The Solar Radio Observations at dm-cm Wavelength ---on Progress of CSRH Project

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Outline

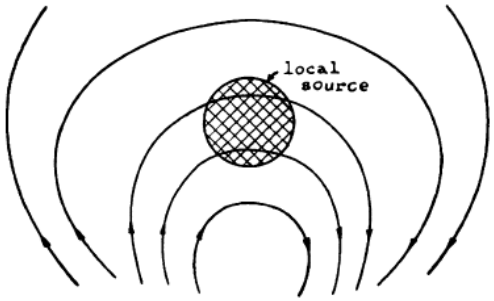
- Introduction
- Some radio FS bursts associated with flare/CME processes
- Recent progress of CSRH
- Summary

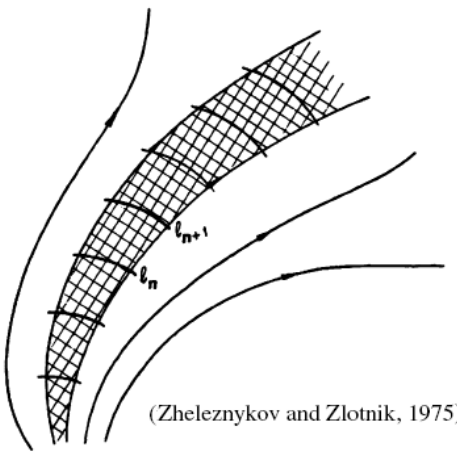
1. Introduction

- **Coronal Mass Ejections, flares, and solar energetic particles, etc., have great influence in solar-terrestrial environment .**
- **These activities are believed due to sudden energy release, particle acceleration, and/or transportation processes of the solar magnetic field**
- **Radio bursts are prompt indicators of various solar activities. Therefore radio observations provide important diagnosing tool on the related parameters such as B, n, T, etc.**

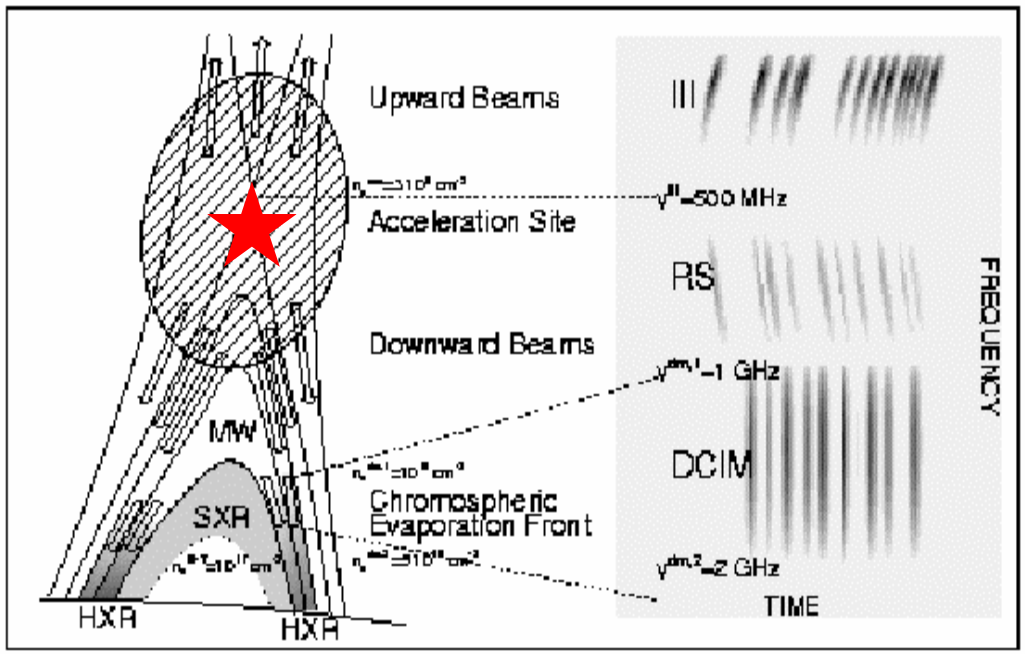
- Radio emission generated by T and non-T electrons, provides important diagnostics in addition to EUV, SXR, HXR, and γ-rays (e.g., Aschwanden 2004).
- Freq. in ~10^2 MHz - <10 GHz corresponds to source n of a few 10^8- 10^{11} cm^{-3}, where primary energy release of flares should take place (e.g., Bastian et al. 1998, Benz 2004)
- Radio FSs such as spikes, zebra patterns, pulsations are generally considered to be closely related to the primary energy release processes (e.g., Holman et al. 1980; Zaitsev & Stepanov 1983; Kliem et al. 2000).

Models for ZPs & FBs to take place

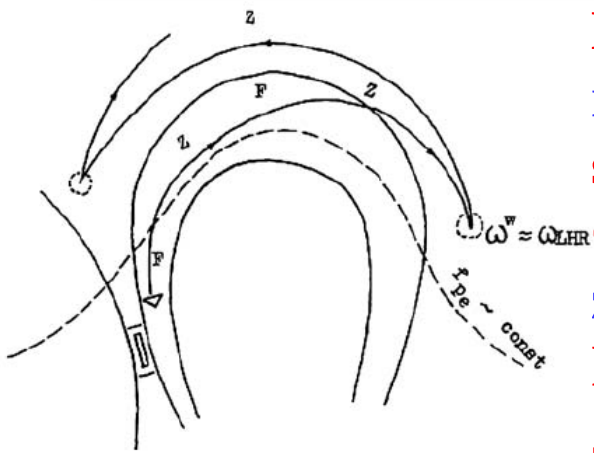




(Zheleznykov and Zlotnik, 1975).



Aschwanden et al.



S qualitative scheme of a whistler trajectory explaining the possibility of ZP conversion into FB and inversely (Chernov, 1990).

Because of high (time/freq) resolutions by Chinese spectrometers in 1-7.6 GHz, detailed spectra of zebra patterns in ~ 3GHz have appeared (Chernov 2006).

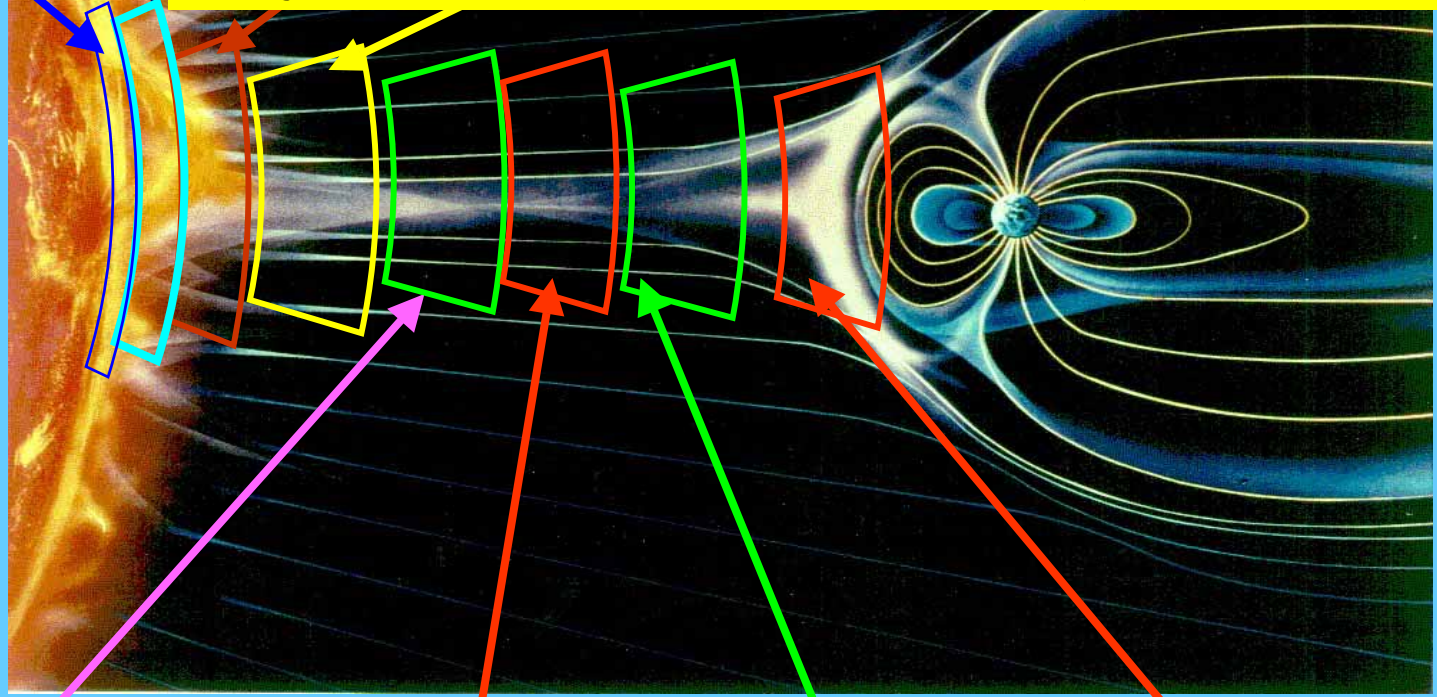
mm-waves
Chromosphere

cm-waves: up chrom. & corona bottom

dm-waves: low corona

Visible: Photosphere

Imaging spectrocopy over cm-λ & dm-λ is important for addressing fundamental problems of energy release, particle acceleration and particle transport (Bastian, et al., ARAA, 1998; Gary & Keller 2004; Aschwanden 2004)



