SOLAR RADIO ASTRONOMY

„CALLISTO instrument and the e-Callisto network“

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Monstein Radio Astronomy Support / IRSOL
Switzerland

Topics of this presentation

- Why Callisto? Requirements for an instrument site.
- Key specifications of Callisto
- System configuration
- Instrument coverage, main burst types
- Network structure and data products (examples)
- Presentation of a few, of currently ~217 instruments out there
- Conclusions

Why Callisto?

Swiss - contribution to IHY2007 and ISWI

Goal: → Understanding Transient Phenomenon in the Solar Corona

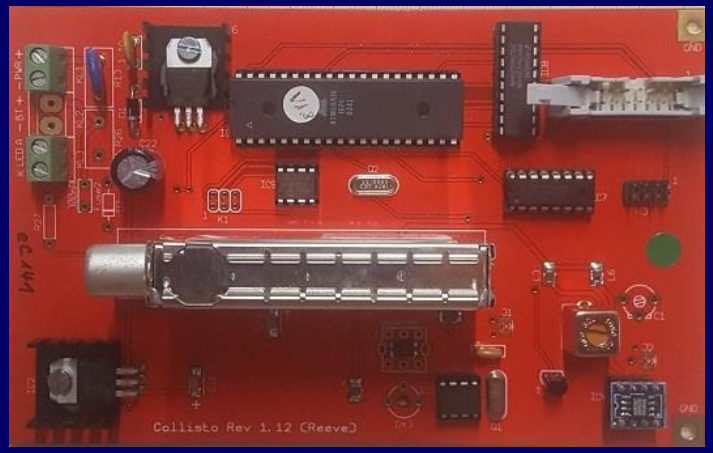
C	**ompound**
A	**stronomical**
L	**ow cost**
L	**ow frequency**
I	**nstrument for**
S	**pectroscopy and**
T	**ransportable**
O	**bservatory**

Requirements for an instrument

- Permanent technical support available ~1% FTE
- Permanent electrical power
- Permanent internet connection (permission for FTP upload)
- Site with lowest possible interference level (rfi)
- Motivation to operate the system and to provide data to ISWI
- Train students to deal with this kind of data
- Budget in the order of 3’000$ (Antenna, LNA, CALLISTO, PC cables, connectors and mechanical structure for antenna.)

Key specifications of Callisto

Parameter	Specification
Frequency range	45.0 MHz … 870.0 MHz (34 cm < λ < 6.7 m)
Radiometric bandwidth	300 KHz
Integration time	1 ms per spectral pixel
Dynamic range	> 40 dB (> 10’000:1)
Noise figure	< 10 dB (< 3’000 K)
Measuring rate	800 frequencies/s
Cost	Hardware ~US520$
Outputs	FIT-files
Components	221



CALLISTO system configuration without LNA

Outdoor antenna

RF

Coax L1

CALLISTO
spectrometer

PSU12V

RS-232

RS-232 USB

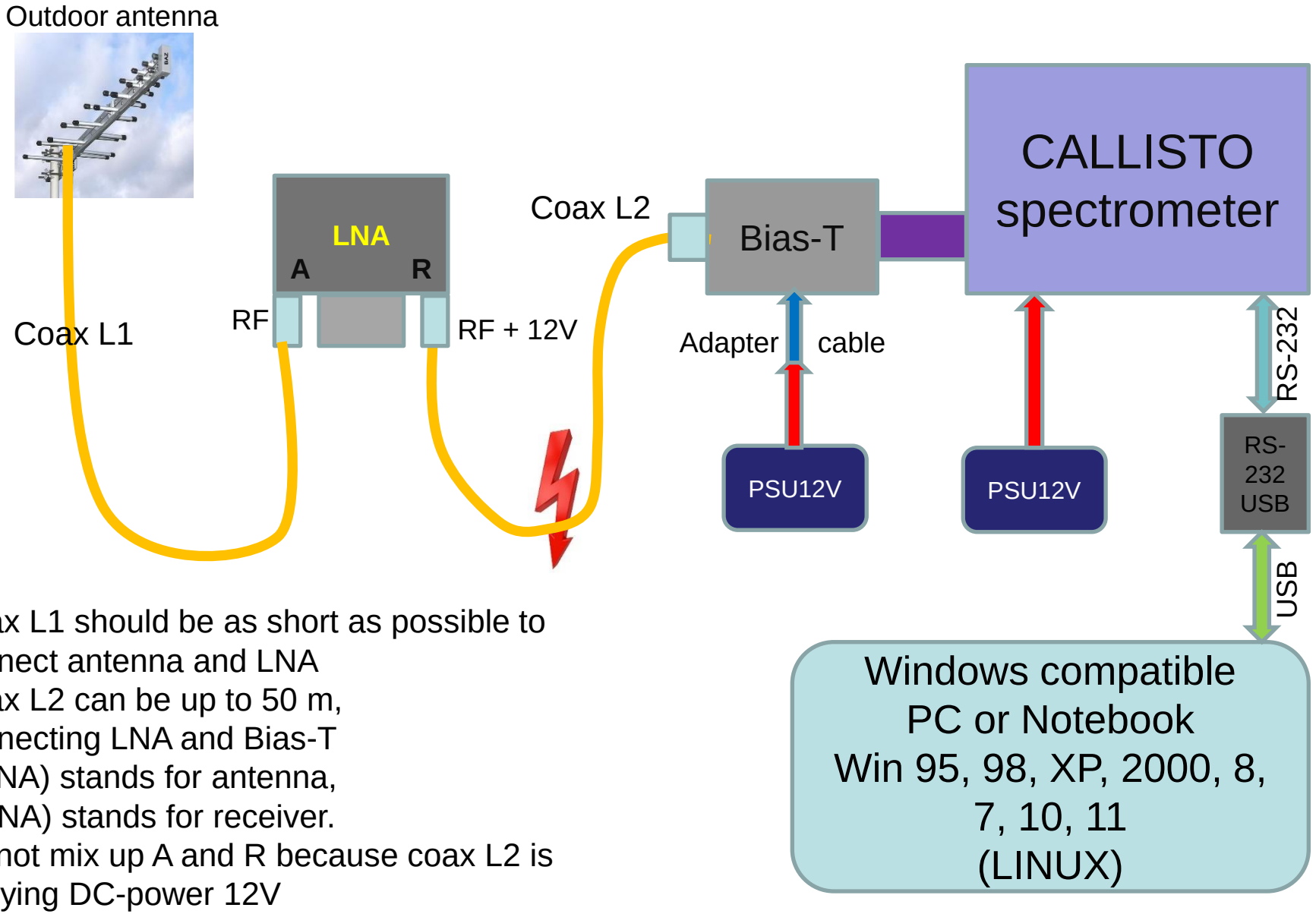
USB

Windows compatible
PC or Notebook
Win 95, 98, XP, 2000, 8, 7, 10, 11
(LINUX)

Coax L1 should be as short as possible and of low loss to connect antenna and Callisto

