Data Processing System of the Radio Heliograph

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Data processing system
1. Hardware
2. Image Processing
3. Calibration

HARDWARE

Main frame : mainly routine image processing
mini-super computer, < 300 MFLOPS
Workstations : interactive image processing
of Heliograph data, Solar-A data, optical data ...

Construction of the data processing system is in 1991.
— Hardware has not confirmed yet.
This presentation is *our plan.*

BASIC REDUCTIONS ON THE MAIN FRAME

1. Daytime (Real time processing)

1 sec data : Digital backend → Data processing system
- Recording in optical disk (~ 1GB/day)
- Construction and Display of snap shot two dimensional images at every 10 sec

{ display on TV monitor
{ record on video tape (quick look monitor)

video movie — dynamical phenomena

- Plot one-dimensional profile
- Rotational Synthesis at every 60(?) minutes

2. Nighttime

Processing 50 msec data during flares
- Read out from the high speed digital data recorder
- Construction of two-dimensional flare images of high time resolution.
- Other reductions

SNAP SHOT

uv-plane — antenna plane
observing the sun projected to the antenna plane
correlation data : north-arm – east-arm, north-arm – west-arm
data point : exactly on the grid points (easily to perform FFT)

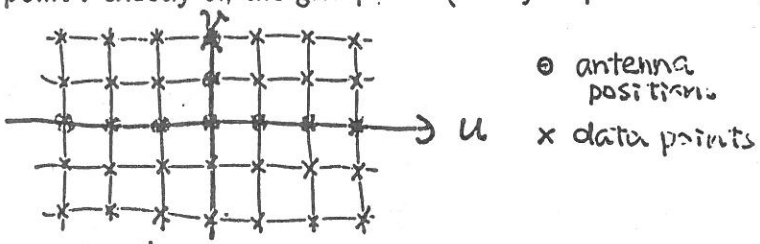
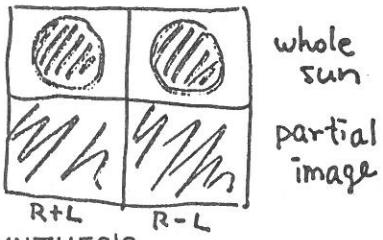


Image construction :

1) FFT — dirty map
2) CLEAN — distorted sun
3) image rotation and stretching — correct image

