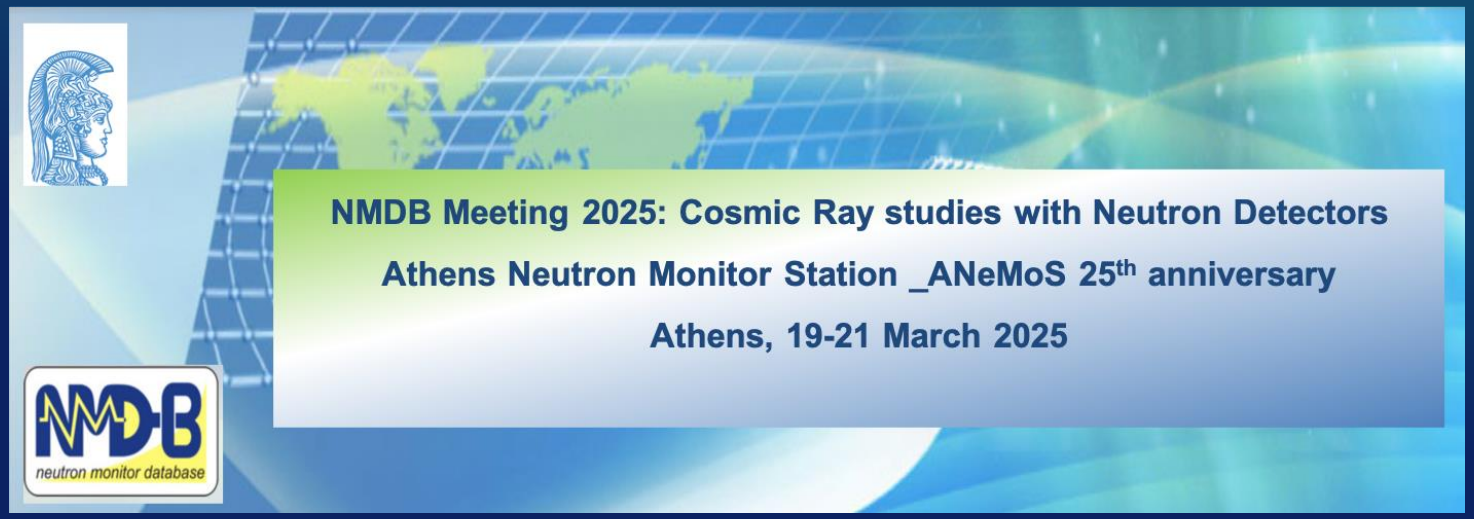
# ARTEMIS–JEAN LOUIS STEINBERG (ARTEMIS-IV/JLS)

# MULTICHANNEL SOLAR RADIO SPECTROGRAPH

# UPGRADING THE INSTRUMENT & A STUDY OF TYPE III BURSTS




F. G. SMANIS

HERON LAB, Dept. of Physics/University of Thessaly

Greece

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# Outline

- *The ARTEMIS-JLS Multichannel Radio Spectrograph*
- *Topology – Antennas – Records – Data*
- *Upgrading the instrument*
- *A study of Type III bursts*
- *Combined observation with other instruments (ground and space)*
- *Summary*

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# ARTEMIS IV J.-L. STEINBERG

## Appareil de Routine pour le Traitement et l'Enregistrement Magnetique de l' Information Spectral

### The Franco Hellenic Solar Radio Spectrograph at Thermopylae, Greece

### observing the Sun at 20 to 650 MHz 365 days/year

- The Solar Radiospectrograph (ARTEMIS-IV) is in operation at the Thermopylae Satellite Station since 1996.
- It was developed by the late professor Costas Caroubalos, in collaboration with J.-L. Bougeret (Observatoire de Paris-Meudon) and their groups. Initially operated by A.Kontogeorgos and P. Tsitsipis of the Lamia TEI
- The HERON LAB, Department of Physics, University of Thessaly has undertaken its development, in close collaboration with the University of Athens and the University of Ioannina.
- The observations extend simultaneously from the base of the Solar Corona (650 MHz) to about 2 Solar Radii (20 MHz) with time resolution 1/10-1/100 sec. The operation is fully automated and is controlled by standard PCs.
- The ARTEMIS-IV publications and Quicklook Spectra are available at the ARTEMIS-IV web page (http://web.cc.uoa.gr/~artemis); high resolution data are made available to collaborating groups on request.
- ARTEMIS dynamic spectra are used by the Radio Monitoring site, at https://secchirh.obspm.fr/

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Πανεπιστήμιο Ιωαννίνων

# Multichannel Radio Spectrograph ARTEMIS IV-JLS

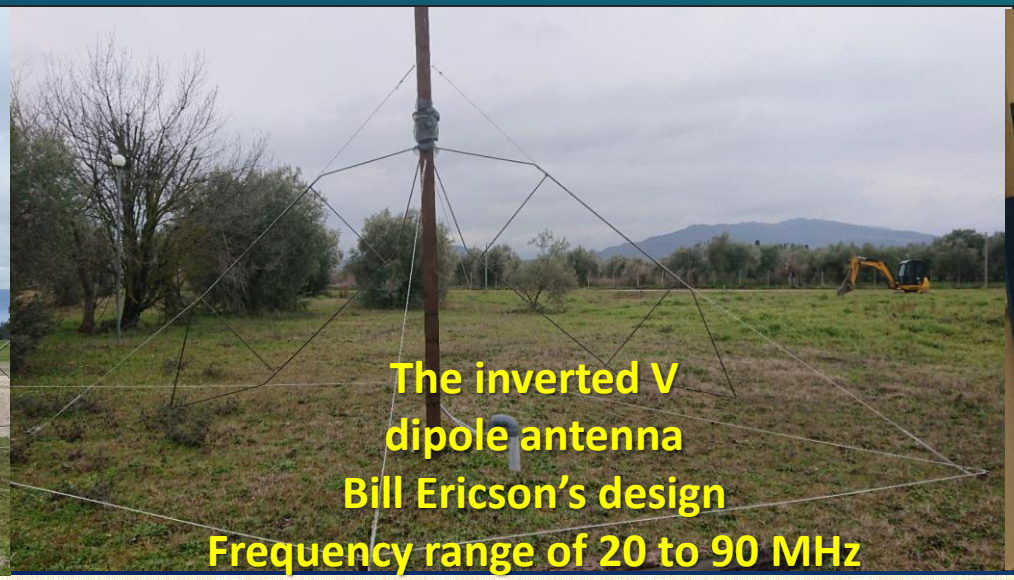
- The instrument records dynamic spectra (radio flux as a function of time and frequency); our observations can be combined with images from the Nançay Radioheliograph, for 3D positional information.

- The ARTEMIS-IV contribution in the study of solar radio bursts comprises two main aspects :

  - Firstly, the investigation of new spectral characteristics, since its high sampling rate favours the study of fine structures in radio events.
  - Secondly, the combined study of solar bursts with NRH, the Nançay Decametric Array, the WAVES receivers, as well as with microwave, optical and EUV data.

# Topology - The previous system

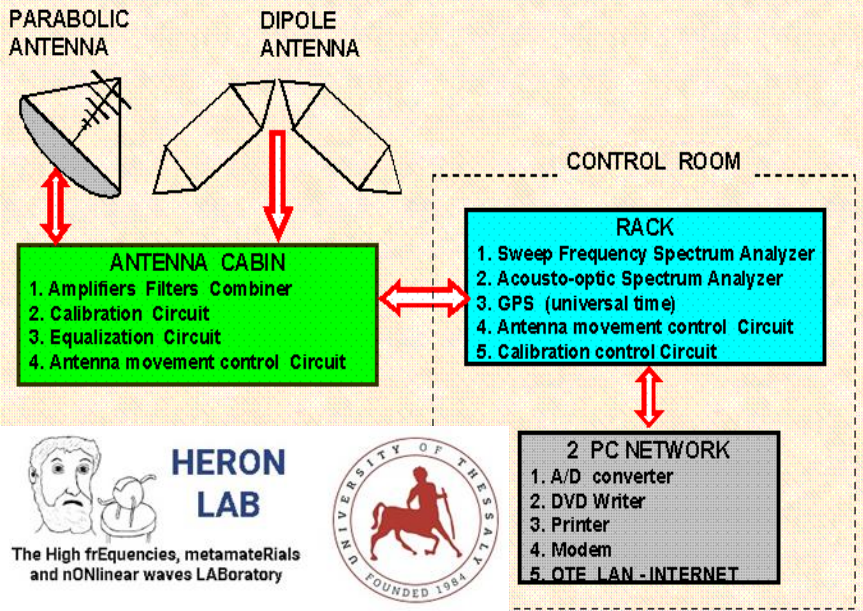
*ARTEMIS IV*
Parabolic (7m diameter) and log-period antenna
Frequency range of 110 to 650 MHz



The inverted V dipole antenna
Bill Ericson's design
Frequency range of 20 to 90 MHz

*The old control room*

*Topology of solar radiospectrograph at Thermopylae*

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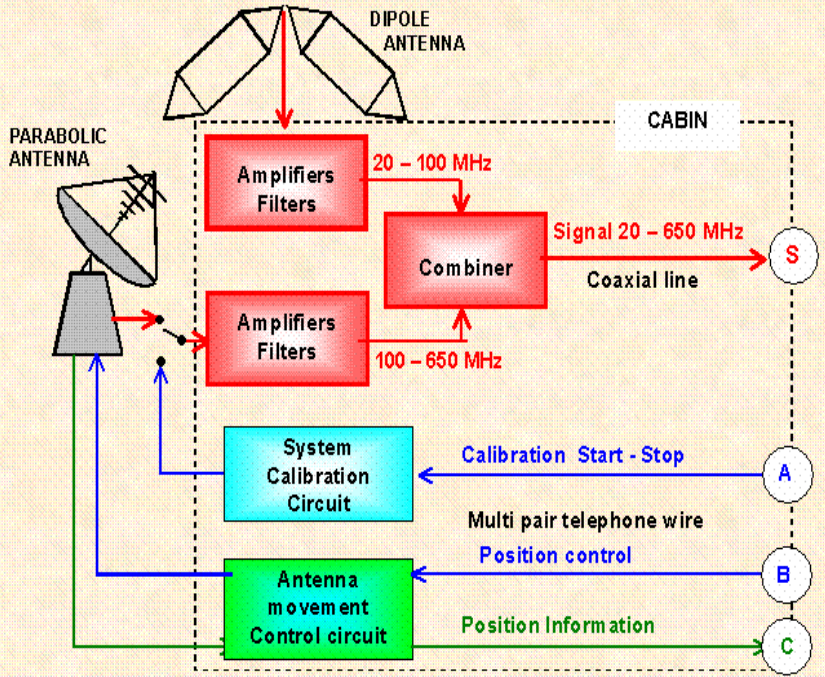
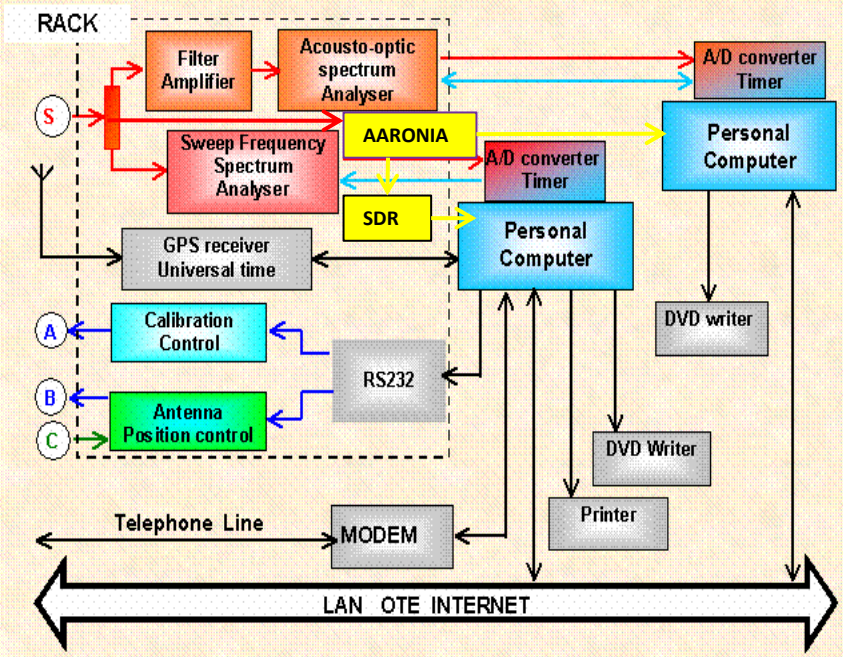
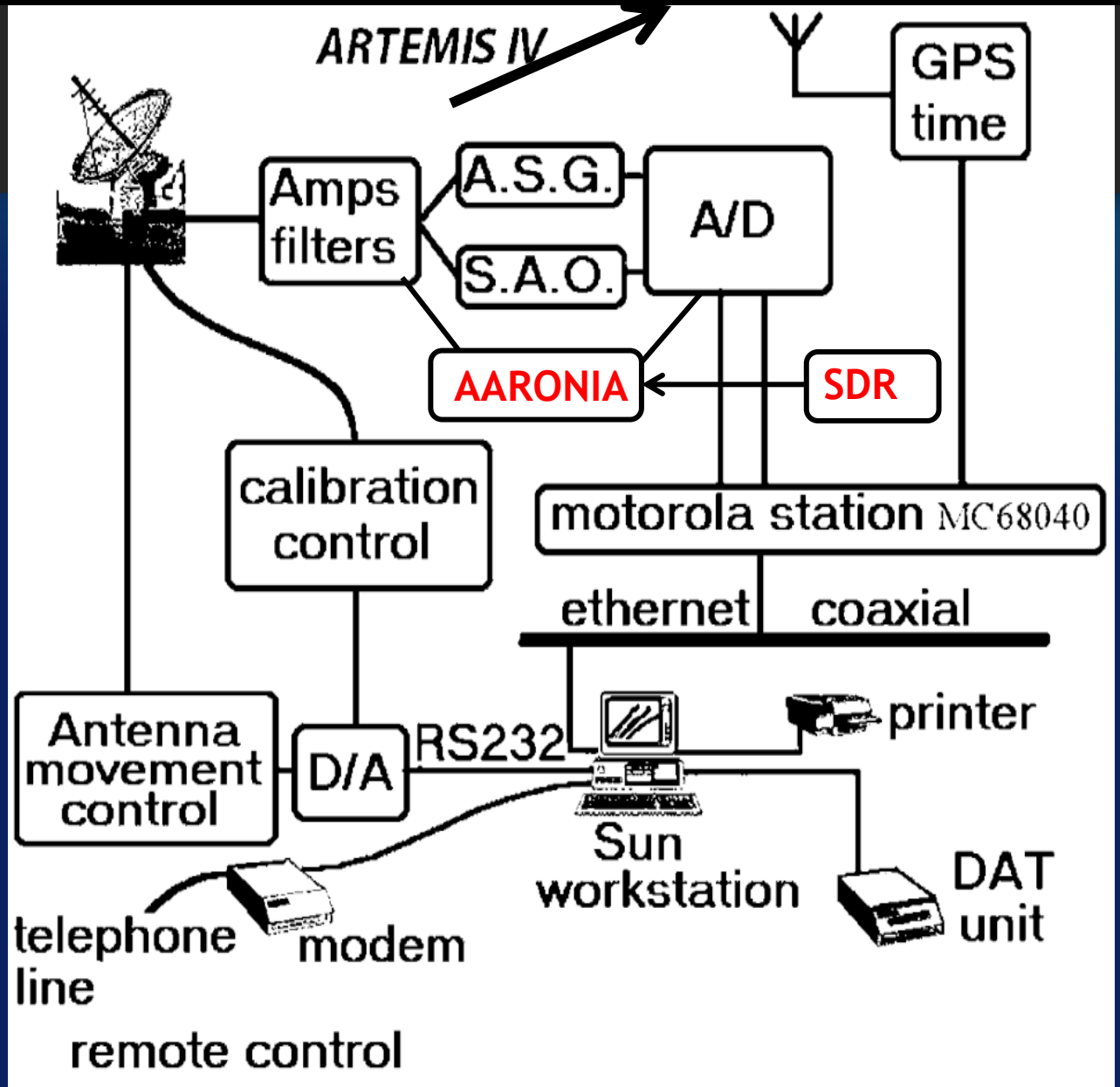
*Antennas and cabin*




*Control room*



# ARTEMIS - J.L.S. block Diagram




❖ ***ASG***

- Spectral range: 20MHz –650MHz
- Sampling : 10 values/sec
- Observation Height : ≈ 1.02 – 1.8 $R_{\odot}$

