Future Solar and Interplanetary Radio Instrumentation for Space Weather Studies in China

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Outlines

- Introduction
- Major Solar Radio Observations
- Future Programs

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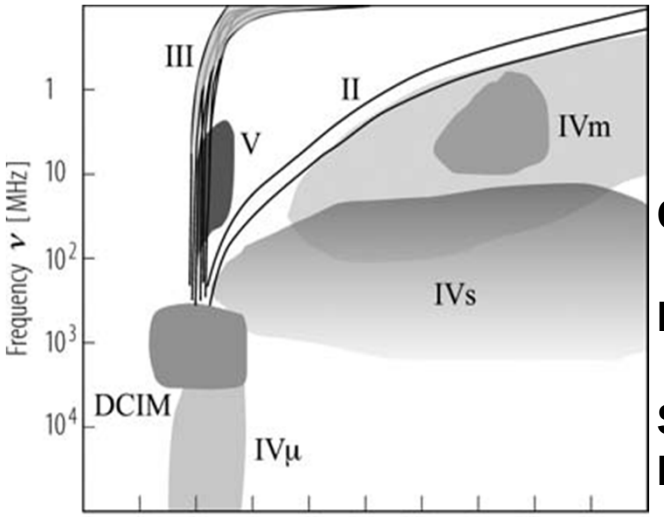
Introduction

- **Solar eruptions are driving sources for Space Weather**
- **Radio bursts are prompt indicators of the various solar activities including flares and CMEs, etc.**
- **Radio observation: a technique which can cover entire regime from the Sun to the Earth environment**
- **Develop imaging-spectroscopy capacity**



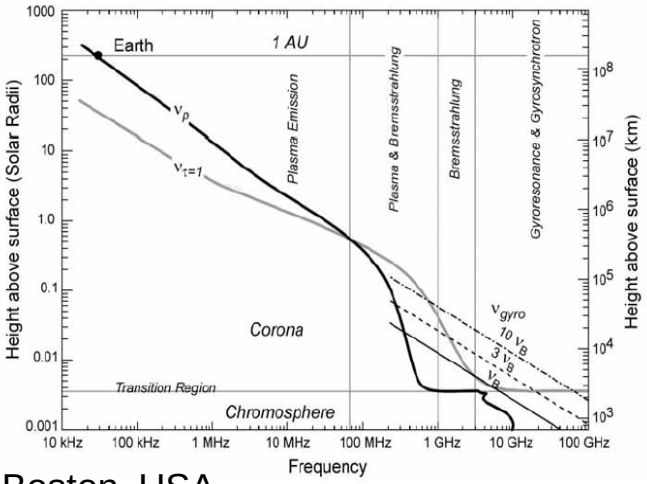
GRH

NRH

SRH

NoRH

（Benz 2009）



Major institutions for solar physics research

With > 60 full-professor level staff members with ~100 PhD students (by Fang)

Introduction

Distribution of the solar facilities

Xinjiang by CMA

Inner Mongolia

HuaiRou

NAOC

SDU, CMA

NU, PMO

FAST

YNAO

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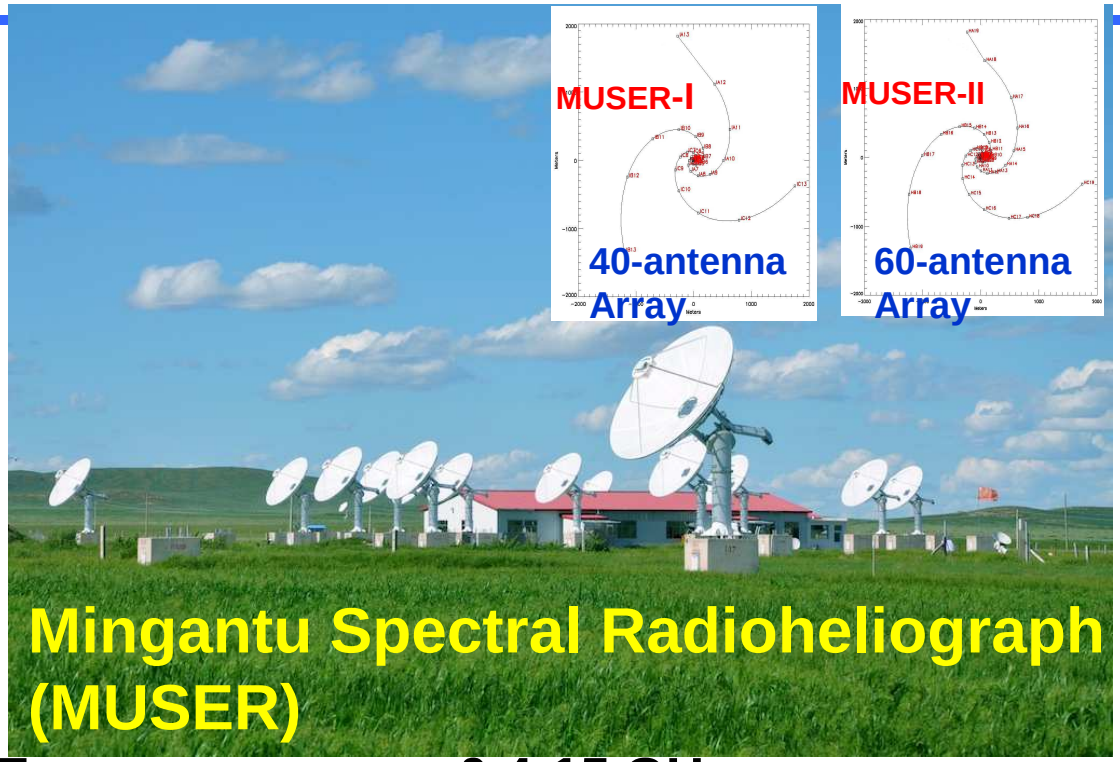
Solar Radio Observation in China

- **NAOC, Beijing**
- **PMO, Nanjing**
- **YNAO, Kunming**
- **Shandong University, Weihai**
- **China University of Science and Technology, Hefei**
- **Shandong, CMA**
- **Xinjiang, CMA**

Mingantu Observing Station

National Astronomical Observatories, CAS



Frequency range: 0.4-15 GHz
Frequency resolution: 64 chan(0.4-2.0GHz)
>32(~500) chan(2.0-15GHz)
Spatial resolution: 1.3˝-50˝
Temporal resolution: ~100 ms
Max. baseline: 3.0 km

