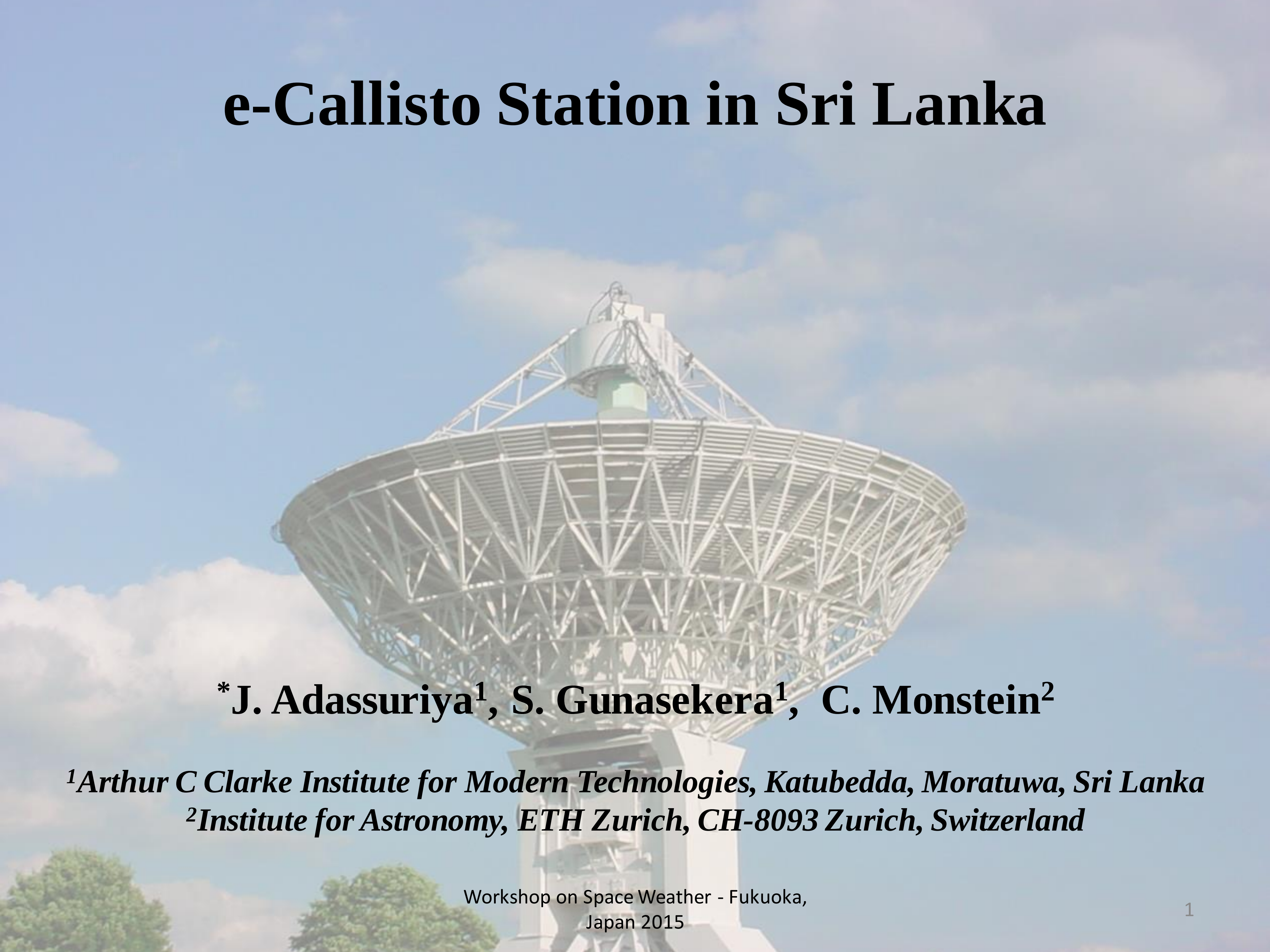

e-Callisto Station in Sri Lanka

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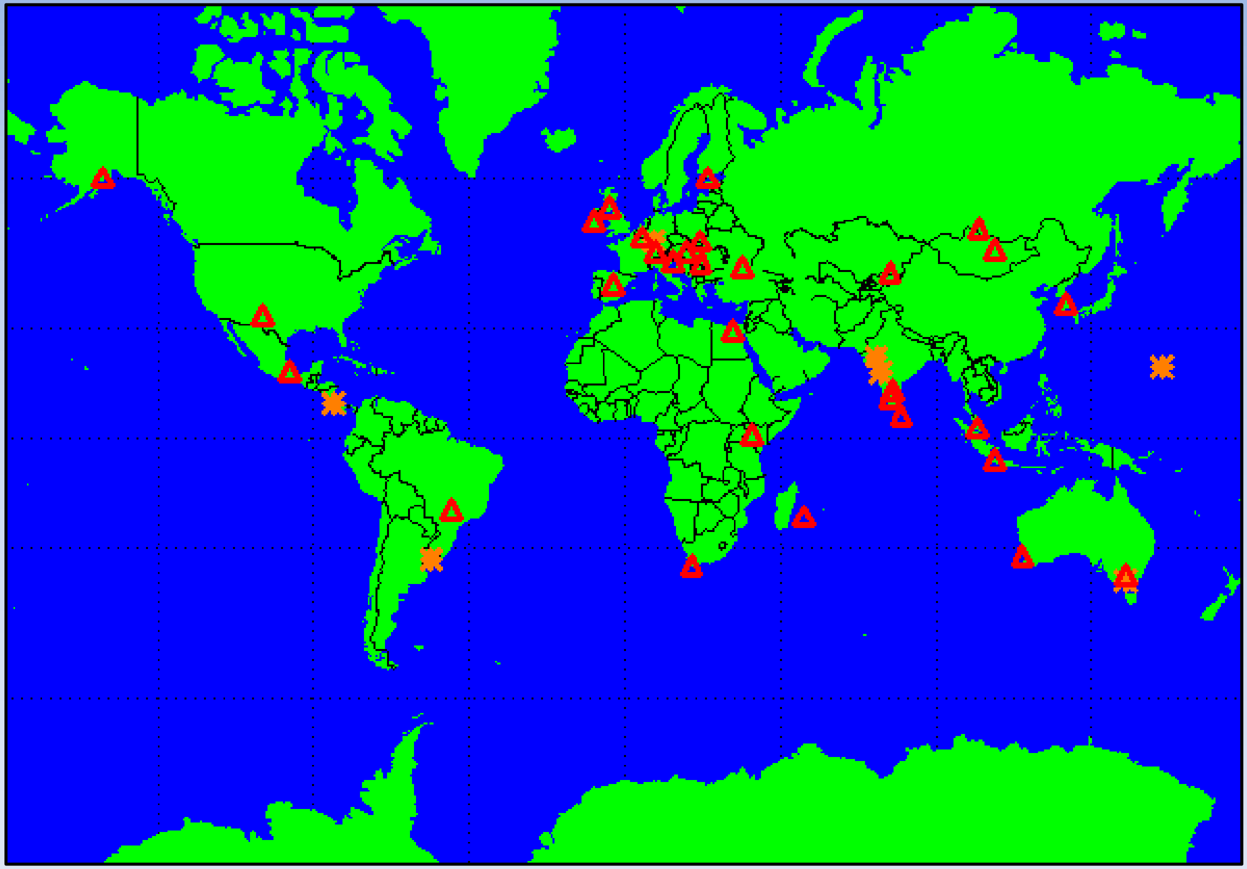
Overview CALLISTO and e-CALLISTO

- Compact Astronomical Low-cost Low frequency Instrument for Spectroscopy and Transportable Observatory *(CALLISTO).*
- e-CALLISTO global network which observes the solar radio bursts in 24 hours.
- As a result of the International Heliophysical Year (IHY), an international program of scientific collaboration planned for 2007.
- More than 70 instruments in almost 38 locations were implemented.



e-Callisto International Network of Solar Radio Spectrometers *(image credited to e-callisto web)*

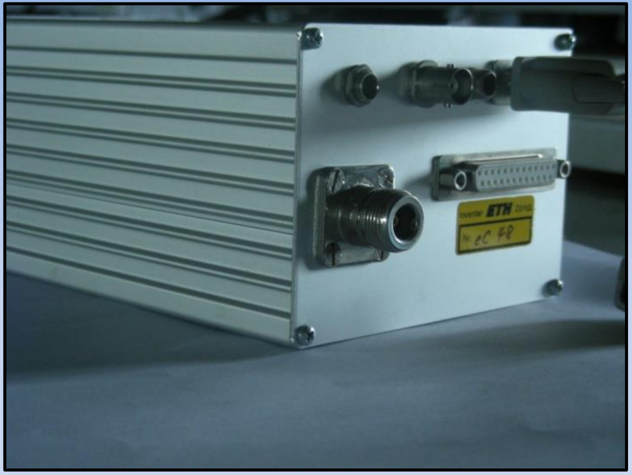
System Configuration

- CALLISTO Spectrometer and controlling software - donated by the Institute of Astronomy of ETH Zurich, Switzerland in year 2011.

