The Karl G Jansky Very Large Array
(formerly known as the EVLA)

Current and future capabilities

Jürgen Ott / Michael Rupen / Gustaaf van Moorsel

Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

NRAO

What is the EVLA?

- The Expanded VLA (EVLA) is a major conversion of the Very Large Array
- First light/fringe in 2010, full operation beginning of 2013
- 5-10 times better continuum sensitivity
- Accessibility of entire 1-50 GHz frequency range (8 feeds)
- Up to 8 GHz bandwidth per observation and polarization
- High dynamic range imaging
- Spectral channels up to 16000 - 4×10^6 channels in up to 64 independent subbands (equivalent to 64 independent correlators)
- Correlator supports up to 32 antennas
- Dynamical scheduling (based on scientific priority, weather conditions, and scheduling efficiency)
- Pipeline-calibrated visibility data plus reference images
- New observation preparation software (OPT)
- New data reduction software (CASA)

NRAO

What is the EVLA?

- 27x25m VLA antennas reconfigurable on baselines 35m to 36km
- located in Southern New Mexico at 2100m altitude

What is the EVLA?

- 27x25m VLA antennas reconfigurable on baselines 35m to 36km
- located in Southern New Mexico at 2100m altitude

Spatial Resolution

- With reconfiguration of the antennas, the EVLA can vary its spatial resolution by a factor of ~50 (depending on largest baseline/telescope separation)
- Reconfiguration every 4 months (modifications during commissioning)

Configuration	A	B	C	D
B_{max} (km[1])	36.4	11.1	3.4	1.03
B_{min} (km[1])	0.68	0.21	0.035[5]	0.035
	Synthesized Beamwidth θ_{HPBW}(arcsec)[1,2,3]			
74 MHz (4 band)	24	80	260	850
1.5 GHz (L)	1.3	4.3	14	46
3.0 GHz (S)[6]	0.65	2.1	7.0	23
6.0 GHz (C)	0.33	1.0	3.5	12
8.5 GHz (X)[7]	0.23	0.73	2.5	8.1
15 GHz (Ku)[6]	0.13	0.42	1.4	4.6
22 GHz (K)	0.089	0.28	0.95	3.1
33 GHz (Ka)	0.059	0.19	0.63	2.1
45 GHz (Q)	0.043	0.14	0.47	1.5

Largest Angular Scale

- The *shortest* baseline sets the largest angular scale that an interferometer is sensitive to
- Compact configurations images have less spatial resolution but cover larger angular scales and increase surface brightness sensitivity

Configuration	A	B	C	D
B_{max} (km[1])	36.4	11.1	3.4	1.03
B_{min} (km[1])	0.68	0.21	0.035[5]	0.035
	Largest Angular Scale θ_{LAS}(arcsec)[1,4]			
74 MHz (4 band)	800	2200	20000	20000
1.5 GHz (L)	36	120	970	970
3.0 GHz (S)[6]	18	58	490	490
6.0 GHz (C)	8.9	29	240	240
8.5 GHz (X)[7]	6.3	20	170	170
15 GHz (Ku)[6]	3.6	12	97	97
22 GHz (K)	2.4	7.9	66	66
33 GHz (Ka)	1.6	5.3	44	44
45 GHz (Q)	1.2	3.9	32	32

Field of view
(depends on diameter of a single antenna)
608'
30'
15'
7.5'
5.3'
3'
2'
1.4'
1'

Receivers

- 8 wideband receivers
- Switching receivers can be as fast as 20s

Band	Range
	(GHz)
20 cm (L)	1.0–2.0
13 cm (S)	2.0–4.0
6 cm (C)	4.0–8.0
3 cm (X)	8.0–12.0
2 cm (Ku)	12.0–18.0
1.3 cm (K)	18.0–26.5
1 cm (Ka)	26.5–40.0
0.7 cm (Q)	40.0–50.0

