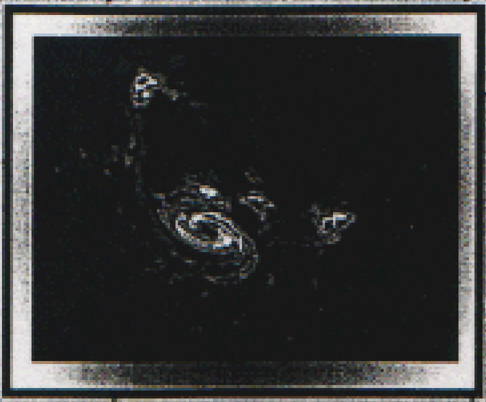
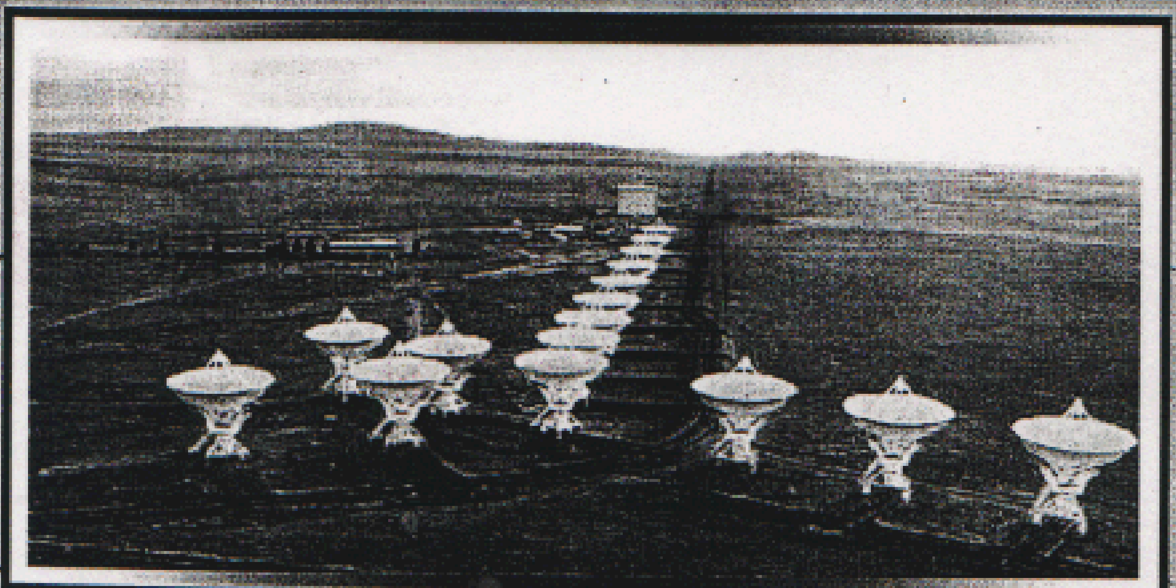
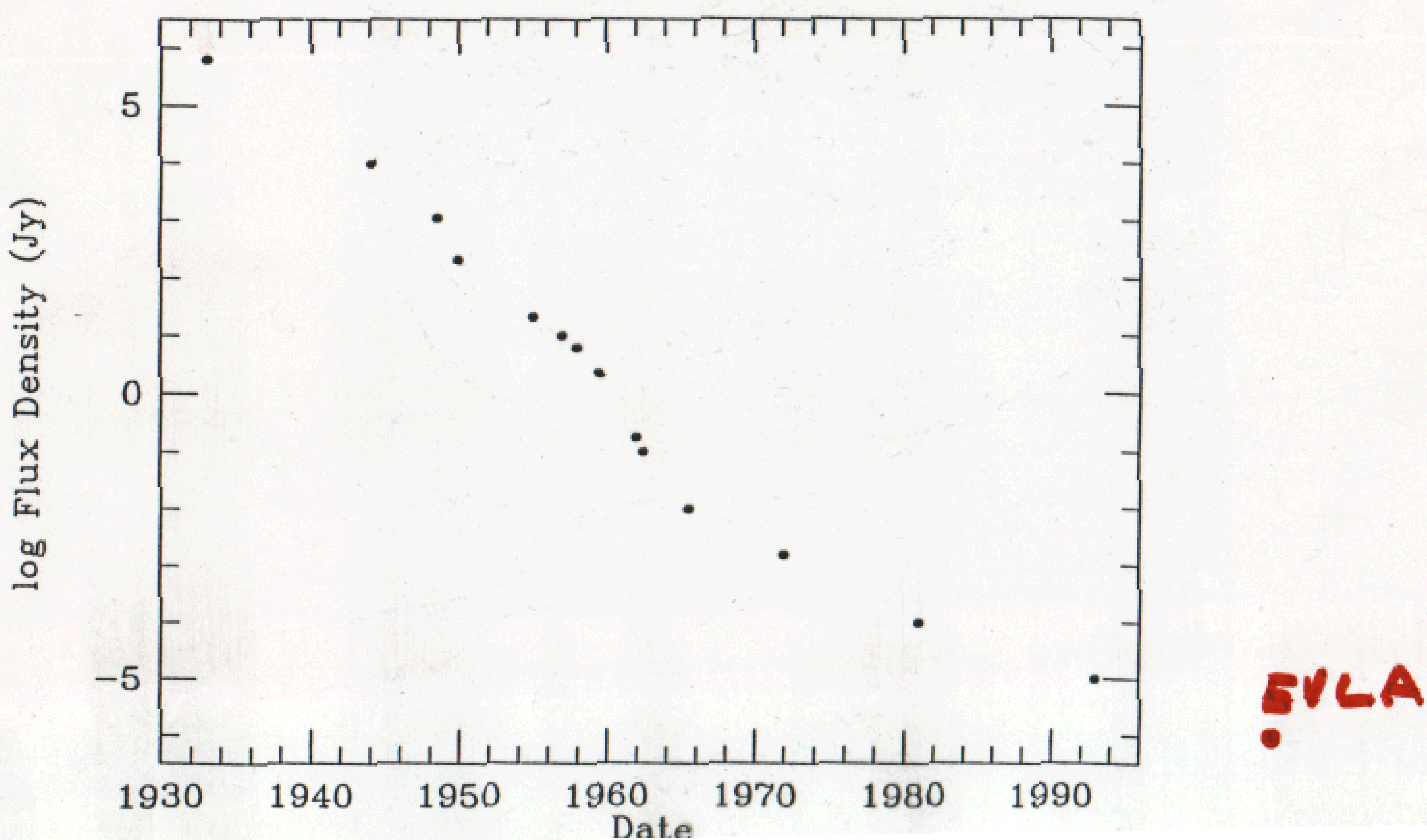