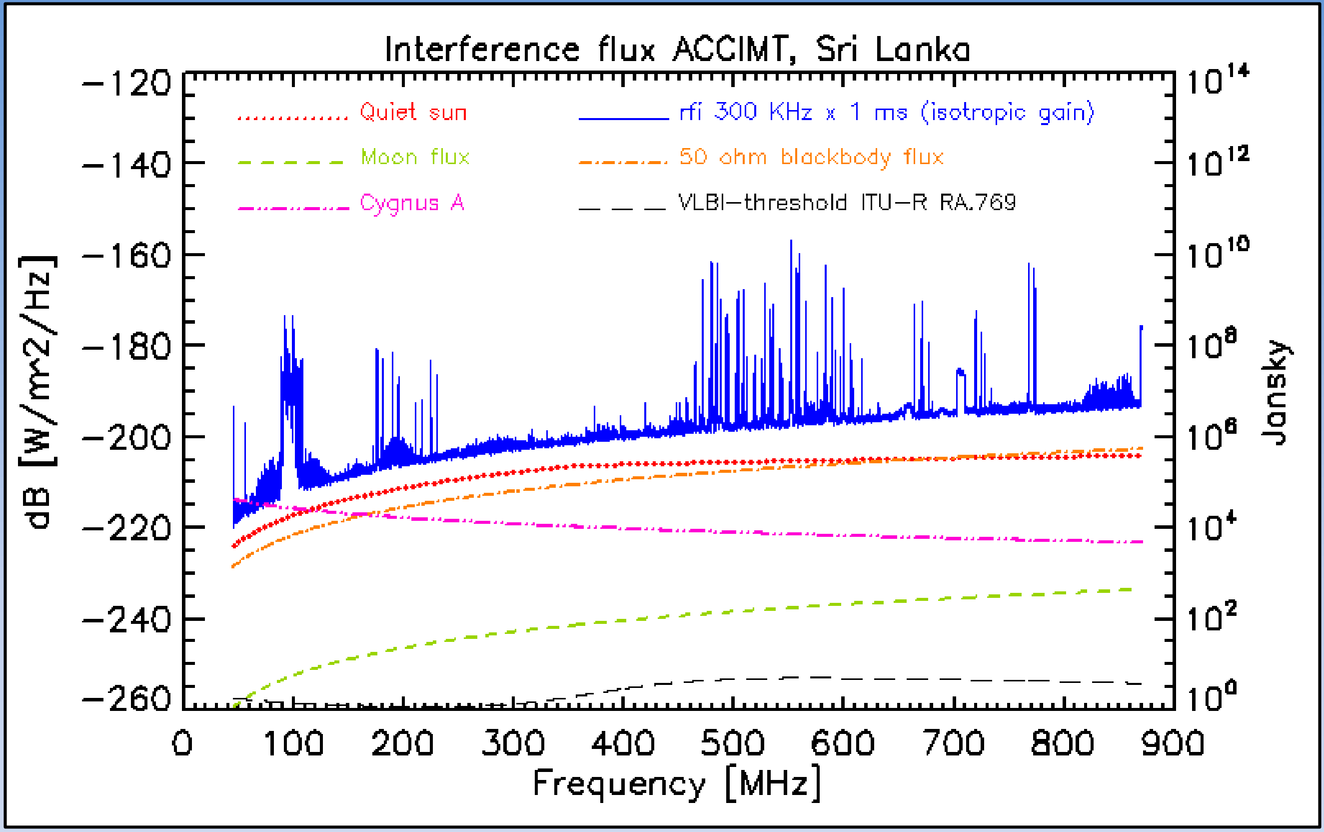
ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Parameter	Specification
Frequency Range	45.0 - 870.0 MHz
Frequency Resolution	62.5 KHz
Radiometric Bandwidth (Δf)	300 KHz at – 3 dB
Dynamic Range	~50 dB at -100 to -50 dBm maximum rf level
Sensitivity	24.5±1 mV/dB
Noise Figure	<10 dB
Maximum Sampling Rate	Internet clock 800 S/s, external clock 1,000 S/s
Number of channels	Nominal 200 frequencies per spectrum 4 sweeps per second
Sampling Rate	800 pixels /s
Power supply	DC 12 ± 2 V/225 mA
Weight	~ 800 g
Dimensions	110 mm × 80 mm × 205 mm
Material cost	< 200 US$
Input data	Three files (configuration, frequency, scheduler)
Output data	Two files (one FITS file per 15 min and one log file per day)

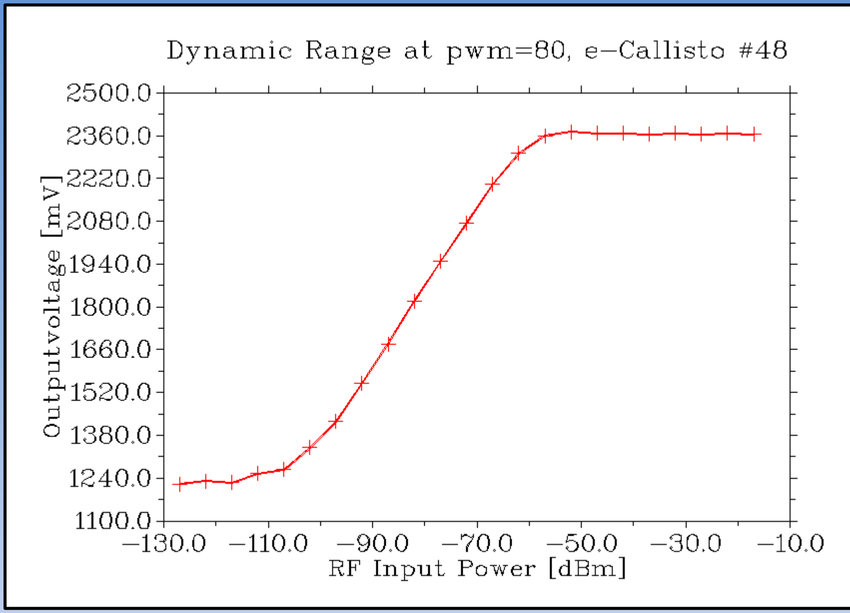


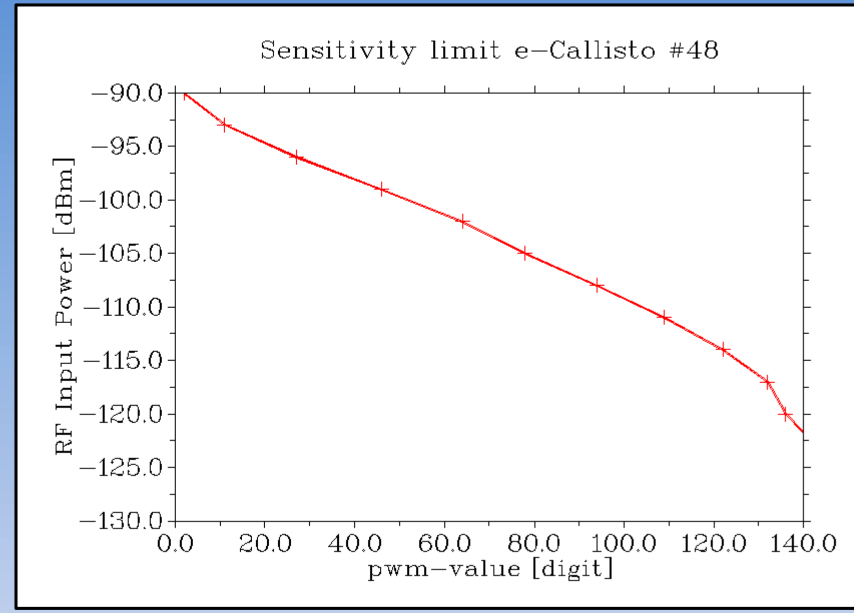
Spectral Overview Compared with Natural Sources



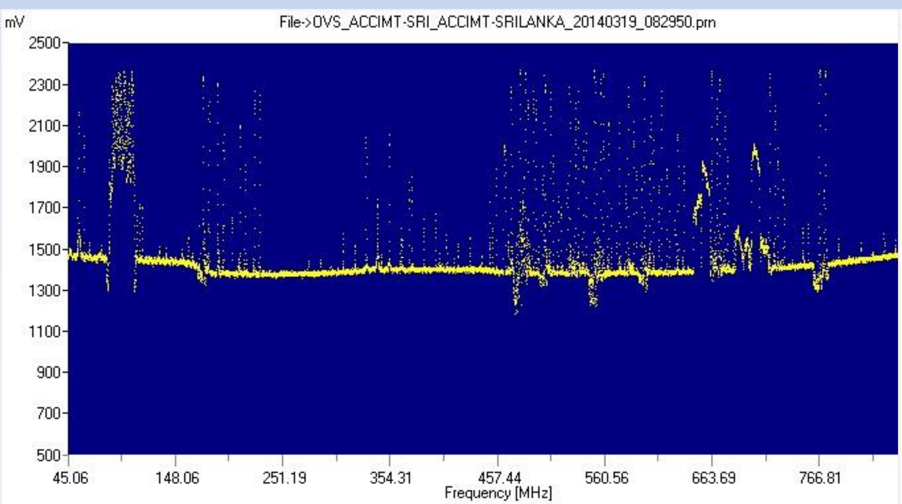
- Spectral Overview while the antenna is attached to the preamplifier.
- Spectral Overview with a 50 Ω termination resistor instead of the antenna attached to the input of the preamplifier as reference.
- Very Long Baseline Interferometry (VLBI) threshold - this is the definition of the ITU of maximum rfi-level to get maximum 10% data loss in radio astronomical observations.
- 50 ohm represents an equivalent antenna temperature of 300 Kelvin.

