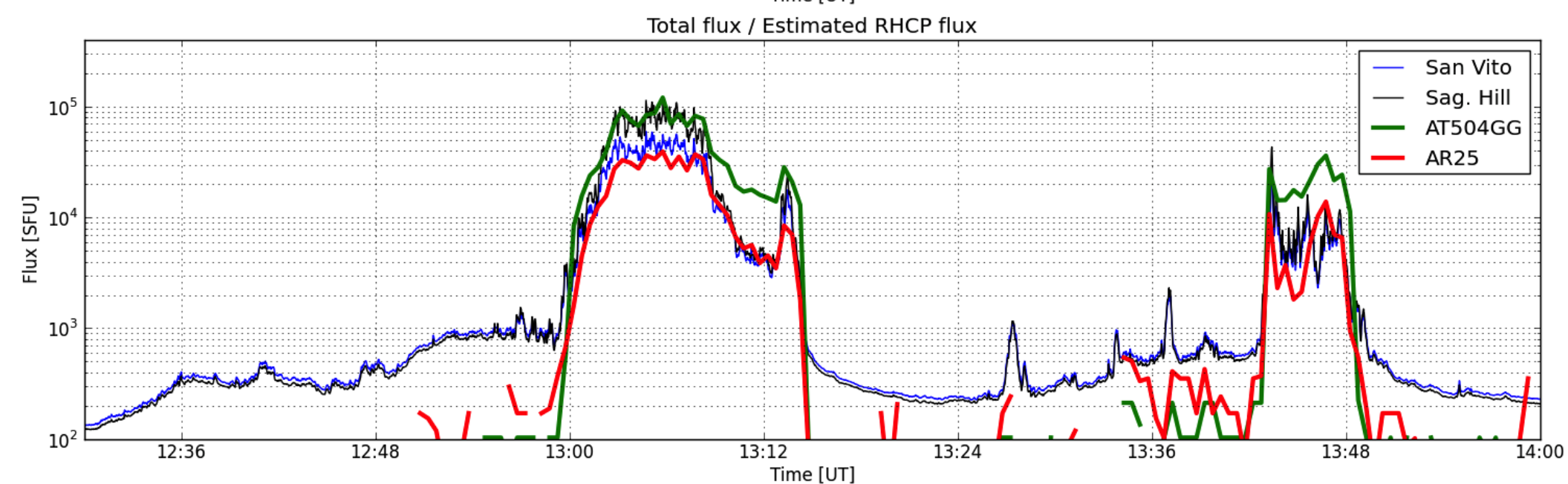
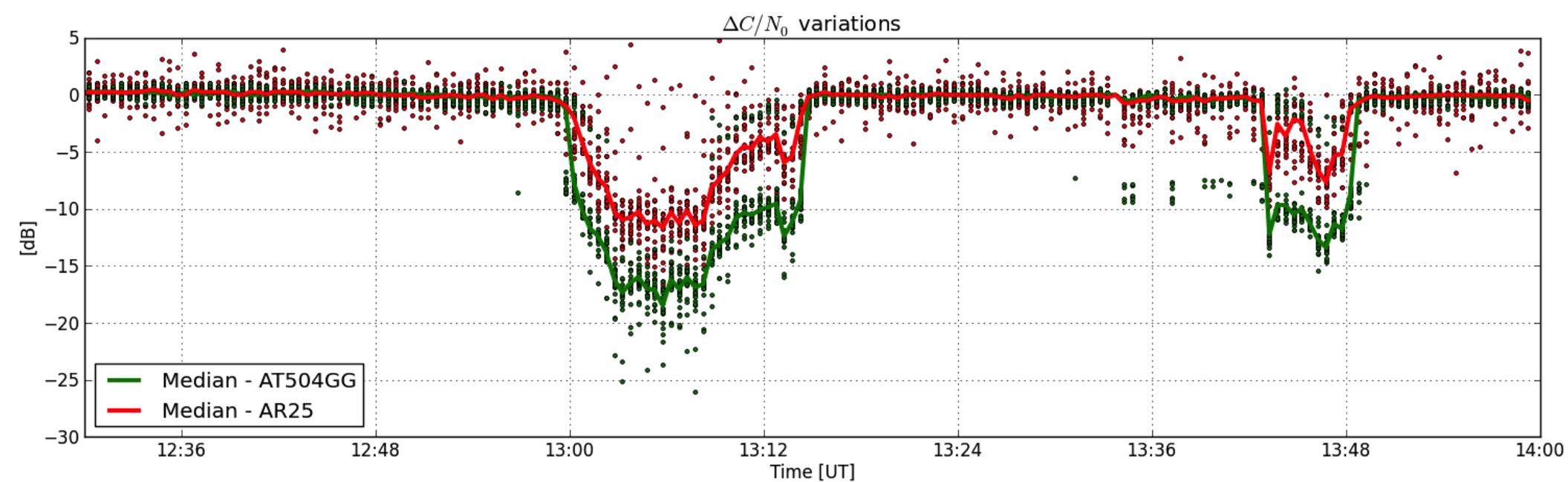
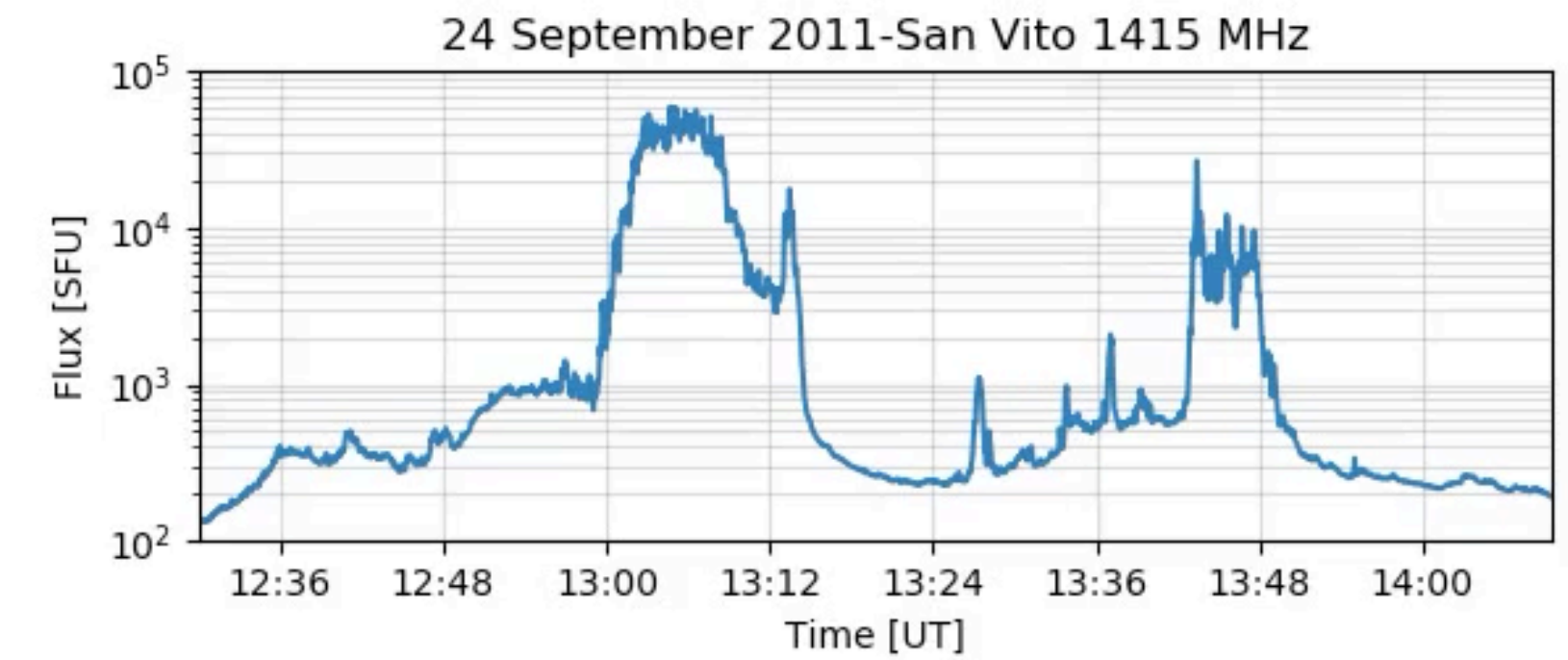