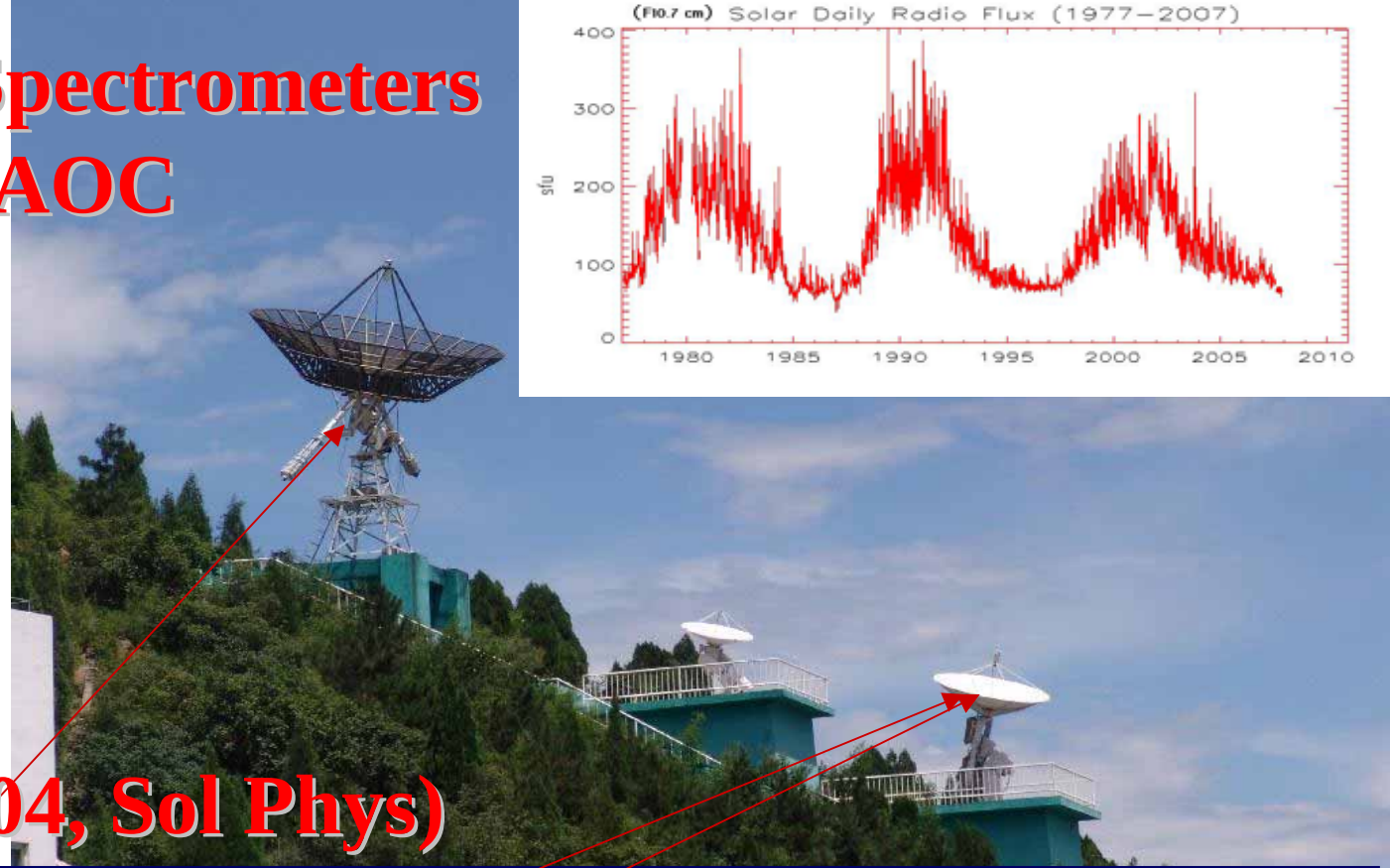
metric waves: corona

Decametric (30MHz):→2R$_\odot$

2MHz:→10R$_\odot$

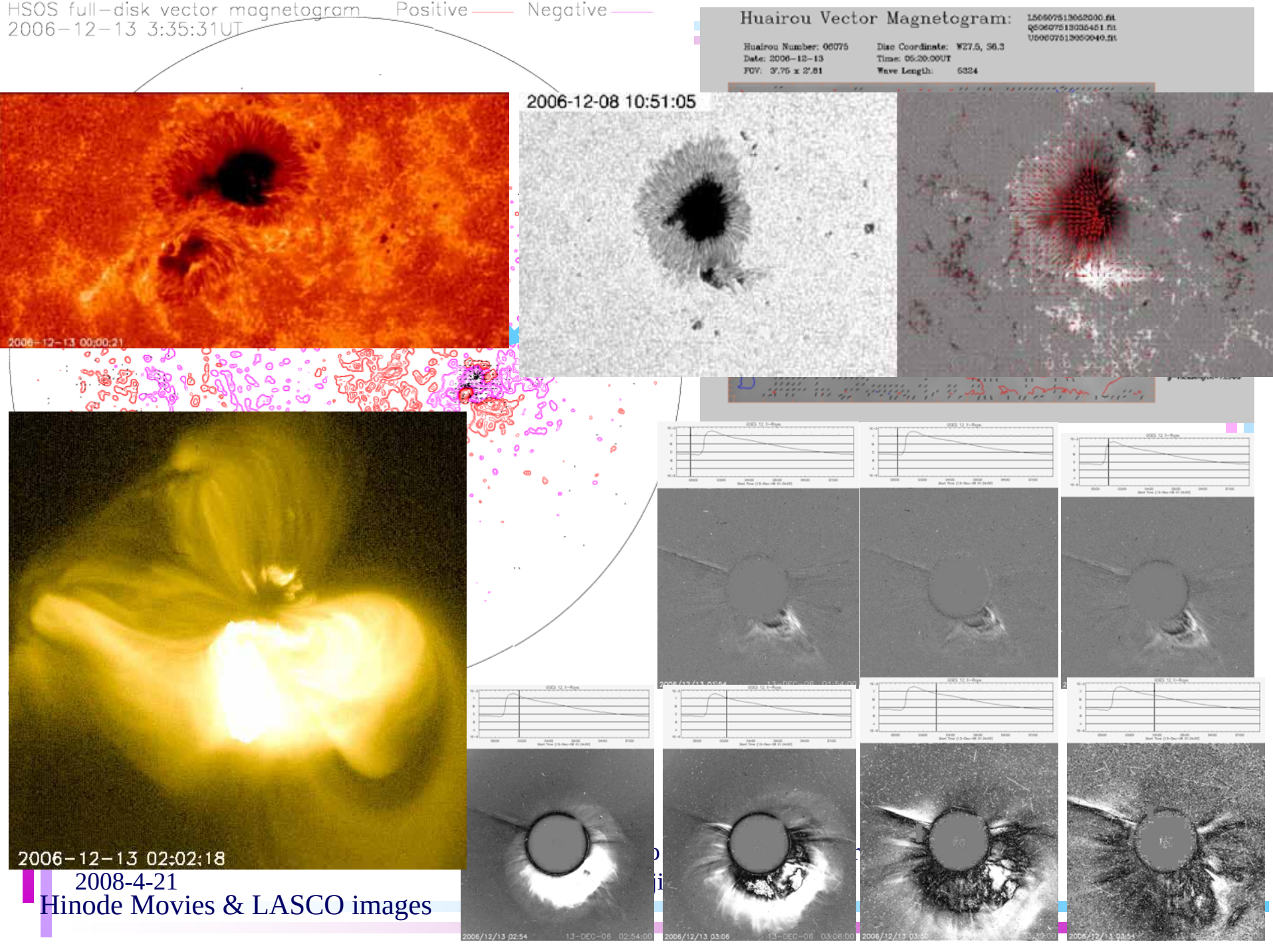
~10 KHz →200R$_\odot$, 1AU

Solar Radio Spectrometers at Huairou/NAOC



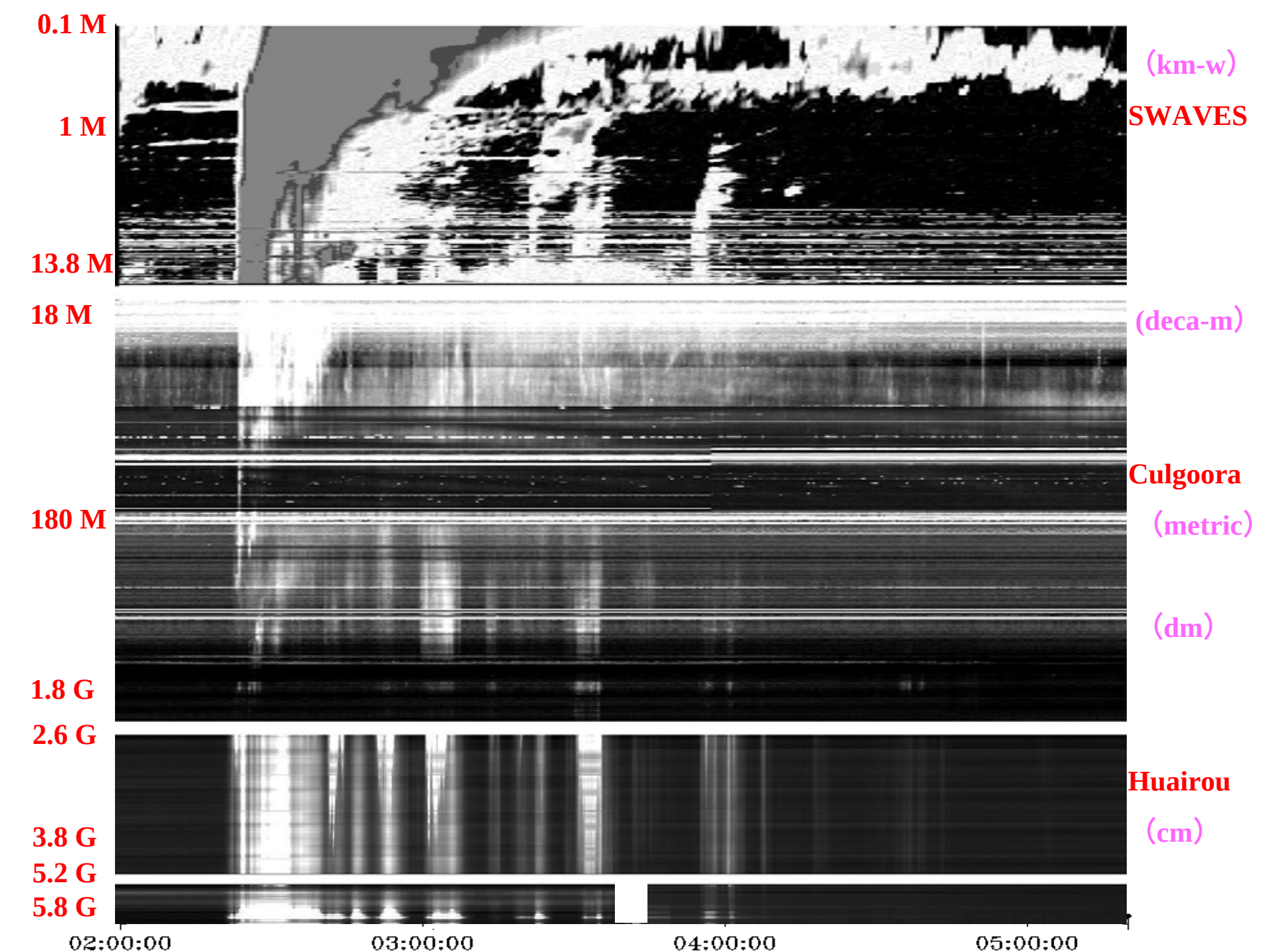
(Fu et al. 2004, Sol Phys)

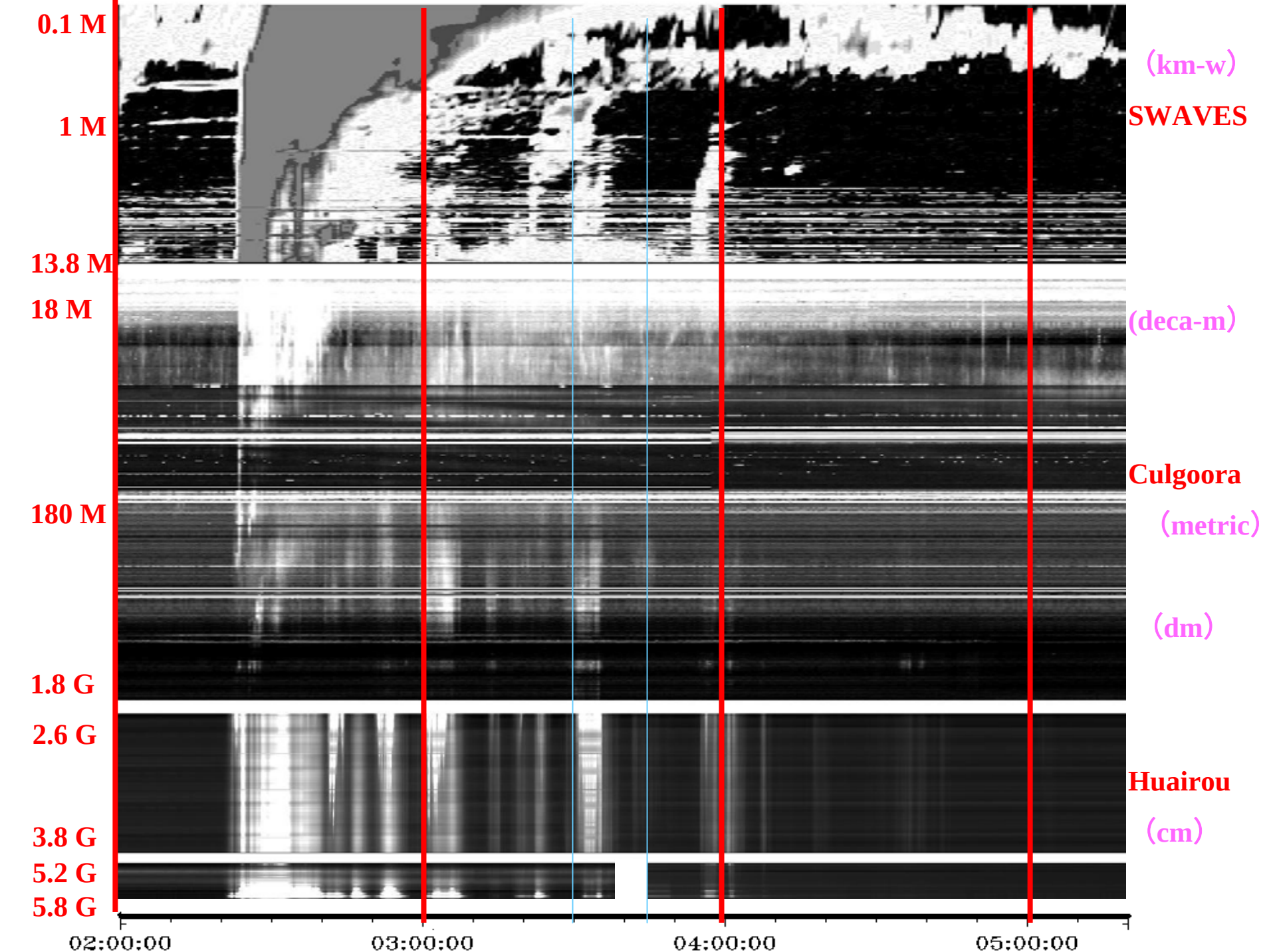
Frequency range	Spectral res.	Time res.	Sensitivity & Dyn. Range	Pol. R/L	Operation since
1.0 - 2.0 GHz	20 MHz 4 MHz	100 ms 5 ms	2% -10 dB of So 2%-10 dB of So	Yes Yes	1994- 2003(upgrade)-
2.6 - 3.8 GHz	10 MHz	8 ms	2% -10 dB of So	Yes	1996-
5.2 - 7.6 GHz	20 MHz	5 ms	2% -10 dB of So	Yes	1999-



2008-4-21

Hinode Movies & LASCO images


0.1 M
1 M
13.8 M
18 M
180 M
1.8 G
2.6 G
3.8 G
5.2 G
5.8 G
(km-w)
SWAVES
(deca-m)
Culgoora
(metric)
(dm)
Huairou
(cm)
02:00:00
03:00:00
04:00:00
05:00:00


