ABSTRACT:

Title: Prospects for high angular resolution at low frequencies

At sufficiently low frequencies, no ground-based radio array will be able to produce high resolution images while looking through the ionosphere. A space-based array will be needed to explore the objects and processes which dominate the sky at the lowest radio frequencies. An imaging radio interferometer based on a large number of small, inexpensive satellites would be able to track solar radio bursts associated with coronal mass ejections out to the distance of Earth, determine the frequency and duration of early epochs of nonthermal activity in galaxies, detect the very extended remnants of ancient galactic supernovae and gamma-ray bursts, and provide unique information about the interstellar medium. Angular resolution would be limited by interstellar and interplanetary scattering to much worse than an arcsecond at frequencies below 10-30 MHz, but this still represents an orders-of-magnitude improvement over existing imaging capabilities at these frequencies.

PROSPECTS FOR HIGH ANGULAR RESOLUTION AT LOW FREQUENCIES

Dayton L. Jones

Jet Propulsion Laboratory,
California Institute of Technology

IAU Symposium 205

August 2000

ALFA Mission Description

- Proposal to NASA Medium-class Explorer (MIDEX) program
- Launch in July 2002
- 16 identical small satellites (12 required)
- Spherical array ~100 km in diameter (can be changed during mission)
- Distant retrograde Earth orbit (~10^6 km from Earth)
- Each satellite contains 2 dipole antennas and two low frequency receivers, and communicates directly with 11-m DSN ground antennas at 0.5 Mb/s
- Frequency range 0.03 - 30 MHz, bandwidth up to 125 kHz
- On-board UHF ranging systems give relative satellite positions to within 3 m

Science Goals

- High resolution imaging in wide, nearly unexplored spectral region will open new vistas in solar, terrestrial, galactic, and extragalactic astrophysics

- Snapshot imaging of solar radio emission

  Track coronal mass ejections all the way from near the sun to the vicinity of Earth

