

Capabilities of the Expanded Very Large Array for Astronomical Surveys

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& the EVLA construction and commissioning team

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The EVLA and Surveys

- The Expanded Very Large Array will provide new and powerful capabilities for radio astronomical surveys as well as multi-wavelength follow-up observations of other surveys. Available starting 1 March 2010 with increasing capabilities.
- For more on the EVLA see talks/posters:
 - Rick Perley (387.03 talk Thursday)
 - Aeree Chung (347.01 talk this morning Wednesday)
 - Urvashi Rau (357.01 talk this morning Wednesday)
 - Others earlier in meeting (Claussen, Momjian, Ott, Rupen, Wrobel)

The Expanded Very Large Array

...is a major upgrade of the Very Large Array

- improves all capabilities of the VLA -- except spatial resolution -- by at least an order of magnitude.
 - Full frequency coverage from 1 to 50 GHz (<1 GHz in bands)
 - Up to 8 GHz instantaneous bandwidth
 - New digital correlator with unprecedented capabilities
 - $\sim 3 \mu\text{Jy}$ (1- σ , 1-Hr) point-source continuum sensitivity at most bands.
 - $\sim 1 \text{ mJy}$ (1- σ , 1 km/sec, 1 Hr) line sensitivity at most bands.
- Counting all sources, a \$90M project.
- The Project began in 2001, and will be completed in 2012 – on time, on spec, on budget.
 - EVLA science observing (limited modes) starts March 2010!

Overall EVLA Performance Goals



- Orders of magnitude performance improvement!

Parameter	VLA	EVLA	Factor
Continuum Sensitivity (1- σ , 1 hr.)	30 μ Jy	3 μ Jy	10
Maximum BW in each polarization	0.1 GHz	8 GHz	80
# of frequency channels at max. BW	16	16,384	1024
Maximum number of freq. channels	512	4,194,304	8192
Coarsest frequency resolution	50 MHz	2 MHz	25
Finest frequency resolution	381 Hz	0.12 Hz	3180
# of full-polarization spectral windows	2	64	32
(Log) Frequency Coverage (1 – 50 GHz)	22%	100%	5

The EVLA for Survey Science

- Spectral Coverage
 - 21cm HI line to $z=0.4$ (1.4-1GHz)
 - key molecular transitions, masers
 - radio recombination lines
 - redshifted CO
- Continuum Sensitivity
 - Synchrotron, free-free, dust
 - Polarimetry (magnetic fields)
- The Time Domain
 - 100ms integrations, dynamic spectra
 - Pulsar gating (future)



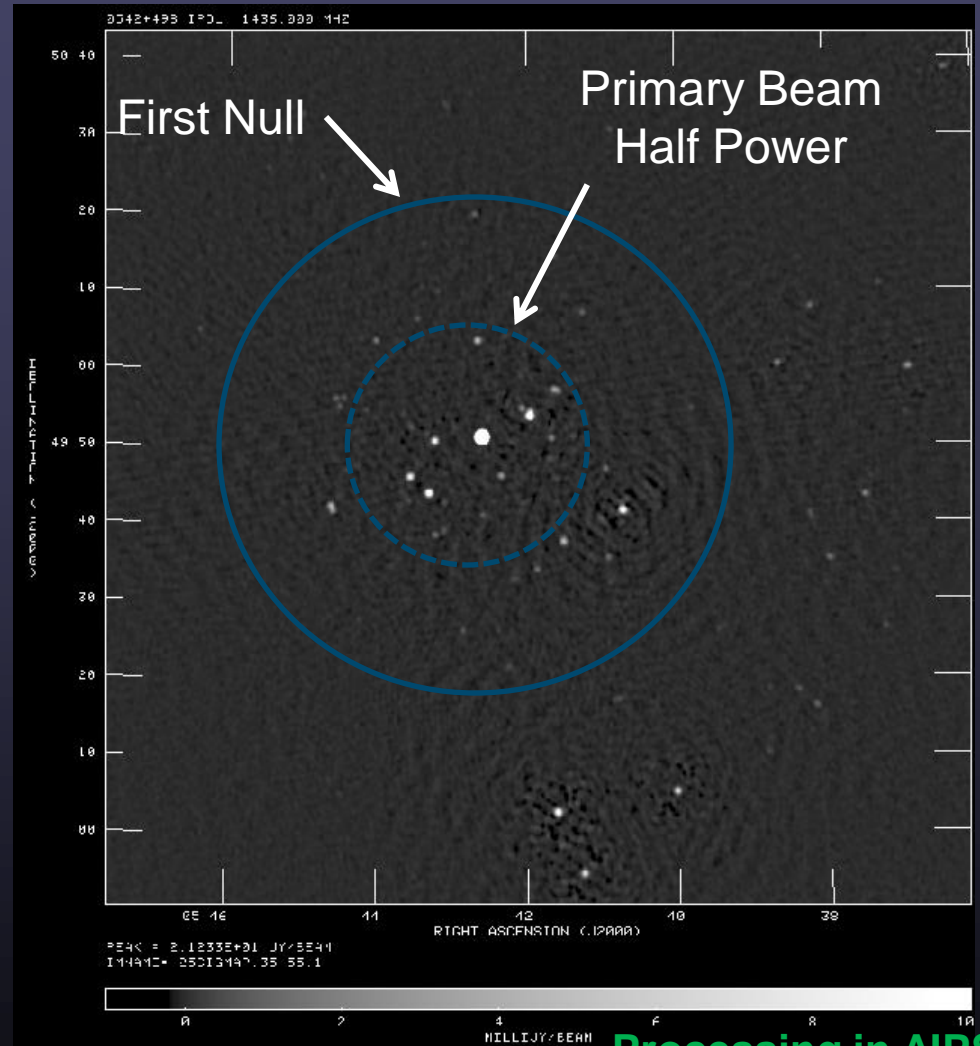
Wide-band spectral coverage
Wide field (e.g. with mosaicing)
High sensitivity
Full Polarization
Use for Surveys and Follow-up
Available starting March 1 2010!

