FASR Antenna Size and Configuration

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Strawman FASR Specifications*

Frequency range	~0.1 – 30 GHz
Frequency resolution	0.1%, 0.1 – 3 GHz 1%, 3 – 30 GHz
Time resolution	10 ms, 0.1 – 3 GHz 100 ms, 0.3 – 30 GHz
Number antennas	~100 (5000 baselines)
Size antennas	D = 2 – 7 m
Polarization	IV/QU
Angular resolution	$20/\nu_9$ arcsec
Field of View	$19/(D\nu_9)$ deg

*revised

Does size matter?

Not necessarily!

The SNR on each interferometric baseline depends on system temperature, antenna temperature, whether the source is resolved by an individual antenna, and whether it is resolved by the interferometer.

In general:

$$\Delta T = \left[\frac{T_A^2 + T_A T_{sys} + T_{sys}^2 / 2}{\Delta n \Delta t} \right]^{1/2}$$

When $T_A << T_{sys}$

$$\Delta T \approx \frac{1}{\sqrt{2}} \frac{T_{sys}}{\sqrt{\Delta n \Delta t}}.$$

$$SNR = \frac{T_C}{\Delta T} = \frac{T_C \sqrt{2 \Delta n \Delta t}}{T_{sys}} \propto \frac{T_A}{T_{sys}}$$

$$T_A = \frac{S A_{eff}}{2 k_B}$$

What about cases where $T_A >> T_{sys}$

Case 1: Source is unresolved by either the or by the interferometer (e.g., a bright radio burst)

$$\Delta T \approx \frac{T_A}{\sqrt{\Delta n \Delta t}}$$

$$SNR = \frac{T_C}{\Delta T} \propto \frac{T_A \sqrt{\Delta n \Delta t}}{T_A} = \sqrt{\Delta n \Delta t}$$

$$T_A >> T_{sys}$$

Case 2: Source is unresolved by the antennas but is resolved by the interferometer (e.g., quiet Sun)

Noise is uncorrelated

$$\Delta T \approx \frac{T_A}{\sqrt{2\Delta n \Delta t}}$$

$$SNR = \frac{T_C}{\Delta T} \propto \frac{T_A \sqrt{2\Delta n \Delta t}}{T_A} = \sqrt{2\Delta n \Delta t}$$

$$T_A >> T_{sys}$$

Case 3: Source is resolved by the antennas and by the interferometer (large antennas or high frequencies, quiet Sun)

Noise is uncorrelated

$$\Delta T \approx \frac{T_A}{\sqrt{2\Delta n \Delta t}} \approx \frac{hT_B}{\sqrt{2\Delta n \Delta t}}$$

$$SNR = \frac{T_C}{\Delta T} \propto \frac{T_A \sqrt{2\Delta n \Delta t}}{hT_B} \propto A_{eff} \sqrt{2\Delta n \Delta t}$$

• Unless an antenna resolves the a strong source, its size is largely irrelevant!

• The sensitivity of the VLA is no better than FASR for sources unresolved by the antennas.

• The VLA will be more sensitive than FASR for quiet Sun studies (but this does not mean that FASR cannot do excellent QS studies)

We should choose our antenna size(s) based on sampling in the uv plane and consideration of QS studies (at high frequencies).

FASR Configuration

Radio array configurations are selected according to differing criteria:

Science: imaging properties

ease of deconvolution

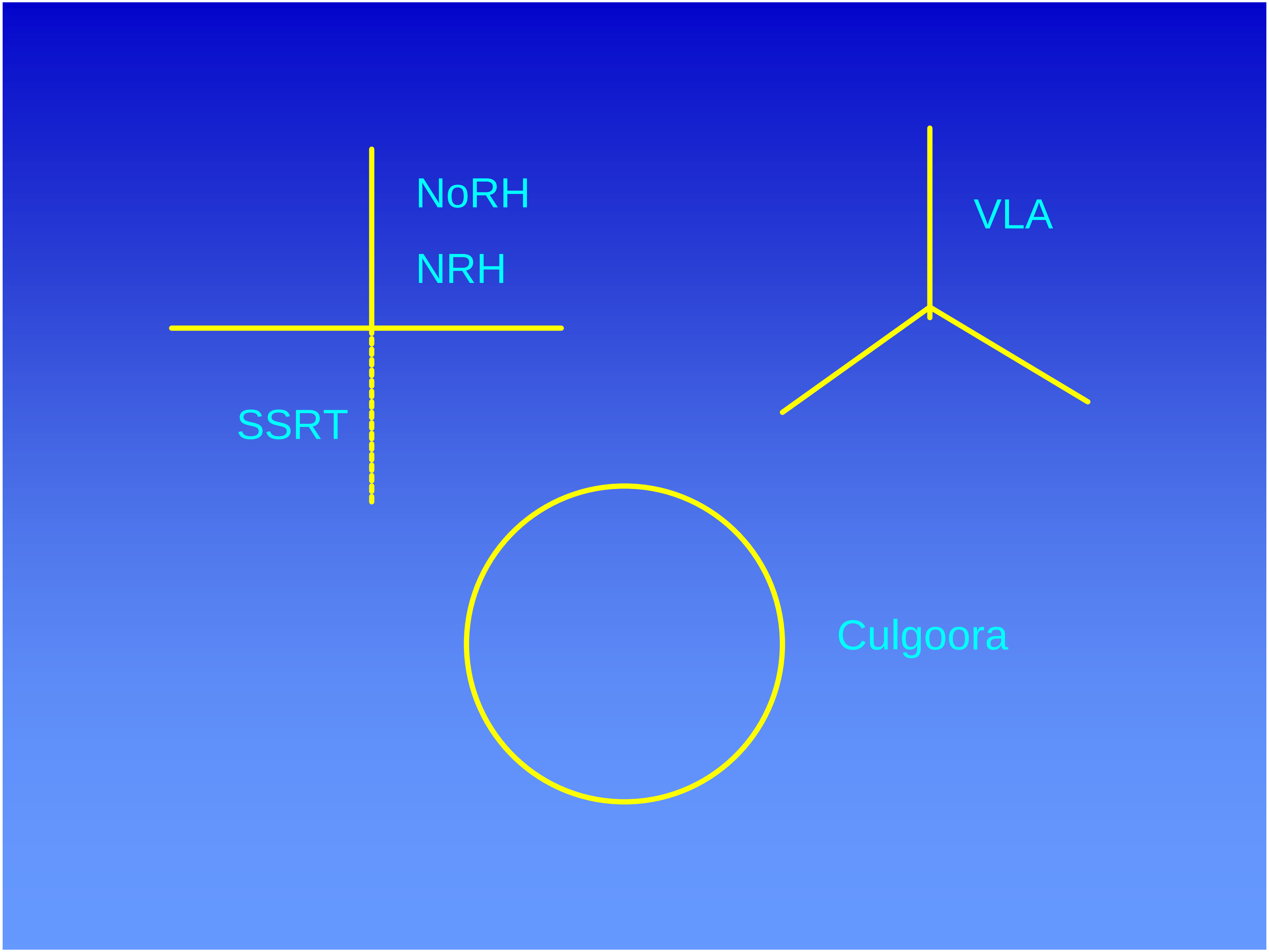
scalability

calibration

Practical: power

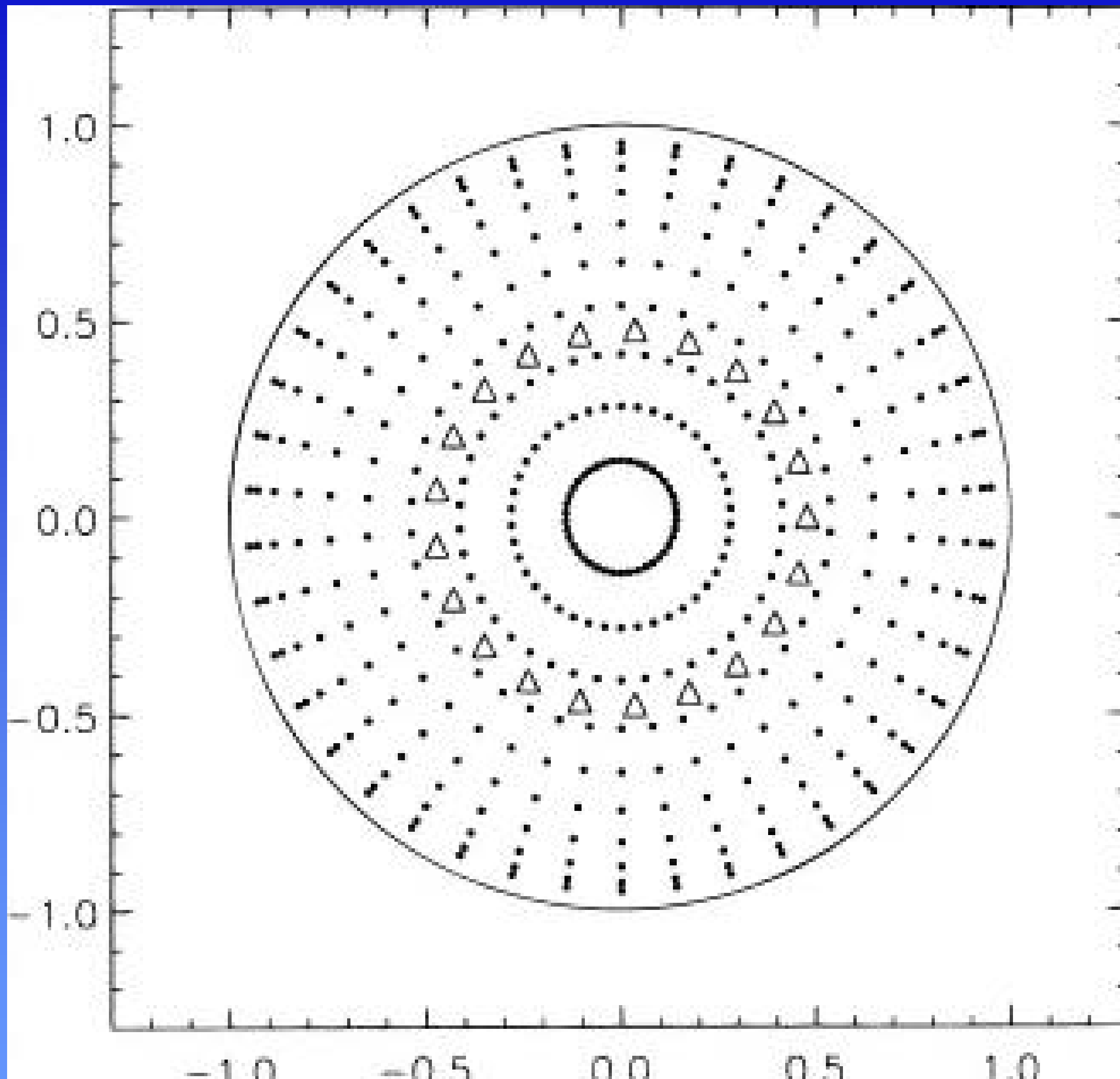
data transmission

antenna moves


NoRH
NRH
VLA
SSRT
Culgoora

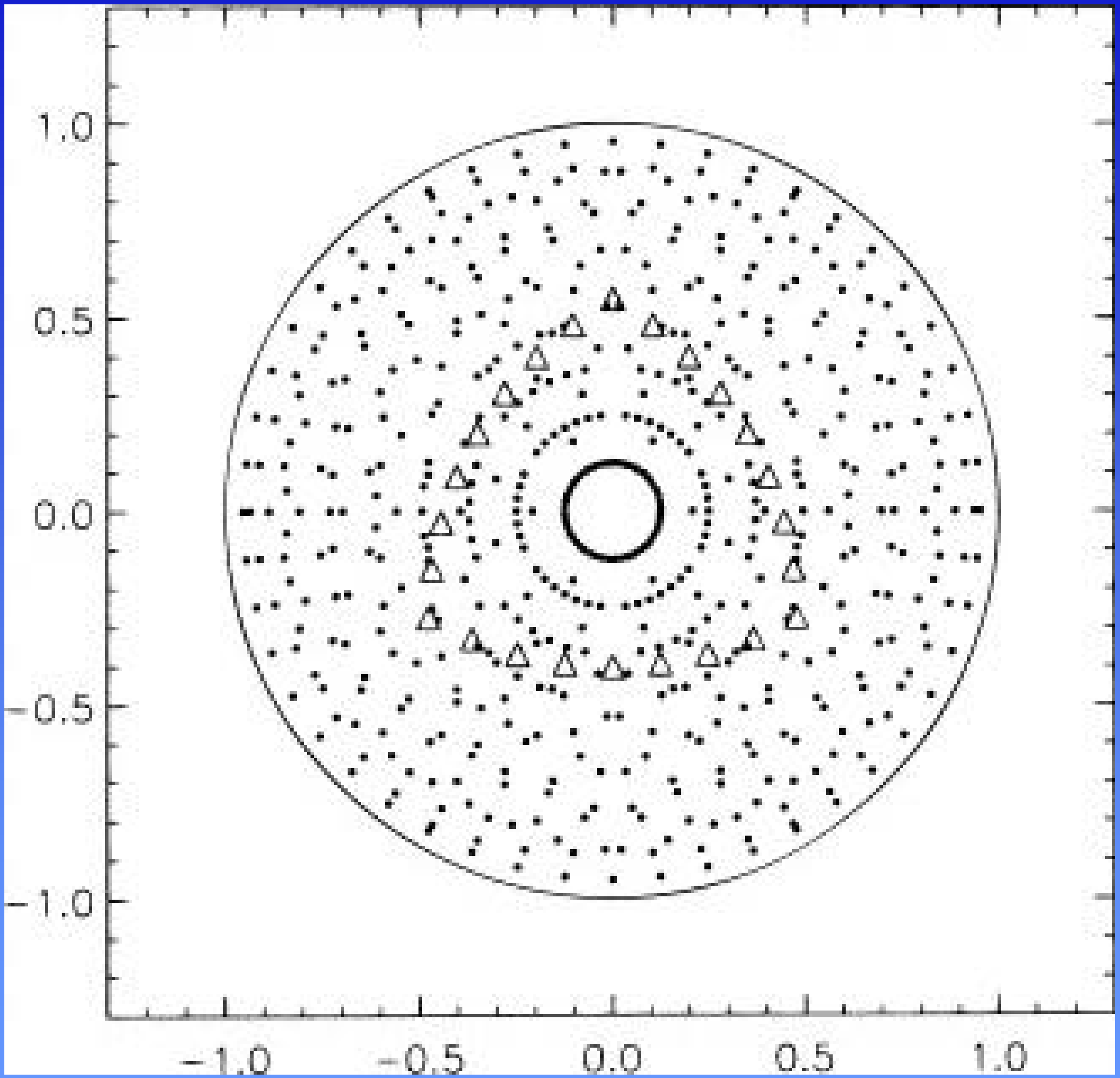
The distribution of antennas has therefore been optimized according to a variety of criteria:

- Uniformity of uv sampling