THE VLA EXPANSION PROJECT PHASE I: THE ULTRASENSITIVE ARRAY




log Flux Density (Jy)
5
0
−5
1930
1940
1950
1960
1970
1980
1990
Date
EVLA

WHY EXPAND THE VLA?

The VLA is a wonderful instrument, and it's still very useful as the most flexible and sensitive multi-purpose radio telescope in the world. But...

- it's 20 years old: 1st VLA antenna came on-line 24 October 1975!!
- we can do a lot better, very cheaply: keep the good stuff (antennas, railroad track, buildings, ...), just replace the electronics

OVERVIEW OF THE PROJECT

The VLA Expansion Project consists of:

- wider bandwidths: 8 GHz vs. 100 MHz per polarization
- new correlator: 262,144 vs. 8 channels in 100 MHz
- new receivers: continuous, 0.2–50 GHz
- longer baselines: 4mas vs. 50mas at 45 GHz

⇒ continuum sensitivity ($\sim 1\mu$Jy vs. $\sim 10\mu$Jy in 12hrs)

⇒ instantaneous spectral indices, rotation measures, uv-coverage

⇒ instantaneous velocity coverage (53,300 km/s vs. 666 km/s at 45 GHz; H I z=0.0–0.6 vs. z=0.0–0.07)

⇒ lines at arbitrary redshift

The improvement between the expanded and the current VLA roughly corresponds to the difference between a fully-equipped HST and a ground-based telescope with photographic film and no spectrograph.

