A New Radioheliograph at Nobeyama

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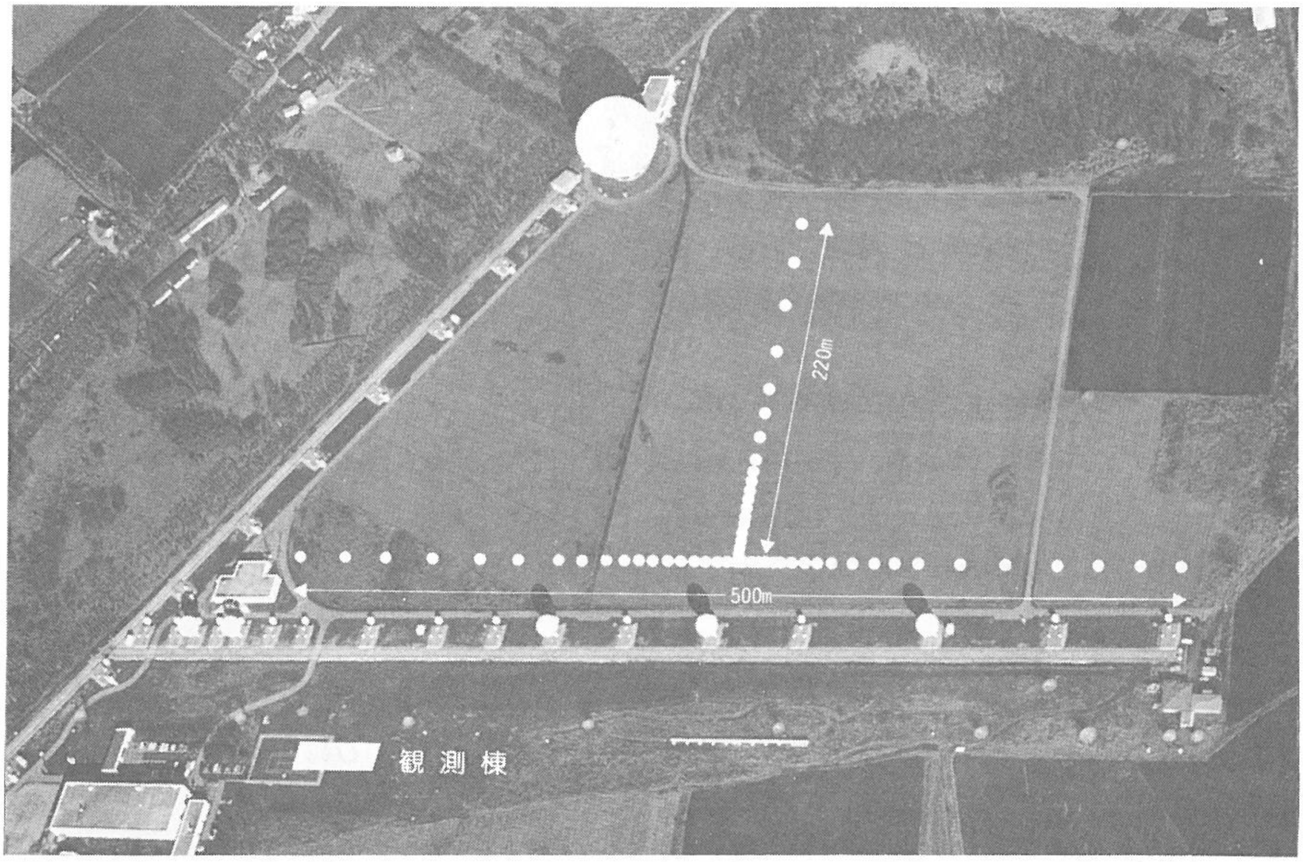


Construction: 1990 and 1991 fiscal years
start observations in summer 1992

Main Purpose:
Two dimensional map in short cm – mm wavelengths

Solar flares: First priority
transient phenomena
in small, restricted area ($\leq 3' \times 3'$)
highly time varying (≤ 1 s)

Global structures: chromosphere – transition region structures
stationary
whole Sun

Scientific Objectives

Solar flares :

explosive release of energy stored in coronal mag. field.

↓

essential to reveal coronal magnetic field structure and its time development in various phases of a solar flare.

