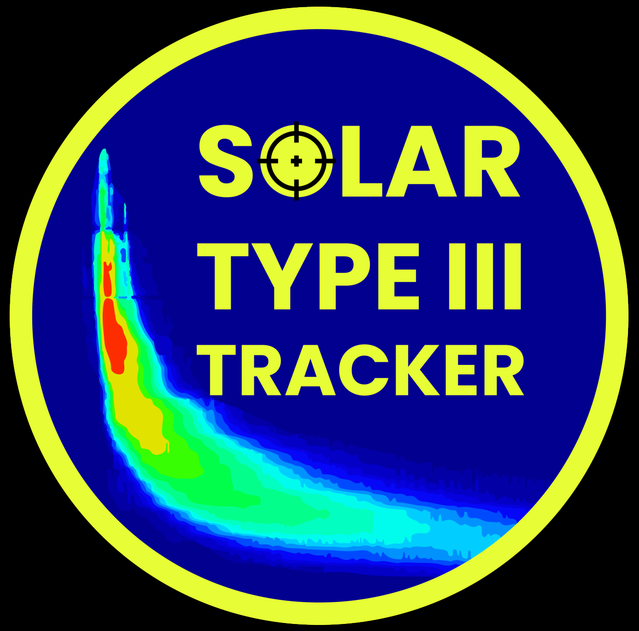


Solar Radio Burst Tracker

A citizen science campaign

Solar Orbiter - RPW

Type III bursts catalogue

Katerina Pesini, Radboud University & LIRA (Paris Observatory)