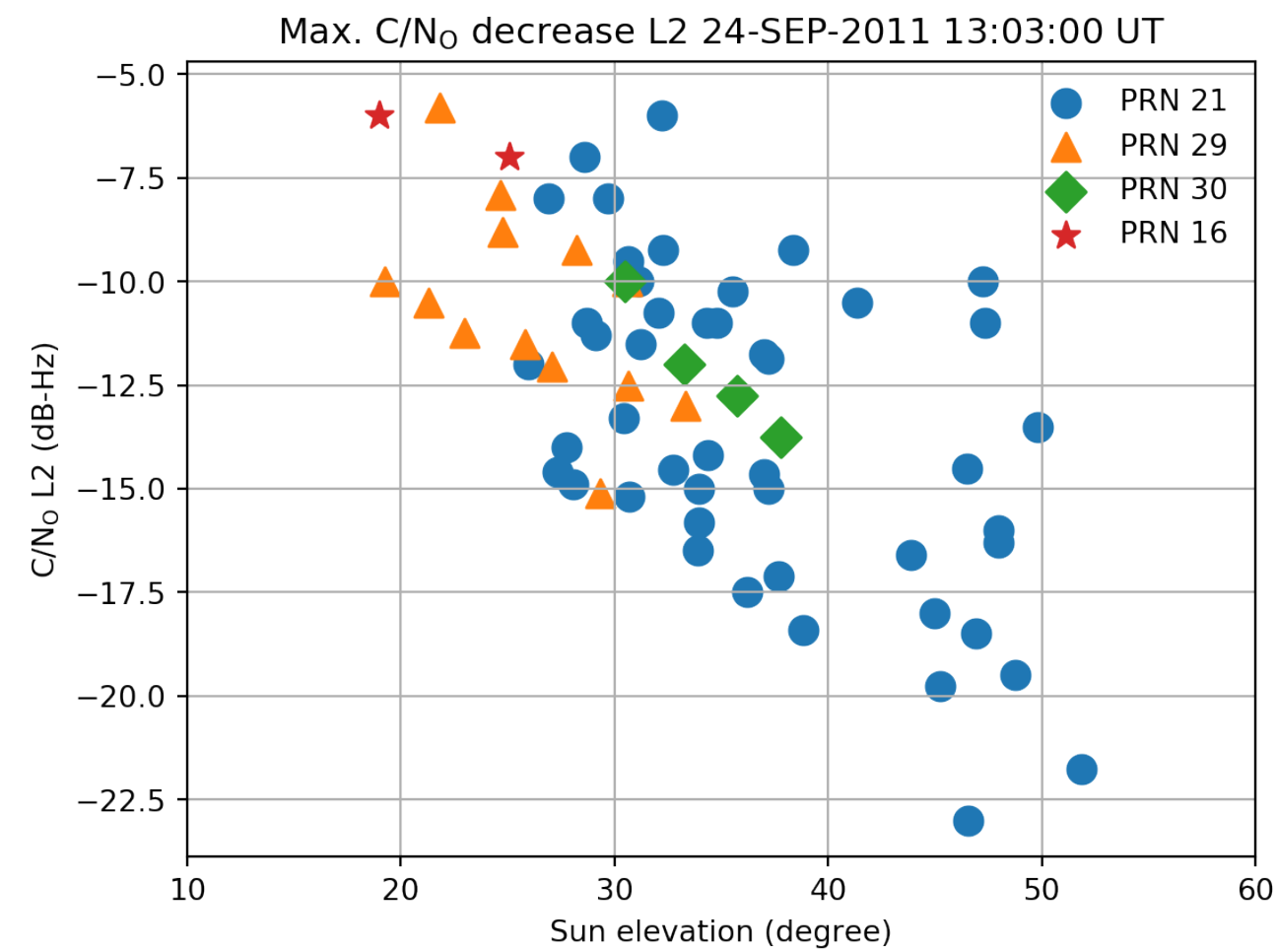
# GOES Xray Flux | Humain radio spectra [ARCAS + HSRS] - 2022/03/28