0.1 M
1 M
13.8 M
18 M
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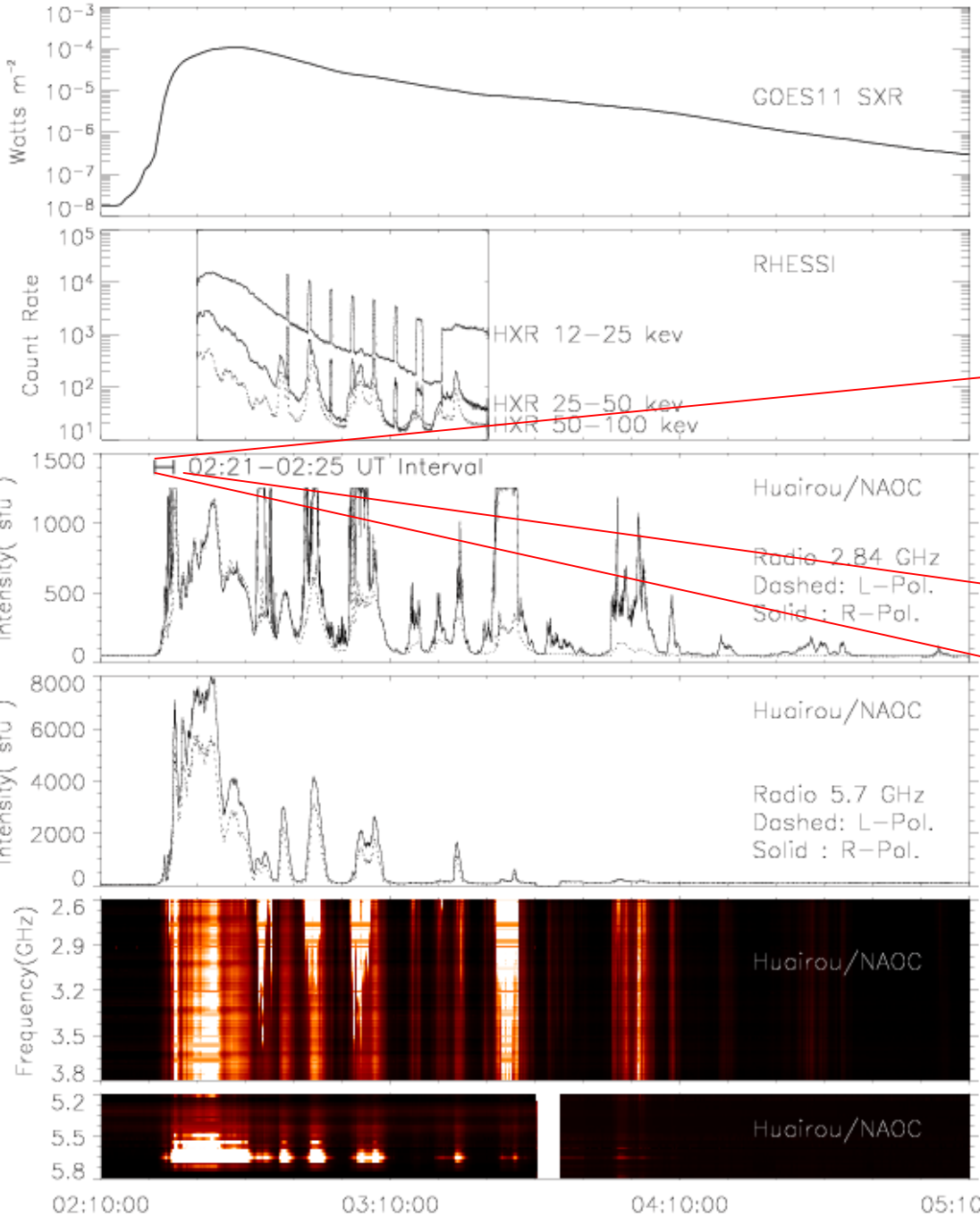
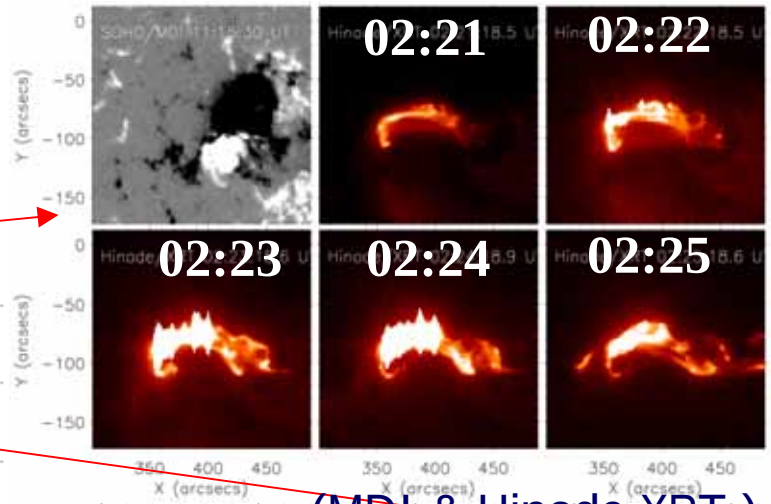
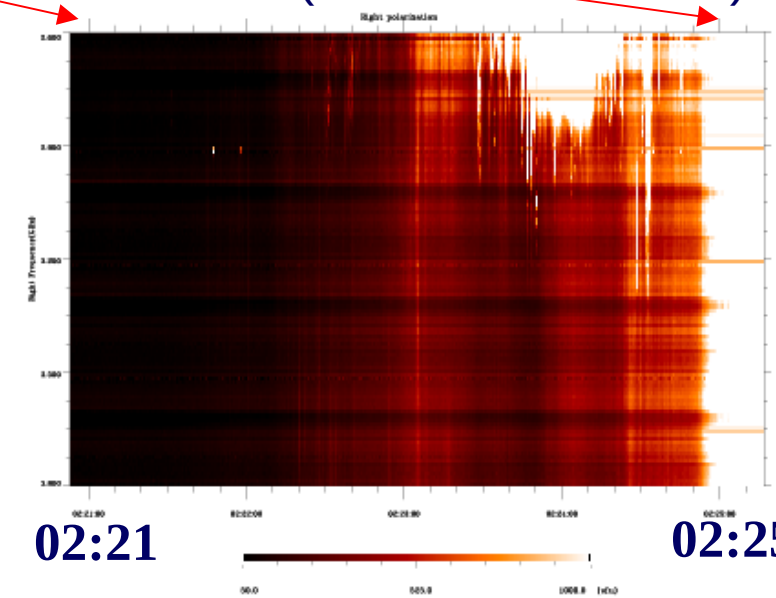
Culgoora
(metric)
(dm)
Huairou
(cm)
02:00:00
03:00:00
04:00:00
05:00:00

Imp. Phase



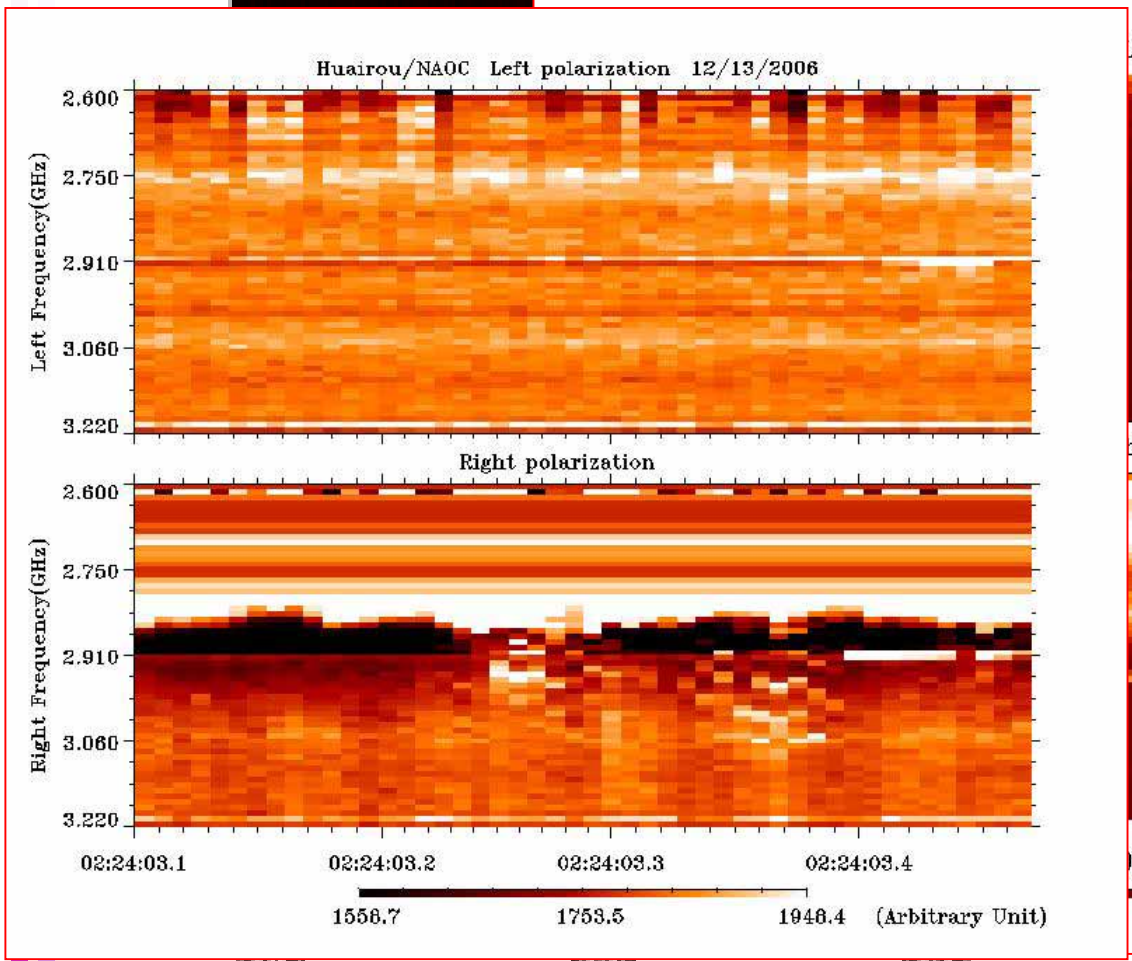


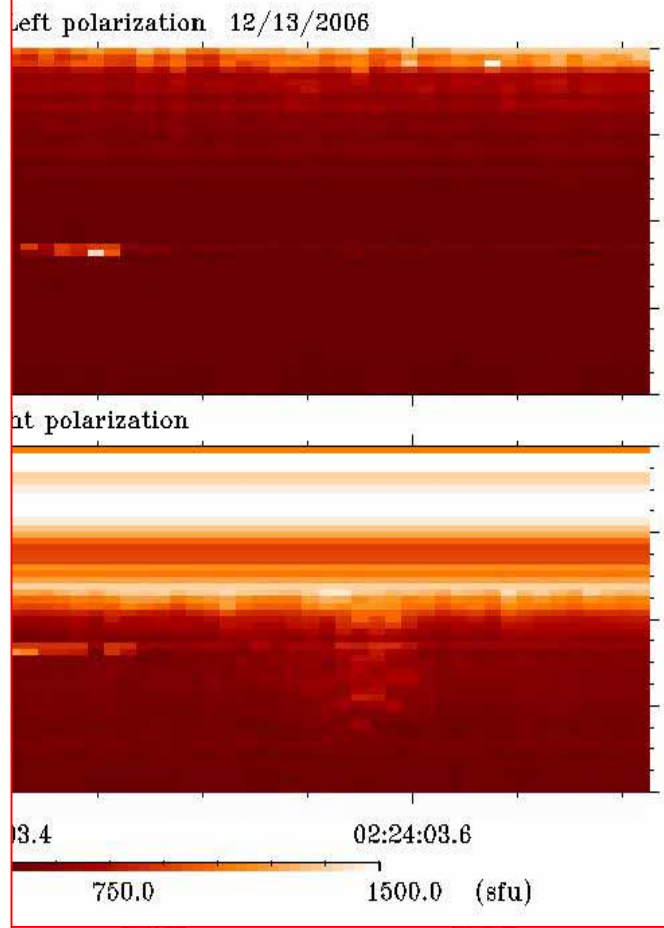
(MDI & Hinode XRT)



(Yan et al. 2007 PASJ)