  Monitor the response of Earth's magnetosphere to solar disturbances

  Forecast geomagnetic storms to within hours, days in advance

- Multi-frequency all-sky survey

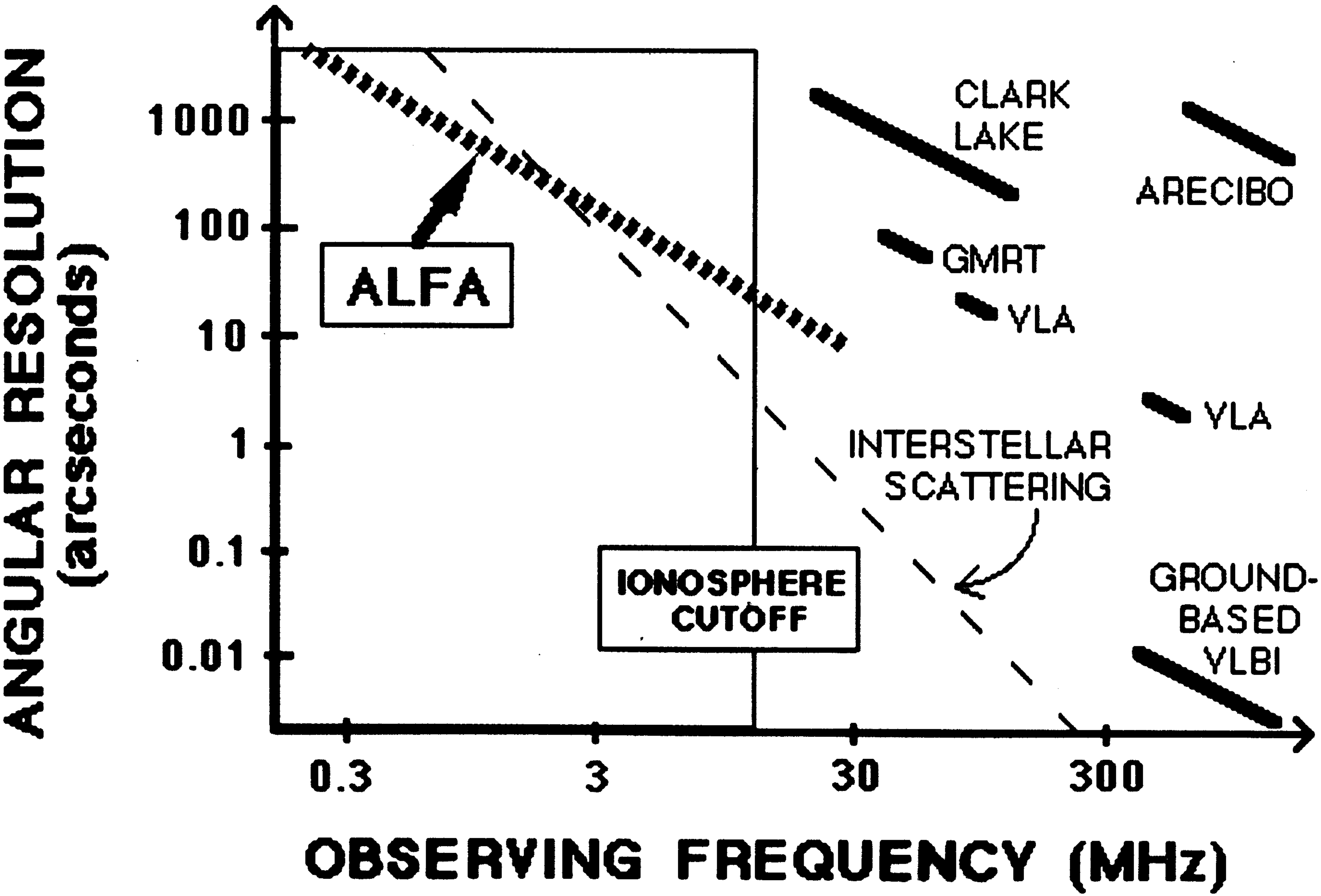
  Fossil radio galaxies preserve evidence of prior epochs of nuclear activitiy

  Detection of old, large supernova and γ-ray burst remnants

  Distribution of diffuse ionized hydrogen and low energy cosmic rays in our galaxy

  Coherent radio emission from accretion disks, supernova remnants, and relativistic jets

  High potential for new discoveries


ANGULAR RESOLUTION (arcseconds)
1000
100
10
1
0.1
0.01
0.3
3
30
300
OBSERVING FREQUENCY (MHz)
ALFA
IONOSPHERE CUTOFF
CLARK LAKE
ARECIBO
GMRT
VLA
VLA
INTERSTELLAR SCATTERING
GROUND-BASED VLBI

All-Sky Imaging

- All directions imaged simultaneously

  ~1000 field of view, each 7 x 7 degrees

  Source components removed from each field of view during deconvolution are also subtracted from the visibility data for all other fields of view