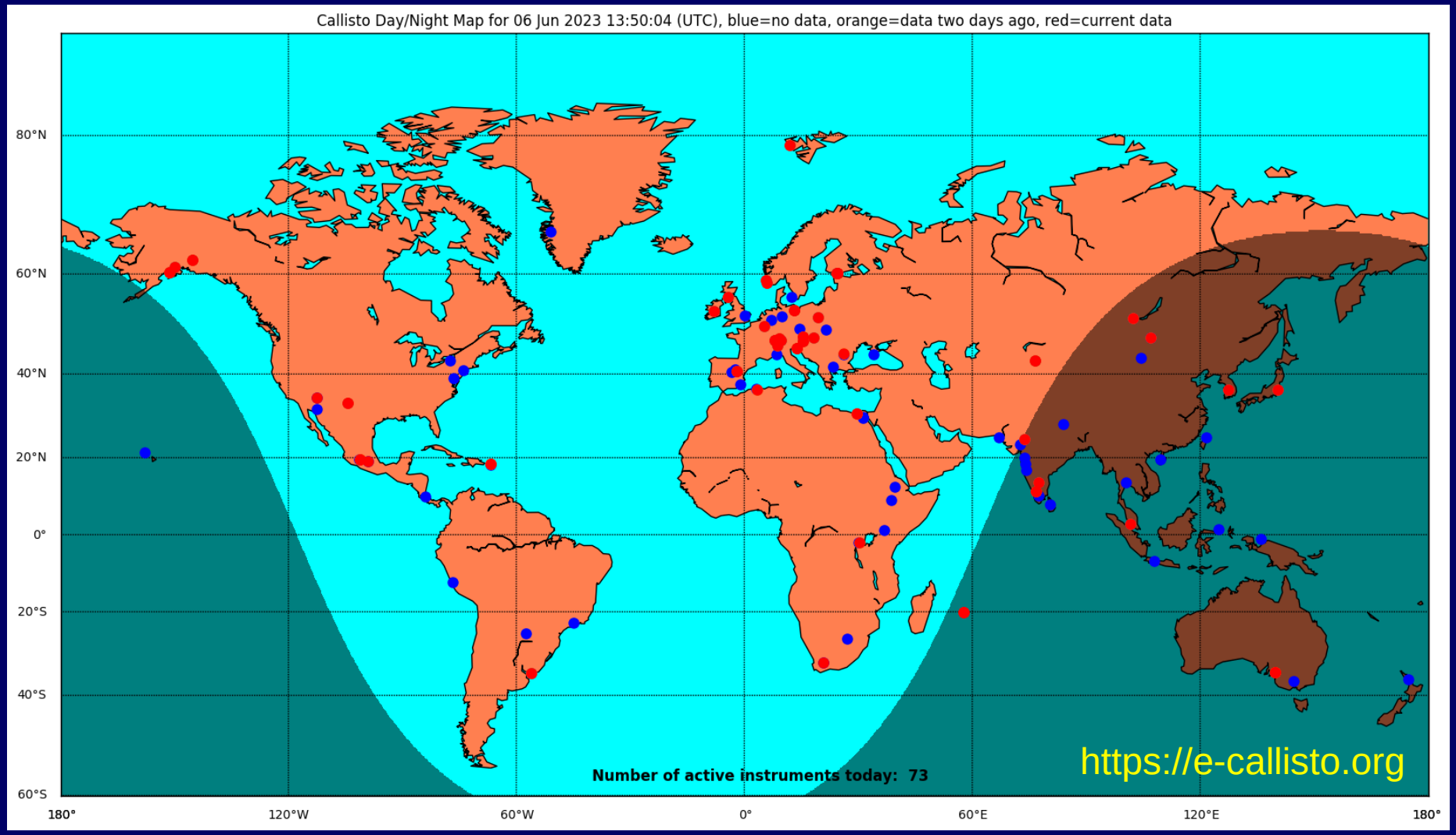
This configuration is meant for sites with strong local interference which may saturate the system.

CALLISTO system configuration with LNA



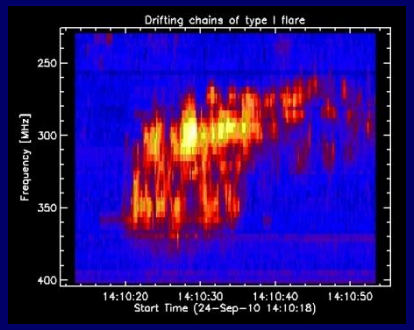
Coax L1 should be as short as possible to connect antenna and LNA
Coax L2 can be up to 50 m, connecting LNA and Bias-T
A(LNA) stands for antenna,
R(LNA) stands for receiver.
Do not mix up A and R because coax L2 is carrying DC-power 12V

Coverage

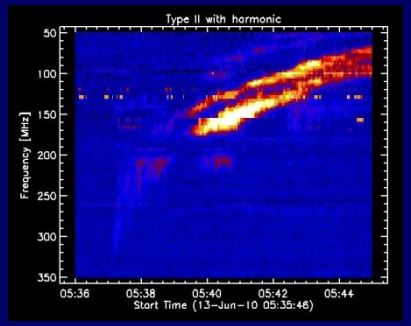


Status May 2023: ~218 instruments at 128 different locations worldwide.
Reached 100 % coverage 24/7 all over the seasons in May 2013

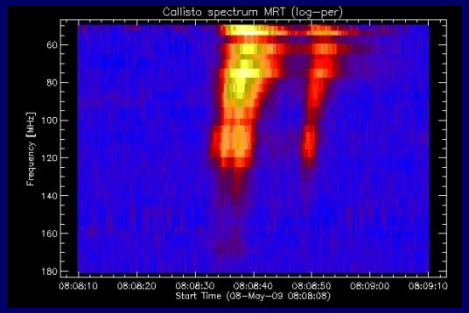
CALLISTO selected burst types



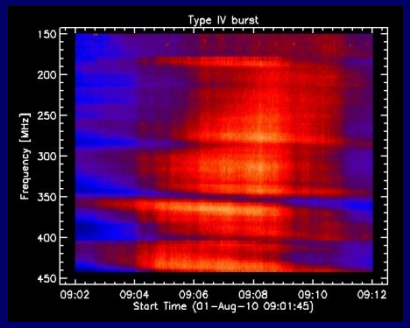
Noise storm or type I



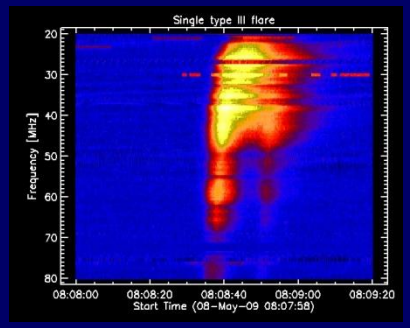
Type II with split band



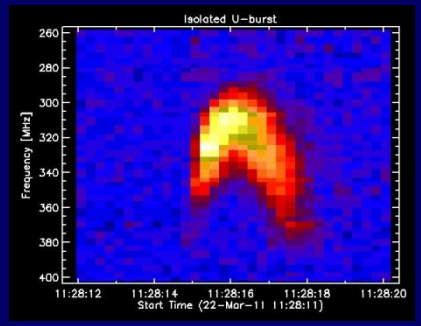
Isolated type III



Type IV



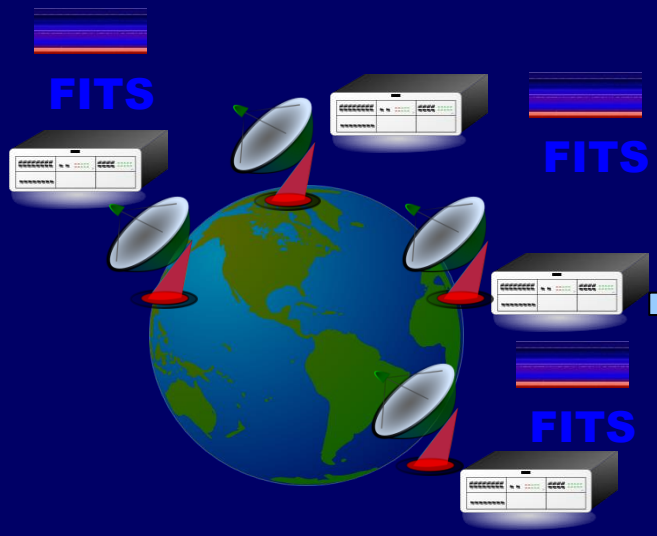
Type V



U-burst

Access to burst- and rfi-catalogue here:
https://www.e-callisto.org/GeneralDocuments/BurstCatalog.pdf

