EVLA
Phase II (Completion) Goals

Rick Perley
EVLA Project Scientist

Completing the EVLA

- Phase I of the EVLA will provide fantastic sensitivity, frequency resolution and access.
- But much of the science available with these capabilities will be compromised unless a similar improvement in resolution is gained.
- Increasing the EVLA resolution by a factor of 10, and combining the EVLA with the VLBA will give a single instrument with a resolution range of 10^6, over a frequency range of 1000.
- This is the goal of the EVLA Completion.

EVLA Completion Goals

1. Increase VLA resolution by a factor of 10, with imaging performance equal to current VLA.
   - Consists of ~8 new ‘stations’ within NM, plus 2 existing VLBA antennas (PT, LA).
   - All ten will be connected by fiber to the new correlator
   - The ten-element array is called the New Mexico Array

EVLA Completion Goals

2. Extend low-frequency limit below 1 GHz.
   - Continuous coverage to ~ 300 MHz, perhaps lower?
   - Must be done with prime-focus feeds.
   - This requires a removable subreflector.
3. Improve low surface brightness imaging capabilities.
   - Construction of a new ‘E’-configuration.

➢ In addition, we will plan for the eventual integration of the VLBA, to form a single, real-time continental-scale interferometer array.

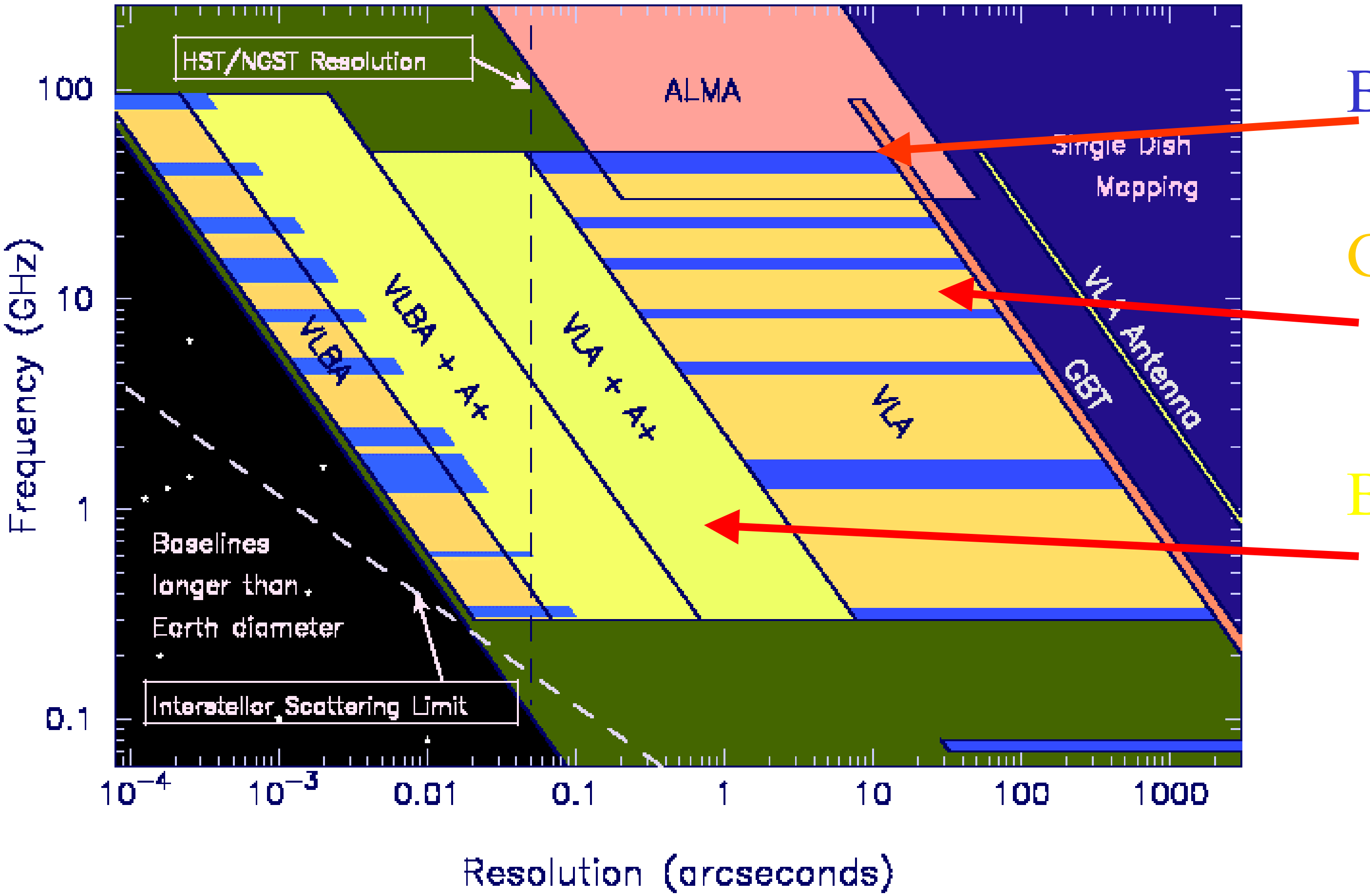
New Mexico Array

- Key Scientific Driver: Milliarcsecond Imaging of Thermal Sources.
    - σ_T ~ 30 K from 2-40 GHz, with resolution 6-60 mas
    - σ_S ~ 10 μJy at 0.1 arcsecond resolution at 1.5 GHz
- This combination of sensitivity and resolution opens up new classes of sources for detailed mapping:
    - Stellar atmospheres, binary stars, novae
    - Proto-planetary disks
    - Hypercompact Galactic HII Regions
    - Extra-galactic HII Regions

New Mexico Array

- Flexibility of Configuration:
  - NMA+VLA: ~37 antennas offer unbeatable performance and flexibility.
  - The NMA alone is an always-available stand-alone instrument
    - Sensitivity of current VLA, with 10x the resolution
- Pathway to the Future
    - Integration with the VLBA – a single array, flexibly configured.
    - Possible growth path to the SKA.

