Energy release from the magnetic reconnection diffusion region: new cluster results

Baolin Tan

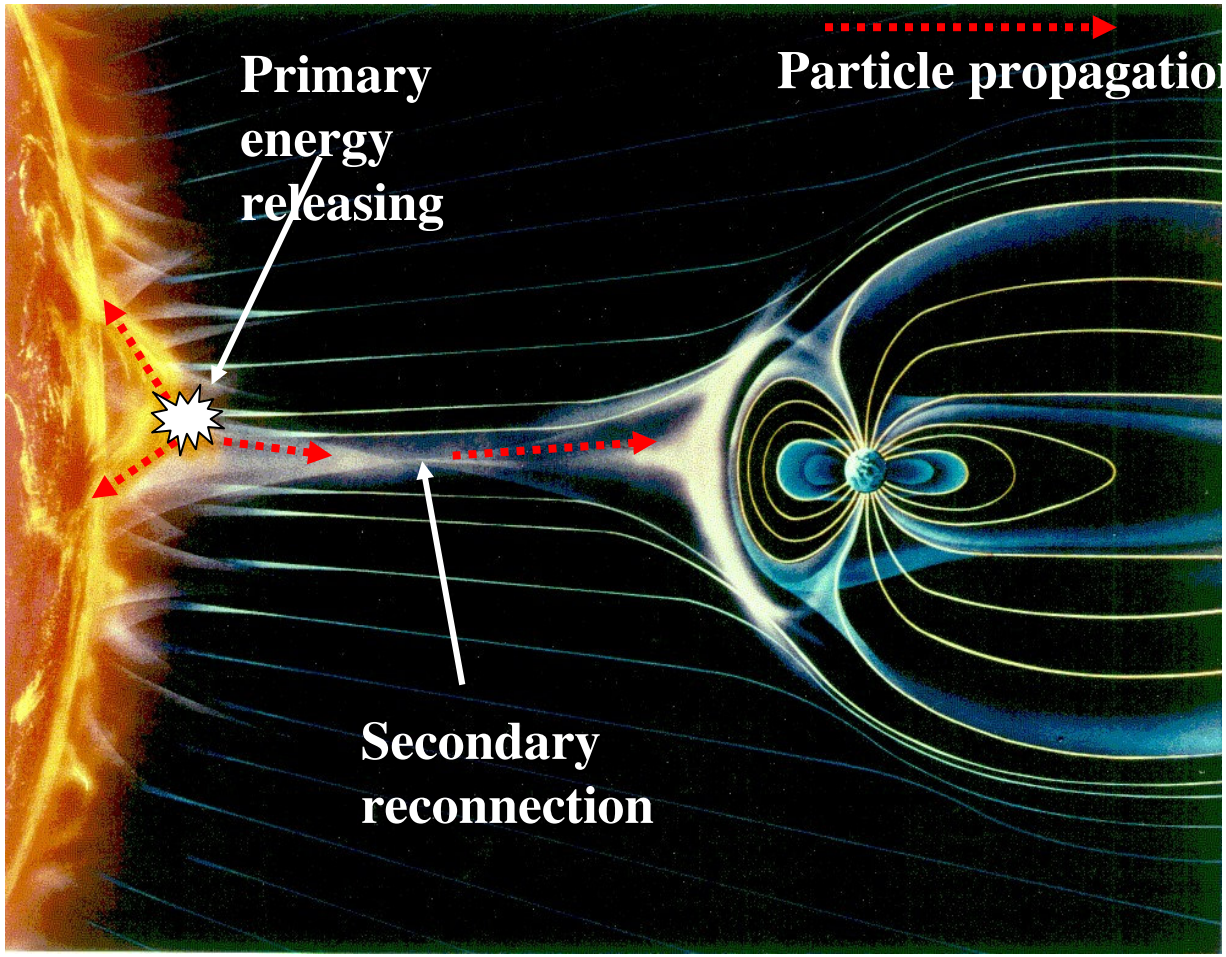
Key Laboratory of Solar activity, National Astronomical Observatories of Chinese Academy of Sciences

Email: bltan@nao.cas.cn

Online

1. Microwave observations and energy release from magnetic reconnection region
2. New cluster results of microwave spectral fine structures
3. A brief introduction of the Chinese Spectral Radio Heliograph (CSRH)

1. Energy release from magnetic reconnection region



Total flare energy:

4×10^{32}erg.

Among them,

Plasma clouds

2×10^{32}erg (50%)

Nonthermal particles

1×10^{32}erg (25%),

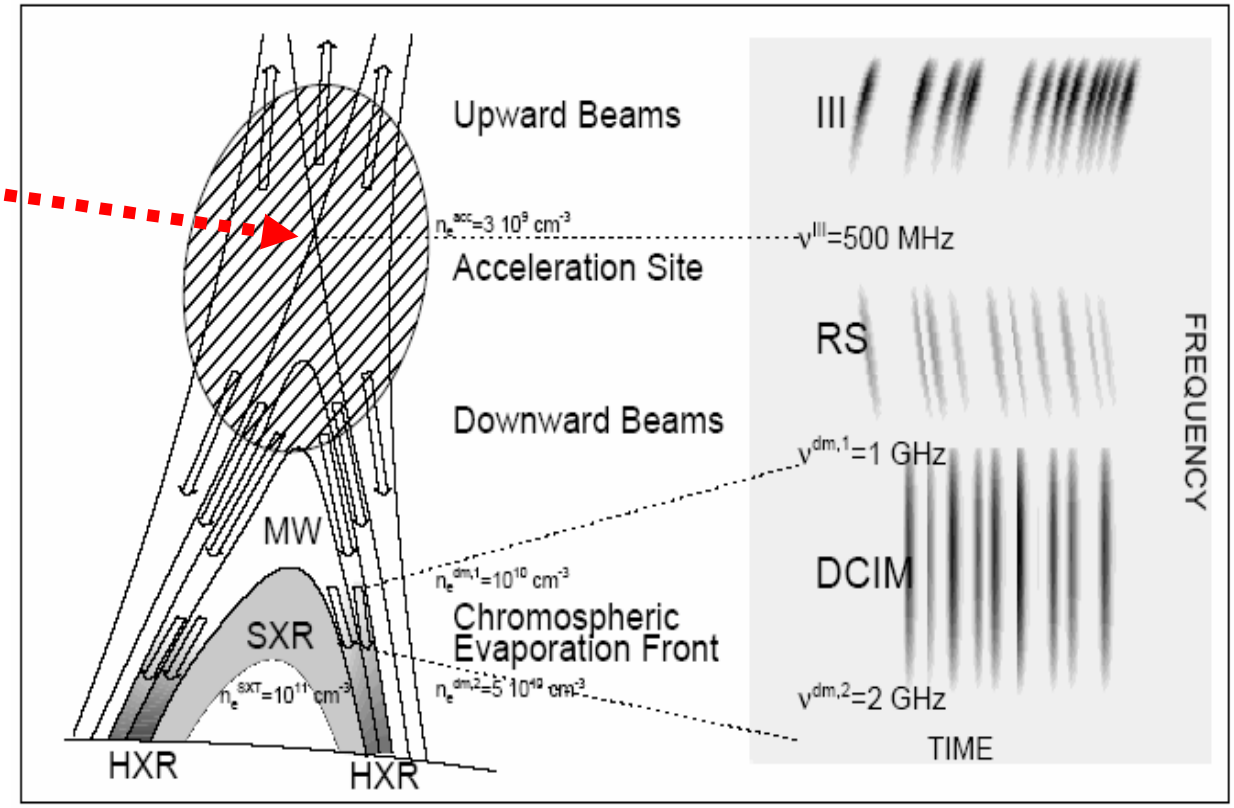
Electromagnetic waves

1×10^{32}erg (25%)

Energy release from flare source region

Reverse type III bursts provide a **reverse frequency (f_R)** related to the magnetic reconnection site.

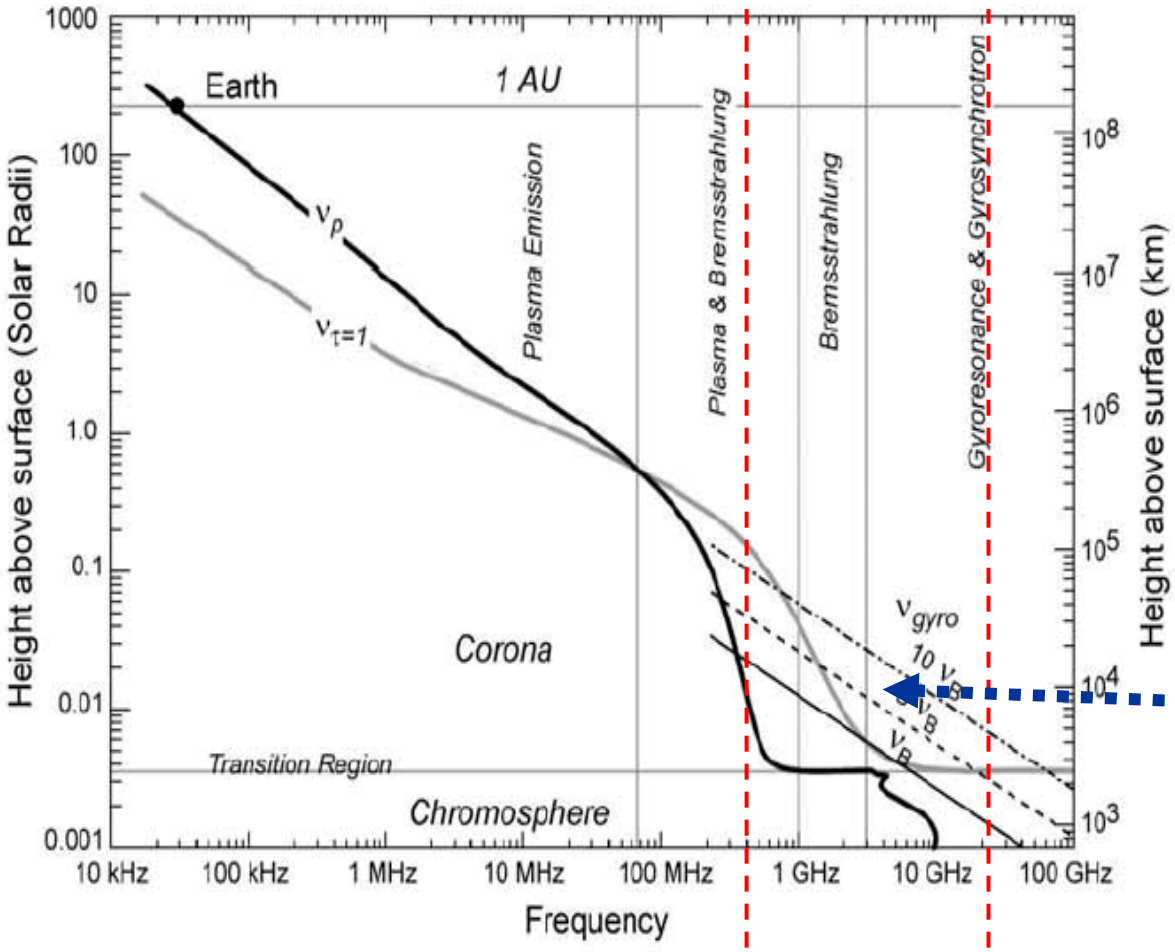
f_R is at 400 – 1000 MHz. Generally, strong flares have relative low f_R, and have a relative high reconnection site.