e-Callisto network

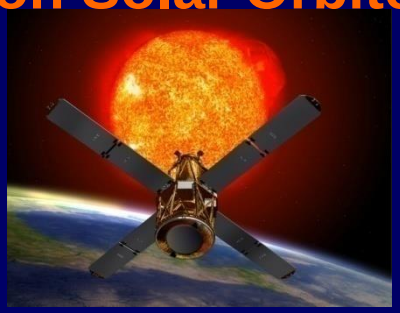


FTP

University of Applied Sciences Switzerland Dr. André Csillaghy

Control / management by me, the instrument PI

> 2020 → STIX on Solar Orbiter

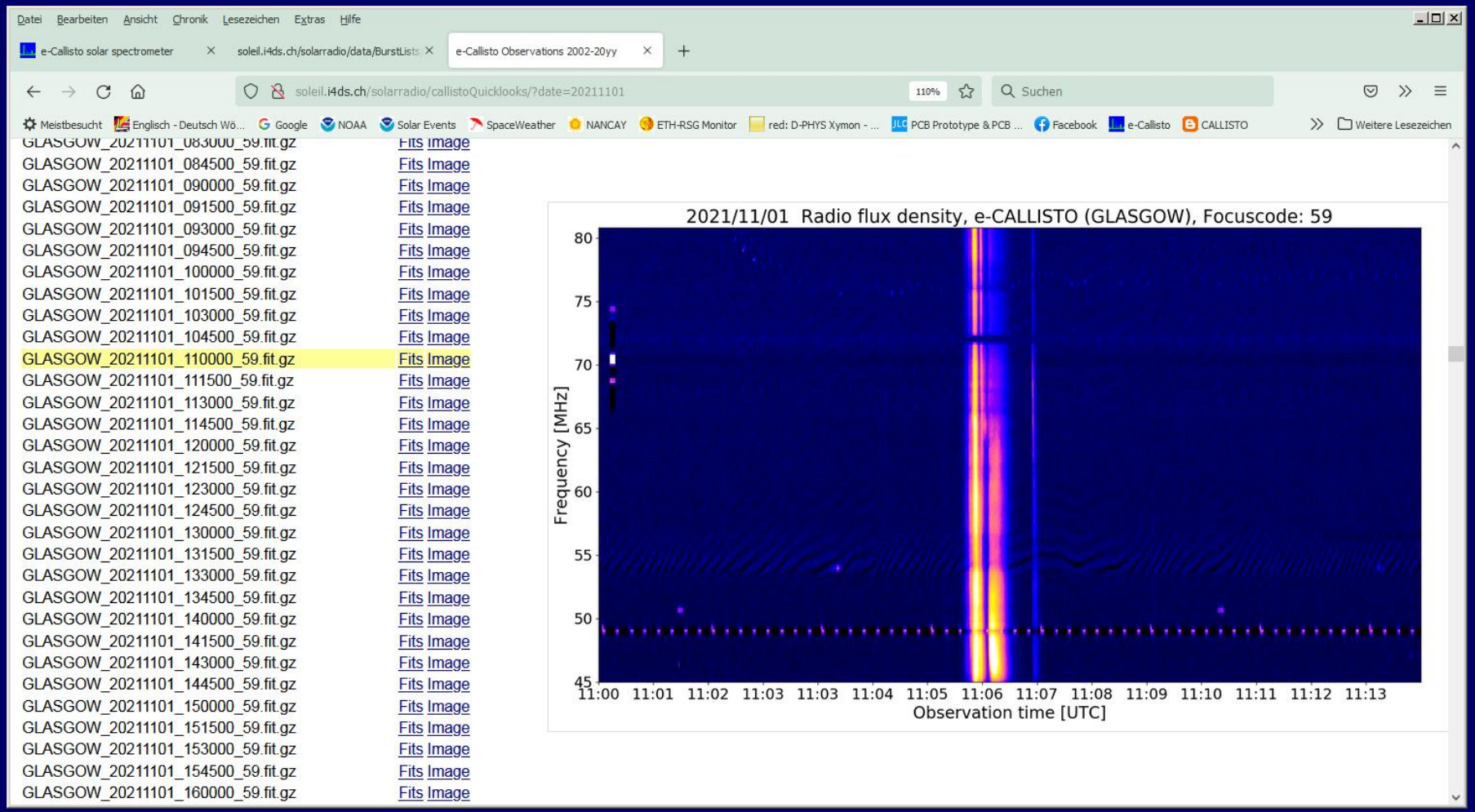


Hosts send data actively via FTP to the central data server.

We provide:
→ 15’ FIT-files and
→ 15’ QuickViews
→ Daily spectral overviews
→ Daily light curves
→ Burst list

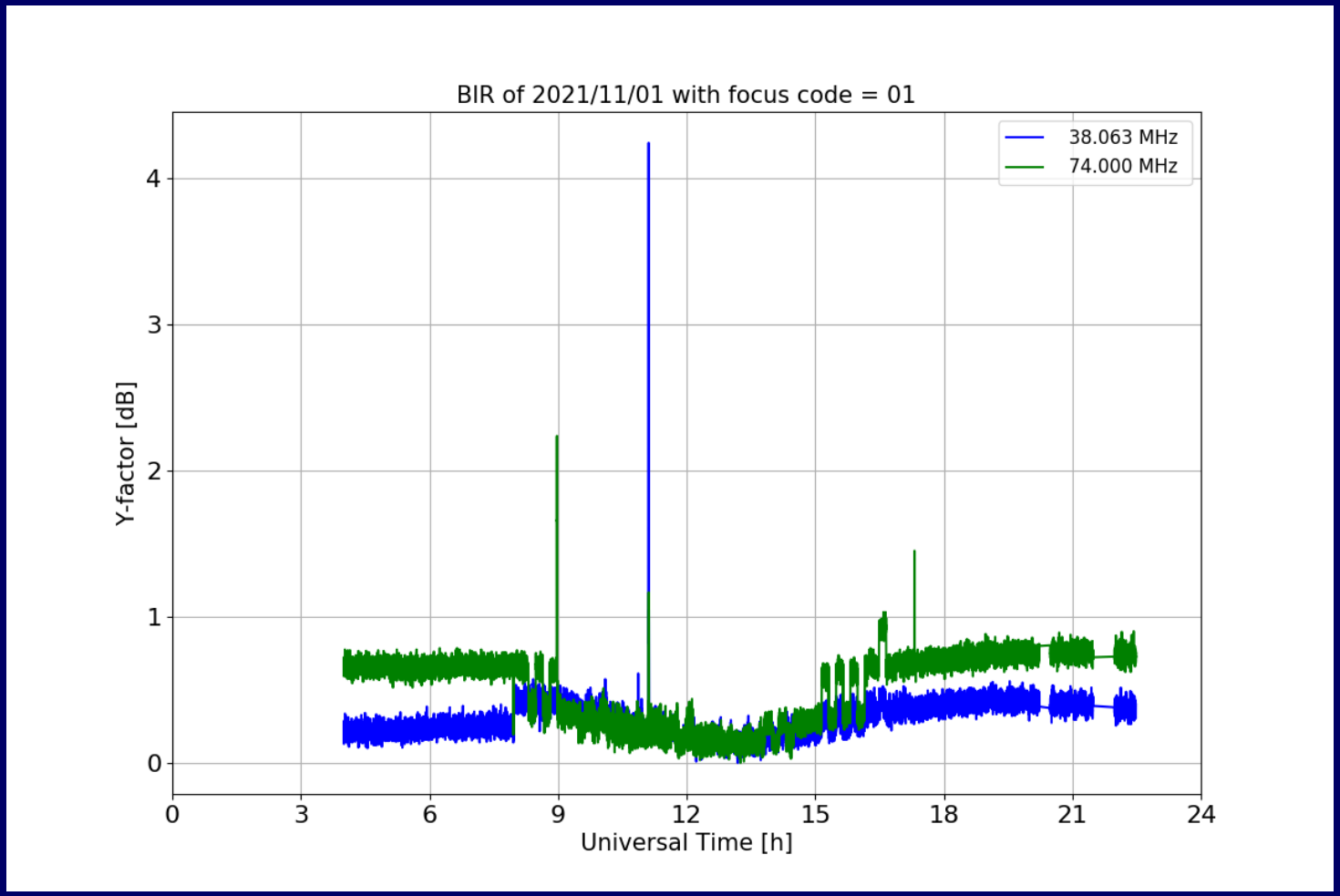
What kind of processed data do we provide?