- Minimization of sidelobes
- Topological constraints
- Operational constraints
- etc

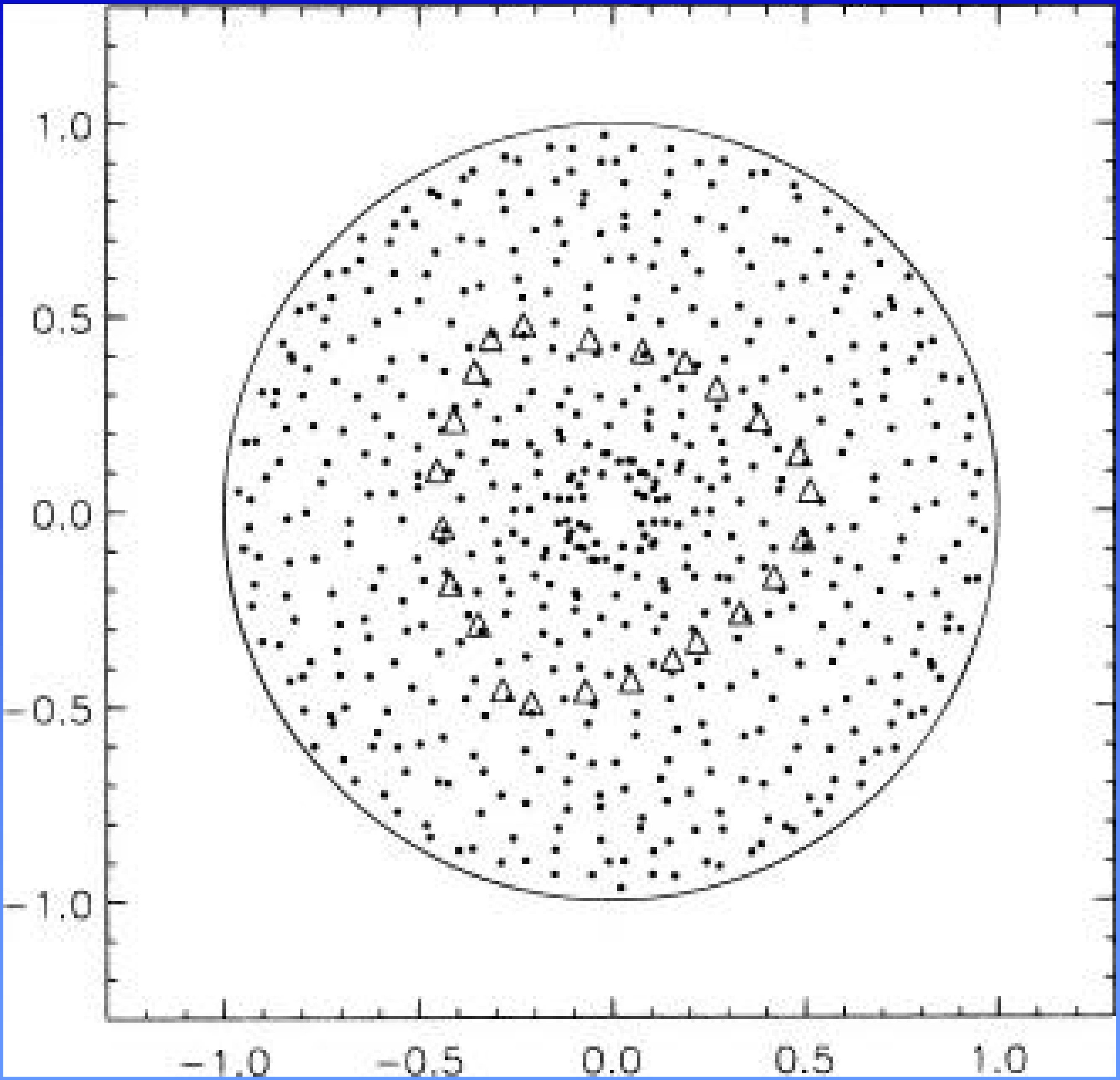


1.0
0.5
0.0
-0.5
-1.0
-1.0
-0.5
0.0
0.5
1.0

Rouleaux triangle



Keto 1997



1.0
0.5
0.0
−0.5
−1.0
−1.0
−0.5
0.0
0.5
1.0

FASR Array Configuration

An interesting optimization problem …

How does one simultaneously satisfy the following constraints?