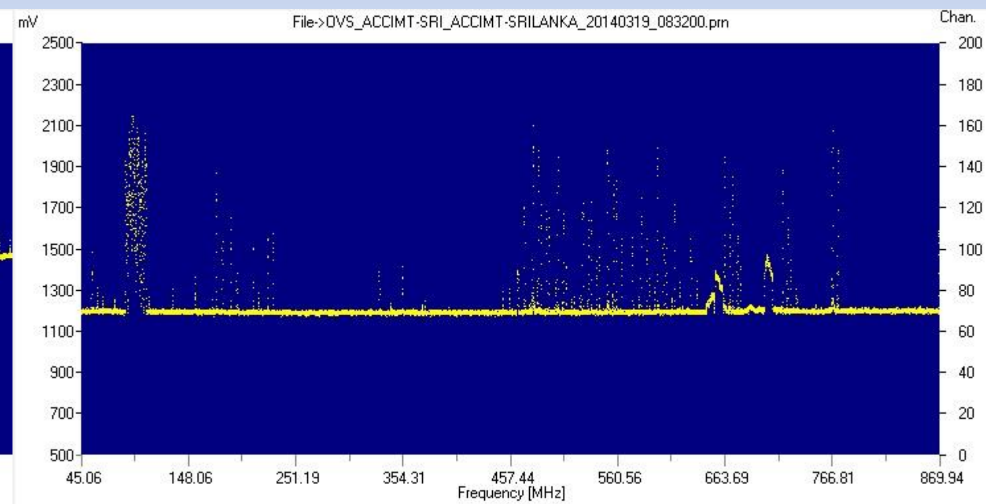
Receiver Characteristics





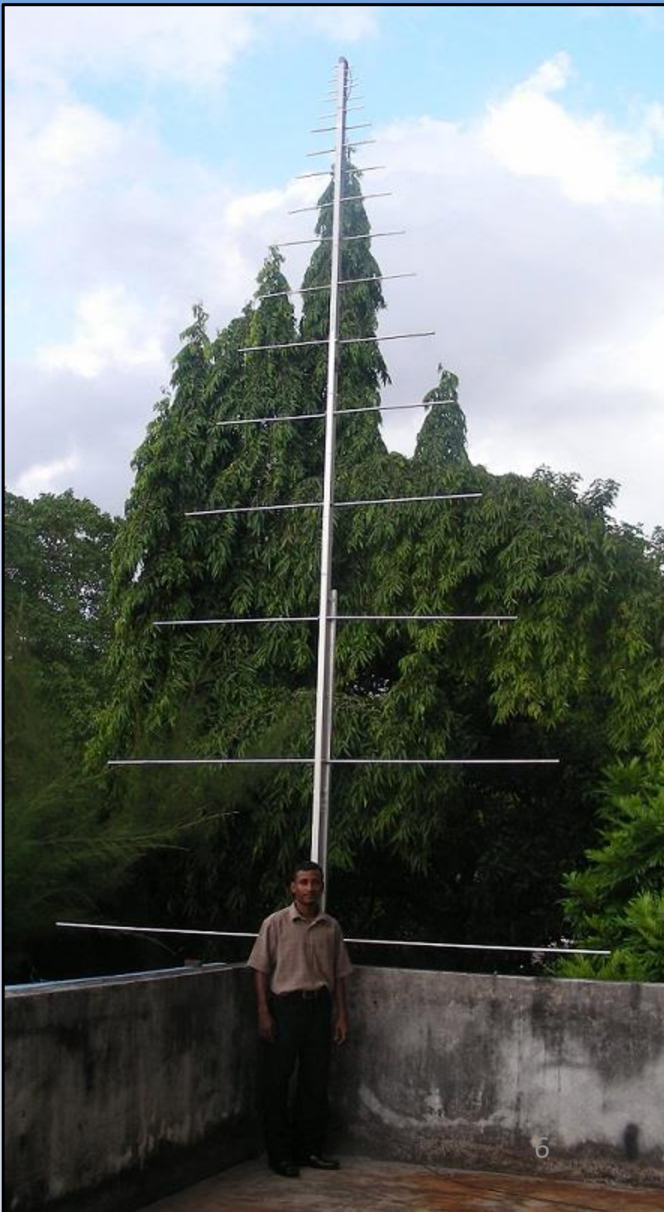
• Dynamic range of Callisto receiver. The saturation take place when the antenna exceeds -60 dBm.
• Sensitivity plot shows that the minimum sensitivity can be shifted by 40 dB by gain control (PWM)
• At high interfered locations the sensitivity has to bring down.

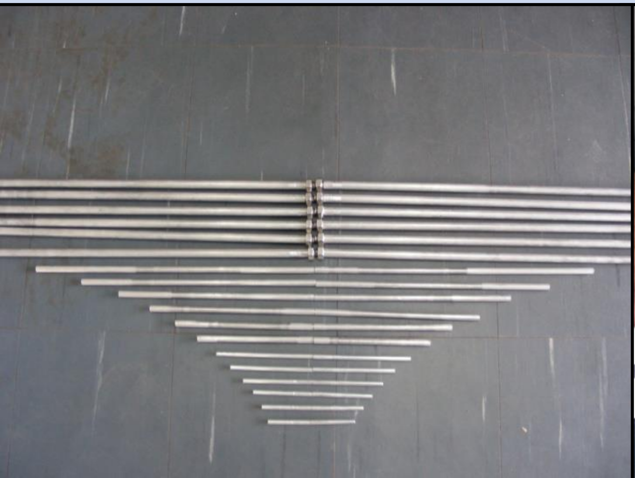




Logarithmic – Periodic Antenna and Pre- Amplifier - ACCIMT

Parameter	Specifications
Range	45 – 870 MHz
Theoretical Gain	7 dBi
Average Impedance	49.3 Ω
VSWR	<1.5
Overall Height	5.38 m
Width of the longest dipole	3.33 m
Plane of Polarization	Linear polarized pointing to zenith
Bandwidth	60 degrees from zenith
Effective Area	1.7 m^2 at 145 MHz
Approximate Cost	250 USD