1. Raw data (FIT-files) and quick views: http://soleil.i4ds.ch/solarradio/callistoQuicklooks/



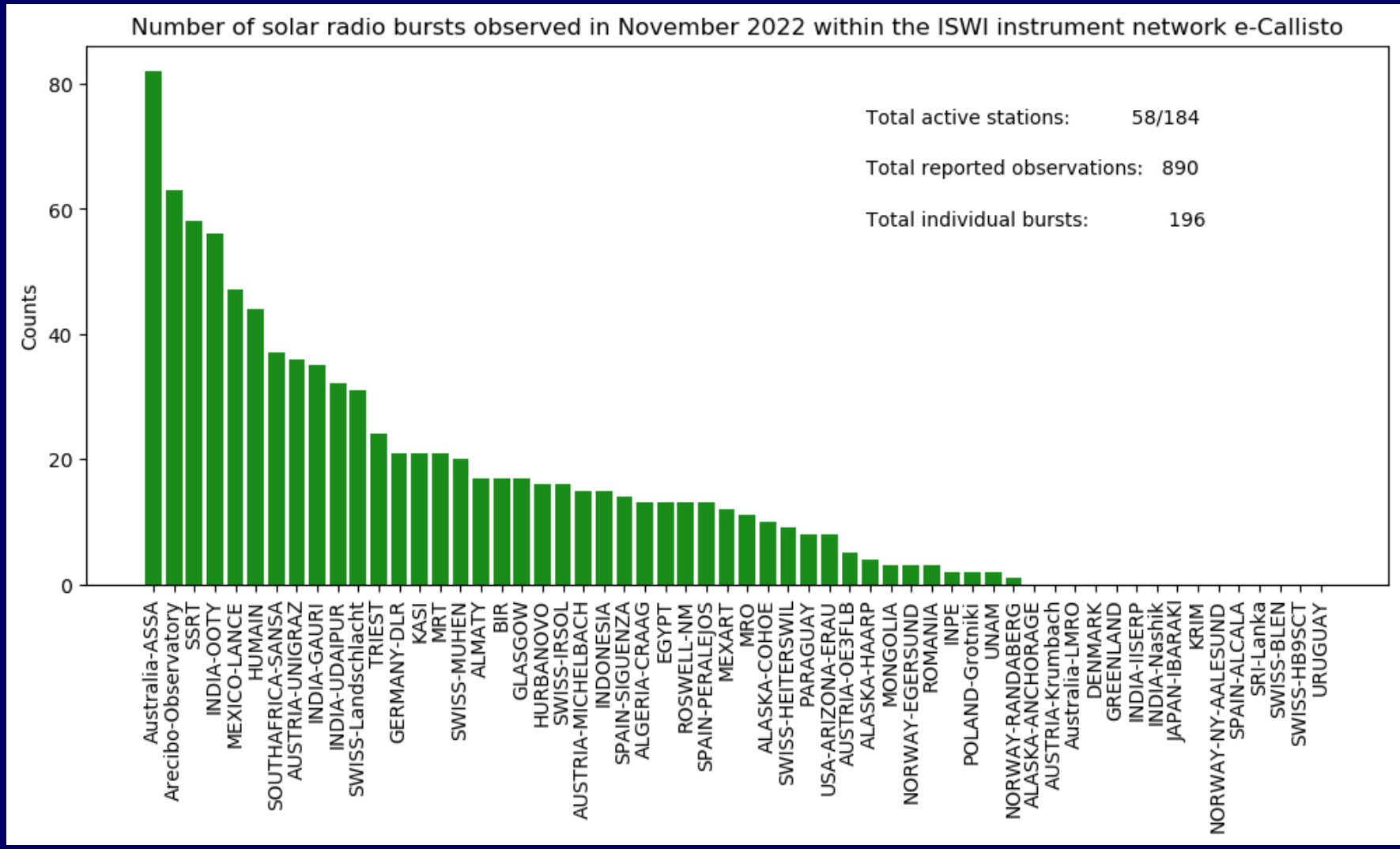
What kind of processed data do we provide?

2. Daily light curves: http://soleil.i4ds.ch/solarradio/data/Lightcurves/



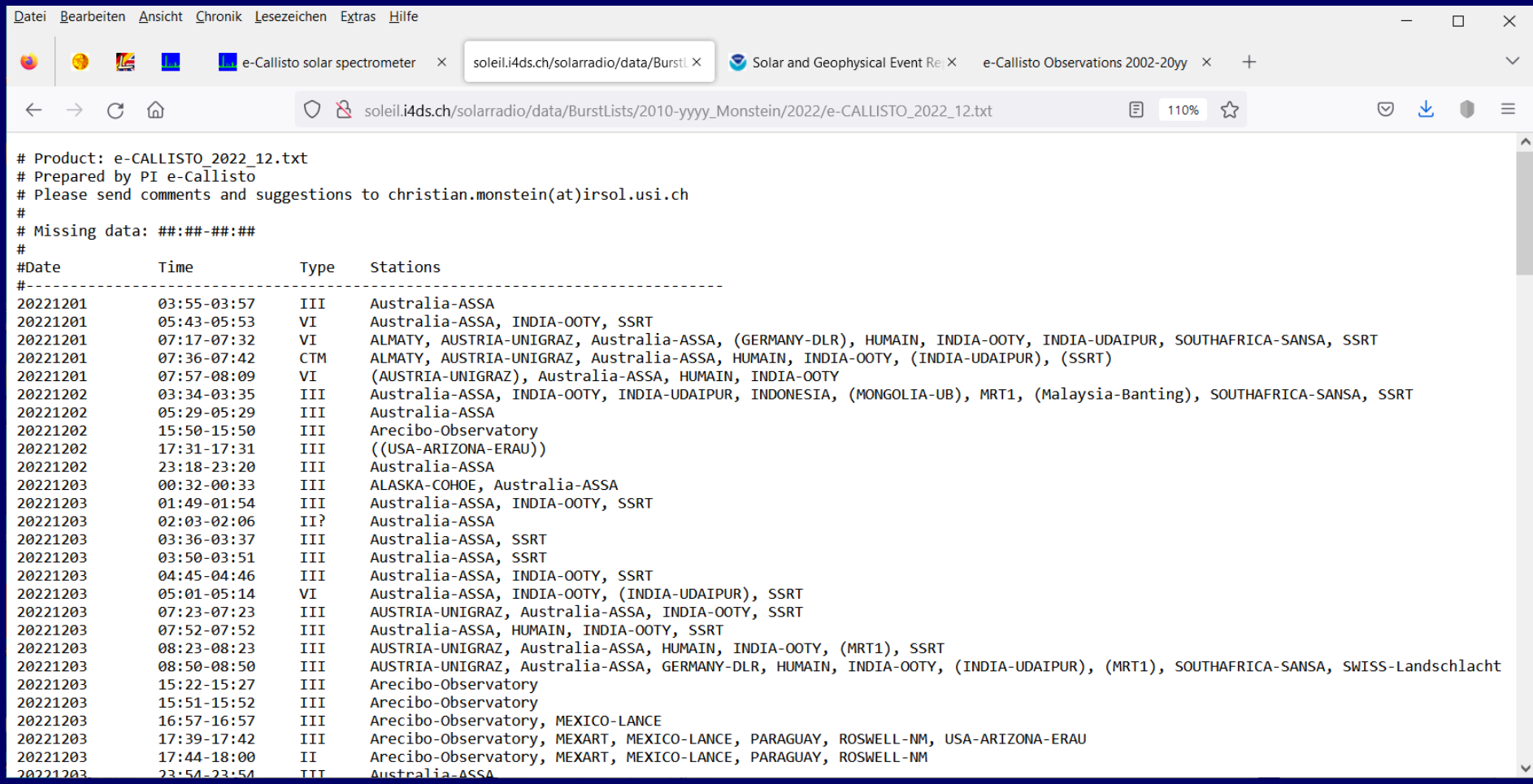
What kind of processed data do we provide?