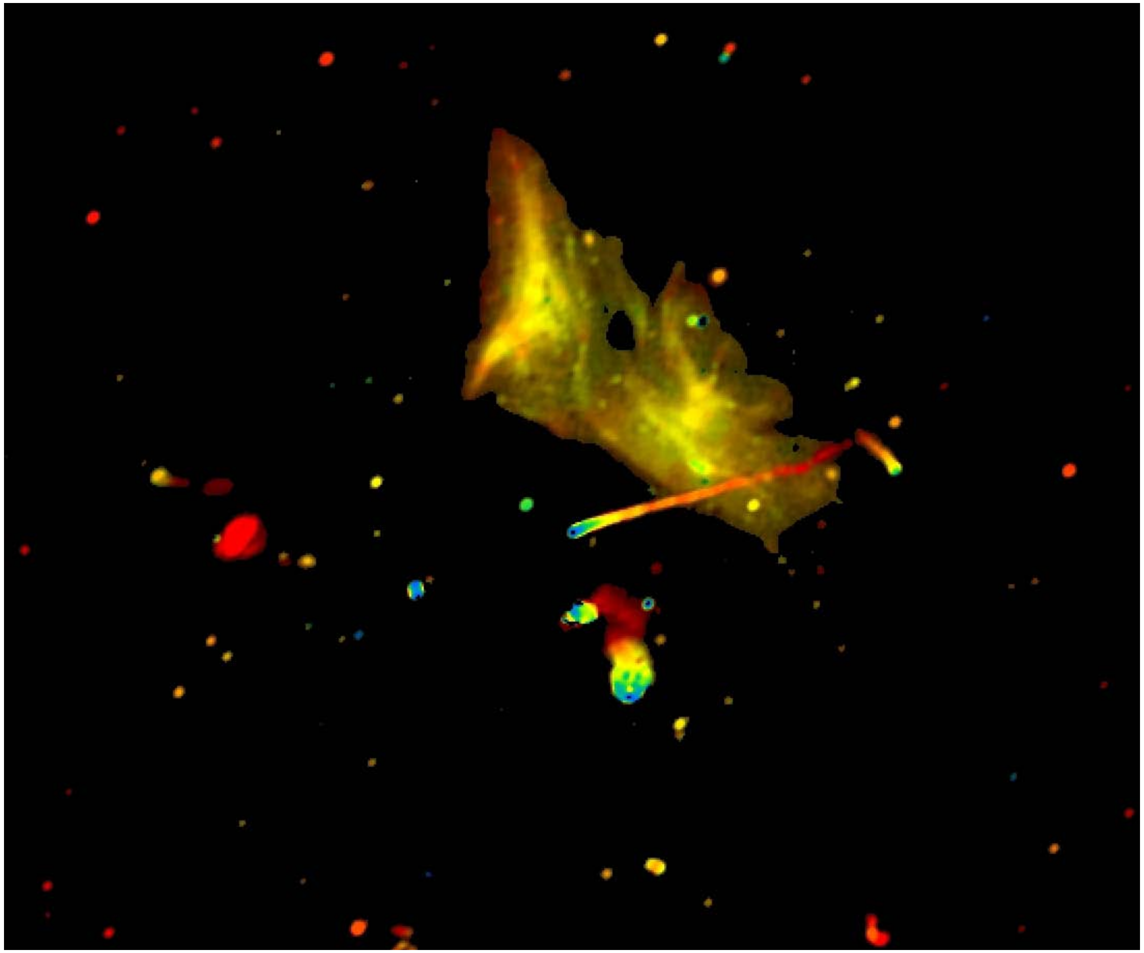
Receivers

- Wideband receivers 1 GHz @ L-band to 13.5 GHz @ Ka-band (correlator can go up to 8 GHz)
- Better sensitivity (cf. VLA max. bandwidth 50 MHz)
- Better image fidelity, higher dynamic range with a goal of 10^6 (filling in gaps in the uv-coverage/multi-frequency synthesis; better RFI isolation)
- Determination of spectral indices in single observations
- Multi-line observations at identical weather conditions for accurate line ratios

Band	Range
	(GHz)
20 cm (L)	1.0–2.0
13 cm (S)	2.0–4.0
6 cm (C)	4.0–8.0
3 cm (X)	8.0–12.0
2 cm (Ku)	12.0–18.0
1.3 cm (K)	18.0–26.5
1 cm (Ka)	26.5–40.0
0.7 cm (Q)	40.0–50.0