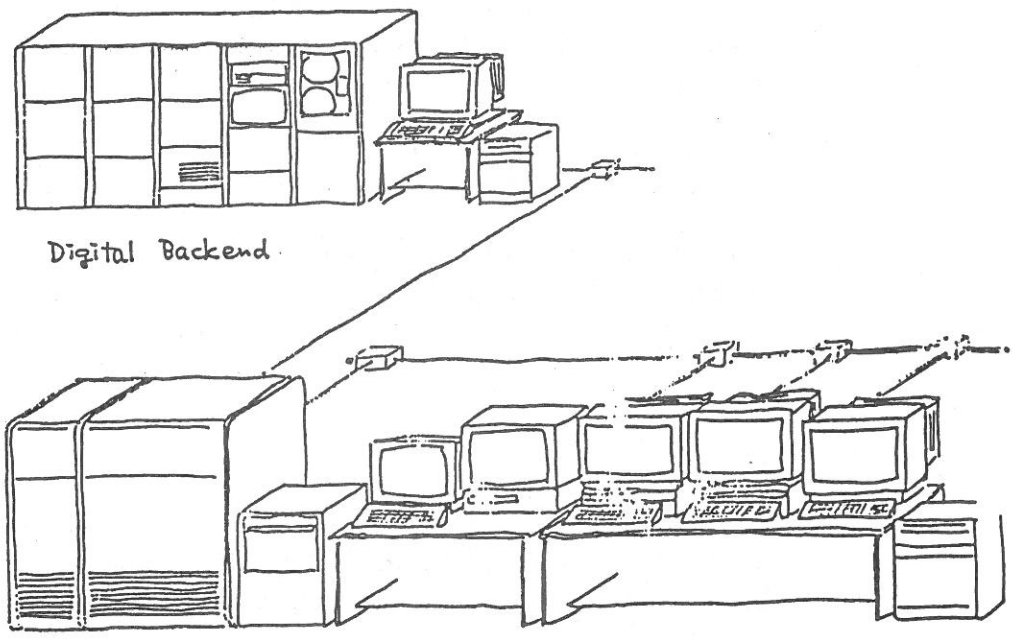


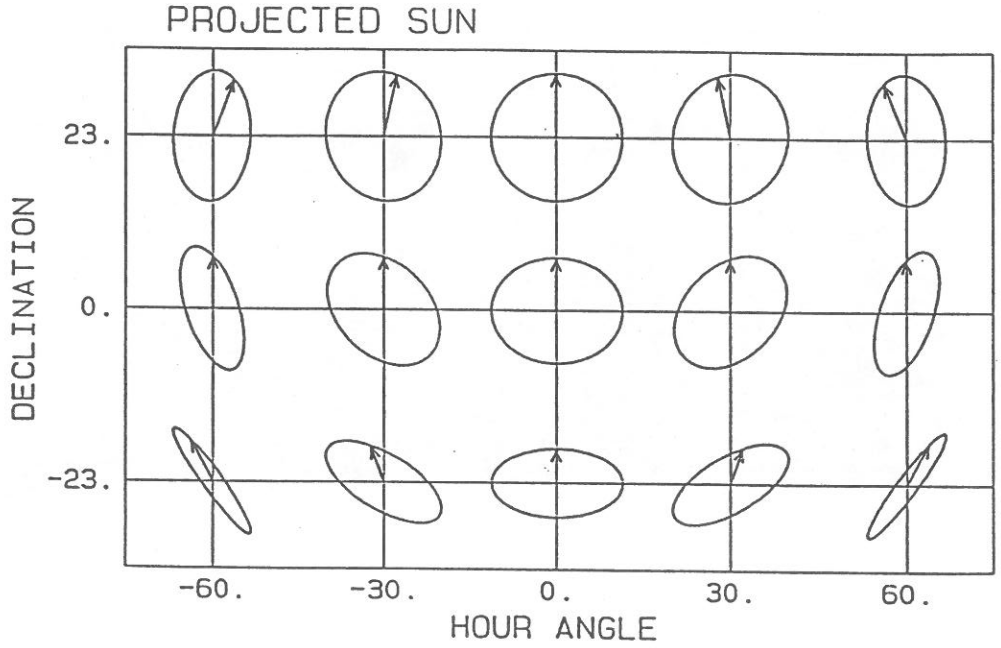
ROTATIONAL SYNTHESIS

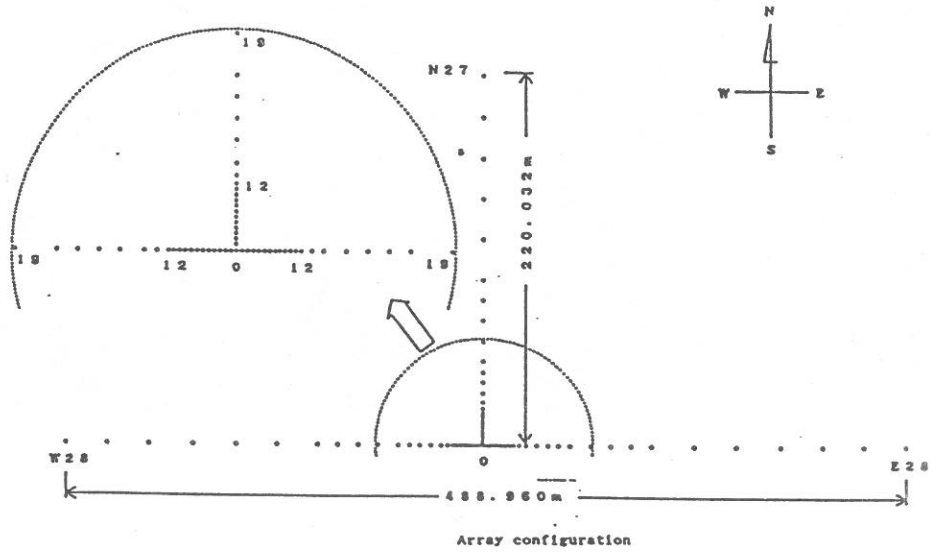
To get high S/N image of the quiet sun
Usual method in radio astronomy, but there are some difficulties for the solar observation :

