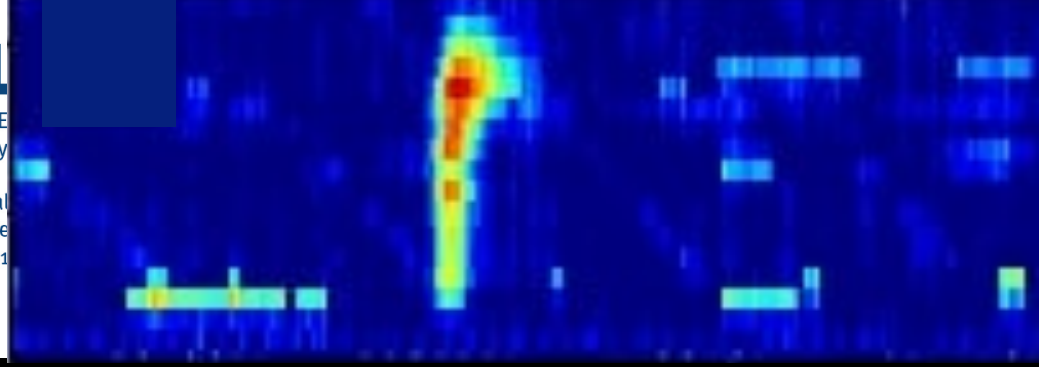

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Commissioning of CALLISTO spectrometers in Peru and observations of type III Solar Radio Bursts

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AGENCIA ESPACIAL DEL PERU CONIDA

PUCP

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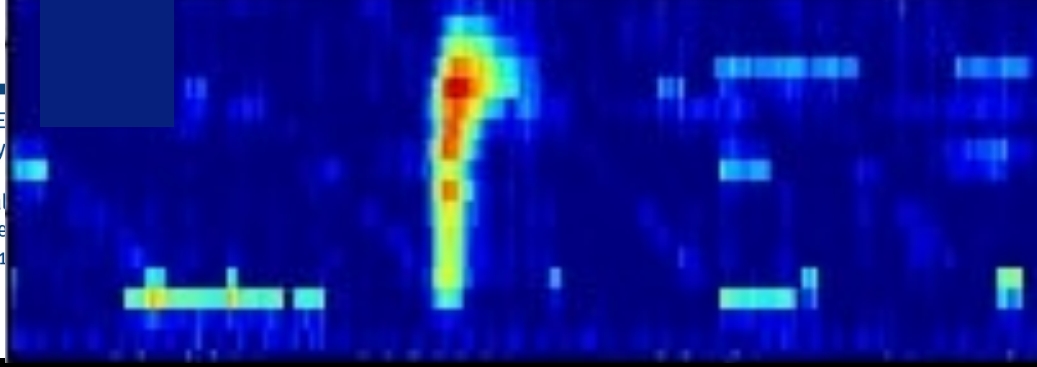

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Research in Astronomy and Astrophysics

CALLISTO facilities in Peru: spectrometer commissioning and observations of type III solar radio bursts