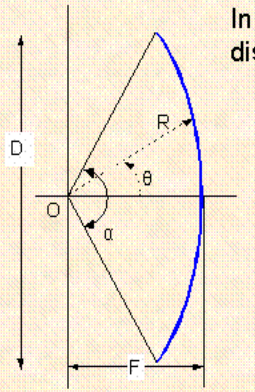
❖ ***SAO***

- Spectral range: 270MHz – 450MHz
- Sampling : 100 values/sec

Ref: Kontogeorgos et.al_2006 ,Tsitsipis et.al_2007

# The reception

## The parabolic reflector



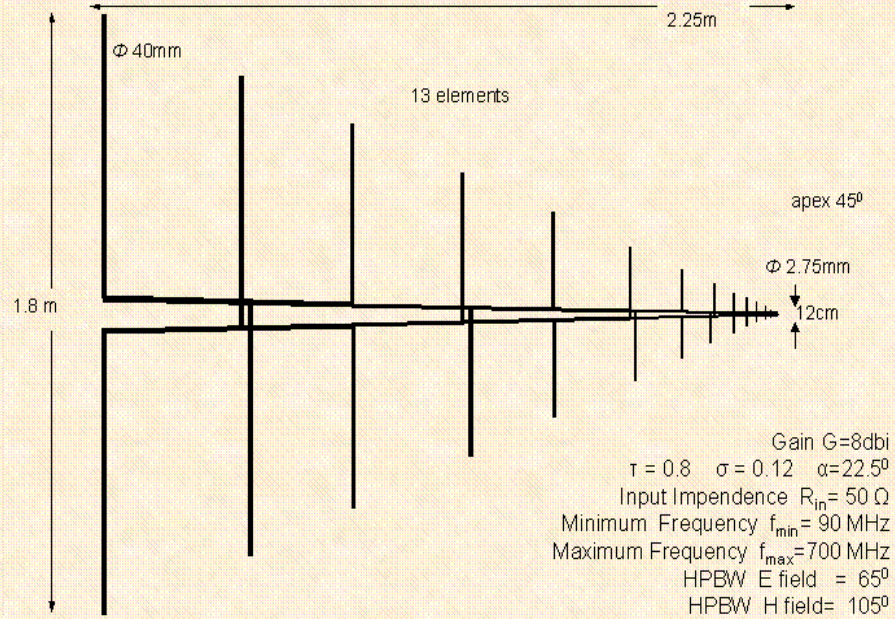

In polar coordinates the radial distance R from the center O is

$$R = \frac{2 \cdot F}{1 + \cos(\theta)}$$

θ the angle from the x axis

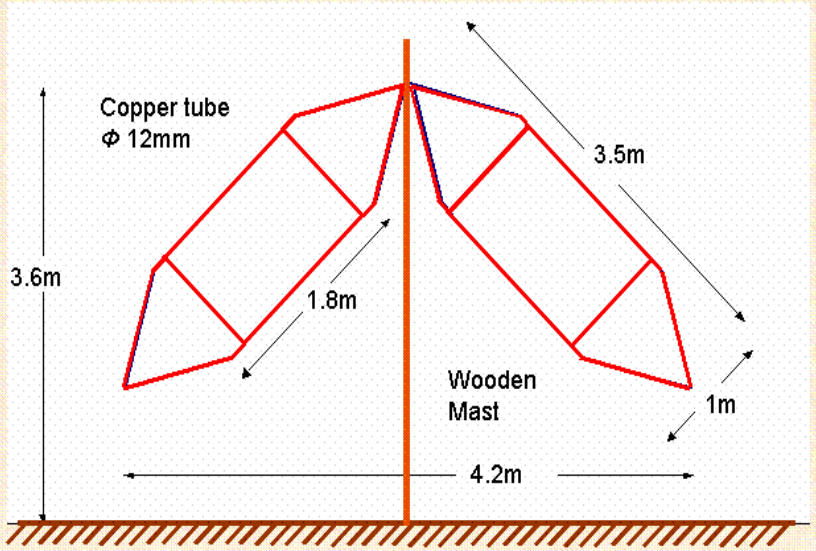
Focal length F = 3 m
Angular span α = 120$^0$
Diameter D = 7 m
Effective Aperture $A_{ef}$=38.5m$^2$
Gain G=17dbi @ f=100MHz
Gain G=26dbi @ f=300MHz
Gain G=32dbi @ f=600MHz

## The log_period antenna



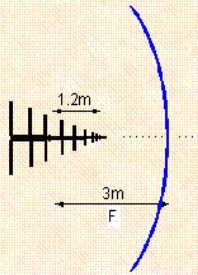

Gain G=8dbi
τ = 0.8 σ = 0.12 α=22.5$^0$
Input Impendence $R_{in}$= 50 Ω
Minimum Frequency $f_{min}$= 90 MHz
Maximum Frequency $f_{max}$=700 MHz
HPBW E field = 65$^0$
HPBW H field= 105$^0$

## Inverted V Dipole Antenna for 20 - 100MHz Band

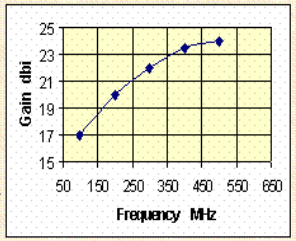



## From the antennas to the control room

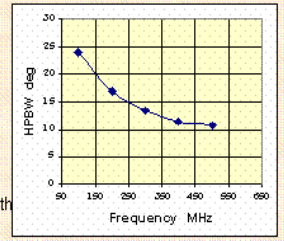
### The log-period antenna feeding the parabolic reflector



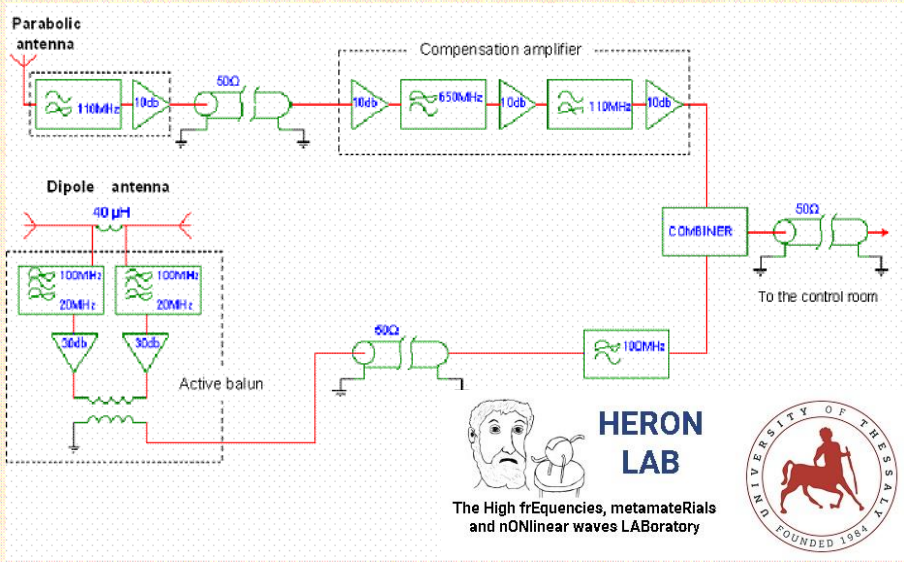

The log-period vertex is at a distance of 1.2m from the focal point of the parabola dish and 1.8m from the parabola vertex




The whole antenna gain for the receiving frequencies




The whole antenna Half Power Beam Width in degrees for the receiving frequencies




## The Rack

Antenna Position Control

Sweep Frequency Analyzer

GPS

Calibration Control

Acoustooptic Frequency Analyzer

Computers

Aaronia Spectran V5 RSA

# Database

## The ARTEMIS–Jean Louis Steinberg (ARTEMIS-IV) Multichannel Radiospectrograph of the University of ATHENS

Last Update: Tuesday, April 12, 2022

**LOCATION: Thermopylae, GREECE**
**(Lat: 38° 49′ N, Lon: 22° 41′ E)**

**The ARTEMIS IV Parabolic Antenna**

*Left to Right: X. Moussas, A. Kontogeorgos, P. Preka-Papadema, C. Bouratzis, C. Alissandrakis, C. Caroubalos, A. Nindos, C. Zographos, A. Hillaris, S. Patsourakos, P. Tsitsipis.*

***Photograph by S. Armatas***

**THE ARTEMIS-IV GROUP**

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Costas Caroubalos (*Deceased*)
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John Polygiannakis (*Deceased*)
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G. Dumas (*Retired*)

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Theofanis Smanis (tsmanis@uth.gr)

**TECHNICAL DESCRIPTION**

**QUICK LOOKS and ARTEMIS IV Type II List (1998-2011):**
For ARTEMIS IV FITS files please use the ARTEMIS JLS DATABASE.

***The compilation of the Data Base was supported by the Onassis Foundation Grant 15153 and the University of Athens Research Committee Grant, 15018.***

For assistance you may contact Assistant Professor P. Preka-Papadema or Dr Alexander Hillaris.

**PUBLICATIONS:**

**SOLAR SURVEY ARCHIVE**

**Link to the ATHENS NEUTRON MONITOR**

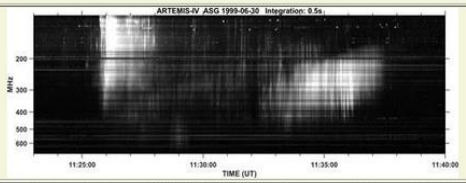
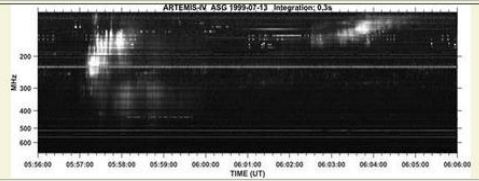
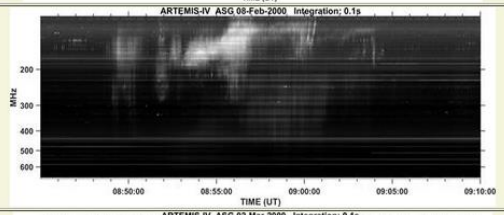
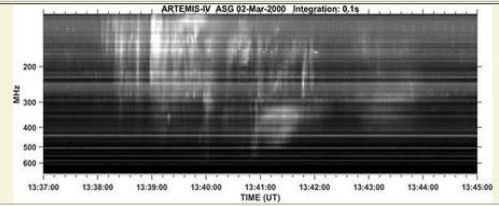
**The RADIO AND PLASMA WAVE INVESTIGATION on the WIND Spacecraft**

**Link to the UNIVERSITY OF ATHENS SPACE PHYSICS GROUP**

**The CESRA list of data centres (observatories) providing solar radio observations**

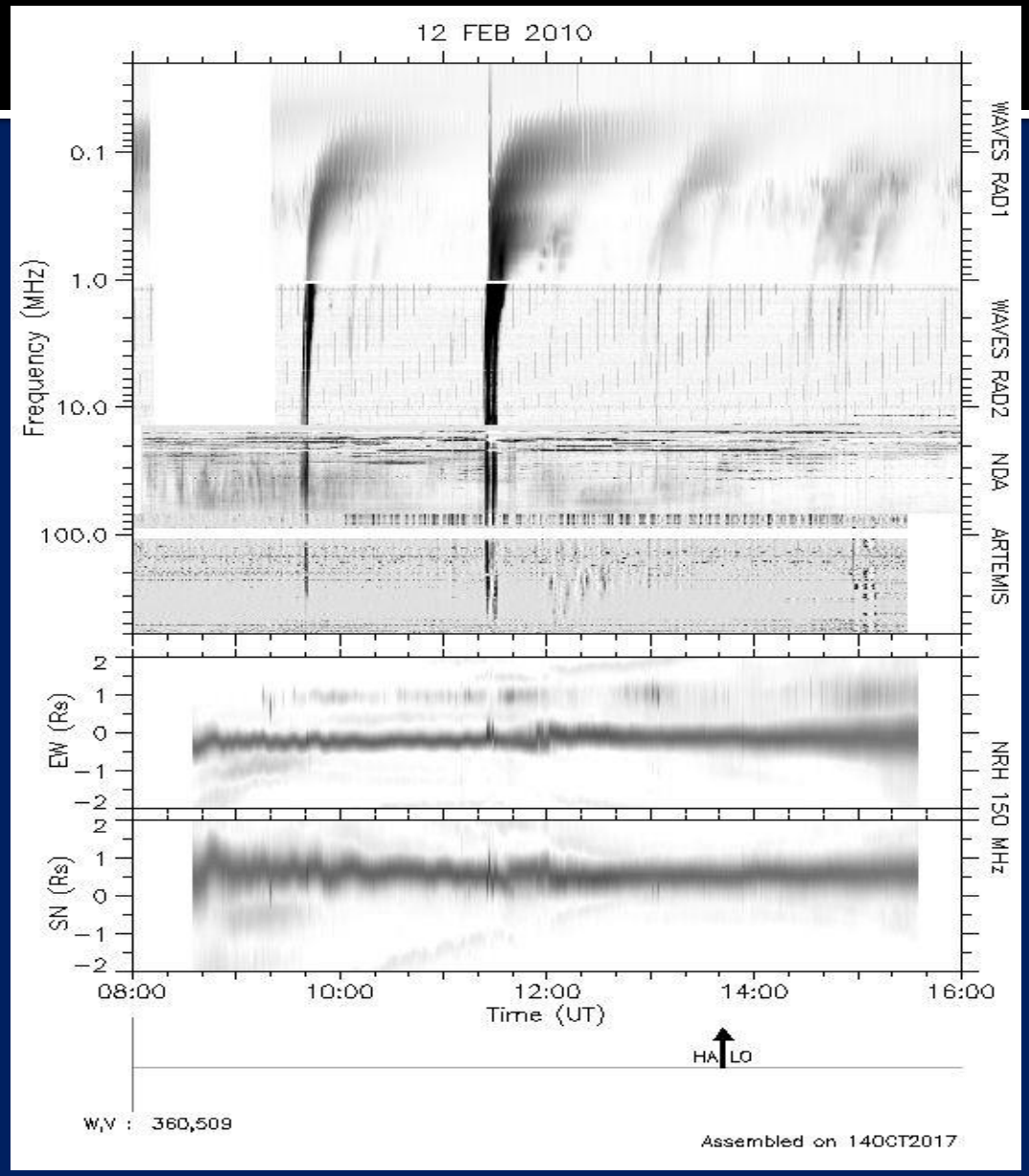
http://artemis-iv.phys.uoa.gr/

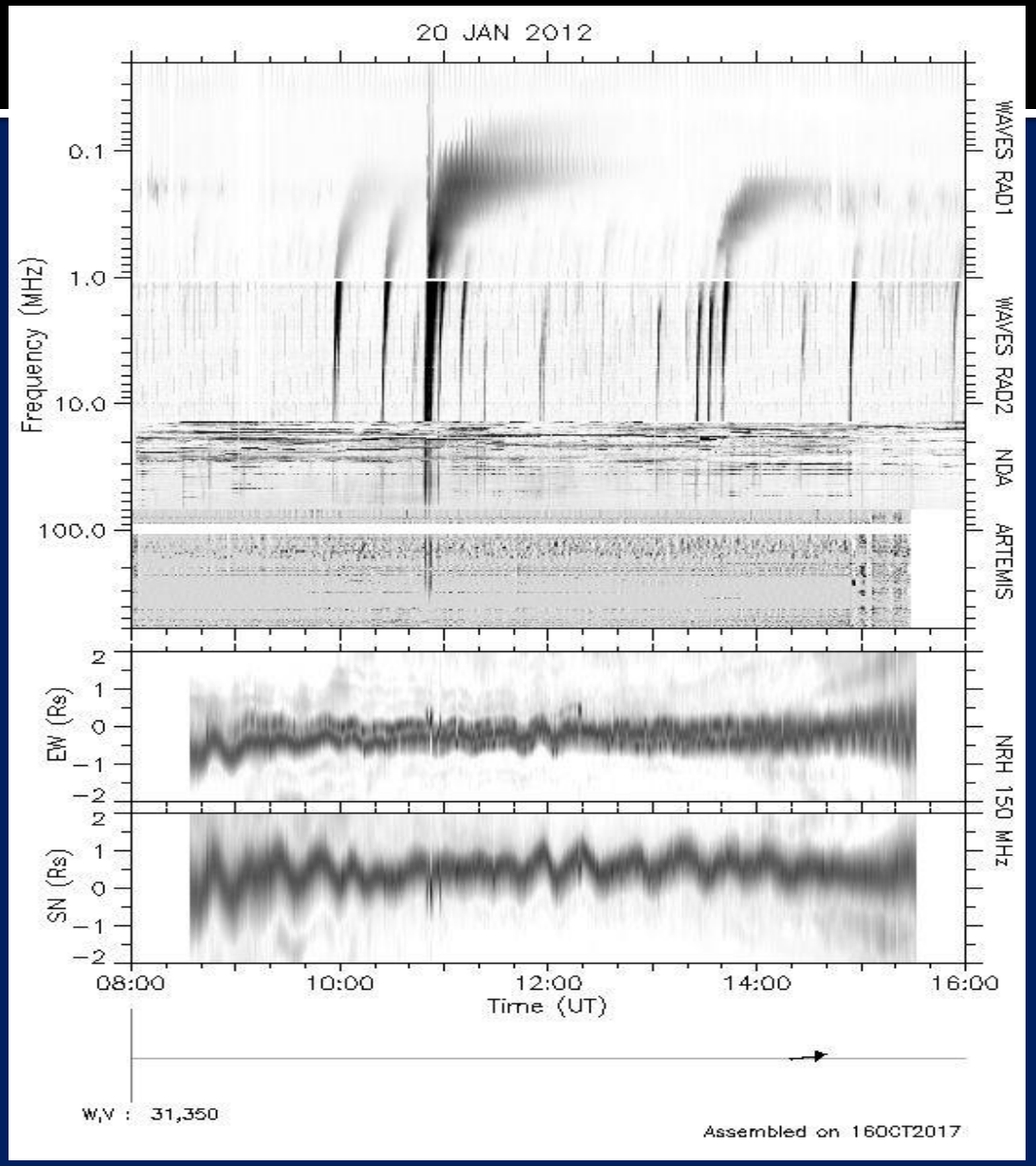
## The ARTEMIS–Jean Louis Steinberg Radiospectrograph (ARTEMIS-IV) GALLERY of Selected Dynamic Spectra

| Date | Dynamic Spectrum | Description (and links to publications) |
|---|---|---|
| 1999-June-30 |  | ASG Dynamic Spectrum 630-110 MHz Type IV preceded by Type III G See Caroubalos & al (2004) |
| 1999-July-13 |  | ASG Dynamic Spectrum 630-110 MHz Type II/IV preceded by Type III G See Caroubalos & al (2004) |
| 2000-February-08 |  | ASG Dynamic Spectrum 630-110 MHz Type II/IV preceded by Type III G See Caroubalos & al (2004) |
| 2000-March-02 |  | ASG Dynamic Spectrum 630-110 MHz Type III GG, and type II/IV See Caroubalos & al (2004) |