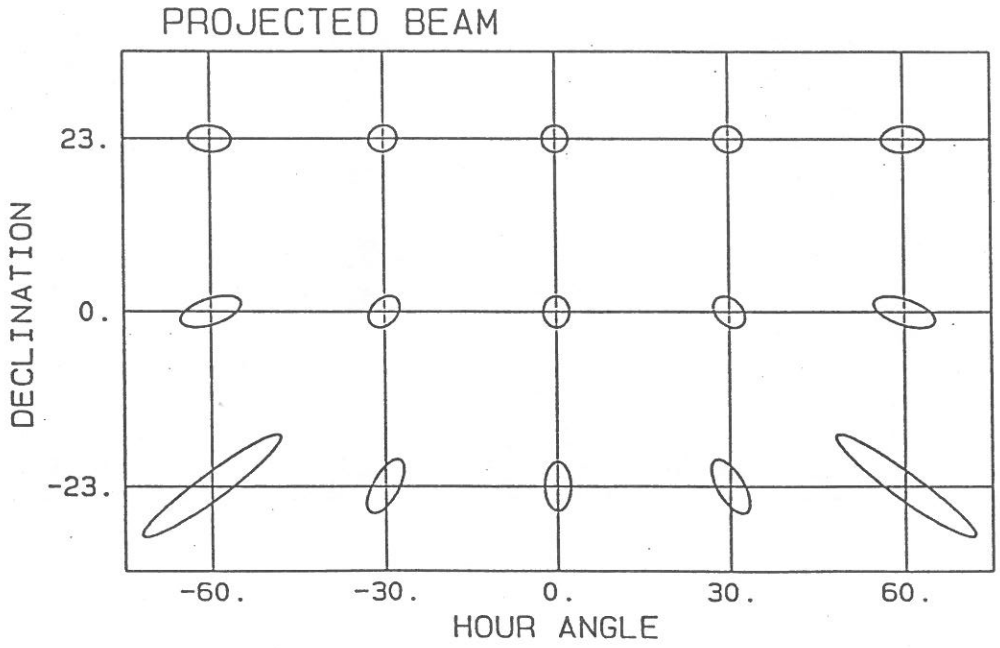
- Time varying structure
- Solar rotation
- Wide field of view

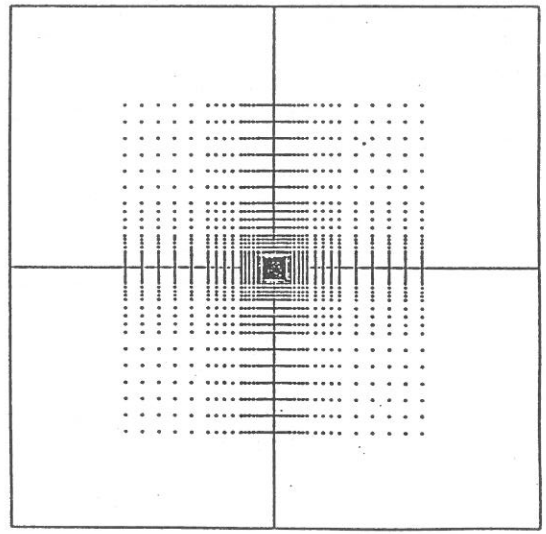
Examples of *uv*-coverage maps and beams