3×10^{16} op/s vs 10^{12} op/s

PRACTICALITIES

Cost: \$160 M
($76.2 M for Phase I [Ultrasensitive Array])

Timescale: 7 years for Phase I
(set by correlator, and refurbishing 28 antennas)

Current status:

- Proposal for Phase I submitted to NSF
- Decadal review rated EVLA as 4th priority among large projects (2nd among ground-based)
- Possible international collaborations (Mexico, Canada)
- Work in progress:
  - Pie Town link (fiber, VLBA connection)
  - 23/43 GHz receivers (UNAM, NSF, MPIfR) [with WVR]
  - feed cones
  - low-frequency feed design
  - correlator, FIR filter designs (with HIA, ALMA)
  - on-line system

Table 0.1.2. Astrometry with the A+ configuration

Frequency (GHz)	Resolution (milliarcsec)	Rms Noise (μJy)	Rms Position (μarcsec)
0.25	800	88	70,000
0.37	500	42	21,000
0.57	340	20	6,700
0.90	220	8.1	1,800
1.50	125	4.4	550
3.0	64	2.7	170
6.0	32	1.8	59
10.0	20	2.2	44
15.0	13	2.2	29
22.0	9	2.7	24
33.0	6	2.4	15
45.0	4	5.6	23

15 μas

Astrometric accuracy of the A+ configuration, defined as the resolution divided by the signal-to-noise ratio achieved for a 1 mJy point source in 2 hours.

configuration will provide the answers, detecting proper motions of 30 km/sec at kpc distances with only a month between the observations.

