



SOLAR RADIO ASTRONOMY

„CALLISTO instrument and the e-Callisto network“

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Topics of this presentation

- Why Callisto?
- Key specifications of Callisto
- Instrument coverage, burst type and interference issue
- Presentation of a few, of currently ~144 instruments
- Network structure and current user statistics
- Examples of recent solar radio events
- Conclusions

Why Callisto?

Swiss - contribution to IHY2007 and ISWI

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

Key specifications of Callisto

Parameter

Specification

Frequency range 45.0 MHz ... 870.0 MHz ($34 \text{ cm} < \lambda < 6.7 \text{ m}$)

Radiometric bandwidth 300 KHz

Integration time 1 ms

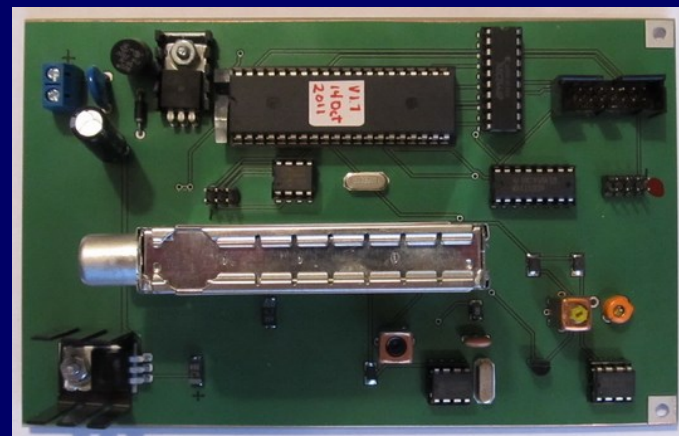
Dynamic range $> 40 \text{ dB}$ ($> 10'000:1$)

Noise figure $< 10 \text{ dB}$ ($< 3'000 \text{ K}$)

Measuring rate 800 frequencies/s

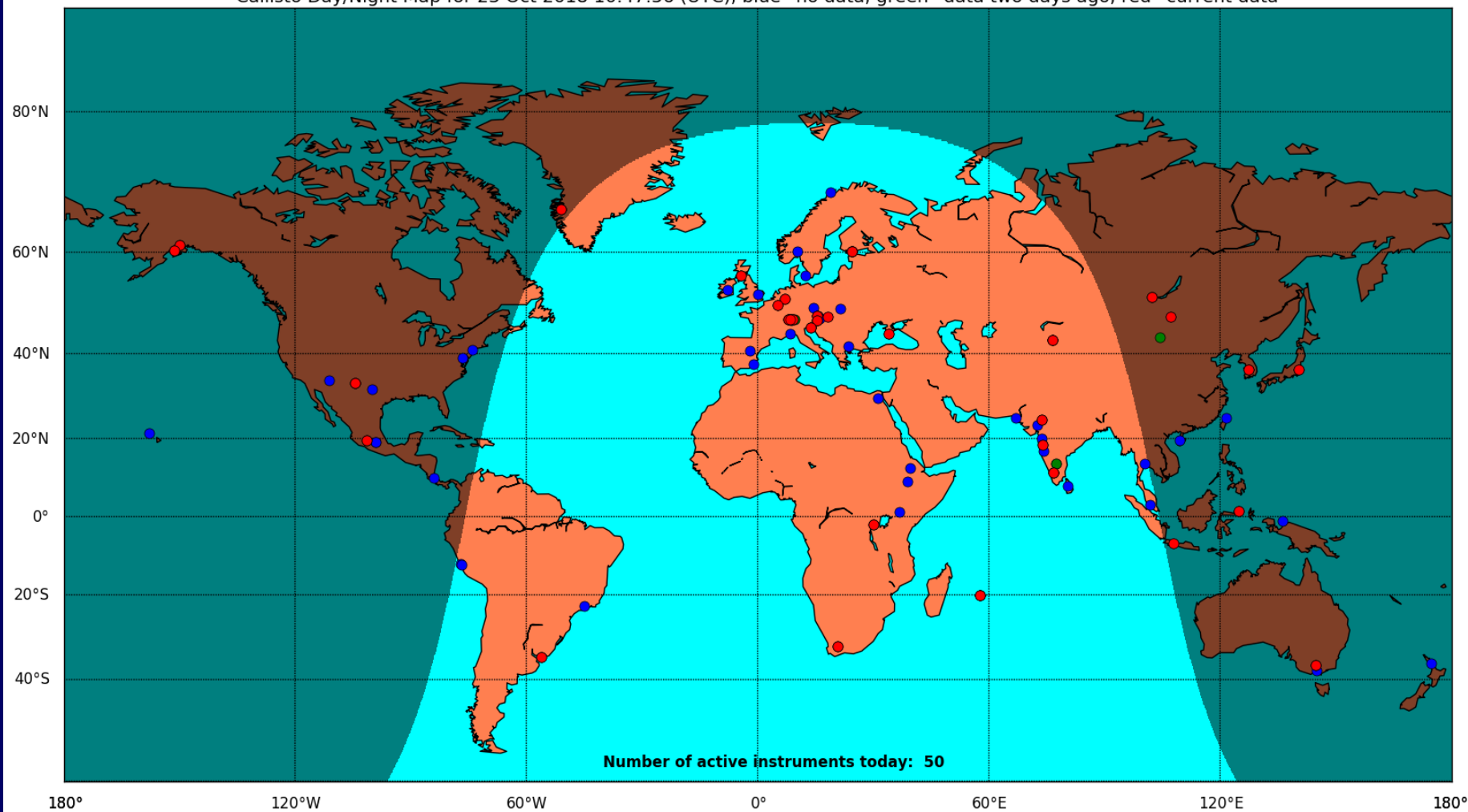
Cost Hardware ~US500\$

Outputs FITS-files



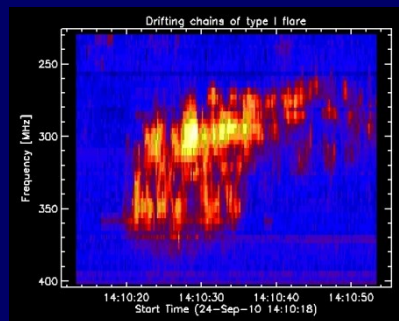
Coverage

Callisto Day/Night Map for 23 Oct 2018 10:47:56 (UTC), blue=no data, green=data two days ago, red=current data

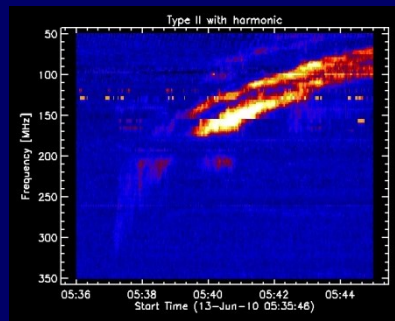


Status October 2018: ~152 instruments at 80 different locations worldwide.
Reached 100 % coverage all over the seasons in May 2013