SCIENCESCOPE

The Stars Are Out in China

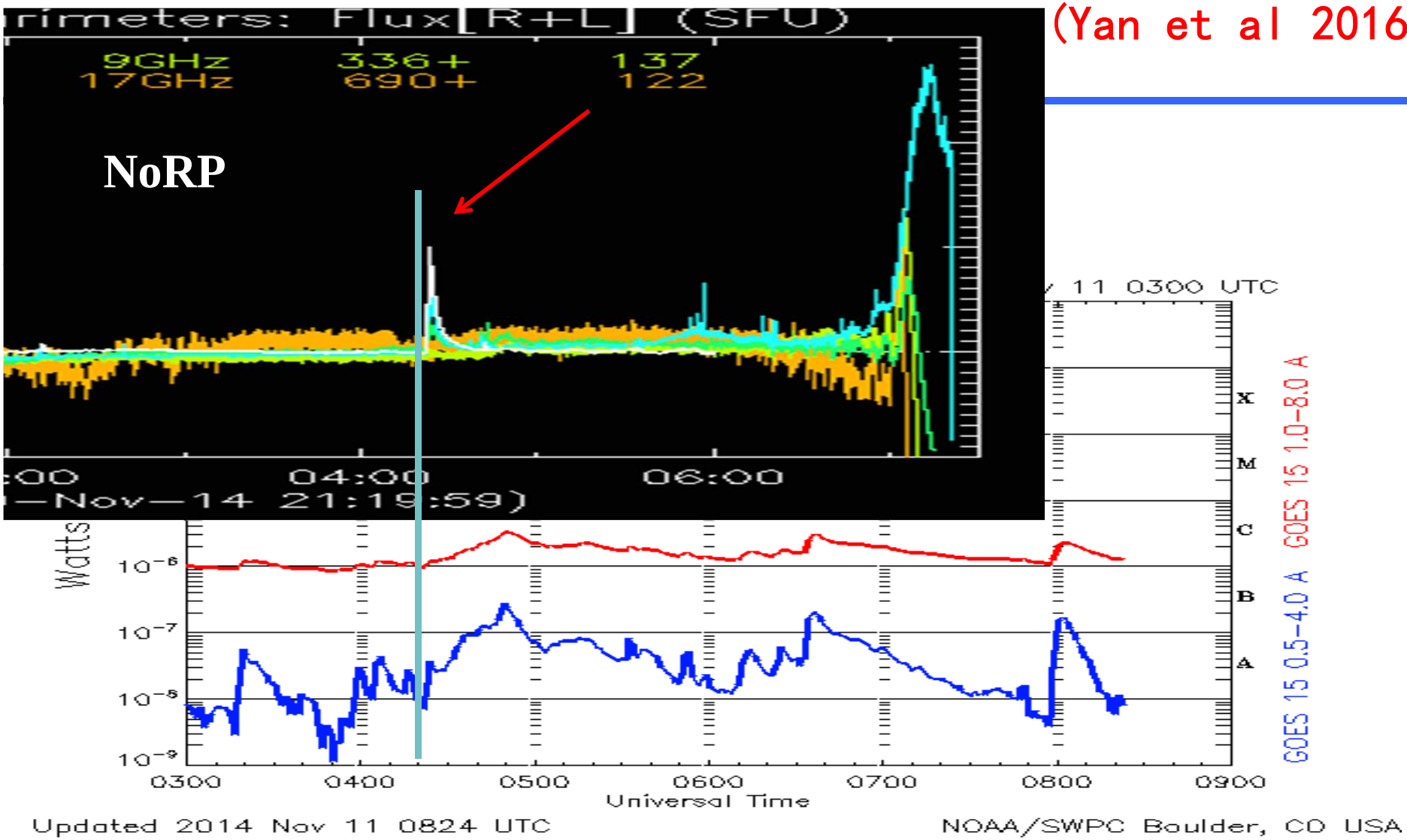
BEIJING—China is building a new set of ears tuned to our nearest star. Last month, the government of Inner Mongolia provided land to the National Astronomical Observatories of the Chinese Academy of Sciences for the Chinese Spectral Radioheliograph (CSRH), one of two major ground-based solar instruments that China's scientific community plans for the coming decade. Construction will begin later this month on the $7.3 million facility, which will listen in on radio bursts that could presage coronal mass ejections and solar flares. When directed at Earth, these ionic tidal waves can trigger geomagnetic storms that disable satellites and knock out power grids. Set to open in 2010, CSRH will consist of 40 radio dishes, each 4.5 meters wide. They will be clustered on the steppe in a zone devoid of earthly radio waves—apart from stray cell phone signals—260 kilometers northwest of Beijing.

Meanwhile, there's work on a complementary facility, the Frequency-Agile Solar Radiotelescope (FASR). In June, the National Radio Astronomy Observatory (NRAO) and several university partners asked the U.S. National Science Foundation for $25 million to build FASR at Owens Valley Radio Observatory in California. If they receive the funds, the consortium wants to begin building a prototype array at Owens Valley next year, says NRAO's Tim Bastian. –**RICHARD STONE**

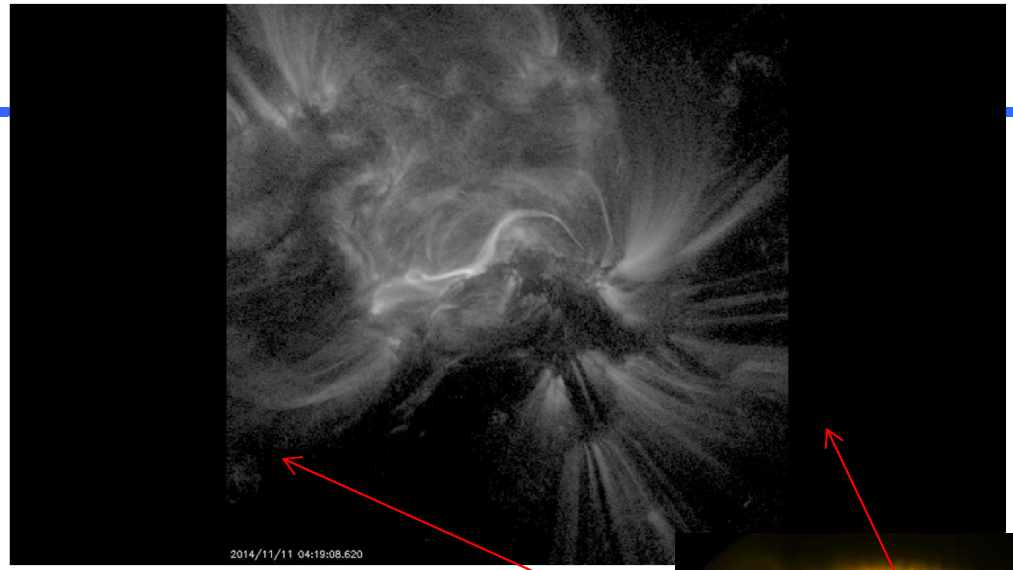
www.sciencemag.org

Station Construction Progress (May 2015 – Present)

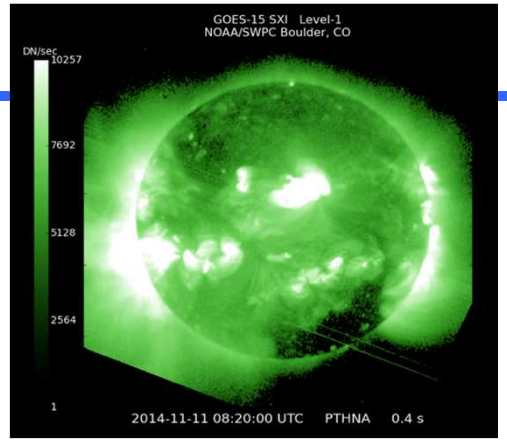
A solar flare and radio bursts on 11 Nov, 2014 (Yan et al 2016)