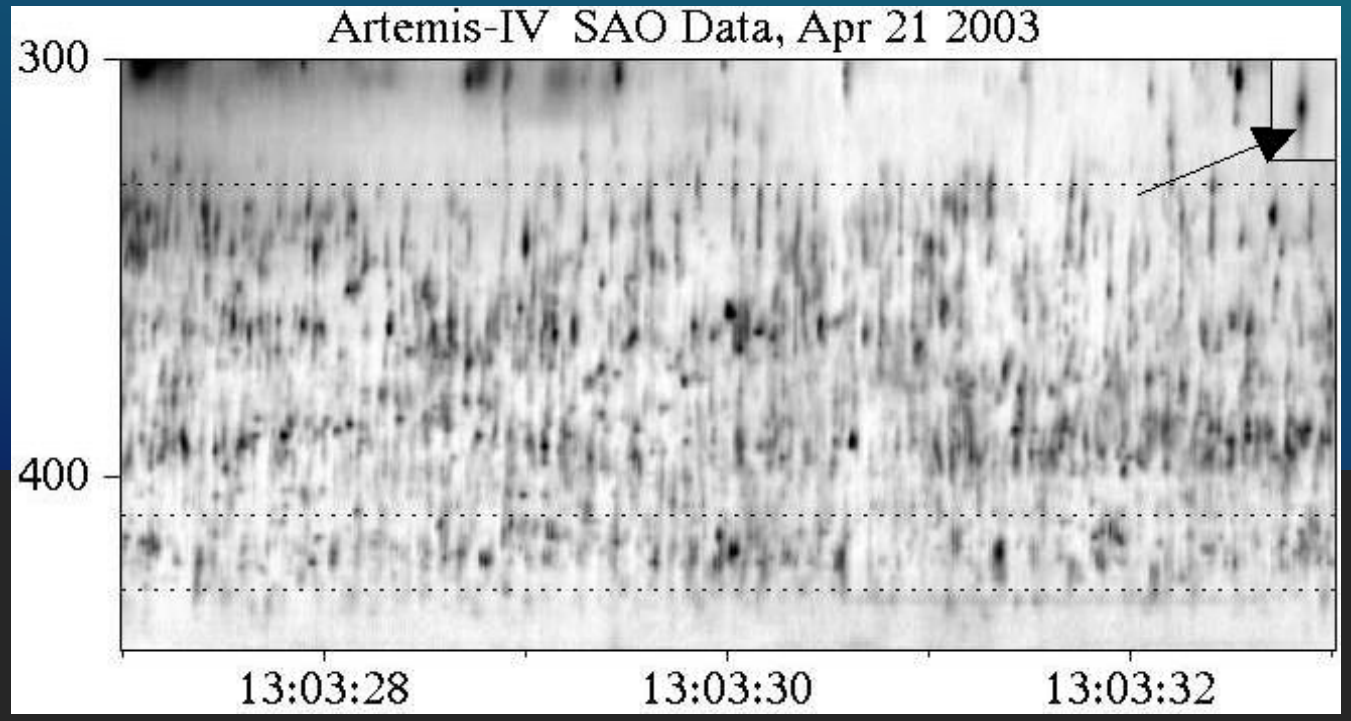
Gallery

# SAMPLE RESULTS from https://secchirh.obspm.fr



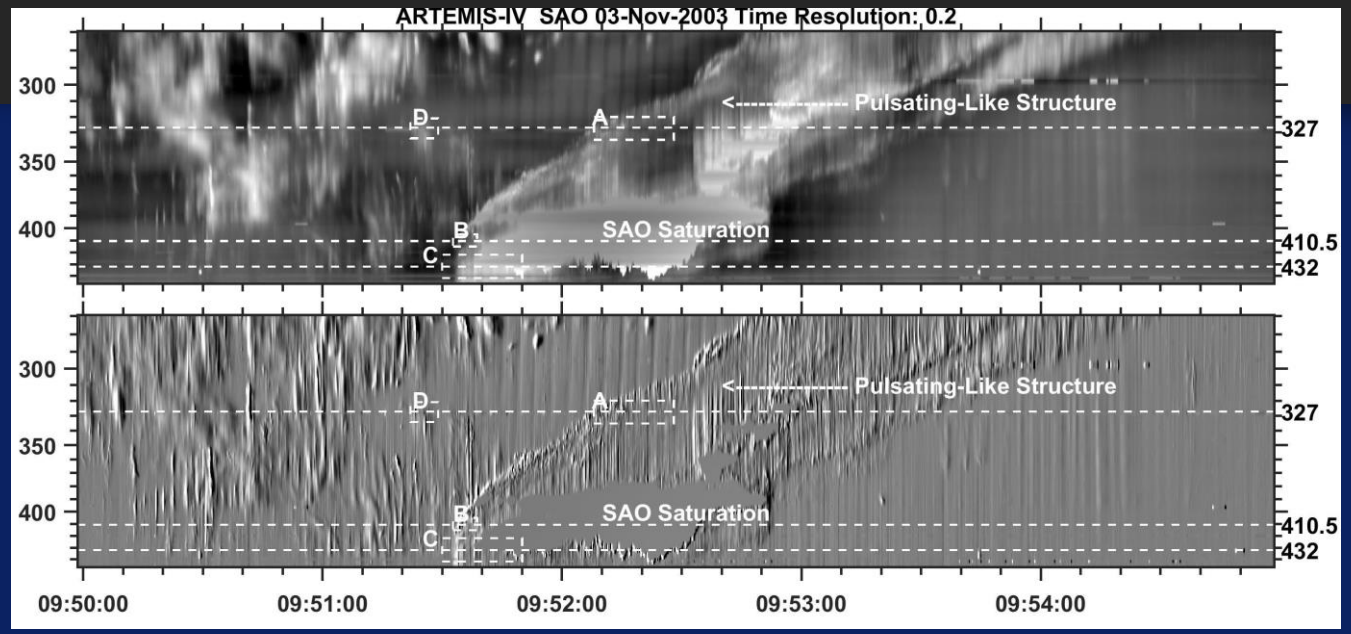



# Sample results




spikes

Bouratzis et al., 2016




a complex event

Armatas et al., 2022

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Solar radio spectrograph

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2022

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- The University of Athens has granted the right of usage of ARTEMIS-IV/JLS to the HERON LAB

- The HERON LAB scientific team has undertaken:
  a) both the operational support and the modernization of the solar radio spectograph ARTEMIS-IV/JLS by designing and forming new microwave devices by using the technology of metamaterials and
  b) participation to the analysis, study and data processing that will be received by the solar spectograph .

# The ARTEMIS team of HERON LAB

## Dr. Giorgos P. Veldes, Head of the HERON LAB

### PHD Candidates (Advisor: Dr. Giorgos P. Veldes, Ass. Prof.)

- **Theofanis G. Smanis,**(member of Adv. Committee: P. Preka-Papadema, Ass. Prof. (ret.)

  Thesis: Solar Physics

- **Ioannis Georgiou, (**member of Adv. Committee, Dr. A. Hamini, LESIA)

  Thesis: Design and implementation of a prototype digital receiver using metamaterials technology for the ARTEMIS- IV/JLS solar radio spectrograph

- **Evaggelos Benatos, (**member of Adv. Committee, Dr. A. Hamini, LESIA)

  Thesis: Design and implementation of a prototype analogue receiver using metamaterials technology for the ARTEMIS-IV/JLS solar radio spectrograph

### Postgraduate Students (Adv: Dr. Giorgos Veldes)

- **Aikaterini Maria Nika,**

  Thesis: Energetic electron populations in space and its correlation with type III radio bursts

- **Konstantinos Bakopoulos**

  Thesis: Programmable metamaterials

- **Evaggelos Koumpouras**

### Technical Laboratory Staff

- **Konstantinos Sagias**

After visiting Nancay in France and following the standards of ORFEES the improvements of the facilities with the new shelter and control room are in order for the new ARTEMIS at Thermopylae in Greece

ORFEES / NANCAY / FRANCE


ARTEMIS / THEMOPYLAE / GREECE

# The old ARTEMIS IV topology vs The new ARTEMIS IV/JLS Shelter & Control room


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WORK STATION AND STORAGE – HERON LAB – UNIVERSITY OF THESSALY

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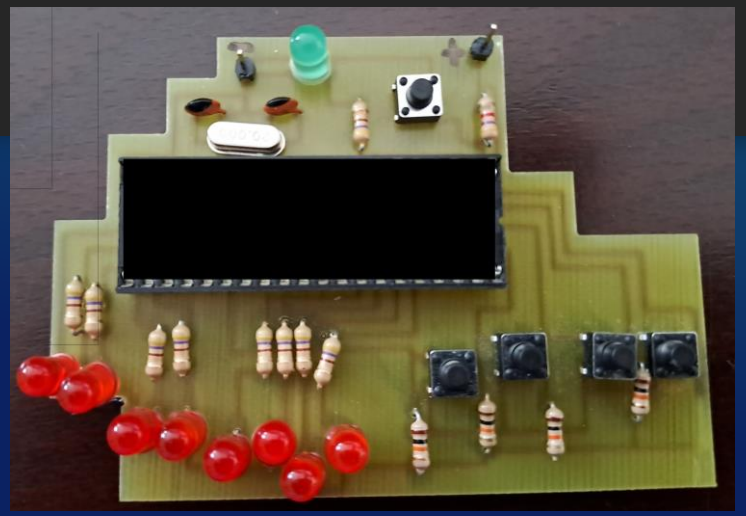
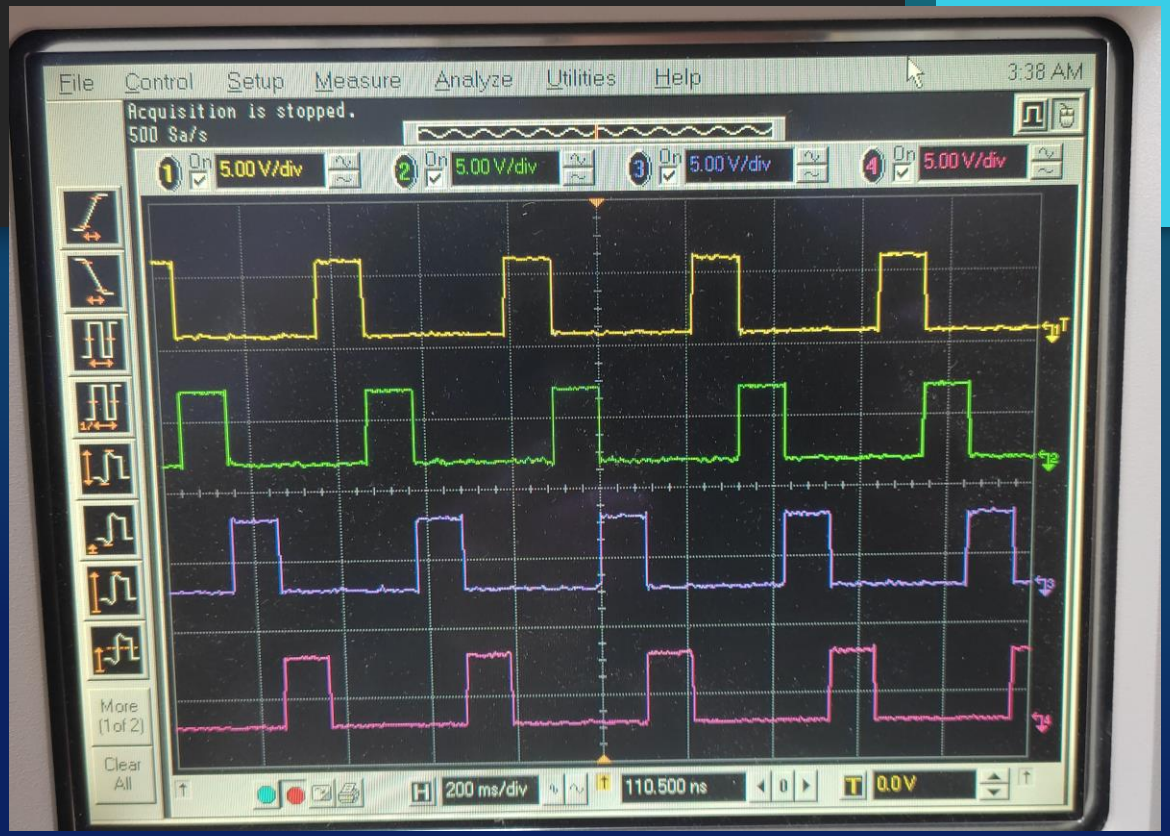
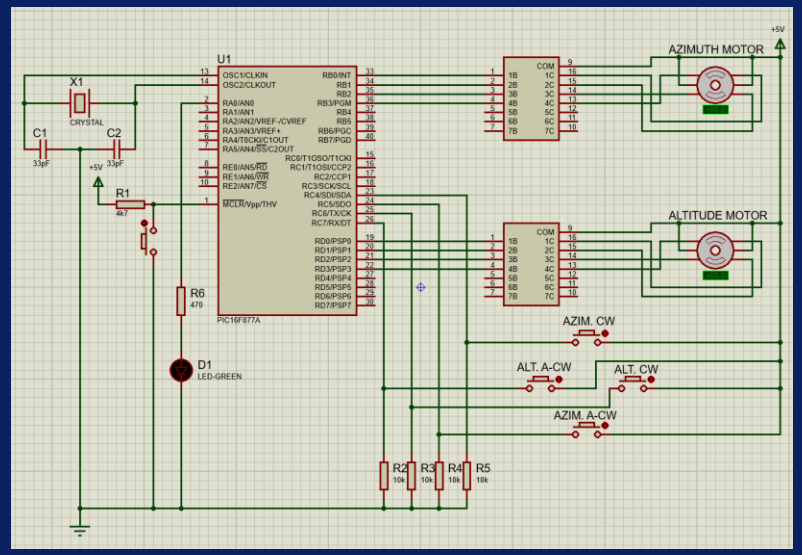
# New Control System for the Parabolic Antenna