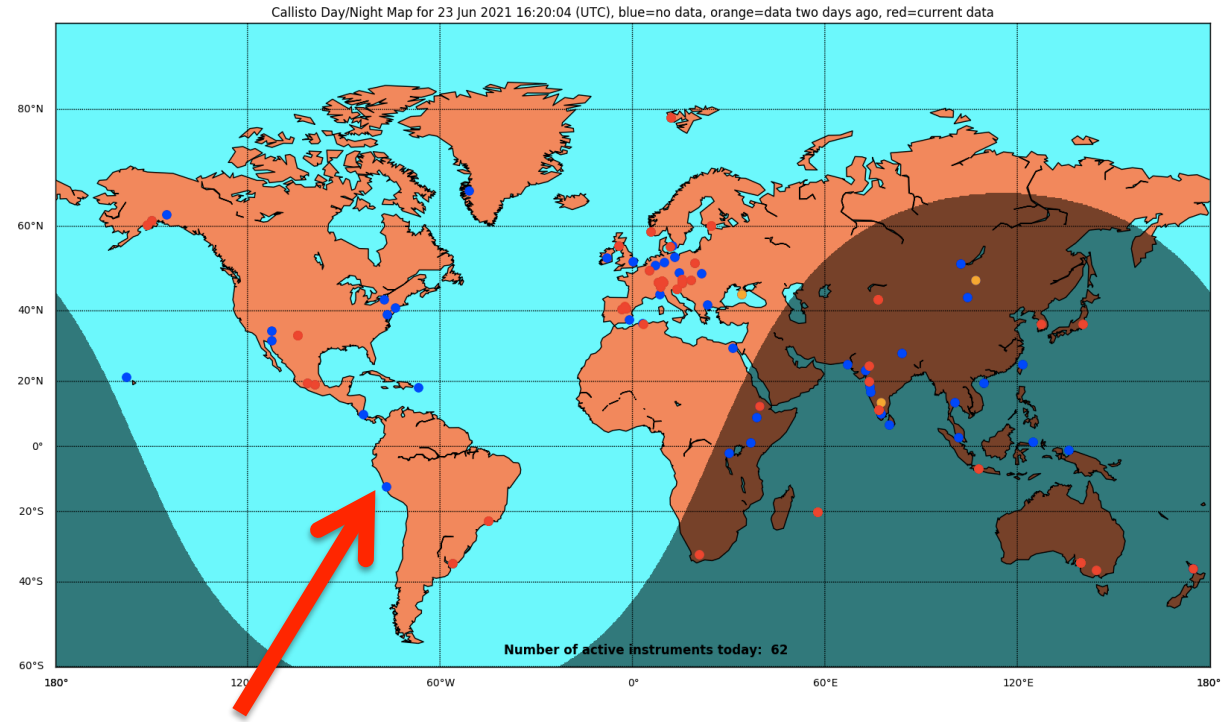
Javier Alonso Rengifo[1,2], Verónica Loaiza-Tacuri[3,2], José Bazo[1] and Walter Robert Guevara Day[4,2]

e-CALLISTO

CALLISTO: Compound Astronomical Low frequency Low cost Instrument for Spectroscopy and Transportable Observatory

> 170 stations,
Daily data from ~60 stations

Monitor solar radio activities:
45 - 870 MHz



- Strategic location near Equator: observing the Sun evenly throughout the year
- Unique in its time-zone (**GMT-5**) coverage.