3. Statistics about observed bursts: http://www.e-callisto.org/Data/data.html



What kind of processed data do we provide?

4. Burst list: http://soleil.i4ds.ch/solarradio/data/BurstLists/2010-yyyy_Monstein/




```
# Product: e-CALLISTO_2022_12.txt
# Prepared by PI e-Callisto
# Please send comments and suggestions to christian.monstein(at)irsol.usi.ch
#
# Missing data: ##:##-##:##
#
#Date          Time           Type    Stations
#-------------------------------------------------------------------------------
20221201       03:55-03:57    III     Australia-ASSA
20221201       05:43-05:53    VI      Australia-ASSA, INDIA-OOTY, SSRT
20221201       07:17-07:32    VI      ALMATY, AUSTRIA-UNIGRAZ, Australia-ASSA, (GERMANY-DLR), HUMAIN, INDIA-OOTY, INDIA-UDAIPUR, SOUTHAFRICA-SANSA, SSRT
20221201       07:36-07:42    CTM     ALMATY, AUSTRIA-UNIGRAZ, Australia-ASSA, HUMAIN, INDIA-OOTY, (INDIA-UDAIPUR), (SSRT)
20221201       07:57-08:09    VI      (AUSTRIA-UNIGRAZ), Australia-ASSA, HUMAIN, INDIA-OOTY
20221202       03:34-03:35    III     Australia-ASSA, INDIA-OOTY, INDIA-UDAIPUR, INDONESIA, (MONGOLIA-UB), MRT1, (Malaysia-Banting), SOUTHAFRICA-SANSA, SSRT
20221202       05:29-05:29    III     Australia-ASSA
20221202       15:50-15:50    III     Arecibo-Observatory
20221202       17:31-17:31    III     ((USA-ARIZONA-ERAU))
20221202       23:18-23:20    III     Australia-ASSA
20221203       00:32-00:33    III     ALASKA-COHOE, Australia-ASSA
20221203       01:49-01:54    III     Australia-ASSA, INDIA-OOTY, SSRT
20221203       02:03-02:06    II?     Australia-ASSA
20221203       03:36-03:37    III     Australia-ASSA, SSRT
20221203       03:50-03:51    III     Australia-ASSA, SSRT
