Solar Radio Spectrometers in Slovakia – status report on registration of solar radio bursts

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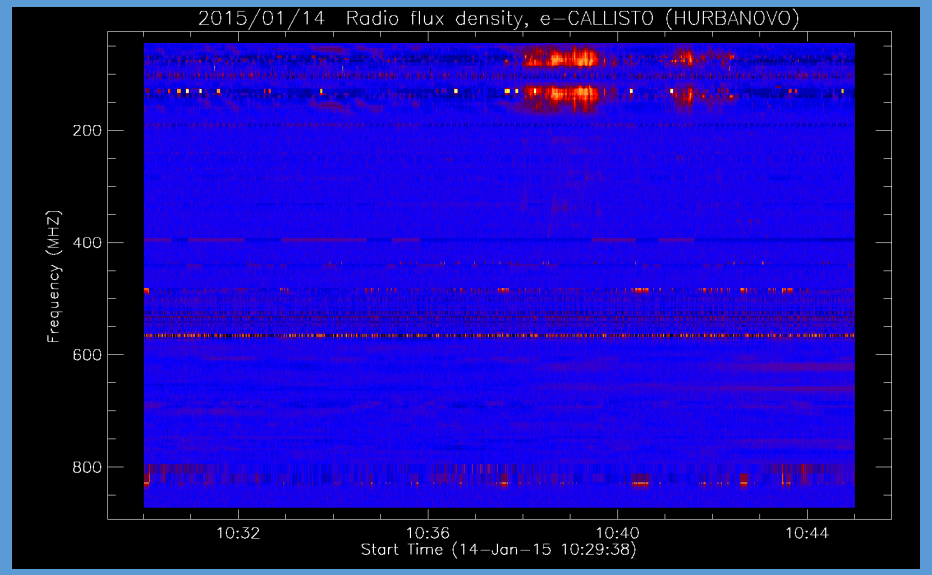
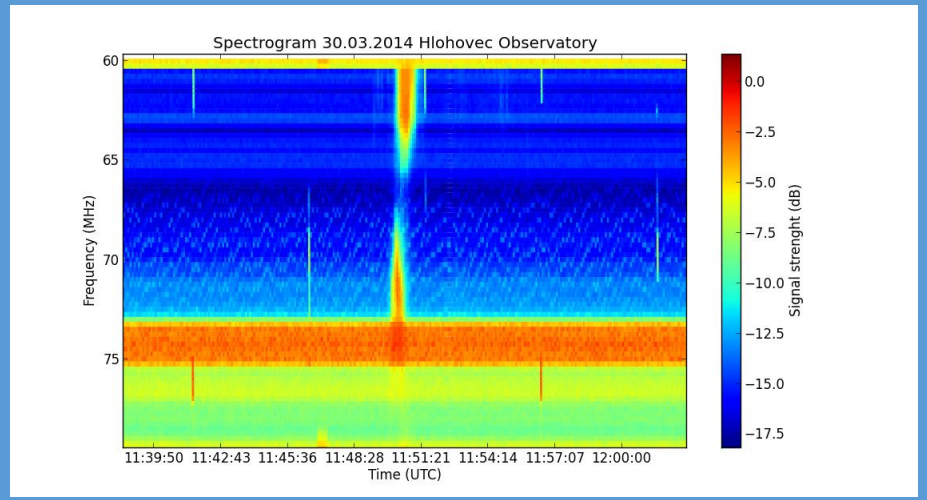




2.1. CALLISTO IN HURBANOVO

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

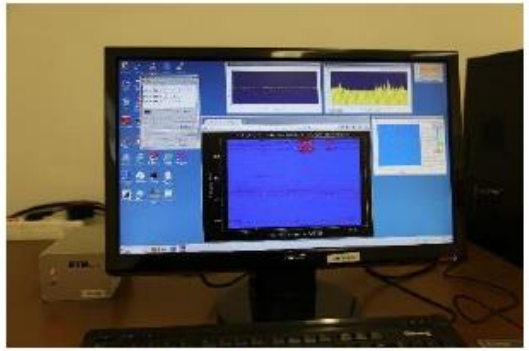
CALLISTO site is located in the **Slovak Central Observatory (SCO)** in Hurbanovo [47.9° N, 18.2° E, 115 m a.s.l., GMT + 01h]. Callisto radio spectrometer has been installed in the SCO in December 2011. Detailed information on installation, radio frequency interference (RFI) in Hurbanovo, first results, etc. is published in **Dorotovič and Pintér (2014)**.

Here we present only some changes in the CALLISTO set up that contributed to better sensitivity of the registered radio spectrograms:

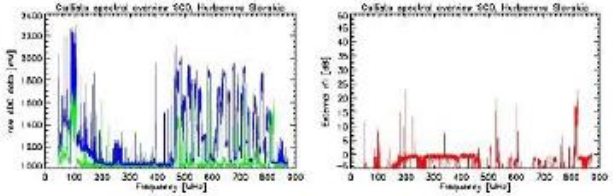
- both the rotator and the tracking controller were installed for better sensitivity to observe morning and evening events (rotations in steps of 30° in every 2 hours),
- the amplifier was mounted very close to the antenna,
- coaxial cable was shortened to ~8 meters to lower signal loss.

Log-Periodic Antenna CLP-5130-2N

Controllers for the morning start time (1), time interval of one single rotation (2), duration of single antenna rotation (3), and evening stop time (4).



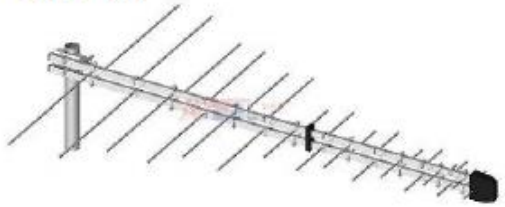
CALLISTO eC50 + PC



Callisto spectral overview SCO

2.3. SOLAR RADIO SPECTROMETER IN HLOHOVEC

Another very simple and cheap solar radio spectrometer has been installed in the Astronomical Observatory and Planetarium of M. R. Štefánik in Hlohovec [48.42° N, 17.8° E, 231 m a.s.l., GMT + 01h] in the end of 2013. It was set up by **J. Karlovský** using a LPD antenna, a software radio receiver RTL-SDR, and an amplifier with gain of 25 dB.