# Impact of solar radio bursts

# Impact on GNSS systems

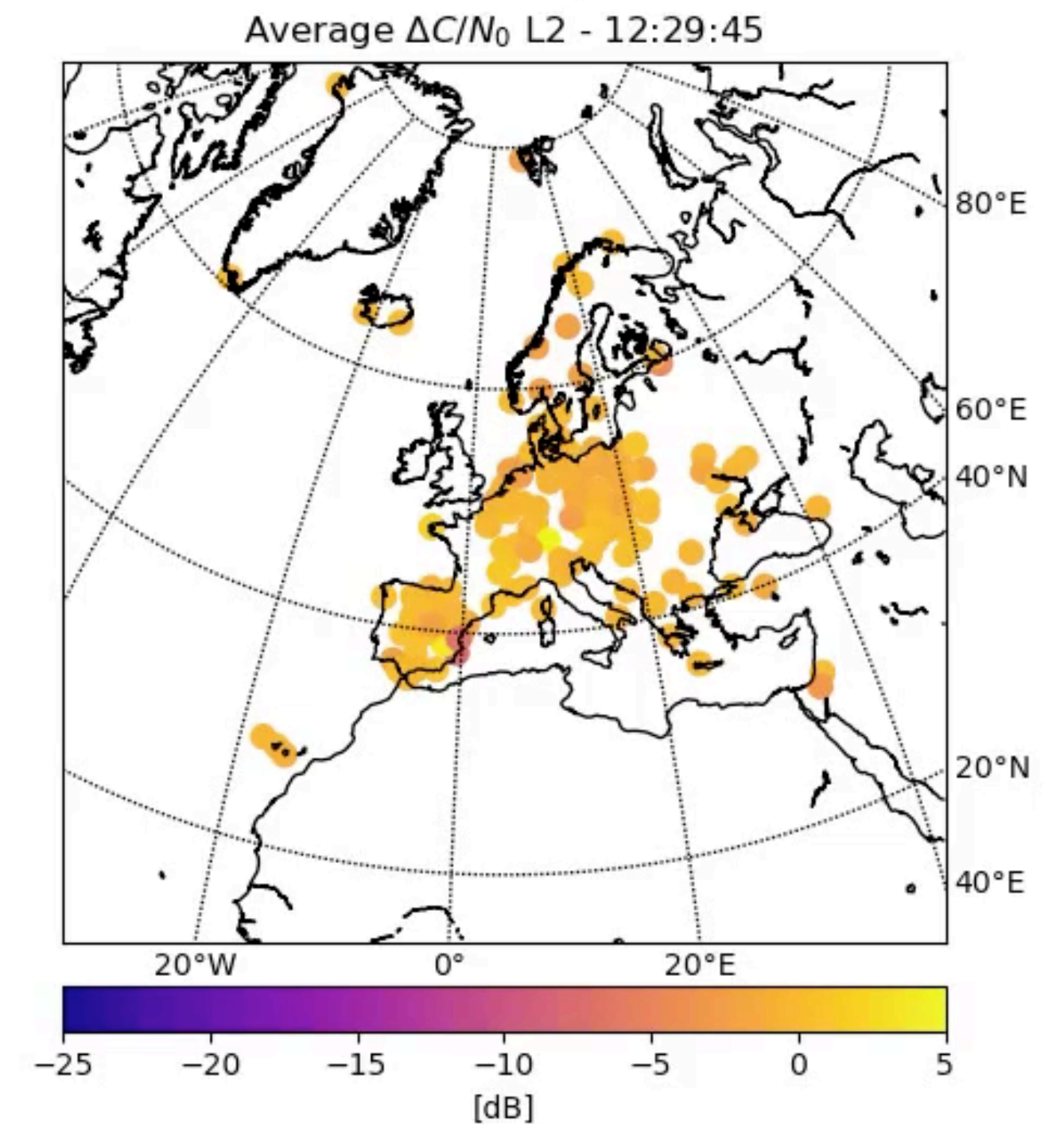
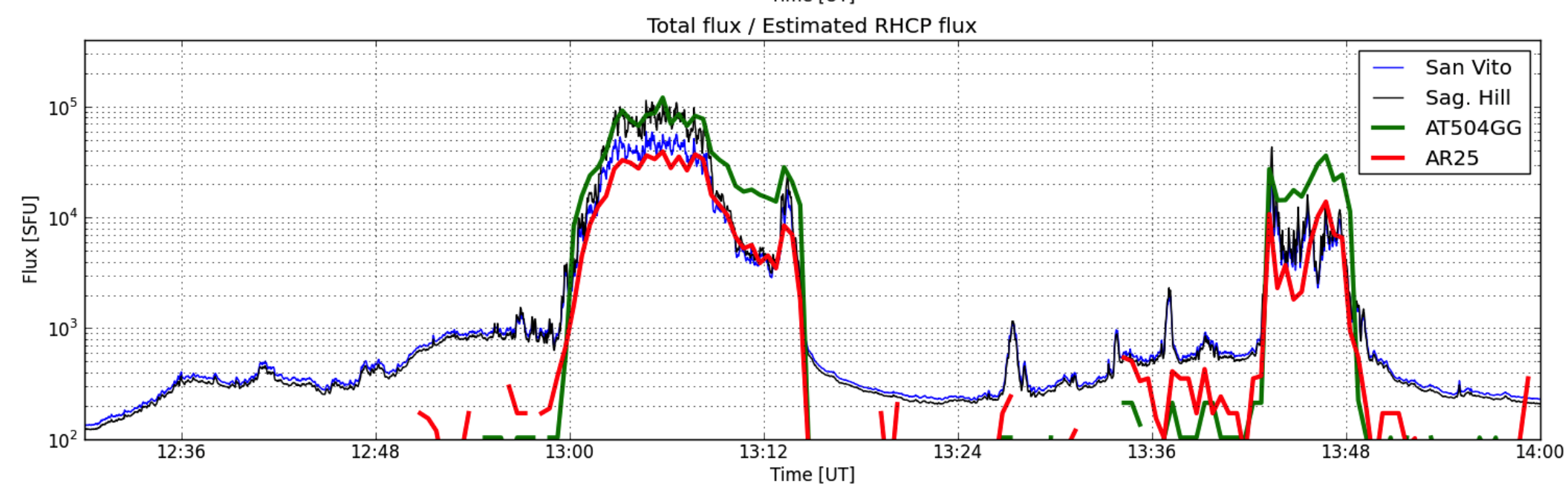