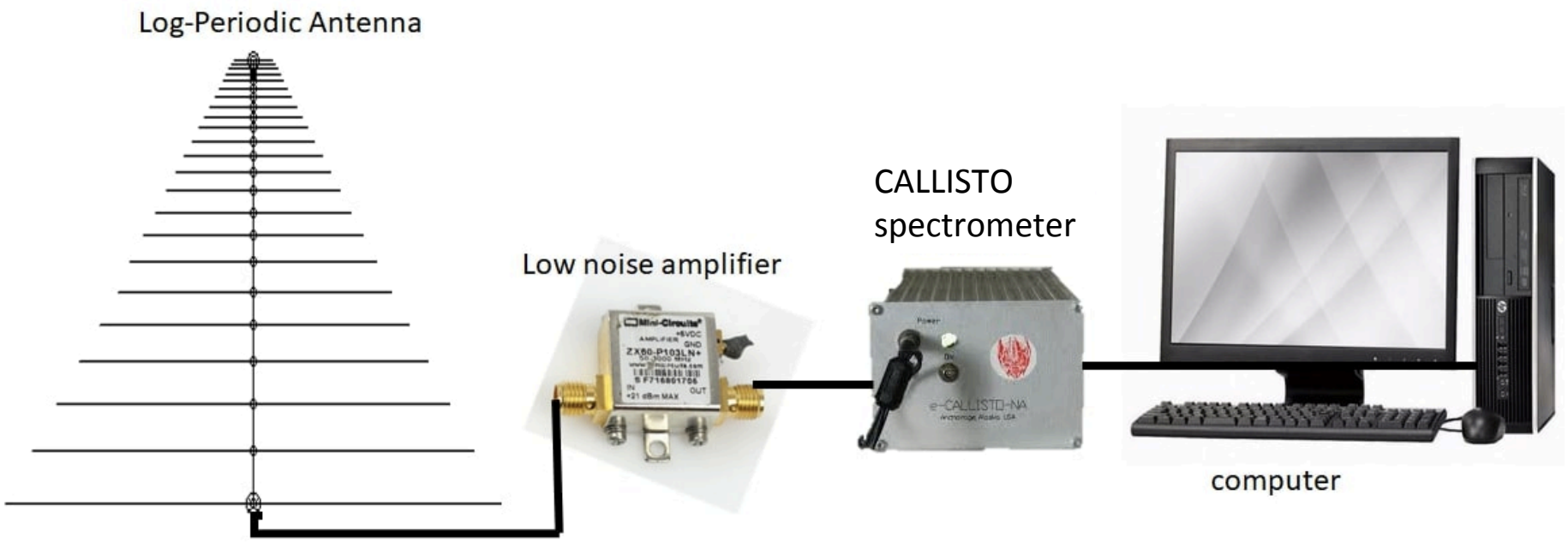
Installation & Commissioning

- 2012 - 2014 by the Astrophysics Directorate of **CONIDA** (Comisión Nacional de Investigación y Desarrollo Aeroespacial)

CALLISTO NA-06 (2012) at main office of CONIDA (Lima center)

CALLISTO NA-18 (2014) at CONIDA scientific site (Pucusana)