(Aschwanden & Benz, 1997)

Higher or lower than f_R, especially in the microwave range (~ 300 MHz-10 GHz) there are many **spectral fine structures** with short timescale and high brightness temperature, which may reflect the physical details of particle acceleration, propagation, and energy releasing.

Co-existing of multiple emission mechanisms



$$\nu_p = 8.98\times10^3\sqrt{n_e}$$

$$\nu_{\tau=1} \approx 0.5 n_e T_e^{-3/4} L^{1/2}$$

$$\nu_B = 2.8\times10^6 B$$

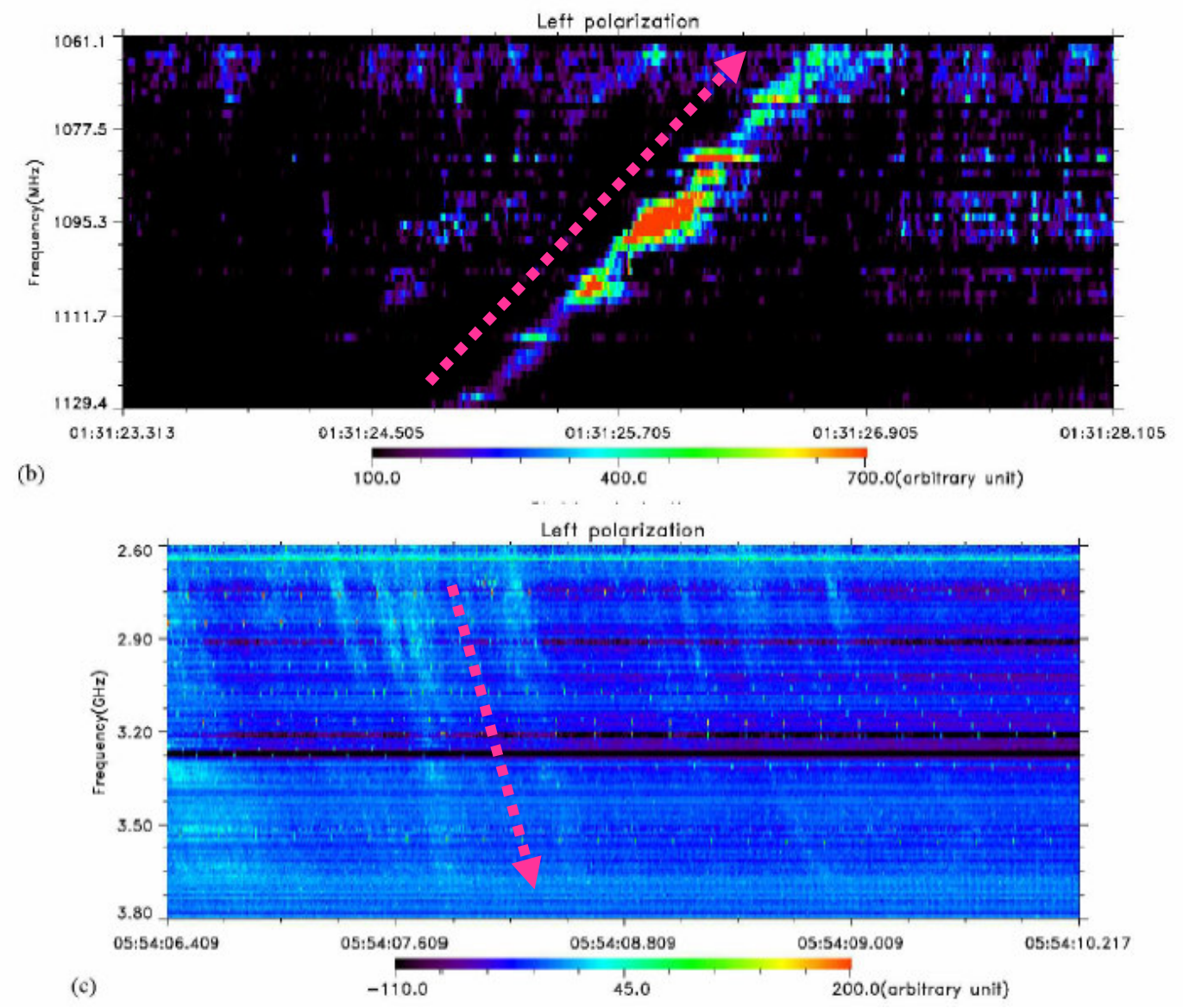
（Gary，1999）

- **Bremsstrahlung**
- **Gyroresonance**
- **Plasma emission**

dm-cm wavelength

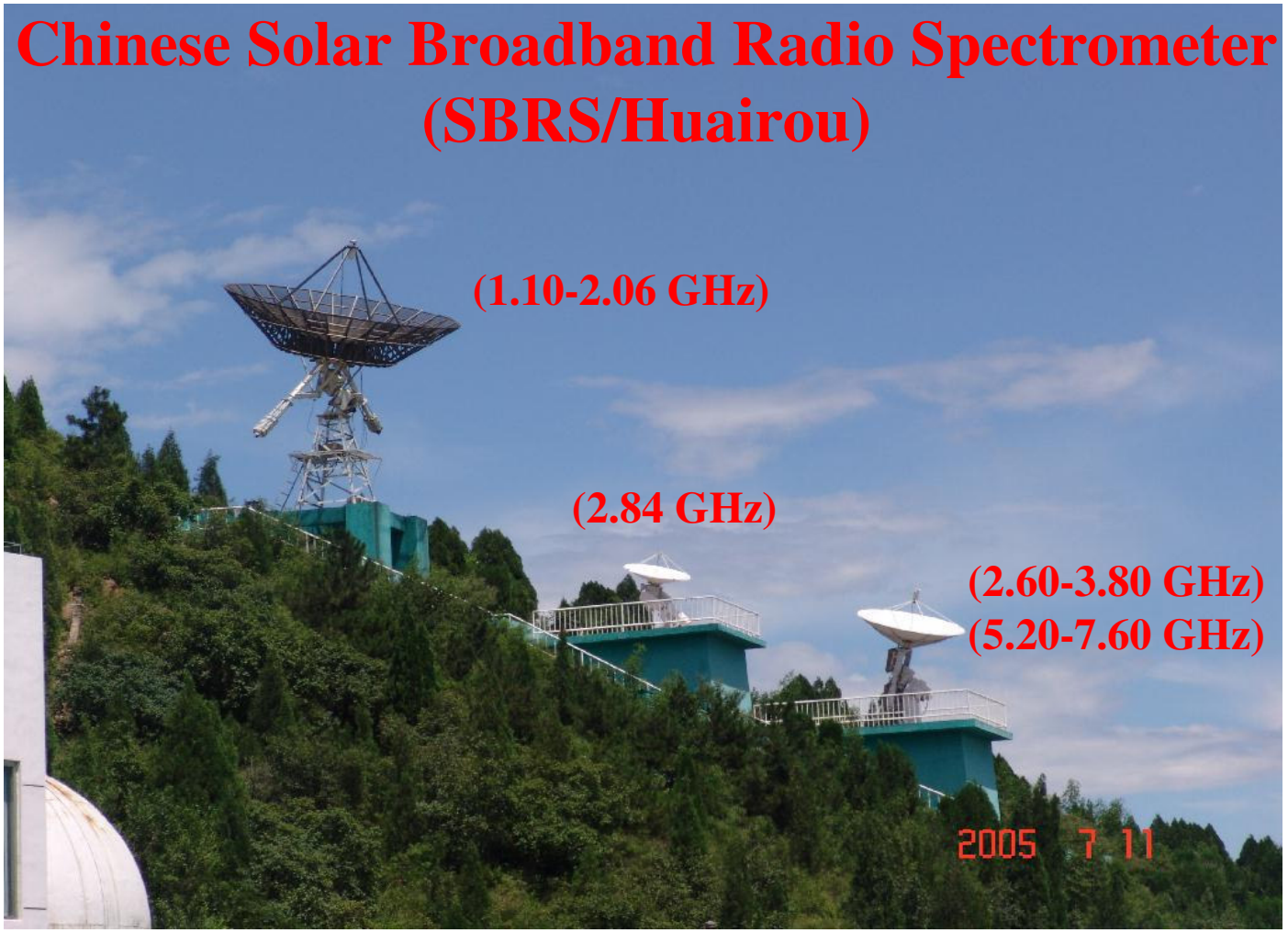
An event with reverse type III burst.

It indicate that f_R is in the range between 1100 and 2600 MHz.