Resolution-Frequency Coverage of NRAO Telescopes



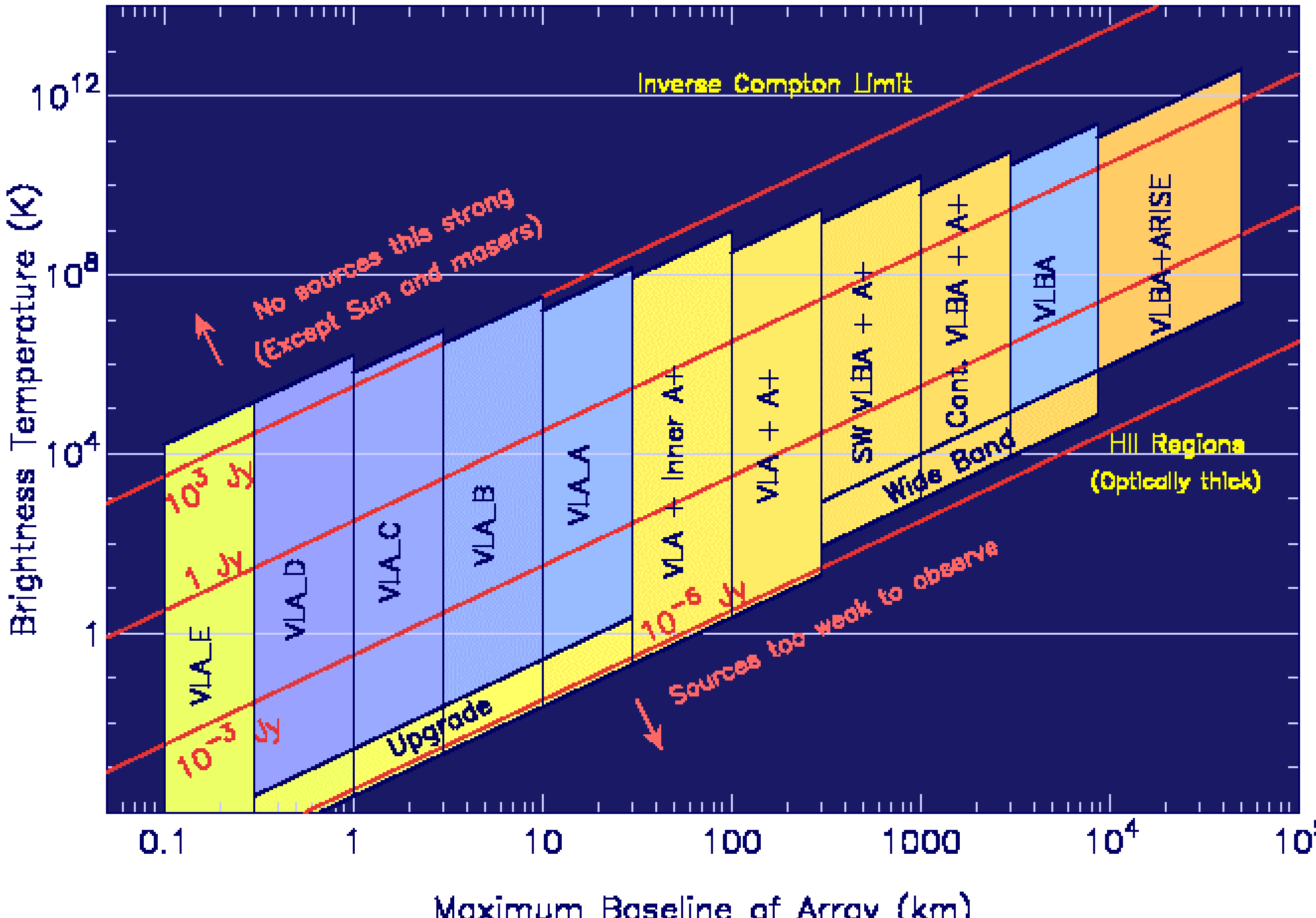
Blue bars – VLA now

Golden yellow – Phase I

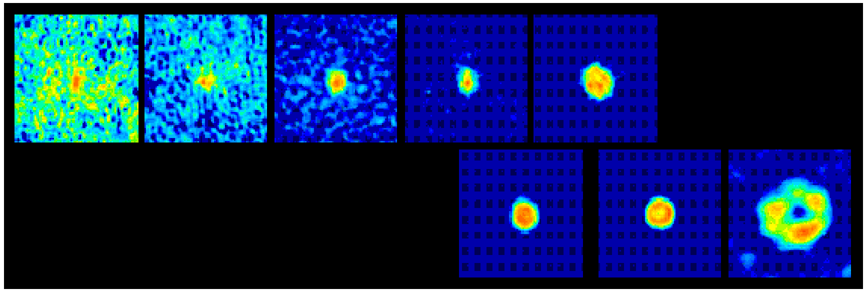
Bright yellow – Phase II

Brightness Temperature Coverage of EVLA & VLBA

- Blue: Now
- Yellow: Future
- NMArray gives mas imaging of thermal sources



NMA Science: Novae



- Imaging every nova in the Galaxy, within a few days of the explosion:

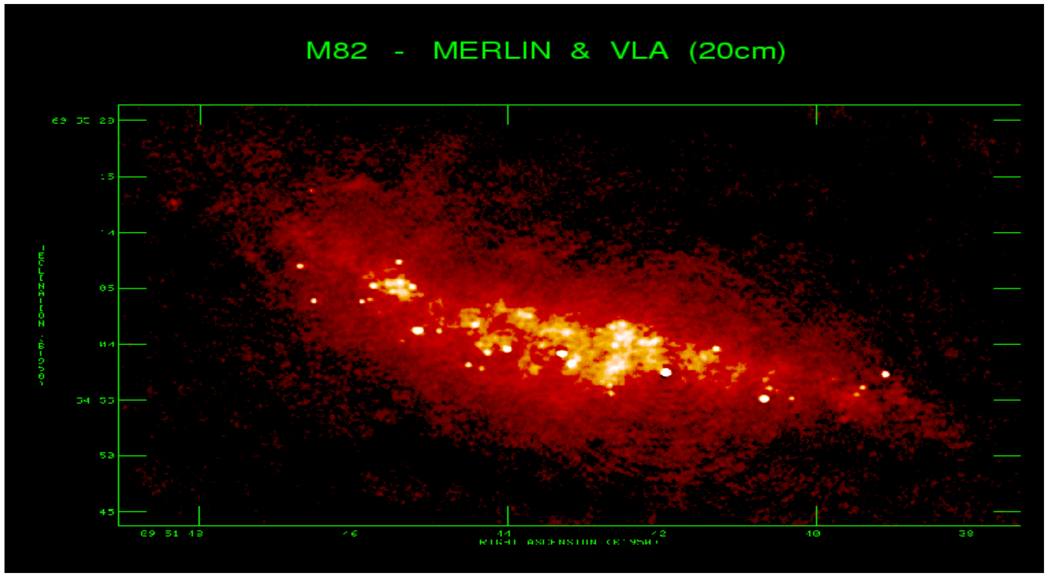
$$\Theta = 0.57\ v_{1000}\ t_{day}/d_{kpc}\ \text{milliarcseconds}$$

→ Evolution from optically thick to thin

→ Mass estimate

→ 3D temperature/density distributions

NMA Science: Nearby Galaxies



- Resolve ultra-compact HIIs throughout M31/M33 (Θ=0.03pc)
- Map Tycho/Kepler SNR analogues in M81/M82 (Θ=0.1pc)
- Image >50 star clusters in the Antennae (<10pc resolution)

NMA Science: High z Mapping

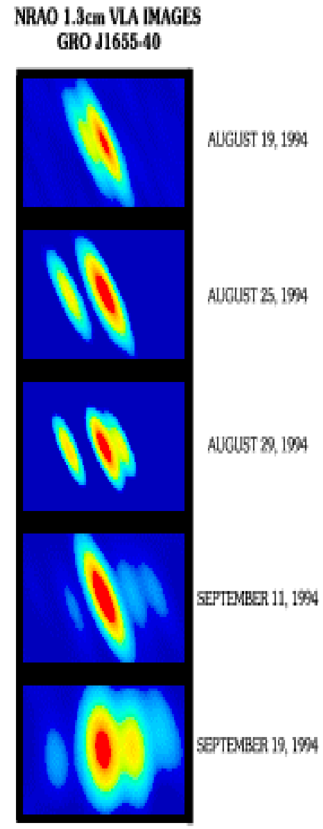
- Distinguishing AGNs from starbursts:
  - HII regions have $T_b<10^5$ K

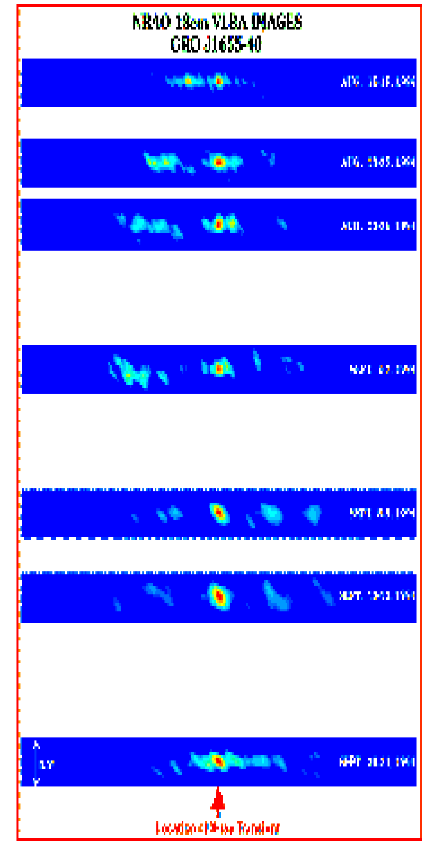
  → Sources >3.3 mJy which aren't resolved by the NMA must be AGN (independent of freq.)
- 1 kpc > 0.1-0.15 arcsec at all z
  - NMA resolution: Θ=0.125 arcsec at 1.5 GHz !