Log-periodic dipole antenna

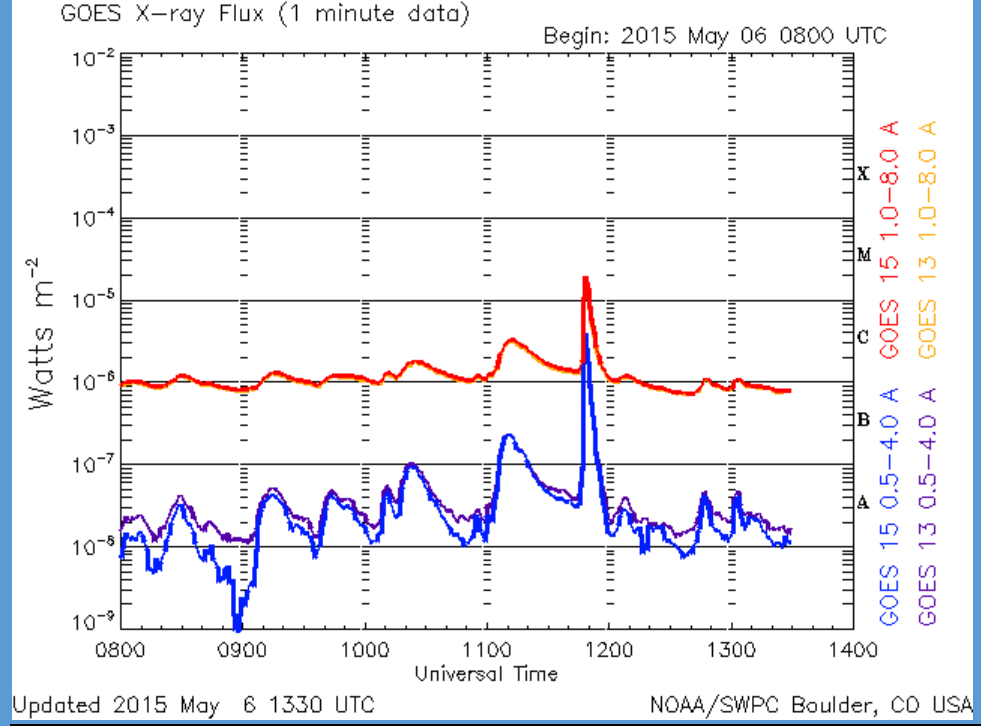
RTL-SDR receiver

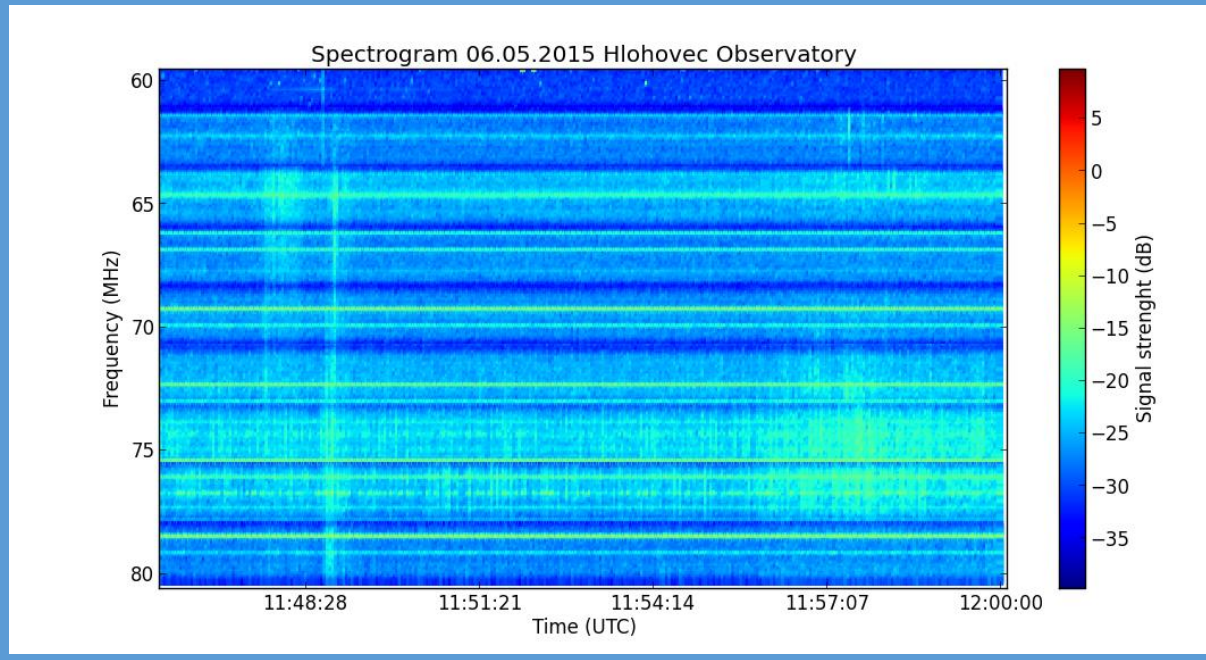
Parameters of the RTL-SDR:

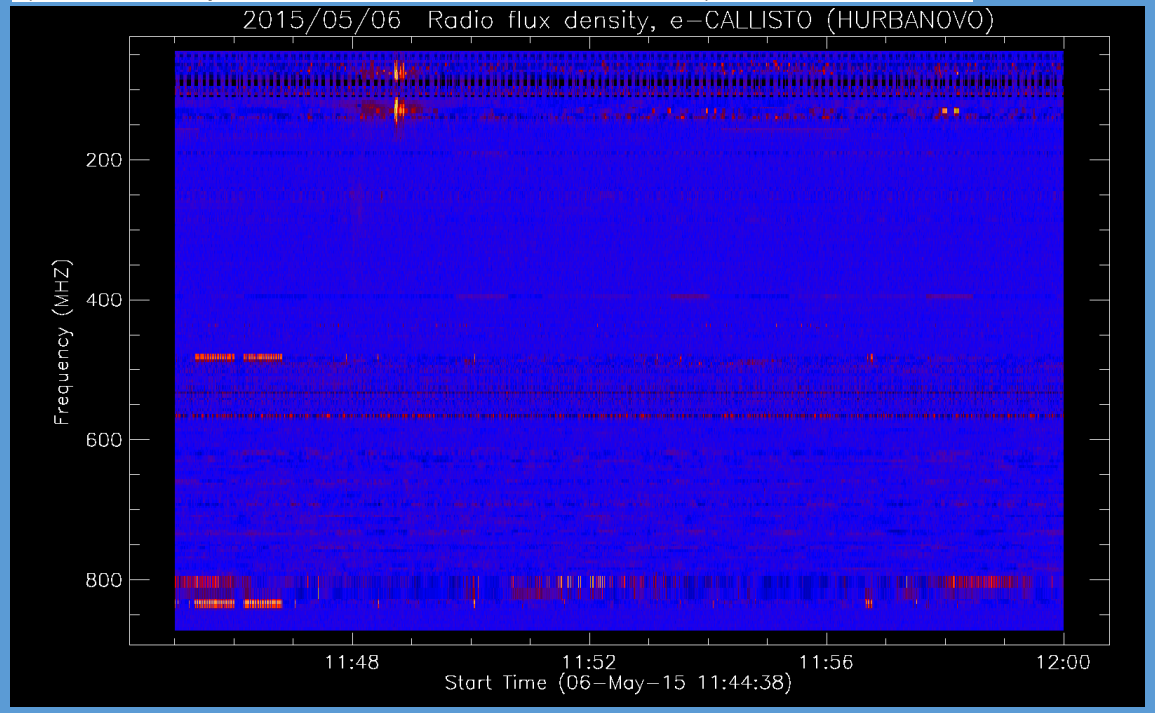
Frequency range	45 - 900 MHz
ADC resolution	8 bit
Sampling frequency	3.2 Msps
Actual usable bandwidth	2.8 MHz
Dynamic range	48 dB

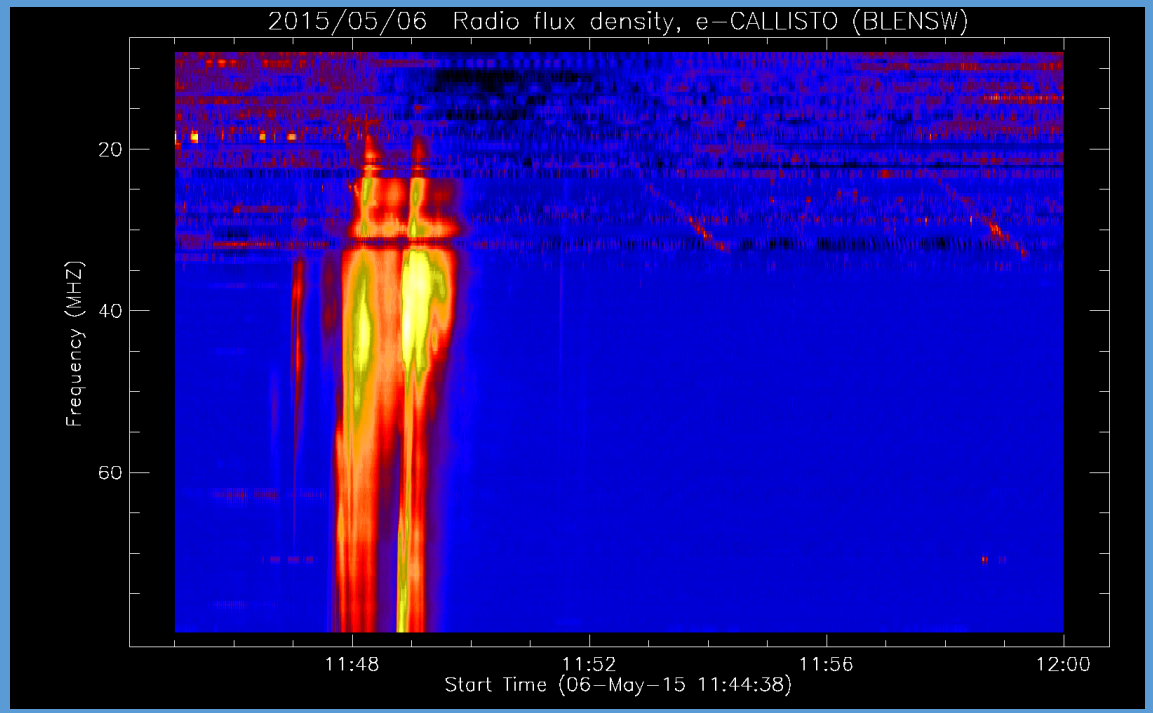
The radio spectrometer registers solar radio flux using a Python software tool in the ranges of 60 – 80 MHz and 120 – 140 MHz, respectively. Data collection is carried out by scanning of the whole frequency range with a lag of 250 kHz, i.e. one single measurement is done in ~5 s (temporal resolution).