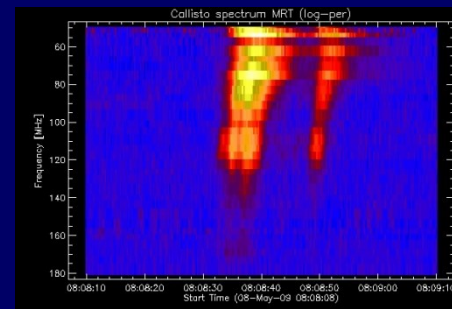
CALLISTO selected burst types



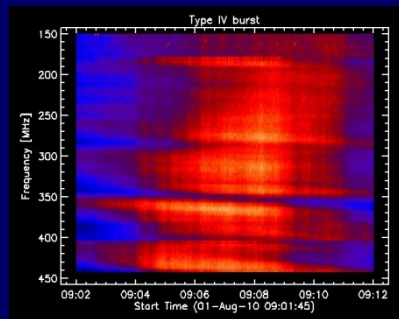
Noise storm or type I



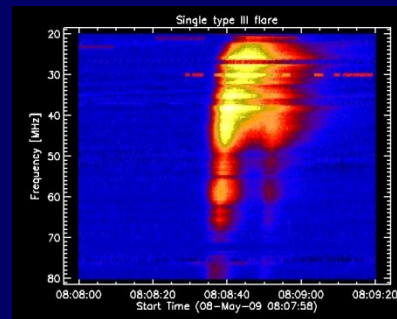
Type II with split band



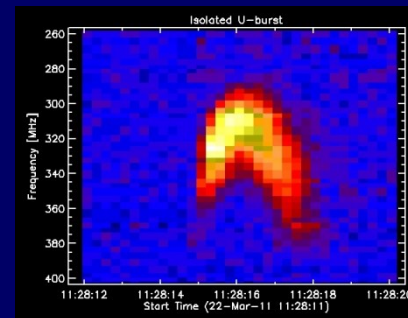
Isolated type III



Type IV



Type V

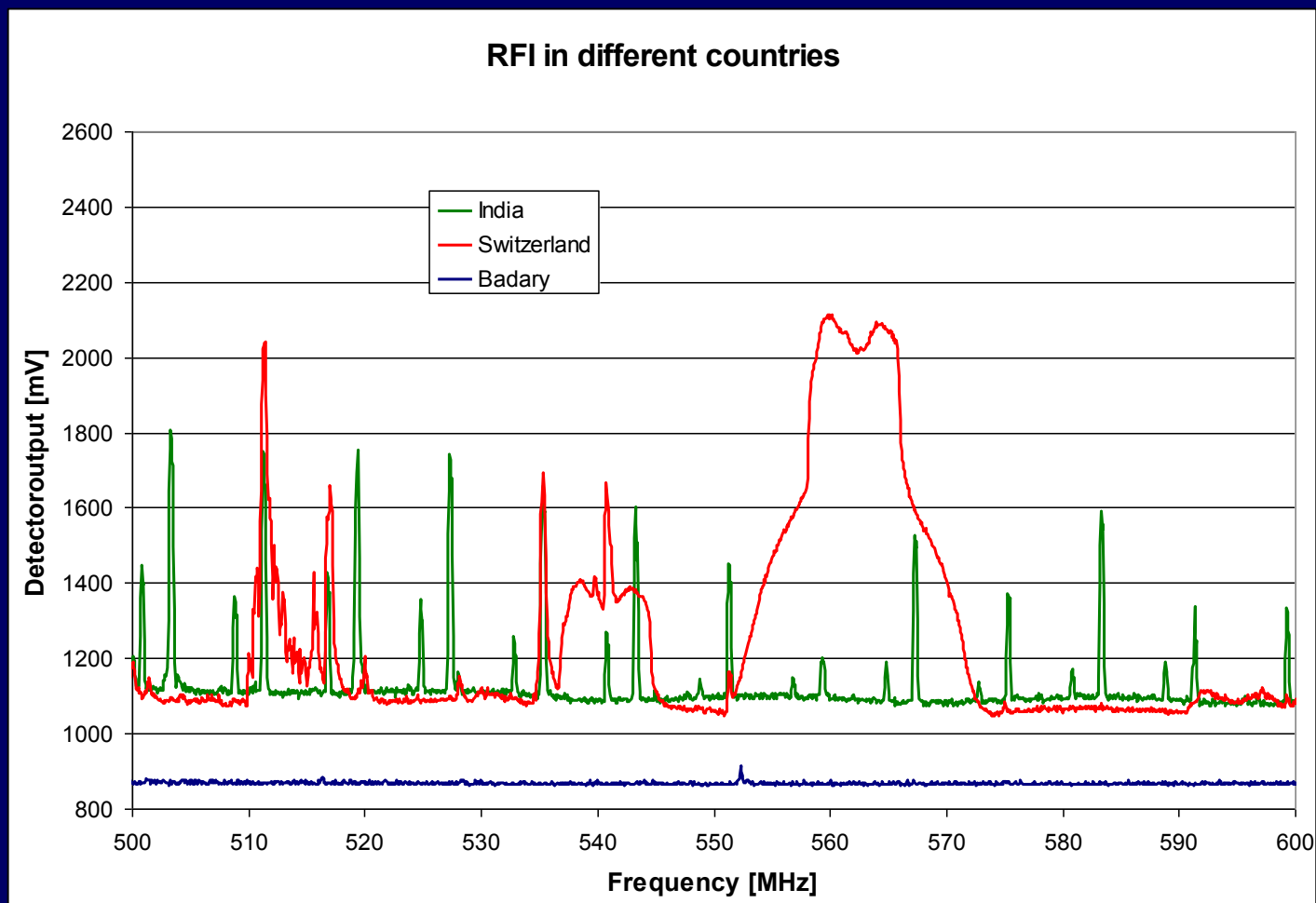


U-burst

Access to burst- and rfi-catalogue here:

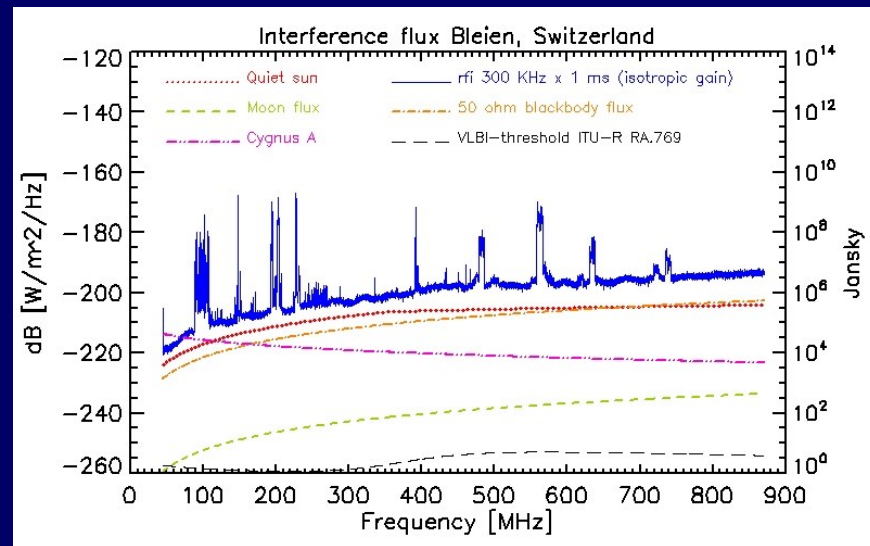
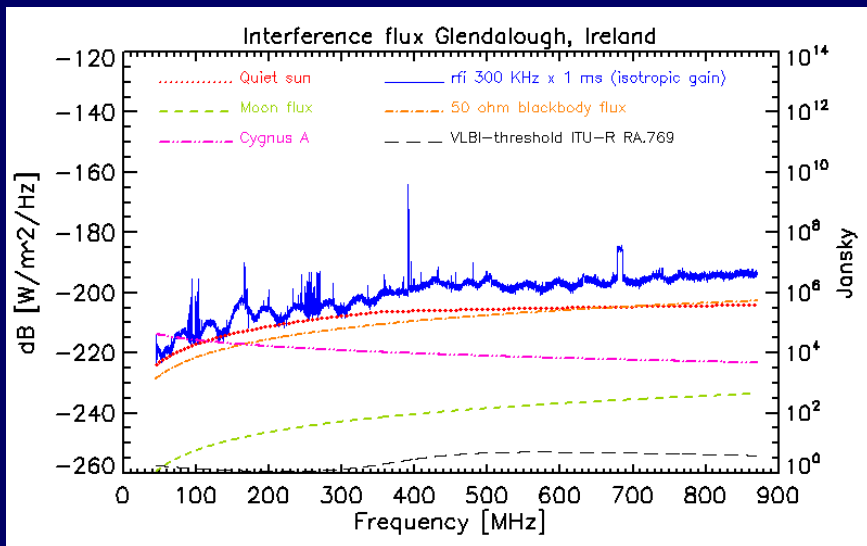
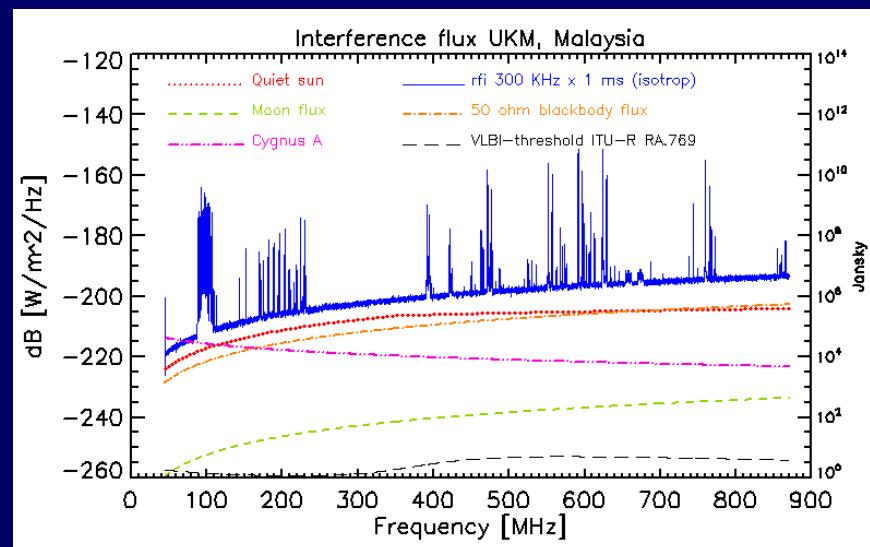
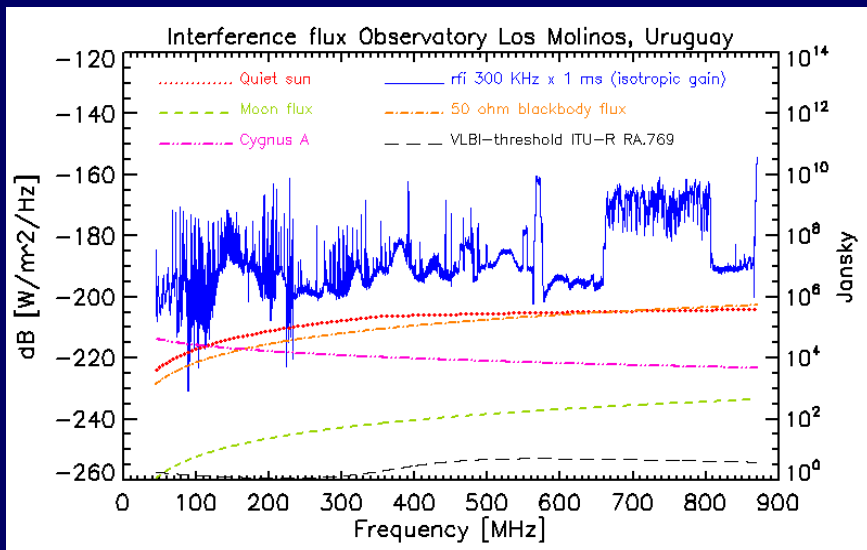
<http://www.e-callisto.org/GeneralDocuments/BurstCatalog.pdf>

Interference situation



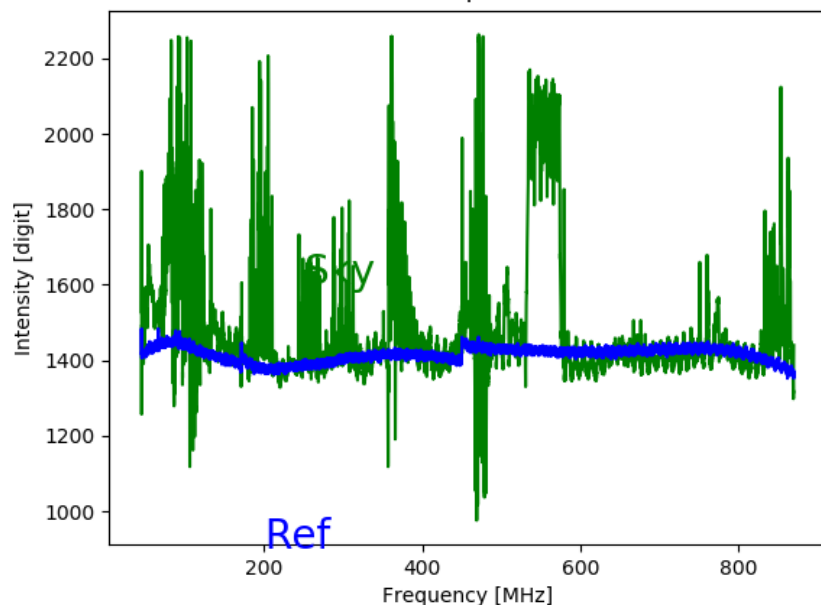
Radio frequency interference Switzerland compared to India and Russia in 2006