Radboud Universiteit

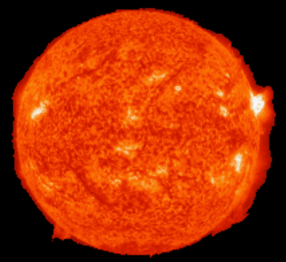
LIRA

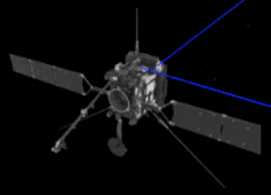
RPW

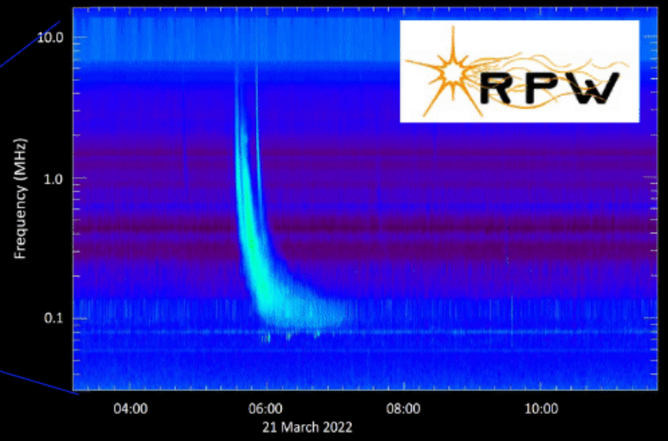
ESA | NASA
solar orbiter

RADBOUD RADIO LAB

Type III bursts - Origin

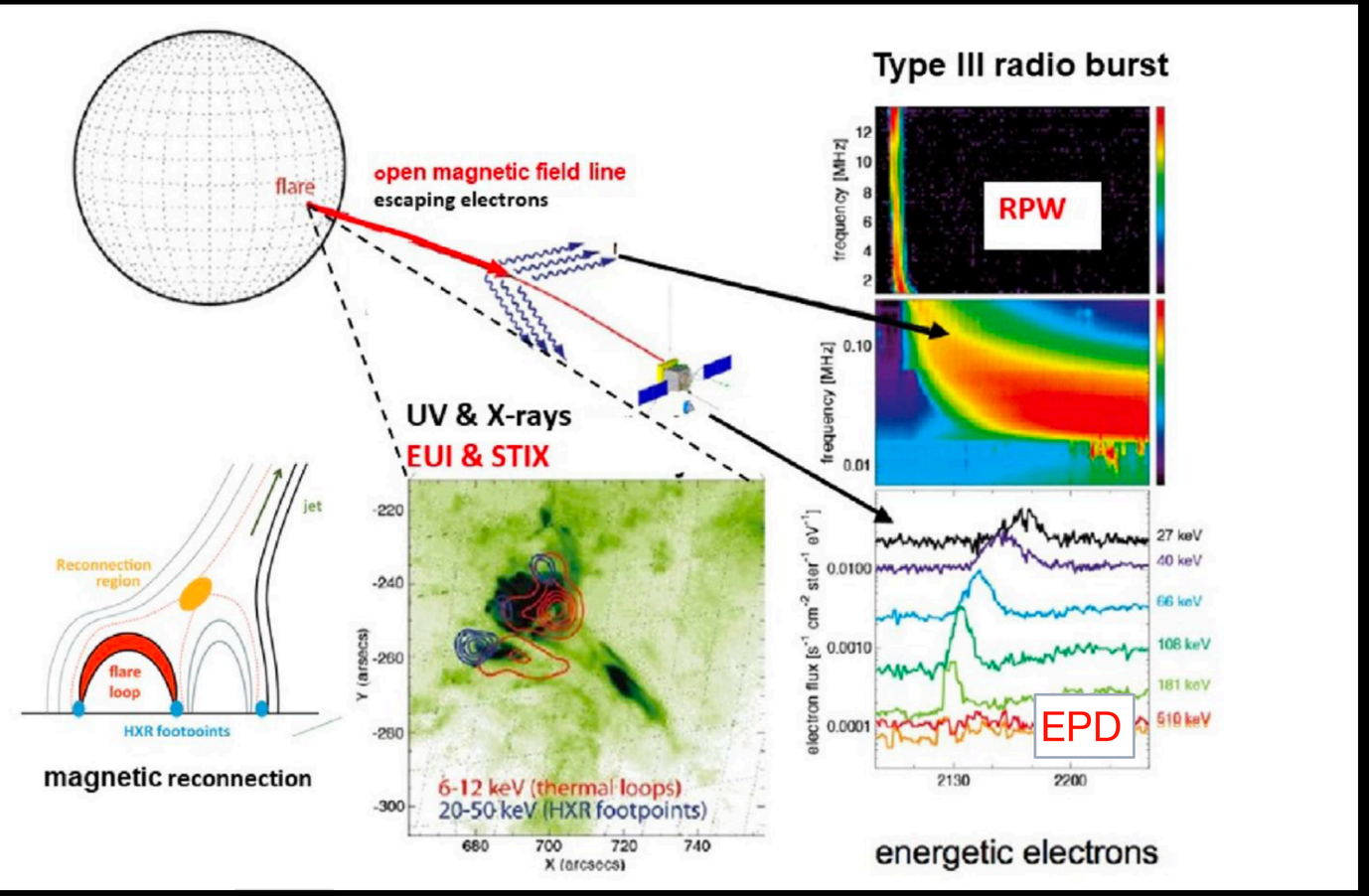






$$f_p \propto \sqrt{n_e}$$

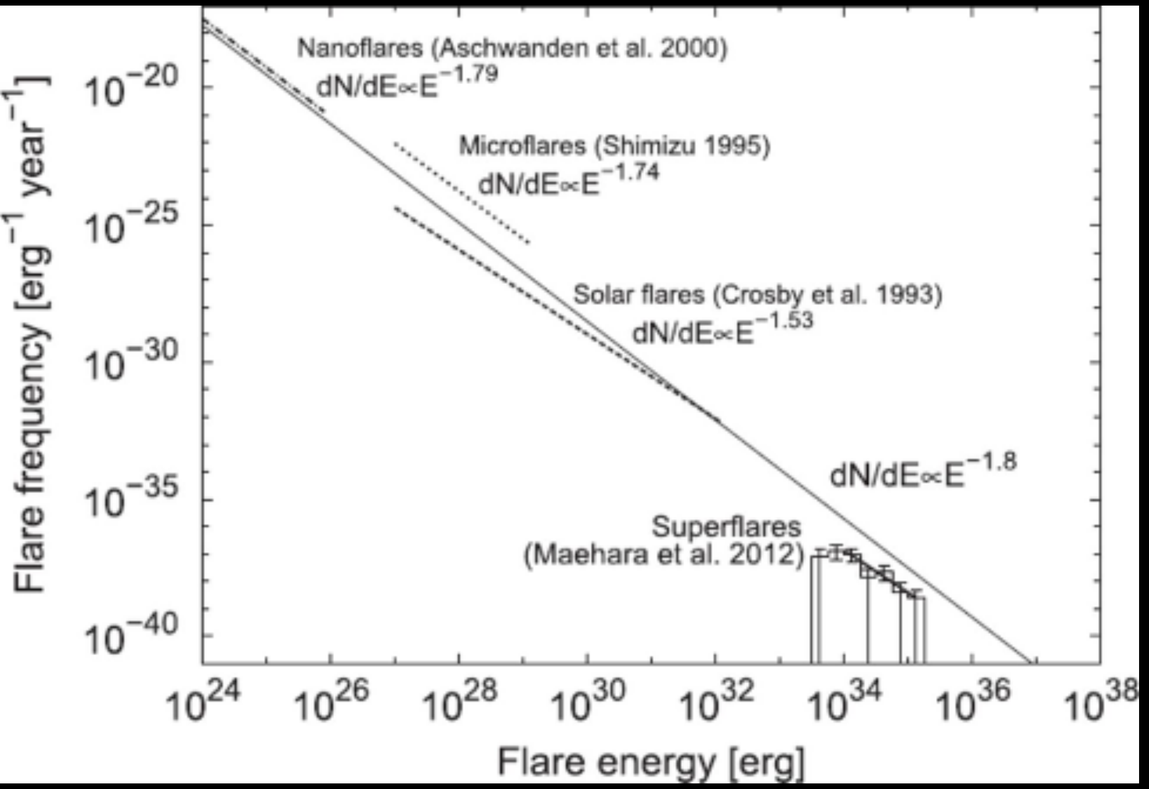
Type III bursts - Solar Flares



- Solar Flare
- Particle Acceleration
- Remotely
- In situ
- X-Rays, UV, Radio
- Particle Energy Distribution

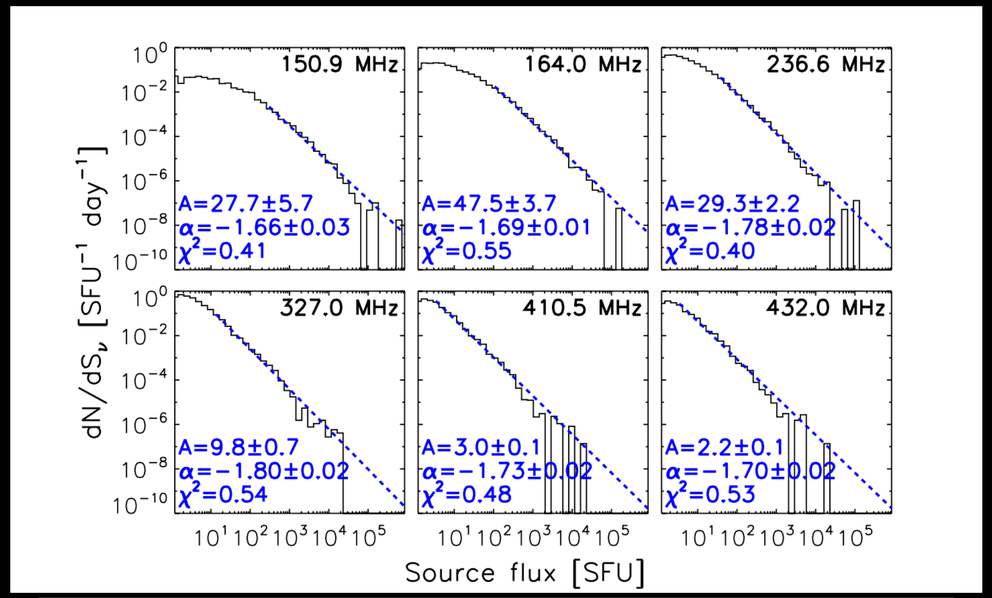
Motivation

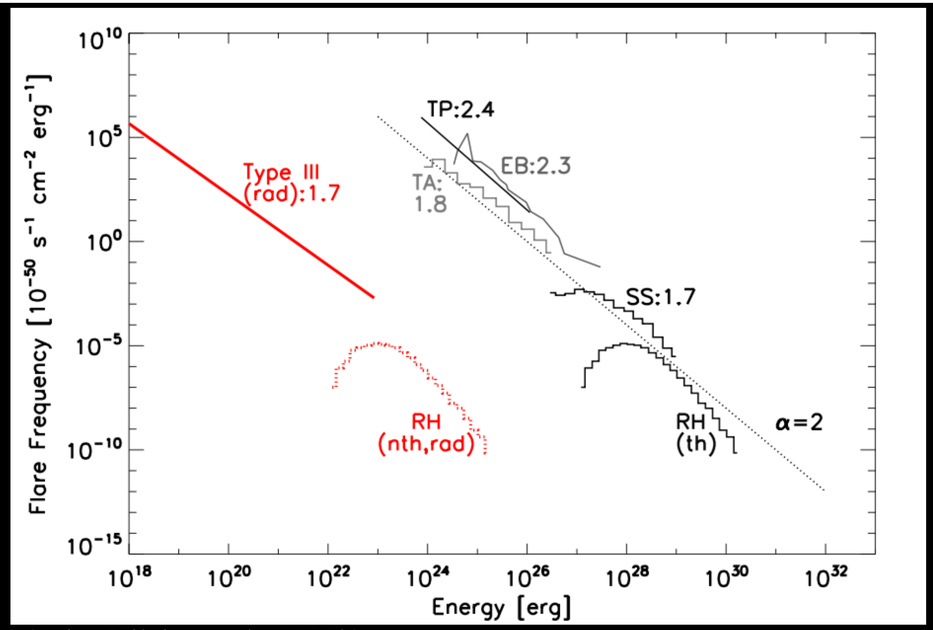
Solar Flares: X-Rays - EUV



(Shibata et al., 2013)

Type III bursts : Metric domain





(Saint-Hilaire et al., 2012b)

Motivation

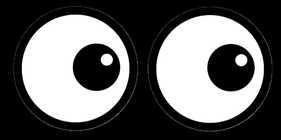
Automatic recognition of type III solar radio bursts
(e.g Lobzin et al., 2009)