  → NMA will have <1Kpc resolution for the entire universe (with sub-μJy sensitivity)

NMA Science: X-ray Transients

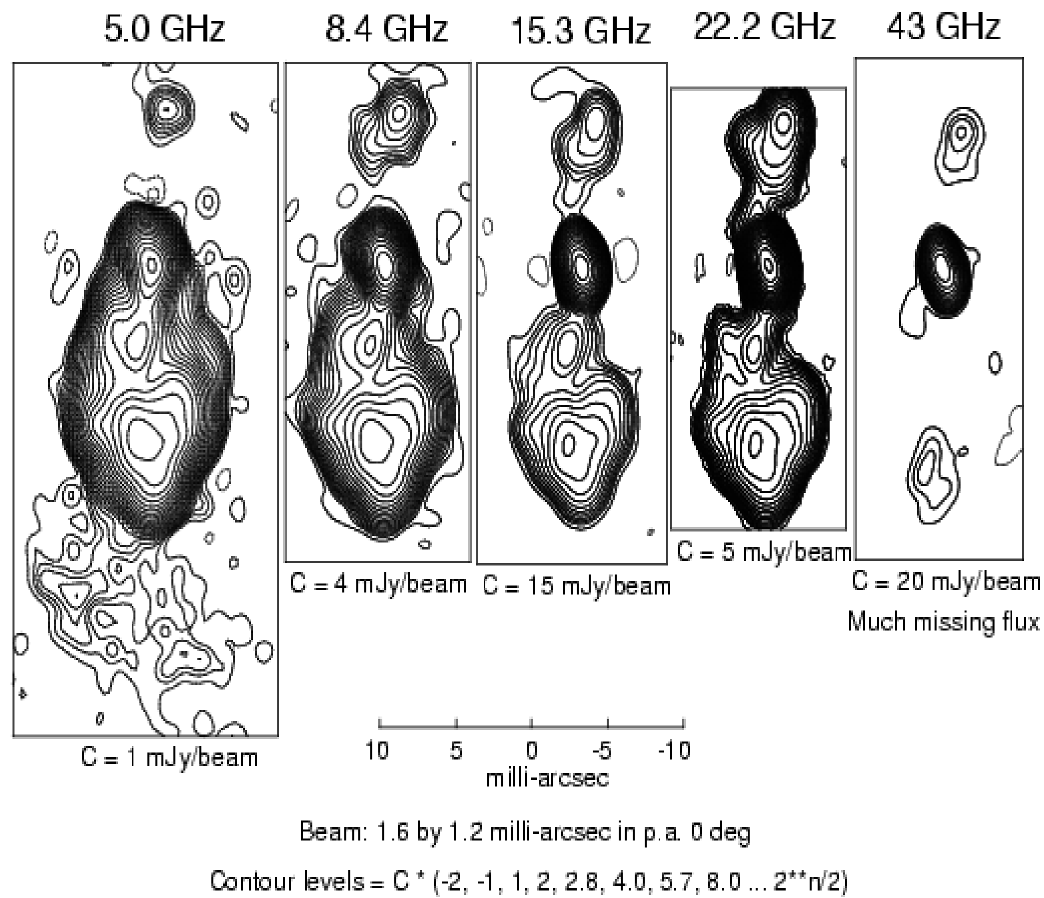
- Ubiquity of jets
- Monitoring: continuous multi-freq. coverage
- Quiescent source imaging
- Check jet “prejudices” (one-sided, flip-flopping, pattern speeds, orientations)





NMA Science: AGNs

- Spectral index imaging
- Milli-halos
- Small-scale diffuse emission (central starbursts?) (cf. Mrk 231)



NM Array Science

- Gravitational Lenses
  - Currently, ~80 are known.
  - Unique value – gives a census based on gravitating matter. Other cosmological census methods are based on light emission.
  - EVLA could find ~1000 lenses (Chris Kochanek)

The New Mexico Array Design Progress

- Design group, led by Frazer Owen, has made considerable progress in defining the array design.

Low-Frequency Science

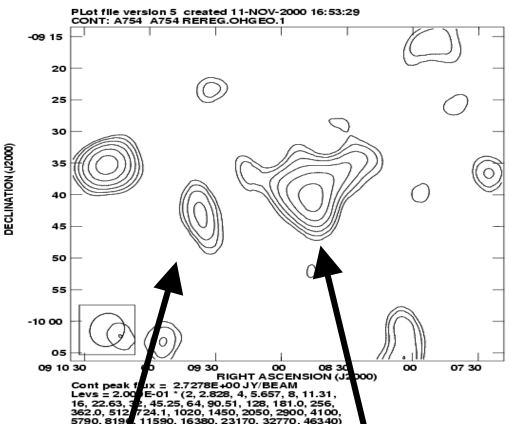
Unique Aspects of Low-Frequency Imaging:

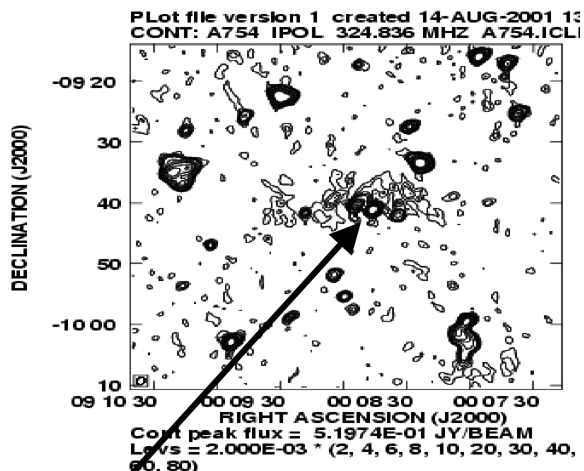
- Long-lived relativistic electrons

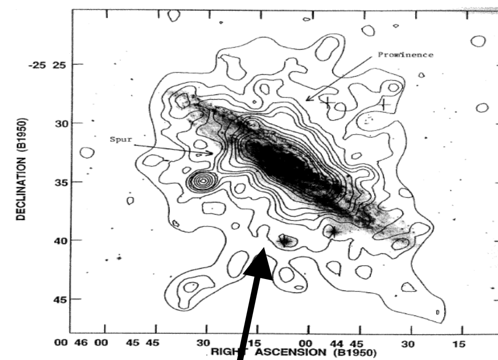
  → relics & halos
- High-z sources (radio continuum, HI, OH)
- Free-free & synchrotron-self absorption
  - Measures B-fields, thermal densities
- Faraday rotation & scattering (scale as ν^{-2} & ν^{-4})
  - Measure B-fields, thermal densities

Low-Frequency Science

Relics and Halos







?

Abell 754

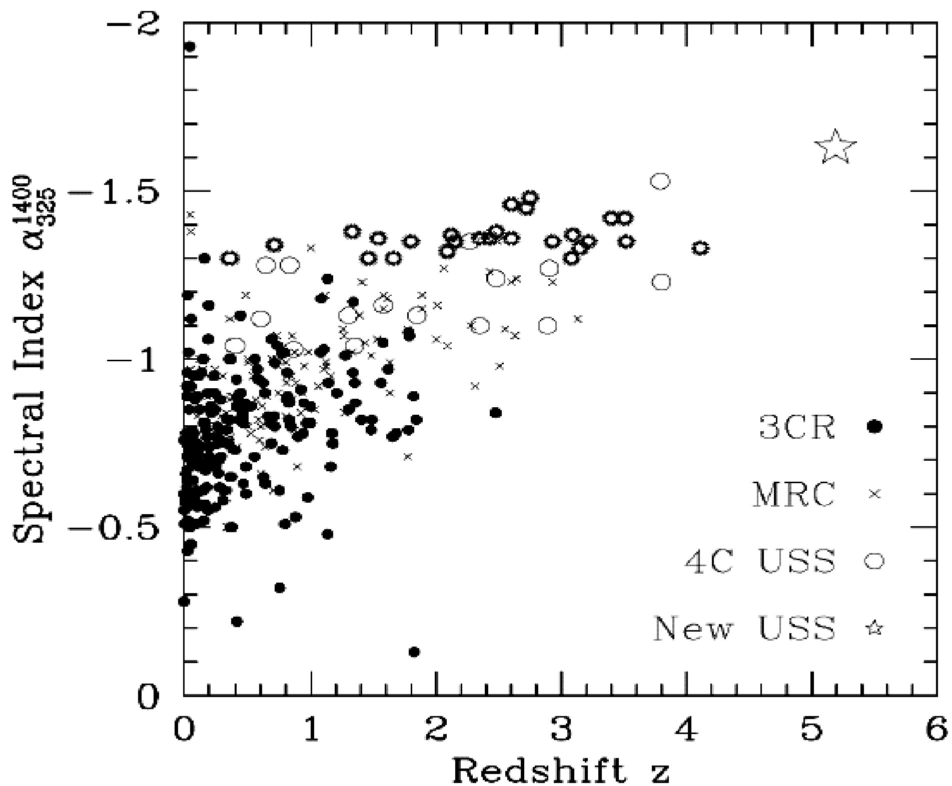
NGC 253

Low-Frequency Science

Finding USS sources:

Showing the relationship between α and z.

Deep surveys at low frequencies are used to find high-z sources.



Low-Frequency Science

Damped Lyα Systems:

HI absorption

- Opacity & optical N_H → T_{spin}
- 21cm profile → gas kinematics
- NMA → image absorption

  → rotation curves!