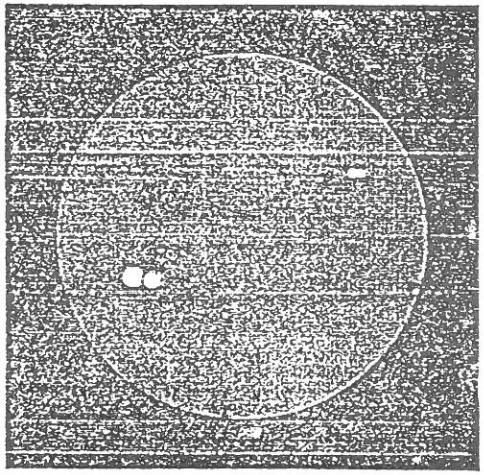



PROJECTED SUN
DECLINATION
23.
0.
-23.
-60.
-30.
0.
30.
60.
HOUR ANGLE

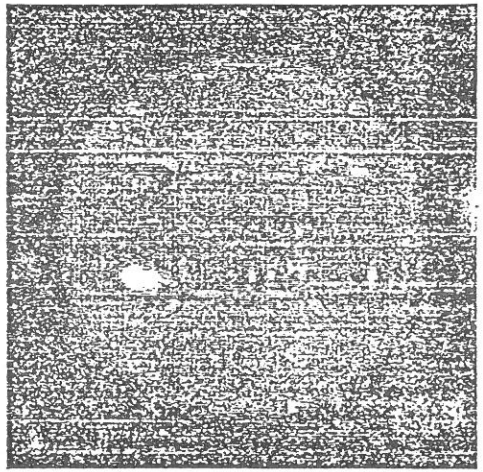

N
W
E
S
N27
220.032m
W28
E28
488.960m
Array configuration


PROJECTED BEAM
DECLINATION
23.
0.
-23.
-60.
-30.
0.
30.
60.
HOUR ANGLE

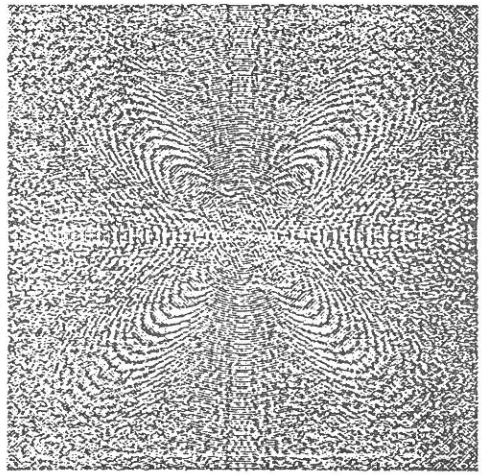




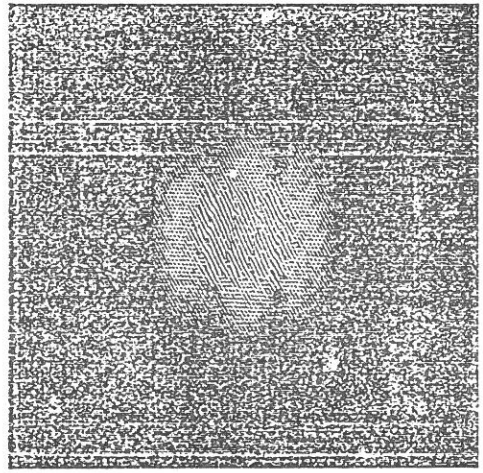
model sun



dirty map

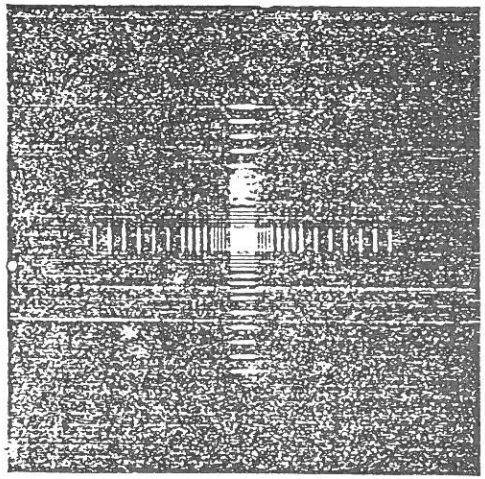


cos

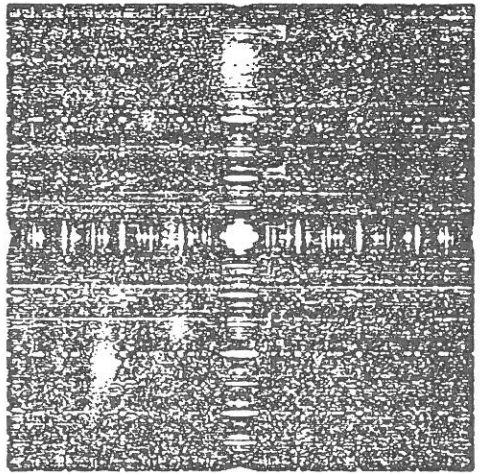


sin

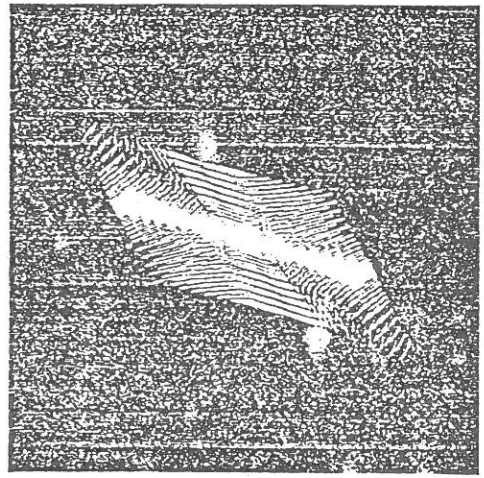
hour angle $-45° \sim -30°$
declination $-23°$