Early EVLA Testing Results

- A 12-antenna sub-array has been established to test correlator capabilities from the WIDAR-0 prototype.
- This test configuration provides:
 - 8192 channels
 - Full polarization
 - Up to eight adjacent spectral windows
- Test observations in 1—2 and 18 – 26 GHz bands are shown on subsequent slides.
 - Data processing in both AIPS and CASA possible

3C147 Deep Field @ 1440 MHz

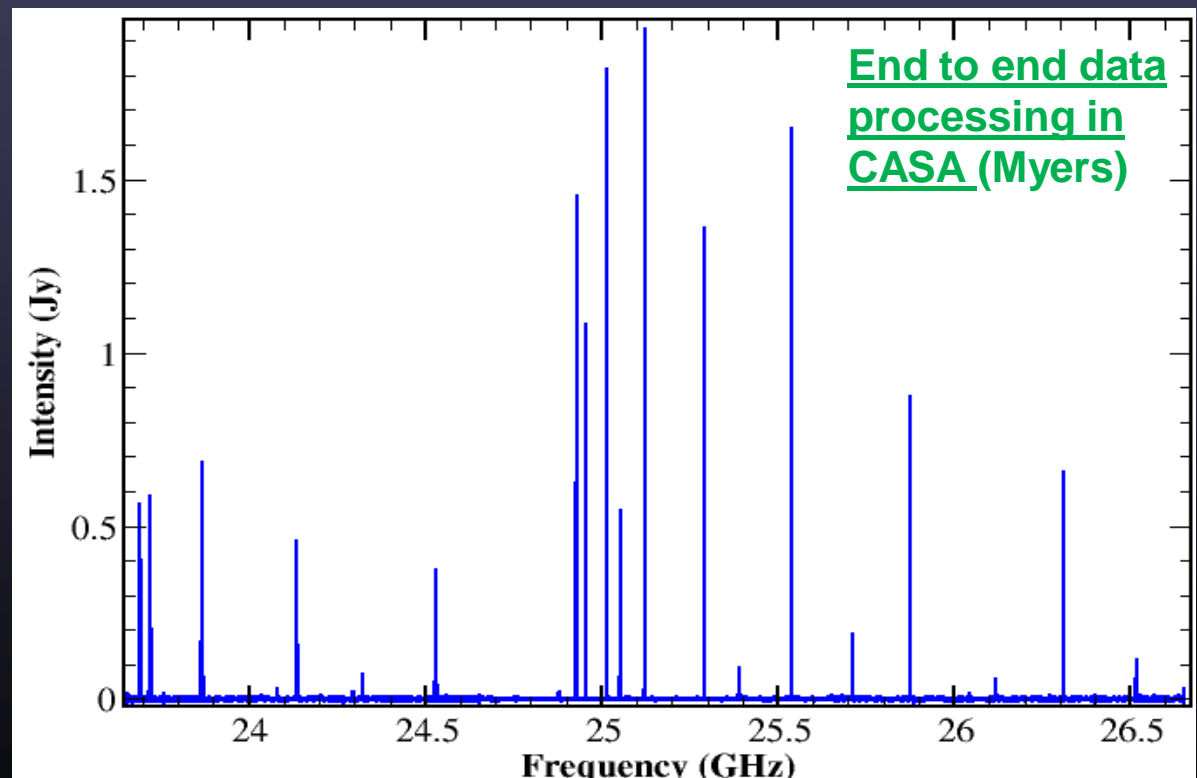
- 12 antennas, 110 MHz bandwidth, 6 hours integration
 - Fidelity ~ 400,000:1
 - Peak/rms ~ 850,000:1
- artifacts are due to structure in the antenna primary beams
 - Advanced imaging software (e.g. Urvashi Rau talk)
- This is the highest fidelity image ever made with the VLA – using only a fraction of the capability!