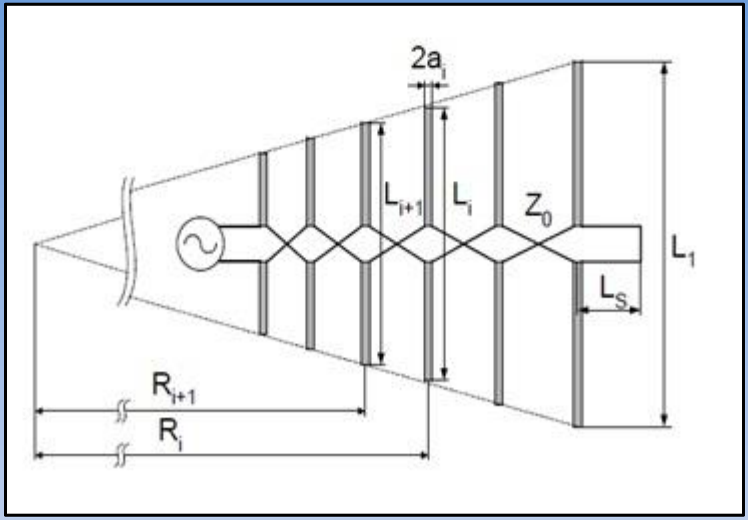


Design Steps of Log-Periodic Antenna

Periodicity $\tau = 0.822$

Relative Spacing $\sigma = 0.243\,\tau - 0.051$

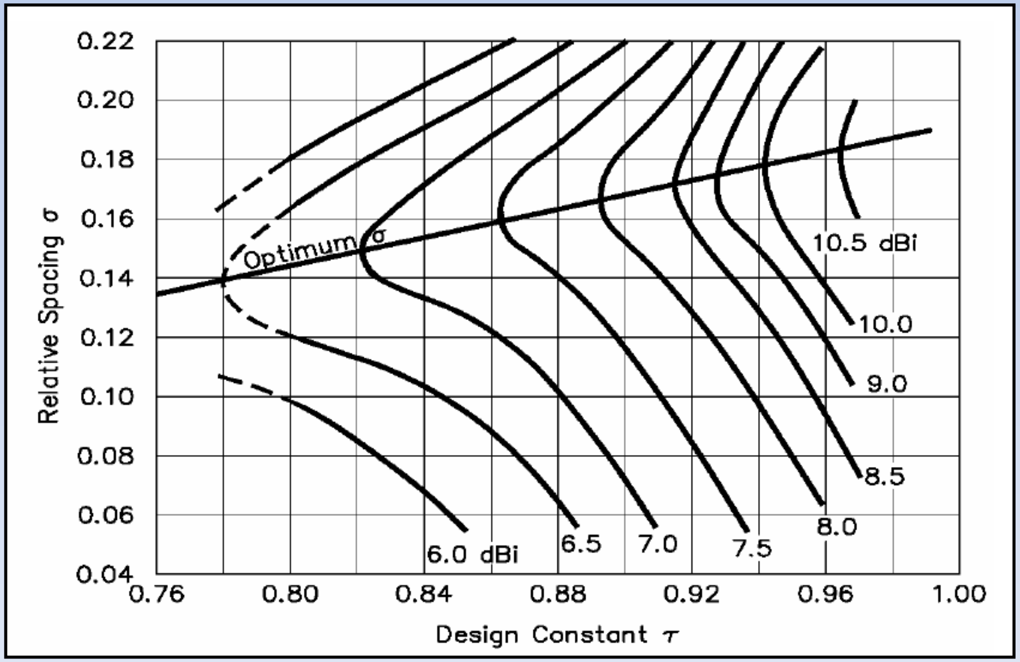
$\sigma = 0.149$



Number of Dipoles $N = 1 + \dfrac{\log B_s}{\log\left(\frac{1}{\tau}\right)}$

Dipole Length $l_{i+1} = \tau l_i$

Relative Spacing $R_{i+1} = \tau R_i$



Images Credited : F. Hutira & Jan Bezek

Design Steps of Log-Periodic Antenna

Slimness Factor

$$S = \frac{l_i}{2a_i}$$

Characteristics Impedance

$$Zo = \frac{R_o^2\sqrt{\tau}}{8Z_{avg}\sigma} + R_o\sqrt{\left(\frac{R_o\sqrt{\tau}}{8Z_{avg}\sigma}\right)^2 + 1}$$

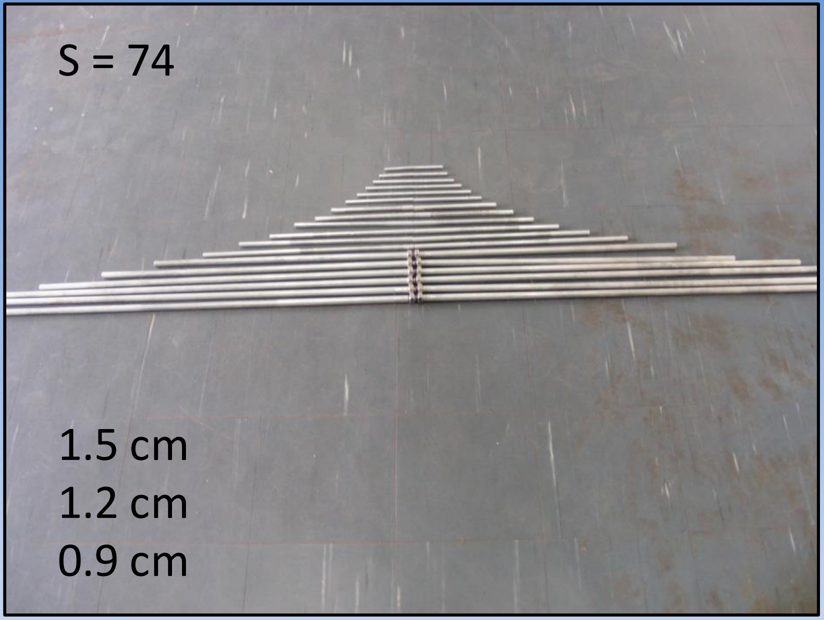
Separation of Two Booms

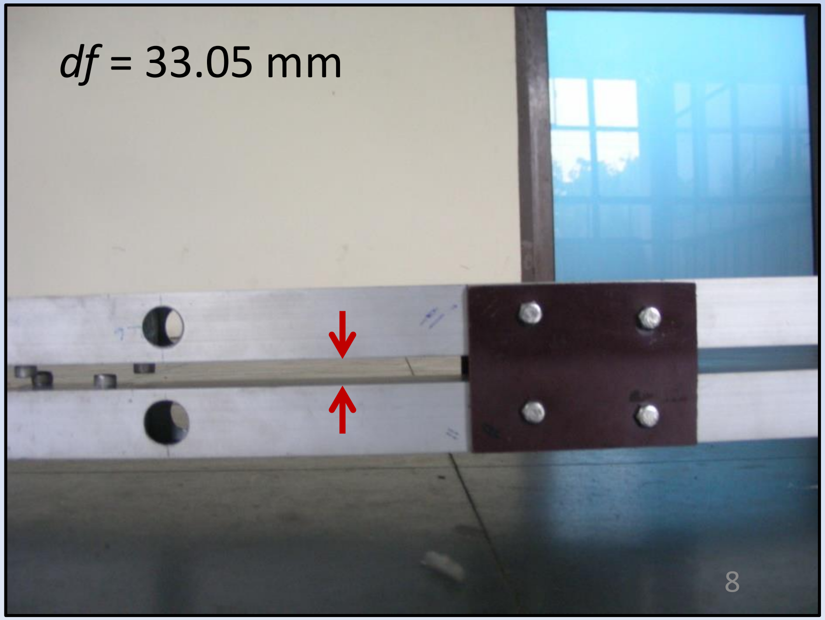
$$df = b\cosh\left[\frac{Zo}{120}\right]$$

$$VSWR = \frac{1+|\rho|}{1-|\rho|}$$

$$\rho = \frac{z_a - z_o}{z_a + z_o}$$

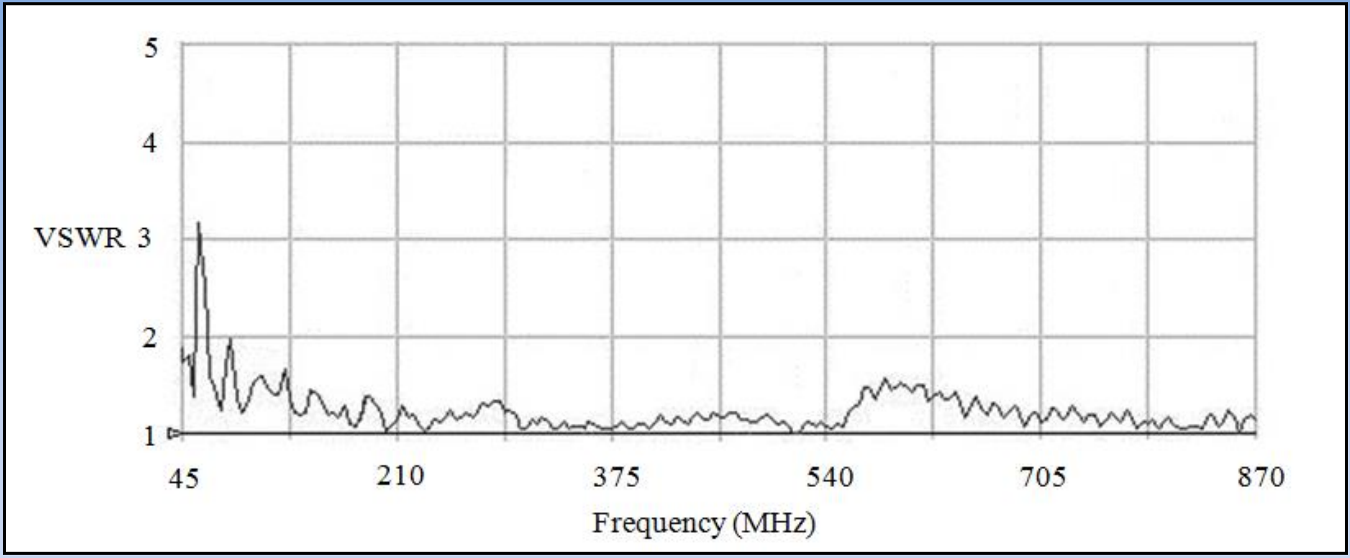
ρ - reflection coefficient
Z_a – antenna impedance
Z_o – transmission line impedance