  Simulations show that technique works

- Angular resolution ~1 arcminute at 10 MHz

- Two imaging modes

  Snapshot imaging of strong, rapidly evolving sources such as solar radio bursts

  Long-term integrations to obtain maximum sensitivity and dynamic range

- Observing lifetime 2 years

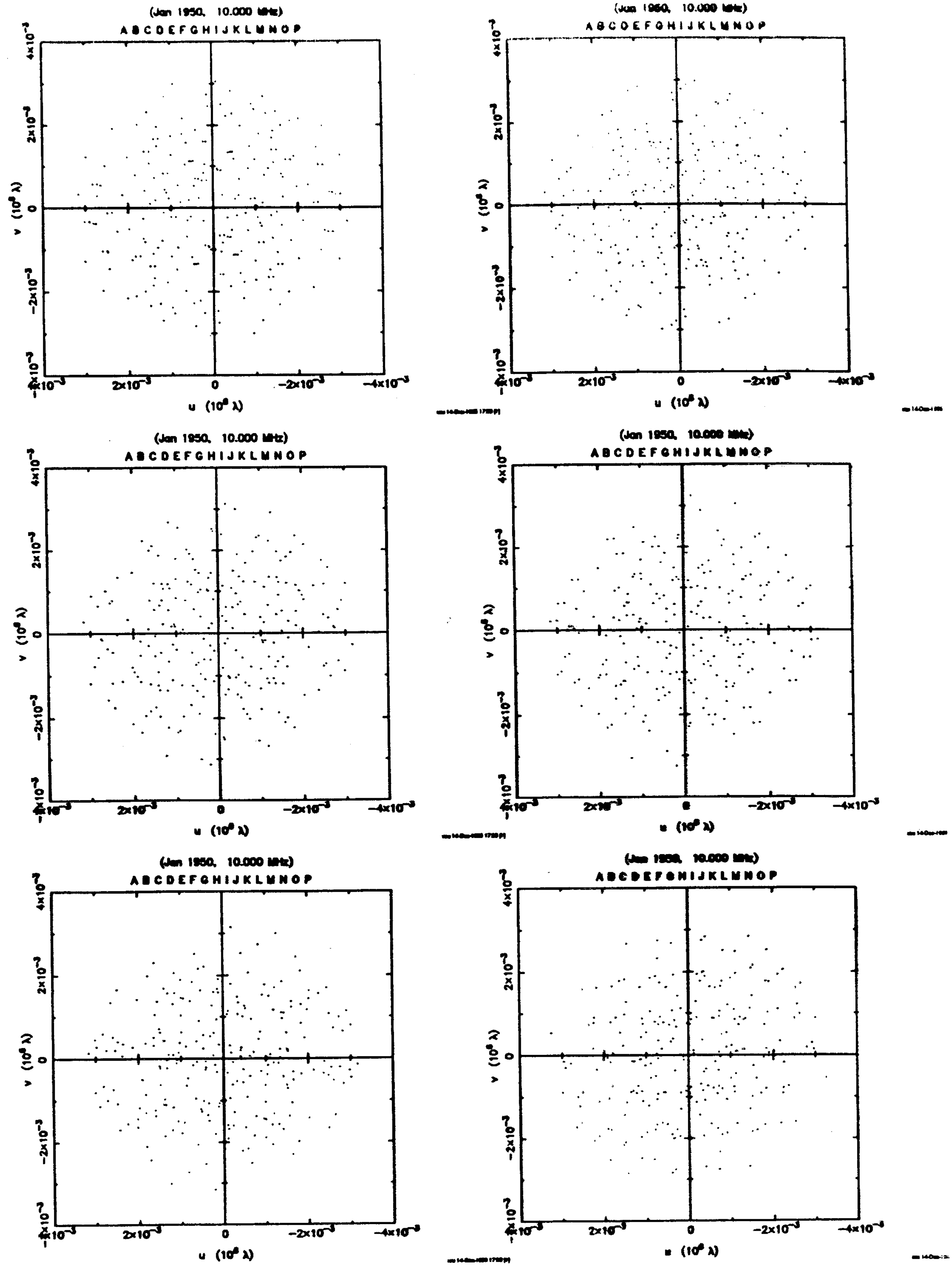


Figure 1: Array 15sn2 – (u, v) coverage for 0, 12, 24, 37, 53, and 90deg ecliptic latitude.

Snapshot
"RA" = 06:01:00

Summary

- All-sky imaging requires good (u,v) plane sampling in all directions simultaneously - this in turn requires a minimum of 12-14 array elements
- Distances ~10^6 km from Earth are sufficient to remove RFI problems
- A low-frequency imaging interferometer in space is technically viable, affordable, & scientifically exciting
- Solar, terrestrial, galactic, and extra-galactic astrophysics will all benefit
- New discoveries are likely in this wide, largely unexplored spectral region