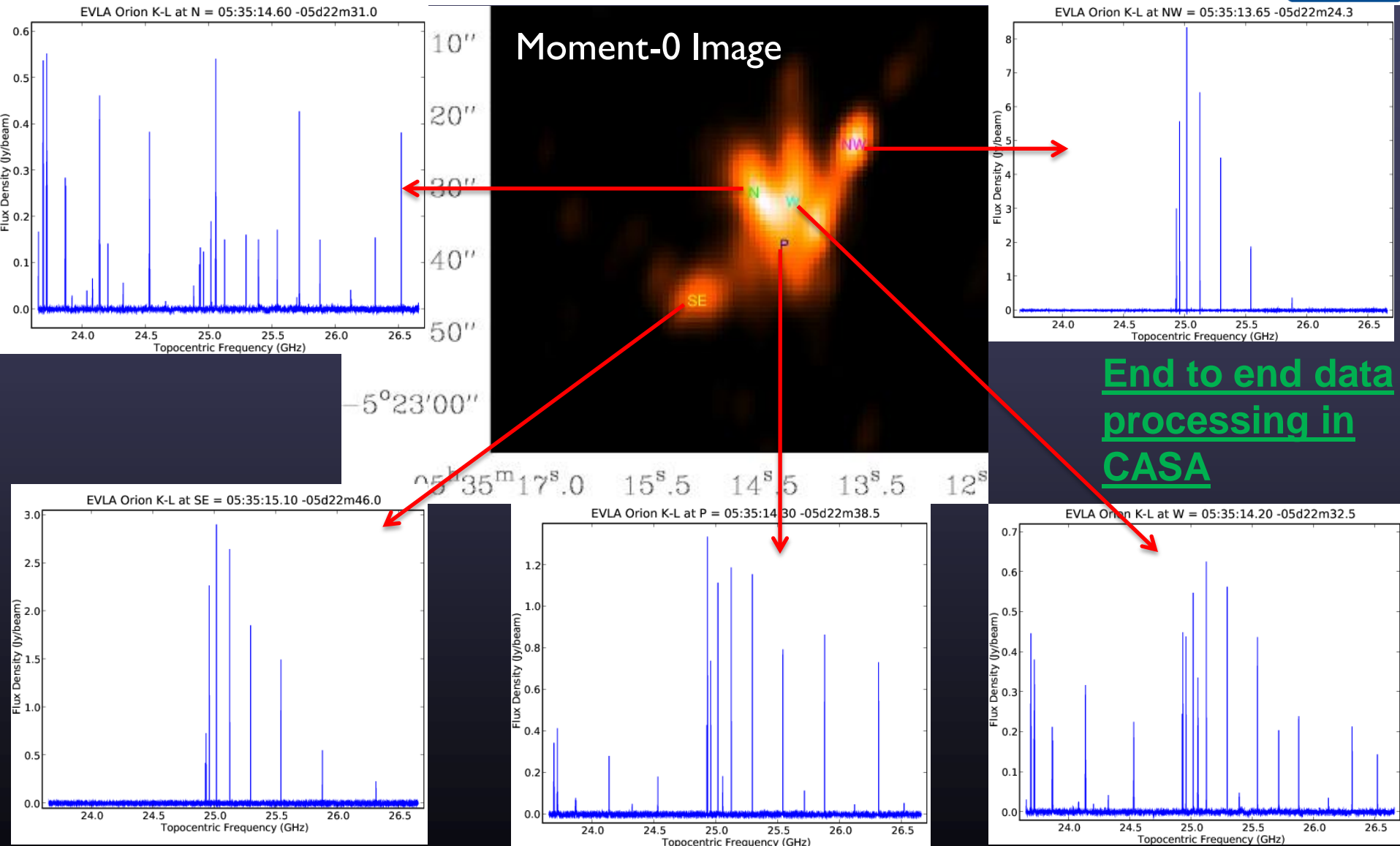
Processing in AIPS
 R. Perley

The Spectrum of Orion-KL – 3 GHz Wide

- Three short (90m,90m,30m) observations of the hot core of Orion, each 1024 MHz wide, ~ 1.5 km/sec velocity and $2.5''$ spatial resolution
- From NH_3 are the 8 lowest meta-stable inversion transitions $(J,K) = (1,1)$ to $(8,8)$, two meta-stable $(9,8)$ and $(10,9)$ lines, the $(6,6)$ line from $^{15}\text{NH}_3$ isotopologue, and the $4(1,4)$ - $4(0,4)$ line from singly deuterated ammonia, NH_2D .
- Two E/A doublets of methyl formate: CH_3CHO
- OCS 2-1
- Three unidentified lines
- Ten strong methanol maser lines from $J_{k=2} - J_{k=1}$ E-type series ($J=2 - 11$).
- Clear spatial segregation of oxygenated vs. nitrogenated molecules.

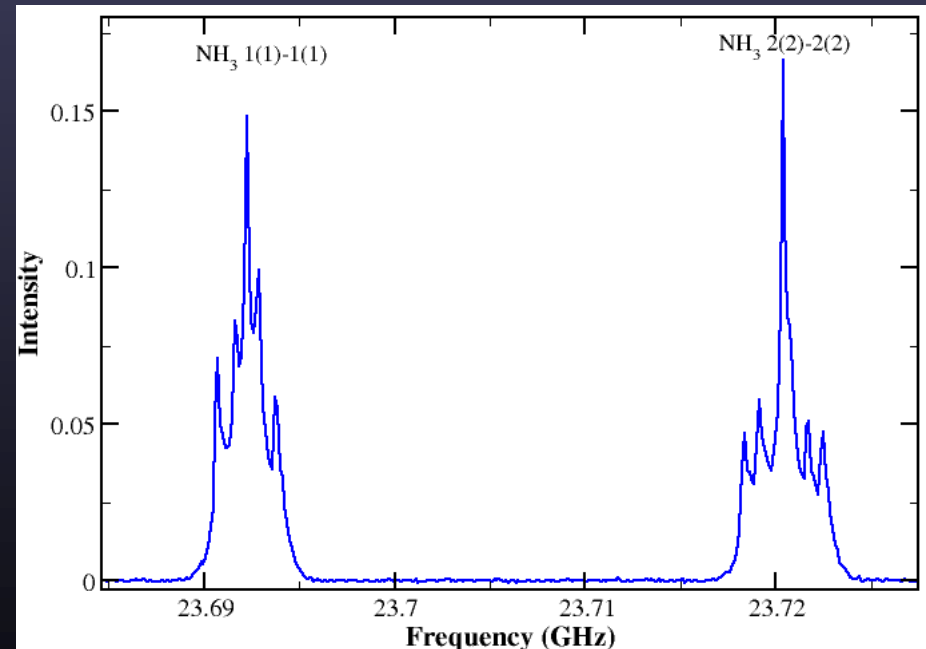
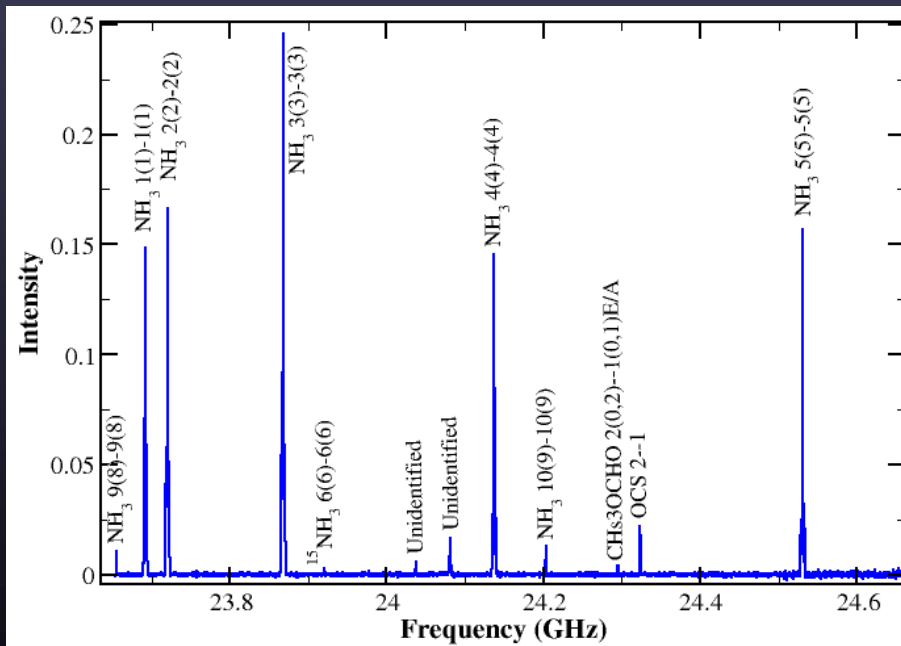