Wideband Imaging

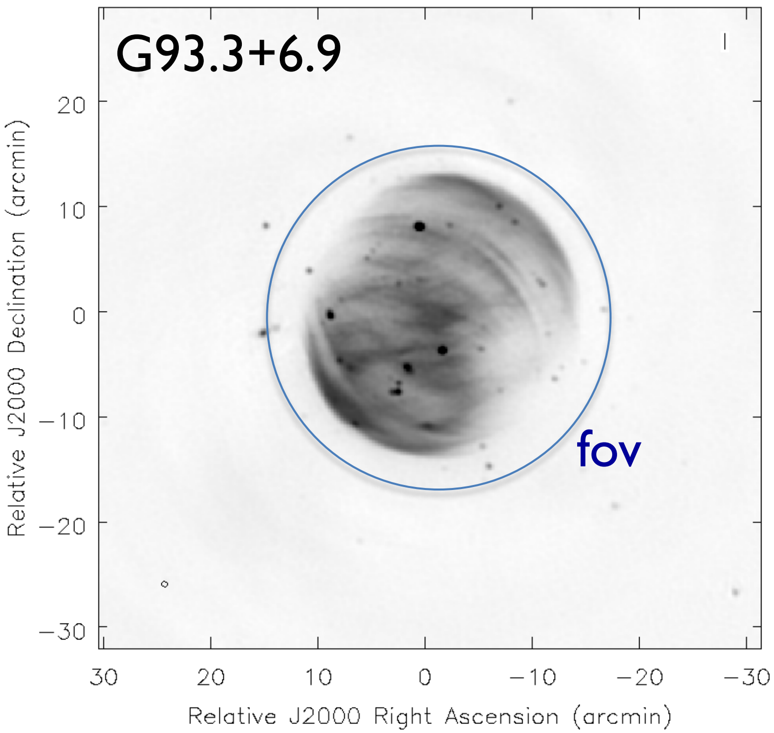
- Relics and Jets in Abell 2256
- Color: spectral index



Owen, Rudnick, Eilek, Rau, Bhatnagar, Kogan

Wideband Imaging

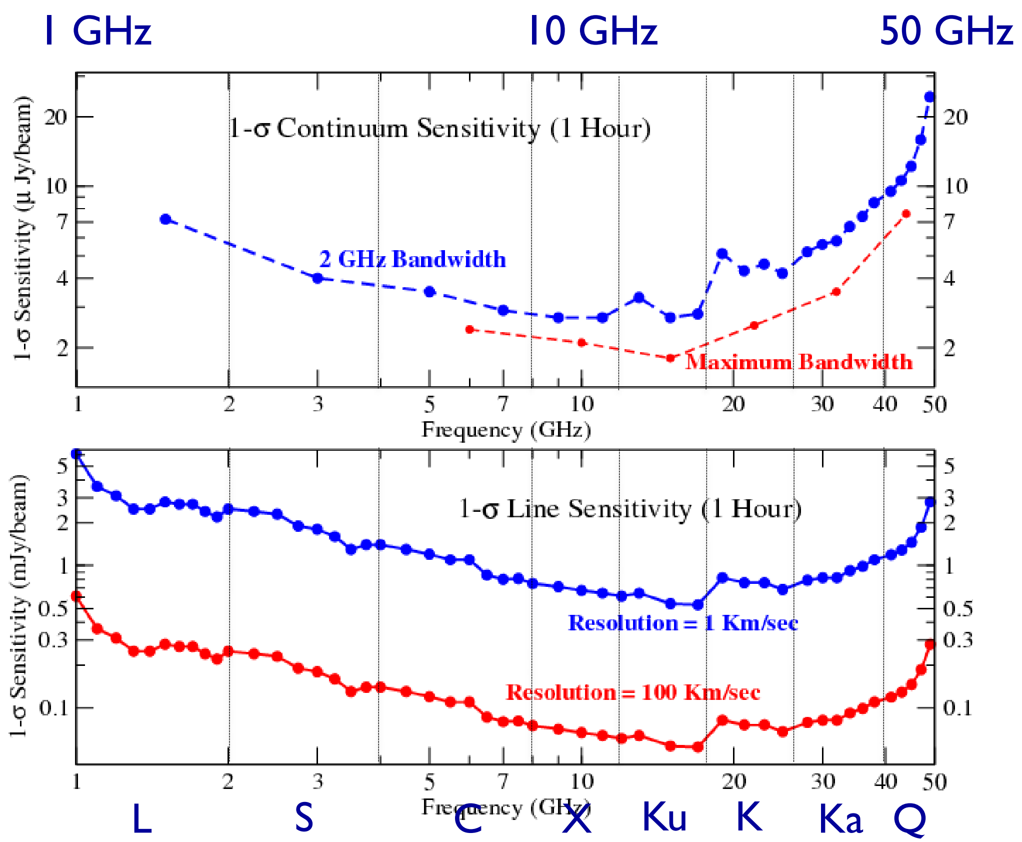
- Wide-band, wide-field imaging
- Multi-scale cleaning
- A-projection for wide-field imaging