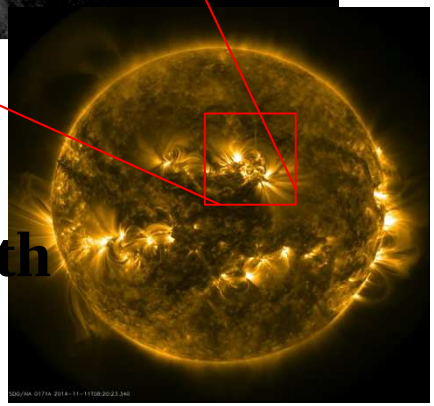
The solar flare starting at 04:22 on 11 Nov 2014



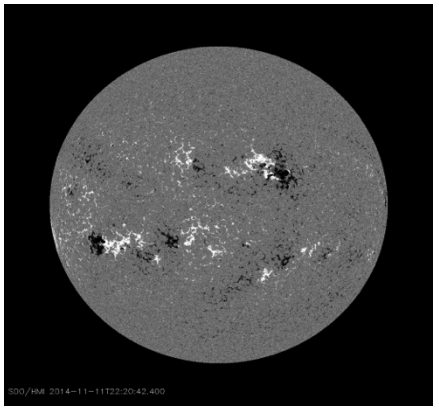
AIA131 movie



GOES SXR



AIA 171

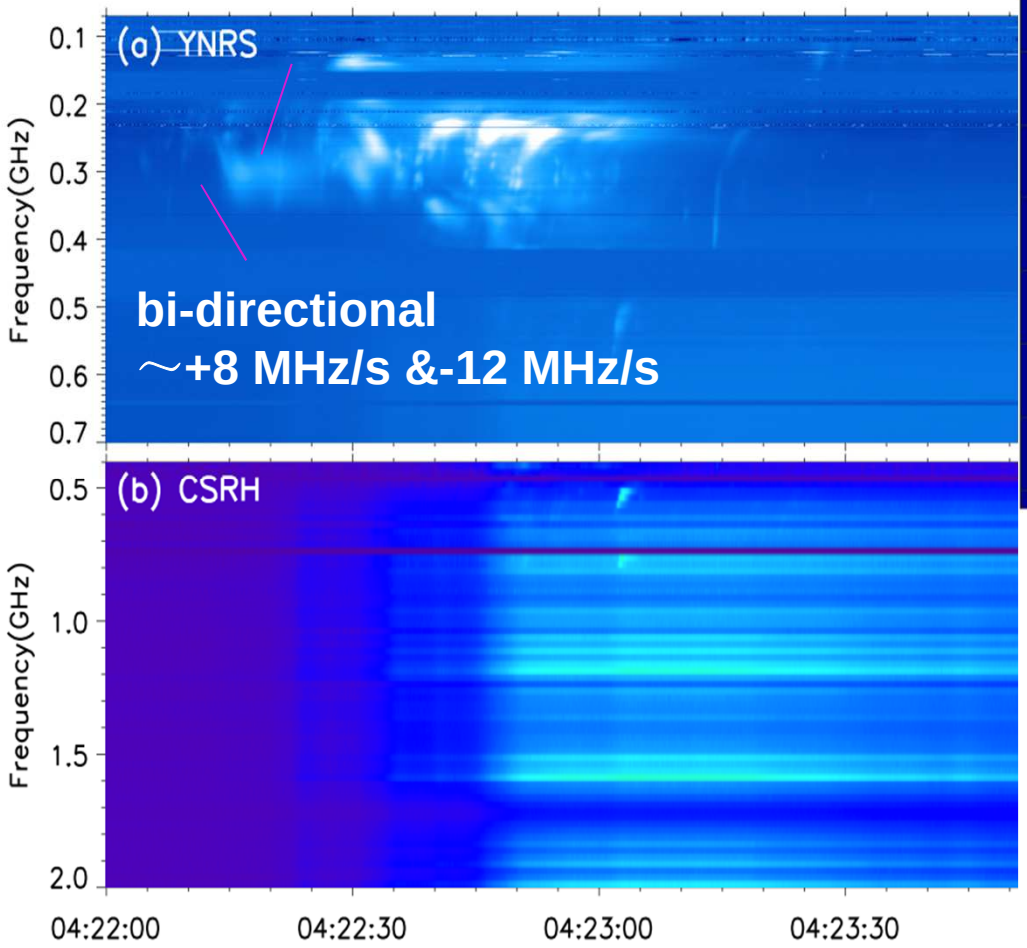


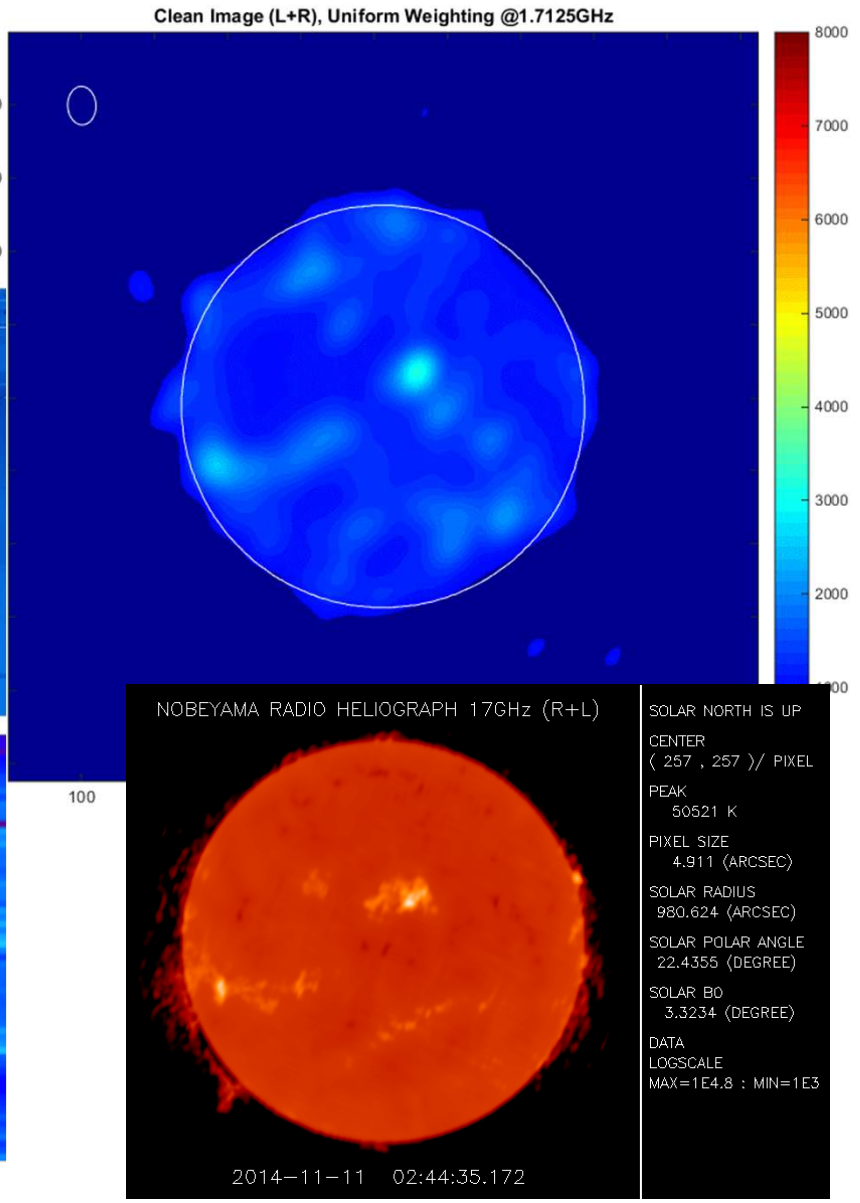
HMI / SDO

SGD associates the radio burst with the disk center flare event

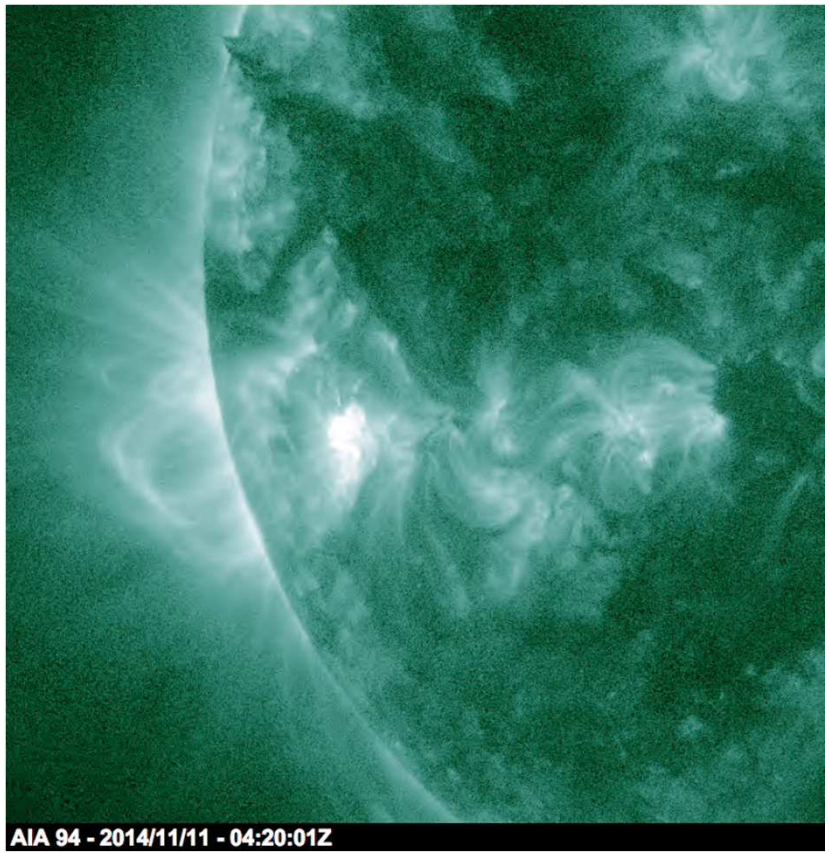