Spectra from 96x96x24012 image cube



Orion: Expanding the Frequency Scale

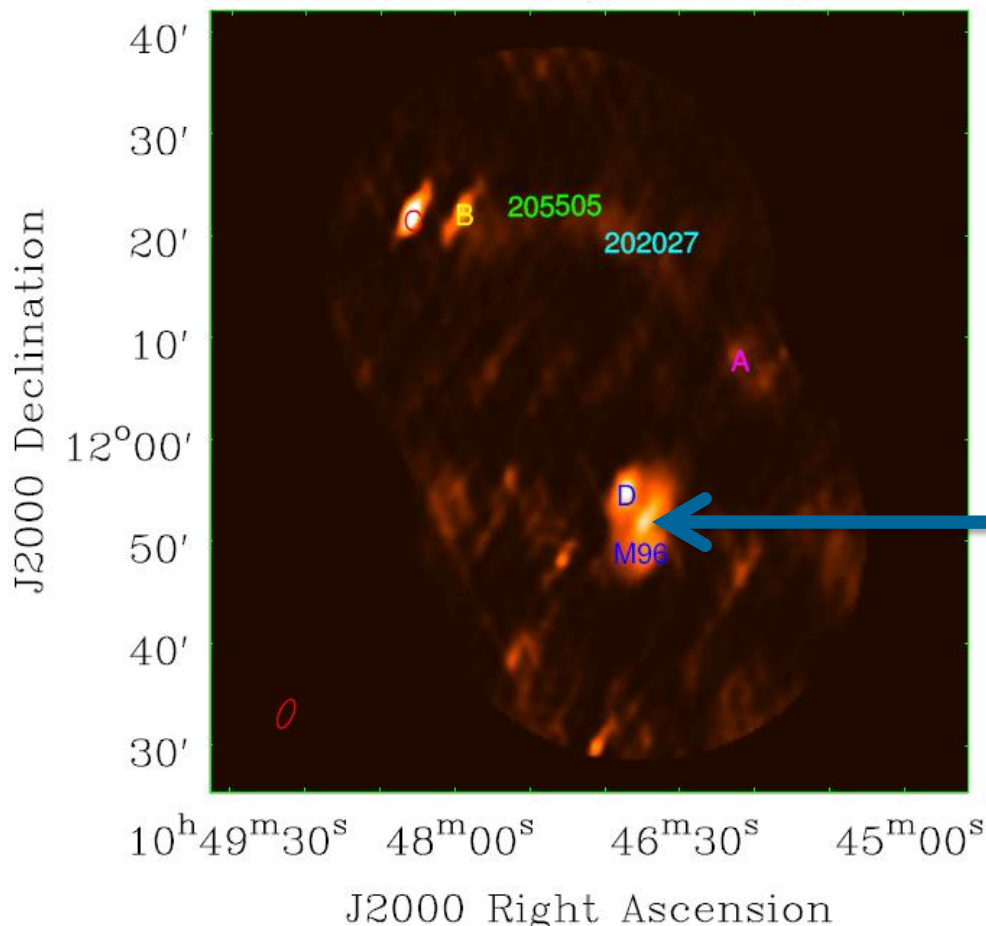
- Left Side: The lowest 1.0 GHz, showing some of the identifications.
- Right Side: A close-up of the two lowest meta-stable transitions, showing the 5 main groups of hyperfine structure which are blended in the Orion-KL spectrum.