(Fu, et al, 2004, ChJAA)

Chinese Solar Broadband Radio Spectrometer (SBRS/Huairou)



(Fu et al. 2004)

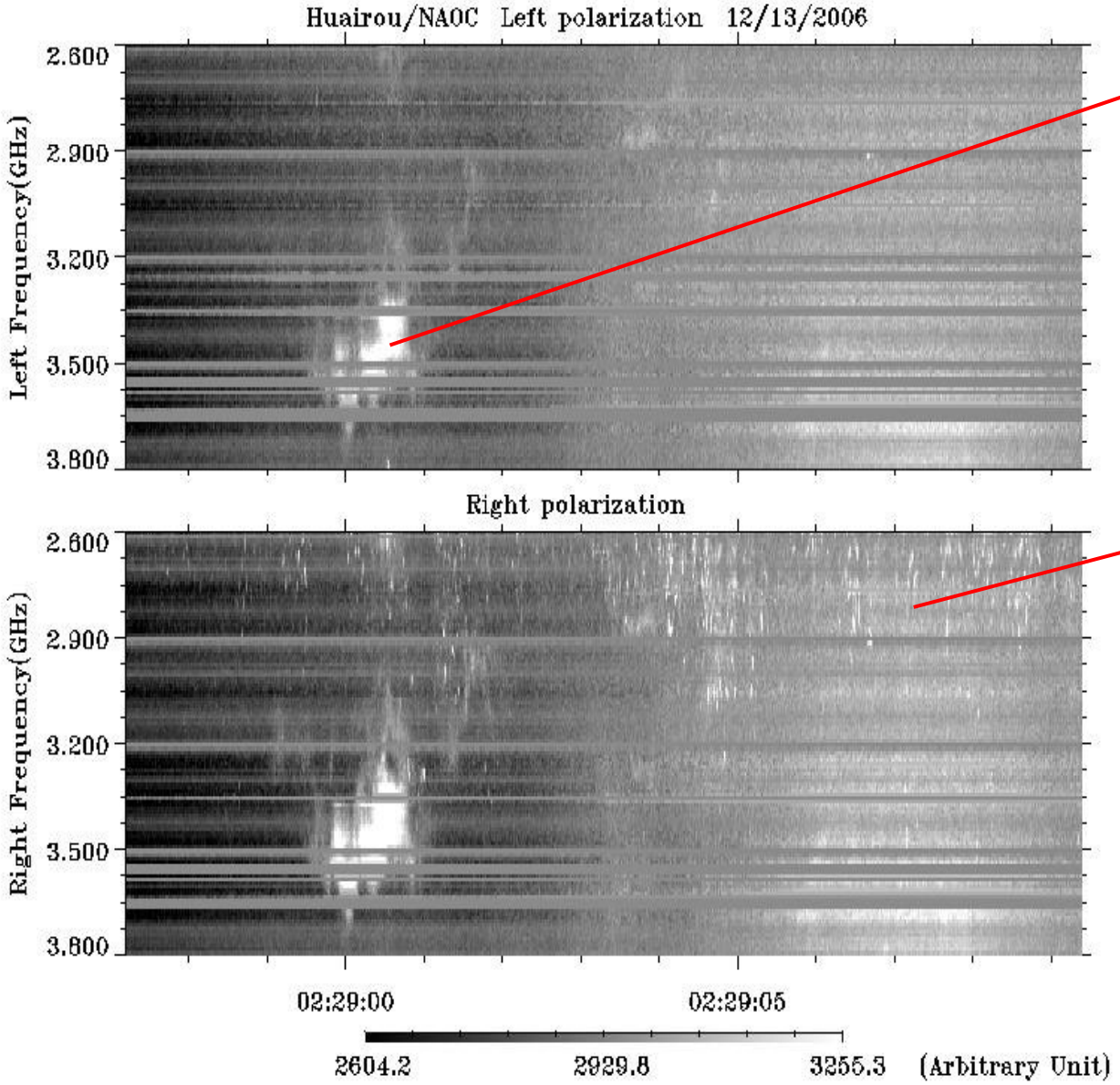
Besides SBRS/Huairou, there are another two telescopes in China:

SBRS/Yunnan at 0.65-1.50 GHz

SBRS/Nanjing at 4.5-7.5 GHz

Frequency	Freq. resolution	Cadence	Sensitivity	Polarization	Observation
1.10 - 2.06GHz	4 MHz	5 ms	2% of quiet Sun	R, L	1994-
2.60 - 3.80GHz	10 MHz	8 ms	2% of quiet Sun	R, L	1996-
5.20 - 7.60GHz	20 MHz	5 ms	2% of quiet Sun	R, L	1999-
2.84 GHz	--	0.2 s	2% of quiet Sun	R, L	1974-

2. New cluster results of microwave spectral fine structures



Patch

Isolated, weakly polarization, lifetime at ~ 1 s.

May related to some isolated burst.

Spikes

Very short lifetime (decades of ms), strongly polarization, in groups, very high brightness temperature

May related to some strong multi-site of reconnections.

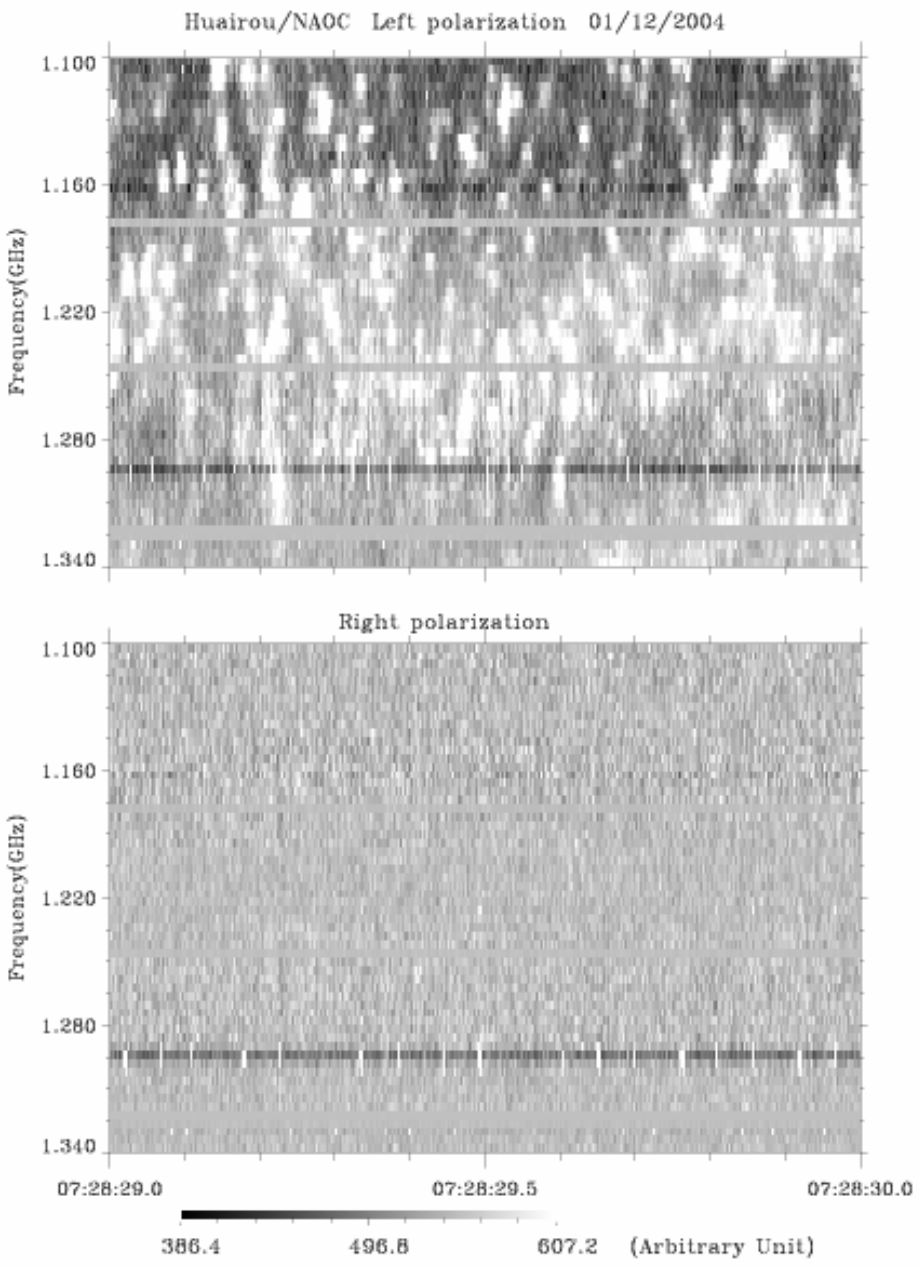
Dot bursts

Clusters of dot bursts distribute irregularly in the decay phase.

Different from the regular distributing dot bursts on some trajectories in previous observations (Karishan, 2003).

duration: ~ 16-23 ms
Freq bandwidth: 24 – 30 MHz
Polarization: ~ 90%
Part of dots:
df/dt ~ -4.10 ~ -8.60 GHz/s

(Huang & Tan, 2012, ApJ, 745, 186)

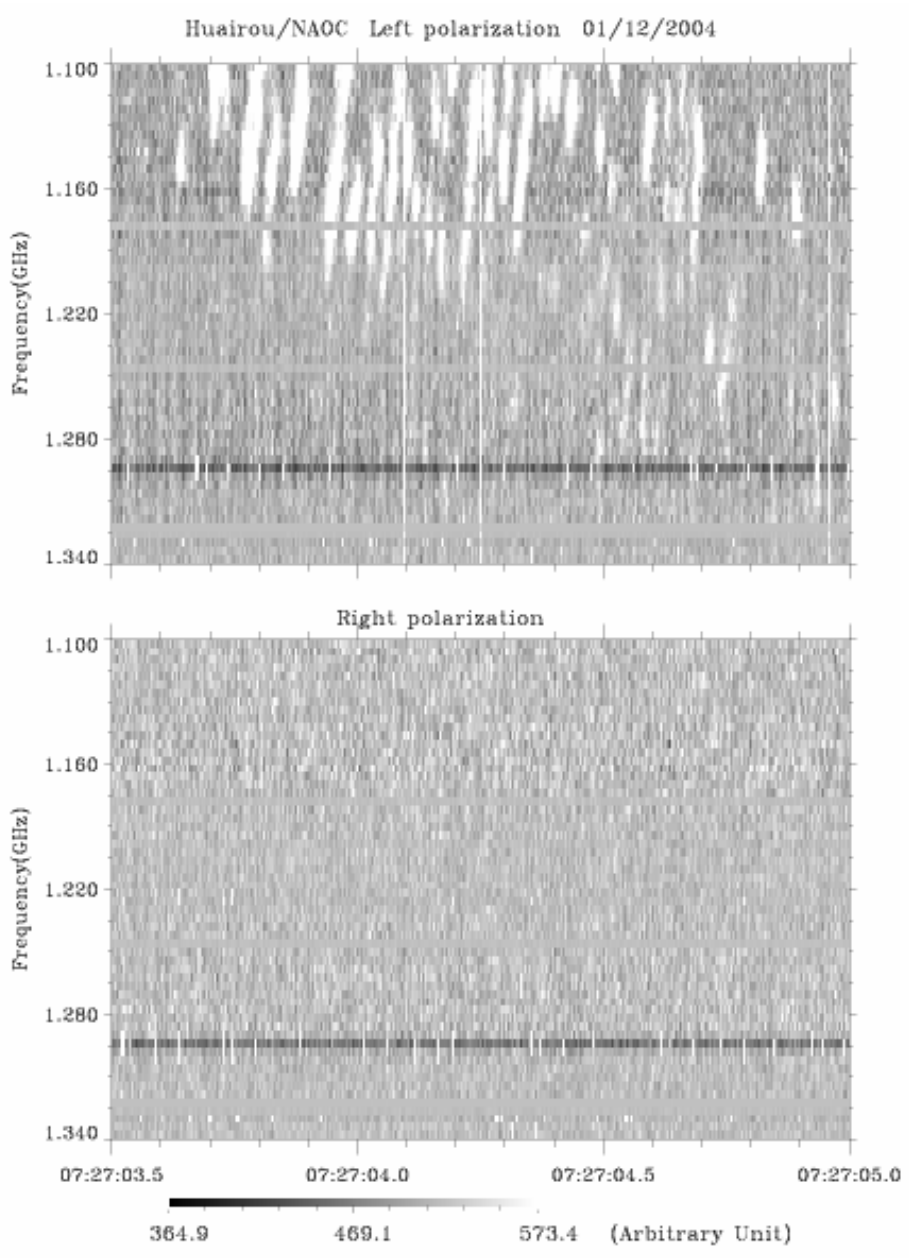


Spike bursts

Several clusters of spike bursts distribute irregularly in the decay phase.