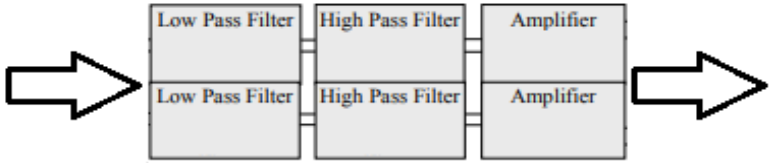




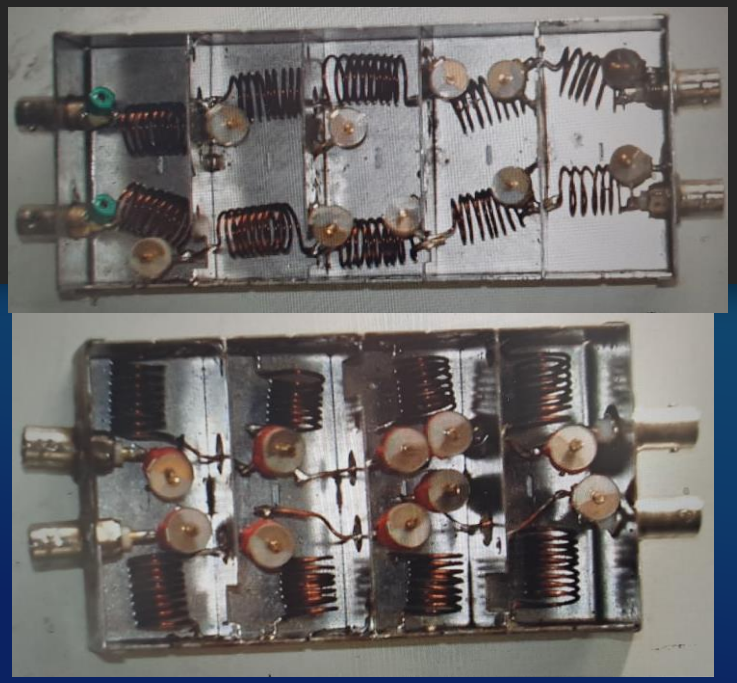



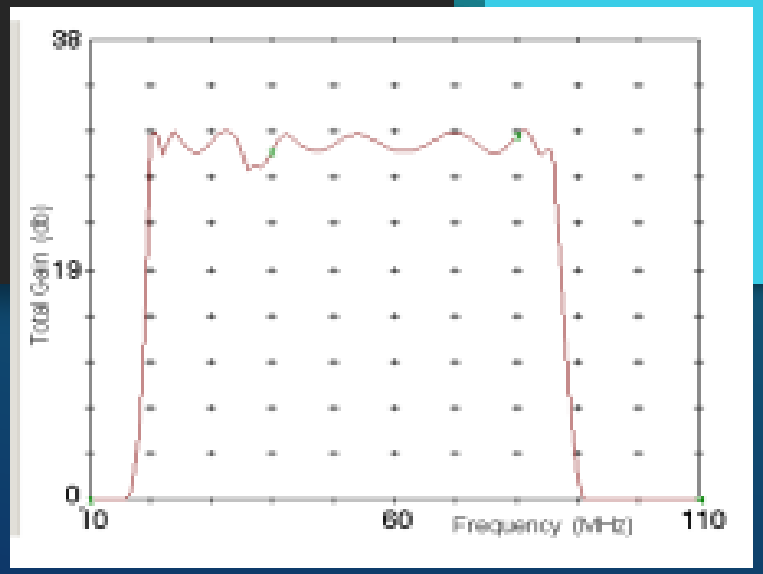
# New Filter Design with transmission lines metamaterial technology

From:



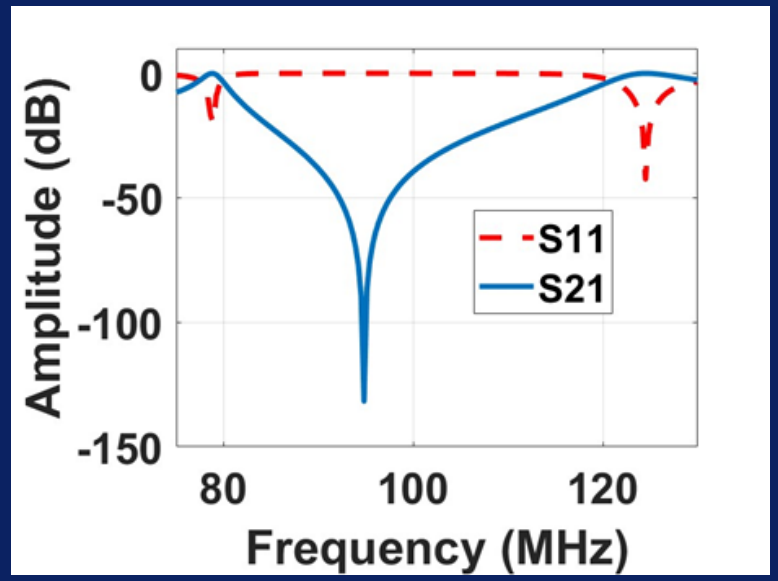

The combination of a LPF and a HPF pass the signal of a frequency band from 20 MHz to 88 MHz using conventional analog technique

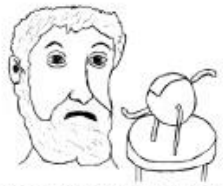





To:


Band-Reject Filter (BRF) rejects the signals of a frequency band from 80 MHz to 120 MHz using Composite Right/Left-Handed (CRLH) elements.



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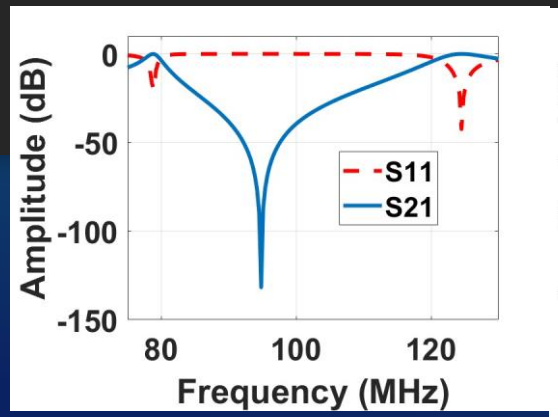
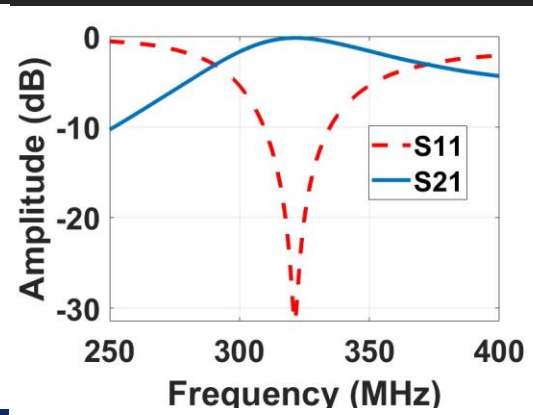
# New Filter Design with transmission lines metamaterial technology

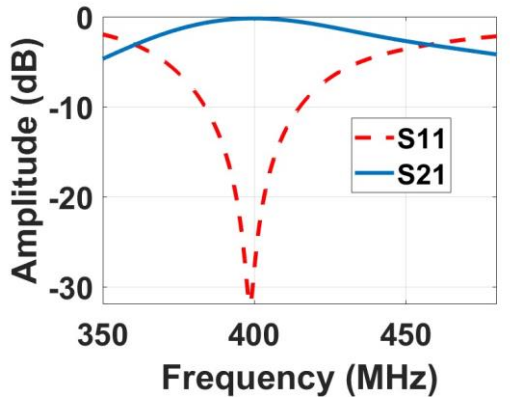
## Band Bank Filter

**BRF** Band Reject Filter

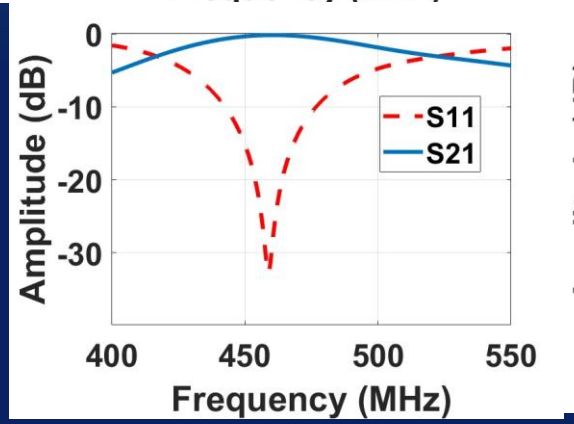
**BPF** Band Pass Filter

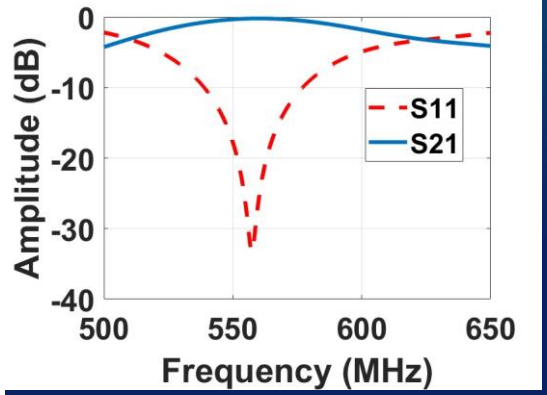


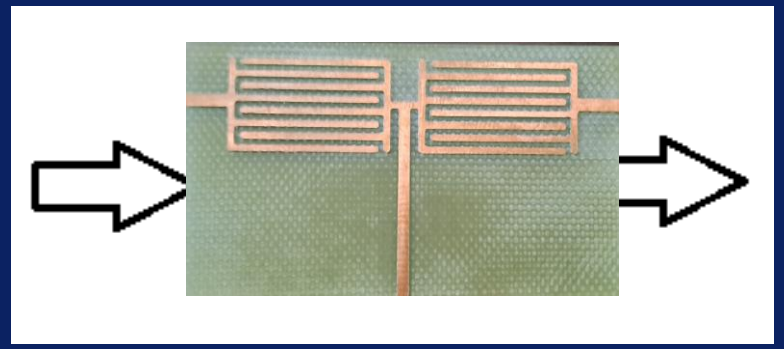







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# Computed Directivity of the Parabolic and log periodic (feed) antenna system

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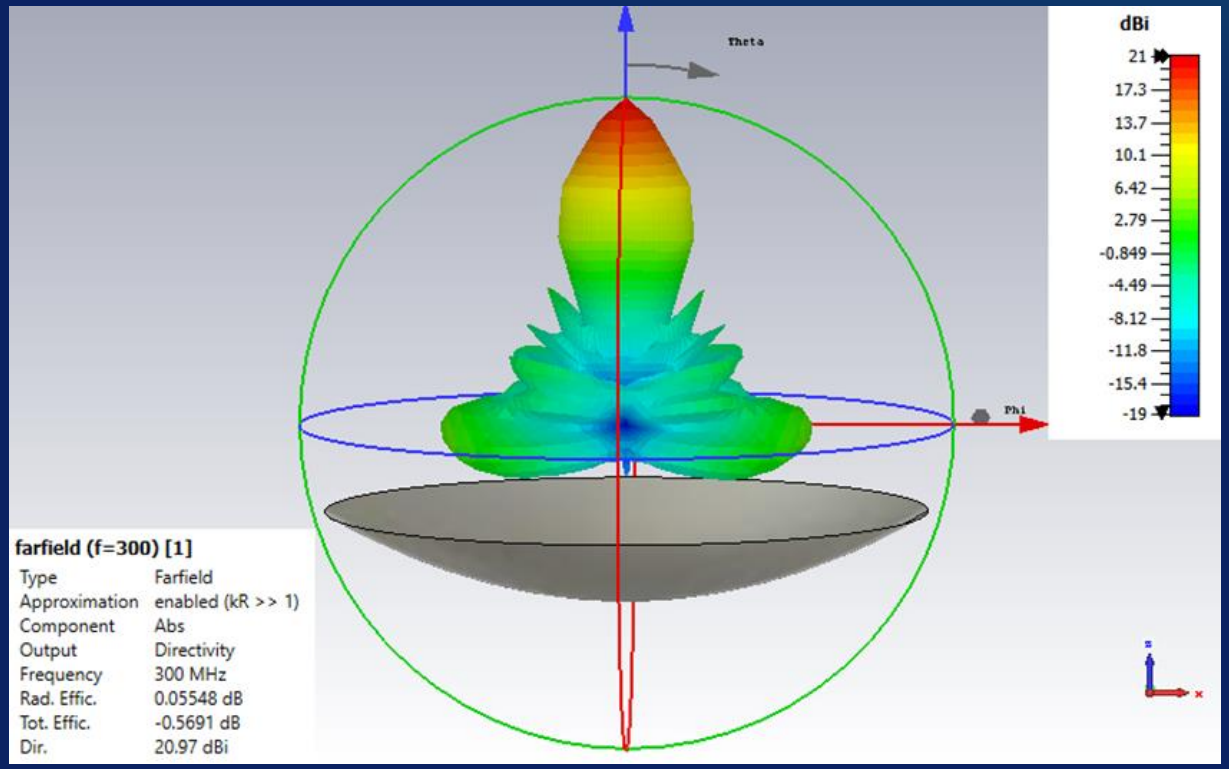
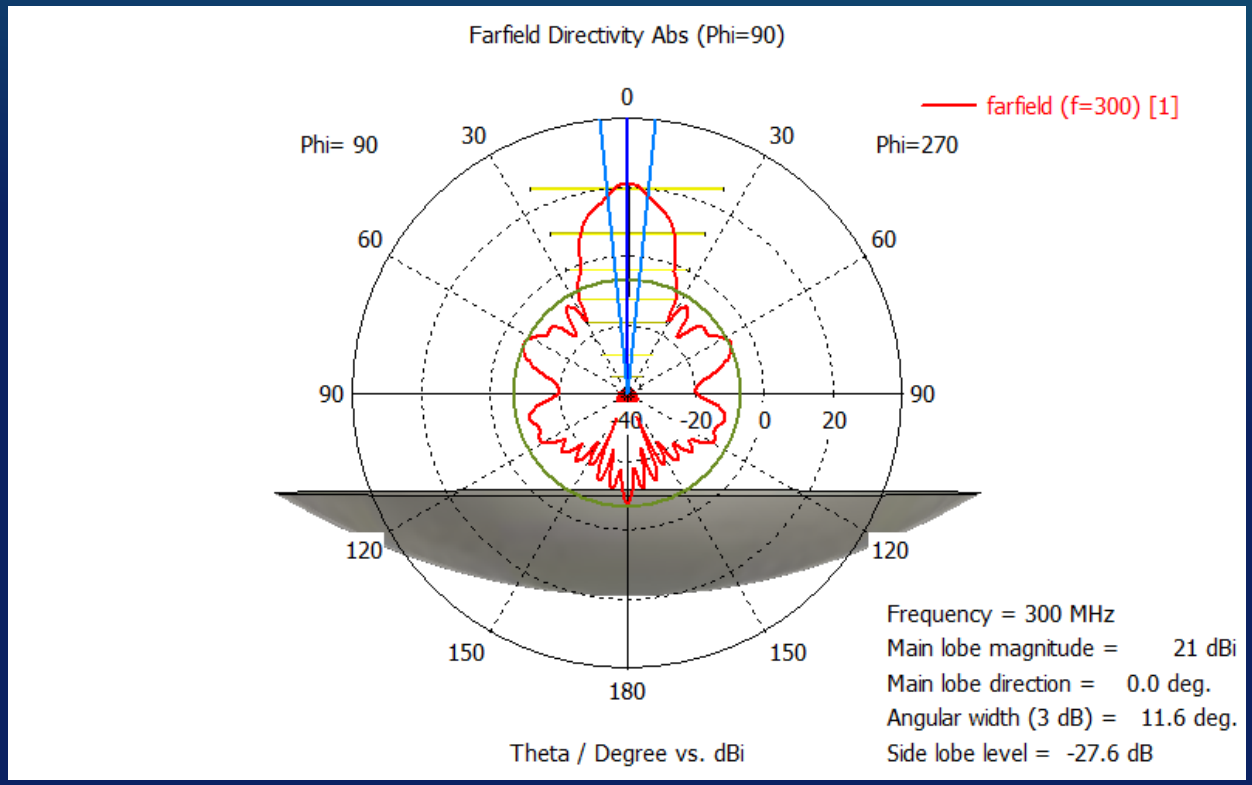
## Frequency: 300MHz