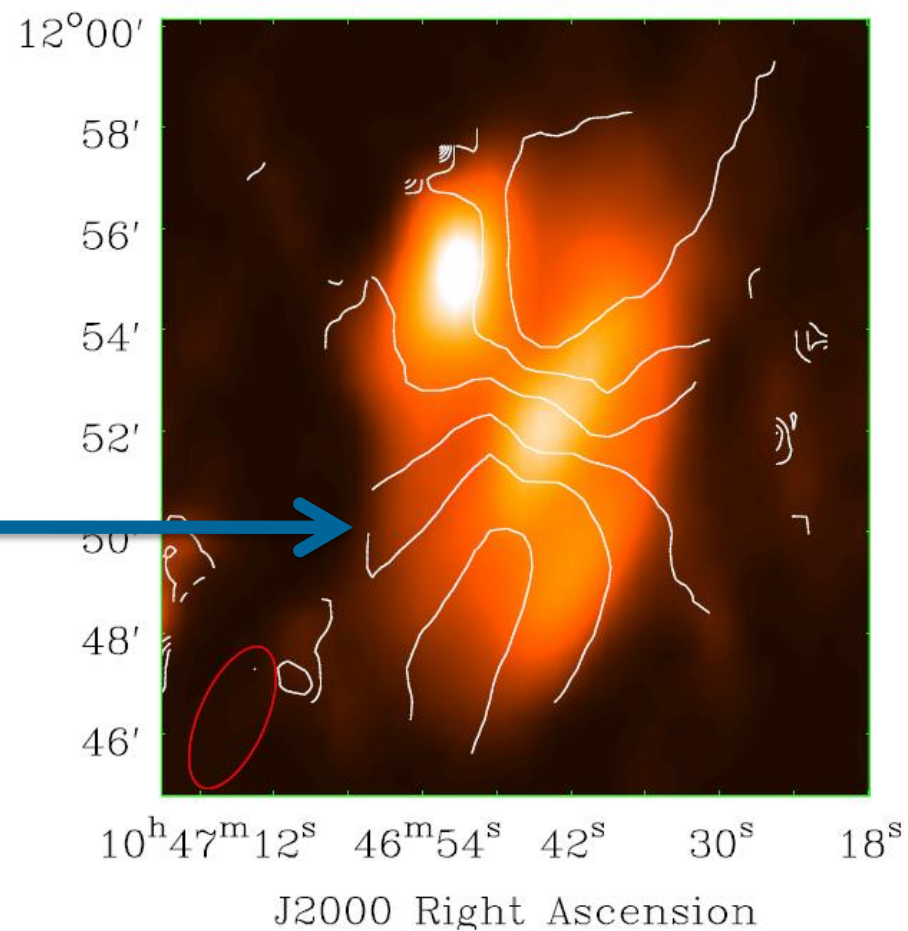
HI in Leo Group (Ring) Region

- “OSRO”-mode observation
 - 1 sub-band, 256 channels, 2MHz BW, 2 pol (~1 hr)