Interference situation worldwide

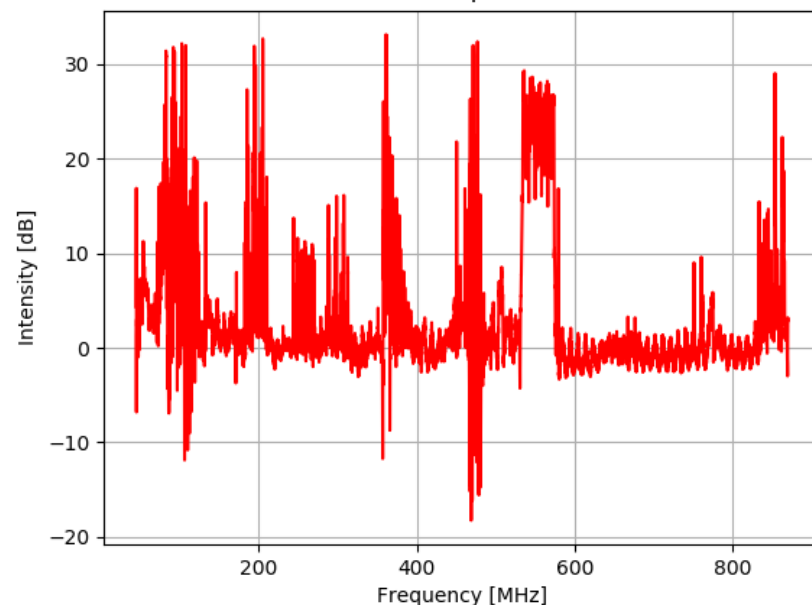


Interference situation Pokhara

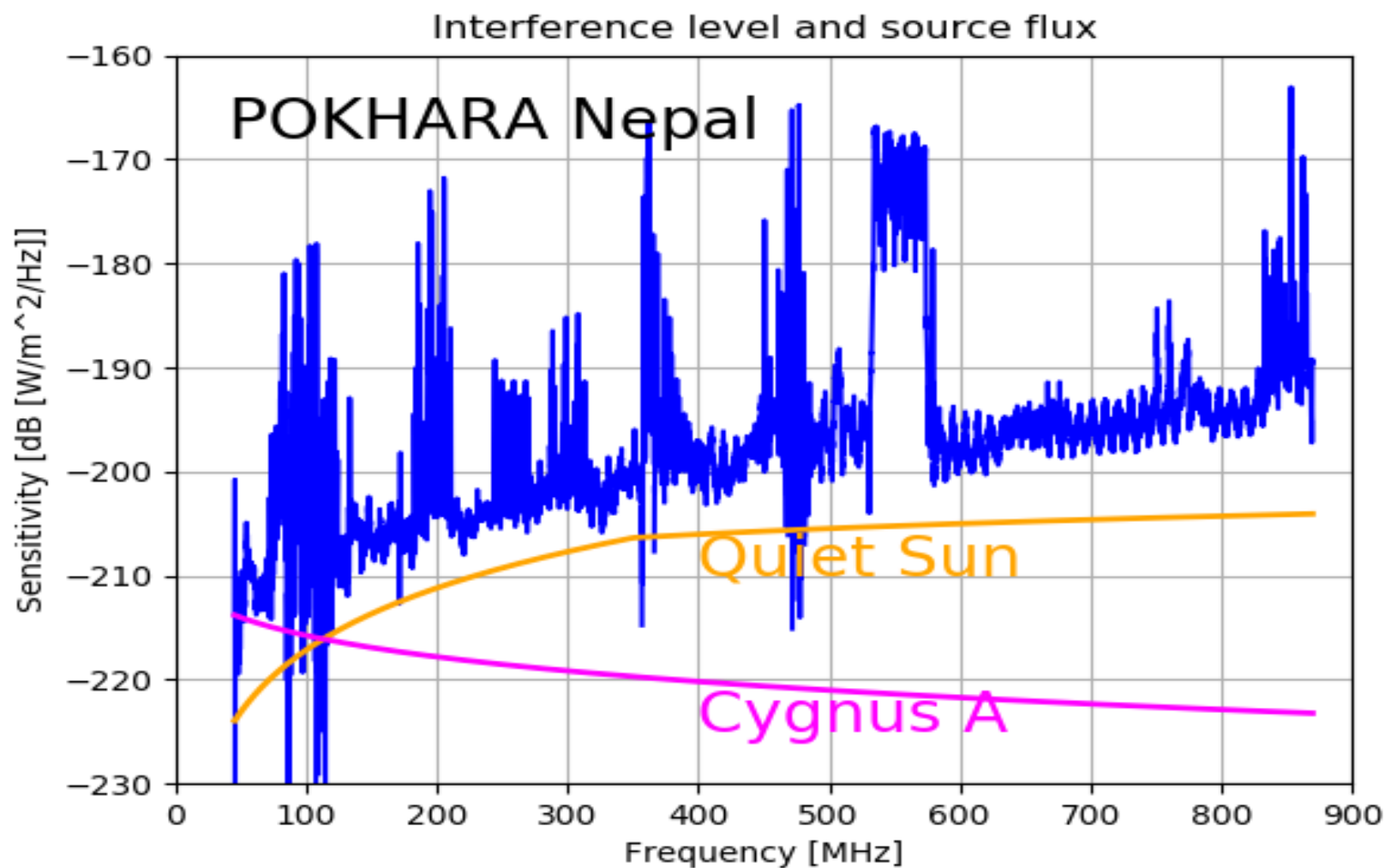
Raw data from spectral overview



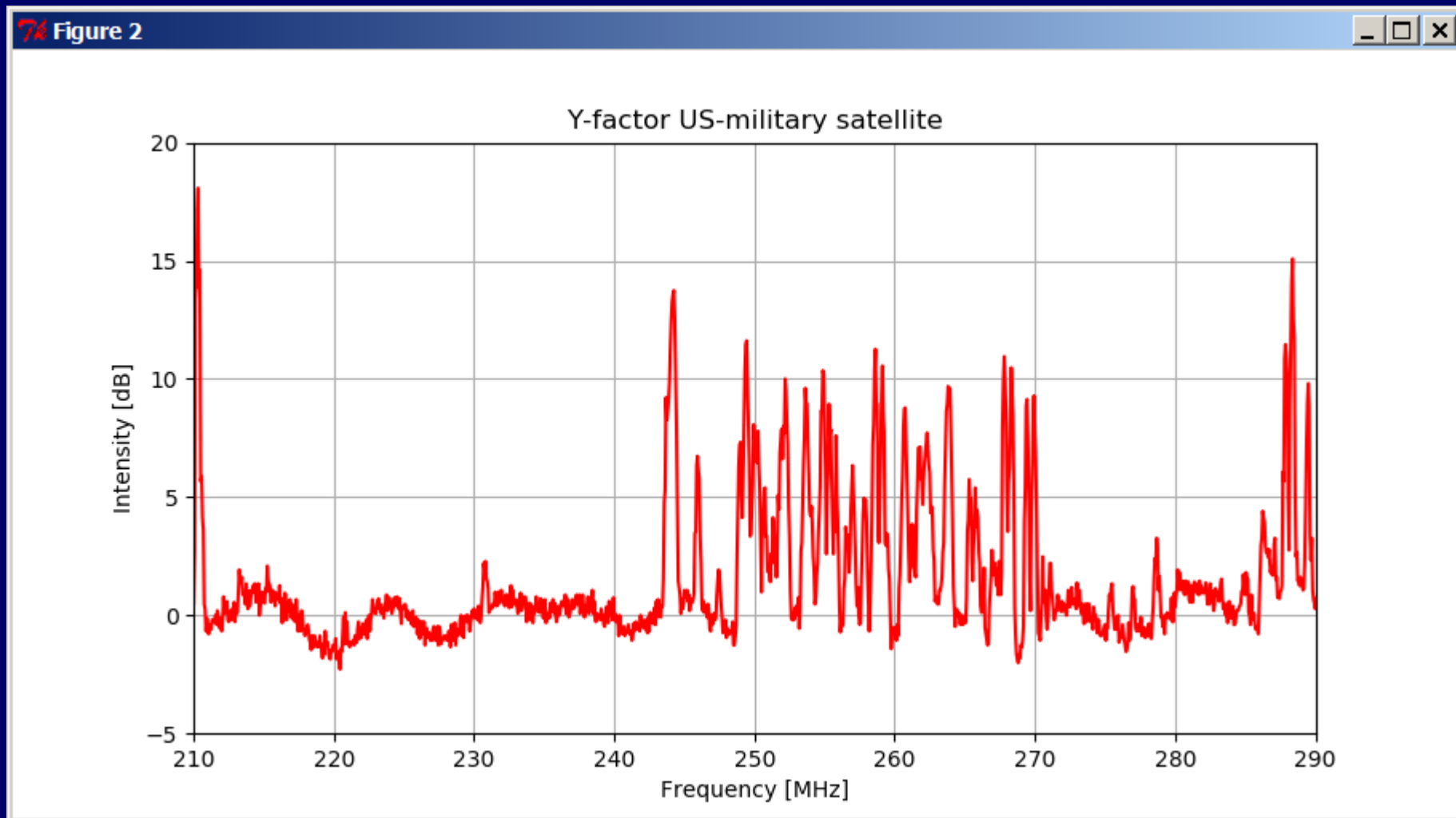
External rfi from spectral overview



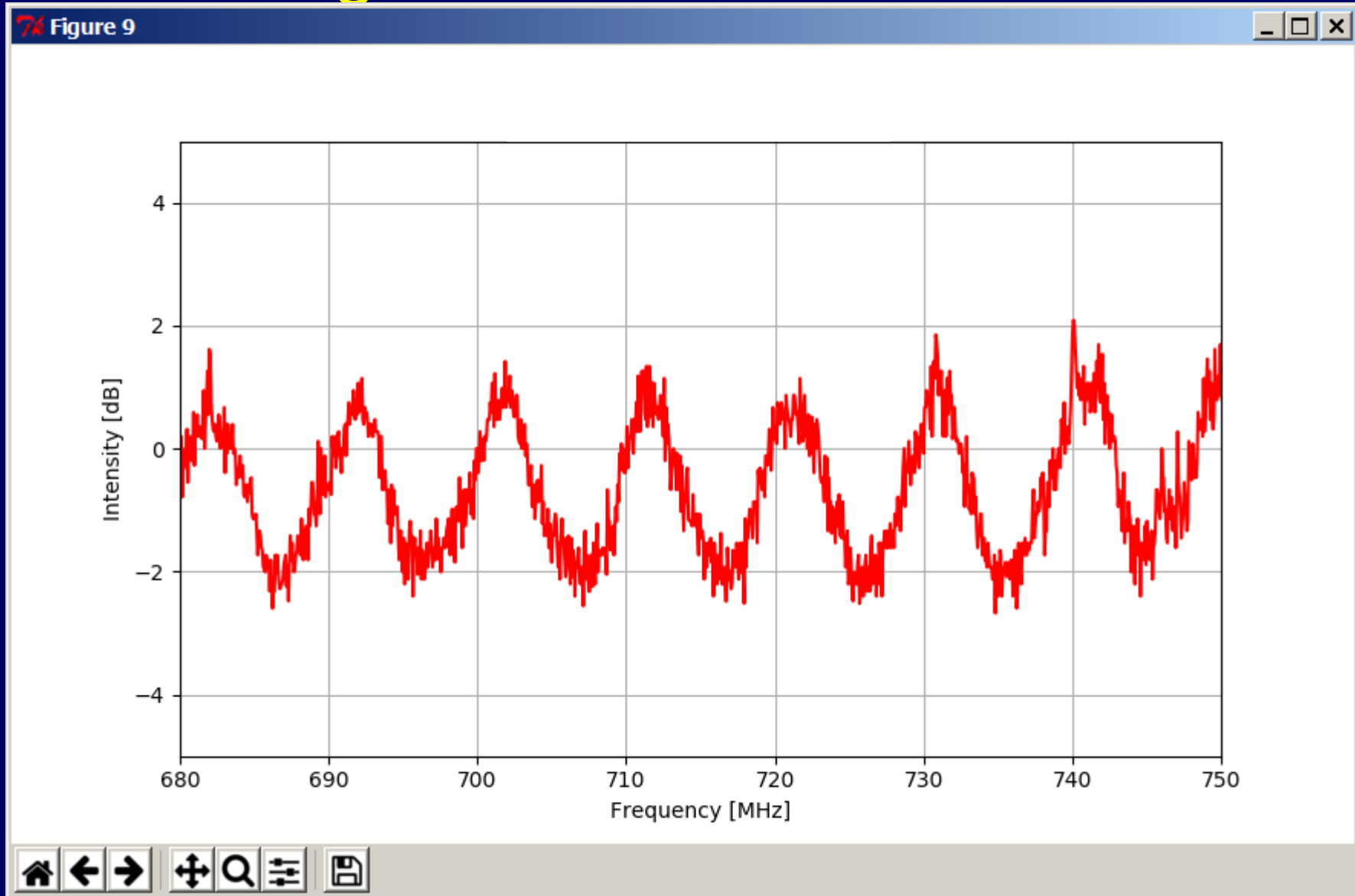
Interference situation Pokhara



Interference situation Pokhara



Standing waves antenna Pokhara



A few examples of Callisto stations

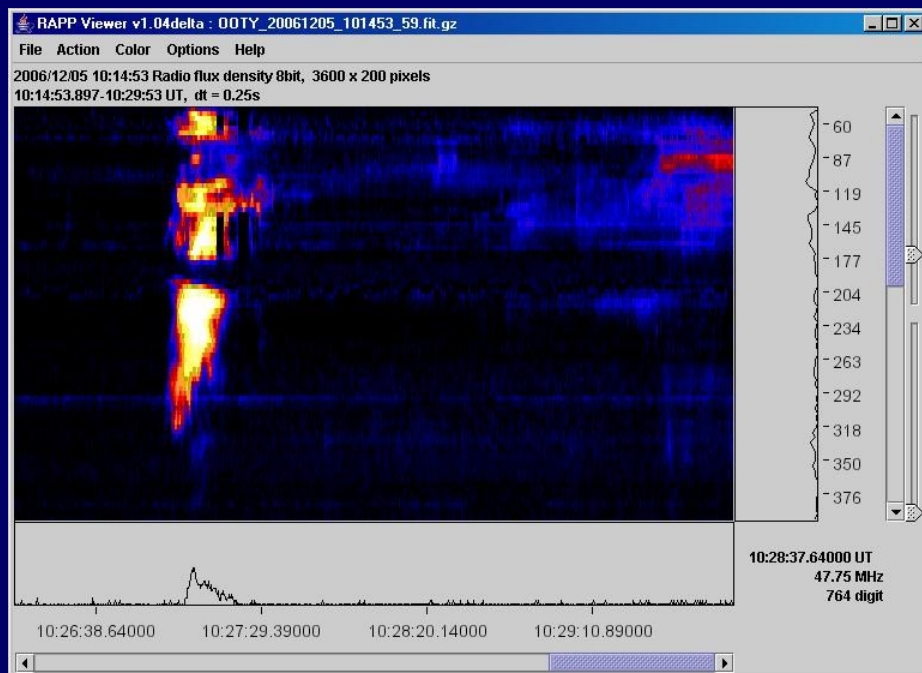
Callisto at TIFR in Ootacamund (Ooty), India



Left: Self built antenna.

Right: Operator at the Institute of
Radio Astronomy and Nuclear Physics,
Tamil Nadu, Ooty, India 2006

Callisto at TIFR in Ootacamund (Ooty), India



Astronomical outcome, first light