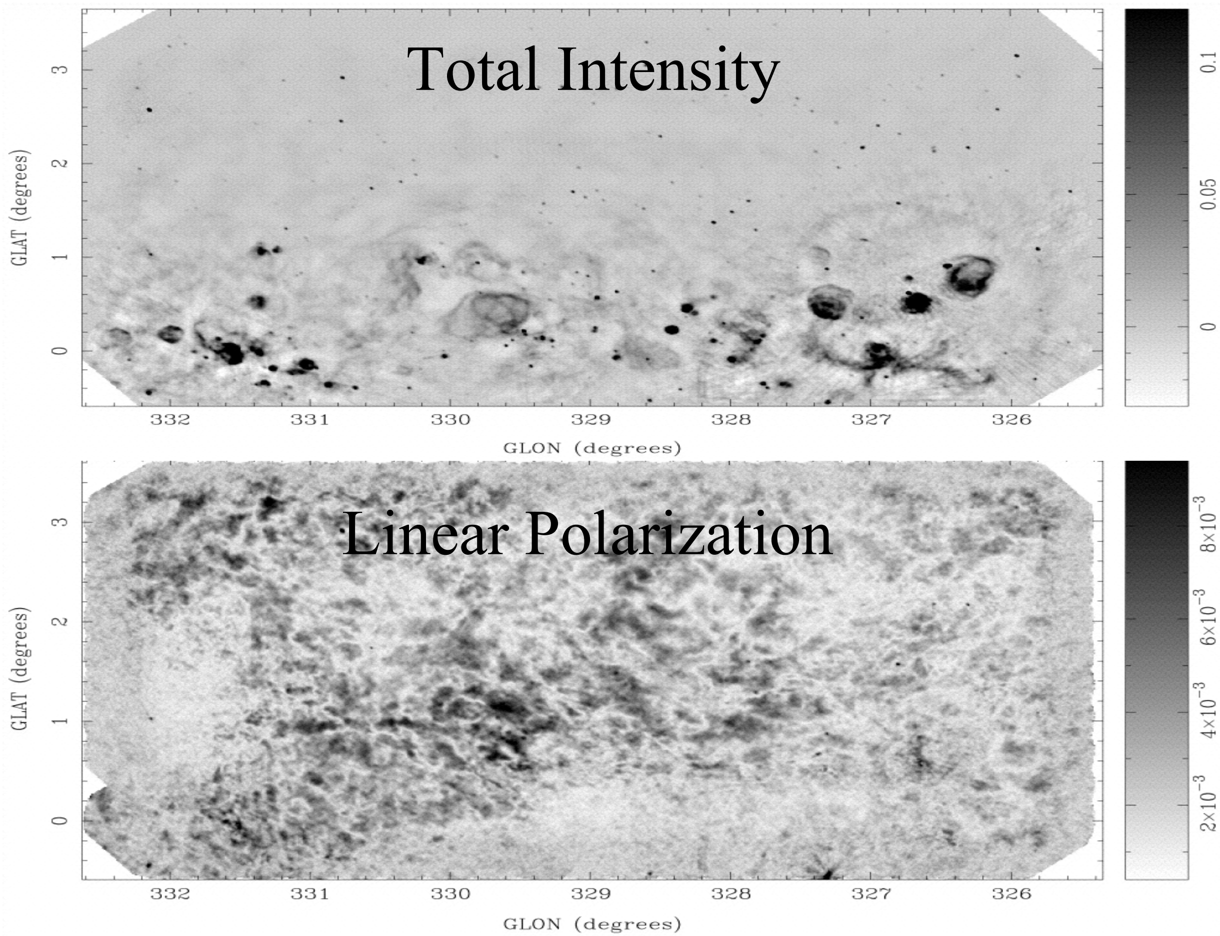
Low-Frequency Science

ISM Polarimetry

- Linearly polarized signals are rotated during ISM propagation
  - Faraday rotation goes as λ^2
  - Sensitive to very small fluctuations in ISM
  - Lower frequencies are most sensitive, but high resolution needed.
- Trace regions of turbulence, e.g. near supernova remnants
- Monitor polarization for time variability

  → track size scales, velocities in ISM

Low-Frequency Science



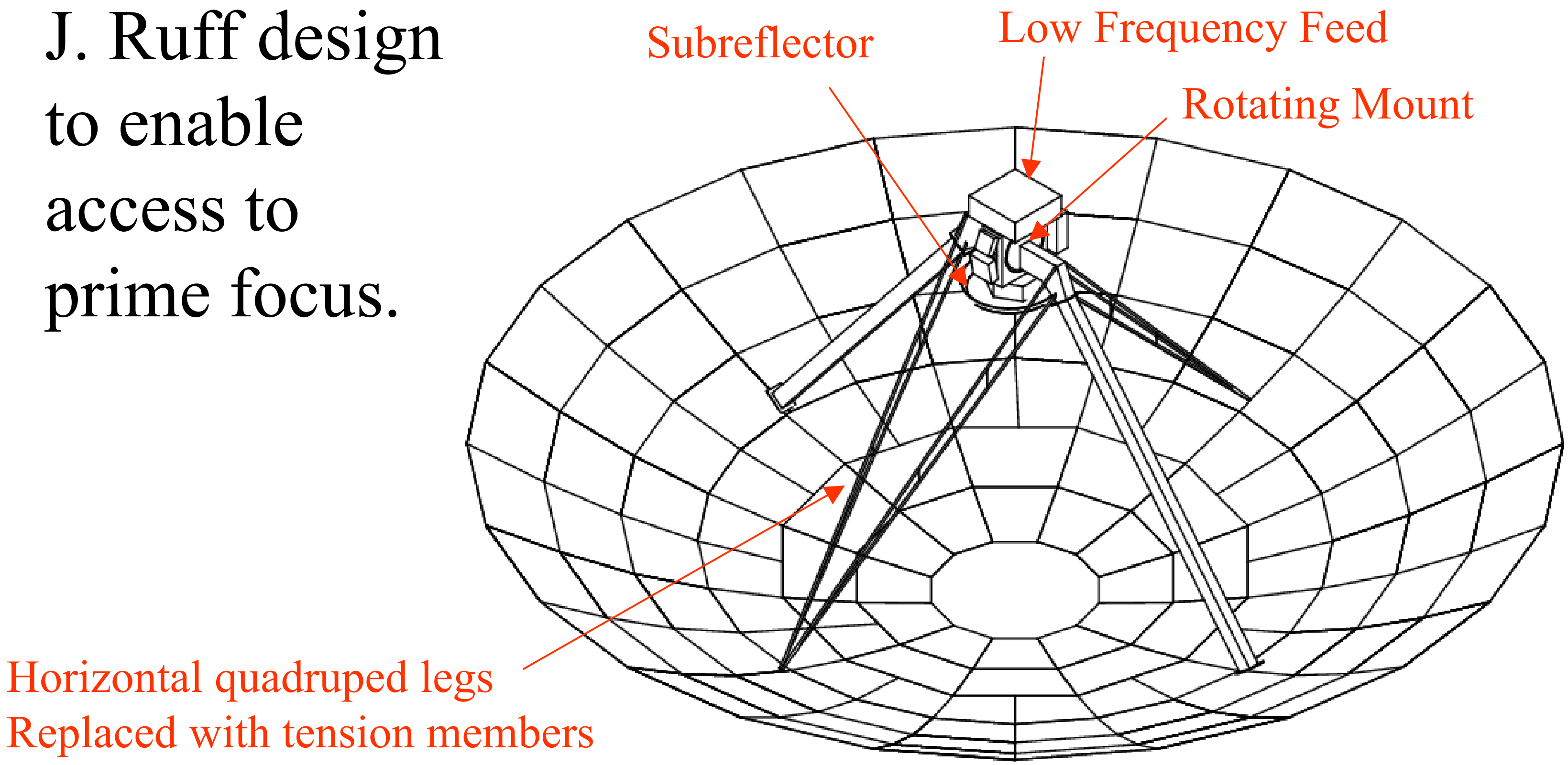
Two Views of the Galactic Plane at 21 cm.