EVLA Leo Ring M96 Region



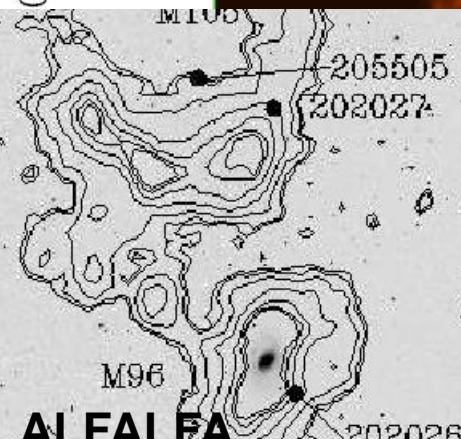
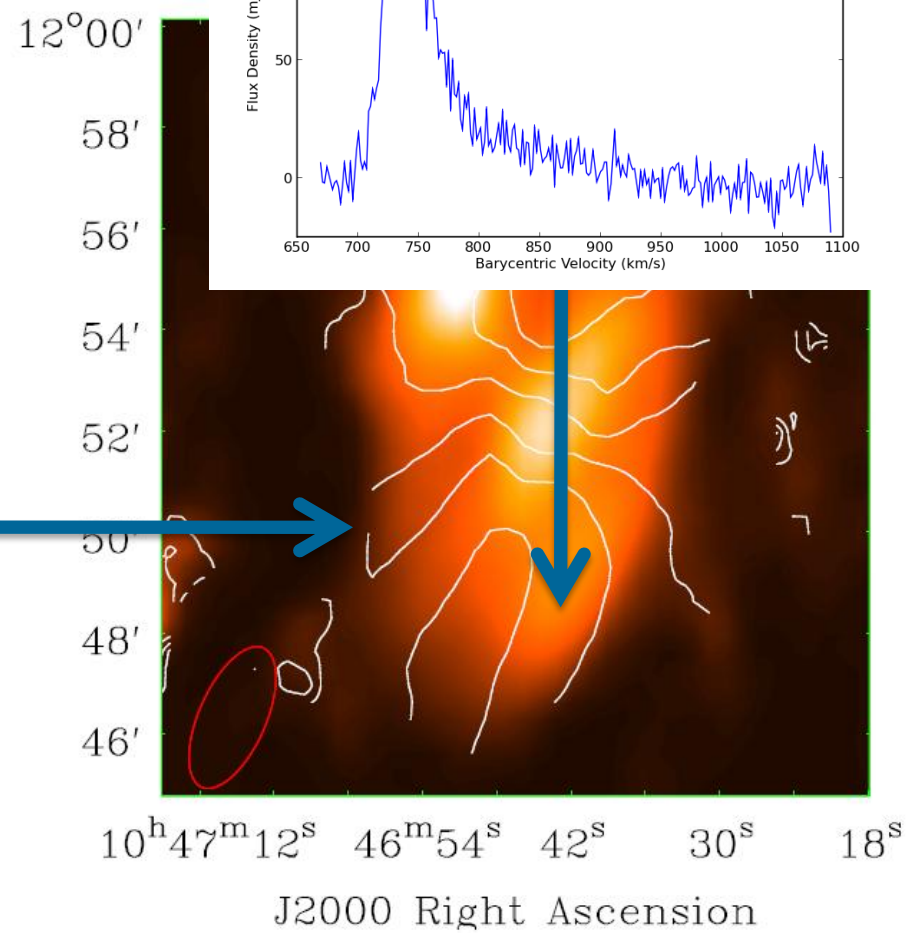
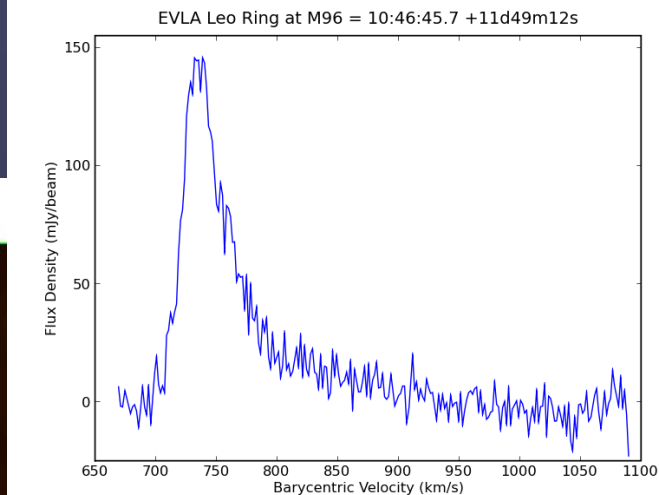
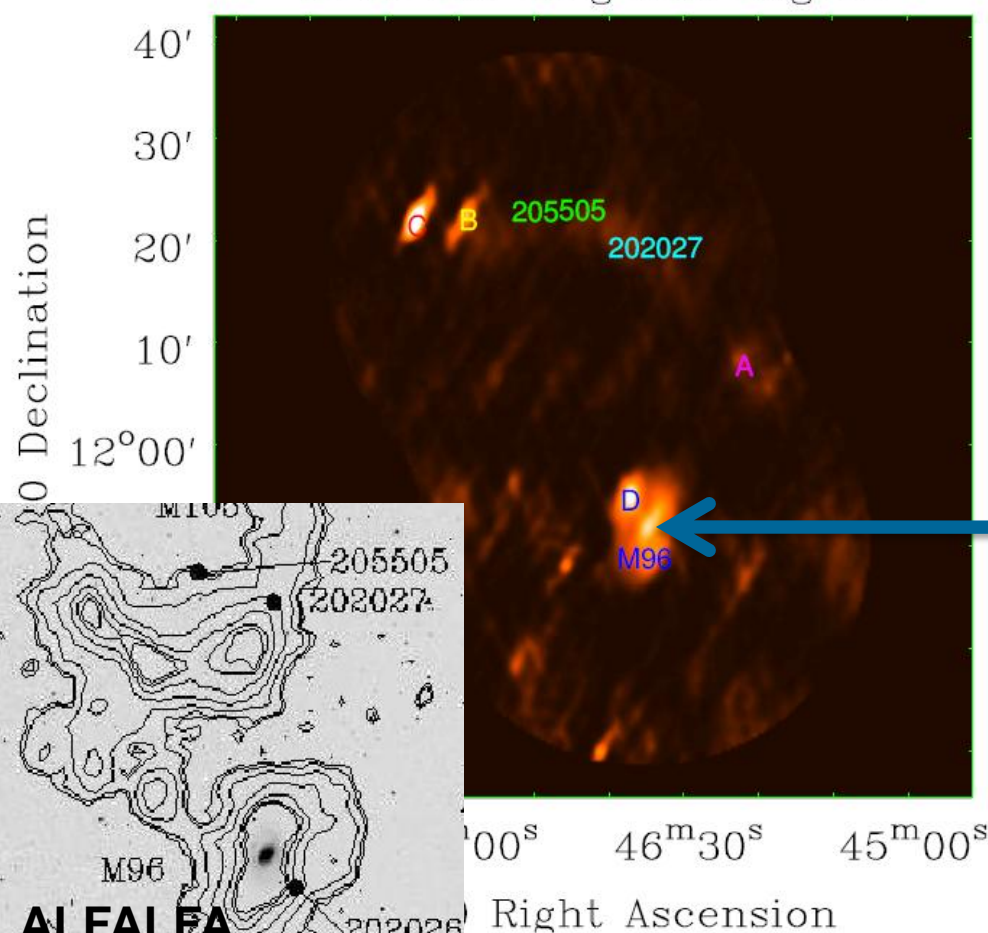
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The Future: EVLA to SKA