Bhatnagar, Green, Rau, Golap, Rupen & Perley

Sensitivity

- At 10 GHz: in 1h, a 1σ noise of 2 μJy continuum
- 0.8 mJy in 1 km s^{-1} channel

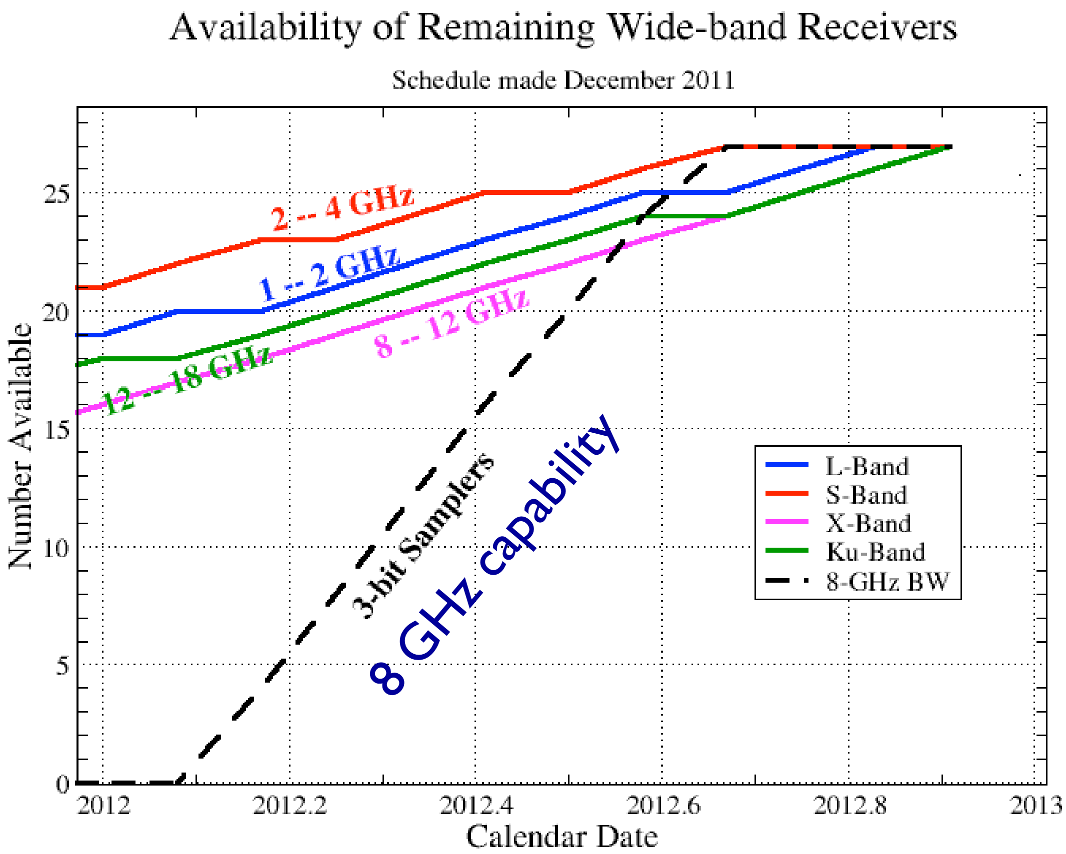


VLA – EVLA Comparison

Parameter	VLA	EVLA
Continuum sensitivity (1s, 9 hr)	10 μJy	1 μJy
Maximum bandwidth	0.1 GHz	8 GHz
Number of frequency channels at maximum bandwidth	16	16,384
Maximum number of frequency channels	512	4,194,304
Coarsest frequency resolution	50 MHz	2 MHz
Finest frequency resolution	381 Hz	0.12 Hz
Frequency coverage, 1 - 50 GHz	22%	100%
Number of baselines	351	351
Maximum spatial resolution (5GHz)	0.3”	0.3”

Receiver Availability

- Majority of receivers is already installed, a few more remaining, installation of 3-bit samplers (required for 8 GHz bandwidth) will commence soon



Complete:

C: 4-8 GHz

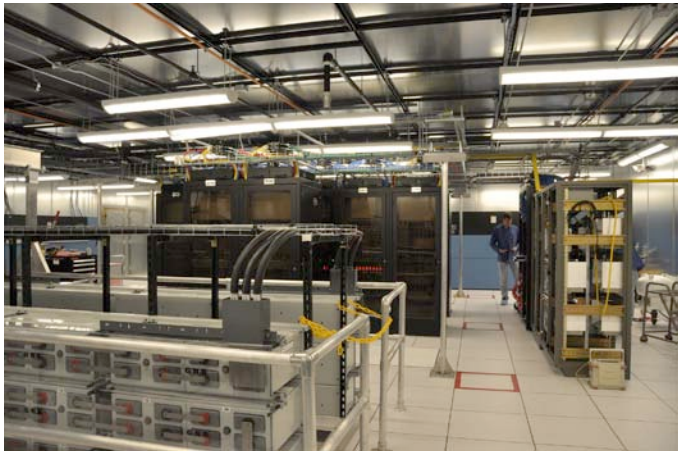
K: 18-26.5 GHz

Ka: 26.5–40GHz

Q: 40-50GHz

WIDAR Correlator

- WIDAR: Wideband Interferometric Digital Architecture
- 10^{16} calculations/s
- Fiber bandwidth: 3 Tbits/s = 48 million phone calls
- 16 GHz per antenna = 2600 TV channels
- 175 kW = 350 refrigerators electricity usage
- 160 Gbits/s output
- 160 baseline boards
- 120 station boards



CNRC-NRC

Corrélateur
WIDAR
Correlator

NRAO

WIDAR Correlator

Final specs:

- 64 independent subbands act like 64 independent correlators independent in bandwidth, channelization, polarization products
- Each subband:
    - Up to 4 polarization products
    - 31 kHz – 128 MHz bandwidth
    - Up to 16384 channels
    - 2 Hz – 2 MHz bandwidth
- Baseline board stacking (trading subbands for additional channels)
- Recirculation (trading integration time for additional channels)

WIDAR Correlator

Examples:

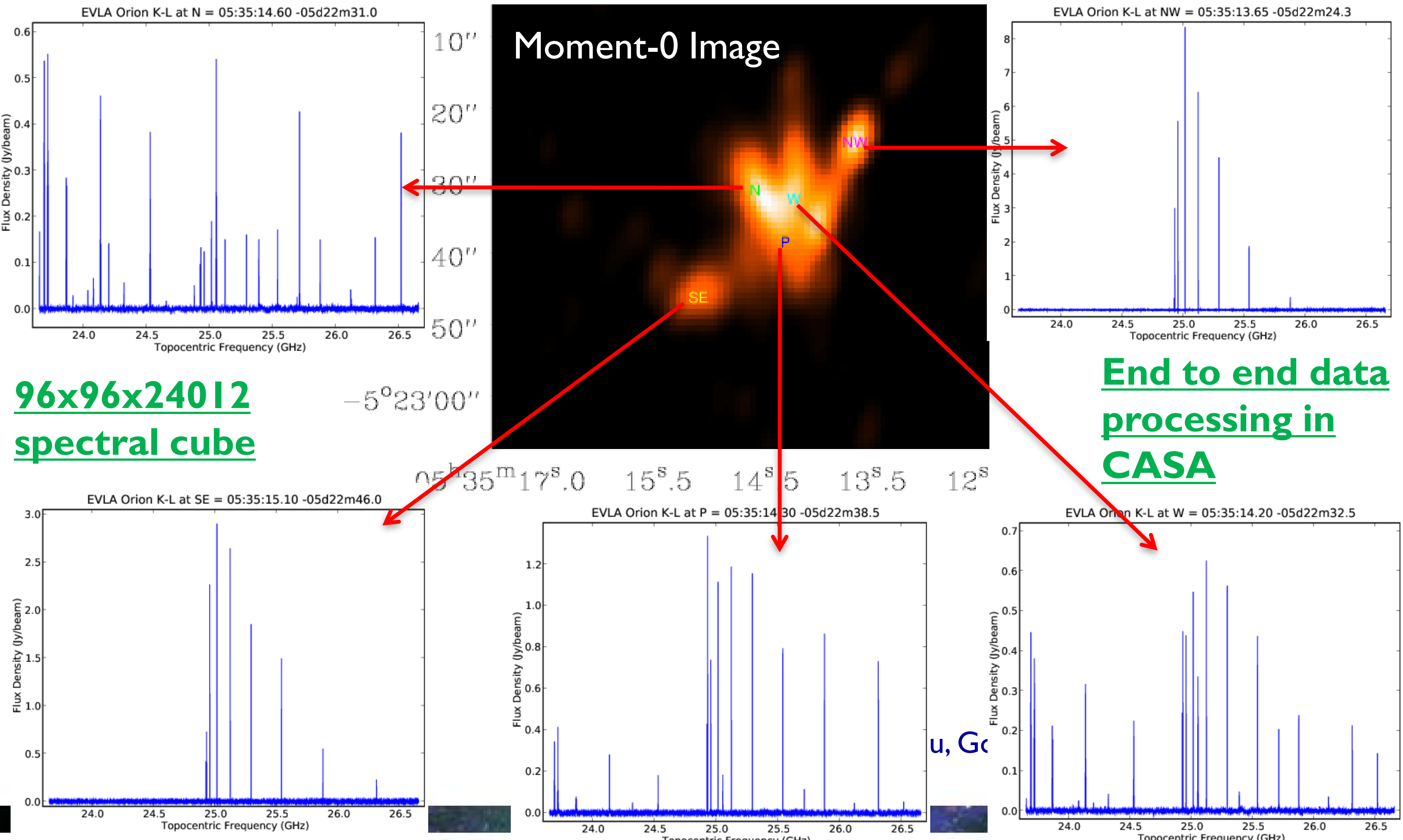
- Ka-band (1cm): 2x1 GHz imaging (captures tens of important molecular lines) with 3 km/s spectral resolution (dual pol), 1s integration times

  even more channels with recirculation

- L-band (21cm): full stokes continuum at 2 MHz resolution (using 8 subbands) plus sub km/s imaging on HI, OH, radio recombination lines (up to 56 additional subbands!), all simultaneously

- S-band (13cm): 31 Radio recombination lines at once with sub-km/s resolution; sensitivity increase by stacking