Not efficient for **faint**
Type III bursts

Not efficient for
lower frequencies

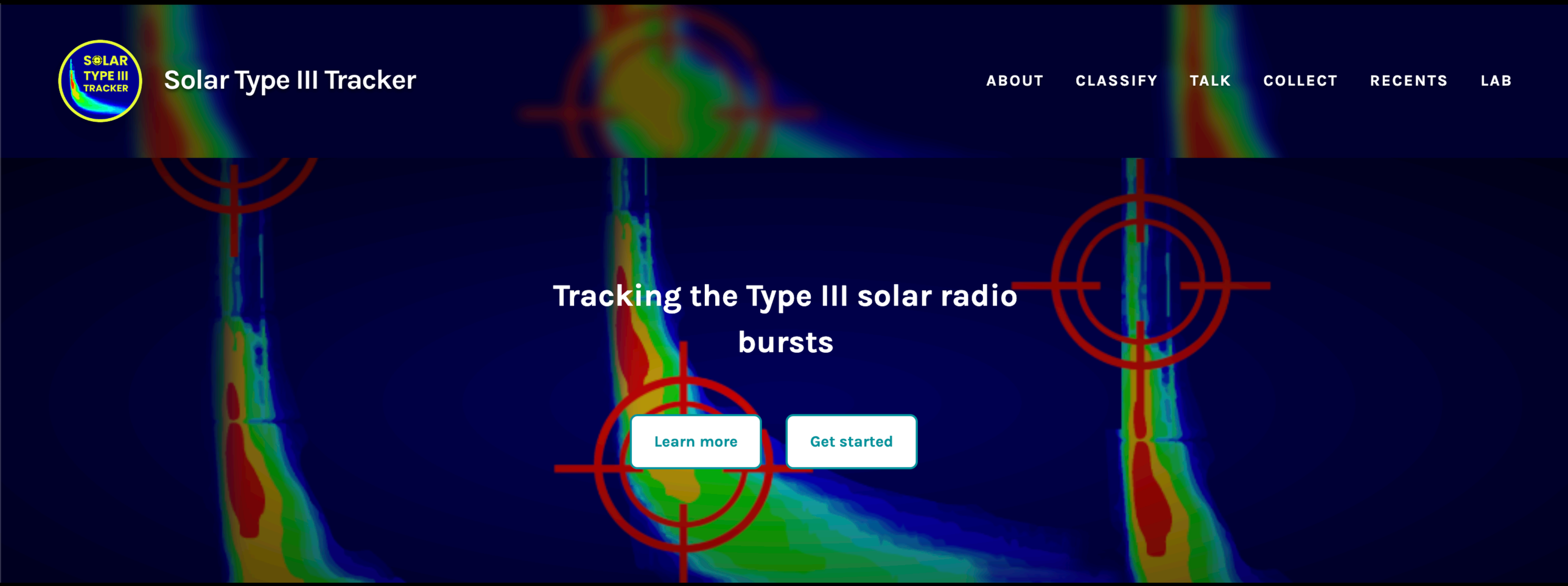
SOLUTION!

Human participation



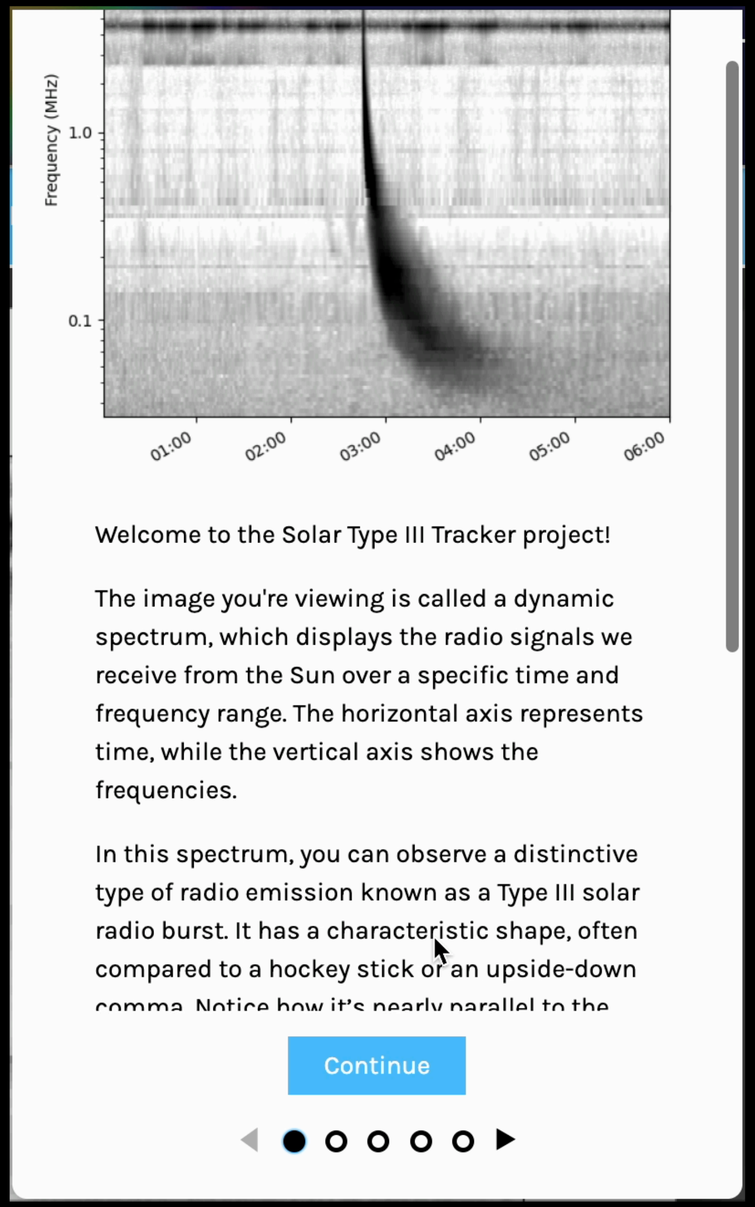
Zooniverse-Solar Radio Burst Tracker

Project walk through



Zooniverse-Solar Type III tracker

Project walk through



Tutorial:

1) Short

2) Steps

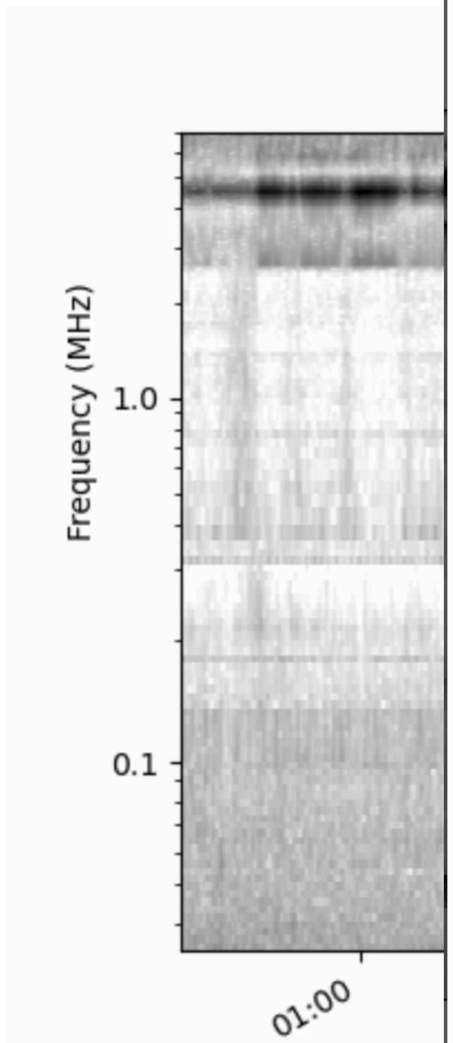
3) Tips

4) Engaging phrases

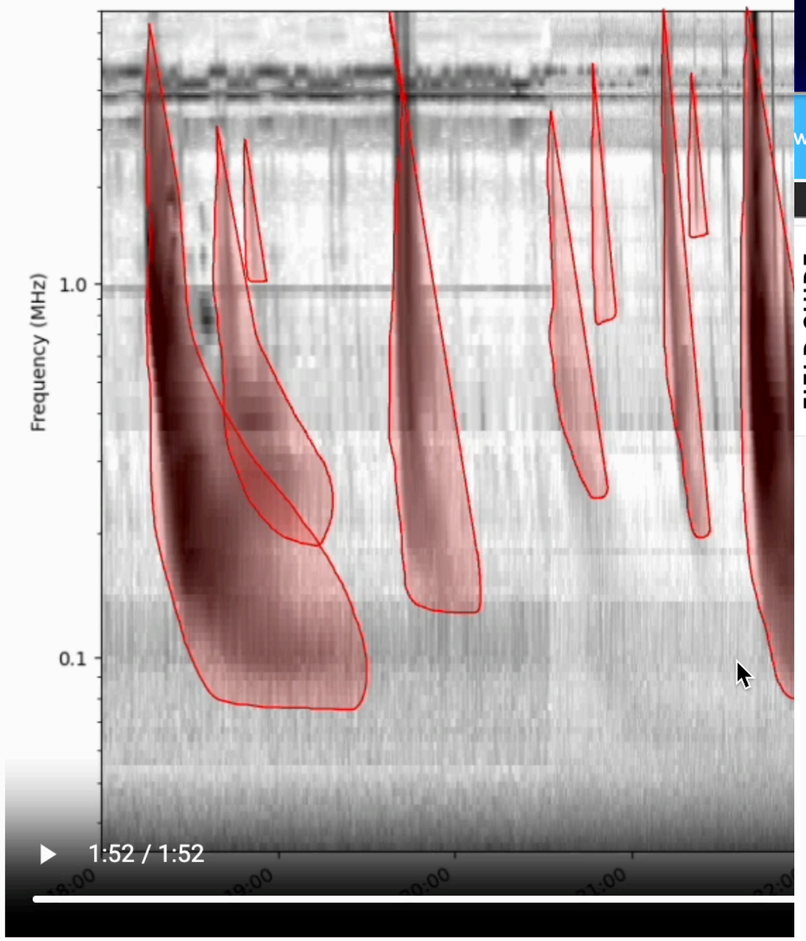
5) Understandable from a 12-years old

Zooniverse-Solar Type III tracker

Project walk through



examples.



There will be cases where you won't observe any Type III bursts, som
others where you'll see many. Check the video below for examples.

FIELD GUIDE

FIELD GUIDE


Isolated Type III solar radio bursts


Complex type III structure- Multiple injections


Complex type III structure-Distorted signals

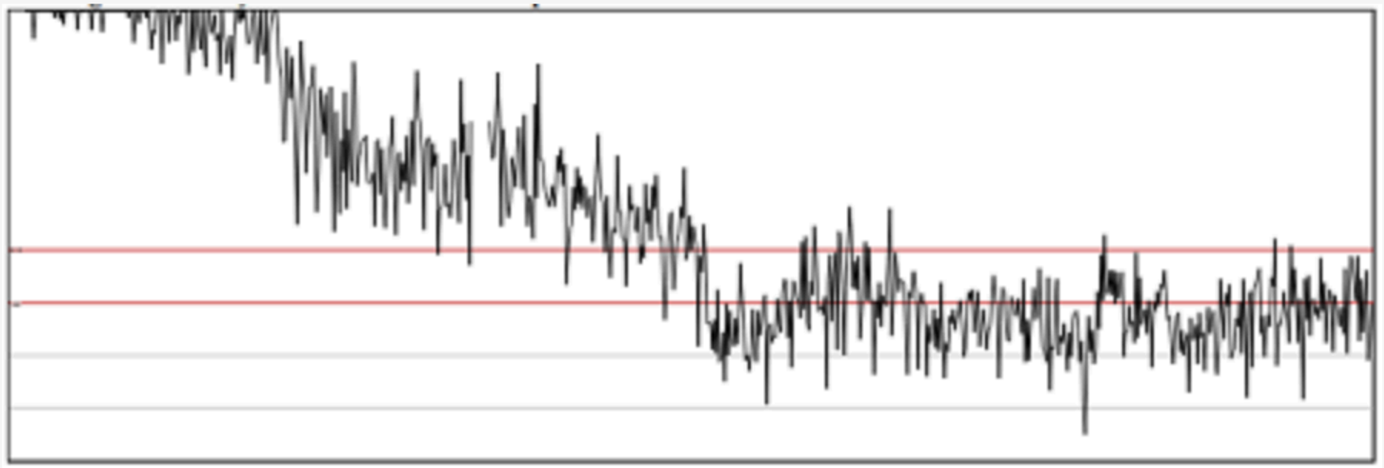

Type III storms


Missing data

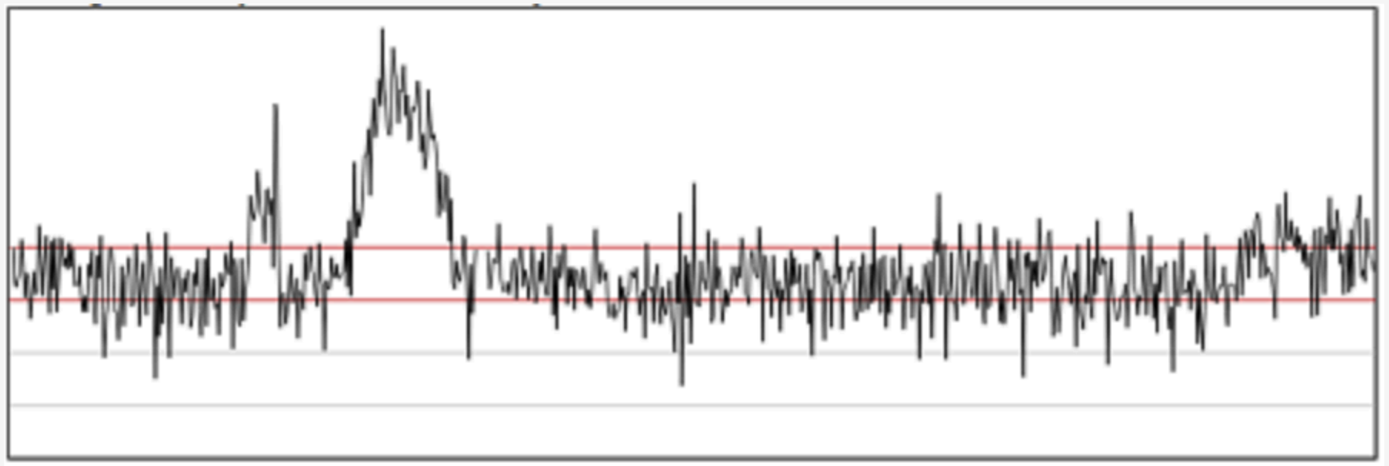

Split Type III solar radio bursts


Spacecraft Noise


Artifacts



Unusual high level of the interfering signal at just under 200 kHz, then reducing to normal low level.