duration: ~ 18-25 ms
Freq bandwidth: 28 – 72 MHz
Polarization: ~ 80%
Part of dots:
df/dt ~ -2.31 ~ -9.66 GHz/s

(Huang & Tan, 2012, ApJ, 745, 186)



Narrow-band Type III bursts

Duration: ~ 0.6 s

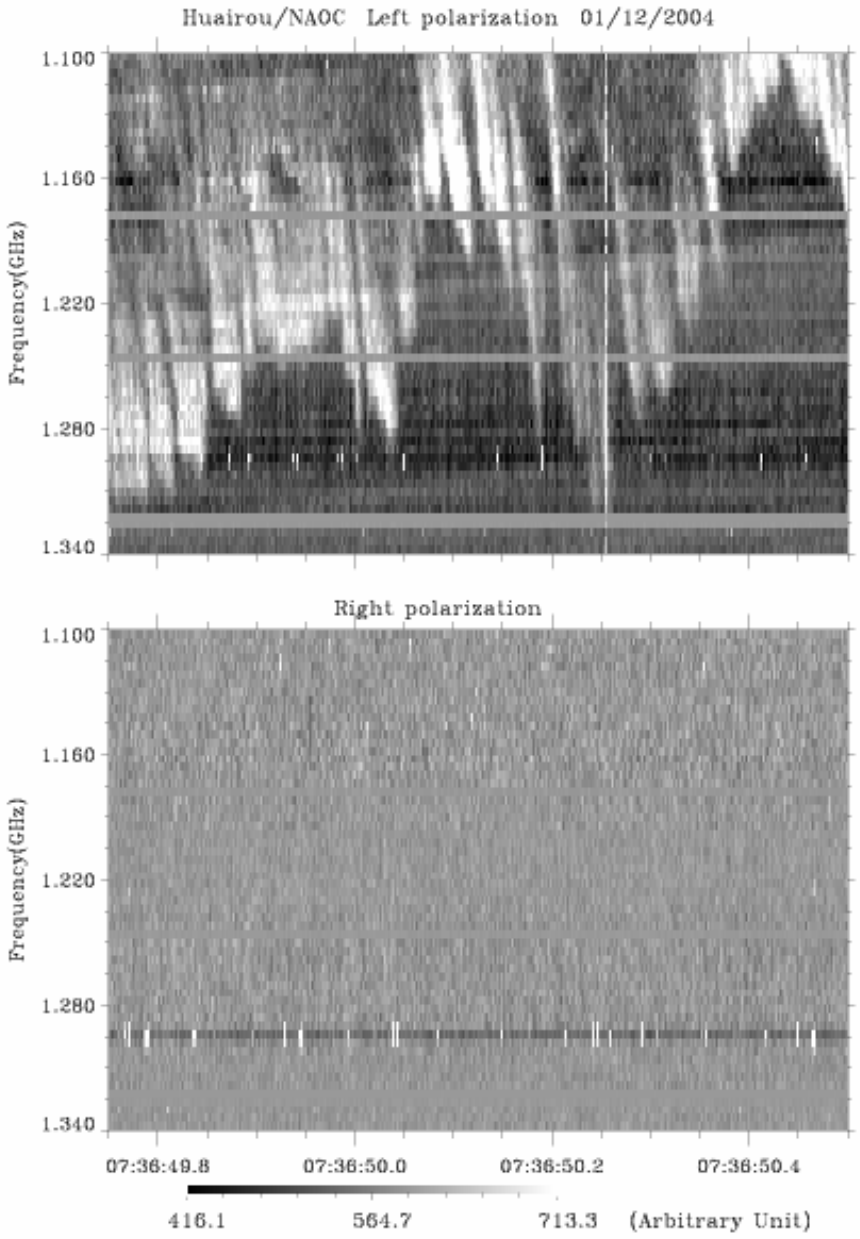
Freq bandwidth: 50 ~ 110 MHz

Polarization: ~ 85%

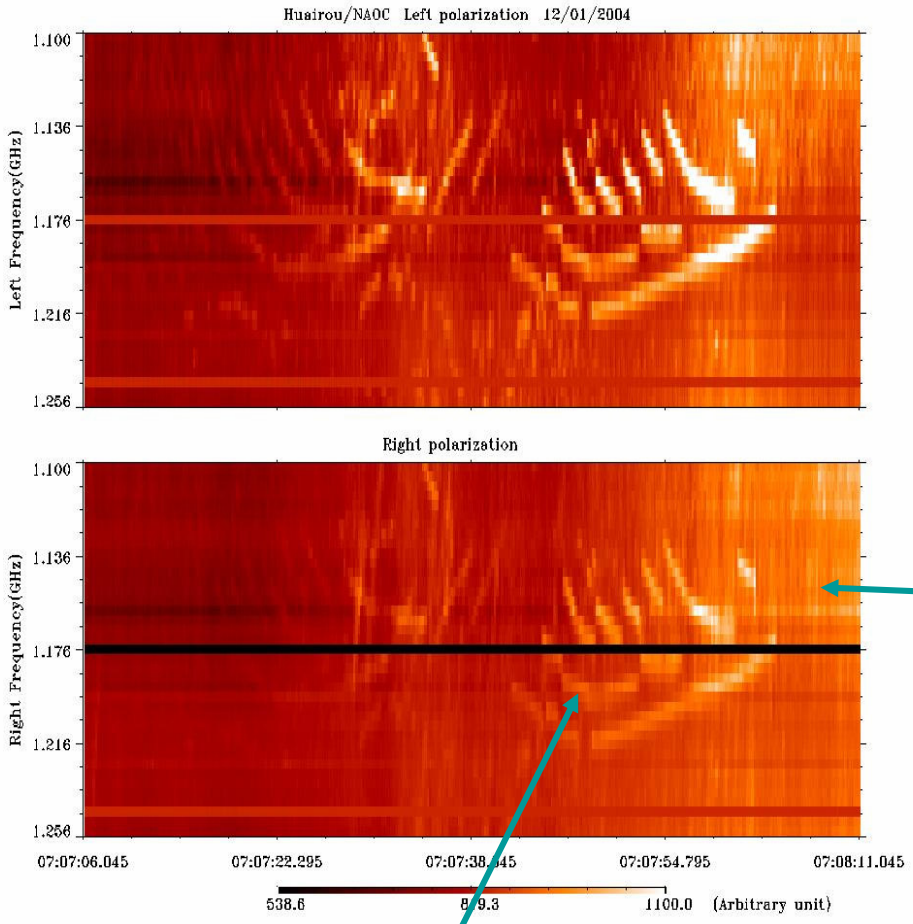
Part of dots:

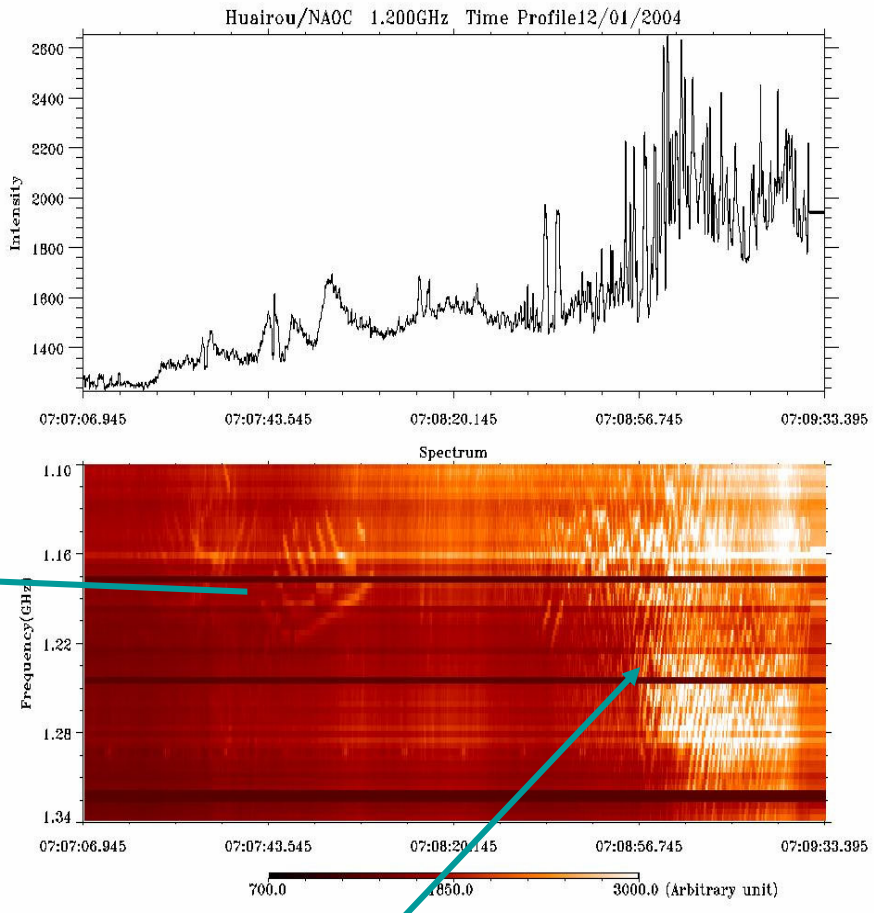
df/dt ~ 3.20 ~ 9.60 GHz/s

Periodicity: P ~ 20-30 ms



(Huang & Tan, 2012, ApJ, 745, 186)