Nobeyama Radioheliograph :

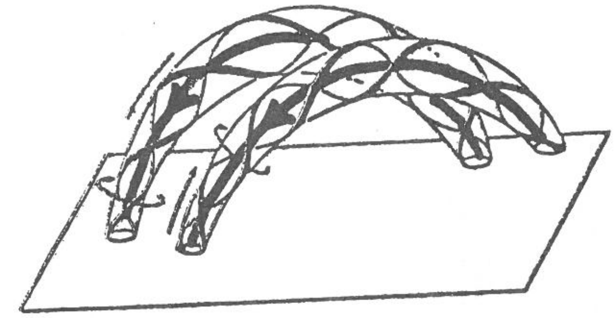
get such information through observations of radio emission from high energy electrons generated in a flare region

Phase	Time Scale	Characteristics	Observed Phenomena
Build Up	~ day	energy store in coronal mag. field	shear of mag. field emergence of new mag. field
Preflare	tens of min.	beginning of collapse of coronal mag. field	pre-heating variation of pol. str. of μ-wave sources (prominence CME)
Flash	~ min	explosive release of mag. energy	particle acc. & heating Shock wave generation
Post-Burst	tens of min.	gradual relaxation of coronal mag. field	gradual plasma heating & acc. plasma motion

1. A Simple Loop or Archade

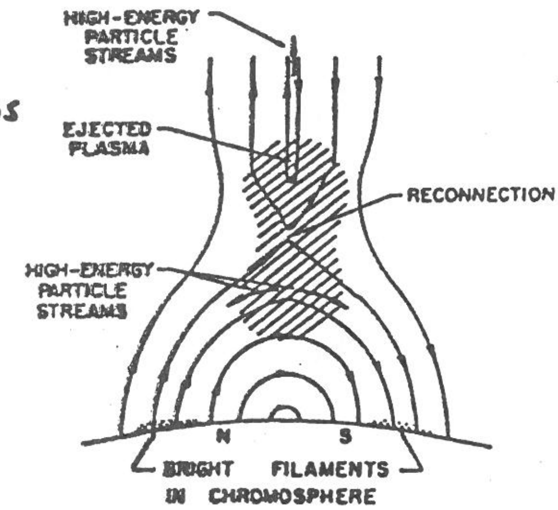
Anomolous registivity

2. Current Sheets between Two Loops



Gold & Hoyle model
Tajima & Sakai

3. Large Scale Current Sheets between Open Mag. Field Lines



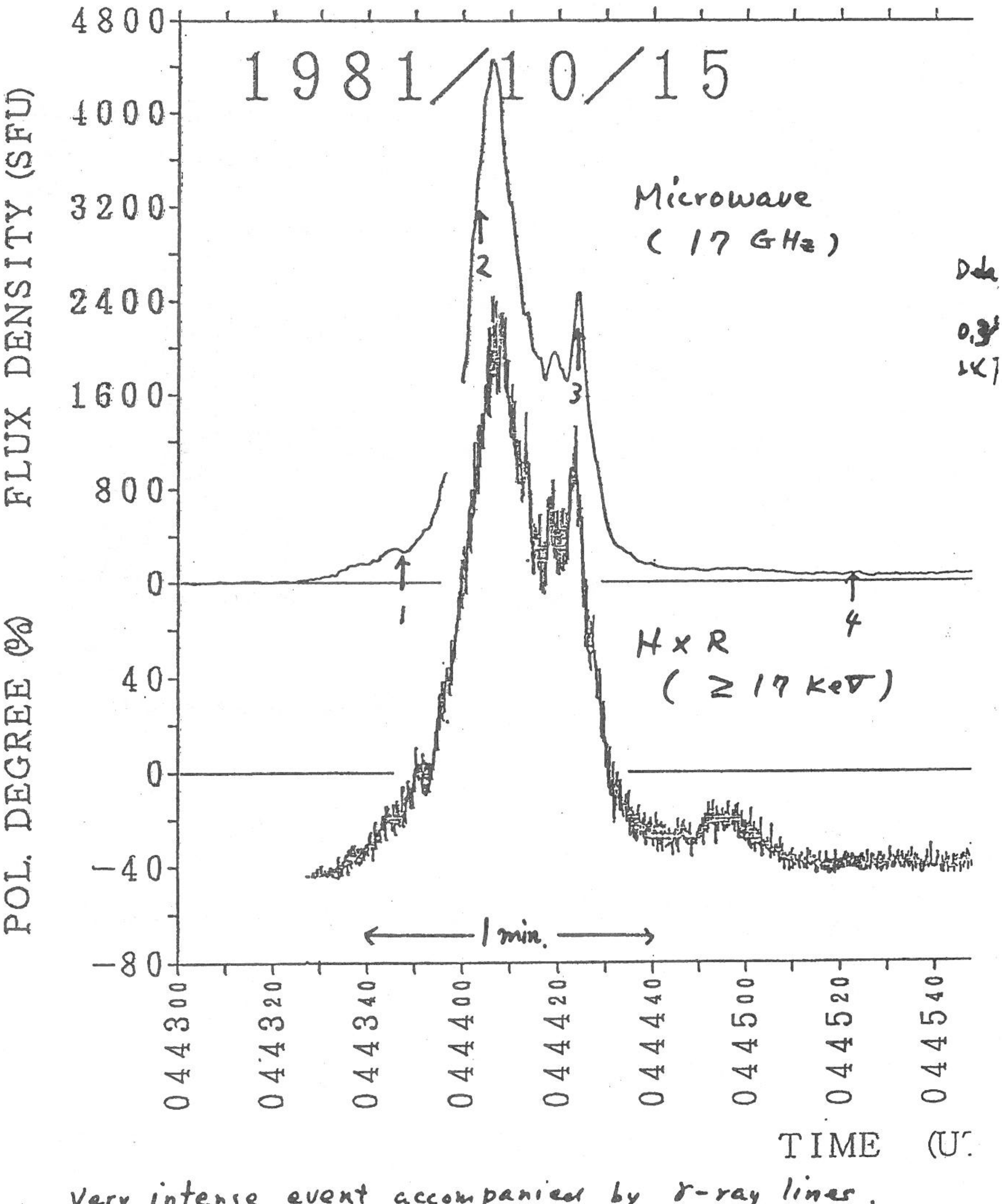
Sturrock model

4. Shock Acceleration

What flare mechanism actually works,
and
Whether different kinds of flares correspond to different flare mechanism.

1981 Oct. 15 Event

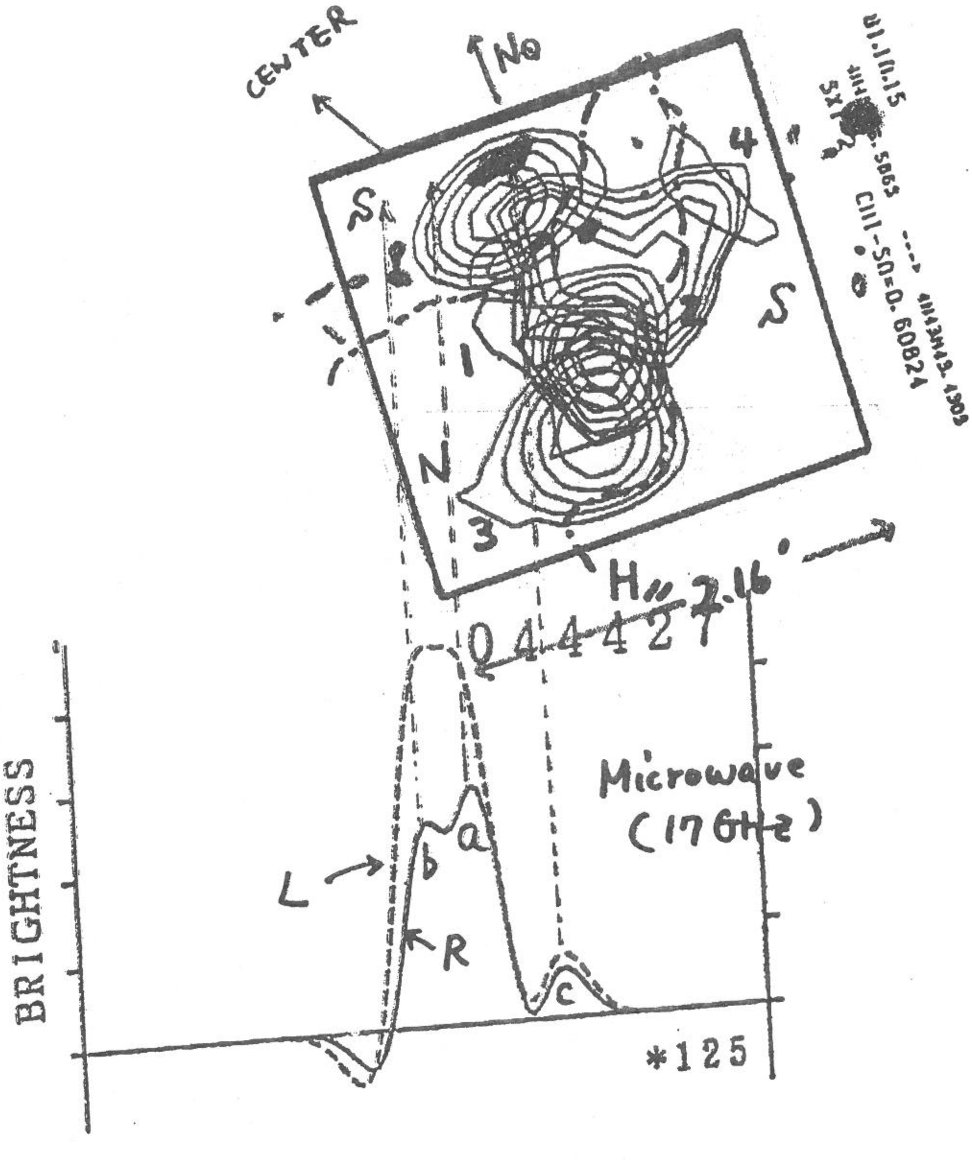
(Nitta, Dennis, & Kiplinger 1990; Nakajima et al.)