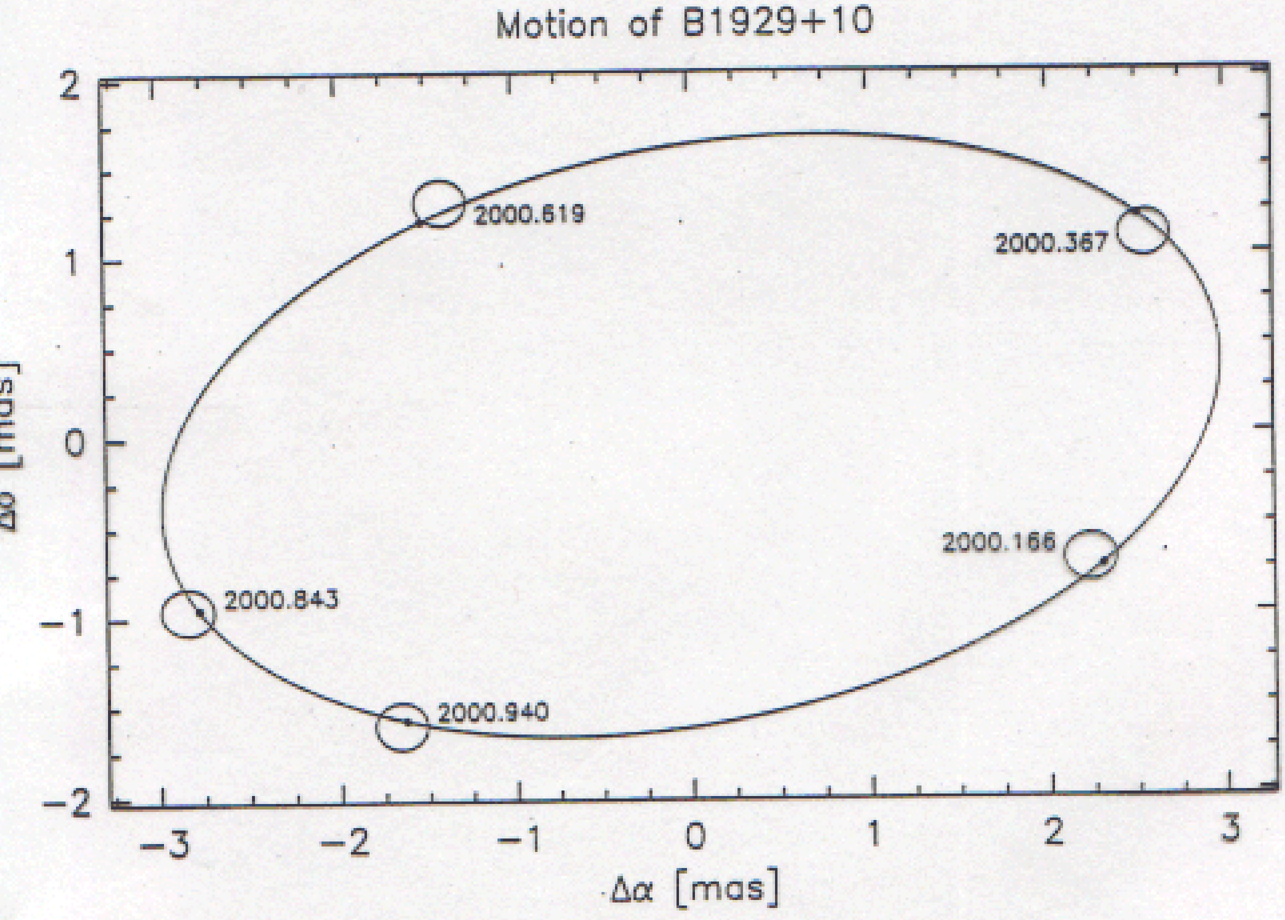
Pulsars

The A+ configuration will be the best instrument in the world for pulsar astrometry. Most such measurements today are done at 1.4 to 1.8 GHz because of the sharp decline in flux density with frequency ($-2.4 \lesssim \alpha \lesssim -1.4$, $S_\nu \propto \nu^\alpha$). With the expanded VLA, most pulsar astrometry will probably be done in either the 2–4 GHz band or the 4–8 GHz, since the increase in sensitivity more than compensates for the roughly 4 or 16-fold decrease in brightness. The higher frequency not only provides a smaller beam, but also reduces ionospheric effects by the square of the frequency ratio. Accurate parallaxes could be measured for $\sim$ 150 pulsars out to 3 kpc, and for $\sim$ 50 out to 8 kpc. In addition to providing a large number of distances independent of electron density models, these data will yield very sensitive proper motion estimates, giving an unparalleled data base of pulsar space motions.

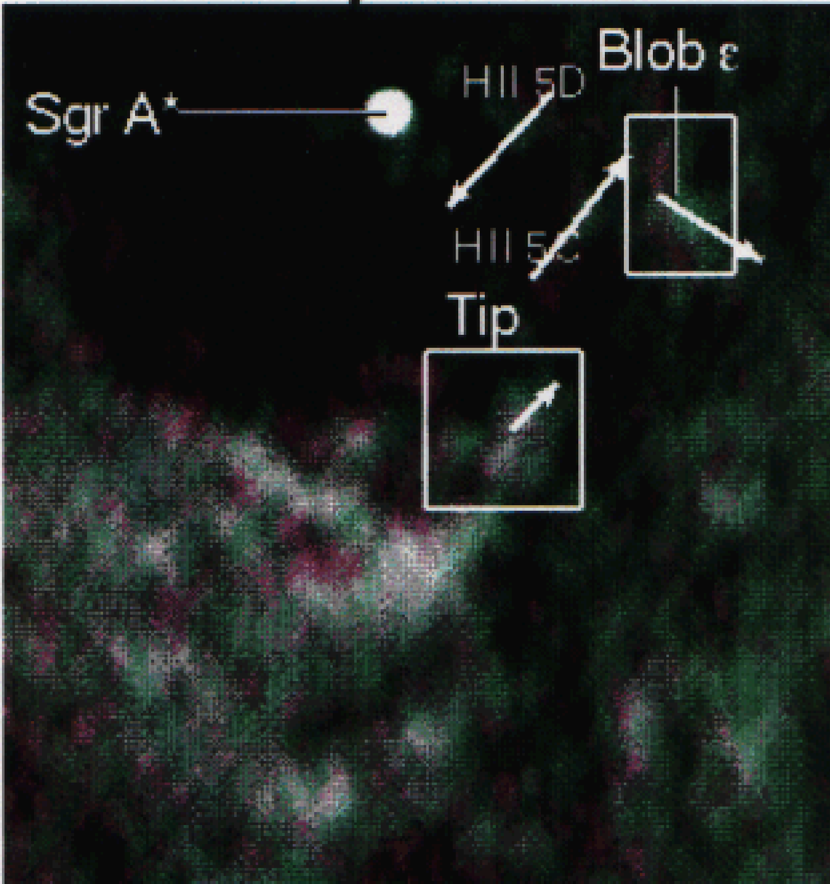
The Galactic Center

The A+ configuration will allow measurements of ionized gas proper motions within a few tenths of a parsec of the Galactic center with accuracies of about 1 km/sec within a single year, making it possible to measure *accelerations* as well as simple velocities. Similar studies of stellar OH, H_2O, and SiO masers will provide even stronger constraints on the Galactic mass distribution on scales