Pulse at about 90 kHz.

Any idea of the sources?

Zooniverse-Solar Type III tracker

Forum

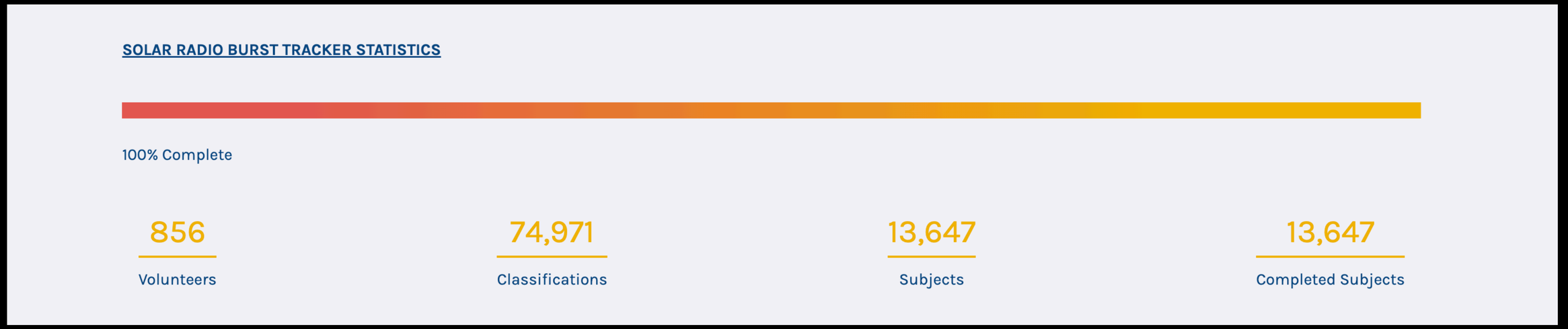
March 14th 2023, 11:37 pm

Thank you to @kpesini and [redacted] for replying. Perhaps now the human species and life on Earth has a slightly better chance of surviving.

Zooniverse-Solar Type III tracker

Statistics

1) Registered Volunteers: 856
2) Complete spectra : 13,647
3) Duration : 40 days



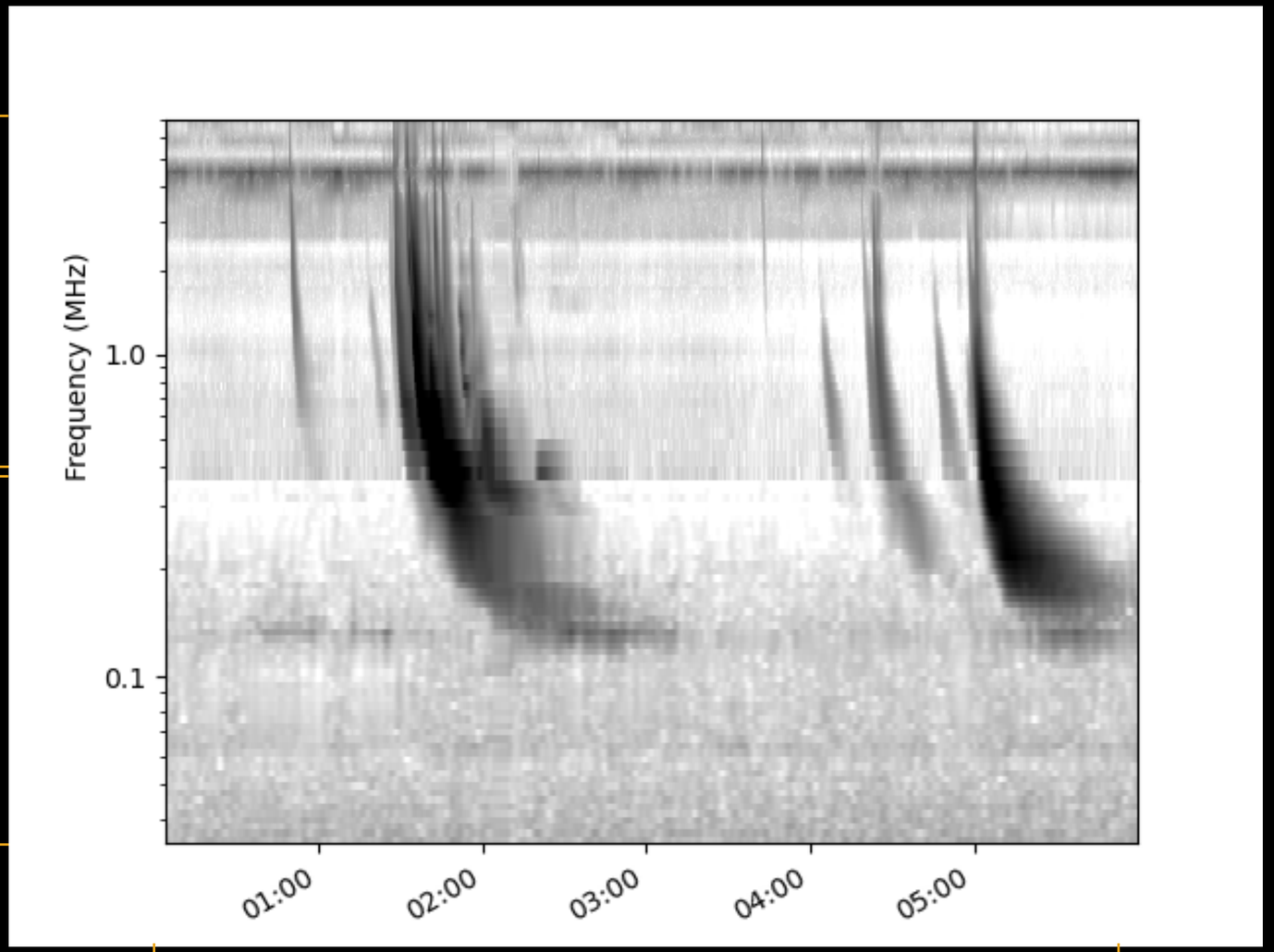
Zooniverse-Solar Type III tracker

Preparation

RPW data (2020-2025)