### 3D far field pattern




### 2D far field pattern



# Computed Directivity of the Parabolic and log periodic (feed) antenna system

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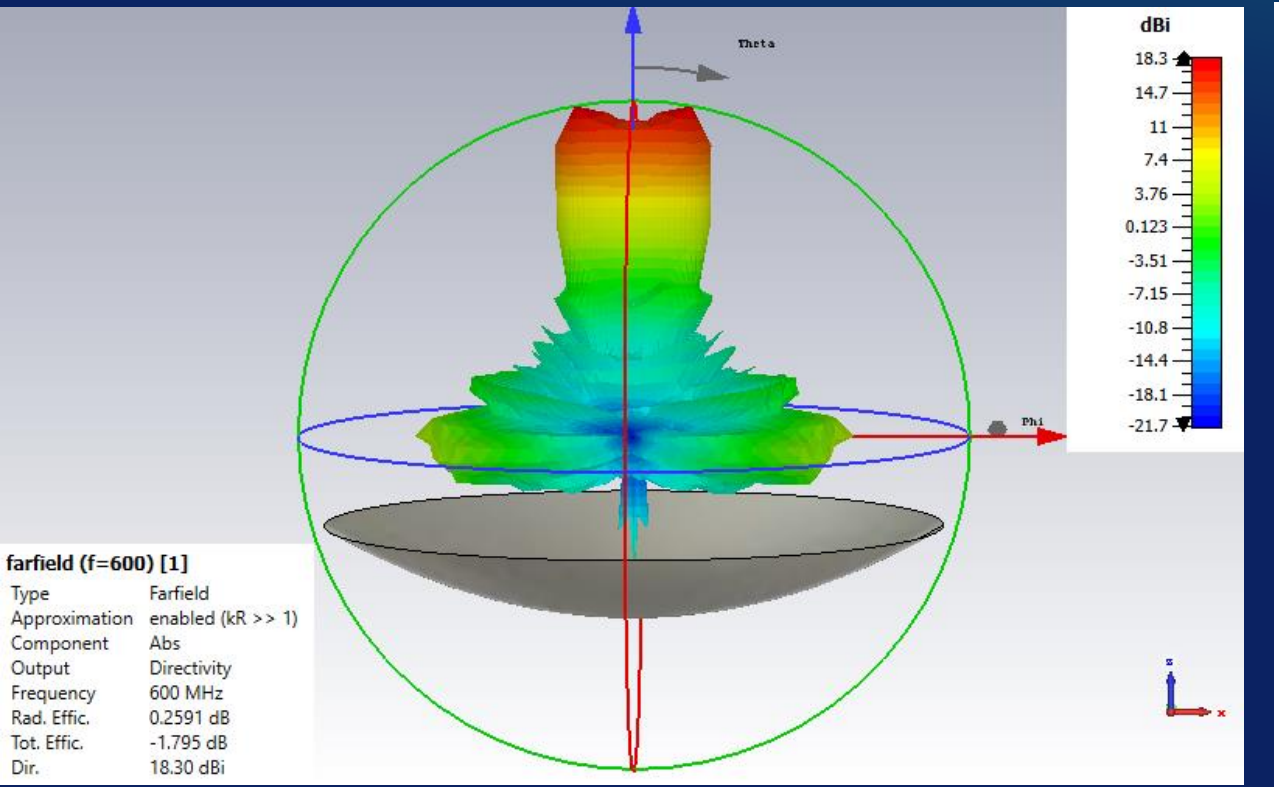
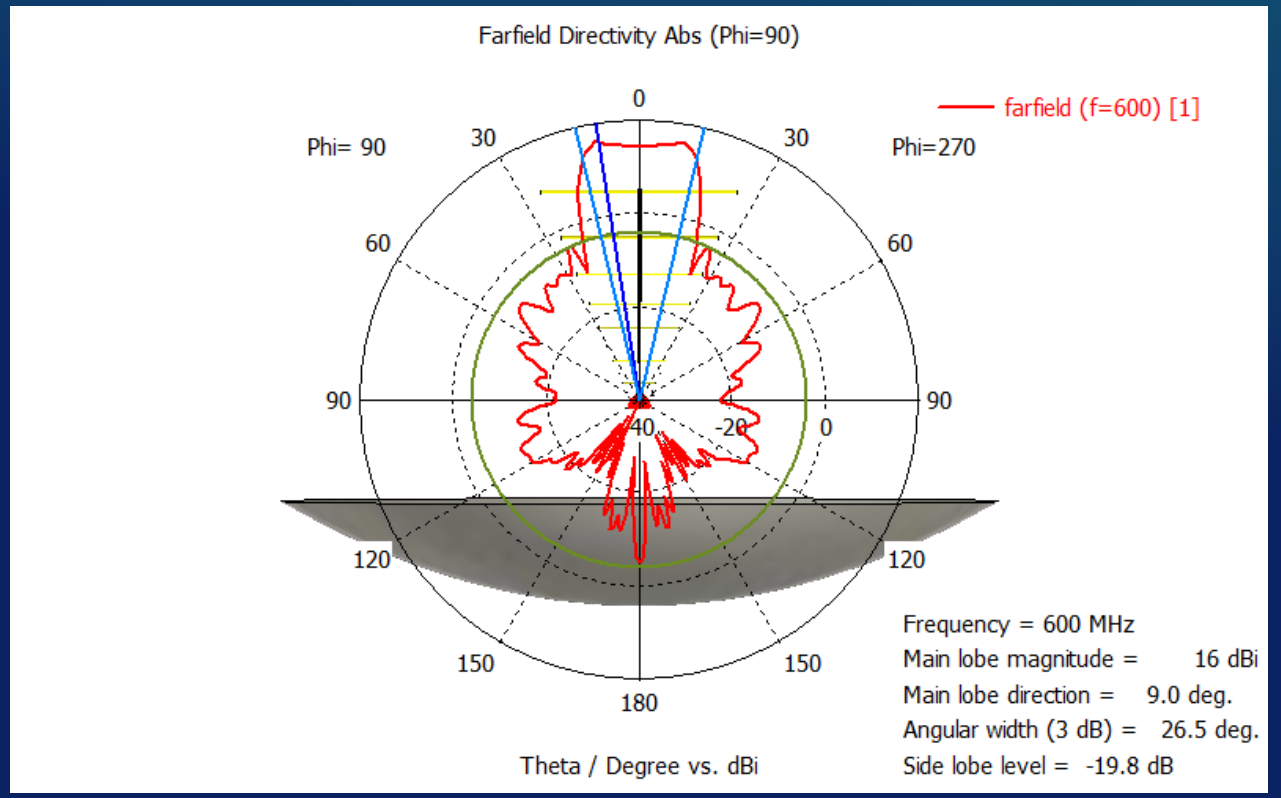
## Frequency: 600MHz

### 3D far field pattern




### 2D far field pattern



| Spectrum Analyzer | | Frequency range | Analog to Digital Converter |
|---|---|---|---|
| ARTEMIS | ASG: | Frequency range 20–650 MHz<br>630 channels of 1 Mhz<br>Resolution time 0,1 sec | 225 Ksamples/sec<br>4096 values |
|  | SAO: | Frequency range 270–450 MHz<br>128 channels of 1,4 Mhz<br>Resolution time 0,01 sec | 225 Ksamples/sec<br>4096 values |
| New ARTEMIS | FPGA | Frequency range 20-650 Mhz<br>5 sub-bands of 125 MHz<br>with 2048 channels each<br>Resolution time 0,01 sec | 250 Msamples/sec<br>16.192 values |

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# Full configuration of the new system

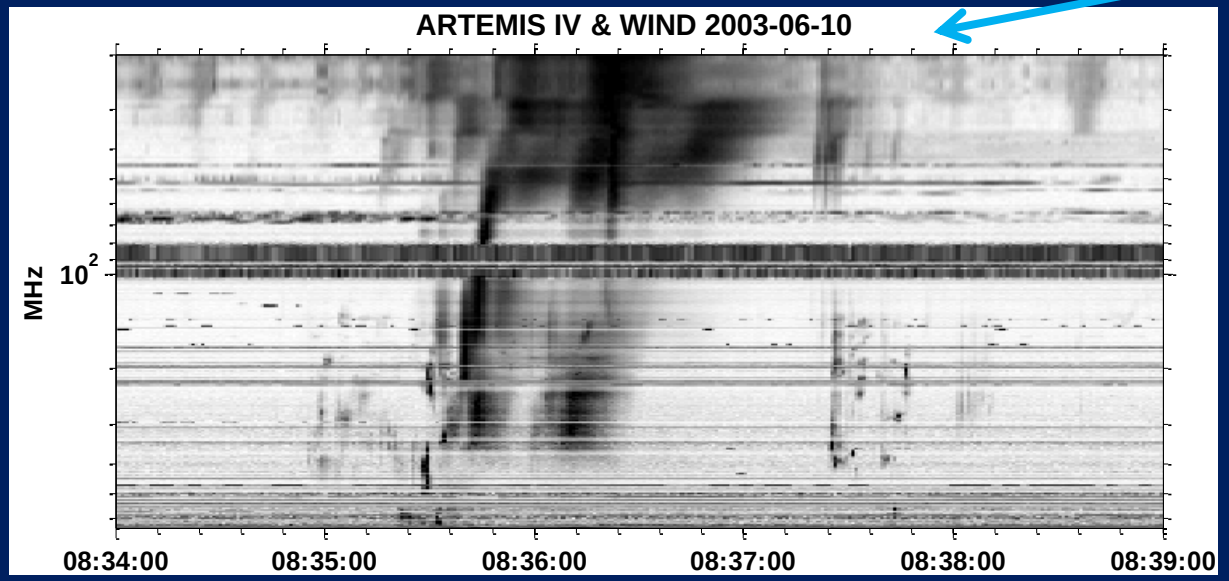
- FPGA
- 14 bit Analog to Digital Converter – 250 Msamples/s
- Radio frequency Interpolation (RFI)
- 1st Receiver calibration
- 2nd Flux calibration
- Average frequencies
- Data storage or real time presentation

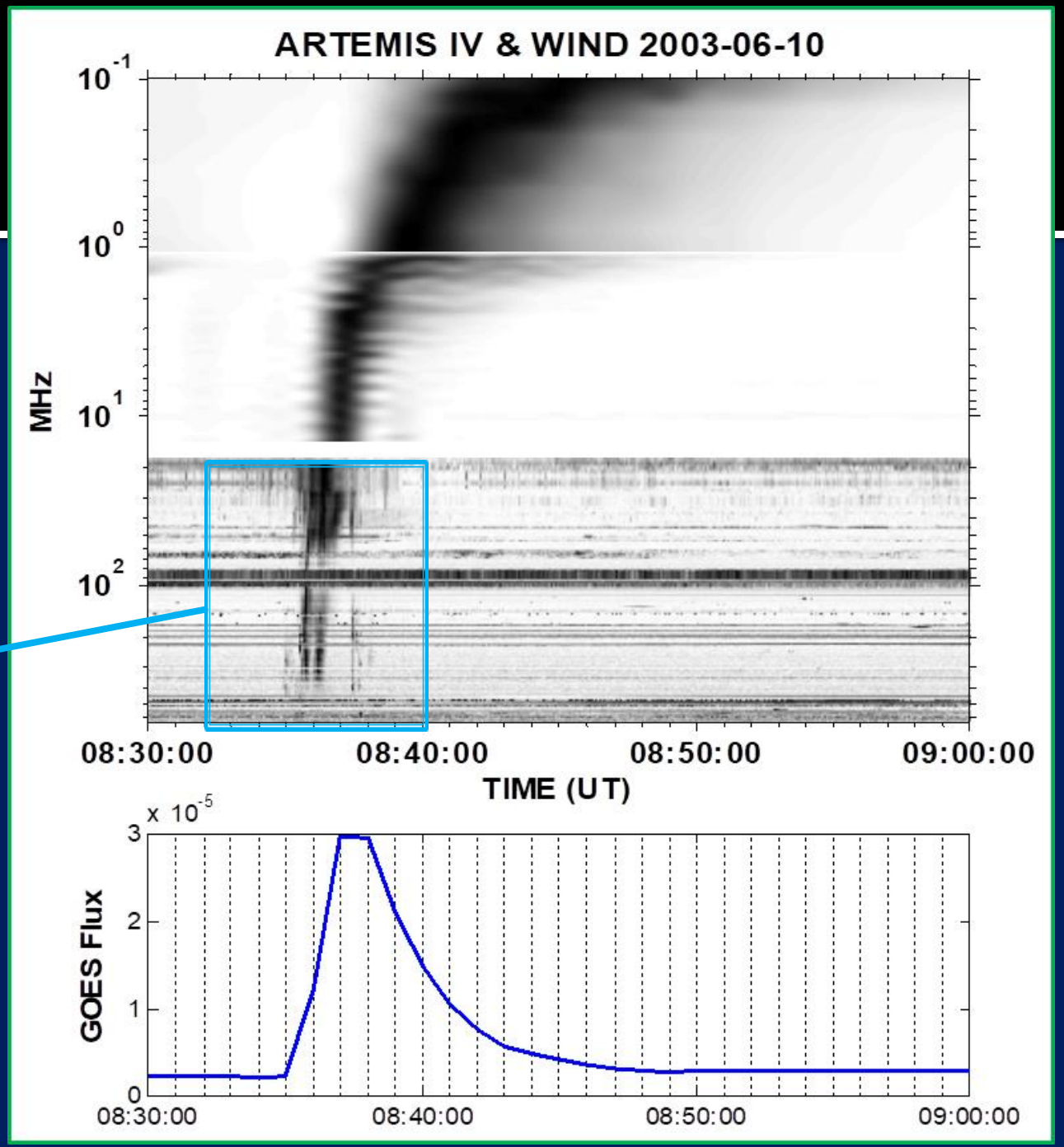
# PART 2 Study of Type III bursts

- Search for spikes and narrowband structures to type III bursts.
- To this purpose we examine spikes near the onset time and the starting frequency in type III burst dynamic spectra.
- To compare the characteristics of narrowband structures and type IIIs such as the frequency drift rate.
- To trace the propagation of energetic electron beams, moving with a velocity of about c/3 along coronal magnetic field lines.
- The occurrence of a type-III radio burst as a precondition for the detection of near-relativistic electrons ahead of more hazardous protons from Solar Energetic Particle (SEP) events

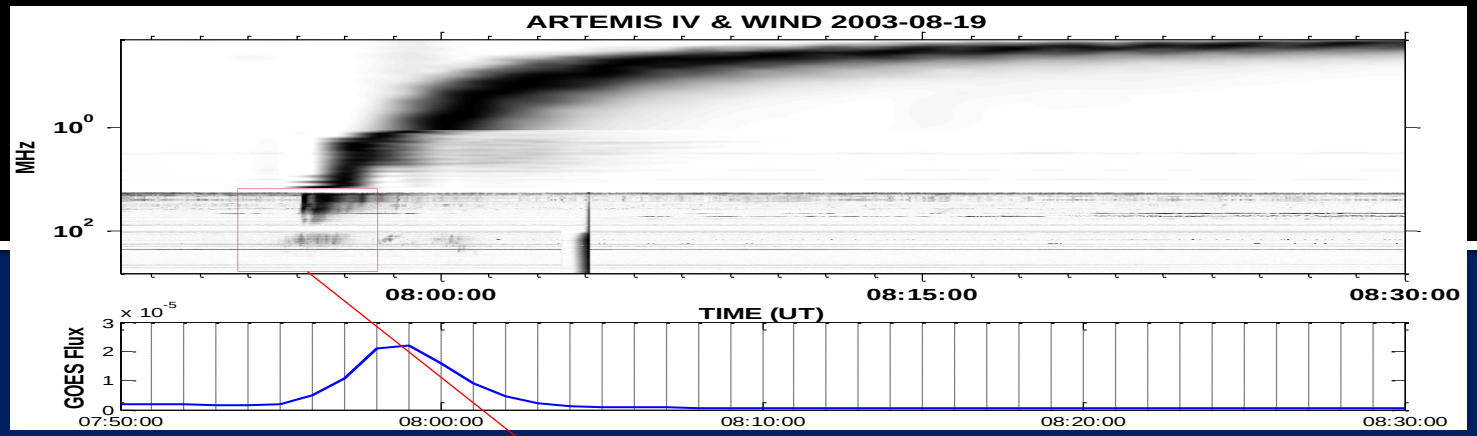
# Groups of type III bursts

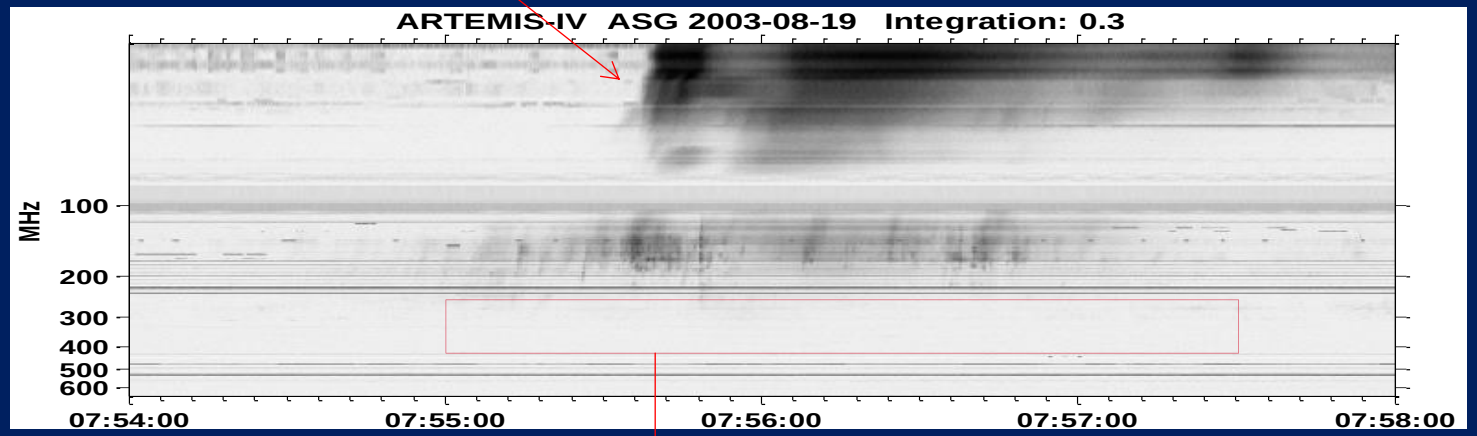
- Their duration increases with time due to exciter dispersion.
- They appear in groups of ten or more, often at the impulsive phase of flares.
- Low frequency (large scale) isolated events appear as extensions of high frequency (small scale) groups of type III bursts.