200		B0422	0449	0606	LEA	1	FLA	N16W11	1F	ERU	2205
200		0422	0422	0423	LEA	G	RBR	245	730		2205
200		0423	0423	0423	LEA	G	RBR	1415	100		2205
200	+	0423	////	0424	CUL	C	RSP	018-430	III/1		2205

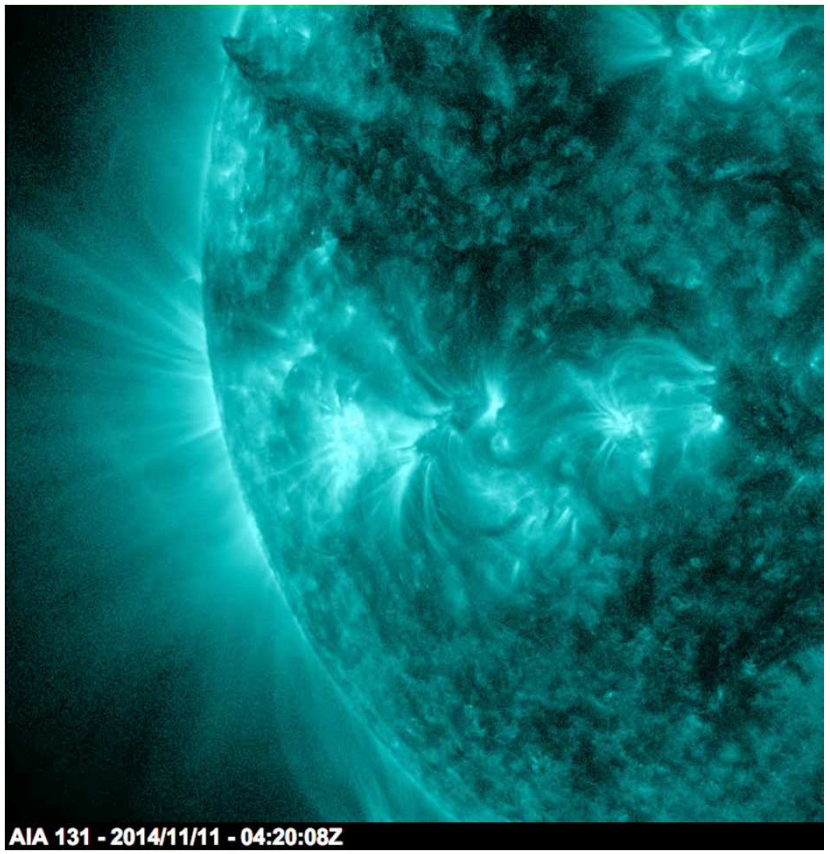
- **(L + R) polarizations (Preliminary results)**
- **04:21-04:24UT@10s interva & 3ms integral time**