Station setup

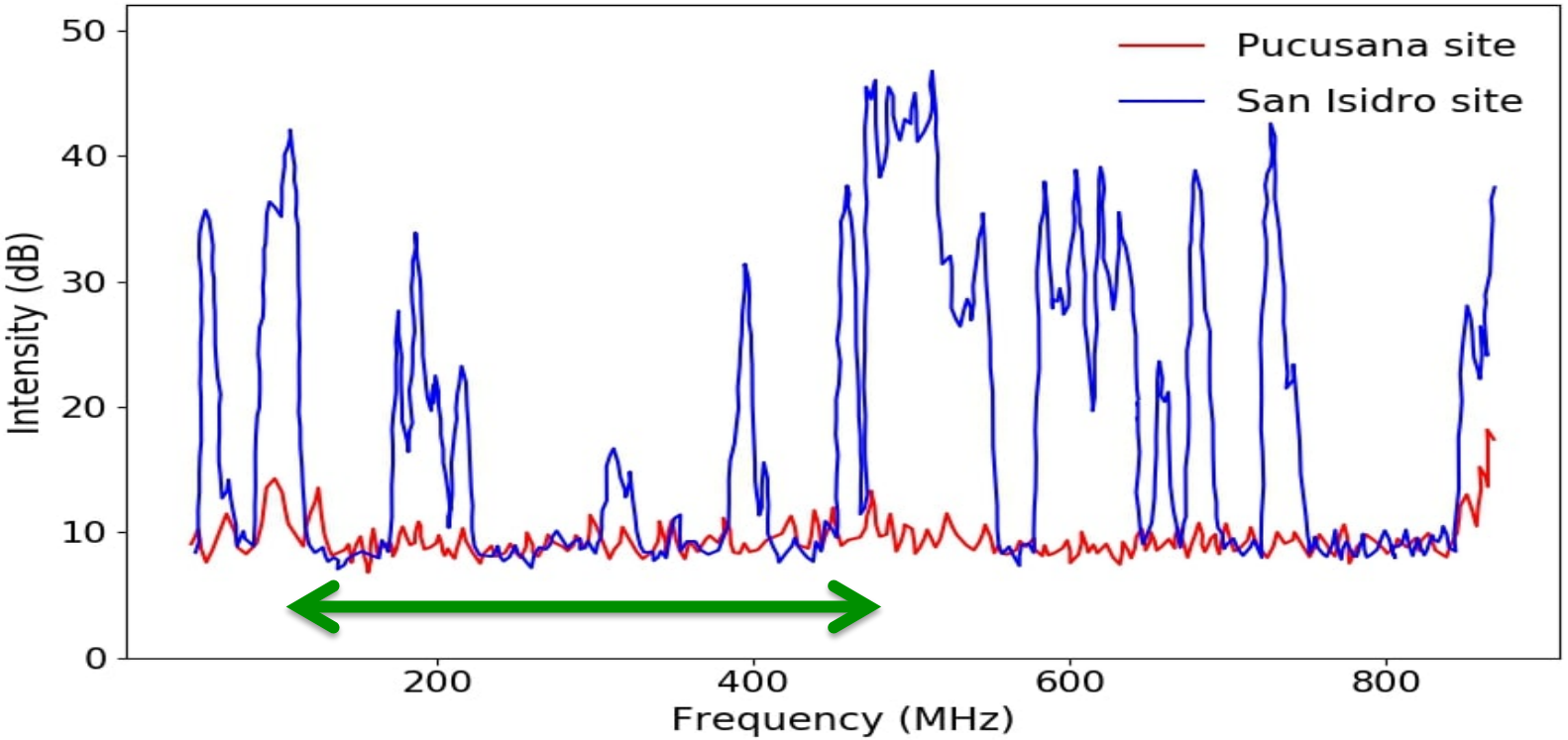


LPDA antenna with 23 elements: 70–1000 MHz

- heterodyne receiver
- upto 400 frequencies per spectrum
- 1ms integration time

Data coverage: 70 - 870 MHz

Radio Frequency Interference

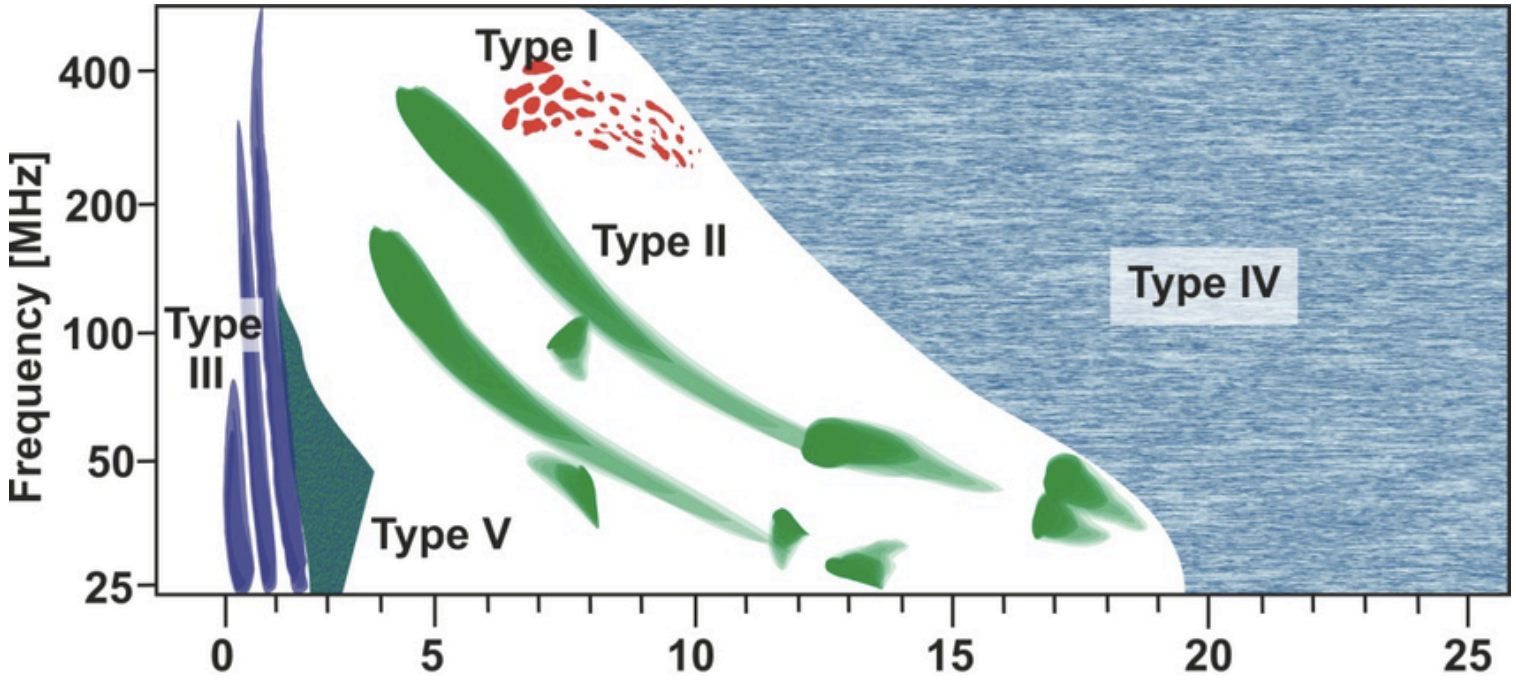


Simple dipole + spectral analyzer

- San Isidro: large background: significant telecommunication activities
- Pucusana: lower background noise, natural terrain shielding (surrounding hills).

Type III Solar Radio Bursts (SRBs)

- Common transient bursts.
- **Fast drift from higher to lower frequencies over time**
- Duration: single (1-3 s) , group bursts (1-5min)
- Produced by non-thermal electrons accelerated in the solar corona during flares.