 Isolated type III burst

Gastronomic highlight

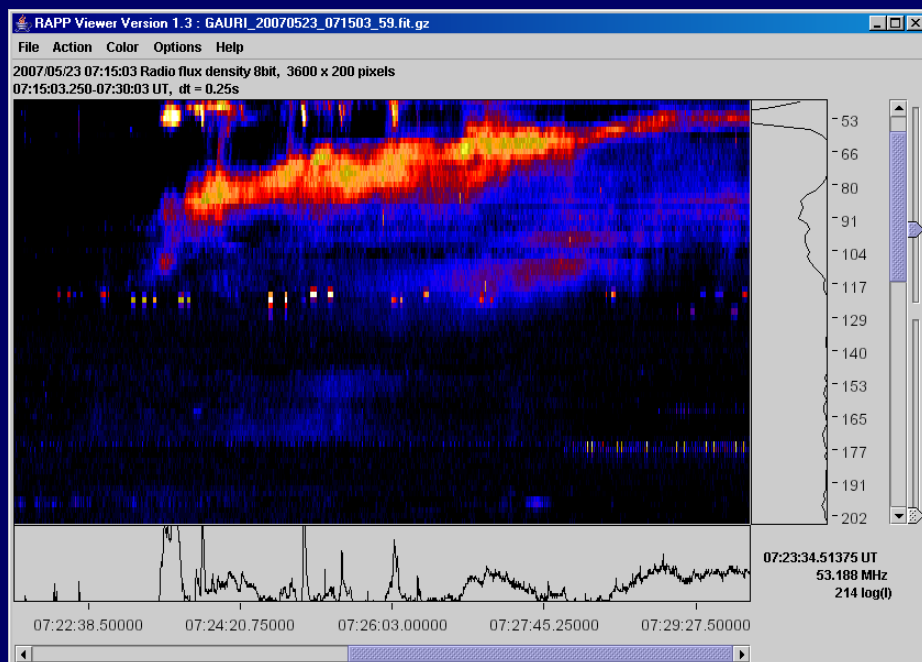
Callisto at IIA in Gauribidanur, India



Left: Self built antenna.

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

Callisto at IIA in Gauribidanur, India



Astronomical outcome, first light.
A type II burst, triggered by CME



Gastronomic highlight

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



5 GHz antenna farm
of SSRT in Siberia

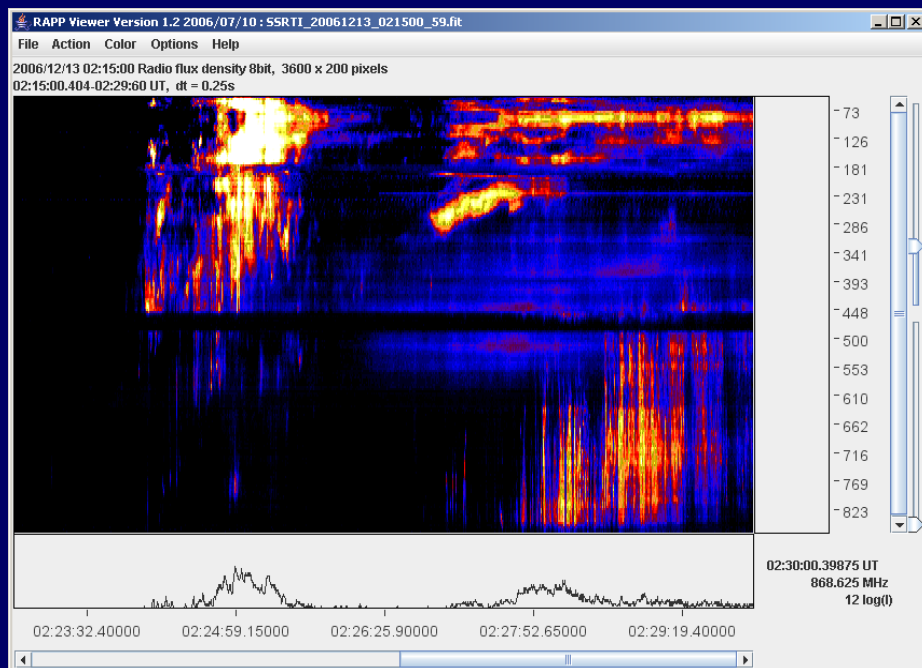


Antenna attached to dish



Sergey and Andrey at SSRT

Callisto Badary / Siberia Russian Federation

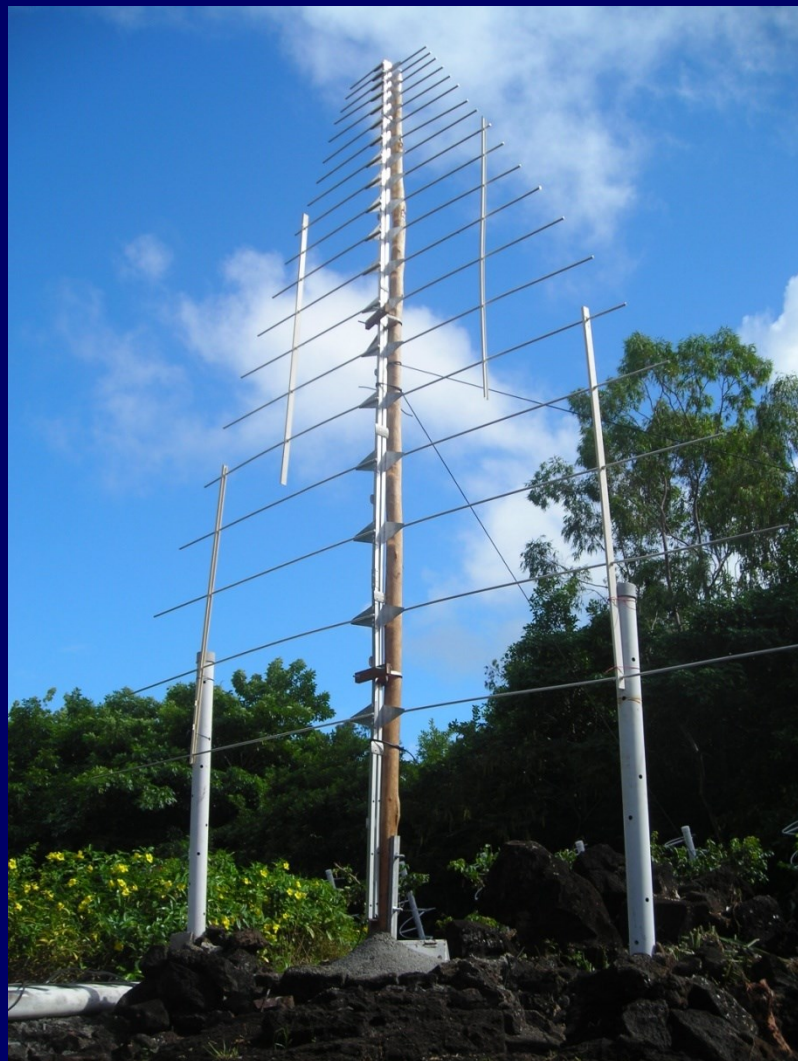


Astronomical outcome, first light.
Type II, III, IV bursts and
decimetric pulsations