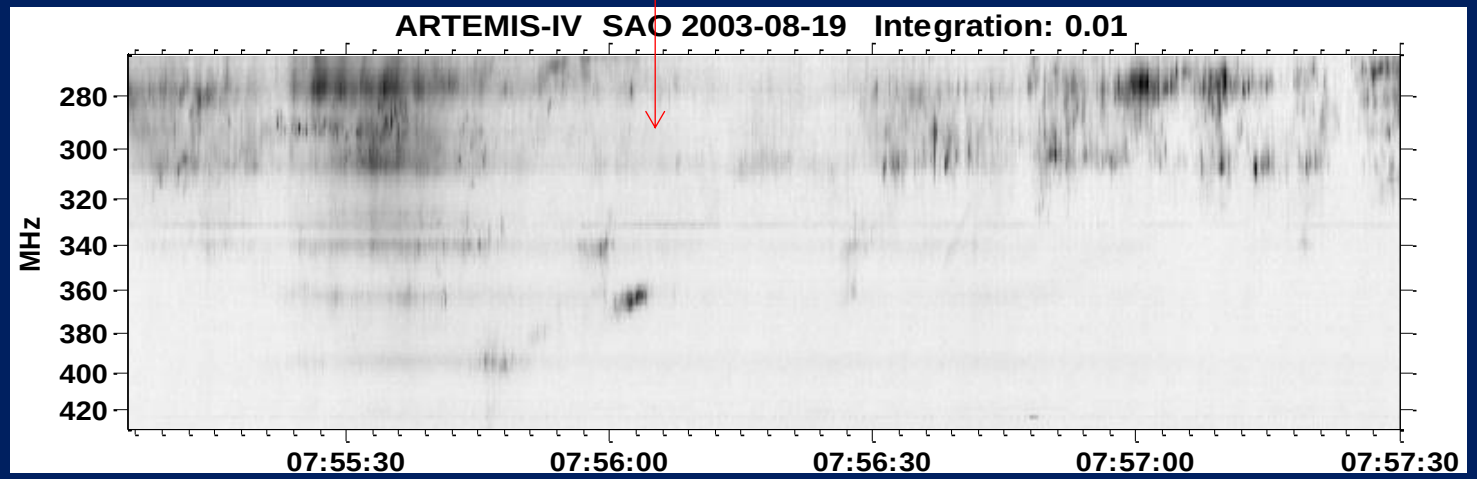


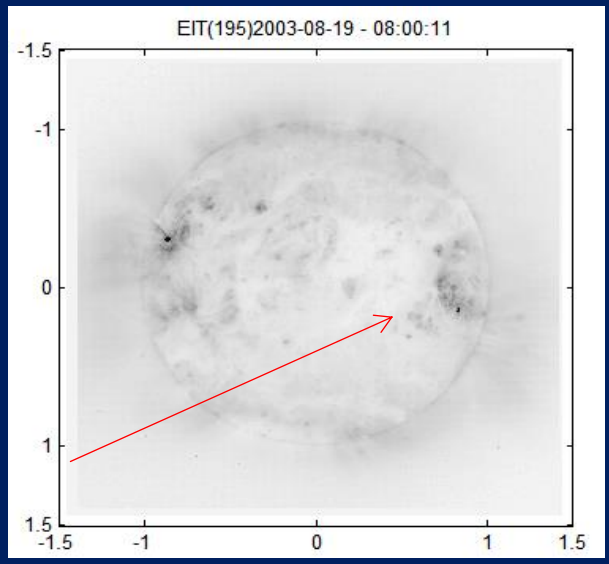



# 19 August, 2003



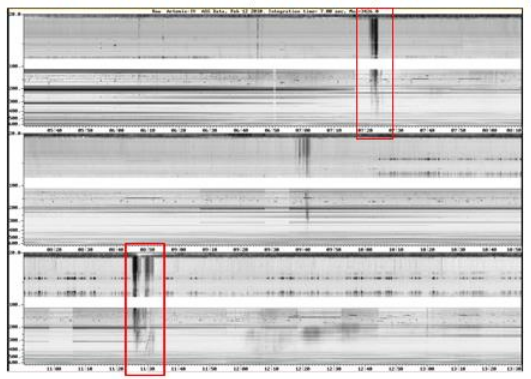



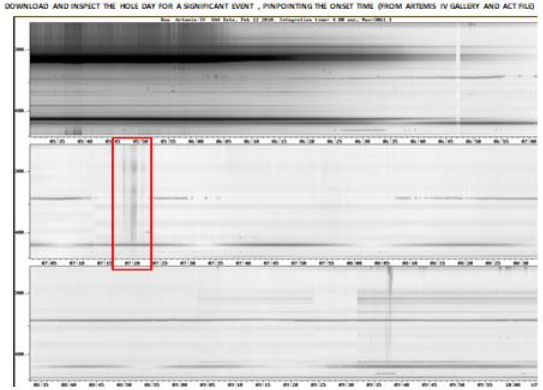

| Flare (SXR) | 07:38 | 08:01 | 07:59 |
|---|---|---|---|
| Position | S12 | W63 | |
| AR | 10431 | | |
| Class | M 2.0 | | |

# Spectra from our data base

ASG_10212_QUICKLOOK



ACT_10212_07.20_QUICKLOOK



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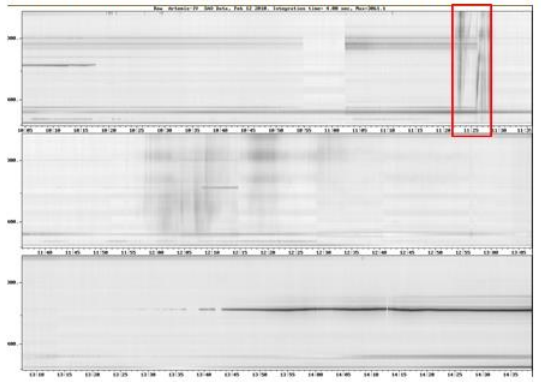
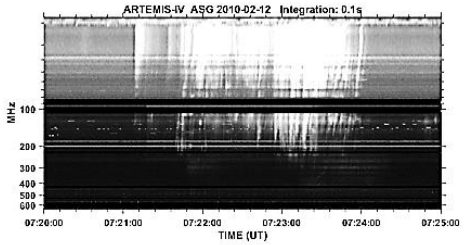
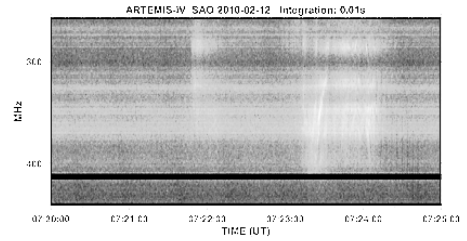