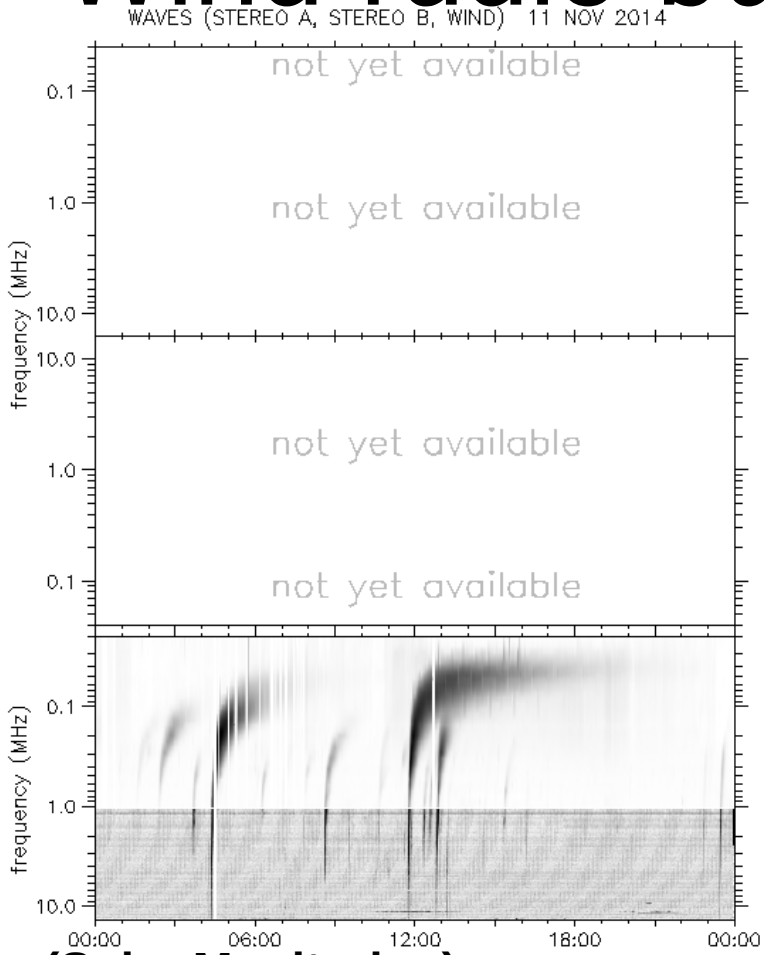


SDO/AIA observations indicate an eruptive process

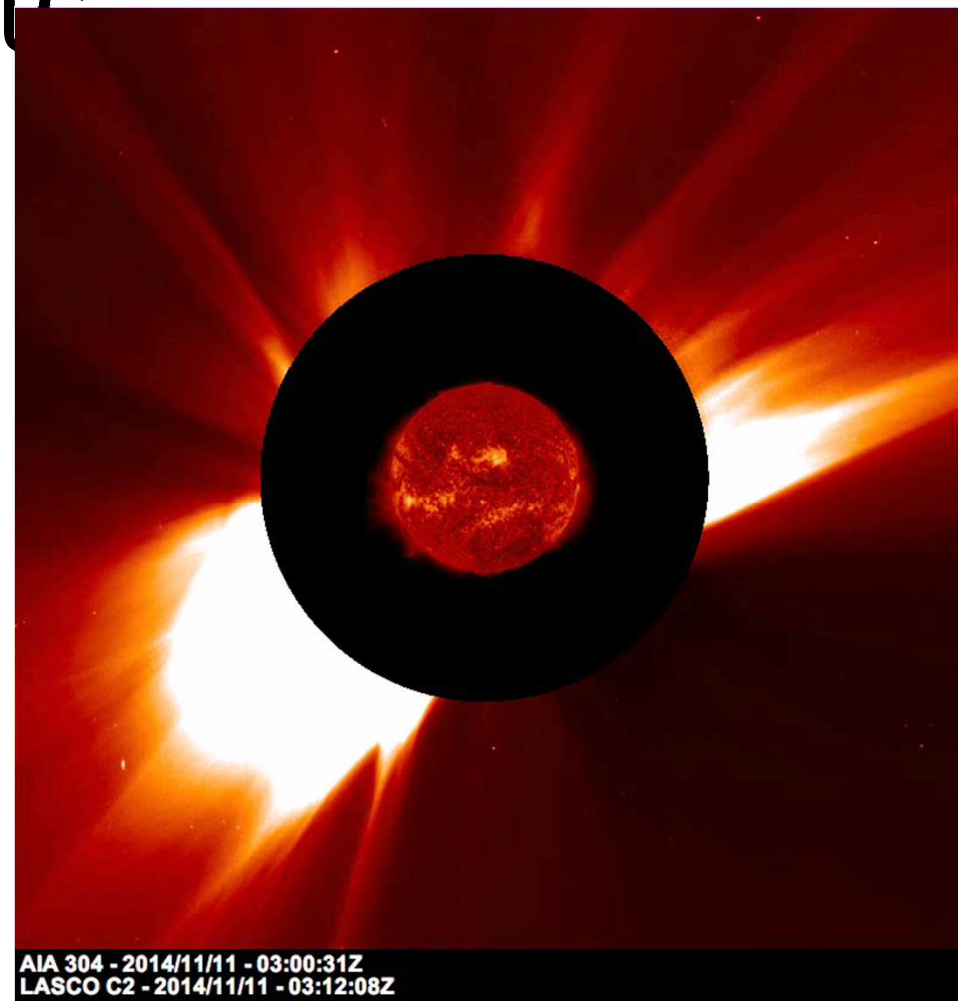




LASCO / C2 & Wind radio bursts



(Solar Monitoring)



2014/11/11

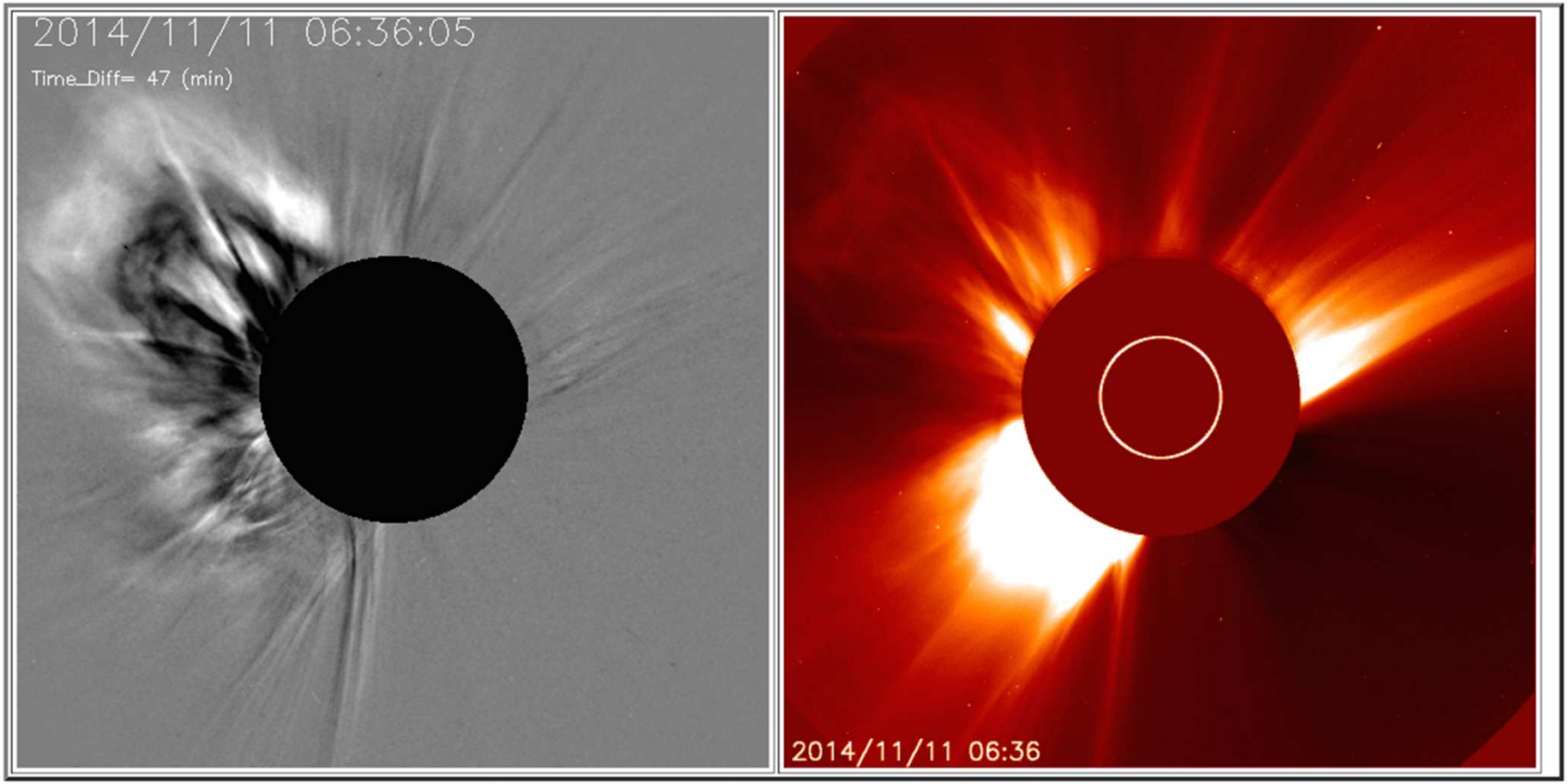


Image of the solar corona, taken by the LASCO coronagraph (C2) on the SOHO observatory