WALTER BRISKEN'S PHD THESIS 2001

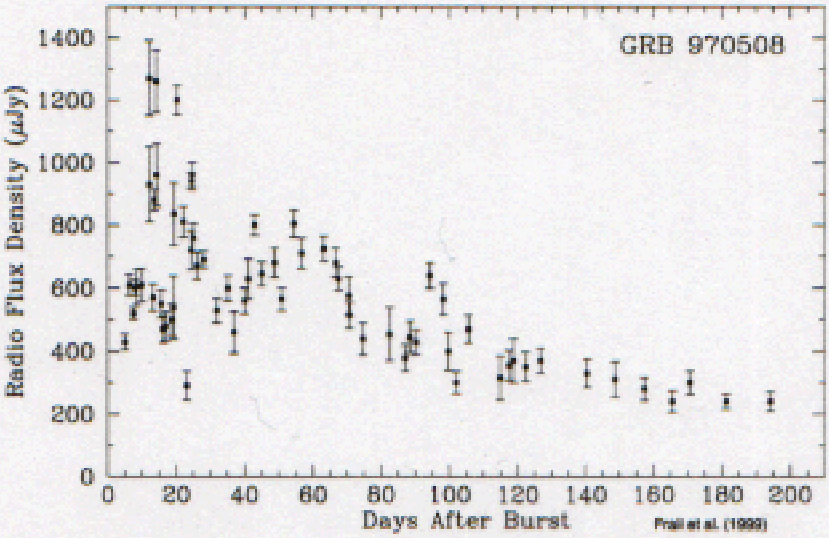


The Minicavity and Its East Rim



2 arcsec
0.08 parsec

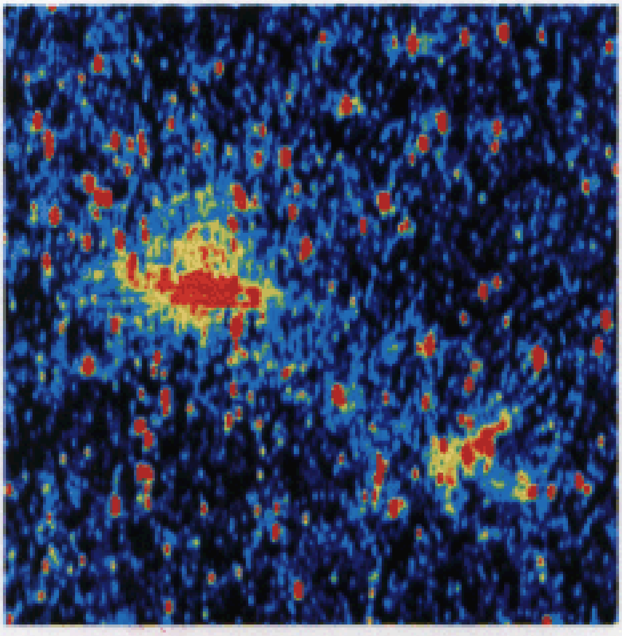
GAMMA-RAY BURSTS



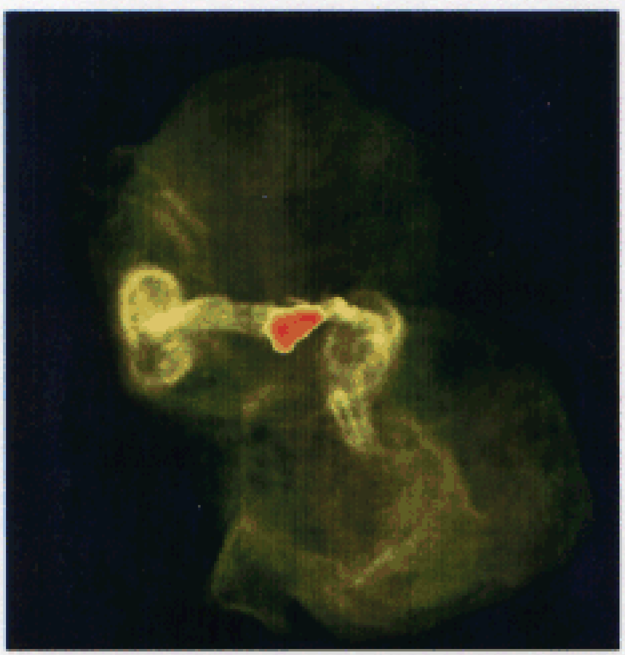
8.46 GHz lightcurve of GRB 970508 (courtesy D. Frail)