06 May 2015:

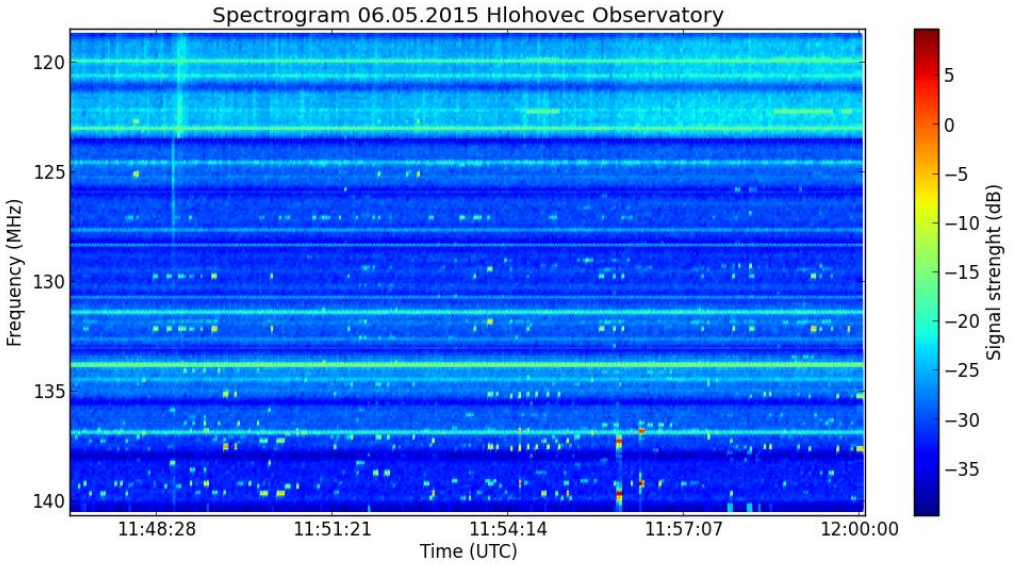

GOES X-ray Flux (1 minute data)
Begin: 2015 May 06 0800 UTC
Watts m-2
Universal Time
GOES 15 1.0-8.0 A
GOES 13 1.0-8.0 A
GOES 15 0.5-4.0 A
GOES 13 0.5-4.0 A
Updated 2015 May 6 1330 UTC
NOAA/SWPC Boulder, CO USA


Spectrogram 06.05.2015 Hlohovec Observatory
Frequency (MHz)
Time (UTC)
Signal strenght (dB)

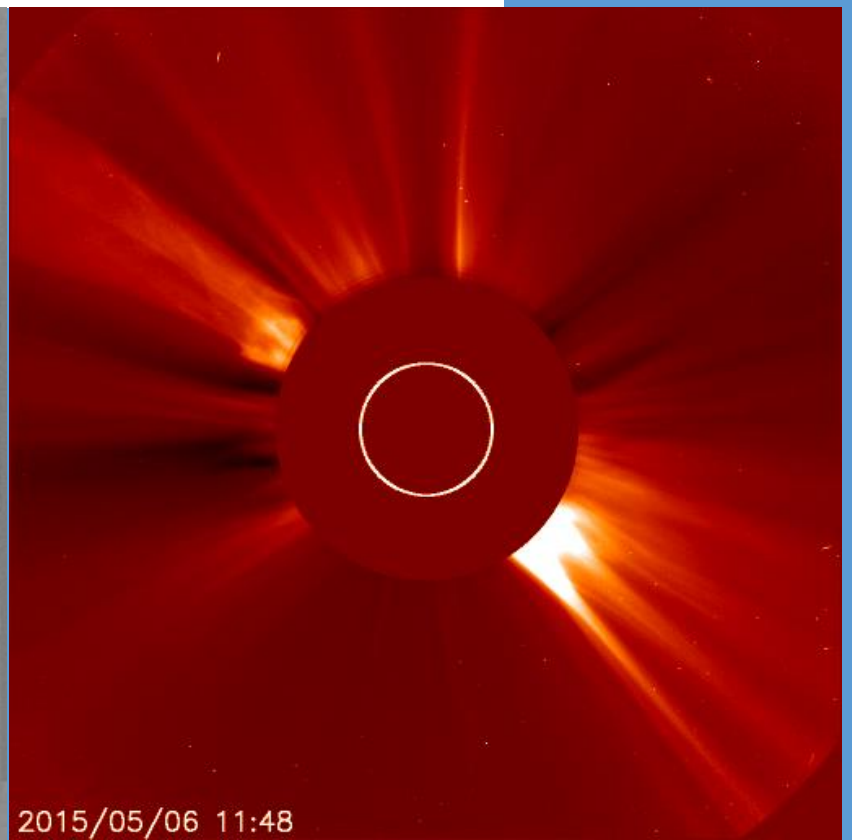

2015/05/06 Radio flux density, e-CALLISTO (HURBANOVO)
Frequency (MHZ)
Start Time (06-May-15 11:44:38)


2015/05/06 Radio flux density, e-CALLISTO (BLENSW)
Frequency (MHZ)
Start Time (06-May-15 11:44:38)

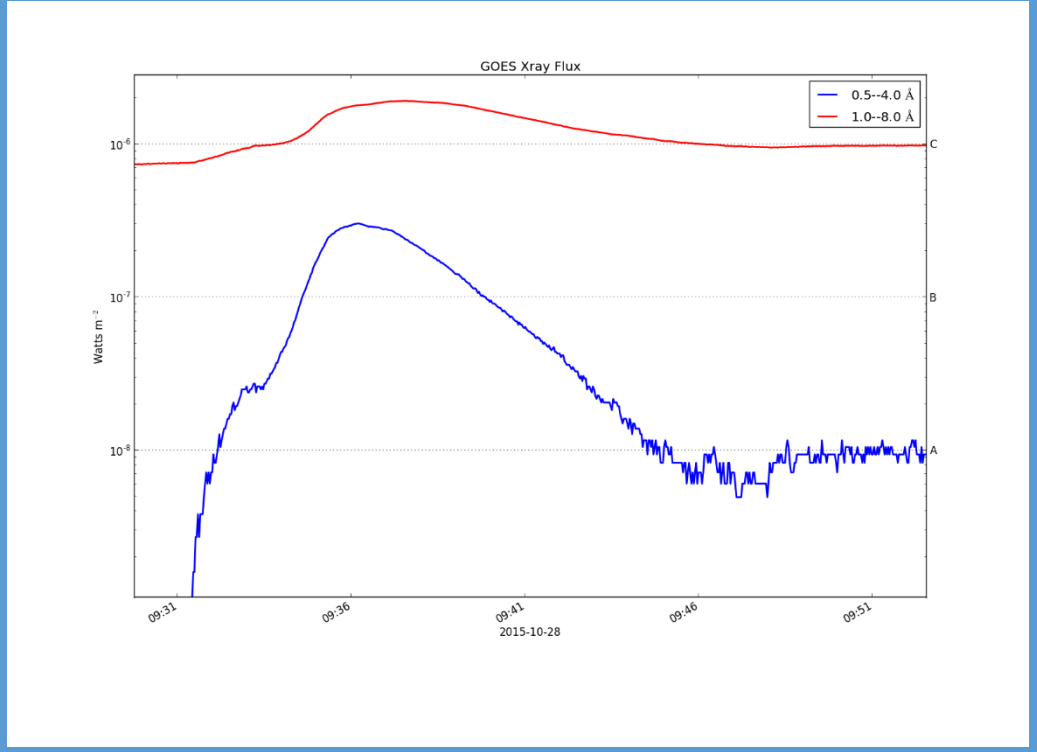
06 May 2015:

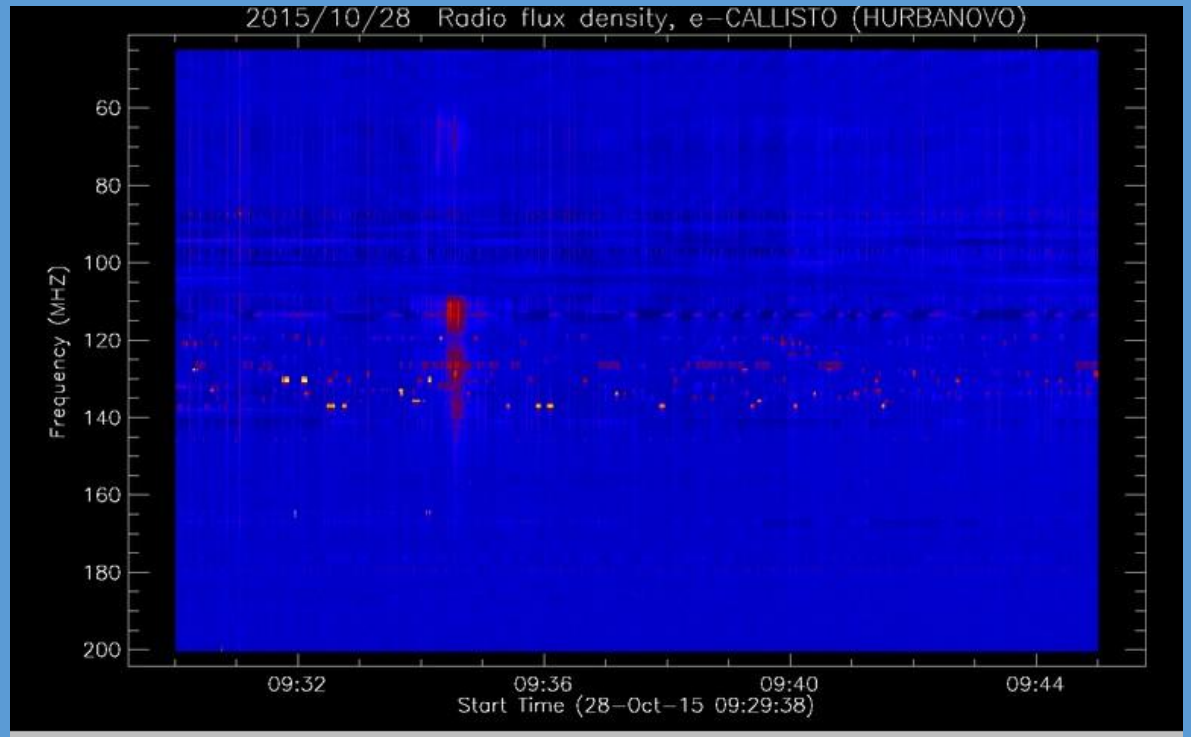

Spectrogram 06.05.2015 Hlohovec Observatory
Frequency (MHz)
120
125
130
135
140
11:48:28
11:51:21
11:54:14
11:57:07
12:00:00
Time (UTC)
5
0
−5
−10
−15
−20
−25
−30
−35
Signal strenght (dB)

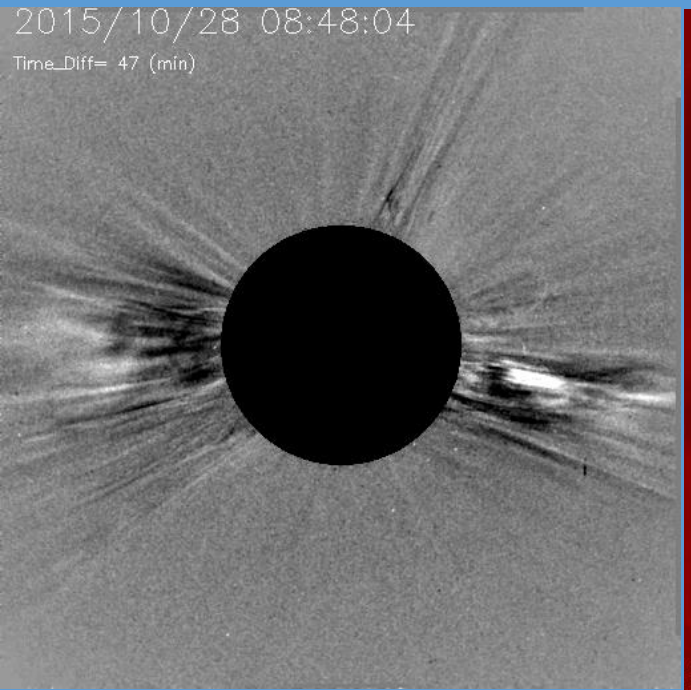

2015/05/06 11:48:05
Time_Diff= 36 (min)

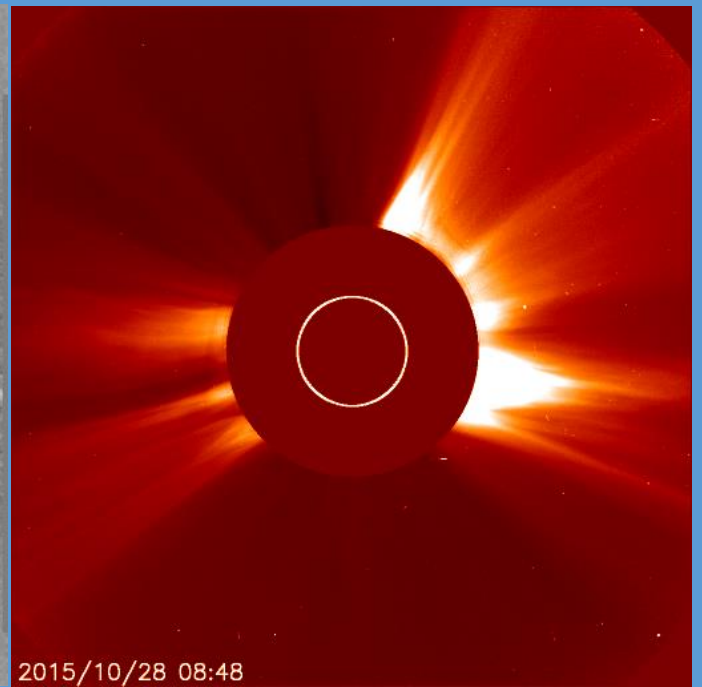

2015/05/06 11:48

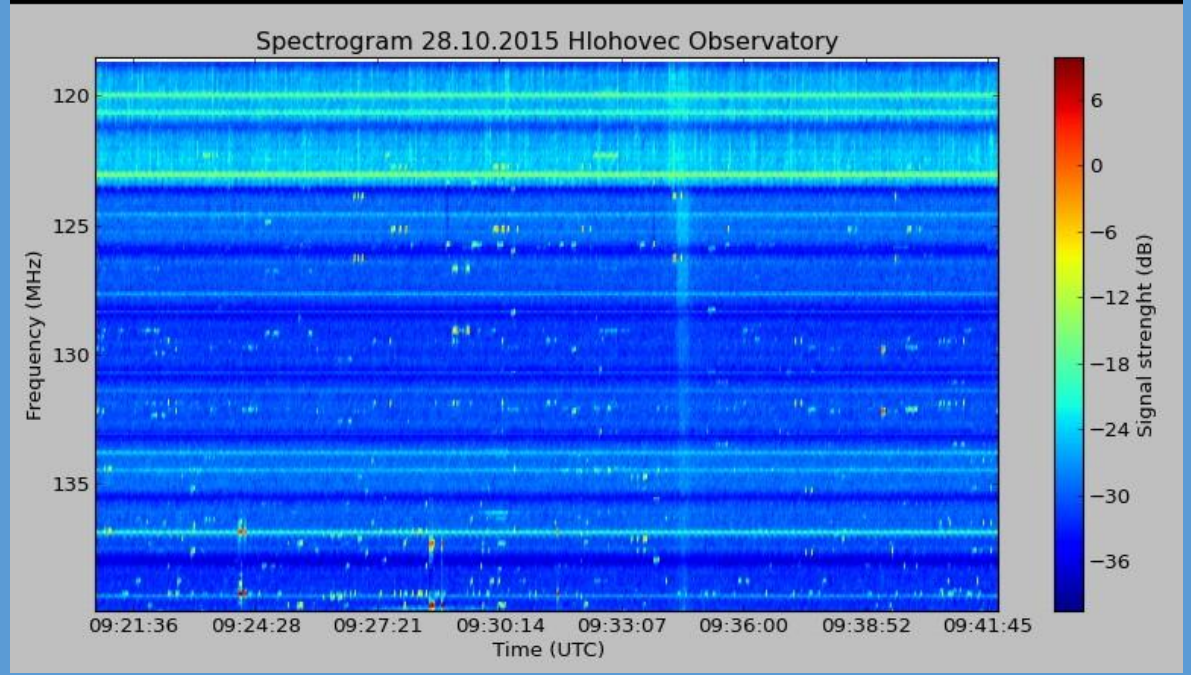
28 Oct 2015:


GOES Xray Flux
0.5--4.0 Å
1.0--8.0 Å
Watts m⁻²
C
B
A
09:31
09:36
09:41
09:46
09:51
2015-10-28

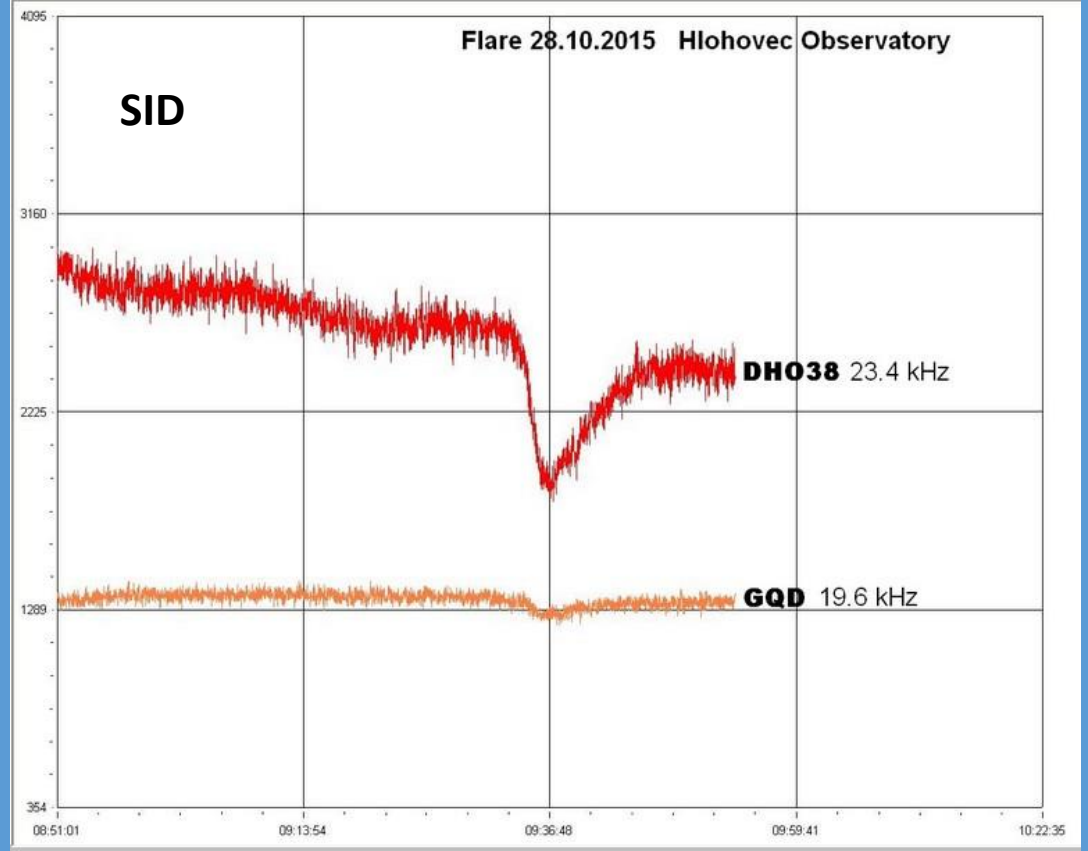

2015/10/28 Radio flux density, e-CALLISTO (HURBANOVO)
Frequency (MHZ)
60
80
100
120
140
160
180
200
09:32
09:36
09:40
09:44
Start Time (28-Oct-15 09:29:38)

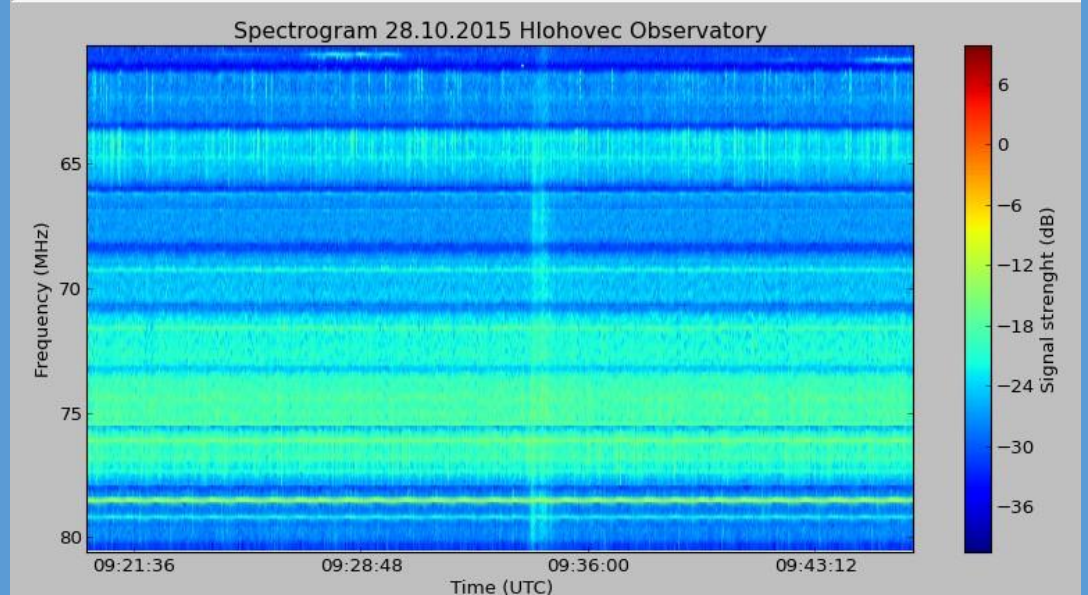

2015/10/28 08:48:04
Time_Diff= 47 (min)