Very intense event accompanied by γ-ray lines.

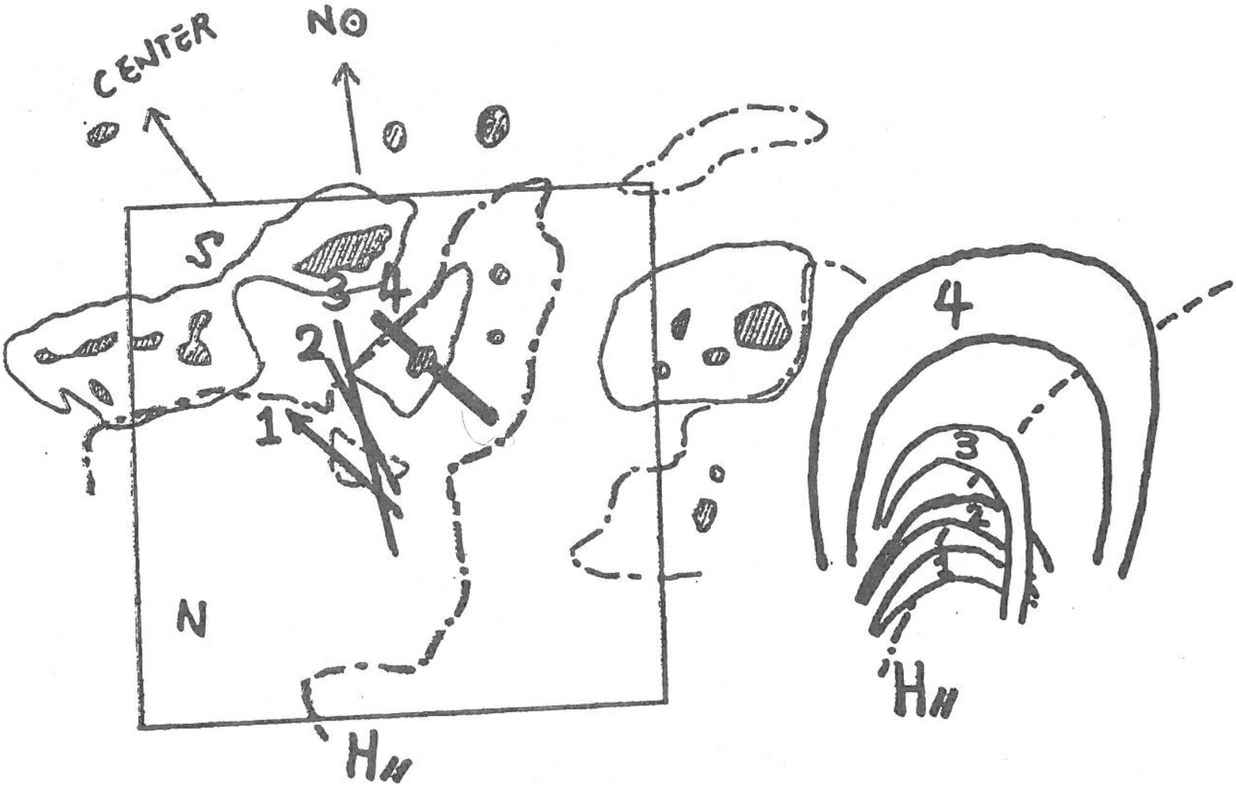
Microwave and HXR peak times coincide within 0.3 s.