HFR

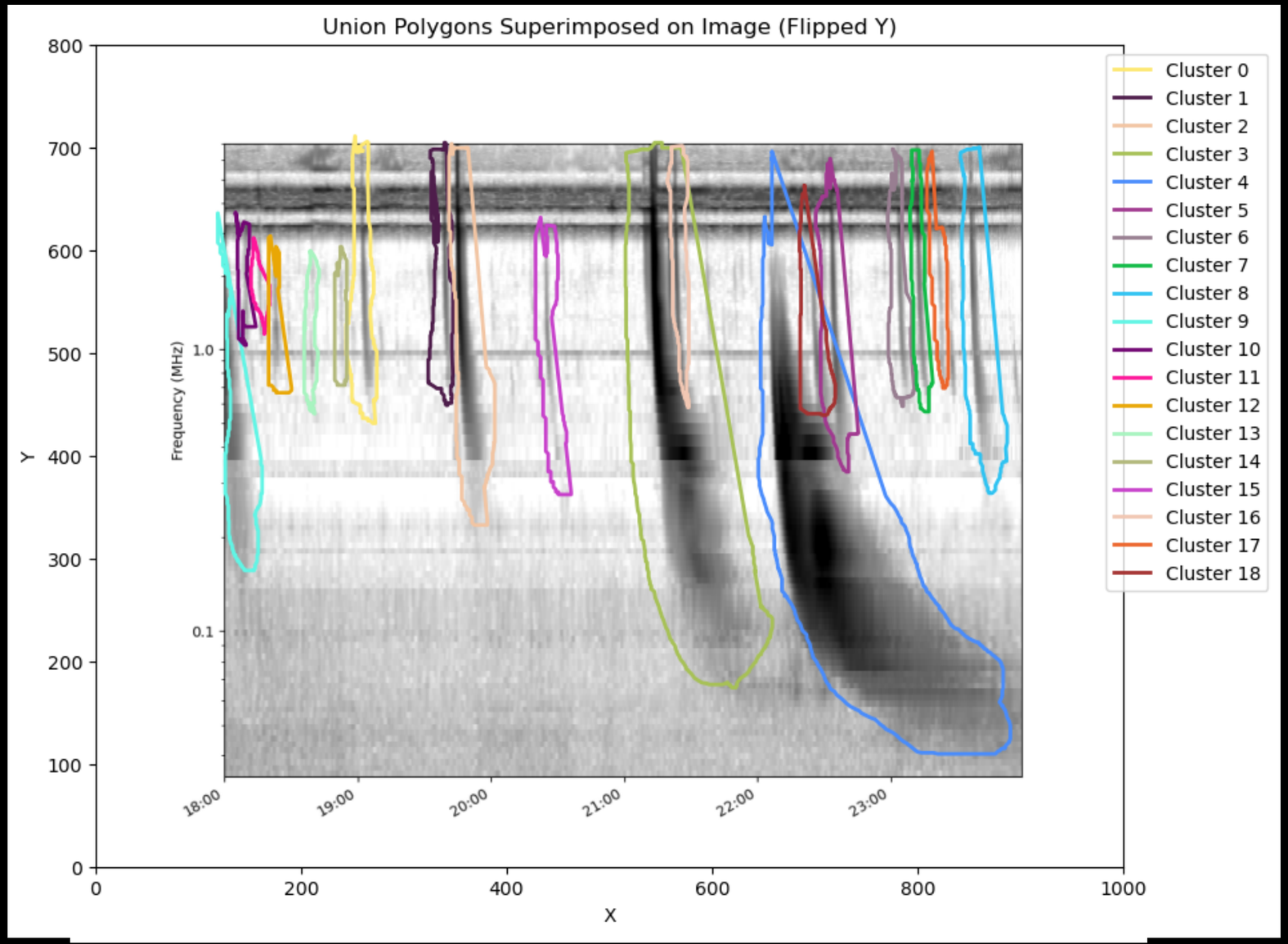
TNR



6 hours

Zooniverse-Solar Type III tracker

Post Data Processing



Zooniverse-Solar Type III tracker

Expected Results

Type III

Time Range

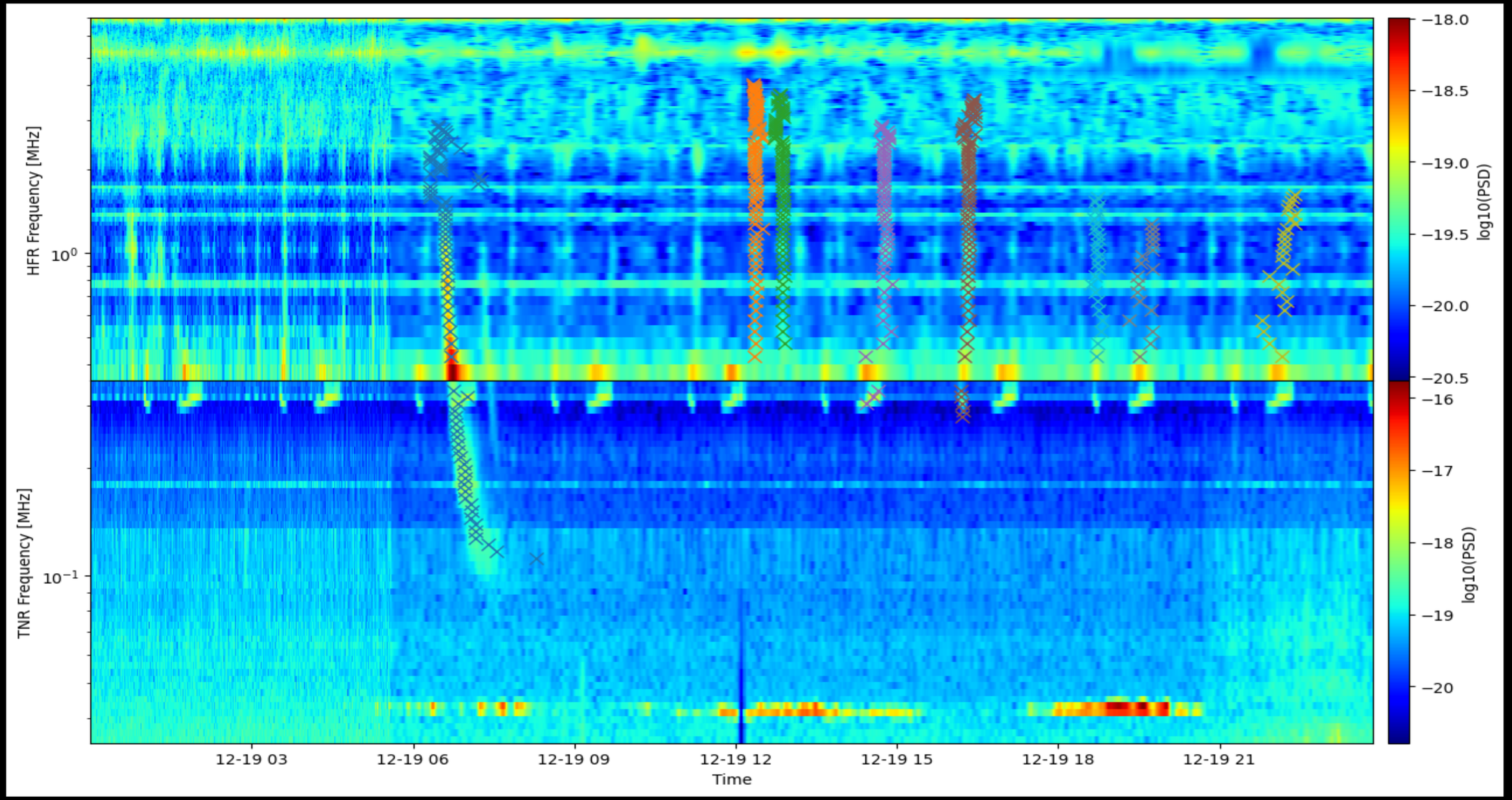
Frequency range

Number of users

Drift rate

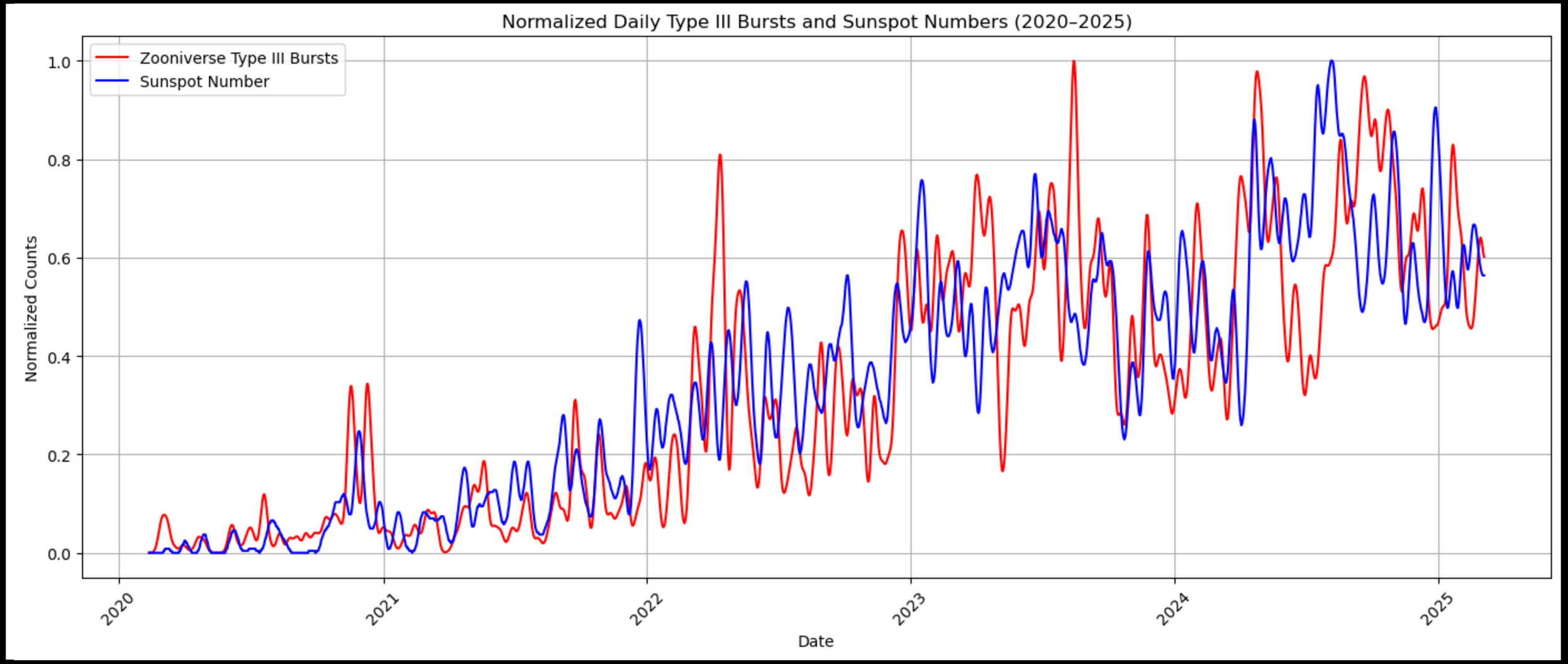
Zooniverse-Solar Type III tracker

Expected Results



Zooniverse-Solar Type III tracker

Expected Results



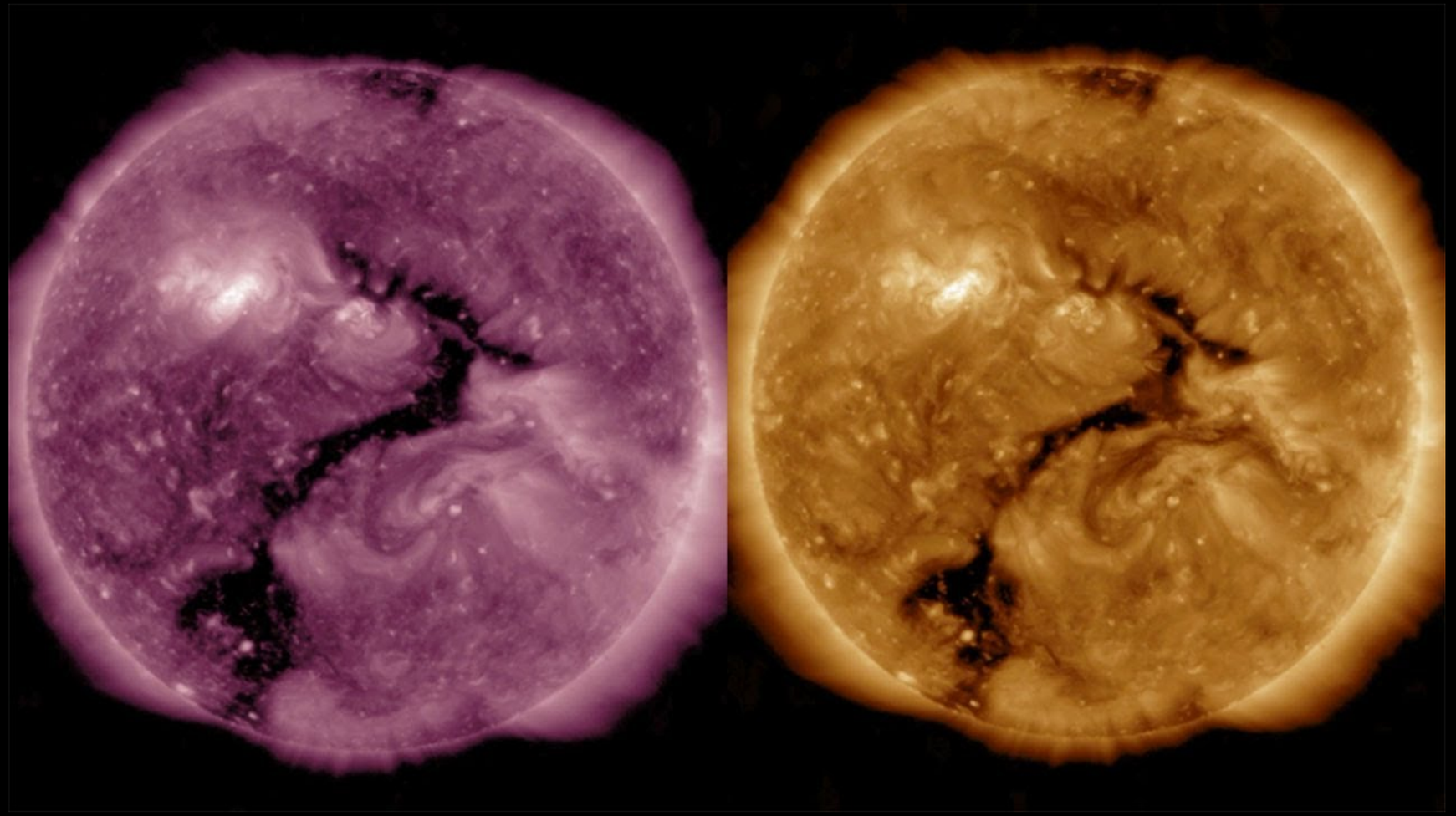
RPW Type III catalog - Applications

- **Extensive public** Type III catalog from RPW
- Comparison of **fainter Type III** signals with weaker Solar flares => microflares, nanoflares
- Muti-wavelength observations from the **same spacecraft**
- Solar Type III tracker for **STEREO**, **Wind** and **PSP**
- Extensive Type III catalog **1994-2025**
- Comparison of Type III periodicity with two **Solar Cycles**
- Optimization of **automatic Type III detection** for future observations

Science is not distant or inaccessible—science should be for everyone!

LINK : https://www.zooniverse.org/projects/xbonnin/solar-radio-burst-tracker

Questions??