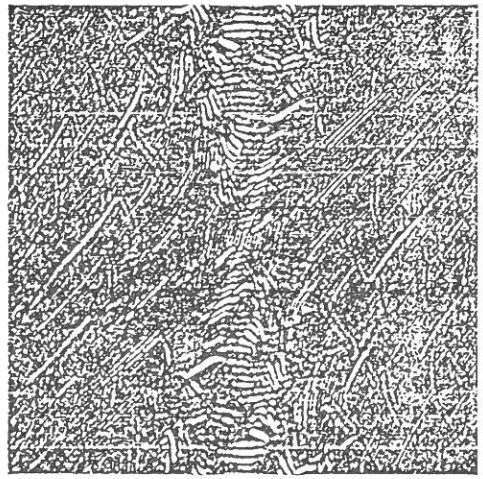
uv-coverage



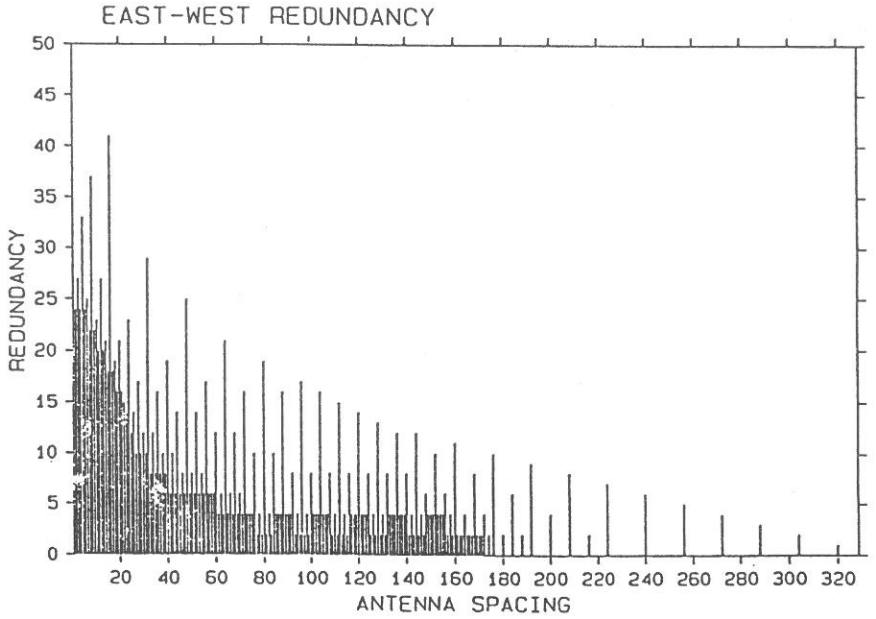
beam

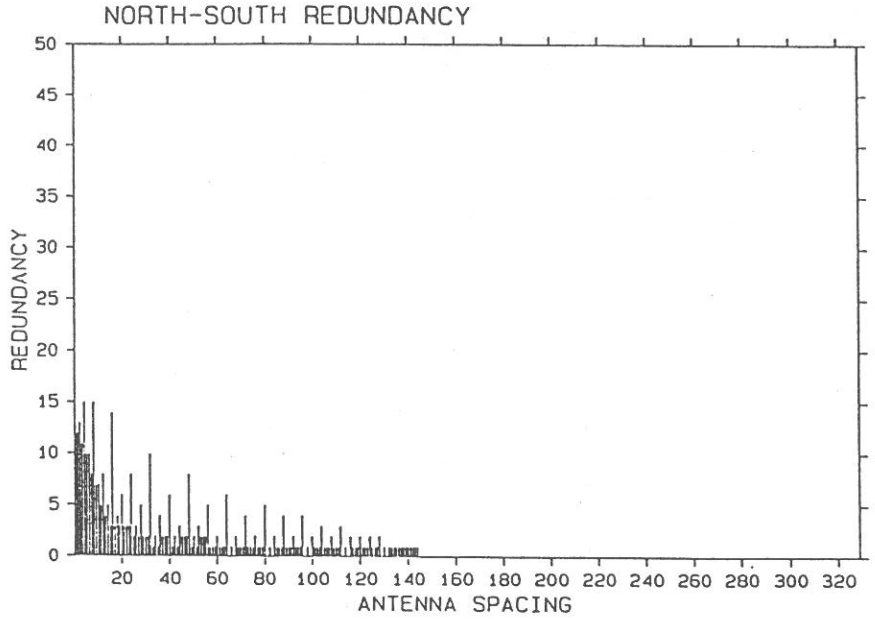


uv-coverage

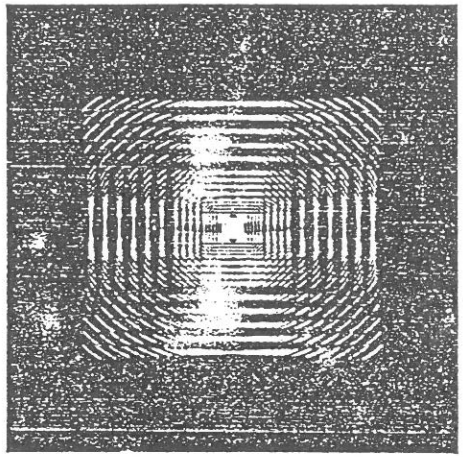


beam

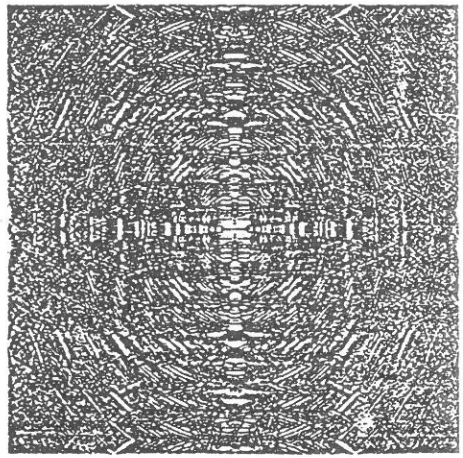




hour angle -7.5^h - 7.5^h
declination $23°$



uv - coverage



beam

CALIBRATION

systematic errors : antenna phase errors and gain errors
— can be cancelled by calibration

calibration with a point source – impossible
small antenna, not cooled detector – cosmic point sources can not be detected
→ self-calibration with antenna array redundancy
One-dimensional data — many antenna pairs of same separation

for phase data :
c_{ij} : observed phase from the correlation of the ith and jth antenna
a_i : phase error of the nth antenna
S_i : true phase

spacing d (fundamental) :

$$\begin{aligned} a_0 - a_1 \quad &\dots + S_1 = c_{01} \\ a_1 - a_2 \quad &\dots + S_1 = c_{12} \\ a_2 - a_3 \quad &\dots + S_1 = c_{23} \\ &\vdots \end{aligned}$$

spacing $2d$:

$$\begin{aligned} a_0 - a_2 \quad &\dots + S_2 = c_{02} \\ a_1 - a_3 \quad &\dots + S_2 = c_{13} \\ &\vdots \end{aligned}$$

and so on.

number of unknowns a_m, S_n < number of correlations
→ least square method