Finger-like structure

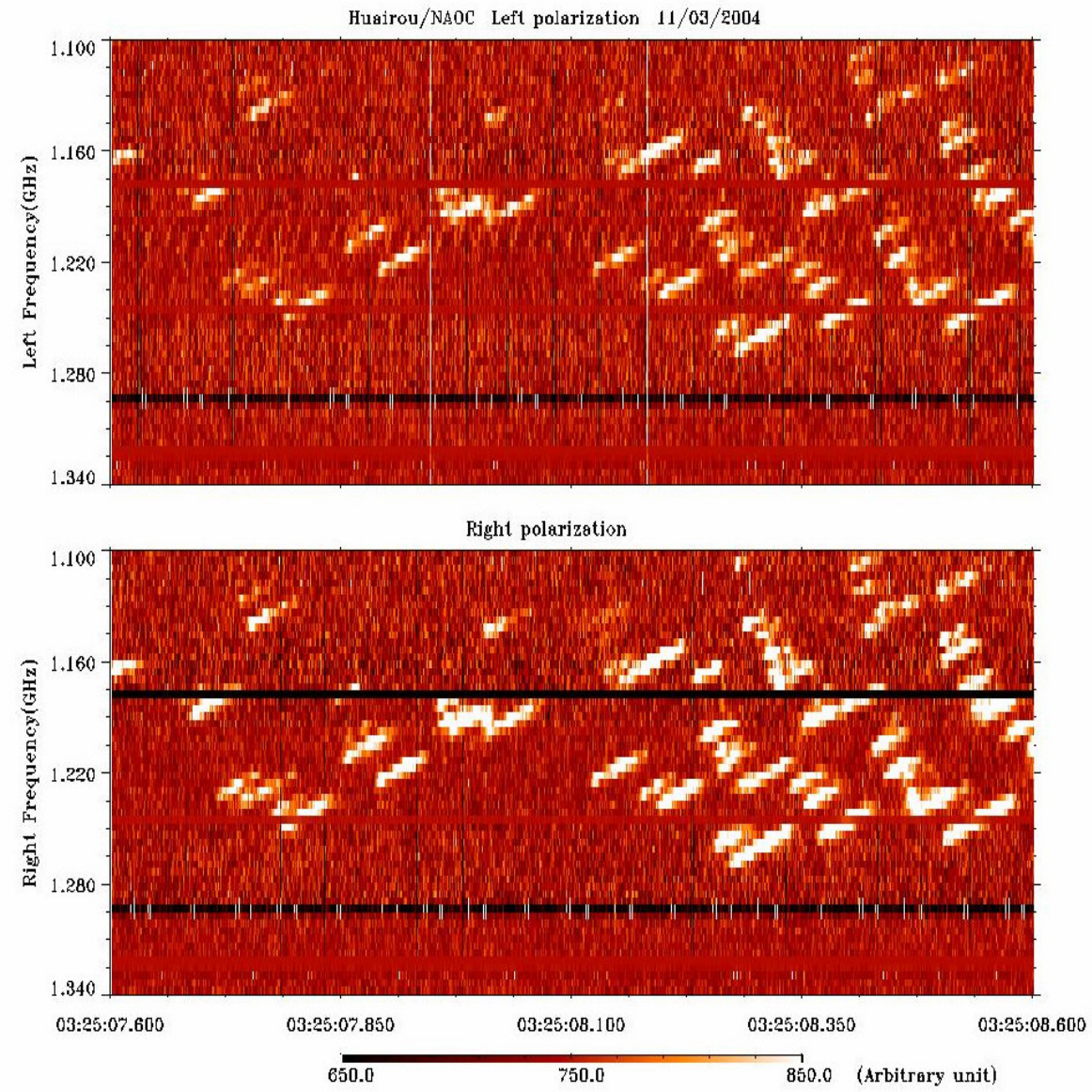
Multi-frequency, bandwidth, frequency-drifting rate, and life-time. Weakly polarization.

(Huang & Yan, 2007, AdSpR)

Zebra pattern structure

Weakly polarization, strips with paralleled equidistance.

May related to plasma resonance processes.



Fish-group structure

Moderate frequency drifting rate

Weakly polarization

Always in pairs.

Its formation mechanism is an open problem.

Zigzag pattern drifting QPP

Long-duration M8.6 flare with a powerful CME in AR10720.

In the early rising phase of the flare

weakly right-handed circular polarization.

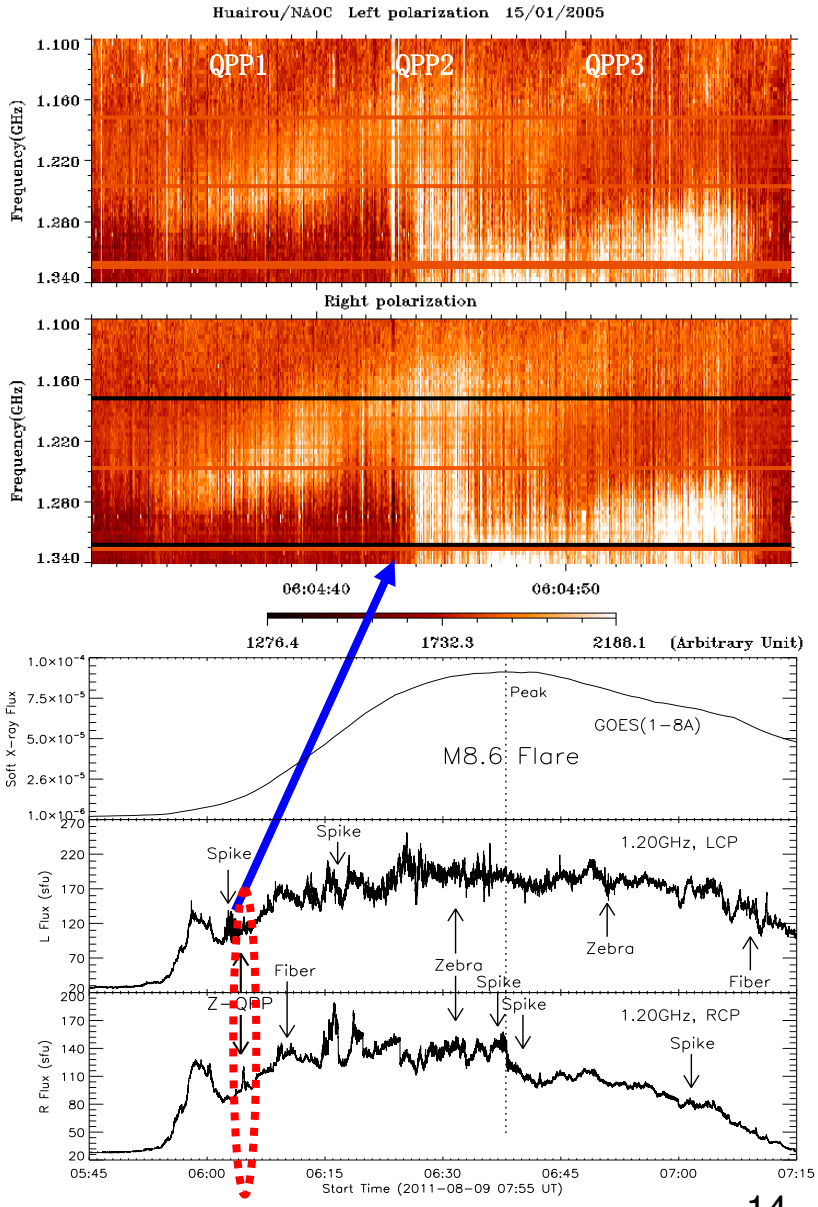
Period: ~ 40-60 ms, Duration: ~ 18 s

Slowly global frequency drifting rate: -(5.6-16.5) MHz/s (source motion)

Fast pulse frequency drifting rate: 2.3-20 GHz/s (non-thermal particles)

Reflect the kinematic features of the source region, the source width variations (~1000 km to 3300 km).

Many concomitant fine structures (ms spikes, zebra patterns, fibers, etc), show the dynamic processes of non-thermal particles



(Tan, 2012, IAUS 294)

QPP with superfine structure

2011-08-09, X6.9 flare

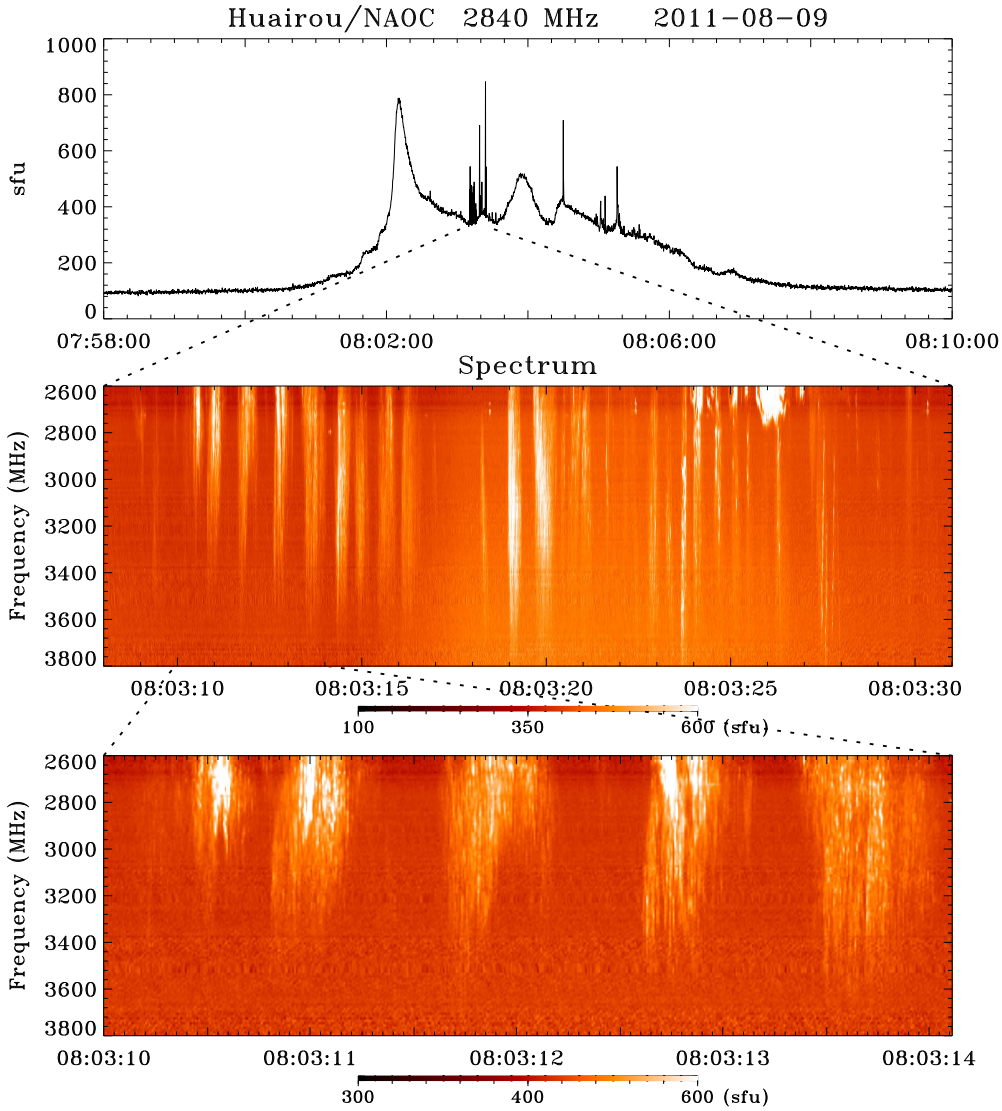
A QPP occurred just before the flare maximum