1981 Oct. 15 Event



a, b, c sources flare up simultaneously with accuracy of ≲ 0.4 s.

1981 Oct. 15 Event



1) Impulsive phase is associated with a sheared magnetic loop, while decay phase with a less-sheared magnetic loop.

2) Different peaks correspond to different loops. The growth of the loop is not a continuous process, but a discrete jump from one loop to other loop.

Very interesting event.

Much more examples will be observed with both Radioheliograph and Solar-A in systematic way.

Requirements for Radioheliograph

should be designed mainly for solar obs..

1. Observing Frequency : in optically thin region
2. Wide Field of View : the whole Sun

   to catch flares whenever those occur on the Sun.

   Systematic study

   Complete sampling
3. Images of High Dynamic Range

   to reveal the whole structure of flare region.

4. Spatial Resolution : several arc sec

5. Temporal Resolution : << 1 s

   to trace streaming of high energy electrons.

6. Accurate Determination of Absolute Position

   for comparison with observations at other frequencies (Hα, X-ray).

   Multi-frequency observations become increasingly important for solar flare study.

Spatial resolution $(0.5 \times \frac{\lambda}{L})$: 8 arcsec
Limited by land problem.

Temporal resolution : 50 ms , 1 s

$$\Delta T \lesssim \frac{\text{Spatial Res.}}{\text{Velocity of 100 keV ele.}}$$

Polarization : Right and Left circular pol.
Accuray $\left(\frac{R-L}{R+L} \right) \lesssim 0.01$

Observing time : ± 4 hrs summer
± 2.5 hrs winter
Limitted by overlapping of adjacent antennas

<u>Why we choose "multiple T-array"</u>

1) Vast amount of high time resolution data
Necessity of real time monitor
⇩
require high speed imaging

Fourier synthesis is done very fast with equally spaced T-array.
Aerial calibration can be easily made by making use of redundancy of antenna arrangement.

2) Determination of absolute position of flare images for comparison with Hα, X-ray images.
By using the sharp limb of the whole Sun image of high quality, obtainted with the dense array of d, 2d, and 4d.
Accuracy : $\lesssim$ 5 arcsec from simulation.

Design and Characteristics of Radioheliograph

Phase Calibration

consists of small antennas.
can not use radio stars as calibration sources, but use only the Sun itself.

⇩

Self-Calibration System using redundancy of equally-spaced T-array.

developed for both 17-GHz interferometer at Nobeyama and 8-cm Radioheliograph at Toyokawa.

Expected Dynamic Range of Images

100 : 1 for snap-shot mode
1000 : 1 for rotational synthesis mode with observing time of 30 min.