- find & track $\sim$ 100/yr (vs. current 1/yr)
- measure size and expansion rate (from scintillation)
- follow evolution (temporal and spectral) from ultrarelativistic to non-relativistic shock
- progenitors: where do they live? (astrometry)
- detection statistics: are they optically obscured?
- types of GRB: SGR, SNe, classical GRB are all distinguishable at radio wavelengths
- deep, sensitive, repeated survey give γ-ray beaming angle (from number of transients with no GRB counterparts)

Galaxy Clusters with the Expanded VLA



Coma Cluster at 90cm (courtesy L. Feretti)

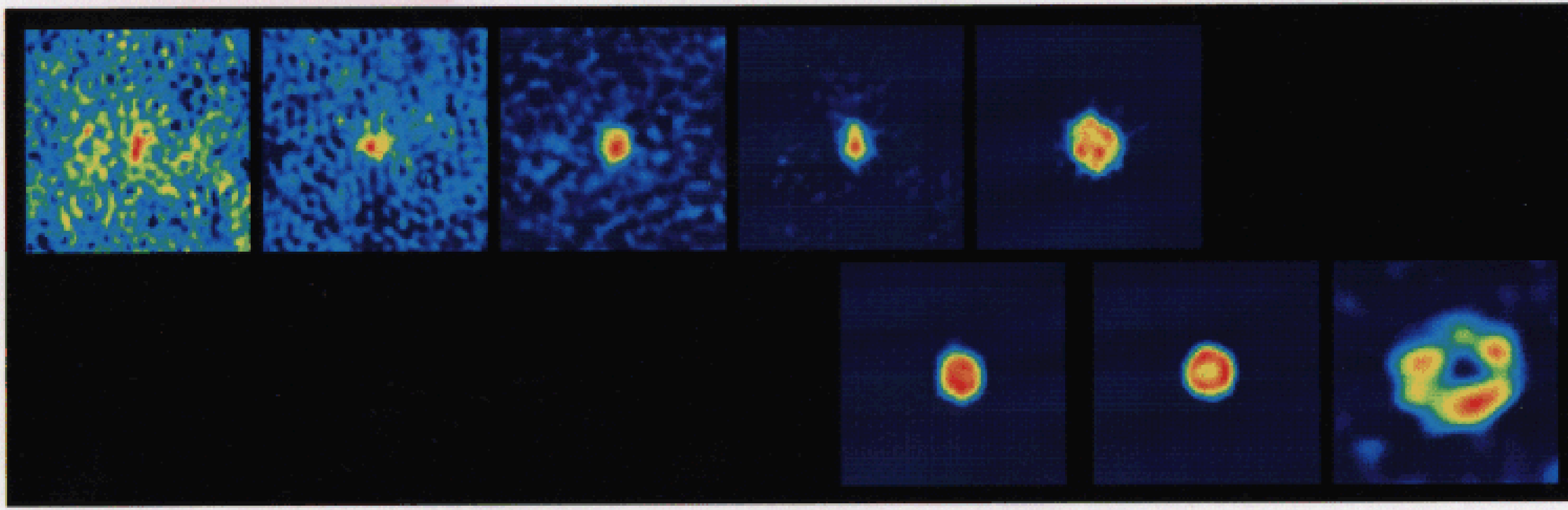


M87 at 90cm (courtesy F. Owen)

- Detailed imaging of fainter haloes
- Polarization mapping
- Faraday rotation towards 1mJy sources
- With X-rays, obtain detailed maps of the magnetic field strength and electron density across entire clusters
- Jet bending due to ICM (FR I) to $z > 3$
- Radio source heating of ICM to $z \sim 0.2$
- Extend Butcher-Oemler studies to z$\sim$ 1–2
- Distinguish star formation from AGNs to z$\sim$0.5
- Weak lensing (more background sources)

NOVA V1974 CYG 1992

MERLIN



VLA ↗

ADD SPECTROSCOPY ON RECOMBINATION LINES → V_{LOS}.