Duration: ~ 20 s

Period: 0.42-0.70 s

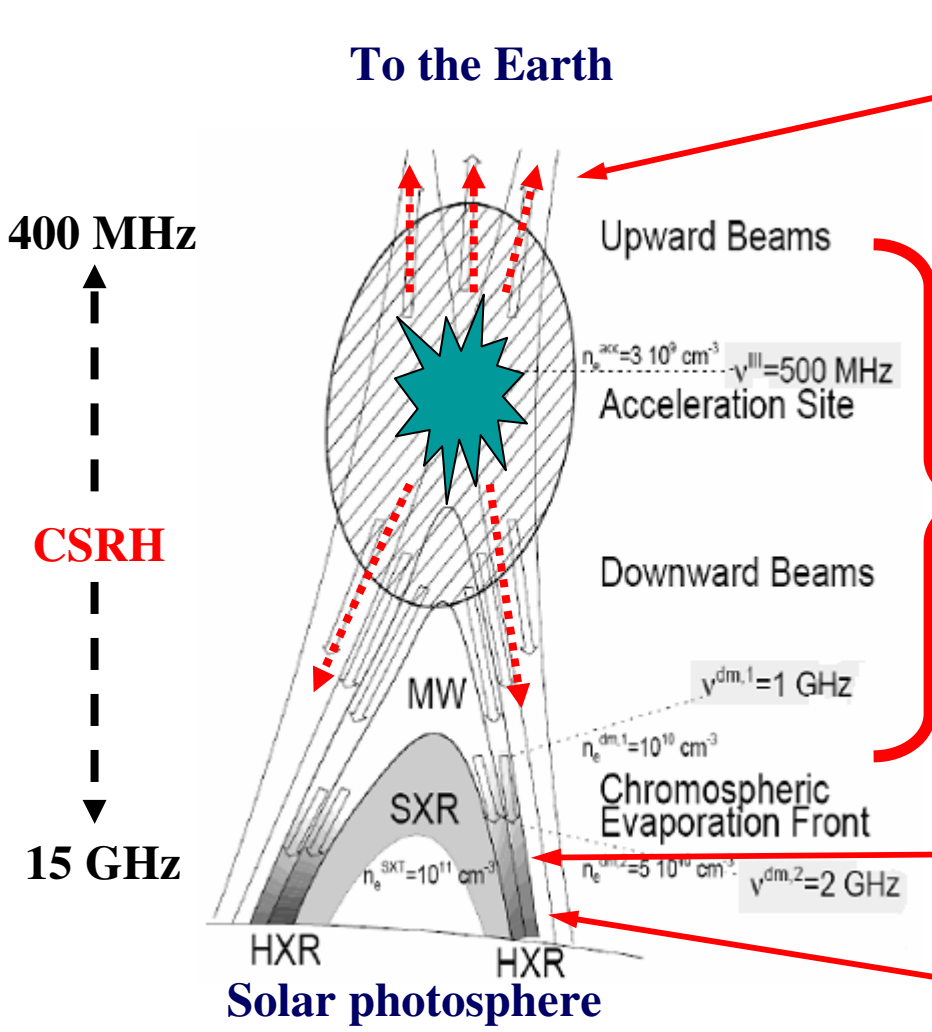
Each pulse consists of a group of ms spikes or narrow-band type III busts (**microwave elementary burst**).

The concomitant Zebra pattern implies the weak magnetic filed, and dispels the ECME mechanism of spikes. The possible mechanism is the **plasma emission**.



（Tan & Tan, 2012, ApJ, 749, 28）

3. A brief introduction of the Chinese Spectral Radio Heliograph (CSRH)



164, 236, 327, 410, 432
NRH (Nancay)

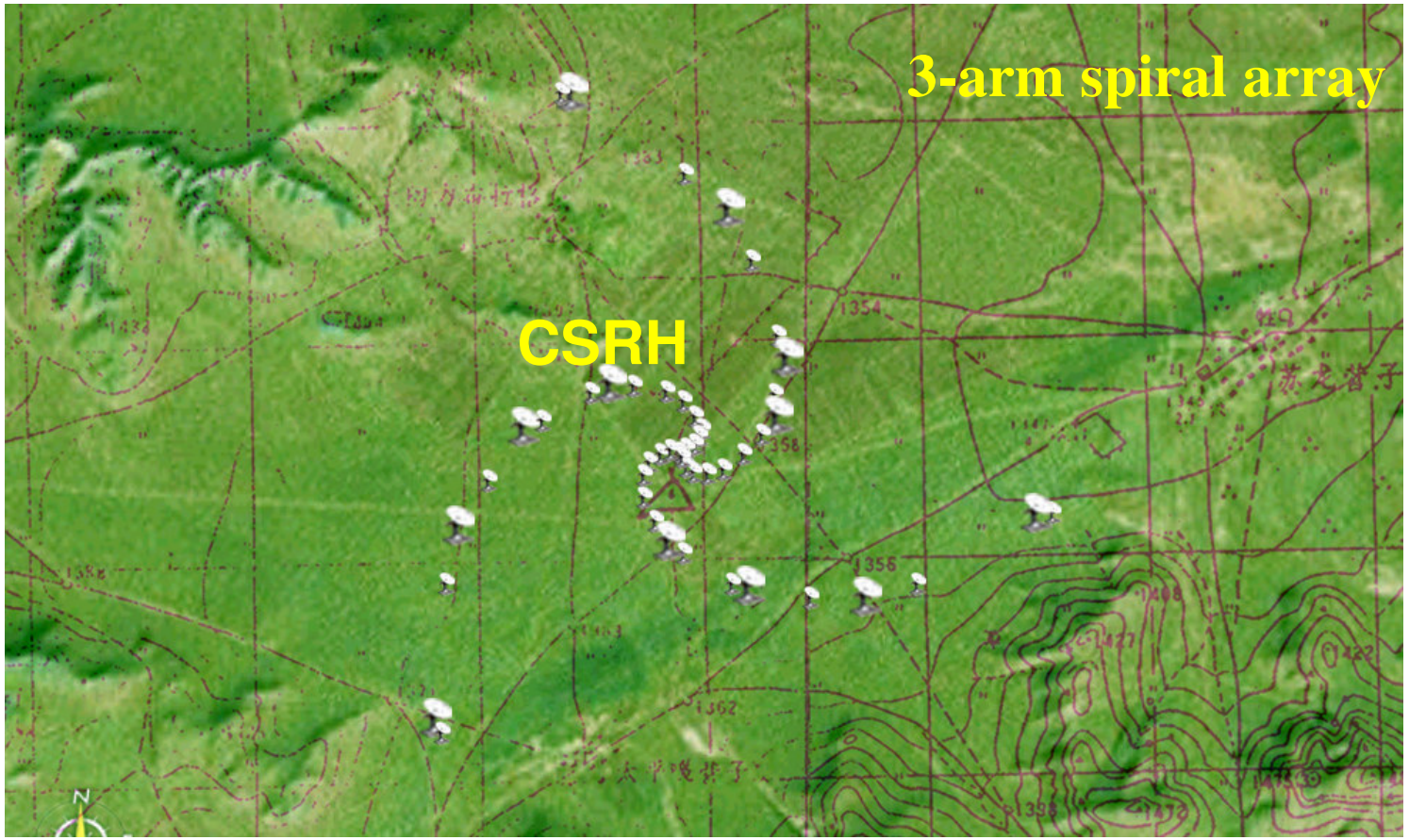
CSRH main goal: To understand the mechanism of solar eruptions by **spectral imaging observations** with high frequency resolution, high spatial resolution, and high cadence in broadband frequency range.

So far, such observations is **blank**.

5.70 GHz, SSRT, Russia

17 GHz, & 34 GHz, NoRH

Chinese Spectral Radioheliograph (CSRH)



Science (2008) reported its development, and said "a new set of ears turned to our nearest star" .

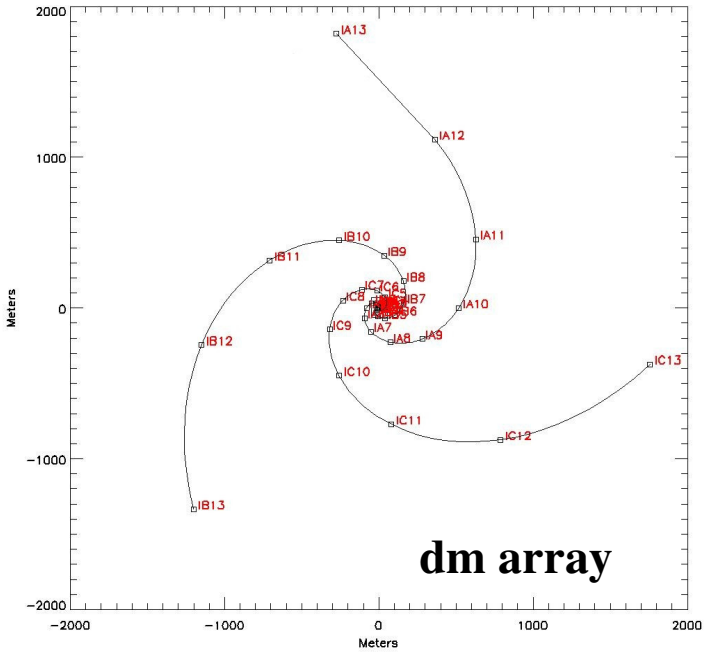
CSRH project is leading by Prof. Yihua Yan. It is capable of true imaging spectroscopy with high temporal-spatial-spectral resolutions simultaneously. It will open new windows for solar flares & CMEs.