- Large field of view
- Excellent imaging of compact and diffuse emissions
- Satisfy these requirements over three decades of frequency coverage
- Satisfy these requirements with a fixed array

An attractive possibility: a "self-similar" array configuration (Bastian 1998, Conway 1998)

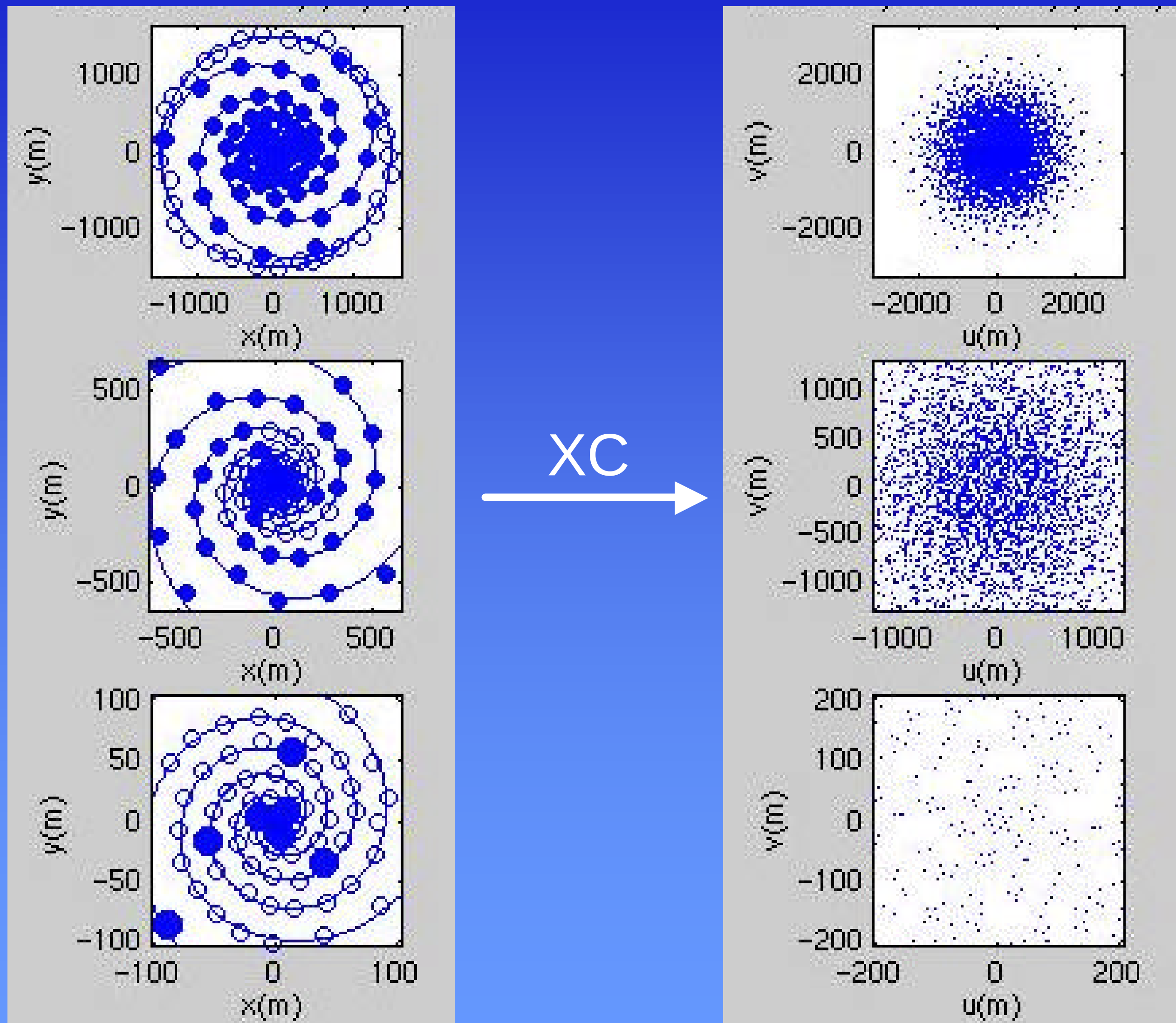
Suppose we have N antennas. We wish to arrange them such that the minimum distance of an antenna from the center of the array is r_{min} and the maximum is r_{max}.