Zooniverse-Solar Type III tracker

Project walk through

Research | The Team | Education | FAQ

Introduction

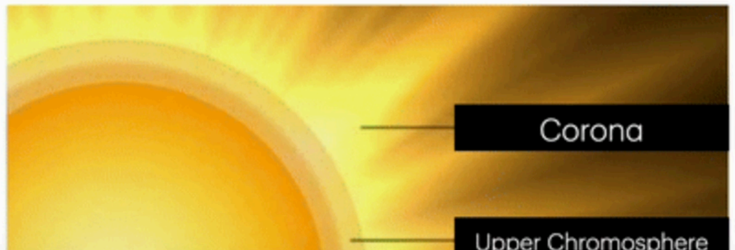
The Sun is our closest star — just 150 million kilometers away! It has three layers in its atmosphere: the Corona (outermost), the Chromosphere, and the Photosphere (the surface we see). The Sun is mostly made of Hydrogen, but also has Helium and other elements. Because the Sun is so hot, it turns these elements into plasma — a supercharged gas made of tiny particles like ions and electrons.

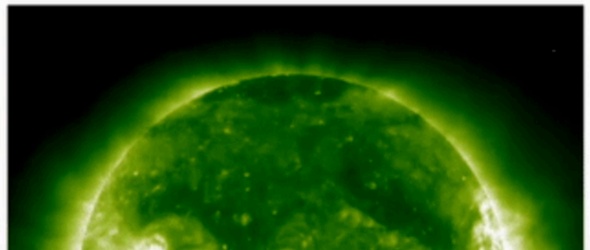
Deep inside the Sun, plasma moves around and creates powerful electric currents. These currents make a magnetic field that shoots up to the surface, creating sunspots. This magnetic field drives **solar activity**, which is what makes the Sun so exciting!

One example of solar activity is a **solar flare**. A solar flare is a massive burst of energy that shoots out from the Sun's surface. This explosion heats up the plasma, speeds up tiny particles like electrons, and sends out intense radiation in the form of gamma rays, X-rays, UV light, microwaves, and radio waves.

These bursts of energy can send high-speed particles flying through space. Some of these particles cause **Type III solar radio bursts**, which are the focus of our project. These bursts happen when fast-moving electrons, accelerated by solar flares, send out **radio waves**!

This project is led by researchers from LIRA, Paris Observatory in France and Radboud University (Netherlands). By studying these radio bursts, we can learn about solar activity, the Sun's hidden secrets, and how particles behave in space. Plus, it's a great way to uncover more about how the Sun affects Earth and space around us.





Zooniverse-Solar Type III tracker

Post Data Processing

Steps

1. Receive meta-data => **pixel coordinates**

2. **Clustering algorithm** => Multiple users defining the same area

3. Define the **Type III areas**

4. Transform the x and y coordinates of the Type III areas => **Frequency and Time**

Zooniverse-Solar Type III tracker

Post Data Processing

Density Based Clustering Algorithm (DBSCAN)

- Clustering based on the **distance matrix**
- **Eps (ε)** : Maximum distance between shapes & **Min_samples**: Minimum number of neighboring shapes

NOTE! A cluster cannot contain shapes from the same user!!!

Zooniverse-Solar Type III tracker

Post Data Processing

Steps

A. Receive meta-data => **pixel coordinates**

B. Cluster the shapes

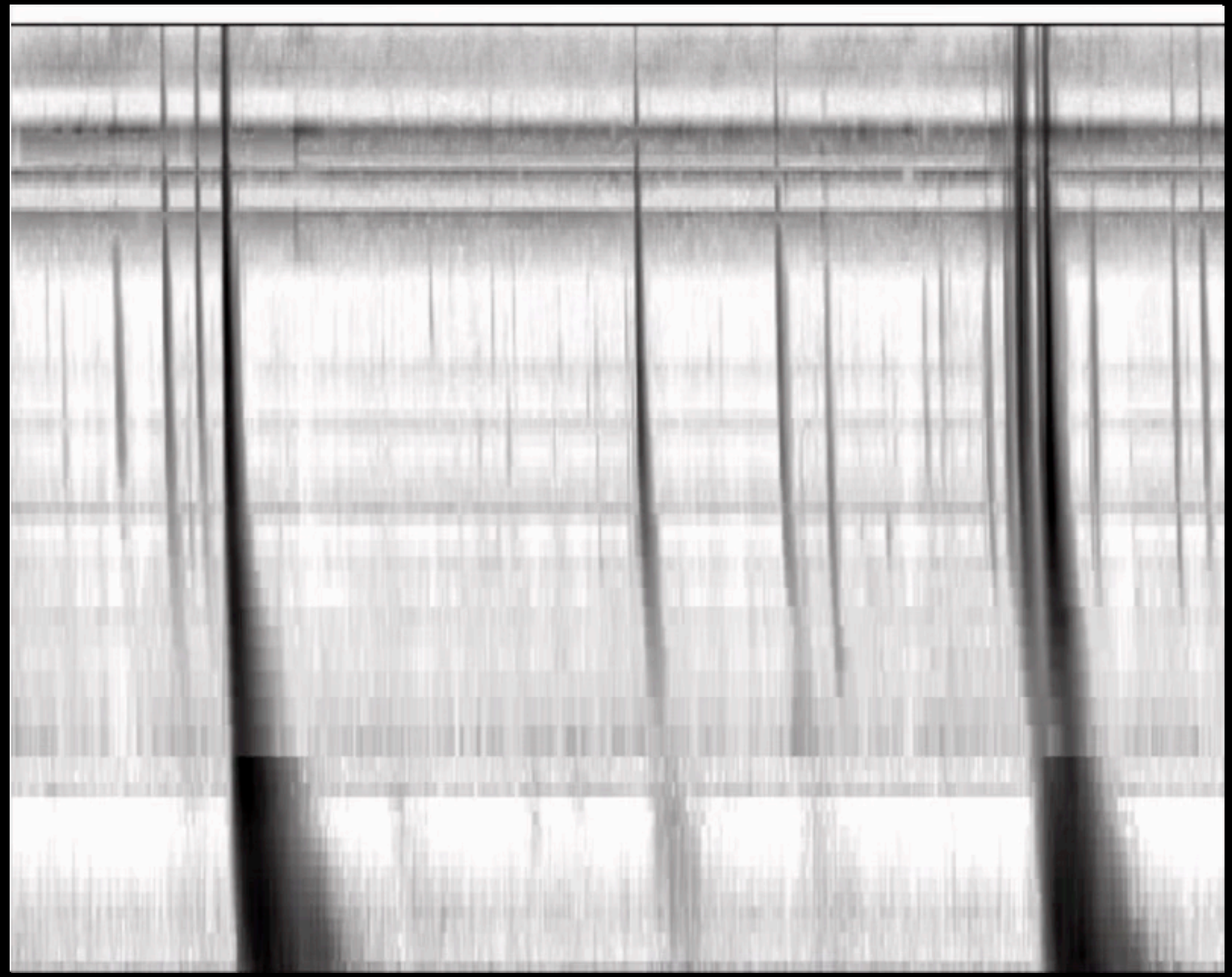
B1. **IoU** = $\frac{Intersection}{Union}$

B2. **Distance** = **1-IoU,** $0 \leq distance \leq 1$

B3. Perform a Density Based Clustering Algorithm

Zooniverse-Solar Type III tracker

Project walk through



BACK UP

4 kHz-1MHz (TNR)

500 kHz-16MHz (HFR)

Selected frequencies => 4kHz-8MHz => avoid HF noise