QUASAR
ABSORPTION LINE SYSTEMS

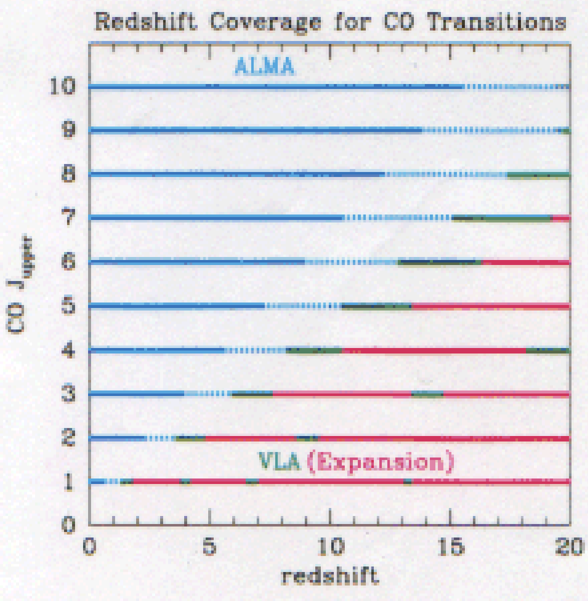
Unbiased spectral line surveys:

- no dust obscuration
- H I: $z=0$ to ≥ 0.4 towards *random* background sources
- CO J=1–0: $z=1.3$–3.4
- HCN, HCO+: $z=0.7$–2.3

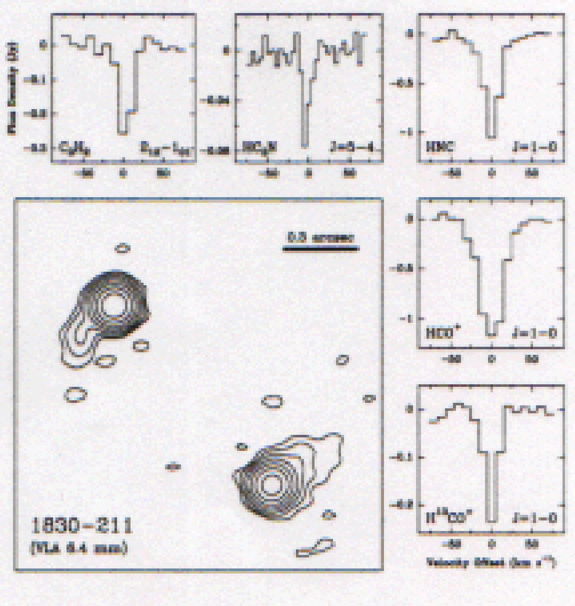
⇒ evolution of cosmic neutral baryons from $z=0$ to 3

⇒ large-scale structure

⇒ estimates of CMB temperature



CO transitions observable with ALMA and the EVLA



Absorption lines at $z=0.88582$ towards PKS 1830–211 (courtesy C. Carilli)

Table 1: **Key Capabilities of the Current and the Expanded VLA.**

Parameter	VLA	EVLA – Phase I The Ultrasensitive Array	EVLA – Phase II The New Mexico Array
Point Source Sensitivity	10μJy	0.8μJy	0.6μJy
No. of baseband pairs	2	4	4
Maximum bandwidth in each polarization	0.1 GHz	8 GHz	8 GHz
No. of frequency channels at maximum bandwidth	16	16,384	16,384
Maximum number of frequency channels	512	16,384[1]	16,384[1]
Maximum frequency resolution	381 Hz	$\sim$ 1 Hz	$\sim$ 1 Hz
(Log) Frequency coverage, 0.3–50 GHz	25%	75%	100%
No. of baselines	351	351	666
Spatial Resolution (5 GHz)	0.4 arcsec	0.4 arcsec	0.04 arcsec