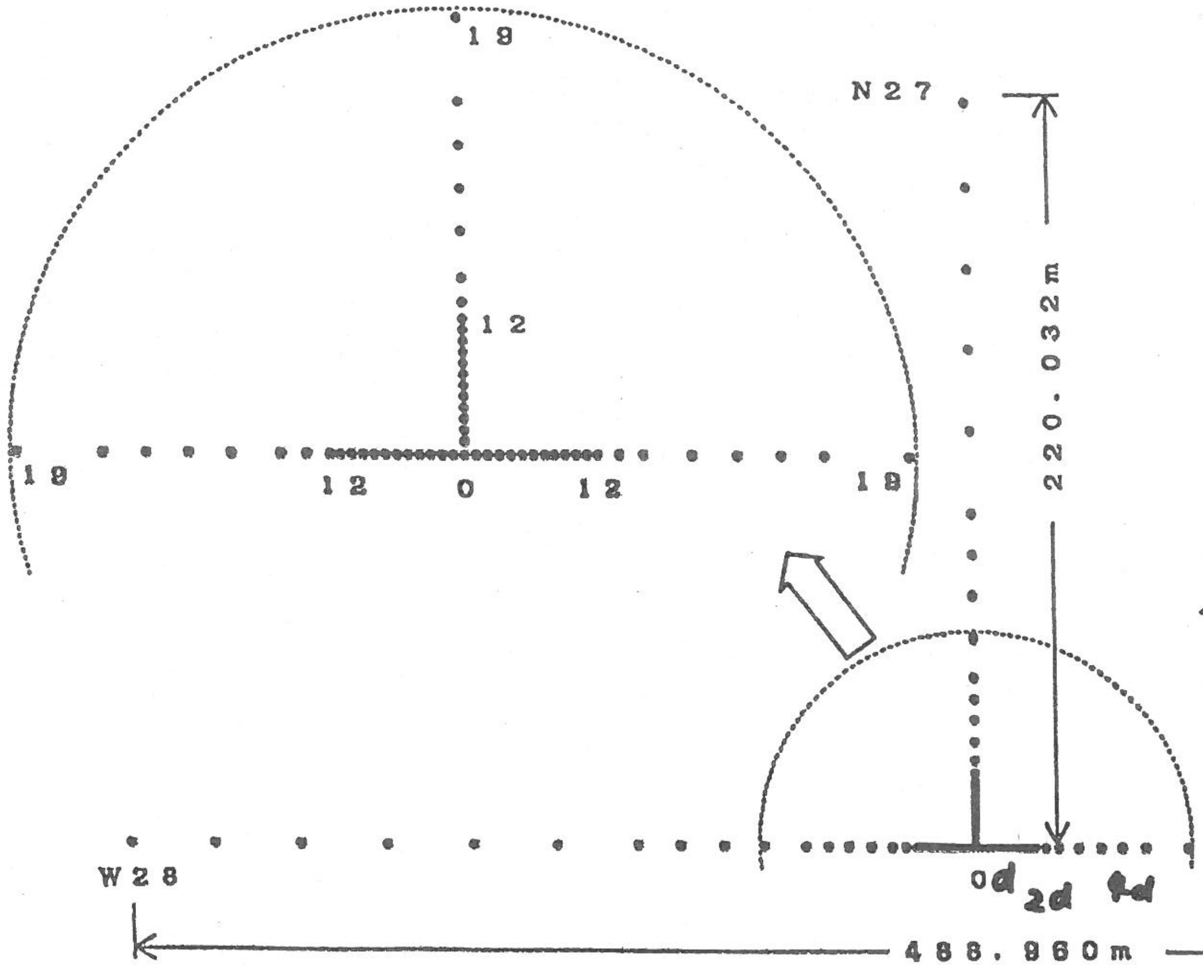
Two Frequency Operation at 17 GHz and 34 GHz

in near future (probably, immediately after completion of Radioheliograph at 17 GHz)

Front-end for two-frequecy operation is design and tested.