20221203       04:45-04:46    III     Australia-ASSA, INDIA-OOTY, SSRT
20221203       05:01-05:14    VI      Australia-ASSA, INDIA-OOTY, (INDIA-UDAIPUR), SSRT
20221203       07:23-07:23    III     AUSTRIA-UNIGRAZ, Australia-ASSA, INDIA-OOTY, SSRT
20221203       07:52-07:52    III     Australia-ASSA, HUMAIN, INDIA-OOTY, SSRT
20221203       08:23-08:23    III     AUSTRIA-UNIGRAZ, Australia-ASSA, HUMAIN, INDIA-OOTY, (MRT1), SSRT
20221203       08:50-08:50    III     AUSTRIA-UNIGRAZ, Australia-ASSA, GERMANY-DLR, HUMAIN, INDIA-OOTY, (INDIA-UDAIPUR), (MRT1), SOUTHAFRICA-SANSA, SWISS-Landschlacht
20221203       15:22-15:27    III     Arecibo-Observatory
20221203       15:51-15:52    III     Arecibo-Observatory
20221203       16:57-16:57    III     Arecibo-Observatory, MEXICO-LANCE
20221203       17:39-17:42    III     Arecibo-Observatory, MEXART, MEXICO-LANCE, PARAGUAY, ROSWELL-NM, USA-ARIZONA-ERAU
20221203       17:44-18:00    II      Arecibo-Observatory, MEXART, MEXICO-LANCE, PARAGUAY, ROSWELL-NM
20221203       23:54-23:54    III     Australia-ASSA
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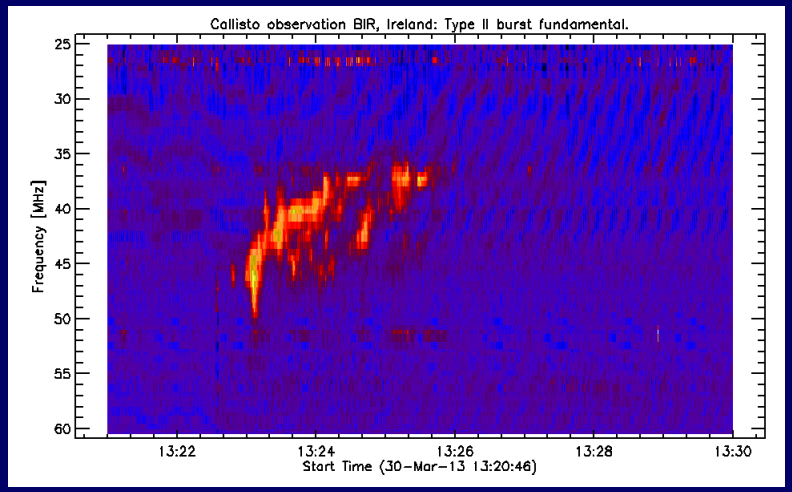
Advantage of distributed instruments



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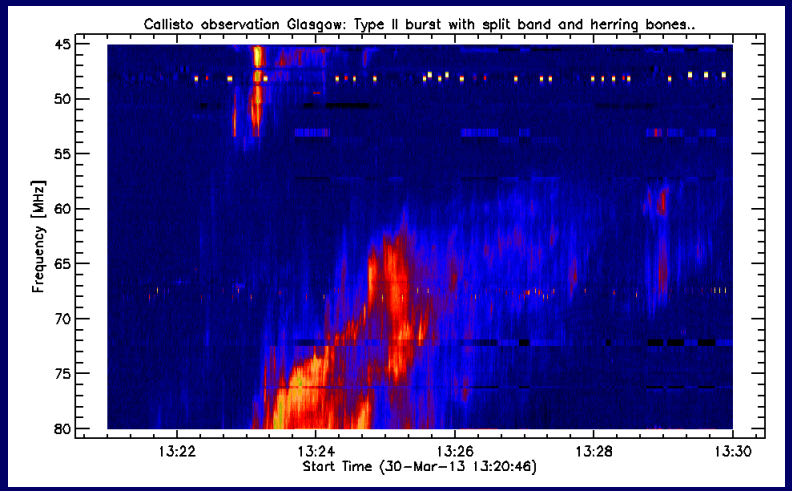

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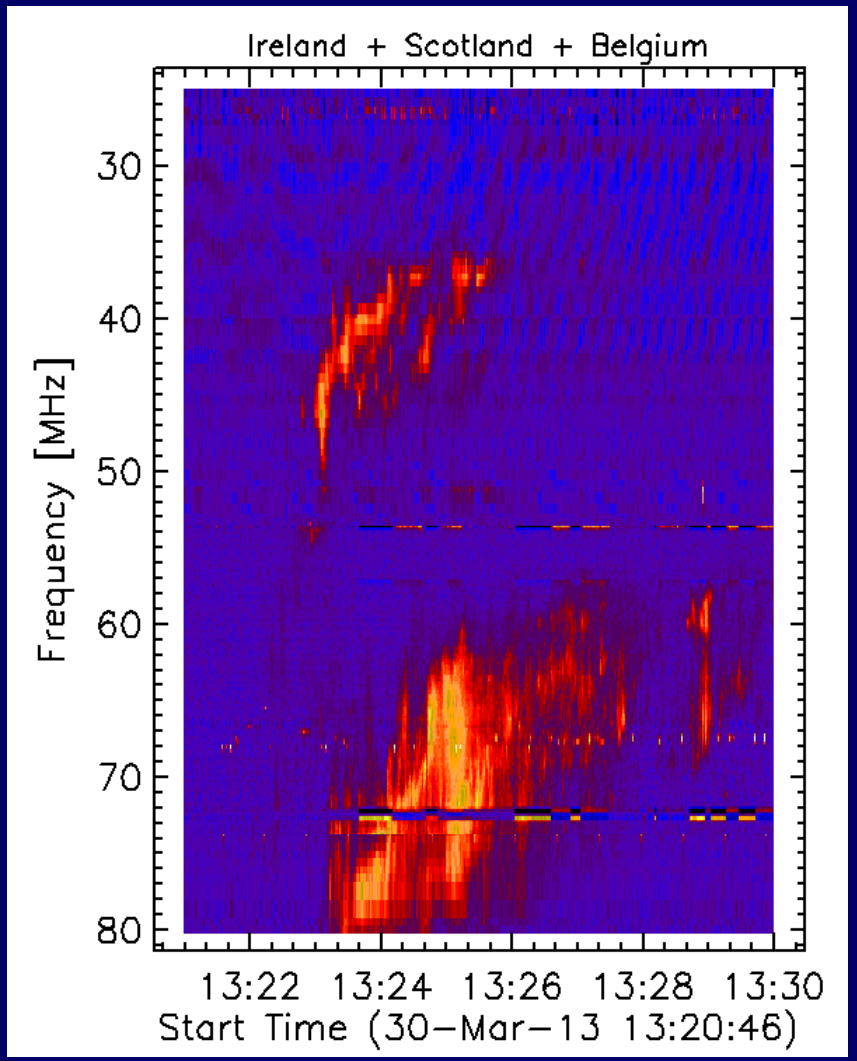
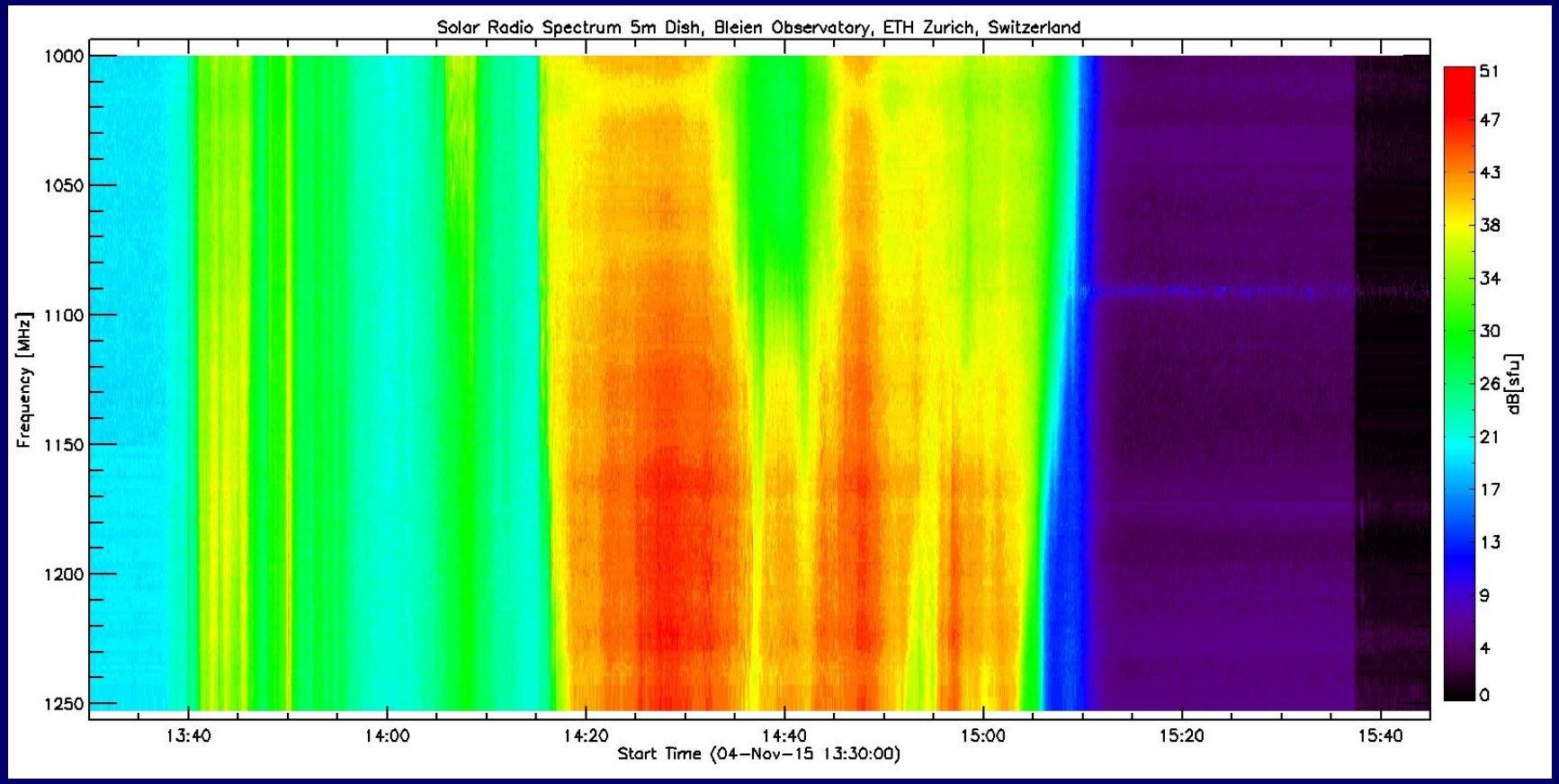


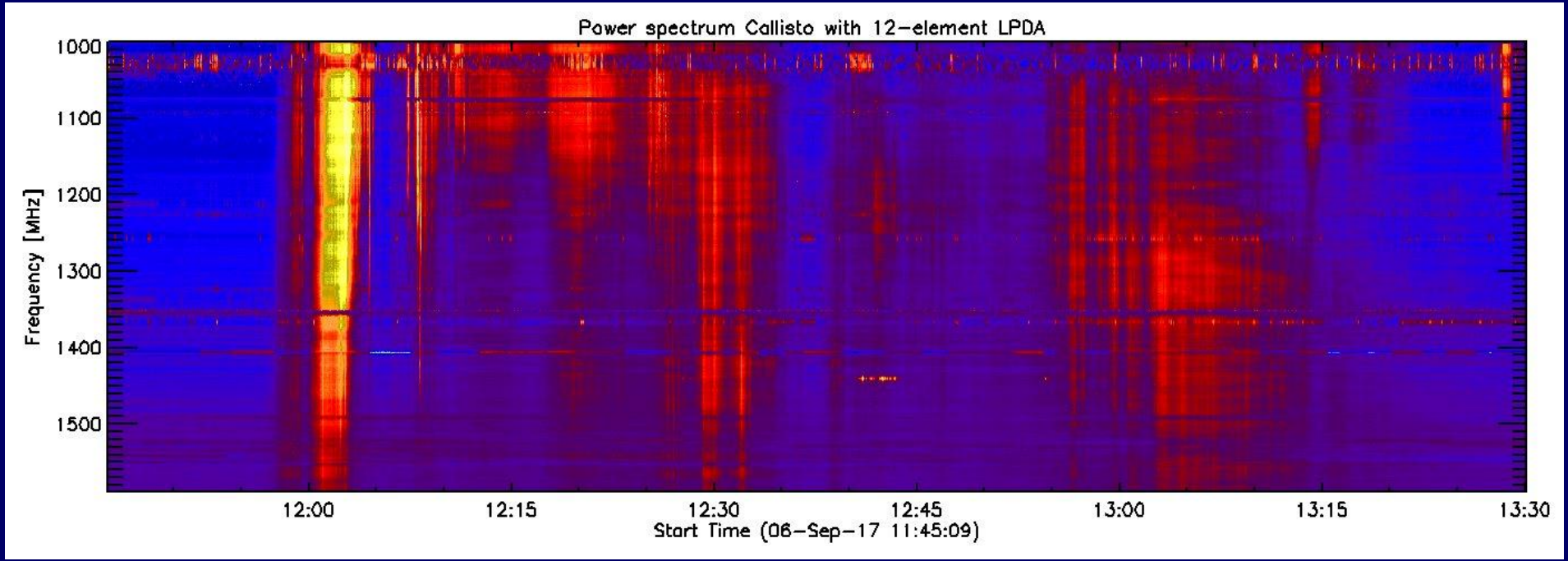
Ireland 25-60 MHz + Glasgow 45-80 MHz + Belgium 45-80 MHz

Solar radio burst shut down Swedish airport



STOCKHOLM 04-Nov-2015 — Swedish aviation officials say a solar storm has knocked out their air traffic control systems, prompting them to shut down the country's airspace for more than an hour.