Sub-sec zebras (>50) extended from type IV continuum

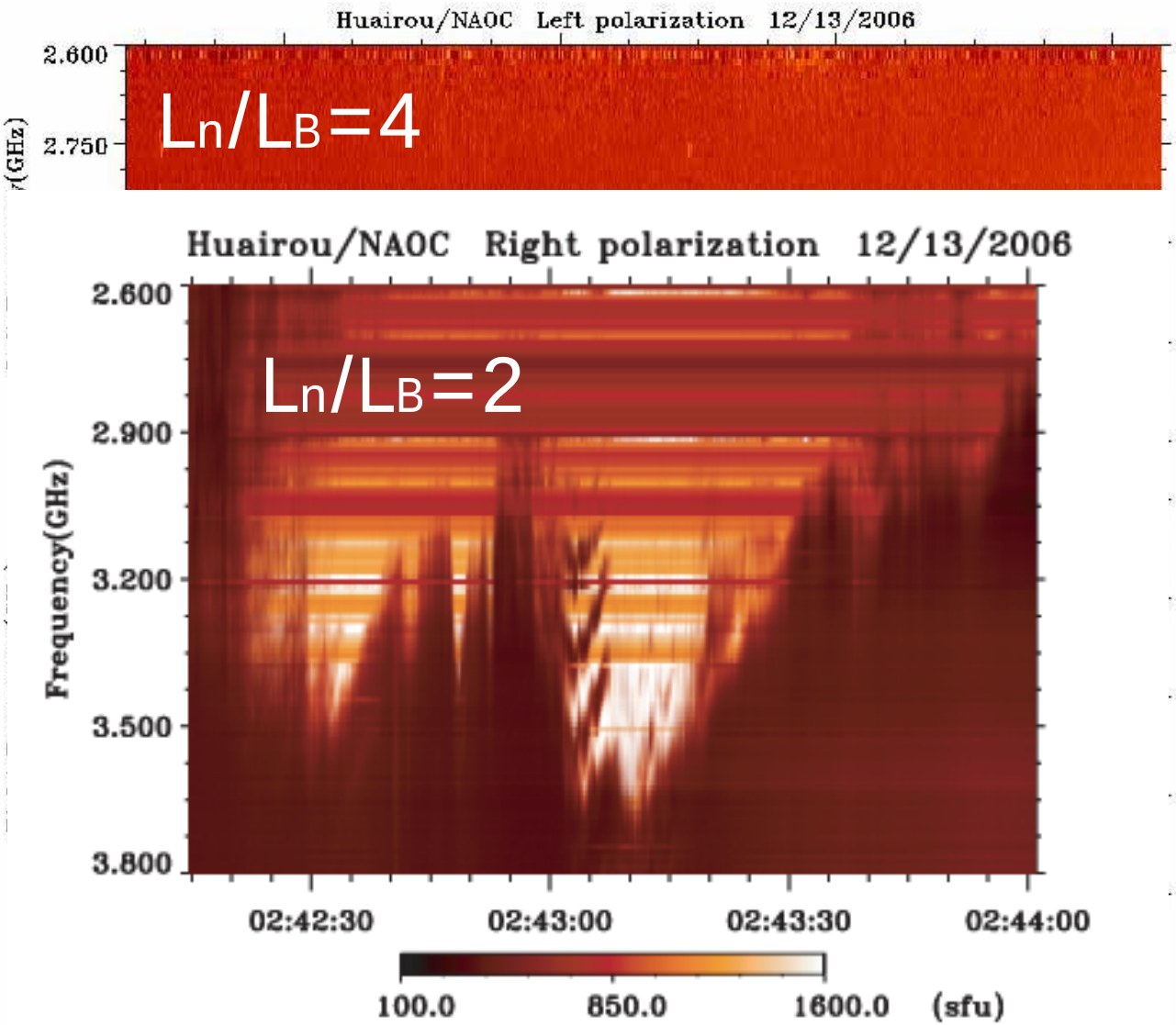




02:21

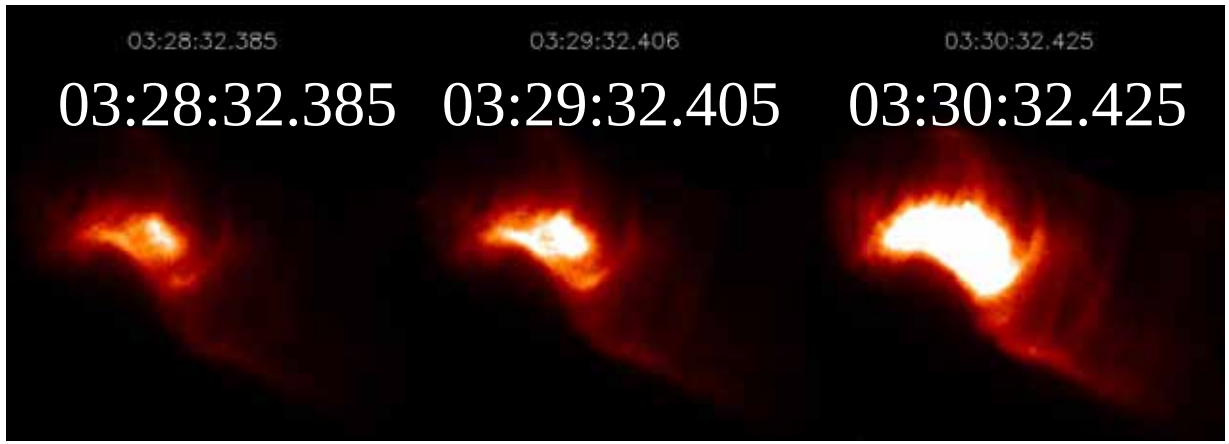
02:25

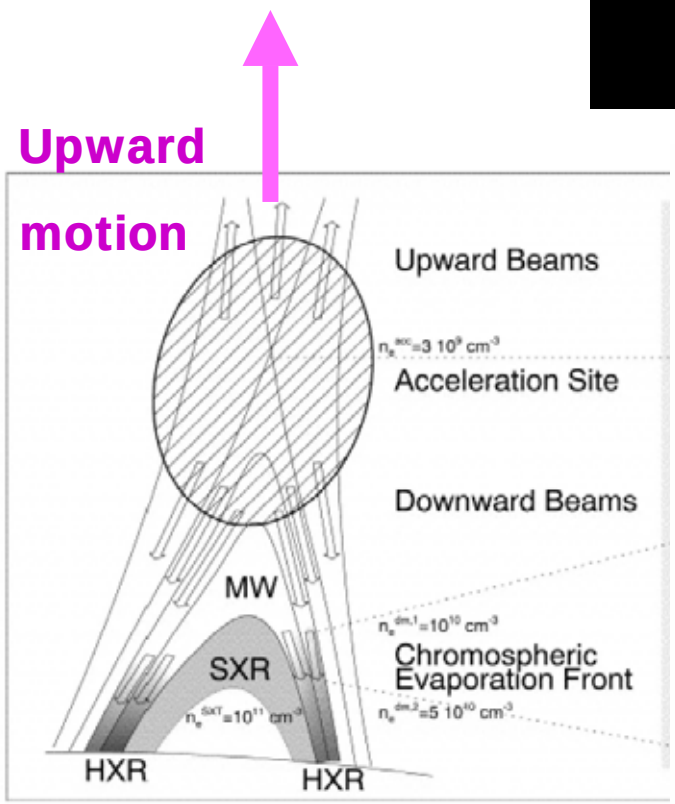
Spiky Zebra & Pulsations.



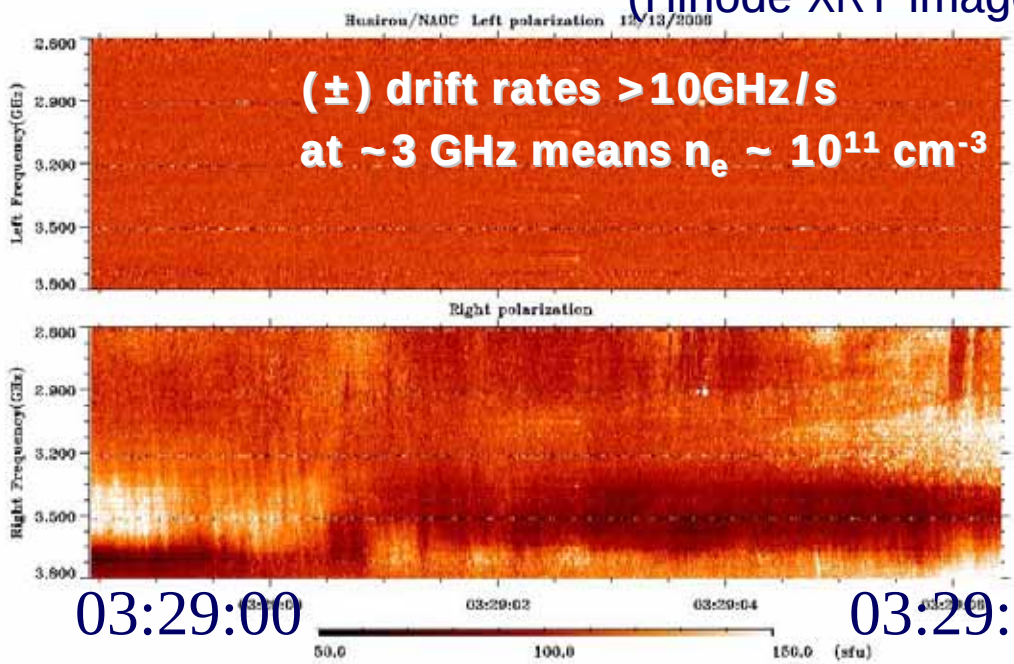
From whistler wave model (Chernov et al. 2005) and DPR model (Kuznetsev & Tsap 2007), we estimate $n \sim 10^{11} cm^{-3}$, B~ 50–170G in impulsive Phase. ~90–200G 2min after flare peak. But scale height ratio decreased by a factor of 2 (Yan et al 2007).

Drifting bi-directional bursts for ~20s, or upward motion of the reconnection site, for 13 Dec 2006 flare event, was observed

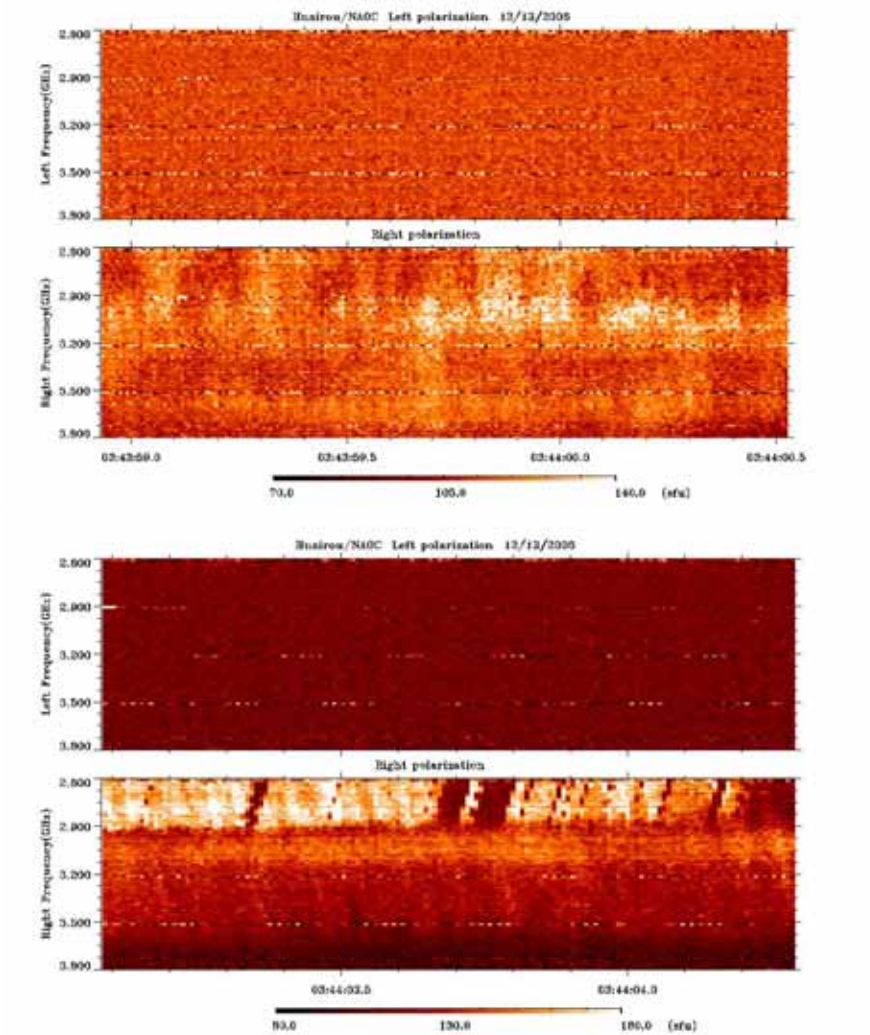




(Hinode XRT images)

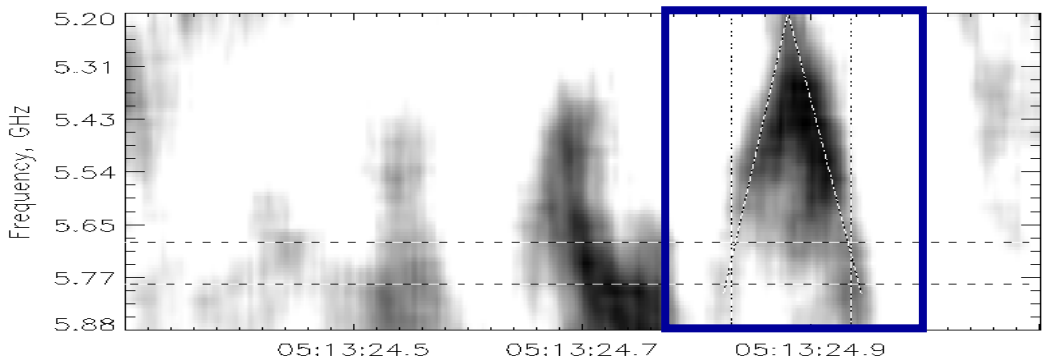


Another drifting bi-directional bursts around 03:44 UT for 13 Dec 2006 flare event

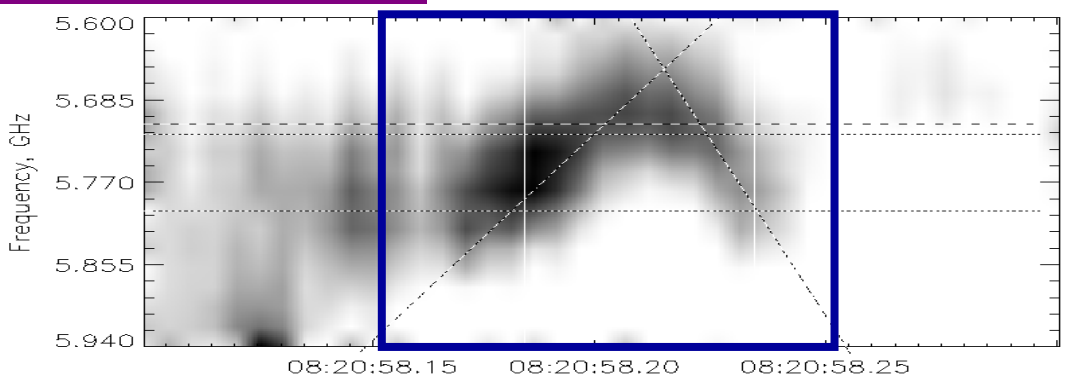


Coherent emission: U-burst

30 March 2001

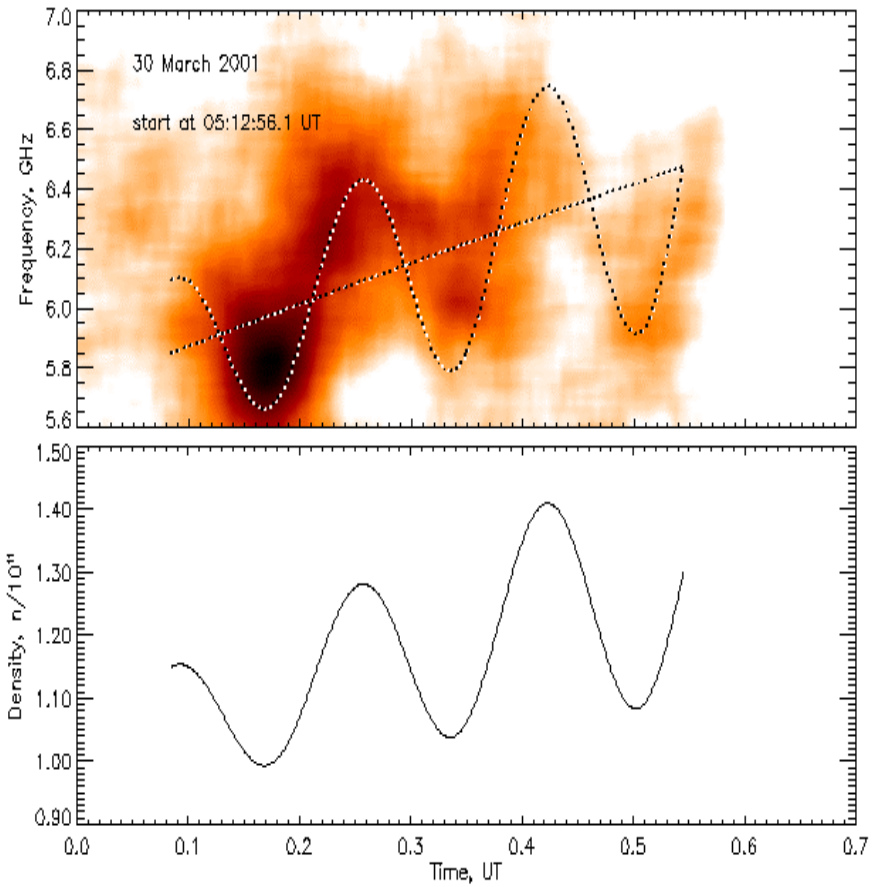


17 September 2001



- Exciter at m-dm λ's: e-beam moving along a magnetic loop with density minimum at the loop top. Plasma parameters are stationary.
- But the SSRT image show distance between sources at different branches is short (<30 Mm).
- In cm- λ' s U-structures are produced by density variations due to a plasma response to a heating pulse. The source size along the loop is order of a few Mm.

Bounce period or transverse MHD oscillations of loop?



Two variants to explain:

- Bounce period of the short electron beam in the long magnetic loop.