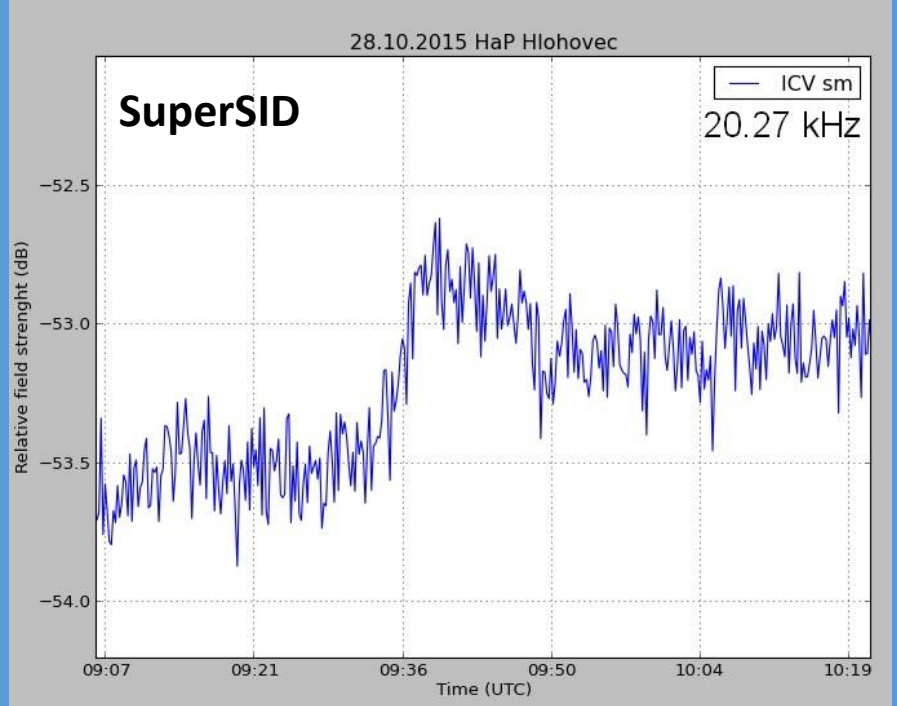

2015/10/28 08:48

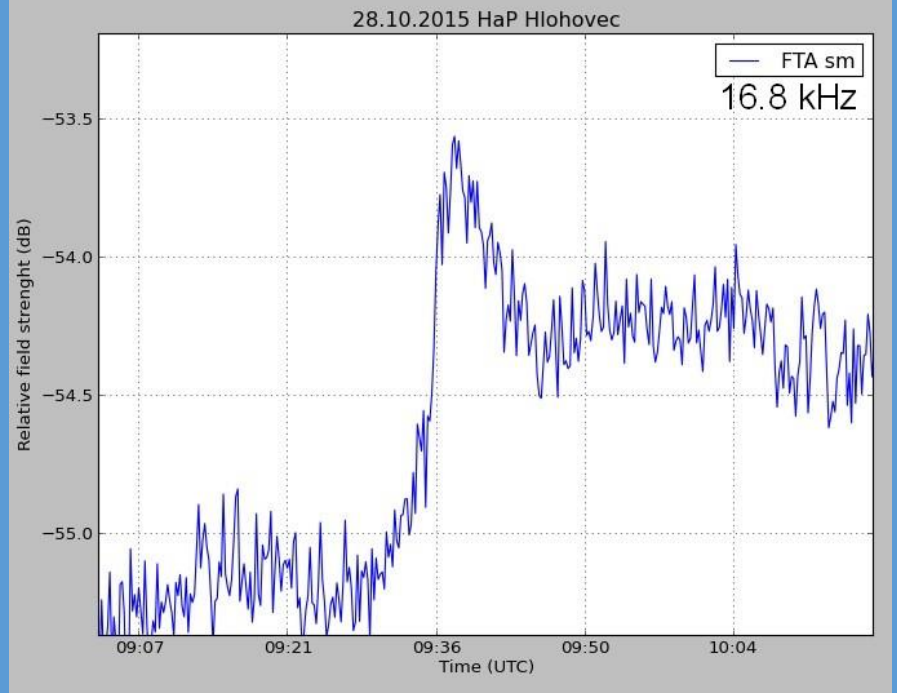

Spectrogram 28.10.2015 Hlohovec Observatory
Frequency (MHz)
120
125
130
135
09:21:36
09:24:28
09:27:21
09:30:14
09:33:07
09:36:00
09:38:52
09:41:45
Time (UTC)
Signal strenght (dB)
6
0
-6
-12
-18
-24
-30
-36

28 Oct 2015:

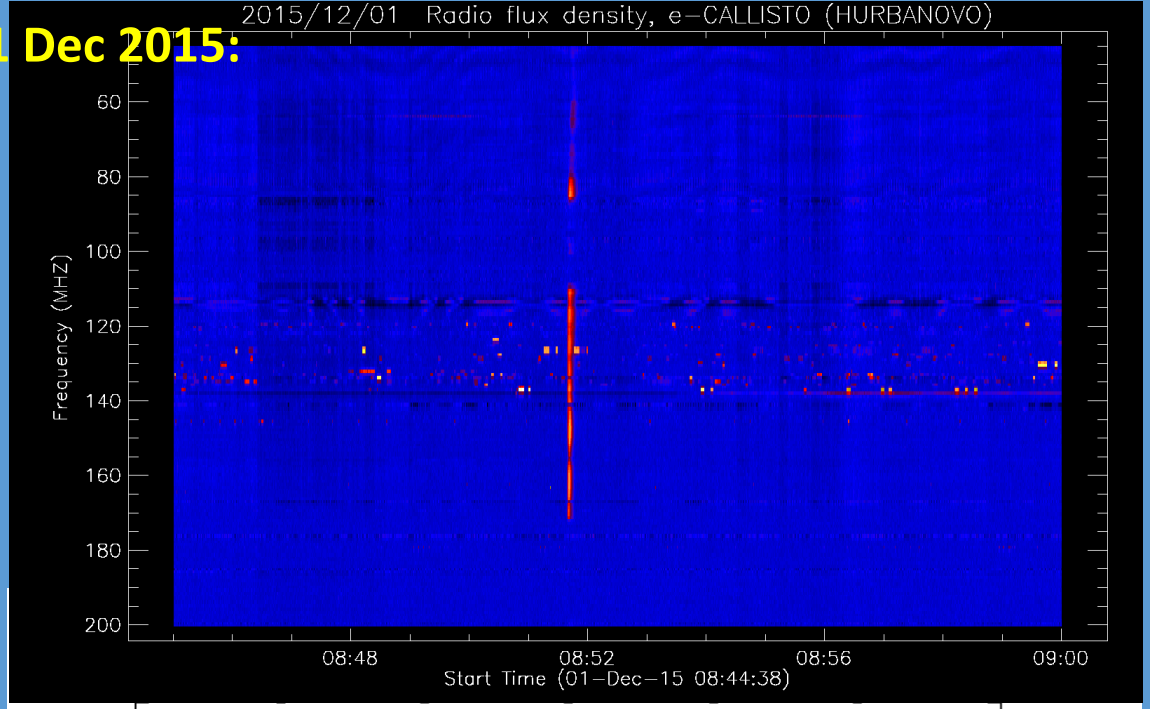

Flare 28.10.2015 Hlohovec Observatory
SID
DHO38 23.4 kHz
GQD 19.6 kHz
4095
3160
2225
1289
354
08:51:01
09:13:54
09:36:48
09:59:41
10:22:35

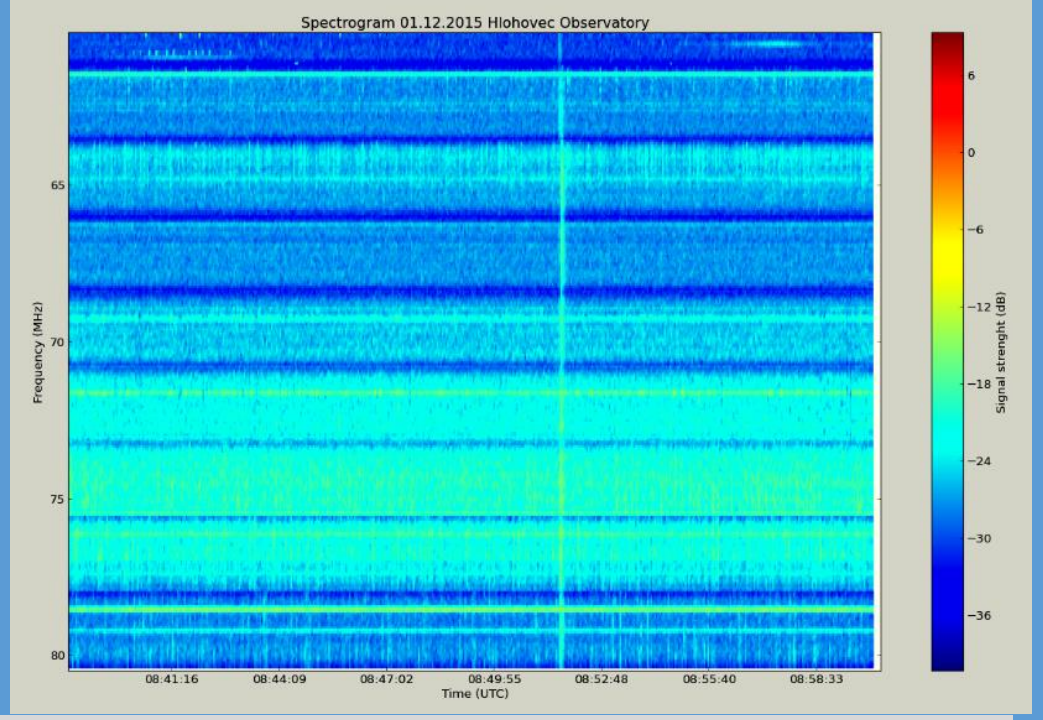

Spectrogram 28.10.2015 Hlohovec Observatory
Frequency (MHz)
65
70
75
80
09:21:36
09:28:48
09:36:00
09:43:12
Time (UTC)
Signal strenght (dB)
6
0
−6
−12
−18
−24
−30
−36