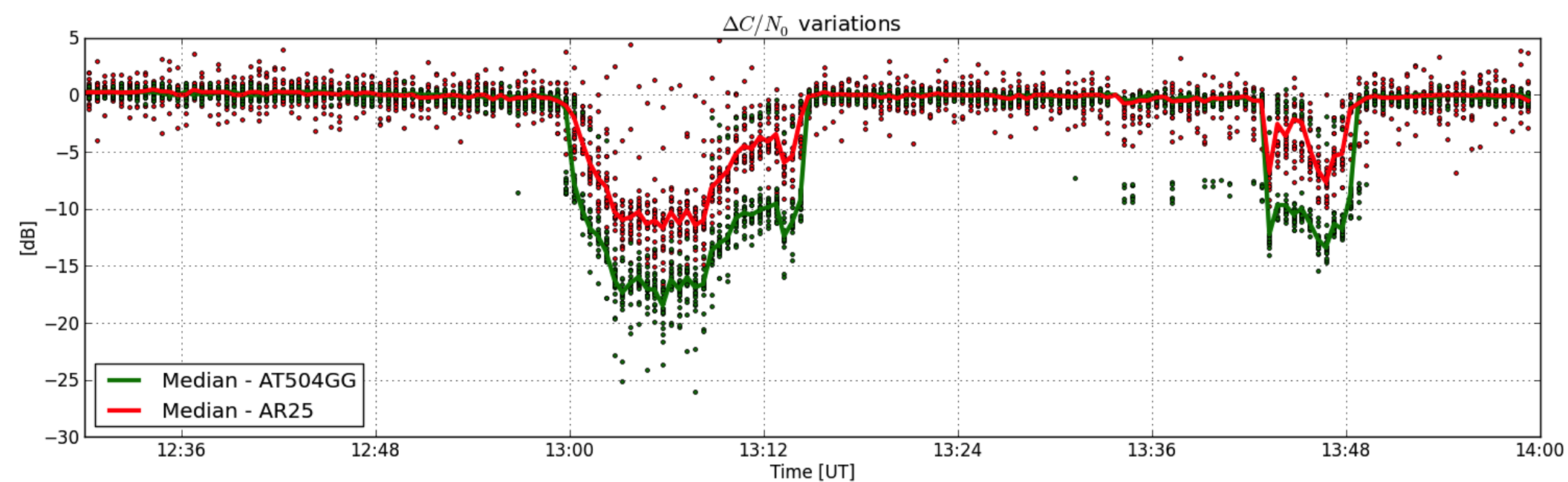
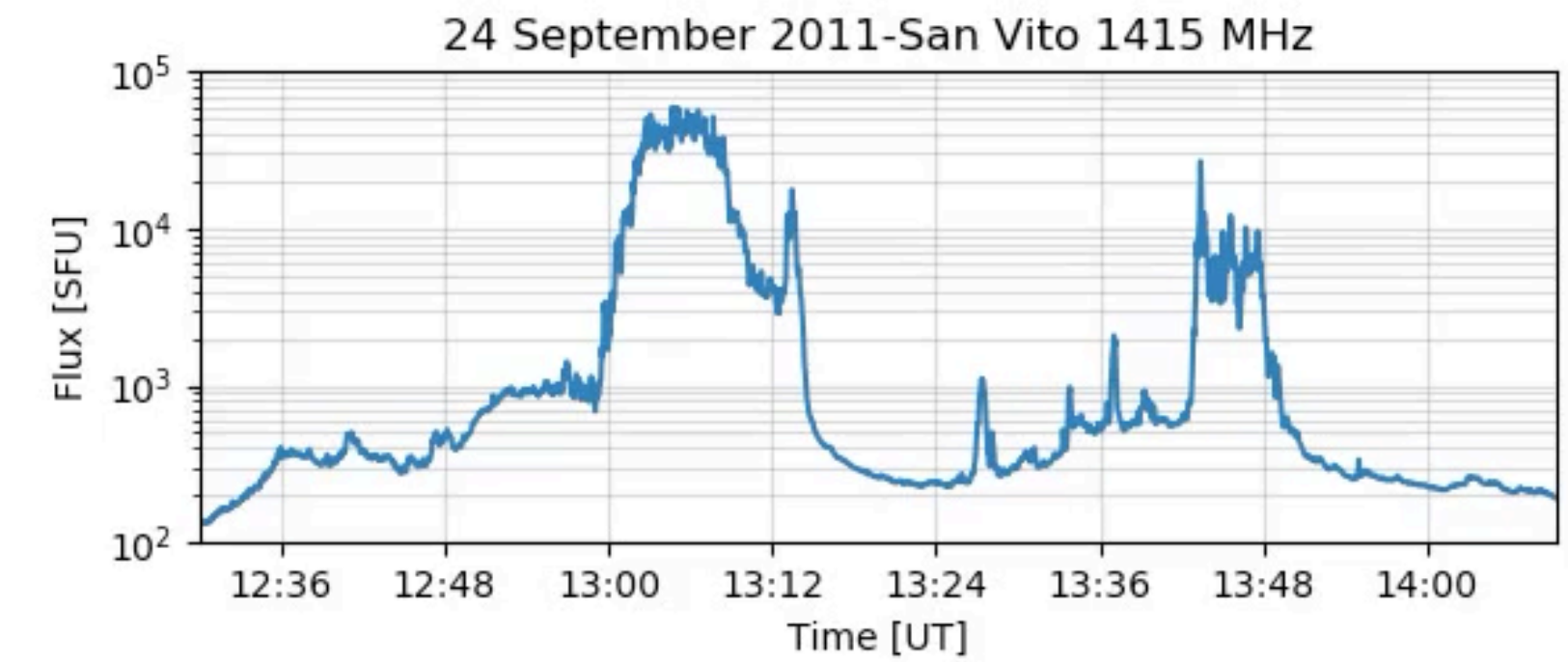
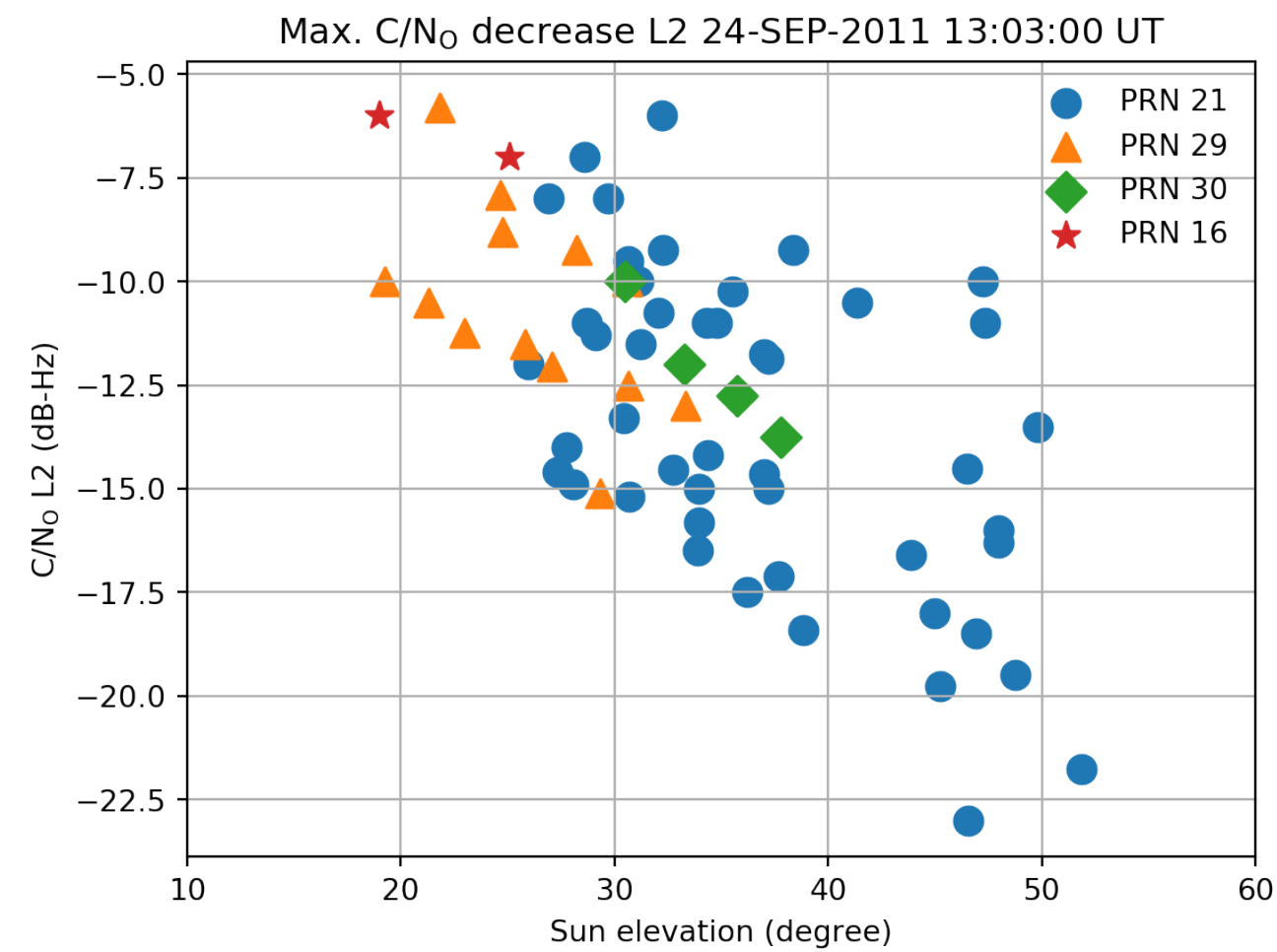
## GPS September 24 2011