- The EVLA will be “complete” in 2012
 - Small enhancements planned for 2010-2019 decade such as compact E-configuration, improved receivers below below 1 GHz, WVR for high-frequency observing.
 - Synergy with Allen Telescope Array (ATA)
- Beyond EVLA – the SKA-high and NAA
 - “North America Array” (NAA) submitted to Decadal Survey as a Design, Development, and Prototyping project (Myers et al.).
 - Part of the international “Square Kilometre Array” (SKA) program as the high-frequency counterpart to the mid-frequency (Cordes et al.) and low-frequency (Backer et al.) SKA components.

NAA High-Level “Design” and Goals



- NAA concept
 - 1-50 GHz capability
 - “core” 5-45 GHz, two 3:1 bands (5-15, 15-45 GHz)
 - At least 10 x EVLA sensitivity
 - 5 x EVLA on baselines < 500km and 500-3800+ km
 - Grow from EVLA + VLBA + GBT + ATA?
- Science Goals
 - Drivers: megamasers (dark energy, BH masses), weighing dark matter (lensing), imaging galaxies in early Universe (lines, continuum), protoplanetary disks, super-star clusters and supernovae, SNe and GRB, obscured pulsars and motions, Local Group motions (astrometry)
 - For more information: <http://www.nrao.edu/nio/naa/>

For more information...

- AAS upcoming talks/posters (this meeting)
 - Rick Perley (387.03 talk Thursday)
 - Aeree Chung (347.01), Urvashi Rau (357.01) talks this morning!
- Project Websites
 - Expanded Very Large Array (EVLA) <http://www.aoc.nrao.edu/evla/astro/>
 - North America Array (NAA) <http://www.nrao.edu/nio/naa/>
- Astro2010 Decadal Submissions
 - NRAO Decade2010 <http://www.nrao.edu/A2010/>
 - “Great Surveys of the Universe” S.T. Myers <http://arxiv.org/abs/0904.2593>
- SKA Info
 - <http://www.skatelescope.org>
 - particularly see the “Science Book” by Carilli & Rawlings (New Astronomy Reviews, Vol.48, Elsevier, December 2004)