From lifetime duration follows beam velocity of 0.45c and the loop length about 20 Mm

- Transverse MHD oscillations of the loop (for B=100 G, diameter of the loop must be about 100 km)

Trend of the frequency drifting rate corresponds to density rising

$$\partial f / \partial t \approx 1.25\ GHz/s \Rightarrow \partial n / \partial t \approx 5 \times 10^{10}\ cm^{-3}/s$$

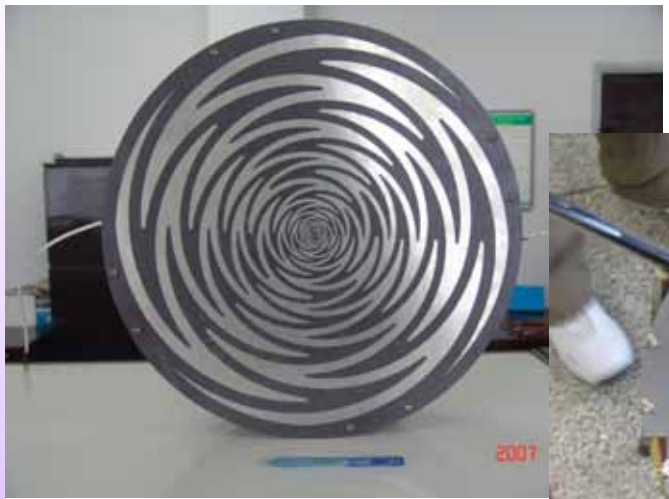
Altyntsev A.T, et al. (2003, A&A)

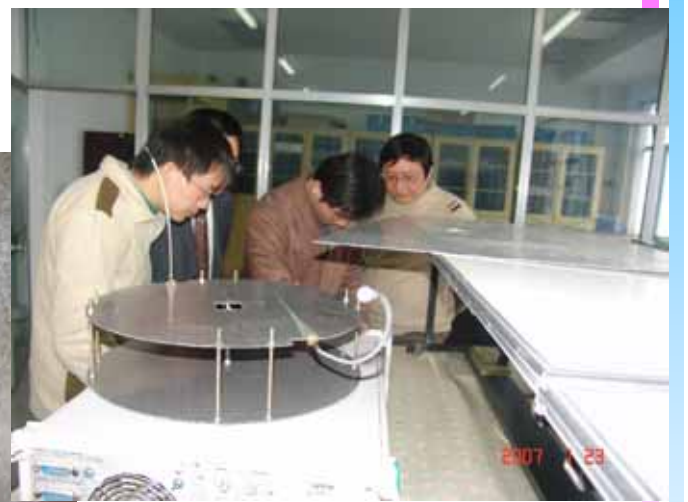
require a new instrument: capable of true imaging spectroscopy, with high temporal, spatial, and spectral resolutions ---- CSRH or FASR.

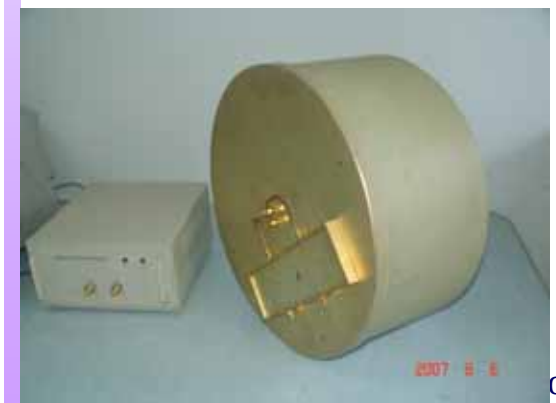
III. Recent Progresses of CSRH

- Array design and radio image process studies
- Antenna & feed design
- RF design
- Optic fiber transmission test
- Digital correlation receiver (prototype)
- 2-element aperture synthesis prototype
- Site survey & RF monitoring

Prototypes of Sinuous Feed in 0.4-15 GHz







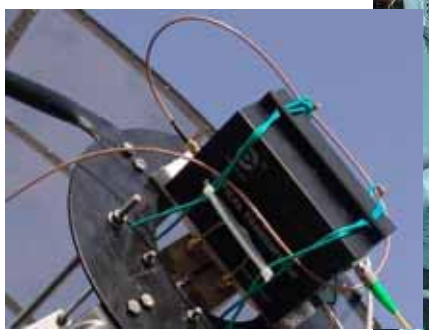
Assembly of feed in 0.4-2 GHz

CSRH Specifications

Range	**~0.4–15 GHz （λ：~75 –2 cm）**
Frequency Res.	**64 or 128 chan （I: 0.4-2 GHz）**
	32 or 64 chan （II: 2-15 GHz）
Spatial Res.	**1.3”– 50”**
Temporal Res.	**~<100 ms （0.4-15 GHz)**
Dynamic Range	**25 db （snapshot）**
Polarizations	**Dual circular L, R**
Array	**I: 40×4.5m**
	II: 60×2m parabolic antennas
Lmax	**3 km**
Field of view	**0.6°– 7°**

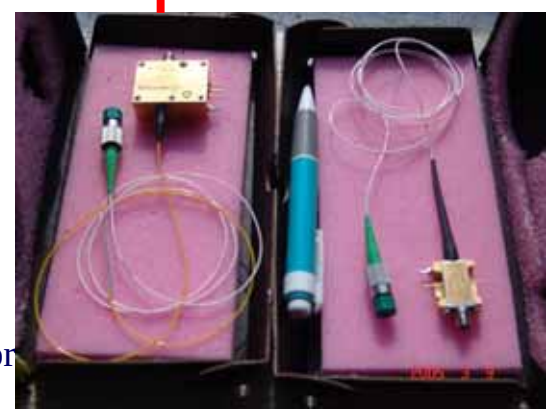
FOXCOM

EMCORE

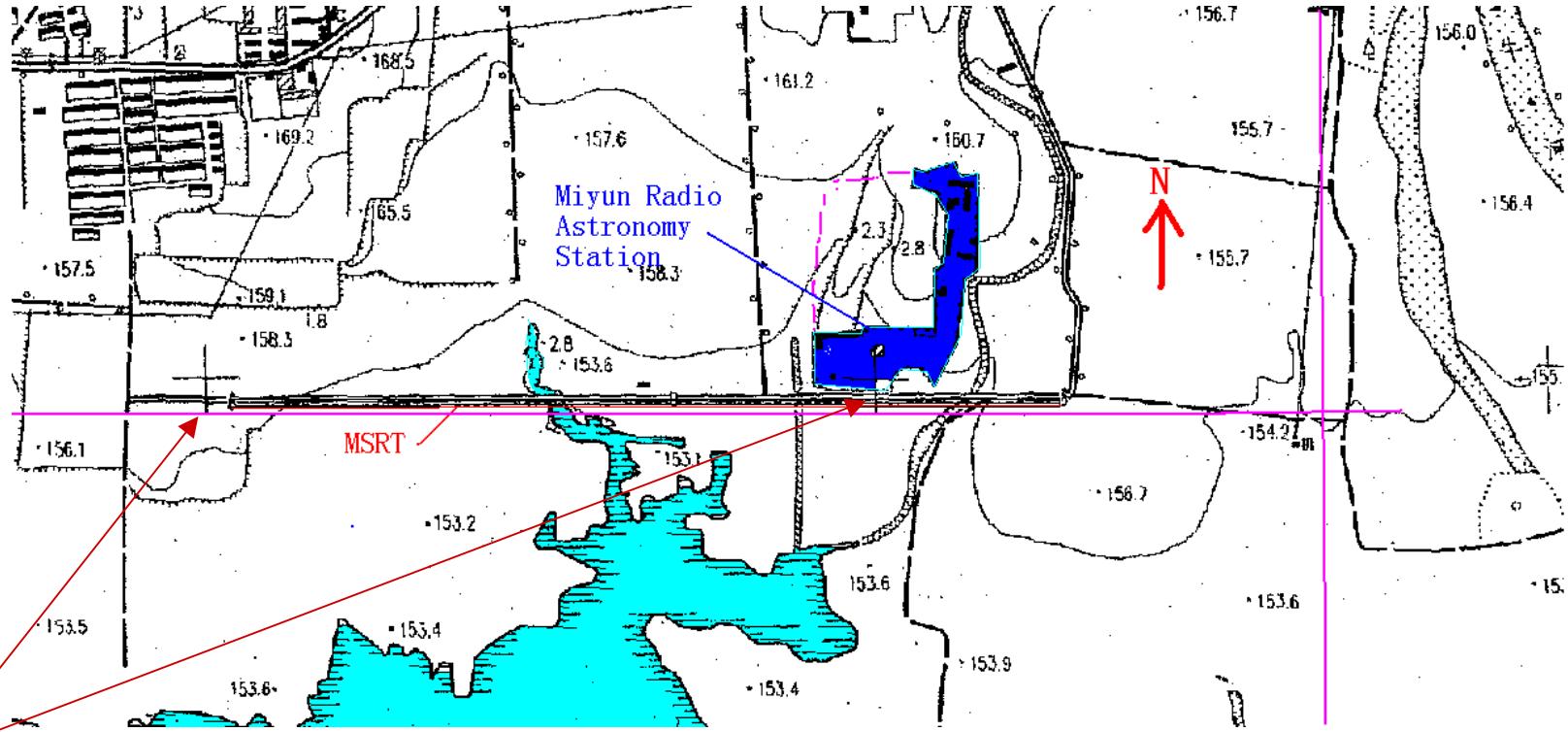


PPM

Miteq



2-element prototype

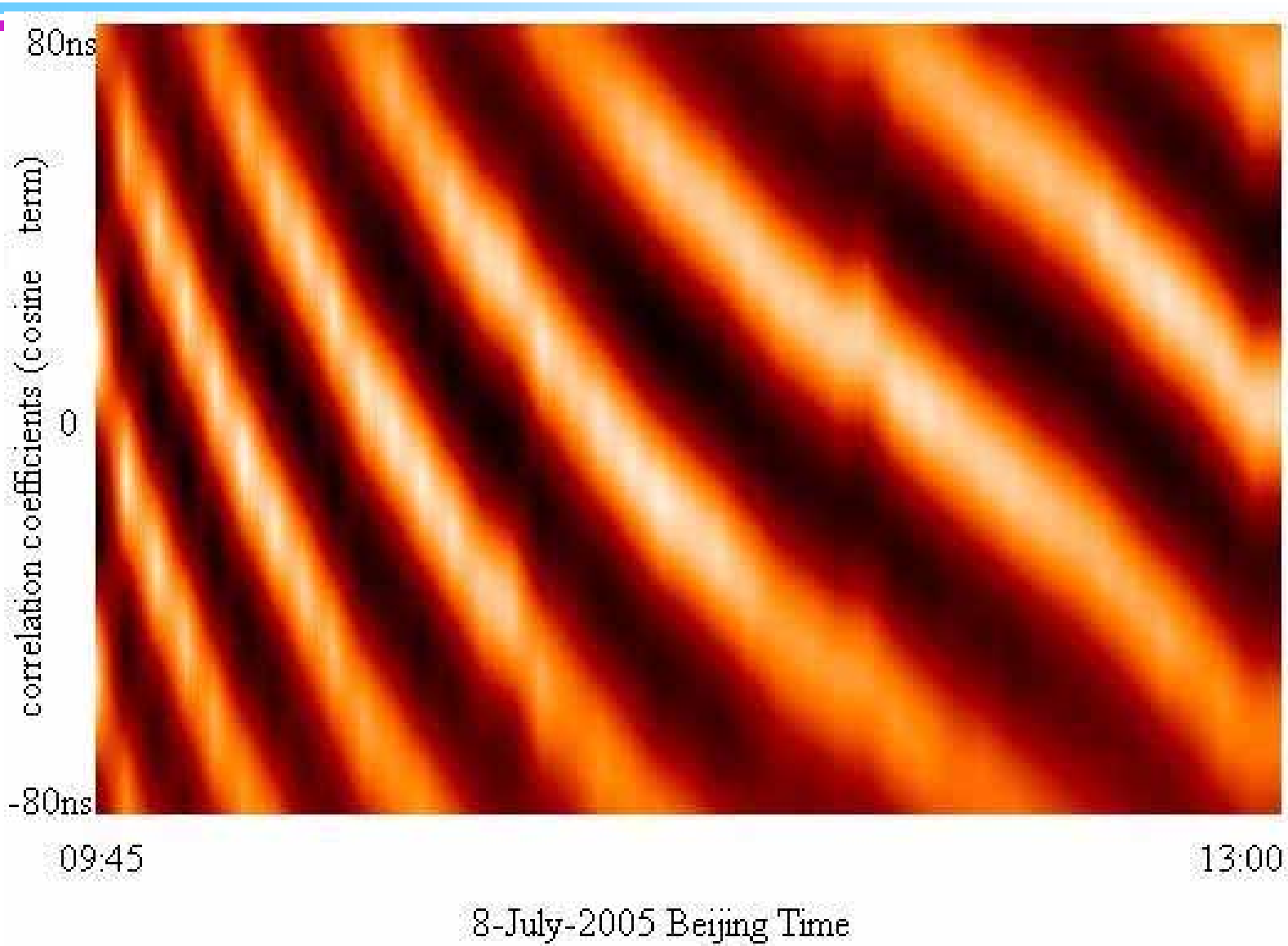


2-element prototype

Indoor:

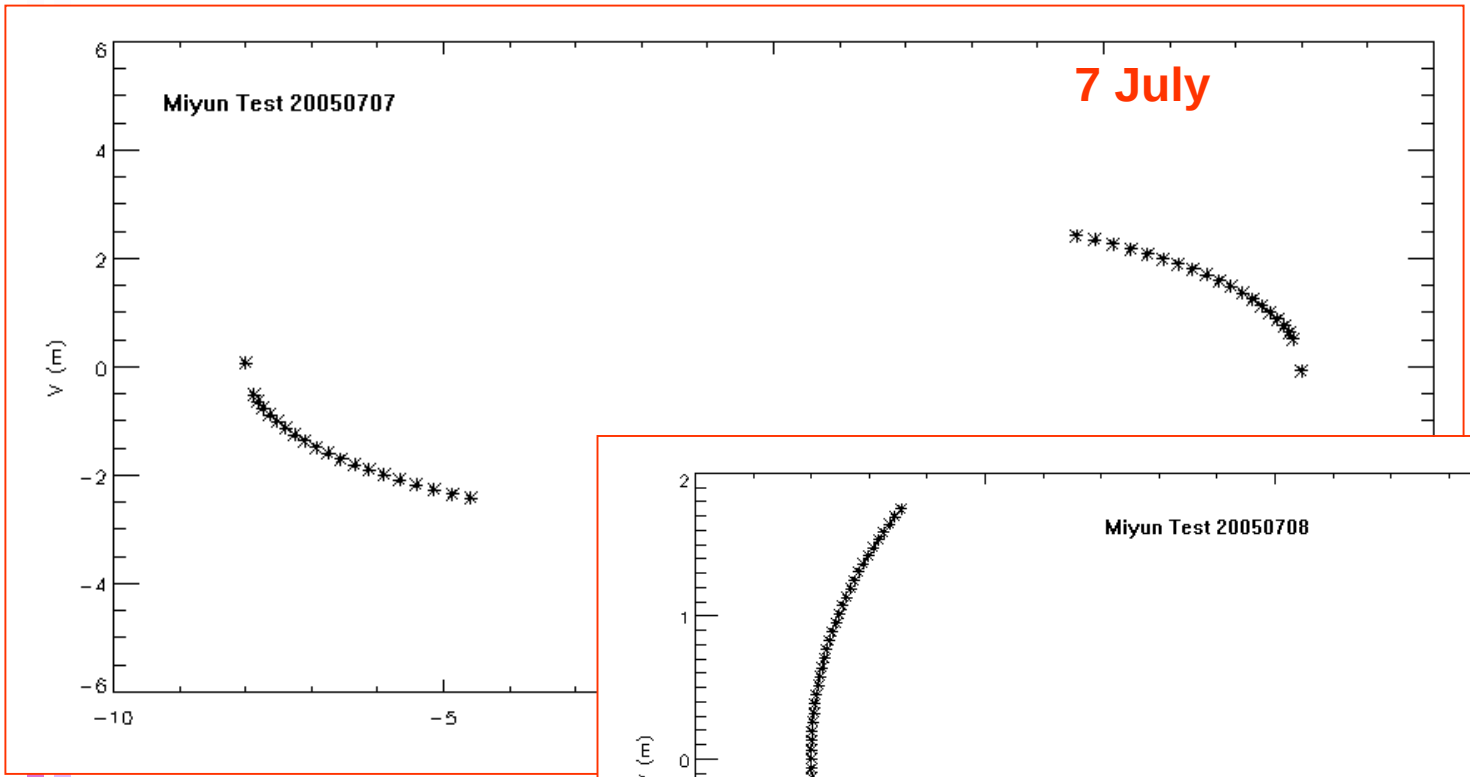
OP Rx,
Ana. Rx.
A/D
Digital
Delay &
Correl.