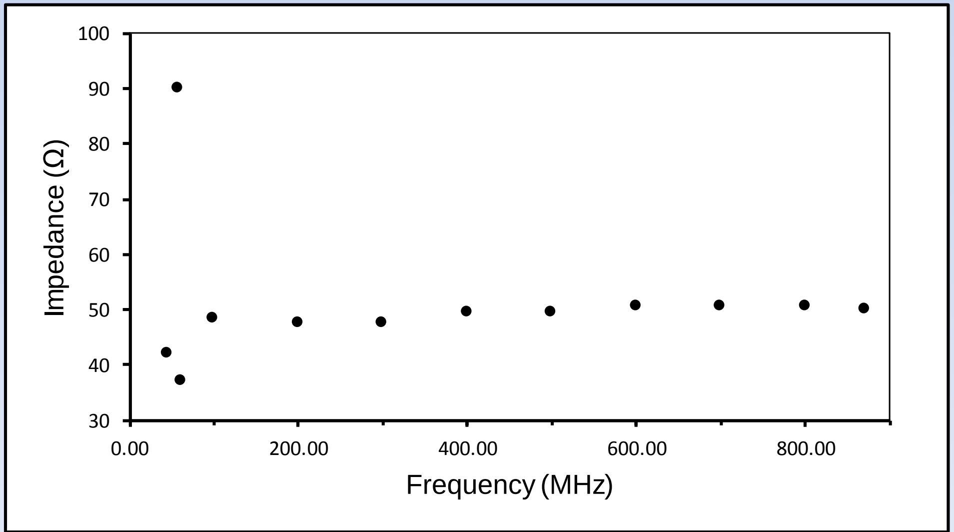




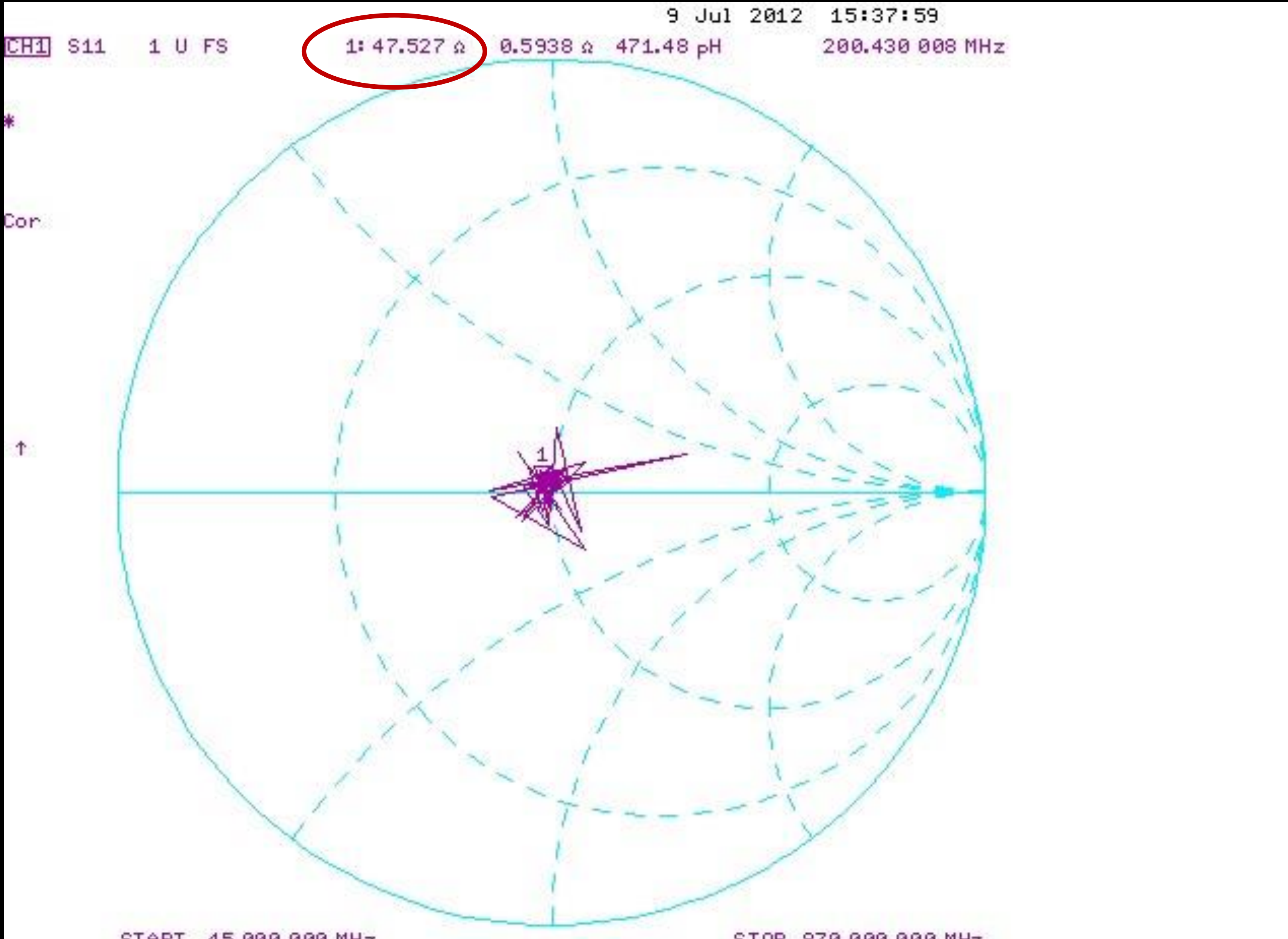
Performances of the Antenna

- The purpose of the precise designing and measurements is to achieve the overall impedance of the antenna to be 50 Ω and hence maintain the VSWR < 1.5 for the entire frequency range.

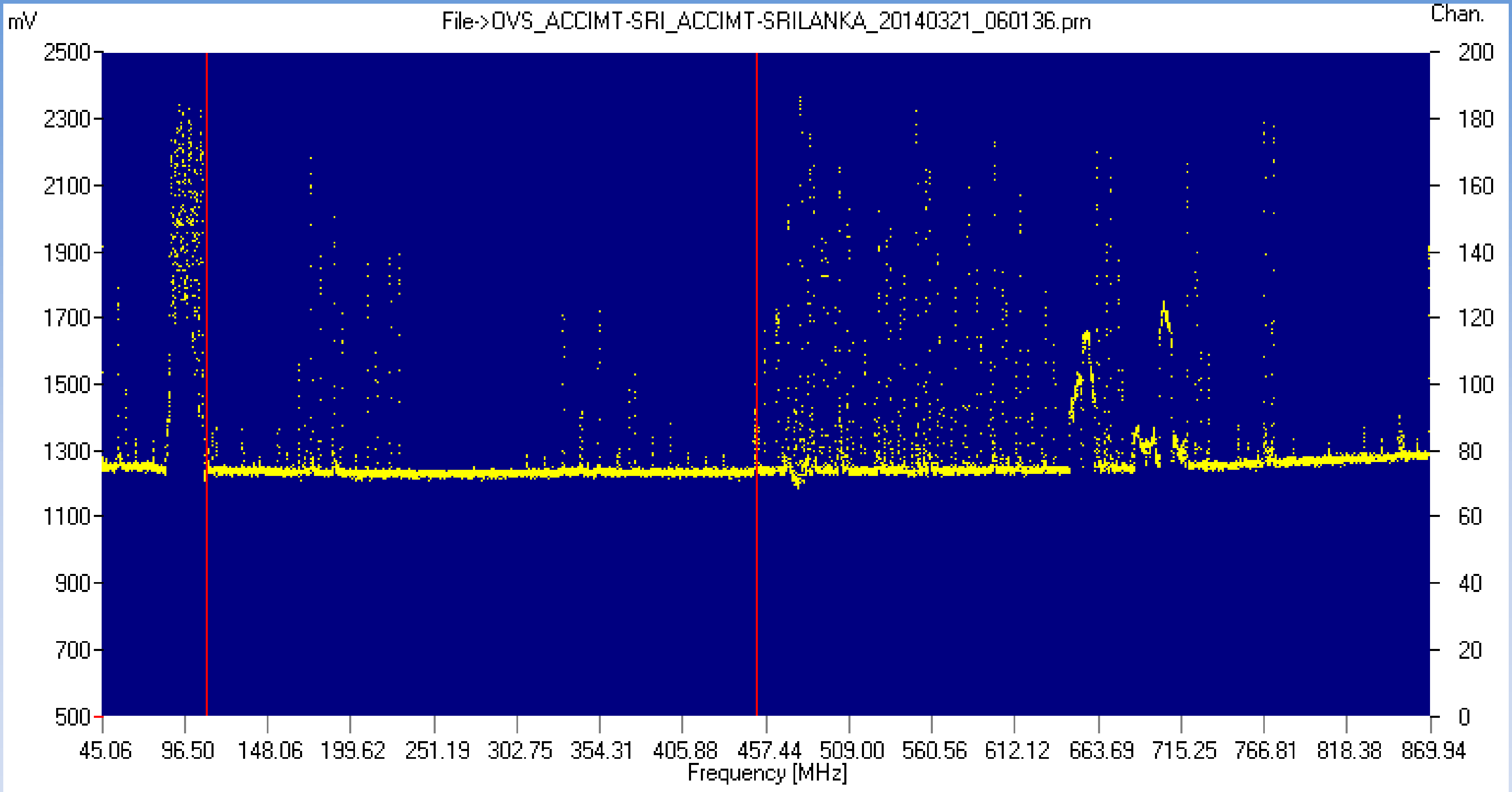




- The impedance is fluctuating very much from 50 Ω below 90 MHz.
- The resulting VSWR alos > 1.5 below 90 MHz.


9 Jul 2012 15:37:59
CH1 S11 1 U FS
1: 47.527 Ω 0.5938 Ω 471.48 pH 200.430 008 MHz
Cor
1
START 45.000 000 MHz
STOP 870.000 000 MHz

Spectral Response of the System (45 MHz – 870 MHz)



- The system is set to the minimum interference band (110 MHz – 452 MHz).
- This band avoids the VSWR anomalies in the lower frequency range and interference in higher frequencies.