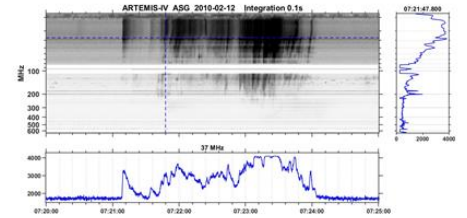
spectra_image_7.20 - 7.25 ASG



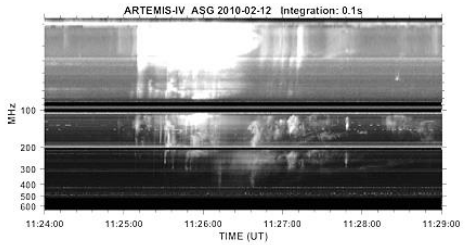

spectra_image 7.20 - 7.25 SAO



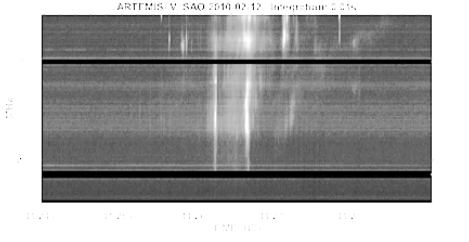

combine profiles



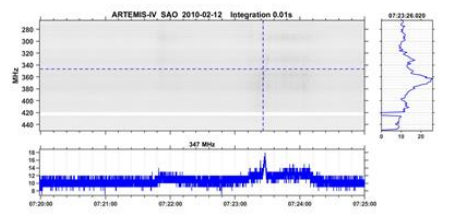

spectra_image 11.25 - 11.29 ASG



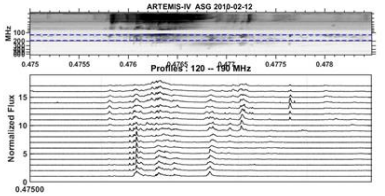

spectra_image 11.25 - 11.29 SAO



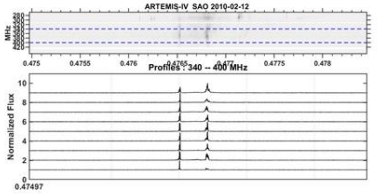

combine profiles

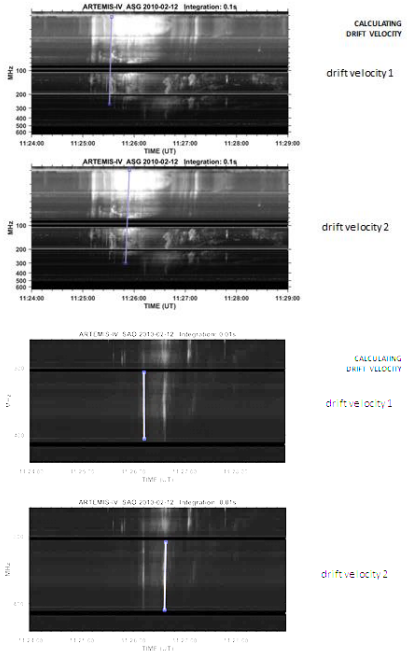


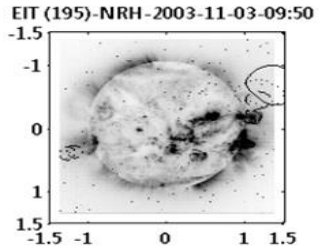

profile 120 - 190 MHz

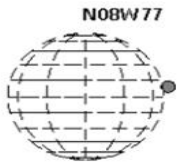


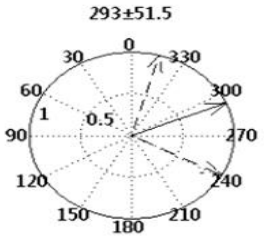

profile 340 - 400 MHz

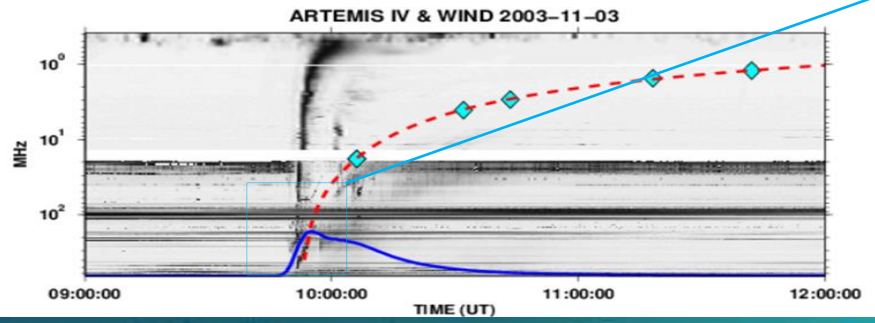


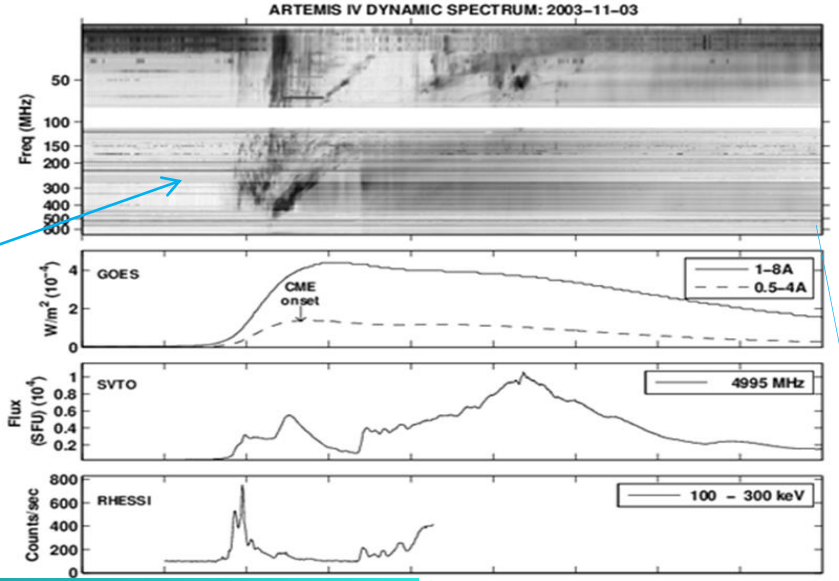



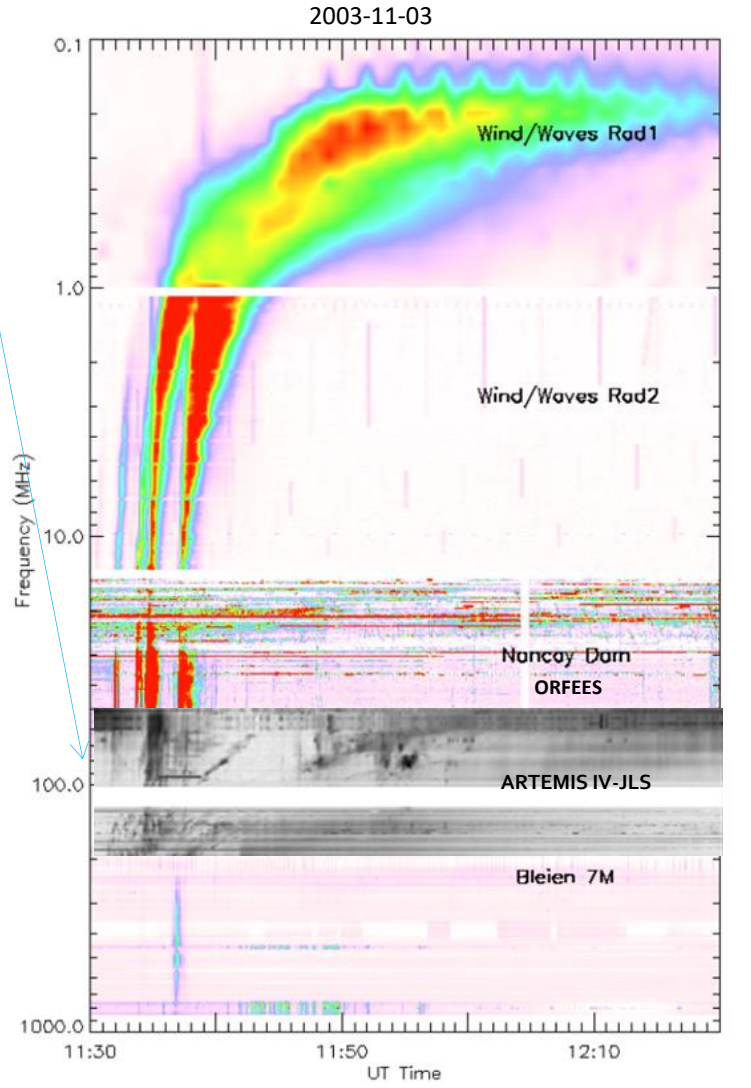


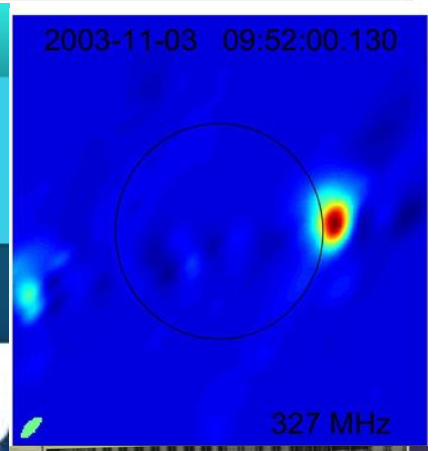




CONTROL ROOM
THERMOPYLAE
STATION

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WORK STATION AND STORAGE – HERON LAB – UNIVERSITY OF THESSALY

# Combined Observations

l'Observatoire de Paris – LESIA

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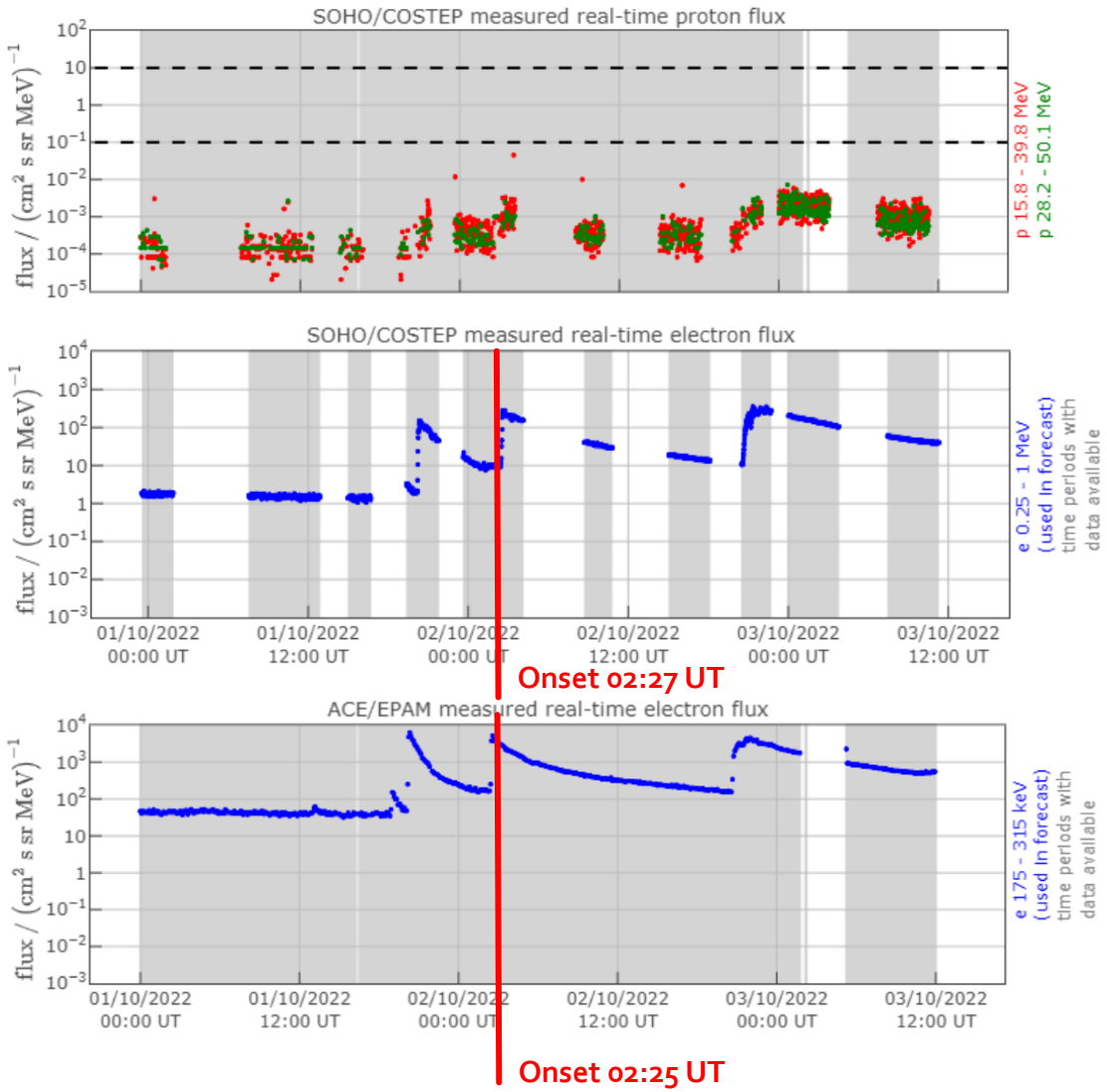
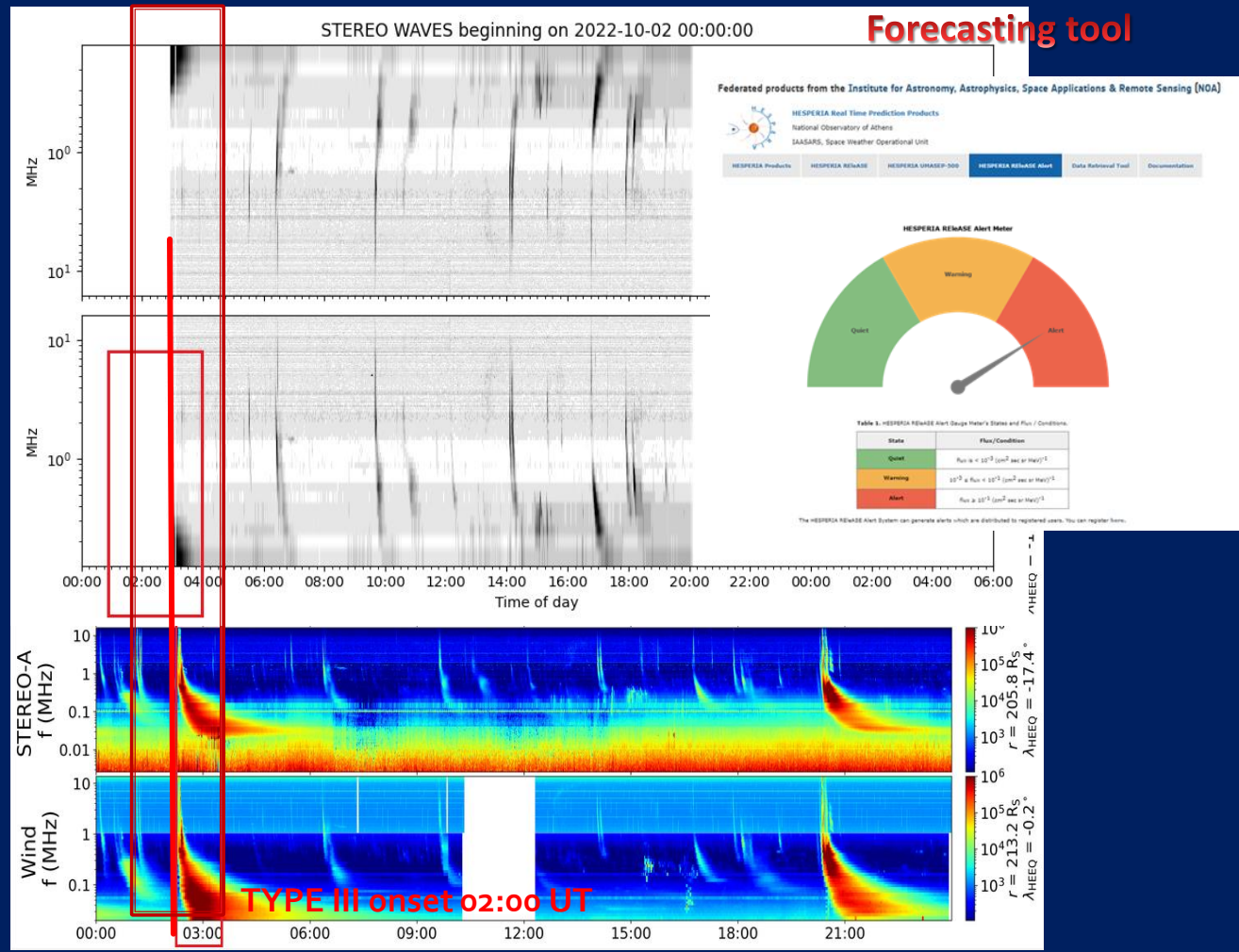
# Combined Observations ( Type III's – electrons - protons)

HESPERIA REleASE+

## 2 October 2022




## Arik Posner et al 2024 , Space Weather



# Data Set

## (*the importance of being faint*)

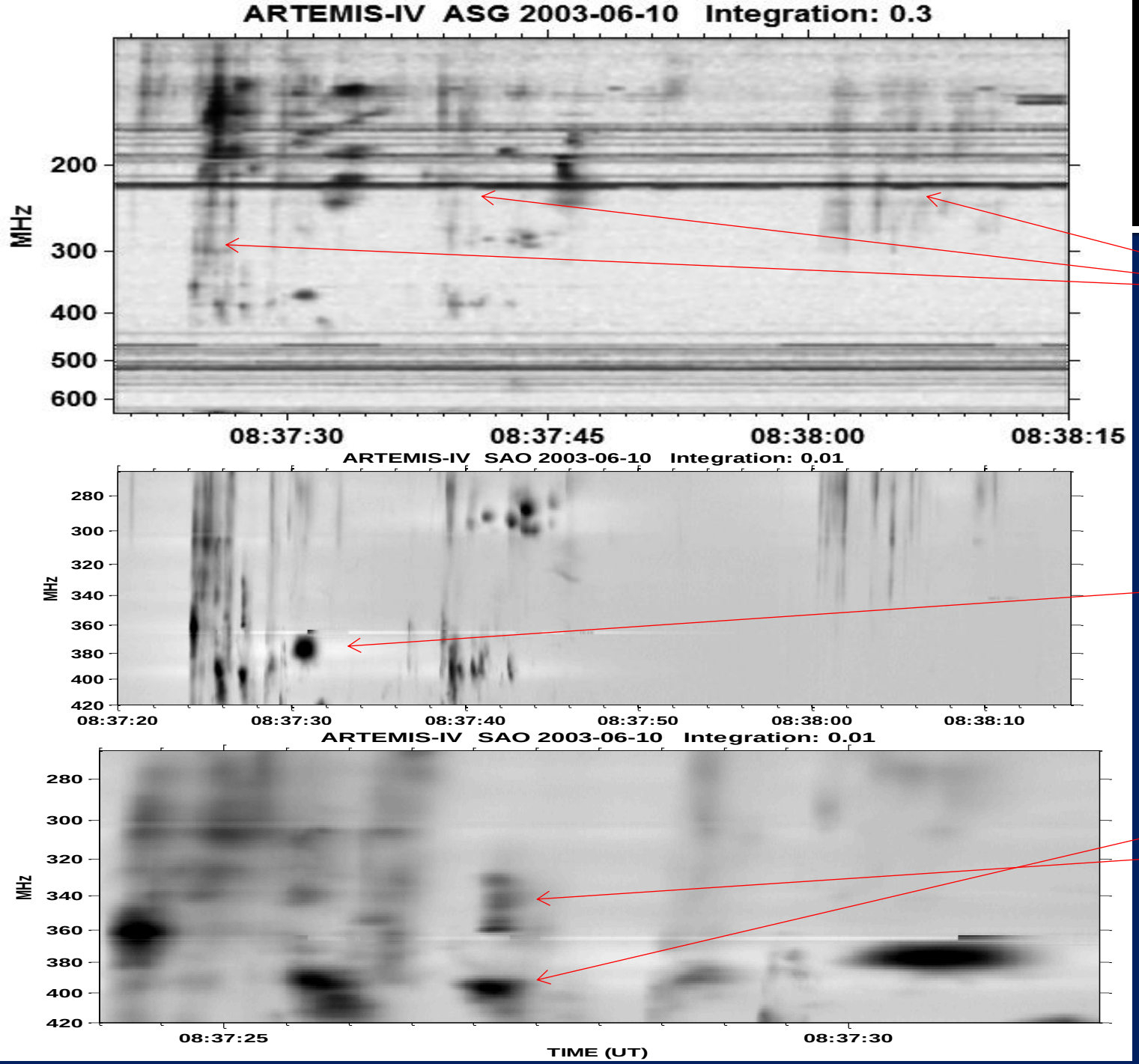
- We are studying faint and isolated type III bursts with narrowband fine structures at the starting frequency in order to avoid confusion from complex groups. Our data set comprises 12 type III bursts, 5 of them isolated . A good number of faint events appear on 10 June, 2003.
- Another precondition for selection of an event with spikes, was that the starting frequency of type III had to be within the frequency range (270 – 450 MHz) of the high resolution receiver (SAO).

**What is the smallest time scale?**

- Near the starting frequencies of type III bursts (m-dm range), short and narrowband bursts – spikes abound.

# 10 June, 2003

## Detail of the event



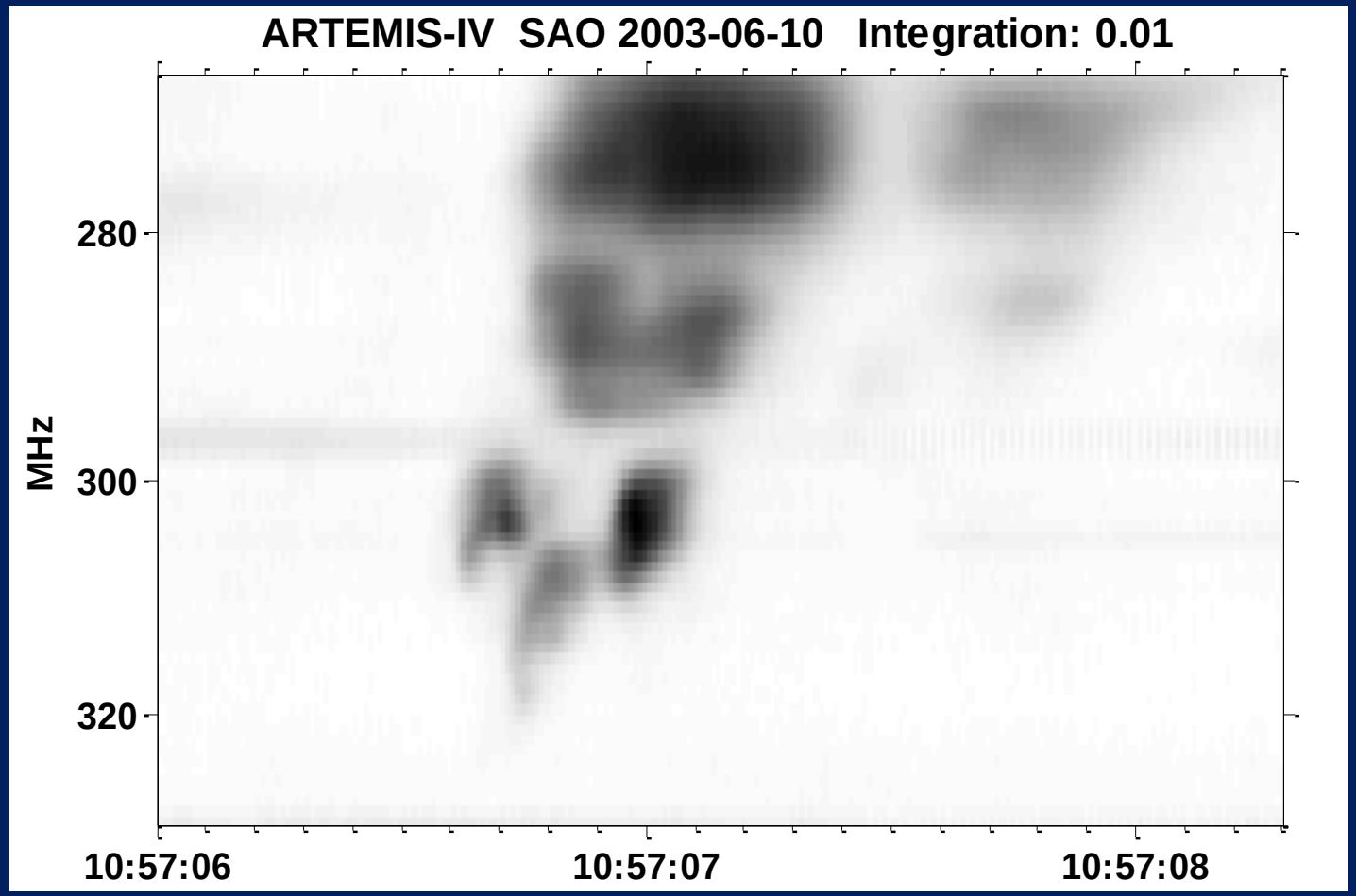

Groups of type III bursts.