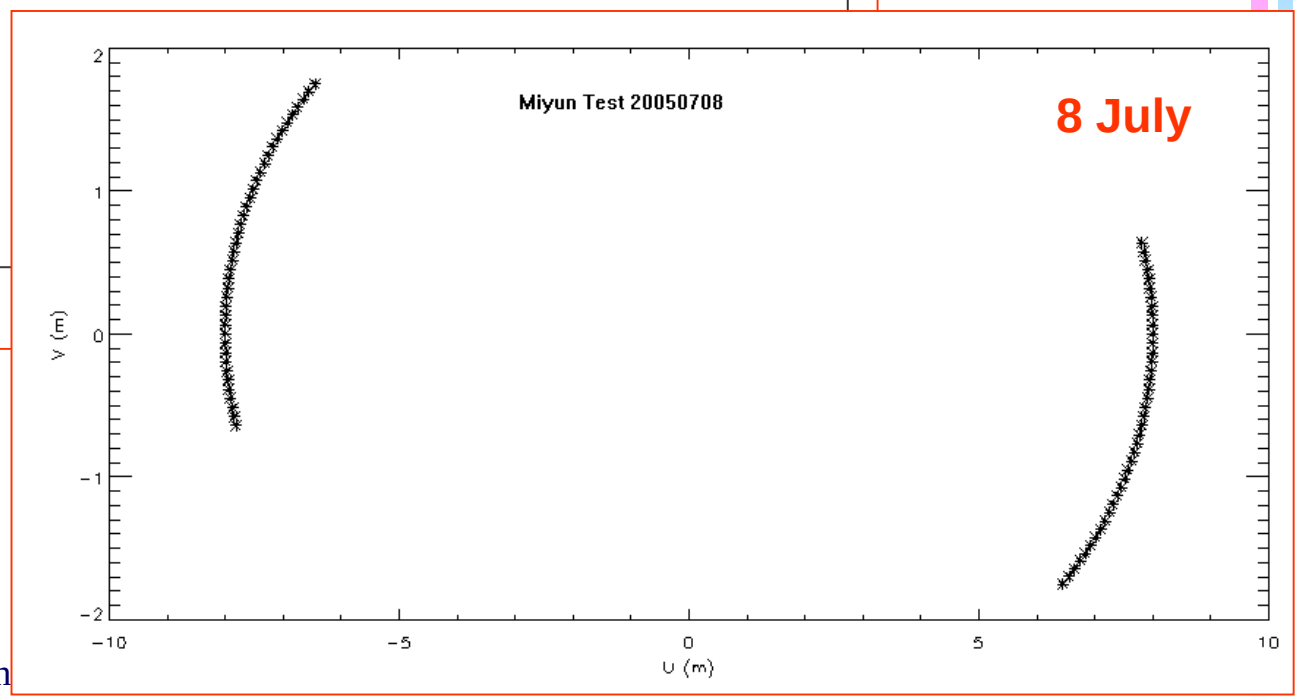
Outdoor: 2*4.5m dish
Feed, LNA, Op.
Tx 1.2-1.8GHz
1Km Op.Fib.



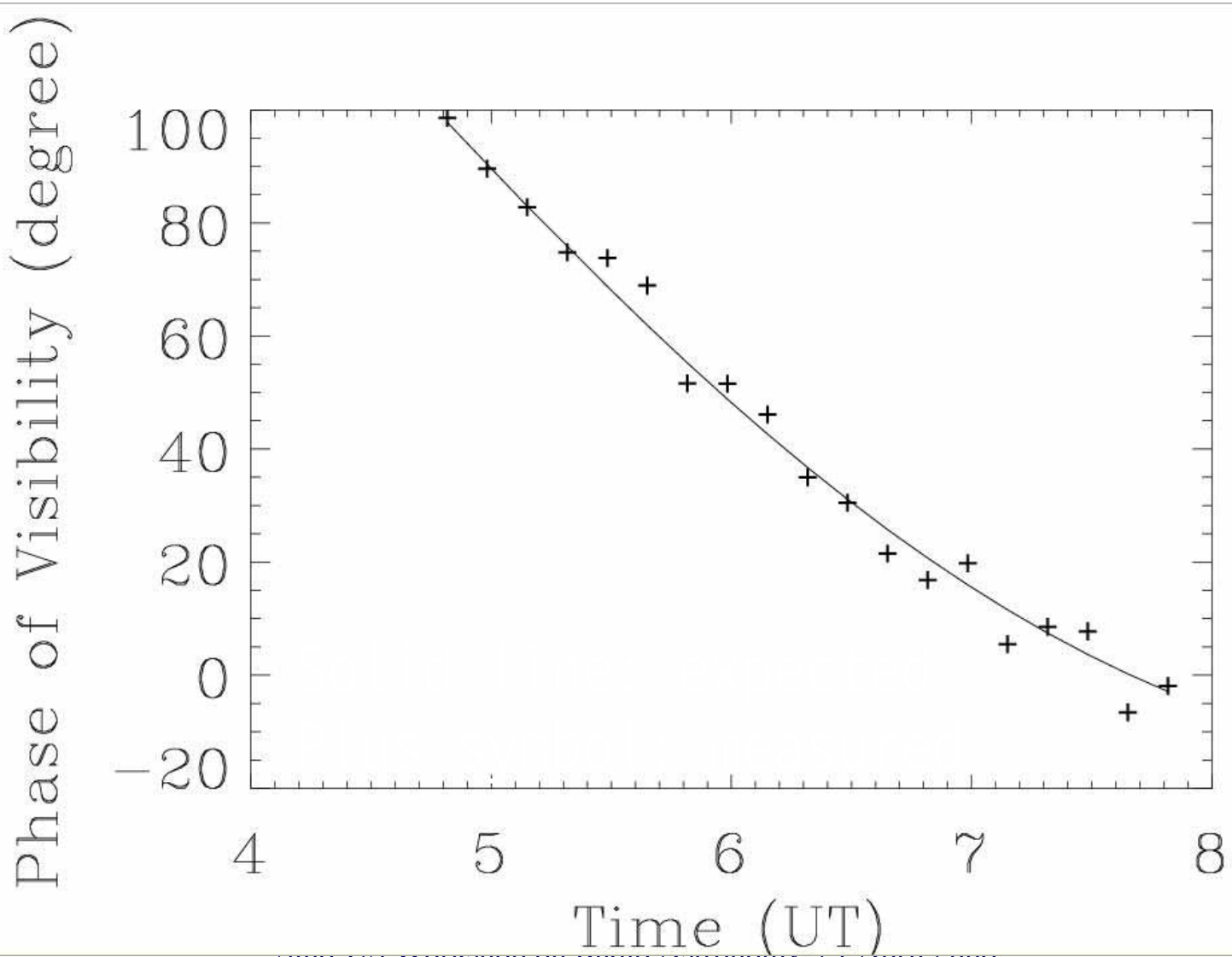
For short baseline of 8 m.

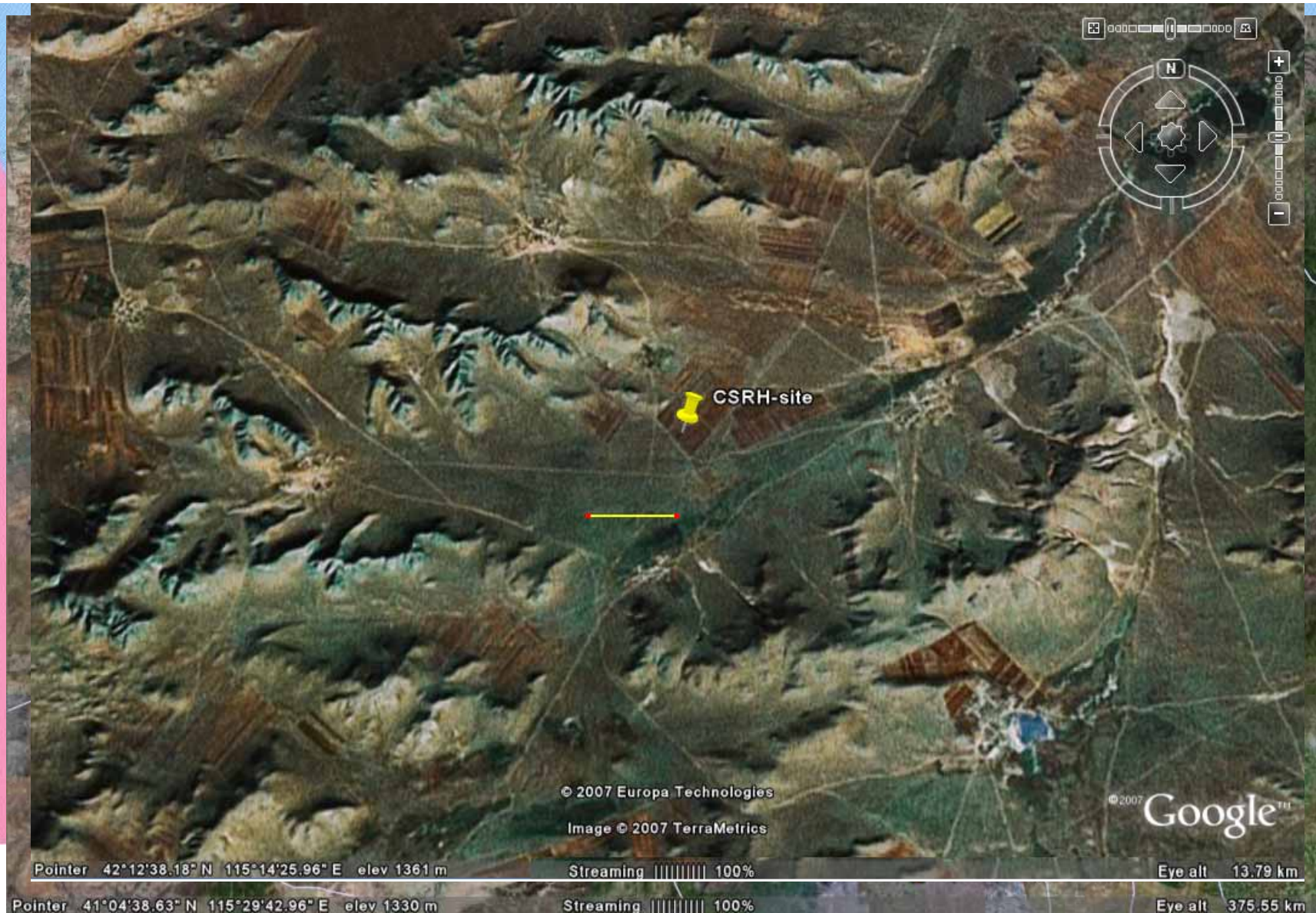
UV coverage for 7 & 8 July 2005



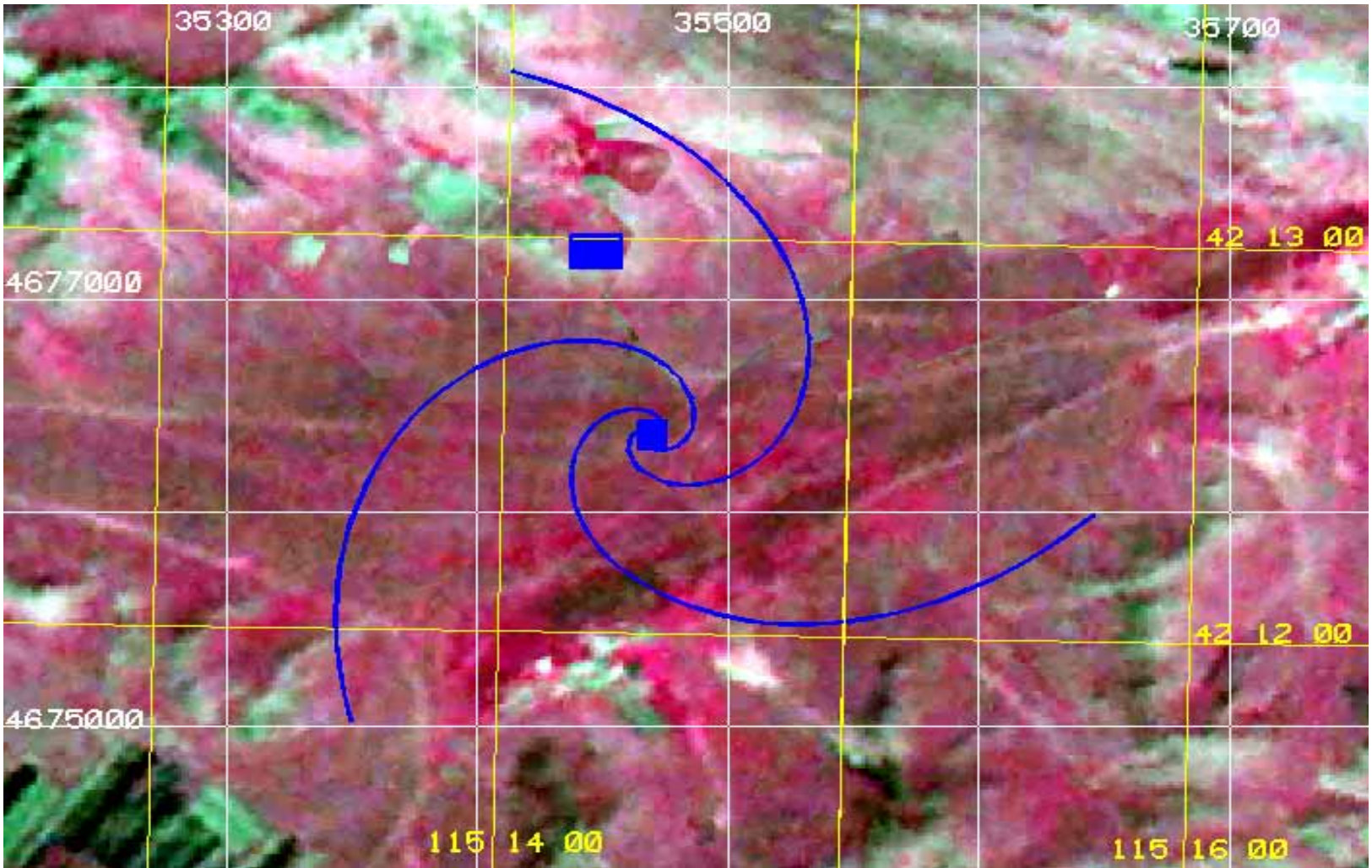


7 July 2005, Phase of Visibilities vs time




CSRH-site
© 2007 Europa Technologies
Image © 2007 TerraMetrics
©2007 Google™
Pointer 42°12'38.18" N 115°14'25.96" E elev 1361 m
Streaming 100%
Eye alt 13.79 km
Pointer 41°04'38.63" N 115°29'42.96" E elev 1330 m
Streaming 100%
Eye alt 375.55 km