Low-Frequency Extension

- Cassegrain focus not useable for λ > 30cm
- To employ prime focus, subreflector must be removed.
- A rotating system has been designed, but not tested.
- Testing of this design is included in Phase I, but no schedule has been developed.

Rotating Subreflector Mount

- J. Ruff design to enable access to prime focus.

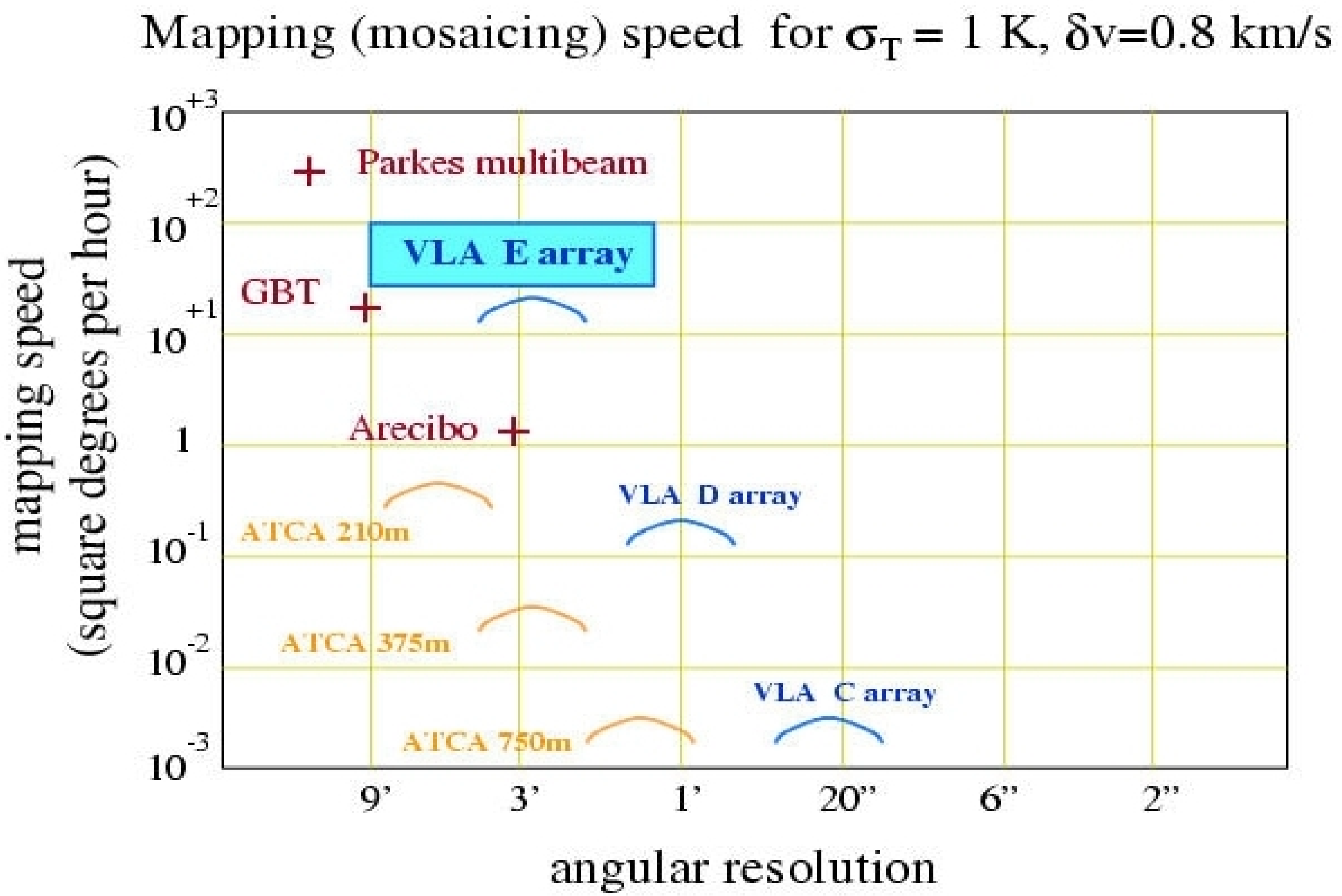


E Configuration Science

- Surface brightness sensitivity
  - Although D-configuration can do low-surface brightness imaging, it is much slower.
- Image quality
  - Denser uv-coverage → lower sidelobes at low resolution → superior imaging performance
  - Fidelity improved by factor ~7 (Holdaway 1996)

→Mosaics would be faster & will produce superior images, particularly when GBT data are included.

E Configuration Science



- Unique combination of resolution, mapping speed, and fidelity
- Especially important for spectroscopy of thermalized lines

E Configuration Science

The Local HI Web

- Theory + opt. studies suggest there should be a "web" of low column density gas joining nearby galaxies.
- A deep (2700hr) integration with VLA/E would yield an rms of 3×10^{15} cm^{-2} (δv =1 km/s)

E Configuration Science

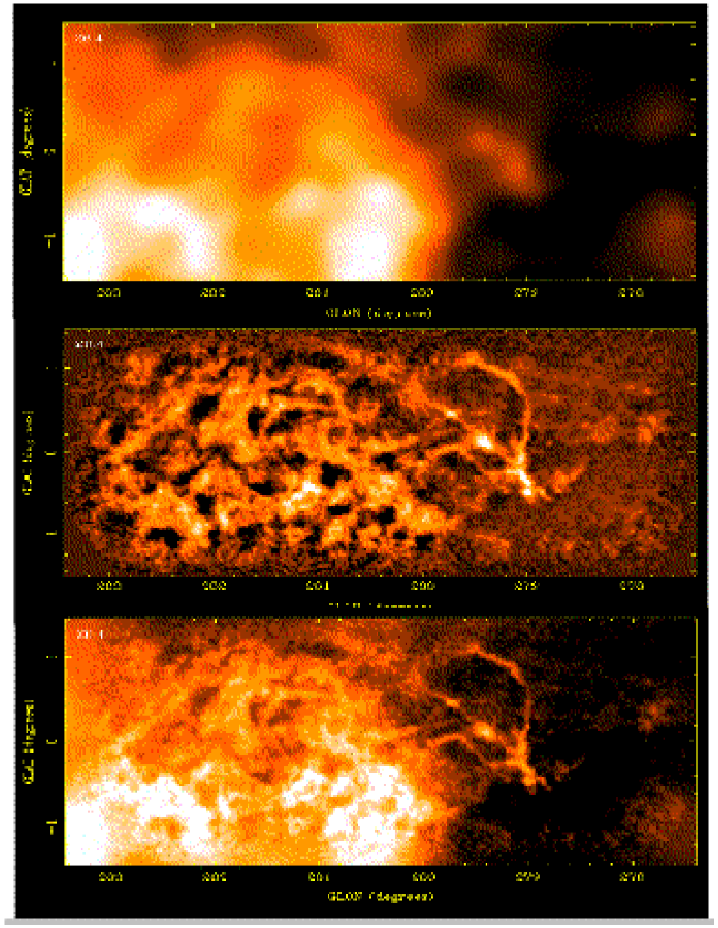
Large-scale Mosaics

Galactic Chimney GSH277+0+36

Parkes

ATCA

Parkes + ATCA



'E-Configuration' Studies

- Frazer is leading a design effort here, and will report on this in the next talk.

Interaction of EVLA with SKA