Details of type III groups. Bi-directional structures appear on dynamic spectrum.

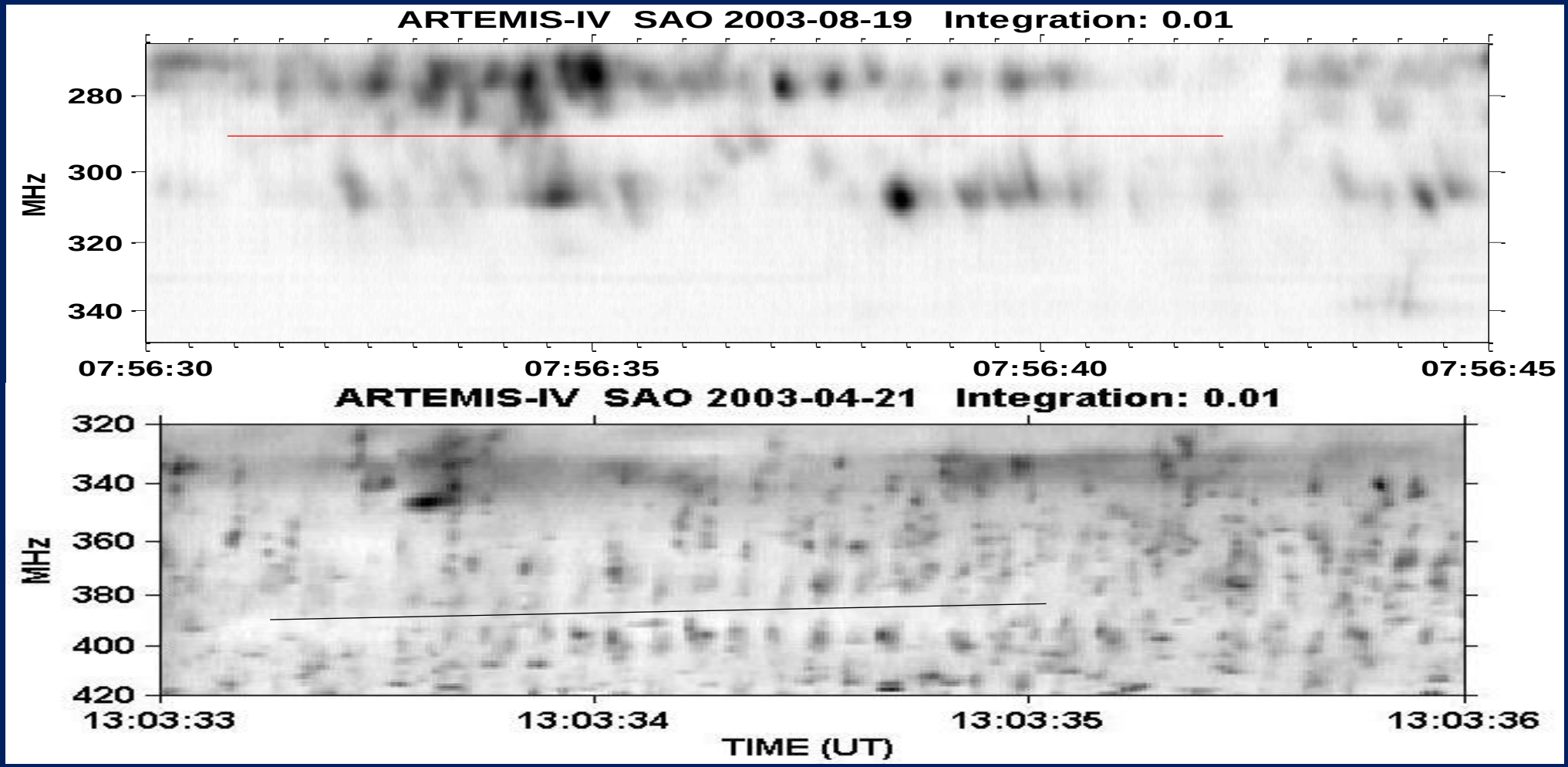
Negative and positive drifting structures suggest a possibility small scale reconnection!

# Narrowband Bursts of the Type III Family

Narrow band bursts of the type III family (J - U) with duration (~100 ms) and bandwidth (~ 2.5 %) comparable to the typical spike.



# Bidirectional spikes separated by a straight line

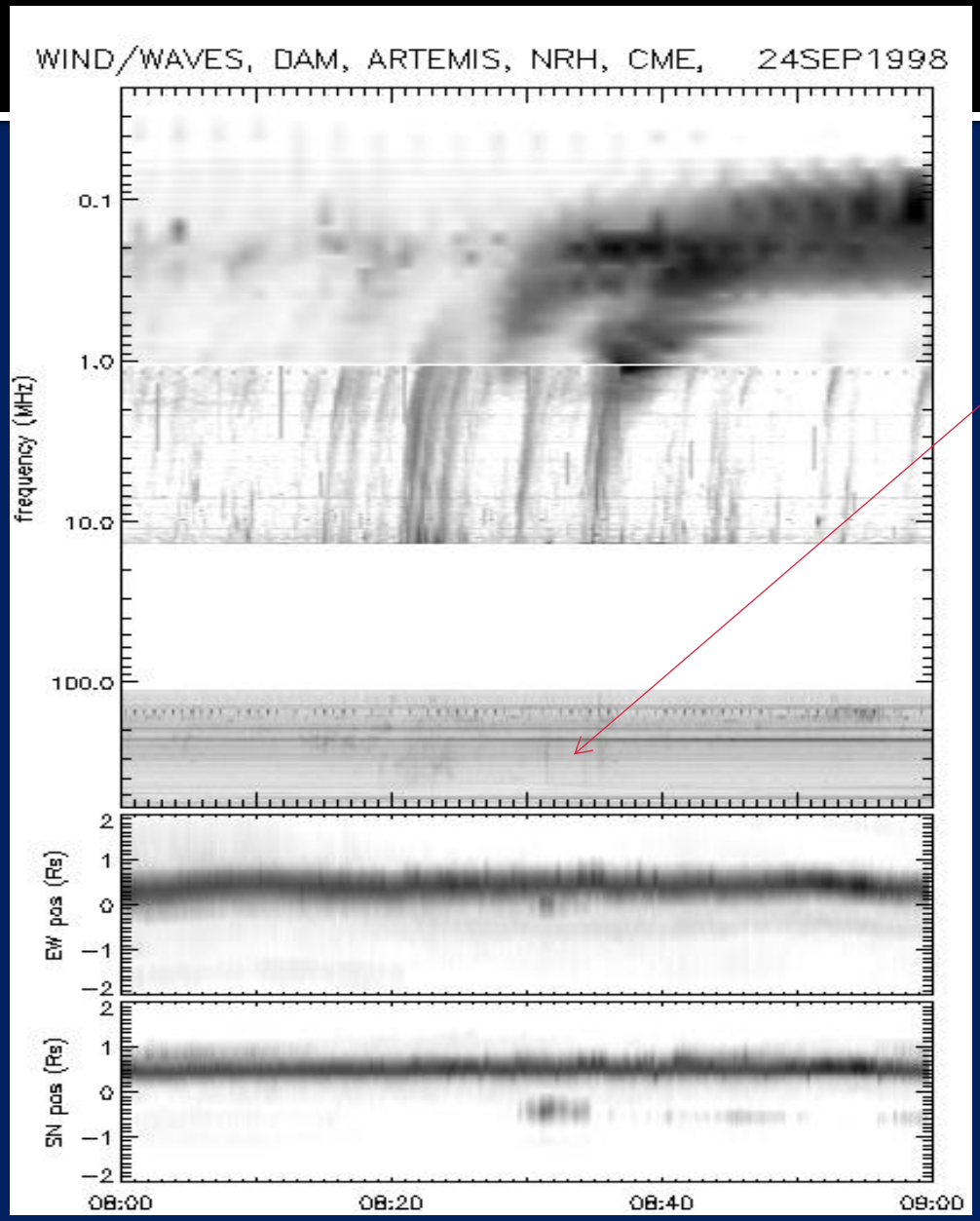


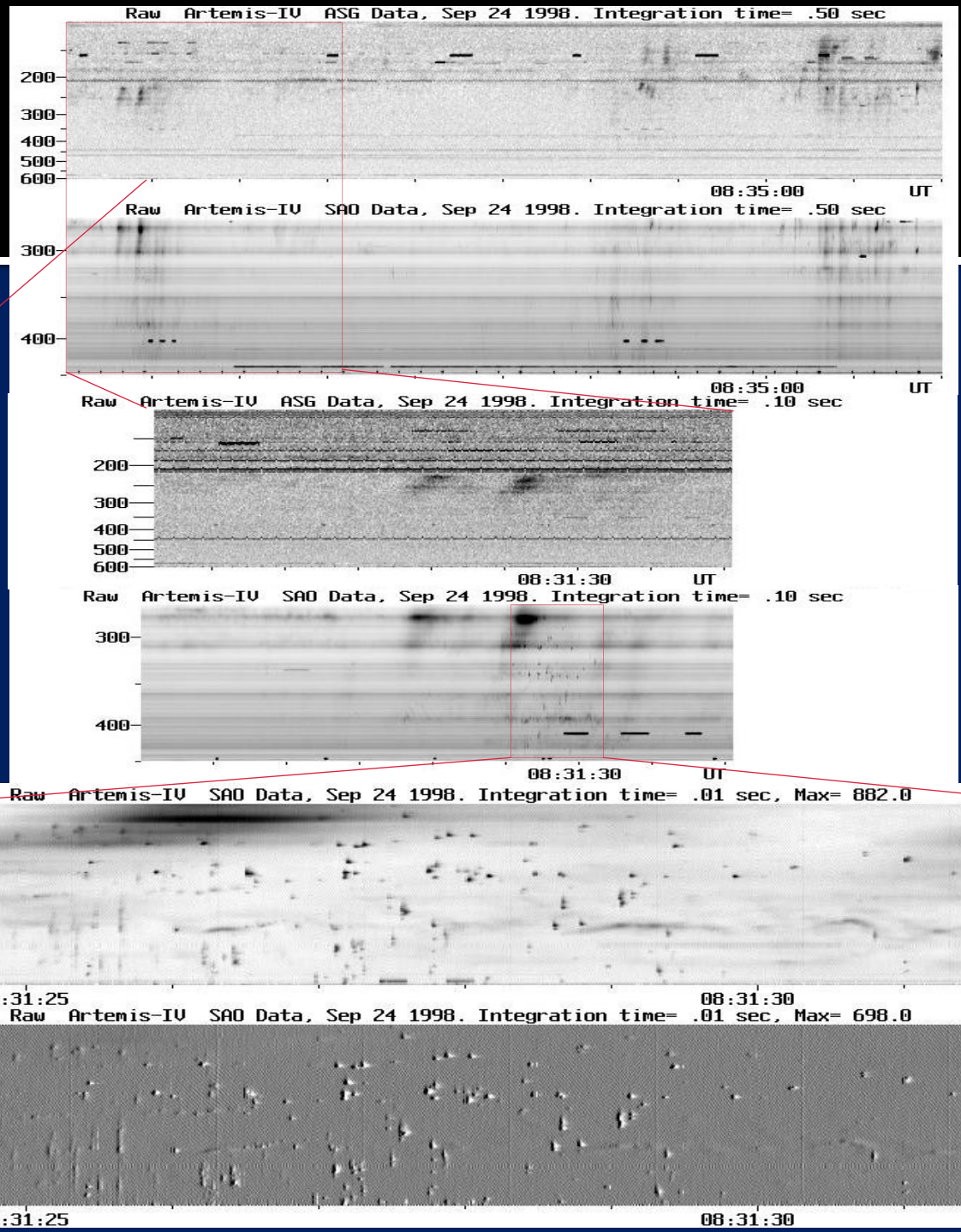

Type III onset

Type IV
fine structure

Bouratzis et al 2016

# 24 September, 1998



# Summary

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- The multichannel radio spectrograph ARTEMIS-JLS (formerly ARTEMIS-IV), records data from the Sun, in the radio spectral range of 20 – 650 MHz and sampling 10 spectra/sec (ASG) and 100 spectra/sec (SAO).
- Various structures have been observed, for the first time, in extraordinary detail, not possible with any other instrument.
- The study of phenomena helped in their understanding and their physical interpretation, as well as the correlation with other needed aspects, such as the forecasting tools to predict solar weather and the hazards of solar wind, making space travelling safer in the near future.
- For the comprehensive study of phenomena, the combination with data from other observatories is required. Thus, on the one hand, the information is extended to other spectral regions, and, on the other hand, we obtain a two-dimensional image (from the Nançay radio heliograph) or other solar orbiting spacecrafts , in order to understand the geometry of the phenomena.

# Summary


- We are studying the relationship of type III bursts and narrowband structures (spikes) , from high temporal resolution recordings of ARTEMIS-IV.
- We presented a few well observed events, indicating the narrowband structures and spikes of Type IIIs.
- Further confirmation requires radio imaging data and a lucky coincidence, that spikes will be at some frequency channel of the NRH.
- Further studies involving imaging data should shed more light to this relationship.

# And in the future;


- A database is created for easier data access.
- There is a very large number of phenomena (type II, III and IV) that need to be addressed.
- The fine structure that is embedded in these phenomena is of great interest to the scientific community.
- The relationship between type III electron beams and SEP events has been established and the need is to calibrate all the measurements of Type IIIs or solar radio bursts experiments, in order to validate and improve the performance of our forecasting tools.
- Solar weather and forecasting tools must implement and correlate solar eruptive events and its stucture, in order to secure space travelling and exploration in the near future.

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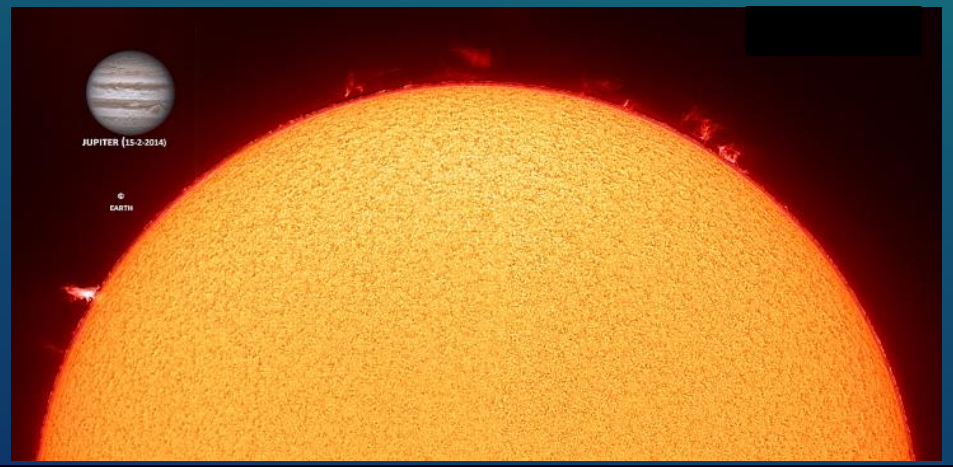


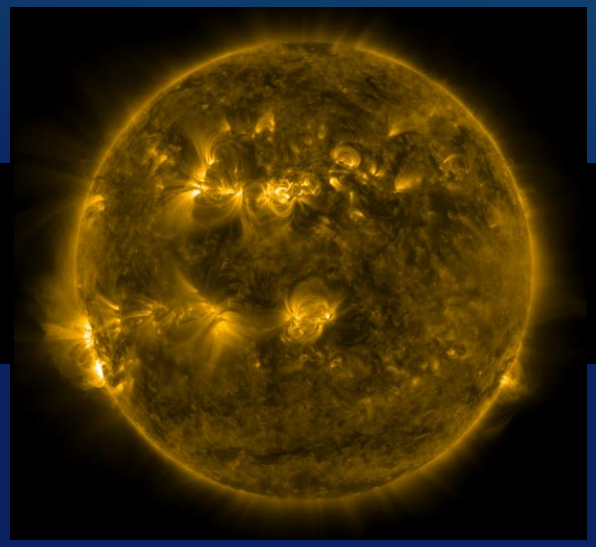

# THANK YOU VERY MUCH !!!

F.G. Smanis

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