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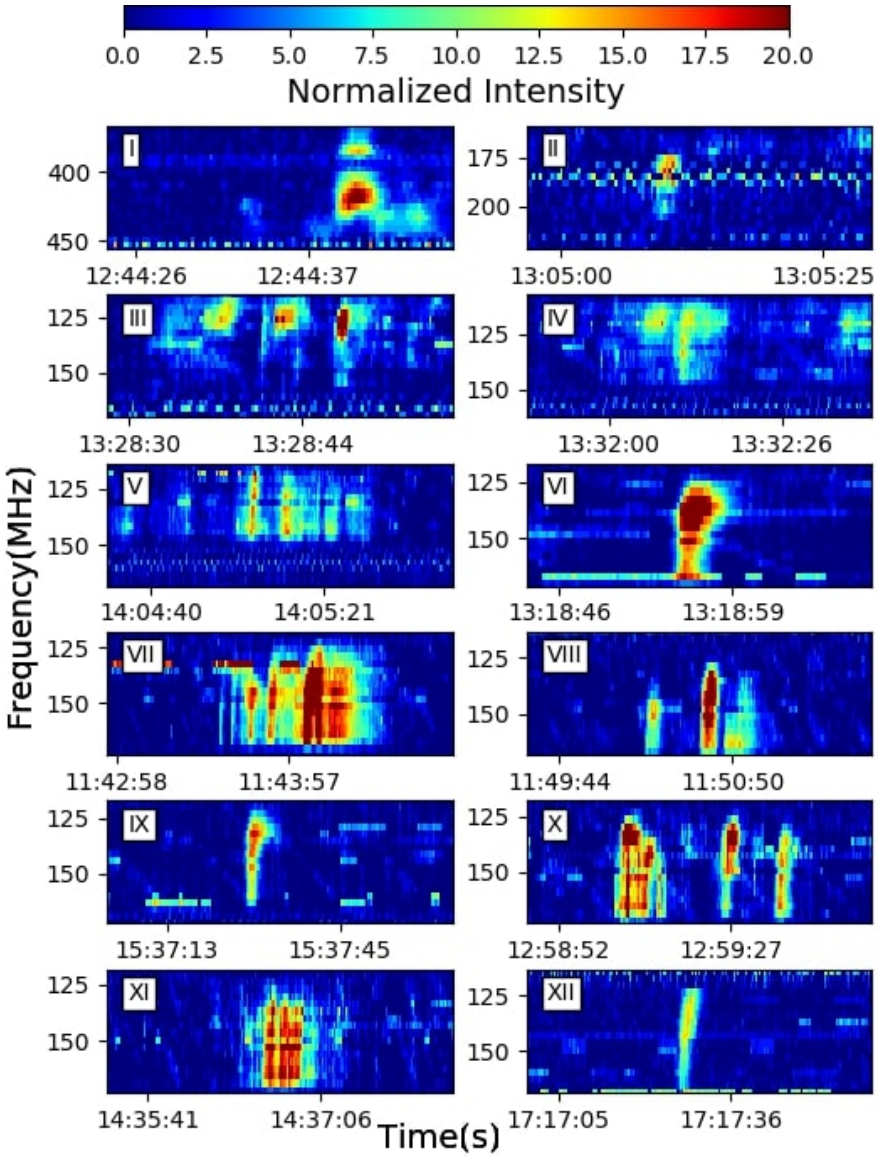
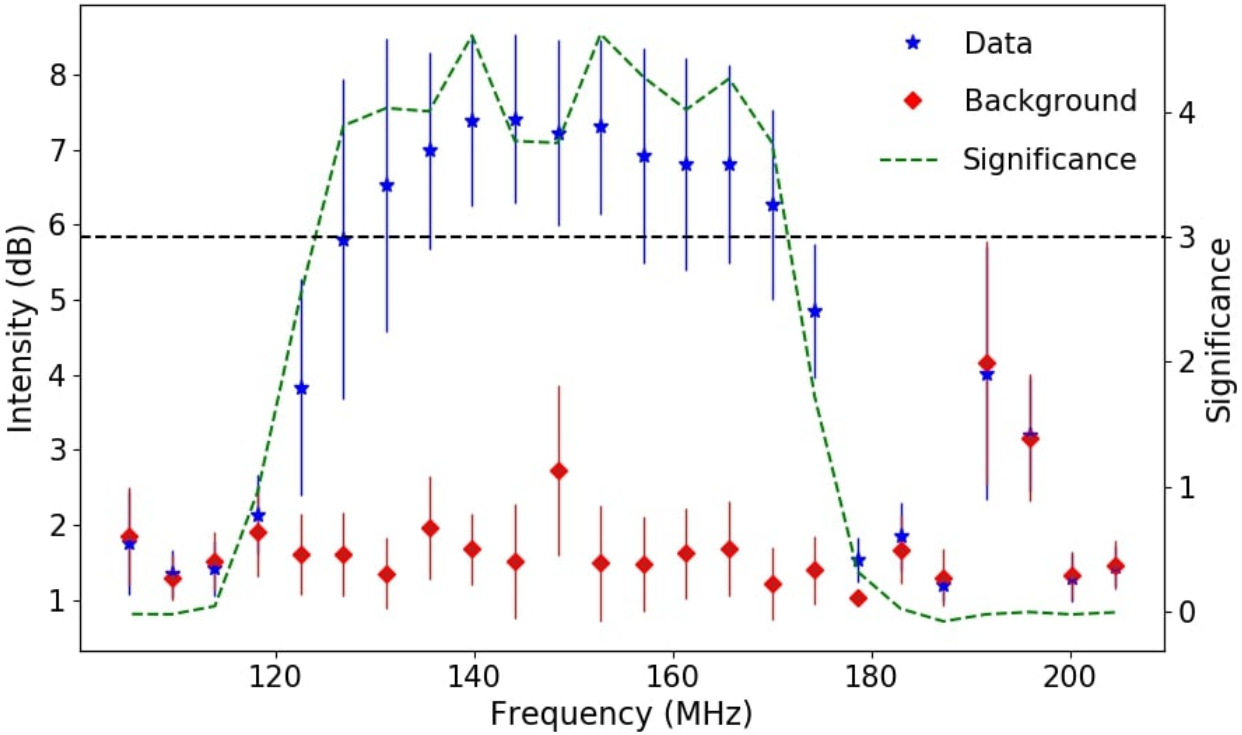
Radio Observations at Pucusana



- Data taking: 10/10/2014 – 08/03/2016
- Stored in e-CALLISTO network FHNW Windisch server.
- Most significant signals: 12 events. (12/2014 – 06/2015)

- Time independent low-level standing-wave pattern removed.

Burst signal analysis



$$S = \frac{n-b}{\sqrt{b}}$$

Background: mean intensity in a 15-minute interval from one day before.

Signal: mean intensity for each frequency over the time interval of the burst(i.e., ≈ 2 s).

Frequency range: where signal is above background given a significance cut.