	17 GHz	34 GHz	
Spatial Reso.	8"	4"	
Temporal Reso.	100 ms	100 ms	Both operation
	50 ms	51 ms	Either

Array Configuration



Obs. frequency : 17 GHz

Ant. diameter : 80 cm

⇒ BW : 90 arcmin

number : 84

Array configuration : Multiple T-array

dense : inner part

sparse : outer part

to sample UV-plane uniformly in rot. synthesis mode

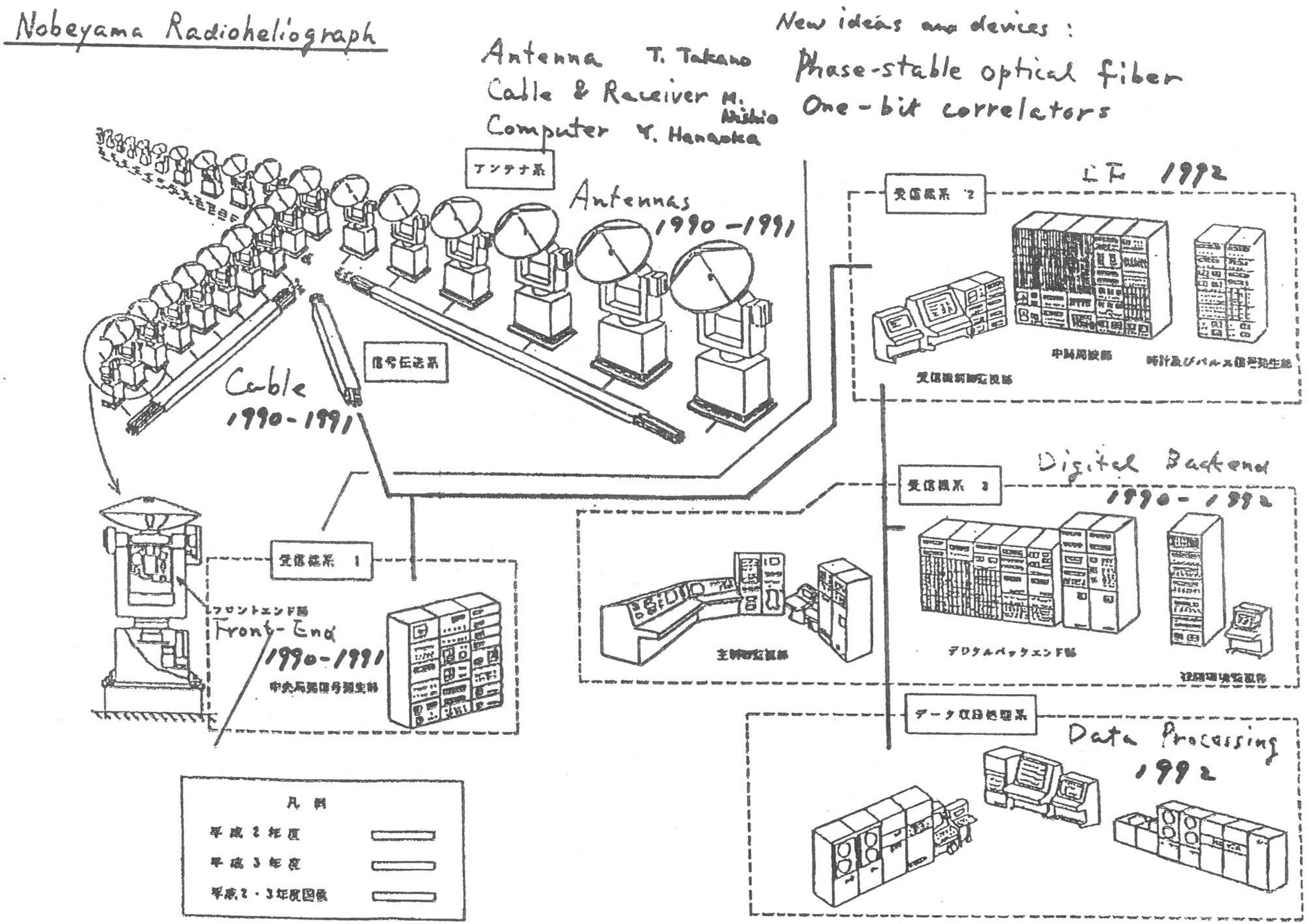
d, 2d, 4d, 8d, 16d

d = 1.528 m (~ 87λ)

⇒ FOV : 40 arcmin

Array of 16d + 8d : Snap-shots for flares

Rotational synthesis (≥ 30 min) : Whole Sun maps for large scale str. or flare build-up.



Nobeyama Radioheliograph
New ideas and devices :
Phase-stable optical fiber
One-bit correlators
Antenna T. Takano
Cable & Receiver M. Nishio
Computer Y. Hanaoka
アンテナ系
Antennas 1990-1991
信号伝送系
Cable 1990-1991
受信系 1
フロントエンド部
Front-End 1990-1991
受信系 2
IF 1992
中間周波部
時計及びパルス信号発生部
受信機制御監視部
受信系 3
Digital Backend 1990-1992
主制御監視部
デジタルバックエンド部
データ収録処理系
Data Processing 1992
凡例
平成2年度
平成3年度