The potential solar radio bursts detecting by the system…

$$A_{effective} = \frac{\lambda^2}{4\pi} . G$$

Effective area of the antenna (λ = 145 MHz) = 1.7 m^2

$$T_{sys} = T_{sky} + T_{Rx}$$

System noise = 2910 K

$$PFD_{sys} = K.T_{sys}$$

Power flux density = 4 x 10^{-20} W/Hz or -194 dBW/Hz

- Assume that a solar radio bursts can be reliably detected if it is at least 10dB above the system noise floor

- The required solar burst power flux density is = - 194 dBW + 10 dB = -184 dBW

$$PFD_{Burst} = \left[10^{\frac{-184}{10}}\right]$$

Power flux density for the burst = 3.98 X 10^{-19} dBW/Hz

$$S = 2\left(\frac{PFD_{Burst}}{A_{effective}}\right)$$

Spectral flux density = 4.68 x 10^{-19} W/m^2/Hz

By definition one solar flax unit (sfu) = 10^{-22} W/m^2/Hz

Spectral flux density = **4680 sfu** at 145 MHz

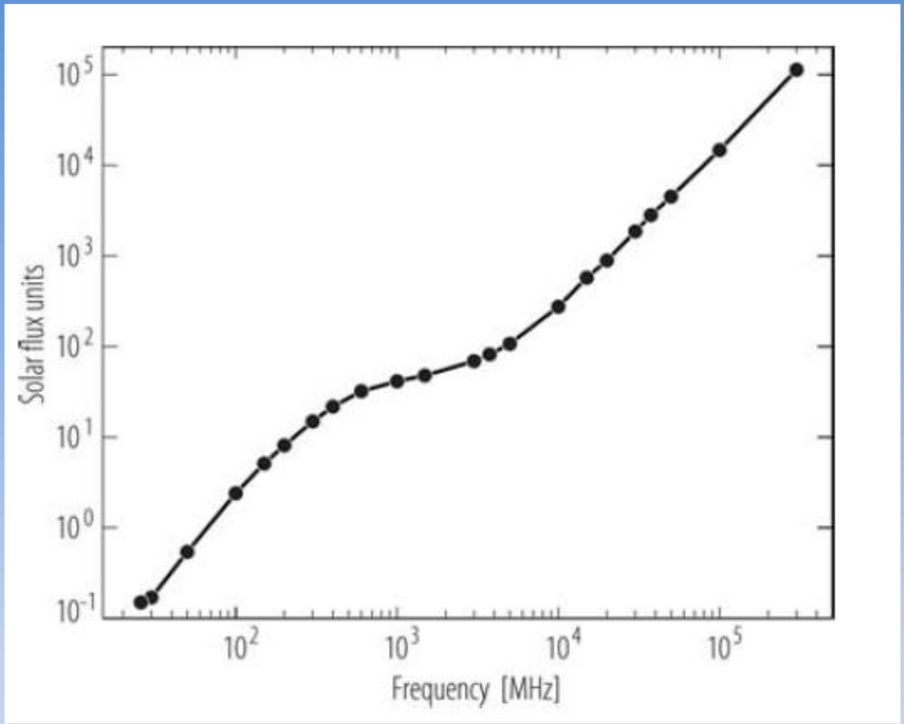


Image Credited: Radio Emission of the quiet Sun (Arnold O. Benz)

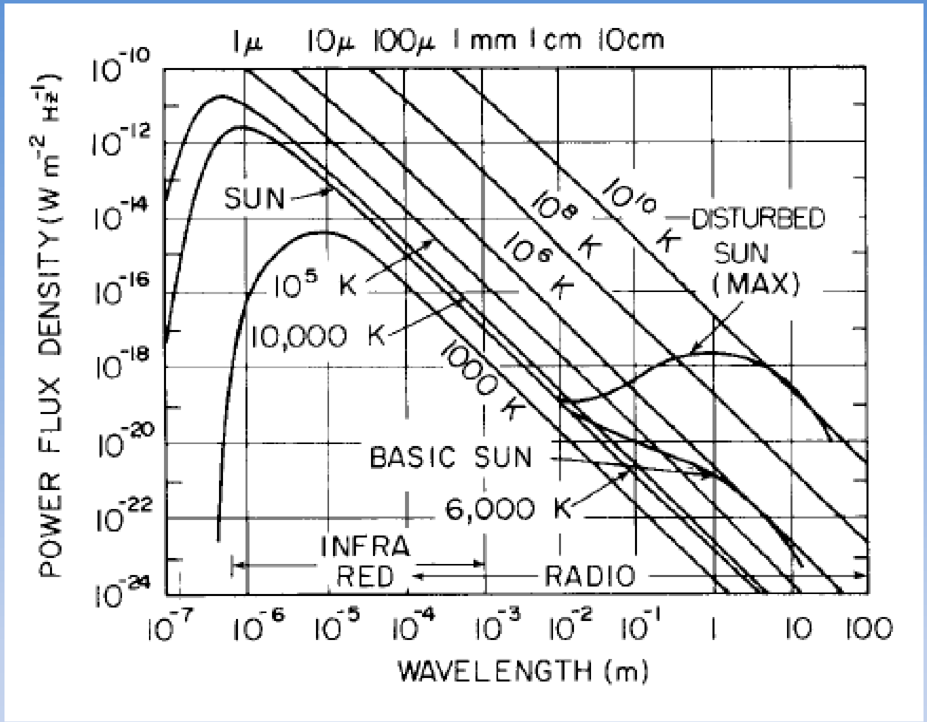


Image Credited: Solar Radio Emission (W. R. Barron)

- Radio emission of the quiet sun at 145 MHz is less than 10 sfu.
- Radio emission of the disturbed sun at 145 MHz is around 10000 sfu.
- But the Radio Bursts of 10000 sfu are very rare.

Coverage of the Local System

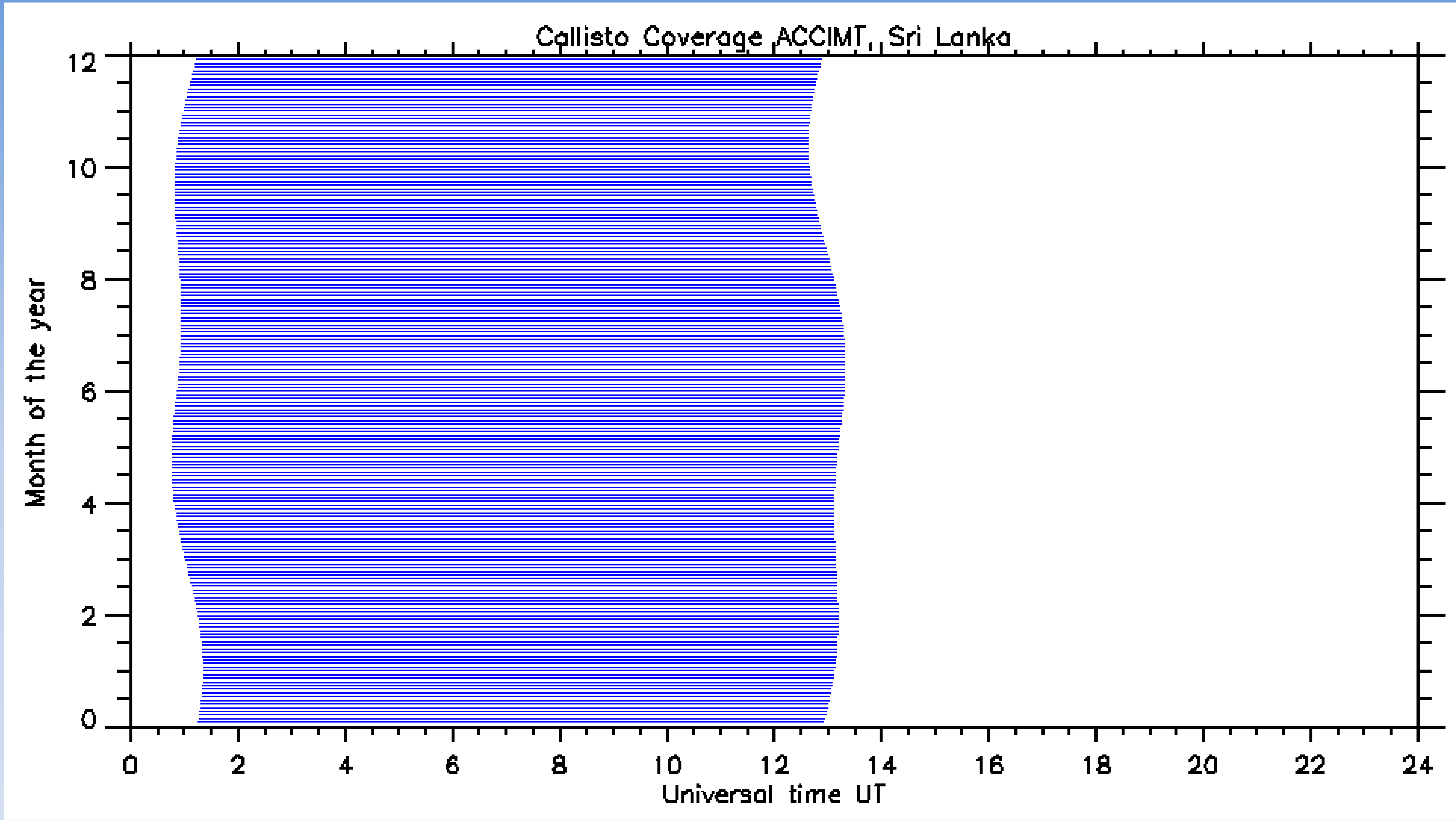


Image Credited: http://www.e-callisto.org (Christian Monstein)

Interference level (rfi) taken from a single 15 minute FIT-file per location of the e-Callisto network.