Gastronomic highlight

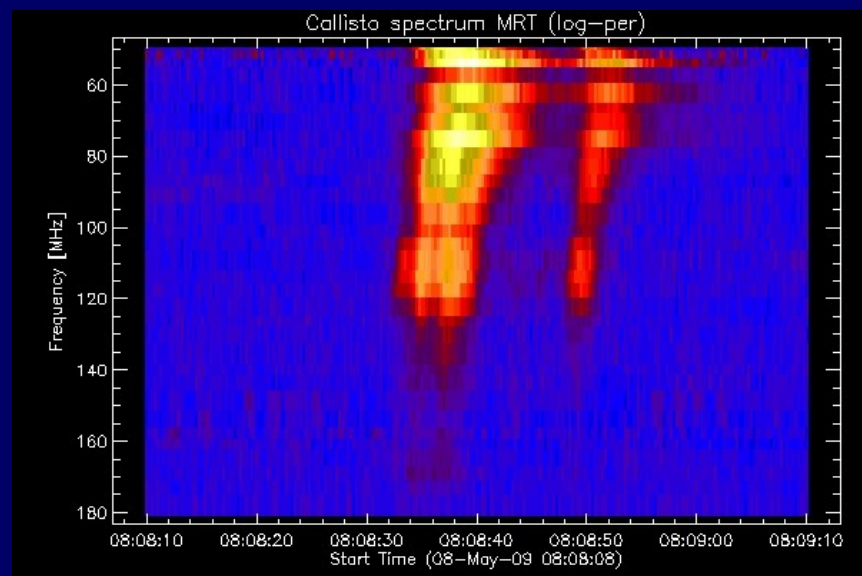
Callisto in Bras d'Eau Flacq, University of Mauritius



Self built log-per 20 MHz ... 150 MHz and

Callisto in air-conditioned receiver room
in Bras d'Eau, Poste de Flacq, Mauritius

Callisto University of Mauritius



Astronomical outcome, first light
on May 1st 2009 08:08:30 UT.
A small group of type III burst,
also known as 'isolated' type III

Gastronomic result ...

Callisto at RCAG in Ulaan Baatar, Mongolia

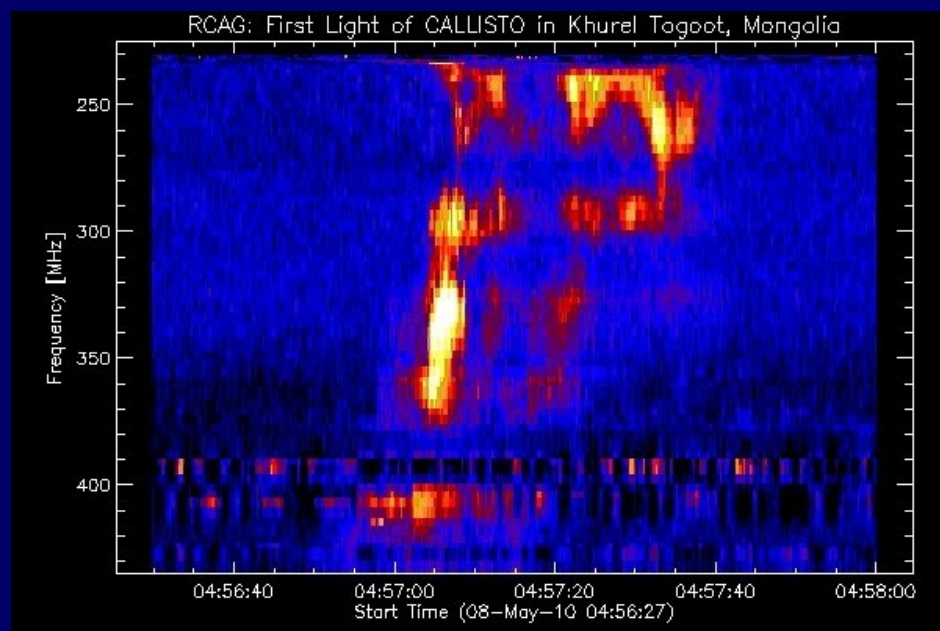


Munkhbayar Bazargur
and his colleague mounting
a Chinese DVB-T - antenna



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 Ulaan Baatar, Mongolia



First light from Khurel Togoot,
Ulaan Baatar, Mongolia
Burst type not clear



Gastronomic result ...
to be flushed with
some beer and vodka...

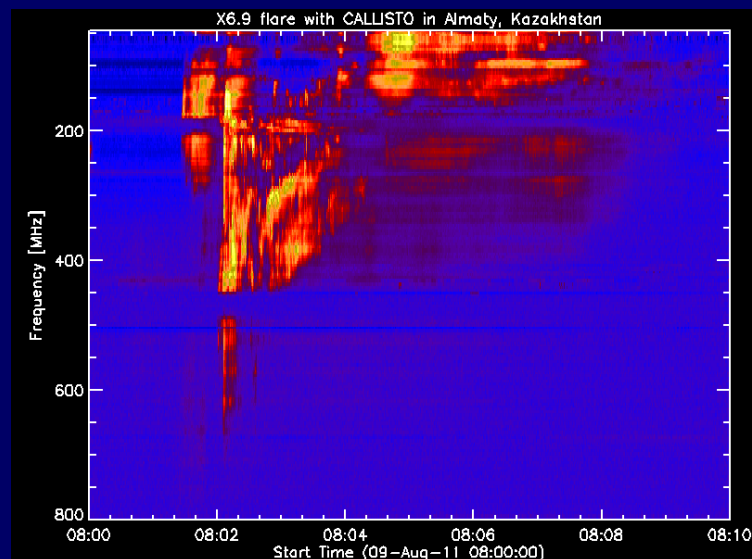
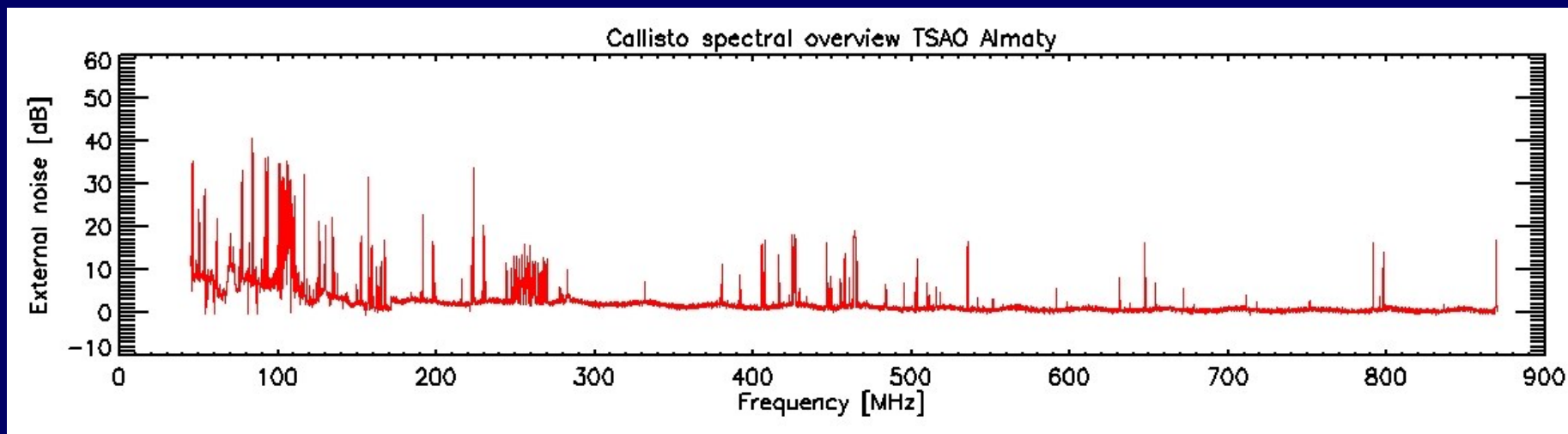
Callisto at Institute of Ionosphere Almaty, Kazakhstan



12 m parabolic dish
Tian Shan mountains,
2735 m asl



Callisto Almaty, Kazakhstan



Spectral overview (top), 1st light (bottom left), Gastronomy 'plov' (bottom right)

Callisto Cachoeira Paulista, Brazil

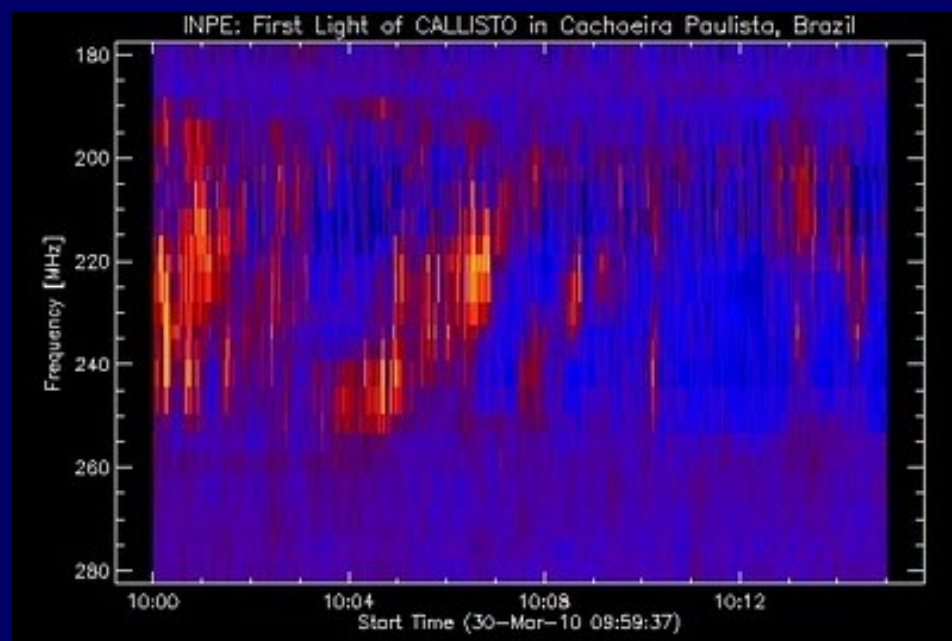


Log-per antenna in Cachoeira Paulista between Sao Paulo and Rio de Janeiro (BDA).



Two Callisto for two polarizations and a PC in the office of INPE in Sao Jose Dos Campos.