Comparison between VLA and N Radioheliograph

	VLA (15 GHz)	N Radioheliograph (17 GHz)
Field of View	3.5′	full Sun (40′)
Spatial Reso.	~1″ (C)	~10″
Temporal Reso.	1^s	50 ms
Number of Antennas	27	84
Number of Correlators (Nc)	243	1,568
Number of Pixel (Np)	44,000.	58,000.
Nc / Np	$\frac{1}{180}$	$\frac{1}{37}$
Observing Time	several wks/y	whole year

Nobeyama Radioheliograph

lots of large flares, complete sampling
(systematic study)

complementary

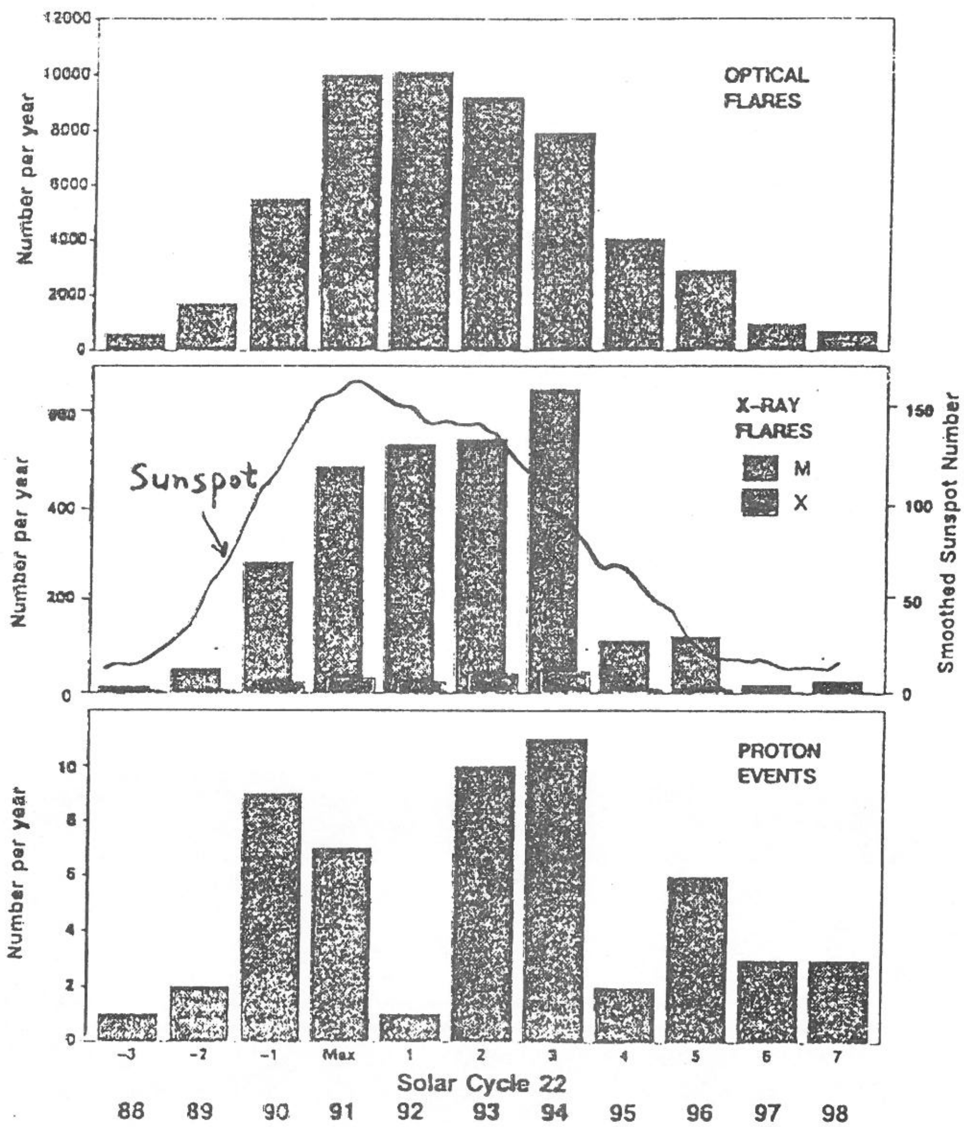
VLA :

small flares, in-complete sampling
(some new finding)

Note that large flares have possibly larger dimension than small flares.

Solar Activity & Satellite Project

Cycle 21 Observations / Projection for Cycle 22



regular observation

Heliograph

Solar - A x, γ

CORONAS x, γ, UV

GEOTAIL Particle