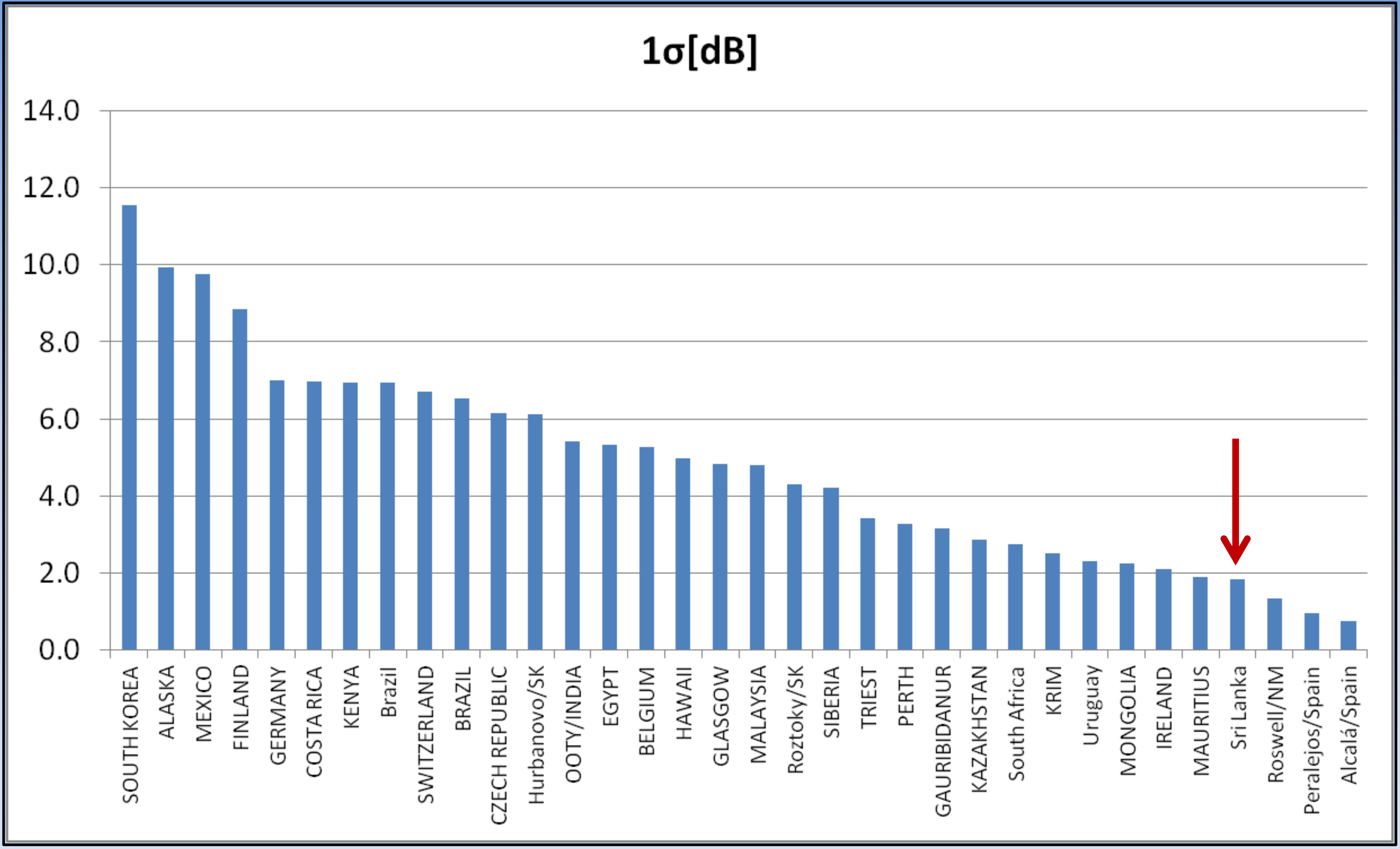
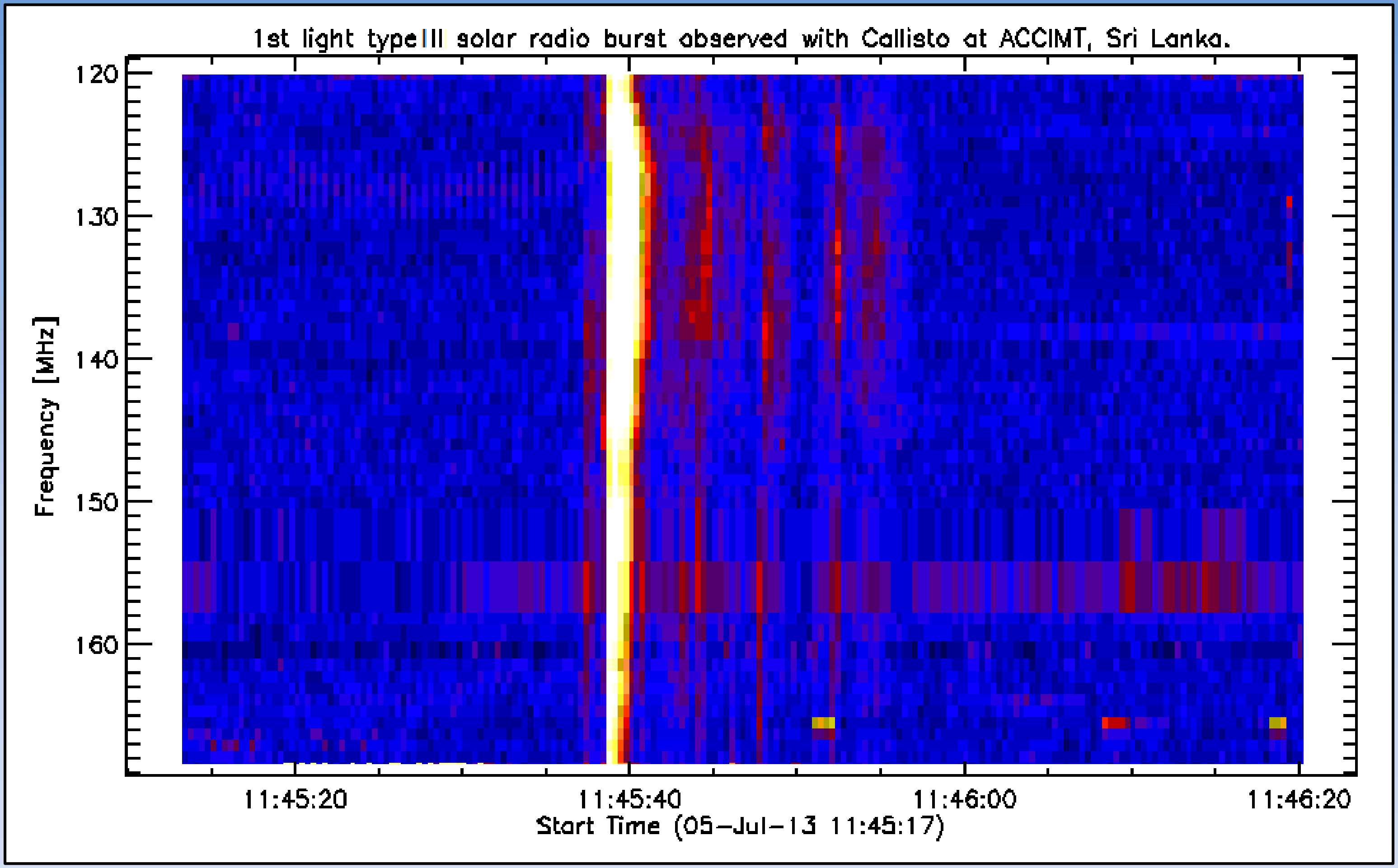