Callisto Cachoeira Paulista, Brazil

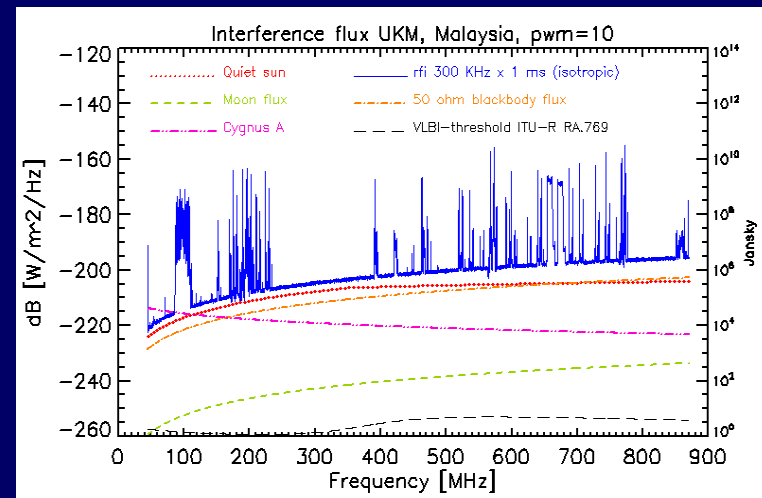
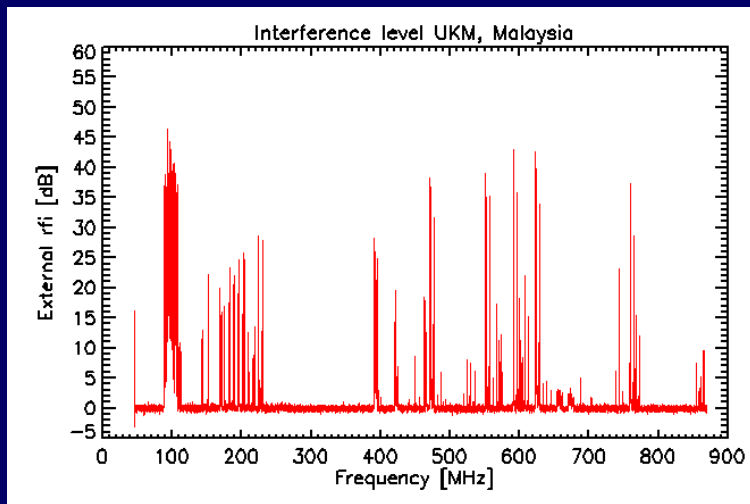


Astronomical outcome:
First light on March 30th, 2010 at 10:00UT
in Cachoeira Paulista, a
series of type I bursts (noise storm)

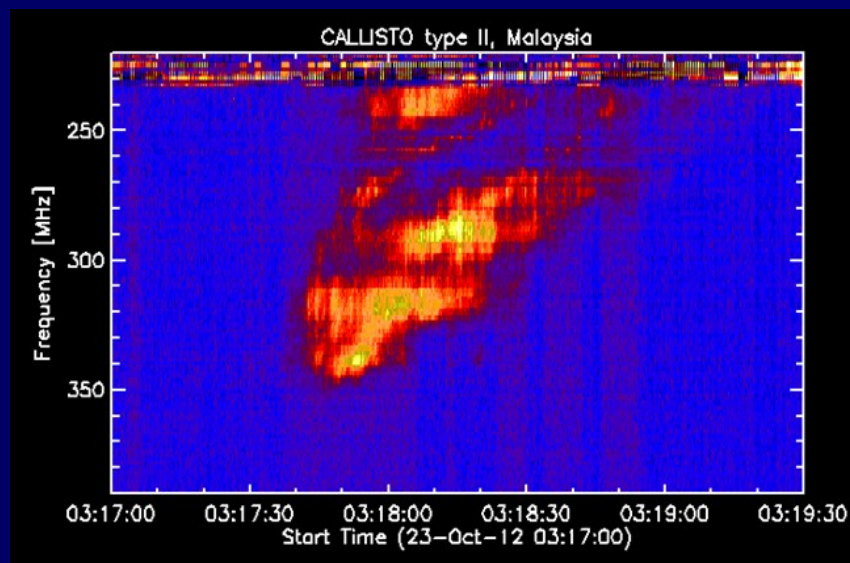


Gastronomic result ...

Callisto at National Space Centre near Kuala Lumpur, Malaysia



Callisto at National Space Centre near Kuala Lumpur, Malaysia

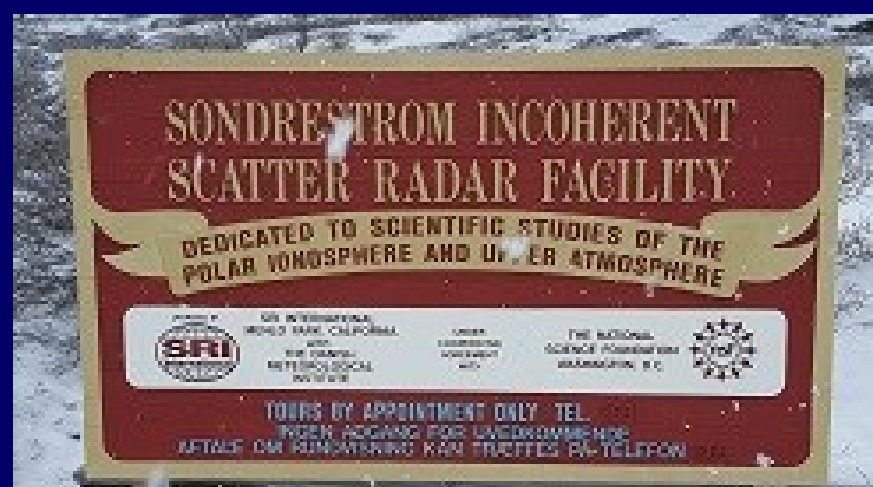
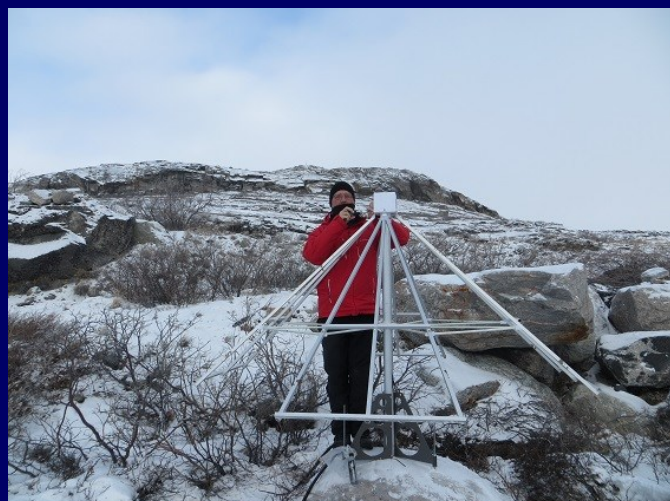
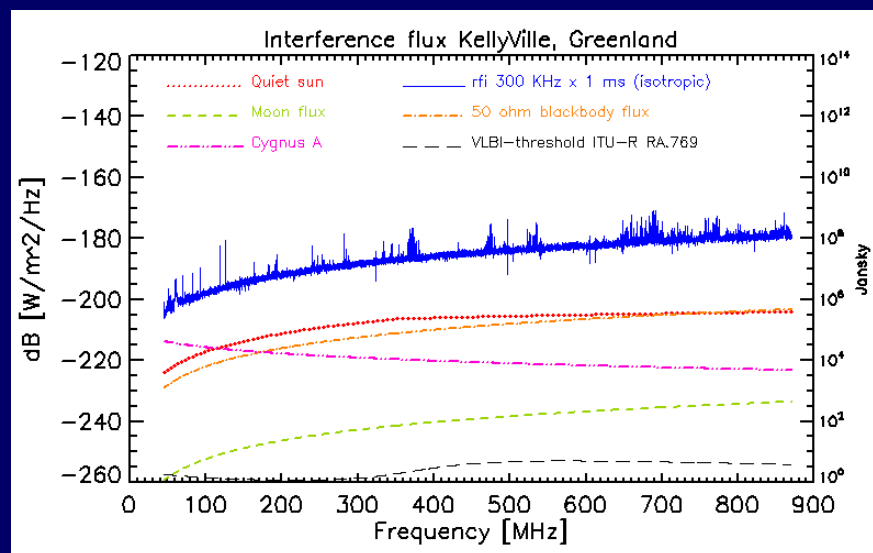


Astronomical outcome:
Type II burst with fundamental
and harmonic

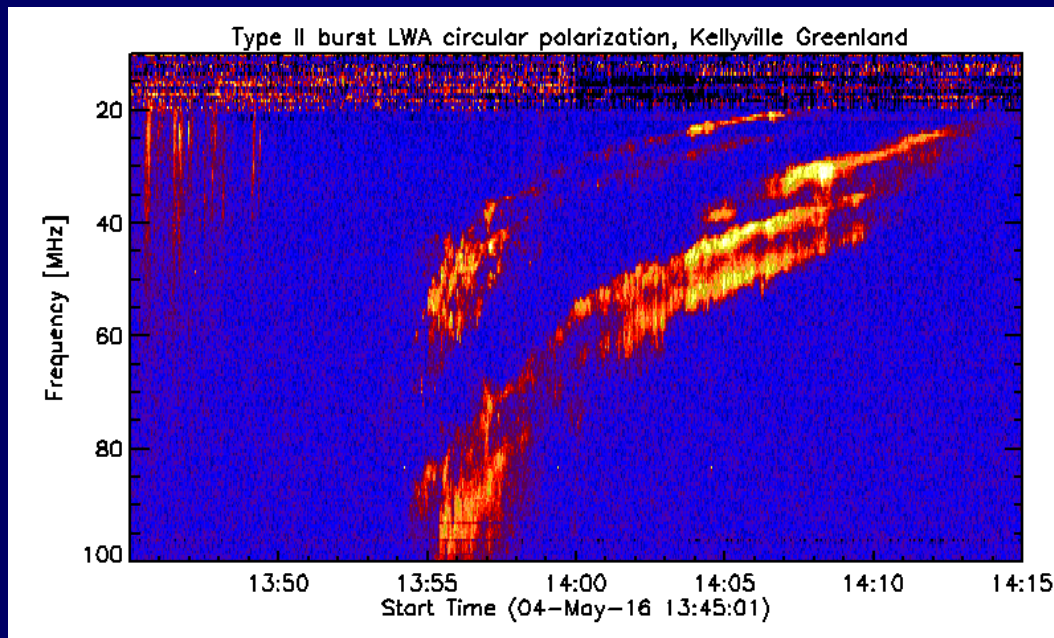


Gastronomic result ...

Callisto in Kangerlussuaq, Greenland



Callisto in Kangerlussuaq, Greenland



Astronomical outcome:
Type II burst with fundamental
and harmonic, both with split band.



Gastronomic result ...