Strong solar radio burst observed in L-band



Observation of a strong X9.33 solar event with the prototype of the spectrometer, designed for the Norwegian Space Centre, see also: https://www.spaceweatherlive.com/en/news/view/301/20170906-major-x933-solar-flare

2nd part

A few examples of Callisto stations

Callisto at IIA in Gauribidanur, India

Heliograph 40 – 150 MHz, 384 LPDA, 1280m x 441m

Left: Self built antenna.

Right: V. C. Kathiravan at
Indian Institute of Astrophysics
Gauribidanur, India 2006

Callisto at Institute of Solar-Terrestrial Physics (*ISTP*) in Badary / Siberia, Russian Federation

5 GHz antenna farm of SSRT in Siberia

Antenna attached to dish

Sergey and Andrey at SSRT

Callisto at RCAG in Ulaan Baatar, Mongolia

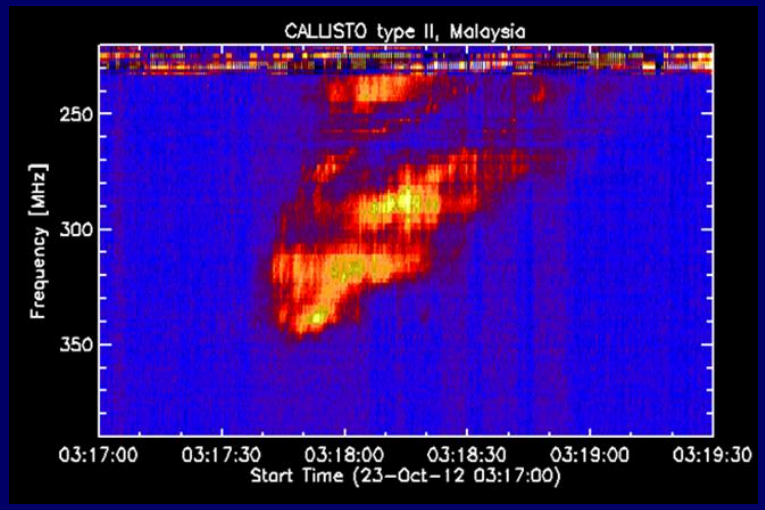
Munkhbayar Bazargur
and his colleague mounting
a Chinese DVB-T - antenna

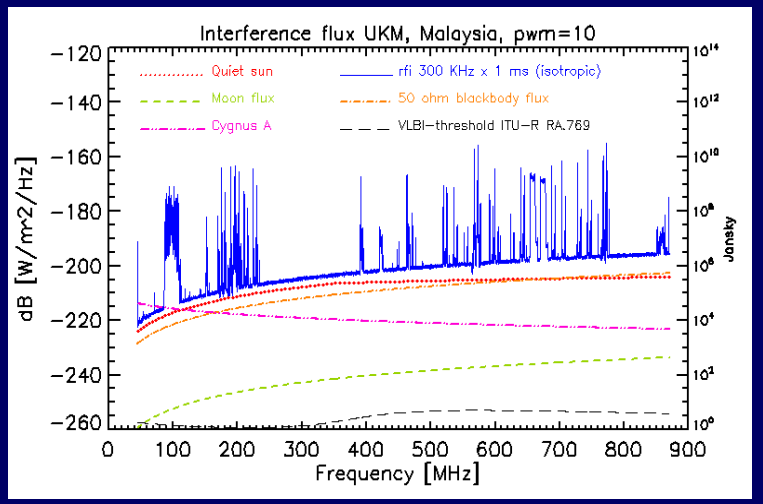
Callisto and PC in the office of the RCAG
(Research Center of Astronomy and Geophysics)
located at the observatory site at Khurel Togoot
near Ulaan Baatar, Mongolia

Callisto at Institute of Ionosphere Almaty, Kazakhstan

12 m parabolic dish
Tian Shan mountains next to Kirgistan,
2’735 m asl

Callisto at National Space Centre near Kuala Lumpur, Malaysia





Callisto at Udaipur Solar Observatory India

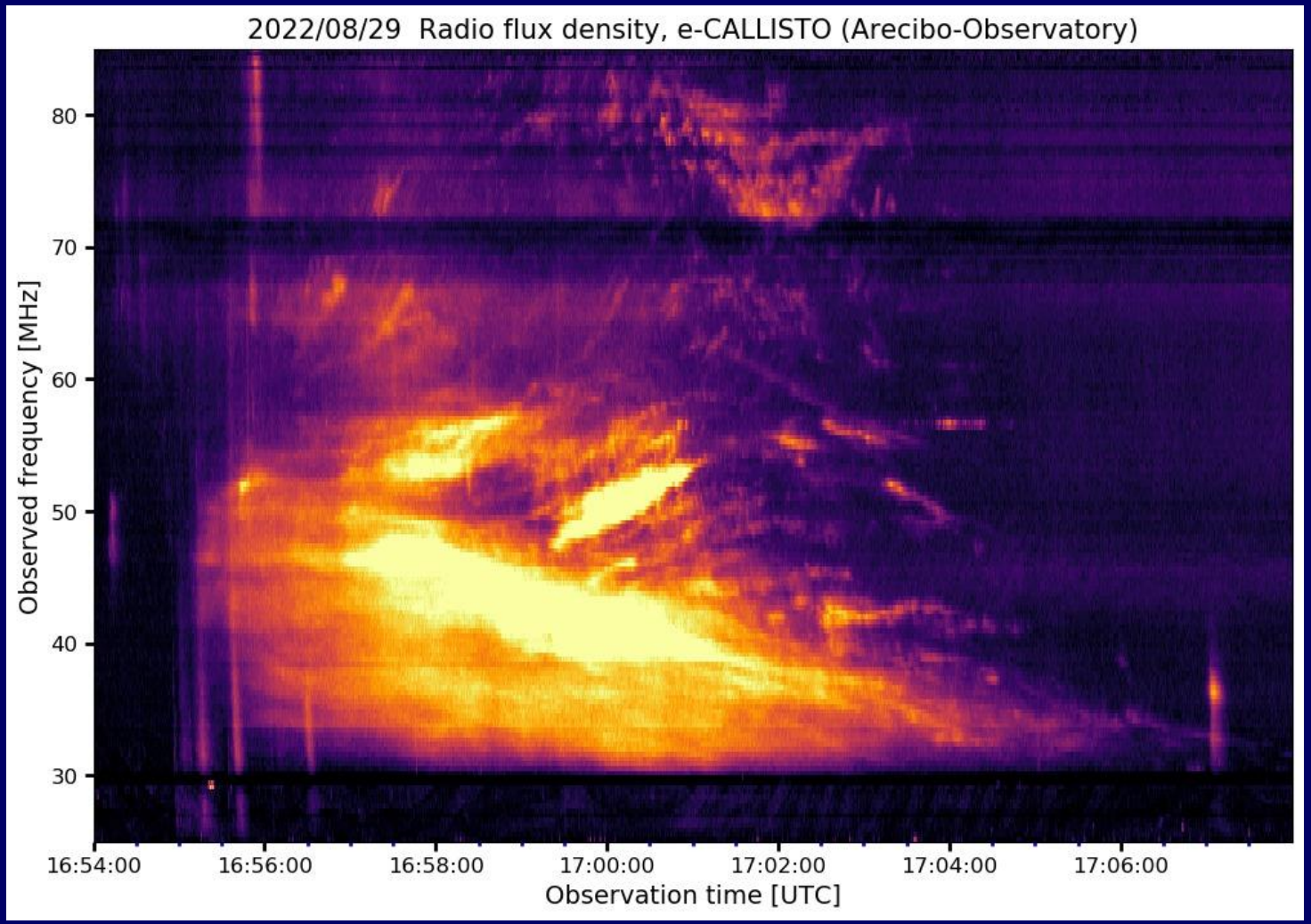
Left: PC and Callisto
with Dr. Bhuwan Joshi USO

Below:
Antenna on a concrete pole
and shielded shed

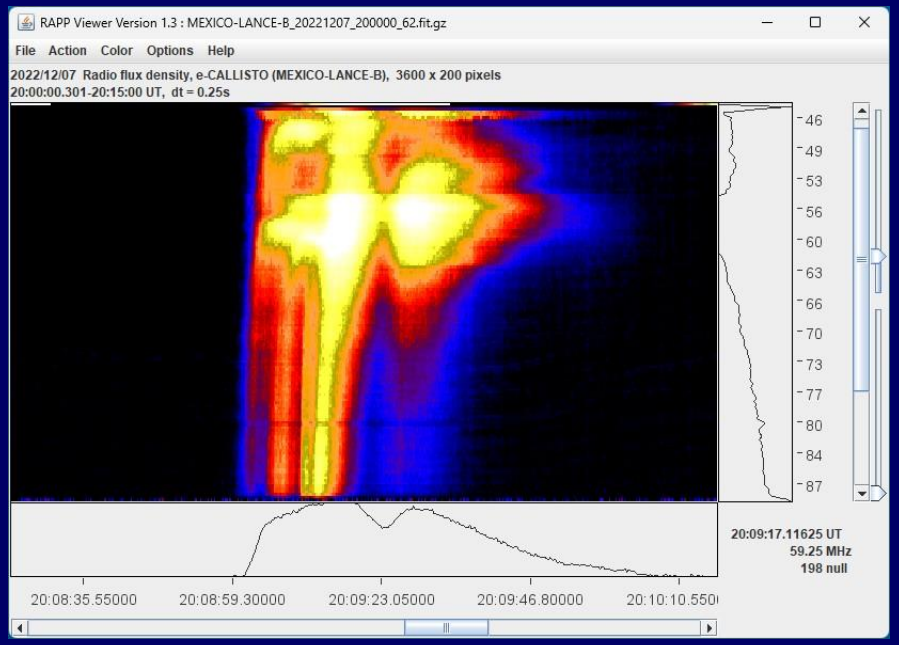
Callisto at Arecibo, Puerto Rico

Myself, Alessandra Abe Pacini and Alfredo Santoni.
Now operated by P. K. Manoharan AO