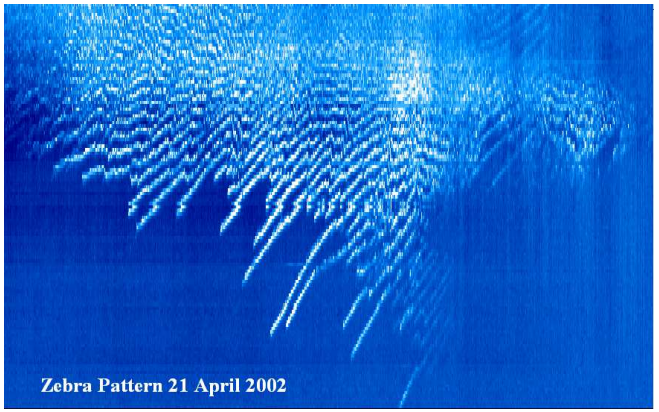
Start | Pause | Faster | Slower | Reverse | Rewind | Next | Prev.

Frame: Displaying 30 of 107 Speed: 1 (frames/sec)

Monthly Table (2014/11)

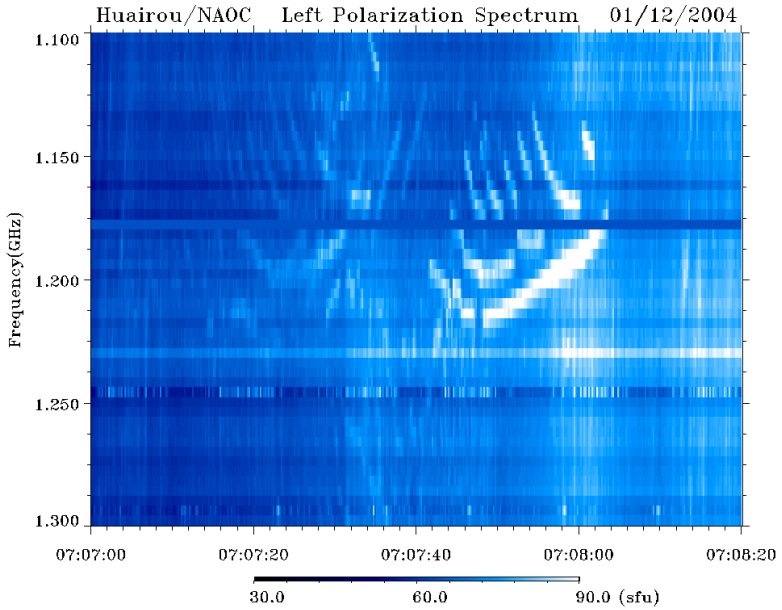
Home

Solar Broadband Radio Spectrpmeter (SBRS/Huairou)



Frequency: 1.10-2.06 GHz(5ms)
2.60-3.80 GHz(8ms)
5.20-7.60 GHz(5ms)

- **Braodband**
- **High time & frequency resolutions**



Fuxian Lake Solar Observatory,
Yunnan Astronomical Observatory, CAS

Average Depth： 87 m

Average r_0 : 12.3 cm (one year)
(Fried number)

Sunshine time： 2200 h/year

From Kunming： 60 km (E102N24)

Altitude: 1722 m

11-m antenna for 70-700 MHz fast dynamic spectrometer

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Radio Astronomy in China

Non-solar dedicated facilities:

- **FAST (500m) in commissioning**
- **QTT (110m) is funded partially**
- **Jingdong Telescope (120m) is approved**

Solar & IP facilities

- **In Meridian II which is approved**

Low frequency in space

- **DCLE in Chang'E**

Meridian-II Project

National Science Infrastructure Project under "13th 5-year plan" program (2016-2020)

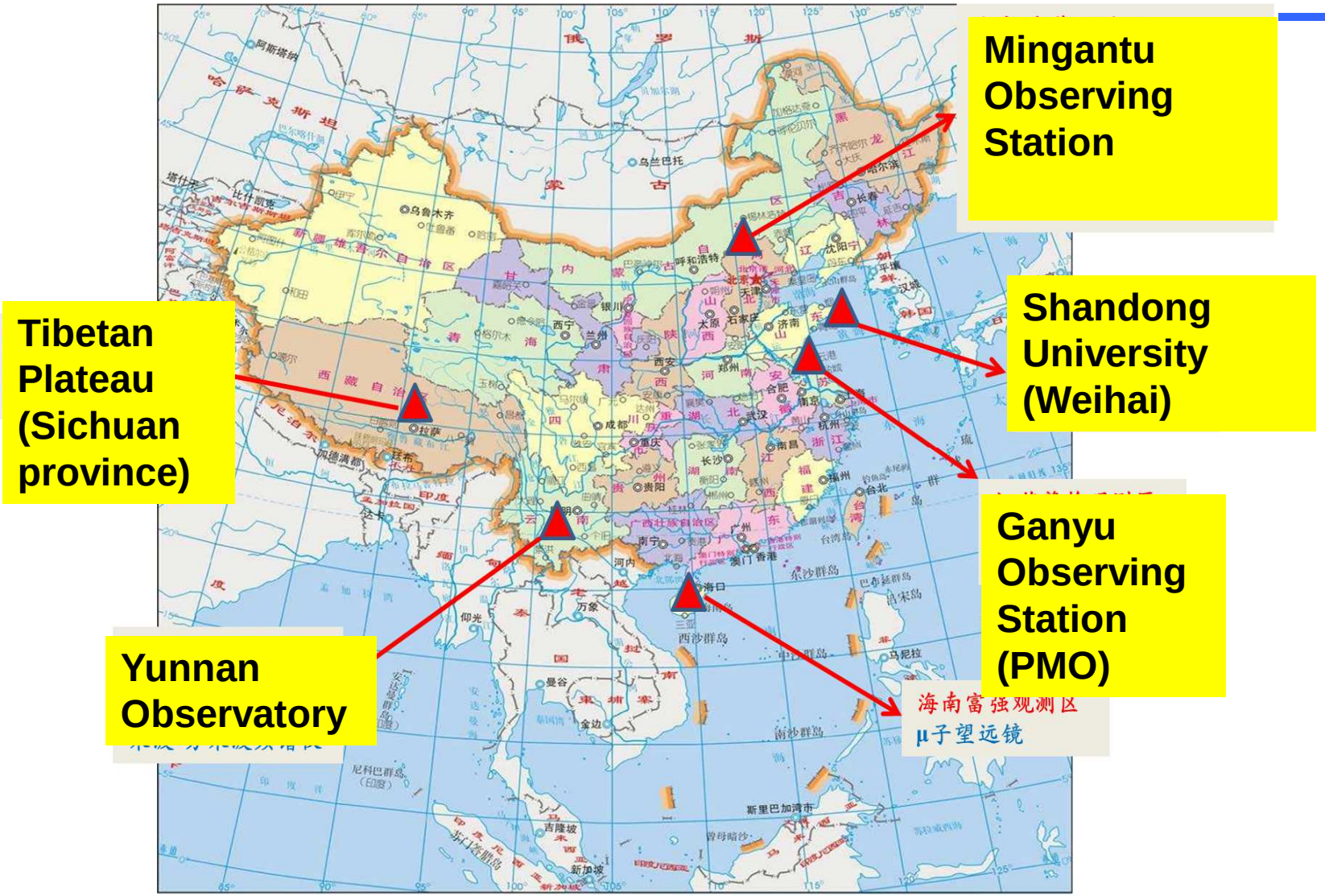
Solar & Interplanetary Subsystem as a new part in Meridian-II:

- **Metric & decametric arrays in Tibetan Plateau (by NSSC) & Mingantu**
- **IPS telescope with 3 stations and 2 frequencies including major one at Mingantu**
- **Coronagraph, magnetograph, etc.**

Use 2 20 m antennas for MUSER-I Calibration

Add 2-3 ~15 m antennas for MUSER-II Calibration

New Solar & IP Facilities in Meridian-II

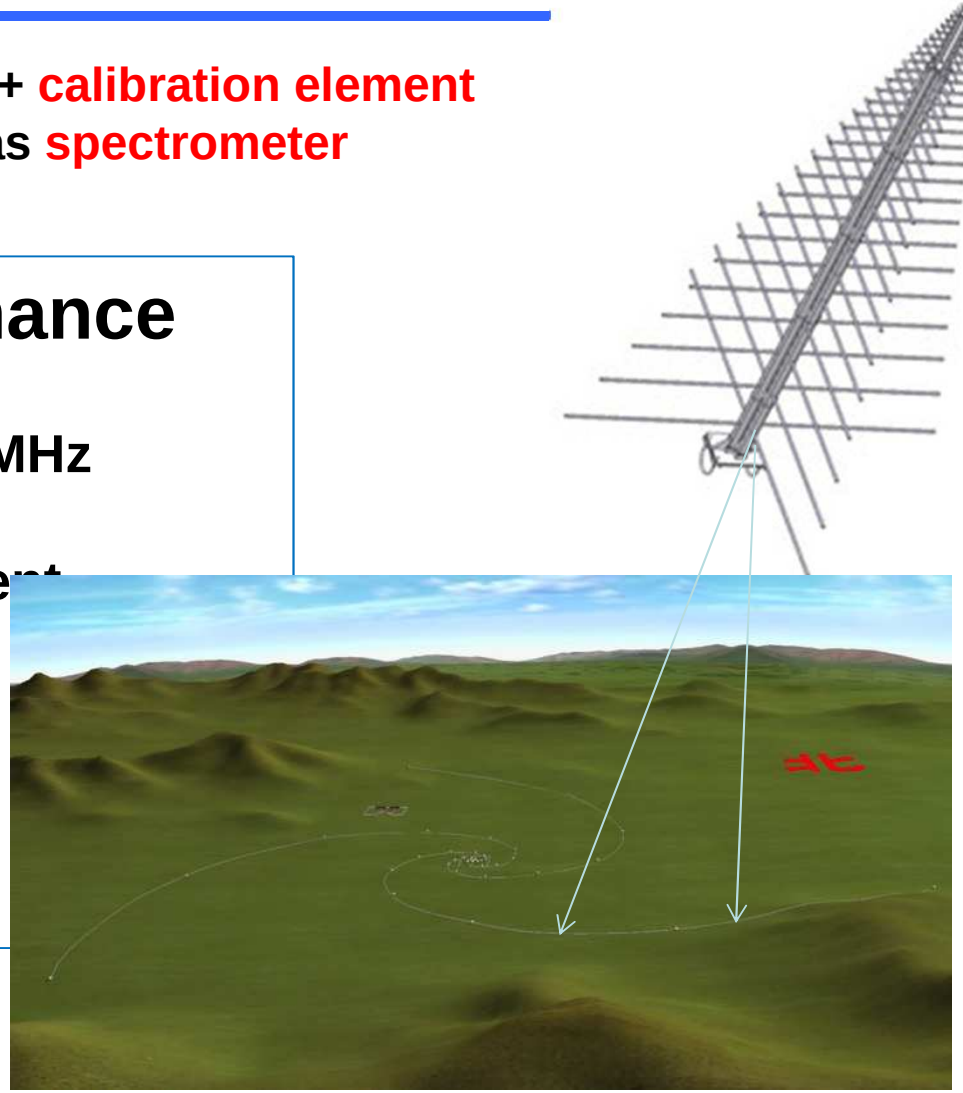


MUSER at metric & decametric wavelengths

- Array of ~100 LPDA elements + calibration element
- Calibration element also use as spectrometer

Straw-man performance

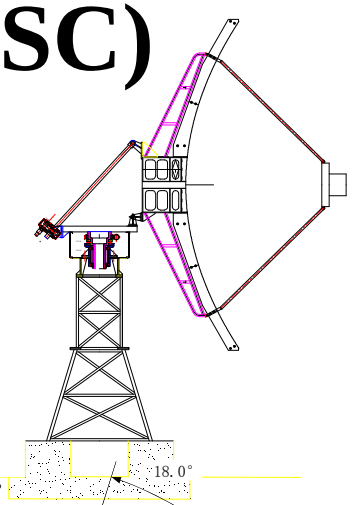
Freq range： 30 ～ 240 (400) MHz
Antennas： ～100 LPDA +
calibration element
Max baseline： ～3000 m
Δf： 1 ~5 MHz
Δt： ~100 ms
Δx： ～(50”)1.4’－11.2’
Polarization： I、Q、U、V



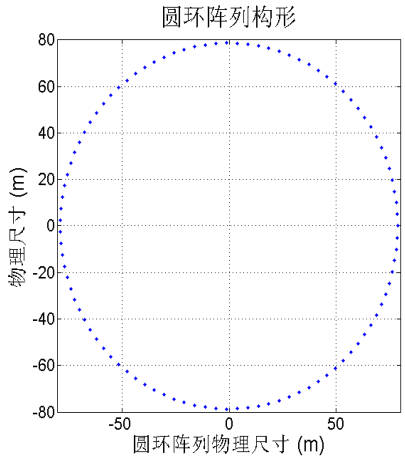
Circular Solar Radio Image Telescope in Tibetan Plateau (NSSC)