- Many of the key issues confronting SKA development must be addressed for the EVLA:
  - Wide-bandwidth FO transmission
  - RFI-tolerant design
  - RFI excision, avoidance, and subtraction.
  - Hi-Fidelity Imaging (all Stokes' parameters)
  - Data availability and archiving
  - End-to-End Computing and overall Data Management
  - Exploration of the uJy sky, (before the nJy).
  - Remote site selection and operation
- EVLA is the SKA (without the collecting area)

EVLA → SKA ?

- NRAO approach is to provide a growth path from VLA ⇨ EVLA ⇨ SKA.
- Even if SKA is developed elsewhere, the technology development underway for EVLA is crucial to SKA success.

Issues

- Station Definition
  - EVLA goal is to provide the capability to do the science – as soon as feasible.
  - 25-meter antennas have solid advantages
    - Simple optics, known properties.
  - They are also big and expensive.
  - SKA-style array may provide more collecting area for less cost.
  - Significant disadvantages – shadowing, variable station beam, performance losses at highest and lowest frequencies

Issues

- Interaction with SKA
  - SKA Advocates are not enthusiastic about Phase 2.
  - We believe our approach is safe and solid – we can provide the capability with high confidence of success.
- Location of ‘Orphan components’ – Low Frequencies and E-configuration.
  - Priority of returning to Phase I. Trade-offs.

Issues

- Timing: When to submit proposal? When to design for completion?