Marqué, Bergeot, Aerts, Chevalier et al.  
(poster @ ESSW9, 2012)

# Impact on GNSS systems

## GPS September 24 2011

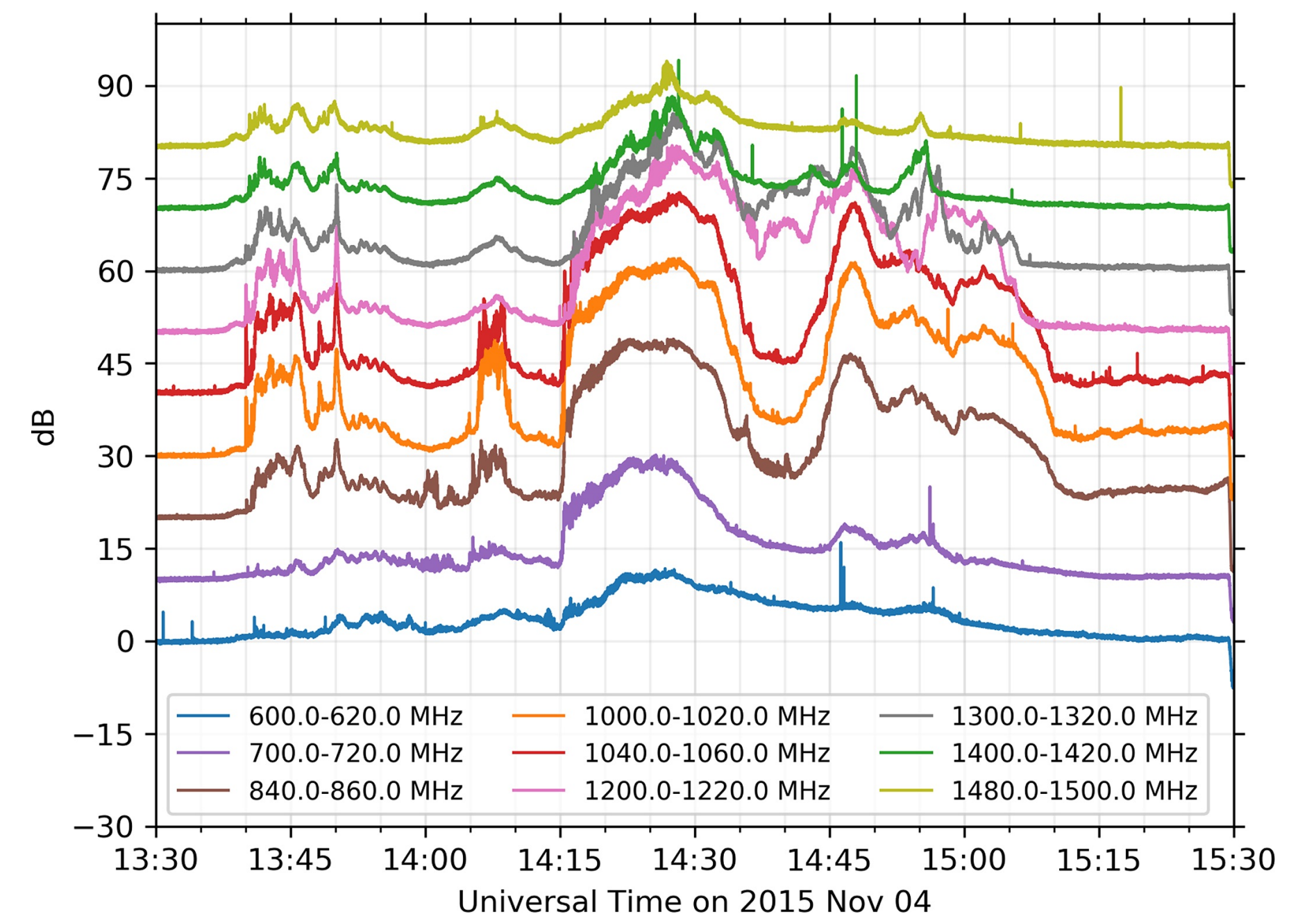
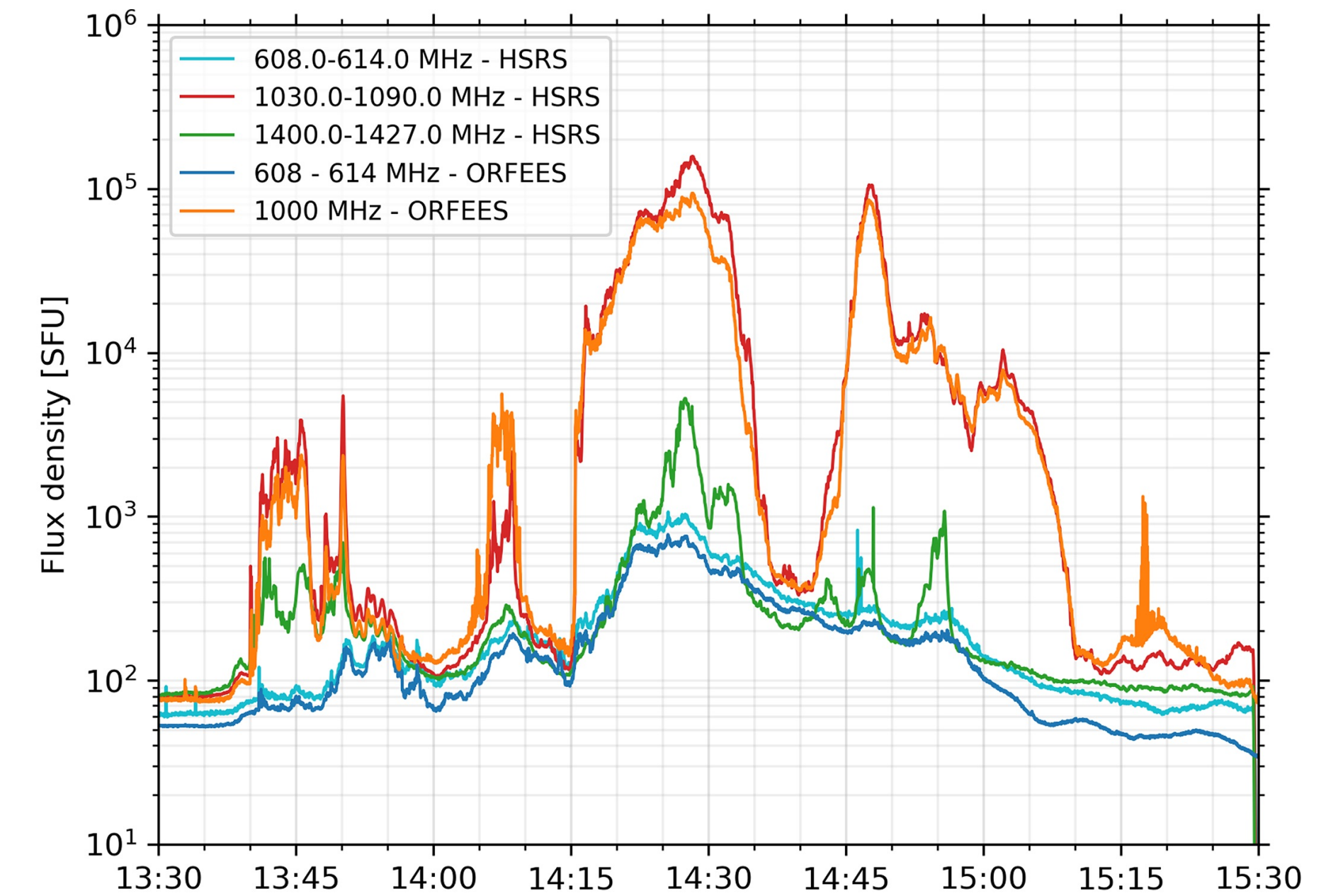


Marqué, Bergeot, Aerts, Chevalier et al.  
(poster @ ESSW9, 2012)