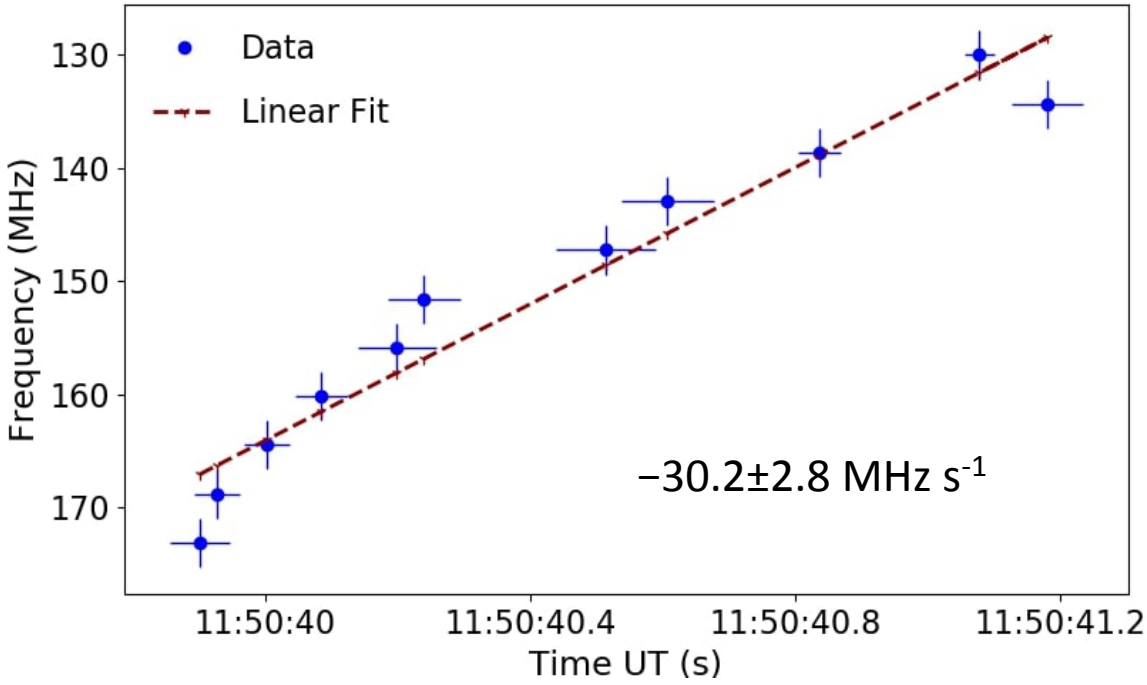
Frequency drift rate

Drift rate: displacement of frequency representing the burst peak flux in a time interval:

$$D = \frac{df}{dt} = \frac{f_f - f_i}{t_f - t_i}$$

Procedure:

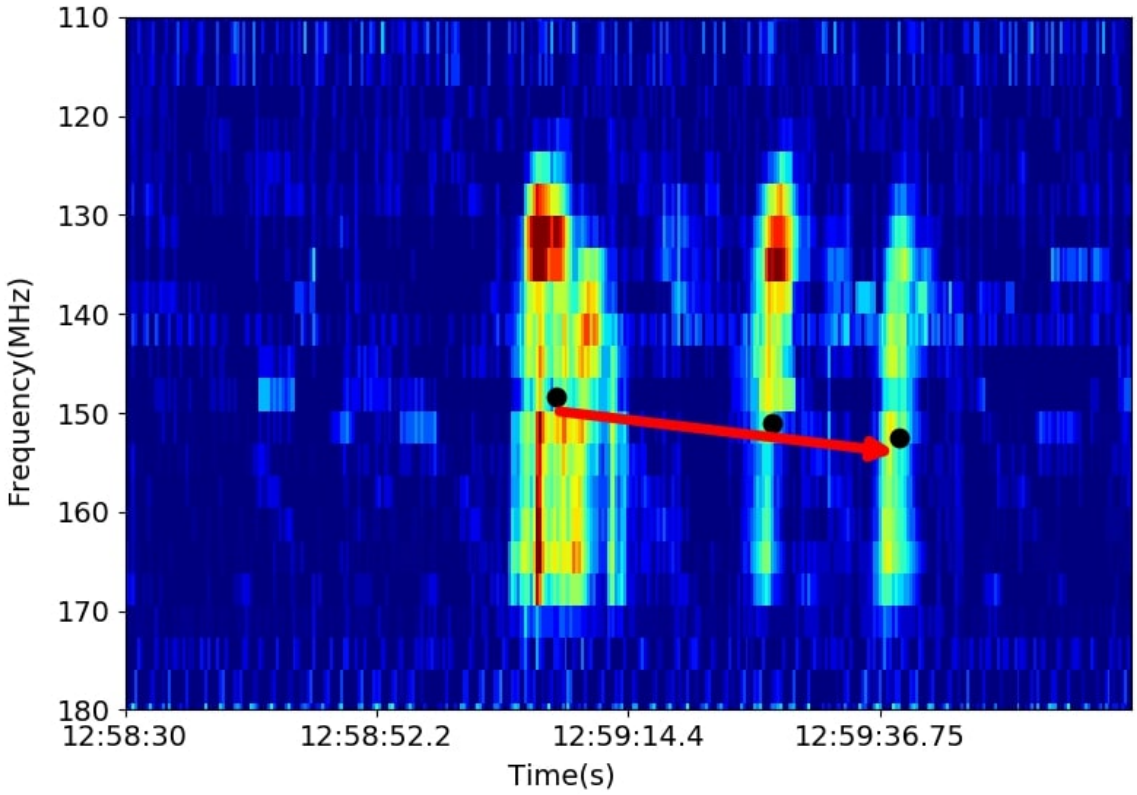
- For each LC fit a Gaussian around the peak flux
- Taking the ordered pair of central time and frequency of fit.
- Fit a linear regression of these points.