Callisto at Mekelle University



Top: Tsega Leul at Mekelle University



Right: Gebregiorgis Abraha working at antenna

Callisto at PRL, Udaipur India



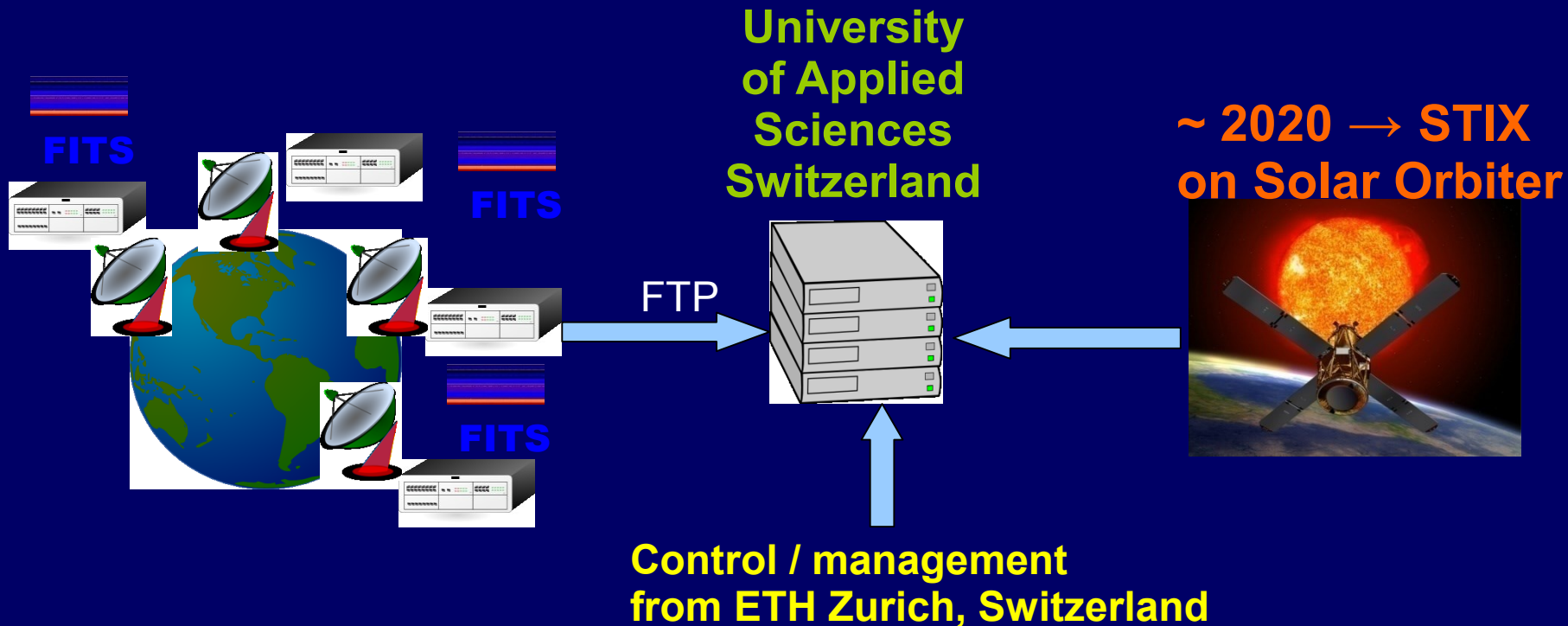
Left: PC and Callisto at PRL

Below: Antenna and shed



Callisto at Pokhara Nepal

e-Callisto network

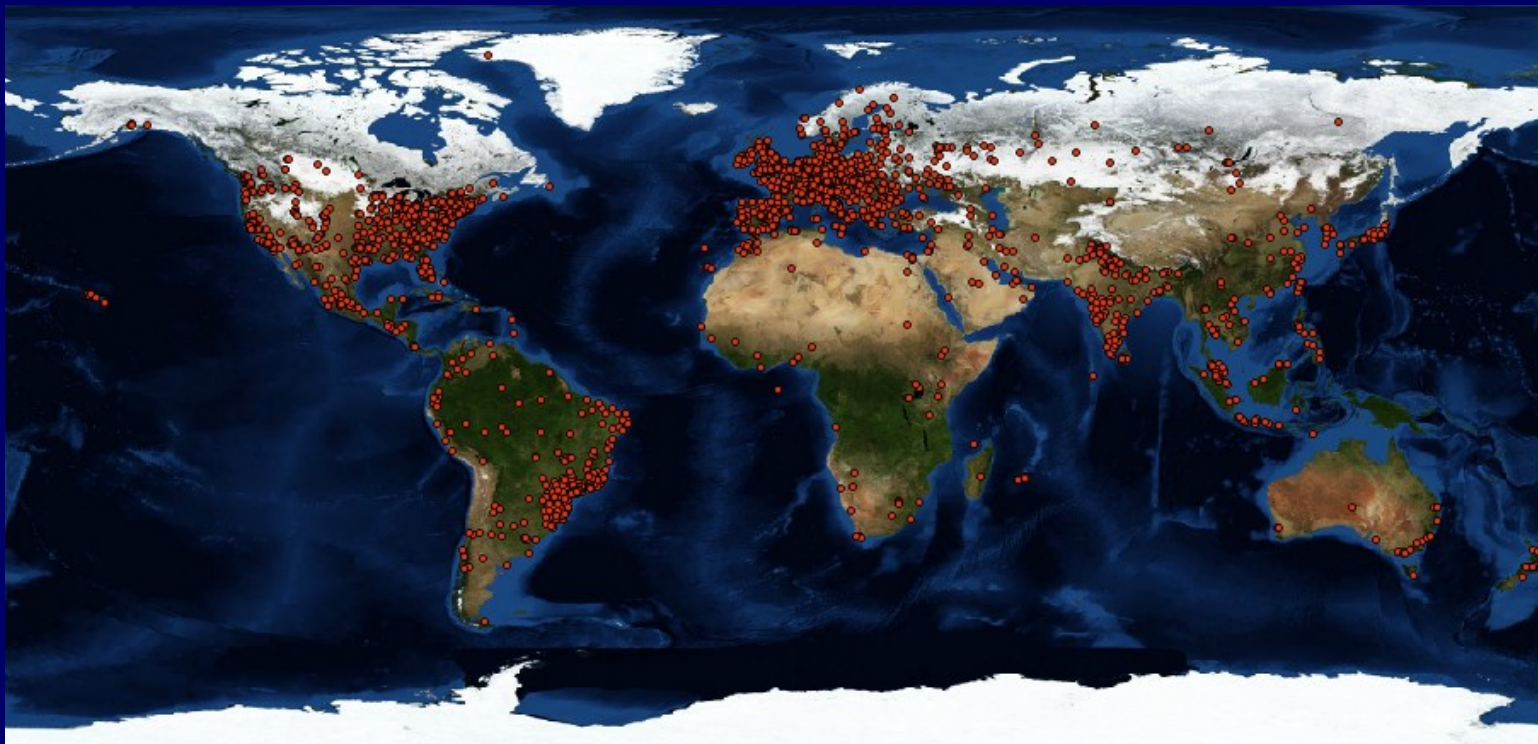


Hosts send data actively via FTP
to the central data server.

We provide:

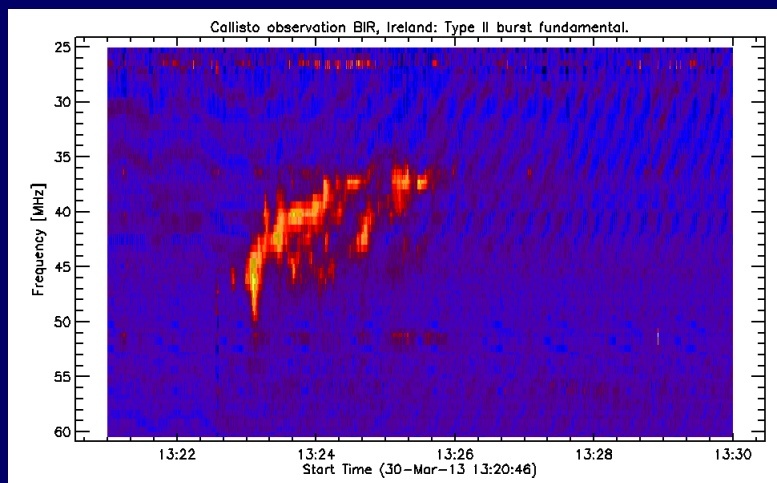
- 15' FIT-files and
- 15' QuickViews
- Daily overviews
- Daily light curves

Current User Statistics



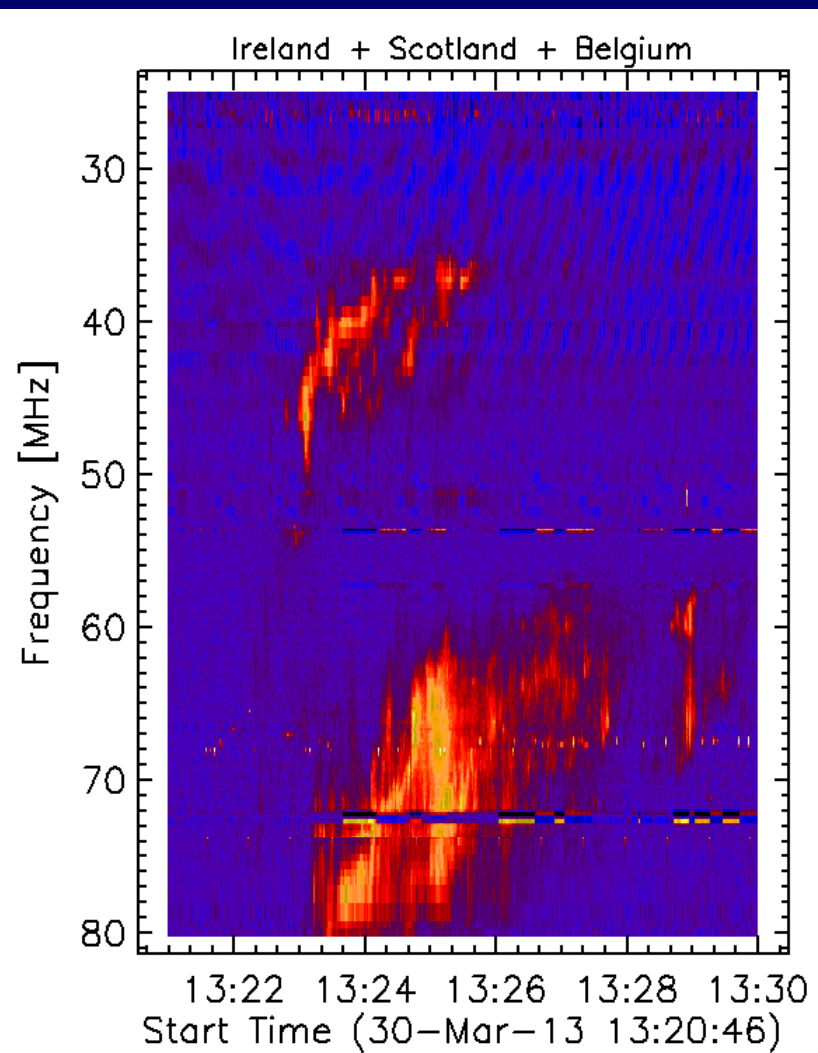
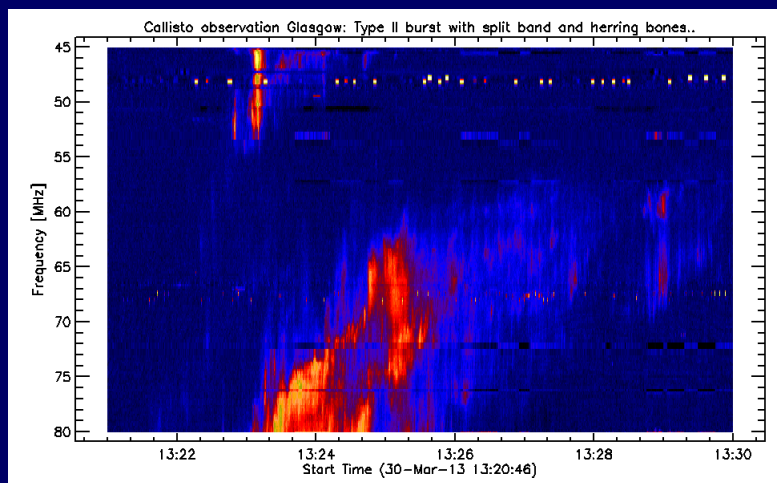
- ~ 700 worldwide visits per month from 127 countries
- ~ 60 GByte solar radio data per year (gzipped FIT-files)
freely accessible for everyone
- 40 Tera Byte data archive available at University of
Applied Sciences, Institute for 4D technologies (FHNW).