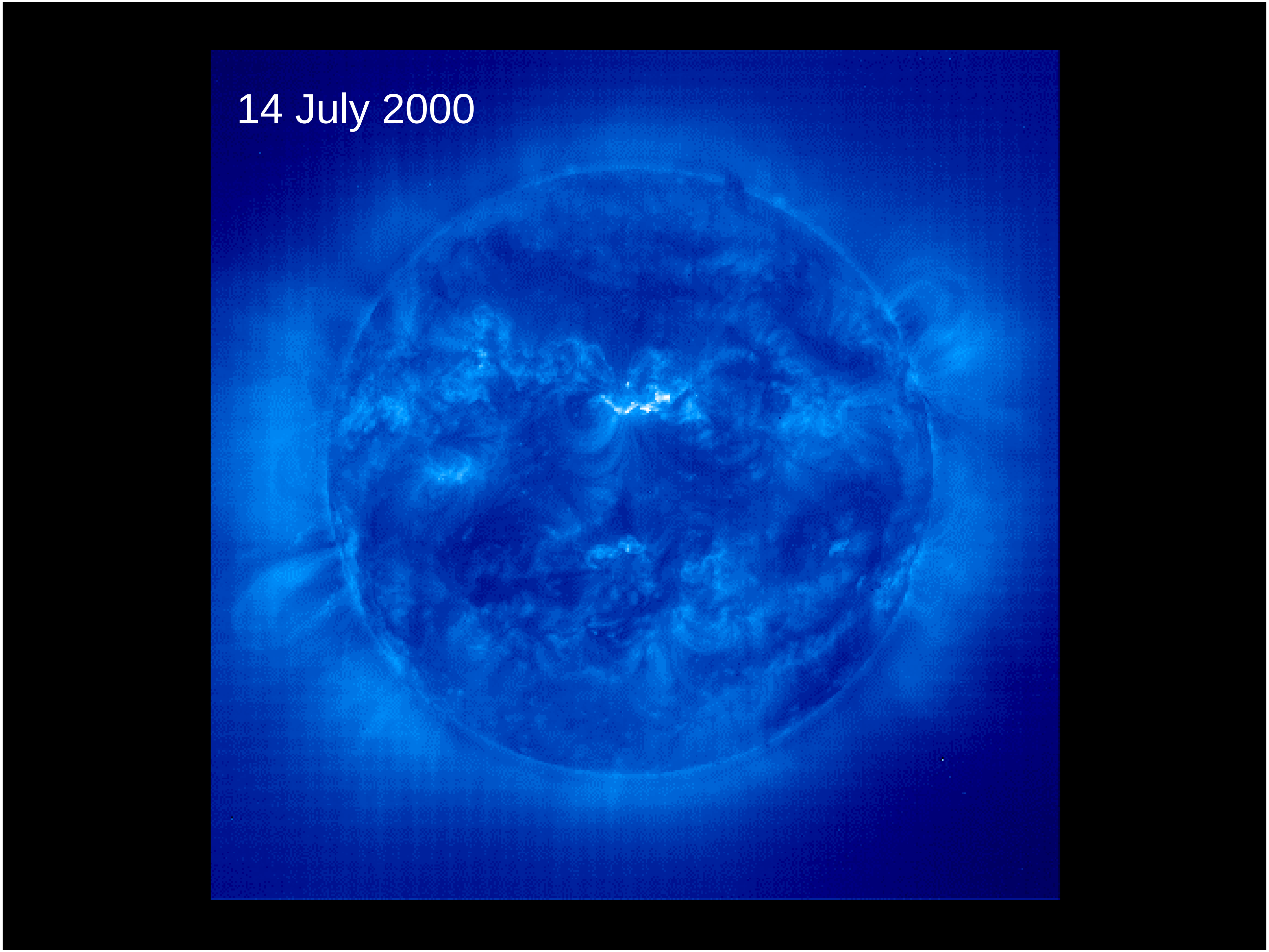
Choose

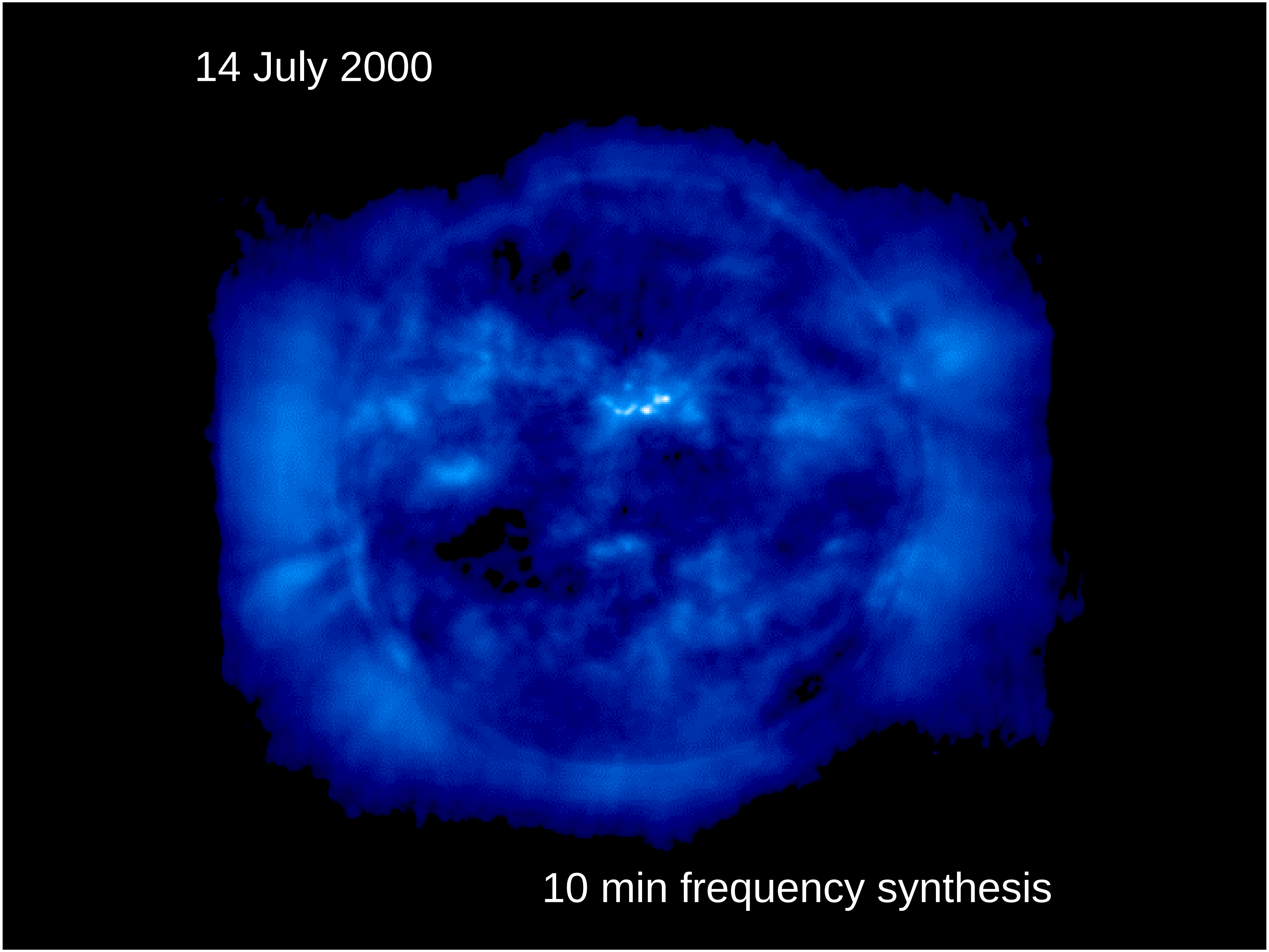
$$r = r_{\min}\left(\frac{r_{\max}}{r_{\min}}\right)^{1/(N-1)}$$

Several arms of N antennas each may be deployed. To improve azimuthal sampling, the arms may be spirals.