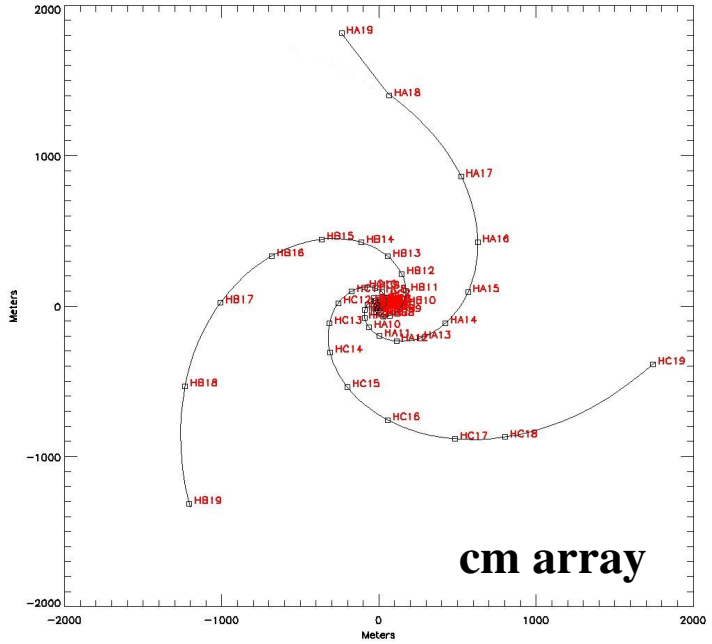
CSRH-I

Frequency：**0.4-2.0 GHz**
Antenna： Φ 4.5m×40
FOV: >2.33° (2 GHz)
Channel: 64
Freq. resolution：25 MHz
Cadence：25 ms
Spatial resolution：10.3"-51.6"
Image dynamic range：>25dB
polarization：R, L

CSRH-II

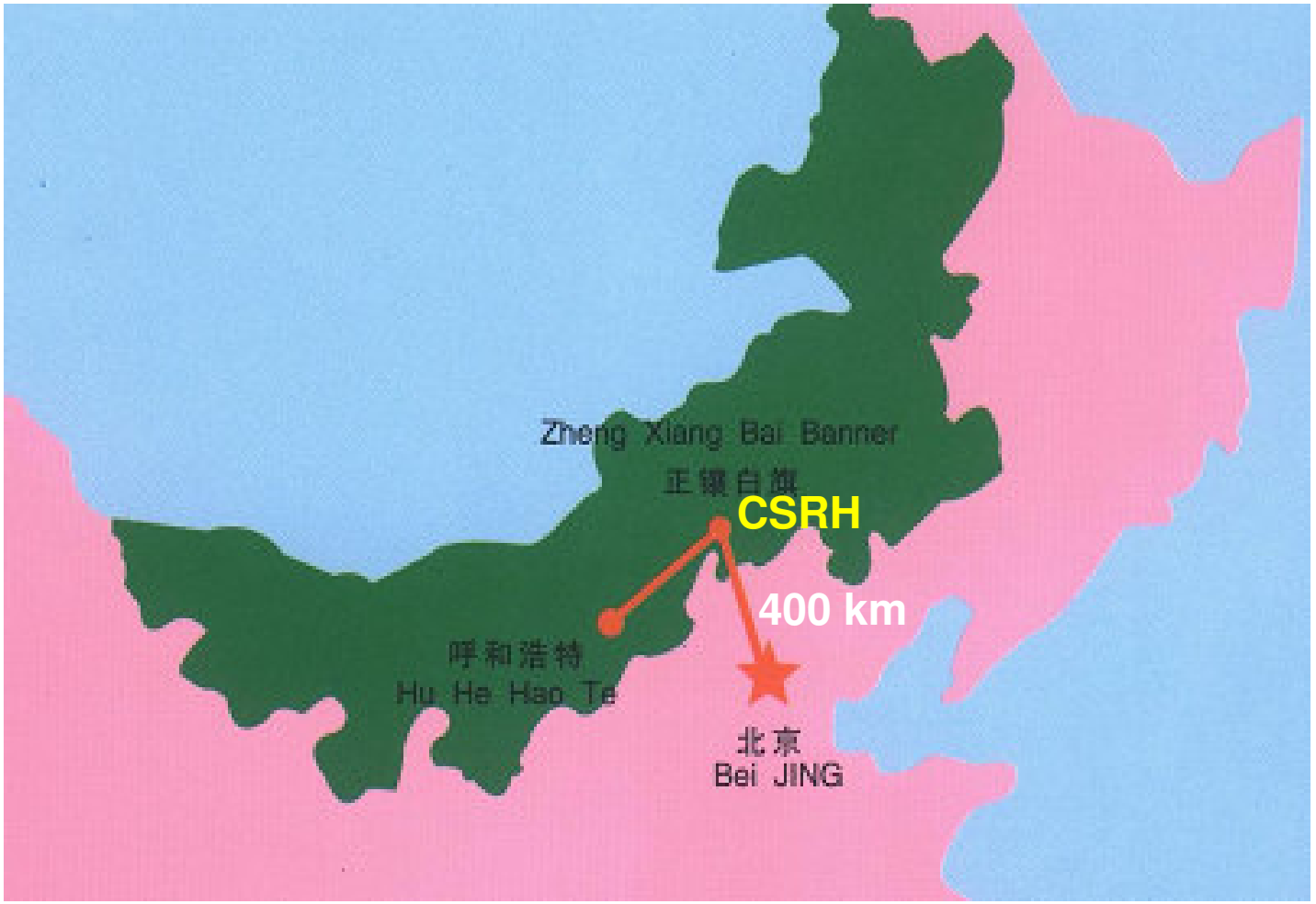
Frequency: **2.0-15.0 GHz**
Antenna： Φ2.0m×60
FOV: >0.7° (15 GHz)
Channel: > 500
Freq. resolution：~ 25 MHz
Cadence：~ 200 ms
Spatial resolution：1.4"-10.3"
Image dynamic range：>25 dB
polarization：R, L





Max Baseline: **3 km**, **aperture-synthesis** technology

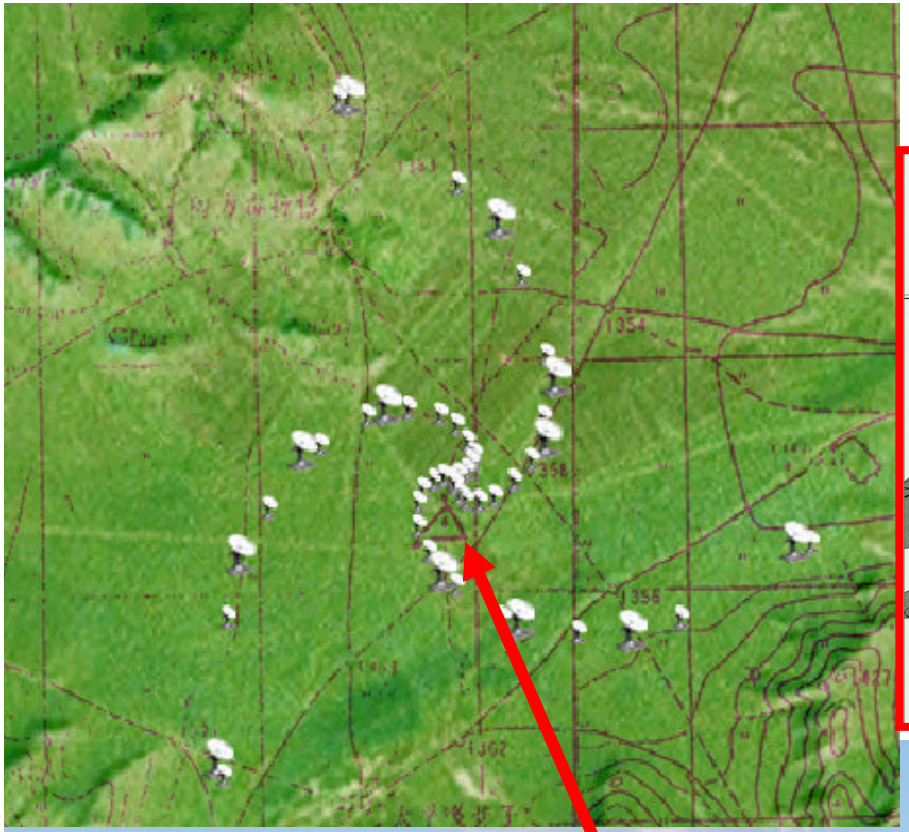
Recent development

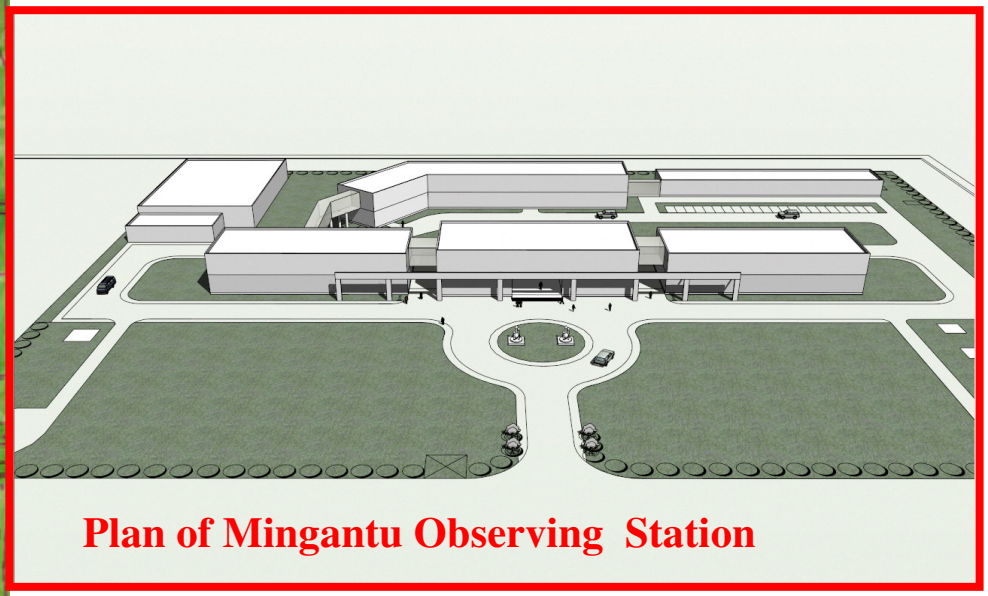


Site of CSRH: Inner Mongolia, 400 km northeast from Beijing.