Site survey

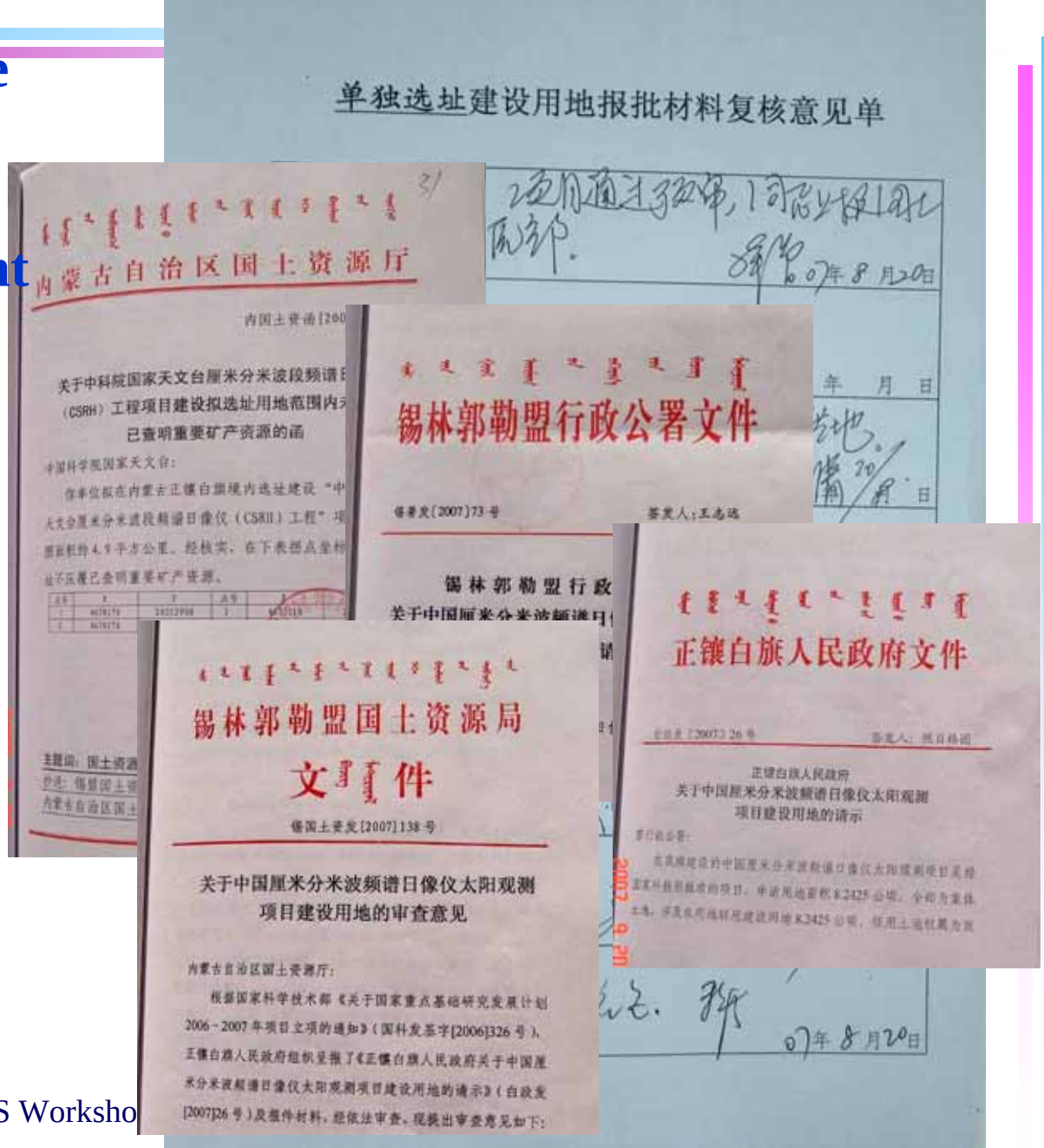

35300
35500
35700
42 13 00
4677000
42 12 00
4675000
115 14 00
115 16 00

Officially approved the Land Transfer to NAOC by Inner Mongolian Government in Dec 2007

Passed evaluations of 8 divisions:

分别通过了：

科技规划处、
地籍处、
土地利用处、
执法监察局、
地址环境处、
矿产资源储量处、
计划财务处、
政策法规处
等八个部门的审批



Radio Quiet Zone Protection issued by Frequency Allocation Committee of Inner Mongolia, China

内蒙古自治区无线电管理委员会办公室文件

内无办［2007］131号

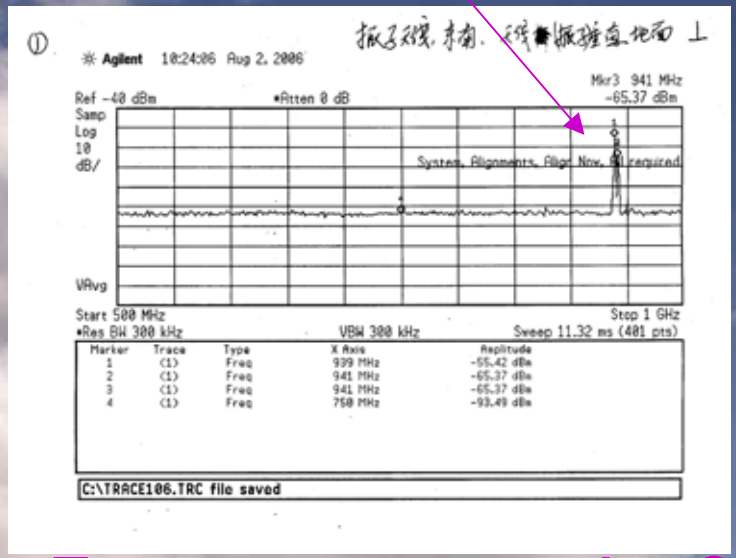
关于对正镶白旗太阳射电日像仪
重点电磁保护的通知

锡林郭勒盟行署办公室，锡林郭勒盟无线电管理处，正镶白旗人民政府办公室，民航华北地区空中交通管理局内蒙古分局，各电信运营企业：

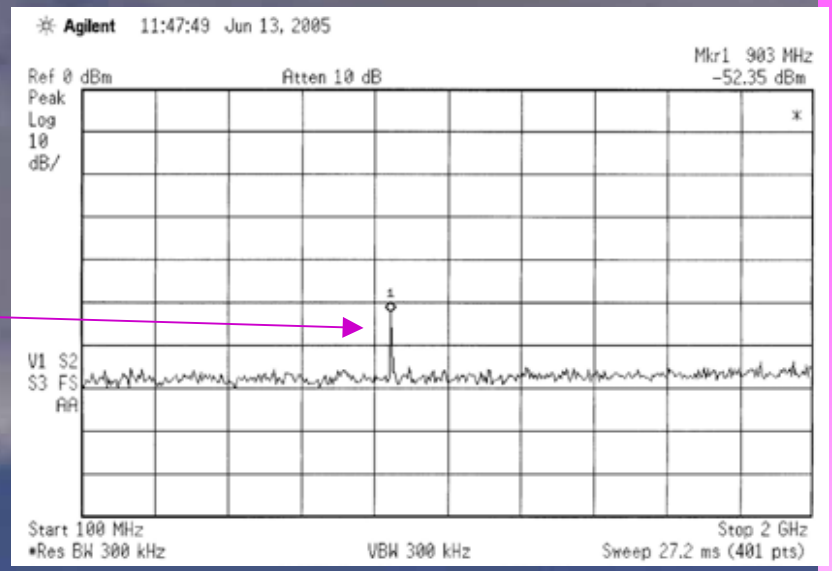
中科院国家天文台新建正镶白旗太阳射电观测站是国家973计划重点项目，该站厘米分米波频谱日像仪通过对太阳射电成像观测，研究日冕磁场结构与演化，从而在国际上首次实现在厘米-分米波段上同时以高空间、高时间、高频率观测太阳活动的动力学性质，在空间天气监测和研究中起到重要作用。作为国际新一代射电日像仪，可望在日冕物理研究中取得重要原创性研究成果。