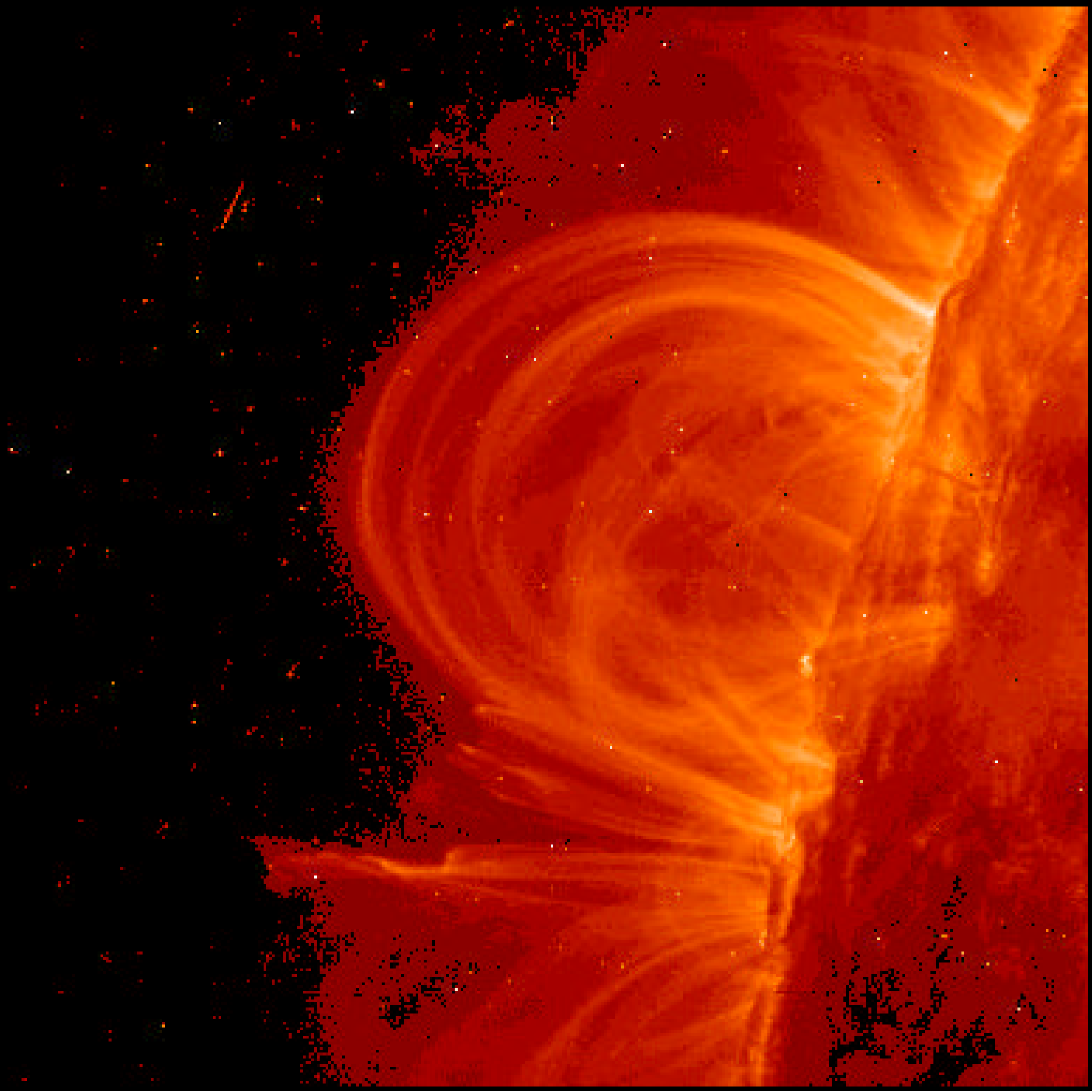
Log spiral

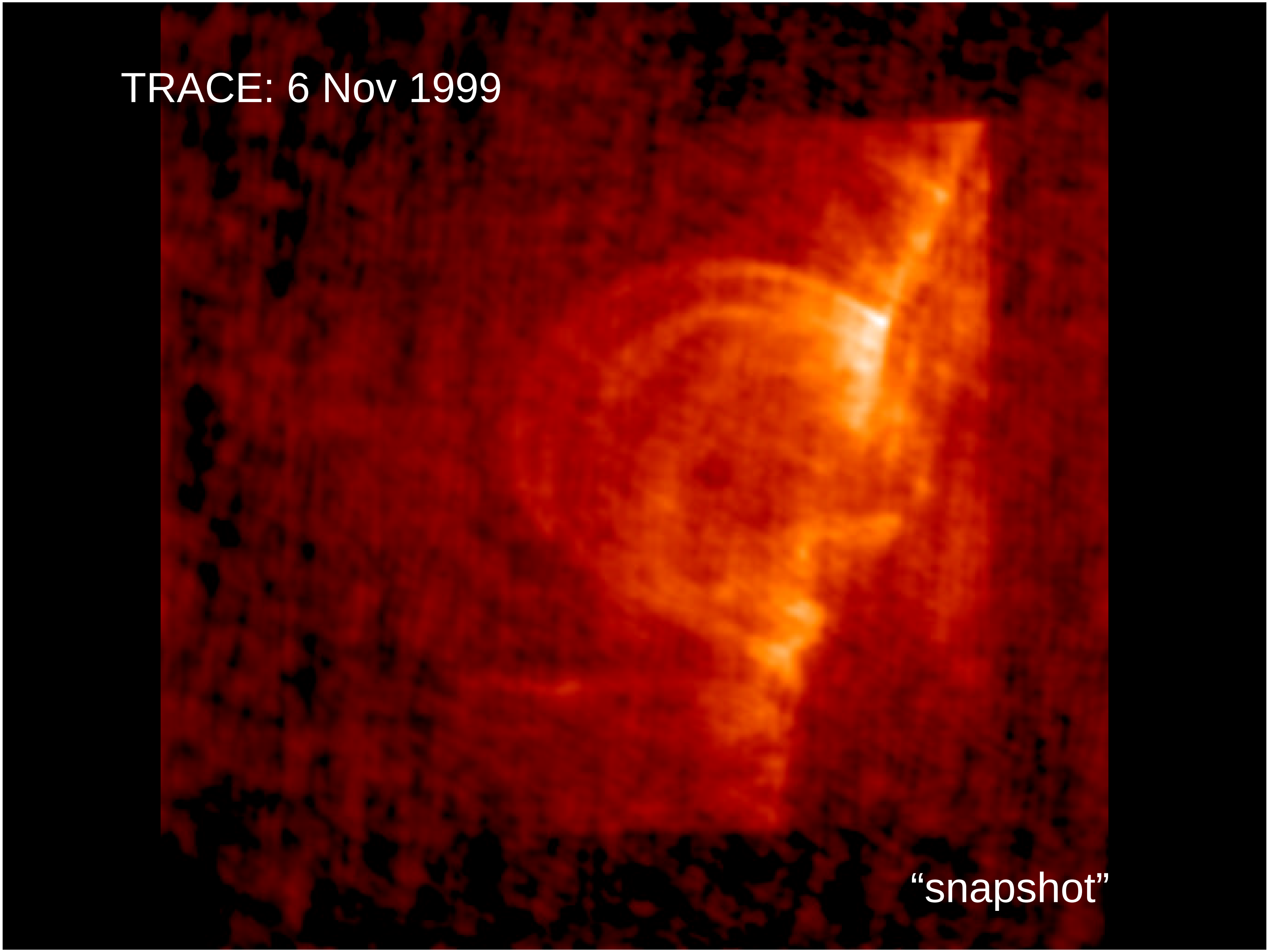


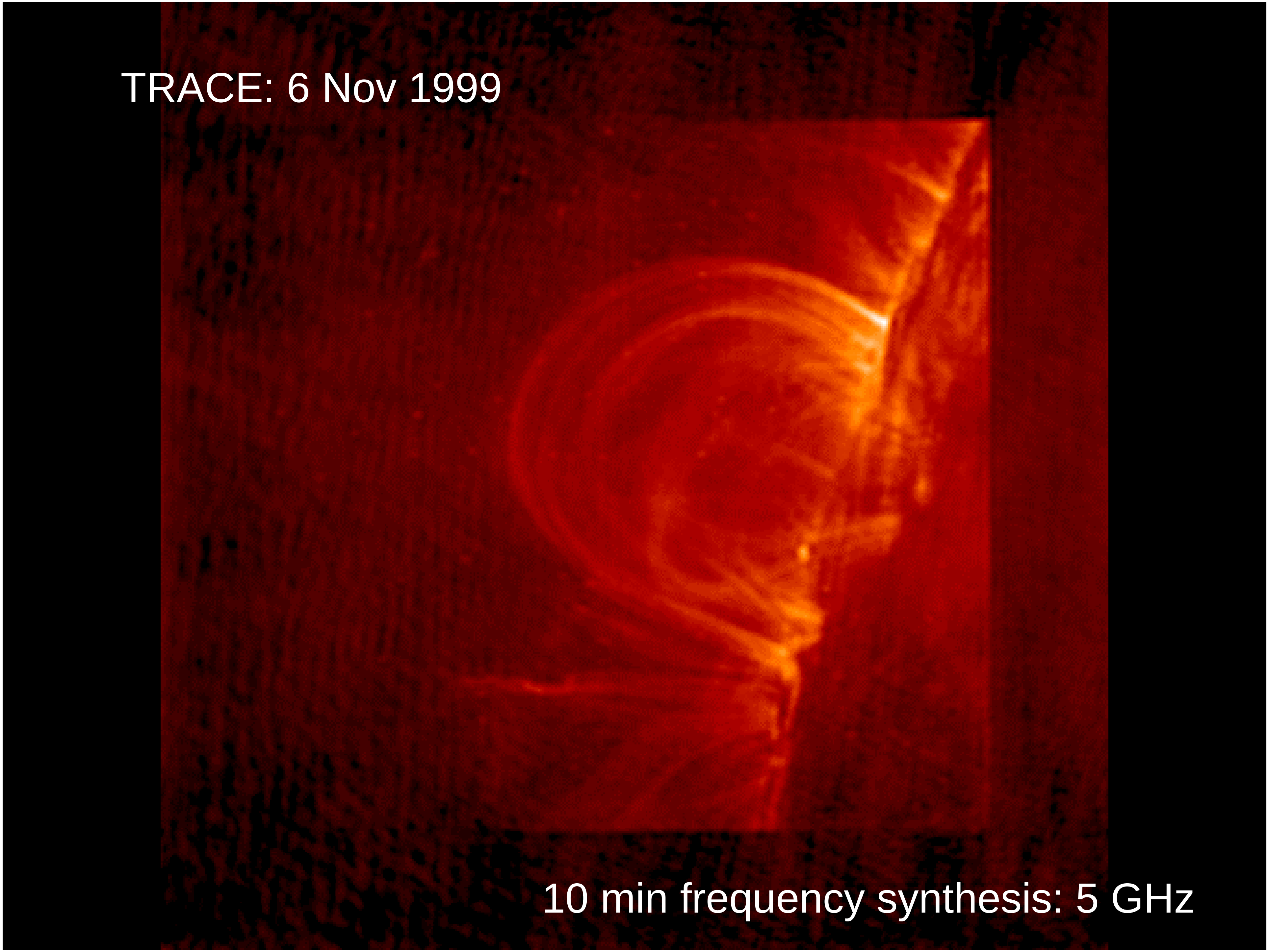

14 July 2000


14 July 2000