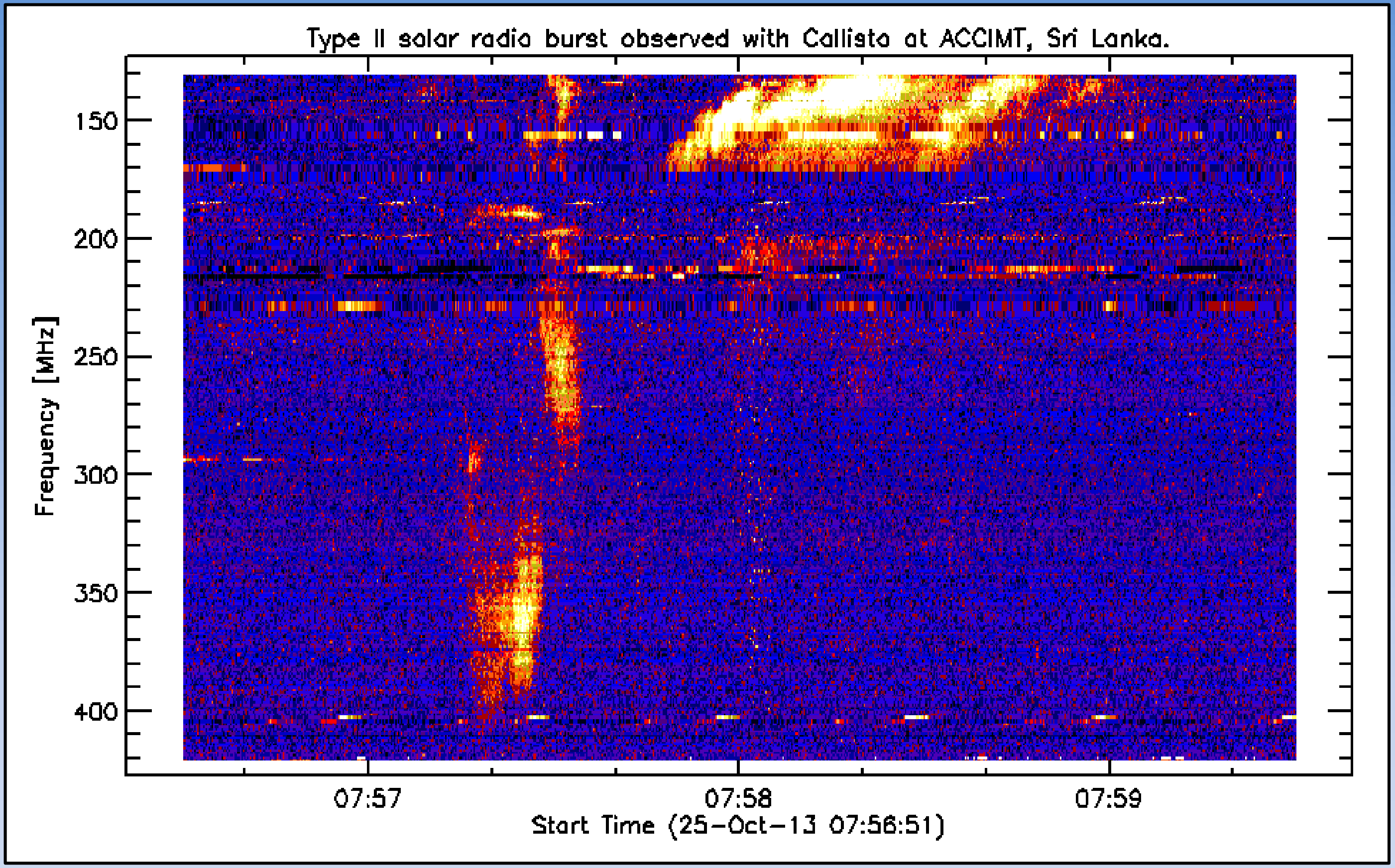
Image Credited: http://www.e-callisto.org (Christian Monstein)

Best ones with low interference level are Spain, Roswell NM, Mauritius, Sri Lanka, Ireland, Mongolia and Kazakhstan.

First Result

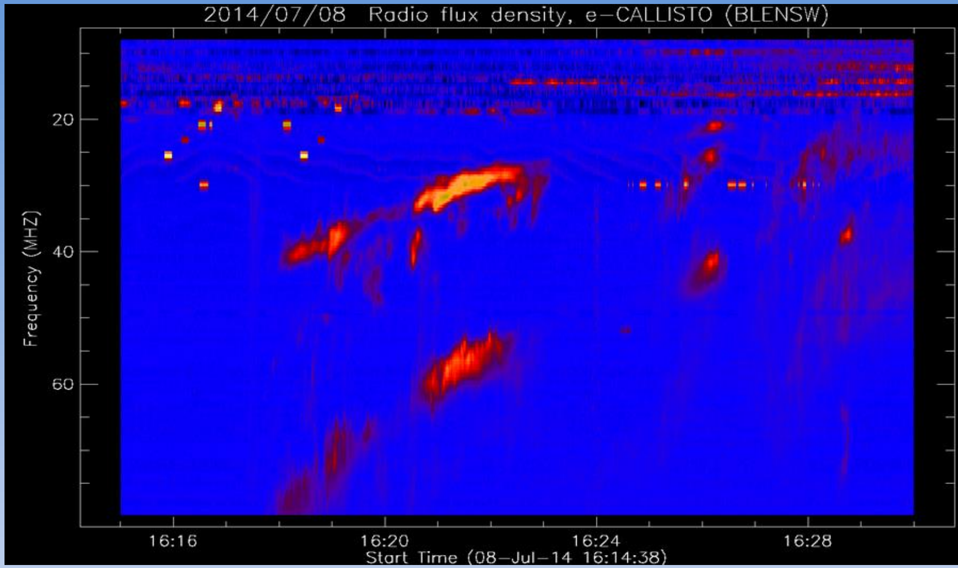


Type III solar radio burst occurred on 2013 July 05 at 06:15:55 UT originated by C 2.2 solar flare.



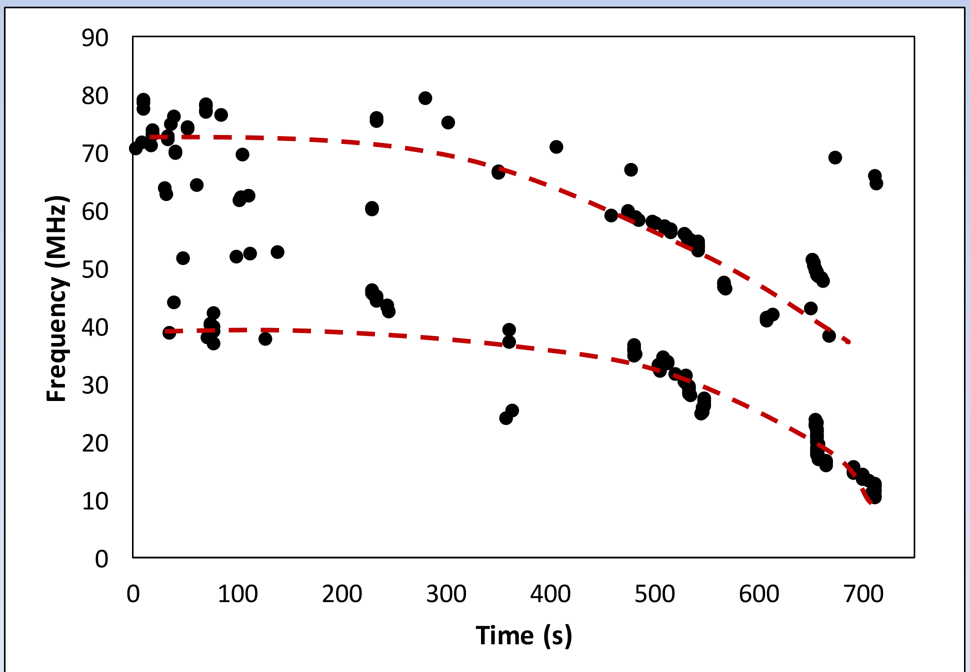
Type II solar radio burst occurred on 2013 October 25 originated by X 1.7 class solar flare at 07:53:00 UT.

Estimating the Plasma Frequency



Average drift rate at the observing frequency **'ν'** in the metric band which covers the CALLISTO data

$$\frac{d\nu}{dt} = -0.01\,\nu^{1.84} \quad \text{Mzs}^{-1}$$



Frequency difference $d\nu = 10.35 - 36.6 = -26.25$ MHz

Time difference $dt = 712 - 481 = 231$ s

Therefore drift rate is $\frac{d\nu}{dt} = -\frac{26.25}{231} = -0.1136$ MHzs^{-1}

Drift frequency is $\nu = \sqrt[1.84]{-100\frac{d\nu}{dt}} = 3.75$ MHz.

Type II burst			Type III burst		
Burst	**dv/dt**	**ν (MHz)**	**Burst**	**dv/dt**	**ν (MHz)**
2013.11.08 MRT1	-2.5744	20.42	2013.07.05 ACCIMT	-18.0000	58.77
2013.11.19 MRT3	-0.7856	10.72	2013.10.25 BLEN7M	-17.4722	57.83
2014.01.08 ALMATY	-2.8287	21.50	2013.11.19 BLEN7M	-5.8642	31.95
2014.04.16 ROSWELL-NM	-0.0694	02.87	2013.12.07 KRIM	-4.7595	28.52
2014.04.18 BLENSW	-0.1089	03.66	2014.02.12 MRT1	-55.2500	108.11
2014.07.08 BLENSW	-0.1136	03.75	2014.03.29 GLASGOW	-0.2122	05.26
2014.07.08 ROSWELL-NM	-0.1062	03.61	2014.04.02 GLASGOW	-0.6036	09.28
2014.08.24 MRT1	-0.5174	08.54	2014.06.10 BLEN7M	-20.1404	62.47
2014.11.05 GAURI	-0.5668	08.97	2014.06.11 OOTY	-71.0667	123.96
2014.11.05 MRT3	-2.4654	19.95	2014.10.16 BLEN7M	-32.3750	80.86

Conclusions

- In collaboration with ETH Zurich, the Arthur C Clarke Institute successfully constructed a **CALLISTO station in Sri Lanka.**

- **This is the first observation facility to investigate celestial object in radio region in Sri Lanka.**

- The system is connected to the **e-CALLISTO network** which included another solar observation station in radio region.

- The system is **capable of detecting** solar radio burst in **moderate solar flares** as well. (Type C class solar flares)

- The system can be used for **research purpose** as well as **developments** by:
  - contributing for data analysis
  - enhancing the system, introducing **solar tracker**, **designing pre-amplifier** etc.

Thank You

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