# Impact on radar systems

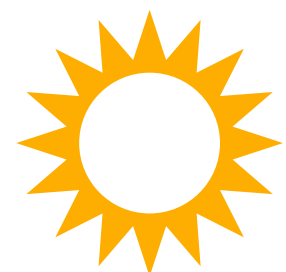
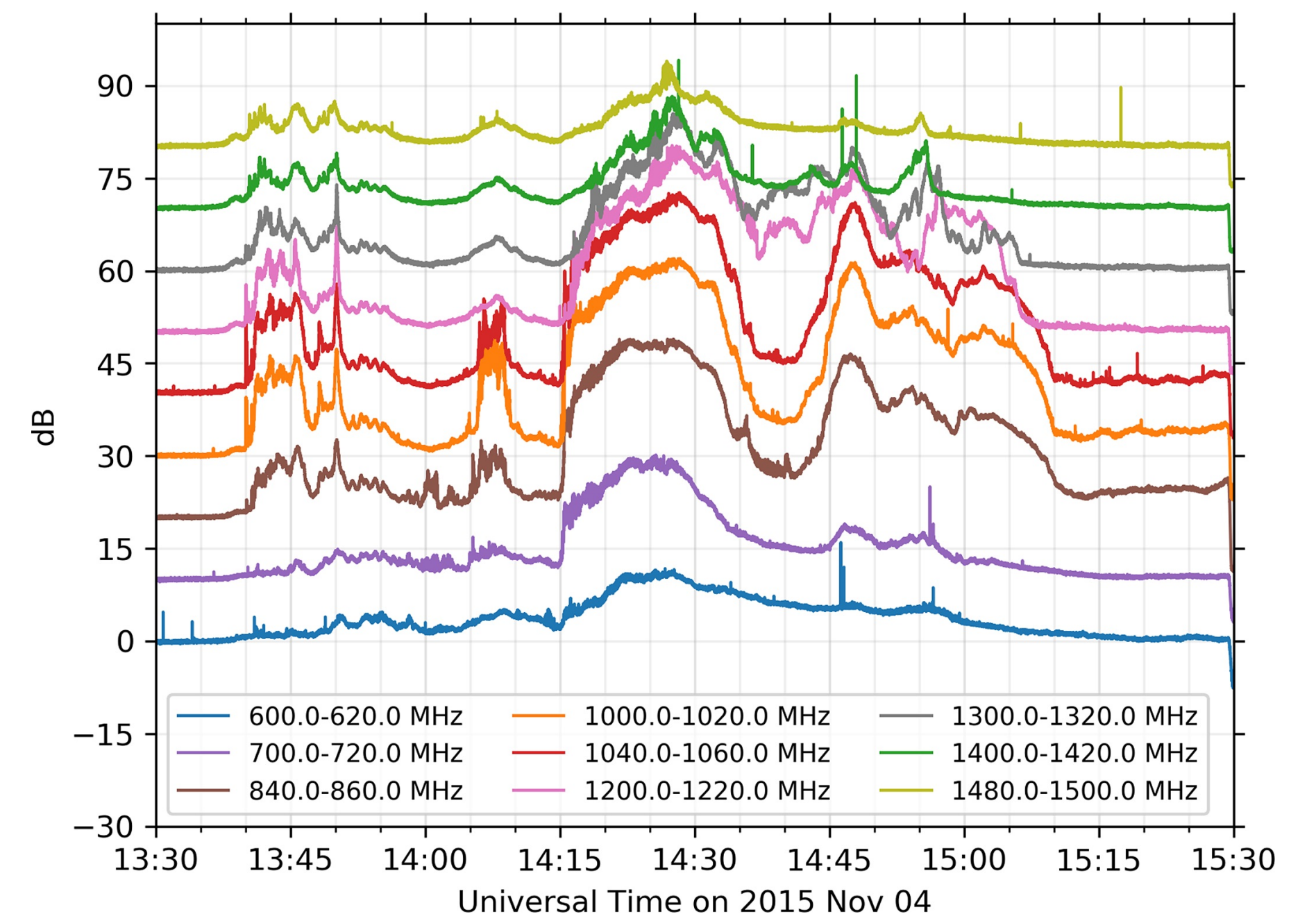