10 min frequency synthesis

TRACE: 6 Nov 1999




TRACE: 6 Nov 1999
“snapshot”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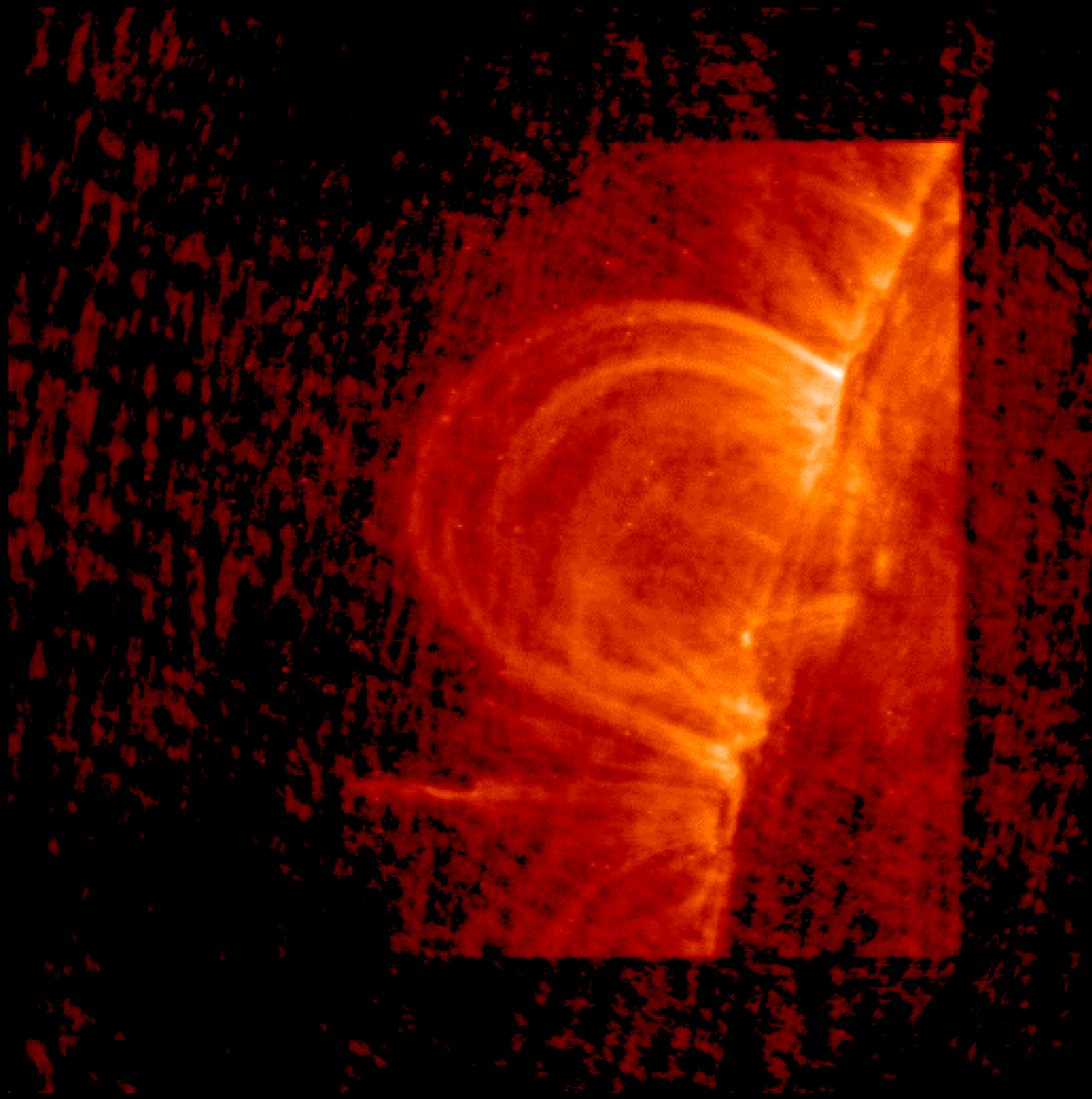