Advantage of distributed instruments



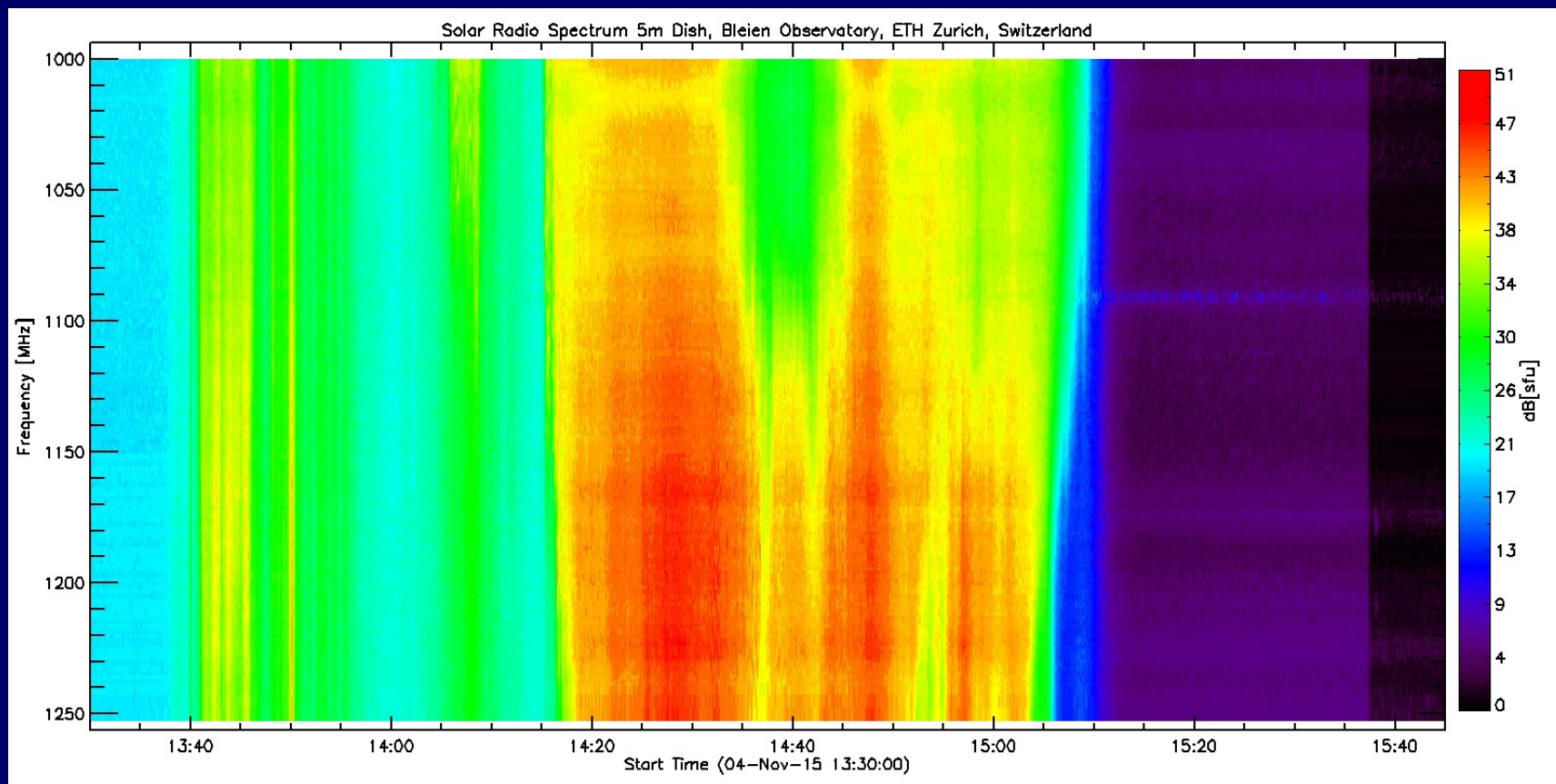
+

=



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

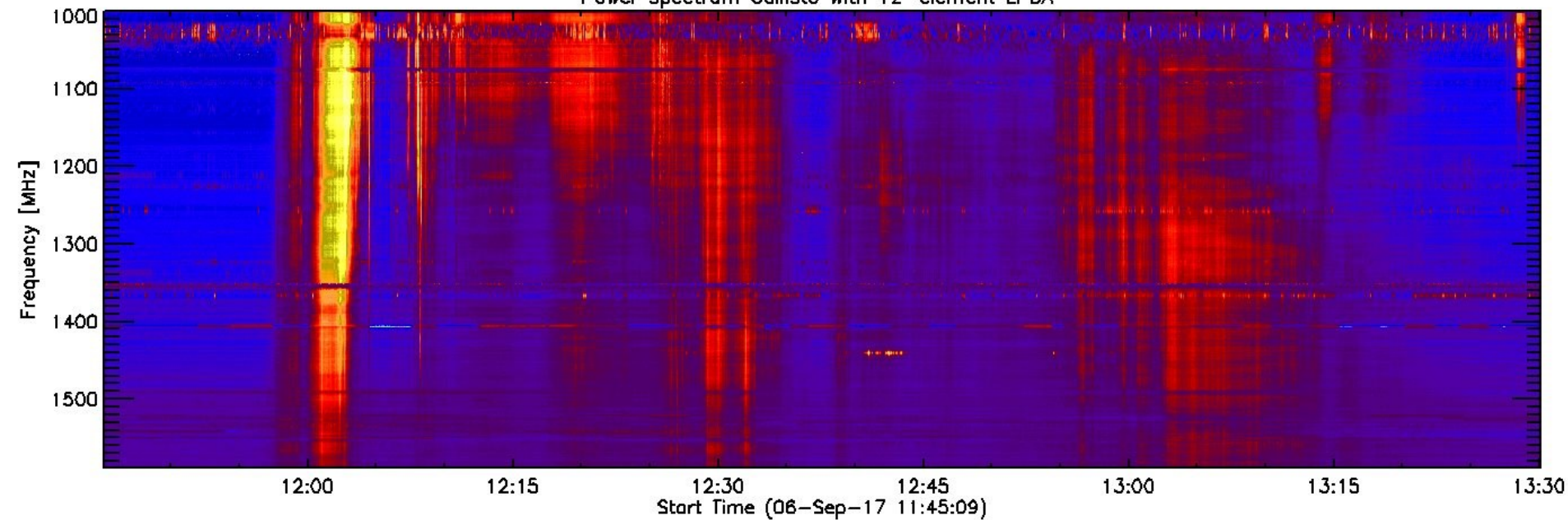
Solar radio burst shut down Swedish airport



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

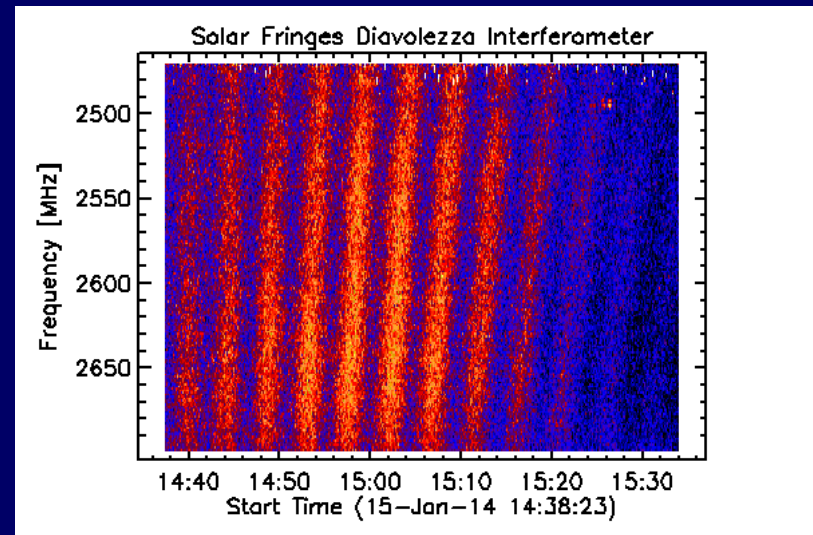
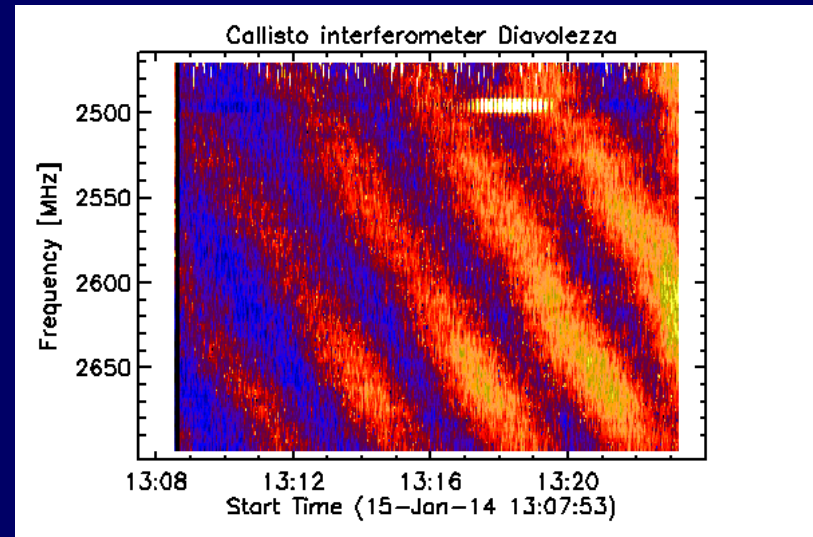
Power spectrum Callisto with 12-element LPDA



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>

Solar Radio Interferometer



Conclusions

- Network is still growing, currently requests from: Spain, Algeria, Côte d'Ivoire, Ecuador, Nigeria, Cuba, Oman, Nepal, Azores and Ethiopia is still on the agenda)
- Geographical coverage to be improved, especially American/Pacific region
- Data quality is improving (learning process)
- ↕
- rfi situation is getting worse worldwide
- More science could be done (educational problem)
- Only very little funding available to further support instruments & training in developing countries.



Additional information:

<http://e-callisto.org>

We are also on FaceBook



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