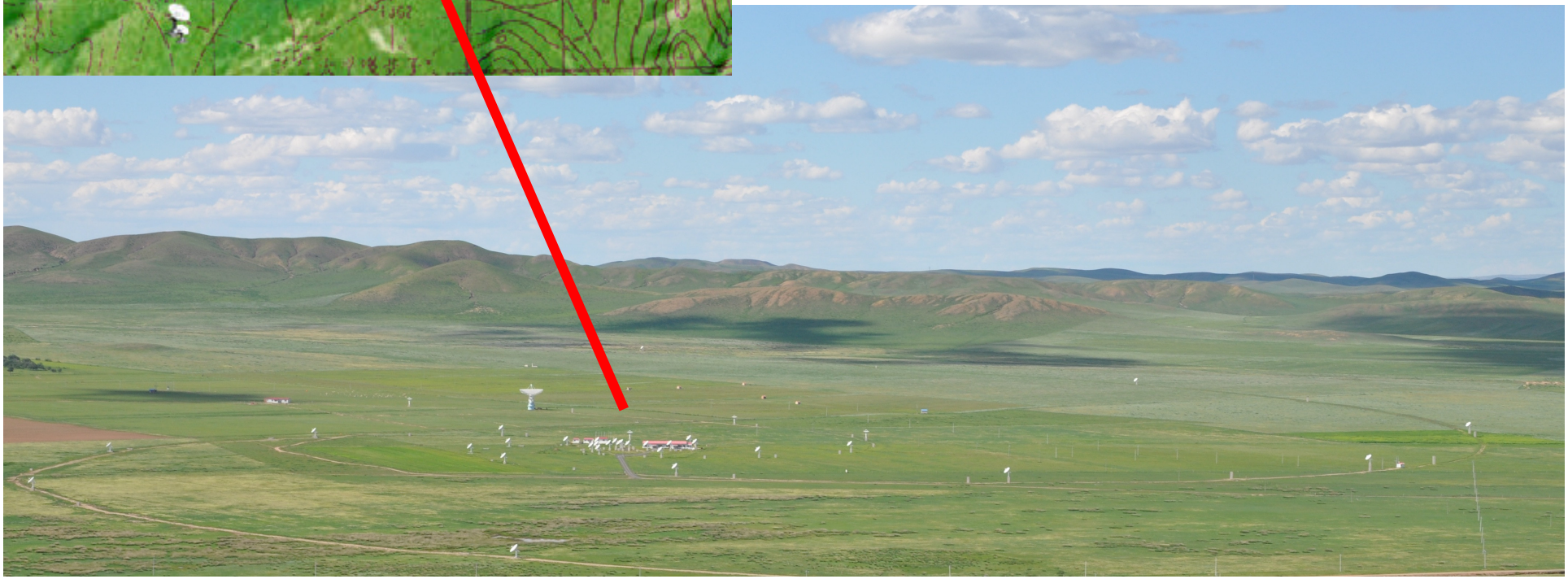
Start construction: 2009.01, **Planning completion**: 2014

Array Construction





Plan of Mingantu Observing Station



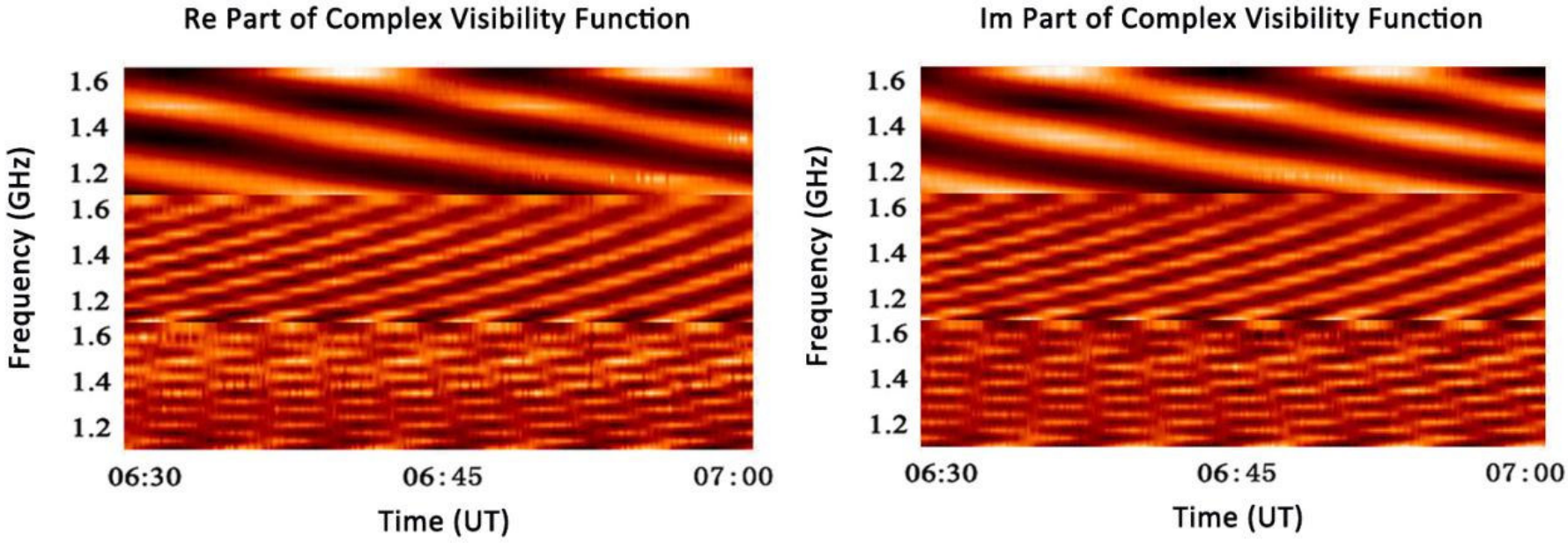
Current situation

CSRH-I (0.4-2.0 GHz): finish the installation of the hardware system (including 40 antenna of 4.5 m radius, feed system, receivers), set about the development of data system, start the test observation now.

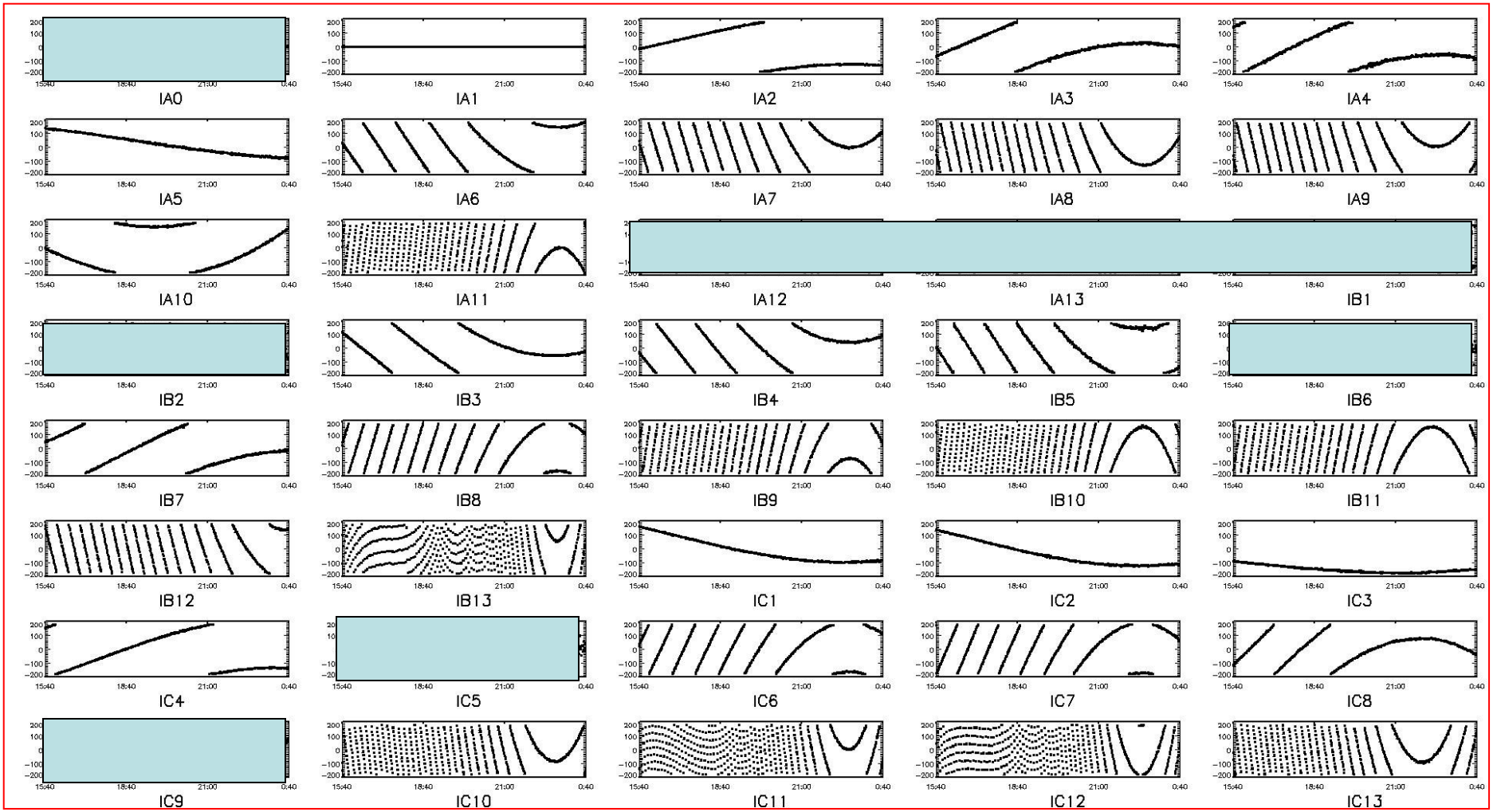
CSRH-II (2.0-15.0 GHz): begin installation of 60 antenna (2.0 m radius) and other hardware system since 2012-7, and is due to finish in 2013.

CSRH-I test observation on 27 Dec 2011

Preliminary results of the correlation fringes of the Sun from 3 different short baselines.



Preliminary results of CSRH-I test observation of FY-2E satellite on 2012-March-27



Fringes of the Sun & Cyg A have been obtained for all baselines.

Thanks for your attention!