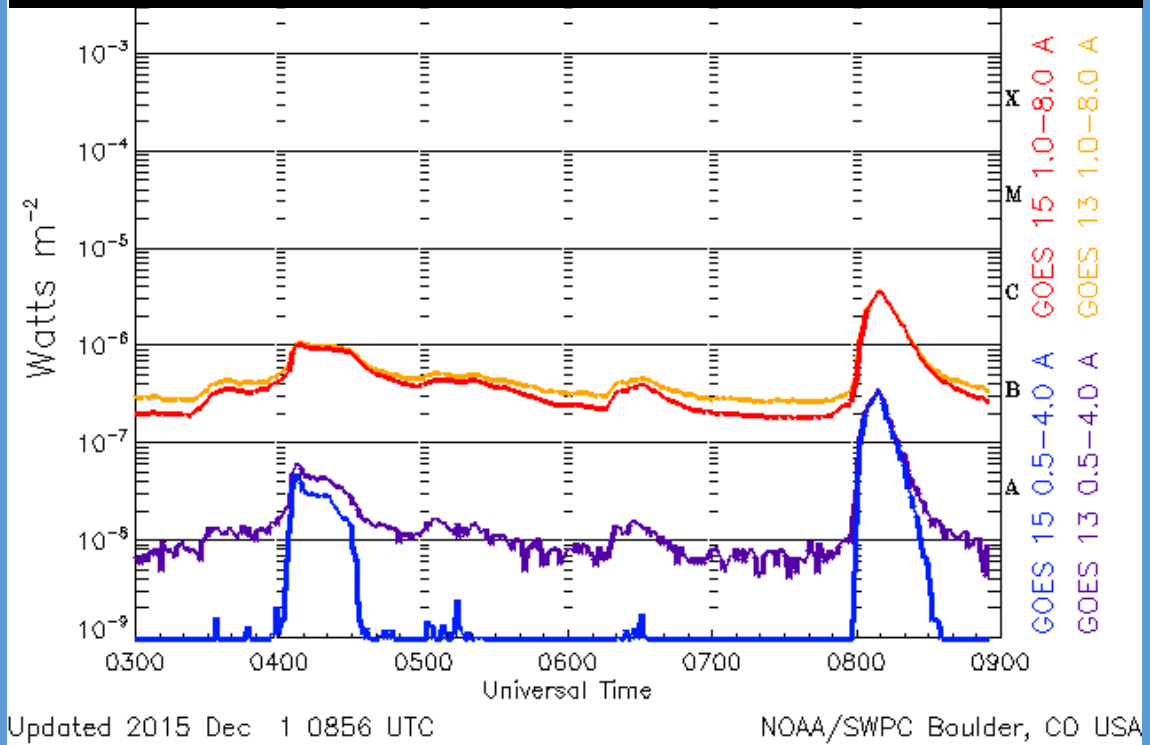

28.10.2015 HaP Hlohovec
SuperSID
ICV sm
20.27 kHz
Relative field strenght (dB)
−52.5
−53.0
−53.5
−54.0
09:07
09:21
09:36
09:50
10:04
10:19
Time (UTC)

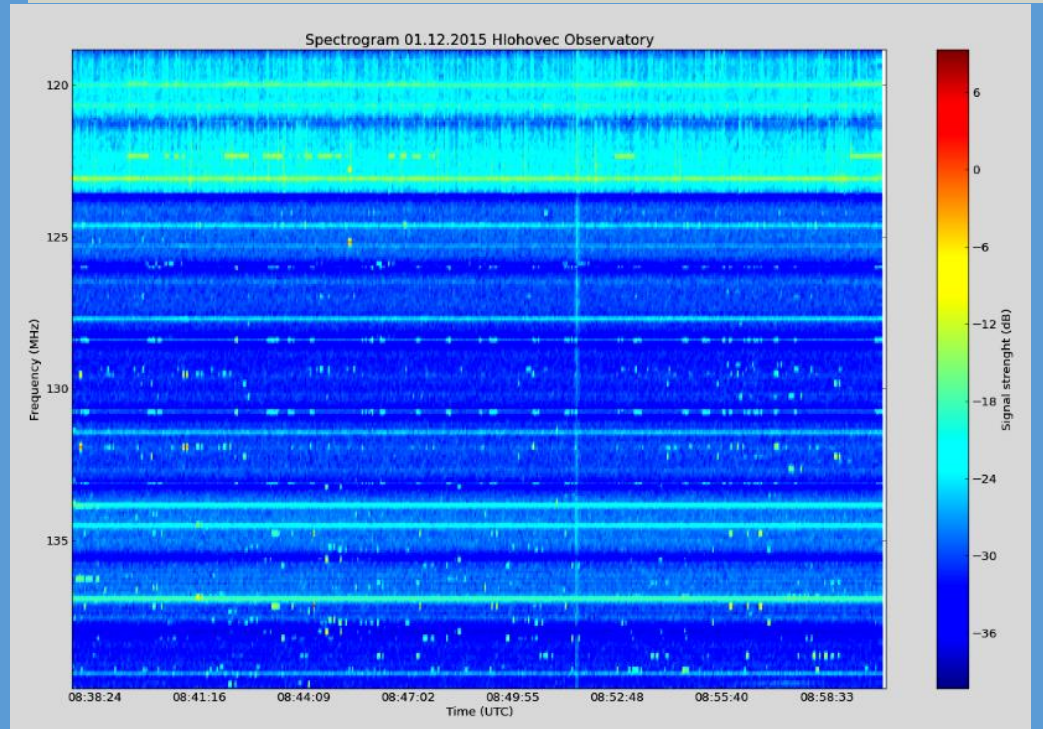

28.10.2015 HaP Hlohovec
FTA sm
16.8 kHz
Relative field strenght (dB)
−53.5
−54.0
−54.5
−55.0
09:07
09:21
09:36
09:50
10:04
Time (UTC)

1 Dec 2015:

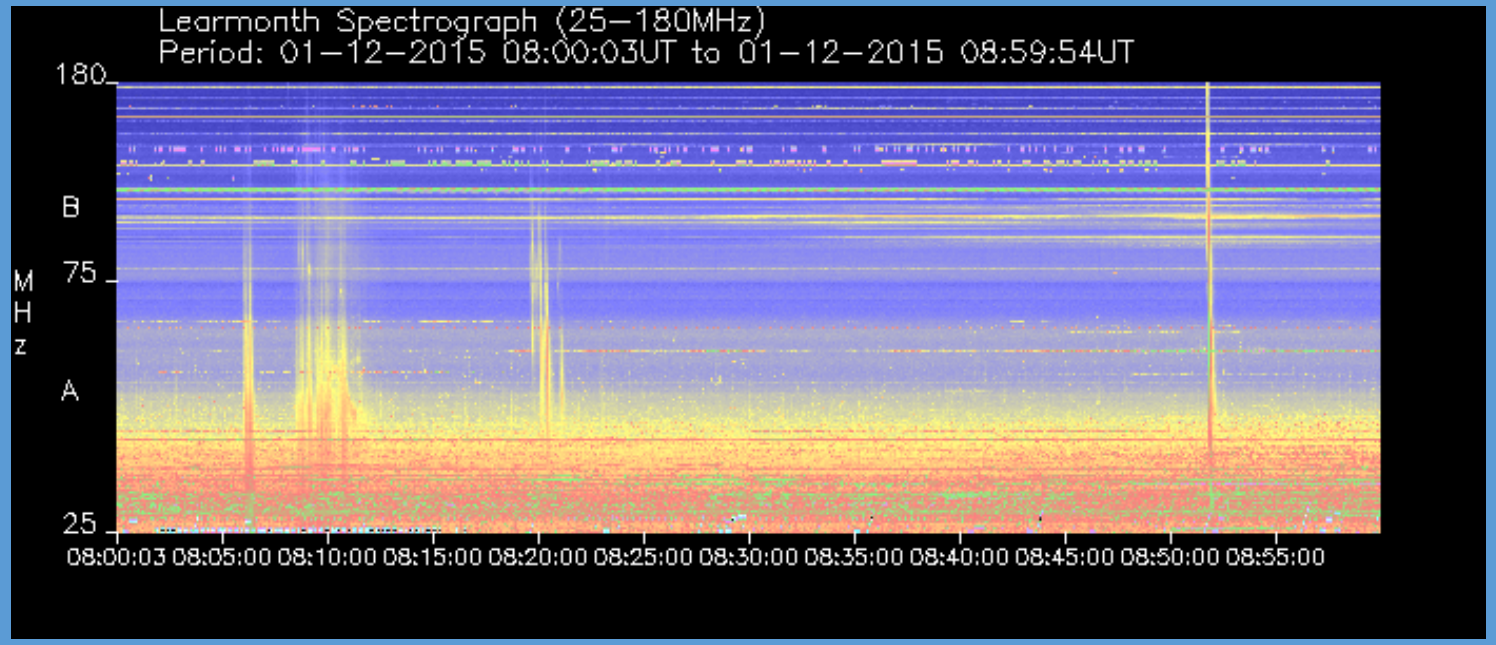

2015/12/01 Radio flux density, e-CALLISTO (HURBANOVO)
Frequency (MHz)
60
80
100
120
140
160
180
200
08:48
08:52
08:56
09:00
Start Time (01-Dec-15 08:44:38)