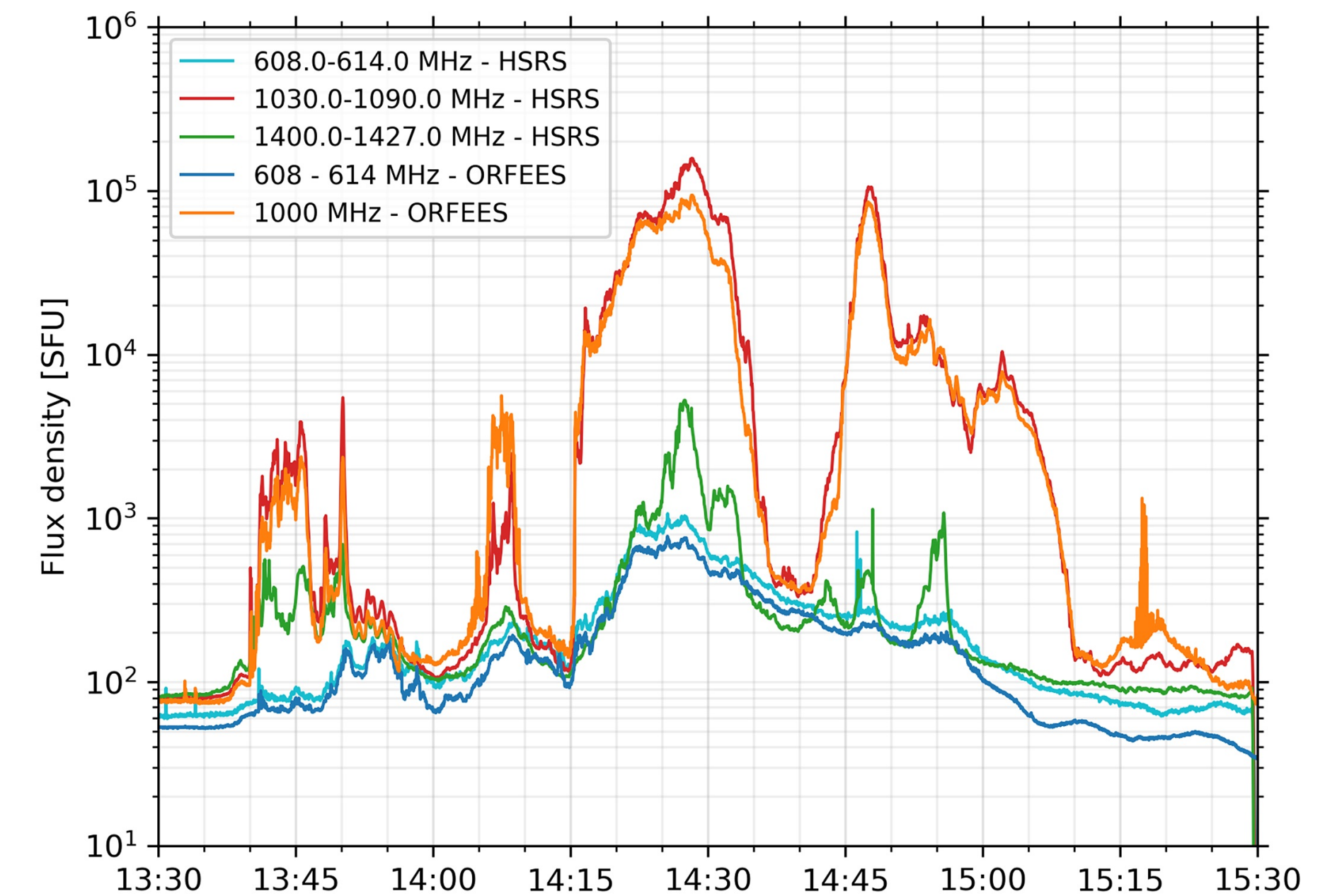
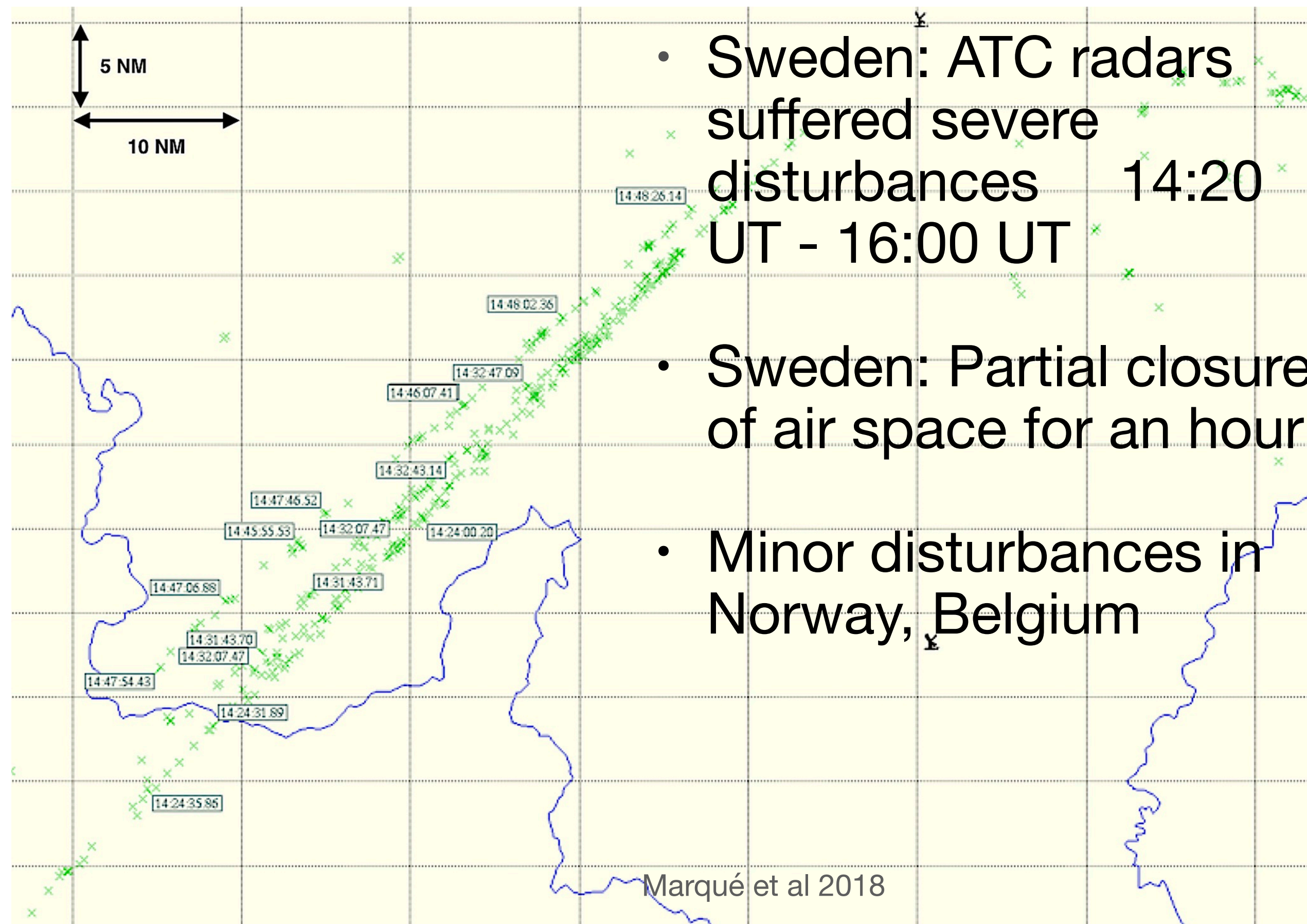
November 4 2015