Burst Duration: average of FWHM of all frequency profiles fits.

Global frequency drift

- For solar events with a group of consecutive bursts:
  variation of central burst frequency during the time of the event
- 4 group burst calculated.



Radio Burst Properties

SRB	Date (UT)	cut (σ)	Frequency Range (MHz)	Drift (MHz/s)	Duration (s)	Global Drift (MHz/s)
I	2014/12/21 - 12:44:39	2.5	411 - 433	−84.0 ± 28.2	1.39 ± 0.02	s
II	2014/12/21 - 13:05:08	1	178 - 196	−41.4±5.4	1.32±0.03	s
III	2015/01/14 - 13:28:47	3.5	122 - 140	−15.5±0.5	3.12±0.16	0.55±0.35
IV	2015/01/14 - 13:32:10	3	118 - 140	−14.0±3.3	3.77±0.27	*
V	2015/01/14 - 14:05:02	2.5	131 - 157	−35.2±1.8	2.11±0.08	0.20 ± 0.14
VI	2015/01/25 - 13:18:54	2	122 - 174	−39.2±2.4	1.50±0.02	s
VII	2015/01/26 - 11:44:01	4	127 - 170	−23.8±4.6	4.48±1.66	0.51±0.17
VIII	2015/01/26 - 11:50:37	3	127 - 170	−30.2±2.8	2.91±0.03	*
IX	2015/01/26 - 15:37:27	1.5	123 - 140	−18.8±3.9	2.05±0.03	s
X	2015/02/01 - 12:59:26	2	127 - 149	−18.5±1.4	1.88±0.03	0.14±0.02
XI	2015/02/01 - 14:36:38	2.5	127 - 170	−25.3±5.8	2.99±0.18	†
XII	2015/06/30 - 17:17:26	1	114 - 170	−23.1±1.5	1.49±0.02	s

- All have negative drift rates.
- SRBs between 114 and 174 MHz: **$\langle D \rangle = -25.8 \pm 3.72$ MHz s^{-1} .**

Conclusions

- Two e-CALLISTO stations have been installed and commissioned in Lima, Peru.
- During data acquisition the detector was unique in its time-zone coverage.
- RFI was analyzed: San Isidro station was not suitable for identifying SRBs, Pucusana station has a lower background due to the natural terrain shielding.
- We have demonstrated that Pucusana e-CALLISTO station was able to observe type III SRB events in the metric and decimetric bands.
- 12 type III SRB radio bursts have been identified:
  - frequency range = 114 - 174MHz,
  - drift rate = –25.8 ± 3.7 MHz s−1,
  - duration = 2.6 ± 0.3 s
- Global frequency drift for group bursts = 0.4 ± 0.1 MHz s^{-1}