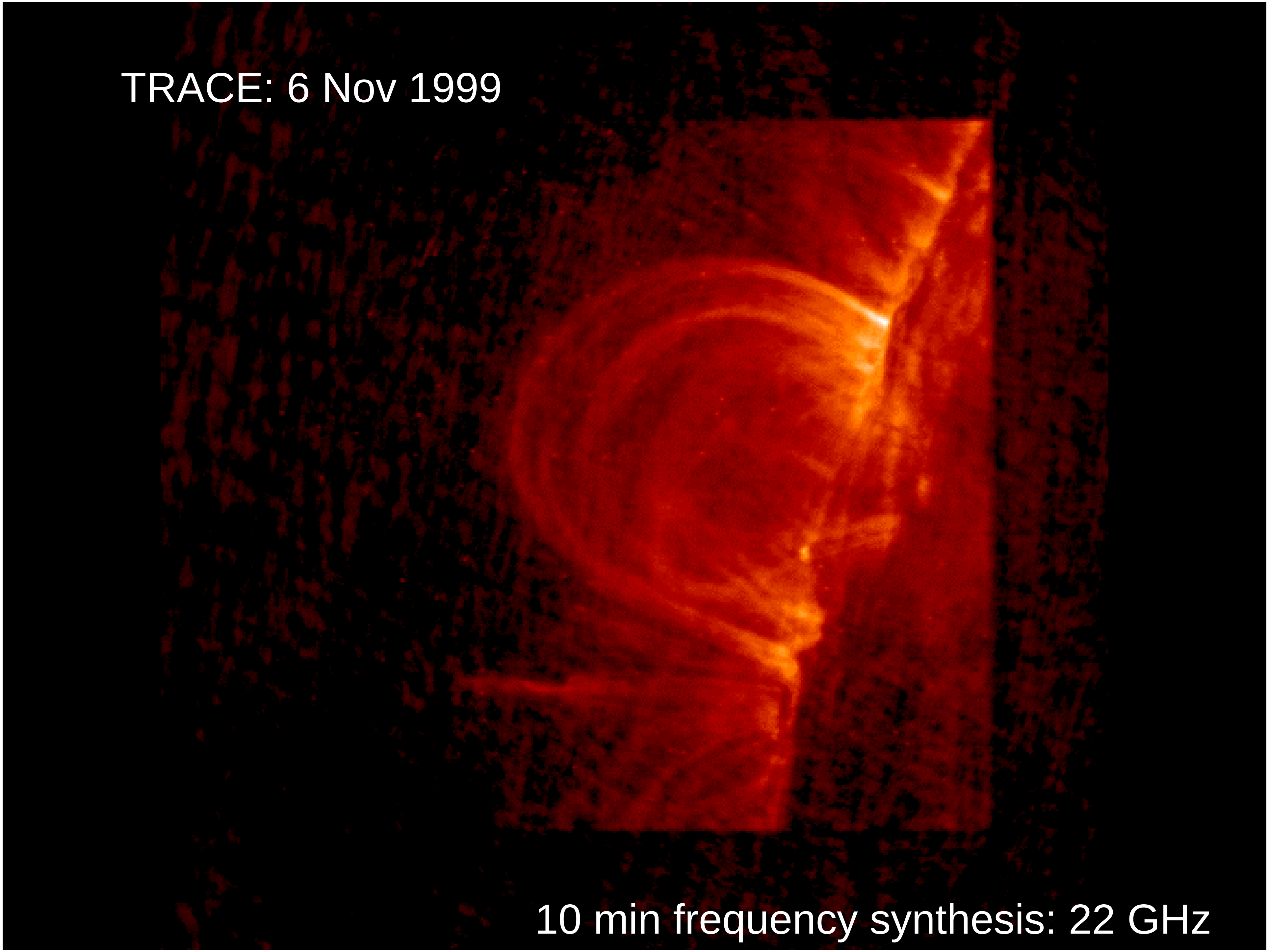
10 min frequency synthesis: 5 GHz



10 min frequency synthesis: 22 GHz


TRACE: 6 Nov 1999
10 min frequency synthesis: 22 GHz