- Sweden: ATC radars suffered severe disturbances 14:20 UT - 16:00 UT
- Sweden: Partial closure of air space for an hour
- Minor disturbances in Norway, Belgium



# Impact on radar systems

## November 4 2015



	<b>Frequency range</b>	<b>Properties</b>	<b>Impact</b>
<b>Noise storms / Type I</b>	HF, VHF	can be intense, long duration (days), frequent	<b>Possible</b>
<b>Type II</b>	HF, VHF	last few minutes, rare	<b>No</b>
<b>Type III</b>	HF, VHF	Intense, short duration, very frequent	<b>No</b>
<b>Type IV</b>	HF, VHF, UHF	Intense, long duration, broadband	<b>Yes</b>

**Links**

# Where to find solar radio data?

burst & radio events	<a href="https://www.swpc.noaa.gov/products/solar-and-geophysical-event-reports">https://www.swpc.noaa.gov/products/solar-and-geophysical-event-reports</a> <a href="https://www.ncei.noaa.gov/products/space-weather/partners/swpc-products-and-data">https://www.ncei.noaa.gov/products/space-weather/partners/swpc-products-and-data</a>
Recent radio flux	<a href="https://services.swpc.noaa.gov/text/solar_radio_flux.txt">https://services.swpc.noaa.gov/text/solar_radio_flux.txt</a>
F10.7	<a href="https://spaceweather.gc.ca/forecast-prevision/solar-solaire/solarflux/sx-5-en.php">https://spaceweather.gc.ca/forecast-prevision/solar-solaire/solarflux/sx-5-en.php</a>
Humain data	<a href="https://www.sidc.be/humain">https://www.sidc.be/humain</a> 🇧🇪