Nice observation from Arecibo Observatory



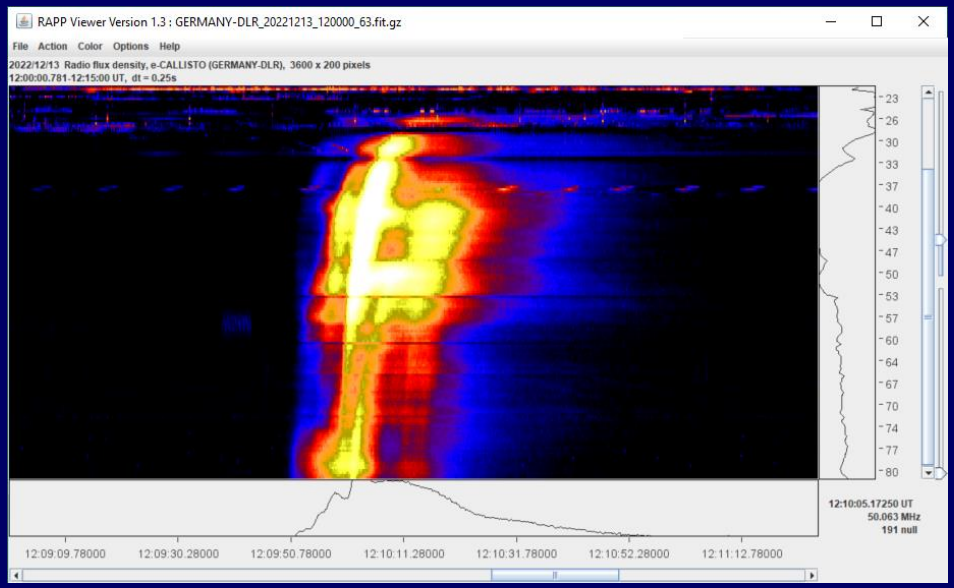
Mexico new antenna, an LWA



From left to right: Alexis Morales (student) Rafael Tovar (technical staff at MEXART) Ernesto Andrade-Mascote
(head of technical staff at MEXART)
Oscar Godines-Torres (student)
Marco Medina-del-Angel (student)
behind everyone Luis Maya-Sierra (technical staff)

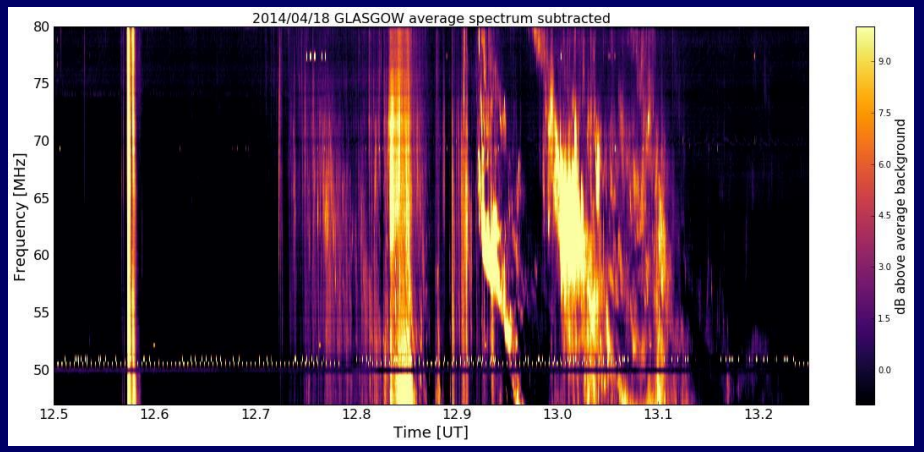
Dr. Ernesto Aguilar Rodríguez
Instituto de Geofísica
Unidad Michoacán
Antigua Carretera a Pátzcuaro
Ex-Hacienda San José de la Huerta
Morelia, Michoacán, Mexico

DLR: dual polarization spectrometer



Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
Institut für Solar-Terrestrische Physik
Kalkhorstweg 53
17235 Neustrelitz, Germany
Contact: Dr. Daniela Banyś

Callisto in Glasgow, UK



Colin Hunter, observatory technician
https://www.astro.gla.ac.uk/

Conclusions

- Network is still growing, currently requests from different countries

- Often lack of funding as well as lack of permanent people to operate & maintain an instrument.

- Many locations are suffering from power fail, internet fail or even from war

- Geographical coverage to be improved, especially American/Pacific region

- Interference situation is getting worse worldwide, new instruments should be placed at very remote locations, not on top of the university roof.

- More science could and should be done (but is often an educational issue)

- Beside scientific workshops also dedicated technical workshops should be organized

Additional information:

https://e-callisto.org

We are also on FaceBook

Christian Monstein
Monstein Radio Astronomy Support / IRSOL
Switzerland