Multi-Line Imaging: Orion KL

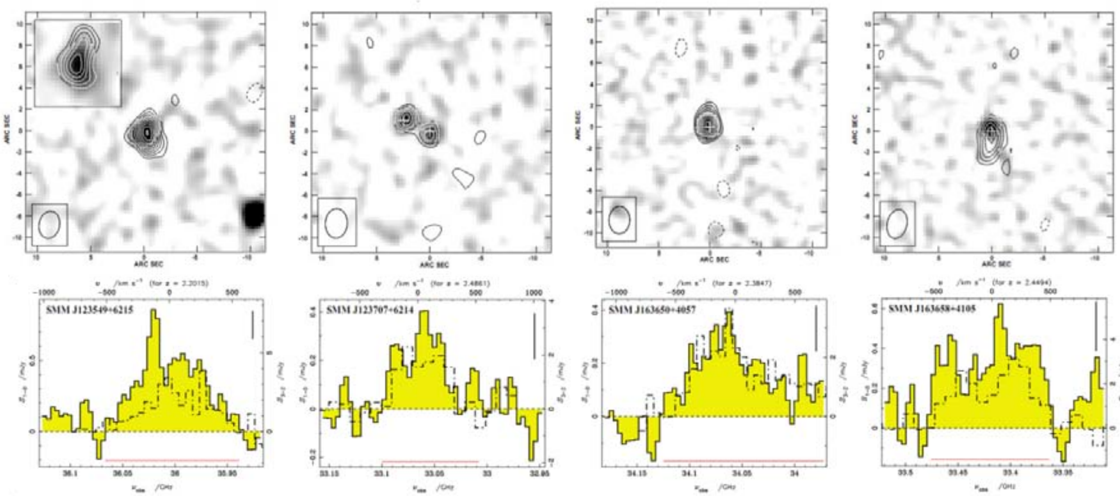


96x96x24012 spectral cube

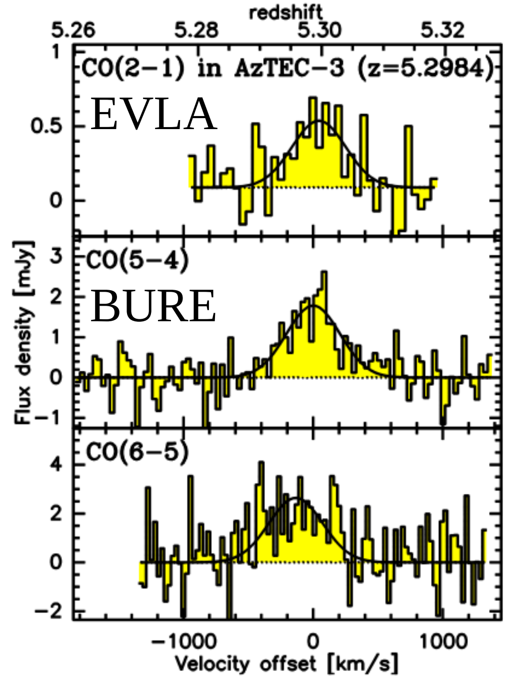
End to end data processing in CASA

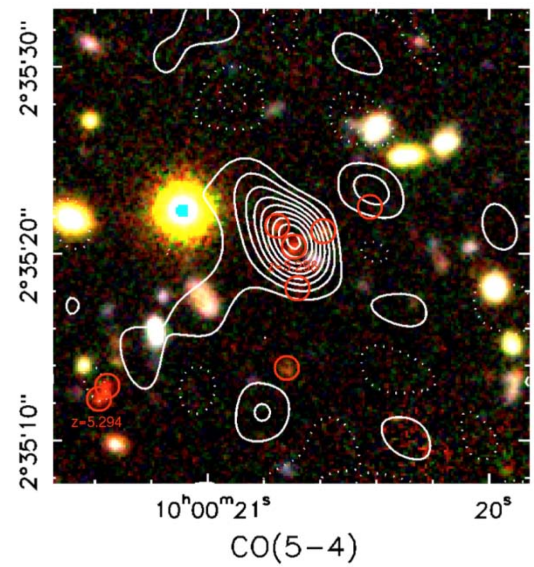
High z spectral surveys

- EVLA is giving access to low excitation CO lines at intermediate z and high excitation lines at high z
- Wideband enables blind CO surveys
- Perfect complement to ALMA and other (sub)mm observatories



Extended, low excitation CO in z~2.3 SMG (Ivison ea)





Multitransition CO study of most distance SMG z=5.3 (Riechers, Capak ea)

Courtesy C. Carilli

NRAO

OSRO modes

- During commissioning we offer open shared risk (OSRO) observing and resident shared risk observing (RSRO) for those who come to Socorro and help to commission the EVLA for at least 3 months
- OSRO capabilities are better tested but more limited than RSRO correlator modes