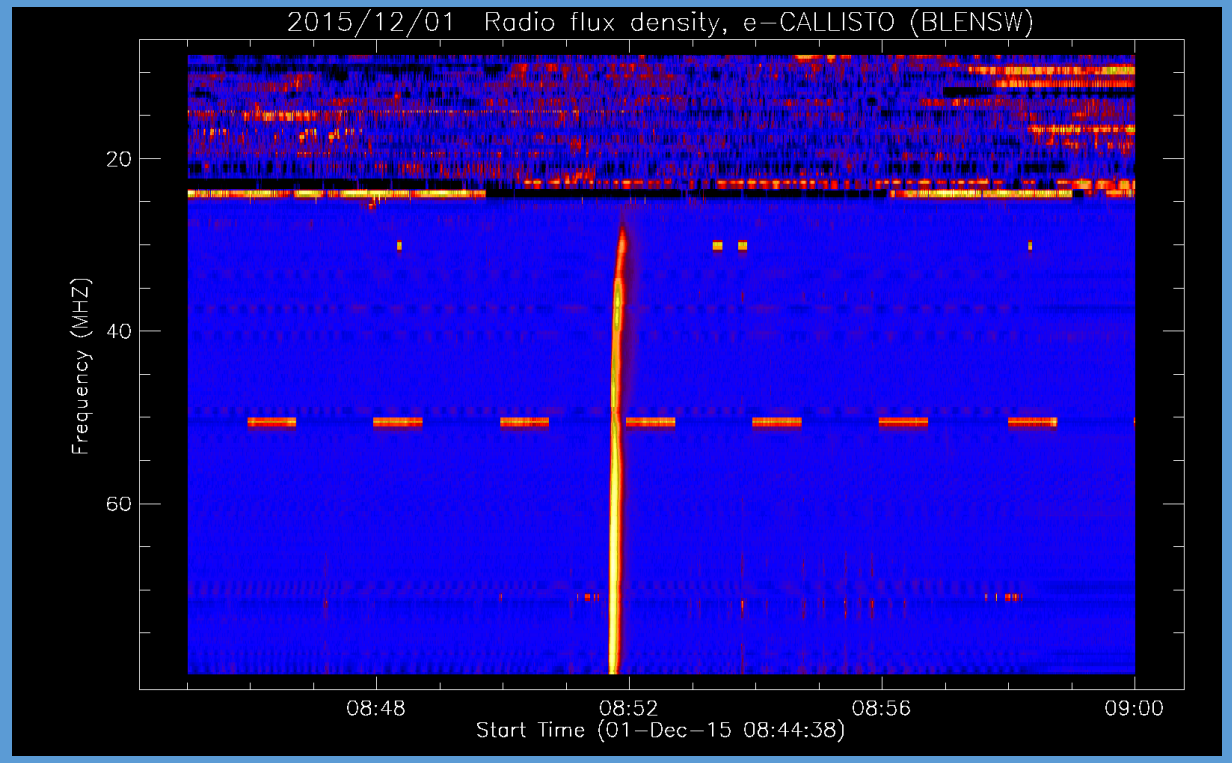

Spectrogram 01.12.2015 Hlohovec Observatory
Frequency (MHz)
65
70
75
80
08:41:16
08:44:09
08:47:02
08:49:55
08:52:48
08:55:40
08:58:33
Time (UTC)
Signal strenght (dB)
6
0
-6
-12
-18
-24
-30
-36


Watts m-2
10-3
10-4
10-5
10-6
10-7
10-8
10-9
X
M
C
B
A
GOES 15 1.0-8.0 A
GOES 13 1.0-8.0 A
GOES 15 0.5-4.0 A
GOES 13 0.5-4.0 A
0300
0400
0500
0600
0700
0800
0900
Universal Time
Updated 2015 Dec 1 0856 UTC
NOAA/SWPC Boulder, CO USA


Spectrogram 01.12.2015 Hlohovec Observatory
Frequency (MHz)
120
125
130
135
08:38:24
08:41:16
08:44:09
08:47:02
08:49:55
08:52:48
08:55:40
08:58:33
Time (UTC)
Signal strenght (dB)
6
0
-6
-12
-18
-24
-30
-36

1 Dec 2015:


Learmonth Spectrograph (25–180MHz)
Period: 01–12–2015 08:00:03UT to 01–12–2015 08:59:54UT
180
B
75
M
H
z
A
25
08:00:03 08:05:00 08:10:00 08:15:00 08:20:00 08:25:00 08:30:00 08:35:00 08:40:00 08:45:00 08:50:00 08:55:00


2015/12/01 Radio flux density, e–CALLISTO (BLENSW)
20
40
60
Frequency (MHZ)
08:48
08:52
08:56
09:00
Start Time (01–Dec–15 08:44:38)

- Solar Radio Bursts – classification:
  Bruzek and **Durrant** (1977 / Slovak transl. 1983)

Solar Radio Burst Classifications

TYPE	CHARACTERISTICS	DURATION	FREQUENCY RANGE	ASSOCIATED PHENOMENA
I	Short, narrow-bandwidth bursts. Usually occur in large numbers with underlying continuum.	Single burst: ~ 1 second Storm: hours - days	80 – 200 MHz	Active regions, flares, eruptive prominences.
II	Slow frequency drift bursts. Usually accompanied by a (usually stronger intensity) second harmonic.	3- 30 minutes	Fundamental: 20 – 150 MHz	Flares, proton emission, magnetohydrodynamic shockwaves.
III	Fast frequency drift bursts. Can occur singularly, in groups, or storms (often with underlying continuum). Can be accompanied by a second harmonic	Single burst: 1 - 3 seconds Group: 1 -5 minutes Storm: minutes - hours	10 kHz – 1 GHz	Active regions, flares.
IV	Stationary Type IV: Broadband continuum with fine structure	Hours - days	20 MHz – 2 GHz	Flares, proton emission.
	Moving Type IV: Broadband, slow frequency drift, smooth continuum.	30 – 2 hours	20 – 400 MHz	Eruptive prominences, magnetohydrodynamic shockwaves.
	Flare Continua: Broadband, smooth continuum.	3 – 45 minutes	25 – 200 MHz	Flares, proton emission.
V	Smooth, short-lived continuum. Follows some type III bursts. Never occur in isolation.	1-3 minutes	10 - 200 MHz	Same as type III bursts.

- **Kliem, Karlický, and Benz** (2000), Solar flare radio pulsations as a signature of dynamic magnetic reconnection [Astronomy and Astrophysics, Vol. 360, p.715-728]
- **Cane, Erickson,** and **Prestage** (2002), Solar flares, type III radio bursts, coronal mass ejections, and energetic particles [JGR, 107]

- **Cairns et al.** (2003), Type II solar radio bursts: Theory and space weather implications [SSR, 107: 27–34]

- Solar radio burst and their potential use as diagnostics of Space Weather:
  White (2007) [Solar Radio Bursts and Space Weather, Asian Journal of Physics],
  Gopalswamy (2012) [Solar Radio Bursts and Space Weather, NASA, Technical Report, GSFC.ABS.7212.2012]

- Interference and interruption of service of wireless communications systems due to solar radio bursts.

- **RadioSun-5,** May 23-27, 2016, České Budějovice, Czech Republic