RFI Measurements

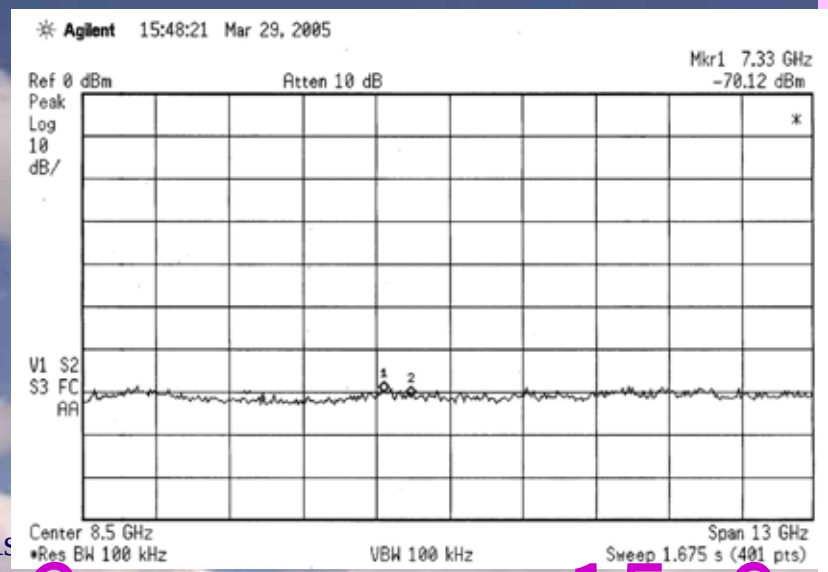
Mobile phone signals



0.5 1 G

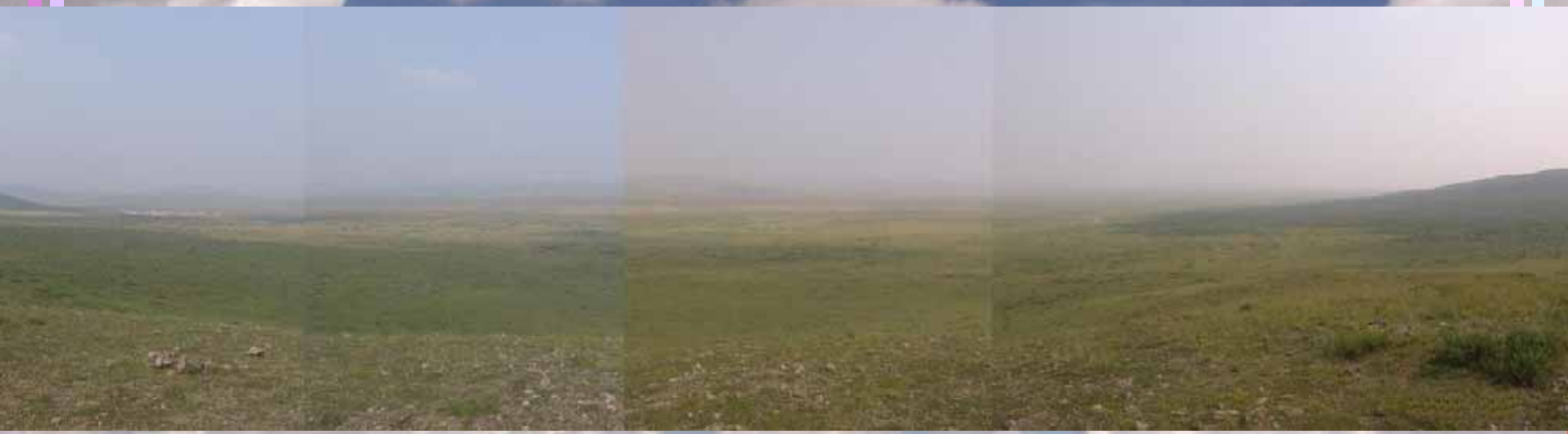


0.1 2 G

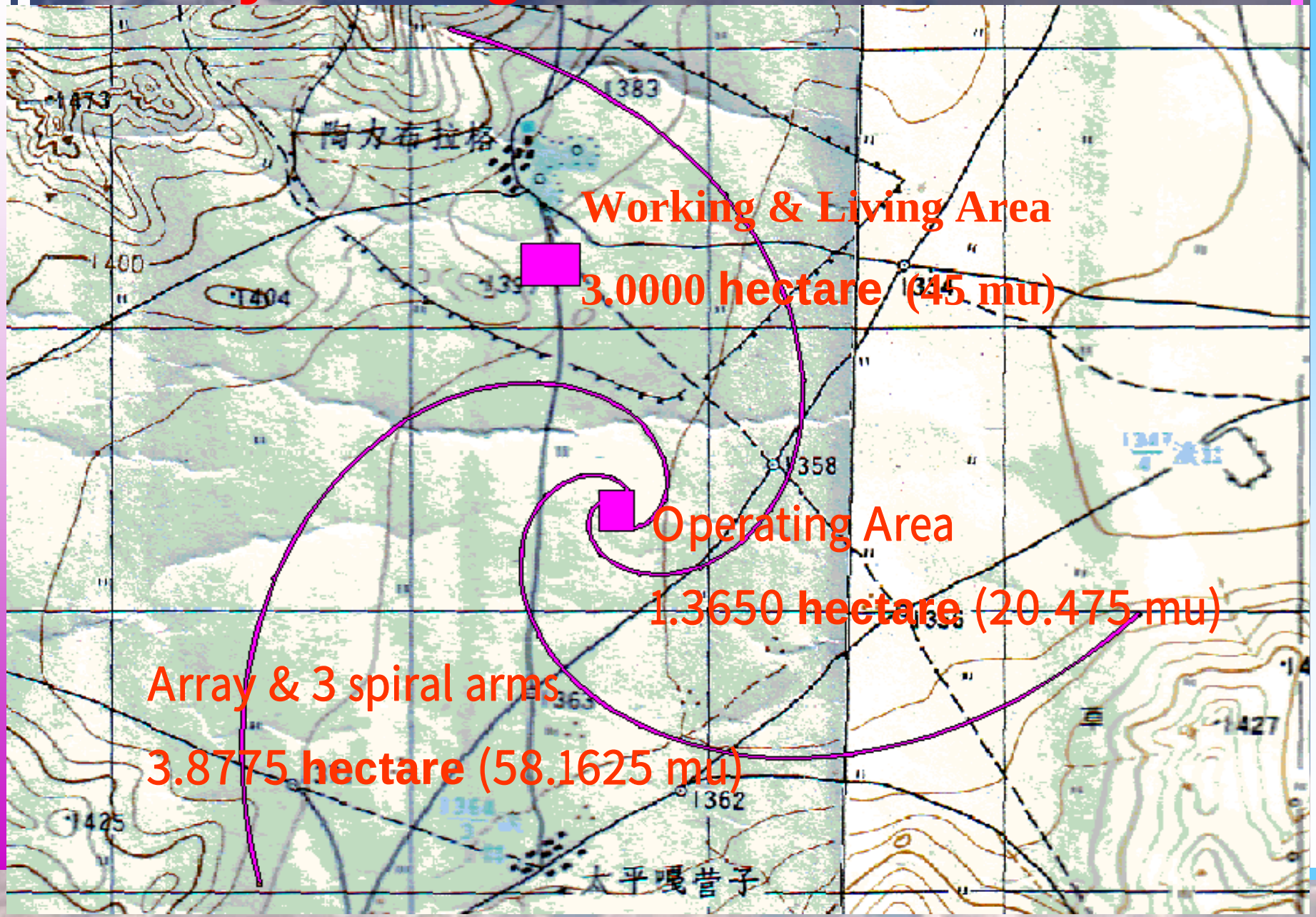


2 15 G

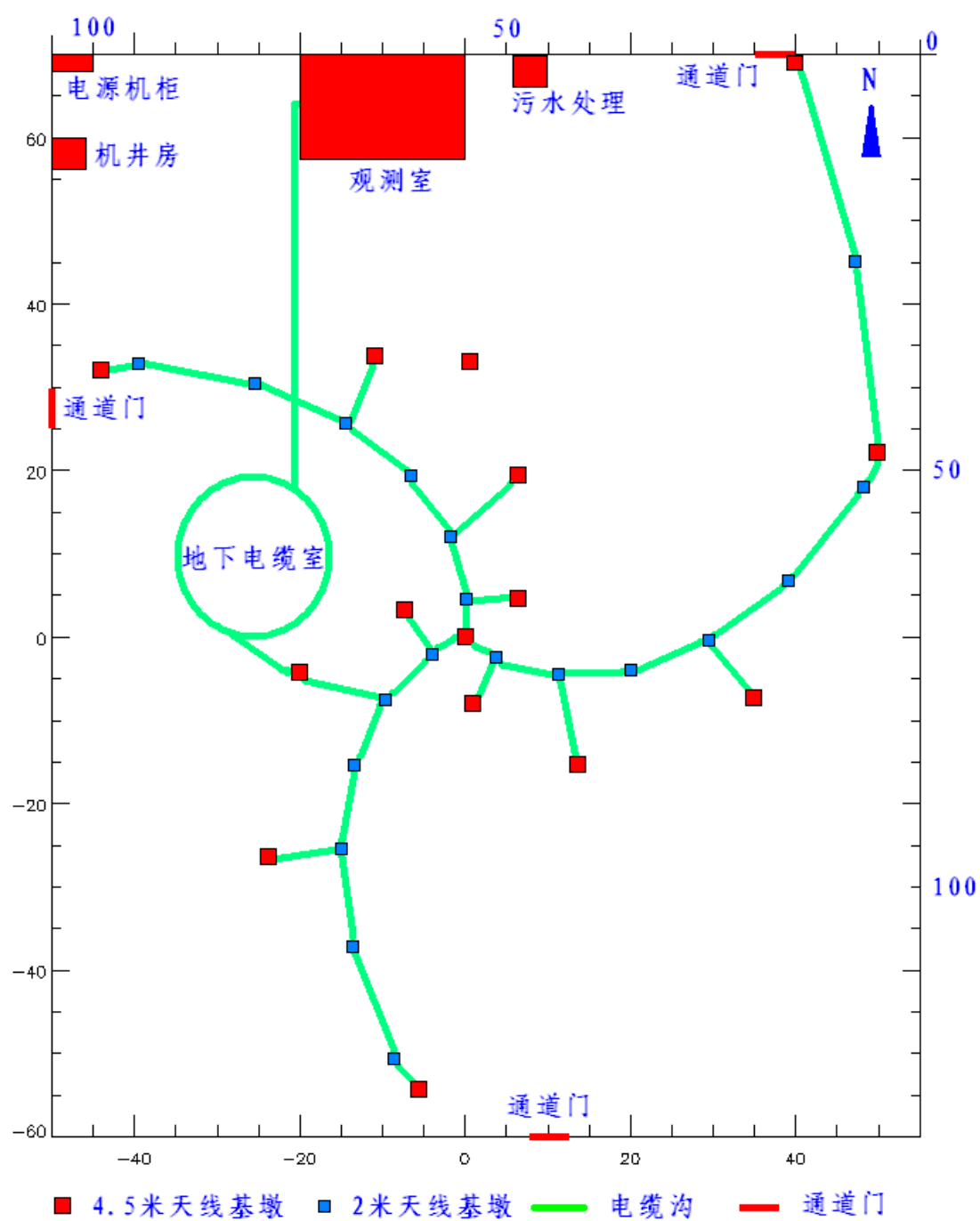
Site view



Array arrangement



Working and Living Area

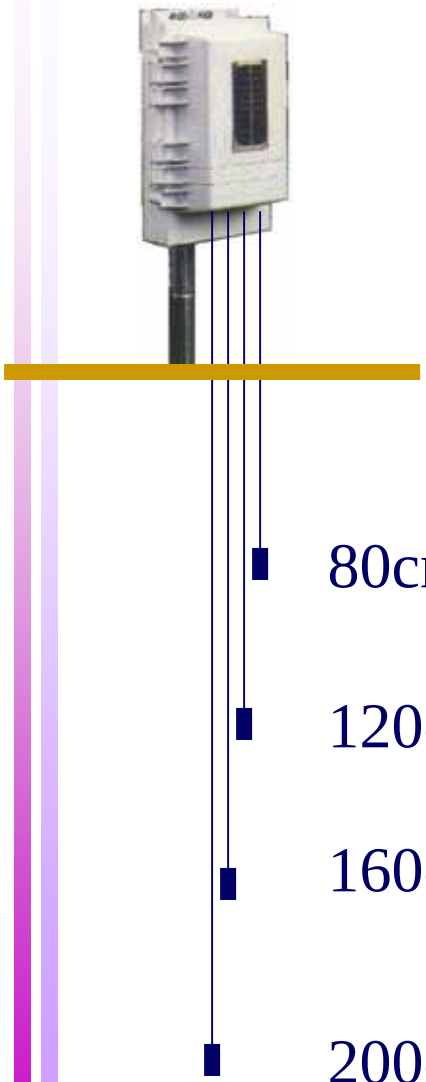


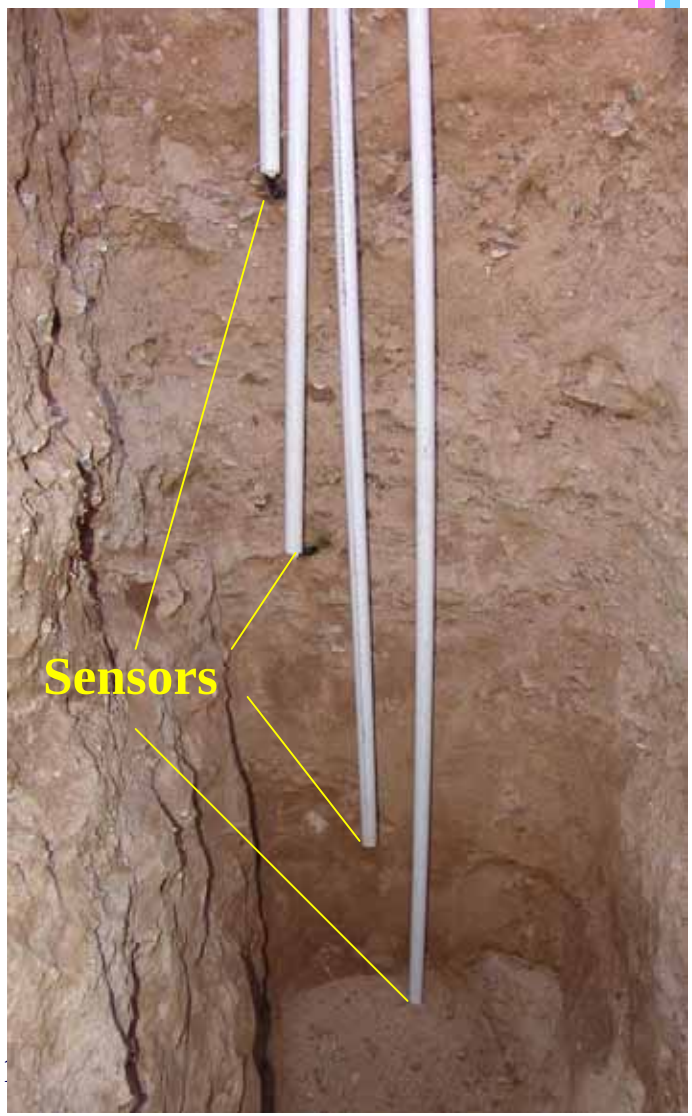
Schematic arrangement in central operating area

ny, 21 April 2008,

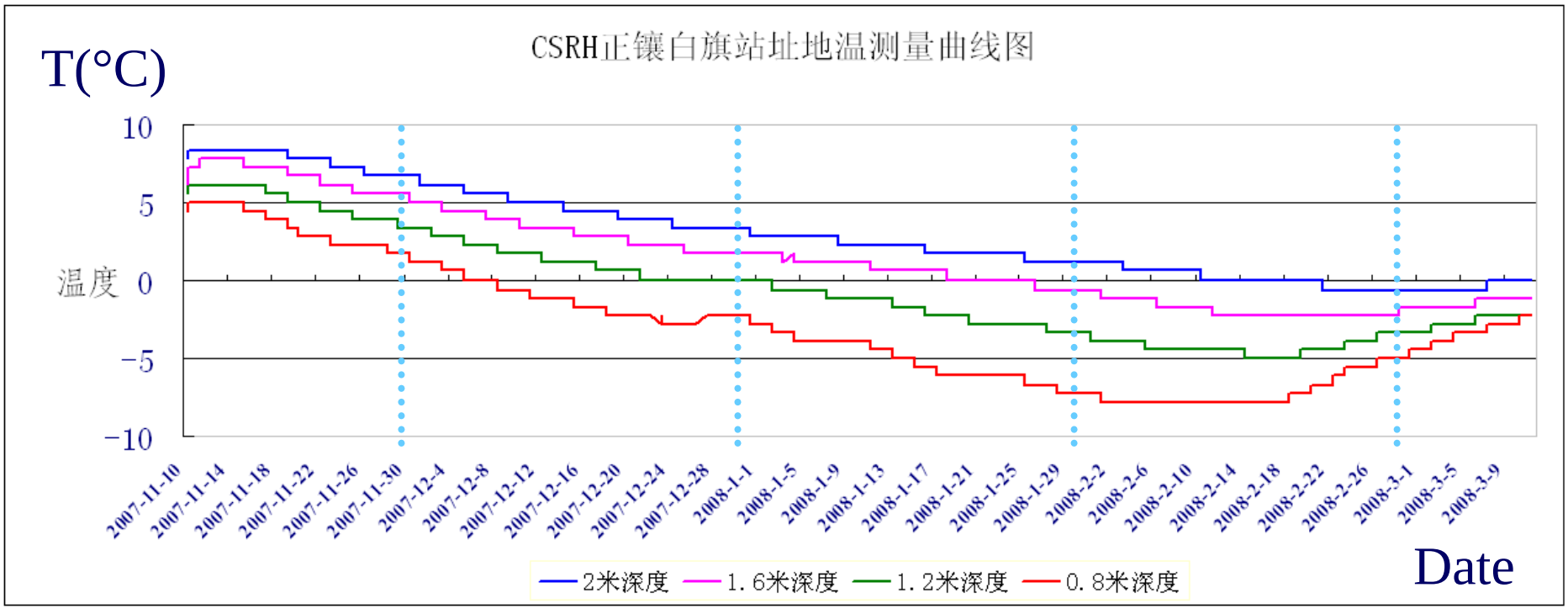
Construction of an Automatic Weather Station in Nov. 2007

Measurements of Soil Temperatures





Distribution of soil temperatures



Present Status

I. lar

ped

II. fer

c

07.

III.

OST

IV. joint

Evaluation Meeting on CSRH Designs held during 1-2 April 2008 by NAOC

Future Plans

I. Radio quiet zone protection

II. CSRH-I during 2008-2010

III. CSRH-II from 2010(?)-