- For the 1 Feb 2012 deadline, we offer the following OSRO capabilities:
- 2 GHz bandwidth, 1 GHz on each baseband, each up to 8 subbands
- Doppler setting
- Each subband:
  - 31kHz – 128 MHz bandwidth with 64 channels, 4 polarization products or
  - 31kHz – 128 MHz bandwidth with 128 channels, 2 polarization products
  - subbands must be contiguous in frequency

NRAO

RSRO modes

- 2 or 8 GHz bandwidth (use of 3-bit samplers)
- 64 subbands
- Independently tunable
  - Basic subband setting: 31 kHz-128 MHz bandwidth , 64 channels, full pol or
  - 31 kHz – 128 MHz bandwidth, 128 channels, dual pol
  - Baseline board stacking (trading subbands for additional channels)
  - Recirculation (trading integration time for additional channels)

- Data rates can be very large and some restrictions apply

NRAO

Advanced Modes for RSRO

- Capabilities:
  - Multiple sub-arrays
  - OTF mosaicing
  - Phased EVLA and single-dish VLBI → Amy Mioduszewski's presentation
  - Solar and planetary observing
  - Pulsar observing
  - Observing with the 3-bit sampler system
  - Fast correlator dumps
  - Low frequency (<1 GHz) observing
- Other commissioning activities:
  - Pipeline heuristics, including automated flagging and data quality analysis
  - Testing of new full-field, wide-bandwidth imaging algorithms
  - Advanced data analysis tools

Data Reduction

- OSRO data reduction is possible in CASA and AIPS
- RSRO and full EVLA data reduction in CASA only
- Data volumes can be very large and parallelization of the software is currently underway
- CASA contains new wide-band, wide-field imaging algorithms
- On-the-fly Interferometry/Mosaicing
- Development of automatic RFI flagging
- A computing cluster will be available for users in Socorro
- Hardware recommendations are provided on our webpage for those who decide to upgrade their own computing equipment

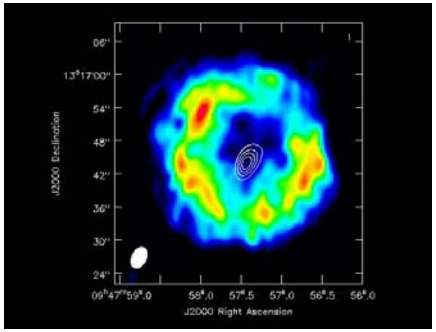
CASA
Common Astronomy Software Applications

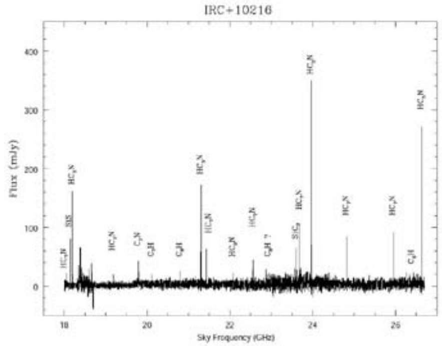
NRAO

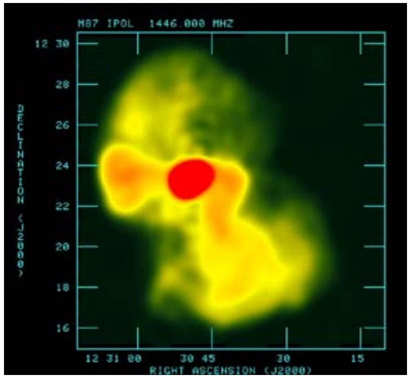
EVLA

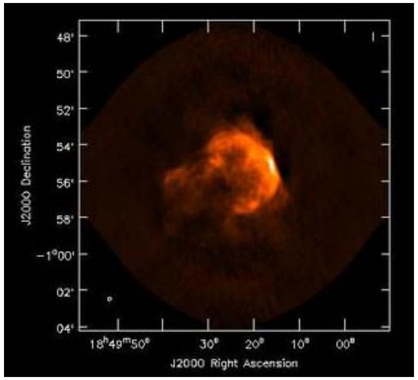
Next proposal deadline: 1 Feb 2012

science.nrao.edu









http://science.nrao.edu/evla/earlyscience/demoscience/