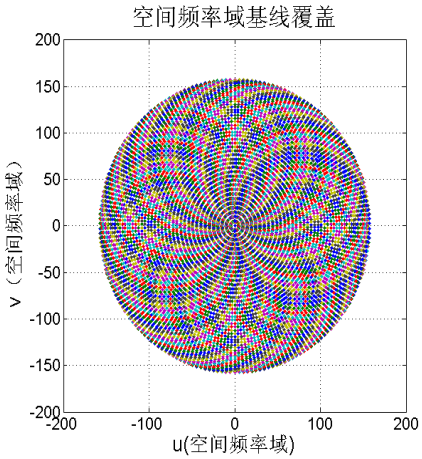
Main specification

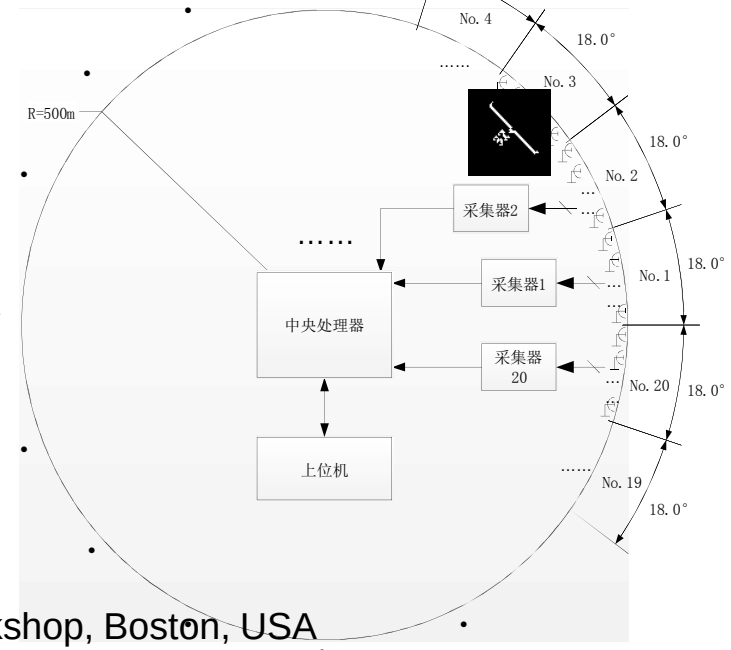
frequency range： 150MHz – 450MHz
Freq. resolution：2MHz（image），<10KHz（spectra）
Time resolution：0.1s（event）， 1s（daily）
Space resolution：≈4‘50“(150MHz)，≈1’37” (450MHz)
Antennas：401
maximum baseline ：1000m
antenna diameter：4m-6m
polarization：（H、V）



Configuration & uv coverage

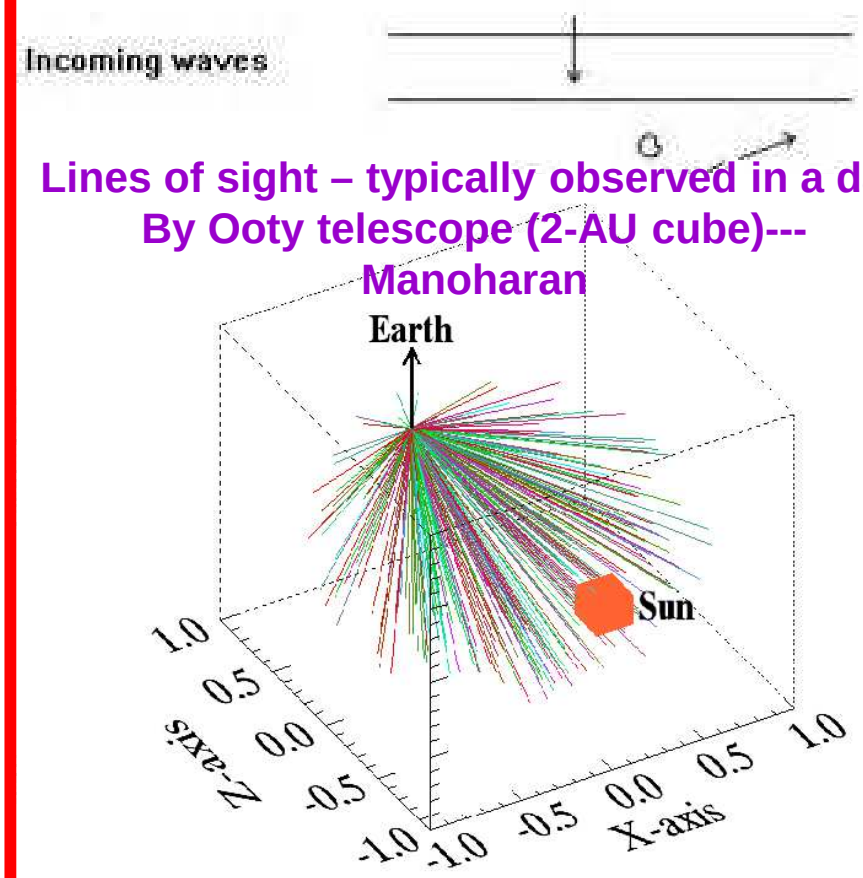






Interplanetary scintillation (IPS)

Current facilities: (ORT, MEXART) 1 station with larger collecting areas
(STEL) multiple-stations with intermediate size

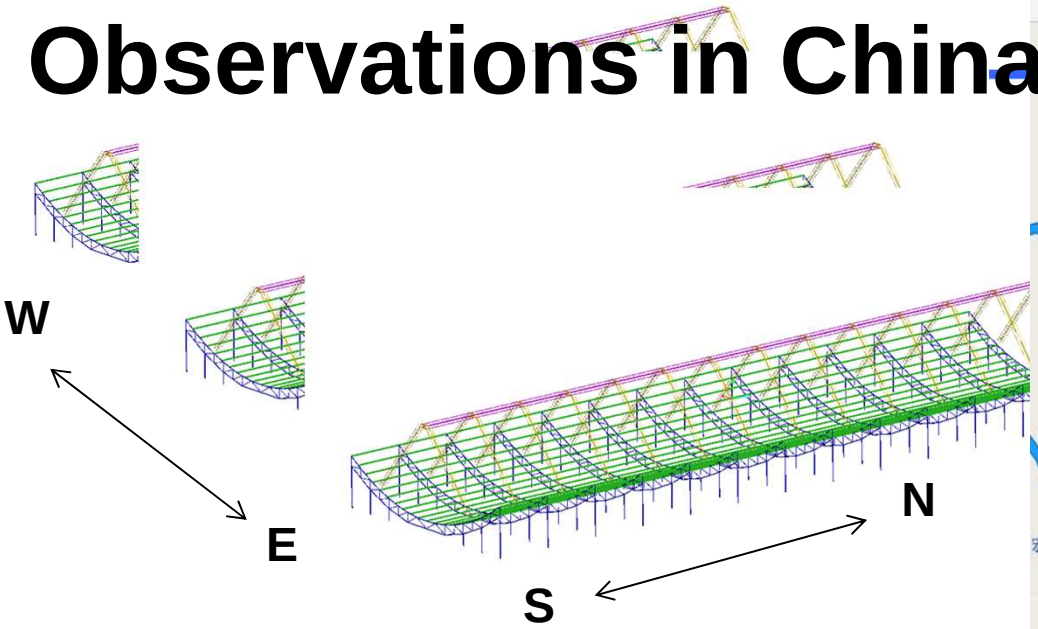


Lines of sight – typically observed in a day By Ooty telescope (2-AU cube)--- Manoharan

Multiple Station IPS
100*20 ＋74*27 m antennas
~100 radio sources
v deduced from measurement

So, IPS technique applies "CT" to reconstruct 3-d solar wind structure. It would desire to achieve direct measurements from observing more radio sources!

A New Telescope Concept for IPS Observations in China (Yan et al. 2017)



- **Mingantu IPS Main Station with 3 140 m (NS) * 40 m(EW) cylinders with collecting area ~ Ooty telescope**
- **Two sub-stations with ~> Φ10m steerable parabolic antennas**

(Profs. Ramesh and Manoharan are gratefully acknowledged for the comments and suggestions to improve the design for Chinese IPS telescope.)

Summary

- **Solar & Interplanetary sub-system has been included in Meridian-II project**
- **China Solar Radio observing facilities will play important role in future space weather studies and monitors.**